Virtual Conference
iThemba LABS, South Africa
20 - 24 September 2021
https://indico.tlabs.ac.za/event/101/

# Recent test on the construction of a new correlator for neutrons and charged particles

# NArCoS

## (Neutron Array for Correlation Studies)


E. V. Pagano[1*], G. Cardella[2], E. De Filippo[2], E. Geraci[2,3], B. Gnoffo[2,3], C. Guazzoni[4], C. Maiolino[1], N.S. Martorana[1,3], A. Pagano[2], S. Pirrone[2], G. Politi[2,3], F. Rizzo[1,3], P. Russotto[1] and M. Trimarchi[2,5].

[1]INFN, Laboratori Nazionali del Sud, Catania, Italy
[2]INFN, Sezione di Catania, Catania, Italy.
[3]Dipartimento di Fisica ed Astronomia, Università di Catania, Catania, Italy.
[4]Politecnico di Milano, Dip. Elettronica, Informazione e Bioingegneria and INFN sez. Milano, Italy.
[5]Dipartimento di Scienze MIFT, Università di Messina, Messina, Italy.
*epagano@lns.infn.it

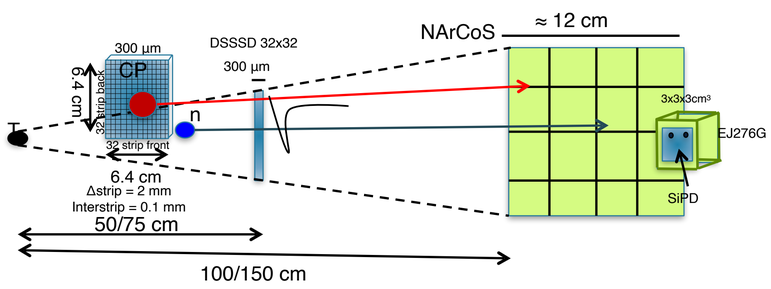


**Abstract:** With the advent of new facilities for radioactive ion beams mainly rich in neutrons, SPES @ LNL, FRAISE @ LNS and FAIR @ GSI only to give some examples, the detection of neutrons among charged particles in Heavy radioactive Ion collisions became mandatory, with high angular and energy resolutions, and the construction of new detection systems suitable for this esperimenta purpose became important.
The contribution will illustrate the results of recent tests performed on new plastic material the EJ276 both in the "green-shifted" and in the ordinary version, coupled with PMT and Si-PMT. These experimental works are aimed at the construction of a prototype of a detector for neutrons and charged particles with high energy and angular resolution [1,2,3].

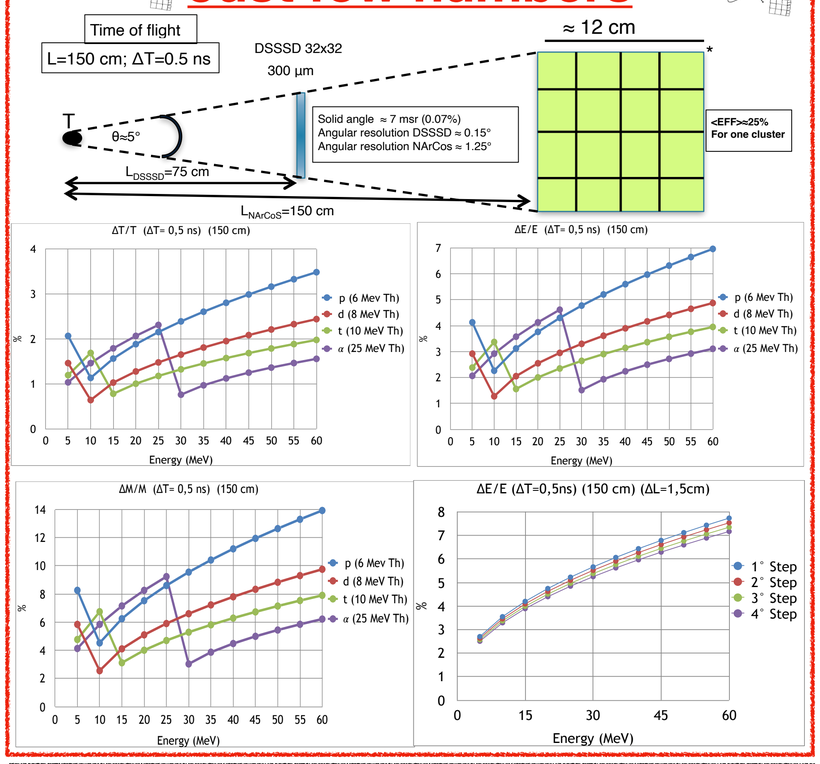

## IDEA

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

- Candidate: The plastic scintillator EJ276-Green Type (ex EJ299-33) (3x3x3cm³)
- 1 cluster: 4 consecutive cubes -> 3x3x12 cm³
- Reading the light signal: SSi-PM and digitalization
- Modular, reconfigurable (in mechanic and electronic)
- Discrimination of n/γ from PSD (but also light charged particles)
- Energy measurement from ToF (Δt≤1 ns with $L_{ToF}$≈1÷1.5m)
  TOF measured using the RF of the CS or with an ancillary MCP (low intensity exotic beams)

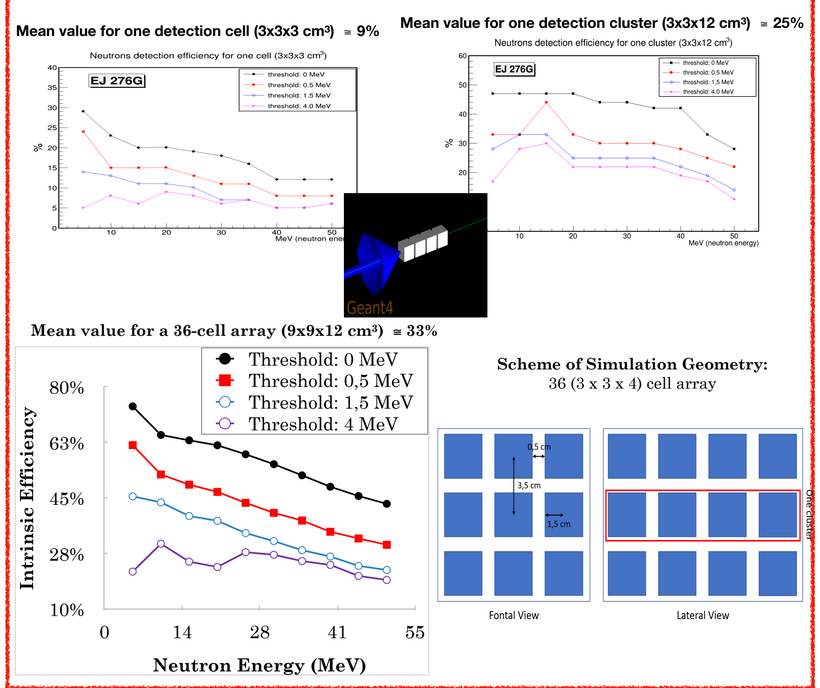



## Just few numbers




## Efficiency calculation (GEANT4)

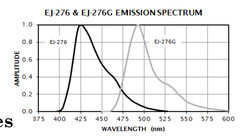
GEANT 4 simulation in order to estimate the neutron detection efficiency




## Recent results: Test with radioactive source @LNS

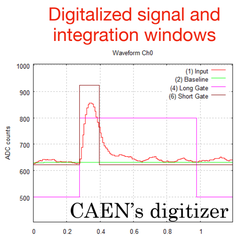
(low background condition )

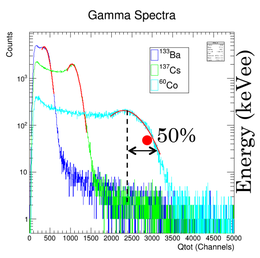

- **Detectors configurations**
  - EJ-276G + PMT
  - EJ-276 + i-Spector
  - EJ-276G + i-Spector
- **Test by using radioactive sources**
  - Vacuum Chamber
  - Pb shield
  - Gamma sources: 133Ba, 137Cs, 60Co, 152Eu
  - Alpha source: ²⁴¹Am
  - Digitizer from CAEN




i-Spector of CAEN (3x3 cm SiPM and electronics)

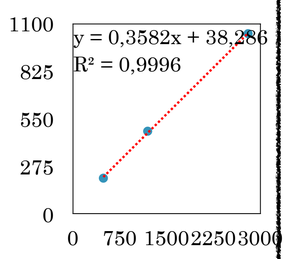
Digitalized signal and integration windows



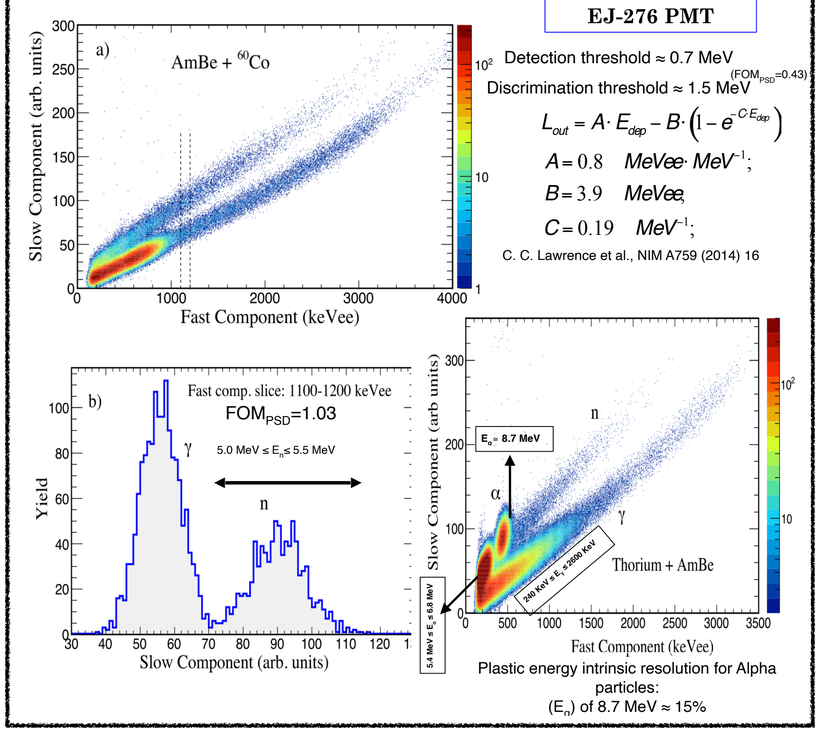

EJ-276G + i-Spector

Good linearity in energy calibration




## Some results: Discrimination/resolution

E. V. Pagano et al. NIM A 889 (2018) 83-88

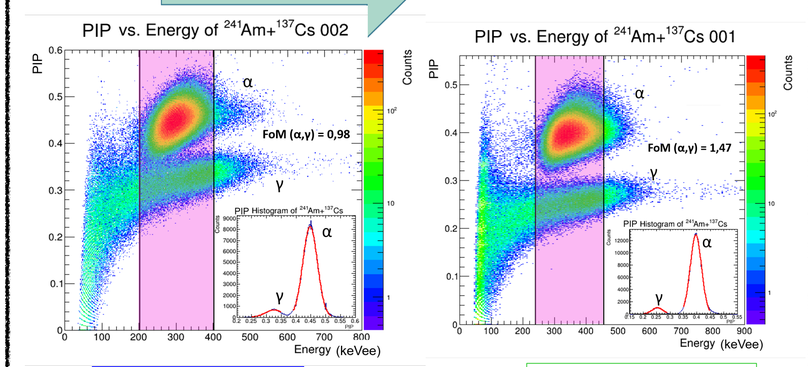



C. C. Lawrence et al., NIM A759 (2014) 16

## Some results: PSD comparison

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

PIP = Particle Identification Parameter

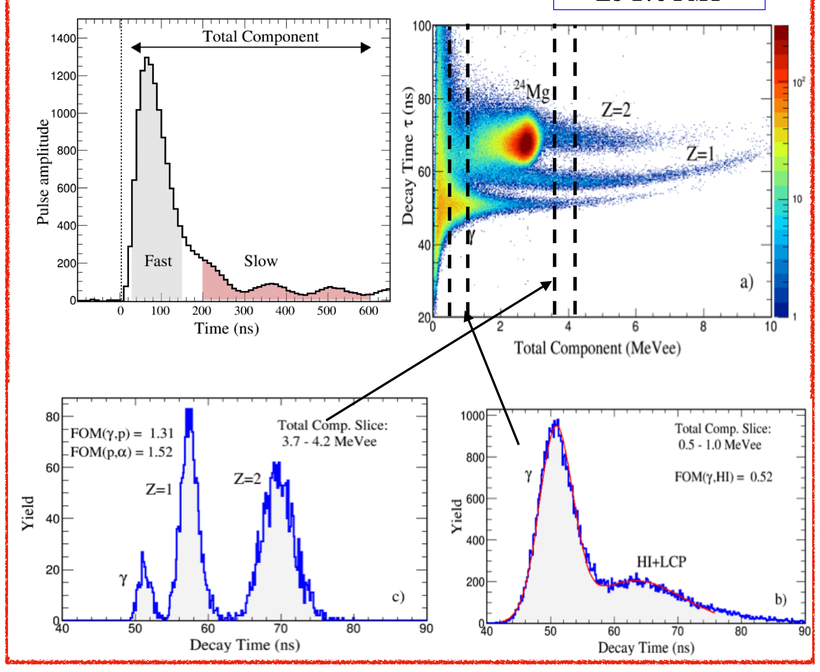



| Detector | FoM |
|---|---|
| i-Spector + EJ-276 | 0.98 |
| i-Spector + EJ-276G | 1.47 |
| PMT + EJ-276G | 1.03 |

## tests in high background condition

The test was done during the Barrier experiment @ LNS ²⁴Mg+⁹⁰,⁹²Zr @ 71.5MeV < E < 81 MeV

E. V. Pagano et al. NIM A 905 (2018) 47-52

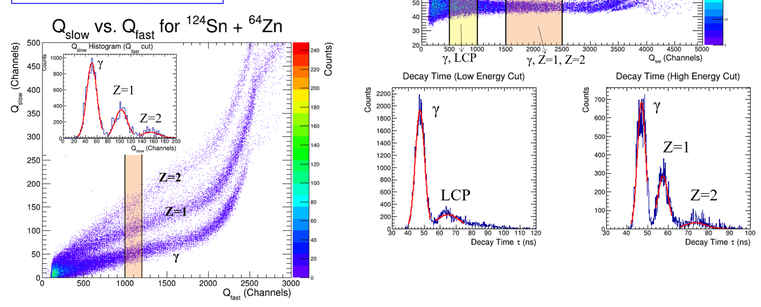



## tests in high background condition

CHIFAR exp @LNS (spokesperson:E.V. Pagano, E. De Filippo, P. Russotto)

- **Data analysis of heavy ion reactions:**
  - CHIMERA scattering chamber (LNS)
  - Detector at 11° in lab frame
  - Beam: ¹²⁴Sn at 20 MeV/A (CHIFAR experiment)
  - Targets: ⁶⁴Zn and ⁶⁴Ni
  - GET digital electronics

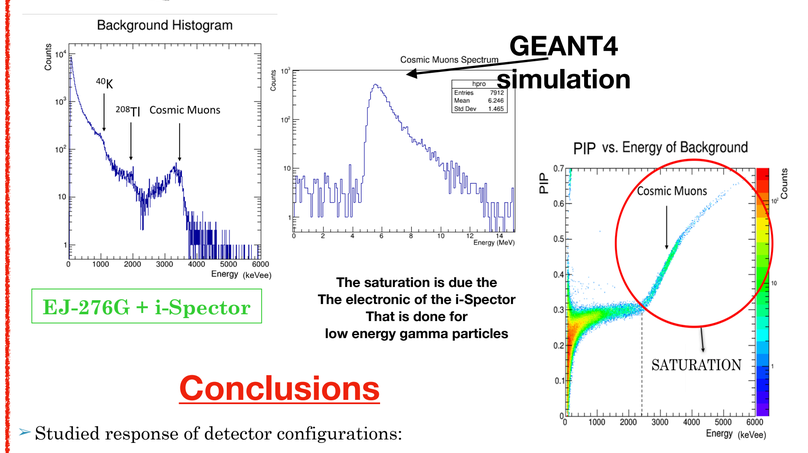
EJ-276 + i-Spector




| PSD Method | FoM(γ, Z=1) | FoM(Z=1, Z=2) | FoM(γ, LCP) |
|---|---|---|---|
| Integration | 1.08 | 0.78 | - |
| Decay Time | 0.95 | 0.87 | 0.71 |

LCP = Light Charged Particles
Neutrons included in Z=1

## background measurements (Without Pb shield)




## Conclusions

- Studied response of detector configurations:
  - Lab experiment with radioactive sources (low background):
    - Good linearity in light output between 207 - 1041 keVee
    - Good quality of PSD, specially for **EJ-276G + i-Spector** with FoM(α,γ) = 1.47
    - Pulse saturation due to signal processing electronics
  - Data analysis of heavy ion reactions (high background):
    - Good PSD capabilities studied through two techniques
- GEANT4 Simulation: ~33% neutron efficiency for 36-cell array at 1.5 MeV threshold


[1] E. V. Pagano et al. NIM A 889 (2018) 83-88
[2] E. V. Pagano et al. NIM A 905 (2018) 47-52
[3]E. V. Pagano et al., Proc. 13th Int. Conf. on Nucleus-Nucleus Collisions JPS Conf. Proc. 32, 010096 (2020)