Comparison tables: BBOB 2010 noisy testbed with BBOB 2009 as reference in 2-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: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	0.90	4.0	5.0	5.6	7.2	8.4	10	11	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	3.8	**2.5**	4.2	6.6	8.1	9.5	10	12	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	3.8	**2.4**	4.8	7.4	8.3	8.7	11	12	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**2.4**	**1.4**	4.3	7.0	7.3	7.9	8.9	11	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	4.6	3.2	6.5	8.5	14	13	14	15	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	5.0	**2.5**	5.0	7.0	7.0	7.7	7.9	9.1	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	3.2	**1.7**	3.3	5.4	6.3	6.6	7.2	8.4	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	3.2	**1.6**	**2.9**	**4.1**	**4.8**	**5.2**	**5.3**	**6.2**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	4.6	**2.5**	3.3	5.2	5.5	6.4	6.0	7.3	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	3.2	**1.7**	**2.1**	**2.3**	**2.0**	**1.9**	**1.7**	**1.6**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	10	13	14	9.3	13	19	40	49	92	2502	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	5.2	**2.5**	3.8	7.7	8.1	8.9	10	12	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	3.6	3.2	5.8	7.5	8.5	9.2	11	12	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**2.3**	3.1	10	22	30	35	38	46	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**2.4**	**1.8**	**2.1**	**2.3**	**2.5**	**2.3**	**2.0**	**1.9**	NEWUOA [16]
Basic RCGA	**1**	**1**	**2.3**	3.2	32	62	67	86	111	192	Basic RCGA [17]
SPSA	24	41	173	159	282	907	764	687	631	641	SPSA [9]

Table 2: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.90	3.5	5.4	8.3	10	11	12	16	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	5.6	3.2	5.2	5.7	6.6	8.6	9.3	10	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	3.3	**2.7**	**3.1**	4.7	6.7	7.1	7.6	8.7	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	3.2	**2.2**	4.1	5.1	6.2	6.9	8.0	8.7	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	3.1	**2.8**	4.0	5.0	7.5	7.6	10	12	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	4.0	**2.7**	3.9	**4.1**	5.1	5.4	5.5	6.6	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	4.0	**2.3**	3.2	4.2	4.8	5.6	6.0	6.6	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	3.1	**2.5**	**2.6**	**3.0**	**3.7**	**3.8**	**4.3**	**4.7**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	3.3	**2.3**	3.2	**3.0**	**3.9**	**4.1**	**4.5**	5.0	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.2**	4.0	**2.1**	**2.6**	4.4	**4.1**	**3.7**	**3.4**	**2.8**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	13	16	16	7.1	39	36	47	45	705	3827	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	4.1	3.5	5.9	5.8	7.0	7.9	8.2	9.1	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**2.8**	3.4	5.6	5.2	5.9	7.4	8.0	8.4	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**2.3**	4.3	11	17	25	26	32	34	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	7.1	11	9.3	7.0	6.6	5.8	5.2	**4.4**	NEWUOA [16]
Basic RCGA	**1**	**1**	**2.0**	3.3	24	47	56	75	103	146	Basic RCGA [17]
SPSA	9.1	16	27	239	265	255	254	873	870	4083	SPSA [9]

Table 3: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	0.90	3.9	4.7	4.7	4.7	4.9	4.9	6.8	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	3.4	3.3	5.3	9.3	13	17	22	23	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	3.0	**1.9**	4.0	8.0	13	16	19	21	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**2.5**	**2.0**	4.2	8.0	12	15	19	20	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	3.0	3.2	7.3	10	13	16	21	23	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	4.0	**2.1**	4.4	6.4	9.3	12	15	16	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**2.8**	**1.5**	3.6	6.2	9.1	11	14	14	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**2.4**	**1.6**	**2.6**	**4.8**	**7.0**	**8.4**	**11**	**11**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	4.3	**2.3**	3.5	5.4	8.1	10	13	13	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	3.1	**1.8**	**2.1**	**3.0**	**4.1**	**4.4**	**7.1**	**6.9**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	12	19	19	6.9	12	19	35	75	82	189	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	3.2	**2.4**	4.4	8.2	12	16	21	21	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	4.0	3.3	5.7	8.5	14	17	22	23	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**2.4**	**2.6**	13	30	51	63	83	94	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	3.2	**1.6**	**2.1**	**3.1**	**4.2**	**4.9**	**6.4**	**7.8**	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.6**	3.9	22	52	110	167	268	423	Basic RCGA [17]
SPSA	22	38	369	195	256	375	1471	4060	11338	12346	SPSA [9]

Table 4: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$	0.60	2.0	2.7	7.3	97	120	124	126	128	132	$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$
(1,2)-CMA-ES	4.3	4.2	7.5	28	9.3	16	19	20	20	29	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.5**	4.0	5.8	22	4.9	8.6	10	10	10	11	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	3.2	**1.9**	4.8	14	4.4	8.5	11	12	12	13	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	11	4.8	9.2	37	11	22	29	57	58	74	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	4.2	3.6	6.6	13	**2.8**	**2.8**	3.0	3.2	3.3	3.4	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	4.6	3.2	5.6	18	**2.3**	**2.5**	**2.6**	**2.7**	**2.9**	**3.0**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.6**	**1.3**	**2.9**	**7.5**	**1.7**	**1.8**	**2.0**	**2.1**	**2.1**	**2.3**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**2.8**	**1.7**	**3.6**	12	**2.9**	3.8	3.9	4.0	4.0	4.1	(1,4s)-CMA-ES [3]
avg NEWUOA	5.2	**2.8**	4.3	**7.8**	**1.2**	3.5	5.3	6.4	6.8	8.7	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	45	18	20	19	26	72	199	197	305	392	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**2.8**	**2.2**	**3.5**	**5.8**	**1.2**	**1.8**	**2.1**	**2.3**	**2.4**	**2.7**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	5.3	3.2	5.1	15	**2.7**	3.2	3.9	4.1	4.4	4.6	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.8**	**2.3**	6.6	11	3.1	4.3	5.1	5.8	6.5	7.5	CMA+DE-MOS [13]
NEWUOA	7.3	**2.9**	6.4	13	3.4	6.5	10	13	12	13	NEWUOA [16]
Basic RCGA	3.2	**2.0**	7.7	19	34	89	245	514	1709	*10e-5/5e4*	Basic RCGA [17]
SPSA	611	294	840	1711	4319	*39e-2/1e5*	.	.	.	.	SPSA [9]

Table 5: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.60	2.0	2.7	7.4	178	186	190	195	198	205	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	5.8	4.7	7.3	35	9.3	18	32	54	68	66	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	4.8	3.4	12	17	**2.3**	8.4	17	35	36	38	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**2.4**	**1.8**	**4.3**	**8.3**	3.3	13	22	32	41	40	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	4.7	3.3	12	36	4.4	16	42	119	121	156	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	4.4	4.0	5.6	35	**2.9**	4.9	6.4	6.4	6.3	6.3	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.7**	**2.4**	**4.1**	23	**1.8**	**3.6**	**4.0**	**4.3**	**4.3**	**4.4**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	5.4	**2.8**	5.6	17	**2.6**	4.5	5.4	5.9	6.8	6.7	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	3.3	5.8	**5.2**	24	3.1	6.2	7.3	7.8	7.8	7.7	(1,4s)-CMA-ES [3]
avg NEWUOA	6.4	3.7	7.0	13	**2.3**	8.6	29	55	196	388	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	50	21	18	17	41	238	959	2211	3364	6907	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	8.3	3.1	6.6	**8.3**	**1.0**	**1.5**	**1.9**	**2.0**	**2.0**	**2.2**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	6.5	3.7	5.5	16	**2.3**	5.4	5.7	5.8	5.9	6.1	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.6**	**2.3**	6.2	**7.4**	**1.6**	**2.9**	**3.4**	**3.7**	**4.0**	**4.7**	CMA+DE-MOS [13]
NEWUOA	6.3	**2.7**	7.9	16	3.1	6.3	22	42	41	115	NEWUOA [16]
Basic RCGA	3.3	3.9	8.1	11	13	50	165	465	1153	*18e-5/5e4*	Basic RCGA [17]
SPSA	519	302	320	1513	1483	8005	*34e-2/1e5*	.	.	.	SPSA [9]

Table 6: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.60	2.0	2.7	7.6	70	140	176	206	245	325	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	8.0	7.2	28	53	13	9.3	8.4	7.5	6.5	5.1	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	5.1	4.8	6.8	12	4.8	3.8	3.8	3.6	3.3	**2.7**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	3.8	3.2	5.4	**3.9**	4.8	3.1	3.2	**3.0**	**2.6**	**2.1**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	4.8	3.3	3.9	84	30	21	18	20	18	16	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	5.4	3.2	6.1	11	**2.7**	**1.7**	**1.6**	**1.4**	**1.3**	**1.1**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.8**	**1.7**	4.2	6.3	**2.0**	**1.4**	**1.3**	**1.3**	**1.1**	**0.97**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	4.7	3.0	**3.0**	**2.8**	**1.3**	**1.1**	**1.0**	**1.0**	**0.91**	**0.76**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**2.8**	**1.7**	**2.6**	10	**2.9**	**1.8**	**1.7**	**1.5**	**1.3**	**1.1**	(1,4s)-CMA-ES [3]
avg NEWUOA	4.6	**2.2**	3.7	**4.5**	**2.1**	**2.1**	3.2	3.3	4.3	5.9	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	54	36	96	91	15	10	8.7	7.7	35	30	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	3.4	3.5	8.3	7.7	**2.1**	**1.7**	**1.5**	**1.5**	**1.4**	**1.2**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	3.1	**2.2**	3.9	9.2	3.4	**2.6**	**2.6**	**2.5**	**2.3**	**2.0**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.6**	**2.2**	6.1	13	3.9	3.6	3.7	3.5	3.6	3.3	CMA+DE-MOS [13]
NEWUOA	3.1	**2.1**	**2.6**	6.1	**2.0**	**2.3**	3.2	3.2	4.8	5.7	NEWUOA [16]
Basic RCGA	**2.4**	3.2	6.8	12	18	103	308	384	658	2206	Basic RCGA [17]
SPSA	1018	895	2614	6207	3396	10059	*40e-2/1e5*	.	.	.	SPSA [9]

Table 7: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.90	6.6	14	57	79	101	128	211	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	30	14	10	3.9	5.1	7.8	11	13	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	4.4	5.2	4.0	**1.8**	**1.6**	**1.5**	**1.5**	**1.6**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**2.3**	**2.2**	**1.9**	**1.4**	**1.6**	**1.9**	**1.6**	**2.0**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	5.4	**2.4**	5.2	6.0	7.2	8.7	7.6	9.1	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	11	3.6	7.7	**2.6**	**2.2**	**2.1**	**2.1**	**1.8**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	7.3	**2.2**	4.4	**1.5**	**1.3**	**1.3**	**1.7**	**1.4**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**2.1**	**1.8**	**1.6**	**0.66**	**0.75**	**0.75**	**1.4**	**1.2**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	6.1	11	7.7	**2.4**	**2.5**	**2.1**	**2.0**	**2.0**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	14	32	24	13	15	31	45	80	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	9.2	14	20	6.9	11	3.6	25	84	153	303	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	5.2	**2.7**	**2.7**	**1.3**	**1.2**	**1.2**	**1.1**	**0.98**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	5.6	**1.9**	**2.7**	**1.2**	**1.1**	**1.2**	**1.1**	**1.00**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**2.5**	**2.0**	6.1	4.5	6.0	5.9	5.7	4.5	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	26	20	31	17	20	37	82	83	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.8**	**2.0**	9.1	8.6	10	8.8	13	20	Basic RCGA [17]
SPSA	16	21	483	1439	3795	4061	3907	14051	*27e-3/1e5*	.	SPSA [9]

Table 8: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.90	15	101	713	1711	2608	3684	7989	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.2**	17	13	5.6	3.7	14	*26e-4/1e4*	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	30	17	8.8	6.5	41	*29e-4/1e4*	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	30	7.8	5.5	10	38	*60e-4/1e4*	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	17	12	10	8.9	*56e-4/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	49	12	4.1	**2.1**	7.5	54	38	*61e-5/1e4*	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	86	14	5.8	**2.4**	4.7	17	*50e-5/1e4*	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	14	14	6.1	5.7	5.7	17	*48e-5/1e4*	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	145	26	8.7	3.8	4.8	18	40	*51e-5/1e4*	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	87	42	20	18	16	*14e-3/6e3*	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	1612	6028	4047	310	143	67	53	61	188	184	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1.2**	5.7	6.0	**3.5**	**0.82**	**0.68**	**0.99**	**1.0**	**0.79**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**3.7**	**3.8**	**1.6**	**0.97**	**0.93**	**1.0**	**1.1**	**0.76**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**2.4**	**1.0**	**2.3**	**1.8**	**1.6**	**4.1**	**4.5**	**3.7**	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	121	56	24	22	25	*13e-3/6e3*	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**2.3**	**1.3**	12	20	21	28	46	*21e-5/5e4*	Basic RCGA [17]
SPSA	27	126	204	101	101	88	*28e-4/1e5*	.	.	.	SPSA [9]

Table 9: 02-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ 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_{best}/D	0.50	0.50	0.90	4.8	6.3	34	34	48	48	48	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1.5**	**2.5**	3.4	4.5	**1.5**	4.3	3.8	5.1	9.2	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**2.6**	**2.0**	**2.8**	**1.4**	**2.3**	**2.3**	3.3	5.3	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1.7**	**1.4**	**2.8**	**1.1**	**1.9**	**1.7**	**2.3**	3.7	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	6.6	3.7	5.0	6.4	9.4	7.4	8.2	15	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	4.3	**2.1**	3.0	**0.97**	**1.8**	**1.7**	**2.5**	3.7	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	5.1	**2.6**	4.0	**1.1**	**1.9**	**1.8**	**2.3**	**3.5**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**2.5**	**1.9**	**3.0**	**0.96**	**1.4**	**1.3**	**1.8**	**2.4**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**2.2**	**1.4**	**2.9**	**0.96**	**1.7**	**1.5**	**1.9**	**2.6**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	3.3	**2.6**	15	7.0	9.0	11	15	31	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	14	21	21	6.9	11	7.0	116	95	889	29122	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	3.2	**2.0**	3.4	**1.2**	**2.0**	**2.4**	3.1	4.8	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**2.0**	**1.4**	3.8	**1.2**	**2.1**	**2.2**	3.4	5.4	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**2.3**	**2.3**	8.6	5.9	8.8	11	14	24	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	3.3	3.6	12	5.6	10	13	22	36	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.8**	**2.5**	15	10	19	24	36	67	Basic RCGA [17]
SPSA	19	32	282	131	273	349	1660	2432	9217	*72e-6/1e5*	SPSA [9]

Table 10: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.60	2.2	3.6	17	312	651	1159	2181	4204	4577	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	3.4	**1.7**	23	11	3.4	6.1	6.9	15	34	*22e-5/1e4*	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	15	7.2	7.7	5.7	**2.1**	3.3	4.4	5.5	4.6	15	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**3.1**	3.3	5.2	5.6	**1.5**	**3.2**	8.2	8.0	17	32	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	5.3	15	17	18	4.2	4.7	6.3	8.9	7.6	31	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	3.2	**2.2**	**3.7**	6.0	4.1	5.9	5.4	4.6	3.5	5.0	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	4.8	**3.0**	**3.2**	**1.8**	**1.7**	**1.7**	**1.9**	**1.6**	**1.1**	**1.3**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	4.9	**2.3**	7.3	5.3	**2.1**	4.4	3.9	4.0	**2.6**	3.3	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	4.2	**2.6**	3.9	8.2	**2.8**	3.3	**2.9**	**2.8**	**2.8**	**2.7**	(1,4s)-CMA-ES [3]
avg NEWUOA	3.8	10	11	5.1	**2.5**	**3.0**	6.8	11	5.9	*12e-4/5e3*	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	211	120	89	24	13	201	1238	*99e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	3.3	**2.3**	**3.7**	**3.7**	6.1	5.3	3.2	**1.7**	**0.94**	**0.90**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	7.3	3.6	4.6	8.0	4.2	5.1	**3.2**	**1.9**	**0.99**	**0.96**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.6**	**2.2**	6.6	285	16	15	9.1	5.1	**2.7**	**2.6**	CMA+DE-MOS [13]
NEWUOA	22	15	16	15	**2.9**	4.4	9.1	36	*19e-4/5e3*	.	NEWUOA [16]
Basic RCGA	**2.4**	**2.0**	**3.1**	**4.1**	5.1	22	33	39	55	157	Basic RCGA [17]
SPSA	531	198	339	832	1381	*38e-2/1e5*	.	.	.	.	SPSA [9]

Table 11: 02-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.60	3.7	12	59	359	2707	6359	14589	30930	84555	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	18	7.2	5.9	8.5	12	6.2	*21e-3/1e4*	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	3.4	8.2	9.0	3.6	11	26	*30e-3/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	20	16	11	8.9	7.3	12	*17e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	36	7.8	8.9	10	6.8	12	*15e-3/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	62	21	12	4.7	**5.5**	3.5	**5.1**	**4.9**	4.8	*61e-4/1e4*	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	58	15	11	6.7	5.8	**2.9**	11	*47e-4/1e4*	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	20	5.4	**3.6**	4.5	6.3	6.9	11	*12e-3/1e4*	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	8.7	16	11	7.6	9.2	3.4	7.3	*17e-4/1e4*	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	72	48	45	29	53	33	*26e-2/6e3*	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	570	605	196	64	22	15	33	101	48	*22e-4/1e5*	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	4.6	**2.7**	7.5	3.3	**3.9**	**3.2**	**3.9**	**2.4**	**1.3**	**0.51**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**3.3**	4.3	5.0	**3.3**	**4.8**	**2.0**	**4.3**	**2.6**	**1.3**	**0.55**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.7**	**1.4**	**2.0**	**2.2**	44	23	12	6.1	**3.3**	**1.3**	CMA+DE-MOS [13]
NEWUOA	137	33	21	25	19	11	*68e-3/6e3*	.	.	.	NEWUOA [16]
Basic RCGA	**2.5**	**1.1**	**1.1**	**1.5**	9.1	4.0	5.7	16	24	*32e-5/5e4*	Basic RCGA [17]
SPSA	73	23	52	152	173	544	*51e-3/1e5*	.	.	.	SPSA [9]

Table 12: 02-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.60	2.0	2.7	7.3	312	522	577	618	686	766	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	6.1	4.1	9.2	25	6.2	4.8	5.2	5.7	6.6	6.2	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.9**	**2.5**	34	81	3.8	3.4	4.2	4.1	3.9	3.6	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	4.6	3.7	7.8	46	**2.1**	**2.0**	**2.2**	**2.2**	**2.1**	**2.0**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	12	6.8	8.2	104	8.9	15	24	36	33	56	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	6.4	3.7	5.0	11	**0.83**	**0.93**	**1.00**	**1.1**	**1.0**	**1.0**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	7.1	3.9	**4.5**	**4.3**	**0.62**	**0.72**	**0.82**	**0.86**	**0.83**	**0.86**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	4.1	**2.4**	6.3	15	**0.88**	**0.70**	**0.72**	**0.72**	**0.69**	**0.69**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	3.2	**2.3**	**4.5**	12	**1.1**	**0.95**	**0.97**	**0.99**	**0.94**	**0.91**	(1,4s)-CMA-ES [3]
avg NEWUOA	4.7	**2.5**	5.1	11	**1.1**	4.6	22	118	*19e-4/5e3*	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	36	28	27	44	5.0	79	309	*12e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	3.1	**1.7**	4.9	16	**1.0**	**0.88**	**0.91**	**0.94**	**0.90**	**0.91**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**2.7**	**2.2**	**4.0**	**5.1**	**0.64**	**0.92**	**1.1**	**1.2**	**1.1**	**1.3**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.6**	**2.3**	6.7	11	**1.1**	**1.8**	**2.1**	**2.2**	**2.3**	**2.7**	CMA+DE-MOS [13]
NEWUOA	5.1	**2.7**	5.0	13	**1.2**	**1.7**	10	112	101	*70e-5/5e3*	NEWUOA [16]
Basic RCGA	4.6	3.0	8.9	**9.0**	4.2	43	85	114	240	447	Basic RCGA [17]
SPSA	12128	3760	2996	3330	671	2693	2435	*21e-2/1e5*	.	.	SPSA [9]

Table 13: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	0.50	1.1	2.4	16	44	70	87	87	87	438	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	**1.9**	8.4	8.0	7.3	13	23	34	34	34	12	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.3**	4.6	4.4	**3.9**	**7.6**	**7.8**	10	10	10	4.0	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**2.8**	4.9	4.5	6.6	12	19	22	22	22	5.0	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	14	8.4	10	9.3	14	18	39	39	39	11	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**2.0**	**2.0**	**2.9**	15	14	13	16	16	16	4.2	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.8**	16	8.8	6.5	12	12	16	16	16	3.5	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	3.4	3.8	3.6	7.0	15	12	**10**	**10**	**10**	**2.1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**2.9**	5.6	13	8.4	16	17	14	14	14	4.0	(1,4s)-CMA-ES [3]
avg NEWUOA	**2.1**	13	10	6.1	**10**	19	33	33	33	13	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	35	29	17	41	350	978	1184	1184	1184	556	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**2.4**	3.0	**2.2**	10	17	12	14	14	14	**2.8**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.3**	**2.6**	3.8	19	15	**11**	**9.4**	**9.4**	**9.4**	**2.4**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.4**	**2.1**	**3.1**	**3.9**	**6.3**	**6.9**	**7.4**	**7.4**	**7.4**	**1.9**	CMA+DE-MOS [13]
NEWUOA	**2.4**	8.7	12	5.8	16	29	42	42	42	14	NEWUOA [16]
Basic RCGA	**1.5**	**1.6**	4.7	**3.7**	85	177	212	212	212	52	Basic RCGA [17]
SPSA	17	18	19	1040	901	3536	2899	2899	2899	761	SPSA [9]

Table 14: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.83	4.4	21	349	1237	2671	2671	2671	4340	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1.5**	28	7.0	15	6.3	9.2	25	25	25	33	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	17	43	14	12	4.6	6.2	6.9	6.9	6.9	*32e-4 /1e4*	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	8.8	41	26	19	5.7	6.6	17	17	17	*63e-4 /1e4*	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	17	33	12	13	8.3	7.4	7.8	7.8	7.8	16	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.9**	43	17	12	**3.8**	4.1	4.8	4.8	4.8	17	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.5**	19	7.6	15	5.7	6.4	5.1	5.1	5.1	8.0	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	4.5	71	31	20	4.5	**3.4**	7.0	7.0	7.0	10	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.4**	44	14	19	7.1	13	7.6	7.6	7.6	**4.7**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.5**	66	29	16	26	21	33	33	33	20	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	618	605	211	197	60	33	21	21	21	45	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1.8**	14	8.6	10	**2.8**	**1.7**	**1.7**	**1.7**	**1.7**	**1.3**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.9**	**4.2**	**2.6**	**5.6**	**1.6**	**0.73**	**0.84**	**0.84**	**0.84**	**0.83**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.4**	**2.8**	**1.3**	**3.8**	8.9	4.3	**2.2**	**2.2**	**2.2**	5.0	CMA+DE-MOS [13]
NEWUOA	**1.9**	41	69	53	38	71	33	33	33	*21e-2 /6e3*	NEWUOA [16]
Basic RCGA	**1.8**	**1.8**	**1.1**	**6.3**	18	22	20	20	20	17	Basic RCGA [17]
SPSA	99	270	107	184	81	88	118	118	118	*63e-4 /1e5*	SPSA [9]

Table 15: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	1.0	1.6	6.4	112	180	197	197	197	271	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**2.0**	3.8	5.0	7.0	**1.8**	4.3	6.9	6.9	6.9	19	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1.2**	**2.4**	6.2	5.1	**1.6**	**2.3**	5.5	5.5	5.5	16	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.9**	**2.1**	5.3	4.9	**1.5**	**2.9**	6.0	6.0	6.0	13	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1.7**	**1.9**	5.2	7.3	**1.6**	7.4	9.1	9.1	9.1	18	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.4**	**2.2**	4.7	**4.9**	**1.1**	**2.2**	**2.5**	**2.5**	**2.5**	3.0	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.3**	**2.5**	**3.1**	**4.9**	**1.3**	**2.3**	**2.2**	**2.2**	**2.2**	**2.4**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.9**	**2.2**	**3.4**	5.9	**0.91**	**1.2**	**2.0**	**2.0**	**2.0**	**1.8**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**2.5**	4.3	6.1	**3.9**	**0.89**	**1.9**	**2.2**	**2.2**	**2.2**	**2.6**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.5**	**2.8**	6.5	7.3	**2.9**	6.1	7.1	7.1	7.1	12	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	14	12	14	18	99	325	551	551	551	1224	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1.3**	3.3	**3.8**	5.4	**1.4**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**2.7**	4.5	5.2	14	**2.2**	**2.4**	**2.5**	**2.5**	**2.5**	**2.2**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.4**	**2.1**	4.1	5.6	**1.9**	**2.0**	6.3	6.3	6.3	5.3	CMA+DE-MOS [13]
NEWUOA	**2.0**	**2.5**	4.5	12	**2.9**	4.4	11	11	11	11	NEWUOA [16]
Basic RCGA	**1.6**	**1.9**	5.2	59	24	101	113	113	113	136	Basic RCGA [17]
SPSA	47	48	110	435	151	268	778	778	778	2416	SPSA [9]

Table 16: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	3.3	6.8	25	50	78	103	138	165	521	894	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	12	12	13	23	31	70	102	194	131	160	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.0**	9.4	22	28	48	128	116	159	64	50	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.4**	4.4	11	**10**	35	69	88	189	135	166	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	13	40	16	26	39	165	*12e-3/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.9**	**2.2**	15	20	35	44	42	**36**	16	9.4	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.9**	**2.5**	10	25	34	49	48	46	18	12	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.8**	8.0	15	20	**21**	**34**	**35**	37	14	9.4	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**2.5**	**2.3**	**6.4**	24	**30**	49	51	50	19	14	(1,4s)-CMA-ES [3]
avg NEWUOA	7.9	6.2	12	**15**	32	98	125	479	*14e-3/5e3*	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	67	132	512	1079	3593	6360	10202	*34e-2/1e5*	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	3.2	**2.9**	25	22	**19**	**15**	**14**	**12**	**3.9**	**2.4**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.7**	3.8	28	42	36	**36**	**30**	**26**	**8.4**	**5.1**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.2**	3.7	33	83	70	56	44	38	**13**	**7.9**	CMA+DE-MOS [13]
NEWUOA	5.4	4.6	**6.3**	**18**	38	107	571	*50e-3/5e3*	.	.	NEWUOA [16]
Basic RCGA	**1.9**	4.5	**4.6**	102	476	859	1611	2102	670	817	Basic RCGA [17]
SPSA	20	19	61	307	1150	4537	10864	*43e-3/1e5*	.	.	SPSA [9]

Table 17: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	4.8	17	84	673	3227	6957	14112	14949	18210	21616	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	9.2	8.6	8.9	6.0	5.6	*12e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	6.6	7.5	8.0	5.4	5.7	21	11	*11e-2/1e4*	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	8.8	7.7	10	**3.7**	6.9	*14e-2/1e4*	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	10	8.4	9.4	8.6	13	*31e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	11	9.3	10	3.8	**2.0**	10	*36e-3/1e4*	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	14	6.2	7.3	**3.3**	6.0	10	*12e-2/1e4*	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	15	13	10	4.6	3.3	6.0	10	*59e-3/1e4*	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	7.9	8.7	**4.8**	4.5	**2.7**	**3.9**	11	*33e-3/1e4*	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	15	32	24	10	8.4	*78e-2/6e3*	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	50	112	115	32	62	103	103	*17e-2/1e5*	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	5.5	5.5	**5.0**	**3.6**	**1.8**	**0.99**	**0.67**	**0.67**	**0.61**	**0.63**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**3.2**	**4.8**	10	4.5	**2.0**	**1.5**	**0.95**	**0.96**	**0.95**	**0.93**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.1**	**1.2**	**1.6**	3.7	4.2	4.3	**2.4**	**2.6**	**2.4**	**2.9**	CMA+DE-MOS [13]
NEWUOA	43	25	29	12	26	*97e-2/6e3*	.	.	.	.	NEWUOA [16]
Basic RCGA	**1.7**	**1.6**	5.9	22	15	13	11	*73e-3/5e4*	.	.	Basic RCGA [17]
SPSA	58	41	80	129	131	214	105	*35e-2/1e5*	.	.	SPSA [9]

Table 18: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$	2.1	2.5	10	52	66	252	292	326	388	486	$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$
(1,2)-CMA-ES	7.5	12	55	19	18	5.4	5.1	5.5	5.1	4.6	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.6**	5.5	45	18	17	4.7	4.3	4.0	3.6	3.2	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	4.4	11	20	8.4	7.7	**2.8**	**2.7**	**2.7**	**2.4**	**2.1**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	3.2	14	131	52	64	24	25	23	20	16	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	3.6	6.6	12	4.7	4.1	**1.4**	**1.3**	**1.2**	**1.1**	**1.0**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	3.7	6.6	9.1	3.5	3.9	**1.2**	**1.1**	**1.2**	**1.0**	**1.0**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	3.6	7.3	5.9	**2.0**	**2.2**	**0.68**	**0.65**	**0.65**	**0.60**	**0.56**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**2.4**	**3.9**	**4.8**	**2.8**	**3.2**	**0.93**	**0.93**	**0.91**	**0.82**	**0.72**	(1,4s)-CMA-ES [3]
avg NEWUOA	**2.4**	**2.3**	**2.8**	3.8	12	9.0	21	221	*90e-5/5e3*	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	42	142	61	44	533	615	1377	1231	3617	2888	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	3.0	8.1	7.9	**3.4**	**3.7**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	3.8	6.5	12	4.8	5.7	**2.4**	**2.5**	**2.4**	**2.2**	**1.9**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.5**	10	8.6	4.8	6.0	**2.0**	**2.2**	**2.5**	**2.5**	**2.9**	CMA+DE-MOS [13]
NEWUOA	**2.1**	**2.6**	**5.6**	4.2	11	10	35	71	187	*11e-4/5e3*	NEWUOA [16]
Basic RCGA	4.0	5.4	76	100	462	253	280	1078	907	*16e-3/5e4*	Basic RCGA [17]
SPSA	61	400	1210	755	4425	5579	*20e-2/1e5*	.	.	.	SPSA [9]

Table 19: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.70	5.4	36	88	520	950	2384	5041	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.1**	**2.5**	4.0	6.4	6.7	3.9	7.4	7.7	29	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**2.0**	3.1	8.4	4.0	**2.8**	**1.2**	**2.2**	3.3	14	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.2**	**2.0**	5.4	**2.8**	**2.4**	**2.1**	3.1	**2.9**	8.7	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.6**	**2.2**	4.9	4.4	7.0	4.8	15	61	*90e-6/1e4*	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**2.1**	3.3	4.0	3.9	**1.9**	**1.1**	**1.5**	**1.9**	8.8	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.1**	**2.1**	6.8	**2.3**	**1.5**	**1.5**	**2.0**	**1.6**	6.1	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.9**	**3.0**	5.6	**1.4**	**1.6**	**0.70**	**1.3**	**1.3**	14	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.4**	**3.0**	13	3.6	3.1	**1.0**	**2.2**	**2.1**	9.0	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.4**	**2.9**	18	8.0	14	5.9	6.6	6.8	*67e-6/5e3*	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	12	20	17	**3.7**	**1.8**	13	81	83	183	*34e-6/1e5*	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1.1**	**1.7**	6.6	**1.7**	**1.3**	**0.78**	**1.6**	**1.0**	**0.76**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.7**	3.8	7.9	**2.2**	**1.5**	**1.1**	**2.5**	**1.6**	**1.9**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.2**	**1.9**	**2.8**	5.1	5.7	**1.5**	**1.2**	**0.67**	**0.55**	CMA+DE-MOS [13]
NEWUOA	**1**	**2.6**	3.1	15	8.6	23	7.1	19	33	15	NEWUOA [16]
Basic RCGA	**1**	**1.2**	**1.4**	**2.2**	3.2	8.8	4.5	11	10	19	Basic RCGA [17]
SPSA	15	32	35	933	1158	2645	838	*21e-3/1e5*	.	.	SPSA [9]

Table 20: 02-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.70	5.7	187	1257	2862	12965	37703	94320	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.7**	19	34	6.0	7.5	*76e-4/1e4*	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.1**	19	19	4.7	14	*12e-3/1e4*	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**2.9**	22	19	4.9	8.2	*52e-4/1e4*	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.1**	12	33	9.3	13	52	*15e-3/1e4*	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.3**	**2.6**	41	4.4	7.4	**15**	*56e-4/1e4*	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.5**	36	26	5.0	**4.3**	49	*25e-4/1e4*	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.5**	17	26	4.9	4.3	*54e-4/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1.6**	9.5	3.9	7.9	*79e-4/1e4*	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	9.5	37	74	42	15	*94e-3/6e3*	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	423	709	620	222	37	66	247	*53e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1.2**	**2.0**	**8.7**	**2.4**	**0.94**	**1.1**	**0.68**	**0.53**	**0.56**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.5**	3.5	23	**3.5**	**1.5**	**1.5**	**0.78**	**0.45**	**0.64**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.3**	**1.9**	**4.5**	**3.0**	4.4	16	**11**	**4.1**	**5.7**	CMA+DE-MOS [13]
NEWUOA	**1**	3.1	48	61	41	34	*98e-3/6e3*	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.3**	**2.0**	**1.6**	6.8	13	19	16	19	*31e-5/5e4*	Basic RCGA [17]
SPSA	57	173	152	151	107	254	*13e-3/1e5*	.	.	.	SPSA [9]

Table 21: 02-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.70	3.5	21	72	164	376	560	851	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.6**	**2.3**	3.8	**2.5**	4.1	6.6	5.9	7.5	10	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.3**	**2.2**	**2.5**	**2.0**	**1.1**	**1.5**	**2.9**	3.5	4.9	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.3**	**2.5**	3.4	**1.0**	**1.1**	**1.3**	**1.7**	**2.2**	**2.7**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.3**	4.1	5.0	**1.8**	3.4	16	18	30	84	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.2**	3.1	3.2	**1.5**	**0.99**	**0.92**	**0.85**	**1.1**	**1.4**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.5**	**2.9**	3.2	**1.6**	**1.3**	**1.3**	**1.4**	**1.3**	**1.4**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.2**	**2.2**	**2.0**	**0.97**	**0.68**	**0.70**	**0.72**	**0.71**	**0.71**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.7**	**2.7**	**2.8**	**1.1**	**0.78**	**0.69**	**0.72**	**0.73**	**0.79**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.6**	**2.6**	5.7	4.4	6.3	22	35	*31e-5/5e3*	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	15	25	22	31	10	10	61	339	2516	*13e-5/1e5*	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1.3**	**2.7**	3.1	**1.4**	**1.2**	**1.3**	**1.1**	**1.2**	**1.4**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**2.0**	4.1	3.7	**1.6**	**1.0**	**1.6**	**2.0**	**2.2**	**2.6**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.2**	**2.1**	4.1	5.7	3.8	3.9	**2.9**	**2.9**	3.3	CMA+DE-MOS [13]
NEWUOA	**1**	**1.6**	**2.7**	4.4	3.0	7.6	14	57	121	*40e-5/5e3*	NEWUOA [16]
Basic RCGA	**1**	**1.3**	**1.7**	**2.0**	8.0	6.2	14	15	37	104	Basic RCGA [17]
SPSA	33	60	126	806	2749	1758	1936	*13e-3/1e5*	.	.	SPSA [9]

Table 22: 02-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	1.5	48	261	705	1122	1676	2176	4781	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**2.9**	14	5.0	4.8	12	61	*53e-4/1e4*	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.3**	**2.3**	**3.3**	**1.6**	4.9	10	19	32	*98e-5/1e4*	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.7**	12	3.7	3.1	4.1	38	*32e-4/1e4*	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.6**	23	4.2	7.0	22	*16e-3/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.3**	5.7	5.9	3.3	3.1	4.7	14	32	*23e-5/1e4*	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.1**	4.7	3.8	**2.5**	**2.8**	**3.3**	6.0	7.6	31	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.4**	31	**2.2**	**2.1**	**2.4**	5.9	14	20	*38e-5/1e4*	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.9**	36	4.4	5.7	7.3	20	27	67	*32e-4/1e4*	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.3**	14	10	33	55	*11e-2/5e3*	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	12	16	16	21	37	91	195	*53e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1.3**	3.5	**1.2**	**0.81**	**0.78**	**0.75**	**0.69**	**0.90**	**0.60**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.3**	29	3.9	**2.5**	**1.2**	**1.1**	**1.00**	**0.98**	**0.74**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.4**	**2.1**	30	21	10	7.5	**5.8**	**5.1**	**2.9**	CMA+DE-MOS [13]
NEWUOA	**1**	**1.7**	10	16	30	54	*99e-3/5e3*	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**2.2**	10	22	14	21	25	45	*25e-6/5e4*	Basic RCGA [17]
SPSA	21	38	60	803	*44e-2/1e5*	.	.	.	.	.	SPSA [9]

Table 23: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	1.6	106	3186	12428	19367	28294	50007	1.09e5	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1.8**	26	7.1	47	*24e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1.2**	**2.8**	18	**4.8**	7.2	*13e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.1**	6.1	30	7.5	45	*23e-2/1e4*	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.2**	48	10	22	*18e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.8**	21	8.6	**3.5**	*83e-3/1e4*	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.3**	**7.3**	**4.7**	11	*13e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**2.0**	29	6.3	4.4	**12**	*98e-3/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**2.8**	78	6.8	11	*11e-2/1e4*	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	10	66	24	28	*46e-2/6e3*	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	261	1354	557	126	20	25	*48e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**2.0**	19	5.7	**0.88**	**0.54**	**0.71**	**0.81**	**0.67**	**0.82**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.6**	18	**3.7**	**0.74**	**0.69**	**1.0**	**0.90**	**0.75**	**0.72**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.5**	**1.9**	40	39	18	**15**	**11**	**7.9**	**5.2**	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	56	32	28	*44e-2/6e3*	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.5**	**2.9**	21	23	*11e-2/5e4*	.	.	.	.	Basic RCGA [17]
SPSA	32	64	137	76	221	*22e-2/1e5*	.	.	.	.	SPSA [9]

Table 24: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	1.8	32	158	340	996	1737	2798	4510	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**2.1**	3.9	13	14	26	69	*60e-4/1e4*	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1.8**	**3.0**	3.4	**1.9**	4.5	12	*98e-5/1e4*	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1.9**	3.1	**2.8**	4.5	5.5	8.4	82	*89e-5/1e4*	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1.7**	15	12	13	44	*16e-3/1e4*	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	3.9	3.3	7.8	4.5	6.4	8.0	25	*23e-5/1e4*	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1.4**	3.2	4.5	**1.4**	**2.7**	3.2	10	50	*23e-5/1e4*	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1.8**	26	5.1	**1.8**	**1.6**	**1.7**	11	51	*23e-5/1e4*	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.1**	**1.5**	**1.8**	10	4.6	5.0	8.0	85	*42e-5/1e4*	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1.7**	12	9.3	22	61	*98e-3/5e3*	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	14	20	36	11	38	142	226	814	*19e-4/1e5*	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1.8**	**2.2**	**1.0**	**0.89**	**1.5**	**1.1**	**1.1**	**1.5**	**2.0**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.4**	3.5	**1.2**	**0.69**	**0.81**	**1.3**	**1.4**	**2.0**	**2.5**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.5**	**1.9**	3.1	15	20	10	**6.2**	**7.8**	**7.4**	CMA+DE-MOS [13]
NEWUOA	**1**	**2.2**	5.6	6.5	14	46	*33e-3/5e3*	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.1**	**1.2**	3.0	23	25	33	56	130	*19e-5/5e4*	Basic RCGA [17]
SPSA	48	90	4547	844	468	2050	*37e-3/1e5*	.	.	.	SPSA [9]

Table 25: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.50	0.50	0.50	74	575	1228	1927	3778	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	5.6	14	105	4.4	4.1	4.0	6.1	*63e-7/1e4*	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1**	5.8	54	**1.6**	**2.8**	3.1	5.5	12	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	**3.9**	**34**	**2.6**	3.4	4.4	7.0	18	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1.1**	11	137	3.2	5.5	4.4	7.6	38	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	**4.5**	**25**	**1.9**	5.7	5.2	7.9	12	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1.1**	5.9	49	**2.5**	4.0	3.5	3.8	4.1	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	5.5	61	3.1	3.4	**2.1**	3.1	6.5	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1.2**	5.2	**31**	**1.8**	6.1	6.0	6.2	18	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**2.3**	6.9	46	**1.8**	**2.7**	**2.4**	**2.3**	6.2	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	14	20	25	34	87	5.0	5.4	6.8	14	40	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1.1**	**4.7**	53	**1.4**	**1.5**	**1.0**	**1.4**	**0.94**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1.2**	5.9	34	**2.1**	**2.0**	**1.3**	**1.9**	**1.4**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	5.8	44	**1.2**	**0.47**	3.3	**2.2**	**1.2**	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**2.0**	6.1	77	**1.4**	**2.6**	**2.1**	**2.6**	10	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.2**	6.4	58	**1.9**	**2.7**	4.7	5.0	13	Basic RCGA [17]
SPSA	22	32	37	61	169	**2.2**	98	230	344	*45e-5/1e5*	SPSA [9]

Table 26: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	0.50	0.50	0.50	151	1709	3408	5528	18193	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**2.3**	53	300	7.2	6.8	20	26	*75e-5/1e4*	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1.1**	**4.2**	141	6.3	4.8	6.0	8.0	*23e-5/1e4*	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	**3.5**	236	4.0	8.9	7.9	27	*81e-5/1e4*	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1.1**	39	246	9.1	8.5	12	25	*12e-4/1e4*	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	6.3	336	4.4	3.6	9.0	12	7.7	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	7.4	111	3.3	3.9	3.8	5.6	*64e-6/1e4*	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1.1**	41	113	**2.3**	3.1	3.6	5.5	8.0	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1**	12	256	3.4	4.8	4.7	*18e-5/1e4*	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	26	95	667	15	11	7.8	*18e-4/6e3*	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	284	472	608	704	1604	57	22	40	37	*32e-6/1e5*	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1**	4.5	230	**1.9**	**1.4**	**1.0**	**0.97**	**1.5**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1**	**4.2**	**73**	**1.9**	**1.1**	**2.0**	**2.2**	**1.6**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	**3.9**	**49**	**0.58**	12	18	20	19	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**2.1**	200	595	15	52	*32e-4/6e3*	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.1**	4.6	**47**	**0.72**	**0.98**	**1.3**	**1.4**	**2.0**	Basic RCGA [17]
SPSA	16	50	86	193	1851	88	111	95	80	*18e-4/1e5*	SPSA [9]

Table 27: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}/D$	0.50	0.50	0.50	0.50	0.50	93	593	2014	3386	3638	$\mathrm{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	**1**	**1**	**1**	10	53	**2.5**	5.1	**2.8**	**2.7**	4.9	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1.1**	6.4	39	**1.2**	**2.0**	**0.95**	**0.86**	**1.6**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	4.9	33	**1.1**	**2.7**	**1.6**	**1.4**	**1.6**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1.2**	11	86	**2.5**	8.2	3.6	3.7	19	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	**3.5**	**17**	**2.7**	3.5	**2.1**	**1.3**	**1.6**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	4.3	**21**	**2.6**	3.0	**1.7**	**1.4**	**1.4**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1.1**	4.3	**21**	**2.7**	**2.7**	**1.2**	**0.81**	**0.97**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1**	**3.3**	82	**2.1**	**2.4**	**0.94**	**0.72**	**0.69**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**1.3**	7.2	72	**1.6**	3.5	**1.8**	**2.5**	*16e-6/5e3*	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	12	17	19	28	70	**1.6**	**2.2**	4.6	12	66	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1.4**	6.1	39	**2.5**	**2.7**	**1.1**	**0.77**	**0.85**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1**	4.2	78	**1.2**	**1.7**	**1.0**	**0.72**	**1.6**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	3.9	31	**0.89**	**0.88**	**1.5**	**2.6**	3.5	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**2.1**	6.2	95	**1.8**	4.9	3.8	**2.8**	9.0	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.2**	**3.7**	41	**1.4**	4.0	**2.6**	**2.5**	29	Basic RCGA [17]
SPSA	26	39	94	636	4930	125	181	165	*40e-5/1e5*	.	SPSA [9]

Table 28: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.90	21	67	157	194	205	297	310	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	4.1	10	9.4	6.2	6.9	7.2	5.6	6.8	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**0.93**	**5.6**	**6.1**	5.3	6.2	5.9	4.6	5.7	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1.7**	**2.7**	**3.7**	**3.9**	**4.8**	**5.7**	**4.5**	4.7	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	7.3	8.8	**5.5**	**3.9**	7.1	10	10	11	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1.7**	21	14	6.4	6.9	6.6	4.6	**4.5**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**2.1**	12	12	7.1	6.1	**5.8**	**4.0**	**4.4**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1.8**	14	10	**4.2**	**3.6**	**3.7**	**2.6**	**2.5**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1.2**	6.7	10	5.9	**5.2**	7.2	5.6	5.4	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**2.9**	21	9.3	7.9	7.4	8.7	10	32	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	13	19	15	16	44	20	48	76	244	563	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**2.0**	26	16	7.8	11	19	13	14	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**0.78**	9.4	11	8.9	7.3	7.3	5.2	5.2	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.4**	35	84	50	41	40	28	29	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**1.9**	17	10	10	10	16	14	20	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.1**	**1.8**	18	16	30	66	57	149	Basic RCGA [17]
SPSA	10	22	35	309	656	812	2220	2096	*83e-4/1e5*	.	SPSA [9]

Table 29: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.90	33	110	261	951	1622	2972	5330	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	9.3	8.2	13	13	10	17	16	27	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1.8**	11	10	7.6	4.7	15	48	*12e-5/1e4*	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1.3**	11	11	11	3.9	12	8.3	27	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	18	8.5	**6.5**	11	8.6	6.3	10	*60e-6/1e4*	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1.3**	8.1	8.9	8.3	3.8	**4.6**	**3.3**	**6.4**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1.7**	**7.0**	**5.7**	**4.3**	**3.0**	**4.9**	**3.7**	8.5	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1.6**	11	9.2	**5.0**	4.3	5.2	5.6	13	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**0.81**	7.6	**5.6**	7.3	**3.6**	5.0	11	*31e-6/1e4*	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	52	25	31	27	9.4	25	29	16	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	288	439	273	92	53	95	39	69	56	274	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1.6**	13	13	**6.5**	**2.2**	**2.4**	**3.2**	**5.4**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1.7**	7.4	12	9.3	5.6	8.2	4.7	**3.2**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.4**	**1.4**	13	49	28	20	11	6.9	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	24	23	21	26	19	25	31	*37e-4/6e3*	NEWUOA [16]
Basic RCGA	**1**	**1**	**0.85**	**0.64**	13	15	13	11	24	135	Basic RCGA [17]
SPSA	5.1	48	96	100	66	108	55	81	150	*86e-6/1e5*	SPSA [9]

Table 30: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	0.77	23	99	248	399	824	886	2221	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**2.0**	40	33	18	13	6.2	7.8	3.2	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1.4**	30	16	8.8	5.7	**2.8**	**2.7**	**1.1**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1.5**	14	15	11	7.2	4.5	4.2	**1.8**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**2.6**	41	54	32	20	10	10	4.3	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**2.0**	22	13	6.2	4.5	**2.2**	**2.0**	**0.84**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**2.4**	15	10	7.0	4.6	**2.3**	**2.2**	**0.89**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1.4**	**6.5**	8.8	**5.2**	**3.3**	**1.6**	**1.9**	**0.76**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1.3**	9.0	13	5.3	**3.4**	**1.6**	**1.5**	**0.63**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	3.2	8.2	**3.7**	**2.6**	**3.6**	3.9	7.5	6.9	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	8.8	12	11	7.8	22	18	30	71	130	127	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1.5**	6.6	6.5	39	26	13	12	33	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1.2**	8.3	18	8.7	5.8	3.1	**3.0**	**1.2**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.7**	**1.1**	**0.97**	10	24	20	18	15	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**2.8**	10	**5.4**	**3.7**	3.8	3.6	4.7	6.6	NEWUOA [16]
Basic RCGA	**1**	**1**	**2.0**	**1.1**	8.5	21	37	45	63	76	Basic RCGA [17]
SPSA	22	34	84	662	510	298	243	285	486	311	SPSA [9]

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