# An ACO Algorithm Benchmarked on the BBOB Noiseless Function Testbed

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# ABSTRACT

 $ACO_{\mathbb{R}}$  is an ant colony optimization algorithm for continuous domains. In this article, we benchmark  $ACO_{\mathbb{R}}$  on the BBOB noiseless function testbed, and compare its performance to PSO, ABC and GA algorithms from previous BBOB workshops. Our experiment shows that  $ACO_{\mathbb{R}}$  performs better than PSO, ABC and GA on the moderate functions, ill-conditioned functions and multi-modal functions. Among 24 functions,  $ACO_{\mathbb{R}}$  solved 19 in dimension 5, 9 in dimension 20, and 7 across dimensions from 2 to 40. Furthermore, in dimension 5, we present the results of the  $ACO_{\mathbb{R}}$  when it uses variable correlation handling. The latter version is competitive on the five dimensional functions to (1+1)-CMA-ES and BIPOP-CMA-ES.

# **Categories and Subject Descriptors**

G.1.6 [Numerical Analysis]: Optimization—global optimization, unconstrained optimization; F.2.1 [Analysis of Algorithms and Problem Complexity]: Numerical Algorithms and Problems

## **General Terms**

Algorithms

## Keywords

Benchmarking, Black-box optimization, Ant colony optimization, Continuous domains

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## 1. INTRODUCTION

The ant colony optimization (ACO) metaheuristic was originally proposed for solving discrete optimization problems [2]. Recently, the adaption of ACO algorithms for continuous domains received increasing attention [9, 11, 13]. Socha and Dorigo [13] replaced the discrete probability distribution with probability density functions (PDFs) in the solution construction for continuous domains, and thus proposed an ACO algorithm for continuous domains, called ACO<sub>R</sub>. The popularity of ACO<sub>R</sub> is illustrated by the more than 260 citations according to Google Scholar as of March 2012 and by being one of top 10 cited papers of the recent five years in the European Journal of Operational Research. However, ACO<sub>R</sub> has not been benchmarked so far on the BBOB function testbed.

In this article, we benchmark  $ACO_{\mathbb{R}}$  on the BBOB noiseless function testbed. We test two versions of  $ACO_{\mathbb{R}}$ . The first version uses the original mechanism, proposed in [13] to handle variable correlations; the second version does not use this mechanism. In what follows, these two versions are called  $ACO_{\mathbb{R}}$ -vch and  $ACO_{\mathbb{R}}$ , respectively. As a better illustration, we compare the performance of  $ACO_{\mathbb{R}}$  to the data obtained by three standard nature-inspired algorithms PSO [4], ABC [3], and GA [12] which have been benchmarked in the previous BBOB workshops. Furthermore, we compare  $ACO_{\mathbb{R}}$ -vch to performance data for (1+1)-CMA-ES [1] and for BIPOP-CMA-ES [6] from the BBOB 2009 workshop.

## 2. ALGORITHM PRESENTATION

 $ACO_{\mathbb{R}}$  [13] uses a solution archive to create a probability distribution of promising solutions over the search space. The solution archive is initialized by k random solutions. The algorithm iteratively updates the solution archive by generating m new solutions and then keeping only the best k solutions of the k + m solutions. Solutions are generated variable by variable based on a Gaussian kernel, which is defined as a weighted sum of several Gaussian functions  $g_j^i$ , where j is a solution index and i is a variable index. The Gaussian kernel for variable i is:

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$$G^{i}(x) = \sum_{j=1}^{k} \omega_{j} g_{j}^{i}(x) = \sum_{j=1}^{k} \omega_{j} \frac{1}{\sigma_{j}^{i} \sqrt{2\pi}} e^{-\frac{(x-\mu_{j}^{i})^{2}}{2\sigma_{j}^{i}}}, \quad (1)$$

where  $j \in \{1, ..., k\}$ ,  $i \in \{1, ..., D\}$ , with D being the problem dimensionality, and  $\omega_j$  is a weight associated with the ranking of solution  $s_j$  in the archive, rank(j).  $\omega_j$  is defined by:

$$\omega_j = \frac{1}{qk\sqrt{2\pi}} e^{\frac{-(rank(j)-1)^2}{2q^2k^2}},$$
 (2)

where q is a parameter. In  $g_j^i(x)$  of Equation 1,  $\mu_j^i = s_j^i$ , and  $\sigma_j^i$  is equal to

$$\sigma_j^i = \xi \sum_{r=1}^k \frac{|s_r^i - s_j^i|}{k - 1}, \qquad (3)$$

where  $\xi$  is a parameter. The ACO<sub>R</sub> we test here is based on a re-implementation in C++ of the original implementation in R that was used in [13].

### 3. EXPERIMENTAL PROCEDURE

We use here the parameter values that were recommended in the original paper [13], that is: m=2, k=50, q=0.1,  $\xi=0.85$ . A maximum of  $10^7$  function evaluations was used. Every periodic 25000 iterations with a relative solution improvement less than  $10^{-8}$ ,  $ACO_{\mathbb{R}}$  restarts without forgetting the best-so-far solution. To ensure that the final best solution is inside the bounds, the bound constraints are enforced by clamping each generated solution that violates the bound constraint to the nearest solution on the bounds. The negative impact of an infeasible final solution outside the bounds on algorithm comparisons was presented by Liao et al. [10].

#### 4. **RESULTS**

Results from experiments following the procedure in [7] on the benchmark functions from [5,8] are presented in Figures 1 2, and 3 and in Tables 1 and 2.

Among the 24 functions,  $ACO_{\mathbb{R}}$  solved 19 (16 with a 100% success rate) in dimension 5 and 9 (6 with a 100% success rate) in dimension 20.  $ACO_{\mathbb{R}}$  solved all the moderate and multi-modal functions in dimension 5, in which  $ACO_{\mathbb{R}}$  almost reaches a 100% success rate for all these functions expect one failure trial in  $f_{19}$ .  $ACO_{\mathbb{R}}$  solved  $f_1$ ,  $f_2$ ,  $f_5$ ,  $f_6$ ,  $f_8$ ,  $f_9$ ,  $f_{21}$  over dimensions from 2 to 40.

We compare the performance of  $ACO_{\mathbb{R}}$  to the data obtained by PSO, ABC and GA in previous BBOB workshops. As seen from Figures 2 and 3, we observe that  $ACO_{\mathbb{R}}$ obtains better performance than the references when comprehensively considering all functions. Figures 2 clearly illustrates that  $ACO_{\mathbb{R}}$  obtains better run-time performance than PSO, ABC and GA on the moderate functions, illconditioned functions and multi-modal functions. Especially on the moderate functions, across dimensions 5 and 20,  $ACO_{\mathbb{R}}$  clearly dominates PSO, ABC and GA.

We also observe that  $ACO_{\mathbb{R}}$  solved two Rosenbrock functions ( $f_8$  and  $f_9$ ) on dimension 20 with a 100% success rate, and solved two Schaffers F7 functions ( $f_{17}$  and  $f_{18}$ ) on dimension 5 with a 100% success rate. However,  $ACO_{\mathbb{R}}$  does not perform very good on multi-modal functions of higher dimensions and even some weakly structured functions of lower dimensions. In the comparisons, PSO is the only one that could solve the Katsuura function  $(f_{23})$  of dimension 2 and 3; ABC obtained the best performance on the two separable Rastrigin functions.

## 5. CPU TIMING EXPERIMENT

The ACO<sub>R</sub> was run on  $f_8$  until at least 30 seconds have passed. These experiment were conducted with Intel Xeon E5410 (2.33 GHz) on Linux (kernel 2.6.9 - 78.0.22). The results were 3.0E-06, 3.0E-06, 6.5E-04, 7.5E-04, 9.5E-04 and 1.4E-03 seconds per function evaluation in dimensions 2, 3, 5, 10, 20, and 40, respectively.

#### 6. **DISCUSSION**

We additionally present some performance results of  $ACO_{\mathbb{R}}$ -vch comparing it to the data obtained by (1+1)-CMA-ES and BIPOP-CMA-ES in the BBOB 2009 workshop. We restrict the comparison to functions of 5 dimensions. In Figure 4, we observe that  $ACO_{\mathbb{R}}$ -vch greatly improves over  $ACO_{\mathbb{R}}$  in functions with moderate or high conditioning  $(f_6 - f_{14})$  and that ACO<sub>R</sub>-vch performs very competitive to (1+1)-CMA-ES and BIPOP-CMA-ES. In the separable, multi-modal and weakly structured functions, ACO<sub>R</sub>vch performs slightly worse than  $ACO_{\mathbb{R}}$ , while  $ACO_{\mathbb{R}}$ -vch performs clearly better than  $ACO_{\mathbb{R}}$  on moderate and illconditioned functions. Both  $ACO_{\mathbb{R}}$  and  $ACO_{\mathbb{R}}$ -vch obtain a better performance than (1+1)-CMA-ES in the separable, multi-modal functions, or when comprehensively considering all functions. In the weakly structured functions and multimodal functions they perform worse that BIPOP-CMA-ES, while they perform better on the separable functions.

# 7. CONCLUSION

In this article, we present benchmark results for a reimplementation of  $ACO_{\mathbb{R}}$  on the BBOB noiseless function testbed. Furthermore, we discuss the performance of  $ACO_{\mathbb{R}}$ vch with variable correlation handling. It is observed that the latter version is competitive to (1+1)-CMA-ES and BIPOP-CMA-ES in functions with moderate or high conditioning.

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Figure 1: Expected running time (ERT in number of *f*-evaluations) divided by dimension for target function value  $10^{-8}$  as  $\log_{10}$  values versus dimension. Different symbols correspond to different algorithms given in the legend of  $f_1$  and  $f_{24}$ . Light symbols give the maximum number of function evaluations from the longest trial divided by dimension. Horizontal lines give linear scaling, slanted dotted lines give quadratic scaling. Black stars indicate statistically better result compared to all other algorithms with p < 0.01 and Bonferroni correction number of dimensions (six). Legend:  $\circ$ :ACOR,  $\nabla$ :PSO,  $\star$ :ABC,  $\Box$ :GA



Figure 2: Bootstrapped empirical cumulative distribution of the number of objective function evaluations divided by dimension (FEvals/D) for 50 targets in  $10^{[-8..2]}$  for all functions and subgroups in 5-D. The "best 2009" line corresponds to the best ERT observed during BBOB 2009 for each single target.



Figure 3: Bootstrapped empirical cumulative distribution of the number of objective function evaluations divided by dimension (FEvals/D) for 50 targets in  $10^{[-8..2]}$  for all functions and subgroups in 20-D. The "best 2009" line corresponds to the best ERT observed during BBOB 2009 for each single target.

$\Delta f_{\mathrm{opt}}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ	$\Delta f_{\text{opt}}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f1	11	12	12	12	12	12	15/15	f13	132	195	250	1310	1752	2255	15/15
ACOR	4.7(5)	<b>15</b> (3)*	$26(4)^{\star 2}$	$47(6)^{*4}$	$67(4)^{\star 4}$	90(6)* <sup>4</sup>	15/15	ACOR	99(221	) 475(603	) <b>2137</b> (23	99) <b>5448</b> (	7655) <b>8.1e</b>	<b>4</b> (9e <b>4</b> )≎ 1e7	0/15
PSO	<b>3.7</b> (3)	22(6)	55(18)	182(30)	317(45)	450(55)	15/15	PSO	1579(190)	0) 1.0e4(1e)	(4) 2.8e4(3e)	$e^{4)} \propto$	$\infty$	$\infty$ 5e5	0/15
ABC	12(14)	32(24)	62(30)	122(25)	191(14)	255(15)	15/15	ABC	<b>18</b> (15)	<b>187</b> (186	) 6618(70	$(06) \propto$	$\infty$	$\infty$ 5e5	0/15
GA	8.7(7) 3	362(196)	1182(175)	2940(390)	5384(387)	8329(789)	13/15	GA	242(30)	728(131)	6) 4394(50	$(25) \infty$	$\infty$	$\infty$ 5e5	0/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f2	83	87	88	90	92	94	$\frac{15}{15}$	f14	10	41	58	139	251	476	15/15
ACOB	<b>6.0</b> (0.6)	*3 7.4(0.6)	*3 8.7(0.8)*	4 12(1)*4	14(0.8) * 4	17(1)*4	15/15	ACOB	1.7(2)	4.7(2)	$6.3(1)^{*4}$	$9.3(3)^{*4}$	<sup>4</sup> 123(85)	4.8e4(5e	4)0/15
PSO	32(8)	41(6)	49(5)	68(8)	89(11)	105(11)	15/15	PSO	1.9(2)	5.6(3)	15(4)	30(8)	218(157)	∞ 5e5	0/15
ABC	11(6)	18(11)	26(10)	38(13)	50(10)	62(7)	15/15	ABC	3.5(3)	11(8)	19(7)	679(802)	 ∞	$\infty$ 5e5	0/15
GA	333(63)	456(52)	606(74)	1304(66)	2158(2751)	2530(2707)	13/15	GA	2.1(2)	91(64)	267(66)	350(71)	<sup>∞</sup>	$\infty 5e5$	0/15
A.£	1 - 1	1-0	1 - 1	1-9	1-5	1 - 7		Δf.	1.01	1.00	10.1	10.2	10.5	10.7	
$\frac{\Delta J_{\rm opt}}{m}$	Ter	100	10-1	1e-3	10-5	10-7	#succ	- Jopt	101 E11	0210	10260	20072	20760	21250	#-Succ
13	716	1622	1637	1646	1650	1654	15/15	115	511	9310	19309	20073	20709	21309	14/10
RCOR DCO	1.7(0.8)	30(38) EE(1EE)	241(107)	240(100) 275(207)	239(103)	239(103)	0/15	ACOR	5.3(4)	7.7(11)	17(27)	16(26)	16(25)	15(25)	15/15
ADC	$\frac{32(2)}{10}$	35(135)	$\frac{2}{3}$ <b>1 9</b> (0, c) <b>*</b>	4 0 5 (307)	4 9 9 (0 5)*	3 4 4(0 7)*2	0/10	ABC	16(7)	221(269)	366(394)	353(411)	342(391)	333(375)	1/15
ABC	10(0.6)	18(0)	1.8(0.6) 25(2)	- <b>2.7</b> (0.5)*	- <b>3.6</b> (0.5)"	~ 4.4(0.7)~-	13/13	CA	13(7) 25(9)	243(279)	267(292)	255(421)	245(291)	00 JeJ	0/15
GA	19(2)	18(2)	23(2)	43(4)	112(150)	200(102)	11/15	GA	33(8)	51(103)	307(382)	333(431)	343(381)	00 565	10/10
$\Delta f_{\text{opt}}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	lel	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f4	809	1633	1688	1817	1886	1903	15/15	f16	120	612	2662	10449	11644	12095	15/15
ACOR	2.0(1) 7	783(1075)	2.5e4(3e4)	2.3e4(3e4)	2.2e4(2e4)	2.2e4(3e4)	3/15	ACOR	7.0(9)	325(232)	154(187)	66(77)	<b>70</b> (66)	<b>75</b> (83)	15/15
PSO	3.0(1.0) 1	41(163)	4152(4813)	3859(4746)	3720(4110)	3687(4203)	1/15	PSO	2.4(3)	6.2(5)	<b>59</b> (95)	89(105)	300(345)	580(641)	0/15
ABC	1.1(0.6)*	2.4(1)* <sup>3</sup>	<b>2.9</b> (1.0)	<sup>4</sup> 4.3(2) <sup>*3</sup>	$4.9(2)^{*4}$	6.0(2)*4	15/15	ABC	2.3(1)	10(6)	95(103)	∞ 1.40(1.80)	$\infty$	$\infty$ 5e5	0/15
GA	18(4)	20(2)	26(3)	41(7)	58(5)	185(141)	9/15	GA	2.1(2)	84(59)	93(99)	148(170)	621(690)	605(726)	0/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f5	10	10	10	10	10	10	15/15	f17	5.2	215	899	3669	6351	7934	15/15
ACOR	8.5(1)	12(2)	13(3)	<b>13</b> (3)	<b>13</b> (3)	<b>13</b> (3)	15/15	ACOR	3.1(3)	1.8(0.4)*	<sup>2</sup> 0.95(0.2)	*4 2.8(8)*3	$7.5(9)^{*3}$	$11(14)^{*3}$	15/15
PSO	10(2)	14(5)	16(6)	16(6)	16(6)	16(6)	15/15	PSO	3.3(4)	169(2)	142(279)	548(681)	514(630)	420(498)	1/15
ABC	32(17)	49(28)	58(34)	59(35)	59(35)	59(35)	15/15	ABC	6.5(7)	15(15)	64(52)	$\infty$	$\infty$	$\infty$ 5e5	0/15
GA	481(267)	2072(463)	3983(388	) 9220(765)	) $1.7e4(13)$	3833.4e4(4852)	)0/15	GA	5.4(6)	46(12)	36(4)	189(226)	550(591)	$\infty$ 5e5	0/15
$\Lambda f_{+}$	1e1	1e0	1e=1	1e=3	1e=5	1e=7	#succ	$\Delta f_{opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
	114	214	281	580	1038	1332	15/15	f18	103	378	3968	9280	10905	12469	$\frac{15}{15}$
ACOR	9 4(1)	2 6(0 8)	3 1 1 (0 0)	*4 9 4(0 4)	4 2 8(0 4)*	4 2 7 (0 2)*	45/15	ACOR	1 9(1)	2 4(1)*2	5 8(14)	2 36(38)*3	82(70)	80(60)	15/15
PSO	4.7(2)	9.0(5)	11(4)	11(2)	10(2)	11(1)	15/15	PSO	22(2)	6.6(5)	113(134)	~	~ ~	∞ 5e5	0/15
ABC	4.7(2)	15(10)	365(891)	619(881)	10(2) 198(722)	507(674)	6/15	ABC	5.0(5)	27(25)	300(315)	~	~	$\infty$ 5e5	0/15
GA	66(56)	148(60)	381(80)	1.2e4(1e4)	400(122) m	∞ 5e5	0/15	GA	22(16)	59(15)	34(64)	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~	∞ 5e5	0/15
	00(00)	1.0	1 1	1.201(101)	1 5	1 7	10/10	A.£	1-1	1-0	1 - 1	1 - 9	1.5	1 - 7	
$\Delta J_{opt}$	161	Teo	1e-1	1e-3	1e-5	1e-7	#succ	<u> </u>	101	100	1e-1	1e-3	10-5	1.0.5	#succ
f7	24	324	1171	1572	1572	1597	15/15	119 ACOB	1	1	242	1.2e5	1.2e5	1.2e5	15/15
ACOR	<b>6.5</b> (3)	2.1(1)	<b>32</b> (25)	<b>25</b> (18)* <sup>2</sup>	<b>25</b> (18)* <sup>2</sup>	<b>25</b> (18)* <sup>2</sup>	15/15	PSO	25(20)	2291(2959	) 020(011)	(30) $(30)$	61(70)	61(61)	0/15
PSO	11(7)	9.5(15)	587(807)	541(673)	541(578)	533(670)	6/15	ARC	33(30) 34(46)	2808(2014	) 2448(305)	1) 20	01(70)	01(01)	0/15
ABC	20(29)	16(14)	62(58)	957(1230)	957(1113)	1359(1566)	1/15	GA GA	34(40) 35(22)	1 204(730)	(434)	(1) = 0	~	∞ 5e5	0/15
GA	50(56)	35(14)	57(12)	524(640)	524(640)	523(630)	5/15	0.4	00(20)	1.204(1000	) 033(430	.) 00(03)			10/10
$\Delta f_{\rm opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	lel	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f8	73	273	336	391	410	422	15/15	f20	16	851	38111	54470	54861	55313	14/15
ACOR	5.5(0.9)	11(2)	43(4)	$120(11)^{*2}$	<b>199</b> (10)*4	$278(10)^{*4}$	15/15	ACOR	6.0(2)	3.2(4)	3.3(4)	2.3(3)	2.3(3)	2.3(3)	15/15
PSO	13(4)	153(14)	201(76)	467(112)	781(138)	1103(132)	7/15	PSO	8.7(5)	3.1(1)	27(33)	19(23)	19(23)	18(23)	5/15
ABC	6.0(4)	12(10)	52(17)	2509(2946)	$\infty$	$\infty$ 5e5	0/15	ABC	(.2(4))	1.5(1)	1(0.2)	1 2(0.2)	) 1.5(1)	2.6(2)	15/15
GA	186(35)	837(975)	$\infty$	$\infty$	$\infty$	$\infty$ 5e5	0/15	GA	47(30)	21(4)	1(0.2)	1.3(0.2)	2.0(0.4)	5.0(5)	11/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f9	35	127	214	300	335	369	15/15	f21	41	1157	1674	1705	1729	1757	14/15
ACOR	12(3)	<b>21</b> (8)	<b>59</b> (26)	251(139)	467(266)	655(376)	15/15	ACOR	3.8(4)	118(196)	299(212)	294(209)	290(206)	285(202)	15/15
PSO	25(13)	938(1971)	678(1197)	1129(1116)	2361(2609)	2753(2720)	5/15	PSO	2.0(2)	379(434)	262(448)	258(440)	255(291)	252(286)	8/15
ABC	14(9)	69(113)	699(808)	$\infty$ .	$\infty$	$\infty 5e5$	0/15	ABC	3.2(2)	1.8(2)	6.7(8)	<b>13</b> (13) <b>7</b> 0(140)	84(108)	265(350)	8/15
GA	423(82)	5.6e4(7e4)	$\infty$	$\infty$	$\infty$	$\infty$ 5e5	0/15	GA	4.6(5)	3.3(4)	61(150)	70(148)	139(154)	291(428)	8/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1	1e0	1e-1 :	1e-3	1e-5	1e-7	#succ
f10	349	500	574	626	829	880	15/15	f22	71	386	938 :	1008	1040	1068	14/15
ACOR	662(773)	1848(1729	) 3067(1662	2) 5253(2231	) 5798(2317	) 9645(6851)	1/15	ACOR	2.9(3)	143(261) 8	355(1544)	797(1437)	774(1394)	756(1359)	15/15
PSO	1739(2099)	3260(3445	i) ∞	$\infty$	$\infty$	$\infty$ 5e5	0/15	PSO	2.6(2)	325(647) 4	169(535)	439(744)	<b>429</b> (721)	<b>422</b> (702)	8/15
ABC	2.1e4(2e4)	~ `	∞	$\infty$	$\infty$	$\infty$ 5e5	0/15	ABC	5.1(5)	<b>7.6</b> (11)	35(44)	<b>374</b> (501)	3311(3605)	6900(7495)	0/15
GA	2372(2927)	$\infty$	$\infty$	$\infty$	$\infty$	$\infty$ 5e5	0/15	GA	6.0(6)	18(12) 3	388(546) 1	489(1598)	6830(7723)	$\infty$ beb	0/15
$\Delta f_{ort}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ	$\Delta f_{\rm opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f11	143	202	763	1177	1467	1673	15/15	f23	3.0	518	14249	31654	33030	34256	15/15
ACOD	120(100)	259/72)	119(24)	190(96)	159/201*2	177(24)*3	15/15	ACOR	2.6(3)	86(79)	$\infty$	~	$\infty$	$\infty 1e7$	0/15
PSO	130(102) 01(61)	200(72)	102(69)	164(65)	100(30) <sup>11</sup>	$\pm 11(34) \approx 201(202)$	10/10 9/1F	PSO	2.2(2)	20(17)	<b>243</b> (254)	* ∞	$\infty$	$\infty$ 5e5	0/15
ARC	31(01) 160(240)	200(121) 6099(6591	123(08) 0226(1-4)	104(00)	243(32) 20	391(303)	0/10	ABC	2.2(2)	<b>19</b> (16)	$\infty$	$\infty$	$\infty$	$\infty$ 5e5	0/15
GA	100(240) 339(65)	7131(8799	) 9353(1c4)	~	30 20	∞ 5e5	0/15	GA	1.5(1)	59(61)	$\infty$	$\infty$	$\infty$	$\infty$ 5e5	0/15
	000	. 101(0/22	, 5555(164)	~	~	~ 000	1 0/10	$\Delta f_{opt}$	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
$\Delta f_{opt}$	101	1e0	1e-1	1e-3	1e-5	1e-7	#succ	f24	1622	2.2e5	6.4e6	9.6e6	1.3e7	1.3e7	3/15
f12	108	268	371	461	1303	1494	15/15	ACOR	8.2(6)	155(169)	<sup>∞</sup>	$\infty$	$\infty$	$\infty 1e7$	0/15
ACOR	4129(7120)	3.3e4(4	e4) 7.8e4(	(9e4) ∞	~ ~ ~	$\infty 1e7$	0/15	PSO	<b>5.7</b> (5)	$\infty$	$\infty$	$\infty$	$\infty$	$\infty$ 5e5	0/15
ARC	(47(2312)	3750(46	(1) = 5412(	0740) <b>1.5</b> 0 6746)	344 (2e4¢)0	∞ 5e5	0/15	ABC	13(18)	$\infty$	$\infty$	$\infty$	$\infty$	$\infty$ 5e5	0/15
CA	99(78)	547(47 2440(28	4) 0802( 51) 1.0-4/	$(140) \propto (140) \approx (140$	~	$\infty$ ses	0/15	GA	21(9)	$\infty$	$\infty$	$\infty$	$\infty$	$\infty$ 5e5	0/15
JA	331(140)	2449(28	01) 1.9e4(	x	œ	J 363	0/10								

Table 1: Expected running time (ERT in number of function evaluations) divided by the respective best ERT measured during BBOB-2009 (given in the respective first row) for different  $\Delta f$  values in dimension 5. The central 80% range divided by two is given in braces. The median number of conducted function evaluations is additionally given in *italics*, if  $\text{ERT}(10^{-7}) = \infty$ . #succ is the number of trials that reached the final target  $f_{\text{opt}} + 10^{-8}$ . Best results are printed in bold.

| →Jopt  | 1e1  | 1e0  
   | 1e-1  | 1e-3  | 1e-5  
   | 1e-7   | #succ   | $\Delta f_{opt}$   
  | 1e1  | 1e0  | 1e-1   
  | 1e-3   | 1e-5   | 1e-7   | #succ   
   |
--	--
---	---
--	---
---	--
--	---
--	--
f1	43
   | 43  | 43  | 43  
   | 43   | 15/15   | f13  
  | 652  | 2021   | 2751   
  | 18749  | 24455  | 30201  | 15/15   
   |
| ACOR   | 24(5)  | 49(8)  
   | 60(8)   | 95(9)*2   | 129(10)*4   
   | 164(8)*4   | 15/15   | ACOR   
  | 1.8e4(2e4)   | 3.2e4(4e4)   | 5.1e4(6e4)   
  | 0 00   | ~  | $\infty 1e7$   | 0/15  
   |
| PSO  | 24(3)  | 2200(20)   
   | 2446(21)  | 2562(27)  | 2680(41)  
   | 2000(40)   | 14/15   | PSO  
  | 6156(7673)   | 6441(7421)   | 1.0e4(1e4)   
  | 1495(160   | $(0) \propto$  | $\infty 2e6$   | 0/15  
   |
| FSU<br>ADC   | 22(0)  | 3399(39)   
   | 3440(31)  | 177(00)   | 3080(41)  
   | 3808(48)   | 14/15   | ADC  
  | 0100(1010)   | <b>5111(1121</b> )   | <b>005</b> (705)*  
  | 2 1555(100   | , o, oe  | 0.0 200  | 0/15  
   |
| ABC  | 36(24)   | 66(41)   
   | 94(56)  | 177(69)   | 292(17)   
   | 374(23)  | 15/15   | ABC  
  | 25(11)   | 73(81)   | 627(735)   
  | - 1555(178   | \$() ∞   | $\infty zeb$   | 0/15  
   |
| GA   | 876(65)  | 1905(154)  
   | 3205(241)   | 3.1e4(5e4)  | 6.7e5(7e5)  
   | $\infty$ 2eb   | 0/15  | GA   
  | 5116(6184)   | $\infty$   | $\infty$   
  | $\infty$   | $\infty$   | $\infty$ 2eb   | 0/15  
   |
| $\Delta f_{opt}$   | 1e1  | 1e0  
   | 1e-1  | 1e-3  | 1e-5  
   | 1e-7   | #succ   | $\Delta f_{opt}$   
  | 1e1  | 1e0  | 1e-1   
  | 1e-3   | 1e-5   | 1e-7   | #succ   
   |
| f2   | 385  | 386  
   | 387   | 390   | 391   
   | 393  | 15/15   | f14  
  | 75   | 239  | 304  
  | 932  | 1648   | 15661  | 15/15   
   |
| 100D   | 10(0.0)  | 10(0 7)*   
   | 3 14(0 5)*  | 4   | 001   
   | 4 05 (0 0) *4  | 15/15   | ACOD   
  | 15(4)  | 200  | 11(0) *3   
  | ao(1)*3  | 1010   | 10001  | 0/15  
   |
| ACOR   | 10(0.9)  | 12(0.7)  
   | 14(0.5)   | 17(1)   | 21(0.9)   
   | 25(0.9)  | 15/15   | ACOR   
  | 15(4)  | 9.5(2)   | 11(2)  
  | 30(8)  | $\infty$   | $\infty$ 1e7   | 0/15  
   |
| PSO  | 4580(7798)   | 4572(5190)   
   | 4571(7763   | 4547(7700   | ) 4542(7666)  
   | 4533(7626)   | 8/15  | PSO  
  | 6.7(3)^  | 12(3)  | 20(3)  
  | 54(14)   | ~ ~  | $\infty$ 2eb   | 0/15  
   |
| ABC  | 12(5)  | 16(4)  
   | 24(6)   | 40(8)   | 56(6)   
   | 70(6)  | 15/15   | ABC  
  | 18(16)   | 18(11)   | 28(8)  
  | 3378(3218  | ) ∞  | $\infty 2e6$   | 0/15  
   |
| GA   | 3231(2721)   | 6772(7870)   
   | 7.3e4(9e4)  | $\infty$  | $\infty$  
   | $\infty$ 2e6   | 0/15  | GA   
  | 277(74)  | 319(48)  | 477(66)  
  | $\infty$   | $\infty$   | $\infty 2e6$   | 0/15  
   |
| Δf.  | 161  | 1e0  
   | 1e-1  | 16-3  | 1e-5  
   | 10-7   | #succ   | $\Delta f$ .   
  | 101  | 1.00   | 10-1   
  | 10-3   | 1e-5   | 10-7   | #81100  
   |
| <u>  Jopt</u>  | 5000   | 100  
   |   | 70-0  | 10-0  
   | TC-1   | # 5400  | <u> Jopt</u>   
  | 101  | 100  | 10-1   
  | 10-5   | 10-0   | 10-1   | #-3400  
   |
| 13   | 5066   | 7626   
   | 7635  | 7643  | 7646  
   | 1051   | 15/15   | f15  
  | 30378  | 1.5e5  | 3.1e5  
  | 3.2e5  | 4.5e5  | 4.665  | 15/15   
   |
| ACOR   | 1018(1197)   | $\infty$   
   | $\infty$  | $\infty$  | $\infty$  
   | $\infty$ 1e7   | 0/15  | ACOR   
  | <b>919</b> (1161)  | $\infty$   | $\infty$   
  | $\infty$   | $\infty$   | $\infty$ 1e7   | 0/15  
   |
| PSO  | $\infty$   | $\infty$   
   | ~   | $\infty$  | ~ ~   
   | $\infty 2e6$   | 0/15  | PSO  
  | $\infty$   | $\infty$   | $\infty$   
  | $\infty$   | $\infty$   | $\infty 2e6$   | 0/15  
   |
| ABC  | 1.5(0.8)   | )*4 <b>2.7</b> (1  
   | )*4 3.0(2)  | *4 3.6(2)   | <sup>4</sup> 4.1(1) <sup>*4</sup>   
   | 4.9(0.8)*4   | 15/15   | ABC  
  | $\infty$   | $\infty$   | $\infty$   
  | $\infty$   | $\infty$   | $\infty 2e6$   | 0/15  
   |
| GA   | 29(5)  | 3709(406   
   | í8) ∞ Í   | ~ `   | ~ `   
   | $\infty 2e6$   | 0/15  | GA   
  | $\infty$   | $\infty$   | $\infty$   
  | $\infty$   | $\infty$   | $\infty 2e6$   | 0/15  
   |
|  | - (-)  |  
   |   |   |   
   |  | - / -   | A.£  
  | 1 - 1  | 1-0  | 1 - 1  
  | 1 - 9  | 1 - 5  | 1 - 7  | 1.4   
   |
| $\Delta J_{opt}$   | 161  | 160  
   | 1e-1  | 1e-3  | 1e-5  
   | 1e-7   | #succ   | △Jopt  
  | 161  | 160  | 16=1   
  | 16=3   | 16=0   | 10=7   | #succ   
   |
| f4   | 4722   | 7628   
   | 7666  | 7700  | 7758  
   | 1.4e5  | 9/15  | f16  
  | 1384   | 27265  | 77015  
  | 1.9e5  | 2.0e5  | 2.2e5  | 15/15   
   |
| ACOR   | 1.5e4(1e4)   | $\infty$   
   | $\infty$  | $\infty$  | $\infty$  
   | $\infty 1e7$   | 0/15  | ACOR   
  | 1.0e5(1e5)   | $\infty$   | $\infty^{*4}$  
  | $\infty^{*4}$  | $\infty^{*4}$  | $\infty 1e7^{*4}$  | 0/15  
   |
| PSO  | 5940(6989)   | $\infty$   
   | $\infty$  | $\infty$  | $\infty$  
   | $\infty$ 2e6   | 0/15  | PSO  
  | 111(11)  | $\infty$   | $\infty$   
  | $\infty$   | $\infty$   | $\infty 2e6$   | 0/15  
   |
| ABC  | 2 0(1)*  | 4 12(2   
   | ×4 5 B(4)   | *4 63(4)  | 4 7 3(4) *4   
   | 0.45(0.2)*   | 45/15   | ABC  
  | 13(14)   | ~  | ~  
  | ~  | <u>~</u>   | $\infty$ 2e6   | 0/15  
   |
| GA   | 65(5)  | 3751/410   
   | (4)   | 0.0(4)  | ~   
   | ~ 2.6  | 0/15  | GA   
  | 138(40)  | 1037(1138  | ) ~  
  | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~  | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~  | x 2e6  | 0/15  
   |
| GA   | 03(3)  | 5751(418   
   | $\infty$  | 00  | 00  
   | SC 260   | 0/15  | GA   
  | 100(40)  | 1001(1100  | ) 00   
  | $\sim$   | $\sim$   | 00 200   | 10/10   
   |
| $\Delta f_{opt}$   | 1e1  | 1e0  
   | 1e-1  | 1e-3  | 1e-5  
   | 1e-7   | #succ   | $\Delta f_{opt}$   
  | 1e1  | 1e0  | 1e-1   
  | 1e-3   | 1e-5   | 1e-7   | #succ   
   |
| f5   | 41   | 41   
   | 41  | 41  | 41  
   | 41   | 15/15   | f17  
  | 63   | 1030   | 4005   
  | 30677  | 56288  | 80472  | 15/15   
   |
| ACOR   | 10(2)*2  | 10(4)*2  
   | 10(4)   | 3 19(4)*  | 4 10(4)*4   
   | 10(4)*4  | 1 5 / 1 5   | ACOP   
  | 12(8)  | $(1)^{*4}$   | 269(447)*3   
  | 4564(505   | 3) ~   | $\sim 1e7$   | 0/15  
   |
| ACOR   | 10(3) -  | 12(4)  
   | 12(4)   | 12(4)   | 12(4)   
   | 12(4)  | 15/15   | ACON   
  | 12(0)  | 4.3(1)   | 209(447)   
  | 4004(000   | 3) 00  | 00 107   | 0/10  
   |
| PSO  | 4.3e4(5e4)   | 4.3e4(5e4  
   | ) 4.3e4(7e  | 4) 4.3e4(7  | 'e4) 4.3e4(5e   
   | 4) 4.3e4(5e4)  | 8/15  | PSO  
  | 3.2(2)***  | 2502(2914)   | $\infty$   
  | $\infty$   | $\infty$   | $\infty$ 2e6   | 0/15  
   |
| ABC  | 69(23)   | 90(36)   
   | 93(38)  | 93(36)  | 93(36)  
   | 93(36)   | 15/15   | ABC  
  | 34(27)   | $\infty$   | $\infty$   
  | $\infty$   | $\infty$   | $\infty 2e6$   | 0/15  
   |
| GA   | 2158(156)  | 4592(305)  
   | 7519(403  | 1.4e4(5)  | 574) 2.2e4(81)  
   | 7) 2.3e5(2e5)  | 0/15  | GA   
  | 57(54)   | 92(8)  | 7070(7745)   
  | $\infty$   | $\infty$   | $\infty 2e6$   | 0/15  
   |
| Δf.  | 161  | 1e0  
   | 10-1  | 16-3  | 1e-5  
   | 1e-7   | Hence   | $\Delta f$ .   
  | 101  | 1e0  | 10-1   
  | 16-3   | 1e-5   | 1e-7   | Hence   
   |
| <u>A Jopt</u>  | 101  | 2010   
   | 2440  | 10-0  | 10-0  
   | 10-1   | # 5400  | -Jopt  
  | 101  | 100  | 10-1   
  | 10-5   | 10-0   | 10-7   | #-Succ  
   |
| 16   | 1296   | 2343   
   | 3413  | 5220  | 6728  
   | 8409   | 15/15   | 118  
  | 621  | 3972   | 19561  
  | 67569  | 1.3e5  | 1.5e5  | 15/15   
   |
| ACOR   | 6.5(2)*  | <sup>3</sup> 5.3(1) <sup>3</sup>   
   | 4.8(0.  | 9)*4 <b>4.7</b> (0.)  | 5)*4 <b>4.8</b> (0.6)   
   | )*4 <b>4.9</b> (0.6)   | <b>11</b> 5/15  | ACOR   
  | 4.7(2)   | 3.5(1)*4   | 493(607)   
  | $\infty$   | $\infty$   | $\infty 1e7$   | 0/15  
   |
| PSO  | 1082(1566)   | 1009(1291  
   | ) 705(884)  | 502(604)  | 423(485)  
   | 577(631)   | 5/15  | PSO  
  | 236(9)   | $\infty$   | $\infty$   
  | $\infty$   | $\infty$   | $\infty 2e6$   | 0/15  
   |
| ABC  | 46(54)   | 453(588)   
   | 2587(268  | 7) ∞ .  | $\infty$  
   | $\infty 2e6$   | 0/15  | ABC  
  | 4.6e4(5e4)   | $\infty$   | $\infty$   
  | $\infty$   | $\infty$   | $\infty 2e6$   | 0/15  
   |
| GA   | 1956(2329)   | 00   
   | ~   | <u>~</u>  | ~   
   | $\infty 2e6$   | 0/15  | GA   
  | 76(15)   | 311(506)   | ~  
  | ~  | ~  | $\infty 2e6$   | 0/15  
   |
   |   |   |   
   |  | 1.07 - 0  |  
  | 10(10)   | 011(000)   |  
  |  |  |  | 10/10   
   |
| $\Delta f_{opt}$   | lel  | 1e0  
   | 1e-1  | 1e-3  | 1e-5  
   | 1e-7   | #succ   | $\Delta f_{\rm opt}$   
  | 1e1  | 1e0  | 1e-1   
  | 1e-3   | 1e-5   | 1e-7   | #succ   
   |
|  | 1051   | 4974   
   | 0503  | 16594   | 16594   
   | 16969  | 15/15   | £1.0   
  | 1  | 1  | 3 4 65   
  | 6.2e6  | 6.7e6  | 6.7e6  | 15/15   
   |
| f7   | 1351   | 44/4   
   | 9505  | 10524   | 10024   
   | 10505  | 10/10   | 119  
  | +  | 1  | 0.400  
  |  |  |  | 110/10  
   |
| f7<br>ACOR   | <b>76</b> (36)   | 3.5e4(3  
   | 9303<br>e4)∞  | 10524<br>∞  | 10524<br>∞  
   | $\infty$ 1e7   | 0/15  | ACOR   
  | 686(252)   | $\infty$   | ∞<br>∞   
  | $\infty$   | $\infty$   | $\infty 1e7$   | 0/15  
   |
| f7<br>ACOR<br>PSO  | <b>76</b> (36)<br>427(745)   | 3.5e4(3)   
   | 9303<br>e4)∞<br>∞   | 10524<br>∞<br>∞   | ∞<br>∞  
   | $\infty 1e7$<br>$\infty 2e6$   | 0/15  | ACOR   
  | 686(252)<br>382(240)*  | $^{1}_{\infty}$  | ~  
  | ~  | ~  | $\infty$ 1e7<br>$\infty$ 2e6   | 0/15  
   |
| f7<br>ACOR<br>PSO<br>ABC   | <b>76</b> (36)<br>427(745)<br>251(328)   | 3.5e4(3)   
   | 9303<br>e4)∞<br>∞   | 10324<br>∞<br>∞   | ∞<br>∞<br>∞   
   | $\infty$ 1e7<br>$\infty$ 2e6<br>$\infty$ 2e6   | 0/15<br>0/15<br>0/15  | ACOR<br>PSO  
  | 686(252)<br><b>382</b> (240)* <sup>2</sup>   | $2 \infty$   | ∞<br>∞   
  | ∞<br>∞   | $\infty$   | $\infty$ 1e7<br>$\infty$ 2e6<br>$\infty$ 2e6   | 0/15  
   |
| f7<br>ACOR<br>PSO<br>ABC<br>GA   | 76(36)<br>427(745)<br>251(328)<br>77(15)   | 4274<br>3.5e4(3)<br>∞<br>∞   
   | 9303<br>e4)∞<br>∞<br>∞  | ∞<br>∞<br>∞   | ∞<br>∞<br>∞   
   | $\infty$ 1e7<br>$\infty$ 2e6<br>$\infty$ 2e6<br>$\infty$ 2e6   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15  | ACOR<br>PSO<br>ABC   
  | 686(252)<br><b>382</b> (240)*<br>2292(1142)  | $2 \infty$   | ∞<br>∞<br>∞  
  | $\infty$<br>$\infty$<br>$\infty$   | $\infty$<br>$\infty$<br>$\infty$   | $\infty$ 1e7<br>$\infty$ 2e6<br>$\infty$ 2e6   | 0/15<br>0/15<br>0/15  
   |
| f7<br>ACOR<br>PSO<br>ABC<br>GA   | <b>76</b> (36)<br>427(745)<br>251(328)<br>77(15)   | 4274<br>3.5e4(3)<br>∞<br>∞<br>∞  
   | 9303<br>e4)∞<br>∞<br>∞<br>∞   | 10324<br>∞<br>∞<br>∞  | ∞<br>∞<br>∞<br>∞  
   | $\infty 1e7$<br>$\infty 2e6$<br>$\infty 2e6$<br>$\infty 2e6$   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15  | ACOR<br>PSO<br>ABC<br>GA   
  | 686(252)<br>$382(240)^{+2}$<br>2292(1142)<br>1.4e4(3105)   | ) $6.5e5(1e)$  | ∞<br>∞<br>∞<br>∞<br>∞  
  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$   | 80<br>80<br>80<br>80<br>80   | $\infty 1e7$<br>$\infty 2e6$<br>$\infty 2e6$<br>$\infty 2e6$   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15  
   |
| f7<br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$   | <b>76</b> (36)<br>427(745)<br>251(328)<br>77(15)<br>1e1  | 3.5e4(3)<br>$\infty$<br>$\infty$<br>$\infty$<br>1e0  
   | 9303<br>e4)∞<br>∞<br>∞<br>∞<br>1e-1   | 10324<br>∞<br>∞<br>∞<br>∞<br>1e-3   | ∞<br>∞<br>∞<br>∞<br>1e-5  
   | $ \begin{array}{c} \infty 1e7 \\ \infty 2e6 \\ \infty 2e6 \\ \infty 2e6 \\ 1e-7 \end{array} $  | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$   
  | 686(252)<br><b>382</b> (240)*<br>2292(1142)<br>1.4e4(3105)<br>1e1  | 1<br>∞<br>2<br>∞<br>0<br>6.5e5(1e<br>1e0   | ∞<br>∞<br>∞<br>∞<br>∞<br>∞<br>5)*∞<br>1e-1   
  | ∞<br>∞<br>∞<br>∞<br>∞  | ∞<br>∞<br>∞<br>∞<br>1e-5   | $\infty 1e7$ $\infty 2e6$ $\infty 2e6$ $\infty 2e6$ 1e-7   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ   
   |
| f7<br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br>f8   | <b>76</b> (36)<br>427(745)<br>251(328)<br>77(15)<br>1e1<br>2039  | 3.5e4(3)<br>~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~   | 9303<br>e4) ∞<br>∞<br>∞<br>1e-1<br>4040   | 10324<br>∞<br>∞<br>∞<br>1e-3<br>4219  | ∞<br>∞<br>∞<br>1e-5<br>4371   | $\begin{array}{c} \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ \hline 4484 \end{array}$  | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ<br>15/15  | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$  | 686(252)<br><b>382</b> (240)* <sup>2</sup><br>2292(1142)<br>1.4e4(3105)<br>1e1   | $2 \frac{1}{\infty} \frac{1}{\infty} \frac{1}{\infty} \frac{1}{\infty} \frac{1}{\infty} \frac{1}{1} $  | ∞<br>∞<br>∞<br>∞<br>5) &<br>1e-1 :  | ∞<br>∞<br>∞<br>∞<br>∞<br>Le-3  | ∞<br>∞<br>∞<br>∞<br>1e-5   | $\infty 1e7$ $\infty 2e6$ $\infty 2e6$ $\infty 2e6$ 1e-7 $5.6e6$   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ   |
| f7<br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br>f8<br>ACOB   | <b>76</b> (36)<br>427(745)<br>251(328)<br>77(15)<br>1e1<br>2039<br>24(8)   | $ \begin{array}{r}                                     $   
   | 5303<br>$e4) \infty$<br>$\infty$<br>1e-1<br>4040<br>72(101)   | 10324<br>∞<br>∞<br>∞<br>1e-3<br>4219<br><b>89</b> (86)  | 10524<br>$\infty$<br>$\infty$<br>1e-5<br>4371<br>$107(84)^{*3}$   
   | $ \begin{array}{c}                                     $   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ<br>15/15  | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b>   
  | <sup>1</sup> 686(252)<br><b>382</b> (240)* <sup>1</sup><br>2292(1142)<br>1.4e4(3105)<br>1e1<br>82<br>1.6(4)  | $2 \\ \infty \\ 2 \\ \infty \\ 0 \\ 6.5e5(1e) \\ 1e0 \\ 46150 \\ 1.6(1) \\ 1.6(1) \\ 1.6(1) \\ 0 \\ 1.6(1) \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ $   | ∞<br>∞<br>∞<br>5) \$4<br>1e-1 3<br>3.1e6 3   
  | ∞<br>∞<br>∞<br>∞<br>1e-3   | ∞<br>∞<br>∞<br>1e-5<br>5.6e6   | $\infty 1e7$ $\infty 2e6$ $\infty 2e6$ $\infty 2e6$ 1e-7 5.6e6 2e(28)  | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ<br>14/15  
   |
| f7<br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br>f8<br>ACOR<br>PSO  | $\begin{array}{c} 1331\\ \textbf{76}(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64) \end{array}$   | 3.5e4(3)<br>$\infty$<br>$\infty$<br>1e0<br>3871<br>66(114)<br>307(335)   
   | 9303<br>$e4) \infty$<br>$\infty$<br>$\infty$<br>1e-1<br>4040<br>72(101)<br>350(329)   | 16524<br>∞<br>∞<br>∞<br>1e-3<br>4219<br><b>89</b> (86)<br>466(348)  | $ \begin{array}{c} \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{*3} \\ 894(743) \end{array} $   
   | $\begin{array}{c} \infty 1e^{7} \\ \infty 2e6 \\ \infty 2e6 \\ \infty 2e6 \\ 1e-7 \\ 4484 \\ 125(83)^{*4} \\ 3277(3290) \end{array}$   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ<br>15/15<br>15/15   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR   
  | <sup>1</sup> 686(252)<br><b>382</b> (240)* <sup>1</sup><br>2292(1142)<br>1.4e4(3105)<br>1e1<br>82<br><b>16</b> (4)<br><b>17</b> (0)  | $\begin{array}{c} & 1 \\ & \infty \\ & \infty \\ 2 \\ & \infty \\ \end{array}$ $\begin{array}{c} & \infty \\ & 0 \\ \hline & \mathbf{6.5e5}(1e) \\ \hline & 1e0 \\ \hline & 46150 \\ & 1.6(1) \\ 5 \\ \hline & 5 \\ \end{array}$   | $\infty$<br>$\infty$<br>$5)^{\frac{1}{2}}$<br>1e-1<br>3.1e6<br>24(24)<br>2   
  | ∞<br>∞<br>∞<br>2.5.5e6<br>2.7(28) ::   | $\infty$ $\infty$ $\infty$ $\infty$ $1e-5$ 5.6e6 <b>26</b> (30)  | $\infty 1e7  \infty 2e6  \infty 2e6  \infty 2e6  1e-7  5.6e6  26(28)$  | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ<br>14/15<br>1/15  
   |
| f7<br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br>f8<br>ACOR<br>PSO  | $\begin{array}{c} 1351\\ \textbf{76}(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3\\ 24(8) \\ 42(8) \\ 90(64) \\ 3 \\ 24(8) \\ 90(64) \\ 3 \\ 3 \\ 24(8) \\ 4 \\ 3 \\ 3 \\ 3 \\ 4 \\ 4 \\ 4 \\ 4 \\ 4 \\ 4$   | $\begin{array}{c} 3.5e4(3)\\ \infty\\ \infty\\ \infty\\ 1e0\\ 3871\\ 66(114)\\ 307(335)\\ \end{array}$   
   | 5303<br>$e4) \infty$<br>$\infty$<br>$\infty$<br>1e-1<br>4040<br>72(101)<br>350(329)<br>$1e0(5)^{4}$   | 10524<br>∞<br>∞<br>∞<br>4219<br><b>89</b> (86)<br>466(348)<br><b>89</b> (86)  | $ \begin{array}{c} \infty \\ \infty \\ \infty \\ 1e-5 \\ 4371 \\ 107(84)^{*3} \\ 894(743) \end{array} $   
   | $\begin{array}{c} \infty 167 \\ \infty 2e6 \\ \infty 2e6 \\ \infty 2e6 \\ 1e-7 \\ 4484 \\ 125(83)^{\star 4} \\ 3277(3290) \end{array}$   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ<br>15/15<br>15/15<br>1/15   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO  
  | 686(252)<br><b>382</b> (240)*<br>2292(1142)<br>1.4e4(3105)<br>1e1<br>82<br><b>16</b> (4)<br>17(6)  | $\begin{array}{c} & 1 \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ &$  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$55)^{\frac{1}{2}}$<br>1e-1<br>3.1e6<br>24(24)<br>2<br>$\infty$  
  | ∞<br>∞<br>∞<br>∞<br>2.1e-3<br>5.5e6<br>27(28) :  | ∞<br>∞<br>∞<br>∞<br>1e-5<br>5.6e6<br><b>26</b> (30)<br>∞   | $\infty 1e7  \infty 2e6  \infty 2e6  \infty 2e6  1e-7  5.6e6  26(28)  \infty 2e6 $   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br><u>#succ</u><br>14/15<br>1/15<br>0/15   
   |
| $\begin{array}{c} \mathbf{f7} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \underline{\Delta f_{\text{opt}}} \\ \mathbf{f8} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \end{array}$  | <b>76</b> (36)<br>427(745)<br>251(328)<br>77(15)<br>1e1<br>2039<br>24(8)<br>90(64)<br><b>3.9</b> (2)*4   | $\begin{array}{c} 3.5e4(3)\\ \infty\\ \infty\\ 0\\ 1e0\\ 3871\\ 66(114)\\ 307(335)\\ 5.9(2)^{\star4} \end{array}$  
   | $5303 \\ 9303 \\ e4) \infty \\ \infty \\ \infty \\ 1e-1 \\ \hline 4040 \\ 72(101) \\ 350(329) \\ 10(3)^{*4} \\ \hline$  | 10324<br>∞<br>∞<br>∞<br>1e-3<br>4219<br><b>89</b> (86)<br>466(348)<br>353(367)  | $ \begin{array}{c} \infty \\ \infty \\ \infty \\ 1e-5 \\ 4371 \\ 107(84)^{*3} \\ 894(743) \\ \infty \end{array} $   
   | $\begin{array}{c} \cos 167 \\ \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \hline 1e-7 \\ \hline 4484 \\ 125(83)^{\star 4} \\ 3277(3290) \\ \infty \ 2e6 \end{array}$   | 0/15<br>0/15<br>0/15<br>0/15<br><u>#succ</u><br>15/15<br>15/15<br>1/15<br>0/15  | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO<br>ABC   
  | $\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\star 2} \\ 2292(1142) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(4) \\ 17(6) \\ 16(5) \end{array}$  | $\begin{array}{c} & 1 \\ & & \\ & & \\ 2 \\ & & \\ \infty \\ \end{array}$ $\begin{array}{c} & & \\ & & \\ 1e0 \\ \hline & & \\ 46150 \\ & & \\ 1.6(1) \\ 50(65) \\ \hline & & \\ 0.12(0.1)_{1}^{*} \end{array}$  | $5.400 \\ \infty \\ \infty \\ 5.5 \times 4 \\ 1e-1 \\ 3.1e6 \\ 24(24) \\ 2\infty \\ \infty \\ 3 \\ \infty \\ 0 \\ 3 \\ \infty \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0$  
  | ∞<br>∞<br>∞<br>∞<br>5.5e6<br>\$7(28) :<br>∞<br>∞   | ∞<br>∞<br>∞<br>∞<br>1e-5<br>5.6e6<br>26(30)<br>∞<br>∞  | $\infty 1e7  \infty 2e6  \infty 2e6  \infty 2e6  1e-7  5.6e6  26(28)  \infty 2e6  \infty 2e6  \infty 2e6  0  0  0  0  0  0  0  0  0  0$  | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>14/15<br>1/15<br>0/15<br>0/15   
   |
| $\begin{array}{c} \mathbf{f7} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \underline{\Delta f_{\text{opt}}} \\ \mathbf{f8} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \end{array}$  | $\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{\star 4}\\ \infty\end{array}$   | $\begin{array}{c} 3.5e4(3)\\ \infty\\ \infty\\ \infty\\ \infty\\ 3871\\ 66(114)\\ 307(335)\\ 5.9(2)^{*4}\\ \infty\end{array}$  
   | $5303 \\ 9303 \\ \infty \\ \infty \\ \infty \\ 1e-1 \\ 4040 \\ 72(101) \\ 350(329) \\ 10(3)^{*4} \\ \infty $  | $ \begin{array}{c} 10324 \\ \infty \\ \infty \\ 1e-3 \\ 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \end{array} $  | $ \begin{array}{c} \infty \\ \infty \\ \infty \\ 1e-5 \\ 4371 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \end{array} $   
   | $\begin{array}{c} 10303\\ \infty\ 1e7\\ \infty\ 2e6\\ \infty\ 2e6\\ 2e6\\ 1e-7\\ 125(83)^{\star4}\\ 3277(3290)\\ \infty\ 2e6\\ \infty\ 2e6\\ \end{array}$  | 0/15<br>0/15<br>0/15<br>0/15<br>15/15<br>15/15<br>1/15<br>0/15<br>0   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO<br>ABC<br>GA   
  | $\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\star 2} \\ 2292(1142) \\ 1.4e4(3105) \\ 1e1 \\ \hline 82 \\ 16(4) \\ 17(6) \\ 16(5) \\ 503(56) \\ \end{array}$   | $\begin{array}{c} & 1 \\ & \infty \\ 2 & \infty \\ & \infty \end{array}$ $\begin{array}{c} & 0 \\ \hline \mathbf{6.5e5}(1e \\ \hline 1e0 \\ \hline 46150 \\ 1.6(1) \\ 50(65) \\ \hline 0.12(0.1) \\ 2.8(0.4) \end{array}$  | 5.460<br>$\infty$<br>$5.5)$ $\frac{1}{24}$<br>1e-1<br>3.1e6<br>24(24)<br>2<br>24(24)<br>2<br>3<br>24(24)<br>2<br>3<br>24(24)<br>2<br>3<br>24(24)<br>2<br>3<br>4<br>4<br>3<br>4<br>4<br>4<br>4<br>4<br>4<br>4<br>4  
  | ∞<br>∞<br>∞<br>∞<br>1e-3<br>5.5e6<br>•7(28) :<br>∞<br>∞  | $\infty$ $\infty$ $\infty$ $\infty$ 1e-5 5.6e6 26(30) $\infty$ $\infty$ $\infty$   | $\infty 1e7  \infty 2e6  \infty 2e6  \infty 2e6  1e-7  5.6e6  26(28)  \infty 2e6  0 2e7  0 2e6  0 2e7  0 2e7  0 2e7  0 2e7  0 2e7  0 2e6  0 $   | $\begin{array}{c} 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ \end{array}$ $\begin{array}{c} \# \text{succ} \\ 14/15 \\ 1/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ \end{array}$   
  |
| $\begin{array}{c} \mathbf{f7} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \underline{\Delta f_{\text{opt}}} \\ \mathbf{f8} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \underline{\Delta f_{\text{opt}}} \\ \text{fort} \end{array}$   | $\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{\star 4}\\ \infty\\ 1e1 \end{array}$  | 3.5e4(3<br>∞<br>∞<br>3871<br>66(114)<br>307(335)<br>5.9(2)*4<br>∞<br>1e0   | $\begin{array}{c} 3503\\ \pm 4) \infty \\ \infty \\ \infty \\ 1e-1 \\ 4040 \\ 72(101) \\ 350(329) \\ 10(3)^{*4} \\ \infty \\ 1e-1 \\ \end{array}$   | $\begin{array}{c} \infty \\ \infty \\ \infty \\ 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \end{array}$   | $ \begin{array}{c} \infty \\ \infty \\ \infty \\ 1e-5 \\ 4371 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ 1e-5 \\ \end{array} $  | $\begin{array}{c} \infty \ le7 \\ \infty \ le7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 4484 \\ 125(83)^{\star 4} \\ 3277(3290) \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline \end{array}$  | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ<br>15/15<br>15/15<br>1/15<br>0/15<br>0/15   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO<br>ABC<br>GA  | $\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\star} \\ 2292(1142) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(4) \\ 17(6) \\ 16(5) \\ 503(56) \end{array}$   | $\begin{array}{c} & 1 \\ & & \\ & & \\ 2 \\ & & \\ \infty \\ \hline & & \\ \hline \\ \hline$   | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$5.5) \frac{54}{4}$<br>1e-1<br>24(24)<br>224(24)<br>224(24)<br>224(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)<br>204(24)  | ∞<br>∞<br>∞<br>1e-3<br>5.5e6<br>77(28) :<br>∞<br>∞<br>∞  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>1e-5<br>5.6e6<br>26(30)<br>$\infty$<br>$\infty$<br>$\infty$  | $\infty 1e7$ $\infty 2e6$ $\infty 2e6$ $2e6$ 1e-7 5.6e6 2e6(28) $\infty 2e6$ $\infty 2e6$ $\infty 2e6$ $\infty 2e6$  | $\begin{array}{c} 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ \end{array}$ $\begin{array}{c} \# \text{succ} \\ 14/15 \\ 1/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ \end{array}$  |
| f7<br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br>f8<br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br>f9   | $\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ \end{array}$  | $\begin{array}{c} 3.5e4(3)\\ \infty\\ \infty\\ 1e0\\ 3871\\ 66(114)\\ 307(335)\\ \textbf{5.9}(2)^{*4}\\ \infty\\ 1e0\\ 3102\\ \end{array}$   
   | $\begin{array}{c} 3303\\ 9303\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e-1\\ 4040\\ 72(101)\\ 350(329)\\ 10(3)^{*4}\\ \infty\\ 1e-1\\ 3277\\ \end{array}$   | $\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 3455 \end{array}$  | $ \begin{array}{c} \infty \\ \infty \\ \infty \\ 1e-5 \\ 4371 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ 1e-5 \\ 3594 \\ \end{array} $  
   | $\begin{array}{c} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 3727\\ \end{array}$  | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>#succ<br>15/15<br>15/15<br>1/15<br>0/15<br>0/15<br>#succ<br>15/15   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$   
  | 686(252)           382(240)*1           2292(1142)           1.4e4(3105)           1e1           82           16(4)           17(6)           16(5)           503(56)           1e1  | $\begin{array}{c} & 1 \\ & & \\ & & \\ 2 & & \\ & &$  | $\begin{array}{c} & & & & \\ & &
& \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & &$  | ∞<br>∞<br>∞<br>5.5e6<br>57(28) =<br>∞<br>∞<br>∞<br>∞<br>∞  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>5.6e6<br>26(30)<br>$\infty$<br>$\infty$<br>$\infty$<br>1e-5<br>-5  | $ \begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ 1e-7 \\ \hline \end{array} $  | 0/15<br>0/15<br>0/15<br>0/15<br>14/15<br>1/15<br>0/15<br>0/15<br>0/15<br>#succ  
   |
| $\begin{array}{c} \mathbf{f7} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \end{array} \\ \begin{array}{c} \Delta f_{\text{opt}} \\ \overline{\mathbf{f8}} \\ \text{ACOR} \\ \text{PSO} \\ \end{array} \\ \begin{array}{c} ABC \\ \text{GA} \\ \end{array} \\ \begin{array}{c} \Delta f_{\text{opt}} \\ \overline{\mathbf{f9}} \\ \end{array} \\ \begin{array}{c} \overline{\mathbf{f9}} \\ \overline{\mathbf{f9}} \\ \end{array} \end{array}$   | $\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 4e(7)^{*3}\\ \end{array}$   | $\begin{array}{c} 4214\\ 3.5e4(3)\\ \infty\\ \infty\\ \infty\\ 0\\ 3871\\ 66(114)\\ 307(335)\\ 5.9(2)^{*4}\\ \infty\\ 1e0\\ 3102\\ \pi_{2}(2)^{*4} \end{array}$  |   | $\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ \hline 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 3455 \\ -\infty \\ 1e-3 \\ -\infty \\ 1$ | $ \begin{array}{c}     10324 \\     \infty \\     \infty \\     \infty \\     1e-5 \\     4371 \\     107(84)^{*3} \\     894(743) \\     \infty \\     \infty \\     1e-5 \\     3594 \\     4ep(ep)^{*4} \\      4ep(ep)^{*4} \\      4ep(ep)^{*4} \\      4ep(ep)^{*4} \\      4ep(ep)^{*4} \\      4ep(ep)^{*4} \\      4ep(ep)^{*4} \\      4ep(ep)^{*4} \\      4ep(ep)^{*4} \\      4ep(ep)^{*4} \\$   | $\begin{array}{c} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 3727\\ 3727\\ 051(1c)\\ \end{array}$  | 0/15<br>0/15<br>0/15<br>0/15<br>15/15<br>15/15<br>1/15<br>0/15<br>#succ<br>15/15<br>0/15<br>#succ   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b>  | $\begin{array}{c} {}^{6} 686(252) \\ 382(240)^{\pm 2} \\ 2292(1142) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(4) \\ 17(6) \\ 16(5) \\ 503(56) \\ 1e1 \\ 561 \end{array}$   | $\begin{array}{c} & 1 \\ & \infty \\ 2 & \infty \\ 2 & \infty \\ & 0 \end{array}$ $\begin{array}{c} 1 \\ 6.5e5(1e) \\ \hline 46150 \\ 1.6(1) \\ 50(65) \\ 0.12(0.1) \\ 2.8(0.4) \\ 1e0 \\ \hline 6541 \end{array}$   | $\begin{array}{c} & 3.145 \\ & \infty \\ & \infty \\ & 5.5 \\ 5.5 \\ 24(24) \\ 224(24) \\ 224(24) \\ 2 \\ 24(24) \\ 2 \\ 2 \\ 2 \\ 2 \\ 4 \\ \infty \\ 6 \\ 6 \\ 6 \\ 1e-1 \\ 1 \\ 14103 \\ 1 \end{array}$  | ∞<br>∞<br>∞<br>4e-3<br>5.5e6<br>17(28)<br>≈<br>∞<br>∞<br>∞<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•   | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>1e-5<br>5.6e6<br>26(30)<br>$\infty$<br>$\infty$<br>$\infty$<br>1e-5<br>15567   | $\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 1e-7 \\ 17589 \end{array}$  | 10/15<br>0/15<br>0/15<br>0/15<br>0/15<br>1/15<br>0/15<br>0/15   |
| $\begin{array}{c} \mathbf{f7} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \underline{\Delta f_{\text{opt}}} \\ \mathbf{f8} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \underline{\Delta f_{\text{opt}}} \\ \mathbf{f9} \\ \text{ACOR} \\ \end{array}$   | $\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 057(7-7)\\ \end{array}$  | $\begin{array}{c} 3.5e4(3) \\ \infty \\ \infty \\ \infty \\ 1e0 \\ 3871 \\ 307(335) \\ 5.9(2)^{*4} \\ \infty \\ \frac{1e0}{3102} \\ 78(8)^{*4} \end{array}$  
   |   | $\begin{array}{c} 16524\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 4219\\ 89(86)\\ 466(348)\\ 353(367)\\ \infty\\ 1e-3\\ 3455\\ 286(31)^{\star 4} \end{array}$  | $\begin{array}{c} 10524\\ \infty\\ \infty\\ \infty\\ 0\\ 1e-5\\ 4371\\ 107(84)^{*3}\\ 894(743)\\ \infty\\ \infty\\ 1e-5\\ 3594\\ 473(52)^{*4} \end{array}$  
   | $\begin{array}{c} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \end{array}$   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>15/15<br>15/15<br>1/15<br>0/15<br>0   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br>F20<br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br>F21<br>ACOR   
  | $\begin{array}{c} {}^{6} 686(252) \\ 382(240)^{*} \\ 2292(1142) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(4) \\ 17(6) \\ 16(5) \\ 503(56) \\ 1e1 \\ 561 \\ 2743(8906) \end{array}$   | $\begin{array}{c} & & & \\ & & & \\ & & & \\ 2 & & & \\ & & & \\ 2 & & & \\ 2 & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ \hline \\ & & & \\$   | $\begin{array}{c} 3.1e6 \\ 5.5 \\ 5.5 \\ 24 \\ 24 \\ (24) \\ (24)
\\ (24) \\$ | ∞<br>∞<br>∞<br>5.5e6<br>57(28) :<br>∞<br>∞<br>∞<br>∞<br>∞<br>∞<br>∞<br>∞<br>∞<br>∞<br>3.5e6<br>5.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e6<br>3.5e5<br>5.5e6<br>3.5e5<br>5.5e6<br>3.5e5<br>5.5e6<br>3.5e5<br>5.5e6<br>3.5e5<br>5.5e6<br>3.5e5<br>5.5e6<br>3.5e5<br>5.5e6<br>3.5e5<br>5.5e6<br>3.5e5<br>5.5e6<br>3.5e5<br>5.5e5<br>5.5e6<br>3.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5<br>5.5e5 | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>1e-5<br>26(30)<br>$\infty$<br>$\infty$<br>1e-5<br>15567<br>8994(1e4)   | $\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 17589 \\ 7960(9097) \end{array}$   | 18/15<br>0/15<br>0/15<br>0/15<br>0/15<br>14/15<br>0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>15/15<br>1/15   
   |
| $\begin{array}{c} \mathbf{f7} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \mathbf{GA} \\ \mathbf{f8} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \mathbf{\Delta}f_{\text{opt}} \\ \mathbf{f9} \\ \text{ACOR} \\ \text{PSO} \\ \end{array}$   | $\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64) \leq 3\\ 8.9(2) \times 4\\ \infty\\ 1e1\\ 1716\\ 45(7) \times 3\\ 671(437)\\ \end{array}$   | $\begin{array}{c} 3.5 \text{e4}(3) \\ \infty \\ \infty \\ \infty \\ 0 \\ 3871 \\ 66(114) \\ 307(335) \\ \textbf{5.9}(2)^{\star 4} \\ \infty \\ \hline \\ \textbf{100} \\ \textbf{78}(8)^{\star 4} \\ \infty \end{array}$   
   |   | $\begin{array}{c} 16524 \\ \infty \\ \infty \\ \infty \\ \infty \\ 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 3455 \\ 286(31)^{*4} \\ \infty \end{array}$  | $\begin{array}{c} 10024\\ \infty\\ \infty\\ \infty\\ 4371\\ 107(84)^{\star 3}\\ 894(743)\\ \infty\\ 1e-5\\ 3594\\ 473(52)^{\star 4}\\ \infty\end{array}$  
   | $\begin{array}{c} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 3277(3290)\\ \infty \ 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \infty \ 2e6\\ \end{array}$  | 0/15           0/15           0/15           0/15           0/15           0/15           15/15           1/15           0/15           0/15           15/15           1/15           15/15           1/15           0/15           15/15           15/15           15/15           0/15  | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO  
  | $\begin{array}{c} 686(252)\\ 382(240)^{\star^2}\\ 2292(1142)\\ \mathbf{1.4e4}(3105)\\ \mathbf{1e1}\\ 82\\ 16(4)\\ 17(6)\\ 16(5)\\ 503(56)\\ \mathbf{1e1}\\ 561\\ 2743(8906)\\ 1784(3563)\\ \end{array}$  | $\begin{array}{c} & 1 \\ & \infty \\ 2 & \infty \\ & \infty \\ \end{array}$ $\begin{array}{c} 6.5e5(1e \\ 1e0 \\ \hline 1.6(1) \\ 50(65) \\ 0.12(0.1) \\ 1e0 \\ \hline 6541 \\ 9938(1e4) \\ 4281(5198) \end{array}$  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$5.5)$
$\frac{1}{24}$<br>1e-1<br>224(24)<br>224(24)<br>224(24)<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-1<br>1e-2<br>1e-1<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2<br>1e-2  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>5.5e6<br>17(28)<br>$\infty$<br>$\infty$<br>$\infty$<br>1e-3<br>14643<br>561(1e4)<br>8<br>561(1e4)<br>8<br>913(2117)<br>17  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>26(30)<br>$\infty$<br>$\infty$<br>$\infty$<br>1e-5<br>15567<br>8994(1e4)<br>1799(1863)   | $\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \hline 1e-7 \\ 26(28) \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 17589 \\ 7960(9097) \\ 1593(1762) \end{array}$  
  | 13/15<br>0/15<br>0/15<br>0/15<br>0/15<br>1/15<br>0/15<br>0/15<br>0  |
| $\begin{array}{c} \mathbf{f7} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \end{array} \\ \begin{array}{c} \Delta f_{\text{opt}} \\ \overline{\mathbf{f8}} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \end{array} \\ \begin{array}{c} \Delta f_{\text{opt}} \\ \overline{\mathbf{f9}} \\ \overline{\mathbf{f9}} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \end{array} $   | $\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 699(596)\\ \end{array}$   | $\begin{array}{c} 4214\\ \mathbf{3.5e4}(3)\\ \infty\\ \infty\\ \infty\\ \infty\\ 3871\\ 66(114)\\ 307(335)\\ 5.9(2)^{24}\\ \infty\\ \mathbf{1e0}\\ 3102\\ 78(8)^{24}\\ \infty\\ \infty \end{array}$  
   |   | $\begin{array}{c} 16524\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 4219\\ 889(86)\\ 466(348)\\ 353(367)\\ \infty\\ 1e-3\\ 3455\\ 286(31)^{*4}\\ \infty\\ \infty\end{array}$   | $\begin{array}{c} 10524\\ \infty\\ \infty\\ \infty\\ 0\\ 1e-5\\ 3894(743)\\ \infty\\ 1e-5\\ 3594\\ 473(52)^{\star 4}\\ \infty\\ \infty\end{array}$  
   | $\begin{array}{l} 10505\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ \end{array}$   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>15/15<br>1/15<br>1/15   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>ABC  
  | $\begin{array}{c} 686(252)\\ 382(240)^{\star 2}\\ 2292(1142)\\ 1.4e4(3105)\\ 1e1\\ 82\\ 16(4)\\ 17(6)\\ 16(5)\\ 503(56)\\ 1e1\\ 561\\ 2743(8906)\\ 1784(3563)\\ 5.0(3)\\ 5.0(3)\\ \end{array}$   | $\begin{array}{c} & & & \\ & & & \\ & & & \\ 2 & & & \\ & & & \\ 2 & & & \\ &$  | $\begin{array}{c} & 3.1e5\\ \infty\\ & \infty\\ & \infty\\ & 5.5\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $  
  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>5.5c6<br>17(28)<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>561(1e4) 8<br>913(2117)<br>$27(30)^{*2}$  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>5.6e6<br><b>26</b> (30)<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>1e-5<br>15567<br>8994(1e4)<br>1799(1863)<br><b>35</b> (37)* <sup>2</sup>  | $\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 17589 \\ 760(9097) \\ 1593(1762) \\ 85(96)^{\star 2} \end{array}$   | 13/15<br>0/15<br>0/15<br>0/15<br>0/15<br>1/15<br>0/15<br>0/15<br>0  
   |
| $\begin{array}{c} \mathbf{f7} \\ \mathrm{ACOR} \\ \mathrm{PSO} \\ \mathrm{ABC} \\ \mathrm{GA} \\ \\ \overline{\mathbf{f8}} \\ \mathrm{ACOR} \\ \mathrm{PSO} \\ \mathrm{ABC} \\ \mathrm{GA} \\ \\ \overline{\mathbf{f9}} \\ \mathrm{ACOR} \\ \overline{\mathbf{f9}} \\ \mathrm{ACOR} \\ \mathrm{PSO} \\ \mathrm{ABC} \\ \mathrm{GA} \\ \end{array}$   | $\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{\star 4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{\star 3}\\ 671(437)\\ 6690(596)\\ \infty \end{array}$   | $\begin{array}{c} 1214\\ 3.5e4(3)\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ 066(114)\\ 307(335)\\ 5.9(2)^{*4}\\ \infty\\ 1e0\\ 3102\\ 78(8)^{*4}\\ \infty\\ \infty\\ \infty\\ \infty\\ \end{array}$   
   |   | $\begin{array}{c} 16324\\ \infty\\ \infty\\ \infty\\ 0\\ 4219\\ 889(86)\\ 466(348)\\ 353(367)\\ \infty\\ 1e-3\\ 3455\\ 286(31)^{*4}\\ \infty\\ \infty\\ \infty\\ \infty\end{array}$   | $\begin{array}{c} 10024 \\ \infty \\ \infty \\ \infty \\ \infty \\ 3000 \\ 107(84)^{\star 3} \\ 894(743) \\ \infty \\ 1e-5 \\ 3594 \\ 473(52)^{\star 4} \\ \infty \\ \infty \\ \infty \\ \infty \end{array}$  
   | $\begin{array}{c} 10303\\ \infty \ 1e^{7}\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e^{-7}\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ 1e^{-7}\\ 3727\\ 3727\\ 651(74)\\ \infty \ 2e6\\ \end{array}$   | 0/15           0/15           0/15           0/15           0/15           0/15           0/15           15/15           1/15           0/15           0/15           15/15           1/15           0/15           0/15           0/15           0/15           0/15           0/15  | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ABC<br>GA<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>COR<br>CA  
  | $\begin{array}{c} 686(252)\\ 382(240)^{\star 2}\\ 2292(1142)\\ \mathbf{1.4e4}(3105)\\ \mathbf{1e1}\\ 82\\ 17(6)\\ 16(4)\\ 17(6)\\ 16(5)\\ 503(56)\\ \mathbf{1e1}\\ 561\\ 2743(8906)\\ 1784(3563)\\ 5.0(3)\\ 90(10)\\ \end{array}$  | $\begin{array}{c} & & & \\$  | $\begin{array}{c} & & & \\ \infty & & \\ \infty & & \\ \infty & & \\ 5.5)^{\frac{14}{2}} \\ 1e^{-1} & & \\ 3.1e6 & \\ 224(24) & 2\\ 24(24) & 2\\ 4\\ \infty & & \\ 1e^{-1} & 1\\ 14103 & & \\ 14103 & & \\ 99927(1e4) & 9\\ 99927(1e4) & 9\\ 99927(1e4) & 9\\ 99927(1e4) & 9\\ 99927(1e4) & \\ 99927(1e4) & $   | $\infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 5.5e6 \\ 77(28) \\ \infty \\ \infty \\ \infty \\ ee-3 \\ 4643 \\ 561(1e4) \\ 8561(1e4) \\ 8913(2117) \\ 2913(2117) \\
2913(2117) \\ 2913$   | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>5.6e6<br><b>226</b> (30)<br>$\infty$<br>$\infty$<br>1e-5<br><b>15567</b><br><b>8994</b> (1e4)<br><b>1799</b> (1863)<br><b>35</b> (37)*2<br>$\infty$  | $\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 5.6e6 \\ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 17589 \\ 7960 (9097) \\ 1593 (1762) \\ 85 (96)^{*2} \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \hline 595 (162) \\ 85 (96)^{*2} \\ \infty \ 2e6 \\ 85 (96)^{*2}$  | 13/15           0/15           0/15           0/15           0/15           0/15           14/15           1/15           0/15           0/15           0/15           0/15           1/15           0/15           15/15           1/15           1/15           1/15           1/15           1/15           1/15           1/15           1/15  
  |
$\begin{array}{c} \mathbf{f7} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \underline{\Delta f_{opt}} \\ \mathbf{f8} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \underline{\Delta f_{opt}} \\ \mathbf{f9} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{GA} \\ \\ \underline{\Delta f_{opt}} \\ \text{GA} \\ \\ \text{ACOR} \\ \text{COR} \\ \\ \mathbf{f9} \\ \text{ACOR} \\ \\ \mathbf{f9} \\ \text{ACOR} \\ \\ \mathbf{f9} \\ \\ \mathbf{GA} \\ \\ \mathbf{A} \\ \mathbf{f9} \\ \\ \mathbf{GA} \\ \\ \mathbf{A} \\ \mathbf{f9} \\ \\ \mathbf{GA} \\ \\ \mathbf{A} \\ \mathbf{f9} \\ \\ \mathbf{GA} \\ \mathbf{A} \\ \mathbf{A} \\ \mathbf{F} \\ \mathbf{GA} \\ \mathbf{A} \\ \mathbf{F} $	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ \infty\\ 1e1\\ 1716\\ 45(7)^{+3}\\ 6671(437)\\ 699(596)\\ \infty\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ $	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \infty \\ \hline 0 \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ \hline 3102 \\ \hline 78(8)^{*4} \\ \infty \\ \infty \\ \infty \\ 1e0 \\ \end{array}$	$e^{4}$ ) $\infty$ $\infty$ $\infty$ $\infty$ $1e^{-1}$ 4040 72(101) 350(329) $10(3)^{*4}$ $1e^{-1}$ 3277 $119(11)^{*4}$ $\infty$ $\infty$ $1e^{-1}$	$\begin{array}{c} 16524\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 4219\\ 889(86)\\ 466(348)\\ 353(367)\\ \infty\\ 1e-3\\ 3455\\ 286(31)^{*4}\\ \infty\\ \infty\\ \infty\\ 1e-3\\ \end{array}$	$\begin{array}{c} 10524 \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 4371 \\ 107(84)^{+3} \\ 894(743) \\ \infty \\ \infty \\ 1e-5 \\ 3594 \\ 473(52)^{+4} \\ \infty \\ \infty \\ \infty \\ 1e-5 \end{array}$	$\begin{array}{l} 10303\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 1e$	0/15 0/15 0/15 0/15 0/15 15/15 1/15 0/15 0	ACOR PSO ABC GA $\Delta f_{opt}$ <b>f20</b> ACOR PSO ABC GA $\Delta f_{opt}$ <b>f21</b> ACOR PSO ABC GA	$\begin{array}{c} 686(252)\\ 382(240)^{\star}\\ 2292(114)\\ \mathbf{1.4e4}(3105)\\ \mathbf{1e1}\\ 82\\ 16(4)\\ 17(6)\\ 16(5)\\ 503(56)\\ \mathbf{1e1}\\ 561\\ 2743(8906)\\ 1784(3563)\\ 500\\ 90(19) \end{array}$	$\begin{array}{c} & & & \\ & & & \\ & & & \\ 2 & & & \\ & & & \\ 2 & & & \\ & & \\ 2 & & \\ & & \\ \hline & & \\ & & \\ \hline & & \\ &$	$\begin{array}{c} & & & \\ \infty & & \\ \infty & & \\ \infty & & \\ 55) \frac{54}{24} \\ 24(24) & 2 \\ 24(24) & 2 \\ \infty & & \\ 24(24) & 2 \\ 33.1e6 \\ 24(24) & 2 \\ 34 \\ 1e-1 & 1 \\ 14103 & 1 \\ 3927(1e4) & 9 \\ 1988(2340) & 1 \\ 398(496) \end{array}$	$\begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 5.5c6 \\ 17(28) \\ 17(28) \\ \infty \\ \infty \\ \infty \\ \infty \\ 1.4643 \\ 561(1e4) \\ 8913(2117) \\ 27(30)^{*2} \\ 904(1093) \end{array}$	$ \begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 15567 \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \end{array} $	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 17589 \\ 7960(9097) \\ 1593(1762) \\ \textbf{85}(96)^{\star 2} \\ \textbf{\infty} \ 2e6 \\ \textbf{2e6} \\ \textbf{2e6} \\ \infty \ 2e6 \\ \textbf{2e6} $	13/15         0/15         0/15         0/15         0/15         0/15         14/15         1/15         0/15         0/15         0/15         0/15         0/15         1/15         1/15         1/15         1/15         1/15         0/15         0/15
$\begin{array}{r} \mathbf{f7} \\ \mathbf{ACOR} \\ \mathbf{PSO} \\ \mathbf{ABC} \\ \mathbf{GA} \\ \mathbf{\Delta}f_{\mathbf{opt}} \\ \mathbf{f8} \\ \mathbf{ACOR} \\ \mathbf{PSO} \\ \mathbf{ABC} \\ \mathbf{GA} \\ \mathbf{\Delta}f_{\mathbf{opt}} \\ \mathbf{f9} \\ \mathbf{ACOR} \\ \mathbf{PSO} \\ \mathbf{ABC} \\ \mathbf{GA} \\ \mathbf{\Delta}f_{\mathbf{opt}} \\ \mathbf{GA} \\ \mathbf{CA} \\ $	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{\star 4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{\star 3}\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 124\\ 671(437)\\ 671(437$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \hline \infty \\ \hline 0 \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ \hline 3102 \\ \hline 78(8)^{*4} \\ \hline \infty \\ \hline \infty \\ \hline 1e0 \\ \hline 2025 \\ \hline \end{array}$	$ \begin{array}{c} {}_{\rm solution} {}_{\rm $	$\begin{array}{c} 16324\\ \infty\\ \infty\\ \infty\\ \infty\\ 4219\\ 89(86)\\ 466(348)\\ 353(367)\\ \infty\\ 1e-3\\ 3455\\ 286(31)^{*4}\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 14020\end{array}$	$\begin{array}{c} 10024 \\ \infty \\ \infty \\ \infty \\ \infty \\ 3000 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ 1e-5 \\ 3594 \\ 473(52)^{*4} \\ \infty \\ \infty \\ 1e-5 \\ 12020 $	$\begin{array}{c} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 12500\\ 12600\\ $	0/15 0/15 0/15 0/15 0/15 15/15 1/15 0/15 1/15 0/15 0	ACOR PSO ABC GA $\Delta f_{opt}$ <b>f20</b> ACOR PSO ABC GA $\Delta f_{opt}$ <b>f21</b> ACOR PSO ABC GA $\Delta f_{opt}$ <b>f21</b> ACOR ABC ACOR	$\begin{array}{c} 686(252)\\ 382(240)^{\star 2}\\ 2292(1142)\\ \mathbf{1.4e4}(3105)\\ \mathbf{1e1}\\ 82\\ 17(6)\\ 16(5)\\ 503(56)\\ \mathbf{1e1}\\ 561\\ 2743(8906)\\ 1784(3563)\\ 5.0(3)\\ 90(19)\\ \mathbf{1e1}\\ \end{array}$	$\begin{array}{c} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ \hline & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & &$	$\begin{array}{c} & 3.165 \\ \infty \\ \infty \\ \infty \\ 5.5 \\ 3.1e6 \\ 1e-1 \\ 24(24) \\ 224(24) \\ 224(24) \\ 224(24) \\ 24(24) \\ 294(24) \\ 294(24) \\ 1000 \\ 100$	$ \begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 3.5e6 \\ 77(28) \\ \infty \\ \infty \\ 4643 \\ 561(1e4) \\ 8913(2117) \\ 27(30)^{*2} \\ 904(1093) \\ 1e-3 \end{array} $	$ \begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 2e(30) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 15567 \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \\ 1e-5 \end{array} $	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.6e6 \\ 2e(28) \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 17589 \\ 7960 (9097) \\ 1593 (1762) \\ 85 (96)^{\star 2} \\ \infty \ 2e6 \\ 1e-7 \\ \end{array}$	13/15           0/15           0/15           0/15           0/15           0/15           14/15           1/15           0/15           0/15           0/15           0/15           1/15           15/15           1/15           1/15           1/15           1/15           0/15           8/15           0/15
$\begin{array}{r} \mathbf{f7} \\ \mathbf{ACOR} \\ \mathbf{PSO} \\ \mathbf{ABC} \\ \mathbf{GA} \\ \mathbf{ABC} \\ \mathbf{GA} \\ \mathbf{ABC} \\ \mathbf{FSO} \\ \mathbf{ABC} \\ \mathbf{ACOR} \\ \mathbf{PSO} \\ \mathbf{ABC} \\ \mathbf{GA} \\ \mathbf{ACOR} \\ \mathbf{PSO} \\ \mathbf{ABC} \\ \mathbf{GA} \\ \mathbf{ABC} \\ \mathbf{GA} \\ \mathbf{ABC} \\ \mathbf{GA} \\ \mathbf{ABC} \\ $	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 699(596)\\ \infty\\ 1e1\\ 7413$ 7413\\ 7413 7413\\ 7413 7	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \hline \infty \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ 1e0 \\ \hline 88(8)^{*4} \\ \hline \infty \\ \infty \\ 1e0 \\ \hline 8661 \\ \hline \end{array}$	$\begin{array}{c} solution{}{}solution{}{$	$\begin{array}{c} 16024\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 4219\\ 89(86)\\ 466(348)\\ 353(367)\\ \infty\\ 1e-3\\ 3455\\ 286(31)^{*4}\\ \infty\\ \infty\\ 1e-3\\ 14920\\ \end{array}$	$\begin{array}{c} & \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 4371 \\ 107 (84)^{*3} \\ 894 (743) \\ \infty \\ \infty \\ 1e-5 \\ 3594 \\ 473 (52)^{*4} \\ \infty \\ \infty \\ 1e-5 \\ 17073 \end{array}$	$\begin{array}{c} 10.000\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ -7\\ 17476\\ -7\end{array}$	10/15           0/15           0/15           0/15           0/15           0/15           15/15           15/15           1/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15	ACOR PSO ABC GA $\Delta f_{opt}$ $f_{20}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{opt}$ $f_{con}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{con}$ $f_{con}$ $\Delta f_{opt}$ $f_{con}$	$\begin{array}{c} & 686(252) \\ & 382(240)^{\star 2} \\ & 2292(114) \\ & \mathbf{14e4}(3105) \\ & 116(116) \\ &$	$\begin{array}{c} & & & \\ & & & \\ 2 & & & \\ & & & \\ 2 & & & \\ & & & \\ 2 & & & \\ & & & \\ \hline & & & \\ & & & \\ \hline & & & \\ & & & \\ \hline & & & \\ & & & \\ & & & \\ \hline & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ \hline & & & \\$	$\begin{array}{c} & & & \\ \infty & & \\ \infty & & \\ \infty & & \\ 5.5 \times 4 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 4 & & \\ 4 & & \\ 4 & & \\ 4 & & \\ 24(24) & 2 & \\ 1e-1 & & \\ 1e-1 & \\ 23491 & \\ 1e-1 & \\ 23491 & \\ \end{array}$	$ \begin{array}{c} \infty \\ \infty $	$ \begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 15567 \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \\ 1e-5 \\ 26847 \end{array} $	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 266 \\ 266 \\ 266 \\ 26 \\ 266 \\ 266 \\ 266 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \mathbf{2e6} \\ 266 \\ $	13/15           0/15           0/15           0/15           0/15           0/15           1/15           0/15           1/15           0/15           0/15           1/15           0/15           1/15
$\begin{array}{r} {\bf f7}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm GA}\\ {\rm GA}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm ABC}\\ {\rm GA}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm ACOR}\\ {\rm COR}\\ {\rm f10}\\ {\rm ACOR}\\ {\rm$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4) \end{array}$	$\begin{array}{c} 3.5e4(3, \\ \infty \\ \infty \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \infty \\ \hline 3102 \\ \hline 78(8)^{*4} \\ \infty \\ \infty \\ 1e0 \\ \hline 8661 \\ 0 \\ \infty \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \begin{array}{c} \\ \\ \\ \\ \\ \\ \end{array} \\ \begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	$ \begin{array}{c} {}_{\pm 0} \\ {}_{\pm 0} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{0} \\ {}_{0} \\ {}_{10} \\ {}_{3201} \\ {}_{10} \\ {}_{3277} \\ {}_{119} \\ {}_{119} \\ {}_{11} \\ {}_{119} \\ {}_{11} \\ {}_{119} \\ {}_{11} \\ {}_{10735} \\ {}_{\infty} \\ {}_{$	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 286(31)^{*4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \end{array}$	$\begin{array}{c} 10524 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 3594 \\ 473(52)^{*4} \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ \end{array}$	$\begin{array}{c} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ \infty \ 1e7\\ \end{array}$	0/15           0/15           0/15           0/15           0/15           0/15           15/15           1/15           1/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15	ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F21 ACOR PSO ABC GA $\Delta f_{opt}$ F22 ACOR ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC CBC CBC F20 ABC CBC F20 F20 ABC CBC F20 F20 F20 F20 F20 F20 F20 F20	$\begin{array}{c} 686(252)\\ 382(240)^{\star 2}\\ 2292(1142)\\ 1292(1142)\\ 14\\ 11\\ 14\\ 17\\ 16\\ 16\\ 16\\ 16\\ 16\\ 503$	$\begin{array}{c} & & \\$	$\begin{array}{c} & 3.165 \\ \infty \\ \infty \\ \infty \\ 5.5 \\ 3.1e6 \\ 4 \\ 24(24) \\ 224(24) \\ 224(24) \\ 24(24) \\ 29 \\ 3 \\ 4 \\ \infty \\ 1e-1 \\ 14103 \\ 1927(1e4) \\ 91986(2340) \\ 10 \\ 286(2340) \\ 10 \\ 1e-1 \\ 23491 \\ \infty \\ 10 \\ 23491 \\ \infty \\ 10 \\ 10 \\ 10 \\ 10 \\ 10 \\ 10 \\ 10$	$\begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 2e(30) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 15567 \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \\ 1e-5 \\ 26847 \\ \infty \\ 1e-5 \\ 26847 \\ \infty \end{array}$	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 5.6e6 \\ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 17589 \\ 7960 (9097) \\ 1593 (1762) \\ 85 (96)^{\star 2} \\ \mathbf{\infty} \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 2e7 \\ \hline \end{array}$	13/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           1/15           1/15           8/15           0/15           #succ           12/15           0/15
$\begin{array}{r} {\bf f7}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm GA}\\ {\rm f8}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm \Delta}f_{\rm opt}\\ {\rm f9}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm GA}\\ {\rm \Delta}f_{\rm opt}\\ {\rm f10}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ACOR}\\ {\rm PSO}\\ \end{array}$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 2.00e4(2e4)\\ \infty \end{array}$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \hline \infty \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ 1e0 \\ \hline 3102 \\ \hline 78(8)^{*4} \\ \hline \infty \\ \hline \infty \\ \hline 8661 \\ \hline \infty \\ \hline \infty \\ \hline \end{array}$													
   | $\begin{array}{c} {}_{\scriptstyle 840} \\ {}_{\scriptstyle 84} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle 21} \\ {}_{\scriptstyle 101} \\ {}_{\scriptstyle 350(329)} \\ {}_{\scriptstyle 10(3)} \\ {}_{\scriptstyle 10(3)} \\ {}_{\scriptstyle 4} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle 1e-1} \\ {}_{\scriptstyle 3277} \\ {}_{\scriptstyle 119(11)} \\ {}_{\scriptstyle 4} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle 1e-1} \\ \hline \\ {}_{\scriptstyle 10735} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle \infty} \\ {}_{\scriptstyle \infty} \end{array}$   | $\begin{array}{c} 16024 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 3455 \\ 286(31)^{*4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \end{array}$   | $\begin{array}{c} 10524 \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 4371 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ 1e-5 \\ 3594 \\ 473(52)^{*4} \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \end{array}$   
   | $\begin{array}{l} 10303\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 1e7\\ \infty 2e6\\ \end{array}$  | 0/15           0/15           0/15           0/15           0/15           0/15           15/15           15/15           0/15           #succ           15/15           0/15           15/15           0/15           15/15           0/15           #succ           15/15           0/15           0/15           0/15           0/15           0/15  | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f22</b><br>ACOR<br>PSO<br>ABC<br>CGA  
  | $\begin{array}{c} & 686(252) \\ & 382(240)^{\star 2} \\ & 2292(114) \\ & \mathbf{14e4}(3105) \\ & 116(116) \\ &$   | $\begin{array}{c} & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & &$   | $\begin{array}{c} & & & \\ \infty & & \\ \infty & & \\ \infty & & \\ 5.5 \times 4 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 25(30) \times & \\ 398(496) & \\ \mathbf{1e-1} & \\ 23491 & \\ \infty & \\ \end{array}$   
  | $ \begin{array}{c} \infty \\ \infty $  | $\begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 15567 \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \\ \frac{1e-5}{26847} \\ \infty \\ \infty \end{array}$   | $\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 1593(1762) \\ 885(96)^{\times 2} \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 1e7 \\ 2e6 \end{array}$   | 13/15           0/15           0/15           0/15           0/15           0/15           0/15           10/15           1/15           0/15           0/15           1/15           0/15           0/15           0/15           15/15           1/15           1/15           1/15           1/15           1/15           1/15           1/15           1/15           1/15           1/15           1/15           0/15           0/15           0/15           0/15  
  |
$\begin{array}{r} {\bf f7}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf \Delta}f_{{\rm opt}}\\ {\bf f8}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf \Delta}f_{{\rm opt}}\\ {\bf f10}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf ABC$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 6699(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \end{array}$	$\begin{array}{c} 3.5e4(3, \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 0 \\ 166(114) \\ 307(335) \\ 5.9(2)^{*4} \\ \infty \\ 100 \\ 3102 \\ 78(8)^{*4} \\ \infty \\ \infty \\ 0 \\ \infty \\ 1e0 \\ 1e0 \\ 8661 \\ 0 \\ \infty \\ \end{array}$	$ \begin{array}{c} {}_{\rm solution} {}_{\rm $	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 4219 \\ 89(86) \\ 466(348) \\ 355(367) \\ \infty \\ 1e-3 \\ 286(31)^{\star 4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ $	$\begin{array}{c} 10524 \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{\star 3} \\ 894(743) \\ \infty \\ 1e-5 \\ 3594 \\ 473(52)^{\star 4} \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \end{array}$	$\begin{array}{l} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ 0 \ 2e6\\ \infty \ 2e6\\ 0 \$	$\begin{array}{c} 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 15/15\\ 1/15\\ 0/15$	ACOR PSO ABC GA $\Delta f_{opt}$ <b>f20</b> ABC GA $\Delta f_{opt}$ <b>f21</b> ACOR PSO ABC GA $\Delta f_{opt}$ <b>f21</b> ACOR PSO ABC GA $\Delta f_{opt}$ <b>f21</b> ACOR PSO ABC ABC ABC ABC ABC ABC ABC ABC ABC ABC	$\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\star 2} \\ 2292(114) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(4) \\ 17(6) \\ 16(5) \\ 503(56) \\ 1e1 \\ 561 \\ 2743(8906) \\ 1784(3563) \\ 5.0(3) \\ 90(19) \\ 1e1 \\ 467 \\ 1.4e4(2e4) \\ 5.0(5)^{\star} \\ 10(c)^{\star} \end{array}$	$\begin{array}{c} & & \\$	$\begin{array}{c} & & & \\ \infty & & \\ \infty & & \\ \infty & & \\ 5.5)^{\frac{1}{24}} \\ 3.1e6 & (24)^{\frac{1}{24}} \\ 24(24) & 2 \\ 24(24) & 2 \\ 3 \\ 4 \\ \infty & (24)^{\frac{1}{24}} \\ 24(24) & 2 \\ 3 \\ 24(24) & 2 \\ 3 \\ 24(24) & 2 \\ 1 \\ 23 \\ 3 \\ 3 \\ 3 \\ 3 \\ 3 \\ 3 \\ 3 \\ 3 \\ $	$ \begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 5.5e6 \\ 77(28) \\ \infty \\ \infty \\ \infty \\ \infty \\ 27(30)^{+2} \\ 27(30)^{+2} \\ 27(30)^{+2} \\ 24948 \\ \infty \\ \infty \\ \infty \\ \infty \end{array} $	$\begin{array}{c} \infty \\ 0 \\ 0 \\ 0 \\$	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.6e6 \\ 2e6 \\ 2e8 \\ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 17589 \\ 7960 \\ (9097) \\ 1593 \\ (162) \\ 85 \\ (96)^{+2} \\ 85 \\ (96)^{+2} \\ 1.3e5 \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 2e6 \\ 1e-7 \\ 0 \\ 2e6 \\ 0 \\ 1e^{-7} \\ 0 \\ 2e^{-5} \\ 0 \\ 1e^{-5} \\ 1e^{-5} \\ 0 \\ 1e^{-5} \\ 1e^{-$	13/15           0/15           0/15           0/15           0/15           0/15           14/15           1/15           0/15           0/15           0/15           0/15           1/15           1/15           1/15           1/15           8/15           0/15           1/15           8/15           0/15           0/15           0/15
$\begin{array}{c} {\bf f7}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf \Delta}f_{\rm opt}\\ {\bf f8}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf \Delta}f_{\rm opt}\\ {\bf f10}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf \Delta}f_{\rm opt}\\ {\bf f10}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf COR}\\ {\bf COR}\\ {\bf COR}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf COR}\\ {\bf C$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{44}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{+3}\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ \infty\\ \infty\\ \end{array}$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \hline \infty \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ 1e0 \\ \hline 3102 \\ \hline 78(8)^{*4} \\ \hline \infty \\ \infty \\ \hline \infty \\ \hline 8661 \\ \hline \infty \\ \infty \\$	$\begin{array}{c} {}_{\pm 0} \\ {}_{\pm 0} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{1e-1} \\ {}_{350(329)} \\ {}_{10(3)} \\ {}^{\pm 4} \\ {}_{\infty} \\ {}_{1e-1} \\ {}_{3277} \\ {}_{119(11)} \\ {}^{\pm 4} \\ {}_{\infty} $	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 3455 \\ 286(31)^{*4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ $	$\begin{array}{c} & \infty & \\ 1e-5 & \\ 4371 & \\ 107 (84)^{\star 3} & \\ 894 (743) & \\ \infty & \\ \infty & \\ 1e-5 & \\ 17073 & \\ \infty & \\ \infty & \\ 1e-5 & \\ 17073 & \\ \infty & \\ 0 & $	$\begin{array}{l} 10303\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 1e7\\ \infty 2e6\\ \end{array}$	0/15 0/15 0/15 0/15 0/15 15/15 15/15 0/15 0	ACOR PSO ABC GA $\Delta f_{opt}$ <b>f20</b> ABC GA $\Delta f_{opt}$ <b>f20</b> ABC GA ACOR PSO ABC GA $\Delta f_{opt}$ <b>f20</b> ACOR PSO ABC GA ACOR PSO ABC GA ACOR PSO ABC ABC ABC ABC ABC ABC ABC ABC ABC ABC	$\begin{array}{c} & 686(252) \\ & 382(240)^{\star 2} \\ & 2292(114) \\ & \mathbf{14e4}(3105) \\ \hline 1e1 \\ & 82 \\ & 17(6) \\ & 17(6) \\ & 16(5) \\ & 503(56) \\ \hline 1e1 \\ & 2743(8906) \\ & 1784(3563) \\ & 50(3) \\ & 90(19) \\ \hline 1e1 \\ & 467 \\ & 1.4e4(2e4) \\ & 5.0(5)^{\star} \\ & 10(6) \\ \end{array}$	$\begin{array}{c} & 1 \\ & 2 \\ & \infty \\ & \infty \\ \end{array} \\ \begin{array}{c} & & & \\ \hline 1e0 \\ \hline 46150 \\ & & \\ 1.6(1) \\ 50(65) \\ & & \\ 0.12(0.1)^{+} \\ & & \\ 2.8(0.4) \\ \hline 1e0 \\ \hline 6541 \\ & & \\ 9938(1e4) \\ & & \\ 22(50)^{+} \\ & & \\ 625(766) \\ \hline 1e0 \\ & & \\ 5580 \\ & & \\ 3585(5376) \\ & & \\ 3585(5376) \\ & & \\ 411(539) \\ & & \\ 47(67) \\ \end{array} \end{array}$	$\begin{array}{c} & & & \\ \infty & & \\ \infty & & \\ \infty & & \\ 55) \frac{4}{8} & \\ 1e-1 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 4 & & \\ 4 & & \\ 4 & & \\ 4 & & \\ 4 & & \\ 1e-1 & \\ 14103 & 1 & \\ 9927(1e4) & 9 & \\ 1986(2340) & 1 & \\ 91986(2340) & 1 & \\ 186(2340) & 1 & \\ 25(30)^{\star} & \\ 398(496) & \\ 1e-1 & \\ 23491 & \\ \infty & \\ \infty & \\ \hline & \\ 77(86)^{\star} & \\ \end{array}$	$ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \\ 1e-5 \\ 26847 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \end{array}$	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26 \\ 26 \\ 226 \\ 226 \\ 226 \\ \infty \ 2e6 \\ 2e6 \\ 2e6 \\ 1e-7 \\ 17589 \\ 7960 (9097) \\ 1593 (1762) \\ 885 (96) ^{\times 2} \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 1e7 \\ \infty \ 2e6 \\ 2e6 \\ 1e-3 \\ 2e6 \\ 2$	13/15           0/15           0/15           0/15           0/15           0/15           0/15           1/15           1/15           0/15           0/15           0/15           1/15           1/15           1/15           1/15           1/15           1/15           1/15           8/15           0/15           0/15           0/15
$\begin{array}{r} {\bf f7}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf \Delta}f_{\rm opt}\\ {\bf f8}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf \Delta}f_{\rm opt}\\ {\bf f9}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf AEC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ABC}\\ {\bf A$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 669(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ \infty\\ 1e1\\ 1e1\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \infty \\ \hline \infty \\ \infty \\ \hline \infty \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ \hline 3102 \\ \hline 78(8)^{*4} \\ \hline \infty \\ \hline \infty \\ \hline 8661 \\ \hline 0 \\ \infty \\ \infty \\ \infty \\ \hline \infty \\ 1e0 \\ \hline \end{array}$	1e-1 $10(3)^{*4}$ $\infty$ 1e-1 $10(3)^{*4}$ $\infty$ 1e-1 $10^{*4}$ $\infty$ 1e-1 $10^{*4}$ $\infty$ 1e-1 $10^{*5}$ 1e-1 $10^{*5}$ 1e-1	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 4219 \\ 89(86) \\ 466(348) \\ 3353(367) \\ \infty \\ 1e-3 \\ 286(31)^{\star 4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ 1e-3 \\ 1e-3$	$\begin{array}{c} 10524 \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ $	$\begin{array}{c} 10303\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 2e6\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\$	0/15 0/15 0/15 0/15 0/15 15/15 15/15 1/15 0/15 0	ACOR PSO ABC GA $\Delta f_{opt}$ <b>f20</b> ACOR PSO ABC GA $\Delta f_{opt}$ <b>f21</b> ACOR PSO ABC GA $\Delta f_{opt}$ <b>f21</b> ACOR PSO ABC GA ABC GA COR PSO ABC GA ABC GA ABC GA ABC GA ABC GA ABC GA ABC GA ABC GA ABC GA ABC GA ABC GA ABC GA ABC ABC ABC ABC ABC ABC ABC ABC ABC AB	$\begin{array}{c} 686(252)\\ 382(240)^{\star 2}\\ 2292(114)\\ \mathbf{14e4}(3105)\\ \mathbf{1e1}\\ 82\\ 16(4)\\ 17(6)\\ 503(56)\\ \mathbf{1e1}\\ 501\\ 503(56)\\ \mathbf{1e1}\\ 501\\ 503(56)\\ \mathbf{1e1}\\ 1784(3563)\\ 5.0(3)\\ 90(19)\\ \mathbf{1e1}\\ 467\\ \mathbf{1.4e4}(2e4)\\ 5.0(5)^{\star}\\ 100(53)\\ \end{array}$	$\begin{array}{c} & & \\$	$\begin{array}{c} & & & \\ \infty & & \\ \infty & & \\ \infty & & \\ 5.5) \frac{k4}{2} \\ \hline 3.1e6 & & \\ 24(24) & 2 \\ 2 \\ \frac{2}{3} \\ - \\ 2 \\ 4 \\ - \\ 2 \\ - \\ 2 \\ 4 \\ - \\ - \\ 2 \\ - \\ 2 \\ 4 \\ - \\ - \\ 2 \\ - \\ 2 \\ - \\ - \\ - \\ - \\ -$	$ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ 26(30) \\ \infty \\ \infty \\ 26(30) \\$	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 5.6e6 \\ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 0 \\ 2e6 \\ 1e-7 \\ 17589 \\ 7960 (9097) \\ 1593 (1762) \\ 85 (96)^2 \\ 85 (96)^2 \\ 85 (96)^2 \\ \mathbf{1e} \\ 1.3e5 \\ \infty \ 2e6 \\ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \end{array}$	13/15         0/15           0/15         0/15           0/15         0/15           0/15         1/15           1/15         0/15           0/15         1/15           1/15         1/15           1/15         1/15           1/15         1/15           8/15         0/15           1/2/15         0/15           0/15         0/15           0/15         0/15           0/15         0/15           0/15         0/15
$\begin{array}{r} {\bf f7}\\ {\bf ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\bf \Delta}f_{\rm opt}\\ {\bf f8}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm ABC}\\ {\rm GA}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm \Delta}f_{\rm opt}\\ {\bf f9}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm \Delta}f_{\rm opt}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm \Delta}f_{\rm opt}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm COR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm COR}\\ {\rm COR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm COR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm COR}\\ {\rm COR}\\ {\rm COR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm COR}\\ {\rm COR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm COR}\\ {\rm COR}\\ {\rm COR}\\ {\rm PSO}\\ {\rm COR}\\ {\rm COR}$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 6690(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ \infty\\ 1e1\\ 1690\\$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \infty \\ \hline \infty \\ 0 \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ 1e0 \\ \hline 3102 \\ 78(8)^{*4} \\ \hline \infty \\ \infty \\ 0 \\ \hline 8661 \\ 0 \\ \infty \\ \infty \\ \infty \\ 1e0 \\ \hline 8661 \\ 0 \\ \infty \\ \infty \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0$	$ \begin{array}{c} {}_{\rm solution} {}_{\rm $	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 4219 \\ 889(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 3455 \\ 286(31)^{*4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ \infty \\ \infty \\ 1e-3 \\ \infty \\ $	$\begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 4371 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ 1e-5 \\ 1$	$\begin{array}{c} 10.000\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 1$	0/15 0/15 0/15 0/15 15/15 15/15 1/15 0/15 0	ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F21 ACOR PSO ABC GA $\Delta f_{opt}$ F22 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F21 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F21 ACOR PSO ABC GA $\Delta f_{opt}$ F21 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC ACOR F20 ABC ACOR F20 ABC ACOR F20 ABC ACOR F20 ABC ACOR F20 ABC ACOR F20 ABC ACOR F20 A ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 ACOR F20 F20 F20 F20 F20 F20 F20 F20 F20 F20	$\begin{array}{c} 686(252)\\ 382(240)^{\star 2}\\ 2292(114)\\ \mathbf{1.4e4}(3105)\\ 1e1\\ 16(4)\\ 17(6)\\ 16(5)\\ 503(56)\\ 1e1\\ 2743(8906)\\ 1784(3563)\\ 5.0(3)\\ 90(19)\\ 1e1\\ 467\\ \mathbf{1.4e4}(2e4)\\ 5.0(5)^{\star}\\ 10(6)\\ 110(53)\\ 1e1\\ \end{array}$	$\begin{array}{c} 1 \\ 2 \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} 0 \\ \hline 46150 \\ 1.6(1) \\ 50(65) \\ 0.12(0.1)^{4} \\ 2.8(0.4) \\ 1e0 \\ \hline 6541 \\ 9938(1e4) \\ 4281(5198) \\ 22(50)^{4} \\ 625(766) \\ 1e0 \\ \hline 5580 \\ 3585(5376) \\ 411(539) \\ 47(67) \\ 1452(1615) \\ 1e0 \\ \end{array}$	$\begin{array}{c} & & & \\ \infty & & \\ \infty & & \\ \infty & & \\ \infty & & \\ 55) \frac{4}{8} & \\ 1e-1 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 24(24) & 2 & \\ 1e-1 & \\ 14103 & 1 & \\ 9927(1e4) & 9 & \\ 9986(2340) & 1 & \\ 9986(2340) & 1 & \\ 19986(2340) & 1 & \\ 25(30)^{*} & \\ 398(496) & \\ 1e-1 & \\ 23491 & & \\ \infty & & \\ 77(86)^{*2} & & \\ \infty & & \\ 1e-1 & \\ \end{array}$	$\infty$ $\infty$ $\infty$ $\infty$ $\infty$ $\infty$ $\infty$ $\infty$	$\begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \\ 1e-5 \\ 26847 \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \end{array}$	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 17589 \\ 7960(9097) \\ 1593(1762) \\ 85(96)^{\star 2} \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 1e7 \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 2e6 \\ 1e-7 \\ $	13/15           0/15           0/15           0/15           0/15           0/15           1/15           1/15           0/15           0/15           0/15           0/15           0/15           15/15           15/15           15/15           1/15           1/15           1/15           1/15           1/15           1/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15
$\begin{array}{r} {\bf f7}\\ {\bf ACOR}\\ {\rm PSO}\\ {\rm AECGR}\\ {\rm GA}\\ {\bf \Delta} f_{\rm opt}\\ {\bf f8}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\bf \Delta} f_{\rm opt}\\ {\bf f9}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\bf \Delta} f_{\rm opt}\\ {\bf f10}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\bf \Delta} f_{\rm opt}\\ {\bf f11}\\ {\bf f11}\\ \end{array}$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ \infty\\ 1e1\\ 1002\\ 1e1\\ 1e1\\ 1002\\ 1e1\\ 1e1\\ 1002\\ 1e1\\ 1e1\\ 1e1\\ 1002\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e1\\ 1e$	$\begin{array}{c} 3.5e4(3, \\ \infty \\ 1e0 \\ 5.9(2)^{*4} \\ \infty \\ 3102 \\ 78(8)^{*4} \\ \infty \\ \infty \\ 1e0 \\ 8661 \\ 0 \\ \infty \\ \infty \\ \infty \\ 1e0 \\ 1e0 \\ 2228 \\ 0 \\ \infty \\ \infty$	$\begin{array}{c} 1e-1\\ & & \\ & &												
\\ & & \\$  | $\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 286(31)^{*4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ 39762 \\ 9762 \\ \end{array}$  | $\begin{array}{c} 10324 \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 12285 \\ \end{array}$  
   | $\begin{array}{c} 10303\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 2e6\\ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 2e6\\ 1e-7\\ 17476\\ \infty 2e6\\ \infty 2e6\\ 2e6\\ 2e6\\ 2e6\\ 1e-7\\ 14831\\ 1e-7\\ 14831\\ \end{array}$   | 0/15<br>0/15<br>0/15<br>0/15<br>0/15<br>15/15<br>15/15<br>1/15<br>0/15<br>0   | ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f20</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f21</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f22</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f22</b><br>ACOR<br>PSO<br>ABC<br>GA<br>$\Delta f_{opt}$<br><b>f22</b><br>ACOR<br>PSO<br>ABC<br>GA<br>ACOR<br>PSO<br>ABC<br>GA<br>ACOR<br>PSO<br>ABC<br>GA<br>ACOR<br>PSO<br>ABC<br>GA<br>ACOR<br>PSO<br>ABC<br>ABC<br>ABC<br>ABC<br>ACOR<br>PSO<br>ABC<br>ABC<br>ABC<br>ABC<br>ABC<br>ABC<br>ABC<br>ABC   
  | $\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\star 2} \\ 2292(114) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(5) \\ 503(56) \\ 1e1 \\ 503(56) \\ 1e1 \\ 503(56) \\ 1784(3563) \\ 5.0(3) \\ 9.0(3) \\ 100(19) \\ 1e1 \\ 467 \\ 1.4e4(2e4) \\ 5.0(5)^{\star} \\ 10(6) \\ 110(53) \\ 1e1 \\ 10 \\ 2 \\ 2 \\ 2 \\ 10 \\ 10 \\ 10 \\ 10 \\$  | $\begin{array}{c} & & \\$   | $\begin{array}{c} & & & & \\ & & & & \\ & & & & \\ & &
& \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ &$  | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$   | $\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>26(30)<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$35(37)^{*2}$<br>$\infty$<br>1e-5<br>26847<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>26847<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>26847<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$<br>$\infty$   | $\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 1.7589 \\ 7960(9097) \\ 1593(1762) \\ 85(96)^2 \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 8.4e5 \\ \hline \end{array}$  | 10/15           0/15           0/15           0/15           0/15           14/15           1/15           1/15           0/15           #succ           1/15           1/15           1/15           1/15           1/15           1/15           1/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15  
   |
$\begin{array}{r} {\bf f7}\\ {\bf ACOR}\\ {\rm PSO}\\ {\rm AECGR}\\ {\rm GA}\\ {\rm \Delta} \underline{f_{\rm opt}}\\ {\rm f8}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm ABC}\\ {\rm GA}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm AECOR}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ACOR}\\ {\rm A$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{\star 4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{\star 3}\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ \infty\\ 1e1\\ 1002$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \hline \infty \\ \hline \infty \\ \hline \infty \\ \hline 0 \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ \hline 1e0 \\ \hline 3102 \\ \hline 78(8)^{*4} \\ \hline \infty \\ \hline \infty \\ \hline 0 \\ 8661 \\ \hline 0 \\ \hline 0 \\ \hline 2228 \\ 1328(2262) \\ \hline 1328(2262) \\ \hline \end{array}$		$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 200 \\ 1e-3 \\ 3455 \\ 286(31)^{*4} \\ \infty \\ 286(31)^{*4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ 0 \\ 1e-3 \\ 9762 \\ 995(1040) \end{array}$	$\begin{array}{c} 10324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 3000 \\ \hline \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	$\begin{array}{c} 10303\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ \end{array}$	0/15           0/15           0/15           0/15           0/15           15/15           15/15           1/15           0/15           #succ           15/15           0/15	ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F21 ACOR PSO ABC GA $\Delta f_{opt}$ F22 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F21 ACOR F20 ABC GA $\Delta f_{opt}$ F21 ACOR F20 ABC GA $\Delta f_{opt}$ F21 ACOR F20 ABC GA $\Delta f_{opt}$ F21 ACOR F20 ABC GA $\Delta f_{opt}$ F21 ACOR F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC COR F20 ABC GA ABC ABC ABC ABC ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 ABC COR F20 F20 ABC COR F20 F20 F20 F20 F20 F20 F20 F20 F20 F20	$\begin{array}{c} 686(252)\\ 382(240)^{\star 2}\\ 2292(114)\\ 1.4e4(3105)\\ 1e1\\ 16(4)\\ 17(6)\\ 16(5)\\ 503(56)\\ 1e1\\ 2743(8906)\\ 1784(3563)\\ 5.0(3)\\ 90(19)\\ 1e1\\ 467\\ 1.4e4(2e4)\\ 5.0(5)^{\star}\\ 10(6)\\ 110(53)\\ 1e1\\ 3.2\\ 3.2\\ 3.2\\ 3.2\\ 3.2\\ 3.2\\ 3.2\\ 3.2$	$\begin{array}{c} & & & \\ & & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & &$	$\begin{array}{c} & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & &$	$\infty$ $\infty$ $\infty$ $\infty$ $\infty$ $\infty$ $\infty$ $\infty$	$\begin{array}{c} \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ 0 \\ \infty \\ 0 \\ \infty \\ 0 \\ 0 \\$	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 17589 \\ 7960(9097) \\ 1593(1762) \\ 85(96)^{\star 2} \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 1e7 \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \end{array}$	13/15           0/15           0/15           0/15           0/15           14/15           1/15           0/15           1/15           0/15           1/155           0/15           15/15           15/15           1/15           1/15           0/15
$\begin{array}{r} {\bf f7}\\ {\bf f7}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm AECG}\\ {\rm GA}\\ {\rm \Delta} f_{\rm opt}\\ {\rm f8}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm \Delta} f_{\rm opt}\\ {\rm f9}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm \Delta} f_{\rm opt}\\ {\rm f10}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm \Delta} f_{\rm opt}\\ {\rm f10}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm \Delta} f_{\rm opt}\\ {\rm f11}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm PSO}\\ {\rm PSO}\\ {\rm PSO}\\ {\rm SO}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ACOR}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ACOR}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ACOR}\\ {\rm ACOR}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ACOR}\\ {\rm ACOR}$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 1002\\ 1002(53)\\ 143(47)^{*3}\\ \end{array}$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \infty \\ \infty \\ \hline \infty \\ \infty \\ \hline \infty \\ 5.9(2)^{*4} \\ \hline \infty \\ 5.9(2)^{*4} \\ \hline \infty \\ 78(8)^{*4} \\ \hline \infty \\ \infty \\ 1e0 \\ \hline 8661 \\ 0 \\ \infty \\ \infty \\ \infty \\ 1e0 \\ \hline 1e0 \\ \hline$	$\begin{array}{c} 1e-1 \\ 4040 \\ 72(101) \\ 350(329) \\ 10(3)^{*4} \\ \infty \\ 1e-1 \\ 119(11)^{*4} \\ \infty \\ 1e-1 \\ 10735 \\ \infty \\ \infty \\ 1e-1 \\ 10735 \\ \infty \\ \infty \\ 1e-1 \\ 10735 \\ 0 \\ 10745 \\ $	$\begin{array}{c} 16324\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 4219\\ 89(86)\\ 466(348)\\ 353(367)\\ \infty\\ 1e-3\\ 286(31)^{*4}\\ \infty\\ \infty\\ 1e-3\\ 14920\\ \infty\\ \infty\\ 1e-3\\ 14920\\ \infty\\ 0\\ \infty\\ 1e-3\\ 9762\\ 995(1040)\\ 132(12) \end{array}$	$\begin{array}{c} 10324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ 1e-5 \\ 12285 \\ 1037(1426) \\ 148(16) \end{array}$	$\begin{array}{l} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 651(74)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ 2019(2158)\end{array}$	$\begin{array}{c} 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ \end{array}\\ \hline\\ 15/15\\ 15/15\\ 1/15\\ 0/1$	ACOR PSO ABC GA $\Delta f_{opt}$ f20 ACOR PSO ABC GA $\Delta f_{opt}$ f21 ACOR PSO ABC GA $\Delta f_{opt}$ f22 ACOR ABC GA $\Delta f_{opt}$ PSO ABC GA $\Delta f_{opt}$ f21 ACOR PSO ABC ACOR ACOR PSO ABC ACOR ACOR PSO ABC ACOR PSO ABC ACOR ACOR ACOR ACOR ACOR ACOR ACOR ACO	$\begin{array}{c} 1\\ 686(252)\\ 382(240)^{\star 2}\\ 2292(114)\\ 1.4e4(3105)\\ 1e1\\ 82\\ 16(6)\\ 17(6)\\ 16(5)\\ 503(56)\\ 1e1\\ 503(56)\\ 1e1\\ 503(56)\\ 1784(3563)\\ 90(19)\\ 1e1\\ 467\\ 1.4e4(2e4)\\ 5.0(5)^{\star}\\ 10(6)\\ 110(53)\\ 1e1\\ 3.2\\ 1.8(2)\\ \end{array}$	$\begin{array}{c} & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & &$	$\begin{array}{c} & & & & & \\ & & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & &$	$ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ 35(37)^{*2} \\ \infty \\ 35(37)^{*2} \\ \infty \\ \end{array} \\ \begin{array}{c} 26847 \\ \infty \\ $	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \textbf{2e6} \\ \textbf{1e-7} \\ \textbf{1.593(1762)} \\ \textbf{85(96)^{*2}} \\ \textbf{85(96)^{*2}} \\ \textbf{85(96)^{*2}} \\ \textbf{82e6} \\ ne-7 \\ \textbf{1.3e5} \\ \infty \ 2e6 \\ ne-7 \\ \textbf{8.4e5} \\ \infty \ 2e7^{*3} \\ \textbf{8.4e5} \\ \infty \ ne7^{*3} \end{array}$	10/15           0/15           0/15           0/15           0/15           14/15           1/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15
$\begin{array}{r} {\rm f7}\\ {\rm ACOR}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ \\ {\rm \Delta} {f_{\rm opt}}\\ {\rm f8}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm AEOR}\\ {\rm AEOR}\\ {\rm PSO}\\ {\rm AEOR}\\ {\rm AEOR}\\ {\rm PSO}\\ {\rm AEOR}\\ {$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ \infty\\ 1e1\\ 1002\\ 1002(53)\\ 143(47)^{*3}\\ \infty \end{array}$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \hline \infty \\ 5.9(2)^{*4} \\ \hline \infty \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ \hline 3102 \\ \hline 78(8)^{*4} \\ \hline \infty \\ \hline \infty \\ \hline \infty \\ \hline 0 \\ \hline 8661 \\ \hline 0 \\ \hline 2228 \\ \hline 128(2262) \\ \hline 1328(2262) \\ \hline \infty \\ \hline \end{array}$	$\begin{array}{c} {}_{\rm e4}{}_{\rm 0}{}_{\rm \infty}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 10(3)^{*4}}{}_{\rm \infty}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 10735}{}_{\rm 1e-1}{}_{\rm 10735}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 10735}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 10735}{}_{\rm 0}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 10735}{}_{\rm 0}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 10735}{}_{\rm 0}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 10735}{}_{\rm 0}{}_{\rm 0}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 10725}{}_{\rm 0}{}_{\rm 0}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 1e-1}{}_{\rm 10725}{}_{\rm 0}{}_{\rm 0}{}_{\rm 1e-1}{}_{\rm 1$	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 3455 \\ 286(31)^{\star 4} \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 9762 \\ 995(1040) \\ 132(12) \\ \infty \end{array}$	$\begin{array}{c} 10324 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 3 \\ 3 \\ 3 \\ 3 \\ 3$	$\begin{array}{l} 10303\\ \infty \ 1e^{7}\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e^{-7}\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e^{-7}\\ 3727\\ 651(74)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e^{-7}\\ 17476\\ \infty \ 2e6\\ 1e^{-7}\\ 17476\\ \infty \ 2e6\\ 1e^{-7}\\ 17476\\ \infty \ 2e6\\ 1e^{-7}\\ 114831\\ 1462(1688)\\ 2019(2158)\\ \infty \ 2e6\\ \infty \ 2e6\\ \end{array}$	0/15 0/15 0/15 0/15 0/15 15/15 15/15 1/15 0/15 0	ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F21 RCOR PSO ABC GA $\Delta f_{opt}$ F22 ACOR PSO ABC GA $\Delta f_{opt}$ F23 ACOR PSO ABC GA	$\begin{array}{c} & 686(252) \\ & 382(240)^{\pm 2} \\ & 32292(114) \\ & 12292(114) \\ & 11 $	$\begin{array}{c} & & & \\$	$\begin{array}{c} & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ \mathbf{24(24)} & & & & \\ & & & & & \\ \mathbf{24(24)} & & & & \\ & & & & & & \\ & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & \\$	$ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 35(37)^{*2} \\ \infty \\ 35(37)^{*2} \\ \infty \\ 26847 \\ \infty \\ 26847 \\ \infty \\ \infty \\ 1e-5 \\ 8.1e5 \\ \infty^{*3} \\ \infty \\ \infty \end{array}$	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ 2e6 \\ 2e6 \\ 1e-7 \\ 17589 \\ 7960(9097) \\ 1593(1762) \\ 85(96)^{\star 2} \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 1e7 \\ 2e6 \\ 2e6 \\ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 1e7^{\star 3} \\ \infty \ 2e6 \end{array}$	10/15           0/15           0/15           0/15           0/15           14/15           1/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           1/15           #succ           12/15           0/15
$\begin{array}{r} {\bf f7}\\ {\bf f7}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm GA}\\ {\rm GA}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm ACOR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm ACOR}\\ {\rm FSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm GA}\\ {\rm COR}\\ {\rm FSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm GA}\\ {\rm COR}\\ {\rm FSO}\\ {\rm ABC}\\ {\rm GA}\\ {\rm COR}\\ {\rm PSO}\\ {\rm ABC}\\ {\rm COR}\\ {\rm COR}\\$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 672(437)\\ 679(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ 1e1\\ 1002(53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ \end{array}$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \infty \\ \infty \\ \hline \infty \\ \infty \\ \hline \infty \\ 5.9(2)^{*4} \\ \hline \infty \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ \hline 78(8)^{*4} \\ \hline \infty \\ \hline 8661 \\ ) \\ \infty \\ \hline \infty \\ \hline 1e0 \\ \hline 8661 \\ ) \\ \infty \\ \hline 1e0 \\ \hline 12228 \\ 1328(2262) \\ \hline 1328(2262) \\ \hline 186(29) \\ \hline \infty \\ \hline \end{array}$	$\begin{array}{c} {}_{\scriptstyle 840} \\ {}_{\scriptstyle 840} \\ {}_{\scriptstyle 80} \\ {}_{\scriptstyle 80}$	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 3455 \\ 286(31)^{*4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 9762 \\ 995(1040) \\ 132(12) \\ \infty \\ \infty \\ \infty \end{array}$	$\begin{array}{c} 10524 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 1285 \\ 1037(1426) \\ 148(16) \\ \infty \\ \infty \end{array}$	$\begin{array}{l} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 651(74)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ 1e-7\\ 17476\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ \infty \ 2e6\\ 1e-7\\ 1462(1688)\\ \infty \ 2e6\\ \infty $	$\begin{array}{c} 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 15/15\\ 1/15\\ 1/15\\ 0/15$	$\begin{array}{c} \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{ABC} \\ \text{ABC} \\ \text{ABC} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{CA} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text{CA} \\ \text{ACOR} \\ \text{PSO} \\ \text{ABC} \\ \text$	$\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\pm 2} \\ 2292(114) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(5) \\ 503(56) \\ 1e1 \\ 503(56) \\ 1e1 \\ 503(56) \\ 1734(3563) \\ 5.0(5)^{\pm} \\ 5.0(5)^{\pm} \\ 90(19) \\ 1e1 \\ 1.4e4(2e4) \\ 5.0(5)^{\pm} \\ 10(6) \\ 110(53) \\ 1e1 \\ 3.2 \\ 1.8(2) \\ 2.2(2) \\ 1.1(0.5) \\ \end{array}$	$\begin{array}{c} & & \\$	$\begin{array}{c} & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ 24(24) & 2 \\ 24(24) & 2 \\ 24(24) & 2 \\ 24 $	$ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 35(37)^{*2} \\ \infty \\ 1e-5 \\ 26847 \\ \infty \\ \infty \\ 1e-5 \\ 8.1e5 \\ \infty \\ \times^3 \\ \infty \\ $	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \textbf{2e6} \\$	13/15           0/15           0/15           0/15           0/15           0/15           14/15           0/15           0/15           i/15           0/15
f7 ACOR PSO ABC GA $\Delta f_{opt}$ f8 ACOR PSO ABC GA ACOR PSO ABC GA ACOR PSO ABC GA ACOR PSO ACOR ACOR ACOR ACOR ACOR ACOR ACOR ACO	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ 1e1\\ 1002\\ 1002(53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ 4e1\\ 6e1\\ 6e1\\ 8e2\\ 8e2\\ 8e4(3e4)\\ 6e1\\ 6e1\\ 8e2\\ 8e2\\ 8e2\\ 8e2\\ 8e3\\ 8e3\\ 8e3\\ 8e3\\ 8e3\\ 8e3\\ 8e3\\ 8e3$	$\begin{array}{c} 1214\\ 3.5e4(3,\infty)\\ \hline 3.5e4(3,\infty)\\ \hline \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \hline \infty\\ 5.9(2)^{*4}\\ \infty\\ 100\\ \hline 3102\\ \hline 78(8)^{*4}\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e0\\ \hline 8661\\ 0\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e0\\ 1228\\ 1328(2262)\\ 186(29)\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ 0\\ 1e0\\ 1228\\ 1328(2262)\\ 186(29)\\ \infty\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\$	$\begin{array}{c} {}_{\rm e4} \\ {}_{\rm e4} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{1e-1} \\ {}_{3277} \\ {}_{119(11)} \\ {}^{*4} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{\infty} \\ {}_{1e-1} \\ {}_{10735} \\ {}_{\infty} \\ {}_{\infty}$	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 4219 \\ 89(86) \\ 466(348) \\ 355(367) \\ \infty \\ 1e-3 \\ 3455 \\ 286(31)^{*4} \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ $	$\begin{array}{c} 10524 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \end{array}$ $\begin{array}{c} 1e-5 \\ 107(84)^{\star 3} \\ 894(743) \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 1037(1426) \\ 148(16) \\ \infty \\ \infty \\ \end{array}$	$\begin{array}{c} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 3727\\ 651(74)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ \infty \ 2e6\\ \infty \ 2e6\\ 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ 2019(2158)\\ 20$	0/15           0/15           0/15           0/15           0/15           0/15           15/15           15/15           0/15	ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ F21 ACOR PSO ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC CGA ACOR PSO ABC GA ACOR PSO ABC GA ACOR PSO ABC GA ACOR PSO ABC GA ACOR PSO ABC GA ACOR PSO ABC GA ACOR PSO ABC ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO PSO ACOR PSO PSO ACOR PSO PSO PSO PSO PSO PSO PSO PSO PSO PSO	$\begin{array}{c} 686(252)\\ 382(240)^{\star 2}\\ 2292(114)\\ \mathbf{14e4}(3105)\\ \mathbf{1e1}\\ 82\\ 17(6)\\ 16(5)\\ 503(56)\\ \mathbf{1e1}\\ 501\\ 503(56)\\ \mathbf{1e1}\\ 503\\ 503(56)\\ \mathbf{1e1}\\ 503\\ 5$	$\begin{array}{c} & & & \\$	$\begin{array}{c} & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ \hline 3.1e6 & & & & \\ 3.1e6 & & & & \\ \hline 3.1e6 & & & & \\ 24(24) & & & & \\ 24(24) & & & & \\ \hline & & & & & \\ \hline & & & & & \\ \hline & & & &$	$ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 35(37)^{*2} \\ \infty \\ 35(37)^{*2} \\ \infty \\ $	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 17589 \\ 7960(9097) \\ 1593(1762) \\ 85(96)^{*2} \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 1e7 \\ \infty \ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 2e6 \\ 2e6 \\ 2e6 \\ 2e6 \\ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \end{array}$	10/15           0/15           0/15           0/15           0/15           14/15           1/15           0/15           0/15           10/15           0/15           10/15           1/15           1/15           1/15           1/15           0/15
$\begin{array}{c} \mathbf{f7}\\ \mathbf{ACOR}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{GA}\\ \mathbf{\Delta}f_{opt}\\ \mathbf{f8}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{GA}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{GA}\\ \mathbf{ABC}\\ \mathbf{GA}\\ \mathbf{ABC}\\ \mathbf{GA}\\ \mathbf{ABC}\\ \mathbf{GA}\\ \mathbf{ABC}\\ \mathbf{GA}\\ \mathbf{ACOR}\\ \mathbf{F10}\\ F$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 6671(437)\\ 6699(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ 1e1\\ 1002(53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ 1e1\\ \end{array}$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \infty \\ \infty \\ \hline \infty \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ \hline 3102 \\ 78(8)^{*4} \\ \hline \infty \\ \infty \\ \hline 78(8)^{*4} \\ \hline \infty \\ \infty \\ \hline 8661 \\ ) \\ \infty \\ \infty \\ \hline 1e0 \\ \hline 1228 \\ 1228 $	$\begin{array}{c} 1e-1 \\ 4040 \\ 72(101) \\ 350(329) \\ 10(3)^{\star 4} \\ \infty \\ 1e-1 \\ 3277 \\ 119(11)^{\star 4} \\ \infty \\ 1e-1 \\ 10735 \\ \infty \\ \infty \\ 1e-1 \\ 10735 \\ \infty \\ \infty \\ 1e-1 \\ 1079(809) \\ 109(12) \\ \infty \\ \infty \\ 1e-1 \\ 109(12) \\ 0 \\ 0 \\ 0 \\ 109(12) \\ 0 \\ 0 \\ 0 \\ 109(12) \\ 0 \\ 0 \\ 0 \\ 109(12) \\ 0 \\ 0 \\ 0 \\ 109(12) \\ 0 \\ 0 \\ 0 \\ 0 \\ 109(12) \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ $	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 280 \\ 89 \\ 89 \\ 89 \\ 86 \\ 4219 \\ 89 \\ 88 \\ 88 \\ 353 \\ 363 \\ 363 \\ 363 \\ 333 \\ 353 \\ 363 \\ 286 \\ (31)^{*4} \\ \infty \\ \infty \\ 286 \\ (31)^{*4} \\ \infty \\ 286 \\ (31)^{*4} \\ \infty \\ 286 \\ 345 \\ 286 \\ 345 \\ 286 \\ 345 \\ 286 \\ 345 \\ 286 \\ 345 \\ 286 \\ 345 \\ 286 \\ 345 \\ 286 \\ 2$	$\begin{array}{c} 10324 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ 1e-5 \\ 12285 \\ 1037(1426) \\ 148(16) \\ \infty \\ \infty \\ 1e-5 \\ \end{array}$	$\begin{array}{l} 10303\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ 2019(2158)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 1e$	0/15           0/15           0/15           0/15           0/15           1/15           1/15           1/15           1/15           1/15           0/15           #succ           15/15           0/15	ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ABC GA $\Delta f_{opt}$ ACOR PSO ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F20 ABC GA ACOR PSO ABC ABC ABC ABC ABC ABC ABC ABC ABC ABC	$\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\star 2} \\ 2292(114) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(5) \\ 503(56) \\ 1e1 \\ 503(56) \\ 1e1 \\ 2743(8906) \\ 1784(3563) \\ 50(13) \\ 90(19) \\ 1e1 \\ 164(2e4) \\ 1.4e4(2e4) \\ 1.4e4(2e4) \\ 1.6(5) \\ 10(53) \\ 1e1 \\ 3.2 \\ 1.8(2) \\ 2.2(2) \\ 1.1(0.5) \\ 1.7(2) \\ 1e1 \\ 1.4e4 \\ 1$	$\begin{array}{c} & & & \\$	$\begin{array}{c} & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & & \\ & & & & & \\$	$ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ \end{array} \\ \begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \end{array} \\ \begin{array}{c} \infty \\ 26847 \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} 1e-5 \\ 8.1e5 \\ \infty \\ \times 3 \\ \infty \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \textbf{2e6} \\ \infty \ 2e6 \\ \textbf{2e6} \\ \textbf{1e-7} \\ \textbf{1.3e5} \\ \infty \ 2e6 \\ \textbf{2e6} \\ 2e6$	$\begin{array}{l} 10/15\\ 0/15$
$\begin{array}{c} \mathbf{f7}\\ \mathbf{ACOR}\\ \mathbf{ACOR}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{ABC}\\ \mathbf{CACOR}\\ \mathbf{PSO}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{ABC}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{ABC}\\ \mathbf$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 669(596)\\ \infty\\ 1e1\\ 1.002\\ 1002(53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ 1e1\\ 1002\\ 1002\\ 102(53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ 1e1\\ 1042\\ \end{array}$	$\begin{array}{c} 1214\\ 3.5e4(3,\infty)\\ \hline 3.5e4(3,\infty)\\ \hline \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \hline \infty\\ 5.9(2)^{*4}\\ \infty\\ 100\\ \hline 3102\\ \hline 78(8)^{*4}\\ \infty\\ \infty\\ \infty\\ 0\\ 1e0\\ \hline 2228\\ 1328(2262)\\ \hline 186(29)\\ \infty\\ \infty\\ 1e0\\ 1938\\ \hline \end{array}$	$\begin{array}{c} 1e-1\\ 4040\\ 72(101)\\ 350(329)\\ 10(3)^{\star 4}\\ \infty\\ 1e-1\\ 3277\\ 119(11)^{\star 4}\\ \infty\\ 1e-1\\ 10735\\ \infty\\ \infty\\ 1e-1\\ 10735\\ \infty\\ \infty\\ 1e-1\\ 10735\\ \infty\\ \infty\\ 1e-1\\ 6278\\ 0679(809)\\ 109(12)\\ \infty\\ \infty\\ 1e-1\\ 2740\\ \end{array}$	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 4219 \\ 89(86) \\ 466(348) \\ 3353(367) \\ \infty \\ 1e-3 \\ 3455 \\ 286(31)^{\star 4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 9762 \\ 995(1040) \\ 132(12) \\ \infty \\ \infty \\ 1e-3 \\ 4140 \\ \end{array}$	$\begin{array}{c} 10024\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e-5\\ 3594\\ 473(52)^{\star 4}\\ \infty\\ \infty\\ 1e-5\\ 17073\\ \infty\\ \infty\\ 1e-5\\ 17073\\ \infty\\ \infty\\ 1e-5\\ 1037(1426)\\ 148(16)\\ \infty\\ \infty\\ 1e-5\\ 12285\\ 1037(1426)\\ 148(16)\\ \infty\\ \infty\\ 1e-5\\ 12407\\$	$\begin{array}{l} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 3727\\ 3727\\ 651(74)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ 2019(2158)\\ 2019(2158)\\ 2019(2158)\\ \infty \ 2e6\\ \infty$	0/15           0/15           0/15           0/15           0/15           0/15           15/15           15/15           0/15           15/15	ACOR PSO ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F21 ACOR PSO ABC GA $\Delta f_{opt}$ F21 ABC ABC GA $\Delta f_{opt}$ F22 ABC GA $\Delta f_{opt}$ F20 ABC GA $\Delta f_{opt}$ F21 ABC ABC GA $\Delta f_{opt}$ F21 ABC ABC GA $\Delta f_{opt}$ F21 ABC ABC GA $\Delta f_{opt}$ F21 ABC ABC ABC ABC ABC ABC ABC ABC ABC ABC	$\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\star 2} \\ 2292(114) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 17(6) \\ 16(5) \\ 503(56) \\ 1e1 \\ 561 \\ 2743(8906) \\ 1784(3563) \\ 5.0(3) \\ 90(19) \\ 90(19) \\ 1e1 \\ 467 \\ 1.4e4(2e4) \\ 5.0(5)^{\star} \\ 10(6) \\ 110(53) \\ 1e1 \\ 1.8(2) \\ 2.2(2) \\ 1.1(0.5) \\ 1.7(2) \\ 1e1 \\ \end{array}$	$\begin{array}{c} & & & \\$	$\begin{array}{c} & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ 3.1e6 & & & & \\ 3.1e6 & & & & \\ 24(24) & & & & \\ 24(24) & & & & \\ 24(24) & & & & \\ 24(24) & & & & \\ & & & & \\ & & & & \\ & & & & $	$\begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 5.6e6 \\ 2e(30) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 15567 \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \\ 35(37)^{*2} \\ \infty \\ 1e-5 \\ 8.1e5 \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 8.1e5 \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 1e-5$	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 17589 \\ 7960(9097) \\ 1593(1762) \\ 85(96)^{*2} \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 1e7 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 1e-7 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\$	10/15 0/15 0/15 0/15 14/15 0/15 0/15 0/15 1/15 1/15 1/15 1/15 1
$\begin{array}{c} \mathbf{f7}\\ \mathbf{ACOR}\\ \mathbf{ACOR}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{GA}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{GA}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{GA}\\ \mathbf{ACOR}\\ \mathbf{F10}\\ \mathbf{ACOR}\\ \mathbf{F10}\\ \mathbf{ACOR}\\ \mathbf{F10}\\ \mathbf{ACOR}\\ \mathbf{F10}\\ \mathbf{ACOR}\\ \mathbf{F10}\\ \mathbf{ACOR}\\ AC$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 692(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ 1e1\\ 1002(53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ 1e1\\ 1042\\ 3665(4801)\\ \end{array}$	$\begin{array}{c} 3.5e4(3) \\ \hline 3.5e4(3) \\ \hline \infty \\ \infty \\ \infty \\ \hline \infty \\ 3871 \\ 66(114) \\ 307(335) \\ \hline 5.9(2)^{*4} \\ \hline \infty \\ \hline 3102 \\ 78(8)^{*4} \\ \hline \infty \\ \hline \infty \\ \infty \\ \hline 8661 \\ ) \\ \infty \\ \infty \\ \hline 1e0 \\ \hline 2228 \\ 1228 \\ (2262) \\ \hline 188 \\ (29) \\ \hline \infty \\ \hline 1938 \\ 1.0e4(1e^i) \\ \hline 1938 \\ 1.0e4(1e^i) \\ \hline 100 \\ \hline $	$\begin{array}{c} 1e-1\\ 4040\\ 72(101)\\ 350(329)\\ 10(3)^{\star 4}\\ \infty\\ 1e-1\\ 3277\\ 119(11)^{\star 4}\\ \infty\\ \infty\\ \infty\\ 1e-1\\ 10735\\ \infty\\ \infty\\ \infty\\ 1e-1\\ 10735\\ \infty\\ \infty\\ \infty\\ 1e-1\\ 10735\\ \infty\\ \infty\\ 1e-1\\ 10740\\ 109(12)\\ \infty\\ \infty\\ 1e-1\\ 109(12)\\ \infty\\ \infty\\ 1e-1\\ 2740\\ 109(12)\\ \infty\\ \infty\\ 1e-1\\ 2740\\ 109(12)\\ \infty\\ \infty\\ 1e-1\\ 2740\\ 109(12)\\ \infty\\ \infty\\ 1e-1\\ 240(3ec)\\ 109(12)\\ 0\\ 109(12)\\ 0\\ 109(12)\\ 0\\ 109(12)\\ 0\\ 109(12)\\ 0\\ 109(12)\\ 0\\ 109(12)\\ 0\\ 0\\ 109(12)\\ 0\\ 0\\ 0\\ 109(12)\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\$	$\begin{array}{c} 16324\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 4219\\ 89(86)\\ 466(348)\\ 353(367)\\ \infty\\ 1e-3\\ 286(31)^{*4}\\ \infty\\ \infty\\ \infty\\ 14920\\ \infty\\ 1e-3\\ 14920\\ \infty\\ 1e-3\\ 975(1040)\\ 132(12)\\ \infty\\ \infty\\ 1e-3\\ 975(1040)\\ 132(12)\\ \infty\\ \infty\\ 1e-3\\ 14140\\ 1410\\ 112\\ \infty\\ 1e-3\\ 1$	$\begin{array}{c} 10324 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ 1e-5 \\ 12285 \\ 1037(1426) \\ 148(16) \\ \infty \\ \infty \\ 1e-5 \\ 12407 \\ \infty \\ $	$\begin{array}{l} 10303\\ \approx 1e7\\ \approx 2e6\\ \approx 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \approx 2e6\\ 2e6\\ 1e-7\\ 651(74)\\ \approx 2e6\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ \infty 2e6\\ 1e-7\\ 1462(1688)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 14827\\ \infty 1e7\\ 0e7\\ 0e7\\ 0e7\\ 0e7\\ 0e7\\ 0e7\\ 0e7\\ 0$	$\begin{array}{c} 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 1/15\\ 1/15\\ 0/15\\$	$\begin{array}{c} \begin{array}{c} \operatorname{ACOR} \\ \operatorname{PSO} \\ \operatorname{ABC} \\ \operatorname{ABC} \\ \operatorname{ABC} \\ \operatorname{ABC} \\ \operatorname{ABC} \\ \operatorname{ACOR} \\ \operatorname{PSO} \\ \operatorname{ABC} \\ \operatorname{ABC} \\ \operatorname{GA} \\ \operatorname{ACOR} \\ \operatorname{PSO} \\ \operatorname{ABC} \\ \operatorname{GA} \\ \operatorname{ABC} \\ \operatorname{GA} \\ \operatorname{ABC} \\ \operatorname{CA} \\ \operatorname{PSO} \\ \operatorname{ABC} \\ \operatorname{GA} \\ \operatorname{ABC} \\ \operatorname{CA} \\ \operatorname{PSO} \\ \operatorname{ABC} \\ \operatorname{CA} \\ $	$\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\star 2} \\ 2292(114) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(5) \\ 503(56) \\ 1e1 \\ 1754(3563) \\ 503(56) \\ 1e1 \\ 2743(8906) \\ 1754(3563) \\ 90(19) \\ 1e1 \\ 1.4e4(2e4) \\ 1.6(5)^{\star} \\ 10(6) \\ 10(53) \\ 1e1 \\ 3.2 \\ 1.8(2) \\ 2.2(2) \\ 1.1(0.5) \\ 1.7(2) \\ 1e1 \\ 1.3e6 \\ \end{array}$	$\begin{array}{c} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ \hline & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & &$	$\begin{array}{c} & & & & & & \\ & & & & & & \\ & & & & & $	$\begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \\ \frac{1e-5}{2e6847} \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 8.1e5 \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 8.1e5 \\ \infty \\ \infty \\ 1e-5 \\ 5.2e7 \\ \end{array}$	$\begin{array}{l} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \mathbf{2e6} \\ \infty \ 2e6 \\ \mathbf{2e6} \\ \mathbf{1e-7} \\ \mathbf{1.3e5} \\ \infty \ 2e6 \\ \mathbf{2e6} \\ 2e6$	$\begin{array}{l} 10/15\\ 0/15$
$\begin{array}{c} \mathbf{f7}\\ \mathbf{ACOR}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{ABC}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{ABC}\\ \mathbf{ABC}$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 669(596)\\ \infty\\ 1e1\\ 1002\\ 1002(53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ 1e1\\ 1042\\ 3665(4801)\\ 1704(1934)\\ \end{array}$	$\begin{array}{c} 1214\\ 3.5e4(3,\infty)\\ \hline 3.5e4(3,\infty)\\ \hline \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \hline \infty\\ 5.9(2)^{*4}\\ \infty\\ 100\\ \hline 3102\\ \hline 78(8)^{*4}\\ \infty\\ \infty\\ \infty\\ 0\\ 100\\ \hline 88661\\ 0\\ \infty\\ \infty\\ \infty\\ 0\\ 1e0\\ \hline 2228\\ 1328(2262)\\ \hline 186(29)\\ \infty\\ \infty\\ 0\\ 1e0\\ \hline 1938\\ 1.0e4(1e,\infty)\\ \infty\\ \end{array}$	$\begin{array}{c} 1e-1 \\ 4040 \\ 72(101) \\ 350(329) \\ 10(3)^{*4} \\ \infty \\ 1e-1 \\ 119(11)^{*4} \\ \infty \\ 1e-1 \\ 10735 \\ \infty \\ 1e-1 \\ 10748 \\ $	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 4219 \\ 89(86) \\ 466(348) \\ 3353(367) \\ \infty \\ 3455 \\ 286(31)^{\star 4} \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 1410 \\ 1 \\ \infty \\ \infty \\ \infty \\ 0 \\ 1e-3 \\ 1e$	$\begin{array}{c} 10024\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e-5\\ 4371\\ 107(84)^{\star 3}\\ 894(743)\\ \infty\\ \infty\\ \infty\\ 1e-5\\ 17073\\ \infty\\ \infty\\ 1e-5\\ 17073\\ \infty\\ \infty\\ 1e-5\\ 1037(1426)\\ 148(16)\\ \infty\\ \infty\\ \infty\\ 1e-5\\ 12207\\ \infty\\ \infty\\ \infty\\ \infty\\ 12407\\ \infty\\ \infty\\$	$\begin{array}{l} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ \infty \ 2e6\\ \infty \ 2e6\\ 2e6\\ 2e6\\ 2e6\\ 2e6\\ 2e6\\ 2e6\\ 2e6\\$	$\begin{array}{c} 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 15/15\\ 15/15\\ 0/1$	ACOR PSO ABC GA $\Delta f_{opt}$ F20 ACOR PSO ACOR PSO ACOR PSO ABC GA $\Delta f_{opt}$ F21 ACOR PSO ABC GA $\Delta f_{opt}$ F22 ACOR PSO ABC GA $\Delta f_{opt}$ F23 ACOR PSO ABC GA $\Delta f_{opt}$ F23 ACOR PSO ABC GA $\Delta f_{opt}$ F23 ACOR PSO ABC GA $\Delta f_{opt}$ F23 ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ABC ACOR PSO ABC ABC ABC ACOR PSO ABC ABC ABC ABC ABC ACOR PSO ABC ABC ABC ACOR PSO ABC ABC ACOR PSO ABC ABC ACOR PSO ABC ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ABC ACOR PSO ACOR PSO ACOR PSO ACOR ACOR PSO ABC ACOR ACOR ACOR ACOR ACOR ACOR ACOR ACO	$\begin{array}{c} 1 \\ 686(252) \\ 382(240)^{\star 2} \\ 2292(114) \\ 1.4e4(3105) \\ 1e1 \\ 82 \\ 16(4) \\ 17(6) \\ 16(5) \\ 503(56) \\ 1e1 \\ 503(56) \\ 1e1 \\ 561 \\ 2743(8906) \\ 1784(3563) \\ 5.0(3) \\ 90(19) \\ 1e1 \\ 1.4e4(2e4) \\ 5.0(5)^{\star} \\ 10(6) \\ 1.1(0.5) \\ 1.1(0.5) \\ 1.1(0.5) \\ 1.7(2) \\ 1e1 \\ 1.3e6 \\ \infty \end{array}$	$\begin{array}{c} 1 \\ \infty \\ 2 \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} 0 \\ \hline & 0 \\ \hline \hline & 0 \\ \hline & 0 \\ \hline \hline \hline & 0 \\ \hline \hline \hline & 0 \\ \hline \hline \hline \hline & 0 \\ \hline \hline \hline \hline \hline \hline & 0 \\ \hline \hline$	$\begin{array}{c} & & & & & \\ & & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & &$	$\begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 1e-5 \\ 15567 \\ 15567 \\ 8994(1e4) \\ 1799(1863) \\ 35(37)^{*2} \\ \infty \\ 1e-5 \\ 26847 \\ \infty \\ \infty \\ 1e-5 \\ 8.1e5 \\ \infty \\ \infty \\ 1e-5 \\ 8.1e5 \\ \infty \\ \infty \\ 1e-5 \\ 5.2e7 \\ \infty \\ \end{array}$	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ \hline 5.6e6 \\ 26 \\ 26 \\ 26 \\ 26 \\ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 1.593 \\ 7960 \\ (9097) \\ 1593 \\ (1762) \\ 85 \\ (96)^2 \\ 85 \\ (96)^2 \\ 85 \\ (96)^2 \\ 85 \\ 2e6 \\ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 2e6 \\ 1e-7 \\ 5.2e7 \\ 5.2e7 \\ \infty \ 1e7 \\ \end{array}$	$\begin{array}{c} 10/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 0/15 \\ 1/15 \\ 1/15 \\ 1/15 \\ 1/15 \\ 1/15 \\ 0$
f7 ACOR PSO AGOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO AABC GA ACOR PSO AABC GA ACOR PSO AABC GA ACOR PSO AABC GA ACOR PSO AABC GA ACOR PSO AACOR PSO ACOR ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR PSO ACOR ACOR PSO ACOR ACOR ACOR ACOR ACOR ACOR PSO ACOR ACOR ACOR PSO ACOR ACOR ACOR ACOR ACOR ACOR ACOR ACO	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 671(437)\\ 669(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ 1e1\\ 1002(53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ 1e1\\ 1042\\ 3665(4801)\\ 1704(1934)\\ 26(5)\\ \end{array}$	$\begin{array}{c} 3.5e4(3, \\ \infty \\ \infty \\ \infty \\ \infty \\ 0 \\ 1e0 \\ 3871 \\ 66(114) \\ 307(335) \\ 5.9(2)^{*4} \\ \infty \\ 1e0 \\ 8102 \\ 78(8)^{*4} \\ \infty \\ \infty \\ 1e0 \\ 8661 \\ 0 \\ \infty \\ \infty \\ 1e0 \\ 1228 \\ 1$	$\begin{array}{c} \text{solution} \\ solutio$	$\begin{array}{c} 16324\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 4219\\ 89(86)\\ 466(348)\\ 353(367)\\ \infty\\ 1e-3\\ 3455\\ 286(31)^{*4}\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 14920\\ \infty\\ \infty\\ 1e-3\\ 995(1040)\\ 132(12)\\ \infty\\ \infty\\ 1e-3\\ 14140\\ 132(12)\\ \infty\\ \infty\\ \times\\ 7248/76\\ 80\\ 80\\ 80\\ 80\\ 80\\ 80\\ 80\\ 80\\ 80\\ 80$	$\begin{array}{c} 10324 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ 1e-5 \\ 12285 \\ 1037(1426) \\ 148(16) \\ \infty \\ \infty \\ 1e-5 \\ 12407 \\ \infty \\ \infty \\ \infty \\ 711^{*2} \\ \infty \\ \infty \\ \infty \\ 711^{*2} \\ \infty \\ $	$\begin{array}{l} 10303\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 2e6\\ \infty 2e6\\ 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ 2019(2158)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 14821\\ 1462(1688)\\ 2019(2158)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 13827\\ \infty 2e6\\ \infty 2e6\\ \end{array}$	$\begin{array}{c} 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 1/15\\ 1/15\\ 0/15\\$	ACOR PSO ABC GA $\Delta f_{opt}$ $f_{20}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ $f_{21}$ $f_{22}$ $ACOR PSO ABC GA \Delta f_{opt}f_{21}f_{22}ACOR PSO ABC CA PSOABC CA CA PSOABC CA PSOABC CA PSOABC CA CA CA CA CA CA CA CA CA C$	$\begin{array}{c} & 686(252) \\ & 382(240)^{\star 2} \\ & 32292(114) \\ & 14(3105) \\ & 16(15) \\ & 17(6) \\ & 10(6) \\ & 10(6) \\ & 10(6) \\ & 10(6) \\ & 10(6) \\ & 10(6) \\ & 10(6) \\ & 10(6) \\ & 10(6) \\ & 110(6) \\ $	$\begin{array}{c} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ \hline & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & &$	$\begin{array}{c} \infty \\ 1e^{-1} \\ 24(24) \\ 22(24) \\ 24(24) \\ 2 \\ 24(24) \\ 2 \\ 24(24) \\ 2 \\ 24(24) \\ 2 \\ 2 \\ 398(496) \\ 1e^{-1} \\ 23491 \\ \infty \\ 23491 \\ \infty \\ 1e^{-1} \\ 23491 \\ \infty \\ \infty \\ 1e^{-1} \\ 23491 \\ \infty \\ \infty \\ 1e^{-1} \\ 1 \\ 5.2e7 \\ \infty \\ $	$ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ 26(30) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 0 \\ 35(37)^{*2} \\ \infty \\ \frac{1e-5}{26847} \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 8.1e5 \\ \infty \\ $	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ 2e6 \\ 2e6 \\ 2e6 \\ 1e-7 \\ 1593(17529) \\ 7960(9097) \\ 1593(17529) \\ 85(96)^{\times 2} \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 1e7 \\ \infty \ 2e6 \\ 2e6 \\ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 2e6 \\ 2e7 \\ 2e6 \\ 2e$	$\begin{array}{c} 10/15\\ 0/15$
$\begin{array}{c} \mathbf{f7}\\ \mathbf{ACOR}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{ABC}\\ \mathbf{ACOR}\\ \mathbf{PSO}\\ \mathbf{ABC}\\ ABC$	$\begin{array}{r} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 669(596)\\ \infty\\ 1e1\\ 1716\\ 45(7)^{*3}\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 1002\\ 1002(53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ 1e1\\ 1042\\ 3665(4801)\\ 1e1\\ 1042\\ 3665(4801)\\ 1704(1934)\\ 26(5)\\ \end{array}$	$\begin{array}{c} 1214\\ 3.5e4(3,\infty)\\ \hline 3.5e4(3,\infty)\\ \hline 0\\ \infty\\ \infty\\ \infty\\ \hline 0\\ 3871\\ 66(114)\\ 307(335)\\ \hline 5.9(2)^{*4}\\ \infty\\ \hline 3102\\ 78(8)^{*4}\\ \infty\\ \hline 3102\\ 78(8)^{*4}\\ \infty\\ \hline 0\\ 8661\\ \hline 0\\ 2228\\ 1328(2262)\\ \hline 186(29)\\ \infty\\ \infty\\ \hline 1e0\\ 1228\\ 1328(2262)\\ \hline 186(29)\\ \infty\\ \infty\\ \hline 1e0\\ 1938\\ 1.0e4(1e,\infty)\\ \hline 0\\ 10\\ 10\\ 10\\ 10\\ 10\\ 10\\ 10\\ 10\\ 10\\ $	$\begin{array}{c} 1 \\ 1 \\ 1 \\ 2 \\ 1 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\$	$\begin{array}{c} 16324\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ 89(86)\\ 466(348)\\ 3353(367)\\ \infty\\ 286(31)^{*4}\\ \infty\\ \infty\\ 286(31)^{*4}\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 14920\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ \infty\\ 1e-3\\ 14920\\ \infty\\ \infty\\$	$\begin{array}{c} 10324 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{*3} \\ 894(743) \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 17073 \\ \infty \\ \infty \\ 1e-5 \\ 12285 \\ 1037(1426) \\ 148(16) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 12285 \\ 1037(1426) \\ 148(16) \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 12407 \\ \infty \\ $	$\begin{array}{l} 10303\\ \infty \ 1e7\\ \infty \ 2e6\\ \infty \ 2e6\\ 2e6\\ 1e-7\\ 4484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 17476\\ \infty \ 2e6\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ 2019(2158)\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 13827\\ \infty \ 2e6\\ \infty \ 2e6\\ 1e-7\\ 13827\\ \infty \ 1e7\\ 2019(2158)\\ \infty \ 2e6\\ \infty $	0/15           0/15           0/15           0/15           0/15           0/15           0/15           15/15           1/15           0/15           #succ           0/15           #succ           15/15           0/15	ACOR PSO ABC GA $\Delta f_{opt}$ <b>f20</b> ACOR PSO ABC GGA $\Delta f_{opt}$ <b>f21</b> ACOR PSO ABC GGA $\Delta f_{opt}$ <b>f22</b> ACOR PSO ABC GGA $\Delta f_{opt}$ <b>f23</b> ACOR PSO ABC GGA $\Delta f_{opt}$ <b>f23</b> ACOR PSO ABC GA $\Delta f_{opt}$ <b>f23</b> ACOR PSO ABC ABC ACOR PSO ABC ABC ABC ABC ABC ABC ABC ABC ABC ABC	$\begin{array}{c} & 686(252) \\ & 382(240)^{\star 2} \\ & 322(240)^{\star 2} \\ & 2292(1146) \\ & 11(6) \\ &$	$\begin{array}{c} 1 \\ \infty \\ 2 \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} 0 \\ \hline 46150 \\ 1.6(1) \\ 50(65) \\ 0.12(0.1)^{*} \\ 2.8(0.4) \\ 1e0 \\ \hline 6541 \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 9938(164) \\ 1e0 \\ \hline 5580 \\ 3585(5376) \\ 1100$	$\begin{array}{c} \infty \\ 1e-1 \\ 24(24) \\ 24(24) \\ 2 \\ 24(24) \\ 2 \\ 24(24) \\ 2 \\ 24(24) \\ 2 \\ 24(24) \\ 2 \\ 3 \\ \infty \\ 2 \\ 24(24) \\ 9 \\ 9927(1e4) \\ 9 \\ 9986(2340) \\ 1e-1 \\ 23(491) \\ 25(30)^{*} \\ 398(496) \\ 1e-1 \\ 23(491) \\ \infty \\ \infty \\ \infty \\ 1e-1 \\ 67457 \\ \infty \\ \infty \\ \infty \\ 1e-1 \\ 15.2e7 \\ 5.2e7 \\ 5.2e7 \\ \infty \\ \infty \\ \infty \\ \infty \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0$	$\begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} 35(37)^{*2} \\ 35(37)^{*2} \\ \end{array} \\ \begin{array}{c} \infty \\ 35(37)^{*2} \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty $	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26 \\ 26 \\ 26 \\ 26 \\ 2e6 \\ 2e6 \\ 2e6 \\ 2e6 \\ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 1e-7 \\ 8.4e5 \\ \infty \ 2e6 \\ 2e6 $	$\begin{array}{c} 10/15\\ 0/15$
$\begin{array}{c} {\bf f7}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABCC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf AAC}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf AAC}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf AAC}\\ {\bf ACOR}\\ {\bf PSO}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ABC}\\ {\bf GA}\\ {\bf ABC}\\ {\bf CACOR}\\ {\bf ABC}\\ {\bf ABC}\\ {\bf CACOR}\\ {\bf ABC}\\ {\bf ABC}\\ {\bf CACOR}\\ {\bf ABC}\\ {\bf A$	$\begin{array}{c} 1351\\ 76(36)\\ 427(745)\\ 2251(328)\\ 77(15)\\ 1e1\\ 2039\\ 24(8)\\ 90(64)\\ 3.9(2)^{*4}\\ \infty\\ 1e1\\ 1716\\ 671(437)\\ 699(596)\\ \infty\\ 1e1\\ 7413\\ 2.0e4(2e4)\\ \infty\\ \infty\\ 1e1\\ 1002\\ (53)\\ 143(47)^{*3}\\ \infty\\ 2.9e4(3e4)\\ 1e1\\ 1042\\ 2.9e4(3e4)\\ 1e1\\ 1042\\ 3665(4801)\\ 1704(1934)\\ 26(5)\\ \infty\\ \end{array}$	$\begin{array}{c} 3.5e4(3, \\ \infty \\ 3.5e4(3, \\ \infty \\ \infty \\ \infty \\ 1e0 \\ 3871 \\ 66(114) \\ 307(335) \\ 1 \\ 5.9(2)^{*4} \\ \infty \\ 1e0 \\ 8661 \\ 0 \\ \infty \\ \infty \\ 1e0 \\ 18661 \\ 0 \\ \infty \\ \infty \\ 1e0 \\ 1328(2262) \\ 1328(2262) \\ 1328(2262) \\ 1328(2262) \\ 1328(2262) \\ 1328(2262) \\ 1328(2262) \\ 1328(2262) \\ 1328(2262) \\ 0 \\ \infty \\ 100 \\ 100 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0$	$\begin{array}{c} {}_{\scriptstyle 8003} \\ {}_{\scriptstyle 800} \\ {}_{\scriptstyle 800}$	$\begin{array}{c} 16324 \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 4219 \\ 89(86) \\ 466(348) \\ 353(367) \\ \infty \\ 1e-3 \\ 3455 \\ 286(31)^{*4} \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 14920 \\ \infty \\ \infty \\ \infty \\ 1e-3 \\ 975(1040) \\ 132(12) \\ \infty \\ \infty \\ 1e-3 \\ 1e-3 \\ 1410 \\ 1410 \\ 1 \\ \infty \\ \times \\ 7243(76) \\ \infty \\ \infty \\ \end{array}$	$\begin{array}{c} 10324 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 107(84)^{+3} \\ 894(743) \\ \infty \\ \infty \\ \infty \\ 1e-5 \\ 1285 \\ 1037(1426) \\ 148(16) \\ \infty \\ \infty \\ 1e-5 \\ 12285 \\ 1037(1426) \\ 148(16) \\ \infty \\ \infty \\ 1e-5 \\ \infty \\ \infty \\ 1e-5 \\ \infty \\ $	$\begin{array}{l} 10303\\ \infty 1e7\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 1484\\ 125(83)^{*4}\\ 3277(3290)\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 651(74)\\ \infty 2e6\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 17476\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 14831\\ 1462(1688)\\ 2019(2158)\\ \infty 2e6\\ 1e-7\\ 13827\\ \infty 2e6\\ \infty 2e6\\ 1e-7\\ 13827\\ \infty 2e6\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\$	$\begin{array}{c} 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 0/15\\ 1/15\\ 0/15\\$	ACOR PSO ABC GA $\Delta f_{opt}$ $f_{20}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{22}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{22}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{22}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ $f_{22}$ ACOR PSO ABC GA $\Delta f_{opt}$ $f_{21}$ $f_{22}$ $f_{22}$ $f_{22}$ $f_{22}$ $f_{23}$ $ACOR PSO ABC GA \Delta f_{opt}f_{24}f_{25}f_{24}f_{25}$	$\begin{array}{c} & 686(252) \\ & 382(240)^{\star 2} \\ & 322(240)^{\star 2} \\ & 2292(1146)^{\star 2} \\ & 1292(1146)^{\star 2} \\ & 110^{\star 2$	$\begin{array}{c} 1 \\ 2 \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} 0 \\ \hline 46150 \\ 1.6(1) \\ 50(65) \\ 0.12(0.1)^{*} \\ 2.8(0.4) \\ 1e0 \\ \hline 6541 \\ 9938(1e4) \\ 1e0 \\ \hline 55580 \\ 3585(5376) \\ 411(539) \\ 47(67) \\ 1452(1615) \\ 1e0 \\ \hline 1614 \\ \infty \\ 1654(1724) \\ 78(66)^{*3} \\ 4570(4340) \\ 1e0 \\ \hline 7.5e6 \\ \infty \\ \infty \\ \infty \\ \infty \\ \end{array}$	$\begin{array}{c} & & & & & \\$	$\infty$ $\infty$ $\infty$ $\infty$ $\infty$ $\infty$ $\infty$ $\infty$	$\begin{array}{c} \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ 0 \\ \infty \\ \end{array} \\ \begin{array}{c} \infty \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0$	$\begin{array}{c} \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.6e6 \\ 26(28) \\ \infty \ 2e6 \\ 2e6 \\ 2e6 \\ 2e6 \\ 1e-7 \\ 17589 \\ 7960(9097) \\ 1593(1762) \\ 1593(1762) \\ 85(96)^{\times 2} \\ \infty \ 2e6 \\ 1e-7 \\ 1.3e5 \\ \infty \ 2e6 \\ 2e6 \\ 2e6 \\ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.2e7 \\ \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 1e-7 \\ 5.2e7 \\ \infty \ 1e7 \\ \infty \ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ \infty \ 2e6 \\ 2e6 \\ \infty \ 2e6$	$\begin{array}{c} 10/15\\ 0/15$

Table 2: Expected running time (ERT in number of function evaluations) divided by the respective best ERT measured during BBOB-2009 (given in the respective first row) for different  $\Delta f$  values in dimension 20. The central 80% range divided by two is given in braces. The median number of conducted function evaluations is additionally given in *italics*, if  $\text{ERT}(10^{-7}) = \infty$ . #succ is the number of trials that reached the final target  $f_{\text{opt}} + 10^{-8}$ . Best results are printed in bold.



Figure 4: Bootstrapped empirical cumulative distribution of the number of objective function evaluations divided by dimension (FEvals/D) for 50 targets in  $10^{[-8..2]}$  for all functions and subgroups in 5-D. The "best 2009" line corresponds to the best ERT observed during BBOB 2009 for each single target.

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