

# TRACE: a highly-segmented silicon array for RIB facilities

**Daniele Mengoni**  
for the GHT collaboration

Università and INFN - Padova

*EGAN workshop, GSI*  
*23-26 June 2014*



# Outline

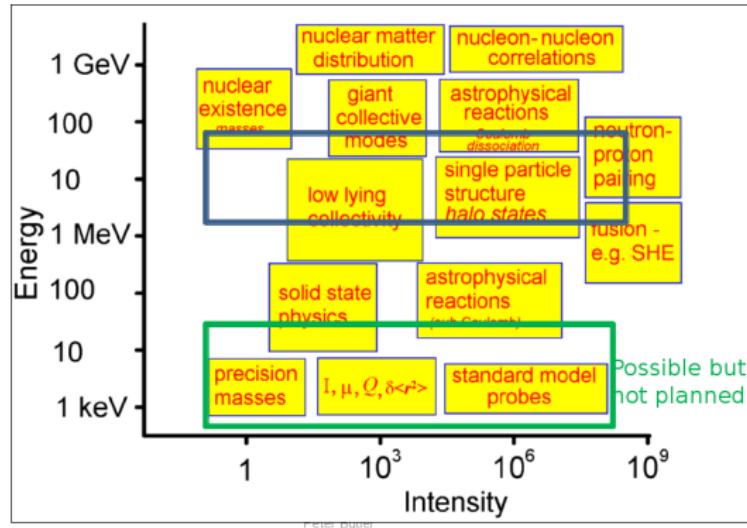
1 Introduction

2 Detectors & electronics

3 Present & future



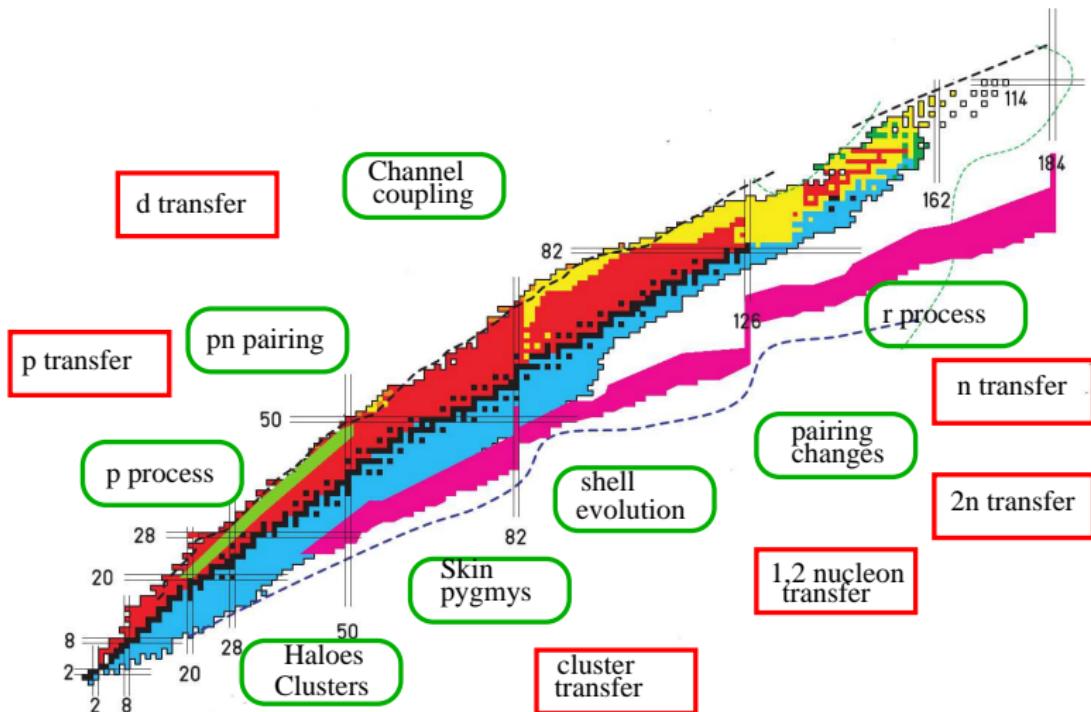
# Phisycs at (low energy) RIB



- SPES 5 $\mu$ A p on U stack target
- discrete and collective states
- 1,2-nucleon transfer
- interest in reaction also

credits Y.Blumenfeld, SPES workshop 2014

# Transfer and binary reactions with RIB



# Ambit of the new silicon-based array

- emerging RIB facilities



- Energy regime

few MeV → tens of MeV/u

Discrimination

PSA,  $\Delta E-E$ , ToF

- Special targets

cryogenic: H<sub>2</sub>, He<sub>2</sub>, film (Chymene), etc.

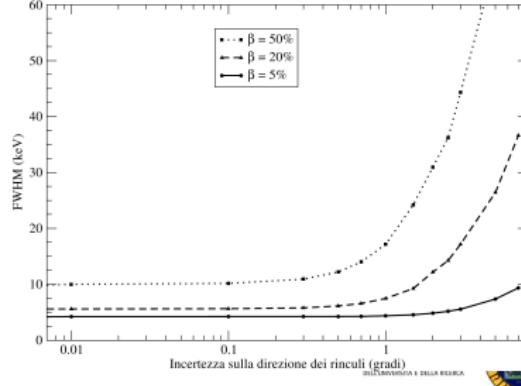
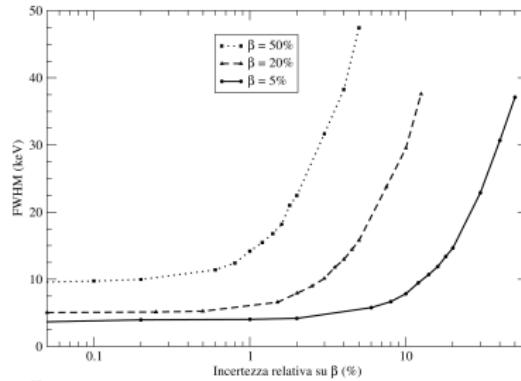
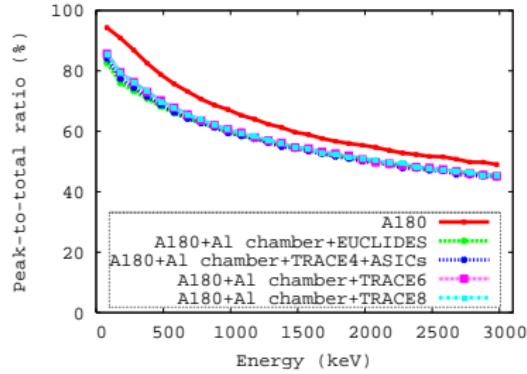
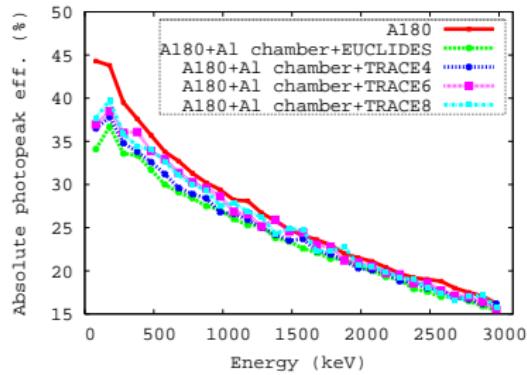
polarized

- Flexibility

coupling with others detectors [AGATA, PARIS, etc]

# Coupling with (tracking-)gamma array: AGATA

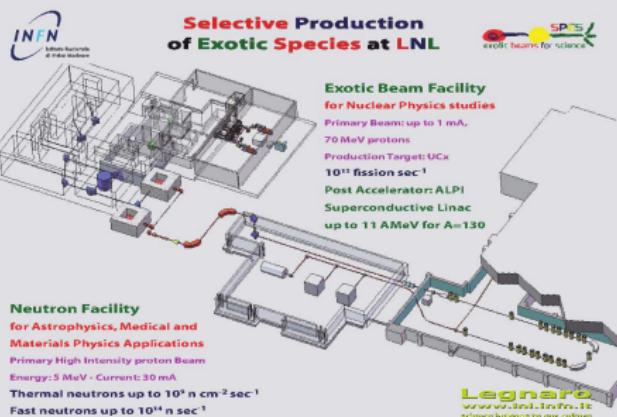
## Complementary detector requirements



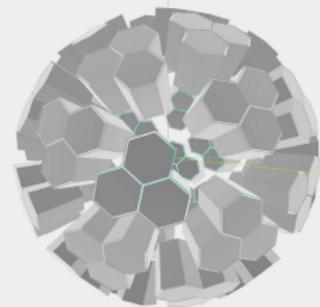
# II workshop held in Legnaro - May 2014

The future context at LNL

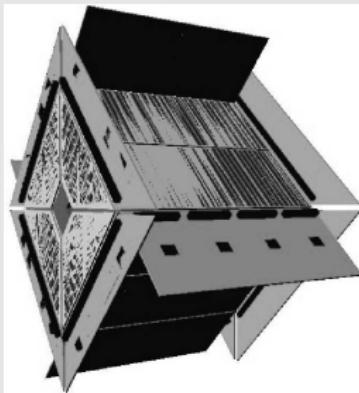
## SPES



GALILEO



TRACE



# Letters of Intent

## 2nd SPES workshop, 2014

- Exploring the Z=32 triaxiality corridor towards N=50 via safe Coulex  
*M.Zielinska*
- Spectroscopy studies around 78Ni and beyond N = 50 via transfer and Coulomb excitation reactions.  
*J.J. Valiente-Dobon, A. Gadea, R. Orlandi, E. Clement*
- Nuclear magicity at Z 50 N 82. Neutron capture cross section via the surrogate method.  
*D.Mengoni, G.deAngelis*
- Transfer reaction measurements for r-process nucleosynthesis  
*S.D.Pain*
- Structure of Sb nuclei around 132Sn as a testing ground for realistic shell model interactions.  
*B. Szpak*
- Low-lying dipole excitation via nuclear probes in exotic nuclei.  
*E.Lanza, D.Mengoni, F.C.L.Crespi*
- Search for Exotic-Octupole deformation effects in n-rich Ce-Xe-Ba Nuclei.  
*E.Sahin*
- Coulomb Excitation measurements of Radioactive Ions:  $N \geq 82$  and  $Z \geq 50$   
*B.Melon*
- Shape coexistence in Kr isotopes towards N=60  
*V.Modamio*
- The Onset of deformation in the n-rich Y isotopes.  
*M.Kmiecik*

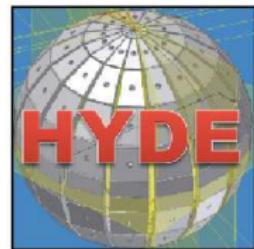


# LCP Complementary/Stand-alone detectors

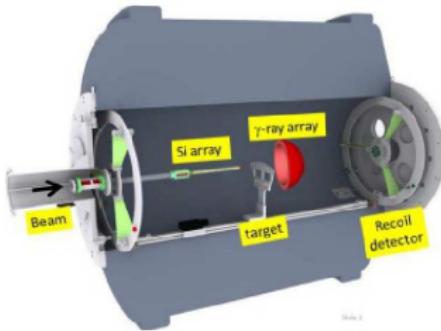
- Silicon based array

**TRACE**

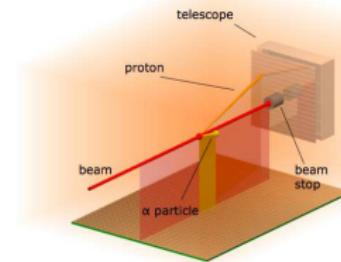
**GASPARD**



- Solenoid

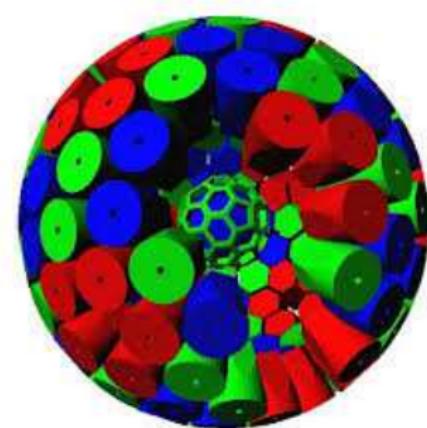
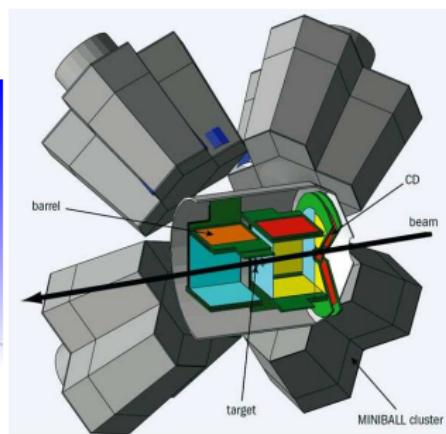
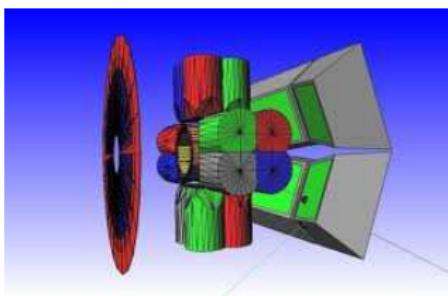


- Active target



# [Typical] Experimental setup

predecessors



# TRACE-GASPARD

Highly-segmented silicon detectors for particles and light ions detection.

- Silicon-telescope array for direct reactions → neutron-rich nuclei delivered at the new facilities.

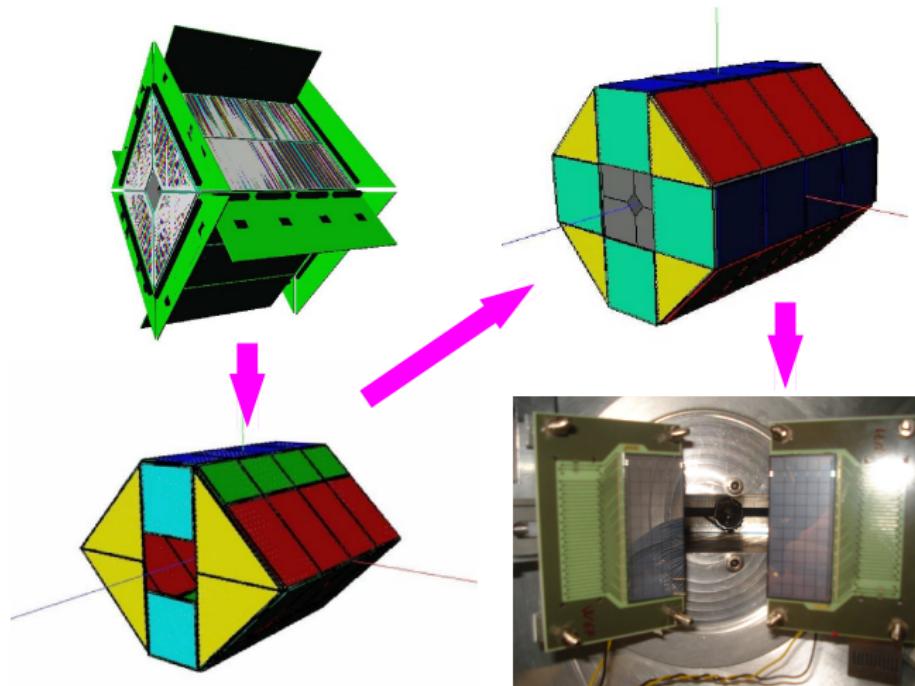
## Novelty

- Highly-uniform nT detectors
- Digital electronics to embed PSA capability
- Trigger-less system



# TRACEx: the genesis

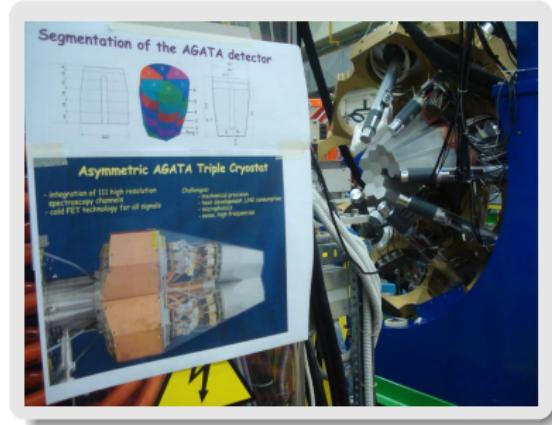
## high angular resolution and coverage



# TRACE+AGATA

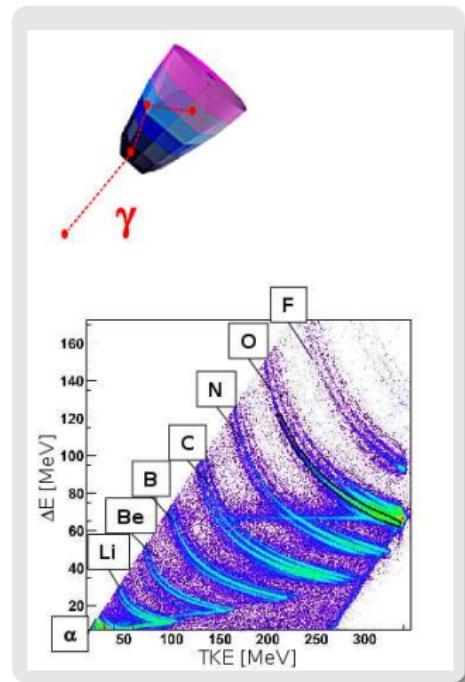
A.Gadea et al. NIM A654 (2011) 88

- Study of High-Lying States in  $^{208}\text{Pb}$  with the AGATA Demonstrator [FCL.Crespi, PRL in press]
- Confirmation of the molecular structure of excited bands in  $^{21}\text{Ne}$
- Study of high-lying bound and unbound states in  $^{124}\text{Sn}$  and  $^{140}\text{Ce}$  via inelastic scattering of  $^{17}\text{O}$  ions [L.Pellegrini, submitted to the collab.]

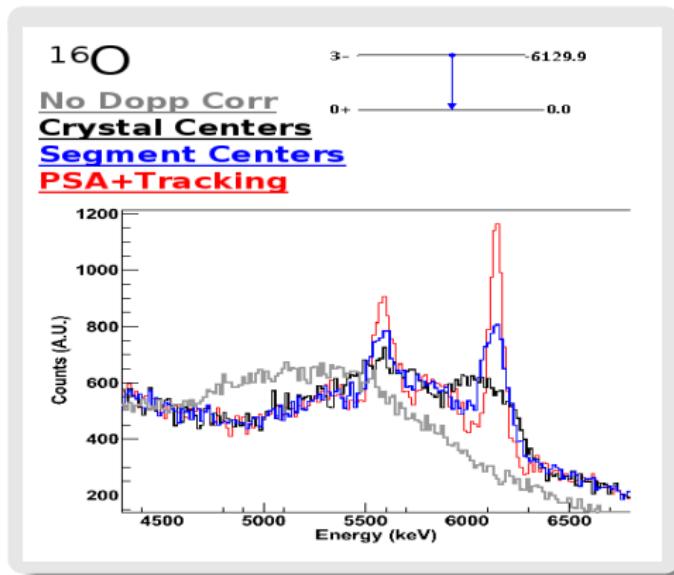


# TRACE telescope

Performance of the AGATA-TRACE setup, binary reaction



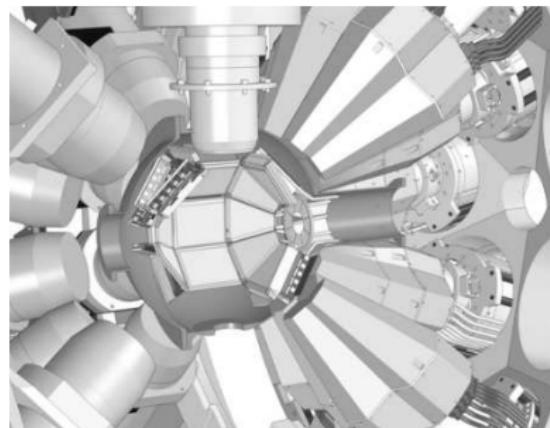
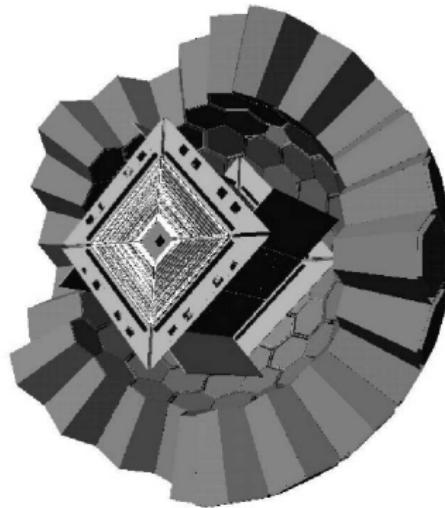
- Z and M up to Z = 9
- $\beta \sim 20\%$



- $^{16}\text{O}$  channel: high energy  $\gamma$ -ray low background from target.....
- FWHM  $\sim 0.9\%$
- Good PSA performance

# Project and collaboration

## TRACE-GASPARD collaboration agreement



### GHT Collaboration Agreement

- **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



# Collaboration agreement



IPN Orsay, GANIL, CEA Saclay

INFN (LNL-Pd-Mi), University of Padova, Milano

University of Valencia, University of Huelva

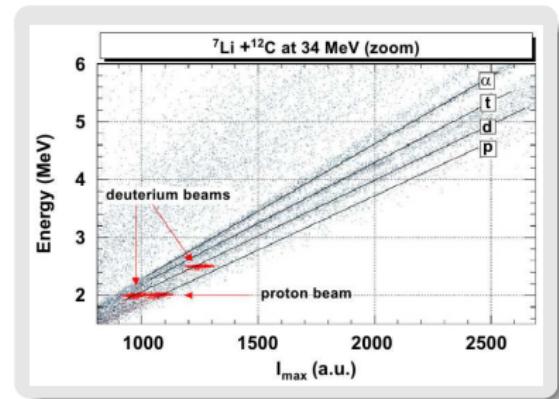
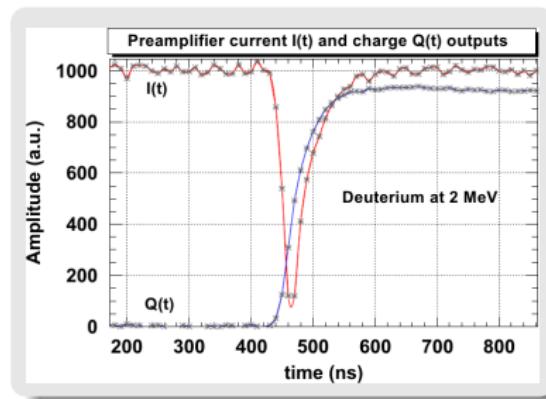
- Digital PSA for LCP discrimination
- nT Detectors [Micron SC, FBK]
- Integrated Electronics
- Physics





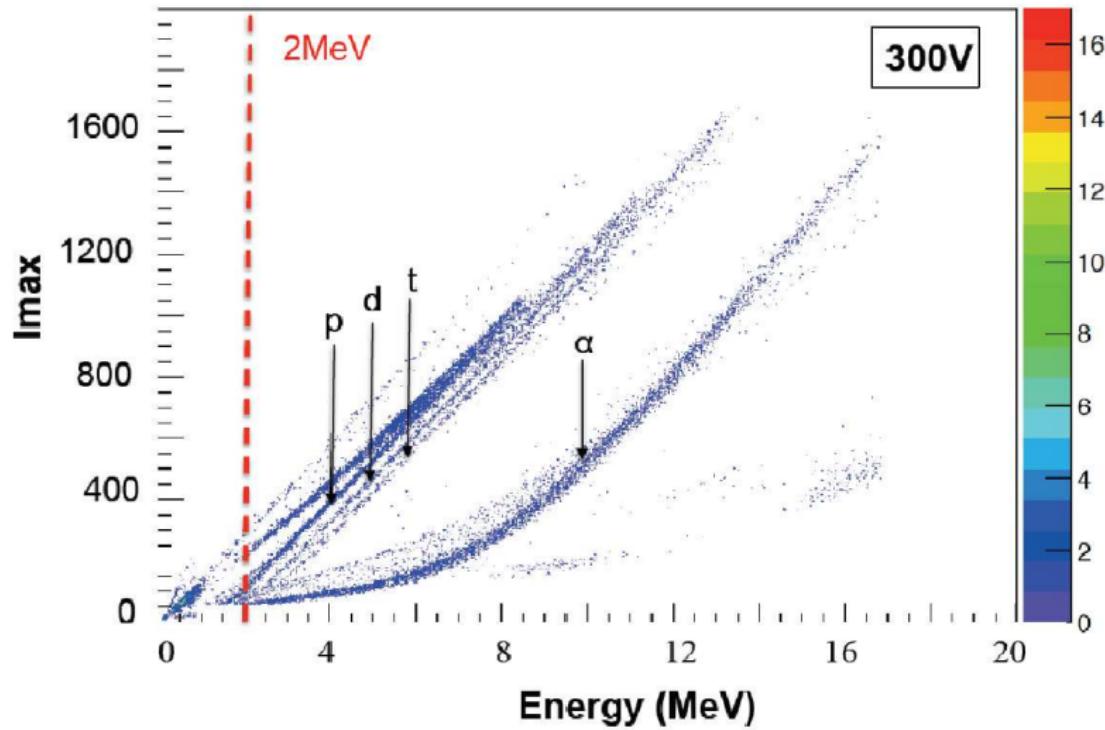
## Identification of light particles by means of pulse shape analysis with silicon detector at low energy

J.A. Dueñas <sup>a,\*</sup>, D. Mengoni <sup>b</sup>, V.V. Parkar <sup>a</sup>, R. Berjillos <sup>a</sup>, M. Assie <sup>c</sup>, D. Beaumel <sup>c</sup>,  
A.M. Sánchez-Benítez <sup>a</sup>, I. Martel <sup>a</sup>



# Separation

Best result - slight underdepletion

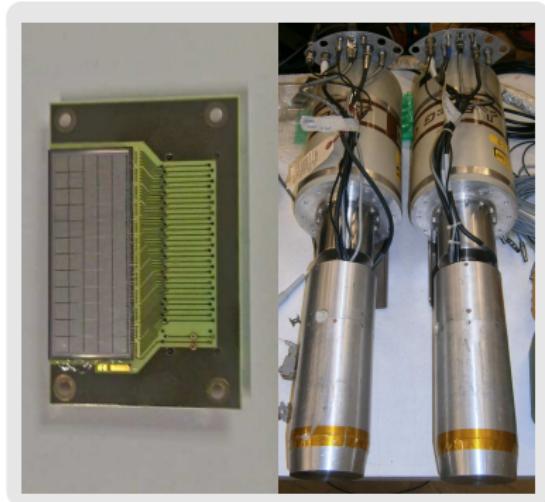
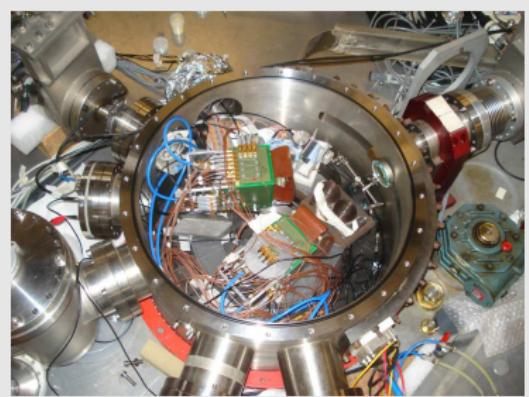


# PSA setup, Nov 2012 @ LNL

TRACE Si + GASP HPGe

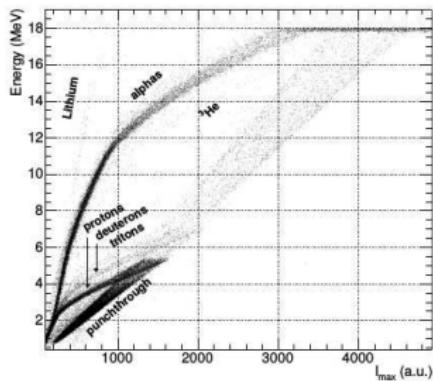
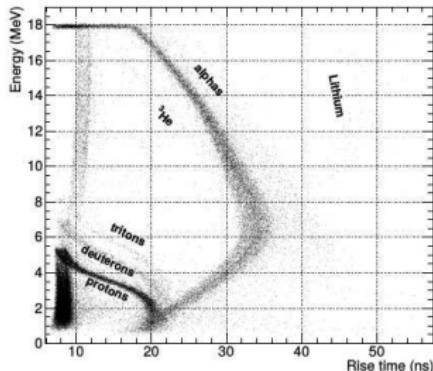
## Goals

- PSA on FZ 200  $\mu\text{m}$ -thin detectors
- 100 MHz sampling frequency

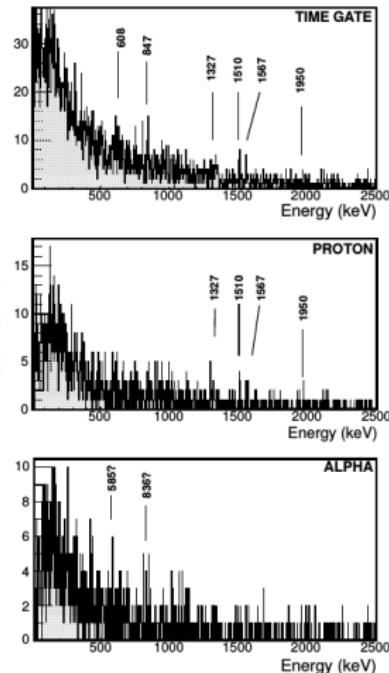


# PSA experiment

on the WG this afternoon, L.Grassi

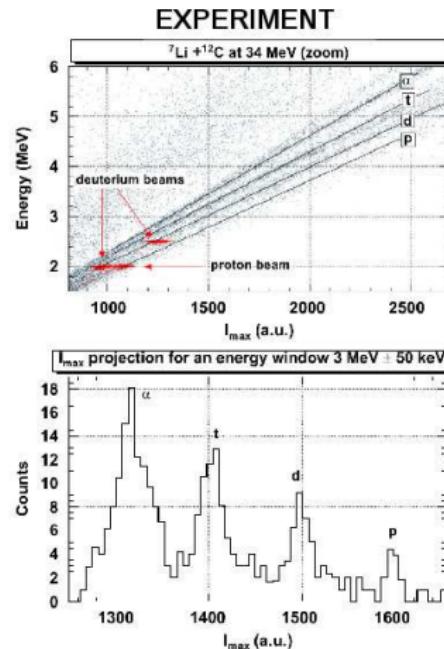
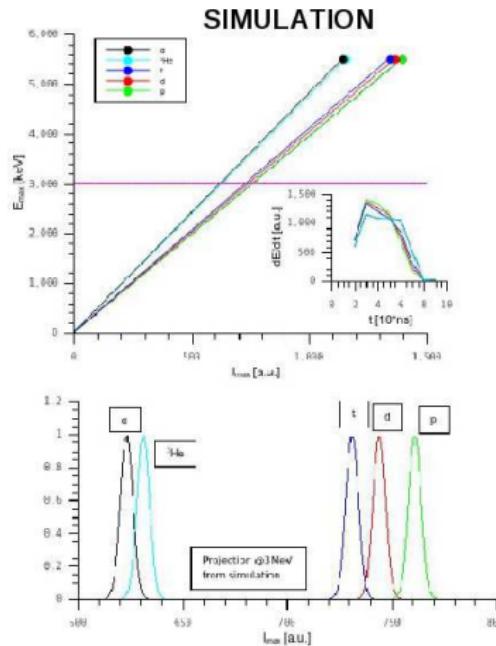


- one only signal (charge)
- thin silicon detector
- slow sampling rate



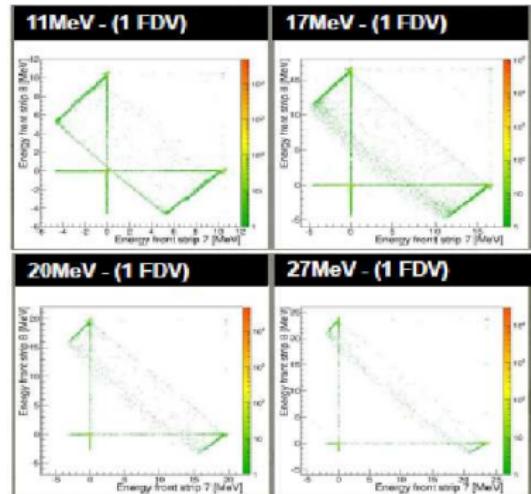
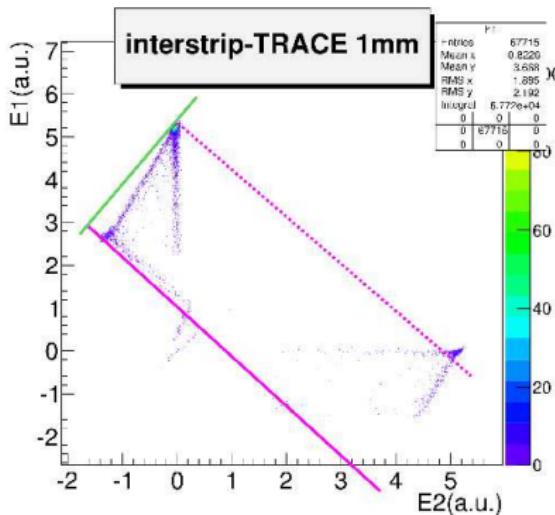
# Signal Simulations

trade-off thickness vs threshold. Results obtained using ADL from B.Bruynel



# Interpad

efficiency loss



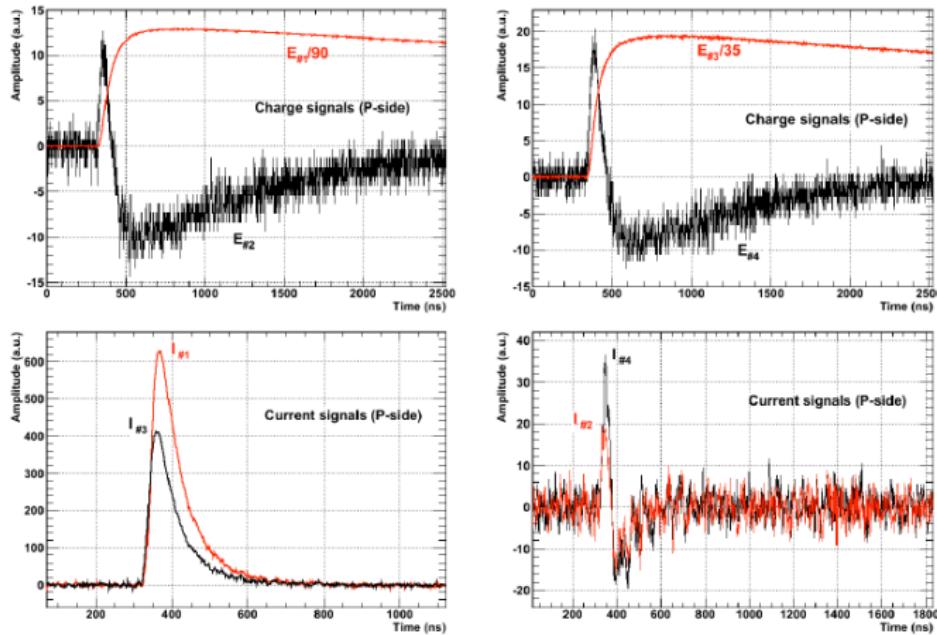
M.Gelain et al., EPJ WoC, INPC2013



# TRANSIENT + XT SIGNALS

Interstrip nT dets. New test envisaged with microbeam

Multi-Event within the recorded time-window (# 444)



J.Duenas, D Mengoni, M.Assie et al., NIMA 2014

# FEE/BEE/DAQ TRACE-GASPARD

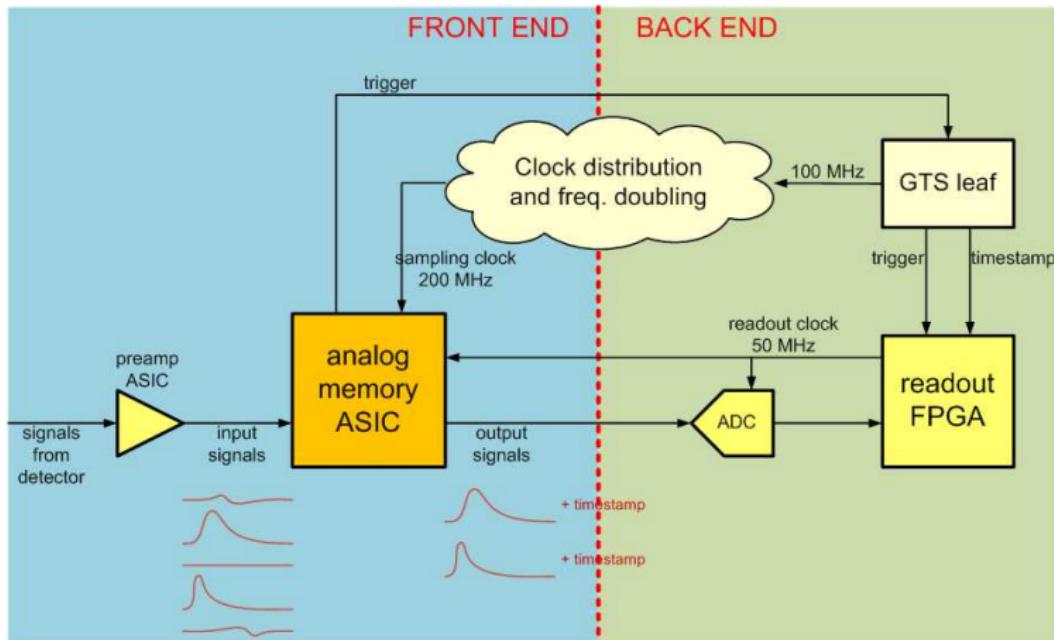
## COMPACT INTEGRATED ELECTRONICS

- PREAMPLIFIER: IPACI (Orsay), I2C preamp (Milano)
- FEE sync and trigger array of analog memories (Valencia)
- BEE slow rate ADC: Padova

- working principle
- sustainable rate
- noise and energy resolution
- power consumption

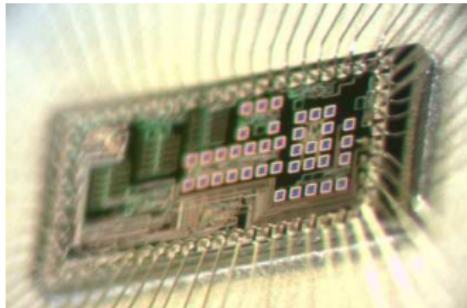


# FEE/BBE Layout



# Preamplifier

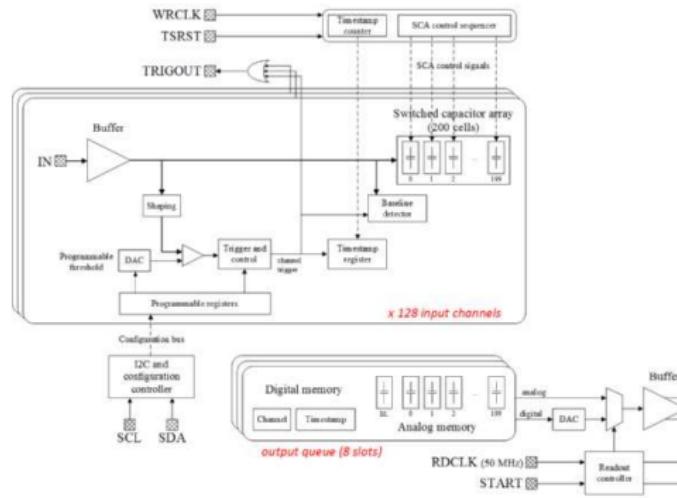
INFN Milano → S.Capra WG on Wed.



- occupancy: 1mm<sup>2</sup>/ch
- monochannel p,n - test in Sept
- four channel submission batch end of July
- 12-16 chan ASIC forthcoming Nov

# Digitizer

CSIC Valencia → R.Aliaga WG on Wed.

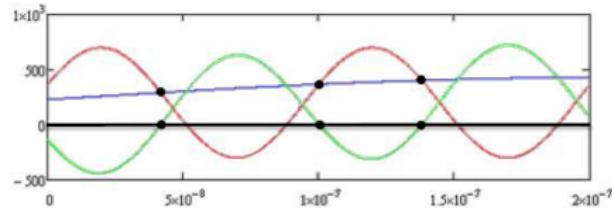


- Purpose: Capture pulse waveforms, generate trigger ( $1 \mu\text{s}$  @ 200 MHz)
- 64/128 input channels with independent trigger
- 1 output channel (analog), external ADC
- Pulse timestamping, synchronizable ASICs
- Pipelined SCA structure: area reduction, zero deadtime
- No deadtime (limited by readout rate)
  - 0.18  $\mu\text{m}$  technology, <10mW/channel expected
- Currently under design, first prototype expected Q1 2015

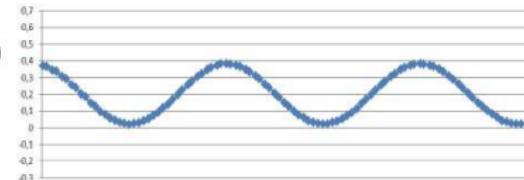
# External ADC

INFN Padova

- Signal and  $V_{REF}$  are sent to the differential LVDS input comparator of the FPGA
- External oscillator used to produce  $V_{REF}$  sinusoid and the FPGA clock
- Delay line TDCs measure time differences further converted to voltages

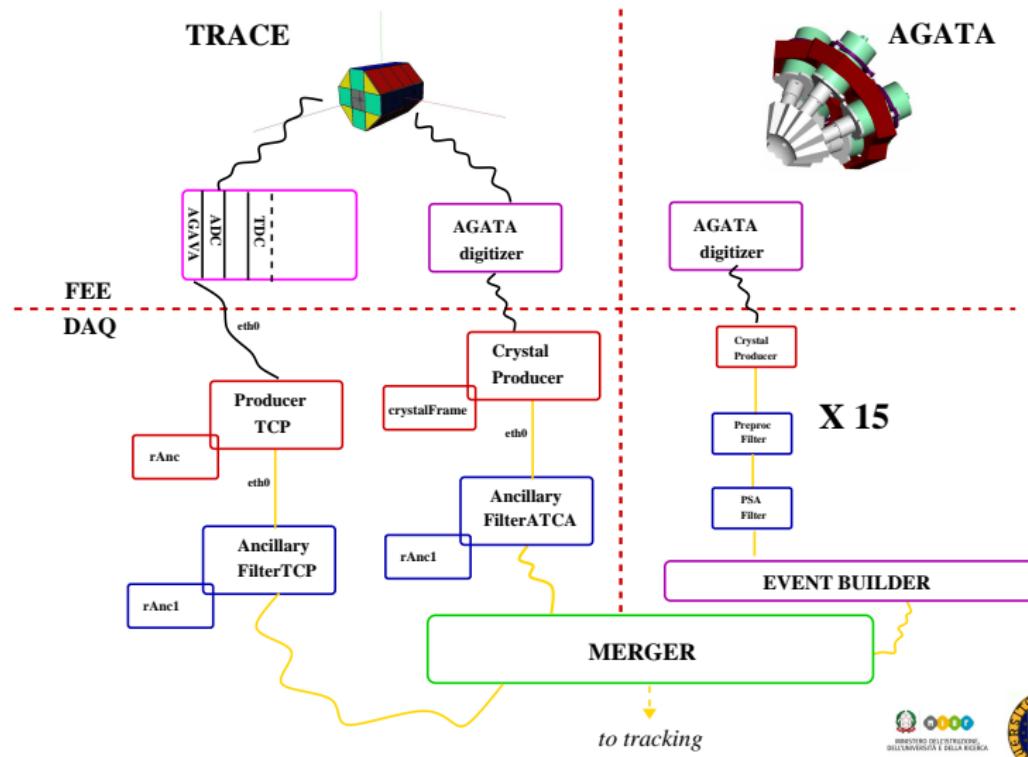


- Porting from Virtex6 to Virtex7
  - Clock rate increase (125 → 200 MHz)
  - Shorten delay line (816 → 204 cells)
    - ↳ More channels
- ENOB ~12 bit @ 50MHz



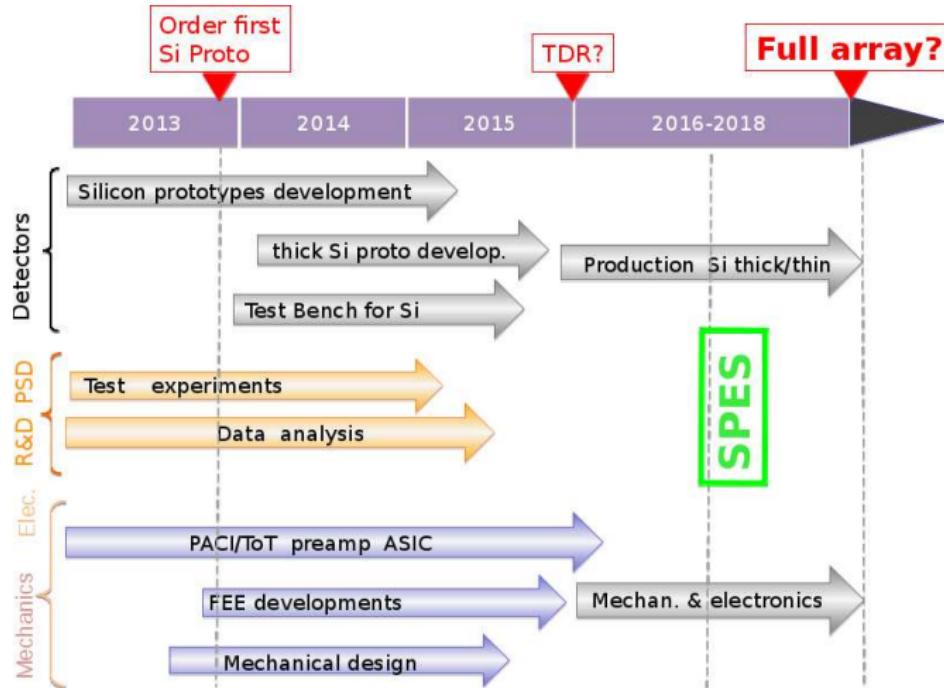
# DAQ

## NARVAL+UserLibraries



# Perspective

## Work plan



# Summary & Conclusions

- Existing Detectors. Possible integration.
  - PSA achieved under testing conditions (radiation hardness?)
  - FEE/BEE started
  - Natural extension of DAQ (AGATA one)
- 
- purchase and test of new 6-inch detectors, thin and thick
  - finalize prototyping read-out chain. Integration. Test.

