Comparison with State-of-the-Art: Traps and Pitfalls

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Popular road to publication

- Create some algorithm
- Compare to state-of-the-art
- If the algorithm is better for some problems, then write an article

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- What is state-of-the-art? – known algorithms with source code available in researchers favorite programming language
- Cite the first paper that introduced algorithm used in comparison

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- These details can be filled in different ways by the developers
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- CMA-ES will serve as an example of a good method, with high-quality implementations
- Implementations in Python, Matlab, C, Java were downloaded from the author's homepage

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Experimental setup

- For all implementations, the same population size, initial σ, and maximal number of objective function evaluations were set
- The comparison and analysis of the results were performed by COCO using 24 noiseless single-objective functions formerly used in 2009 in Workshop on Real-Parameter Black-Box Optimization Benchmarking
- Bounds of the area of interest were used as bounds for constrained search, which better reflects a real-world application
- Python version comes with two constraint handling techniques – transformation (default) and weighted quadratic penalty
- A simple implementation in Python which was meant for reading, was also included in the experiments as it is used in direct translations into other languages

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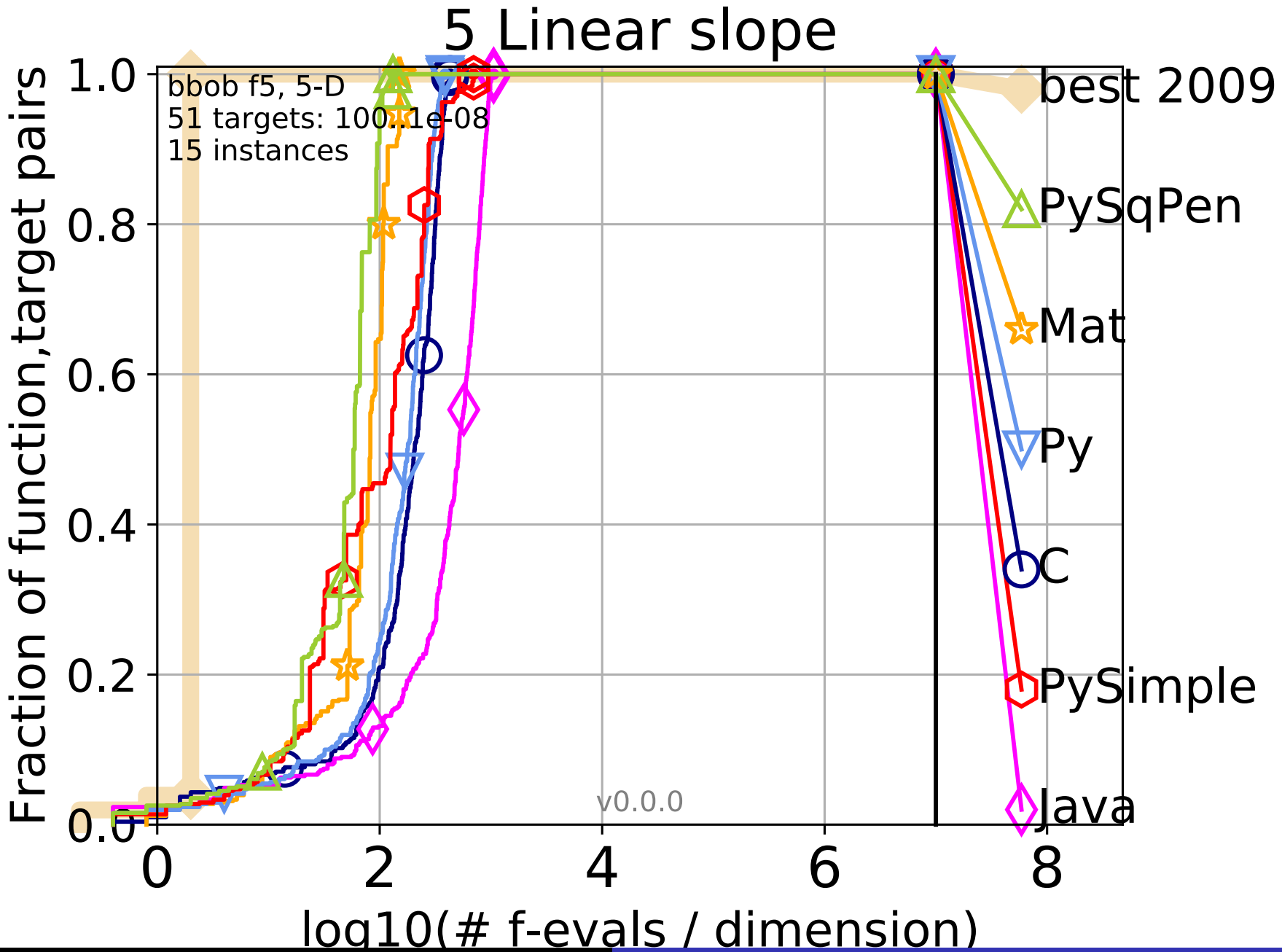

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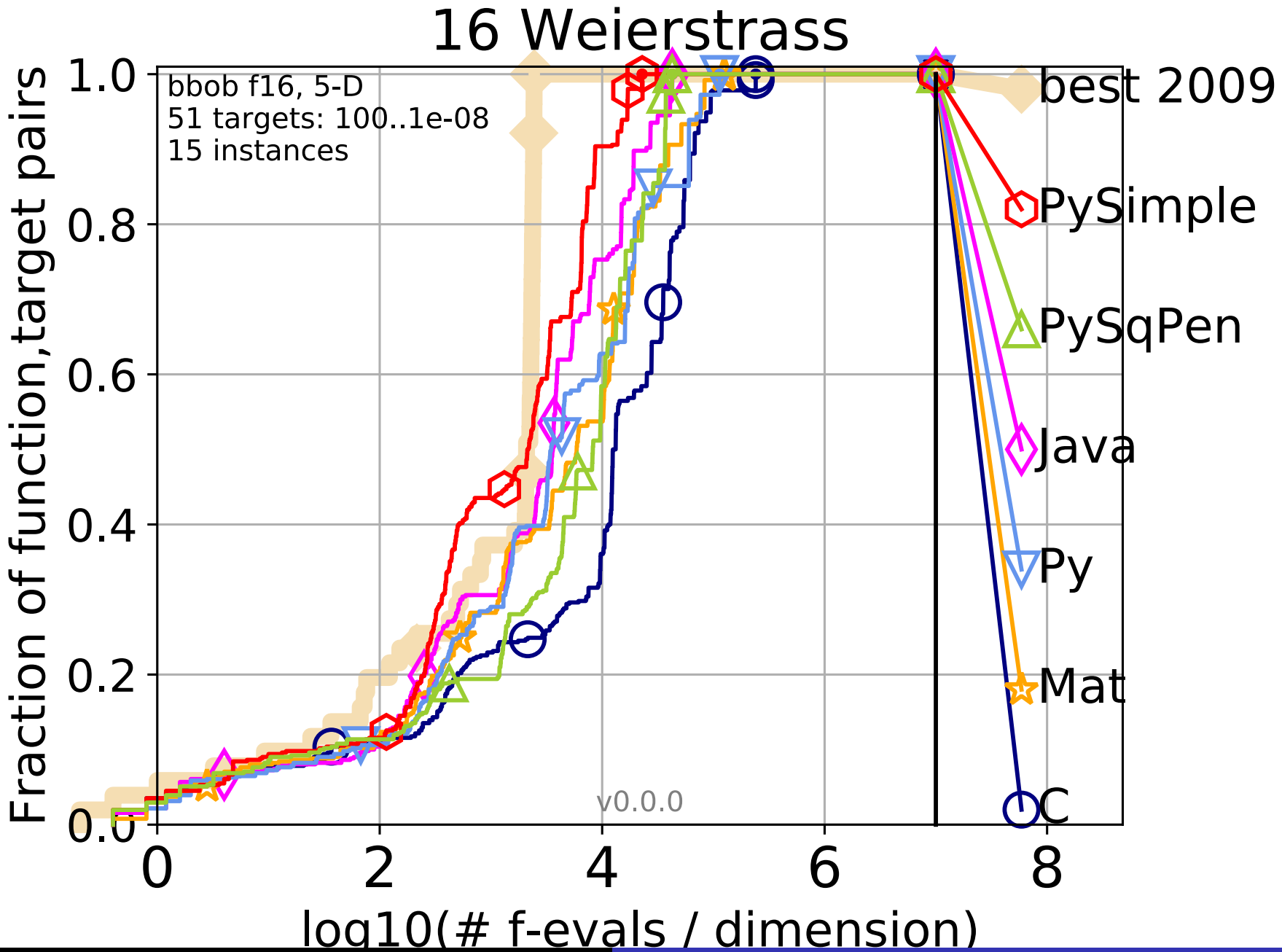

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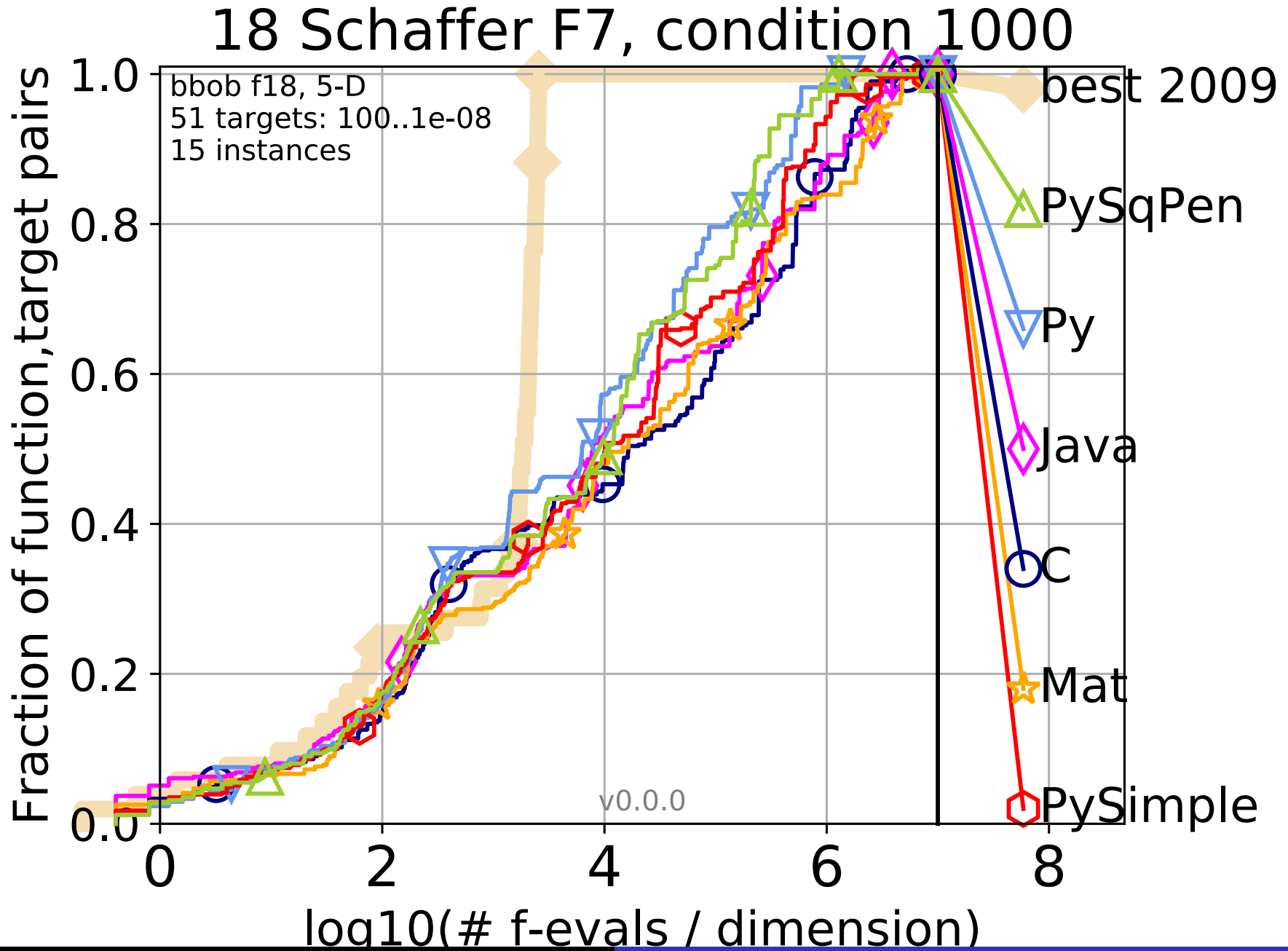

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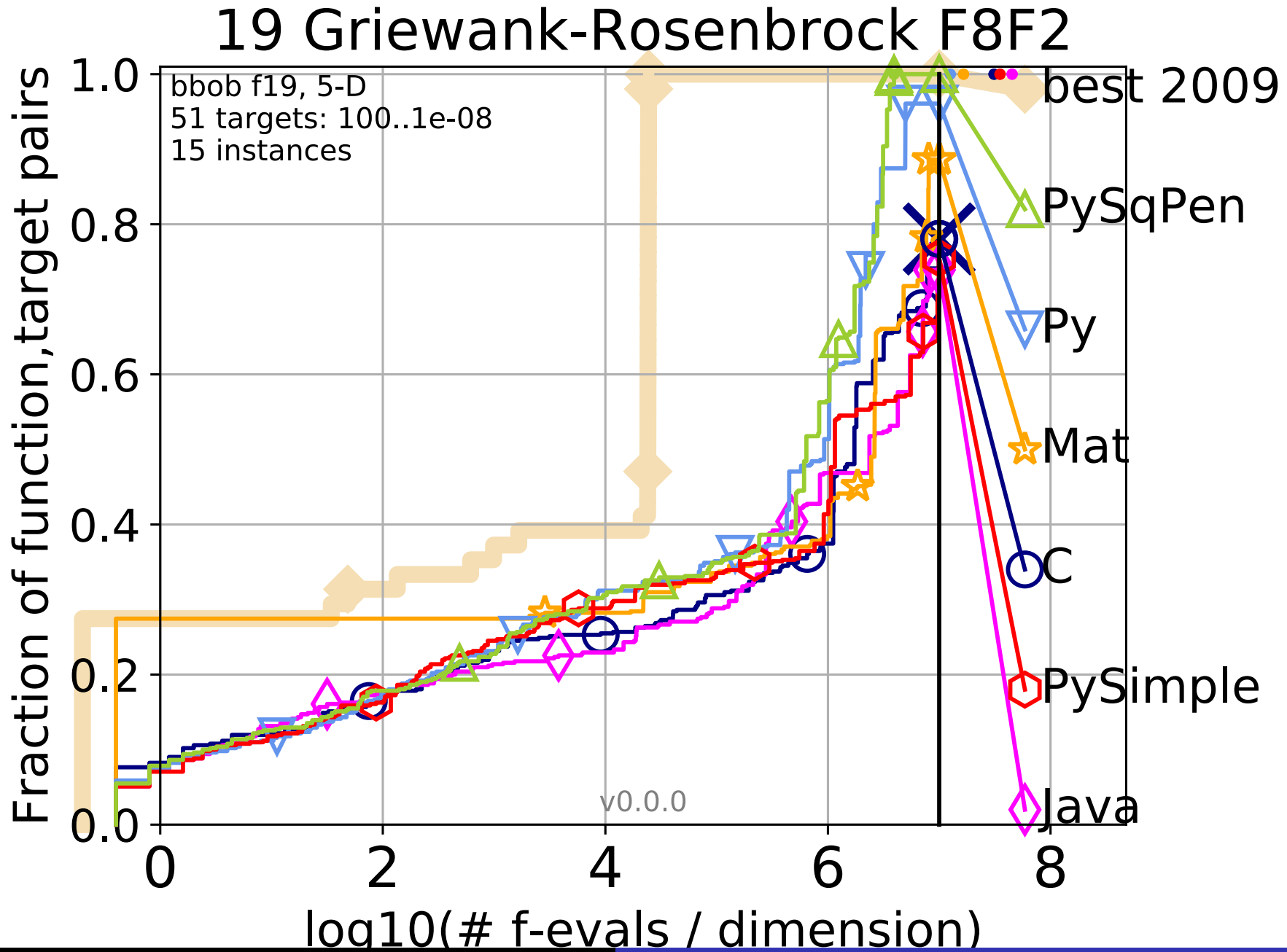

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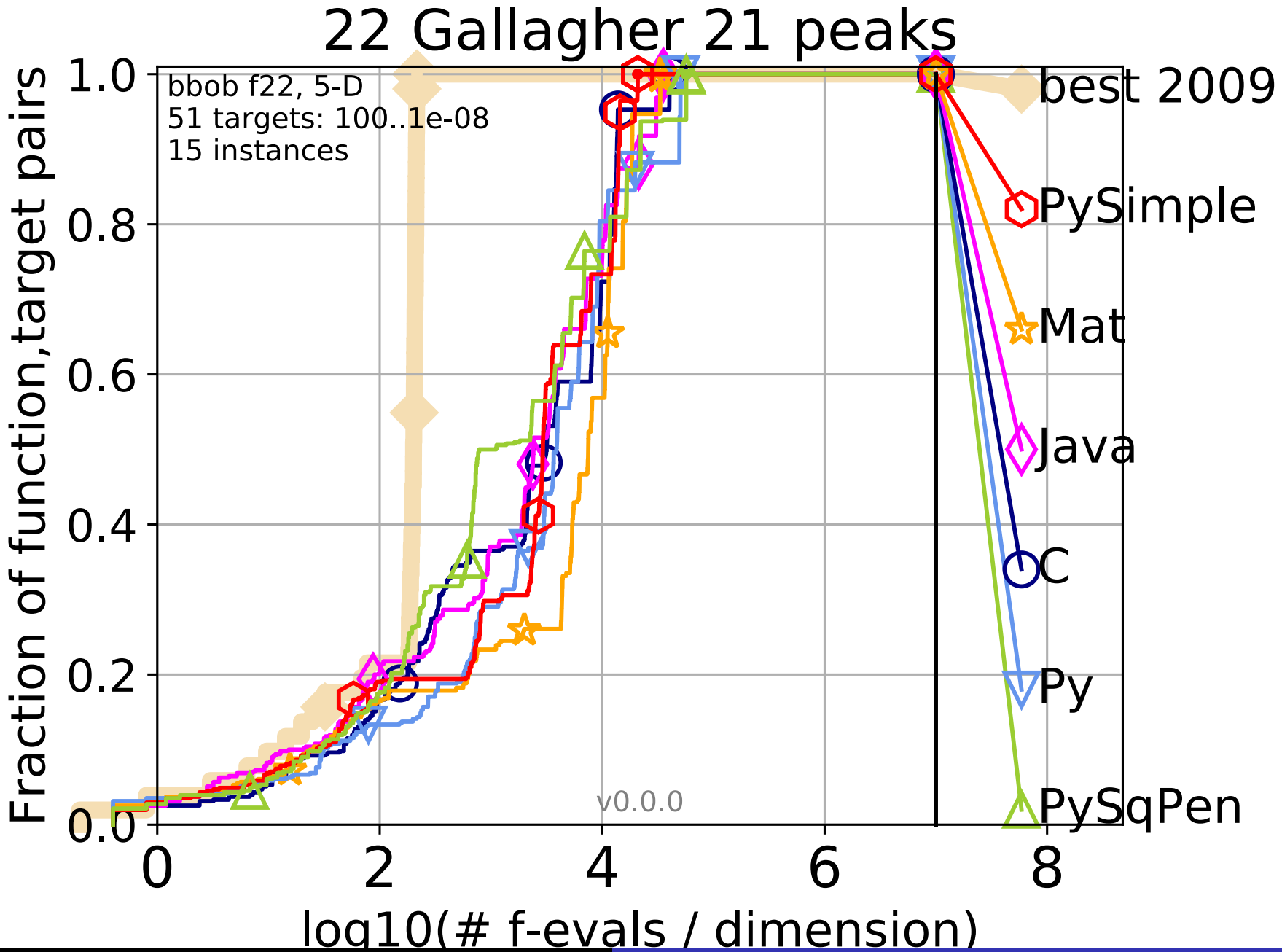

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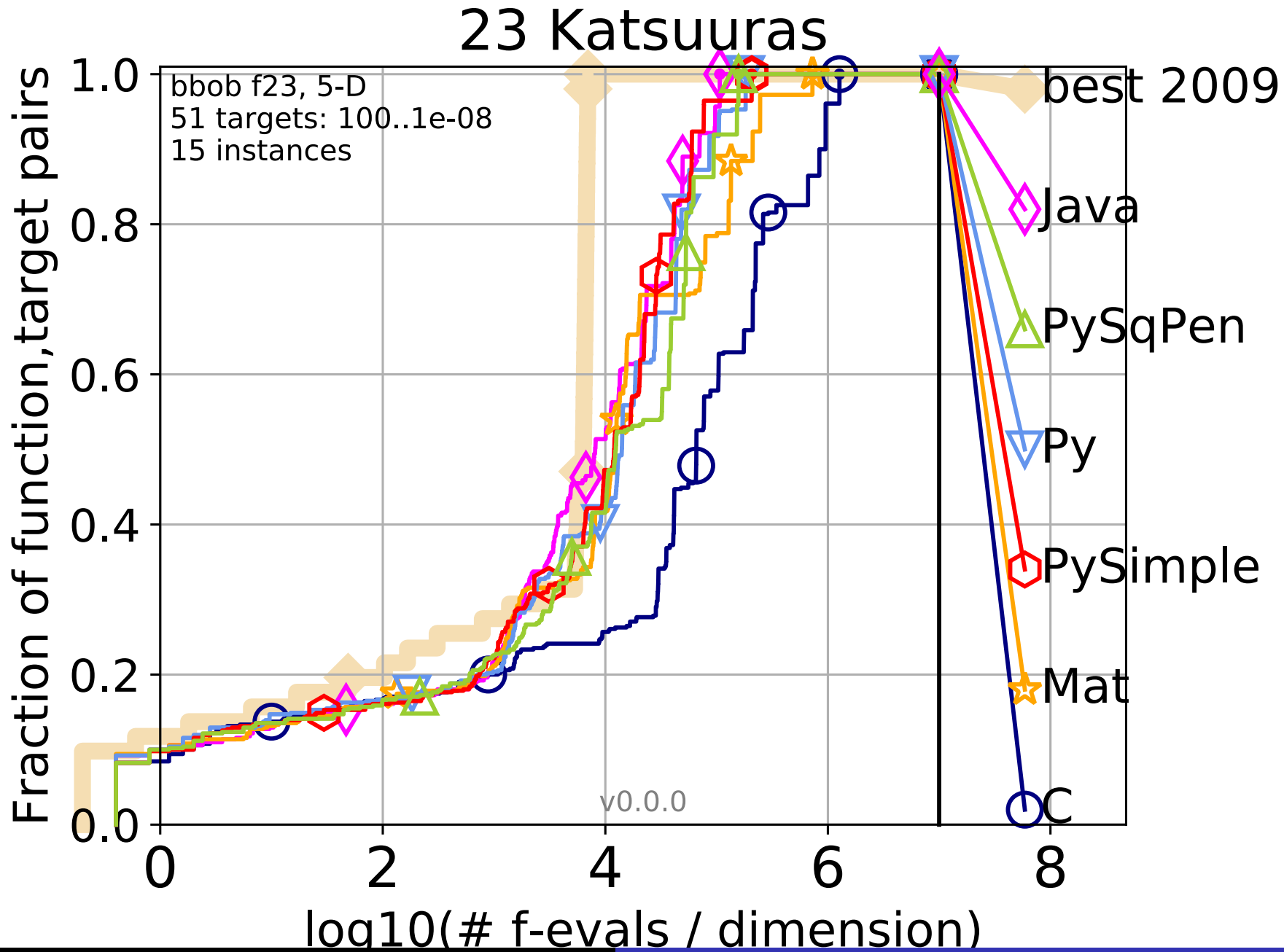

Meaning of values in table

- The numbers in tables show average runtime divided by the best value measured during BBOB-2009 competition
- The target error level was set to 10^{-5}
- The half difference between 10 and 90%- tile of bootstrapped run lengths was put in braces as dispersion measure

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Results in 5D

Fun.	C	Java	Matlab	Python	Py. sim.	Py. sq. pen.	Py. sq
f1	88 (8)	**78** (13)	84 (6)	86 (10)	89 (7)	81 (8)	
f2	46 (5)	44 (3)	41 (2)	**27** (3)	43 (6)	28 (4)	
f3	379 (249)	**283** (246)	341 (395)	601 (254)	472 (702)	328 (315)	
f4	7045 (1e4)	6783 (7417)	9937 (2e4)	6026 (6540)	5732 (2212)	**3908** (2539)	
f5	140 (24)	351 (42)	47 (15)	115 (13)	97 (73)	**33** (9)	
f6	2.6 (0.3)	2.4 (0.5)	2.4 (0.2)	2.5 (0.2)	**2.3** (0.3)	2.4 (0.1)	
f7	13 (12)	7.2 (10)	9.4 (13)	**2.8** (2)	8.1 (4)	2.9 (5)	
f8	12 (5)	10 (2)	12 (4)	12 (15)	10 (2)	**9.1** (1)	
f9	12 (2)	12 (4)	12 (6)	14 (9)	13 (4)	**11** (4)	
f10	8.4 (4)	5.2 (0.4)	4.8 (0.7)	4.3 (2)	4.7 (0.3)	**3.1** (0.2)	
f11	3.2 (1)	2.9 (0.2)	2.7 (0.2)	2.2 (1)	2.8 (0.3)	**1.5** (0.2)	
f12	6.8 (5)	5.7 (4)	4.2 (3)	6.4 (5)	6.2 (2)	**3.4** (2)	
f13	3.4 (0.8)	3.6 (0.9)	3.3 (0.6)	**2.1** (0.7)	3.1 (0.4)	2.3 (1)	
f14	11 (0.8)	12 (2)	11 (2)	7 (0.8)	11 (1)	**6.4** (0.8)	
f15	**20** (29)	**20** (22)	44 (24)	23 (36)	25 (26)	35 (48)	
f16	24 (31)	5.7 (8)	11 (11)	12 (20)	**2.5** (3)	8.2 (7)	
f17	20 (13)	**7.2** (5)	13 (6)	12 (12)	16 (11)	12 (13)	
f18	140 (104)	133 (313)	245 (325)	53 (43)	109 (108)	**40** (66)	
f19	358 (448)	389 (306)	290 (144)	117 (34)	382 (272)	**86** (67)	
f20	106 (252)	61 (59)	102 (120)	49 (31)	49 (60)	**35** (13)	
f21	15 (20)	**7.1** (5)	12 (12)	14 (4)	13 (15)	18 (18)	
f22	39 (31)	47 (78)	56 (47)	59 (33)	**35** (28)	43 (136)	
f23	50 (91)	**5** (3)	17 (36)	6.6 (8)	6 (4)	7.7 (12)	
f24	∞	∞	**60** (60)	62 (44)	∞	∞	

Meaning of values in table

- Algorithms that use the same bound constraint handling were compared in pairs using the Wilcoxon rank-sum test along with the Bonferroni correction by the number of functions
- The star means that there is a statistically significant difference with p-value 0.05. The number k after the star shows the p-value was 10^{-k}

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Fun.	C	Matlab	Python	Py. sq. pen.	Py. sq. pen. vs Matlab	Py. vs C
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f24	∞	**60** (60)	62 (44)	∞		

Tracing the differences

- Bound constraint handling
- Internal stopping conditions (sanity checks) – 8 in C, 11 in Python; stopTolFun, stopTolFunHist, stopTolX are different
- After setting Python like C, Python was interrupted on function 19
- Implementing different versions of the method – Python implements ActiveCMA version
- Different heuristics used to detect and escape from flat areas of the fitness
- Different values used in initialization of internal recombination weights

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Article-implementation relation

- Which article describes the CMA-ES?
- Authors of the CMA-ES cited sequence of four articles when referring to CMA-ES
- Article-implementation relation is not clear:
  - there are no references in the C code
  - there are two references connected with additional improvements of the method in Python
  - there are five references in Matlab and five in Java, four of them are common for both implementations

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Best practice recommendations

- Publishers should require the availability of the source code for all new optimization methods
- Authors should reveal how all parameters were set up, not only in the proposed method but also in methods used for comparison
- The code used for running experiments should be available
- Authors should use the most up-to-date trusted implementation of the state-of-the-art and reveal its origin, name, and version
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- Authors of articles and authors of implementations should identify the method used for constraint handling

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Conclusions

- The choice of a particular implementation of even a popular and standard algorithm may have a substantial impact on the results obtained in research studies or applications
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The end

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