Tracker Commissioning and Operation

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27/10/14

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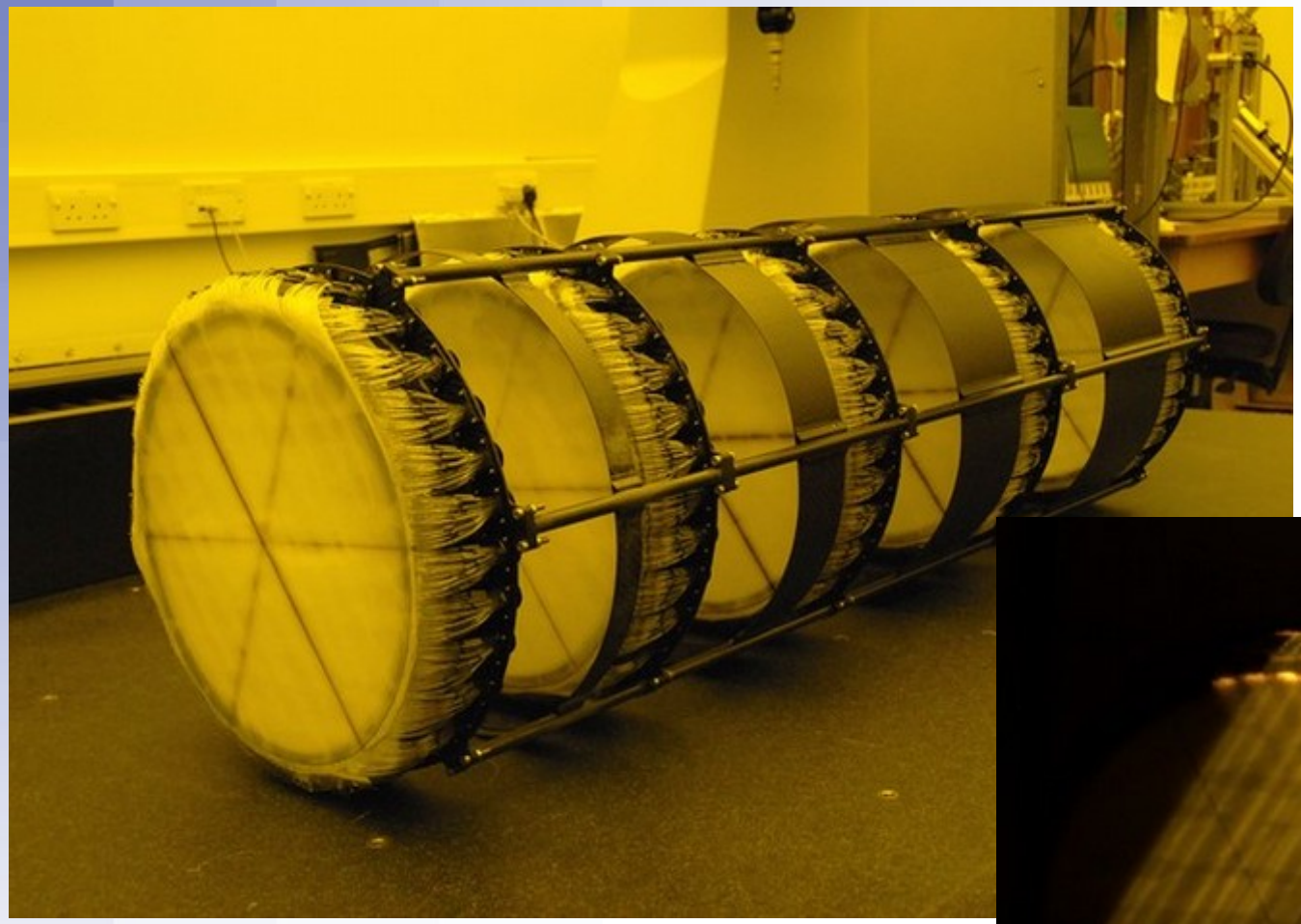
Overview

- Current Status
- Commissioning plans
  - Equipment and facilities servicing.
  - Electronics QA.
  - Fibre QA.
  - LED tests.
  - Data runs.
- Alignment plans.
- Tracker software
  - MC, geometry, reconstruction, emittance, online monitoring...

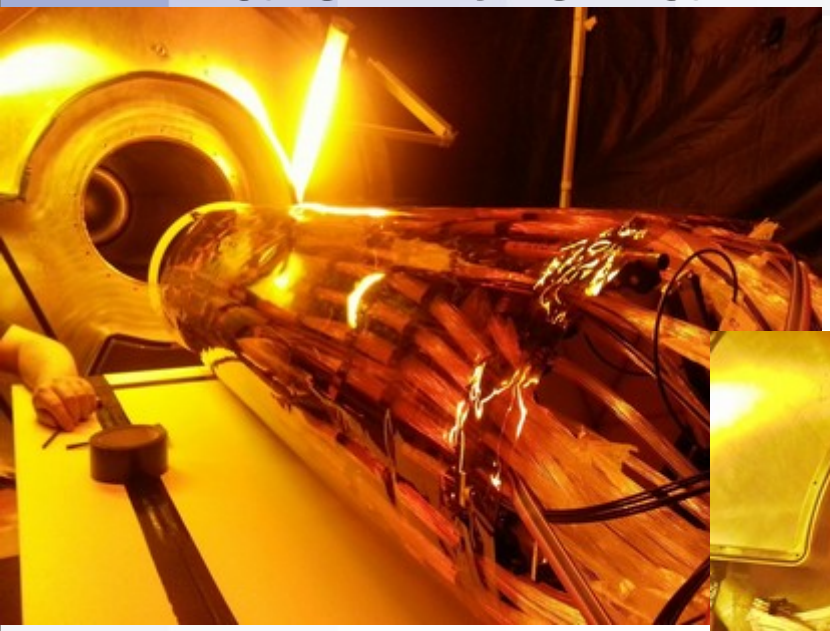
The Trackers

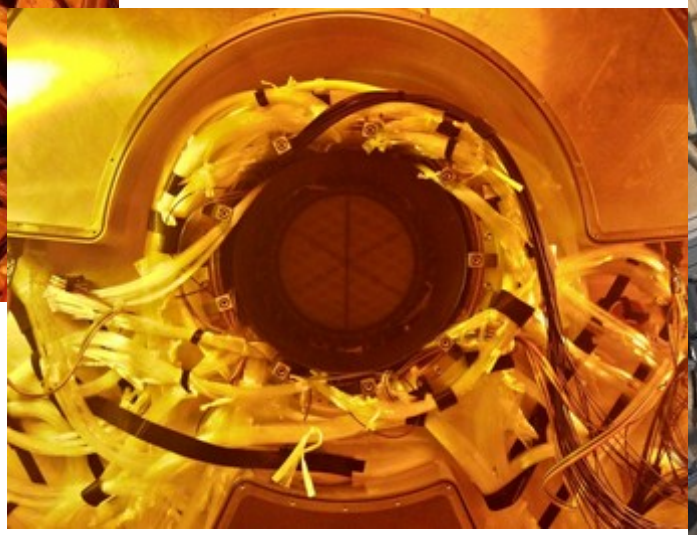


http://arxiv.org/pdf/1005.3491v2.pdf

Current Status

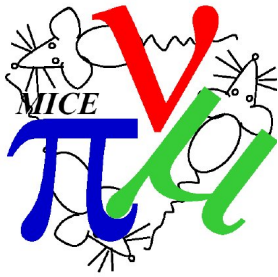
- The trackers are built, well understood and fully cosmics tested.
- Both are installed in their respective SS's and are in the hall.






MICE MUON BEAM

Tracker Commissioning Plan

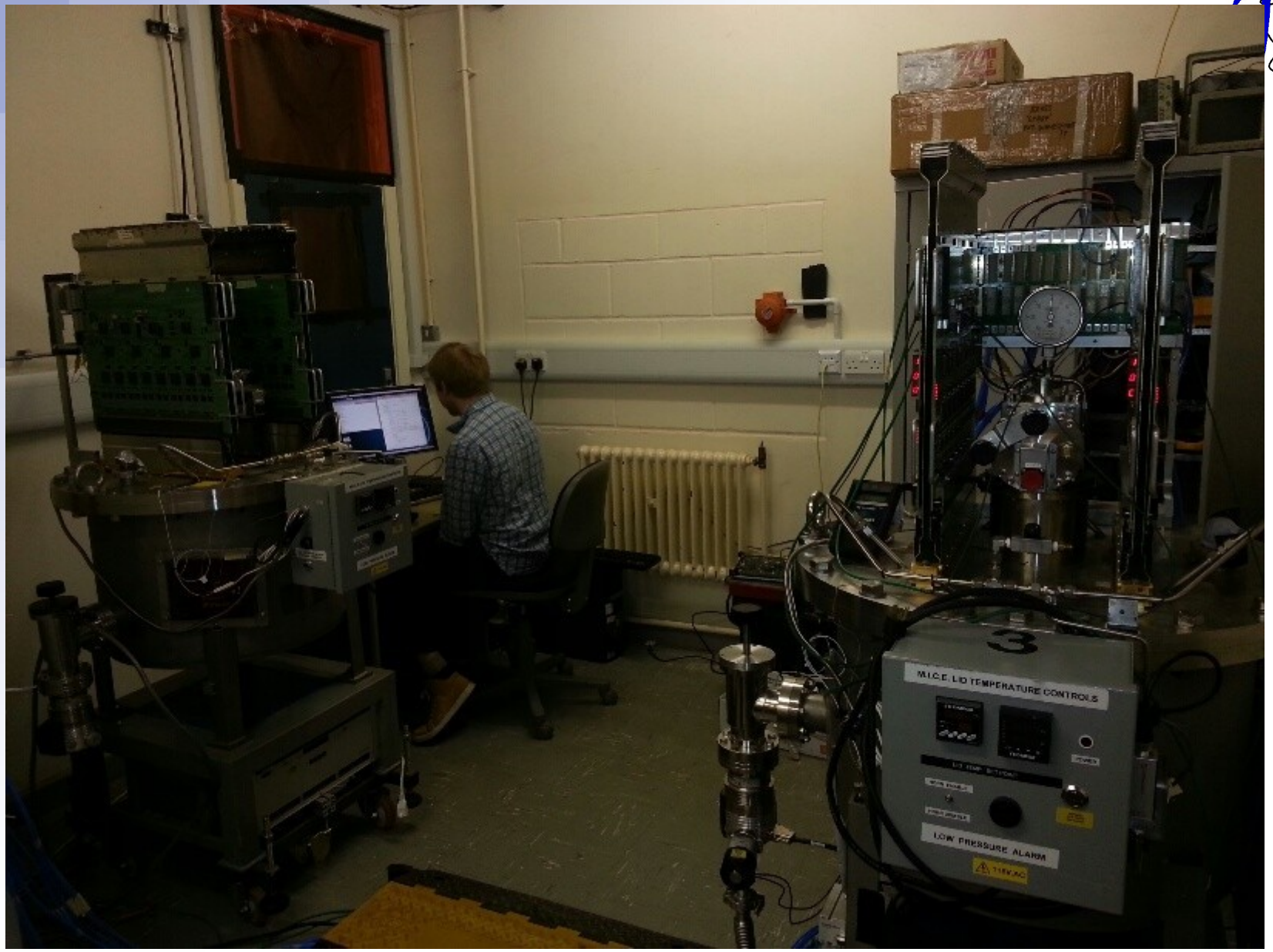


- √ Services (inc helium lines, vacuum, downstream racks etc) to run cryostats installed in MICE hall by Nov 2014.
- √ Servicing of cold heads and compressors.
- √ PSU checked/fixed/replaced.
- √ All systems that can be QA'd are being/have been QA'd.
- √ Commissioning plan.
- Alignment of Trackers ← in progress

Tracker commissioning

- Efficiency studies are underway.
- LED system is in place in the Trackers and will be used for readout calibration and eventually for timing calibration.
  - Illuminate all channels with LED and measure mean light yield (scaled to LED location)
  - Use efficiency map to re-simulate performance and emittance resolution
  - Work taking place in November
- Waveguides (fresh for QA) will be installed and the mapping checked in November.
- Installation of all compressor/cryostats. Cool-down of cryostats full test of vacuum and cryo systems.
- Upload firmware onto electronics spares taken from D0.
- Alignment work is in progress and will take us through to the end of the year.

Electronics QA



For full details see David Adey's Talk Yesterday

QA of existing electronics

8/30 – 9/13

- QA setup using fast-DAQ and internal triggering of AFES – no external pulser or RF period generator

- 16 AFE boards (front end electronics – lots of spares) currently in use rotating on cryostat 3

- All currently used LVDS cables (data cables, very difficult to replace)

- All currently used VLSB boards (VME buffers, almost impossible to replace)

For full details see David Adey's Talk Yesterday

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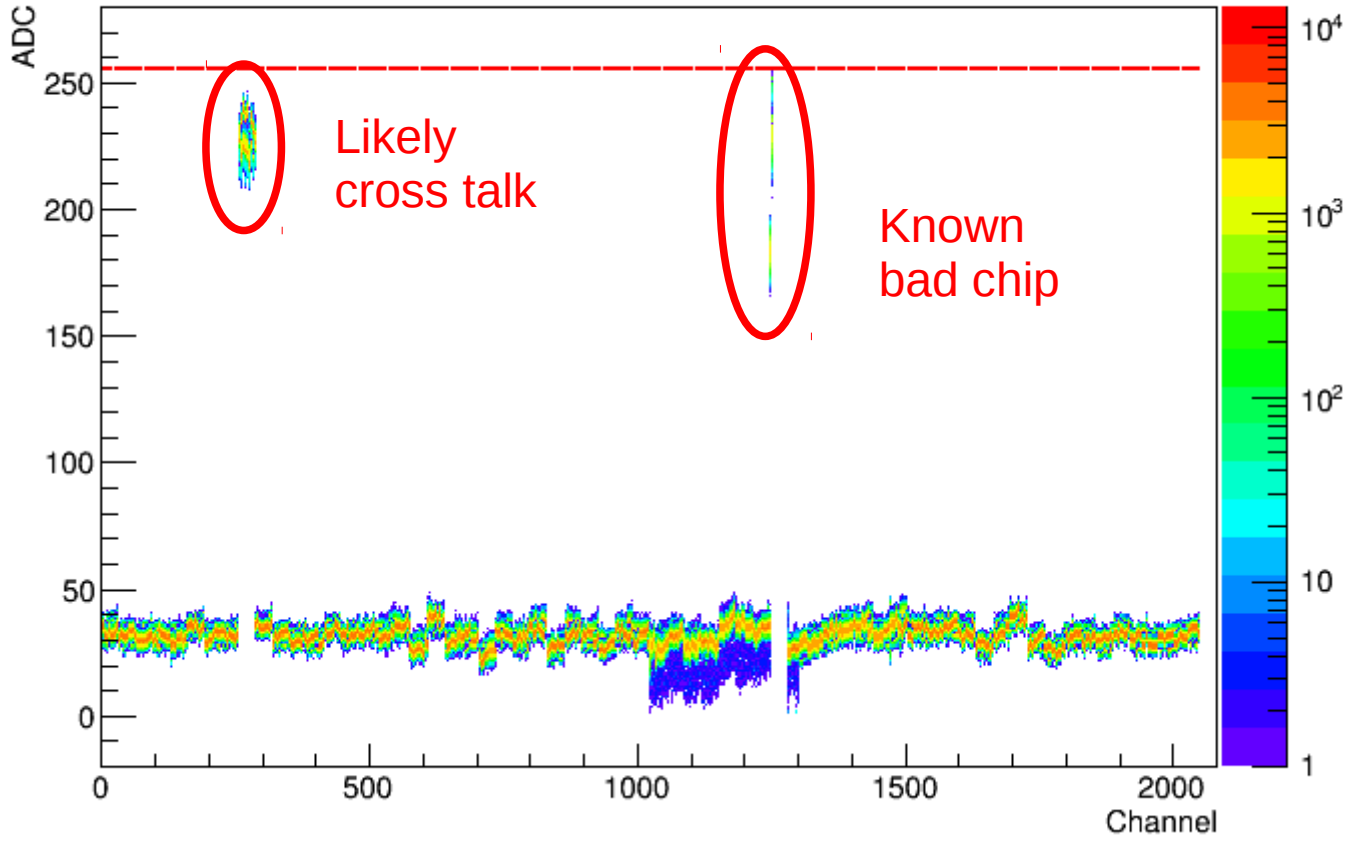


For full details see David Adey's Talk Yesterday

Electronics QA Summary

- 3 boards with complete dead/malfunctioning chips
- Up to 4 more boards with semi-functioning chips eg. Cross talk.
- Cross talk may not be so much of an issue using real signal injection, and should in any case be dealt with by reconstruction – low level noise issue
- One known dead LVDS cable out of 64 – spares available but limited
- All bias circuits were confirmed. Heater circuits unavailable without cold system
- VLSBs functional except for one known board with single dead bit on event number input – 50% spares
- VME controller failed on final run – probably the fibre

For full details see David Adey's Talk Yesterday

Next

- Modify, upload firmware on new set of spares (4 + 16 taken from D0)
- Verify spare set
- Replace boards with dead chips
- Firmware updates and replacements can take place during installation in November
- Second round of QA depending on time

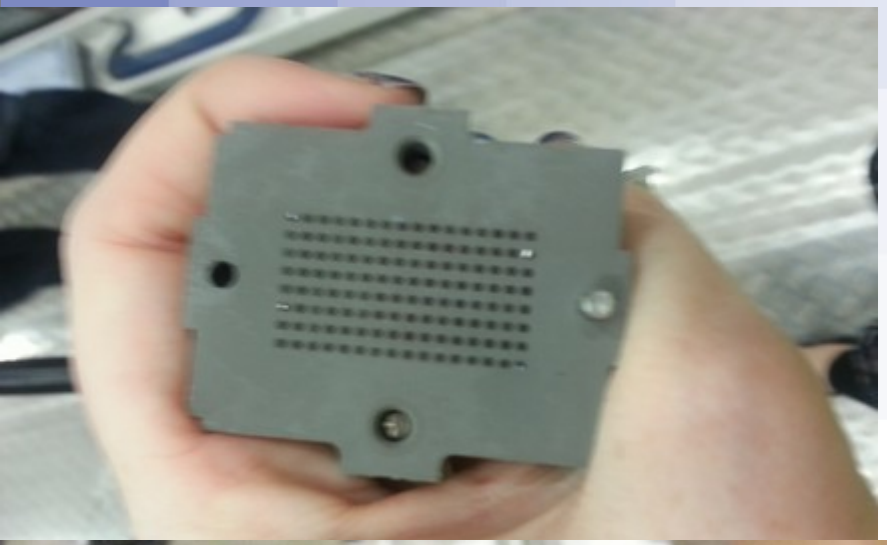
External Waveguide QA

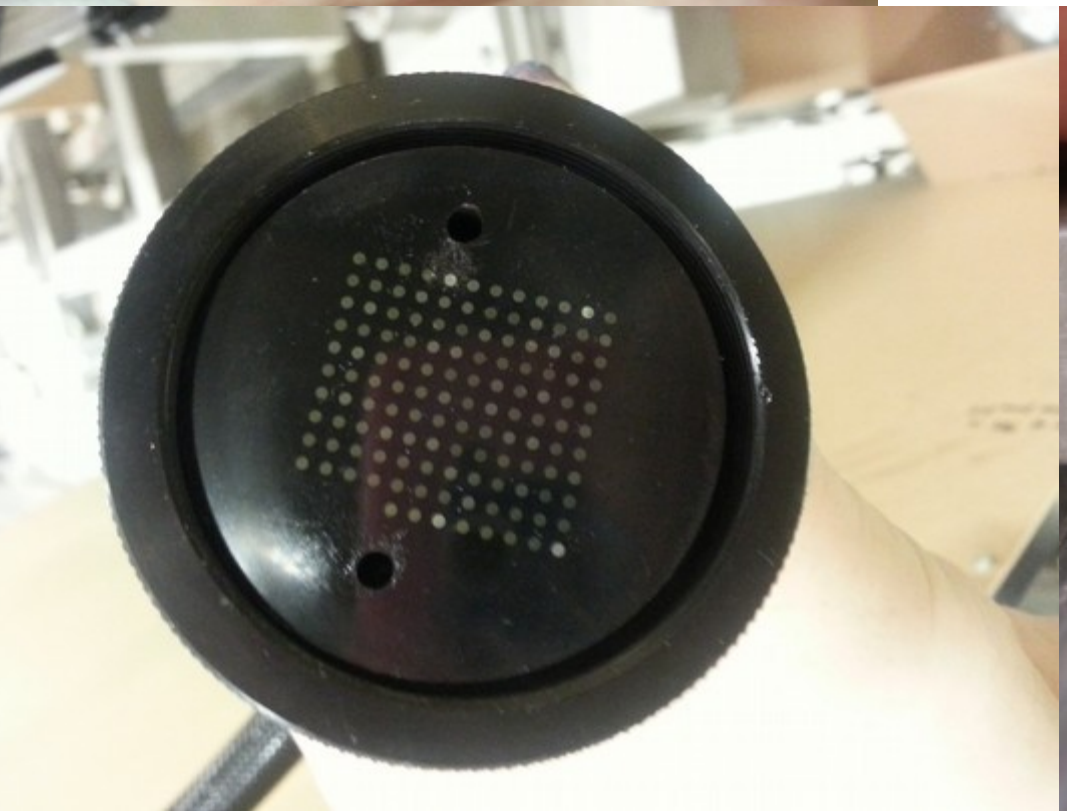
The Team:
Jan Greis
Kevin Ladhams
Celeste Pidcott
Melissa Uchida

Motivation:

The Waveguides

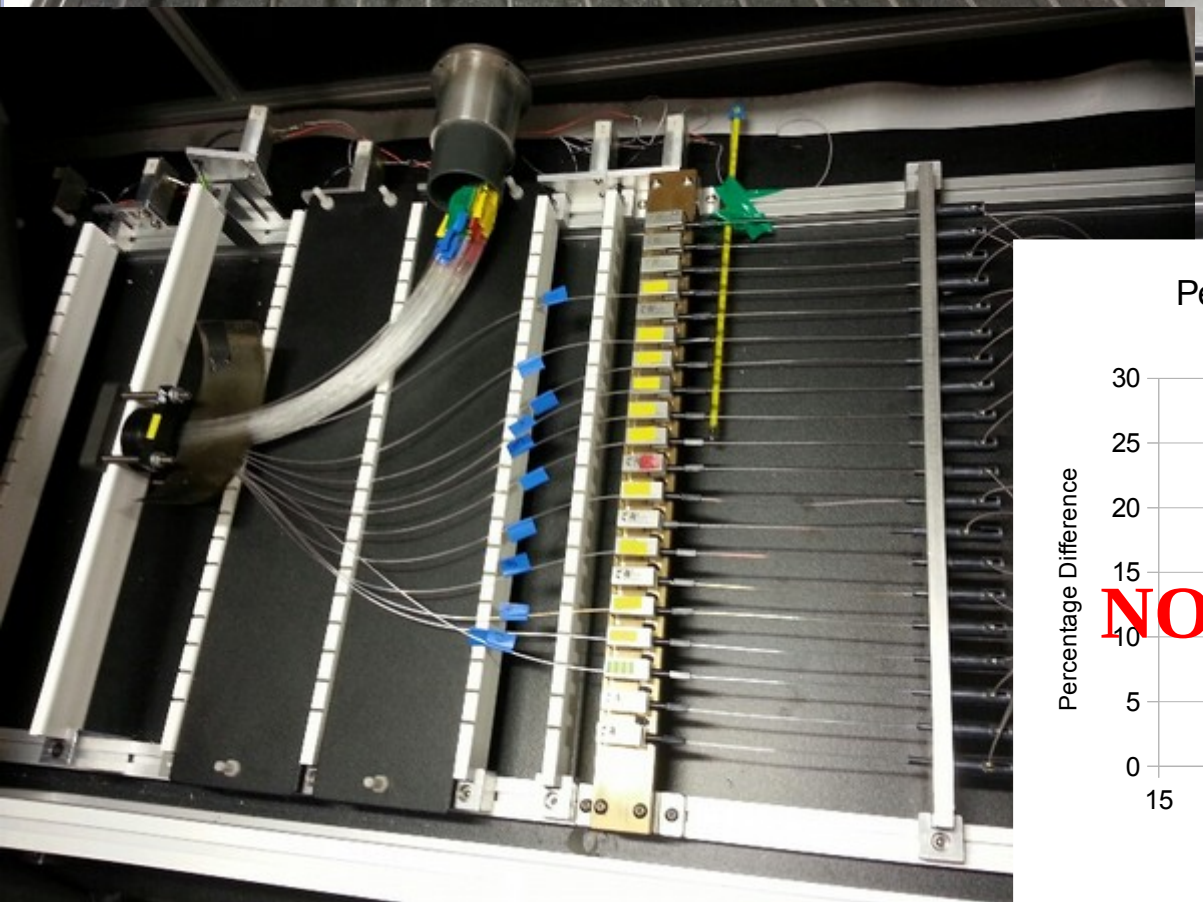
- All fibres transmit light but
- ~3/128 show signs of damage
- Effect likely due to cracks
- Extent of impact on light yield unknown – Purpose of QA

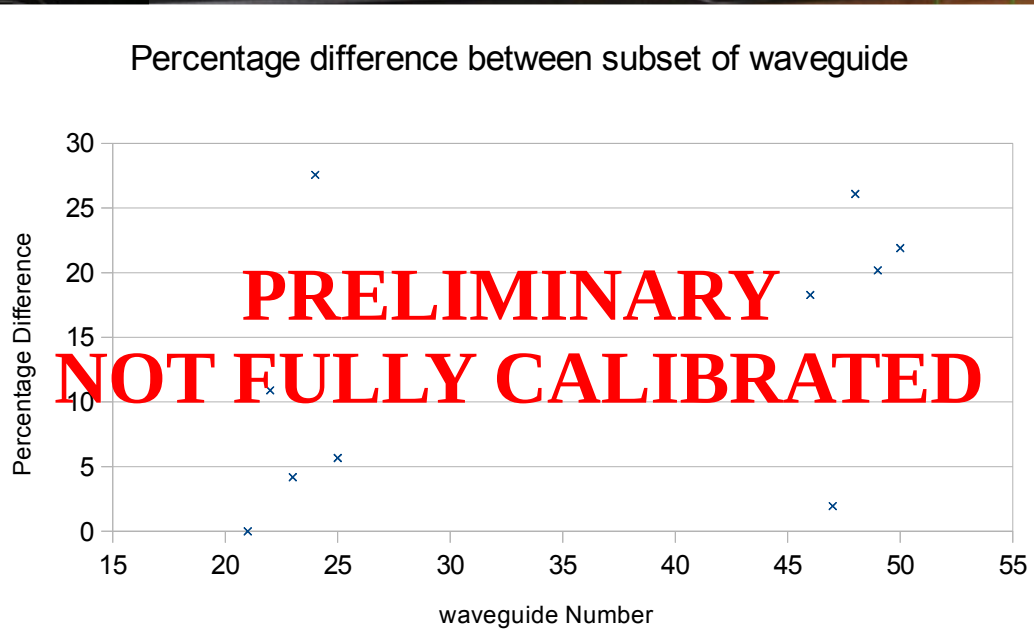




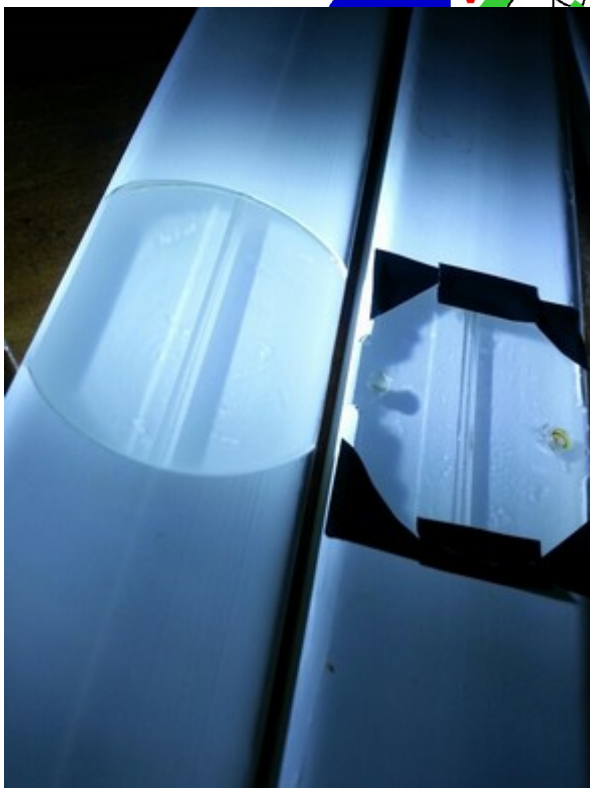
External Waveguide QA

The Scanner





Lightguide Fibre QA



- We adapted an existing scanner that was built for T2K to allow us to keep costs down.
  - Waveguides connect to a connector piece (as they will on the Tracker). Nothing was taken apart/changed/fiddled with.
  - Fibres illuminated by scintillator bars of extruded polystyrene with LED input
- Fibre QA does not impact tracker installation or commissioning.
- Every element has been fully calibrated and all systematics considered.
- Half of the fibres scanned.
- Data analysis underway.
- We have a plan in place for production of spare lightguides.

Alignment

- Mechanical alignment
  - of tracker inside bore to ~250 microns.
  - of SS (physical) bore to cold mass to <1mm. ←field maps available and will be analysed.
  - of SS in hall possible to ~1mm .
- Internal alignment

  a)Rotational offsets between tracker stations ← work in progress.

  b)Non-parallel tracker stations (pitch) ← Has been considered but has been shown to have negligible impact.

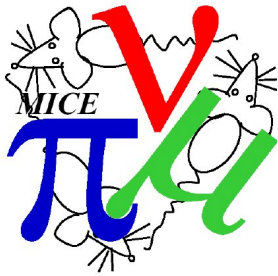
  c)X-Y offsets in trackers stations ← Accounted for in software by E. Santos.
- Between US and DS Trackers
  - Misalignment between the two Trackers ← work in progress.

See talk by M. A. Uchida yesterday

Alignment Between Tracker Detectors

- Tracker misalignment **cannot** affect emittance of the beam only the measurement of it...
- Compare tracker, bore and cold mass alignment data.
  - We have the data from SSU and SSD is available
- Study (mathematically) the effect of misalignments (offset and rotation) between Trackers on emittance measurement sensitivity.
- Full MC study of misalignment including scattering effects with manually offset DS Tracker to US Tracker by <3mm and <3mrad.
- From this we will finalise our plan to handle this in SW.
- Track based alignment using beams without field.
  - Run plan being determined.

Tracker commissioning Data runs



- Readout commissioning – no beam, random, cosmic and LED triggering to iron out VME based trigger logic – 2 days

- Calibration – no beam runs with LED varying bias, discriminator and TDCs (latter two not Step 4 essential) – 4 days (bias) + 4 days (discriminators) + 4 days (timing) = 12 days

- Timing commissioning – starting with LED and moving to beam to ensure integration and veto period align with arrival of particles – 5 days

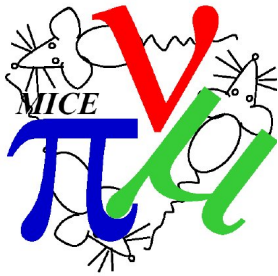
- Alignment checks – no field straight tracks to reconstruct actual alignment of tracker in reference frame – 5 days

TOTAL: 24 days

Tracker Software

For full details see A.Dobbs' SW and C. Hunt's Emittance talk from parallels

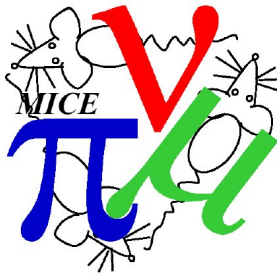
Software since last CM



- Full real geometry now in MC (inc He window and diffuser) thanks to the Chris' Heidt and Hunt.
- Kalman now probably in final form (E. Santos has finished), latest updates in trunk and will in be MAUS 0.9.2.
- MC noise algorithm updated.
- Emittance studies underway, seeing reasonable numbers for the emittance error.
- Online plots under are defined, agreed and in development.

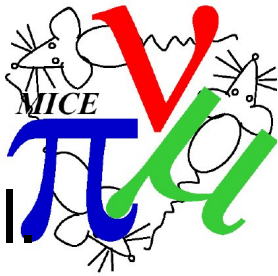
For full details see A.Dobbs' SW and C. Hunt's Emittance talk from parallels

Software Next Steps



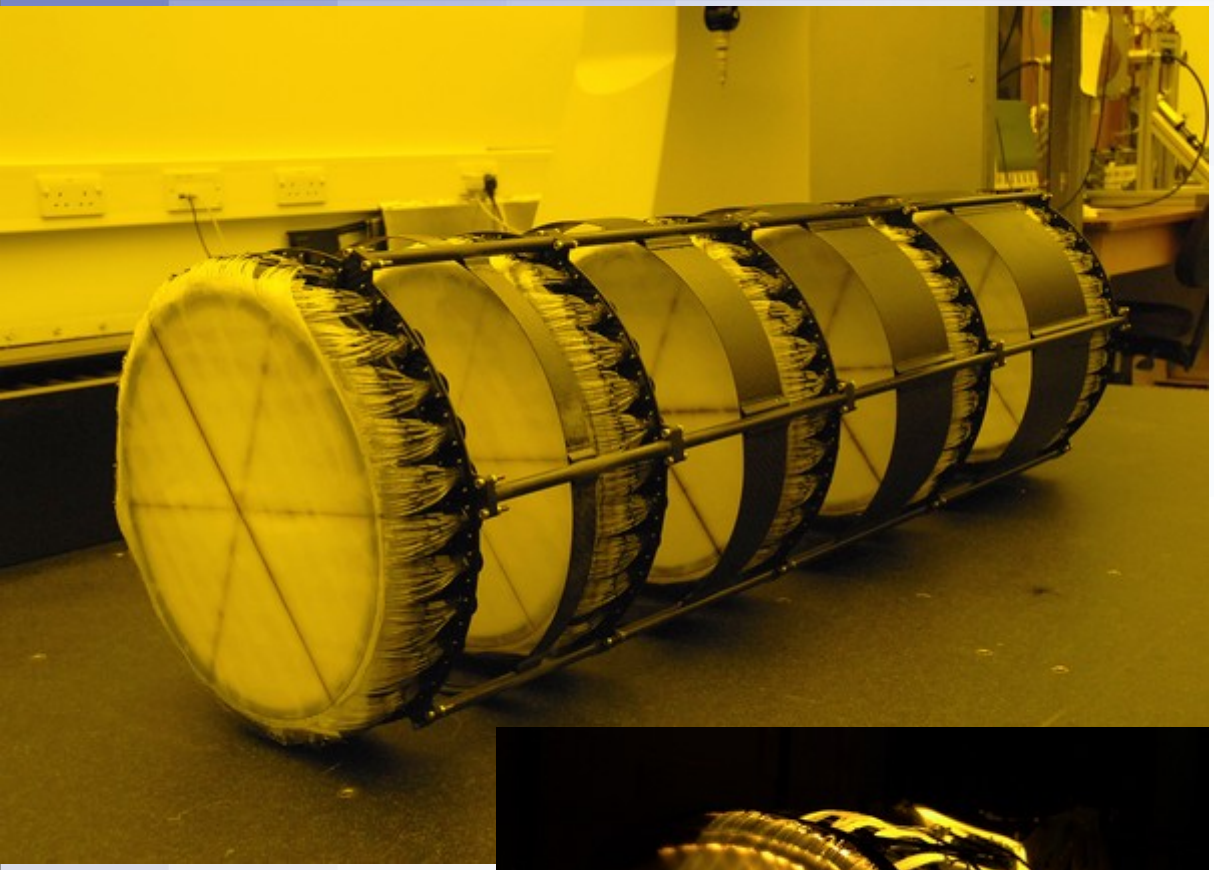
- Low p_t efficiency is poor, need to determine if and how much this is a problem ← A. Dobbs
- No trigger MC and pattern recognition not properly tested ← R. Bayes
- Real data unpacking broke between MAUS 0.7.5 and 0.7.6 ← D. Adey
- Determine if we need to improve final emittance reconstruction performance ← C. Hunt
- Finish implementing analysis framework ← A. Dobbs
- Get MC ADC smearing / finish noise work ← C. Heidt
- Handle shared spacepoints ← A. Dobbs
- Create online displays ← M.A. Uchida
- Track and spacepoint level efficiency studies ← A. Dobbs and C. Hunt
- Documentation ← A. Dobbs
- Tracker software paper in production (first draft to be circulated very soon) ← A. Dobbs

Conclusions



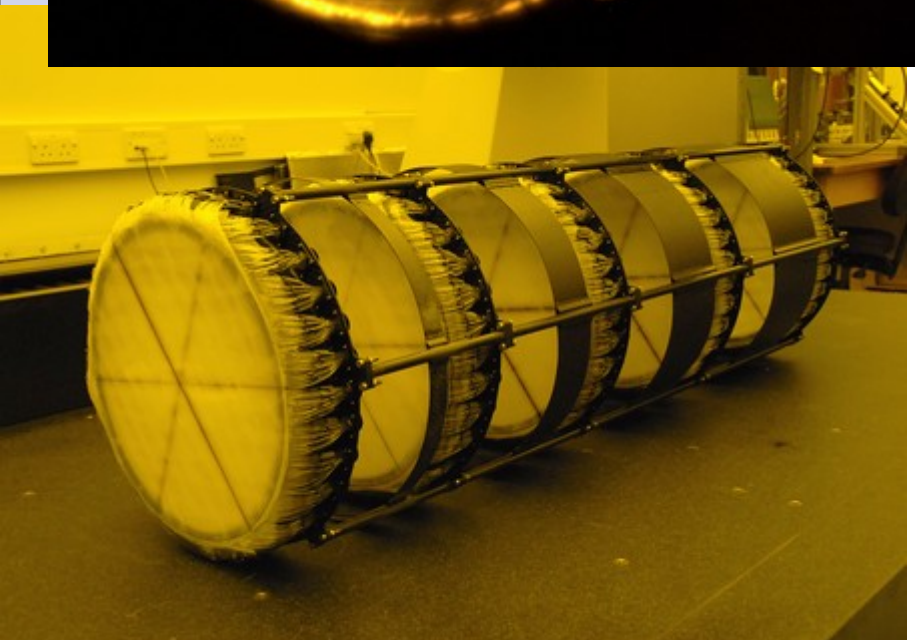
- Both Trackers installed and the USS and DSS in hall.
- Diffuser fitted.
- Services are ready for us in the hall so that we can run cryostats.
- Commissioning has already begun and a lot of work is happening in November.
- Everything that can be QA'd or serviced has been/is being.
- Alignment work is in its early stages but will push forwards.
- Software in good shape and improving all the time.
- Emittance using software.

The Trackers



- Two scintillating fibre trackers, one upstream, one downstream of the cooling channel.
- Each within a 4T spectrometer solenoid.
- Each tracker is 110 cm in length and 30 cm in diameter.
- 5 stations per tracker at varying separations in z between 20 and 35 cm.
- LED calibration system.

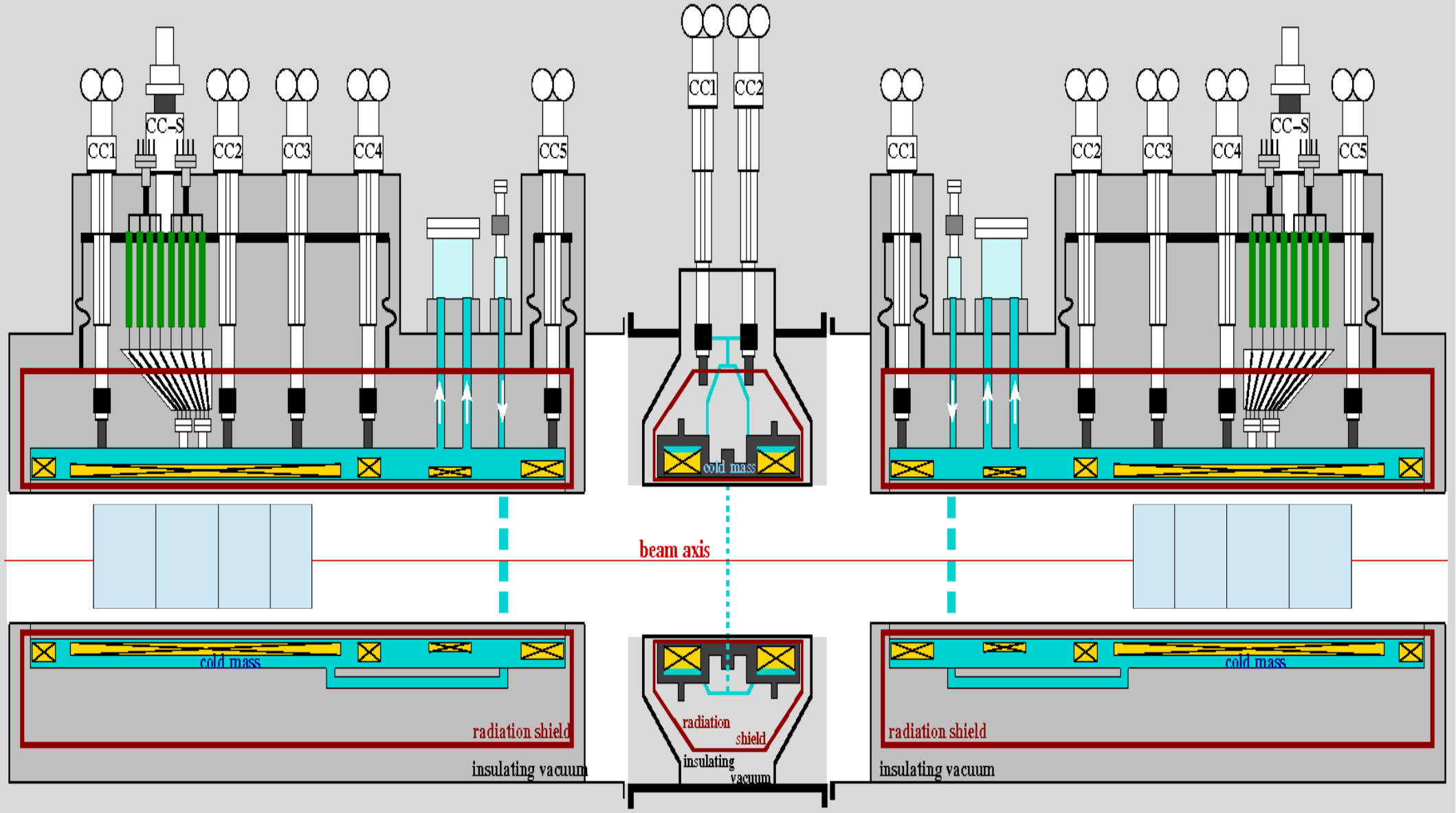
The Trackers



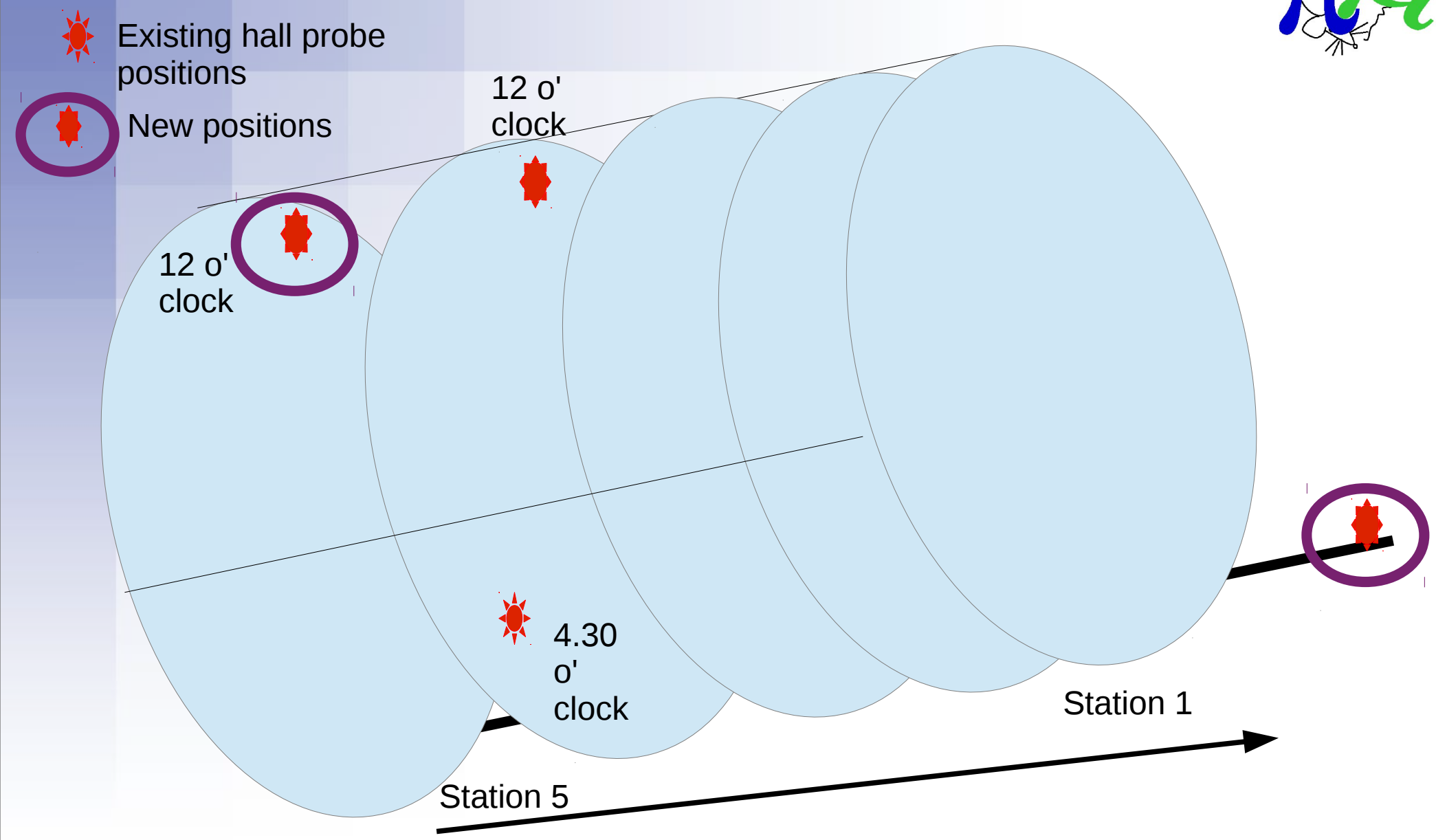
- 350 µm scintillating fibres are glued into doublet layers with a thickness of 627µm.
- 7 fibres are grouped into a single readout channel. (This reduces the number of readout channels, while maintaining position resolution)
- 3 doublet layer fibre planes per station, each offset by 120 deg.
- Position resolution of 470 µm per doublet layer.
- Fibres readout by Visible Light Photon Counters, operating at liquid He temperatures.
- Digitised by FPGA based system from D0.

Spectrometer Solenoids

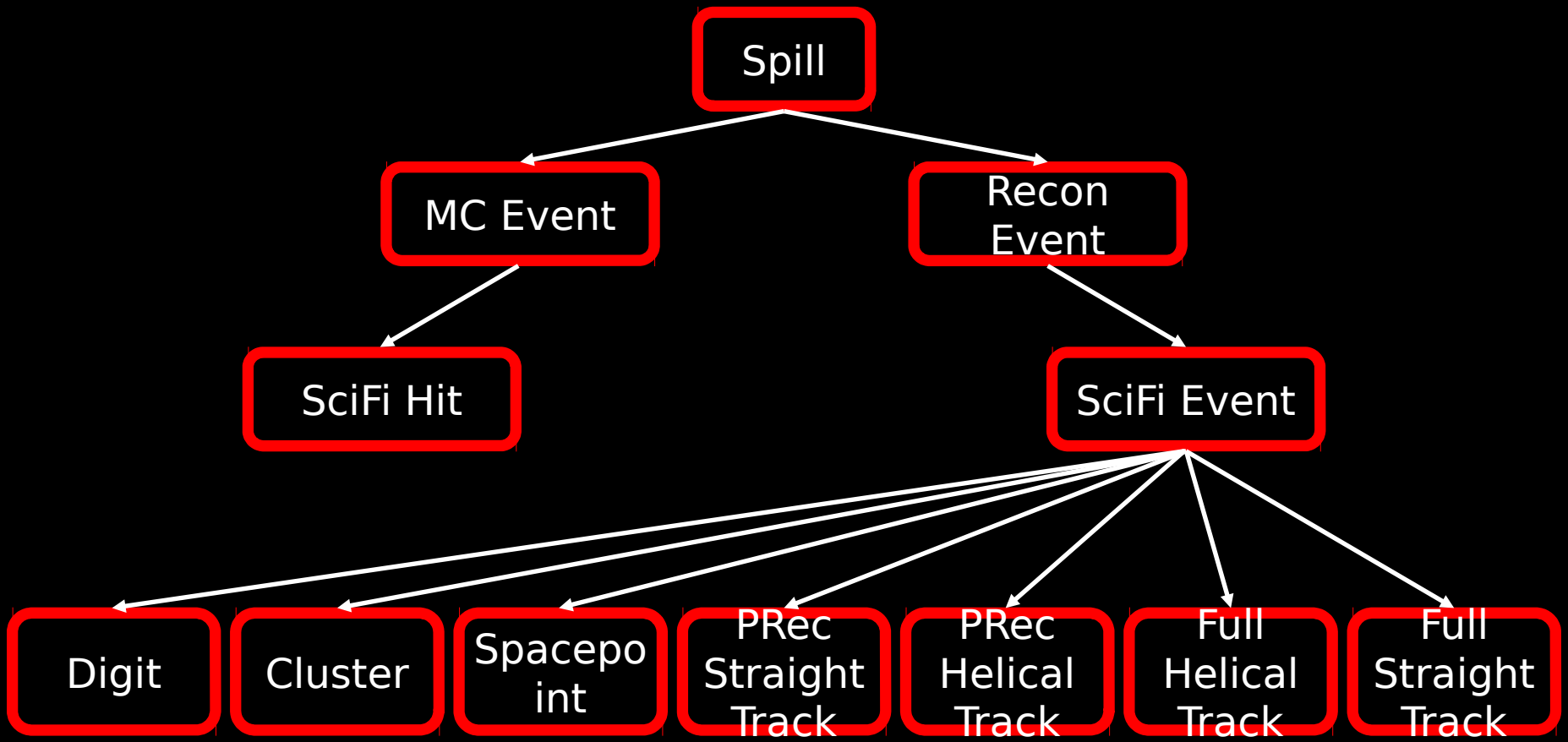
Not to scale



Hall Probe Positions



Data Structure I



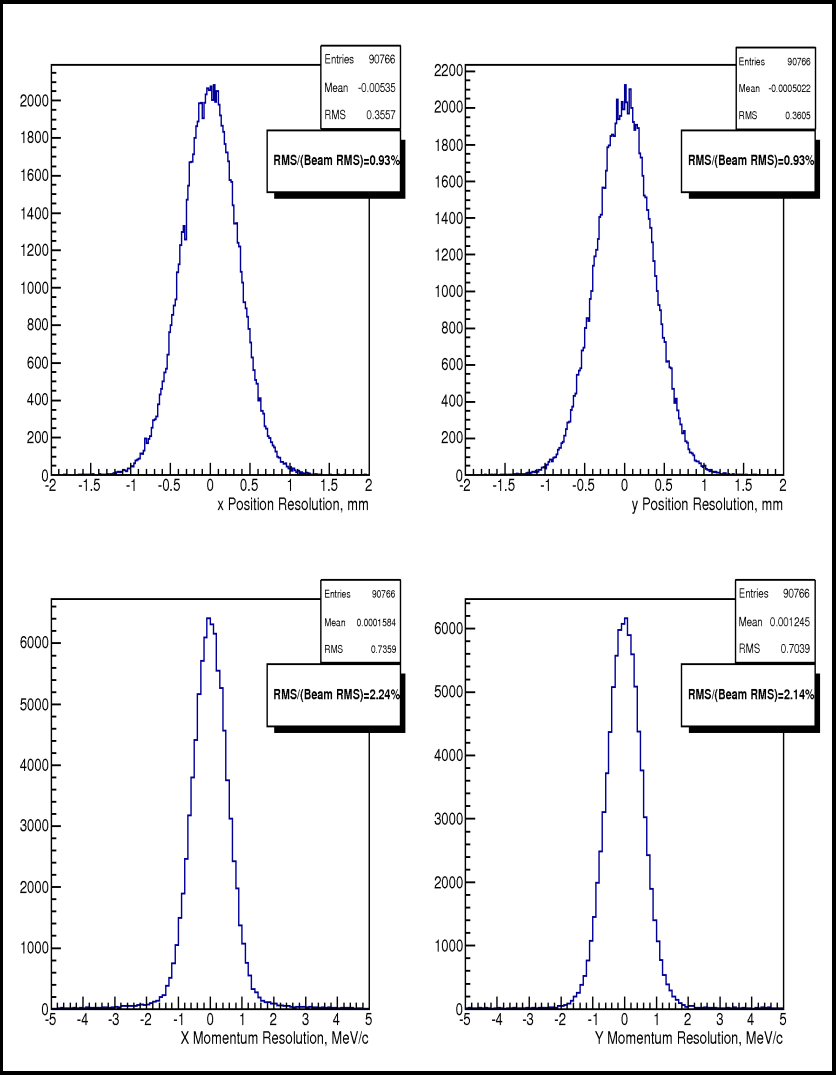
Data Structure II

- **Hits** – Monte Carlo objects formed when a particle traverse a detector
- **Digits** – Detector response to a channel hit
- **Clusters** – Groups of digits from adjacent channels in same plane
- **Spacepoints** – 2 or 3 clusters from different planes on the same station, giving an (x,y) position
- **PRec Tracks** – Tracks found by Pattern Recognition
- **Full Tracks** – The final tracks produced by the Kalman fitter

Reconstruction

- Digitisation – unpack the real data or digitise MC data
- Clustering – look for adjacent channel hits and group them
- Spacepoints Reconstruction – look for intersecting clusters on different planes
- Pattern Recognition – use a linear least squares circle fit in x-y, and straight line fit in s-z to associate spacepoints with tracks
- Final track fit – use a Kalman filter to smooth and filter the tracks, accounting with multiple coulomb scattering and energy loss

Kalman



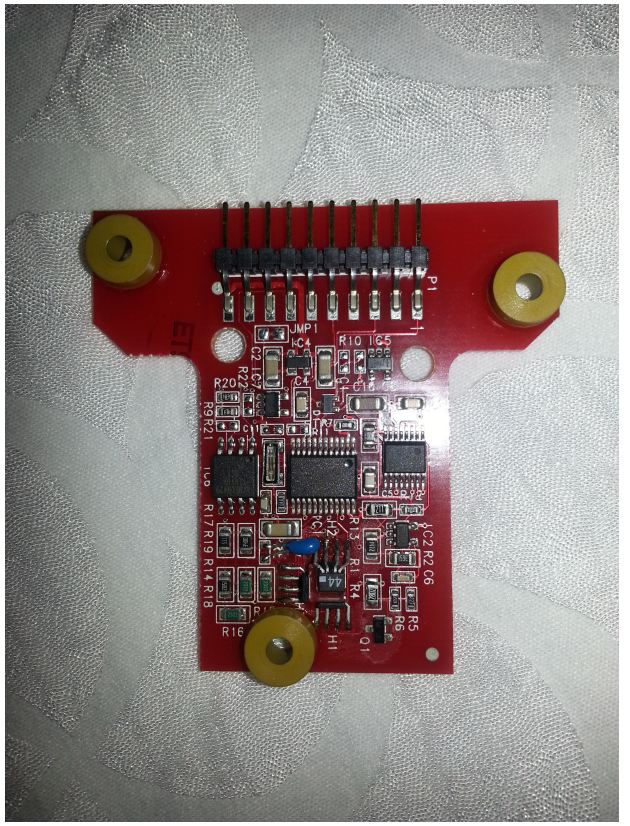
- Resolution of the track parameters computed as the difference between MC truth and reconstruction values
- The distribution RMS to beam RMS ratio is shown
- Requirement of being able to measure 10% change in beam emittance to 1% accuracy means that transverse momentum resolution must be better than 10% of the beam RMS
- Results show we are well within this requirement!

Magnetic Field Homogeneity

Inside solenoids

SS data analysis under way by

V. Blackmore.

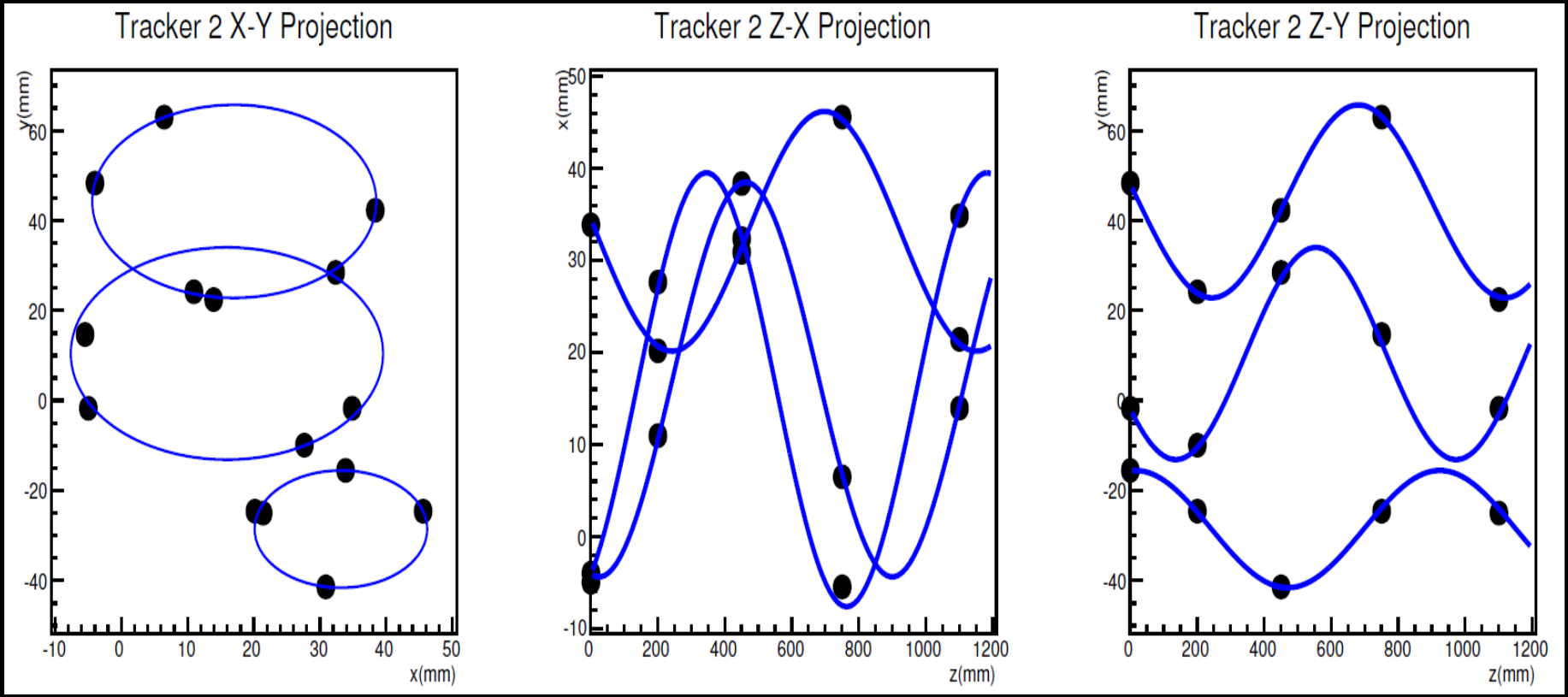


Inside trackers

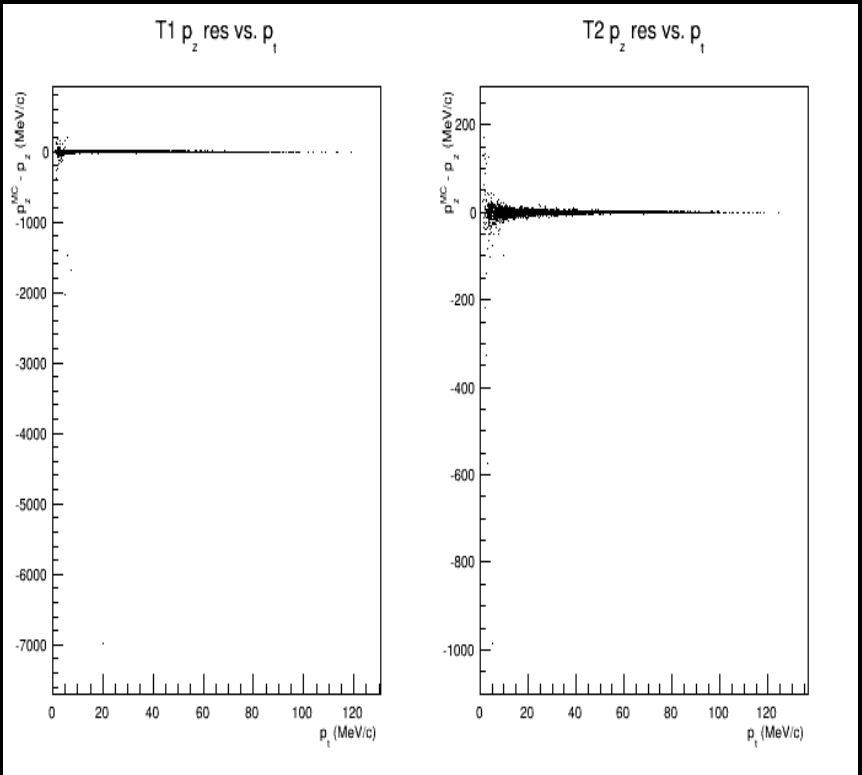
Hall probes inside trackers.

- We have 4 probes per tracker.
- 3 z and 3 rotational positions
- Software that will work with our C&M is in place but we will be working to develop and improve it.

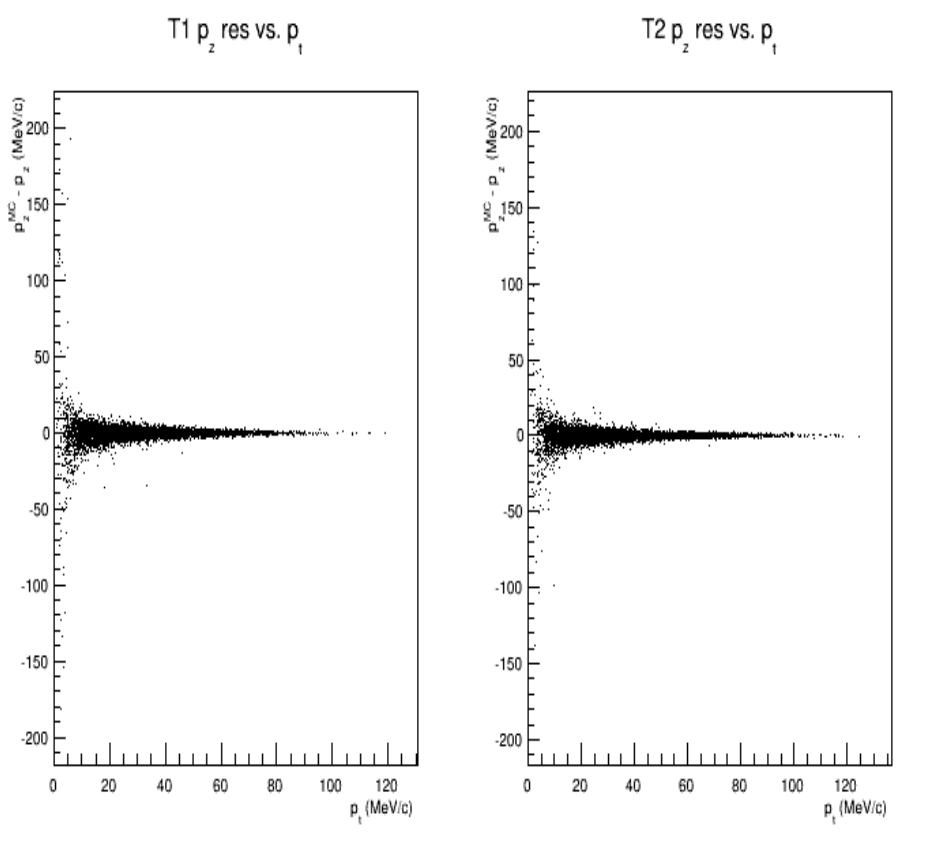
Pattern Recognition



Helical Pattern Recognition tracks in T2, shown using a Reducer



Zoom



Longitudinal momentum residual vs transverse momentum

- Low pt tracks produce larger pz momentum residuals – in keeping with expectations