

Tracker alignment with MILLEPEDE

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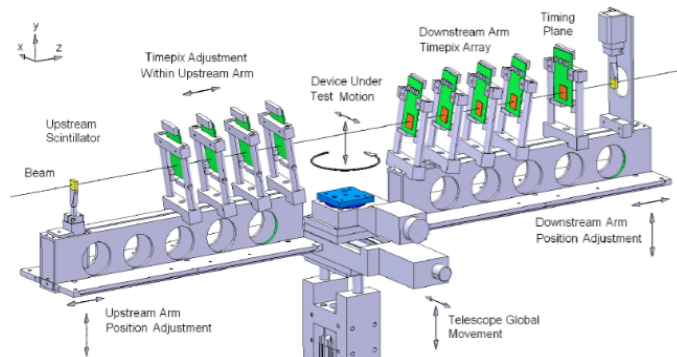
Multiple Scattering with Field Off



- 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

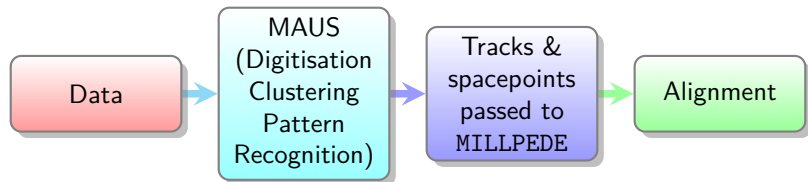
- Bach - common software-tool to align telescope-like detectors.
Employs the MILLEPEDE alignment algorithm
- MILLEPEDE - solves a linear least squares problem with a simultaneous fit of all global and local parameters



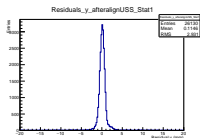
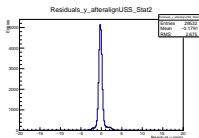
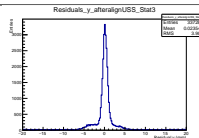
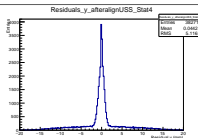
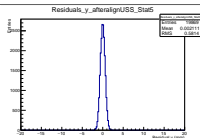
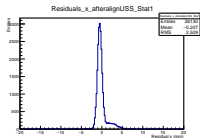
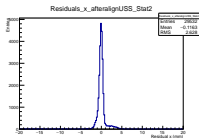
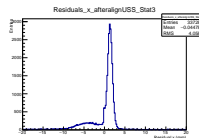
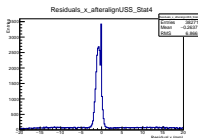
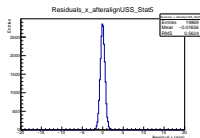
<https://svnsrv.desy.de/viewvc/aidasoft/AIDAAlign/>

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 Offsets Upstream

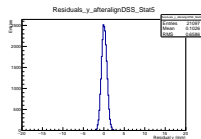
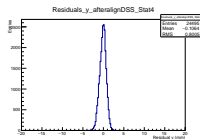
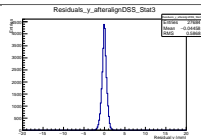
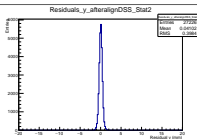
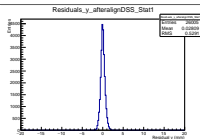
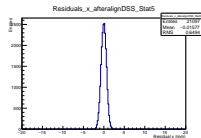
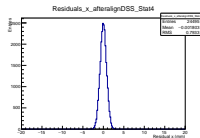
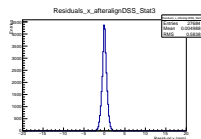
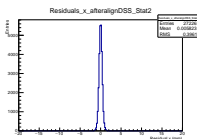
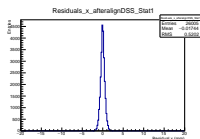
Station	Position			Alignment Offset		
	x	y	θ_z	x	y	θ_z
5	0	0	0	-0.7328	1.1520	-0.0541
4	-0.5694	-0.604	0	-1.1779	-0.7081	0
3	-1.2021	-0.1657	0	1.1970	-1.0435	0
2	-0.5709	-0.7375	0	0	0	0
1	0	0	0	-0.3255	-0.8879	0

Station 2 is fixed in MILLEPEDE so the offset is 0

Positions are taken from CMM measurements done at Imperial

Alignment done with 36k tracks

Alignment Residuals Downstream



Alignment Offsets Downstream

Station	Position			Alignment Offset		
	x	y	θ_z	x	y	θ_z
5	0	0	0	1.0071	-0.6264	0.0244
4	-0.5694	-0.604	0	0.4493	-0.6224	0
3	-1.2021	-0.1657	0	0	0	0
2	-0.5709	-0.7375	0	-0.3811	0.4910	-0.0097
1	0	0	0	-0.6928	0.8729	-0.0153

Station 3 is fixed in MILLEPEDE so the offset is 0

Positions are taken from CMM measurements done at Imperial

Alignment done with 27k tracks

Tracker to Tracker Alignment

To-Do List

- ① Create single track for all spacepoints from both trackers - fitting done with Minuit as packaged in ROOT
- ② Use only two stations for tracker to tracker alignment. Plane that defines the centre of each tracker volume in z
 - ▶ Stations within tracker are considered 'fixed' with respect to each other
- ③ Perform tracker-to-tracker alignment

Alignment Offsets Tracker to Tracker

Station	Position			Alignment Offset		
	x	y	θ_z	x	y	θ_z
USS (549.55)	0	0	0	0	0	0
DSS (5450.8922)	0	0	0	-24.5067	-12.2534	0

USS is fixed in MILLEPEDE so the offset is 0

Compare with technical drawings to confirm hypotheses

Alignment done with 27k tracks

Residual plots are 0 in two plane scenario

Status

- MILLEPEDE built & running with MAUS framework
- Internal alignment with MC complete
- First pass at tracker to tracker alignment with MC complete

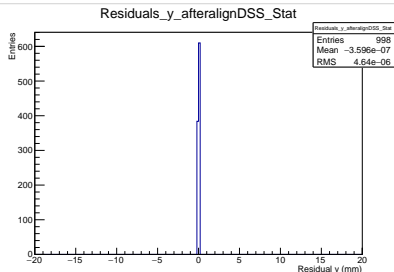
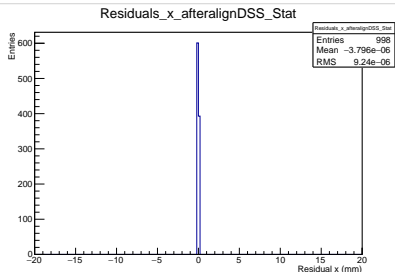
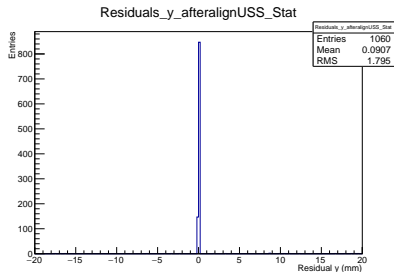
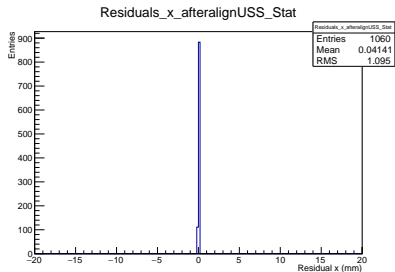
Needs more work

- Refine MILLEPEDE setup DOF, constraint equations, parameter freedom etc
- Run over MICE data

Conclusions

- Preliminary numbers for alignment
- MILEPEDE alignment study well under way but further worked need to tie down setup
- We have Step IV data - so organising the study as quickly as possible

Tracker to Tracker Residuals



Tracker Internal Alignment

range in which MILLEPEDE looks for Δ	
σ_x	0.1 mm
σ_y	0.1 mm
$\sigma_{x'}$	10 mrad
residual cut	40 mm
DOF	x, y, z'