

Realistic treatment of time in ILD digitizers.

ILD phone meeting

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DESY

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Context

Fast timing detectors more and more studied in HEP and ILD

Current investigations in ILD:

- Detectors: LGAD among others...
- Where to equip? SIT? SET? ECal? HCal?
- What to study?

Possible usage of fast timing:

- Time of flight: using calorimeters? tracking detectors? dedicated detector?
- 5D Particle flow algorithm: decrease confusion with better separation while clustering
- Pile-up reduction

Ongoing studies with TOF by B. Dudhar (HLR), M. Kuhara (HLR/DET) and A. Irls (ANA)



Digitization in ILD

Run early in reconstruction for all detectors

- Silicon tracking detectors, TPC, calorimeters, muon chambers

Focus on calorimeter digitizers: `RealisticCaloDigi` and `RealisticCaloReco`

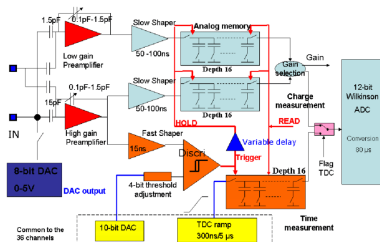
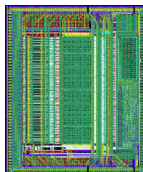
- Detectors: ECal and HCal, barrel, endcap and ring
- Technology dependant implementations (silicon VS scintillator)
- Realistic:
 - Apply energy threshold (0.5 MIP usually)
 - Apply energy calibration per layer
 - Apply mis-calibration factors
 - Apply dead cell randomization
 - Apply electronics noise
- But... treatment of timing is approximate (see next slides)



Omega ASICs

The ReadOut Chip (ROC) saga

- Front-end electronics for ILC calorimeters:
 - HARDROC: SDHCAL
 - MICROROC: DHCAL
 - SPIROC: AHCAL
 - SKIROC: SiWECal
- **Fast shaper**: Signal shaping input to discriminator
- **Slow shaper**: Final signal shaping readout



The SPIROC 2 ASIC

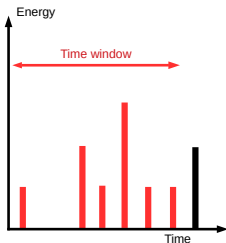
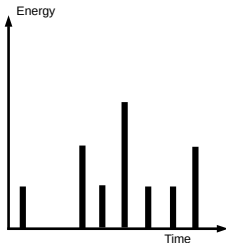


RealisticCaloDigi

Current implementation (Standard)

For every hit:

- Sum up energy of all MC contributions (MCCs) within t_{win} (default: [-10, 100] ns)
- If passing the threshold:
 - Set hit time to earliest MCC time
- If earliest hit time is not within time window → Set hit time to 0 (???)
- Output
 - One CalorimeterHit
 - Energy = energy sum of MCCs
 - Time = earliest MCC time (or 0)



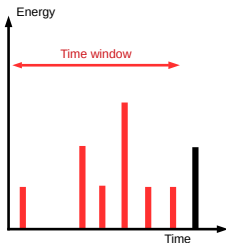
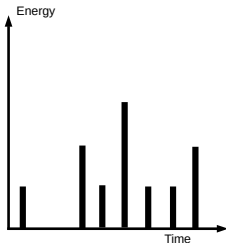
RealisticCaloDigi

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Good approximation but doesn't reflect the ROC implementation



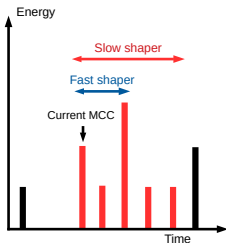
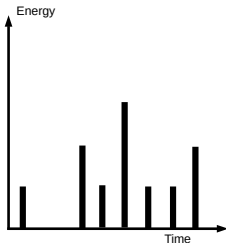
RealisticCaloDigi

New implementation (ROC)

For every hit:

- Sort MCCs by time
- Starting from earliest MCC:
 - Sum up energy of MCCs within t_{fast}
 - If not passing the energy threshold
→ Next !
 - If passing
→ Time = current MCC time, and stop !
- If passing the threshold:
 - Sum up energy of MCCs within t_{slow}
- Output
 - One CalorimeterHit
 - Energy = energy sum of MCCs within t_{slow}
 - Time = time of earliest MCC passing threshold

Implementation from AHCAL testbeam digi-
tizer in CaliceSoft (E. Brienne)



RealisticCaloDigi

New processor parameters and values

New processor parameters

- integrationMethod: "Standard" (default) or "ROC"
- fastShaper: Fast shaper value (unit ns)
- slowShaper: Slow shaper value (unit ns)
- timingResolution: Gaussian smearing for time resolution (unit ns)

Current parameter values

- SiWECal:
 - fastShaper: 90 ns
 - slowShaper: 180 ns
 - timingResolution: 700 ns (**but currently no smearing**)
- AHCal:
 - fastShaper: 15 ns
 - slowShaper: 50 ns
 - timingResolution: 700 ns (**but currently no smearing**)



Analysis setup

Using iLCSoft v02-02 (latest as of today)

Simulation with `ddsim`

- Single photons @ 30 GeV \sim 400k events
- Single K_L^0 @ 30 GeV \sim 150k events

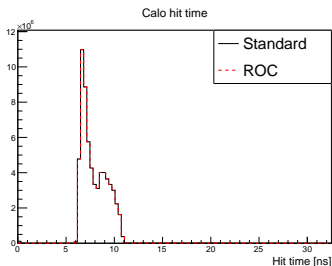
Looking at:

- Individual hit times
- Individual hit energy
- Total hit energy sum in the event
- Total number of hits

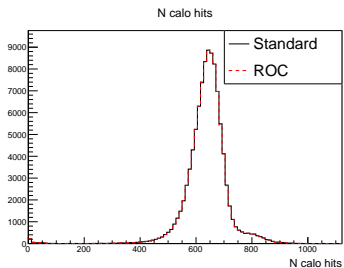
All after digitization and reconstruction (current calibration applied)
Look separately in ECal and HCal



Single photons (30 GeV) - ECal only



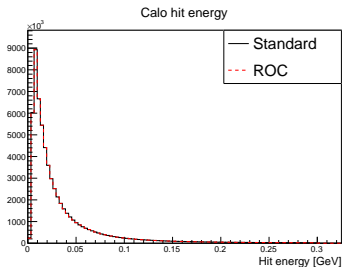
Individual hit time stamps



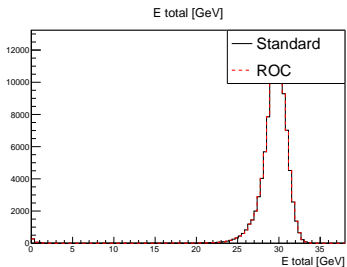
Total number of hits

Identical distributions ...

Single photons (30 GeV) - ECal only



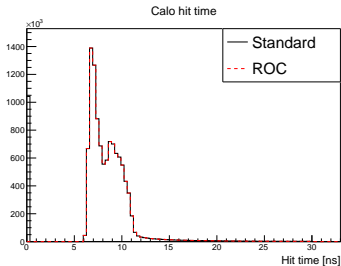
Individual hit energies



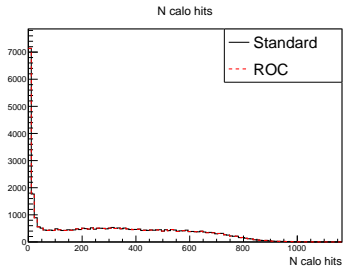
Total energy sum

Identical distributions ...

Single K_L^0 (30 GeV) - ECal only



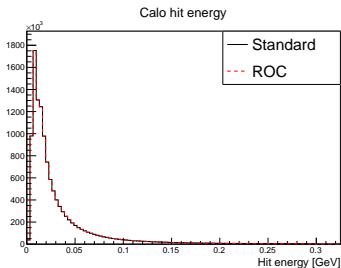
Individual hit time stamps



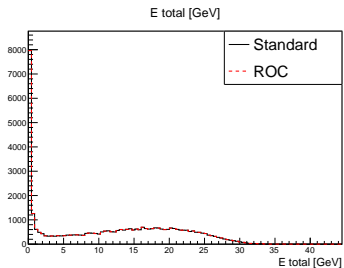
Total number of hits

→ Non negligible number of cases of wrong time stamping in standard implementation (bin at $t=0$)

Single K_L^0 (30 GeV) - ECal only



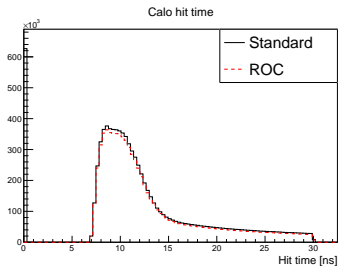
Individual hit energies



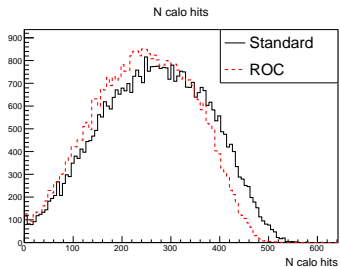
Total energy sum

Everything else looks identical ...

Single K_L^0 (30 GeV) - HCal only



Individual hit time stamps



Total number of hits

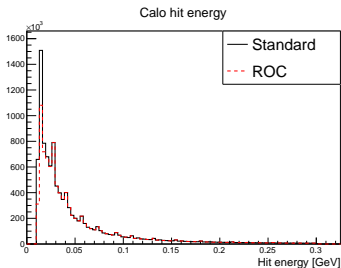
→ Again: wrong time stamps for standard impl. (bin at $t=0$)

→ Less hits due to parameter change:

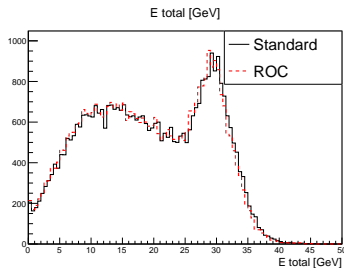
$$t_{win}=100 \text{ ns} \rightarrow t_{slow}=50 \text{ ns}$$



Single K_L^0 (30 GeV) - HCal only



Individual hit energies



Total energy sum

- Only very low energetic hits cut away
- Affecting a little bit the overall energy calibration

Conclusion and outlook

New implementation of calorimeter digitizer

- More realistic timing treatment
- Matches the ROC signal shaping
- Still need iterations with calorimeter experts
- Follow the code evolution here:
→ <https://github.com/iLCSoft/MarlinReco/pull/83>

Comparison of the two implementations showed:

- Photons in ECal have identical behavior
- Differences for K_L^0 ...
 - Bin at $t=0$ disappears with new implementation
 - A few low energetic hits cut away (parameter updates)
 - Number of hits and total energy are lower
 - Probably requires a calibration after code update

