Metrology and Precision of the ALFA Detector at ATLAS

DESY Summer Student Program 2008

Summie: Adam Roe Supervisor: Tobias Haas Working With: Dennis Petschull

Zeus Group Meeting 15 Sept 2008

The ALFA Concept Goal:

Provide a absolute calibration for luminosity measurements done by LUCID

Method:

Measure the elastic scattering cross section in special high- β runs

Measure the elastic scattering rate as a function of momentum transfer, using LHC as spectrometer

Principle: Optical Theorem

$$\sigma_{tot} = \frac{16\pi(\hbar c)^2}{(1+\rho^2)} \frac{1}{(R_{elas}+R_{inel})} \frac{dR_{elas}}{dt}|_{t=0}.$$

Adam Roe

DESY Summer Student 2008

The ALFA Detector

Roman Pot, integrated with Vacuum



Adam Roe

DESY Summer Student 2008

Precision and Goals

For small momentum transfers:

 $-t=(p\theta)^2.$

For -t = 0.005, $\theta = 10 \mu rad$, $\rightarrow \Delta x \approx 2.4 \text{ mm after } 240 \text{m}$

Resolving differences in t requires precision of $\sigma_x = \sigma_y = 30 \mu m$. '!



Plate Geometry

- 64 scintillating fibers on each side of each plates, connected to one PMT
- 10 plates (20 layers) on each side of beam
- Plates are not identical, but "staggered" by 50µm to increase resolution
- Exact fiber position is not known a priori: gluing procedure leaves gaps between fibers :(

Adam Roe

DESY Summer Student 2008

Simulation of Precision

(using someone else's code)



Measured Geometry I



DESY Summer Student 2008

Adam Roe

Measured Geometry II



Huge deviations seen earlier by Dennis between measured and ideal, ranging out to .5mm!!

Adam Roe

DESY Summer Student 2008

Effect on Precision



Adam Roe

(in)sanity check: 44 > 30 !!

DESY Summer Student 2008 15 September 2008 Zeus Group

Accuracy of Measurements

The important question: How accurate are our measurements? i.e. Are the large deviations of positions measurements real or do they correspond to our own uncertainty?

Microscope



Dennis

Many possible sources of inaccuracy! - light source - camera motion - optical abberations

- zooming

Light Source

Adam Roe

Idea: Measure Plates (w/o) fibers for better handle

DESY Summer Student 2008 Zeus Group 15 September 2008

Plates I: Method



Method: Measure points along edges w.r.t. lower hole, fit lines and find corners. Old/New: How plate is fixed on.

Then: Compare corners to ideal positions

Adam Roe

DESY Summer Student 2008

Plates II: Deviations



Both are OK. Not the source of earlier (huge) deviations seen by Dennis.

Leaves open 2 likely explanations of earlier strip measurements:

- Resultant of measurement method (i.e. Not "real" effects")
- Really there, but not a result of the plate geometry,

Need to remeasure the plates!

Adam Roe

DESY Summer Student 2008

Plates III: Correlations



In general: there is no dX dY correlation

Adam Roe

DESY Summer Student 2008

Plate IV: Precision



Precise to within 5u with this method

Adam Roe

DESY Summer Student 2008



DESY Summer Student 2008

Adam Roe

Conclusions

- Luminosity Measurements are difficult at Hadron Colliders.
- Our measurement methods have precision <10 um
- Boards are machined with <20 um precision
- Total accuracy of machining & measuring <50 um
- Test Beams are fun.

Big Thanks to Tobias Haas and Dennis Petschull!

Adam Roe