



SDHCAL digitizer status

HGC4ILD - High Granularity Calorimeters for ILD WS

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IPNL

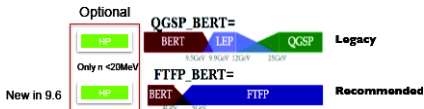
3 February 2015

Outline

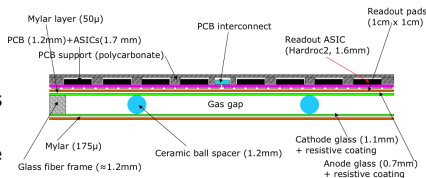
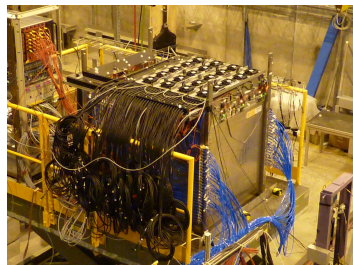
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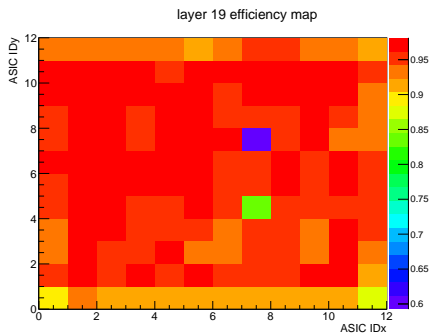
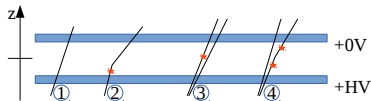
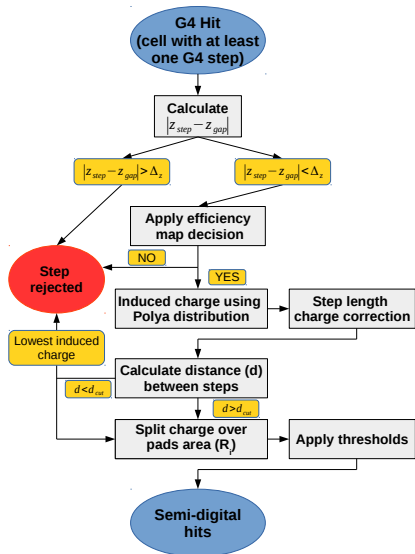
Introduction

- SDHCAL prototype simulation :
 - Geant4 version 9.6.p01 is used
 - FTFP_BERT_HP and QGSP_BERT_HP are used



- pi-, mu-, e- and proton simulated samples
 - simulation output : list of GEANT4 steps inside gas gaps and deposited energy in gas by those steps
- Digitizer : simulate the GRPC response to charged particles → transform GEANT4 steps into realistic semi-digital hits.
 - MarlinReco v01-10 in ilcsoft v01-17-06 is the baseline





SDHCAL Digitizer

- Poly function :

$$P(q) = \left(q \frac{1 + \theta}{\bar{q}}\right) e^{-\frac{q}{\bar{q}}(1+\theta)} \quad (1)$$

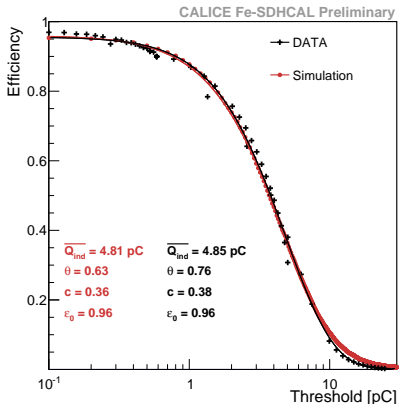
- Poly parameters extracted from threshold scan
- Charge spread function :

$$f_n(x, y) = \sum_{i=0}^n \alpha_i e^{-\frac{(x_0-x)^2 + (y_0-y)^2}{\sigma_i^2}} \quad (2)$$

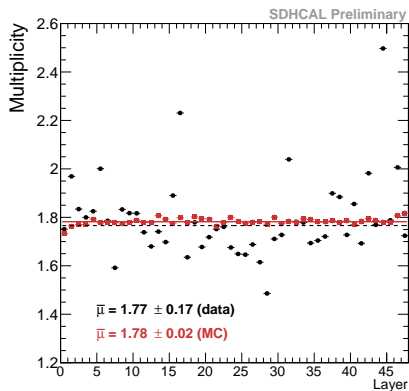
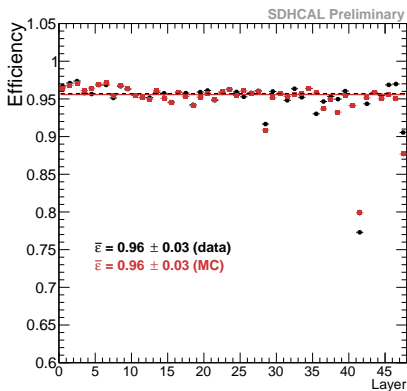
- Charge spread parameters : (tuned with muons)

Parameter	Value
α_0	1
α_1	0.00072
σ_0	1 mm
σ_1	10 mm

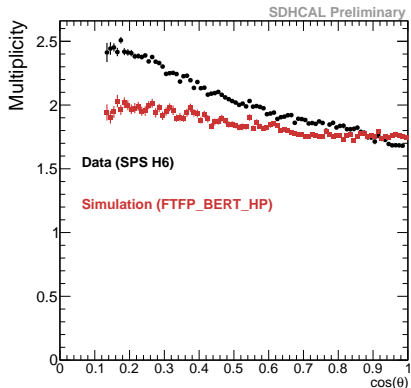
- $d_{cut} = 1mm$ (tuned with electrons)



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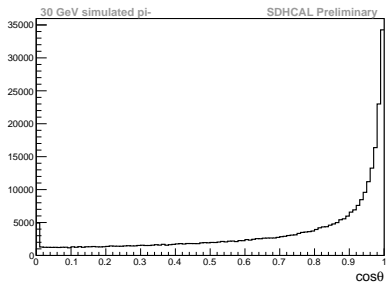


SDHCAL Digitizer



- θ = angle between reconstructed track and normal to RPCs
- need an angle correction to reproduce the multiplicity as function of $\cos\theta$:

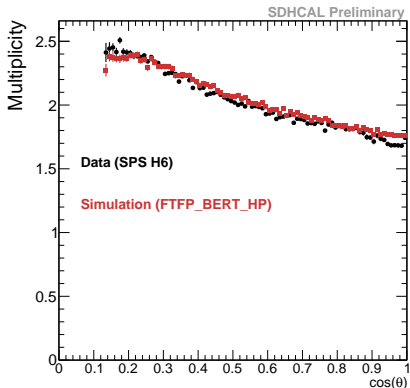
SDHCAL Digitizer



- θ = angle between reconstructed track and normal to RPCs
- need an angle correction to reproduce the multiplicity as function of $\cos\theta$:

$$Q_{Corrected} = \begin{cases} Q_{ind} \left(\frac{d_s}{d_{gap}} \right)^\kappa & \text{if } \frac{d_s}{d_{gap}} > 1 \\ Q_{ind} & \text{otherwise} \end{cases} \quad (3)$$

SDHCAL Digitizer



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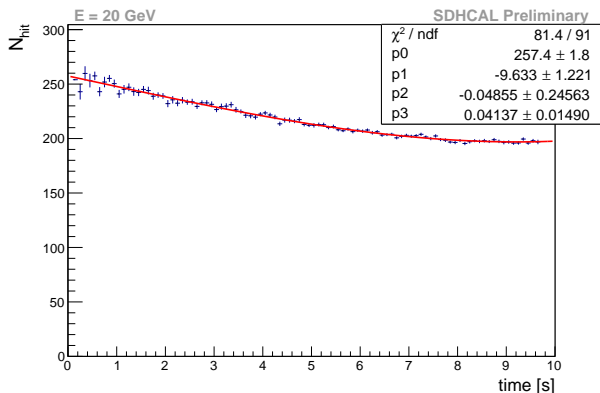
$$Q_{Corrected} = \begin{cases} Q_{ind} \left(\frac{d_s}{d_{gap}} \right)^\kappa & \text{if } \frac{d_s}{d_{gap}} > 1 \\ Q_{ind} & \text{otherwise} \end{cases} \quad (3)$$

- $\kappa = 0.45$ (tuned with cosmics)
- not yet available in MarlinReco

Data time calibration

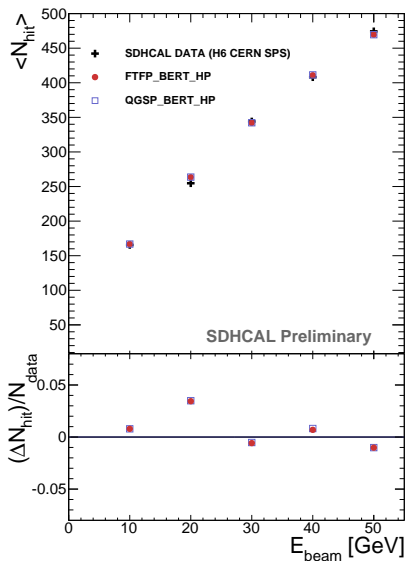
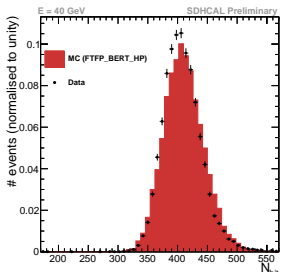
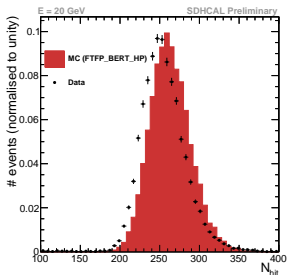
- Charge screening effect because of glass resistivity
- One calibration per run; per threshold

$$N_i^{corr} = N_i - \sum_{j=1}^d p_j t^j \quad (4)$$

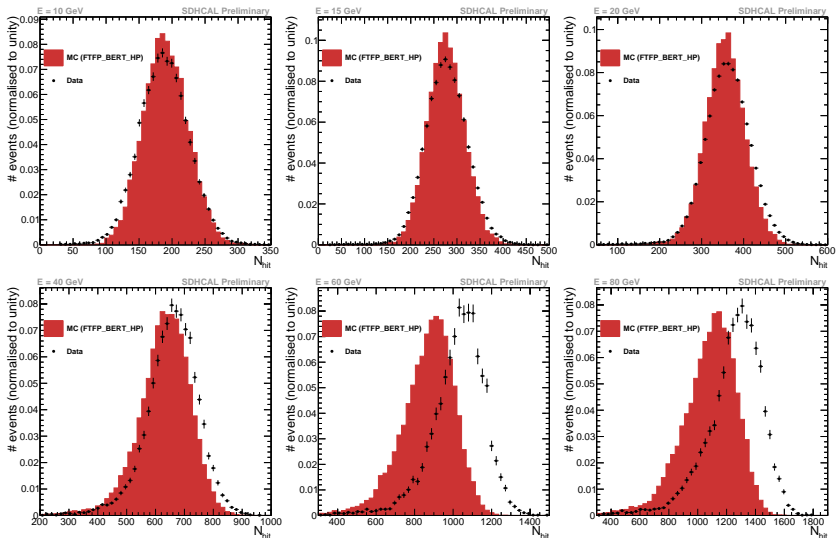


Electromagnetic shower number of hits

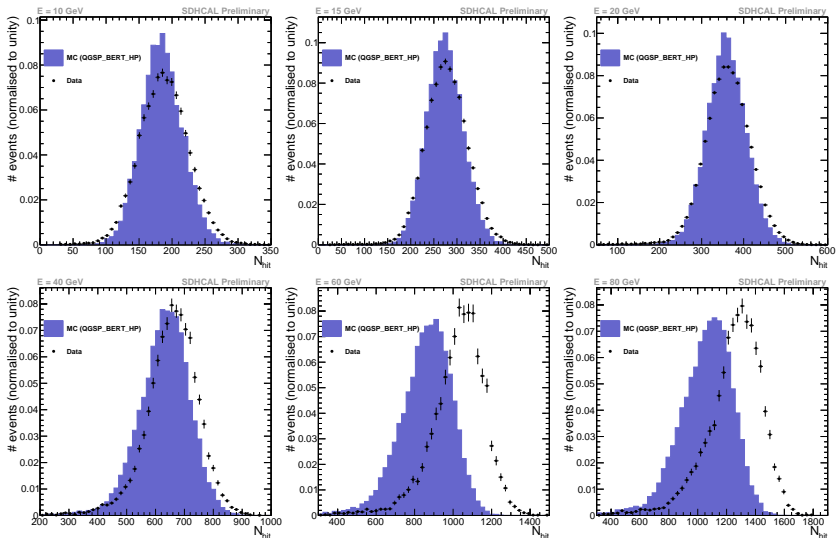
Electromagnetic shower data used for parameter optimisation.



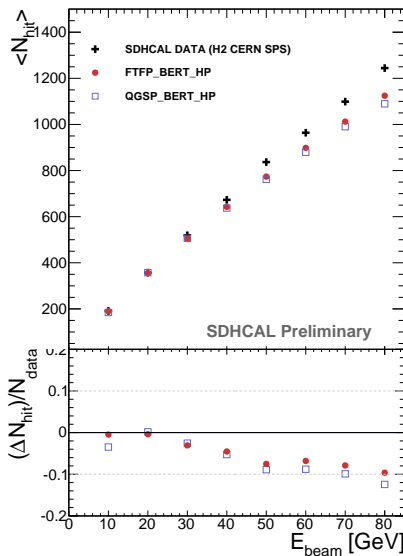
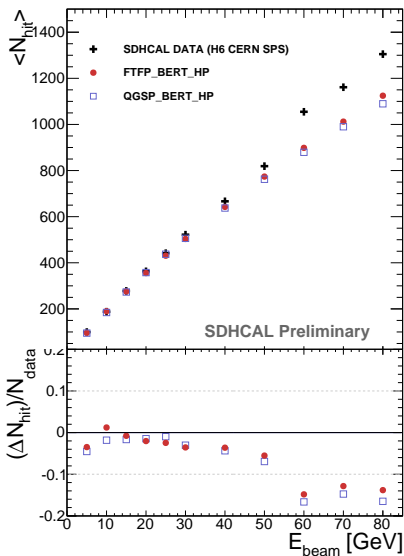
Hadronic shower number of hits



Hadronic shower number of hits

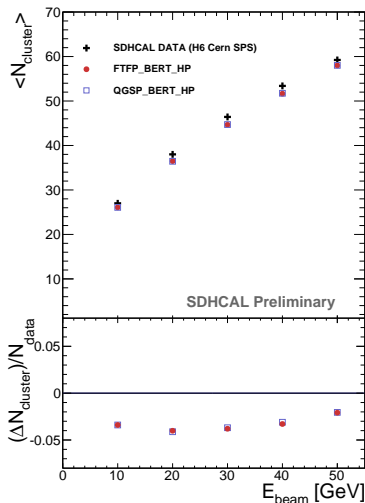


Hadronic shower number of hits

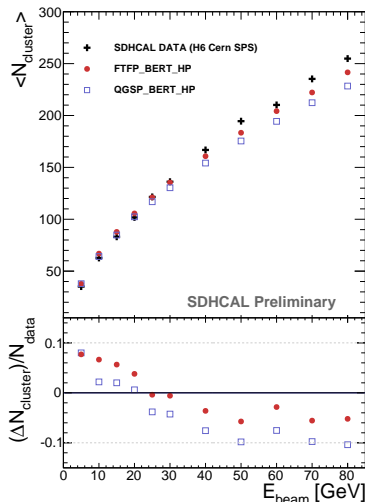


Shower number of clusters

• Electromagnetic showers

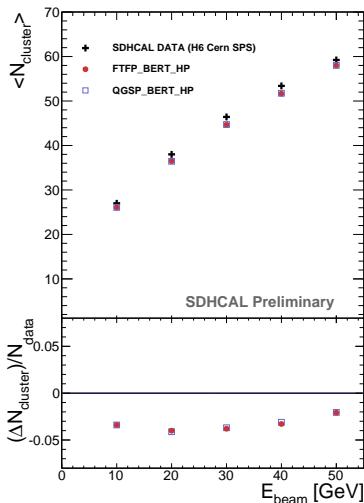


• Hadronic showers

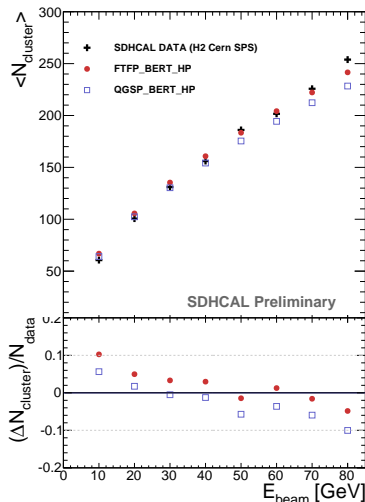


Shower number of clusters

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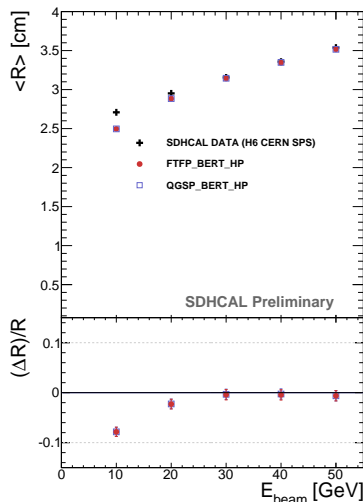
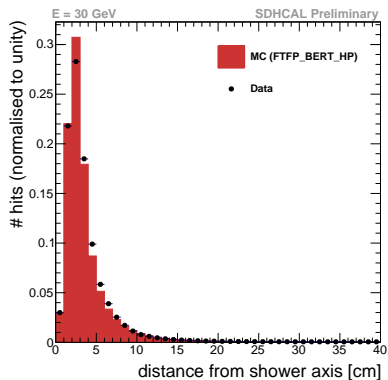


• Hadronic showers

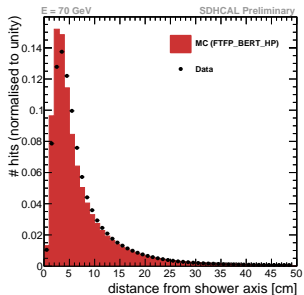
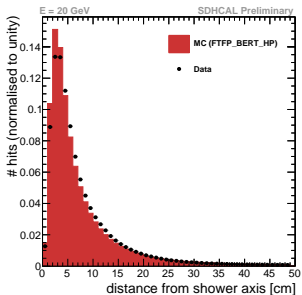
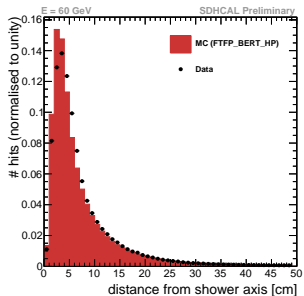
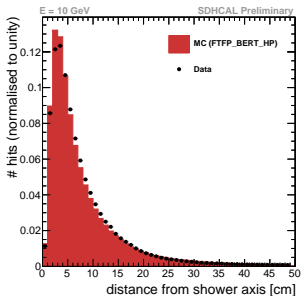


Electromagnetic shower radial profile

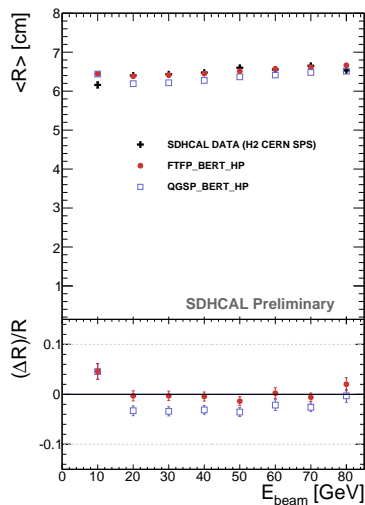
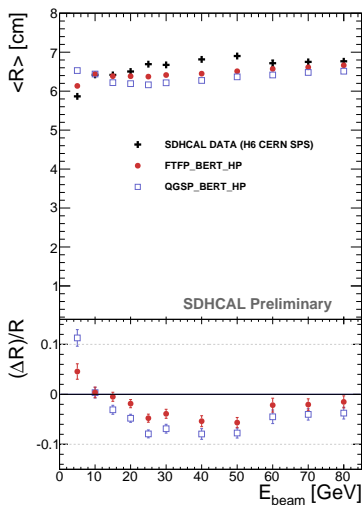
- Shower axis determined by a linear fit of the shower
- Measurement of number of hits inside 1 cm width rings around the axis
- Data time calibration for each ring



Hadronic shower radial profile



Hadronic shower radial profile



Conclusion

- Digitizer parameters tuned with muon and electron data.
- Muon and electromagnetic shower simulation are in good agreement with data.
- Significant disagreement between data and simulation above 50 GeV on total number of hits for hadronic showers. Investigation on shower topology is ongoing.
- CALICE note on the digitizer is in preparation.