

Comparison tables: BBOB 2010 function testbed with BBOB 2009 as reference in 3-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: 03-D, running time excess $ERT/ERT_{\text{best}} 2009$ 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	1	6.3	9.3	16	26	31	40	46	66	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	2.9	5.2	12	18	24	31	38	51	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1.9	4.0	8.2	13	19	23	30	41	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	5.5	6.7	12	19	28	34	42	60	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	3.1	4.5	10	14	19	24	29	37	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.1	3.4	4.5	8.3	12	17	22	27	35	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.4	3.4	5.8	8.8	12	15	20	26	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.2	2.7	3.7	6.7	11	14	18	24	30	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	2.3	3.9	8.8	12	16	20	23	31	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	2.9	4.8	8.4	12	15	19	23	29	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	5.4	20	41	64	88	118	147	210	Artif Bee Colony [9]
avg NEWUOA	1	1.3	2.4	1.1	1.1	1.1	1.1	1.1	1.1	1.1	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1.1	23	13	14	24	40	69	107	139	197	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.1	2.4	15	33	53	76	96	118	163	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	3.4	14	35	57	79	105	126	174	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	3.6	6.4	11	16	23	28	33	44	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	3.6	4.9	11	18	23	30	35	47	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.1	2.5	18	48	72	100	128	152	208	CMA+DE-MOS [19]
NBC-CMA	1	1	2.3	16	45	57	66	79	90	112	NBC-CMA [22]
POEMS	1	1	173	108	191	479	961	1309	1628	2506	POEMS [18]
PM-AdapSS-DE	1	1.4	2.4	16	33	55	77	99	120	166	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	49	90	165	1519	3923	6568	9419	15398	pPOEMS [18, 21]
Basic RCGA	1	1.1	2.0	20	77	152	268	497	693	1315	Basic RCGA [25]
SPSA	1	33	19	11	14	17	20	24	27	34	SPSA [14]

Table 3: 03-D, running time excess $ERT/ERT_{\text{best}} 2009$ 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	1.3	4.5	50	60	252	250	248	248	247	246	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.4	2.7	4.1	16	108	108	107	107	107	106	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.2	2.4	8.5	10	101	126	125	124	124	123	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.1	6.2	62	78	<i>20e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	4.2	10	8.0	40	39	39	39	39	39	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.1	2.6	7.5	7.6	36	41	41	41	41	41	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.2	2.4	6.6	10	42	42	42	42	42	41	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	2.6	9.3	12	58	58	58	58	57	57	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.5	3.0	8.9	14	95	95	94	94	94	93	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.1	3.3	14	6.1	47	47	46	46	46	46	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.1	2.3	5.8	1.1	1.8	2.4	2.8	3.4	3.7	4.4	Artif Bee Colony [9]
avg NEWUOA	1	4.4	9.4	5.0	33	33	33	33	33	32	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	7.5	15	89	343	813	819	1018	1434	1430	1421	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	2.4	6.6	2.5	3.5	4.0	4.2	4.3	4.6	4.9	Adap DE (F-AUC) [11]
DE (Uniform)	1.1	1.3	8.7	2.9	135	135	134	134	134	133	DE (Uniform) [10]
IPOP-aCMA-ES	1.1	3.5	3.0	2.7	13	17	17	17	17	18	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.1	3.7	7.5	3.4	25	33	34	34	35	36	IPOP-CMA-ES [23]
CMA+DE-MOS	1.1	2.3	10	1.7	2.6	3.2	3.6	4.0	4.4	5.1	CMA+DE-MOS [19]
NBC-CMA	1.1	2.1	9.2	5.9	31	31	31	31	31	31	NBC-CMA [22]
POEMS	33	227	28	7.8	24	28	31	35	38	46	POEMS [18]
PM-AdapSS-DE	1.5	2.2	7.8	2.5	29	59	59	59	59	59	PM-AdapSS-DE [10, 11]
pPOEMS	1.2	43	30	20	60	87	125	151	174	235	pPOEMS [18, 21]
Basic RCGA	1	2.2	21	22	36	52	64	66	68	71	Basic RCGA [25]
SPSA	97	9807	4164	<i>25e-1/1e5</i>	.	.	.	.	.	.	SPSA [14]

Table 4: 03-D, running time excess $ERT/ERT_{\text{best}} 2009$ 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	0.33	1.8	13	269	289	307	317	330	338	348	ERT_{best}/D
(1,2)-CMA-ES	2.5	3.9	34	68	<i>20e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.6	1.7	25	22	153	144	139	134	131	127	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.1	2.1	26	38	235	221	214	206	201	196	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.3	2.2	67	166	494	465	450	433	422	411	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.7	1.3	18	18	109	103	99	96	93	91	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.5	1.4	11	10	121	113	110	106	103	100	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.2	1.0	9.4	23	71	67	65	62	61	59	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.8	2.2	26	20	57	54	52	50	49	48	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.1	1.9	36	32	236	222	215	207	201	196	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.5	1.3	20	16	63	59	57	55	54	52	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.3	1.3	6.5	1.7	2.6	3.0	3.5	3.9	4.4	5.2	Artif Bee Colony [9]
avg NEWUOA	2.9	9.2	11	14	162	153	148	142	139	135	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	14	7.7	665	<i>42e-1/1e5</i>	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.5	1.4	11	252	1390	1307	1265	1217	1187	1155	Adap DE (F-AUC) [11]
DE (Uniform)	1.2	1.5	11	31	524	493	477	460	448	436	DE (Uniform) [10]
IPOP-aCMA-ES	1.9	2.2	8.2	463	<i>92e-2/2e5</i>	.	.	.	.	.	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.8	2.4	12	440	4534	4262	4124	3969	3869	3763	IPOP-CMA-ES [23]
CMA+DE-MOS	1.7	1.4	11	2.3	5.6	5.8	6.0	6.2	6.5	7.0	CMA+DE-MOS [19]
NBC-CMA	1.3	2.4	12	28	104	98	95	91	89	87	NBC-CMA [22]
POEMS	105	116	43	17	41	42	43	46	48	53	POEMS [18]
PM-AdapSS-DE	2.0	1.5	12	200	958	901	872	840	836	814	PM-AdapSS-DE [10, 11]
pPOEMS	1.3	51	41	35	66	107	122	149	163	211	pPOEMS [18, 21]
Basic RCGA	1.5	1.2	31	2636	<i>11e-1/5e4</i>	.	.	.	.	.	Basic RCGA [25]
SPSA	24	8590	11838	<i>11e+0/1e5</i>	.	.	.	.	.	.	SPSA [14]

Table 5: 03-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											
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	1.7	4.1	7.1	7.5	7.7	7.7	7.7	7.7	7.7	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.2	2.6	4.0	4.1	4.2	4.2	4.2	4.2	4.2	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.3	2.0	3.2	3.2	3.2	3.2	3.2	3.2	3.2	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.1	4.6	8.0	8.4	8.4	8.5	8.5	8.5	8.5	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.7	3.0	5.4	5.6	5.7	5.7	5.7	5.7	5.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.3	2.5	3.7	3.7	3.8	3.8	3.8	3.8	3.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.1	1.5	2.6	2.7	2.7	2.7	2.7	2.7	2.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.6	2.7	3.6	3.8	3.8	3.8	3.8	3.8	3.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	2.3	3.7	3.9	3.9	3.9	3.9	3.9	3.9	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.8	2.4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.5	15	31	35	35	35	35	35	35	Artif Bee Colony [9]
avg NEWUOA	1	1.5	1.3	1.5	1.5	1.5	1.5	1.5	1.5	1.5	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	10	5.1	7.6	8.0	8.0	8.0	8.0	8.0	8.0	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.2	8.7	16	17	17	17	17	17	17	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.3	6.5	18	20	20	20	20	20	20	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	3.3	6.0	6.4	6.4	6.4	6.4	6.4	6.4	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.3	3.4	5.7	5.7	5.7	5.7	5.7	5.7	5.7	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.3	10	23	35	35	35	35	35	35	CMA+DE-MOS [19]
NBC-CMA	1	1.3	19	50	52	52	52	52	52	52	NBC-CMA [22]
POEMS	1	19	117	152	173	185	186	186	186	186	POEMS [18]
PM-AdapSS-DE	1	1.4	6.4	18	19	19	20	20	20	20	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.1	110	144	170	178	184	185	186	186	pPOEMS [18, 21]
Basic RCGA	1	1.3	148	664	1102	1568	1996	4562	29702	<i>11e-6/5e4</i>	Basic RCGA [25]
SPSA	1	15	11	19	20	20	20	20	20	20	SPSA [14]

Table 6: 03-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	4.0	3.3	5.0	7.6	6.3	6.1	5.8	5.3	5.0	5.5	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.7	2.6	3.8	4.4	4.1	4.4	4.8	4.4	4.1	4.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	2.3	2.0	2.9	3.5	3.5	3.7	3.4	3.3	3.4	3.4	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.2	4.6	8.2	8.4	6.9	8.0	7.5	6.8	6.8	7.2	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.0	2.7	1.9	2.5	2.3	2.4	2.5	2.3	2.4	2.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	2.3	1.9	2.3	2.7	2.6	2.6	2.6	2.3	2.4	2.5	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	2.1	1.7	1.5	1.8	1.8	1.8	1.7	1.8	1.7	1.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.0	2.5	1.7	2.1	1.9	2.0	1.9	2.0	2.0	2.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.7	2.4	1.6	2.0	1.9	1.9	1.8	1.8	1.8	1.9	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.9	1.6	1.8	2.0	1.7	1.7	1.6	1.5	1.5	1.6	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.4	2.2	3.8	13	43	163	445	490	592	524	Artif Bee Colony [9]
avg NEWUOA	1.2	2.3	2.6	2.9	2.9	3.8	3.9	4.1	4.3	4.7	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	7.3	74	115	312	207	488	608	526	603	2355	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	4.9	2.8	5.3	8.8	8.9	9.0	8.9	9.1	8.7	9.5	Adap DE (F-AUC) [11]
DE (Uniform)	3.6	4.1	4.3	9.2	9.5	10	10	10	10	10	DE (Uniform) [10]
IPOP-aCMA-ES	4.0	4.3	3.3	3.3	3.2	3.3	3.2	2.9	3.0	3.0	IPOP-aCMA-ES [17]
IPOP-CMA-ES	3.9	2.8	2.8	3.3	3.3	3.3	3.2	3.0	3.0	3.1	IPOP-CMA-ES [23]
CMA+DE-MOS	4.2	3.4	5.8	14	13	15	14	13	13	14	CMA+DE-MOS [19]
NBC-CMA	6.0	3.5	4.5	14	11	9.3	8.4	7.6	7.2	6.9	NBC-CMA [22]
POEMS	150	84	34	61	83	92	101	95	96	109	POEMS [18]
PM-AdapSS-DE	5.1	3.3	3.7	8.6	8.7	9.2	9.4	9.3	9.4	10	PM-AdapSS-DE [10, 11]
pPOEMS	89	74	37	228	455	618	631	670	717	803	pPOEMS [18, 21]
Basic RCGA	23	14	13	160	302	813	1494	3510	4760	<i>18e-4/5e4</i>	Basic RCGA [25]
SPSA	23	4689	11501	11802	14416	<i>11e+0/1e5</i>	.	.	.	.	SPSA [14]

Table 7: 03-D, running time excess $ERT/ERT_{\text{best}}^{2009}$ on f_7 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid											
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	1.3	3.4	15	11	17	83	202	202	202	256	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.5	3.2	3.4	6.8	8.0	20	27	27	27	51	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.3	2.4	3.9	3.4	5.2	25	44	44	44	59	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.1	2.1	6.9	18	17	107	179	179	179	389	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.3	4.8	3.9	2.2	3.1	3.4	6.7	6.7	6.7	16	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.3	2.1	2.2	2.1	1.9	3.3	3.2	3.2	3.2	3.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.4	1.9	14	3.8	1.6	2.2	3.9	3.9	3.9	6.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.2	2.5	3.4	2.6	2.6	3.3	5.6	5.6	5.6	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.9	1.7	2.7	1.9	0.82	2.2	2.5	2.5	2.5	2.3	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.5	2.1	2.2	2.2	1.3	1.3	1.5	1.5	1.5	1.4	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.2	1.6	6.1	8.0	10	22	85	85	85	125	Artif Bee Colony [9]
avg NEWUOA	1.3	3.5	1.2	6.8	4.8	19	41	41	41	37	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	17	164	246	781	2492	9087	8751	8751	8751	7880	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.3	1.5	2.4	3.4	1.1	1.2	1.4	1.4	1.4	1.5	Adap DE (F-AUC) [11]
DE (Uniform)	1.3	1.5	5.5	4.2	1.3	1.4	1.6	1.6	1.6	1.6	DE (Uniform) [10]
IPOP-aCMA-ES	1.3	2.6	2.9	1.7	0.93	0.90	1.0	1.0	1.0	1.1	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.5	2.4	3.5	7.2	2.0	1.6	1.9	1.9	1.9	1.8	IPOP-CMA-ES [23]
CMA+DE-MOS	1.1	2.2	3.0	4.4	2.3	2.2	2.3	2.3	2.3	2.4	CMA+DE-MOS [19]
NBC-CMA	1.1	2.2	4.2	4.9	2.5	2.2	2.2	2.2	2.2	2.1	NBC-CMA [22]
POEMS	92	240	76	28	27	26	28	28	28	28	POEMS [18]
PM-AdapSS-DE	1.5	1.8	4.3	3.5	1.2	1.3	1.6	1.6	1.6	1.6	PM-AdapSS-DE [10, 11]
pPOEMS	1.6	33	61	30	40	67	91	91	91	106	pPOEMS [18, 21]
Basic RCGA	1.1	2.1	5.6	43	80	161	212	212	212	208	Basic RCGA [25]
SPSA	59	193	20672	30144	<i>69e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 8: 03-D, running time excess ERT/ERT_{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	5.0	10	12	28	16	17	18	18	18	18	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.8	2.2	10	20	9.3	10	11	11	11	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	2.6	6.2	12	29	12	12	13	13	13	13	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.8	2.2	3.9	50	23	25	28	29	29	29	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.4	4.3	3.8	11	5.3	5.4	5.7	5.9	6.0	6.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.9	3.3	3.5	13	6.7	6.7	6.8	6.8	6.9	7.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	2.4	2.6	3.5	10	4.3	4.4	4.6	4.6	4.7	4.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	2.5	1.6	2.0	10	5.0	5.4	5.7	5.7	5.8	5.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.5	2.6	2.5	6.5	2.9	3.0	3.0	3.1	3.2	3.4	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.7	1.7	2.1	4.8	2.3	2.3	2.5	2.5	2.7	2.8	(1+2ms)-CMA-ES [2]
Artif Bee Colony	2.1	3.9	3.8	17	26	235	3088	21956	<i>12e-4/1e5</i>	.	Artif Bee Colony [9]
avg NEWUOA	3.1	1.9	1.9	2.6	1.0	0.98	0.98	1.00	1.0	1.0	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	35	17	25	50	21	22	22	22	24	25	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	3.5	4.7	9.1	13	7.2	7.9	8.5	9.1	10	11	Adap DE (F-AUC) [11]
DE (Uniform)	5.1	5.2	8.4	16	9.5	11	12	13	14	15	DE (Uniform) [10]
IPOP-aCMA-ES	3.6	4.1	3.5	7.4	3.8	4.1	4.2	4.3	4.5	4.7	IPOP-aCMA-ES [17]
IPOP-CMA-ES	3.8	4.6	4.9	13	5.8	5.7	5.8	5.9	6.2	6.3	IPOP-CMA-ES [23]
CMA+DE-MOS	3.4	6.1	11	19	12	13	13	14	15	16	CMA+DE-MOS [19]
NBC-CMA	4.9	5.8	8.8	13	6.8	7.3	7.9	8.1	8.4	8.9	NBC-CMA [22]
POEMS	147	55	44	88	55	74	163	283	300	380	POEMS [18]
PM-AdapSS-DE	2.2	4.5	8.7	13	7.0	8.7	10	56	56	54	PM-AdapSS-DE [10, 11]
pPOEMS	125	53	43	148	221	376	479	643	794	1066	pPOEMS [18, 21]
Basic RCGA	2.6	7.0	13	61	640	1150	3462	<i>14e-3/5e4</i>	.	.	Basic RCGA [25]
SPSA	490	275	267	8639	5825	24022	<i>12e-1/1e5</i>	.	.	.	SPSA [14]

Table 9: 03-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	15	86	11	14	16	17	18	18	18	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	15	42	5.2	10	10	11	11	12	12	12	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	7.8	39	16	17	13	13	13	14	13	14	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	10	54	4.8	6.7	16	21	22	24	24	25	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	10	37	4.2	7.4	6.4	6.6	6.9	7.0	7.2	7.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	11	36	3.1	3.8	4.1	4.6	5.0	5.2	5.4	5.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	9.4	23	2.5	3.1	3.5	3.9	4.1	4.2	4.3	4.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	11	39	2.7	9.1	7.2	7.3	7.3	7.3	7.3	7.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	10	31	2.6	3.3	2.9	3.1	3.1	3.3	3.4	3.6	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	11	26	2.8	3.9	3.3	3.3	3.4	3.5	3.6	3.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	11	54	5.2	7.3	93	473	4854	26815	<i>24e-4/1e5</i>	.	Artif Bee Colony [9]
avg NEWUOA	11	20	1.7	1.7	1.2	1.1	1.1	1.1	1.2	1.2	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	125	163	26	37	29	27	27	28	28	29	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	14	42	7.7	10	9.3	11	19	22	24	24	Adap DE (F-AUC) [11]
DE (Uniform)	11	45	9.2	9.1	10	12	13	14	14	15	DE (Uniform) [10]
IPOP-aCMA-ES	10	38	3.5	5.9	4.8	4.8	5.1	5.3	5.4	5.6	IPOP-aCMA-ES [17]
IPOP-CMA-ES	5.5	19	3.0	4.8	4.4	4.8	5.0	5.2	5.5	5.7	IPOP-CMA-ES [23]
CMA+DE-MOS	10	55	11	4.9	6.9	9.3	10	11	12	14	CMA+DE-MOS [19]
NBC-CMA	8.8	56	10	9.1	8.7	9.3	10	10	10	11	NBC-CMA [22]
POEMS	603	753	55	213	138	176	252	352	461	604	POEMS [18]
PM-AdapSS-DE	7.7	31	7.6	8.4	8.4	10	10	11	12	13	PM-AdapSS-DE [10, 11]
pPOEMS	466	780	59	146	322	466	624	763	945	1276	pPOEMS [18, 21]
Basic RCGA	12	69	12	181	1567	7119	<i>94e-3/5e4</i>	.	.	.	Basic RCGA [25]
SPSA	5984	12372	1417	9774	<i>12e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 11: 03-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 2009 on f_{11} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

11 Discus											
$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$	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	10	74	36	27	14	12	12	12	12	11	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	18	80	28	23	12	10	10	10	10	9.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	16	44	20	19	9.5	8.5	8.3	8.2	8.2	8.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	34	119	36	36	19	17	17	17	16	15	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.2	18	10	8.8	4.7	4.3	4.3	4.3	4.2	4.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.2	24	12	9.3	4.7	4.3	4.3	4.3	4.3	4.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	6.7	11	7.0	6.9	3.6	3.2	3.1	3.1	3.1	3.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.7	15	9.3	7.5	4.0	3.7	3.6	3.6	3.6	3.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.8	13	5.9	5.3	2.8	2.5	2.5	2.5	2.5	2.5	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	3.9	6.8	5.3	4.5	2.5	2.3	2.2	2.2	2.2	2.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.0	8.2	28	262	2431	<i>14e-2/1e5</i>	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	1.9	2.6	2.0	3.3	2.5	2.7	3.3	3.7	4.3	5.0	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	12	172	78	59	29	25	24	24	23	23	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	13	20	5.7	5.5	3.0	3.4	3.7	4.3	4.6	5.3	Adap DE (F-AUC) [11]
DE (Uniform)	10	15	5.9	5.6	3.3	3.5	3.9	4.4	4.9	5.7	DE (Uniform) [10]
IPOP-aCMA-ES	6.1	9.1	5.3	4.5	2.4	2.3	2.3	2.4	2.5	2.5	IPOP-aCMA-ES [17]
IPOP-CMA-ES	6.0	13	9.2	7.5	4.0	3.7	3.7	3.7	3.7	3.7	IPOP-CMA-ES [23]
CMA+DE-MOS	13	23	17	17	8.8	8.5	8.7	9.0	9.0	9.4	CMA+DE-MOS [19]
NBC-CMA	11	25	11	16	9.1	8.8	9.2	9.1	9.0	9.1	NBC-CMA [22]
POEMS	79	81	138	716	641	891	1259	1627	1683	2371	POEMS [18]
PM-AdapSS-DE	11	17	6.1	5.6	3.4	3.6	4.1	4.5	4.9	5.6	PM-AdapSS-DE [10, 11]
pPOEMS	70	62	86	383	312	447	534	679	787	943	pPOEMS [18, 21]
Basic RCGA	11	17	342	1203	2947	8132	<i>58e-2/5e4</i>	.	.	.	Basic RCGA [25]
SPSA	10	224	3544	18559	<i>58e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 12: 03-D, running time excess ERT/ERT_{best} 2009 on f_{12} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar											
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	23	43	55	39	27	28	27	23	22	21	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.9	11	25	16	11	10	10	8.2	8.1	8.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	10	15	25	17	11	10	9.4	7.3	6.9	6.7	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	18	51	96	90	60	55	52	50	46	67	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.7	8.9	19	13	8.0	7.4	7.2	5.4	5.2	5.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.4	8.8	17	12	7.9	7.3	7.1	5.5	5.3	5.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.1	3.0	13	10	6.8	6.4	6.2	4.9	4.7	4.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	3.4	6.8	7.2	5.6	5.6	5.5	4.3	4.2	4.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.1	3.8	10	6.2	4.1	3.9	3.8	2.9	2.9	3.0	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	3.1	3.6	10	7.9	5.1	5.0	4.7	3.6	3.5	3.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	10	18	53	283	1651	10641	<i>12e-2/1e5</i>	.	.	.	Artif Bee Colony [9]
avg NEWUOA	1.1	1.9	4.5	3.2	2.2	2.2	2.2	1.8	1.8	1.9	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	25	33	1357	1390	1873	2084	2726	3153	2827	2491	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	14	15	14	44	146	132	173	126	114	145	Adap DE (F-AUC) [11]
DE (Uniform)	16	16	14	8.1	227	277	251	246	221	196	DE (Uniform) [10]
IPOP-aCMA-ES	4.7	4.7	10	7.8	6.2	6.0	5.9	4.7	4.6	4.5	IPOP-aCMA-ES [17]
IPOP-CMA-ES	6.0	7.3	8.9	6.6	4.5	4.6	4.6	3.7	3.7	4.1	IPOP-CMA-ES [23]
CMA+DE-MOS	24	23	25	19	13	12	12	9.3	9.2	9.1	CMA+DE-MOS [19]
NBC-CMA	16	16	24	15	10	11	11	8.8	8.5	8.7	NBC-CMA [22]
POEMS	122	173	2189	3753	4466	5469	<i>22e-2/3e5</i>	.	.	.	POEMS [18]
PM-AdapSS-DE	14	17	344	284	229	505	456	360	324	286	PM-AdapSS-DE [10, 11]
pPOEMS	190	430	852	604	443	539	618	543	582	650	pPOEMS [18, 21]
Basic RCGA	41	42	592	577	414	1104	1141	3519	<i>96e-3/5e4</i>	.	Basic RCGA [25]
SPSA	3876	5174	7183	11674	12506	<i>21e+0/1e5</i>	.	.	.	.	SPSA [14]

Table 13: 03-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 2009 on f_{13} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge											
Δf_{target} $\text{ERT}_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} $\text{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	2.6	7.3	21	29	27	29	26	23	24	41	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	0.92	2.8	17	26	33	32	25	31	36	56	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.8	4.2	15	19	21	22	20	19	28	72	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.8	7.8	17	45	47	47	37	46	67	91	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.8	2.9	6.6	8.1	8.7	7.9	6.1	6.9	6.9	8.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	3.1	5.2	8.6	8.2	7.8	5.9	7.0	7.1	7.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.8	2.1	3.4	5.1	5.9	6.1	4.6	5.3	6.3	6.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.5	2.3	7.3	7.7	7.6	7.2	5.6	5.8	6.0	5.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.3	2.3	4.1	7.7	6.9	6.6	5.2	5.2	5.0	6.0	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	0.87	3.6	5.2	5.1	5.1	4.8	3.4	3.6	3.6	4.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.1	6.7	12	160	3803	31398	<i>86e-3/1e5</i>	.	.	.	Artif Bee Colony [9]
avg NEWUOA	2.5	1.0	5.6	14	42	114	159	277	256	<i>36e-4/8e3</i>	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	17	8.4	1628	2638	18147	<i>61e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.6	5.8	7.4	7.7	8.6	8.8	7.0	7.1	7.3	7.2	Adap DE (F-AUC) [11]
DE (Uniform)	1.4	7.1	8.8	8.9	10	10	7.6	7.7	7.9	7.7	DE (Uniform) [10]
IPOP-aCMA-ES	2.2	2.7	3.4	3.6	3.9	4.3	3.3	3.2	3.4	3.4	IPOP-aCMA-ES [17]
IPOP-CMA-ES	2.2	3.0	3.4	5.0	5.9	5.7	4.6	4.4	4.6	4.5	IPOP-CMA-ES [23]
CMA+DE-MOS	1.4	4.5	14	15	15	15	11	11	11	10	CMA+DE-MOS [19]
NBC-CMA	1.5	7.9	9.5	9.1	12	12	8.8	8.7	8.7	8.6	NBC-CMA [22]
POEMS	191	48	67	1186	3456	4088	11632	<i>43e-4/3e5</i>	.	.	POEMS [18]
PM-AdapSS-DE	2.0	5.8	7.8	8.1	9.5	10	7.5	7.6	7.8	7.7	PM-AdapSS-DE [10, 11]
pPOEMS	1.6	51	101	595	922	1236	1020	1162	1390	1653	pPOEMS [18, 21]
Basic RCGA	1.2	10	115	440	1252	3765	5106	4324	3914	<i>46e-3/5e4</i>	Basic RCGA [25]
SPSA	21	34	110	2720	41486	<i>67e-2/1e5</i>	.	.	.	.	SPSA [14]

Table 14: 03-D, running time excess $ERT/ERT_{\text{best}}^{2009}$ 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	1.2	13	6.3	6.5	7.3	12	17	21	18	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.1	1.6	4.2	4.4	4.9	6.8	10	15	16	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	2.3	2.5	3.1	3.9	5.1	9.3	13	12	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.3	3.5	3.3	5.1	8.5	12	25	31	27	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.7	4.7	2.8	3.3	3.9	4.2	5.6	7.7	6.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.1	2.9	2.0	2.6	3.0	3.5	5.7	7.2	7.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.3	1.8	1.5	2.2	2.6	3.0	3.9	5.2	4.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.5	4.2	1.8	2.6	3.5	4.4	5.2	6.6	5.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.1	3.4	2.2	3.0	2.9	3.4	4.0	4.4	3.9	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	1.8	2.1	2.6	2.5	2.7	3.4	3.8	3.3	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.2	1.5	8.9	14	26	315	2547	12654	<i>55e-6/1e5</i>	Artif Bee Colony [9]
avg NEWUOA	1	1.2	4.7	1.2	1.1	1.1	1.2	1.6	2.7	6.9	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	5.7	25	44	14	12	15	25	37	36	422	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.1	2.1	3.7	10	12	10	10	10	8.3	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.1	1.6	4.4	11	14	11	12	12	8.8	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	2.3	2.7	3.7	4.2	3.7	4.5	5.0	4.2	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.5	2.8	3.7	4.0	4.6	4.8	5.8	6.8	5.8	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.1	1.2	4.0	15	17	15	17	18	14	CMA+DE-MOS [19]
NBC-CMA	1	1.3	2.2	5.8	12	12	9.4	10	11	8.7	NBC-CMA [22]
POEMS	1	39	269	54	63	113	138	161	313	14624	POEMS [18]
PM-AdapSS-DE	1	1.6	1.9	5.4	12	12	11	11	11	8.7	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.1	41	43	91	467	735	1010	1223	1506	pPOEMS [18, 21]
Basic RCGA	1	1.1	1.9	10	36	71	210	646	1886	<i>51e-7/5e4</i>	Basic RCGA [25]
SPSA	10	47	534	295	205	165	429	785	2270	<i>48e-7/1e5</i>	SPSA [14]

Table 15: 03-D, running time excess ERT/ERT_{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											
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	2.1	7.9	7.6	31	67	51	50	49	48	47	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.1	3.3	2.7	8.2	12	9.0	8.8	8.7	8.5	8.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.6	3.7	3.6	10	11	8.4	8.3	8.1	7.9	7.7	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.4	4.7	9.0	39	33	25	25	24	24	23	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.8	2.5	3.9	5.7	7.0	5.3	5.2	5.1	5.0	4.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	2.1	1.2	2.9	8.3	6.3	6.2	6.1	6.0	5.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.5	2.7	2.2	2.0	2.6	2.0	1.9	1.9	1.9	1.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.1	3.2	4.2	3.9	22	17	17	16	16	16	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.8	3.2	2.5	3.8	11	8.3	8.2	8.1	7.9	7.7	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.4	2.5	2.1	7.0	7.2	5.5	5.4	5.3	5.1	5.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.1	1.8	3.6	34	42	88	250	496	<i>29e-3/1e5</i>	.	Artif Bee Colony [9]
avg NEWUOA	2.0	3.4	3.2	3.7	3.1	2.3	2.3	2.2	2.1	2.1	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	18	23	12	36	325	519	<i>99e-2/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.3	1.9	1.8	1.4	0.41	0.37	0.38	0.40	0.40	0.43	Adap DE (F-AUC) [11]
DE (Uniform)	1	3.9	2.3	1.6	3.9	3.0	3.0	3.0	2.9	2.9	DE (Uniform) [10]
IPOP-aCMA-ES	2.5	4.2	0.98	1.6	1.0	0.85	0.85	0.85	0.85	0.85	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.3	2.9	2.4	1.4	1.2	0.93	0.93	0.93	0.92	0.93	IPOP-CMA-ES [23]
CMA+DE-MOS	1.3	1.5	4.9	3.8	1.5	1.6	1.6	1.6	1.6	1.6	CMA+DE-MOS [19]
NBC-CMA	1.2	1.3	3.2	3.1	3.1	2.4	2.3	2.3	2.3	2.2	NBC-CMA [22]
POEMS	1	217	15	26	85	65	65	64	63	62	POEMS [18]
PM-AdapSS-DE	1.4	2.6	2.3	1.5	3.9	3.0	3.0	3.0	2.9	2.9	PM-AdapSS-DE [10, 11]
pPOEMS	1.1	20	17	46	23	21	23	26	28	32	pPOEMS [18, 21]
Basic RCGA	1.3	2.0	5.3	24	9.3	7.5	9.4	12	17	39	Basic RCGA [25]
SPSA	282	9719	473	3249	<i>21e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 16: 03-D, running time excess $ERT/ERT_{\text{best}}^{2009}$ 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} 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
	0.33	0.40	14	106	194	263	621	720	1068	1120	
(1,2)-CMA-ES	1	1.5	19	37	96	160	68	92	<i>25e-2/1e4</i>	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	2.4	12	21	40	26	27	23	42	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.7	2.5	11	19	25	17	22	16	64	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.4	27	33	97	129	115	<i>17e-2/1e4</i>	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.5	3.3	13	15	19	10	9.2	8.7	61	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.3	5.4	5.3	8.1	8.6	5.6	5.4	5.0	5.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.2	1.9	4.5	5.3	6.5	7.3	10	6.9	6.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.8	6.2	8.1	12	18	14	19	16	22	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.4	3.1	3.7	10	20	28	30	27	66	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.2	1.9	3.4	4.7	13	12	34	41	60	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.8	1.2	3.1	19	142	2272	<i>45e-4/1e5</i>	.	.	Artif Bee Colony [9]
avg NEWUOA	1	1.3	3.7	6.1	23	59	73	<i>19e-3/7e3</i>	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1.2	15	14	91	445	5699	<i>80e-3/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.3	2.5	4.4	6.7	5.8	2.7	12	8.5	8.2	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.2	2.2	4.5	7.3	7.5	3.4	3.1	2.2	2.2	DE (Uniform) [10]
IPOP-aCMA-ES	1	1.2	1.5	3.2	2.7	3.1	1.5	1.3	0.93	0.93	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.7	2.2	3.2	3.8	3.3	1.4	1.3	0.88	1.1	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.2	1.5	5.3	4.4	3.8	1.9	1.8	1.3	1.4	CMA+DE-MOS [19]
NBC-CMA	1	1.5	1.5	7.5	7.1	8.6	3.8	3.4	2.4	2.4	NBC-CMA [22]
POEMS	1	20	18	28	523	521	225	195	133	128	POEMS [18]
PM-AdapSS-DE	1	1.4	1.6	6.4	11	11	17	15	10	10	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.4	18	15	85	112	105	139	103	119	pPOEMS [18, 21]
Basic RCGA	1	1	1.6	17	45	117	125	135	117	199	Basic RCGA [25]
SPSA	2.7	107	106	312	1571	<i>28e-2/1e5</i>	.	.	.	.	SPSA [14]

Table 17: 03-D, running time excess ERT/ERT_{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										
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	0.33	0.33	1.2	26	94	164	378	602	782	1156	ERT_{best}/D
(1,2)-CMA-ES	1	1.7	6.4	11	25	138	<i>14e-3/1e4</i>	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.3	4.0	5.1	3.9	4.3	11	54	187	<i>26e-5/1e4</i>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.5	3.8	1.3	5.1	7.5	22	119	184	124	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	388	113	30	50	859	<i>44e-3/1e4</i>	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.3	19	7.4	8.4	16	19	28	91	<i>12e-5/1e4</i>	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.6	4.1	4.5	3.3	5.9	4.2	15	61	129	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.7	13	3.6	3.8	3.8	6.5	17	87	<i>58e-6/1e4</i>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.1	3.9	4.9	6.9	12	18	<i>54e-5/1e4</i>	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.4	12	5.2	15	36	88	243	<i>26e-4/1e4</i>	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.2	10	6.3	6.3	13	17	55	92	125	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.5	3.2	6.6	11	42	469	2342	1803	<i>11e-4/1e5</i>	Artif Bee Colony [9]
avg NEWUOA	1	1.9	3.3	8.0	13	153	<i>32e-3/5e3</i>	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	6.9	19	16	17	12	243	739	2328	1793	<i>61e-4/1e5</i>	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.3	4.3	3.3	2.7	2.6	1.6	1.4	1.3	1.2	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.3	2.2	3.6	2.8	2.7	1.7	1.4	1.4	1.3	DE (Uniform) [10]
IPOP-aCMA-ES	1.1	2.3	4.5	6.6	2.8	2.1	1.6	1.2	1.2	0.95	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	3.5	20	2.2	1.1	1.8	1.2	1.1	1.1	1.0	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.3	2.4	5.9	6.8	6.2	5.2	4.3	3.7	3.4	CMA+DE-MOS [19]
NBC-CMA	1	1.4	2.6	4.0	2.1	1.7	0.93	0.72	1.4	1.2	NBC-CMA [22]
POEMS	1	164	184	22	26	28	18	15	15	30	POEMS [18]
PM-AdapSS-DE	1	1.5	1.9	3.7	2.5	2.7	1.7	1.3	1.3	1.2	PM-AdapSS-DE [10, 11]
pPOEMS	1.1	1.2	16	19	129	185	125	108	106	105	pPOEMS [18, 21]
Basic RCGA	1	1.3	3.1	25	72	81	51	111	155	<i>63e-6/5e4</i>	Basic RCGA [25]
SPSA	57	21735	32080	4518	1302	2511	<i>11e-1/1e5</i>	.	.	.	SPSA [14]

Table 18: 03-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} 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	1.2	5.9	9.0	29	23	137	<i>69e-3/1e4</i>	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	3.6	1.3	10	14	26	<i>42e-3/1e4</i>	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	5.4	1.4	4.2	6.1	20	<i>11e-3/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	5.8	15	46	103	<i>24e-2/1e4</i>	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.1	4.1	5.4	7.2	5.5	16	120	<i>12e-3/1e4</i>	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.1	4.8	4.6	5.0	3.1	6.2	18	<i>24e-4/1e4</i>	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	4.2	4.0	4.7	5.8	8.7	17	107	<i>15e-4/1e4</i>	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.2	4.6	5.2	12	8.8	19	125	<i>15e-3/1e4</i>	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	3.6	6.0	21	11	35	<i>42e-3/1e4</i>	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	61	5.8	11	9.5	26	128	<i>24e-3/1e4</i>	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	3.1	3.4	15	70	315	<i>23e-3/1e5</i>	.	.	.	Artif Bee Colony [9]
avg NEWUOA	1.3	4.8	11	30	15	89	<i>76e-3/6e3</i>	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	12	38	13	62	284	<i>19e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.1	2.6	2.9	3.7	0.86	0.57	0.67	0.76	0.78	0.86	Adap DE (F-AUC) [11]
DE (Uniform)	1.5	2.8	3.5	3.6	0.86	0.57	0.68	0.77	0.78	0.86	DE (Uniform) [10]
IPOP-aCMA-ES	1	7.4	1.3	1.3	0.61	0.91	0.90	0.86	0.92	0.94	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.3	6.4	1.4	1.8	1.2	1.0	1.2	1.3	1.4	1.3	IPOP-CMA-ES [23]
CMA+DE-MOS	1.1	1.8	2.9	7.8	2.1	1.7	2.0	1.9	1.8	2.0	CMA+DE-MOS [19]
NBC-CMA	1.3	3.4	2.3	4.8	19	8.1	7.1	6.6	5.8	5.4	NBC-CMA [22]
POEMS	43	260	23	27	8.9	50	110	107	158	226	POEMS [18]
PM-AdapSS-DE	1.5	3.6	2.1	3.6	0.86	0.55	0.66	0.76	0.77	0.85	PM-AdapSS-DE [10, 11]
pPOEMS	1.1	54	28	82	55	42	53	67	68	83	pPOEMS [18, 21]
Basic RCGA	1	1.6	24	86	61	327	<i>33e-3/5e4</i>	.	.	.	Basic RCGA [25]
SPSA	43	1240	3787	3149	1547	<i>20e-1/1e5</i>	.	.	.	.	SPSA [14]

Table 19: 03-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	4.8	469	177	30	<i>32e-3/1e4</i>	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	6.7	239	132	20	<i>39e-3/1e4</i>	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	8.5	556	87	21	29	29	29	29	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	31	550	173	31	58	58	58	58	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	5.5	329	99	6.7	12	12	12	12	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.1	10	420	60	10	13	13	13	12	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	10	171	89	6.7	28	28	27	27	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	11	251	123	65	<i>58e-3/1e4</i>	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	7.4	415	186	20	18	18	18	18	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.1	12	364	121	14	28	28	28	28	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.1	12	391	52	8.0	24	72	295	<i>14e-5/1e5</i>	Artif Bee Colony [9]
avg NEWUOA	1	1.5	13	319	122	39	76	76	76	76	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	6.2	15	47	346	150	49	98	266	265	566	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.1	12	218	27	5.0	12	12	12	12	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.1	7.3	335	32	5.5	13	13	13	13	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	6.0	234	41	4.0	4.6	4.6	4.7	4.7	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.1	11	196	67	4.4	4.1	4.1	4.1	4.1	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.1	11	213	5.8	3.7	3.6	3.7	3.7	3.8	CMA+DE-MOS [19]
NBC-CMA	1	1.2	8.9	235	29	3.2	4.3	4.3	4.3	4.3	NBC-CMA [22]
POEMS	1	42	611	1680	251	81	168	167	169	169	POEMS [18]
PM-AdapSS-DE	1	1.9	7.9	237	25	2.3	12	12	12	14	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.5	260	1717	259	10	11	13	15	21	pPOEMS [18, 21]
Basic RCGA	1	1.1	10	273	16	8.7	24	51	141	289	Basic RCGA [25]
SPSA	18	71	258	10394	2974	637	<i>83e-3/1e5</i>	.	.	.	SPSA [14]

Table 20: 03-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	1.8	2.6	2.8	128	764	799	827	842	858	925	ERT_{best}/D
(1,2)-CMA-ES	4.5	4.2	4.9	4.1	16	15	17	17	16	15	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.4	2.8	3.2	8.1	41	39	38	37	36	34	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	2.6	3.2	3.9	7.9	91	87	84	83	81	75	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.3	7.9	7.7	11	32	32	31	31	30	28	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.8	2.0	2.8	4.1	11	11	10	10	10	9.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.3	1.3	2.0	7.8	18	17	16	16	16	15	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.2	1.6	1.7	4.7	54	52	50	49	48	45	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	0.95	1.4	1.9	6.0	21	20	19	19	19	17	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.1	2.1	2.4	3.0	10	10	9.5	9.3	9.1	8.5	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.3	1.4	1.8	2.0	9.2	8.8	8.5	8.4	8.3	7.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	2.6	5.0	5.6	1.1	1.3	1.8	3.7	6.0	6.9	9.3	Artif Bee Colony [9]
avg NEWUOA	1.5	1.3	1.3	2.3	10	9.5	9.2	9.0	8.9	8.2	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	10	12	13	158	<i>45e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.6	2.9	4.5	3.7	34	33	32	31	31	28	Adap DE (F-AUC) [11]
DE (Uniform)	2.9	3.4	4.6	2.8	34	32	32	31	31	28	DE (Uniform) [10]
IPOP-aCMA-ES	2.3	1.9	2.0	5.1	5.8	5.9	5.9	5.9	5.9	5.6	IPOP-aCMA-ES [17]
IPOP-CMA-ES	2.1	2.8	2.9	4.5	5.6	5.7	5.6	5.7	5.7	5.4	IPOP-CMA-ES [23]
CMA+DE-MOS	3.0	3.9	4.5	4.3	3.5	4.0	4.8	4.9	5.1	7.8	CMA+DE-MOS [19]
NBC-CMA	1.9	4.0	4.9	3.8	13	12	12	12	12	11	NBC-CMA [22]
POEMS	110	83	80	8.2	146	141	138	137	135	128	POEMS [18]
PM-AdapSS-DE	1.9	2.5	2.8	2.8	21	20	20	19	19	18	PM-AdapSS-DE [10, 11]
pPOEMS	63	60	65	20	17	27	36	44	52	64	pPOEMS [18, 21]
Basic RCGA	2.2	3.2	4.6	64	217	916	887	<i>41e-2/5e4</i>	.	.	Basic RCGA [25]
SPSA	34	39	51	5071	<i>15e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 21: 03-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										
Δft_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δft_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	6.8	11	25	28	27	27	27	26	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	1.6	7.7	7.7	11	11	11	11	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1.8	8.1	12	13	18	17	17	17	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	4.1	21	40	42	40	40	40	39	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	1.4	7.4	13	13	12	12	12	12	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	1.1	5.4	21	26	27	27	27	26	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.6	5.1	7.4	7.3	7.0	6.9	6.9	6.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	2.4	8.0	11	11	11	11	11	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	2.5	5.3	10	10	9.4	9.2	9.2	9.0	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	1.7	7.4	8.9	8.7	8.4	8.3	8.2	8.1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	2.4	2.5	3.7	5.9	10	26	60	145	Artif Bee Colony [9]
avg NEWUOA	1	1	4.0	2.5	2.1	2.0	2.0	2.0	2.0	2.0	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	19	10	35	220	305	293	577	573	559	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	2.0	2.1	1.6	2.0	2.4	2.7	2.9	3.1	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	1.3	1.9	1.9	2.3	2.6	2.8	3.0	3.3	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	1.8	6.6	10	10	10	10	11	11	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	1.5	11	10	11	11	11	11	11	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1	1.7	13	22	106	488	746	744	860	CMA+DE-MOS [19]
NBC-CMA	1	1	1.3	5.1	31	55	52	52	51	50	NBC-CMA [22]
POEMS	1	1	90	1001	800	777	745	739	735	722	POEMS [18]
PM-AdapSS-DE	1	1	1.1	1.7	52	51	49	48	48	47	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	31	12	11	24	39	57	92	145	pPOEMS [18, 21]
Basic RCGA	1	1	1.8	21	59	162	164	216	269	293	Basic RCGA [25]
SPSA	1	30	30	439	1223	1188	1139	1134	1155	2915	SPSA [14]

Table 22: 03-D, running time excess ERT/ERT_{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	4.0	17	28	35	34	33	33	32	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	15	11	22	25	25	25	25	24	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	7.1	7.6	20	31	30	35	34	33	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	18	16	26	26	27	27	27	27	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	4.0	7.8	7.8	7.9	7.6	7.5	7.4	7.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	3.6	6.8	7.3	7.4	7.2	7.2	7.1	7.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.8	10	15	16	15	15	15	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	9.0	7.0	10	10	10	9.4	9.3	9.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	6.4	8.7	7.2	7.2	6.9	6.8	6.7	6.6	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	3.1	2.7	3.4	3.5	3.3	3.3	3.3	3.3	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	2.5	1.7	4.3	29	105	241	329	4862	Artif Bee Colony [9]
avg NEWUOA	1	1	2.8	2.0	2.9	2.9	2.8	2.9	2.9	3.1	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	16	3.6	43	237	523	798	1172	1152	1117	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	2.1	2.2	132	130	123	120	118	115	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	1.3	1.5	132	130	123	120	118	115	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	6.6	7.1	27	83	228	224	222	217	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	1.2	5.0	21	90	247	290	286	281	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1	1.5	16	22	28	31	42	44	193	CMA+DE-MOS [19]
NBC-CMA	1	1	1.4	109	174	225	213	208	204	198	NBC-CMA [22]
POEMS	1	1	2130	623	989	974	921	901	889	868	POEMS [18]
PM-AdapSS-DE	1	1	1.3	127	213	209	198	193	190	184	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	29	12	211	227	234	266	298	361	pPOEMS [18, 21]
Basic RCGA	1	1	1.3	32	111	389	518	601	1218	5387	Basic RCGA [25]
SPSA	1	28	31	320	5903	12219	<i>40e-2/1e5</i>	.	.	.	SPSA [14]

Table 23: 03-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}^{2009}$ 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} $\text{ERT}_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} $\text{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	1	1	7.2	37	237	177	197	194	190	<i>68e-2/1e4</i>	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	6.5	12	48	104	57	89	87	<i>22e-2/1e4</i>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	5.3	18	69	81	45	64	63	61	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	10	54	231	180	199	<i>66e-2/1e4</i>	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	2.5	7.3	20	16	10	10	10	11	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	3.0	6.2	19	21	14	14	14	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	6.1	8.2	30	27	15	14	14	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	9.5	16	40	41	34	43	43	55	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	5.6	3.4	13	19	13	15	20	29	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	4.9	3.6	10	21	16	25	24	23	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	4.2	10	<i>24e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	1	1	11	2.5	22	85	147	<i>46e-3/7e3</i>	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	7.1	16	11	<i>29e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	3.1	3.1	5.1	6.6	5.1	6.4	7.8	10	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	4.0	2.4	5.3	7.2	5.5	6.9	8.4	11	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	7.2	5.3	10	7.7	4.3	5.4	5.4	5.4	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	4.9	5.2	80	60	33	32	32	31	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1	3.9	7.5	10	8.6	5.2	5.2	5.3	5.4	CMA+DE-MOS [19]
NBC-CMA	1	1	2.7	15	353	263	145	142	140	134	NBC-CMA [22]
POEMS	1	1	20	21	106	141	83	85	86	88	POEMS [18]
PM-AdapSS-DE	1	1	4.1	2.5	5.7	26	16	17	19	20	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	14	64	264	276	189	227	255	328	pPOEMS [18, 21]
Basic RCGA	1	1	5.4	16	271	837	<i>15e-2/5e4</i>	.	.	.	Basic RCGA [25]
SPSA	1	26	113	946	<i>99e-2/1e5</i>	SPSA [14]

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