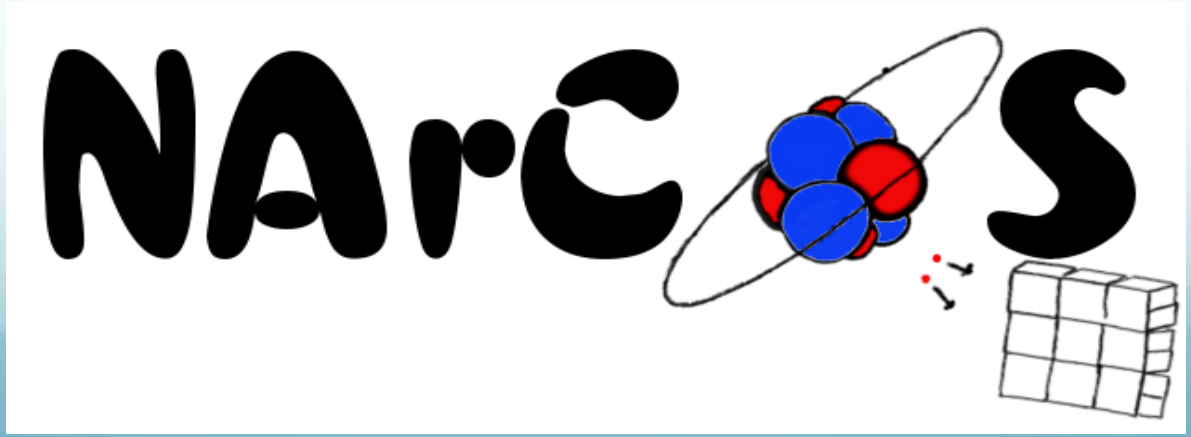
IWM-EC 2018
International Workshop on
Multi facets of Eos and Clustering
22-25 May 2018 *Dipartimento di Fisica e Astronomia & Laboratori Nazionali del Sud*
Catania, Italy
INFN
Istituto Nazionale di Fisica Nucleare

The NArCos project

(Neutron ARray for Correlation Studies)

E.V. Pagano[1] for NEWCHIM Collaboration

[1]INFN- Laboratori Nazionali del Sud



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E. V. Pagano
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Project's motivations

The advent of the new facility for RIBs
(in particular for the n-rich ones)

FAIR
Facility for Antiproton and Ion Research in Europe GmbH

FRIBS @ LNS

FRIB

GANIL
laboratoire commun CEA/DSM CNRS/IN2P3
Spiral2

SPES
exotic beams for science

Now, more than never, with the efforts of the international community to construct the new facility for the RIBs, we have more e more demanding for the simultaneous detection of charged particles and neutrons with high energy and angular resolution, in fact, in particular for the n-rich beams, neutrons assume a fundamental role, in the deep understanding of the property of the involved mechanism (both for dynamics and spectroscopy).

The neutron contribution reconstruction obtained by using reasonable assumptions and theoretical models validated for stable nuclei will be actually more and more questionable with RIBs.

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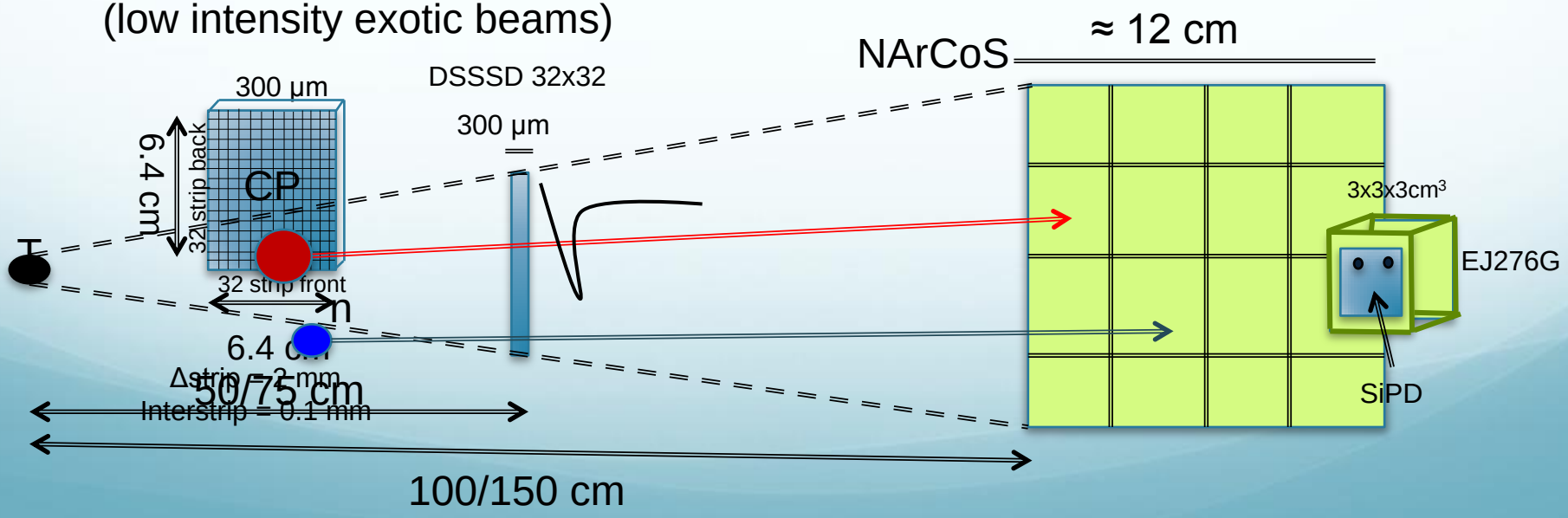
IDEA

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

- Candidate: The plastic scintillator EJ276G (ex EJ299-33) (3x3x3cm^3)
- 1 cluster: 4 consecutively cubes → 3x3x12 cm^3
- Reading the signal: Si-PD or 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 (Δt≤1.5 ns with L_{ToF}≈1÷1.5m)

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



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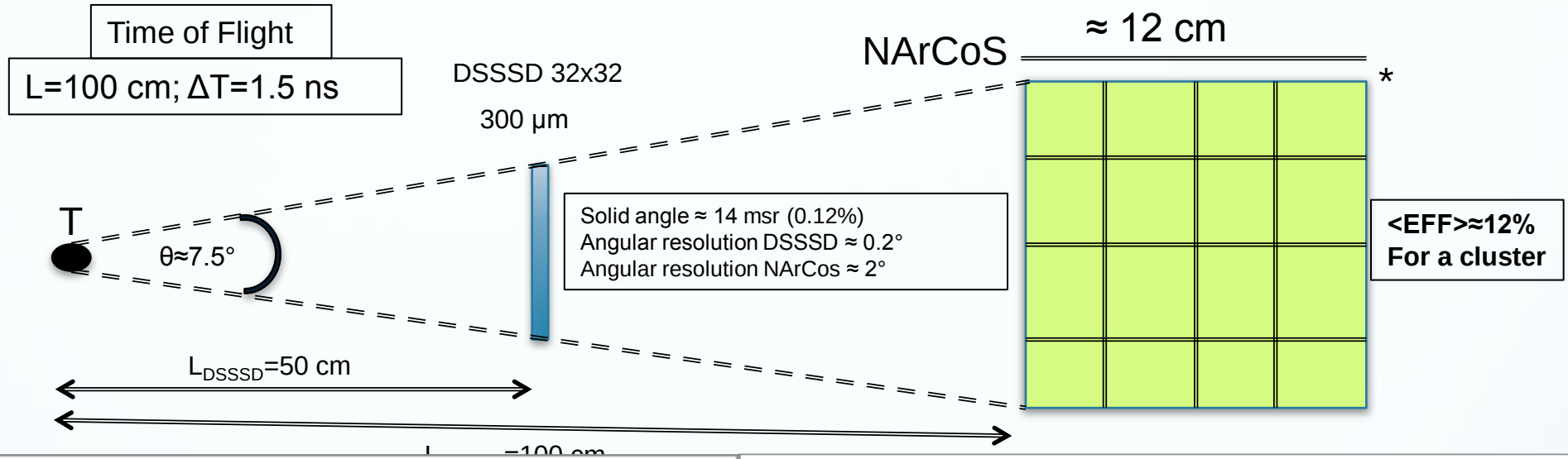
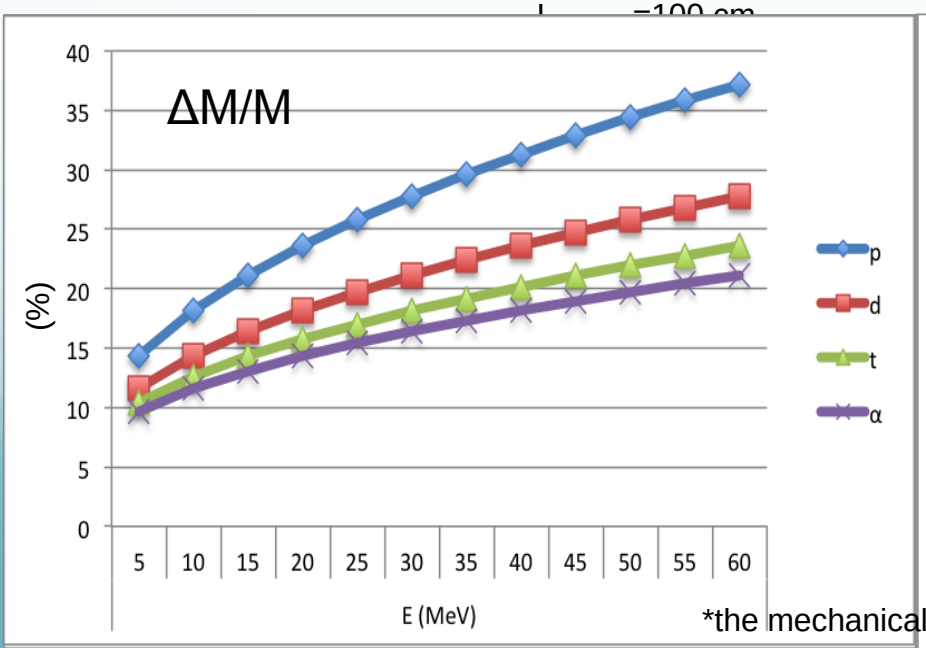
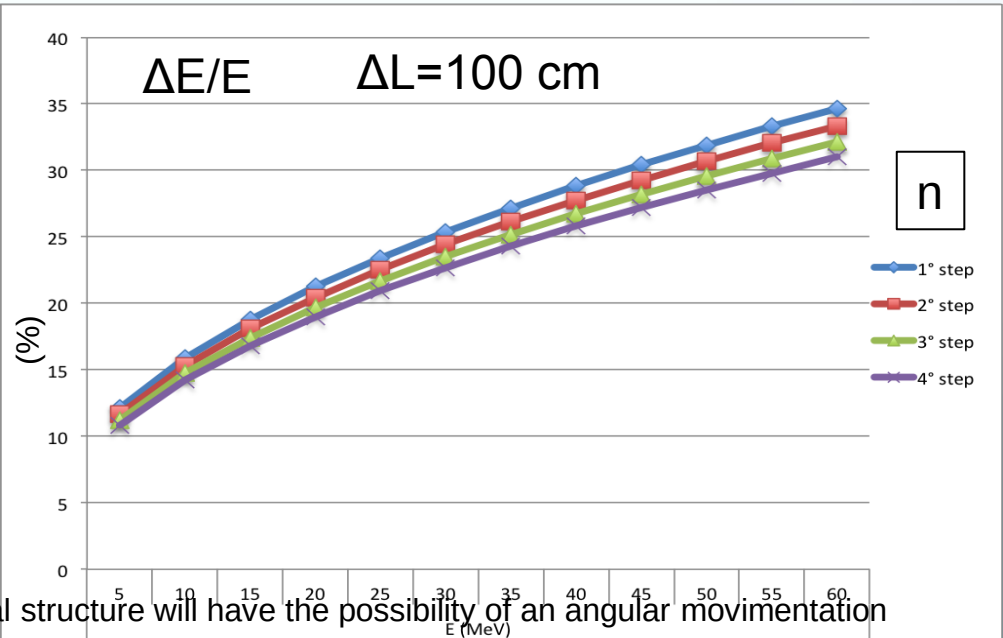
Just few numbers…







*the mechanical structure will have the possibility of an angular movimentation

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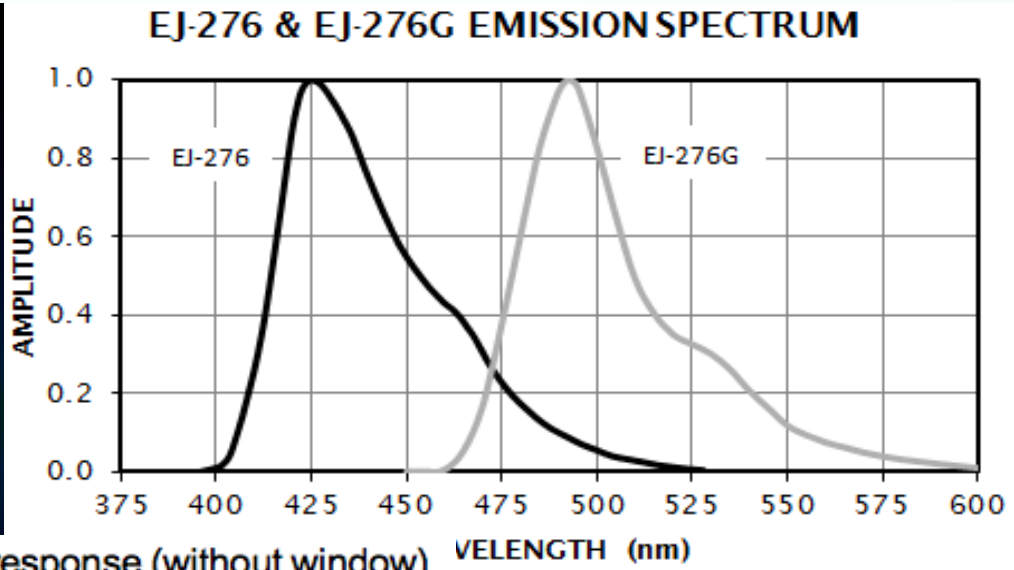
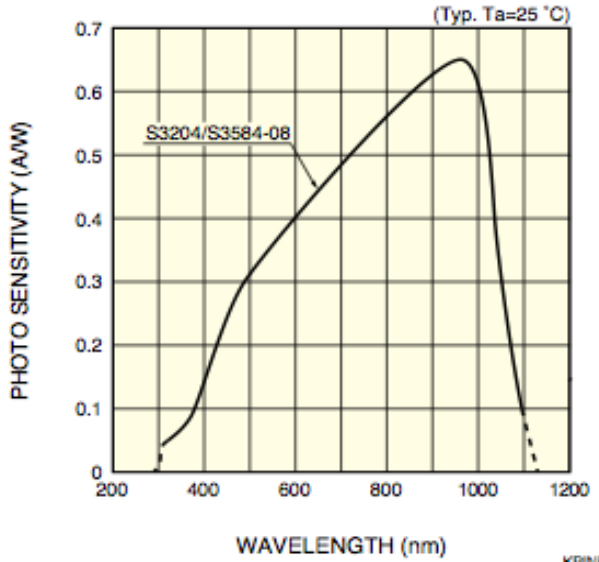
EJ-276G

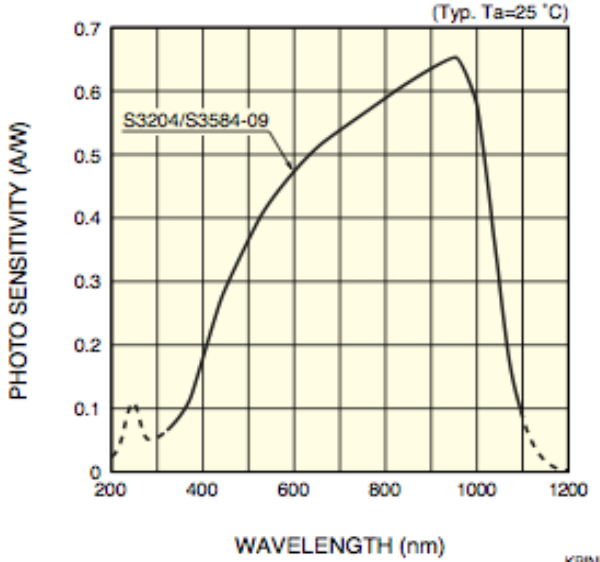
(ex EJ-299-33)

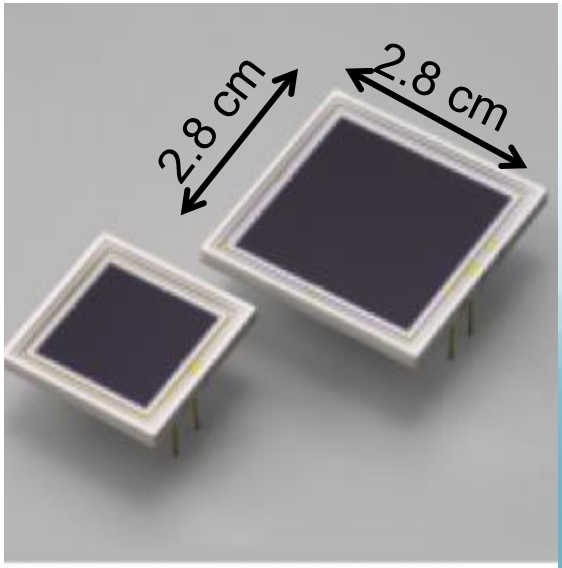


■ Spectral response



■ Spectral response (without window)





es are also available without window.

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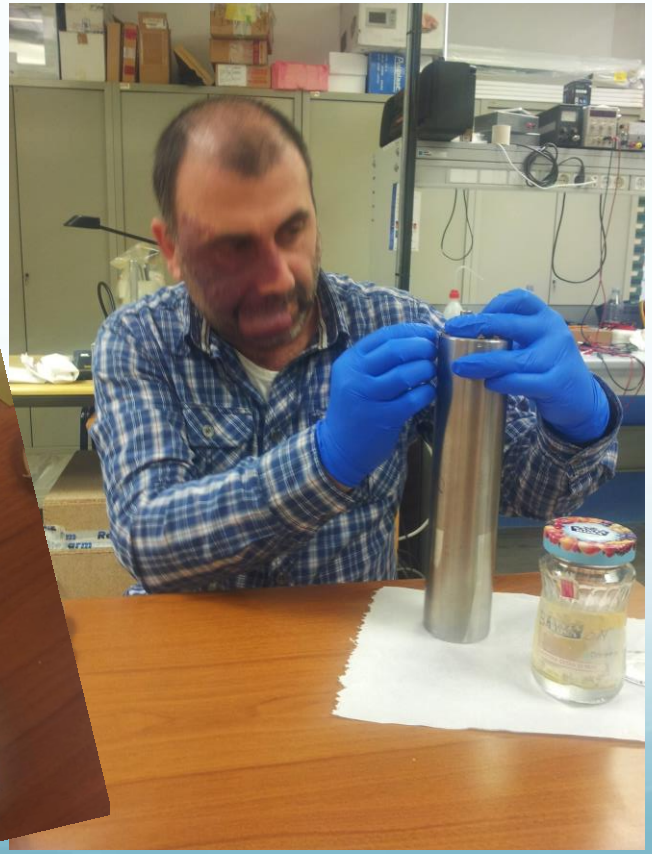
Some pictures: preparation

- Dimensions: 3x3x3 cm^3
- Average efficiency (from MCNPX) ≈ 3%
- Read by the PMtube: EMI-9544QA
- High Voltage: 1500-1700 V



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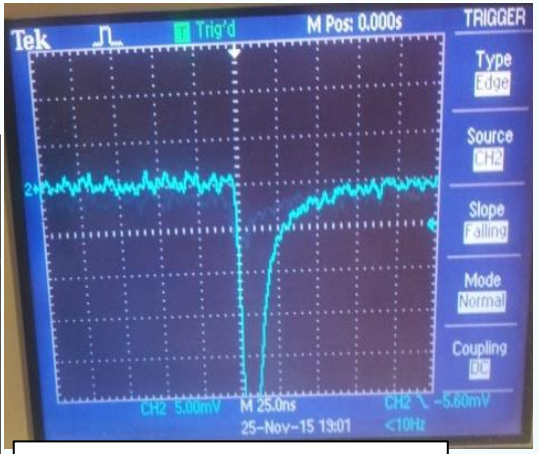
Some pictures: First tests using sources (controlled background condition)



PM -EMI 9954QA
Like in ARGOS detector

G. Lanzanó, et al NIM A 312, 3, (1992), 515-520

Sources:
1)γ ^{60}Co
2)α ^{241}Am
3)α ^{232}Th
4) n e γ AmBe

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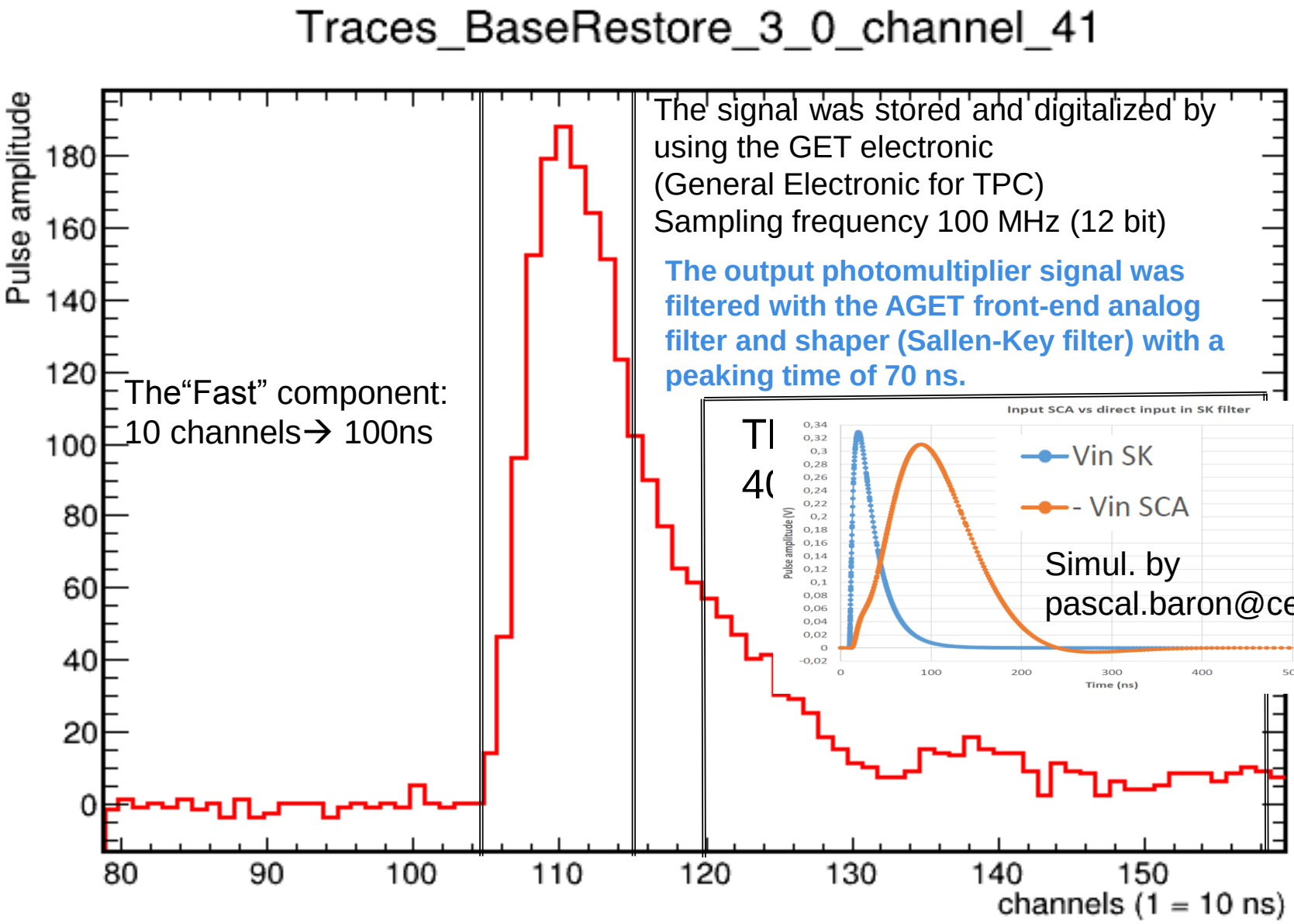
Some new results: the digitalized signal



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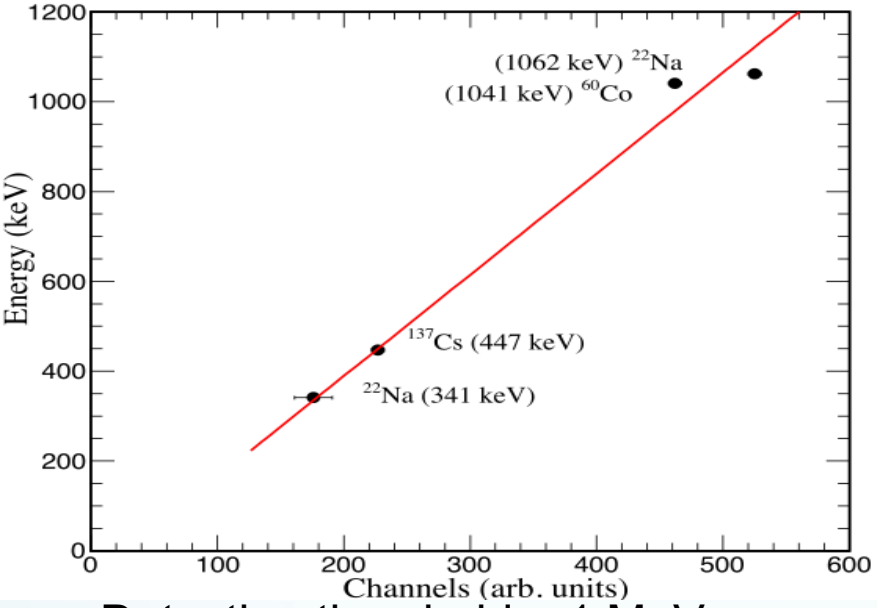
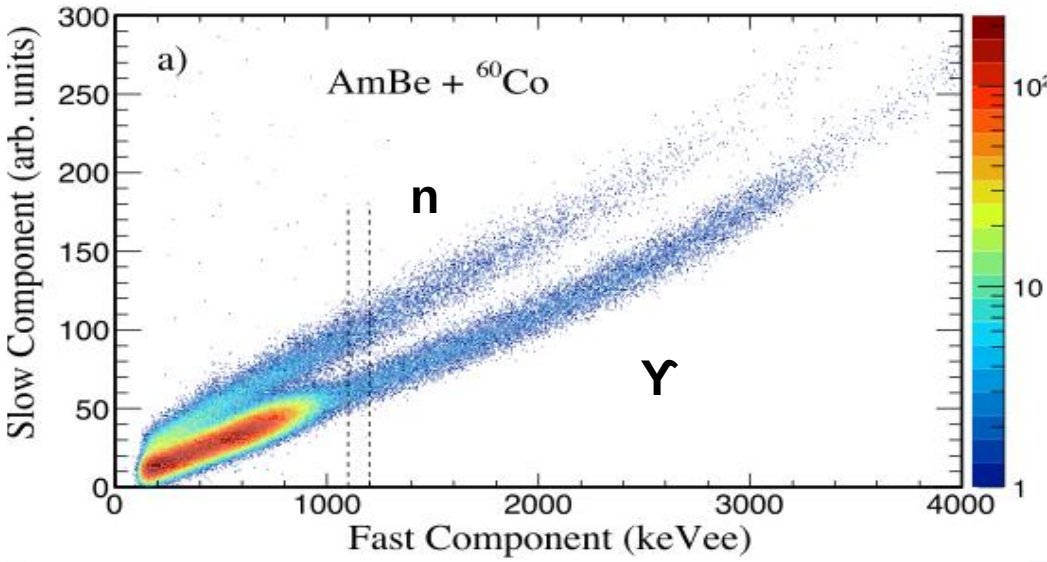
Some new results: some spectra

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





Detection threshold ≈ 1 MeV

Discrimination threshold ≈ 2.5 MeV

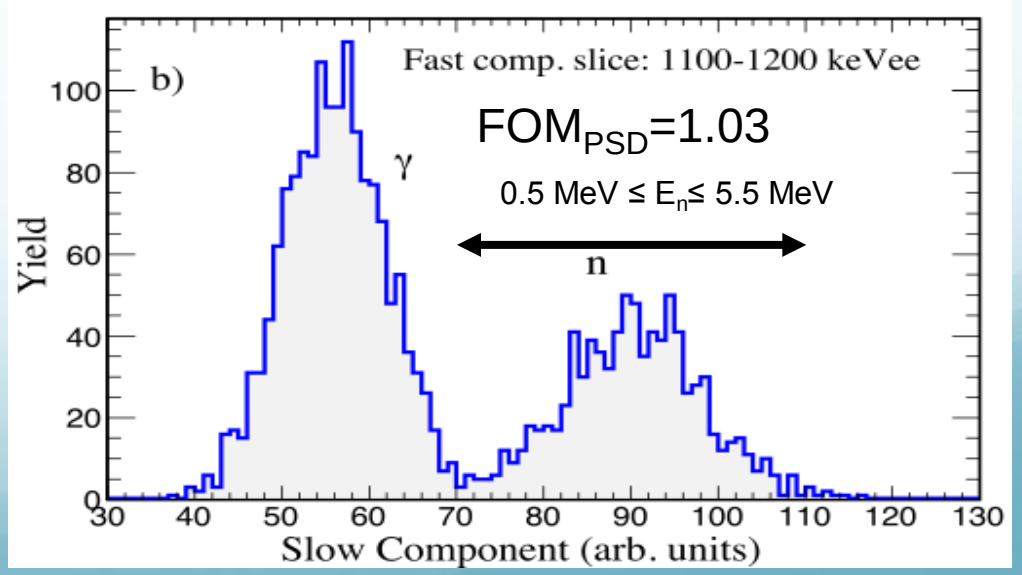
$$L_{out} = A \times E_{dep} - B \times \left(1 - e^{-C \times E_{dep}}\right)$$

$A = 0.8 \quad MeVee \times MeV^{-1}$;

$B = 3.9 \quad MeVee$;

$C = 0.19 \quad MeV^{-1}$;

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



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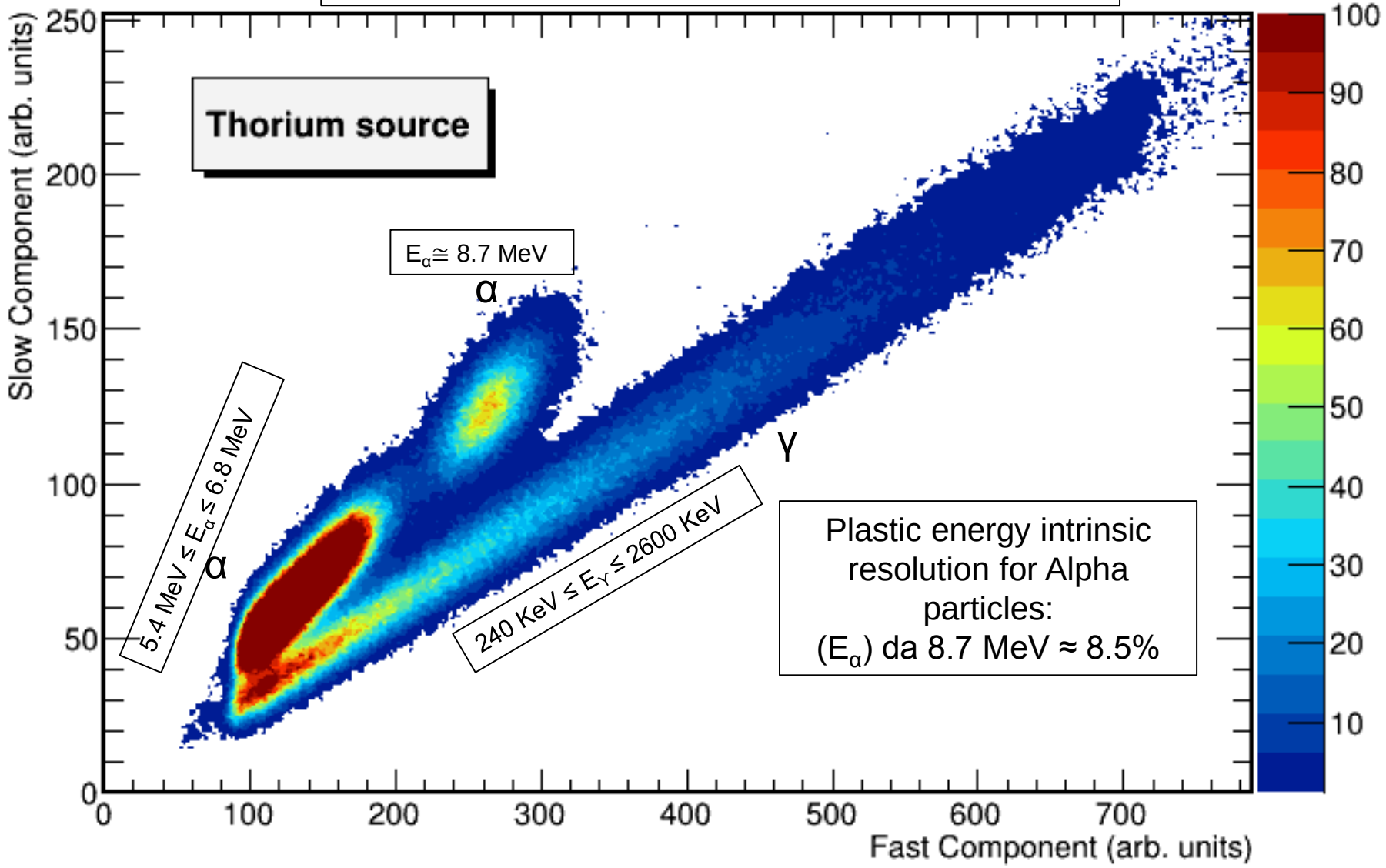

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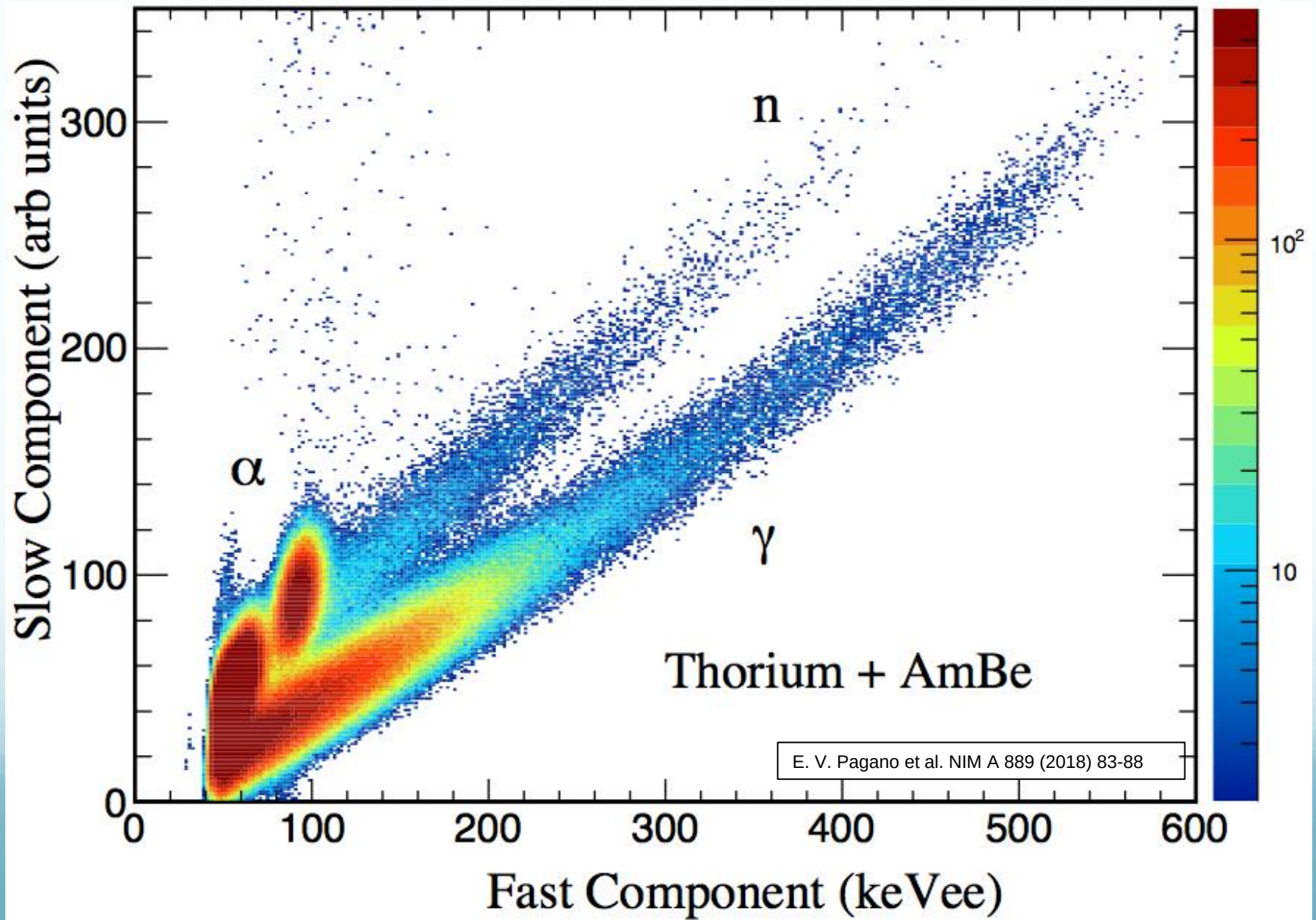

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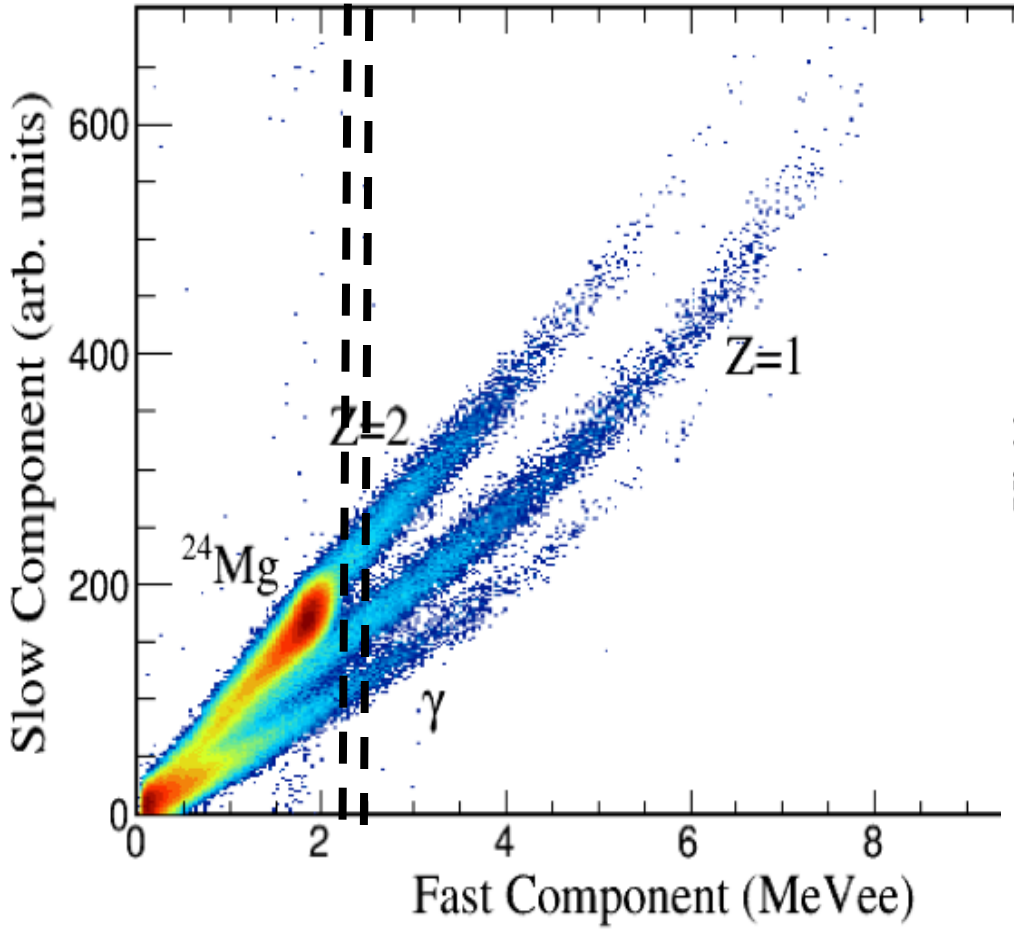
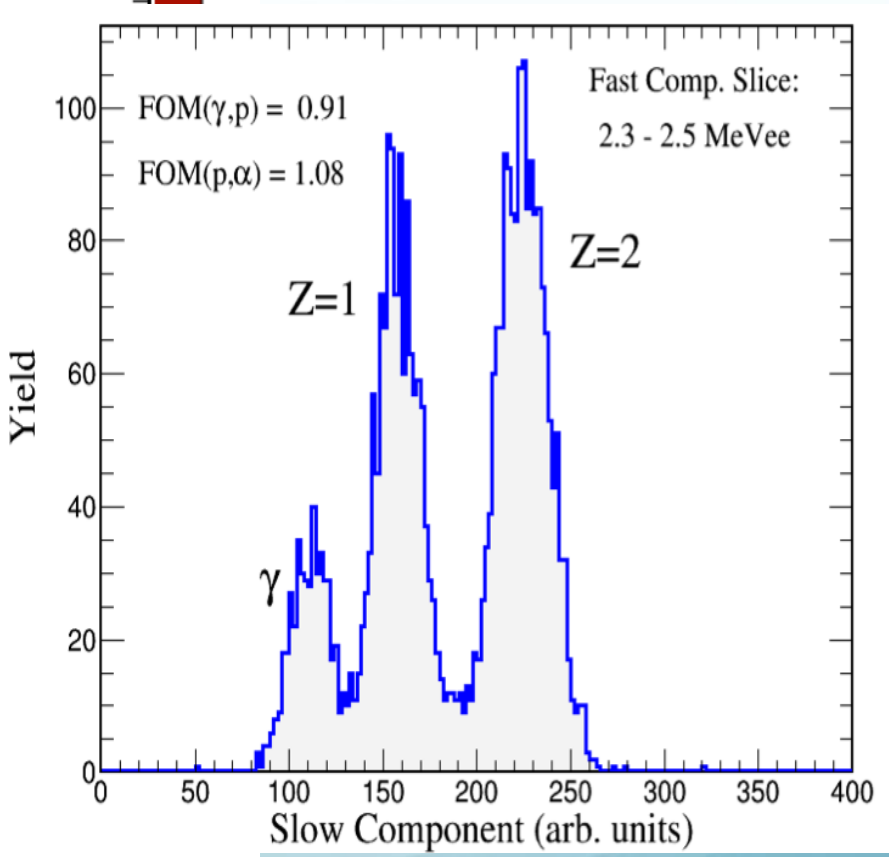
Latest results: test in high background condition

Test performed during the Barier experiment $^{24}Mg+^{90,92}Zr$ @ 71.5MeV < E< 81 MeV (@ LNS)

E. V. Pagano et al. NIM A accepted





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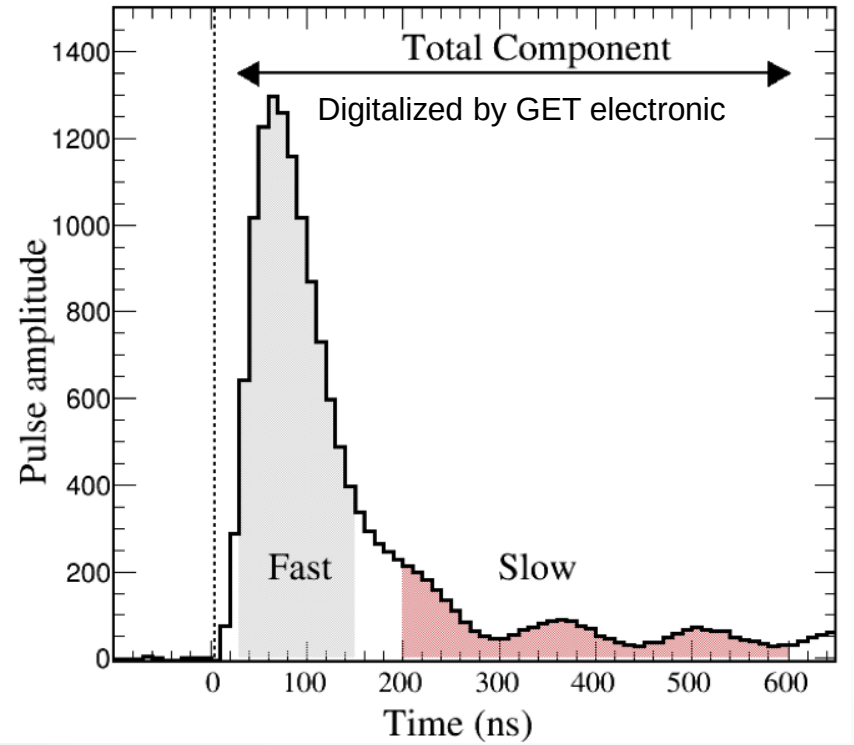
Latest results: High test in high background condition

E. V. Pagano et al. NIM A accepted



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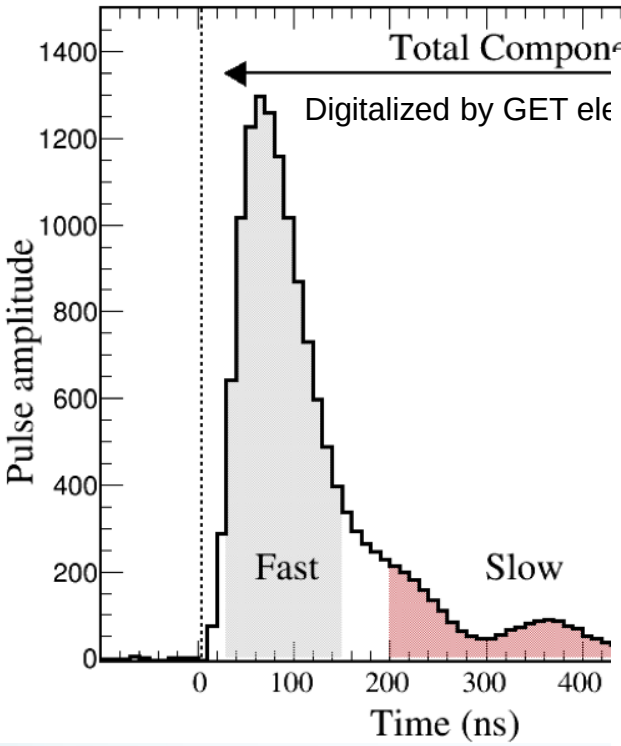

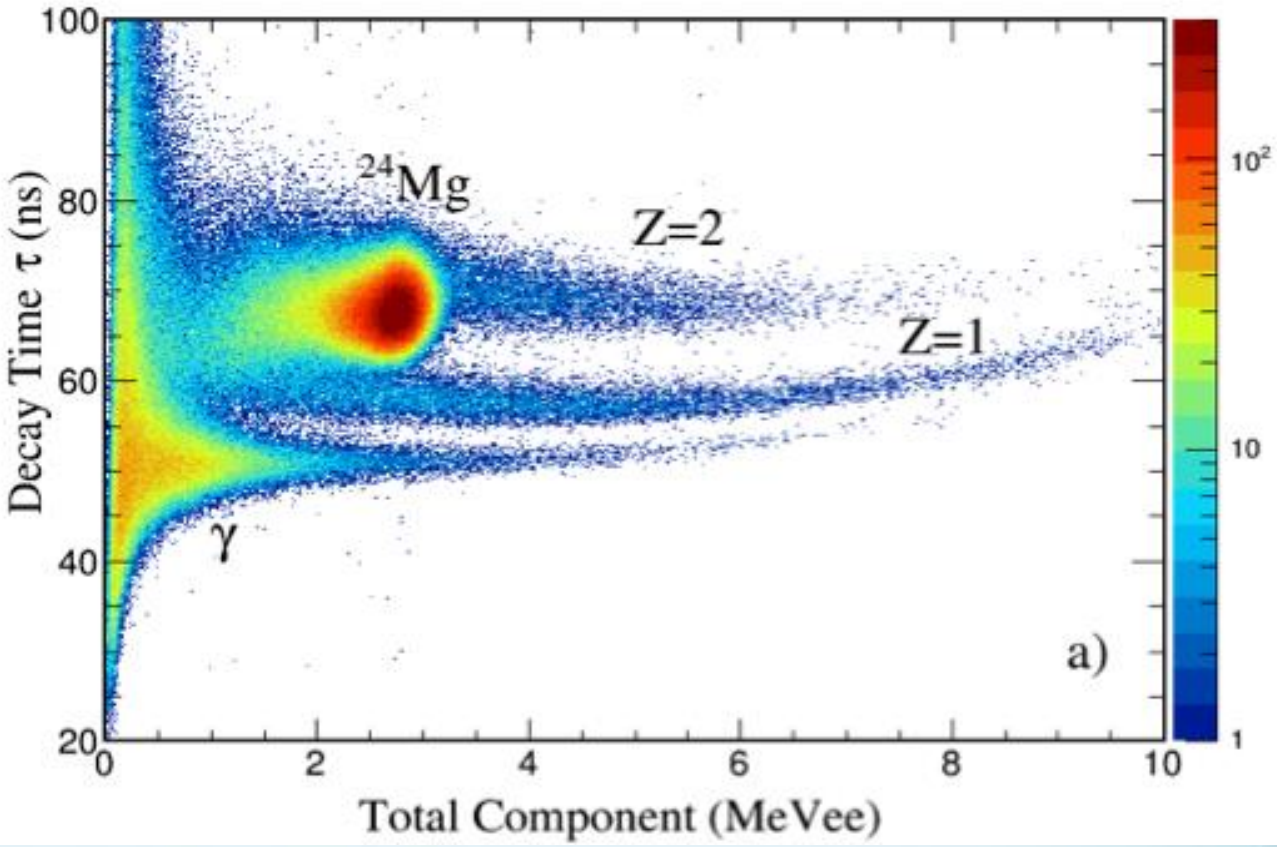

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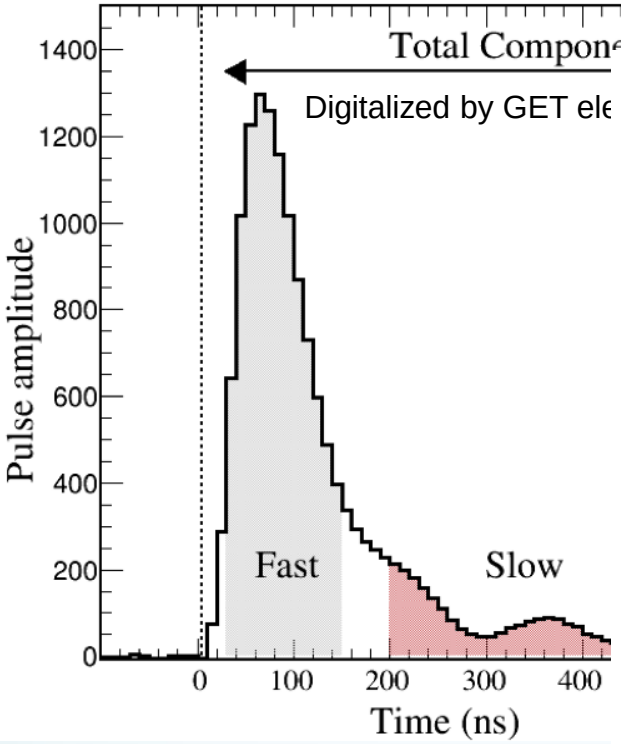

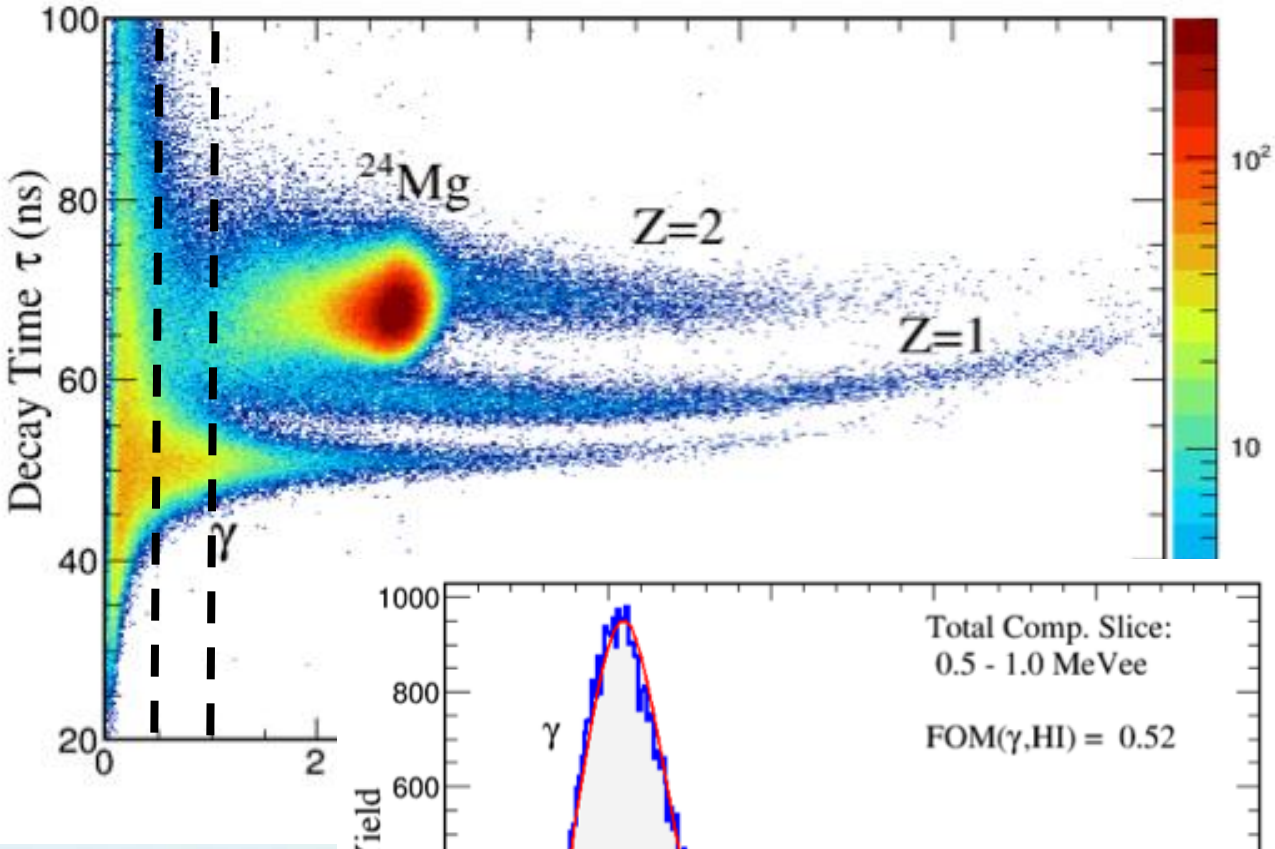

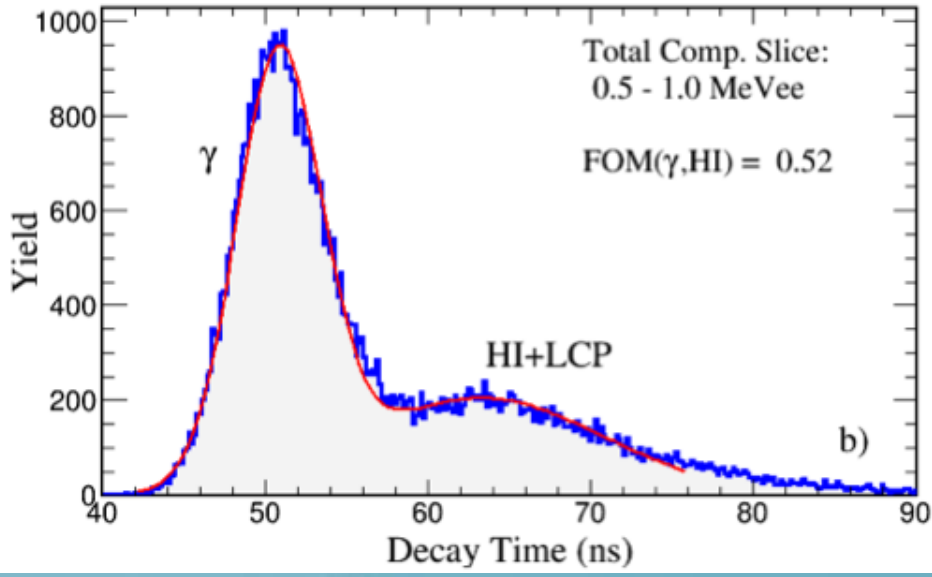

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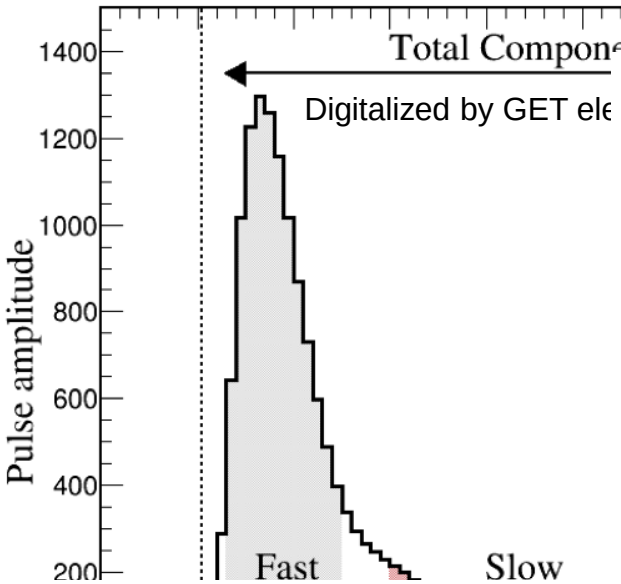

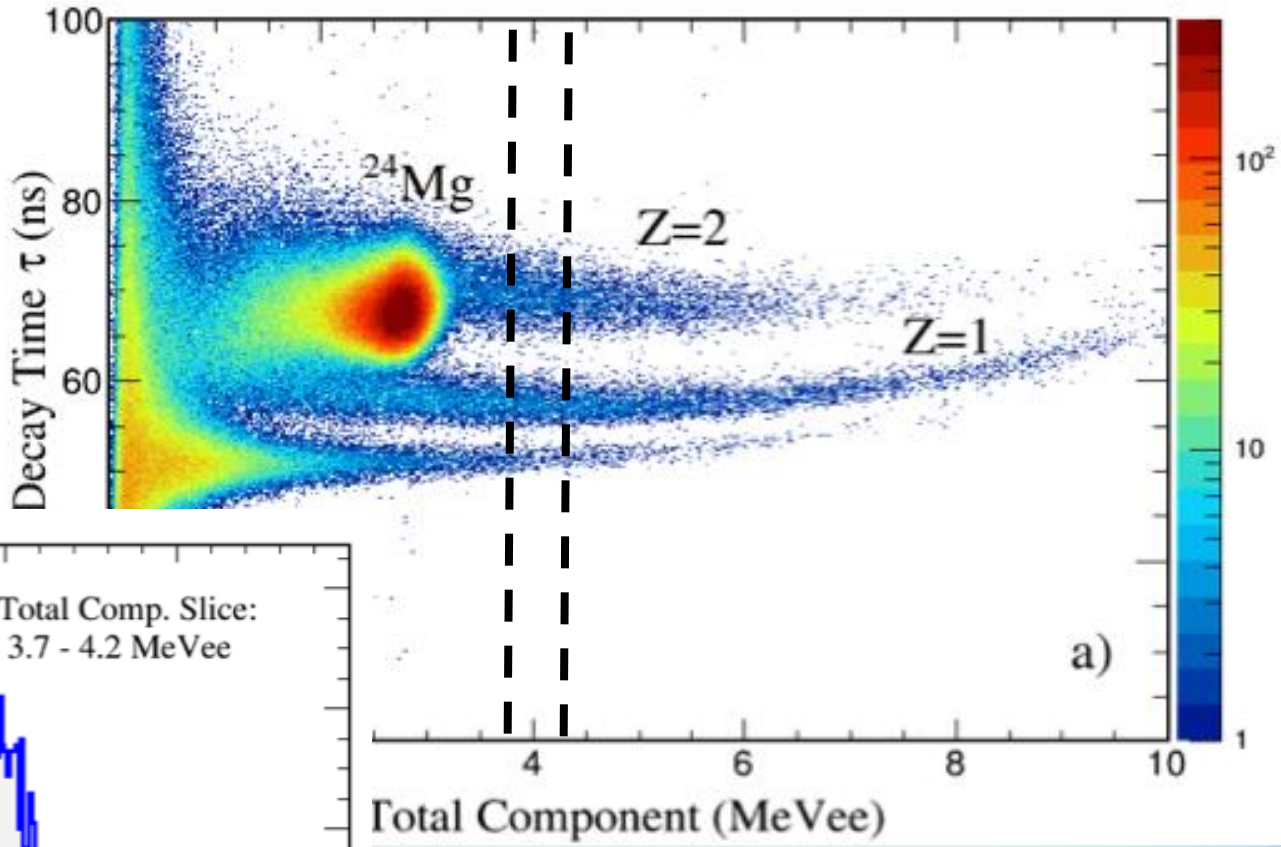

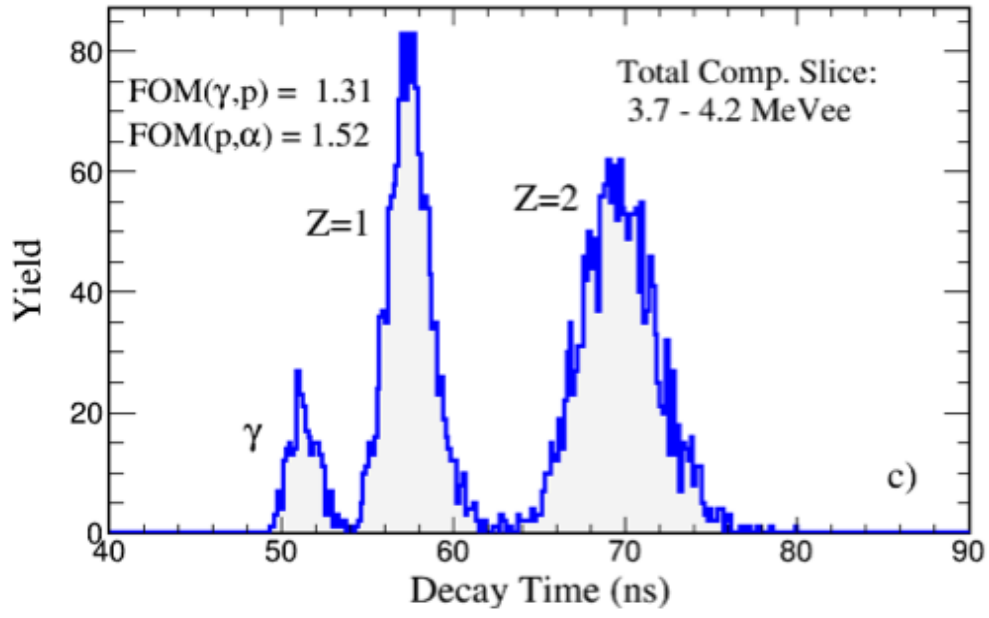

Purposes of the project

Energy of interest: 5≤ E ≤100 AMeV (having particular attention to the Fermi regime)

Fundamental nuclear physic

- Intensity interferometry (HBT effect)
  n-n, n-p, n-LCP, n-IMF, n-TLF, n-PLF
- Studies related to the nuclear symmetry energy (EOS) and its dependence to the nuclear density
- Neutron stars (nuclear astrophysics)
- Reaction mechanism
- Reaction times
- Clustering
- Validation of nuclear dynamics model (BUU,QMD)
- Measurements of the neutron signal in the n-rich RIBs (SPES, SPIRAL2, FRIB, FAIR)

Some applications

- Radioprotection
- Measurement of neutron flux (single measurement, cross section)
- Validation of MC based code (GEAN4, MCNPX)

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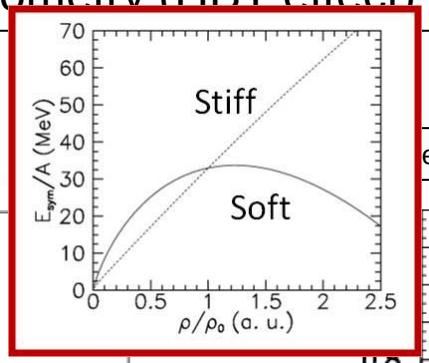
Purposes of the project: a few example for the fundamental nuclear physic

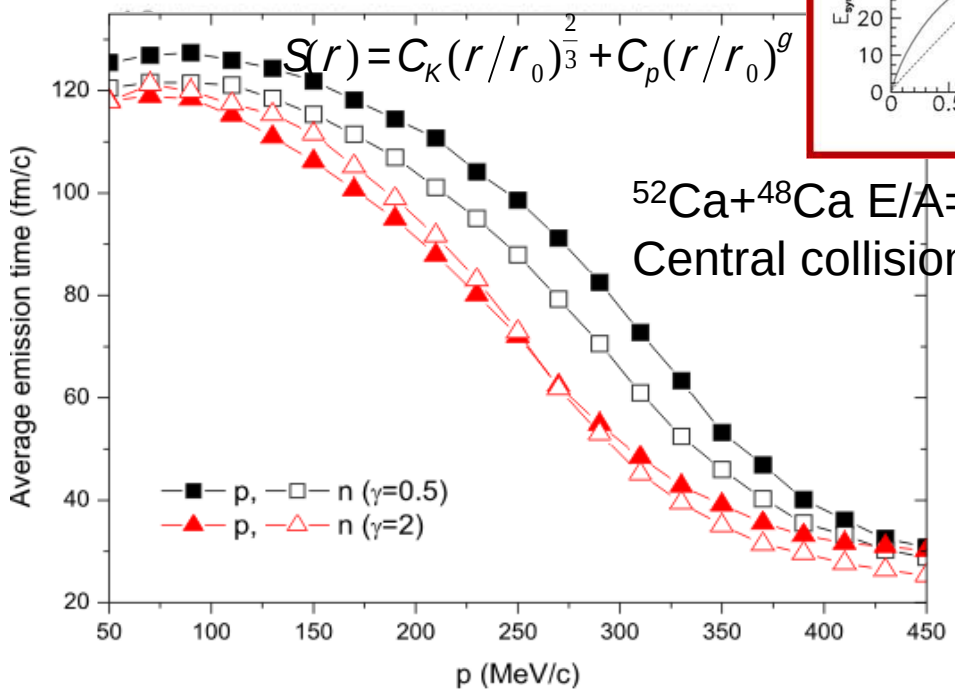
Intensity interferometry (HBT effect)

Correlation functions

$1+$

N. Colonna et al., PRL **75**, 23 (1995) 4190-4193

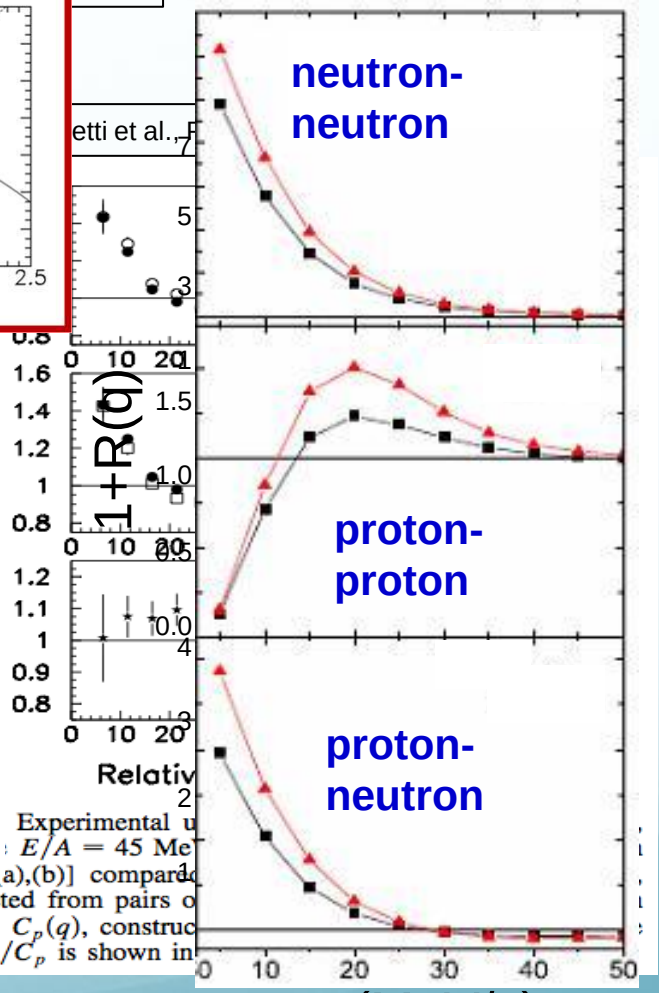




$^{52}Ca+^{48}Ca$ E/A=80MeV
Central collision

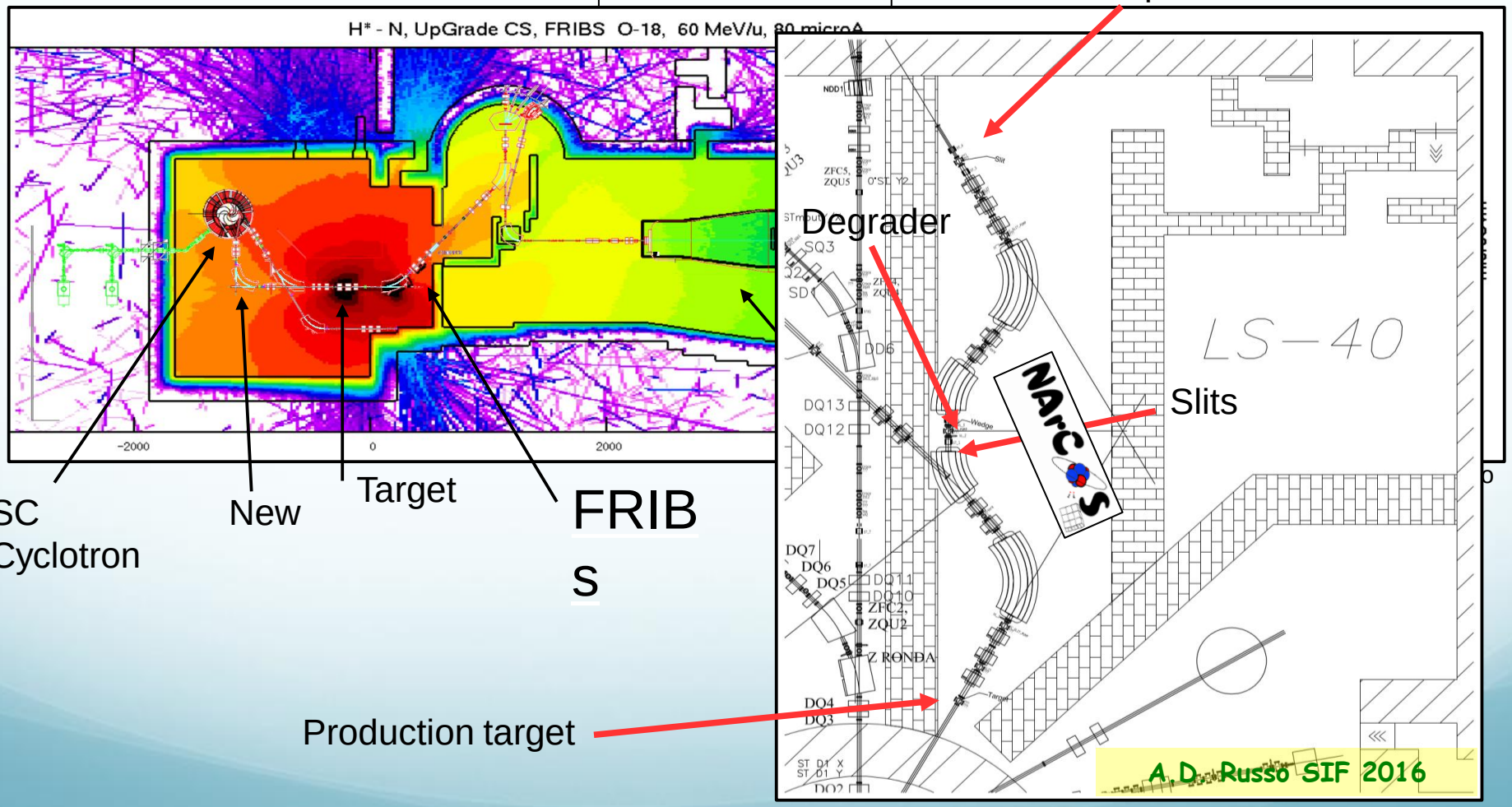
Lie-Wen Chen et al., PRL (2003); PRC(2005)

FIG. ... on the total neutron pair momentum in the compound nucleus frame. The solid and dashed curves are results of theoretical calculations with the indicated emission time scales.



Purposes of the project: a few example applications

FRIBS @ LNS



Purposes of the project: a few example applications

Anti-cancer therapy:
Risk of secondary radio-induced cancers

In proton therapy, in particular in the paediatric one (but not only), the “damage” caused from neutrons to the healthy cells is one of the causes of the so called “ secondary radio-induced tumors” in particular if there are used degraders or collimators (passive technique)[1].

[1] Hall, E. J (2006) Intensity-modulated radiation therapy, protons, and the risk of second cancers.
Int J Radiat Oncol Biol Phys 65: 1-7.

Validation of Monte Carlo codes

Measurement of cross sections ($d^2\sigma/d\theta dE$) have a huge interest for the validations of Monte Carlo code like GEANT4 in particular for neutrons in the Fermi energy regime

External interest for the project

MIFT DIPARTIMENTO DI SCIENZE MATEMATICHE E INFORMATICHE SCIENZE FISICHE E SCIENZE DELLA TERRA

UNIVERSITÀ DEGLI STUDI DI MESSINA

Prof. Salvatore Magazù
Full Professor of Experimental Physics
Dipartimento di Scienze Matematiche e Informatiche, Scienze Fisiche e Scienze della Terra
Università di Messina
Viale Ferdinando Stagno D'Alcontres n°31, S. Agata, P.O. Box: 55, 98166 Messina, Italy
Phone: +39 090 6765025
Fax: +39 090 395004

Messina, 6th July 207

DECLARATION

To whom it may concern, in charge of Full Professor of Experimental Physics since 2002 at the Department of Mathematical and Computer Science, Physical Sciences and Earth Sciences of the Messina University (Italy), of President of the Interuniversity Consortium for Applied Physics, of previous chairman of the Scientific Committee on Glass Forming Systems at the European Synchrotron Radiation Facility (ESRF, Grenoble), member of several Scientific Committees of synchrotron radiation and neutron scattering at ESRF and at Institute Laue Langevin (ILL, Grenoble), and member of the italian team for the neutron scattering project VESPA for the European Spallation Source, I strongly support the project leaded by Dr. Emanuele Pagano and I declare that the portable neutron source hosted at the Department of Mathematical and Computer Science, Physical Sciences and Earth Sciences of the Messina University is available for all the experimental tests requested in the project Dr. E. Pagano will be dealing with.

Prof. Salvatore Magazu'

Science & Technology Facilities Council

Science and Technology Facilities Council

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Italy

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Mobile +44 (0) 7712403568
E-mail triestino.minniti@stfc.ac.uk

Date: 10-July-2017

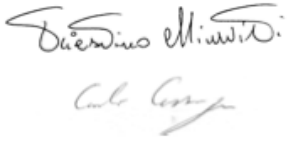
Research Project: Neutron Array for Correlations Studies (NArCoS)

The aim of the "Neutron Array for Correlations Studies" (NArCoS) research project focuses on the development of a neutron detector prototype for neutron spectroscopy. We believe that it will benefit from the experience about neutrons detection that is available at the ISIS spallation neutron source (UK) and from the availability of neutron beam time required for testing purpose. Moreover, this project can represent a further extension in neutron detection for applications at ISIS and in general for neutron spallation sources.

For these reasons, we are pleased to express with this letter our interest and research involvement.

Yours sincerely,

Dr. Triestino Minniti
Dr. Carlo Cazzaniga
Staff Scientist, STFC



CONCLUSIONS

In this talk the necessity to integrate neutrons detection and charged particles in the same detection cell has been discussed in view of reaction studies at Fermi energy with both stable and exotic beams.

An example of single detection cell, such as an EJ276 (ex-Ej-299-33) plastic scintillator, has been considered in some details. Experimental results, obtained by PM read out, have discussed.

In order to allow easier assembling of a large number of detection cells (~100) in cluster configuration, read-out by Si-PM or Si-PD have been envisaged for future steps of experimental investigation.

NArCoS is thought to be a flexible and portable device able to be coupled with complex charge particle detection systems (CHIMERA, FARCOS, INDRA,FAZIA,….) for particle-particle correlations including neutrons.

Thank you for the attention

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