Pile-up simulation - update on CsI

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Pile-up simulation using cosmic-ray data

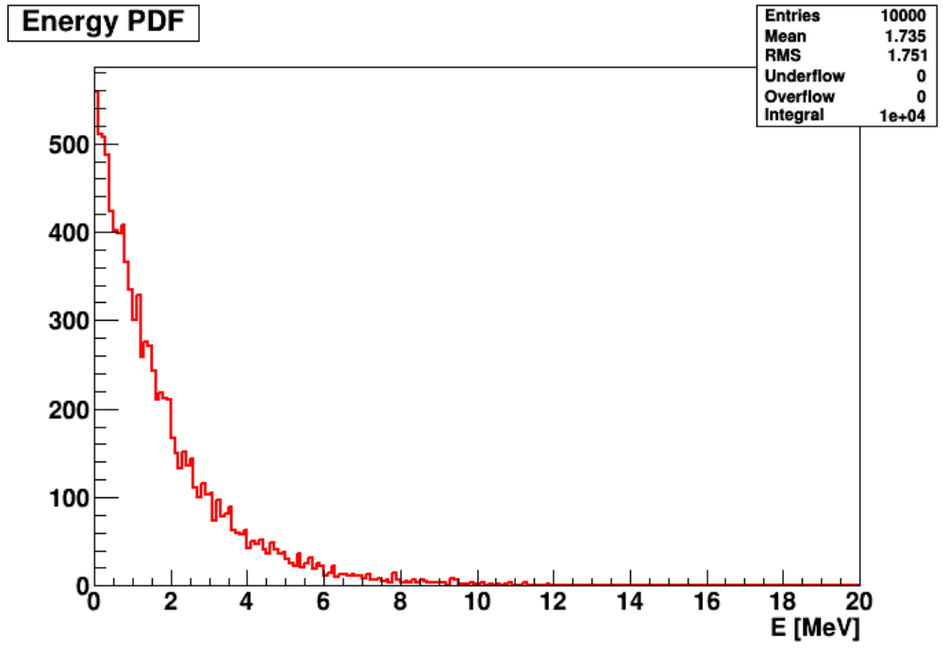
- CR data were collected with:
  - a Belle CsI(Tl) crystal with PIN diode and standard Belle preampl readout
    - time window of 12μsec @ 500MSa/s (6000 samples).
    - **MPV** of CR track = **40 MeV**
  - a pure CsI crystal with LA hamamatsu APDs + CREMAT preamp
    - Combined LAAPD+excelitas @ LNF run 168
    - time window of 10μsec sampled at 1GSa/s (10000 samples)
    - **MPV** of CR track = **30 MeV**

- Pile-up hits are simulated using real waveforms buffered from previous events.
  - require amplitude to be > 2.0mV (CsI(Tl)) or 0.5mV (CsI) to have a non-empty background event

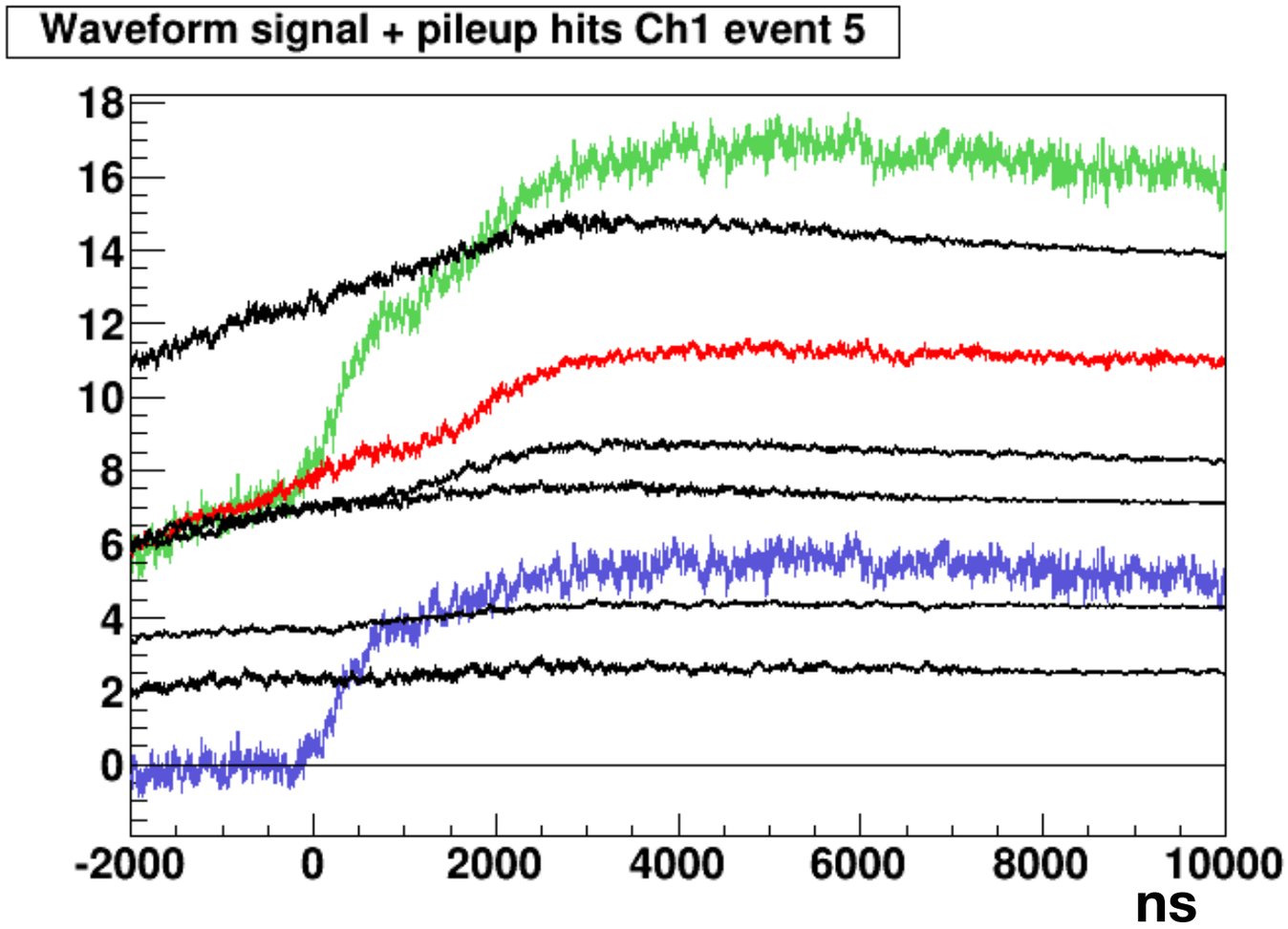
Pile-up simulation using cosmic-ray data (II)

- Amplitude of buffered event is rescaled to obtain amplitude of background hit

- Background hits from simulation have an exponential energy distribution
  - use background level of crystal #80 (layer 2 of fwd endcap) from MC campaign 11: on average **5.1MeV in 3hits** per μs with a minimum energy of 0.5MeV (B. Oberhof)
  - Use exponential energy distribution with mean **$\lambda = E_{average}/nhit$** =5.1MeV/3hits;
  - assume time distribution is flat in interval [-2,+10] μs
  - on average 5.1 x 12 = **61 MeV** in 3x12 = **36 hits**, are added to each 12μs long waveform

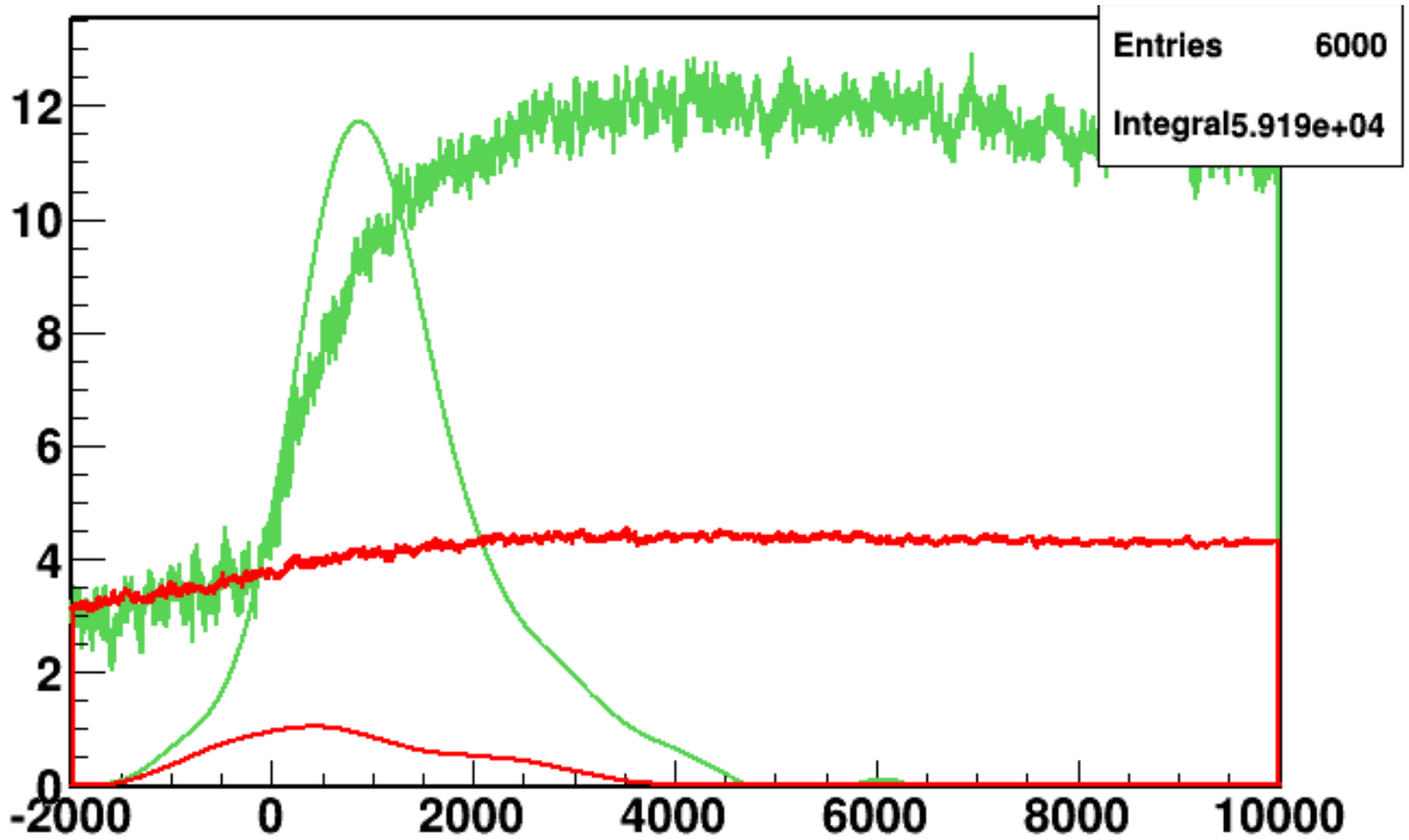


For illustration - Signal + background hits



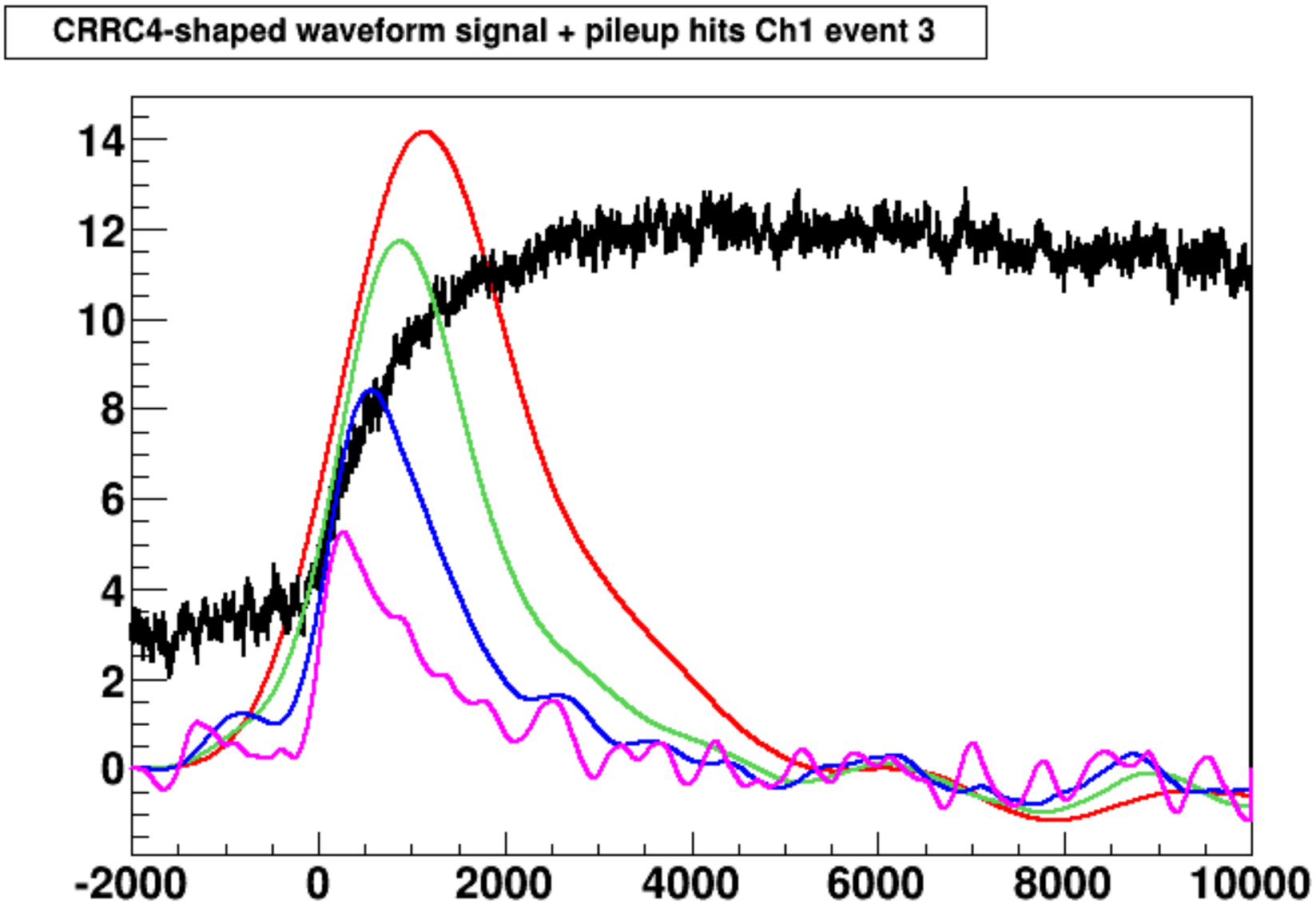
Indigo waveform is the original signal, **red** waveform is the background resulting from the algorithm, **green** waveform is the sum. More background samples from other events are shown by the **black** curves. Large fluctuations in background size and shape are observed.

CR-(RC)^4 shaping



Shaping CR-(RC)^4 with tau=500ns applied to “signal+background” and “background only”

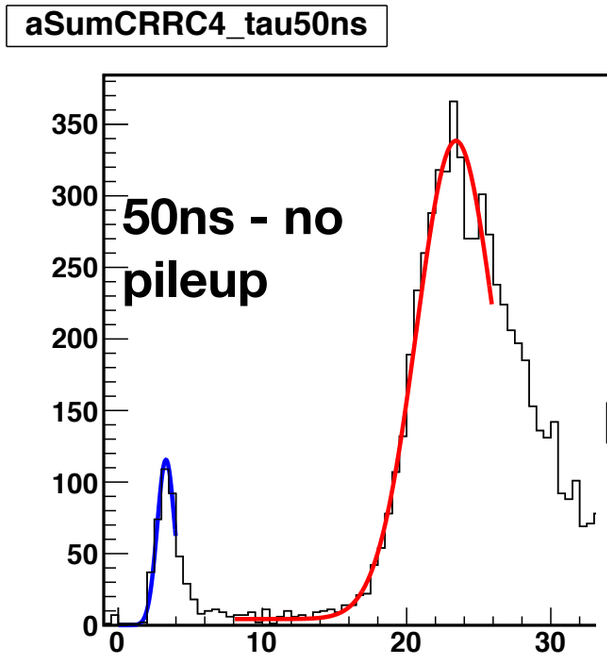
CR-(RC)^4 shaping

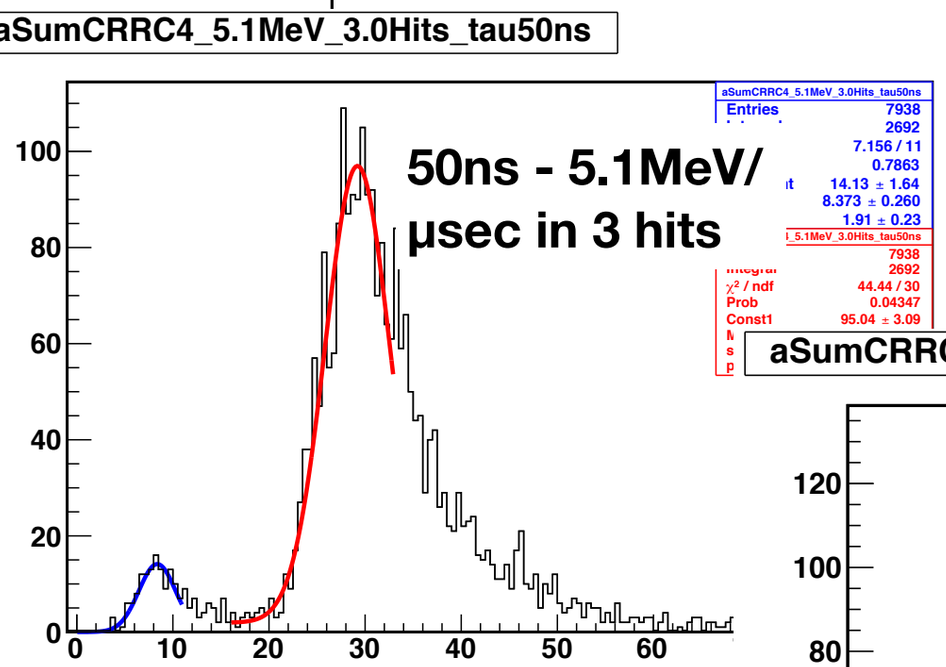


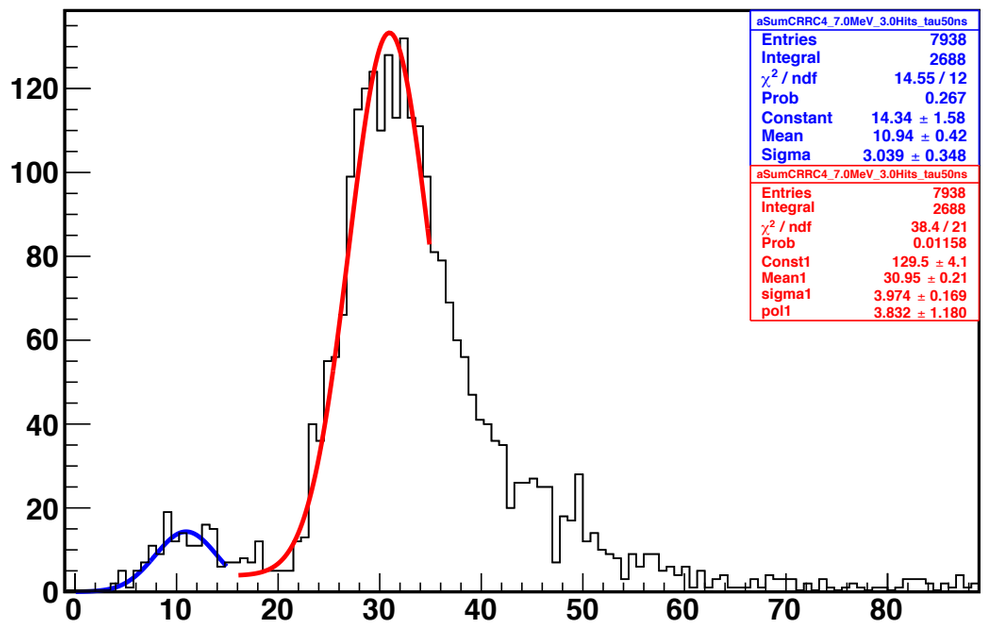
Shaping CR-(RC)^4 with tau=**700**, **500**, **300**, **150** ns

Pure CsI

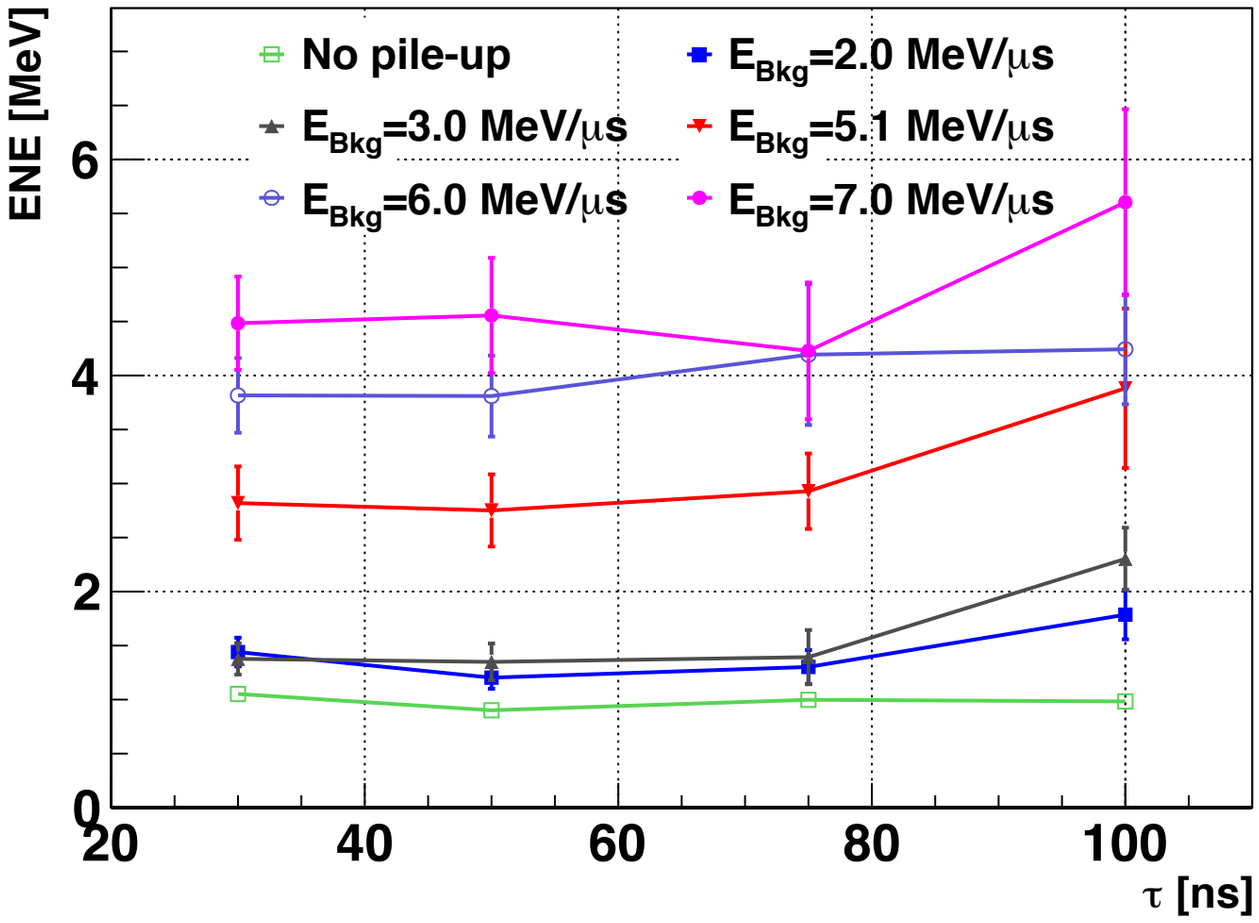
Sample fits for ENE





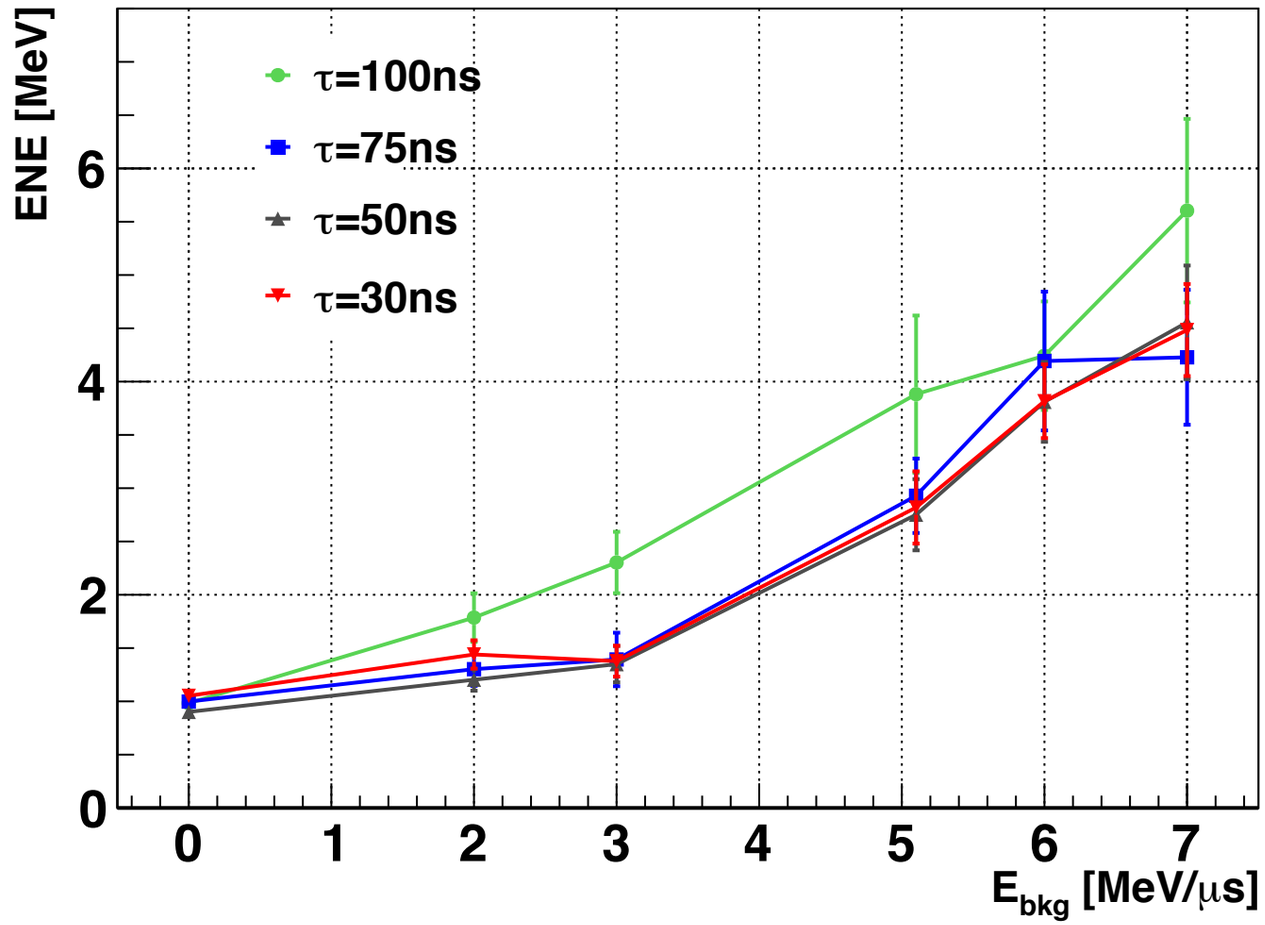


Pure CsI: ENE vs tau



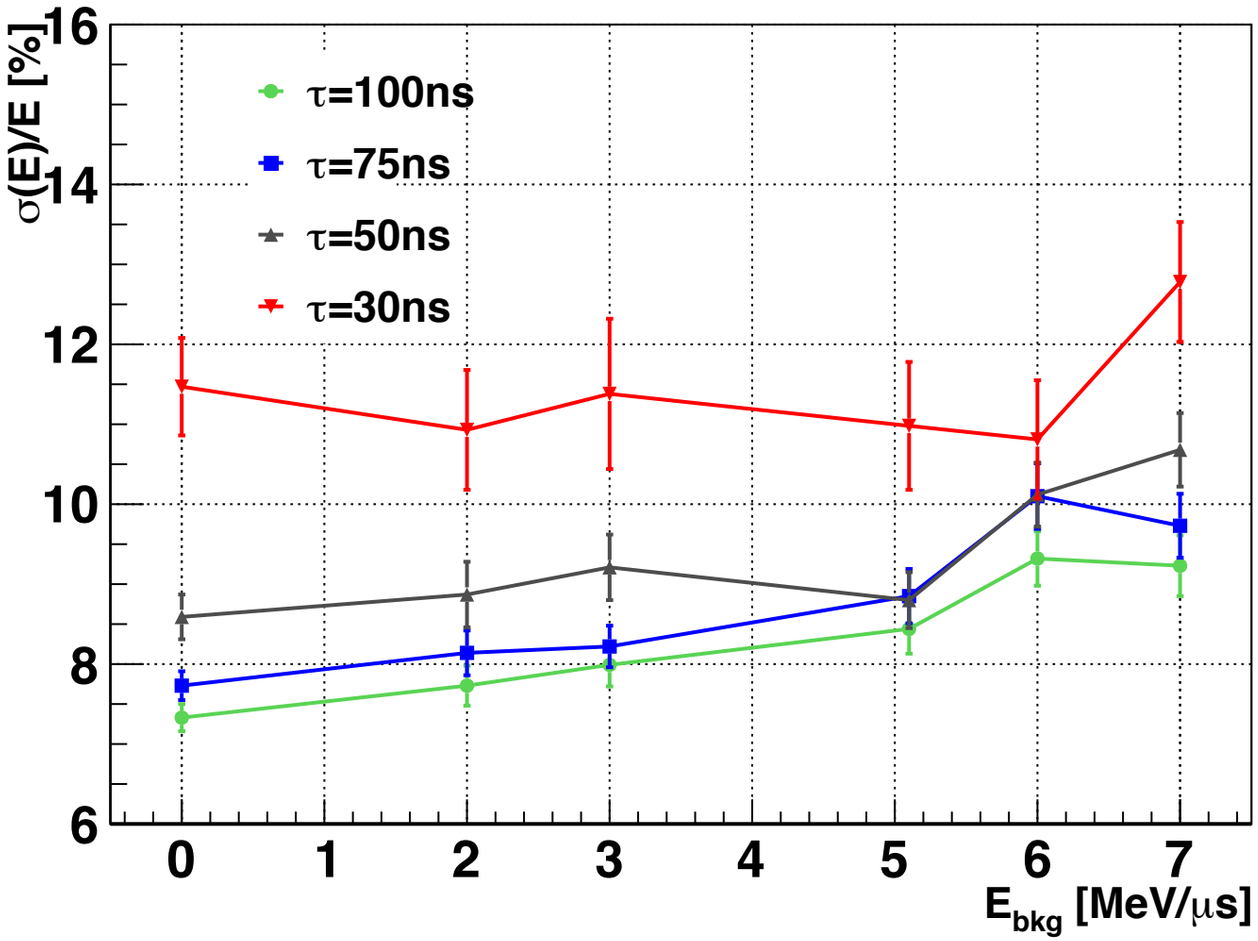
Remind: **5.1**MeV/μsec in **3**hits/μsec (crystal #80)
Simulation of 2.0, 3.0, 6.0, 7.0 MeV/μsec *still in 3 hits/μsec*

Pure CsI: ENE vs E_{bkg}, for different taus

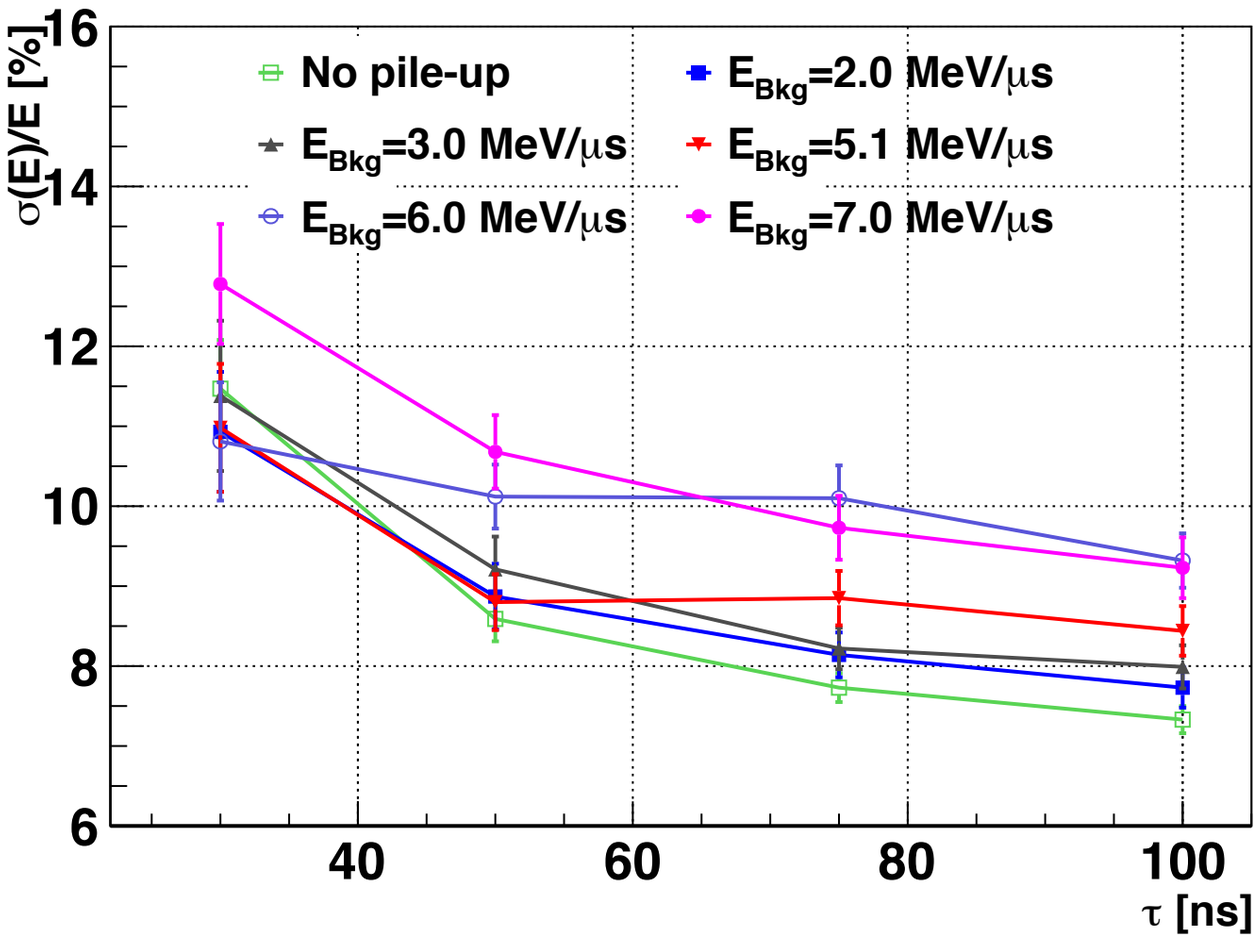


Pile up contribution increases only for tau >=100

Pure CsI: σ(E)/E vs E_{bkg}



Pure CsI: σ(E)/E vs τ

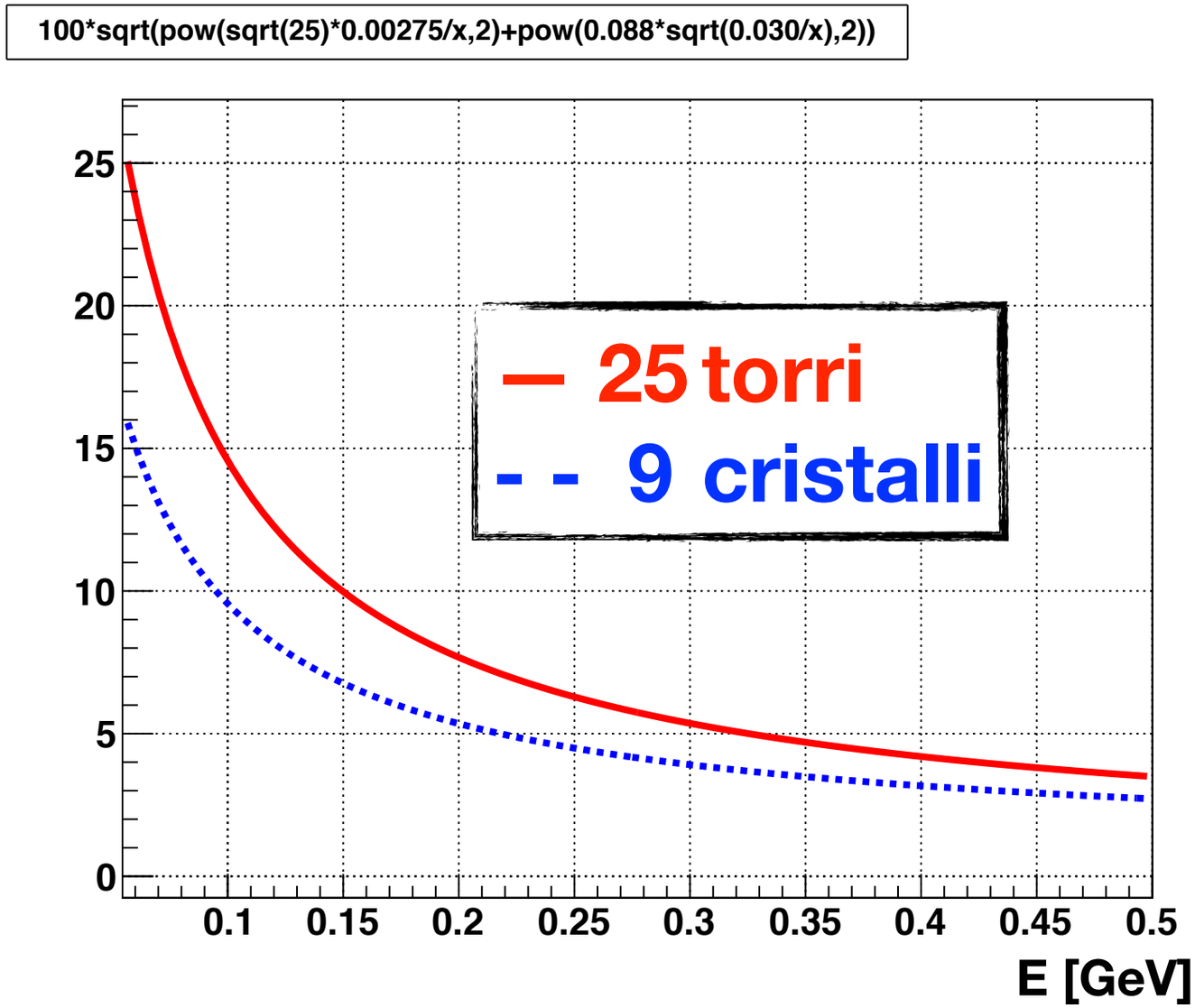


Pure CsI: σ(E)/E vs E τ=50ns E_{Bkg}=5.1MeV/μs

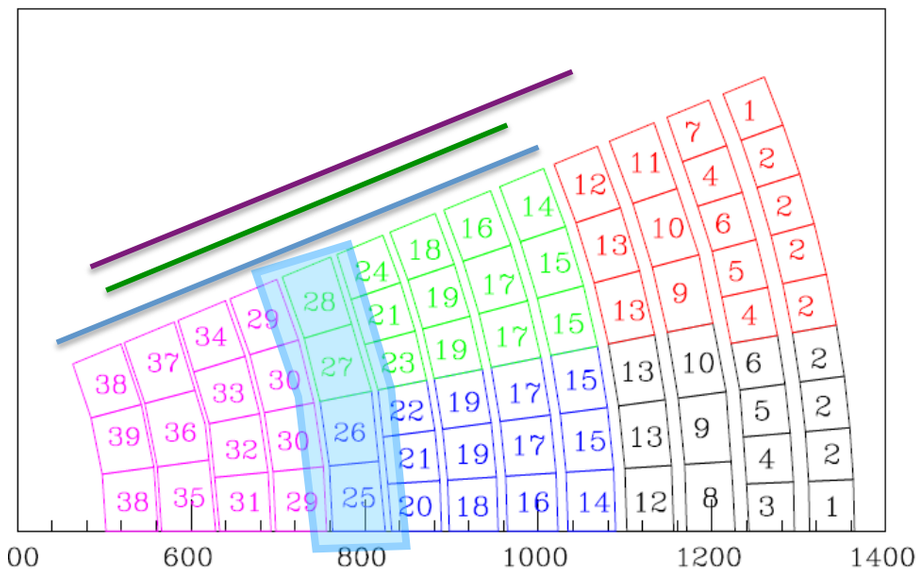
$$\sigma(E)/E = \sqrt{25}\times\mathbf{ENE}/E \oplus reso_{cosmici}\times\sqrt{(0.030/E)}$$

$$\sigma(E)/E = \sqrt{9}\times\mathbf{ENE}/E \oplus reso_{cosmici}\times\sqrt{(0.030/E)}$$

@ E_{bkg}=5.1MeV/μs, τ=50ns:
ENE=2.75MeV σ/E=8.8%



Prossimo passo: studio CsI **puro** vs **(Tl)** per E_{bgk} nei ring >= 4



Ripetere lo studio per i valori di Ebkg che competono ai ring “utili”

Esempio (B. Oberhof, MC campaign 11):

- **1.57MeV**/μs in **0.75** hits ring 4 higher background “sector 1”
- **0.32MeV**/μs in **0.54** hits ring 4 lower background “sector 8”