Analysis on CERN TB2022-06 Data

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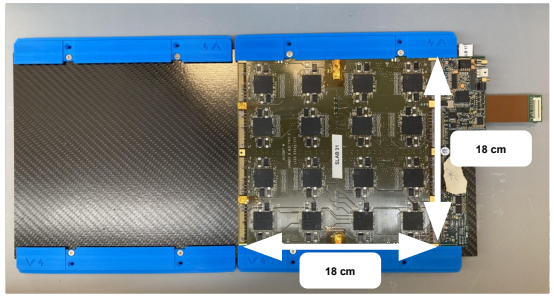
Affiliation:

In collaboration with:

- **SiW-ECAL**
  - Sensors
    - 15 layers
    - 16 chips
    - 64 channel
    - **15,360 cells**
  - Active : Silicon
    Absorb : Tungsten
- **CERN SPS Beam**
  - Energies
    - e : 10, 20, 40, 60, 80, 100, 150 GeV
    - μ : 50, 150 GeV
    - π : 10, 20, 70, 100, 150, 200 GeV



Datasets

Data Used

- Electron Data

Energy (GeV)	Run ID
10	90320
20	90378
40	90375
60	90372
80	90367
100	90365
150	90355

MC Used

- Simulation software provided by Fabricio [GitHub Link]
- Run Setting
  - Electron beam with same energy as Data
  - Single incoming electron per event
  - Same simulated detector setup as TB2022-06
- Not uploaded to eos or anything

Energy	NEvents	NHits	Hits/Event
10	4999	826,350	165.303
20	4999	1,355,706	271.195
40	4999	2,164,765	433.040
60	4999	2,814,062	562.925
80	4999	3,371,195	674.374
100	4999	3,867,467	773.648
150	4999	4,903,946	980.985

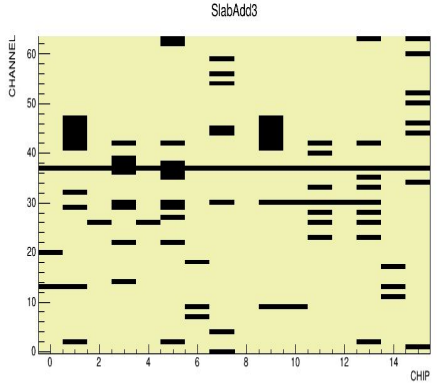
Simulation

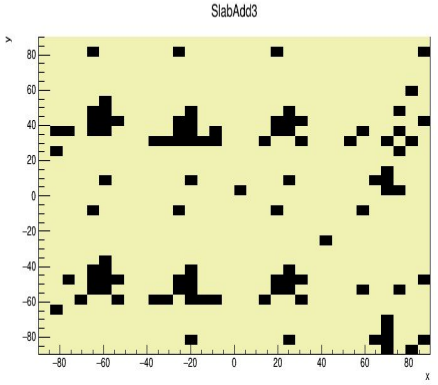
Energy	NEvents	NHits	Hits/Event
10	15120	1,813,628	119.949
20	81540	12,518,701	153.528
40	71698	16,537,826	230.660
60	47063	12,498,777	265.575
80	138585	56,395,730	406.940
100	38248	28,857,999	754.497
150	10750	10,132,062	942.517

Reconstruction

Masking Effect

- There are 15 x 16 x 64 = 15,360 cells in overall SiWECAL
- Some of which were required to be **masked** due to:
  - Electrical cross talk
  - Wafer delamination
  - Connector to the SL board
- Notably, cell 37 has consistently been masked in each chip, representing a recurring anomaly.
- The cumulative effect of such masked cells is substantial and should not be underestimated.
- For an extended period, simulations did not incorporate the consideration of this masking effect.





Procedure

Masking Simulation

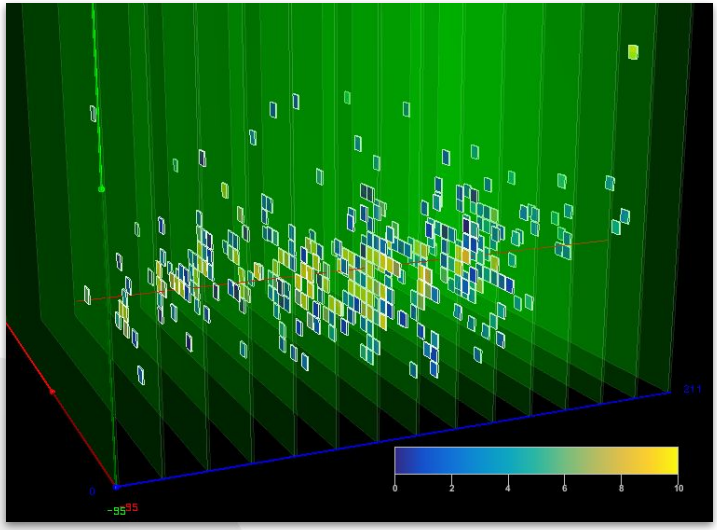
- Masking patch was introduced by Fabricio in SiWECAL-Sim
- Each hit registered in the simulation is associated with the masking information based off the Run_Settings files.
- One need to retrieve and match the masking pattern, same as the one in the reconstruction.

Beam Position

- It is worth highlighting that, generated beam position and size significantly affects the final energy and hit distributions.
- The input beam position and size for the generator will not necessarily be identical to the final beam spot shape. One needs to play around with parameters to get them right.

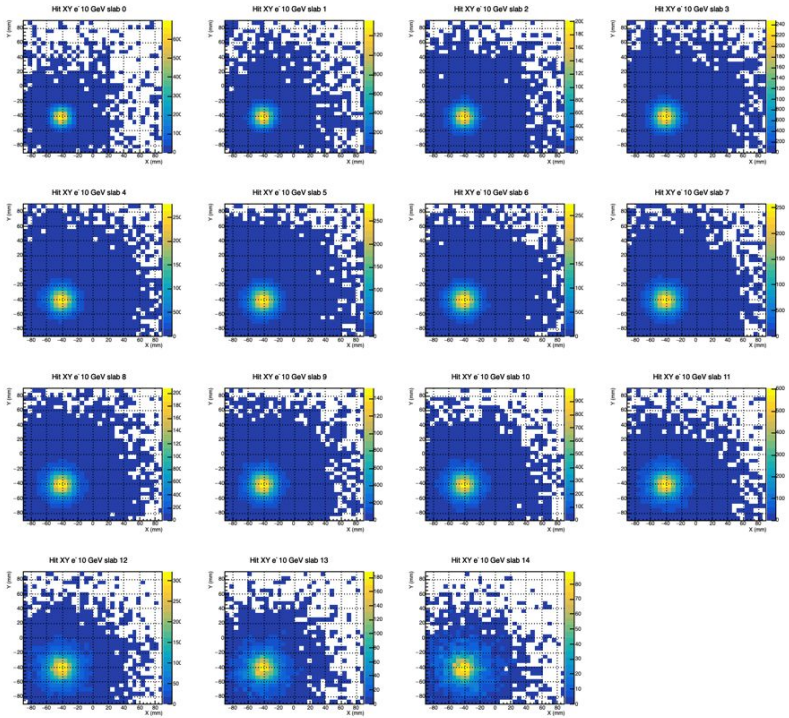
Selection

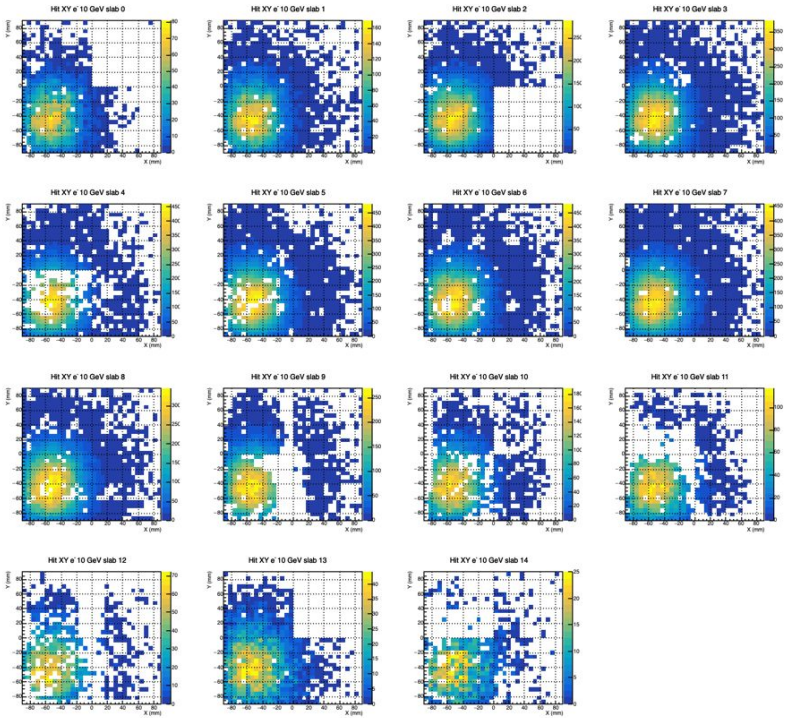
- More than 13 coincidences
- Hit Energy > 1
- Hit SCA < 2



Masking in Action

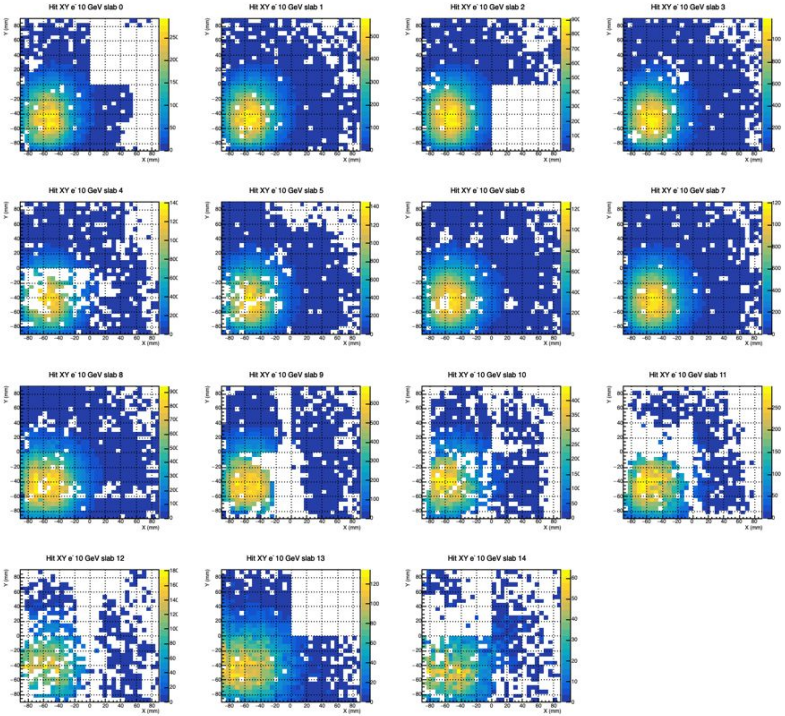
e- 10 GeV simulation



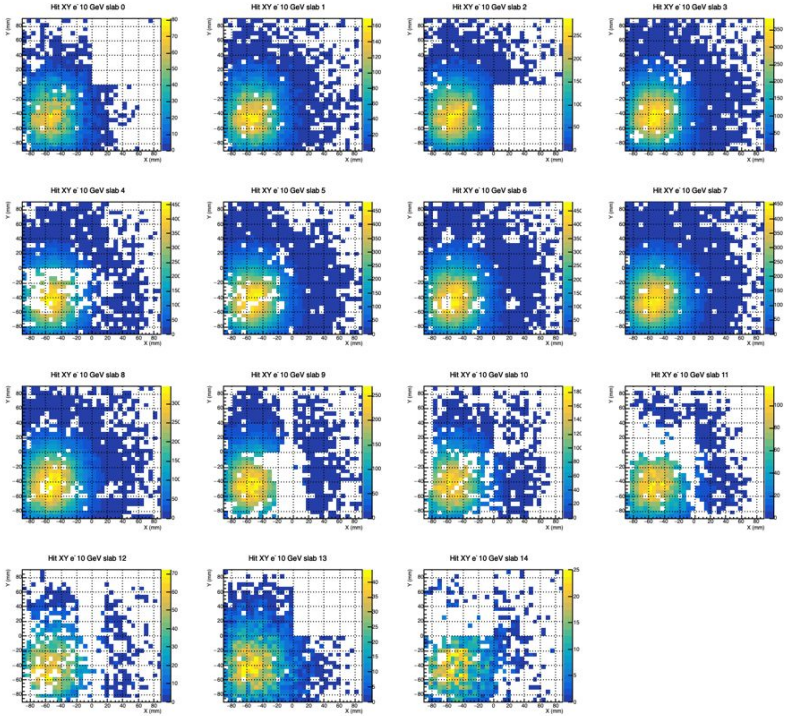


Masking in Action

e- 10 GeV reconstruction

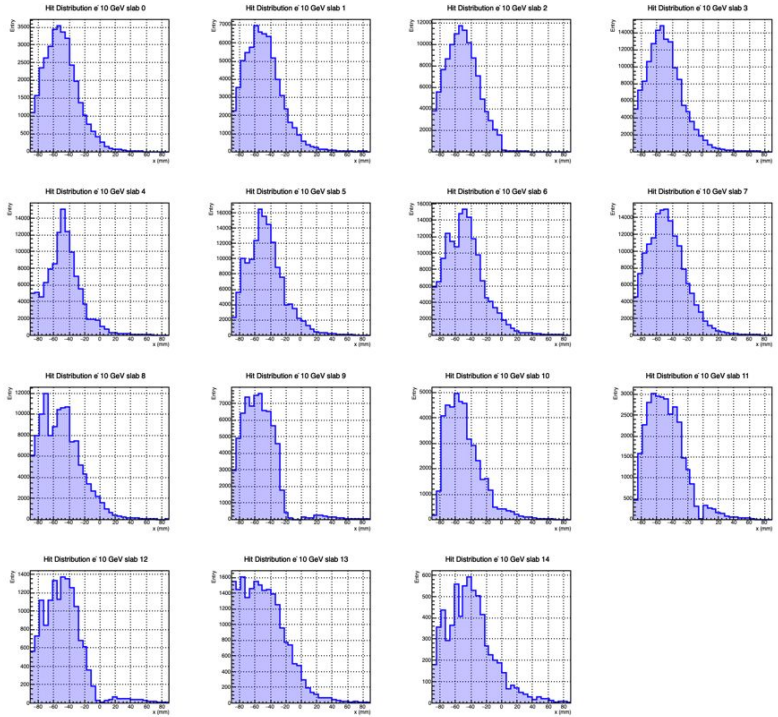


e- 10 GeV simulation

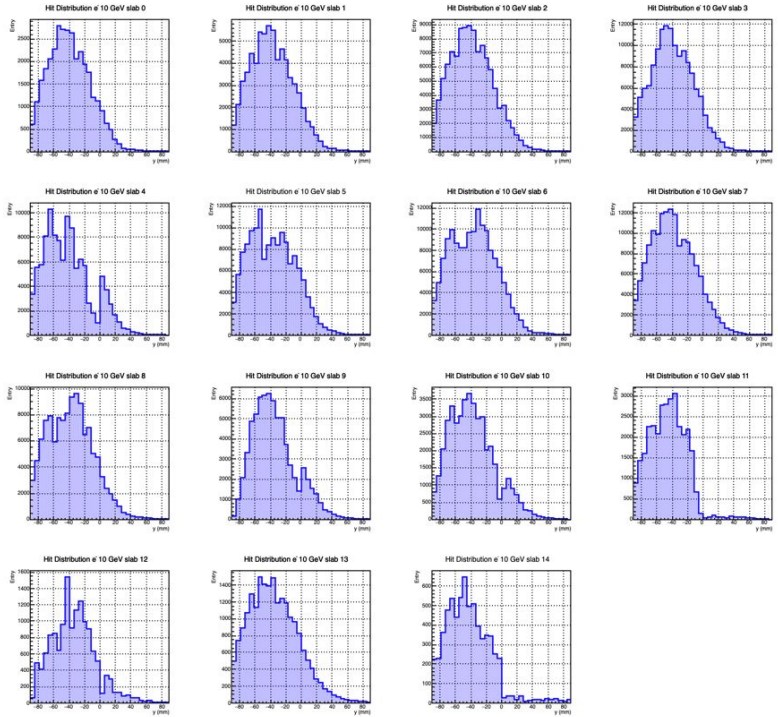


XY Hit Projections

e- 10 GeV Hit Map X Projection



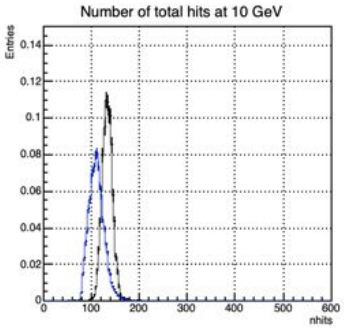
e- 10 GeV Hit Map Y Projection

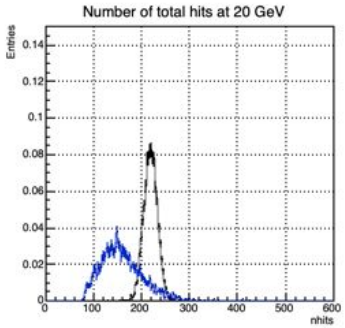


Gaussian fit was performed for the first few projection distribution
to nurture the input parameter for the simulation

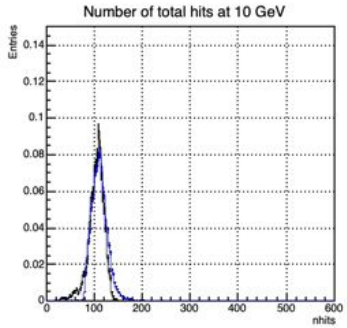
Number of Total Hits

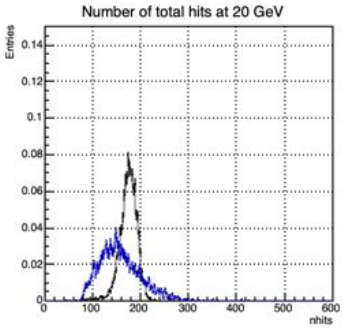
No mask





With mask

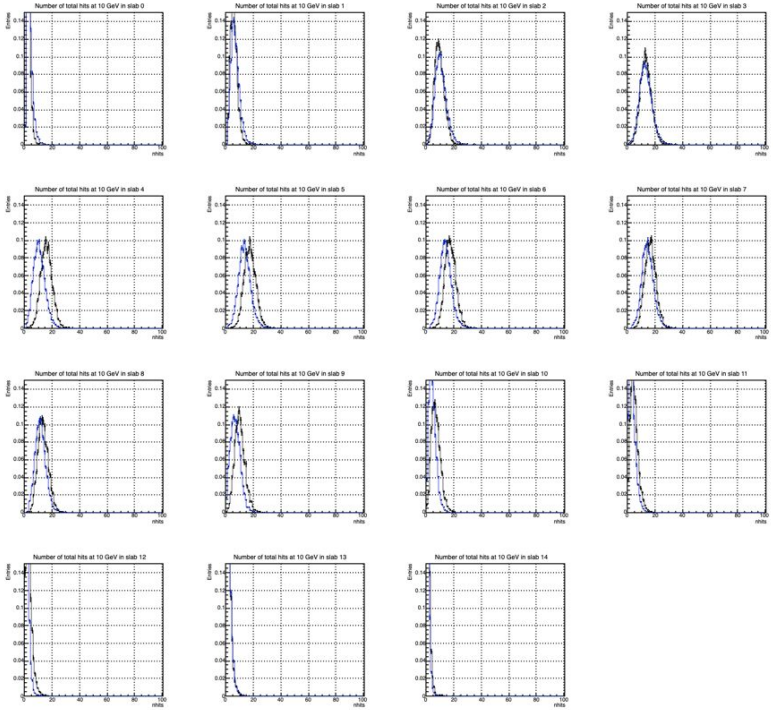




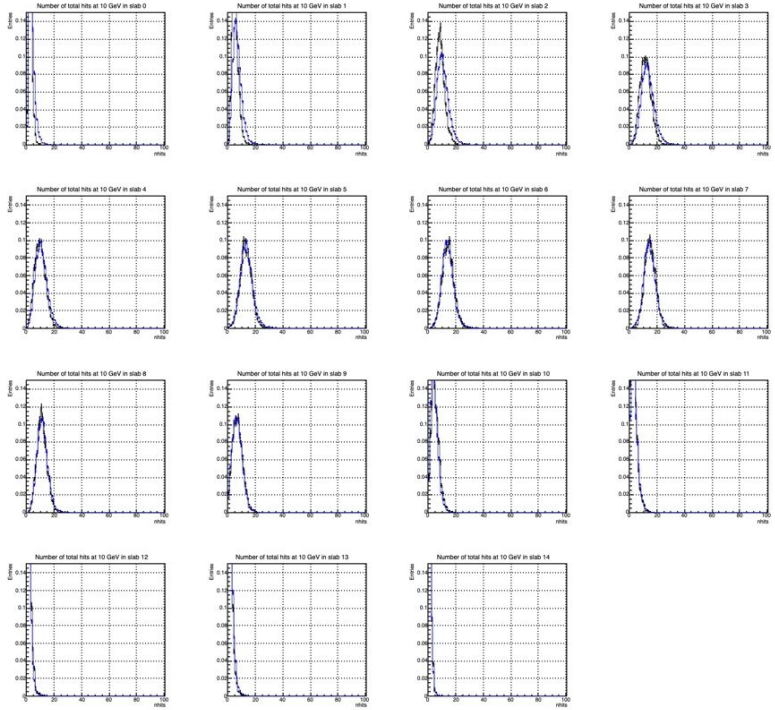
- The simulated number of total hits now gets scaled down to more appropriate value
- Reconstruction now has better agreement with simulation.

Total Hits per Slab

No mask (e- 10GeV)

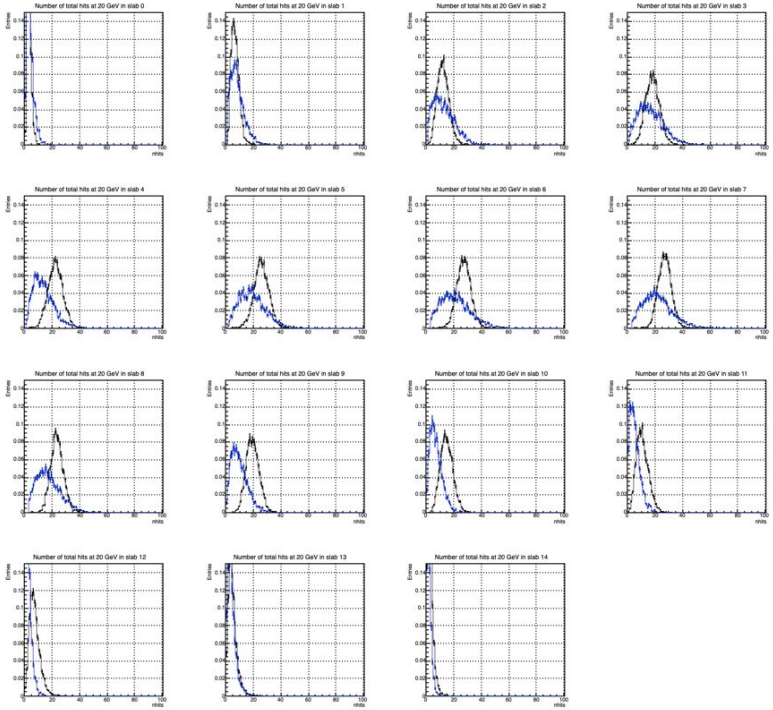


With mask

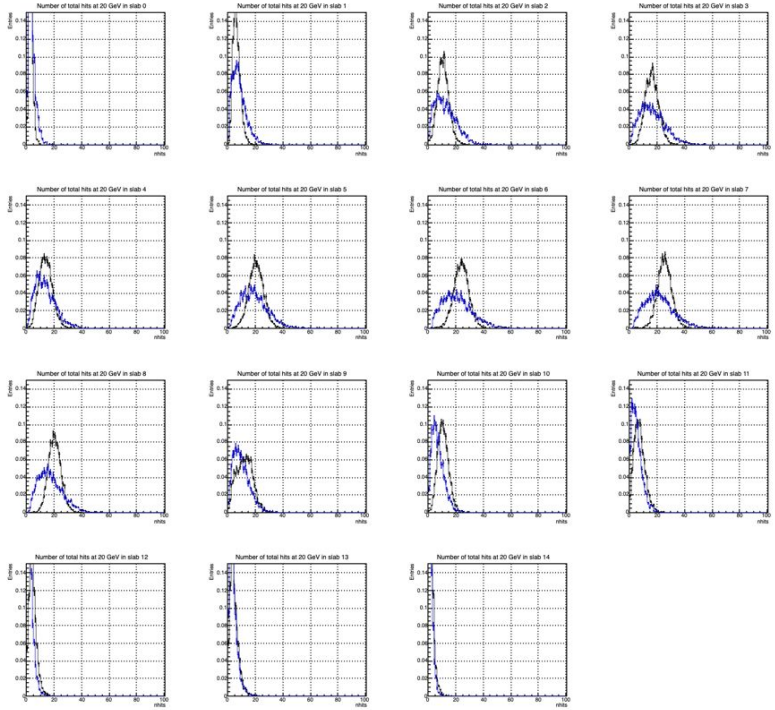


Total Hits per Slab

No mask (e- 20GeV)

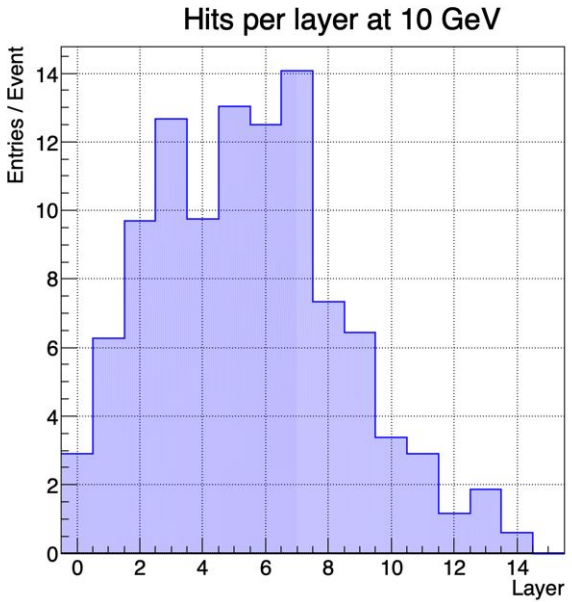


With mask

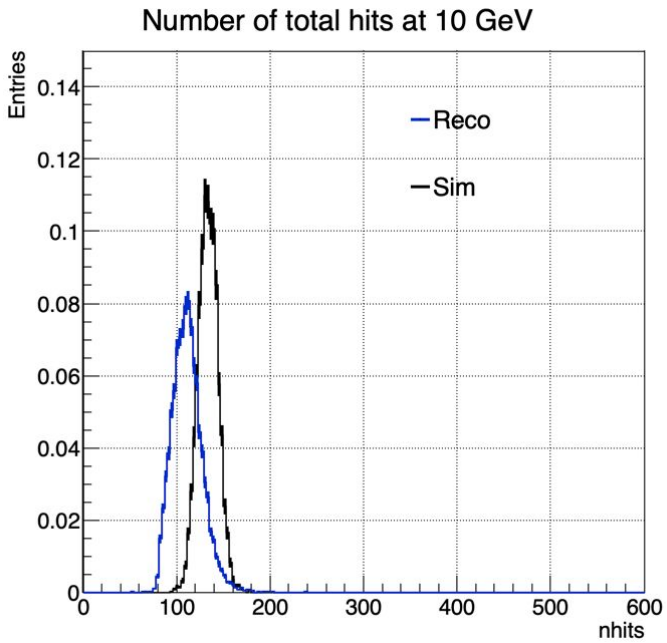


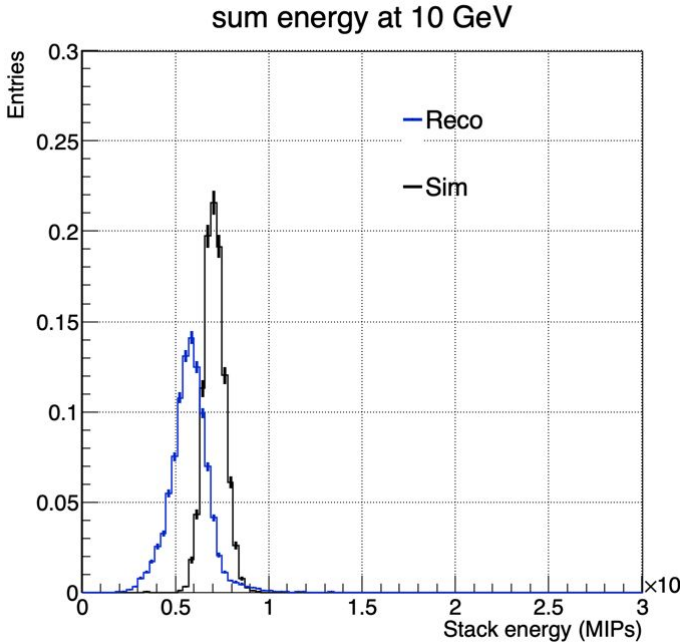
Hits per Layer

- Layer numbers of the deposited hits were plotted.
- The distribution should roughly correspond to the shower profile of the electron beam at 10 GeV.
- Shower maximum observed around slab 5-7.
- Some non-continuity in the distribution (e.g. layer 4), is caused by masking and wafer delamination, which leads to inability for the hit registration.

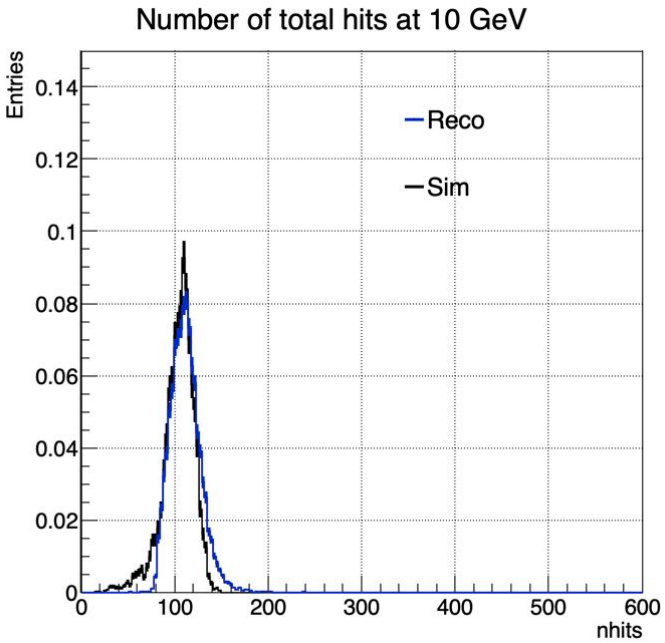


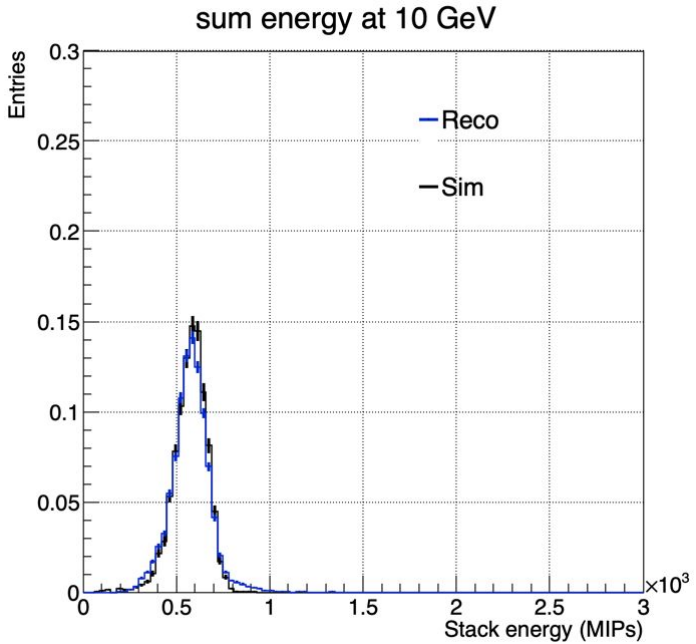
Hit Quality Checks (without mask)





Hit Quality Checks (without mask)



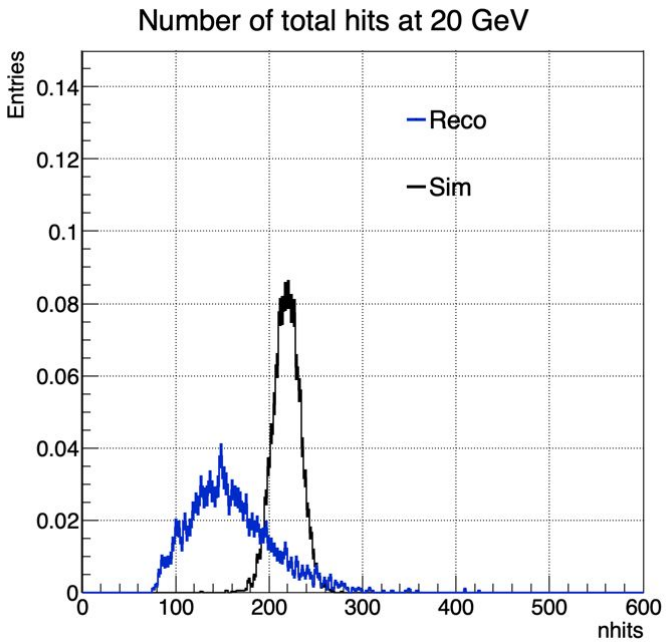


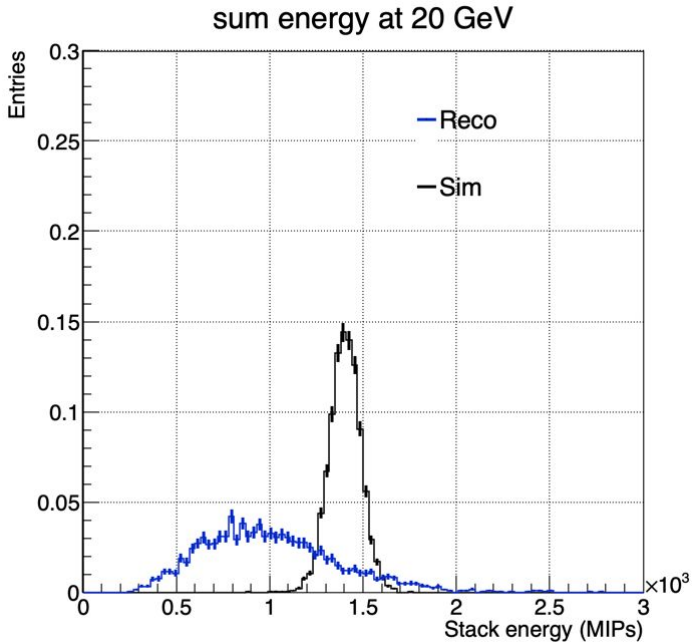
Summary

- **Masking Studies**
  - New features are now taken into account in simulation
    - Masking
    - Beam axis position
    - Beam axis width
  - They all significantly contribute to the final hit counts.
- **Comparison**
  - The total number of hits for 10 GeV do get closer to the generation, as the simulated distribution shift down.
    - Conquering another energy regime following the 1-6 GeV studies from DESY TB.
  - It is also clear that some slabs still lack in number hits. (20 GeV ~)
- **Take home message**
  - The masking effect and beam settings in both simulation and reconstruction must not be underestimated.
  - The simulation parameter should be adjusted for every runs (validate the simulation settings for each)

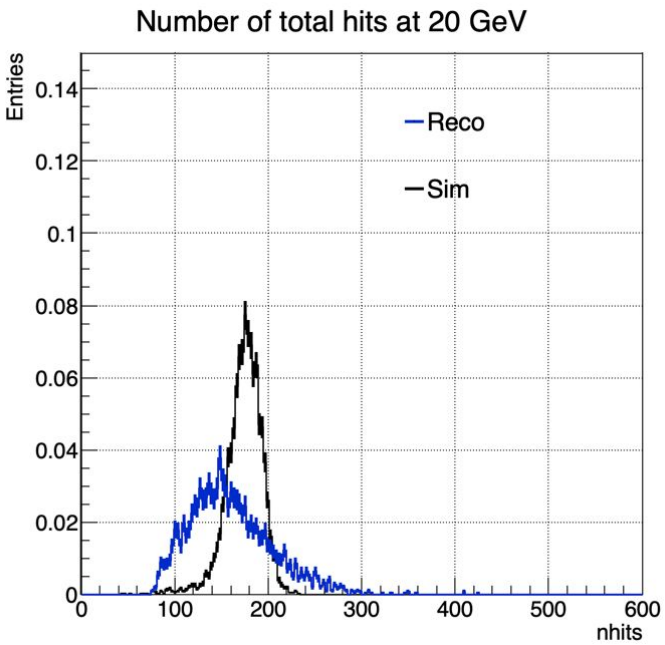
Backup

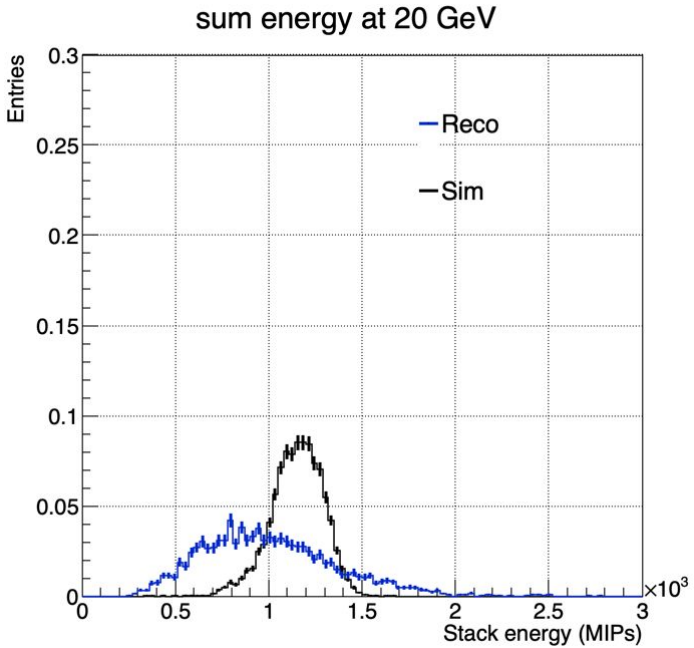
Hit Quality Checks (without mask)



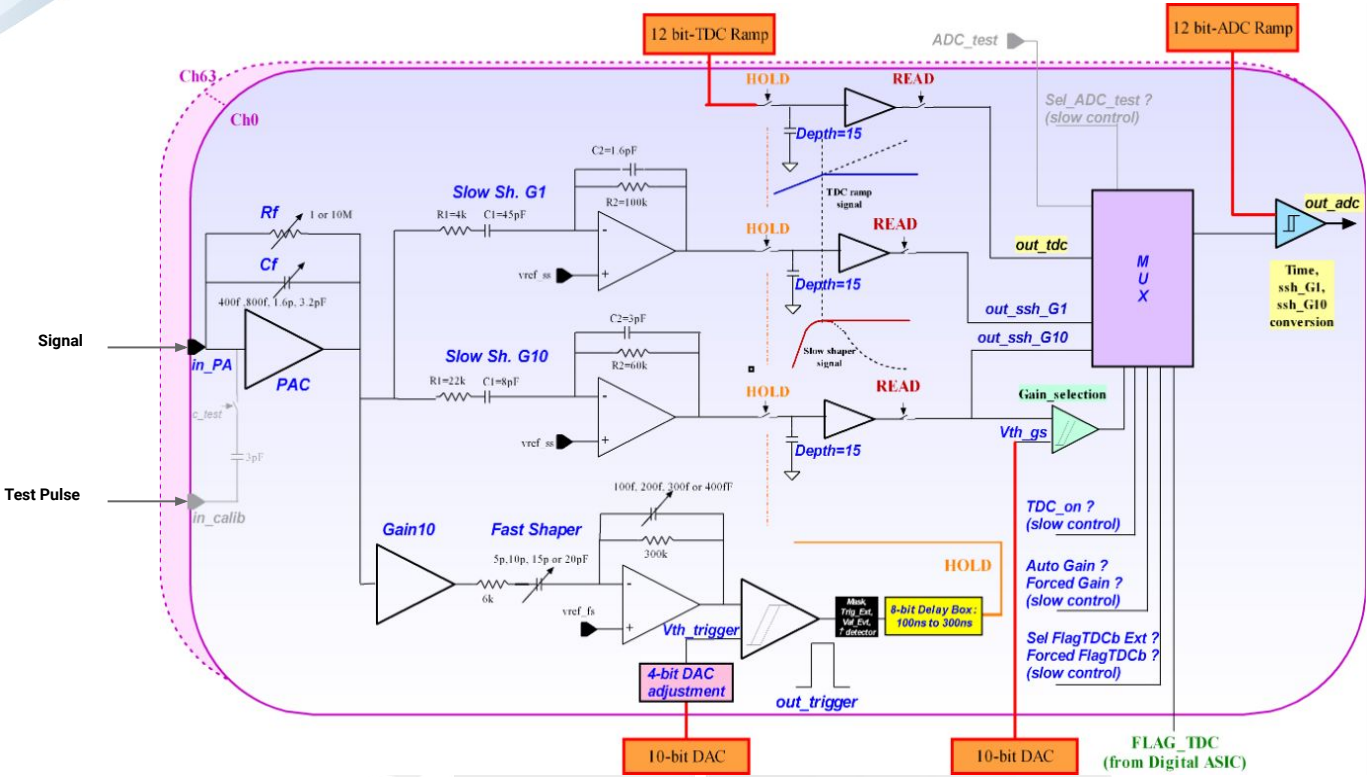


Hit Quality Checks (without mask)



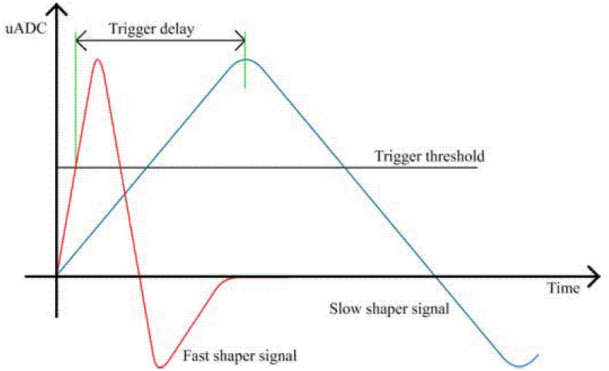


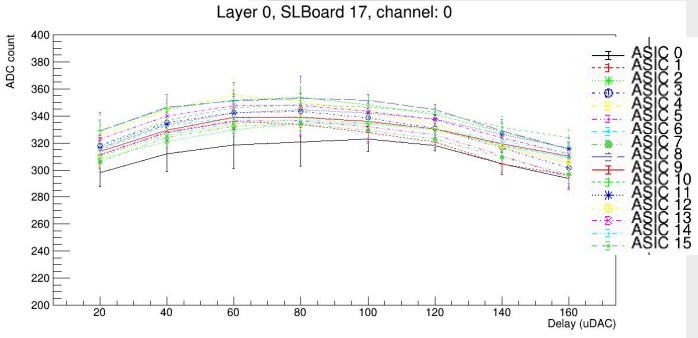
Electronic Circuit Layout for the SKIROC 2

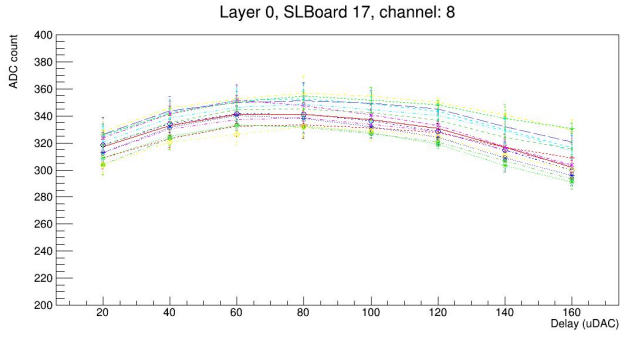


Hold Scan

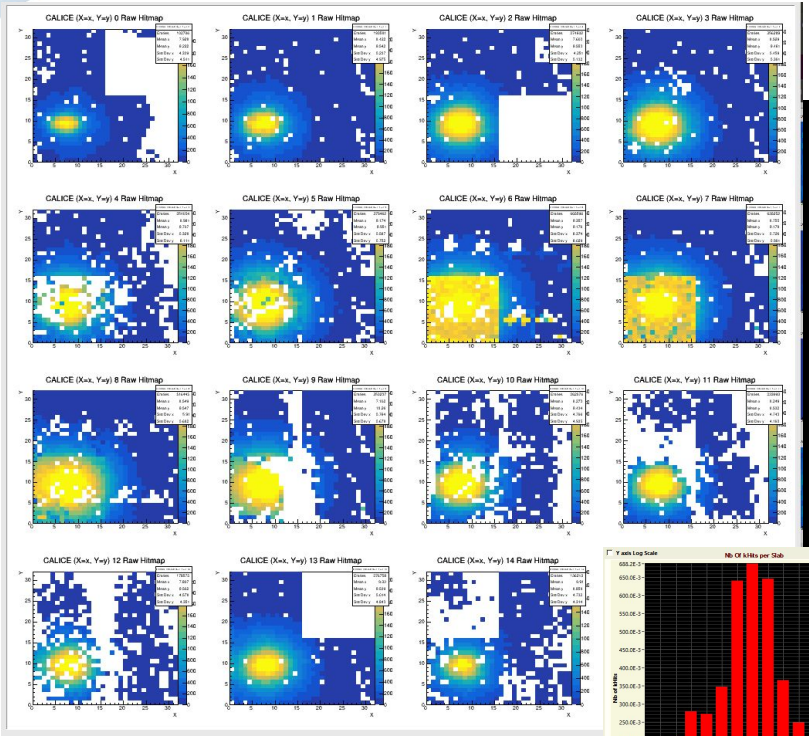
- Signal is needed to be read along the pulse that is generated by the slow shaper. This timing is managed by trigger delay.
  - Optimum trigger delay depends on the threshold.
- The delay-for-hold can be configured via DAQ software.
  - Inject the signal to row-by-row with signal amplitude of 1.2V
  - Hold scan was performed from the range of 20-160 in steps of 20.

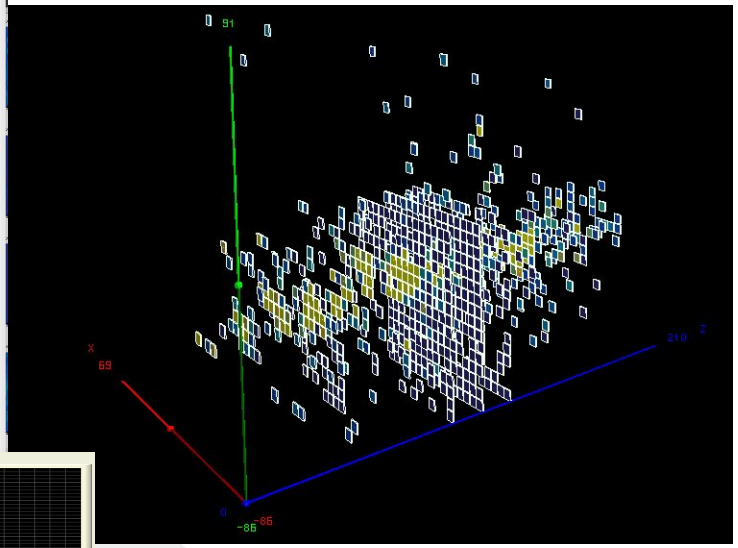


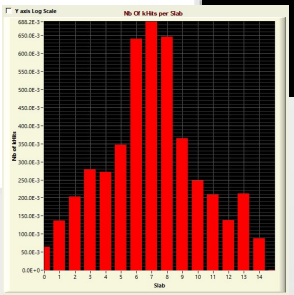




Wafer Delamination







Particle Identification

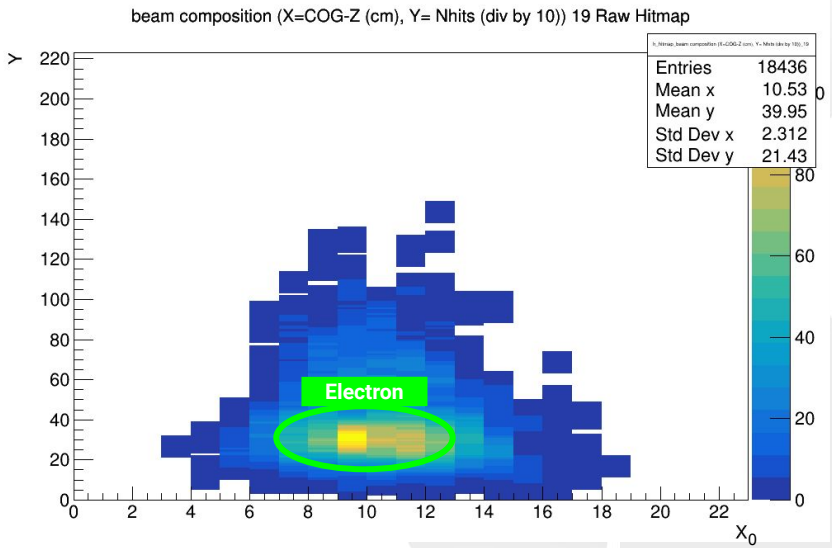


Fig. SiWECAL Electron 150 GeV

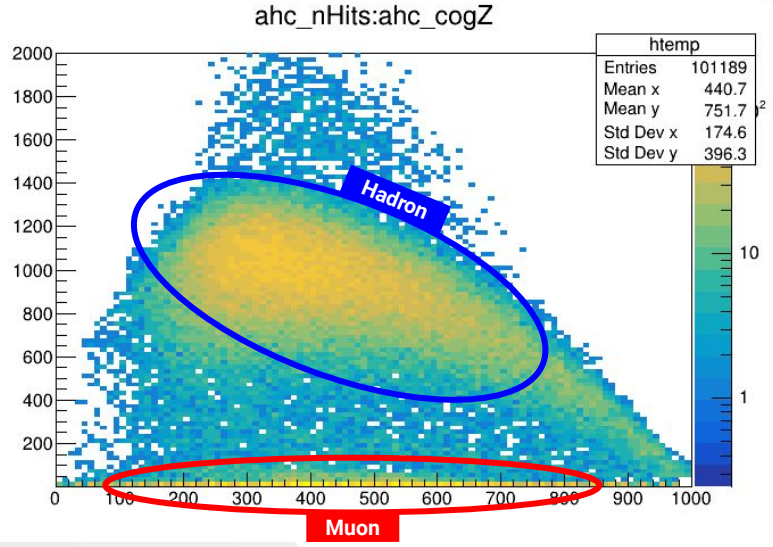
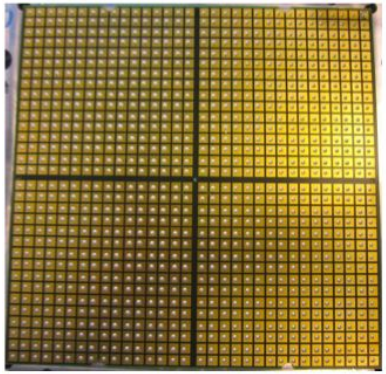


Fig. AHCAL Pion 200 GeV

Wafer Delamination



Metrology and PCB Deformation

- Setup of a device to measure the flatness of the PCB at different stages
- PCBs will be out into cabling machine and dimensions will be monitored before and afterwards

Glue – Alternative agents and procedures

- After discussion with Astronomy Institute of Paris and Epotek
- Test glue of type H20E as alternative to Epotek J2189
  - Should have higher mechanical stability
- Use EPOTEK 301-2 as underfill for mechanical stabilisation (proposal of Epotek)
  - This underfill has low viscosity that ensures mechanical stability by capillary effect
  - First tests carried out – Stay tuned for results
- Alternative proposal EPOTEK 353ND-T
  - Epoxy for gluing electrical component, could be used to stabilise glued sensor at sensor boundaries
  - Data sheet in backup

  Further alternatives will be studied

Pull tests

- IJCLab will prepare pull tests in order to get a quantitative picture of the mechanical stability of the glue
- Maybe in combination with C2N – A CNRS Institute specialised for materials

New FE boards

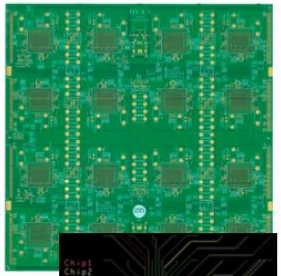
LLR, IJCLab, LPNHE, OMEGA

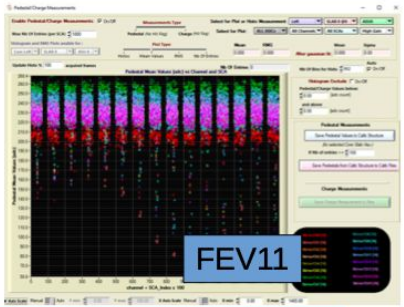
Improvements:

- Power distributions
  - Local power regulation
  - Local High Voltage filtering & Supply
- Signal distribution (buffering), data paths
- Monitoring (single ID, temp, probe analogue line)
- ASIC shielding/routing

Status:

- pre-version 2.0 tested, minor corrections needed
  - Noise uniformity dramatically improved (ex: outliers in thr. / 20 !)
- version 2.1 produced, … in metrology
  - before cabling, 2nd metrology, gluing, …
  - All material available : ASICs being tested





Pedestal measurements vs. Ch# + Mem#×100)