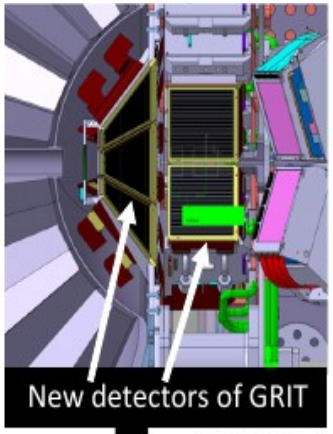
MUGAST: commissioning

Daniele Mengoni, for the MUGAST/GRIT collaboration

Dipartimento di Fisica e Astronomia "G.Galilei" Università
INFN – Sezione di Padova

MUGAST

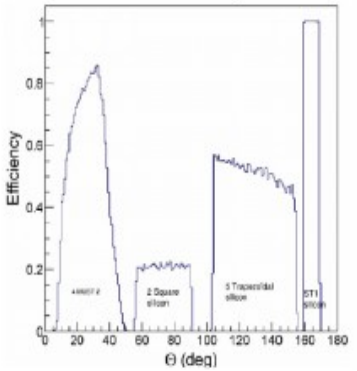
an intermediate step toward the completion of the full array

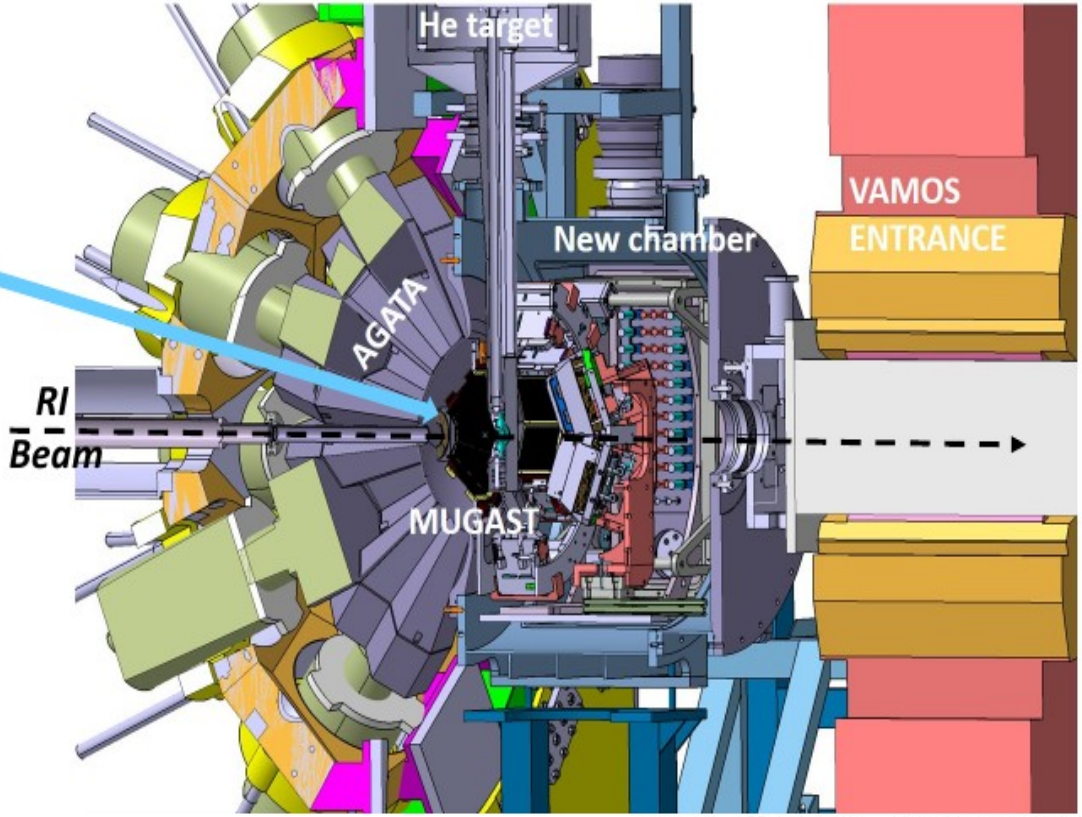


~ 3000 channels

MUGAST configuration:

- 5 trapezoids backward
- 2 Squared around 90deg.
- 4 MUST2 telescopes forward





AGATA efficiency : ~ 8% at 1.3 MeV

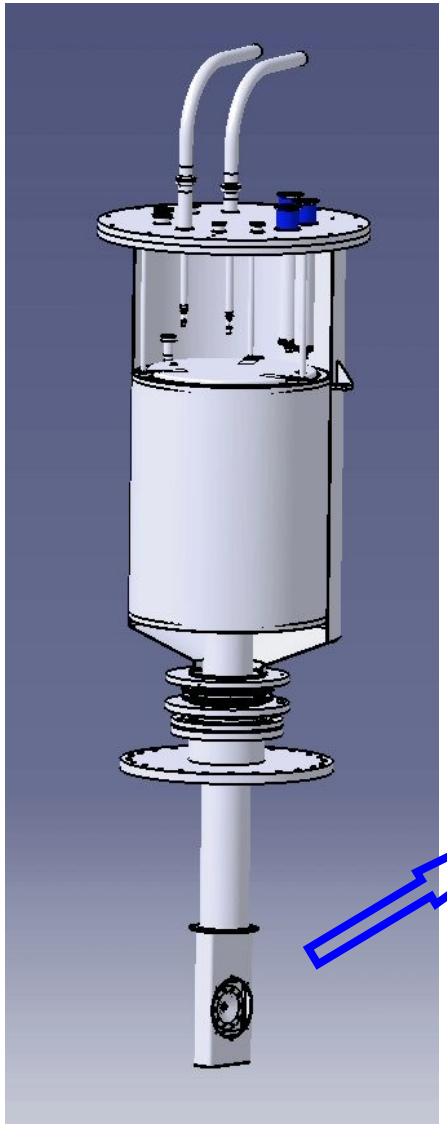
MUGAST: new DSSD NT detectors +MUST2 electronics + combination with gamma array

Solid 3H target

- 30-50 ug/mc2 effective thickness
- ~1 GB activity
- Ti sheet 500 ug/cm2
- Purchase directly from a company
- Possible at GANIL (in principle)

Possible reactions: (t, α), (t,p), ….

Cryo ^{4,3}He target



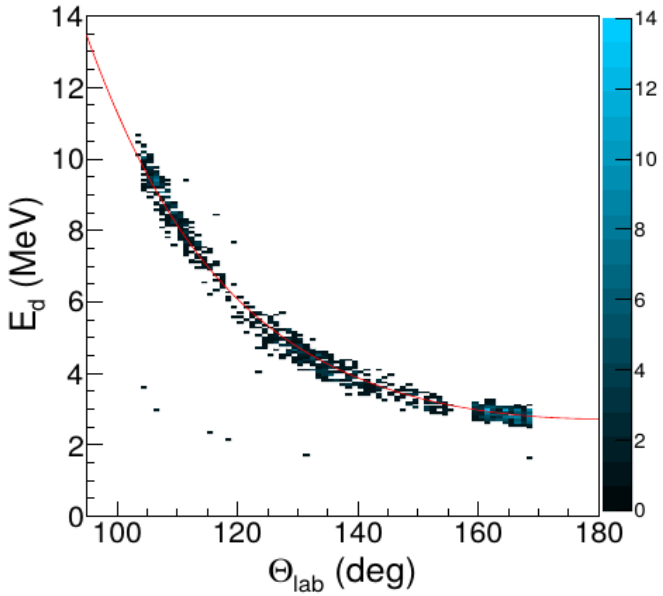
Previously used
at SPEG / GANIL

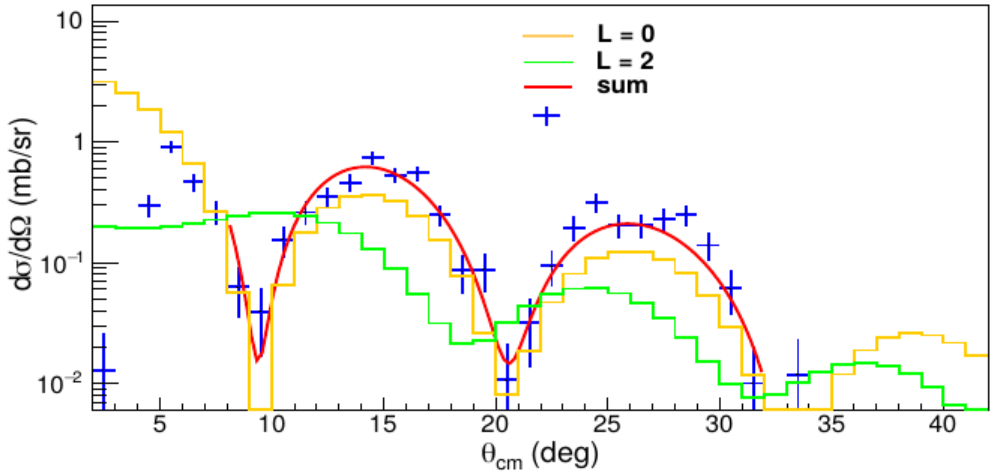
Ø 16 mm, 3mm thick
Havar windows, 3.8 microns
T = 8.5 K
P = 1 bar
Limited angular range

- Designed for the use of direct reactions with ^{3,4}He probe in Inverse kinematics
  Concept : cooled gas cell at 5~8 K to maximize density
- Possible reactions: (α,^{3}He), (α,t), (α,^{6}He),…
- Now under study ^{3}He version:
  (^{3}He,d) proton stripping
  (^{3}He,p) d transfer for np pairing
  ….(^{3}He, n)

Simulation

SP strength



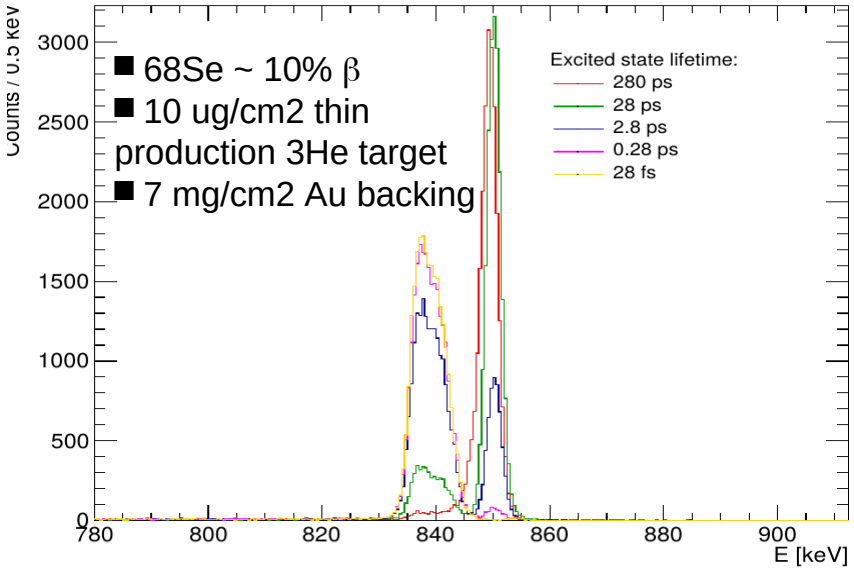


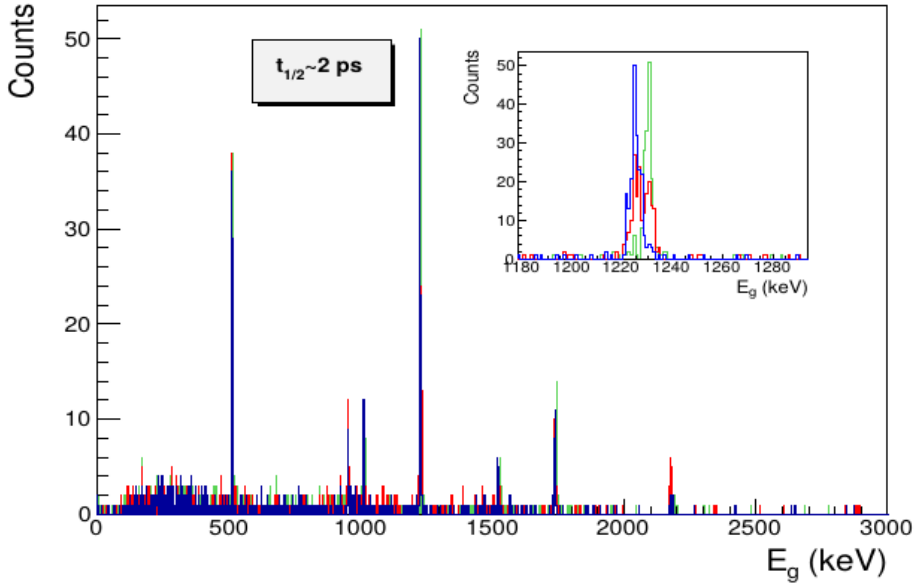
- Calculation (FRESCO, TWOFNR etc)
- Simulation (NPTool), MUGAST only.

- Resolve states with high resolution: DC (Kinematics reconstruction with MUGAST or direct detection in VAMOS). AGATA simulation

- VAMOS ongoing (?)

Lifetime measurements



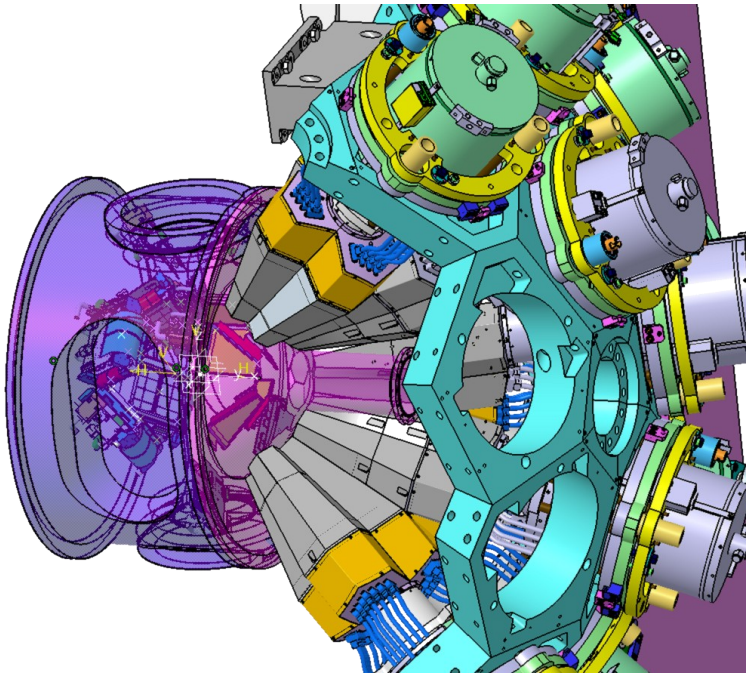


- Our AGATA simulation code

Physics

LoIs Science campaign

SPIRAL1 beams



Nuclear astrophysics:

- **^{15}O(^{6}Li,d)^{19}Ne** *(C.Diget, Univ. of York, N. de Séréville, IPNO)*
- ^{25}Al(^{3}He,d) *(N.de Séréville, F. Hammache, IPNO)*
- ^{30}P(^{3}He,d) or (d,p) *(N.de Séréville, F.Hammache, IPNO)*
- ^{60}Fe(d,p) *(A.Matta, W.Catford, University of Surrey)*
- ^{79}Se(d,p)^{80}Se *(G. de Angelis, INFN-LNL, D.Mengoni, University of Padova, C.Domingo Pardo, CSIC Valencia)*

Shell evolution

- ^{56}Ni(d,p)(d,t) *(F.Flavigny, IPNO, O.Sorlin, GANIL)*
- ^{28}Mg(d,p) *(A.Matta, W.Carford, University of Surrey)*
- ^{74}Kr(d,p) *(A.Matta, W.Carford, University of Surrey)*
- ^{48}Cr(d,p)^{49}Cr *(A.Gadea, CSIC Valencia)*
- ^{30}Mg(d,d)(d,p) *(B.Fernandez-Dominguez, University of Santiago, W.Catford, University of Surrey)*
- ^{67}As,^{63}Ga(^{3}He,d) *(D.Mengoni, University of Padova)*
- ^{44,46}Ar(t,p) *(D.Mengoni, University of Padova)*
- ^{66}Ni(t,p),^{44}Ar(t,p) (^{14}C,^{12}C)(^{18}O,^{16}O) *(L.Fortunato, J.A.Lay, University of Padova)*

Clusters, pairing, correlations & others

- ^{56}Ni(^{3}He,p)(^{6}Li,α) *(M.Assie, IPNO)*
- ^{45}K + ^{7}Li -> ^{46}Ca+α *(S.Leoni, University of Milano, B.Fornal, Krakow)*
- ^{16}O + ^{A}Z *(G.Verde, INFN Catania and IPNO)*
- ^{14}O(p,p) *(I.Stefan, IPNO)*

SPIRAL1 beams (available at the coming PAC)

SPIRAL1 Beams:

The SPIRAL 1 commissioning validated of the production of radioactive ion beams for the following elements:

- All elements available from Nanogan (**He, N, O, F, Ne, Ar, Kr**)
- **Mg, K, Na** from the FEBIAD source

MUGAST+AGATA+VAMOS

APPROVED EXP

- 15O(α,γ)19Ne (ACCEPTED 36 Uts highest priority), C.Diget et al, York
- … [Recovery of 14O from LISE experiment..]

PROPOSALS (Nov. 2018)

- Collectivtiy *and* SP states below 48Ca: 47Ar (D.Mengoni et al., Uni PD)
- Proton occupation in 46Ar (A.Gottardo et al., INFN LNL)
- SF in 46Ar (A.Lemasson et al., GANIL)

- 29Mn Island of inversion (A.Matta, LPC Caen)
- 20O 3N forces (E.Clement et al., GANIL)
- 85Kr s-process (F.Recchia et al., Uni. PD)

LoIs

- *np* T=0 pairing (M. Assie et al.,IPNO), Shell evolution in the vicinity of 56Ni (Flavigny et al., IPNO)
- (t,a) reaction in the vicinity of 68Ni,46Ar, 56Ni (S.Bottoni et al., Uni MI)

Commissioning
(not so original) ideas

Source test

- Detector test
- FEE(MUST2)/BEE(VXI) test
- Slow control test
- ...
- ...

starting Fall 2018 (GANIL, G3)

(My) Ideas for in-beam tests

- Coupling (to some extent this could also be done with a source 241Am). Any issue expected? Low rate?
- Parasitic stable beam → SF on the backward angles not to damage the detectors. VAMOS closed (scattering in AGATA?). Or Spiral1 beam to check the coupling of AGATA VAMOS and MUGAST at experiment rate.
- EXTRA points:
  - Test with a LHe target to characterize the background?
  - No issue for lifetime, according to my understanding.

Spring (April) 2019, GANIL (G1)

Detector status

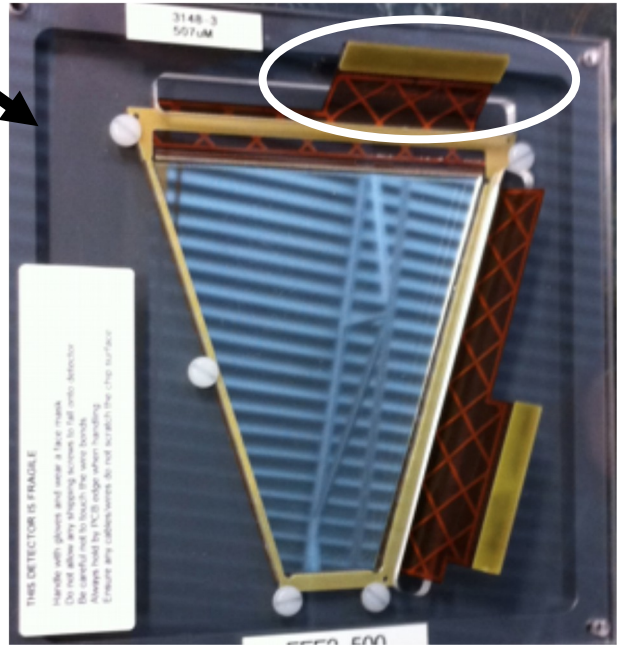
Thin trapezoidal dets

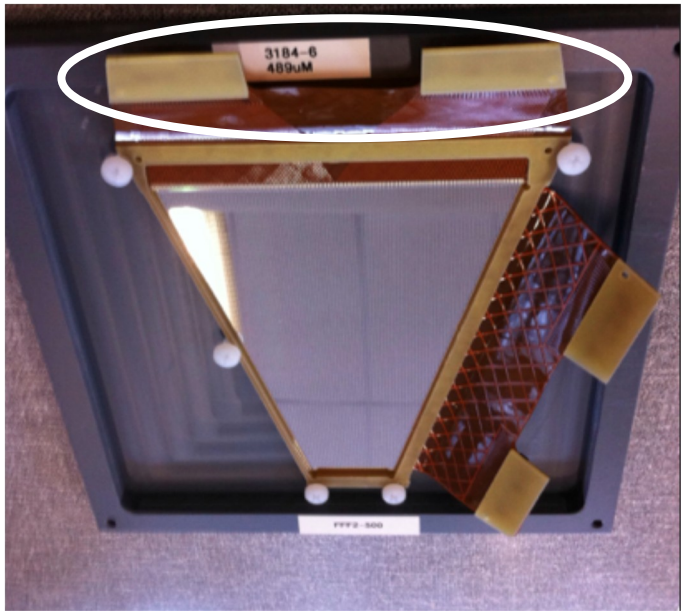
Ordered at Micron Semiconductors : nTD, 4 deg. cut

- 2 prototypes 500 um **IPNO (nov. 2013)**
- 3 pre-series **U. Surrey, Santiago, IPNO (end 2015)**

Received :

- 1st prototype june 2015
- **2nd prototypes and pre-series (4 +2) received feb-march 2017**
  --> 6 detectors available





Test bench at IPN Orsay

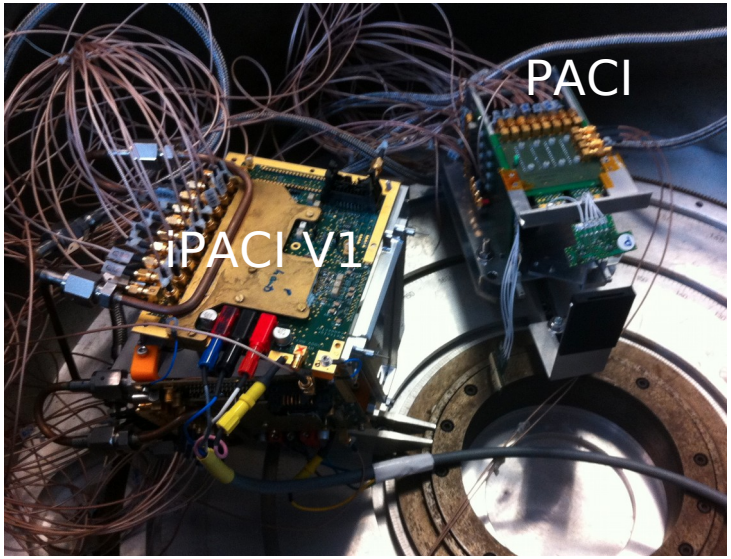
- Numerical:
  1) PACI : 4X+4Y (discrete version)
  2) iPACI: 9X+9Y (integrated FEE)

--> Read by WaveCatcher digitizer (64ch) (LAL)

- Analog (MUFEE) : 128X+128Y

  --> possibility to read all 256 channels

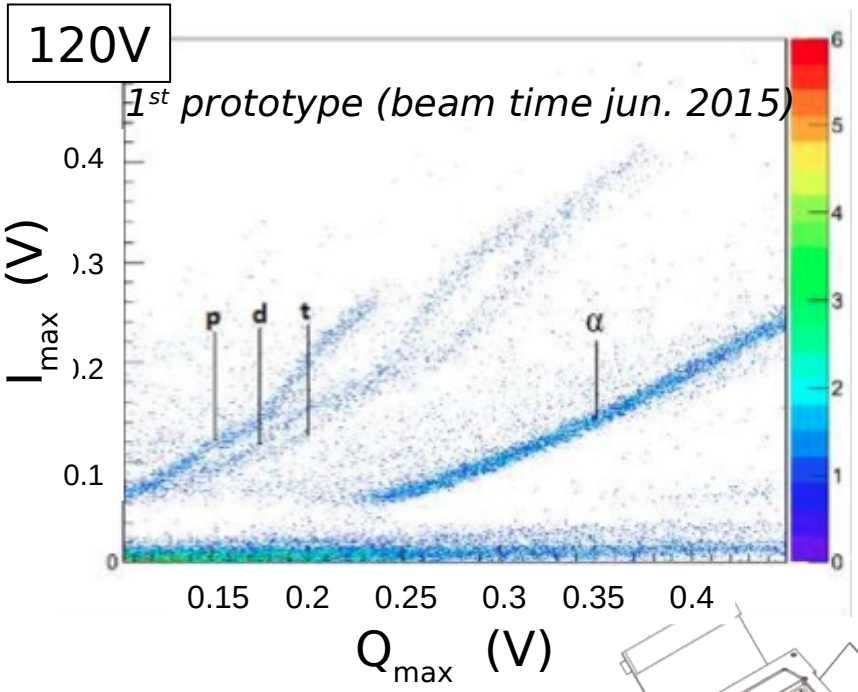
- In-beam test @ ALTO (2017), for PSD and radiation damage
- New proposal submitted (2018) for the commissioning of the entire setup, trape + square
- New technical proposal submitted (2018) for the in-beam characterization of the square dets and test of the other integrated preamp

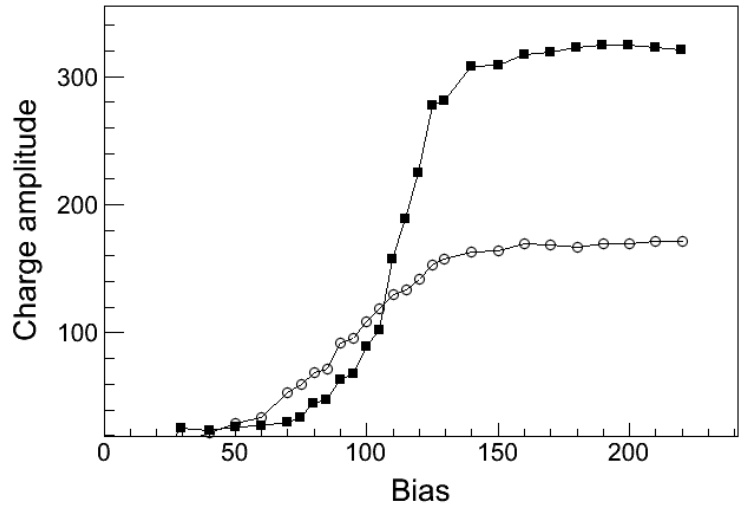


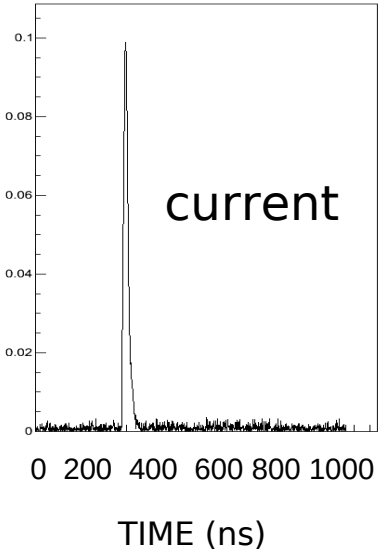
Our approach for PID

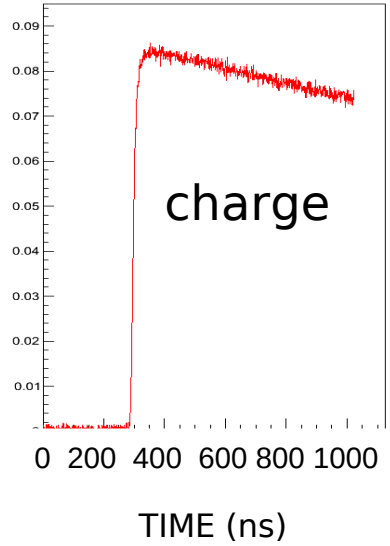
- Plot of the current vs. bias
  --> the detector is depleted around 120V

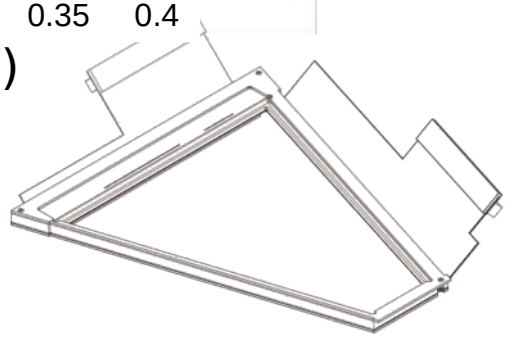
- Imax vs. Energy plot





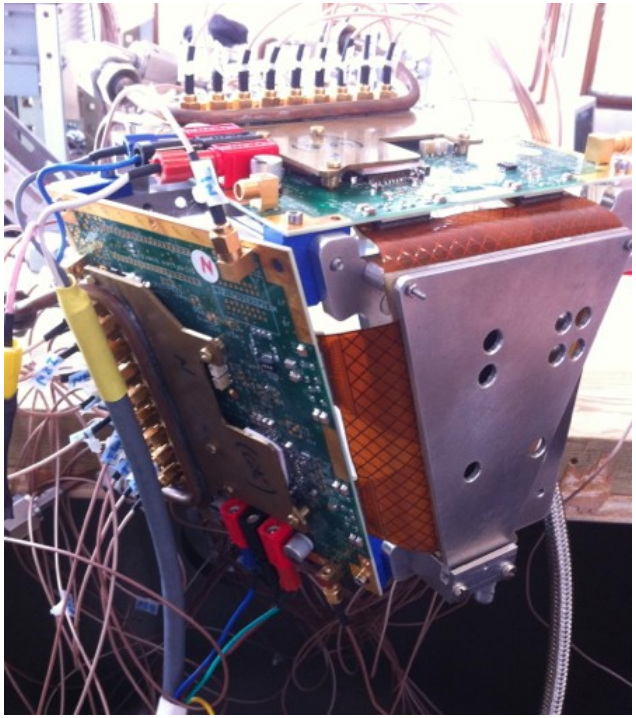


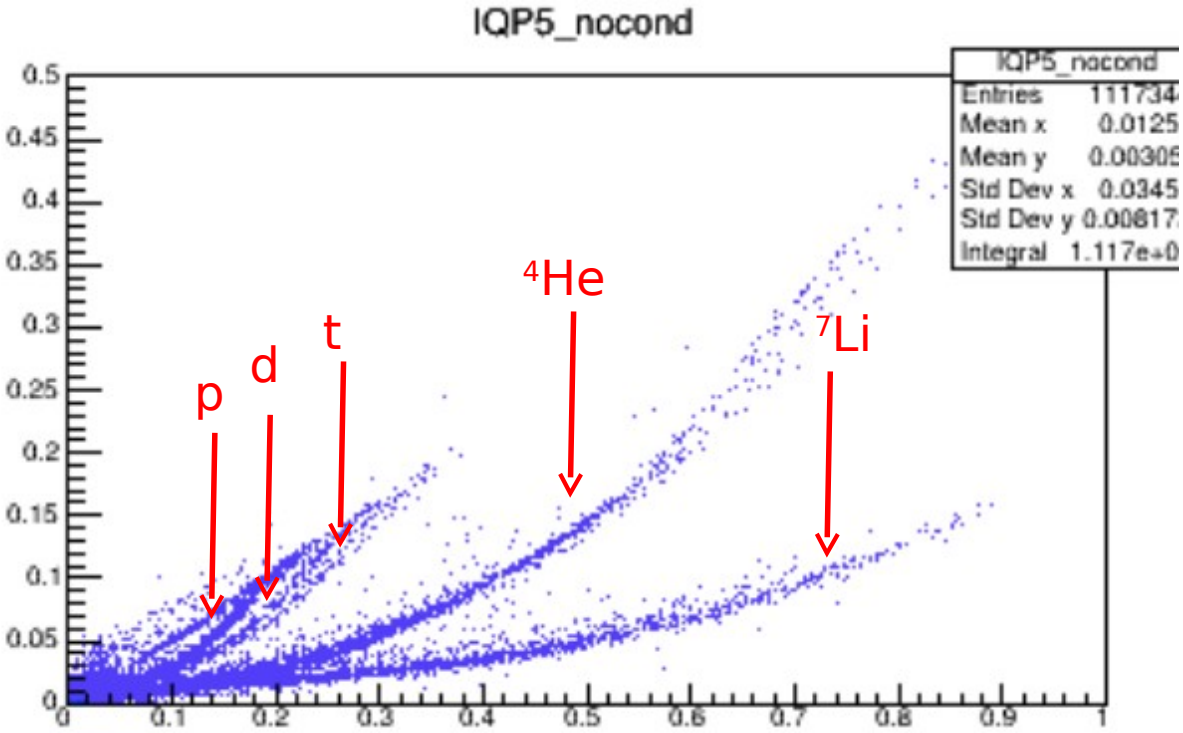




PSA with trape det

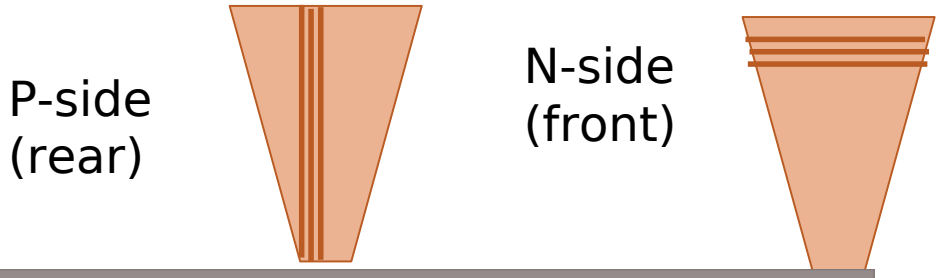
- Test at ALTO Nov 2017 for PSA with trapezoidal detectors





Online spectrum, no condition...

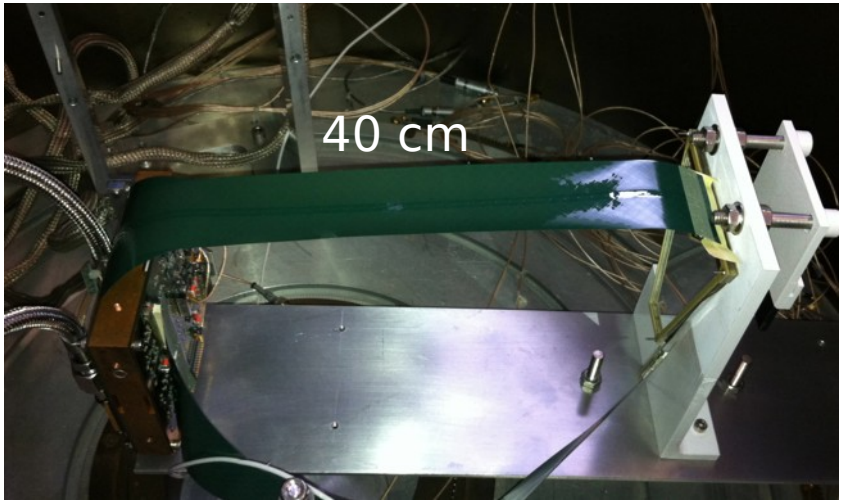
List of the tested detectors



nb	thickness	resolution P-side	resolution N-side
5	484 um	45 keV	30 keV
6	489 um	40 keV	33 keV
7	469 um	60 keV	40 keV
8	375 um	45 keV	35 keV
9	376 um	40 keV	35 keV
10	463 um	40 keV	30 keV

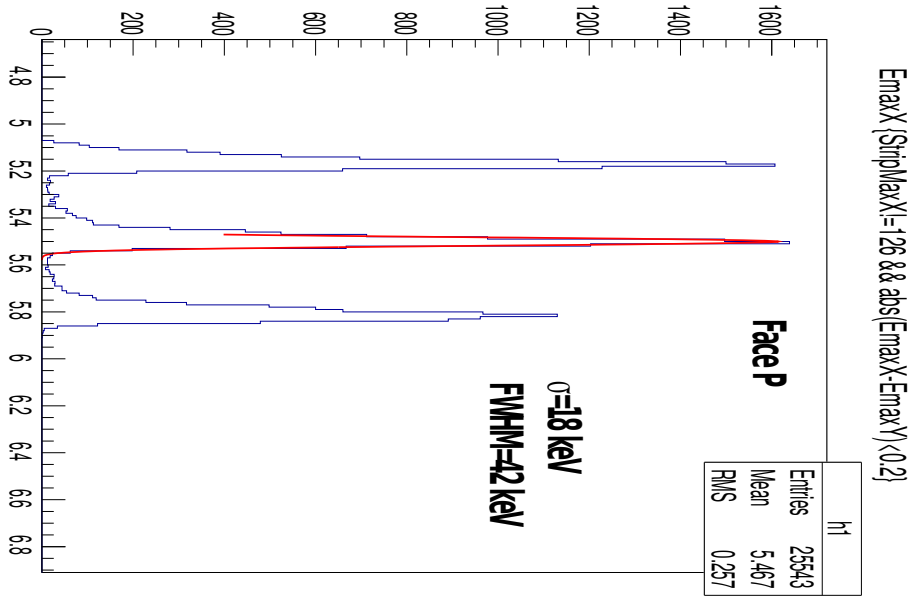
N-side (front) always better than P-side

Some results _1



- Test with long (40cm) kaptons
- In MUGAST, typical kapton length ~40cm
  --> never tested before
- MUST2 has about 20 cm long kaptons

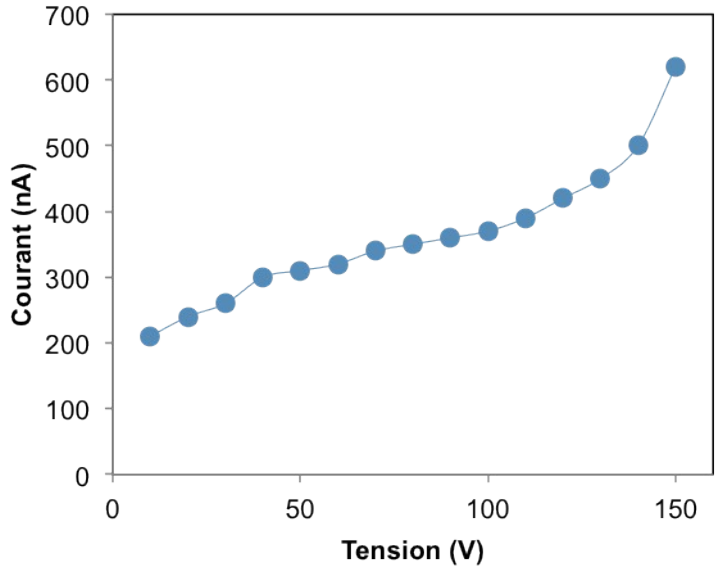
Sum of all strips (N or P side)



Trape #5

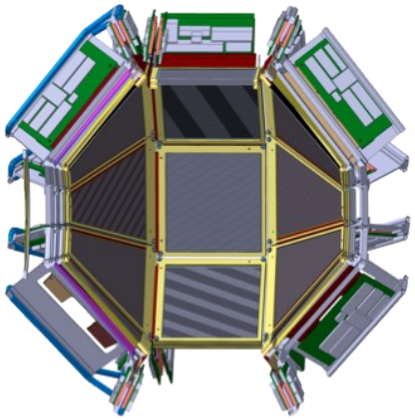
All strips summed, P-side

FWHM= 46 keV



All strips summed, N-side
FWHM = 30 keV

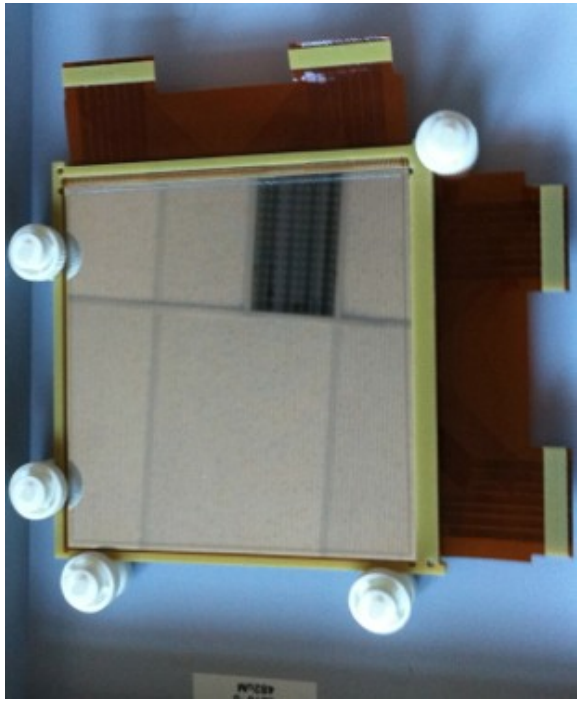
Square dets

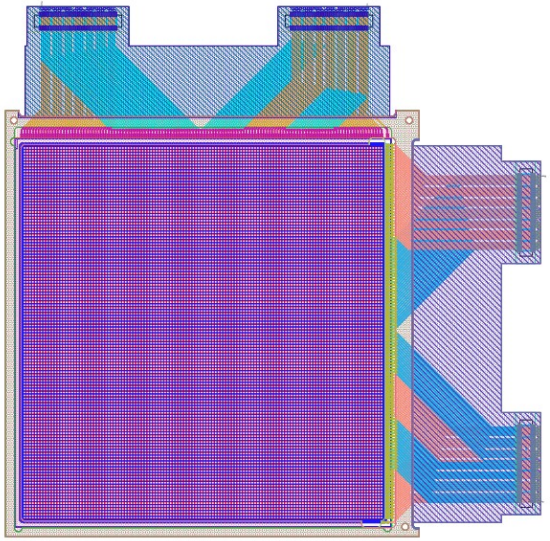


Ordered at Micron Semiconductors :

- 2 prototypes **500 μm INFN (end 2014)**
- 1 prototype FZ 1.5 mm INFN (end 2014)

All prototypes received March 2017 and tested on MUGAST testbench





Square proto with MUFEE

nb	thickness	resolution P-side	resolution N-side
4	495 um	40 keV	40 keV
3	482 um	40 keV	40 keV
1	1500 um	- keV	70 keV

Thin square detectors

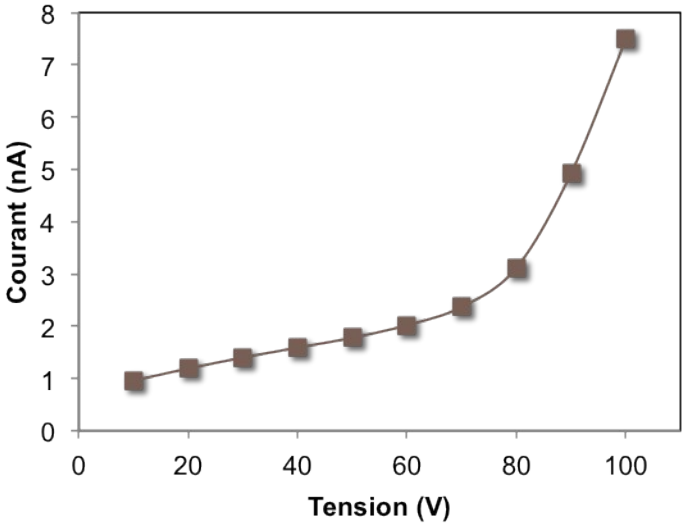
N-side

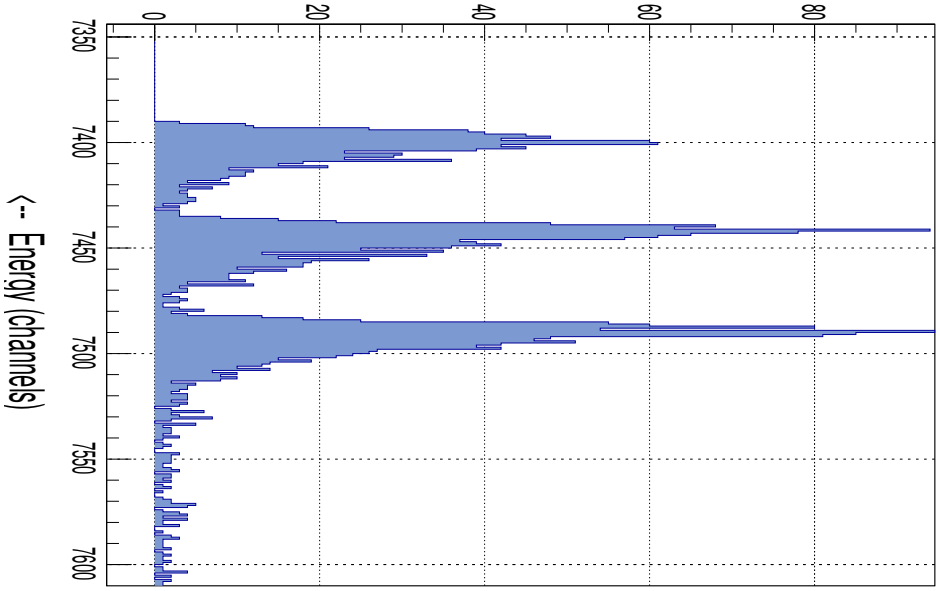
P-side

Energy (MeV)

Thick square

- Bias = 100V, I_{leak}= 7.5 uA
- Injection side : N
- Resolution N-side : 70 keV (FWHM)





Electronics

Extension of MUST2 FEE/BEE

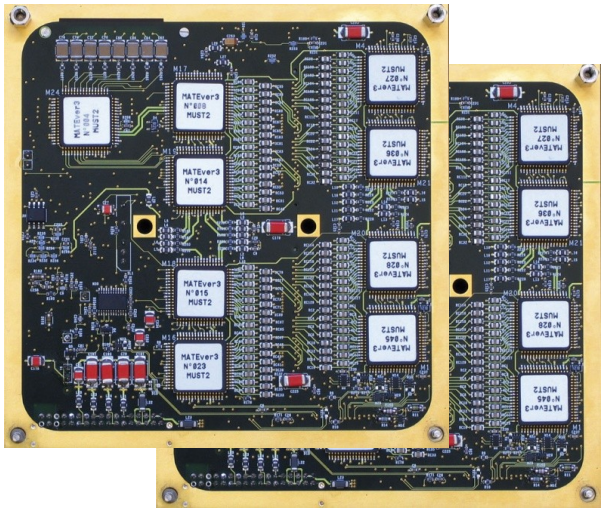
- 7 new pairs of MUFEE boards were redone (received may 2017)

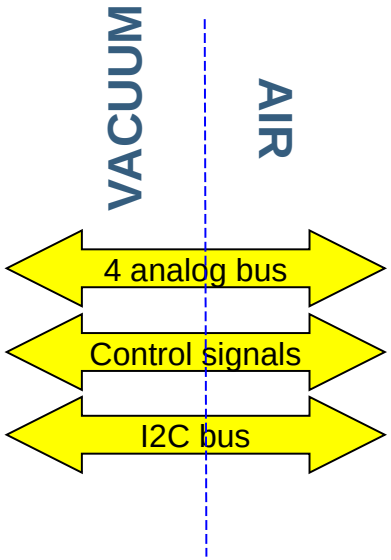
+ 3 pairs of spare (no ASIC)

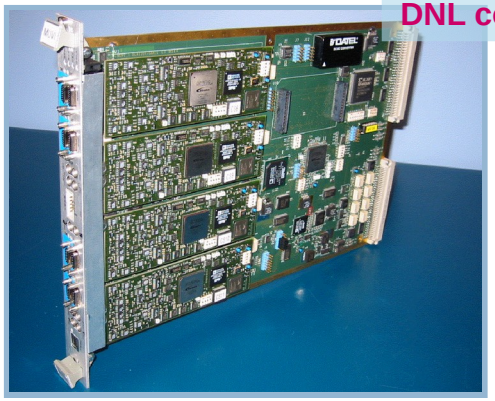
- **Tests of the MUFEEs with pulser and MUVI**
  -> to be performed by the end of the year
  -> 2 MUVI never used in experiments to be tested at the same time

- **BT box redone at LPC Caen (18 channels in total)**

MOTHER BOARDS (IPNO)







VXI board (GANIL)
16 ADC14 bits
2.3K parameters
2MHz
Slow Control I2C
Pedestal substraction
DNL correction

Mechanics

Reaction chamber

- Received 2017
- Support for detectors and electronics received (2017)
- internal mechanics OK (received)
- <u>ordered :</u>
  - feedthroughs
  - cooling blocs for electronics (GANIL)
  - kaptons for trapezoidal detectors (INFN)
  - kaptons for square detectors
  - modification of cryogenic target and support

Conclusions

- Basically ready to run ...
- New in-beam (TANDEM) commissioning of the full setup, during Autumn this year at IPN Orsay.
- Technical commissioning of the thin and thick square also expected.
- New round at the Nov PAC in GANIL
- More SPIRAL1 beam to come ...