

Testing Geant4 with a simplified calorimeter setup

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Outline

- Motivation
- Description of the setup
- Some results for the June 2005 Geant4 release
- To do list

Motivation

Our goal is to take two **Geant4** versions and compare some **physics observables** between these two versions.

Then, only those distributions which are **statistically different** (i.e. unlikely to be originated from the same parent distribution, whatever it is) should be visually examined by someone, to understand the origin of such difference, either **a bug or an improvement**.

As a start, we consider only **calorimeter observables** sensitive to **hadronic physics**.

Some remarks

- It is very important that the regression testing is automatic, because only in this way it is possible, in practice, to consider a **very large number of distributions**, and **use it regularly**, at least before each new release.
- To do that we need a **statistical package** that offers **several statistical tests** (not only Chi2 and Kolmogorov-Smirnov!), to increase the chances to spot any kind of discrepancy between two distributions.

Simplified Calorimeter setup

- It reproduces, in a simplified way, all the LHC calorimeters: Fe-Sci , Cu-Sci , Cu-Lar , W-Lar
Pb-Sci , Pb-Lar , PbWO4 .
- Beam particle type: π^\pm , K^\pm , K_L^0 , p , n , e^- .
- Beam energy: 1, 2, 3, ..., 10, 20, 30, 40, 50, 60, 80, 100, 120, 150, 180, 200, 250, 300, 1000 GeV.
- The calorimeter is a box. The user can choose:
 - the total thickness of the absorber (in [mm] or λ)
 - the thickness of the active layer
 - the number of layers
 - the number and the size (in [mm] or λ) of the bins of the lateral shower profile.

- **Observables:**
 - total energy deposit in all active layers
 - total energy deposit in the whole calorimeter
 - energy deposit in each active layer
(longitudinal profile)
 - energy deposit in each radial bin
(lateral shower profile).

- The program produces in output a **HBOOK n-tuple**, which stores all the above distributions. Then another program reads two of these n-tuples, makes the statistical tests of the distributions, and produces a **.PS** file whenever the **p-value** of a test is below a certain threshold (currently **1%**).

CPU issue

- 7 calorimeters x 8 particles x 24 beam energies x 5000 events x 5 physics lists .
- About **0.07 sec/GeV** (@1 GHz CPU) to simulate an hadronic shower with LHEP or QGSP.
- Use some biasing techniques (keep 1 $e^-/e^+/\gamma$ every 2 or 4 with weight 2 or 4), and kill neutrons below 1 MeV, to speed up the execution.
- Overall, it takes **few years of CPU time**, but concentrated in 1-2 weeks. Difficult to use lxbatch, better to use the **Grid** and/or **LHC@home**.

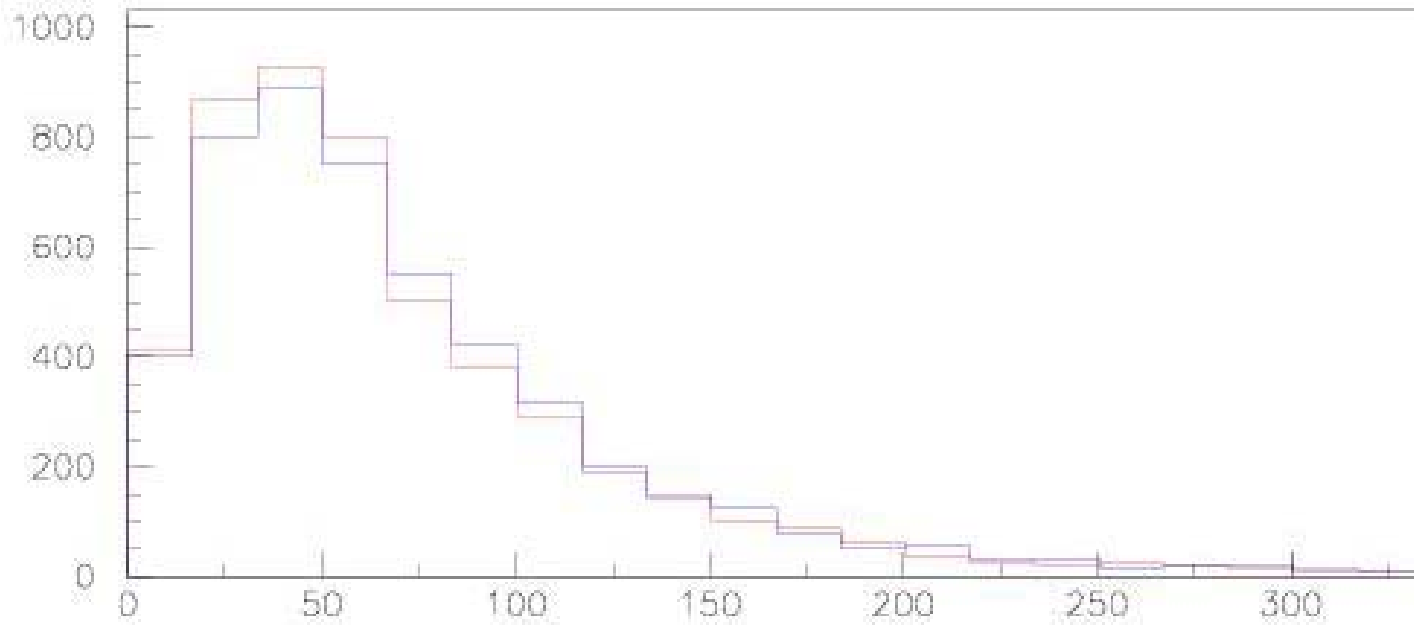
Geant4 release 7.1 (June 2005)

- G4 7.1.cand01 versus G4 7.0.p01 .
- 10 lambdas, 20 layers, 4 mm active layers
radius bins of 0.25 lambdas, 10 radial bins
biasing for beam energies ≥ 10 GeV .
- SLC 3.0.x g++ 3.2.3 .
Run on the Grid as ALICE Virtual Organization.
- No 1 TeV job: 1288 jobs per Physics List.
Each job that ends normally produced a tar-ball
of about 2.8 MB size containing the results.

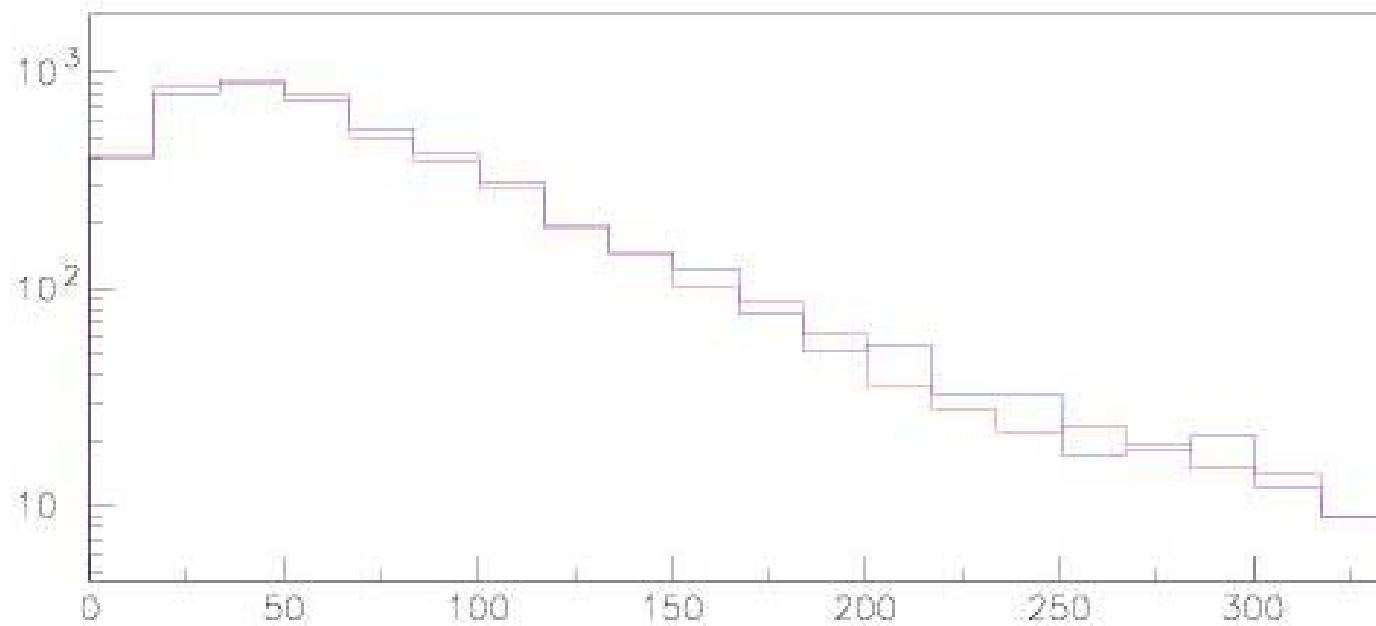
Results

- ❑ **LHEP**: 85% of the jobs completed;
123 .PS files to examine.
- ❑ **QGSP**: 53% of the jobs completed;
57 .PS files to examine.
- ❑ **QGSC**: 77% of the jobs completed;
273 .PS files to examine.
- ❑ **QGSP_BIC**: 73% of the jobs completed;
127 .PS files to examine.
- ❑ **QGSP_BERT**: 60% of the jobs completed;
106 .PS files to examine.

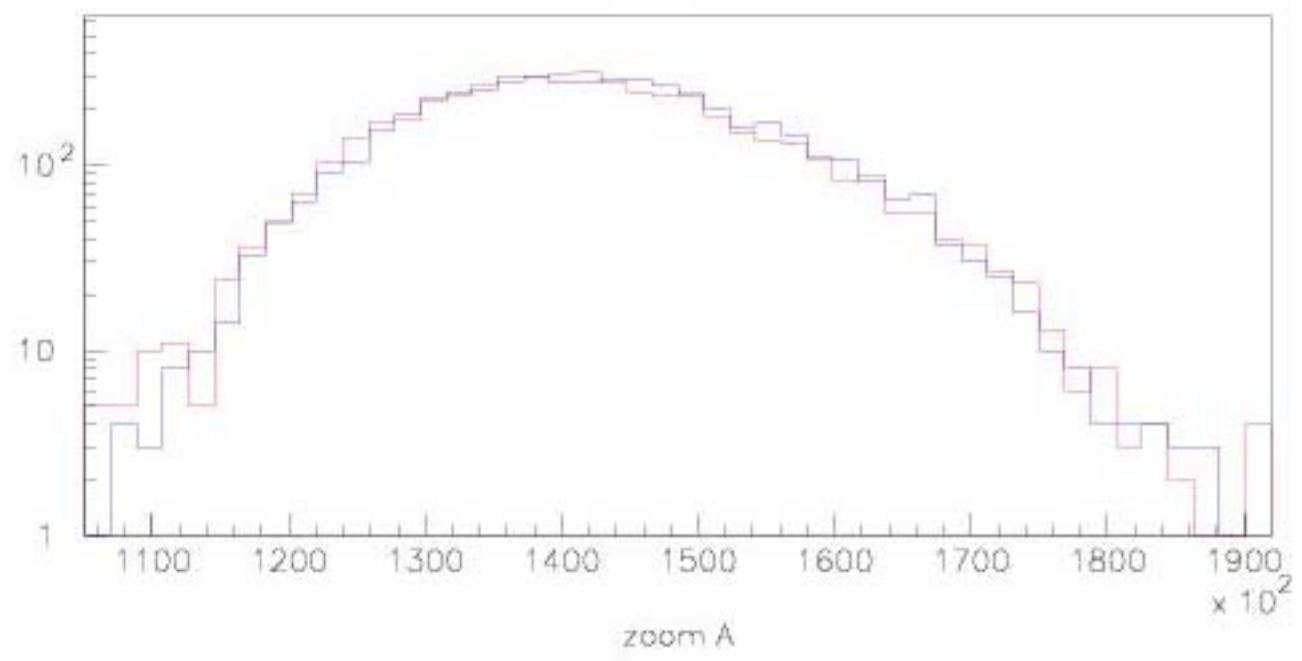
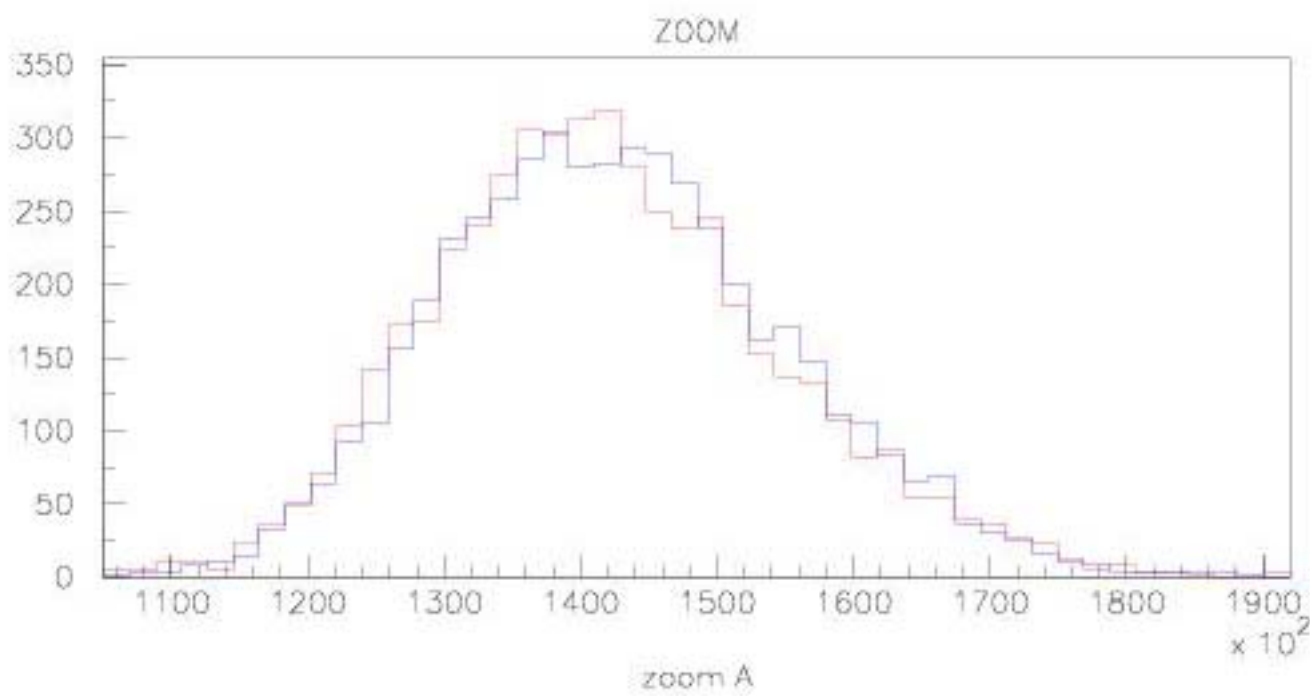
ZOOM



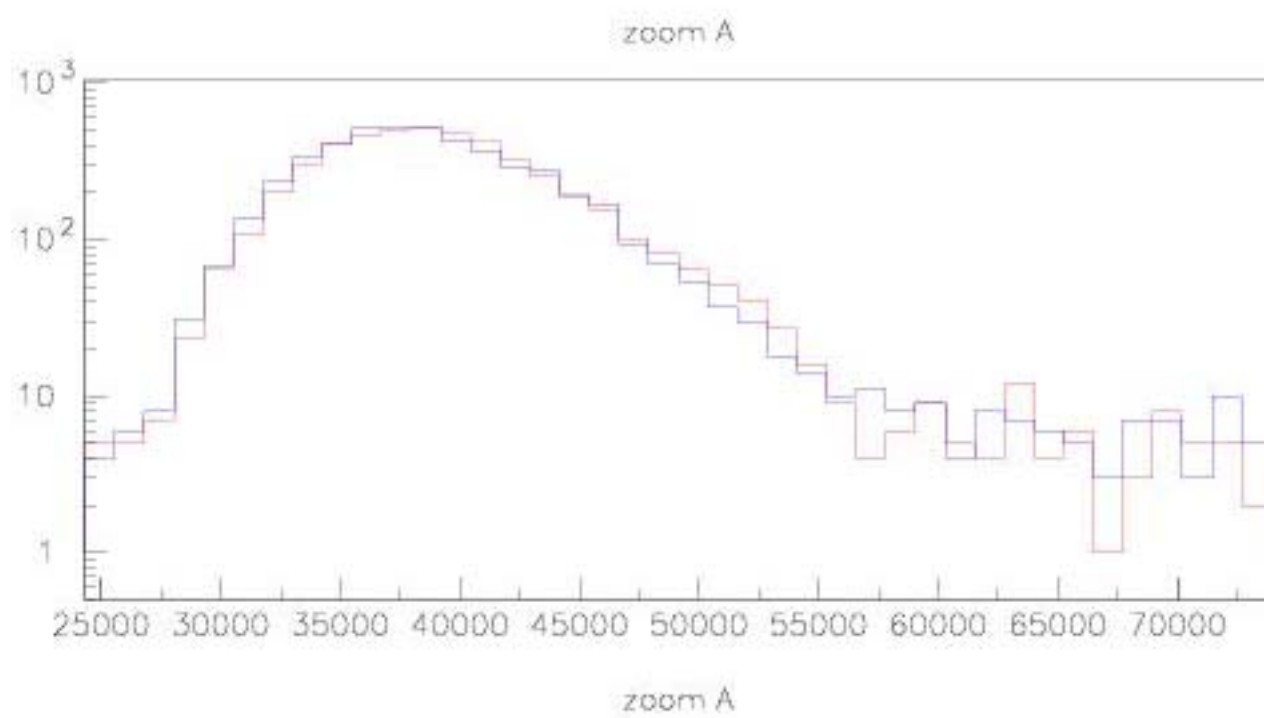
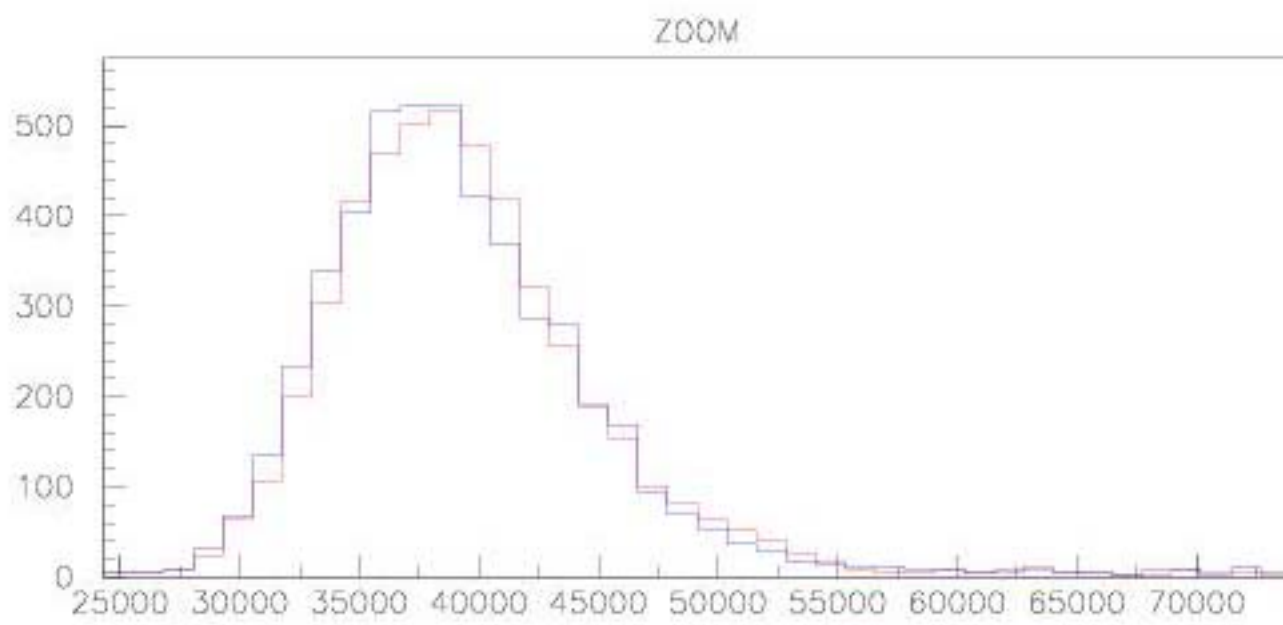
zoom A



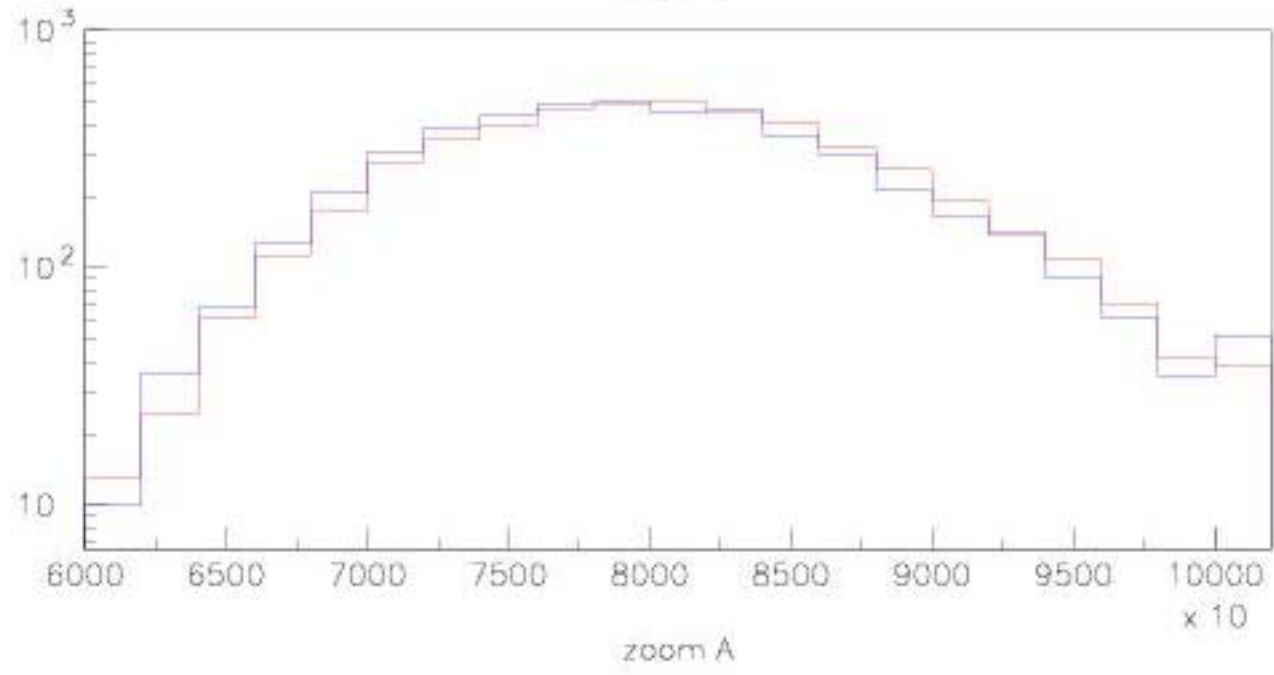
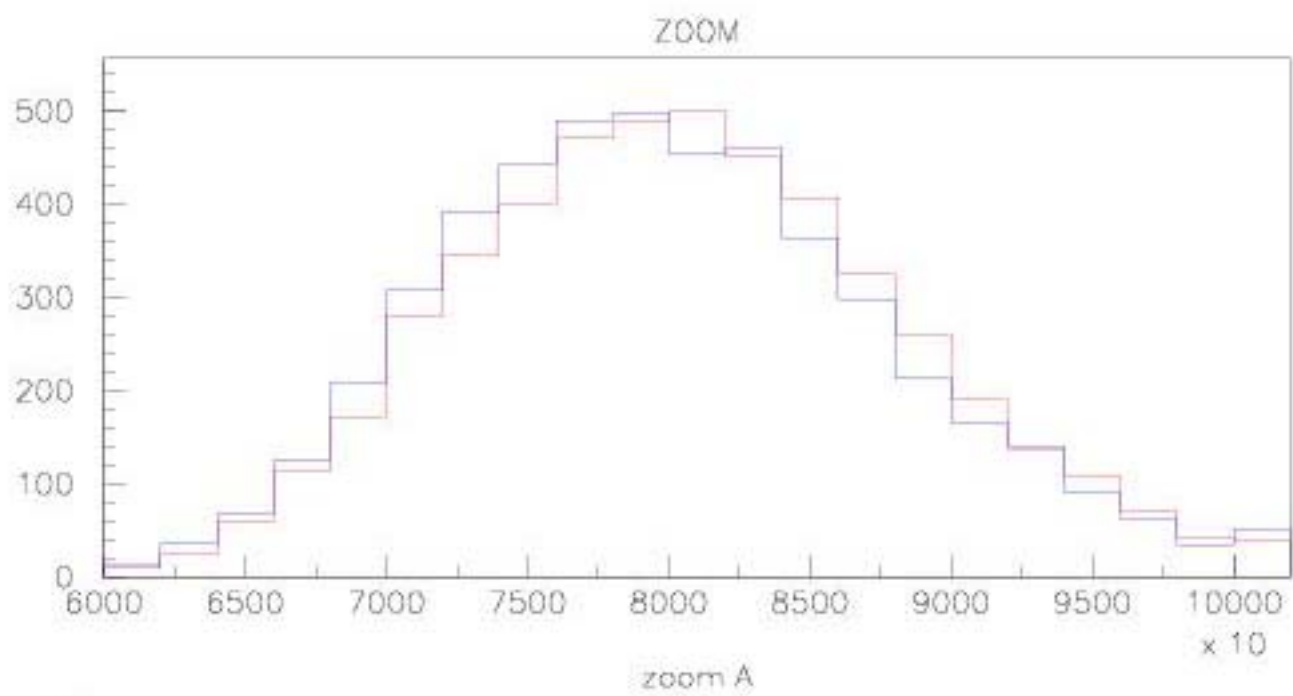
LHEP
Cu-Sci
K-
80 GeV
R1
 $p_{KS}=0.002$



QGSP
Cu-Sci
K-
180 GeV
plot 2
 $p_{KS}=0.001$

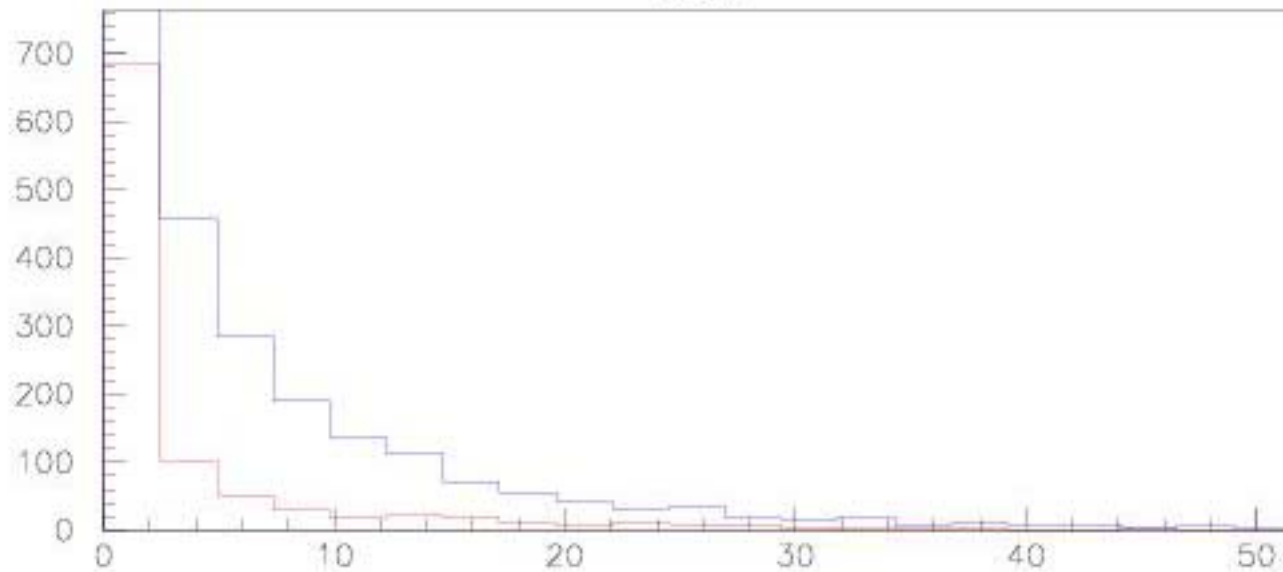


QGSC
Fe-Sci
K+
50 GeV
plot 2
 $p_{KS}=0.006$

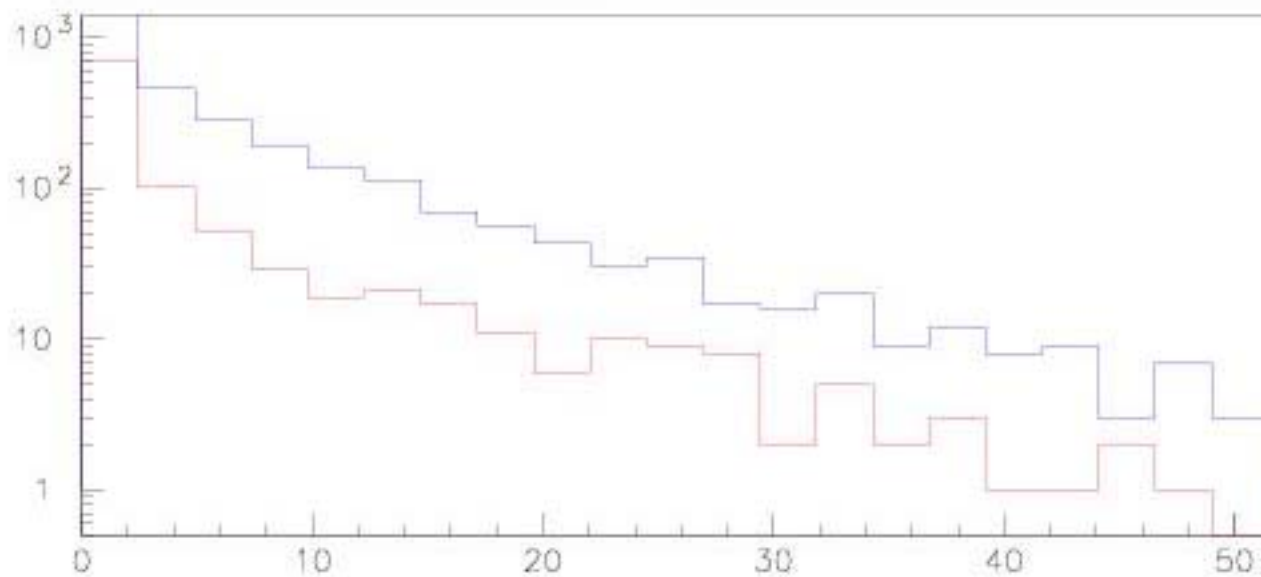


QGSC
 Fe-Sci
 pi-
 100 GeV
 plot 2
 $p_{KS} = 6 \times 10^{-5}$

ZOOM



zoom A



zoom A

QGSP_BIC

Pb-LAr

K_L^0

4 GeV

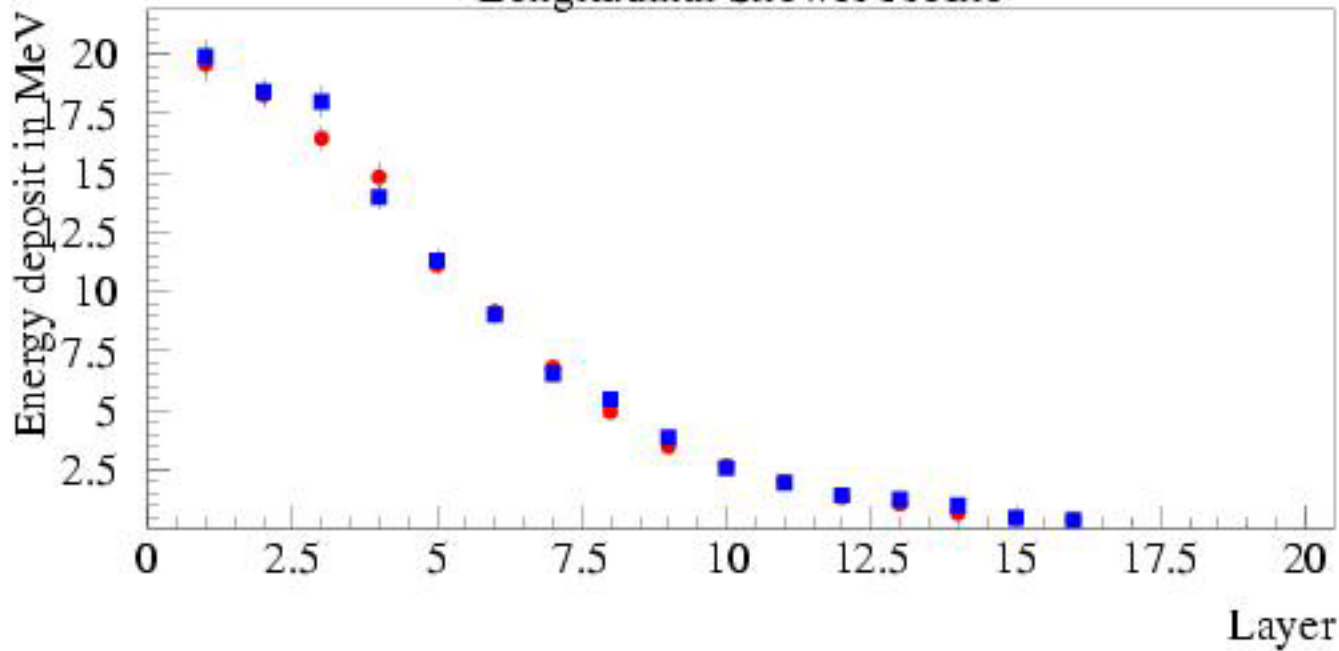
LO

$p_{KS} = 1 \times 10^{-26}$

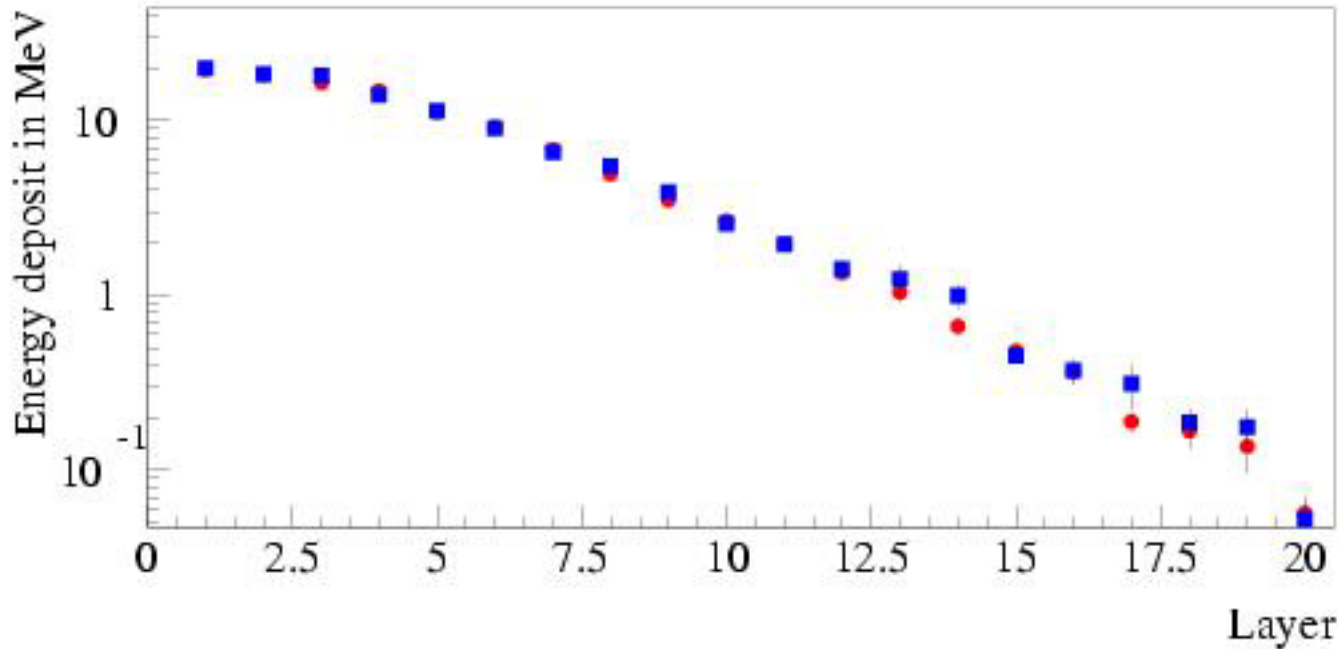
Summary plots

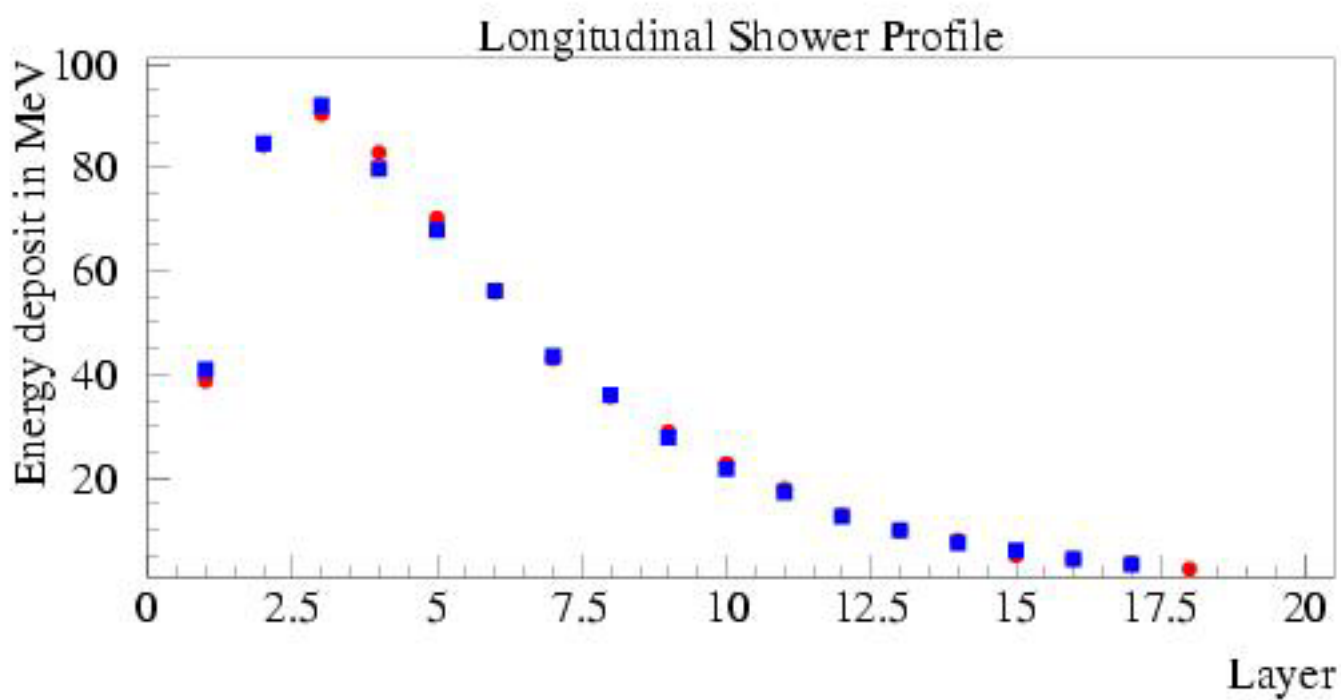
- As post-processing, using only the log files produced during the simulation, some summary .PS plots can be produced:
 - longitudinal shower profiles
 - transverse shower profiles
 - energy resolutions vs. beam energy
 - e/π ratios vs. beam energy
 - sampling fractions vs. beam energy
- Some unphysical “jumps” are observed at 10 GeV, because biasing is not applied below such value.

Longitudinal Shower Profile

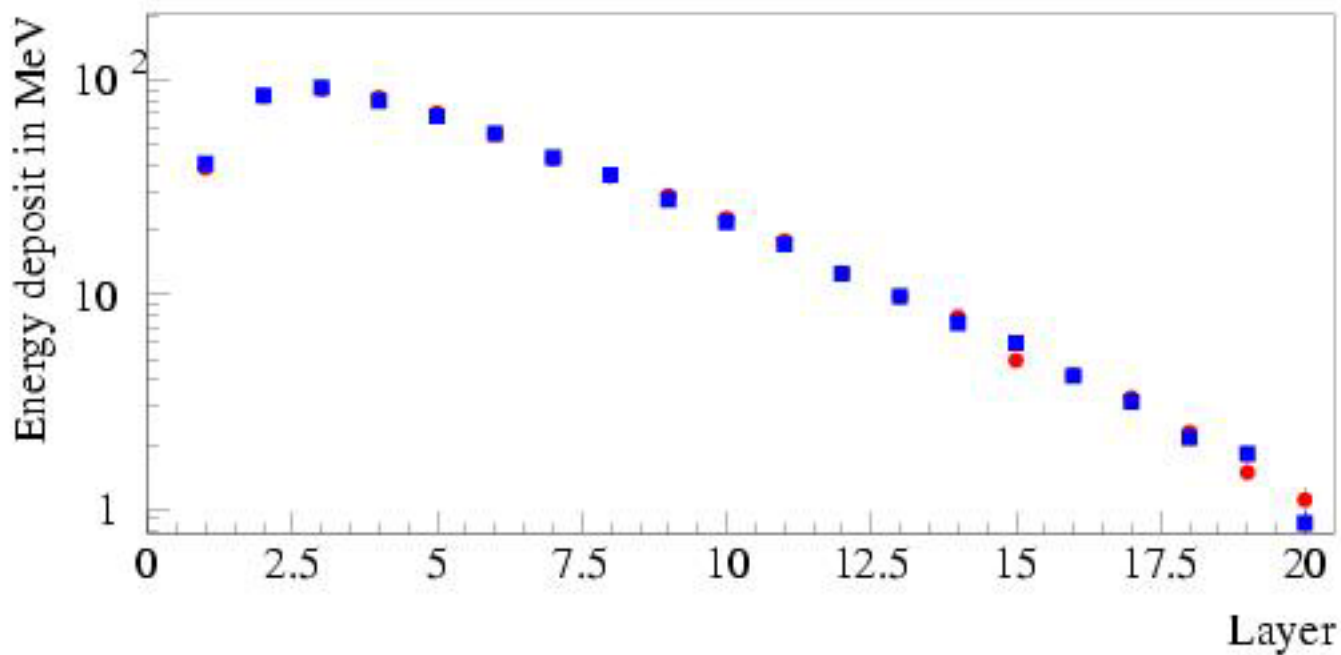


QGSP_BIC
Pb-LAr
n
30 GeV

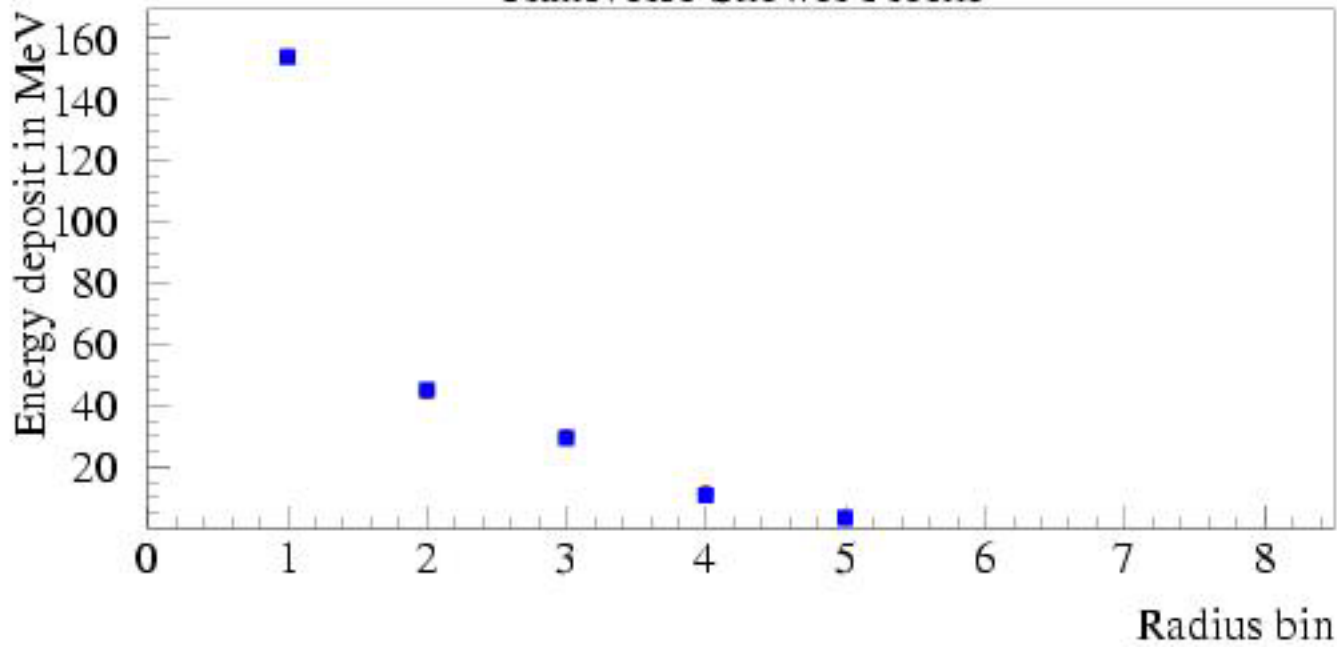




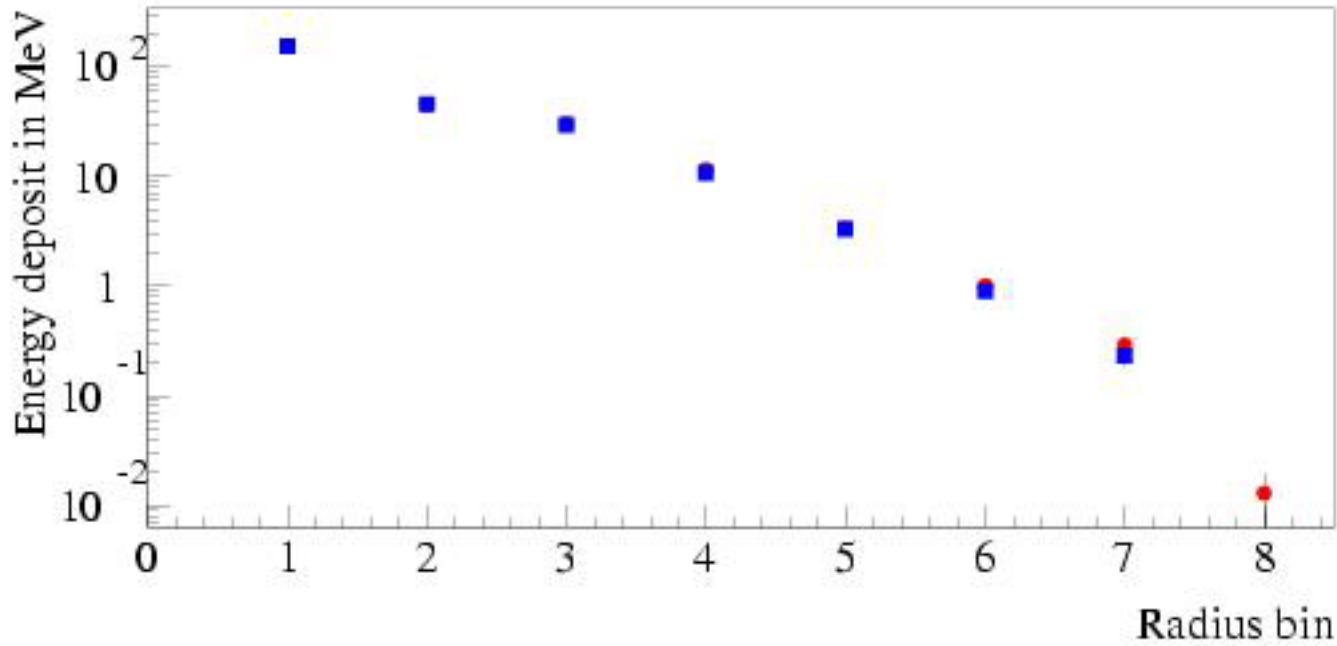
QGSP
Cu-LAr
 π^+
100 GeV



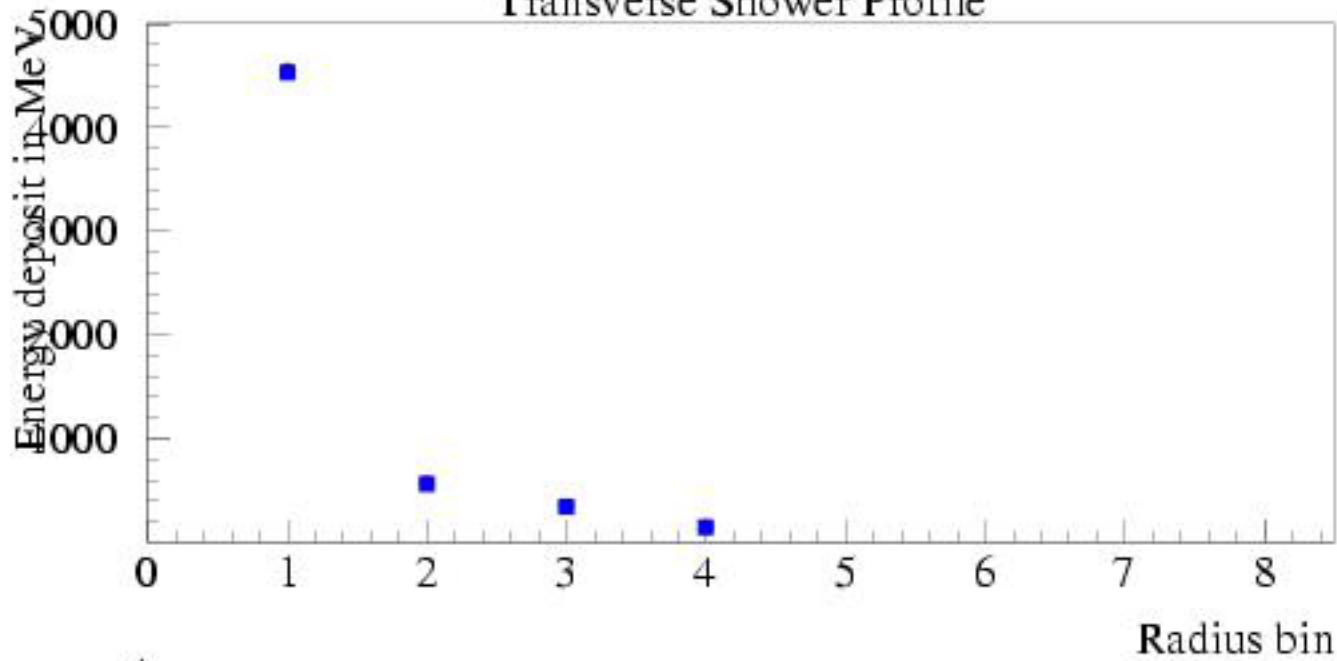
Transverse Shower Profile



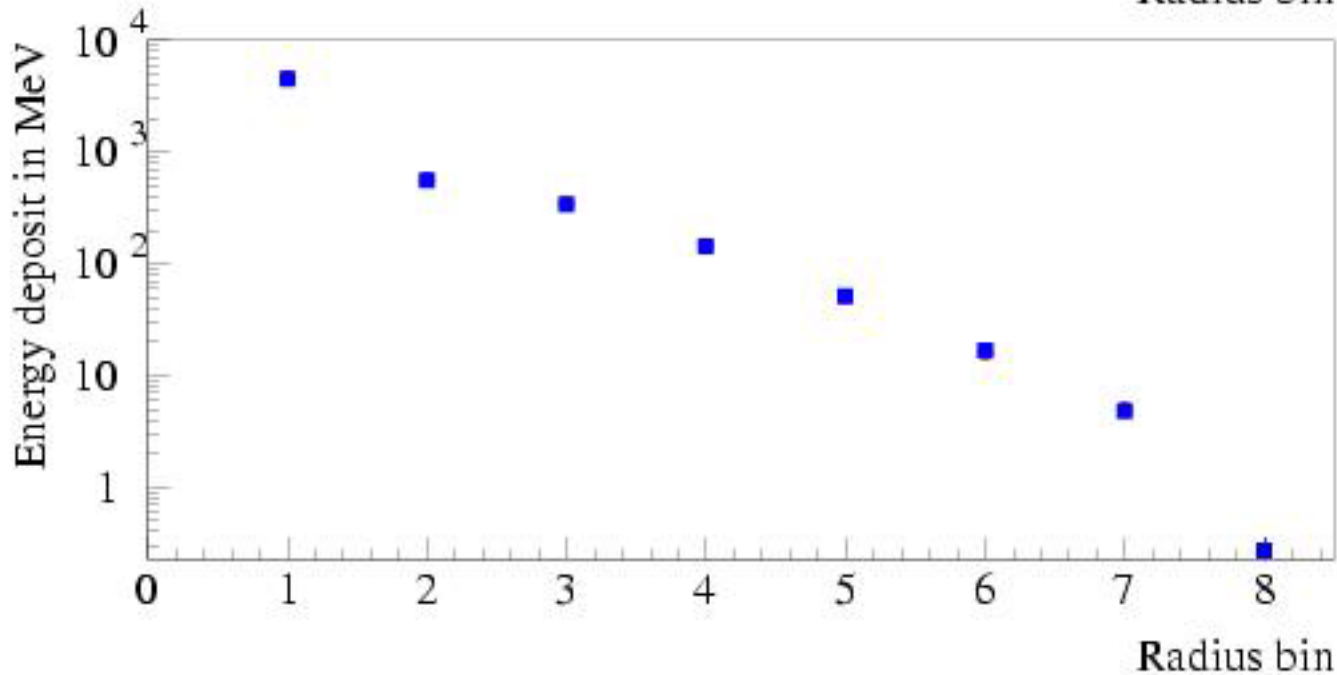
QGSC
Fe-Sci
K⁺
40 GeV



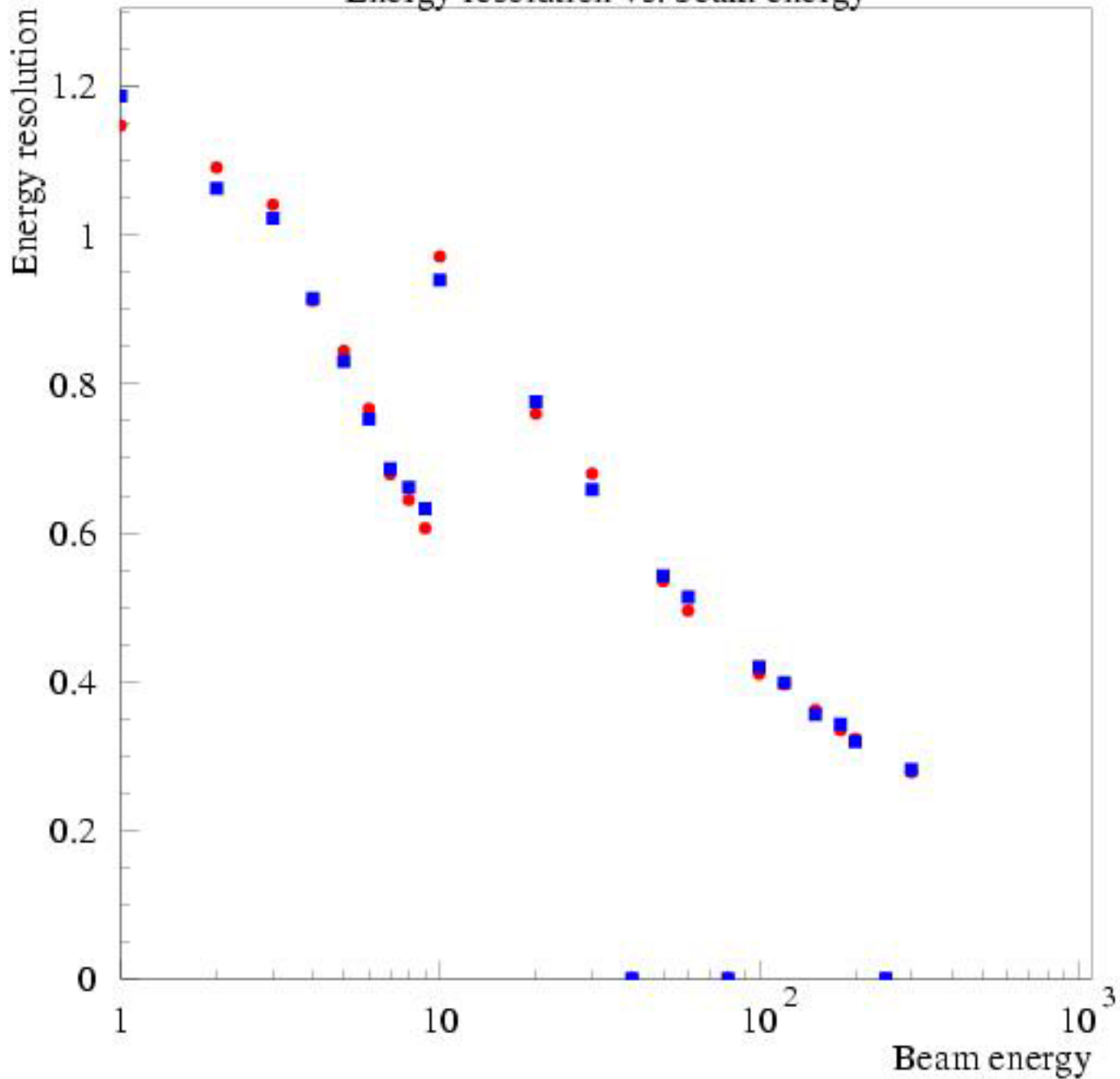
Transverse Shower Profile



QGSP_BERT
PbWO4
 π^-
200 GeV

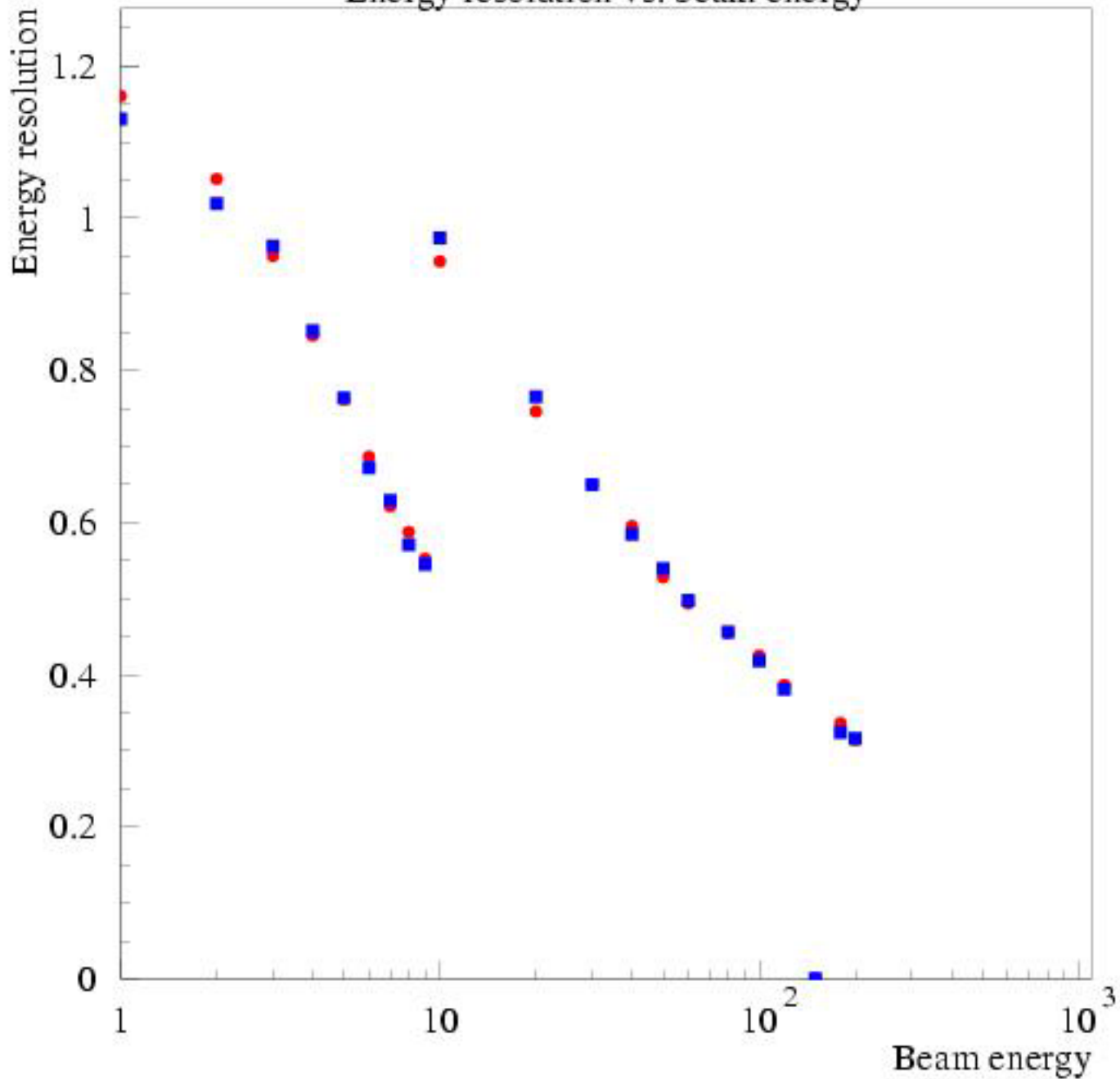


Energy resolution vs. beam energy

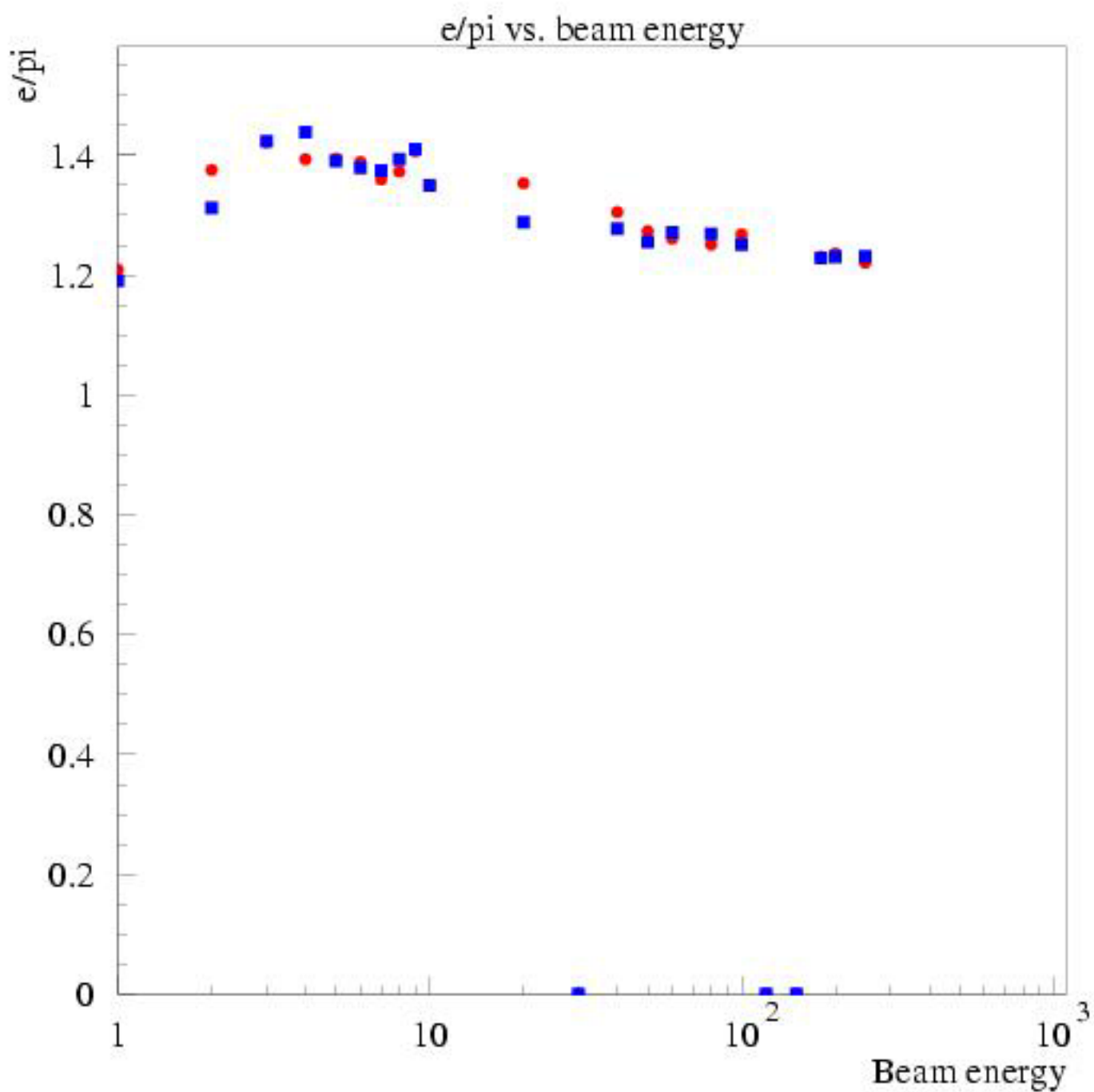


LHEP
Pb-LAr
p

Energy resolution vs. beam energy

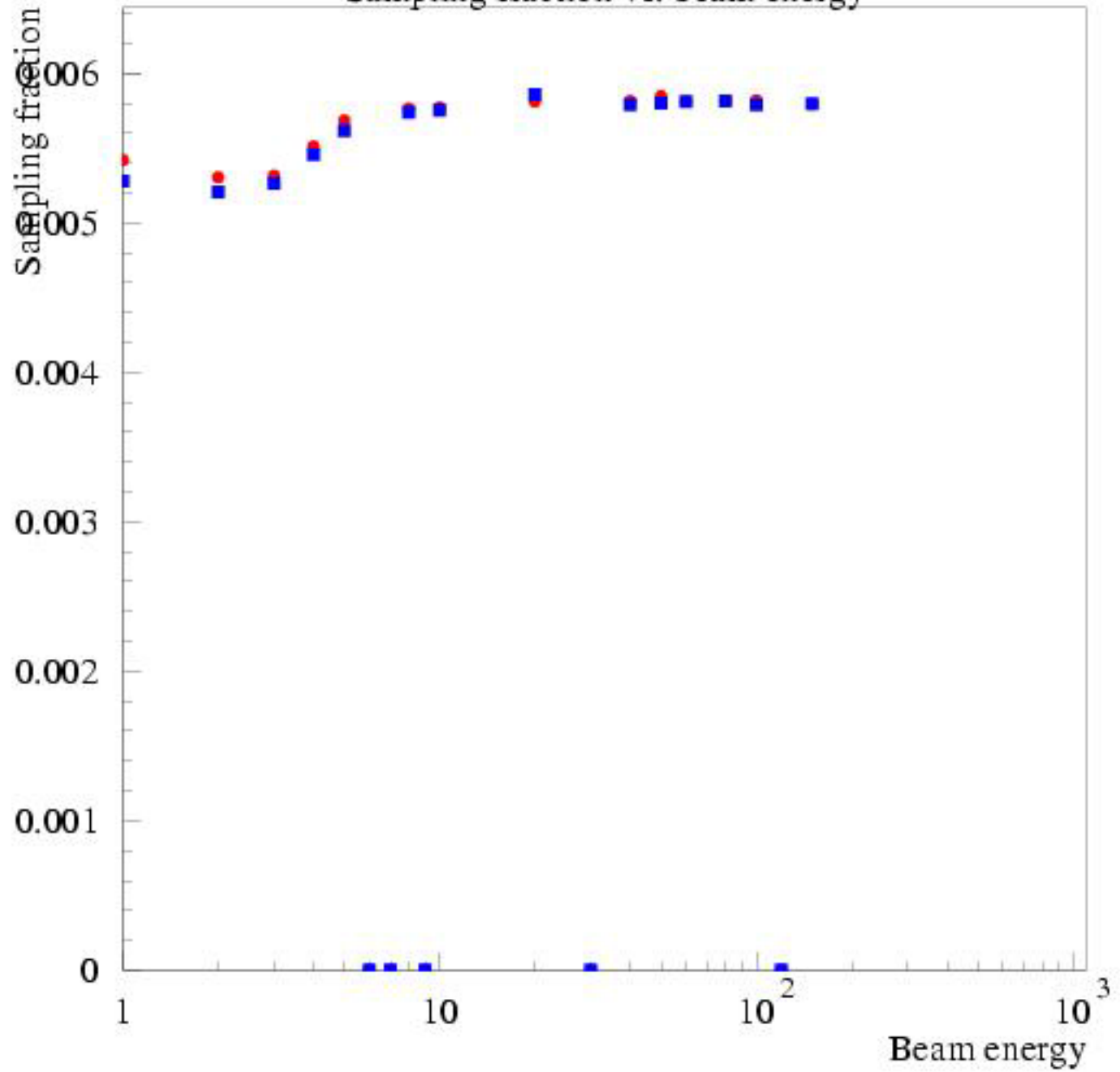


LHEP
W-LAr
 π^-



LHEP
Cu-LAr

Sampling fraction vs. beam energy



LHEP
Cu-Sci
 π^+

To Do list

NB The code and the scripts are in Geant4 CVS:

[processes/hadronic/models/verification/full_setups/StatAccepTest](#)

- ❑ Include more **statistical tests**
- ❑ Study the **power** of these tests
- ❑ Database & Web interface
- ❑ Include more observables
- ❑ Extend to electromagnetic shower shapes
- ❑ Integrate all the efforts for testing Geant4