

Luminosity measurements using the ATLAS Forward Proton (AFP) detector



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V4-HEP

13/03/2024



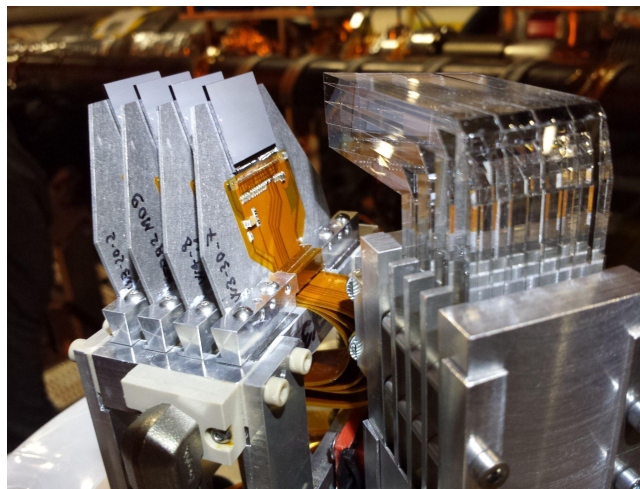
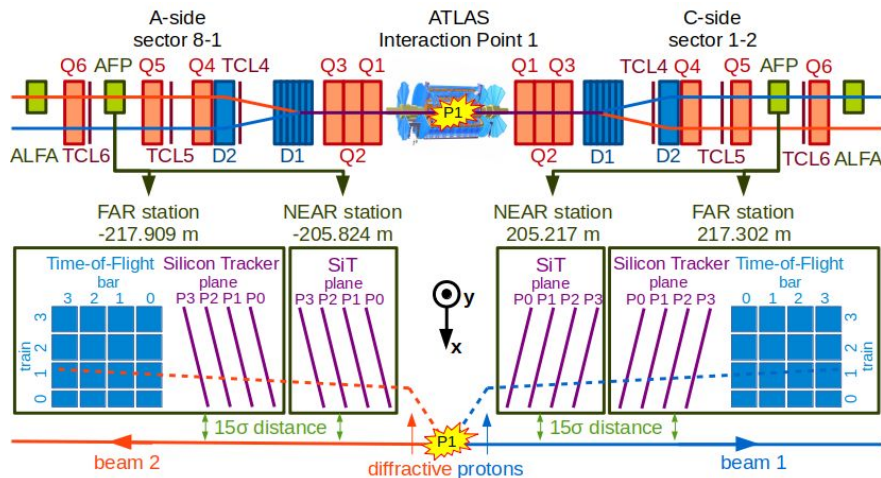
Disclaimer

The contents of this presentation are work-in-progress.
The final results may differ from the presented state.

All presented data originate from high- μ run 431885 (20/08/2022)

ATLAS Forward Proton (AFP)

- Forward detector - located in the LHC tunnel outside ATLAS cavern
- Moves close to the beam once stable beams are declared
- Two stations on each side of ATLAS
- All stations host Silicon Tracker (SiT) with four layers of pixel chips
- Far stations host also Time-of-Flight (ToF) detector

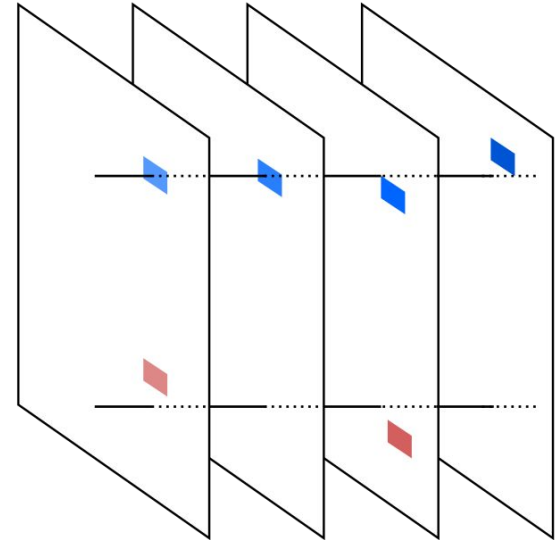
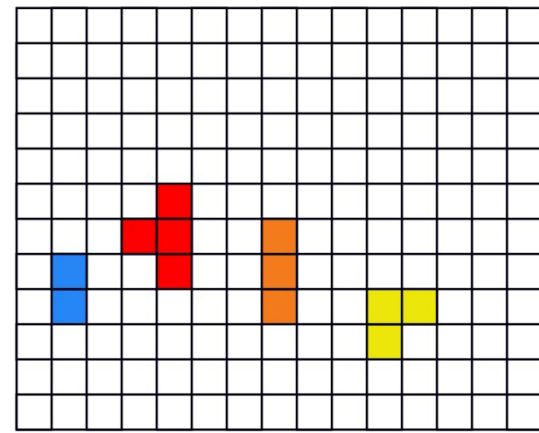


ATLAS Luminosity

- Granularity of one luminosity block (lumiblock/LB)
 - Each LB can have different length
 - Usually around 60 seconds
- Instantaneous luminosity decreases with time
 - Due to beam-beam collisions
 - Due to unpaired collisions
 - with remaining gas in LHC
 - with collimators
- Attempt to measure by counting AFP tracks
- Using only events selected by ATLAS random trigger
 - to have unbiased dataset

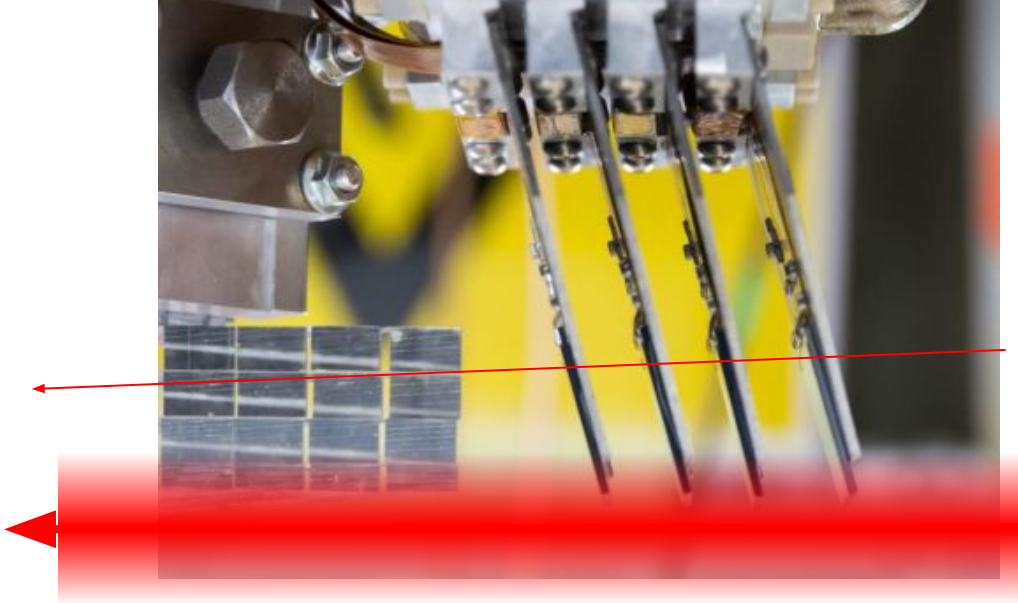
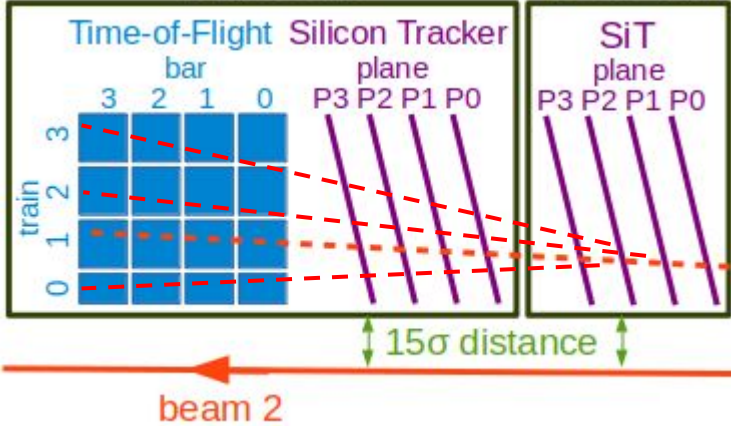
AFP SiT Reconstructed Objects

- Hits
 - Individual pixels activated by a proton
 - Fake hits produced by noisy pixels
- Clusters
 - Groups of adjacent pixels in a layer
 - Clusters produced by two particles can overlay
- Tracks
 - Groups of clusters across layers
 - Reconstructed using Kalman Filter
 - Currently, requires cluster in at least 3 out of 4 planes



Background

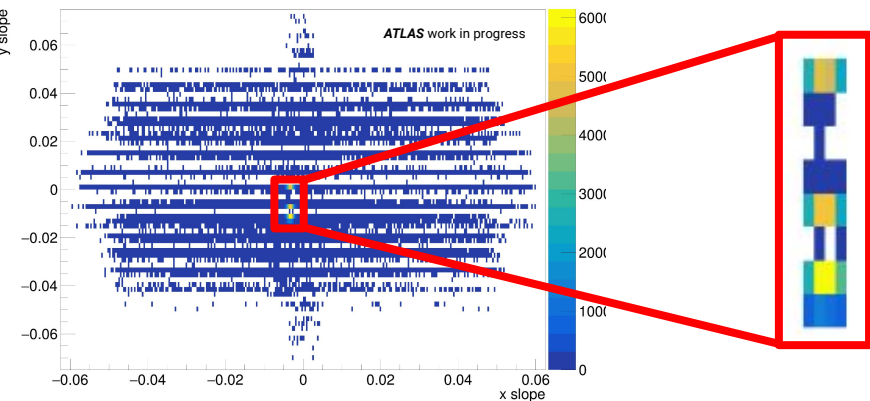
- Tracks not coming from IP
- Produced by:
 - material activation
 - beam halo
 - showers



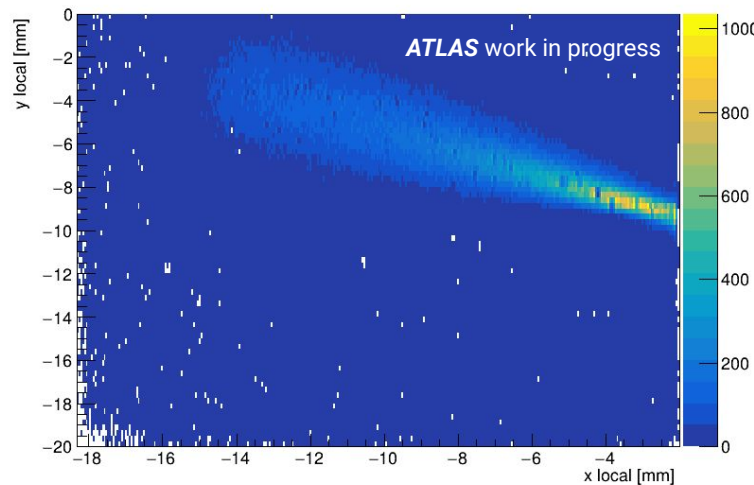
Background rejection

- Track rejection based on its properties
 - x/y local coordinate
 - x/y slope
- Tracks coming from IP
 - forming diffraction pattern
 - with very specific slope

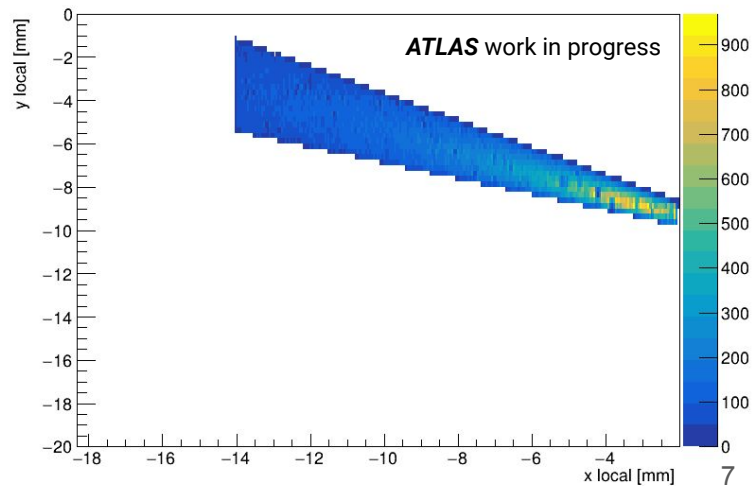
Map of track slopes in A Far - all



Map of tracks in A Far - all

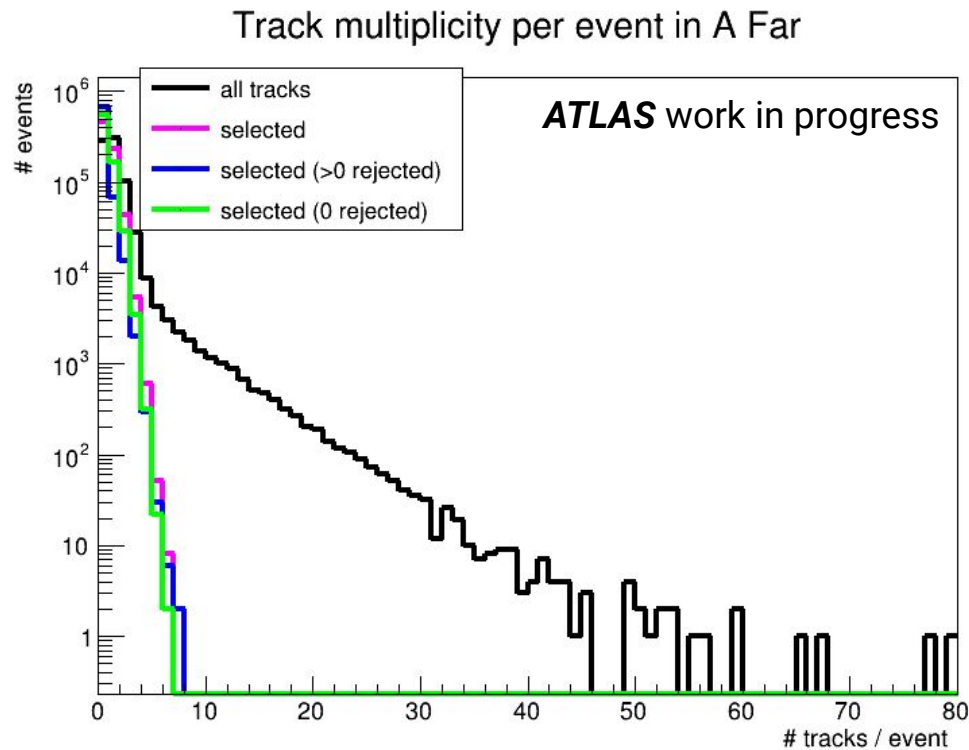


Map of tracks in A Far - selected tracks



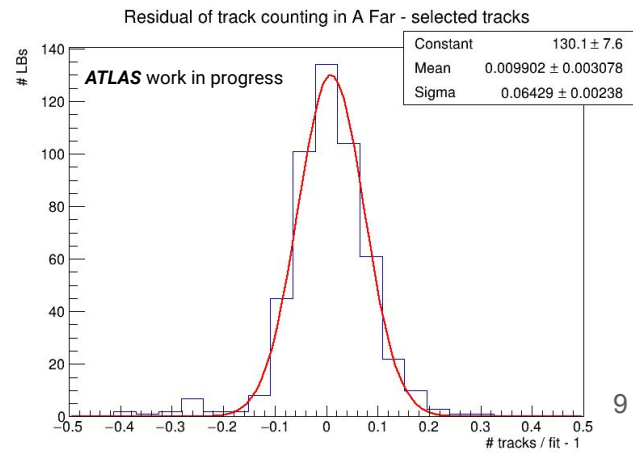
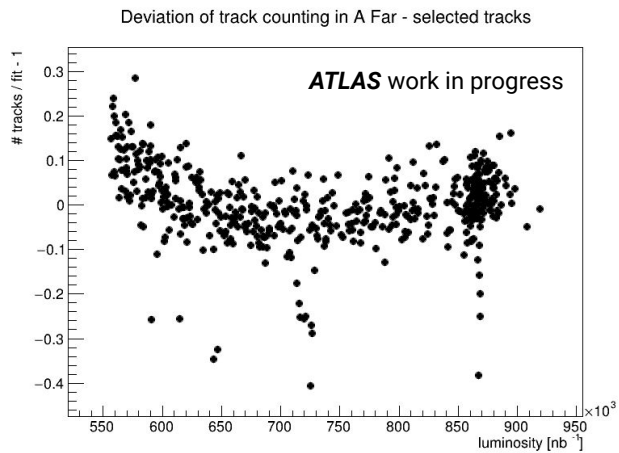
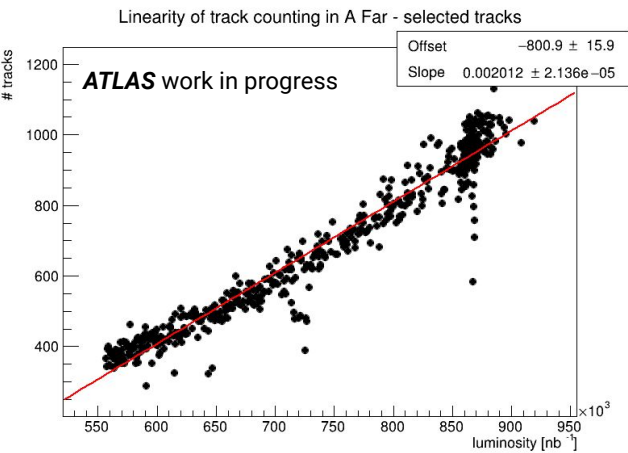
Background rejection

- Track rejection alone works well
- No need for event rejection



Track counting

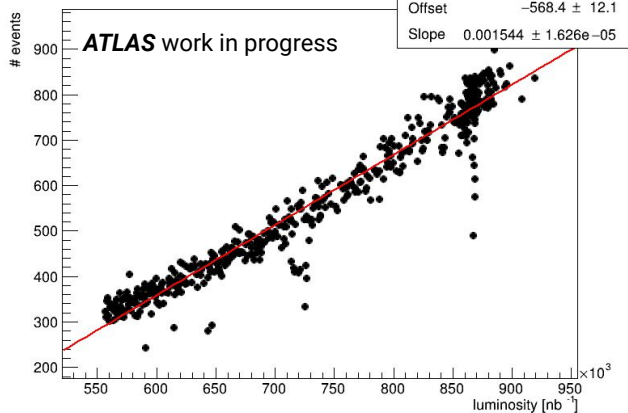
- Linearity not restored
 - Negative offset of linear fit
 - slope ~ 2 tracks / μb^{-1}
 - offset ~ -800 tracks
 - 0 tracks at $\sim 400 \mu\text{b}^{-1}$
 - Bend in fit deviations plot



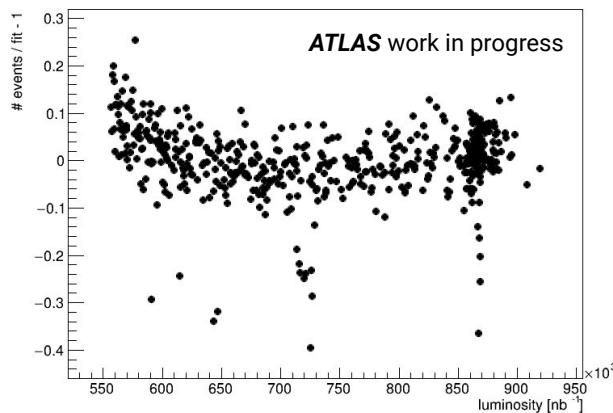
Event counting

- Events containing at least 1 track
- Each event is counted just once
 - Track multiplicity does not matter
- Also not linear
 - Negative offset of linear fit
 - slope ~ 1.5 events / μb^{-1}
 - offset ~ -568 tracks
 - Bend in fit deviations plot

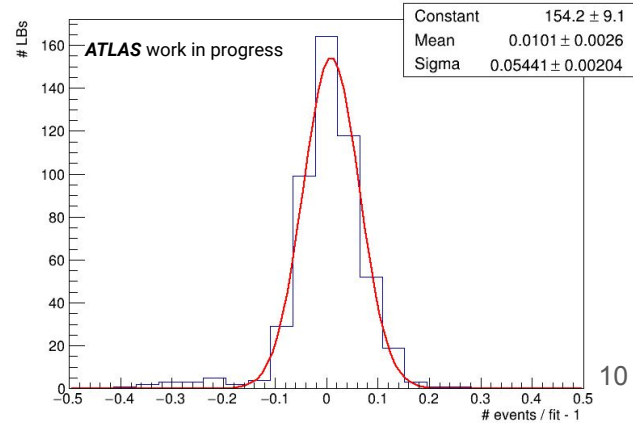
Linearity of event counting in A Far - selected tracks



Deviation of event counting in A Far - selected tracks

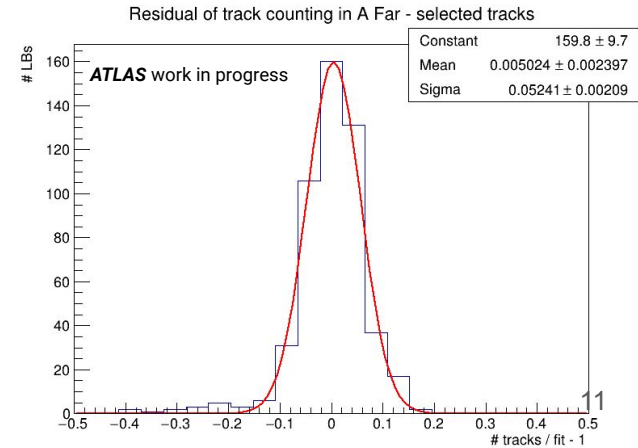
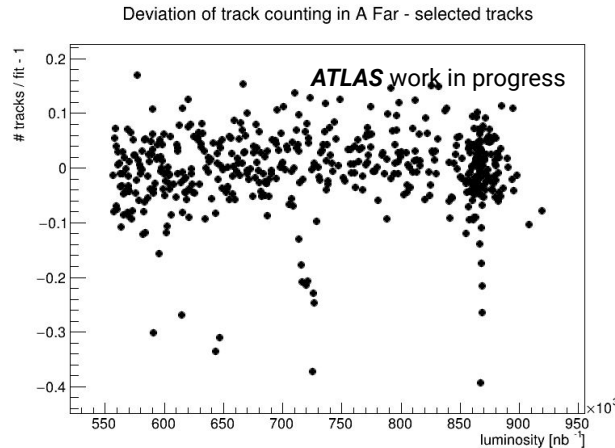
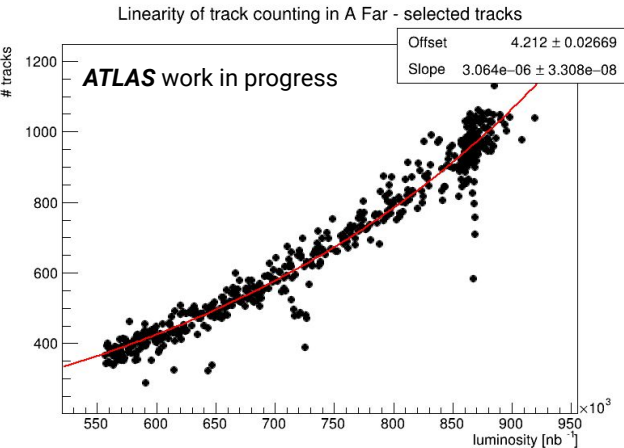


Residual of event counting in A Far - selected tracks



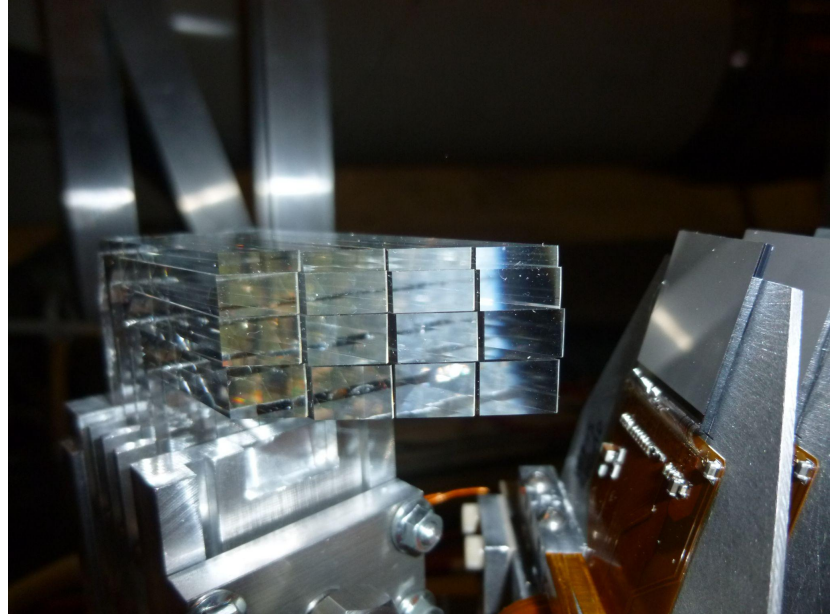
Exponential fit

- Track and event counting not linear
 - suggests real non-linear relation
- Attempt to fit using exponential function
- Best fit so far
- starting value ~ 67.5 tracks
- growth constant $\sim 3.064e-6$ nb
- precision $\sim 5.2\%$



Plans for improvements

- using ToF information
 - arrival at the right time
- cut on the number of hit pixels
- cut on energy deposited to pixels
- using AFP calibration stream
 - contains all AFP L1 triggered events
 - + ATLAS random triggered events
 - unbiased
 - much higher statistics
 - ATLAS random trigger < 40 tracks / second
 - increase in measurement precision



Conclusions and outlook

- Goal: Detailed study of using AFP for luminosity measurements
- Advantage of AFP being very close to the proton beam
- Sufficient statistics for luminosity measurement using track counting

Plans for the future:

- Test on multiple other runs with different conditions
- Improvement of background rejection to further clean the signal
- Study of effects of background rejection on outliers
- Aiming for contribution to overall ATLAS luminosity determination
- Study of long-term stability

Thank you for attention