

Issues in Geometry and Field

J. Apostolakis

Outline

- Error in Normal for coincident surfaces
 - Spoils optical photon transport
- Stuck tracks in ATLAS (spans G4 9.2 to 9.4)
 - 100sK of steps possible at a boundary
- New ATLAS issues
 - New ‘looping’ related to SubtractionSolid
 - Tracks continue in ‘beam pipe’ for 5 Km ...

Normals and Optical Process

- User (P. Gumplinger) reported issue with normal – needed for reflection, refraction, ..
 - GetLocalExitNormal() vector used with Transformation gives a big error
- Diagnosis is that the ‘Local’ value refers to a different reference frame than the final one
 - User suggested ‘quick’ revisions
 - P.G. was able to use these to run.

Normal in G4Navigator

- Navigator used to provide normal only in ***local coordinates*** and only ***after relocation***
- Extended – it now provides
 - *Value in Global* coordinates – in new method **GetGlobalExitNormal(..)**
 - *result also after ComputeStep*, i.e. before relocation.
- Challenge: changes in several places needed
 - Delicate, must ensure correctness and low overhead.
- Open issue: Replica Navigation
 - Replicas cannot compute a normal
 - Replicas do not provide a solid (issue for Viz too.)

Global Exit Normal

- Move Optical Process to use `GetGlobalExitNormal()`
 - Created to simplify client code (should have done it earlier ...)
- When exiting a volume, there was still a problem
 - The relocation changed the volume hierarchy stored
 - The Get method was using Vector and Transformation which were out of sync.

Current status

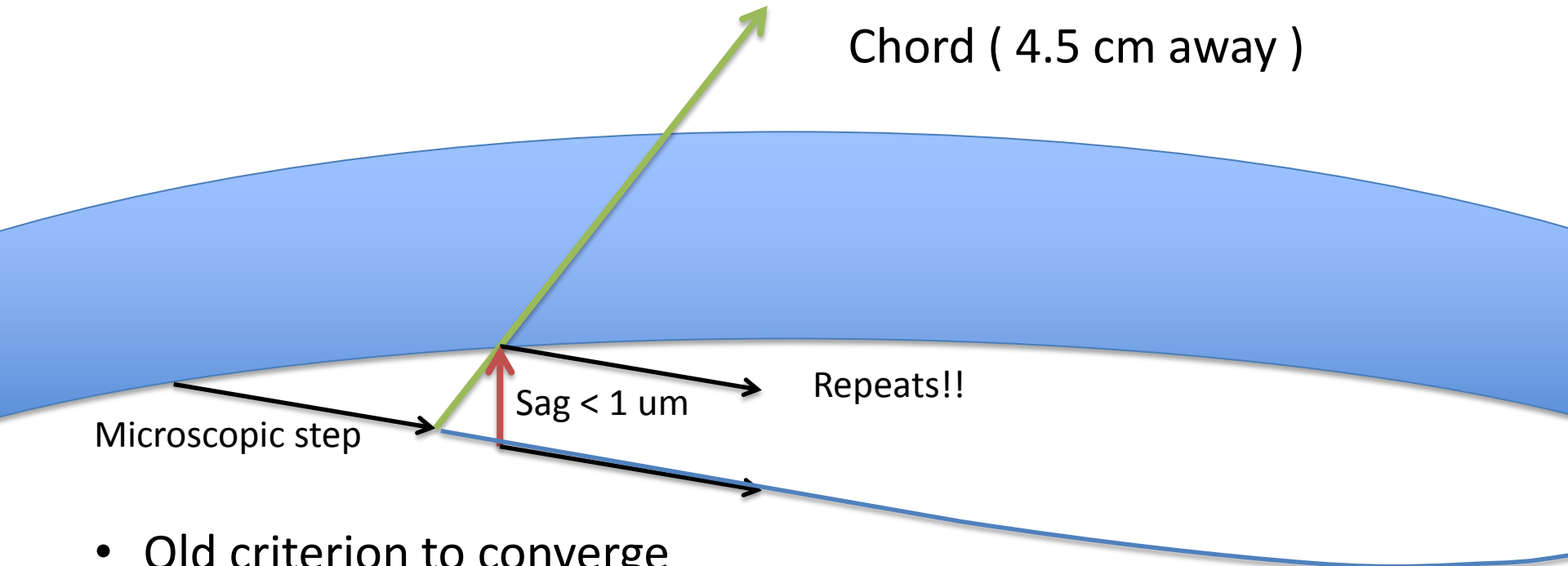
- **Fix:** store the exit normal in Global coordinates
 - Right away – when the vector and reference frame are in sync.
- **Status:** trial of fixes (Peter G.)
 - First trial – situation is improved
 - **Open:** the ‘valid’ flag is currently set to false.
- Fix and a tag are under preparation

STUCK TRACKS – THE SAGA

Stuck Tracks: the issue

- ATLAS reported (2010) stuck tracks $\gg 10,000$ steps
 - Killed any event with 1 bad track
 - Happens in the most complex events (QCD)
 - Used **huge threshold (1M steps)** to get low rate of event rejection
- Problems
 - CPU overhead of order 1%
 - Potential bias – events with high multiplicity rejected more often
- Challenges: Reproduce, Characterize, Understand, then Resolve

Track Stuck on volume boundary



- Old criterion to converge
Sagitta < 1 micron
- Never entered steel
 - Momentum unchanged

- Improved criterion:
 - track momentum points 'into' volume

Stuck track issue & fix

- What happens – why does it get stuck?
 - Small step ($1.6e-06$ mm) in vacuum, then $1.0e-09$, 0, 0, 0 & repeat
 - Momentum taken from integration - never pointed into steel (no E loss)
- Cause: Imprecision in ‘convergence’ criteria for intersection with volume boundary
 - Weakness: criterion to converge `sagitta < delta_intersection`
- Fix improve convergence criterion:
 - `((same) && (track enters solid)) || (sagitta < epsilon_distance))`
- Needs robust implementation of normal in G4Navigator
 - Required revision of methods of the critical G4Navigator class

Result!

- Particles are no longer stuck
 - The full set of 200 ATLAS test SU(3) events complete without any problem!
 - No track requires more than 5,000 steps anymore – at least not due to propagation in field!
- Ran in 4 “configurations”
 - Debug and optimised
 - With and without fix for muon single scattering (Vladimir Iv.) which caused $\frac{1}{4}$ events to get ‘stuck’
- Issue is resolved!

- Fix / improvements are
 - Prepared for 9.4 patch
 - included in 9.5 cand 02/03
- Working on tests and ‘revised’ fix
 - Identified ToDos for further improvements.

Use in production

- Four new cases of looping
 - Traced to SubtractionSolid and LocateIntersection
 - called by PropagatorInField
 - Improvement created in Solid
 - Solved 75% of the cases (3/4)
 - Weaknesses remain in DistanceToIn and in Locator (was calling repeatedly)

THE END – THANK YOU

Test cases

- Existing, used
 - Test “NTST”, based on Babar tracker
 - Stress test for Intersection Locator classes (Tatiana)
 - Unit tests
- Multiple geometries – no test yet
 - problem reported by Joseph when scoring triggers use of 2nd geometry
- NEED to add test to stress the issue of boundary crossing – new specialised test(s).

Status - Details

- Fixed problem with multiple geometries
 - Improved MultiNavigator
 - Chose better method for computation (VIntersectionLocator)
- Final fixes for Normal (and improved criterion)
 - included in 9.5-cand 02 and -cand03,
 - Readied for inclusion in 9.4-patch03
- Requested by ATLAS to create 'revised' fix
 - That works with old header files for 9.4p1 & p2

To Dos / Proposal

- Extend test suite to cover the challenging test cases
 - Custom example with many volume interfaces, low energy charged tracks
 - Include multiple geometries
- Revise Replica Navigation to provide Normals
 - ‘Hole’ in current code for Replicas
 - Useful for additional optimisation / recovery in Geometry
- Review and rewrite key code in field category
 - Key classes are complex, and difficult to read / improve
 - Keep/add hooks for diagnostics with few lines
 - Seek performance improvement with improved code, design
 - One of few places in G4 where a lot of computation is done in a few classes
 - New ideas: use trajectory class, interpolation, and/or vector code ...
- Key issues:
 - Locators (complicated, hard to understand, fix, improve => refactor, improve)
 - Propagator In Field: review how it handles mildly ‘stuck’ tracks, improve implementation, simplify