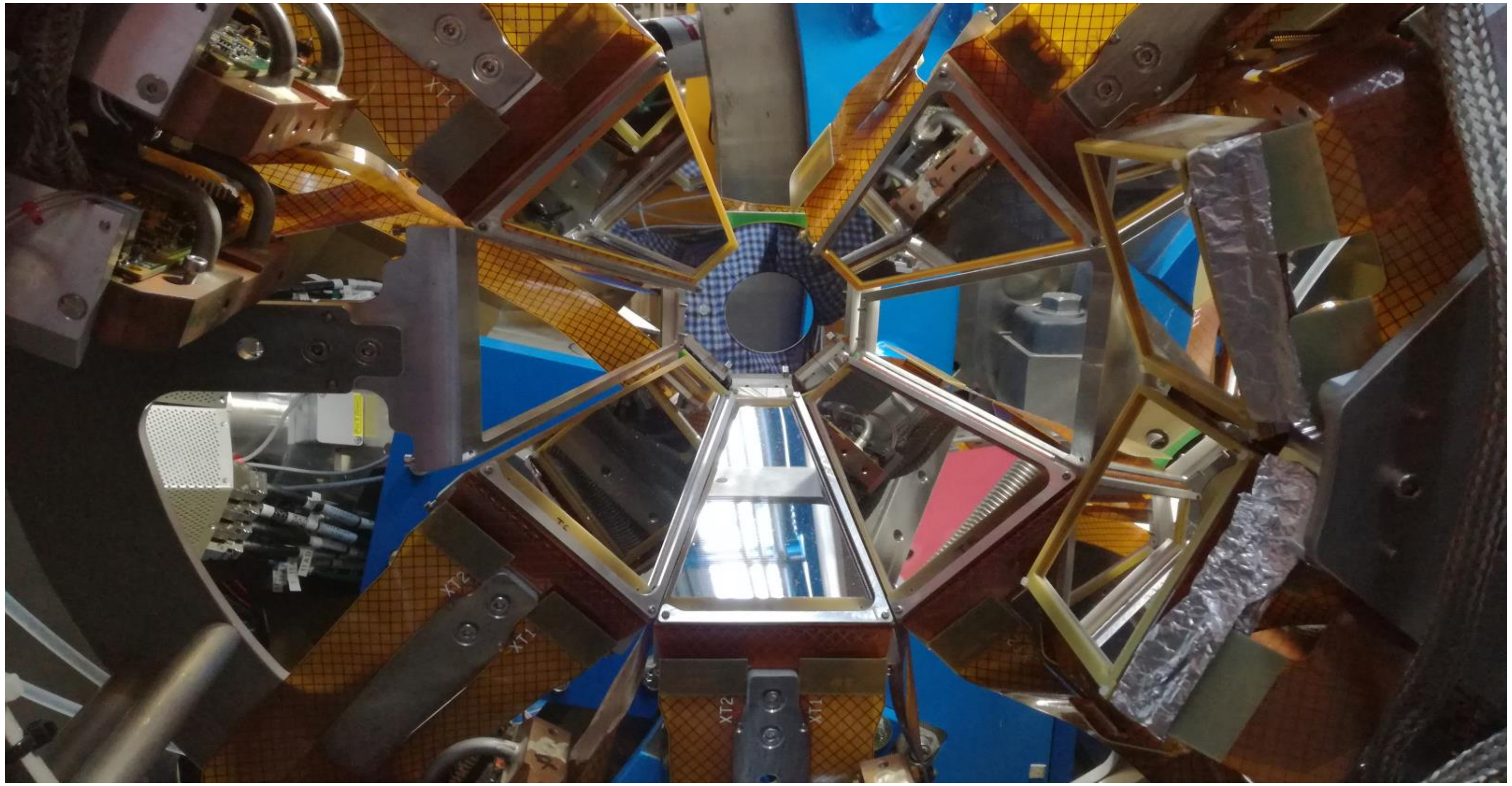
Performances of thin detectors and design improvements



Franco Galtarossa, IPN Orsay

GRIT Workshop

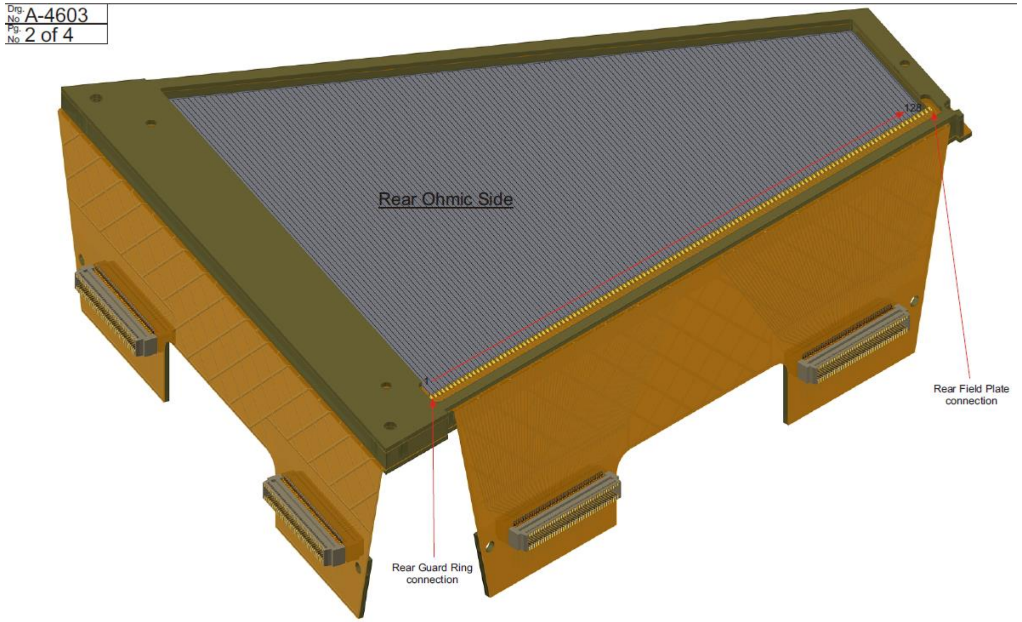
Firenze, 9-11 October 2019

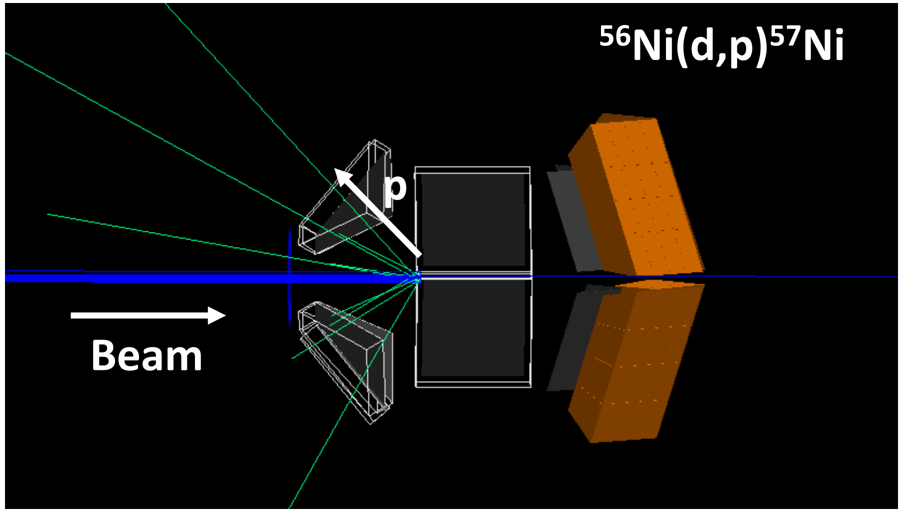
Outline

- Introduction
- In-beam tests @ ALTO on trapezoid detectors
- Pulse-shape analysis and particle identification
- Possible design developments

Introduction

Wafer type	nTD 6 inches
Thickness	500 µm
Active area	64 cm^2
Metal coverage	0.1 µm uniform
Dead layer	0.1 µm on the N-side
Number of strips	128X + 128Y
θ_{lab} coverage	104° - 155°
Distance from target	10.5 cm

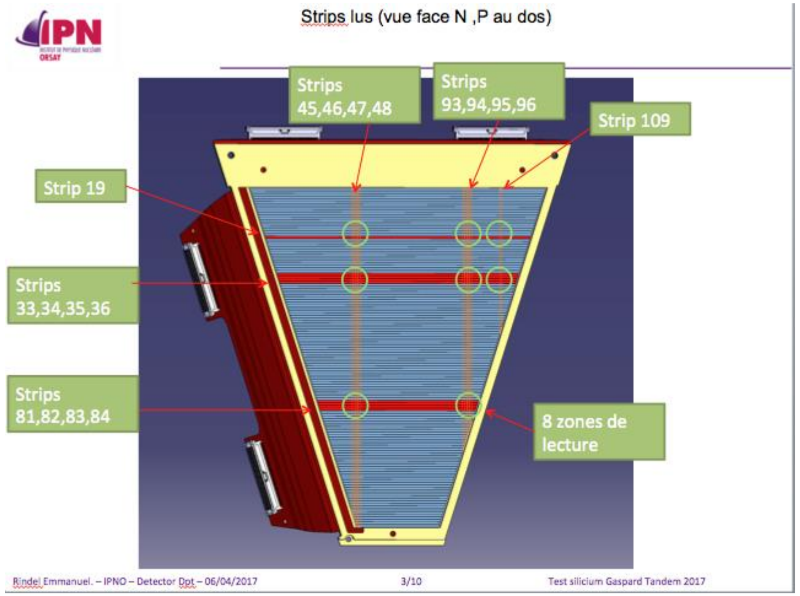


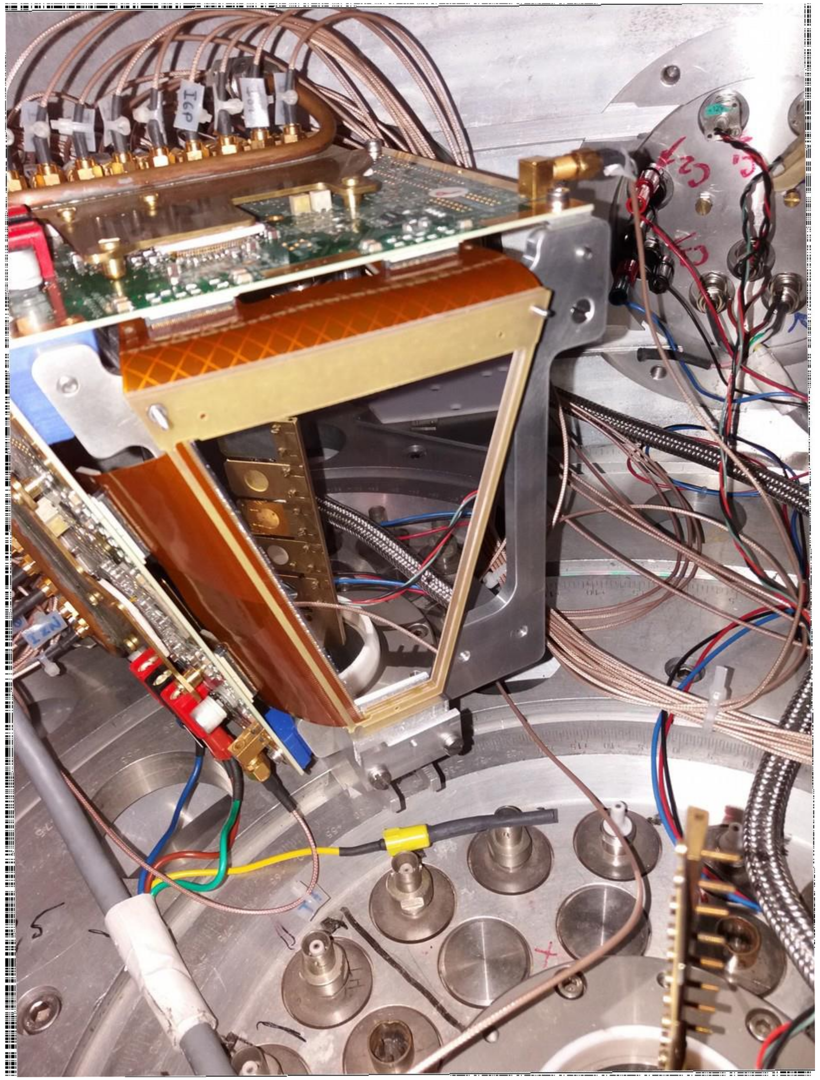


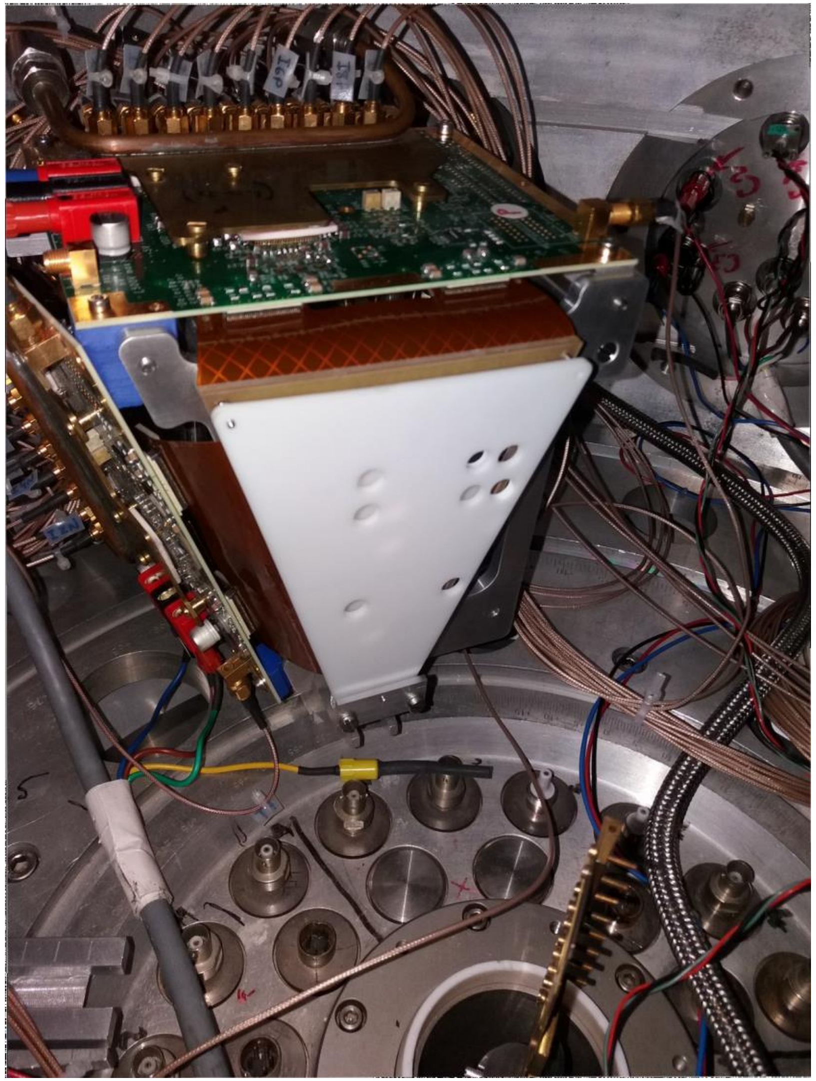
Five of these detectors, placed at backward angles, are currently mounted in GANIL to detect light particles (p, d, t, α) in stripping reactions in inverse kinematics, where the transfer cross sections are usually backward peaked.

In-beam tests @ ALTO

$^{7}Li+^{12}C$ @ E_{lab} = 35 MeV → Favorable reaction producing many Z=1 and Z=2 particles





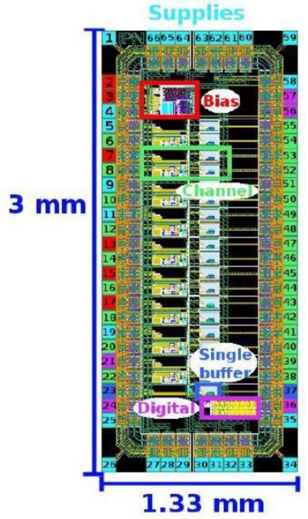


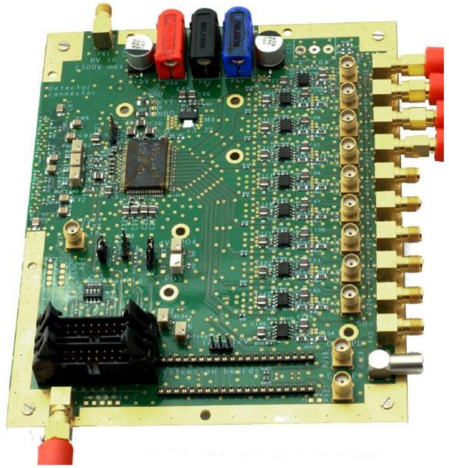
Only 9 strips N-side (front) and 9 strips P-side (back) are connected to the DAQ. Valid events can be registered in the “meeting points” between X and Y strips

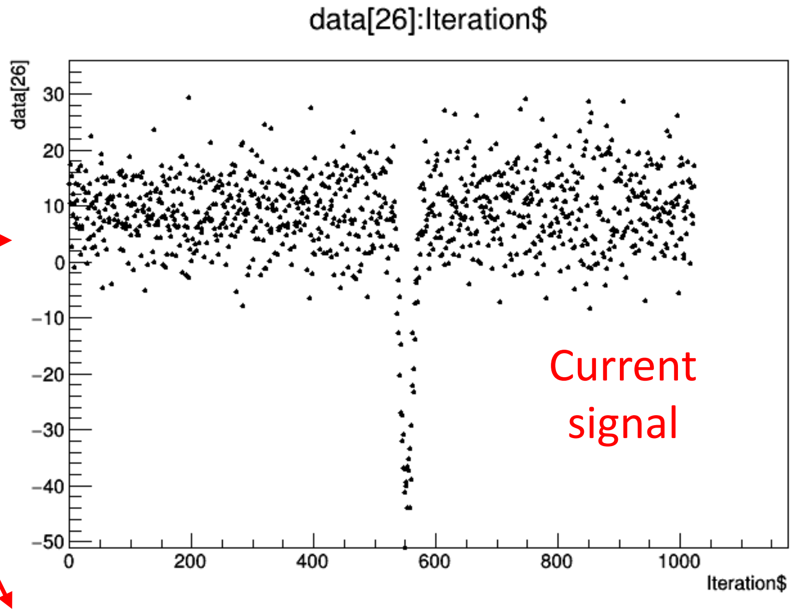
Detector reverse mounted (particles enter through the low electric field side) to have the signal shapes mostly determined by the hole propagation (longer rise time)

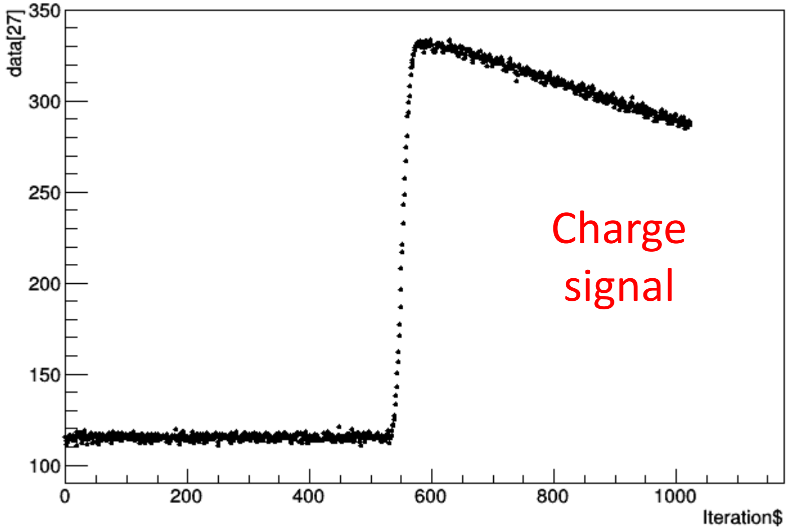
In-beam tests @ ALTO

The signals are sent to the **iPACI** preamplifier, developed by SEP – IPNO.
2 outputs:









See talk by E. Rauly later this morning

H. Hamrita *et al.*, Nucl. Instr. Meth. A **531** (2004) 607

The preamplified signals are then digitized by the Wavecatcher digitizer (developed by LAL):

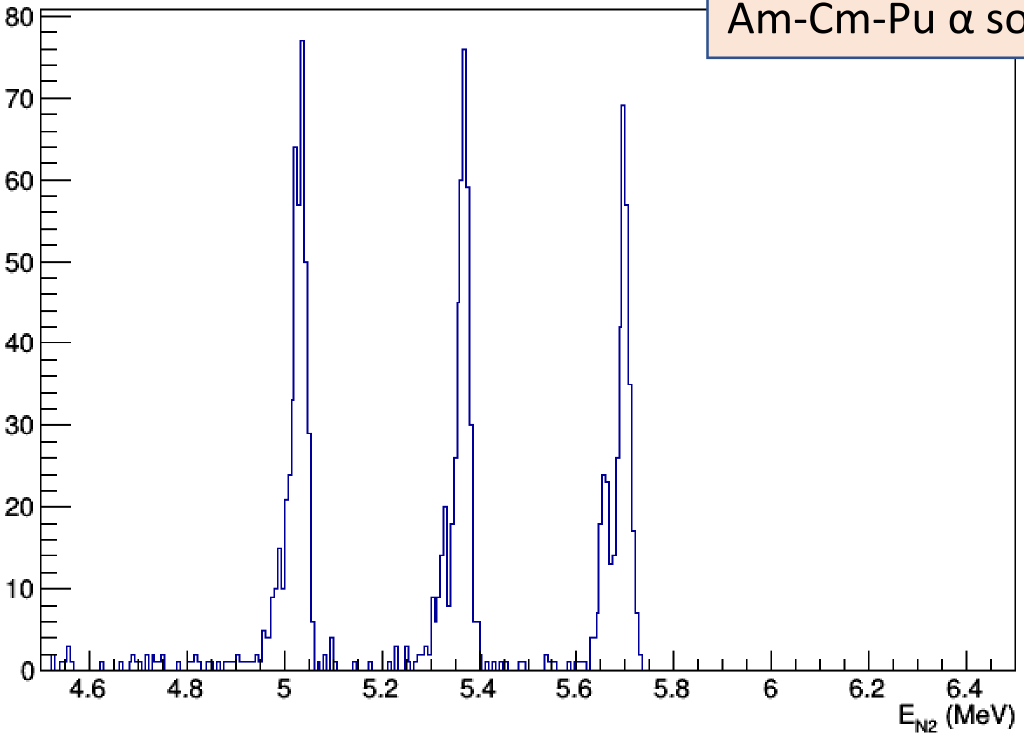
- 64 channels
- 12-bit resolution
- 400 MHz sampling rate

DISCLAIMER: Most of the following slides are based on the work by **Laura Grassi**

α source calibration and resolution measurement

Detector bias voltage: 120 V.
P-N side coincidences.
Resolution per strip around 35 keV.

Am-Cm-Pu α source



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

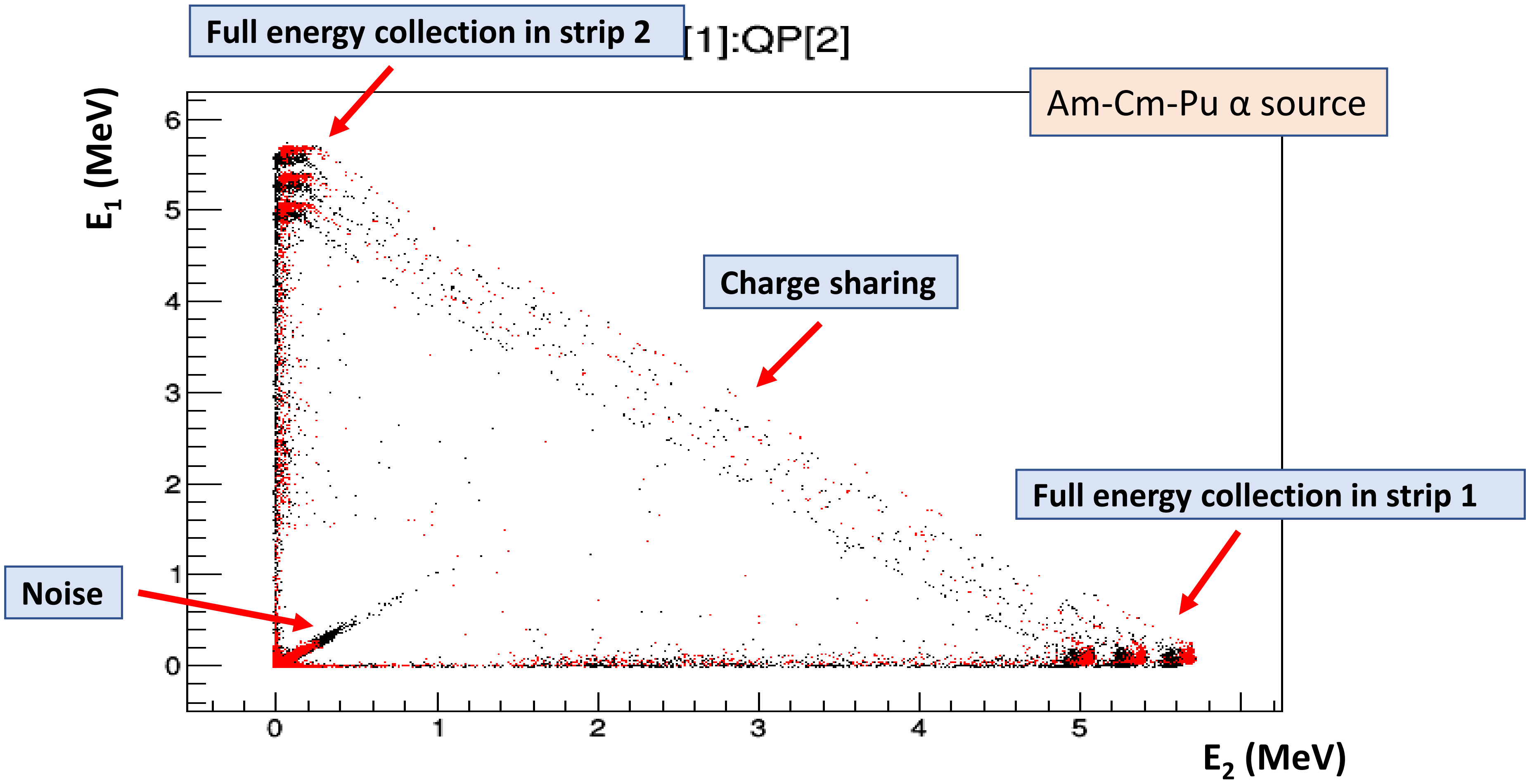
	FWHM (keV)
QP0	33
QP1	34
QP2	40
QP3	43
QP4	35
QP5	32
QP6	36
QP7	33
QP8	not conn.

The N side generally shows a slightly better resolution

α source calibration and resolution measurement

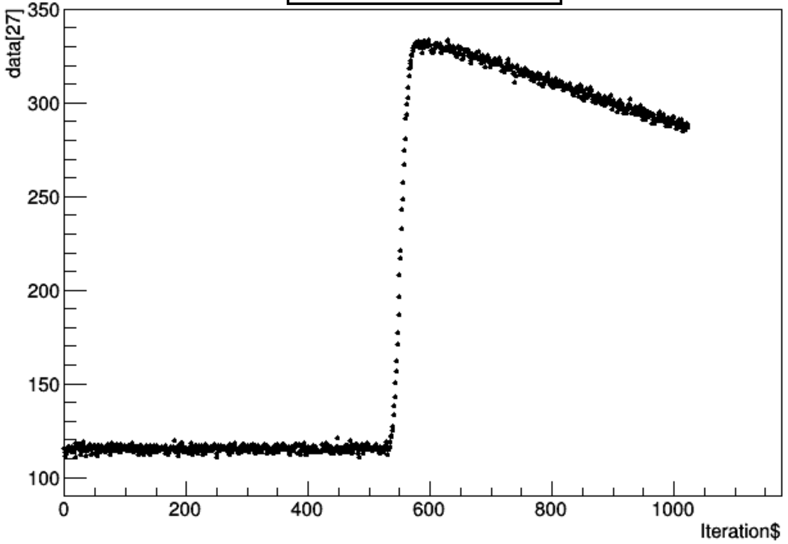
Interstrip events can be seen: the energy of the α particle is shared between two adiacent strips

Black points: multiplicity back side = 0
Red points: multiplicity back side = 1



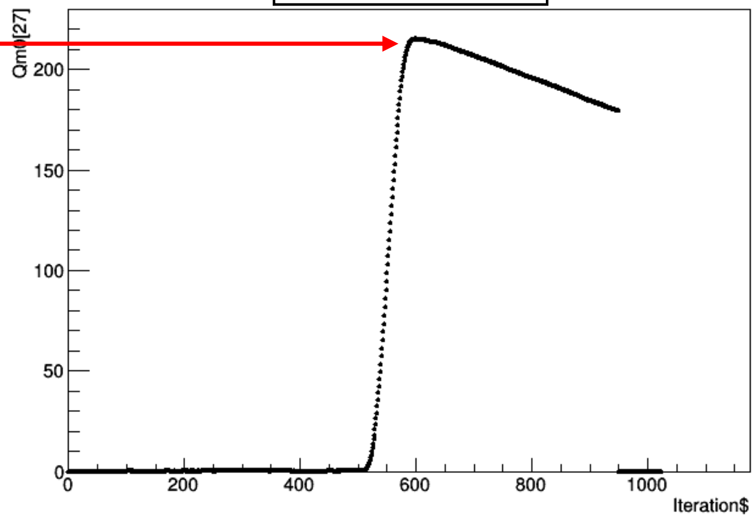
Pulse-Shape Analysis

Charge signal



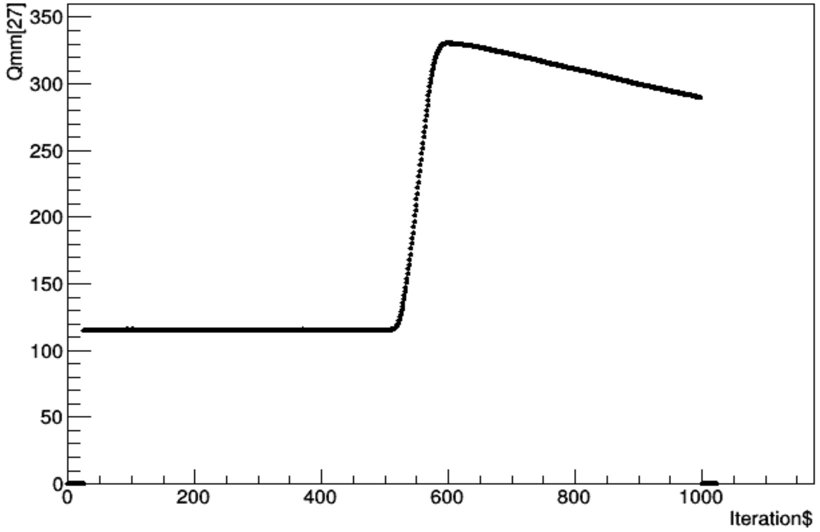
Maximum of the charge signal proportional to energy

Charge signal



Moving average filter

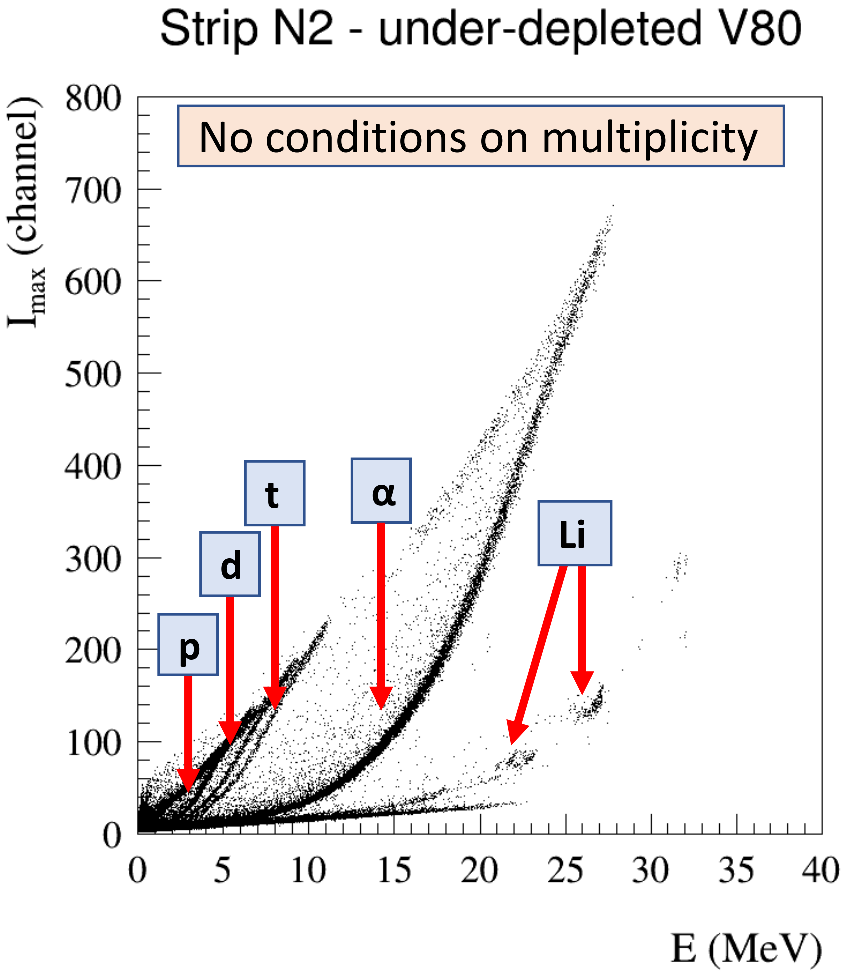
Charge signal

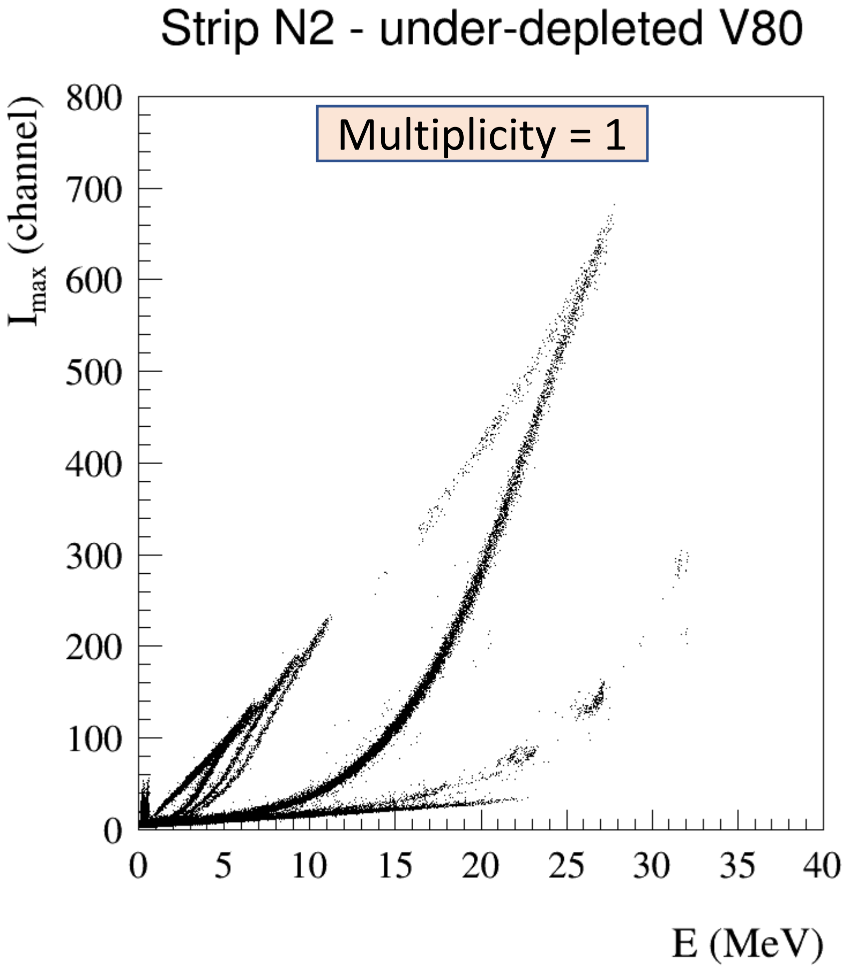


Baseline restoration

Particle identification

Working with an under-depleted detector allows to perform PSA on signals with higher rise time at the expense of resolution

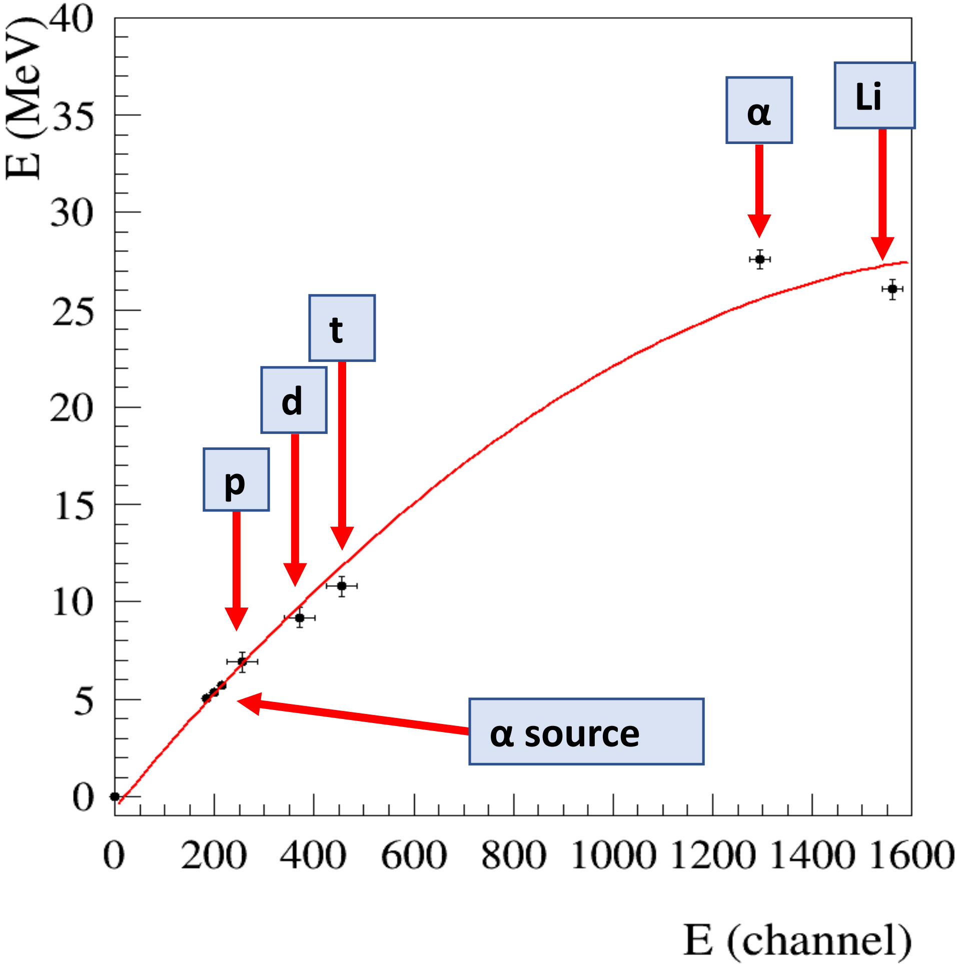


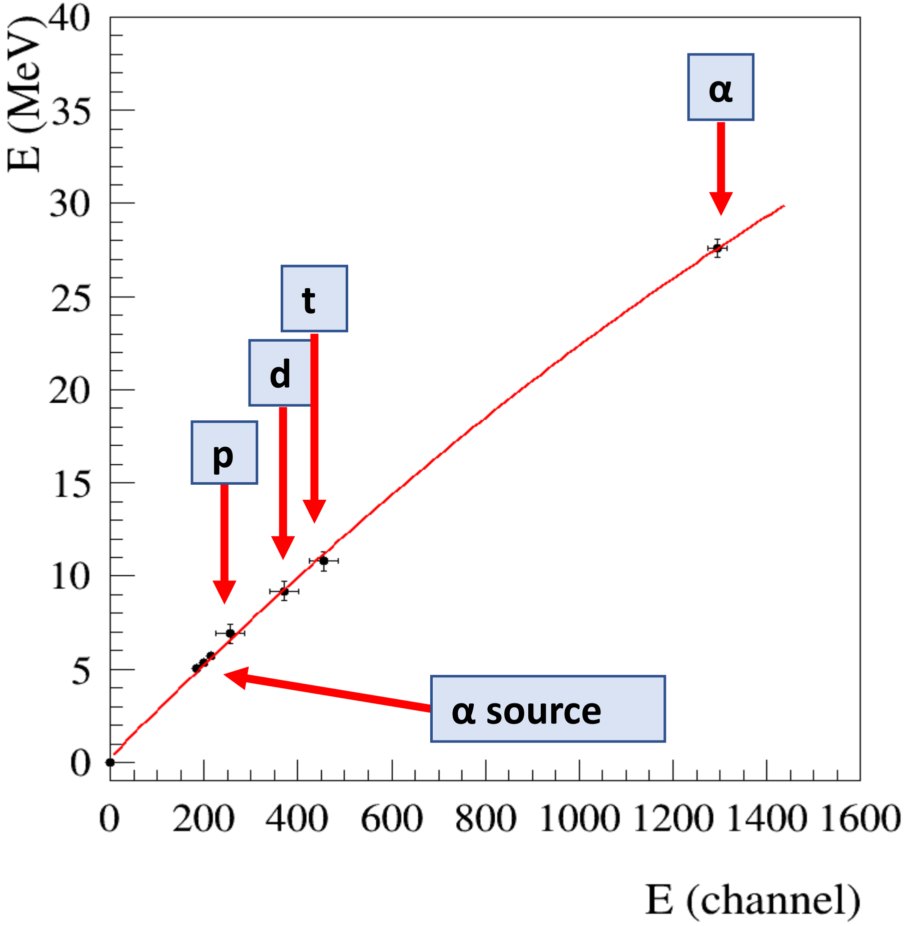


Punch-through is present for all particles except Li. The punch-through energy can be used for calibration purposes, together with the energy of the elastically-scattered Li ions.

Calibration extrapolation at high energies

The calibration looks very unlinear at high energies, probably because the Li point is wrongly attributed to elastically-scattered Li. For this reason the last point was removed.

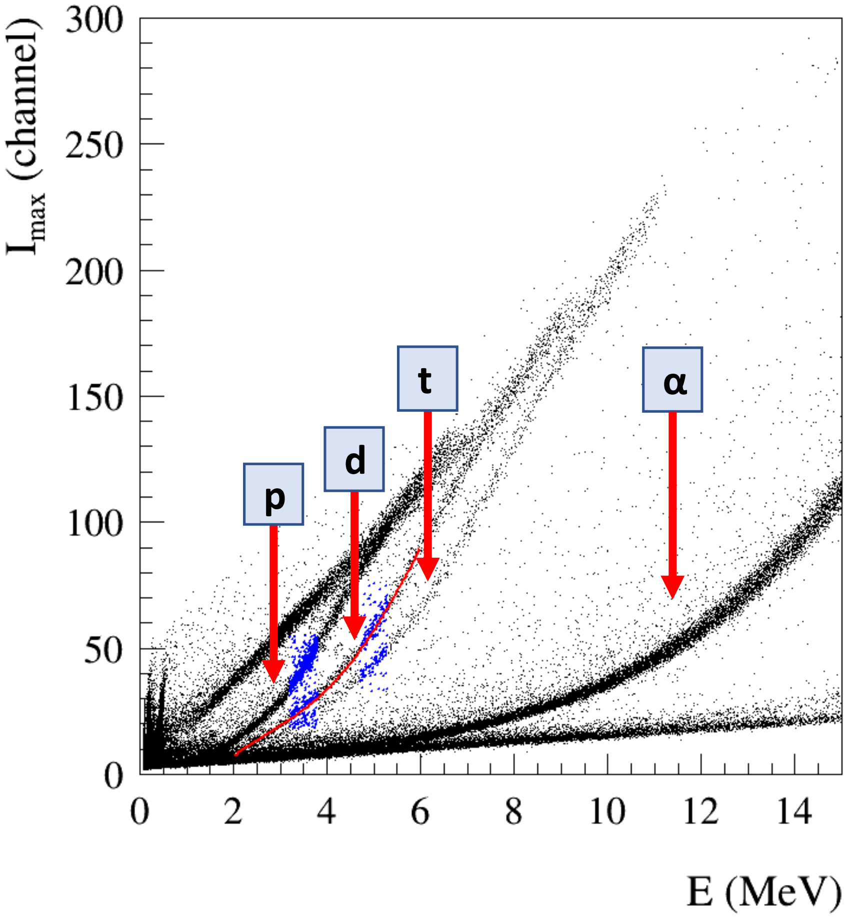




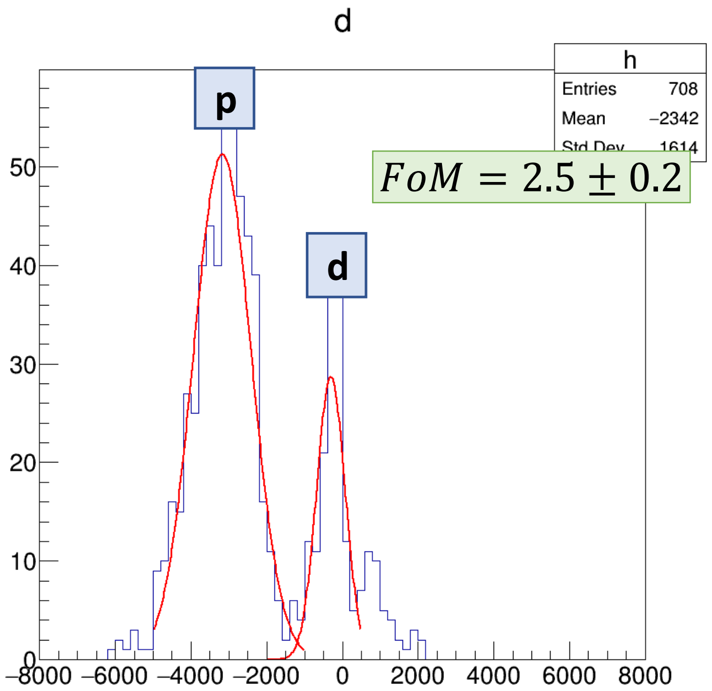
Particle identification – N side

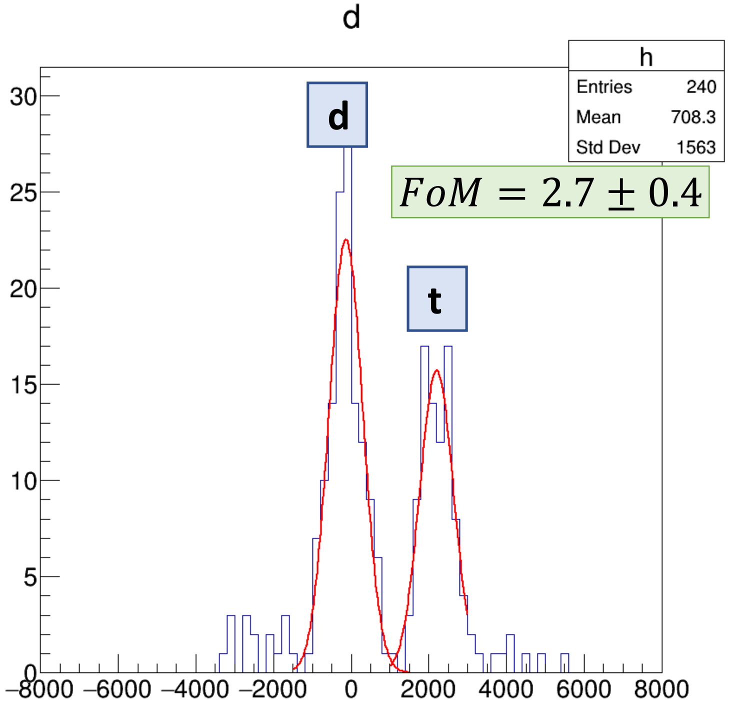
Enough separation for p-d and d-t identification could be reached only by under-depleting the detector down to 80 V

Zoom on the low-energy region



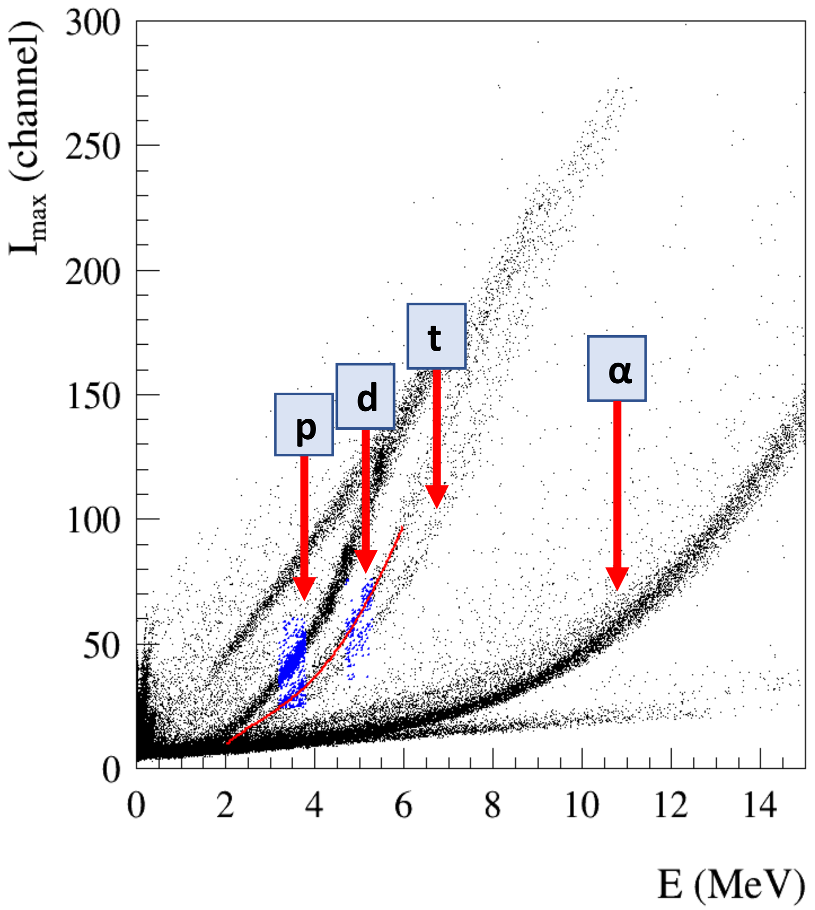
$$FoM = \frac{2|\mu_0 - \mu_1|}{2.35\,(\sigma_0 + \sigma_1)}$$





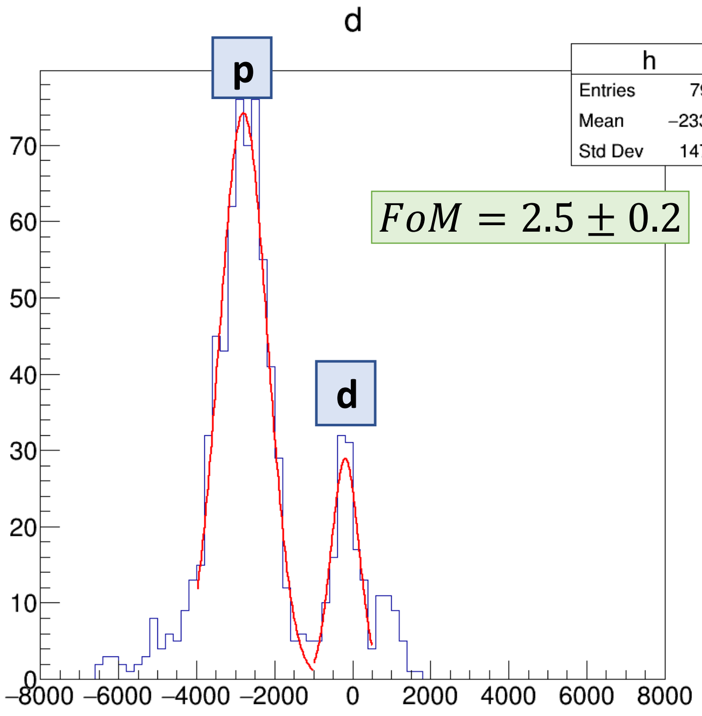
Particle identification – P side

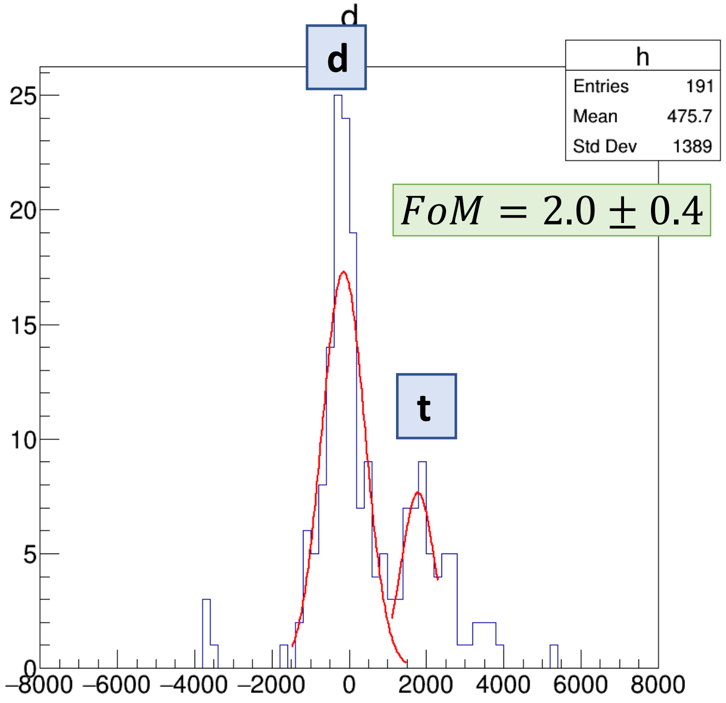
Zoom on the low-energy region



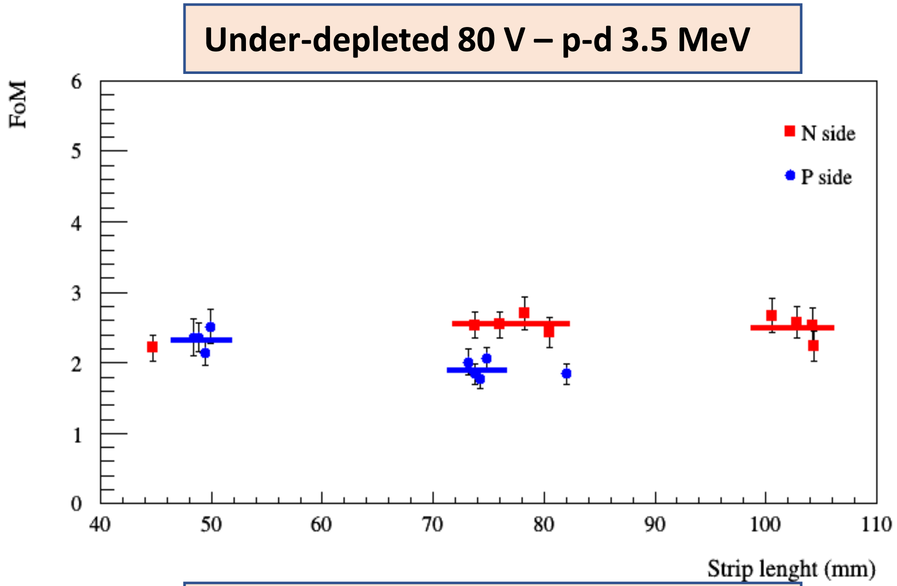
Enough separation for p-d and d-t identification could be reached only by under-depleting the detector down to 80 V

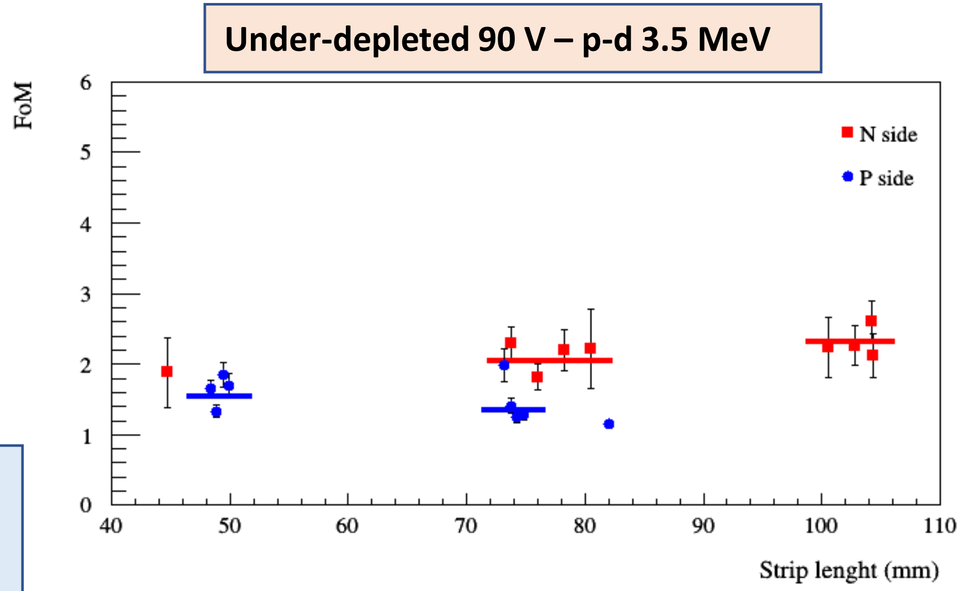
$$FoM = \frac{2|\mu_0 - \mu_1|}{2.35\ (\sigma_0 + \sigma_1)}$$



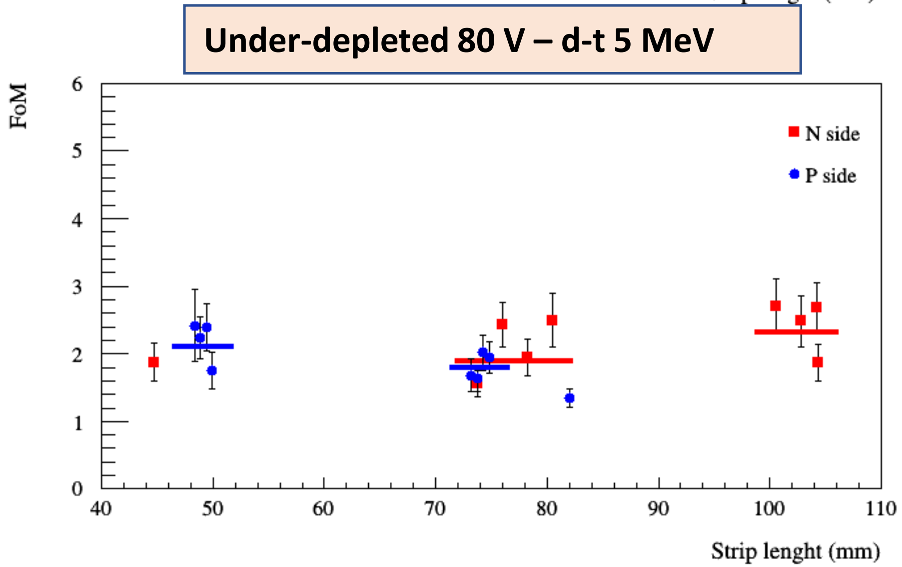


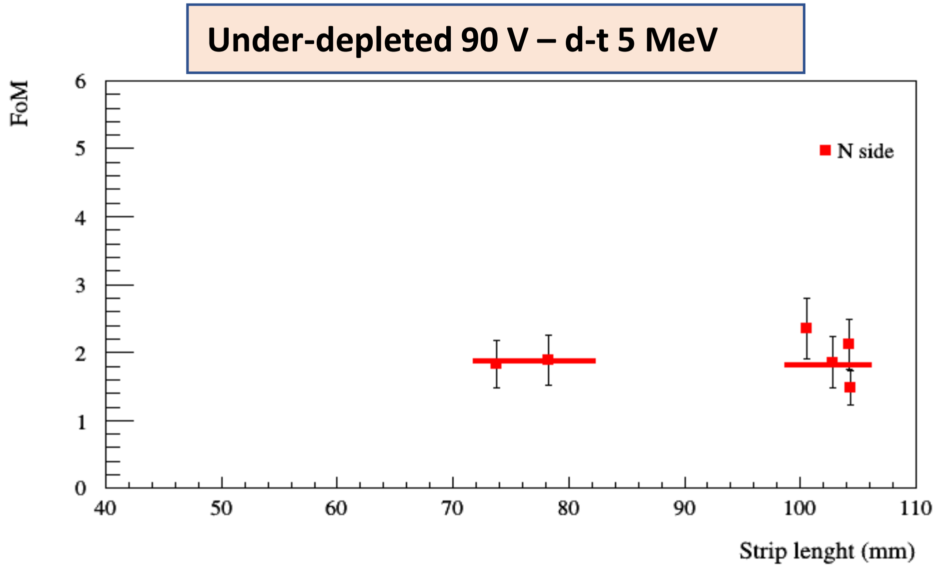
FoM versus strip length



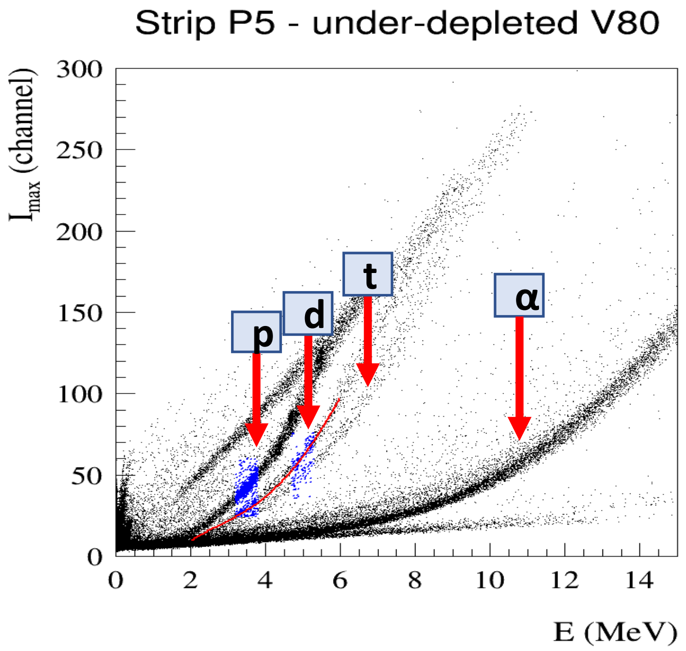


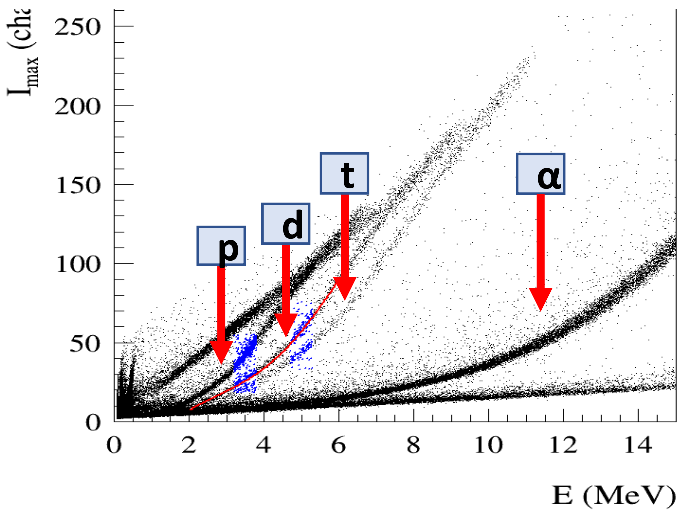
No clear dependence of the FoM on the strip length

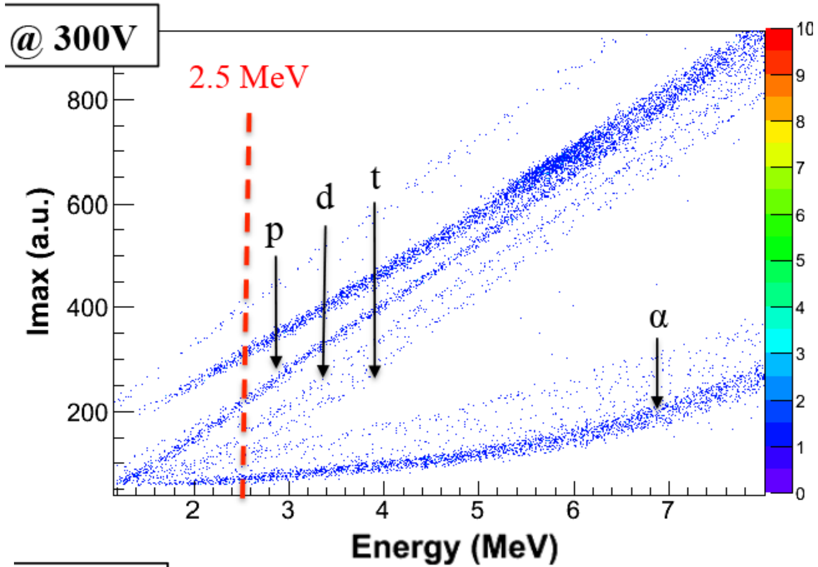


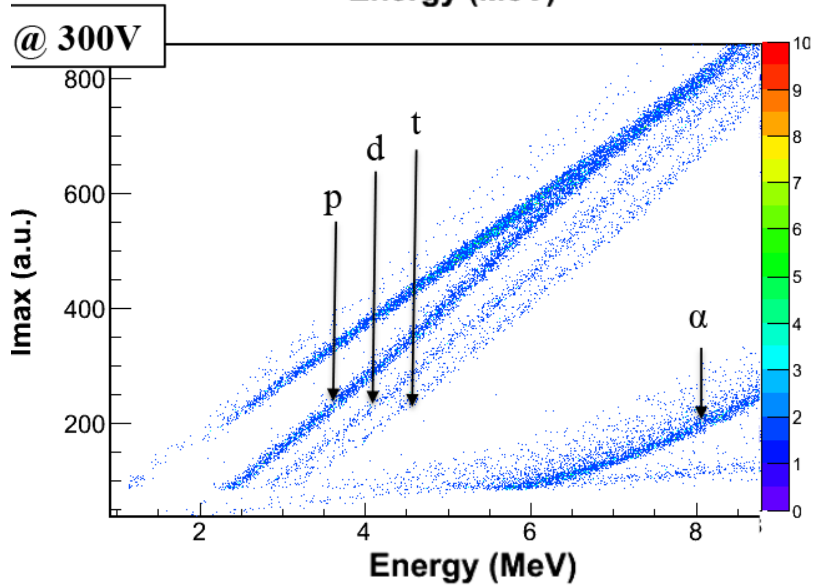


Particle identification (Z = 1 isotopes)







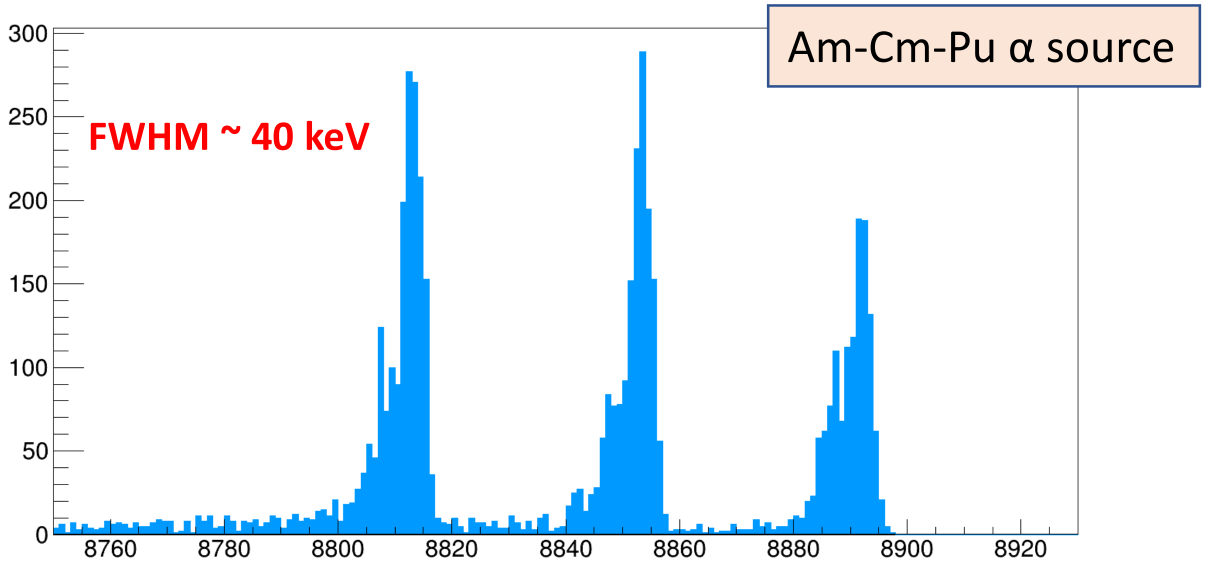


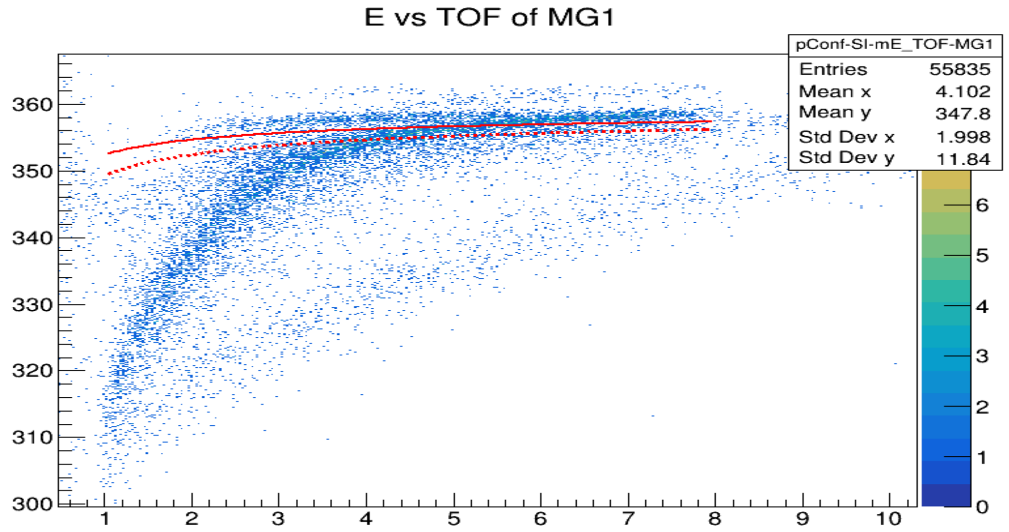
Comparison with the identification obtained in previous tests of a square detector (62 mm x 62 mm, 500 µm thick, reverse mounted), with the detector just at depletion voltage

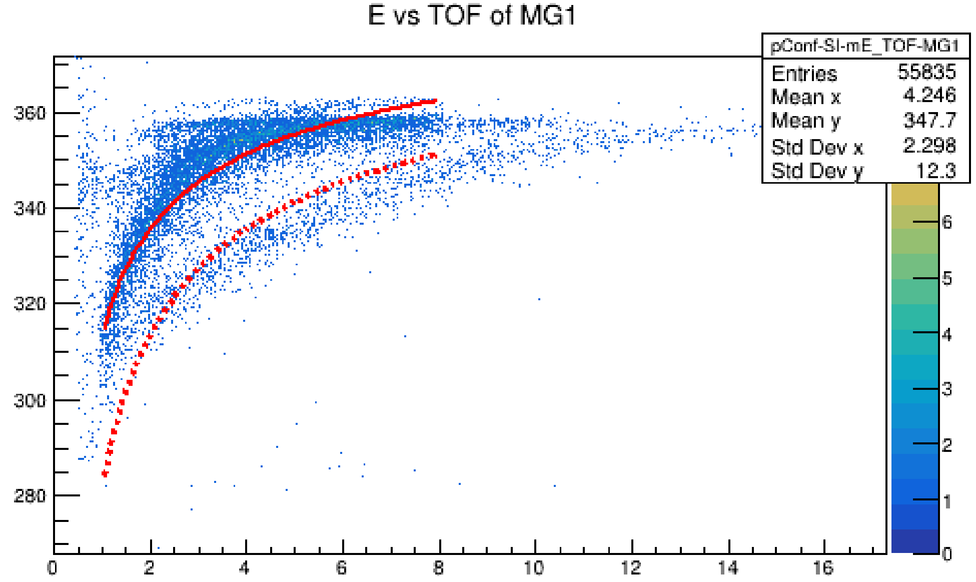
The trend of the curve I_{max} vs E for the different particles is detector dependent

M. Assié *et al.*, Eur. Phys. J A (2015) **51**: 11

Status during the GANIL campaign (summer 2019)





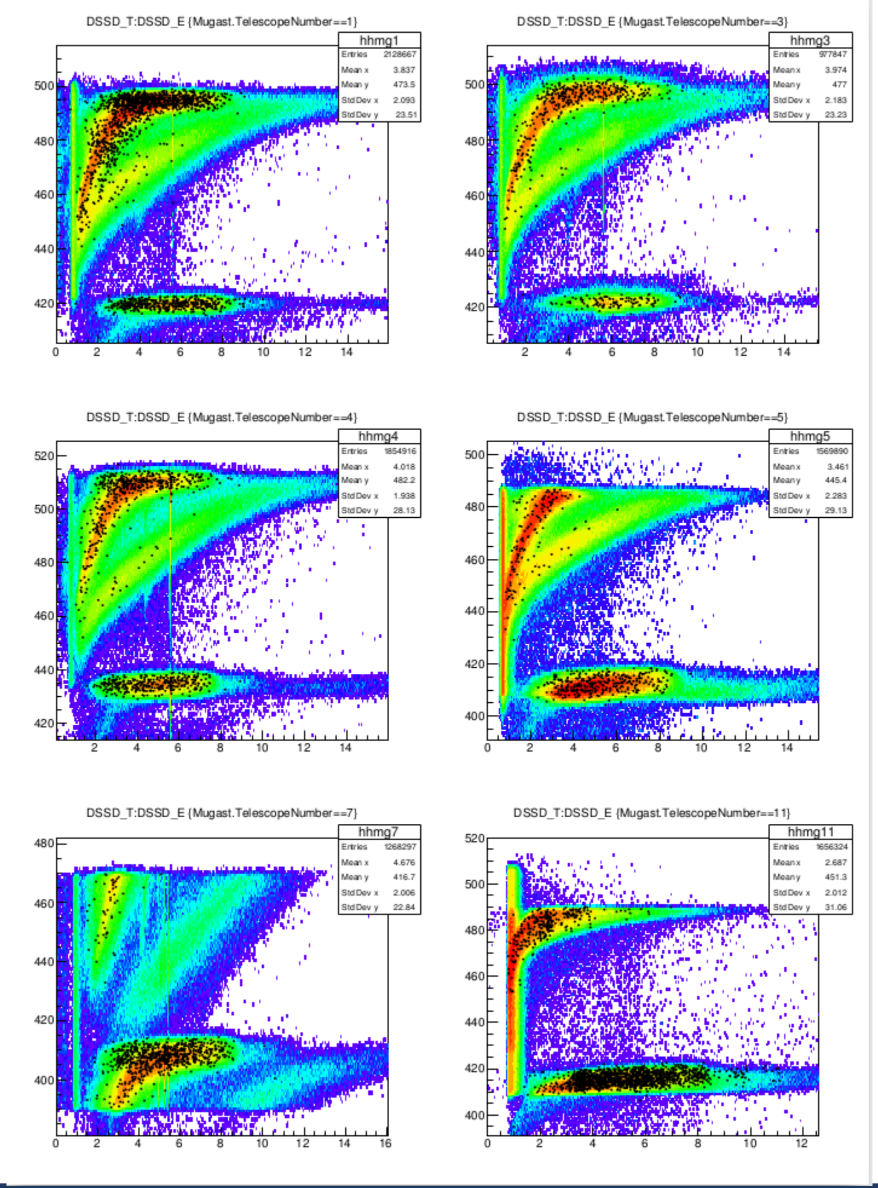


$$ToF = offset - \sqrt{\frac{md^2}{2E}}$$

m = particle mass (p, d, α …)
E = particle energy
d = distance target-detector (~ 10 cm)
offset = 360 ns (ToF CATS-target + delays)

In the E-ToF spectra to fit the data one should set a distance target-detector larger than the real one. The discrepancy is larger if, as in this case, the detectors are reverse mounted (low-field or ohmic side towards the incoming particles): the timing signal has a longer rise time and this can affect the absolute time determination.

Status during the GANIL campaign (summer 2019)

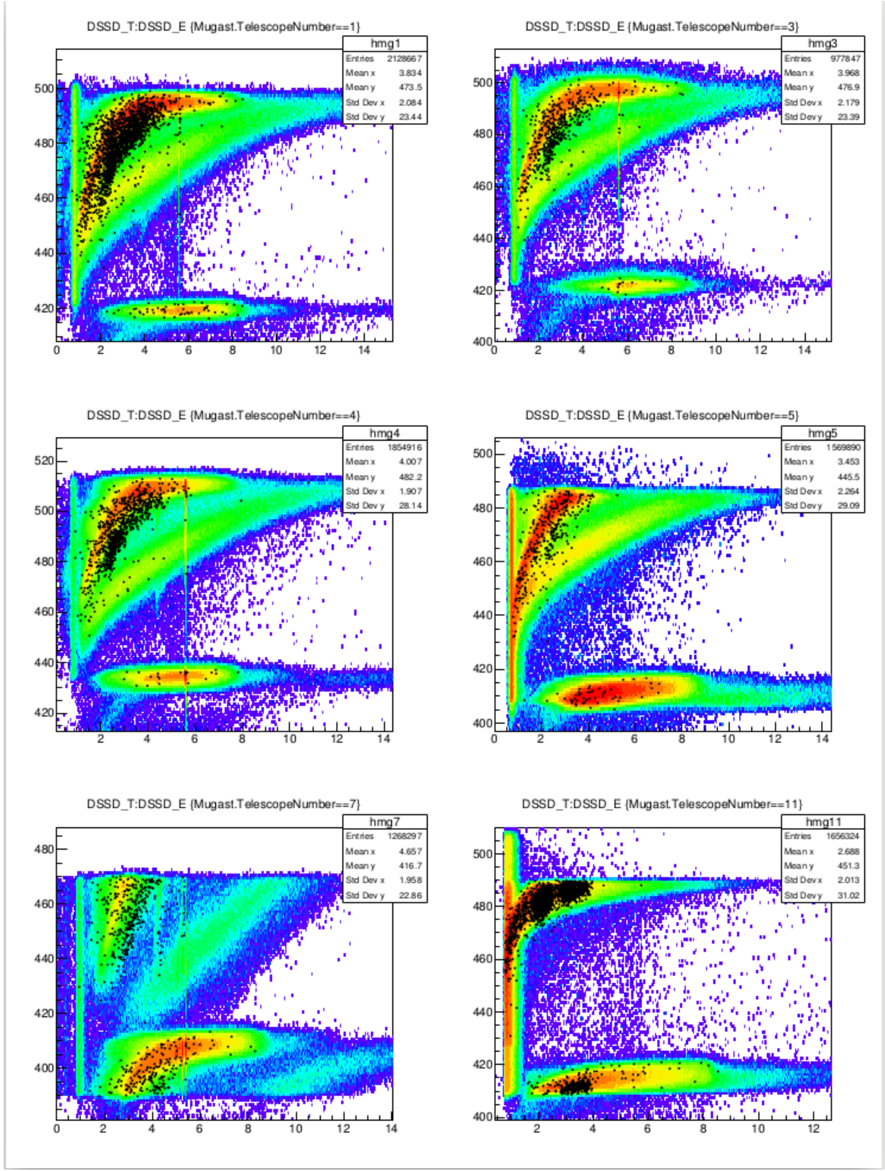


$^{15}O(^{7}Li,t)^{19}Ne$

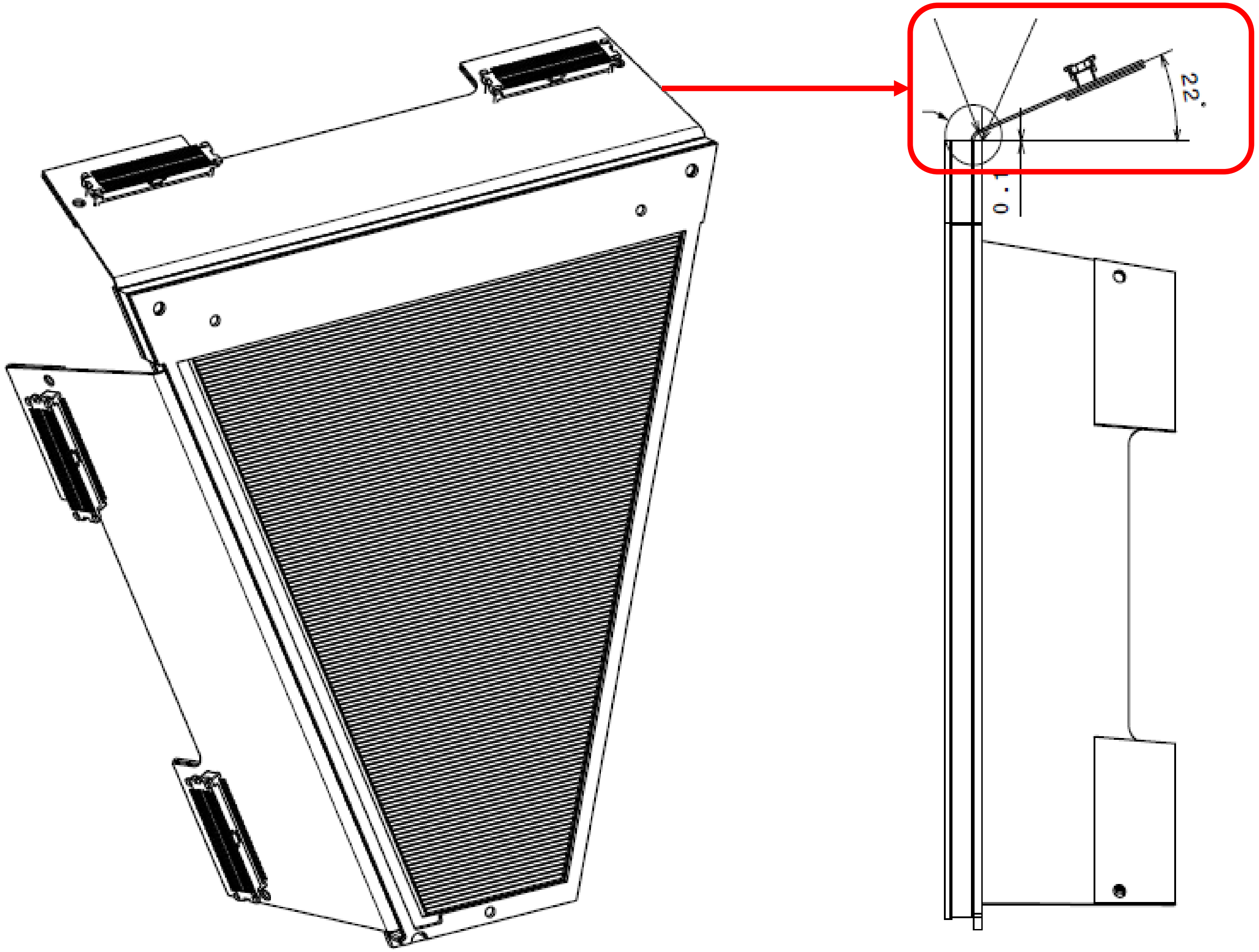
Poor timing resolution (timing with beam RF

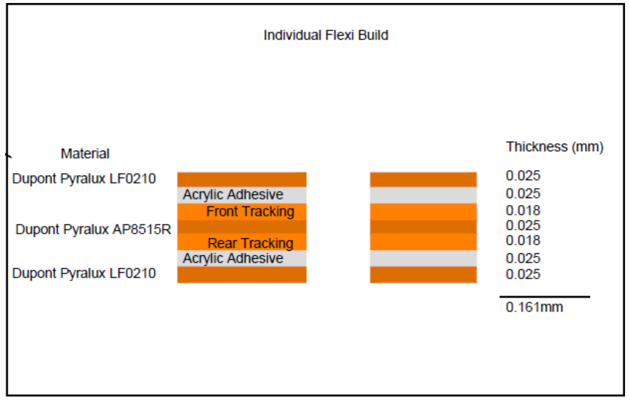
MUGAST identification matrices gated on ^{18}Ne and ^{20}Ne in VAMOS

MUGAST identification matrices gated on ^{19}Ne in VAMOS



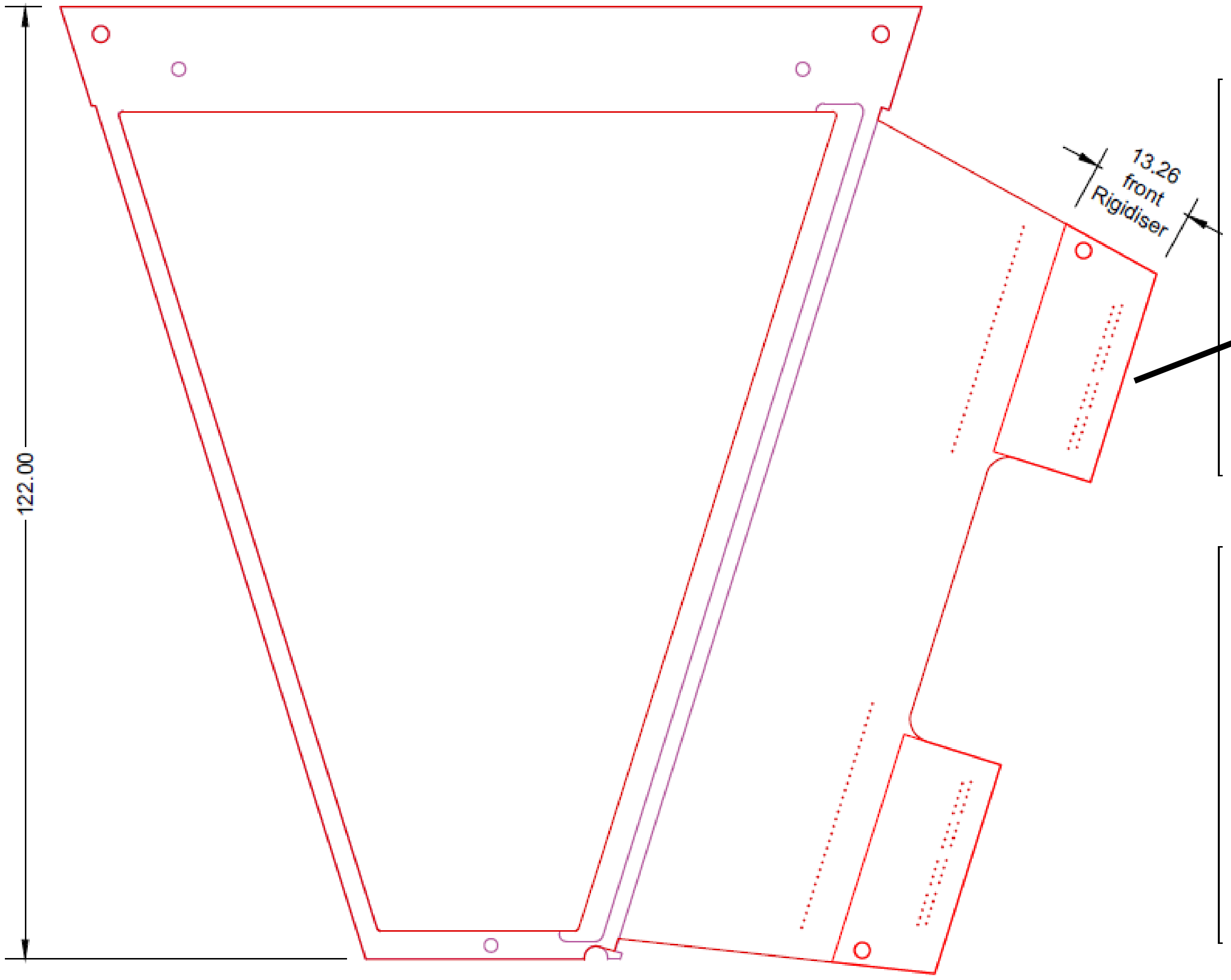
Design improvement

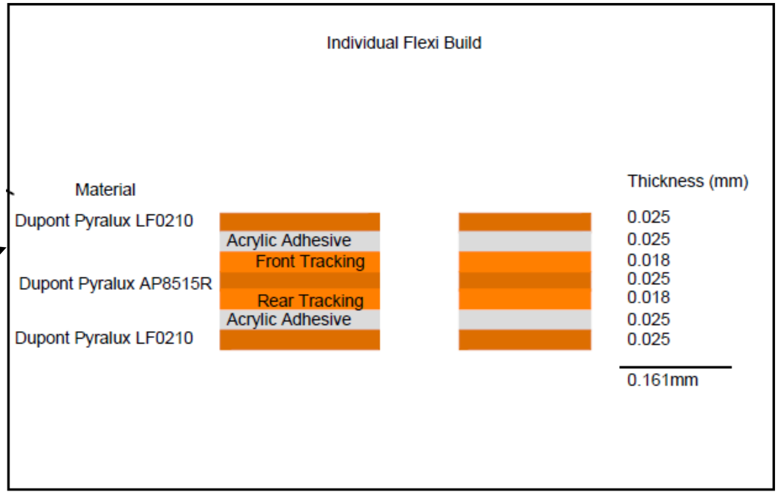




The kapton connection exits the frame with an angle of 22° and, due to its quite high rigidity, it is mechanically difficult to handle.
It would be nice to foresee a design with an exit et 0°, also in view of the more compact configuration with a full ring of trapezoid detectors.

Design improvement





It would be important to reduce as much as possible the thickness of the kapton connection to increase its flexibility. Removing the mesh would surely help in this sense but at the expense of the quality of the signals.

Conclusions

- We showed the general characteristics of the trapezoid detectors which compose MUGAST.
- PSA has been performed in in-beam tests of the detectors. Protons, deuterons and tritiums can be well distinguished.
- The particle identification does not seem to depend on the strip length.
- We outlined possible design developments in view of the next experimental campaign and of a more compact configuration with more detectors.