Towards a Generic Tool for Calorimeter Fluxes Estimations

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ILD SWANA
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ÉCOLE POLYTECHNIQUE

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IN2P3
Les deux infinis

Rationale

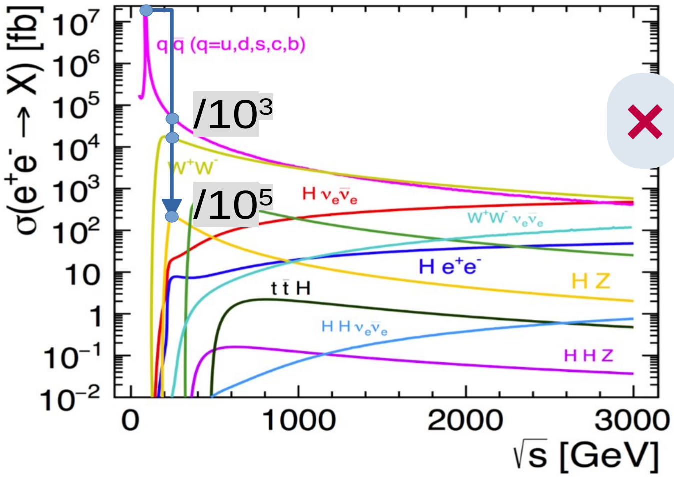
ILD calorimeters

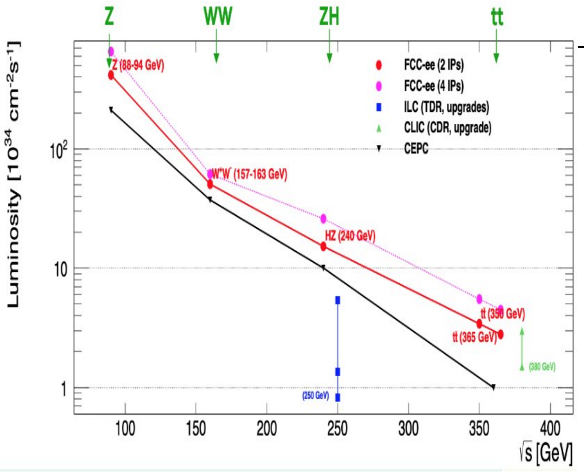
- Designed for ILC
  - Power pulsing, low occupancy
- Marginaly adapted for CLIC
  - Physics : number of layers
- Partially adapted for CEPC
  - Lower granularity
- Needs strong adaptation for EW physics

Revisiting the HG calorimeters for ee-Colliders

Large panel of running conditions

- 90GeV × 10^7 fb × $5{\cdot}10^{36}$ cm^{-2} s^{-1} (qq × 20000 ILC @ 250)
- 150 GeV (WW) + 250 GeV (ZH)+ 280 GeV (tt)
  ~10^4 fb × $5{\cdot}10^{35}$ cm^{-2} s^{-1} (qq × 5–10 ILC @ 250)





Are the current hypothesis viable ?

- Cooling, DAQ, etc.
- 1 detector fit-all ?
  - What are the limits :
    - power vs Granularity vs active cooling ?
- New electronics (DRD6):
  - TSMC 130 nm vs AMS 130 nm
  - Running mode (continuous, trigger-less)

Calorimeter Fluxes

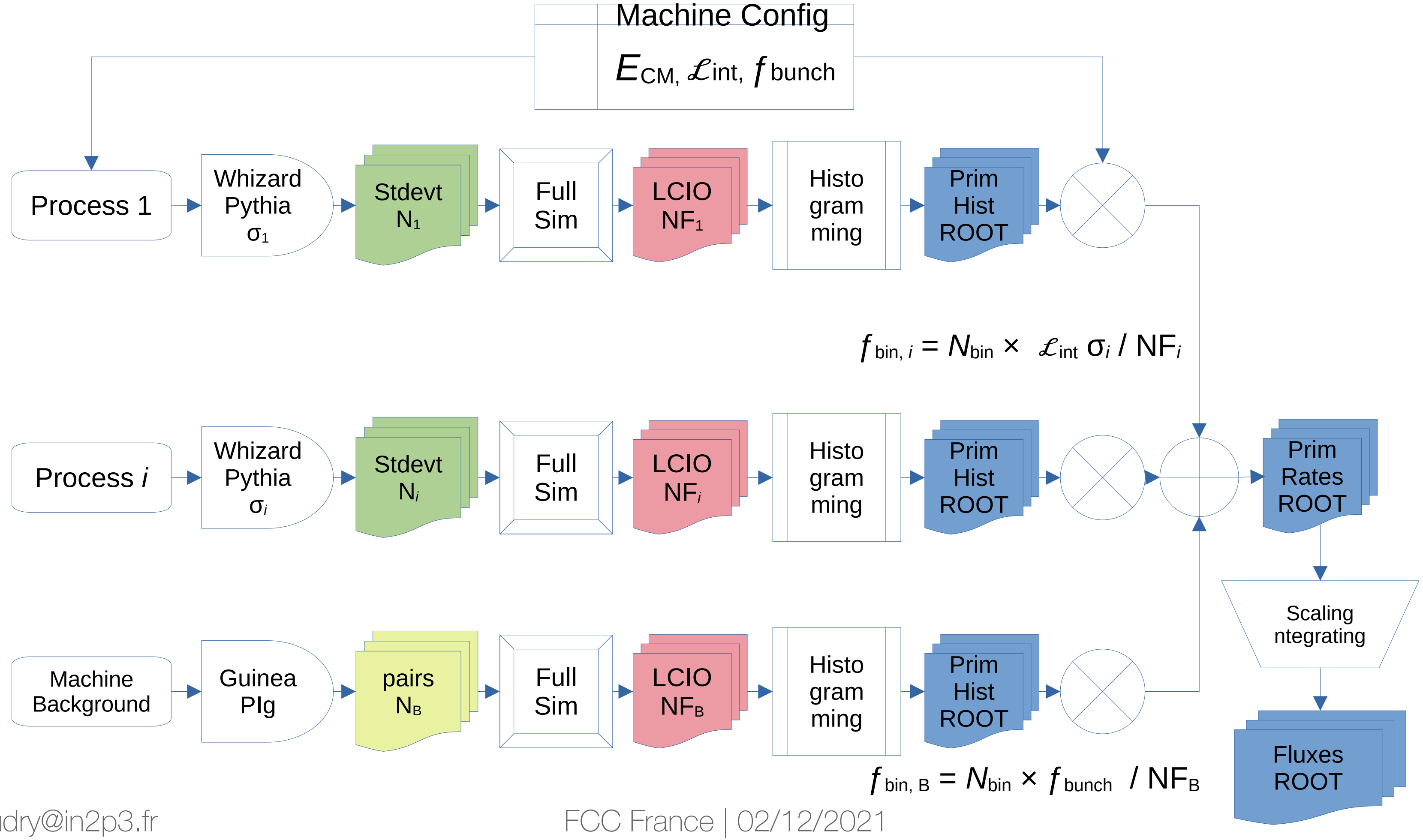
Quantities useful for self-triggering (low occup)
Front-End electronics & Design

- Number of hits/s per ASICs
  - ➡ Power (Energy per conversion)
  - ➡ Memory size
- Distribution of Energy & Time
  - ➡ Dynamic ranges
  - ➡ Power per conversion (Wilkinson ADCs)
  - ➡ Double hits
- Data output
  - ➡ Data Flux per readout partition (DAQ)

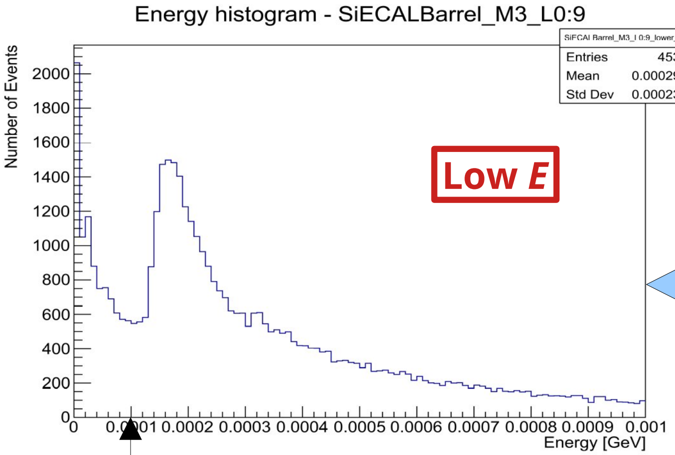
Other quantities

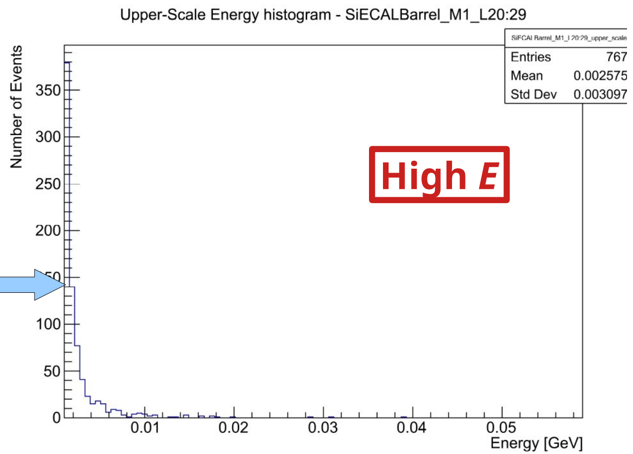
- Deposited energies
  - ➡ Radiation

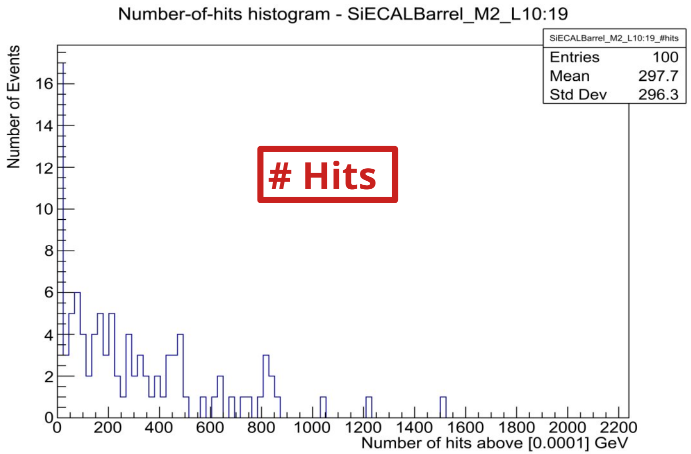
Flux to Fluxes

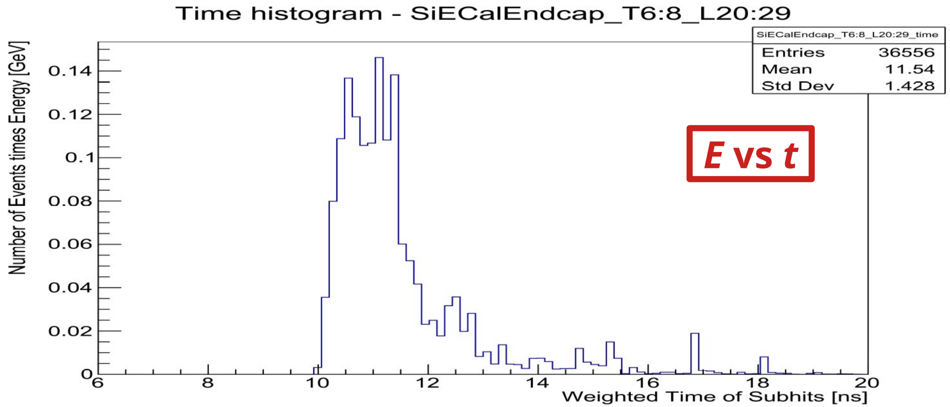


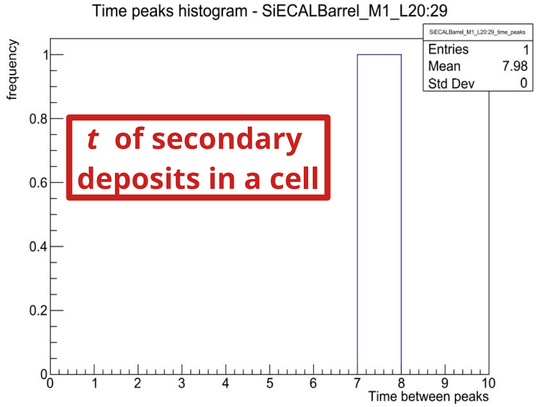
Primary histograms







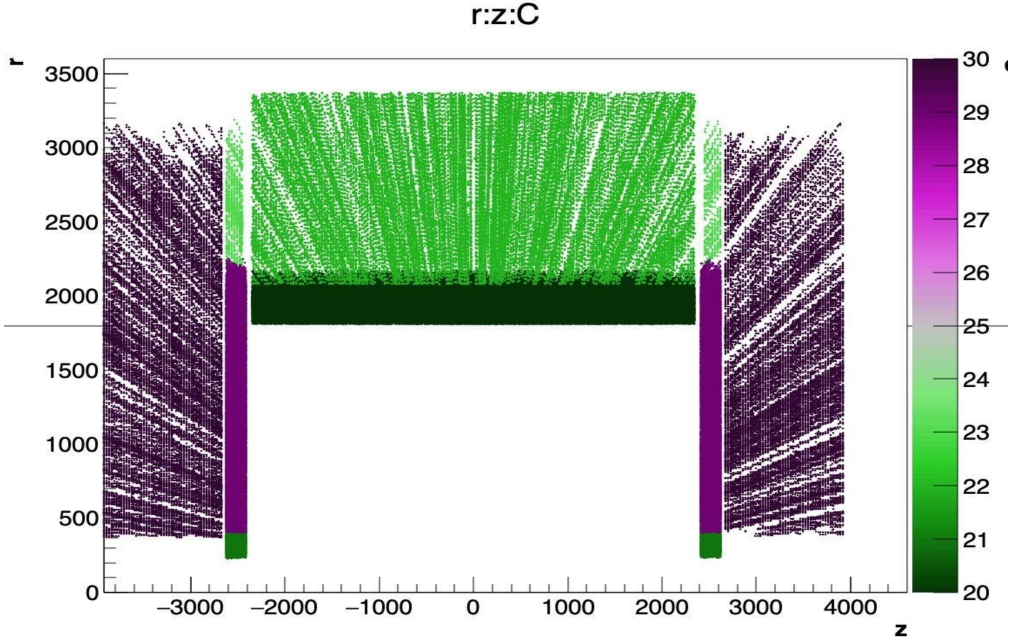




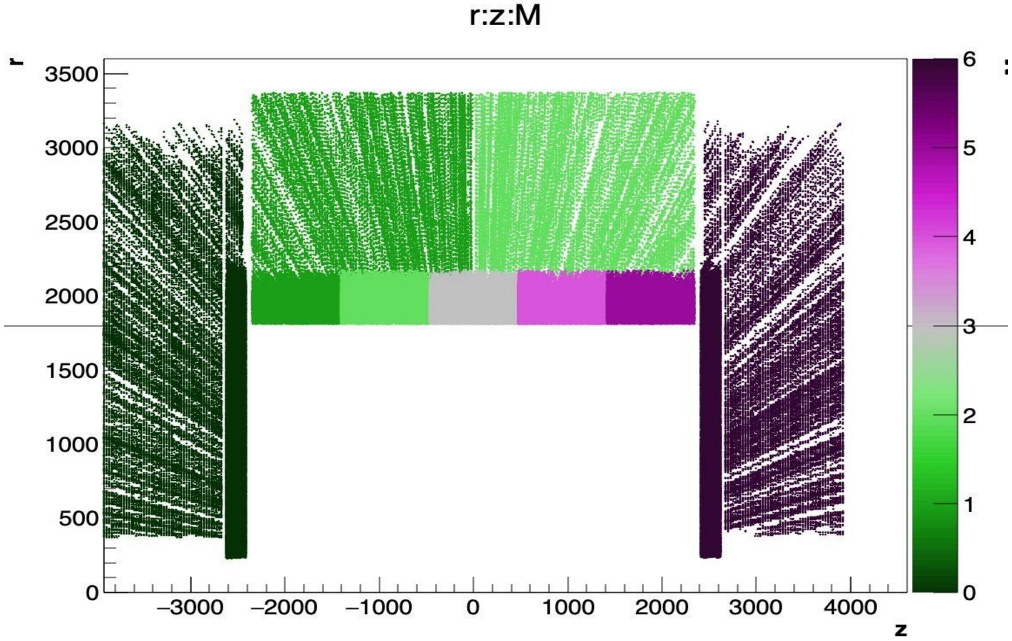
100 events
qqH @ 240 GeV

Segmentation by “Logical Geometry” C:M:S:T:L:I:J

Calorimeters systems C



Calorimeters Modules



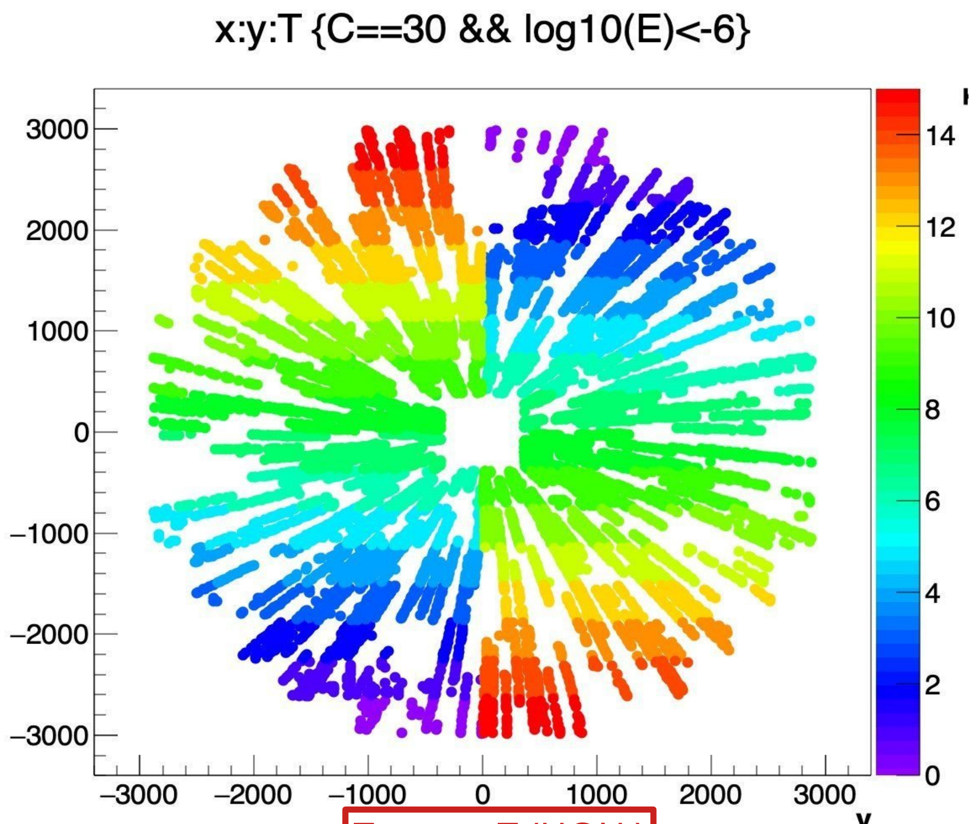
Useful segmentation & grouping:

- Physics: Group of uniform (rates) regions (~cosθ)
- Technical: Readout & Cooling Partition (ASIC, SLAB, Tower, Module)

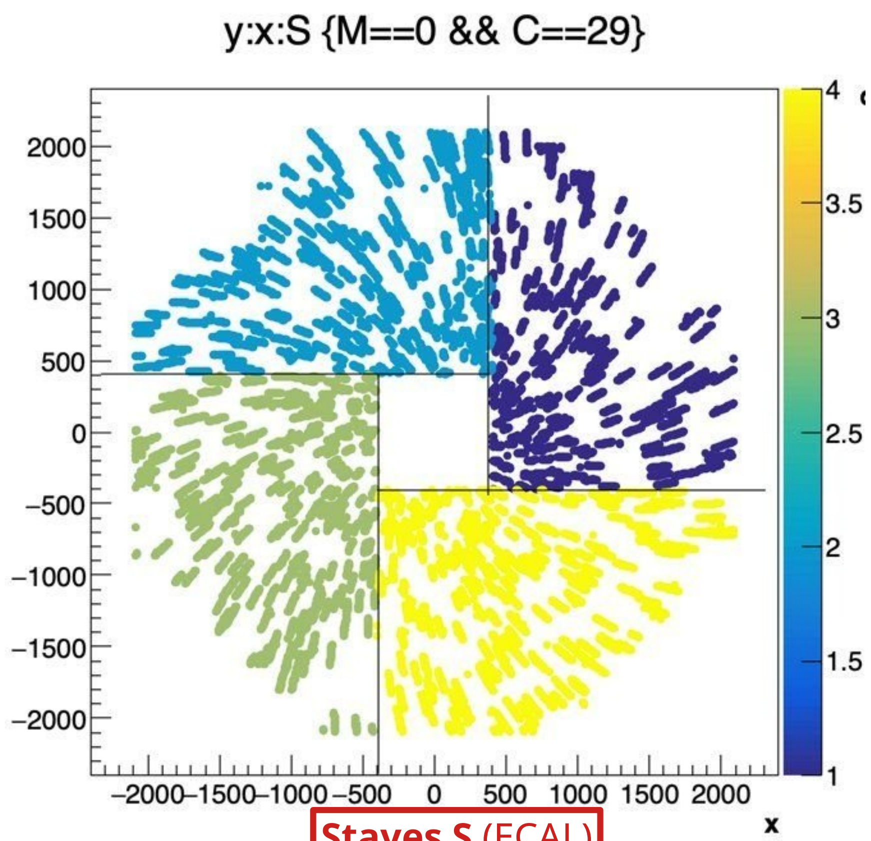
Useless individuation:

- (Individual layers)
- Symmetrical : staves (φ), Forward–Backward (±θ)

Logical Geometry

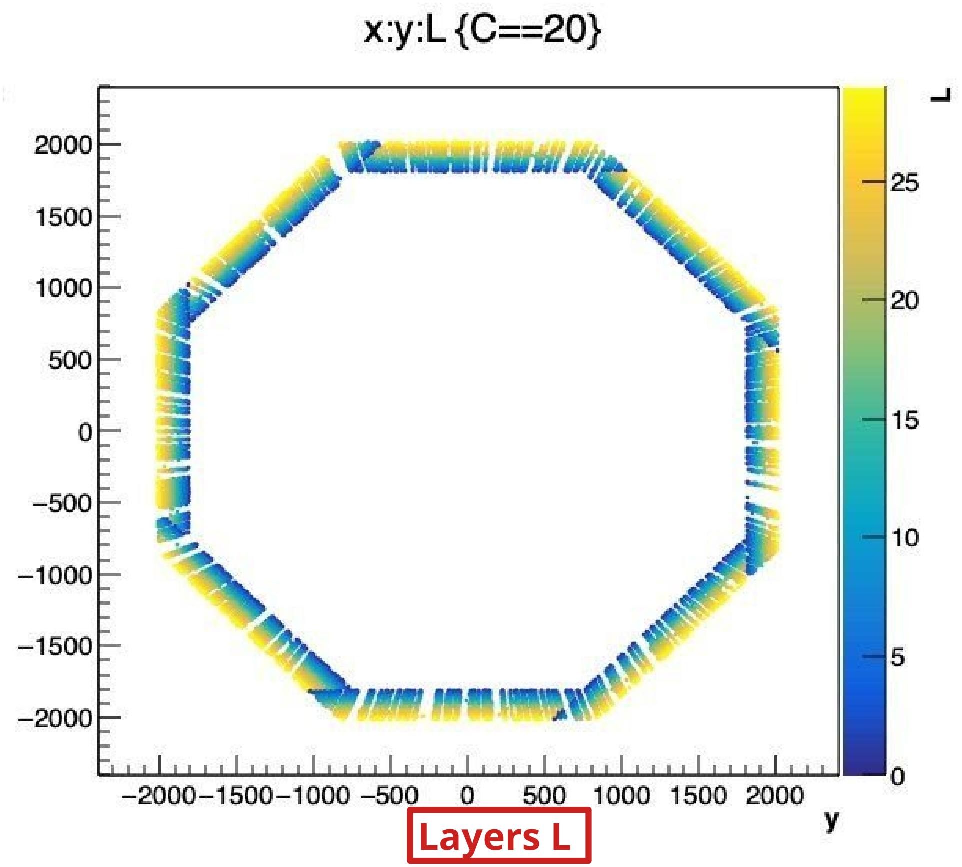


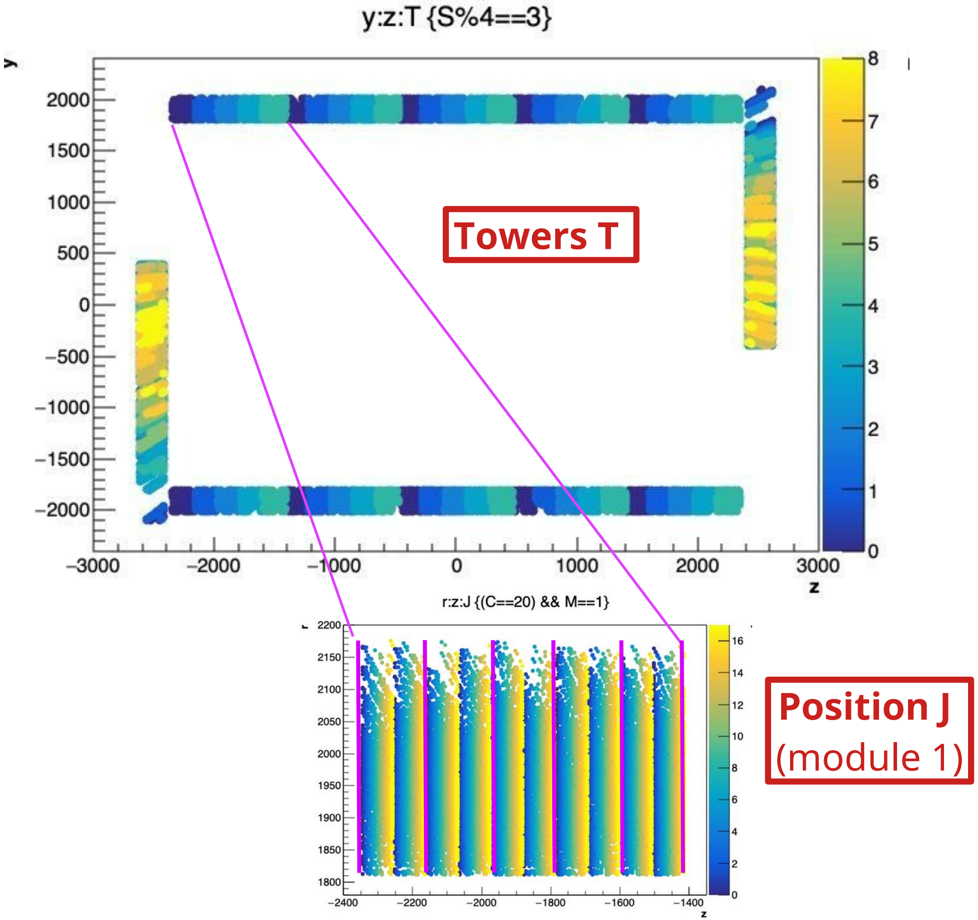
Towers T (HCAL)



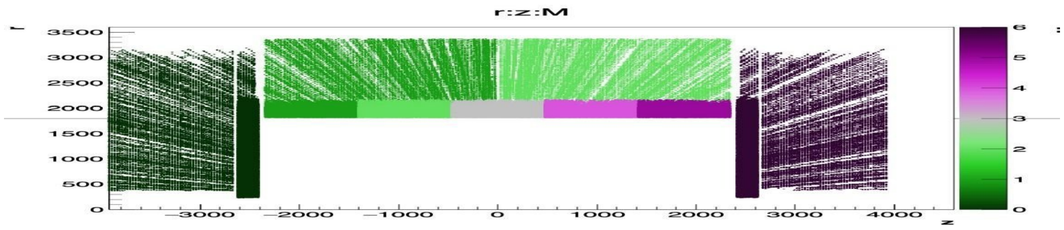
Staves S (ECAL)

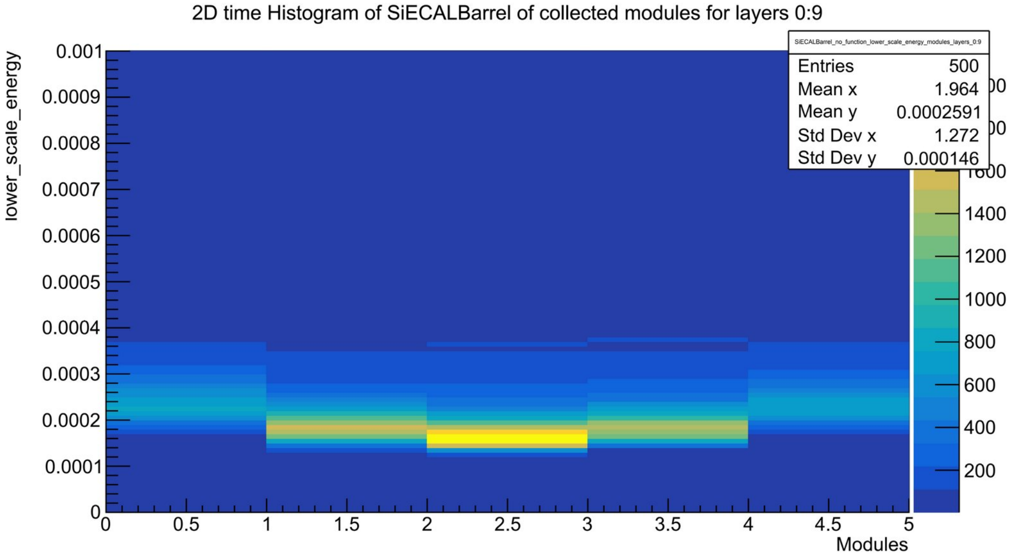
Logical Geometry (ECAL)



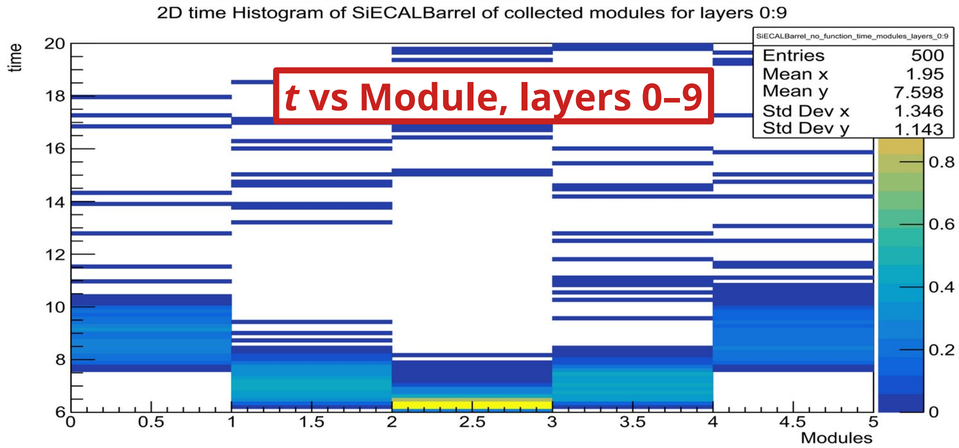


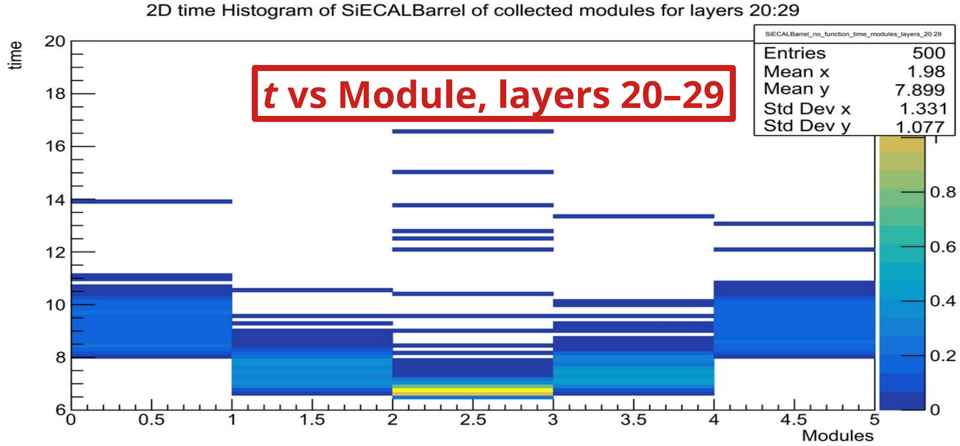
Cross-check : muons





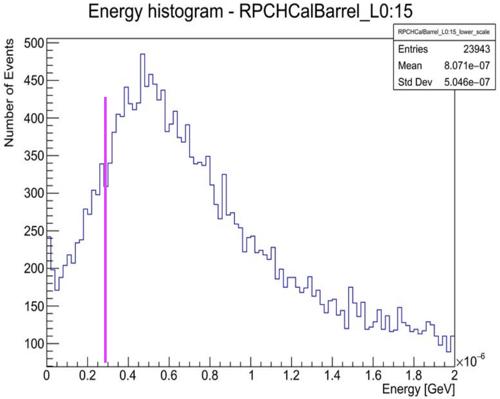
Low *E* vs Module

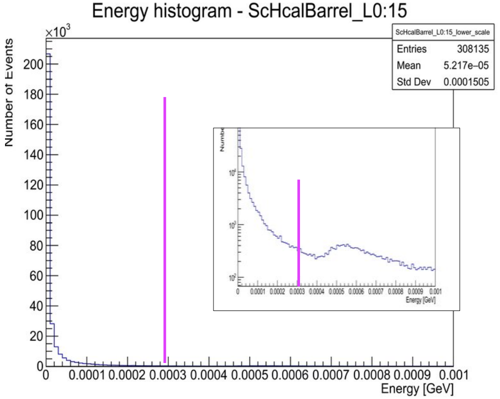


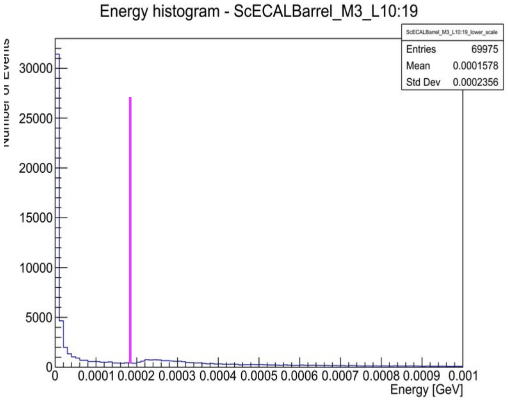


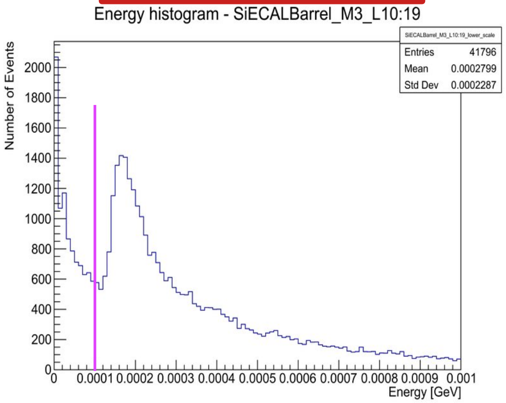
System low energy & #hit responses

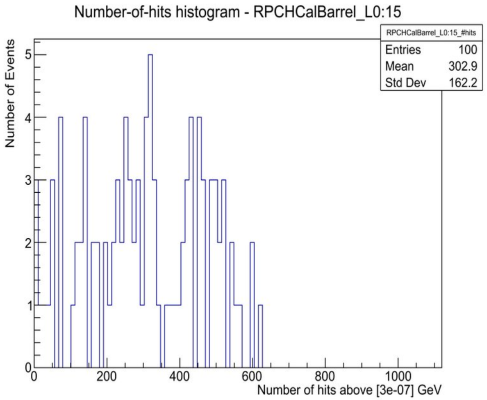
SDHCAL | **AHCAL** | **Sc ECAL** | **Si ECAL**

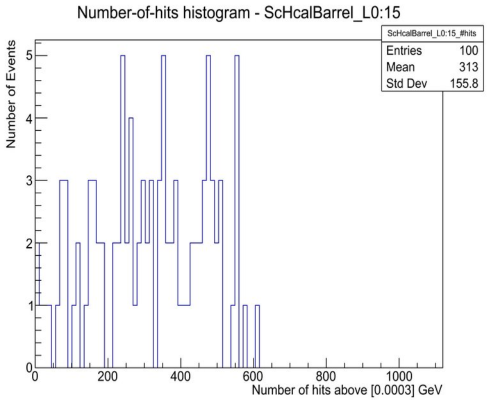


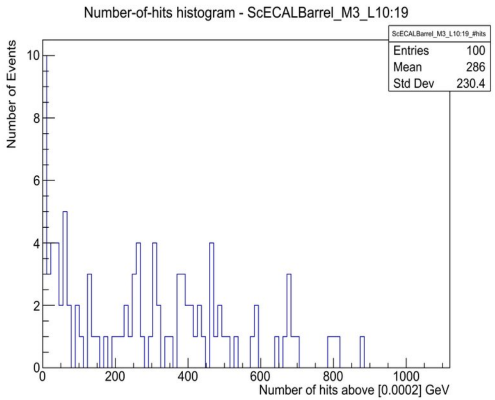


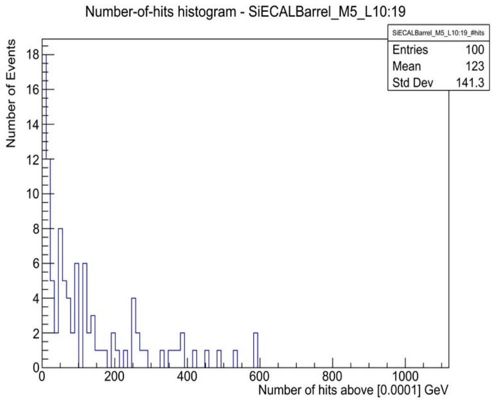












Code K. Hassouna

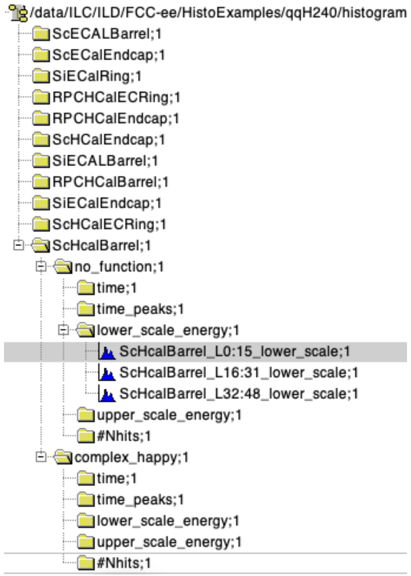
Python code

Production of Primary histograms

- LcioReader from pyLCIO
- Mapping & Selection
  - Cell_id decoding [J. Kunath]
  - Highly configurable
- ROOT histograms
  - System and histo type hierarchie
  - Auto-rescalable (high E)

```
system_limits = {"ECALBarrel" : (8, 5, 5, 30) , "EndCaps" : (4, "0-6", 5, 30)}
#selection format "S:M:T:L" conditions => "*:*:2:0-4,5-10" means no selection on M, S, 1 histo per 2 tower , 1 for layer 0 to 5, and one for layers in 5 to 10.
#The keys of the dictionary are the system names. Each key has a value composed of 4 lists.
# The first list has the collections' names.
# The second one has the selections we impose on the histograms made in the order given above.
# The third list has 4 lists each with 2 arguments. Each list has the bin number (the first argument) and the maximum of the range of the histogram (the second argu
# The fourth list has the energy threshold that we use in the Nhits histogram.
dictionary_of_system = {
#       System          Xollwctiona                                            Stave  MOdules               Towers                         Layers
        "SiECalEndcap": (["ECalEndcapSiHitsEven", "ECalEndcapSiHitsOdd"],     [["*"],["*"],                 ["0","1:2","3:5","6:8"],       ["0:9","10:19","20:29"]],
        "SiECALBarrel": (["ECalBarrelSiHitsEven", "ECalBarrelSiHitsOdd"],     [["*"],["1","2","3","4","5"], ["*"],                         ["0:9","10:19","20:29"]],
        "SiECalRing": (["EcalEndcapRingCollection"],                          [["*"],["*"],                 ["*"],                         ["0:9","10:19","20:29"]],
        "ScECalEndcap": (["ECalEndcapScHitsEven", "ECalEndcapScHitsOdd"],     [["*"],["*"],                 ["0","1:2","3:5","6:8"],       ["0:9","10:19","20:29"]],
        "ScECALBarrel": (["ECalBarrelScHitsEven", "ECalBarrelScHitsOdd"],     [["*"],["1","2","3","4","5"], ["*"],                         ["0:9","10:19","20:29"]],
        "RPCHCalEndcap": (["HCalEndcapRPCHits"],                              [["*"],["*"],                 ["0:3","4:7","8:11","12:15"], ["0:15","16:31","32:48"]],
        "RPCHCalBarrel": (["HCalBarrelRPCHits"],                              [["*"],["*"],                 ["*"],                         ["0:15","16:31","32:48"]],
        "RPCHCalECRing": (["EcalEndcapRingCollection"],                       [["*"],["*"],                 ["*"],                         ["*"]],
        "ScHCalEndcap": (["HcalEndcapsCollection"],                           [["*"],["*"],                 ["0:3","4:7","8:11","12:15"], ["0:15","16:31","32:48"]],
        "ScHcalBarrel": (["HcalBarrelRegCollection"],                         [["*"],["*"],                 ["*"],                         ["0:15","16:31","32:48"]],
        "ScHCalECRing": (["EcalEndcapRingCollection"],                        [["*"],["*"],                 ["*"],                         ["*"]],
        }
```

```
Time bins/max lowE bin/max highE bin/max  #hits bin/max  EThr  Split Func:ranges
[[100, 20], [100, 0.001], [100, 0.03], [100, 35]], [[0.0001]], {}),
[[100, 20], [100, 0.001], [100, 0.03], [100, 35]], [[0.0001]], {}),
[[100, 20], [100, 0.001], [100, 0.03], [100, 35]], [[0.0001]], {}),
[[100, 20], [100, 0.001], [100, 0.03], [100, 35]], [[0.0003]], {}),
[[100, 20], [100, 0.001], [100, 0.03], [100, 35]], [[0.0002]], {}),
[[100, 20], [100, 2e-6],  [100, 3e-5], [100, 35]], [[3e-7]], {}),
[[100, 20], [100, 2e-6],  [100, 3e-5], [100, 35]], [[3e-7]], {complex_sad:["0:79", "80:159", "160:234"]}),
[[100, 20], [100, 0.001], [100, 0.03], [100, 35]], [[0.0001]], {}),
[[100, 20], [100, 0.001], [100, 0.03], [100, 35]], [[0.0001]], {}),
[[100, 20], [100, 0.001], [100, 0.03], [100, 35]], [[0.0003]], {complex_happy:["0:29", "30:59", "60:76"]}),
[[100, 20], [100, 0.001], [100, 0.03], [100, 35]], [[0.0001]], {})
```



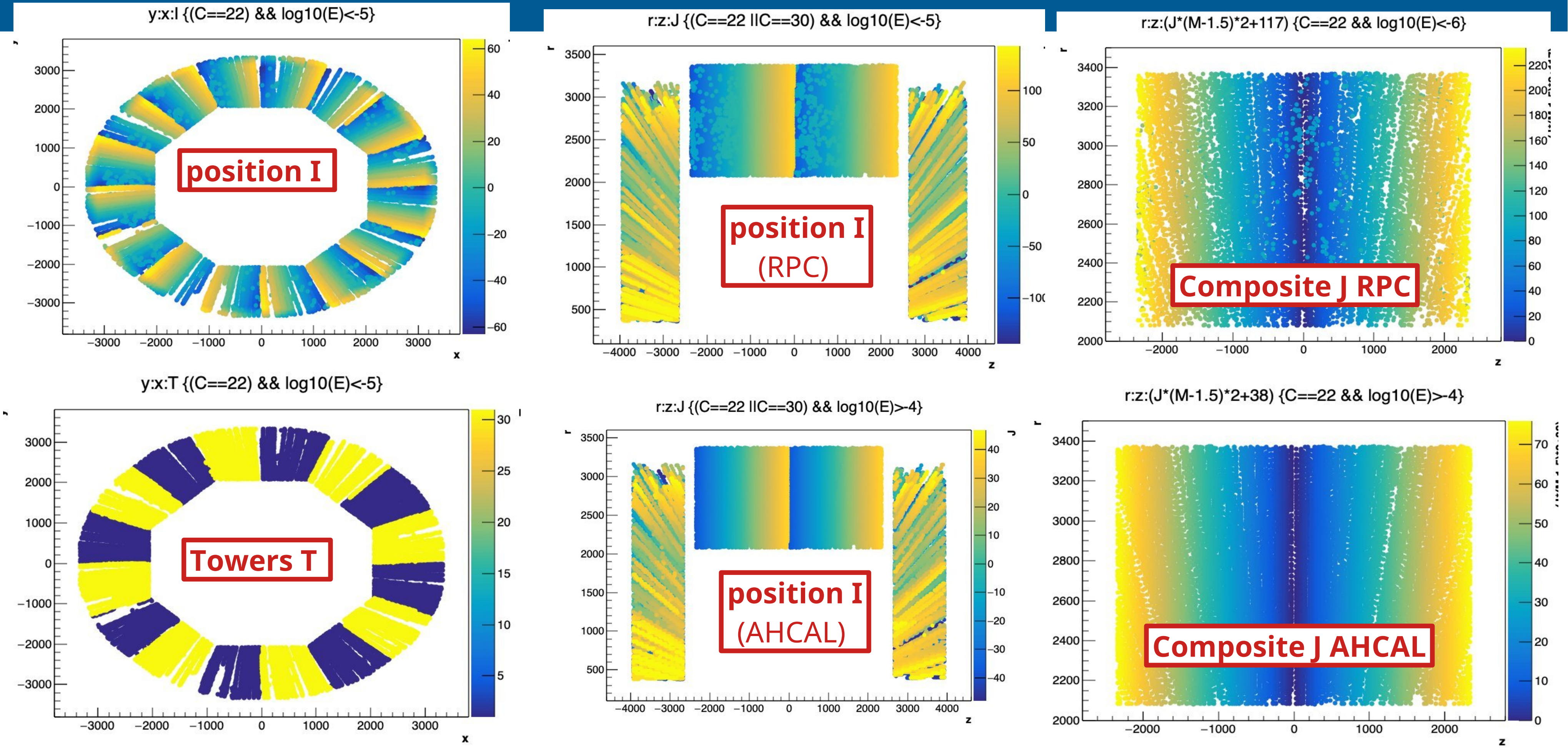
Secondary histograms

- Scaling : e.g. power, datasize = f(#hits, Energy)
- 2D histograms

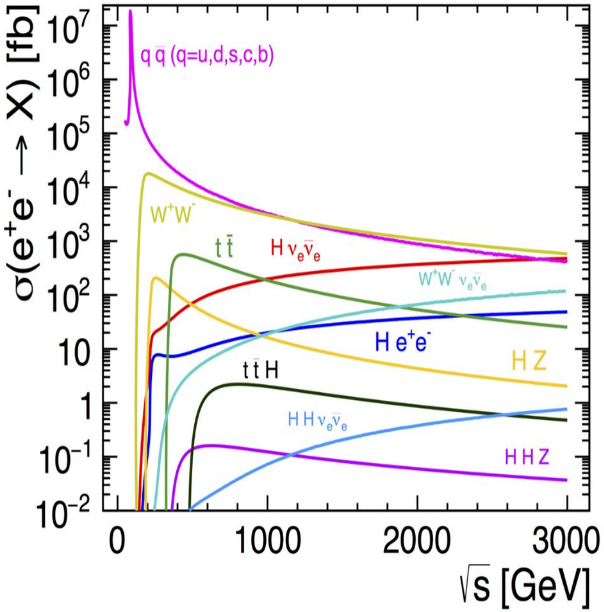
Summing-up of processes & background

- from table

Logical Geometry (HCAL BARRELs)



Processes & Configurations



Processes:

- All
  - ee → qq
  - ee → $\mu\mu$, $\tau\tau$
  - ee → ee (⊃ Bhabha)
  - $\gamma\gamma$→ VV
  - Machine background (ee pairs)
- E_{CM} ≥ 160 GeV
  - ee → WW
- (E_{CM} ≥ 240 GeV)
  - ee → HZ
- (E_{CM} ≥ 360 GeV)
  - ee → $t\bar{t}$

eeColliders Params

Aa Running...	IPs	# Beam energy [GeV]	# Bunches / beam	# Luminosity/IP [$...	Σ Paquet Sep [µs]
FCC-Z2	2	45,6	12000	180	0,025
FCC-Z4	4	45,6	15880	140	0,019
FCC-W	4	80	688	21,4	0,442
FCC-ZH	4	120	260	6,9	1,169
FCC-tt	4	182,5	40	1,2	7,6
ILC250	1	125	3000		0,101
ILC380					
ILC500					
CLIC380					
ILC-GZ					
ILC250-HL					

To be done

Processes

- Check the statistics vs angular distribution for processes
- Simulate & histogram for 2 key energies
  - 90 GeV, 240~250 GeV
  - Now using FCC SW tools (wp8, guineapig)
- Inlcude digitzation (esp. RPCs)
- Feed in realistic electronics numbers
  - power per conversion
  - work on secondary histograms
  - Test electronics hypothesis
    - ADC types, Cell grouping,

Code:

- Complete the summation of processes with proper scaling ($\mathscr{L}$, f_{bunches})
- Improve visualisation
- Improve speed
- expend to vertex/tracker ?

Instrumentation:

- Explore the limits

Longer term:

- Port to key4hep