Importing the downstream beamline from engineering models

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**Abstract**

Simulations of beam-related background show significant contributions from regions downstream of the torus. Up until now the existing shielding and beamline was only partially represented in the GEMC simulation. This note lists the new imports from the engineering models and the modifications applied to the existing geometry.

**CLAS12 Geant4 Simulation**

This CLAS12 spectrometer [1] is simulated using the GEant4 [2] Monte-Carlo (GEMC) package [3]. Its forward detectors are placed between the coils of the superconducting torus magnet [4]. The vacuum line goes through the hub of the magnet. Downstream of the torus, a ‘apex’ shielding, consisting of a steel frame filled with lead, is used to shield background back splashing into the electromagnetic calorimeter. Prior to these modifications, the apex structure was a partial representation of the actual volume, see Fig. 1.

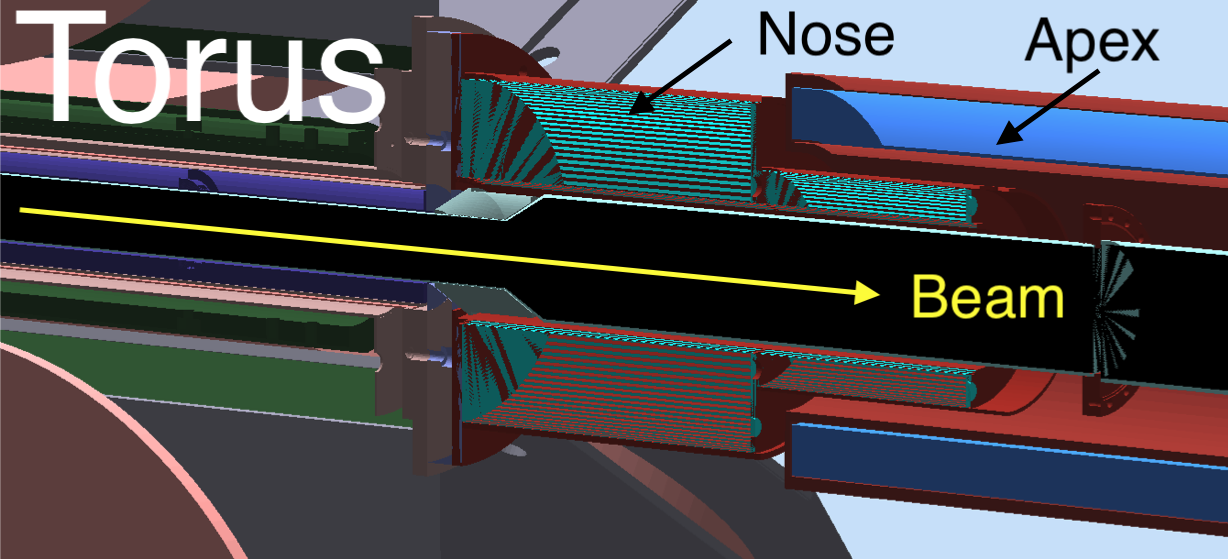


Figure 1. The implementation of the downstream beamline in gemc: a nose fills the air gap from the torus to the apex. The beam goes from left to right. The vacuum line radius increases from 33.3mm to 60.3mm inside the nose.

Detailed studies of beam related background showed backsplash of particles hitting the forward detectors from inside the nose and apex, due to the enlargement of the beam sausage hitting hardware components near the end of the torus hub. Further studies showed evidence of background even after the apex.

The complete vacuum line and beamline shielding

**Engineering Model (Chris can you please add some description of this?)**

[Description, please add pics as necessary]

The model is distributed to GEMC through STEP file, with the solenoid center as frame origin and the beam direction along z. This involves a 180 degrees rotation around the Y axis and a shift of 1273.27mm to account for the different coordinate system used by the engineers

**Geometry Modifications**

**GCard Modifications**

The following gcards have been added to better organize the various experiment configurations:

* beamline\_FTOn.gcard
* beamline\_FTOff.gcard
* beamline\_ELMO.gcard
* beamline\_rghFTOn.gcard
* beamline\_rghFTOut.gcard

The file beamline.gcard has been removed.

**Summary and Conclusions**

This note shows predictions from the CLAS12 simulation for the FTOF counter rates with different shield configurations. These include 4 different lead shields in front of panel 1b if 0.1, 0.2, 0.5, and 1 mm. The simulation also provides predicted counting rates and PMT anode currents that can be compare directly against beam measurements with the FTOF.

From this study three conclusions can be drawn:

1. There is no shielding solution using lead in front of panel 1b that provides a significant reduction of rates or currents. The simulation shows that the rates of low-energy background are significantly reduced, but that due to conversions in the added shielding material, the overall energy deposited in the FTOF remains unchanged.

**References**

*[1] The CLAS12 spectrometer at Jefferson laboratory, Burkert V.D., et al., Nucl.Instrum.Meth.A 959 (2020) 163419*

*[2] Recent Developments in Geant4, J. Allison et al., Nucl. Instrum.Meth.A 835 (2016) 186-225*

*[3] The CLAS12 Geant4 simulation, Ungaro M., et al., Nucl.Instrum.Meth.A 959 (2020) 163422*

*[4] The CLAS12 superconducting magnets, Fair R., et al., Nucl.Instrum.Meth.A 959 (2020) 163578*