GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

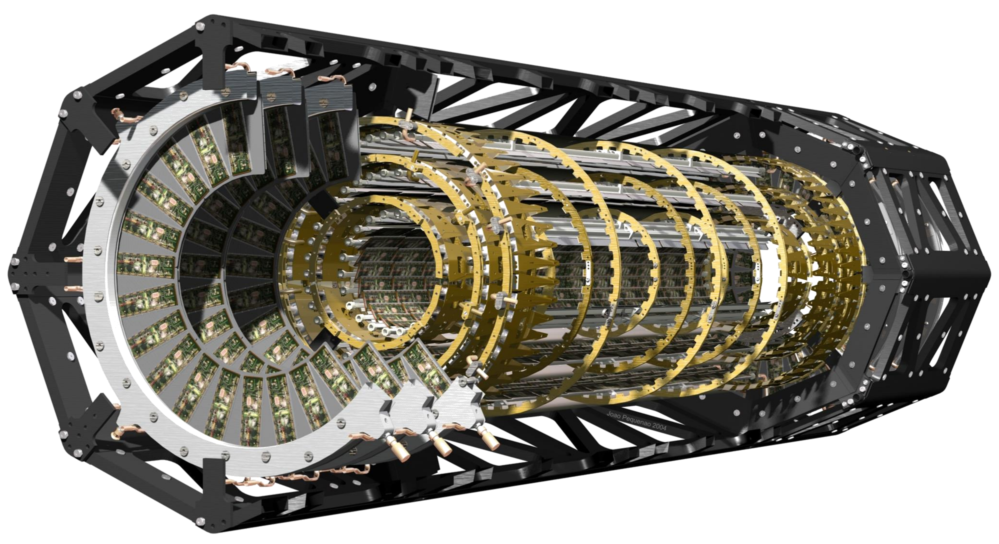
Sommersemester 2017

FORSCHUNGSORIENTIERTES LEHREN UND LERNEN (FOLL)

Calibrating Optical Links of ATLAS Pixel Detector

Research Question

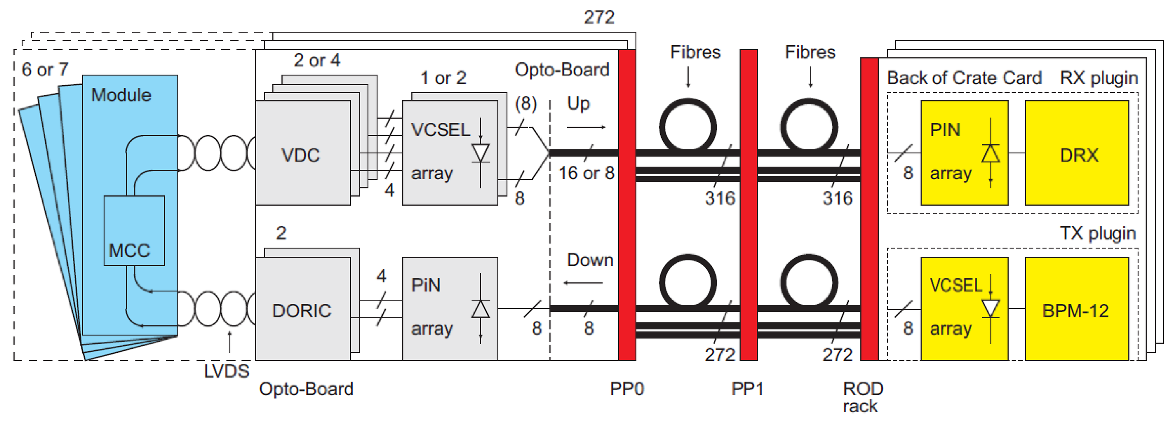
Pixel Detektor



http://atlasexperiment.org/pixel-detector.html

The pixel detector sits at the very core of the ATLAS experiment at CERN closest to the interaction point of the protons. Its roughly 140 million pixels detect the passing through of charged particles across four nested barrel layers. From the position and timing of these events the particles' paths are reconstructed which reveals their charge and momentum.

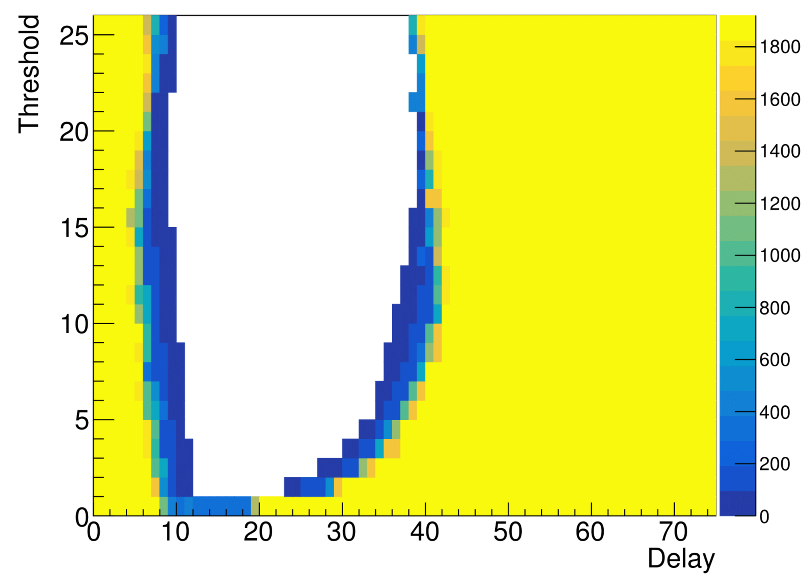
Optical Architecture



G. Aad et al., ATLAS pixel detector electronics and sensors, IOP Publishing Ltd and SISSA, 2008; p. 19

The collected information is sent off the detector through fiber optic cables instead of electrical cables to avoid scattering of particles within the detector. The pixel modules send the bits to the optoboards which perform electrical to optical conversion. Off-detector, the back of crate cards (BOCs) convert back to electrical.

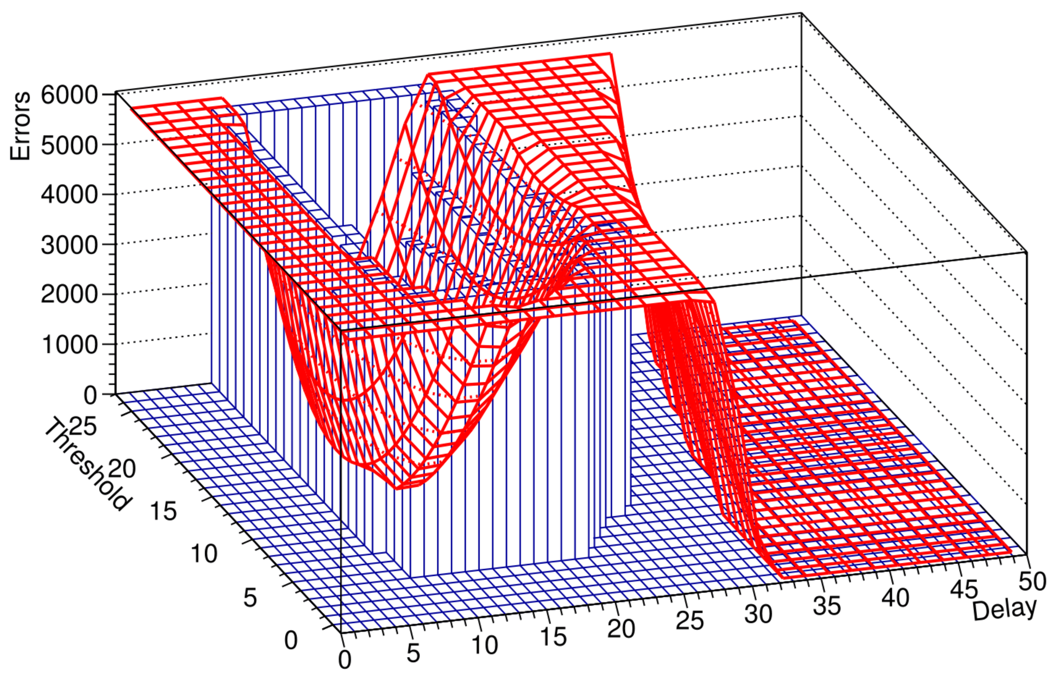
Calibration



The threshold defines the signal intensity necessary for the BOC to register a digital 1. To calibrate the optical links, scans are performed by consecutively setting the delay and threshold for the link to all relevant values and making the modules send a specified digital pattern. From the number of bit errors in the received signal histograms (as seen above) are created.

Our Algorithms

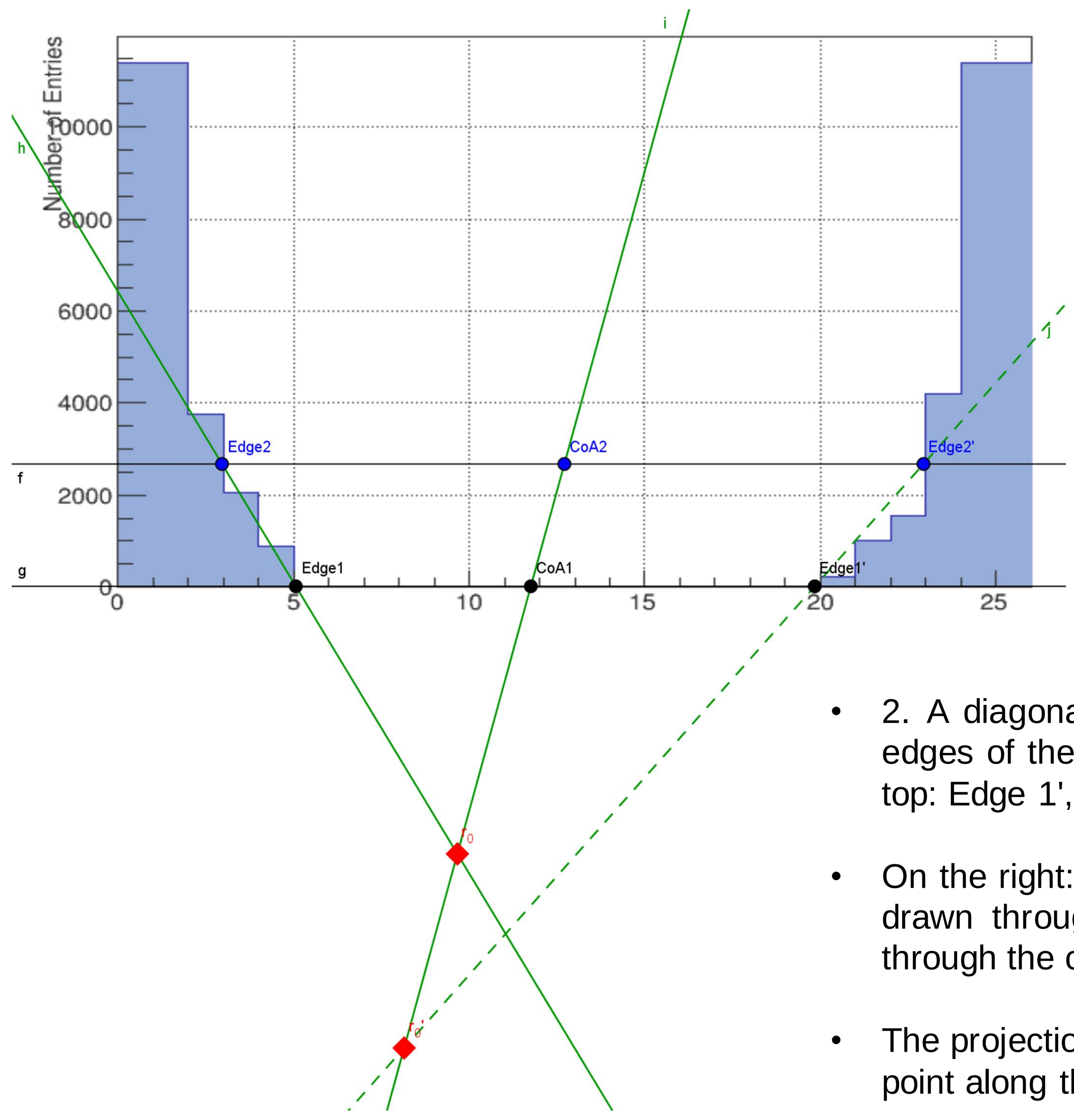
Polynomial Fit Algorithm

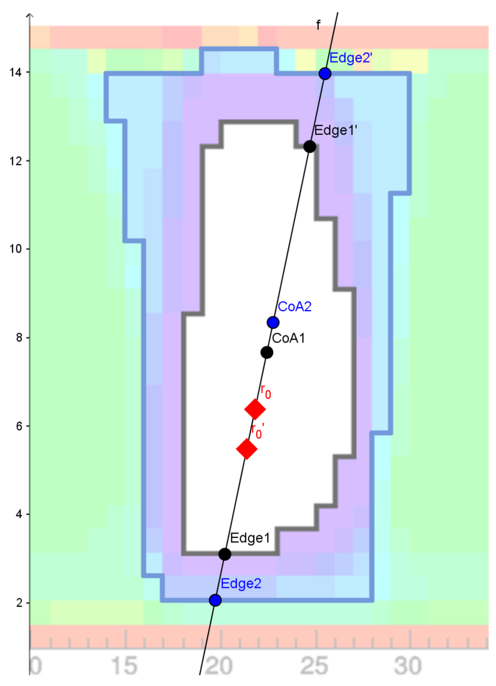


This algorithm tries to exploit that the histogram is assumed to approximate an underlying smooth function. Thus, by fitting a 2D-polymial to the shape of the histogram and numerically calculating its minimum a prediction for the optimal tuning point can be made.

We tried polynomials of degree 2 to 5 and determined that a third degree polynomial presents the best compromise between stability of the fit and accuracy of approximation.

Extrapolating from Slopes



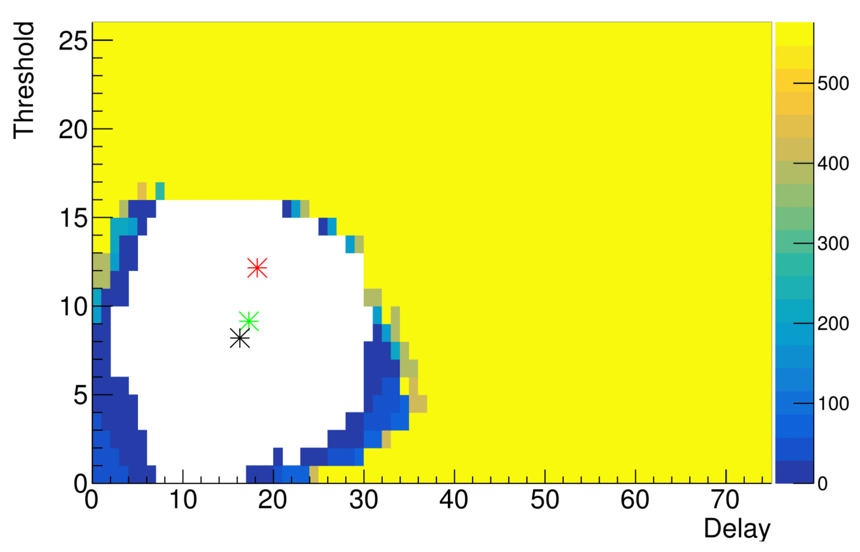


This algorithm uses a geometrical construction to extrapolate the position of the best point from the slopes leading down to the error free region (EFR). It roughly works like this:

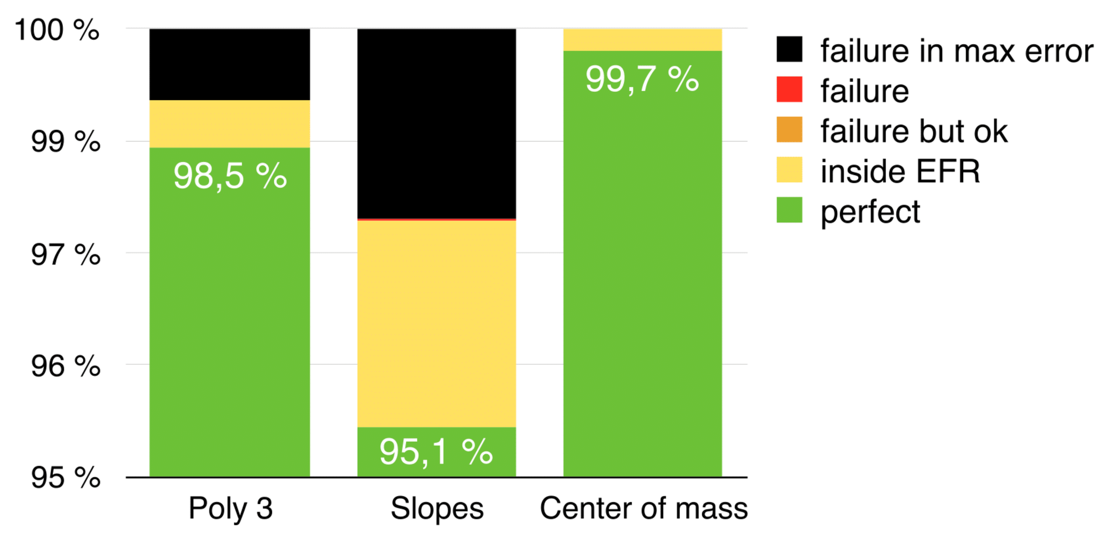
On the left: The centers of mass of the EFR (black border) and of the region with blue border are calculated (CoA1/2).

- 2. A diagonal is drawn through CoA1 and CoA2 and the distances to the edges of the respective error areas are calculated (bottom: Edge 1, Edge 2, top: Edge 1', Edge 2').
- On the right: A cross-section along the diagonal is shown. Straight lines are drawn through the points that approximate the slopes of the edges and through the centers of area.
- The projection of the intersection points on the x-axis constitute the predicted point along the diagonal (r_0 and r_0').

Evaluation of the Algorithms



Example histogram with the found tune points of polynomial fit of third degree (green), "extrapolating from slopes" (red) and center of mass algorithm (black).



Classification of tune points found by the different algorithms ran on all 12202 histograms from the new readout that have error-free settings and on 27429 histograms from the old readout. Please note that the y-axis is set off to ensure good comparability.

According to this evaluation scheme, the center of mass does best, but since it does not take the shape of the region surrounding the EFR into account, the tunepoints are likely not optimal.

The "Slopes" algorithm falls behind in this comparison. Comparing the run time of the algorithms, the "Slopes" algorithm scores better than the polynomial fit but is beaten by the center of mass algorithm. We tried to assess the stability of the algorithms by running them on "worsened" histograms which produced no decisive results.

So far no algorithm can be definitively preferred. For this, long scans with the selected optical parameters will have to be performed.

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