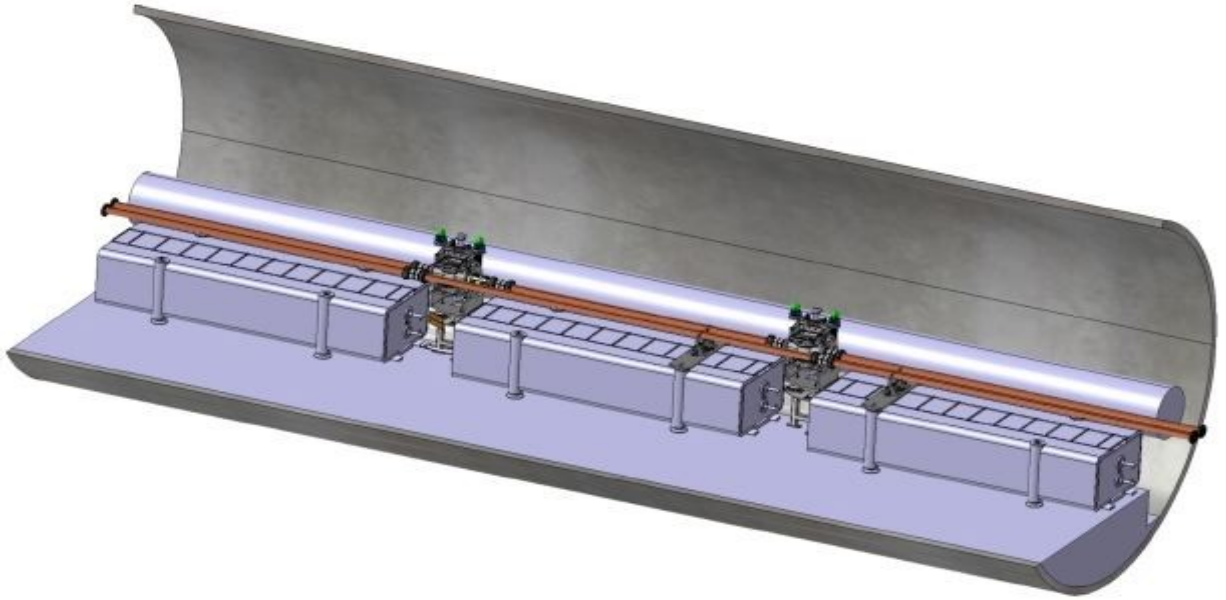
Data analysis and study of the performance of the EUDET beam telescope for the 2009 ALFA test beam



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- EUDET telescope reconstruction software
- Comparison between clustering algorithms
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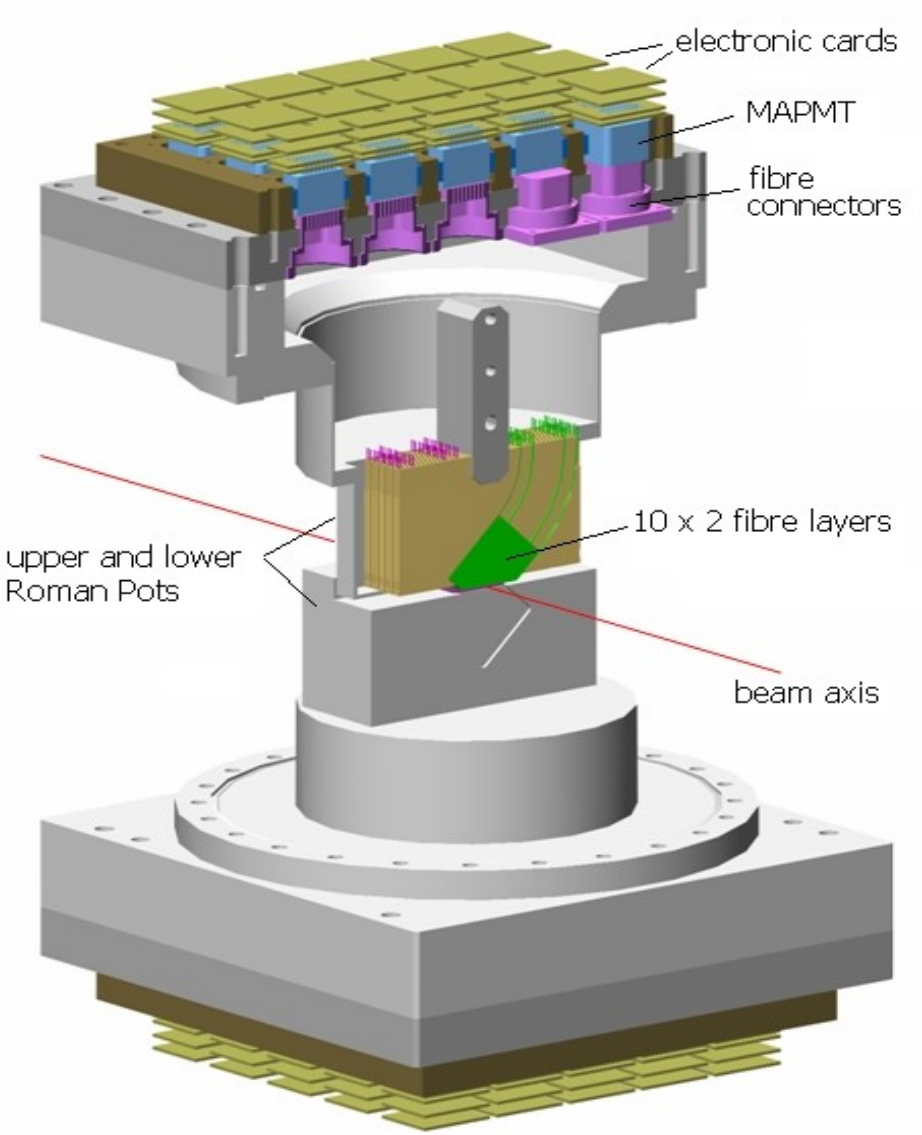
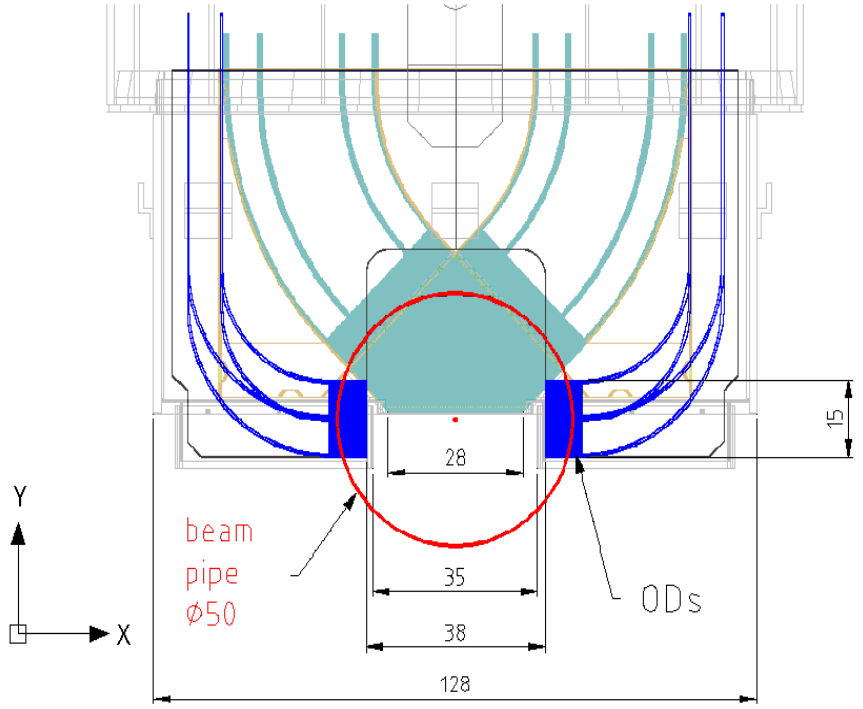
ALFA



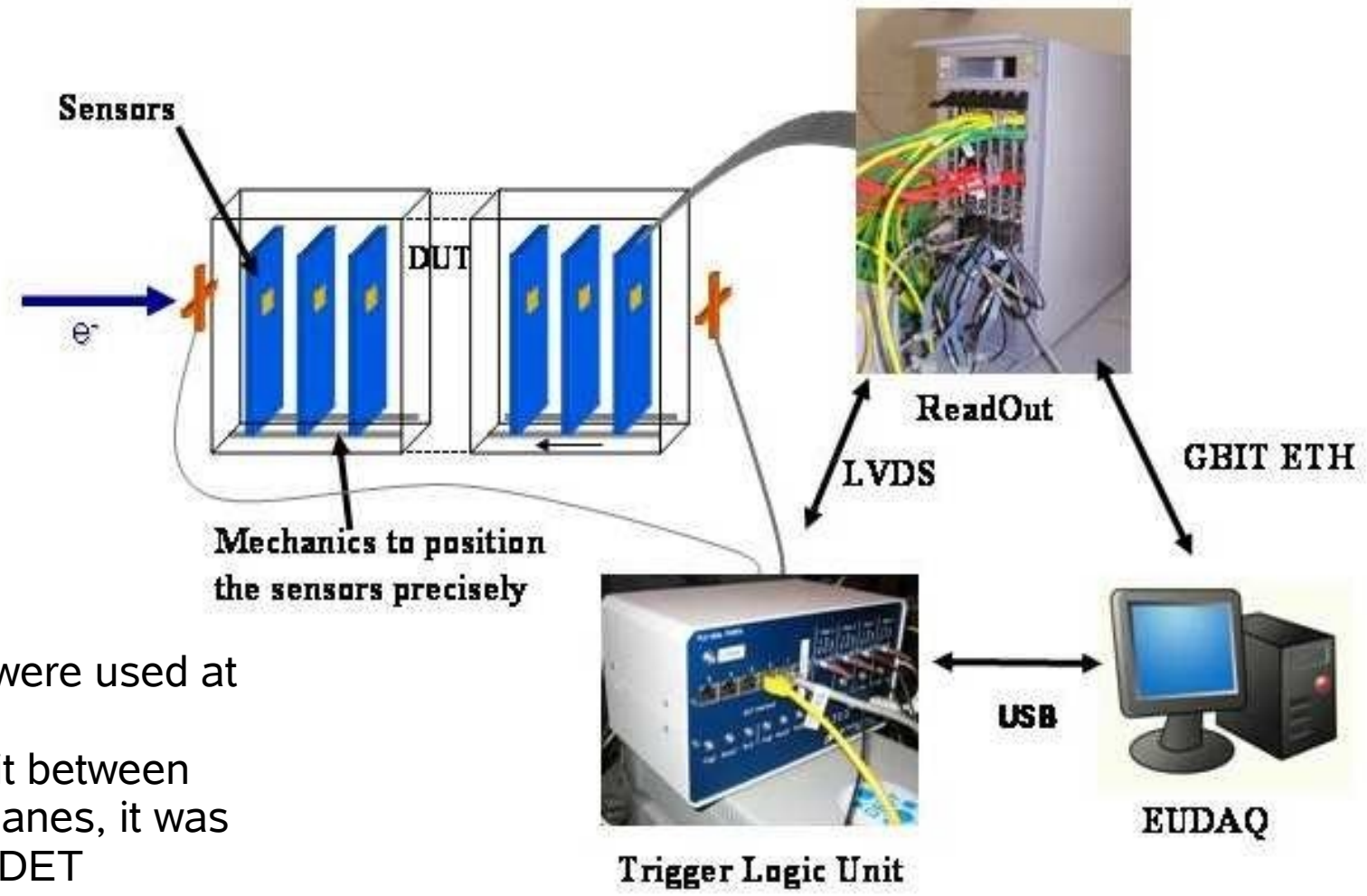
- Absolute Luminosity For ATLAS
- Luminosity precision near 3%
- Calibration of LUCID
- 4 roman pot stations at 240 m from the ATLAS IP
- Scintillating fiber detector in a stereo configuration
- Special beam optics required



EUDET pixel telescope

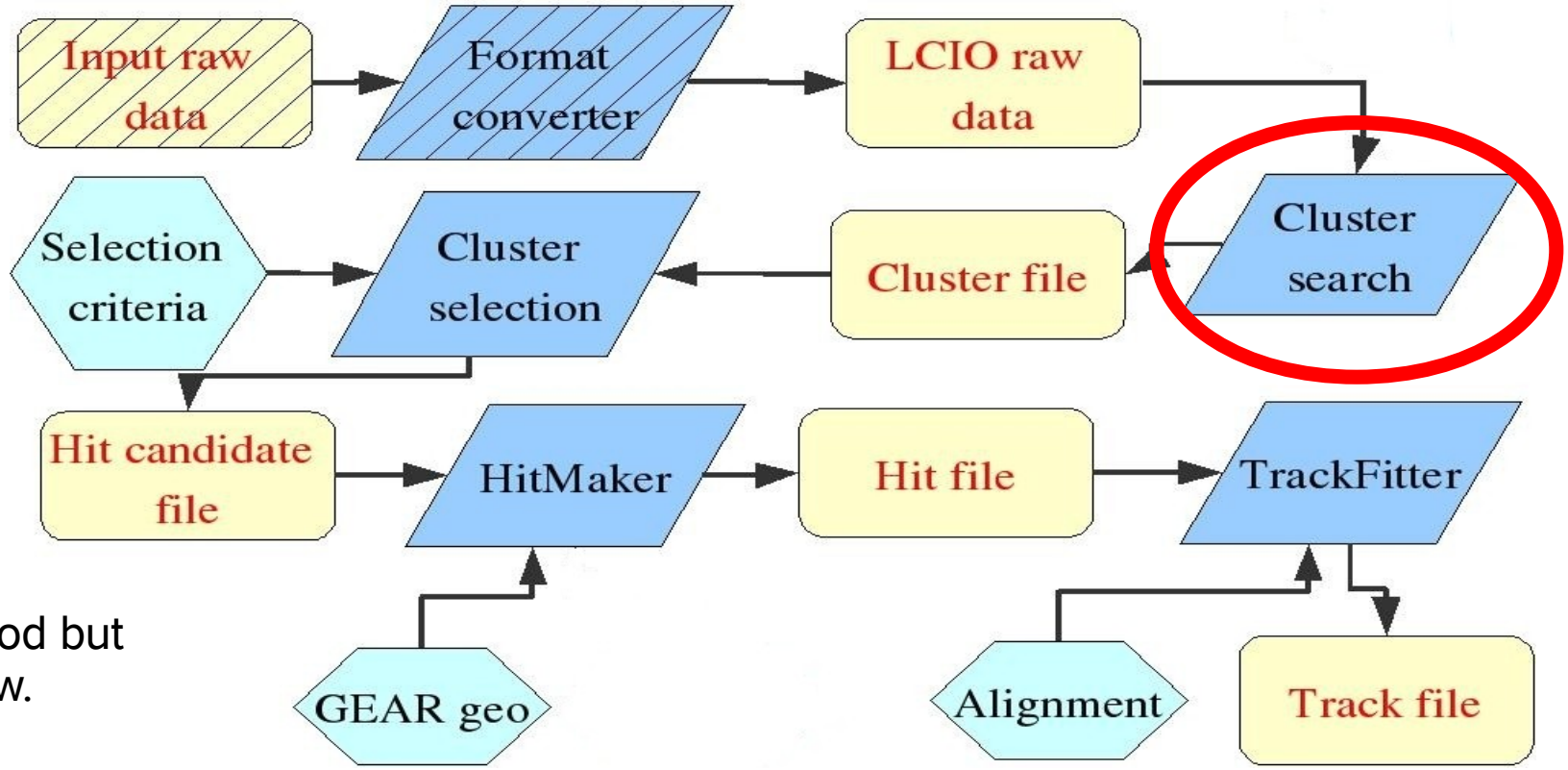
EUDET → Integrated infrastructure initiative for detector R&D

Beam telescope:
- 6 pixel plans
- Pixel pitch 18,4 um
- Resolution better than 5 um
- Digital output



- Only 5 planes were used at the test beam
- ALFA doesn't fit between the telescope planes, it was placed after EUDET

EUTelescope software



It works good but is quite slow.

The slowest processes are clustering and fitting.

Two possible clustering algorithms:

- Digital fixed frame (DF) → slow and accurate
  → Cluster building using a frame that is superimposed to the pixel matrix.
- Sparse cluster 2 (Sp2) → fast, but what about the other features?
  → Cluster building using distance criteria.

We need more speed!

What can we do?

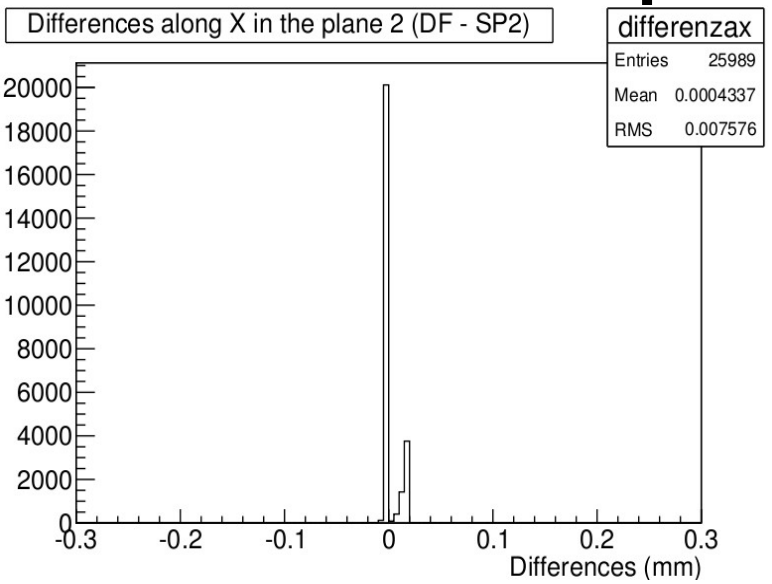
Improvements for the EUDET software are on the way, but ALFA has to wait for the EUDET-people to finish the work.

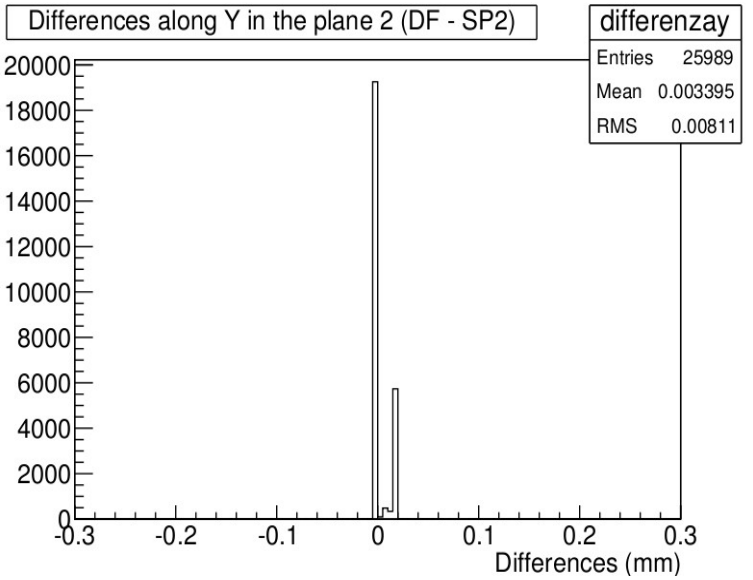
Comparison between the two clustering algorithm:

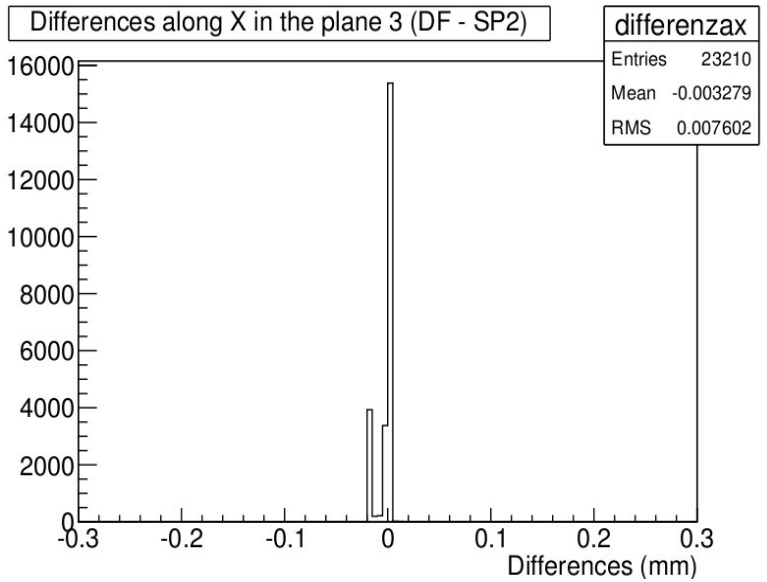
- Consistency
- Execution time
- Precision

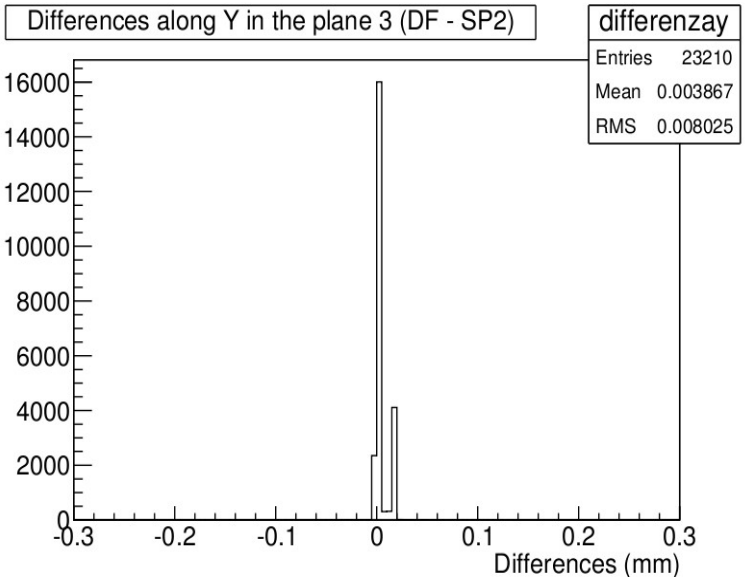
Try to reduce the steps between the raw data and the reconstructed tracks, some of the improvements in the software go in this direction.

Comparison: consistency





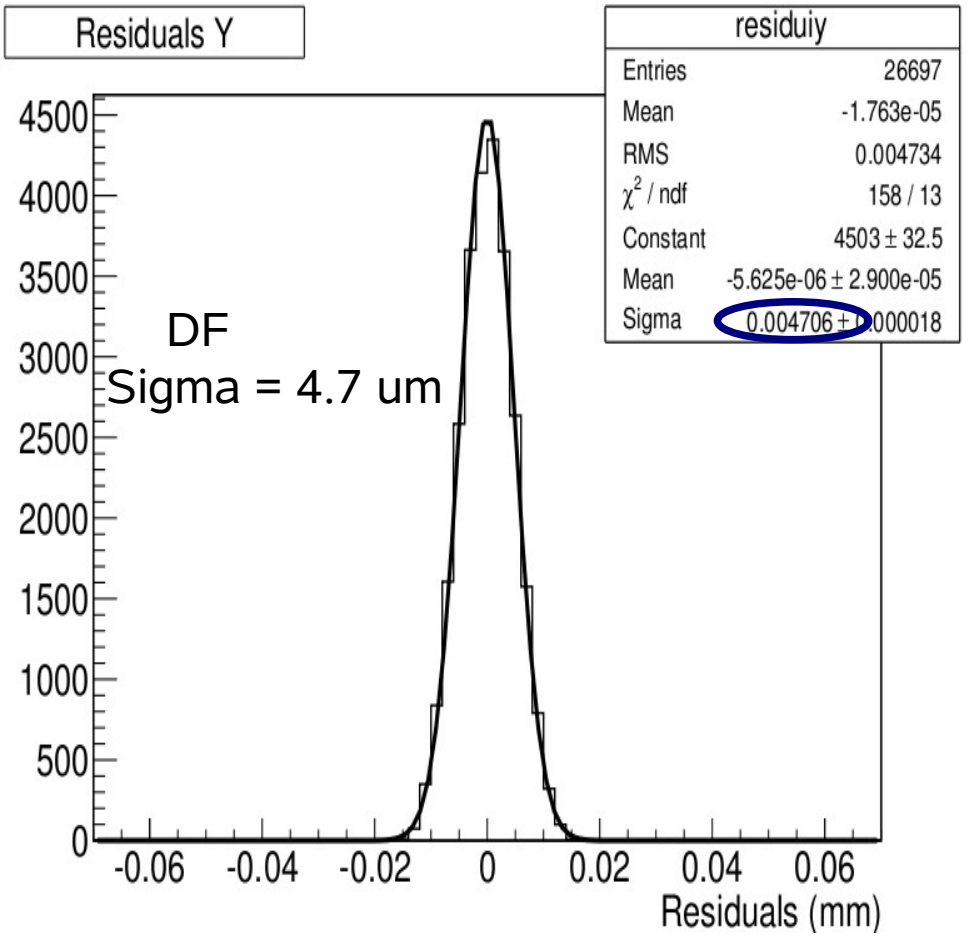


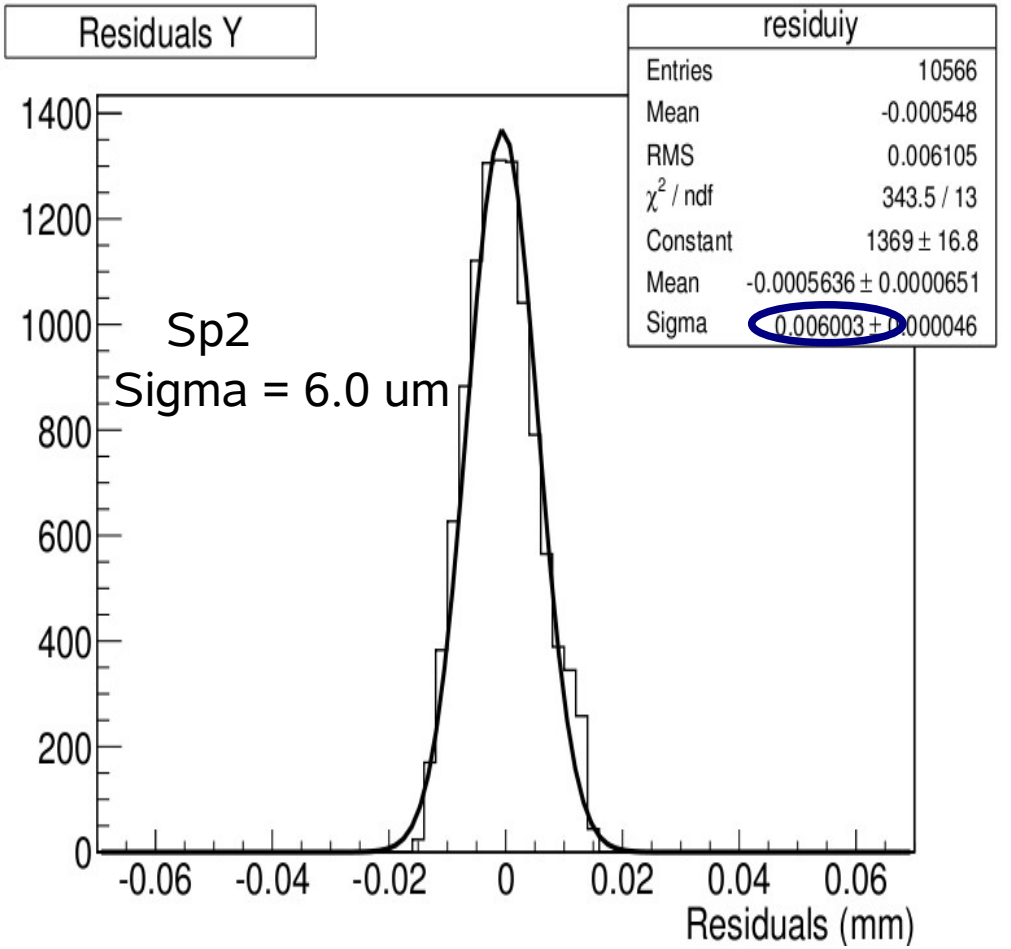


Comparison track by track of the points on the telescope planes 2 and 3.
The tracks are generated using the two algorithms on the same data sample.

The reconstructed tracks are very similar.

Comparison: residuals

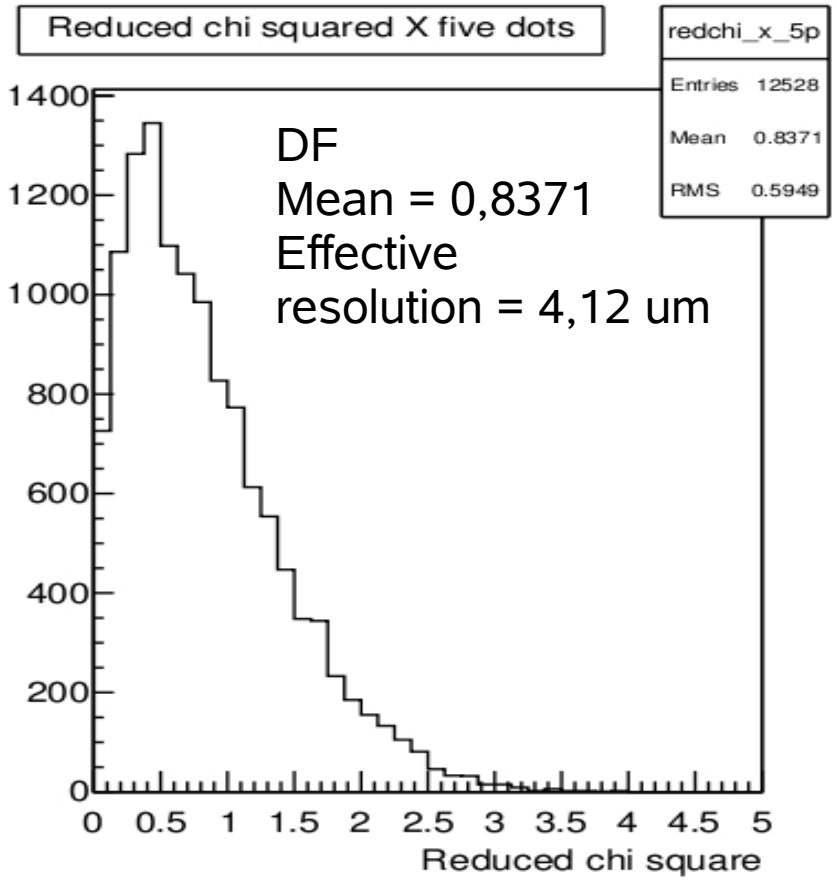


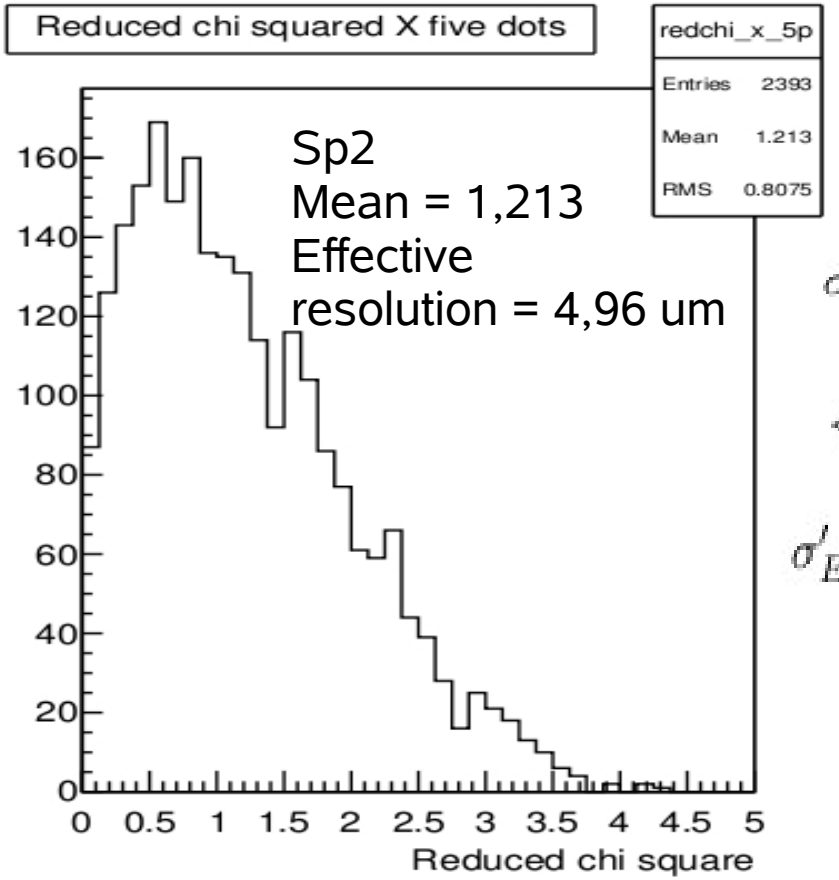


Residual → difference between measured and predicted point

The plane 2 of EUDET has been used as DUT.
The data from this plane aren't used for the track reconstruction.

Comparison: chi square distributions





$$\sigma_{EU} = 4.5\mu m$$

$$< \frac{\chi^2}{ndf} >= M$$

$$\sigma'_{EU} = \sqrt{M} \cdot \sigma_{EU}$$

Tracks that have signal in all the layers, same results for the other tracks

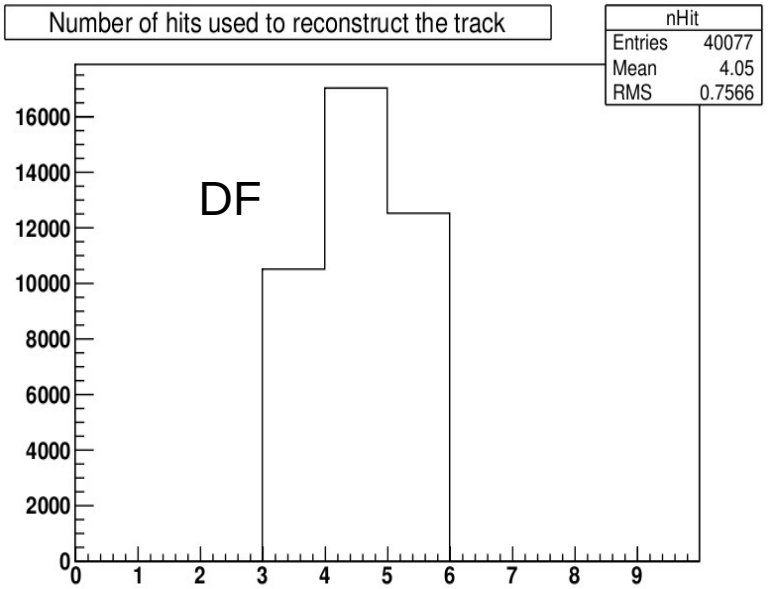
The effective resolution is different from the intrinsic resolution of the detector.
Software introduces some bias.

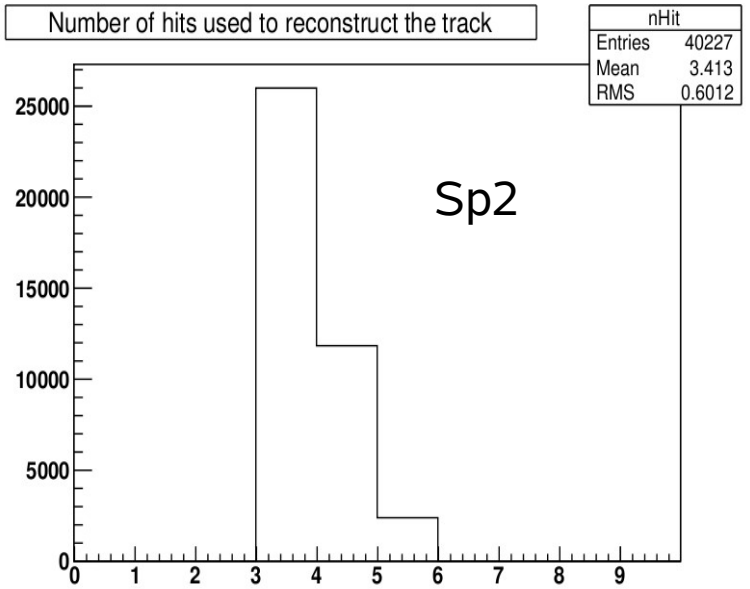
Comparison: other features

Efficency	
DF	94.1%
Sp2	94.0%

Clusters found					
Layer	0	1	2	3	4
DF	82206	110351	163928	143849	145864
Sp2	144157	173566	243518	212444	216296

Clustering speed ratio
Sp2/DF = 3.07





All these quantities came from the same data sample.

Linear combination I

ALFA-EUDET telescope alignment:
using the extrapolated hits positions an alignment is performed considering a shift and a rotation of ALFA in the plane perpendicular to the beam axis.

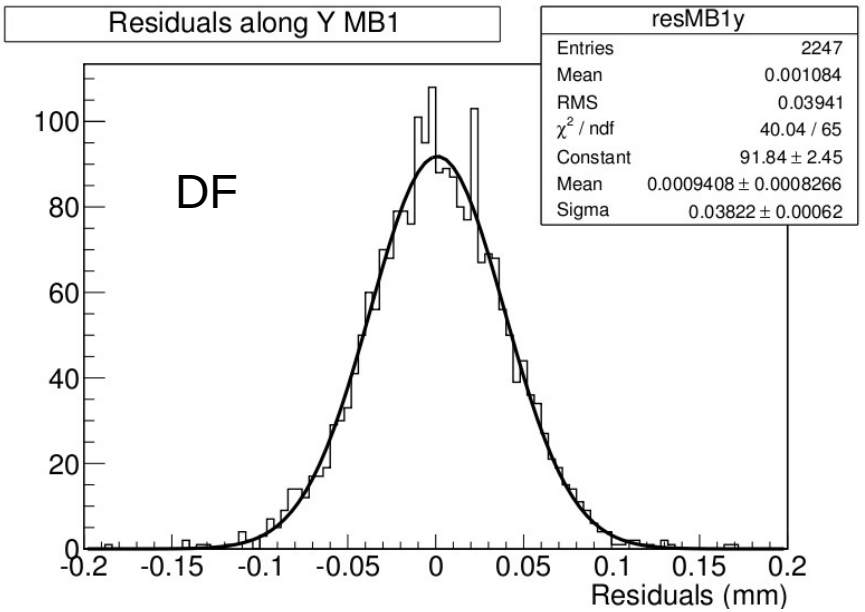
$$X_{ALFA} = c + \sum_{i=0}^{4} (a_i x_i + b_i y_i)$$

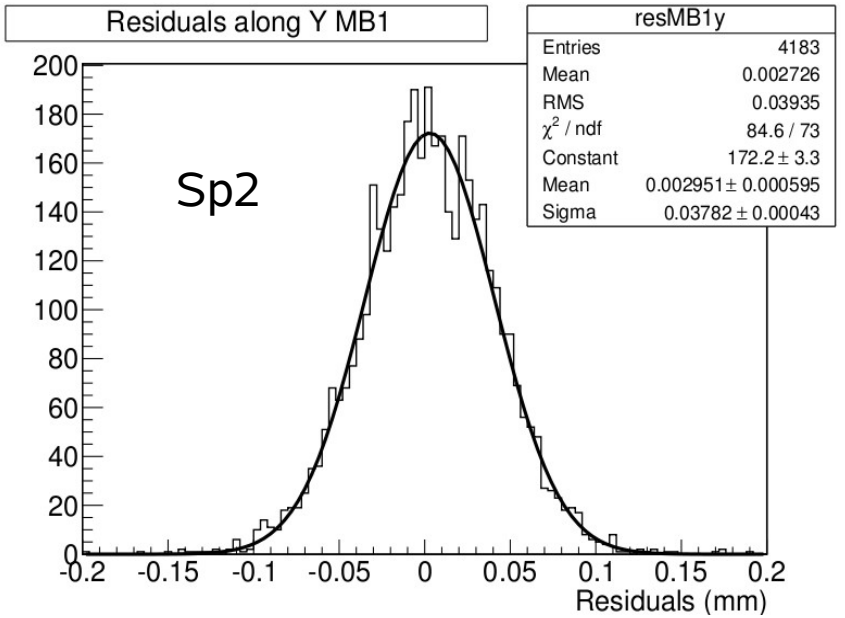
$$Y_{ALFA} = f + \sum_{i=0}^{4} (d_i x_i + e_i y_i)$$

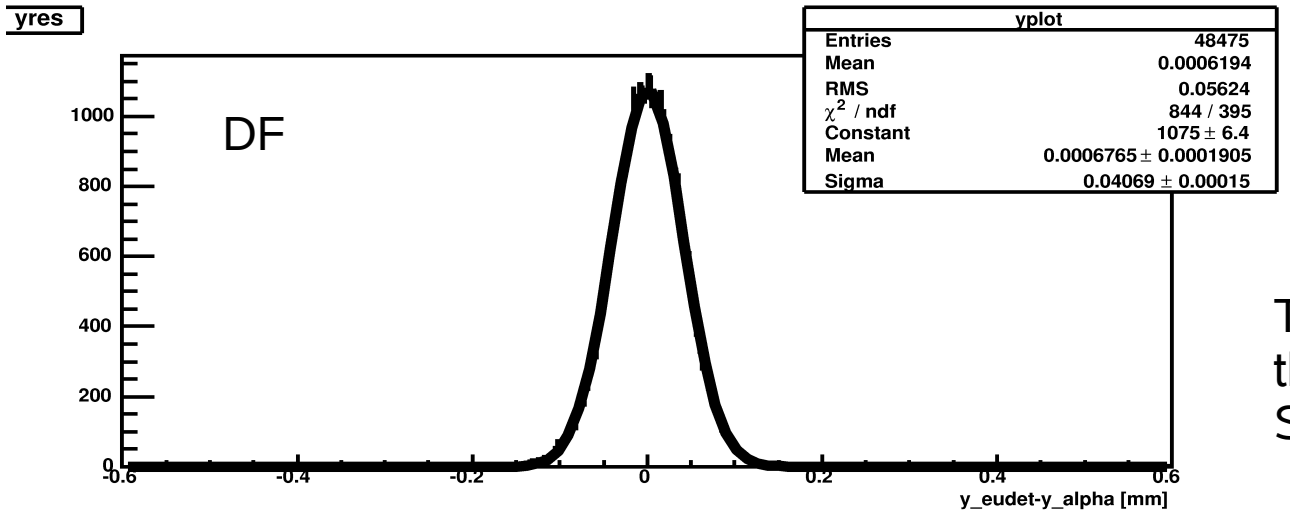
It is possible to express the hits on ALFA as a linear combination of all the measure in the EUDET planes.
In this way all the information we have is included in the prediction.

This method can provide at the same time both the EUDET internal alignment and the ALFA-EUDET telescope alignment.
All the degrees of freedom are considered.

Linear combination II



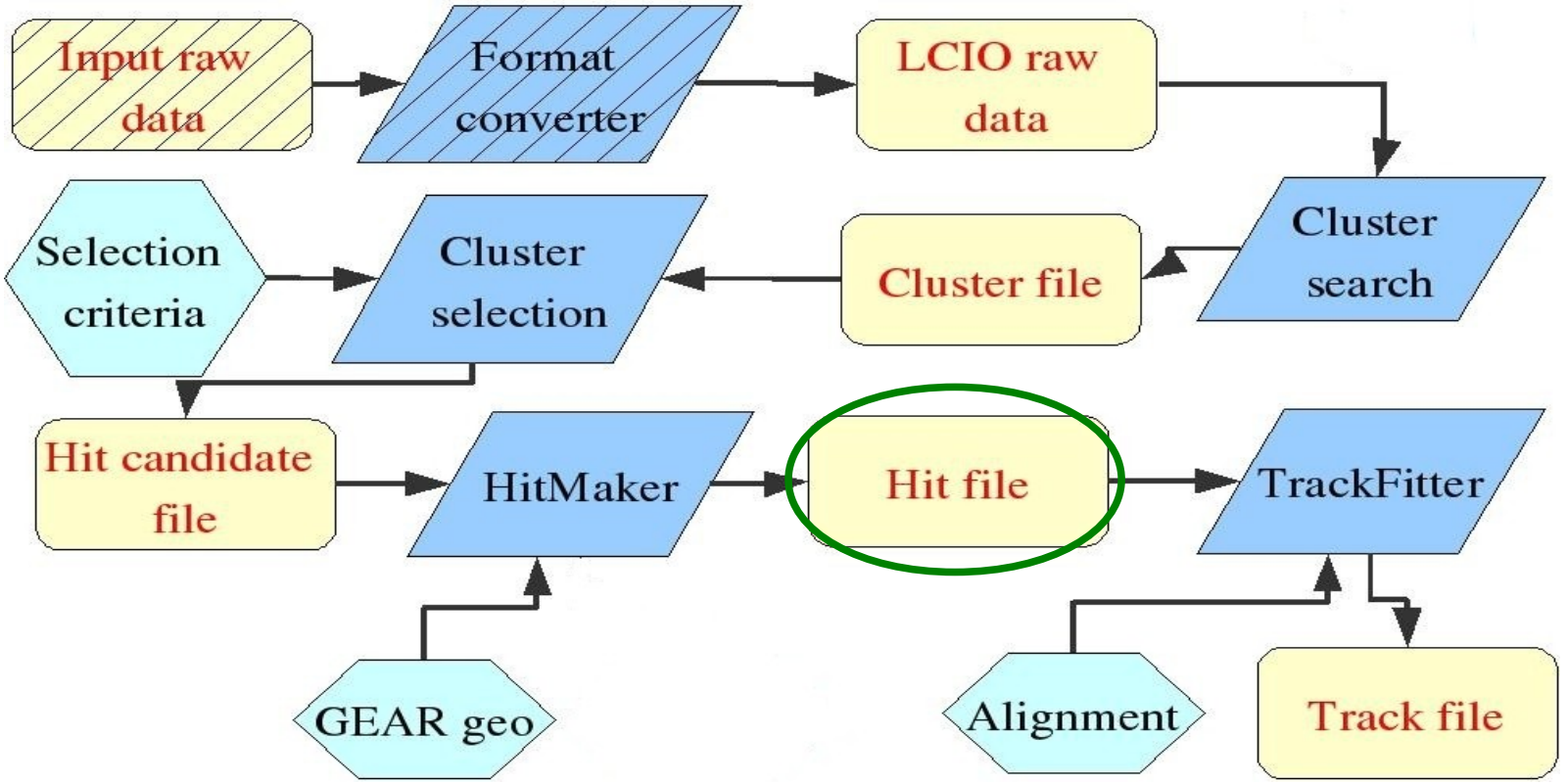




Here the sigma of the distributions is large because of the ALFA precision (>30 um).

There are some bias induced by the data sample.
Same run but different cuts.

Linear combination III



It could be possible to skip the fitter and alignment procedures for some fast controls during the data taking.

Conclusions

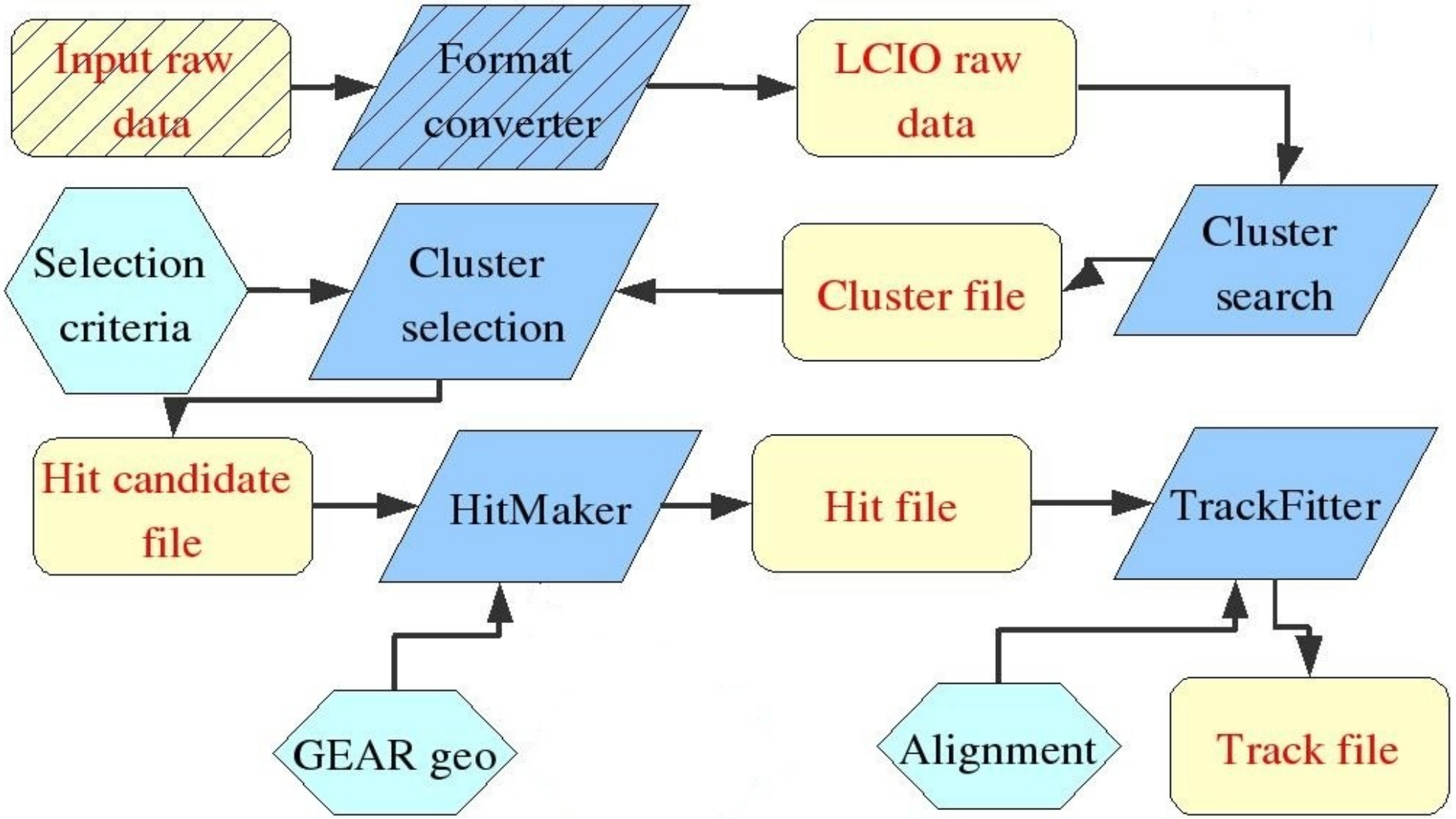
- The DF is more precise than the Sp2
- The Sp2 is about 3 times faster than the DF

In the ongoing test beam, the Sp2 method is used for online control plots during the data taking, while the DF will be used for the offline reconstruction of the tracks after the testbeam.

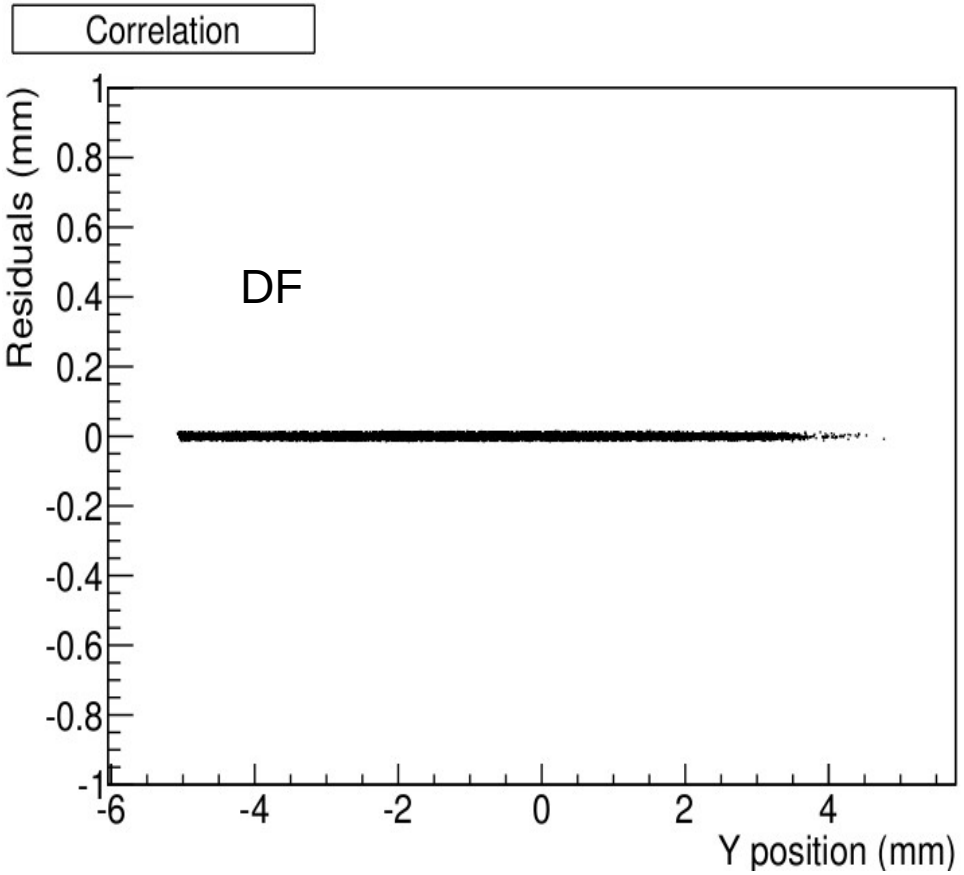
- The linear combination could permit some fast data controls.

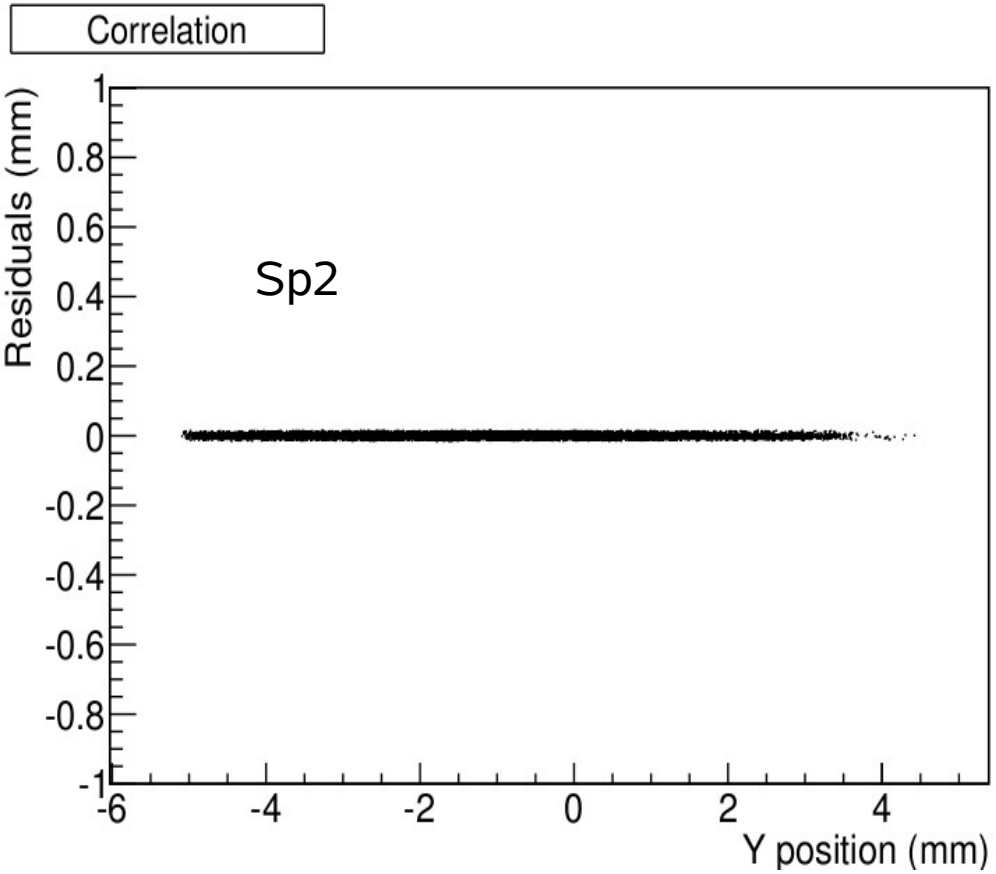
We need more information after the hit maker.

Reconstruction chain



Correlation





Value of the residuals as a function of the measured position on the sensors

No correlation.