SDHCAL simulation status

ILD Optimisation meeting

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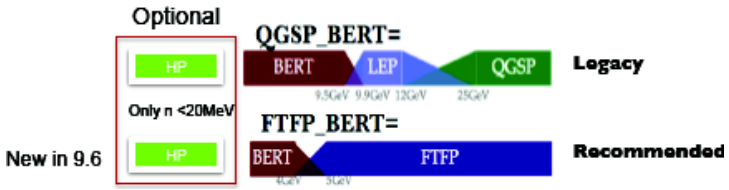
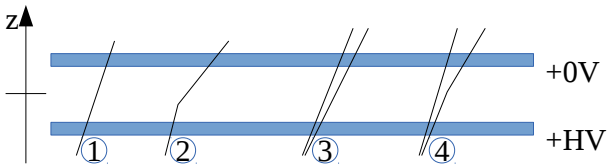
Outline

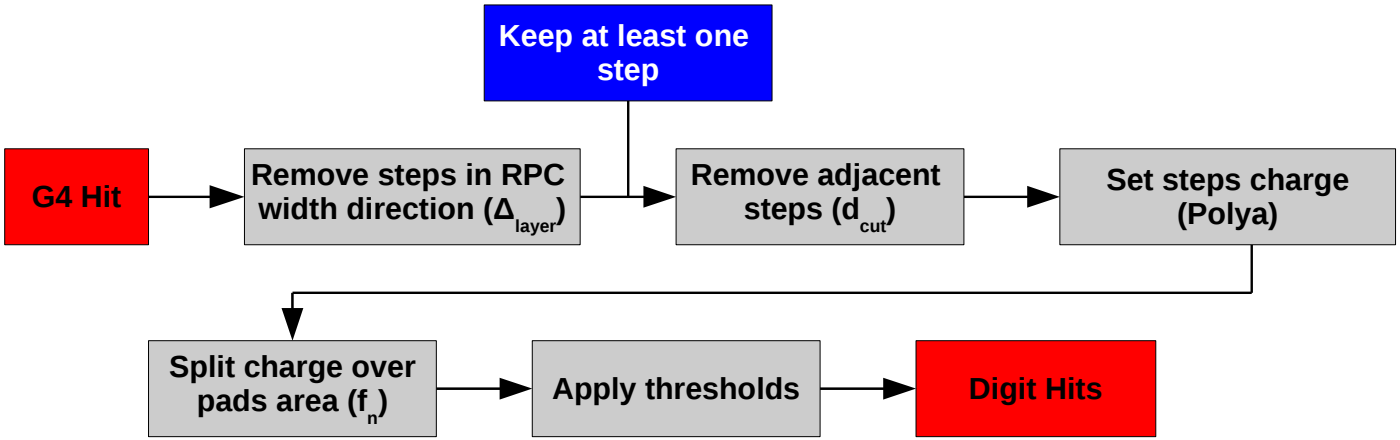
1. SDHCAL simulation and digitization
2. Digitizer on Mips
3. Test on uds Jets
4. Conclusion and plans

SDHCAL Simulation/Digitizer method

- Simulation :
  - Geant4 version 9.6.p01 is used
  - FTFP_BERT_HP and QGSP_BERT_HP are used
  - pi-, mu-, e- and proton simulated samples
- Digitizer : simulate the GRPC response to charged particles
  - MarlinReco v01-09 in ilcsoft v01-17-05 is used







Digitizer update since DBD version

Update of MarlinReco v01-09 since v01-05 for the SDHCAL part :

- Modification of the Polya function to simulate induced charge from charged particles :

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

- Bug fixed in charge splitting procedure ("ChargeSplitterOption" = Function) :

" [ERROR "MySimDigital"] BUG in charge splitter, got a non positive charge : -3.232989 "

- Addition of the "Erf" option to speed up the charge splitting procedure:
  - For each step $\int_{pad\ area} f_n(x,y)dxdy$ for the 25 pads around the step position was performed with $f_n(x,y) = \sum_{i=0}^{n} \alpha_i e^{\frac{(x_0-x)^2+(y_0-y)^2}{\sigma_i^2}}$ $\Rightarrow$ high CPU consumption
  - Integrals are replaced by relation using the error function tabulated in C++ libraries :

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

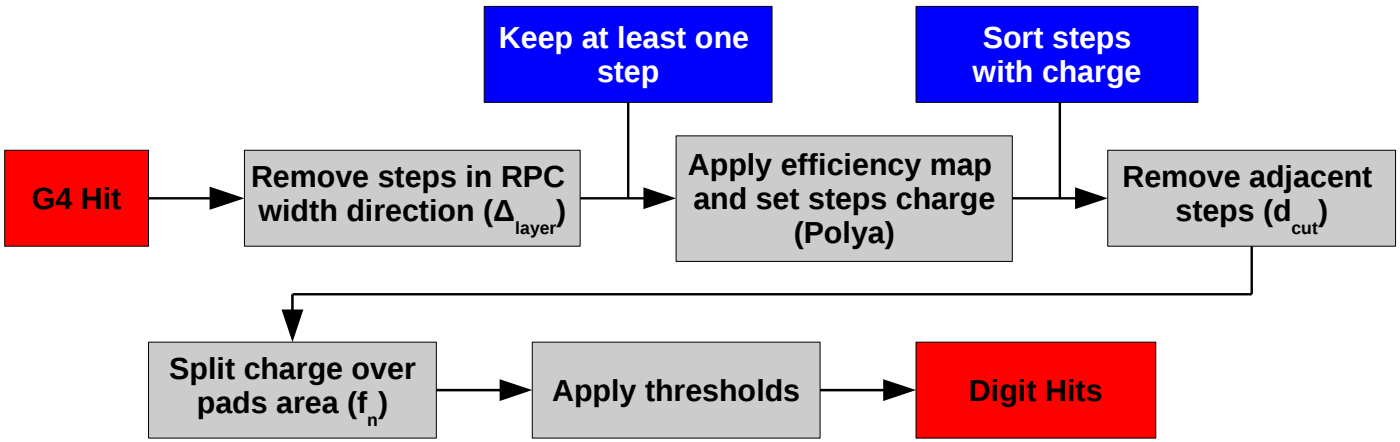
where

$$Erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{t^2} dt \quad (3)$$

Digitizer update since v01-09

Not yet available in ilcsoft :

- Treatement of the screening effect : before applying the cut to remove adjacent steps, the steps are sorted using the charge
- SDHCAL ASIC efficiency map included (only for prototype simulation)



Digitizer parameters

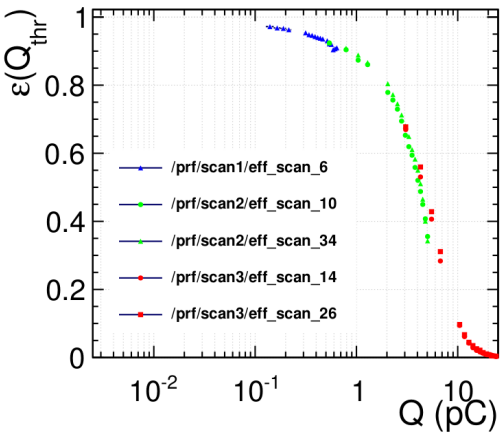
- Polya parameters extracted from threshold scan :
  - Change the threshold value (for few chambers) :

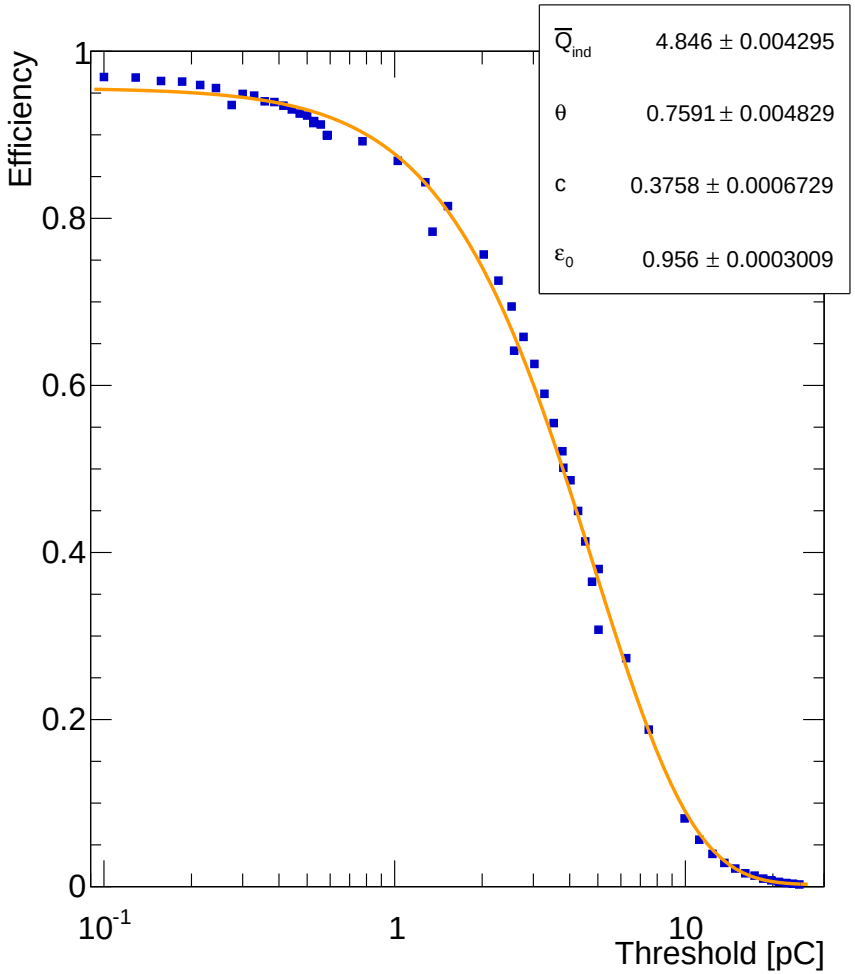
Threshold	Chamber no
1	6, 18, 30
2	10, 22, 34
3	14, 26, 38

  - Estimate the efficiency in those chambers
  - Fit the efficiency with

$$\epsilon(q) = \epsilon_0 - c \int_0^q P(q)dq \qquad (4)$$

ϵ_0 : detector efficiency if $threshold = 0pC$





Digitizer parameters

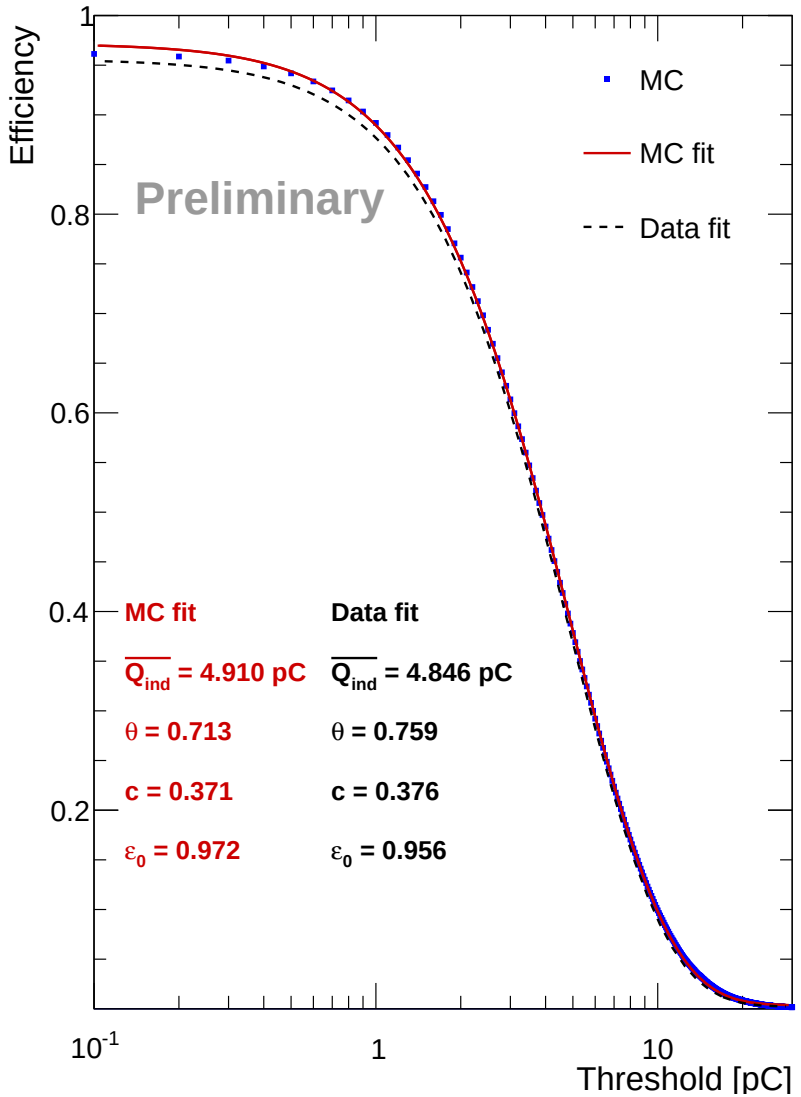
- Polya parameters :

Parameter	Value
$\bar{Q}$	5.5 pC
θ	1.05

- Charge spreading function parameters :

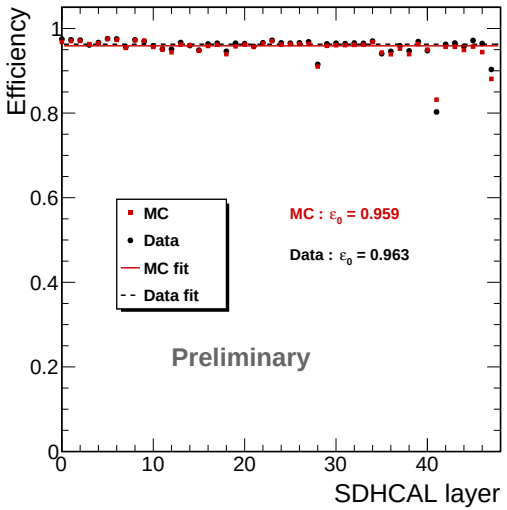
Parameter	Value
α_0	1.0
α_1	0.0007
σ_0	1.0 mm
σ_1	10.6 mm

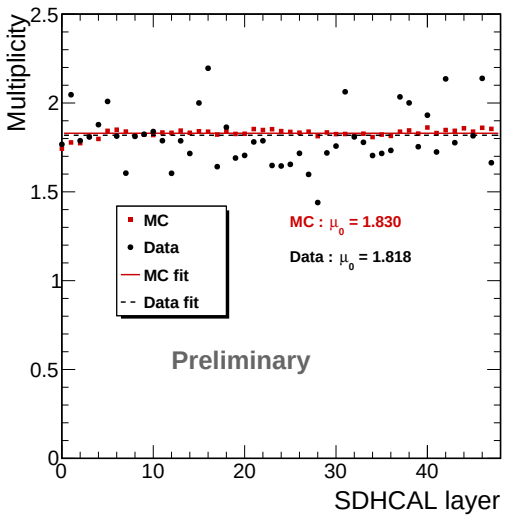
- $d_{cut} = 1.5mm$



Mips study

- Threshold values : 0.114,5.0,15.0 pC
- Track reconstruction :
  - Hits are gathered into clusters if they share an edge
  - Perform principal component analysis. Track kept if $\frac{\sqrt{\lambda_1^2+\lambda_2^2}}{\lambda_3} < 0.02$; with $\lambda_{1,2,3}$ three eigen values of the PCA ($\lambda_1 < \lambda_2 < \lambda_3$)
- Additional selection :
  - $\frac{N_{hit}}{N_{layer}} < 3$
  - $N_{layer} > 30$
- Efficiency and multiplicity per layer estimated using tracks reconstructed with the other layers :
  - Efficiency = presence of at least one cluster within 2.5 cm radius arround the expected track impact
  - Multiplicity = number of hits in the cluster if any





Test on uds Jets

- ilcsoft v01-17-05 for the reconstruction
- New digitizer parameters
- Energy reconstruction in Pandora :

$$E_{reco} = \alpha N_1 + \beta N_2 + \gamma N_3 \quad (5)$$

with N_i : number of hits per threshold

Parameter	Value
α	0.032 *GeV*
β	0.14 *GeV*
γ	0.26 *GeV*

- Tests on standard uds MC : 91, 200, 360 and 500 GeV have been performed but optimization of energy parameters is still ongoing
- New steering file will be officialy available soon

Preliminary results

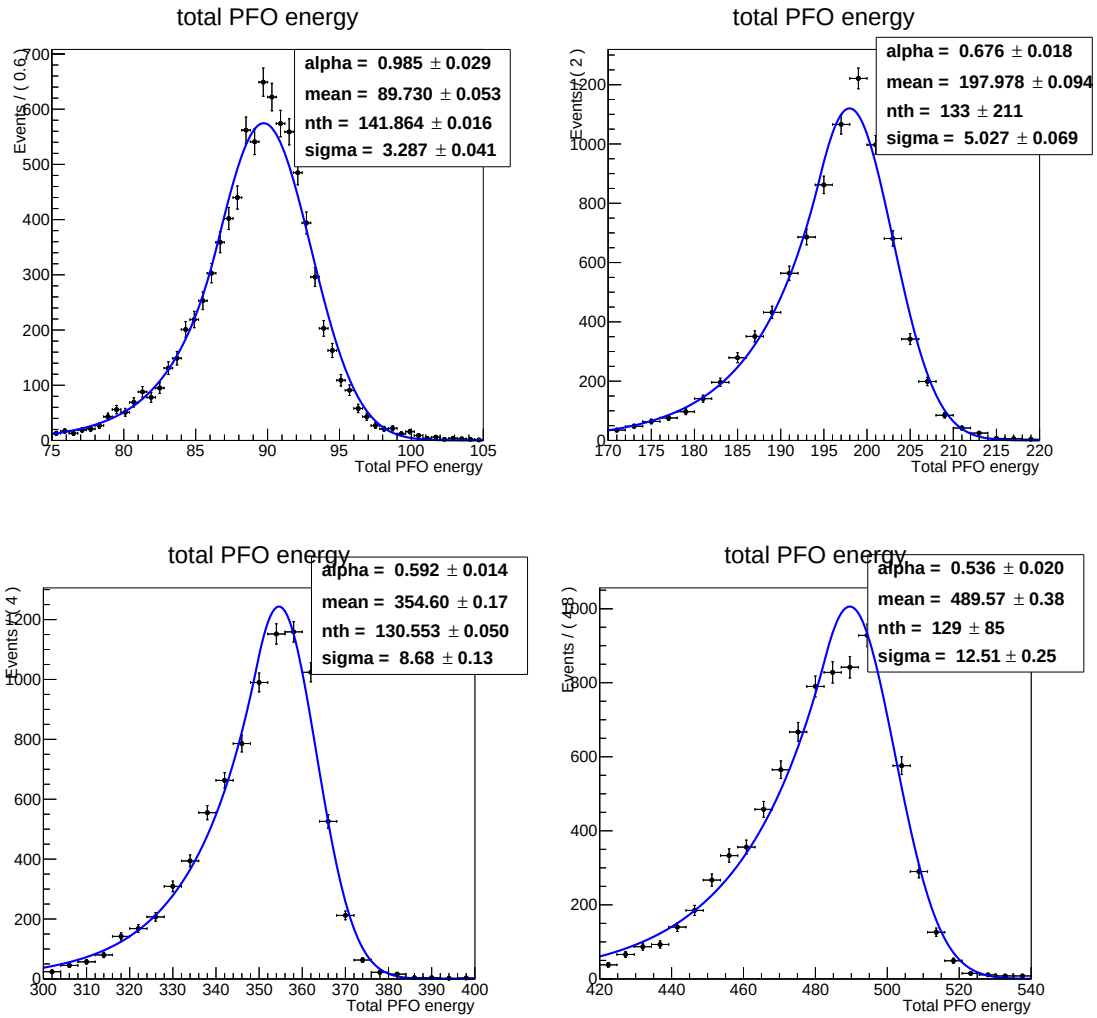
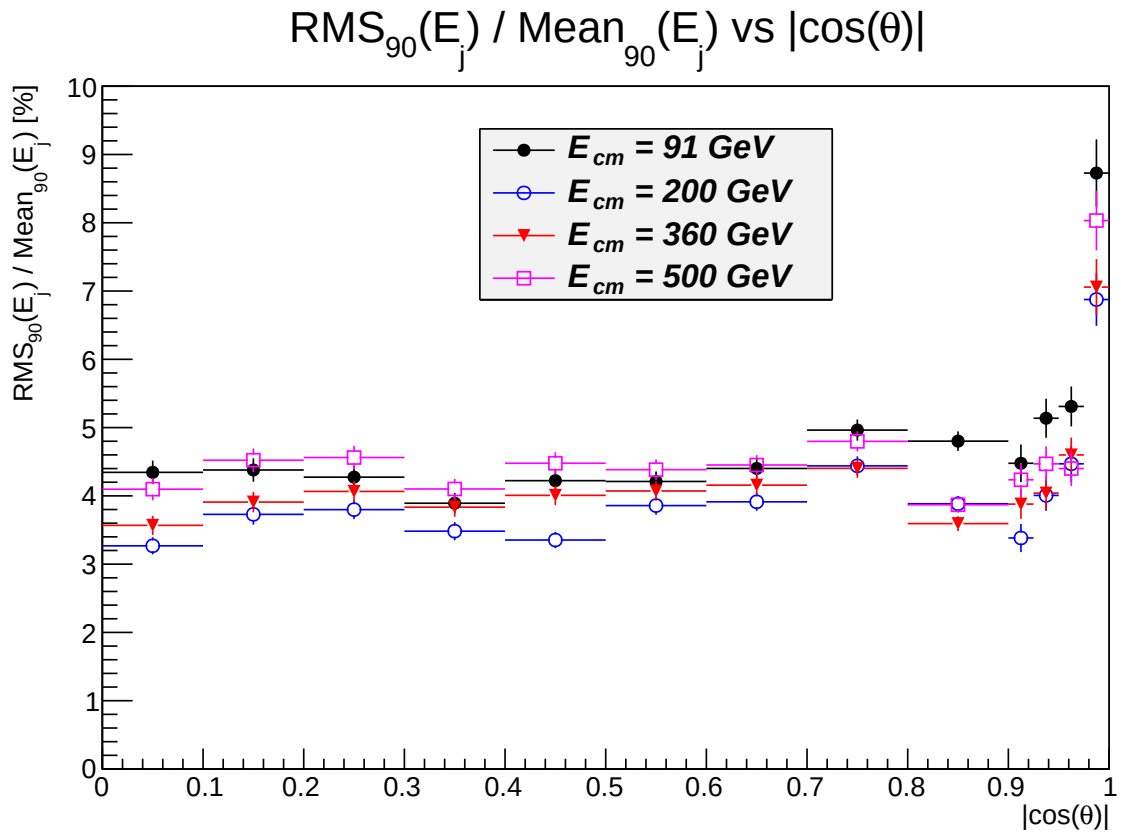


Figure: Energy reconstruction for 91 GeV (top left), 200 GeV (top right), 360 GeV (bottom left), 500 GeV (bottom right).

Preliminary results

Energy, GeV	RMS	RMS90	MEAN90	σ_{CBfit}	E_{recCB}	σ_{Ej}/Ej
91	4.3	2.5	89.6	3.3	89.7	4.6%
200	8.2	5.5	196.7	5.0	198	3.9%
360	15.9	10.3	351.6	8.7	354.6	4.1%
500	25.2	15.6	484.1	12.5	489.6	4.6%



Conclusion :

- SDHCAL digitizer improvement (available since ilcsoft v01-17-05) :
  - Improvement of the speed for the charge splitting procedure
  - One bug was fixed
  - New release is needed to include last updates
- Digitizer parameters extracted from data :
  - Threshold scan quite well reproduced
  - Good agreement between data and MC for the efficiency and the multiplicity
  - We found good agreement between data and simulation for EM and hadronic showers up 50 GeV
- Check of energy reconstruction on uds MC sample has been performed with new digitizer parameters :
  - Energy calibration parameters has to be optimised with new digitizer parameters
  - Standard SDHCAL energy reconstruction (using quadratic parametrisation) needs to be implemented in Pandora
- With the help of Mark Thomson and his team we intend to improve on the results with the ILD option 2
- Steering file for ILD option 2 will be updated soon