Laboratoire d'Annecy-le-Vieux de Physique des Particules

SVD : Single Value Decomposition

a new HPC template method

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Asterics
Astronomy ESFRI & Research Infrastructure Cluster

cta
cherenkov telescope array

cnrs

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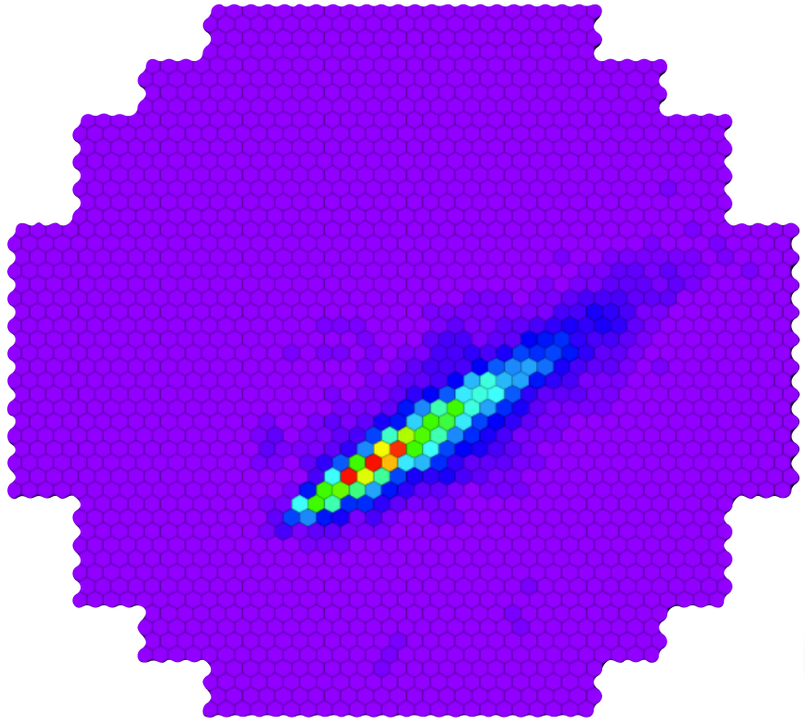
Motivations

- Apply template method for reconstruction of shower parameters to CTA

- Current methods: comparison of full images



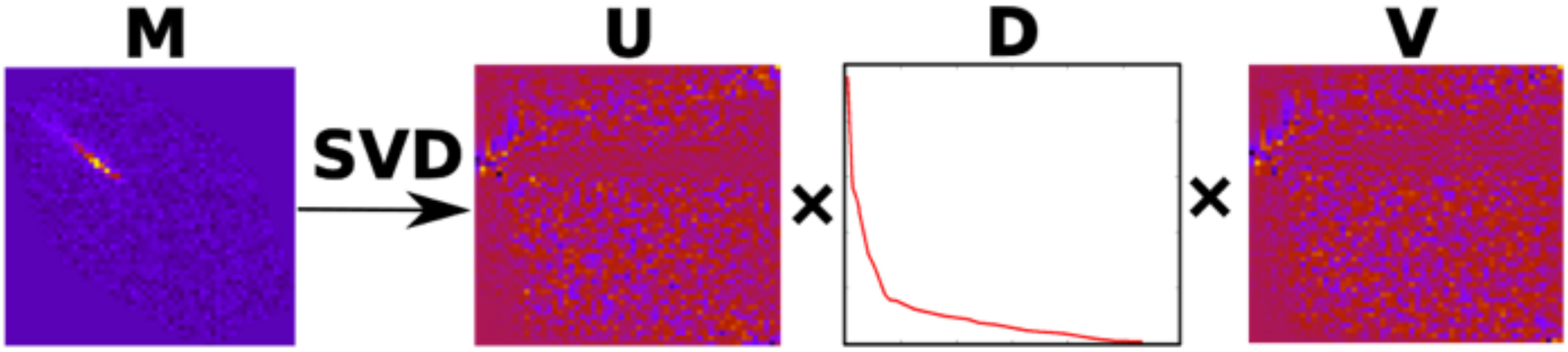
- huge amount of data makes the process slow

- can we reduce the images and keep same amount of information?

→ Single value decomposition

Single value decomposition method

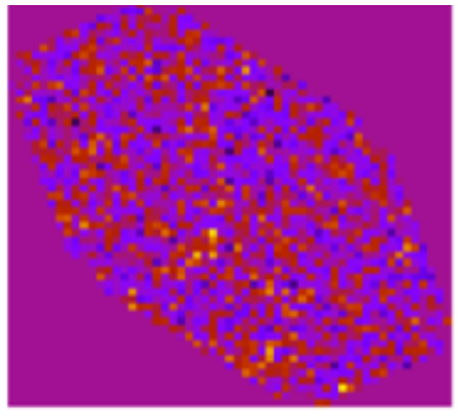
- the image is decomposed into 2 unitary matrices (U,V) and 1 diagonal matrix (D)



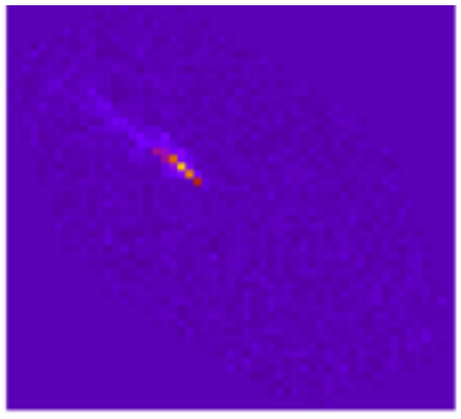
- the single values (SV) of the diagonal matrix (D) are highly correlated to the image morphology
- similar images give similar SV

→ Compare SV instead of full images

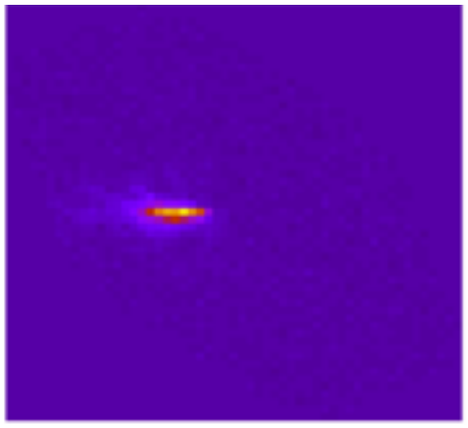
Single value decomposition method: example



Noise

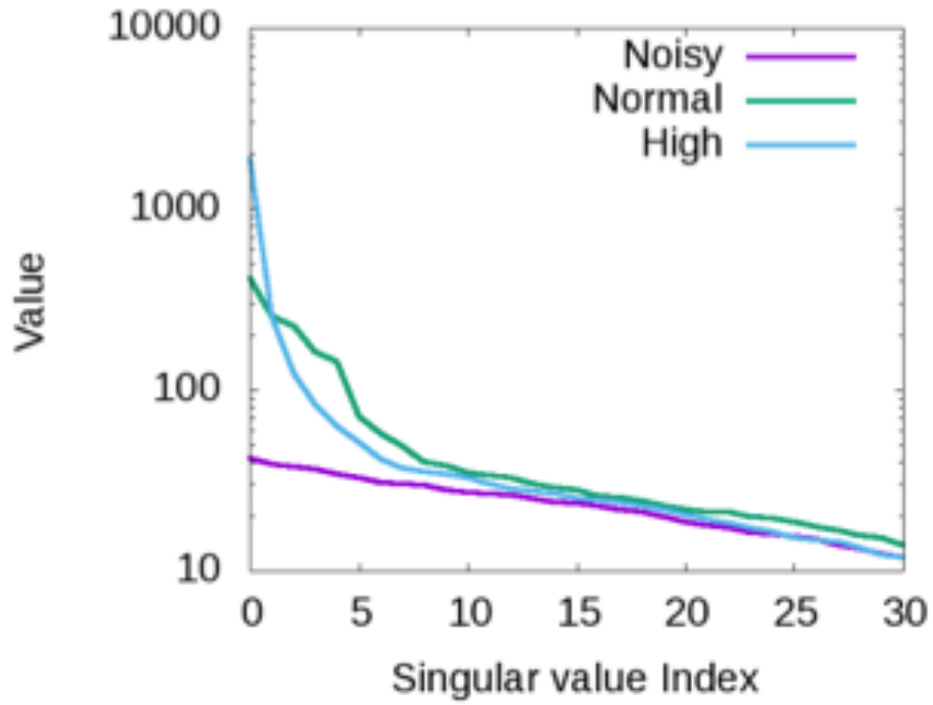


normal S/N



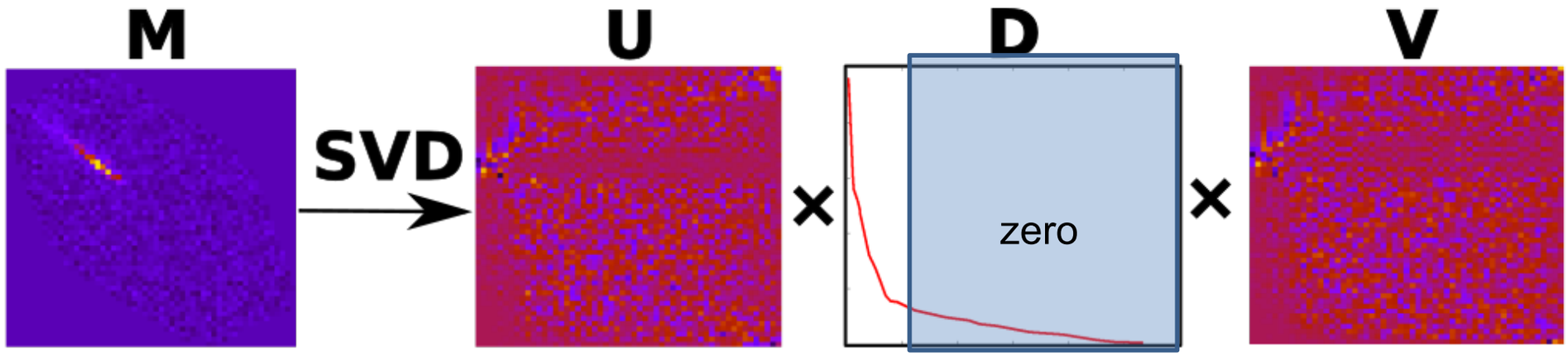
high S/N

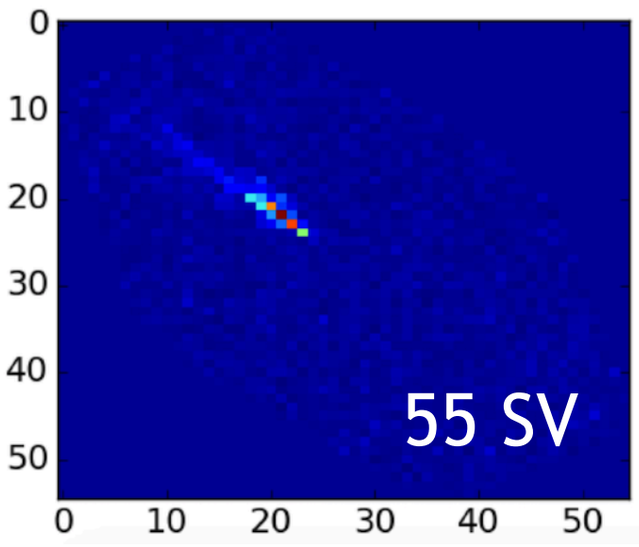
- SV spectrum depends on image morphology
- noisy behavior is eventually reached
- keep only the first single values?

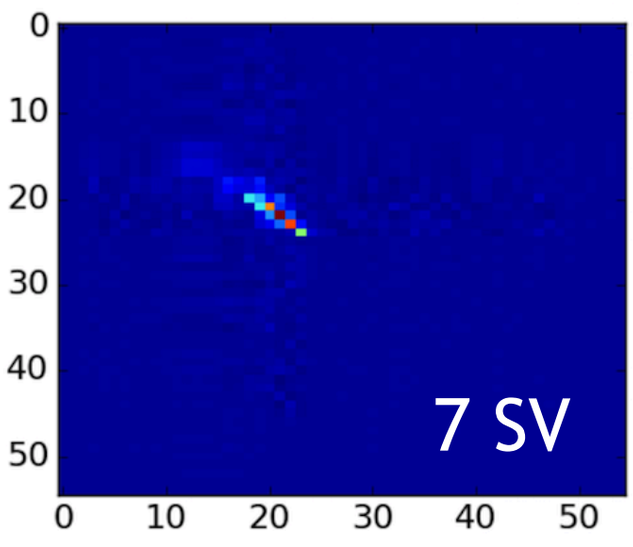


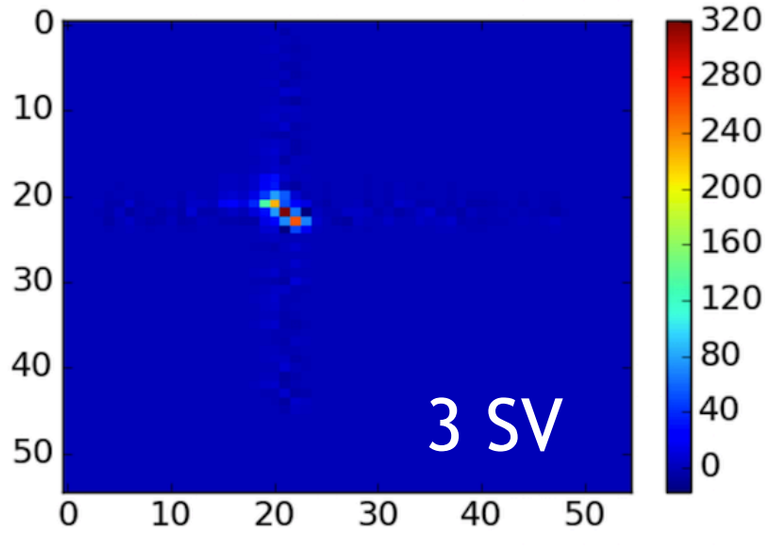
Single value decomposition method: example

- Influence of number SV: reconstruction of the image







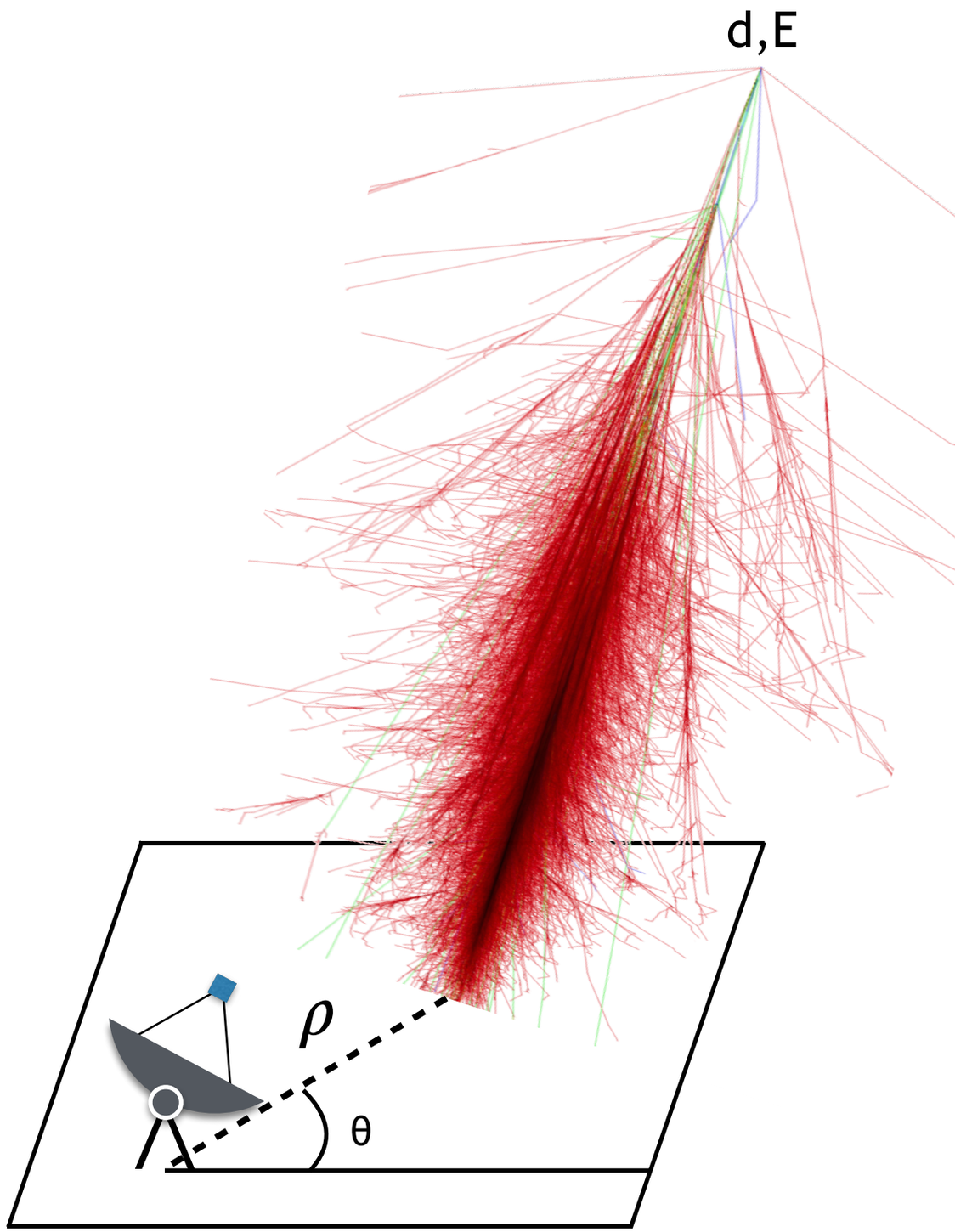


- last SV account for the noisy part
- keep a sufficient number of SV to not loose information (tests ongoing)

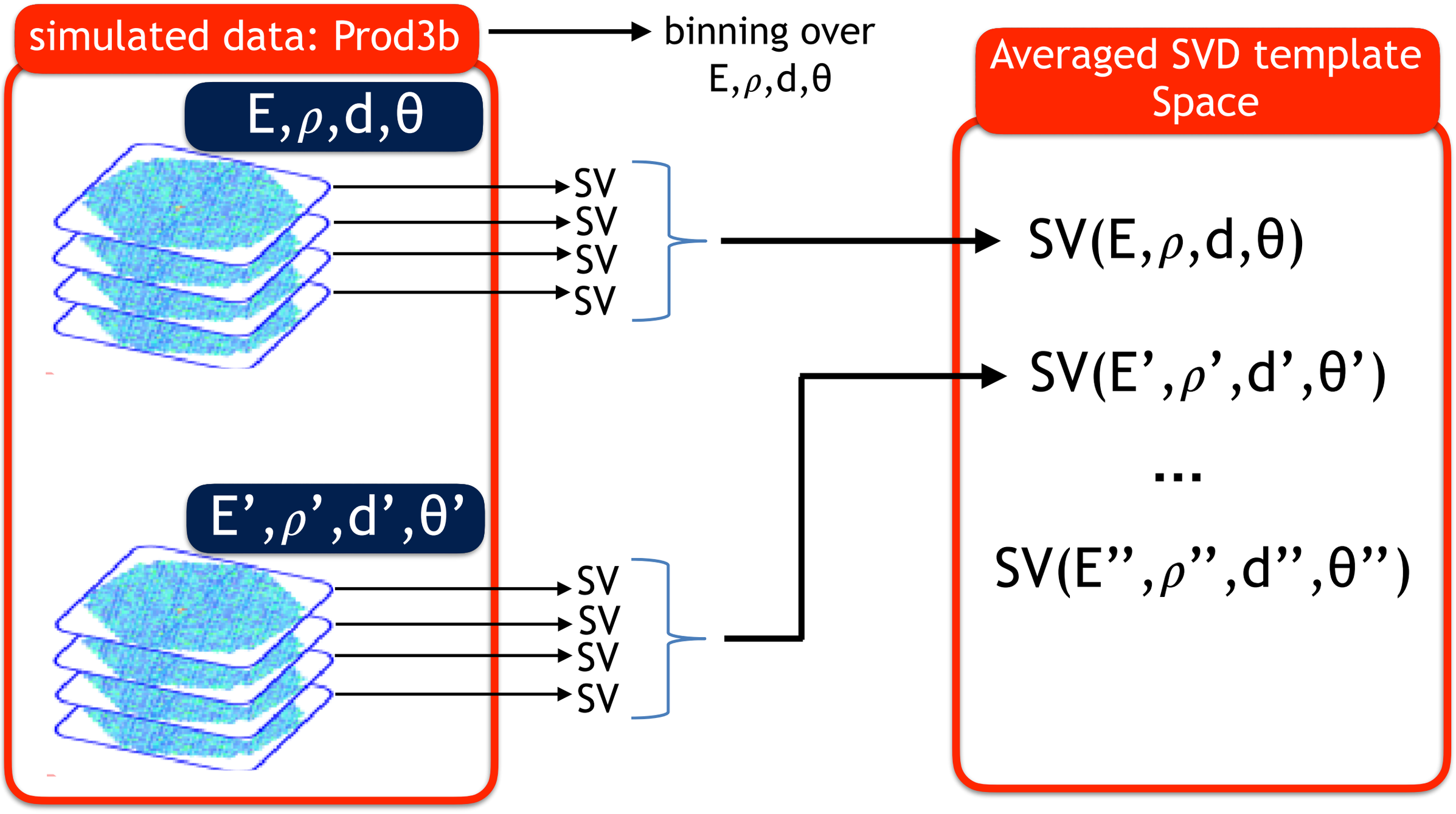
SVD template model

- model parameters:

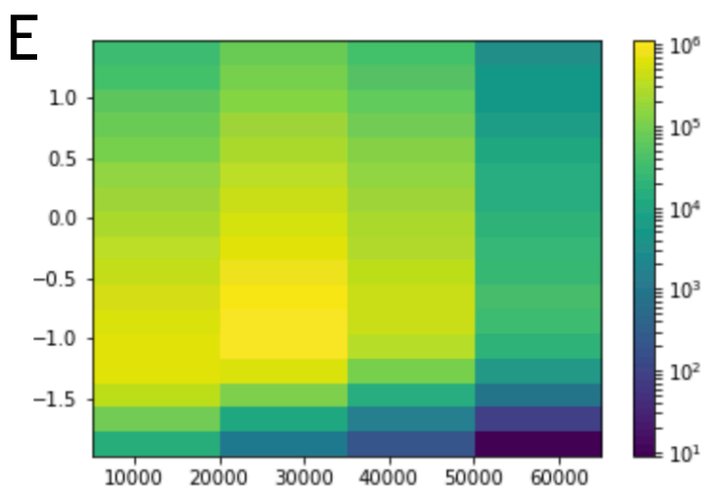
  E: energy
  d: first interaction depth
  ρ: impact parameter
  θ: angular distance
  α: distance from camera center

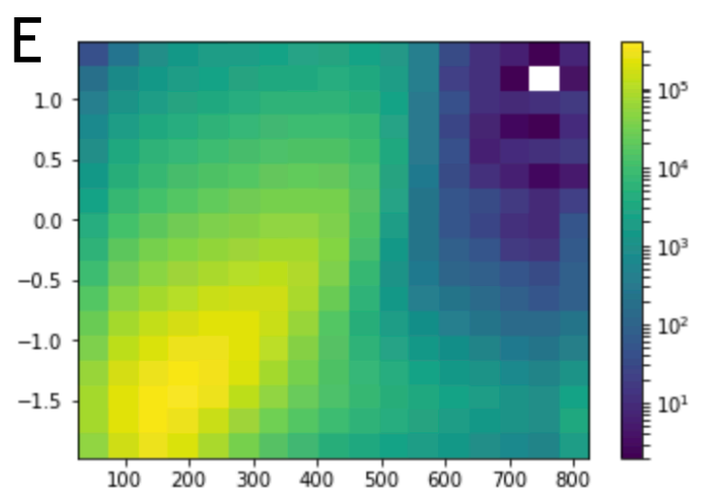


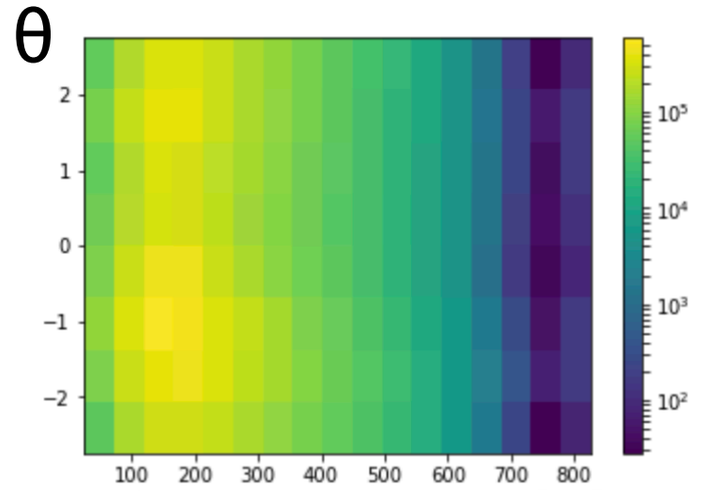
SVD template model creation



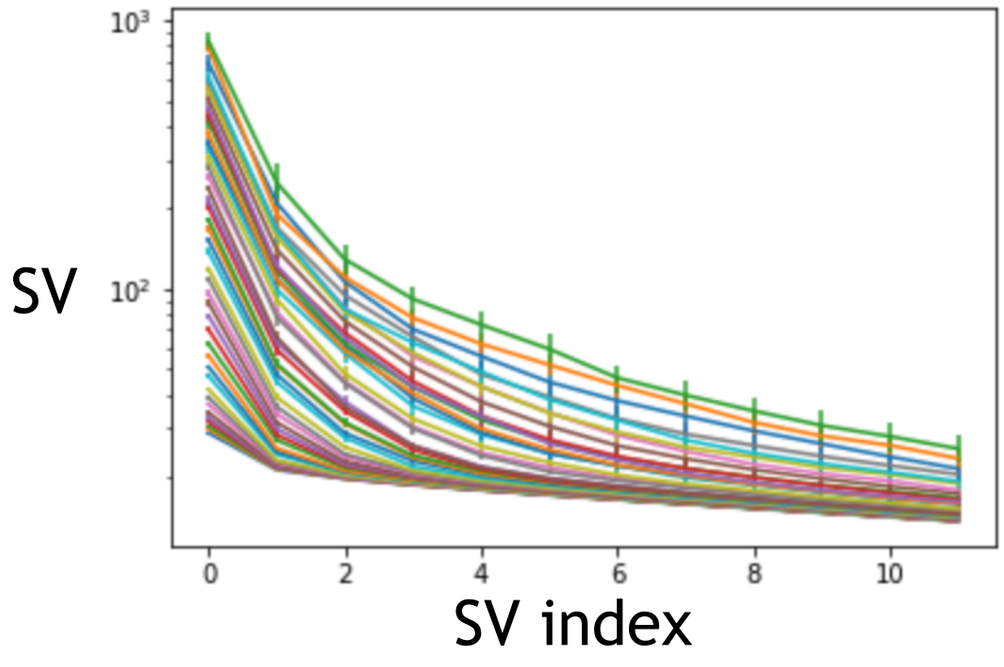
SVD template model: binned parameters space





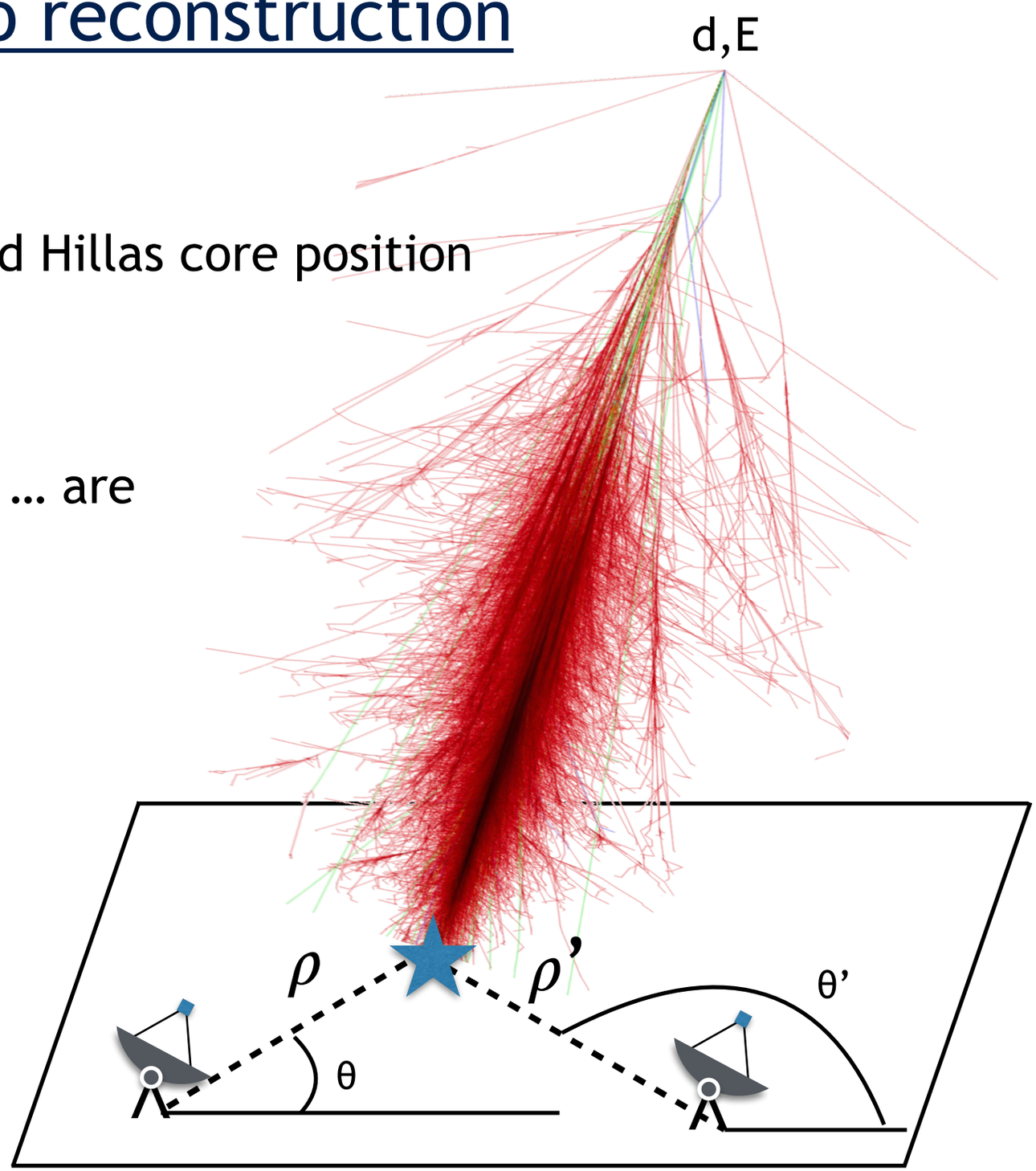


- SV spectra for fixed ρ,d,θ and different E
- higher SV = higher energy
- less fluctuations on lower SV index



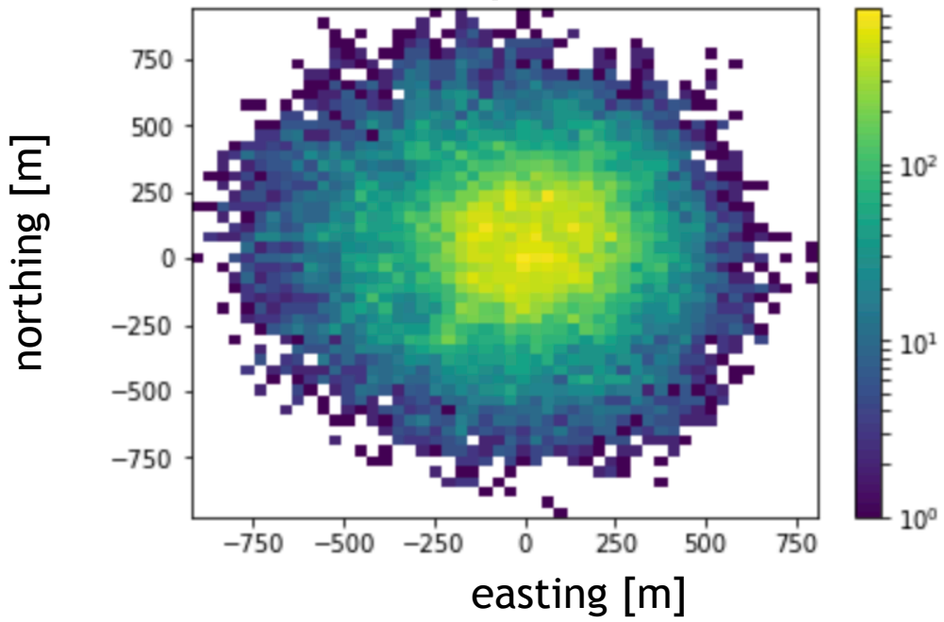
SVD template model: stereo reconstruction

- scan the core position over a grid
- if Hillas successful, scan only around Hillas core position
- for each position:
  - the SV spectra for (ρ,θ), (ρ',θ'), … are retrieved
  - all (d,E) combination are tested
- compute χ^2 test to converge to most likely model
- reconstruction of (E,ρ,d)

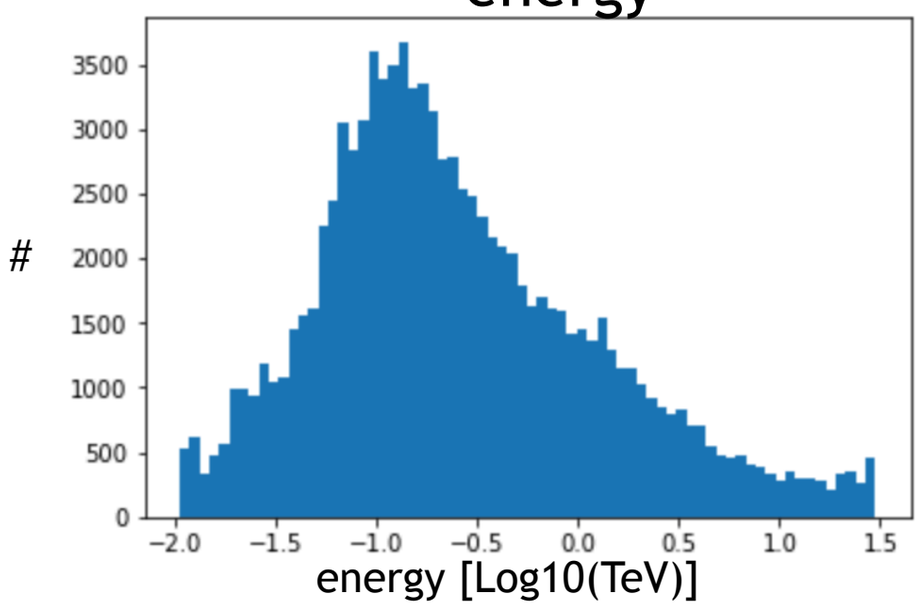


SVD template model: parameters reconstruction

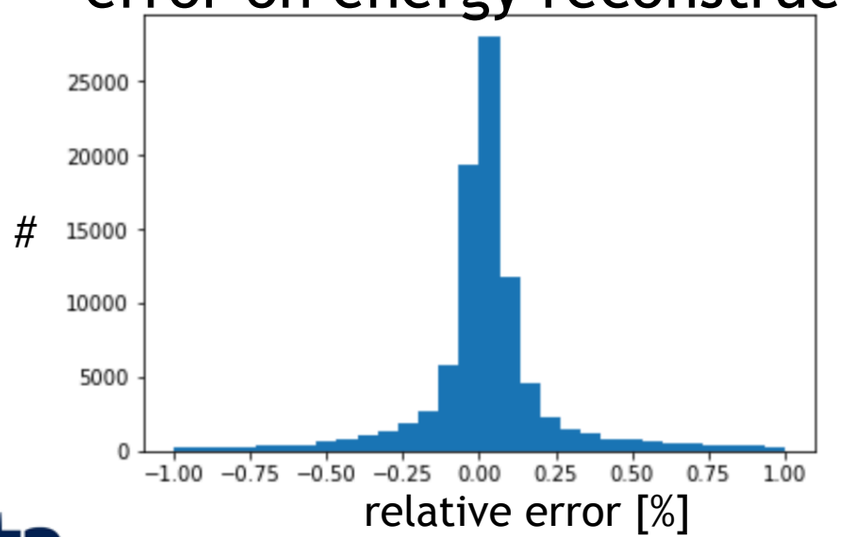
core position



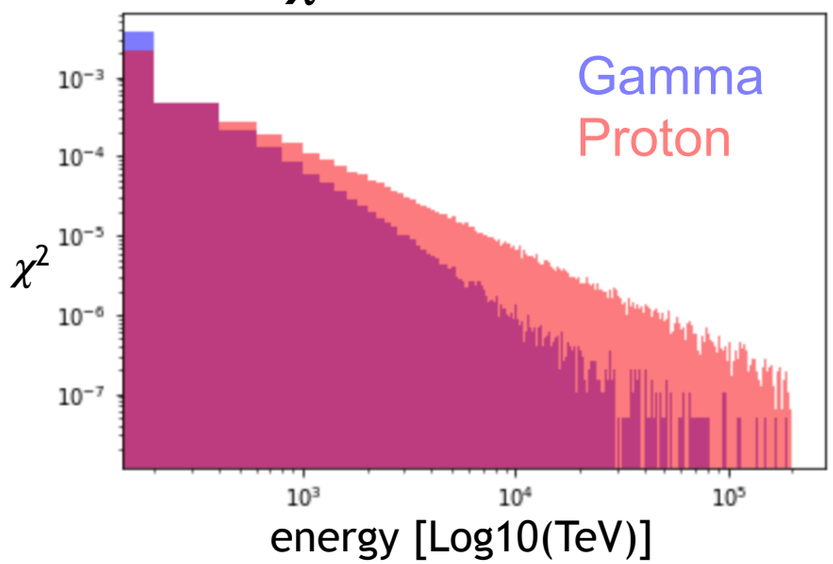
energy



error on energy reconstruction



χ^2 distribution



Conclusion:

- a promising fast template method
- best χ^2 cut removes 70% of protons and 30% of gammas
- error on reconstructed energy: ~15% (30% few months ago)

Ongoing work:

- Number of considerer single values (12 in this case)
- Study of the model parameters