Methods in ALFA Alignment

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ALFA Detectors

- Most particles are captured by the main ATLAS detector
- The main detectors must have holes for the particles to enter
- Some protons scatter at very small angles and continue out of the holes, being missed by the main detector
- Forward detectors help fix this

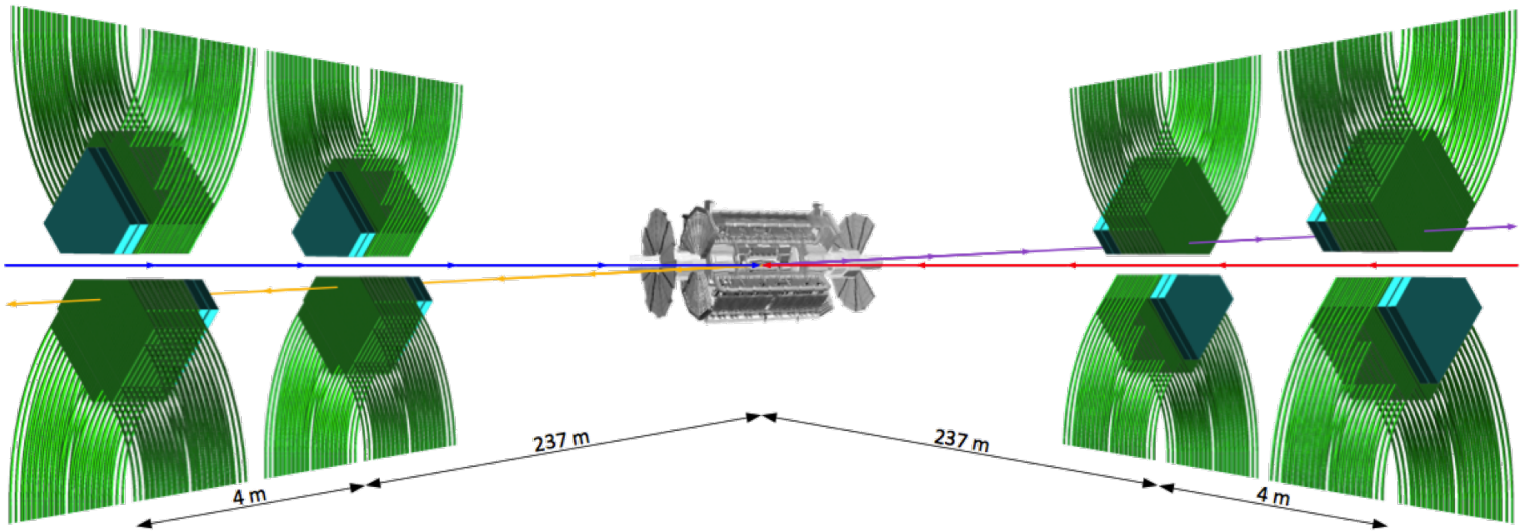


Figure 1 : Protons scattered and detected by ALFA (Not to scale) [4]

ALFA Detectors

- Measures the absolute luminosity and total cross section
- Studies elastic and diffractive protons.
- Precision is *important*
- This precision propagates to the precision of other measurements

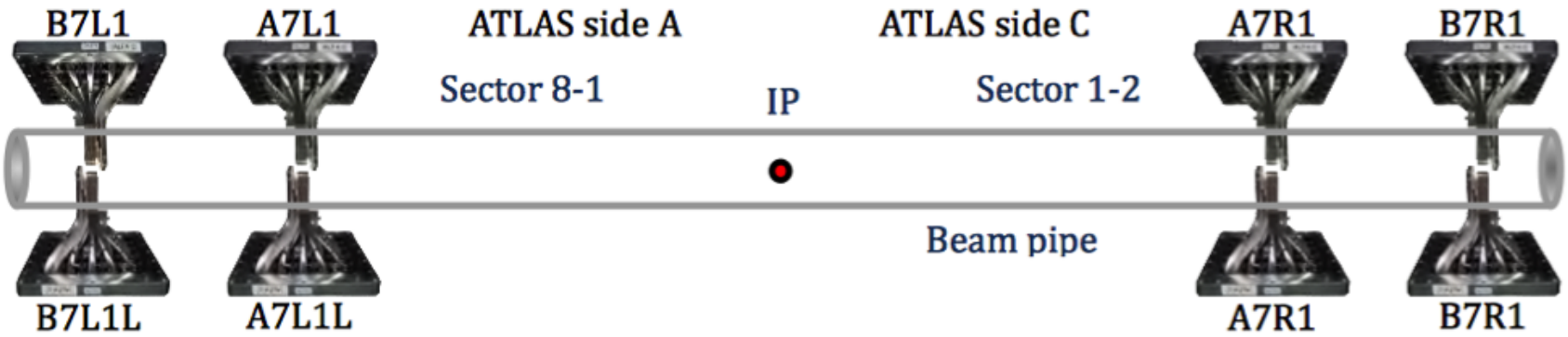


Figure 2 : The position of ALFA with respect to the interaction point (IP) [4]

Physical Motivation

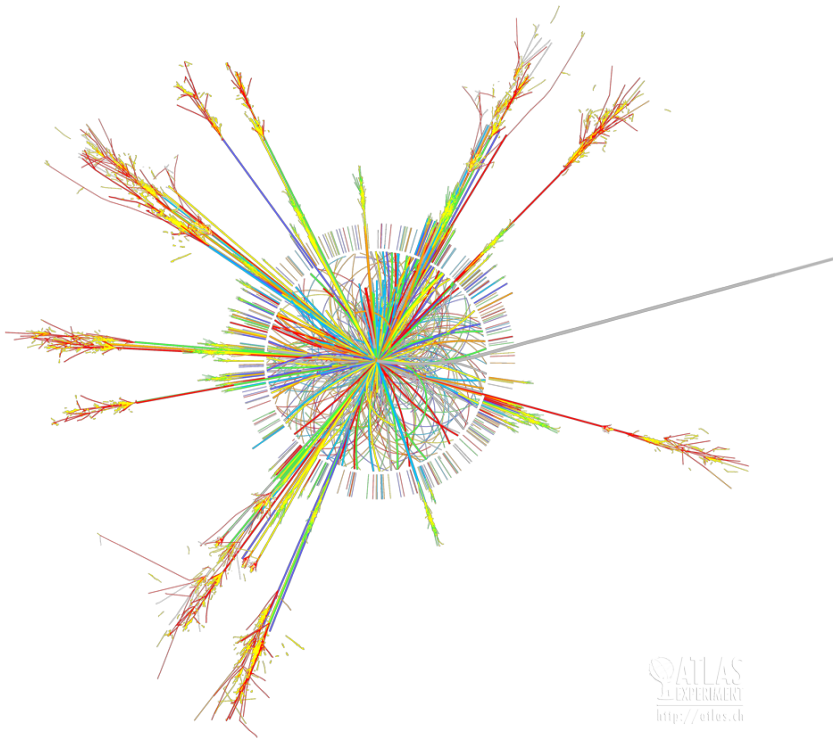


Figure 3 : A simulated *pp* scattering [1]

- Unanswered questions about protons
- ALFA can access physics that is model dependent
- We could learn more about how protons interact with one another

The Detector

- Detector sits in Roman Pot
- Main detector (MD)
  - 20 layers of scintillating fibers
  - u-v pattern gives x, y coordinates
- Overlap detector (OD)
  - Provides relative alignment between MDs

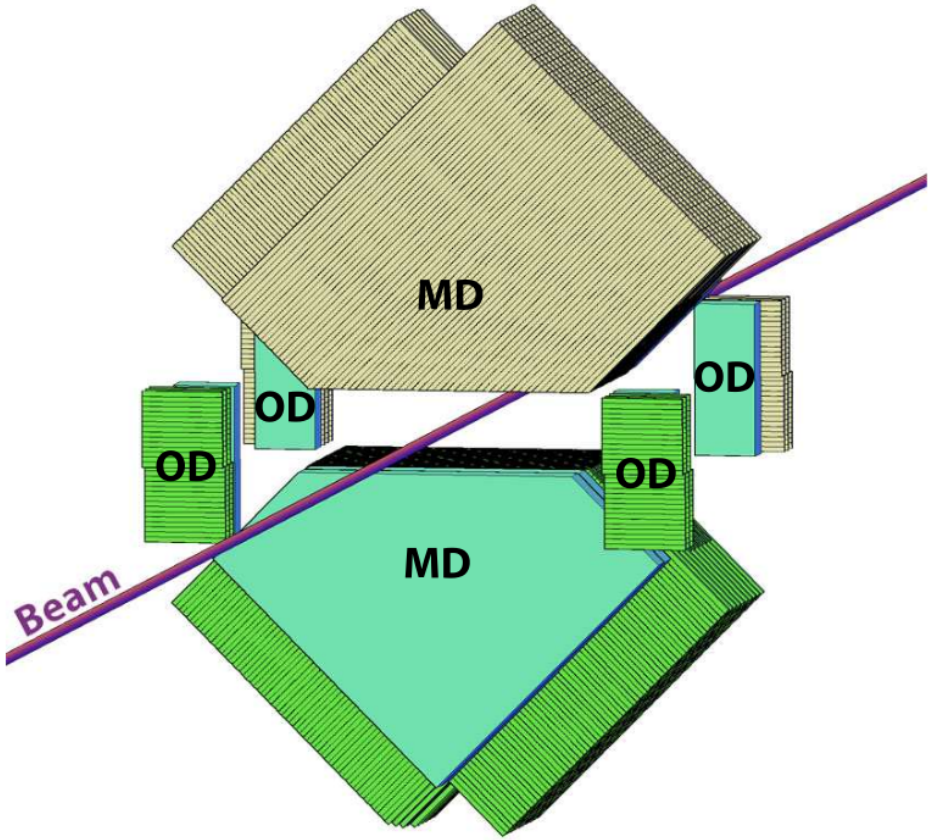


Figure 4 : The main and overlap detectors of ALFA [5]

My Role

- Prepare a skeleton of a future software package
- Determine ALFA alignment to within μm.
- Using single diffractive protons to determine alignment
  - "Hot spot" Method
  - "Kinematic peak" Method

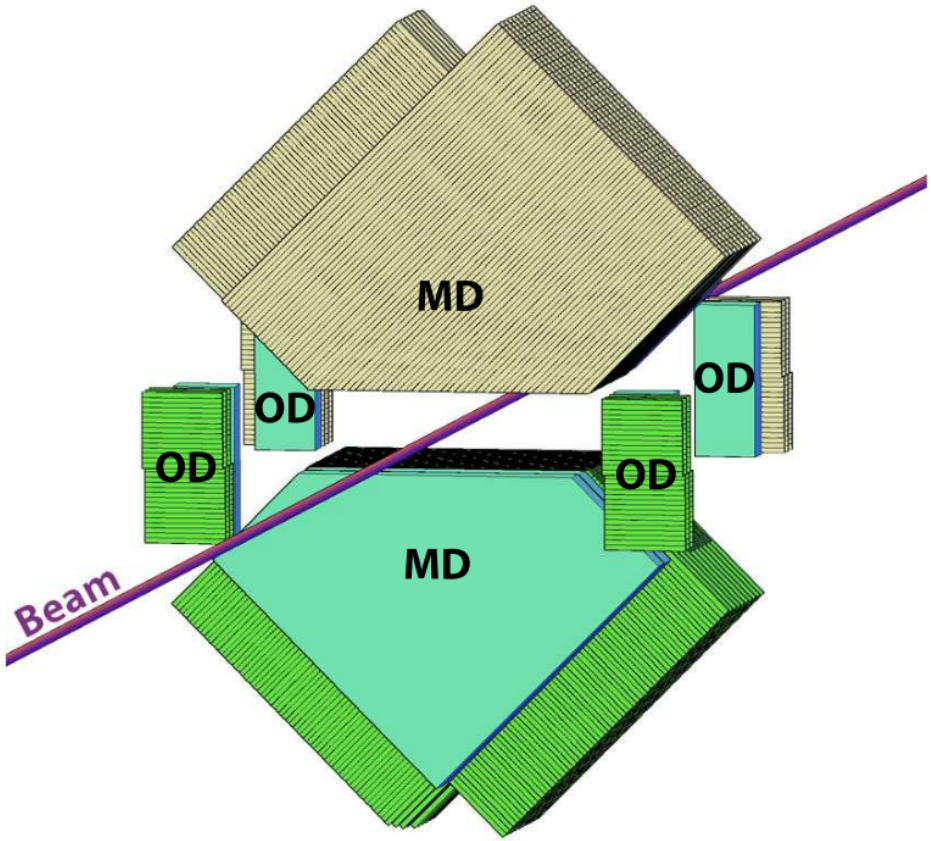
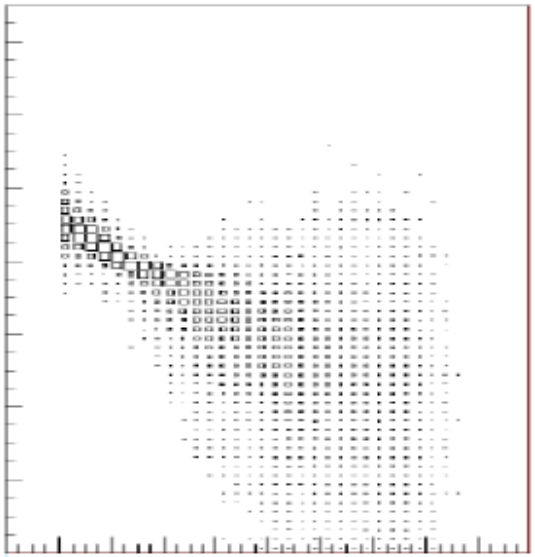


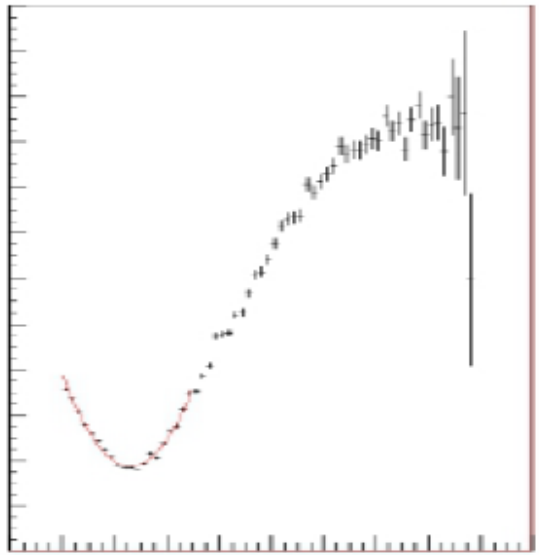
Figure 5 : [5]

Hot Spot: Theory

- The proton tracks have a particular distribution
- "Hot spot" is condensed $\rightarrow$ smaller σ_y.
- The standard deviation minimized at the dense region

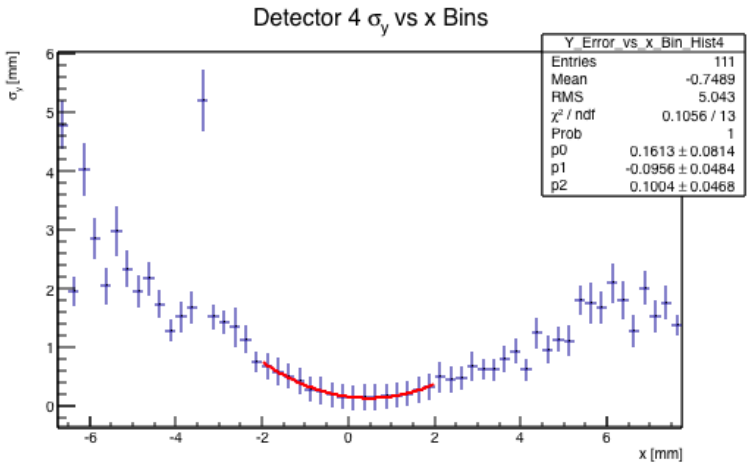


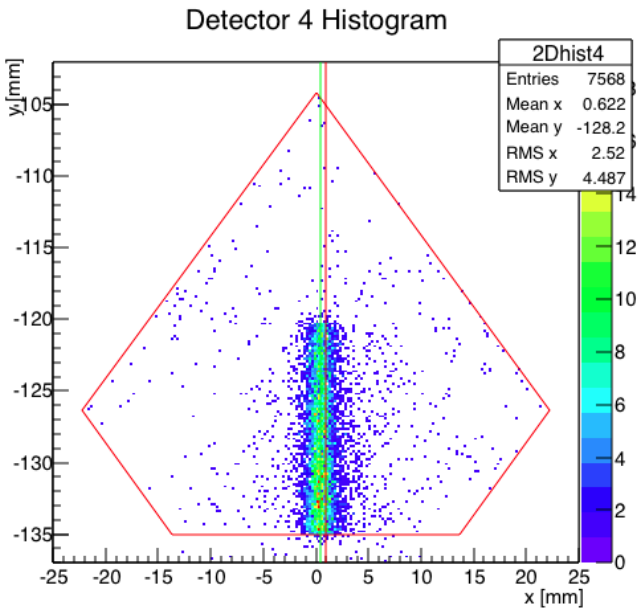
(a) The hitmap of SD events on the AFP detector.



(b) σ_y of x profile vs bins in x.

Hot Spot: Results





- True x shift: 100 μm

Det. #	Shift (μm)	% Err
5	100.9	0.89%
6	123.2	23%
7	106.2	6.2%
8	96.6	3.4%

Kinematic Peak: Theory

- Reconstruct the t distribution $d\sigma/dt$, where

$$t = (p_i - p_f)^2$$

- An important distribution to measure, in general.

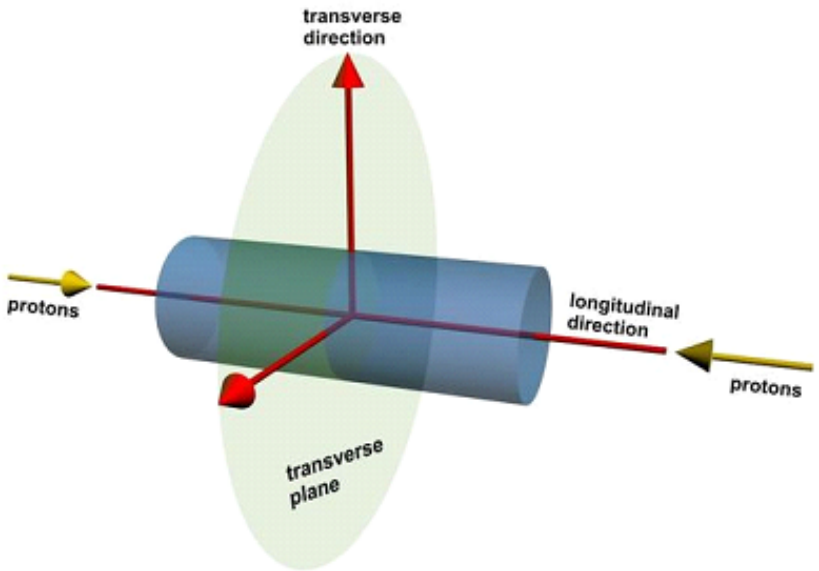


Figure 6 : The ATLAS coordinate system [2]

Kinematic Peak: Theory

- Create reconstructed t distribution.
- Compare to the ideallized distributions if the detectors were positioned perfectly
- Determine the shift needed to recreate ideal distributions

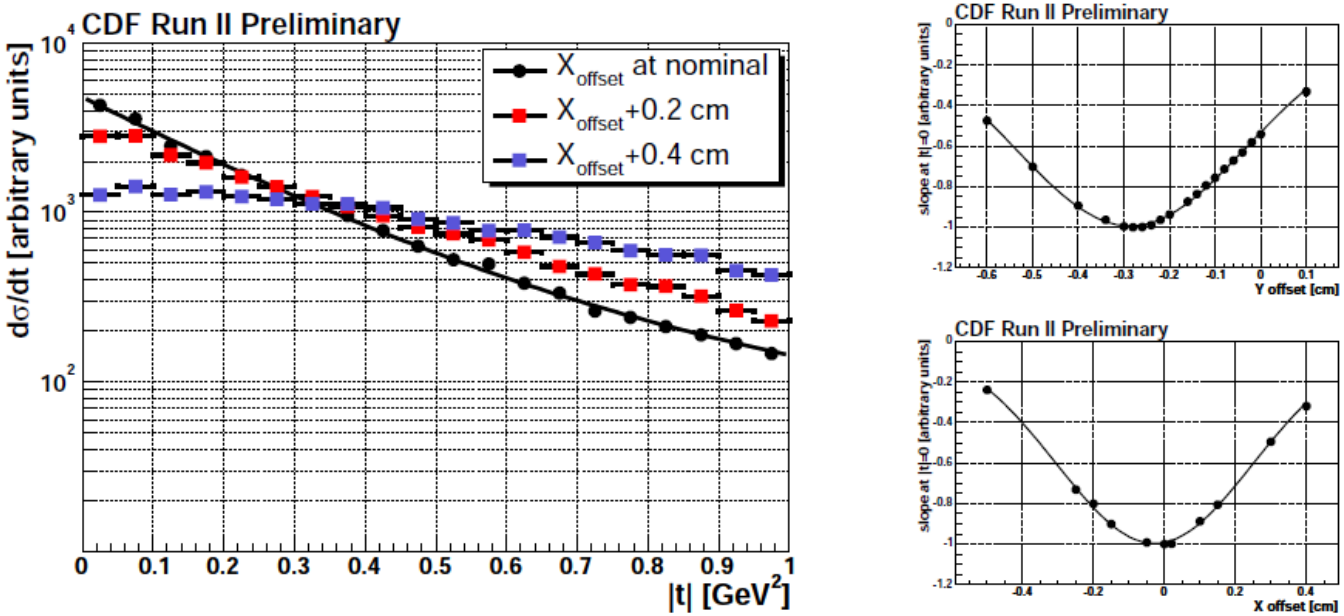


Figure 7 : *Left:* The t-distribution for various shifts X_{offset}. *Right:* $|b|$ slope vs Y (*top*) and X (*bottom*) [3]

Kinematic Peak: Results

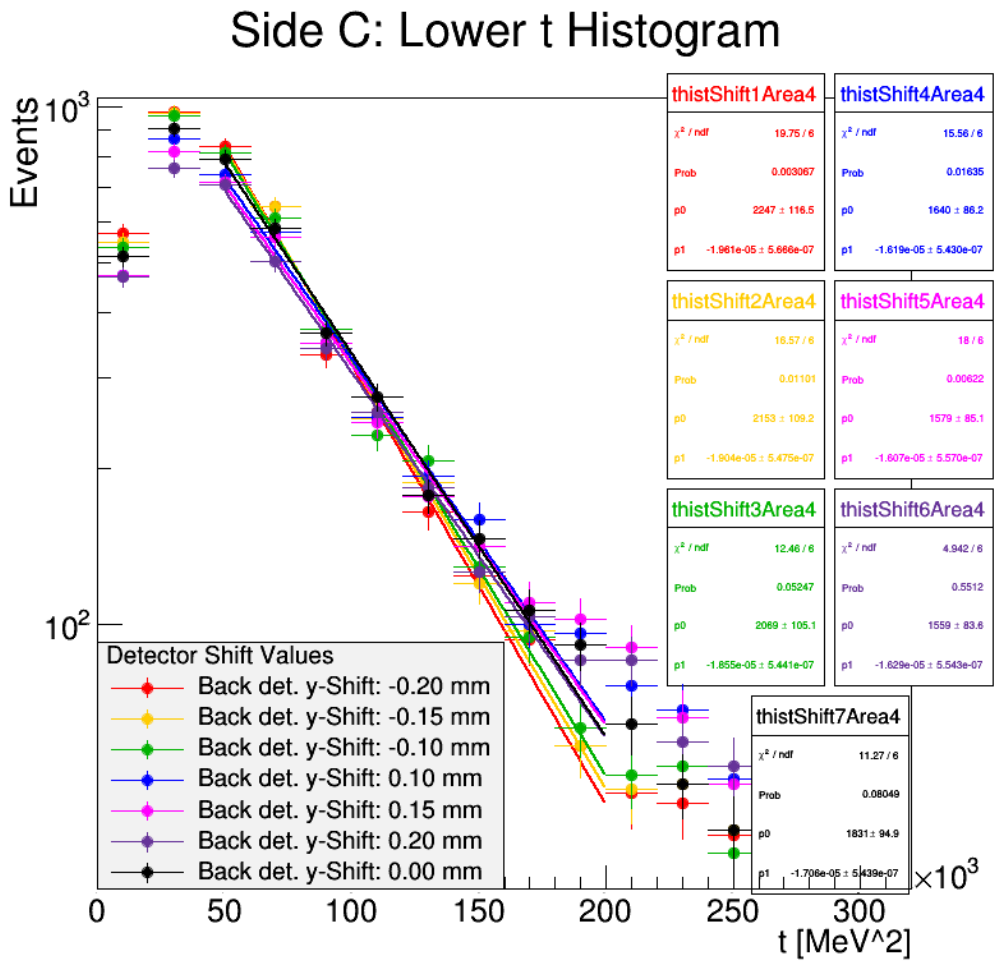
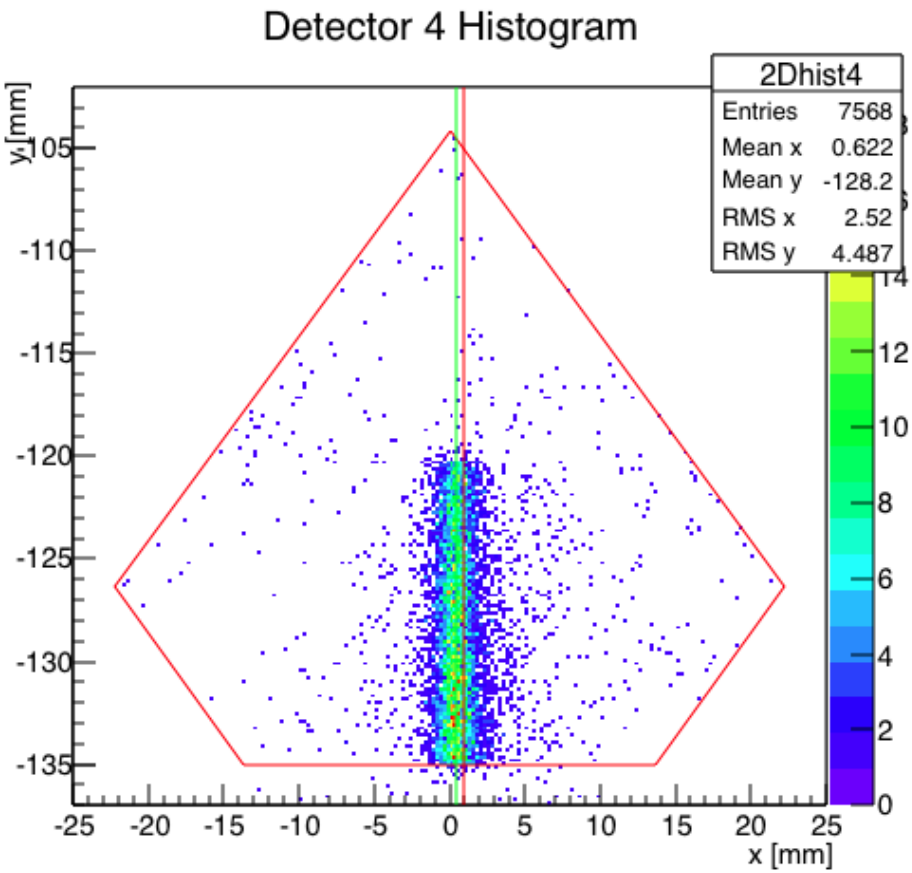
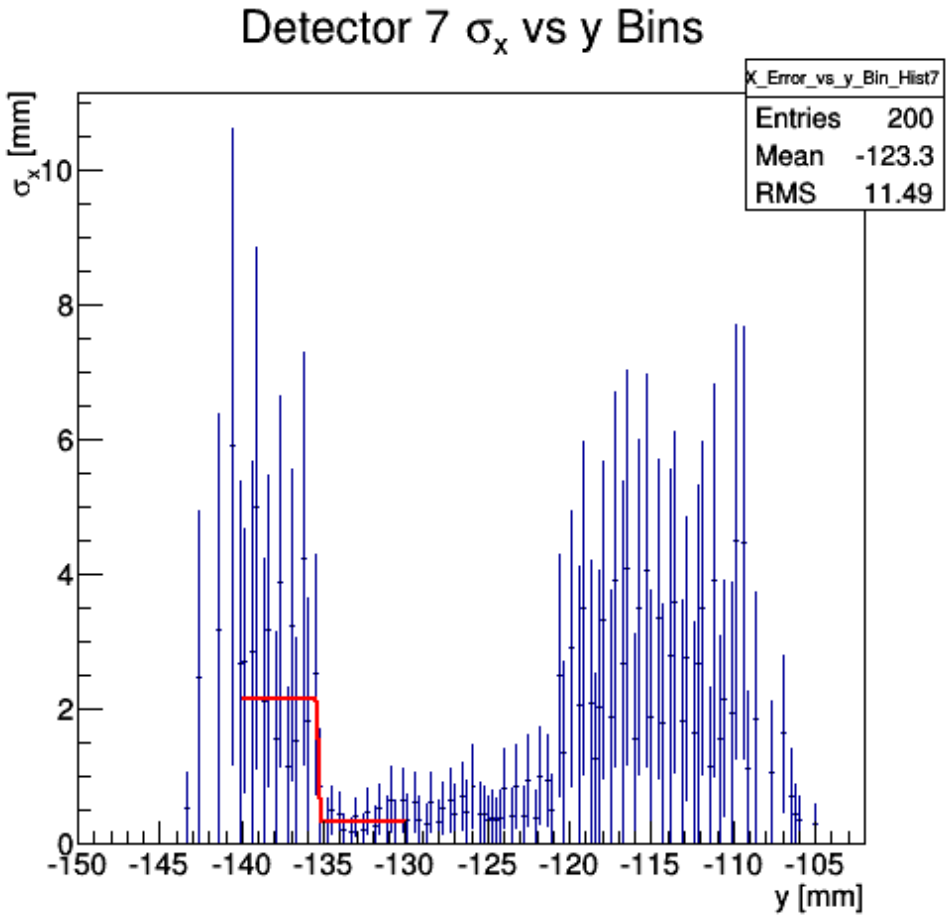


Figure 8 : t-distribution for various shifts in y-direction

Edge Fit





Percent Error: 0.193397%

Future Work

- Test precision of kinematic peak and detector edge method
- Test code on LHC data
- Adapt code to work on both ALFA and AFP detectors

What I Learned

- Programming
  - C++
  - ROOT
- Detector physics, particularly ALFA
- Proton reconstruction methods
- Lectures!
  - The Standard Model
  - String Theory
  - Future colliders
  - Neutrino physics
  - etc.

Pictures

Thanks!

The End

Thanks for listening!

References I

[1] `http://atlas.ch/atlas_photos/fulldetector/events_jpg.html`.

[2] `http://hypatia.iasa.gr/en/help.html`.

[3] Michele Gallinaro.

[4] Sune Jakobsen. *Commissioning of the Absolute Luminosity For ATLAS detector at the LHC*. PhD thesis, University of Copenhagen, 2013.

[5] H Stenzel. Measurement of the total cross section from elastic scattering in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector. Jun 2014.