Comparison tables: BBOB 2010 noisy testbed in 5-D

The BBOBies

August 30, 2010

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 [10, 6]. The experimental set-up is described in [9].

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. Consequently, the best (smallest) value is 1 and the value 1 appears in each column at least once. See [9] for details on how ERT is obtained. Bold entries in the table correspond to values below 3 or the top-three best values.

Table 1: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	5.2	11	14	17	19	20	21	23	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.2**	3.5	**3.0**	4.1	4.8	5.6	6.6	7.2	8.5	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	3.1	**1.8**	**2.3**	3.2	3.5	3.9	4.3	4.8	5.7	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1.6**	**2.0**	**2.6**	**3.0**	3.3	3.8	4.3	5.0	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**2.9**	3.2	4.3	4.7	5.0	5.8	6.3	7.8	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1.2**	**1.9**	**2.3**	**2.7**	3.0	3.6	4.0	4.6	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.3**	**1**	**1.4**	**1.8**	**2.3**	**2.7**	**2.9**	3.3	4.1	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.2**	**1.0**	**1.1**	**1.5**	**1.7**	**2.0**	**2.3**	**2.5**	**3.0**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	3.3	**1.1**	**1.4**	**1.7**	**2.0**	**2.3**	**2.6**	**2.9**	3.5	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**2.6**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	41	61	9.5	8.6	9.1	10	11	12	13	16	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1.2**	**1.2**	**2.0**	**2.7**	3.4	3.8	4.4	4.9	6.0	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.2**	**1.4**	**2.3**	**3.0**	3.5	4.0	4.5	5.1	6.0	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	3.1	7.9	12	13	16	18	20	24	CMA+DE-MOS [12]
NEWUOA	**1**	3.6	**1.1**	**1.1**	**1.3**	**1.5**	**1.7**	**1.9**	**1.9**	**2.0**	NEWUOA [15]
Basic RCGA	**1**	**1.1**	3.3	17	31	52	75	102	133	189	Basic RCGA [16]
SPSA	40	64	35	117	246	255	301	325	368	6241	SPSA [8]

Table 2: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	5.1	10	15	19	22	24	27	30	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.4**	4.0	4.0	4.3	4.6	5.1	5.9	6.2	7.1	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.4**	**1.7**	**2.3**	**2.4**	**3.0**	3.2	3.5	3.9	4.5	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**2.4**	**1.8**	**2.3**	**2.7**	**2.8**	3.1	3.3	3.5	4.1	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**2.3**	**1.8**	3.6	4.4	4.6	5.3	5.6	6.0	6.9	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1.4**	**1.7**	**2.0**	**2.1**	**2.4**	**2.7**	**3.0**	3.5	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.7**	**1.0**	**1.6**	**1.9**	**1.9**	**2.3**	**2.5**	**2.6**	**3.0**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	**1.2**	**1.4**	**1.7**	**1.8**	**2.0**	**2.0**	**2.4**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.6**	**1.2**	**1.4**	**1.6**	**1.9**	**2.1**	**2.2**	**2.3**	**2.9**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.3**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	45	79	9.1	10	10	10	10	11	12	13	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1.4**	**1.5**	**2.3**	**2.6**	3.1	3.3	3.8	3.9	4.6	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.5**	**1.5**	**2.2**	**2.8**	**3.0**	3.3	3.9	4.2	4.8	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	**2.5**	8.7	11	12	14	15	16	18	CMA+DE-MOS [12]
NEWUOA	**1**	3.9	**2.7**	4.1	4.8	11	13	18	21	27	NEWUOA [15]
Basic RCGA	**1**	**1.2**	4.5	20	27	40	58	80	99	138	Basic RCGA [16]
SPSA	41	60	863	3390	6811	6831	6080	7162	15738	*31e-3/1e5*	SPSA [8]

Table 3: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	4.7	8.7	21	29	38	48	57	79	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.5**	**2.9**	4.2	**2.6**	**2.8**	**3.0**	**2.9**	3.1	3.0	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**2.5**	**1.6**	**2.4**	**1.6**	**1.7**	**1.7**	**1.8**	**1.8**	**1.8**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1.8**	**2.3**	**1.6**	**1.5**	**1.5**	**1.6**	**1.6**	**1.6**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**2.1**	3.8	4.4	**2.8**	**2.6**	**2.6**	**2.7**	**2.7**	**2.7**	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.6**	**1**	**1.9**	**1.3**	**1.3**	**1.4**	**1.4**	**1.5**	**1.5**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.3**	**1.2**	**1.8**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.2**	**1.1**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.6**	**1.4**	**1.8**	**1.4**	**1.4**	**1.3**	**1.3**	**1.3**	**1.2**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**2.5**	**1.2**	**1**	**1.0**	**1.1**	**2.1**	3.4	5.1	10	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	32	57	9.1	10	5.7	5.5	5.0	4.9	5.2	5.9	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1**	**1.3**	**2.6**	**1.8**	**1.8**	**1.8**	**1.8**	**1.9**	**1.9**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.4**	**1.7**	**2.5**	**1.9**	**1.9**	**2.0**	**2.1**	**2.1**	**2.1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	3.5	8.4	7.9	7.7	7.8	8.0	8.8	8.8	CMA+DE-MOS [12]
NEWUOA	**1**	3.5	**1.1**	**1.2**	**1.6**	**1.9**	10	11	22	40	NEWUOA [15]
Basic RCGA	**1**	**1.3**	3.3	17	17	27	38	47	53	65	Basic RCGA [16]
SPSA	51	202	70	76	48	52	68	698	11449	*42e-6/1e5*	SPSA [8]

Table 4: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	4.2	24	36	308	437	513	556	585	605	643	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	6.5	3.5	3.8	6.6	32	136	*98e-3/1e4*	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.7**	3.8	3.2	**2.1**	7.6	8.7	8.2	8.3	8.1	7.7	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**2.9**	**1.3**	**1.6**	4.7	8.5	15	15	14	14	13	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	3.7	3.7	3.5	6.4	30	60	261	*69e-3/1e4*	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.8**	**1.7**	**1.5**	**2.1**	**2.9**	**2.6**	4.2	4.0	3.9	3.7	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.2**	**1.6**	**1.4**	**2.5**	**2.0**	**2.4**	**2.3**	**2.2**	**2.1**	**2.0**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.0**	**1.4**	**1.3**	**2.1**	**2.9**	**2.6**	**2.4**	**2.3**	**2.3**	**2.1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.5**	**1.2**	**1.3**	4.5	8.3	11	10	10	9.4	8.9	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.2**	**1.3**	**1**	**2.5**	4.5	8.6	14	14	13	17	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	20	5.9	5.4	292	264	225	208	198	191	180	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**3.0**	**1.3**	**1.5**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1.9**	**1**	**1.3**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	IPOP-CMA-ES [14]
CMA+DE-MOS	5.5	3.9	5.0	**2.0**	**2.1**	**2.0**	**2.0**	**2.0**	**2.0**	**2.1**	CMA+DE-MOS [12]
NEWUOA	**1**	**1.3**	**1.2**	**1.7**	3.5	8.4	15	66	*14e-4/5e3*	.	NEWUOA [15]
Basic RCGA	6.5	3.6	10	191	254	663	613	1245	*12e-1/5e4*	.	Basic RCGA [16]
SPSA	173	68	*36e+0/1e5*	.	.	.	.	.	.	.	SPSA [8]

Table 5: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	3.3	18	34	680	1331	1414	1463	1499	1525	1576	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	9.1	3.4	3.0	3.3	15	49	100	97	*18e-2/1e4*	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	4.9	**2.6**	**2.0**	**2.5**	7.6	14	29	*88e-3/1e4*	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	3.8	3.0	**2.1**	**1.5**	3.9	33	*38e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	7.2	**2.4**	4.8	4.3	15	*14e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	3.9	4.1	**2.7**	5.2	11	23	49	100	*14e-2/1e4*	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.7**	4.1	**2.6**	**2.5**	9.2	30	48	47	95	92	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.6**	**1.3**	**1**	**1.8**	6.8	32	98	96	94	91	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.9**	**1**	**1.6**	**2.8**	12	32	99	97	*12e-2/1e4*	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.4**	**2.5**	**1.7**	**1**	**1.5**	6.2	21	66	65	*45e-4/7e3*	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	22	8.2	5.6	418	1054	992	959	936	920	890	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**2.0**	3.6	**2.7**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**2.5**	**1.8**	**1.6**	**1.6**	**1.2**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	IPOP-CMA-ES [14]
CMA+DE-MOS	6.9	4.7	4.7	**2.5**	**1.7**	**1.9**	**2.2**	**2.2**	**2.2**	**2.3**	CMA+DE-MOS [12]
NEWUOA	**1**	**1.9**	**1.6**	**1.1**	**2.6**	7.1	*38e-3/5e3*	.	.	.	NEWUOA [15]
Basic RCGA	9.2	7.4	13	45	94	259	251	*51e-2/5e4*	.	.	Basic RCGA [16]
SPSA	550	172	*36e+0/1e5*	.	.	.	.	.	.	.	SPSA [8]

Table 6: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	3.8	10	16	161	296	339	361	378	393	415	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	5.0	9.5	8.3	8.6	6.1	6.0	6.0	5.9	5.8	5.7	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	4.1	5.1	4.7	**2.0**	**1.8**	**1.9**	**1.9**	**2.0**	**2.0**	**2.0**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**2.0**	3.3	3.8	**2.1**	**1.7**	**1.7**	**1.8**	**1.8**	**1.8**	**1.8**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	6.6	9.0	9.3	5.6	4.8	4.9	5.0	5.0	5.0	5.0	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**2.2**	3.2	3.1	**2.3**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.6**	**1.8**	**2.3**	**1.9**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.5**	**1.3**	**1.5**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**2.2**	**1.6**	**2.5**	**1.2**	**1.0**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.8**	**1.2**	**1**	**1**	**1.7**	6.0	13	45	293	*21e-5/8e3*	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	15	11	10	4.9	3.5	23	22	21	21	21	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1.9**	**2.3**	**2.8**	**1.2**	**1.1**	**1.2**	**1.3**	**1.3**	**1.3**	**1.4**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1.9**	**2.8**	3.6	**1.7**	**1.6**	**1.8**	**1.8**	**1.9**	**1.9**	**1.9**	IPOP-CMA-ES [14]
CMA+DE-MOS	5.5	6.3	10	3.5	**2.9**	**2.9**	3.0	3.1	3.2	3.5	CMA+DE-MOS [12]
NEWUOA	**1**	**1**	**1.1**	**1.5**	3.5	28	87	*79e-4/7e3*	.	.	NEWUOA [15]
Basic RCGA	7.1	10	25	238	339	512	977	*44e-2/5e4*	.	.	Basic RCGA [16]
SPSA	568	1872	2419	*26e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 7: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	13	45	99	174	251	281	331	414	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.3**	11	44	302	*18e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**2.3**	7.9	6.1	23	57	262	*91e-5/1e4*	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	3.8	7.8	19	35	106	243	438	*17e-4/1e4*	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	7.5	45	414	*23e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.9**	8.2	9.1	12	19	43	91	*62e-5/1e4*	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	3.3	3.9	7.1	4.8	**5.7**	10	**12**	23	351	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	3.1	4.9	4.8	6.7	**8.8**	22	58	351	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.1**	8.5	10	24	64	92	504	*66e-4/1e4*	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**2.7**	41	323	*14e-1/6e3*	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	52	72	**2.8**	**2.5**	**4.5**	9.0	38	103	226	972	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1.2**	**1.2**	**2.8**	**1.8**	**1.3**	**1.1**	**1.1**	**1.1**	**1.2**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**2.0**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	**1.9**	24	19	13	14	16	16	16	CMA+DE-MOS [12]
NEWUOA	**1**	**2.7**	37	197	*17e-1/5e3*	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1.5**	**1**	11	9.5	9.1	9.4	12	**14**	**16**	Basic RCGA [16]
SPSA	50	82	5176	*88e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 8: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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
ERT$_{\text{best}}$/D	0.20	0.20	14	703	1855	3138	3952	5735	7305	11152	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.7**	55	*23e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**2.7**	34	33	*18e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.1**	40	64	*19e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**2.8**	114	101	*22e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.7**	**7.5**	23	80	*11e-1/1e4*	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.4**	31	**11**	*84e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	3.7	20	19	*94e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**2.7**	31	100	*15e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	3.0	195	64	*27e-1/6e3*	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	5825	9728	366	20	**12**	**11**	**14**	**15**	**21**	**67**	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	12	13	**1**	**1**	**1.0**	**1**	**1.1**	**1.1**	**1.4**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.7**	11	**1.2**	**1.1**	**1**	**1.2**	**1**	**1**	**1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	**3.1**	139	195	247	418	288	227	*89e-2/1e5*	CMA+DE-MOS [12]
NEWUOA	**1**	48	97	93	*41e-1/5e3*	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1**	**1**	19	47	111	*16e-2/5e4*	.	.	.	Basic RCGA [16]
SPSA	436	1305	112	14	378	*15e-2/1e5*	.	.	.	.	SPSA [8]

Table 9: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	4.2	13	24	39	57	74	91	127	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**2.7**	**2.9**	**2.4**	3.2	3.7	3.9	4.8	4.7	5.1	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	3.3	**2.2**	**2.2**	**2.2**	**2.0**	**2.1**	**2.0**	**1.9**	**2.0**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.3**	**1.8**	**1.9**	**1.8**	**1.6**	**1.6**	**1.7**	**1.7**	**1.6**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	3.1	3.1	3.6	3.8	4.5	4.6	4.6	5.1	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.1**	**1.8**	**2.0**	**1.8**	**1.9**	**2.0**	**2.1**	**2.2**	**2.1**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1.5**	**1.2**	**1.4**	**1.6**	**1.6**	**1.7**	**1.8**	**1.8**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.2**	**1.6**	**1.2**	**1.4**	**1.4**	**1.4**	**1.3**	**1.3**	**1.3**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.5**	**2.2**	3.1	46	90	*67e-4/6e3*	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	41	62	11	7.3	5.5	210	4881	*17e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1.1**	**1.6**	**1.7**	**1.9**	**2.0**	**1.9**	**2.0**	**2.2**	**2.3**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**1.5**	**1.9**	**2.0**	**2.1**	**2.1**	**2.2**	**2.2**	**2.2**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	3.2	7.7	8.6	9.3	9.4	10	10	11	CMA+DE-MOS [12]
NEWUOA	**1**	**1.7**	**2.6**	11	148	1690	*41e-3/5e3*	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1.3**	4.7	18	22	27	32	38	48	80	Basic RCGA [16]
SPSA	50	101	73	839	6210	*13e-2/1e5*	.	.	.	.	SPSA [8]

Table 10: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	7.9	31	103	4452	24292	68291	85486	86710	87738	89816	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	22	12	59	*69e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	3.8	6.0	6.2	3.5	**2.8**	**1**	*10e-1/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	7.6	4.8	3.9	**2.3**	**2.8**	**2.1**	*67e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	32	32	84	*92e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	10	7.7	5.5	**2.0**	5.9	**2.1**	*74e-2/1e4*	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	5.5	5.5	**2.8**	**1**	**1.0**	**2.1**	*37e-2/1e4*	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.0**	**3.0**	**3.0**	**1.6**	**1**	**2.2**	*28e-2/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	4.6	3.6	6.7	**2.5**	**2.7**	*79e-2/1e4*	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	25	52	443	*27e+0/6e3*	.	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	76	56	23	*33e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1.3**	**1.7**	**1**	6.6	3.2	**1.4**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**1.3**	13	3.4	**1.2**	**1**	**1**	**1**	**1**	IPOP-CMA-ES [14]
CMA+DE-MOS	3.8	7.1	19	55	65	23	**18**	**18**	**18**	**18**	CMA+DE-MOS [12]
NEWUOA	21	35	216	16	*13e+0/5e3*	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**2.8**	4.8	8.9	52	30	11	*18e-1/5e4*	.	.	.	Basic RCGA [16]
SPSA	113	440	13632	*31e+0/1e5*	.	.	.	.	.	.	SPSA [8]

Table 11: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	35	230	738	3.40e5	1.57e6	1.48e7	1.48e7	1.48e7	1.48e7	1.49e7	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	19	107	*12e+1/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	11	24	*71e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	18	33	*72e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	25	75	*10e+1/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	9.0	10	101	*20e+0/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	3.9	7.6	40	*18e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	4.7	10	55	*22e+0/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	9.3	20	194	*42e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	56	56	*20e+1/6e3*	.	.	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	48	36	40	4.2	*36e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1.4**	**1.5**	**1**	**2.6**	**8.9**	*88e-2/1e6*	.	.	.	.	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**1.4**	5.4	**4.4**	**1**	**1**	**1**	**1**	**1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**2.6**	31	30	**1**	**1**	*20e-1/1e5*	.	.	.	.	CMA+DE-MOS [12]
NEWUOA	31	90	*36e+1/5e3*	.	.	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1.1**	**2.4**	**4.5**	**2.2**	*26e-1/5e4*	.	.	.	.	.	Basic RCGA [16]
SPSA	31	56	1976	*20e+0/1e5*	.	.	.	.	.	.	SPSA [8]

Table 12: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	3.3	10	38	387	555	633	683	714	738	779	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	5.1	13	4.5	8.1	8.6	10	10	10	10	10	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**3.0**	**3.0**	**1.3**	**2.3**	**2.5**	**2.6**	**2.8**	**2.7**	**2.7**	**2.8**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	3.8	4.2	**1.5**	**1.5**	**1.7**	**1.7**	**1.7**	**1.8**	**1.8**	**1.8**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	10	9.2	3.6	7.5	13	15	19	18	18	17	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**2.6**	**2.5**	**1**	**2.1**	**2.2**	**2.2**	**2.3**	**2.3**	**2.3**	**2.3**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.8**	**2.6**	**1.1**	**1.0**	**1.3**	**1.4**	**1.4**	**1.4**	**1.4**	**1.5**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.1**	3.2	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.7**	**2.5**	**1.0**	**1.3**	**1.4**	**1.4**	**1.5**	**1.5**	**1.5**	**1.5**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.5**	**2.5**	**1.7**	4.2	29	145	*14e-2/7e3*	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	23	11	4.0	720	1185	*20e-1/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	3.1	**2.8**	**1.3**	**1.1**	**1.3**	**1.5**	**1.5**	**1.5**	**1.6**	**1.6**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	3.1	**2.8**	**1.2**	**1.2**	**1.7**	**1.9**	**2.0**	**2.0**	**2.1**	**2.1**	IPOP-CMA-ES [14]
CMA+DE-MOS	6.7	6.9	4.1	**2.3**	**2.7**	3.0	3.1	3.3	3.4	3.9	CMA+DE-MOS [12]
NEWUOA	**1**	**1**	**1.1**	6.7	130	*44e-2/5e3*	.	.	.	.	NEWUOA [15]
Basic RCGA	8.2	11	14	113	214	1130	*70e-2/5e4*	.	.	.	Basic RCGA [16]
SPSA	354	512	604	*45e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 13: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	3.4	97	293	1238	1313	1535	1535	1535	1557	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	4.4	14	5.4	65	*11e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1.9**	8.3	**1.9**	4.0	16	112	*12e-2/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.1**	3.5	**1.7**	4.4	34	109	*18e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1.1**	9.3	5.7	48	*91e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.4**	3.5	**2.4**	4.2	14	51	92	92	92	*19e-2/1e4*	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.3**	**2.6**	**1.2**	**3.6**	**6.4**	52	44	44	44	45	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.8**	**1.1**	**1.8**	5.2	11	51	44	44	44	43	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	9.2	**1.6**	8.3	13	56	48	48	48	48	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.7**	13	3.9	40	72	*13e-1/6e3*	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	67	7.3	5.3	169	328	*58e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**2.9**	**2.6**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1.4**	**1.1**	**1**	**1.8**	**1.9**	**2.2**	**2.1**	**2.1**	**2.1**	**2.1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1.5**	**1**	7.0	15	10	**13**	**13**	**13**	**13**	**13**	CMA+DE-MOS [12]
NEWUOA	**2.1**	8.1	3.6	57	*18e-1/5e3*	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1.7**	**1.1**	**2.7**	28	30	67	109	109	109	149	Basic RCGA [16]
SPSA	72	13	516	*56e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 14: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	2.9	490	1317	5378	9801	10047	10047	10047	10293	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1.3**	116	32	*11e+0/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1.5**	70	7.9	*63e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.3**	112	17	*79e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	38	45	18	*73e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**2.3**	44	5.7	*46e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.3**	**14**	4.3	*30e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	53	21	5.9	112	*21e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.4**	18	6.6	*53e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.3**	91	23	*11e+0/6e3*	.	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	1787	581	47	135	*19e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1.3**	28	**1.0**	**1.4**	**1.0**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1.3**	33	**1**	**1**	**1**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1.5**	**2.0**	19	290	71	**52**	**79**	**79**	**79**	**78**	CMA+DE-MOS [12]
NEWUOA	**1**	121	14	*89e-1/5e3*	.	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1.2**	**1**	**3.7**	**35**	**65**	*41e-2/5e4*	.	.	.	.	Basic RCGA [16]
SPSA	1025	428	57	548	*29e-1/1e5*	.	.	.	.	.	SPSA [8]

Table 15: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.23	2.3	14	79	415	495	702	702	702	896	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1.9**	3.3	4.9	7.0	58	*13e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1.5**	**2.2**	**1.7**	**3.0**	5.8	50	99	99	99	159	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**2.6**	**2.6**	**2.1**	**1.9**	6.6	41	64	64	64	164	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1.2**	**2.6**	4.4	13	44	*17e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.7**	**1.5**	**1.6**	**2.1**	4.9	21	97	97	97	79	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.4**	**1.2**	**1.1**	**1.7**	**2.2**	**12**	19	19	19	46	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.5**	**1.2**	**2.7**	**2.0**	4.1	23	35	35	35	37	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.5**	**1.4**	**1.8**	**2.2**	6.1	41	65	65	65	*11e-3/1e4*	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.3**	**1**	5.2	24	*10e-2/6e3*	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	55	11	7.9	521	1588	2865	2019	2019	2019	*31e-2/1e5*	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1.1**	**1.7**	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1.1**	**1**	**1.5**	**2.9**	**2.4**	**2.7**	**2.2**	**2.2**	**2.2**	**1.8**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1.4**	**2.1**	4.9	23	28	23	**17**	**17**	**17**	**13**	CMA+DE-MOS [12]
NEWUOA	**1.9**	**1.1**	**2.7**	17	37	*34e-2/4e3*	.	.	.	.	NEWUOA [15]
Basic RCGA	**1.2**	**1.5**	68	84	96	707	511	511	511	400	Basic RCGA [16]
SPSA	51	55	204	2021	3406	*12e-1/1e5*	.	.	.	.	SPSA [8]

Table 16: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	48	293	1012	1794	2524	3093	3918	4024	4139	4325	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	14	20	*42e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	3.9	4.6	9.0	26	*37e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	4.9	7.6	30	81	*17e+0/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	19	33	142	*72e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	3.4	4.8	7.4	24	*57e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.4**	**2.6**	**4.4**	18	*33e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.9**	3.9	4.6	**10**	57	46	37	*28e-1/1e4*	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	4.4	5.1	11	*86e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	14	32	*95e+0/6e3*	.	.	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	270	4821	*33e+1/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1.8**	3.5	**3.5**	**3.8**	**3.3**	**3.0**	**2.5**	**2.5**	**2.5**	**2.5**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.3**	9.4	10	**8.6**	**9.0**	**7.1**	**7.0**	**6.8**	**6.6**	CMA+DE-MOS [12]
NEWUOA	13	18	*74e+0/5e3*	.	.	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**2.1**	19	33	88	285	*22e-1/5e4*	.	.	.	.	Basic RCGA [16]
SPSA	957	4910	*74e+1/1e5*	.	.	.	.	.	.	.	SPSA [8]

Table 17: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	61	1297	3481	7328	9644	11204	12787	13732	14995	17590	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	52	54	*32e+1/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	16	33	*19e+1/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	25	113	*31e+1/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	58	111	*31e+1/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	6.3	19	*13e+1/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	7.5	**6.6**	*82e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	6.5	23	*13e+1/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	12	16	*14e+1/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	21	67	*30e+1/6e3*	.	.	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	406	206	206	*14e+1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	4.6	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**3.7**	**1**	**1.6**	**2.0**	**1.8**	**1.6**	**1.6**	**1.6**	**1.5**	**1.5**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	18	24	**18**	**20**	**17**	**15**	**14**	**15**	**13**	CMA+DE-MOS [12]
NEWUOA	23	*41e+1/5e3*	.	.	.	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**2.8**	6.8	**19**	100	*45e-1/5e4*	.	.	.	.	.	Basic RCGA [16]
SPSA	354	151	*13e+1/1e5*	.	.	.	.	.	.	.	SPSA [8]

Table 18: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	5.3	11	98	173	241	277	302	323	339	382	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	7.6	16	8.0	9.1	8.2	9.3	10	11	12	13	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	7.7	11	4.0	3.4	**2.9**	**2.9**	**2.9**	**2.8**	**2.8**	**2.8**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	6.3	7.4	**2.3**	**2.3**	**2.4**	**2.3**	**2.3**	**2.2**	**2.2**	**2.1**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	8.2	17	16	14	20	21	26	33	56	68	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	4.3	7.2	**2.0**	**2.0**	**1.7**	**1.8**	**1.8**	**1.8**	**1.8**	**1.9**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	3.2	5.9	**1.7**	**1.7**	**1.4**	**1.4**	**1.4**	**1.5**	**1.5**	**1.5**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.6**	**4.3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	4.6	7.3	**1.7**	**1.4**	**1.2**	**1.2**	**1.3**	**1.3**	**1.3**	**1.3**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.2**	**1**	**1.6**	12	83	*18e-2/7e3*	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	34	708	295	874	1149	5059	*21e-1/1e5*	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	3.1	6.3	**1.5**	**1.2**	**1.2**	**1.2**	**1.2**	**1.3**	**1.3**	**1.4**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	3.7	9.2	**2.8**	**2.8**	**2.5**	**2.6**	**2.6**	**2.6**	**2.7**	**2.6**	IPOP-CMA-ES [14]
CMA+DE-MOS	10	17	3.2	**2.5**	**2.2**	**2.3**	**2.8**	3.2	3.6	4.2	CMA+DE-MOS [12]
NEWUOA	**1**	**1.3**	3.8	15	151	*30e-2/5e3*	.	.	.	.	NEWUOA [15]
Basic RCGA	6.8	534	432	2000	*45e-1/5e4*	.	.	.	.	.	Basic RCGA [16]
SPSA	57	262	2263	*18e+0/1e5*	.	.	.	.	.	.	SPSA [8]

Table 19: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	2.7	46	131	356	1131	3165	3431	6022	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.1**	13	22	150	*12e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**2.5**	5.6	7.1	11	92	*16e-3/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**2.6**	4.4	7.7	26	88	*18e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	11	30	30	1087	*20e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.1**	8.4	6.4	18	39	*62e-4/1e4*	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.9**	13	**3.1**	**6.4**	**10**	40	45	*42e-4/1e4*	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**2.1**	7.7	5.5	10	17	125	*55e-4/1e4*	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	5.2	12	20	117	*23e-3/1e4*	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	3.4	16	67	*42e-2/6e3*	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	62	92	13	27	45	172	181	*23e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**2.4**	**1.3**	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**1**	**1**	**1.2**	**1.0**	**1.5**	**1.5**	**2.1**	**2.3**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.2**	**2.2**	143	58	29	12	**6.4**	**6.9**	**4.1**	CMA+DE-MOS [12]
NEWUOA	**1**	**1.7**	23	100	*90e-2/5e3*	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1.2**	**1.2**	18	19	11	**11**	40	*20e-5/5e4*	.	Basic RCGA [16]
SPSA	51	67	2680	*32e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 20: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.21	2.8	443	2447	5038	9959	16295	28976	72546	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.4**	89	43	*14e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	32	53	104	61	*11e-1/1e4*	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.6**	40	34	*10e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	59	59	44	*14e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	10	41	21	*77e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**2.7**	15	**8.6**	*66e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	52	74	13	*69e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.8**	44	20	*83e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	40	109	64	*15e-1/6e3*	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	1223	2046	778	111	51	33	72	*13e-3/1e5*	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**2.1**	21	**1**	**1**	**1.1**	**1.2**	**1.2**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**7.0**	**2.1**	**1.0**	**1**	**1**	**1**	**1.3**	**1.3**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	**2.9**	83	199	97	**49**	**47**	**55**	**22**	CMA+DE-MOS [12]
NEWUOA	**1**	31	150	72	*24e-1/5e3*	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1.2**	**1**	22	**18**	**32**	*50e-3/5e4*	.	.	.	Basic RCGA [16]
SPSA	194	1014	318	217	*84e-2/1e5*	.	.	.	.	.	SPSA [8]

Table 21: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.23	3.0	16	31	75	162	306	467	698	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.1**	**2.6**	4.0	3.3	4.7	5.7	6.6	7.5	16	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.4**	**1.4**	**1.6**	**1.6**	**1.7**	**2.1**	**2.9**	3.2	5.0	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1.5**	**1.5**	**1.5**	**1.2**	**1.7**	**1.7**	**1.9**	**2.4**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	3.9	3.1	4.1	3.9	4.0	11	9.4	16	48	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.8**	**1**	**1.7**	**1.6**	**1.6**	**1.9**	**1.9**	**2.0**	**2.3**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.5**	**2.0**	**1.6**	**1.5**	**1.5**	**1.8**	**1.6**	**1.7**	**2.1**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.1**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**2.7**	**1.5**	**1.4**	**1.3**	**1.2**	**1.2**	**1.2**	**1.3**	**1.4**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**2.9**	**2.5**	4.6	78	1122	*38e-3/6e3*	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	46	55	9.4	6.0	5.1	686	8809	*55e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**2.9**	**1.8**	**1.6**	**1.8**	**1.6**	**1.5**	**1.4**	**1.4**	**1.5**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.4**	**1.1**	**1.6**	**1.8**	**1.6**	**2.1**	**2.9**	3.5	4.1	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	**2.0**	6.8	7.1	5.7	4.4	4.1	3.8	4.4	CMA+DE-MOS [12]
NEWUOA	**1**	3.5	**2.8**	21	132	*86e-3/4e3*	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1.2**	**1.2**	16	20	16	59	2413	*22e-5/5e4*	.	Basic RCGA [16]
SPSA	42	66	69	9513	*11e-1/1e5*	.	.	.	.	.	SPSA [8]

Table 22: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	3.7	326	808	2202	2907	3456	7093	13010	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.2**	5.8	32	*80e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.1**	3.3	**5.0**	*34e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.4**	3.8	6.6	*57e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.1**	21	42	*96e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.1**	4.7	11	*53e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**2.9**	5.5	*38e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**2.7**	5.1	*35e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	11	12	*57e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.5**	3.3	36	*11e-1/6e3*	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	33	46	7.1	7.5	64	158	*62e-3/3e4*	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1.1**	**1.6**	**1.4**	**1.6**	**1.0**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.3**	**2.6**	**1**	**1**	**1**	**1.2**	**1.3**	**1.0**	**1.1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	**1**	117	148	68	54	46	**23**	**17**	CMA+DE-MOS [12]
NEWUOA	**1**	**1.9**	7.4	97	*18e-1/5e3*	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1.1**	**1.3**	8.5	**8.5**	**11**	**21**	**44**	*72e-5/5e4*	.	Basic RCGA [16]
SPSA	53	87	64	*46e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 23: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	3.7	1994	8536	20823	44694	56322	75790	1.99e5	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.1**	45	*28e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	37	71	*22e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.1**	45	*29e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	33	52	*26e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.2**	24	72	*15e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	9.1	24	**34**	*15e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	23	75	*18e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	42	75	*14e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**2.5**	48	*26e-1/6e3*	.	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	1886	2342	870	70	*14e-1/4e4*	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1.3**	17	**1.5**	**1.3**	**1.0**	**1**	**1**	**1**	**1.3**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.4**	**14**	**1**	**1**	**1**	**1.1**	**1.3**	**1.2**	**1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	**1**	115	**183**	*18e-1/1e5*	.	.	.	.	CMA+DE-MOS [12]
NEWUOA	**1**	**1.3**	39	*37e-1/5e3*	.	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1.1**	**1.2**	48	*11e-1/5e4*	.	.	.	.	.	Basic RCGA [16]
SPSA	77217	77493	7333	*71e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 24: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.21	3.3	50	443	1531	3792	4933	8445	11261	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	6.5	103	328	*52e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.1**	**2.0**	**2.2**	14	97	*65e-3/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.2**	**2.5**	4.5	10	*60e-3/1e4*	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.7**	57	225	*88e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**2.9**	**1.7**	17	56	*13e-2/1e4*	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1.4**	**2.1**	7.1	46	*41e-3/1e4*	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.2**	**1.1**	6.1	8.4	93	*46e-3/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.6**	10	16	34	*10e-2/1e4*	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.9**	3.6	72	*63e-2/6e3*	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	54	71	11	4.6	38	*44e-3/6e4*	.	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1.2**	**1.6**	**1**	**1**	**1**	**1**	**1**	**1.0**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.7**	**1.6**	**1.0**	**1.9**	**1.2**	**1.3**	**1.2**	**1**	**1.1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	**1**	4.8	**6.8**	**4.0**	**2.6**	**2.3**	**3.6**	**3.2**	CMA+DE-MOS [12]
NEWUOA	**1**	**1.1**	**1.8**	129	*11e-1/4e3*	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1**	**1.4**	52	19	11	11	71	*55e-5/5e4*	.	Basic RCGA [16]
SPSA	59	90	306	13461	*39e-1/1e5*	.	.	.	.	.	SPSA [8]

Table 25: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	0.20	3.1	162	18741	25208	27184	27488	28028	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1**	7.8	73	*92e-3/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1.3**	4.5	18	*69e-3/1e4*	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	**2.4**	41	*81e-3/1e4*	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1**	16	128	*11e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	**1.3**	16	*58e-3/1e4*	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	**1.5**	16	*58e-3/1e4*	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	**1.3**	15	*54e-3/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1**	3.1	29	*82e-3/1e4*	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**2.0**	5.3	12	*36e-3/6e3*	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	49	65	70	10	4.2	7.6	*10e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1**	**1**	**1.7**	3.9	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**1**	**1.7**	**3.2**	**1.1**	**1.5**	**2.2**	**2.2**	**2.2**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	**1.2**	**2.2**	**1**	6.6	**31**	**28**	**28**	**28**	CMA+DE-MOS [12]
NEWUOA	**1**	**1**	3.9	**1**	7.5	3.7	*40e-3/5e3*	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1**	**1.1**	**1.7**	**1.9**	**1.8**	*82e-4/5e4*	.	.	.	Basic RCGA [16]
SPSA	41	60	35786	2327	65	75	*51e-3/1e5*	.	.	.	SPSA [8]

Table 26: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	0.20	6.5	114	1.04e5	2.42e6	3.74e6	3.76e6	3.78e6	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1.1**	62	1304	*25e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1**	19	*22e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	22	*20e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	32	18	1262	*26e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	16	*15e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	11	410	*12e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	**2.5**	202	*12e-2/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1.2**	8.6	629	*18e-2/1e4*	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	22	50	800	*26e-2/6e3*	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	1548	1777	5228	242	176	14	*23e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1**	**1**	**1.9**	**14**	**2.4**	*51e-4/4e5*	.	.	.	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**1**	**1.9**	18	**2.0**	**1**	**1**	**1**	**1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	**1.2**	**1.0**	**1**	*23e-3/1e5*	.	.	.	.	CMA+DE-MOS [12]
NEWUOA	**1**	**1**	**1.2**	32	611	*26e-2/5e3*	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1**	**1.1**	**1**	**2.5**	**1**	*11e-3/5e4*	.	.	.	Basic RCGA [16]
SPSA	1.00e6	2.00e6	3.25e6	99552	12626	*16e+2/1e5*	.	.	.	.	SPSA [8]

Table 27: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	0.20	2.9	131	16697	33988	34990	35477	36152	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1**	5.9	21	8.9	*55e-3/1e4*	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1**	**2.2**	7.9	4.2	*44e-3/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	**1.8**	6.9	8.9	*29e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1.3**	4.1	57	*64e-3/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	**1.2**	12	*32e-3/1e4*	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	**1.2**	6.1	8.6	*24e-3/1e4*	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	**1.7**	12	*42e-3/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1**	**1.2**	15	8.7	*29e-3/1e4*	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**2.0**	**1.3**	8.0	*53e-3/6e3*	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	44	62	77	13	3.0	5.5	*92e-4/1e5*	.	.	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1**	**1.1**	**2.1**	4.7	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**1**	**1.0**	**2.4**	**1.1**	**1.2**	**1.4**	**1.4**	**1.4**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	**1.2**	**2.4**	**1**	**1.5**	**9.3**	**43**	**43**	**42**	CMA+DE-MOS [12]
NEWUOA	**1**	**1**	**2.5**	**1**	11	*62e-3/4e3*	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1**	**1.1**	**2.8**	**1.5**	**2.8**	*95e-4/5e4*	.	.	.	Basic RCGA [16]
SPSA	45	56	122	1499	5186	*15e-2/1e5*	.	.	.	.	SPSA [8]

Table 28: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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
ERT$_{\text{best}}$/D	0.20	0.20	15	1446	2483	3968	4430	4659	5193	6634	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	6.9	3.5	6.0	8.6	16	15	*80e-3/1e4*	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	3.0	**1**	**1.3**	**1.0**	**1.0**	**2.0**	**2.1**	**1.8**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	3.2	**1.1**	**1.3**	**1.2**	**1.2**	**1.2**	**1.4**	**2.3**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	14	**2.8**	13	37	33	*31e-2/1e4*	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	4.5	**1.6**	**1.8**	**1.3**	**2.0**	**2.5**	3.1	4.7	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**2.7**	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	5.0	**1.1**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.3**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	6.2	**1.8**	**2.6**	3.1	3.3	3.3	8.3	10	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	16	5.4	4.7	22	*31e-2/6e3*	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	37	52	3.6	49	84	102	92	87	78	99	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1**	3.8	**1.0**	29	19	17	16	14	11	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**1.5**	8.3	105	115	103	98	88	69	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	**2.5**	34	68	43	38	37	33	26	CMA+DE-MOS [12]
NEWUOA	**1**	**1**	18	10	27	*19e-1/5e3*	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1**	**1**	7.7	10	8.7	12	12	11	11	Basic RCGA [16]
SPSA	27	55	5241	*89e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 29: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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	0.20	0.20	35	18178	1.45e5	1.45e5	3.45e5	3.83e5	3.84e5	3.88e5	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	61	*33e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	40	*34e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	44	**2.5**	*23e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	70	8.2	*56e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	12	**1.4**	**1.0**	*20e-1/1e4*	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	10	**2.5**	*17e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	12	**1.9**	*19e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	14	**1.7**	**1**	**1**	*20e-1/1e4*	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	25	**2.4**	*30e-1/6e3*	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	2252	4483	850	14	10	10	4.1	3.7	3.7	3.7	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1**	3.8	**1.2**	**1.3**	**2.8**	**1.2**	**1.1**	**1.0**	**1.0**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**3.1**	**1.5**	**1.5**	**2.6**	**1.1**	**1**	**1**	**1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	**1.4**	8.0	3.5	5.3	**2.2**	**2.0**	**2.0**	**2.0**	CMA+DE-MOS [12]
NEWUOA	**1**	**1**	45	**1.8**	*61e-1/5e3*	.	.	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1**	**1**	**1**	**1.0**	**2.4**	**1**	**1.9**	**1.9**	**1.9**	Basic RCGA [16]
SPSA	626	2123	411	*58e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 30: 05-D, running time excess ERT/ERT$_{\text{best}}$ 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$_{\text{best}}$/D	0.20	0.20	11	689	2109	2125	2140	2154	2163	2188	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	14	11	6.5	7.7	8.9	8.9	8.9	11	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	7.2	4.0	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	5.2	3.3	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.4**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	37	14	12	12	12	12	12	12	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	5.3	5.9	3.5	3.5	3.5	3.5	3.8	3.8	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	3.6	**2.9**	**2.9**	**2.9**	**2.9**	**2.9**	**2.9**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	6.8	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	3.3	3.3	4.3	4.2	4.2	4.2	4.2	4.2	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**1.3**	**1.5**	**1.7**	4.6	9.2	41	*14e-3/6e3*	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	35	57	5.1	48	42	96	320	319	*31e-3/1e5*	.	CMA-EGS (IPOP,r1) [7]
IPOP-aCMA-ES	**1**	**1**	**1.4**	34	113	112	111	111	111	110	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**1.2**	14	92	113	113	112	112	111	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	**2.4**	69	63	93	92	92	92	91	CMA+DE-MOS [12]
NEWUOA	**1**	**1**	**2.2**	**2.6**	**2.9**	15	*62e-3/4e3*	.	.	.	NEWUOA [15]
Basic RCGA	**1**	**1**	**2.5**	59	21	23	23	29	29	31	Basic RCGA [16]
SPSA	40	62	141	460	*19e-1/1e5*	.	.	.	.	.	SPSA [8]

References

[1] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Benchmarking the (1, 4)-CMA-ES with mirrored sampling and sequential selection on the noisy BBOB-2010 testbed. In Pelikan and Branke [13], pages 1625–1632.

[2] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Investigating the impact of sequential selection in the (1, 2)-CMA-ES on the noisy BBOB-2010 testbed. In Pelikan and Branke [13], pages 1605–1610.

[3] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Investigating the impact of sequential selection in the (1, 4)-CMA-ES on the noisy BBOB-2010 testbed. In Pelikan and Branke [13], pages 1611–1616.

[4] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Mirrored variants of the (1, 2)-CMA-ES compared on the noisy BBOB-2010 testbed. In Pelikan and Branke [13], pages 1575–1582.

[5] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Mirrored variants of the (1, 4)-CMA-ES compared on the noisy BBOB-2010 testbed. In Pelikan and Branke [13], pages 1583–1590.

[6] S. Finck, N. Hansen, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2010: Presentation of the noisy functions. Technical Report 2009/21, Research Center PPE, 2010.

[7] Steffen Finck and Hans-Georg Beyer. Benchmarking CMA-EGS on the BBOB 2010 noisy function testbed. In Pelikan and Branke [13], pages 1641–1648.

[8] Steffen Finck and Hans-Georg Beyer. Benchmarking SPSA on BBOB-2010 noisy function testbed. In Pelikan and Branke [13], pages 1665–1672.

[9] N. Hansen, A. Auger, S. Finck, and R. Ros. Real-parameter black-box optimization benchmarking 2010: Experimental setup. Technical Report RR-7215, INRIA, 2010.

[10] N. Hansen, S. Finck, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2009: Noisy functions definitions. Technical Report RR-6869, INRIA, 2009. Updated February 2010.

[11] Nikolaus Hansen and Raymond Ros. Benchmarking a weighted negative covariance matrix update on the BBOB-2010 noisy testbed. In Pelikan and Branke [13], pages 1681–1688.

[12] Antonio LaTorre, Santiago Muelas, and José María Peña. Benchmarking a MOS-based algorithm on the BBOB-2010 noisy function testbed. In Pelikan and Branke [13], pages 1725–1730.

[13] Martin Pelikan and Jürgen Branke, editors. *Genetic and Evolutionary Computation Conference, GECCO 2010, Proceedings, Portland, Oregon, USA, July 7-11, 2010, Companion Material*. ACM, 2010.

[14] Raymond Ros. Black-box optimization benchmarking the IPOP-CMA-ES on the noisy testbed: comparison to the BIPOP-CMA-ES. In Pelikan and Branke [13], pages 1511–1518.

[15] Raymond Ros. Comparison of NEWUOA with different numbers of interpolation points on the BBOB noisy testbed. In Pelikan and Branke [13], pages 1495–1502.

[16] Thanh-Do Tran and Gang-Gyoo Jin. Benchmarking real-coded genetic algorithm on noisy black-box optimization testbed. In Pelikan and Branke [13], pages 1739–1744.