Comparison Tables: BBOB 2013 Testbed in 3-D (Expensive Setting)

The BBOBies

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Abstract

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking at GECCO 2013 with a focus on benchmarking black-box algorithms for small function evaluation budgets ("expensive setting"), see `http://coco.gforge.inria.fr/doku.php?id=bbob-2013`. About 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 [6, 4]. The experimental set-up is described in [5].

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 [2]) 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 [5] 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 gives an overview on all algorithms submitted to the noise-free testbed in 2013.

Table 1: Names and references of all algorithms submitted for the noise-free testbed

algorithm short name	paper	reference
BIPOP-aCMA-STEP los	BI-Population CMA-ES Algorithms with Surrogate Models and Line Searches (Page 1177)	[11]
BIPOP-saACM-k los	BI-Population CMA-ES Algorithms with Surrogate Models and Line Searches (Page 1177)	[11]
CMAES hut	An Evaluation of Sequential Model-Based Optimization for Expensive Blackbox Functions (Page 1209)	[8]
DE pal	Benchmarking a Hybrid Multi Level Single Linkage Algorithm on the BBOB Noiseless Testbed	[12]
HCMA los	BI-Population CMA-ES Algorithms with Surrogate Models and Line Searches (Page 1177)	[11]
HMLSL pal	Benchmarking a Hybrid Multi Level Single Linkage Algorithm on the BBOB Noiseless Testbed	[12]
IPOP-10DDr lia	Bounding the Population Size of IPOP-CMA-ES on the Noiseless BBOB Testbed (Page 1161)	[9]
IPOP-500 lia	Bounding the Population Size of IPOP-CMA-ES on the Noiseless BBOB Testbed (Page 1161)	[9]
IPOP-tany lia	Testing the Impact of Parameter Tuning on a Variant of IPOP-CMA-ES with a Bounded Maximum Population Size on the Noiseless BBOB Testbed (Page 1169)	[10]
IPOP-texp lia	Testing the Impact of Parameter Tuning on a Variant of IPOP-CMA-ES with a Bounded Maximum Population Size on the Noiseless BBOB Testbed (Page 1169)	[10]
IPOP lia	Bounding the Population Size of IPOP-CMA-ES on the Noiseless BBOB Testbed (Page 1161)	[9]
	Testing the Impact of Parameter Tuning on a Variant of IPOP-CMA-ES with a Bounded Maximum Population Size on the Noiseless BBOB Testbed (Page 1169)	[10]
MLSL pal	Benchmarking a Hybrid Multi Level Single Linkage Algorithm on the BBOB Noiseless Testbed	[12]
OQNLP pal	Comparison of Multistart Global Optimization Algorithms on the BBOB Noiseless Testbed (Page 1153)	[13]
P-DCN tra	Multiobjectivization with NSGA-II on the Noiseless BBOB Testbed (Page 1217)	[15]
P-zero tra	Multiobjectivization with NSGA-II on the Noiseless BBOB Testbed (Page 1217)	[15]
SMAC hut	An Evaluation of Sequential Model-Based Optimization for Expensive Blackbox Functions (Page 1209)	[8]
U-DCN tra	Multiobjectivization with NSGA-II on the Noiseless BBOB Testbed (Page 1217)	[15]
U-zero tra	Multiobjectivization with NSGA-II on the Noiseless BBOB Testbed (Page 1217)	[15]
fmincon pal	Comparison of Multistart Global Optimization Algorithms on the BBOB Noiseless Testbed (Page 1153)	[13]
fminunc pal	Comparison of Multistart Global Optimization Algorithms on the BBOB Noiseless Testbed (Page 1153)	[13]
ga100 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
grid100 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
grid16 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
hill hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
lmmCMA aug	Benchmarking the Local Metamodel CMA-ES on the Noiseless BBOB'2013 Test Bed (Page 1225)	[1]
memPSODE vog	Adapt-MEMPSODE: A Memetic Algorithm with Adaptive Selection of Local Searches (Page 1137)	[16]
prcga saw	Benchmarking Projection-Based Real Coded Genetic Algorithm on BBOB-2013 Noiseless Function Testbed (Page 1193)	[14]
ring100 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
ring16 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
simplex pal	Comparison of Multistart Global Optimization Algorithms on the BBOB Noiseless Testbed (Page 1153)	[13]

Table 2: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_1 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target.46350.8(e)-0.46074srporrespondin0(r5-0.552(E)-0.01.756(R)82.8633(T)0.094654198T)0.8318-3.4832Td[(b)-28.58

Table 3: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_2 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f2	*6.3e+6*:1.5	*6.3e+5*:4.3	*4.0e+4*:10	*1.0e+2*:32	*1.0e-8*:49	15/15
BIPOP-aCMA	**1.7**(2)	**2.7**(3)	**2.3**(2)	**1.9**(0.2)	**3.3**(0.2)	15/15
BIPOP-saAC	**2.9**(4)	**2.1**(2)	**2.9**(4)	3.9(1)	6.1(0.7)	15/15
CMAES hut	**1.1**(1.0)	**1.1**(2)	3.3(3)	10(6)	∞ *303*	0/15
DE pal	**1.2**(0.7)	**0.95**(0.9)	3.5(4)	6.9(2)	27(1)	15/15
HCMA los	**1.3**(2)	**1.4**(0.8)	**0.96**(0.3)	**1.1**(0.8)	**4.6**(3)	15/15
HMLSL pal	**1.7**(1)	3.3(2)	**2.4**(1)	**1.4**(0.6)	6.2(6)	15/15
IPOP-10DDr	**1.3**(0.7)	**1.9**(1)	**2.2**(2)	8.6(5)	26(3)	15/15
IPOP-500 l	**1.3**(0.7)	**1.9**(1)	**2.2**(2)	8.6(5)	26(3)	15/15
IPOP-tany	**1.9**(0.7)	**2.2**(2)	**2.1**(2)	7.7(4)	25(2)	15/15
IPOP-texp	5.2(11)	3.2(5)	**2.8**(3)	9.0(4)	26(2)	15/15
IPOP lia	**1.3**(0.7)	**1.9**(1)	**2.2**(2)	8.6(5)	26(3)	15/15
MLSL pal	**1.7**(1)	3.3(2)	**2.4**(1)	**1.4**(0.6)	**5.2**(4)	15/15
OQNLP pal	4.1(5)	3.3(0.2)	**2.7**(2)	**1.4**(0.4)	152(181)	5/15
P-DCN tra	**1.1**(0.3)	**2.4**(4)	5.1(5)	10(11)	852(958)	15/15
P-zero tra	**1.1**(0.3)	**2.1**(4)	4.1(6)	11(10)	6.8e4(7e4)	9/15
SMAC hut	**1.1**(1.0)	**0.77**(0.5)	**1.0**(0.7)	4.5(3)	∞ *300*	0/15
U-DCN tra	**1.1**(0.3)	**1.4**(2)	6.0(7)	45(38)	1.5e4(3e4)	13/15
U-zero tra	**1.1**(0.3)	**1.3**(2)	4.3(4)	65(74)	∞ *3e6*	0/15
fmincon pa	**1.7**(1)	3.3(2)	**2.4**(1)	**1.4**(0.6)	5.6(5)	15/15
fminunc pa	**2.0**(3)	**2.2**(1)	**1.3**(0.6)	**1.9**(0.8)	**4.7**(1)	15/15
ga100 hol	**1.5**(1)	**1.8**(1)	5.6(5)	44(29)	∞ *2e5*	0/15
grid100 ho	**1.3**(0.7)	**1.8**(2)	3.3(4)	70(54)	∞ *2e5*	0/15
grid16 hol	**1.5**(1)	**1.2**(0.9)	5.0(7)	31(38)	∞ *2e5*	0/15
hill hol	5.2(4)	4.1(4)	6.5(6)	20(14)	∞ *2e5*	0/15
lmmCMA aug	**2.0**(2)	**1.8**(2)	**1.5**(1)	**2.3**(0.6)	**5.0**(0.8)	15/15
memPSODE v	**2.7**(2)	**1.8**(2)	3.0(2)	3.5(0.5)	6.1(1.0)	15/15
prcga saw	**1.2**(1.0)	**1.3**(1)	3.5(4)	10(5)	698(946)	15/15
ring100 ho	**1.3**(0.7)	**0.95**(0.8)	**1.9**(3)	51(29)	∞ *2e5*	0/15
ring16 hol	**1.6**(1.0)	**1.4**(1)	8.7(9)	28(25)	∞ *2e5*	0/15
simplex pa	11(14)	10(1)	4.8(1.0)	6.4(2)	12(3)	15/15

Table 4: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_3 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f3	*1.0e+2*:2.2	*6.3e+1*:6.1	*4.0e+1*:10	*1.6e+1*:32	*4.0e+0*:319	15/15
BIPOP-aCMA	**2.5**(3)	**1.8**(1)	**2.0**(0.3)	**1.6**(0.6)	**0.47**(0.1)	15/15
BIPOP-saAC	3.7(3)	**2.7**(2)	**2.2**(1)	**2.5**(2)	**1.8**(2)	15/15
CMAES hut	5.6(8)	**2.9**(3)	3.1(4)	**2.7**(1)	**1.6**(2)	7/15
DE pal	**2.2**(2)	**1.9**(1)	**2.0**(1)	**2.9**(2)	**1.1**(0.5)	15/15
HCMA los	3.1(3)	**2.0**(2)	**1.9**(2)	**1.5**(0.9)	**0.66**(0.3)	15/15
HMLSL pal	5.0(4)	4.8(9)	5.5(6)	7.5(5)	**1.6**(0.5)	15/15
IPOP-10DDr	**1.8**(2)	**1.7**(2)	**2.5**(2)	**2.0**(1)	**2.7**(3)	15/15
IPOP-500 l	**1.8**(2)	**1.7**(2)	**2.5**(2)	**2.0**(1)	**2.7**(3)	15/15
IPOP-tany	**1.8**(2)	**1.7**(2)	**2.2**(2)	4.7(2)	**2.9**(3)	15/15
IPOP-texp	**2.1**(3)	**1.3**(1)	**1.7**(2)	3.7(2)	3.6(2)	15/15
IPOP lia	**1.8**(2)	**1.7**(2)	**2.5**(2)	**2.0**(1)	**2.7**(3)	15/15
MLSL pal	4.8(4)	4.7(7)	6.3(8)	7.2(7)	**2.8**(2)	15/15
OQNLP pal	21(36)	15(14)	15(14)	10(5)	**2.7**(2)	15/15
P-DCN tra	**2.0**(3)	**2.4**(2)	4.5(4)	80(230)	95(118)	15/15
P-zero tra	**2.5**(3)	3.6(2)	7.9(3)	81(92)	50(32)	15/15
SMAC hut	**0.97**(1)	**0.98**(1.0)	**1.0**(1)	4.4(3)	3.2(3)	4/15
U-DCN tra	**1.9**(3)	**2.4**(3)	**2.4**(2)	4.0(3)	**1.2**(0.8)	15/15
U-zero tra	**2.5**(3)	**2.1**(2)	**2.1**(2)	**2.1**(2)	**0.83**(0.7)	15/15
fmincon pa	5.2(4)	4.8(8)	5.6(6)	7.1(7)	3.2(4)	15/15
fminunc pa	4.3(9)	5.4(6)	10(10)	8.7(6)	**2.2**(2)	15/15
ga100 hol	**2.5**(2)	**2.5**(3)	4.7(5)	10(8)	3.4(1)	15/15
grid100 ho	**1.1**(0.9)	**1.1**(0.9)	**2.9**(3)	17(13)	7.3(4)	15/15
grid16 hol	**1.5**(1)	**1.9**(3)	4.5(5)	6.1(4)	**2.3**(2)	15/15
hill hol	6.2(7)	3.1(3)	**2.1**(2)	**2.1**(1)	**0.60**(0.3)	15/15
lmmCMA aug	**1.4**(3)	**1.2**(1)	**1.5**(1)	**1.5**(0.8)	**1.3**(2)	15/15
memPSODE v	4.2(3)	**2.8**(3)	4.1(3)	8.2(11)	6.3(7)	15/15
prcga saw	**1.6**(2)	**1.0**(0.9)	**1.7**(2)	3.8(1)	**2.1**(0.9)	15/15
ring100 ho	**1.5**(2)	**1.5**(2)	3.8(5)	14(12)	5.6(2)	15/15
ring16 hol	**2.2**(3)	**2.5**(4)	4.0(4)	5.9(4)	**1.8**(1)	15/15
simplex pa	45(73)	29(30)	24(17)	15(7)	5.4(4)	15/15

Table 5: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_4 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f4	*1.0e+2*:5.4	*6.3e+1*:10	*6.3e+1*:10	*2.5e+1*:36	*4.0e+0*:617	15/15
BIPOP-aCMA	**2.9**(2)	**2.9**(2)	**2.9**(2)	**2.0**(1)	**2.9**(6)	15/15
BIPOP-saAC	**0.98**(1)	**1.0**(1)	**1.0**(1)	**1.7**(1)	**2.6**(3)	15/15
CMAES hut	**1.8**(2)	**2.0**(2)	**2.0**(2)	**2.8**(2)	3.5(4)	2/15
DE pal	**1.8**(2)	**2.1**(2)	**2.1**(2)	**2.7**(2)	**0.78**(0.3)	15/15
HCMA los	**2.8**(3)	**2.6**(2)	**2.6**(2)	**1.7**(1)	**1.0**(2)	15/15
HMLSL pal	**2.0**(1)	**2.3**(2)	**2.3**(2)	3.7(4)	**1.1**(0.7)	15/15
IPOP-10DDr	**1.6**(2)	**2.7**(2)	**2.7**(2)	**1.9**(1)	4.5(5)	15/15
IPOP-500 l	**1.6**(2)	**2.7**(2)	**2.7**(2)	**1.9**(1)	4.6(5)	15/15
IPOP-tany	**1.5**(2)	**1.7**(2)	**1.7**(2)	**1.8**(0.9)	4.7(5)	15/15
IPOP-texp	**0.91**(1)	**1.2**(2)	**1.2**(2)	3.0(2)	4.6(6)	15/15
IPOP lia	**1.6**(2)	**2.7**(2)	**2.7**(2)	**1.9**(1)	4.6(5)	15/15
MLSL pal	**1.9**(1)	**2.3**(2)	**2.3**(2)	3.8(4)	3.5(4)	15/15
OQNLP pal	5.0(15)	9.1(10)	9.1(10)	6.6(5)	5.7(6)	11/15
P-DCN tra	**2.5**(2)	4.9(5)	4.9(5)	11(8)	28(33)	15/15
P-zero tra	**2.7**(3)	6.1(3)	6.1(3)	196(235)	76(112)	15/15
SMAC hut	**0.38**(0.5)	**1.4**(1)	**1.4**(1)	**2.8**(3)	∞ *300*	0/15
U-DCN tra	**1.8**(1)	**2.6**(2)	**2.6**(2)	**2.7**(2)	**1.1**(0.8)	15/15
U-zero tra	**2.0**(1)	**2.3**(2)	**2.3**(2)	**1.7**(0.9)	**1.6**(2)	15/15
fmincon pa	**2.0**(1)	**2.1**(2)	**2.1**(2)	3.7(3)	4.2(4)	15/15
fminunc pa	**2.6**(6)	4.0(5)	4.0(5)	6.3(8)	4.0(3)	15/15
ga100 hol	**1.8**(1)	**1.7**(2)	**1.7**(2)	7.9(6)	**2.8**(1)	15/15
grid100 ho	**1.3**(1)	3.6(3)	3.6(3)	17(12)	7.5(5)	15/15
grid16 hol	**2.2**(2)	4.1(4)	4.1(4)	4.8(2)	**1.5**(0.7)	15/15
hill hol	**2.9**(3)	**1.8**(2)	**1.8**(2)	**1.3**(0.9)	**0.59**(0.5)	15/15
lmmCMA aug	**0.40**(0.2)	**0.95**(0.9)	**0.95**(0.9)	**1.5**(0.7)	**1.8**(2)	13/15
memPSODE v	3.6(3)	3.9(3)	3.9(3)	5.7(6)	4.3(3)	15/15
prcga saw	**1.0**(0.8)	**1.9**(2)	**1.9**(2)	3.2(2)	3.8(3)	15/15
ring100 ho	**1.6**(3)	**2.1**(2)	**2.1**(2)	10(11)	4.7(1)	15/15
ring16 hol	**1.5**(3)	3.4(4)	3.4(4)	5.5(3)	**1.3**(0.6)	15/15
simplex pa	11(22)	17(20)	17(20)	8.7(7)	4.8(6)	15/15

Table 6: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_5 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f5	*4.0e+1*:2.2	*2.5e+1*:4.8	*1.0e-8*:6.6	*1.0e-8*:6.6	*1.0e-8*:6.6	15/15
BIPOP-aCMA	**2.3**(1)	**1.3**(0.2)	**1.2**(0)	**1.2**(0)	**1.2**(0)	15/15
BIPOP-saAC	3.7(3)	**2.5**(2)	5.7(2)	5.7(2)	5.7(2)	15/15
CMAES hut	5.2(4)	3.6(2)	6.0(4)	6.0(4)	6.0(4)	15/15
DE pal	**2.5**(3)	3.8(6)	486(27)	486(27)	486(27)	15/15
HCMA los	**2.0**(1)	**1.1**(0.5)	**1.6**(0.5)	**1.6**(0.5)	**1.6**(0.5)	15/15
HMLSL pal	**2.3**(0)	**1.0**(0)	21(27)	21(27)	21(27)	15/15
IPOP-10DDr	**1.6**(2)	**2.3**(1)	16(33)	16(33)	16(33)	15/15
IPOP-500 l	**1.6**(2)	**2.3**(1)	16(33)	16(33)	16(33)	15/15
IPOP-tany	4.9(5)	3.2(2)	8.2(6)	8.2(6)	8.2(6)	15/15
IPOP-texp	13(13)	7.3(7)	40(32)	40(32)	40(32)	15/15
IPOP lia	**1.6**(2)	**2.3**(1)	16(33)	16(33)	16(33)	15/15
MLSL pal	**2.3**(0)	**1.0**(0)	37(54)	37(54)	37(54)	15/15
OQNLP pal	7.3(0)	3.5(0)	**3.0**(0)	**3.0**(0)	**3.0**(0)	15/15
P-DCN tra	**1.9**(1)	**2.0**(1)	218(47)	218(47)	218(47)	15/15
P-zero tra	**1.9**(1)	4.0(7)	146(59)	146(59)	146(59)	15/15
SMAC hut	**1.8**(0.9)	**1.2**(0.4)	**1.1**(0.2)	**1.1**(0.2)	**1.1**(0.2)	15/15
U-DCN tra	**1.9**(1)	**2.8**(2)	∞	∞	∞ *3e6*	0/15
U-zero tra	**1.9**(1)	**2.2**(2)	∞	∞	∞ *3e6*	0/15
fmincon pa	**2.3**(0)	**1.0**(0)	34(97)	34(97)	34(97)	15/15
fminunc pa	4.1(0)	**1.9**(0)	**3.2**(0)	**3.2**(0)	**3.2**(0)	15/15
ga100 hol	**1.6**(1)	**2.5**(3)	104(20)	104(20)	104(20)	15/15
grid100 ho	**2.8**(2)	4.3(4)	154(89)	154(89)	154(89)	15/15
grid16 hol	**2.8**(2)	4.0(7)	45(27)	45(27)	45(27)	15/15
hill hol	6.6(7)	4.4(4)	8.1(6)	8.1(6)	8.1(6)	15/15
lmmCMA aug	3.6(2)	**2.6**(1)	4.4(2)	4.4(2)	4.4(2)	15/15
memPSODE v	**1**(0.7)	**1.1**(1)	14(5)	14(5)	14(5)	15/15
prcga saw	4.5(3)	12(11)	∞	∞	∞ *2e5*	0/15
ring100 ho	**2.3**(2)	3.1(4)	134(38)	134(38)	134(38)	15/15
ring16 hol	**2.4**(2)	5.3(6)	34(9)	34(9)	34(9)	15/15
simplex pa	22(0.7)	11(0.6)	44(52)	44(52)	44(52)	15/15

Table 7: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_6 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f6	*6.3e+4*:1.8	*6.3e+3*:3.7	*4.0e+1*:13	*1.0e+1*:34	*6.3e-4*:159	15/15
BIPOP-aCMA	**2.3**(2)	**2.8**(4)	**3.0**(2)	**2.7**(2)	3.0(0.3)	15/15
BIPOP-saAC	3.8(4)	4.5(3)	**2.9**(3)	3.3(2)	3.2(2)	15/15
CMAES hut	4.5(4)	3.5(3)	**2.6**(2)	**2.0**(1)	∞ *303*	0/15
DE pal	**1.8**(2)	**2.6**(4)	3.3(3)	3.3(3)	10(2)	15/15
HCMA los	**2.0**(2)	**1.6**(2)	**2.3**(2)	**2.9**(2)	4.5(2)	15/15
HMLSL pal	**23**(2) *4* (0.	3.1(3)*4 3*.	**2.4**(3)	**1.5**(1)	**1.2**(0.5)	15/15
IPOP-10DDr	**1.5**(1)	**2.0**(2)	**1.2**(1)	**2.2**(1)	3.1(0.5)	15/15
IPOP-500 l	**1.5**(1)	**2.0**(2)	**1.2**(1)	**2.2**(1)	3.1(0.5)	15/15
IPOP-tany						

Table 8: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_7 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f7	*2.5e+2*:1.5	*6.3e+1*:4.2	*1.0e+1*:11	*2.5e+0*:38	*4.0e-1*:174	15/15
BIPOP-aCMA	**2.6**(2)	**2.3**(2)	**3.0**(3)	**2.1**(2)	**1.0**(0.8)	15/15
BIPOP-saAC	**2.2**(2)	**2.0**(2)	**2.5**(2)	**1.7**(2)	**1.0**(0.7)	15/15
CMAES hut	**1.8**(2)	**1.7**(1)	**2.7**(2)	**2.1**(1)	**1.2**(1)	12/15
DE pal	**1.3**(1)	**2.8**(4)	4.0(3)	3.5(2)	**1.8**(0.7)	15/15
HCMA los	**2.8**(3)	**2.3**(1)	**1.9**(2)	**2.7**(4)	**1.2**(1)	15/15
HMLSL pal	**1.8**(2)	**1.9**(2)	3.8(3)	4.4(3)	**2.5**(1)	15/15
IPOP-10DDr	**1.6**(1.0)	**1.6**(2)	4.2(2)	3.7(3)	**2.0**(2)	15/15
IPOP-500 l	**1.6**(1.0)	**1.6**(2)	4.2(2)	3.7(3)	**2.0**(2)	15/15
IPOP-tany	**1.4**(1.0)	**1.7**(2)	3.2(3)	**2.0**(1.0)	**1.0**(0.7)	15/15
IPOP-texp	**1.5**(1)	**1.9**(2)	**2.2**(1)	4.7(10)	**2.8**(3)	15/15
IPOP lia	**1.6**(1.0)	**1.6**(2)	4.2(2)	3.7(3)	**2.0**(2)	15/15
MLSL pal	**2.0**(2)	**2.3**(2)	4.7(6)	15(13)	63(57)	14/15
OQNLP pal	4.1(6)	4.8(3)	4.9(6)	4.8(2)	**2.4**(1)	15/15
P-DCN tra	**1.3**(0.7)	8.1(2)	40(70)	978(53)	282(194)	15/15
P-zero tra	**1.3**(0.7)	**1.9**(2)	14(22)	37(50)	90(135)	15/15
SMAC hut	**1.1**(1)	**1.3**(2)	**1.2**(1)	**0.85**(0.7)	**0.82**(0.7)	14/15
U-DCN tra	**1.3**(0.7)	**2.0**(2)	6.8(9)	11(13)	211(553)	15/15
U-zero tra	**1.3**(0.7)	**1.9**(2)	4.4(4)	5.8(4)	295(746)	15/15
fmincon pa	**2.2**(3)	**2.2**(2)	5.0(4)	15(24)	25(30)	15/15
fminunc pa	**2.0**(2)	**1.9**(2)	4.0(4)	10(10)	42(53)	15/15
ga100 hol	**2.1**(2)	**1.5**(1)	4.7(5)	7.7(6)	5.8(2)	15/15
grid100 ho	**1.6**(2)	**1.8**(2)	5.6(4)	14(16)	34(70)	15/15
grid16 hol	**1.3**(1.0)	3.7(2)	6.1(6)	7.1(4)	11(14)	15/15
hill hol	**2.7**(3)	3.4(3)	6.0(7)	10(22)	79(108)	15/15
lmmCMA aug	**1.2**(1.0)	**1.4**(2)	**1.5**(1)	**2.6**(4)	**1.4**(2)	15/15
memPSODE v	**2.6**(2)	**2.6**(2)	6.3(3)	23(29)	16(16)	15/15
prcga saw	**1.7**(1)	**1.5**(1)	**2.6**(4)	3.1(3)	5.2(5)	15/15
ring100 ho	**1.4**(1.0)	**2.0**(3)	3.4(3)	8.6(8)	10(5)	15/15
ring16 hol	**1.9**(1)	**1.3**(1)	5.0(6)	3.9(6)	8.4(13)	15/15
simplex pa	**2.3**(3)	**2.2**(2)	**2.9**(3)	6.3(5)	15(17)	15/15

Table 9: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_8 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the ta

Table 10: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_9 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f9	*1.0e+1*:21	*6.3e+0*:25	*4.0e+0*:32	*2.5e+0*:48	*6.3e-3*:152	15/15
BIPOP-aCMA	4.5(2)	5.8(5)	6.3(10)	5.9(10)	5.9(4)	15/15
BIPOP-saAC	**2.9**(2)	**2.7**(0.8)	**2.4**(0.9)	**2.2**(2)	**2.4**(0.8)	15/15
CMAES hut	3.4(1)	3.6(3)	3.9(2)	4.3(4)	∞ *303*	0/15
DE pal	8.6(4)	8.4(3)	8.0(5)	6.8(3)	12(4)	15/15
HCMA los	**2.7**(3)	3.0(3)	3.3(2)	3.6(2)	3.0(1)	15/15
HMLSL pal	**0.53**(0)$_{\downarrow 4}$	**0.44**(0)$_{\downarrow 4}$	**0.34**(0)$_{\downarrow 4}$	**0.23**(0)$_{\downarrow 4}$	**0.48**(0.0)	15/15
IPOP-10DDr	4.3(3)	4.3(2)	4.7(1)	4.6(4)	6.6(3)	15/15
IPOP-500 l	4.3(3)	4.3(2)	4.7(1)	4.6(4)	6.6(3)	15/15
IPOP-tany	3.0(1)	3.1(1)	3.1(1)	4.2(5)	6.1(2)	15/15
IPOP-texp	**1.9**(1)	**1.9**(1)	**1.8**(1)	3.1(3)	6.4(3)	15/15
IPOP lia	4.3(3)	4.3(2)	4.7(1)	4.6(4)	6.6(3)	15/15
MLSL pal	**0.53**(0)$_{\downarrow 4}$	**0.44**(0)$_{\downarrow 4}$	**0.34**(0)$_{\downarrow 4}$	**0.23**(0)$_{\downarrow 4}$	**0.48**(0.0)	15/15
OQNLP pal	**0.48**(0)$_{\downarrow 4}$	**0.45**(0.0)$_{\downarrow 4}$	**0.37**(0)$_{\downarrow 4}$	**0.25**(0)$_{\downarrow 4}$	**0.49**(0.0)	15/15
P-DCN tra	13(15)	493(1602)	755(2628)	557(1843)	668(681)	15/15
P-zero tra	13(13)	1684(4202)	2231(5617)	1639(4261)	1468(1665)	15/15
SMAC hut	7.0(6)	7.9(5)	12(12)	14(13)	∞ *300*	0/15
U-DCN tra	14(13)	18(14)	80(95)	58(65)	2.9e4(3e4)	7/15
U-zero tra	10(7)	21(16)	45(48)	33(36)	∞ *3e6*	0/15
fmincon pa	**0.53**(0)$_{\downarrow 4}$	**0.44**(0)$_{\downarrow 4}$	**0.34**(0)$_{\downarrow 4}$	**0.23**(0)$_{\downarrow 4}$	**0.48**(0.0)	15/15
fminunc pa	**0.43**(0)$^{\star}_{\downarrow 4}$	**0.36**(0)$^{\star 2}_{\downarrow 4}$	**0.28**(0)$^{\star 2}_{\downarrow 4}$	**0.19**(0)$^{\star 2}_{\downarrow 4}$	**0.45**(0.0)	15/15
ga100 hol	16(11)	18(10)	20(12)	21(11)	2302(2489)	5/15
grid100 ho	31(19)	41(39)	50(50)	52(42)	1.4e4(2e4)	1/15
grid16 hol	17(13)	130(38)	104(33)	75(22)	1.5e4(2e4)	1/15
hill hol	7.2(8)	64(19)	68(91)	292(220)	1.4e4(2e4)	1/15
lmmCMA aug	**1.6**(0.6)	**1.6**(0.5)	**1.4**(0.3)	**1.1**(0.5)	**1.5**(0.4)	15/15
memPSODE v	3.8(0.6)	3.7(0.7)	3.2(1)	**2.7**(2)	**1.6**(0.7)	15/15
prcga saw	4.8(4)	5.3(4)	4.7(3)	3.5(2)	1393(1626)	9/15
ring100 ho	30(28)	46(24)	44(25)	32(18)	1010(1097)	9/15
ring16 hol	13(7)	13(8)	14(11)	17(10)	∞ *2e5*	0/15
simplex pa	**1.3**(0.0)	**1.4**(0.1)	**1.6**(0.7)	**1.2**(0.6)	**1.5**(0.2)	15/15

Table 11: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{10} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f10	*6.3e+6*:1.7	*1.6e+5*:4.4	*4.0e+4*:12	*4.0e+2*:37	*1.0e+0*:152	15/15
BIPOP-aCMA	**1.2**(0.6)	3.5(4)	**2.2**(2)	5.7(2)	3.8(0.7)	15/15
BIPOP-saAC	**2.0**(3)	**2.8**(3)	**2.4**(3)	**2.8**(0.7)	**1.3**(0.3)	15/15
CMAES hut	**2.0**(2)	4.0(3)	**2.2**(2)	4.8(2)	∞ *303*	0/15
DE pal	**1.4**(2)	3.9(4)	**2.2**(2)	8.7(4)	10(5)	15/15
HCMA los	**1.8**(1)	**2.3**(0.9)	**1.7**(1)	3.3(2)	**1.7**(0.2)	15/15
HMLSL pal	**1.5**(2)	3.6(5)	**1.7**(2)	**1.1**(0.9)	**0.38**(0.2)	15/15
IPOP-10DDr	**0.88**(0.3)	**1.9**(2)	3.6(6)	7.2(4)	5.8(1)	15/15
IPOP-500 l	**0.88**(0.3)	**1.9**(2)	3.6(6)	7.2(4)	5.8(1)	15/15
IPOP-tany	**0.88**(0.3)	**2.1**(3)	**2.1**(2)	7.6(3)	5.5(2)	15/15
IPOP-texp	**0.92**(0.3)	**2.3**(2)	**1.4**(1)	5.8(4)	4.4(2)	15/15
IPOP lia	**0.88**(0.3)	**1.9**(2)	3.6(6)	7.2(4)	5.8(1)	15/15
MLSL pal	**1.5**(2)	3.6(5)	**1.7**(2)	**1.1**(0.9)	**0.38**(0.2)	15/15
OQNLP pal	3.2(4)	3.5(2)	**1.4**(0.3)	**1.1**(0.4)	**0.45**(0.2)	15/15
P-DCN tra	**1.4**(0.9)	3.7(5)	3.5(3)	45(61)	2188(3783)	15/15
P-zero tra	**1.4**(0.9)	**2.6**(3)	**2.5**(2)	46(54)	1.0e4(1e4)	12/15
SMAC hut	**1.0**(0.9)	**1.2**(1)	**0.87**(0.5)	**2.3**(1)	∞ *300*	0/15
U-DCN tra	**1.4**(0.9)	**2.7**(3)	**2.1**(2)	35(53)	1.3e4(2e4)	10/15
U-zero tra	**1.4**(0.9)	**2.5**(2)	3.2(4)	79(129)	2.8e4(3e4)	7/15
fmincon pa	**1.5**(2)	3.6(5)	**1.7**(2)	**1.1**(0.9)	**0.38**(0.2)	15/15
fminunc pa	**1.6**(1)	**2.3**(2)	**1.1**(0.7)	**1.6**(1.0)	**0.95**(0.3)	15/15
ga100 hol	**1.1**(0.9)	4.3(6)	4.0(4)	26(27)	4164(4834)	3/15
grid100 ho	**1.4**(2)	3.4(4)	**2.7**(3)	66(80)	1.4e4(2e4)	1/15
grid16 hol	**1**(0.6)	3.7(3)	3.4(4)	55(90)	∞ *2e5*	0/15
hill hol	3.8(3)	3.2(4)	**2.3**(2)	36(24)	6686(7813)	2/15
lmmCMA aug	**1.4**(2)	**2.5**(2)	**1.5**(1)	**1.5**(0.8)	**1.1**(0.3)	15/15
memPSODE v	**1.8**(1)	4.3(3)	**3.0**(3)	**3.0**(0.6)	**1.6**(0.6)	15/15
prcga saw	**1.2**(1)	**2.9**(2)	**2.0**(2)	254(418)	1987(2588)	7/15
ring100 ho	**1.3**(1)	**2.0**(3)	3.2(4)	36(35)	3262(3630)	4/15
ring16 hol	**1.4**(0.9)	**2.7**(2)	4.1(4)	36(31)	3088(3714)	4/15
simplex pa	8.9(13)	8.7(5)	3.8(1)	5.5(2)	**2.7**(1)	15/15

Table 12: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{11} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f11	*2.5e+6*:1.9	*4.0e+5*:4.5	*6.3e+4*:9.4	*2.5e+1*:36	*2.5e-1*:174	15/15
BIPOP-aCMA	**1.5**(1)	3.1(3)	**2.3**(2)	11(5)	3.4(0.9)	15/15
BIPOP-saAC	4.0(4)	**2.3**(2)	**2.0**(2)	4.4(2)	**1.2**(0.2)	15/15
CMAES hut	**2.2**(2)	**1.8**(2)	**2.1**(2)	22(22)	∞ *303*	0/15
DE pal	**1.6**(1)	**1.9**(2)	**2.8**(3)	12(6)	8.9(2)	15/15
HCMA los	**2.6**(2)	**1.8**(1)	**1.2**(0.3)	3.4(3)	**1.4**(0.2)	15/15
HMLSL pal	**2.6**(2)	**1.8**(0.6)	**1.2**(0.5)	**0.61**(0.2)	**0.18**(0.0)	15/15
IPOP-10DDr	**1.8**(2)	**1.9**(2)	**2.0**(2)	15(10)	5.6(1)	15/15
IPOP-500 l	**1.8**(2)	**1.9**(2)	**2.0**(2)	15(10)	5.6(1)	15/15
IPOP-tany	**2.1**(1)	**2.4**(2)	**2.3**(2)	12(10)	5.3(0.9)	15/15
IPOP-texp	5.3(7)	3.3(4)	**2.5**(2)	11(9)	5.1(0.9)	15/15
IPOP lia	**1.8**(2)	**1.9**(2)	**2.0**(2)	15(10)	5.6(1)	15/15
MLSL pal	**2.6**(2)	**1.8**(0.6)	**1.2**(0.5)	**0.61**(0.2)	**0.18**(0.0)	15/15
OQNLP pal	5.1(4)	3.2(0.6)	**1.8**(0.2)	**1.3**(0.3)	**0.46**(0.1)	15/15
P-DCN tra	**1.9**(2)	**2.1**(2)	**1.8**(1)	61(134)	394(233)	15/15
P-zero tra	**1.9**(2)	**2.3**(2)	**2.5**(3)	395(617)	843(369)	15/15
SMAC hut	**1.5**(1)	**1.1**(1)	**0.82**(0.4)	3.1(3)	∞ *300*	0/15
U-DCN tra	**1.7**(2)	**1.7**(1)	**2.0**(2)	21(30)	5109(4419)	15/15
U-zero tra	**1.9**(2)	**1.8**(2)	**2.2**(2)	74(131)	4146(5594)	15/15
fmincon pa	**2.6**(2)	**1.8**(0.6)	**1.2**(0.5)	**0.61**(0.2)	**0.18**(0.0)	15/15
fminunc pa	**2.7**(2)	**1.8**(1)	**1.2**(0.6)	**0.77**(0.3)	**0.98**(1.0)	15/15
ga100 hol	**1.3**(2)	**1.1**(0.9)	**2.2**(2)	690(2107)	5933(6311)	2/15
grid100 ho	**1.8**(2)	**1.4**(2)	**2.1**(2)	806(2111)	1.3e4(1e4)	1/15
grid16 hol	**1.6**(2)	**1.4**(1)	**3.0**(3)	155(306)	1861(1729)	6/15
hill hol	6.2(10)	3.5(5)	**2.0**(3)	195(236)	2782(3025)	4/15
lmmCMA aug	3.2(3)	**2.2**(2)	**1.6**(0.8)	**2.0**(1)	**1.1**(0.3)	15/15
memPSODE v	**2.2**(2)	**1.4**(0.6)	**1.6**(2)	4.6(2)	**1.7**(0.4)	15/15
prcga saw	**1.2**(1)	**1.1**(1)	**1.3**(1)	38(9)	2154(2461)	5/15
ring100 ho	**1.2**(1)	**1.2**(1)	**1.8**(2)	36(39)	1077(1297)	8/15
ring16 hol	**1.9**(2)	**2.0**(2)	**1.4**(1)	54(72)	1339(1451)	7/15
simplex pa	15(12)	9.2(1)	4.9(0.7)	3.2(2)	3.5(0.9)	15/15

Table 13: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{12} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f12	*1.0e+8*:1.5	*1.0e+7*:3.6	*6.3e+5*:13	*6.3e+2*:31	*1.0e+0*:168	15/15
BIPOP-aCMA	**1.0**(0.7)	3.2(3)	3.6(2)	6.1(2)	8.4(9)	15/15
BIPOP-saAC	**2.6**(3)	3.4(4)	**2.9**(2)	3.2(0.4)	3.6(6)	15/15
CMAES hut	**0.96**(0.7)	**1.6**(2)	**2.5**(2)	5.0(2)	27(28)	1/15
DE pal	**1.8**(1)	**1.9**(2)	**2.6**(3)	15(6)	27(27)	15/15
HCMA los	**0.91**(0.7)	**1.9**(2)	**1.3**(0.5)	**2.8**(2)	4.6(5)	15/15
HMLSL pal	**1**(1)	**1.6**(2)	**1.2**(0.6)	**1.2**(0.5)	**0.77**(0.8)	15/15
IPOP-10DDr	**1.3**(1)	**1.5**(1)	**2.4**(2)	4.6(1)	6.8(6)	15/15
IPOP-500 l	**1.3**(1)	**1.5**(1)	**2.4**(2)	4.6(1)	6.8(6)	15/15
IPOP-tany	**1.7**(2)	**1.9**(2)	**1.8**(2)	4.7(2)	7.4(7)	15/15
IPOP-texp	**2.1**(3)	**2.9**(3)	**2.1**(1)	4.0(1)	10(10)	15/15
IPOP lia	**1.3**(1)	**1.5**(1)	**2.4**(2)	4.6(1)	6.8(6)	15/15
MLSL pal	**1**(1)	**1.6**(2)	**1.2**(0.6)	**1.2**(0.5)	**0.77**(0.8)	15/15
OQNLP pal	**1.8**(4)	**2.9**(2)	**1.5**(0.5)	**1.6**(0.6)	**1.4**(1)	15/15
P-DCN tra	**1.0**(0.3)	**1.5**(0.8)	5.0(4)	7.3(4)	1.6e4(2e4)	9/15
P-zero tra	**1.0**(0.3)	**1.4**(0.8)	6.1(6)	6.1(4)	4.9e4(6e4)	4/15
SMAC hut	**0.87**(0.7)	**0.96**(1.0)	**1.2**(2)	9.0(10)	∞ *300*	0/15
U-DCN tra	**1.0**(0.3)	**1.5**(0.8)	4.0(3)	43(42)	2.7e4(4e4)	6/15
U-zero tra	**1.0**(0.3)	**1.4**(0.8)	3.2(4)	49(55)	3.6e4(4e4)	5/15
fmincon pa	**1**(1)	**1.6**(2)	**1.2**(0.6)	**1.2**(0.5)	**0.77**(0.8)	15/15
fminunc pa	**1.3**(1)	**2.0**(2)	**1.3**(1)	**0.98**(0.9)	**0.80**(0.8)	15/15
ga100 hol	**1.2**(1)	**1.5**(2)	7.5(8)	72(37)	3758(4446)	3/15
grid100 ho	**0.83**(0.3)	**1.3**(2)	**2.9**(4)	138(61)	2852(3164)	4/15
grid16 hol	**0.91**(0.7)	**0.96**(1)	3.7(5)	64(43)	5967(7036)	2/15
hill hol	4.3(6)	3.4(5)	**2.4**(2)	30(31)	2503(3132)	4/15
lmmCMA aug	**0.87**(0.7)	**1.6**(2)	**1.4**(1)	**1.7**(0.4)	**1.6**(1)	15/15
memPSODE v	**1.7**(3)	**2.4**(3)	3.2(3)	3.3(0.4)	**2.6**(2)	15/15
prcga saw	**0.91**(0.3)	**1.4**(1)	3.7(5)	10(3)	213(315)	12/15
ring100 ho	**1.1**(0.7)	**1.6**(2)	7.4(13)	103(61)	712(680)	11/15
ring16 hol	**1.0**(1.0)	**1.3**(1)	5.0(6)	41(24)	1983(2640)	5/15
simplex pa	7.2(14)	12(7)	7.7(4)	4.8(1)	**2.9**(2)	15/15

Table 14: 03-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{13} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding $\text{ERT}_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f13	*1.0e+3*:1.6	*4.0e+2*:6.8	*2.5e+2*:11	*4.0e+1*:30	*2.5e-3*:182	15/15
BIPOP-aCMA	**1.2**(2)	**2.1**(2)	**2.1**(1)	4.0(1)	3.4(0.6)	15/15
BIPOP-saAC	**0.96**(0.3)	**1.1**(1)	**1.4**(1)	**2.2**(0.9)	**1.5**(0.4)	15/15
CMAES hut	3.6(4)	**2.6**(2)	**2.2**(2)	3.2(2)	∞ *303*	0/15
DE pal	**0.87**(0.3)	**1.4**(1)	**1.7**(2)	4.7(2)	17(3)	15/15
HCMA los	**1.3**(2)	**1.0**(0.7)	**0.96**(0.3)	**1.8**(2)	**1.8**(0.4)	15/15
HMLSL pal	**0.79**(0)	**1.2**(1.0)	**1.3**(0.7)	**0.96**(0.2)	**0.63**(0.1)	15/15
IPOP-10DDr	**1.1**(0.6)	**1.8**(2)	**2.2**(2)	3.3(0.8)	5.6(1)	15/15
IPOP-500 l	**1.1**(0.6)	**1.8**(2)	**2.2**(2)	3.3(0.8)	5.6(1)	15/15
IPOP-tany	**1.1**(0.6)	**1.7**(1)	**1.6**(1)	**2.8**(0.9)	5.5(1)	15/15
IPOP-texp	**1.9**(1)	**2.2**(2)	**2.3**(2)	**2.9**(1)	5.2(1)	15/15
IPOP lia	**1.1**(0.6)	**1.8**(2)	**2.2**(2)	3.3(0.8)	5.6(1)	15/15
MLSL pal	**0.79**(0)	**1.2**(1.0)	**1.3**(0.7)	**0.96**(0.2)	**0.63**(0.1)	15/15
OQNLP pal	**1.2**(0)	**2.1**(2)	**1.8**(0.5)	**1.4**(0.4)	3.6(3)	15/15
P-DCN tra	**1.3**(2)	3.6(4)	5.7(5)	15(20)	3.0e4(3e4)	6/15
P-zero tra	**1.3**(2)	**1.9**(2)	4.1(4)	55(96)	2.3e5(2e5)	1/15
SMAC hut	**0.87**(0.6)	**0.84**(0.8)	**0.79**(0.4)	**0.98**(0.5)	∞ *300*	0/15
U-DCN tra	**1.3**(2)	**1.5**(1)	**2.9**(3)	13(10)	∞ *3e6*	0/15
U-zero tra	**1.3**(2)	**1.5**(1)	**2.3**(1)	13(7)	∞ *3e6*	0/15
fmincon pa	**0.79**(0)	**1.2**(1.0)	**1.3**(0.7)	**0.96**(0.2)	**0.63**(0.1)	15/15
fminunc pa	**1.1**(0)	**1.4**(0.9)	**1.2**(0.5)	**0.97**(0.4)	**0.87**(0.2)	15/15
ga100 hol	**1.1**(0.6)	**1.3**(1)	3.9(4)	15(14)	∞ *2e5*	0/15
grid100 ho	**1.7**(2)	**1.4**(1)	3.7(4)	32(19)	∞ *2e5*	0/15
grid16 hol	**0.92**(0.6)	**1.3**(1)	**2.8**(4)	21(12)	∞ *2e5*	0/15
hill hol	4.2(7)	**2.4**(2)	**2.2**(2)	57(92)	∞ *2e5*	0/15
lmmCMA aug	**1.3**(2)	**1.2**(1)	**1.2**(0.9)	**1.6**(0.4)	**1.5**(0.3)	15/15
memPSODE v	**2.0**(2)	**1.8**(2)	**2.5**(2)	**2.9**(1)	**1.7**(0.6)	15/15
prcga saw	**1.5**(0.6)	**2.5**(1)	**2.8**(6)	5.7(5)	1507(1864)	6/15
ring100 ho	**1.2**(0.9)	**1.5**(1)	**2.4**(2)	27(20)	∞ *2e5*	0/15
ring16 hol	**1.1**(0.6)	**2.7**(4)	3.9(3)	10(9)	∞ *2e5*	0/15
simplex pa	**2.5**(0)	6.7(5)	7.7(4)	7.4(5)	4.5(2)	15/15

Table 15: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{14} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f14	*1.0e+1*:2.2	*6.3e+0*:4.2	*2.5e+0*:10	*6.3e-2*:31	*2.5e-6*:160	15/15
BIPOP-aCMA	3.7(5)	3.8(4)	3.7(3)	4.2(2)	3.9(0.7)	15/15
BIPOP-saAC	**2.9**(3)	**2.4**(3)	**2.4**(3)	3.3(1)	**2.0**(0.2)	15/15
CMAES hut	3.2(4)	**2.3**(3)	3.1(3)	3.8(1)	∞ *303*	0/15
DE pal	**1.4**(2)	**2.1**(2)	**2.4**(2)	7.9(2)	15(4)	15/15
HCMA los	4.3(4)	**2.8**(3)	**1.9**(2)	3.9(2)	**2.3**(0.3)	15/15
HMLSL pal	**1.3**(1)	**1**(1.0)	**0.83**(0.5)	**0.82**(0.2)	10(14)	15/15
IPOP-10DDr	**2.3**(3)	**2.0**(2)	3.1(3)	3.7(2)	6.6(0.9)	15/15
IPOP-500 l	**2.3**(3)	**2.0**(2)	3.1(3)	3.7(2)	6.6(0.9)	15/[illegible]
IPOP-tany	**2.7**(4)	**1.7**(2)	**2.0**(2)	3.5(0.9)	6.0(0.8)	15/[illegible]
IPOP-texp	**2.8**(6)	**1.9**(3)	**2.0**(2)	**3.0**(2)	5.4(1)	15/[illegible]
IPOP lia	**2.3**(3)	**2.0**(2)	3.1(3)	3.7(2)	6.6(0.9)	15/[illegible]
MLSL pal	**1.3**(1)	**1**(1.0)	**0.83**(0.5)	**0.82**(0.2)	140(201)	9/15
OQNLP pal	**2.7**(3)	**2.2**(2)	**1.7**(0.6)	**1.2**(0.6)	10(9)	15/15
P-DCN tra	**1.7**(2)	**1.4**(2)	4.7(6)	11(7)	1.9e4(2e4)	9/[illegible]5
P-zero tra	**1.5**(2)	**1.2**(1)	4.0(4)	8.8(6)	4.6e4(5e4)	5/1[illegible]
SMAC hut	**1**(0.9)	**0.90**(0.8)	**1.683 7**(8)	**0.847194 44**	**4.98132 f 11.5559 0**	**1.021**

5/ PPO

Table 17: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{16} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f16	*6.3e+1*:1.5	*2.5e+1*:8.2	*1.6e+1*:10	*1.0e+1*:41	*2.5e+0*:208	15/15
BIPOP-aCMA	**2.2**(2)	**1.9**(2)	3.3(3)	**1.9**(2)	**1.9**(3)	15/15
BIPOP-saAC	**1.7**(1.0)	**2.1**(3)	4.2(4)	**2.4**(2)	**2.4**(3)	15/15
CMAES hut	**1.4**(2)	**1.7**(2)	**2.4**(3)	**1.2**(1)	**1.3**(1)	11/15
DE pal	**1.7**(1.0)	**1.5**(1)	**2.3**(2)	**1.2**(2)	**2.4**(4)	15/15
HCMA los	3.6(4)	**2.4**(3)	3.2(4)	**1.3**(1)	**2.5**(4)	15/15
HMLSL pal	7.7(3)	6.6(10)	7.7(8)	3.0(3)	4.6(5)	15/15
IPOP-10DDr	**1.9**(2)	**1.2**(1)	**2.1**(3)	**1.1**(1)	**1.0**(0.9)	15/15
IPOP-500 l	**1.9**(2)	**1.2**(1)	**2.1**(3)	**1.1**(1)	**1.0**(0.9)	15/15
IPOP-tany	**2.0**(2)	**1.3**(1)	**2.1**(2)	**1.5**(3)	3.3(4)	15/15
IPOP-texp	**1.7**(1)	**1.7**(2)	3.4(4)	**2.2**(3)	**1.4**(1)	15/15
IPOP lia	**1.9**(2)	**1.2**(1)	**2.1**(3)	**1.1**(1)	**1.0**(0.9)	15/15
MLSL pal	7.7(3)	6.8(10)	8.7(8)	3.3(4)	**2.9**(4)	15/15
OQNLP pal	35(57)	14(13)	18(14)	5.1(3)	5.9(8)	15/15
P-DCN tra	**2.1**(0.7)	**1.2**(1)	**2.4**(4)	**0.93**(1)	**1.5**(1)	15/15
P-zero tra	**1.5**(0.7)	**0.99**(1)	11(1.0)	3.1(0.8)	1092(161)	14/15
SMAC hut	**2.2**(2)	**1.3**(1)	**1.7**(1)	**0.64**(0.8)	**0.59**(0.7)	14/15
U-DCN tra	**1.5**(0.7)	**1.1**(1)	**1.6**(2)	**1.0**(1)	**2.0**(2)	15/15
U-zero tra	**1.5**(0.7)	**0.97**(0.9)	**1.9**(2)	**1.2**(1)	**2.6**(3)	15/15
fmincon pa	7.7(3)	6.3(9)	8.2(9)	3.4(3)	4.1(3)	15/15
fminunc pa	30(76)	15(16)	13(14)	4.7(4)	13(13)	15/15
ga100 hol	**2.4**(3)	**1.6**(2)	4.1(6)	**1.9**(2)	3.2(2)	15/15
grid100 ho	**1.5**(2)	**2.3**(3)	**2.6**(3)	**1.5**(1)	4.6(5)	15/15
grid16 hol	**1.2**(0.7)	**1.1**(1.0)	**2.8**(3)	**1.2**(2)	9.4(6)	15/15
hill hol	**2.5**(3)	**2.0**(2)	**2.0**(2)	**1.4**(2)	4.9(9)	15/15
lmmCMA aug	**2.9**(3)	**1.5**(1)	4.2(6)	**1.5**(1)	**1.7**(2)	15/15
memPSODE v	**2.3**(4)	**1.4**(2)	**2.9**(4)	**2.0**(1)	10(13)	15/15
prcga saw	**1.6**(2)	**1.2**(1)	**2.3**(3)	**1.7**(2)	**1.8**(2)	15/15
ring100 ho	**2.3**(2)	**1.2**(1)	**1.8**(2)	**1.3**(2)	**2.9**(3)	15/15
ring16 hol	**1.3**(0.7)	**1.4**(1)	**2.7**(3)	**1.2**(1)	**2.0**(3)	15/15
simplex pa	119(104)	27(19)	25(6)	7.4(2)	**2.4**(0.7)	15/15

Table 18: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{17} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f17	*1.6e+1*:1.8	*1.0e+1*:3.6	*6.3e+0*:14	*2.5e+0*:34	*2.5e-1*:189	5/5
BIPOP-aCMA	**1.6**(0.6)	**2.6**(3)	**1.4**(2)	**2.0**(1)	**2.1**(3)	15/15
BIPOP-saAC	5.4(7)	5.4(6)	**2.4**(2)	5.1(2)	**2.3**(3)	15/15
CMAES hut	**2.0**(3)	**2.6**(3)	**1.6**(1)	**1.7**(2)	**0.99**(0.5)	14/15
DE pal	**2.1**(1)	**2.7**(3)	**2.1**(2)	**3.0**(2)	**2.6**(1)	15/15
HCMA los	4.9(3)	4.2(5)	3.1(3)	**2.9**(2)	**2.6**(3)	15/15
HMLSL pal	21(47)	23(49)	14(17)	21(14)	14(19)	15/15
IPOP-10DDr	**2.7**(4)	**2.5**(2)	**1.5**(1)	**1.9**(1)	**1.7**(0.5)	15/15
IPOP-500 l	**2.7**(4)	**2.5**(2)	**1.5**(1)	**1.9**(1)	**1.7**(0.5)	15/15
IPOP-tany	**2.7**(3)	**3.0**(2)	**1.4**(0.9)	**1.7**(0.9)	**2.1**(0.4)	15/15
IPOP-texp	4.9(7)	20(16)	10(24)	6.9(13)	**2.5**(3)	15/15
IPOP lia	**2.7**(4)	**2.5**(2)	**1.5**(1)	**1.9**(1)	**1.7**(0.5)	15/15
MLSL pal	21(46)	23(51)	15(18)	21(16)	139(173)	12/15
OQNLP pal	16(36)	15(18)	7.6(5)	6.4(3)	22(30)	12/15
P-DCN tra	**2.3**(3)	**2.4**(3)	**1.2**(1)	24(44)	1.5e4(2e4)	8/15
P-zero tra	**2.1**(3)	**2.3**(2)	**1.3**(1)	92(142)	3.2e4(4e4)	5/15
SMAC hut	**1.2**(1)	**1.9**(2)	**0.93**(1.0)	**1.7**(2)	12(13)	2/15
U-DCN tra	**1.9**(2)	**2.3**(2)	**1.2**(1)	**3.0**(3)	2560(6257)	15/15
U-zero tra	**2.0**(3)	**2.3**(3)	**1.5**(1)	3.3(3)	592(462)	15/15
fmincon pa	18(47)	21(37)	13(16)	34(89)	164(184)	13/15
fminunc pa	13(36)	10(18)	5.2(4)	6.7(3)	35(48)	15/15
ga100 hol	**1.9**(1)	3.3(3)	**1.7**(2)	4.2(6)	11(6)	15/15
grid100 ho	**2.8**(3)	3.1(4)	**2.3**(2)	7.6(10)	74(46)	15/15
grid16 hol	**2.4**(2)	3.2(5)	**1.8**(3)	6.7(6)	134(335)	14/15
hill hol	5.0(6)	5.5(5)	**2.5**(3)	5.0(4)	75(80)	14/15
lmmCMA aug	**0.93**(0.6)	**0.94**(1)	**0.77**(0.8)	**1.3**(0.8)	**0.85**(0.9)	15/15
memPSODE v	3.0(2)	3.2(2)	6.3(16)	19(25)	22(10)	15/15
prcga saw	**1.1**(0.8)	**1.5**(2)	**0.91**(1)	**2.1**(2)	12(18)	15/15
ring100 ho	**2.2**(2)	3.6(5)	**2.8**(3)	6.0(6)	22(10)	15/15
ring16 hol	**2.7**(3)	**2.4**(2)	**1.4**(1)	3.1(3)	20(17)	15/15
simplex pa	29(64)	24(32)	12(9)	12(5)	55(78)	14/15

Table 19: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{18} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f18	*6.3e+1*:1.8	*4.0e+1*:4.8	*2.5e+1*:13	*1.0e+1*:40	*6.3e-1*:184	15/15
BIPOP-aCMA	5.0(5)	3.2(4)	**2.7**(2)	**2.1**(2)	**2.6**(5)	15/15
BIPOP-saAC	5.0(6)	3.4(4)	**1.9**(2)	**1.3**(0.9)	**2.9**(3)	15/15
CMAES hut	3.6(4)	**2.7**(3)	**1.3**(1)	**1.3**(0.9)	**3.4**(3)	6/15
DE pal	**2.5**(3)	4.7(6)	**2.4**(2)	**1.8**(1)	**3.7**(2)	15/15
HCMA los	7.2(8)	3.4(3)	**1.8**(2)	**1.5**(1)	4.6(5)	15/15
HMLSL pal	25(29)	19(24)	8.4(12)	8.4(6)	16(7)	15/15
IPOP-10DDr	3.7(4)	18(2)	7.5(2)	3.1(1)	5.5(8)	15/15
IPOP-500 l	3.7(4)	18(2)	7.5(2)	3.1(1)	5.5(8)	15/15
IPOP-tany	3.1(4)	**2.9**(3)	**1.8**(2)	**1.6**(0.9)	4.2(6)	15/15
IPOP-texp	9.1(14)	6.1(7)	3.2(3)	**1.5**(1)	5.7(8)	15/15
IPOP lia	3.7(4)	18(2)	7.5(2)	3.1(1)	5.5(8)	15/15
MLSL pal	26(29)	20(27)	9.3(10)	10(6)	151(126)	13/15
OQNLP pal	28(49)	19(22)	11(8)	7.7(3)	19(16)	14/15
P-DCN tra	3.5(4)	**2.2**(3)	**1.7**(2)	36(22)	1.4e4(2e4)	8/15
P-zero tra	3.1(3)	**2.6**(3)	**1.8**(2)	37(5)	1.9e4(2e4)	7/15
SMAC hut	**2.2**(2)	**1.4**(2)	**0.95**(1)	**1.0**(0.9)	∞ *300*	0/15
U-DCN tra	4.4(4)	**2.2**(2)	**1.4**(1)	**2.8**(4)	1711(2367)	14/15
U-zero tra	3.2(3)	**1.6**(1)	**1.3**(1)	**2.3**(3)	1640(1808)	15/15
fmincon pa	26(29)	20(22)	9.1(9)	8.1(4)	213(216)	12/15
fminunc pa	16(27)	11(11)	5.4(4)	4.9(3)	133(143)	11/15
ga100 hol	3.4(3)	**2.8**(1)	**1.6**(1)	**2.9**(3)	25(11)	15/15
grid100 ho	**2.4**(3)	**1.8**(2)	**2.1**(3)	4.7(5)	270(419)	13/15
grid16 hol	**2.9**(4)	3.1(4)	**1.7**(2)	5.2(3)	474(817)	10/15
hill hol	14(21)	7.2(8)	4.4(4)	**2.9**(3)	209(412)	13/15
lmmCMA aug	**1.6**(2)	**1.3**(1)	**1.1**(1)	**0.74**(0.4)	**1.5**(2)	15/15
memPSODE v	4.8(5)	4.2(3)	**2.3**(2)	14(21)	49(40)	15/15
prcga saw	**2.4**(2)	**1.7**(1)	**1.3**(2)	**2.0**(2)	41(74)	15/15
ring100 ho	5.7(5)	4.3(4)	**2.8**(3)	6.3(8)	36(22)	15/15
ring16 hol	**2.4**(2)	3.1(4)	**2.1**(3)	3.5(3)	30(29)	15/15
simplex pa	46(63)	27(26)	16(10)	9.1(1)	39(30)	15/15

Table 20: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{19} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f19	*1.6e-1*:81	*1.0e-1*:109	*6.3e-2*:109	*4.0e-2*:119	*1.6e-2*:1230	15/15
BIPOP-aCMA	33(33)	57(90)	118(91)	117(82)	19(22)	15/15
BIPOP-saAC	37(48)	40(39)	62(51)	76(82)	13(13)	15/15
CMAES hut	56(56)	41(43)	∞	∞	∞ *303*	0/15
DE pal	15(12)	22(17)	35(30)	47(59)	16(19)	14/15
HCMA los	25(40)	38(40)	56(58)	100(101)	13(13)	15/15
HMLSL pal	**0.21**(0)$_{\downarrow}$	**0.16**(0)$_{\downarrow}$	**0.16**(0)$_{\downarrow}$	**0.14**(0)$_{\downarrow}$	**0.03**(0)$_{\downarrow 4}$	15/15
IPOP-10DDr	163(367)	152(270)	165(274)	311(331)	41(52)	15/15
IPOP-500 l	163(367)	152(270)	165(274)	295(331)	31(37)	15/15
IPOP-tany	128(269)	177(265)	282(249)	374(532)	57(73)	15/15
IPOP-texp	142(305)	135(296)	199(374)	312(377)	35(38)	15/15
IPOP lia	163(367)	152(270)	165(274)	295(331)	31(37)	15/15
MLSL pal	**0.21**(0)$_{\downarrow}$	**0.16**(0)$_{\downarrow}$	**0.16**(0)$_{\downarrow}$	**0.14**(0)$_{\downarrow}$	**0.03**(0)$_{\downarrow 4}$	15/15
OQNLP pal	**0.15**(0)$_{\downarrow}$	**0.11**(0)$^{\star 4}_{\downarrow}$	**0.11**(0)$^{\star 4}_{\downarrow}$	**0.10**(4e-3)$^{\star 4}_{\downarrow}$	**0.03**(4e-4)$_{\downarrow 4}$	15/15
P-DCN tra	136(135)	171(362)	207(385)	311(352)	346(729)	14/15
P-zero tra	2504(3741)	2382(4313)	2867(5331)	3042(4972)	497(584)	15/15
SMAC hut	∞	∞	∞	∞	∞ *300*	0/15
U-DCN tra	41(47)	353(919)	924(1290)	2851(4708)	934(1257)	13/15
U-zero tra	59(67)	304(723)	468(725)	1671(3158)	1359(1717)	11/15
fmincon pa	**0.21**(0)$_{\downarrow}$	**0.16**(0)$_{\downarrow}$	**0.16**(0)$_{\downarrow}$	**0.14**(0)$_{\downarrow}$	**0.03**(0)$_{\downarrow 4}$	15/15
fminunc pa	**0.21**(0.0)$_{\downarrow}$	**0.16**(0.0)$_{\downarrow}$	**0.16**(0.0)$_{\downarrow}$	**0.15**(0.0)$_{\downarrow}$	**0.02**(2e-3)$^{\star 4}_{\downarrow 4}$	15/15
ga100 hol	38(23)	58(42)	78(70)	181(226)	44(39)	15/15
grid100 ho	104(66)	122(152)	426(654)	738(809)	216(246)	6/15
grid16 hol	66(80)	216(487)	447(558)	623(806)	147(178)	8/15
hill hol	68(93)	81(107)	188(206)	441(492)	276(335)	5/15
lmmCMA aug	29(30)	27(24)	47(46)	58(59)	5.6(6)	4/15
memPSODE v	76(70)	78(49)	124(96)	135(76)	26(23)	15/15
prcga saw	6.3(4)	12(5)	44(44)	89(170)	22(31)	15/15
ring100 ho	67(58)	77(77)	151(143)	337(320)	113(127)	10/15
ring16 hol	32(33)	48(18)	106(133)	355(560)	87(96)	11/15
simplex pa	**0.14**(0.0)$_{\downarrow}$	**0.14**(0.0)$_{\downarrow}$	**0.16**(0.0)$_{\downarrow}$	**0.16**(0.0)$_{\downarrow}$	**0.03**(6e-3)$_{\downarrow 4}$	15/15

Table 21: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{20} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f20	*4.0e+3*:3.5	*2.5e+3*:4.3	*4.0e+0*:13	*1.6e+0*:41	*1.0e+0*:385	5/5
BIPOP-aCMA	3.5(3)	3.4(3)	3.0(1)	7.2(12)	3.2(4)	15/15
BIPOP-saAC	**1.8**(2)	**1.5**(1)	**2.0**(2)	11(13)	**2.1**(2)	15/15
CMAES hut	**1.6**(2)	**1.5**(2)	**2.6**(1)	**3.9**(4)	**2.6**(3)	4/15
DE pal	**1.1**(1)	**1.2**(0.9)	4.4(4)	7.5(3)	**2.0**(1)	15/15
HCMA los	**1.9**(1)	**1.7**(1)	**1.0**(0.5)	8.7(12)	4.2(5)	15/15
HMLSL pal	**1.7**(0)	**1.4**(0)	**1.2**(0)	10(3)	**1.6**(1)	15/15
IPOP-10DDr	**0.77**(0.9)	**2.7**(2)	**2.9**(1)	**5.0**(2)	4.6(4)	15/15
IPOP-500 l	**0.77**(0.9)	**2.7**(2)	**2.9**(1)	**5.0**(2)	4.6(4)	15/15
IPOP-tany	**0.77**(0.9)	**1.1**(0.7)	3.2(1)	19(20)	8.5(8)	15/15
IPOP-texp	**0.46**(0.3)	**0.89**(0.8)	**1.6**(1)	15(13)	**2.5**(2)	15/15
IPOP lia	**0.77**(0.9)	**2.7**(2)	**2.9**(1)	**5.0**(2)	4.6(4)	15/15
MLSL pal	**1.7**(0)	**1.4**(0)	**1.2**(0)	8.6(2)	**1.5**(2)	15/15
OQNLP pal	3.5(0)	3.0(0)	**2.2**(0)	7.6(2)	**2.0**(2)	15/15
P-DCN tra	**1.4**(1)	**2.3**(2)	3.9(3)	14(26)	485(928)	15/15
P-zero tra	**1.4**(1)	**2.6**(3)	6.5(6)	8924(2e4)	3223(3570)	15/15
SMAC hut	**1.2**(0.4)	**1.2**(0.4)	**1.4**(2)	6.4(6)	5.7(6)	2/15
U-DCN tra	**1.4**(1)	**2.3**(2)	3.5(3)	7.2(8)	8.7(2)	15/15
U-zero tra	**1.4**(1)	**2.2**(2)	**2.9**(2)	19(19)	30(18)	15/15
fmincon pa	**1.7**(0)	**1.4**(0)	**1.2**(0)	8.7(6)	**1.6**(1)	15/15
fminunc pa	**1.4**(0)	**1.2**(0)	**2.9**(0)	9.1(2)	**2.2**(2)	15/15
ga100 hol	**1.7**(2)	**1.5**(2)	12(13)	14(10)	3.9(3)	15/15
grid100 ho	**1.9**(2)	**1.8**(2)	11(14)	35(20)	8.0(7)	15/15
grid16 hol	**1.5**(1)	**1.3**(1)	6.2(7)	15(5)	4.0(4)	15/15
hill hol	**2.8**(3)	**2.8**(3)	3.8(3)	**5.1**(4)	8.2(16)	15/15
lmmCMA aug	**1.4**(0.7)	**1.3**(0.7)	**1.6**(1.0)	15(24)	8.6(8)	7/15
memPSODE v	**2.6**(2)	**2.9**(2)	4.1(2)	14(25)	7.0(6)	15/15
prcga saw	**0.81**(0.7)	**0.95**(0.8)	**1.9**(2)	16(8)	8.1(13)	15/15
ring100 ho	**0.98**(0.9)	**0.89**(0.7)	7.2(6)	22(12)	6.3(3)	15/15
ring16 hol	**1.3**(1)	**1.7**(2)	7.1(7)	12(6)	**2.2**(1)	15/15
simplex pa	10(0.3)	8.9(0.2)	5.2(2)	14(11)	3.6(3)	15/15

Table 22: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{21} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f21	*1.6e+1*:2.5	*1.0e+1*:5.9	*6.3e+0*:14	*2.5e+0*:41	*1.6e+0*:167	15/15
BIPOP-aCMA	3.8(5)	**2.6**(3)	**2.4**(2)	4.9(10)	4.5(6)	15/15
BIPOP-saAC	**1.3**(1)	**1.1**(0.9)	**1.3**(1)	**0.94**(1)	**2.1**(5)	15/15
CMAES hut	3.4(3)	**2.1**(0.9)	**1.7**(1)	**2.1**(4)	**1.4**(2)	10/15
DE pal	**2.1**(3)	**2.1**(2)	**2.4**(2)	**1.7**(1)	**2.2**(1)	15/15
HCMA los	3.4(3)	**2.3**(2)	**2.1**(2)	**1.2**(1)	**1.4**(2)	15/15
HMLSL pal	5.2(3)	4.2(6)	4.1(4)	**2.9**(3)	**1.9**(1)	15/15
IPOP-10DDr	**1.9**(2)	**1.6**(1)	**2.0**(2)	3.2(3)	**2.0**(3)	15/15
IPOP-500 l	**1.9**(2)	**1.6**(1)	**2.0**(2)	3.2(3)	**2.0**(3)	15/15
IPOP-tany	**1.3**(1.0)	**1.1**(1)	**1.5**(2)	**2.6**(2)	**2.3**(3)	15/15
IPOP-texp	**1.8**(2)	**1.3**(2)	4.8(1)	5.6(11)	**2.5**(6)	15/15
IPOP lia	**1.9**(2)	**1.6**(1)	**2.0**(2)	3.2(3)	**2.0**(7)	15/15
MLSL pal	5.1(3)	4.0(6)	4.7(5)	**2.3**(2)	**1.1**(1.0)	15/15
OQNLP pal	5.1(4)	4.0(4)	**2.7**(2)	**2.7**(3)	**1.3**(1)	15/15
P-DCN tra	**1.7**(2)	**1.5**(2)	**2.5**(4)	1.1e4(4e4)	2.7e4(4e4)	6/15
P-zero tra	**1.7**(2)	**1.4**(2)	**1.8**(3)	1.1e4(4e4)	2.0e4(3e4)	7/15
SMAC hut	**1.2**(1.0)	**1.2**(1)	**1.8**(2)	**0.93**(0.7)	**0.68**(0.4)	15/15
U-DCN tra	**1.5**(2)	**1.2**(2)	**1.4**(2)	**2.0**(3)	**1.8**(1)	15/15
U-zero tra	**1.6**(2)	**0.99**(1)	**0.88**(1)	**2.3**(3)	3.7(6)	15/15
fmincon pa	5.1(2)	4.3(6)	4.5(4)	**2.6**(3)	**1.5**(1)	15/15
fminunc pa	4.4(6)	4.7(7)	4.5(4)	**2.4**(2)	**1.4**(0.9)	15/15
ga100 hol	**1.8**(2)	**0.87**(0.8)	**1.5**(2)	**2.1**(2)	**2.5**(4)	15/15
grid100 ho	**1.2**(1)	**1.3**(2)	**1.2**(1)	**1.8**(1)	5.3(3)	15/15
grid16 hol	**1.4**(1.0)	**1.1**(0.9)	**1.2**(1)	**2.3**(2)	**1.9**(2)	15/15
hill hol	5.7(7)	5.5(9)	3.4(6)	3.4(4)	67(5)	14/15
lmmCMA aug	**2.2**(2)	**2.2**(2)	**2.9**(2)	**1.6**(3)	**0.69**(1)	15/15
memPSODE v	**2.6**(2)	**2.3**(2)	3.3(3)	7.4(6)	3.5(6)	15/15
prcga saw	**1.4**(1.0)	**0.72**(0.9)	**1.4**(2)	**1.6**(2)	10(10)	15/15
ring100 ho	**2.2**(2)	**1.5**(2)	**1.6**(2)	**2.9**(6)	**1.7**(2)	15/15
ring16 hol	**2.2**(3)	**1.5**(2)	**1.9**(2)	**1.6**(2)	**1.9**(2)	15/15
simplex pa	20(20)	19(21)	13(10)	6.9(5)	**2.4**(2)	15/15

Table 23: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{22} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f22	*4.0e+1*:2.9	*2.5e+1*:5.2	*1.0e+1*:18	*6.3e+0*:33	*1.0e+0*:170	5/5
BIPOP-aCMA	**1.7**(2)	**2.2**(2)	**1.4**(1.0)	3.0(2)	6.9(7)	15/15
BIPOP-saAC	10(4)	6.1(2)	**2.4**(1)	**1.8**(1)	4.5(5)	15/15
CMAES hut	**2.8**(3)	**2.3**(3)	**3.0**(3)	**2.1**(2)	**1.7**(2)	9/15
DE pal	**1.7**(1)	**1.3**(1)	**1.4**(1)	**1.5**(2)	56(177)	13/15
HCMA los	**2.6**(2)	**2.3**(1.0)	**1.3**(1)	**1.9**(1)	3.5(8)	15/15
HMLSL pal	4.2(4)	4.1(8)	**2.3**(3)	3.1(3)	**1.7**(2)	15/15
IPOP-10DDr	**2.0**(2)	**1.5**(2)	**1.7**(2)	**1.5**(1)	3.4(3)	15/15
IPOP-500 l	**2.0**(2)	**1.5**(2)	**1.7**(2)	**1.5**(1)	3.4(3)	15/15
IPOP-tany	**1.8**(2)	**1.2**(0.9)	**1.4**(2)	6.5(13)	8.3(9)	15/15
IPOP-texp	**1.5**(0.9)	**1.8**(2)	5.0(2)	6.5(14)	11(12)	15/15
IPOP lia	**2.0**(2)	**1.5**(2)	**1.7**(2)	**1.5**(1)	3.4(3)	15/15
MLSL pal	4.3(4)	4.0(8)	**2.0**(2)	**2.9**(3)	**1.3**(0.8)	15/15
OQNLP pal	4.9(4)	5.8(8)	**3.0**(4)	**2.7**(3)	3.3(4)	13/15
P-DCN tra	**1.1**(0.9)	**1.3**(2)	**2.0**(3)	6496(3)	1.2e4(2e4)	9/15
P-zero tra	**1.1**(0.9)	**1.5**(2)	**2.3**(2)	2.3e4(5e4)	3.5e4(4e4)	5/15
SMAC hut	**1.4**(1)	**0.96**(0.8)	**0.80**(0.8)	**0.85**(0.6)	**0.58**(0.6)	15/15
U-DCN tra	**1.1**(0.9)	**0.96**(1.0)	1.4(2)	**1.9**(2)	**2.3**(2)	15/15
U-zero tra	**1.1**(0.9)	**1.5**(2)	**1.8**(2)	**2.7**(2)	3.5(3)	15/15
fmincon pa	4.3(4)	4.2(8)	**2.4**(3)	**2.5**(2)	**1.1**(0.8)	15/15
fminunc pa	3.5(4)	3.7(5)	**1.8**(2)	**2.7**(3)	**1.2**(1.0)	15/15
ga100 hol	**1.7**(2)	**1.6**(1)	**1.7**(1)	**1.7**(2)	65(3)	14/15
grid100 ho	**1.4**(1)	**1.2**(1)	**1.6**(2)	**1.9**(2)	**2.7**(3)	15/15
grid16 hol	**1.0**(0.9)	**0.83**(0.5)	**1.8**(2)	3.3(4)	7.4(4)	15/15
hill hol	4.9(5)	4.2(4)	**2.1**(2)	**1.7**(2)	298(442)	12/15
lmmCMA aug	**1.6**(1)	**1.7**(2)	**1.3**(1.0)	**1.5**(0.8)	5.1(7)	12/15
memPSODE v	**2.7**(3)	**2.9**(2)	**1.2**(0.9)	**1.0**(1)	17(26)	15/15
prcga saw	**1.2**(0.5)	**1.6**(2)	**1.5**(2)	**1.6**(2)	9.4(20)	15/15
ring100 ho	**1.3**(1)	**1.4**(1)	**2.0**(2)	**2.2**(2)	3.3(4)	15/15
ring16 hol	**0.98**(0.7)	**1.8**(1)	**3.0**(3)	3.7(5)	4.2(8)	15/15
simplex pa	24(30)	21(31)	10(9)	9.1(6)	3.3(3)	15/15

Table 24: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{23} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f23	*1.0e+1*:2.6	*6.3e+0*:16	*4.0e+0*:44	*2.5e+0*:79	*1.6e+0*:198	15/15
BIPOP-aCMA	5.9(6)	**1.6**(2)	**1.7**(2)	3.0(3)	6.2(7)	15/15
BIPOP-saAC	3.4(3)	**2.2**(3)	3.5(4)	7.2(7)	6.3(6)	15/15
CMAES hut	3.7(3)	**2.7**(4)	**2.9**(4)	12(13)	∞ *303*	0/15
DE pal	4.1(4)	**1.7**(1)	**2.2**(2)	**3.0**(3)	5.2(5)	15/15
HCMA los	7.4(8)	3.2(3)	3.5(4)	5.2(6)	5.0(5)	15/15
HMLSL pal	14(16)	6.2(8)	3.2(4)	3.8(3)	**2.0**(2)	15/15
IPOP-10DDr	3.8(4)	**1.8**(1)	**2.1**(2)	5.1(5)	5.4(6)	15/15
IPOP-500 l	3.8(4)	**1.8**(1)	**2.1**(2)	5.1(5)	5.4(6)	15/15
IPOP-tany	**2.9**(2)	**2.1**(3)	**2.1**(2)	4.4(4)	6.0(4)	15/15
IPOP-texp	3.7(4)	**2.5**(4)	**1.5**(1)	4.9(5)	4.8(3)	15/15
IPOP lia	3.8(4)	**1.8**(1)	**2.1**(2)	5.1(5)	5.4(6)	15/15
MLSL pal	15(16)	6.4(9)	3.3(4)	**3.0**(3)	**1.7**(1)	15/15
OQNLP pal	14(33)	4.5(8)	4.9(5)	4.5(4)	**2.9**(4)	15/15
P-DCN tra	3.6(5)	**2.3**(2)	**1.9**(2)	**2.6**(2)	3.2(2)	15/15
P-zero tra	3.8(4)	**1.8**(1)	**1.4**(1)	3.9(5)	4.7(6)	15/15
SMAC hut	3.5(3)	**1.5**(2)	**2.0**(2)	4.5(5)	11(11)	2/15
U-DCN tra	**2.9**(3)	**1.9**(2)	**1.9**(2)	4.2(6)	5.2(4)	15/15
U-zero tra	**2.6**(3)	**1.5**(1)	**1.8**(3)	3.0(2)	9.3(17)	15/15
fmincon pa	13(15)	4.3(8)	3.2(4)	**2.4**(2)	**1.6**(2)	15/15
fminunc pa	11(21)	5.0(6)	3.2(3)	3.1(2)	**1.7**(1)	15/15
ga100 hol	4.7(3)	**1.4**(1)	**1.4**(1)	4.7(7)	9.0(10)	15/15
grid100 ho	4.2(3)	**1.7**(3)	**1.8**(2)	**2.3**(2)	12(12)	15/15
grid16 hol	3.3(5)	**1.5**(2)	**2.0**(2)	7.1(5)	13(17)	15/15
hill hol	6.4(7)	**2.7**(3)	**1.5**(2)	4.6(6)	6.3(10)	15/15
lmmCMA aug	5.5(5)	**2.0**(1)	**2.9**(3)	**2.7**(2)	3.9(5)	13/15
memPSODE v	**2.7**(3)	**1.8**(2)	**2.1**(0.7)	**2.8**(0.3)	**2.6**(5)	15/15
prcga saw	4.5(5)	**2.1**(3)	**2.5**(3)	4.1(4)	4.7(6)	15/15
ring100 ho	**3.2**(3)	**2.3**(2)	**1.7**(2)	3.9(5)	5.3(7)	15/15
ring16 hol	4.2(6)	**1.8**(2)	**2.8**(4)	7.6(7)	7.4(6)	15/15
simplex pa	80(104)	19(18)	10(7)	7.7(3)	3.2(1)	15/15

Table 25: 03-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{24} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f24	*4.0e+1*:4.6	*2.5e+1*:13	*1.6e+1*:47	*1.6e+1*:47	*6.3e+0*:382	15/15
BIPOP-aCMA	**2.6**(2)	**3.0**(1)	**1.9**(1)	**1.9**(1)	**1.5**(1)	15/15
BIPOP-saAC	**2.8**(3)	**2.2**(2)	**1.3**(0.8)	**1.3**(0.8)	**2.1**(3)	15/15
CMAES hut	**1.2**(1)	**1.9**(2)	**1.5**(1.0)	**1.5**(1)	**1.4**(1)	7/15
DE pal	**1.6**(1)	**1.9**(1)	**2.6**(1)	**2.6**(1)	**2.3**(2)	15/15
HCMA los	**1.8**(1)	**1.2**(0.7)	**1.8**(1)	**1.8**(1)	**1.3**(1)	15/15
HMLSL pal	3.8(3)	**2.9**(1)	**2.3**(3)	**2.3**(3)	**1.7**(0.8)	15/15
IPOP-10DDr	**1.4**(2)	**2.1**(1)	**1.5**(0.8)	**1.5**(0.8)	**2.4**(3)	15/15
IPOP-500 l	**1.4**(2)	**2.1**(1)	**1.5**(0.8)	**1.5**(0.8)	**2.4**(3)	15/15
IPOP-tany	**1.4**(2)	**2.1**(2)	**1.3**(0.6)	**1.3**(0.6)	**2.2**(2)	15/15
IPOP-texp	**0.74**(0.5)	**1.2**(1)	**1.0**(0.8)	**1.0**(0.8)	**2.1**(3)	15/15
IPOP lia	**1.4**(2)	**2.1**(1)	**1.5**(0.8)	**1.5**(0.8)	**2.4**(3)	15/15
MLSL pal	3.7(3)	**2.9**(1)	**2.4**(3)	**2.4**(3)	**1.6**(2)	15/15
OQNLP pal	**2.5**(2)	**2.2**(2)	5.8(2)	5.8(2)	**1.3**(0.6)	15/15
P-DCN tra	**2.5**(2)	3.4(3)	8.3(19)	8.3(19)	64(109)	15/15
P-zero tra	**2.8**(2)	3.1(2)	120(181)	120(181)	264(262)	15/15
SMAC hut	**2.0**(2)	**2.6**(2)	**2.2**(1)	**2.2**(1)	3.6(4)	3/15
U-DCN tra	**2.0**(1)	**3.0**(1)	**2.7**(3)	**2.7**(3)	6.2(10)	15/15
U-zero tra	**2.0**(1)	**1.7**(1)	**1.5**(2)	**1.5**(2)	4.4(4)	15/15
fmincon pa	3.7(3)	**2.9**(1)	**2.1**(2)	**2.1**(2)	**1.2**(1)	15/15
fminunc pa	**2.0**(2)	**2.7**(3)	**3.0**(3)	**3.0**(3)	**2.5**(2)	15/15
ga100 hol	**1.6**(2)	**2.4**(2)	3.7(3)	3.7(3)	6.3(6)	15/15
grid100 ho	**2.3**(3)	3.6(3)	5.8(7)	5.8(7)	14(13)	15/15
grid16 hol	**2.7**(3)	4.3(4)	**2.8**(3)	**2.8**(3)	6.0(7)	15/15
hill hol	**2.6**(3)	**2.5**(3)	3.6(4)	3.6(4)	5.8(6)	15/15
lmmCMA aug	**1.5**(1)	**2.3**(2)	**1.7**(1)	**1.7**(1)	**0.98**(1)	15/15
memPSODE v	**2.5**(2)	5.1(4)	10(20)	10(20)	6.9(8)	15/15
prcga saw	**1.8**(2)	**2.3**(2)	**1.4**(2)	**1.4**(2)	4.6(10)	15/15
ring100 ho	**2.1**(3)	3.6(3)	4.7(5)	4.7(5)	6.2(4)	15/15
ring16 hol	**2.3**(3)	3.2(3)	**2.8**(2)	**2.8**(2)	3.8(3)	15/15
simplex pa	6.3(6)	5.5(2)	8.1(2)	8.1(2)	3.1(3)	15/15

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