IFD2022 - INFN Workshop on Future Detectors

INFN
Istituto Nazionale di Fisica Nucleare

TWO SHOTS ON

1. *THE NEW NEUTRON HODOSCOPE*
2. *RIBs CHARACTERIZATION FOR FRAISE, THE NEW FRAGMENT IN-FLIGHT SEPARATOR AT INFN- LNS*

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NArCoS

FRAISE: a new FRAgment In-flight SEparator
Approved inside POTLNS PON

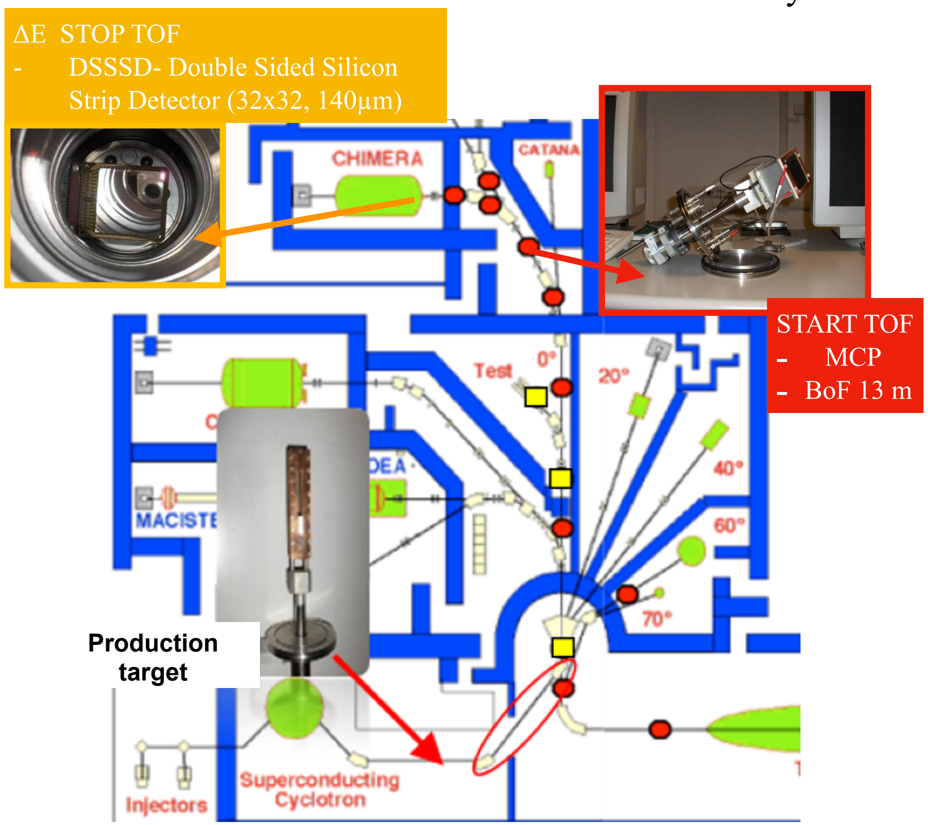
What we did @FRIBs facility

At INFN-LNS RIBs were produced, from 2001 to 2019, using the FRIBs (in Flight Radioactive Ion Beams at LNS) facility through the In-Flight fragmentation employing a maximum beam power of 100 W

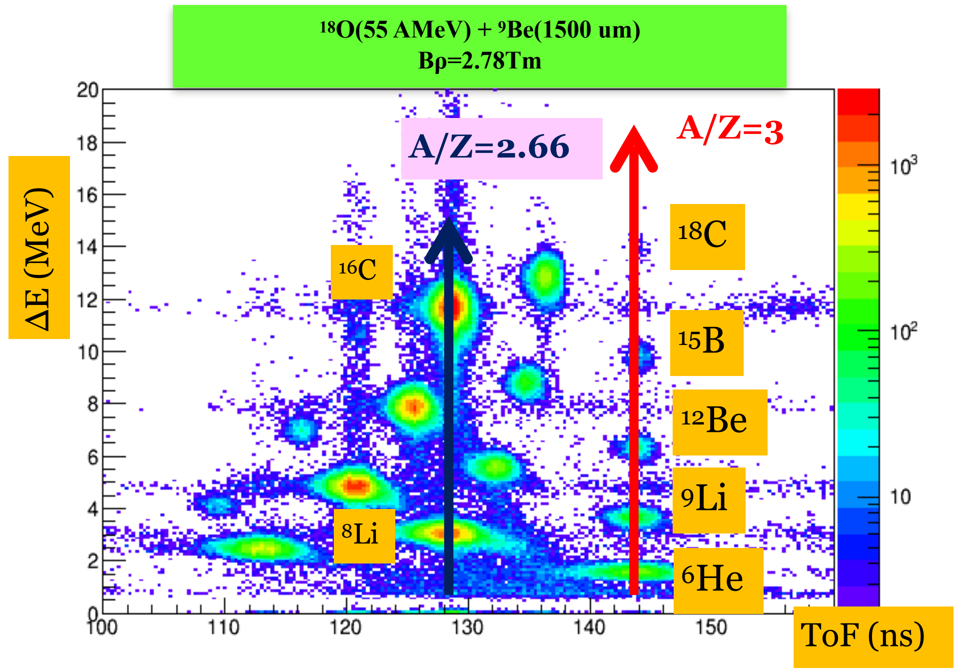
As known the produced beam is a *«cocktail beam»*, we need :

- Diagnostics system DSSSDs + plastic scintillators, to achieve an optimal transport from the production target to the final user point
- Tagging device for the CHIMERA array (ΔE-ToF method for PID identification, MCP-DSSSD system)

RIBs produced: from ^{6}He to ^{68}Ni
with max intensity of ≈ 10^5 pps



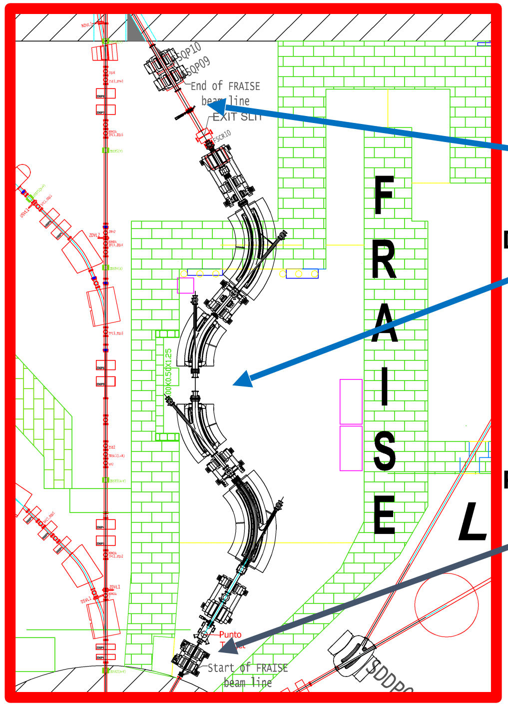
Lombardo I. et al., Nucl. Phys. B Proc. Suppl., 215 (2011) 272



Characteristics:
MCP: up to 10^5 pps, Δt ≈ 200-300 ps;
DSSSD: max rate 200 kHz (light ions), 30 kHz (medium and heavy ions).
Worsening of performances in ≈ 1 week;
Time resolution Δt <≈1 ns ;

FRAISE: a new FRAgment In-flight SEparator
Approved inside POTLNS PON

The building of a new fragment separator FRAISE (Fragment In- Flight Separator) is ongoing at INFN-LNS to provide high intensity (10^3 –10^7 pps) RIBs using the In-Flight Fragmentation method and employing a primary beam power of 2-3 kW. We expect an increasing up to two order of magnitude to the respect of the preset situation.



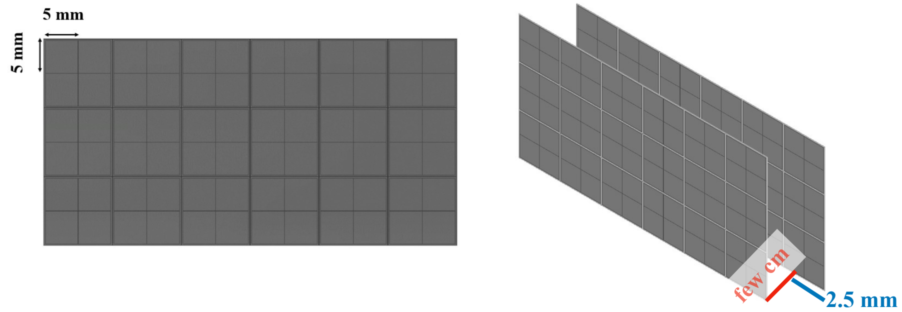
Some examples (E/A≈ 50 MeV)

Nuclide of interest	Intensity* (kHz)
^{8}B	3100
^{14}Be	3
^{13}N	23000
^{14}O	1400
^{16}C	14000
^{17}F	170000
^{19}O	2300
^{34}Ar	8200

New radiation-hard tagging systems are needed to measure features of RIBs:

- Need of a point-to-point measurement of cocktail intensity, relative composition (PID), energy distribution, 2D profile, angular distribution during optimization
- Monitoring of beam properties, start time for event-by-event ToF/energy measurement during data taking

100 μm thick fully depleted SiC rad-hard multi-pad sensors: up to 10^7 pps over the whole system with $\Delta t \approx 200$ ps (≈0.1% precision on energy for 20 m base-of-flight) if 200 μm inter-pad dead zone, 10% dead area



- Front-end: Custom multi/channel ASIC with charge preamplifier configuration and analog pre-processing optimized for amplitude and time measurements
- Full waveform digitizers and synchronization with CHIMERA/FARCOS DAQ

Martorana N.S., Il Nuovo Cimento 44 C (2021) 1
Martorana N.S. et al., Il Nuovo Cimento 45 C (2022) 63
Russo A.D. et al., Nucl. Instrum. Methods B, 463 (2020) 418
Russotto P. et al., J. Physics: Conf. Ser., 1014 (2018) 012016
F. Risitano, Tesi di Laurea Magistrale, Università degli Studi di Messina, Italy

NArCoS (Neutron Array for Correlation Studies)

Idea for a new Neutron Hodoscope

To realize a prototype of detector able to detect at the same time charged particles and neutrons with high energy and angular resolution for reaction studies and applications

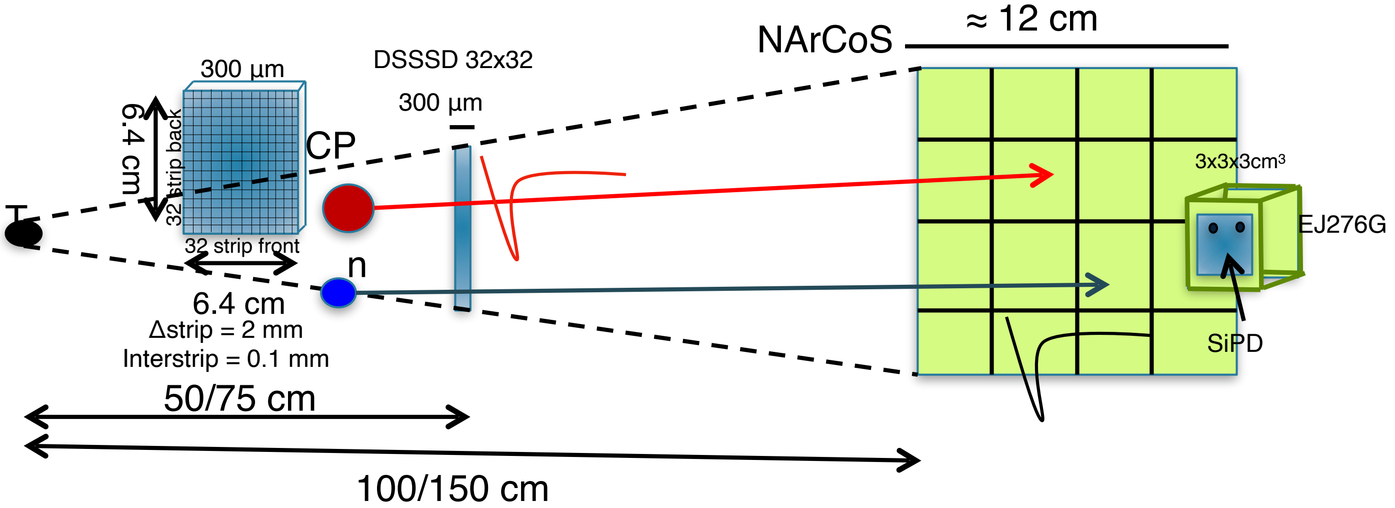
Detector

- Candidate: The plastic scintillator EJ276-Green Type (ex EJ299-33) ($3x3x3cm^3$)
- 1 cluster: 4 consecutively cubes -> $3x3x12\ cm^3$
- Neutron detection efficiency ≈ 50% for the prototype
- Reading the light signal: Si-PM and digitalization
- Modular, reconfigurable (in mechanic and electronic)
- Discrimination of n/γ from PSD (but also light charged particles)
- Energy measurement from ToF ($\Delta t \leq 0.5$ ns with $L_{ToF} \approx 1 \div 1.5$m)

TOF measured using the RF of the CS or with an ancillary MCP (low intensity exotic beams)

Physic cases

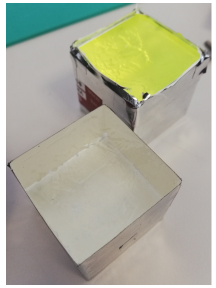
- Neutron-particles correlations (HBT)
- Reaction Dynamics and time scale
- Symmetry Energy in EoS of nuclear matter
- Nuclear structure of unbound exotic nuclei
- In medium nuclear interaction
- Nuclear astrophysics (neutron stars and nucleosynthesis processes)
- Medical application (neutron production cross section, differential cross sections)

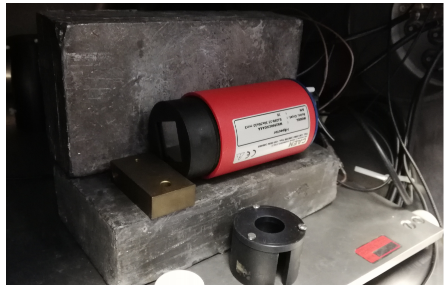


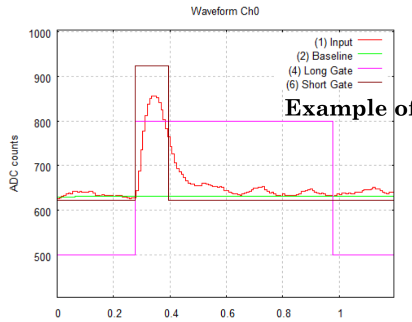
PSD studies using sources

- **Detector Configurations:**
  - EJ-276G + PMT
  - EJ-276 + i-Spector
  - EJ-276G + i-Spector
- **Lab measurements with radioactive sources:**
  - Vacuum Chamber
  - Pb shield
  - Gamma sources: ^{133}Ba, ^{137}Cs, ^{60}Co, ^{152}Eu
  - Alpha source: ^{241}Am
  - Digitizer from CAEN

E.V.Pagano, G. Politi, A. Simancas et al., in preparation



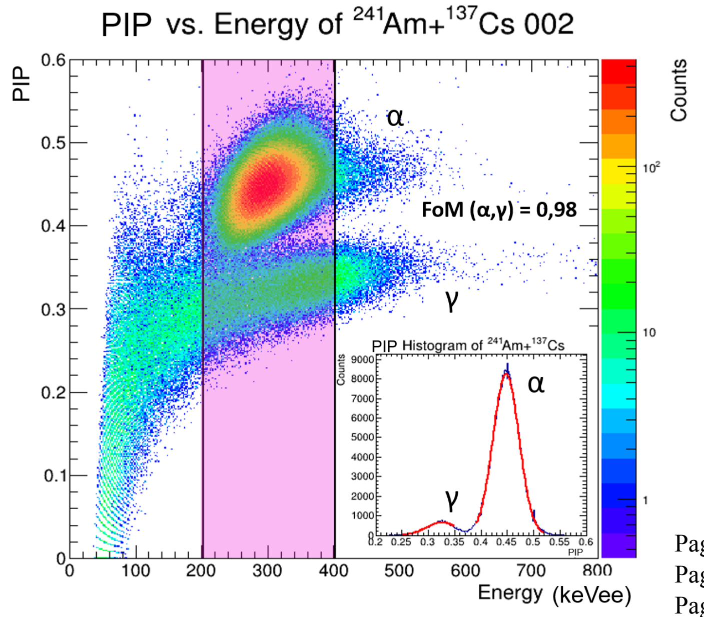




Example of signal and integration windows

Particle Identification Paramenter

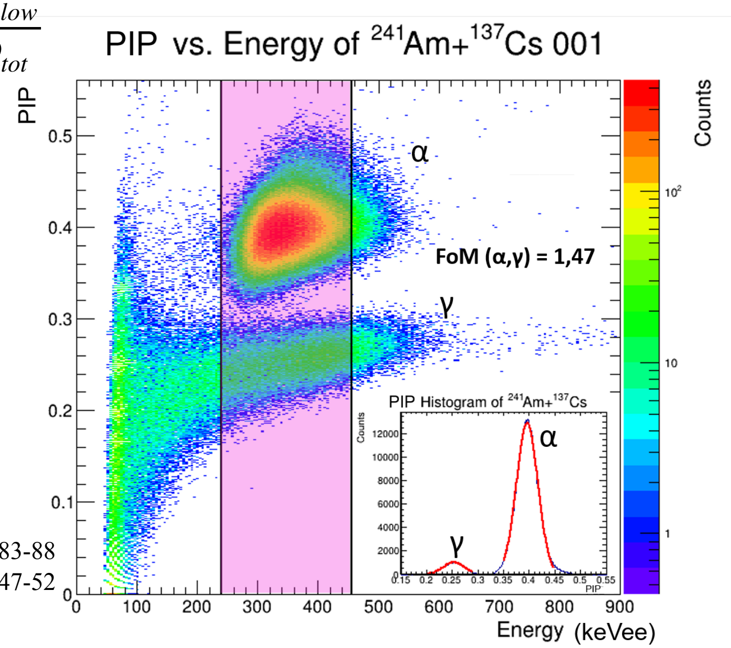
$$PIP = 1 - \frac{Q_{fast}}{Q_{tot}} = \frac{Q_{slow}}{Q_{tot}}$$



EJ-276 + i-Spector

Results

Detector	FoM
i-Spector + EJ-276	0.98
i-Spector + EJ-276G	1.47
PMT + EJ-276G	1.03



EJ-276G + i-Spector

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