Pulse shape analysis in highly segmented Silicon detectors with Wave-Catcher

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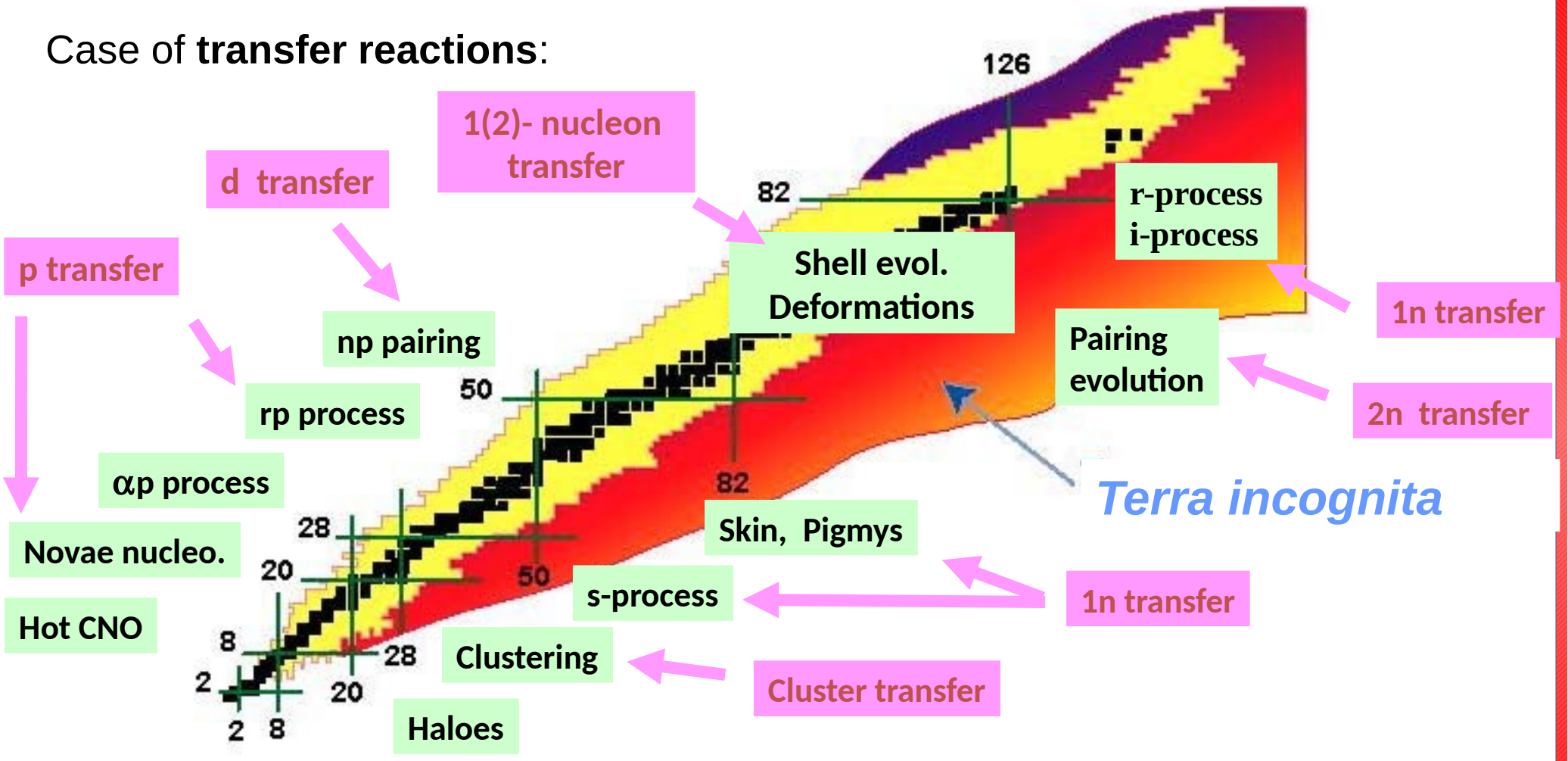
GRIT – *Direct reactions*

A great tool to investigate Exotic Nuclei and Astrophysical processes

Case of **transfer reactions**:

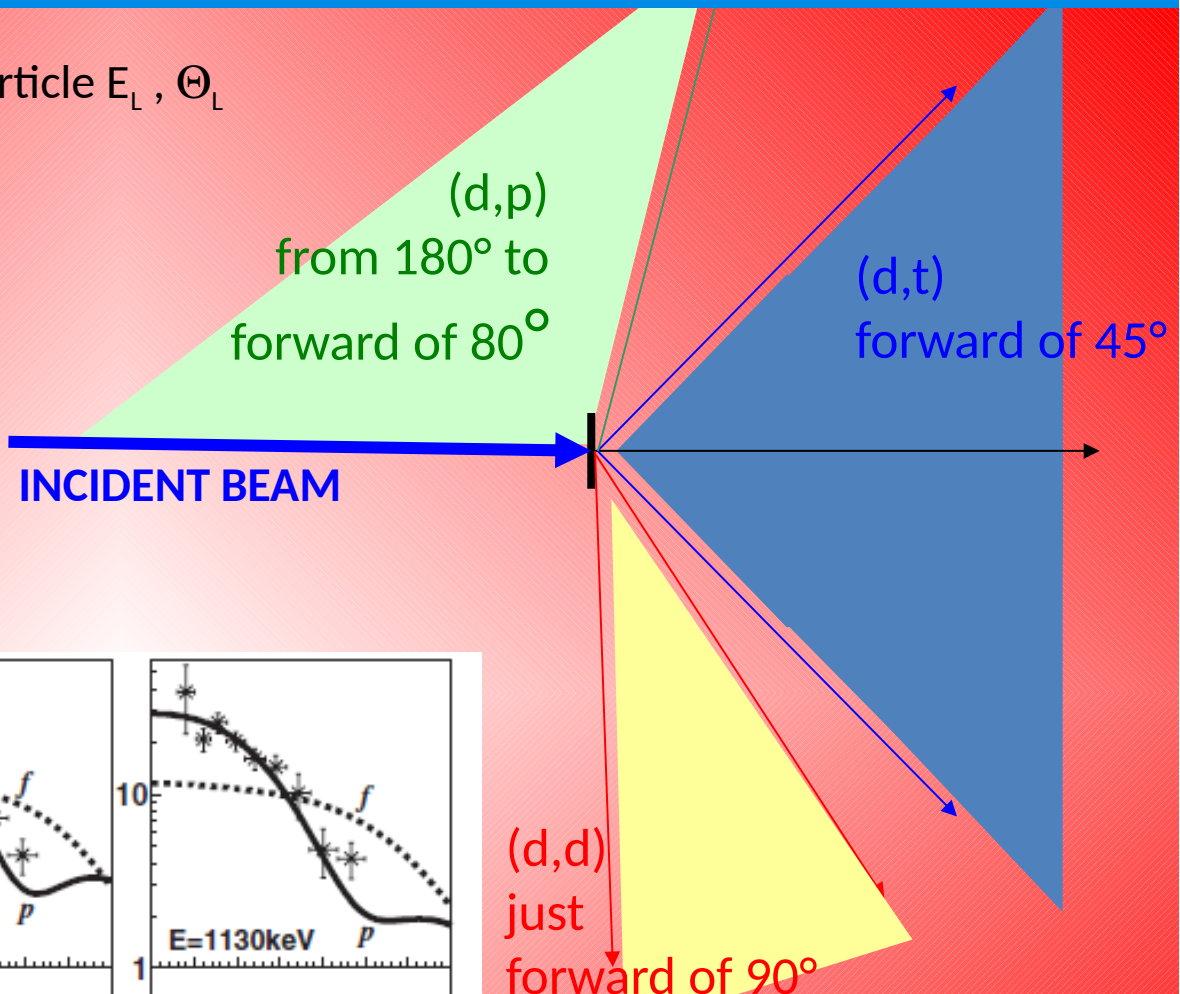


GRIT – *Methodology with exotic beams*

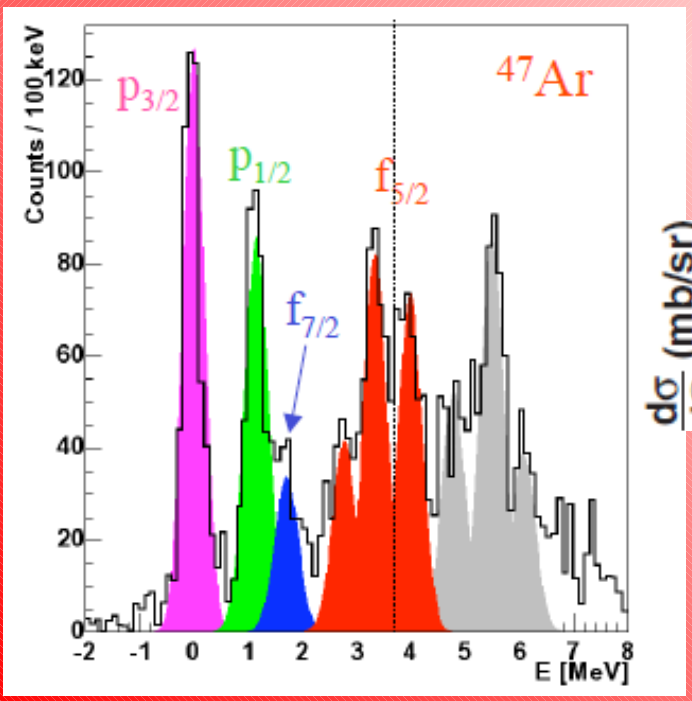
Early works : detect the light recoiling particle E_L , Θ_L

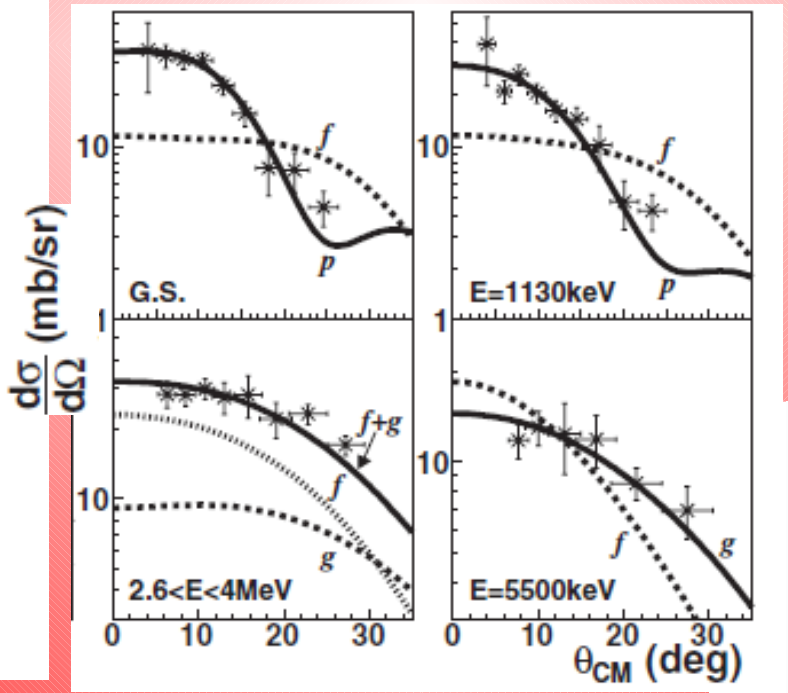
- Excitation energies
- Differential cross-sections

⇒ **Spin, parities and Overlaps < i|f >**
(Shell Model, ab initio,..)

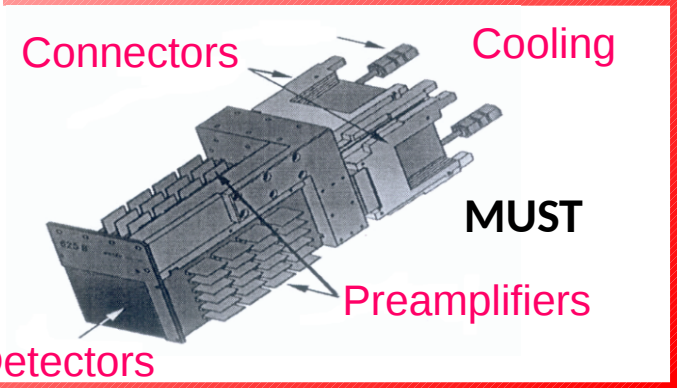


Ex: ^{46}Ar(d,p) @ GANIL/SPEG
using the **MUST** array





Reduction of N=28 gap
L.Gaudefroy, O.Sorlin et al., PRL (2006)



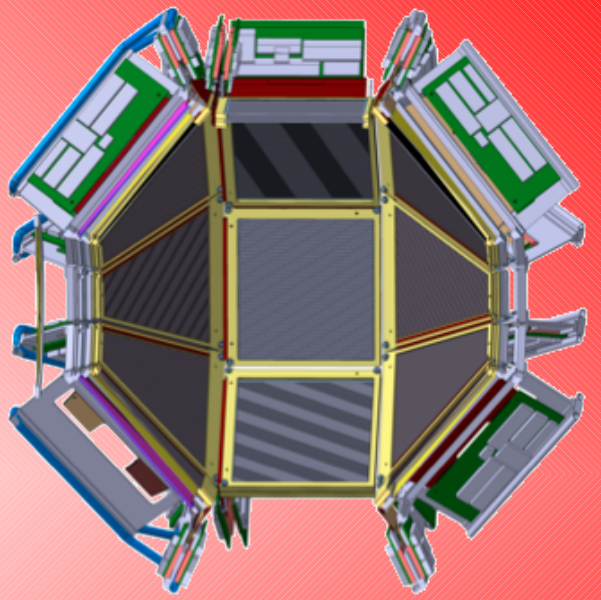
Y.Blumenfeld et al., NIM A421 (1999)

GRIT (Granularity Resolution Identification Transparency)

2 shapes of detectors : square & trapezoid

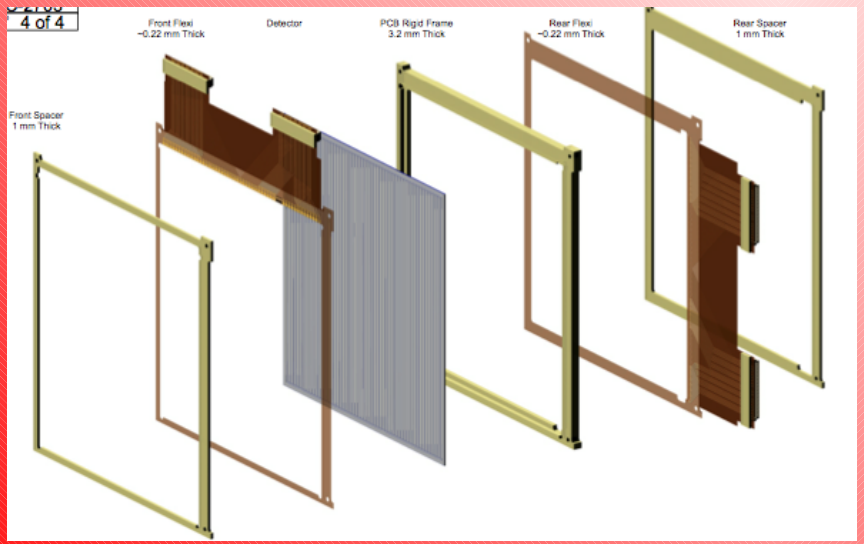
- Two-layers for square detectors (500um +1.5mm)
- Two to three layers for trapezoidal detectors (500um +1.5mm+1.5 mm)

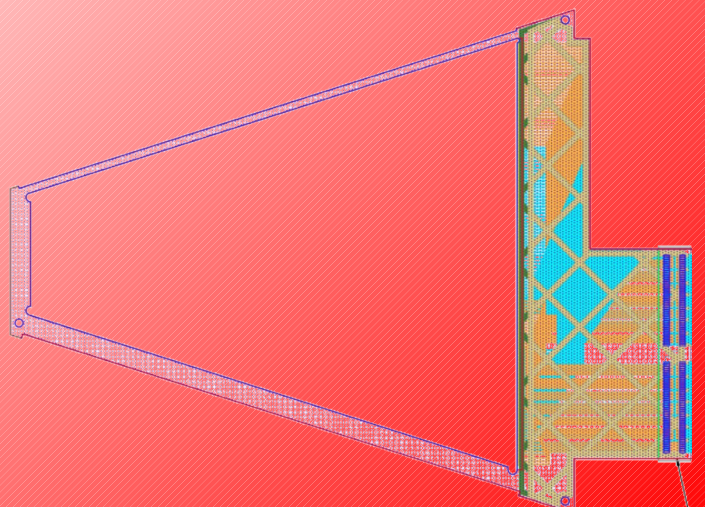
- Specific and challenging design for all thin DSSSD :
  - ☑ nTD type (better uniformity in resistivity <5%)
  - ☑ 4 degrees cut (“random” cut)
  - ☑ large size (6 inches)
    128x128 pixels 760 µm^2 (60 µm interstrip)
  - ☑ reverse mounted (N-side = front-side)
  - ☑ very thin frames (to minimize the dead zones)



Design : Ph. Rosier & E. Rindel (IPN)

- **Integration into AGATA and PARIS**
- **Integration of special targets (e.g. CHyMENE)**
- **Implementation of state of the art PID technique**



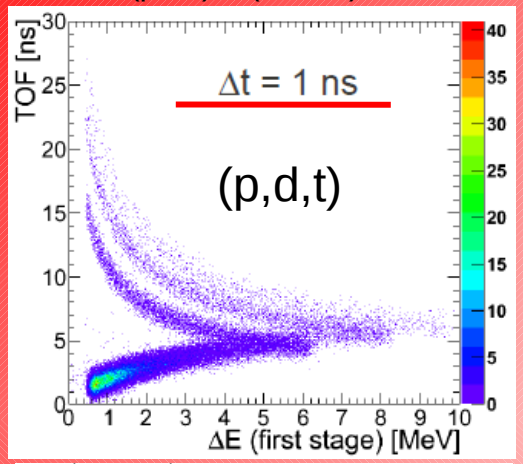


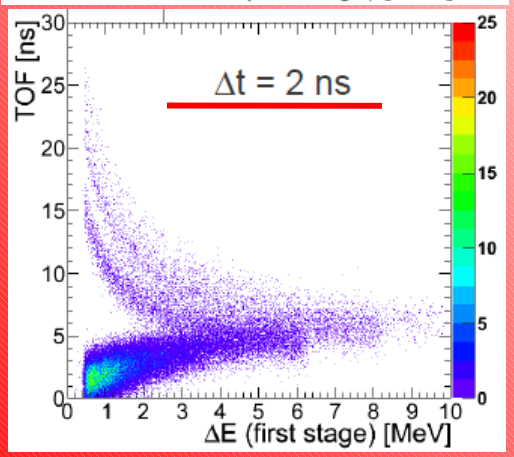
GRIT - *Simulations of Pid of low-energy light particle*

Time of flight

Z = 1

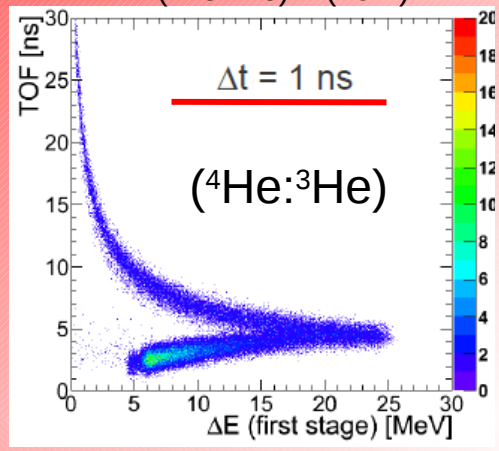
(p,d,t) = (10:4:1)





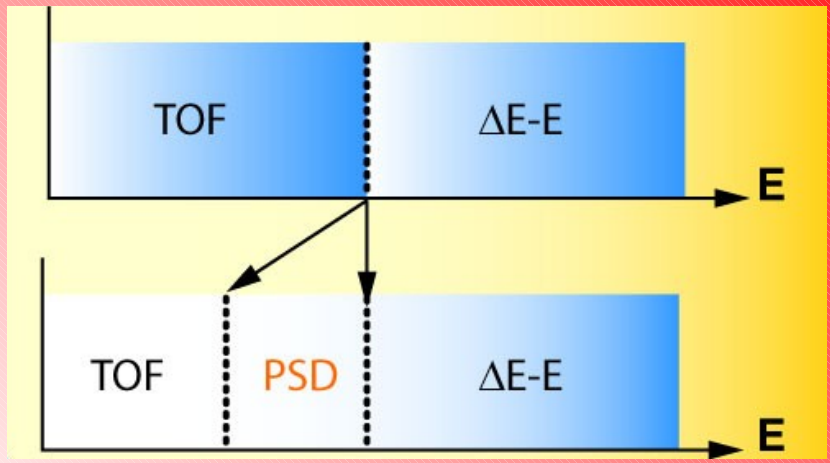
Z = 2

(^{4}He:^{3}He) = (10:1)



No separation for
t/^{3}He, ^{6}He/^{6}Li

Option chosen: PSA



- More compact device
- Less Si layers
- Digital electronics

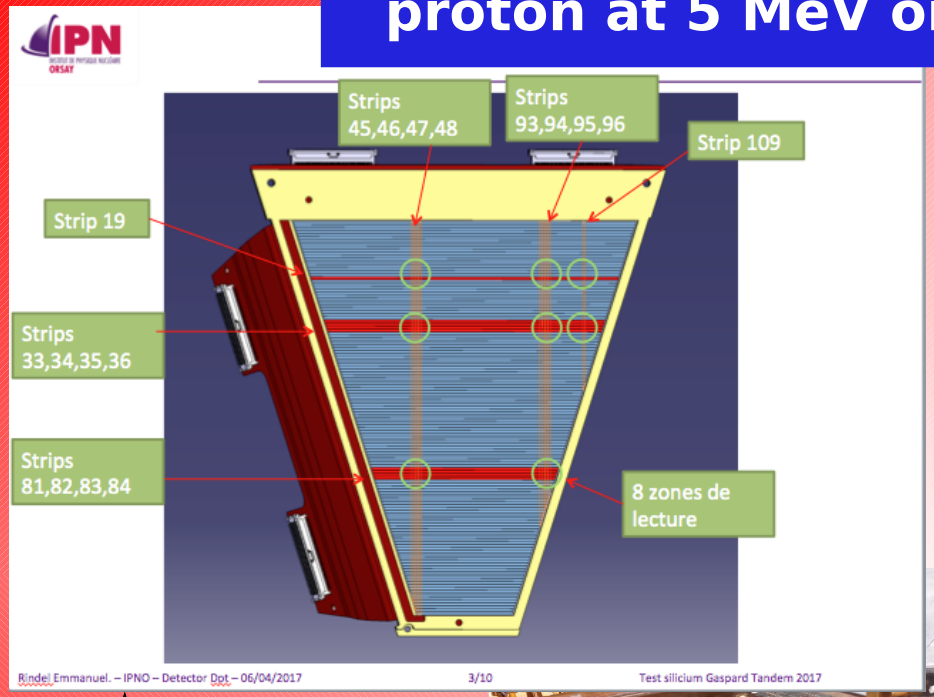
FAZIA studies :
Bardelli et al, NIM 2009
Barlini et al, NIM 2009
Carboni et al, NIMA 2012

GHT studies :
J. Duenas et al, NIMA 2012
J. Duenas et al, NIMA 2013
D. Mengoni et al, NIMA 2014

- *Most of the R&D for GASPARD-TRACE has focussed on the PSA performances for light nuclei*
  - *Which quality ? Which lower threshold in energy ?*
  - *What sampling ? Which signals ?*
- *Aim : determine electronics specifications*

GRIT - PSA

^{7}Li at 35 MeV on ^{12}C target
proton at 5 MeV on Au target



N

P

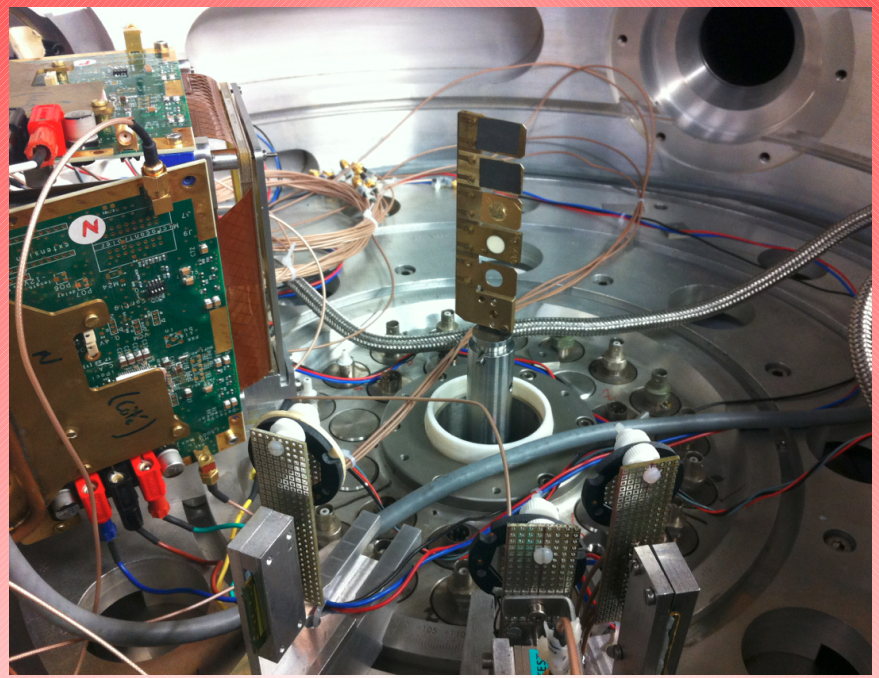
9 strips N side
and
9 strips P side
connected to DAC

GRIT - PSA

Configuration 1

^{7}Li at 37 MeV on ^{12}C for isotopic identification purpose

Trapezoid ~40° left side
PACI1 ~10° right side
PACI2 ~40° right side
PARC ~25° right side

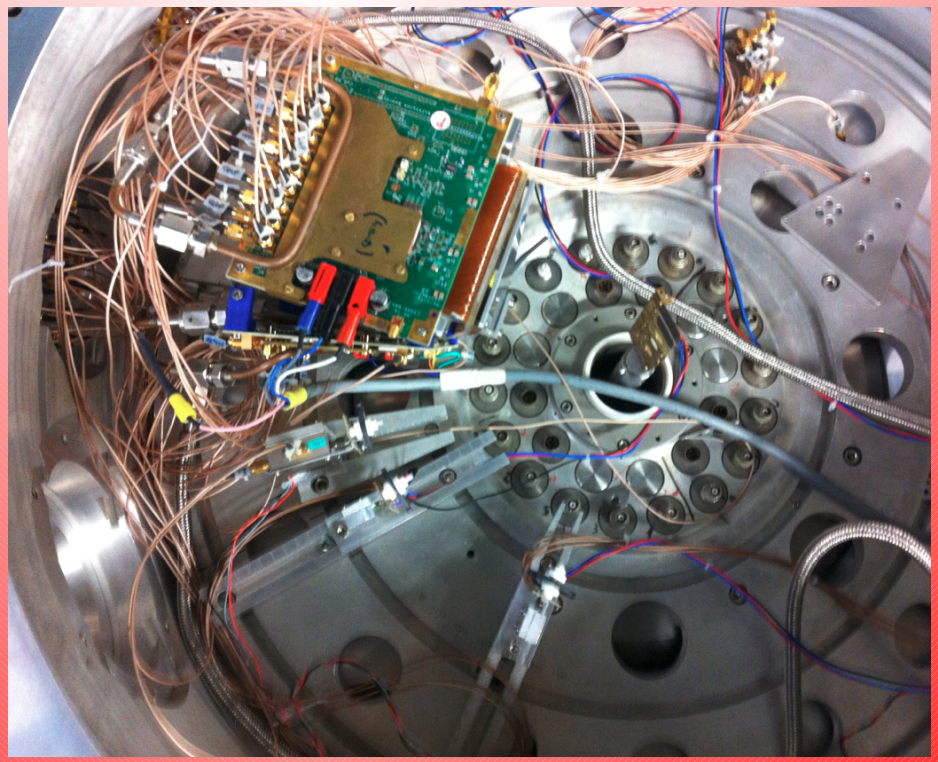


First Time, pulse shape with trapezoid detector and digital acquisition system

Configuration 2

Proton beam on ^{197}Au for radiation damages studies

Trapezoid ~40° left side
PACI2 ~5° left side
PARC ~5° right side
PACI1 ~ 40° right side



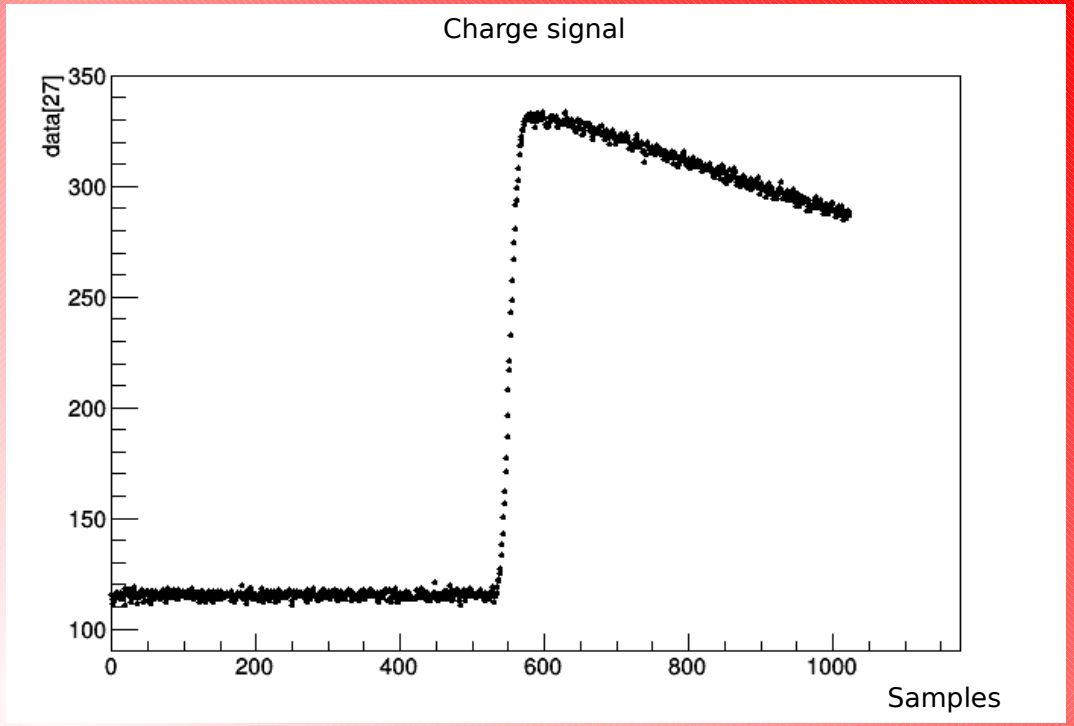
GRIT - PSA

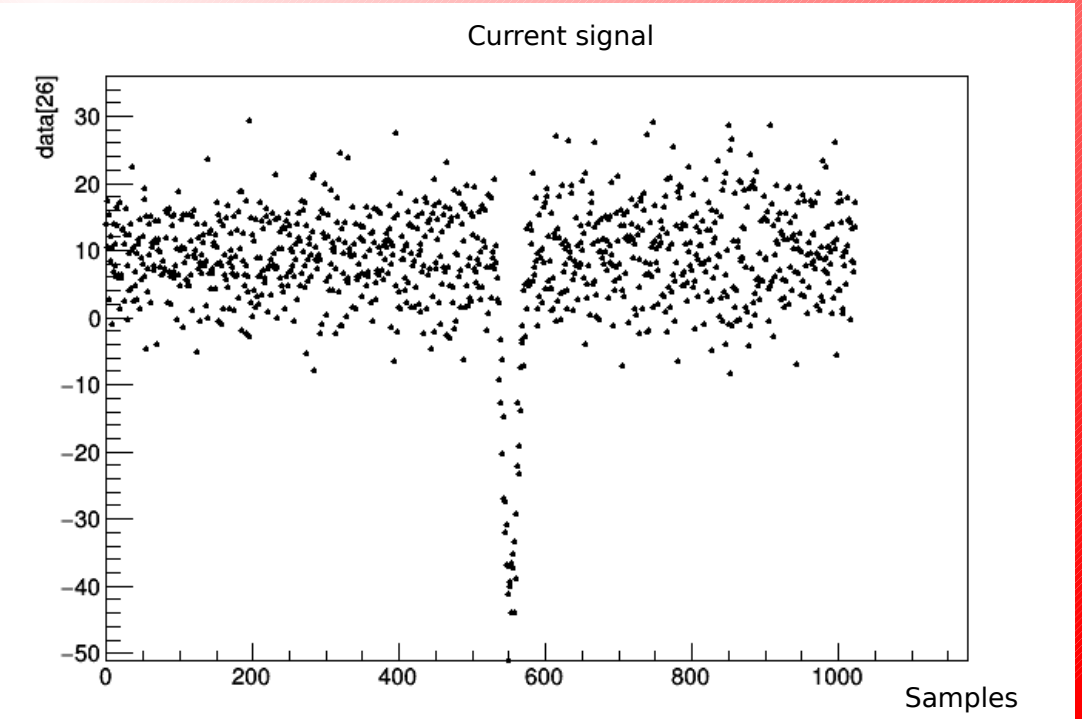
Eletronics chain

Pre-amplifier iPACI version 1
developed by SEP – IPNO
Charge and current signals

Wave-catcher digitizer (64ch)
(developed by LAL)
First time on Linux-Narval
(presented by Tijani Id Barkach)

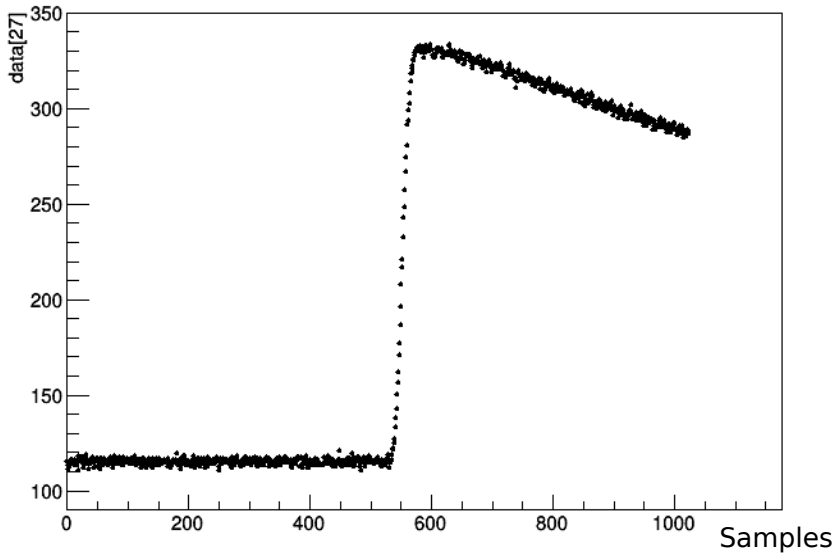
400 MHz sampling
Up to 1.3 GHz



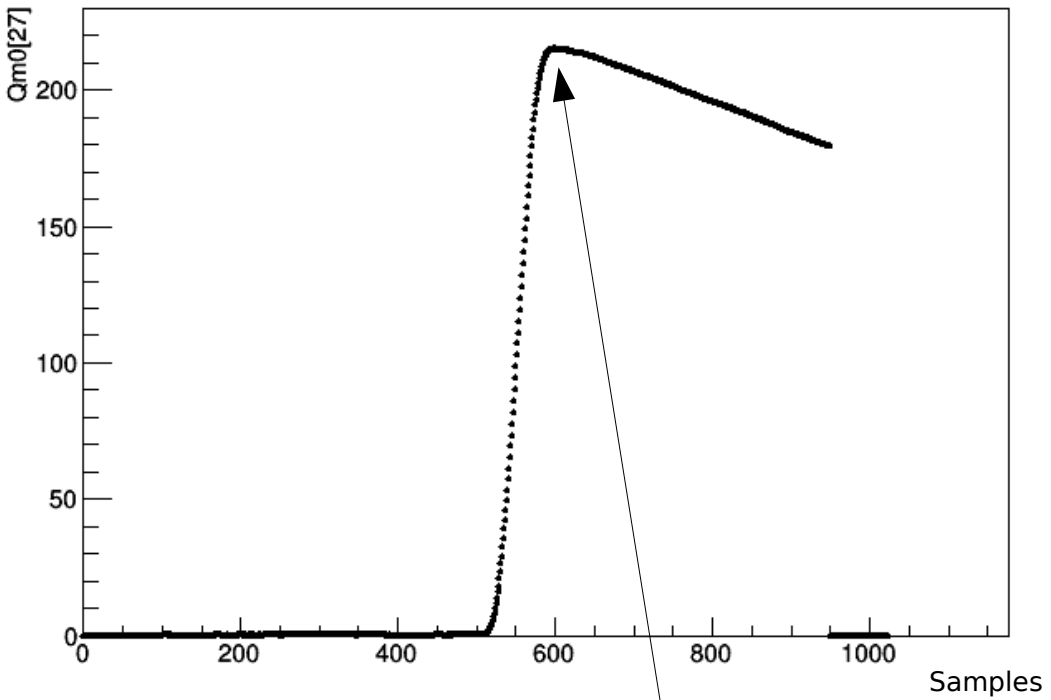


GRIT - PSA

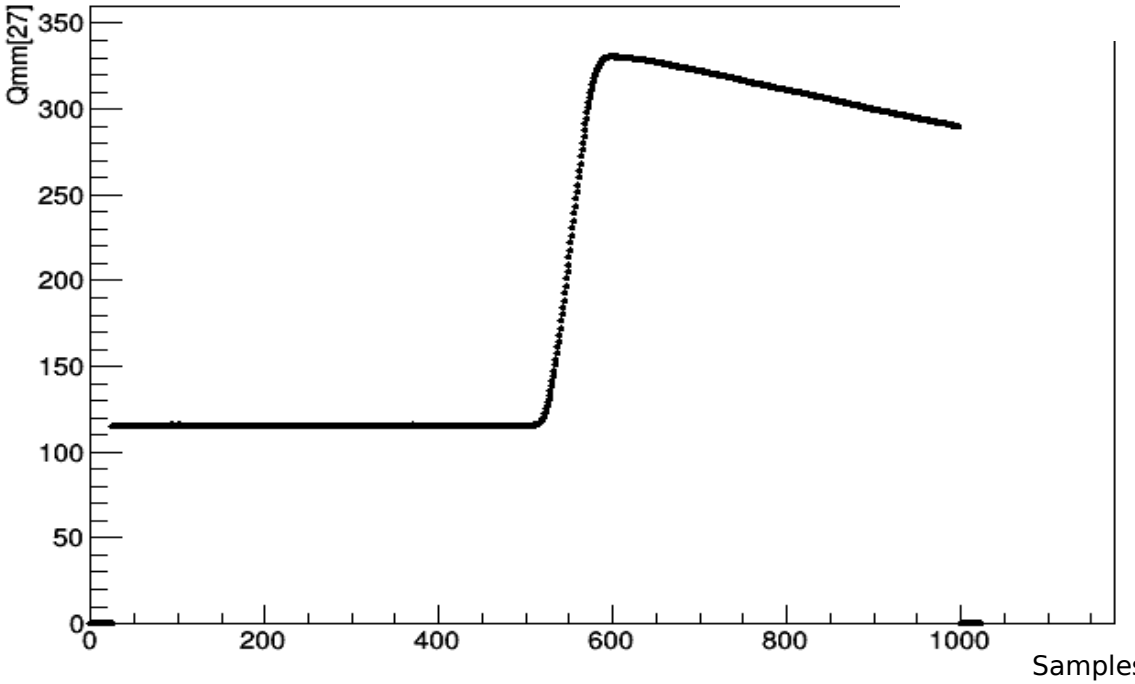
Charge signal



Step 2 → baseline reconstruction



Step 1 → moving average filter



Step 3 → Max Charge proportional to the Energy

GRIT - Strip resolution

Coinc P and N side
FWHM (keV)

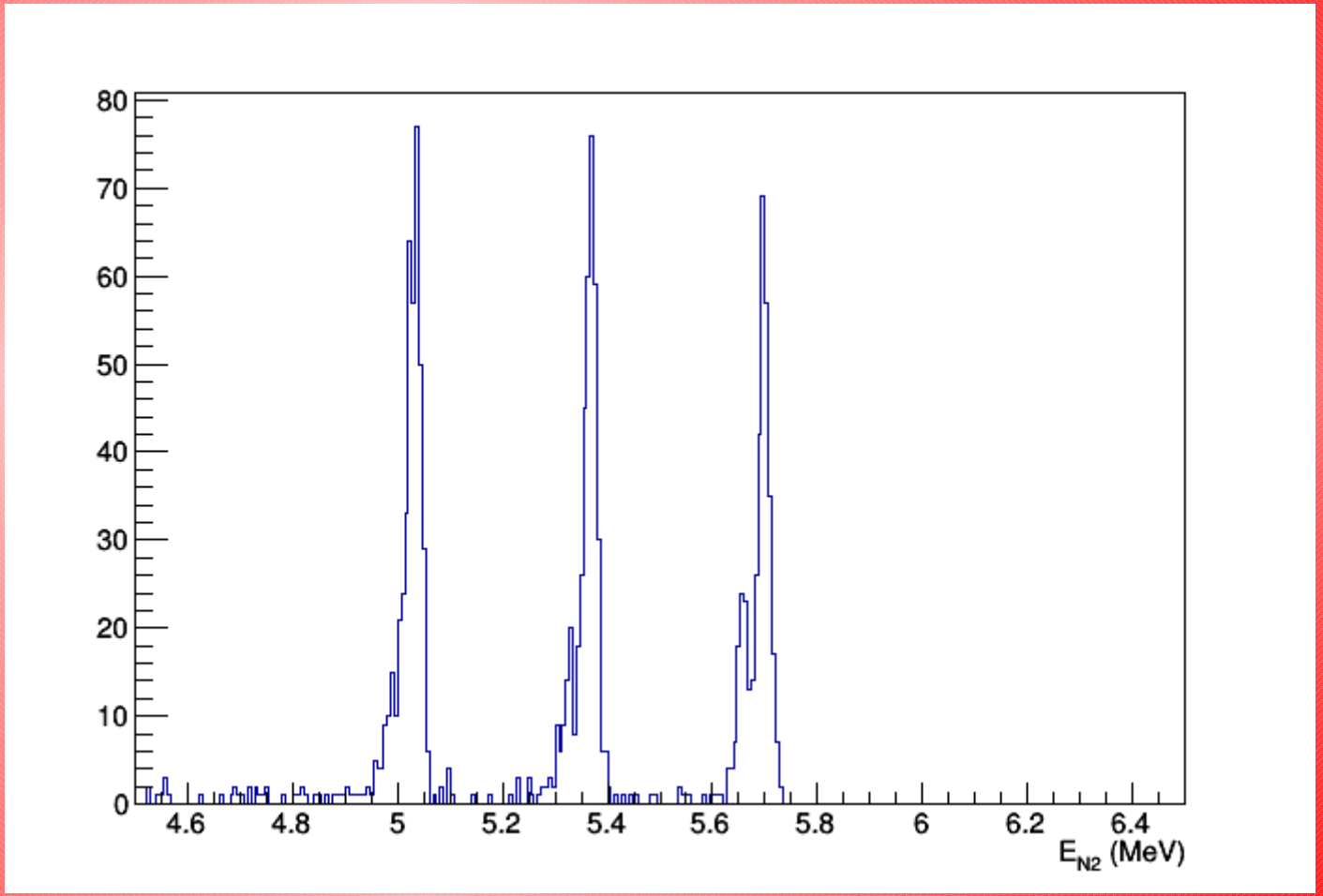
QN0 31
QN1 32
QN2 28
QN3 29
QN4 29
QN5 32
QN6 33
QN7 30
QN8 36

QP0 33
QP1 34
QP2 40
QP3 43
QP4 35
QP5 32
QP6 36
QP7 33
SP8 not connected

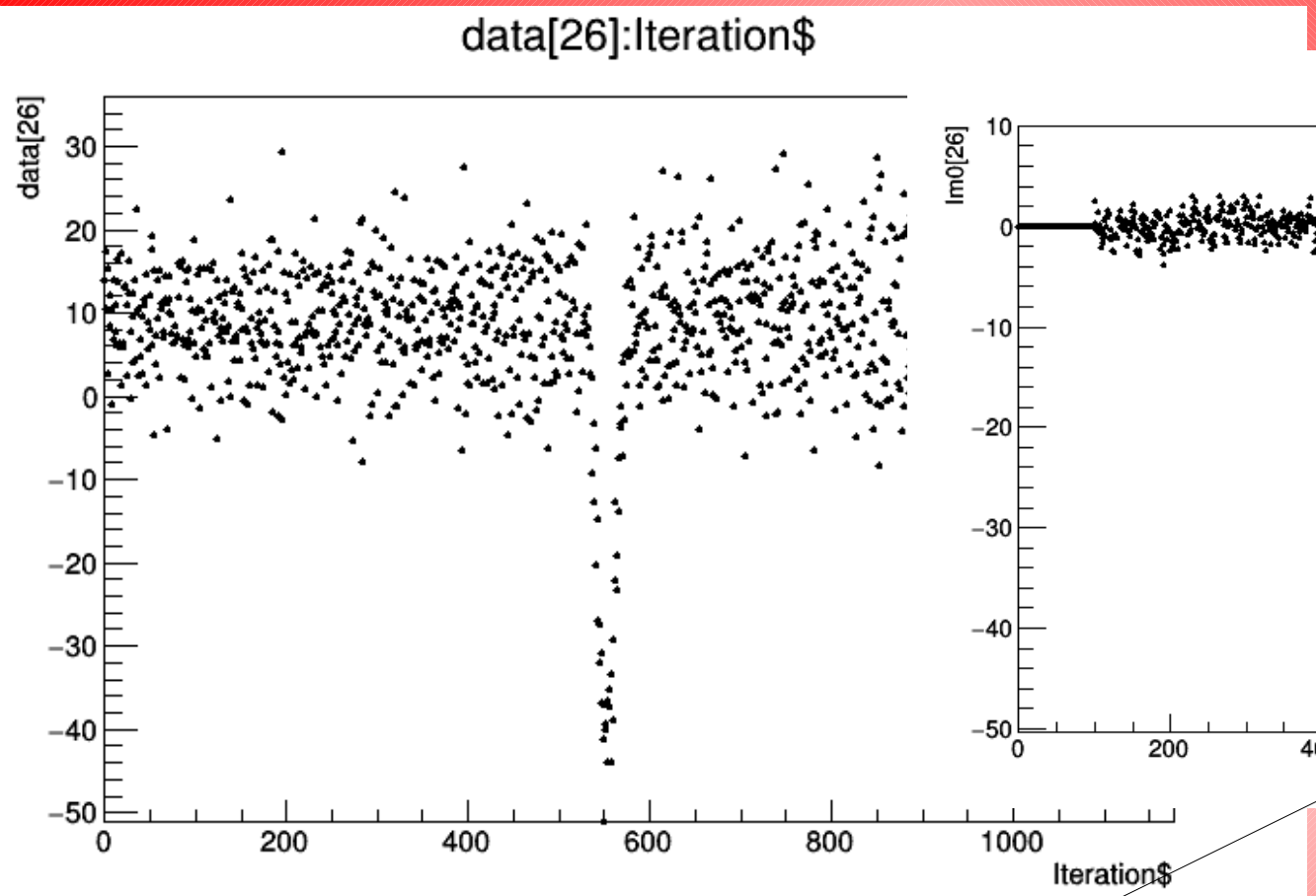
QPACI1 49
QPACI2 64
IPACI1 206
IPACI2 250

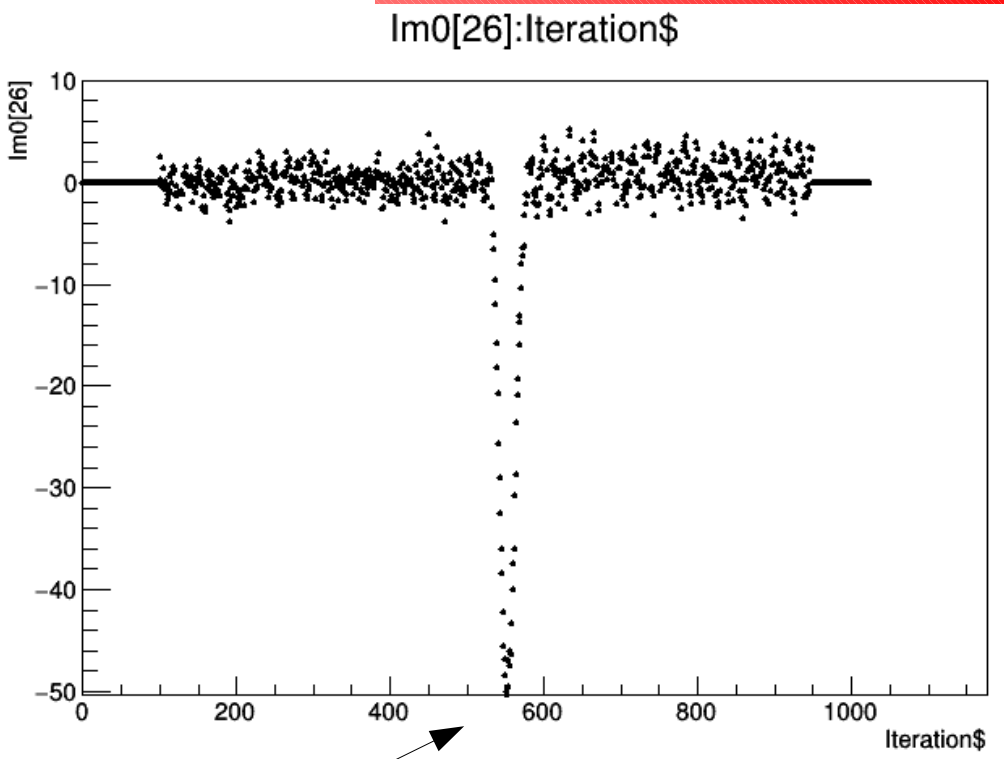
After all…. Resolution alpha in keV

Bias 120 V dead layer : 0.3 Al and 0.5 Si (um)



GRIT - PSA



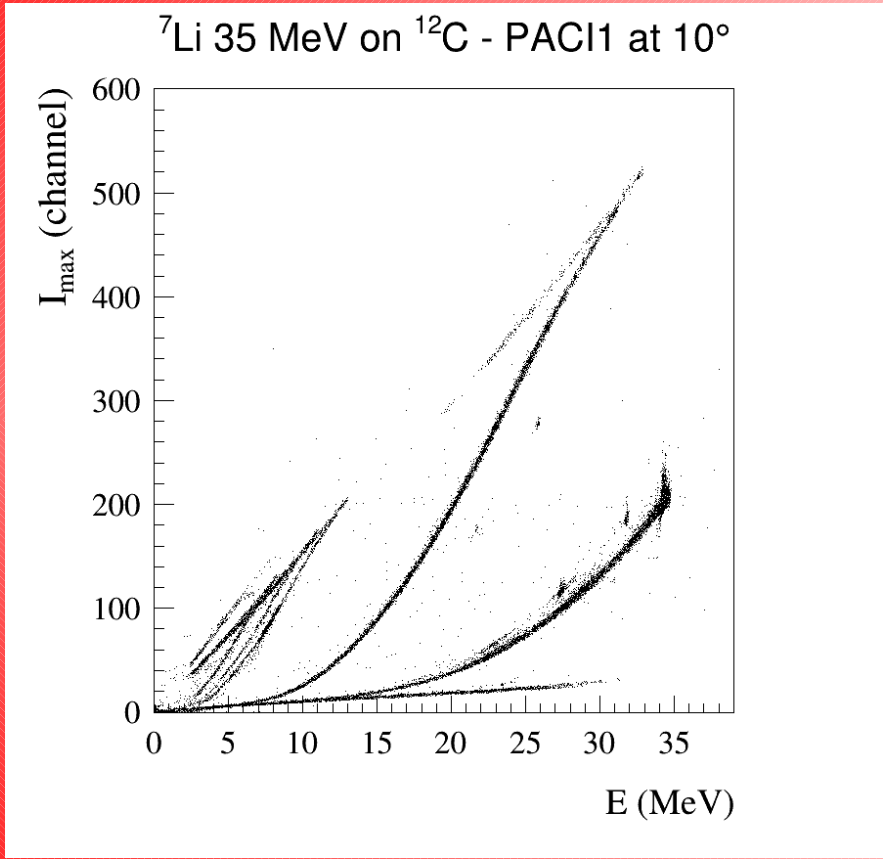


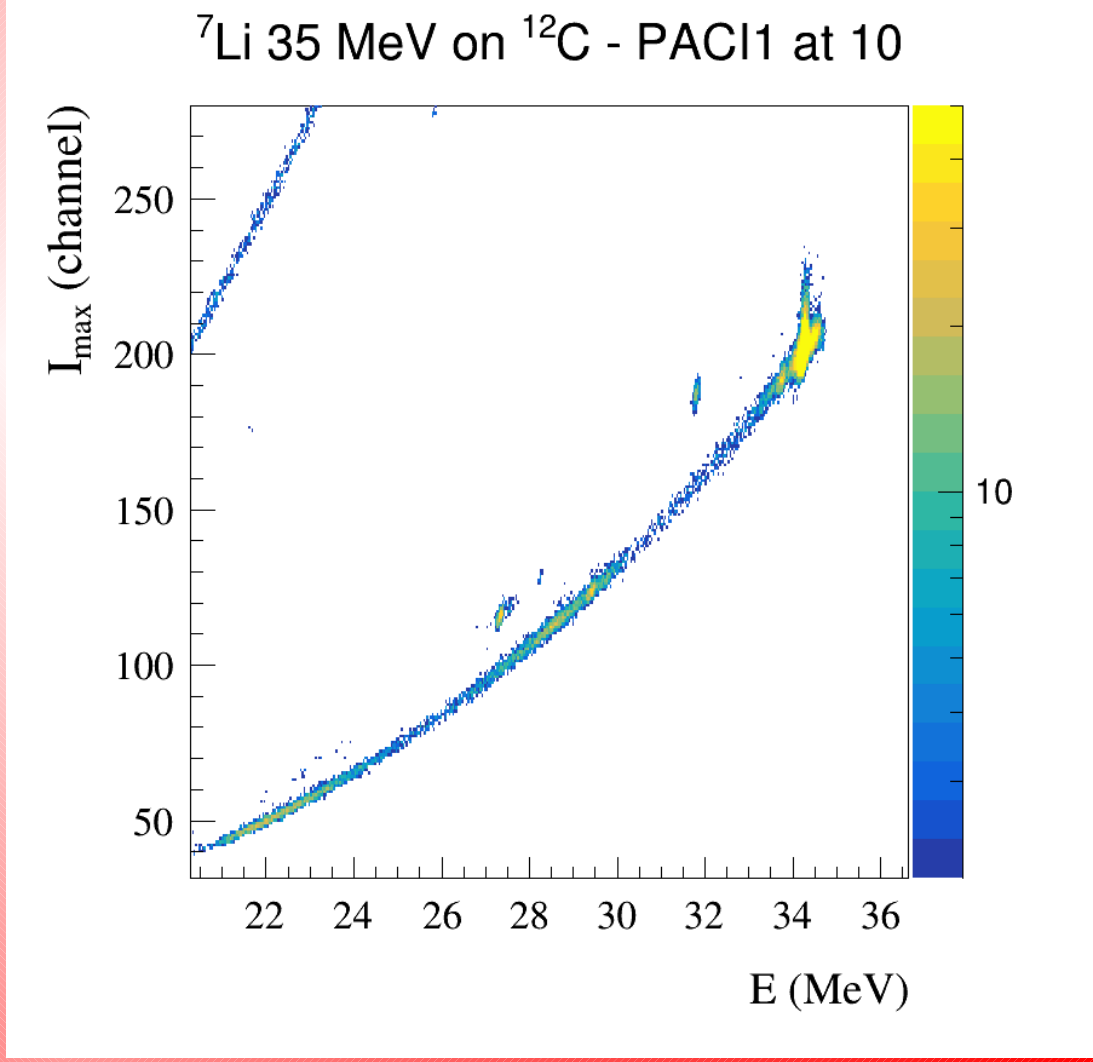
Max Current Signal related to the particle detected

GRIT - PSA

$^{7}Li + ^{12}C$ 35 MeV

PACI1 at 10°and Bias 120V
Calibrated in energy with punch trough p,d,t, He

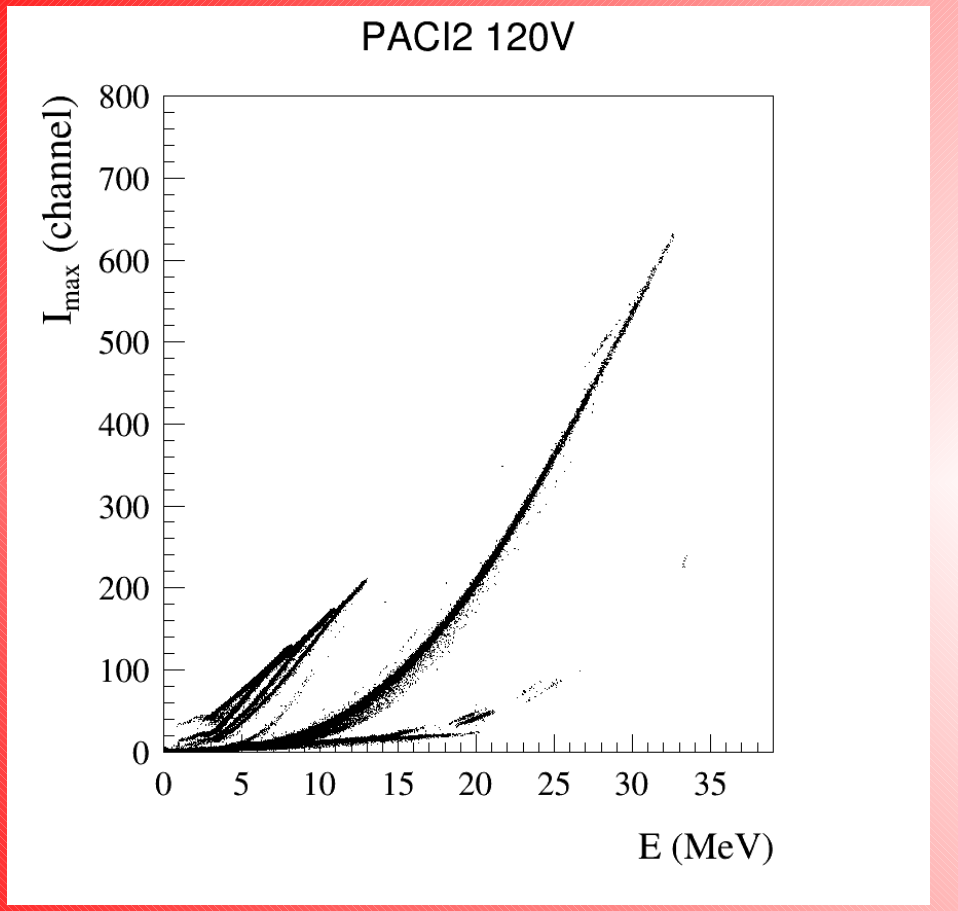


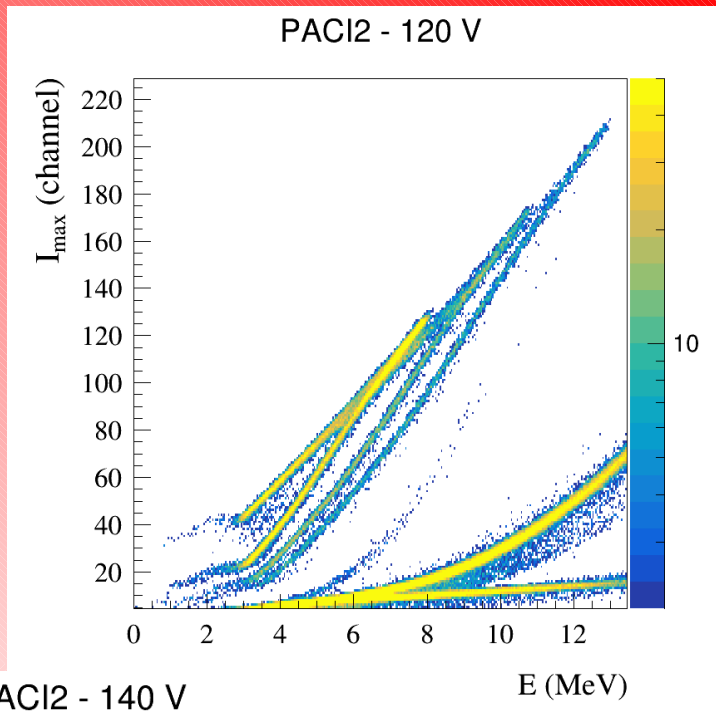


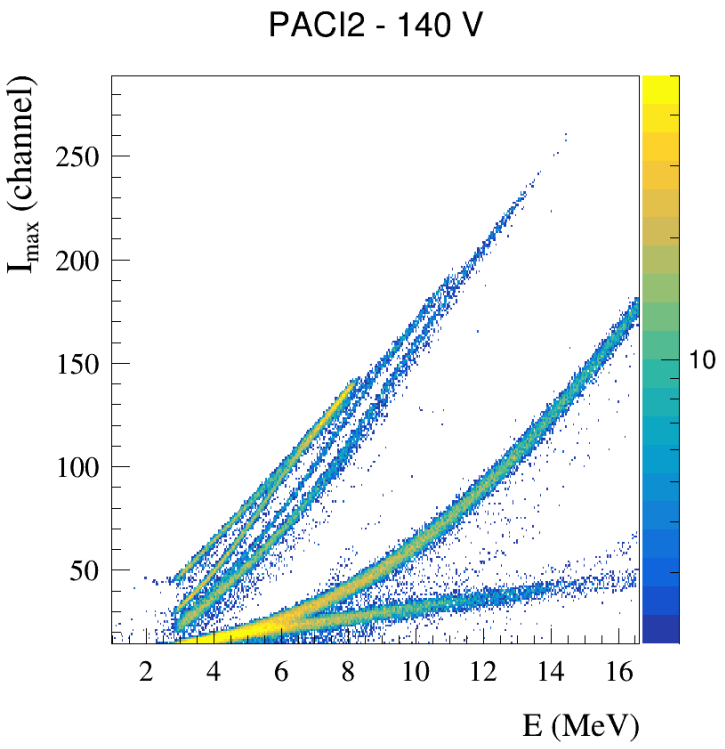
^{7}Li
GS 34.1 MeV
1st 33.6 MeV
2nd 29.4 MeV

GRIT - PSA

PACI2 at 40°and Bias 120V
Calibrated in energy with punch trough p,d,t, He

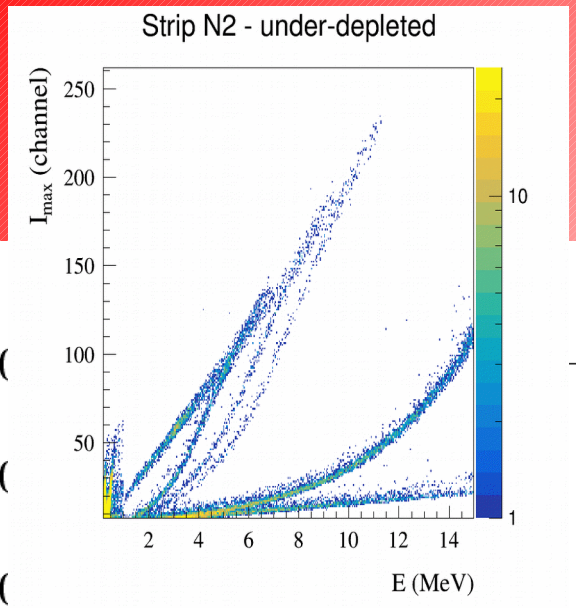


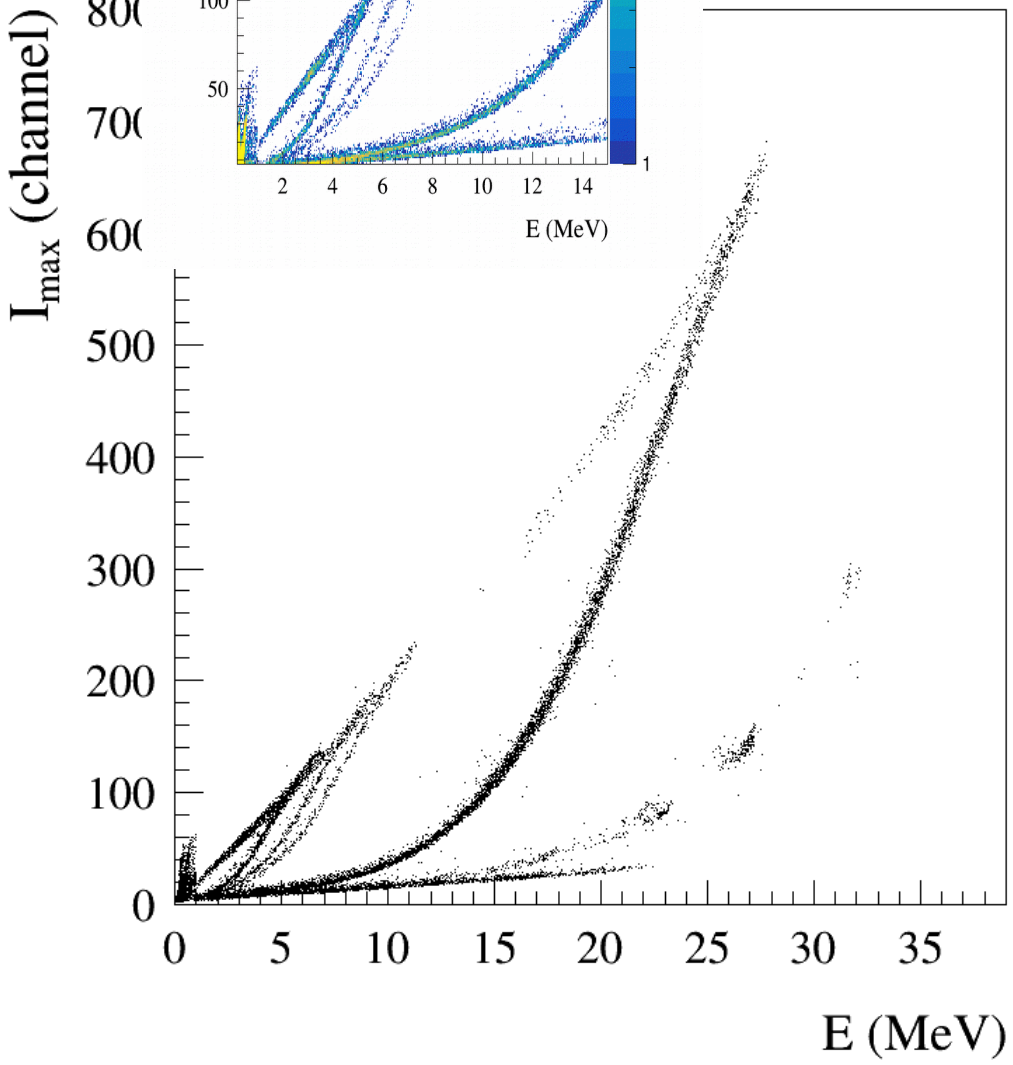


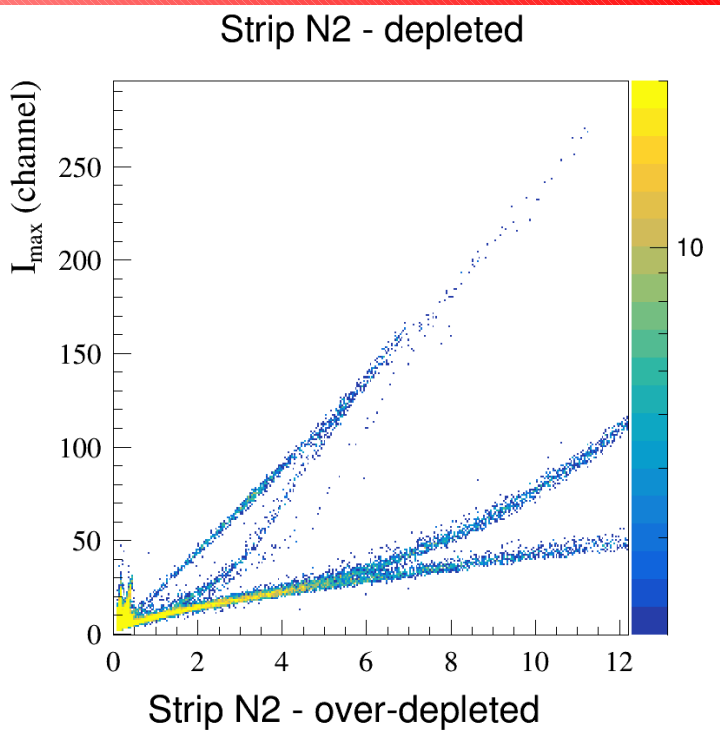


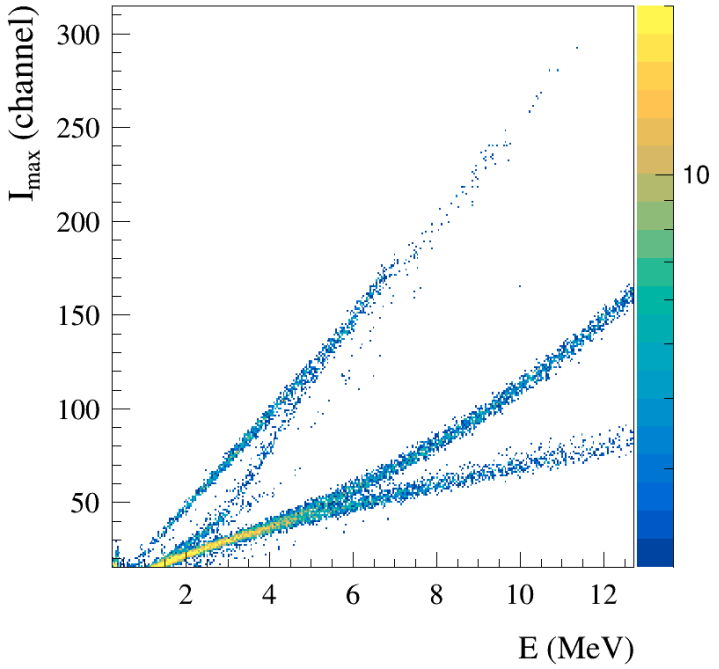
Check points for calibration
GS 26.0, 1st 25.6, 2nd 21.6 MeV

GRIT - PSA

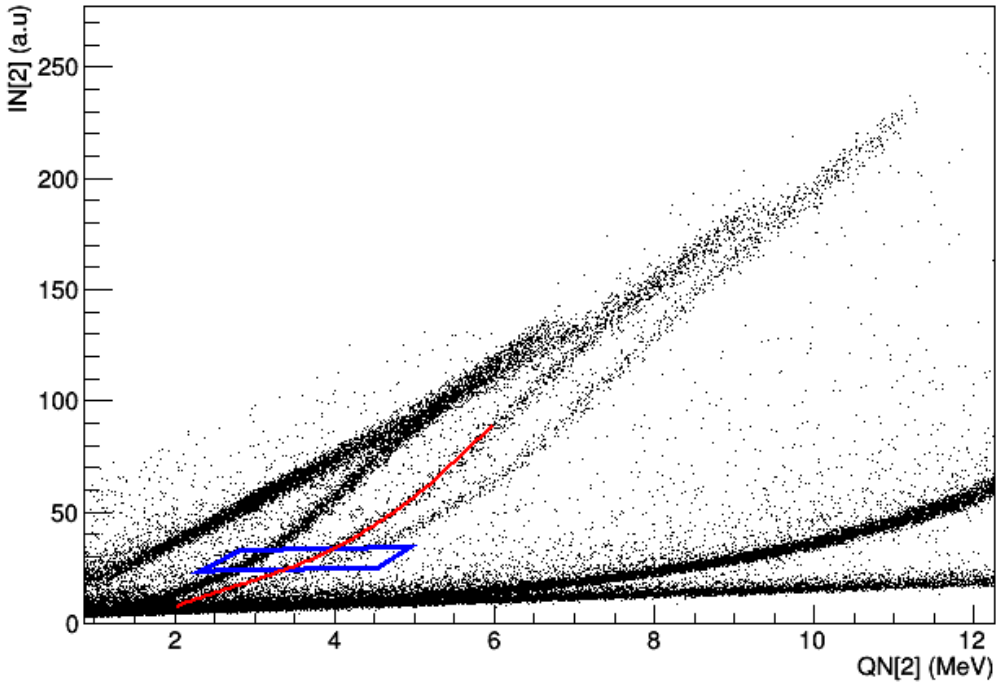

Strip N2 - under-depleted
I_{max} (channel)
E (MeV)

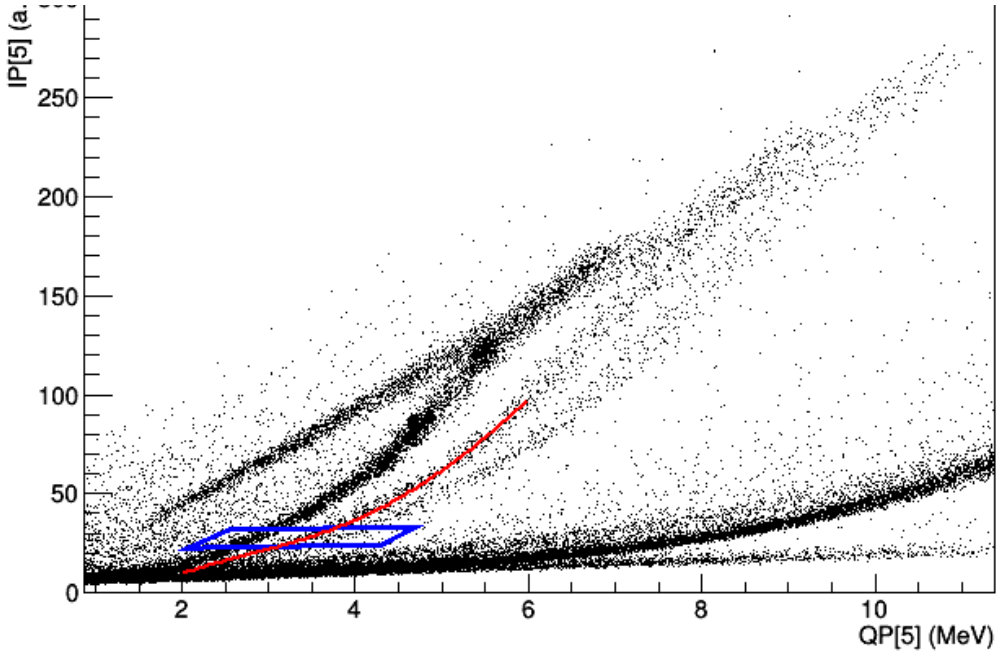

- Strip N2
I_{max} (channel)
E (MeV)

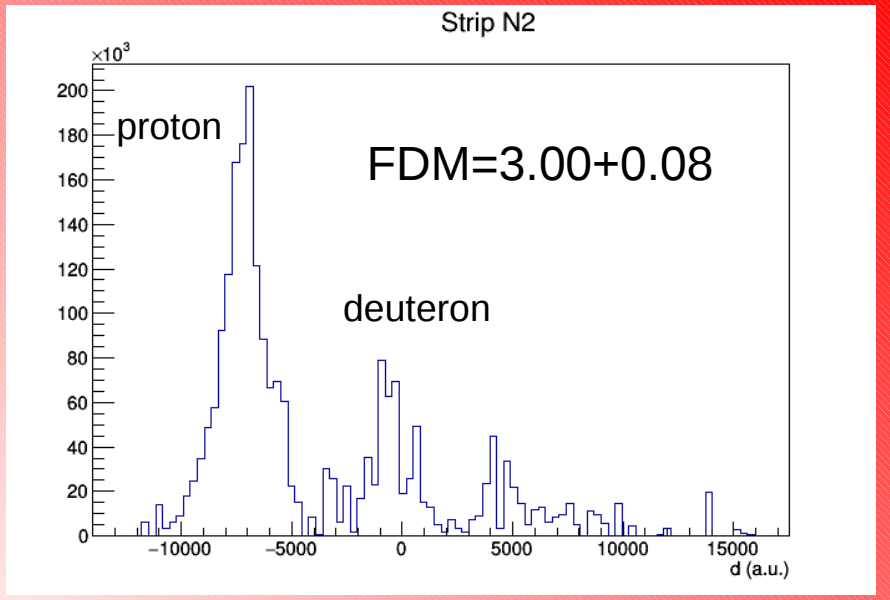

Strip N2 - depleted
I_{max} (channel)


Strip N2 - over-depleted
I_{max} (channel)
E (MeV)

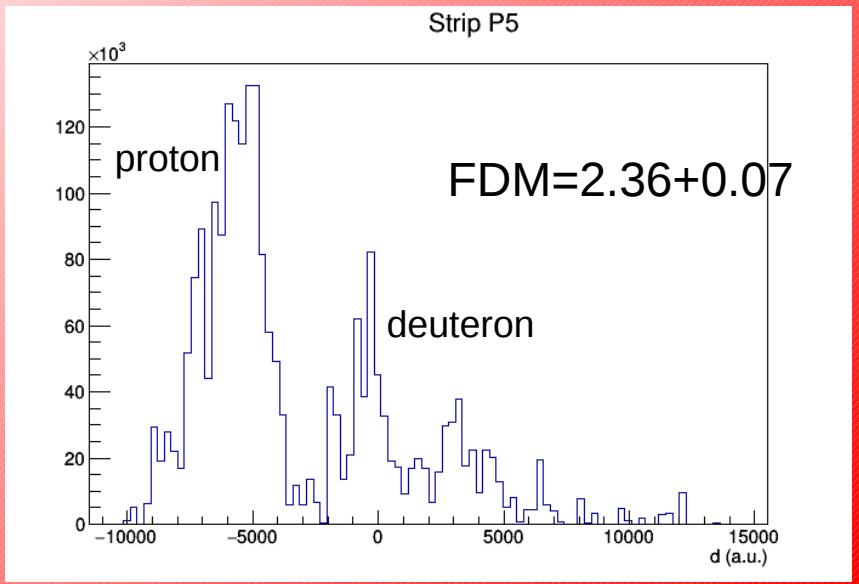
GRIT - PSA



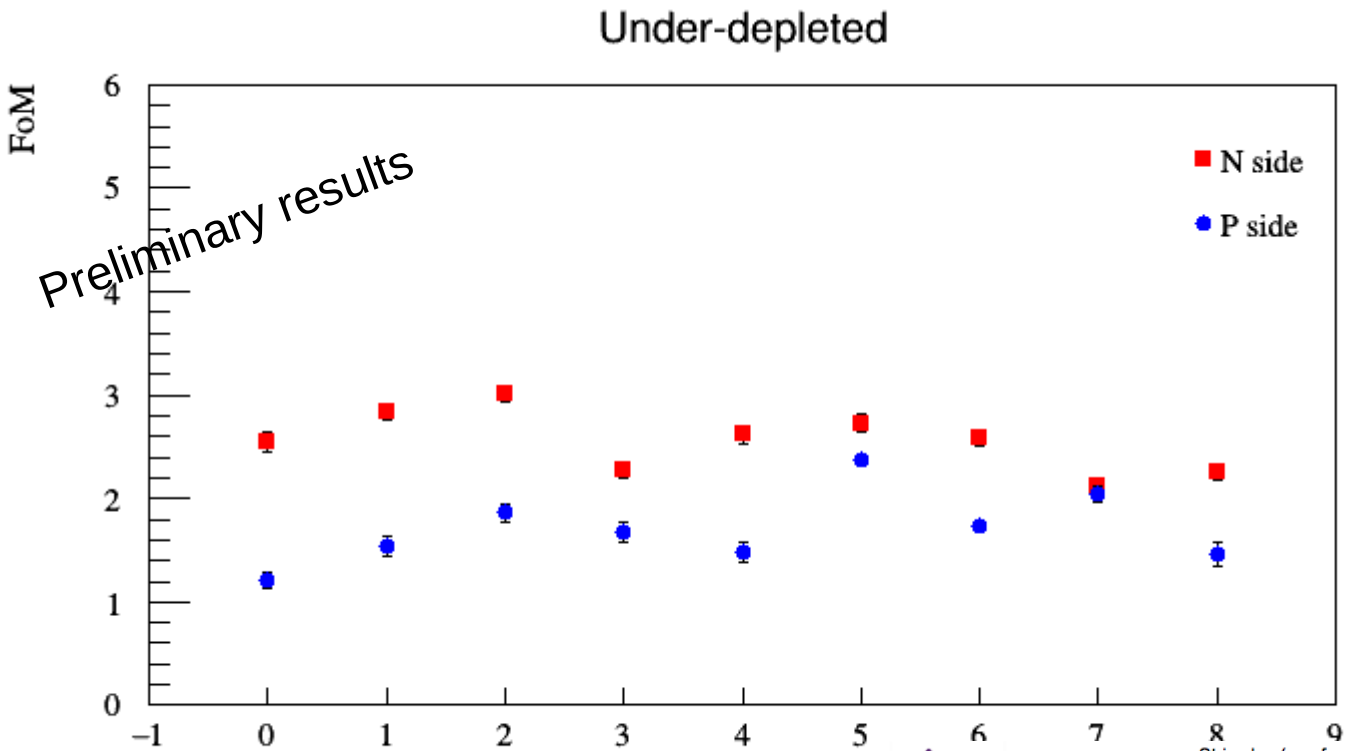




$$FoM = \frac{2|\mu_p - \mu_d|}{2.35(\sigma_p + \sigma_d)}$$

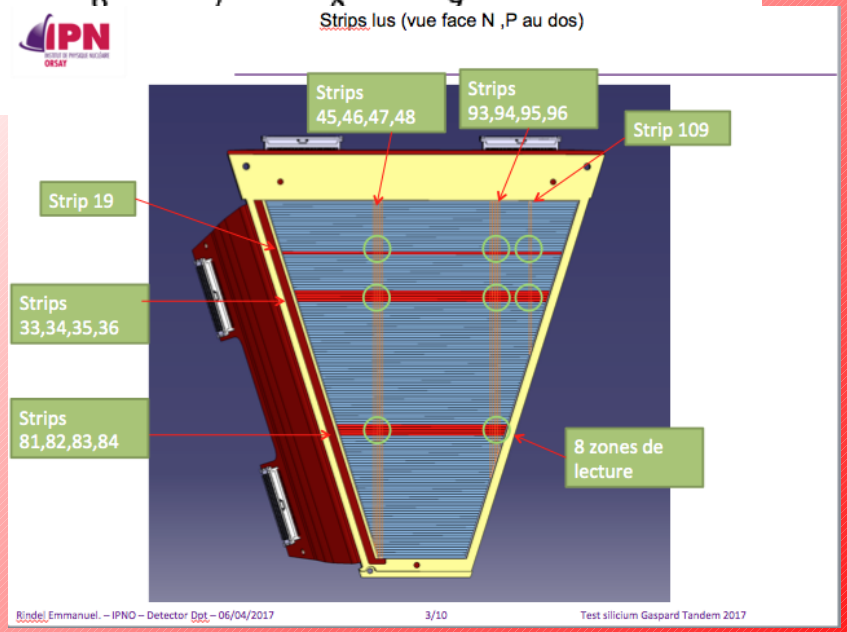


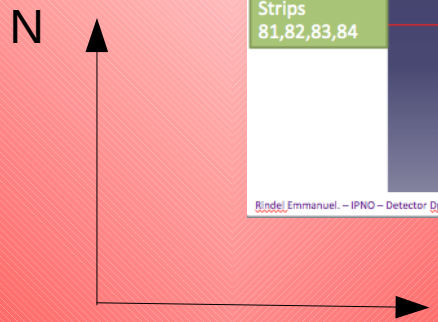
GRIT - PSA



$$FoM = \frac{2|\mu_p - \mu_d|}{2.35(\sigma_p + \sigma_d)}$$

No sensitivity to the length of the strip





GRIT - PSA

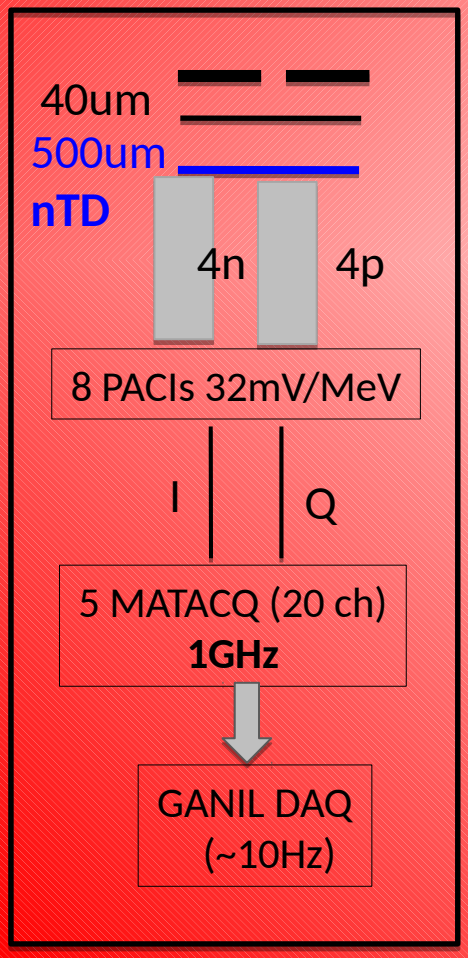
PSA with nTD 500um, 8° cut, 128X+128Y strips BB13 (Micron),

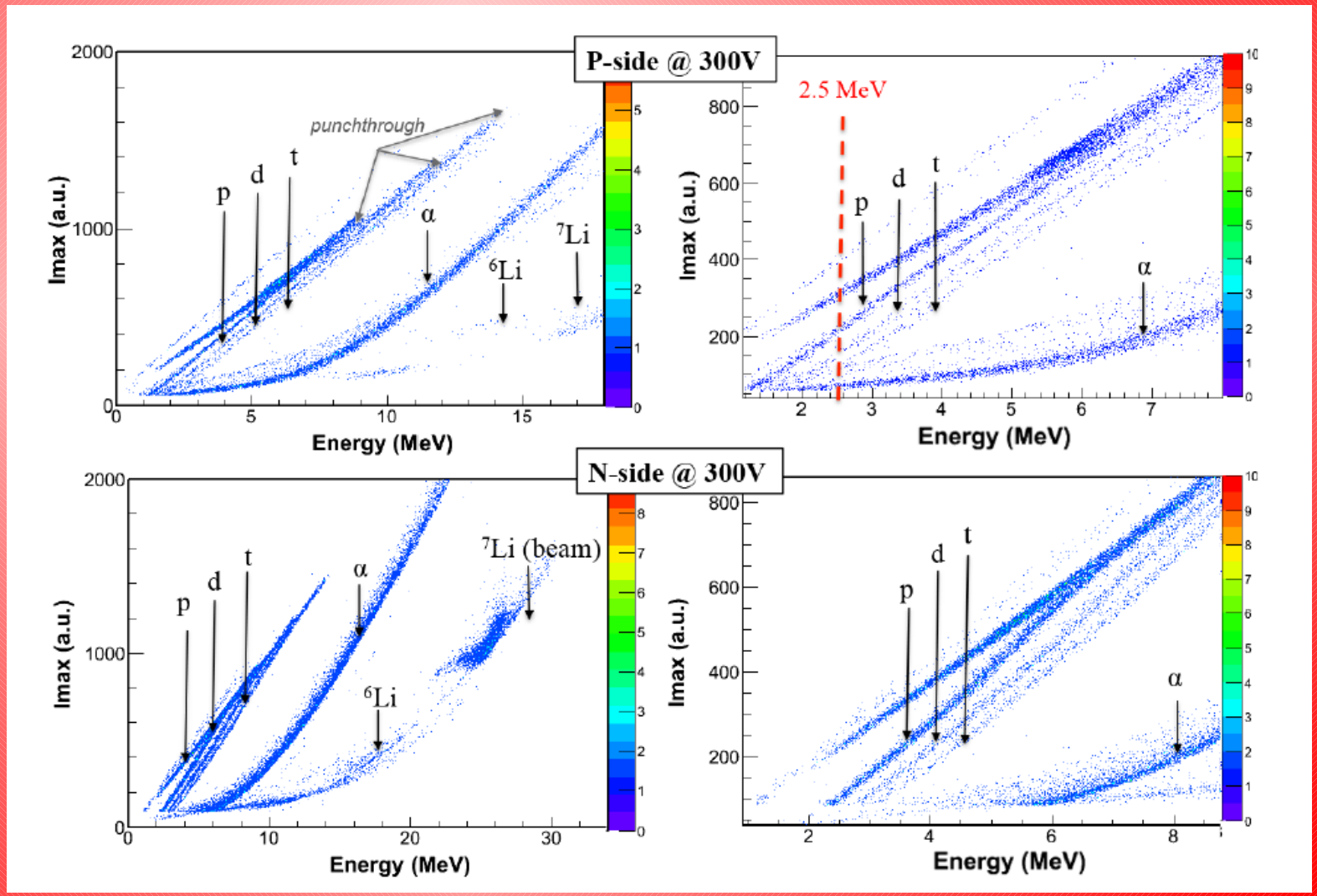
M. Assié Eur. Phys. J. A (2015) 51:11

Pitch **<500um**, high density connectors, special packaging with narrow frames

Preamps : PACI gain ~32 mV/MeV

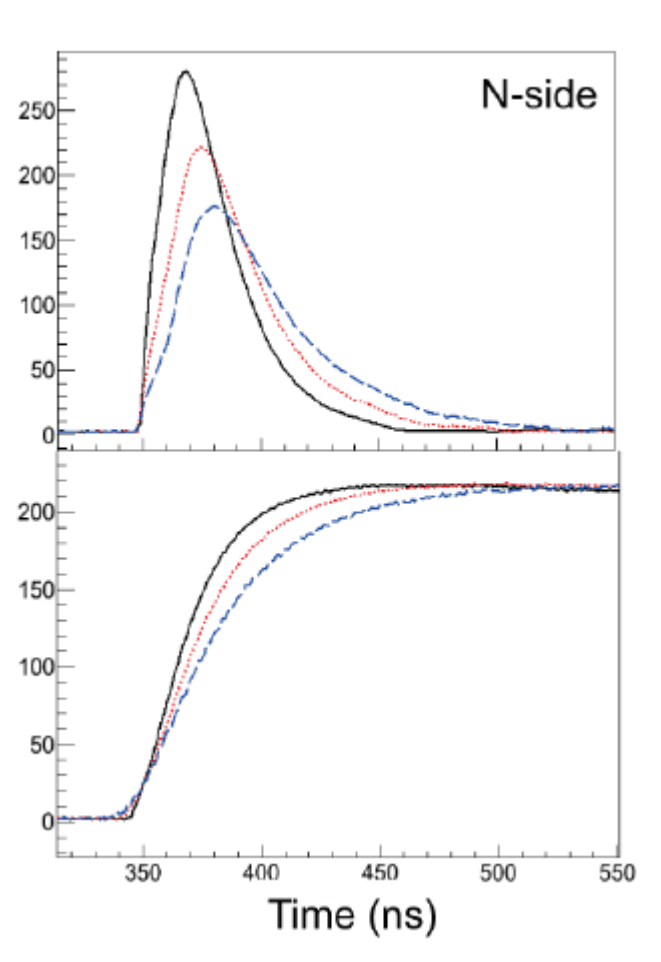
Digitizers : **5 MATACQ** - **1GHz** sampling GANIL DAQ : 20 digital channels 10Hz





GRIT - PSA

PSA with nTD 500um, 8° cut, 128X+128Y strips
BB13 (Micron)



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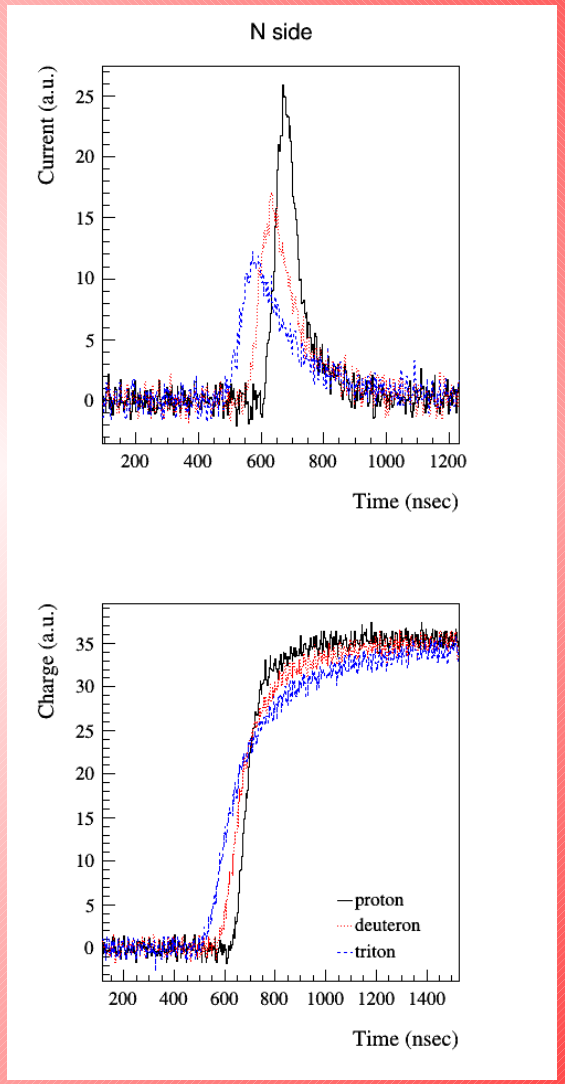
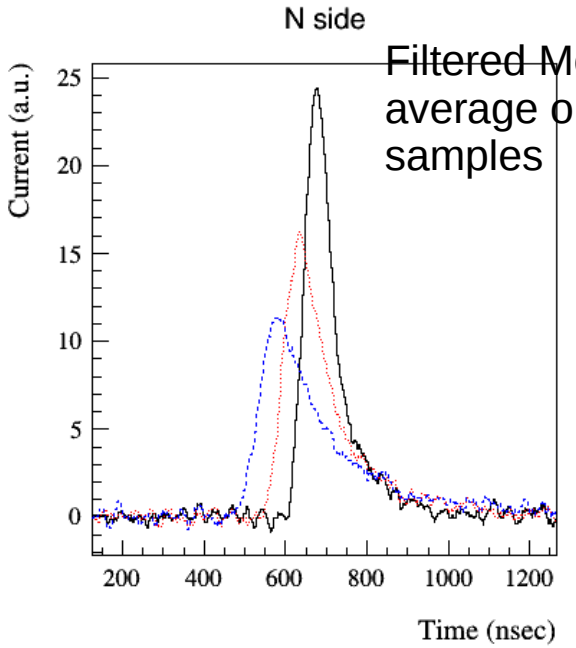
Previous experiment,
MATACQ 1GHz sampling
14 bits

PSA with nTD 500um, 8° cut, no strips
same preamplifier PACI
same selection p,d,t at 4 MeV

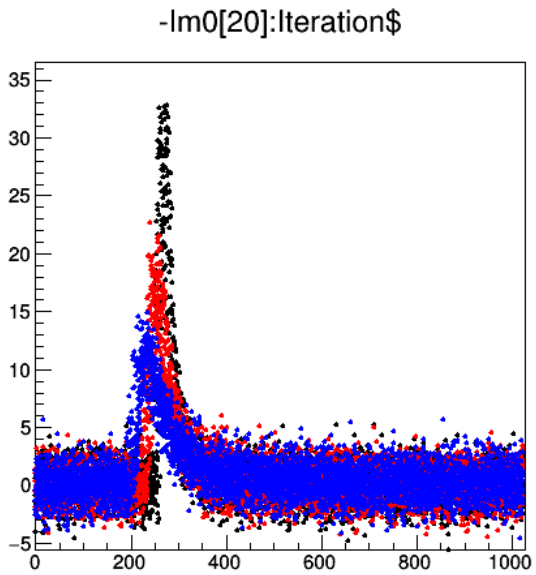


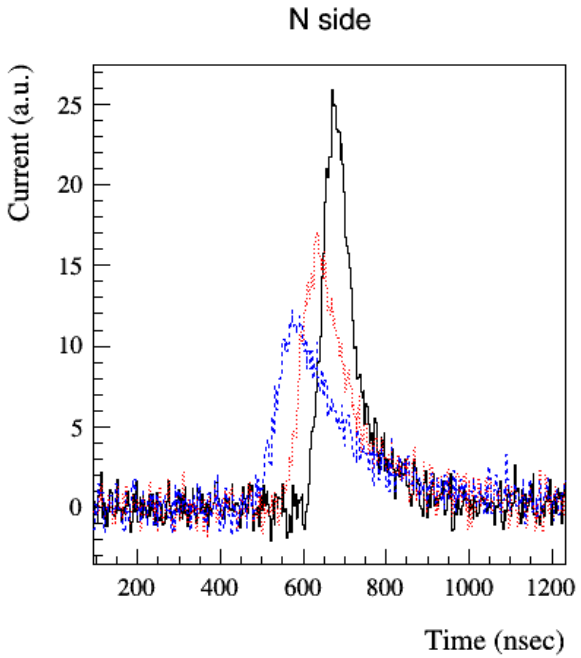
400 MHz sampling 12bits

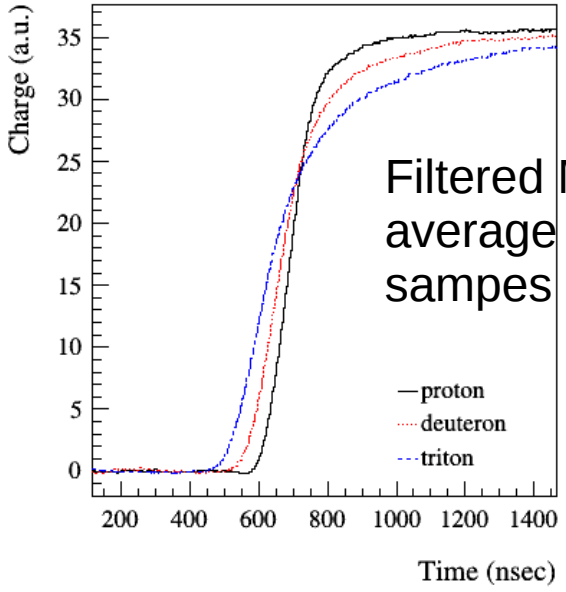
GRIT - PSA



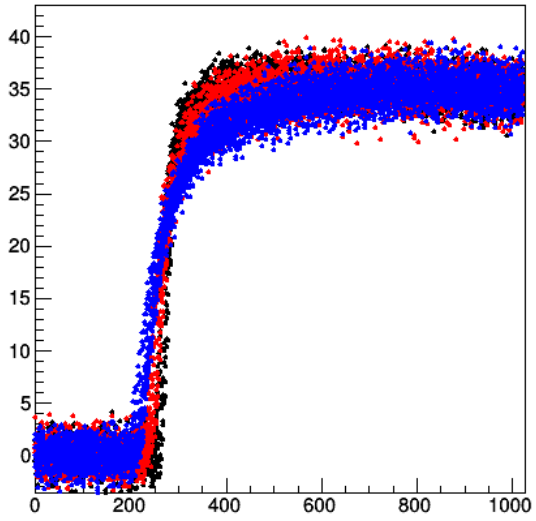
Filtered Moving average on 7 samples

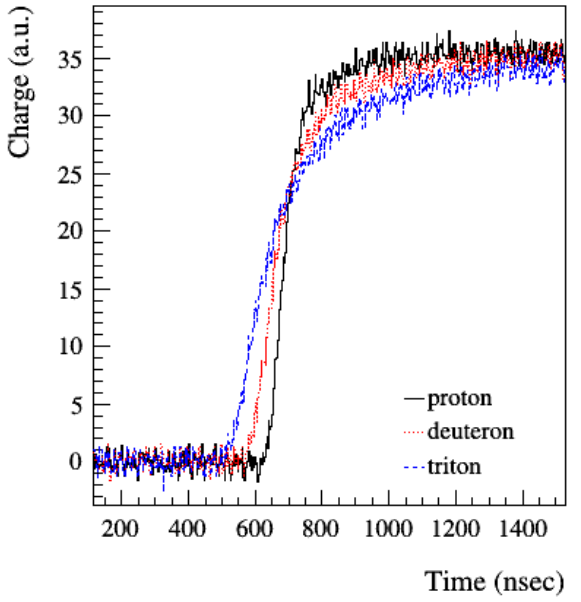




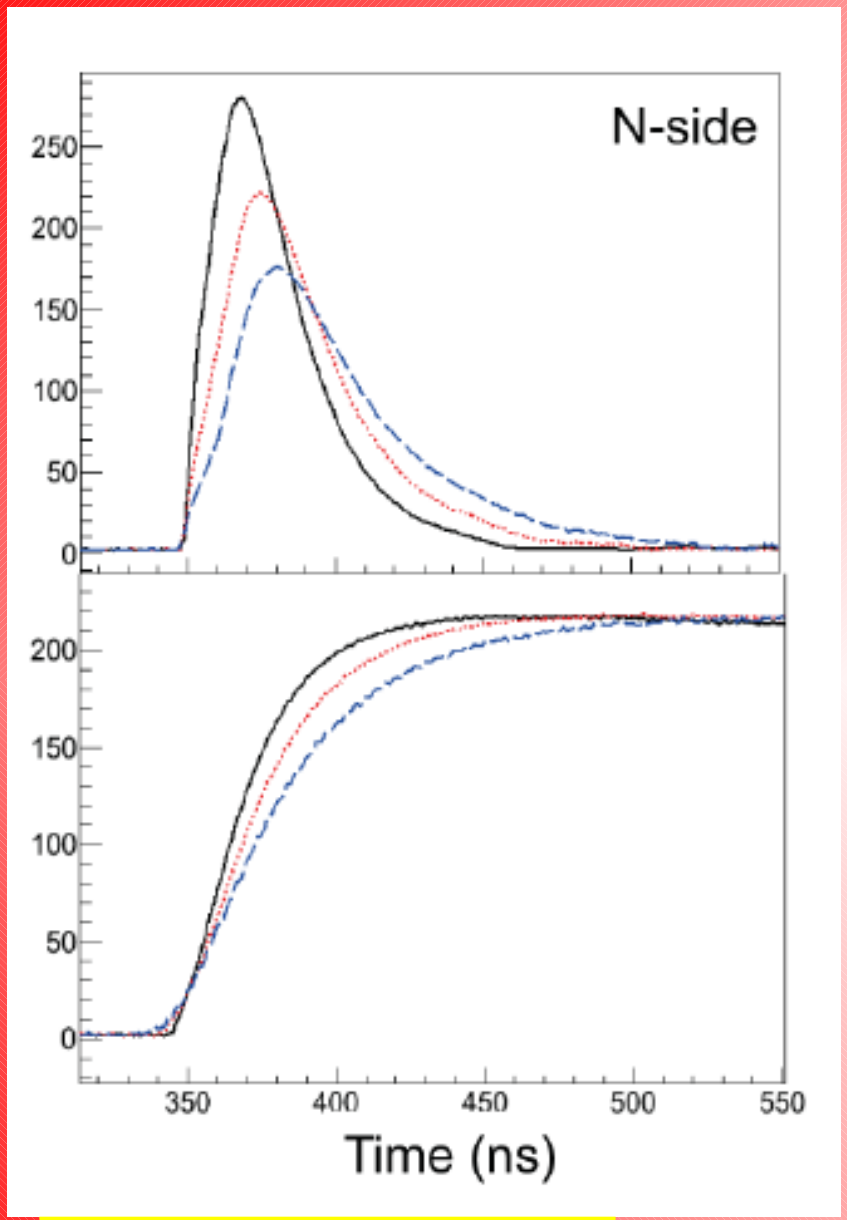


Filtered Moving average on 51 sampes





GRIT - PSA



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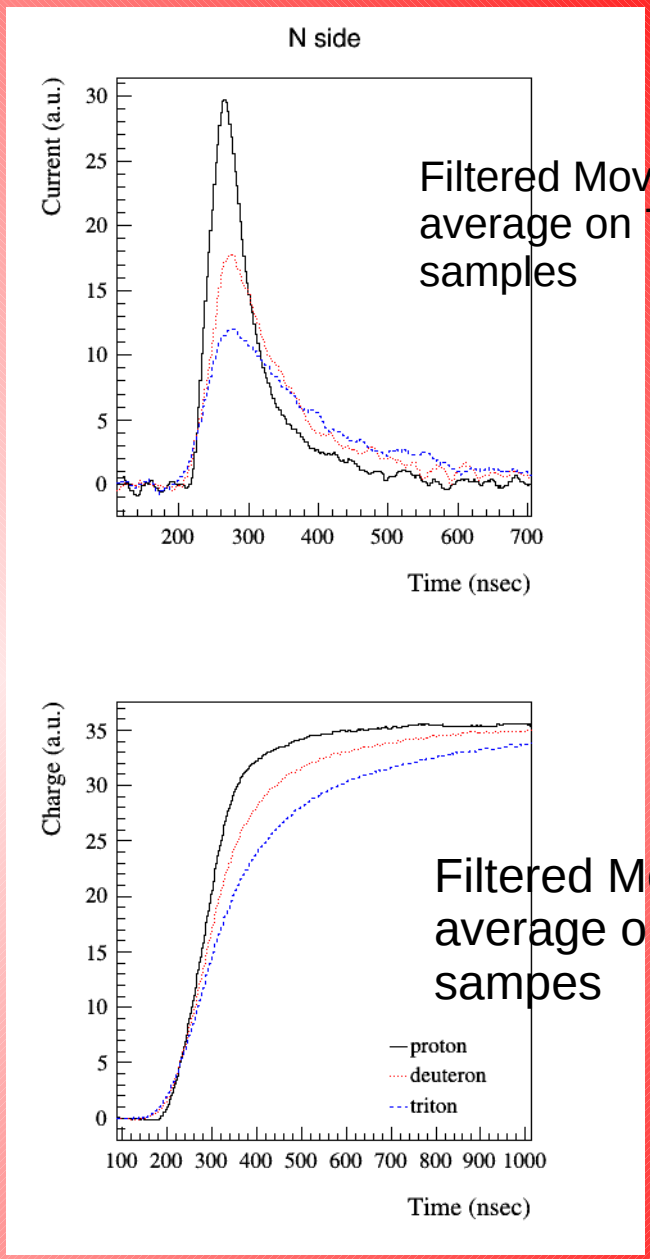
Previous experiment,
MATACQ 1GHz sampling
14 bits



400 MHz sampling on 1024 points 14bits

Conclusion

- Pulse shape analysis with new digital acquisition

- Studies of the isotopic identification for different length strips

- Radiation damage on nTD type

- Improvements are required to decrease the noisy coming from the wave-catcher

Writing Rate with Windows ~120 Hz
" with Linux ~80 Hz (due to PC and USB).

It should be the same...

With Matacq + VXI ~ 5 Hz (but less noisy...)

To be continued…

A suivre !