Track Reconstruction with ATLAS Upgrade Prototypes using the General Broken Lines Algorithm within EUTelescope

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Abstract

The General Broken Lines (GBL) algorithm has been successfully integrated into the EUTelescope framework. This is designed to be a generic fitter for many different testbeam setups. Many datasets have been successfully reconstructed and all examples can be found installed with EUTelescope by default. A subset of these are ATLAS upgrade inner tracker prototypes. These prototypes are a variety of strip and pixel sensors which have been tested at the DESY/SLAC testbeam.

Background

EUTelescope, GBL and Alignment with Millepede

EUTelescope is a highly generic testbeam reconstruction and analysis framework[3]. Track reconstruction begins at pattern recognition and then using five step reconstructs the tracks and adds the information needed to align the detector planes. Pattern recognition is needed to identify the hits which make up a track. Two different forms of pattern recognition exist for use with GBL

- **Clustering** Propagate all hits to the first plane and cluster.
- **Triplets** Associate two hits together to form doublet track and three to form triplet. Continue association to create final track.

The GBL track fitting and alignment comes in five steps:

- Link GBL points together to form a complete track described by discrete points. Figure 1 shows the linking of GBL points together using the initial trajectory parametrized.
- Points which correspond to hits have measurements added with errors. The red points on the green planes of figure 1 correspond to measurements.
- Points which model scattering have kink angles and errors added. The orange points on figure 1 show these points. These points allow a kink to be formed relative to the track incidence at that point.
- Global derivatives which relate motions of the sensors with local frame residuals are added for alignment.
- Local derivatives are added to determine parameters which relate to the track's residual on certain planes. Useful for kink angle estimations.

This information is needed for all track fitting and alignment, apart from the local derivatives.

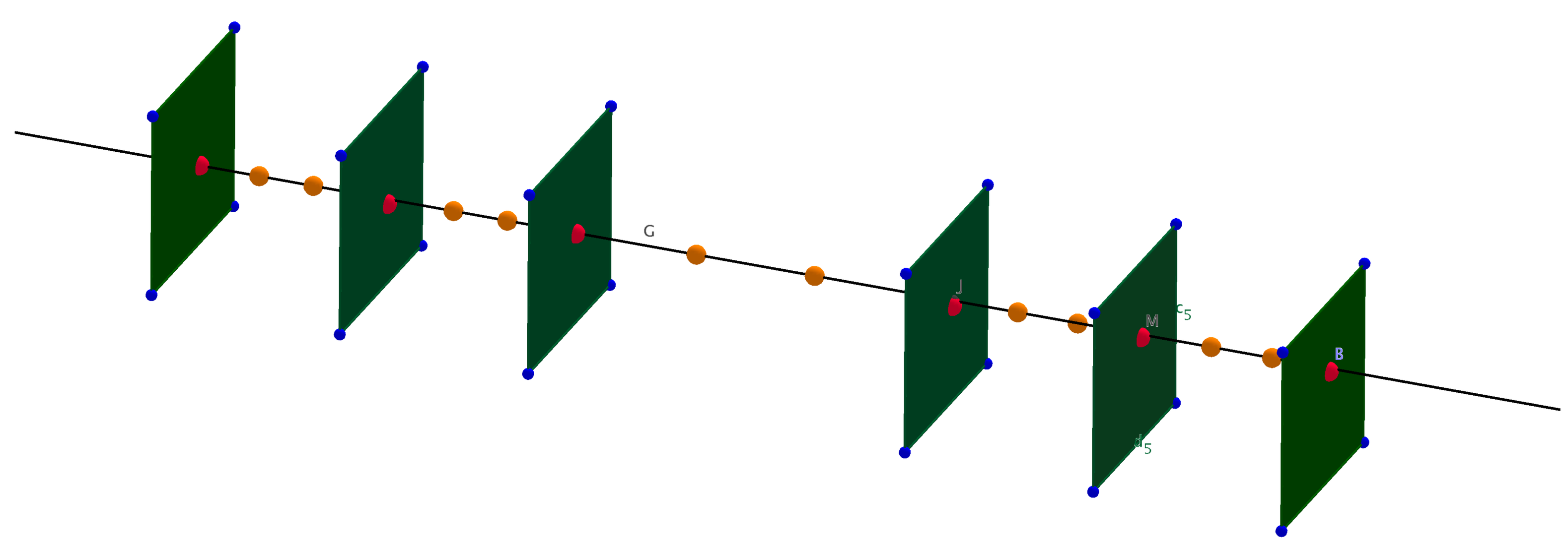

Figure 1: A simple illustration of the linking of discrete points to form a continuous track. The green planes correspond to the mimosa sensors used to reconstruct the track onto devices of interest. Any number of additional planes can be added to this setup. The full track does not have to be considered but only the locations with measurements and scattering. The red points are measurement/scattering locations, the orange are only scattering. All the points are linked together by Jacobians which are determined from the initial trajectory. The location of the points are not correct in the diagram and depends on the material distribution for each setup.

ATLAS Pixels

One example of the various ATLAS pixels sensors reconstructed is the Quad module. The Quad module is a large area sensor that is compatible with the geometry of the outer barrel layers and forward disks of the upgraded pixel tracker. It is readout with 4 FEI4 chips of 50x250 μm^2 pixel size[1]. The space inbetween the 4 FEI4s is bridged with ganged pixels.

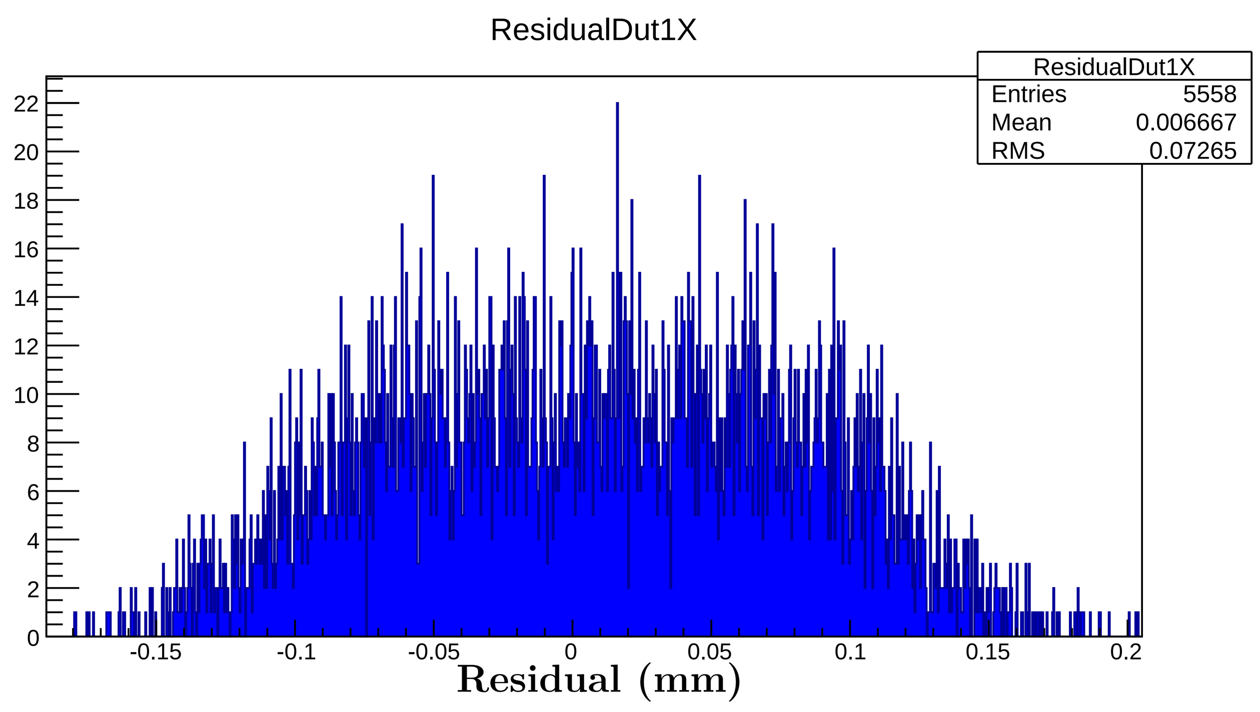

Figure 2: Quad module local X axis residual for DESY 4 GeV beam. RMS is comparable with the expected 250 μm pitch assuming a uniform distribution of predicted hits on each pixel.

ATLAS strips

The ATLAS12 sensor is a n$^+$-in-p strip device of pitch 70 μm[2].

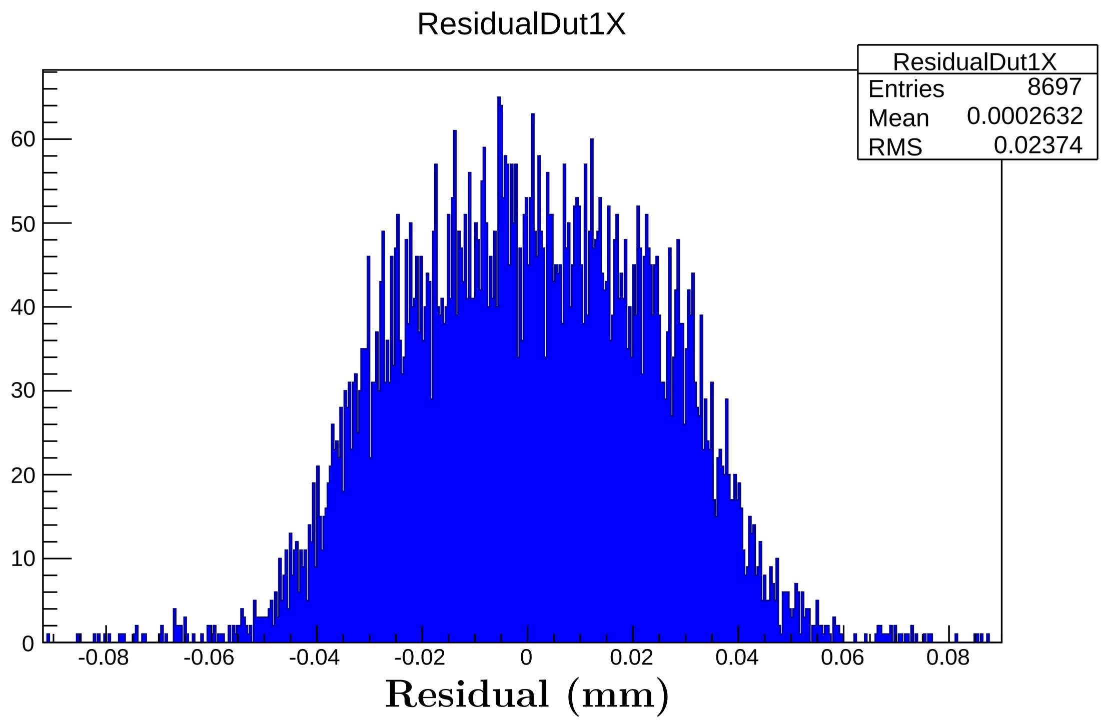

Figure 3: This dataset was taken at DESY with beam energy 4.4 GeV. The residual is along the X axis in the local frame. The local frame is the one with the X axis perpendicular to strips. This sensor has not undergone full body alignment due to large correlations in the rotations round the X/Y axis and Z shifts. This is due to the large offsets of the hit strips in the local frame. The beam divergence of the DESY beam is approximately 1.5 μRad, therefore these rotations are weak modes relative to the tracks fit characterized by the chi2 test statistic .

Additional Features

This track fitting procedure has been used for many different purposes. Some are complete and others are in development. In all cases examples from the raw data to the final reconstructed tracks are available as part of the EUTelescope examples.

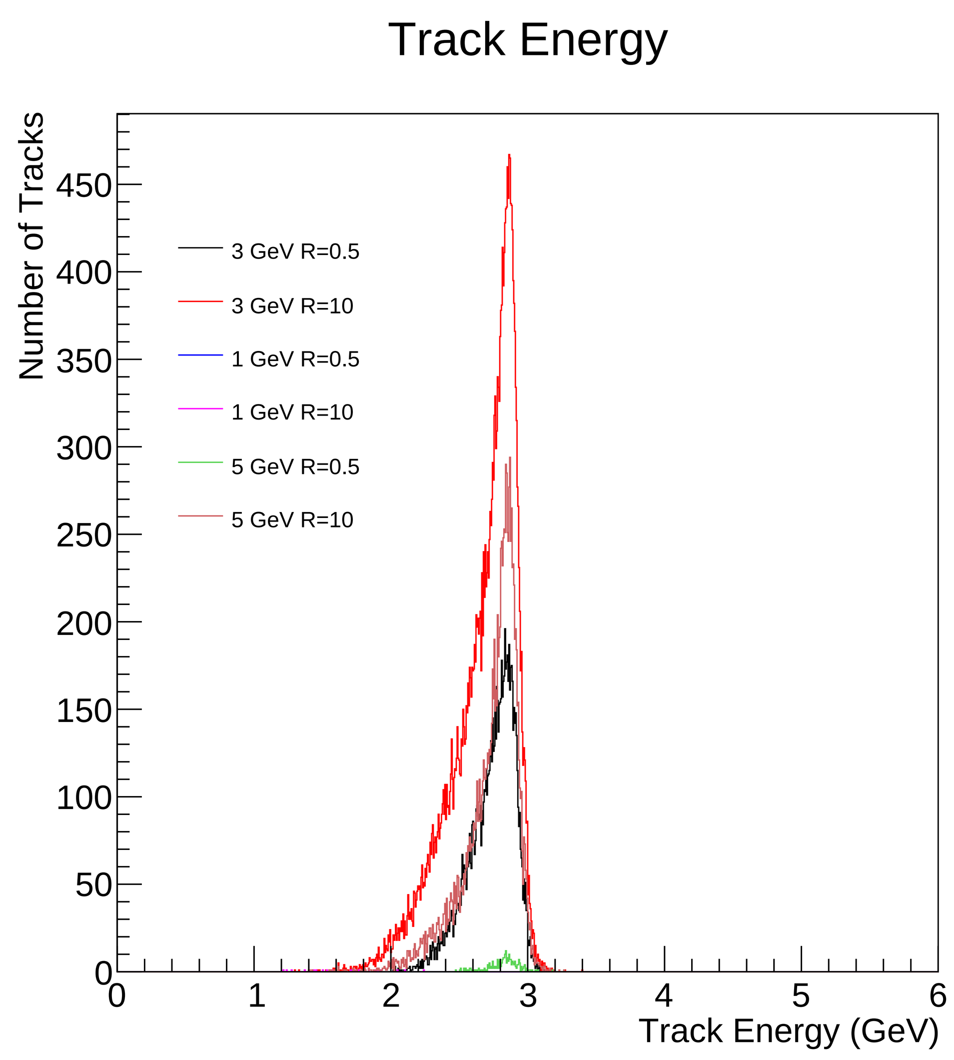

Figure 4: Measurement of beam energy using the curvature of the beam with 1T magnetic field. The clustering pattern recognition was used to find tracks to be fitted. The R parameter is the clustering window in which hits will be assumed to form a track if within this window. The beam energy is the pattern recognition assumption during clustering. No bias was found between pattern recognition settings and the final measured beam energy.

References

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