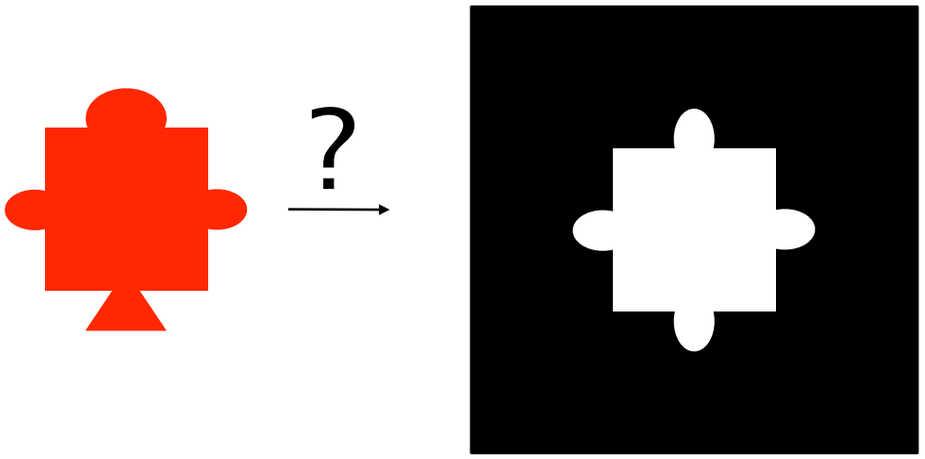
Optimization of Accelerator Parameters

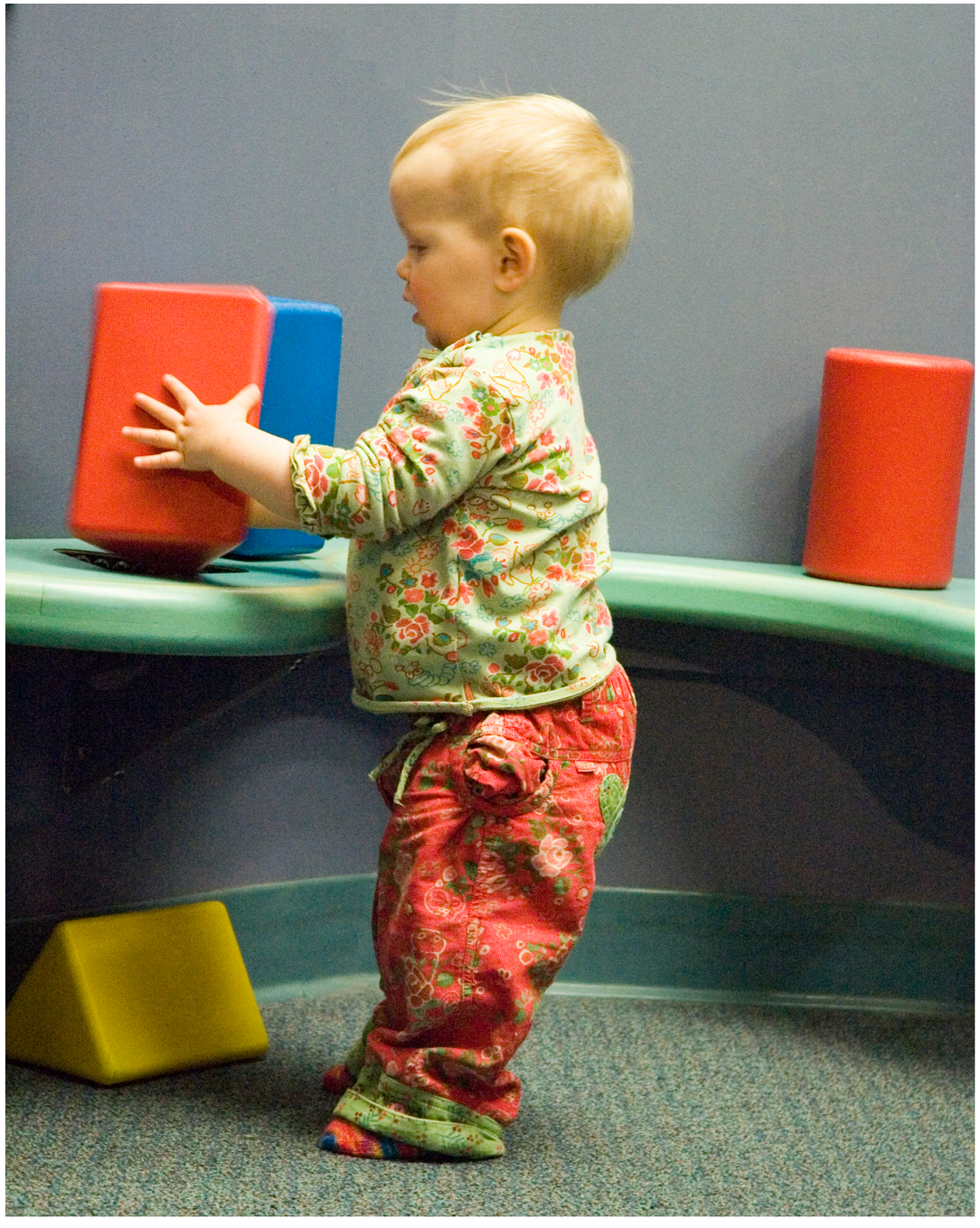
- Task: optimize the accelerator settings.
  - Goal: minimize emittance (for example)
  - Parameters: everything that can be controlled by EPICS

- This is difficult to optimize:
  - Many parameters
  - Non-linear dependence of the optimization goal on the parameters
  - How stable is the solution?
  - Many local optima; looking for a global optimum

➡ Use a genetic algorithm

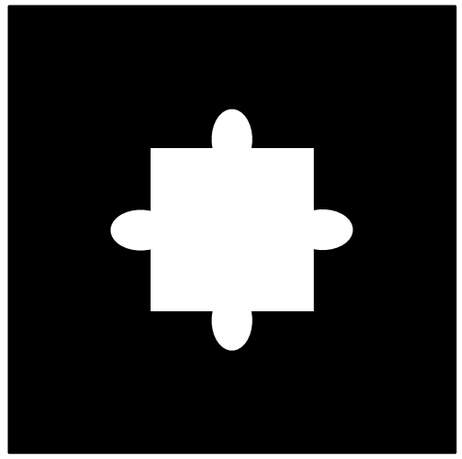
Fitting Puzzle Pieces



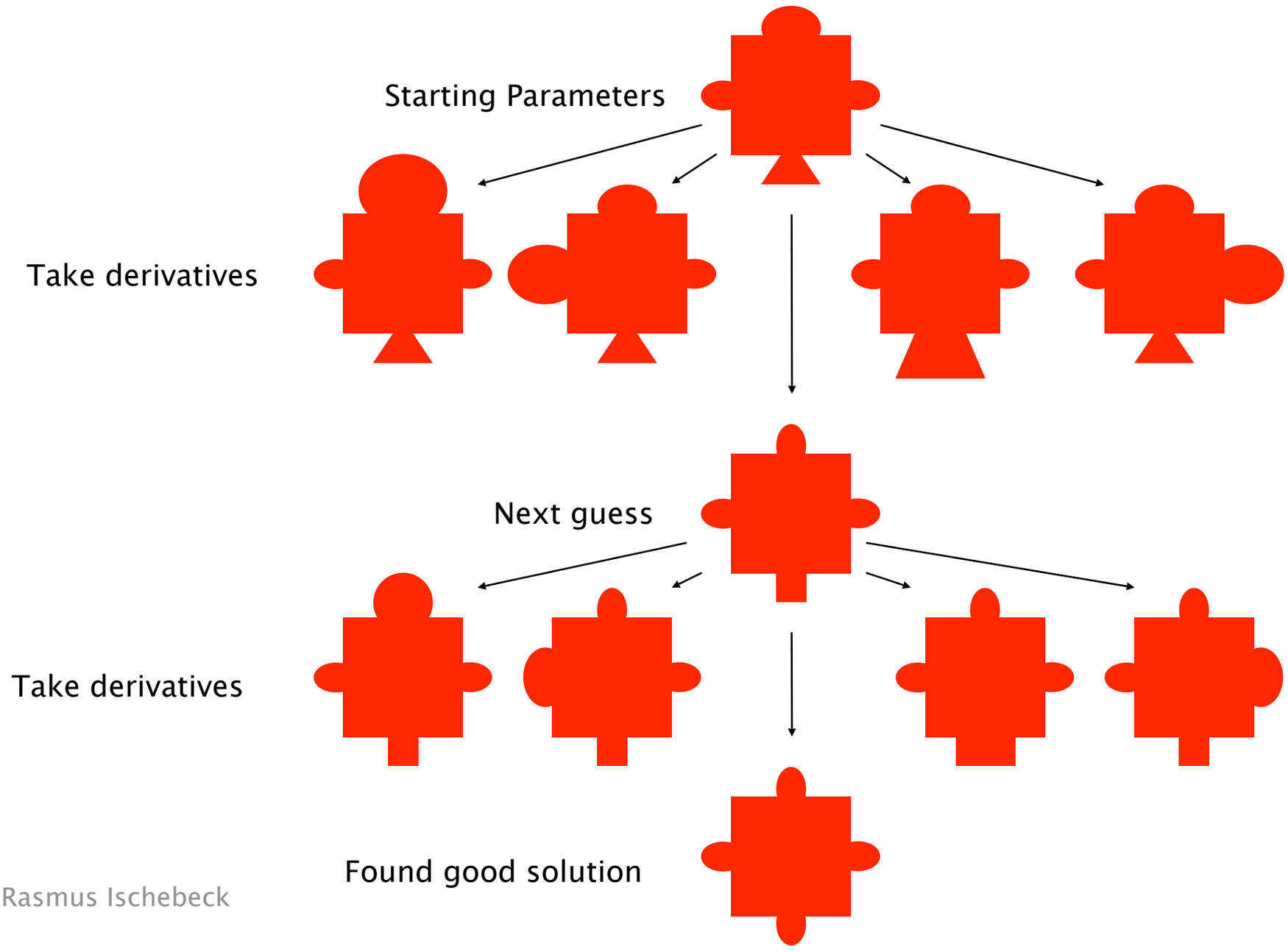


Rasmus Ischebeck

Fitting Puzzle Pieces

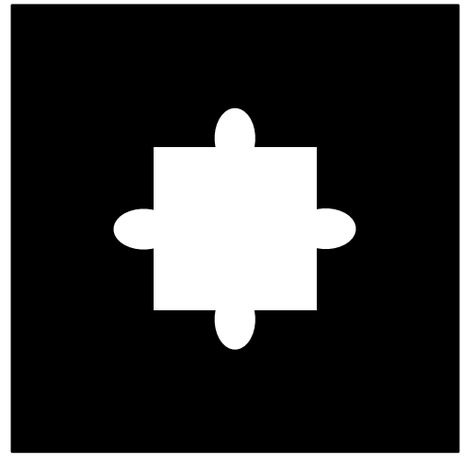


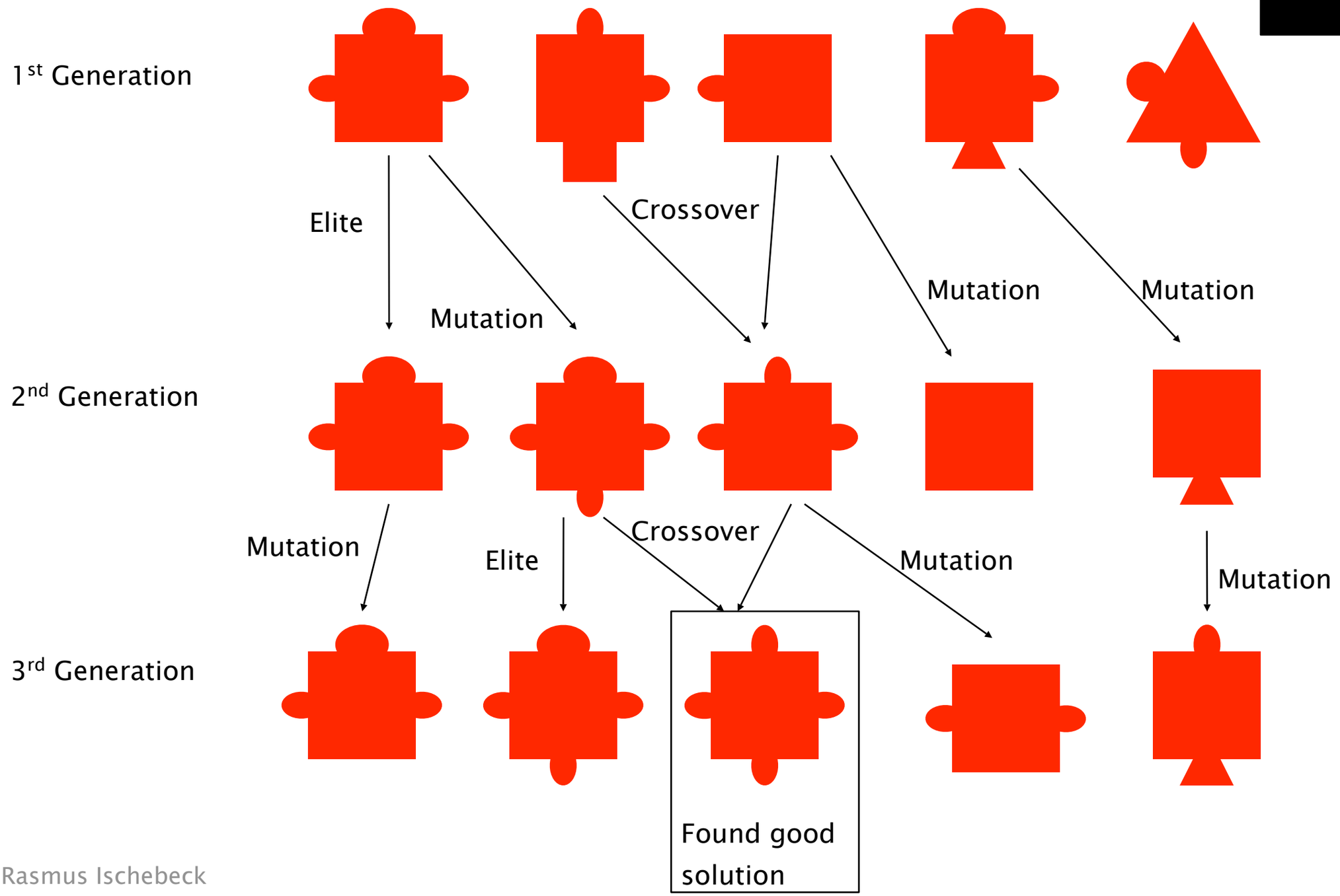
Subspace Trust Region Method



Rasmus Ischebeck

Genetic Algorithm





OBLA 500 keV

- We would like to minimize the projected emittance of the beam
- Related optimization goal:

  minimize beam size on telescope camera, while keeping the charge high
- Define

  Fitness = $\sigma_x \cdot \sigma_y$ / Q

  (median of 10 measurements)

Fitness

10^2

50 100 150 200 250 300

Charge

10^7

10^6

50 100 150 200 250 300

sigmaX

10^{-3}

50 100 150 200 250 300

sigmaY

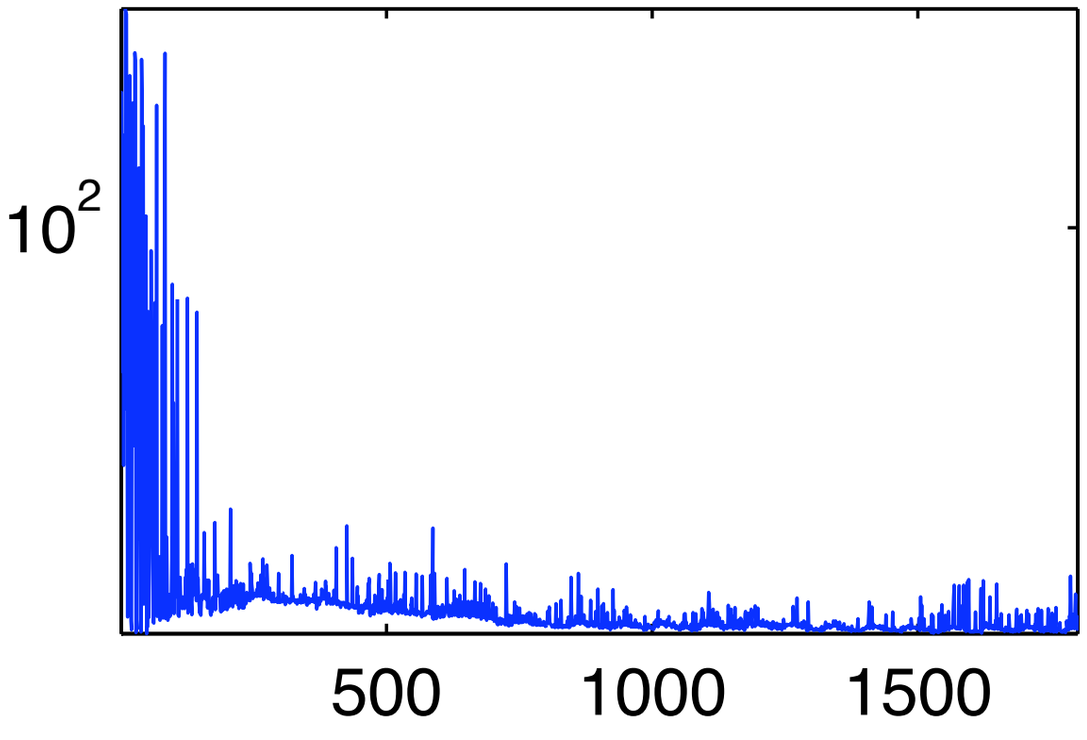
10^{-3}

50 100 150 200 250 300

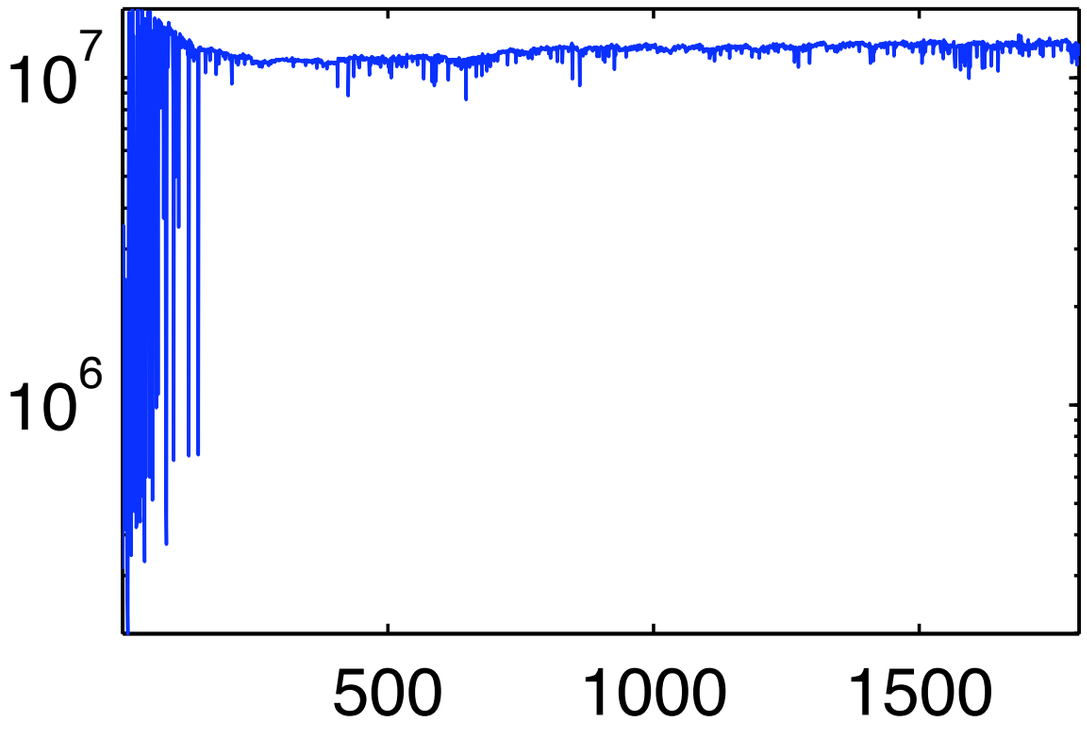
Specific Issues when Optimizing Hardware

- Noise in the measurements
- The accelerator drifts during the optimization
  - The optimum solution changes
  - Need to re-adjust parameters

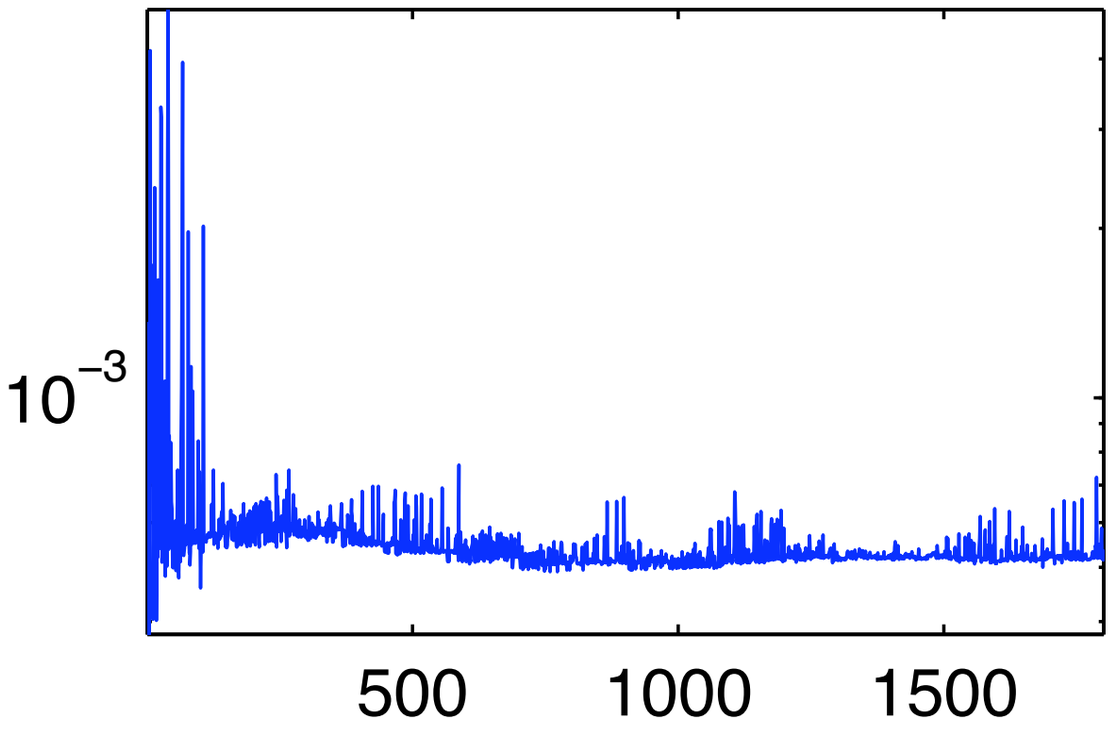
Fitness



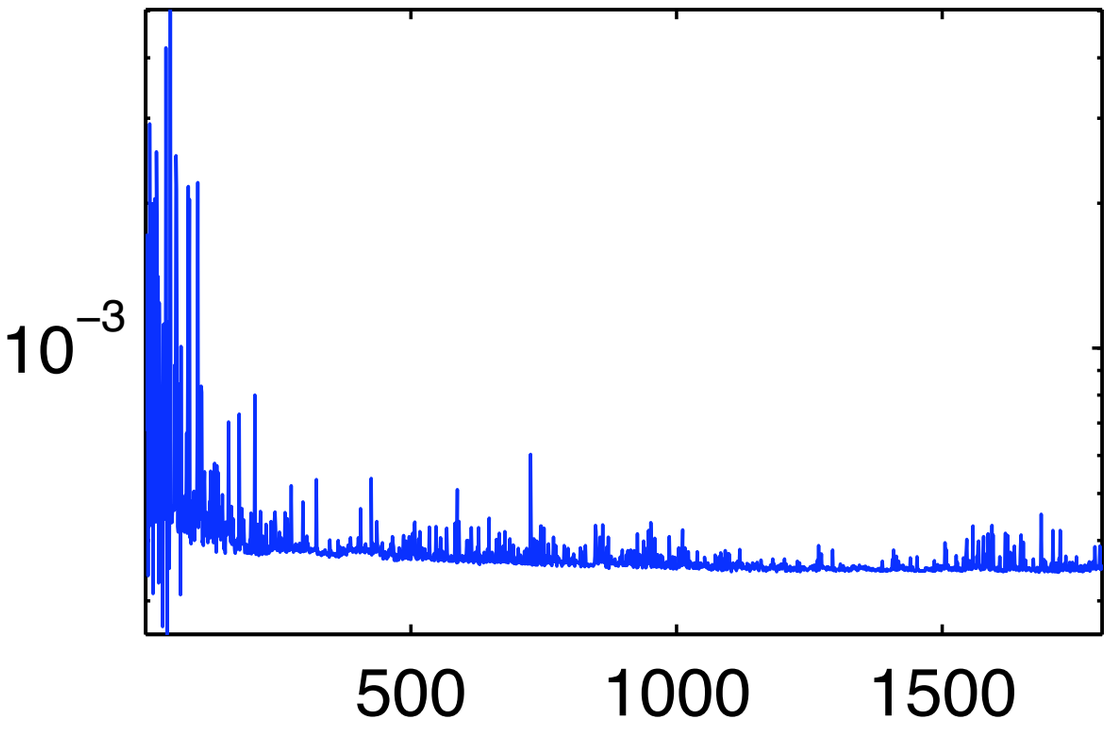
Charge



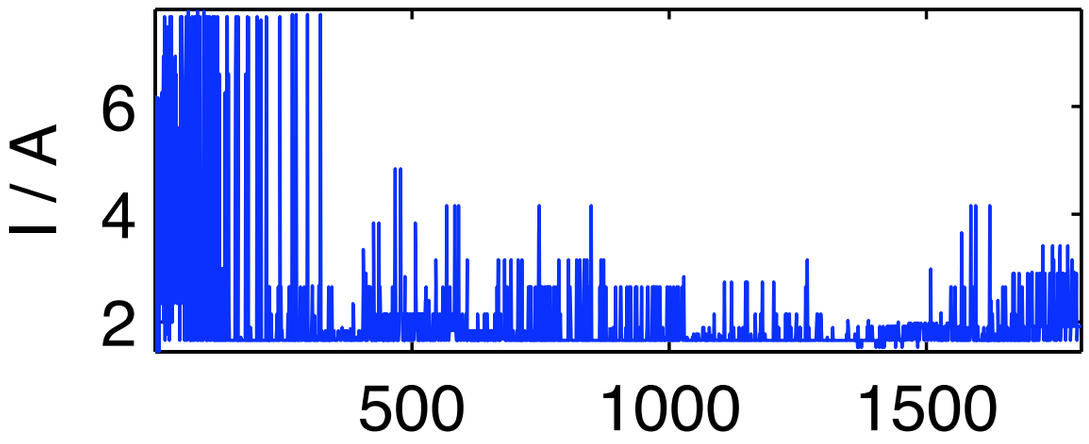
sigmaX



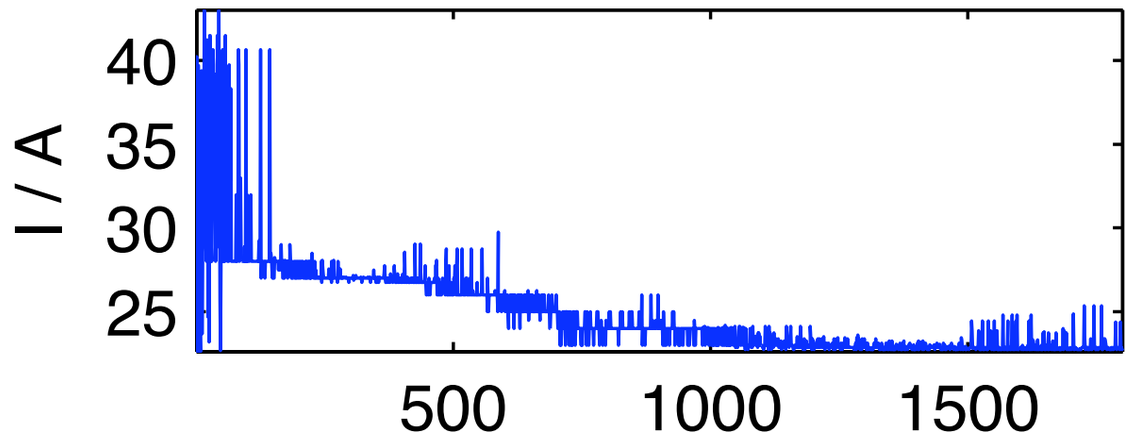
sigmaY



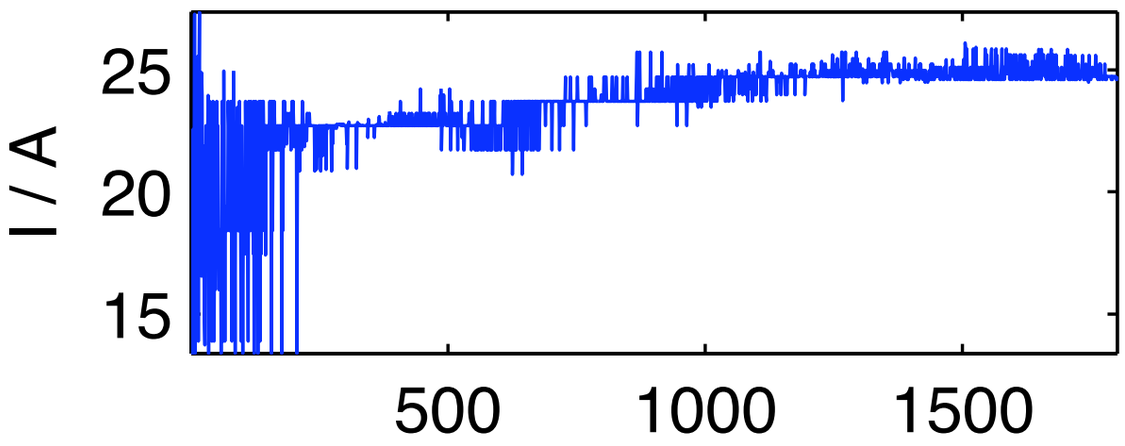
FINEG–MSL10C



FINEG–MSL10



FINEG–MSL20



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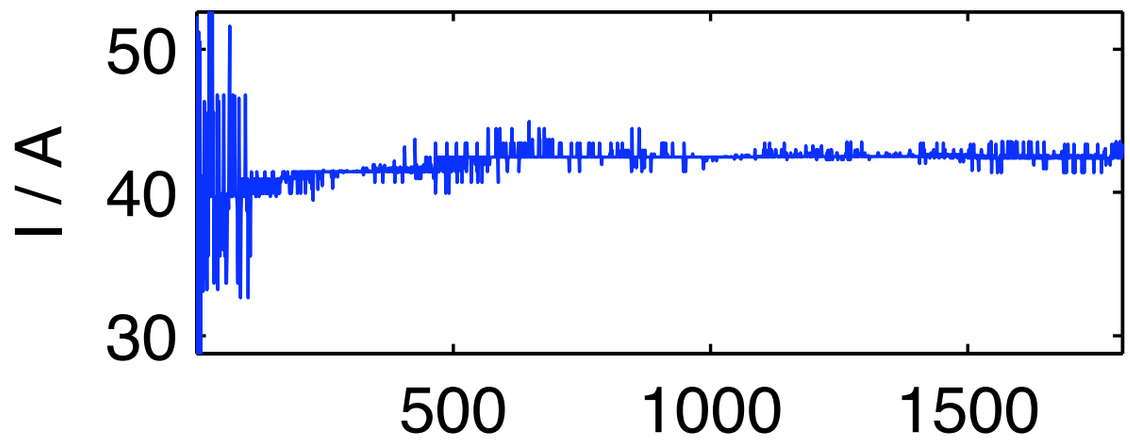
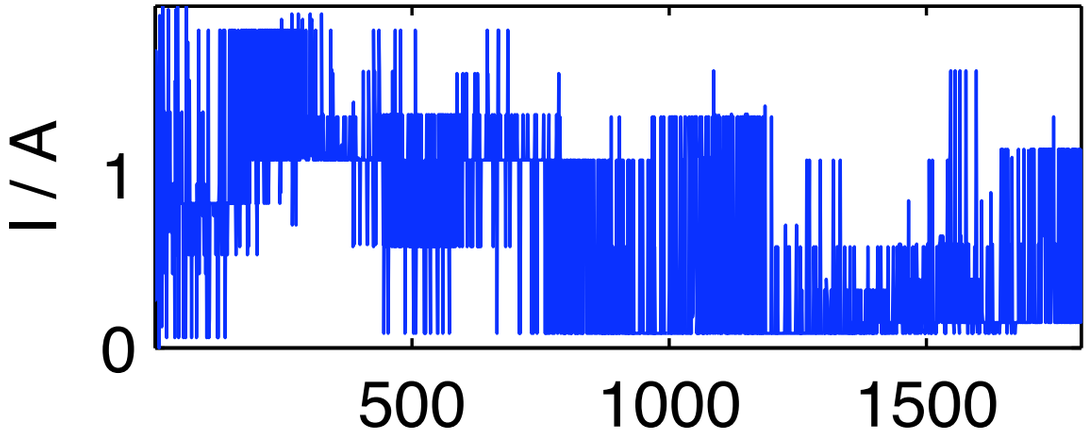
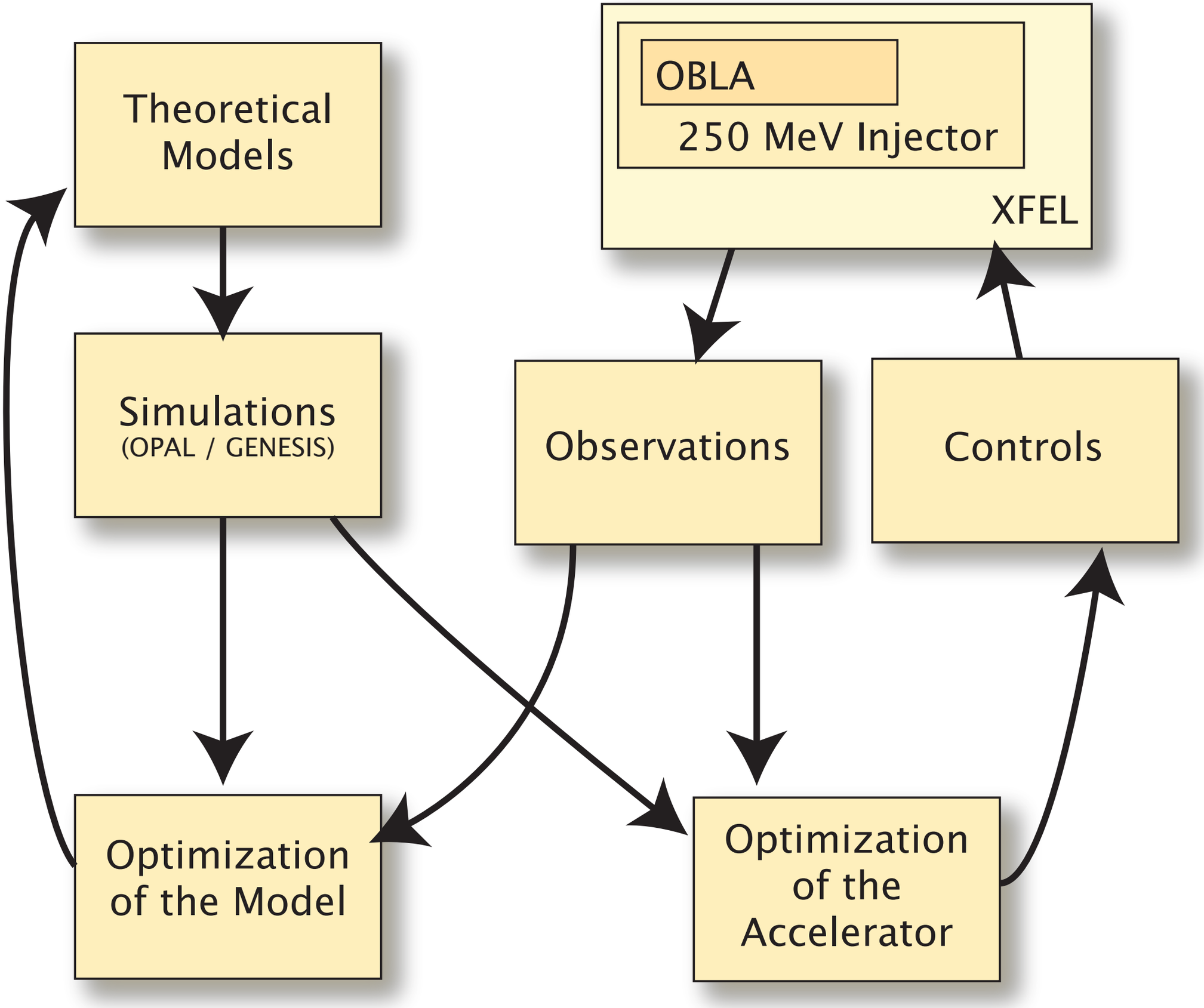


FINEG–MSL40



Next Steps

- Use “soft” bounds to parameters
- Optimize more than one target, e.g. emittance, charge (Multicomponent objective function)
- Find a more difficult problem (OBLA 4 MeV, 250 MeV, PSI-XFEL)
- How stable is the solution?
- Combine with optimization of accelerator simulation


Theoretical Models
Simulations (OPAL / GENESIS)
OBLA
250 MeV Injector
XFEL
Observations
Controls
Optimization of the Model
Optimization of the Accelerator