Requirements for propagators for Muon detectors

S. Lacaprara, N. Neumeister
N. Amapane

Summary

- Propagation in the muon system: why and where
- Why geane
- Requirements for GEANE replacement
- Problematics for muons
- Future issue

Propagation in Muon detector:

- Propagation in high and non constant B field
- Propagation through iron (energy loss, multiple scattering)
- Both effect co-exist in the same propagation.
- Propagation needed for two pourposes: navigation and tracking (KF)

Use of propagation

Navigation

Muon choice:

- Simple DetLayer structure
- Close to trivial navigation between DetLayers
- Final DetUnit finding delegate to DetLayers
- Need to optimize DetLayers for Muon system

Track fitting (KF)

- Use propagation to define predictedState to be updated via KF
- Full state and error matrix needed

Needs for Muon

- In general, given a state in a chamber (but not necessarily), we want to have the state at a “next” chamber.
- Different need for navigation and track fitting:
  - **Navigation: Coarse extrapolation to get the correct DetUnit in a DetLayer, either for state and error matrix. DetUnits are big (meters).**
  - **Extrapolation mainly through iron (can be 1 m)**
  - **Precision may depends from the initial state “precision”, but in general few cm are always enough.**
  - **Full precision of extrapolation not needed!**

- For track fitting
  - More precision needed
  - Again across iron and B non const
  - In general fewer extrapolations needed, so can be slower
  - Again the extrapolation precision should be compared with the initial state errors
  - If the initial state is “well” defined (usually after few steps in the Kalman Filter), full precision from extrapolation is needed

Why GEANE

Advantages:

- Tool available and reliable: C++ wrapper to access full functionality from ORCA: latest addiction is extrap to cylinder
- Take properly into account non const B field and material crossed
- CMS geometry fully available from CMSIM implementation

Drawbacks:

- Generally slow, 90% of muon reco spent there
- More important, optimization and/or improvement not even tried due to Fortran (and code complexity) obstacle
- Used often too freely: sometime un-necessary large number of extrapolations due to not optimized code.
- Last year works in optimize the code, mainly the navigation, together with a nice time profiling, gave a large decrease of number of propagation and so in cpu time: factor ~ 8!!
- Generally (past) feeling :”someday, someone will provide a super-tool, so fast we don’t need to care too much”...

Requirements for Geane replacement

- Same capability to handle B and material
- FASTER than geane
- Flexible: can choice (eventually at run time) wheter to have accurate but (relatively) slow propagation or fast and coarse
- Same (or extended) geane interface for backward compatibility

Meaning of flexibility:

- We can decide where to live in a speed vs accuracy space
- Decision based on use: navigation or KF
- Define a “minimal error” or “needed accuracy” to decide wheter to go into coarse mode
- Take into account the initial state accuracy to understand which degree of precision is usefull (eg if the init state has an σ(pos)˜10cm => full precision is a waste of time)
- Can decide, even at run time, the granularity of material and/or B, to reduce time
- Vincenzo’s work on B granularity in geane results in 40% speed-up present!

Building geometry for propagator

- So far, only sensitive volume described in ORCA: DT, CSC, RPC
- Non-active material (mainly iron, but not only) described only in CMSIM for geant3 simulation
- GEANE interfaces directly to geant3 geom to the material positioning and definition
- How to do after geane?

Two possible choice:

- Geant4 has similar, detailed description of all meterial: can be used for propagation?
- In general MC and reco needs are different
- How to implement flexiblity on geometry details?
- Or implement a complete model of the non sensitive volumes also in ORCA, optimized for reconstruction.
- In principle better for optimization, but a really hard work!!

- Sensitive volume are very simple: just parallelepipeds, rectangular or trapezoidal
- Iron is much more complex: simple volumes plus strange shapes connecting the big pieces

- Not easy to model it in ORCA
- Work already done in OSCAR, do we need to duplicate it??

- For the tracker not so complex: surface approximation describes fairly good the geometry
- B field can be non constant inside iron, is the surface approx still correct?
- Thickness of iron depends on position and direction (not just a matter of cosθ, think about the boundary of a DT).
- In case modelling iron in ORCA, who's going to do the work? Muon people? Propagator people?

Other future issue

- Now we know B “perfectly”, namely with the same precision of MC simulation
- In the real world that will be not possible
- B field in real CMS will be sampled, and eventually measured with tracking during calibration
- In any case precision not infinite:
- Sooner or later Paris will ask: “Which is the impact of non perfect knowledge of B field on reconstruction?” Or “how precisely do we need to know B to get a resolution of X%?”
- Geane replacement and/or B field description should allow to perform these kind of studies