Tracker alignment & Multiple Scattering Measurement with Field Off

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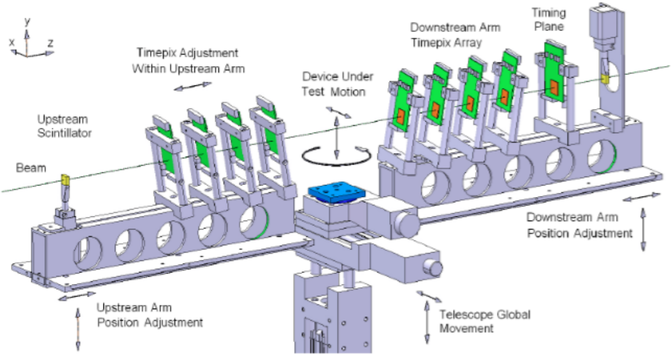
29/10/2015

Multiple Scattering with Field Off

- Particles follow straight tracks through the spectrometers, scattering off absorber material in AFC
- Use TOFs to measure momentum, KL, EMR & CKOVs for PID
- Measure multiple scattering as a function of momentum

Tracker Alignment

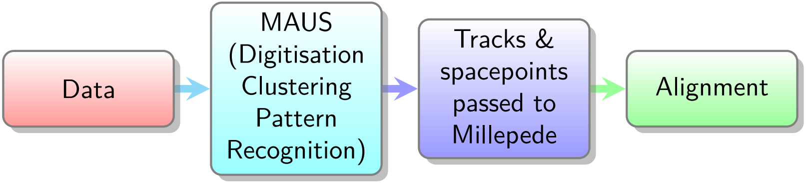
- Bach - common software-tool to align telescope-like detectors. Employs the MILLEPEDE alignment algorithm
- MILLEPEDE - solves a linear least squares problem with a simultaneous fit of all global and local parameters



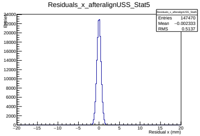
https://svnsrv.desy.de/viewvc/aidasoft/AIDAAlign/

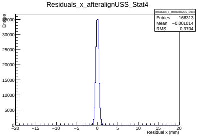
Tracker Internal Alignment

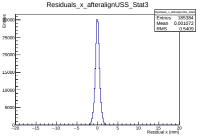
- Tracker frames were surveyed at Imperial - position of stations known accurately
- First test: Can Millepede return the correct internal alignment of the tracker stations?
- Alignment done with (3,240) MC beam

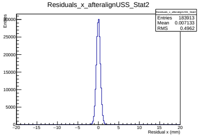


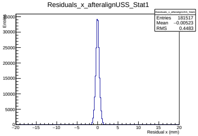
Alignment Residuals Upstream

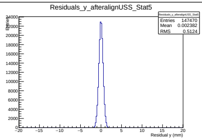


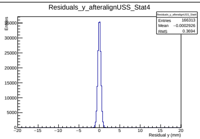


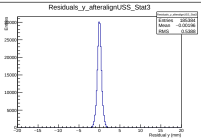


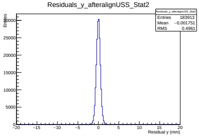


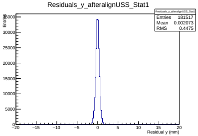




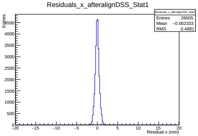


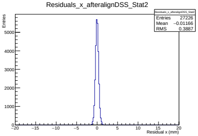


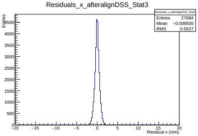


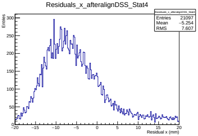


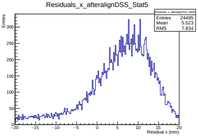
Alignment Residuals Downstream

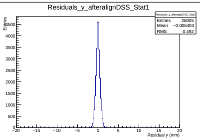


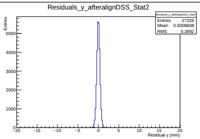


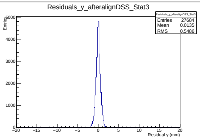


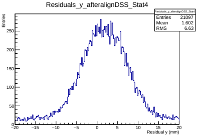


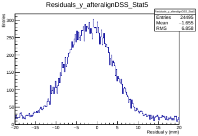












Tracker Alignment

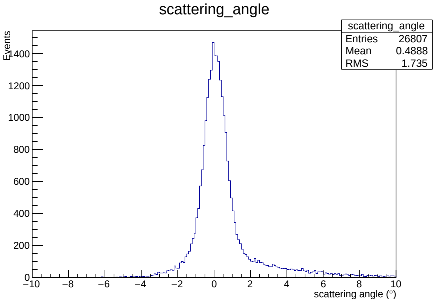
To-Do List

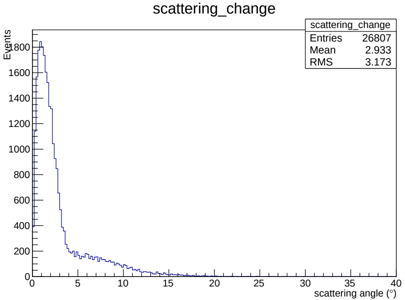
- Run `MILLEPEDE` over MICE data
- Create single track for all spacepoints from both trackers
- Perform tracker-to-tracker alignment

Tracker Internal Alignment

range in which MILLEPEDE looks for Δ	
σ_x	1 mm
σ_y	1 mm
$\sigma_{x'}$	60 mrad
residual cut	40 mm
DOF	x,y,z'

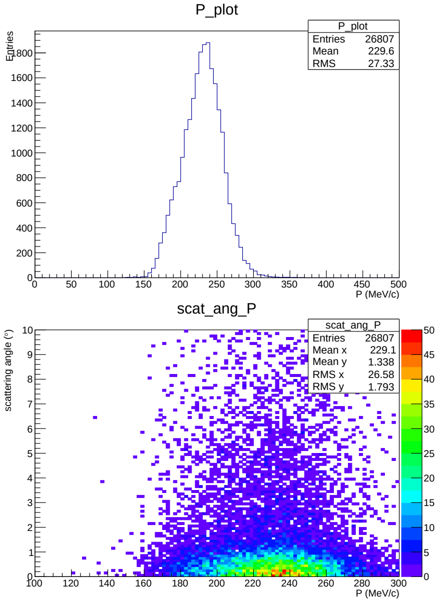
Measurement Principle





- (3, 240) MC beam
- Pattern recognition provides straight tracks & angles in each tracker
- Calculate the change in angle between US and DS trackers
- Top plot: dot product of upstream track with beam axes minus dot product of downstream track with beam axes
- Bottom plot: dot product of direction vectors of upstream and downstrean tracks

Measurement Principle



- Pattern recognition provides straight tracks & angles in each tracker
- Calculate the change in angle between US and DS trackers
- Top plot: Momentum
- Bottom plot: Angle with momentum

Beam Settings

- To maximise the no. of particles reaching TOF2 emittance should be 3π, then scan across momentum range
- Repeat MuScat settings to perform direct comparison with MuScat data. Beam P at absorber 172 MeV/c - settings will be taken from Magic spreadsheet

Systematic Errors

• Windows	$\rightarrow$ Run empty channel
• Field residuals from PRY	$\rightarrow$ Run MC with no fields (in touch with Holger about field maps)
• Tracker fitting	$\rightarrow$ Kalman residuals
• Resolution of tracker	$\rightarrow$ Deconvolution calculation
• TOF calibration	$\rightarrow$ Shift TOF selection $\pm$ 0.1 ns
• Monochromatic P_z beam	$\rightarrow$ Change selection

Misalignment of Trackers

1 Where are the trackers with respect to each other?
   - Correct this with rotation of downstream tracks

2 To within what tolerance do we know this?
   - This is the systematic error on the measurement

$\rightarrow \pm 10$ mrads^{-1} (based on estimate of alignment tolerence)

PID

1 Run with all particles

2 Run with only muons

$\rightarrow \pm 1\%$ (From MC study)

Distance between projected tracks cut

Ensures that tracks pass through absorber volume

Unpacking Tracker Resolution

$$D_{\text{obs}} = R \cdot \epsilon \cdot \theta_{true}$$

$$\rightarrow \theta_{true} = \epsilon^{-1} \cdot R^{-1} \cdot D_{\text{obs}}$$

$$\rightarrow \theta_{true} = \begin{pmatrix} \epsilon_{1,1} & 0 & \cdots & 0 \\ 0 & \epsilon_{1,1} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \epsilon_{m,n} \end{pmatrix} \cdot \begin{pmatrix} & R_{x,1} & \cdots & R_{x,m} \\ R_{\theta,1} & R_{x_1,\theta_1} & \cdots & R_{x_m,\theta_1} \\ \vdots & \vdots & \ddots & \vdots \\ R_{\theta,n} & R_{x_1,\theta_n} & \cdots & R_{x_m,\theta_n} \end{pmatrix}$$

$$\begin{pmatrix} & R_{y,1} & \cdots & R_{y,m} \\ R_{\theta,1} & R_{y_1,\theta_1} & \cdots & R_{y_m,\theta_1} \\ \vdots & \vdots & \ddots & \vdots \\ R_{\theta,n} & R_{y_1,\theta_n} & \cdots & R_{y_m,\theta_n} \end{pmatrix} \cdot \begin{pmatrix} D_{x1,1} & 0 & \cdots & 0 \\ 0 & D_{x2,2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & D_{xm,n} \end{pmatrix}$$

$$\begin{pmatrix} D_{y1,1} & 0 & \cdots & 0 \\ 0 & D_{y2,2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & D_{ym,n} \end{pmatrix}$$

http://arxiv.org/pdf/hep-ex/0512005v1.pdf

Data Requirements

1. Angular acceptance of trackers is 26 mrads^{-1}
2. P resolution of TOFs is $\sim$ 5 MeV/c this is our monochromatic in P beam
3. Errors are Poissonian $\rightarrow \sqrt{N}$ to get errors to 1% need 10k particles per P bite
4. Systematics are similar levels $\sim$ 2-3%
5. Sum of all P bites should give data sample of size comparible to MuScat data sample size
6. Extrapolating from June run 7157 to achieve the required statistics need 600k TOF2 triggers per point
7. Can be collected in $\sim$ 24 hrs (total $\sim$ 4 days)

Status

- Basic measurement principle understood
- First pass batch MC study under way

Needs more work

- Use Kalman residuals
- Run global PID over sample
- Runs at 3π 140, 200, 172 & 240 MeV/c need $\sim 6 \times 10^5$ triggers at TOF2

Conclusions

- Preliminary look at multiple scattering study
- Tracker alignment study well under way
- Step IV data is here so organising the analysis as quickly as possible