SDHCAL digitisation

Calice Collaboration Meeting - Argonne

Arnaud Steen

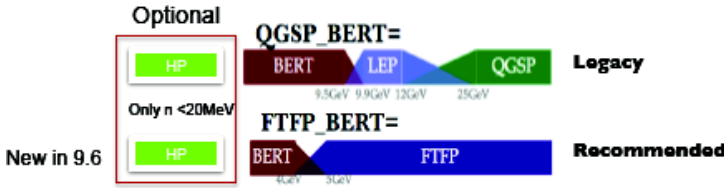
IPNL

19-21 March 2014

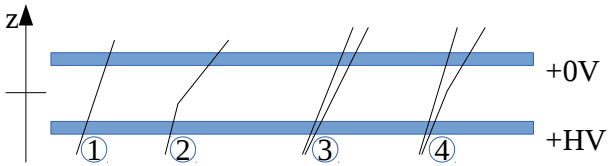
Outline

Simulation/Digitizer method

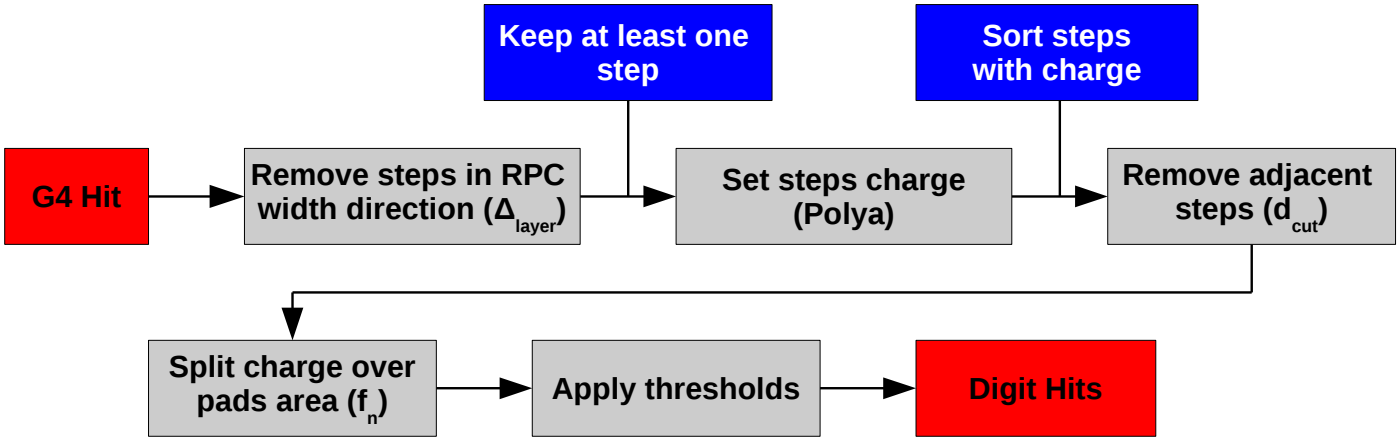
Simulation :



- Geant4 version 9.6.p01 is used
- FTFP_BERT_HP is used

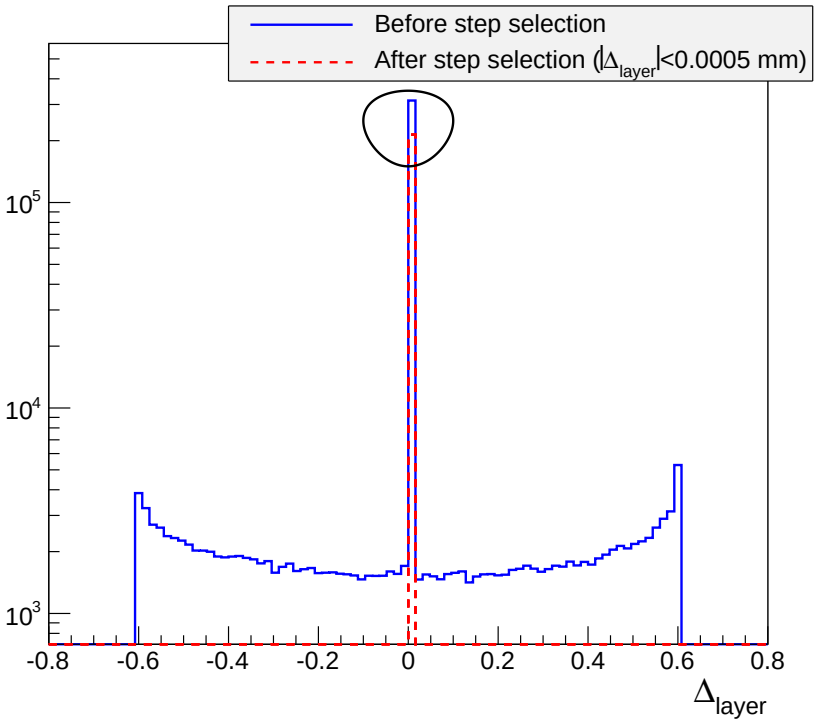


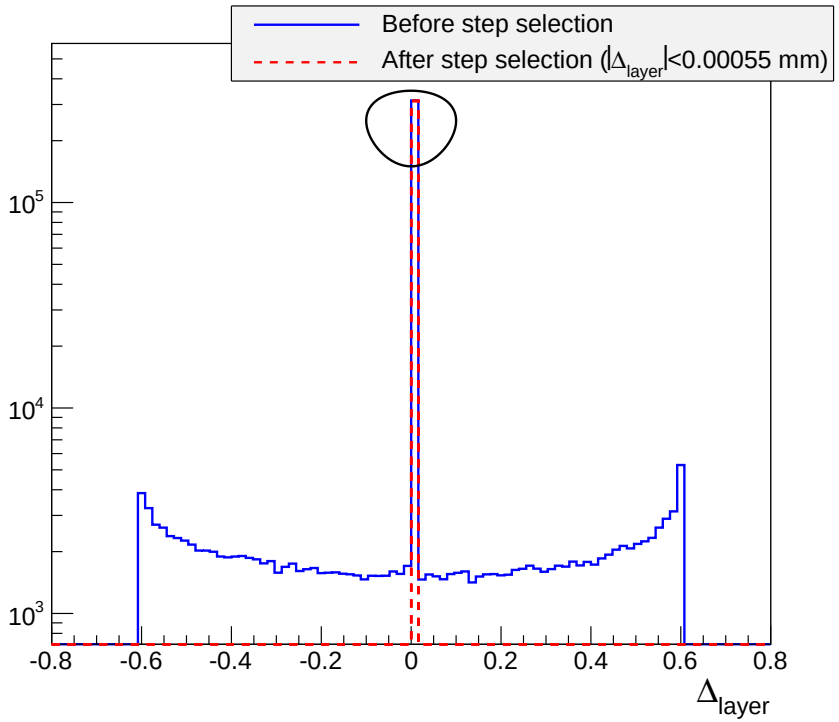
Digitizer :



Bug correction

- $\Delta_{layer} = stepMidPosition - rpcMidPosition$
- Difference between simulation program parameters and gear file used for digitization induces a shift for Δ_{layer}

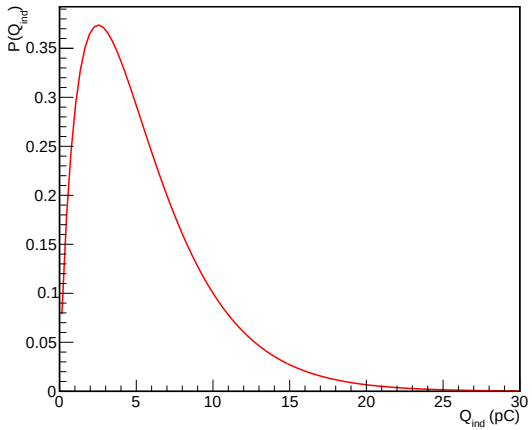




Digitizer functions

- Polya function to simulate induced charge from charged particles :

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



- Charge splitting function :

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

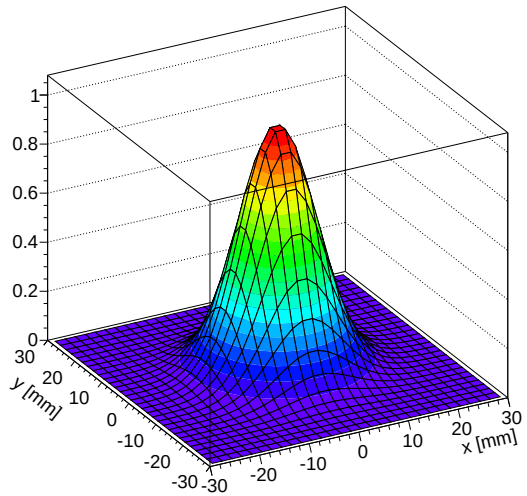
with $\alpha_0 > \alpha_1 > ... > \alpha_n$ and $\sigma_0 < \sigma_1 < ... < \sigma_n$

- Speed up integration over pads area using the error function $Erf(x)$, tabulated in C++ libraries (factor >10) :

$$\int_a^b e^{\frac{x^2}{\sigma^2}} dx = \frac{\sqrt{\pi}\sigma}{2}(Erf(\frac{b}{\sigma}) - Erf(\frac{a}{\sigma})) \quad (3)$$

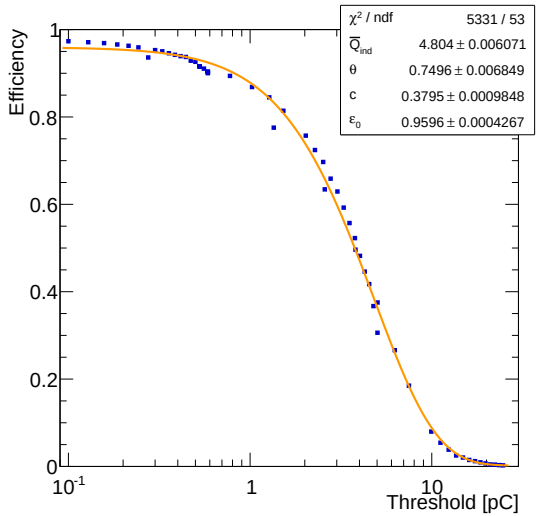
where

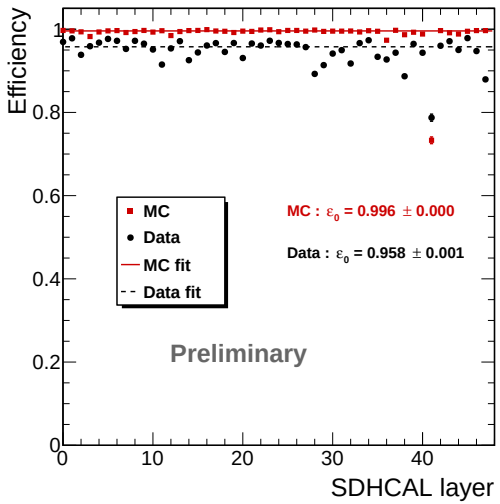
$$Erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{t^2} dt \quad (4)$$



Mips study

- Hits in prototype dead cells (<1%) removed in simulation before the analysis
- Polya parameters extracted from a threshold scan study
- First Threshold value : 0.114 pC
- Mips selection :
  - $\frac{N_{hit}}{N_{layer}} < 3$
  - $N_{layer} > 30$
  - $\frac{\sqrt{\lambda_1^2+\lambda_2^2}}{\lambda_3} < 0.02$; with $\lambda_{1,2,3}$ three eigen values of a PCA ($\lambda_1 < \lambda_2 < \lambda_3$)





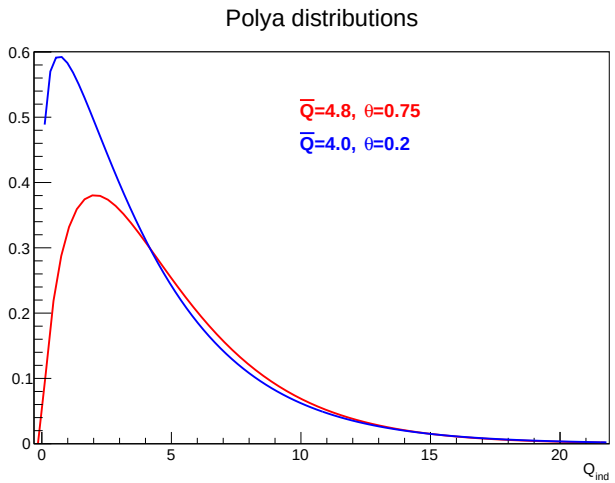
Mips study

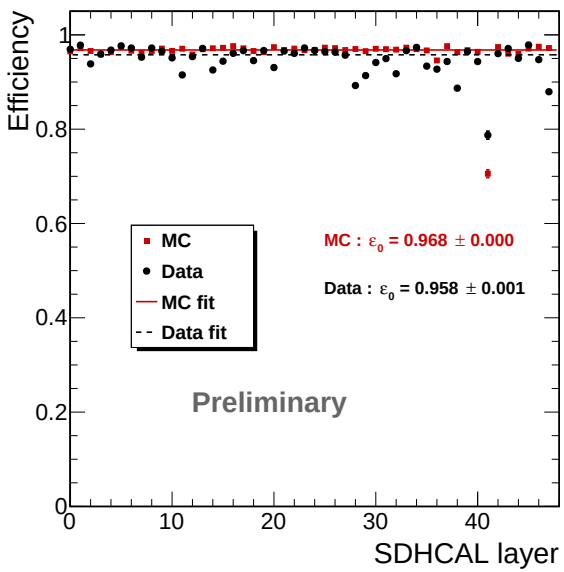
Need to introduce inefficiency in simulation :

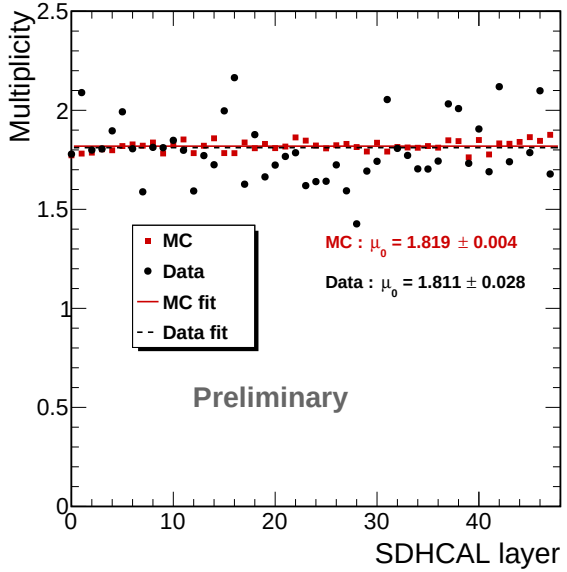
- Change Polya parameters : $\bar{Q} = 4.0pC$; $\theta = 0.2$
- Threshold 1 : 0.160 pC

Charge splitting function parameters (f_2):

Parameter	Value
α_0	1
σ_0	1 *mm*
α_1	0.0019
σ_1	9.2 *mm*



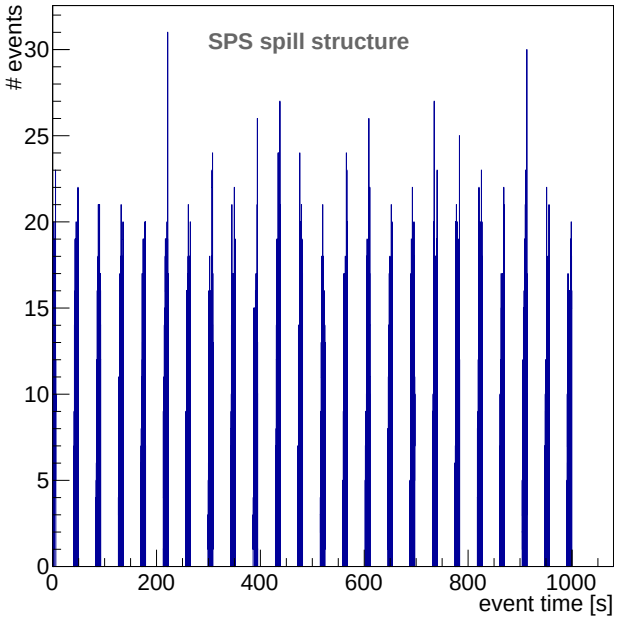


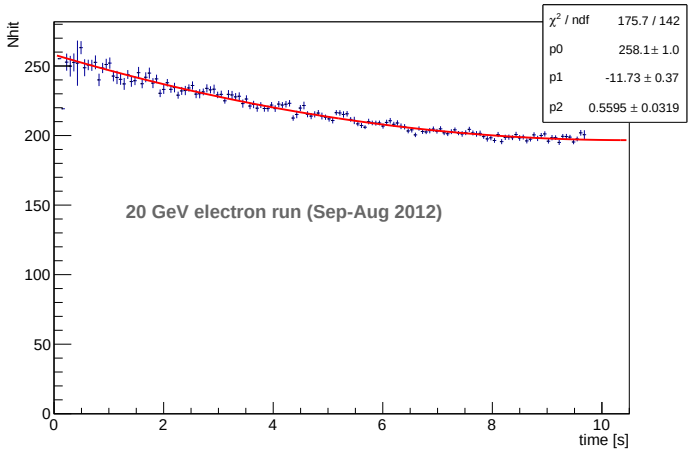


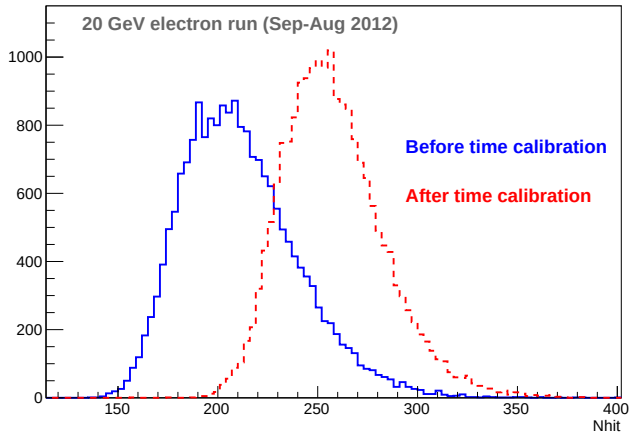
Data time Calibration

- Time to absorb the charge in the glass
- Event time in the spill ($\simeq$ 10 s at SPS) is reconstructed
- One calibration per run per threshold

$$N_{corrected} = N_{hit} - (p_2 SpillTime^2 + p_1 SpillTime) \quad (5)$$



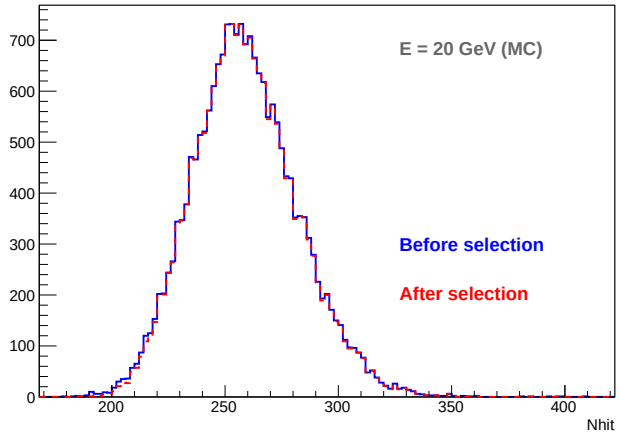


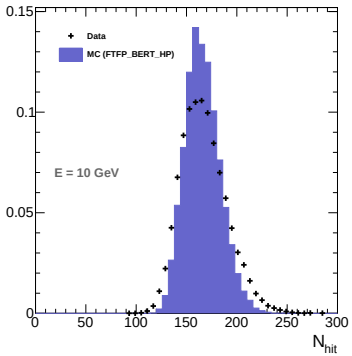


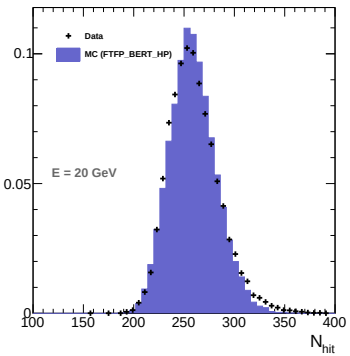
Electromagnetic shower

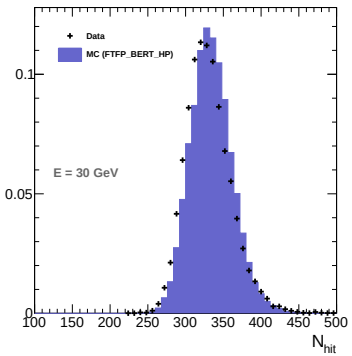
- $d_{cut} = 0.5\ mm$
- Electron selection :
  - $N_{hit}/N_{layer} > 3$
  - $\frac{N_{Int\ \ layer}}{N_{layer}} > 20\%$
  - $0 \leq Z_{begin} < 5$
  - $N_{layer} < 30$
  - $V_1 V_2 > cut(E_{beam})$ with $V_1 = \frac{N_{hit}^{25}}{N_{hit}}$ ans $V_2 = \frac{FD_{3D}}{ln N_{hit}}$

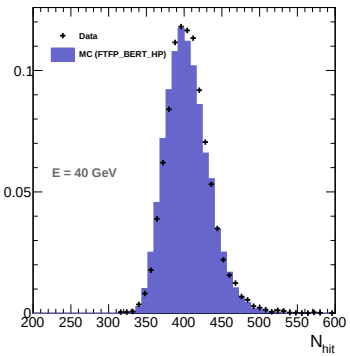
$E_{beam}[GeV]$	cut
10	0.18
20	0.17
30	0.16
40	0.15
50	0.13

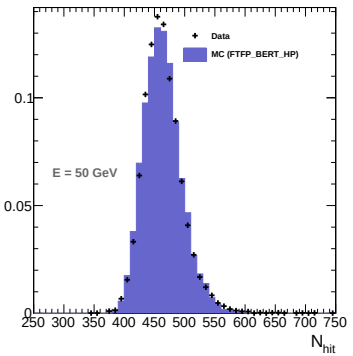








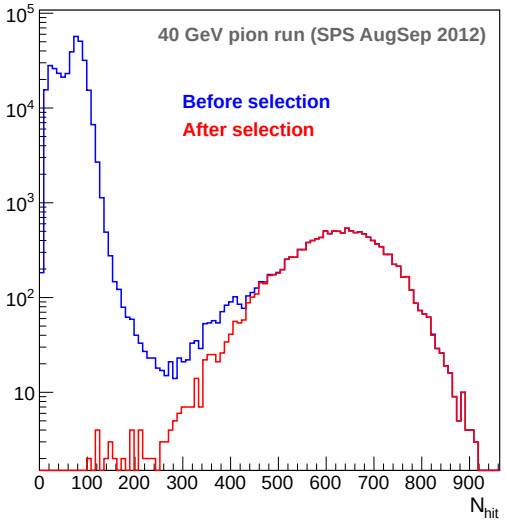


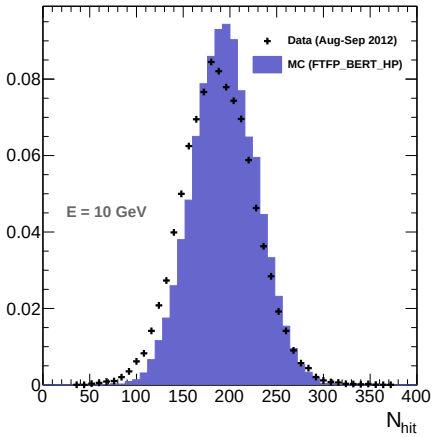


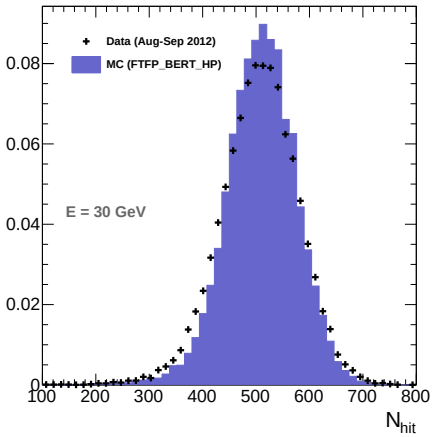
Hadronic shower

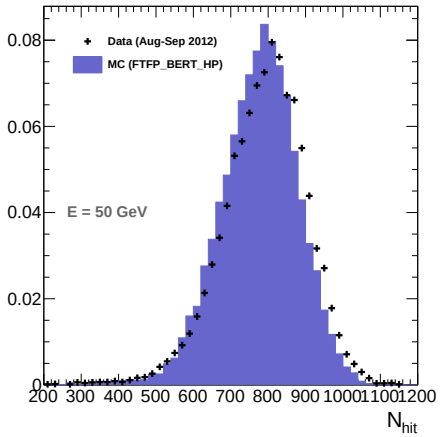
- Thresholds :
  $0.160,\ 3.9,\ 11.0\ pC$
- Pion selection :
  - $\frac{N_{hit}}{N_{layer}} > 3$
  - $SSL >= 0$
  - $\frac{N_{Int\ \ layer}}{N_{layer}} > 20\%$
  - $V_1.V_2 < cut(E_{beam})$

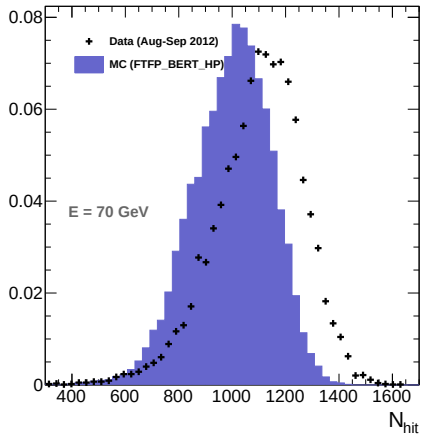
$E_{beam}[GeV]$	cut
5	0.20
$10-15$	0.18
$20-25$	0.17
30	0.16
40	0.15
$50-70$	0.13
80	0.12









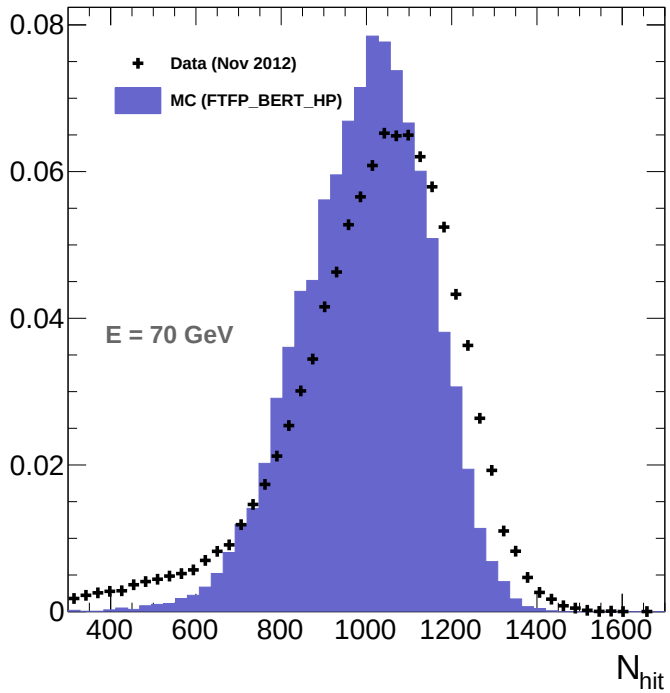


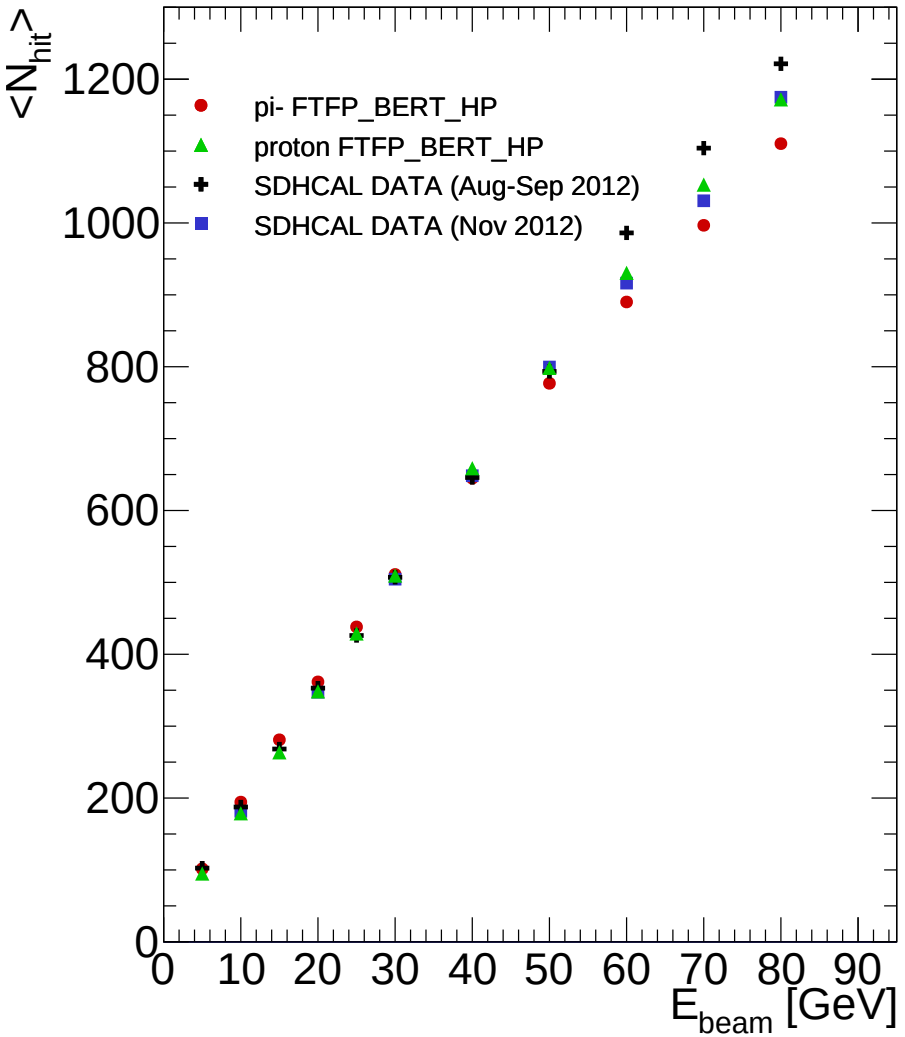
Hadronic shower

- Proton contamination in H6 beam line above 20 GeV *[NIM A 621 (2010) 134-150]* .

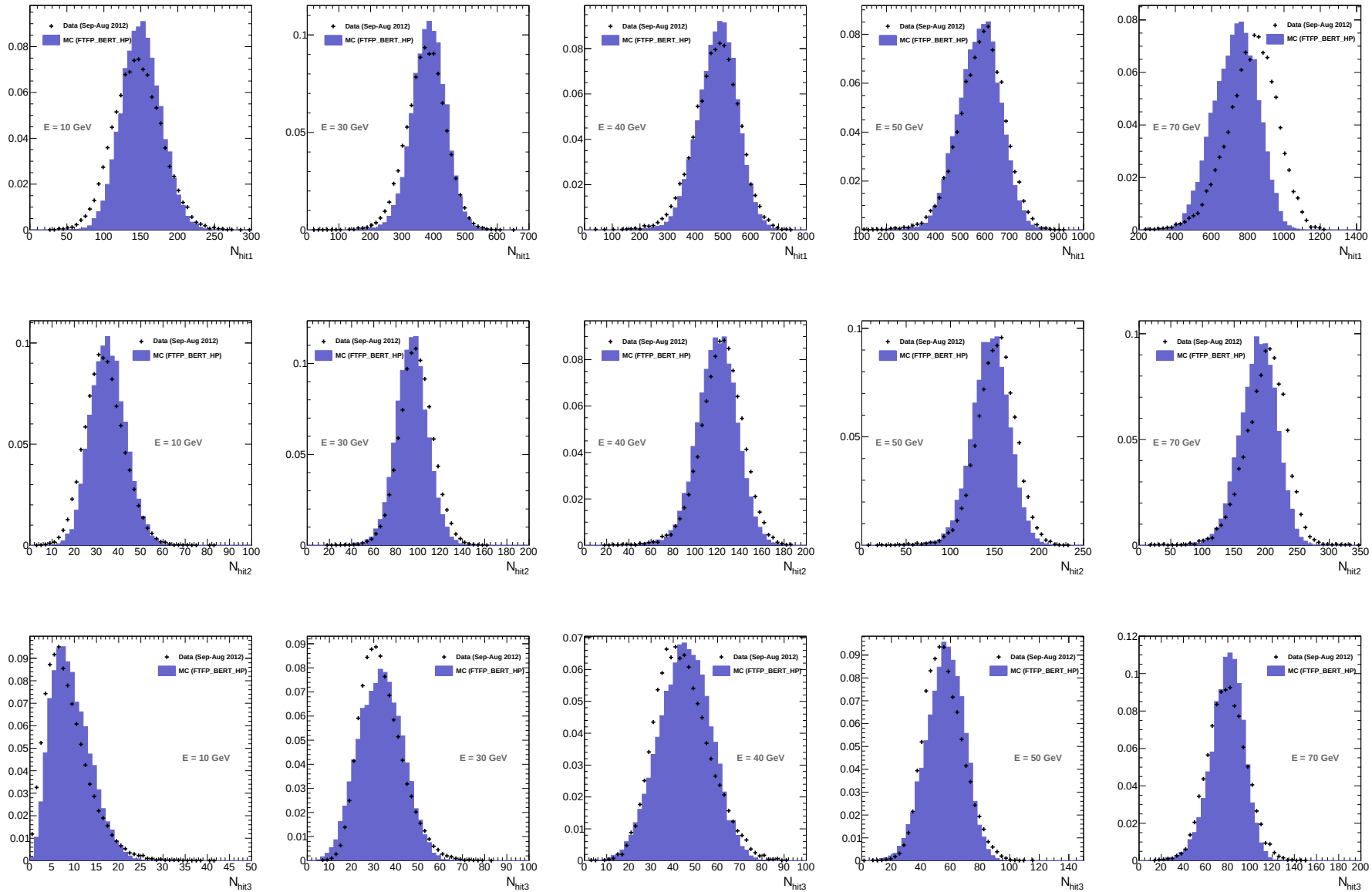
Energy [*GeV*]	Fraction of protons
50	0.45 ± 0.12
100	0.61 ± 0.06

- November 2012 data in H2 beam line

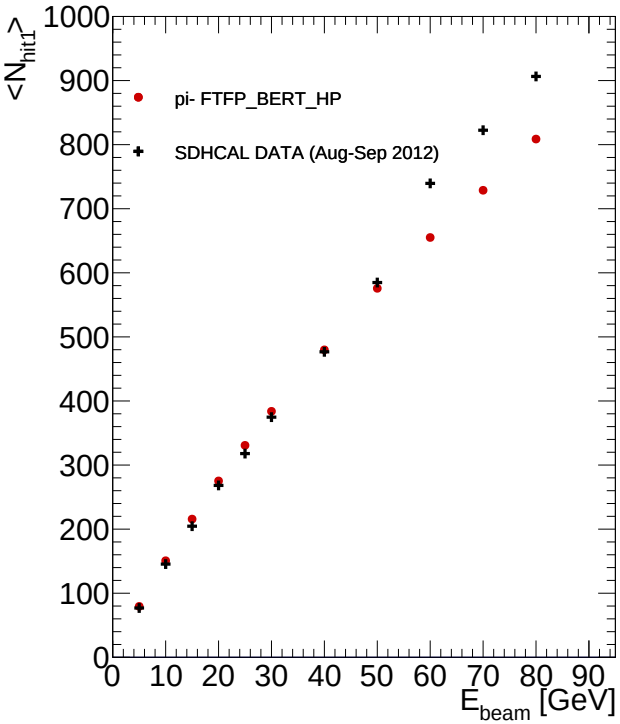


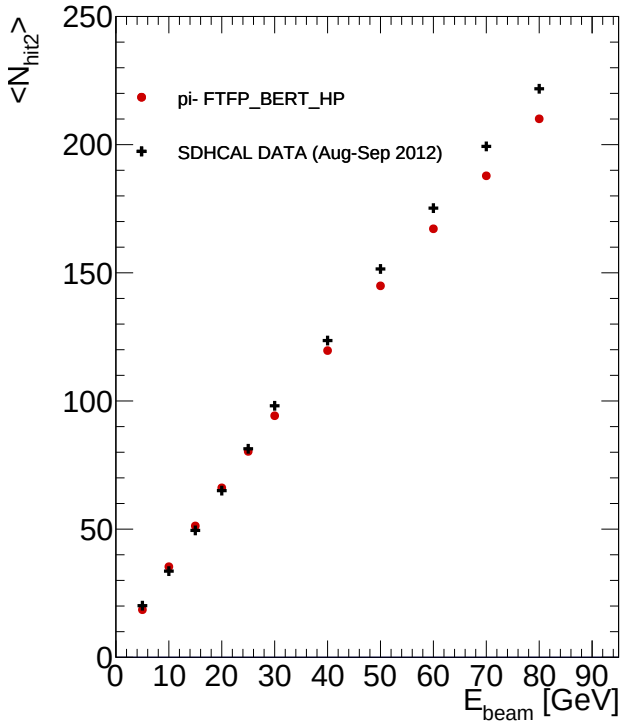


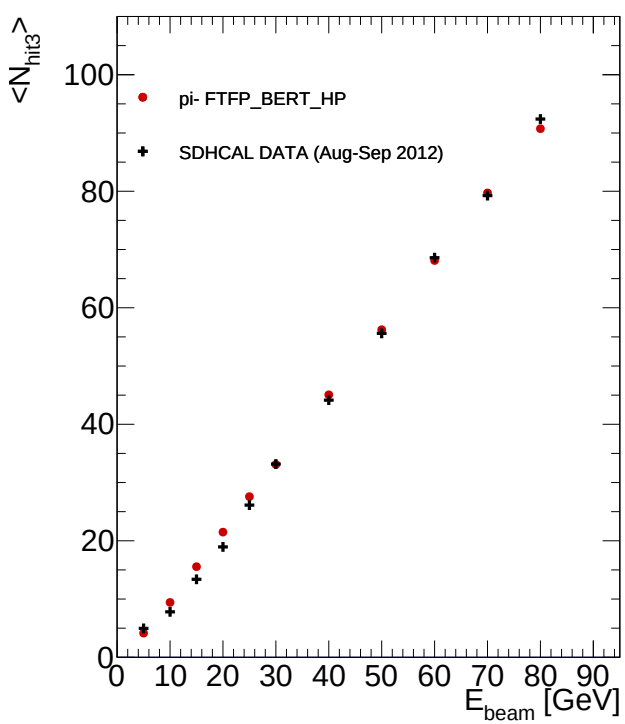
Hadronic shower



Hadronic shower







Conclusion :

- Bug corrections have been done
- Erf option is available in ILC Soft version v01-17-05 (MarlinReco v01-08-01)
- Digitizer parameters tuned with electrons and with muons :
  - Polya and charge splitting functions tuned with muons.
  - d_{cut} tuned with electrons.
  - Only thresholds 2 and 3 tuned with pions.
- Good agreement between data and simulation found for muons and electrons (total number of hits).
- Good agreement between data and simulation found for pions until 50 GeV.

Plans :

- Study hadronic shower models.
  - Energy resolution
  - Shower topology : profile, density, track segments
- Full ILD simulation study :
  - ILD optimization : HCAL radius, cell size