

## Status and perspectives of HYDE detector

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Sánchez-Benítez

For the HYDE collaboration.



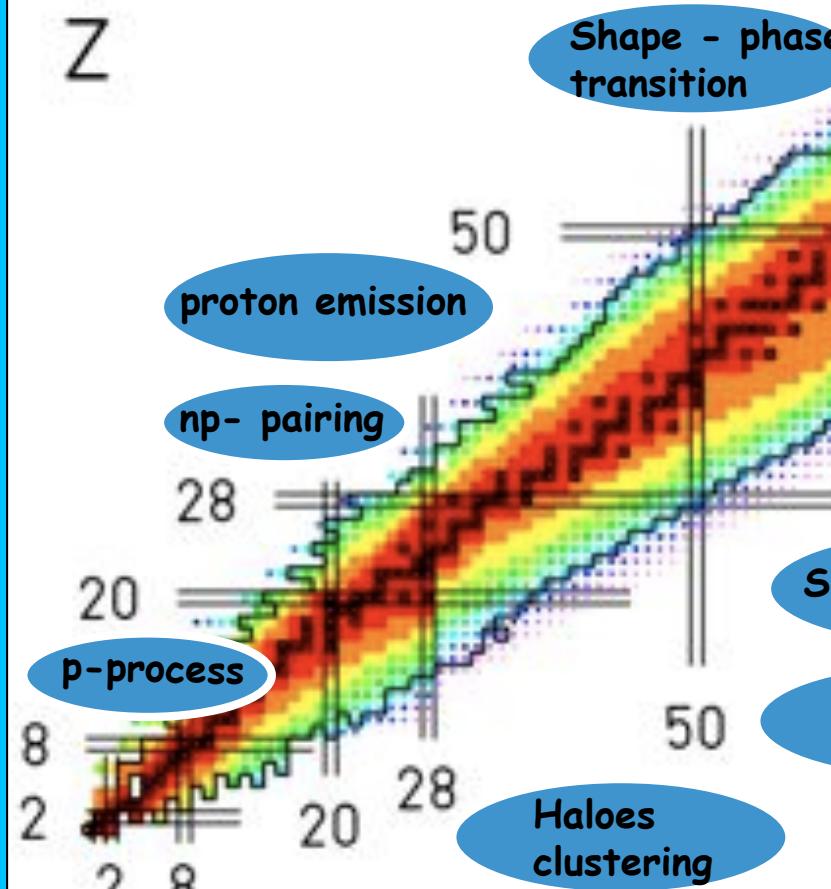
# Direct nuclear reactions for spectroscopy at FAIR

d transfer  
p transfer  
 $1/2n$  transfer

Elastic/inelastic  
Breakup

Resonant scattering

Z



82

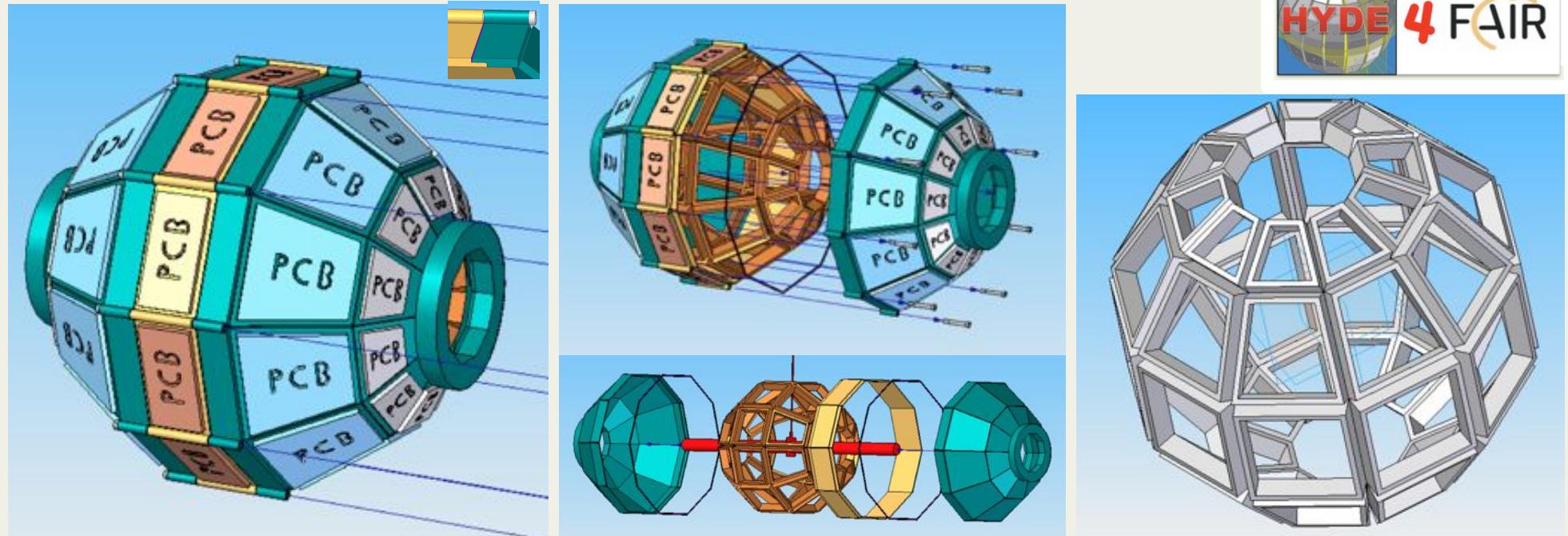
126

82

N

- $10^{10}/\text{s}$
- $10^8/\text{s}$
- $10^6/\text{s}$
- $10^3/\text{s}$
- $10^0/\text{s}$
- $10^{-3}/\text{s}$
- $10^{-6}/\text{s}$

# Mechanical design of HYDE



## Characteristics:

- ~ 4 PI ARRAY
- Detection of charged particles.
- Particle ID using PSA , DE/E and TOF.
- Energy & angular resolution ( $< 150$  keV,  $1^\circ/0.1^\circ$ ).
- Large multiplicity ( $> 3$ )

## Design constraints:

- Subsystem of AGATA array
- Use at other RIB facilities (SPIRAL2, HIE-  
LEGNARO-SPES)
- Modularity and portability

## Construction:

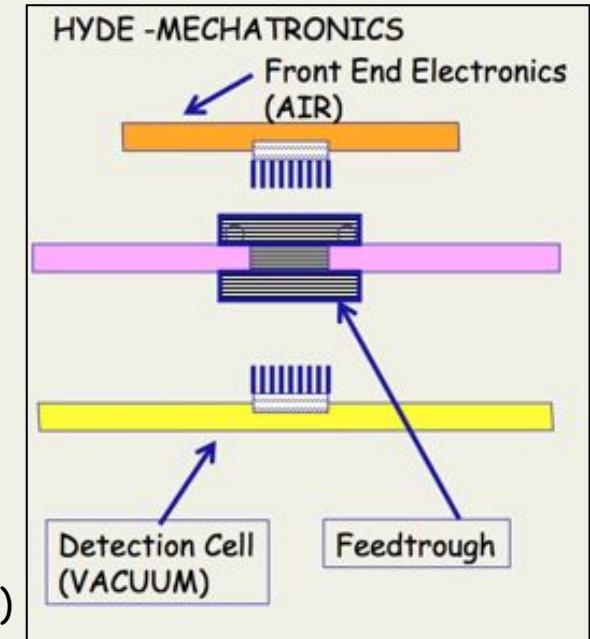
- Chamber  $< 380$  mm diameter
- 49 DETECTOR CELLS
- 3 different shapes: square
  - + 2 trapezoids fitting 4" wafer.
- Cylindrical symmetry/10 sides

## Mechatronics

- FFE on air
- 31.360 channels
- High density feedthroughs
- Multiplexing.

## Detector cell (Silicon)

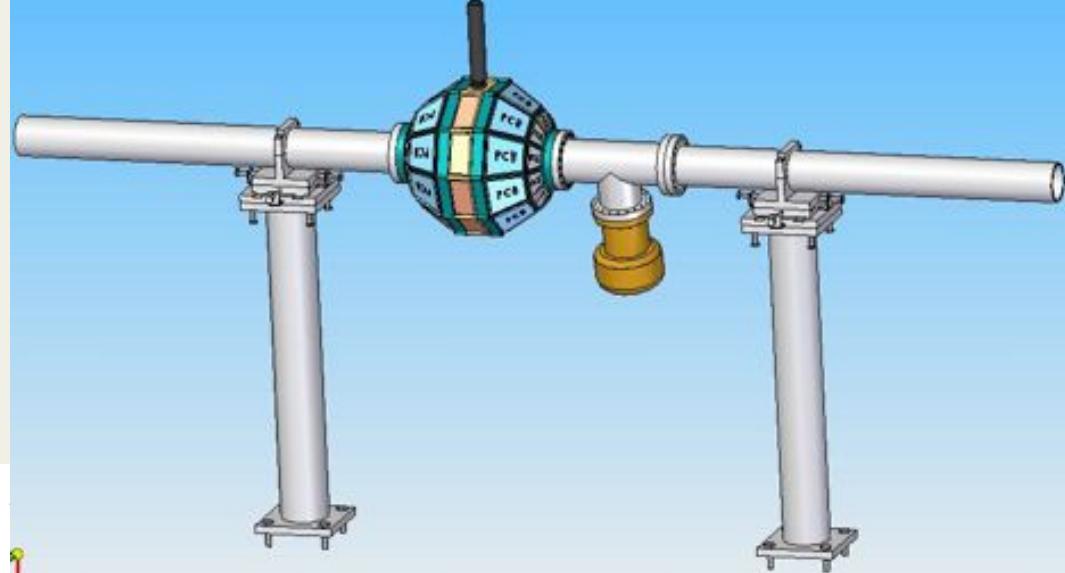
- 4 inches, NTD silicon wafers
- Strip size 0,4 mm, Multilayer (5 layer)



# HYDE at Low Energy Branch

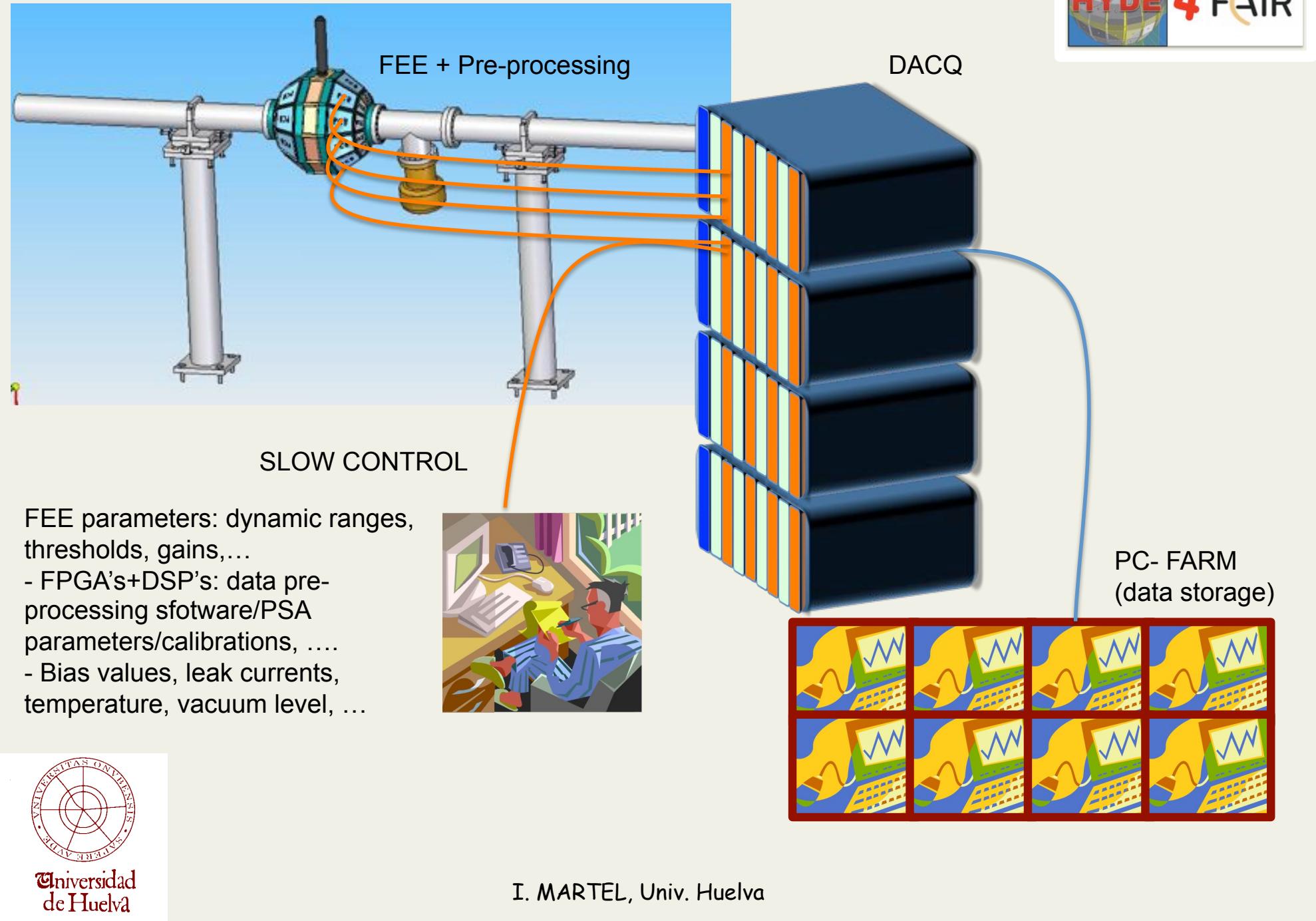


4 FAIR



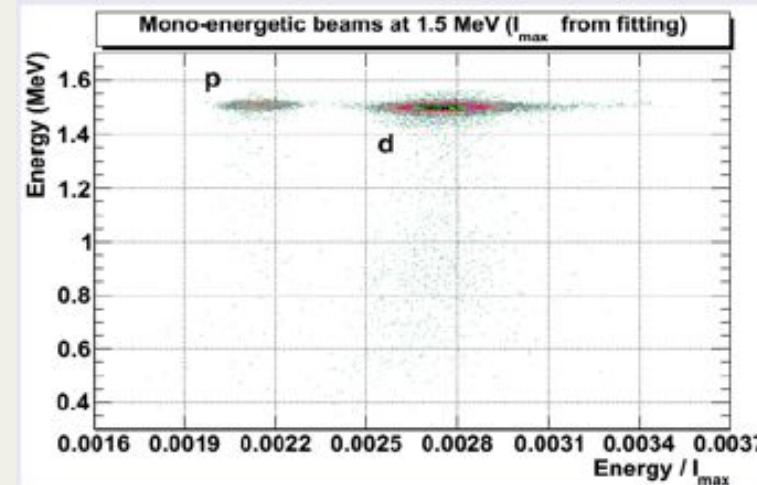
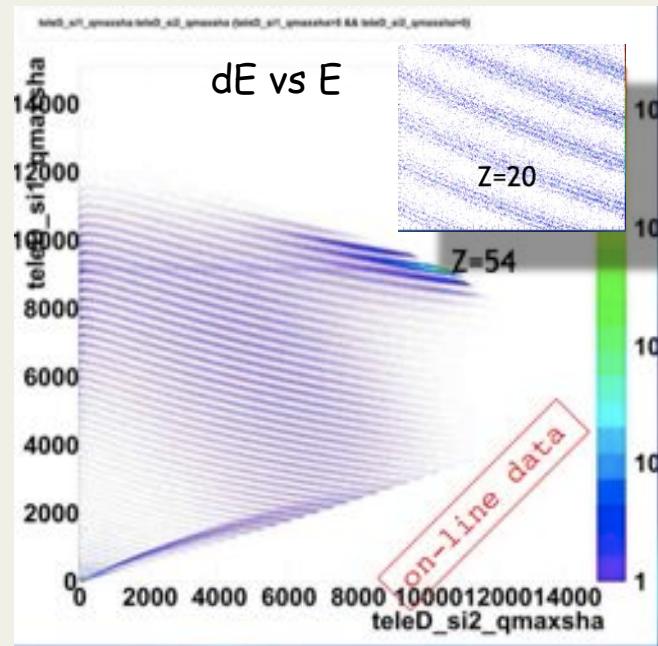
- Target insertion from any lateral side
- Well adapted for small cryogenic targets (SHIMENE) - central square: 97 x 97 mm<sup>2</sup>)
- Platform for detector maintenance and operation in an off-line setup.

# HYDE - FRONT END ELECTRONICS, DACQ AND CONTROL



# HYDE - PARTICLE IDENTIFICATION

Results from FAZIA collaboration (G. POGGI, Spiral2 Week January 2010)/LNS-Catania experiments.

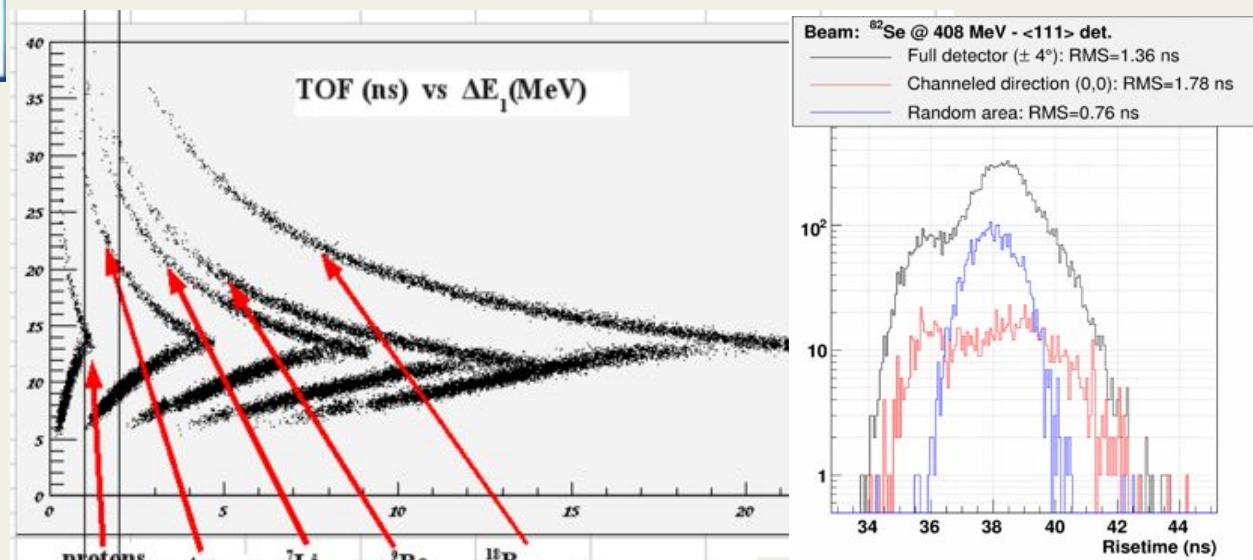


- Last PSA test at Orsay Tandem for light particles/500um NTD looks promising → test thin silicon (20um/100um)

- Good identification up to  $Z \sim 25$  with  $\sim 5\text{GeV}$
- 100MS/s 14 bit digitizer
- Highly uniform Si: NTD
- Silicon doping uniformity  $\sim 1\%$  (TOPSIL)
- Channeling
- Voltage stability



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TOF simulation for HYDE/A. Sánchez-Benítez)  
Limited by Si response  $\sim 1\text{ns}$

L.Bardelli et al, NIM A605 (2009) 353

# HYDE - DETECTOR CELL - Prototype / 2010



## 4-Layer prototype (~62 x 62 mm<sup>2</sup>)

- NTD-20  $\mu\text{m}$  32 strip/side (PSA,  $\Delta E$ ,  $E$ ).
- NTD-100  $\mu\text{m}$  128 strip/side (PSA,  $\Delta E$ ,  $E$ ).
- FZ-500  $\mu\text{m}$  128 strip/side (PSA,  $\Delta E$ ,  $E$ ).
- FZ-1.5 mm stack 32 strip/side ( $\Delta E$ ,  $E$ ).
- 640 electronic channels/cell.

(128 x 128, 0.4 mm pitch,  $\delta\theta \sim 0.1^\circ$ )

Preamplifier BW ~300 MHz

FEE:

PSA type, 1GSs  $\rightarrow$  32 ch/board  
DE-E type (standard) 100 MSs  
 $\rightarrow$  608 ch/board

DE/E:

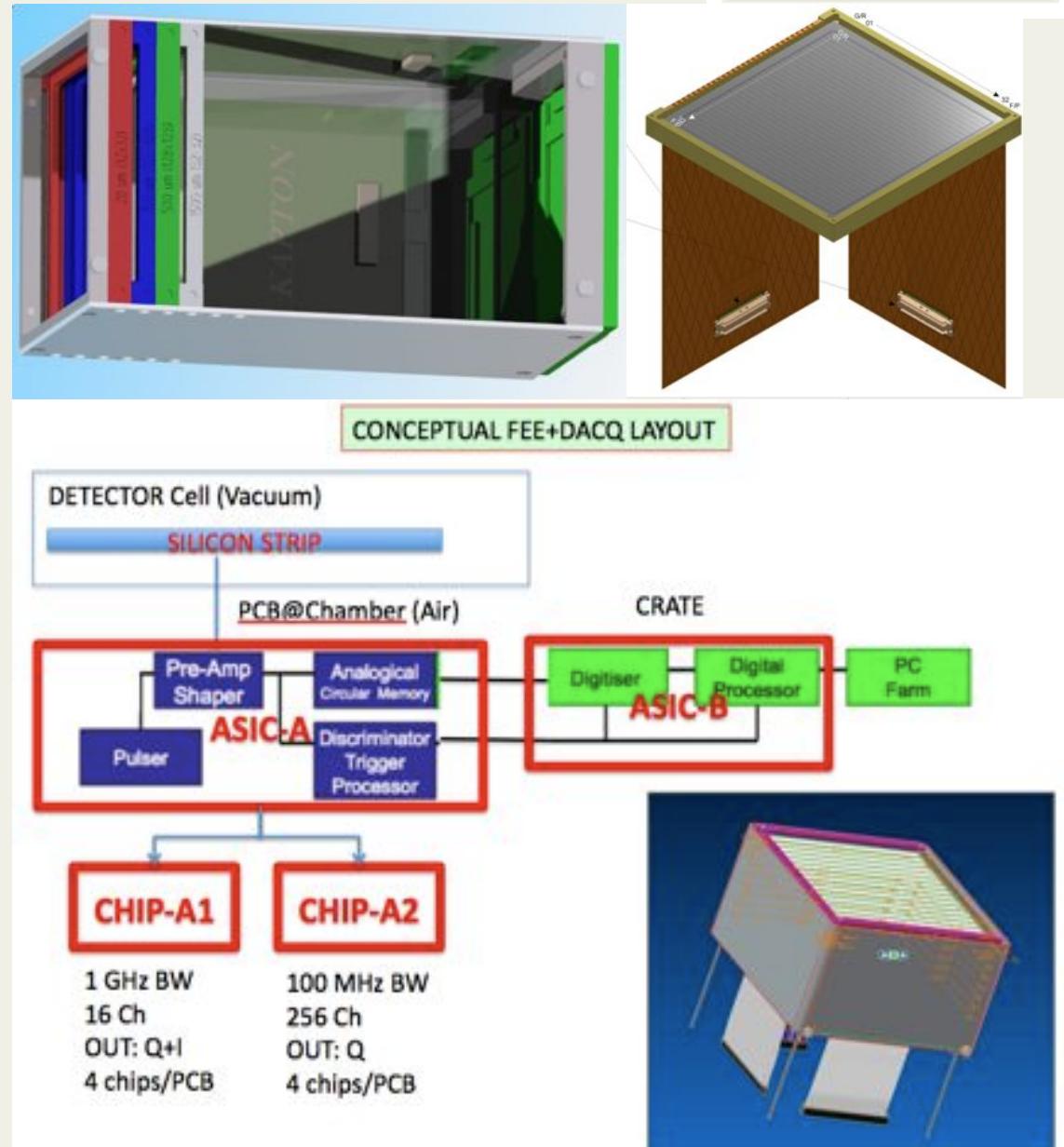
$\rightarrow$  down to  $\sim 1$  MeV/u  
 $\rightarrow$  Up to  $\sim 30$  MeV/u

From protons to heavy ions (40Ar)  $\rightarrow$  4 stages telescope.

PSA & TOF: on the 20um layer.



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# HYDE - DETECTOR CELL - Prototype / 2010

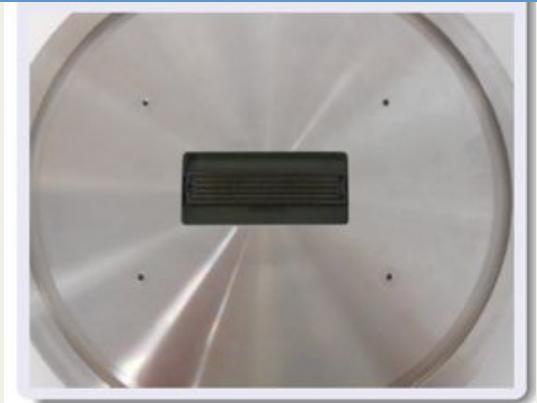


20um, 32 x 32 st/2mm p.

100 um, 128 x 128 st/2mm p.  
500 um, 128 x 128 st/2mm p.  
1500 um, 32 x 32 st/2mm p.



Vacuum-side



Air-side



Detectors arrived to Huelva last week  
Micronsemiconductors Ltd.

Test flange + sub-flange for prototype

500 connectors ~1 cm x 5 cm



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# HYDE - PRODUCTION OF SILICON DETECTORS



Centro Nacional de Microelectrónica-CNM (CSIC, Barcelona)

CDTI - "Industry of Science". Grant# IDC-2010-1133: Huelva - CNM- Arquimea SL- Expace SL.

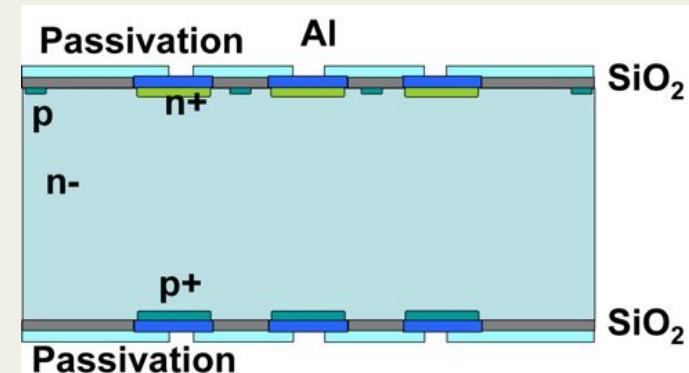
Setup of technology for double side silicon strip detectors (DSSSD)

- Program (2 years, 2011- 2012):

1. Fine tuning of production cycle for DSSSD detectors 300um thick, low segmentation, valid for nuclear spectroscopy (res ~ 30 keV). Detector characterization at Detector Lab/Huelva.
2. Thin DSSSD production with high segmentation ( $32 \times 32 / 128 \times 128$ ): 20um & 100um. Format ~ 4 inches wafer.
3. Final production of realistic prototype of HYDE in NTD silicon.

- 9 level process:

Num	Nombre	Cara	Campo	Propósito
1	P-Diff	Componente	Oscuro	Aislamiento entre pistas
2	N-Diff	Componente	Oscuro	Pistas detectoras cara superior
3	Back-diff	Dorso	Oscuro	Pistas cara inferior
4	Window	Componente	Oscuro	Contacto metal-Si cara superior
5	Metal	Componente	Claro	Metal cara superior
6	Back-window	Dorso	Oscuro	Contacto metal-Si cara posterior
7	Back-metal	Dorso	Claro	Metal cara posterior
8	Passivation	Componente	Oscuro	Pasivación cara superior
9	Via (back-pass)	Dorso	Oscuro	Pasivación cara posterior

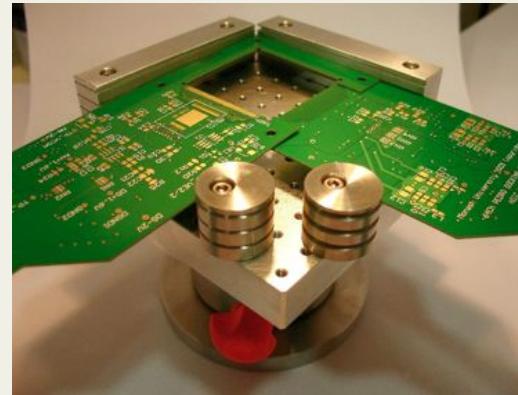
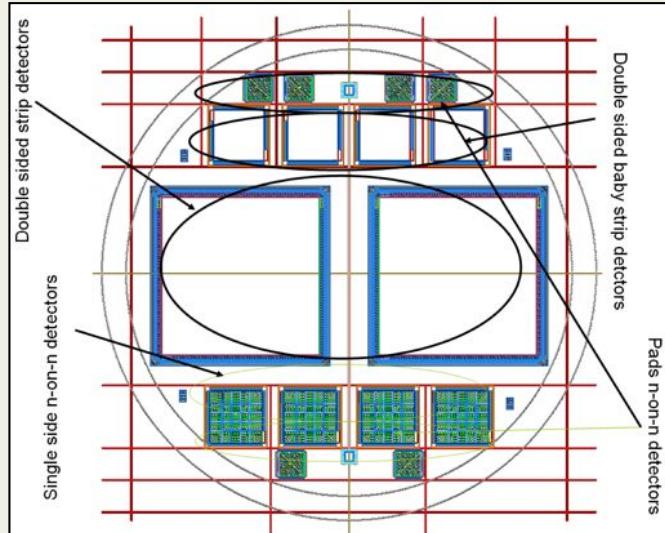


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Production test: 4 inch wafer, 300um thick// 16 x 16 strips// Standard silicon

Each wafer contains two HYDE detectors and some auxiliary detectors.



CNM-Barcelona/Detector workbench developed for double side bonding



PCB for packaging a DSSSD detector sample

- 16 x 16 strips DSSD
- 300 um wafer

DSSD sample will be sent to Huelva for evaluation



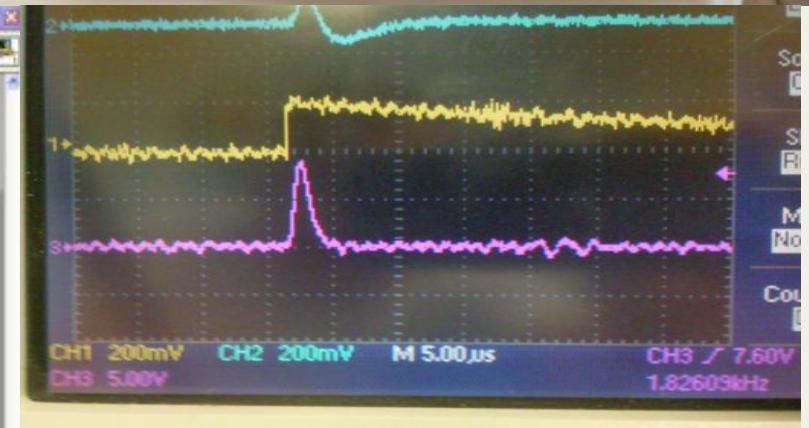
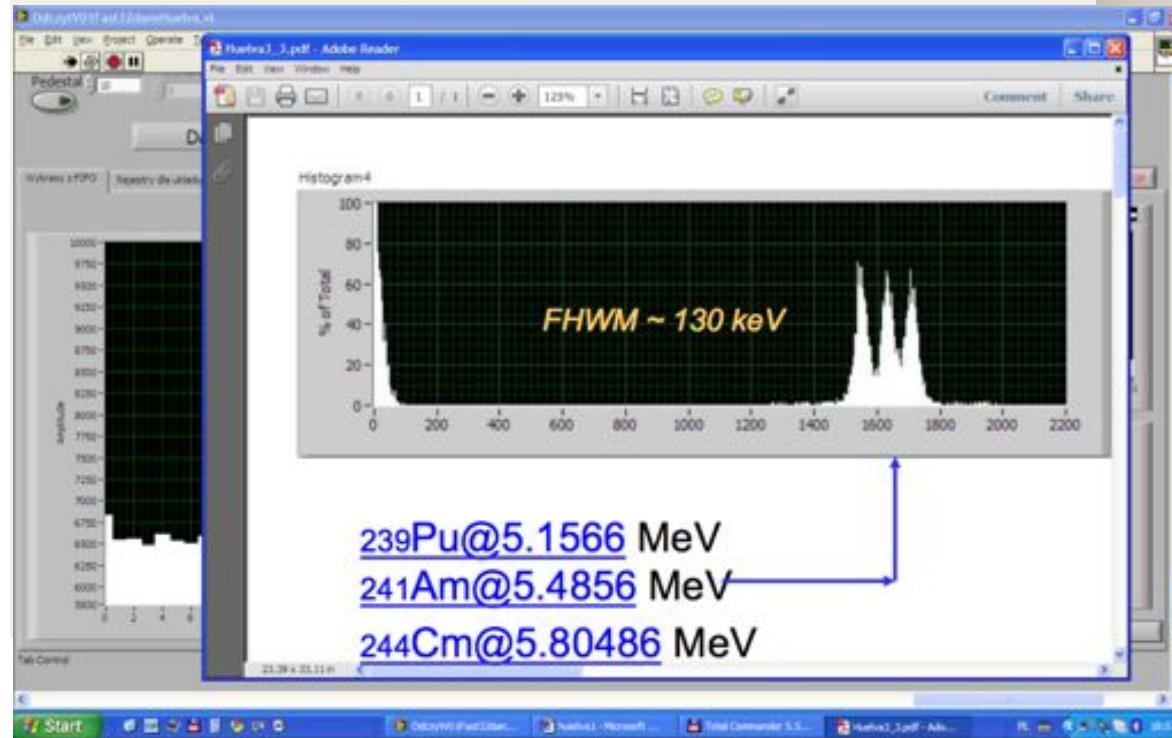
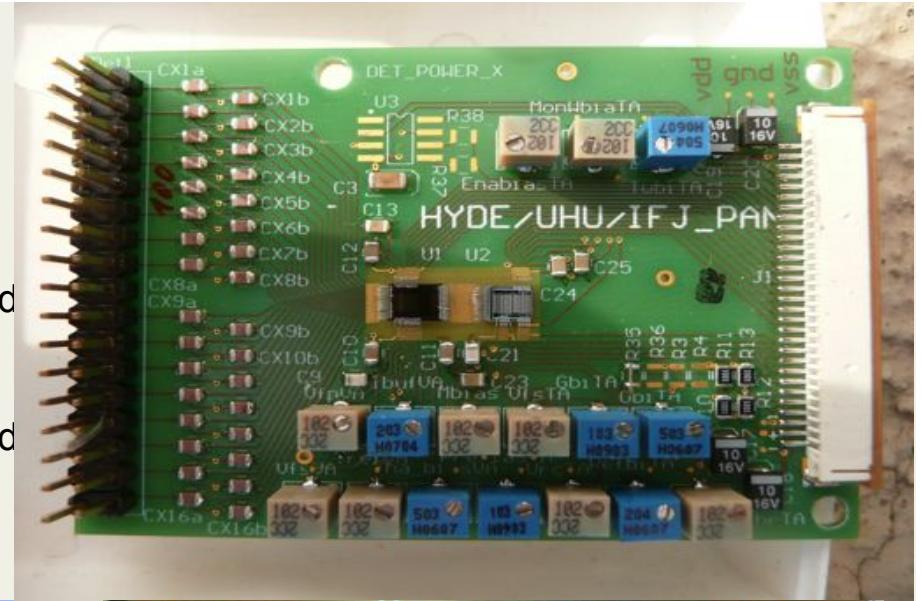
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# HIGH DENSITY FEE

## First tests May 2011

- First test board with VA-TA chips (IDEAS-Norway)
- Hybrid equipped with Readout board (ADC and dedicated XILINX SPARTAN FPGA).
- Readout frequency, 4 MHz clk. (8  $\mu$ s for 32 channels)
- Dead time for 1 KHz event rate per detector is estimated to be around 0.8%.
- Power dissipation is around 100 mW per hybrid.



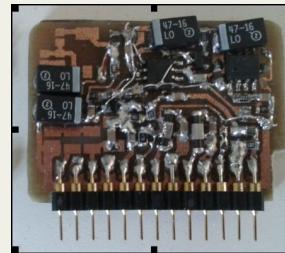
- All tests were done at UHU 18 – 27 May 2011.
- After the tests → decisions shall be taken to design dedicated ASICs (multichannel amplifier) and/or Hybrids.

## The P.A.C.O preamplifier

**Charge Preamplifier:** charge and current outputs

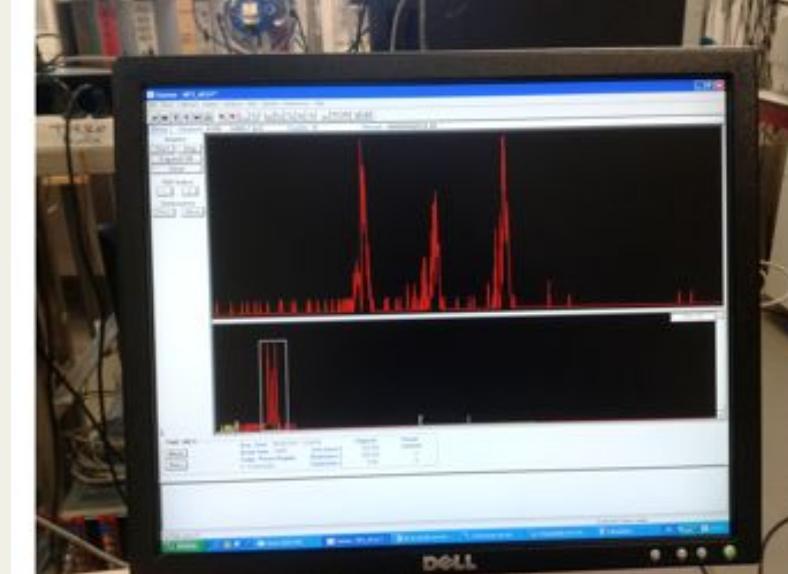
### Input Stage

- JFET channel Device
- Matching Input Impedance
- High Gain Amplification ( $gm=7.5mA/V$ )



- Test with triple alpha source + 25um silicon PIP detector
- ORTEC Shaper **575A**
- Energy resolution ~20 keV

Measurements	Prototype
Output Amplitude	40mV
BW	300 mHz
Dynamic Range	67.2dB



# HIGH SPEED FEE

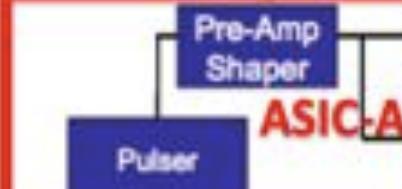
## HYDE – FRONT END ELECTRONICS

### CONCEPTUAL FEE+DACQ LAYOUT

DETECTOR Cell (Vacuum)

**SILICON STRIP**

PCB@Chamber (Air)



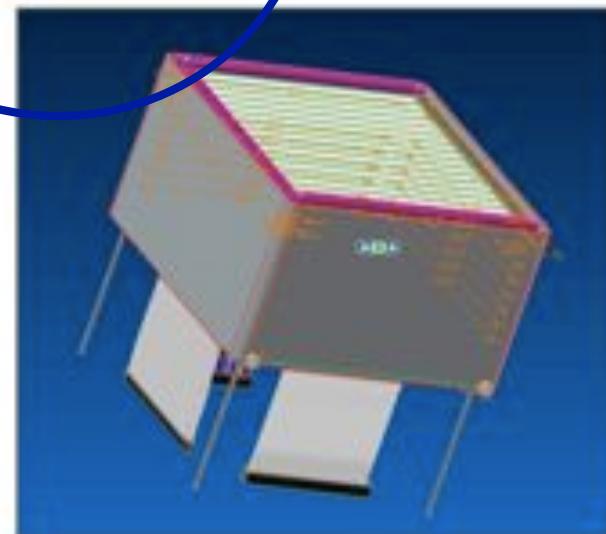
*Industrial project  
Already financed*

1 GHz BW  
16 Ch  
OUT: Q+I  
4 chips/PCB

CRATE



PC Farm



**CHIP-A1**

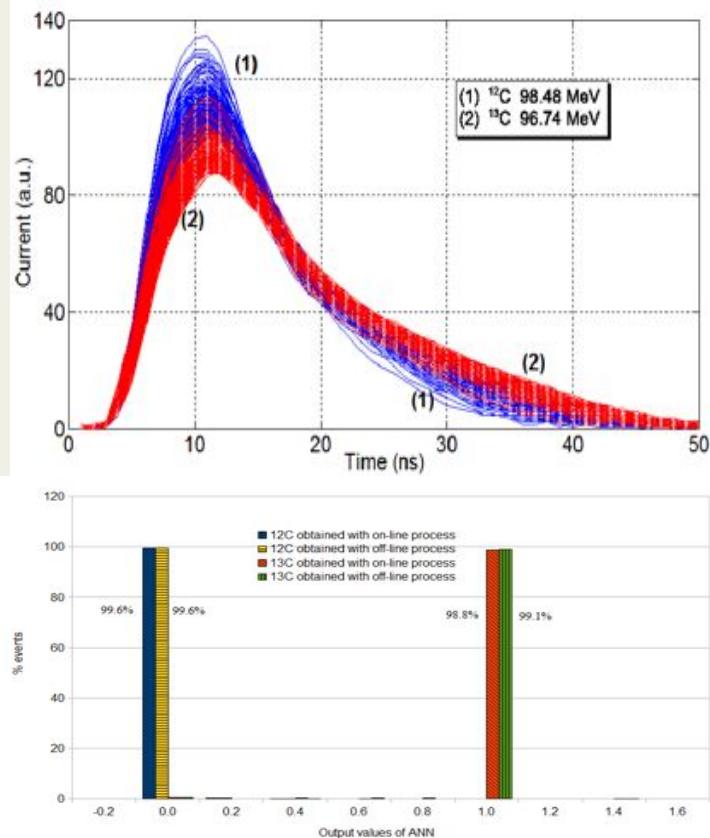
**CHIP-A2**





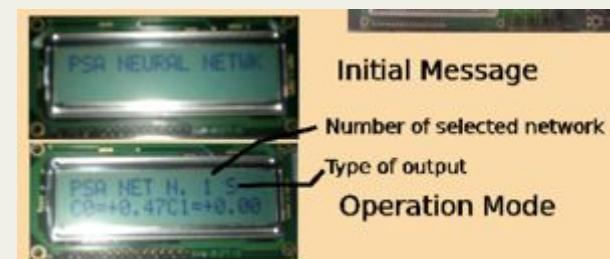
# FPGA implementation of neural networks for PSA

## Test with $^{12,13}\text{C}$ ions @ 7 MeV/u



Configuration parameters  
Neurons per MLP: 2  
Architecture: 8x8x2 layers  
Data size: 14 bits

No. MLP in FPGA: 8  
Device: Spartan3AN-700



Mean deviation between on-line and off-line identification below 1%  
Maximum data input frequency: 236 MHz  
Maximum operation frequency: 74 MHz  
Identification delay about 20  $\mu\text{s}$  to a clock frequency of 50 MHz



## Characteristics of the beam after the energy buncher

300 MeV/u:

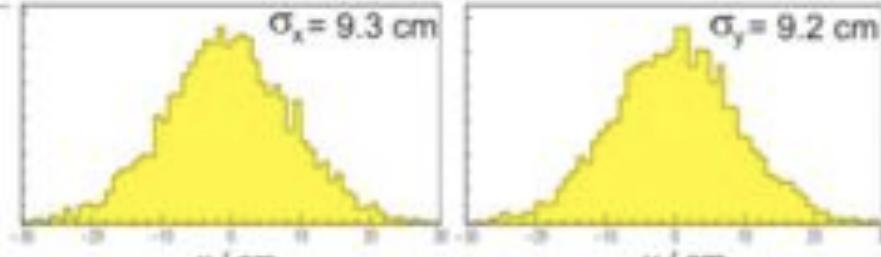
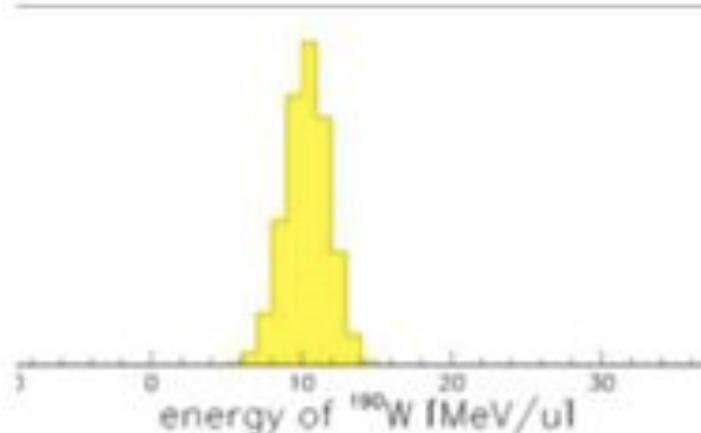
$$\sigma_E \sim 0.3 \text{ MeV/u}$$

5 MeV/u:

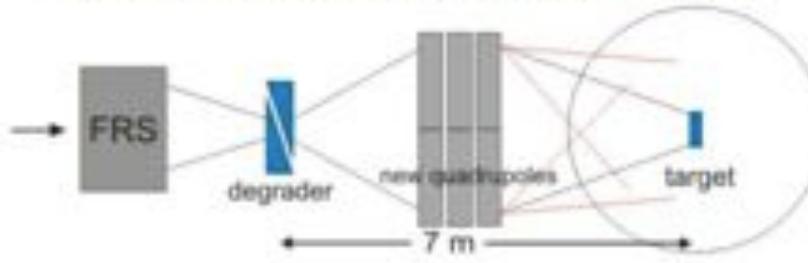
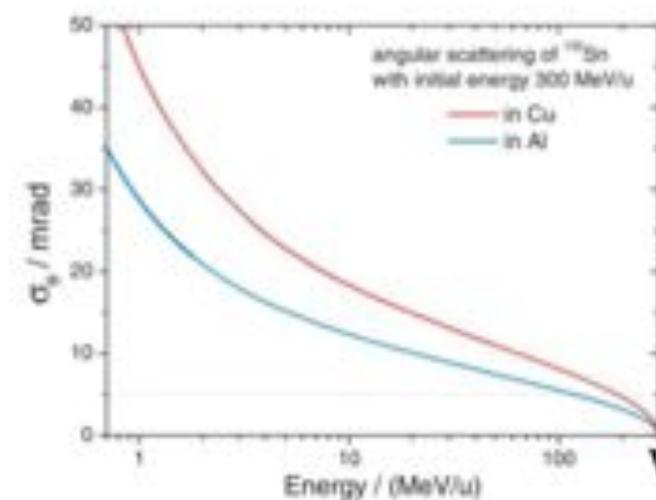
$$\sigma_E \sim 3 \text{ MeV/u}$$

$$\sigma_\alpha \sim 5 \text{ mrad}$$

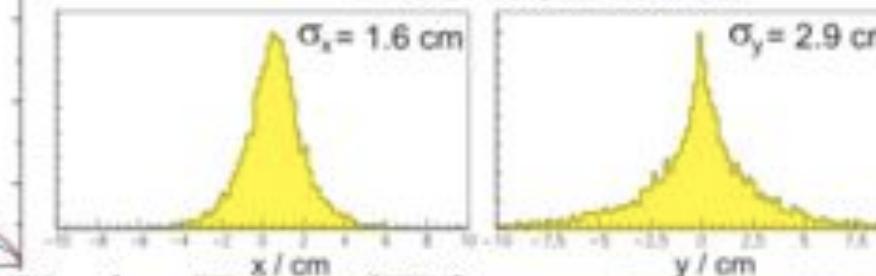
$$\sigma_\alpha \sim 20 \text{ mrad}$$



### Refocusing of the low energy beam



limit of  $E = 5 \text{ MeV/u} \pm 2.5 \text{ MeV/u}$

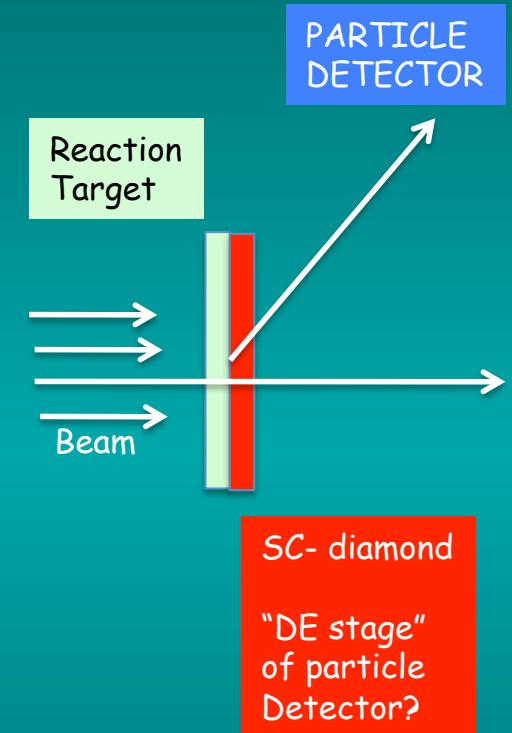
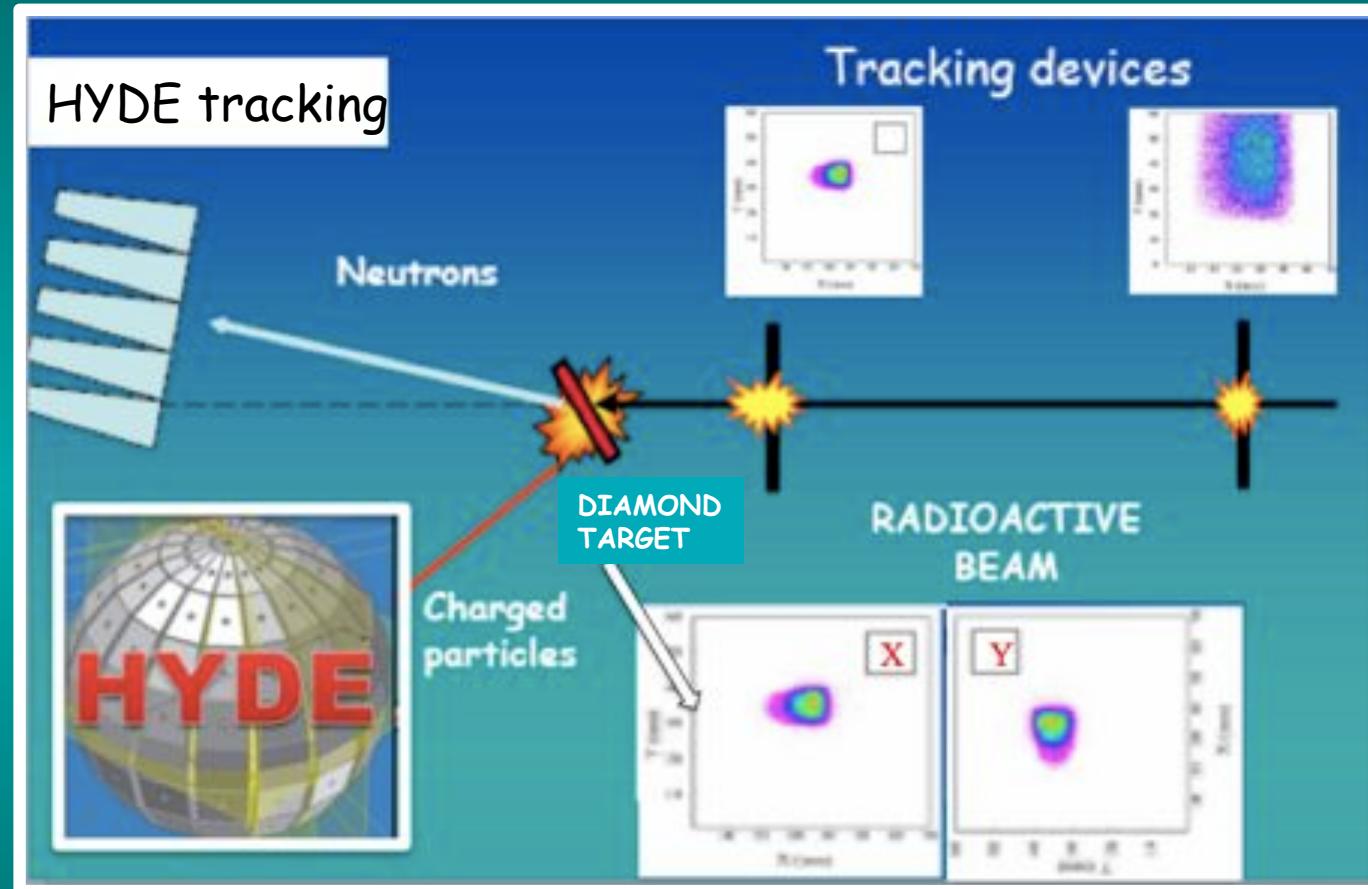


Warning: FRS, not SFRS

Courtesy of H. Weick

## IMPROVE SCENARIO BY USING ACTIVE TARGETS AS AN ION TRACKER

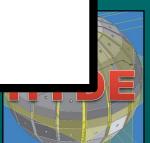
TARGET → Stripped Diamond Detector  
→ SINGLE CRYSTAL CVD MATERIAL



### SC-CVD-DIAMONDS:

Timing properties < 50 ps  
Energy resolution of about ~1%  
Tracking Efficiency close to 100%

Minimum thickness < 40  $\mu\text{m}$   
Radiation hardness ( $10^7$  ions/s)  
Position resolution < 1  $\text{mm}^2$   
"Large" covering area (~  $10 \times 10 \text{ mm}^2$ )



## DIAMOND CHARACTERIZATION AT THE UNIVERSITY OF HUELVA (DETECTOR LAB.)

### The detector

- ◆ SC-CVD diamond film 50  $\mu\text{m}$  thickness ( $4 \times 4 \text{ mm}^2$ ).
- ◆ Ohmic contacts: DLC (3 nm) / Pt (16 nm) / Au (200 nm).
- ◆ Al wire bonding connections.
- ◆ Transmission type mounting.
- ◆ Final capacitance of the detector 9.5 pF.



Huelva prototype of diamond detector  
(already available commercially)

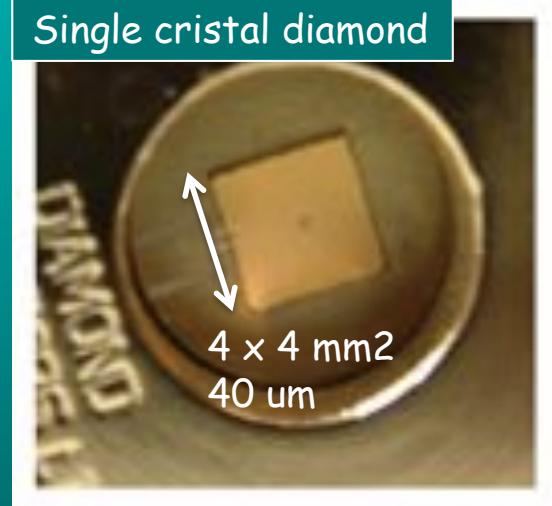
\* Collaboration with companies:

- Element 6
- Diamond Detectors Ltd

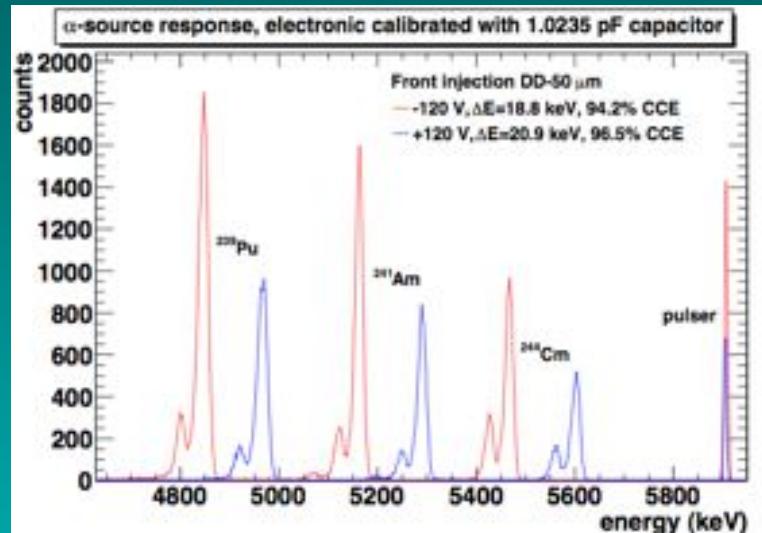
\* We are working for common interest at different institutions/applications →

GSI/FAIR → Tracking systems

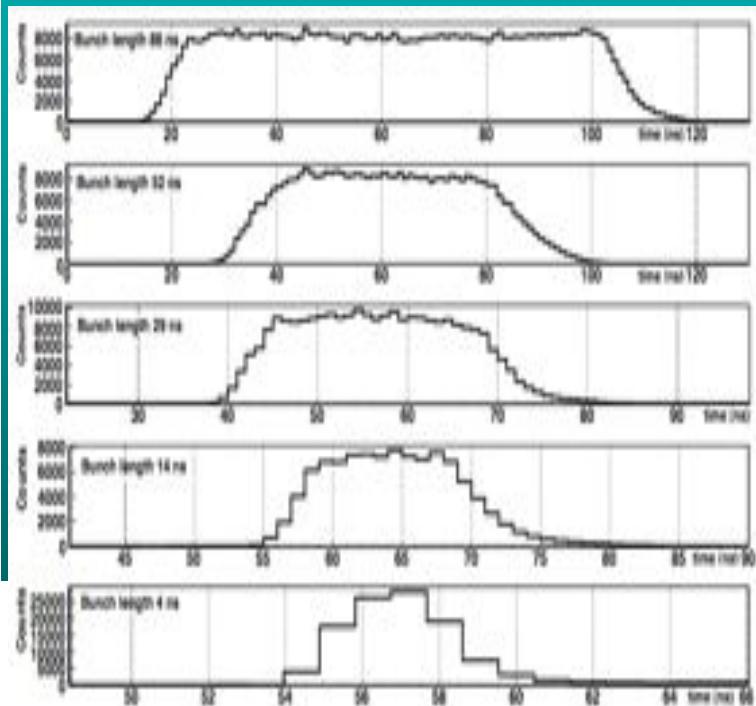
GANIL/SPIRAL2, IPN/ORSAY → Beam diagnostics



# Diamond Detectors for Beam Diagnostic: Test at Orsay Tandem with $^{12}\text{C}$ ions/20 MeV

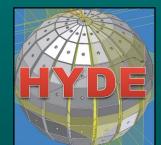
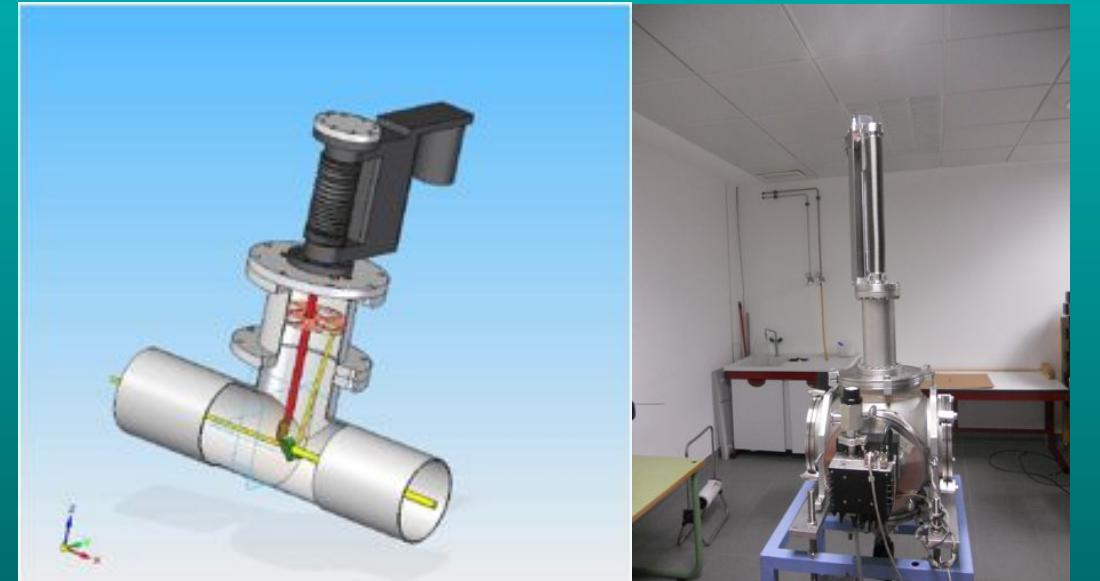


Time structure of bunches



- Single crystal diamond films.
- Thickness 500  $\mu\text{m}$ .
- Good Timing & Energy resolution.
- Studies on different contacts.
- Experiments done for Beam monitoring at Orsay Tandem 2010.

Diagnostic system being built at Univ. Huelva for Spiral2 (preparatory phase UE FP7).





Thanks for your attention!



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