Geant4 User Requirements from HEP Energy Frontier Experiments

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Geant4 Collaboration Meeting, Ferrara, 12 September 2016

Outline

- Open requirements
- ATLAS
- CMS
- LHCb
- ALICE
- CALICE
- FCC

Open requirements

- **#3901** : Complete destruction of G4 objects at exit
  - From CMS; assigned to Makoto; made progress in MT
- **#3701** : Use of Geant4e in track fitting
  - From CMS, now general; assigned to Pedro;
    CMS has already a working set-up
- **#3602** : Optimise structure of Geant4 libraries
  - From CMS, now general; assigned to Ben; started
- **#3301** : MT processing driven by experiment framework
  - From CMS, now general, assigned to Andrea, Makoto, John A.;
    on CMS side, issues are now all solved; progress expected for 10.3

ATLAS

(Z. Marshall)

ATLAS : General

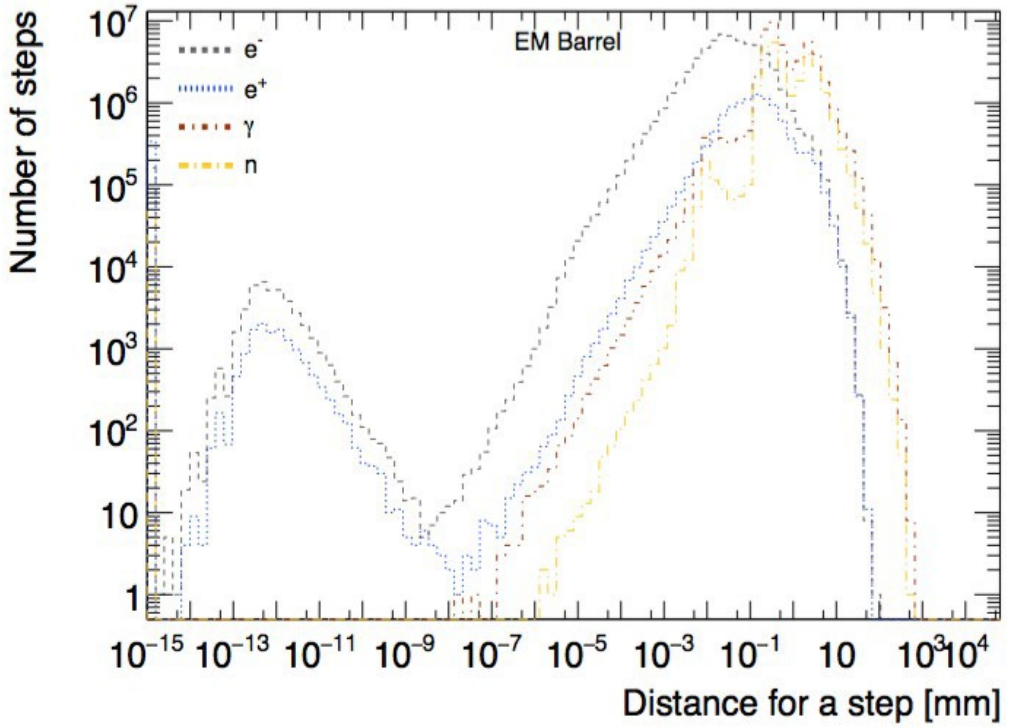
- *"It's impossible to put in a simple 'requirement' line the constant improvement of CPU usage, memory usage, stability, physics performance (and tuning), and so on that the Geant4 collaboration takes care of. This goes beyond just bug-fixing support, and has been invaluable for ATLAS and for the other collaborations. Setting forth a requirement like "Improve the CPU usage by 5%" does not do the work justice, nor do never-ending requirements like "Make it faster." It's worth keeping in mind that every 1% CPU you all save us translates to significant savings on a major simulation production campaign like the one we are about to undertake, and we rely massively on the accuracy of Geant4's physics modeling for exploiting the full physics potential of the LHC."*
- The 10% CPU improvement we gain from the move from G4 9.6 to 10.1 is invaluable to the collaboration
- The marked improvement in hadronic physics from the FTFP_BERT_ATL physics list is something that our analysis teams are looking forward to!

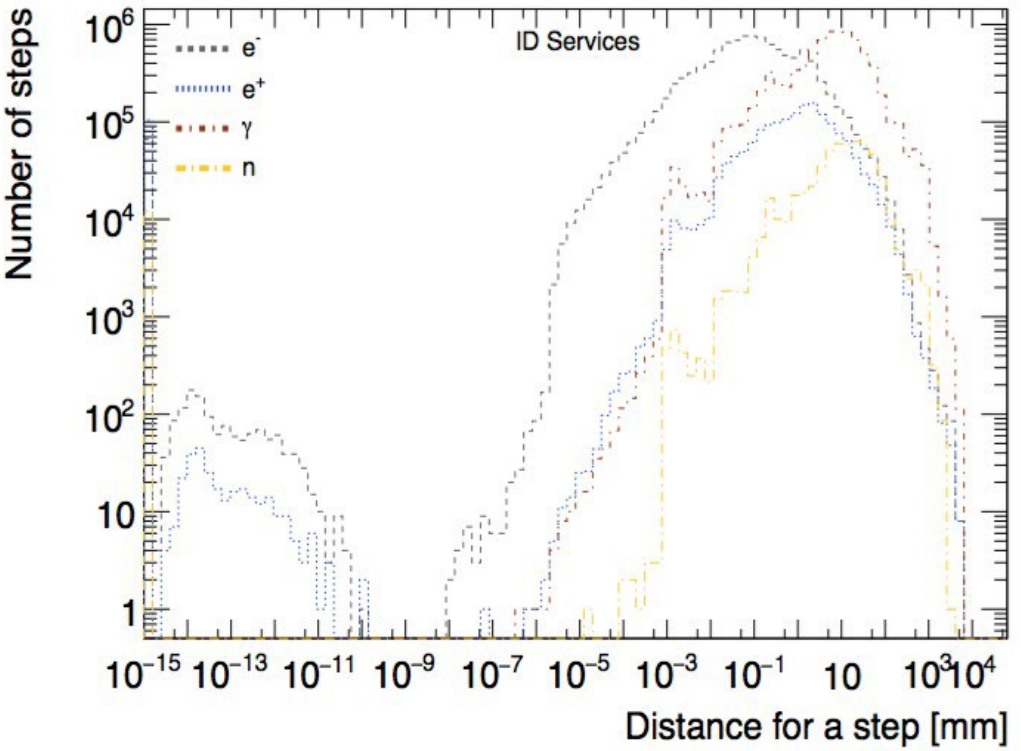
ATLAS : MT Support

- As ATLAS gets closer to achieving a multi-threaded simulation, we are spotting more pieces of the infrastructure that need a bit of help. We've gotten quite a bit of help along those lines, but it's always possible that we run into something that we need an interface change.
  Please continue to help!
  Nice examples so far:
  - const return for secondaries generated in a step
  - multi-SensitiveDetectors
  - multi-UserActions

ATLAS : Fix the Small Steps

- We still have a high rate of tiny steps in the detector
  - Could have a real impact on CPU usage and crash rates...
- Not limited to a single sub-system
- Appears linked to charged particles & EM physics





ATLAS : Reproducibility

- We appear to have reproducibility starting from an arbitrary event in G4 10.1
  - Great! Remember that the easier reproducibility gets, and the easier it is for us to provide you with a clear example of the problem, the faster it will be for all of us to debug. This goes also for function calls (if we can inject specific particles with specific momenta deep into some call chain, then this would make debugging and unit-testing easier).
- We are hot on the heels of the non-reproducibility between Intel and AMD silicon
  - Our production system is a mixture of the two types of silicon; this prevents reproducing some crashes and having fully reproducible results
  - It appears at the moment to be related to neutronInelastic at low energy, but we are working hard to pin this down further

ATLAS : Miscellanea (1/2)

- Any hope to resolve the field design issue discovered a year ago?
  - G4FieldManager and G4Stepper own copies of the field pointer, and even for steppers owned by specific managers these are not required to be in sync
- Taking hadronic cross sections from a DB instead of small files
  - Previously this was being worked on, but lost momentum (important for avoiding problematic lazy initialization)
- Provide alternative physics lists for systematics
  - The recommendation was revealed to be not great in agreement at high energy, from what we understand?
  - We very much support the **re-tune of QGSP** to make it competitive again
- Please don't forget about the outstanding tough issues
  - **EM and hadronic shower shapes are both too narrow in ATLAS**
- Please let's get the G4Nystrom stepper working
- Extending key physics lists to high energy to ensure that they cover the full range of the LHC is important to ATLAS's physics program

ATLAS : Miscellanea (2/2)

- Overlapping volumes are a known frustration when dealing with data alignments of geometries
  - Any chance to get better documentation of the geometry tolerance system so that we can understand how serious a problem this is, whether it can be tolerated at some level, etc? It is not something we can completely avoid with these alignments, unfortunately.
- Please help us continue to chase rare crashes / errors
  - Right now most of these seem to come from propagation in field and navigation; we are anticipating another bug-hunting campaign when the new production begins
  - The old large-angle scattering issue is the kind of thing that we'd like to chase – cases where the simulation quietly does something unphysical. Dropping low-energy particles under some circumstances is another example of this.
- Interface updates discussed in the context of fast sim
  - Unit-test-like calls with particle and target material to hadronic interactions modules would be very helpful!

CMS

(V. Ivanchenko)

Geant4 status in CMS

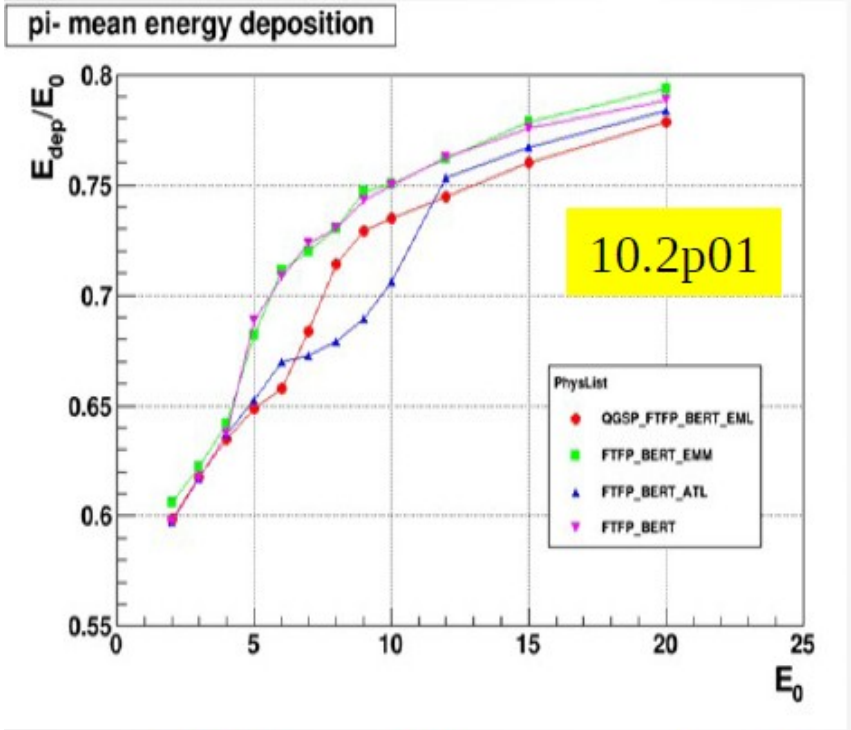
- Production version of Geant4 for run-2 (2015-2016)
  - Geant4 version10.0p02 built in sequential mode + number of private patches
  - Production platform slc6_amd64_gcc491
  - Default physics list: QGSP_FTFP_BERT_EML
  - ~10 billion events already produced

- Current development versions of Geant4 in CMSSW
  - Geant410.2p02 built in MT mode + private patches:
    - FTF model parameters as in 10.1p03
    - Recent G4SubtractedSolid fix
  - Production platform slc6_amd64_gcc530
    - Will ran at GRID with 4 or 8 threads queues
  - Default physics list: FTFP_BERT_EMM
    - EMM means Opt1 EM physics in all detectors, Opt0 physics inside HCAL
    - Physics validation is in progress and not yet fully completed
  - Urgent problem requires a fix:
    - G4CutTubs FatalException at construction

- Near future
  - CMS plan to evaluate usage of VecGeom for development starting from this year

CMS feedback on Geant4 10.2 deployment

Simulation of simplified combined calorimeter

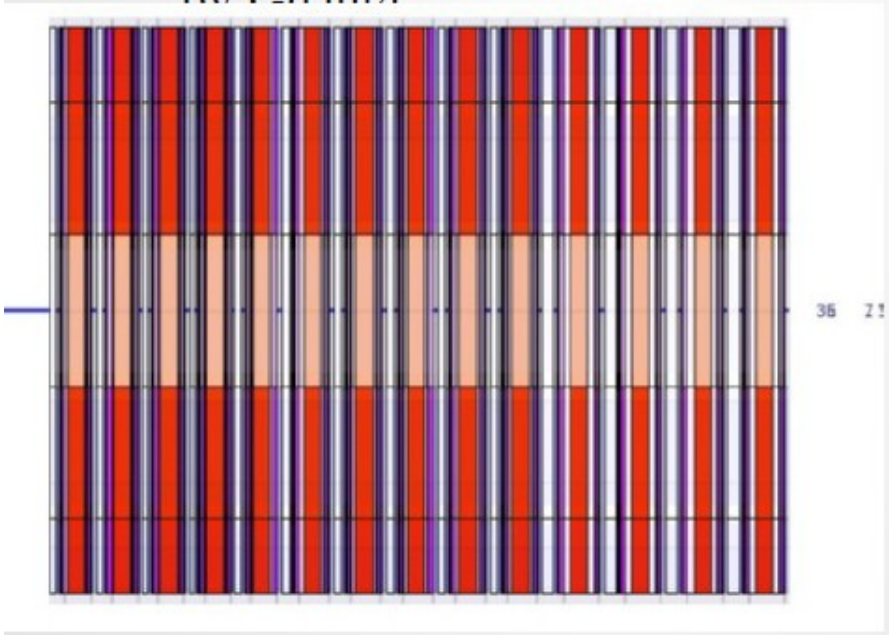


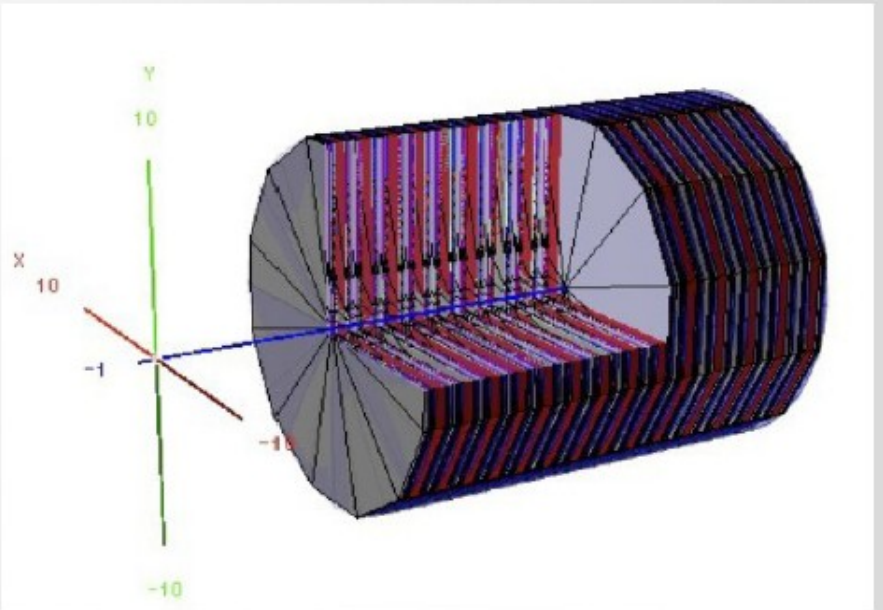
- CMS calorimeter structure is specific:
  - Combined response of crystal ECAL and sampling HCAL with a sampling fraction ~1%
- This combined calorimeter is very sensitive to relatively minor change of hadronic models
  - Mainly for the FTF model and the Bertini cascade
- Geant4 10.2p01 overestimates this response for pi+, pi-, p compared to 10.0p02
  - Results of test46 demonstrate sensitivity of the response to Physics List
- We also committed many efforts comparing Geant4 predictions and test-beam data
  - 4 special patches of the FTF model configuration were studied

- CMS would propose for Geant4 hadronic team take into account such calorimeter results in regular validations
  - Corresponding software test46 is a part of Geant4 tests

CMS Upgrade

- CMS is working on new high granular and high resolution endcup calorimeter
  - General conception of the calorimeter is approved
  - Development and final design are in progress
- Currently new test-beams for the new CMS endcup calorimeter are carried out at FNAL and CERN
  - Currently first data for electromagnetic part (W/Si structure) is exposed at the test-beam facilities
  - CMS proposes that this new calorimeter setups should be under regular validation by Geant4





LHCb

(G. Corti)

LHCb

- NOT YET AVAILABLE

ALICE

(A. Morsch, I. Hrivnacova)

ALICE

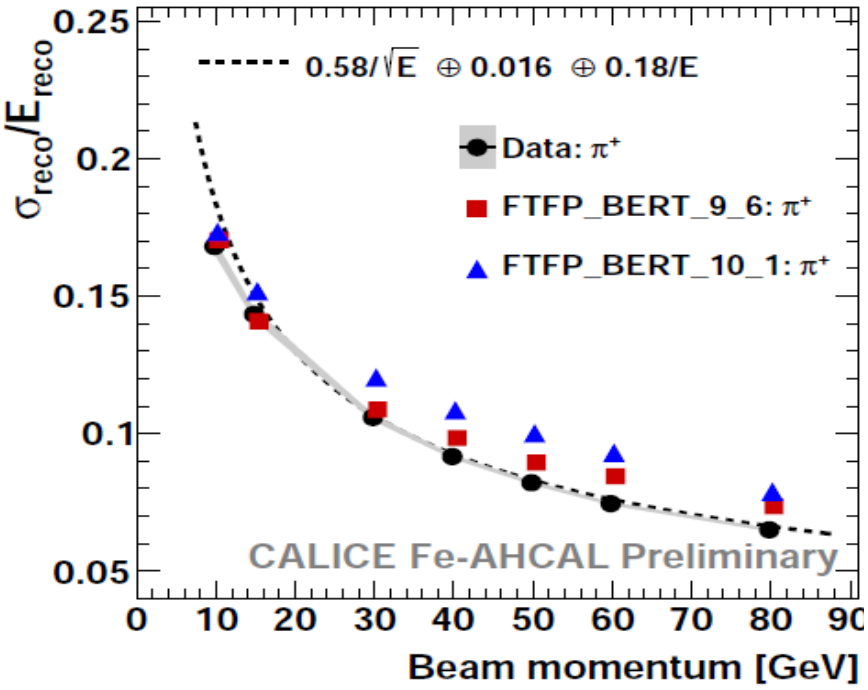
- No requirements from ALICE
- Corrected some issues with calorimeters, HMPID and TRD
- Current version: Geant4 10.1.p03

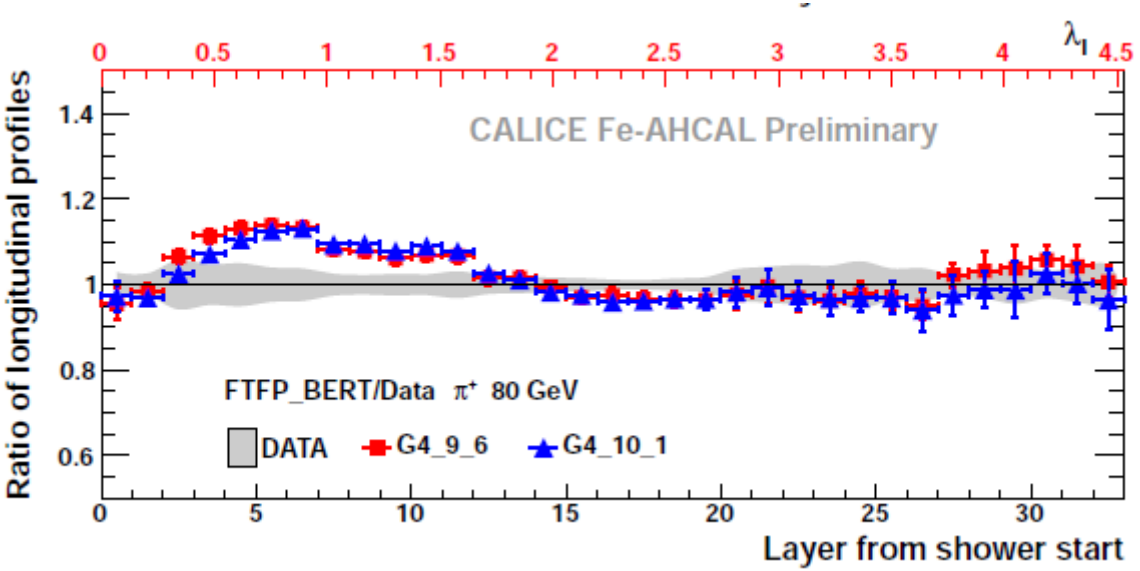
CALICE

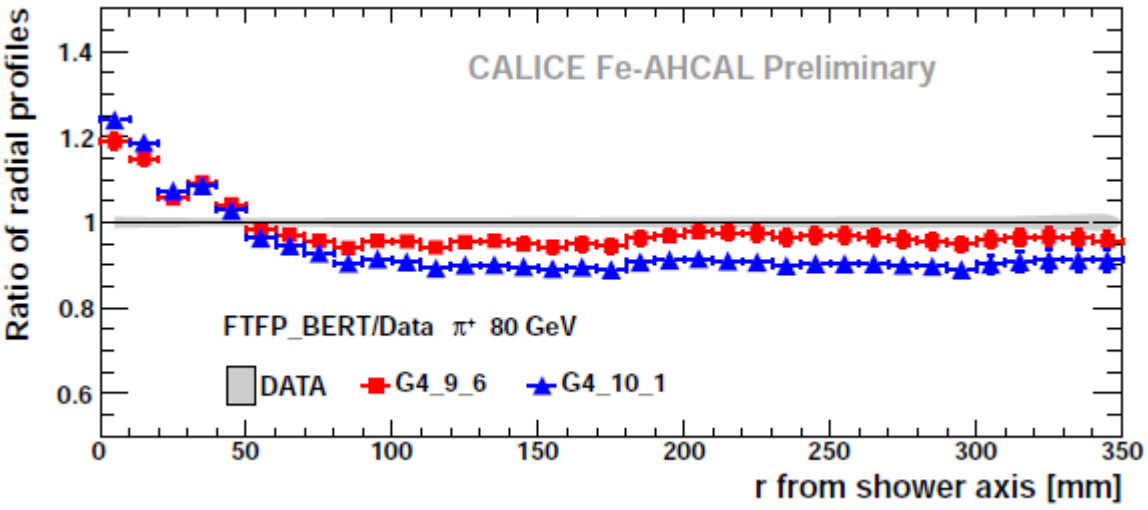
(A. Dotti)

CALICE (1/2)

AHCAL (Fe-Sci) G4 **10.1** *vs* **9.6**



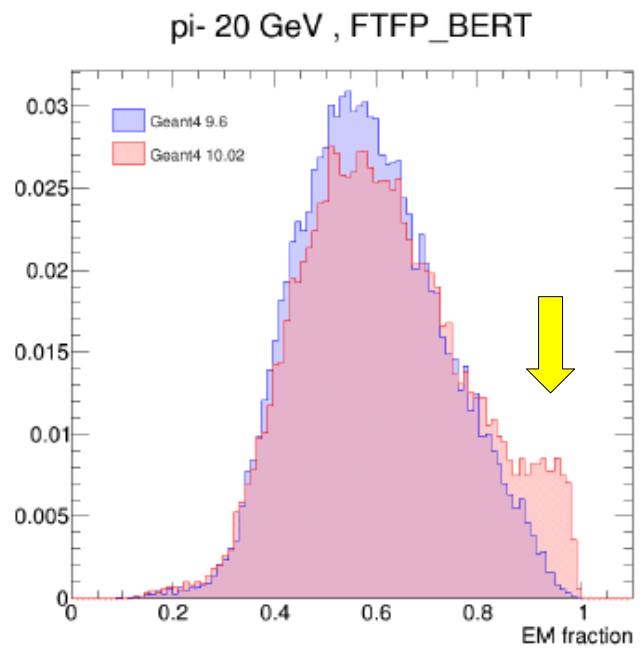


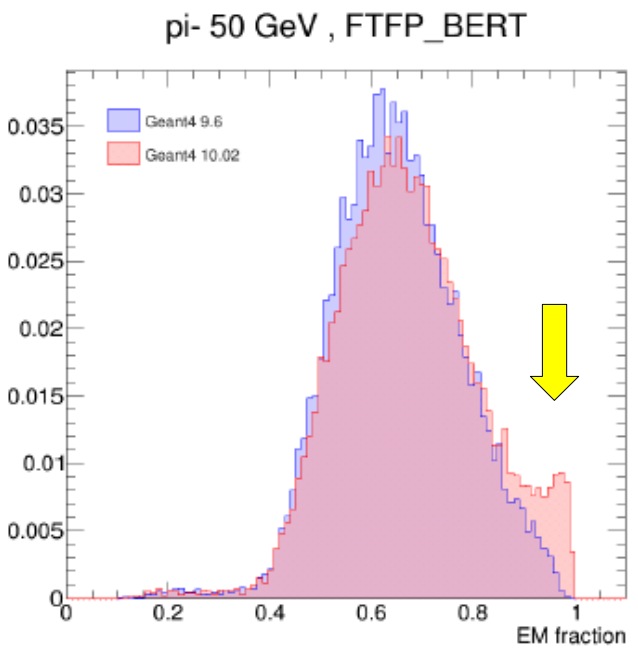


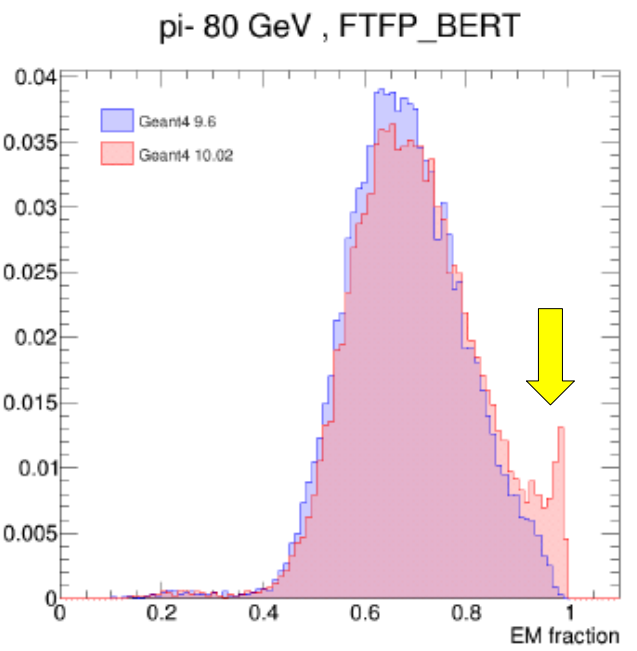
CALICE (2/2)

Simulation

SDHCAL (Fe-Gas) G4 **10.2** *vs* **9.6**







- In G4 10.0 quark-exchange (e.g. $\pi^- p \rightarrow \pi^0 n$, $\pi^+ n \rightarrow \pi^0 p$) has been added to FTF model to better describe hadron-nucleon thin-target data
- Implementation in hadron-nucleus can be either improved (Pauli blocking) or suppressed by hand if needed

FCC

(B. Hegner, A. Zaborowska)

FCC

- Using as much as possible of the support for the LHC experiments, and the physics validation of CALICE
- Peculiarities of FCC
  - Higher energies (√s = 100 TeV)
  - Use of fast-simulation capabilities of Geant4