

Cavern Background

The intense beams and large cross sections at the LHC give rise to high flux of background throughout the ATLAS detector cavern. This background, composed mainly of low energy neutrons and photons, can cause radiation damage to detector elements and front-end electronics. The induced hits increase detector occupancy. It is important to properly simulate this background so we can understand the sources and attempt to shield them. Cavern background is also crucial for sLHC upgrade.

ATLAS carried out such a calculation several years ago. It used the detector and shielding geometries known at that time. This calculation needs to be updated now to reflect the geometries as expected for the start-up of beams in late 2009. SLAC is spearheading this effort.

Tool

It is generally accepted that the physics modeling in the [FLUKA](#) package gives the best agreement with data for the low-energy neutrons and photons that are important here. On the other hand, ATLAS has little expertise with FLUKA but has much experience with [Geant4](#), which is regarded as having a more flexible geometry definition. We therefore decided to use [FLUGG](#), which couples Geant4 geometry with FLUKA physics.

Validation against previous studies

The earlier studies made by the ATLAS Radiation Background Task Force (RBTF) have been reported in [ATL-GEN-2005-001](#). The first figure shows a quadrant of the layout, for $z \leq 24$ m and $r \leq 12$ m, as modeled in the report.

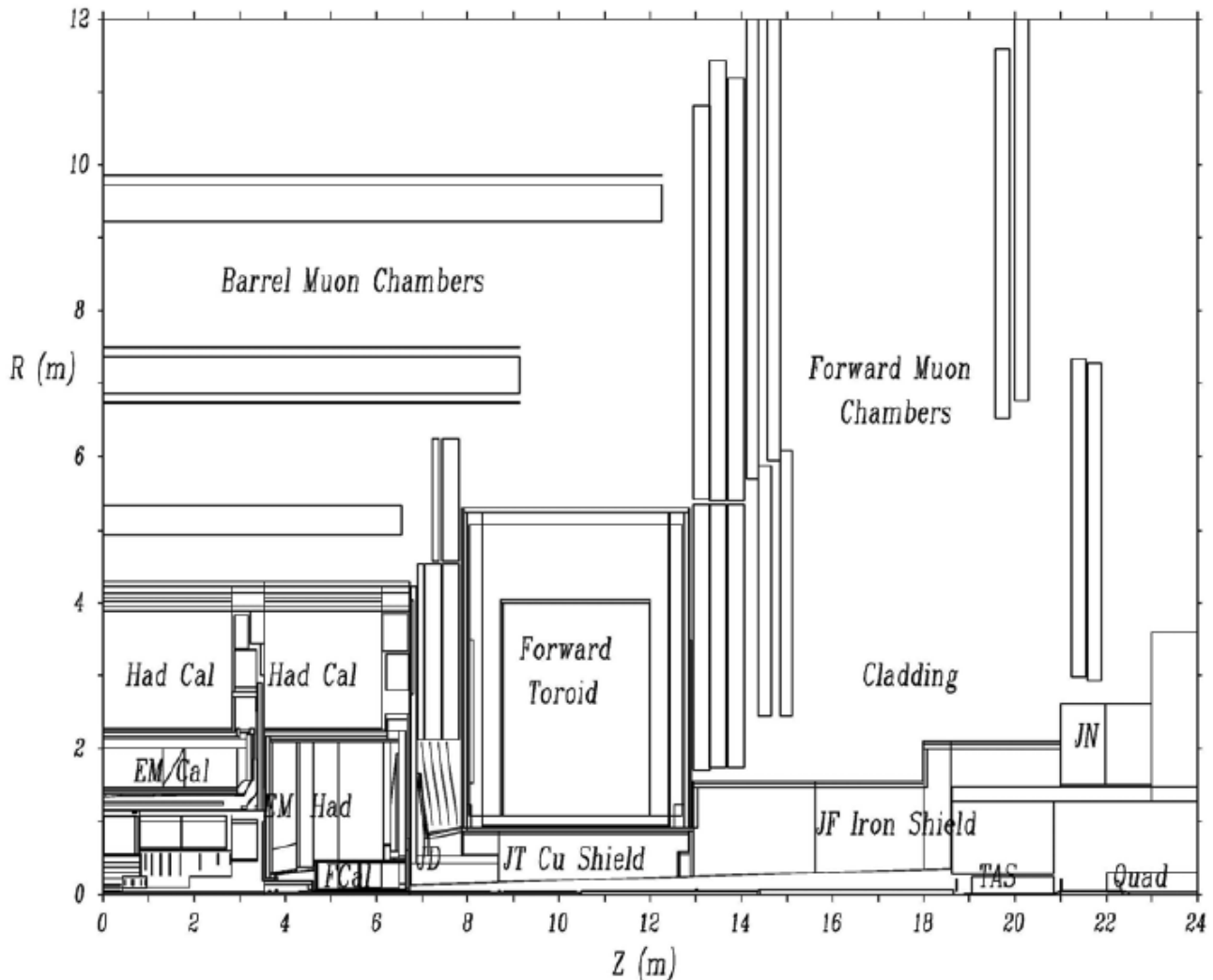


Fig. 1 A full quadrant of the ATLAS Jan03 layout as modelled with GCALOR.

The next figure is the calculated neutron flux.

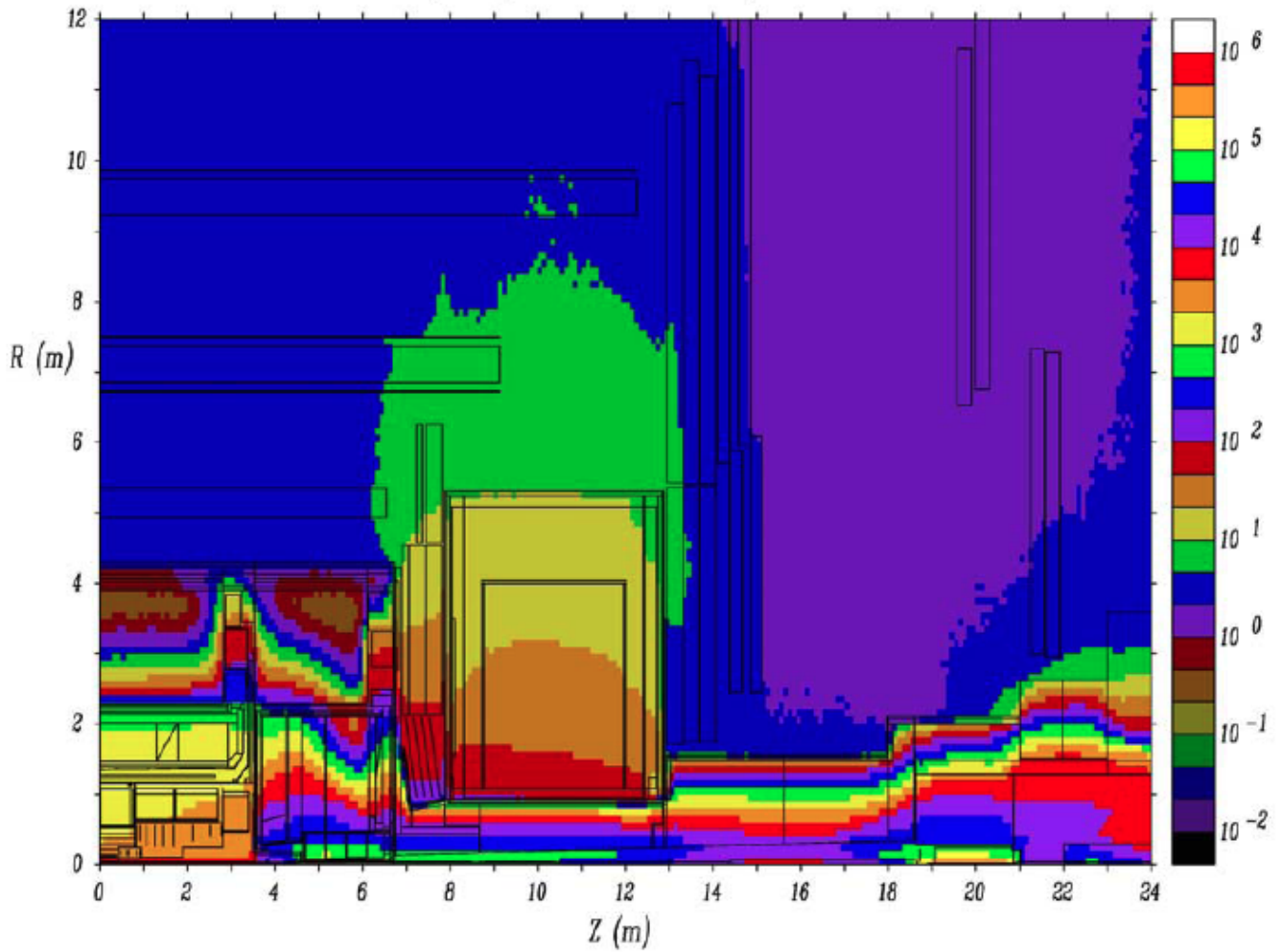
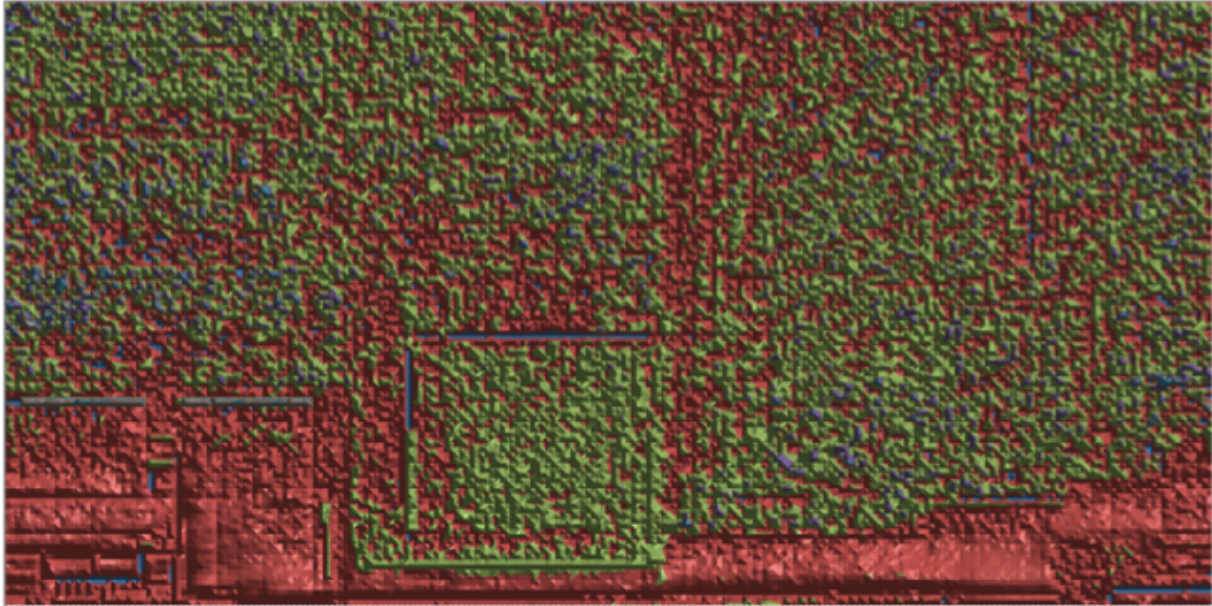


Fig. 2 The neutron flux in the G3/GCALOR Jan03 baseline geometry.

We used the same geometry, materials, etc as in this report, and compare our FLUGG results with the G3/GCALOR results from the RBTF. This is done by plotting the ratio of calculated quantities as a color map in (z,r) plots. Here are two examples for energy deposition and neutron respectively from 2009.

our/GCalor_091008: edep

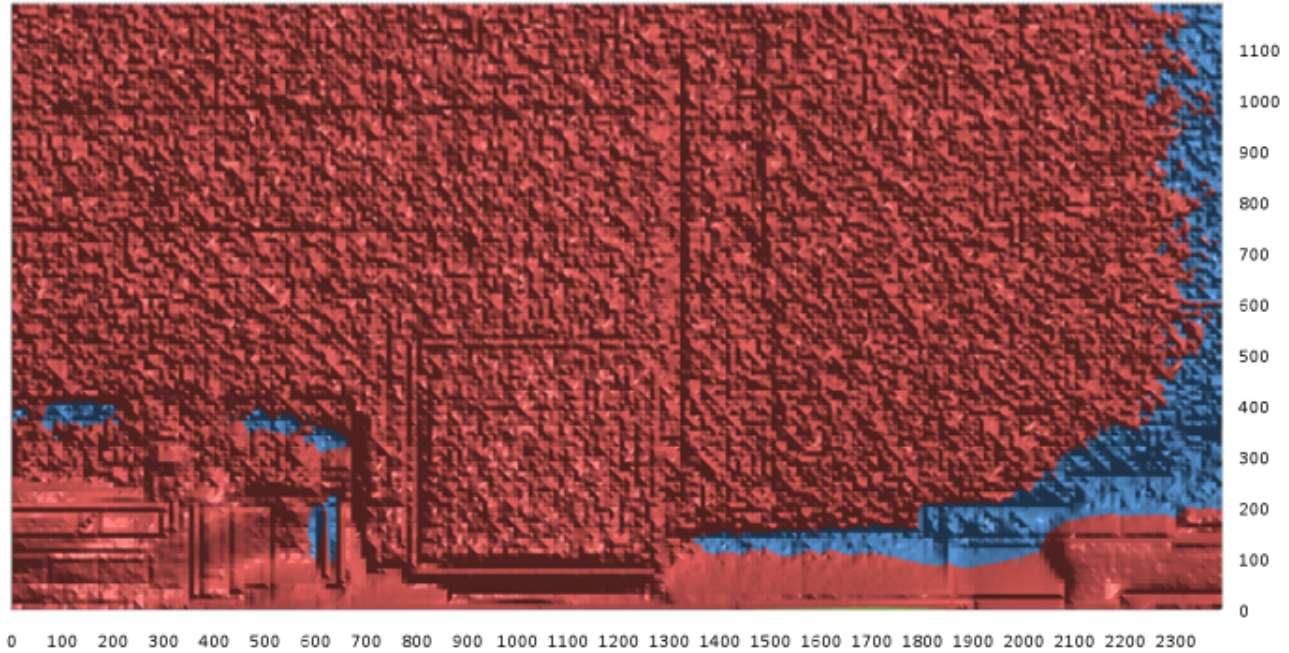
■ 1.25E-01-5.00E-01 ■ 5.00E-01-2.00E+00 ■ 2.00E+00-8.00E+00 ■ 8.00E+00-3.20E+01 ■ 3.20E+01-1.28E+02
■ 1.28E+02-5.12E+02 ■ 5.12E+02-2.05E+03 ■ 2.05E+03-8.19E+03 ■ 8.19E+03-1.64E+04



0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300

our/GCalor_091008: neutron

■ 1.25E-01-5.00E-01 ■ 5.00E-01-2.00E+00 ■ 2.00E+00-4.00E+00



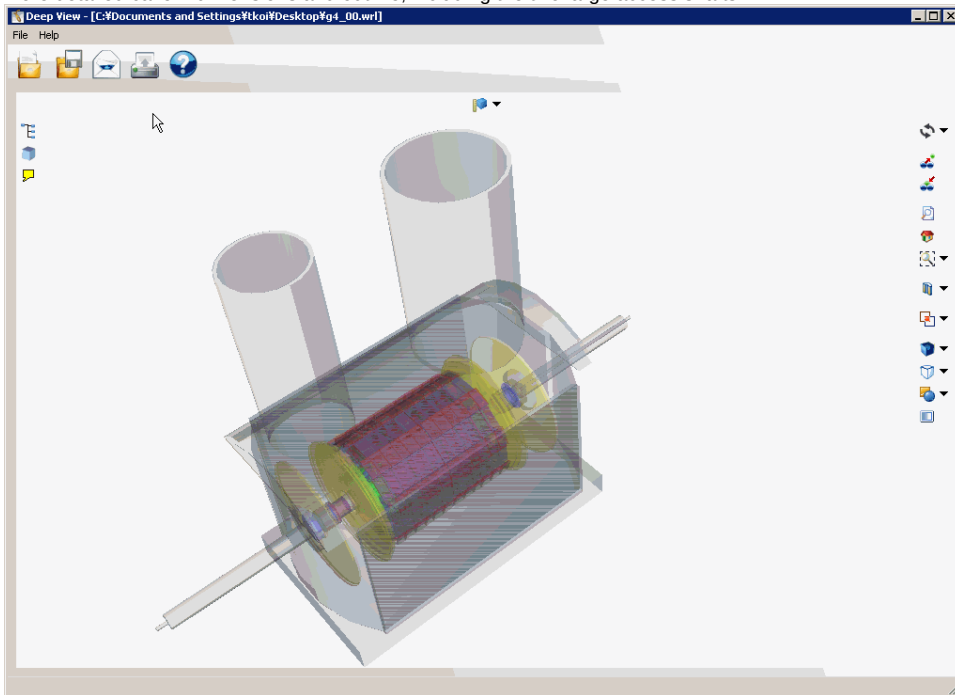
The differences between our results and RBTF results are now resolved. However, we will not post the new comparison plots since a uniform color is very boring! The agreement between FLUGG and G3/GCALOR is good, and the new application has been validated.

Start-Up for 2009-2010

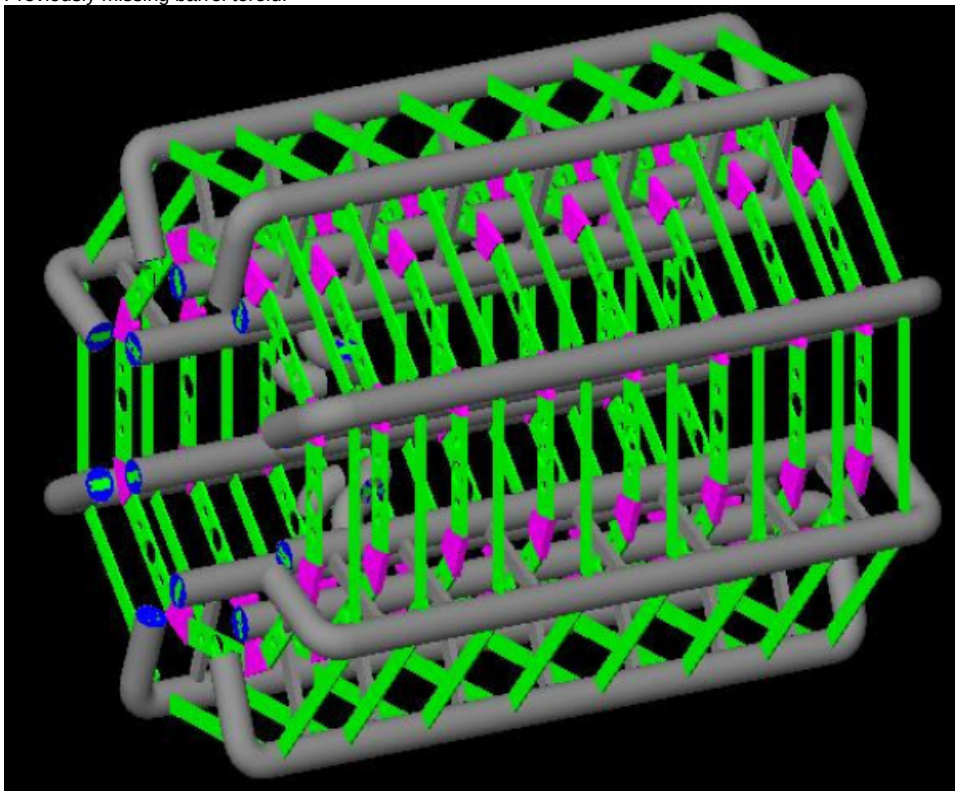
There is already a very detailed Geant4 description of the ATLAS detector used in physics event simulation; however, it is far too complicated for this application. Instead, we will update the validation geometry to be consistent with the full ATLAS description, e.g.

- Beam line and shielding.
- Gap between barrel and toroid.

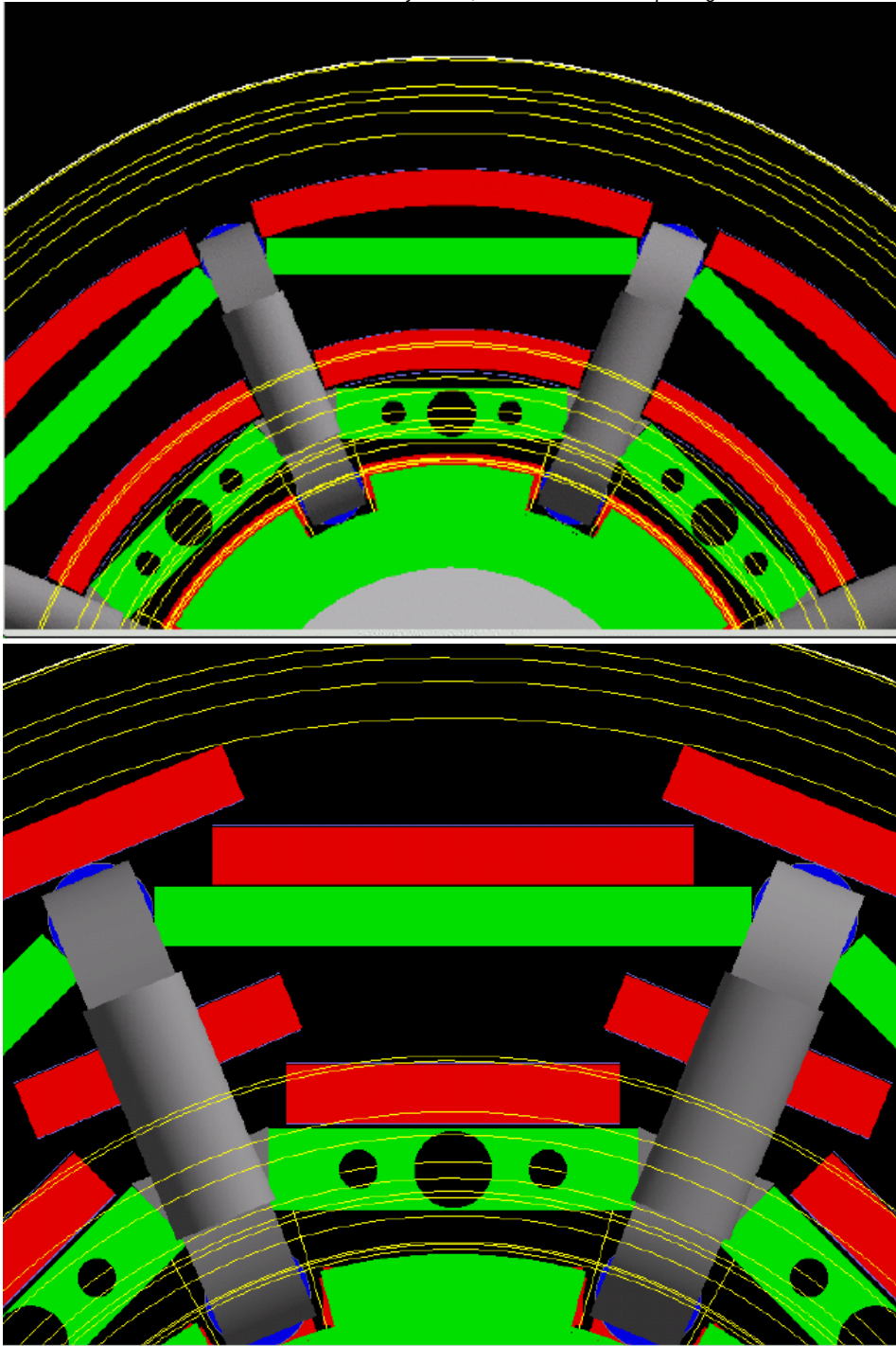
- More detailed cavern dimensions and outline, including the two large access shafts.



- Previously missing barrel toroid.



- Barrel muon chambers used to be modeled as cylinders, now modeled as flat packages.



- Proper position of endcap muon chambers.

Some simplifications have been made, especially detector internal geometries which are important for detector response but not for this application. It is important to maintain the proper isotopic composition of materials as neutron cross sections are sensitive.

Validation against data

Now that there is data from LHC, the calculations can be compared with the measured counting rates in muon detectors. A minimum instantaneous luminosity is necessary so cavern background is not overwhelmed by cosmic rays, electronic noise and so on. While some detector components may need a minimum luminosity of $\sim 10^{31} \text{ cm}^{-2} \text{ sec}^{-1}$, there are studies that can be undertaken with the data already in hand. For example, there are indications that the barrel MDT chambers see the predicted spatial distribution.

Cavern background files

The calculated background can be added to signal Monte Carlo events to simulate what a real event would look like in the presence of background. We define "scoring volumes" around muon chambers in the FLUGG application, and write out all particles that cross into these scoring volumes. This file of 4-

vectors is then used as input in normal ATLAS simulation. Each particle is tracked through ATLAS, depositing energy in the detector like particles from other sources. We add these energy deposits to those from the signal Monte Carlo event, and then simulate the detector's electronic response to this combination of signal plus background.

sLHC Studies

ATLAS will be replacing the Inner Detector tracker for Super LHC. It is expected to be an all-Silicon detector with pixels and strips. We believe additional shielding is needed for the FCAL. It is also expected to replace part of the muon spectrometer detectors. The scope of the muon upgrade has great uncertainty at this time. It can be as little as replacing the endcap detectors at small radii, or it can be replacing all muon detectors, depending on the background level. One of the goals of the cavern background calculation is to provide a more reliable prediction.

Status

As of May 2010, the validation against RBTF is complete, the start-up geometry has been implemented, and preliminary cavern background files have been written out. We are now working on using these background files in ATLAS simulation. Comparison with data is starting.

Meetings and Material

Agendas can be found at <http://indico.cern.ch/categoryDisplay.py?categId=225> with schedules and connection details.

Reports

1. [Radiation Background Task Force Summary Report](#).

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