Status of Geant4 Simulations & Comparison with Data

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LCG Physics Validation for LHC Simulations
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Status: Grid Simulations

- “Geant4 package” installed on grid
  - geant4-09-03-ref-05, geant4_vmc, CLHEP
  - tests with QGSP_BERT_{EMV, CHIPS}, CHIPS, (+optical)
- first central production in Mai 2010
  - 100.000 p+p events, Pythia D6T, 7TeV, QGSP_BERT_EMV
  - analysis discovered issues in implementation
  - so far, 7 generations of geant4 packages were tested, each with new improvements
  - detector experts have access to centrally produced Geant4 data and can start to validate it
  - small analysis can be performed, QA...

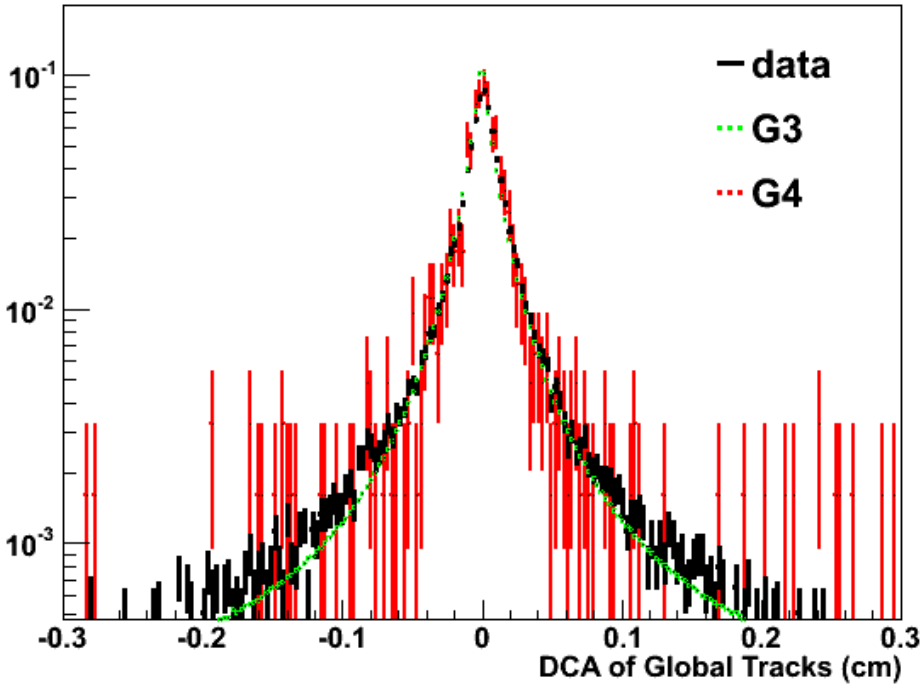
Data Sets for Comparison

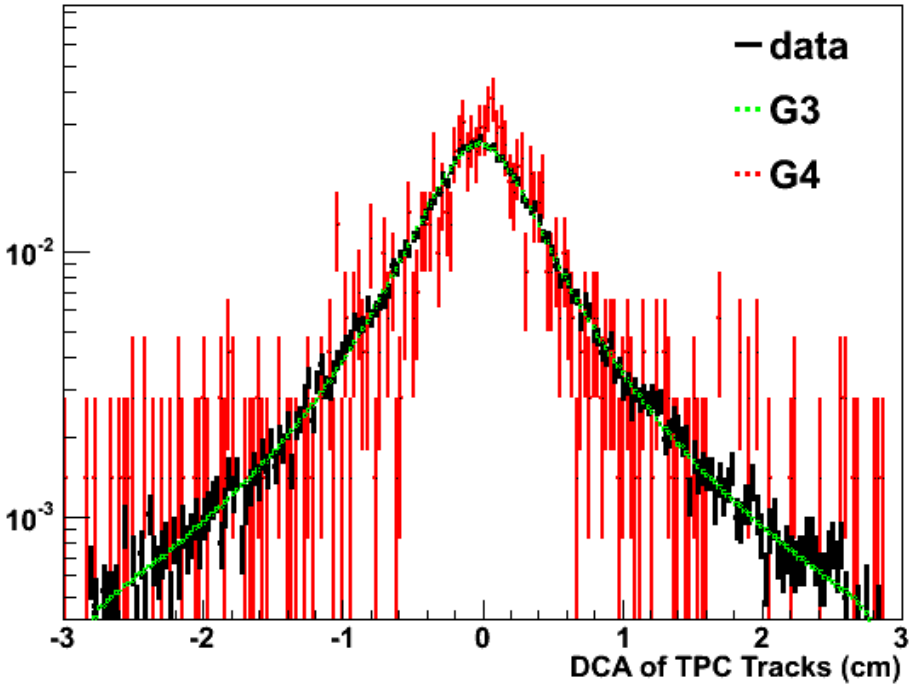
- 7 TeV
  - data: run 116571 (LHC10b period, pass2 reconstruction)
  - Geant3 (Phojet, LHC10b1)
  - Geant4, private production, Phojet
    - Physics Lists
      - QGSP_BERT_EMV (+ optical)
      - QGSP_BERT_CHIPS
      - CHIPS
    - TPC models
      - default (tuned for Geant3 simulations)
      - SetPrimaryIonisation(kTRUE)
      - photo-absorption ionization model (PAI)

Compare Track Properties
7 TeV p+p
Data - Geant3 - Geant4

QGSP_BERT_EMV

Distance of Closest Approach

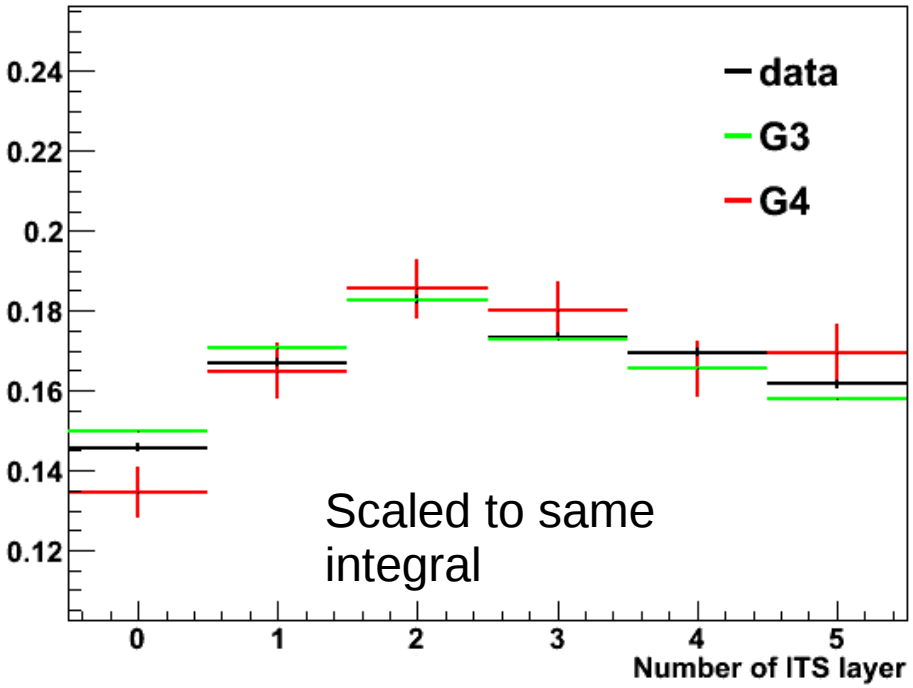




- DCA of global tracks and of TPC tracks
- all data agree good

Hits in ITS Layer

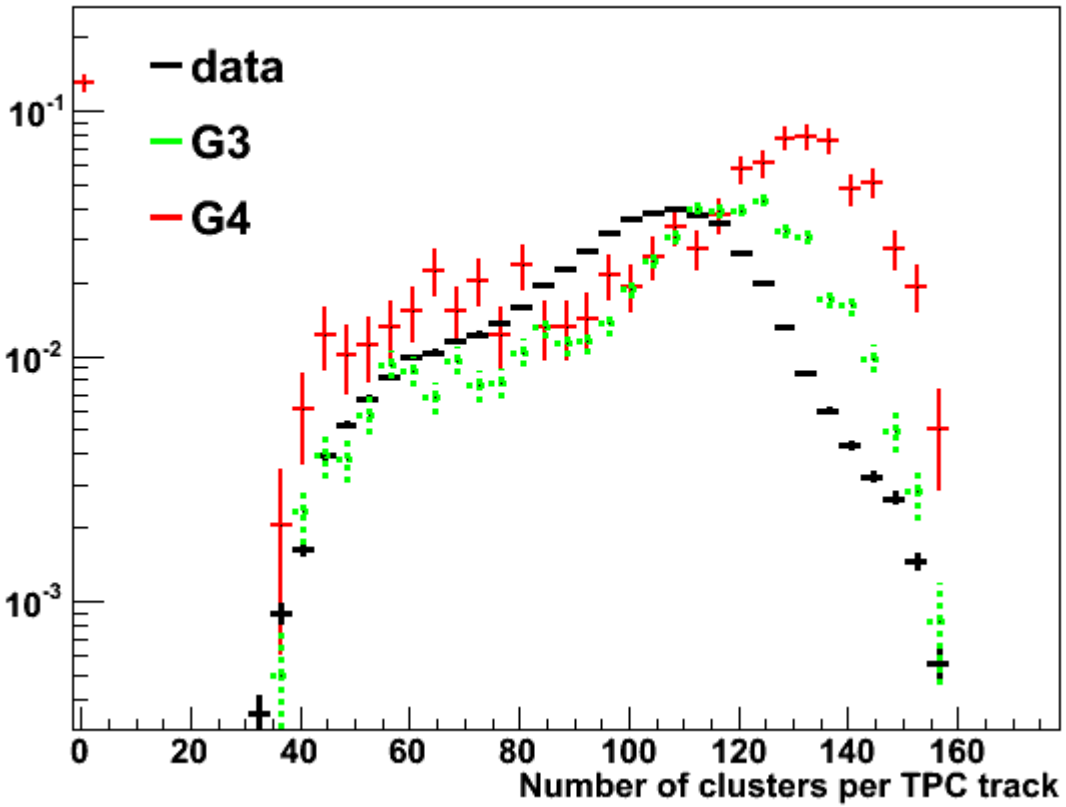
- ITS, the Inner Tracking System, is build out of six layers of silicon detectors



- data, Geant3 and Geant4 results give consistent results for the ITS
- before huge differences as high layer numbers
- need higher statistics to check in more detail

TPC Cluster Distribution

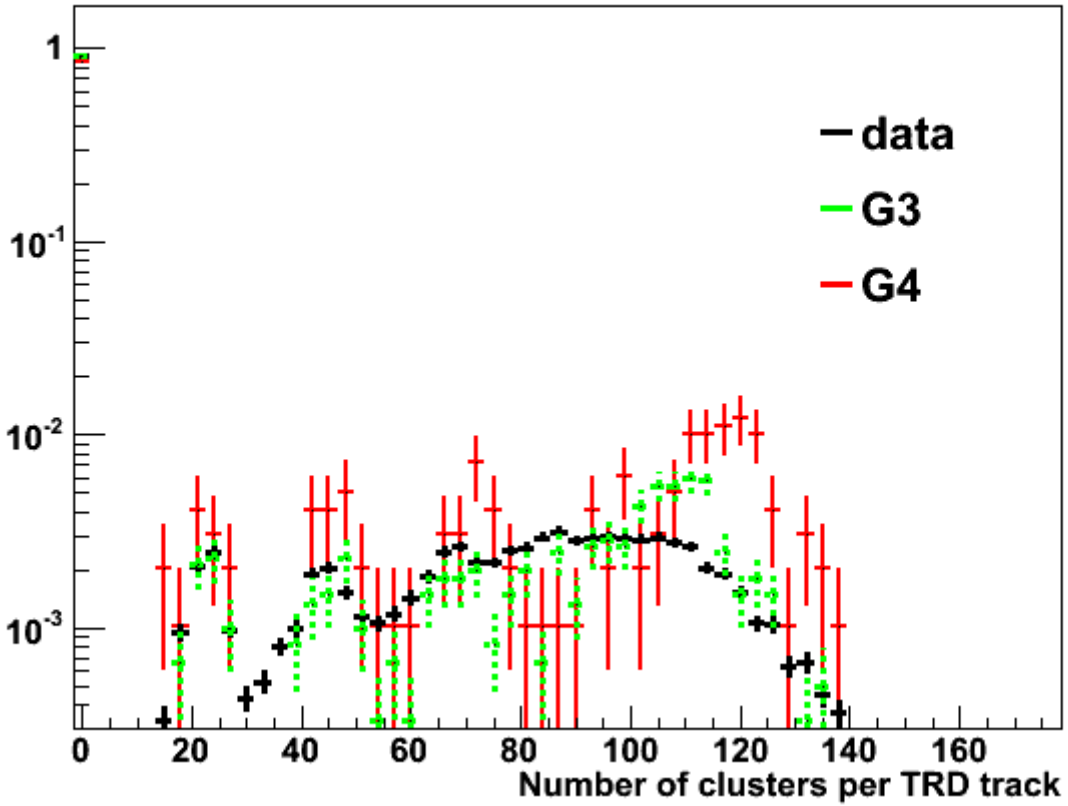
- the Time Projection Chamber is the main device, in the ALICE ‘central barrel’, for tracking of charged particles and particle identification



- maximum of NCL distribution differs strongly
- difference between Geant4 and data ΔNCL=30
  - energy loss is higher in Geant4
  - more clusters are produced
  - change energy loss model or tune gas gain

TRD Cluster Distribution

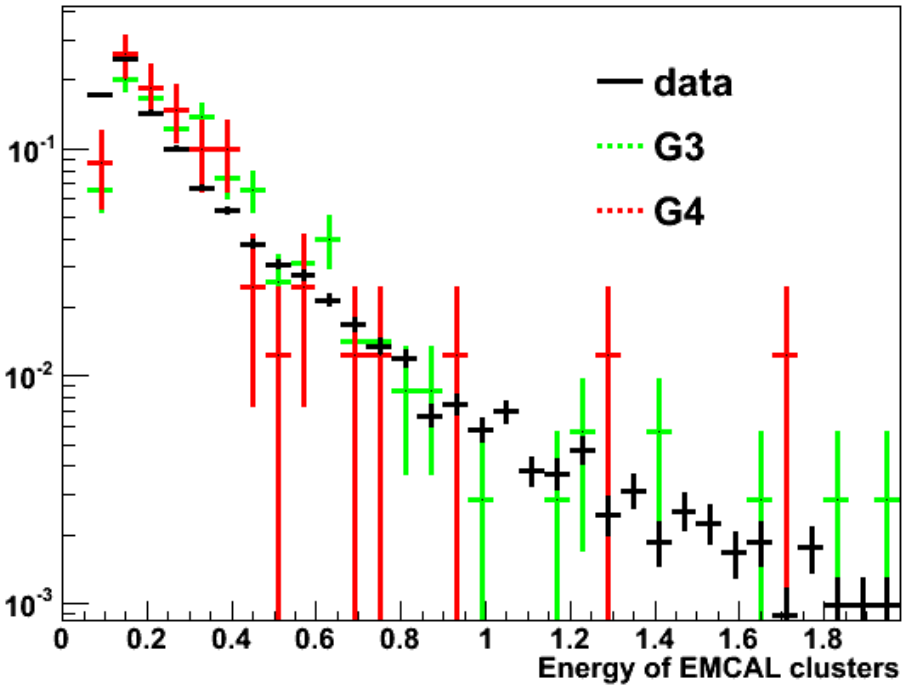
- the Transition Radiation Detector is build out of 6 chamber layers. These are visible in NCL distribution



- the simulated data shows a peak at high NCL, which is not visible in real data
- Geant4 results are shifted to higher numbers of clusters
  - energy loss is higher
  - more clusters are produced
  - change energy loss model or tune gas gain also in TRD

Calorimeter: EMCal

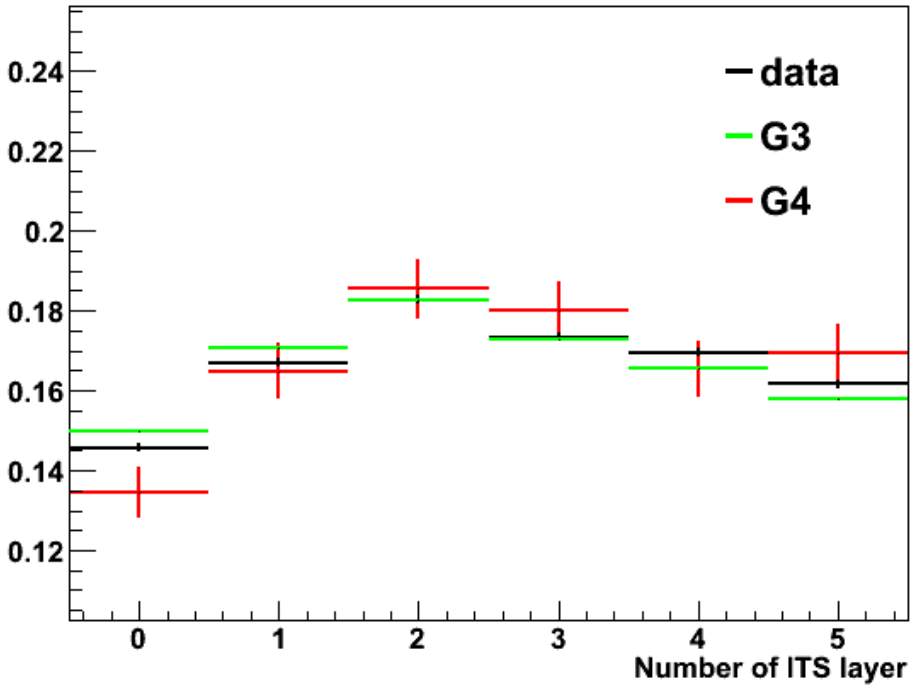
- EMCal is Electromagnetic Calorimeter of ALICE

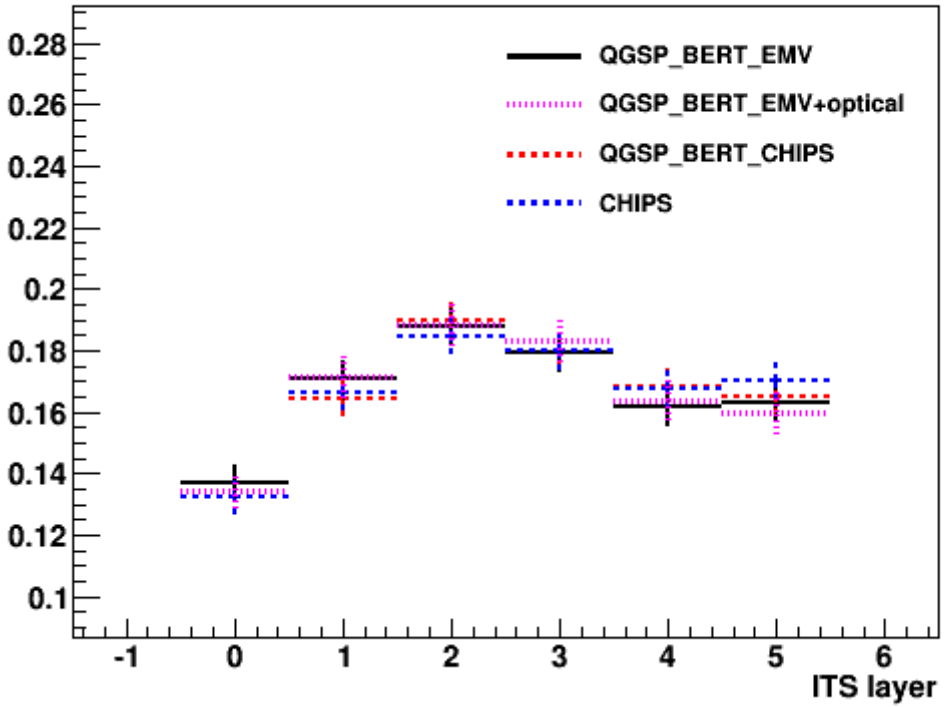


- energy measured in the EMCAL deposited per cluster shows same shape in data, Geant4 and Geant3
- for more detailed comparison, more Geant4 events are needed.

Comparison: Physics Lists

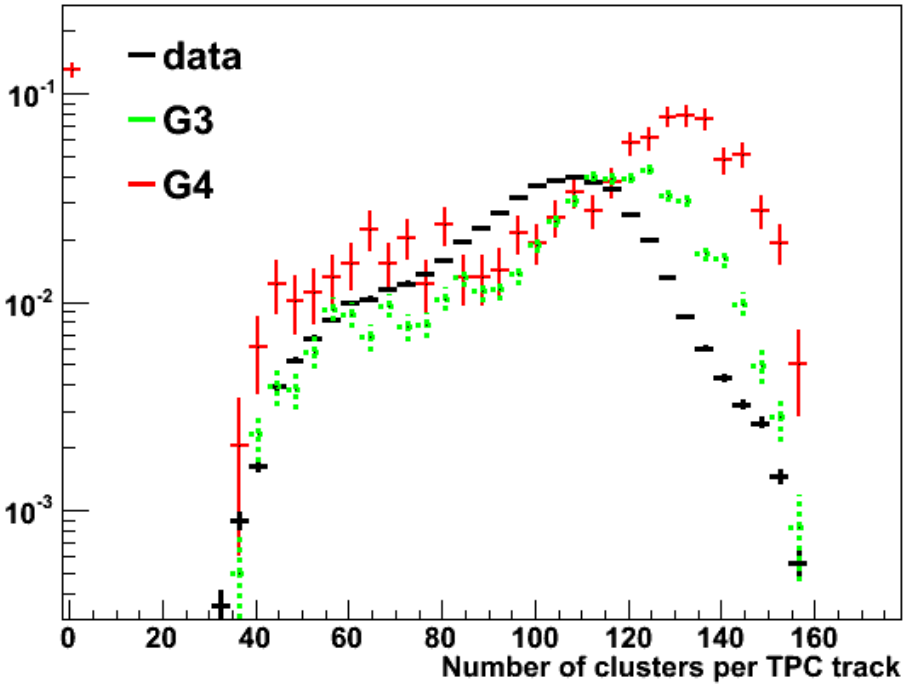
Hits in ITS Layer

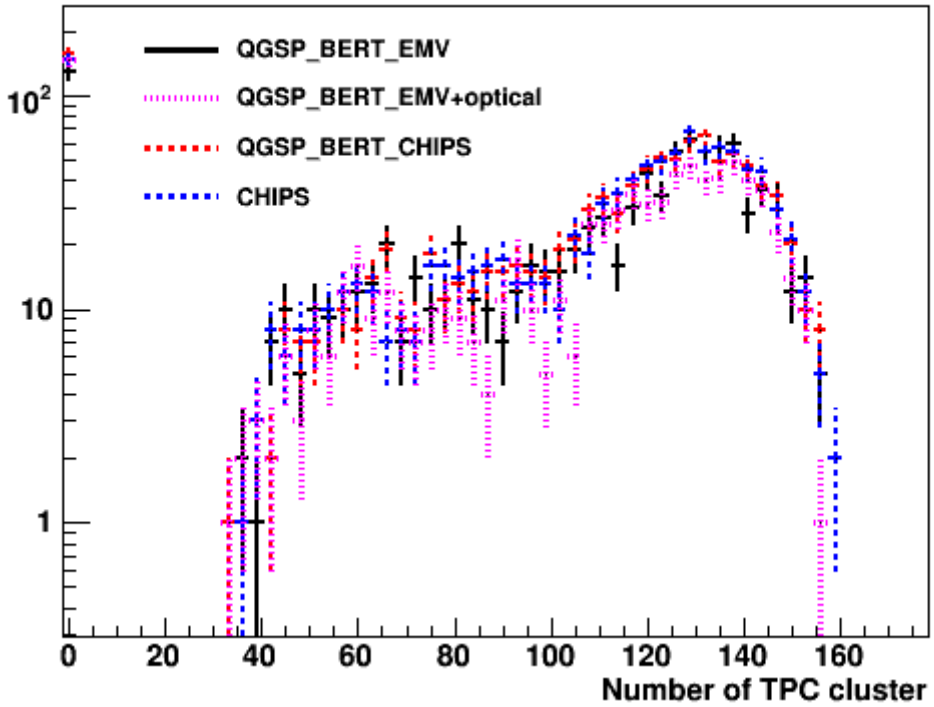




- different Physics Lists give same results
  - Geant4 is consistent within changing PLs
- good agreement with data and Geant3

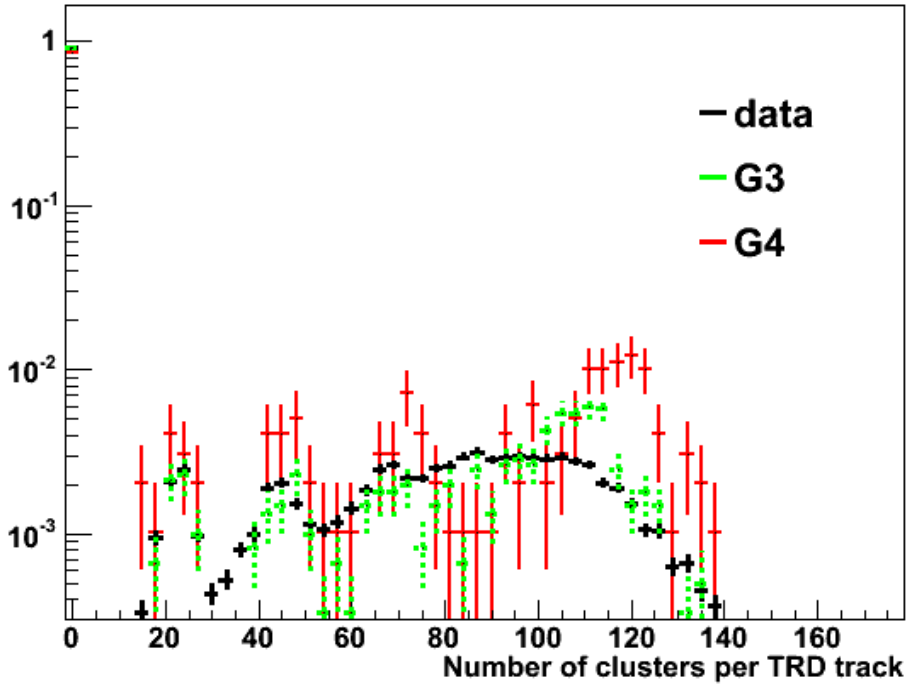
TPC Cluster

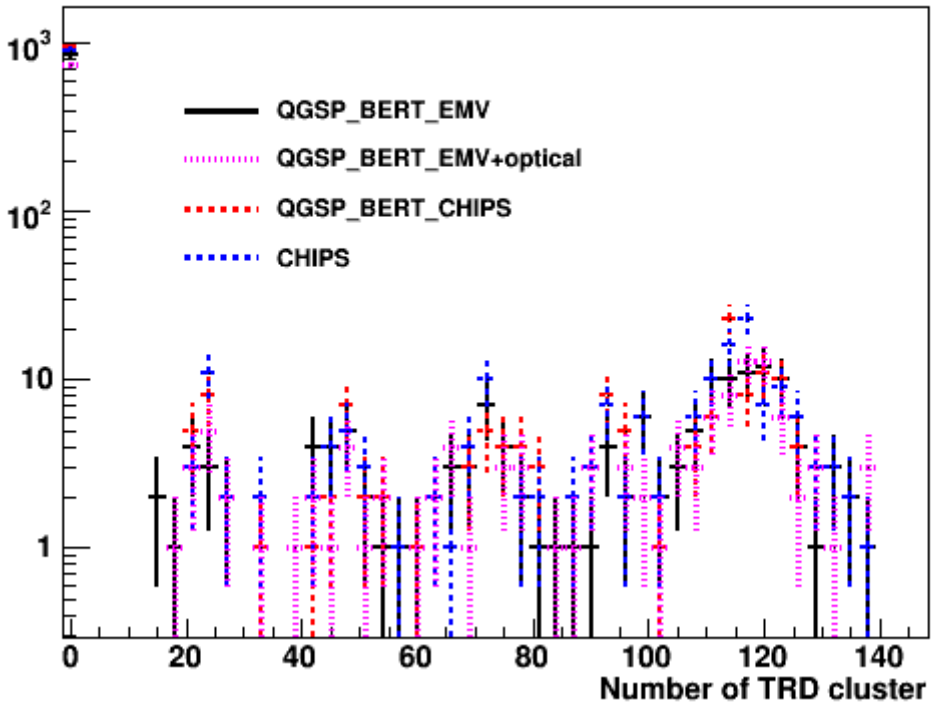




- different Physics Lists give same results
  - Geant4 is consistent
  - but results are shifted compared to real data and Geant3

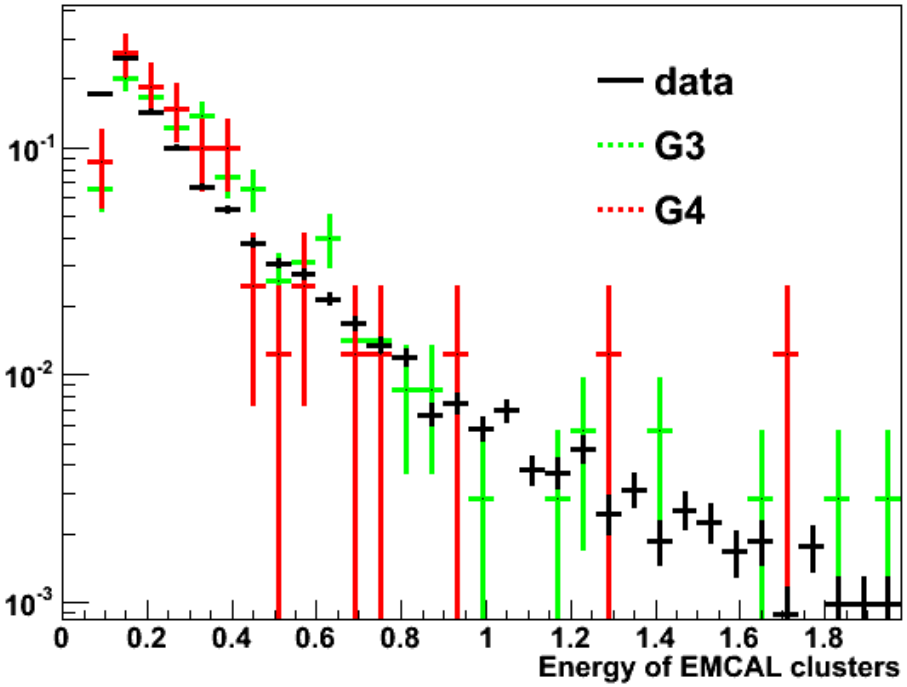
TRD Cluster

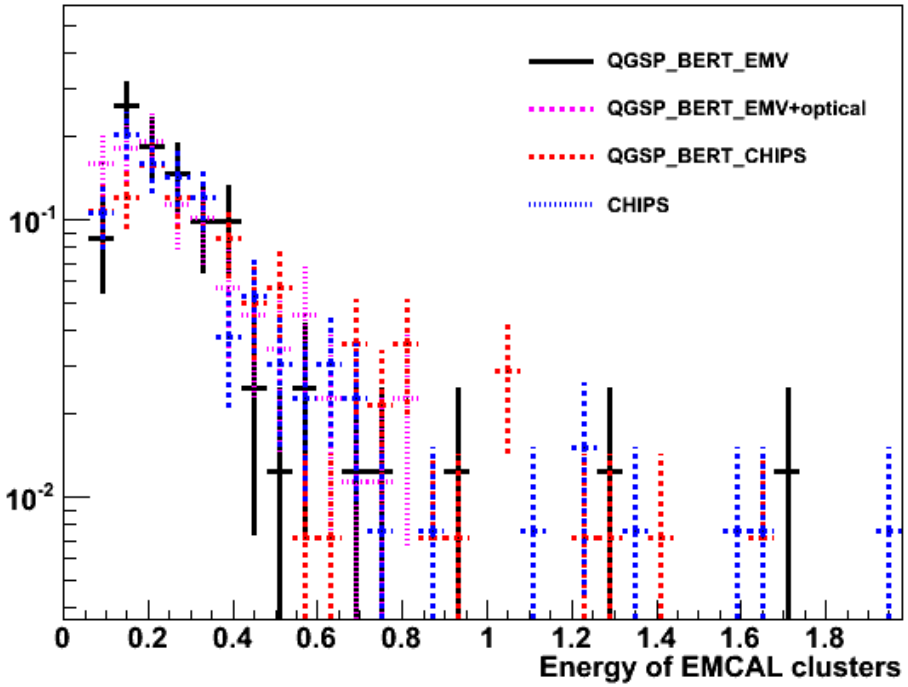




- different Physics Lists give same results
  - Geant4 is consistent
  - but results shows differences to real data
- also need higher statistics in TRD

Calorimeter EMCal





- different Physics Lists give same results
  - need more statistics

TPC Settings

Possible TPC Settings

- default
  - settings for energy loss as they are used in Geant3 simulation
  - see AliTPCv2::StepManager()
- SetPrimaryIonisation
  - change energy loss model to primary ionization in TPC StepMananger of simulation
  - see AliTPCv2::StepManager()
- SetPrimaryIonisation+Photoabsorption ionization model
  - primary ionization plus a PAI model added via geant4_vmc
  - see next slide

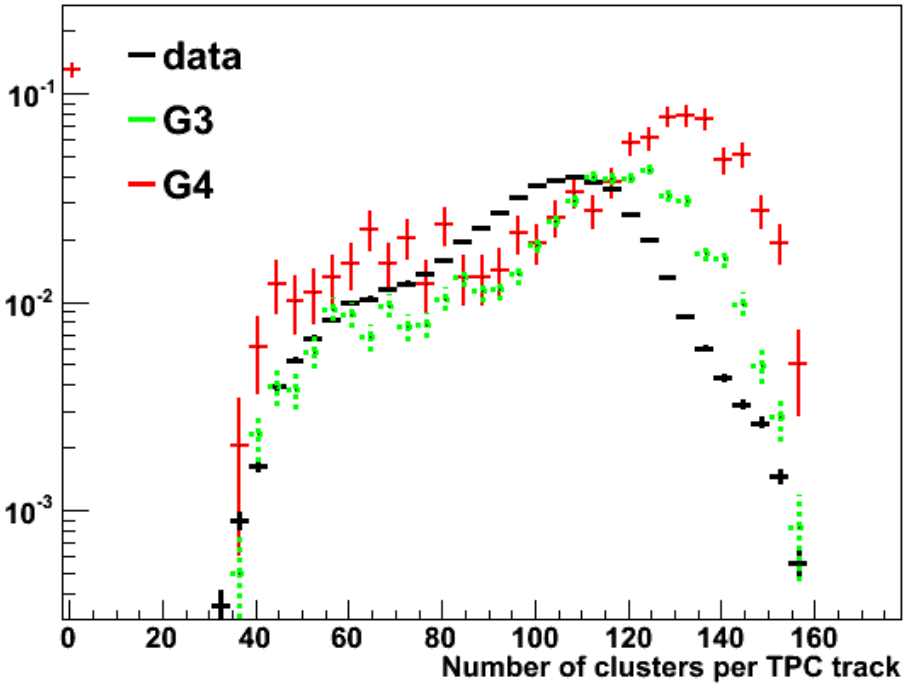
Photo-Absorption Ionization Model

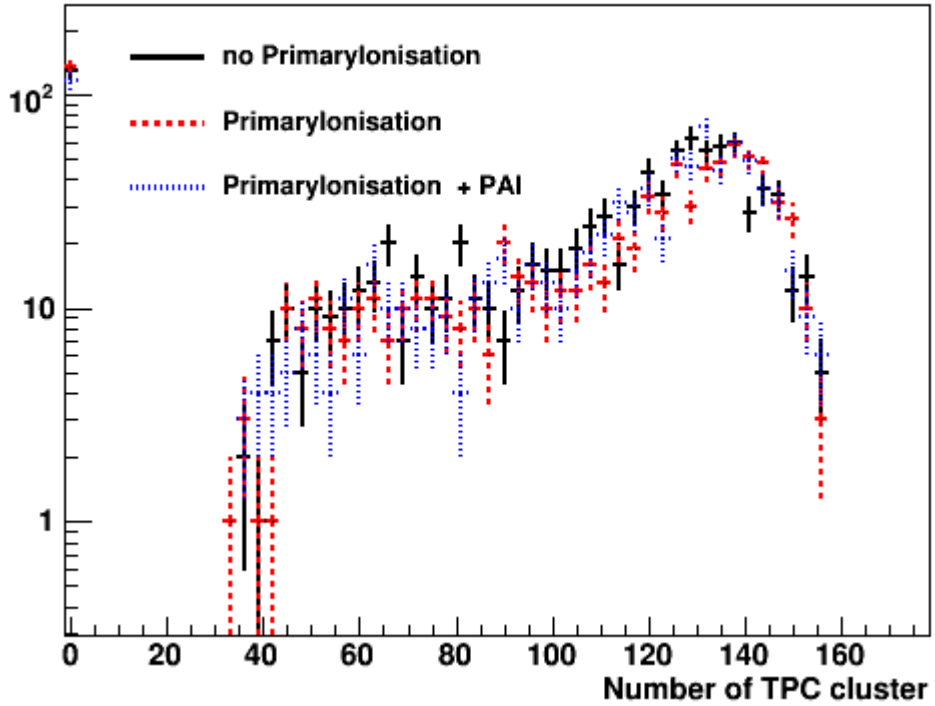
the Geant4 PAI model of energy loss and fluctuations is activated for the region with TPC (or TRD) gas:

```
// Set PAI model for TPC (TPC_Ne-CO2-N-2)
  geant4->ProcessGeantCommand("/mcPhysics/emModel/selectMedium 219");
  geant4->ProcessGeantCommand("/mcPhysics/emModel/setElossModel PAI");
  geant4->ProcessGeantCommand("/mcPhysics/emModel/setFluctModel PAI");
  geant4->ProcessGeantCommand("/mcPhysics/emModel/setParticles  all");

  // Set PAI model for TRD (TRD_XeCO2)
  geant4->ProcessGeantCommand("/mcPhysics/emModel/selectMedium 291");
  geant4->ProcessGeantCommand("/mcPhysics/emModel/setElossModel PAI");
  geant4->ProcessGeantCommand("/mcPhysics/emModel/setFluctModel PAI");
  geant4->ProcessGeantCommand("/mcPhysics/emModel/setParticles  all");
```

TPC Settings



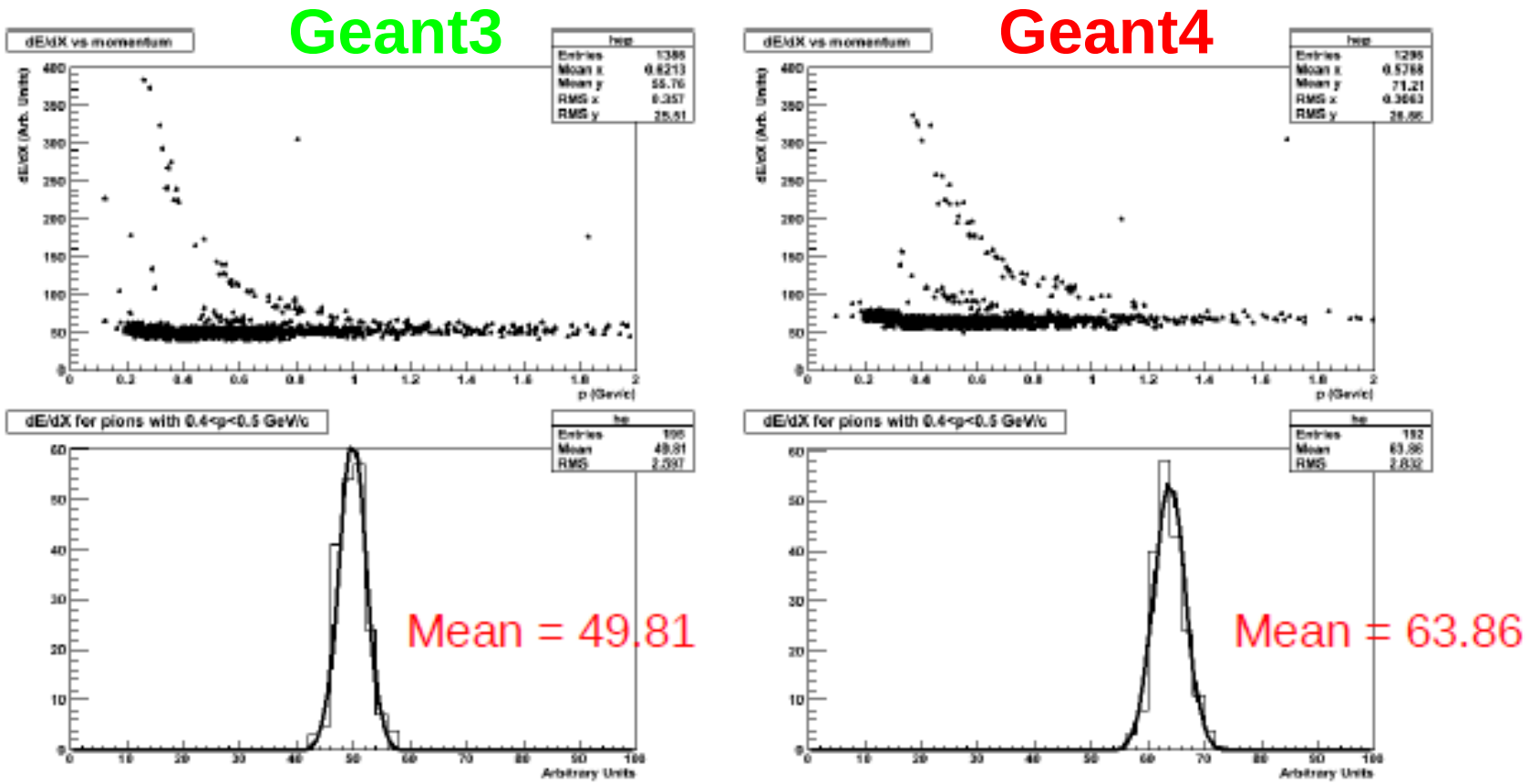


- different models give only slightly different NCL for Geant4
- compared to difference to real data, TPC results are not sensitive to model change
- neither PL nor models change TPC results sufficient
  - Check energy loss

Energy Loss in TPC

dE/dx:

dE/dx for pions in limited pT range:



- dE/dx for pions with 0.4 < pT< 0.5 GeV/c is much higher for Geant4 → leads to higher numbers of clusters
- outlook: tune gas gain = conversion dE→nel to fit in dE from G4
  - yesterday's discussion with Vladimir, Ivana, and Marian

Additional Checks

Time Consumption

- simulation time per PL (on my private machine, can differ)
  - Geant3: 106 sec/ev (160 sec/ev) (32/97)
  - QGSP_BERT_EMV: 142 sec/ev (198 sec/ev)
  - QGSP_BERT_EMV+optical 220 sec/ev (277 sec/ev)
  - QGSP_BERT_CHIPS 220 sec/ev (278 sec/ev)
  - CHIPS 318 sec/ev (368 sec/ev)

simulation time

Summed time: Simulation, digitization. ..

How can we reduce time consumption, especially with CHIPS PLs?

Production coming soon...

- planed to start the central productions this week using Revision AliRoot v18-Rev-23
  - 100,000 events each using
    - QGSP_BERT_EMV
    - QGSP_BERT_EMV +optical
    - QGSP_BERT_EMV + different TPC E-loss models
    - QGSP_BERT_CHIPS
    - CHIPS

Warnings in CHIPS and QGSP_BERT_CHIPS


```
G4PropagatorInField::ComputeStep() - WARNING
 Zero progress for 51 attempted steps.
 Proposed Step is 2.1145530897359e-05 but Step Taken is 2.1145530897359e-05
 For Particle with Charge = -1 Momentum = 403.34902802447 Mass = 139.57
in volume DDIP
G4PropagatorInField::ComputeStep() - WARNING
 Zero progress for 51 attempted steps.
 Proposed Step is 2.1145522686234e-05 but Step Taken is 2.1145522686234e-05
 For Particle with Charge = -1 Momentum = 403.34902802447 Mass = 139.57
in volume SD6D
...
```

- happens often in CHIPS and is repeated many times
- happens sometimes in QGSP_BERT_CHIPS
- was reported Geant4 team
  - is this serious? Increases the log very much

G4Transportation kills track

```
>>> Event 5

 G4Transportation is killing track that is looping or stuck
This track has 106.7424917058 MeV energy.
Number of trials = 0    No of calls to AlongStepDoIt = 16243593

 G4Transportation is killing track that is looping or stuck
This track has 126.85150432809 MeV energy.
Number of trials = 0    No of calls to AlongStepDoIt = 16357964

>>> Event 6

...
```

- happens sometimes with all PLs
- number of trials=0 !!
- was reported to Geant4 team
  - How can we check, where and why this happens

Summary

- ITS results of data, Geant3 and Geant4 are close to each other
- TPC and TRD Geant4 results show differences to data
  - tested different E-loss models
  - tested different PLs
  - outlook: tune the gas gain
- EMCAL results are close to each other
- central production is expected soon
  - enables to investigated detailed differences with high statistics
  - also simulation output (Hits, Digits) will be stored for that purpose

Thanks a lot, Ivana Hrivnacova and Olga Vladimirovna Datskova!!