Silicon detectors in gamma spectroscopy

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IPN, Orsay - France
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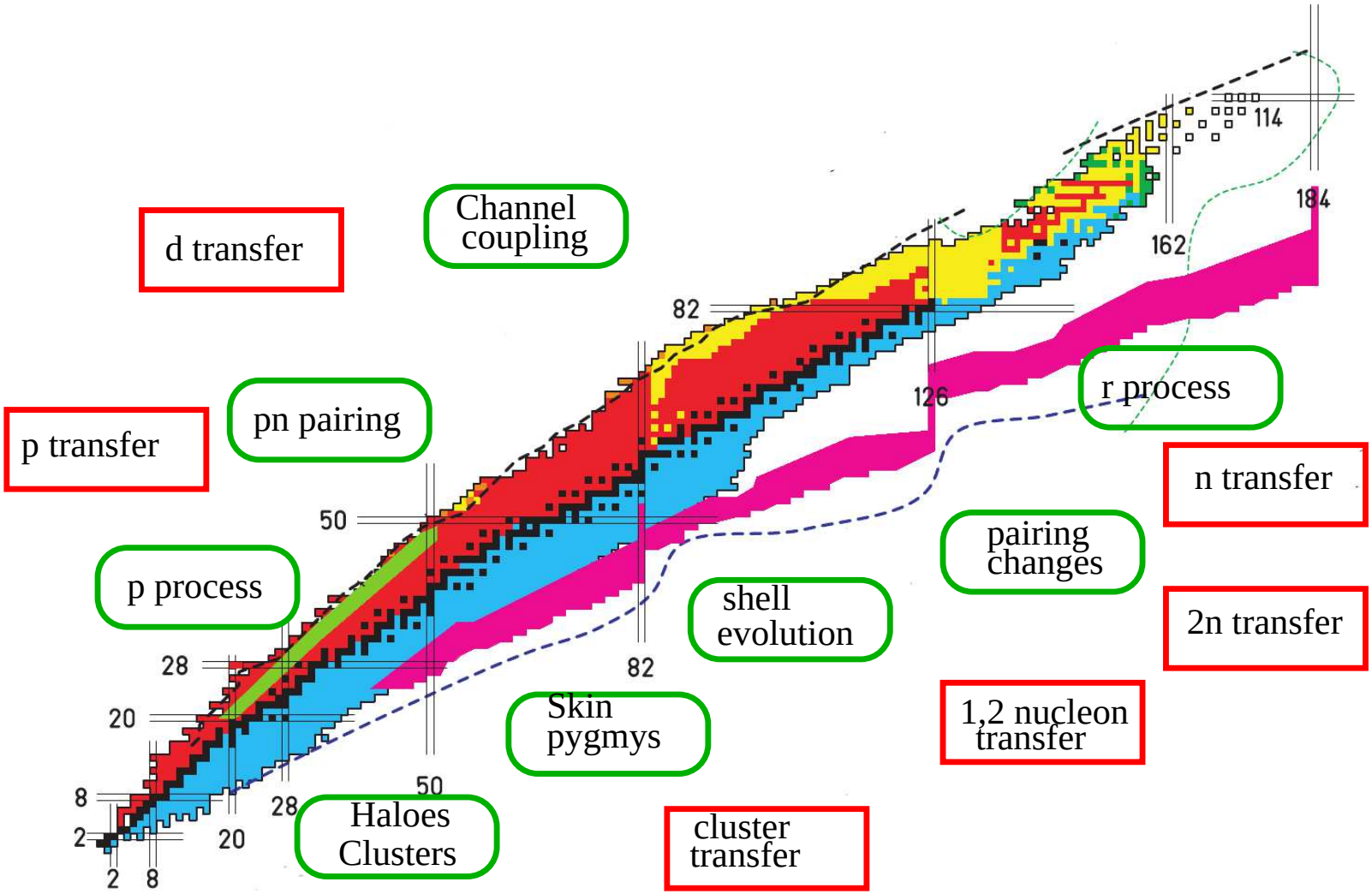
Outline

1. Introduction
   - Nuclear structure by means of gamma spectroscopy
2. Light charged particle ancillary
   - Silicon-based array
3. TRACE
   - Performance with AGATA
   - PSA campaign
   - FEE-BEE-DAQ

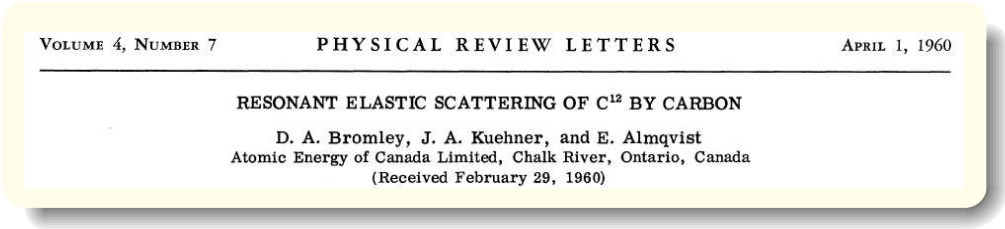
Transfer reactions with RIB

an old tool to access new phenomena



The age of silicon

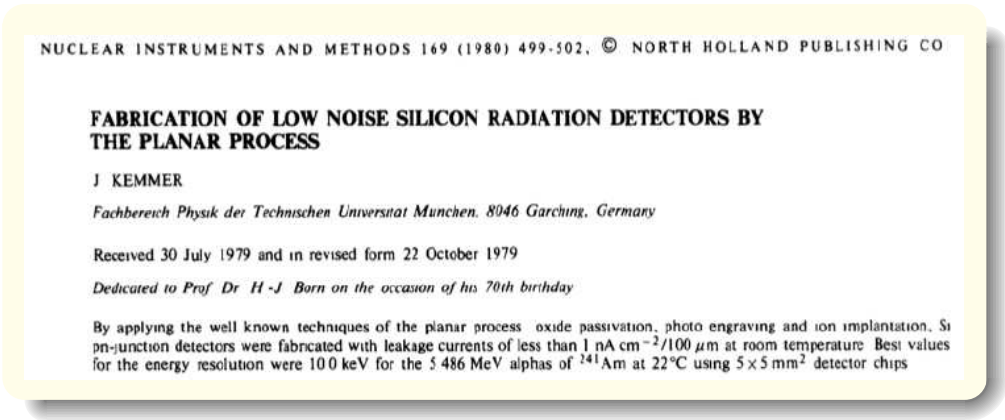
- 1951 First detectors with Germanium pn-Diodes (McKay)
- 1960 Working samples of p-i-n-Detectors for α- and β-spectroscopy (E.M.Pell)
- 1964 Use of semiconductor detectors in experimental nuclear physics (G.T.Ewan, A.J.Tavendale)
- 1960ies Semiconductor detectors made of germanium and silicon become more and more important for energy spectroscopy(D.A.Bromley PRL4(1960)365)
- 1980 Litographic tecnique for planar diode (J.Kemmer NIMA169(1980)499)



VOLUME 4, NUMBER 7 PHYSICAL REVIEW LETTERS APRIL 1, 1960

RESONANT ELASTIC SCATTERING OF C^{12} BY CARBON

D. A. Bromley, J. A. Kuehner, and E. Almqvist
Atomic Energy of Canada Limited, Chalk River, Ontario, Canada
(Received February 29, 1960)



NUCLEAR INSTRUMENTS AND METHODS 169 (1980) 499-502, © NORTH HOLLAND PUBLISHING CO

FABRICATION OF LOW NOISE SILICON RADIATION DETECTORS BY THE PLANAR PROCESS

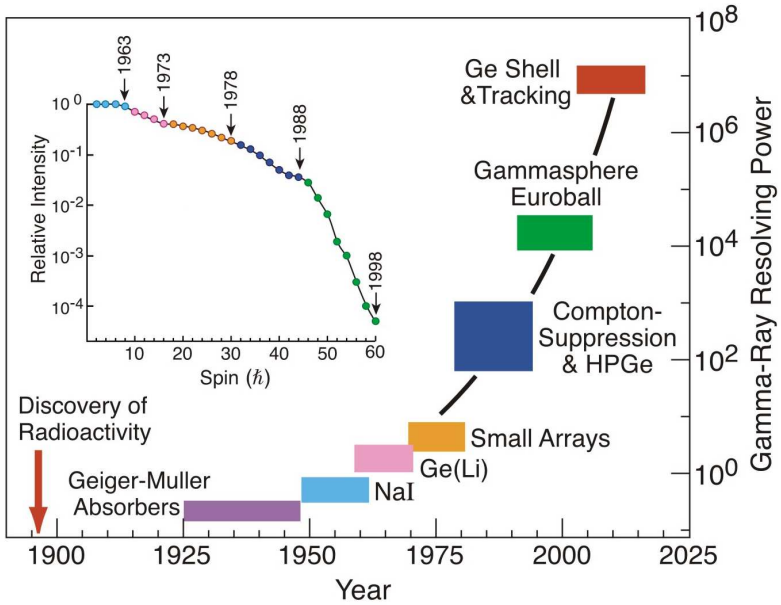
J KEMMER

Fachbereich Physik der Technischen Universitat Munchen, 8046 Garching, Germany

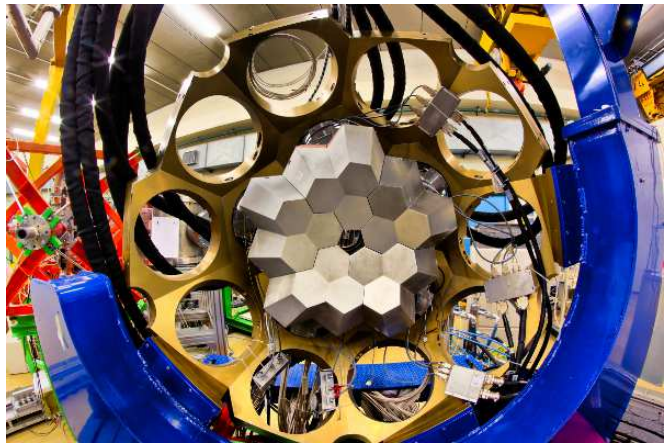
Received 30 July 1979 and in revised form 22 October 1979

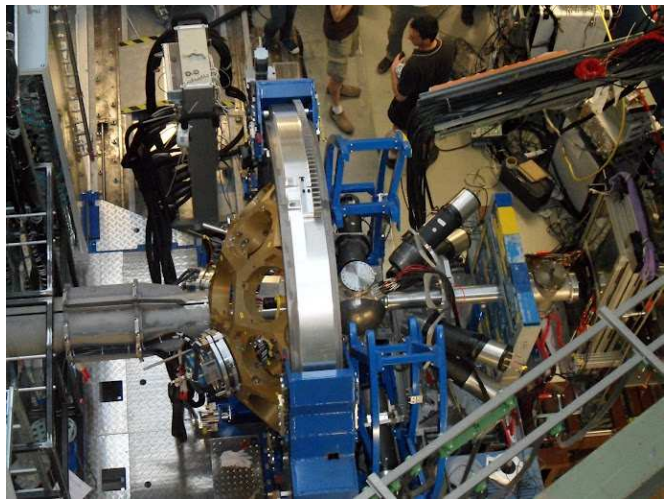
Dedicated to Prof Dr H -J Born on the occasion of his 70th birthday

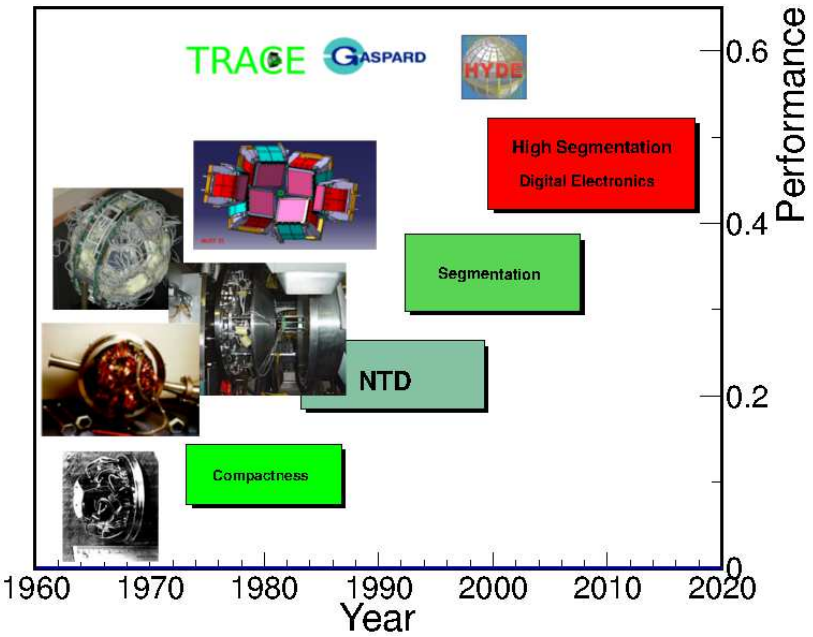
By applying the well known techniques of the planar process oxide passivation, photo engraving and ion implantation, Si pn-junction detectors were fabricated with leakage currents of less than 1 nA cm^{-2}/100 μm at room temperature Best values for the energy resolution were 10 0 keV for the 5 486 MeV alphas of ^{241}Am at 22°C using 5 x 5 mm^2 detector chips



- Resolving power

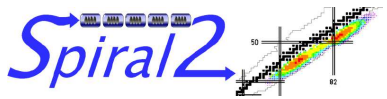






Ambit of the new silicon-based array

- emerging RIB facilities



- Energy regime

  few MeV $\rightarrow$ tens of MeV/u

  Discrimination

  PSA, EΔE
- Special targets

  cryogenic:H_2, He_2, etc.
- Flexibility

  coupling with others detectors

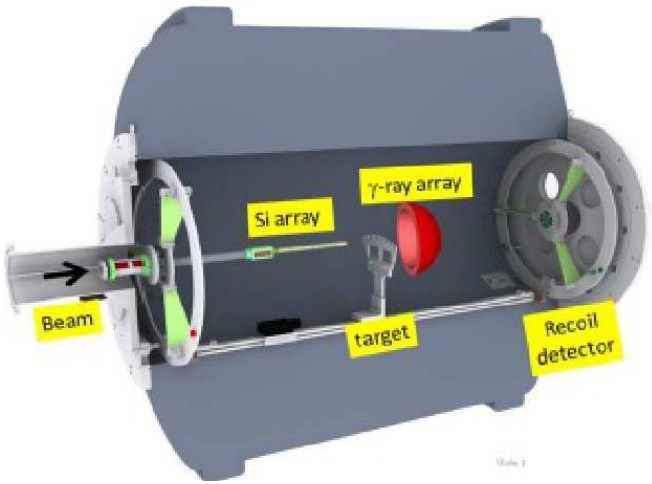
Light charged particle Complementary detectors

- Silicon based array

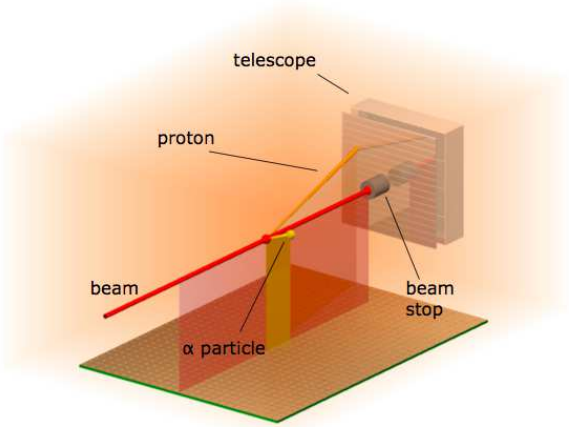
TRACE

GASPARD

- Solenoid



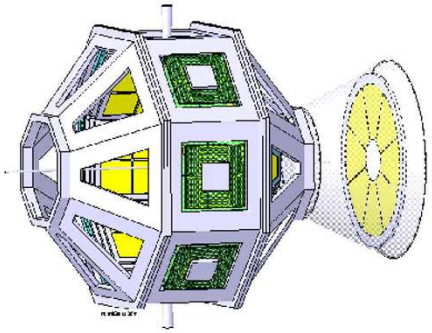
- Active target



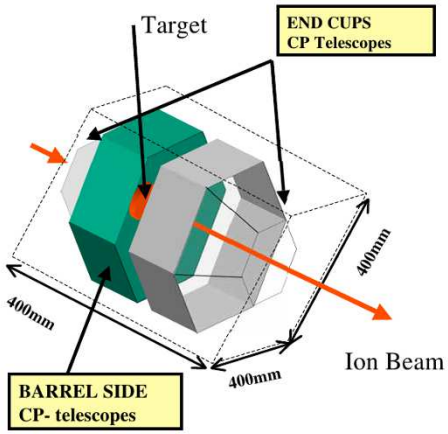
Si-based arrays

panorama

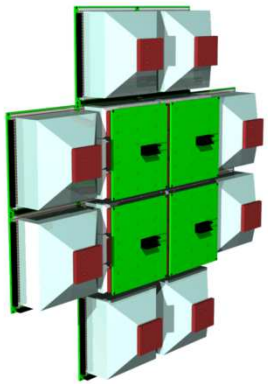
TRACE



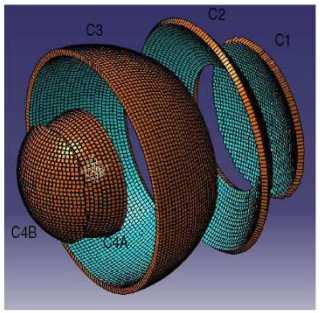
GASPARD



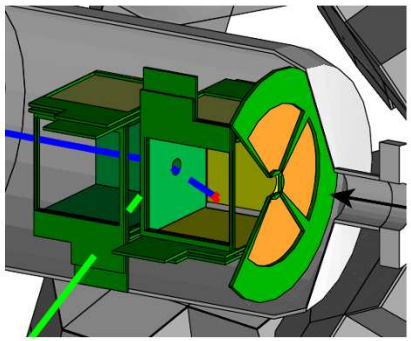
HYDE



LYCCA



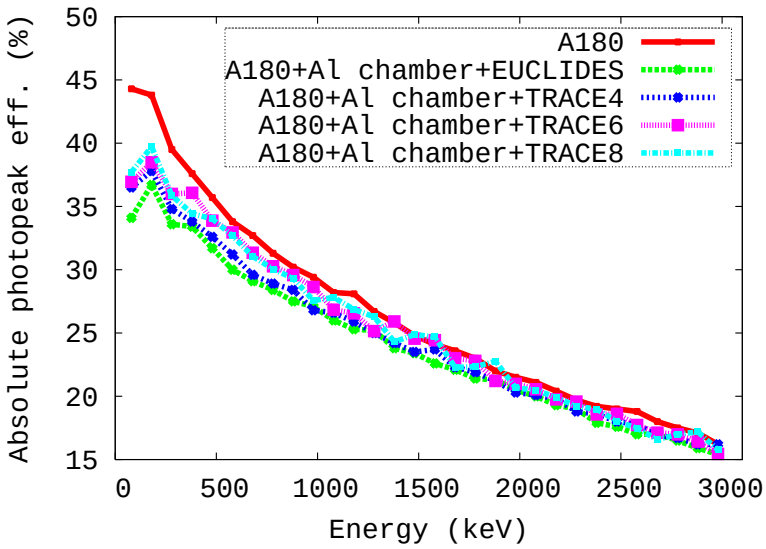
FAZIA

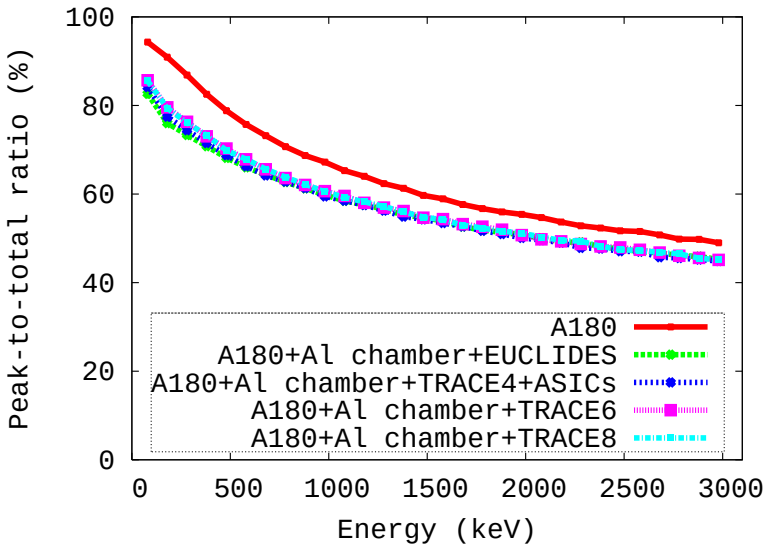


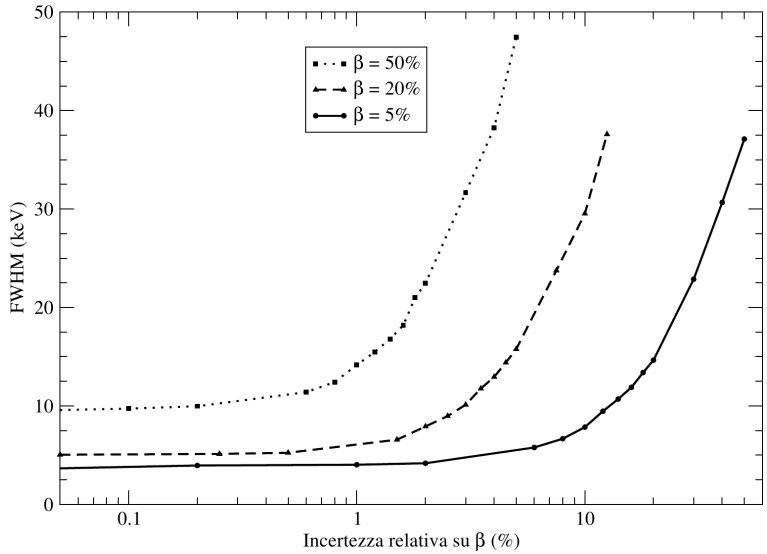
T-REX

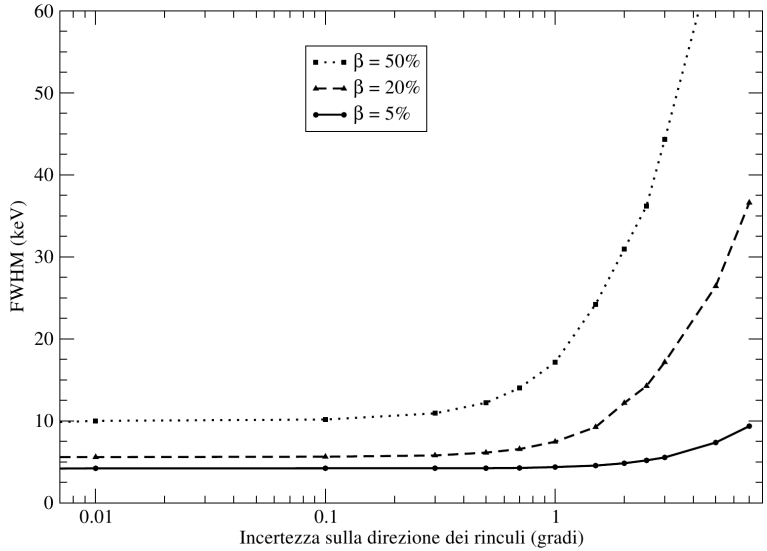
Ancillary detector requirements

Coupling with (tracking-)gamma array: AGATA, PARIS



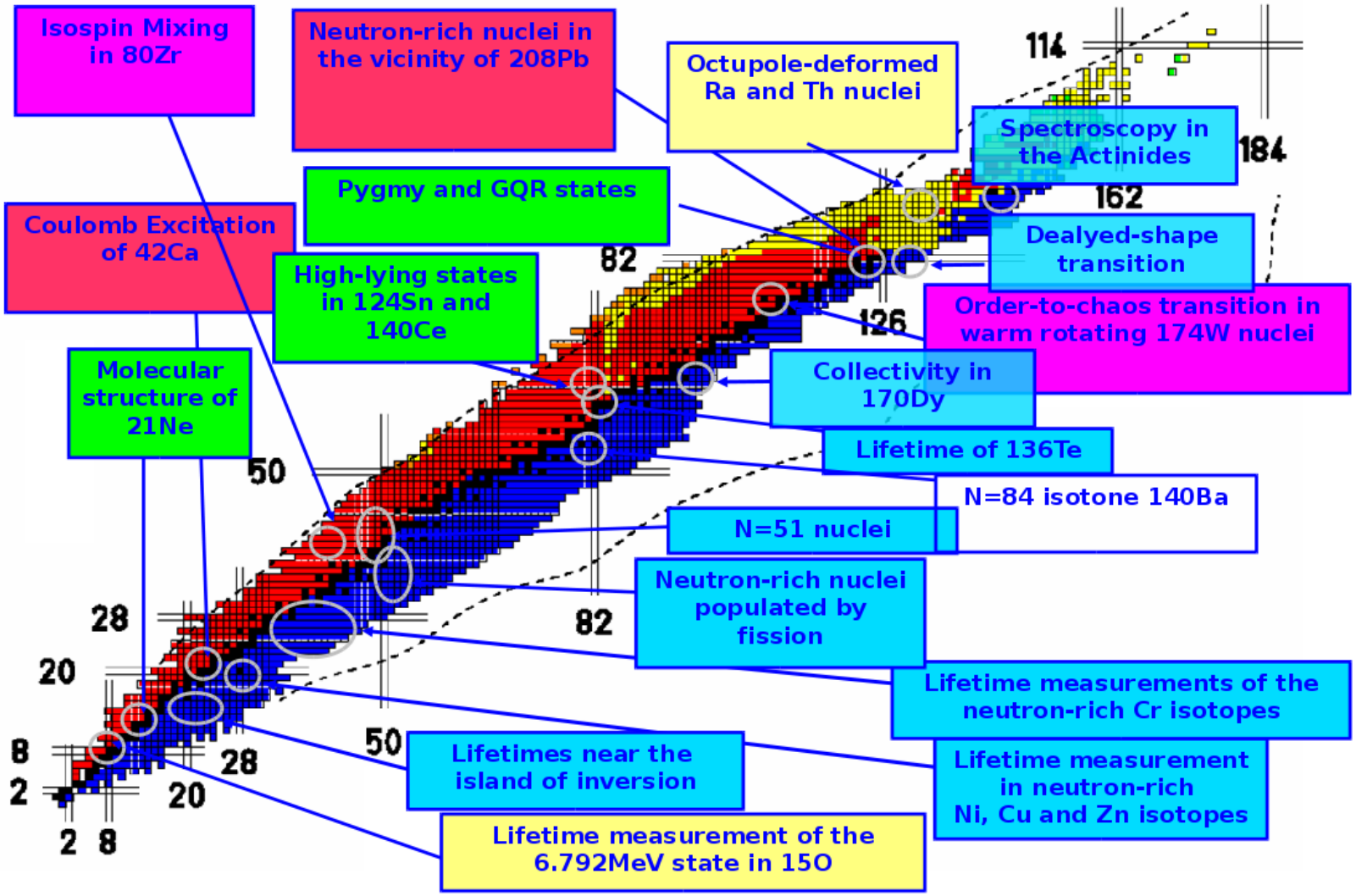






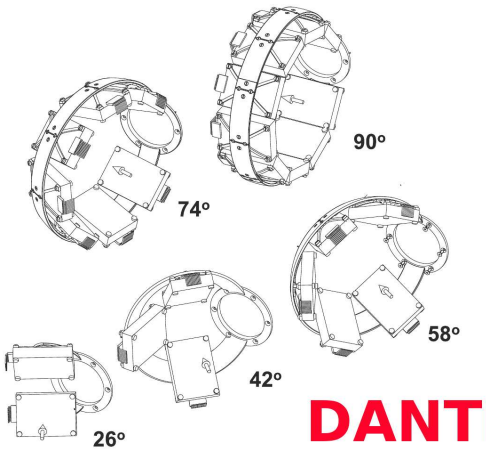
The physics campaign with LNL stable beam

The experimental runs

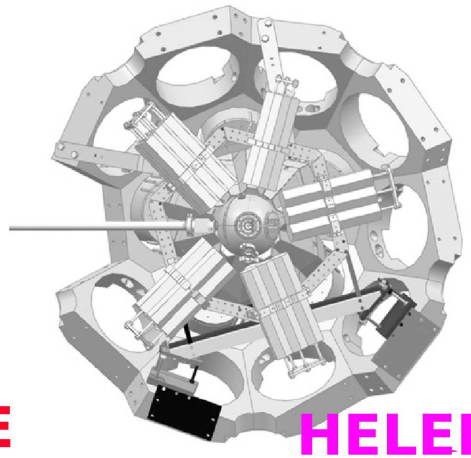


Complementary detectors

LNL

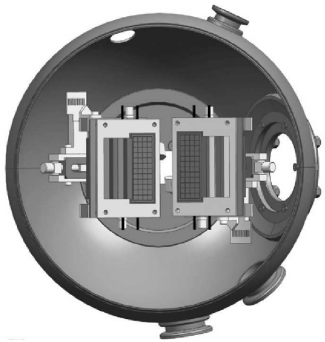


DANTE

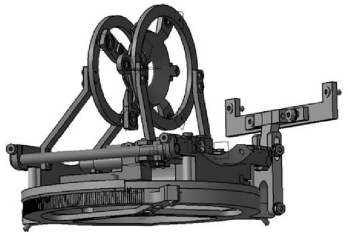


HELENA

TRACE



PLUNGER



TRACE

Highly-segmented silicon-pad detector for particles and light ions detection.

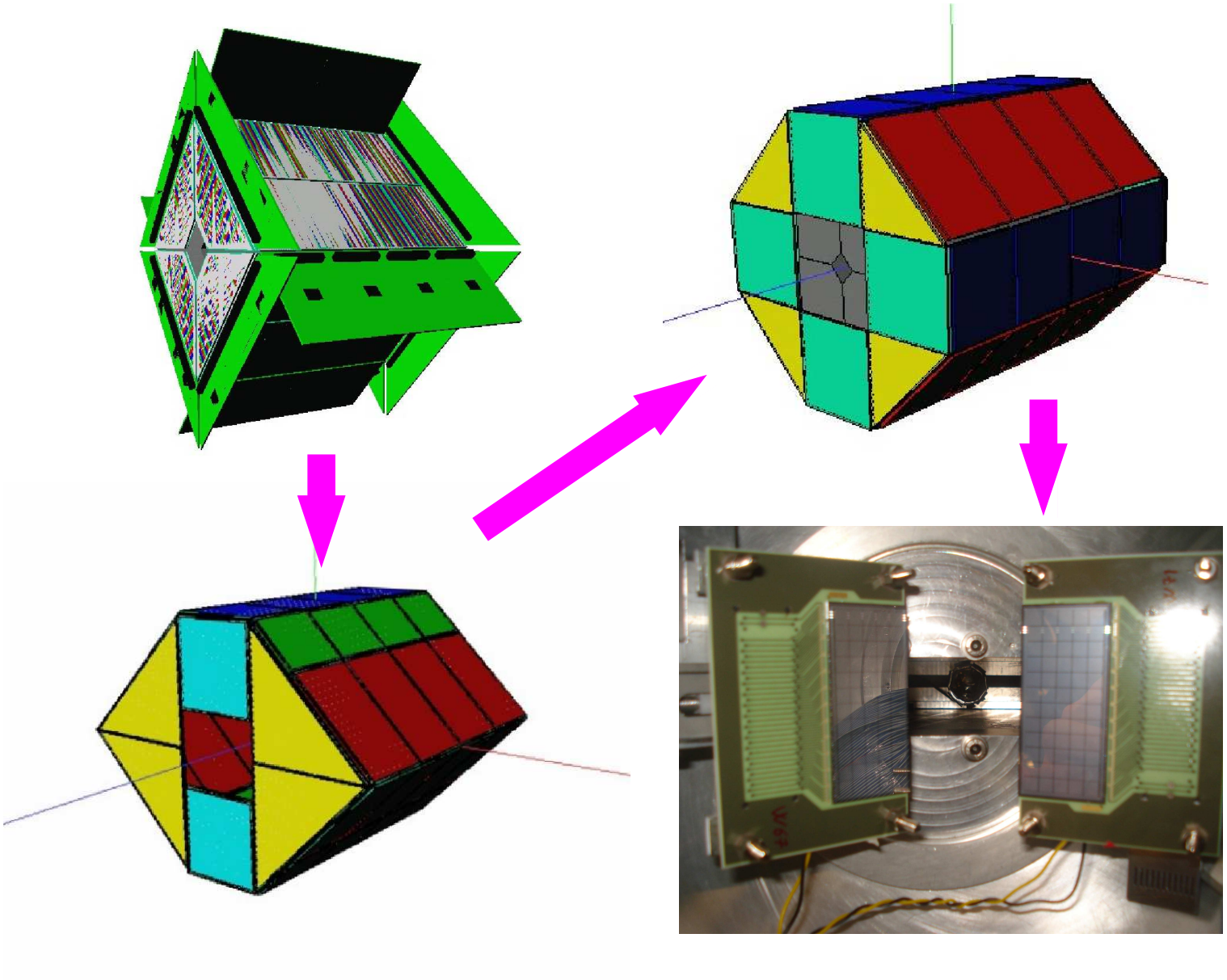
- Two-layer silicon-telescope array to be used as an ANCILLARY of large gamma-ray spectrometers

- Direct (TRANSFER and COULEX) $\rightarrow$ neutron-rich nuclei delivered at the new facilities.
- FE reaction $\rightarrow$ proton-rich nuclei

What is new then?

- Digital electronics (with embedded PSA capability)
- Triggerless system
- NT detectotors

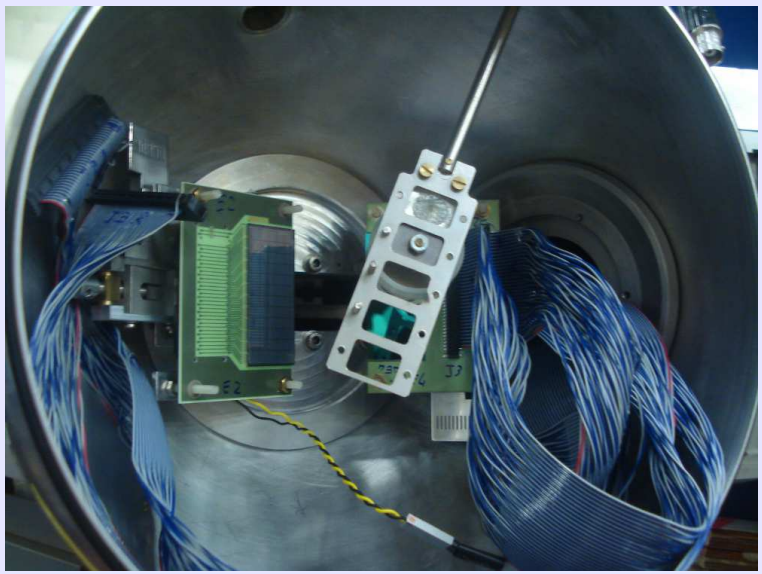
TRACEx: the genesis

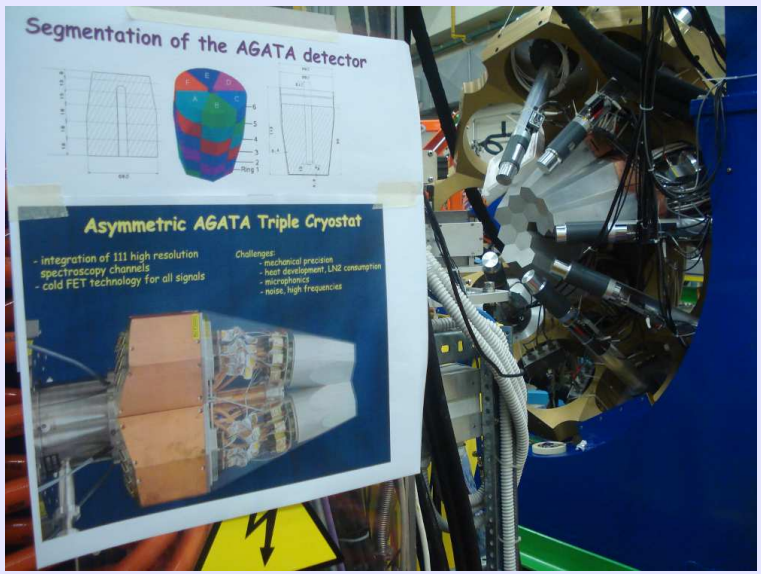


TRACE+AGATA

Three in-beam experiments

- Study of High-Lying States in ^{208}Pb with the AGATA Demonstrator
- Confirmation of the molecular structure of excited bands in ^{21}Ne
- Study of high-lying bound and unbound states in ^{124}Sn and ^{140}Ce via inelastic scattering of ^{17}O ions

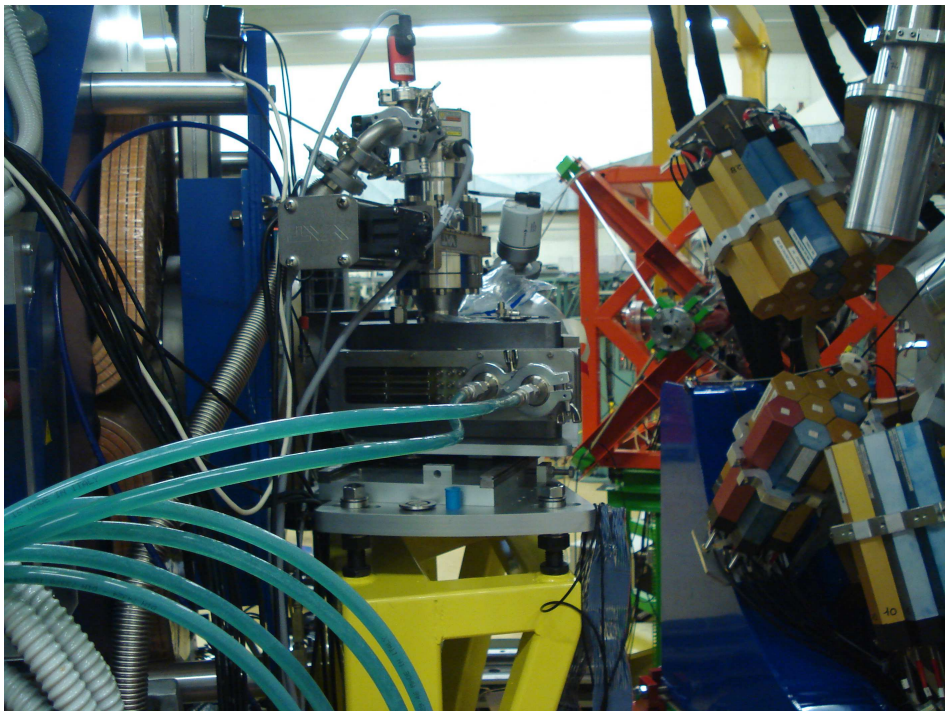




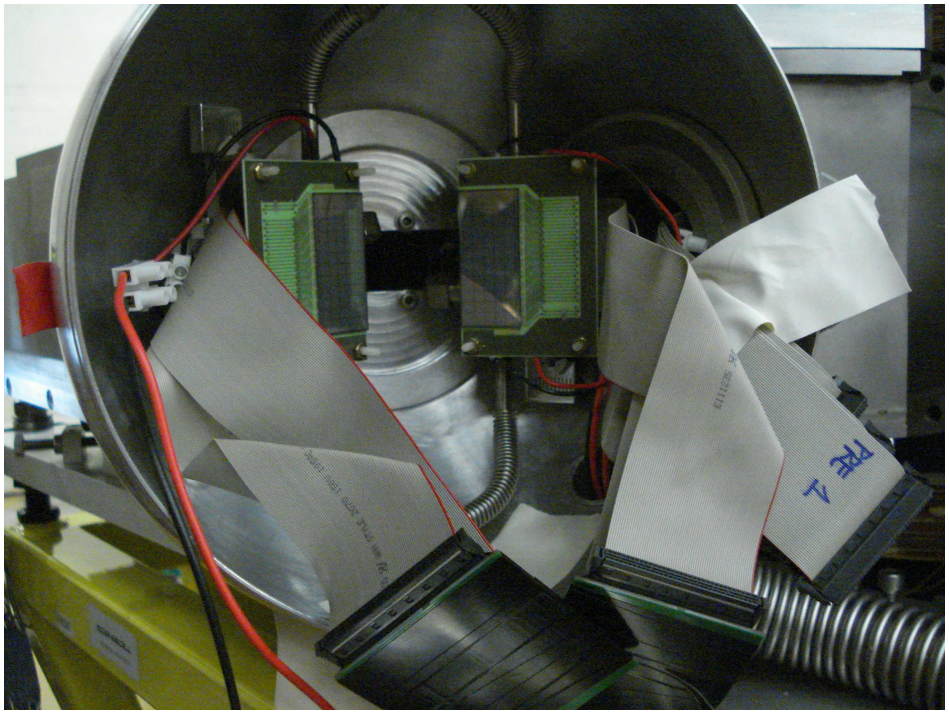
Study of high-lying states in ^{208}Pb and ^{90}Zr

^{17}O(340MeV)+^{90}Zr,^{208}Pb.

R.Nicolini,D.Mengoni



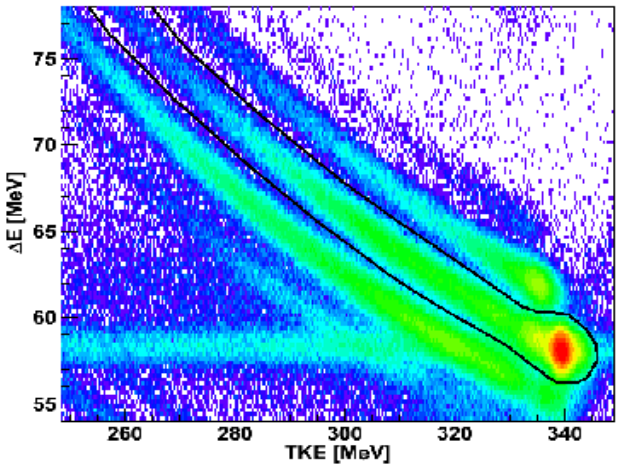
- AGATA DEMO 4ATCs
- Scintillator array:Large volume $LaBr_3$:Ce,BaF_2.
- Highly segmented Silicon telescope

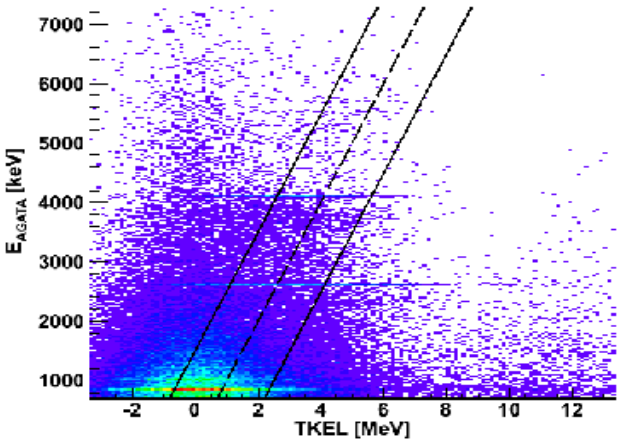


- Pad segmentation: 60 (5x12) pixels
- Pixel area of 4x4 mm^2, Cooled $\sim$-30 °C
- E detector: 1-mm thick
- ΔE detector: 200-μm thick

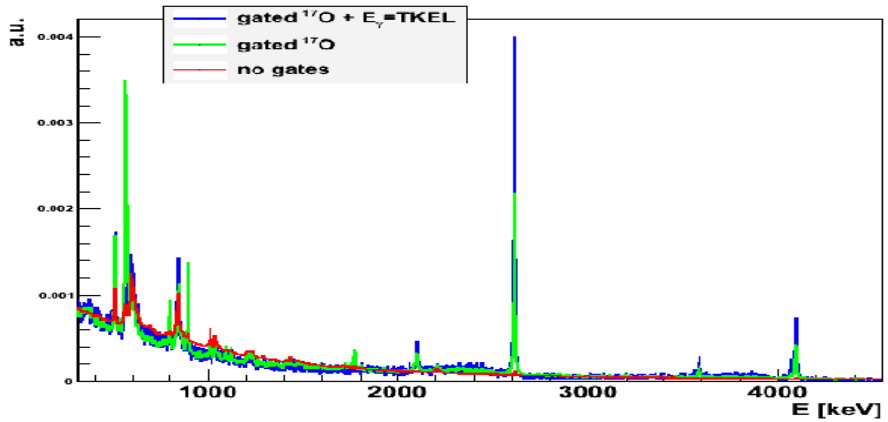
Study of high-lying states in ^{208}Pb and ^{90}Zr

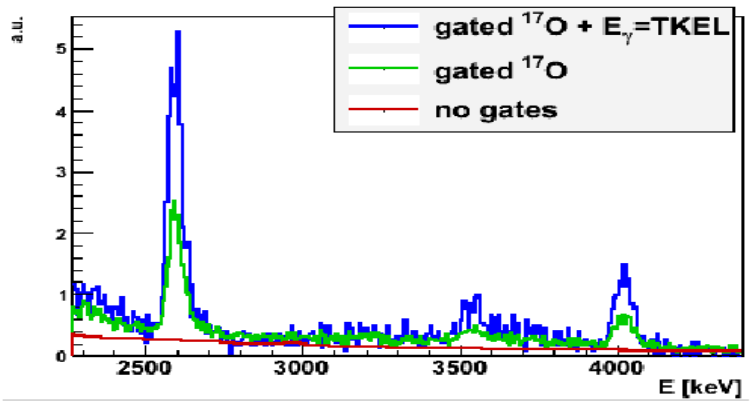
Courtesy of R.Nicolini (INFN-Mi). ⇝ L.Pellegri on Wednesday.





- Select ^{17}O scattering
- Recoil Doppler correction
- Select Eγ = TKEL

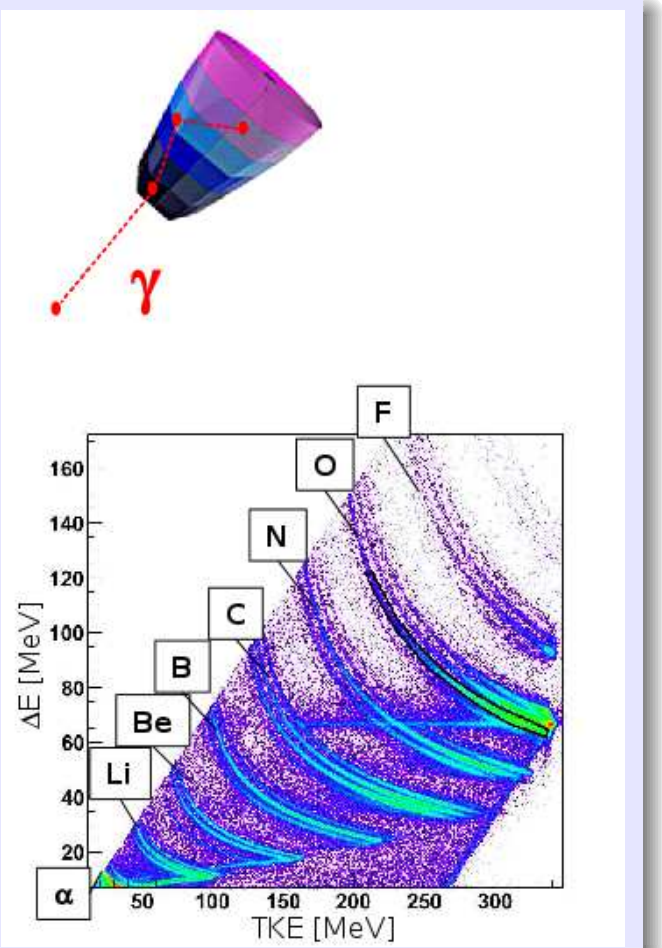




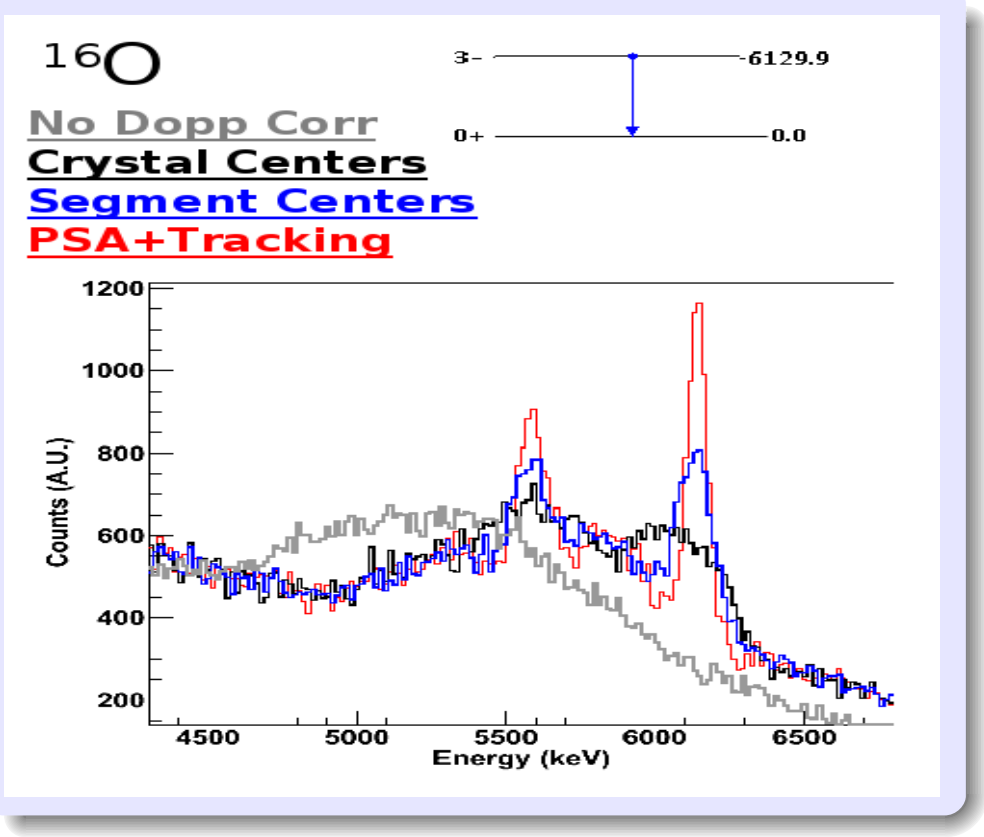
- Lines visible in the pygmy region ∼6MeV
- Possible different lines from NRF
- RPA calculations

TRACE telescope

Performance of the AGATA-TRACE setup (Coulex)



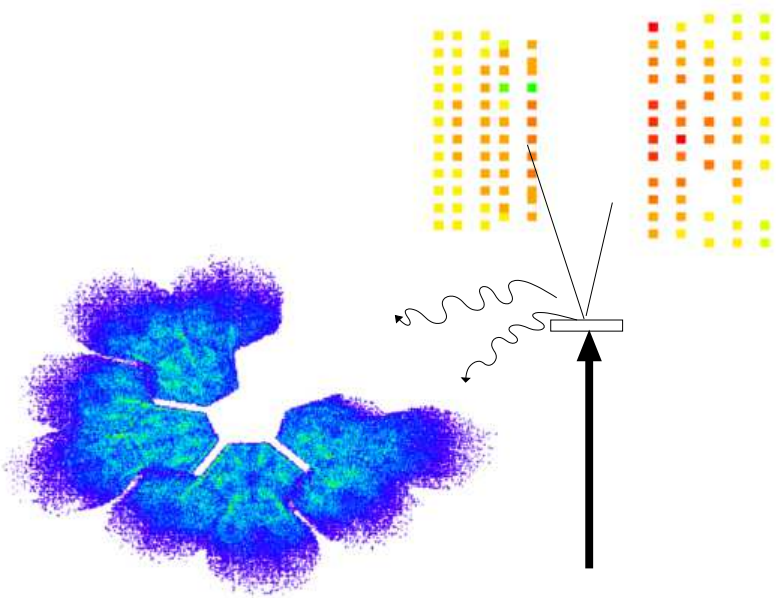
- Z and M up to Z = 9
- β ∼20%

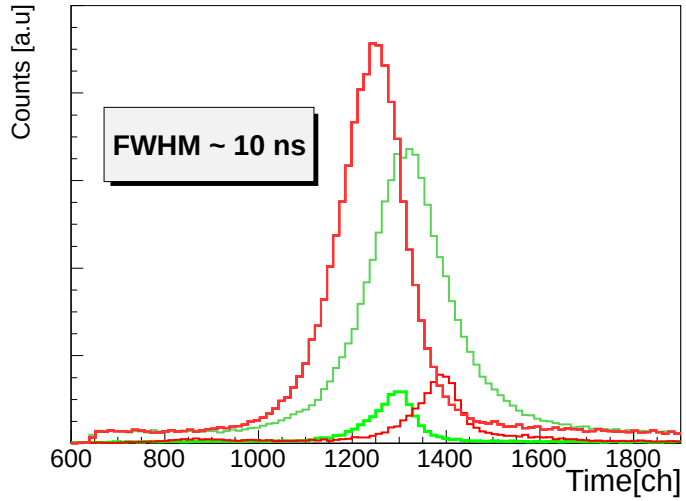


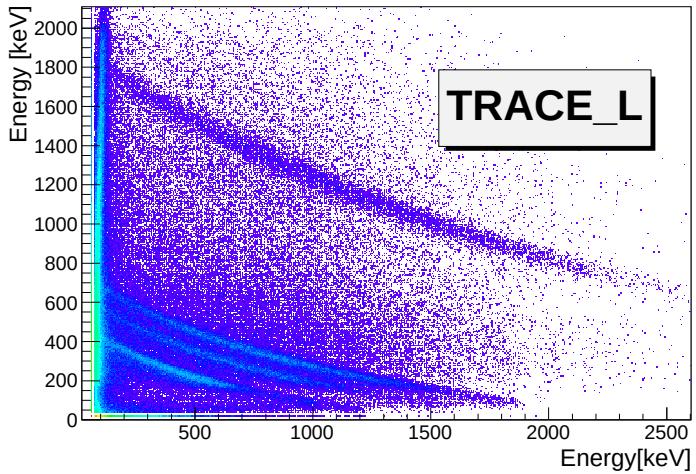
- ^{16}O channel: high energy γ-ray low background from target.....
- FWHM ∼ 0.9%
- Good PSA performance

TRACE for light-charged particles

^{7}Li+^{16}O Quasi-fusion reaction for ^{21}Ne







- TRACE-$\gamma\gamma$
- kinematic reconstruction of the binary partner

⇝C.Wheldon on Wednesday

PSA campaign

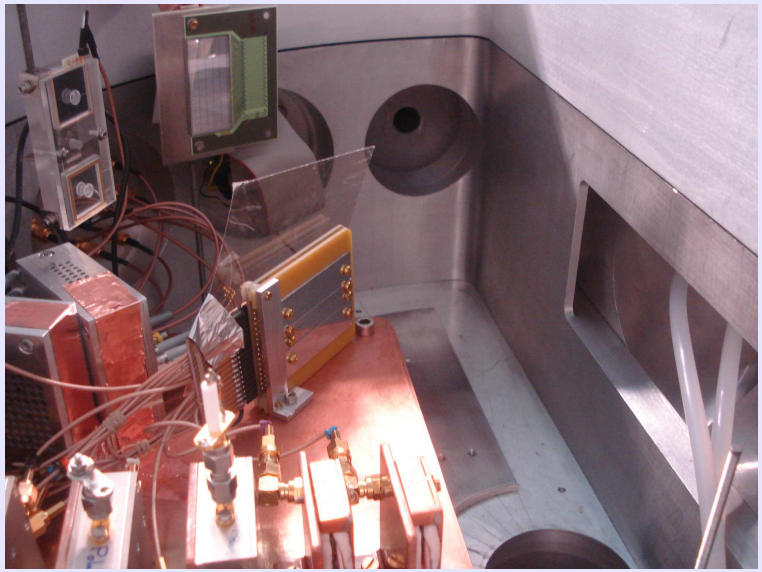
TRACE-GASPARD-HYDE collaboration

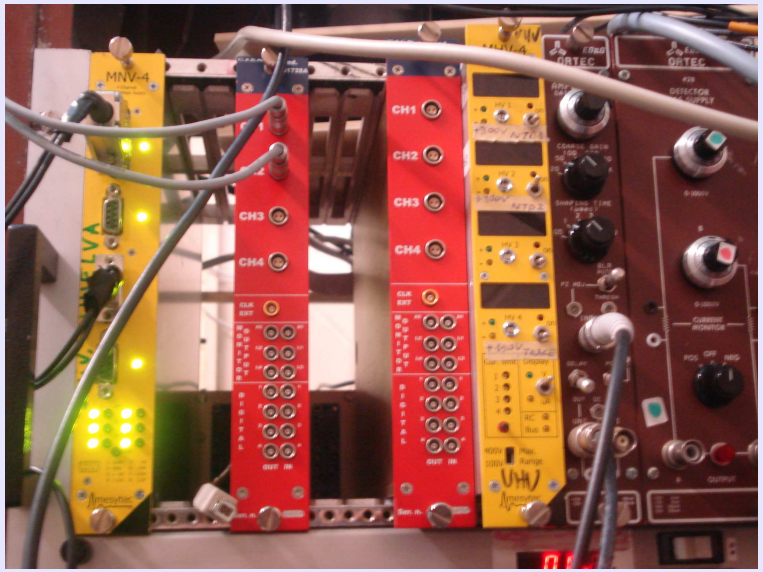
- Orsay: proof of principle for the discrimination of light charged particles with single-pad NTD det.
- Orsay: test for segmented DSSSDs
- LNL: test for higher Z,A and coupling with a tracking array

Goals

- PSA on light-charged particles
- Enhance the geometrical resolution via transient signals

PSA experiment at the ORSAY tandem accelerator





Setup

- 200-μm thick TRACE prototype at forward angle
- 500-μm thick single pad FAZIA prototype
- FEE: Mesytec pre + 2 CAEN digitizer(100MHz,14bits)
- MUST2 strip detector with MATAQ boards FEE electronics

Nuclear Instruments and Methods in Physics Research A 676 (2012) 70–73

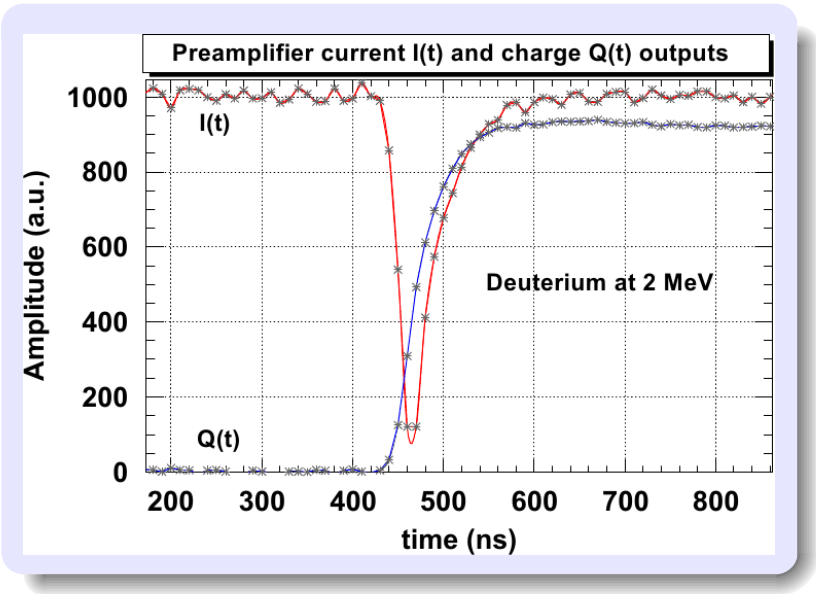
Contents lists available at SciVerse ScienceDirect

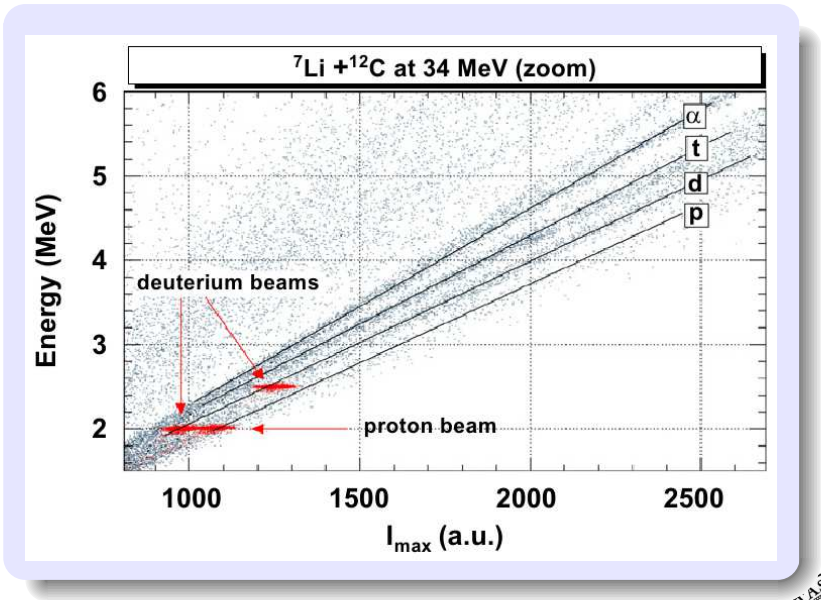
Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

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

J.A. Dueñas [a,*], D. Mengoni [b], V.V. Parkar [a], R. Berjillos [a], M. Assie [c], D. Beaumel [c], A.M. Sánchez-Benítez [a], I. Martel [a]

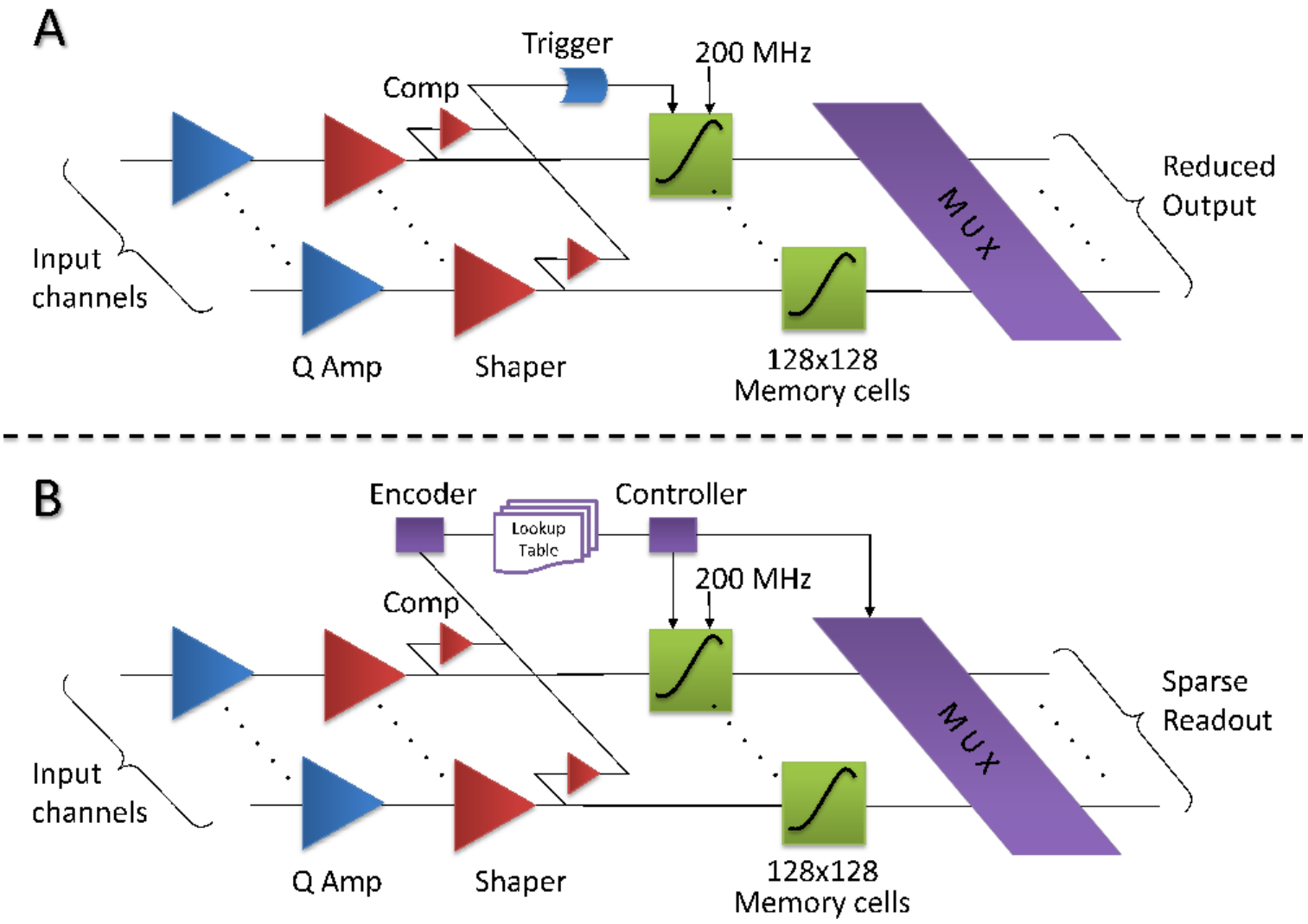




⇝J.Duenas,M.Assie,T.Kröll on Thursday

FEE: Preamp + Analog memories

Solution **A** MUX: ∼5Khz/128ch; Solution **B**: sparse readout

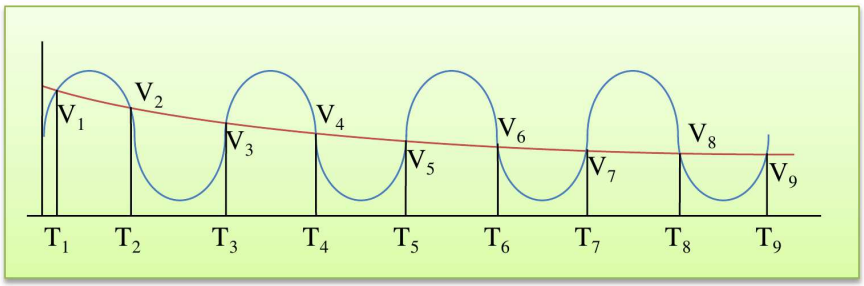


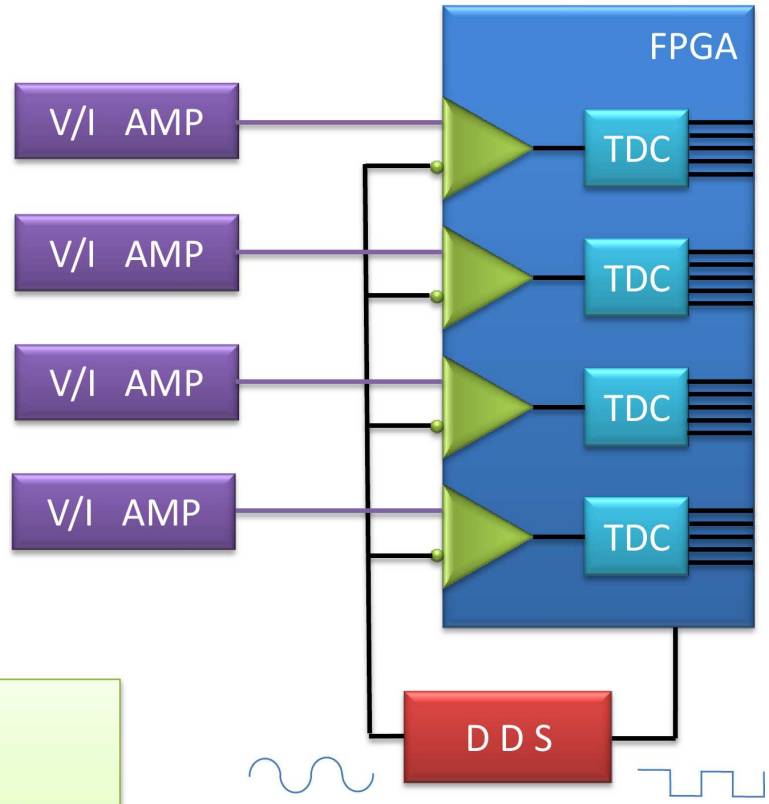
⇝Synergy WG on Thursday

FPGA as ADC: a local solution for the BEE

cheaper (and high integration?)

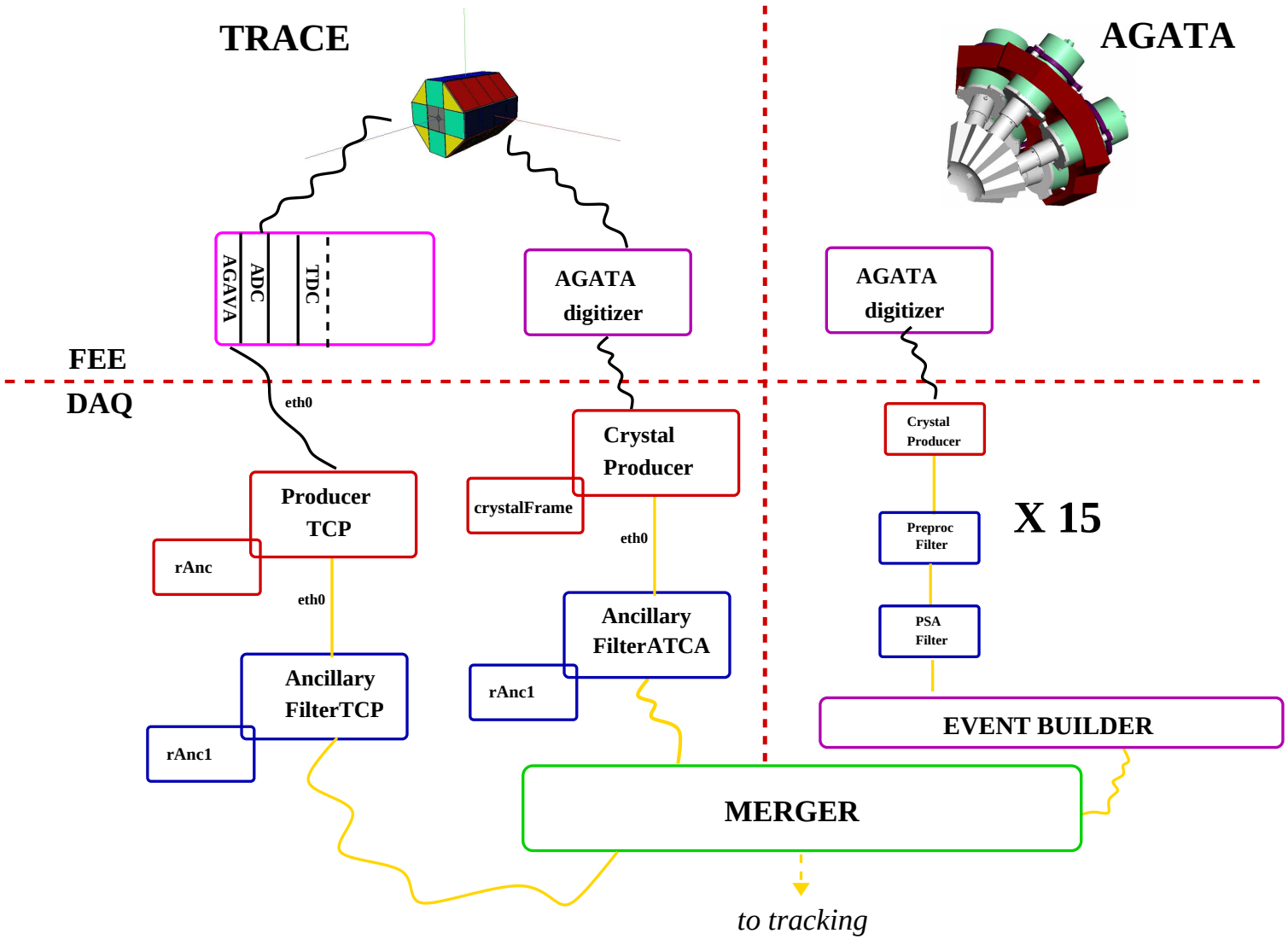
- From PA directly to FPGA differential inputs
- External digital synthesizer used to produce a V_{REF} sinusoid
- TDCs measure time differences further converted to voltage





⇝A.Triossi on Thursday

DAQ


TRACE
AGATA
AGAVA
ADC
TDC
AGATA digitizer
AGATA digitizer
FEE
DAQ
eth0
Crystal Producer
Producer TCP
crystalFrame
Crystal Producer
X 15
rAnc
eth0
eth0
Preproc Filter
Ancillary FilterTCP
Ancillary FilterATCA
PSA Filter
rAnc1
rAnc1
EVENT BUILDER
MERGER
to tracking

Summary and conclusions

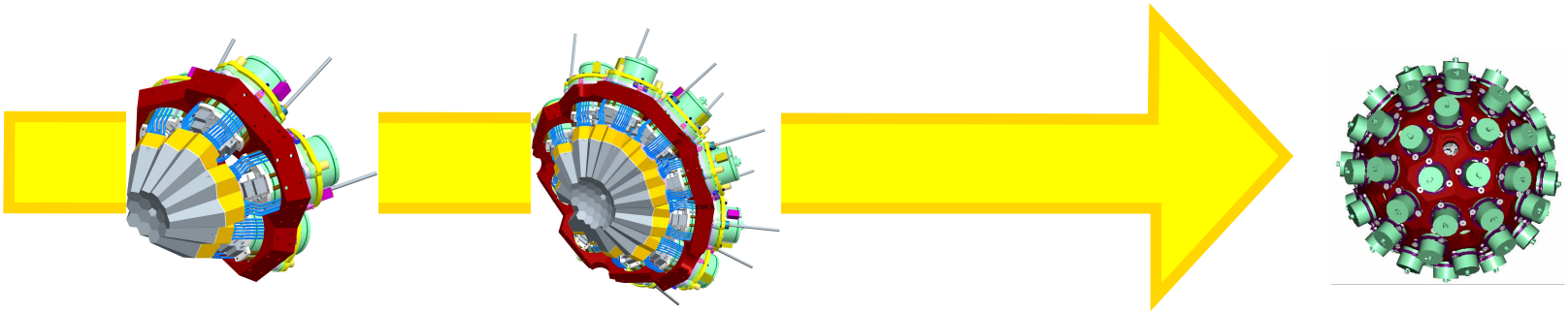
- Various Si arrays partners projects on going at the emerging RIB sites.
- Si array design mainly driven by DR prescriptions.
- TRACE was successfully used for the AGATA Physics campaign at LNL.

- Needs for synergy efforts to build up a state-of-the-art Si array

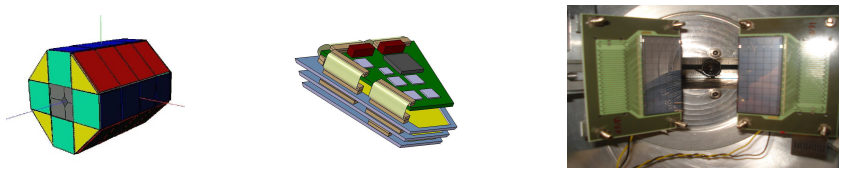
Timeline

2011	2012	2013	2014	2020

AGATA

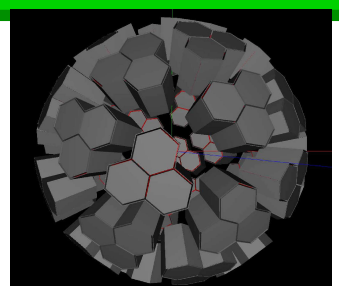


TRACE



simulation + electronics + demonstrator

GALILEO



SPES exotic beams for science

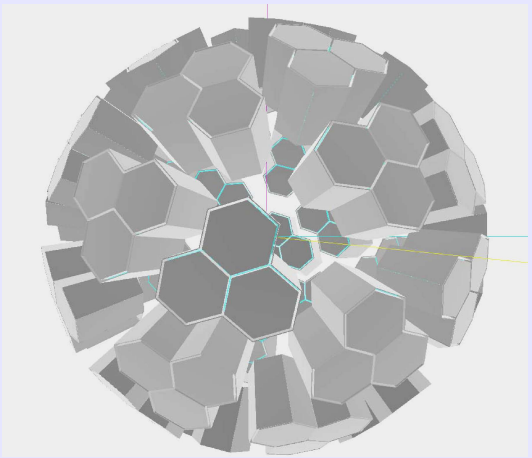
LNL

GANIL

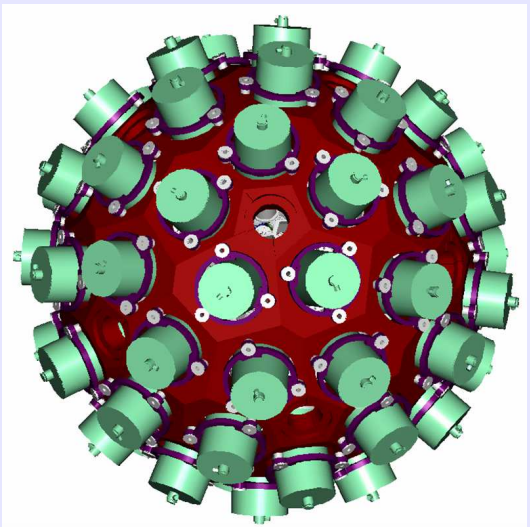
Spiral2

Perspectives

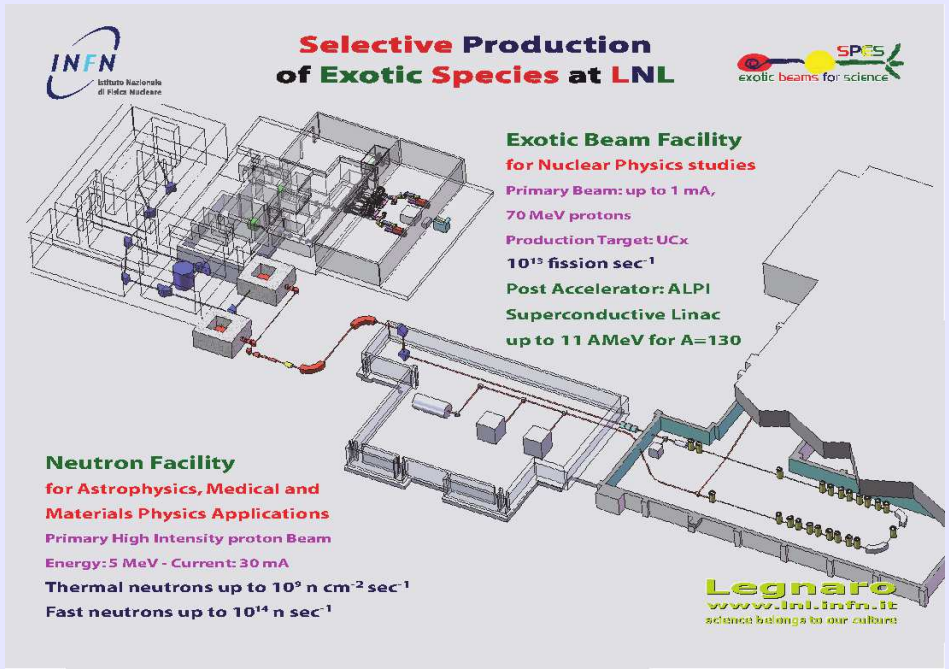
GALILEO



AGATA



SPES



Synergies

- GASPARD (SPIRAL2-GANIL)
- HYDE (FAIR-GSI)