

Comparison tables: BBOB 2010 function testbed with BBOB 2009 as reference in 5-D

The BBOBies

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Abstract

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking at GECCO 2010, see <http://coco.gforge.inria.fr/doku.php?id=bbob-2010>. More than 30 algorithms have been tested on 24 benchmark functions in dimensions between 2 and 40. A description of the used objective functions can be found in [16, 12]. The experimental set-up is described in [15].

The performance measure provided in the following tables is the expected number of objective function evaluations to reach a given target function value (ERT, expected running time), divided by the respective value for the best algorithm in BBOB-2009 (see [7]) if an algorithm from BBOB-2009 reached the given target function value. The ERT value is given otherwise (ERT_{best} is noted as infinite). See [15] for details on how ERT is obtained. Bold entries in the table correspond to values below 3 or the top-three best values.

Table 1: 05-D, running time excess ERT/ERT_{best} 2009 on f_1 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	3.1	7.4	15	27	37	47	54	63	80	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	3.2	10	15	21	28	35	40	53	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.3	2.1	7.2	13	18	24	30	35	45	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.3	4.5	12	22	29	38	48	55	71	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.1	2.5	6.9	11	16	21	25	30	40	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.1	2.2	6.2	10	15	19	23	27	37	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.0	5.0	8.3	12	15	18	22	30	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.9	2.5	6.5	10	15	18	22	26	34	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.1	2.1	5.6	10	13	17	21	24	32	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	1.5	4.9	8.0	12	15	18	21	28	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.4	12	32	62	89	122	156	191	255	Artif Bee Colony [9]
avg NEWUOA	1	3.3	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	2.3	27	7.2	16	24	34	43	55	67	87	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.3	5.9	37	67	104	132	166	203	266	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.3	8.6	42	80	117	155	194	236	313	DE (Uniform) [10]
IPOP-aCMA-ES	1	1.3	3.2	8.9	15	22	27	33	39	51	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.1	2.5	8.0	14	20	27	32	39	51	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.1	6.5	33	66	90	121	142	169	217	CMA+DE-MOS [19]
NBC-CMA	1	1.3	5.6	26	42	53	65	74	85	108	NBC-CMA [22]
POEMS	1	263	102	136	329	766	1195	1592	2001	2796	POEMS [18]
PM-AdapSS-DE	1	2.1	4.8	39	74	111	145	182	223	292	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.2	97	129	614	2849	5775	8274	12299	18337	pPOEMS [18, 21]
Basic RCGA	1	1.1	8.7	72	155	329	561	831	1141	1741	Basic RCGA [25]
SPSA	1	43	11	15	19	22	27	31	36	44	SPSA [14]

Table 2: 05-D, running time excess $ERT/ERT_{\text{best}}^{2009}$ on f_2 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	46	45	57	61	64	65	66	67	68	69	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	28	30	37	40	42	43	44	44	45	46	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	30	27	30	34	35	36	36	36	37	37	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	35	59	66	74	81	83	85	86	87	89	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	13	14	20	22	24	24	25	25	26	27	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	11	12	16	19	22	22	23	23	24	24	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	8.6	12	14	15	16	16	17	17	18	18	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	12	15	18	21	22	22	23	23	23	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	6.0	6.9	11	13	13	14	14	14	15	15	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	6.6	7.7	10	11	12	12	13	13	13	14	(1+2ms)-CMA-ES [2]
Artif Bee Colony	10	8.9	11	18	26	30	38	44	50	62	Artif Bee Colony [9]
avg NEWUOA	1.2	2.0	6.4	21	41	56	75	92	108	145	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	48	53	68	69	69	70	72	72	73	75	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	13	14	18	22	26	30	35	38	42	50	Adap DE (F-AUC) [11]
DE (Uniform)	14	16	20	24	30	35	40	45	50	58	DE (Uniform) [10]
IPOP-aCMA-ES	7.5	8.5	10	12	14	14	15	16	16	18	IPOP-aCMA-ES [17]
IPOP-CMA-ES	9.4	10	14	16	18	18	19	20	21	22	IPOP-CMA-ES [23]
CMA+DE-MOS	16	19	23	29	35	40	46	51	55	64	CMA+DE-MOS [19]
NBC-CMA	16	18	23	27	30	31	33	34	35	37	NBC-CMA [22]
POEMS	119	145	200	295	341	371	438	494	550	636	POEMS [18]
PM-AdapSS-DE	15	16	19	24	28	33	38	42	47	55	PM-AdapSS-DE [10, 11]
pPOEMS	139	842	1208	1316	1735	2219	2549	2927	3091	3928	pPOEMS [18, 21]
Basic RCGA	34	46	78	125	169	207	252	309	347	1069	Basic RCGA [25]
SPSA	5535	43870	<i>46e+1/1e5</i>	.	.	.	.	.	.	.	SPSA [14]

Table 3: 05-D, running time excess ERT/ERT_{best} 2009 on f_3 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	2.7	24	39	<i>80e-1/1e4</i>	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.2	2.6	3.5	147	454	453	452	451	451	450	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.6	6.2	441	<i>30e-1/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	2.2	15	28	225	<i>60e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.4	4.3	434	<i>20e-1/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.5	1.5	4.5	79	443	442	441	440	440	439	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.3	1.6	2.8	98	<i>20e-1/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.2	1.1	5.9	<i>30e-1/1e4</i>	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.7	1.6	7.2	<i>30e-1/1e4</i>	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.9	1.8	3.4	91	<i>20e-1/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.3	2.7	1.0	1.5	1.8	2.4	2.7	3.2	3.6	4.4	Artif Bee Colony [9]
avg NEWUOA	3.3	4.8	3.0	130	<i>40e-1/6e3</i>	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	18	7.6	40	2261	4484	4473	4463	<i>20e-1/1e5</i>	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.2	2.7	3.4	12	59	59	60	60	60	60	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.6	3.5	12	125	125	125	125	125	126	DE (Uniform) [10]
IPOP-aCMA-ES	1.4	2.4	1.1	20	1359	1356	1353	1351	1350	1348	IPOP-aCMA-ES [17]
IPOP-CMA-ES	2.3	1.7	2.2	70	3130	3121	3113	3108	3106	3099	IPOP-CMA-ES [23]
CMA+DE-MOS	1.2	3.3	1.5	1.6	2.4	2.9	3.2	3.4	3.8	4.4	CMA+DE-MOS [19]
NBC-CMA	1.5	2.1	1.9	30	155	154	154	154	154	154	NBC-CMA [22]
POEMS	168	77	4.0	11	36	38	42	45	48	54	POEMS [18]
PM-AdapSS-DE	1.5	2.1	4.9	33	166	217	362	470	621	621	PM-AdapSS-DE [10, 11]
pPOEMS	1.3	66	4.8	30	64	92	116	140	158	203	pPOEMS [18, 21]
Basic RCGA	1.1	4.0	3.4	37	89	95	114	116	118	120	Basic RCGA [25]
SPSA	54	8613	<i>21e+0/1e5</i>	.	.	.	.	.	.	.	SPSA [14]

Table 4: 05-D, running time excess ERT/ERT_{best} 2009 on f_4 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separ											
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D											ERT_{best}/D
(1,2)-CMA-ES	3.5	13	75	<i>80e-1/1e4</i>	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.3	3.0	11	<i>40e-1/1e4</i>	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.1	3.4	8.8	445	<i>30e-1/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.5	10	48	<i>98e-1/1e4</i>	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.7	2.0	10	<i>40e-1/1e4</i>	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.8	1.9	4.6	450	<i>40e-1/1e4</i>	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.5	1.7	2.9	456	<i>30e-1/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	3.0	11	448	433	416	403	395	388	385	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.3	1.9	22	<i>50e-1/1e4</i>	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.8	2.0	7.1	444	<i>40e-1/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.5	5.7	1.1	2.4	2.9	3.4	4.3	4.6	4.9	6.0	Artif Bee Colony [9]
avg NEWUOA	5.4	10	14	<i>50e-1/8e3</i>	.	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	28	5.2	309	<i>70e-1/1e5</i>	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.4	5.8	5.7	625	<i>20e-1/1e5</i>	.	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	1.6	5.2	5.1	626	1941	1864	1803	1771	1739	1723	DE (Uniform) [10]
IPOP-aCMA-ES	2.1	2.5	1.8	<i>29e-1/2e5</i>	.	.	.	.	.	.	IPOP-aCMA-ES [17]
IPOP-CMA-ES	2.7	2.6	2.0	<i>29e-1/2e5</i>	.	.	.	.	.	.	IPOP-CMA-ES [23]
CMA+DE-MOS	1.6	3.1	1.6	3.6	5.6	5.8	6.1	6.4	6.6	7.3	CMA+DE-MOS [19]
NBC-CMA	1.7	4.6	2.6	221	1252	1202	1163	1142	1121	1111	NBC-CMA [22]
POEMS	240	60	4.9	43	118	117	116	118	119	124	POEMS [18]
PM-AdapSS-DE	3.3	6.9	4.9	4295	<i>30e-1/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	1.5	67	6.8	36	79	106	120	141	158	198	pPOEMS [18, 21]
Basic RCGA	1.9	6.7	14	<i>30e-1/5e4</i>	.	.	.	.	.	.	Basic RCGA [25]
SPSA	67	2112	4238	<i>36e+0/1e5</i>	.	.	.	.	.	.	SPSA [14]

Table 5: 05-D, running time excess $ERT/ERT_{\text{best}} 2009$ on f_5 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope											
$\Delta\text{ftarget}$ ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta\text{ftarget}$ ERT_{best}/D
(1,2)-CMA-ES	1	4.9	5.7	7.5	8.1	8.1	8.1	8.1	8.1	8.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	2.6	3.1	4.8	4.8	4.9	4.9	4.9	4.9	4.9	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	2.0	2.6	3.3	3.5	3.5	3.5	3.5	3.5	3.5	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	3.1	5.7	8.4	9.1	9.1	9.1	9.1	9.1	9.1	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.8	3.2	4.3	4.5	4.5	4.5	4.5	4.5	4.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	2.7	3.3	4.5	4.8	4.8	4.8	4.8	4.8	4.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.8	2.4	3.5	3.6	3.6	3.6	3.6	3.6	3.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.5	2.9	3.9	4.0	4.0	4.0	4.0	4.0	4.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	2.9	2.0	2.9	3.0	3.0	3.0	3.0	3.0	3.0	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.4	1.8	2.7	2.9	2.9	2.9	2.9	2.9	2.9	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.4	32	49	58	59	59	59	59	59	Artif Bee Colony [9]
avg NEWUOA	1	4.1	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	9.0	4.9	6.9	7.2	7.3	7.3	7.3	7.3	7.3	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.7	15	23	24	24	24	24	24	24	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.4	20	34	35	35	35	35	35	35	DE (Uniform) [10]
IPOP-aCMA-ES	1	3.7	4.6	6.3	6.8	6.8	6.8	6.8	6.8	6.8	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	4.5	4.6	6.0	6.3	6.3	6.3	6.3	6.3	6.3	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.8	20	42	50	50	51	51	51	51	CMA+DE-MOS [19]
NBC-CMA	1	1.8	33	39	43	43	43	43	43	43	NBC-CMA [22]
POEMS	1	430	161	203	222	229	230	231	231	231	POEMS [18]
PM-AdapSS-DE	1	1.5	24	33	36	36	36	36	36	36	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.3	153	203	215	217	218	218	218	218	pPOEMS [18, 21]
Basic RCGA	1	2.0	327	747	1146	1577	2004	2429	2866	3740	Basic RCGA [25]
SPSA	1	12	9.3	13	14	14	14	14	14	14	SPSA [14]

Table 6: 05-D, running time excess ERT/ERT_{best} 2009 on f_6 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	2.6	13	5.9	5.1	5.0	4.8	4.3	4.2	3.9	4.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.5	6.4	2.7	2.4	2.5	2.1	1.8	1.7	1.4	1.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.5	4.2	2.2	2.0	2.1	1.9	1.6	1.4	1.1	1.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.8	11	6.5	6.6	7.7	7.3	6.8	6.5	5.8	5.9	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	2.2	2.4	1.6	1.8	1.8	1.7	1.5	1.4	1.3	1.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	2.2	4.7	1.8	1.6	1.7	1.5	1.3	1.2	1.00	0.96	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.9	2.8	1.1	1.1	1.2	1.1	0.91	0.83	0.70	0.69	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	2.0	5.0	1.8	1.9	1.9	1.8	1.5	1.4	1.1	1.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.8	3.5	1.8	1.5	1.9	1.7	1.4	1.3	1.1	1.4	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.2	2.3	1.1	1.2	1.6	1.4	1.4	1.6	1.6	2.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.7	8.3	4.9	15	365	408	619	522	498	507	Artif Bee Colony [9]
avg NEWUOA	1.2	2.6	1.3	1.6	2.6	2.6	2.6	2.6	2.4	2.5	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	5.0	54	241	657	518	518	372	300	220	230	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	4.8	7.1	6.5	7.6	8.5	8.1	7.0	6.5	5.3	5.4	Adap DE (F-AUC) [11]
DE (Uniform)	4.7	7.2	9.0	9.2	10	9.2	7.8	7.3	6.1	6.1	DE (Uniform) [10]
IPOP-aCMA-ES	2.6	5.3	2.5	2.1	2.2	2.0	1.6	1.5	1.2	1.2	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.9	3.2	2.5	2.1	2.2	2.0	1.7	1.5	1.3	1.2	IPOP-CMA-ES [23]
CMA+DE-MOS	11	11	8.0	8.6	8.8	7.7	6.3	5.7	4.8	4.6	CMA+DE-MOS [19]
NBC-CMA	9.2	8.5	8.2	19	16	11	8.4	6.8	5.1	4.3	NBC-CMA [22]
POEMS	102	81	26	46	54	51	45	43	36	37	POEMS [18]
PM-AdapSS-DE	6.0	7.4	8.1	8.1	9.0	8.3	7.3	6.7	5.7	5.7	PM-AdapSS-DE [10, 11]
pPOEMS	91	76	31	202	313	323	306	300	266	282	pPOEMS [18, 21]
Basic RCGA	29	28	26	72	255	434	598	<i>47e-4/5e4</i>	.	.	Basic RCGA [25]
SPSA	521	13582	28485	32769	25181	<i>44e+0/1e5</i>	.	.	.	.	SPSA [14]

Table 8: 05-D, running time excess $ERT/ERT_{\text{best}}^{2009}$ on f_8 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	6.5	12	10	10	14	14	15	15	15	15	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.1	5.7	5.6	5.7	7.2	7.8	8.1	8.3	8.4	8.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.2	4.5	4.2	5.8	6.8	7.3	7.5	7.6	7.6	7.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	7.8	15	12	14	19	19	20	20	21	21	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	2.6	2.9	2.6	4.9	5.7	5.8	5.9	6.1	6.2	6.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	2.0	3.2	2.9	3.6	4.3	4.7	4.8	5.0	5.0	5.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.4	2.6	2.3	2.9	3.5	3.6	3.7	3.8	3.8	4.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.5	2.3	2.4	4.1	5.0	5.2	5.4	5.4	5.5	5.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.5	2.5	2.3	3.5	3.8	3.8	3.8	3.9	4.0	4.1	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.7	2.0	1.9	3.0	3.2	3.2	3.3	3.4	3.4	3.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	4.4	5.0	6.0	12	52	449	2509	<i>10e-4/1e5</i>	.	.	Artif Bee Colony [9]
avg NEWUOA	1.3	1.6	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	11	9.0	8.2	7.6	8.2	8.5	8.8	9.3	10	11	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	6.5	11	13	8.9	11	11	11	12	13	14	Adap DE (F-AUC) [11]
DE (Uniform)	7.2	12	15	10	14	16	17	17	18	20	DE (Uniform) [10]
IPOP-aCMA-ES	2.1	2.4	2.8	3.0	3.6	3.8	4.0	4.1	4.2	4.5	IPOP-aCMA-ES [17]
IPOP-CMA-ES	2.6	3.8	3.5	4.8	5.3	5.5	5.6	5.7	5.8	6.1	IPOP-CMA-ES [23]
CMA+DE-MOS	6.3	6.8	11	11	12	13	13	14	14	15	CMA+DE-MOS [19]
NBC-CMA	4.4	7.5	7.1	7.0	8.1	8.4	8.6	8.8	8.9	9.3	NBC-CMA [22]
POEMS	66	40	58	52	117	380	689	1132	1485	2230	POEMS [18]
PM-AdapSS-DE	5.5	11	13	9.4	15	18	19	19	20	21	PM-AdapSS-DE [10, 11]
pPOEMS	56	36	84	262	365	482	583	689	795	1052	pPOEMS [18, 21]
Basic RCGA	5.7	12	32	558	1450	2992	2983	9295	<i>54e-2/5e4</i>	.	Basic RCGA [25]
SPSA	360	1473	3764	12308	<i>50e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 9: 05-D, running time excess ERT/ERT_{best} 2009 on f_9 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	131	285	12	27	24	23	21	21	20	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	62	164	7.4	14	12	12	11	11	11	10	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	57	273	14	12	11	10	10	9.3	9.2	8.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	98	382	16	51	40	37	34	33	33	31	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	31	218	9.0	14	11	10	9.4	9.1	9.0	8.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	30	111	5.2	9.5	8.2	7.6	7.2	7.0	7.0	6.7	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	26	117	5.4	10	7.7	6.8	6.3	6.1	6.0	5.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	28	128	5.7	11	9.2	8.3	7.7	7.4	7.3	6.9	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	22	65	3.3	13	9.0	7.8	7.2	6.8	6.8	6.4	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	25	102	4.6	6.2	5.0	4.4	4.2	4.0	4.0	3.9	(1+2ms)-CMA-ES [2]
Artif Bee Colony	86	259	14	69	699	3988	<i>13e-3/1e5</i>	.	.	.	Artif Bee Colony [9]
avg NEWUOA	20	56	2.4	3.1	2.1	1.8	1.7	1.6	1.6	1.5	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	276	692	48	79	56	50	45	46	46	45	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	97	393	24	18	16	16	16	16	16	17	Adap DE (F-AUC) [11]
DE (Uniform)	143	444	30	23	21	22	21	21	22	22	DE (Uniform) [10]
IPOP-aCMA-ES	28	97	5.4	6.2	5.7	5.3	5.0	4.9	5.0	4.9	IPOP-aCMA-ES [17]
IPOP-CMA-ES	29	92	6.0	11	8.7	7.9	7.5	7.3	7.3	7.2	IPOP-CMA-ES [23]
CMA+DE-MOS	98	367	13	10	17	18	17	17	17	17	CMA+DE-MOS [19]
NBC-CMA	84	281	15	11	11	10	10	9.5	10	9.5	NBC-CMA [22]
POEMS	1148	1606	109	116	176	616	1039	1473	1856	2809	POEMS [18]
PM-AdapSS-DE	90	374	25	22	21	22	21	21	21	22	PM-AdapSS-DE [10, 11]
pPOEMS	1126	1981	287	563	596	630	722	850	994	1200	pPOEMS [18, 21]
Basic RCGA	118	318	40	8950	<i>17e-1/5e4</i>	.	.	.	.	.	Basic RCGA [25]
SPSA	8379	1.78e5	13128	56959	<i>54e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 14: 05-D, running time excess ERT/ERT_{best} 2009 on f_{14} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	14 Sum of different powers										
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1.8	2.3	5.0	5.9	6.3	8.3	11	13	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	4.3	3.5	3.9	4.3	5.8	8.2	11	9.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.8	3.1	3.2	3.3	3.6	4.8	6.9	9.2	8.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.2	3.5	6.4	6.4	6.3	11	14	17	16	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.6	1.7	1.9	3.1	3.2	4.2	5.0	6.8	5.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.6	2.3	2.1	2.9	3.3	3.9	4.6	6.0	5.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.5	1.7	1.8	2.3	2.3	2.9	3.6	4.5	4.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	2.5	2.0	2.0	2.5	3.0	3.8	4.2	5.2	4.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.6	1.2	1.8	2.3	2.5	2.7	3.1	4.1	3.3	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.6	0.82	1.4	1.7	2.0	2.7	2.9	3.2	2.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.9	3.5	11	19	29	679	33788	<i>27e-5/1e5</i>	.	Artif Bee Colony [9]
avg NEWUOA	1	1.7	2.1	1.0	1.0	1.0	1.2	1.8	5.0	1029	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	4.1	25	14	7.3	7.5	8.8	17	21	27	203	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.3	2.2	9.4	15	15	13	11	11	8.2	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.2	2.3	10	16	18	15	13	13	9.3	DE (Uniform) [10]
IPOP-aCMA-ES	1	2.3	1.5	2.2	3.2	3.6	3.6	3.4	3.8	2.9	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.3	2.2	2.9	3.8	4.3	4.7	4.7	5.4	4.4	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.2	2.9	13	14	15	14	13	14	11	CMA+DE-MOS [19]
NBC-CMA	1	1.3	1.4	7.0	8.7	8.1	7.4	6.6	7.7	6.4	NBC-CMA [22]
POEMS	1	280	111	43	79	124	136	130	501	<i>46e-8/3e5</i>	POEMS [18]
PM-AdapSS-DE	1	1.5	1	9.4	17	17	15	12	12	8.9	PM-AdapSS-DE [10, 11]
pPOEMS	1	69	61	47	140	597	798	868	1057	2134	pPOEMS [18, 21]
Basic RCGA	1	1.1	1.5	23	40	59	273	1453	14895	<i>90e-6/5e4</i>	Basic RCGA [25]
SPSA	24	120	167	106	86	69	99	601	2141	<i>60e-7/1e5</i>	SPSA [14]

Table 15: 05-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 2009 on f_{15} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin												
$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$	
(1,2)-CMA-ES	1.5	5.7	27	76	<i>50e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	1	2.2	8.1	26	<i>30e-1/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	1	1.8	11	25	<i>30e-1/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	1.1	6.5	129	<i>99e-1/1e4</i>	.	.	.	.	.	.	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	1.5	2.9	8.2	38	<i>20e-1/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	1.3	2.5	3.7	18	<i>20e-1/1e4</i>	.	.	.	.	.	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	1.1	1.5	2.8	13	38	37	36	36	35	34	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	1.7	7.3	8.5	40	<i>30e-1/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	1.5	2.3	6.1	<i>20e-1/1e4</i>	.	.	.	.	.	.	(1+1)-CMA-ES [8]	
(1+2ms)-CMA-ES	1	1.2	4.6	38	<i>20e-1/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	1.1	2.8	15	243	<i>11e-1/1e5</i>	.	.	.	.	.	Artif Bee Colony [9]	
avg NEWUOA	1.3	2.0	5.8	46	<i>30e-1/6e3</i>	.	.	.	.	.	avg NEWUOA [24]	
CMA-EGS (IPOP,r1)	15	7.1	8.6	95	185	366	361	354	<i>20e-1/1e5</i>	.	CMA-EGS (IPOP,r1) [13]	
Adap DE (F-AUC)	1.1	3.8	5.4	2.0	7.5	7.4	7.3	7.2	7.1	6.9	Adap DE (F-AUC) [11]	
DE (Uniform)	1.2	4.5	4.8	2.2	3.0	3.0	3.0	2.9	2.9	2.9	DE (Uniform) [10]	
IPOP-aCMA-ES	1	2.3	1.5	0.89	1.0	1.0	1.0	1.0	1.0	1.0	IPOP-aCMA-ES [17]	
IPOP-CMA-ES	1.3	1.3	2.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	IPOP-CMA-ES [23]	
CMA+DE-MOS	1.1	2.5	4.3	1.4	1.6	1.6	1.6	1.6	1.6	1.6	CMA+DE-MOS [19]	
NBC-CMA	1.1	2.7	2.3	4.3	16	16	15	15	15	14	NBC-CMA [22]	
POEMS	154	92	18	232	335	329	324	319	314	305	POEMS [18]	
PM-AdapSS-DE	1.4	2.4	5.4	6.3	3.2	3.2	3.2	3.3	7.6	7.4	PM-AdapSS-DE [10, 11]	
pPOEMS	1.3	73	57	29	60	61	62	63	64	66	pPOEMS [18, 21]	
Basic RCGA	1.1	3.1	25	9.4	12	12	12	12	15	20	Basic RCGA [25]	
SPSA	35780	5960	2251	<i>13e+0/1e5</i>	.	.	.	.	.	.	SPSA [14]	

Table 16: 05-D, running time excess ERT/ERT_{best} 2009 on f_{16} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass											
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D	0.20	0.24	24	122	532	2033	2090	2283	2329	2419	ERT_{best}/D
(1,2)-CMA-ES	1	1.4	42	259	<i>14e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	16	29	45	70	69	63	62	<i>18e-2/1e4</i>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.2	15	43	38	36	<i>17e-2/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.3	58	589	<i>28e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.1	7.2	27	31	34	<i>22e-2/1e4</i>	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.3	2.9	5.8	12	6.1	11	29	<i>98e-4/1e4</i>	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.5	5.6	16	19	15	33	<i>39e-3/1e4</i>	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.8	8.1	20	33	72	<i>14e-2/1e4</i>	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.2	2.0	21	19	33	<i>71e-3/1e4</i>	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.2	1.7	7.7	16	<i>62e-3/1e4</i>	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.7	2.3	10	95	<i>48e-3/1e5</i>	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	1	1.2	2.6	12	47	<i>35e-2/8e3</i>	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1.3	20	7.8	179	409	324	671	<i>15e-2/1e5</i>	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.2	6.4	39	31	8.2	12	11	11	10	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.2	4.3	44	20	13	17	16	16	15	DE (Uniform) [10]
IPOP-aCMA-ES	1	1.1	3.9	2.4	1.7	0.56	0.82	0.84	0.84	0.85	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.3	2.5	2.3	1.7	0.55	0.96	0.94	0.94	0.95	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.6	1.6	2.9	2.6	1.2	1.2	1.2	7.7	7.7	CMA+DE-MOS [19]
NBC-CMA	1	1.3	3.0	4.0	1.3	0.81	0.86	0.84	0.83	0.83	NBC-CMA [22]
POEMS	1	57	11	14	92	56	74	68	68	66	POEMS [18]
PM-AdapSS-DE	1	1.3	3.9	124	55	16	20	18	28	27	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.5	10	52	40	53	116	110	113	116	pPOEMS [18, 21]
Basic RCGA	1	1.4	2.4	60	49	80	351	322	<i>16e-3/5e4</i>	.	Basic RCGA [25]
SPSA	4.3	280	548	1367	594	349	695	<i>12e-1/1e5</i>	.	.	SPSA [14]

Table 17: 05-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 2009 on f_{17} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	17 Schaffer F7, condition 10											
$\Delta \text{ftarget}$ $\text{ERT}_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta \text{ftarget}$ $\text{ERT}_{\text{best}}/D$	
(1,2)-CMA-ES	1	1.1	52	54	404	<i>14e-2/1e4</i>	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.3	6.7	5.3	6.2	13	64	<i>51e-4/1e4</i>	.	.	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	1	1.3	5.3	5.0	13	22	<i>87e-4/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	1	1.3	52	87	397	<i>36e-2/1e4</i>	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	116	20	18	31	<i>27e-3/1e4</i>	.	.	.	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	1	1	20	2.3	4.1	7.2	90	<i>34e-4/1e4</i>	.	.	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	1	1.1	5.1	0.71	4.5	28	<i>12e-3/1e4</i>	.	.	.	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	1	1	4.2	3.6	18	54	<i>23e-3/1e4</i>	.	.	.	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	1	1	15	25	94	<i>14e-2/1e4</i>	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.2	15	17	24	<i>38e-3/1e4</i>	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.1	6.5	15	64	1259	<i>31e-3/1e5</i>	.	.	.	Artif Bee Colony [9]	
avg NEWUOA	1	1.2	3.1	42	405	<i>24e-2/1e4</i>	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	17	37	17	3.3	2.5	40	62	120	1104	<i>36e-5/1e5</i>	CMA-EGS (IPOP,r1) [13]	
Adap DE (F-AUC)	1	1.2	5.7	3.9	2.3	1.2	1.3	1.3	1.3	1.4	Adap DE (F-AUC) [11]	
DE (Uniform)	1	1	3.8	4.3	2.7	1.4	1.6	1.6	1.5	1.6	DE (Uniform) [10]	
IPOP-aCMA-ES	1	1.3	4.3	0.89	0.53	0.59	0.77	0.74	1.00	1.1	IPOP-aCMA-ES [17]	
IPOP-CMA-ES	1	1.1	4.8	1.1	0.97	0.61	0.77	0.80	0.81	1.0	IPOP-CMA-ES [23]	
CMA+DE-MOS	1	1.1	2.8	5.8	5.2	3.9	5.4	4.7	3.9	4.0	CMA+DE-MOS [19]	
NBC-CMA	1	1.2	5.6	2.2	1.9	0.74	0.68	0.68	1.6	3.3	NBC-CMA [22]	
POEMS	1	78	221	17	15	8.2	14	61	98	139	POEMS [18]	
PM-AdapSS-DE	1	1.3	4.2	4.0	2.3	1.2	1.4	1.4	1.3	1.4	PM-AdapSS-DE [10, 11]	
pPOEMS	1	1.3	169	22	88	57	71	75	73	82	pPOEMS [18, 21]	
Basic RCGA	1	1.1	2.9	57	48	35	56	124	173	<i>30e-5/5e4</i>	Basic RCGA [25]	
SPSA	35977	77306	48618	2098	2228	2447	<i>85e-2/1e5</i>	.	.	.	SPSA [14]	

Table 18: 05-D, running time excess ERT/ERT_{best} 2009 on f_{18} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	18 Schaffer F7, condition 1000										
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D	0.20	0.24	21	76	794	1690	1856	2076	2181	2494	ERT_{best}/D
(1,2)-CMA-ES	1.1	2.4	36	201	<i>11e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	4.7	3.7	28	23	<i>16e-2/1e4</i>	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	5.4	8.2	27	21	83	<i>13e-2/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	7.6	29	601	<i>19e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	3.5	3.0	31	21	84	<i>14e-2/1e4</i>	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	2.1	1.9	5.9	9.2	19	<i>67e-3/1e4</i>	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	2.7	3.1	18	6.4	84	<i>39e-3/1e4</i>	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	5.4	8.8	35	20	<i>13e-2/1e4</i>	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	4.1	8.6	52	87	<i>42e-2/1e4</i>	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.1	3.6	15	48	33	85	<i>14e-2/1e4</i>	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.1	1.6	5.0	27	300	<i>14e-2/1e5</i>	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	1	5.4	10	272	<i>57e-2/3e4</i>	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	28	53	2.2	7.2	25	122	<i>22e-3/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	2.4	4.3	3.8	0.75	0.55	0.69	0.75	0.88	0.98	Adap DE (F-AUC) [11]
DE (Uniform)	1	2.7	4.0	4.3	0.81	0.58	0.73	0.80	0.95	1.1	DE (Uniform) [10]
IPOP-aCMA-ES	1	5.8	3.5	1.6	0.70	0.69	0.77	0.73	0.80	0.84	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.6	7.5	1.2	2.7	0.87	1.1	1.0	0.98	1.0	0.99	IPOP-CMA-ES [23]
CMA+DE-MOS	1.1	1.7	4.9	6.7	2.9	1.7	1.7	1.6	1.6	2.0	CMA+DE-MOS [19]
NBC-CMA	1	2.3	3.1	3.0	0.41	0.48	1.2	3.4	6.2	15	NBC-CMA [22]
POEMS	2.5	260	19	23	33	207	449	2029	<i>15e-3/3e5</i>	.	POEMS [18]
PM-AdapSS-DE	1.1	4.4	4.3	4.1	0.76	0.54	0.67	0.74	0.89	1.0	PM-AdapSS-DE [10, 11]
pPOEMS	1.1	77	18	95	34	30	39	46	55	69	pPOEMS [18, 21]
Basic RCGA	1	3.5	7.9	88	23	35	187	347	<i>53e-4/5e4</i>	.	Basic RCGA [25]
SPSA	3.33e5	6.26e5	19476	18540	<i>31e+1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 19: 05-D, running time excess ERT/ERT_{best} 2009 on f_{19} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	31	16363	<i>56e-2/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	62	4556	945	<i>27e-2/1e4</i>	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.4	22	8527	1393	<i>39e-2/1e4</i>	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	55	25341	<i>59e-2/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	21	6463	<i>39e-2/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	20	8960	659	<i>19e-2/1e4</i>	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	17	3093	478	7.0	6.1	6.1	6.0	6.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	25	10110	<i>34e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	13	5123	1482	<i>20e-2/1e4</i>	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	17	6018	233	<i>98e-3/1e4</i>	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.2	34	2898	3823	69	<i>12e-2/1e5</i>	.	.	.	Artif Bee Colony [9]
avg NEWUOA	1	1	24	15619	995	<i>55e-3/1e5</i>	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	17	37	97	5695	2016	33	<i>73e-3/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.1	29	2586	1726	10	11	11	11	10	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.2	35	3449	1630	15	13	13	13	13	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	14	1207	123	0.84	0.95	0.95	0.96	0.96	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	21	1720	125	1.2	1.1	1.1	1.1	1.1	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.2	27	658	108	3.9	4.8	4.8	4.8	4.8	CMA+DE-MOS [19]
NBC-CMA	1	1.1	39	2946	2141	40	35	35	35	35	NBC-CMA [22]
POEMS	1	202	1047	30587	10531	98	87	86	86	86	POEMS [18]
PM-AdapSS-DE	1	1.7	37	2000	2054	22	19	19	19	29	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.1	982	18467	1645	12	27	27	27	27	pPOEMS [18, 21]
Basic RCGA	1	1.1	33	1019	463	<i>63e-3/5e4</i>	.	.	.	.	Basic RCGA [25]
SPSA	36	97	422	2.10e5	29091	<i>59e-2/1e5</i>	.	.	.	.	SPSA [14]

Table 20: 05-D, running time excess ERT/ERT_{best} 2009 on f_{20} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

20 Schwefel $x*\sin(x)$											
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D	2.7	3.0	3.2	170	7622	10272	10894	10921	10972	11063	ERT_{best}/D
(1,2)-CMA-ES	3.4	4.1	4.7	19	<i>67e-2/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.9	4.0	4.5	11	<i>67e-2/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.4	4.5	4.7	9.3	18	14	13	13	13	13	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.3	8.2	8.9	14	<i>67e-2/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	2.3	3.3	3.3	10	9.4	7.0	6.6	6.6	6.6	6.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.6	2.5	2.8	6.9	<i>47e-2/1e4</i>	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.8	2.5	2.6	7.6	<i>47e-2/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.8	2.6	2.8	6.8	<i>47e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.2	2.7	2.8	10	19	14	13	13	13	13	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.7	2.2	2.6	5.4	19	14	13	13	13	13	(1+2ms)-CMA-ES [2]
Artif Bee Colony	4.5	6.3	7.2	1.5	0.55	0.48	0.58	1.1	1.5	2.6	Artif Bee Colony [9]
avg NEWUOA	1.2	1.1	1	8.4	12	8.6	8.2	8.1	8.1	8.0	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	7.1	8.7	9.2	869	<i>12e-1/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	3.0	5.5	6.8	7.6	6.9	5.1	4.9	4.9	4.8	4.8	Adap DE (F-AUC) [11]
DE (Uniform)	5.9	8.6	11	10	9.2	6.8	6.4	6.4	6.4	6.4	DE (Uniform) [10]
IPOP-aCMA-ES	2.1	3.0	3.9	10	1.4	1.1	1.1	1.1	1.1	1.1	IPOP-aCMA-ES [17]
IPOP-CMA-ES	2.4	3.7	3.9	11	1.4	1.1	1.1	1.1	1.1	1.1	IPOP-CMA-ES [23]
CMA+DE-MOS	5.0	10	10	2.7	0.43	0.49	0.55	0.70	1.0	1.1	CMA+DE-MOS [19]
NBC-CMA	3.1	6.5	7.9	5.0	25	19	18	18	18	17	NBC-CMA [22]
POEMS	82	86	84	8.4	30	22	21	21	21	21	POEMS [18]
PM-AdapSS-DE	4.9	11	11	14	9.4	7.0	6.6	6.6	6.6	6.6	PM-AdapSS-DE [10, 11]
pPOEMS	81	78	81	17	17	13	13	14	14	15	pPOEMS [18, 21]
Basic RCGA	4.0	8.1	8.7	439	95	<i>97e-2/5e4</i>	.	.	.	.	Basic RCGA [25]
SPSA	13	19	25	<i>18e-1/1e5</i>	.	.	.	.	.	.	SPSA [14]

Table 21: 05-D, running time excess ERT/ERT_{best} 2009 on f_{21} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	21 Gallagher 101 peaks										
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	6.9	8.6	13	13	13	13	13	12	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	5.7	5.8	9.0	9.0	8.9	8.9	8.9	8.8	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	2.4	5.0	10	9.4	9.4	9.4	9.3	9.2	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	24	14	23	23	23	23	23	22	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	5.7	2.9	6.9	6.8	6.8	6.8	6.8	6.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	3.5	3.4	6.1	6.1	6.1	6.0	6.0	6.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	1.2	1.7	3.1	3.1	3.1	3.1	3.1	3.1	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	5.1	4.3	5.3	5.3	5.3	5.2	5.2	5.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	2.7	3.4	5.6	5.5	5.5	5.5	5.5	5.4	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	7.6	3.8	7.5	7.4	7.4	7.3	7.3	7.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	3.2	1.8	6.7	10	13	24	84	265	Artif Bee Colony [9]
avg NEWUOA	1	1	1.7	2.5	3.6	3.5	3.5	3.5	3.5	3.5	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	21	3.4	114	217	267	287	327	374	458	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	5.2	1.7	110	109	109	108	107	106	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	4.5	33	76	76	75	75	74	74	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	3.5	7.3	32	33	33	33	33	33	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	6.3	5.6	30	30	31	31	31	31	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1	4.6	69	280	478	485	485	483	527	CMA+DE-MOS [19]
NBC-CMA	1	1	2.5	96	119	118	117	116	115	114	NBC-CMA [22]
POEMS	1	1	25	744	1429	1415	1405	1397	1389	1371	POEMS [18]
PM-AdapSS-DE	1	1	4.0	33	201	199	198	196	195	192	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	28	11	214	238	243	254	263	283	pPOEMS [18, 21]
Basic RCGA	1	1	2.5	84	105	129	129	134	135	140	Basic RCGA [25]
SPSA	1	34	34	299	1985	1967	1958	1997	4056	3995	SPSA [14]

Table 22: 05-D, running time excess $ERT/ERT_{\text{best}}^{2009}$ on f_{22} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	18	31	31	30	30	29	29	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	10	11	20	19	19	19	18	18	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	15	21	51	49	48	47	47	46	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	23	32	49	47	46	46	45	44	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	6.9	13	16	16	15	15	15	15	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	12	10	12	12	12	12	12	11	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	10	12	15	15	14	14	14	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	16	18	12	11	11	11	11	11	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	3.7	8.0	8.5	8.2	8.0	8.0	7.9	7.8	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	3.1	6.5	4.9	4.7	4.6	4.6	4.6	4.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	5.1	7.6	35	237	374	1160	3311	6900	Artif Bee Colony [9]
avg NEWUOA	1	1	3.4	2.6	2.3	2.3	2.3	2.3	2.4	2.4	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	27	58	336	1483	1421	1384	1364	1933	1885	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	4.8	203	803	768	747	734	724	706	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	6.6	203	469	450	437	430	424	414	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	8.8	21	65	276	270	265	262	257	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	12	48	166	165	161	159	158	155	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1	3.7	24	299	483	557	551	549	541	CMA+DE-MOS [19]
NBC-CMA	1	1	3.0	264	289	360	350	343	339	331	NBC-CMA [22]
POEMS	1	1	1137	2347	2593	2485	2417	2377	2348	2292	POEMS [18]
PM-AdapSS-DE	1	1	4.1	4.6	469	449	437	430	424	414	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	29	24	268	276	284	305	326	362	pPOEMS [18, 21]
Basic RCGA	1	1	6.2	154	365	857	1697	1716	1706	3410	Basic RCGA [25]
SPSA	1	42	676	1318	7823	<i>69e-2/1e5</i>	.	.	.	.	SPSA [14]

Table 23: 05-D, running time excess ERT/ERT_{best} 2009 on f_{23} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	23 Katsuuras										
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	2.8	101	<i>97e-2/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	15	37	16	13	23	23	22	21	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	6.4	23	9.5	26	<i>18e-2/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	3.1	105	<i>98e-2/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	5.7	28	7.0	12	11	22	22	21	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	3.8	12	4.2	<i>87e-3/1e4</i>	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.2	8.9	24	25	<i>20e-2/1e4</i>	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	3.0	23	51	<i>23e-2/1e4</i>	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	5.0	5.4	5.5	12	<i>10e-2/1e4</i>	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	4.7	1.3	9.3	<i>12e-2/1e4</i>	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	2.2	19	<i>37e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	1	1	6.0	2.5	14	<i>15e-2/9e3</i>	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	8.1	15	33	<i>55e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	2.4	9.3	2.3	2.5	3.4	4.4	5.3	6.9	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	2.0	11	2.5	2.7	3.6	4.6	5.5	7.2	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	1.6	20	76	39	34	33	33	32	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	2.2	26	33	17	15	15	14	14	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1	2.2	16	4.1	3.5	3.8	3.7	4.0	3.9	CMA+DE-MOS [19]
NBC-CMA	1	1	1.4	42	299	153	135	132	129	124	NBC-CMA [22]
POEMS	1	1	12	21	41	63	57	56	55	54	POEMS [18]
PM-AdapSS-DE	1	1	1.8	8.9	12	15	14	15	21	27	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	3.4	71	29	43	42	44	47	53	pPOEMS [18, 21]
Basic RCGA	1	1	2.2	37	119	<i>53e-2/5e4</i>	.	.	.	.	Basic RCGA [25]
SPSA	1	105	309	1779	<i>11e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 24: 05-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 2009 on f_{24} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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$\Delta\text{ftarget}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta\text{ftarget}$	
$\text{ERT}_{\text{best}}/D$	0.20	0.20	324	43284	1.27e6	1.92e6	1.92e6	1.92e6	2.57e6	2.57e6	$\text{ERT}_{\text{best}}/D$	
(1,2)-CMA-ES	1	11	40	<i>87e-1/1e4</i>	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	1	7.9	8.3	<i>50e-1/1e4</i>	.	.	.	.	.	.	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	1	7.5	6.0	<i>54e-1/1e4</i>	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	1	15	49	<i>10e+0/1e4</i>	.	.	.	.	.	.	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	1	4.9	5.3	<i>41e-1/1e4</i>	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	1	10	4.4	<i>33e-1/1e4</i>	.	.	.	.	.	.	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	1	6.3	6.0	3.3	<i>31e-1/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	1	3.9	7.0	<i>58e-1/1e4</i>	.	.	.	.	.	.	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	1	9.3	6.2	<i>42e-1/1e4</i>	.	.	.	.	.	.	(1+1)-CMA-ES [8]	
(1+2ms)-CMA-ES	1	5.6	4.7	3.3	<i>50e-1/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	1	6.1	13	<i>42e-1/1e5</i>	.	.	.	.	.	.	Artif Bee Colony [9]	
avg NEWUOA	1	14	2.0	2.2	<i>30e-1/7e3</i>	.	.	.	.	.	avg NEWUOA [24]	
CMA-EGS (IPOP,r1)	31	57	30	<i>23e-1/1e5</i>	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]	
Adap DE (F-AUC)	1	5.7	4.1	3.7	0.13	0.15	0.15	0.15	0.11	0.11	Adap DE (F-AUC) [11]	
DE (Uniform)	1	3.9	4.3	3.7	0.17	0.15	0.15	0.15	0.11	0.11	DE (Uniform) [10]	
IPOP-aCMA-ES	1	6.5	2.6	41	<i>50e-1/3e5</i>	.	.	.	.	.	IPOP-aCMA-ES [17]	
IPOP-CMA-ES	1	6.3	2.9	18	1.4	0.94	0.94	0.94	0.70	0.70	IPOP-CMA-ES [23]	
CMA+DE-MOS	1	5.7	2.2	2.8	0.52	1.2	1.2	1.2	0.87	0.87	CMA+DE-MOS [19]	
NBC-CMA	1	5.5	15	9.4	<i>56e-1/6e4</i>	.	.	.	.	.	NBC-CMA [22]	
POEMS	1	505	72	<i>62e-1/3e5</i>	.	.	.	.	.	.	POEMS [18]	
PM-AdapSS-DE	1	6.8	5.9	6.8	0.24	0.36	0.36	0.36	0.27	0.27	PM-AdapSS-DE [10, 11]	
pPOEMS	1	157	39	7.2	<i>85e-2/3e5</i>	.	.	.	.	.	pPOEMS [18, 21]	
Basic RCGA	1	8.1	3.5	8.2	<i>55e-1/5e4</i>	Basic RCGA [25]	
SPSA	76	3.02e5	4351	<i>74e+0/1e5</i>	SPSA [14]	

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