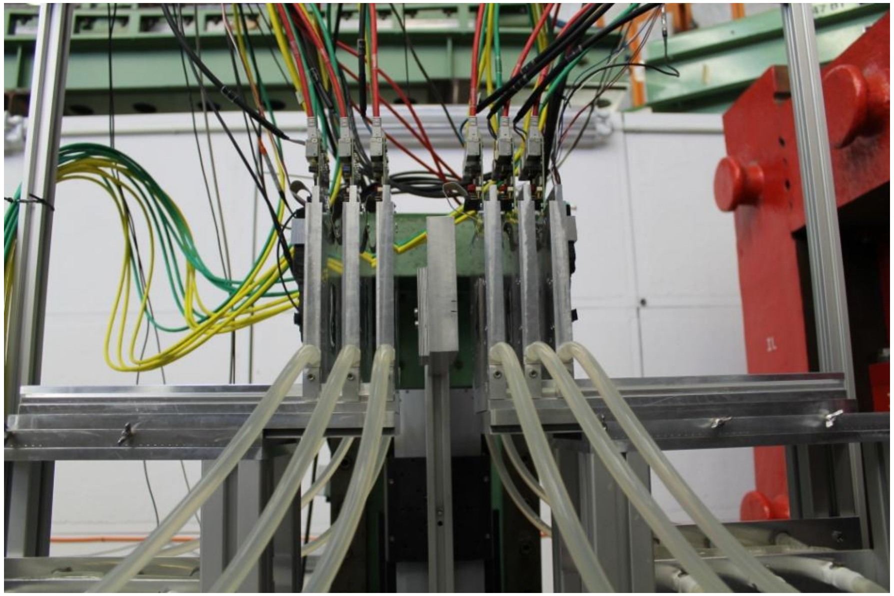
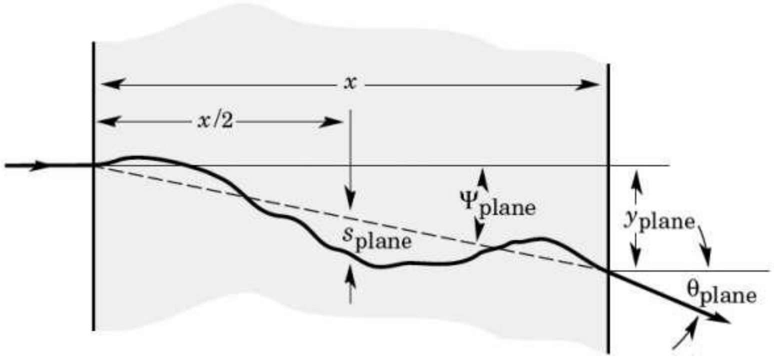
Measuring radiation lengths with DATURA telescope

Preliminary Results





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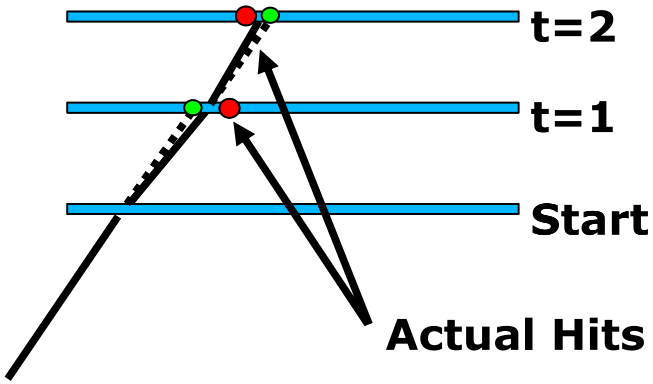
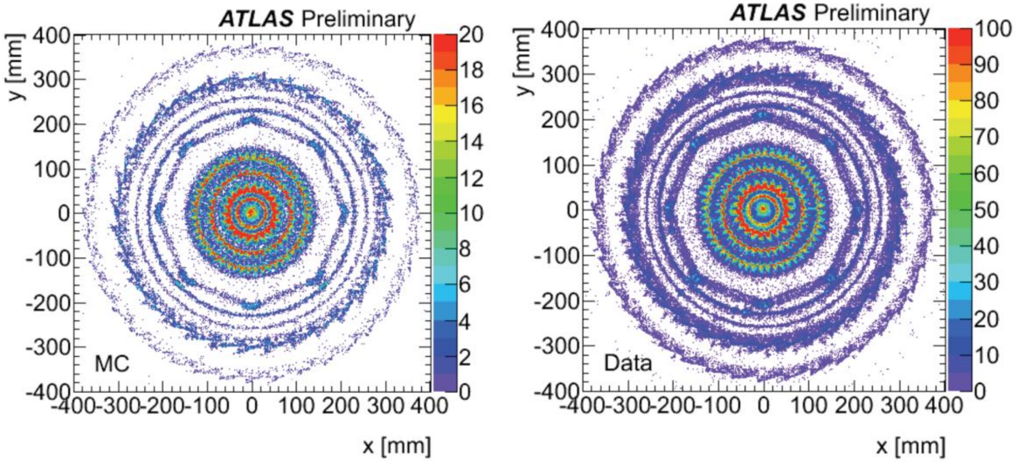
Measuring radiation lengths with DATURA telescope
Hamburg Telescope Workshop, 1st July 2014

Motivation

- Ability to measure radiation lengths very important for particle physics
- Radiation length affects:
  - Tracking in detectors
  - Accurate Monte Carlo simulations
  - Photon conversion rates
  - Understanding new materials (Glue)

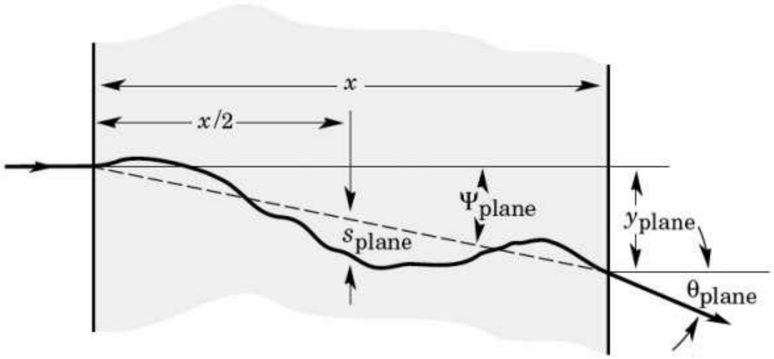


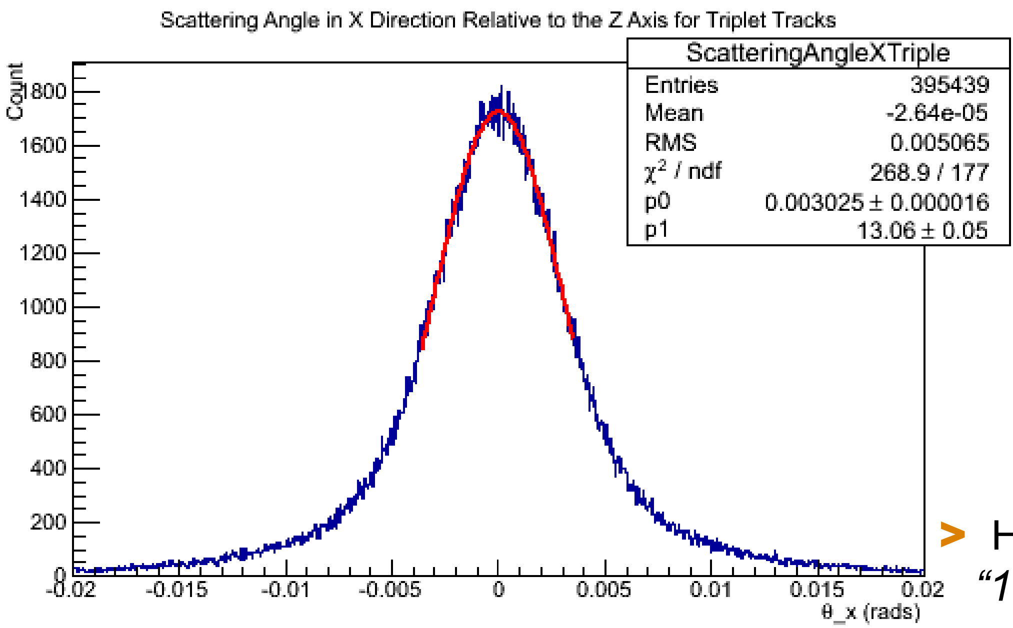
- Measuring scattering angles allows us to calculate radiation length
- Can measure radiation length accurately up to ~6%



Theory

- Multiple scattering can be detected by comparing angles between the front and back arms of the telescope
- Scattering has Gaussian distribution
- Mean scattering is zero
- RMS is dependent on radiation length





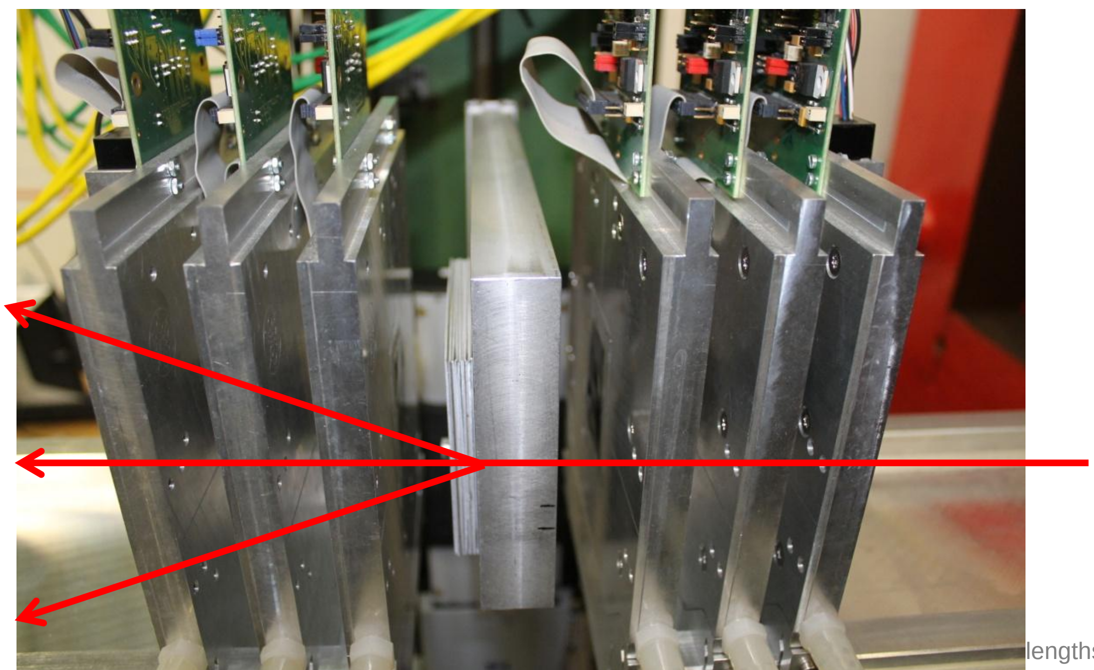
$$\theta_0 = \frac{13.6\,\mathrm{MeV}}{p}\left(\frac{x}{X_0}\right)^{0.555}$$

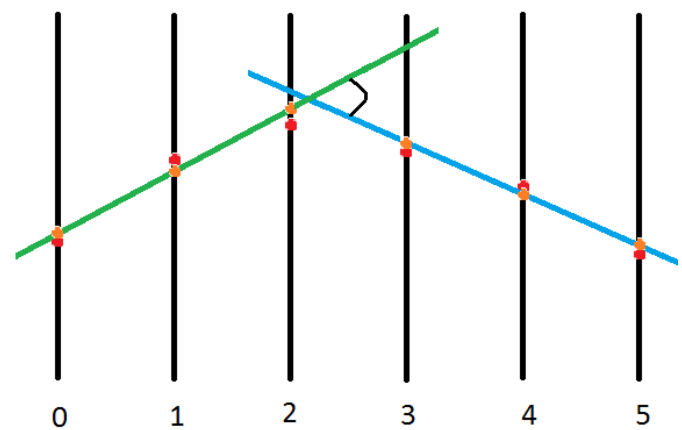
θ_0 = RMS of scattering angle
x = material thickness
X_0 = radiation length
p = momentum (MeV)

- Highland formula is accurate to: *“11% or better, from $0.001 < x/X_0 < 100$”*

Experiment

- Angle currently calculated by two straight lines between arms
- Future: Angle calculated directly from General Broken Lines Fitter
- Change the energy and measure the RMS scattering angle
- From this we can calculate x/x0, using new tool EUTelProcessorRadiationLength, will soon be in repository

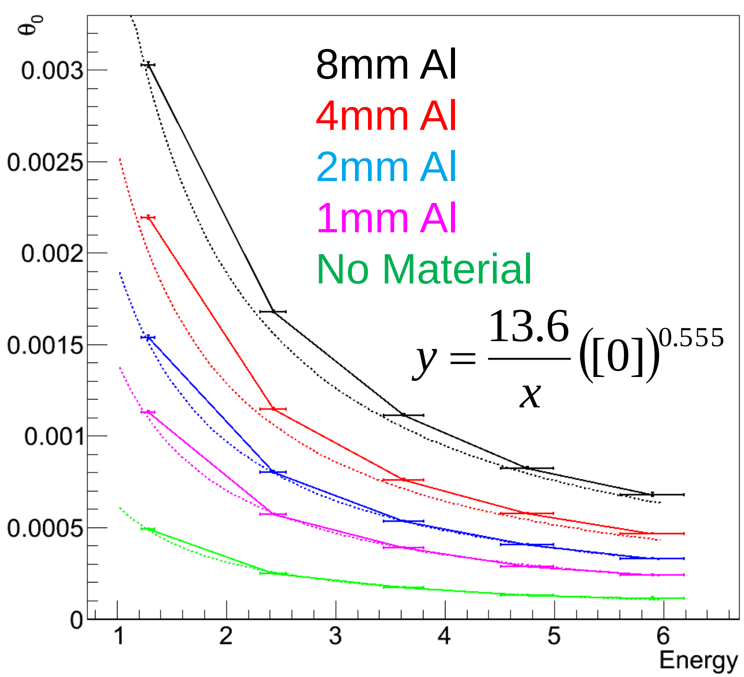


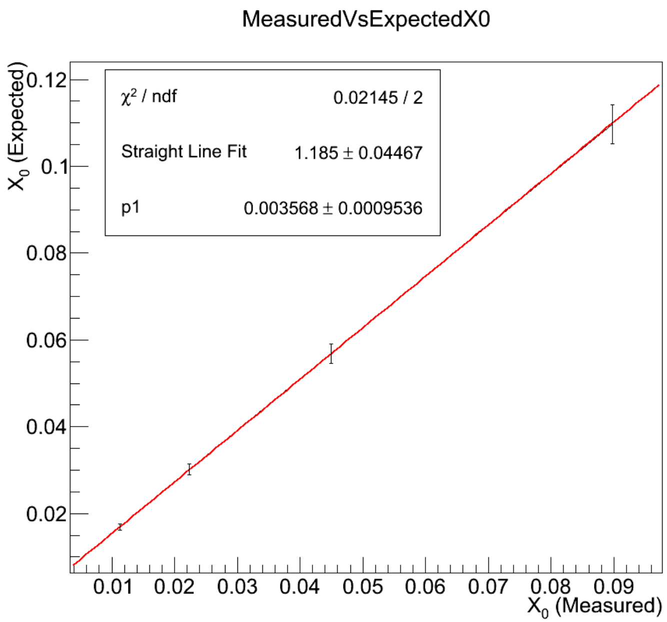


Results

- Current assumes no external factors
  - Radiation length of detector components
  - Radiation length of air
- Can be calibrated by comparing to reference material
  - 1 mm thick aluminium pieces, 99.5% pure
  - Other materials tested but analysis not finished

$$\theta_0 = \frac{13.6\,\mathrm{MeV}}{p}\left(\frac{x}{X_0}\right)^{0.555}$$

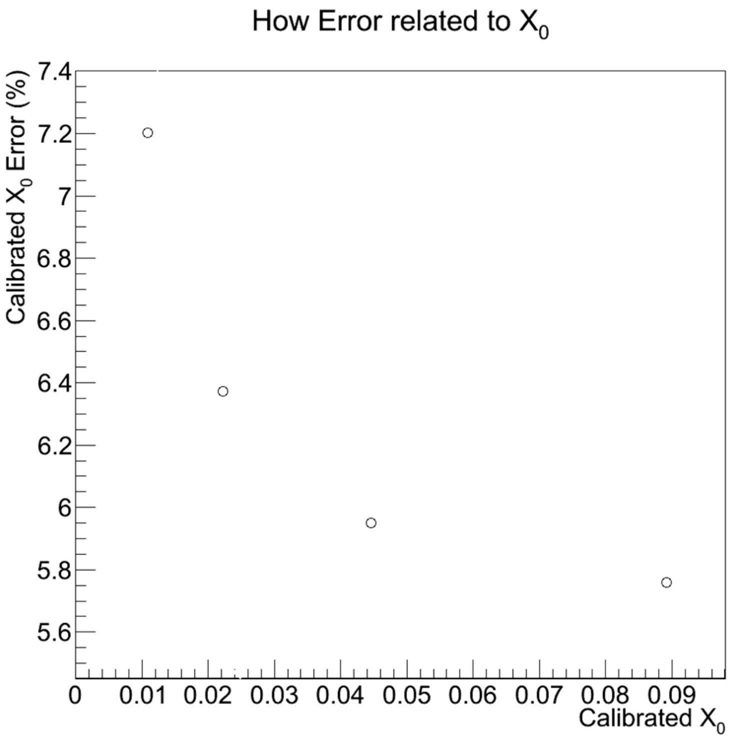




Results

- Errors on the energy are the dominant factor at DESY
- Energy error is given as 5% of the beam energy

- Error on sigma is ~1%
- Theoretical error from Highland Formula < 11%, but exact value unknown



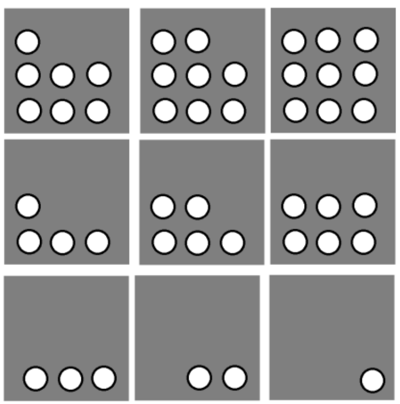
- Highland formula is accurate to:
  "11% or better, from $0.001 < x/X_0 < 100$"

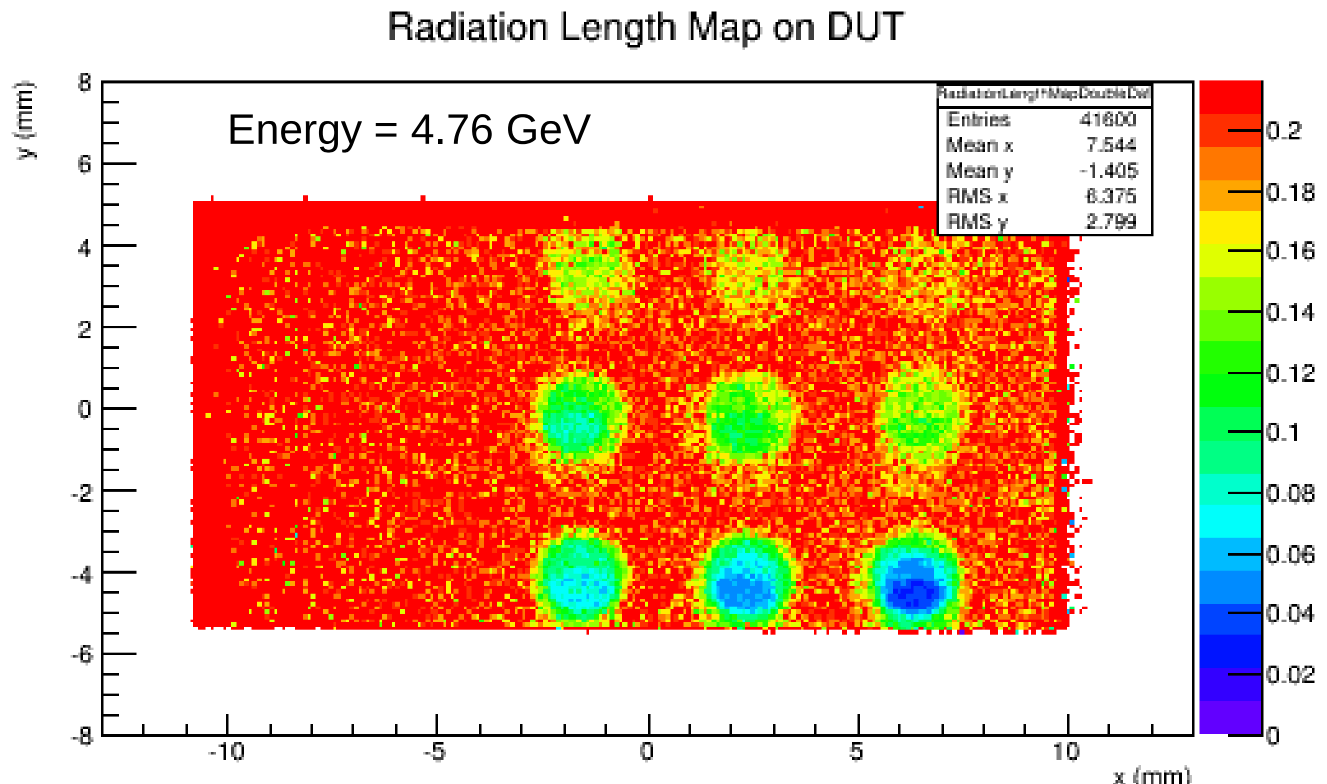
Thickness	Expected X_0	Calibrated X_0	Calibrated X_0 Error	Sigma Deviation
1mm	0.0112	0.0109	6.4%	0.35
2mm	0.0225	0.0222	6.3%	0.22
4mm	0.0450	0.0446	6.1%	0.15
8mm	0.0899	0.0891	5.7%	0.15

Expected values taken from PDG

Radiation length maps

- The calculation of the radiation length can be done as a 2D map
- Example below shows the result when 9 pieces of aluminium with different holes are placed on top of each other.





Plot is for single energy (not energy scan) and is not calibrated

Summary

- Measured radiation length of aluminium plates
- Created radiation length maps
- Dominant uncertainty is energy of the test beam

- In future:
  - Fit using GBL – get rid of need for calibration
  - Bundle tool and scripts for users
  - Finish analysis on other materials

- Thank you for listening