Study for the optimization of the working point of the SAND calorimeter read-out electronics in DUNE: update

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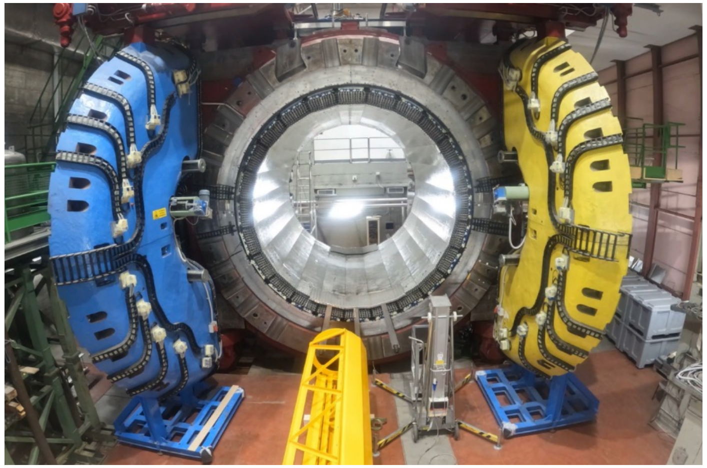

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Test of preamp saturation

with preamplifier

saturation over 3.2 V

In this specific case (negligible cable length) we expect:
$V_{dis}(max) = V_{preamp}(max) \bullet\ 0.5\ = 2.35$ V

Assuming to increase $V_{preamp}(max)$ by 15% while keeping linearity at an acceptable level, e.g. 1% (to be tested), we get:

$V_{preamp}(max\ ) = 5.4$ V
$V_{dis}(max) = V_{preamp}(max) \bullet\ 0.5\ = 2.7$ V

"Stretching" the choice of the dynamic range

Assuming:

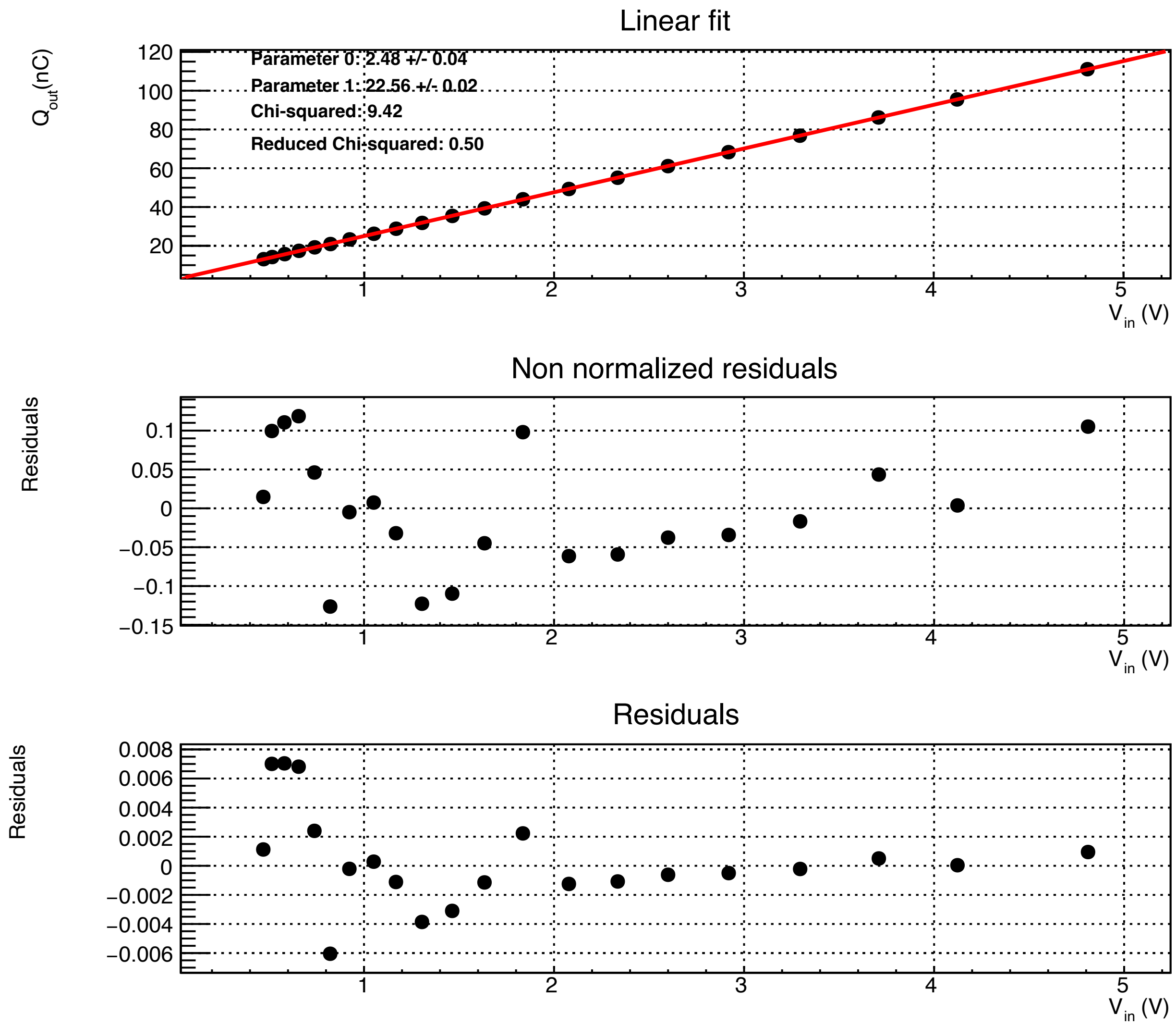
- to increase V_{preamp}(max) by 15% => V_{preamp}(max) = 5.4 V
- (N_{pe} G_{PM})(max) = $95 \cdot 10^7$
- V_{dis}(max) = V_{preamp}(max) • 0.5 • C_{ATT}= 2.0 V
- to have a very low noise environment as in KLOE => lowering (halving) the minimum discriminator/digitizer threshold to V_{TH}= 2.5 mV

G_{PM} ($\times 10^5$)	G_{tot} ($\times 10^6$)	N_{pe}(max)	signal amplitude (mV/pe)	N_{pe}(min) $V_{TH} = 2.5$ mV	MeV at module center
4.8	1.2	~ 2000	1.0	~ 3	3.0
6.4	1.6	~ 1500	1.3	~ 2	2.0
9.5	2.4	~ 1000	2.0	~ 1	1.0

- Different dynamic ranges can be implemented changing G_{PM} => the final choice should be a compromise between an affordable level of events with energy saturated cells, depending on N_{pe}(max), and an acceptable neutron detection efficiency, depending on N_{pe}(min).

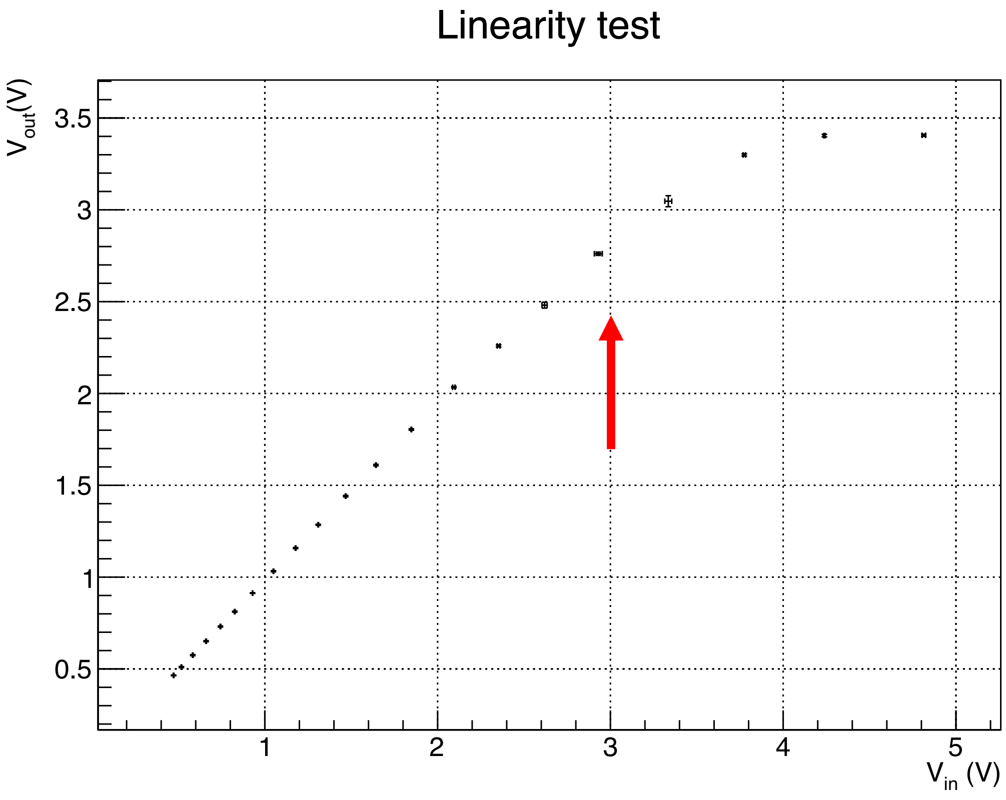
Test of preamp saturation

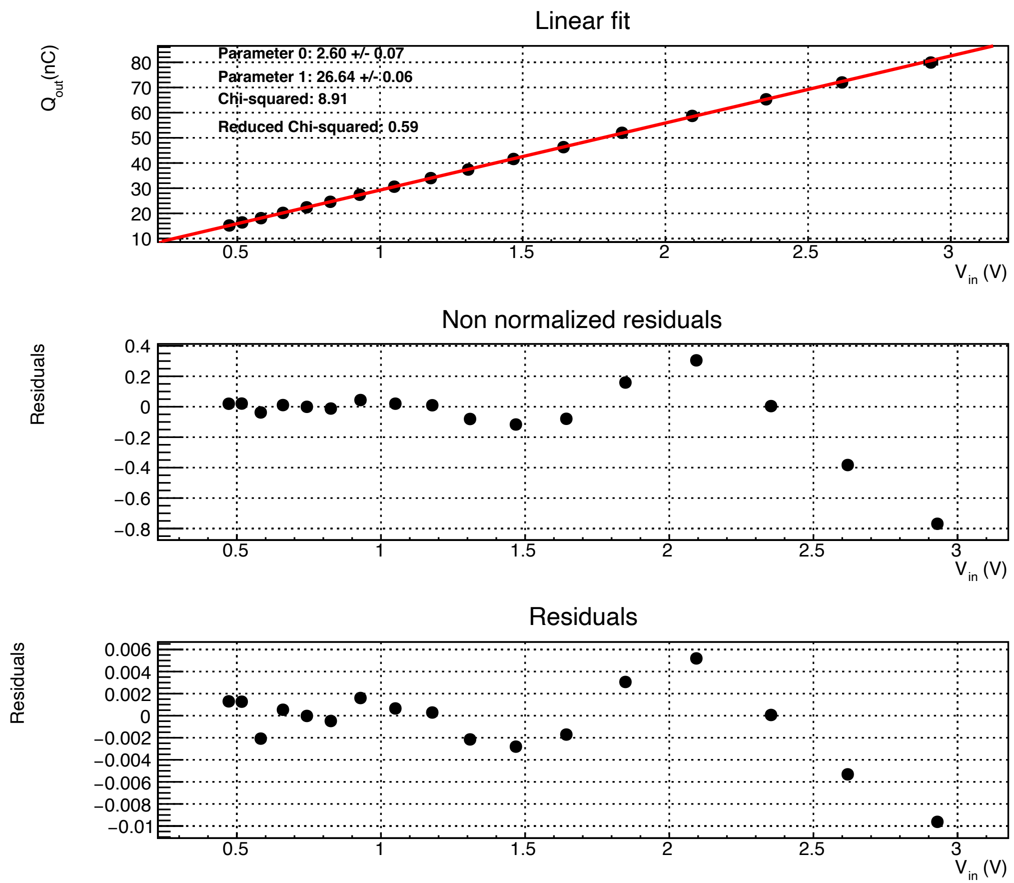
Linearity of the test system without preamp



Test of preamp saturation

Preamp linearity test

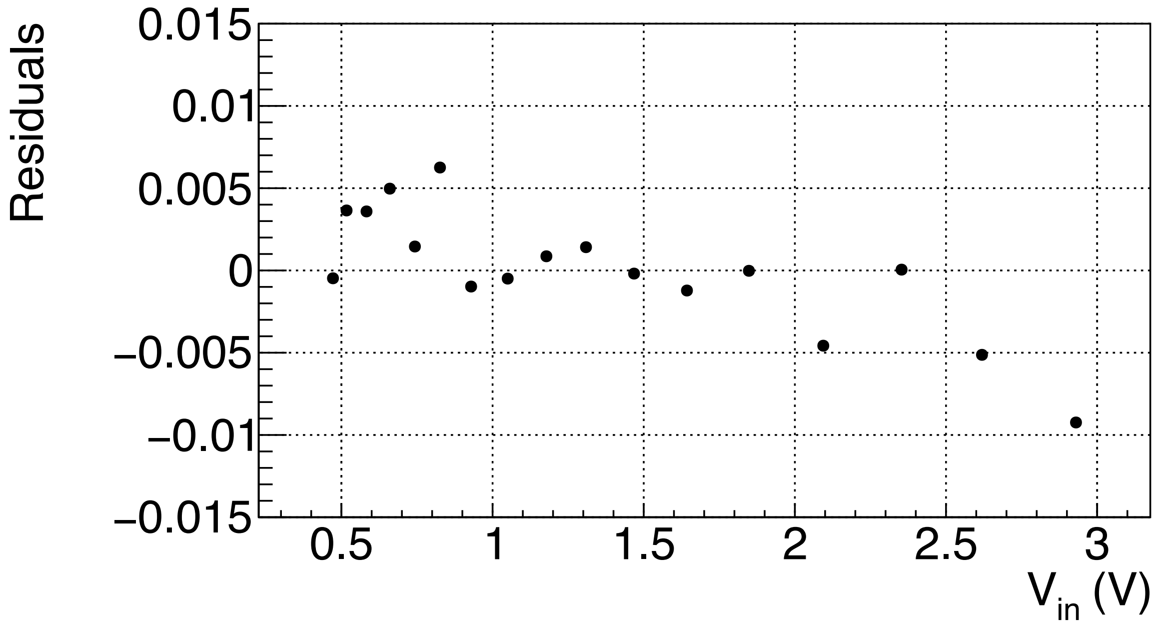




Test of preamp saturation

Preamp linearity test

Residuals after subtraction of system linearity

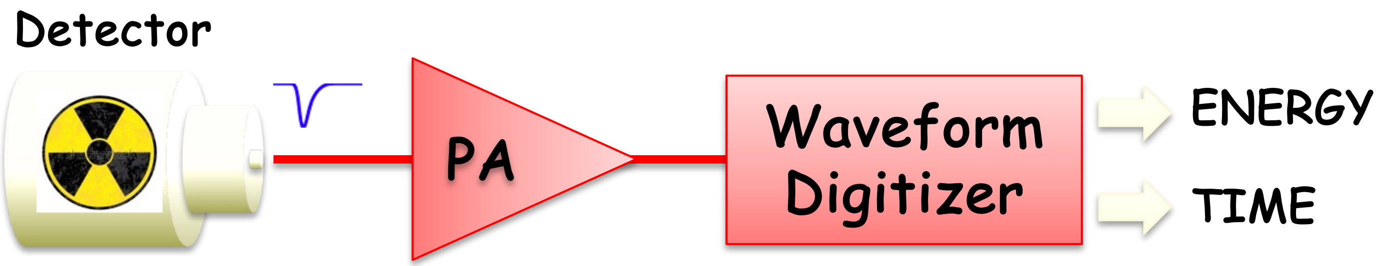


Choice of FEE for SAND/ECAL

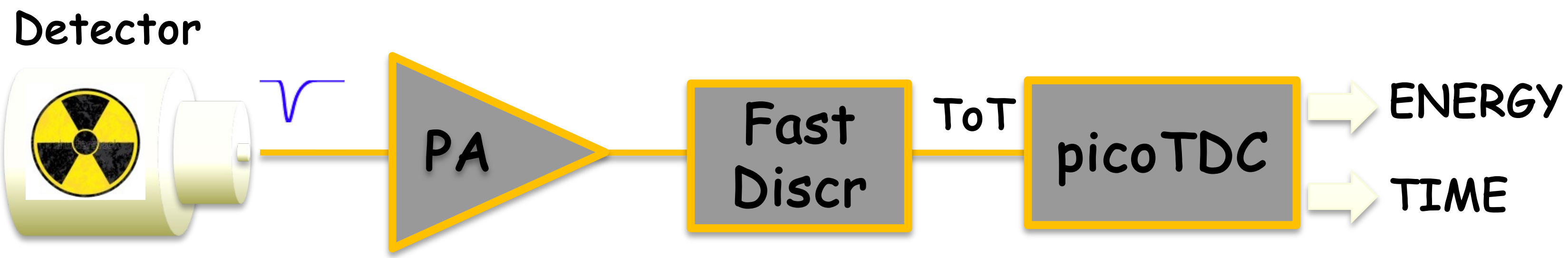
Constraints on signal dynamic range

see previous slides

Two possible read-out schemes:



High Flexibility
Fsampl ~ 1 GS/s =>High Cost
or
Fsampl ~ 125-250 MS/s
+ signal shaper
=>medium Cost



No Flexibility
=>medium cost
energy by ToT
with 2 or more
thresholds not to
worsen energy resol.

CAEN:

possible ready-to-use solution maintaining KLOE energy and time performance

Choice of FEE for SAND/ECAL

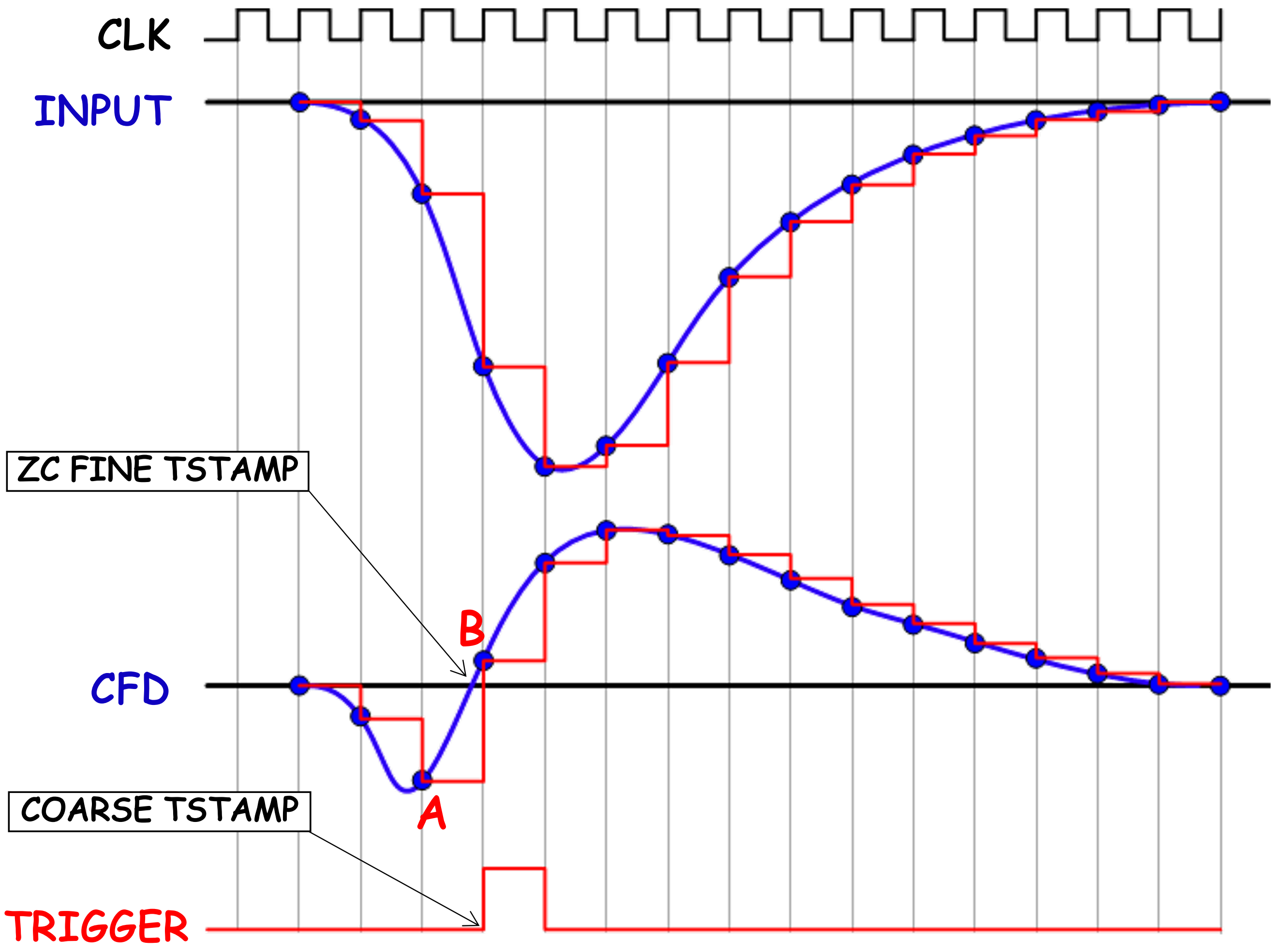
Digitizer solution:
$V_{signal}(max) = 2$ V
$V_{signal}(min) = O(0.1)$ mV
=> no problems to set V_{TH} and $V_{signal}(max)$ to match $V_{dis}(max)$

Best choice, high cost:
1 GS/s digitizer
=> 1 ns: 4-5 time measurements on the rising edge of the 14 ns base signal to preserve time resolution

Lower cost choice:
A shaper is needed to stretch the signal to use a lower cost digitizer, 125 or 250 MS/s => 8 or 4 ns

Optimal choice:
250 MS/s digitizer
=> 4 ns
stretch x4 the signal from 14 to 56 ns to keep the pile-up at the minimum (1%).

Digital CFD with interpolation



Test in CAEN

1) campionare il segnale con un flash ADC a 1 GS/s, almeno 12 bit.
Costosa e non pronta tecnicamente (esiste 10 bit)

2) campionare il segnale con un V2730 oppure V1730, ovvero un digitizer
a 500 MS/s, 14 bit con applicazione algoritmi di correzione
e calibrazione sviluppati ad hoc (sviluppati da CAEN con esito positivo)

3) usare uno shaper analogico che rallenti il segnale originale,
quindi campionarlo con un V2745, ovvero a 125 MS/s, 16 bit.
=> peggioramento pile-up

4) basare il readout su scheda FERS A5203, ovvero TDC a 3 ps di risoluzione.
In questo caso, per avere l'informazione di ampiezza, si usa il parametro TOT
(tempo sopra soglia) che, opportunamente calibrato, potrebbe dare una stima di PHA.
inoltre, il TOT verrebbe anche usato per la correzione dello walk,
una tecnica alternativa al CFD. Probabilmente, data la dinamica di circa 1000,
è necessario prevedere almeno due soglie, quindi servono 2 canali di discriminatore
+ TDC per ogni segnale da leggere.
Il costo a canale dovrebbe comunque essere inferiore rispetto
a quello dei digitizer, anche in caso di doppia soglia.

test in CAEN di 2) e 4) con segnale da impulsatore identico a segnale da PMT.
entro dicembre.