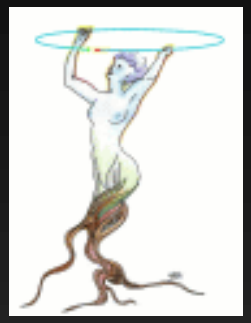

An interface for GEANT4 simulation using ROOT geometry navigation

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ALICE offline Collaboration

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Outline

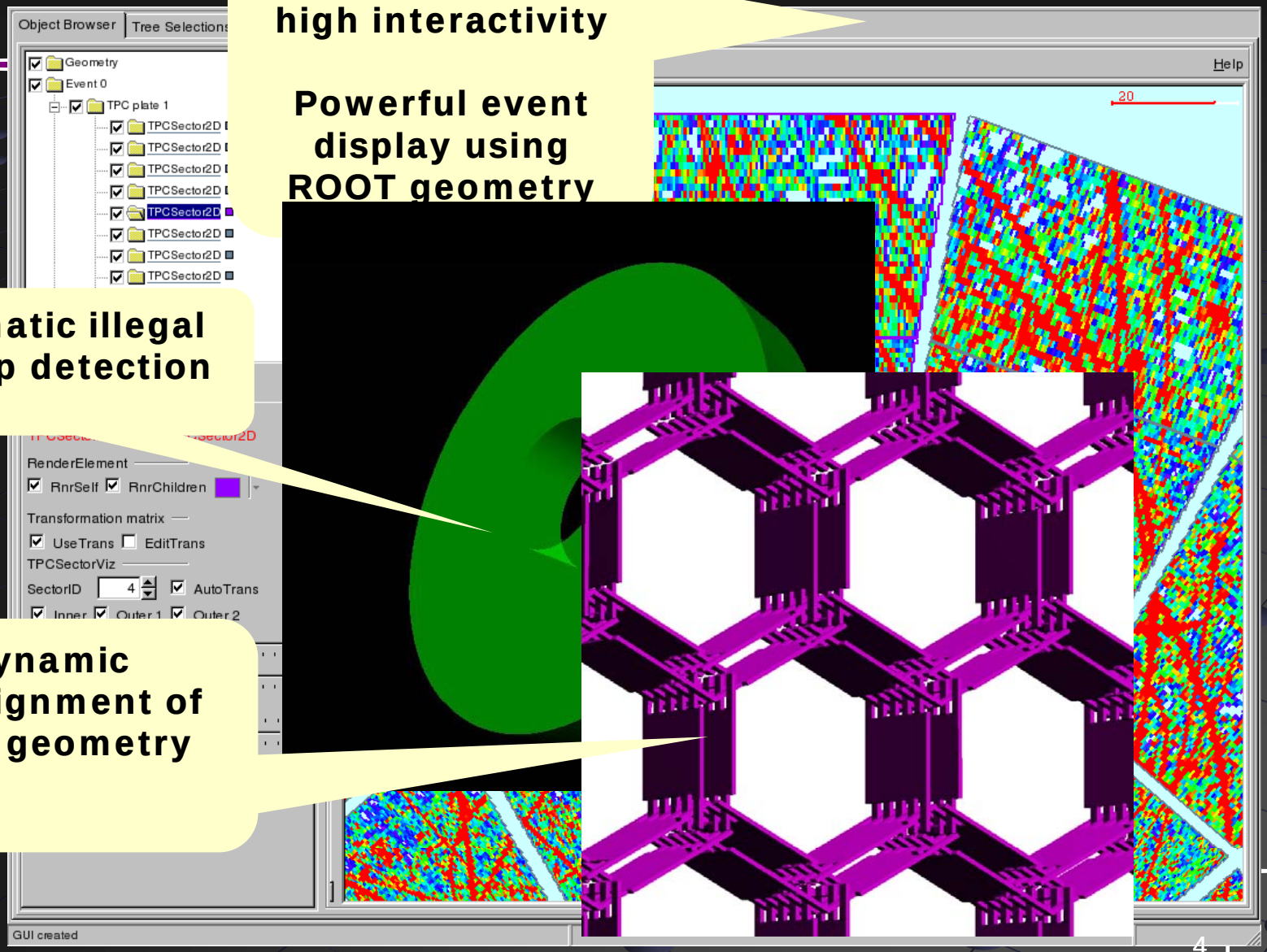
- Motivation
- Integration in GEANT4 VMC
- Ongoing validation procedure
- Some comparisons
- Conclusions

Motivation

- **Running GEANT4 simulation with ROOT geometry modeller**
  - **Currently the only way to run full ALICE simulation with G4**
  - **ROOT *TGeo* is a multi-purpose geometry package independent of any MC framework**
    - **Developed by ALICE offline in collaboration with ROOT team**
    - **Providing navigation functionality designed for tracking detector geometries**
    - **Additional features: checking tools, visualization, alignment tools, ROOT persistency, …**
    - **More about TGeo presented at CHEP03**
- **Having an external geometry description as alternative to MC-embedded models**
  - **Having 3 transport MC's interfaced with the same geometry**
  - **Geometry is used a lot outside the simulation framework**
  - **Important component in making a simulation application survive outside the specific MC framework → Virtual Monte Carlo**

3D graphics with high interactivity

Powerful event display using ROOT geometry



Automatic illegal overlap detection

Dynamic misalignment of ideal geometry

The Virtual Monte Carlo

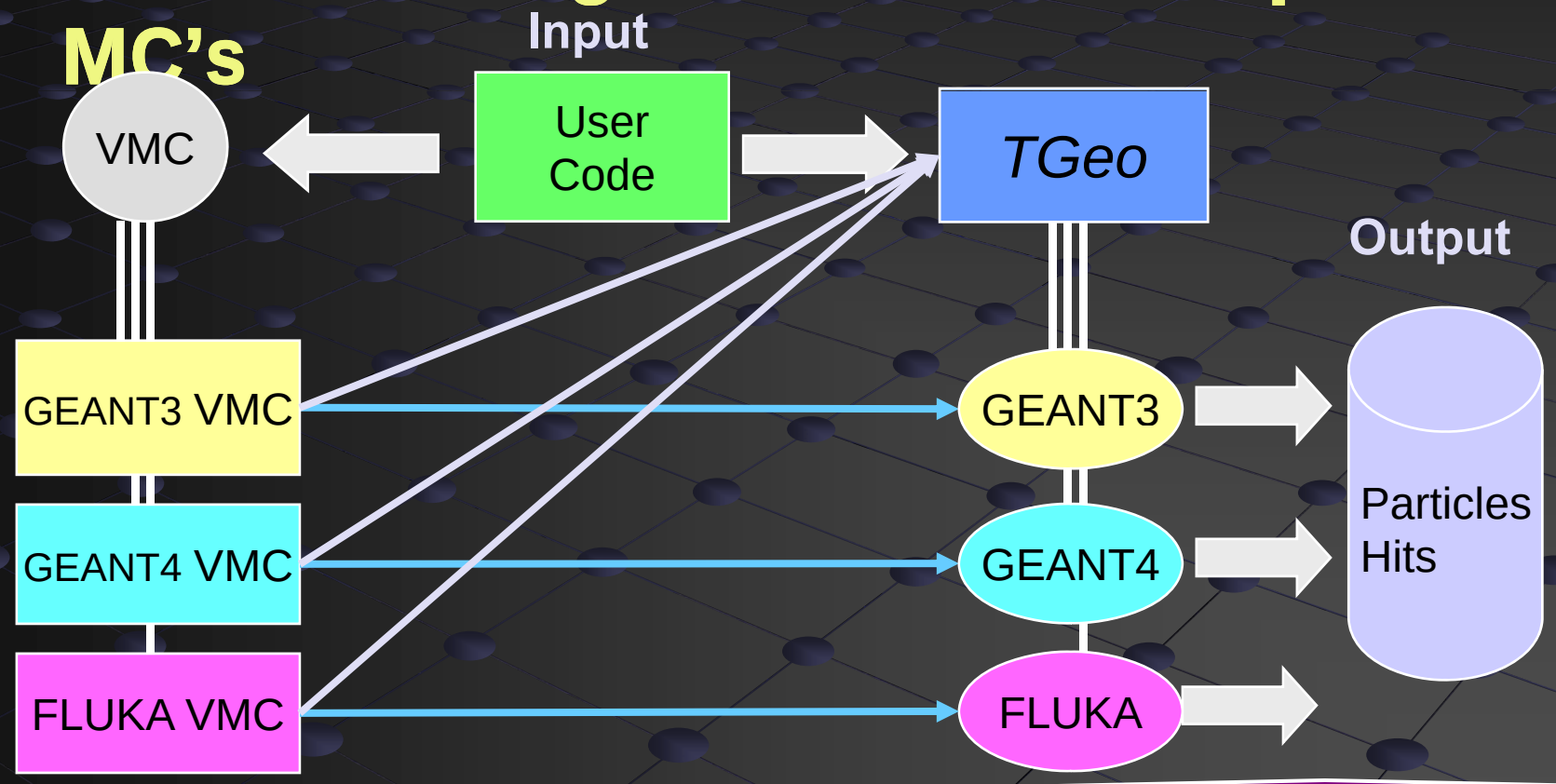
- Allows defining user applications independent of the specific transport code
  - GEANT3, GEANT4 and FLUKA supported so far
  - Keeping the SAME definition for geometry, I/O formats and detector response simulation
    - Allows running the same application with different MC's
- VMC decouples user code from the concrete MC
  - Provides MC-independent API for :
    - Geometry definition, setting up physics, setting up cuts, handling particle stack ... (features very different from one MC to another)
    - Querying MC machine state and kinematics during stepping callbacks (very similar mechanisms)
- More on VMC presentions here

External geometry – a coherent solution

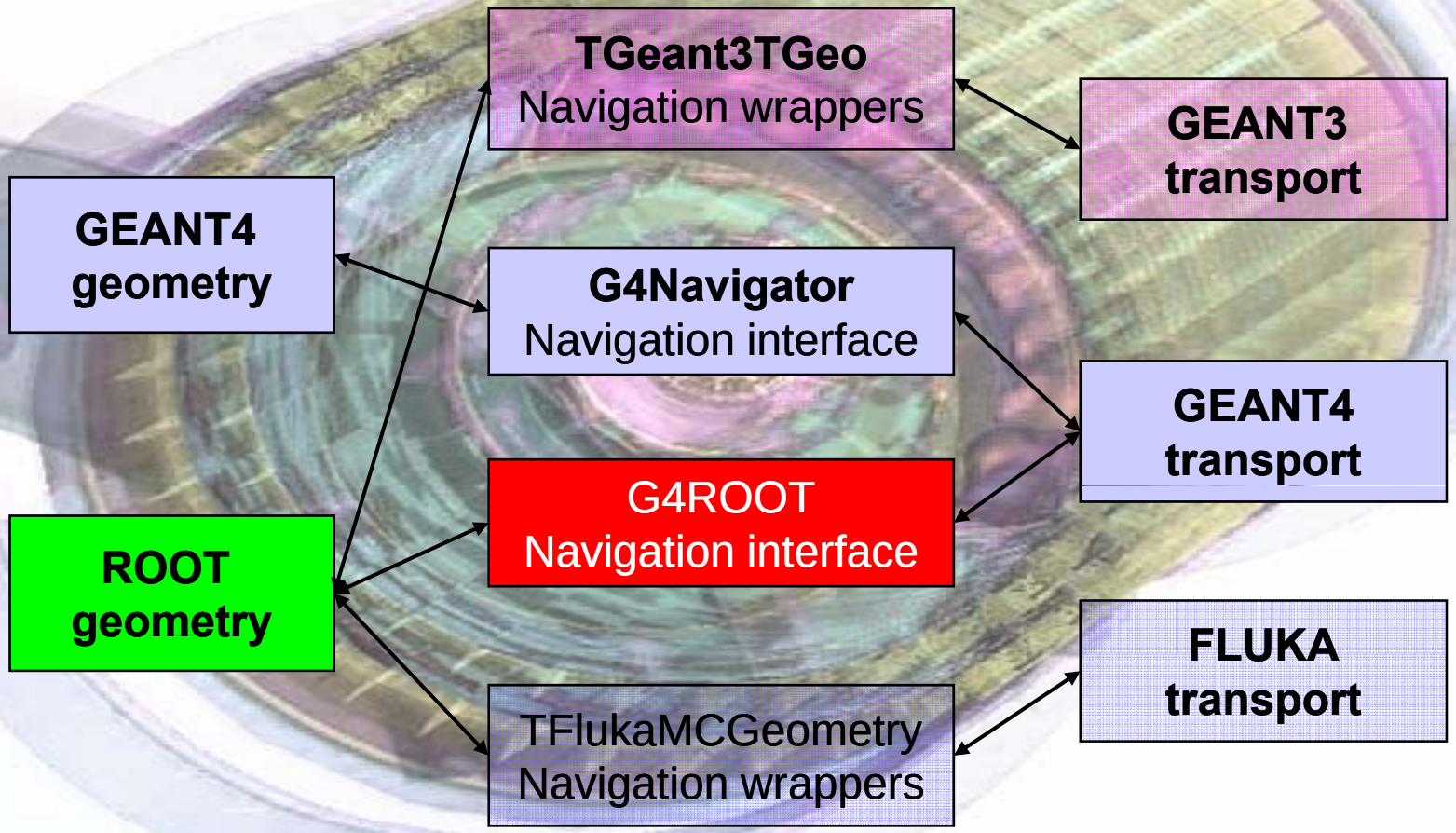
- **Trying to keep the MC native geometry have serious limitations**
  - **The common denominator of all geometry features is rather limited, so conversion is not always possible**
    - **From experience this becomes fast a blocker when trying to make an application for several MC's**
- **One of the reasons TGeo was developed**
  - **Navigation speed was a priority**
    - **Even behind an interface TGeo gains ~8% in simulation speed in case of ALICE compared to GEANT3 native**
      - **Even more in case of non-optimized geometries**
- **In case of FLUKA there were no other way out for running ALICE simulation**
  - **FLUGG interface testing was not a success for us...**
- We needed to make all supported MC transport engines able to work directly with TGeo

TGeo@VMC concept

- **TGeo as navigator for all transport MC's**



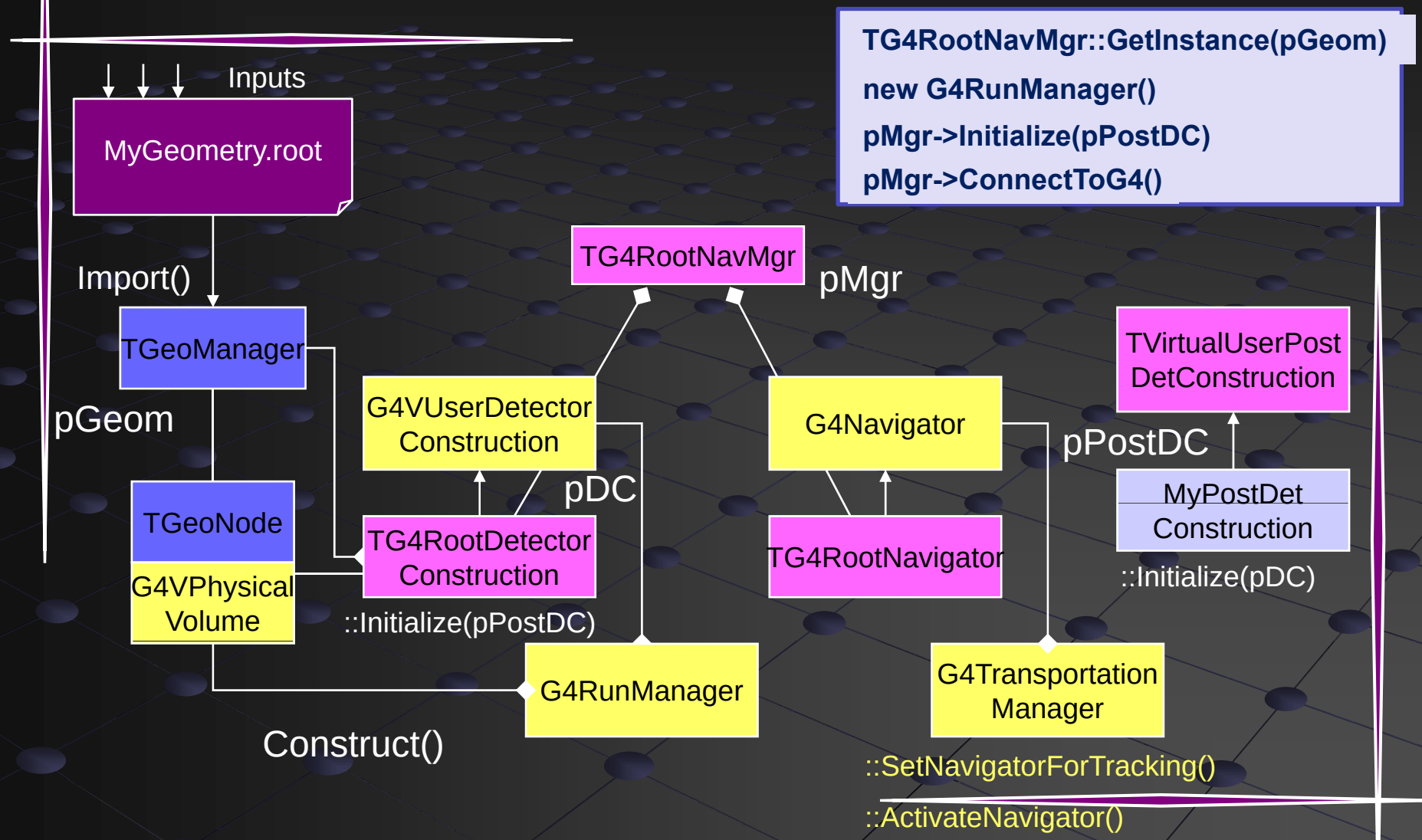
Geometry access during MC transportation



Implementation – navigation interface

- **G4Navigator – base class for GEANT4 navigation**
  - **Provides the entry point for all geometry queries related to navigation**
- **TG4RootNavigator : public G4Navigator**
  - **Implementing methods for locating a point, finding the distance to next boundary, computing the safety distance and the normal to a crossed surface**
- **More implementation details presented at ROOT 2007 workshop**

How it works



TG4RootNavMgr::GetInstance(pGeom)

new G4RunManager()

pMgr->Initialize(pPostDC)

pMgr->ConnectToG4()

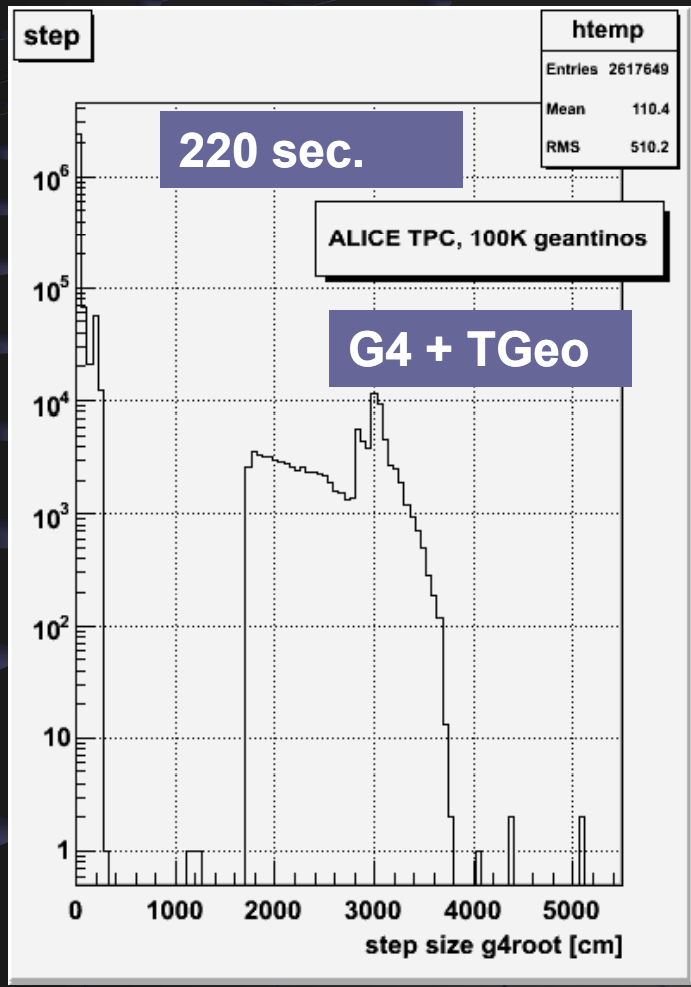
Validation procedure

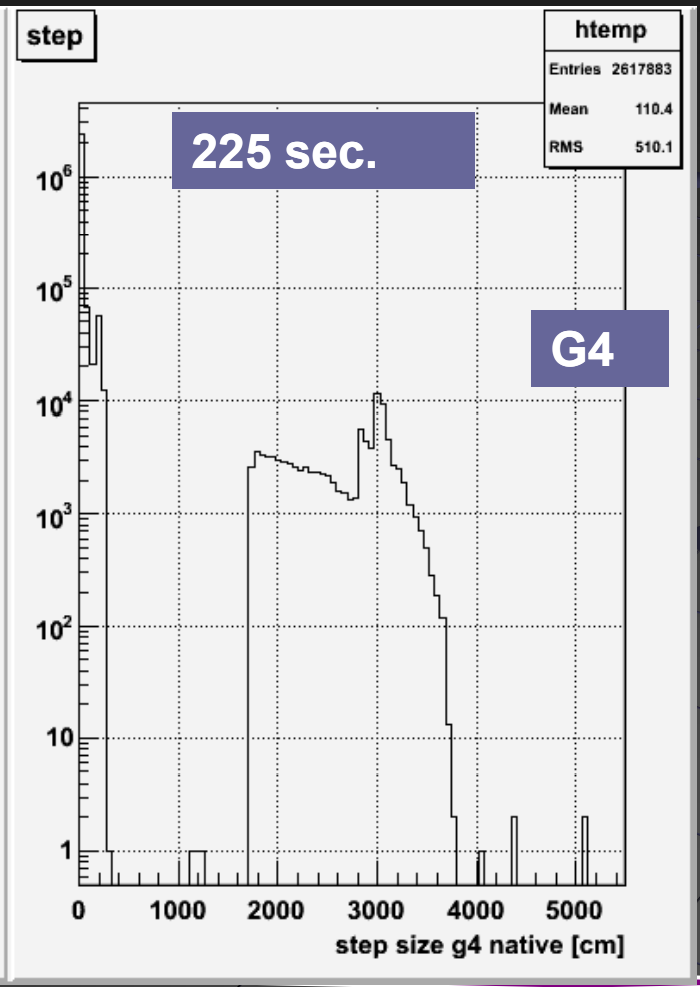
- **Testing with G4 native examples**
  - **Comparing results given by G4/G4ROOT navigation**
  - **Equivalent TGeo geometries with G4 ones**
  - **Done for most Novice examples**
    - **Results either identical or statistically compatible**
- **Tests within VGM test setups**
  - **Checking various geometry configurations and different geometry features**
    - **Boolean operations, divisions, replicas, ...**
  - **Revealed few bugs in the navigation interface that were fixed**
  - **More complex geometries to be compared – extremely performant debugging tool !**

Validation procedure (cont)

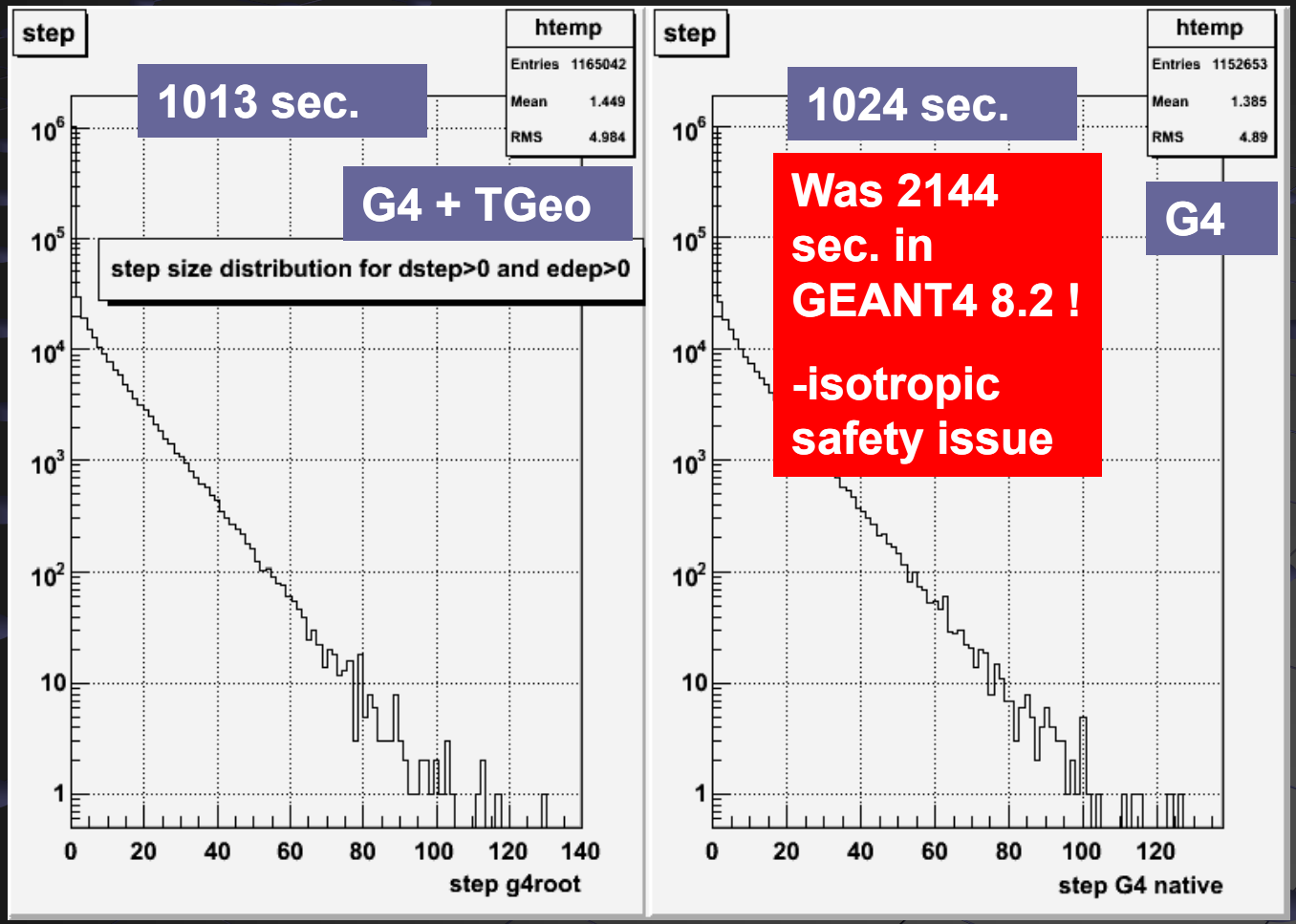
- Tests with GEANT4 VMC
  - Comparisons with physics switched on/off for real experiments
    - ALICE was the first candidate
    - Using GEANT4 9.0 and ROOT 5.17.02
    - Further testing/feedback expected from other VMC users:
      - MINOS, CBM/PANDA@GSI/FAIR
  - Performance comparisons for complex geometries
    - Realistic timing comparisons can only be done for realistic cases (example geometries much too simple)
    - Comparisons for ALICE simulation made for different geometry setups for G4 with native/TGeo navigation and with G3/FLUKA
      - ALICE TPC
      - ALICE barrel detectors
      - Full geometry setup except the components that cannot be converted to a native G4 geometry

Geantinos comparisons (TPC)

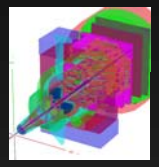




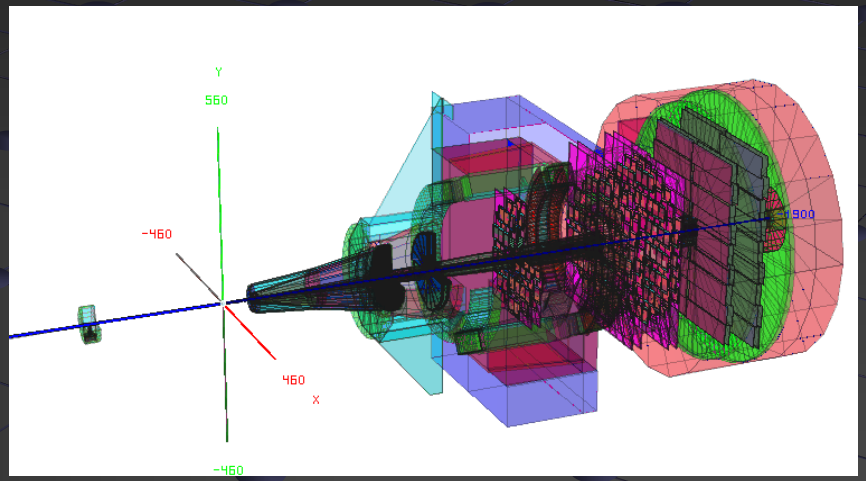
TPC – 5K particles, physics + field



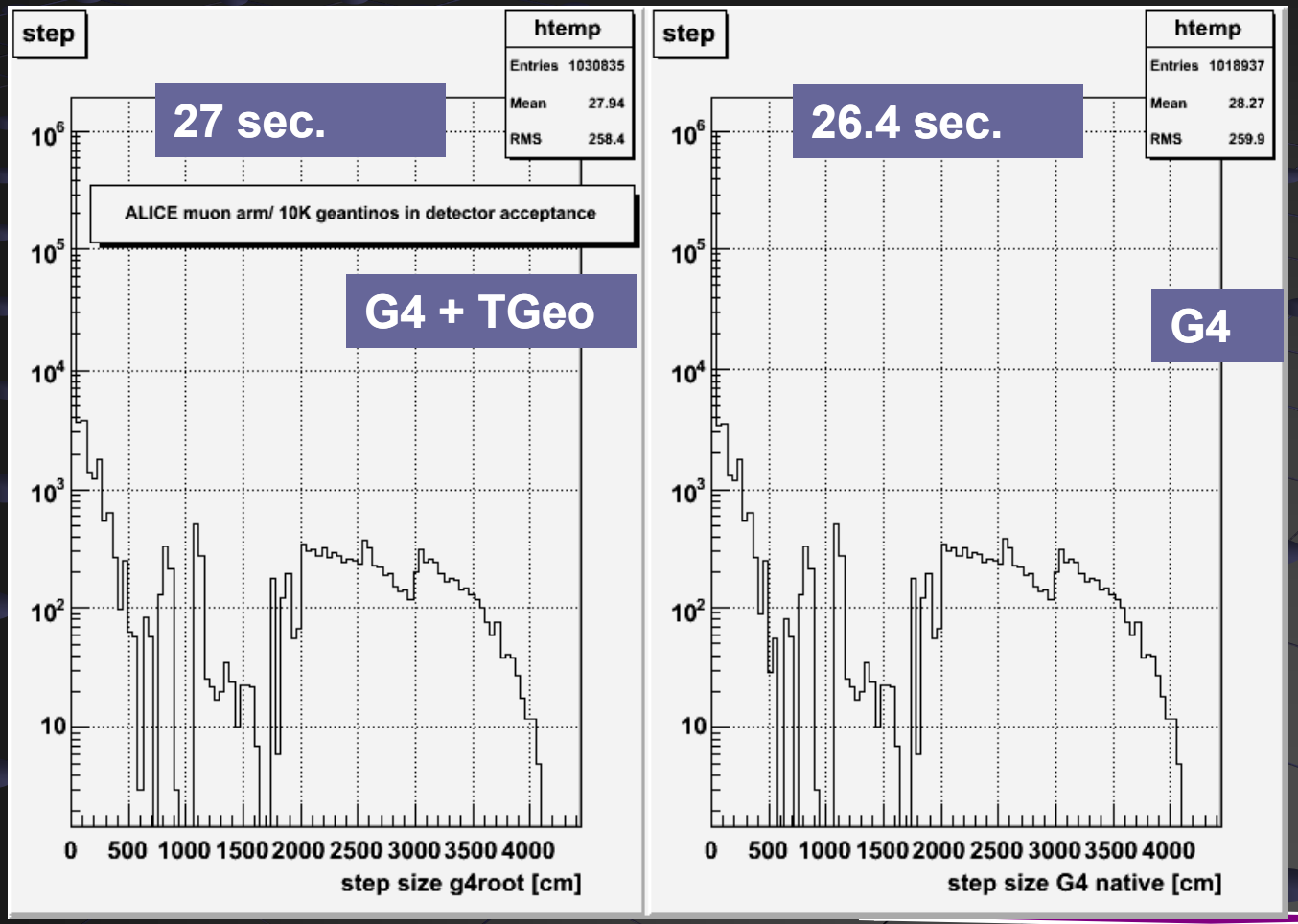
ALICE MUON ARM



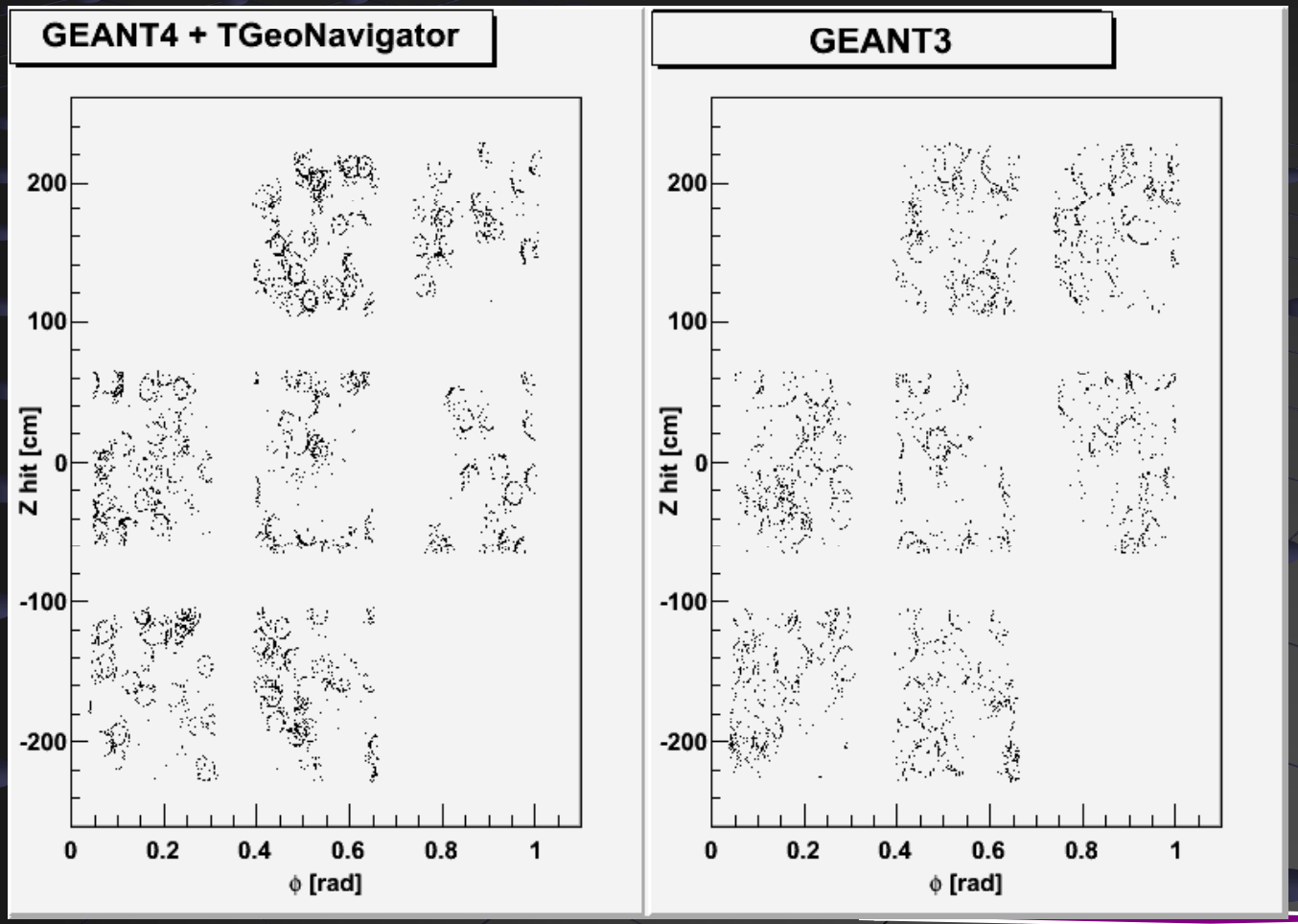
- **10K geantinos within acceptance**
- **500 HIJING parameterized (0.5-999 GeV)**
- **Step length distributions**
- **Most particles stopped within the absorber**



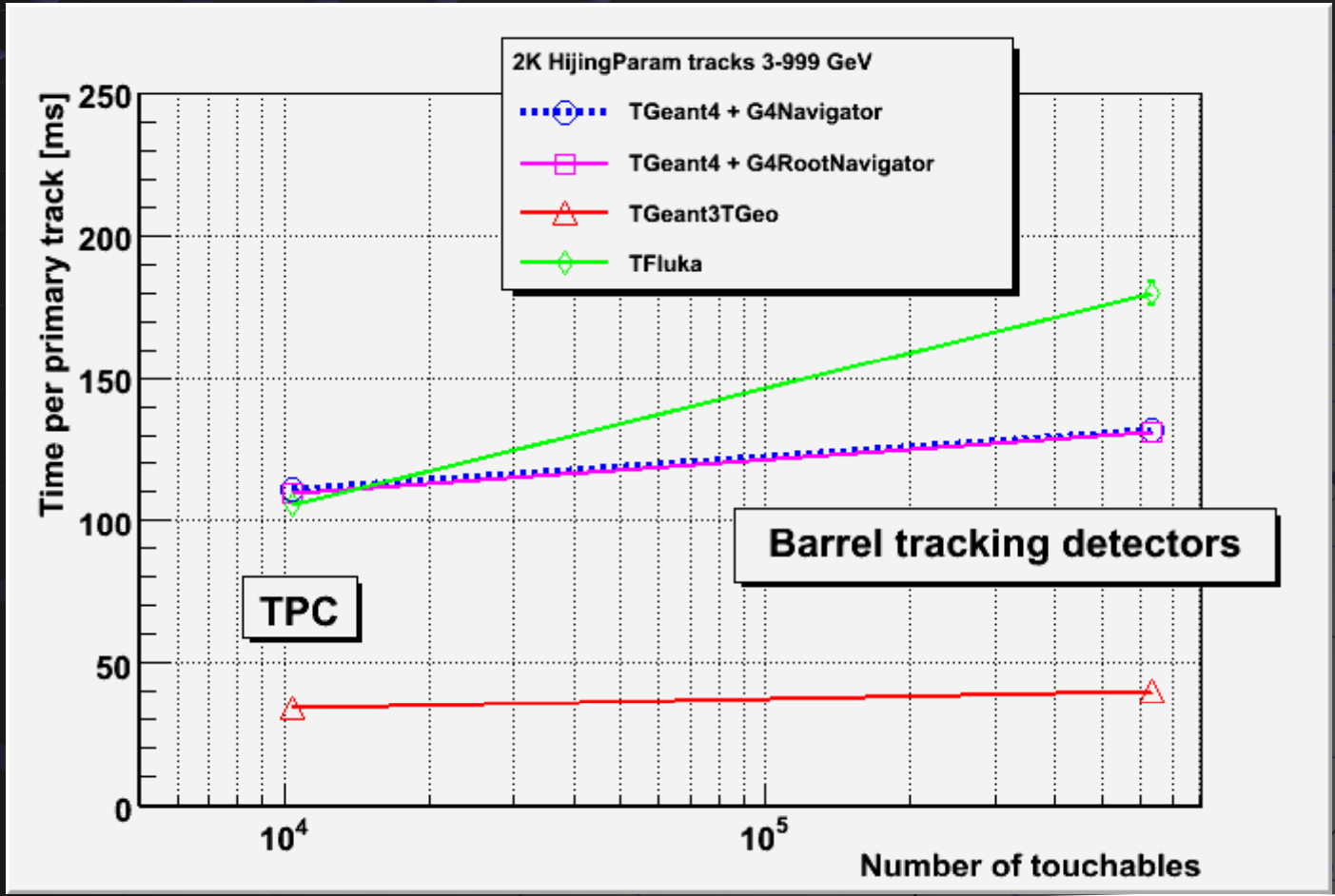
10 K geantinos MUON



HMPID (RICH) simulation



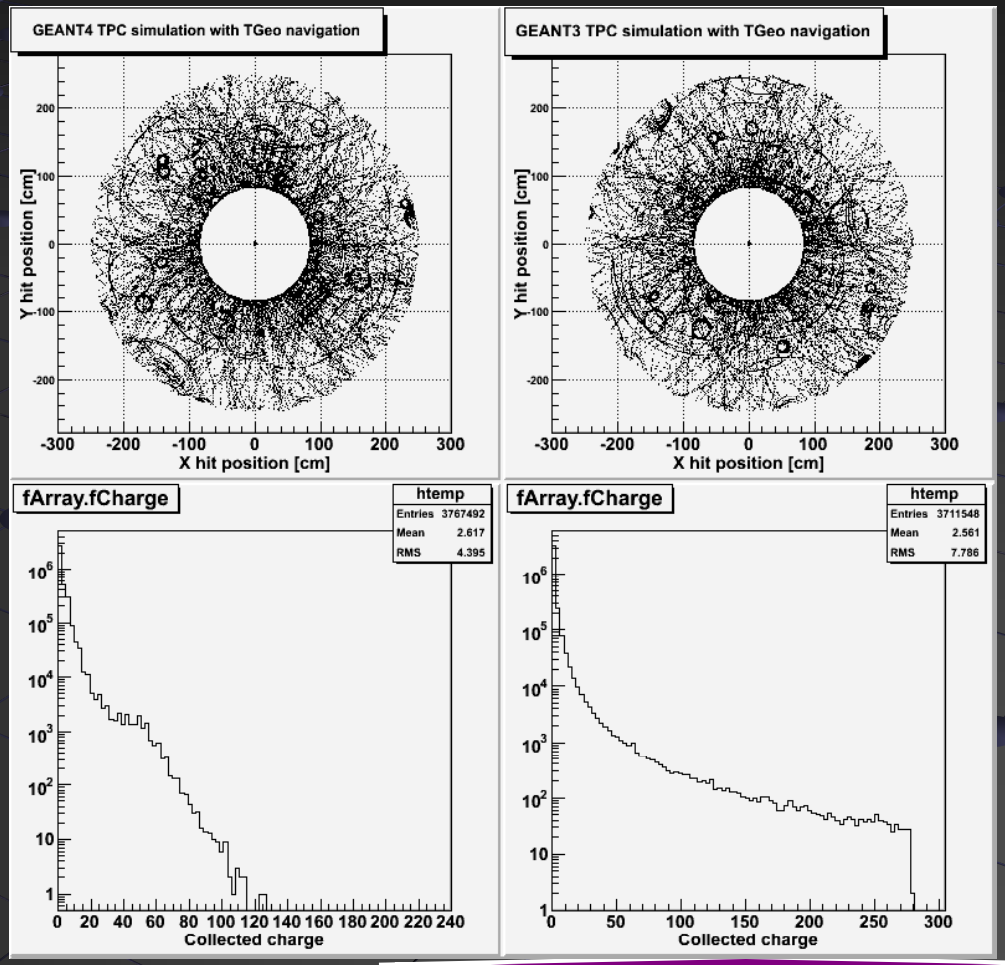
Timing benchmarks



Differences

- Bigger difference in timing with structures in (beam pipe, shielding, …)
  - To be understood by double-checking the cuts
- "Small steps" issue observed for both GEANT4 and FLUKA – affects TPC and TRD simulations

- When the step size is forced to values with energy deposition close to the gas ionization potential, energy loss fluctuations are not correctly considered



Availability

- Interface introduced in ROOT as G4ROOT module
  - README file describing how to compile the module
    - $ROOTSYS/configure --enable-g4root
  - Available starting from:
    - ROOT version 5.14
    - GEANT4 version 8.2
- GEANT4 optical photon transport N06 example interfaced to demonstrate interface usage

Summary

- A navigation interface for GEANT4 simulation using TGeo geometry is available
  - Starting with ROOT v5.14, GEANT4 v8.2
  - Interface used by GEANT4_VMC v2.0
  - The interface requires a TGeo geometry representation and minor additions (example available)
- Most benefits by usage via VMC
  - The same geometry can be used for 3 MC's and in reconstruction/event displays, ...
    - GEANT3, GEANT4 and FLUKA
  - Navigation based on the same geometry allow reliable comparisons for the MC predictions

Summary

- Comparative tests in realistic ALICE setups show consistency between GEANT4 and ROOT geometries
  - Tested with GEANT4 9.0 and ROOT 5.17.02
  - There is no performance penalty observed when running G4 simulation with native compared to ROOT geometry
  - There is a noticeable difference in time between GEANT3 and GEANT4/FLUKA based simulations for ALICE
    - Some tuning is needed both for the physics lists and cuts

Acknowledgements

- **GEANT4 team**
  - **Support for changes in G4Navigator to accommodate this interface**
- **ALICE Offline & ROOT teams**
  - **Supporting the development and facilitating the integration in ROOT framework**
- **All current (and future) contributors...**