VMC: GEANT3 and FLUKA interfaces status

Andrei Gheata

VMC workshop, 29-30 Nov. 2004

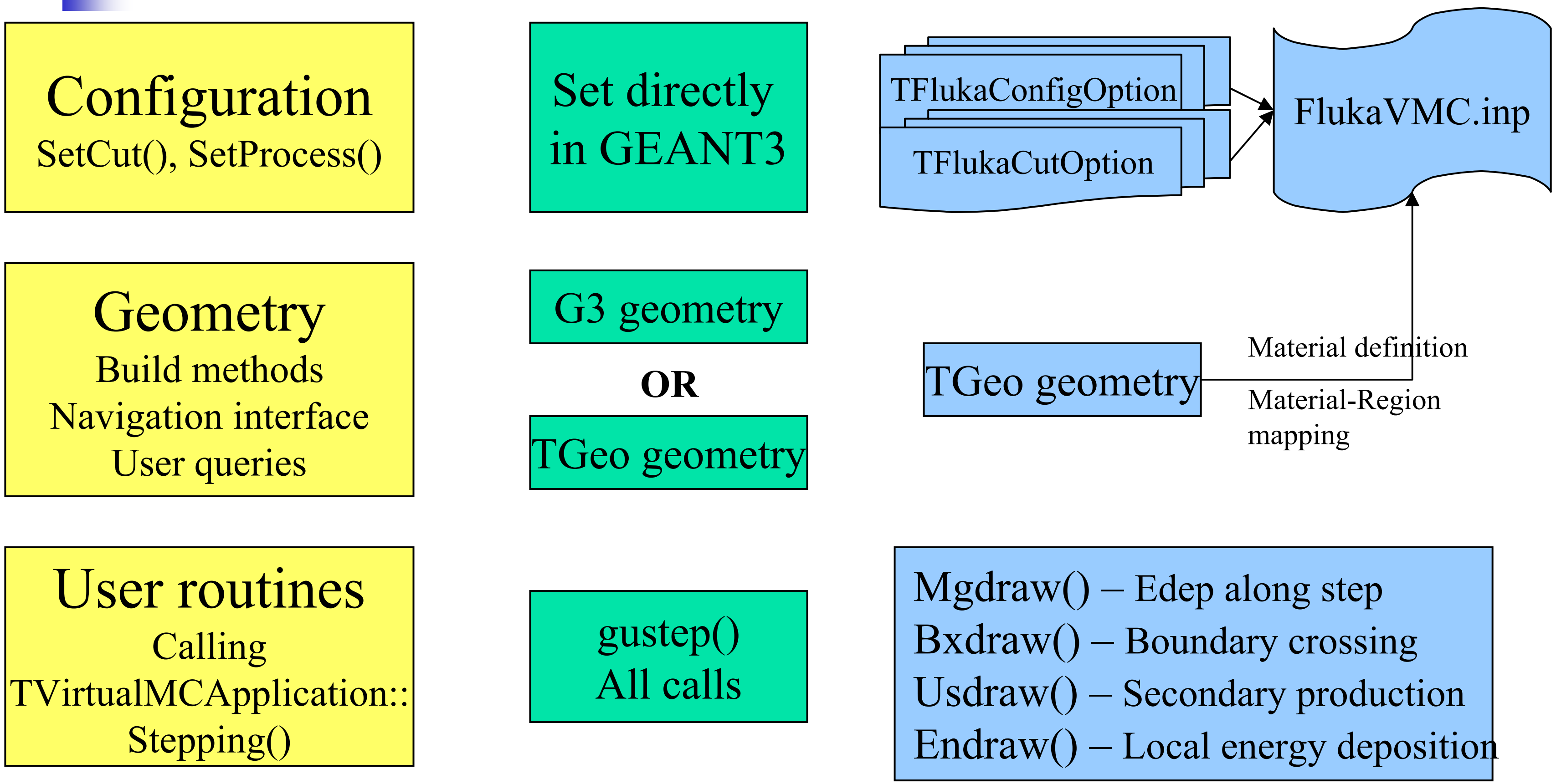
Outline

- General status of implementation
- TGeant3 vs. TFluka
- Configuration
- Geometry
- Stepping
- Validation tests

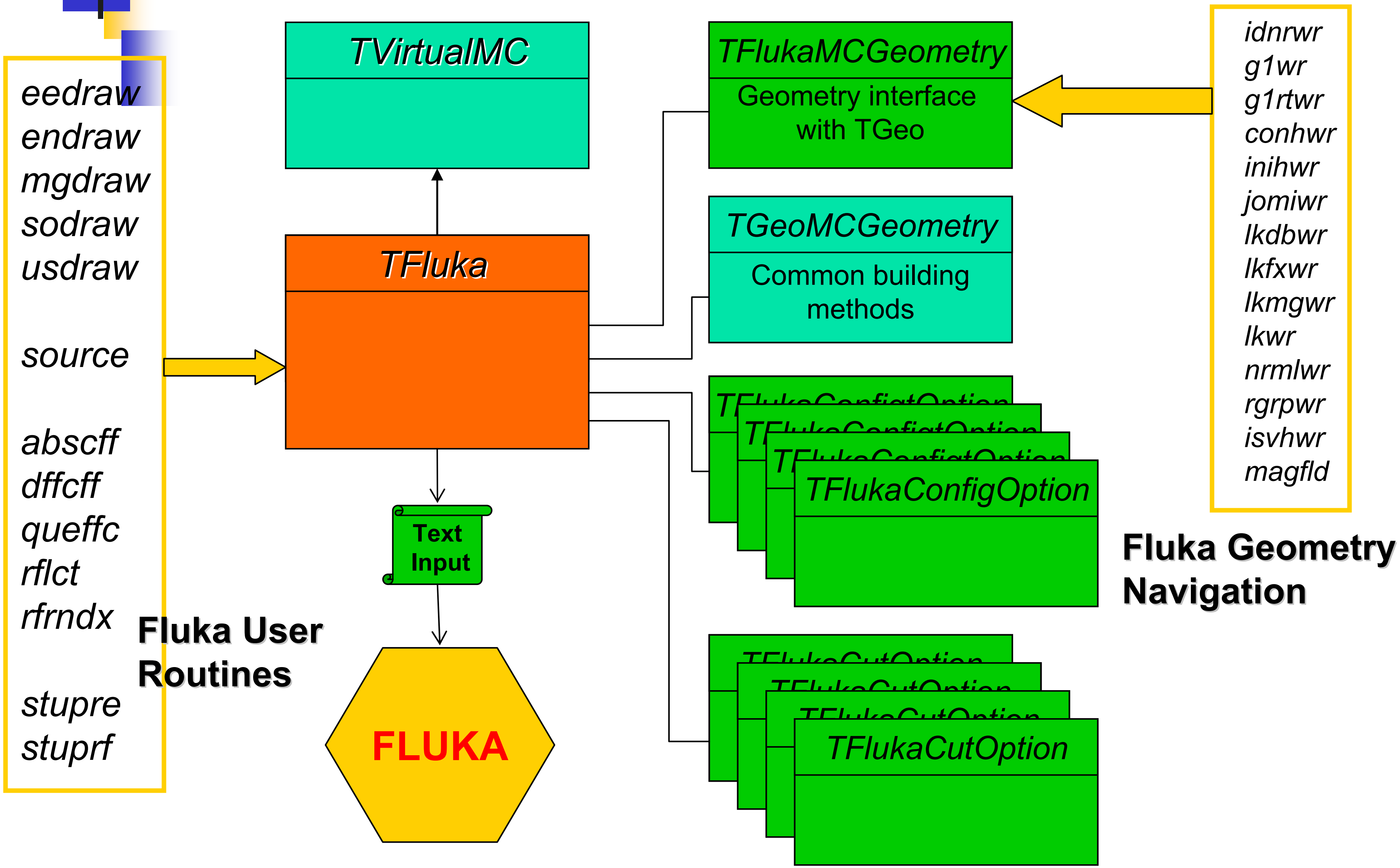
General status

- Implementing the *TVirtualMC* interface for GEANT3 and FLUKA transport engines
- GEANT3 VMC – in production for ALICE, under testing by few other experiments
  - Mostly 1 to 1 mapping with G3 native functions: VMC development was inspired by G3 model
  - Can work either with G3 native or ROOT geometry
- FLUKA VMC – validation phase ongoing
  - Mapping as much as possible VMC physics/cuts configuration with corresponding FLUKA settings
  - Using *TGeo* for geometrical representation and navigation
  - Not yet published in ROOT repository, quite many changes done continuously while testing/validating

TGeant3 vs. TFluka



FLUKA VMC class structure



Specific FLUKA VMC features

- Configuration, material definition/mapping has to be provided to FLUKA as an ASCII input file
  - Automatic process, transparent to users
  - Common global settings (files to be opened by FLUKA + mandatory cards) in a provided file: *coreFlukaVMC.inp*
    - Gives a “hook” for users to personalize some more specific settings (e.g. global tracking precision)
- Some X-sec files from FLUKA distribution have to be sim-linked in the working folder
  - A ROOT macro provided to do this automatically
- FLUKA PEMF file generation on demand
  - Specific to FLUKA, creates the electromagnetic cross-sections file according the material description
  - Currently binned in a big energy range, cannot be personalized (to be done)
- Magnetic field can be switched on/off only globally (FLUKA allows this per region)

Configuration

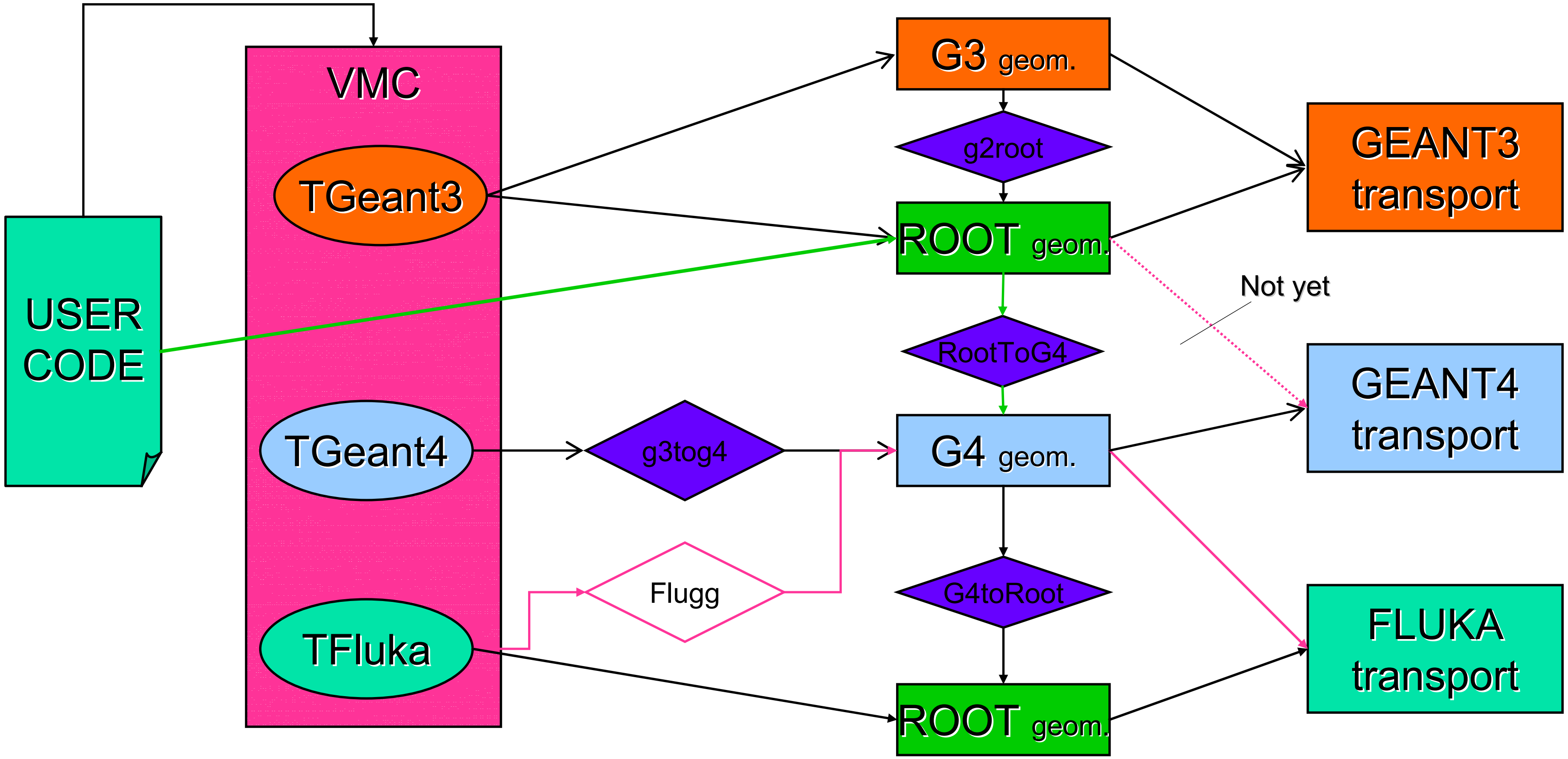
- Global configuration: *SetCut(), SetProcess(), DefineParticle(), DefineIon(), …*
  - Apply globally to simulation
  - Directly applied in case of GEANT3
  - Converted to temporary objects TFlukaCutOption, TFlukaConfigOption in case of FLUKA
    - Converted to FLUKA “cards” appended to FLUKA input during InitPhysics()
    - Most settings mapped with corresponding FLUKA ones, except few (e.g. disabling particle decays)

- Local (per medium) cuts
  - No tracking media in FLUKA, cuts are applied per material/region
  - Energy cut selection material-by-material not possible for some particles
  - Attempts to apply these cuts work in ***TFluka*** as far as there is one material defined per medium
    - Tracking precision can be set different/material, but VMC does not support this

Geometry

- Geometry building interface in VMC matching G3 methods: *Material, Mixture, Medium, Gsvolu, Gspos, Gsposp, Gsdvn, …*
  - Boolean solids not supported !
  - Not compatible with FLUKA native geometry
  - Currently both GEANT3 and FLUKA can work with TGeo geometry, GEANT4 works only with its own => the building interface should be extended to the common denominator TGeo/G4 once migration to G3+TGeo will be completed
- Geometry navigation dependent on MC
  - Implemented via specific wrapper functions in case of TGeo (foreign geometry)
  - Optimized G3+TGeo after several iterations, small gain in performance observed (6-10%) in total simulation time
  - Working FLUKA + TGeo, but debugging is hard and optimization impossible without the source code of FLUKA

Geometry in VMC



Geometry user calls

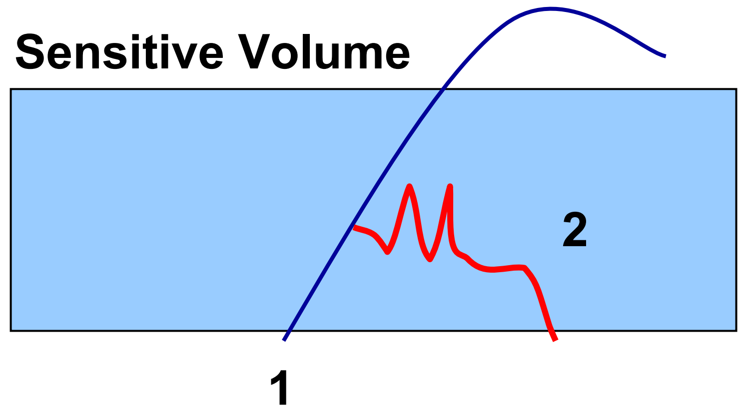
- Quite limited in VMC – user supposed to ask just a limited set of questions to geometry
  - Some geometry state parameters known by MC itself:
    - Current volume ID, current branch in geometry, current material and medium
    - In sync with geometry during user calls in case of TGeo
  - Some functionality offered directly by geometry
    - Local-to-global and inverse conversions, volume lookup by name, material lookup by volume ID, …
    - Can be extended: current global matrix, current geometry depth

Stepping control

- Call-back methods allowing user code notification (TVirtualMCApplication::Stepping) during MC stepping.
  - Track state: PID, status, position, momentum, time, …
  - Step info: energy deposition, step length, …
- Single entry in case of G3: gustep()
- Multiple entries in case of FLUKA: mgdraw(), bxdraw(), usdraw(), endraw()
  - Handling each different types of events
  - Information converted in VMC format
    - Much difficult to manage: state control methods have to act according the event (e.g. energy deposition is read from different sources depending on the callback entry)

FLUKA tracking sequence

- Primary tracking postponed after secondaries are fully tracked
- 4 calls to Stepping() in TGeant3, vs. 6 in TFluka
- Different number of hits, but same energy deposition/digits



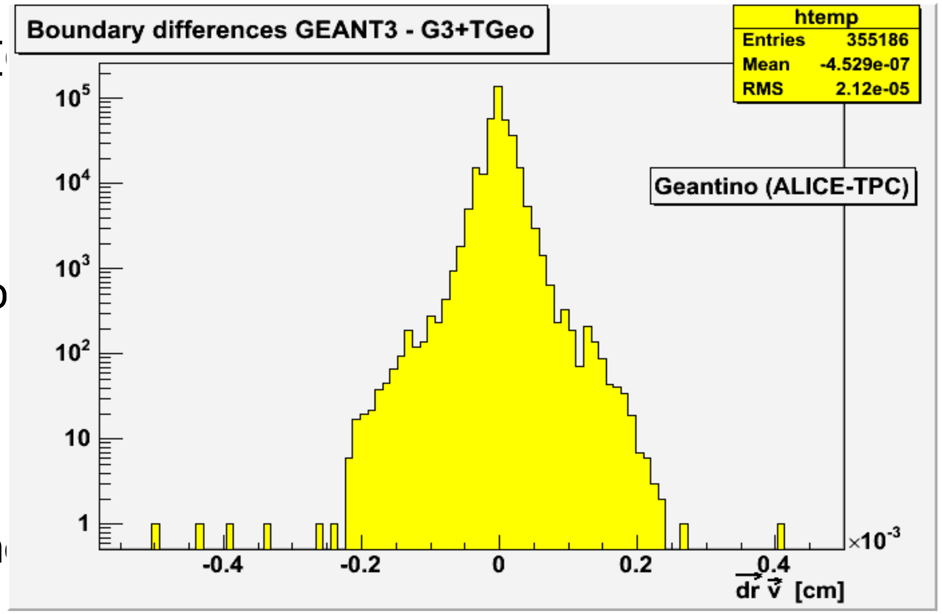
Geant 3
1: entering
1: exiting
2: entering
2: exiting

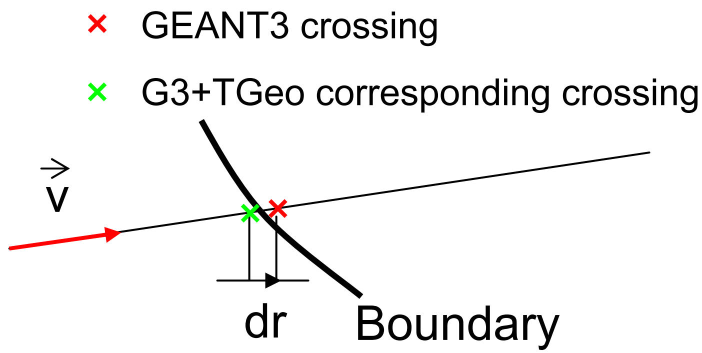
FLUKA
1: entering
1: disappeared
2: entering
2: exiting
1: entering
1:exiting

2 hits → **3 hits**

Validation of G3 + TGeo navigation

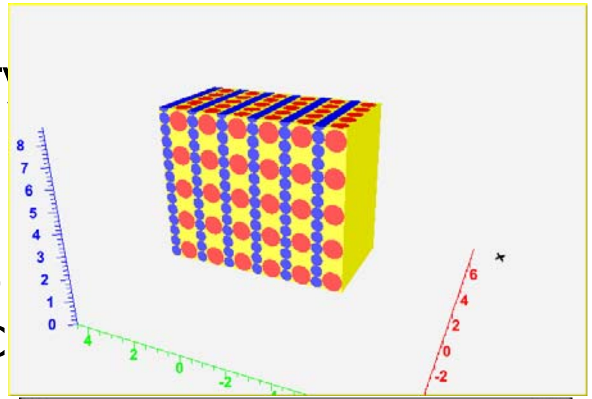
- Comparisons at hits level done in ALI
  - No relevant differences found
    - See "A geometrical modeler for HEP" presentation at CHEP03
  - More detailed analysis at detector mo level to be done
- Comparisons at step level
  - Already done for simple geometries
  - Geantinos shot in partial ALICE geom
    - Differences at the expected level
    - Fine tuning of TGeo behavior when tracking close to boundaries
    - Analysis of possible rounding errors
  - Current version optimized after these tests (6-10% performance gain)

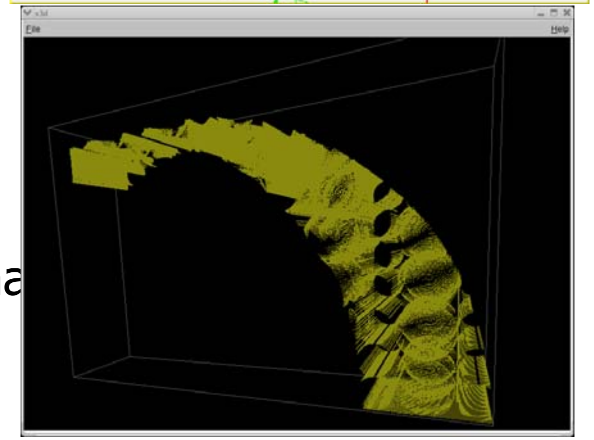




Validation of FLUKA + TGeo

- Comparison between FLUKA native stepping versus TFluka, for a simple example
- Original setup: calorimeter sandwich Pb-Scintillator-Al, 1GeV/c protons in magnetic field
  - Vacuum put everywhere : pure geometr
  - Geometry reproduced identically with TGeo
    - Boolean compositions (150 components)
    - Simple application as the ones from VMC examples
    - Hits collected at boundary crossings: x,y,z, track ID, region number
- Matching procedure track-by-track
  - Computation of the distance between ma points : $dr = (\mathbf{P}_{TFluka} - \mathbf{P}_{FLUKA}) \bullet \mathbf{v}$

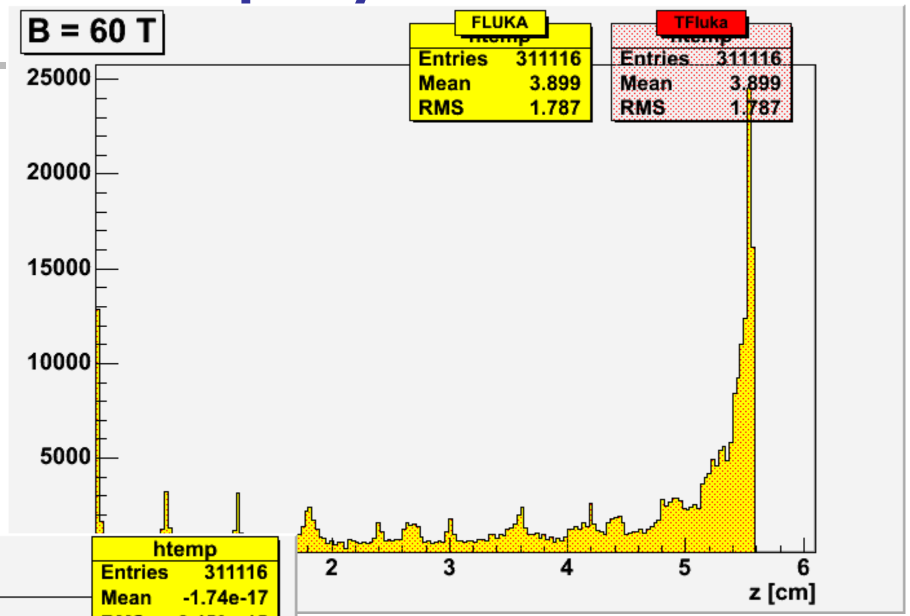


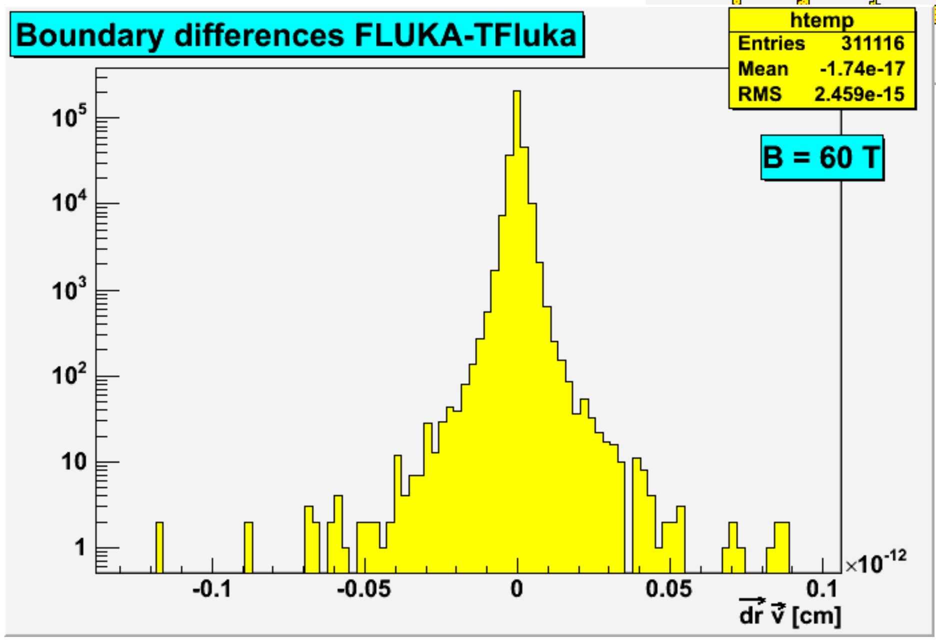


Boundary crossing – no physics

- All crossing points matching
  - Same boundary sequence
- No magnetic field

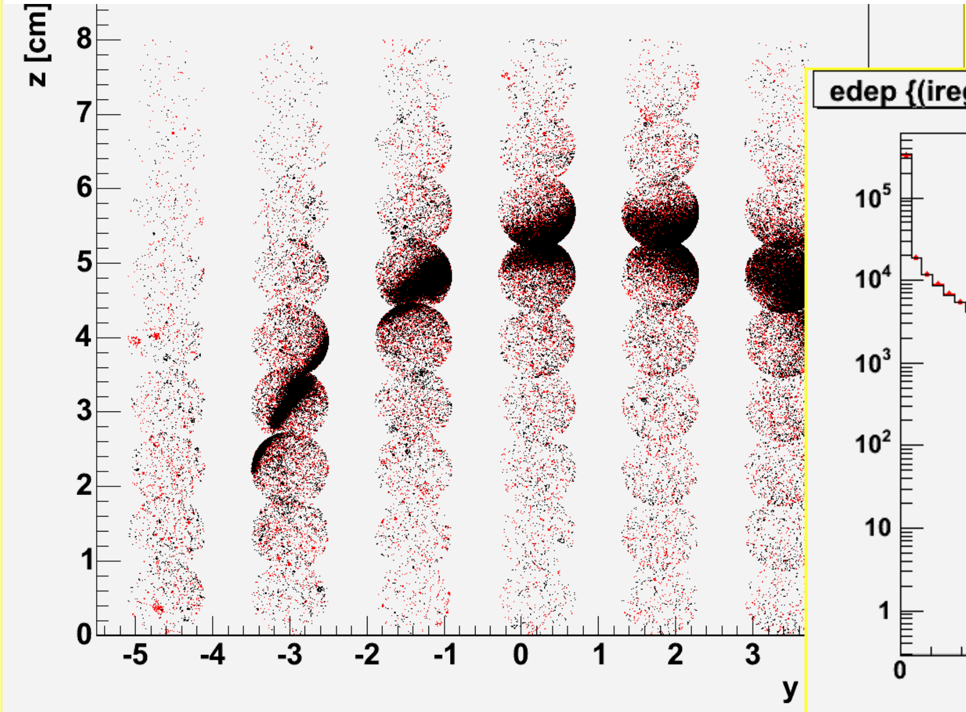
- B = 60 T
  - Helped fixing few bugs first
- Very encouraging since differences are at double-precision error level as expected

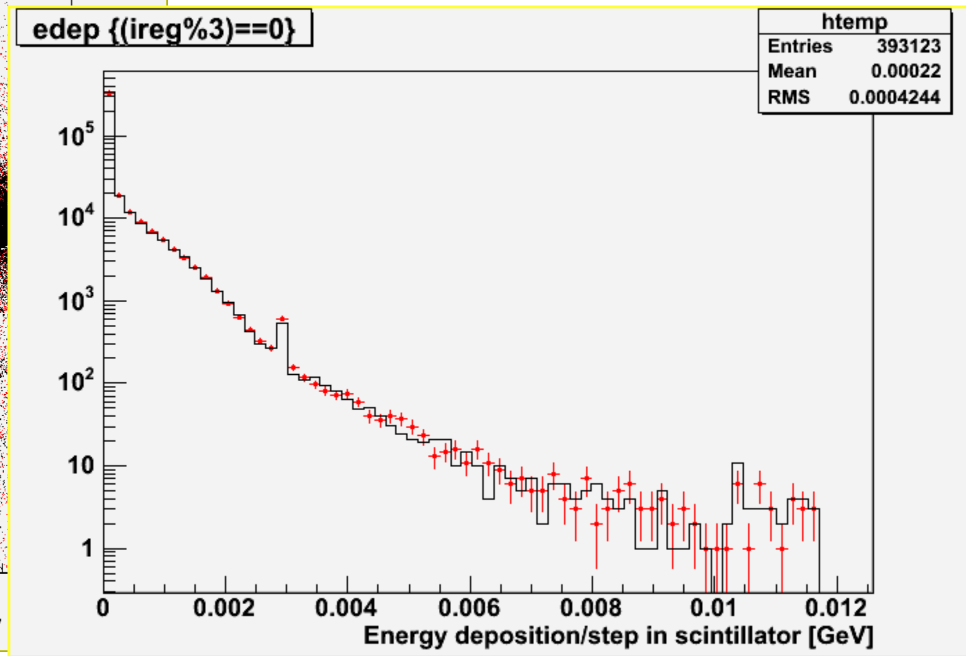




Physics on

- 5000 protons 1GeV/c in 60T x-oriented field
- EM physics on, .pemf file generated by TFluka
- Same input for the native example and TFluka application





Conclusions

- Consolidation of G3 + TGeo geometry
- FLUKA VMC under extensive testing
  - Not yet in ROOT CVS
  - Geometry interface stable, optimizations possible after FLUKA source code will be made public