# Validation of EM physics

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***22th Geant4 Collaboration workshop***

***UOW Campus, Wollongong, Australia***

*25-29 September 2017*

# Outline

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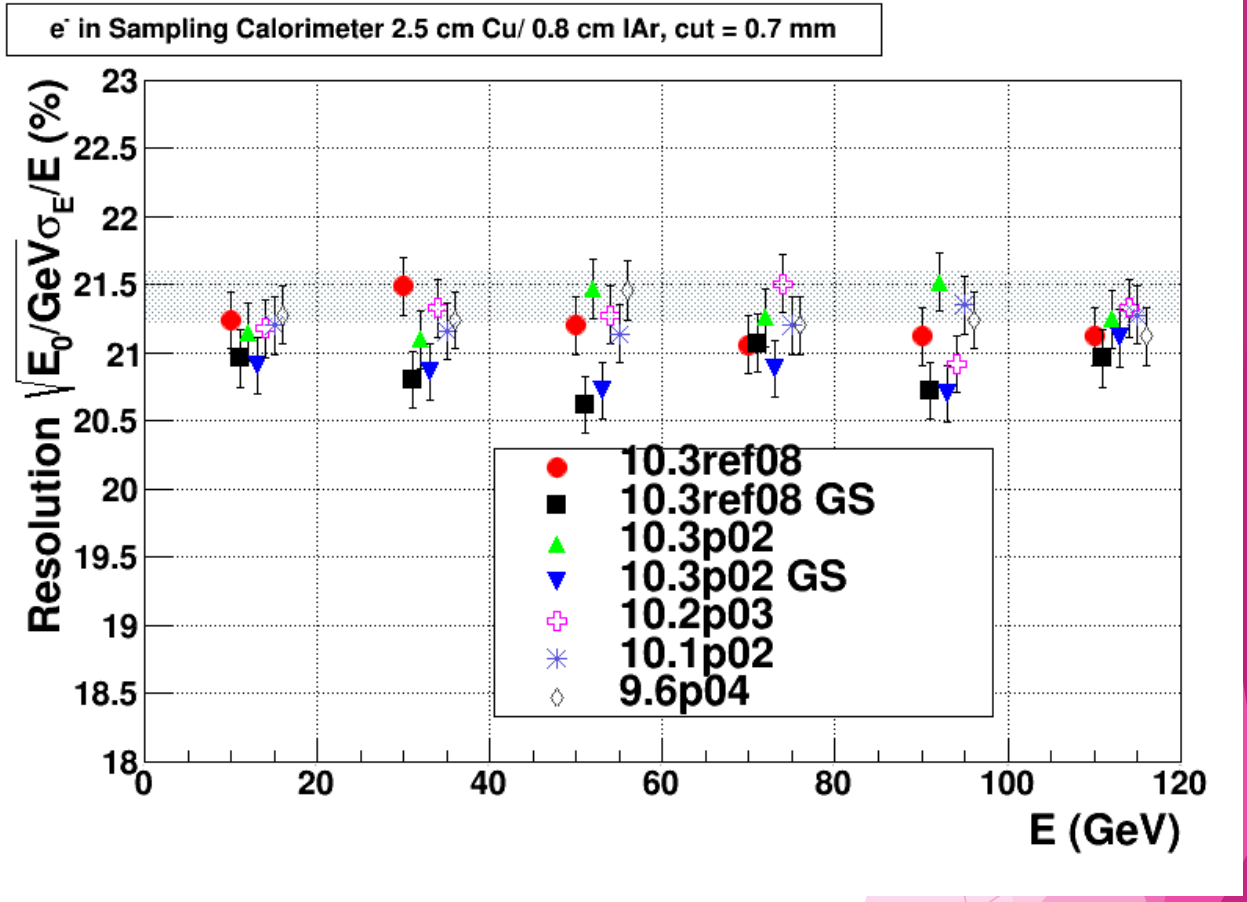
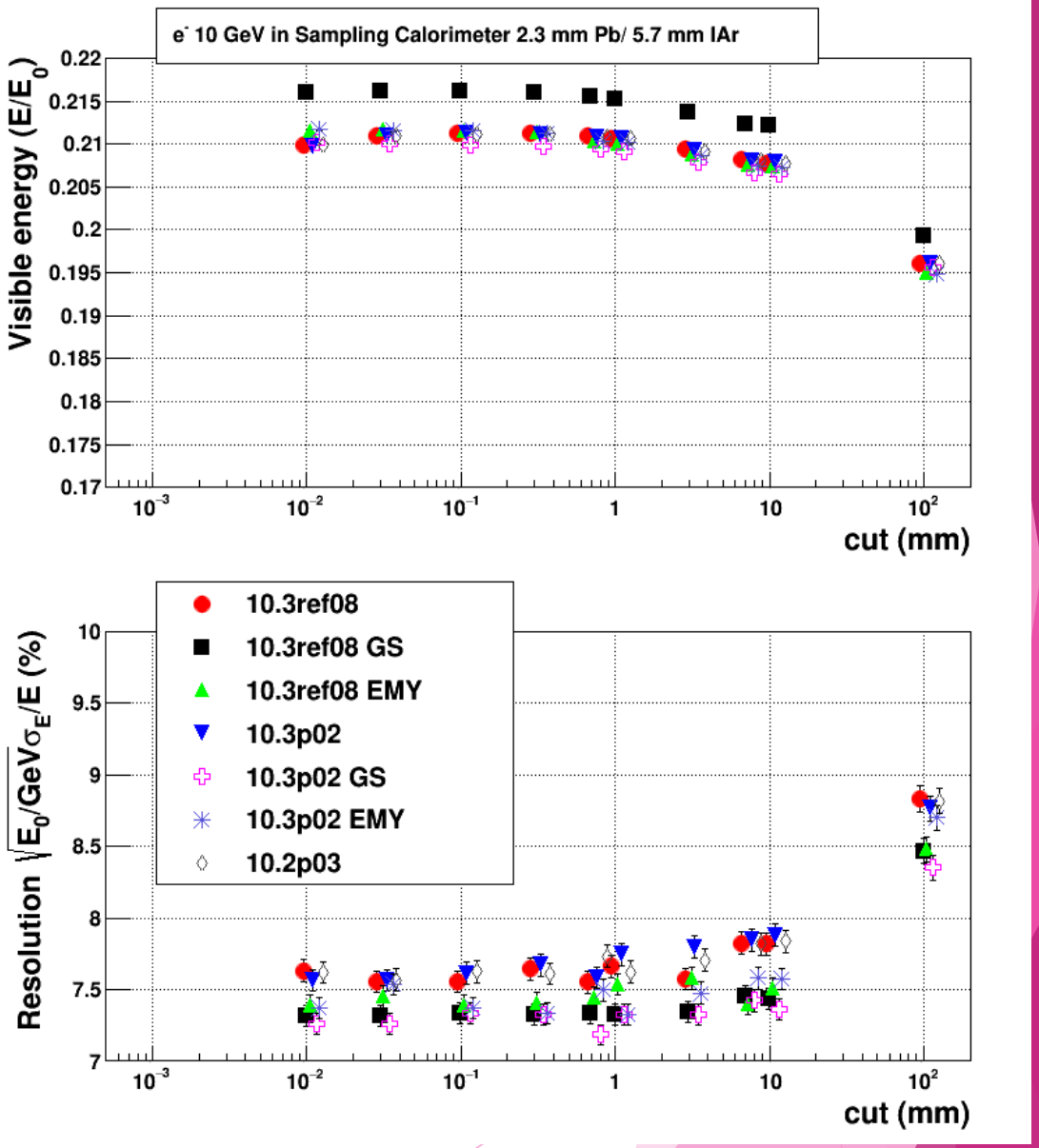



**1st test in the testing suite started in 2005**

# EM testing suite

- Started in 2005
- Published in J. Phys: Conf. Ser. 219: 032044, 2010.
- The goal:
  - systematic validation of EM physics versus data
  - Regression checks of results versus previous Geant4 versions
  - Run after each reference tag or run by request
    - Also run sub-set of tests locally
- Central repository for results based on afs file system where results since 2005 are stored
  - Web access is available
    http://vnivanch.web.cern.ch/vnivanch/verification/verification/electromagnetic/

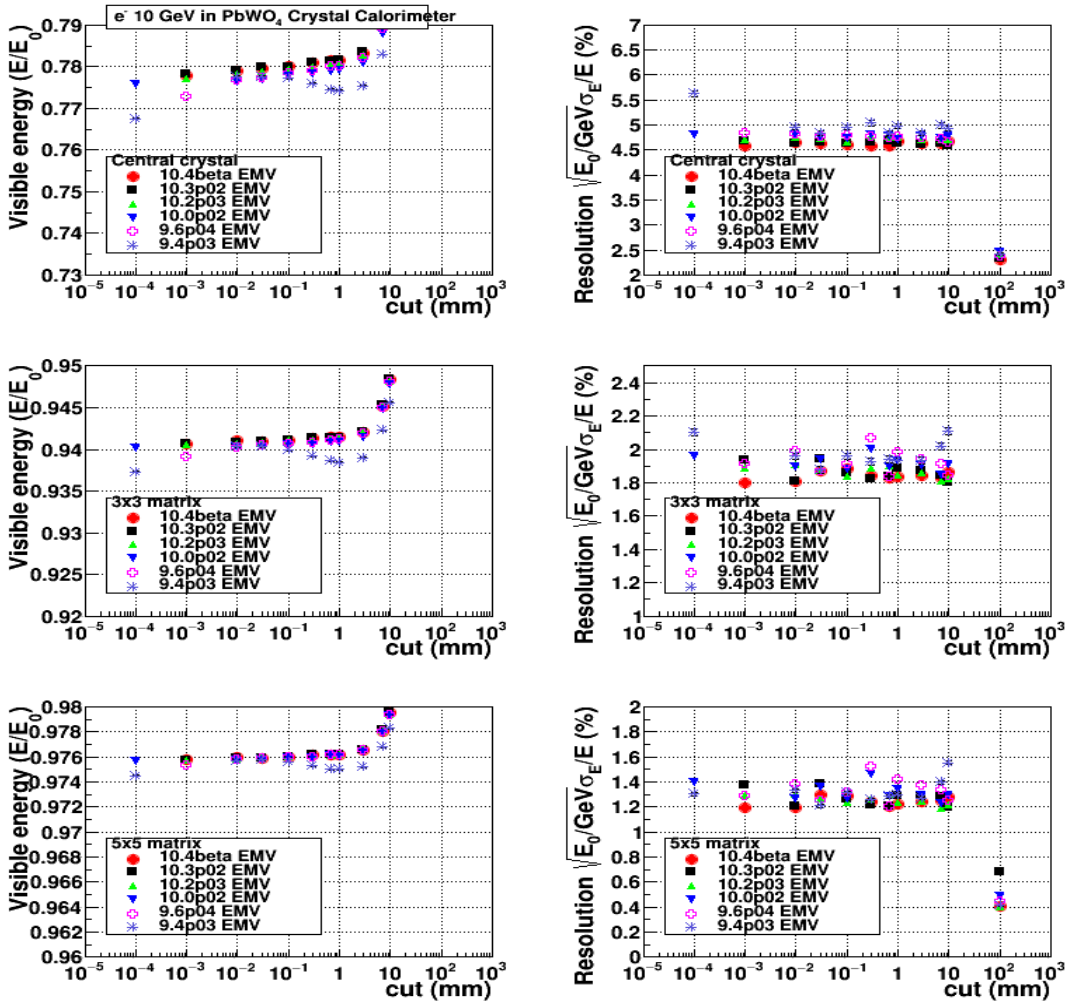


# Real practice of validation

- Validation sequence for EM physics includes
  - Private tests by developers
  - Test by category coordinators based on examples and tests
    - Extended/electromagnetic
    - Extended/medical
    - Extended/medical/dna
    - Dedicated tests test31, test37, test41, test44, tets58
    - All other tests use EM physics
  - Geant4 continues and nightly integration tests
  - For each reference tag we run testing suite
  - User test public Geant4 versions
    - There are many examples when singleton users spot serious problems relevant to LHC
- Testing suite run per reference tag allowing control quality of public versions
  - V.Ivanchenko run at CERN the majority of tests using lxbatch
  - S.Incerti run all DNA tests and Dose point kernel test
  - D.Sawkey run multiple scattering benchmark
  - S.Elles run Fano cavity tests
  - A.Dotti will report on the medical physics benchmark

# Requirements for the testing suite

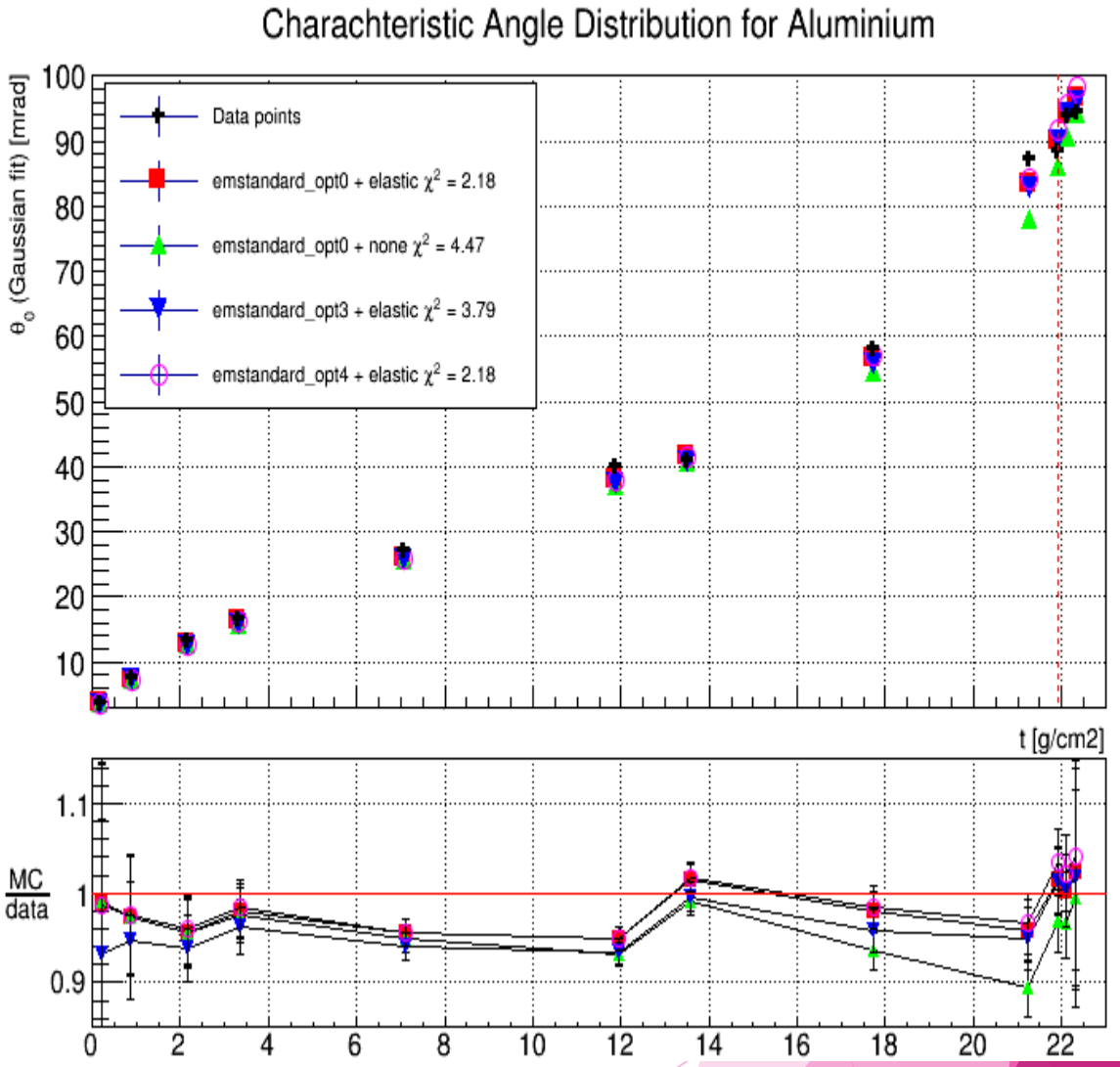
- Where never written but discussed a lot, in particular, at CERN
  - We want to use modern software tools but should be sure that
    - these tools will be maintained in a long term
    - They improve quality of testing and not slow down and stop everything
- Check integration of all EM models/processes and helper classes
  - Each new feature should be tested at least once
- Check physics results for main use cases
  - Versus data
  - In regression to reference version
- Low turn around time
  - Possibility to start tests after reference tag
  - Easy possibility to run locally at any moment full set tests or any subset
  - Lxbatch is used for run on reference tag by one single script
    - Results are available in 1-2 days at afs and in the web
  - Any PC may be used for local run using
- Easy access to results
  - Limited number of clicks to get a particular plot in the web
  - Possibility to overview results in general




**CMS-type simplified crystal calorimeter**

# Coverage of EM validation

- Nightly EM validation is performed using various
  - Tests, examples, benchmarks
  - All ~300 nightly tests execute EM physics
  - We are trying that any EM model is tested , at least, once
    - Any EM physics list is tested, at least, once
    - Any EM option is tested , at least, once
- Trusted data
  - Published in journals or in evaluated DB
  - Do not cover all use cases, energy ranges
  - Included into testing suite
  - This work should continue
  - Implementing one test case requires 1-3 FTE month
    - We use CERN summer student program
- There are critical use cases where data not available
  - Some test cases may be used only in regime of regression between
    - different EM physics lists
    - Different reference versions




**Proton multiple scattering benchmark**

# Recent development on web based tool

- Since 2005 we accumulate a substantial amount of validation results
  - Stored in afs file system accessible via web
  - The testing suite is very robust in running
    - We definitely achieve the goal :
      - the testing suite provides much more results than a developer can do himself
  - Some inefficiency was identified in access to results
    - Too many clicks (2-4) to get a plot of interest
    - Too many plots – difficult to overview reference tag results
    - Too many efforts to make review and conclusion for a given reference tag/single tag
- In 2016 we make efforts to introduce an advanced web tool
  - Decided to use only SLC6 standard software:
    - XML for defining list of tests
    - For interactivity we use php and jawascripts
      - Based on php scripts initially developed by A. Schaelicke
    - For style – html and css
  - Introduced Summary page with the snapshot of most important plots
  - Established functionality to compare results between different reference versions

# Updates of the testing suite

- At CERN the evolution of software is in progress
  - afs will be dropped soon
  - Old approach to build and to run may be absolete soon
- We make a review of software to run and analize the data
  - 2016 experience shows real improvement in testing procedure
  - Decided to move to use more modern tools
  - Preserve efficiency of testing process
- In 2017 we make a technical review of testing suite
  - All tests and benchmarks are migrated from gmake build to cmake
    - Gmake is broken since 10.3
  - All tests and benhcmarks are included in nightly
    - About 20 tests were at validation repository
    - They are built now automatically at CVMFS
  - Migration is done from direct use of ROOT to Geant4 analysis sublibrary
  - Migrate many scripts scripts from C-shell to python
  - Introduce two stages: run and analysis for majority of tests
    - Potentially this will allow automatic run of EM testing suite at any system (lxbatch, grid…)
      - ROOT will not be needed for the run stage anymore
- Results: https://geant4-tools.web.cern.ch/geant4-tools/emtesting/

# Plans for 2018

- Move data structure from afs to EOS or where?
  - First try with EOS is positive but long term accessibility should be understood
    - Efficiency of web access to be tested
  - Need to understand: do we need DB instead of file system?
- Fully migrate to ROOT6
  - Majority of tests/benchmarks work with ROOT6 but not all scripts migrated yet
- Introduce quantitative analysis in all tests
  - Part of tests include $\chi 2$ analysis, another part shows ratio MC/data
  - We need more advanced analysis which may characterized Geant4 EM quality in general or for a subdomain
- We need extension of testing suite
  - In particular, using data collected by Mihaly Novak
- Final remarks:
  - Thanks to the testing suite EM physics in new Geant4 releases are much more clean than 10 years ago
    - In past there were cases when after 1 day after release an immediate patch was required
  - Nevertheless, we are not free from problems, so permanent efforts are needed in this area