# Comparison tables: BBOB 2009 noisy testbed in 2-D

The BBOBies

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**Abstract**

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking at GECCO 2009, see `http://coco.gforge.inria.fr/doku.php?id=bbob-2009`. 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 [13, 8]. The experimental set-up is described in [12].

The performance measure provided in the following tables is the expected number of objective function evaluations to reach a given target function value (ERT, expected running time), divided by the respective value for the best algorithm. Consequently, the best (smallest) value is 1 and the value 1 appears in each column at least once. See [12] for details on how ERT is obtained. All numbers are computed with no more than two digits of precision.

Table 1: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{101}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**101 Sphere moderate Gauss**

| $\Delta$ftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | $\Delta$ftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.9 | 4 | 5 | 5.57 | 7.17 | 8.43 | 9.77 | 11.3 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1** | **1.6** | 4.9 | 32 | 78 | 120 | 160 | 190 | 250 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **2** | **2.6** | 5 | 7.4 | 8.1 | 8.8 | 9.6 | 12 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | 3.2 | **1.7** | **2.1** | **2.3** | **2** | **1.9** | **1.7** | **1.6** | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **2** | 4.9 | 110 | 150 | 160 | 190 | 170 | 190 | BayEDAcG [9] |
| BFGS | **1** | **1** | 140 | 250 | 1900 | 1e4 | *14e-2/4e3* | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | 5.3 | **2.5** | 5.8 | 7.7 | 8.5 | 9.3 | 11 | 13 | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | 3.3 | **2** | 3.9 | 5.5 | 5.8 | 6.3 | 6.1 | 7.2 | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 57 | 33 | 40 | 46 | 49 | 45 | 46 | 51 | DASA [18] |
| DEPSO | **1** | **1** | **2.7** | 5.4 | 20 | 26 | 34 | 34 | 37 | 44 | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.4** | 3.9 | 13 | 18 | 22 | 27 | 31 | 59 | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | 3.2 | **1.3** | **1.4** | **1.4** | **1.1** | **1** | **1** | **1** | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.4** | 6.2 | 22 | 27 | 22 | 19 | 17 | 17 | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **2.5** | **1.9** | 4 | 5.9 | 6.5 | 6.6 | 7.2 | 8.4 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **2.4** | 5.1 | 13 | 22 | 29 | 30 | 27 | 26 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1.1** | **1.2** | **1.5** | **1.2** | 21 | 210 | 1200 | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | **2.4** | **1.8** | **2.1** | **2.3** | **2.5** | **2.3** | **2** | **1.9** | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | 3.3 | **2.3** | 3.5 | 5.2 | 5.3 | 5.9 | 6 | 7.5 | (1+1)-ES [1] |
| PSO | **1** | **1** | **2.3** | 3.6 | 13 | 31 | 52 | 73 | 88 | 130 | PSO [6] |
| PSO_Bounds | **1** | **1** | **2.8** | **2.6** | 11 | 40 | 110 | 180 | 240 | 330 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **1.9** | 3.7 | 34 | 330 | 3100 | 1.8e4 | 3.1e5 | *17e-6/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | **2.9** | **1.9** | 4.3 | 6.3 | 6.2 | 7.3 | 7.8 | 9.2 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **2** | **1** | **1** | **1** | **1** | **1.2** | **1.6** | **1.9** | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.6** | 6 | 14 | 17 | 16 | 15 | 15 | 15 | VNS (Garcia) [10] |

Table 2: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{102}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**102 Sphere moderate unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.9 | 3.53 | 5.37 | 8.3 | 9.57 | 11.1 | 12.5 | 15.5 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1** | **2.1** | 4.4 | 20 | 68 | 91 | 120 | 150 | 190 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1.1** | **2.2** | 3.4 | 4.4 | 5 | 6 | 7.1 | 8.1 | 8.7 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1.2** | 4 | **2.1** | **2.6** | 4.4 | 4.1 | **3.7** | **3.4** | **2.8** | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **1.8** | 5.8 | 9 | 71 | 98 | 92 | 88 | 77 | BayEDAcG [9] |
| BFGS | **1** | **1** | 99 | 340 | 1e3 | *11e-2/4e3* | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | 3.6 | **2.8** | 4.7 | 5.5 | 6.9 | 7.8 | 8.6 | 9.4 | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | **2.4** | **1.9** | **3** | 3.8 | 4.3 | 4.5 | 4.9 | 5.3 | (1+1)-CMA-ES [2] |
| DASA | **1** | 13 | 70 | 57 | 50 | 43 | 44 | 44 | 44 | 47 | DASA [18] |
| DEPSO | **1** | **1** | **2.7** | 5 | 13 | 17 | 24 | 24 | 28 | 34 | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.7** | 3.6 | 9.9 | 12 | 17 | 22 | 27 | 43 | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | 4 | **1.7** | **1.5** | **1** | **1** | **1** | **1** | **1** | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **2.8** | 5 | 18 | 18 | 17 | 15 | 13 | 11 | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **2.7** | 3.3 | 4.1 | 4.3 | 4.8 | 5.5 | 6 | 6.7 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **2.4** | 5.8 | 11 | 15 | 21 | 22 | 21 | 19 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1.2** | **1.1** | **1.2** | **1.4** | 200 | 350 | 3600 | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | 7.1 | 11 | 9.3 | 7 | 6.6 | 5.8 | 5.2 | 4.4 | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | **2.2** | **2.3** | 3.2 | 3.2 | 4 | 4.4 | 4.9 | 5.4 | (1+1)-ES [1] |
| PSO | **1** | **1** | **3** | **2.9** | 11 | 19 | 40 | 50 | 64 | 90 | PSO [6] |
| PSO_Bounds | **1** | **1.1** | 3.2 | 6.5 | 14 | 32 | 82 | 140 | 180 | 240 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **2** | 4.5 | 25 | 140 | 3100 | 1.1e4 | 2.6e5 | *12e-6/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | 5.3 | 3.2 | 4.9 | 5.8 | 6.2 | 6.6 | 6.8 | 7.5 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **2** | **1** | **1** | **1** | **1.4** | **1.7** | **4.5** | **4.3** | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.6** | 7 | 12 | 12 | 12 | 11 | 12 | 12 | VNS (Garcia) [10] |

Table 3: 02-D, running time excess ERT/$\text{ERT}_{\text{best}}$ on $f_{103}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**103 Sphere moderate Cauchy**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\text{ERT}_{\text{best}}$/D | 0.5 | 0.5 | 0.9 | 3.93 | 4.7 | 4.7 | 4.7 | 4.9 | 4.9 | 6.77 | $\text{ERT}_{\text{best}}$/D |
| ALPS | **1** | **1** | 3.1 | 4.6 | 44 | 110 | 190 | 310 | 420 | 6700 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **1.5** | **2.3** | 5.6 | 7.8 | 12 | 16 | 180 | 340 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | 3.1 | **1.8** | **2.1** | **3** | 4.1 | 4.4 | 7.1 | 6.9 | avg NEWUOA [23] |
| BayEDAcG | **1** | **1.1** | **2.6** | **2.5** | 81 | 180 | 190 | 200 | 210 | 270 | BayEDAcG [9] |
| BFGS | **1** | **1** | 8.6 | 3.5 | 4.5 | 4.6 | 4.6 | 4.4 | **4.4** | **3.2** | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | 3.9 | 3.1 | 6 | 9.9 | 14 | 17 | 24 | 24 | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | **2.1** | **1.7** | 4 | 6 | 13 | 30 | 77 | 150 | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 42 | 22 | 37 | 130 | 260 | 1e3 | 3e3 | 1.9e4 | DASA [18] |
| DEPSO | **1** | **1** | **1.6** | **2.7** | 13 | 24 | 34 | 62 | 89 | 230 | DEPSO [11] |
| EDA-PSO | **1** | **1** | **2.2** | 3.4 | 8.9 | 20 | 31 | 60 | 200 | 1.3e4 | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | 3.3 | **1.5** | **1.5** | **1.6** | **1.6** | **1.6** | **1.7** | **1.2** | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **2** | 3.1 | 23 | 30 | 34 | 33 | 39 | 52 | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **2.5** | **2.6** | 4.1 | 6.7 | 9.2 | 13 | 230 | 860 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **2.7** | 3.8 | 14 | 27 | 47 | 60 | 72 | 63 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | **1.3** | **1.9** | **1.9** | **1.9** | 100 | 120 | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | 3.2 | **1.6** | **2.1** | 3.1 | 4.2 | 4.9 | 6.4 | 7.8 | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | **2.1** | **1.5** | 4.2 | 7.2 | 11 | 36 | 78 | 290 | (1+1)-ES [1] |
| PSO | **1** | **1.1** | 3.4 | 3.4 | 11 | 37 | 100 | 240 | 770 | 2.8e4 | PSO [6] |
| PSO_Bounds | **1** | **1** | **2.5** | 3.8 | 17 | 55 | 210 | 3400 | 5700 | 4.3e4 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **2.4** | **3** | 34 | 320 | 3700 | 3.2e4 | 3.1e5 | *96e-7/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | 4.2 | 3.3 | 5.3 | 7.9 | 11 | 14 | 18 | 19 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **2.4** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.6** | 6.7 | 14 | 21 | 24 | 26 | 29 | 29 | VNS (Garcia) [10] |

Table 4: 02-D, running time excess ERT/$\text{ERT}_{\text{best}}$ on $f_{104}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**104 Rosenbrock moderate Gauss**

| $\Delta$ftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | $\Delta$ftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\text{ERT}_{\text{best}}$/D | 0.6 | 2 | 2.7 | 7.27 | 96.9 | 120 | 124 | 126 | 128 | 132 | $\text{ERT}_{\text{best}}$/D |
| ALPS | **2.3** | 3.3 | 11 | 20 | 5.5 | 11 | 19 | 28 | 38 | 58 | ALPS [15] |
| AMaLGaM IDEA | **2.9** | 3.4 | 5.8 | 6.5 | **1.1** | **1.3** | **1.6** | **1.8** | **1.9** | **2.2** | AMaLGaM IDEA [4] |
| avg NEWUOA | 5.2 | **2.8** | 4.3 | 7.8 | **1.2** | 3.5 | 5.3 | 6.4 | 6.8 | 8.7 | avg NEWUOA [23] |
| BayEDAcG | 3.1 | **2.8** | 5.8 | 28 | 32 | *12e-2/2e3* | . | . | . | . | BayEDAcG [9] |
| BFGS | 140 | 110 | 190 | 390 | 220 | *60e-2/3e3* | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | 4.7 | **2.3** | 24 | 12 | **2.5** | 3.5 | 3.8 | 4.3 | 4.6 | 4.9 | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | 4.9 | 3.7 | 8.7 | 12 | **1.9** | **2.4** | 3 | 3 | 3.2 | 3.3 | (1+1)-CMA-ES [2] |
| DASA | 59 | 27 | 89 | 160 | 94 | 130 | 220 | 880 | 2100 | 4.4e4 | DASA [18] |
| DEPSO | **2.6** | **2.6** | 15 | 19 | 4.6 | 6.4 | 8.4 | 14 | 23 | *64e-7/2e3* | DEPSO [11] |
| EDA-PSO | **1.8** | **2.7** | 5.8 | 12 | 7.1 | 18 | 36 | 51 | 65 | 97 | EDA-PSO [5] |
| full NEWUOA | 4.9 | **2.5** | 6.2 | 10 | **1.1** | **1** | **1** | **1** | **1** | **1** | full NEWUOA [23] |
| GLOBAL | **2.2** | **2.4** | 9 | 14 | **1.4** | **1.4** | **1.4** | **1.4** | **1.4** | **1.5** | GLOBAL [20] |
| iAMaLGaM IDEA | 3.9 | **2.6** | **4.1** | **6.1** | **1** | **1.3** | **1.4** | **1.6** | **1.7** | **1.9** | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **2.5** | **2.1** | 7.7 | 8.9 | **1.9** | **2.6** | 3.3 | 3.4 | 3.5 | 3.9 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | 5.7 | 40 | 80 | 490 | 2900 | *20e-5/3e4* | MCS (Neum) [16] |
| NEWUOA | 7.3 | **2.9** | 6.4 | 13 | 3.4 | 6.5 | 10 | 13 | 12 | 13 | NEWUOA [23] |
| (1+1)-ES | 4.8 | 4 | 5.1 | 12 | **1.8** | 10 | 21 | 140 | 240 | 3e3 | (1+1)-ES [1] |
| PSO | **2.2** | **1.9** | 5.3 | 8.2 | 3.2 | 5 | 8.1 | 13 | 17 | 28 | PSO [6] |
| PSO_Bounds | **1.9** | 3.3 | 6.6 | 14 | 4.5 | 8.9 | 27 | 42 | 59 | 87 | PSO_Bounds [7] |
| Monte Carlo | **2.8** | **2.3** | 7 | 17 | 8.6 | 120 | 1600 | 1.3e4 | 1.1e5 | *11e-5/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | 3.3 | **2.1** | 4.9 | 21 | 7.7 | 7.7 | 7.7 | 7.7 | 7.7 | 7.7 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1.7** | **2** | **3.4** | **3.7** | 4.5 | 13 | 28 | 50 | 87 | 140 | SNOBFIT [17] |
| VNS (Garcia) | 9.5 | 3.9 | 8.2 | 14 | **2.3** | **2.3** | **2.5** | **2.6** | **2.7** | 3 | VNS (Garcia) [10] |

Table 5: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on $f_{105}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**105 Rosenbrock moderate unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.6 | 2 | 2.7 | 7.37 | 178 | 186 | 190 | 195 | 198 | 205 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **2.2** | **3** | 4.1 | 22 | 3.7 | 8 | 13 | 19 | 26 | 38 | ALPS [15] |
| AMaLGaM IDEA | **1.4** | **1.7** | 5.6 | 120 | 5.6 | 5.8 | 5.9 | **5.9** | **6** | **6** | AMaLGaM IDEA [4] |
| avg NEWUOA | 6.4 | 3.7 | 7 | 13 | **2.3** | 8.6 | 29 | 55 | 200 | 390 | avg NEWUOA [23] |
| BayEDAcG | 3.9 | **2.3** | 8.7 | 29 | 14 | 71 | *12e-2/2e3* | . | . | . | BayEDAcG [9] |
| BFGS | 64 | 54 | 140 | 340 | 71 | 220 | *32e-2/3e3* | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | 3.8 | **1.6** | 5.5 | **5.7** | **1.1** | **2.6** | **3.6** | **3.6** | **3.8** | **4.1** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | 3.2 | **2.2** | 11 | 16 | **2** | 3.9 | 6.6 | 6.7 | 6.7 | 6.6 | (1+1)-CMA-ES [2] |
| DASA | 53 | 29 | 93 | 300 | 55 | 100 | 350 | 1200 | 2300 | 5.6e4 | DASA [18] |
| DEPSO | **2.3** | 3.4 | 5.8 | 14 | **1.5** | **3.3** | **5.8** | 7.4 | 18 | 150 | DEPSO [11] |
| EDA-PSO | 4.3 | 3.5 | 6.1 | 12 | **2** | 8.7 | 19 | 29 | 41 | 60 | EDA-PSO [5] |
| full NEWUOA | 4.8 | 3.3 | 4.8 | 19 | **2.7** | 8.3 | 11 | 14 | 17 | 48 | full NEWUOA [23] |
| GLOBAL | 3.3 | **2.8** | 4.7 | 15 | **1** | **1** | **1** | **1** | **1** | **1** | GLOBAL [20] |
| iAMaLGaM IDEA | **2.7** | **2.4** | **3.2** | 24 | 7.2 | 8 | 8 | 8 | 8 | 7.9 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | 4.3 | 3 | 5.9 | 11 | **1.6** | 4.7 | 6.6 | 8.6 | 8.7 | 8.7 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | 3.2 | 26 | 120 | 300 | *43e-5/3e4* | . | MCS (Neum) [16] |
| NEWUOA | 6.3 | **2.7** | 7.9 | 16 | 3.1 | 6.3 | 22 | 42 | 41 | 110 | NEWUOA [23] |
| (1+1)-ES | 3.9 | **2.3** | 9.8 | 18 | 3.1 | 10 | 31 | 82 | 220 | 2e3 | (1+1)-ES [1] |
| PSO | 3.2 | **2.5** | 4.7 | 11 | **1.8** | 3.6 | 6.4 | 9.1 | 13 | 19 | PSO [6] |
| PSO_Bounds | **2.9** | **2.8** | 4.9 | 8.8 | **2.3** | 8.7 | 19 | 31 | 39 | 52 | PSO_Bounds [7] |
| Monte Carlo | 3.7 | **2.6** | 7.3 | 32 | 8.3 | 68 | 550 | 7400 | *14e-5/1e6* | . | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | 6 | **2.9** | 38 | 53 | 6.4 | 9.3 | 9.3 | 9.2 | 9.1 | 9 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **2.3** | **1.8** | **3.1** | **6.1** | **1.6** | 5.6 | 7.6 | 12 | 22 | 34 | SNOBFIT [17] |
| VNS (Garcia) | 9.5 | 3.9 | 9 | 13 | 3.5 | 8.2 | 8.2 | 12 | 12 | 14 | VNS (Garcia) [10] |

Table 6: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{106}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**106 Rosenbrock moderate Cauchy**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.6 | 2 | 2.7 | 7.6 | 69.5 | 140 | 176 | 206 | 245 | 325 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | 3.2 | 3.2 | 10 | 15 | 7.2 | 8.2 | 14 | 25 | 72 | 1400 | ALPS [15] |
| AMaLGaM IDEA | **2.6** | **1.9** | 4.6 | 5.8 | 16 | 13 | 11 | 11 | 17 | 27 | AMaLGaM IDEA [4] |
| avg NEWUOA | 4.6 | **2.2** | 3.7 | **4.5** | **2.1** | **2.1** | 3.2 | 3.3 | 4.3 | 5.9 | avg NEWUOA [23] |
| BayEDAcG | **2.4** | **2.3** | 6.1 | 31 | 17 | 95 | 160 | *66e-3/2e3* | . | . | BayEDAcG [9] |
| BFGS | 16 | 10 | 13 | 13 | **2.5** | **2.1** | **1.8** | **1.8** | **1.8** | **1.4** | BFGS [22] |
| BIPOP-CMA-ES | 4.1 | **2.1** | 8 | 17 | 3.3 | **2.8** | **2.6** | **2.6** | **2.4** | **2** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | 3.2 | **2.5** | 5 | 6.4 | **1.2** | **1.7** | **3** | 5 | 6.6 | 16 | (1+1)-CMA-ES [2] |
| DASA | 56 | 28 | 96 | 160 | 100 | 160 | 150 | 760 | 3100 | *30e-7/8e5* | DASA [18] |
| DEPSO | 4.4 | 6 | 17 | 19 | 5.1 | 5.6 | 10 | 18 | 40 | *11e-5/2e3* | DEPSO [11] |
| EDA-PSO | 3.1 | **1.9** | 5 | 9.3 | 5.1 | 12 | 19 | 27 | 43 | 1e3 | EDA-PSO [5] |
| full NEWUOA | 8.8 | 4 | 5 | **5.1** | **1** | **1** | **1** | **1.1** | **1** | **1** | full NEWUOA [23] |
| GLOBAL | **2.2** | 3.4 | 7.4 | 11 | **2.1** | **1.3** | **1.1** | **1** | **1.2** | **1.9** | GLOBAL [20] |
| iAMaLGaM IDEA | **2.7** | **2.5** | 5.2 | 61 | 16 | 17 | 16 | 15 | 20 | 43 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | 4.2 | **2.8** | 5.7 | 10 | **2.9** | **2.5** | **2.3** | **2.4** | **2.4** | **2.1** | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | 8 | 39 | 76 | 210 | 750 | *11e-5/3e4* | MCS (Neum) [16] |
| NEWUOA | 3.1 | **2.1** | **2.6** | 6.1 | **2** | **2.3** | 3.2 | 3.2 | 4.8 | 5.7 | NEWUOA [23] |
| (1+1)-ES | 5.6 | 3.8 | 5.1 | 10 | 3.3 | 8.7 | 19 | 90 | 200 | 4400 | (1+1)-ES [1] |
| PSO | **2.8** | **1.8** | **3.3** | 9 | 4.1 | 5 | 8 | 37 | 140 | 510 | PSO [6] |
| PSO_Bounds | 3.3 | 3 | 10 | 11 | 7.3 | 11 | 52 | 66 | 150 | 930 | PSO_Bounds [7] |
| Monte Carlo | 3.2 | **2.2** | 6.3 | 22 | 20 | 130 | 1500 | 8300 | 5.9e4 | *12e-5/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | 4 | **2.7** | 5.2 | 11 | 4.4 | **2.9** | **2.5** | **2.3** | **2** | **1.6** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **2.3** | **2.5** | 3.5 | 6.9 | **2.6** | 7.7 | 12 | 28 | 74 | *63e-5/3e3* | SNOBFIT [17] |
| VNS (Garcia) | 9.5 | 3.9 | 9.7 | 17 | 3.8 | **2.2** | **2.1** | **1.9** | **1.7** | **1.5** | VNS (Garcia) [10] |

Table 7: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{107}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**107 Sphere Gauss**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.9 | 6.6 | 13.9 | 56.7 | 78.8 | 101 | 128 | 211 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1** | **2.6** | 3.5 | 12 | 9.9 | 12 | 15 | 16 | 15 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **2.3** | **1.7** | **2.3** | **1** | **1** | **1** | **1** | **1.9** | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | 14 | 32 | 24 | 13 | 15 | 31 | 45 | 80 | avg NEWUOA [23] |
| BayEDAcG | **1** | **1.1** | **2.4** | **1.2** | 4 | 4.2 | 4.4 | 4.7 | 4.7 | 4.4 | BayEDAcG [9] |
| BFGS | **1** | **1** | 98 | 110 | 300 | 880 | 660 | 520 | 410 | *65e-3/4e3* | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | 12 | 3.6 | **2.9** | **1.2** | **1.2** | **1.2** | **1.2** | **1** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | 35 | 7.2 | 7.7 | **2.9** | **2.4** | **2.3** | 3.7 | 6.3 | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 210 | 130 | 330 | 190 | 440 | 550 | 1400 | 4100 | DASA [18] |
| DEPSO | **1** | **1** | **2.9** | 4.8 | 6.5 | **3** | 3.8 | 3.7 | 3.6 | 3.1 | DEPSO [11] |
| EDA-PSO | **1** | **1.1** | **1.7** | **2.9** | 4.9 | **2.5** | 4.4 | 6.4 | 9.3 | 9.9 | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | 12 | 9.7 | 21 | 6.9 | 9.6 | 18 | 19 | 28 | full NEWUOA [23] |
| GLOBAL | **1** | **1.1** | **2.6** | **2.7** | 6.9 | 4.8 | 4.4 | 4 | 4.6 | 8 | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **2.5** | 47 | 33 | 8.4 | 6.2 | 5 | 11 | 6.8 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **2.3** | **1.6** | 4.6 | **2.8** | 3.8 | 3.9 | 4.5 | 3 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | **1** | 18 | 57 | 170 | 1400 | *86e-6/3e4* | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | 26 | 20 | 31 | 17 | 20 | 37 | 82 | 83 | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | 8.2 | 8.1 | 8.3 | 4.3 | 3.6 | 3.3 | 3.2 | 4.6 | (1+1)-ES [1] |
| PSO | **1** | **1** | **2** | **2.3** | 4.2 | 3.2 | 4.9 | 6.2 | 7.1 | 6.8 | PSO [6] |
| PSO_Bounds | **1** | **1** | **1.7** | **2.1** | 5.1 | 5.2 | 8.5 | 16 | 19 | 20 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **2.1** | **2.8** | 13 | 19 | 280 | 2400 | 1.8e4 | 7e4 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | 41 | 16 | 8.5 | **2.7** | **2.1** | **1.8** | **2.1** | **1.5** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **2.1** | **1.1** | 6.6 | 6.6 | 6.5 | 6.2 | 6.4 | 7.3 | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.6** | 80 | 42 | 18 | 16 | 12 | 10 | 6.3 | VNS (Garcia) [10] |

Table 8: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on $f_{108}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**108 Sphere unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.9 | 15 | 101 | 713 | 1710 | 2610 | 3680 | 7990 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1** | **2.5** | **1** | **1.9** | **1.3** | **1.1** | **1.6** | **1.9** | **1.5** | ALPS [15] |
| AMaLGaM IDEA | **1** | **1.1** | **1.9** | **1** | 32 | 6.2 | 4.3 | 4.4 | 5.9 | 7.3 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | 87 | 42 | 20 | 18 | 16 | *14e-3/6e3* | . | . | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | 3.1 | 10 | 18 | 18 | 16 | *86e-3/2e3* | . | . | BayEDAcG [9] |
| BFGS | **1** | **1** | 29 | 6.8 | 4.2 | 5 | 7 | *43e-3/800* | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | 93 | 10 | 5.5 | **1.5** | **1** | **1** | **1** | **1** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | 55 | 14 | 8.8 | 4.5 | 11 | 26 | *14e-4/1e4* | . | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 170 | 93 | 88 | 66 | 100 | 300 | 2300 | *99e-6/6e5* | DASA [18] |
| DEPSO | **1** | **1** | **2.4** | **2.9** | **1.9** | **2.4** | 5.4 | *26e-4/2e3* | . | . | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.9** | **1.1** | **1.7** | **1** | **1.2** | **1.3** | **1.6** | **1.2** | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | 62 | 53 | 42 | 42 | *22e-3/7e3* | . | . | . | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.7** | **1.3** | **1.3** | **1.2** | 4.8 | 11 | *34e-4/2e3* | . | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **2.5** | 48 | 20 | 8 | 9.8 | 11 | 9.9 | 8 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **2.7** | **1** | **1.6** | **1** | **1** | **1.4** | **1.4** | **1.2** | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | 3.3 | **2.8** | 5.5 | 11 | 140 | *43e-5/3e4* | . | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | 120 | 56 | 24 | 22 | 25 | *13e-3/6e3* | . | . | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | 36 | 9.4 | 9 | 3.4 | 3.9 | 14 | 31 | 400 | (1+1)-ES [1] |
| PSO | **1** | **1** | **2.4** | **1.1** | **1.3** | **1.3** | **1.9** | 3.3 | **2.6** | **1.8** | PSO [6] |
| PSO_Bounds | **1** | **1** | **2.7** | **1.1** | **1** | **1.3** | 5.6 | 5 | 4.6 | **2.8** | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | 3 | **1.3** | **1.8** | **1.7** | 8.9 | 66 | 480 | *17e-6/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | 600 | 73 | 29 | 6.5 | 4.5 | 4.5 | 5.5 | 19 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **1.3** | **1.2** | 3.6 | **2.8** | 10 | 14 | *58e-4/3e3* | . | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.6** | 46 | 16 | 9.4 | 5.4 | 3.7 | **3** | 4.4 | VNS (Garcia) [10] |

Table 9: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{109}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**109 Sphere Cauchy**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.9 | 4.77 | 6.3 | 33.6 | 34 | 48.2 | 48.2 | 48.2 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1** | 3.1 | 4.3 | 25 | 11 | 60 | 330 | 2400 | 7.5e4 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **2.5** | 3 | 4.6 | 14 | 36 | 54 | 100 | 290 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | 3.3 | **2.6** | 15 | 7 | 9 | 11 | 15 | 31 | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **2.7** | 4.5 | 12 | 9.2 | 13 | 12 | 17 | 28 | BayEDAcG [9] |
| BFGS | **1** | **1** | 15 | 8.3 | 7.6 | **1.4** | **1.4** | **1** | **1** | **1** | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | 3.2 | **2** | 4.1 | **1.5** | **2.3** | **2.1** | 3.4 | 5.4 | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | 4 | **2.5** | 9.3 | 16 | 61 | 240 | 3e3 | *49e-6/1e4* | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 96 | 210 | 470 | 440 | 5700 | 4.2e4 | 1.9e5 | *15e-5/6e5* | DASA [18] |
| DEPSO | **1** | **1** | **2.8** | 5.6 | 18 | 7.5 | 13 | 23 | 75 | *15e-6/2e3* | DEPSO [11] |
| EDA-PSO | **1** | **1** | **2.3** | 3.1 | 8.8 | 4.8 | 45 | 490 | 3800 | *13e-6/1e5* | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | 4 | **1.2** | 3.3 | **1** | **1** | **1.5** | **1.5** | **1.5** | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **2.1** | **2.7** | 18 | 7.8 | 12 | 21 | 61 | *15e-6/2e3* | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **2.8** | **1.8** | **3** | 13 | 29 | 35 | 100 | 320 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **2.2** | **2.4** | 10 | 4.5 | 9.4 | 11 | 16 | 23 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | **1** | 15 | 35 | 31 | 38 | 87 | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | 3.3 | 3.6 | 12 | 5.6 | 10 | 13 | 22 | 36 | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | 3.4 | **1.8** | 4.6 | 3.1 | 31 | 140 | 850 | 5e4 | (1+1)-ES [1] |
| PSO | **1** | **1** | 3 | **2.5** | 12 | 9.4 | 510 | 1100 | 4700 | *17e-6/1e5* | PSO [6] |
| PSO_Bounds | **1** | **1** | **1.7** | **2.1** | 12 | 230 | 1500 | 8500 | 1.4e4 | 2.9e4 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **2.5** | **2.7** | 23 | 58 | 490 | 3e3 | 6.7e4 | *15e-6/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | 3.3 | **2.5** | 3.8 | **1.4** | **2.4** | **2.4** | **3.3** | **4.5** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **1.7** | **1** | **2.6** | **1.6** | 16 | 24 | 39 | 210 | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.6** | 5 | 11 | 3 | 4.1 | 3.8 | 4.7 | 6.2 | VNS (Garcia) [10] |

Table 10: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{110}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**110 Rosenbrock Gauss**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.6 | 2.2 | 3.57 | 17.1 | 312 | 651 | 1160 | 2180 | 4200 | 4580 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **2.8** | **2** | 6.8 | 7.1 | **1.5** | **2.1** | **2.3** | **1.8** | **1.4** | **2.4** | ALPS [15] |
| AMaLGaM IDEA | 4.2 | **2** | 4.2 | 67 | 22 | 16 | 9.2 | 4.9 | **2.6** | **2.4** | AMaLGaM IDEA [4] |
| avg NEWUOA | 3.8 | 10 | 11 | **5.1** | **2.5** | 3 | 6.8 | 11 | 5.9 | *12e-4/5e3* | avg NEWUOA [23] |
| BayEDAcG | **2.4** | **1.7** | 5.7 | 19 | 10 | 44 | *13e-2/2e3* | . | . | . | BayEDAcG [9] |
| BFGS | 41 | 34 | 62 | 89 | 43 | 41 | *52e-2/2e3* | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | 6.2 | 3.5 | **4.1** | 13 | 4 | 5.5 | 3.4 | **2.4** | **1.3** | **1.5** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | 3.4 | **2.5** | **3.2** | 9.3 | **1.7** | **2.8** | **2.4** | 5.8 | 5.8 | 32 | (1+1)-CMA-ES [2] |
| DASA | 130 | 140 | 150 | 110 | 32 | 47 | 100 | 190 | 270 | 2100 | DASA [18] |
| DEPSO | **2.2** | **1.6** | 11 | 6.9 | **1** | **1** | **1** | **1** | **1.4** | *17e-6/2e3* | DEPSO [11] |
| EDA-PSO | **2.2** | **1.7** | 5.3 | 6.4 | **1.6** | 3.2 | 3.3 | **2.9** | **1.9** | **2.6** | EDA-PSO [5] |
| full NEWUOA | 21 | 17 | 26 | 17 | **2.8** | 8.5 | *62e-4/6e3* | . | . | . | full NEWUOA [23] |
| GLOBAL | **2.7** | **2** | 4.9 | **4.7** | **1.3** | **2** | 6.1 | *10e-3/800* | . | . | GLOBAL [20] |
| iAMaLGaM IDEA | **2.4** | **1.8** | 100 | 22 | 9 | 6.6 | 4.1 | **2.5** | **1.4** | **1.3** | iAMaLGaM IDEA [4] |
| MA-LS-Chain | 3 | **2.4** | 6.1 | 5.8 | **1.2** | **2.1** | **2.2** | **1.8** | **1** | **1.9** | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | **1.9** | 10 | 93 | *18e-4/3e4* | . | . | MCS (Neum) [16] |
| NEWUOA | 22 | 15 | 16 | 15 | **2.9** | 4.4 | 9.1 | 36 | *19e-4/5e3* | . | NEWUOA [23] |
| (1+1)-ES | 3.9 | 5.9 | 4.9 | 6.9 | **1.6** | **2.8** | 6.4 | 7.2 | 9.8 | 49 | (1+1)-ES [1] |
| PSO | 3.1 | **1.9** | 5.8 | 6.6 | **1.1** | **1.5** | **1.4** | **1.3** | **1.2** | **1.6** | PSO [6] |
| PSO_Bounds | **2.9** | **2.1** | 7.5 | 12 | **2** | **2.8** | 3.1 | **2.8** | **2.2** | **3** | PSO_Bounds [7] |
| Monte Carlo | 3.1 | **2.7** | 5.5 | 11 | 5.9 | 22 | 180 | 660 | 3600 | *65e-6/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | 4.3 | 4.2 | 4.8 | 28 | 4.5 | 4.4 | 3.8 | **2.1** | **1.1** | **1** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | 3.1 | **2.4** | 5.6 | 7.8 | **2.8** | 3.4 | 5.3 | 16 | *57e-4/3e3* | . | SNOBFIT [17] |
| VNS (Garcia) | 9.5 | 3.5 | 5.9 | 5.3 | 7.3 | 9 | 5.5 | 3.3 | **2.3** | 3.2 | VNS (Garcia) [10] |

Table 11: 02-D, running time excess ERT/$\text{ERT}_{\text{best}}$ on $f_{111}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**111 Rosenbrock unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\text{ERT}_{\text{best}}$/D | 0.6 | 3.73 | 12.1 | 59.4 | 359 | 2710 | 6360 | 14600 | 30900 | 84600 | $\text{ERT}_{\text{best}}$/D |
| ALPS | **2.9** | **1.8** | **1.9** | 4.1 | **2.7** | **1.1** | **1** | **1** | **1** | **1** | ALPS [15] |
| AMaLGaM IDEA | **2.5** | **1** | **1** | 7.6 | 8.3 | 6.3 | 5.5 | 5.5 | 3.2 | **2.1** | AMaLGaM IDEA [4] |
| avg NEWUOA | 72 | 48 | 45 | 29 | 53 | 33 | *26e-2/6e3* | . | . | . | avg NEWUOA [23] |
| BayEDAcG | **2.8** | **1.1** | **2** | 6.4 | 36 | 10 | *35e-2/2e3* | . | . | . | BayEDAcG [9] |
| BFGS | 7.8 | 8.4 | 7.7 | 8.2 | *59e-2/700* | . | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | 4.5 | **2.6** | 7.3 | 6 | **2.4** | **1.5** | 4.2 | 5.9 | 3.1 | **1.3** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | 4.1 | **1.8** | 7.4 | 6.5 | 4 | 3.6 | 7.6 | 10 | *64e-4/1e4* | . | (1+1)-CMA-ES [2] |
| DASA | 230 | 110 | 120 | 91 | 88 | 39 | 110 | 290 | *90e-5/6e5* | . | DASA [18] |
| DEPSO | **1.7** | **2.6** | 3.3 | 5.7 | 5.7 | 11 | *28e-3/2e3* | . | . | . | DEPSO [11] |
| EDA-PSO | **2.1** | **1.7** | **1.4** | **2.1** | **2.2** | **1.1** | 4.7 | 5.1 | 6.4 | 17 | EDA-PSO [5] |
| full NEWUOA | 94 | 37 | 26 | 27 | 31 | 35 | *15e-2/7e3* | . | . | . | full NEWUOA [23] |
| GLOBAL | **1.7** | **1.4** | **1.9** | **2.2** | **2.4** | **1.8** | 3.5 | *54e-3/2e3* | . | . | GLOBAL [20] |
| iAMaLGaM IDEA | **1.9** | **1.6** | **1.4** | 28 | 21 | 10 | 6.2 | 4 | 3.1 | 3.1 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | 3.4 | **1.8** | **1.7** | **1.3** | **2.2** | **1** | **1.2** | **2.1** | **2.2** | *24e-5/1e4* | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **2.4** | **1.4** | **1** | 4.3 | 5.5 | 56 | *75e-4/3e4* | . | . | MCS (Neum) [16] |
| NEWUOA | 140 | 33 | 21 | 25 | 19 | 11 | *68e-3/6e3* | . | . | . | NEWUOA [23] |
| (1+1)-ES | 46 | 12 | 14 | 11 | 5.6 | **2.1** | 5.7 | 10 | 21 | 82 | (1+1)-ES [1] |
| PSO | **2.5** | **1.2** | **1.9** | **2** | **1** | 4.2 | 4.6 | 6.4 | 5.6 | 8.2 | PSO [6] |
| PSO_Bounds | **2.6** | **1.6** | **1.7** | **1.3** | 21 | 3.2 | **2.3** | **2.6** | **2.3** | **1.5** | PSO_Bounds [7] |
| Monte Carlo | 3.9 | **1.6** | **1.5** | **2.7** | 5.5 | 4.3 | 28 | 130 | 480 | *14e-5/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | 4.6 | **1.8** | 11 | 16 | 7.4 | **2.6** | **2.8** | 4.8 | 4.6 | *11e-4/1e4* | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | 5 | **2.4** | **2.8** | 4.2 | 10 | 6.4 | 5.6 | **2.5** | **1.2** | *10e-2/3e3* | SNOBFIT [17] |
| VNS (Garcia) | 9.5 | **2.1** | 78 | 62 | 22 | 5.6 | 4.1 | **2.9** | **2.5** | 47 | VNS (Garcia) [10] |

Table 12: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{112}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**112 Rosenbrock Cauchy**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.6 | 2 | 2.7 | 7.3 | 312 | 522 | 577 | 618 | 686 | 766 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **2.3** | **2.9** | 9.2 | 15 | **1.6** | 3.5 | 7.6 | 78 | 880 | 4.7e4 | ALPS [15] |
| AMaLGaM IDEA | **2.7** | **1.7** | 4.3 | 64 | 14 | 11 | 26 | 32 | 56 | 91 | AMaLGaM IDEA [4] |
| avg NEWUOA | 4.7 | **2.5** | 5.1 | 11 | **1.1** | 4.6 | 22 | 120 | *19e-4/5e3* | . | avg NEWUOA [23] |
| BayEDAcG | **2.4** | **2.2** | 4.5 | 27 | 4.8 | *88e-3/2e3* | . | . | . | . | BayEDAcG [9] |
| BFGS | 33 | 27 | 36 | 47 | 3.4 | 12 | 16 | 29 | 39 | *14e-3/4e3* | BFGS [22] |
| BIPOP-CMA-ES | 4.7 | 3 | 37 | 44 | **1.7** | **1.6** | **1.7** | **1.7** | **1.7** | **1.7** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | 3.4 | **2** | 4.3 | 13 | **1.9** | **3** | 13 | 110 | *52e-5/1e4* | . | (1+1)-CMA-ES [2] |
| DASA | 43 | 23 | 140 | 160 | 26 | 71 | 270 | 3400 | *19e-5/7e5* | . | DASA [18] |
| DEPSO | 3.6 | 4 | 7.4 | 13 | **1.2** | 3.8 | 8.7 | *34e-4/2e3* | . | . | DEPSO [11] |
| EDA-PSO | 3 | **2.5** | 8.1 | 9.2 | **1.9** | 6 | 23 | 290 | 2100 | *12e-5/1e5* | EDA-PSO [5] |
| full NEWUOA | 6.9 | 3 | **3.1** | 16 | **1.3** | **2.5** | 7.4 | 13 | 25 | 53 | full NEWUOA [23] |
| GLOBAL | 3.3 | **2.2** | 8.1 | 16 | **1.2** | **3** | **2.9** | 7.7 | 7 | *10e-3/1e3* | GLOBAL [20] |
| iAMaLGaM IDEA | **1.9** | **1.7** | 4 | 100 | 14 | 19 | 35 | 65 | 67 | 100 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **2.1** | **2.2** | 6.3 | **7.7** | **1** | **1.7** | **2.8** | 3.8 | 3.9 | 9.5 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | 7.7 | 31 | 87 | *11e-4/3e4* | . | . | MCS (Neum) [16] |
| NEWUOA | 5.1 | **2.7** | 5 | 13 | **1.2** | **1.7** | 9.9 | 110 | 100 | *70e-5/5e3* | NEWUOA [23] |
| (1+1)-ES | **2.8** | **2.1** | 3.4 | 15 | **1.9** | 4.5 | 16 | 95 | 800 | *18e-7/1e6* | (1+1)-ES [1] |
| PSO | **1.8** | **2.1** | 8.1 | 9.5 | **1.6** | 4.6 | 89 | 360 | 970 | *41e-5/1e5* | PSO [6] |
| PSO_Bounds | **2.5** | **2.1** | 6.2 | **8.8** | **1.7** | 6.2 | 46 | 230 | 1100 | *10e-5/1e5* | PSO_Bounds [7] |
| Monte Carlo | 3.1 | **2.4** | 5.9 | 14 | 5.6 | 28 | 300 | 2800 | 9800 | *17e-5/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | 3.4 | **2.7** | 5.4 | 9.4 | **1.1** | **1** | **1** | **1.1** | **1** | **1** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **2.9** | **2** | **2.9** | 10 | **2.5** | 7 | 62 | 58 | *12e-3/3e3* | . | SNOBFIT [17] |
| VNS (Garcia) | 9.5 | 3.9 | 9.2 | 14 | **1.3** | **1** | **1** | **1** | **1** | **1** | VNS (Garcia) [10] |

Table 13: 02-D, running time excess ERT/$\text{ERT}_{\text{best}}$ on $f_{113}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**113 Step-ellipsoid Gauss**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\text{ERT}_{\text{best}}$/D | 0.5 | 1.07 | 2.37 | 15.7 | 43.7 | 69.8 | 87.1 | 87.1 | 87.1 | 438 | $\text{ERT}_{\text{best}}$/D |
| ALPS | **1** | **1.6** | **2.2** | 4.3 | 12 | 11 | 13 | 13 | 13 | 4.1 | ALPS [15] |
| AMaLGaM IDEA | **1.3** | **1.6** | **2.3** | **1.1** | **1** | **1** | **1** | **1** | **1** | **1** | AMaLGaM IDEA [4] |
| avg NEWUOA | **2.1** | 13 | 9.5 | 6.1 | 9.7 | 19 | 33 | 33 | 33 | 13 | avg NEWUOA [23] |
| BayEDAcG | **1.3** | **1.3** | **2.4** | **2.3** | 30 | 26 | 69 | 69 | 69 | 20 | BayEDAcG [9] |
| BFGS | 26 | 24 | 81 | 91 | 260 | *60e-2/3e3* | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1.1** | 4.1 | 5.1 | 6.4 | 13 | 14 | 12 | 12 | 12 | **2.5** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | 40 | 21 | 12 | 7.4 | 11 | 17 | 19 | 19 | 19 | 4.4 | (1+1)-CMA-ES [2] |
| DASA | 9.5 | 120 | 220 | 180 | 380 | 600 | 770 | 770 | 770 | 380 | DASA [18] |
| DEPSO | **1.7** | **1.8** | 4.3 | 5.4 | 5.2 | 5.8 | **7.1** | **7.1** | **7.1** | **1.6** | DEPSO [11] |
| EDA-PSO | **1.7** | **1.9** | **2.5** | **2.5** | 6.8 | 19 | 25 | 25 | 25 | 7.3 | EDA-PSO [5] |
| full NEWUOA | **2.2** | 11 | 11 | 4.8 | 17 | 26 | 47 | 47 | 47 | 15 | full NEWUOA [23] |
| GLOBAL | **2** | **1.9** | 4.2 | 4.1 | 5.5 | **5.7** | 7.6 | 7.6 | 7.6 | **1.7** | GLOBAL [20] |
| iAMaLGaM IDEA | **1.6** | **1.6** | **2.9** | **1** | 20 | 13 | 10 | 10 | 10 | **2.1** | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1.1** | **1** | **2.6** | **2.6** | 5.6 | 7.2 | 9.9 | 9.9 | 9.9 | **2.3** | MA-LS-Chain [19] |
| MCS (Neum) | **1.4** | **1.3** | **1** | **1.2** | 6.1 | 37 | 76 | 76 | 76 | 57 | MCS (Neum) [16] |
| NEWUOA | **2.4** | 8.7 | 12 | 5.8 | 16 | 29 | 42 | 42 | 42 | 14 | NEWUOA [23] |
| (1+1)-ES | 9.3 | 10 | 13 | 5.7 | 6.4 | 8.9 | 15 | 15 | 15 | 3.7 | (1+1)-ES [1] |
| PSO | **1.4** | **1.8** | 4.7 | **2.6** | **3.6** | **5.1** | **5.9** | **5.9** | **5.9** | **1.6** | PSO [6] |
| PSO_Bounds | **1.2** | **1.6** | 3.4 | **2** | **4.3** | 11 | 13 | 13 | 13 | 5 | PSO_Bounds [7] |
| Monte Carlo | **1.6** | **1.6** | **2.9** | 4.7 | 18 | 54 | 160 | 160 | 160 | 130 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1.8** | 3.3 | 4.2 | 13 | 32 | 27 | 27 | 27 | 27 | 5.3 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1.1** | **1.8** | 4 | 10 | 20 | 20 | 20 | 20 | 5.1 | SNOBFIT [17] |
| VNS (Garcia) | **1** | **2.2** | **2.7** | 25 | 63 | 52 | 43 | 43 | 43 | 8.6 | VNS (Garcia) [10] |

Table 14: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{114}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**114 Step-ellipsoid unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.833 | 4.43 | 21.3 | 349 | 1240 | 2670 | 2670 | 2670 | 4340 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1.2** | **1** | **1.6** | 3.1 | **1.8** | **1.3** | **1** | **1** | **1** | **1** | ALPS [15] |
| AMaLGaM IDEA | **1.2** | **1.8** | **1.8** | **1.5** | 6.1 | 3.1 | **2.8** | **2.8** | **2.8** | **2.8** | AMaLGaM IDEA [4] |
| avg NEWUOA | **1.5** | 66 | 29 | 16 | 26 | 21 | 33 | 33 | 33 | 20 | avg NEWUOA [23] |
| BayEDAcG | **1.5** | **1.9** | **2.1** | 38 | 37 | 23 | *60e-2/2e3* | . | . | . | BayEDAcG [9] |
| BFGS | 8.8 | 18 | 9.6 | 7.2 | 6.9 | *49e-2/800* | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | 4.1 | 6.5 | 3.3 | 7.8 | **2.3** | **1.7** | **1.8** | **1.8** | **1.8** | **1.5** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1.2** | 27 | 19 | 8.1 | 6.2 | 4.5 | 4 | 4 | 4 | 7.9 | (1+1)-CMA-ES [2] |
| DASA | 100 | 250 | 220 | 220 | 110 | 90 | 120 | 120 | 120 | 160 | DASA [18] |
| DEPSO | **1.8** | **1.7** | **1.3** | 7.8 | 3.3 | 3.1 | 5.5 | 5.5 | 5.5 | 7 | DEPSO [11] |
| EDA-PSO | **1.3** | **1.6** | **1.6** | **2.2** | **1.6** | **2** | **1.1** | **1.1** | **1.1** | **1** | EDA-PSO [5] |
| full NEWUOA | **2.3** | 67 | 91 | 95 | 40 | 18 | 18 | 18 | 18 | *11e-2/7e3* | full NEWUOA [23] |
| GLOBAL | **1.2** | **2.4** | **2.4** | **2.6** | **2** | **2.6** | 3.1 | 3.1 | 3.1 | 6.5 | GLOBAL [20] |
| iAMaLGaM IDEA | **1.3** | **2.3** | 29 | 65 | 23 | 10 | 5.2 | 5.2 | 5.2 | 3.5 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1.2** | **1.5** | **1.9** | **2.8** | **1** | **1** | **1.2** | **1.2** | **1.2** | **1.3** | MA-LS-Chain [19] |
| MCS (Neum) | **1.4** | 3.4 | **1.2** | 5.5 | 3.4 | 7 | 17 | 17 | 17 | *38e-4/3e4* | MCS (Neum) [16] |
| NEWUOA | **1.9** | 41 | 69 | 53 | 38 | 71 | 33 | 33 | 33 | *21e-2/6e3* | NEWUOA [23] |
| (1+1)-ES | **2.2** | 18 | 25 | 13 | 7.2 | 7 | 6.4 | 6.4 | 6.4 | 6.4 | (1+1)-ES [1] |
| PSO | **1.3** | **1.8** | **1** | **1.8** | 23 | 22 | 12 | 12 | 12 | 7.4 | PSO [6] |
| PSO_Bounds | **1.5** | **2.3** | **1** | **1** | 73 | 30 | 15 | 15 | 15 | 9.6 | PSO_Bounds [7] |
| Monte Carlo | **1.5** | **1.7** | **1.2** | **1.6** | **1.9** | 4.3 | 4.7 | 4.7 | 4.7 | 20 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **2.1** | 10 | 15 | 29 | 4.6 | 5.3 | 3.7 | 3.7 | 3.7 | 3.1 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1.7** | **2.7** | **1.5** | 3.8 | **2.6** | **2.5** | **2.9** | **2.9** | **2.9** | **2.6** | SNOBFIT [17] |
| VNS (Garcia) | **1** | **2.9** | **1.4** | 91 | 12 | 7.9 | 6.1 | 6.1 | 6.1 | 4.1 | VNS (Garcia) [10] |

Table 15: 02-D, running time excess ERT/$\text{ERT}_{\text{best}}$ on $f_{115}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**115 Step-ellipsoid Cauchy**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\text{ERT}_{\text{best}}$/D | 0.5 | 1.03 | 1.6 | 6.37 | 112 | 180 | 197 | 197 | 197 | 271 | $\text{ERT}_{\text{best}}$/D |
| ALPS | **1.3** | **2** | **2.7** | 11 | 4.4 | 6.6 | 10 | 10 | 10 | 16 | ALPS [15] |
| AMaLGaM IDEA | **1.3** | **1.3** | **2.5** | **3.1** | 7.5 | 4.8 | 4.4 | 4.4 | 4.4 | 11 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1.5** | **2.8** | 6.5 | 7.3 | **2.9** | 6.1 | 7.1 | 7.1 | 7.1 | 12 | avg NEWUOA [23] |
| BayEDAcG | **1.4** | **1.1** | 7.4 | 31 | 28 | 160 | 140 | 140 | 140 | 100 | BayEDAcG [9] |
| BFGS | 13 | 23 | 92 | 140 | 200 | *49e-2/2e3* | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | 3.4 | 3.5 | 4.9 | 4.7 | **1.2** | **2.2** | **2.6** | **2.6** | **2.6** | **2.1** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1.7** | **2.7** | 5 | 14 | **2.4** | 4.2 | 16 | 16 | 16 | 25 | (1+1)-CMA-ES [2] |
| DASA | 16 | 39 | 140 | 420 | 110 | 230 | 580 | 580 | 580 | 1600 | DASA [18] |
| DEPSO | **1** | **1.4** | 5.4 | 9 | **1.6** | 3.4 | 3.9 | 3.9 | 3.9 | 4.3 | DEPSO [11] |
| EDA-PSO | **1.3** | **1.2** | 3.3 | 4.3 | **2.1** | 4.3 | 17 | 17 | 17 | 64 | EDA-PSO [5] |
| full NEWUOA | **1.7** | **2.5** | 3 | 7.1 | **1.8** | **2.9** | 8 | 8 | 8 | 9.3 | full NEWUOA [23] |
| GLOBAL | **1.9** | **1.9** | 4.7 | 6.6 | **1.9** | 3.1 | 4.6 | 4.6 | 4.6 | 13 | GLOBAL [20] |
| iAMaLGaM IDEA | **1.2** | **1.4** | 3.1 | 28 | 14 | 8.8 | 12 | 12 | 12 | 14 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1.5** | **2** | 4.2 | **3.9** | **1.3** | **2.9** | 3.4 | 3.4 | 3.4 | 4.7 | MA-LS-Chain [19] |
| MCS (Neum) | **1.4** | **1.4** | **1** | 4.4 | **2.5** | 52 | 87 | 87 | 87 | 450 | MCS (Neum) [16] |
| NEWUOA | **2** | **2.5** | 4.5 | 12 | **2.9** | 4.4 | 11 | 11 | 11 | 11 | NEWUOA [23] |
| (1+1)-ES | **1.9** | 3.4 | 5.8 | 16 | **2.4** | 3.7 | 5.5 | 5.5 | 5.5 | 14 | (1+1)-ES [1] |
| PSO | **1.3** | **2.5** | 4.6 | 6.2 | 66 | 72 | 120 | 120 | 120 | 280 | PSO [6] |
| PSO_Bounds | **1.6** | **2.1** | 6.4 | 5.8 | 3 | 44 | 170 | 170 | 170 | 380 | PSO_Bounds [7] |
| Monte Carlo | **1.3** | **1** | **3** | 4.7 | 5.6 | 23 | 89 | 89 | 89 | 260 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1.8** | 4.1 | 4.8 | 7.3 | **1** | **1** | **1** | **1** | **1** | **1** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1.5** | **1.4** | **2.1** | **1** | **2.1** | 7.4 | 22 | 22 | 22 | 63 | SNOBFIT [17] |
| VNS (Garcia) | **1** | **2.3** | 3.9 | 26 | **2.1** | **1.6** | **1.7** | **1.7** | **1.7** | **1.4** | VNS (Garcia) [10] |

Table 16: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{116}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**116 Ellipsoid Gauss**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 3.27 | 6.77 | 24.6 | 50.3 | 77.6 | 103 | 138 | 165 | 521 | 894 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1.8** | 3.1 | 3.6 | 14 | 23 | 33 | 45 | 56 | 30 | 27 | ALPS [15] |
| AMaLGaM IDEA | **1.7** | **1.6** | **1.2** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | AMaLGaM IDEA [4] |
| avg NEWUOA | 7.9 | 6.2 | 12 | 15 | 32 | 98 | 130 | 480 | *14e-3/5e3* | . | avg NEWUOA [23] |
| BayEDAcG | **2.8** | 5.2 | 9.7 | 63 | 110 | 280 | *28e-1/2e3* | . | . | . | BayEDAcG [9] |
| BFGS | 30 | 35 | 60 | 410 | *53e-1/1e3* | . | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1.9** | 9.4 | 15 | 61 | 62 | 51 | 39 | 33 | 11 | 6.5 | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1.7** | **1.7** | 8.1 | 11 | 29 | 49 | 110 | 420 | 270 | 160 | (1+1)-CMA-ES [2] |
| DASA | 48 | 47 | 43 | 130 | 500 | 1e3 | 1900 | 1.3e4 | 1.8e4 | *29e-5/7e5* | DASA [18] |
| DEPSO | **1.4** | 4.2 | 6.8 | 13 | **15** | **24** | 31 | 41 | 18 | 16 | DEPSO [11] |
| EDA-PSO | **1.9** | 3.6 | 5.1 | 18 | 30 | 46 | 64 | 76 | 29 | 27 | EDA-PSO [5] |
| full NEWUOA | 8.3 | 15 | 11 | 17 | 44 | 110 | 320 | *11e-3/6e3* | . | . | full NEWUOA [23] |
| GLOBAL | **1.4** | 4.1 | 3.5 | **8.3** | **12** | 37 | 28 | 31 | 9.8 | 18 | GLOBAL [20] |
| iAMaLGaM IDEA | **1.2** | **1.8** | 6.7 | 24 | 23 | **19** | **14** | **12** | **4.1** | **2.5** | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **2.4** | 3.7 | 3.3 | 11 | 23 | 43 | 49 | 51 | 22 | 15 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | 13 | 86 | 730 | *24e-3/3e4* | . | . | . | MCS (Neum) [16] |
| NEWUOA | 5.4 | 4.6 | 6.3 | 18 | 38 | 110 | 570 | *50e-3/5e3* | . | . | NEWUOA [23] |
| (1+1)-ES | 5.9 | 3.7 | **3.2** | 12 | 20 | 64 | 130 | 500 | 350 | 1500 | (1+1)-ES [1] |
| PSO | **2.3** | 3.7 | 5.9 | 35 | 120 | 100 | 84 | 79 | 28 | 20 | PSO [6] |
| PSO_Bounds | 3.4 | **3** | 13 | 410 | 280 | 230 | 190 | 180 | 82 | 63 | PSO_Bounds [7] |
| Monte Carlo | **2** | **2.5** | 5.5 | 29 | 280 | 2700 | 9200 | 4.1e4 | *80e-5/1e6* | . | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | 11 | 8.1 | 17 | 40 | 41 | 32 | **24** | **20** | **6.5** | **3.9** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1.7** | **1.6** | 5 | **8.9** | 48 | 100 | 120 | *12e-2/3e3* | . | . | SNOBFIT [17] |
| VNS (Garcia) | **1.8** | 4 | 67 | 75 | 55 | 50 | 39 | 35 | 13 | 16 | VNS (Garcia) [10] |

Table 17: 02-D, running time excess ERT/$\mathrm{ERT_{best}}$ on $f_{117}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**117 Ellipsoid unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT_{best}}$/D | 4.77 | 17.4 | 83.7 | 673 | 3230 | 6960 | 14100 | 14900 | 18200 | 21600 | $\mathrm{ERT_{best}}$/D |
| ALPS | **1.6** | **1.8** | **1.6** | **1.1** | **1.1** | **1** | **1.3** | **2.4** | **2.8** | 7.9 | ALPS [15] |
| AMaLGaM IDEA | **1.7** | **1.3** | 4.9 | 9.9 | 4.5 | 4.6 | **2.6** | **2.5** | **2.9** | **4.1** | AMaLGaM IDEA [4] |
| avg NEWUOA | 15 | 32 | 24 | 10 | 8.4 | *78e-2/6e3* | . | . | . | . | avg NEWUOA [23] |
| BayEDAcG | **2.4** | **2.6** | 17 | 42 | *78e-1/2e3* | . | . | . | . | . | BayEDAcG [9] |
| BFGS | 8.6 | 5.3 | 4.9 | 6.2 | **2.7** | *40e-1/600* | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **2.2** | 5.4 | 6.7 | 3.8 | **2.1** | **1.6** | **1** | **1** | **1** | **1** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | 9.5 | 4.5 | 5 | **1.8** | **2.1** | 10 | 10 | *32e-3/1e4* | . | . | (1+1)-CMA-ES [2] |
| DASA | 90 | 80 | 58 | 51 | 46 | 120 | 310 | *71e-4/6e5* | . | . | DASA [18] |
| DEPSO | **1** | 4.1 | 3.6 | **1.9** | 4.1 | *46e-2/2e3* | . | . | . | . | DEPSO [11] |
| EDA-PSO | **1.3** | **2.6** | **1.2** | 6 | **2.4** | **2.5** | 4.6 | 9.6 | 17 | 21 | EDA-PSO [5] |
| full NEWUOA | 55 | 41 | 25 | 14 | 31 | 14 | *87e-2/7e3* | . | . | . | full NEWUOA [23] |
| GLOBAL | **1.4** | **1** | **2.3** | **1.3** | **1.9** | **1.8** | *25e-2/2e3* | . | . | . | GLOBAL [20] |
| iAMaLGaM IDEA | 43 | 12 | 11 | 5.7 | 4.5 | 3.4 | **2** | **2.5** | 3.3 | **6.5** | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1.3** | **1.1** | **1.2** | **1** | **1** | **1.7** | **1.9** | 12 | *27e-4/1e4* | . | MA-LS-Chain [19] |
| MCS (Neum) | **1.4** | **1.2** | **1** | **1.4** | 4.2 | 8.4 | *27e-3/3e4* | . | . | . | MCS (Neum) [16] |
| NEWUOA | 43 | 25 | 29 | 12 | 26 | *97e-2/6e3* | . | . | . | . | NEWUOA [23] |
| (1+1)-ES | 3.1 | 6 | 6.2 | **2.3** | **1.9** | 4 | 8.2 | 46 | 97 | 660 | (1+1)-ES [1] |
| PSO | **1.4** | **1.3** | 4.6 | 55 | 12 | 13 | 11 | 16 | 24 | 66 | PSO [6] |
| PSO_Bounds | **2.2** | **1.1** | **1.6** | 55 | 21 | 17 | 21 | 45 | 37 | 67 | PSO_Bounds [7] |
| Monte Carlo | **1.5** | **1** | **2.8** | 3.2 | 4.4 | 31 | 120 | 940 | *10e-4/1e6* | . | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | 22 | 27 | 10 | 5.3 | **2.8** | **1.9** | **1.2** | **1.9** | 4 | *39e-4/1e4* | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **2.1** | **1.2** | 3.5 | **2.6** | 5.1 | **2.5** | *51e-2/3e3* | . | . | . | SNOBFIT [17] |
| VNS (Garcia) | **1.3** | **1.3** | 41 | 11 | 5.6 | 4.5 | 3.8 | 12 | 29 | 410 | VNS (Garcia) [10] |

Table 18: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{118}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**118 Ellipsoid Cauchy**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 2.1 | 2.5 | 10.5 | 51.5 | 66.2 | 252 | 292 | 326 | 388 | 486 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | 6.3 | 9.9 | 12 | 13 | 20 | 12 | 60 | 630 | 2400 | *44e-7/2e6* | ALPS [15] |
| AMaLGaM IDEA | 4.4 | 7.2 | **3** | **1** | **1** | **1.6** | 4 | 6.2 | 14 | 20 | AMaLGaM IDEA [4] |
| avg NEWUOA | **2.4** | **2.3** | **2.8** | 3.8 | 12 | 9 | 21 | 220 | *90e-5/5e3* | . | avg NEWUOA [23] |
| BayEDAcG | 3.1 | 7.7 | 5.9 | 28 | 66 | 110 | *71e-2/2e3* | . | . | . | BayEDAcG [9] |
| BFGS | 17 | 20 | 17 | 16 | 59 | 49 | 42 | 54 | 45 | 56 | BFGS [22] |
| BIPOP-CMA-ES | 3.5 | 5.7 | 15 | 7.7 | 7.4 | **2.4** | **2.2** | **2.3** | **2.1** | **1.9** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **2.8** | 6.9 | 18 | 11 | 21 | 12 | 45 | 460 | *98e-5/1e4* | . | (1+1)-CMA-ES [2] |
| DASA | 16 | 19 | 130 | 110 | 240 | 120 | 1300 | 1.5e4 | *43e-5/7e5* | . | DASA [18] |
| DEPSO | 5.4 | 11 | 14 | 15 | 29 | 13 | 19 | 92 | *30e-3/2e3* | . | DEPSO [11] |
| EDA-PSO | **2.8** | 5.1 | 9 | 15 | 41 | 49 | 190 | 510 | 1800 | *12e-5/1e5* | EDA-PSO [5] |
| full NEWUOA | **2.3** | **2.6** | **2.3** | **2.8** | 7.3 | 3.5 | 7.5 | 60 | 220 | *40e-5/6e3* | full NEWUOA [23] |
| GLOBAL | 3.6 | 7.8 | 9.5 | 3.6 | **3.1** | **1.5** | **2.8** | 4.1 | 4.9 | *64e-6/800* | GLOBAL [20] |
| iAMaLGaM IDEA | 3.1 | 5.4 | **2.3** | 3.4 | 8.8 | 5 | 8.5 | 9.7 | 14 | 34 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | 5.7 | 7.9 | 6.9 | 6.2 | 7.6 | **2.6** | **2.7** | **3** | 3.8 | 3.9 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1.3** | **1.3** | 41 | 38 | 150 | 1100 | *27e-4/3e4* | . | MCS (Neum) [16] |
| NEWUOA | **2.1** | **2.6** | 5.6 | 4.2 | 11 | 10 | 35 | 71 | 190 | *11e-4/5e3* | NEWUOA [23] |
| (1+1)-ES | 3.6 | 7.8 | 17 | 19 | 41 | 43 | 140 | 1200 | 5400 | *12e-6/1e6* | (1+1)-ES [1] |
| PSO | **2.1** | 5 | 9.5 | 9.4 | 42 | 80 | 200 | 650 | 1200 | *33e-5/1e5* | PSO [6] |
| PSO_Bounds | 3.2 | 7.7 | 12 | 150 | 140 | 180 | 370 | 2200 | *88e-5/1e5* | . | PSO_Bounds [7] |
| Monte Carlo | **2.6** | 8.4 | 14 | 46 | 250 | 340 | 3500 | *64e-5/1e6* | . | . | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | 4.1 | 9.3 | 17 | 6.2 | 6 | **1.9** | **1.7** | **1.6** | **1.4** | **1.3** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1.7** | **2.2** | **1** | **1** | 4.1 | 6.7 | 19 | 110 | 95 | *32e-4/3e3* | SNOBFIT [17] |
| VNS (Garcia) | **2.9** | 9.1 | 14 | 3.7 | **3.4** | **1** | **1** | **1** | **1** | **1** | VNS (Garcia) [10] |

Table 19: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{119}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**119 Sum of different powers Gauss**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.7 | 5.37 | 35.5 | 88 | 520 | 950 | 2380 | 5040 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1.5** | **1.6** | **1.8** | **2.9** | 7 | 3 | **2.9** | **1.9** | 8.5 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **1.7** | 78 | 13 | 12 | 3.3 | **2.5** | **1.2** | **1** | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1.4** | **2.9** | 18 | 8 | 14 | 5.9 | 6.6 | 6.8 | *67e-6/5e3* | avg NEWUOA [23] |
| BayEDAcG | **1** | **1.3** | **1.4** | 6.3 | 4.4 | 4 | **2.1** | 4.4 | 3.9 | *18e-5/2e3* | BayEDAcG [9] |
| BFGS | **1** | 12 | 43 | 58 | 160 | 570 | *13e-2/4e3* | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **2.3** | 3.8 | **2.9** | **1.2** | **1** | **1.6** | 3 | **2** | **3** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | **1.5** | 12 | 7.9 | 7.2 | **1.6** | 3 | **2.4** | 6.6 | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 91 | 280 | 170 | 360 | 200 | 330 | 600 | 1800 | DASA [18] |
| DEPSO | **1** | **1** | **1.6** | **2.5** | 3.6 | 3.7 | **1** | **1** | **1** | *79e-7/2e3* | DEPSO [11] |
| EDA-PSO | **1** | **1.3** | **1.2** | **2.3** | **2.6** | 4.9 | 3.1 | 4.4 | **2.9** | 32 | EDA-PSO [5] |
| full NEWUOA | **1** | **1.6** | 3.2 | 8.7 | 4.8 | 13 | 11 | 15 | 38 | *32e-5/6e3* | full NEWUOA [23] |
| GLOBAL | **1** | **1.3** | **1.6** | **2.3** | 4.1 | 4.3 | **1.6** | **2.2** | **2** | *32e-5/700* | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1.1** | **1.4** | **2.1** | 7.8 | 12 | 4.5 | **3** | **2.1** | **1.6** | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1.2** | **1.7** | **2.6** | **2.6** | 4.3 | **1.4** | **1.3** | **1** | **2.1** | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | **1.2** | 40 | 150 | *18e-4/3e4* | . | . | MCS (Neum) [16] |
| NEWUOA | **1** | **2.6** | 3.1 | 15 | 8.6 | 23 | 7.1 | 19 | 33 | 15 | NEWUOA [23] |
| (1+1)-ES | **1** | **2** | 11 | 22 | 7.3 | 3.6 | **1.1** | 3.1 | 3.3 | 11 | (1+1)-ES [1] |
| PSO | **1** | **1.1** | **2** | 3 | **2.5** | **3.5** | **1.5** | **1.3** | 4.4 | 47 | PSO [6] |
| PSO_Bounds | **1** | **1.1** | **2** | **2** | 3.3 | 5.5 | 3.6 | 4.1 | 4 | 45 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1.4** | **1.7** | **2.1** | 6.8 | 77 | 380 | 2500 | *18e-5/1e6* | . | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1.2** | **1.7** | **2.2** | **1** | 3.8 | **1.3** | **2.8** | **1.7** | **1.2** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1.3** | **1.9** | **1.3** | 3.2 | 4 | **2.7** | 4 | **2.6** | 7.4 | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.1** | 4.2 | **2.8** | **1.8** | **2.5** | **2.9** | **2.4** | 6.6 | VNS (Garcia) [10] |

Table 20: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{120}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**120 Sum of different powers unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.7 | 5.67 | 187 | 1260 | 2860 | 13000 | 37700 | 94300 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1.1** | **1.9** | **1.1** | **2** | **1.2** | **2** | **1** | **1.3** | **6.1** | ALPS [15] |
| AMaLGaM IDEA | **1** | **1.3** | **1.2** | **1.3** | 6.4 | 7.3 | 9.7 | 7.1 | 6.9 | **21** | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | 9.5 | 37 | 74 | 42 | 15 | *94e-3/6e3* | . | . | . | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **1.1** | 3.1 | 22 | *21e-2/2e3* | . | . | . | . | BayEDAcG [9] |
| BFGS | **1** | **2** | 7.6 | 20 | 14 | 9.5 | *13e-2/800* | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **2** | 4.4 | 11 | **2.3** | **1.1** | **1** | **1.2** | **1** | **1** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1.1** | **2.6** | 13 | 3.4 | 9 | 52 | *57e-4/1e4* | . | . | (1+1)-CMA-ES [2] |
| DASA | **1** | 72 | 86 | 310 | 61 | 73 | 310 | 210 | 230 | *89e-5/6e5* | DASA [18] |
| DEPSO | **1** | **1** | **1.5** | 3.2 | **2.2** | 4 | *14e-3/2e3* | . | . | . | DEPSO [11] |
| EDA-PSO | **1** | **1.2** | **1.8** | **1** | **1.1** | **1.4** | 3 | **2.3** | 4.2 | *10e-6/1e5* | EDA-PSO [5] |
| full NEWUOA | **1** | 20 | 48 | 77 | 17 | 76 | *44e-3/7e3* | . | . | . | full NEWUOA [23] |
| GLOBAL | **1** | **1.1** | **1.5** | **2.1** | **1.1** | 3.8 | *13e-3/2e3* | . | . | . | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1.2** | **1.3** | 57 | 26 | 14 | 15 | 14 | 17 | 160 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1.2** | **1.6** | **2.2** | **1** | **1** | **1.8** | **1.1** | **3.9** | *99e-6/1e4* | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | 3.8 | 3.1 | 14 | 41 | *38e-4/3e4* | . | . | MCS (Neum) [16] |
| NEWUOA | **1** | 3.1 | 48 | 61 | 41 | 34 | *98e-3/6e3* | . | . | . | NEWUOA [23] |
| (1+1)-ES | **1** | **2** | 11 | 25 | 4.8 | 5.3 | 10 | 22 | 22 | *50e-7/1e6* | (1+1)-ES [1] |
| PSO | **1** | **1.3** | **2** | **2.4** | 39 | 7 | 5.8 | 3.1 | 4.2 | *12e-6/1e5* | PSO [6] |
| PSO_Bounds | **1** | **1.3** | **1.4** | 3 | **1.1** | 7 | 6.5 | 5.8 | 4.9 | *29e-6/1e5* | PSO_Bounds [7] |
| Monte Carlo | **1** | **1.3** | **1.5** | **2.2** | **2.2** | 5.9 | 26 | 250 | *16e-5/1e6* | . | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1.3** | **3** | 35 | 14 | 5.1 | 5 | 11 | *36e-5/1e4* | . | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1.3** | **1.7** | **2.6** | **2** | 3.9 | *19e-3/3e3* | . | . | . | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.1** | 4 | 20 | 5.9 | 4.9 | 3.3 | 8.1 | 260 | VNS (Garcia) [10] |

Table 21: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{121}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**121 Sum of different powers Cauchy**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.7 | 3.53 | 21 | 71.8 | 164 | 376 | 560 | 851 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1.4** | **2** | 5 | 9.5 | 18 | 90 | 680 | 3500 | *50e-7/2e6* | ALPS [15] |
| AMaLGaM IDEA | **1** | **1.1** | **1.4** | **2.7** | **1.4** | 22 | 30 | 29 | 38 | 160 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1.6** | **2.6** | 5.7 | 4.4 | 6.3 | 22 | 35 | *31e-5/5e3* | . | avg NEWUOA [23] |
| BayEDAcG | **1** | **1.1** | **1.3** | 4.7 | 9.8 | 4.8 | 4.7 | 10 | 53 | *28e-5/2e3* | BayEDAcG [9] |
| BFGS | **1** | 9.6 | 22 | 34 | 16 | 15 | 27 | 46 | 48 | *78e-5/4e3* | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1.5** | 3.1 | 3.5 | **1.4** | **1** | **1.3** | **1.4** | **2** | **2.6** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1.2** | 3.4 | 7.9 | 14 | 21 | 61 | 190 | *62e-5/1e4* | . | (1+1)-CMA-ES [2] |
| DASA | **1** | 14 | 160 | 270 | 230 | 880 | 5500 | *12e-4/6e5* | . | . | DASA [18] |
| DEPSO | **1** | **1.6** | **2.2** | 4.2 | 5.1 | 4.1 | 5.4 | 77 | *38e-5/2e3* | . | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.6** | 4 | 3.2 | 15 | 180 | 1800 | *55e-5/1e5* | . | EDA-PSO [5] |
| full NEWUOA | **1** | **2.1** | 4 | **1.6** | **1.7** | **1.5** | 8.9 | 15 | 25 | *34e-6/5e3* | full NEWUOA [23] |
| GLOBAL | **1** | **1.3** | **1.8** | **2.6** | 7.6 | 5.2 | 10 | 21 | *59e-5/2e3* | . | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1.4** | **1.7** | **2.2** | 15 | 11 | 25 | 32 | 64 | 250 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1.3** | **1.6** | 4.5 | 4 | 4.1 | 4.4 | 4.2 | 7.1 | 38 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | **1** | 99 | 510 | *23e-4/3e4* | . | . | MCS (Neum) [16] |
| NEWUOA | **1** | **1.6** | **2.7** | 4.4 | 3 | 7.6 | 14 | 57 | 120 | *40e-5/5e3* | NEWUOA [23] |
| (1+1)-ES | **1** | **1.6** | 3.2 | 4.8 | 4.3 | 9.8 | 58 | 320 | 5500 | *16e-6/1e6* | (1+1)-ES [1] |
| PSO | **1** | **1.3** | **1.6** | 3.3 | 6.2 | 89 | 310 | 1900 | 2500 | *32e-5/1e5* | PSO [6] |
| PSO_Bounds | **1** | **1.2** | **2.2** | 3 | 7.4 | 240 | 400 | 410 | 1200 | *21e-5/1e5* | PSO_Bounds [7] |
| Monte Carlo | **1** | **1.3** | **1.6** | **2.6** | 9.4 | 70 | 830 | 1.3e4 | 2.7e4 | *27e-5/1e6* | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1.2** | 3 | 5.2 | **1.8** | **1.1** | **1** | **1** | **1.2** | **1** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1.1** | **1.9** | **1.9** | **2.2** | 11 | 73 | *24e-4/3e3* | . | . | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.1** | 6.5 | 4.1 | **1.7** | **1.6** | **1.1** | **1** | **1.1** | VNS (Garcia) [10] |

Table 22: 02-D, running time excess ERT/$\text{ERT}_{\text{best}}$ on $f_{122}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**122 Schaffer F7 Gauss**

| $\Delta$ftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | $\Delta$ftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\text{ERT}_{\text{best}}$/D | 0.5 | 0.5 | 1.47 | 47.7 | 261 | 705 | 1120 | 1680 | 2180 | 4780 | $\text{ERT}_{\text{best}}$/D |
| ALPS | **1** | **1.2** | **2** | **2.9** | 4.4 | 4 | 4.3 | 3.9 | 4.1 | 3.3 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1.1** | **2.5** | 14 | 6.6 | 4.8 | 3.7 | **2.9** | **2.9** | **1.9** | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1.3** | 14 | 9.7 | 33 | 55 | *11e-2/5e3* | . | . | . | avg NEWUOA [23] |
| BayEDAcG | **1.1** | **1.1** | **1.7** | 3.2 | 3.4 | 9.7 | *16e-3/2e3* | . | . | . | BayEDAcG [9] |
| BFGS | **1** | 3.8 | 46 | 40 | *47e-2/3e3* | . | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1.2** | **2.8** | **2** | **1** | **1** | **1** | **1** | **1** | **1** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1.9** | 16 | 5.1 | 9.2 | 9.3 | 60 | *48e-4/1e4* | . | . | (1+1)-CMA-ES [2] |
| DASA | **1** | 30 | 320 | 170 | 300 | 960 | 7700 | *87e-4/6e5* | . | . | DASA [18] |
| DEPSO | **1** | **1.3** | **1** | **2.6** | **2** | **1.5** | **1.9** | **2.1** | 6.9 | *57e-6/2e3* | DEPSO [11] |
| EDA-PSO | **1** | **1.6** | **2.8** | **1.2** | 8.9 | 8.6 | 9.7 | 8.7 | 9 | 5.7 | EDA-PSO [5] |
| full NEWUOA | **1** | **1.4** | 11 | 7 | 20 | 62 | *59e-3/6e3* | . | . | . | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.8** | **1.7** | 3.3 | *64e-3/1e3* | . | . | . | . | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1.3** | **1.7** | 19 | 6.6 | 7.8 | 7.5 | 6.3 | 6 | 3.8 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1.4** | **1.7** | **2.1** | 3.6 | 3.1 | **2.7** | **2.4** | **2.7** | 3 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1.4** | **1** | 23 | 240 | *18e-3/3e4* | . | . | . | MCS (Neum) [16] |
| NEWUOA | **1** | **1.7** | 9.7 | 16 | 30 | 54 | *99e-3/5e3* | . | . | . | NEWUOA [23] |
| (1+1)-ES | **1.1** | 40 | 21 | 3.5 | 7.2 | 16 | 65 | 570 | 2100 | *29e-6/1e6* | (1+1)-ES [1] |
| PSO | **1** | **1.1** | **2.2** | 3.5 | 11 | 7 | 5.6 | 4.8 | 4.8 | 3.1 | PSO [6] |
| PSO_Bounds | **1** | **1.1** | **1.7** | **1.3** | 3.6 | 6.1 | 6.9 | 6.2 | 7.8 | 6.5 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **2.4** | **2.9** | 58 | 1400 | *79e-4/1e6* | . | . | . | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **2.3** | 3.9 | 15 | 5 | **2.4** | **2.5** | **2** | **1.6** | **1.2** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1.3** | **1.8** | **2.5** | **3.2** | 3.1 | 6.1 | *75e-4/3e3* | . | . | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.2** | 27 | 15 | 6.9 | 6.1 | 6.9 | 16 | 59 | VNS (Garcia) [10] |

Table 23: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{123}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**123 Schaffer F7 unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 1.57 | 106 | 3190 | 12400 | 19400 | 28300 | 5e4 | 1.09e5 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1.1** | **1.6** | **1.2** | **1** | **1.6** | **7.6** | **40** | **340** | ***29e-6 /2e6*** | ALPS [15] |
| AMaLGaM IDEA | **1** | **1.3** | **1.7** | 22 | 6 | 13 | 50 | 240 | *98e-5 /1e6* | **.** | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | 9.5 | 66 | 24 | 28 | *46e-2 /6e3* | . | . | . | **.** | avg NEWUOA [23] |
| BayEDAcG | **1** | **1.5** | **2.6** | 23 | *10e-1 /2e3* | . | . | . | . | **.** | BayEDAcG [9] |
| BFGS | **1** | **1** | 6.4 | 7.1 | *53e-2 /800* | . | . | . | . | **.** | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1.1** | 52 | 5.2 | **1.2** | **1** | **1** | **1** | **1** | **1** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1.9** | 20 | 7.7 | 9.9 | 5.8 | *16e-2 /1e4* | . | . | **.** | (1+1)-CMA-ES [2] |
| DASA | **1** | 4.1 | 130 | 77 | 52 | *40e-3 /6e5* | . | . | . | **.** | DASA [18] |
| DEPSO | **1** | **1.2** | **1.7** | **2.7** | **2.1** | *19e-2 /2e3* | . | . | . | **.** | DEPSO [11] |
| EDA-PSO | **1** | **1.1** | **1.6** | **1.4** | **1.2** | 6.5 | *81e-4 /1e5* | . | . | **.** | EDA-PSO [5] |
| full NEWUOA | **1.1** | 11 | 73 | 27 | 31 | *36e-2 /7e3* | . | . | . | **.** | full NEWUOA [23] |
| GLOBAL | **1** | **1.4** | **1.7** | **1.3** | **1.4** | *16e-2 /2e3* | . | . | . | **.** | GLOBAL [20] |
| iAMaLGaM IDEA | **1.1** | **1.4** | **2.1** | 57 | 7.6 | 25 | 130 | 520 | **300** | ***11e-4 /1e6*** | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1.3** | **2.3** | **1.2** | **1.2** | 12 | *32e-3 /1e4* | . | . | **.** | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1.8** | 8.7 | *58e-3 /3e4* | . | . | . | **.** | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | 56 | 32 | 28 | *44e-2 /6e3* | . | . | . | **.** | NEWUOA [23] |
| (1+1)-ES | **1** | **2.5** | 66 | 8.7 | 4.9 | 38 | 350 | *57e-4 /1e6* | . | **.** | (1+1)-ES [1] |
| PSO | **1.1** | **1.1** | **2.4** | 3.2 | 3.9 | 7 | 36 | 51 | *58e-4 /1e5* | **.** | PSO [6] |
| PSO_Bounds | **1.1** | **1.3** | **2.3** | **1.2** | 5.9 | 6.1 | 36 | **26** | *47e-4 /1e5* | **.** | PSO_Bounds [7] |
| Monte Carlo | **1** | **1.2** | **1.8** | **1** | 5.3 | 160 | *12e-3 /1e6* | . | . | **.** | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1.3** | 74 | 23 | 4.7 | *92e-3 /1e4* | . | . | . | **.** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1.4** | **1.2** | **3** | **2.6** | **2.9** | **1.9** | *21e-2 /3e3* | . | **.** | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **2.1** | 46 | 5.1 | 5.7 | 45 | 930 | *21e-5 /1e7* | **.** | VNS (Garcia) [10] |

Table 24: 02-D, running time excess ERT/$\mathrm{ERT_{best}}$ on $f_{124}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**124 Schaffer F7 Cauchy**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT_{best}}$/D | 0.5 | 0.5 | 1.77 | 31.8 | 158 | 340 | 996 | 1740 | 2800 | 4510 | $\mathrm{ERT_{best}}$/D |
| ALPS | **1.1** | **1.4** | **1.5** | **2.5** | 5.8 | 170 | 3900 | *10e-4/2e6* | . | . | ALPS [15] |
| AMaLGaM IDEA | **1** | **1.1** | **1.4** | 11 | 8.3 | 12 | 23 | **28** | **44** | 450 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1.7** | 12 | 9.3 | 22 | 61 | *98e-3/5e3* | . | . | . | avg NEWUOA [23] |
| BayEDAcG | **1** | **1.3** | **1.6** | 3.3 | **2.8** | **2.9** | **9.4** | *15e-4/2e3* | . | . | BayEDAcG [9] |
| BFGS | **1** | 17 | 48 | 78 | *53e-2/4e3* | . | . | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1.4** | 3.3 | 3 | **1** | **1** | **1** | **1.1** | **1.5** | **3.1** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **2.7** | **1.9** | 4.9 | 5.7 | 88 | 140 | *17e-3/1e4* | . | . | (1+1)-CMA-ES [2] |
| DASA | **1.6** | 6 | 110 | 170 | 770 | *32e-3/6e5* | . | . | . | . | DASA [18] |
| DEPSO | **1** | **1.1** | **1.4** | 4 | 4.2 | 8.9 | *79e-4/2e3* | . | . | . | DEPSO [11] |
| EDA-PSO | **1** | **1.1** | **1** | **2** | 9.2 | 1300 | *18e-3/1e5* | . | . | . | EDA-PSO [5] |
| full NEWUOA | **1** | **1.8** | **2.5** | 5.4 | 9.1 | 49 | *17e-3/5e3* | . | . | . | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.2** | **2.8** | 6.7 | 24 | *98e-3/1e3* | . | . | . | GLOBAL [20] |
| iAMaLGaM IDEA | **1.1** | **1.3** | **1.9** | 5.6 | 9.5 | 23 | 30 | 41 | 110 | 670 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1.3** | **2** | **2.1** | **2.6** | 42 | 140 | *14e-3/1e4* | . | . | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | 95 | *68e-3/3e4* | . | . | . | . | MCS (Neum) [16] |
| NEWUOA | **1** | **2.2** | 5.6 | 6.5 | 14 | 46 | *33e-3/5e3* | . | . | . | NEWUOA [23] |
| (1+1)-ES | **1.1** | **1.6** | 10 | 5.6 | 6 | 36 | 2e3 | *10e-4/1e6* | . | . | (1+1)-ES [1] |
| PSO | **1** | **1.3** | **1.3** | **1.8** | 13 | 560 | 470 | *13e-3/1e5* | . | . | PSO [6] |
| PSO_Bounds | **1** | **1.3** | **1.4** | **1.8** | 110 | 430 | *14e-3/1e5* | . | . | . | PSO_Bounds [7] |
| Monte Carlo | **1** | **1.1** | **1.4** | 5.9 | 84 | 2900 | 1.5e4 | *78e-4/1e6* | . | . | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1.1** | 4.9 | **2.2** | **1.5** | **1.6** | **1.3** | **1** | **1** | **1** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1.3** | **2.1** | 3.5 | 8.2 | 110 | *32e-3/3e3* | . | . | . | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **1.9** | 26 | 13 | 22 | 21 | 30 | 220 | **340** | VNS (Garcia) [10] |

Table 25: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{125}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**125 Griewank-Rosenbrock Gauss**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 74.3 | 575 | 1230 | 1930 | 3780 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1** | **1** | 4.3 | 77 | 3.6 | **1.5** | **1.3** | **1.6** | **1.6** | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **1.1** | 3.3 | 38 | **1** | 13 | 7.7 | 5.5 | **2.9** | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | **2.3** | 6.9 | 46 | **1.8** | **2.7** | **2.4** | **2.3** | 6.2 | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **1.3** | 5.5 | **32** | **1.5** | **1** | **2** | 3.4 | *49e-6/2e3* | BayEDAcG [9] |
| BFGS | **1** | **1** | 11 | 87 | 730 | 40 | 49 | 46 | *59e-4/4e3* | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | **1.1** | 5.1 | 34 | **1.9** | **3** | **2.2** | **1.9** | **1.3** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | **1** | 3.5 | 84 | 4 | 4.4 | **2.9** | 4 | 3.2 | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 3.9 | 280 | 2400 | 64 | 91 | 89 | 120 | 220 | DASA [18] |
| DEPSO | **1** | **1** | **1.6** | 5.6 | 120 | **2.5** | **1.7** | **1** | **1** | **1** | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.2** | 3.9 | 52 | **1.4** | **1.9** | **1.9** | **2.4** | **2.1** | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | **1.8** | 7.3 | 66 | **2.5** | 3.5 | **2.8** | **2.7** | 12 | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.1** | 4.7 | 56 | **2.3** | **1.4** | **1** | **1.5** | **1.4** | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **1.2** | 4.7 | 500 | 13 | 20 | 11 | 7.2 | 4.2 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **1.2** | 5.6 | 44 | **2** | 4 | **2.3** | **2.1** | **1.9** | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | **1** | **1.2** | 8 | 10 | 13 | 15 | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | **2** | 6.1 | 77 | **1.4** | **2.6** | **2.1** | **2.6** | 10 | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | 3 | 22 | 130 | 5.5 | 4.2 | 3.7 | **3** | 6.5 | (1+1)-ES [1] |
| PSO | **1** | **1** | **1.1** | 5.1 | 43 | **2.2** | 7.4 | 5.8 | 6.1 | 3.5 | PSO [6] |
| PSO_Bounds | **1** | **1** | **1.3** | 4 | 32 | **1.6** | **2.5** | **2.5** | **1.8** | **2.2** | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **1.1** | 4.1 | 53 | 3.2 | 4.4 | 6.5 | 12 | 160 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | **1** | **2.7** | 200 | 4.3 | 5.4 | 3.6 | 3.3 | **2.4** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **1.2** | 4.9 | **31** | 4.2 | 4.3 | **2.9** | **2.4** | **1.6** | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **1.2** | **2.2** | 44 | **1.7** | 9.3 | 5.9 | 4 | **2.4** | VNS (Garcia) [10] |

Table 26: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{126}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**126 Griewank-Rosenbrock unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 151 | 1710 | 3410 | 5530 | 18200 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1** | **1** | 4.6 | 47 | **1.3** | **1.6** | **1.2** | **2** | **1.4** | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **1.1** | 5 | 41 | 8.3 | 10 | 7.1 | 9.1 | 5.3 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | 26 | 95 | 670 | 15 | 11 | 7.8 | *18e-4/6e3* | . | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **1.1** | 3.6 | 340 | 37 | 7.6 | 8.2 | 5.1 | *26e-3/2e3* | BayEDAcG [9] |
| BFGS | **1** | **1** | **2** | 17 | 170 | 7.7 | *95e-4/900* | . | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | **1** | 4.8 | 42 | **1.4** | **1.5** | **2** | **2.6** | **2.5** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | **1.1** | **2.8** | 230 | **1.9** | 3.9 | 7.4 | 6.2 | *27e-5/1e4* | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 3.7 | 420 | 3400 | 50 | 59 | 60 | 68 | 79 | DASA [18] |
| DEPSO | **1** | **1** | **1.2** | 4.7 | 64 | 3.6 | 3.3 | 4.2 | **2.6** | **1.6** | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.2** | 3.5 | **33** | **1.2** | **1.5** | **2.2** | **2.8** | 3.2 | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | 19 | 130 | 560 | 8.9 | 17 | *27e-4/7e3* | . | . | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.1** | 3.7 | 57 | **1.7** | **2.4** | **1.3** | **1.5** | *17e-4/2e3* | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **1.1** | 4.7 | 960 | 20 | 9.8 | 10 | 14 | 8.4 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **1.3** | 6.3 | 53 | **1.3** | **1** | **1** | **1** | **1** | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | **1** | **1.6** | 3.4 | 4.3 | 7.1 | *19e-6/3e4* | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | **2.1** | 200 | 600 | 15 | 52 | *32e-4/6e3* | . | . | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | **2.1** | 39 | 230 | **2.5** | 4.7 | 6.8 | 8.3 | 8 | (1+1)-ES [1] |
| PSO | **1** | **1** | **1.3** | 5.2 | 57 | **1.2** | 11 | 7.8 | 6.9 | 4.2 | PSO [6] |
| PSO_Bounds | **1** | **1** | **1.1** | 6.7 | 51 | **1** | 4.6 | 4.4 | 4.1 | **2.6** | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **1** | **2.9** | **31** | **1.8** | **1.6** | **2.4** | 4.2 | 13 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | **1.1** | 18 | 590 | 7.8 | 7.4 | 6.6 | 5 | 8.2 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **1.3** | 6.9 | 56 | 5.9 | 10 | 5 | 3.1 | **2** | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **1.2** | **2.2** | 67 | 17 | 7 | 6.4 | 5.4 | 5.4 | VNS (Garcia) [10] |

Table 27: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{127}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**127 Griewank-Rosenbrock Cauchy**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 93 | 593 | 2010 | 3390 | 3640 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1** | **1.1** | 6.3 | 43 | **2** | 3.7 | 4 | 7.1 | 90 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **1.3** | 4.7 | 28 | 11 | 16 | 8.4 | 9.6 | 17 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | **1.3** | 7.2 | 72 | **1.6** | 3.5 | **1.8** | **2.5** | *16e-6/5e3* | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **1.1** | 6.1 | 50 | **1** | **1** | **1** | 4.1 | *62e-6/2e3* | BayEDAcG [9] |
| BFGS | **1** | **1** | 5.2 | 54 | 580 | 15 | 45 | 27 | *16e-4/4e3* | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | **1.1** | 5.3 | 32 | **1.9** | **2.8** | **2** | **1.7** | **2.2** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | **1.1** | 6.5 | 140 | 5.1 | 12 | 8.4 | 14 | *25e-5/1e4* | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 14 | 170 | 2200 | 86 | 210 | 130 | 440 | 2400 | DASA [18] |
| DEPSO | **1** | **1** | **1.3** | 3.1 | **27** | **1.7** | **1.6** | **2.1** | **2** | **4** | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.3** | 3.7 | 40 | **2.1** | 6.4 | 7.9 | 12 | 120 | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | **1.4** | 13 | 84 | **2** | 5.3 | 3.7 | 7.2 | 22 | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.3** | 5.7 | 66 | **2.4** | 7.7 | *16e-4/2e3* | . | . | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **1.1** | **2.8** | **27** | 7.9 | 10 | 11 | 13 | 38 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **1.1** | 7.3 | 44 | **1.3** | 3.3 | **1.9** | 3.2 | 20 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1** | **1** | **1** | 3.2 | 5.6 | 5.8 | 6.4 | *42e-7/3e4* | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | **2.1** | 6.2 | 95 | **1.8** | 4.9 | 3.8 | **2.8** | 9 | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | **1.9** | 6.3 | 64 | **2.2** | 7.1 | 5.4 | 8.4 | 88 | (1+1)-ES [1] |
| PSO | **1** | **1** | **1.4** | 4.3 | 35 | **2.2** | 30 | 19 | 16 | 86 | PSO [6] |
| PSO_Bounds | **1** | **1** | **1** | 7.5 | 44 | **1.4** | 89 | 47 | 37 | 130 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **1.1** | 4.4 | 56 | **2.7** | 6.1 | 4.9 | 11 | 110 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | **1.1** | 4.9 | 47 | **2.8** | 3.7 | **1.6** | **1** | **1** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **1** | 4.7 | 36 | 3.8 | 11 | 5.5 | 11 | 10 | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **1.2** | **2.2** | 48 | 7.5 | 26 | 12 | 8 | 12 | VNS (Garcia) [10] |

Table 28: 02-D, running time excess ERT/$\text{ERT}_{\text{best}}$ on $f_{128}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**128 Gallagher Gauss**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\text{ERT}_{\text{best}}$/D | 0.5 | 0.5 | 0.9 | 20.7 | 67.2 | 157 | 194 | 205 | 297 | 310 | $\text{ERT}_{\text{best}}$/D |
| ALPS | **1** | **1** | **1.3** | **2.2** | **2.2** | **2.3** | **2.7** | 4.9 | 4.5 | 6.2 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **1** | 47 | 32 | 14 | 12 | 13 | 9 | 9.9 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | **2.9** | 21 | 9.3 | 7.9 | 7.4 | 8.7 | 9.7 | 32 | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **1.1** | 4.8 | 3.4 | 5.2 | 11 | 14 | 18 | 45 | BayEDAcG [9] |
| BFGS | **1** | **1** | 12 | 65 | 59 | 60 | 270 | *20e-3/4e3* | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | **1.3** | 7.8 | 8.4 | 5.1 | 7.9 | 7.7 | 5.4 | 5.5 | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | **1.9** | 16 | 6.7 | 3 | **2.5** | **2.6** | **1.8** | **2** | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 50 | 170 | 140 | 72 | 75 | 100 | 180 | 400 | DASA [18] |
| DEPSO | **1** | **1** | **1** | 3.9 | 4.4 | **2.4** | **2.2** | **2.4** | **1.9** | **2.4** | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.1** | 3.5 | **2.2** | **1.7** | **2.6** | 4.9 | 4.6 | 5.8 | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | 3.1 | 21 | 13 | 10 | 10 | 13 | 11 | 15 | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.5** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **1** | 110 | 79 | 41 | 33 | 32 | 22 | 21 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **1.7** | **1.5** | **2.1** | **1.8** | 3.2 | 3.7 | 3 | 3.2 | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1.4** | **2.1** | **1.9** | **1.1** | **1.1** | **1.9** | 8.8 | 82 | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | **1.9** | 17 | 9.5 | 9.8 | 9.8 | 16 | 14 | 20 | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | **1.8** | 11 | 7.5 | 3.7 | 3.7 | 3.5 | **2.7** | 3.4 | (1+1)-ES [1] |
| PSO | **1** | **1** | **1.5** | **2.4** | **1.6** | **1.2** | **1.2** | **1.5** | **1.5** | **2.3** | PSO [6] |
| PSO_Bounds | **1** | **1** | **1.3** | **1.9** | 110 | 46 | 38 | 38 | 28 | 29 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **1.1** | **1.4** | **1.8** | 3.2 | 8.8 | 24 | 31 | 540 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | **1** | 28 | 41 | 21 | 17 | 18 | 14 | 14 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **1.9** | 4.7 | 3.3 | 3 | **2.8** | 4.4 | 3.6 | 5.6 | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **1** | 73 | 59 | 29 | 25 | 24 | 17 | 16 | VNS (Garcia) [10] |

Table 29: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on $f_{129}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**129 Gallagher unif**

| Δftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\mathrm{ERT}_{\mathrm{best}}$/D | 0.5 | 0.5 | 0.9 | 32.7 | 110 | 261 | 951 | 1620 | 2970 | 5330 | $\mathrm{ERT}_{\mathrm{best}}$/D |
| ALPS | **1** | **1** | **1.1** | **1.1** | **1.5** | **1.9** | **1.4** | **1.5** | **1.2** | **1.2** | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **1.4** | 57 | 48 | 41 | 14 | 14 | 9.8 | 6.1 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | 52 | 25 | 31 | 27 | 9.4 | 25 | 29 | 16 | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **1.3** | 5.9 | 21 | 21 | 30 | 17 | *16e-2/2e3* | . | BayEDAcG [9] |
| BFGS | **1** | **1** | 8 | 5.2 | 5.4 | 15 | 13 | *39e-3/800* | . | . | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | **1.8** | 12 | 5.4 | 4.4 | 3.1 | 3.5 | **2.5** | **1.7** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | **1.2** | 10 | 7.2 | 7.7 | 3.1 | **2.4** | **2.4** | 6.3 | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 18 | 87 | 120 | 80 | 36 | 40 | 48 | 130 | DASA [18] |
| DEPSO | **1** | **1** | **1.3** | 3.8 | 4.1 | 3.3 | **2.6** | 5.5 | *93e-5/2e3* | . | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.2** | **1.8** | **1** | **1** | **1** | **1.4** | **1.2** | **1** | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | 32 | 38 | 18 | 59 | 22 | 18 | 32 | *14e-3/7e3* | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.5** | **1** | **1.2** | **2** | **1.2** | **1.1** | **1** | 5.1 | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **1.1** | 56 | 30 | 31 | 11 | 12 | 9.3 | 5.8 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **1.2** | **1** | **1.2** | **1.9** | **1.9** | **1.8** | **1.5** | **1.7** | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1.6** | 3.2 | **2.1** | **2.9** | **2.1** | 4.8 | 7.7 | *27e-7/3e4* | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | 24 | 23 | 21 | 26 | 19 | 25 | 31 | *37e-4/6e3* | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | **1.4** | 7.3 | 6.1 | 7.9 | **3** | **2.6** | 3.8 | 6.1 | (1+1)-ES [1] |
| PSO | **1** | **1** | **1.4** | 220 | 140 | 62 | 29 | 28 | 15 | 11 | PSO [6] |
| PSO_Bounds | **1** | **1** | **1.6** | **1.2** | 66 | 140 | 53 | 32 | 18 | 10 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **1.1** | **1** | **1** | **1.3** | **1.6** | **2.6** | 3.5 | 21 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | **2.7** | 20 | 37 | 35 | 11 | 11 | 5.8 | 3.3 | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **1.3** | 3.6 | **2.7** | **1.9** | **1.3** | **1** | **1** | **1.6** | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **1** | 17 | 48 | 23 | 11 | 6.7 | 4.7 | **3** | VNS (Garcia) [10] |

Table 30: 02-D, running time excess ERT/$\text{ERT}_{\text{best}}$ on $f_{130}$, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

**130 Gallagher Cauchy**

| $\Delta$ftarget | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | $\Delta$ftarget |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\text{ERT}_{\text{best}}$/D | 0.5 | 0.5 | 0.767 | 22.6 | 99.2 | 248 | 399 | 824 | 886 | 2220 | $\text{ERT}_{\text{best}}$/D |
| ALPS | **1** | **1** | **1.7** | **1** | **1** | **1.5** | **1.5** | **1.3** | 4.1 | 15 | ALPS [15] |
| AMaLGaM IDEA | **1** | **1** | **1.2** | 45 | 39 | 16 | 17 | 17 | 20 | 8.1 | AMaLGaM IDEA [4] |
| avg NEWUOA | **1** | **1** | 3.2 | 8.2 | 3.7 | **2.6** | 3.6 | 3.9 | 7.5 | 6.9 | avg NEWUOA [23] |
| BayEDAcG | **1** | **1** | **1.3** | **2.9** | 9 | 11 | 9.7 | 7.9 | 10 | 13 | BayEDAcG [9] |
| BFGS | **1** | **1** | 13 | 22 | 15 | 14 | 12 | 12 | 20 | 25 | BFGS [22] |
| BIPOP-CMA-ES | **1** | **1** | **1.4** | 24 | 21 | 10 | 6.5 | 3.2 | 3 | **1.2** | BIPOP-CMA-ES [14] |
| (1+1)-CMA-ES | **1** | **1** | **1.6** | 11 | 4.3 | **1.8** | 3.1 | 3.1 | 4 | 4.7 | (1+1)-CMA-ES [2] |
| DASA | **1** | **1** | 60 | 85 | 88 | 67 | 63 | 120 | 320 | 700 | DASA [18] |
| DEPSO | **1** | **1** | **2** | **2.3** | **2.6** | **1.8** | **1.8** | **1.2** | **2.5** | **2.3** | DEPSO [11] |
| EDA-PSO | **1** | **1** | **1.6** | **2** | **2.5** | 6.2 | 7.3 | 15 | 21 | 140 | EDA-PSO [5] |
| full NEWUOA | **1** | **1** | **2.3** | 10 | 5 | 3.1 | 3.9 | **2.1** | 3.8 | 6.2 | full NEWUOA [23] |
| GLOBAL | **1** | **1** | **1.3** | **2.3** | **1.4** | **1.5** | **1.4** | **1** | **1** | **1.1** | GLOBAL [20] |
| iAMaLGaM IDEA | **1** | **1** | **1.5** | 86 | 72 | 38 | 27 | 22 | 21 | 13 | iAMaLGaM IDEA [4] |
| MA-LS-Chain | **1** | **1** | **1.5** | **2.4** | **1.6** | **2.1** | **2.2** | **1.7** | **2.1** | **1** | MA-LS-Chain [19] |
| MCS (Neum) | **1** | **1** | **1.7** | **2.2** | **1.1** | **1** | **1** | 4.3 | 17 | 50 | MCS (Neum) [16] |
| NEWUOA | **1** | **1** | **2.8** | 9.8 | 5.4 | 3.7 | 3.8 | 3.6 | 4.7 | 6.6 | NEWUOA [23] |
| (1+1)-ES | **1** | **1** | **2.2** | 6.8 | 4.1 | **2.4** | **2.5** | 3.1 | 3.9 | 6 | (1+1)-ES [1] |
| PSO | **1** | **1** | **1.7** | 330 | 110 | 110 | 150 | 110 | 110 | 70 | PSO [6] |
| PSO_Bounds | **1** | **1** | **1.7** | **2** | 160 | 200 | 170 | 110 | 130 | 83 | PSO_Bounds [7] |
| Monte Carlo | **1** | **1** | **1.3** | **1.6** | **1.5** | **2.1** | 4.1 | 4 | 15 | 38 | Monte Carlo [3] |
| IPOP-SEP-CMA-ES | **1** | **1** | **1** | 7.8 | 14 | 7.9 | 5.9 | **2.9** | **2.8** | **1.1** | IPOP-SEP-CMA-ES [21] |
| SNOBFIT | **1** | **1** | **1** | **2.4** | **1.4** | **1.1** | **2** | **2.1** | 8.1 | 7.4 | SNOBFIT [17] |
| VNS (Garcia) | **1** | **1** | **1.2** | 160 | 60 | 34 | 24 | 14 | 17 | 11 | VNS (Garcia) [10] |

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