

# Stopping Criteria, Initialization, and Implementations of BFGS and their Effect on the BBOB Test Suite

**Aurore Blelly, Matheus Felipe-Gomes, Anne Auger, Dimo Brockhoff**  
Inria and Ecole Polytechnique, France



# Benchmarking

...is benchmarking of algorithm **implementations**

**Goal:** understand impact of

- algorithm parameter settings
- BBOB settings (initialization, instances, ...)
- implementation aspects

for a basic, well-known and often used algorithm:

**BFGS:** quasi-Newton method as proposed by Broyden, Fletcher, Goldfarb, and Shanno

# An (Assisted) Student Project

## Term project @ Ecole Polytechnique

- group of 2 students
- one afternoon a week
- weekly meeting
- from zero to a BBOB paper within a few months

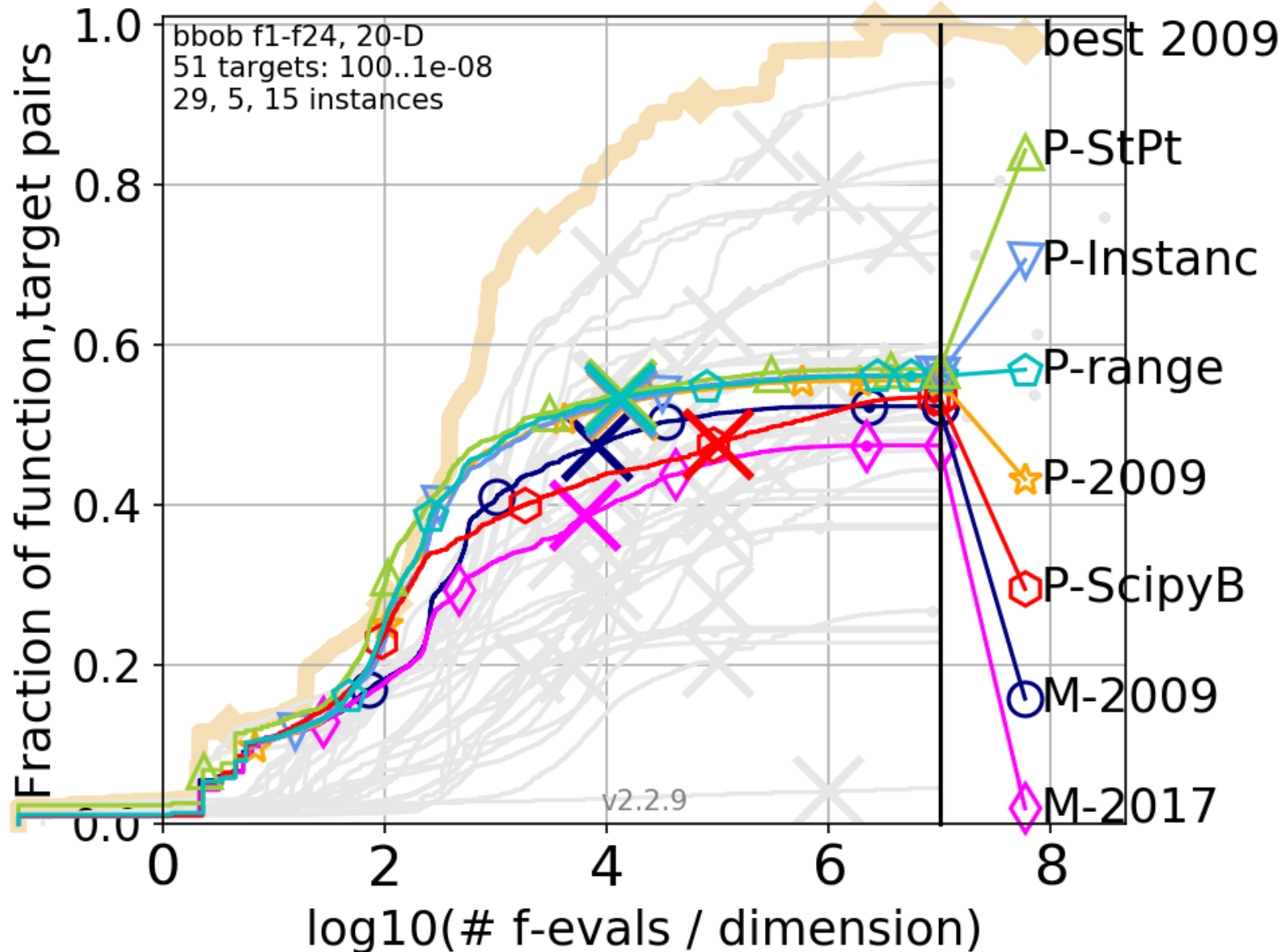
# BFGS in a nutshell

- quasi-Newton method
- in each iteration:
  - find search direction  $p_k$ 
    - via  $B_k p_k = -\nabla f(x_k)$
    - with  $B_k$  an approximation of the Hessian (and the gradient  $\nabla f(x_k)$  estimated by finite differences)
  - do line search along  $p_k$
  - update  $B_k$  (details omitted)
- implemented as default
  - in Matlab's `fminunc`
  - in Python's `scipy.optimize`

# Experimental Setup

- Matlab experiments of Ros from 2009 as baseline
- as well as Posik/Baudis' scipy results (with basin hopping)
- compared to Matlab'17 default (+ same 2009 setup)
- Python version (1.0.1 default as **P-2009**) plus
  - different instances: **P-Instances** with 2017 instances
  - different initial point:
    - **P-StPt** with each restart from 0
    - **P-Range** with random starting point in  $[-4,4]^n$
- little tuning:
  - on rotated ellipsoid and discus only
  - few values of **FiniteDifferenceStepSize** (MATLAB) and **epsilon** (Python) tested
  - best parameter chosen (we observed a clear minimum)

# Summary in 20-D



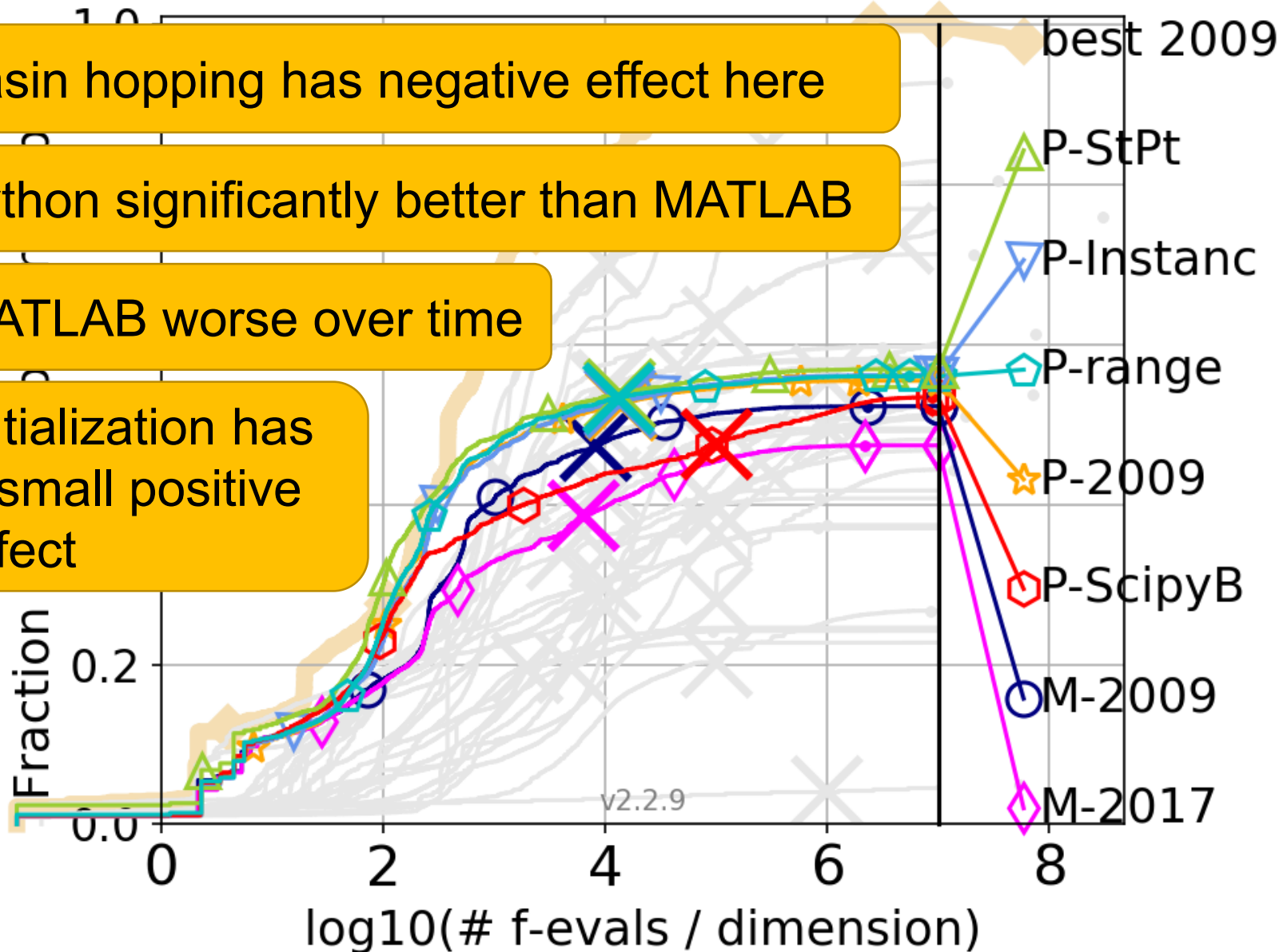
# Summary in 20-D

basin hopping has negative effect here

python significantly better than MATLAB

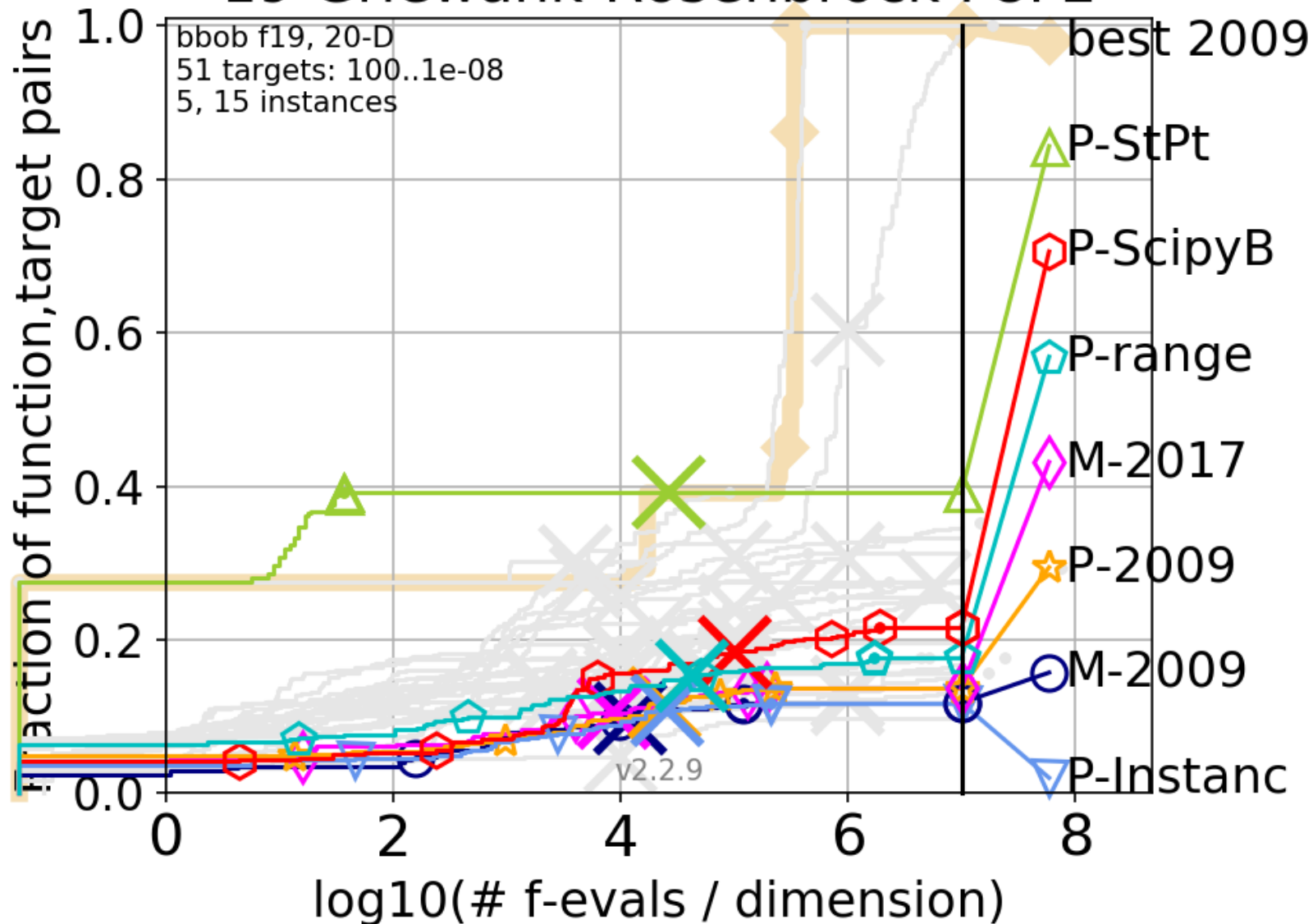
MATLAB worse over time

initialization has a small positive effect



# f19: Indicating the Initialization

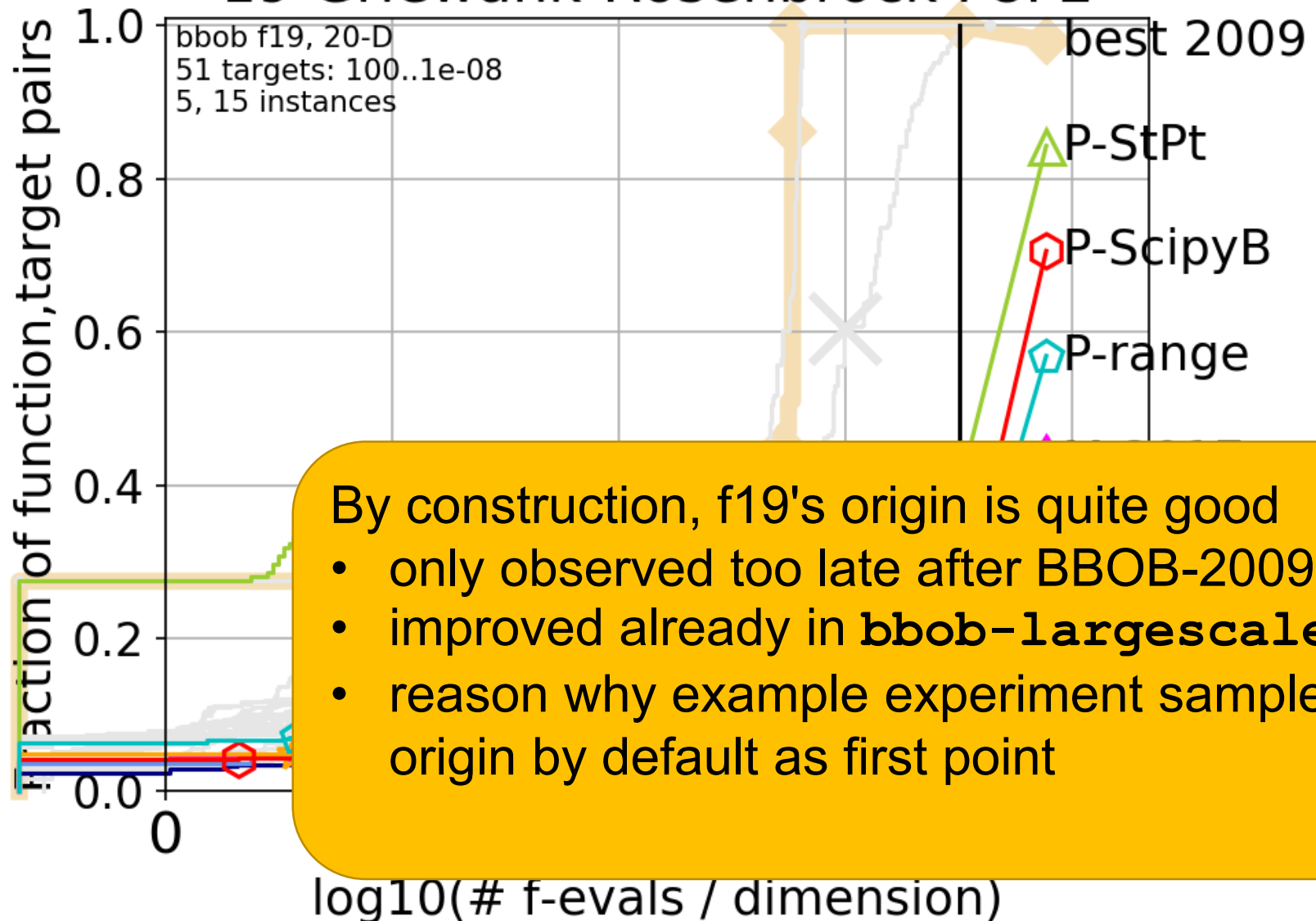
## 19 Griewank-Rosenbrock F8F2



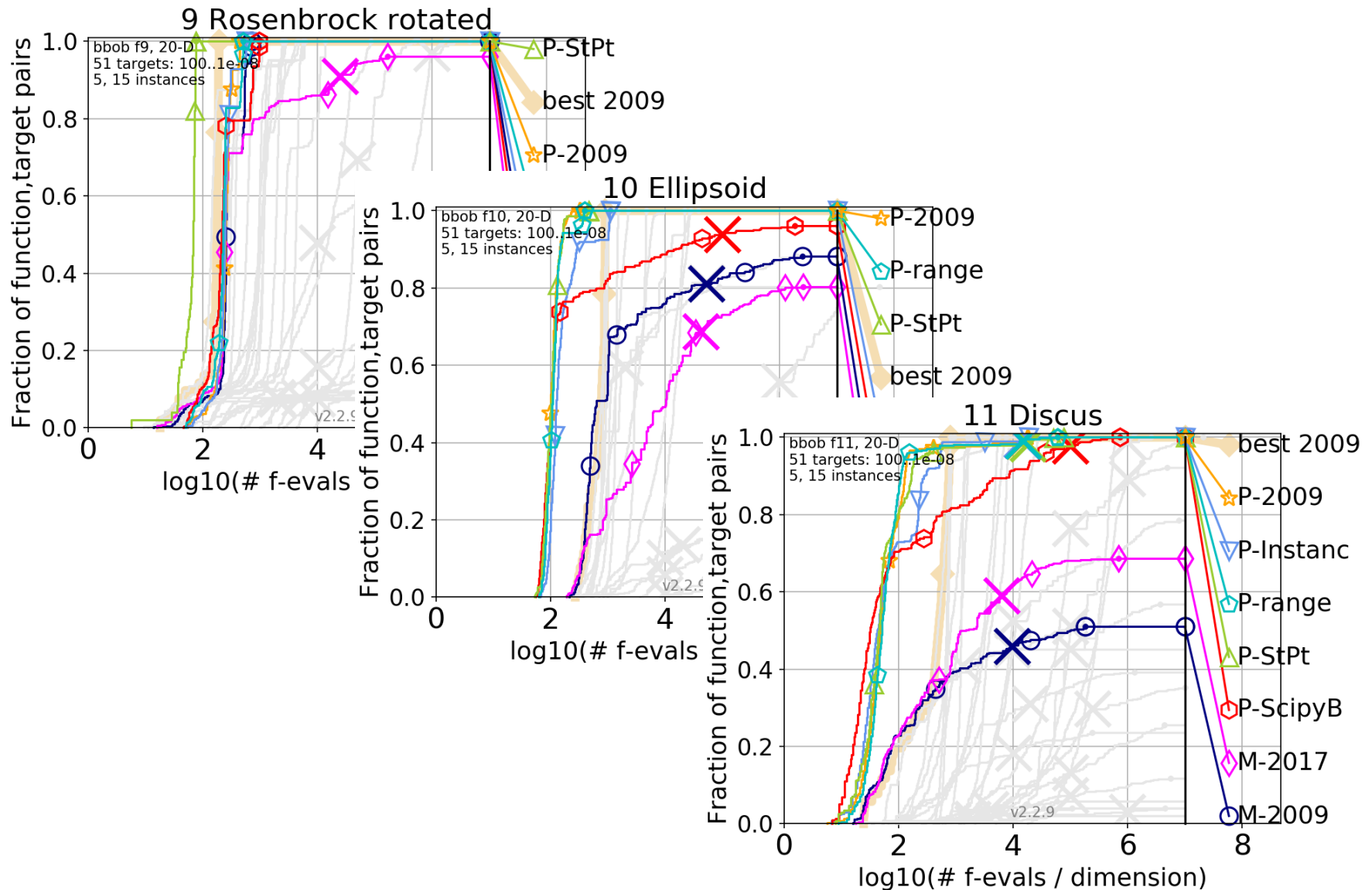


# f19: Indicating the Initialization

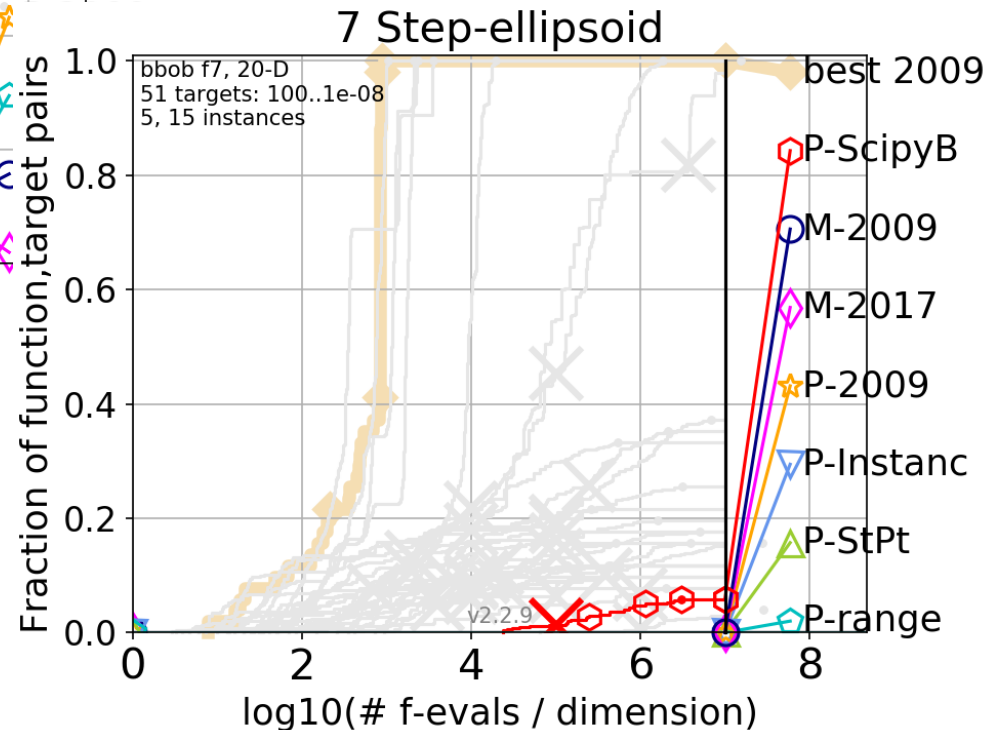
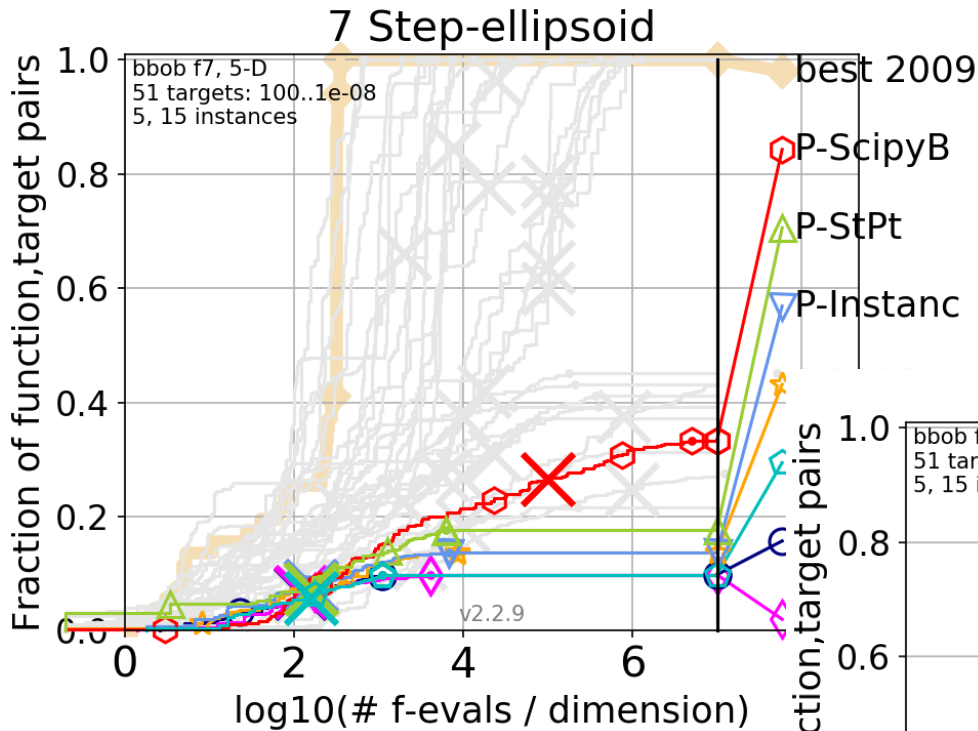
## 19 Griewank-Rosenbrock F8F2



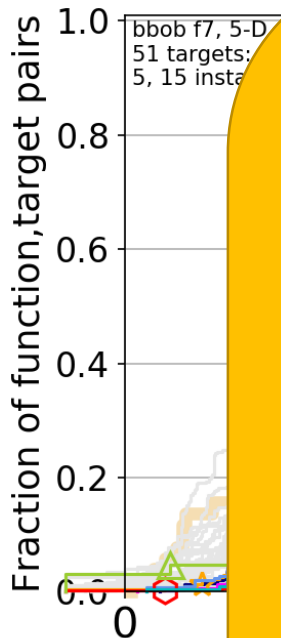
# Most Notable Results



# Pay Attention!



# Pay Attention!



[...]

Function evaluations: 52505

Gradient evaluations: 2384

!(758) f007 Optimization terminated successfully.

Current function value: 1849.514751

Iterations: 0

Function evaluations: 22

Gradient evaluations: 1

Optimization terminated successfully.

Current function value: 1266.195272

Iterations: 0

Function evaluations: 22

Gradient evaluations: 1

Optimization terminated successfully.

Current function value: 2022.714019

[...]

est 2009  
ScipyB  
-2009  
-2017  
2009  
Instanc  
StPt  
-range  
3

# Summary

- Implementation details have a strong effect
  - Python BFGS clearly better than MATLAB
- BBOB instances have little effect
- so does the initialization (but origin as first point best)
- random restarts better on BBOB than basin hopping

# Conclusions

- use Python's BFGS over MATLAB if you can
- pay attention:
  - when applying algorithms
  - when interpreting benchmarking results

**thanks**