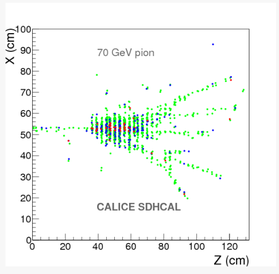
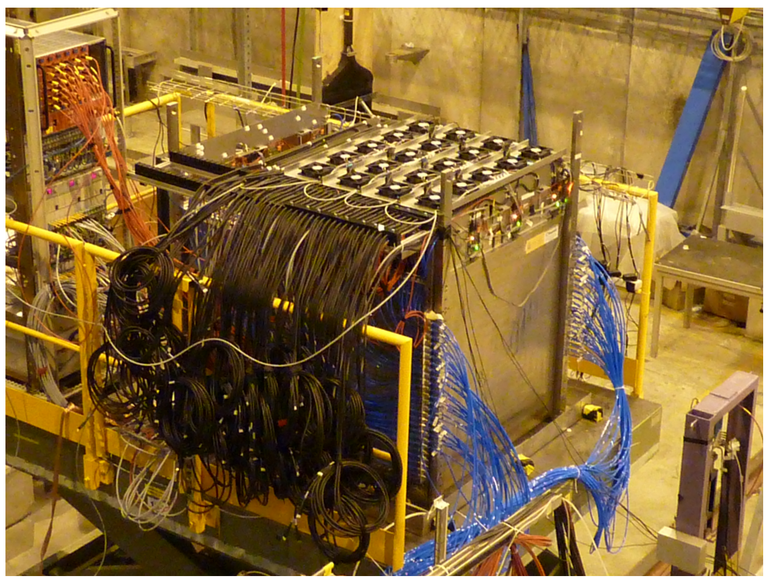


SDHCAL evolution: Time integration and algorithmic improvements for the APRIL Particle Flow

T. Pasquier, G. Grenier, I. Laktineh, B. Li, R. Ete

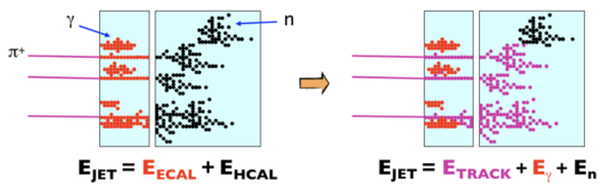
The SDHCAL prototype



- A high granularity sampling HCAL.
- 3 thresholds readout by 1 cm^2 copper pads.
- Technological prototype.
- Up to 50 slots to insert GRPC cassettes.

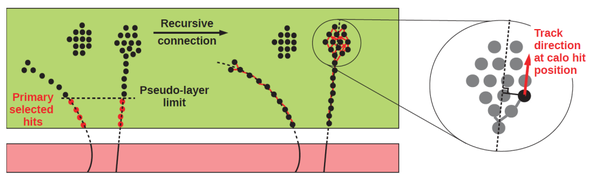
Particle Flow Algorithms

- Use optimal sub-detector for jet energy estimation :
  tracker ($\sim$ 60%), ECAL ($\sim$ 30%), HCAL ($\sim$ 10%)
- Separate energy depositions from close-by particles : **high granularity** is mandatory



The APRIL Particle Flow

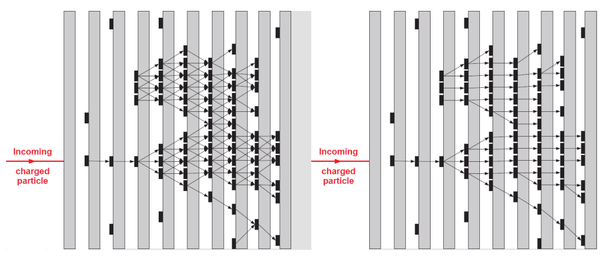
- Based on the Arbor concept and implemented in PandoraSDK
- Track driven clustering → Start the clustering process from hits located nearby the track extrapolation



- Reconstruct the showers as spatial trees
- Merge hits and clusters while $E_{track} > E_{cluster}$

Clustering process :

1. Connect all neighbouring hits (use mlpack NeighborSearch)
2. Clean connectors = keep max one backward connection per hit



Acknowledgements

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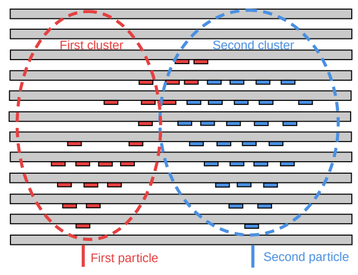
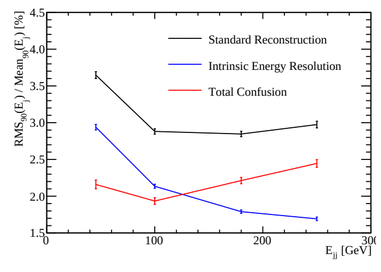
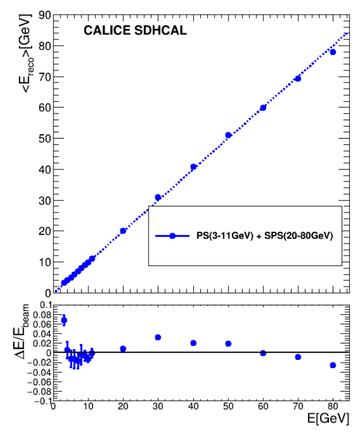
Confusion

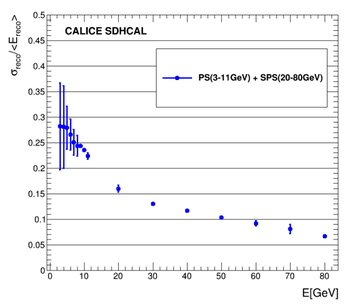




Wrong particle-hit association → confusion → dominant contribution to resolution at higher jet energy ($E \gtrsim 100$ GeV)

Energy reconstruction



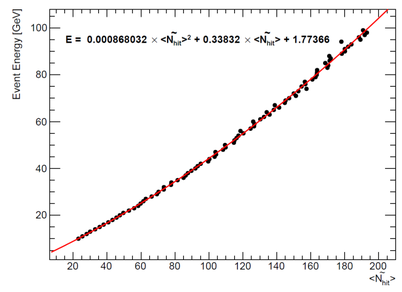


- $E_{reco} = \alpha N_1 + \beta N_2 + \gamma N_3$ where α, β, γ, are quadratic functions of $N_{tot} = N_1 + N_2 + N_3$
- N_i Number of hits with i the highest crossed threshold.

For non normal incidence (angle θ), scale N_i by geometrical factor $\cos(\theta)$.

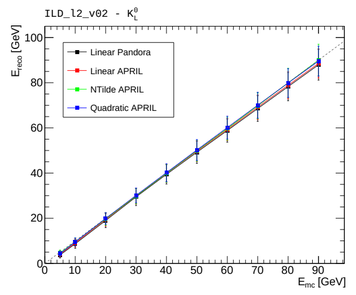
New reco method

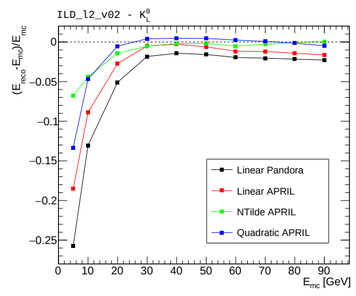
Exploring new reconstruction formulas
Look at correlations between N_1, N_2, N_3 to extract parameters

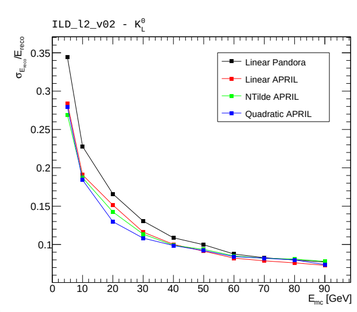


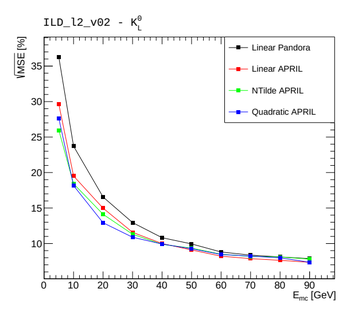
- $\widetilde{N}_{hit} = N_3 + \beta \times (\alpha \times N_1 + N_2)$
- E = quadratic function of $\widetilde{N}_{hit}$

Comparison between linear (α, β, γ constants, $\mathcal{O}(N_i)$), quadratic ($\mathcal{O}(N_i^3)$) and NTilde ($\widetilde{N}_{hit}, \mathcal{O}(N_i^2)$):

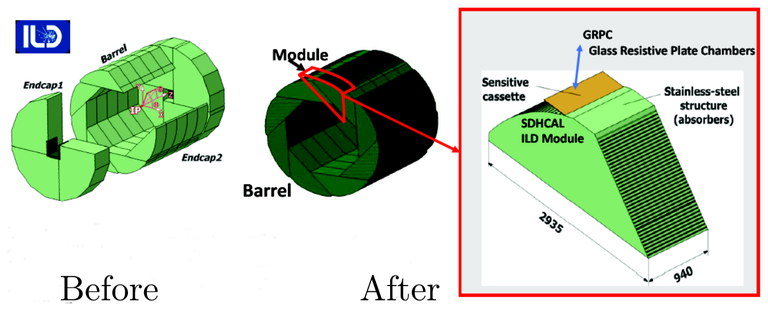




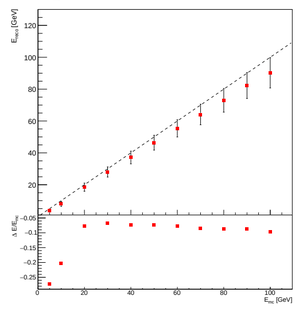




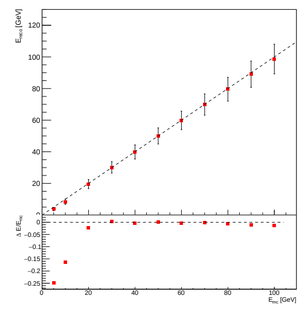
Angular corrections

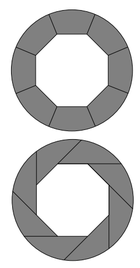


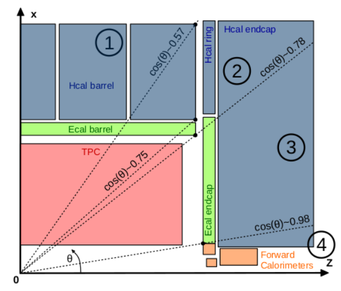
Before



After



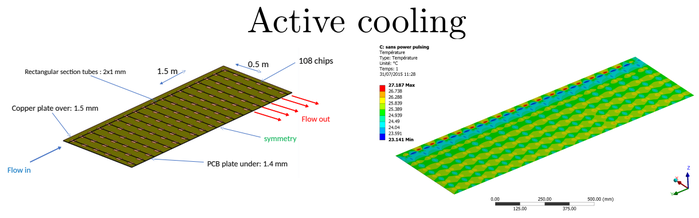




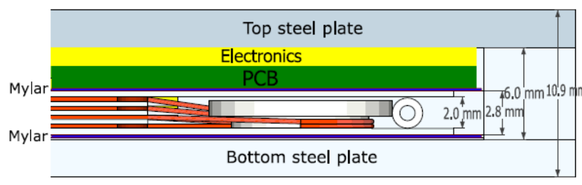
- Angular corrections (θ, ϕ) needed
- Both ILD geometry (Videau and Tesla) taken into consideration

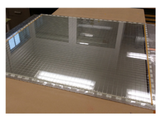
Towards FCC

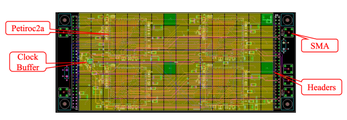
Active cooling



Higher rate : lower resistivity electrodes.
Multigap GRPC : higher rate, $\sim$ 100 ps timing.



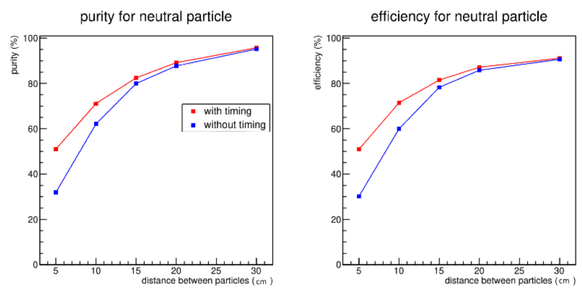




PETIROC ASIC :
32-channels, < 3 mW/ch,
high bandwidth preamp (GBWP > 10 GHz),
dual time and charge measurement (Q>50 fC)
jitter < 20 ps rms at Q > 0.3 pC.

PFA with timing

Switching to multi-gap GRPC ($\sim$ 100 ps resolution)
Separation between a 30 GeV charged hadron and a 10 GeV neutral hadron.



Applications :
Delete non-causal connectors between hits, tag late neutrons to treat them separately, identify the seeds of the showers and count them, hit ordering by time instead of radius...

Bibliography

References

[1] JINST **10** (2015) no.10, P10039
[2] JINST **11** (2016) no.04, P04001
[3] JINST **17** (2022) no.07, P07017
[4] JINST **15**, no.05, C05016 (2020)
[5] R. Ete, HAL-tel-01579761 (in French).