Geometry Development

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Experimental Particle Physics

Outline

Geometry Group Purpose

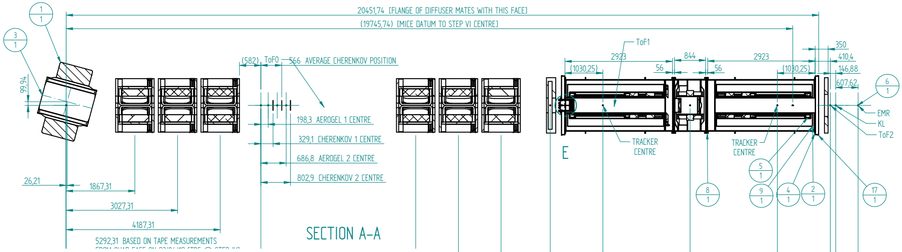
- Precision in the position of experimental elements is a fundamental requirement of simulation and reconstruction.
- Need to match MAUS geometry to equipment in hall.
- In the past all geometries have been implemented by hand.
  - Only as good as the information filtered to the programmer
  - Many hands means less certainty
- Implementing system to extract geometry from engineering drawing
  - As developed by Matthew Littlefield
  - Geometry is written to Calibration Data Base.
  - Geometry indexed by id number, by time, or by run.

Currently involves

Stephania Ricciardi	Validation
Ryan Bayes	Software
Jason Tarrant	CAD Generation

CAD Description of StepIV MICE Channel

CAD Provided by Jason Tarrant. Rendered to GDML using FastRad



Beamline elements

- Positions provided from surveys
- Magnet currents taken from CDB (by run download)
- Default fields for a 6π 200 MeV/c beam.

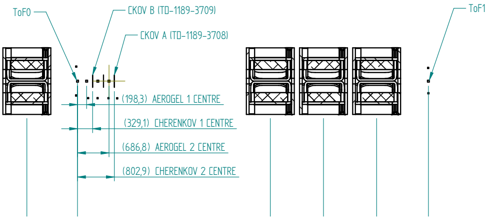
Detectors

- Positions of detectors indicated by "dummy" volumes in CAD.
- Volumes replaced by detector description in processing.

Survey implementation in CAD Description

Survey information implemented in CAD by Jason Tarrant

Detail of Step I Geometry



- Three different types of geometry available
  - Idealized: future geometry; no survey information available
  - Real: geometry from a data collection run.
  - Debug: geometry with only detectors and fields (Step IV).

- Survey information used to place beam line elements in CAD drawings.
- Positions of survey nests given by cubes in CAD GDML.
- Survey nests currently available for
  - TOFs (4 survey nests each)
  - KL (4 survey nests)
  - Ckovs (3 survey nests each)
  - EMR (4 survey nests)
- Position of detectors are fit to match nest positions.

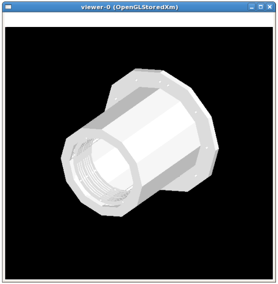
Status of Detector Descriptions

- All detector descriptions are now written to CDB
- Descriptions have been reviewed
  - TOF shielding removed in favour of PRY.
  - KL description updated.
  - Ckov has been completely revised (waiting confirmation).
  - Tracker rotation corrected.
  - EMR now confirmed and committed to CDB.
  - All files are written to be the same as the legacy files.
- All absorbers are now available in CDB
  - Default Step IV option is to use LiH disk absorber.
  - LH2 absorber reviewed and committed.
  - Step IV geometry should be updated when absorber is changed
- Diffuser irises (modelled as annuli) available in CDB.
  - All irises closed by default.
  - CDB interface will be available soon.

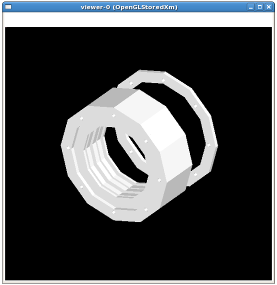
Diffuser in GDML

- CAD includes stainless steel barrel, Tufnol irises, and fittings.
- Irises produced using CGS solids (Brass and Tungsten tubes)

Stainless Steel components



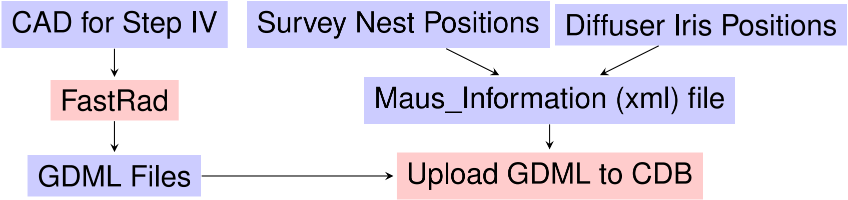
Tufnol components



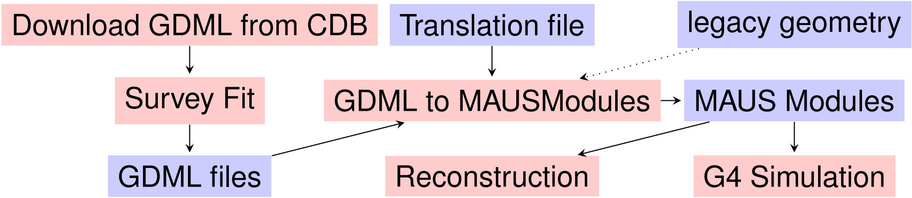
- Iris positions not explicitly included.
- Extracted from Tufnol description.
- Iris positions added to Parent Geometry File during MICE module processing.

Software Workflow Updated

File Preparation Workflow



User Workflow



Running Simulations with CAD Geometry

Steps For Simulation with MAUS

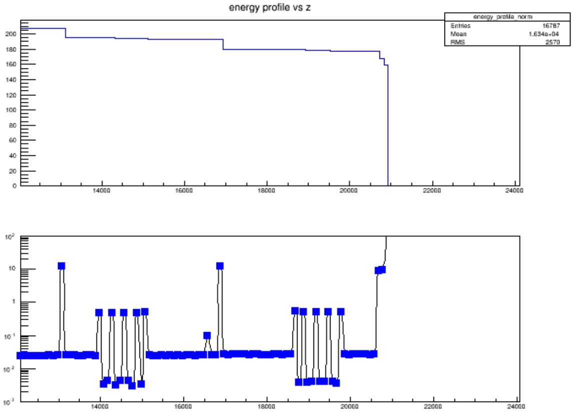
1. Select (by run or ID) and download geometry to {download_directory}.
2. Run simulation script with "–simulation_geometry_file" option
   - e.g. python bin/simulate_mice.py –simulation_geometry_file {download_directory}/ParentGeometryFile.dat

Full simulations completed with this geometry

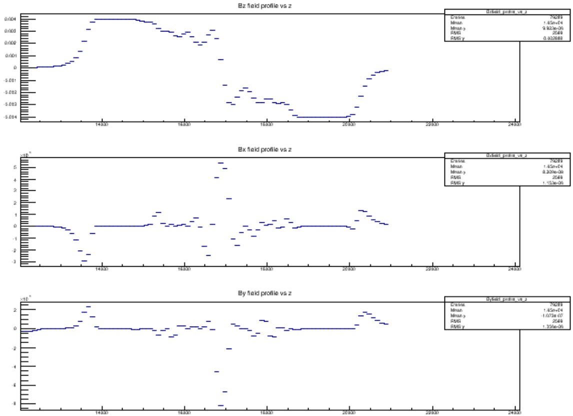
- Single particle simulations with pencil beam for validation.
- SciFi tracker simulations for solenoid field validation.
- Test with G4Beamline interface for transport validation.
- Not done due to limited resources.

Validation of Simulation: Energy Loss

- Single particle run through channel.
- Virtual detectors placed every 10 cm.
- Changes in momentum between planes determined
- Indicates presence of extra material.



Validation: Magnetic Fields in Cooling Cell

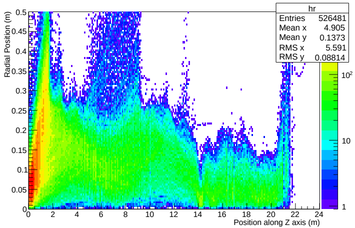


- Fields also sampled from Virt Det.
- Used to verify position and scaling of coils in solenoids.
- Scaling and maps taken from legacy files.
- Positions taken from CAD files.

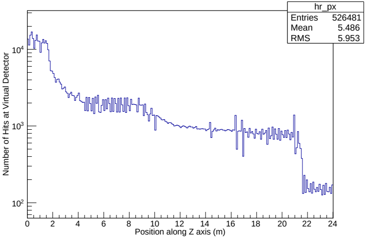
Validation of Simulation: Beam Radius

- Used G4BL interface to simulate several thousand particles.
- Extract positions from virtual planes at 10 cm intervals.
- Extracted μ^+ from 6π200 MeV/c beam.

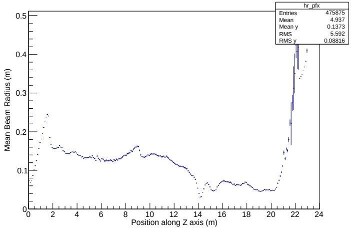
Radial position of muons



Number of muons

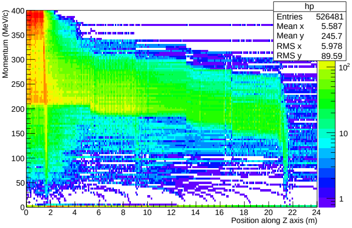


Mean radial position of muons

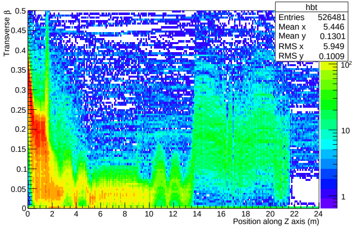


Validation of Simulation: Beam Momentum

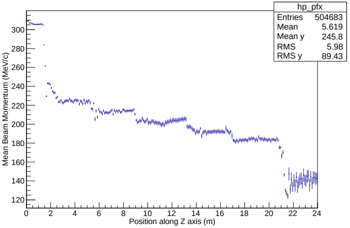
Total muon momentum



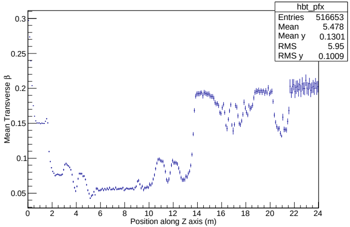
$\beta_\perp = p_\perp / E$



Mean muon momentum



Mean transverse β



Further Validation

Material review

- Ensure that all materials are correctly described
- CAD separated by material — are they properly represented?
  - e.g. Brass not in simulation — has since been added.
- Review now complete.

Reference run simulation

- Use the G4BL interface with a 300 MeV/c pion run.
- Compare the TOF to data.
- Compare the results to G4Beamline.

- Validation test are ongoing for each new CDB upload.
- Corrections are made to the code/geometry model as problems are observed.

Benchmarking Simulations

- CAD derived geometry has seen prohibitive load times in the past.
  - Currently on order of 20 minutes for CAD derived MICE modules.
  - Due to use of Tessellated solids from CAD.
  - Makes debugging and online simulation difficult.
- Consider a number of solutions
  - Reducing geometry to detector and field placements ("Debug")
  - Upgrade to new GEANT4.10.00.
  - Use GDML parser in MAUS simulation.
  - Replace CAD elements with simple elements.
- Methods compared using 10 spills, 1 muon each.

Representative simulation times

Legacy Geometry	8 min 02 s
Debug Geometry	9 min 27 s
CAD Geometry after MM conv.	28 min 27 s
CAD Geometry with GDML interface [a]	7 min 52 s

[a] Not ready for use.

Implementing the GDML Interface

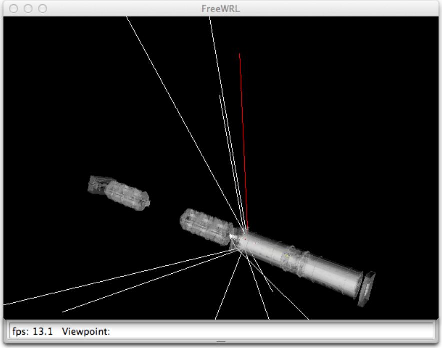
- GDML parser provides better loading performance for Tessellated solids.
- Have adapted the MAUS simulation to use this parser.
- Initial results have shown improvement in load speed.

Needs further development

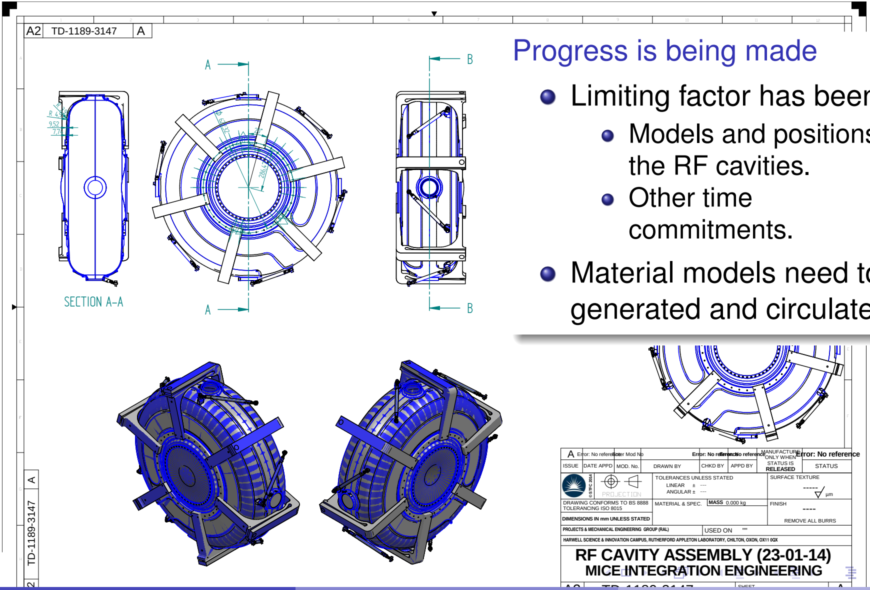
- Issues with definition of sensitive detectors
  - Cannot add logical volumes to parser volume
  - Need to extend GDML definition to include SciFi, KL fibres, EMR bars, etc.
- Problems with tracking.

- Decision point — July 14.

Results of first attempt



Towards a Step V Model



Progress is being made

- Limiting factor has been:
  - Models and positions of the RF cavities.
  - Other time commitments.
- Material models need to be generated and circulated.

Outlook

Step I and Step IV Geometry is ready for use: with caveats

- Validation is ongoing.
- Some detectors (Ckov) are still in flux.
- Full simulation takes significant time to load.

Documentation for use available

- Online Documentation at `http://micewww.pp.rl.ac.uk/projects/maus/wiki/GeomDocWiki`
- Documentation included in MAUS Users Manual.

Remaining work

- Ensure Ckov and Tracker description are finalized.
- Complete Step V model.
- Fully implement GDML parser in MAUS