

Simulation of Pure CsI

Guglielmo De Nardo

University of Napoli Federico II and INFN

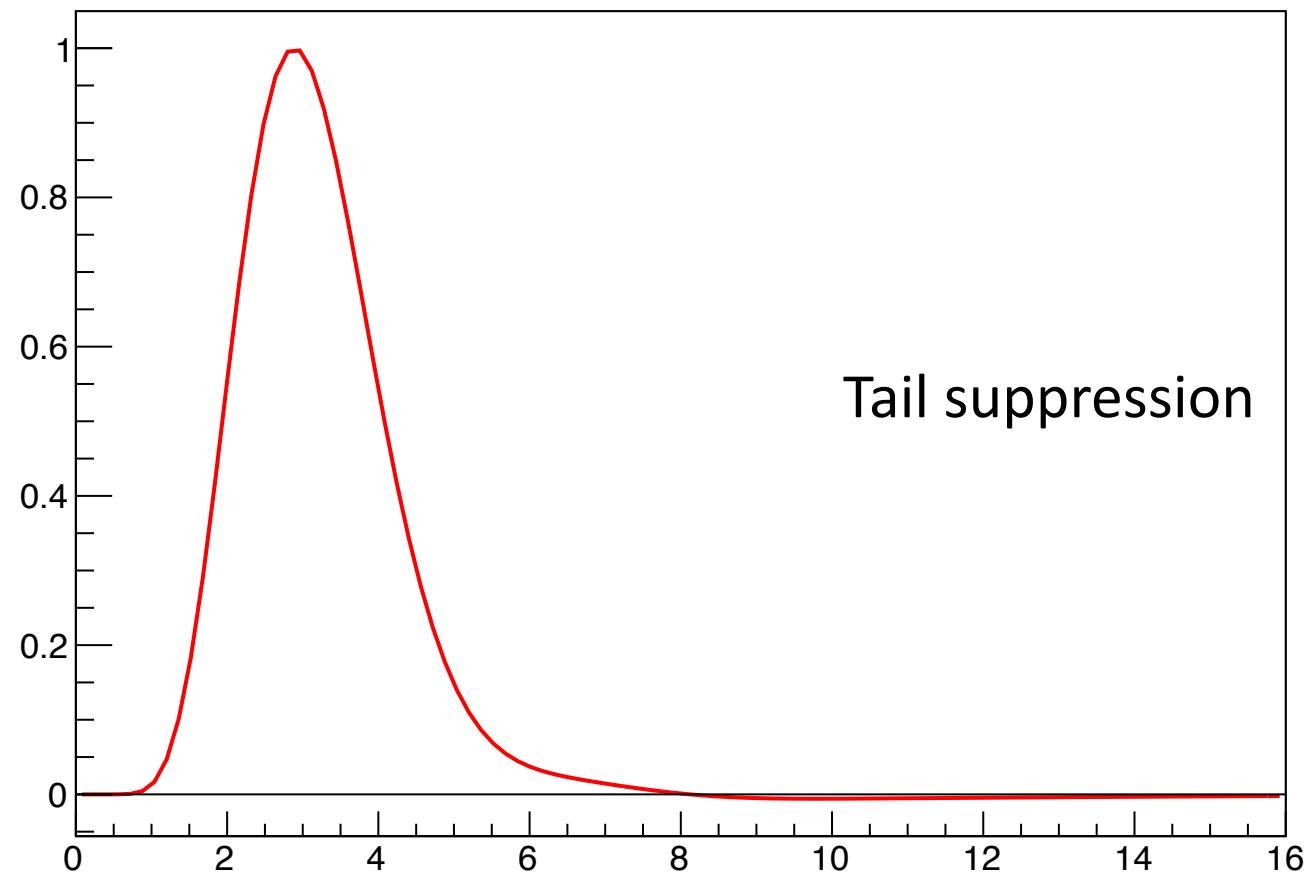
Belle II Italy meeting, December 22 2015

Csi(Tl) digitization

In ECLDigitizerModule:

- Parametrized analytic function (ShaperDSP) to describe electronic signal is sampled every 17.7 ns (ADC tick / 32)
 - This sampling is used to populate ADC counters for each crystal
 - 1 ADC count == 50 KeV (1 / 20 MeV)
 - Baseline (no signal no noise) == 3000 counts
- Waveform fit to adc counts to extract amplitude and time of the signal pulse

fun2



μs

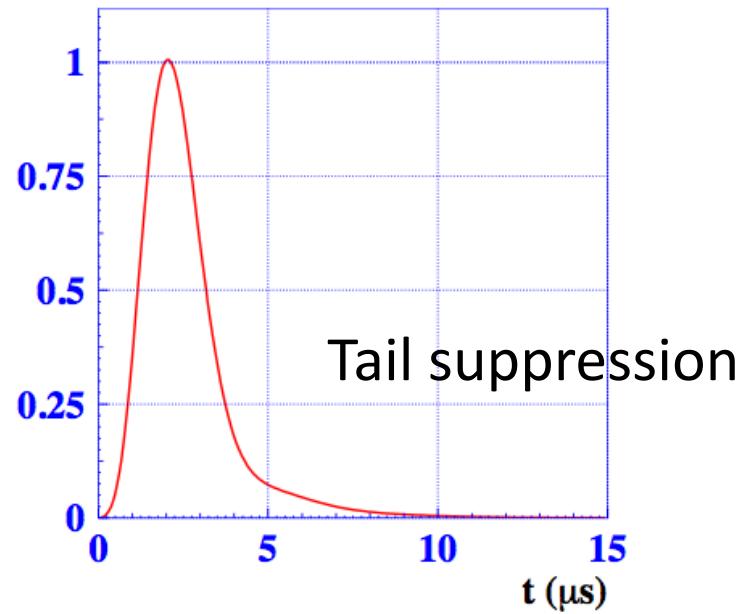
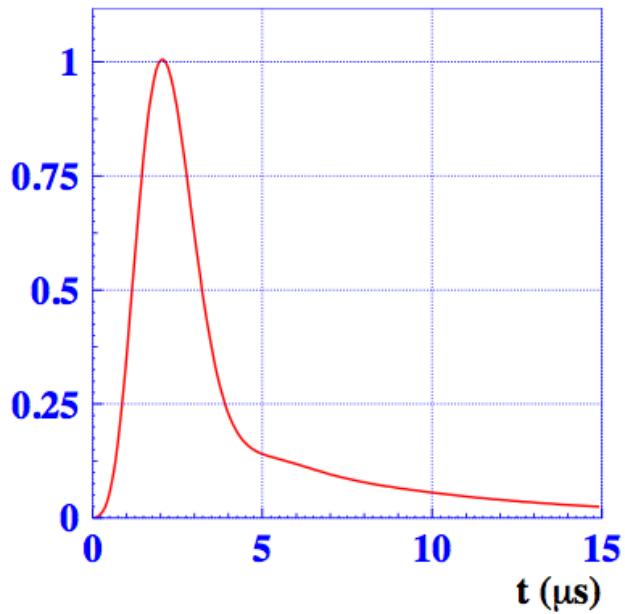
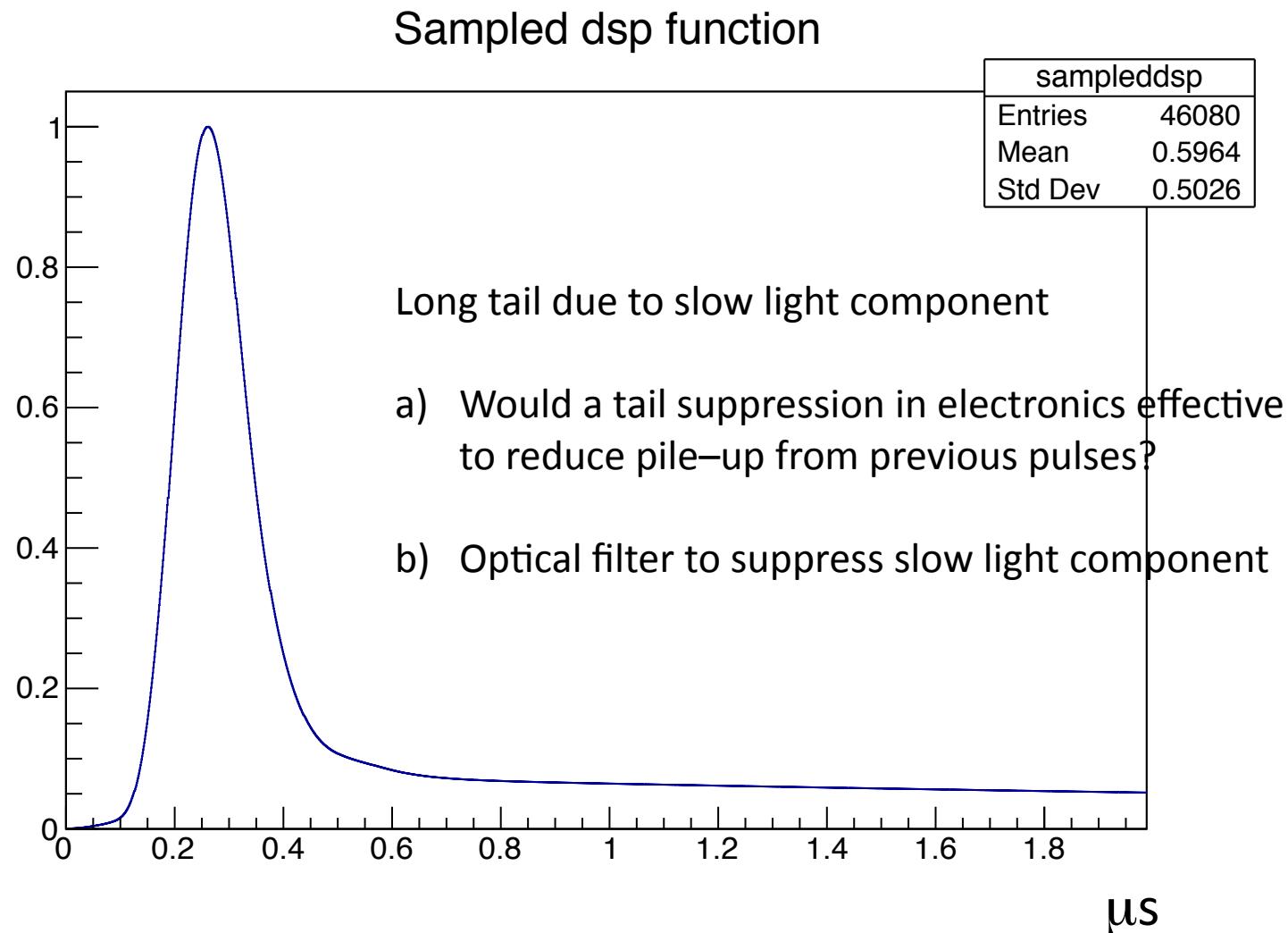


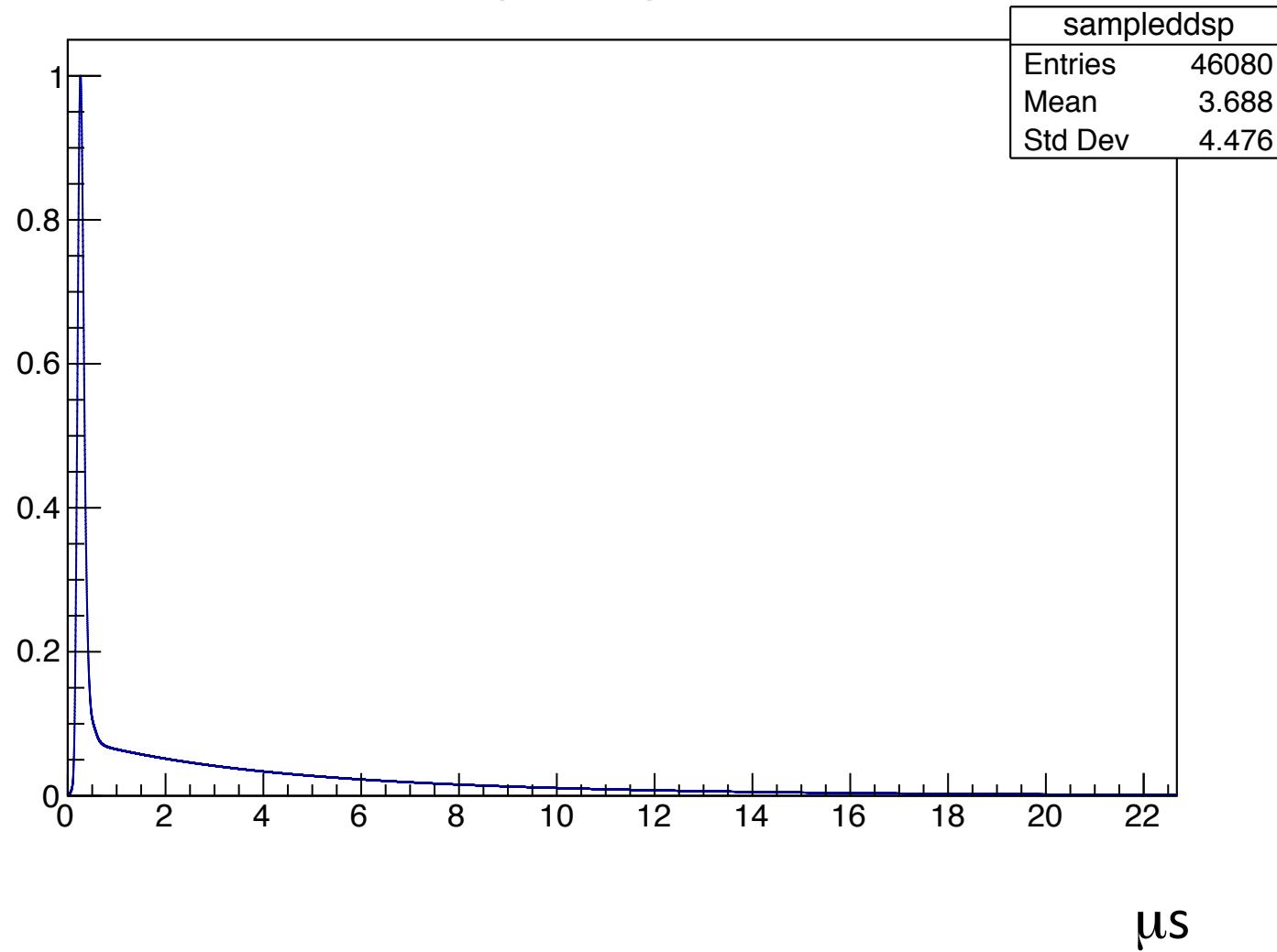
Figure 9.6: Shape of the CsI(Tl) scintillation signal without (left) and with (right) tail suppression.

Shaper function from LNF setup



Shaper function from LNF setup

Sampled dsp function



Digitization of Pure CsI

- Tried to re-use as much as possible existing CsI(TI) software
- ECLDigitizerPureCsI module based on tools already developed for ECLDigitizer
 - Implement same logic
 - 31 ADC counts
 - Input: ECLHits
 - Electronic shape from a template (TH1F) 1 bin == 1 ns
 - Will try same approach for electronic noise and fitting

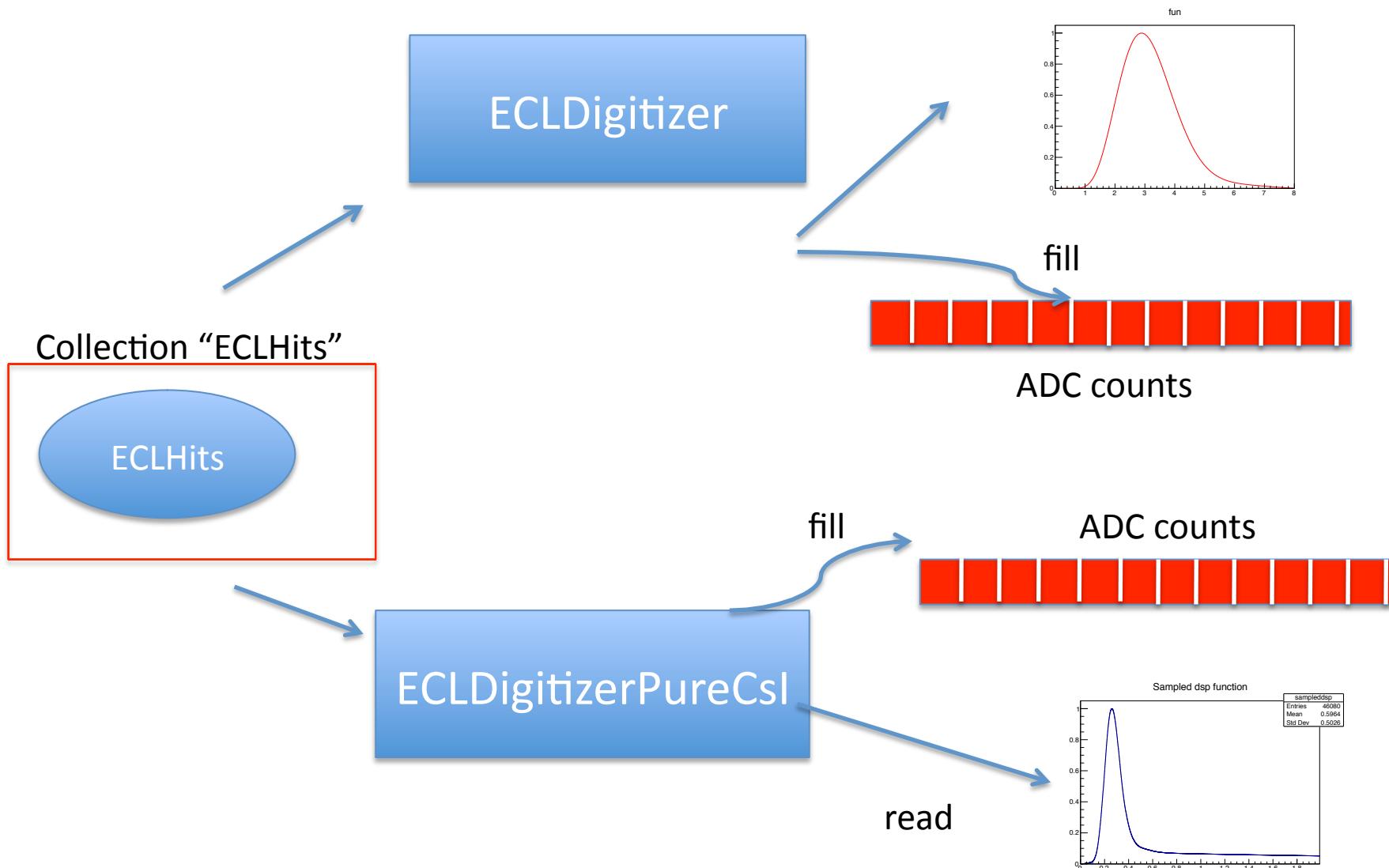
Test configuration

Parameter	Csl(Tl)	Pure Csl
Adc counts	31	31
Shaper tau	500 ns	50 ns
Fundamental f	508 MHz	same
Trigger tick	3.93 ns (2 / f.)	same
ADC tick	567 ns (144 trigger ticks)	31.4 ns 8 trigger ticks
Offset sim t0 → adc t0	+/- 567 ns – 320 ns	Signal starts in bin 17 No trigger sim. yet
Single hit signal length	27.2 μs (48 ADC ticks)	22.6 μs (720 ADC ticks)

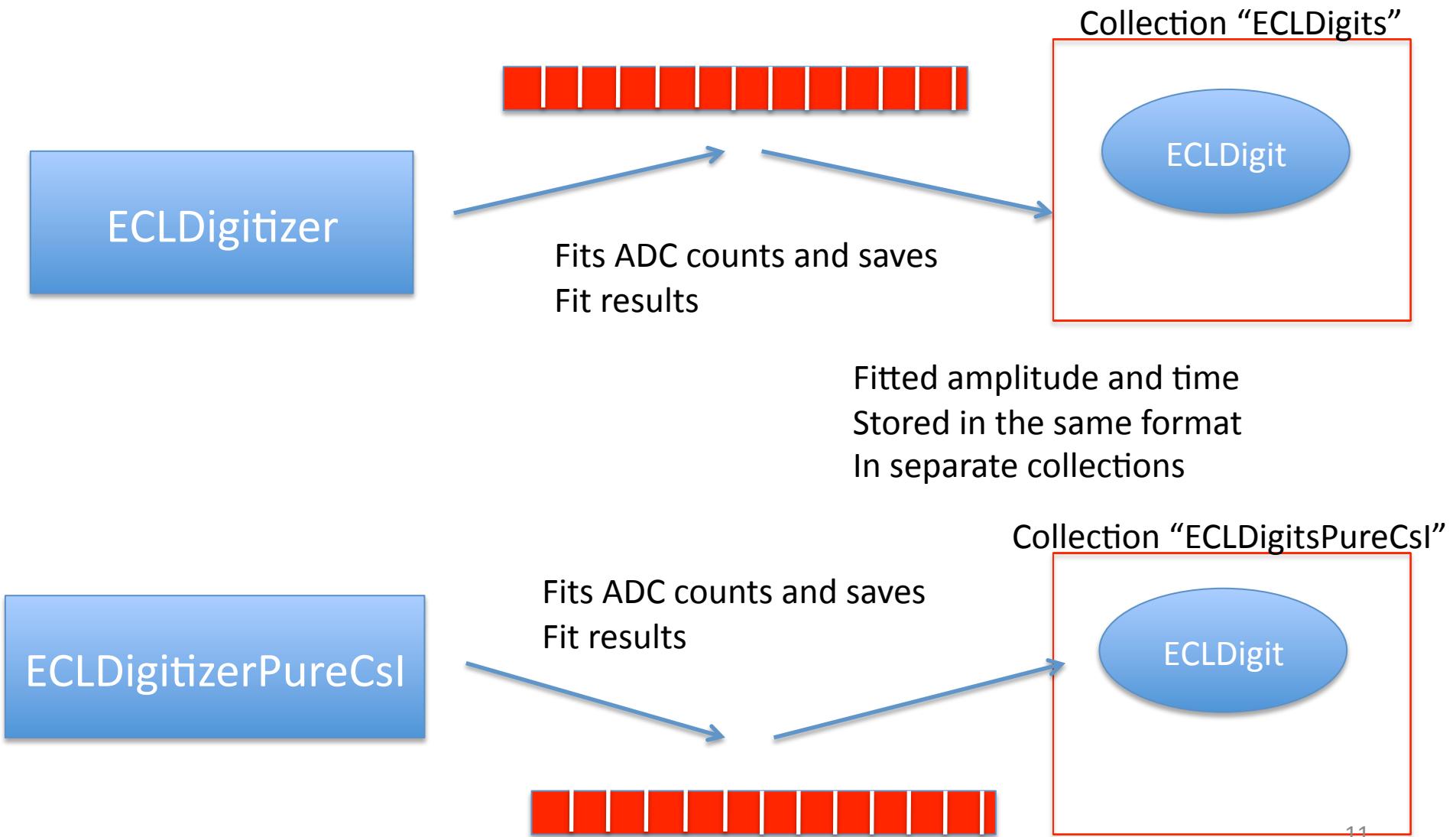
Configurable parameters

Parameter	Csl(Tl)	Pure Csl
Electronic noise	Correlated noise matrix	Same. Currently implemented a single parameter in the module → diagonal matrix
Photostatistics	No	fluctuate LY for each pulse
WF fit with covariance matrix	Yes	Yes, with calibration tools committed in svn

Digitization flow



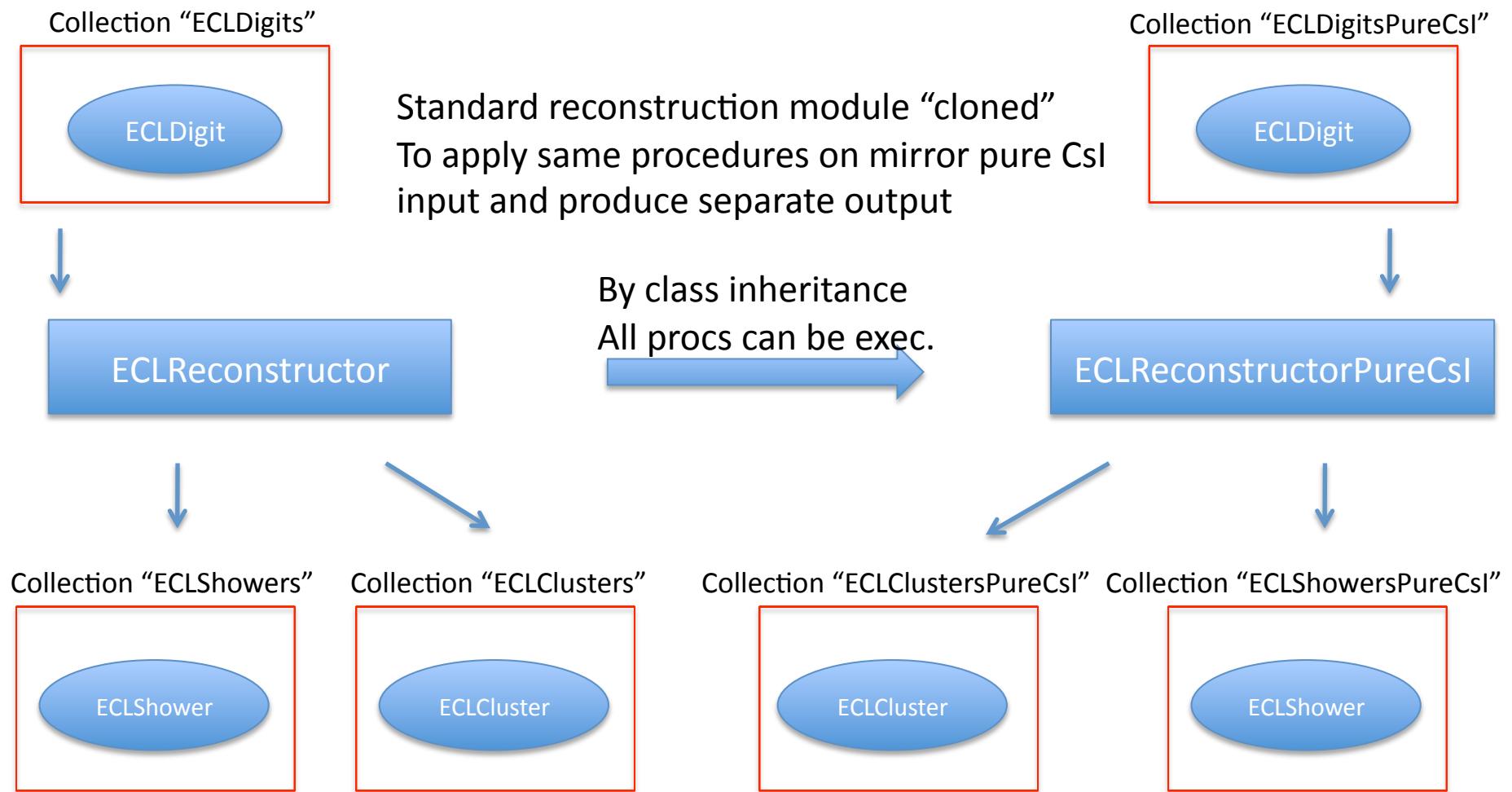
Amplitude and time estimate



Status

- Signal shape is a template read from root file
- ADC counts made exactly the same way as in std ECL digitization
- Electronic noise configurable
 - Any matrix can plugged in.
 - Current implementation: uncorrelated noise, an module parameter to set the sigma in MeV
- Photostatistics configurable
 - Fluctuate the pulse amplitude randomly (gaussian)
- Not able to use same fit software.
 - Rewritten from scratch to implement the same fit procedure
 - Covariance matrix in fit implemented. Default is diagonal.

Cluster reconstruction



The second modules inherits from the first all the methods only overriding the name of input and output lists.

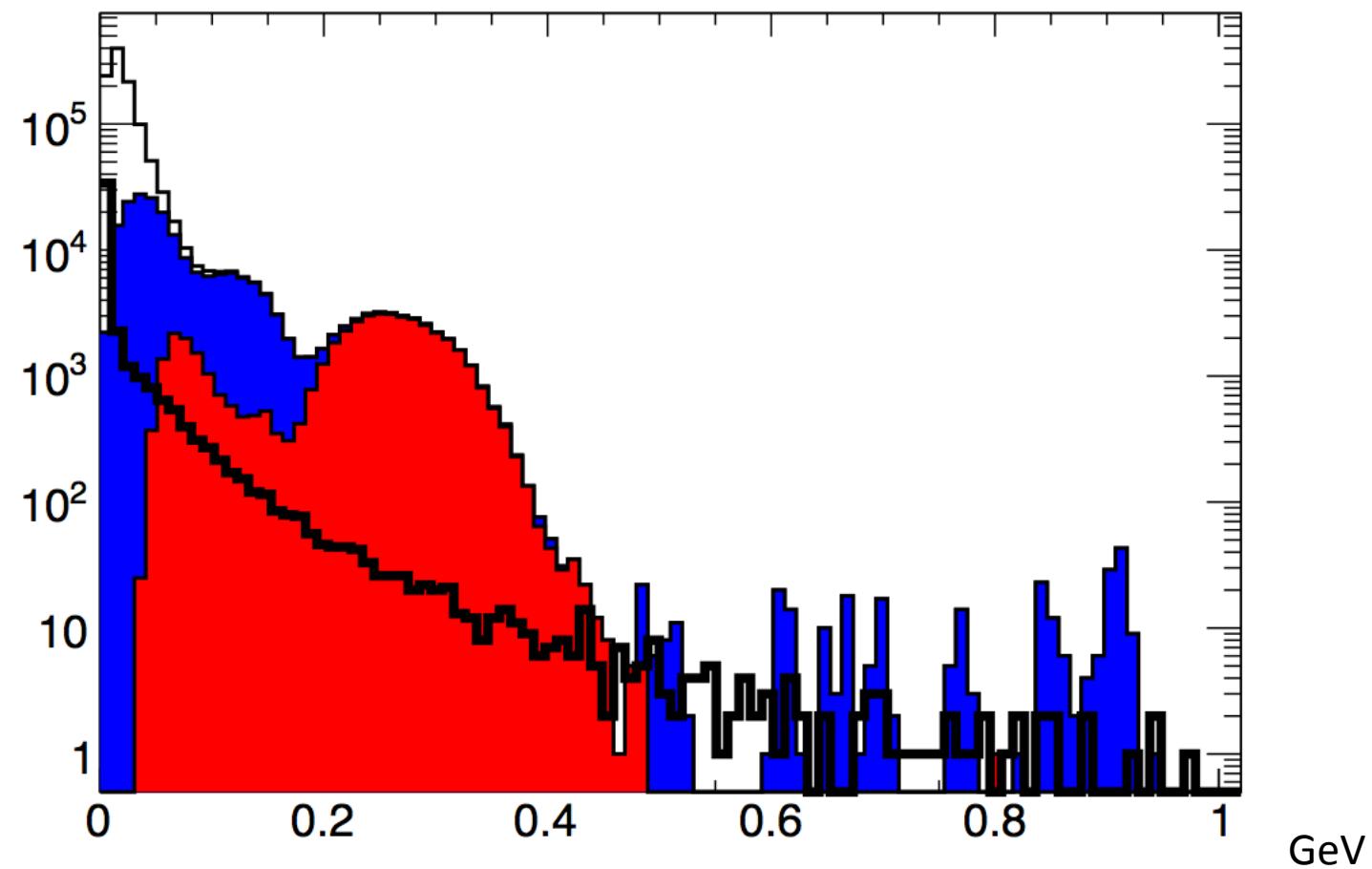
Test

- Sample of 1000 single γ with ParticleGun, with and without background
 - Energy: 100 MeV
 - Acceptance:forward endcap
- Sample of 1000 Y(4S) events with backgrounds to measure and compare performances
- Studied the digitization in very forward region (rings 1-4)

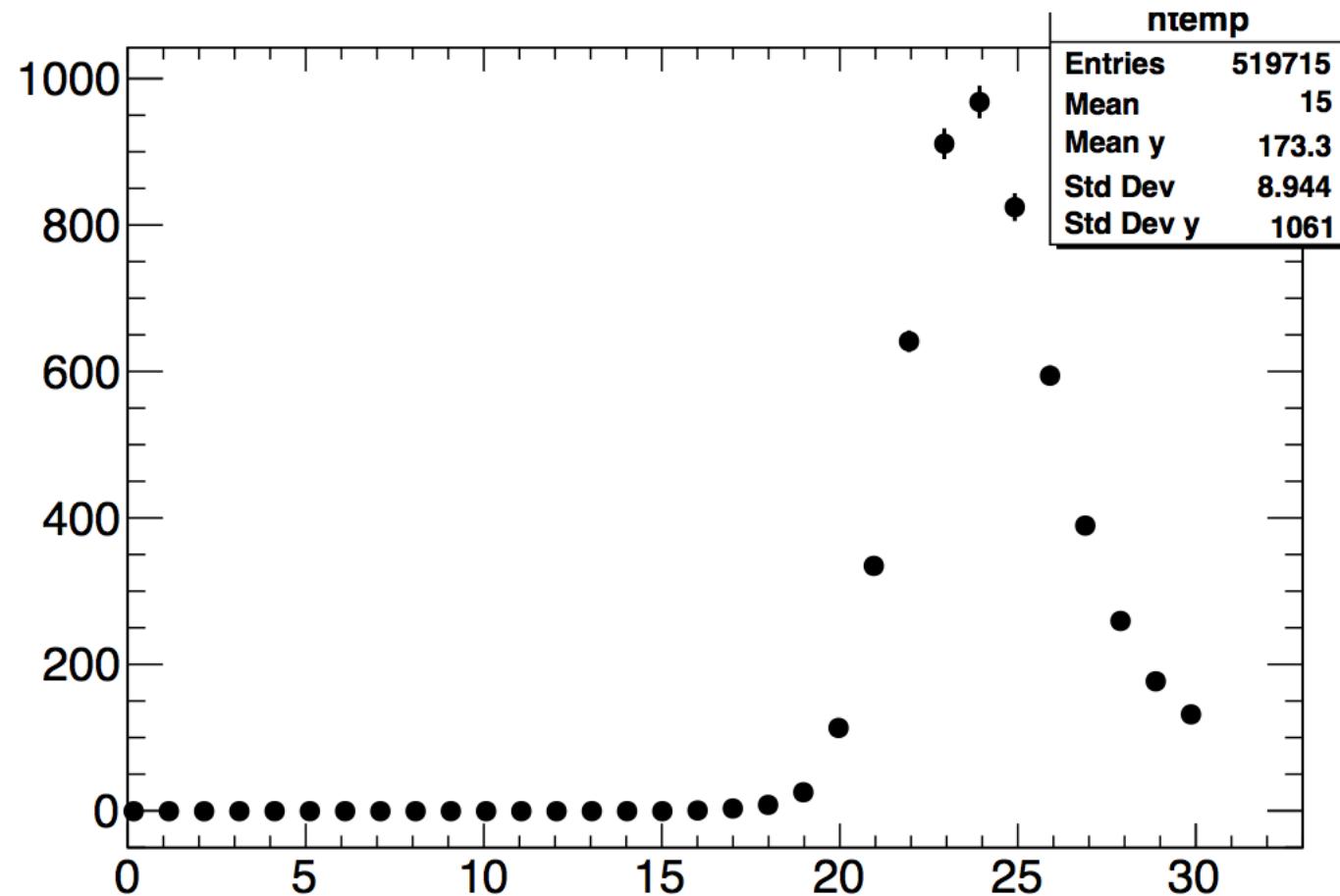
Caveat in Comparing CsI(Tl) vs pure CsI digitization

- no electronic noise, no photostatistics
- Shaper is just a CR RC4, not final electronics
- Light waveform is realistic but not optimized (pile-up is very conservative)

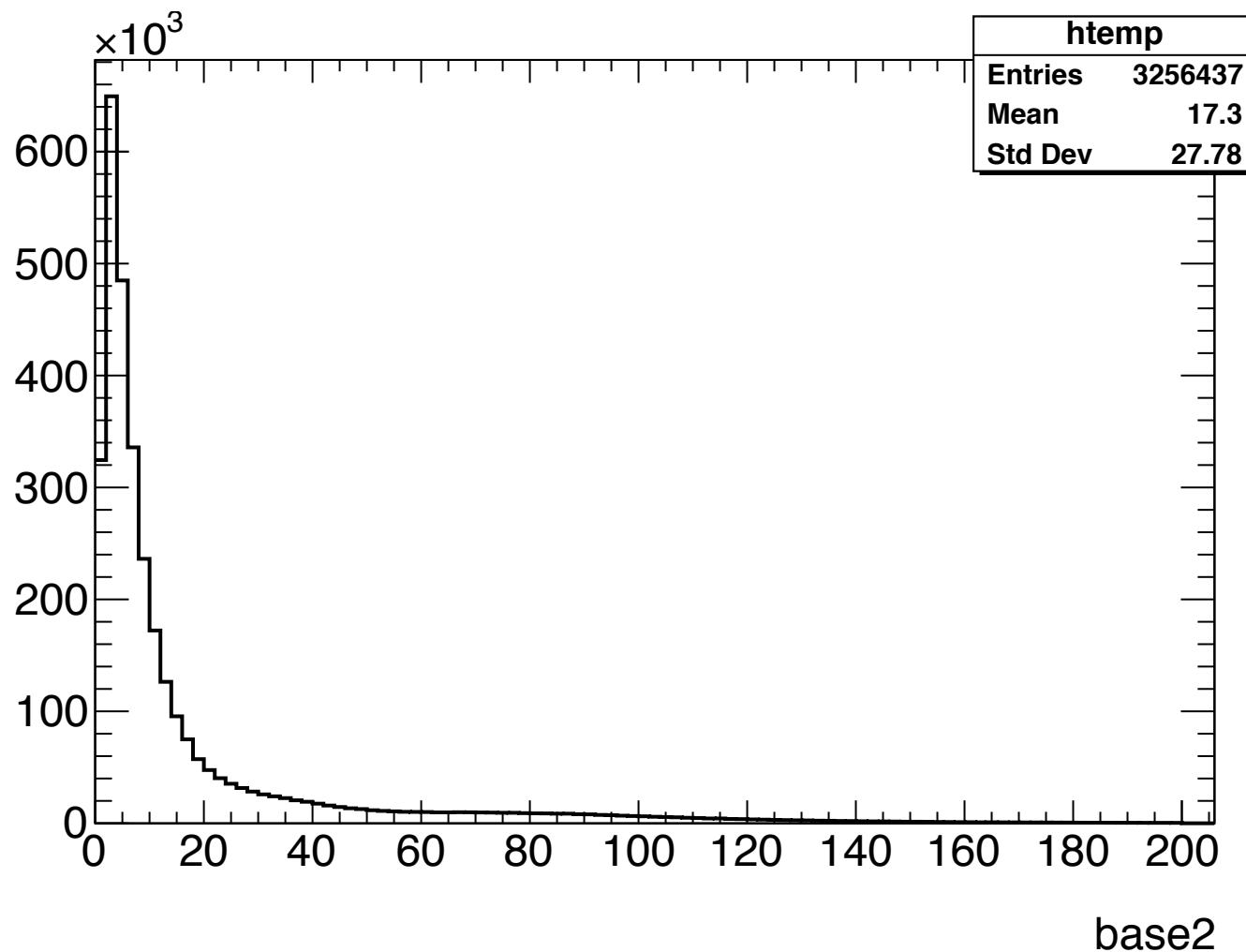
Energy distributions



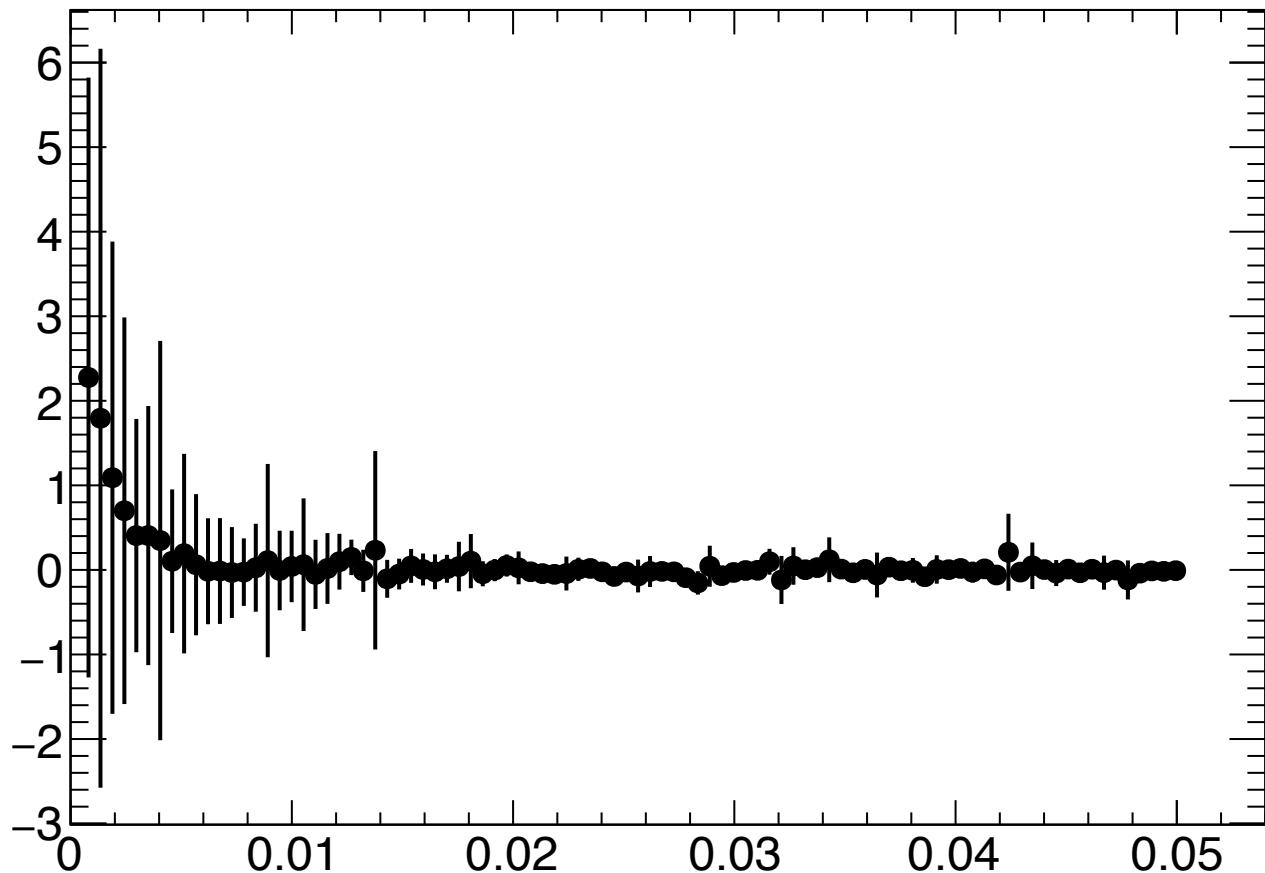
Profile of the adc channels no background – no noise



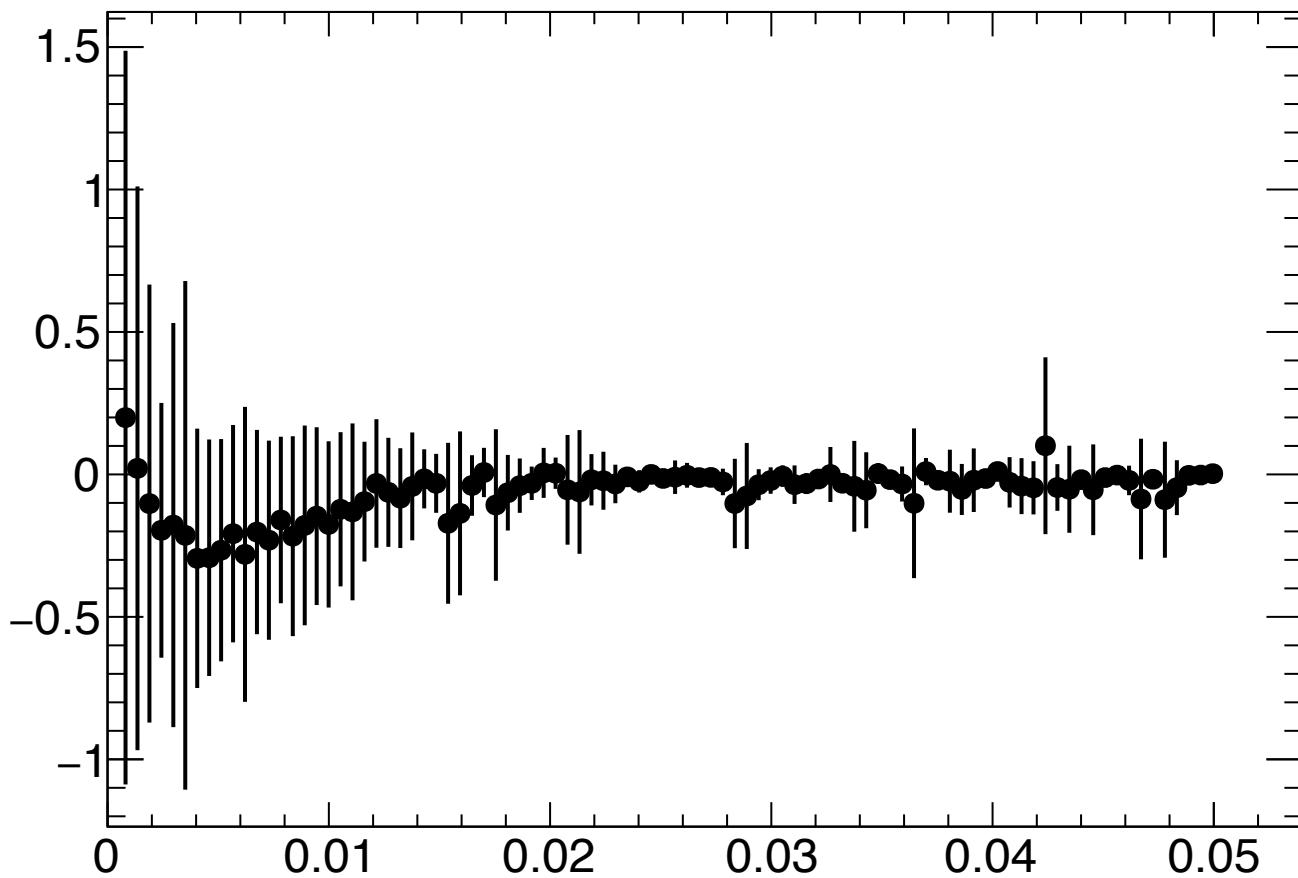
Baseline fluctuations beam background – no noise



E resolution – CsI Tl



E resolution – pure CsI

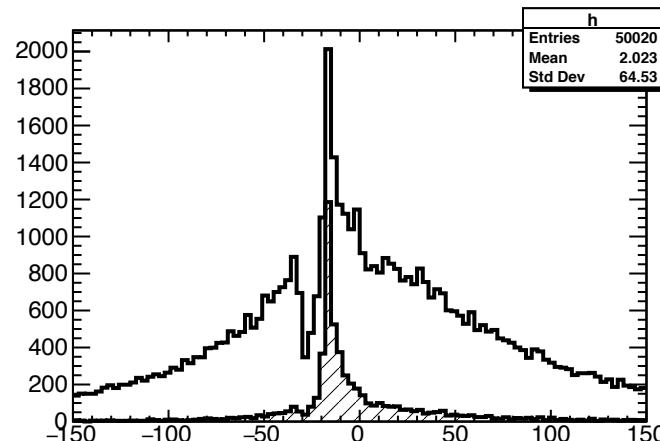


Digit Time distribution

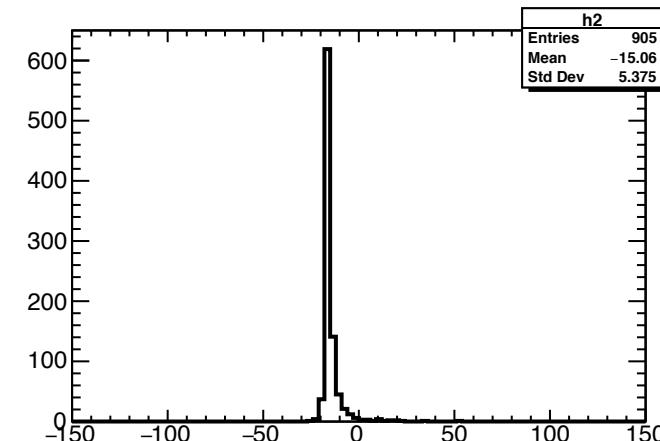
Pure CsI

$-30 < t < 20$

low energy

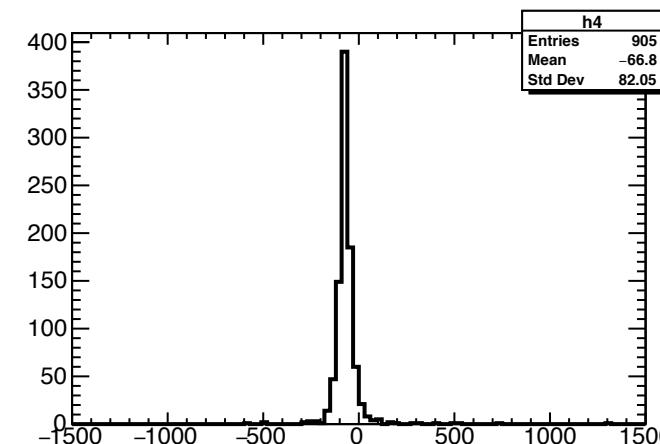
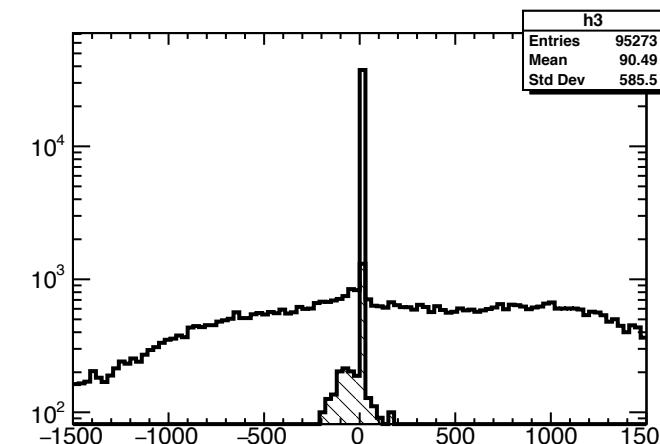


high energy

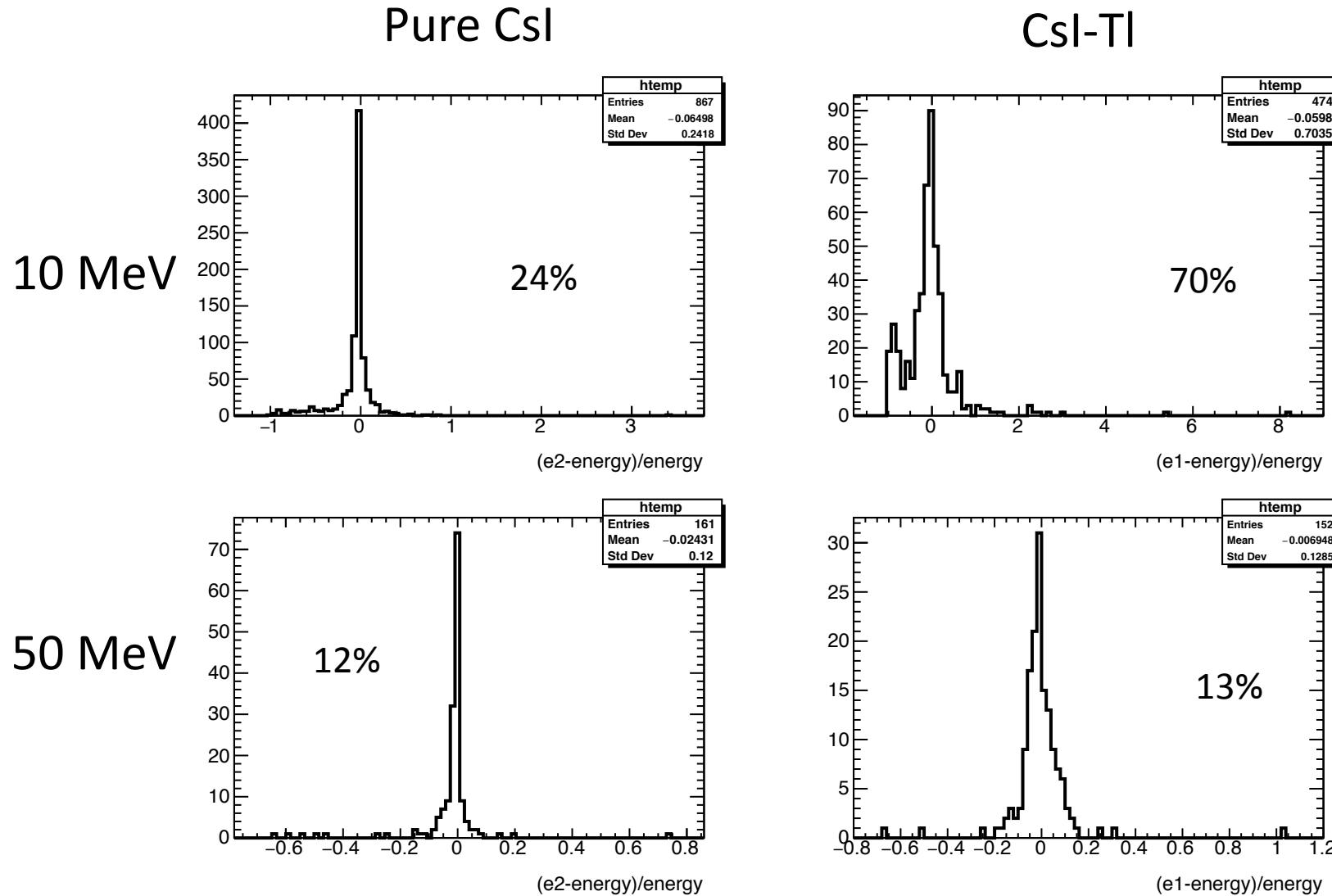


CsI-Tl

$-200 < t < 200$

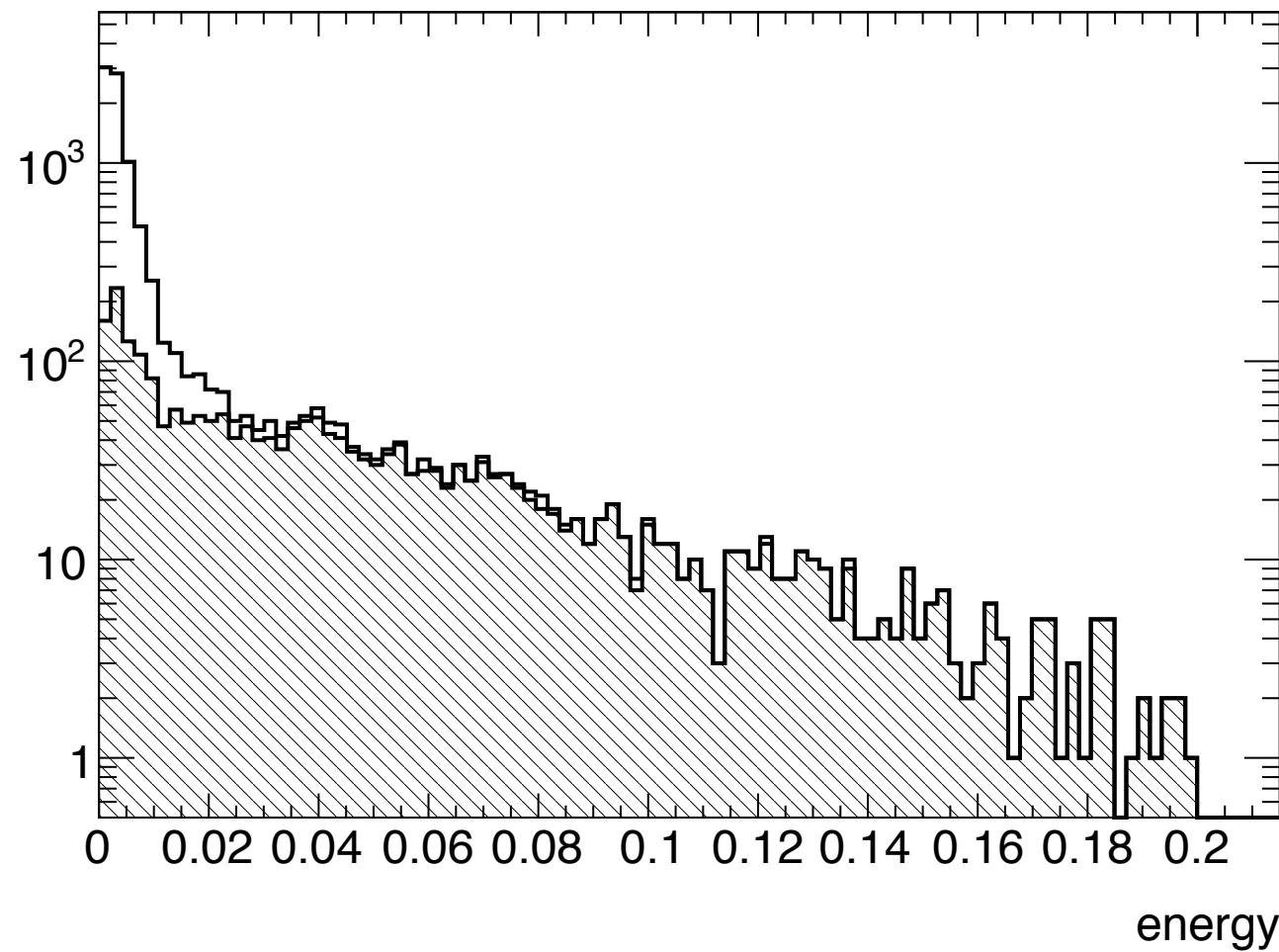


E resolutions for digi in time



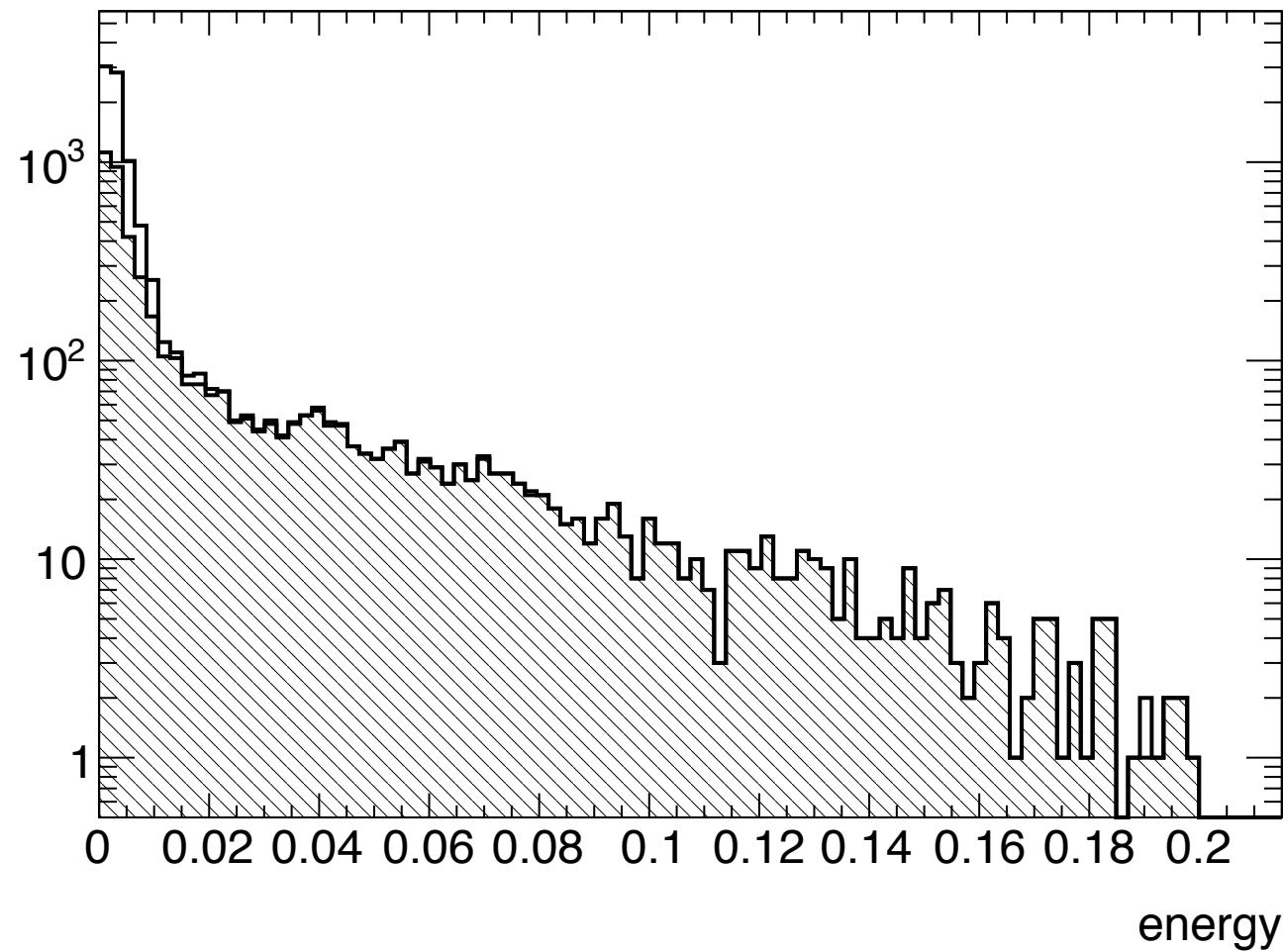
Efficiency - baseline

Comparing in time digit vs crystal with at least 1 MeV energy from physics photon



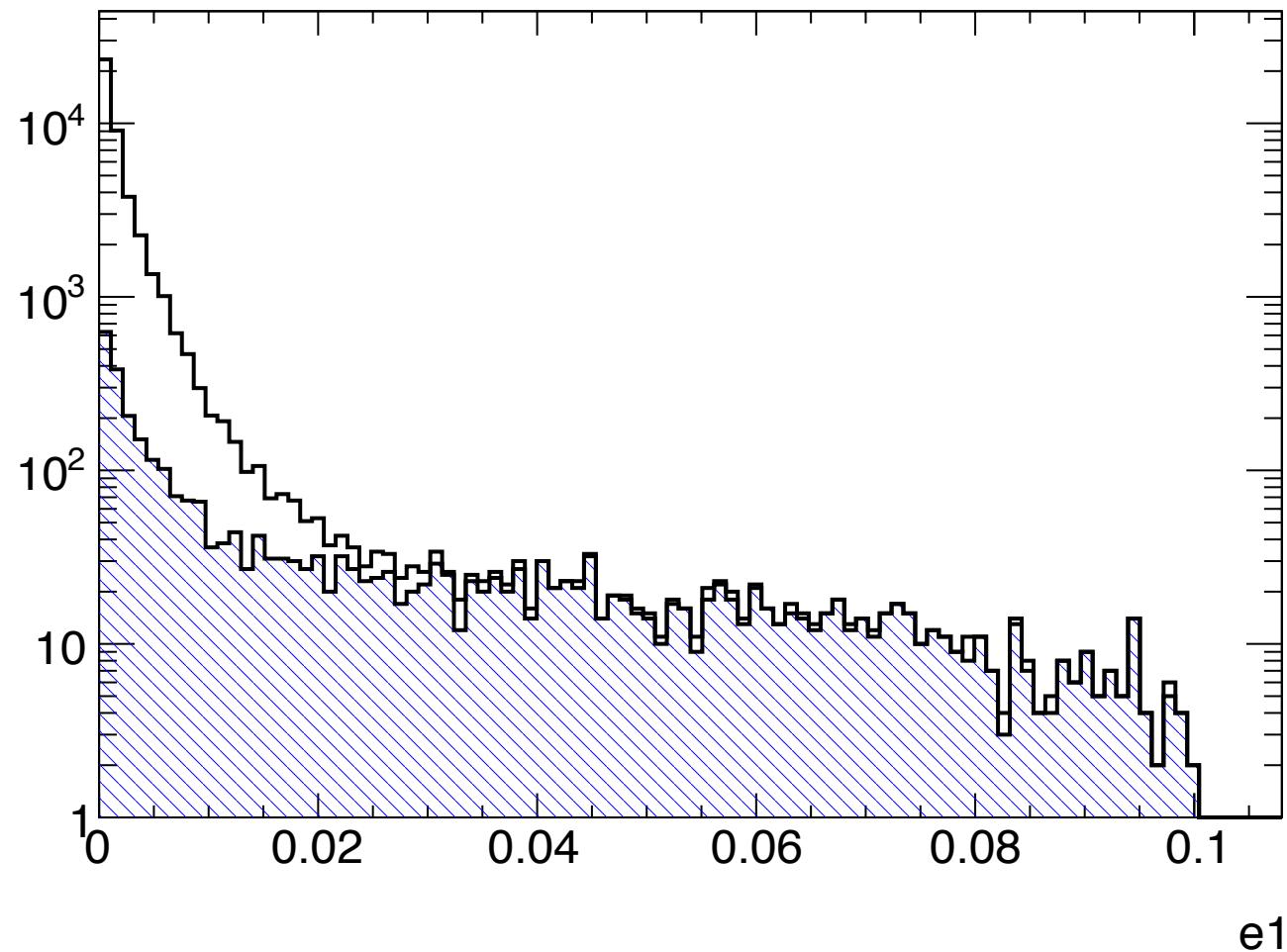
Efficiency – pure CsI

Comparing in time digit vs all digitwith at least 1 MeV energy from physics photon



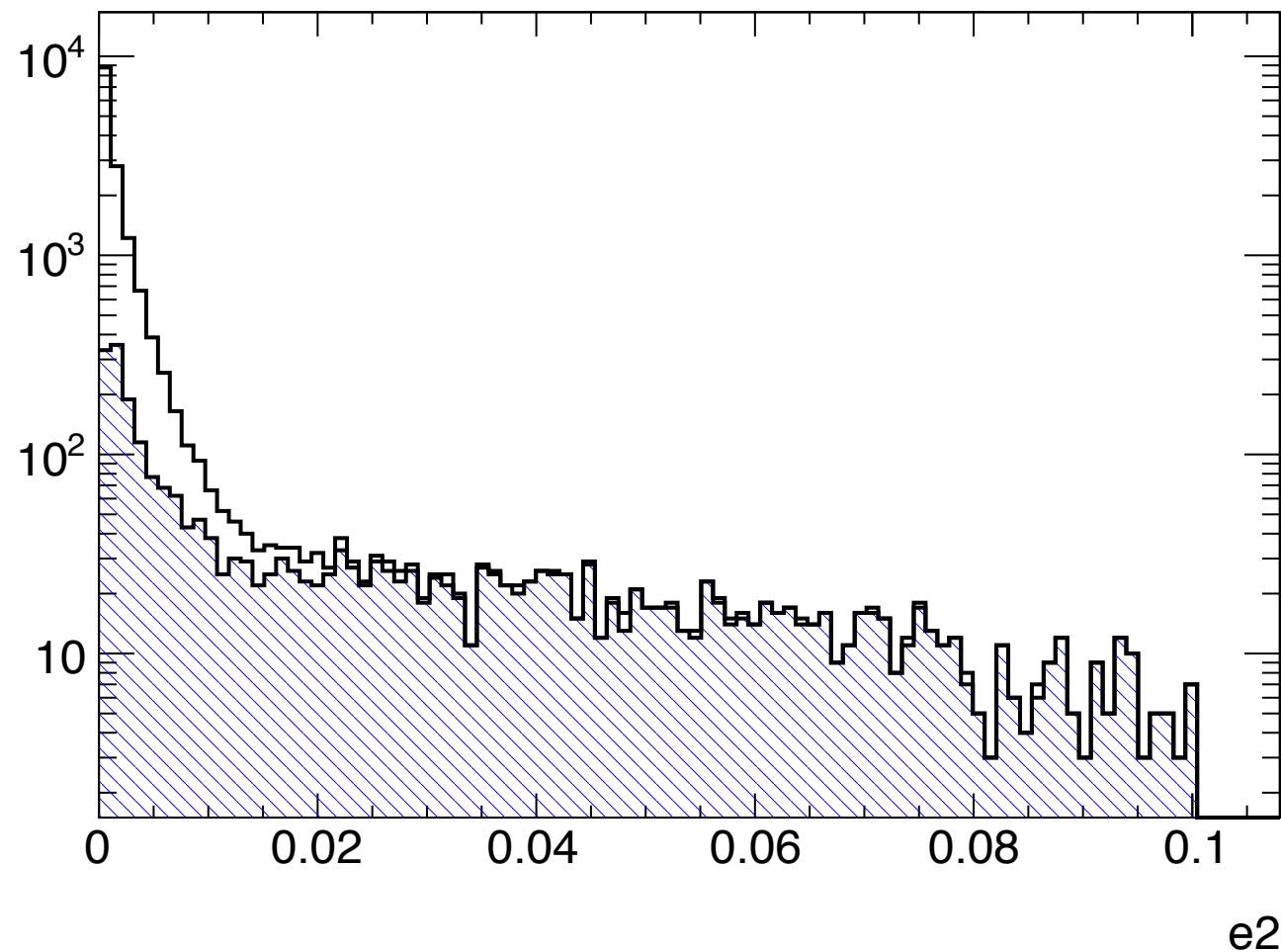
Purity - Baseline

Comparing in time digit with at least 1 MeV energy from physics photon to all in time digits



Purity – pure CsI

Comparing in time digit with at least 1 MeV energy from physics photon to all in time digits



Conclusions

- Developed the framework to simulate simultaneously the response of pure and Tl doped setups
 - Reusing for pure CsI as much as possible components already developed for baseline
 - Data flow completely independent (no side effects on baseline)
- Successfully tested the complete chain up to cluster reconstruction (not shown today)
- Implemented features:
 - Waveform fit of amplitude and time
 - Configurable parameters:
 - Electronic noise providing a matrix for correlated noise
 - Fotostatistics: at present moment the total light yield per pulse can be smeared randomly (gaussian p.d.f) providing the sigma at 1 MeV
 - Trigger fluctuation not yet implemented

Conclusions

- Quick test with 1000 Y(4S) events with background looking at performances in ring 1-4
 - Noise turned off (electronic noise photostatistics)
 - Only “long” shape for waveform (LNF shape)
- As expected pure CsI performing better when superior timing is relevant
 - To reject fake hits (single crystals) for lower energy deposits $E < 20$ MeV in presence of high background level
 - Remain to be understood the impact on reconstruction and physics
- All the software to run simulation, calibration of covariance matrices and producing ntuples is available and up to date in svn, in ecl package
 - For people to make detailed studies and help development