ECL update

C. Cecchi for the ECL italian group

Outline

- Forward ECL upgrade status
- The actual ECL detector → possible improvements

- mini-BEAST
- TEST beam results LNF and Mainz (August 2015)
- Other activities

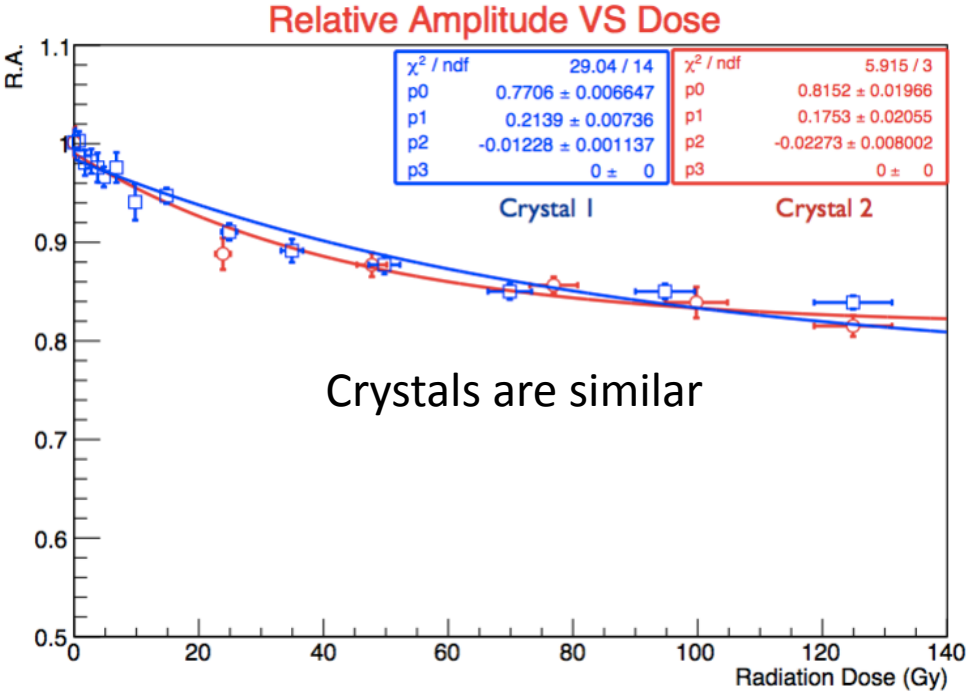
ECL FWD upgrade

The decision on the upgrade has been postponed to February 2016

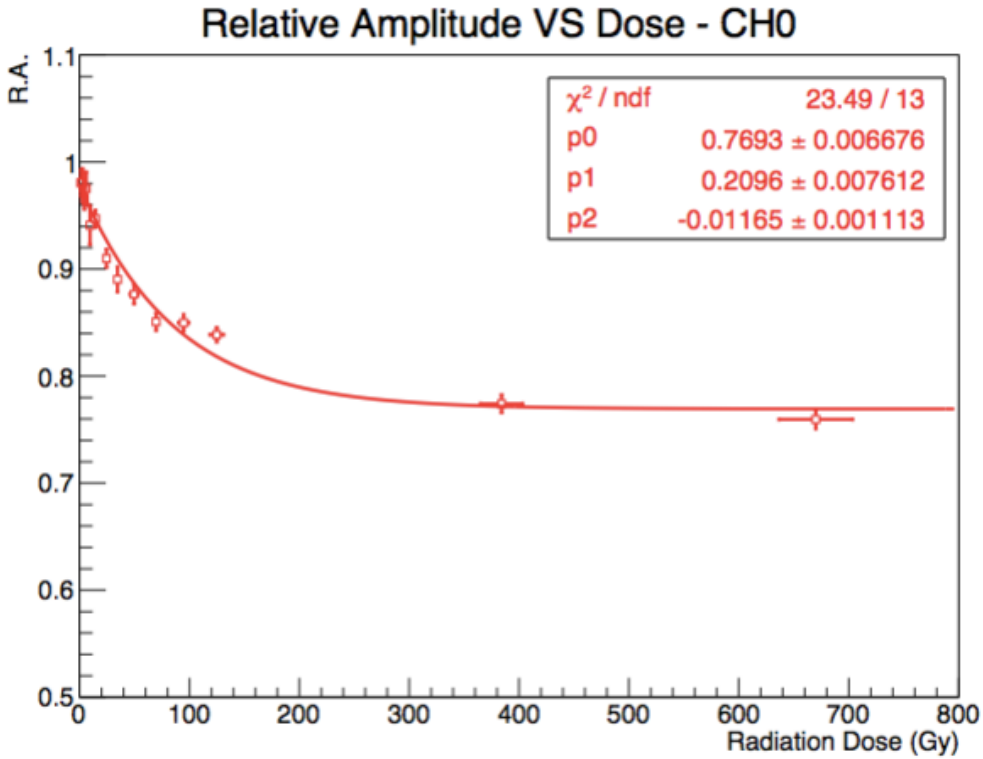
- Rad hard of crystals → 20% LY loss and then saturation
- Rad hard PiN diodes →

- Necessary to have results from performance and physics we are on the way on….the estimation of February is based on this item

Crystals rad-hard



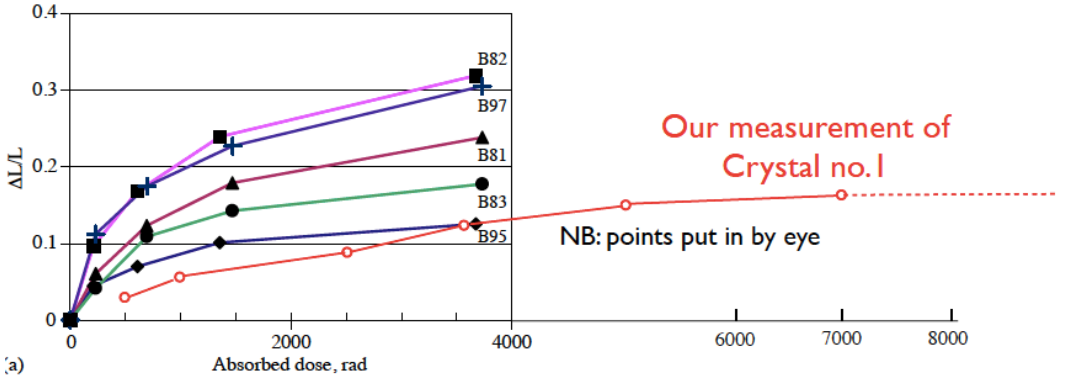
Crystals are similar



Which is the effect on resolution?

D.M.Beylin, et al.

Trapezoidal CsI(Tl) crystals

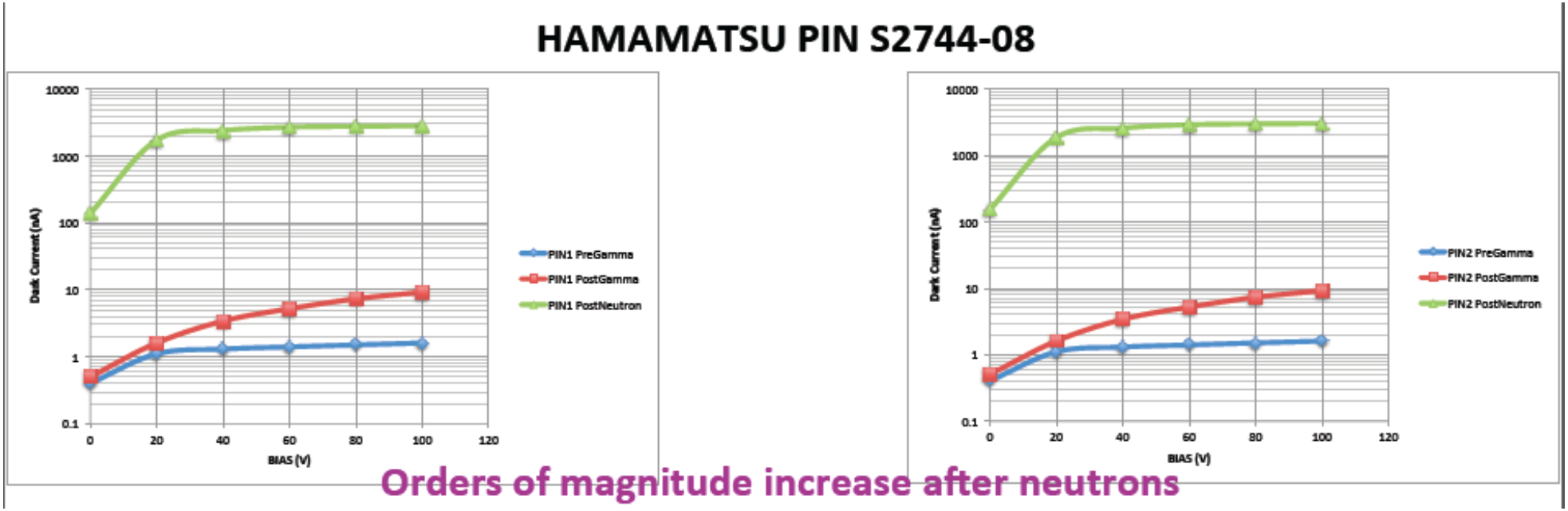


Nuclear Instruments and Methods in Physics Research A 541 (2005) 501–515

Photodetectors rad-hard

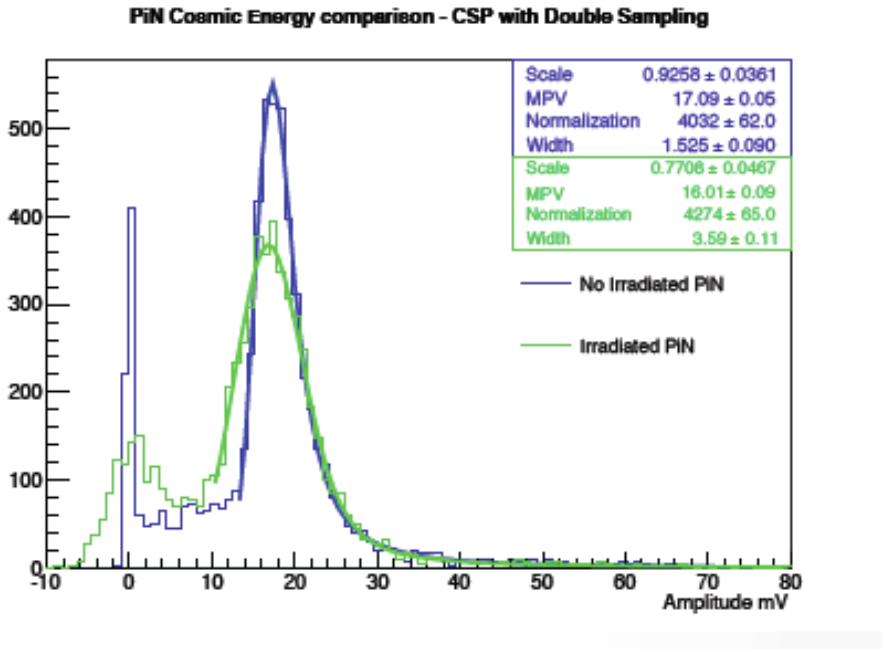
Photons 250 Gy

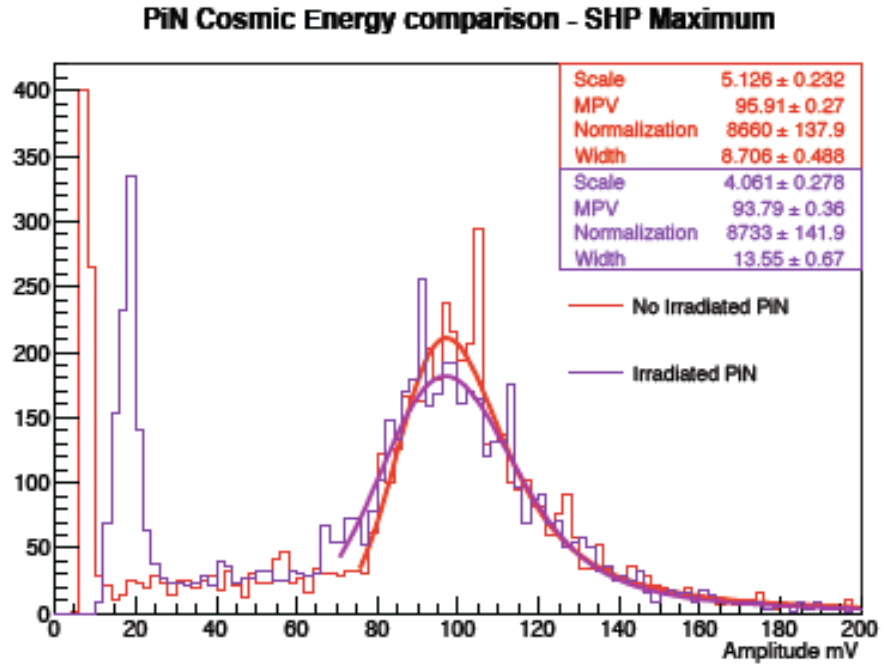
Neutrons 10^12 n/cm^2



Photodetectors recover to a stable dark current value after 1 month annealing at RT

Photodetectors rad-hard





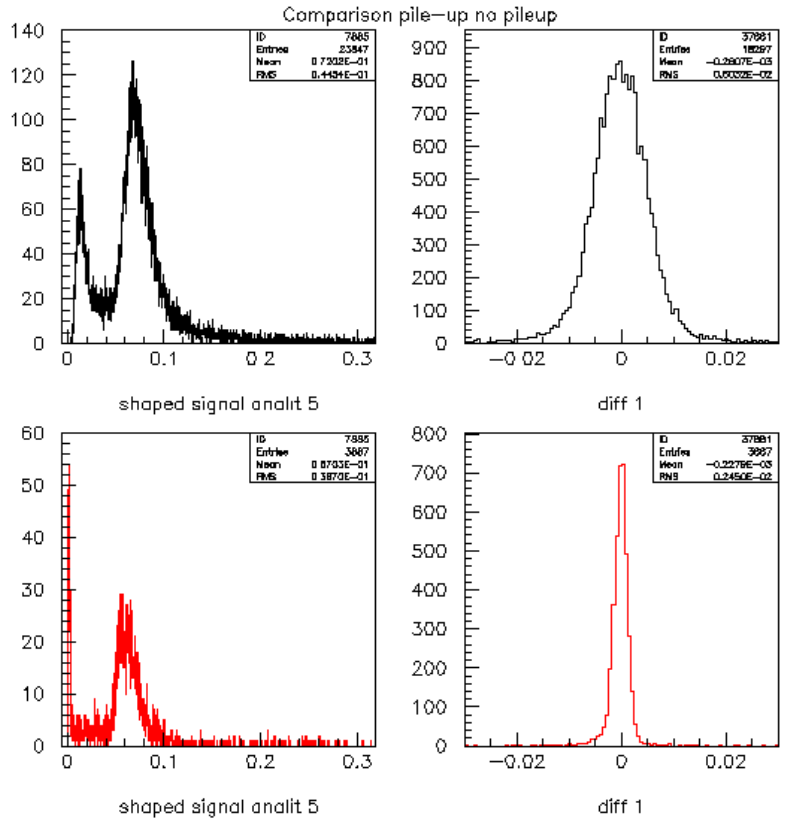
PiN: 1.4 nA → 1.3 µA
LAAPD: 40 nA → 10 µA

PiN:

CSP
630 KeV → 4.9 MeV

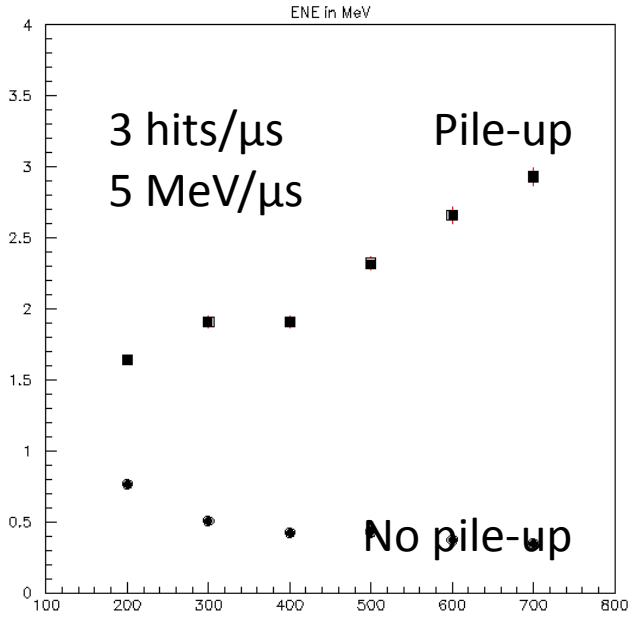
Shaper
220 KeV → 1.14 MeV

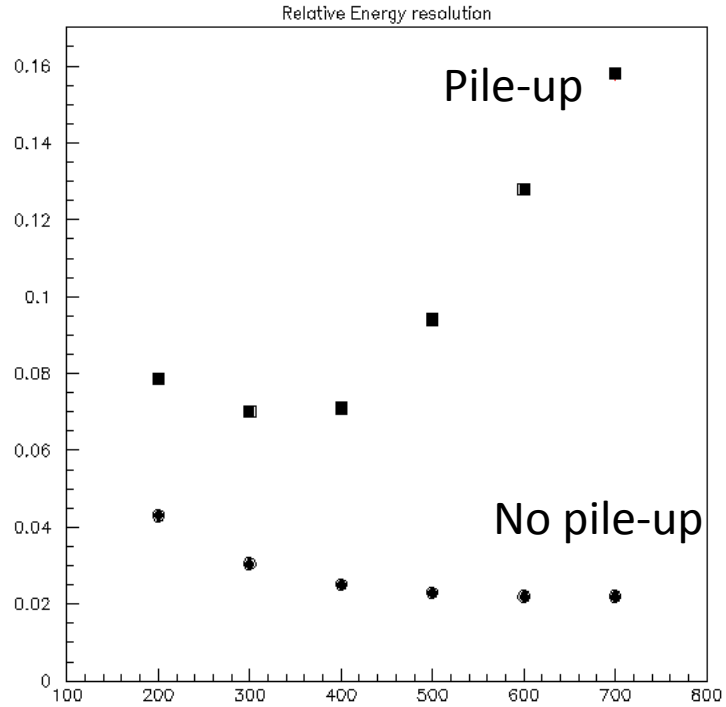
CsI(Tl) simulazione pile-up ed effetti

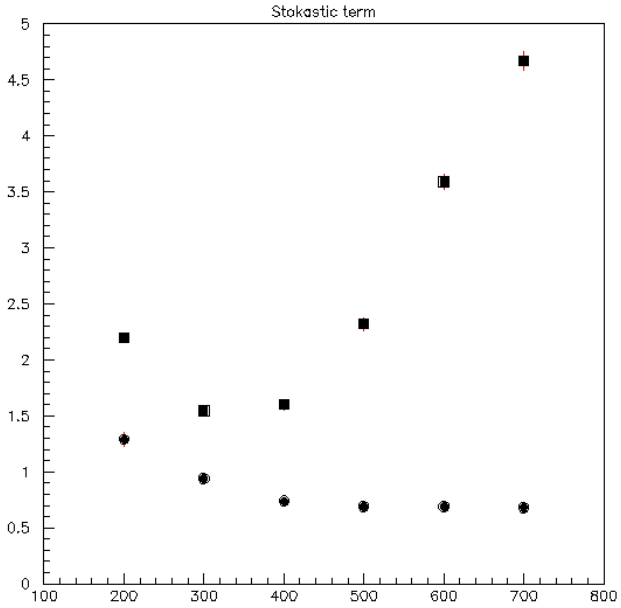


Spettri e differenze di ampiezza dei due PiN con (alto) e senza pile-up (basso)

MeV







Ad esempio a 100 MeV avremo con shaping nominale (500 ns) :

$$\sigma_E = \sqrt{2^2 + 2^2 + .7^2 \times \frac{E}{40.}} = 3.0 MeV_{@100 MeV}$$

ENE Stoch. term

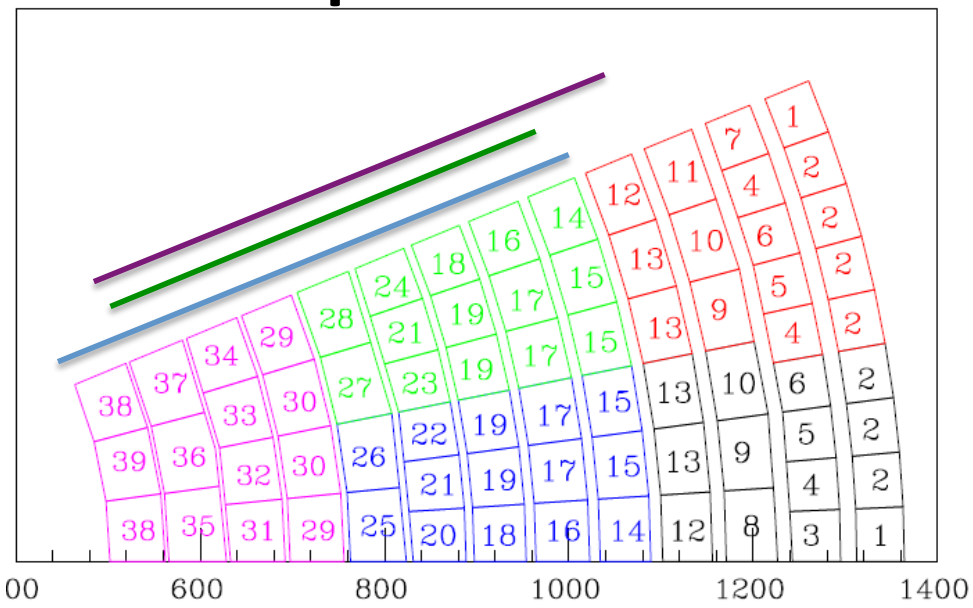
- Prestazioni con pile-up peggiorano notevolmente
- @100 MeV 2.5-3% di risoluzione
- confronto con CsI puro: ENE=0, termine stoc 3%

→ 4.5 MeV@100MeV

- **effetto sulla fisica da studiare**

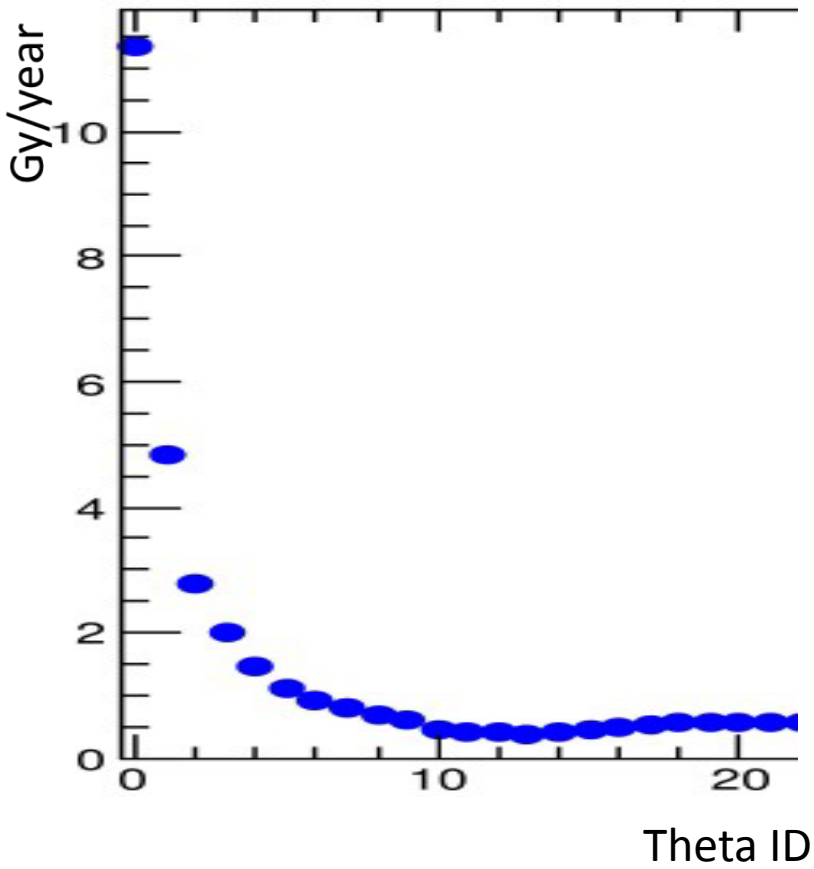
Ipotesi di upgrade

Replacement of the rings: complete or partial?



a) From 0 to 8
b) From 1 to 8
c) From 1 to 9

a) 672 pure CsI + 480 CsI(Tl)
b) 48 CsI(Tl) + 624 pure CsI + 480 CsI(Tl)
c) 48(?) + 720 pure CsI + 384 CsI(Tl) (exclude 1st layer from trigger and maintain same number of trigger cells)



Proposta che stiamo coordinando con le altre istituzioni di ECL Belle2

Proposta di 3 moduli (19% di ECL FWD) completi da assemblare in ECL + commissioning a KEK

Costo di 3 moduli : cristalli per ring dalll'interno (48+64+64+80)

Circa 4.25 keuro/cristallo (costo cristalli italiani 7keuro/cristallo)
→ 121 cristalli

Cristalli	~~**670**~~ **850 Keuro (ricevuta offerta + dimensione cristalli)**	
APD-UV	**219 Keuro**	122 keuro
FE	**31 Keuro**	17 keuro
PTD	**144 Keuro**	144 keuro
uSOP	**60 Keuro**	60 keuro
TOT	**1304 Keuro**	

Attenzione: PTD e uSOP (slow control) è per l'intero detector ECL

1193 keuro → **111 keuro disponibili→ COSA SI GUADAGNA A CAMBIARE I DUE RING PIU' INTERNI????**

OPPURE: 48 + 64 +64 = 176 cristalli

176 x 4250 = 748 keuro

APD 178
FE 25
PPD 144
USOP 60

1155 → 149 keuro disponibili

COME SOPRA: COSA SI GUADAGNA A CAMBIARE I TRE RING PIU' INTERNI????

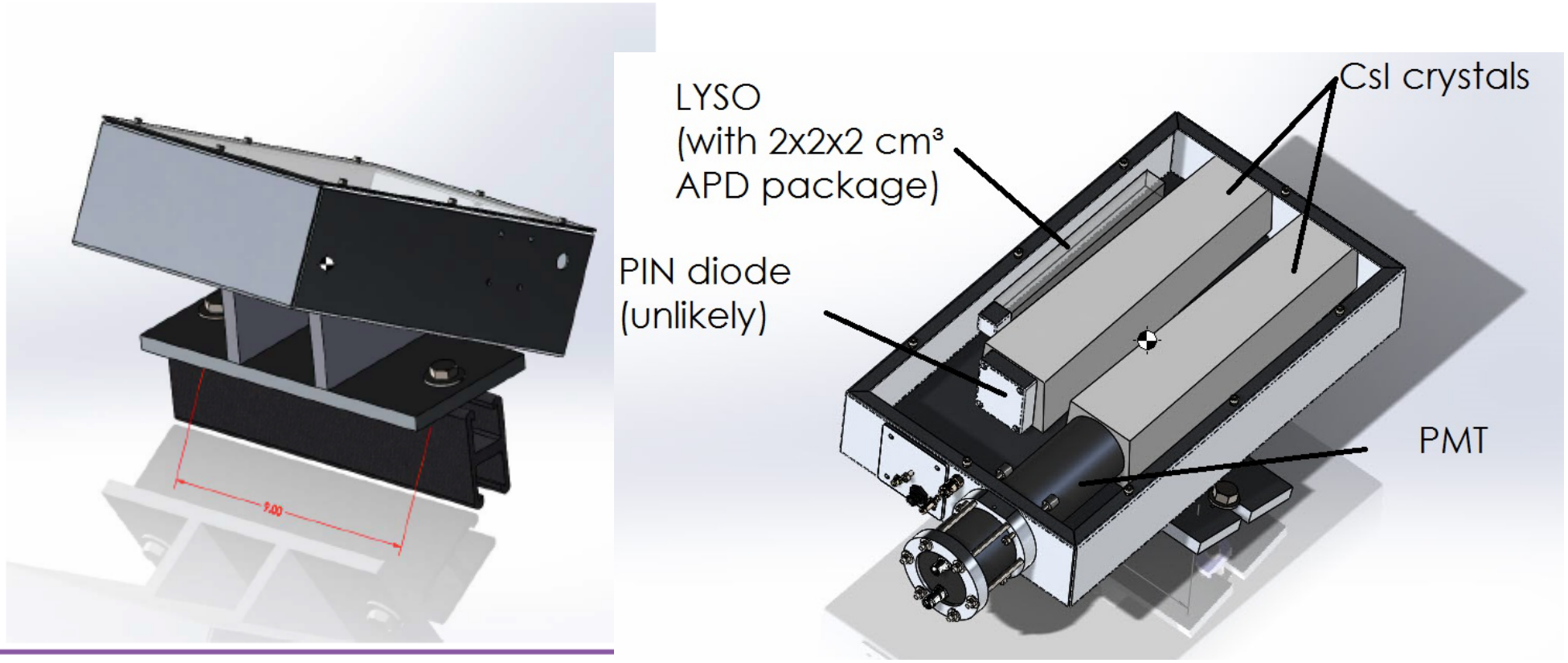
ABBIAMO LE CONOSCENZE PER DECIDERE OGGI? NO!

La data di Febbraio 2016 non è casuale!

MA SOPRATUTTO → UPGRADE NON HA SENSO SE SIAMO SOLI!

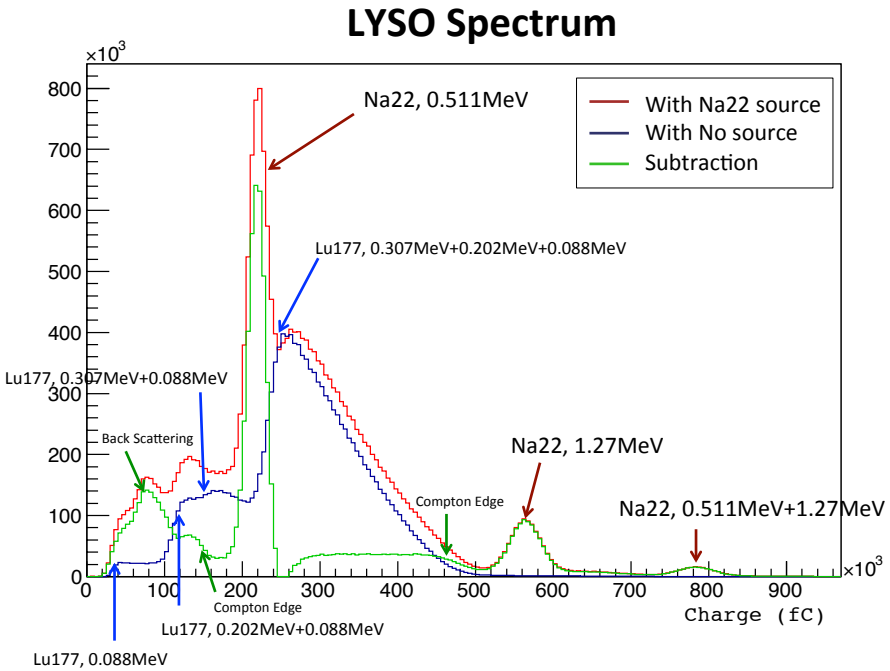
Crystals: CsI + LYSO

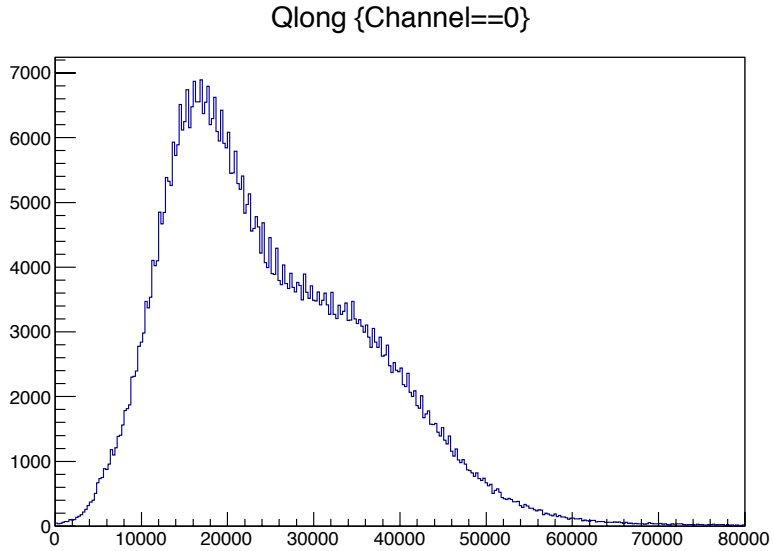
Use 6 CsI pure + 6 CsI(Tl) + 6 LYSO for BCKG and dose measurement (validation simualtion)



Holder for pair of crystal, preliminary mechanical design by U. of Victoria.

Mini-BEAST results

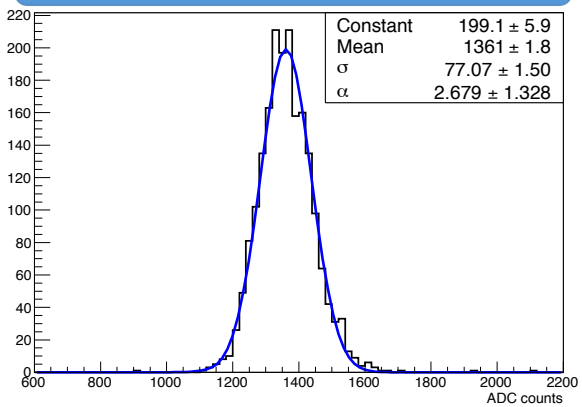




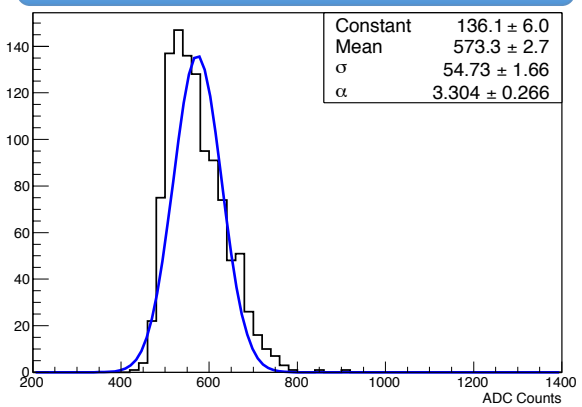
CsI(Tl): not real good performance due to the fact that the crystal is projective and for this test the readout was done from the wrong side (the other side is equipped with PiN)

Beam Test (2014@LNF) results (I)

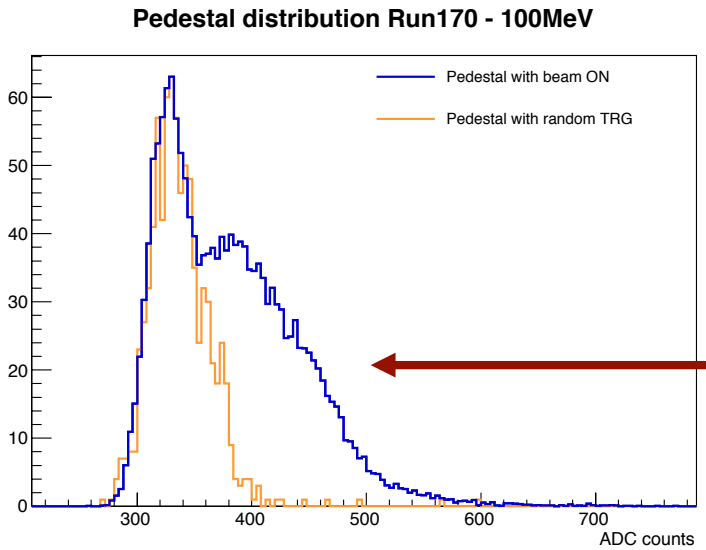
450MeV – CSP output



100MeV – CSP output



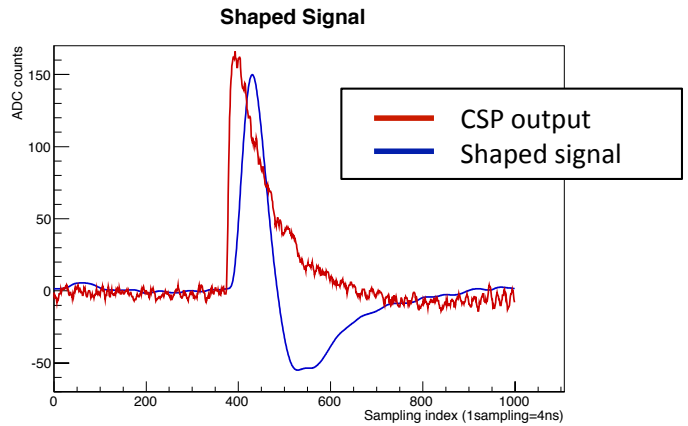
We found some distortion on energy distribution above all at low energies



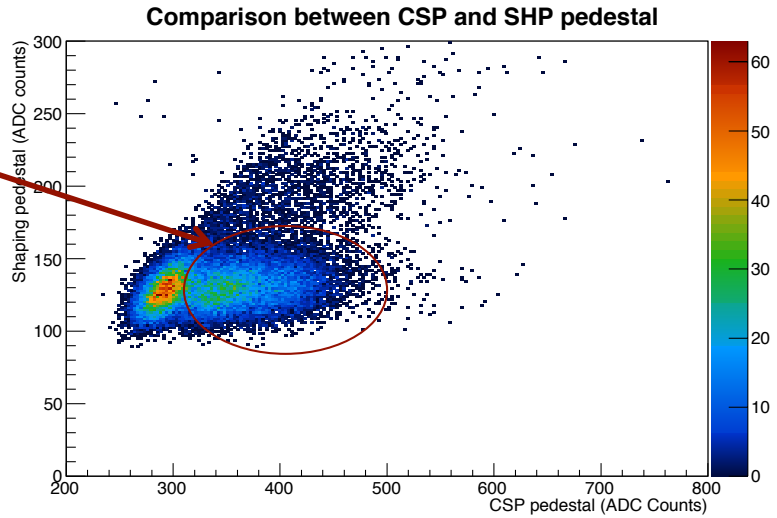
- This is due to pickup noise synchronous to BTF RF trigger
- This is evident when a comparison between pedestal with random trigger and pedestal with BTF RF trigger is performed

Software Shaping

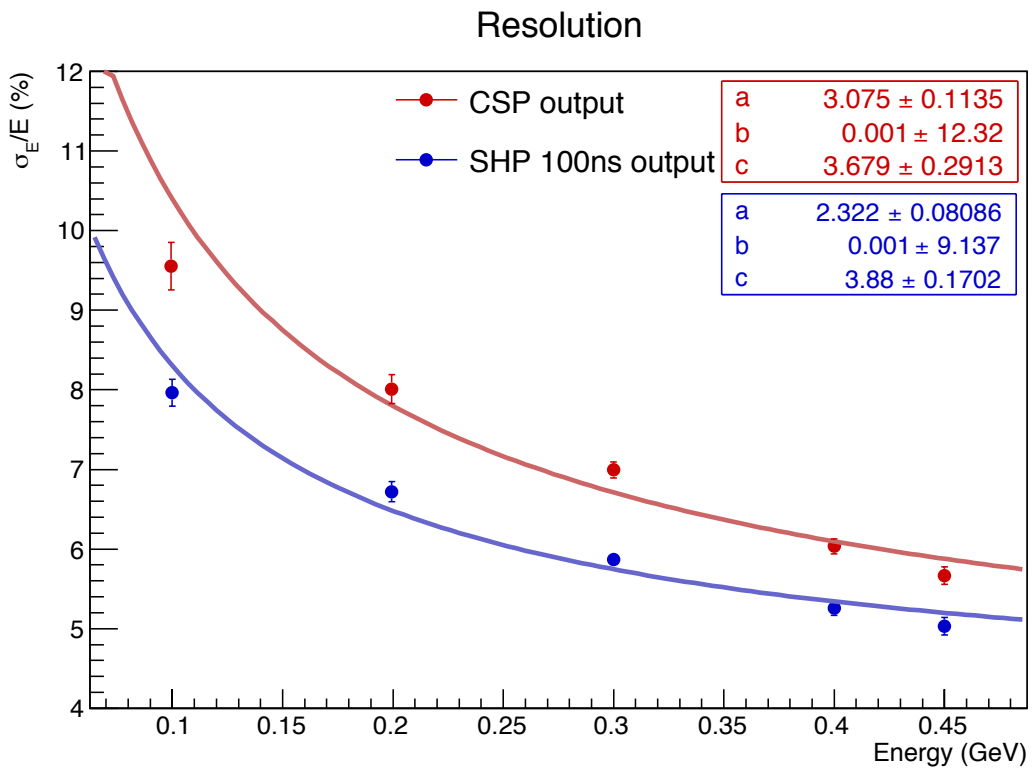
- We apply a software shaping in order to "simulate" the effect of a CR-RC^4 shaping with time constant 100ns



- The CR-RC filter cut also the frequency of the pickup noise (or at least the noise is attenuated)



Beam Test results (III)



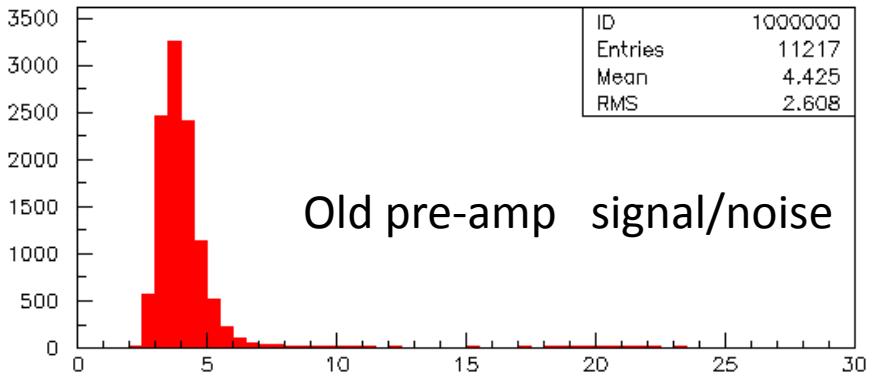
Fit function: $\sigma(E)/E = \frac{a}{\sqrt{E}} \oplus \frac{b}{E} \oplus c$

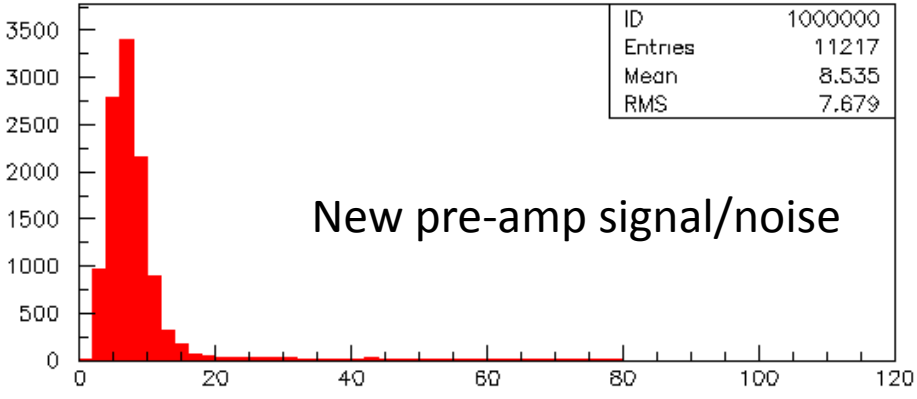
- Resolution compromised by the pickup noise
- Another important effect is the beam degradation due to multiple scattering
  - Matrix – Beam pipe distance ~1.7m
- *b* parameter not extracted correctly
  - Know issue at BTF without beam energy spread correction (to be implemented)

New TEST BEAM AUGUST 2015@Mainz → very clean beam should give final performance

Many other activities are ongoing

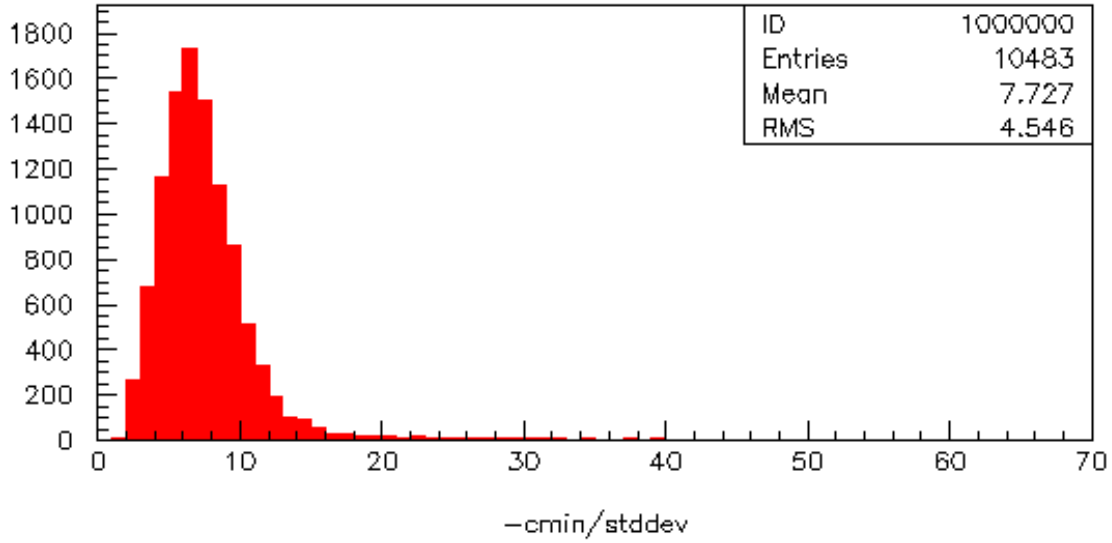
New preamp has been developed at RM3 to enhance S/N for pure CsI crystals



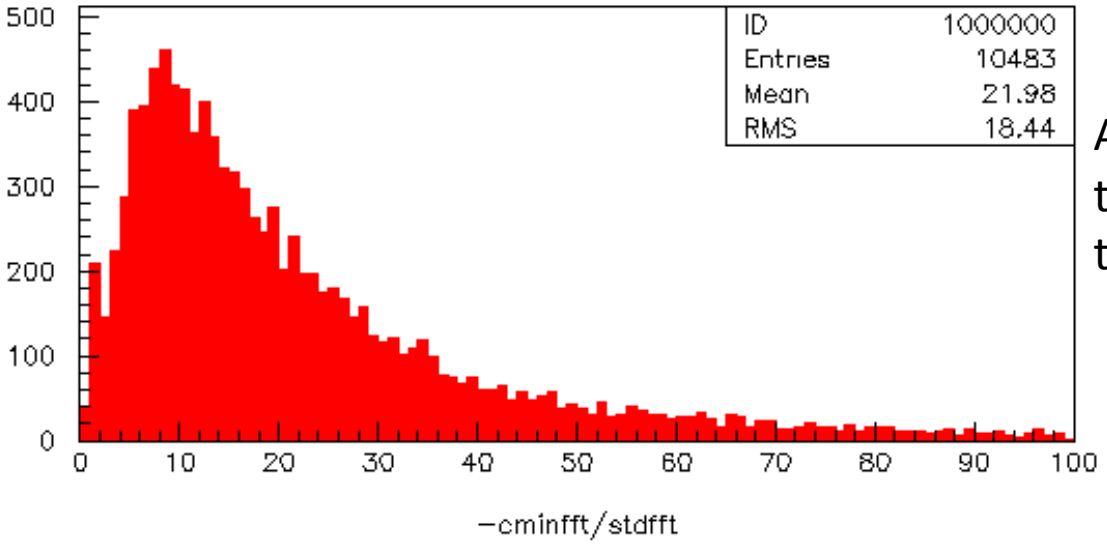


In our setup we gain on S/N a factor 2.6 without shaping. If we had a 12 mV peak (@Test Beam) from cosmic
this would bring our ENE down to 1.5 MeV Single APD no shaping.

What happens if I apply the 200 kHz cut?

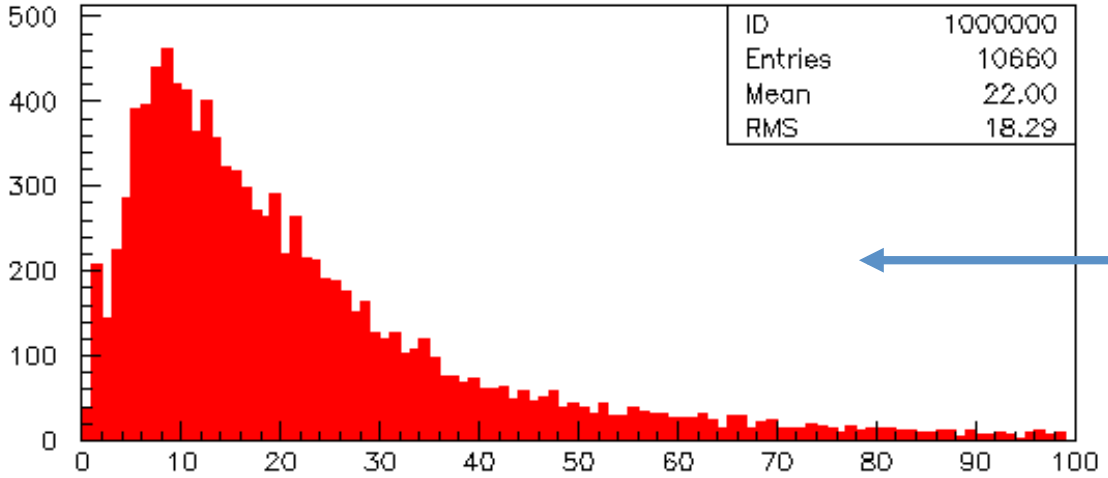


Brickwall filter sharp 200kHz cut

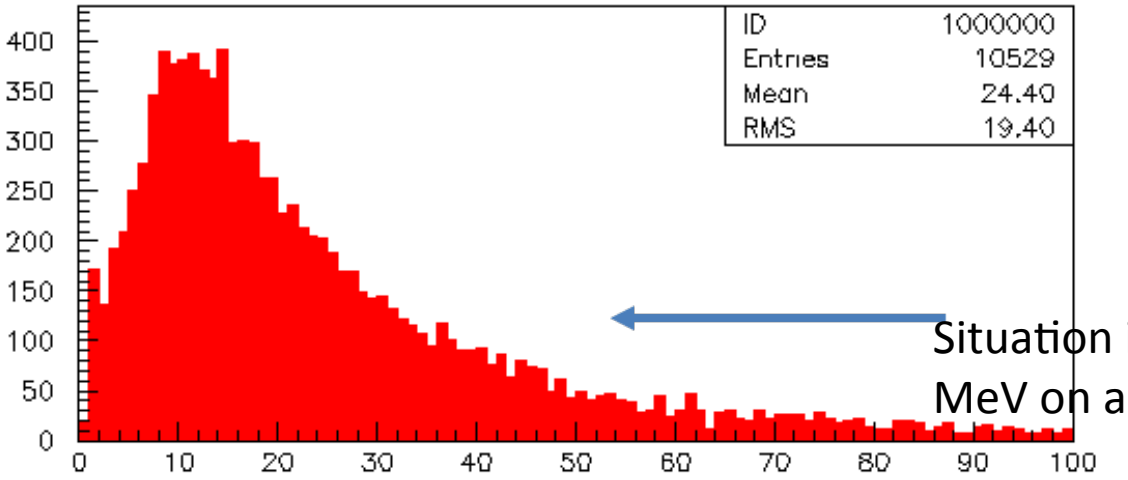


After 200 kHz cut we get a signal to noise ratio better than 20 (1.5 MeV single apd)

What about butterworth filter ?



Sharp cut on frequency (200 kHz)



$$\left|H(j\Omega)\right|^2 = \frac{1}{1+\left(\frac{\Omega}{\Omega_{-3dB}}\right)^{2N}}$$ N=2

Situation improves a little bit we are close to 1 MeV on a single APD!

Conclusions

- Upgrade yes/no → more work is necessary to have the final answer (new preamp, software studies, test beam@Mainz….)
- Many other activities are ongoing in particular to extract the real performance for BelleII with the CsI(Tl) calorimeter → is this detector performant enough for the new phase and for the high luminosity? This is strictly related to the upgrade issue and then very important

- mini-BEAST has performed well and LYSO is fundamental in this game for the background mesaurment