AHCAL
Longitudinal Profiles and Leakage

Experiences with MC Generation for Hadrons

by
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Content

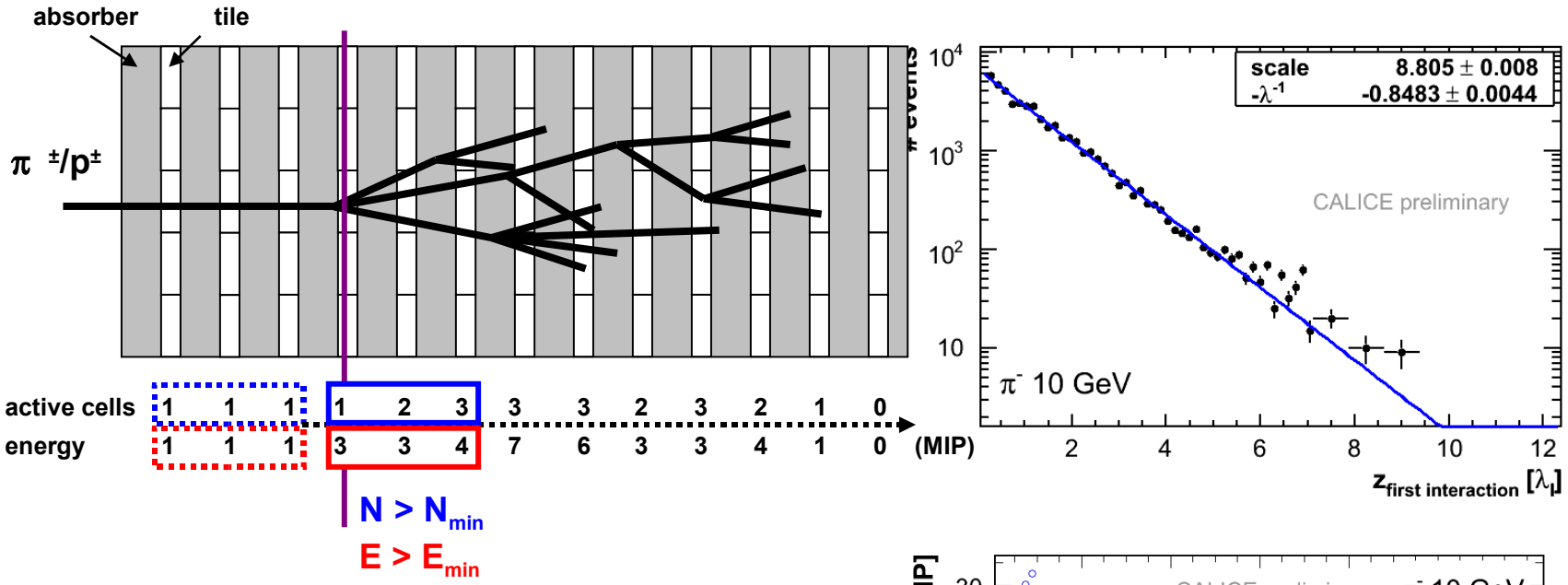
Finding the First Interaction

Measuring and Correcting Leakage

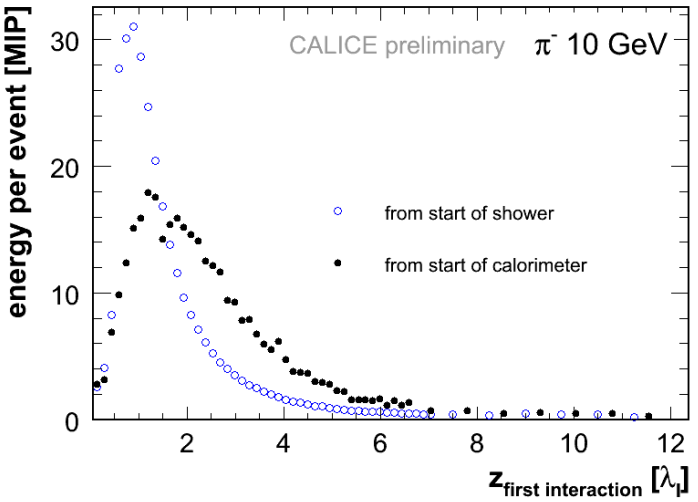
Monte Carlo Generation for the AHCAL

Study of Different Physics Models

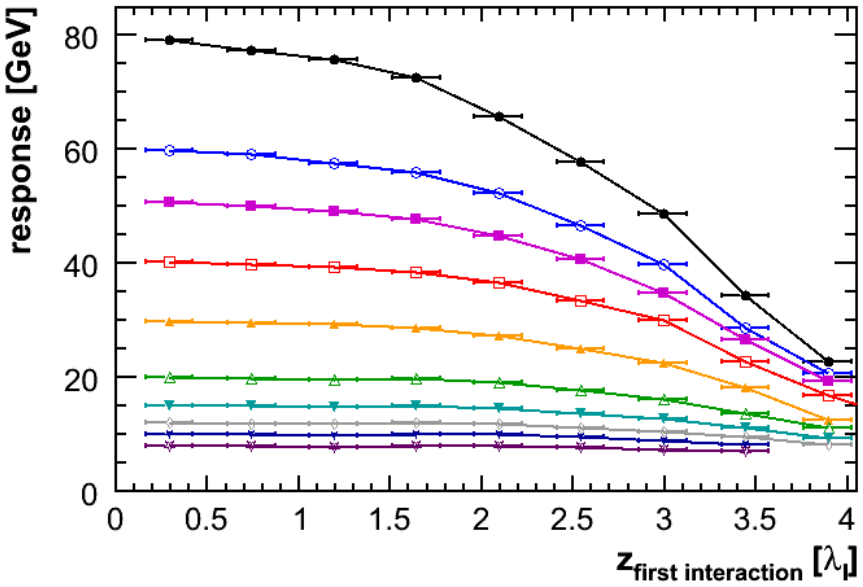
Shower Starting Point

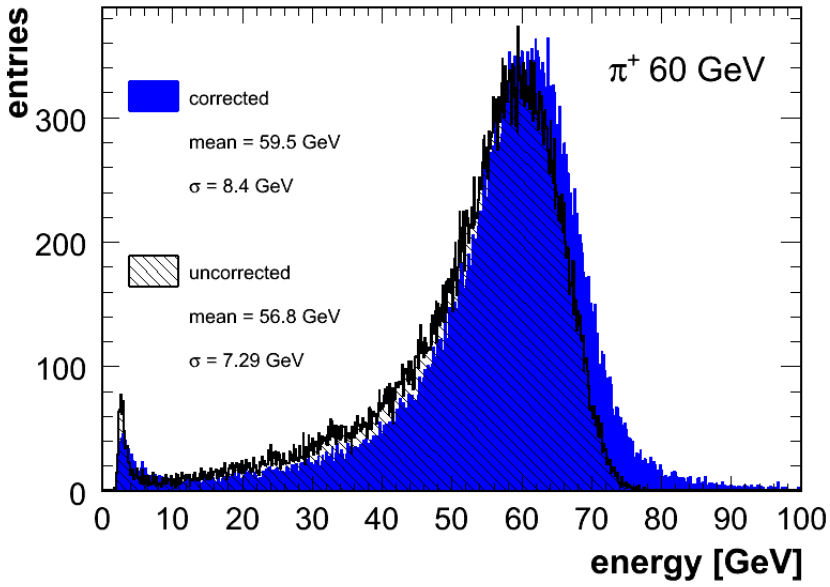


- fine granularity allows to find shower start with simple methods
- measurement of λ_{π} gives expected value
- possibility to measure pure longitudinal profile without fluctuation of first interaction



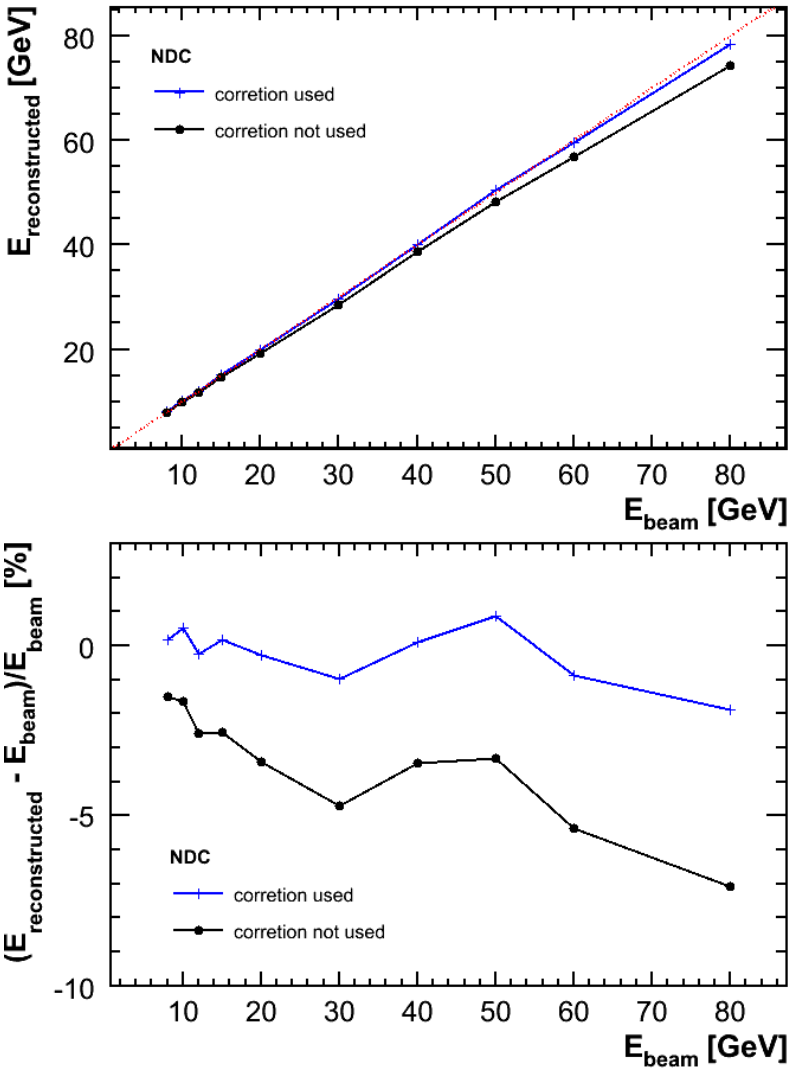
Response Correction





- detector response drops with depth of first interaction due to leakage
- knowing the response allows to correct event by event for leakage
- improves linearity
- should give superior resolution to only energy based correction

Effect of Correction



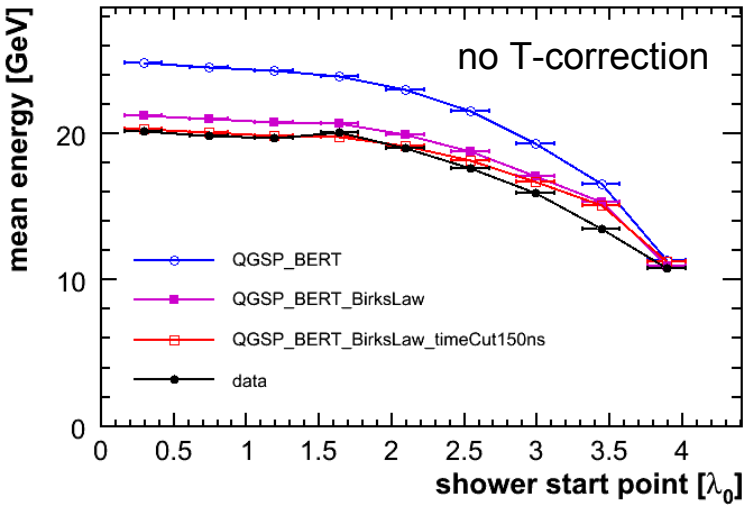
- offset in calibration reduced
- higher response (esp. for high beam energies)
- result for resolution not yet conclusive
  - comparison of relative width would be wrong
  - need to compare with alternative method for linearity correction

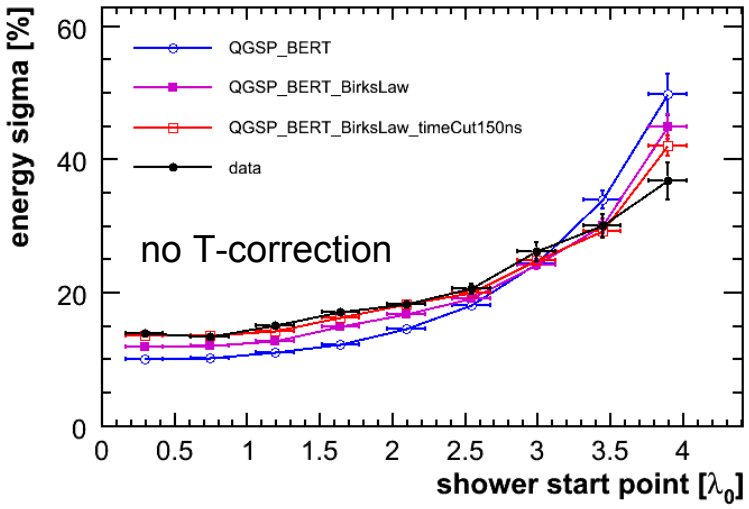
Monte Carlo Simulation of pions in the AHCAL

Issues When Generating MC

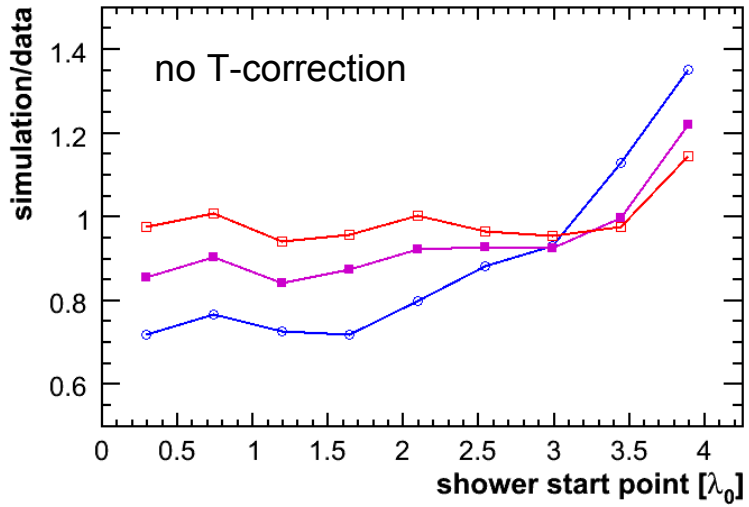
- particle beam
  - momentum, momentum spread — √ from beam-line slow readout
  - spatial distribution — ? from drift chambers
  - multiple scattering — √ from MC
- detector
  - saturation, statistical smearing optical crosstalk — √ digitization chain
  - scintillator effects (Birks') — √ newest Geant4
  - varying calibration (temperature) — ? implementation under test
- electronics
  - limited record time — √ time-cut implemented in Mokka
- choice of physics model
  - to which effects is it sensitive

Testing of Birks' and Time Cut

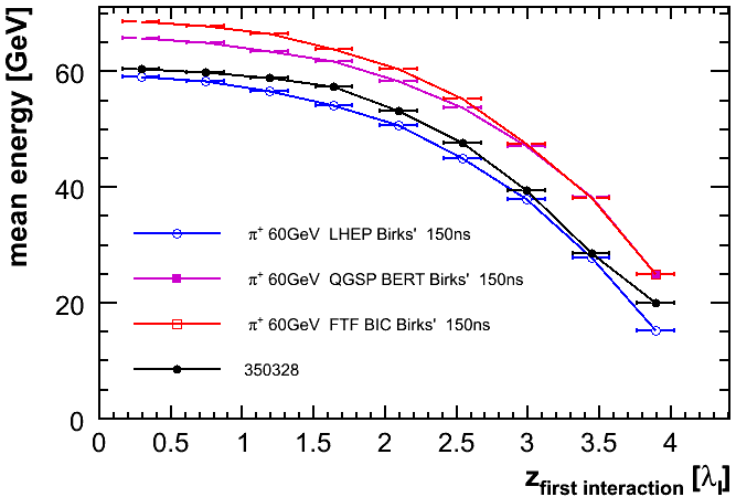


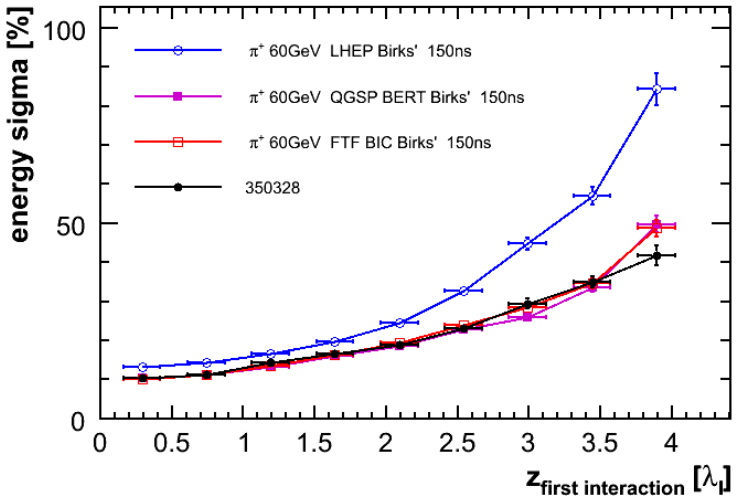


- **Birks'**
  - **25% reduction of visible energy**
  - **more realistic (worse) resolution**
- **time-cut**
  - **5% reduction of visible energy**
  - **improves resolution further**

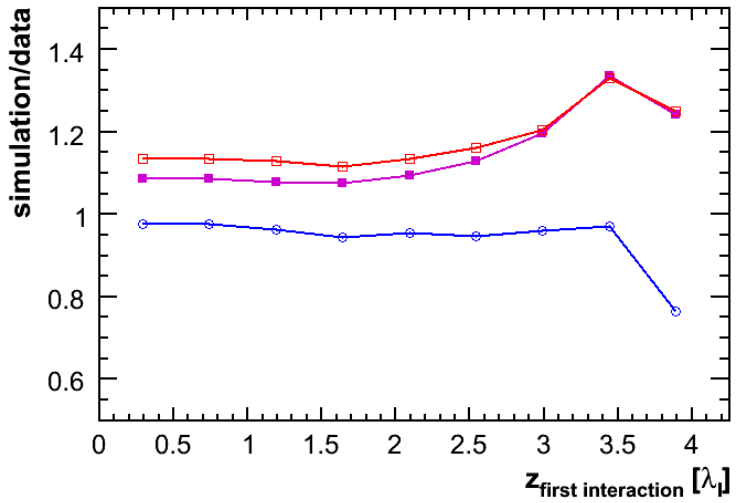


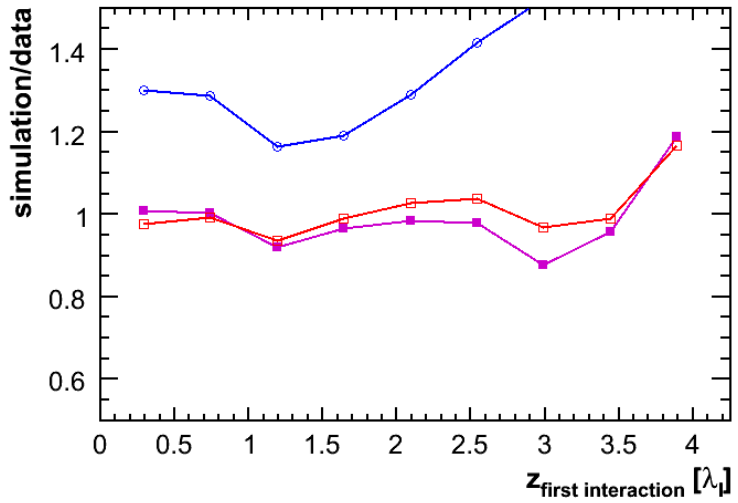
Physics Models
Response & Resolution (high energy)



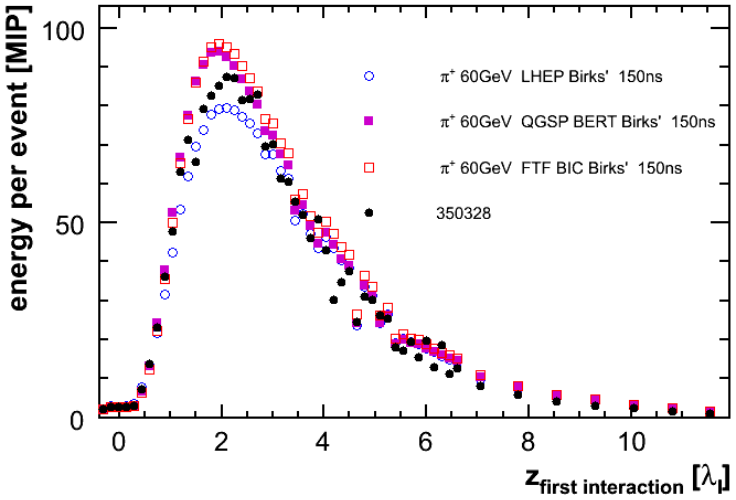


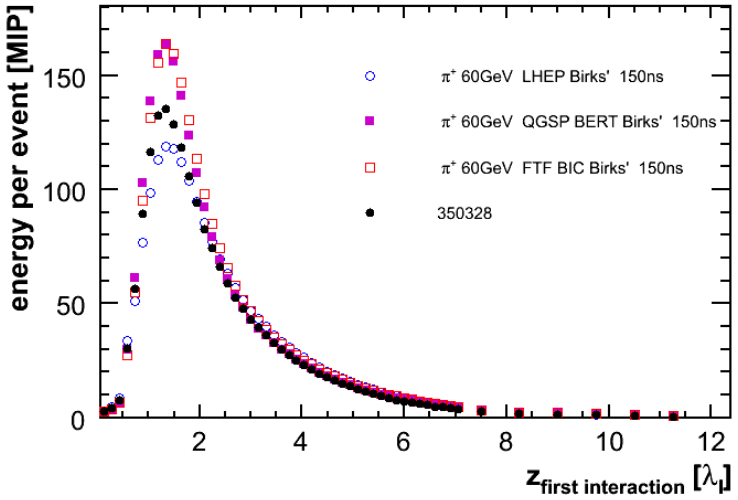
Geant4 9.2





Physics Models – Profiles (high energy)





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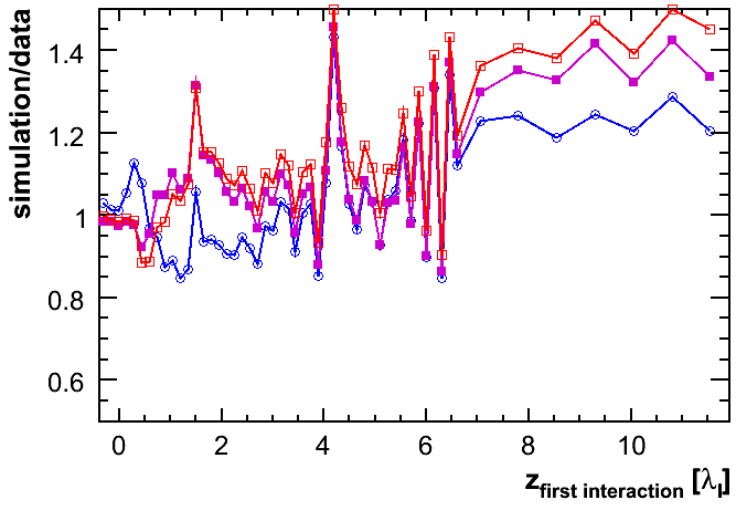
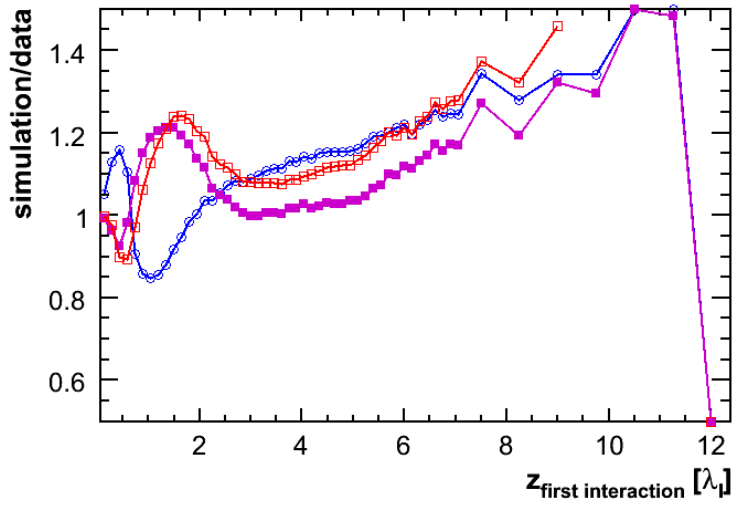
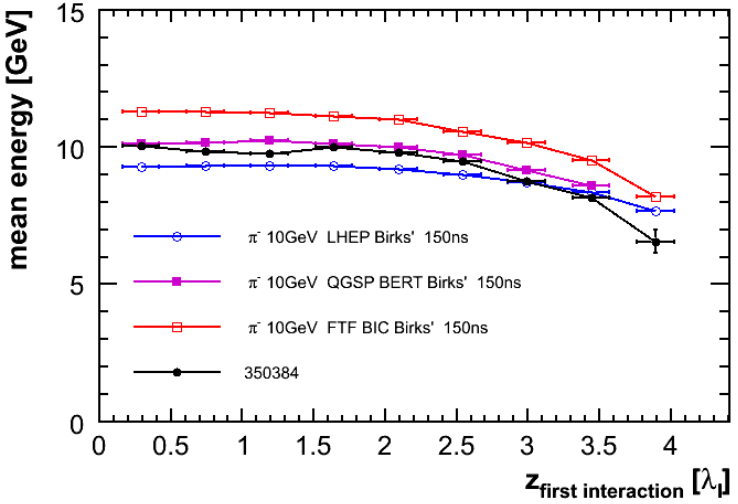
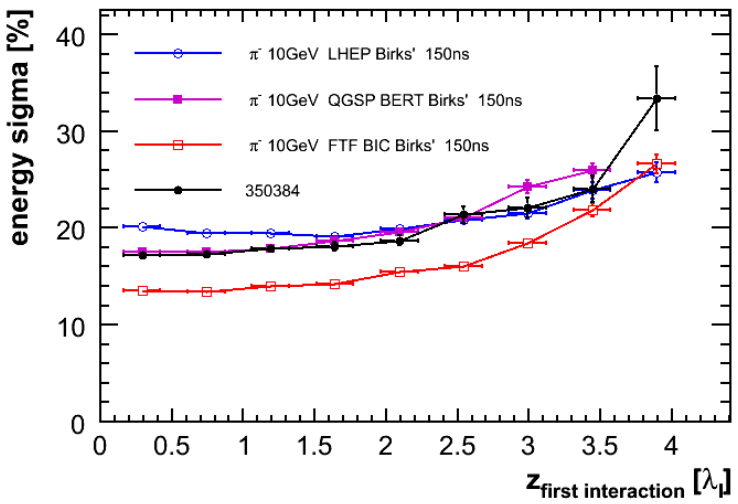
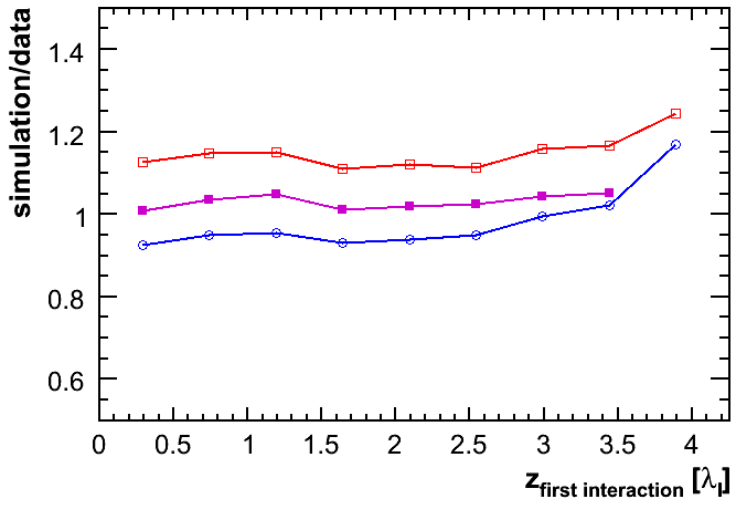


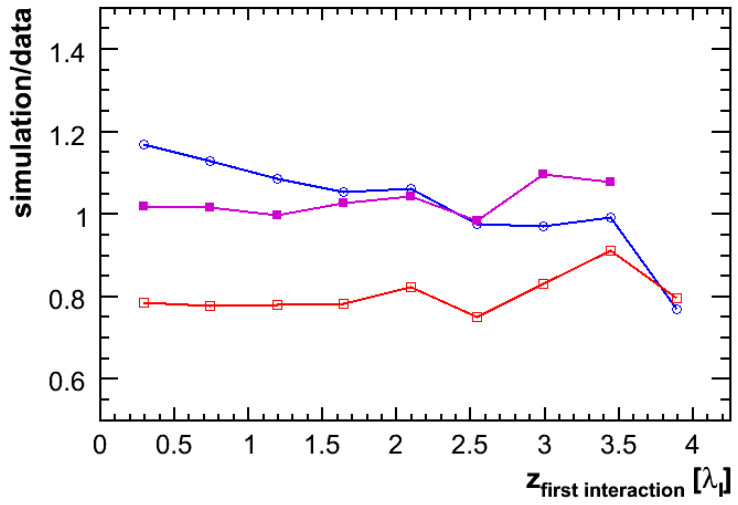


Physics Models
Response & Resolution (low energy)

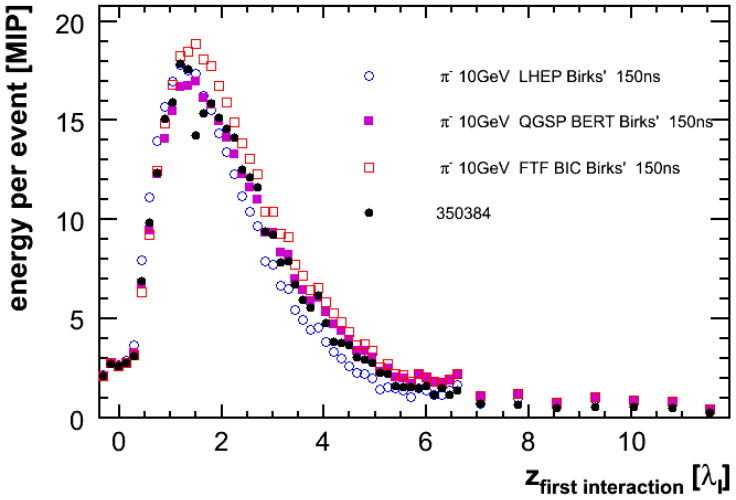


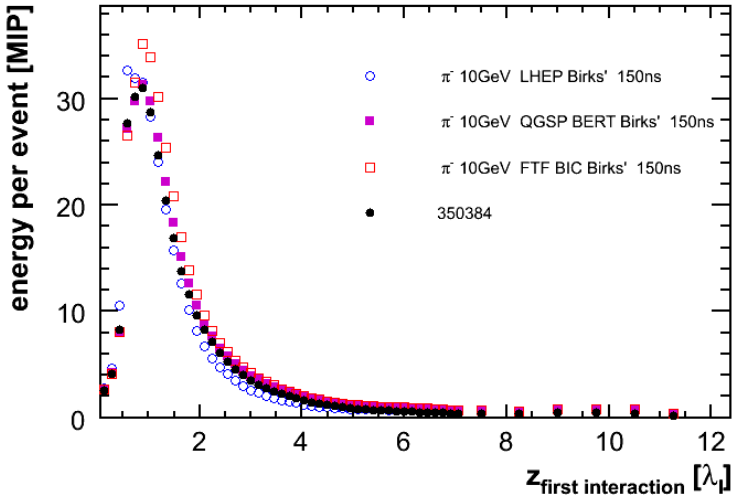


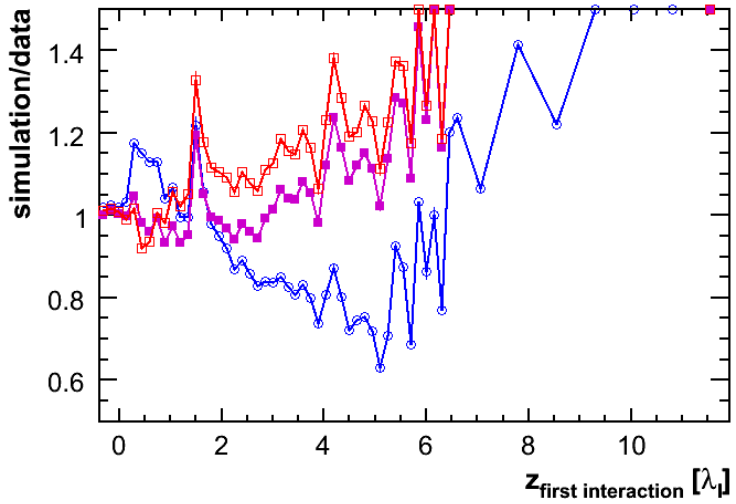


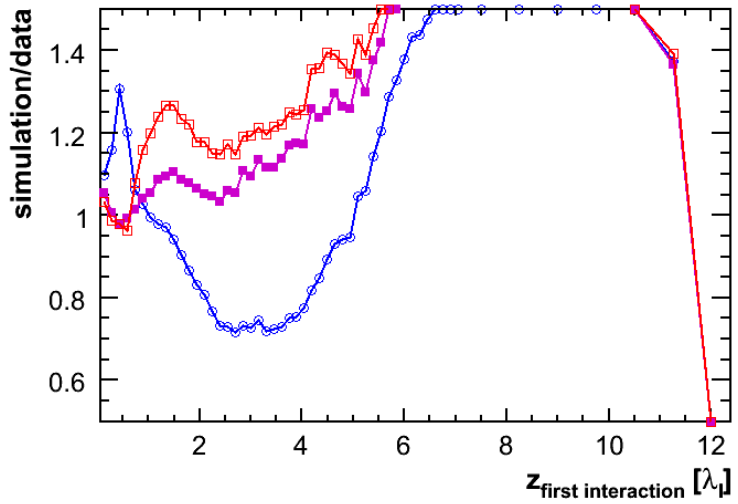


Physics Models – Profiles (low energy)









Observations for Models

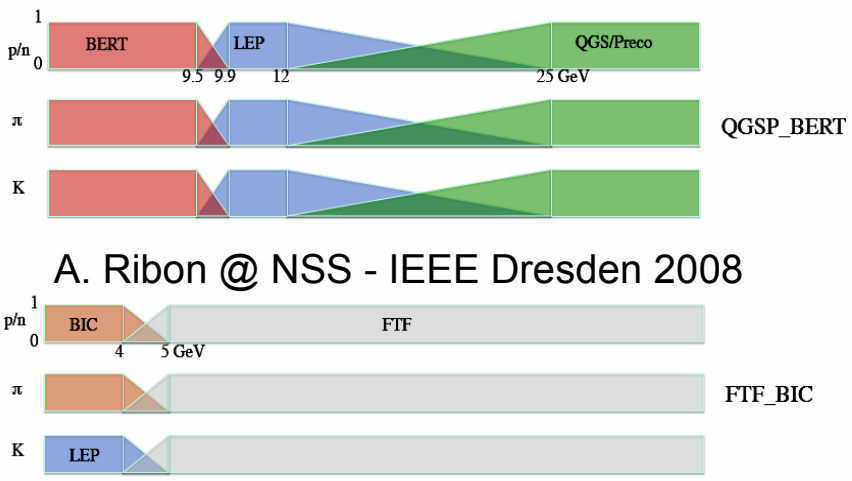
8 GeV to 15 GeV

- LHEP
  - not enough visible energy
  - poor description of resolution
- FTF BIC
  - shows too much visible energy
  - gives too good resolution
- QGSP BERT
  - good visible energy description
  - perfect resolution
  - reasonable matching of profiles
  - by far best matching model

20 GeV to 80 GeV

- LHEP
  - best description of total energy
  - poor description of resolution
- FTF BIC
  - shows too much visible energy
  - resolution well described
- QGSP BERT
  - shows too much visible energy
  - resolution well described
  - still best matching model
- all
  - fail to describe shower maximum

Inside Geant4



- Several models implemented
  - parametrized (LEP, HEP)
  - theory driven (CHIPS, BERT, QGS, BIC)
- No model covers full energy range
  - physics lists combine models
  - transition regions

known features

- LHEP
  - lowest response
  - worst energy resolution
  - good longitudinal profile
- FTF BIC
  - too much energy
  - better proton profiles
  - discontinuity @ 5GeV
- QGSP BERT
  - best for
    - response
    - resolution
    - e/π
  - bad proton profiles
  - discontinuities 10 - 25 GeV

Summary

- The method to correct for longitudinal leakage knowing the shower start was applied for beam Energies between 8 GeV and 80 GeV
- Results show an improvement in response
- The effect on the resolution is still under investigation

- A full set of Monte Carlo simulations is available
- Several important improvements in simulation, digitization and reconstructions lead to more realistic predictions
  - Birks'
  - time-cut
  - temperature effects
- The response and profiles from the leakage analysis are used to compare the prediction of several Geant4 physics lists

Backup

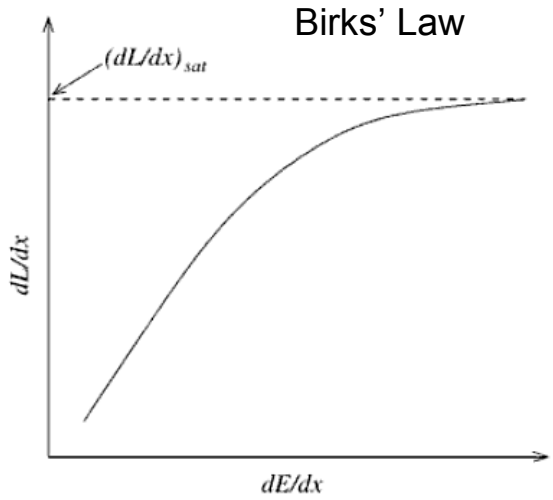
The Summing Problem

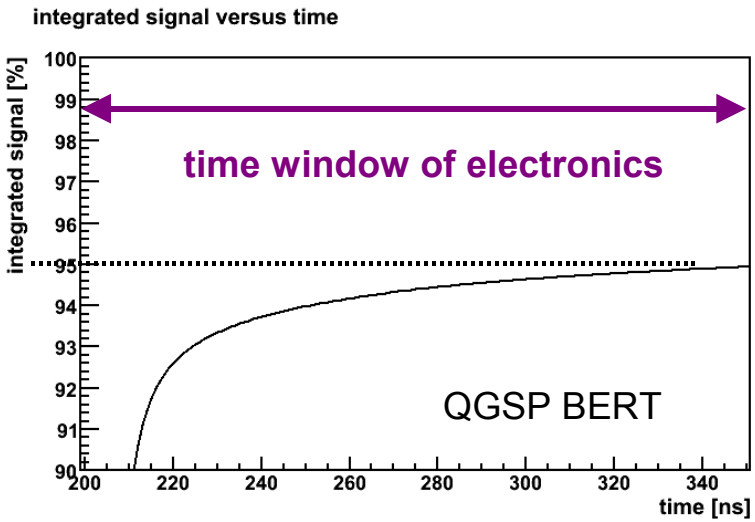
- saturation in the scintillator (Birks' Law)
  - nonlinear relation between deposited energy and scintillation light
  - once cell can have several deposits with different intensities
- timing of electronics
  - time window is defined by primary particle (trigger)
  - energy deposits in the shower will be distributed over some time
  - one cell can have several hits at different times

rather detector effects than physics but digitization (currently) has no access to individual energy deposits

→ use Birks' implementation in Geant4

→ use time-cut already in simulation





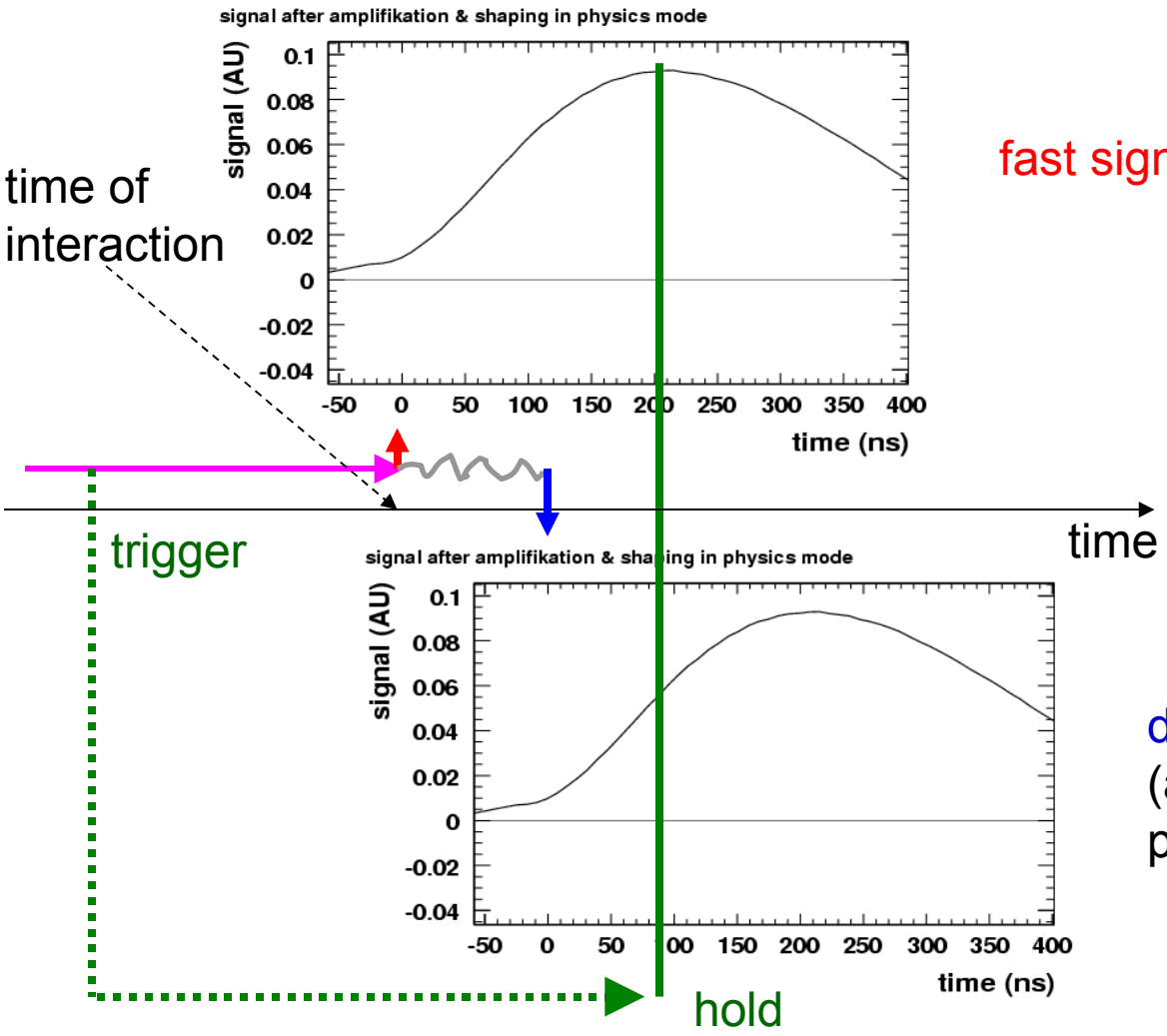
Some More Remarks

- LHEP
  - comparable small sensitivity to Birks'
  - no sensitivity to time cut
- QGSP BERT
  - strong sensitivity to Birks'
  - sensitive to time cut

MC-generation

- many initial parameters
  - more tools necessary
  - some code seems not reliable (TBTrack)
- huge progress in digitization understanding & tools
  - Birks'
  - time cut
  - temperature
- TCMT is only partly integrated into the developments

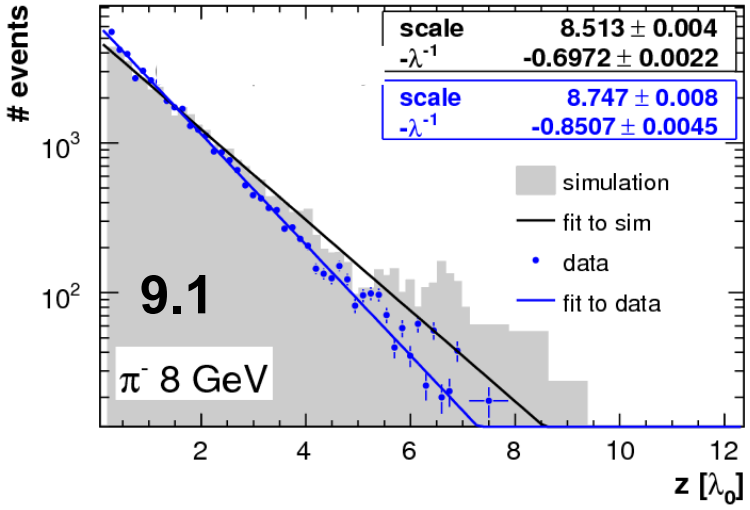
Shaping and Time

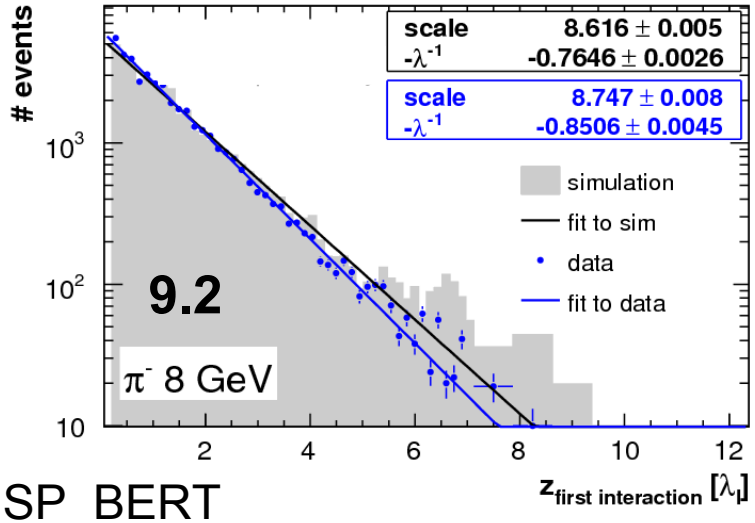


delay	efficiency
50ns	90%
100ns	65%
150ns	30%
>200ns	0%

delayed signal
(after de-excitement process)

Geant4 9.1 vs. 9.2





QGSP_BERT