Comparison tables: BBOB 2010 noisy 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 [11, 7]. The experimental set-up is described in [10].

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 [6]) if an algorithm from BBOB-2009 reached the given target function value. The ERT value is given otherwise ($\mathrm{ERT}_{\mathrm{best}}$ is noted as infinite). See [10] 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_{101}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

101 Sphere moderate Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	1.2	4.4	6.3	6.7	9.3	11	11	13	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	5.6	4.9	7.3	12	10	10	12	13	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1.6**	**2.8**	6.0	7.7	7.6	8.3	9.3	11	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.2**	4.7	3.1	5.7	7.0	6.4	7.3	8.5	10	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	6.9	5.3	7.4	10	10	11	12	14	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	3.6	**3.0**	4.2	5.9	5.5	6.2	7.4	8.2	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**2.6**	**2.9**	3.6	5.2	5.1	5.7	6.4	7.4	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	3.3	**2.6**	**3.1**	**4.1**	**3.9**	**4.2**	**4.9**	**5.5**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	3.6	3.2	3.6	5.0	4.5	4.8	5.5	6.5	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**2.1**	3.4	**1.6**	**1.7**	**1.9**	**1.5**	**1.4**	**1.4**	**1.4**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	14	21	16	12	112	384	484	694	1414	1256	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	4.0	3.8	5.0	7.6	7.2	7.9	9.2	11	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	3.8	3.0	5.1	7.5	7.2	8.1	9.3	11	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	**2.5**	10	21	28	28	30	36	42	CMA+DE-MOS [13]
NEWUOA	**1**	**1.5**	**2.8**	**2.0**	**2.5**	**2.9**	**2.4**	**2.2**	**2.3**	**2.2**	NEWUOA [16]
Basic RCGA	**1**	**1.1**	**2.4**	10	36	73	88	132	182	315	Basic RCGA [17]
SPSA	30	46	198	295	846	1989	1524	1398	1375	3664	SPSA [9]

Table 2: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{102}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

102 Sphere moderate unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	1.2	4.0	7.6	9.3	11	12	13	16	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	5.6	5.6	5.9	7.2	8.1	9.5	11	11	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	3.3	3.9	4.6	5.4	6.2	7.1	7.6	8.6	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	3.1	3.1	4.1	4.9	5.4	6.5	7.1	7.6	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	4.3	5.8	5.3	7.4	8.1	8.9	8.6	14	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	3.2	**2.7**	**2.9**	3.6	4.3	5.1	5.6	6.0	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	4.2	3.3	3.3	4.0	4.7	5.2	5.7	6.0	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**2.6**	**2.2**	**2.2**	**3.1**	**3.4**	**3.9**	**4.1**	**4.5**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	3.0	**2.6**	**2.5**	**3.4**	**3.9**	**4.3**	**4.6**	**5.1**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.9**	3.6	**2.8**	**2.9**	**2.6**	**2.8**	**2.7**	**2.5**	**2.2**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	28	45	21	14	15	19	21	149	1947	4298	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	4.2	3.9	4.1	5.3	6.4	7.2	7.7	8.5	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	4.4	4.2	4.4	5.6	6.7	7.8	8.4	8.8	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	**2.5**	11	17	21	25	29	30	34	CMA+DE-MOS [13]
NEWUOA	**1**	**1.5**	5.9	5.7	5.4	7.2	6.8	8.1	9.1	10	NEWUOA [16]
Basic RCGA	**1**	**1.1**	**1.7**	17	29	43	77	115	167	242	Basic RCGA [17]
SPSA	24	38	470	396	697	2079	2142	2293	5383	87971	SPSA [9]

Table 3: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{103}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

103 Sphere moderate Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	1.2	4.3	6.4	6.4	6.4	6.6	7.7	14	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	6.2	5.1	6.7	10	14	18	19	14	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**2.5**	**2.8**	4.5	7.5	10	12	13	10	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**2.7**	3.0	4.4	7.2	8.7	11	12	9.1	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	3.9	4.3	5.2	7.7	12	15	17	13	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	4.0	3.5	4.0	6.1	7.8	10	11	8.5	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**2.5**	**2.1**	3.9	5.8	7.8	9.4	10	**7.3**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1.9**	**2.0**	**2.6**	**4.1**	**5.1**	**6.8**	**6.9**	**5.3**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	3.8	**2.3**	3.3	5.0	6.7	**8.5**	**8.0**	**6.1**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.9**	3.3	**1.7**	**1.6**	**2.0**	**5.6**	9.2	10	9.0	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	17	30	19	16	22	27	34	1298	2202	2619	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**2.4**	**2.9**	4.6	7.8	10	13	13	10	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	4.0	3.5	4.8	7.9	11	14	14	11	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	**2.5**	11	20	31	42	53	62	51	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	3.4	**2.1**	**2.6**	**3.4**	**4.8**	**5.9**	**5.8**	10	NEWUOA [16]
Basic RCGA	**1**	**1.1**	**2.3**	13	39	69	140	225	281	291	Basic RCGA [17]
SPSA	40	142	360	216	228	400	565	1216	4576	11577	SPSA [9]

Table 4: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{104}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

104 Rosenbrock moderate Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	1.4	7.2	10	69	201	212	216	218	219	223	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	4.2	3.1	6.6	10	14	36	50	88	88	86	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.5**	**1.4**	3.9	4.5	5.7	8.2	8.4	8.9	9.0	9.1	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	3.5	**1.6**	**2.4**	**2.5**	6.5	11	11	11	11	11	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	15	9.1	17	15	23	62	116	115	145	143	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**2.7**	**1.5**	**2.2**	5.3	3.3	3.3	3.4	3.5	3.5	3.6	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	3.6	**1.3**	**2.0**	**2.0**	**1.2**	**1.4**	**1.5**	**1.6**	**1.6**	**1.7**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.1**	**1.1**	**1.5**	**1.8**	**1.1**	**1.3**	**1.3**	**1.4**	**1.4**	**1.5**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	3.9	**1.5**	**2.1**	5.6	4.3	5.8	5.8	5.9	5.9	5.9	(1,4s)-CMA-ES [3]
avg NEWUOA	**2.5**	**0.83**	**0.89**	3.0	**2.6**	3.3	3.4	4.1	4.1	4.1	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	61	19	29	138	255	242	239	314	312	315	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**2.4**	**1.2**	**2.7**	**1.9**	**1.3**	**1.5**	**1.7**	**1.8**	**1.9**	**2.0**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**2.7**	**2.1**	3.3	**2.7**	**2.0**	**2.5**	**2.8**	**2.9**	3.1	3.3	IPOP-CMA-ES [15]
CMA+DE-MOS	3.4	3.3	8.6	3.2	**3.0**	3.9	4.6	5.1	5.4	6.1	CMA+DE-MOS [13]
NEWUOA	**2.8**	**0.92**	**0.95**	**0.95**	**2.7**	8.2	18	28	34	40	NEWUOA [16]
Basic RCGA	3.4	4.0	11	40	169	561	1528	1543	*66e-3/5e4*	.	Basic RCGA [17]
SPSA	611	299	28922	*15e+0/1e5*	.	.	.	.	.	.	SPSA [9]

Table 5: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{105}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

105 Rosenbrock moderate unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	1.4	5.6	9.3	169	357	1076	1082	1087	1090	1099	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	4.1	7.1	8.6	4.9	14	13	27	40	40	131	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.6**	7.5	6.2	**1.7**	6.9	8.4	18	22	30	29	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**2.7**	**2.5**	**2.9**	**1.1**	4.6	5.5	13	40	40	40	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	5.9	7.2	7.0	3.8	12	13	25	42	133	*91e-4/1e4*	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	3.5	**2.3**	3.8	3.3	5.6	4.0	7.0	7.3	7.4	7.3	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	3.7	3.1	3.2	**1.9**	**2.8**	**2.2**	**2.2**	**2.7**	**2.7**	**2.7**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.0**	**1.5**	**1.6**	**1.9**	5.3	**2.4**	**2.5**	**2.5**	**2.5**	**2.5**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	4.0	**2.6**	**2.3**	**2.2**	9.1	4.6	8.1	13	16	16	(1,4s)-CMA-ES [3]
avg NEWUOA	**2.7**	**1.8**	**1.8**	**0.75**	**1.6**	3.2	8.2	35	75	*20e-4/6e3*	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	20	9.1	14	126	410	392	603	601	1289	1279	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	3.0	**2.6**	3.5	**1.7**	**1.9**	**0.77**	**0.81**	**0.84**	**0.85**	**0.89**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**2.9**	**2.8**	4.2	**2.4**	4.4	**1.6**	**1.7**	**1.7**	**1.8**	**1.8**	IPOP-CMA-ES [15]
CMA+DE-MOS	3.5	4.2	10	**1.4**	**1.7**	**0.71**	**0.78**	**0.86**	**0.93**	**1.1**	CMA+DE-MOS [13]
NEWUOA	5.0	**2.2**	**1.5**	**0.67**	**1.9**	**2.0**	7.5	21	69	70	NEWUOA [16]
Basic RCGA	**1.4**	5.0	14	11	104	109	220	675	*26e-3/5e4*	.	Basic RCGA [17]
SPSA	514	176	1.51e5	*18e+0/1e5*	.	.	.	.	.	.	SPSA [9]

Table 6: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{106}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

106 Rosenbrock moderate Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	1.4	7.2	10	23	52	148	253	276	431	482	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	5.2	3.6	4.0	11	12	5.8	4.1	4.1	**2.7**	**2.6**	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	3.1	**2.0**	3.8	13	10	4.3	**2.8**	**2.8**	**1.9**	**1.8**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	3.0	**2.3**	4.1	8.3	6.5	**2.9**	**2.0**	**2.0**	**1.3**	**1.3**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	12	9.2	10	40	29	13	8.8	8.8	5.7	5.3	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	5.3	**2.6**	3.1	9.5	6.6	**2.8**	**1.9**	**1.8**	**1.2**	**1.1**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.8**	**1.6**	3.3	9.0	6.1	**2.6**	**1.7**	**1.6**	**1.1**	**1.0**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.7**	**1.2**	**2.1**	5.0	**3.8**	**1.6**	**1.1**	**1.0**	**0.69**	**0.67**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	3.3	**1.4**	**2.3**	7.3	5.4	**2.3**	**1.5**	**1.5**	**0.98**	**0.92**	(1,4s)-CMA-ES [3]
avg NEWUOA	3.1	**1.1**	**1.1**	**2.4**	**1.9**	**1.0**	**2.1**	3.3	5.0	7.5	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	40	17	17	40	24	10	7.1	7.0	4.8	5.4	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**2.8**	**1.5**	**2.7**	**3.7**	**4.3**	**2.0**	**1.3**	**1.3**	**0.90**	**0.90**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	3.2	**2.3**	3.3	5.1	6.5	3.1	**2.1**	**2.1**	**1.4**	**1.4**	IPOP-CMA-ES [15]
CMA+DE-MOS	3.4	3.9	10	8.6	10	4.8	3.0	3.2	**2.2**	**2.4**	CMA+DE-MOS [13]
NEWUOA	3.0	**0.95**	**1.0**	**3.3**	5.6	4.4	7.4	14	13	33	NEWUOA [16]
Basic RCGA	3.2	4.6	14	145	911	1110	2842	*43e-3/5e4*	.	.	Basic RCGA [17]
SPSA	1188	595	815	9052	*19e-1/1e5*	.	.	.	.	.	SPSA [9]

Table 7: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{107}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

107 Sphere Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	2.0	16	51	77	108	138	168	228	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	22	12	10	22	27	45	203	*28e-6/1e4*	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	7.4	**1.9**	**1.9**	**2.1**	**2.1**	**2.7**	3.2	4.1	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	7.0	**2.2**	**2.2**	3.5	4.7	4.6	7.3	8.2	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	5.9	8.4	13	17	48	115	95	642	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	8.9	3.4	**2.9**	3.3	3.5	4.4	6.2	5.8	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	3.7	**1.2**	**0.71**	**0.82**	**0.96**	**1.2**	**1.1**	**1.5**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.1**	14	**2.5**	**1.2**	**1.6**	**1.6**	**1.9**	3.1	4.2	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1.1**	**2.2**	**1.5**	3.7	3.3	3.9	4.4	10	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	17	20	45	115	360	592	*16e-3/6e3*	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	24	37	13	5.0	6.1	14	49	226	555	6150	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**2.0**	5.4	**1.4**	**0.99**	**0.97**	**0.96**	**1.0**	**1.0**	**1.0**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1.7**	**1.2**	**0.80**	**0.96**	**1.0**	**0.95**	**0.98**	**1.0**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	**1.6**	3.3	5.3	7.2	7.2	7.2	7.2	7.0	CMA+DE-MOS [13]
NEWUOA	**1**	**1.1**	12	29	61	65	150	532	*57e-4/5e3*	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.6**	7.8	9.2	11	13	20	26	31	Basic RCGA [17]
SPSA	36	53	199	8554	13692	18097	13131	*11e-1/1e5*	.	.	SPSA [9]

Table 8: 03-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_{108}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

108 Sphere unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.33	0.33	1.9	33	655	1842	3608	5060	5729	10727	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	34	29	53	*15e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	23	24	25	13	37	*84e-3/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	54	25	23	81	*10e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	30	41	19	79	*88e-3/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.1**	30	**10**	6.0	38	*42e-3/1e4*	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	30	19	**5.9**	**14**	*18e-3/1e4*	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.1**	**10**	14	9.3	38	*38e-3/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	35	20	8.6	77	*39e-3/1e4*	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.5**	121	82	126	*39e-2/6e3*	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	1294	1758	2673	269	44	25	**17**	**25**	**44**	68	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	14	**8.4**	**1.8**	**1.1**	**0.96**	**0.80**	**1.1**	**0.81**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.1**	97	11	**1.3**	**1.0**	**0.89**	**0.92**	**1.1**	**1.0**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	**1.6**	66	138	91	61	49	45	**29**	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	108	56	36	*41e-2/5e3*	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**2.1**	**10**	24	20	22	33	129	*18e-4/5e4*	Basic RCGA [17]
SPSA	111	264	275	166	58	390	*28e-3/1e5*	.	.	.	SPSA [9]

Table 9: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{109}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

109 Sphere Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	1.2	6.8	31	48	64	65	84	84	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	5.4	3.5	**2.0**	**1.9**	**2.8**	3.6	3.9	6.8	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	3.9	**2.9**	**1.3**	**1.6**	**1.7**	**2.3**	**2.4**	3.7	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	3.5	**1.8**	**0.83**	**0.96**	**1.1**	**1.4**	**1.5**	**2.4**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	8.9	7.6	**2.5**	3.1	3.5	4.5	6.1	8.3	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**2.4**	**1.9**	**0.92**	**1.1**	**1.2**	**1.8**	**1.7**	3.0	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	4.1	**2.0**	**1.1**	**1.2**	**1.3**	**1.8**	**1.7**	**2.6**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**2.1**	**1.3**	**0.66**	**0.72**	**0.72**	**0.99**	**0.94**	**1.3**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**2.2**	**1.6**	**0.75**	**0.84**	**0.90**	**1.2**	**1.2**	**1.8**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.5**	3.4	7.6	5.9	8.9	17	58	112	262	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	15	30	21	9.5	4.4	33	403	3363	*20e-5/1e5*	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**2.6**	**2.6**	**1.3**	**1.4**	**1.6**	**2.0**	**2.1**	3.1	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	4.5	**2.3**	**1.2**	**1.3**	**1.7**	**2.3**	**2.4**	3.6	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	**2.5**	6.1	4.2	5.6	6.4	10	12	16	CMA+DE-MOS [13]
NEWUOA	**1**	**1.3**	5.3	6.2	6.4	12	34	146	181	*17e-5/5e3*	NEWUOA [16]
Basic RCGA	**1**	**1.1**	3.4	11	11	14	20	27	33	51	Basic RCGA [17]
SPSA	37	157	448	231	1467	1620	3769	6888	*43e-4/1e5*	.	SPSA [9]

Table 10: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{110}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

110 Rosenbrock Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	1.4	8.4	19	307	2092	6819	11776	20403	20660	21190	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	16	11	10	**2.9**	**1.7**	**2.5**	13	*12e-3/1e4*	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	10	4.3	5.5	**1.3**	**1.4**	**1.0**	**1.7**	3.4	*19e-4/1e4*	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	4.4	4.2	3.6	**1.5**	**1.0**	**1.4**	**2.7**	3.3	*43e-4/1e4*	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	4.9	6.9	10	4.5	3.2	3.8	*17e-3/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	6.1	**2.1**	**1.9**	**2.7**	**1.8**	**2.5**	**2.8**	**2.2**	3.4	6.7	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**3.5**	6.5	6.2	**2.4**	**1.3**	**1.5**	3.7	**2.2**	7.0	*43e-4/1e4*	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	28	8.1	4.1	**1.3**	**1.1**	**1.2**	**1.7**	3.5	3.5	3.4	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**2.8**	**1.2**	**2.5**	**2.0**	**1.2**	**0.82**	**2.5**	7.0	*48e-4/1e4*	.	(1,4s)-CMA-ES [3]
avg NEWUOA	18	18	15	6.6	8.4	*34e-2/6e3*	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	119	85	174	60	103	206	*20e-2/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**2.4**	**1.5**	**1.7**	**1.3**	**2.6**	**1.2**	**0.69**	**0.40**	**0.40**	**0.41**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	3.6	**1.7**	**2.1**	**1.7**	4.9	**2.6**	**1.6**	**0.99**	**0.99**	**0.99**	IPOP-CMA-ES [15]
CMA+DE-MOS	3.7	4.5	6.1	4.9	19	7.6	4.4	**2.6**	**2.6**	**2.6**	CMA+DE-MOS [13]
NEWUOA	23	20	24	9.0	4.3	11	*22e-2/5e3*	.	.	.	NEWUOA [16]
Basic RCGA	4.2	5.3	6.8	5.8	20	23	*94e-3/5e4*	.	.	.	Basic RCGA [17]
SPSA	251	123	1625	*35e-1/1e5*	.	.	.	.	.	.	SPSA [9]

Table 11: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{111}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

111 Rosenbrock unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	3.4	17	58	1158	9991	25295	64938	2.00e5	4.76e5	4.91e5	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	17	19	24	128	*19e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	7.2	8.8	16	12	*98e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	24	11	21	16	*14e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	20	29	39	31	*29e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	6.4	6.6	**5.0**	3.9	**4.2**	*27e-2/1e4*	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	8.3	10	5.8	**2.7**	**3.1**	*32e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	16	8.2	9.3	3.0	*35e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	19	7.6	12	11	*85e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	52	66	55	*45e-1/6e3*	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	246	64	94	15	30	27	*13e-2/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	14	13	**5.0**	**0.86**	**4.2**	**10**	**4.7**	**1.8**	**0.88**	**0.90**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**2.3**	**2.1**	**2.3**	**0.95**	16	16	**6.4**	**2.1**	**0.89**	**0.89**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.0**	**2.0**	17	12	17	**12**	30	*98e-3/1e5*	.	.	CMA+DE-MOS [13]
NEWUOA	32	42	85	32	7.8	*74e-1/5e3*	.	.	.	.	NEWUOA [16]
Basic RCGA	**1.3**	**2.3**	12	3.2	4.5	**14**	**5.4**	*91e-3/5e4*	.	.	Basic RCGA [17]
SPSA	113	87	191	*16e-1/1e5*	.	.	.	.	.	.	SPSA [9]

Table 12: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{112}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

112 Rosenbrock Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	1.4	7.2	10	113	523	826	950	993	1035	1178	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	7.7	7.6	17	28	10	8.7	8.0	7.8	8.5	7.8	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**3.0**	**2.6**	3.3	5.8	**2.5**	**2.0**	**1.9**	**2.0**	**2.0**	**1.9**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	5.1	**2.2**	3.5	5.1	**1.7**	**1.4**	**1.4**	**1.4**	**1.4**	**1.3**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	4.5	4.4	8.7	27	12	16	17	21	31	28	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**2.9**	**1.4**	**2.2**	**1.3**	**0.95**	**0.88**	**0.88**	**0.93**	**0.93**	**0.89**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**3.0**	**1.3**	**2.3**	3.1	**1.1**	**0.90**	**0.87**	**0.87**	**0.86**	**0.83**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.9**	**1.2**	**1.9**	**2.1**	**0.76**	**0.58**	**0.56**	**0.56**	**0.56**	**0.52**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	3.1	**1.6**	**2.7**	4.6	**1.5**	**1.2**	**1.1**	**1.1**	**1.1**	**1.0**	(1,4s)-CMA-ES [3]
avg NEWUOA	**2.8**	**0.93**	**2.1**	**2.2**	**1.8**	10	85	*20e-3/6e3*	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	57	24	23	306	571	1699	*26e-2/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	3.0	**1.8**	3.8	**1.6**	**0.79**	**0.70**	**0.72**	**0.74**	**0.76**	**0.76**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	4.2	**2.3**	3.7	4.6	**1.8**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	IPOP-CMA-ES [15]
CMA+DE-MOS	3.4	4.0	10	**2.4**	**1.9**	**1.6**	**1.6**	**1.8**	**1.9**	**2.0**	CMA+DE-MOS [13]
NEWUOA	**2.0**	**0.89**	**1.3**	**1.7**	**1.4**	8.7	37	73	*44e-4/5e3*	.	NEWUOA [16]
Basic RCGA	**2.7**	3.6	11	18	72	93	365	713	*23e-3/5e4*	.	Basic RCGA [17]
SPSA	1314	1782	2830	12462	*29e-1/1e5*	.	.	.	.	.	SPSA [9]

Table 13: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{113}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

113 Step-ellipsoid Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	1.1	8.8	42	649	1031	1079	1079	1079	1143	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**2.5**	11	6.6	11	**2.6**	6.0	11	11	11	15	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1.4**	**1.3**	**2.6**	**4.1**	**0.84**	**2.9**	4.1	4.1	4.1	6.4	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.2**	**2.4**	8.6	7.4	**1.3**	**1.8**	7.3	7.3	7.3	13	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**2.7**	24	12	8.7	3.6	18	41	41	41	125	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.6**	**3.0**	4.2	4.9	**2.0**	**2.3**	3.5	3.5	3.5	3.8	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.1**	**2.5**	**1.1**	5.7	**1.9**	**2.6**	3.4	3.4	3.4	3.4	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.3**	4.4	6.3	4.9	**1.6**	**2.7**	**2.8**	**2.8**	**2.8**	**3.2**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.3**	**2.8**	**2.4**	**4.6**	**1.7**	**2.2**	3.3	3.3	3.3	5.8	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.6**	5.6	8.2	15	8.0	25	75	75	75	*57e-3/6e3*	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	28	14	22	19	82	292	392	392	392	1280	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	20	8.4	**2.0**	7.7	**0.88**	**0.60**	**0.77**	**0.77**	**0.77**	**0.75**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.7**	**2.7**	**1.8**	6.6	**1.9**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.1**	**1.7**	**1.3**	**4.1**	3.4	3.4	3.5	3.5	3.5	3.5	CMA+DE-MOS [13]
NEWUOA	**1.5**	14	7.7	14	5.1	12	70	70	70	*74e-3/5e3*	NEWUOA [16]
Basic RCGA	**1.1**	**1.6**	**2.1**	11	19	39	38	38	38	38	Basic RCGA [17]
SPSA	40	24	18	1660	1007	1374	*71e-2/1e5*	.	.	.	SPSA [9]

Table 14: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{114}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

114 Step-ellipsoid unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.98	8.5	338	2093	6295	9441	9441	9441	10860	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1.1**	5.1	34	11	21	*31e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1.1**	8.2	17	6.9	21	*30e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.1**	63	32	22	23	*22e-2/1e4*	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1.1**	35	30	12	*52e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.3**	67	21	3.6	7.6	23	*11e-2/1e4*	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.8**	**2.2**	**6.7**	**2.5**	**5.7**	**10**	15	15	15	*83e-3/1e4*	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.8**	27	25	4.0	12	*16e-2/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	17	14	19	6.4	10	*22e-2/1e4*	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	143	104	26	*11e-1/6e3*	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	877	2294	553	127	148	*14e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1.4**	34	25	**1.4**	**0.88**	**0.61**	**0.42**	**0.42**	**0.42**	**0.39**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.1**	12	7.1	**2.4**	**1.6**	**0.81**	**0.60**	**0.60**	**0.60**	**0.59**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.1**	**1.9**	**1.9**	9.3	31	20	13	13	13	**14**	CMA+DE-MOS [13]
NEWUOA	**1**	50	71	31	*11e-1/5e3*	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1.5**	**1.8**	**1.6**	8.0	12	14	**12**	**12**	**12**	20	Basic RCGA [17]
SPSA	271	204	223	63	685	*29e-2/1e5*	.	.	.	.	SPSA [9]

Table 15: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{115}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

115 Step-ellipsoid Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.93	4.0	39	198	280	297	297	297	415	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1.7**	3.2	4.9	**2.7**	7.9	41	63	63	63	*54e-4/1e4*	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1.5**	**2.1**	**1.7**	**2.1**	**2.8**	5.8	12	12	12	21	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.1**	**1.5**	**2.9**	**1.4**	**1.6**	5.0	13	13	13	39	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1.5**	3.8	4.3	3.4	3.4	23	50	50	50	169	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.5**	3.6	**2.9**	**1.4**	**1.6**	**2.8**	4.3	4.3	4.3	6.5	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.4**	**2.9**	**2.7**	**0.88**	**1.3**	**1.4**	3.4	3.4	3.4	4.1	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.1**	**1.4**	**2.1**	**1.2**	**0.87**	**1.4**	**1.6**	**1.6**	**1.6**	**2.1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.1**	**1.9**	4.5	**1.9**	**1.6**	**2.5**	3.1	3.1	3.1	5.3	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.5**	3.1	**1.1**	**2.6**	4.9	19	45	45	45	59	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	24	17	20	122	392	1637	4763	4763	4763	3402	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1.2**	**2.7**	**2.0**	**0.88**	**0.91**	**0.80**	**0.90**	**0.90**	**0.90**	**0.78**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.7**	3.2	6.4	**2.4**	**1.8**	**2.4**	**2.4**	**2.4**	**2.4**	**1.9**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.1**	**2.0**	**2.3**	**2.1**	5.0	7.4	7.6	7.6	7.6	5.6	CMA+DE-MOS [13]
NEWUOA	**2.4**	**2.8**	**0.96**	4.0	8.3	66	215	215	215	154	NEWUOA [16]
Basic RCGA	**1.1**	**0.95**	6.1	56	96	145	138	138	138	129	Basic RCGA [17]
SPSA	52	44	49	576	560	1532	*43e-3/1e5*	.	.	.	SPSA [9]

Table 16: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{116}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

116 Ellipsoid Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	6.2	25	56	881	1473	2051	2381	3153	3205	3790	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	14	14	17	9.4	96	*68e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	6.3	11	14	4.0	8.4	10	14	10	46	*54e-3/1e4*	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	11	12	27	5.6	6.8	34	*45e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	14	36	40	13	46	34	63	*61e-2/1e4*	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**2.4**	**2.3**	12	3.8	11	15	18	15	15	19	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	4.6	**5.9**	10	3.1	4.3	4.9	5.4	7.6	14	12	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	11	8.9	11	**1.8**	4.0	4.5	5.5	7.9	10	*96e-5/1e4*	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	17	7.0	**8.2**	**2.2**	3.9	7.1	13	14	*18e-3/1e4*	.	(1,4s)-CMA-ES [3]
avg NEWUOA	19	24	65	28	*30e-1/6e3*	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	1443	1318	1980	1701	*97e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	6.8	6.2	**5.9**	**1.3**	**1.2**	**1.0**	**0.90**	**0.71**	**0.71**	**0.63**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	4.5	7.4	11	**2.8**	**2.5**	**2.1**	**1.9**	**1.5**	**1.5**	**1.3**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.2**	**2.8**	**7.3**	4.4	**3.0**	**2.4**	**2.2**	**1.9**	**2.0**	**1.9**	CMA+DE-MOS [13]
NEWUOA	12	18	45	41	50	*49e-1/5e3*	.	.	.	.	NEWUOA [16]
Basic RCGA	**2.6**	18	61	26	52	65	*67e-3/5e4*	.	.	.	Basic RCGA [17]
SPSA	98	863	4071	1622	*20e+0/1e5*	.	.	.	.	.	SPSA [9]

Table 17: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{117}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

117 Ellipsoid unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	6.2	77	797	4787	13169	18816	20573	23466	24559	26680	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	43	13	16	30	*84e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	13	13	6.7	30	*56e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	12	7.8	13	10	*93e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	38	16	13	*95e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	13	6.8	5.2	14	*34e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	10	**4.6**	5.6	**6.7**	**3.5**	7.9	*18e-1/1e4*	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	32	6.9	**2.7**	*23e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	21	6.0	5.7	9.3	11	*22e-1/1e4*	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	66	48	33	*44e+0/6e3*	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	559	157	361	293	107	*20e+0/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**10**	**2.7**	**1.8**	**0.95**	**0.56**	**0.44**	**0.55**	**0.56**	**0.57**	**0.66**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	20	5.3	**2.3**	**1.0**	**0.66**	**0.66**	**0.64**	**0.60**	**0.62**	**0.68**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.2**	**3.3**	6.6	8.1	4.6	**6.0**	**7.0**	**6.2**	**6.0**	**5.6**	CMA+DE-MOS [13]
NEWUOA	46	27	96	*23e+0/5e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**2.7**	5.5	7.4	10	16	38	35	*57e-2/5e4*	.	.	Basic RCGA [17]
SPSA	314	120	133	*81e-1/1e5*	.	.	.	.	.	.	SPSA [9]

Table 18: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{118}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

118 Ellipsoid Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	4.7	6.8	36	68	237	284	336	392	428	531	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	11	18	9.4	15	7.2	6.5	6.1	5.8	5.6	6.5	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	4.1	8.8	4.2	7.5	3.4	3.4	3.3	**3.0**	3.0	**2.7**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	4.0	7.4	5.5	5.5	**2.0**	**1.8**	**2.0**	**1.9**	**1.8**	**1.6**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	6.9	13	30	46	23	24	27	23	21	20	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	4.1	6.5	**2.6**	3.2	**1.3**	**1.3**	**1.2**	**1.1**	**1.1**	**1.0**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.5**	6.8	3.2	3.5	**1.2**	**1.2**	**1.1**	**1.1**	**1.1**	**0.99**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.4**	**3.4**	**2.0**	**2.3**	**0.92**	**0.83**	**0.78**	**0.71**	**0.71**	**0.66**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.6**	6.0	3.3	**3.0**	**1.1**	**1.0**	**0.93**	**0.85**	**0.82**	**0.75**	(1,4s)-CMA-ES [3]
avg NEWUOA	**0.98**	**1.4**	**1.0**	5.0	5.4	26	77	*43e-4/6e3*	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	38	81	715	2979	2747	4936	*21e-1/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	3.3	4.9	3.4	**3.0**	**1.0**	**0.98**	**0.95**	**0.89**	**0.94**	**0.94**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	4.3	7.9	6.2	6.7	**2.6**	**2.4**	**2.2**	**2.0**	**2.0**	**1.9**	IPOP-CMA-ES [15]
CMA+DE-MOS	3.3	10	6.0	5.2	**1.9**	**2.0**	**2.3**	**2.5**	**2.8**	3.1	CMA+DE-MOS [13]
NEWUOA	**1.3**	**1.4**	**1.7**	3.7	6.5	43	109	*19e-3/5e3*	.	.	NEWUOA [16]
Basic RCGA	**2.3**	78	142	542	672	1269	2227	*75e-2/5e4*	.	.	Basic RCGA [17]
SPSA	126	254	1406	6641	*41e-1/1e5*	.	.	.	.	.	SPSA [9]

Table 19: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{119}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

119 Sum of diff powers Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	0.73	22	140	203	668	1894	4013	5240	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.3**	6.6	4.3	5.3	17	48	*24e-4/1e4*	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	4.8	3.2	**1.7**	4.2	3.2	8.2	17	*14e-5/1e4*	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.1**	**2.2**	**1.5**	**1.4**	**2.9**	4.5	35	*18e-5/1e4*	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.1**	28	6.9	3.7	39	110	*50e-4/1e4*	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**2.1**	9.2	4.3	**1.5**	**3.0**	**2.4**	4.1	18	*63e-6/1e4*	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.3**	4.7	3.2	**0.92**	**1.5**	**2.3**	3.0	3.9	28	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.8**	12	**1.7**	**0.96**	**1.8**	**2.6**	**2.9**	6.1	*48e-6/1e4*	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	3.7	43	3.7	**2.0**	3.2	4.9	9.3	35	*18e-5/1e4*	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	23	8.2	16	51	*13e-3/6e3*	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	24	36	25	24	25	136	193	367	*11e-4/1e5*	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**2.1**	5.5	**1.1**	**0.55**	**0.92**	**0.77**	**0.87**	**0.72**	**0.79**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.9**	8.4	**0.93**	**0.38**	**0.69**	**0.91**	**1.2**	**1.0**	**1.7**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	**1.2**	**1.2**	**2.6**	4.6	**2.1**	**1.0**	**0.68**	**1.0**	CMA+DE-MOS [13]
NEWUOA	**1**	**2.2**	13	18	27	116	114	*31e-3/5e3*	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.3**	**2.4**	6.6	6.2	7.6	9.3	8.9	24	*17e-6/5e4*	Basic RCGA [17]
SPSA	35	55	187	5891	10571	7294	*10e-1/1e5*	.	.	.	SPSA [9]

Table 20: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{120}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

120 Sum of diff powers unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	0.73	27	601	2312	10645	25282	40067	88603	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	41	43	31	31	*11e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	4.0	58	**7.8**	15	*54e-3/1e4*	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.1**	65	31	29	63	*14e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.3**	22	37	28	29	*13e-2/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	3.1	9.0	11	13	62	*71e-3/1e4*	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.4**	27	12	**7.1**	*44e-3/1e4*	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.7**	**5.3**	17	10	61	*31e-3/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	54	18	14	*51e-3/1e4*	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	24	120	66	40	*36e-2/6e3*	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	779	1826	2111	847	151	74	43	58	*11e-3/1e5*	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**2.2**	14	8.3	**1.9**	**1.6**	**0.66**	**0.49**	**0.57**	**0.50**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.3**	8.6	11	**1.9**	**0.97**	**0.60**	**0.54**	**0.53**	**0.77**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	**1.2**	**3.5**	78	38	**15**	**10**	**10**	**4.4**	CMA+DE-MOS [13]
NEWUOA	**1**	**1.7**	120	62	62	*42e-2/5e3*	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.5**	**3.0**	**5.5**	19	**26**	32	*85e-4/5e4*	.	.	Basic RCGA [17]
SPSA	99	281	549	247	338	*12e-2/1e5*	.	.	.	.	SPSA [9]

Table 21: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{121}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

121 Sum of diff powers Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	0.73	14	39	83	233	500	766	1107	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.3**	**2.7**	**1.6**	**1.6**	**2.4**	3.1	**2.9**	3.9	5.3	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	3.0	**1.1**	**1.1**	**1.4**	**1.7**	**2.0**	**2.2**	**3.0**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1.9**	**1.1**	**1.1**	**0.88**	**1.1**	**1.4**	**1.4**	**1.8**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.6**	**2.6**	**2.7**	**2.8**	7.4	7.3	7.1	12	23	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.3**	**1.5**	**0.78**	**0.78**	**1.2**	**1.1**	**1.1**	**0.95**	**1.1**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.3**	3.9	**1.2**	**0.87**	**1.0**	**1.0**	**0.96**	**0.82**	**1.0**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.4**	**2.3**	**0.99**	**0.64**	**0.66**	**0.66**	**0.54**	**0.52**	**0.56**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.5**	4.6	**1.2**	**0.82**	**0.89**	**0.93**	**0.80**	**0.77**	**0.80**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**2.3**	**2.9**	3.5	5.3	27	319	*47e-4/5e3*	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	18	34	29	7.9	4.6	266	886	2818	*11e-4/1e5*	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**2.8**	**1.1**	**0.92**	**1.0**	**0.90**	**0.80**	**0.87**	**0.90**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.1**	4.3	**1.3**	**1.2**	**1.5**	**1.6**	**1.7**	**1.9**	**2.6**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	**1.2**	**1.4**	4.5	4.7	3.2	**2.4**	**2.3**	**2.6**	CMA+DE-MOS [13]
NEWUOA	**1**	**1.2**	3.2	3.6	7.7	43	*62e-4/5e3*	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.4**	**1.5**	**2.6**	13	11	37	43	161	*19e-6/5e4*	Basic RCGA [17]
SPSA	36	101	278	2723	3628	2262	6233	*24e-2/1e5*	.	.	SPSA [9]

Table 22: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{122}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

122 Schaffer F7 Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	1.9	119	601	1439	2532	3458	4081	6336	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	5.3	7.0	6.8	53	*15e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.8**	5.1	**1.6**	5.0	24	*21e-3/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.3**	6.4	3.1	10	47	*35e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.7**	10	5.2	56	*16e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.3**	6.1	3.5	6.1	47	*20e-3/1e4*	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	4.5	**1.9**	**3.6**	9.3	*85e-4/1e4*	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.3**	3.0	**0.74**	5.3	11	58	*18e-3/1e4*	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**2.3**	11	5.1	11	103	*61e-3/1e4*	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**2.1**	13	22	*37e-2/6e3*	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	29	35	11	4.1	49	147	165	406	*52e-3/1e5*	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1.3**	**2.9**	**1.4**	**0.80**	**0.70**	**0.67**	**0.61**	**0.81**	**0.90**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.1**	**1.9**	**1.1**	**1.1**	**0.69**	**0.76**	**0.84**	**0.96**	**1.1**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.3**	**1.5**	**2.7**	9.2	15	15	17	**22**	**17**	CMA+DE-MOS [13]
NEWUOA	**1**	**1.1**	8.5	21	122	*65e-2/5e3*	.	.	.	.	NEWUOA [16]
Basic RCGA	**1.1**	**1.1**	**1.4**	7.9	13	**8.6**	**13**	**16**	87	*67e-6/5e4*	Basic RCGA [17]
SPSA	69	158	103	2636	*20e-1/1e5*	.	.	.	.	.	SPSA [9]

Table 23: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{123}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

123 Schaffer F7 unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	1.6	515	7277	16727	31053	43067	63620	1.47e5	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	5.9	29	11	*73e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**2.3**	34	7.4	*62e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	20	48	5.0	*65e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.2**	49	15	*90e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.5**	27	7.2	19	*34e-2/1e4*	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.4**	**4.6**	**3.1**	*32e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.4**	30	5.2	*45e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	37	82	10	*59e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	12	118	33	*16e-1/6e3*	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	374	549	697	46	**17**	89	*75e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1.1**	25	**2.9**	**0.56**	**0.71**	**0.75**	**0.75**	**0.84**	**0.92**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.4**	8.5	**1.7**	**0.90**	**0.98**	**0.89**	**0.82**	**0.85**	**1.2**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.3**	**1.8**	171	51	**22**	**16**	**16**	**11**	**4.8**	CMA+DE-MOS [13]
NEWUOA	**1**	12	132	20	*12e-1/5e3*	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.2**	**2.2**	13	47	*36e-2/5e4*	.	.	.	.	Basic RCGA [17]
SPSA	64	46353	22910	1289	*14e-1/1e5*	.	.	.	.	.	SPSA [9]

Table 24: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{124}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

124 Schaffer F7 Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	1.2	65	309	1139	2364	3098	4301	4961	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.4**	43	7.4	34	*82e-3/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.5**	**2.3**	**0.46**	**2.7**	4.1	60	*70e-4/1e4*	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.6**	3.9	**2.2**	3.7	7.6	*73e-4/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.3**	6.4	10	78	*13e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.9**	34	17	8.5	11	60	*79e-4/1e4*	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.1**	**2.8**	**0.89**	**2.1**	**2.9**	6.5	46	*10e-4/1e4*	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.4**	3.7	**2.4**	**1.2**	**1.5**	**5.7**	*91e-5/1e4*	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**2.1**	22	**2.6**	4.2	5.5	63	*45e-4/1e4*	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.5**	11	7.7	59	*18e-2/5e3*	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	15	24	16	6.2	30	103	*11e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**2.0**	4.2	**0.54**	**0.82**	**0.50**	**0.55**	**0.87**	**1.2**	**1.4**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.5**	3.2	**0.59**	**2.0**	**1.1**	**0.79**	**0.96**	**1.5**	**2.4**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.3**	**2.4**	**2.5**	27	10	5.8	**5.0**	**5.0**	**5.0**	CMA+DE-MOS [13]
NEWUOA	**1**	**1.5**	5.6	13	36	*14e-2/5e3*	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.2**	**1.8**	4.5	22	11	18	50	170	*80e-5/5e4*	Basic RCGA [17]
SPSA	27	51	6155	2182	4845	*11e-1/1e5*	.	.	.	.	SPSA [9]

Table 25: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{125}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

125 Griewank-Rosenbrock Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	0.33	0.33	0.33	1473	8226	11656	12117	12667	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1**	19	572	6.4	*69e-4/1e4*	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1**	**8.7**	**207**	3.9	18	13	*38e-4/1e4*	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	10	289	**2.8**	18	13	*53e-4/1e4*	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1.3**	11	791	5.8	*68e-4/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	**8.1**	677	4.8	8.6	*55e-4/1e4*	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	10	508	3.1	8.6	13	12	*31e-4/1e4*	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	**8.9**	298	**2.5**	4.0	13	*31e-4/1e4*	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1**	14	556	5.3	18	*69e-4/1e4*	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**1.4**	9.3	326	**1.6**	3.0	6.9	6.7	*40e-4/6e3*	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	30	38	49	79	569	**1.8**	21	38	57	115	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1.3**	9.5	289	**0.69**	**0.67**	**0.70**	**0.76**	**0.75**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1.2**	11	**243**	**1.4**	**1.1**	**0.98**	**0.97**	**0.99**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	13	**222**	**1.8**	4.0	6.3	6.1	**5.9**	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**2.8**	10	332	**0.88**	**2.8**	**2.0**	**1.9**	*19e-4/5e3*	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.3**	9.3	291	**1.0**	5.2	8.1	59	*54e-5/5e4*	Basic RCGA [17]
SPSA	25	38	41	66	21710	14	*36e-4/1e5*	.	.	.	SPSA [9]

Table 26: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{126}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

126 Griewank-Rosenbrock unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	0.33	0.33	0.33	4499	37712	1.11e5	2.08e5	3.20e5	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1.1**	135	3640	15	*26e-3/1e4*	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1**	87	3050	16	*22e-3/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	148	1434	7.1	*20e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1**	209	5363	*38e-3/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1.2**	15	1230	10	*18e-3/1e4*	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	**11**	1618	3.4	*10e-3/1e4*	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	**6.5**	1116	7.3	*12e-3/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	32	97	1584	5.4	*12e-3/1e4*	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**1.7**	258	6248	*49e-3/6e3*	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	630	728	1797	2592	7997	8.5	4.1	6.1	*22e-4/1e5*	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1**	74	933	**0.68**	**0.89**	**0.66**	**0.49**	**0.49**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1**	15	**645**	**0.85**	**0.88**	**0.81**	**0.95**	**0.91**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	16	**237**	**0.11**	15	*27e-4/1e5*	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	13	266	8605	17	*48e-3/5e3*	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.1**	**7.1**	**350**	**0.31**	**0.65**	**1.1**	**3.5**	*15e-5/5e4*	Basic RCGA [17]
SPSA	18	46208	75111	2.01e5	3.07e5	159	*54e-3/1e5*	.	.	.	SPSA [9]

Table 27: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{127}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

127 Griewank-Rosenbrock Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	0.33	0.33	0.33	1168	13028	15016	15116	15332	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1.3**	11	367	6.1	*76e-4/1e4*	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1.1**	6.9	**184**	**2.1**	**1.8**	4.7	4.6	4.6	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	10	644	3.5	5.5	*54e-4/1e4*	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1**	12	644	7.3	11	*73e-4/1e4*	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	**4.8**	423	6.0	5.4	10	9.5	9.4	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1.1**	9.3	417	3.7	5.4	10	10	10	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	**4.7**	217	**1.5**	**2.2**	**2.0**	**2.0**	**1.9**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1**	13	204	4.5	**2.3**	4.5	4.5	4.4	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**2.1**	11	295	4.5	*61e-4/5e3*	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	14	24	30	55	224	10	24	94	*17e-4/1e5*	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1**	**6.4**	**179**	3.7	**1.2**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1**	14	**189**	4.3	**0.83**	**1.4**	**1.5**	**1.5**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	12	190	**0.19**	**1.9**	**2.7**	**2.7**	**2.8**	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**2.1**	18	278	**1.6**	**2.3**	4.3	4.2	*61e-4/4e3*	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.1**	12	293	**1.1**	**2.3**	8.3	15	46	Basic RCGA [17]
SPSA	31	47	82	1530	45810	582	*22e-3/1e5*	.	.	.	SPSA [9]

Table 28: 03-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}\ 2009}$ on f_{128}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

128 Gallagher Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.33	0.33	1.8	142	375	449	639	903	905	1447	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	4.7	3.7	**2.3**	4.7	4.7	6.8	7.1	7.7	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1.9**	**1.6**	**2.3**	**2.5**	**1.8**	**1.4**	**1.7**	**1.1**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**2.3**	**2.9**	4.0	3.7	3.1	**2.3**	**2.6**	**1.9**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	3.5	3.1	3.4	5.7	5.0	3.9	3.9	4.3	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**2.6**	**2.7**	**2.4**	**2.5**	**1.8**	**1.3**	**1.3**	**0.91**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**2.0**	3.3	4.1	4.0	**2.8**	**2.4**	**2.4**	**1.9**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	3.6	3.1	3.1	**3.6**	**2.5**	**1.9**	**1.9**	**1.2**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**2.7**	3.1	4.8	4.8	3.7	**2.7**	**2.8**	**2.4**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	4.3	10	19	25	18	17	45	*45e-3/6e3*	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	30	40	12	14	48	84	146	264	471	*90e-5/1e5*	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1.2**	7.3	16	36	26	76	76	48	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**2.2**	7.3	12	11	15	11	11	7.3	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**2.3**	33	52	46	32	24	24	16	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**1.7**	7.0	9.1	14	35	84	*89e-4/5e3*	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.3**	18	33	58	49	35	43	41	Basic RCGA [17]
SPSA	20	31	150	1406	1931	3251	2283	*13e-1/1e5*	.	.	SPSA [9]

Table 29: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{129}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

129 Gallagher unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	1.6	121	1131	2617	3861	8261	9454	12845	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	53	15	5.2	54	*23e-3/1e4*	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	21	13	4.8	17	36	*61e-3/1e4*	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	31	18	7.9	18	38	*27e-3/1e4*	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	28	25	11	28	*90e-3/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	14	14	**4.0**	5.7	**11**	18	15	*11e-3/1e4*	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	5.1	**7.3**	**3.2**	**5.3**	12	**8.5**	*47e-4/1e4*	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	10	11	**4.5**	6.2	37	*30e-3/1e4*	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	22	**11**	5.5	7.6	38	18	*14e-3/1e4*	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	51	34	12	15	21	**10**	*23e-2/6e3*	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	181	2286	6231	223	74	45	88	56	157	116	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1.4**	**5.9**	5.0	**2.8**	**12**	**10**	**9.1**	**6.9**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	7.5	12	4.7	**3.3**	**6.1**	13	**11**	**22**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**2.4**	239	81	72	77	51	45	48	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	56	63	21	30	21	*79e-2/5e3*	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.6**	11	12	11	24	14	**13**	**27**	Basic RCGA [17]
SPSA	54	279	1008	171	308	271	*14e-2/1e5*	.	.	.	SPSA [9]

Table 30: 03-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{130}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

130 Gallagher Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.33	0.33	1.8	82	172	305	501	2264	3981	4782	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	**2.9**	38	43	24	15	3.4	**2.3**	**2.0**	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**2.7**	17	14	**7.9**	5.5	**1.2**	**0.71**	**0.60**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1.2**	8.1	**10**	10	5.9	**1.7**	**0.97**	**0.82**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	4.0	32	53	31	19	5.0	**2.8**	**2.4**	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	21	10	13	10	6.0	**1.3**	**0.76**	**0.64**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**2.1**	11	15	8.6	**5.2**	**1.2**	**0.67**	**0.56**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	14	8.5	**7.6**	**5.2**	**3.2**	**0.70**	**0.40**	**0.34**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**2.4**	**7.7**	15	**8.4**	**5.2**	**1.1**	**0.65**	**0.55**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**2.6**	**3.9**	12	8.5	11	5.6	5.7	*90e-5/5e3*	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	22	37	12	54	155	216	204	131	104	*99e-5/1e5*	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**2.3**	19	46	51	57	35	20	17	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	3.1	53	57	33	153	34	19	16	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.8**	90	332	398	389	86	87	73	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**2.0**	**3.0**	**9.4**	18	21	6.6	17	*86e-4/5e3*	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.3**	15	84	132	139	31	23	26	Basic RCGA [17]
SPSA	15	30	103	523	486	574	1367	648	369	*51e-3/1e5*	SPSA [9]

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