Reconstructing air shower profile parameters

Ruben Bekaert

Vrije Universiteit Brussel

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Gaisser-Hillas Profile

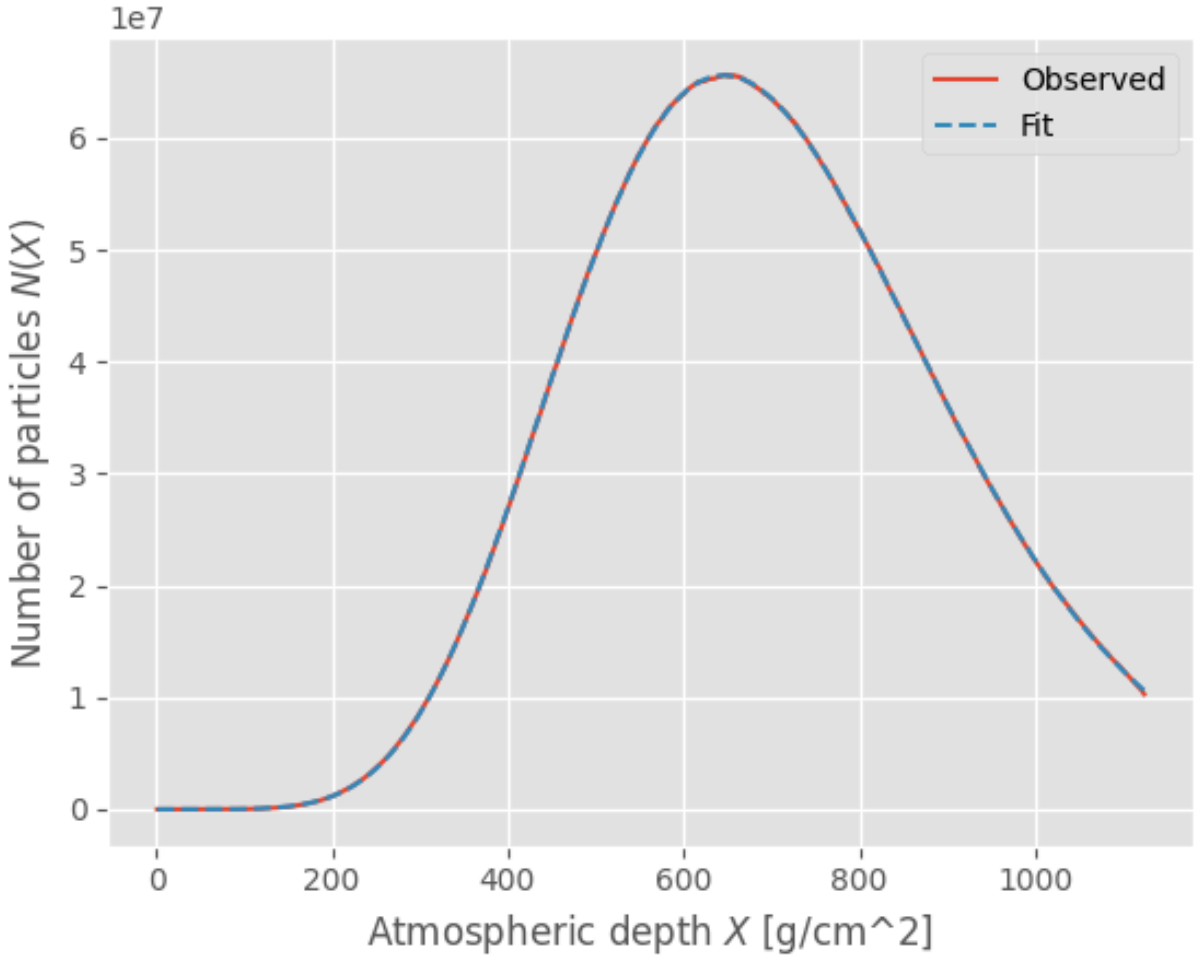
Reduced Gaisser-Hillas longitudinal profile:

$$N(X) = \exp\left(-\frac{X - X_{\max}}{RL}\right) * \left(1 - \frac{R}{L}(X - X_{\max})\right)^{\frac{1}{R^2}}$$

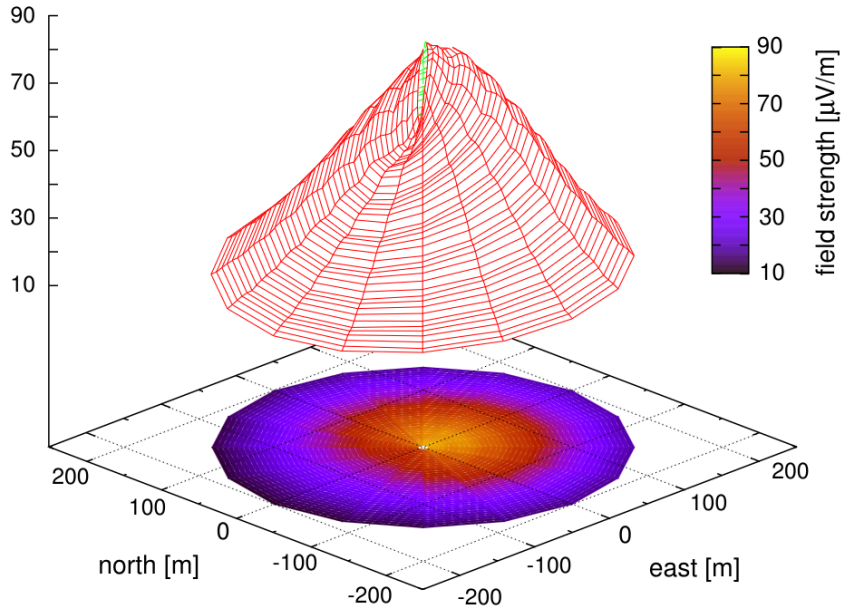
where

- $X_{\max}$ is the atmospheric depth of the peak
- L is a measure of the width of the profile
- R is a measure of the asymmetry (skewness) of the profile

Gaisser-Hillas Profile



Reconstructing from radio



Simulation of the total electric field amplitude in the 40-80 MHz band for a vertical cosmic ray air shower at the site of the LOPES experiment.

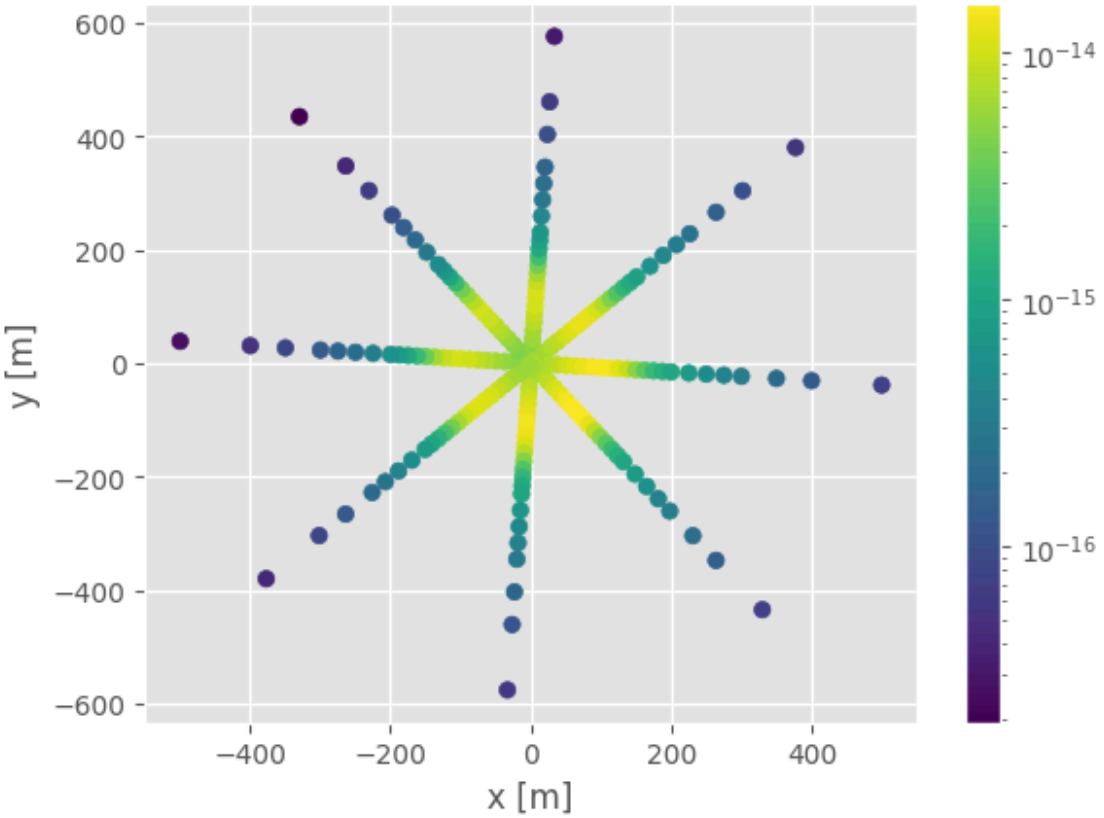
- Run monte carlo simulations to compare LDF with data.
- From those, extract the Gaisser-Hillas parameters.

Using the Mean Square Error (MSE):

$$\mathrm{MSE} = \frac{1}{N}\sum_{i}^{N}(X_i - Y_i)^2$$

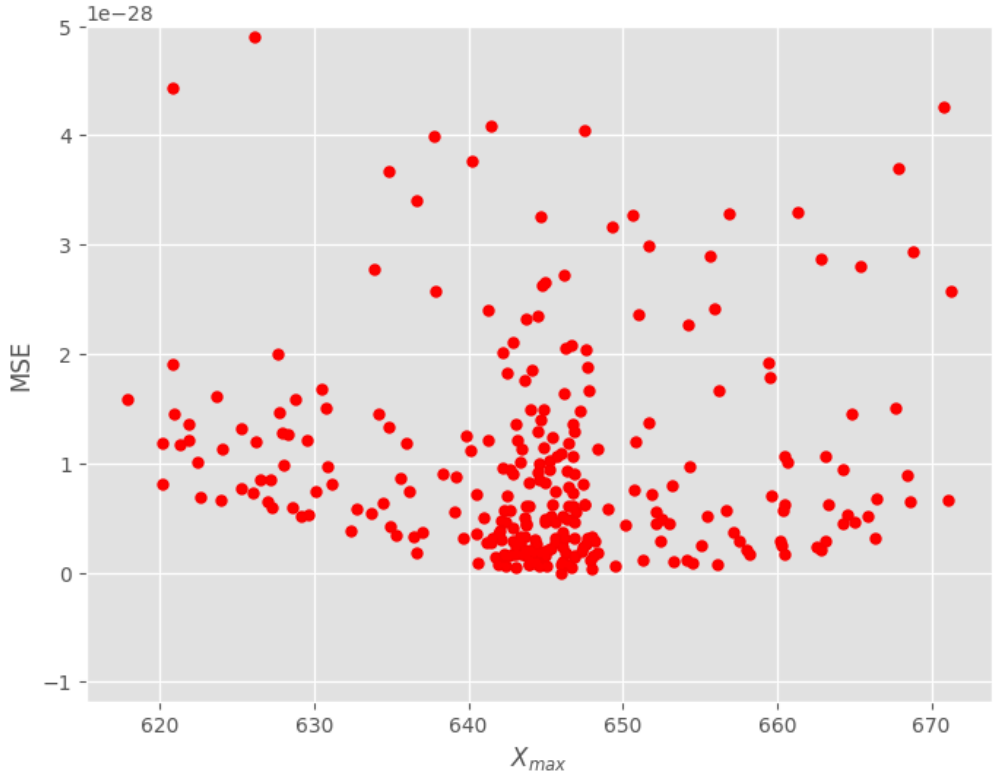
Interpolation

We're using Arthur's interpolation method:



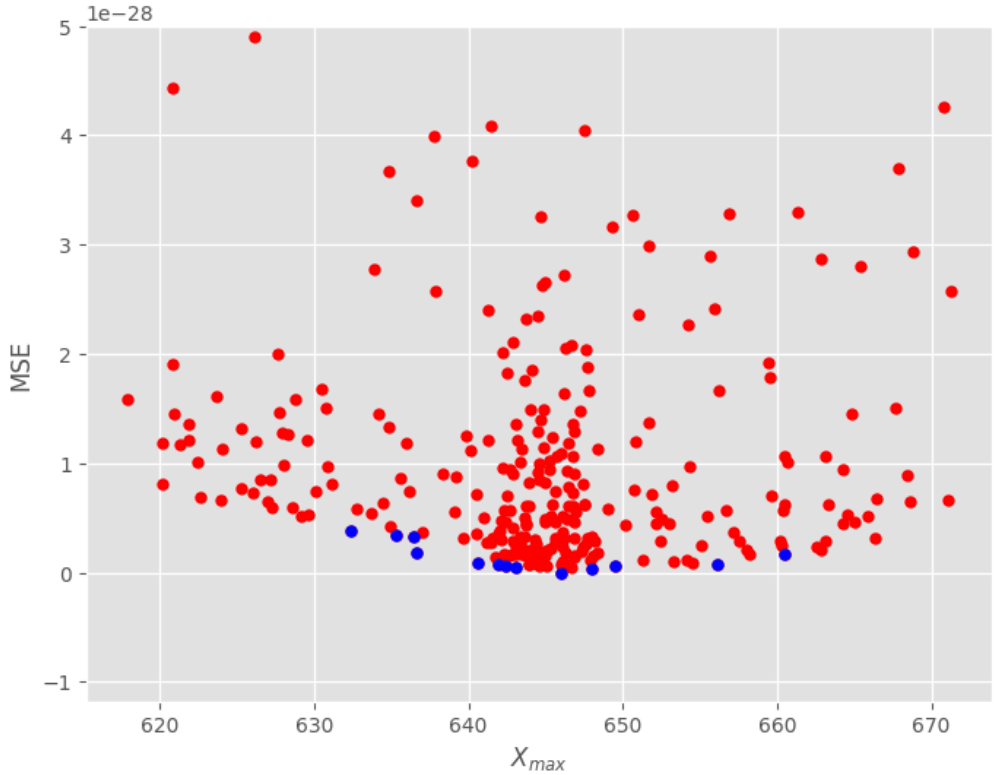
X_max Reconstruction

Plot MSE against X_max:



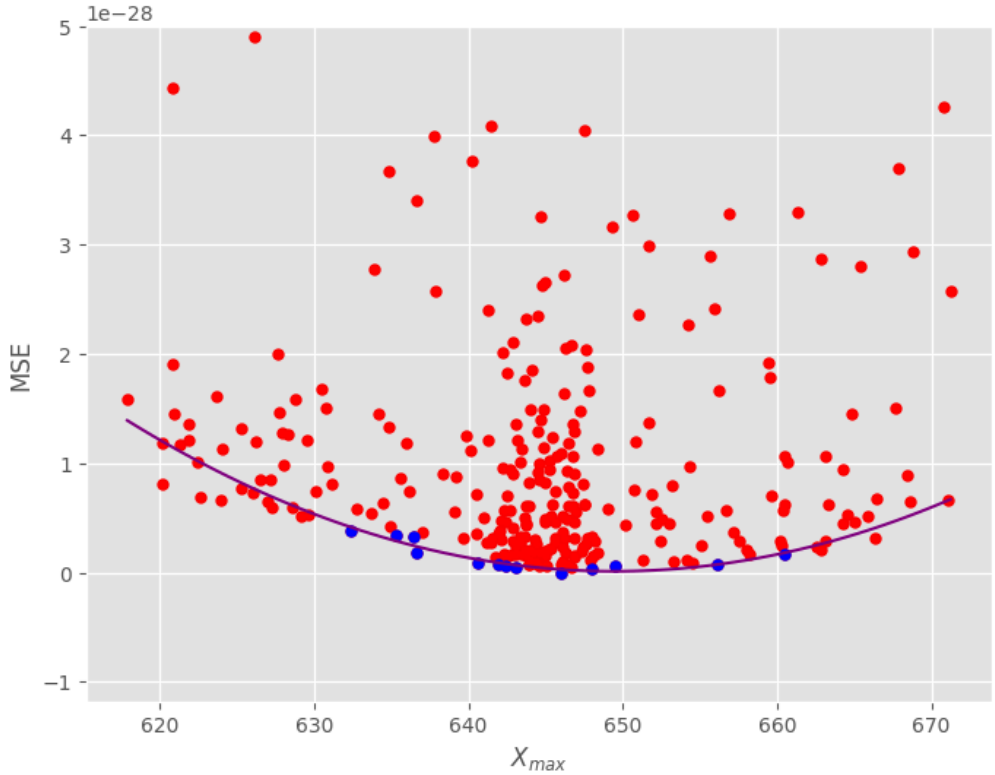
X_max Reconstruction

Find the lower envelope:

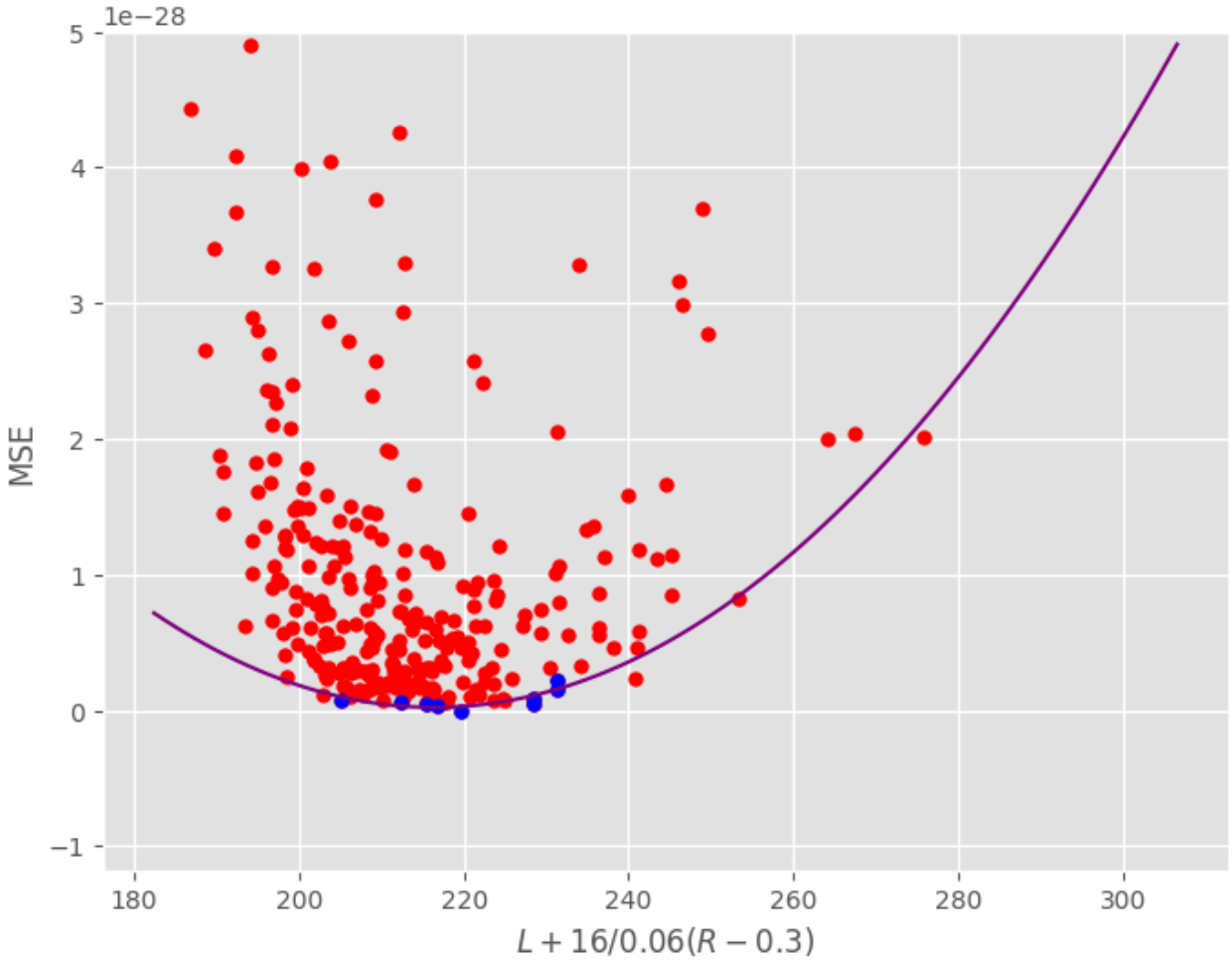


X_max Reconstruction

Fit a parabola to find the minimum:

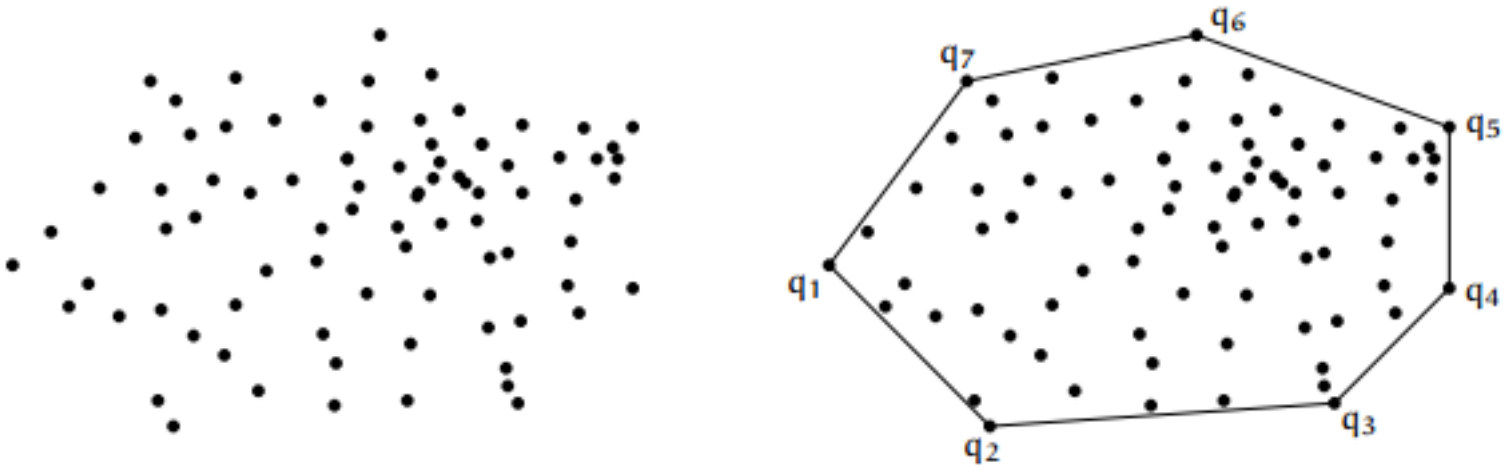


R, L Reconstruction



Generalizing to higher dimension

This can be generalized to higher dimensions by computing the convex hull

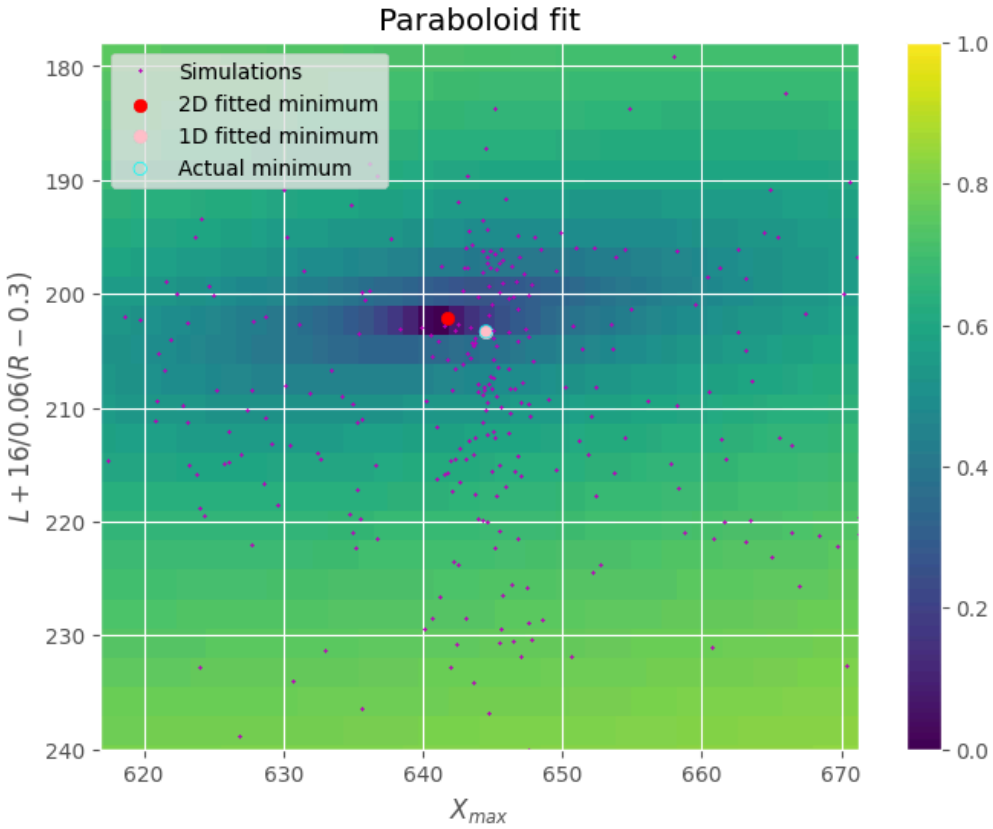


(a) Input. (b) Output.

and finding checking if simplexes are below the center.

Generalizing to higher dimension

We can try to fit both R/L and X_max at the same time:



Next steps

- Add noise, etc.
  - Use better fluence calculation
  - Use χ^2 in stead of MSE
  - Errorbars everywhere!
- Play around with detector layouts
  - Prepare for SKA
  - Study effect of number of antennas
- Study combinations of R, L, X_max (PCA)
  - Try to get the 2D fit to work :(
- Implement in NRR