Geant Tracking Bias for Muons

- Some bias is expected depending on the precision of the G4 tracking.
- Want to keep this below uncertainty on MS-ID alignment.
  - Currently known to ~1mm, unlikely to ever be better than 100 μm
  - If tracking bias is less than 10% of best alignment, 10 μm, we should be ok.
- Bias is most likely to be introduced in the calorimeter: lots of volumes (accordion geometry) means lots of steps.
GeantFollower - realistic mode

(geantinos, PDG 998)

\[ \Delta L = \sqrt{\Delta L_X^2 + \Delta L_Y^2} \]

The extrapolator follows to the curvilinear surface of comparison point, always starting from the initial parameters, but stops at surfaces it would naturally stop in a reconstruction job:
- at all TrackingGeometry surfaces with material between initial point and curvilinear surface.
Calorimeter Simulation Problem

- GeantFollower results showed a -0.1 mm offset when traversing the calorimeter
  - Geantinos are used to avoid potential differences in Eloss/scattering: ideal test particle
  - No bias in MS or ID, as shown at left: origin was likely in Geant4
- This offset is an order of magnitude larger than we would like.
  - Could lead to a curvature shift, affecting $p_T$ measurement.

d0 residual from IP to calo exit: 0.1 mm offset, poor precision, strange shape.
Increasing Precision

• It is necessary then to increase the Geant4 stepping precision.

• To save on CPU, do so only for muons (and geantinos for testing purposes) and only in the calorimeter.
  - Even a small CPU increase can be quite expensive given the large number of simulated events that need to be generated.

• Use the ConfigureForTrack functionality to do this.

• Parameter changes:
  - DeltaIntersection: 0.0001 to 0.00001
  - DeltaOneStep: 0.001 to 0.0001
  - MaximumEpsilonStep: 0.001 to 0.0001
  - MinimumEpsilonStep: 0.00005 to 0.00001
Results

Residual from IP to Calo exit

- With the increased stepping precision, the d0 offset is gone and the resolution is as expected.
- Comparisons of muon tracking between Geant4 and the tracking look good as well.
Validation of ATLAS Geometry Simulation

• Easy for mistakes or discrepancies to be introduced as blueprints are converted into Geant layouts.
• Overlaps in particular could potentially lead to simulation problems.
• Team at the National Technical University of Georgia has developed a validation loop.
  - Blueprints are implemented in Catia, a CAD software.
  - Then exported to Atlas Generic Detector Description XML
    ‣ An internal, temporary geometry representation
  - Used to generate G4 representation of the detector
  - Which is then fed back into Catia, which compares the two
    ‣ Check for, e.g., overlaps (hard to find in Geant), multiple representations, etc.
Simulation Validation Loop

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Transactions:
- T’1 = XML → AGDD2Geo
- T’2 = AGDD2Geo → GeoModel
- T’3 = GeoModel → Geo2G4
- T”1 = Oracle → MuonGeoModel
- T”2 = Oracle → CaloGeoModel
- T”3 = Oracle → ID GeoModel
- T”4 = CATPart → GeoModel
- T1 = Geomodel → Facet
- T2 = Geant4 → Facet

FLUGG

Muon Dead Materials

Persint

XML

Active & rest of Materials

ORACLE

CATIA

Web Applications

CAD Systems

Smartteam

Engineering
Example: ATLAS Magnet Coils

• Geometry implemented in CATIA
  - Partly from CERN SmarTeam database, partly by building 3D model directly from manufacturing drawings

• Then the volumes are combined and simplified to match the Geant implementation in the ATLAS tracking geometry
  - Merge volumes with similar materials
  - Careful to preserve volumes and weights and avoid introducing accidental conflicts
  - Reduces 21 volumes to 9

• Finally, check for integration conflicts with the ATLAS G4 implementation
Summary

• Increase in muon precision in the calorimeter reduced muon tracking bias below the level of alignment uncertainty.
  - Precision implemented only for muons to save CPU.

• Validation loop for G4 implementation of ATLAS geometry being developed.

• Upgrade-related cavern background studies are ongoing.
  - No public results yet unfortunately.