Geometry Development

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1. Introduction
2. CAD Geometry and Geometry Description
3. Geometry in Software
4. Current Status and Outlook

Geometry Group Purpose

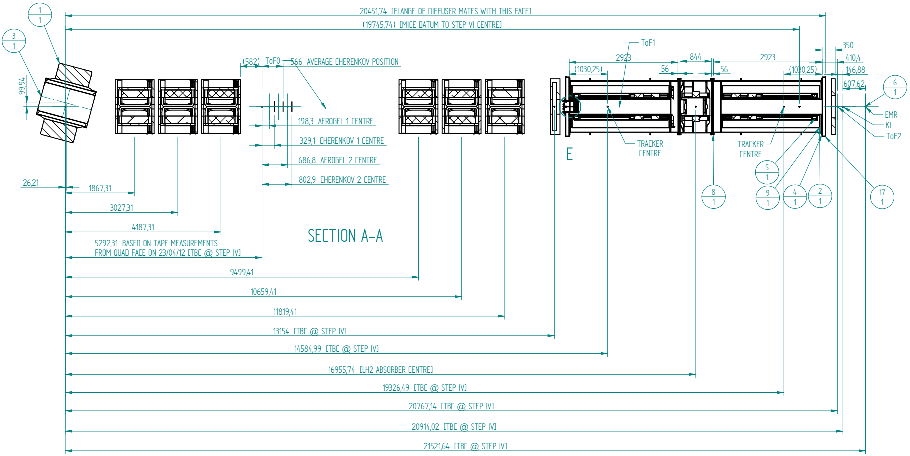
- Precision in the position of experimental elements is a fundamental requirement of simulation and reconstruction.
- Need to match MAUS geometry to surveys
- In the past all geometries have been implemented by hand.
  - Only as good as the information filtered to the programmer
  - Many hands means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

Currently involves

Stephania Ricciardi	Validation
Ryan Bayes	Software
Jason Tarrant	CAD Generation

CAD Description of StepIV MICE Channel

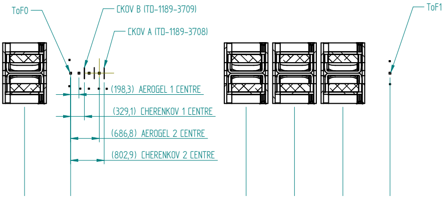
CAD Provided by Jason Tarrant. Rendered to GDML using FastRad



Survey implementation in CAD Description

Survey information implemented in CAD by Jason Tarrant

Detail of Step I Geometry



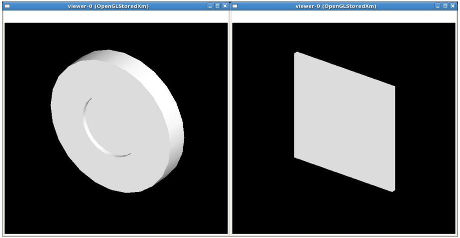
- Two different types of geometry available
  - Idealized: future geometry; no survey information available
  - Real: geometry from a data collection run.

- 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 need to be fit to match nest positions.

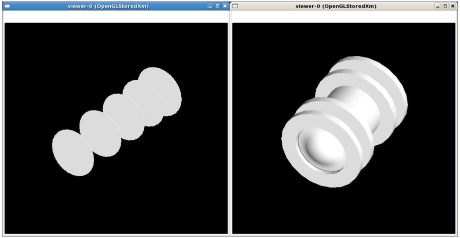
GDML Description of Detectors

GDML descriptions of all detectors (except EMR) now written and in CDB

TOFs and KL



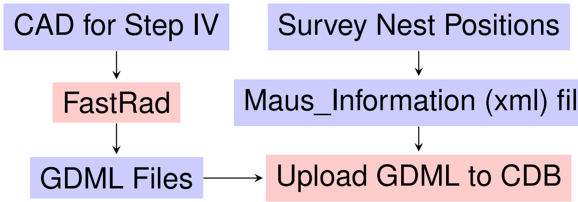
Trackers and Absorbers



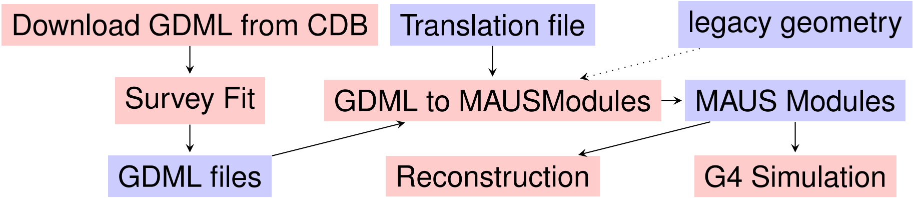
- Cherenkov detector files also written but not shown.
- EMR still needs attention (it may be treated differently anyway).
- All files are under review.
  - Revisions already made in Tracker and TOF1.
- All descriptions are self-contained,
  - Can be used with GEANT4 or ROOT GDML parser.
  - Files written to reproduce legacy geometry files after translation.

Software Workflow Updated

File Preparation Workflow



User Workflow



Detector Survey Fitting Method

- Given:
  - A set of survey points $\vec{q}_i$
  - A locations of survey nests in detector coordinate system $\vec{p}_i$
- Fit location of $\vec{p}$ to $\vec{q}_i$ with a position offset $\vec{k}$ and rotation $\vec{\theta}$.
- Mathematically this is the system of equations:

$$\vec{q}_i' = M\vec{p}_i + \vec{k}$$

where M is the matrix defined by the product of rotation matrices

$$M = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_x & -\sin\theta_x \\ 0 & \sin\theta_x & \cos\theta_x \end{pmatrix} \times \begin{pmatrix} \cos\theta_y & 0 & \sin\theta_y \\ 0 & 1 & 0 \\ -\sin\theta_y & 0 & \cos\theta_y \end{pmatrix} \times \begin{pmatrix} \cos\theta_z & -\sin\theta_z & 0 \\ \sin\theta_z & \cos\theta_z & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

- $\vec{k}$ is the position of the detector centre.

Survey Implementation

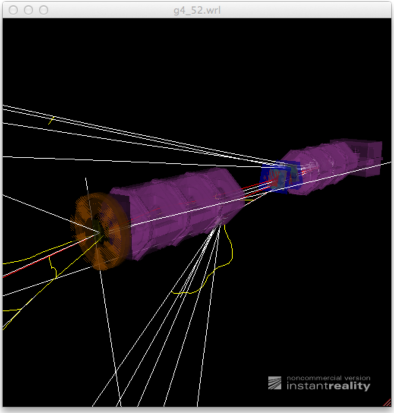
- Detector groups must provide positions of survey nests in detector system.
  - Information written to information file contained in CDB file.
  - Further corrections can be implemented as needed

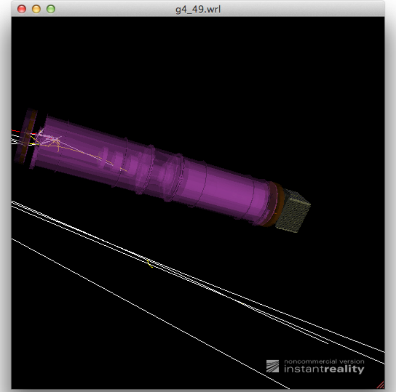
```
<Detector_Information>
        <TOF>
          <TOF0 gdml_posref="posRef_1">
            <Survey Point_Number="0" err="5." gdml_name="Step_9"
                 gdml_posref="posRef_10" units="mm" x="269.46" y="225.205" z="27.403"/>
            <Survey Point_Number="1" err="5." gdml_name="Step_10"
                 gdml_posref="posRef_11" units="mm" x="265.76" y="-225.97" z="25.024"/>
            <Survey Point_Number="2" err="5." gdml_name="Step_11"
                 gdml_posref="posRef_12" units="mm" x="-269.46" y="-225.206" z="24.832"/>
            <Survey Point_Number="3" err="5." gdml_name="Step_12"
                 gdml_posref="posRef_13" units="mm" x="-268.45" y="226.175" z="22.596"/>
          </TOF0>
        </TOF>
</Detector_Information>
```

- Fits completed during geometry download.
  - Option available to reprocess geometry.
- Results written to GDML files before translation.

Geometry In MAUS

- Step I and preliminary Step IV geometries available.
- Right now implemented for simulation using MICE Modules.
- Potential to parse GDML directly for reconstruction.



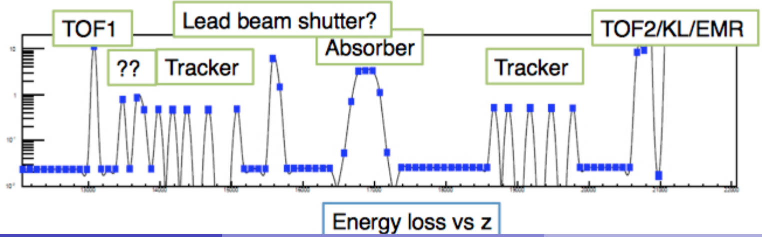


Geometry Validation

From notes by Stefania Ricciardi (abridged)

Need to check software integrity prior to release:

- Test geometry download; application to simulation.
- Test timing of simulation (reconstruction).
- Test geometry survey implementation (does fit work?).
- Gross validation of results:
  - Energy Loss profile, energy deposition
  - Magnetic field
  - Emittance



Geometry Release Procedure

A new geometry will be released when there is a new survey performed in the hall. The procedure is as follows:

	Process	Responsible
1	New geometry is released as a set of gdml files - email sent to Stefania Ricciardi (SR) and Ryan Bayes (RB)	Jason Tarrant
2	New geometry is uploaded to configuration database	RB (or SR)
3	Geometry test period is announced	RB (or SR)
4	Geometry testing	System experts
5	Geometry released	RB (or SR)
6	Update geometry for visualisation tool	

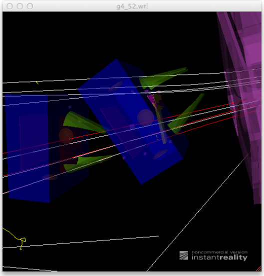
The Detector Geometry Contacts:

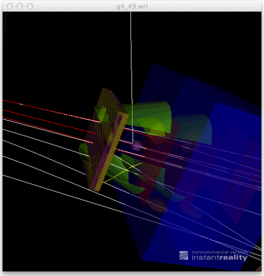
System	Responsible
Beamline	Adam Dobbs
TOF	Durga Rajaram
EMR	Ruslan Asfandiyarov
Ckov	Lucien Cremaldi
Tracker	Chris Heidt
KL	Mariyan Bogomilov
Cooling Channel	Analysis Group c/o Victoria Blackmore

- see `http://micewww.pp.rl.ac.uk/projects/maus/wiki/Geometry_release_procedure`

Remaining Issues

- Ckov survey fits behave strangely
  - Rotations of up to 40° about x-axis.
  - Positions in z and y removed from theoretical position by $\mathcal{O}(20)$ cm
  - Ckov fit disengaged until cause found.
- Ckov detector seems to impinge on TOF0.
- Simulation loading time still $\mathcal{O}(20)$ minutes.
  - Investigating use of GEANT4 persistency libraries for this purpose.
  - Observation: Geometry loaded with G4 GDML parser loads in a fraction of the time.
- Need to simulate blades of diffuser.
  - Work yet done on this.





Current Status of Geometry Implementation

- CAD for StepI, StepIV, StepV, and StepVI geometries exist.
- StepI (real) and StepIV (ideal) geometries accessible from CDB.
- Geometry in CDB now includes TOFs, Ckov, KL, Trackers, and Absorbers.
  - Interface written to reproduce MICE Module files as in legacy files.
  - Need to resolve EMR description and simulation.
  - Need to review Ckov description.
- Detector geometry descriptions are all self contained.
- Geometry testing period to commence soon.
  - Code for survey fit to be added to MAUS release.
  - Need to codify testing requirements for detector groups.
- New documentation ready. See `http://micewww.pp.rl.ac.uk/projects/maus/wiki/GeomDocWiki`