Comparison tables: BBOB 2010 noisy testbed with BBOB 2009 as reference in 20-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: 20-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	0.05	0.28	3.0	21	29	34	35	36	37	39	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	107	17	3.4	3.3	3.5	4.0	4.5	5.0	5.8	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	51	9.1	**1.8**	**1.8**	**1.9**	**2.1**	**2.4**	**2.7**	3.1	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	45	7.4	**1.5**	**1.5**	**1.5**	**1.8**	**2.0**	**2.2**	**2.6**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	94	16	3.1	**2.9**	3.1	3.5	4.0	4.5	5.4	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	38	7.4	**1.5**	**1.5**	**1.6**	**1.9**	**2.2**	**2.5**	**2.9**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	29	5.9	**1.3**	**1.3**	**1.4**	**1.6**	**1.8**	**2.0**	**2.4**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	27	**5.0**	**1.0**	**0.99**	**1.0**	**1.2**	**1.4**	**1.5**	**1.9**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	32	6.0	**1.2**	**1.2**	**1.3**	**1.5**	**1.7**	**2.0**	**2.3**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	19	**3.3**	**0.98**	**0.85**	**0.88**	**0.94**	**1.0**	**1.0**	**1.1**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	319	144	40	7.5	6.4	6.0	6.3	6.7	7.0	7.7	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**15**	6.1	**1.5**	**1.6**	**1.7**	**2.1**	**2.4**	**2.7**	3.3	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**16**	6.0	**1.5**	**1.5**	**1.7**	**2.0**	**2.3**	**2.6**	3.2	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	44	29	6.0	5.2	6.2	7.7	8.1	8.9	11	CMA+DE-MOS [13]
NEWUOA	**1**	**8.9**	**3.1**	**0.85**	**0.90**	**0.97**	**1.1**	**1.2**	**1.5**	**1.6**	NEWUOA [16]
Basic RCGA	**1**	32	39	14	57	165	240	282	314	351	Basic RCGA [17]
SPSA	172	133	83636	*25e+0/1e5*	.	.	.	.	.	.	SPSA [9]

Table 2: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.29	12	20	29	38	46	49	58	70	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	109	5.0	4.1	3.7	3.7	4.1	5.0	5.3	10	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	54	**2.5**	**2.0**	**1.8**	**1.7**	**1.7**	**1.8**	**1.7**	**1.8**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	44	**1.9**	**1.6**	**1.4**	**1.4**	**1.3**	**1.5**	**1.5**	**1.5**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	143	6.0	4.7	4.4	5.5	7.4	13	18	50	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	34	**2.0**	**1.8**	**1.6**	**1.6**	**1.6**	**1.7**	**1.7**	**1.8**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	28	**1.5**	**1.4**	**1.3**	**1.3**	**1.3**	**1.4**	**1.4**	**1.4**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	19	**1.2**	**1.0**	**0.99**	**0.97**	**0.97**	**1.1**	**1.0**	**1.1**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	28	**1.5**	**1.3**	**1.3**	**1.3**	**1.3**	**1.4**	**1.4**	**1.6**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	19	**0.92**	**1.1**	**0.93**	**0.90**	**0.88**	**0.99**	**1.1**	**1.3**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	291	131	10	7.7	6.1	5.3	4.8	4.9	4.5	4.3	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**11**	**1.5**	**1.6**	**1.6**	**1.5**	**1.6**	**1.7**	**1.7**	**1.8**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**15**	**1.6**	**1.6**	**1.6**	**1.5**	**1.6**	**1.8**	**1.7**	**1.8**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	47	9.0	6.3	5.1	5.6	5.8	5.8	5.7	6.1	CMA+DE-MOS [13]
NEWUOA	**1**	**10**	**2.9**	6.1	6.3	22	45	505	*31e-5/5e3*	.	NEWUOA [16]
Basic RCGA	**1**	30	11	15	56	152	178	203	200	195	Basic RCGA [17]
SPSA	218	212	*43e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 3: 20-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	0.05	0.28	3.3	21	31	52	66	80	95	123	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	119	18	3.7	3.1	**2.3**	**2.2**	**2.1**	**2.1**	**2.0**	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	51	7.7	**1.7**	**1.6**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	39	6.4	**1.5**	**1.3**	**1.00**	**0.95**	**0.92**	**0.89**	**0.88**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	103	15	3.1	**2.7**	**2.1**	**2.1**	**2.0**	**2.0**	**1.9**	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	36	6.3	**1.5**	**1.4**	**1.0**	**1.1**	**1.0**	**1.0**	**1.0**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	28	5.1	**1.3**	**1.2**	**0.93**	**0.91**	**0.90**	**0.88**	**0.87**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	23	**4.3**	**0.99**	**0.92**	**0.70**	**0.67**	**0.66**	**0.65**	**0.63**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	32	5.2	**1.3**	**1.2**	**0.88**	**0.86**	**0.84**	**0.83**	**0.82**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	19	**3.0**	**0.95**	**2.0**	20	655	*14e-4/1e4*	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	305	146	36	7.4	5.6	3.8	3.3	3.1	3.1	**3.0**	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**14**	5.4	**1.5**	**1.5**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**13**	5.5	**1.5**	**1.4**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	33	23	6.0	4.6	4.0	4.1	4.3	4.2	4.4	CMA+DE-MOS [13]
NEWUOA	**1**	**9.5**	**2.3**	**1.00**	5.9	44	1231	*48e-4/5e3*	.	.	NEWUOA [16]
Basic RCGA	**1**	26	32	13	72	230	212	195	179	151	Basic RCGA [17]
SPSA	352	615	125	31	30	34	84	17508	*37e-5/1e5*	.	SPSA [9]

Table 4: 20-D, running time excess 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
$\mathrm{ERT}_{\mathrm{best}}$/D	15	48	1185	4283	8566	8897	9124	9293	9472	9809	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	4.2	6.0	63	*14e+0/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.0**	**1.2**	28	34	*12e+0/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.7**	**2.3**	13	*12e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	3.7	5.0	119	*14e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.7**	**1.9**	17	*13e+0/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.3**	**0.82**	12	*97e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.2**	**1.0**	10	35	17	*91e-1/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.3**	**1.1**	21	*12e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**0.63**	**1.4**	11	*98e-1/1e4*	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	7.1	3.1	**1.8**	**4.5**	**2.3**	**2.2**	**2.2**	**2.2**	**2.1**	**2.1**	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1.6**	**0.90**	**4.9**	**1.6**	**0.82**	**0.81**	**0.80**	**0.80**	**0.79**	**0.77**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.6**	**0.97**	**7.5**	**2.5**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.2**	IPOP-CMA-ES [15]
CMA+DE-MOS	7.1	**3.0**	35	10	4.9	4.7	4.6	4.6	4.5	4.3	CMA+DE-MOS [13]
NEWUOA	**0.35**	**1.5**	68	*17e+0/6e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	8.5	10	*18e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	25	*14e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [9]

Table 5: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{105}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

105 Rosenbrock moderate unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	15	59	9594	30547	31585	32129	32475	32754	33011	33512	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	3.7	4.0	16	4.9	*17e+0/1e4*	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.0**	**1.8**	**2.7**	*12e+0/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.6**	**1.9**	6.9	*13e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	4.9	6.7	16	*16e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.7**	**1.5**	7.4	*13e+0/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.4**	**3.0**	6.9	*13e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.1**	**1.3**	**2.6**	*13e+0/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.3**	**2.7**	4.9	*15e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**0.67**	**1.6**	7.2	*12e+0/1e4*	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	6.4	**2.4**	70	*13e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1.5**	**1.5**	**1.2**	**0.43**	**0.43**	**0.44**	**0.44**	**0.44**	**0.44**	**0.44**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.4**	**2.6**	**1.9**	**0.76**	**0.76**	**0.77**	**0.77**	**0.77**	**0.77**	**0.76**	IPOP-CMA-ES [15]
CMA+DE-MOS	7.0	**2.2**	9.2	**2.9**	**2.9**	**2.8**	**2.8**	**2.8**	**2.7**	**2.7**	CMA+DE-MOS [13]
NEWUOA	**0.98**	7.2	*24e+0/5e3*	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	8.8	10	*18e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	37	*14e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [9]

Table 6: 20-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	14	29	574	1083	1187	1239	1274	1301	1325	1368	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	4.3	5.4	**2.3**	3.9	3.9	4.1	4.1	4.1	4.1	4.1	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**2.1**	**1.7**	**0.88**	**1.2**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.8**	**1.7**	**0.71**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.1**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	3.9	3.6	**2.2**	3.9	3.9	3.9	3.9	3.8	3.8	3.8	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.7**	**2.8**	**0.97**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.6**	**1.8**	**0.64**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.1**	**1.3**	**0.55**	**0.59**	**0.61**	**0.62**	**0.62**	**0.62**	**0.62**	**0.62**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.5**	**1.7**	**0.68**	**0.89**	**0.91**	**0.91**	**0.91**	**0.91**	**0.91**	**0.91**	(1,4s)-CMA-ES [3]
avg NEWUOA	**0.70**	**1.4**	8.1	*74e-1/1e4*	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	7.4	5.0	**2.1**	**2.5**	**2.5**	**2.5**	**2.5**	**2.6**	**2.6**	14	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1.6**	**1.5**	**0.77**	**0.76**	**0.84**	**0.88**	**0.89**	**0.90**	**0.91**	**0.91**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.7**	**1.5**	**1.0**	**1.4**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	IPOP-CMA-ES [15]
CMA+DE-MOS	7.8	5.2	**2.0**	9.0	8.7	8.4	8.3	8.2	8.1	8.0	CMA+DE-MOS [13]
NEWUOA	**0.44**	**0.87**	7.0	31	*49e-1/8e3*	.	.	.	.	.	NEWUOA [16]
Basic RCGA	9.3	18	*17e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	133	1736	*52e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 7: 20-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	0.05	8.8	429	679	811	1055	1368	2174	2624	3253	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	433	*83e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	151	*67e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	215	*61e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	998	*87e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	205	*67e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	123	*54e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	148	*56e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	259	*70e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	108	*64e+0/9e3*	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	327	**5.3**	**0.69**	**0.82**	**1.4**	**1.9**	**2.1**	**2.1**	**2.1**	**2.6**	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	8.6	**0.81**	**0.97**	**1.3**	**1.4**	**1.5**	**1.4**	**1.3**	**1.1**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**4.3**	**1.1**	**0.95**	**1.1**	**1.1**	**0.96**	**0.72**	**0.68**	**0.65**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	25	109	160	140	109	87	55	46	37	CMA+DE-MOS [13]
NEWUOA	**1**	96	*57e+0/4e3*	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.3**	**1.7**	**1.9**	4.7	7.0	6.8	5.1	4.7	4.4	Basic RCGA [17]
SPSA	213	812	*65e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 8: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_{108}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

108 Sphere unif

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	19	2903	4861	10152	19820	22282	25366	31511	44879	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	685	*11e+1/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	804	*10e+1/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	594	*98e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	575	*94e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	694	*93e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	601	*96e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	660	*95e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	710	*10e+1/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	698	*11e+1/9e3*	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	18344	114	**2.5**	**3.0**	**2.4**	**1.6**	**2.2**	**3.8**	**6.1**	*13e-6/1e5*	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**14**	**0.74**	**0.98**	**1.0**	**0.84**	**1.1**	**1.6**	**1.5**	**1.5**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	15	**0.72**	**0.87**	**0.66**	**0.57**	**0.77**	**0.89**	**0.94**	**1.0**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**4.5**	*43e+0/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	259	*91e+0/4e3*	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**0.42**	*22e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	9320	90	11	*59e-1/1e5*	.	.	.	.	.	.	SPSA [9]

Table 9: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}$/D	0.05	0.28	17	32	57	84	114	150	179	248	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	107	3.6	3.5	**2.7**	**2.7**	**2.4**	**2.3**	**2.3**	**2.2**	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	56	**1.7**	**1.5**	**1.4**	**1.2**	**1.1**	**1.1**	**1.0**	**0.96**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	35	**1.3**	**1.2**	**0.97**	**0.90**	**0.84**	**0.77**	**0.77**	**0.72**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	107	3.4	**2.8**	**2.3**	**2.1**	**2.0**	**1.9**	**1.8**	**1.8**	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	34	**1.3**	**1.4**	**1.3**	**1.2**	**1.1**	**1.1**	**1.2**	**1.2**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	20	**1.1**	**1.1**	**1.0**	**0.96**	**0.95**	**0.91**	**0.91**	**0.88**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	25	**0.92**	**0.81**	**0.67**	**0.62**	**0.57**	**0.53**	**0.52**	**0.50**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	33	**1.1**	**1.0**	**0.89**	**0.79**	**0.73**	**0.68**	**0.70**	**0.68**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	19	17	*25e-1/9e3*	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	325	141	7.1	5.4	3.7	16693	*19e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**12**	**1.1**	**1.2**	**1.2**	**1.1**	**1.2**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**15**	**1.1**	**1.2**	**1.1**	**1.1**	**1.1**	**1.0**	**1.0**	**1.00**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	50	6.2	4.1	4.3	4.3	4.2	4.1	4.1	4.0	CMA+DE-MOS [13]
NEWUOA	**1**	**10**	17	*33e-1/4e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	34	7.4	10	117	127	111	97	87	70	Basic RCGA [17]
SPSA	311	551	54	2319	5124	*30e-2/1e5*	.	.	.	.	SPSA [9]

Table 10: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{110}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

110 Rosenbrock Gauss

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	185	1271	∞	∞	∞	∞	∞	∞	∞	∞	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	*62e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	*72e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	*56e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	*65e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	*63e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	*35e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	*55e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	*53e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	*55e+3/9e3*	.	.	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	**2.6**	**0.84**	*18e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1.3**	**0.61**	*17e+0/1e6*	.	.	.	.	.	.	.	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**0.84**	**1.1**	*17e+0/1e6*	.	.	.	.	.	.	.	IPOP-CMA-ES [15]
CMA+DE-MOS	49	19	*19e+0/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	*19e+3/4e3*	.	.	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1.4**	**0.63**	*20e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	149	*42e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [9]

Table 11: 20-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	1022	4353	∞	∞	∞	∞	∞	∞	∞	∞	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	*77e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	*84e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	*70e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	*77e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	*79e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	*71e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	*70e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	*63e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	*94e+3/9e3*	.	.	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	**2.4**	**2.1**	*20e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**0.76**	**0.69**	*18e+0/9e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**0.76**	**0.75**	*18e+0/9e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [15]
CMA+DE-MOS	42	164	*28e+1/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	*63e+3/4e3*	.	.	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**0.73**	**1.9**	*49e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	30	*48e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [9]

Table 12: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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
$\mathrm{ERT}_{\text{best}}/D$	14	43	1278	3206	3481	3609	3678	3745	3807	3912	$\mathrm{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	3.9	5.0	3.1	8.4	20	20	40	39	39	38	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1.9**	**1.2**	**0.98**	**1.2**	**1.2**	**1.2**	**1.2**	**1.3**	**1.3**	**1.3**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1.7**	**2.3**	**0.60**	**0.68**	**0.71**	**0.72**	**0.73**	**0.73**	**0.73**	**0.73**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	4.2	4.0	3.8	11	43	*38e-1/1e4*	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1.7**	**2.5**	**1.4**	**1.6**	**2.1**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1.6**	**2.3**	**0.75**	**1.2**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1.0**	**0.95**	**0.35**	**0.48**	**0.50**	**0.50**	**0.50**	**0.50**	**0.50**	**0.50**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1.3**	**2.8**	**0.59**	**0.63**	**0.69**	**0.71**	**0.72**	**0.72**	**0.73**	**0.74**	(1,4s)-CMA-ES [3]
avg NEWUOA	**0.58**	**3.0**	*20e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	7.7	3.8	*18e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1.4**	**1.2**	**0.84**	**0.84**	**0.89**	**0.92**	**0.93**	**0.94**	**0.94**	**0.93**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.6**	**1.9**	**0.95**	**0.94**	**1.0**	**1.0**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-CMA-ES [15]
CMA+DE-MOS	7.3	3.1	**1.9**	3.8	3.8	4.0	4.0	4.0	3.9	3.9	CMA+DE-MOS [13]
NEWUOA	**0.46**	**2.6**	*29e+0/5e3*	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	8.3	11	*18e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	74	1330	*53e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 13: 20-D, running time excess 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
$\mathrm{ERT}_{\text{best}}$/D	0.59	90	2506	18176	28020	29382	29383	29383	29383	29554	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	2007	*51e+1/1e4*	.	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	262	*26e+1/1e4*	.	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	561	*31e+1/1e4*	.	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	2018	*51e+1/1e4*	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	459	*25e+1/1e4*	.	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	221	532	*14e+1/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	103	*18e+1/1e4*	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	268	*29e+1/1e4*	.	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	434	*29e+1/9e3*	.	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	74	**2.2**	**1.6**	81	*21e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	15	**2.7**	**0.60**	**0.27**	**0.27**	**0.29**	**0.29**	**0.29**	**0.29**	**0.29**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**11**	**2.3**	**1.0**	**0.53**	**0.58**	**0.59**	**0.59**	**0.59**	**0.59**	**0.59**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.0**	8.5	27	**9.3**	**10**	**10**	**10**	**10**	**10**	**12**	CMA+DE-MOS [13]
NEWUOA	297	*24e+1/4e3*	.	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1.9**	3.9	**0.77**	*23e-1/5e4*	.	.	.	.	.	.	Basic RCGA [17]
SPSA	58	1044	*98e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 14: 20-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
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	0.59	1656	10409	55895	72257	78465	78525	78525	78525	79096	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	2239	*67e+1/1e4*	.	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	2473	*55e+1/1e4*	.	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	3076	*58e+1/1e4*	.	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	1875	*53e+1/1e4*	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	2210	*56e+1/1e4*	.	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	2064	*51e+1/1e4*	.	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	1088	*53e+1/1e4*	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	1208	*52e+1/1e4*	.	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	695	*44e+1/9e3*	.	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	6491	9.4	**13**	*74e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**70**	**0.84**	**0.64**	**0.35**	**0.53**	**0.62**	**0.62**	**0.62**	**0.62**	**0.63**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	160	**0.80**	**0.59**	**0.68**	**0.84**	**0.91**	**0.91**	**0.91**	**0.91**	**0.92**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.4**	107	*15e+1/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	366	*47e+1/4e3*	.	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1.7**	**8.0**	*46e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	5058	37	*71e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 15: 20-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	0.53	17	120	1513	4587	6334	6340	6340	6340	6450	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	26	5.8	1201	*16e+0/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	15	**1.6**	7.0	*50e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	11	**1.3**	11	*52e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	30	5.7	*21e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	6.5	**1.3**	18	*61e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	6.3	**1.1**	5.9	*40e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	5.9	**0.88**	6.9	*45e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	7.5	**1.3**	26	*65e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	7.2	**0.89**	108	*93e-1/1e4*	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	45	4.4	**1.1**	431	*14e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**3.2**	**1.1**	**1.4**	**1.2**	**0.54**	**0.45**	**0.45**	**0.45**	**0.45**	**0.45**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.9**	**0.94**	**1.1**	**4.8**	**2.2**	**1.8**	**1.8**	**1.8**	**1.8**	**1.9**	IPOP-CMA-ES [15]
CMA+DE-MOS	**2.9**	5.7	**1.3**	191	317	*17e-1/1e5*	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	3.3	**0.58**	236	*18e+0/4e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	4.1	4.8	14	**104**	**77**	*11e-1/5e4*	.	.	.	.	Basic RCGA [17]
SPSA	45	10	966	*12e+0/1e5*	.	.	.	.	.	.	SPSA [9]

Table 16: 20-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
$\mathrm{ERT}_{\text{best}}$/D	1812	9507	24887	34689	44640	50231	51660	52791	54036	56166	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	*29e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	*33e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	*34e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	*29e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	*27e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	*24e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	*23e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	*28e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	*20e+3/9e3*	.	.	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	24	75	*26e+1/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**0.87**	**0.58**	**0.36**	**0.28**	**0.23**	**0.22**	**0.22**	**0.23**	**0.23**	**0.24**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1.4**	**1.3**	**1.2**	**1.1**	**1.00**	**0.92**	**0.92**	**0.92**	**0.93**	**0.93**	IPOP-CMA-ES [15]
CMA+DE-MOS	13	**11**	**5.3**	**4.0**	**3.1**	**2.8**	**2.7**	**2.7**	**2.6**	**2.8**	CMA+DE-MOS [13]
NEWUOA	*22e+3/4e3*	.	.	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1.9**	35	*22e+1/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	*11e+3/1e5*	.	.	.	.	.	.	.	.	.	SPSA [9]

Table 17: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	10122	35527	89270	1.23e5	1.30e5	1.38e5	1.45e5	1.54e5	1.62e5	1.81e5	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	*30e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	*30e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	*30e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	*28e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	*29e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	*30e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	*32e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	*31e+3/1e4*	.	.	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	*24e+3/9e3*	.	.	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	*75e+2/1e5*	.	.	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**0.40**	**0.45**	**0.37**	**0.35**	**0.41**	**0.44**	**0.45**	**0.46**	**0.47**	**0.56**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**0.68**	**0.71**	**0.55**	**0.61**	**0.66**	**0.67**	**0.69**	**0.70**	**0.71**	**0.72**	IPOP-CMA-ES [15]
CMA+DE-MOS	147	*22e+2/1e5*	.	.	.	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	*26e+3/4e3*	.	.	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**11**	*14e+2/5e4*	.	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	*13e+3/1e5*	.	.	.	.	.	.	.	.	.	SPSA [9]

Table 18: 20-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ on f_{118}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

118 Ellipsoid Cauchy

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	26	184	345	589	876	1110	1317	1394	1503	1633	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	6.5	3.2	4.6	10	20	42	55	105	98	*11e-2/1e4*	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	3.3	**1.4**	**1.7**	**1.7**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.4**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	3.1	**1.00**	**1.2**	**1.3**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.0**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	5.7	**3.0**	5.1	14	13	17	56	*13e-3/1e4*	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**2.9**	**1.1**	**1.8**	**1.9**	**2.1**	**2.1**	**1.9**	**2.0**	**2.0**	**2.0**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**2.3**	**0.89**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.3**	**1.2**	**1.2**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**2.0**	**0.71**	**0.83**	**0.81**	**0.74**	**0.69**	**0.64**	**0.64**	**0.61**	**0.60**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**2.4**	**0.97**	**1.1**	**1.1**	**1.1**	**1.2**	**1.1**	**1.2**	**1.2**	**1.2**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1.3**	7.9	*43e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	8.3	**2.5**	3.0	1105	*21e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**2.8**	**0.88**	**0.82**	**0.78**	**0.71**	**0.66**	**0.63**	**0.65**	**0.64**	**0.66**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	4.0	**1.8**	**2.0**	**1.8**	**1.7**	**1.6**	**1.5**	**1.5**	**1.5**	**1.5**	IPOP-CMA-ES [15]
CMA+DE-MOS	6.1	**2.0**	**1.9**	**2.1**	**2.0**	**1.8**	**1.7**	**1.8**	**1.8**	**1.8**	CMA+DE-MOS [13]
NEWUOA	**1.2**	7.9	*62e+0/6e3*	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	46	363	*10e+1/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	20	184	*63e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 19: 20-D, running time excess 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	0.05	0.05	139	1468	1796	3164	20535	47098	69961	95143	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	2220	*21e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	319	517	*13e+0/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	413	508	*14e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	836	*20e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	518	*15e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	67	316	*13e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	208	*13e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	723	505	*15e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	304	*15e+0/9e3*	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	352	545	**1.3**	**1.3**	**1.5**	**3.9**	70	*19e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**18**	**1.6**	**0.62**	**0.83**	**0.92**	**0.42**	**0.29**	**0.25**	**0.28**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	31	**1.9**	**0.58**	**0.69**	**0.80**	**0.58**	**0.58**	**0.59**	**0.97**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**5.1**	9.5	22	28	21	**5.8**	**3.3**	**2.6**	**5.4**	CMA+DE-MOS [13]
NEWUOA	**1**	33	398	*18e+0/4e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**5.2**	**1.8**	**1.6**	**2.4**	6.9	*57e-4/5e4*	.	.	.	Basic RCGA [17]
SPSA	282	359	*19e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 20: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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	0.05	0.05	1802	8940	14054	42575	79607	2.70e5	3.37e5	6.75e5	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	3441	*29e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	4298	*34e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	3333	*33e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	4780	*28e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	4498	*29e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	1819	*30e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	2797	*35e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	4040	*32e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	757	*29e+0/9e3*	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	12827	20132	**4.7**	**5.6**	**5.1**	**4.5**	*16e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	369	**0.62**	**0.64**	**0.79**	**0.83**	**0.78**	**0.43**	**0.44**	**0.40**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**240**	**0.69**	**0.60**	**0.74**	**0.57**	**0.67**	**0.52**	**0.69**	**0.69**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**5.1**	45	*92e-1/1e5*	.	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	593	*30e+0/4e3*	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**3.5**	4.8	*61e-1/5e4*	.	.	.	.	.	.	Basic RCGA [17]
SPSA	10758	31179	231	*12e+0/1e5*	.	.	.	.	.	.	SPSA [9]

Table 21: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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	0.05	0.05	12	38	71	172	465	1099	1722	2870	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	217	4.8	3.4	**3.0**	**2.3**	**1.9**	**1.8**	3.8	*35e-7/1e4*	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	163	**2.2**	**1.4**	**1.2**	**0.93**	**0.81**	**0.69**	**0.80**	6.2	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	133	**1.9**	**1.2**	**1.0**	**0.74**	**0.58**	**0.51**	**0.59**	5.3	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	215	4.5	**2.8**	**2.7**	**1.9**	**1.5**	**1.5**	3.8	*44e-7/1e4*	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	62	**1.8**	**1.5**	**1.4**	**1.1**	**0.87**	**0.79**	**1.0**	**2.1**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	26	**1.4**	**1.1**	**1.0**	**0.87**	**0.73**	**0.62**	**0.75**	**1.2**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	43	**1.1**	**0.80**	**0.71**	**0.52**	**0.41**	**0.35**	**0.39**	**0.53**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	24	**1.5**	**1.1**	**0.90**	**0.69**	**0.55**	**0.46**	**0.58**	**0.98**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	82	49	*40e-1/9e3*	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	301	475	8.1	5.5	5.5	*46e-3/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	20	**1.2**	**1.0**	**1.1**	**0.98**	**0.77**	**0.58**	**0.56**	**0.64**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**18**	**1.3**	**1.1**	**1.1**	**1.1**	**1.1**	**1.2**	**1.4**	**1.9**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**5.1**	6.6	3.4	3.7	3.4	**2.5**	**2.3**	**2.2**	**2.2**	CMA+DE-MOS [13]
NEWUOA	**1**	29	31	*52e-1/4e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**5.3**	5.0	10	36	76	*41e-4/5e4*	.	.	.	Basic RCGA [17]
SPSA	210	876	12355	*10e+0/1e5*	.	.	.	.	.	.	SPSA [9]

Table 22: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.05	35	2600	6978	18826	39669	54172	99925	2.91e5	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	25	99	*87e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	7.9	45	*67e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	6.0	29	*78e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	128	*88e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	9.2	78	*69e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	7.4	34	*68e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	8.5	44	*75e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	7.3	32	*77e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**2.3**	125	*77e-1/9e3*	.	.	.	.	.	.	avg NEWUOA [16]
IPOP-aCMA-ES	**1**	6.0	**2.3**	**0.81**	**0.97**	**0.66**	**0.56**	**0.65**	**0.66**	**0.81**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**2.0**	**2.0**	**0.92**	**0.74**	**0.55**	**0.63**	**0.67**	**0.95**	**0.64**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	4.9	84	72	*14e-1/1e5*	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	6.8	82	*80e-1/4e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.1**	**1.6**	**6.7**	**7.7**	**6.0**	*98e-3/5e4*	.	.	.	Basic RCGA [17]
SPSA	1.00e6	1.00e6	5840	*11e+0/1e5*	.	.	.	.	.	.	SPSA [9]

Table 23: 20-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	0.05	0.05	53	26479	74388	1.63e5	2.64e5	4.89e5	1.36e6	7.92e6	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	148	1303	*12e+0/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	*12e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	215	1341	*12e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	245	627	*13e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	103	651	*11e+0/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	275	*10e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	113	490	*11e+0/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	120	803	*12e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	128	405	*11e+0/9e3*	.	.	.	.	.	.	avg NEWUOA [16]
IPOP-aCMA-ES	**1**	**1.3**	**6.4**	**0.72**	**0.88**	**0.73**	**0.94**	**0.86**	**0.50**	**1.9**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1.7**	**7.2**	**0.72**	**0.61**	**0.69**	**0.80**	**0.71**	**0.62**	*28e-7/1e6*	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	71	*68e-1/1e5*	.	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	53	174	*10e+0/4e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.4**	**7.0**	*48e-1/5e4*	.	.	.	.	.	.	Basic RCGA [17]
SPSA	1.76e6	2.41e6	*20e+1/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 24: 20-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	0.05	0.05	10	98	2042	3225	6346	14253	19427	39957	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1.3**	407	*86e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	6.7	3.7	*33e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	4.6	3.5	1524	*36e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	33	707	*84e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1.2**	143	*46e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	7.0	**2.4**	*23e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	50	*40e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1.5**	22	*50e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	3.3	95	*59e-1/9e3*	.	.	.	.	.	.	avg NEWUOA [16]
IPOP-aCMA-ES	**1**	3.4	**1.1**	**3.9**	**1.0**	**1.0**	**0.91**	**0.71**	**0.76**	**0.62**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1.1**	**0.99**	**0.75**	**0.98**	**0.98**	**0.66**	**0.84**	**0.78**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	4.3	**2.5**	**0.45**	**1.4**	**2.1**	**1.6**	**1.6**	**1.9**	CMA+DE-MOS [13]
NEWUOA	**1**	10	91	*66e-1/4e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1.2**	**2.3**	8.1	3.6	6.0	6.1	15	*39e-5/5e4*	.	Basic RCGA [17]
SPSA	1.00e6	1.00e6	31557	*13e+0/1e5*	.	.	.	.	.	.	SPSA [9]

Table 25: 20-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
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	0.05	0.05	0.05	0.05	0.05	6.24e5	1.25e6	3.12e6	4.01e6	4.03e6	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	**1**	**1**	**1**	9.05e5	*12e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1**	1.46e5	*94e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	1.22e5	*96e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1**	*13e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	1.61e5	*95e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	81397	*88e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	81829	*95e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1**	2.36e5	*10e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	**1**	**493**	*45e-2/9e3*	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	283	321	364	738	9.45e6	*23e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1**	827	**3.85e6**	**0.47**	**1.1**	**0.81**	**1.7**	**1.7**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1**	957	7.10e6	**0.70**	**0.79**	**0.56**	**1.8**	**1.8**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	1527	6.76e6	*18e-2/1e5*	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	**1**	**414**	*49e-2/4e3*	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.1**	**322**	**2.34e6**	*33e-2/5e4*	.	.	.	.	Basic RCGA [17]
SPSA	1.00e6	1.00e6	1.00e6	1.00e6	**3.44e6**	*12e-2/1e5*	.	.	.	.	SPSA [9]

Table 26: 20-D, running time excess 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	0.05	0.05	0.05	0.05	0.05	∞	∞	∞	∞	∞	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1**	*15e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1**	*15e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	*15e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1**	*14e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	*14e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	*13e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	2.92e6	*13e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1**	2.86e6	*13e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	122	2.60e6	*16e-1/9e3*	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	2514	3109	3338	13054	*33e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1**	6417	*30e-2/2e5*	.	.	.	.	.	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1**	**5759**	*28e-2/2e5*	.	.	.	.	.	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	**1527**	*39e-2/1e5*	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	4.2	1.32e5	*12e-1/4e3*	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.1**	**335**	**4.18e6**	*32e-2/5e4*	.	.	.	.	Basic RCGA [17]
SPSA	2.80e7	2.80e7	2.80e7	2.80e7	*45e+3/1e5*	.	.	.	.	.	SPSA [9]

Table 27: 20-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
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	0.05	0.05	0.05	0.05	0.05	79507	2.22e5	3.40e5	3.63e5	3.71e5	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	**1**	**1**	**1**	7537	*70e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1**	595	*52e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**1**	843	*48e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1**	7404	*67e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1**	1139	*44e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1**	756	2.91e6	*39e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**1**	654	*23e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1**	1149	*53e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	7.7	**219**	*43e-2/9e3*	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	292	335	353	754	*28e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1**	**193**	**2.82e5**	**0.75**	**1.0**	**1.2**	**1.1**	**1.1**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**1**	267	**9.58e5**	**1.0**	**0.81**	**0.89**	**0.84**	**0.85**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	1526	**2.24e5**	*44e-3/1e5*	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	3.7	**253**	*45e-2/4e3*	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**1**	314	1.07e6	*59e-3/5e4*	.	.	.	.	Basic RCGA [17]
SPSA	226	276	960	2.30e6	8.02e6	*10e-1/1e5*	.	.	.	.	SPSA [9]

Table 28: 20-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	0.05	0.05	7017	6.69e5	8.61e5	8.61e5	8.61e5	8.62e5	8.62e5	8.62e5	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	*71e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	*65e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	*66e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	*70e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	*66e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	*64e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	*65e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	*68e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	*69e+0/9e3*	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	284	367	**1.8**	**0.12**	**0.12**	**0.12**	**0.12**	**0.16**	**0.16**	**0.17**	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**0.51**	**0.72**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	12	**1.0**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	96	*50e+0/1e5*	.	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	*70e+0/4e3*	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**4.7**	**0.10**	**0.10**	**0.10**	**0.10**	**0.13**	**0.13**	**0.14**	Basic RCGA [17]
SPSA	309	350	*73e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 29: 20-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
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	0.05	0.05	3.91e5	2.07e6	2.08e6	2.08e6	2.09e6	2.10e6	2.10e6	2.12e6	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	**1**	**1**	*73e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	*74e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	*73e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	*72e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	*70e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	*72e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	*72e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	*72e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	*74e+0/9e3*	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	3132	3641	**0.43**	**0.35**	**0.35**	**0.71**	**0.71**	**0.71**	**0.70**	**0.70**	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**0.16**	**0.27**	**0.46**	**0.46**	**0.46**	**0.46**	**0.46**	**0.46**	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	**0.29**	**0.30**	**0.77**	**0.77**	**0.77**	**0.77**	**0.77**	**0.77**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	*59e+0/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	*73e+0/4e3*	.	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	**1.9**	*34e+0/5e4*	.	.	.	.	.	.	Basic RCGA [17]
SPSA	2290	9084	*69e+0/1e5*	.	.	.	.	.	.	.	SPSA [9]

Table 30: 20-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
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	0.05	0.05	245	4657	12618	12648	12688	12729	12755	12860	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	**1**	**1**	**2.1**	**1.8**	**0.96**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	(1,2)-CMA-ES [4, 2]
(1,2m)-CMA-ES	**1**	**1**	**1.0**	**0.61**	**0.61**	**0.61**	**0.61**	**0.61**	**0.61**	**0.61**	(1,2m)-CMA-ES [4]
(1,2ms)-CMA-ES	**1**	**1**	**0.95**	**0.62**	**0.34**	**0.34**	**0.34**	**0.34**	**0.34**	**0.34**	(1,2ms)-CMA-ES [4]
(1,2s)-CMA-ES	**1**	**1**	**1.9**	3.2	3.4	3.4	3.4	3.4	3.3	3.3	(1,2s)-CMA-ES [2]
(1,4)-CMA-ES	**1**	**1**	**1.0**	**0.97**	**0.63**	**0.63**	**0.63**	**0.63**	**0.63**	**0.63**	(1,4)-CMA-ES [5, 3]
(1,4m)-CMA-ES	**1**	**1**	**1.8**	**0.83**	**0.59**	**0.59**	**0.59**	**0.59**	**0.59**	**0.59**	(1,4m)-CMA-ES [5]
(1,4ms)-CMA-ES	**1**	**1**	**0.83**	**0.37**	**0.31**	**0.31**	**0.31**	**0.31**	**0.31**	**0.31**	(1,4ms)-CMA-ES [1, 5]
(1,4s)-CMA-ES	**1**	**1**	**1.2**	**0.95**	**0.95**	**0.95**	**0.94**	**0.94**	**0.94**	**0.94**	(1,4s)-CMA-ES [3]
avg NEWUOA	**1**	**1**	6.6	*45e-1/9e3*	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	295	351	30	15	12	16	*76e-2/1e5*	.	.	.	CMA-EGS (IPOP,r1) [8]
IPOP-aCMA-ES	**1**	**1**	**1.5**	66	54	54	54	54	54	53	IPOP-aCMA-ES [12]
IPOP-CMA-ES	**1**	**1**	4.9	76	37	37	37	37	37	37	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	103	59	52	52	51	51	51	51	CMA+DE-MOS [13]
NEWUOA	**1**	**1**	9.1	*77e-1/4e3*	.	.	.	.	.	.	NEWUOA [16]
Basic RCGA	**1**	**1**	16	8.7	5.0	5.2	6.6	7.2	7.2	9.0	Basic RCGA [17]
SPSA	292	365	5718	*73e+0/1e5*	.	.	.	.	.	.	SPSA [9]

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