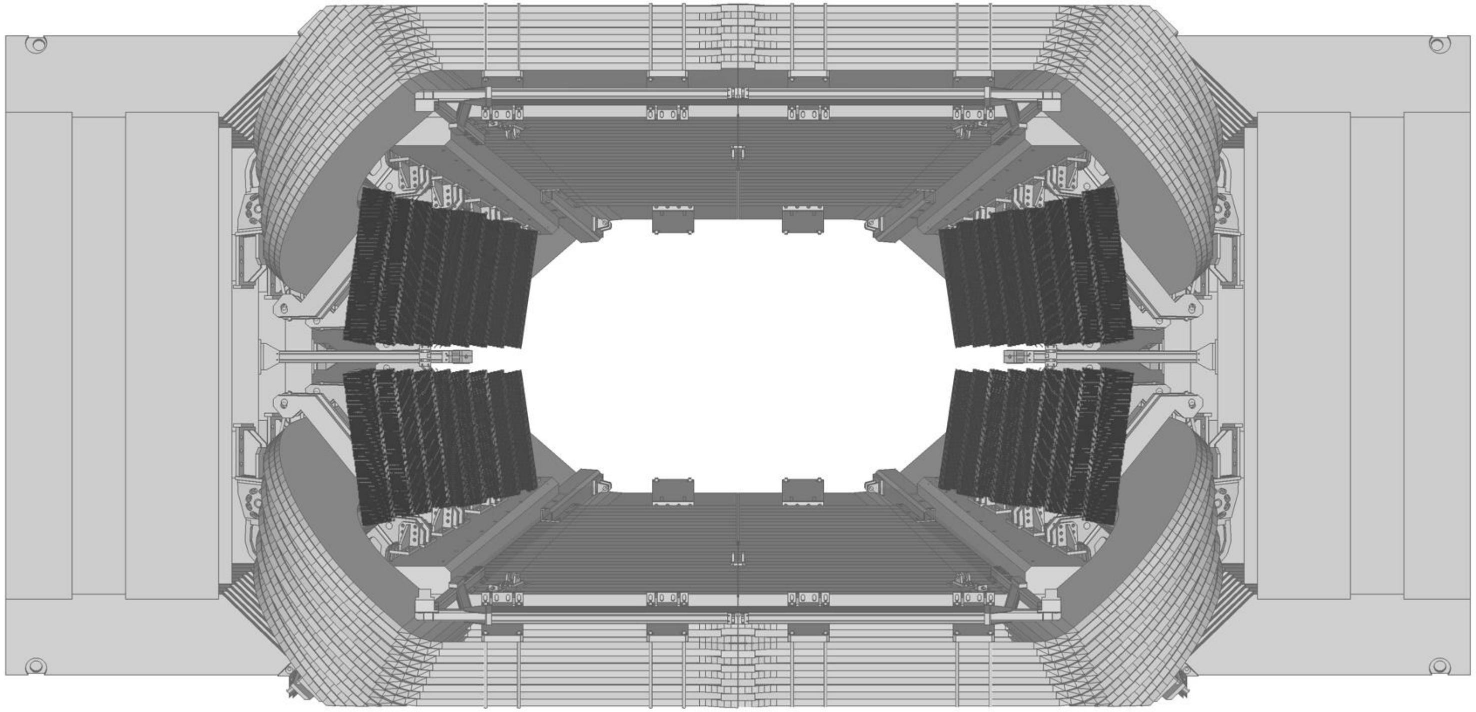
Magnet Station Geometry Optimization



Nicolas Schmidt
Los Alamos National Laboratory

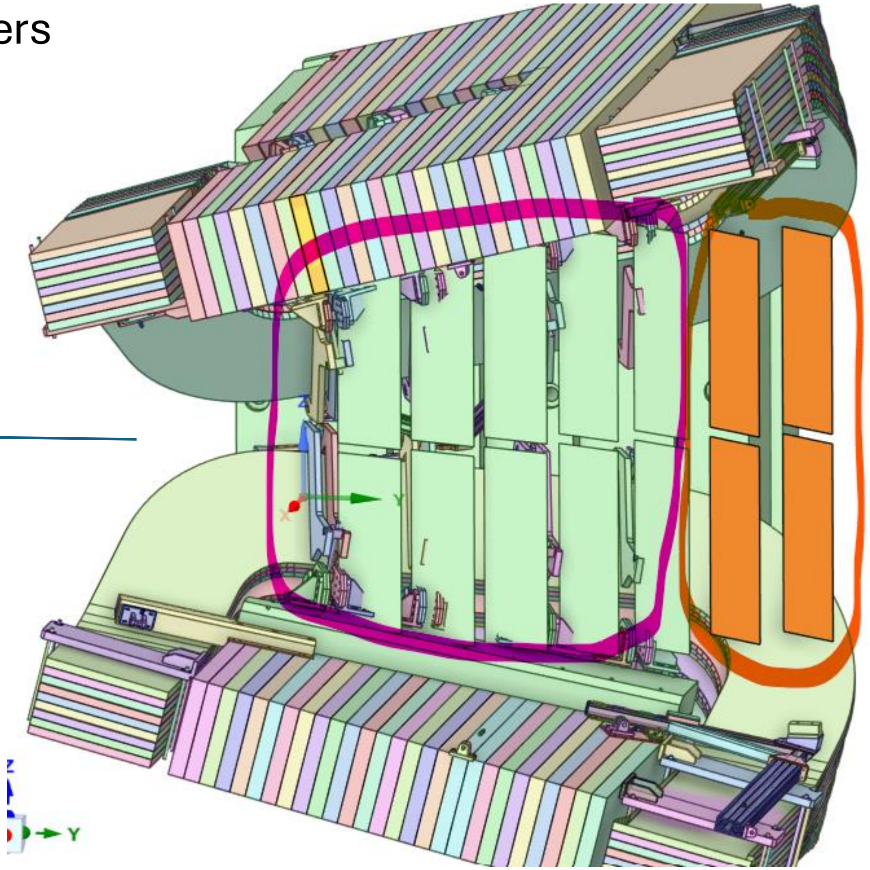
Los Alamos NATIONAL LABORATORY

LHCb

Issues with last design

- Internal magnet support structures not part of Geant4 simulation model
- Significant overlaps found by engineers within CAD model
- Adjustments necessary!

10 panels in collision with MS structure (on one side of MS)



Only 4 panels without collision with MS structure (only on one side of MS)

Thanks for the stp files!

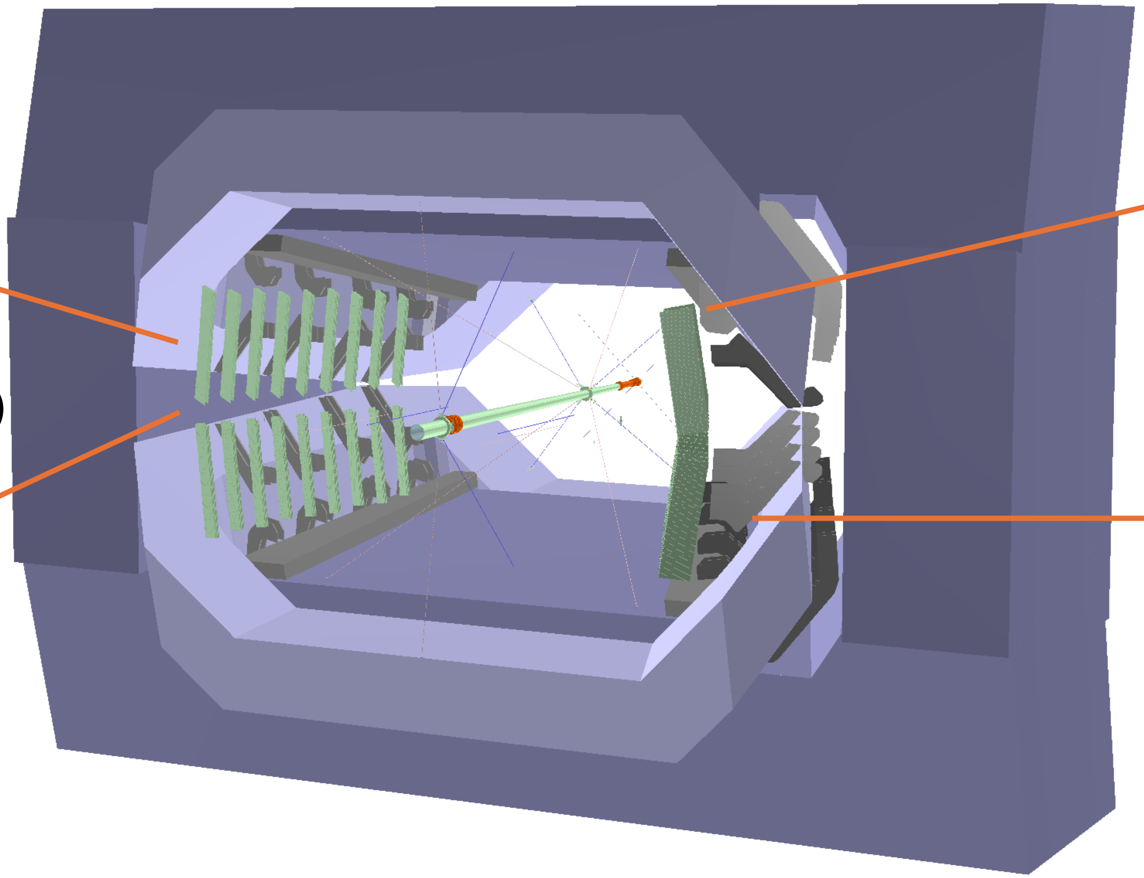
Design changes:

Modules:

- 9 Modules
  - 30cm wide
  - 30cm spaced
  - 0.95m tall first module (larger modules at larger z)
- Approximately 64k channels

Gap between stations increased from 10cm to 20cm

- Reduction of coverage in high activity region



Optimized clearance of support structures

- Small tilt of 8.6 degrees of stations

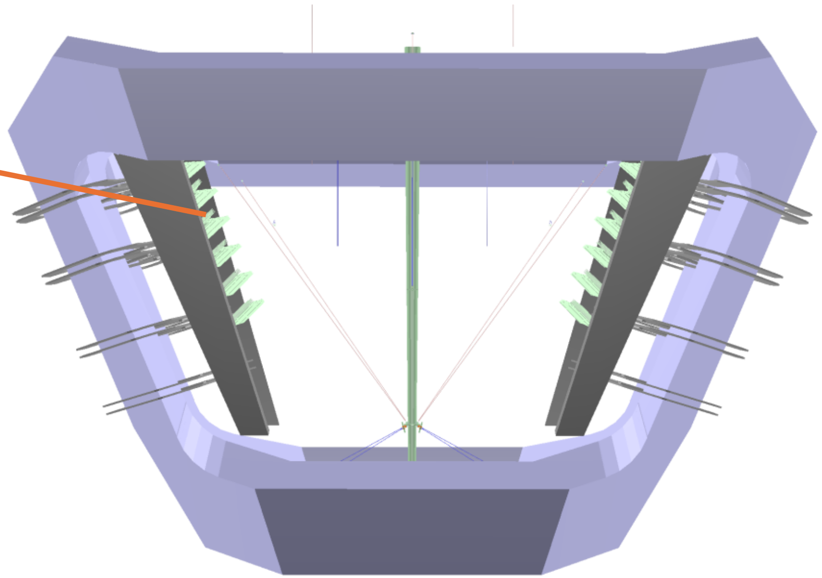
Main support structures added to Geant4 model

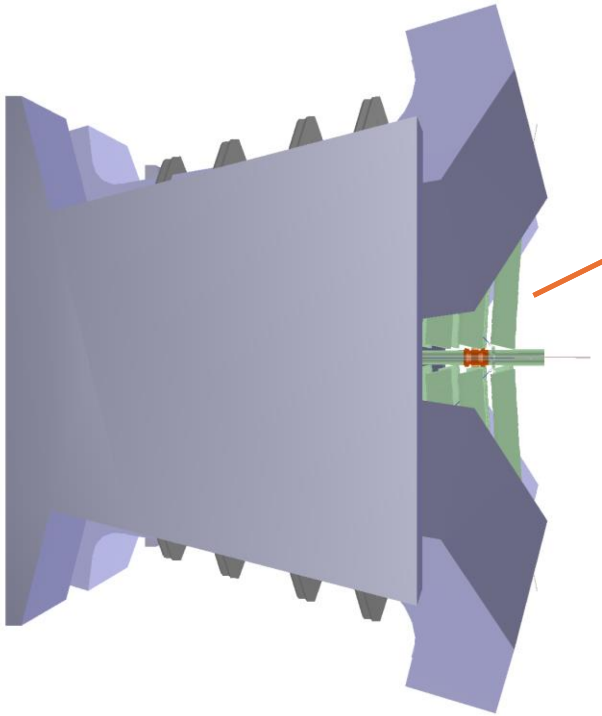
- Based on provided stp file
- Not perfect, but approximately right size and position

Design changes:

Stronger rotation of modules from 40 to 68 degrees

- Needed for tracking performance





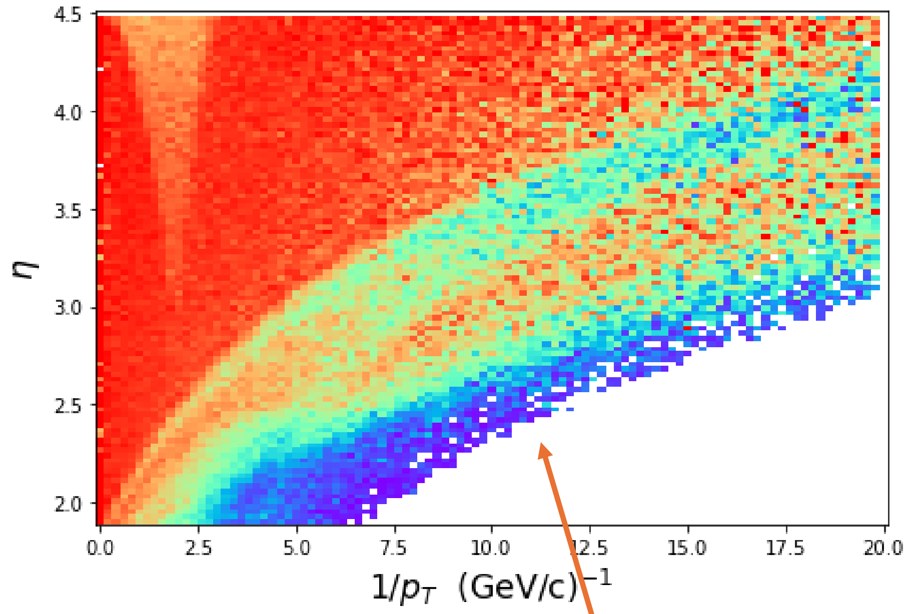
Less protrusion from magnet

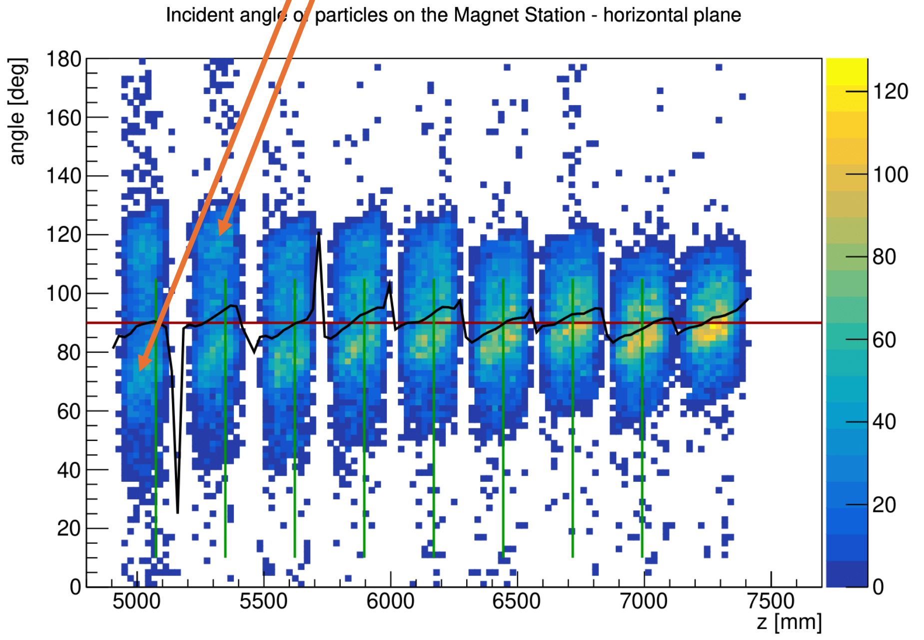
- Should allow for access to magnet without removal of last modules

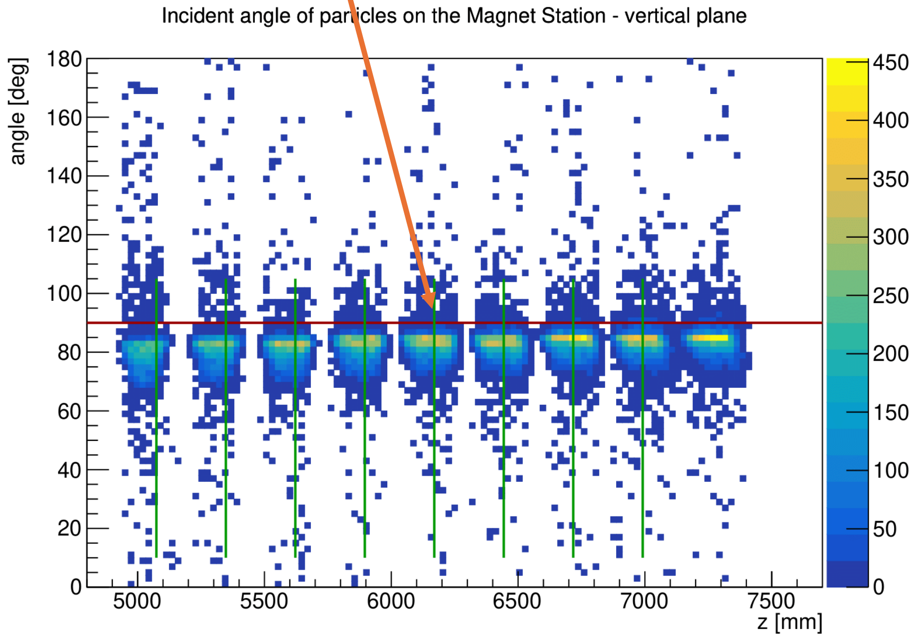
Impact on performance:

Impact angles of particles on Magnet Station are excellent with new design

- Previously small error in computation of angles
- Small tilt of stations retains excellent vertical impact angle
- Horizontal distribution affected by:
    - particles bent in the magnetic field to MS
    - particles directly hitting the MS straight on

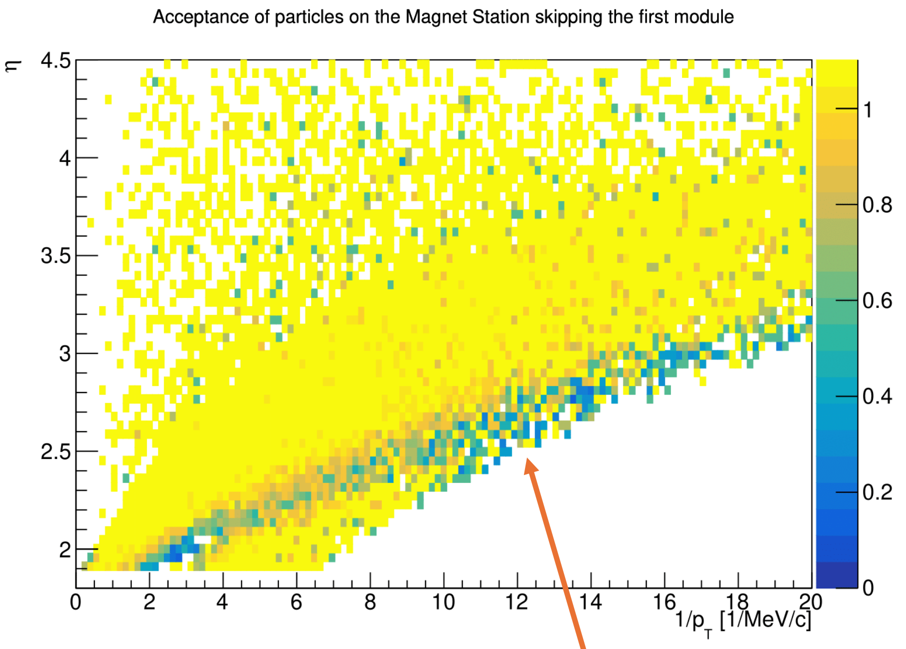






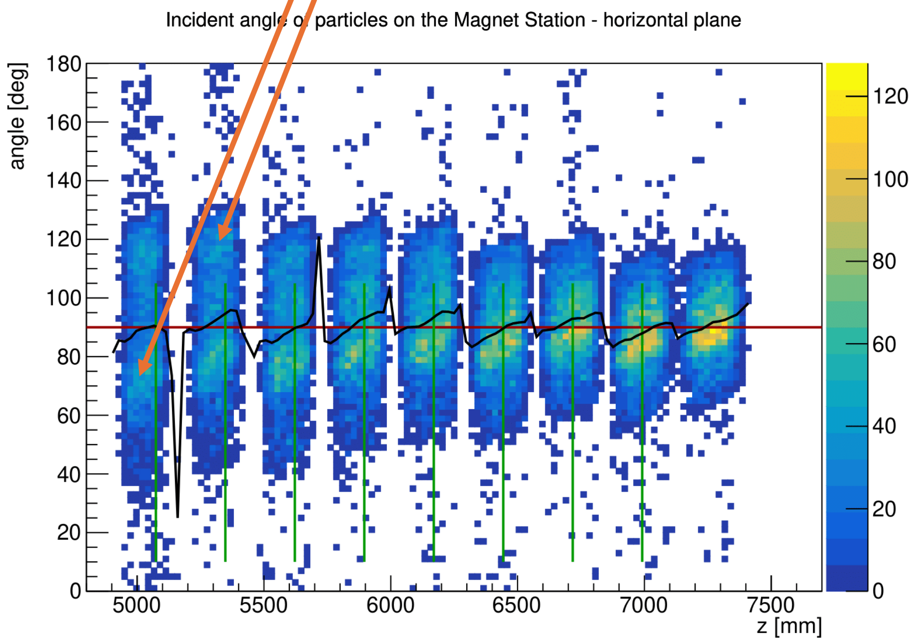
Acceptance of new design comparable to previous version

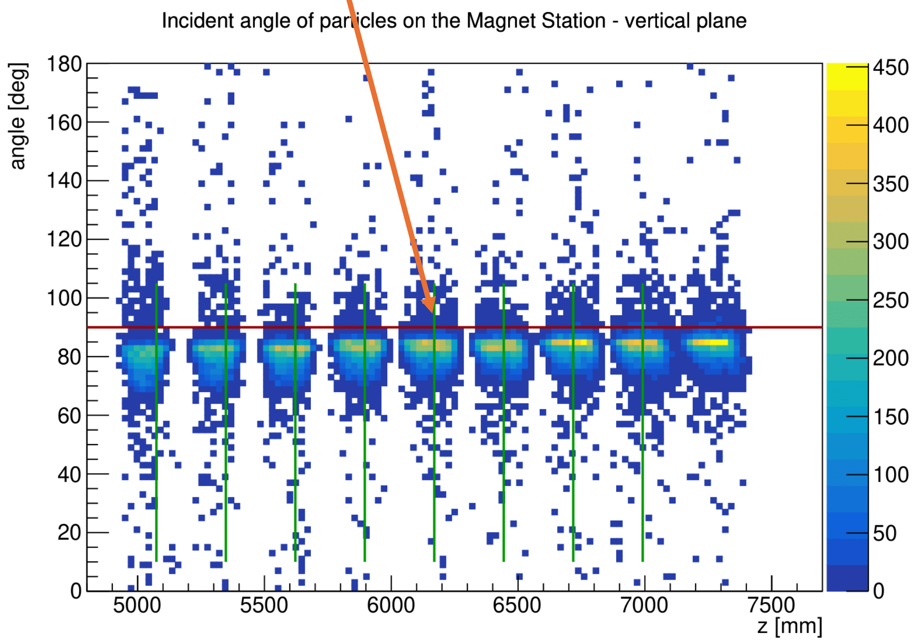
Impact on performance:



Impact angles of particles on Magnet Station are excellent with new design

- Previously small error in computation of angles
- Small tilt of stations retains excellent vertical impact angle
- Horizontal distribution affected by:
  - particles bent in the magnetic field to MS
  - particles directly hitting the MS straight on





Omitting the first module in each station leads to only small acceptance loss

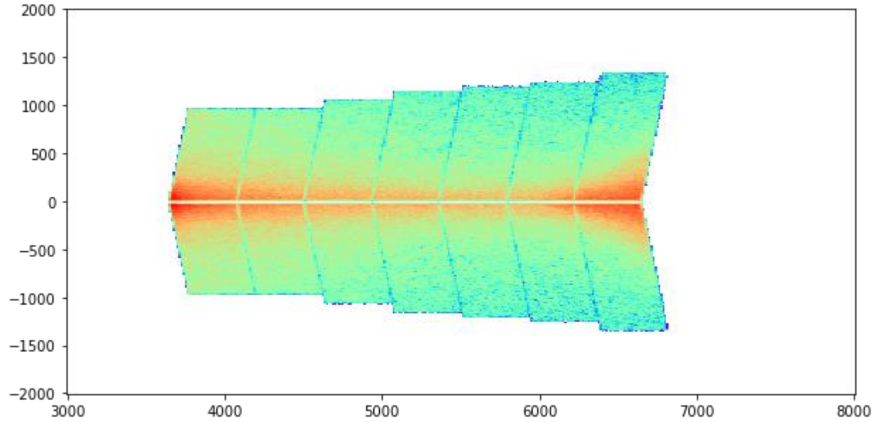
Conclusions

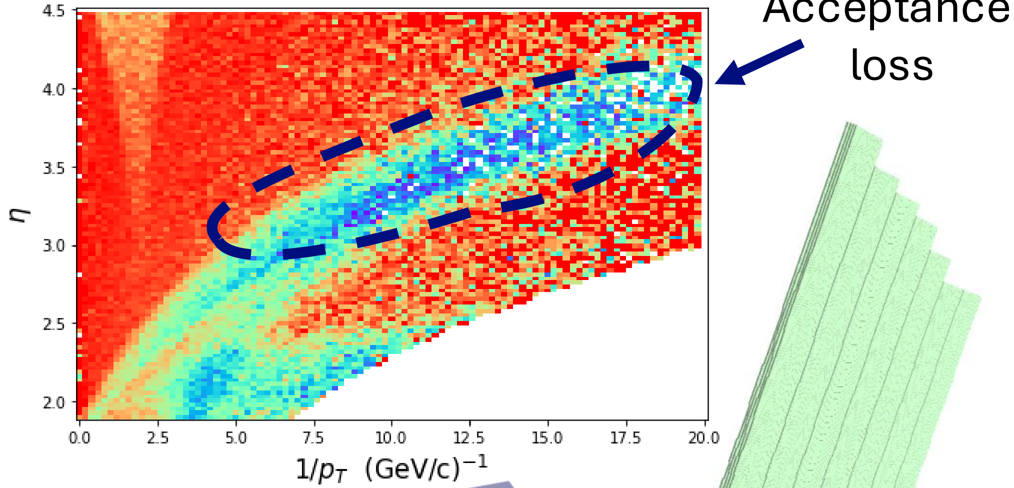
- New geometry created which should clear all internal magnet support structures
  - Reduction to 9 modules with slight tilt of each station
- Corner locations of each module to be sent via mail for implementation in CAD model
- Questions?

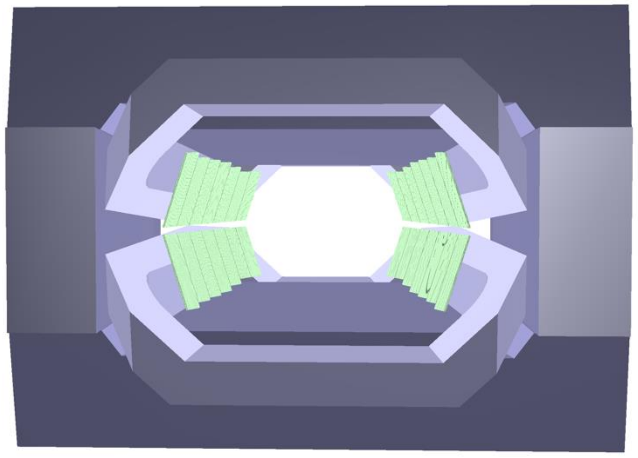
Old stuff from last presentation in the next few slides

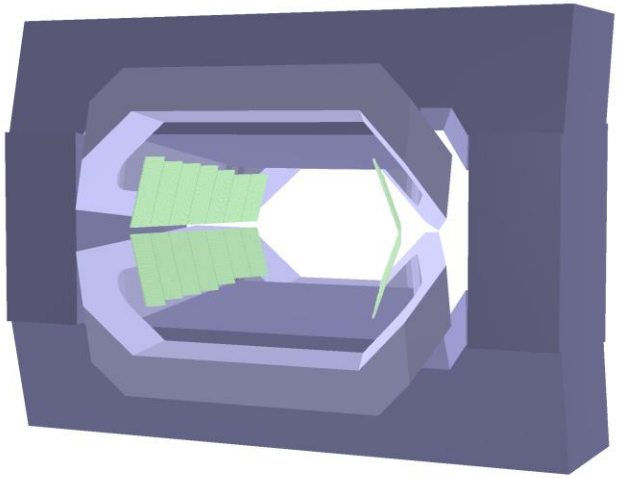
Reminder – Initial design

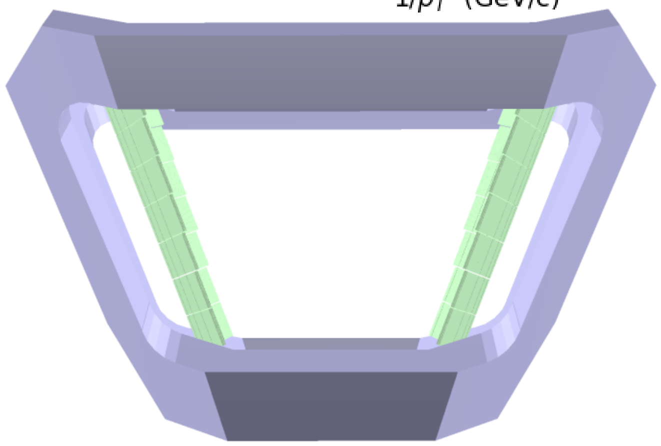
- 7 Modules starting coverage from about z = 3.5m onward
- Modules oriented on tilted planes (4 segments) facing the beam pipe
- Module height from 1.0 to 1.4m depending on z-position
- 74k channels (each individual scintillator bar counts as channel)
- Pros:
  - Easy support structure for large plane detector
- Cons:
  - Not perpendicular to particle trajectory
  - Acceptance gap between MS and SciFi tracker

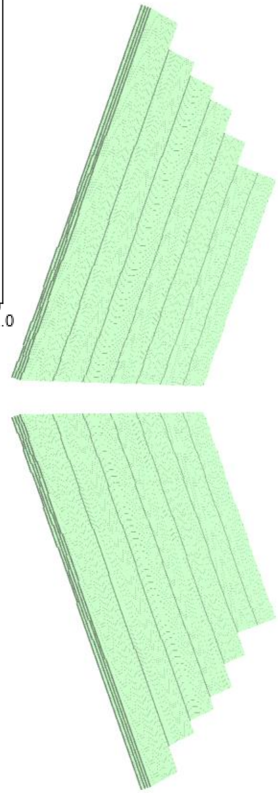












Reminder - Bar segmentation of modules

- 4 layers per module
- Varying bar segmentation per layer
  - Produces desired granularity in y-direction
  - Adjustment for varying module length
- Each segment made of 86 scintillator bars
  - 5x5mm^2 bars with 200micron separation to account for wrapping and tolerances
- Alternating offset of segments
  - Allows for routing of fibers (not yet implemented in simulation)

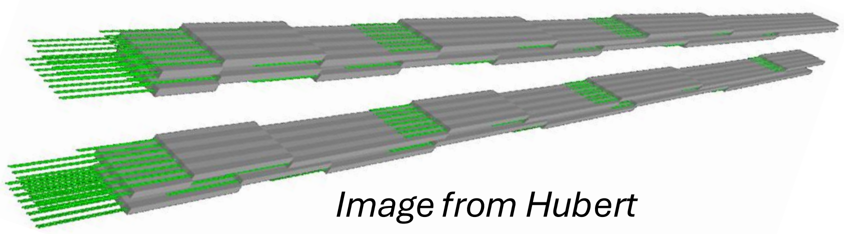
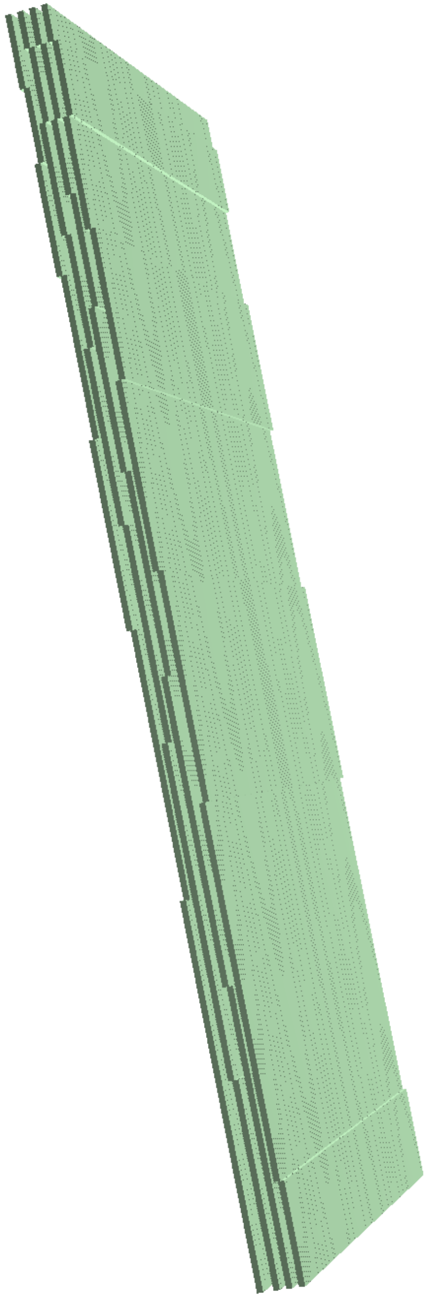
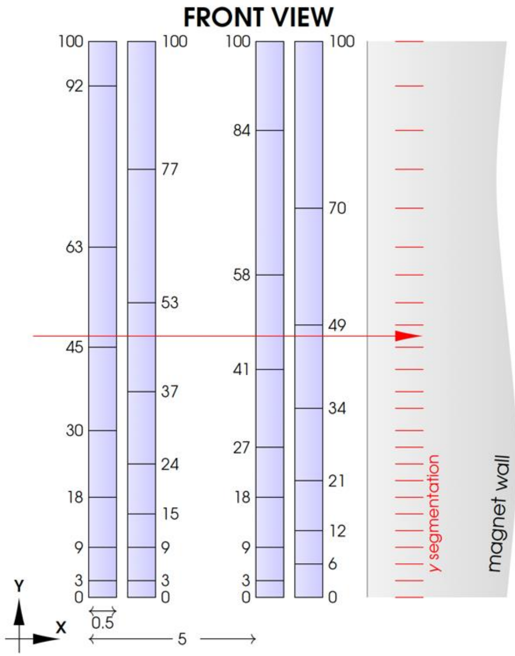
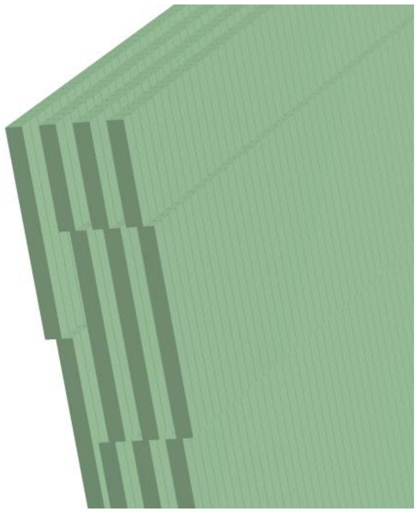


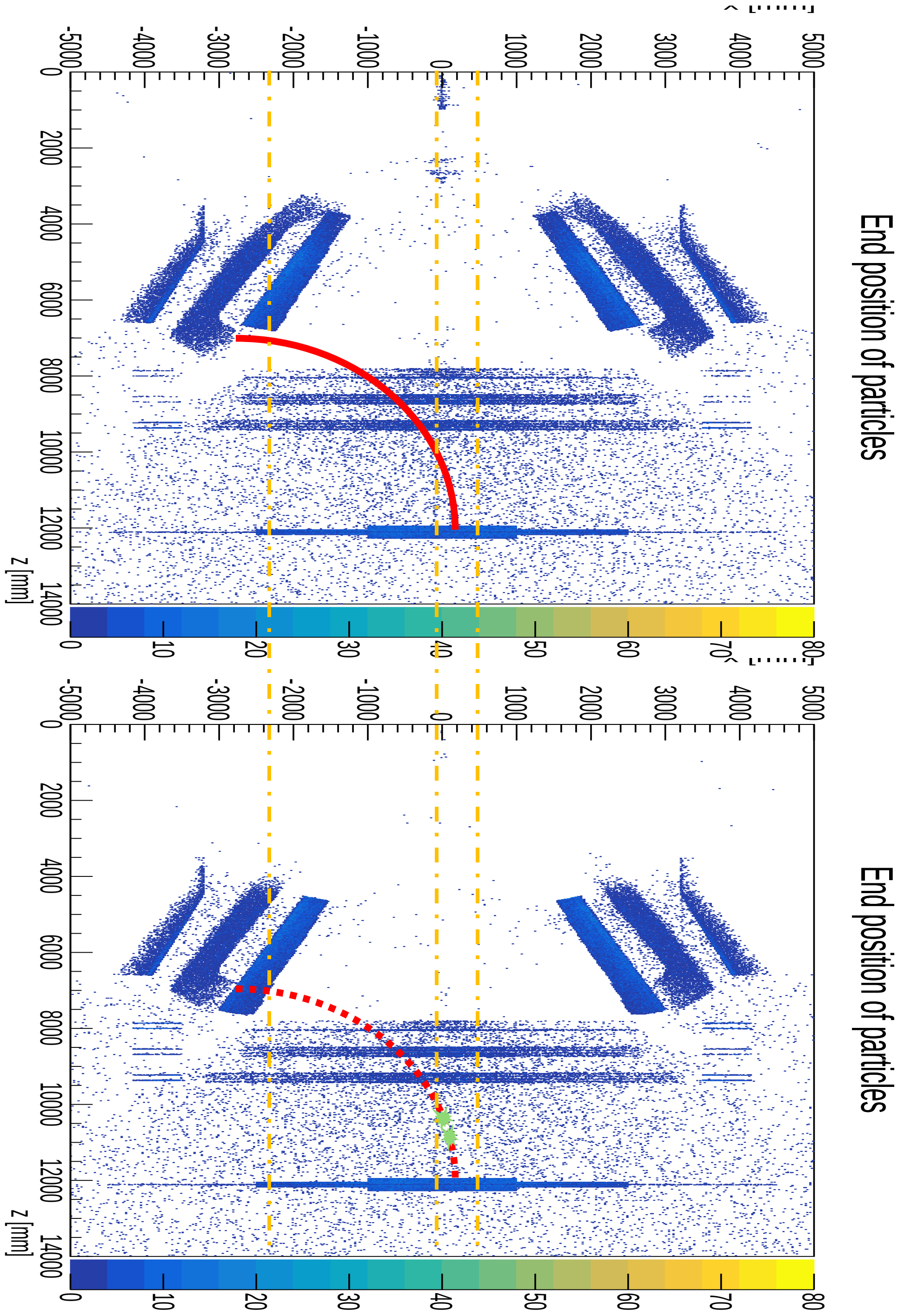
Image from Hubert







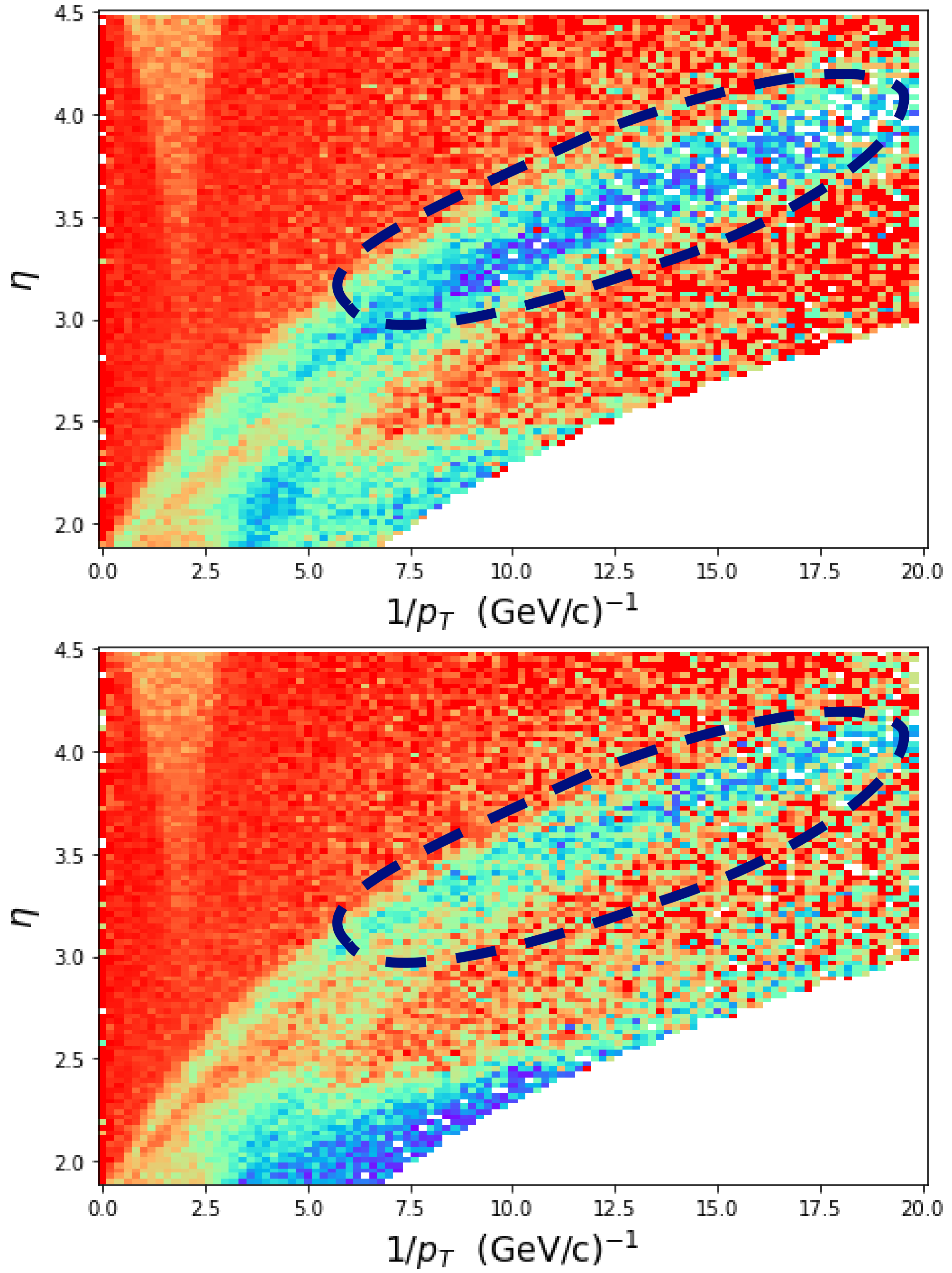
Acceptance Optimization



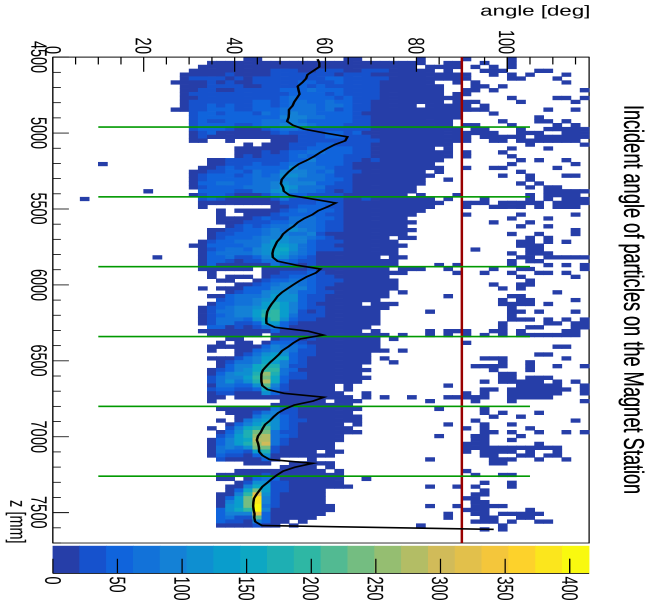
- Removal of first two modules
  - Negligible impact on acceptance (removes small fraction of very soft particles)
  - Frees up about 20k channels AND significant portion of fiber material (longest fibers for readout in first layers)
- Addition of modules at larger z
  - Closes gap between MS and SciFi tracker
  - Improves acceptance significantly
  - Adds 20k channels
  - Support structure to be investigated
  - Last module close to SciFi and outer Magnet edge

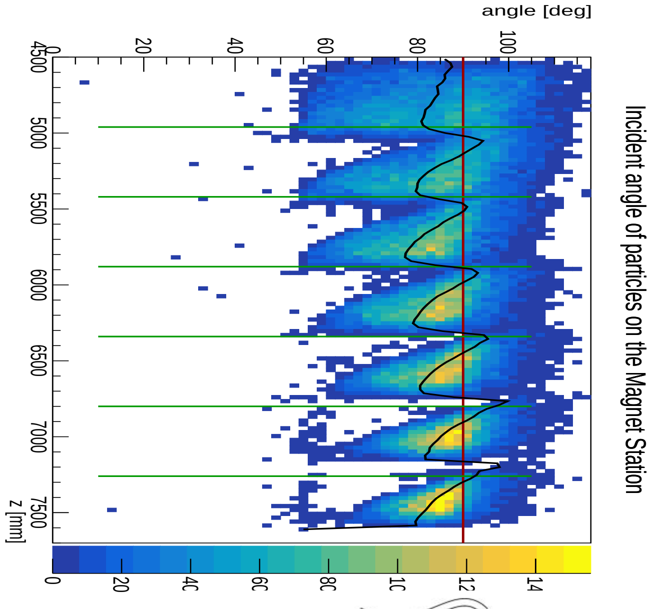
Acceptance Optimization

- Negligble loss at low momentum due to removed first two modules
- Visible improvement of acceptance with addition of two modules at large z
  - See circled area in plots

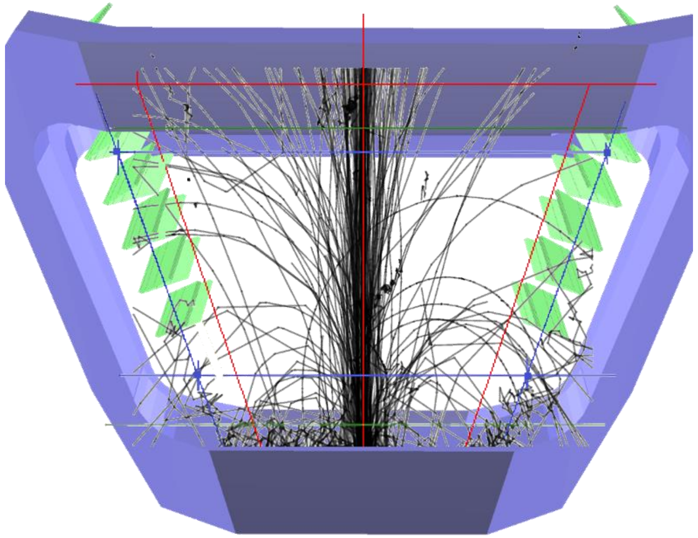


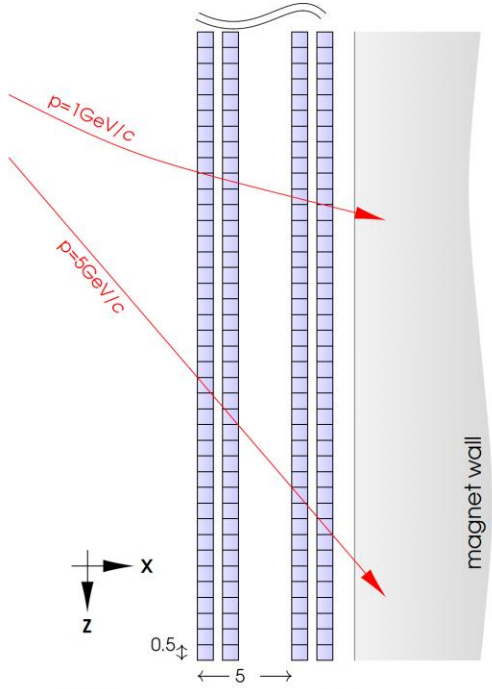
Incident Angle Optimization





- Rotation of modules for average perpendicular incident angle of particles
- Rotations between 40 and 57 degrees
  - Increasing rotation with distance from IP
- Increases tracking performance and reduces occupancy
  - E.g. from crossing of two bars in single layer



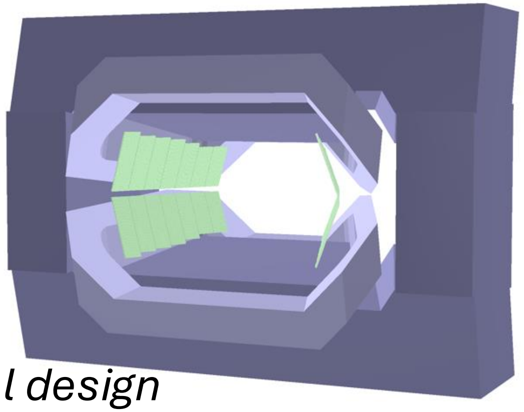


Overview of Design Variations

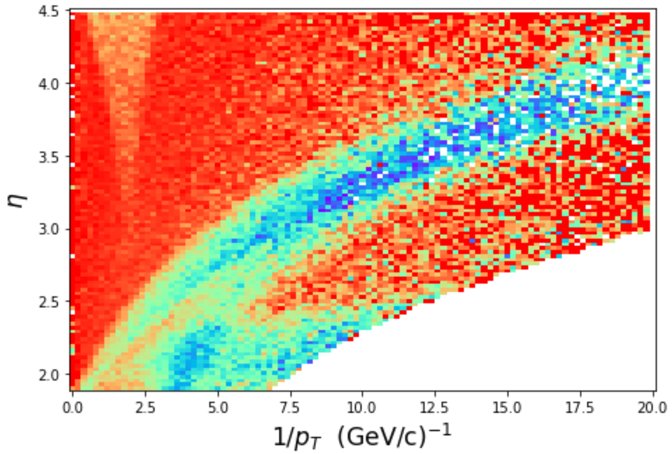
Three versions of MS design:

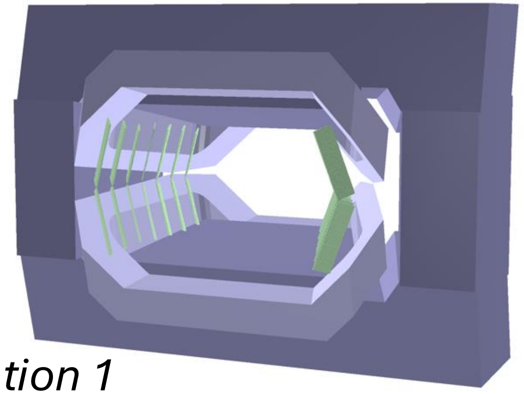
1. Initial design without rotating individual modules for incident angle optimization
2. Variation with individual module rotation
   - ➢ Vastly improved incident angles
3. Variation without station rotation
   - ➢ Vertical orientation of modules, but each module still rotated in y for incident angles

- Similar acceptance for all variations
  - **Final design to be driven by support structure engineering effort**
- More details in next slides

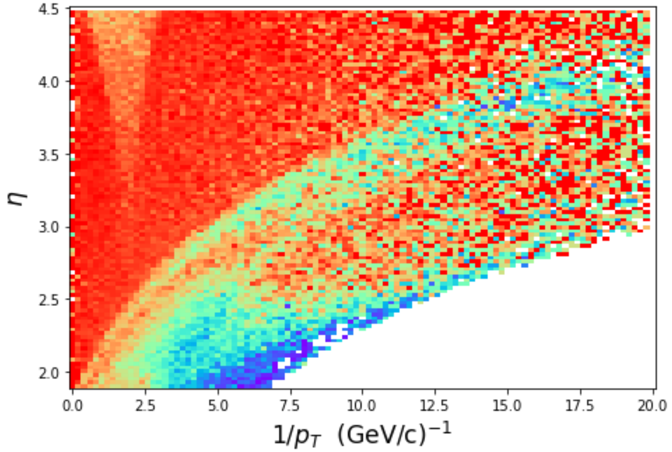


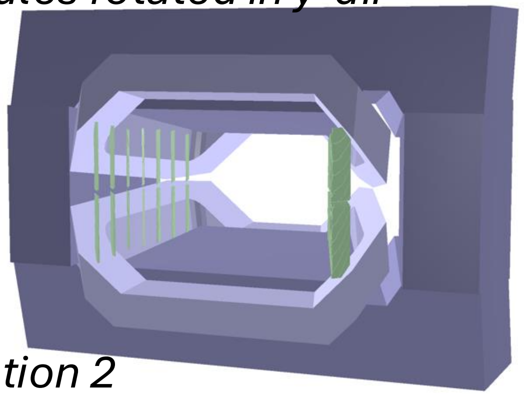
Initial design
no module rotation



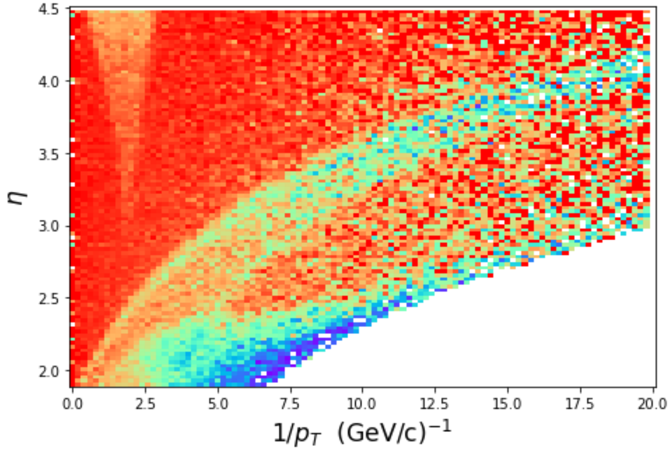


Variation 1
modules rotated in y-dir

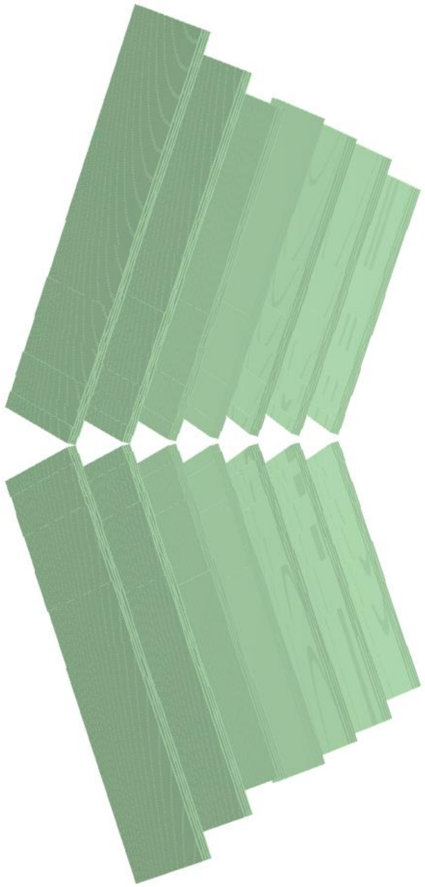




Variation 2
stations not rotated in z-dir

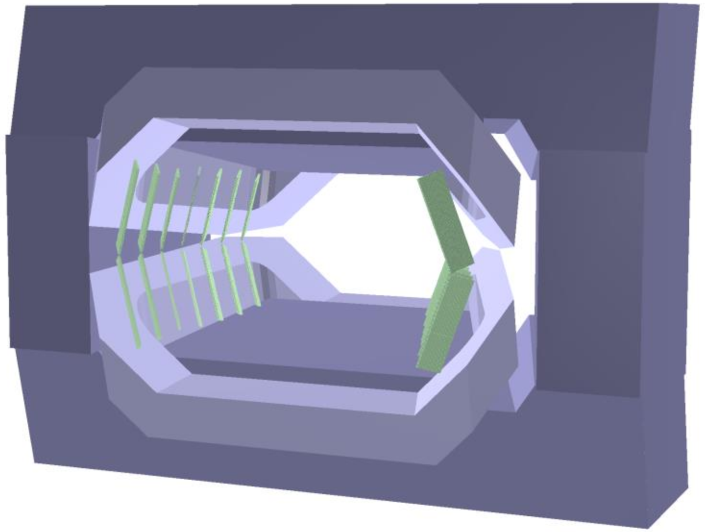


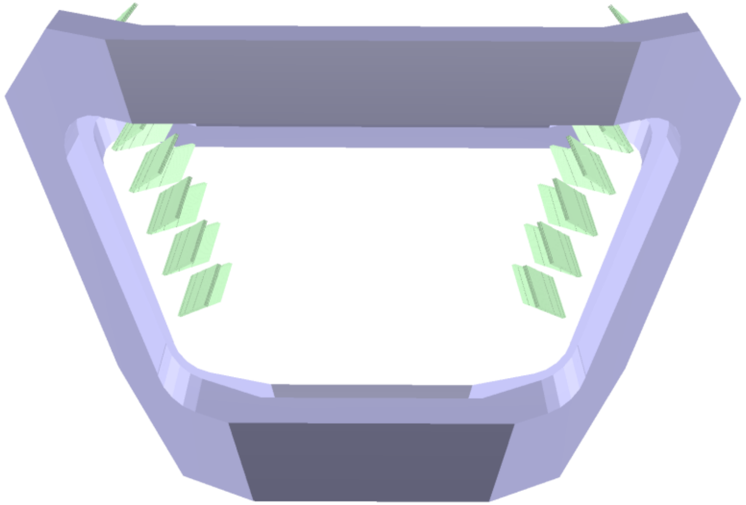
Variation 1 – Design information

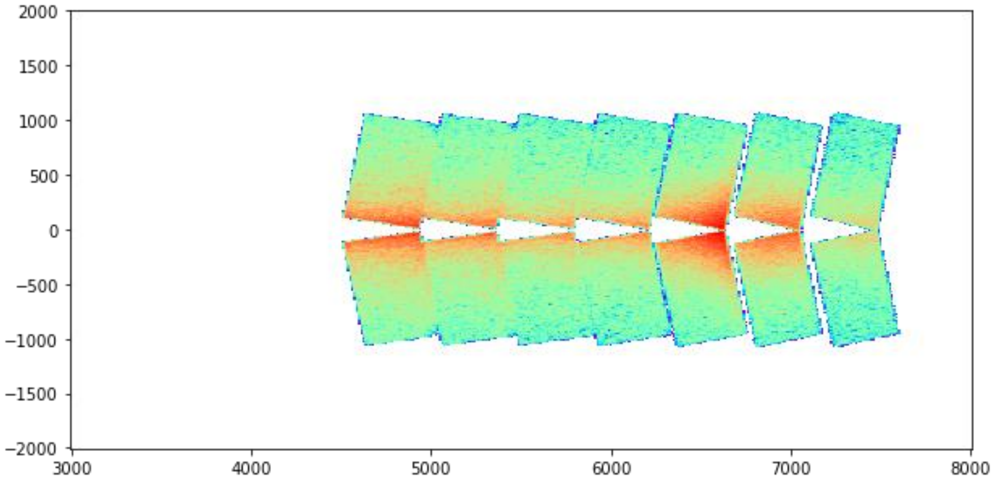


Dimensions:

- 7 Modules with width 45cm and base-height 1m
    - Additional height: 0, 0, 10, 20, 25, 30, 40cm increasing with z
    - Modules rotated by 40, 40, 40, 46, 51, 57, 57 degrees in y
    - Modules placed every 46 cm (can be further optimized to reduce/increase overlap)
- Stations rotated by 19.6 degrees in z and 21.2 degrees in y
- Total of 74k channels (based on 5x5mm^2 bars)







Variation 2 – Design information

Dimensions (changes to variation 1 in red):

- 7 Modules with width 45cm and base-height 1m
  - Additional height: 0, 0, 10, 20, 25, 30, 40cm increasing with z
  - Modules rotated by 40, 40, 40, 46, 51, 57, 57 degrees in y
  - Modules placed every 46 cm (can be further optimized to reduce/increase overlap)
- Stations rotated by ~~19.6 degrees in z~~ and 21.2 degrees in y
- Total of 74k channels (based on 5x5mm^2 bars)