HIGHSPID

(HIgh Granularity HodoScope for Particle IDentification)

Yorick Blumenfeld

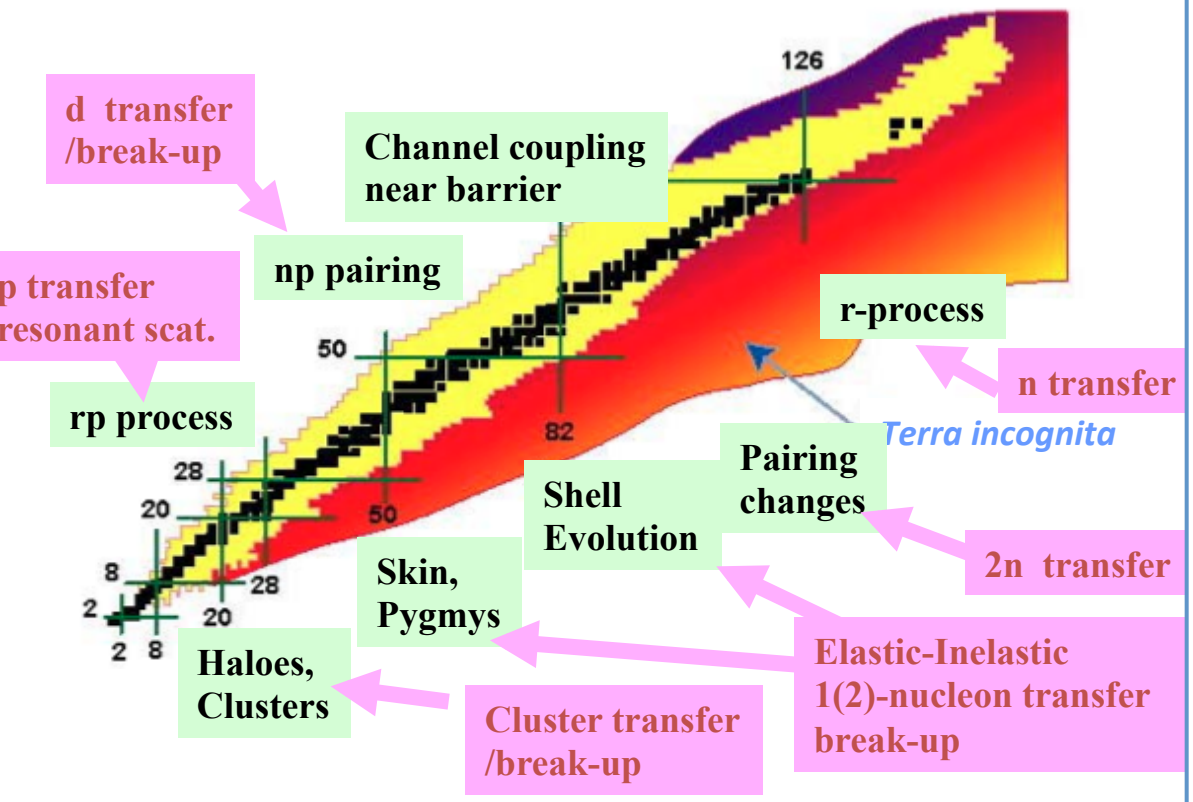
IPNO

OUTLINE

- Background: reactions with radioactive beams
- The HIGHSPID Project
- Results
- Future

Physics cases for direct reactions

Direct reactions : A great tool to investigate Exotic Nuclei and astrophysics processes



Good energy regime :5-100 MeV/A

Methodology :

Radioactive Ion Beam + hadronic probe (H,He…)

↓

Detect the recoil particle with high accuracy

↓

Silicon technology

13 LoI for Spiral2+ LoI @ISOLDE

SHELL EVOLUTION

- How Magic is ^{78}Ni ? *W.Catford et al*
- Spectroscopic studies around ^{78}Ni and beyond N=50 via transfer and coulex *G. De France et al*
- Neutron shell evolution in weakly bound ^{134,135}Sn via (d,p) *V. Lapoux, O.Sorlin*

PAIRING

- Probing the pairing interaction through two-neutron transfer reactions *D.Beaumel et al*
- Study of pair transfer in ^{134}Sn via ^{132}Sn(t,p) *O.Sorlin, K.Wimmer*
- 2p capture on ^{15}O and proton correlation in 2p emission from excited states of ^{17}Ne *M.Assié*

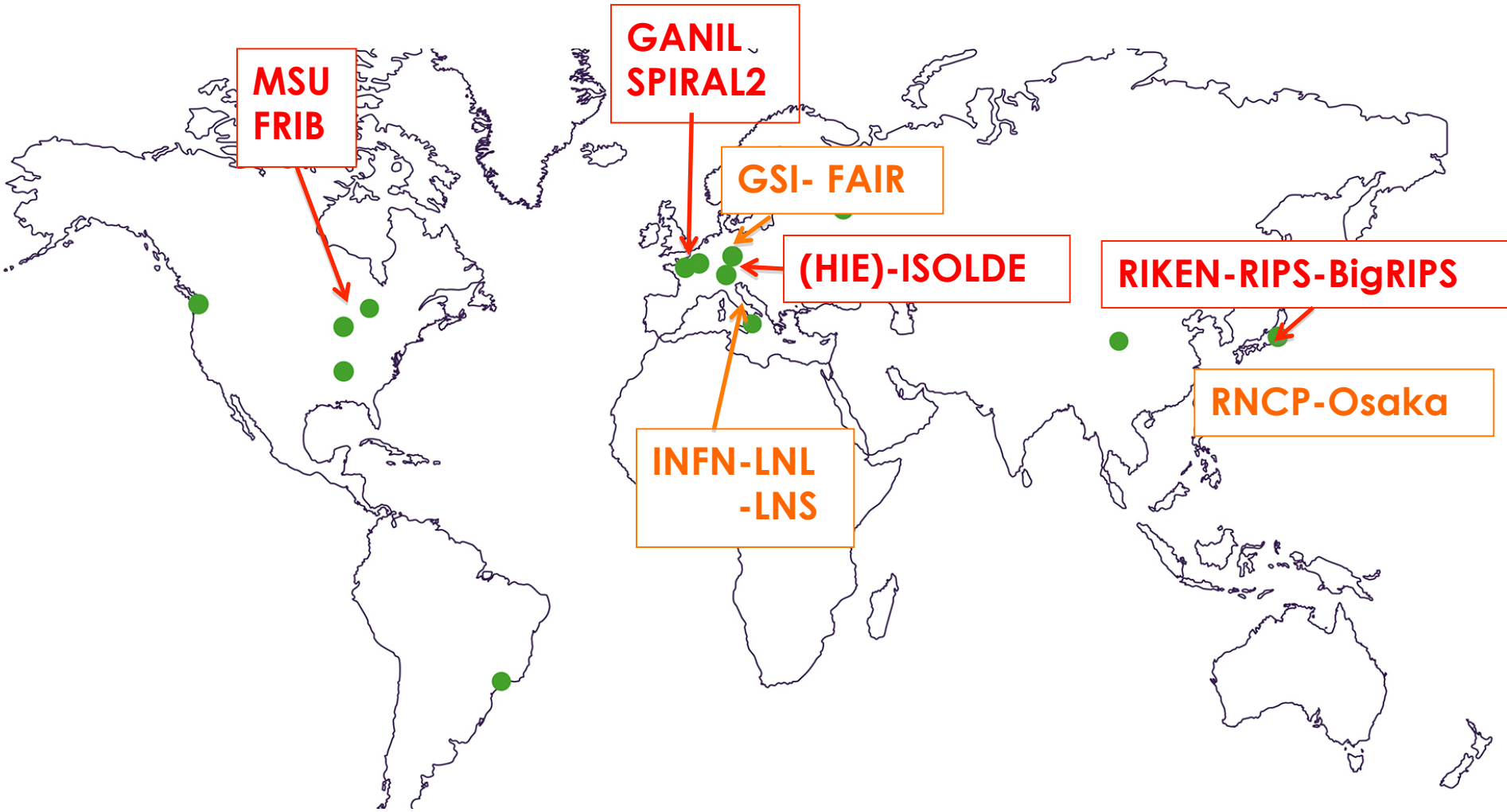
CLUSTERS

- Exploration of cluster breakup in light nuclei *J.A.Scarpaci, M.Assié*

+ NEAR BARRIER REACTIONS, PDR, ASTROPHYSICS

Context for nuclear physics

Radioactive beam facilities worldwide



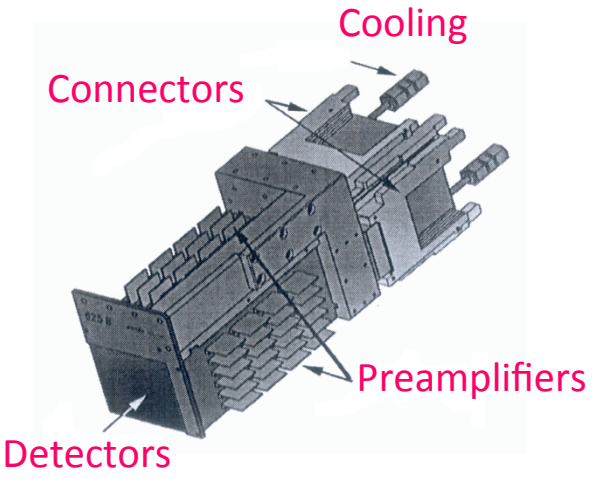
Landscape of Si detectors for RIB Physics @ P2IO Labs

1997 — 2007 — 2019

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

detectors: ***IPN***
electronics: ***IPN***

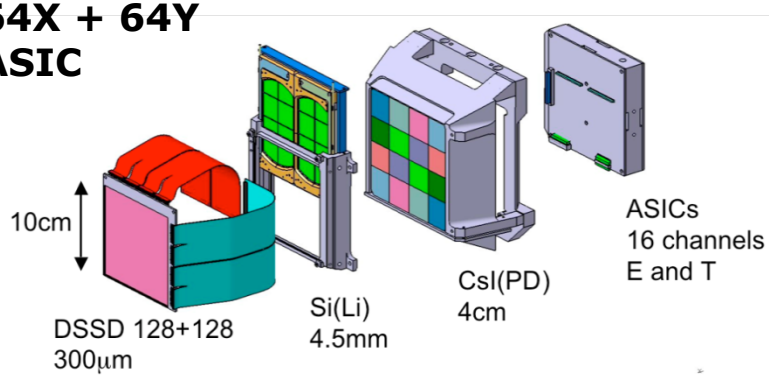
6cm x 6cm CAMBERRA
60 X + 60 Y strips
PAC



MUST2
coll.: *IPN,CEA-Saclay, GANIL*

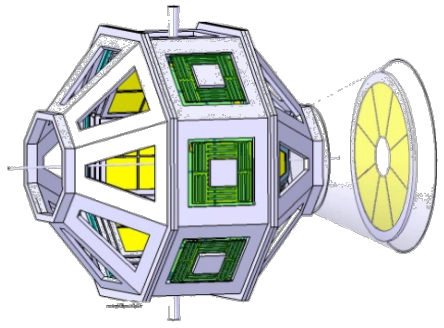
detectors: ***IPN***
*ASIC electronics:****GANIL+Saclay****+****IPN***
DAQ : ***GANIL***
mother boards : ***IPN***

10cm x 10cm MICRON
64X + 64Y
ASIC



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

4π
square + trapezoid
transparency to γ



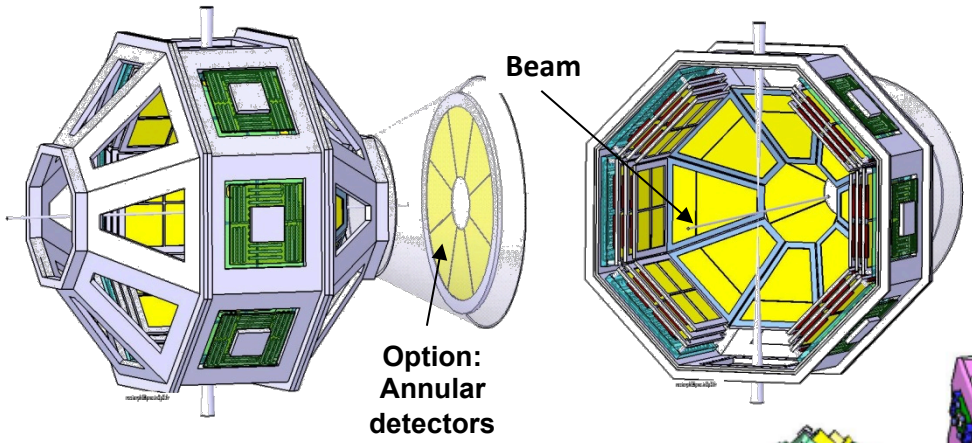
GASPARD

GAmma SPectroscopy and PArticle Detection

4π Si array fully integrable in PARIS/AGATA/EXOGAM2

Collaboration: IPNO, INFN-Legnaro, UHU (Spain)., CEA Saclay, Surrey U., BARC (India)

"GASPARD-TRACE" design



Design : Ph. Rosier (IPN)

Layers of Silicon

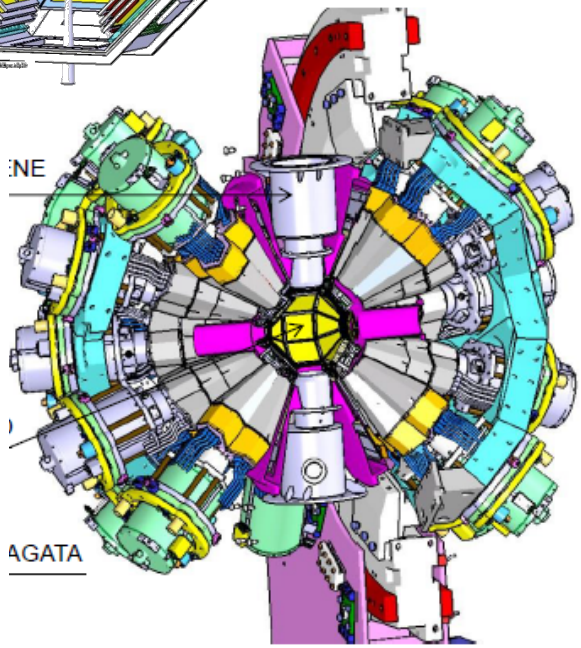
- 300(500) μm DSSD pitch < 1mm
- 1(or 2) x [1.5 mm DSSD pitch~1mm]

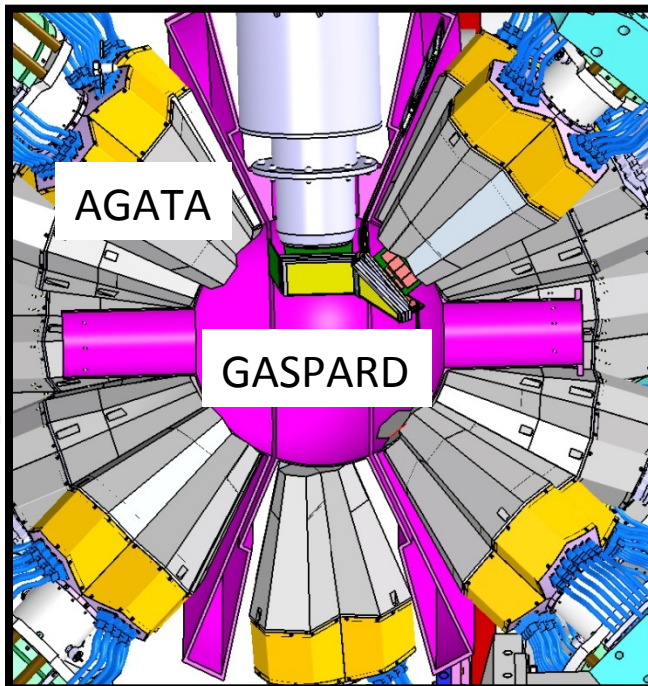
2 main shapes : square & trapezoid,
large area

Electronics :

~ 10000 channels (Digital)
high transparency to γ-rays

→ Big integration challenge

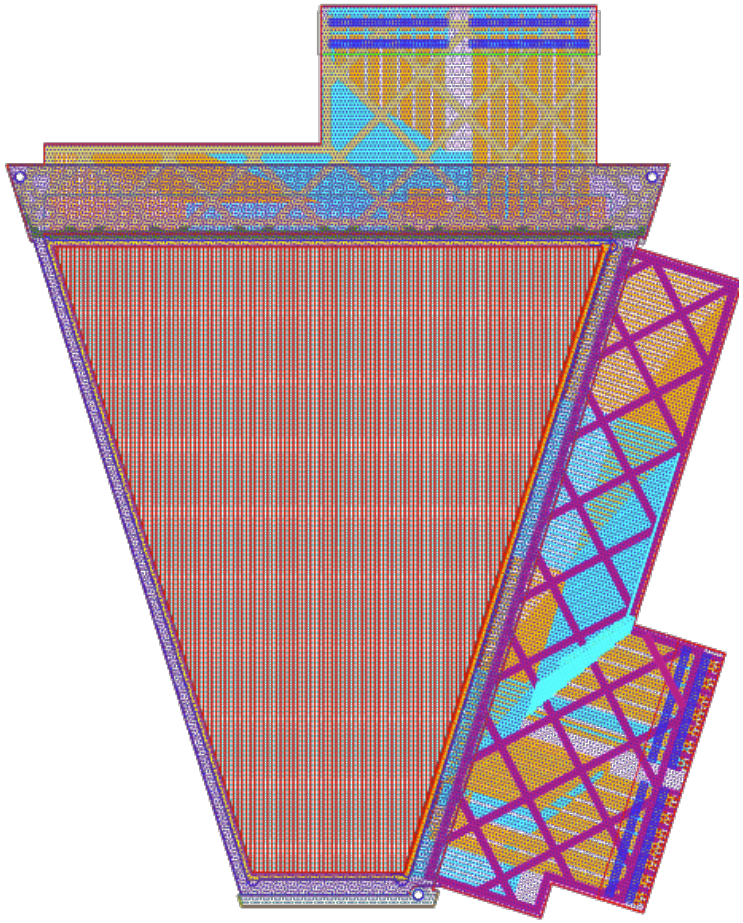




HIGHSPId Project

- Collaboration IPNO, LAL, IRFU
- Scientific Responsible: Y. Blumenfeld (IPNO)
- Technical responsible : B. Genolini (IPNO)
- Grant: 67 K€
- Timeline 2013-2015; extended by 1 year for IRFU
- Goals
  - Equip lab with « Wavecacther » Digitizer for tests
  - Submit iPACI: ASIC version of PACI preamplifier
  - Purchase prototype detector for GASPARD project
  - Design backend electronics

Trapezoidal Si detector for GASPARD



Specifications

- large area , 6'' wafers, nTD, 500um thick

- 128X+128Y (pitch~700 um)

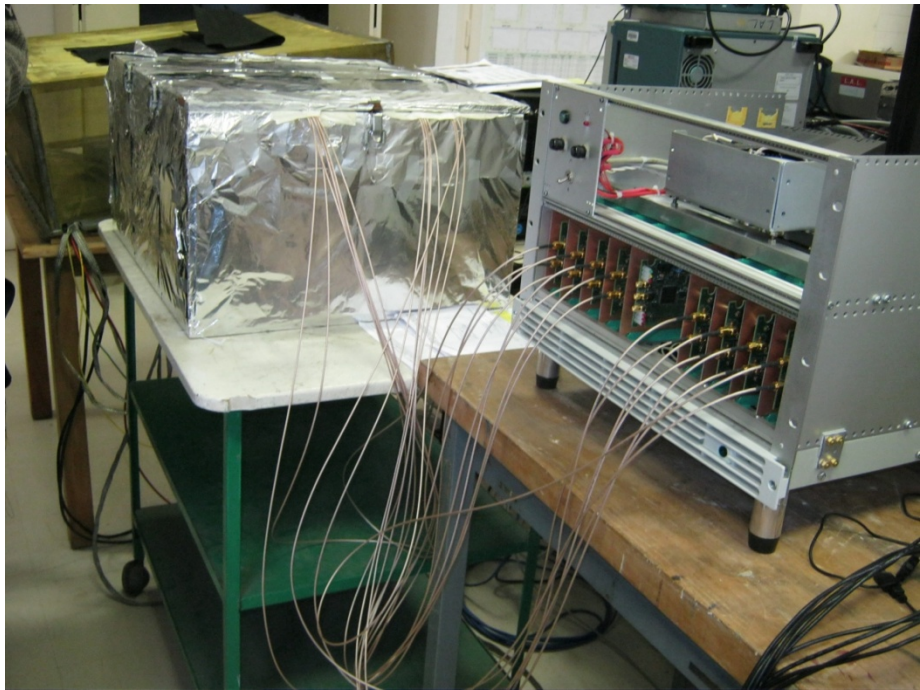
- <100> random cut (8deg)

- Thin frame / Kapton readout at 90deg /High density connectors

- Produced by Micron semi-conductor

WaveCatcher Characteristics

- System equivalent to a 64 Channel Oscilloscope + analysis
- Digitization between 400 MHz and 3 GHz over 1024 channels
- Acquisition rate 100 Hz
- Deadtime 100 μs
- Buffer of 7 events in FPGA



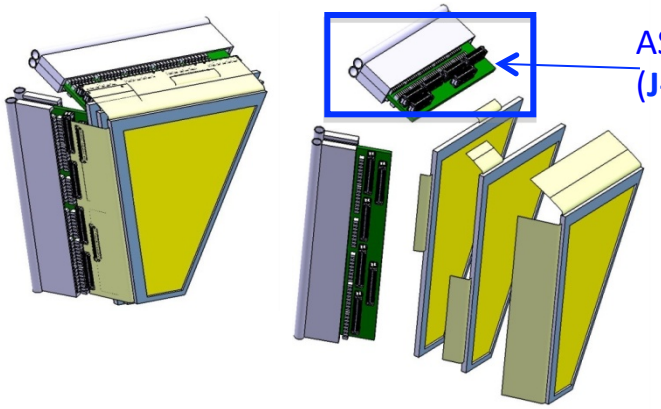
HiGHSPId project

Spokespersons : Y. Blumenfeld, B. Genolini (IPN)
Collaboration: IPNO, LAL, IRFU

Physique des 2 Infinis et des Origines

Grant : 67 k€

- **Electronics developments**
  - ASIC preamp I/Q (iPACI)
  - Digitizeur (Wavecatcher)



ASIC preamps iPACI
(**J-J. Dormard, E. Rauly**, IPNO)

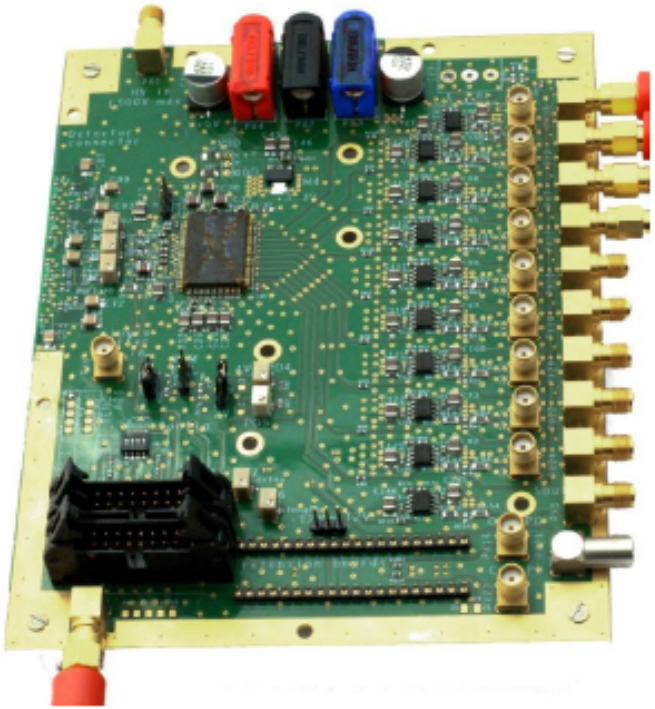
	3,3V version
Energy max	50 MeV
Consumption	3 mA (10mW)
Output swing	2V
Input-refered noise (FWHM)	5 keV (after shaper) 550 e^- (Si)
Resolution	13 bits ENOB
Current gain	2k
Area	> $(100\mu m)^2$
Energy linearity	0.6% FS

Front-End Electronics

iPACI from IPNO (J-J. Dormard) gives **current** & charge signals

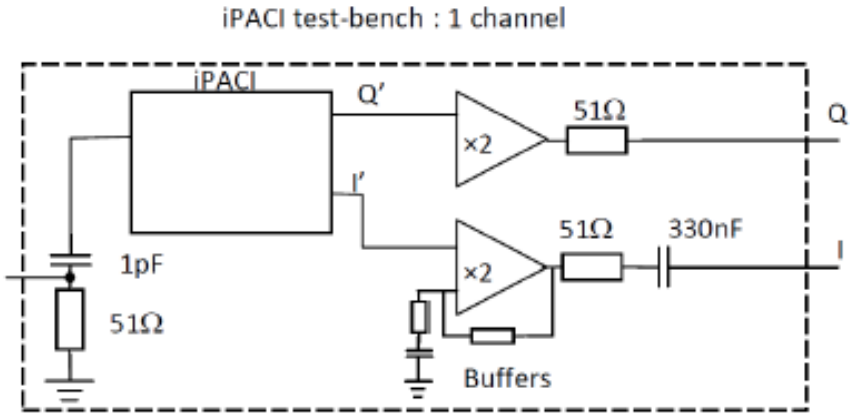
1st version =9 channels (received Jul. 2014)

iPACI Characteristics I

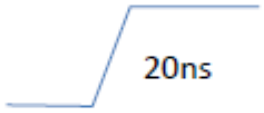


« Test » input

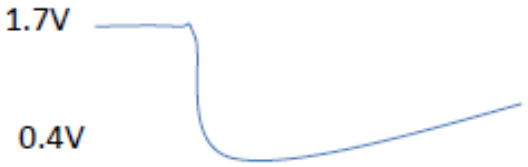
Vinj



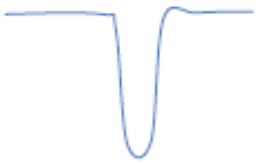
- Injection Vinj on test input
  ⇒Rise time =20ns



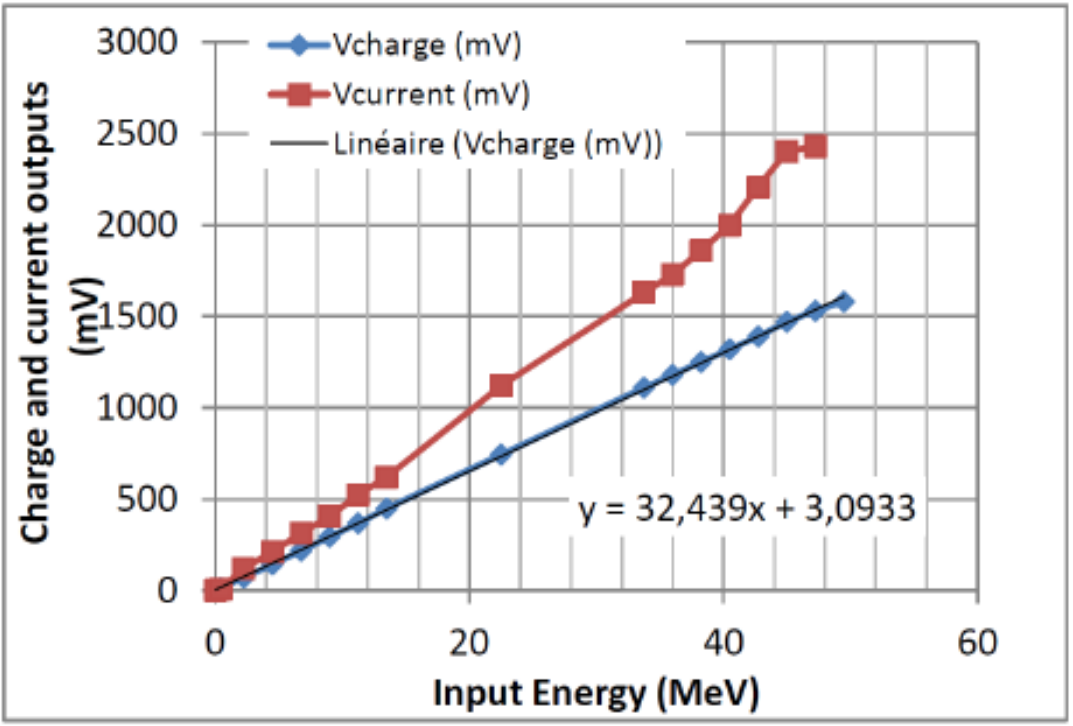
- Charge output =Q



- Current output = I



iPACI Characteristics II



$$Ein\ [MeV] = \frac{10^{-12} \times Vinj \times 3.6}{1.6 \times 10^{-19} \times 10^{6}}$$

- Input injection => leading edge of 20ns in a 1pF injection capacitance
- Charge output gain (51 Ω impedance) = 32mV/MeV-Si
- Charge output => linearity up to 50 MeV
- Current output (for 20ns)=> linearity up to 40 MeV

JJ Dormard and E. Rauly

HiGHSPId project

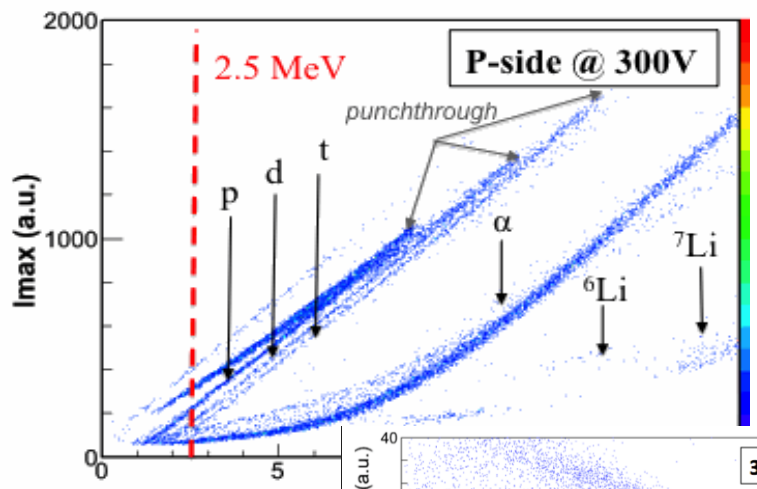
Spokespersons : Y. Blumenfeld, B. Genolini (IPN)
Collaboration: IPNO, LAL, IRFU

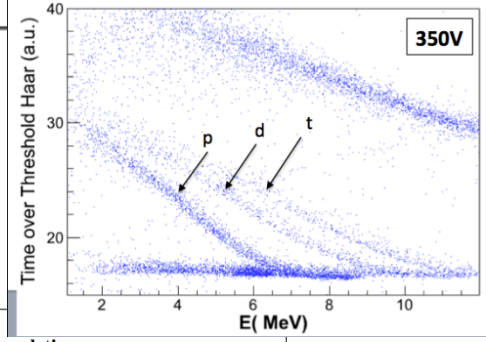
Physique des 2 Infinis et des Origines

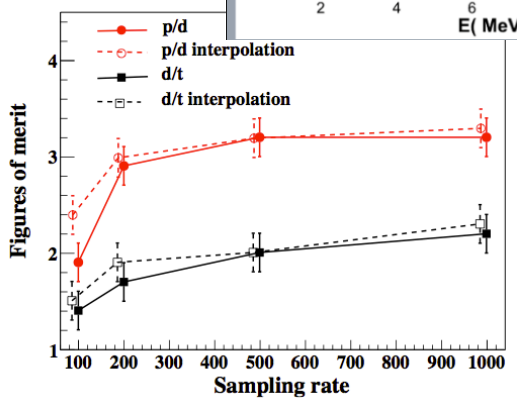
Grant : 67 k€

- **Electronics developments**
  - ASIC preamp I/Q (iPACI)
  - Digitizeur (Wavecatcher)
- **R& D on pulse shape identification**

M.Assié et al., EPJA 51 (2015) 11







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

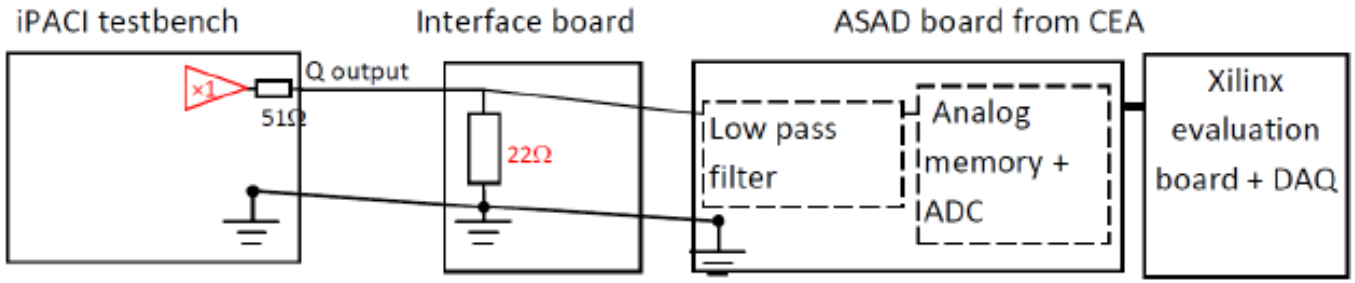
Sampling rate of ADC: **> 200 MHz**

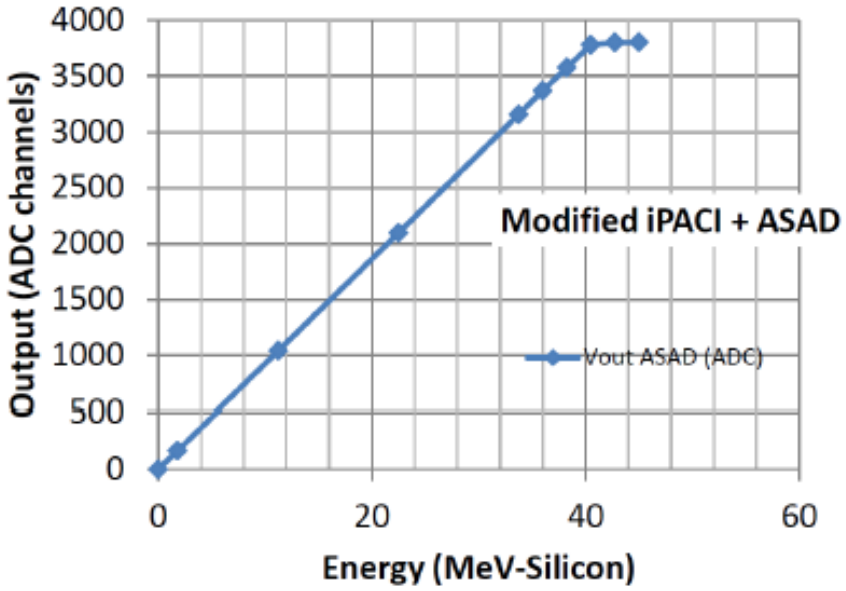
Electronics Requirements

- Current and Charge signals > iPACi
- Digitize current signal with minimum 200 MHz and 100ns range
- Digitize charge signal with 50 MHz or peak sensing (track and hold)
- Attempt to benefit from previous developments at IRFU (or at Valencia)
- IRFU
  - ASAD chip developed for GET
  - SAMPIC chip (needs to be modified)

Backend Tests with ASAD and SAMPIC

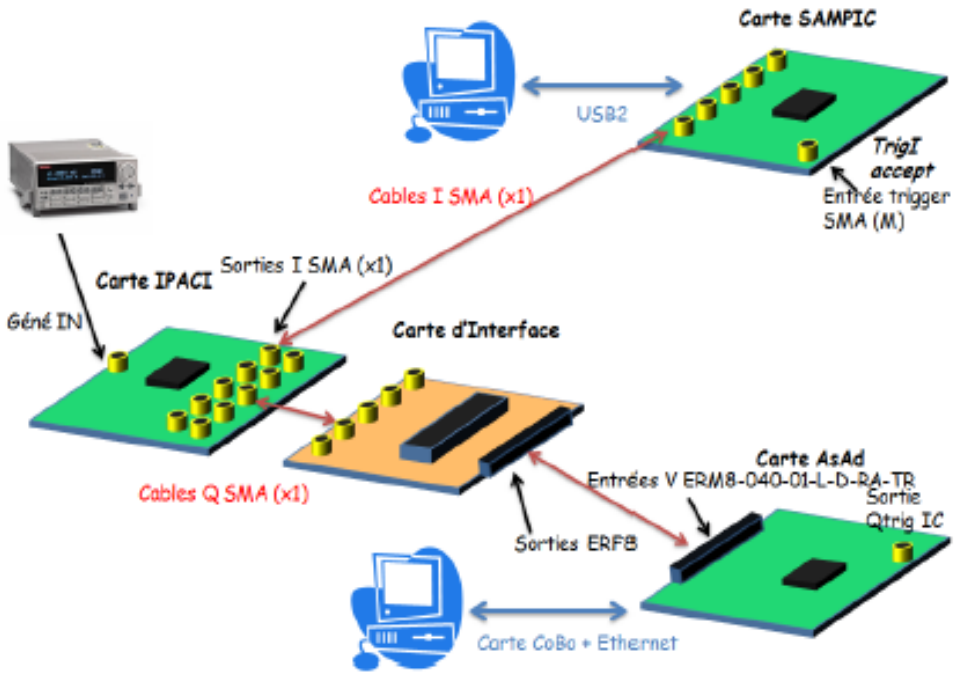
iPACI charge output coupling with ASD board from CEA => **modification** on iPACI + interface board (1)





- 22 Ω input impedance is not recommended. It modifies the shape of the signal

ASAD/SAMPIC test setup



- Charge signals from iPACI can be digitized by ASAD board with minor modifications on boards
- Current signal from iPACI can be digitized by SAMPIC board if the pulse width is lower than 20ns
- Aquisition systems for ASAD and SAMPIC are fully different
- During these tests, I and Q signal correlation was not performed => not so easy

F. Bouyjou, JJ Dormard,
O. Gevin, E. Rauly

Need to strongly modify SAMPIC for lower frequency and larger range

Summary

- What we have accomplished
  - Equipped the lab with a state of the art « Wavecatcher » digitizer for testing purposes
  - Designed, built and tested a Q and I preamp ASIC
  - Studied and validated PSD of Light Charged Particles with a Si-Strip detector
  - Purchased and tested a trapezoidal Si-Strip detector designed for the GASPARD array
  - Performed first tests of signal treatment with ASAD and SAMPIC ASICs
- What remains to be done
  - Link ADAD and SAMPIC acquisition systems
  - Test with Si-Strip detector.