

# Status of



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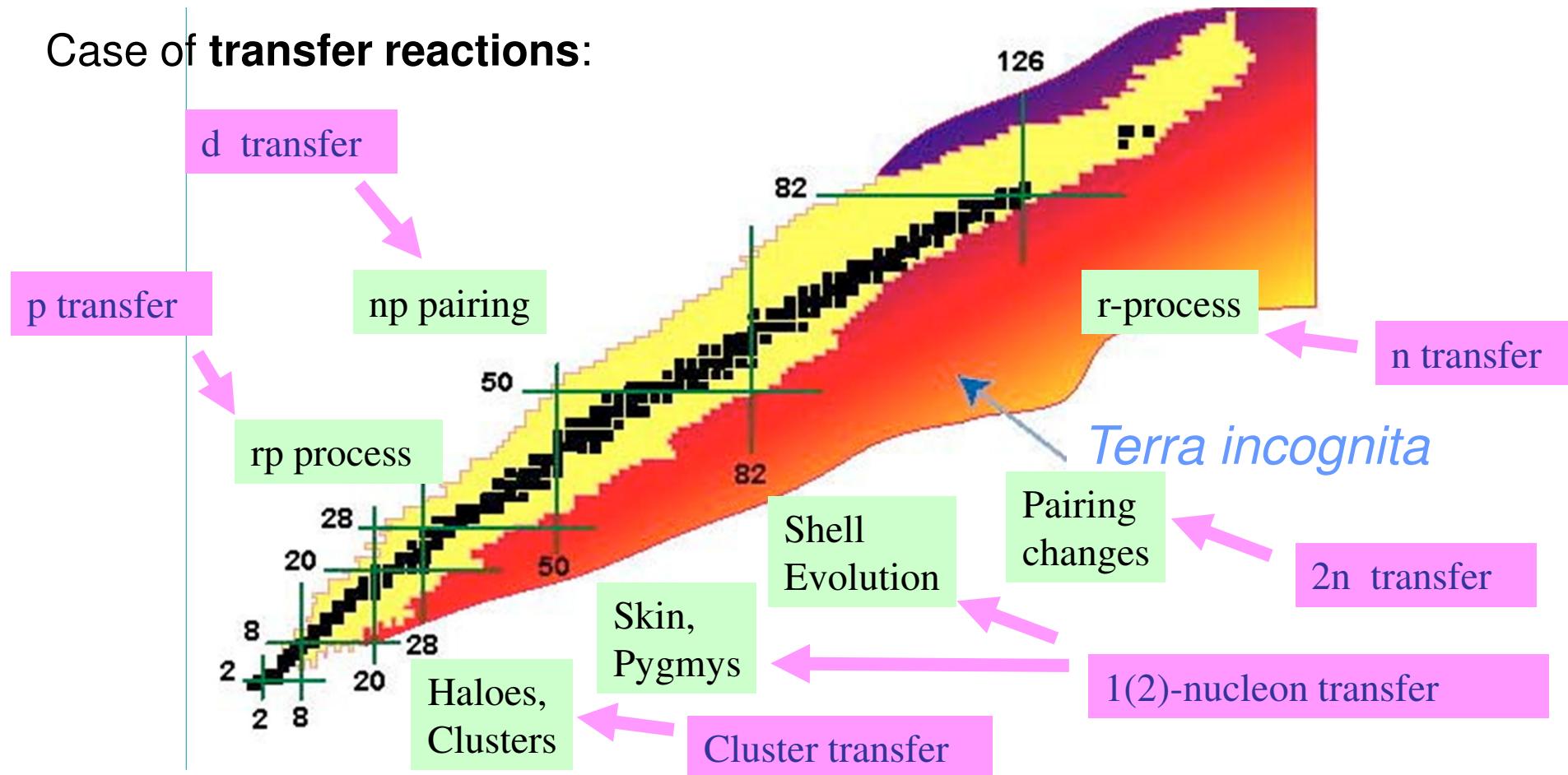
D.Beaumel, IPNO

GHT meeting, Padova, March 25-27, 2015

# Direct reactions

A great tool to investigate Exotic Nuclei and astrophysics processes

Case of transfer reactions:



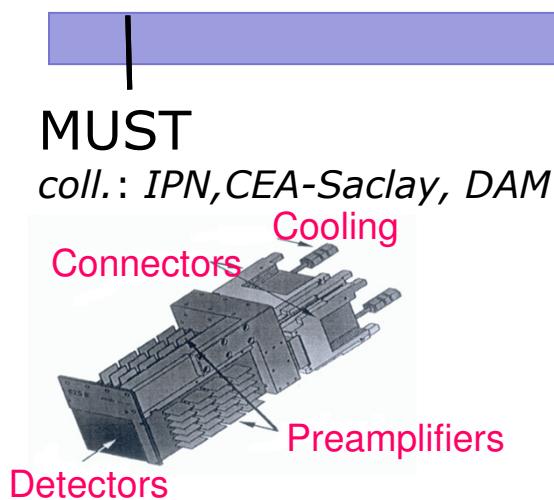
Good energy regime : few MeV/u → few tenths of MeV/u

Methodology : Radioactive Ion Beam  $\longrightarrow$  Light target (H,He...)  
Detect the recoil particle with high accuracy

# Landscape of Si detectors for DR studies

## Light Beams

1997



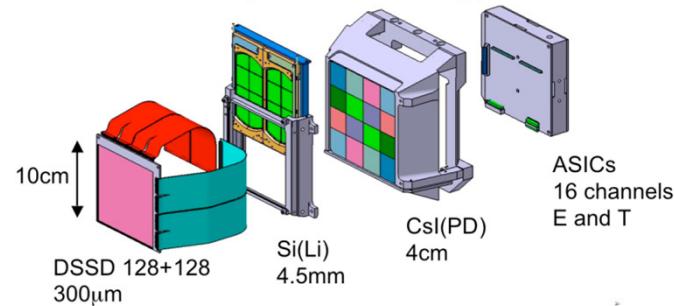
### MUST

*coll.: IPN, CEA-Saclay, DAM*

2007

### MUST2

*coll.: IPN, CEA-Saclay, GANIL*

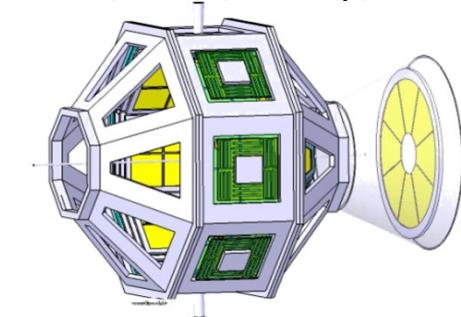


## Fission fragments

2017~

### GASPARD

*coll.: IPN, INFN, BARC  
Irfu, Huelva, STFC, Surrey, GANIL*



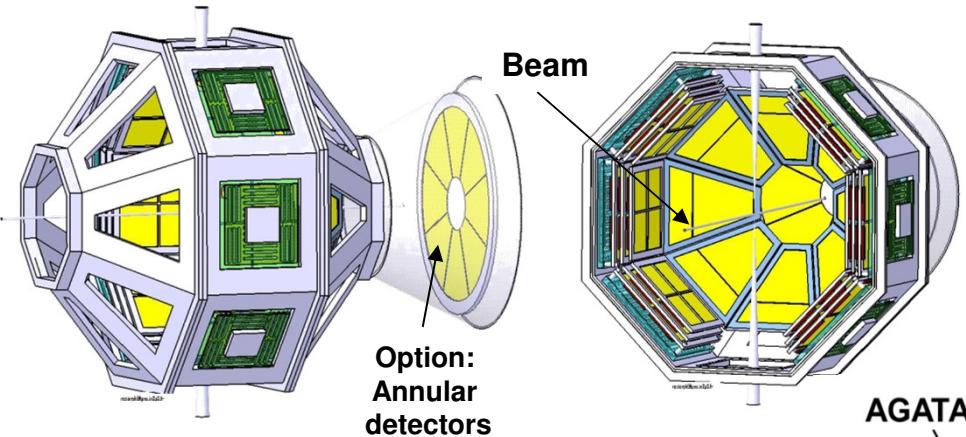
## Particle spectroscopy

## Particle-Gamma spectroscopy

# *A new Si array for reaction studies*

**4 $\pi$ , fully integrable in PARIS/AGATA/EXOGAM2**

## **“GASPARD-TRACE” design**



## **Electronics :**

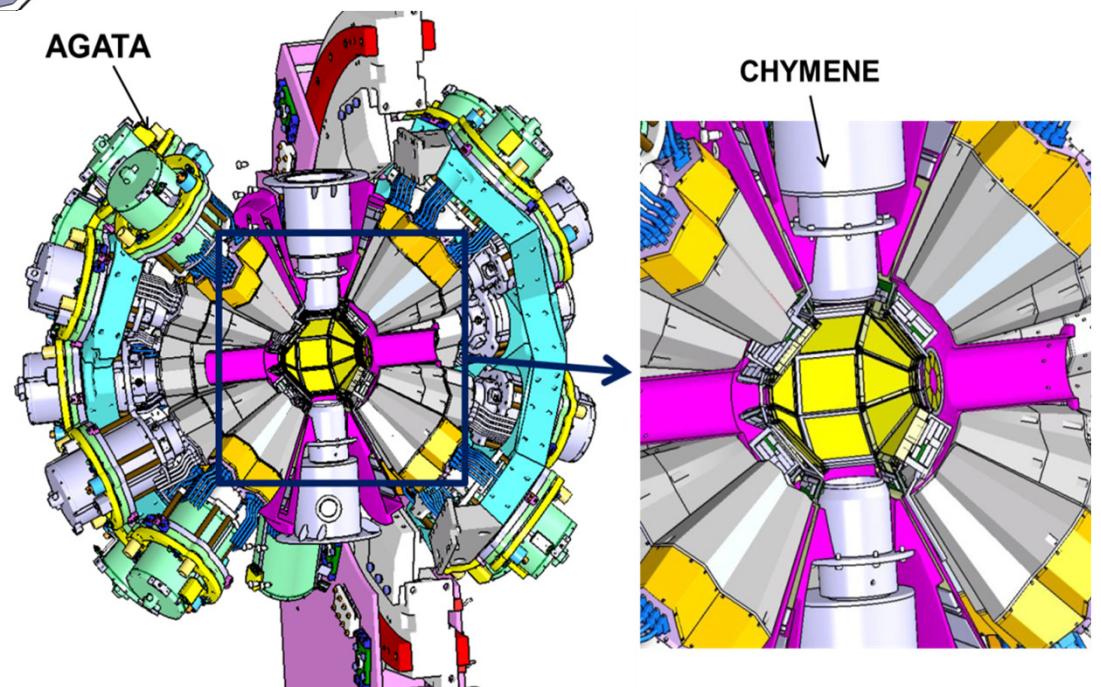
- ~ 10000 channels (Digital)
- high transparency to  $\gamma$ -rays
- Big integration challenge

## *Other features:*

- State of the art for PID  
Pulse Shape Discrimination
- Special targets (pure H,D)
- Portable device

## **Layers of Silicon**

- 300(500)  $\mu\text{m}$  DSSD pitch < 1mm
  - 1(or 2) x [1.5 mm DSSD pitch~1mm]
- 2 main shapes : square & trapezoid,  
large area



# R&D on Pulse Shape Discrimination for light particles

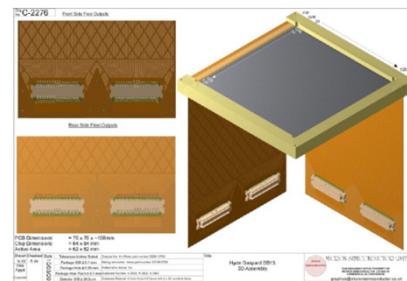
Performed in the framework of the  
**GASPARD-HYDE-TRACE collaboration**

- ✓ *Identification of light particles by means of pulse shape analysis with silicon detector at low energy (J. Duenas et al, NIMA 2012)*
- ✓ *Dependency on the silicon detector working bias for proton–deuteron particle identification at low energies (J. Duenas et al, NIMA 2013)*
- ✓ *Pulse shape discrimination at low energies with a double sided, small-pitch strip silicon detector (B.Genolini et al., NIMA 2013)*
- ✓ *Interstrip effects influence on the particle identification of highly segmented silicon strip detector in a nuclear reaction scenario (J. Duenas et al., NIMA 2014)*
- ✓ *“Digital pulse-shape analysis with a TRACE early silicon prototype” (D. Mengoni et al, NIMA 2014)*
- ✓ *“Characterization of light particles ( $Z < 2$ ) discrimination performances by pulse shape analysis techniques with high-granularity silicon detector” (M.Assié et al., EPJA 2015)*

# R&D on Pulse Shape Discrimination for light particles

Using our early prototype from MICRON SC  
(delivered end of 2011)

- NTD, 500um
- 128X+128Y, 500um pitch
- 90 deg kapton readout



$^{7}\text{Li} + ^{12}\text{C}$  reaction

Light particle discrimination :

- Z=1 : good FoM down **to 2.5 MeV**
- Z=2 : (*preliminary*) seems ok

Best observables:

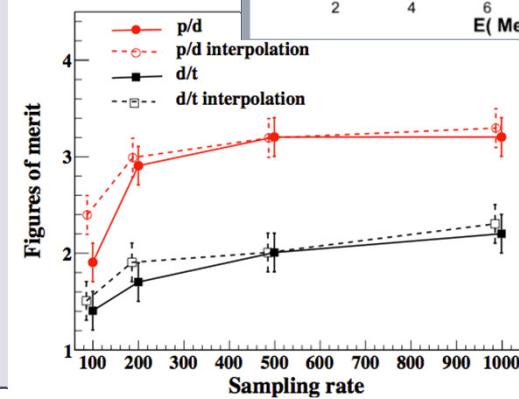
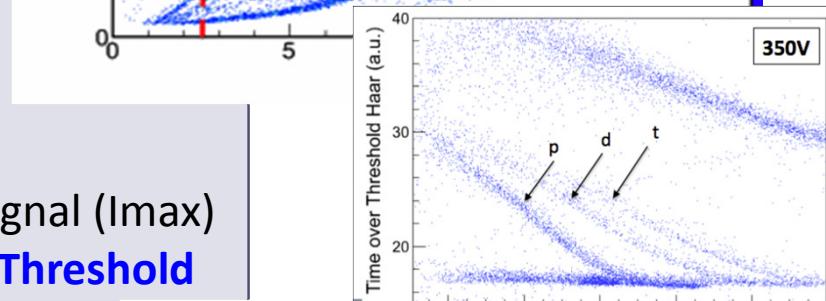
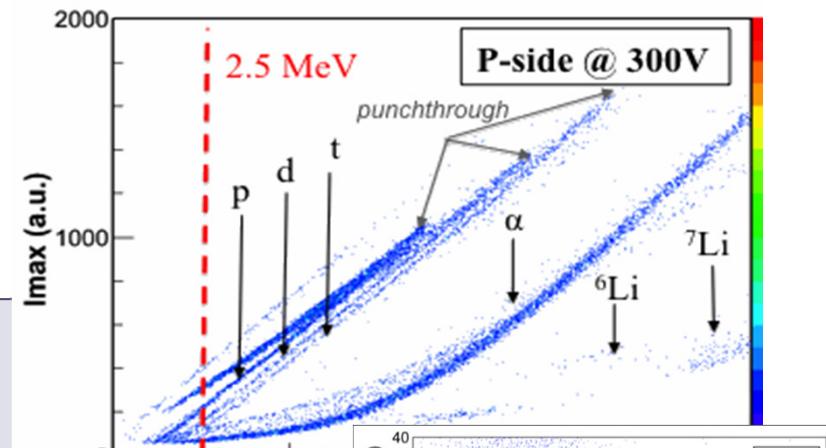
- Raw data : **maximum of the current signal (Imax)**
- Filtered data : **Haar filter + Time over Threshold**

Bias of the detector :

- Option 1 : at depletion + Imax
- Option 2 : over-depleted + Haar-ToT

Sampling rate of ADC: > 200 MHz

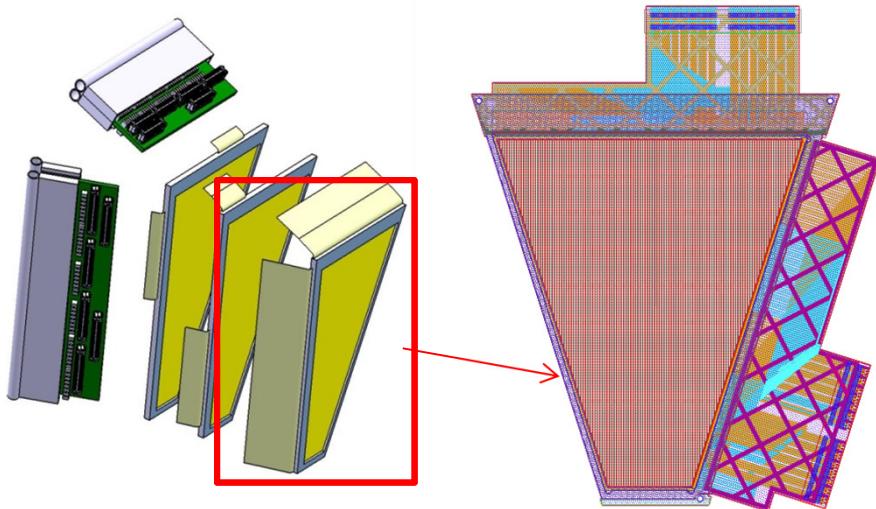
M.Assié et al., EPJA 2015



See talks by M.Assie, A.S.Torrento, J.Duenas

# *Silicon developments*

Final design (approved)



## **Silicon detectors plan (short term):**

- .1<sup>st</sup> layer (trapez.): 2 prototypes ordered  
**(Micron) in 2013 (IPNO)**
- 1<sup>st</sup> layer(square) : 2 prototypes ordered  
**(Micron) in 2014 (INFN-Padova)**
- .2<sup>nd</sup> layer (thick square) & 2<sup>nd</sup> layer (thick trapez): BARC-IPNO

### **Specifications**

- large area , 6" wafers, nTD, 500um thick
- 128X+128Y (pitch~700 um)
- <100> random cut (8deg)
- Thin frame / Kapton readout at 90deg /High density connectors

### Test bench

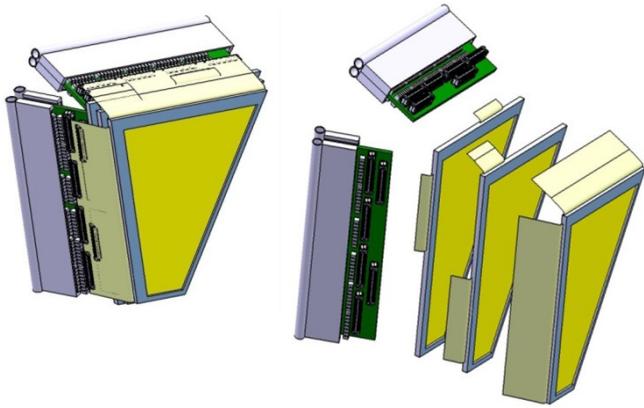
Test of uniformity In resistivity

Leakage current /strip, capacitance/strip, interstrip resistance

**Trapezoid to be commissioned soon**

***See update by M.Assié***

# *Electronics developments*



## Front-End Electronics

- **iPACI** from IPNO (J-J. Dormard) gives **current & charge signals**  
1st version = 9 channels (received Jul. 2014)
- **Integrated PAC** from INFN (S. Capra) to have large range in energy, 1st version = 4 ch
- **ADC : analog memories** from INFN (discrete) to be tested

### **FEE/BEE challenges:**

- Integration of many channels
- Compacity

### **Option A : analog electronics**

- Peak finder (integrated in iPACI) for I and Q
- Multiplexing

### **Option B : digital electronics**

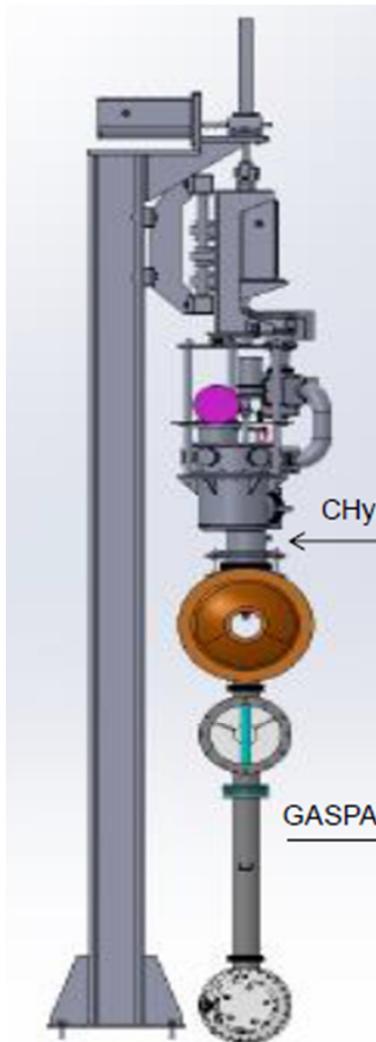
- High sampling rate (500MHz)
- Large nimir of channels, power consumption (under vacuum ?)

*See Electronics sessions*

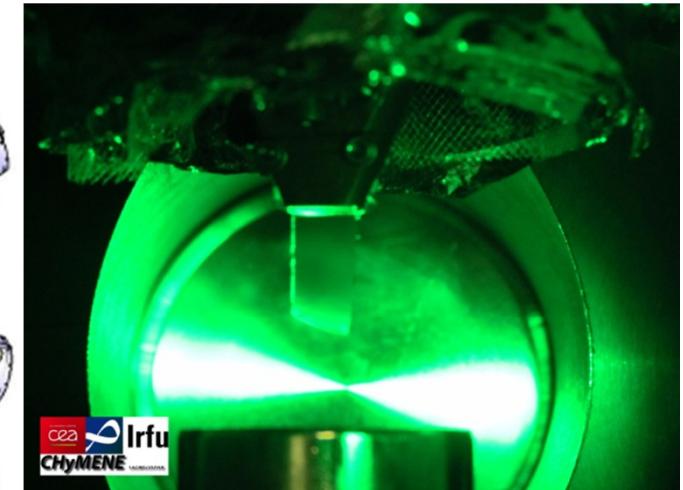
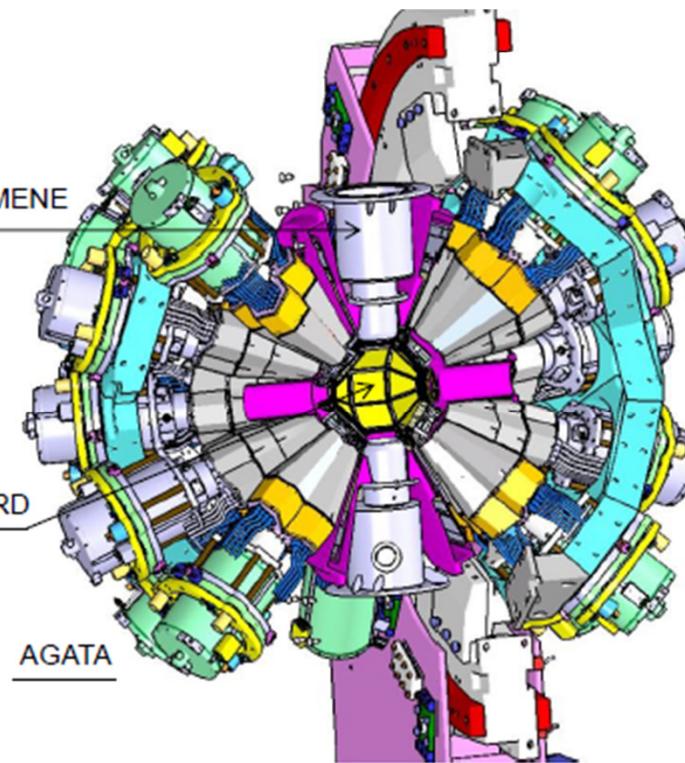
# The CHyMENE H/D windowless target

Cible d' HYdrogène Mince pour l' Etude des Noyaux Exotiques

*System providing continuous extrusion of  $^1\text{H}$  or  $^2\text{H}$  through a rectangular extruder nozzle defining the target-film thickness*



Pure H or D film with thickness 50~300 microns

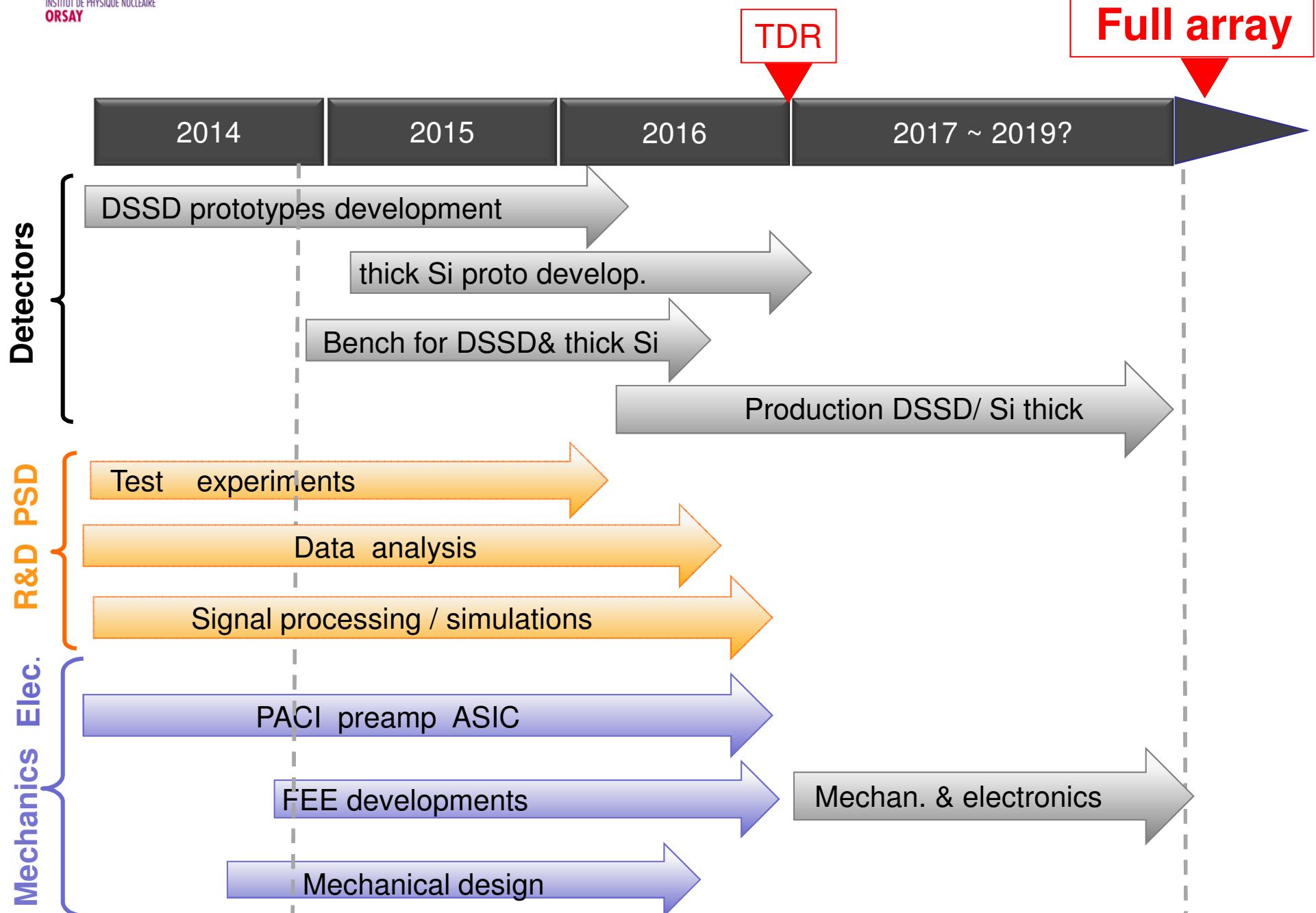


CHyMENE collaboration :

- CEA/IRFU Saclay  
*project coordinator: A. Gillibert*
  - CEA/DAM Bruyères
  - IPN Orsay
- Grant from ANR ~550k€

**See talk by A.Gillibert**

# Timelines



# MUGAST

## (MUST2 - GASPARD – TRACE)

**FROM 2017**

We can perform **high resolution reaction studies** using

- AGATA@ VAMOS
- The new SPIRAL1 beams

In particular ***stripping reactions e.g. (d,p)***

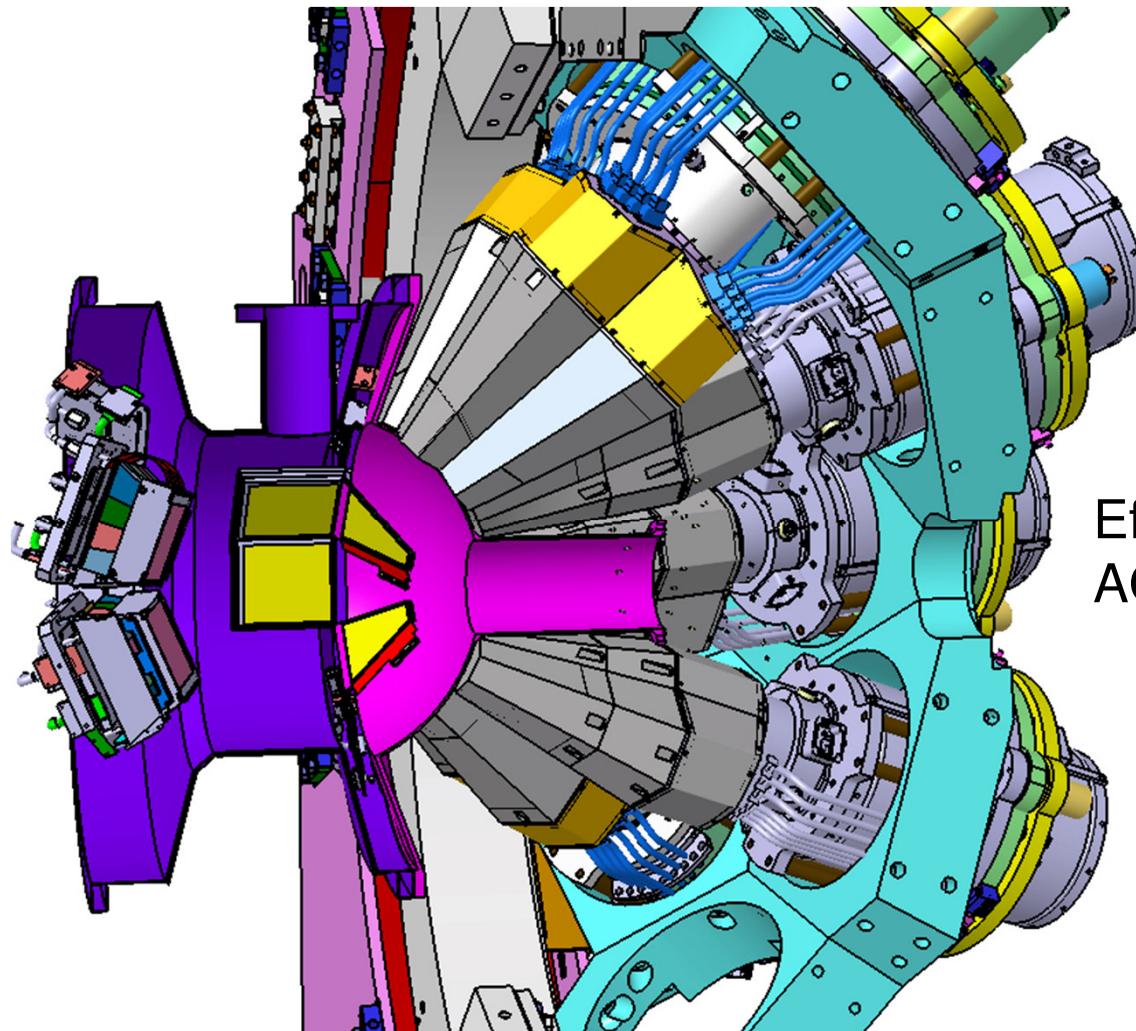
By implementing and “intermediate” configuration

- GASPARD-TRACE prototypes
  - + few MUST2 telescopes
- One-layer philosophy (VAMOS)
- CHYMENE
- MUST2 electronics with new connectics

100 k€, 2years

# MUGAST

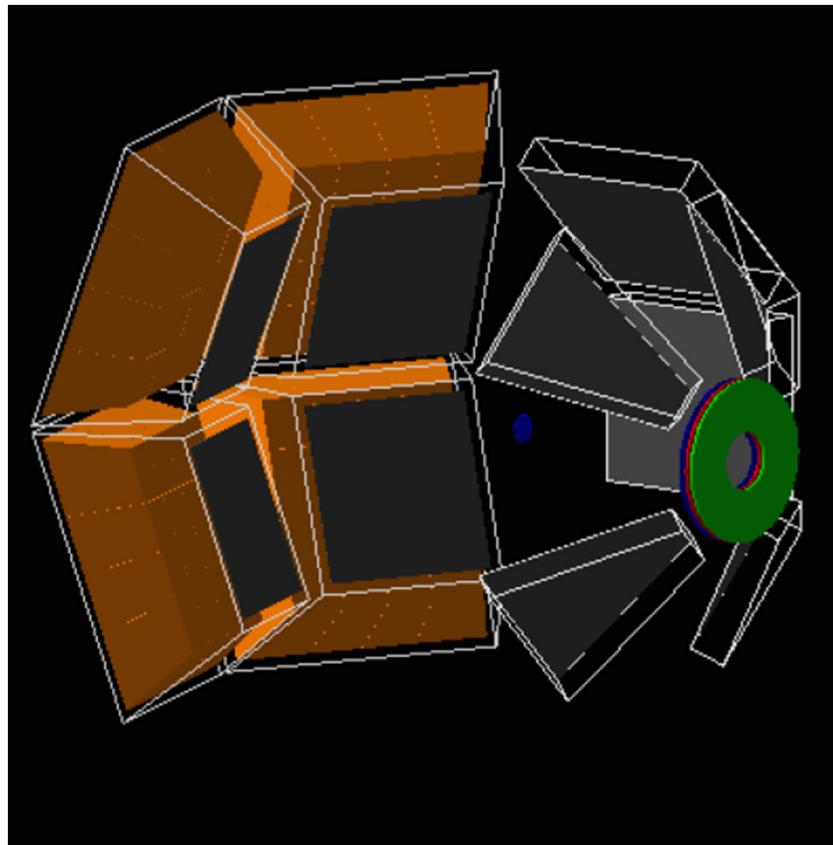
(MUST2 - GASPARD – TRACE)



Efficiency of  
AGATA  $1\pi$  ~10%

*See talks by M.Assié, Ph.Rosier, E.Rindel*

# *Simulations*

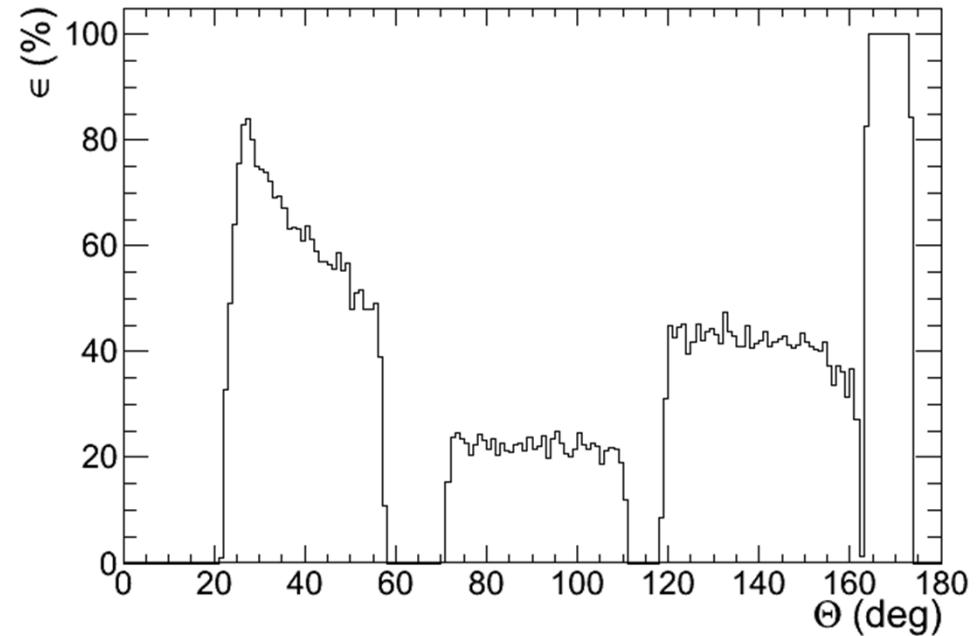


A.Matta, Univ. of Surrey

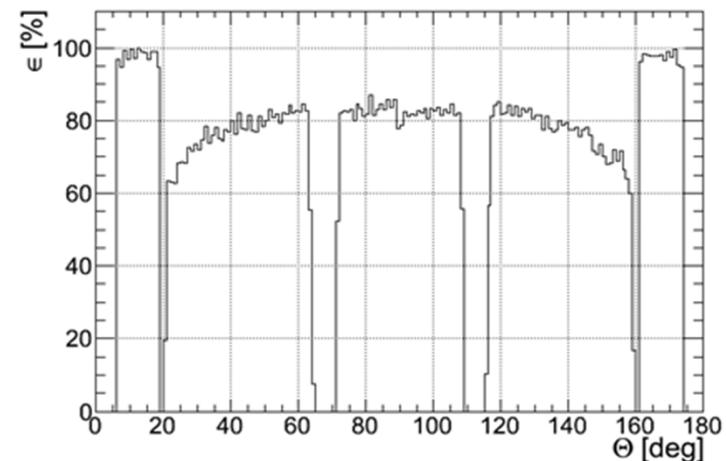
SIMULATION CODE AVAILABLE

*See talks by M.Labiche*

EFFICIENCY MUGAST



EFFICIENCY FULL ARRAY



# Meeting on Physics cases with MUGAST (Jan 2015)

$^{75}\text{Kr}$  (d,p) ,  $^{29}\text{Mg}$  (d,p),  $^{60}\text{Fe}$ (d,p)    Shell structure evolution (A.Matta, W.Catford, Univ. of Surrey)

$^{56}\text{Ni}$  (d,p),  $^{27}\text{Na}$  (d,p), Shell structure evolution (O.Sorlin, GANIL)

$^{79}\text{Se}$ (d,p)   Neutron Xsec by surrogate Method (G.de Angelis, INFN LNL, D.Mengoni, UNiv. And INFN Padova)

$^{56}\text{Ni} + ^7\text{Li}$    Shape coexistence in  $^{60}\text{Zn}$  (D. Mengoni, Univ. and INFN Padova, G. de Angelis, INFN LNL)

$^{30}\text{P}$ (d,p) Nucleosynthesis (N.de Sérerville, F.Hammache, IPNO)

$^{48}\text{Cr}(^3\text{He},\text{p})$  neutron-proton pairing (M.Assié, IPNO)

$^{15}\text{O}(^6\text{Li},\text{d})^{19}\text{Ne}$  Nucleosynthesis (C.Diget, Univ. of York, N. de Sérerville, IPNO)

$^{25}\text{Al}(^3\text{He},\text{d})$  Nucleosynthesis (N.de Sérerville, F.Hammache, IPNO)

Ge, Se (d, $^6\text{Li}$ ) Shell Structure evolution (F.Flavigny, IPNO)

$^{48}\text{Cr}(\text{d},\text{alpha}), (\text{d},^6\text{Li})$  Pairing and quartetting (M.Assié, IPNO)

$^{45}\text{K} + ^7\text{Li}$  Incomplete fusion (S.Leoni, Milano, B.Fornal, Krakow)

$^{14}\text{O}(\text{p},\text{p})$  Resonant gamma decay of unbound states (I.Stefan, IPNO)

$^{16}\text{O} + ^{27}\text{Al}$  Nuclear dynamics (G.Verde, IPNO)

***Large majority of stripping reactions***

# Reaction studies using the MUGAST+AGATA setup at VAMOS

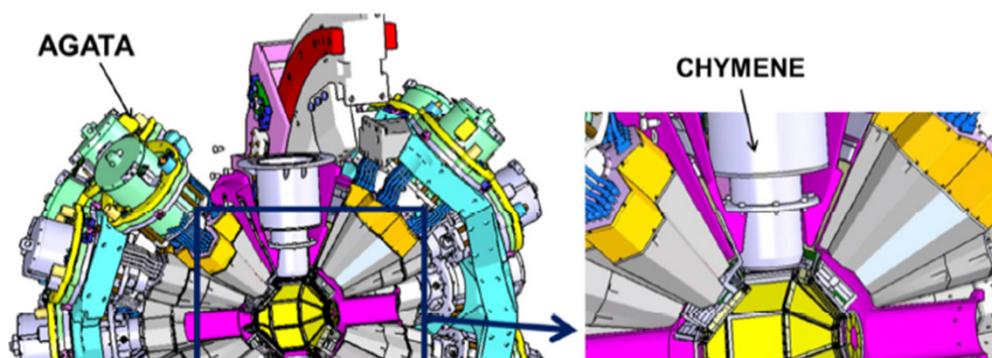
## Letter of Intent to the AGATA collaboration

D.Beaumel, IPN Orsay

D.Mengoni, University and INFN Padova

### 1. Introduction

The GASPARD and TRACE high granularity Silicon arrays have been natively designed for optimal integration in new generation gamma detectors such as AGATA with the aim of performing high-resolution reaction studies. Indeed, the coupling to AGATA allows a very large gain in excitation energy resolution, in comparison with the case where the excitation energy is deduced from the recoil charged-particle measurement. The GASPARD and TRACE collaboration are now converging to build such new-generation Si ensemble in common, with a timeline of 2019-20 for completion of the final  $4\pi$  array, ready for the emerging ISOL facilities, like SPES and SPIRAL1. A view of such ultimate GASPARD-TRACE setup sitting inside AGATA is shown in Fig.1.



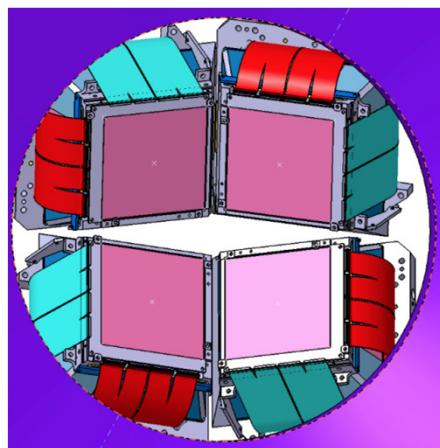
# Short and mid-term perspectives

## MUGAST & demonstrator phase

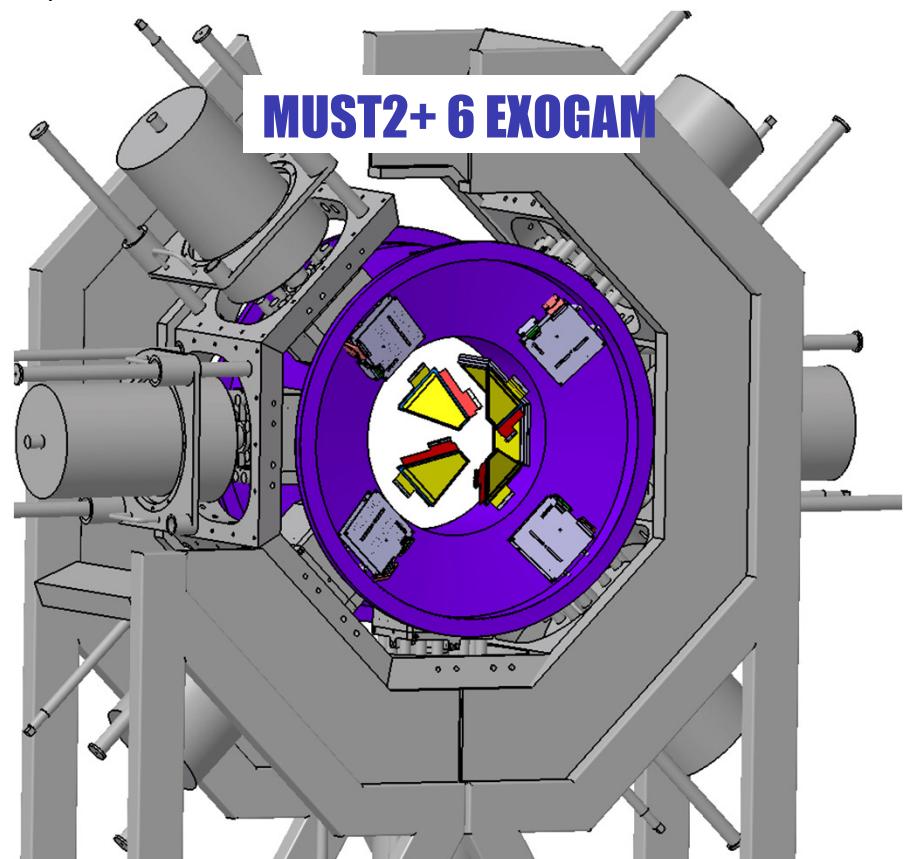
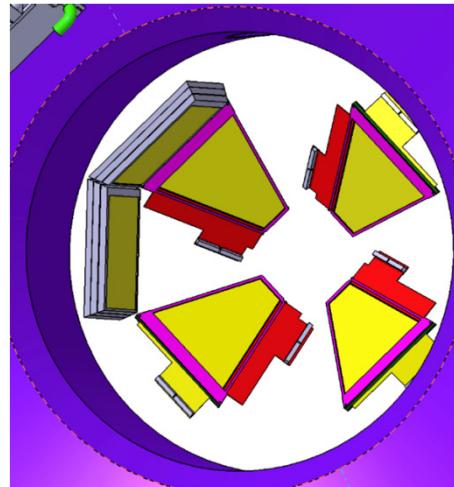
« MUGAST » configuration = MUST2 + GASPARD (trapeze) +TRACE (square)  
available for AGATA campaign at GANIL (end 2016)  
read by **MUST2 electronics (MUFEE+MUVI)**

- **Ancillary detectors :**
  - 6 PARIS clusters (if available)
  - 6 EXOGAM

**MUST2 [close config.]**



**TRAPEZES (GASPARD)  
+CARRES (Trace)**



# Collaboration agreement

*Under elaboration (D.Mengoni, DB)*

**Goal** : converge towards a common portable device to be used at



**2 phases scheme** :

- 2015-2016 : (full) Si prototypes developments, Electronics dev. and full definition, TDR
- 2017 ~ 2019? : Construction

## GHT Collaboration Agreement

### 1. Introduction

GHT (acronym for GASPARD, HYDE and TRACE, in reference to the corresponding initial projects) is an international collaboration aimed to develop a new detector for optimal study of reactions using low and intermediate energy beams at existing and forthcoming radioactive ion beam facilities. It consists in a new type of compact, highly segmented, silicon array, fully integrable within next generation gamma detectors such as AGATA and PARIS. Such new type of Silicon-based array is also meant to offer state-of-the art particle identification to improve separation of the various reaction channels and reduce the physical background. Native integration of special targets such as the pure

