DREB 2016 July 11th-15th, Halifax, Canada

Istituto Nazionale
di Fisica Nucleare

Isoscalar excitation of the Pygmy Dipole Resonance in ^{68}Ni

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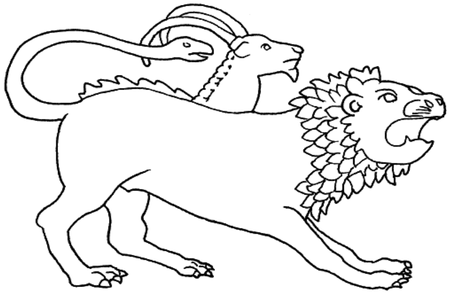

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Outline

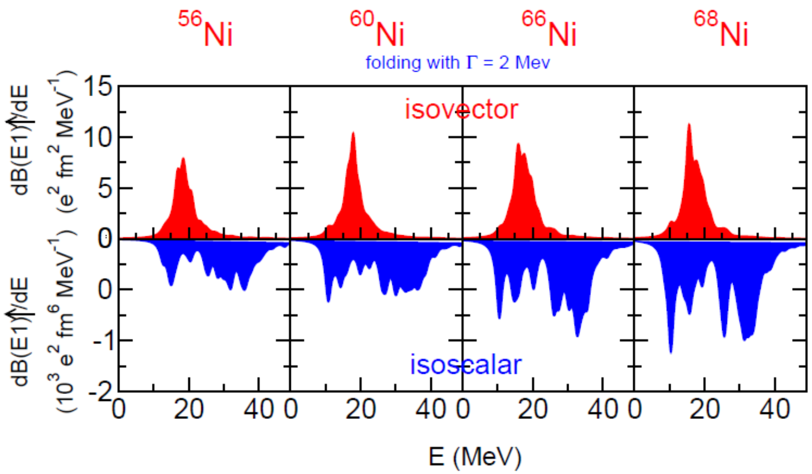
- Introduction
  - Pygmy Dipole Resonance
  - Isoscalar and Isovector probes

- Search for the Pygmy resonance on ^{68}Ni
  - Description on experimental setup (CHIMERA & FARCOS)
  - Preliminary results

- Outlook

Pygmy Dipole Resonance

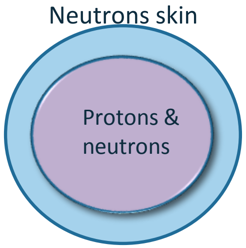
The first evidence of an accumulation of low-lying E1 strength in heavy-nuclei, larger than that due to the tail of the Giant Dipole Resonance (GDR), date back to early ‘70 → Pygmy Dipole Resonance



PDR modes are connected to the neutron excess→ ^{132}Sn, ^{68}Ni

P. Adrich et al. (LAND-FRS Collaboration), *Phys. Rev. Lett.* **95**, 132501 (2005)

A. Klimkiewicz et al. (LAND-FRS Collaboration), *Nucl. Phys. A* **788**, 145 (2007)



As soon as there is an increase of neutrons number, a small peak becomes appreciable in the isovector (isoscalar) response

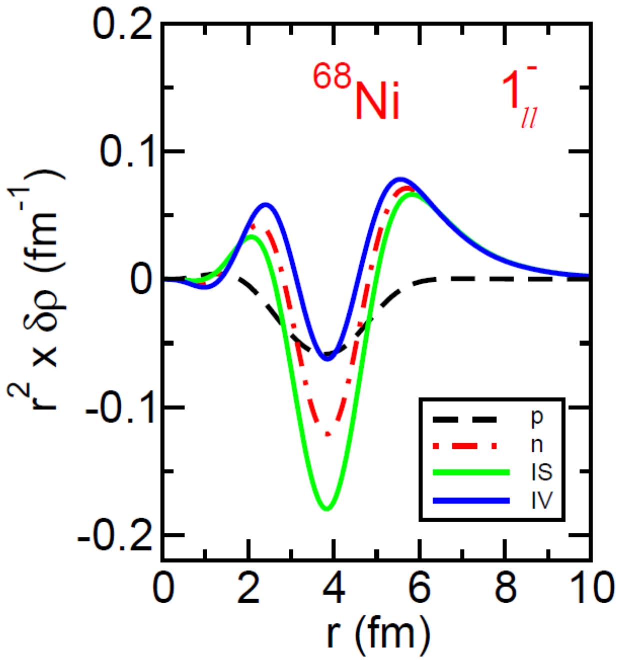
A recent revue can be found in: *Progress in Particle and Nuclear Physics*, **70**, 210 ,(2013) by D. Savran, T. Aumann, A. Zilges and in A. Bracco, F.C.L. Crespi and E.G. Lanza, *Eur. Phys. J. A* ***51**, 99 (2015)*

E. G. Lanza, F. Catara, D. Gambacurta, M. V. Andrès and P. Chomaz , *Phys. Rev. C* **79**, 054615 (2009)

E. G. Lanza, A. Vitturi, M. V. Andrés, F. Catara and D. Gambacurta, *Phys. Rev. C* **84**, 064602 (2011)

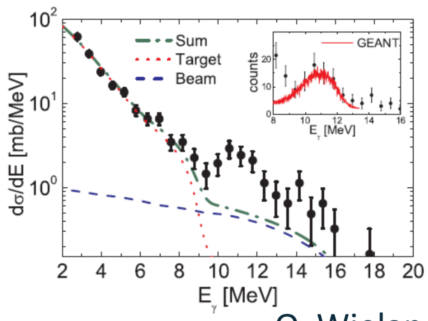
Pygmy Dipole Resonance

One can notice that:
The neutrons and protons transition densities are in phase inside the nucleus, and at the surface only the neutron part survives→ theoretical definition of the PDR
At the interior the isoscalar part is much more pronounced than that the isovector one, at the surface both have almost the same strength



Isovector Probe

PDR can be induced by virtual photon scattering (Coulomb excitation) or real photon scattering (RNF) (D. Savran et al., *Phys. Rev. Lett.* **100**, 232501 (2008))



O. Wieland et al., *Phys. Rev. Lett.* **102**, 092502 (2009)

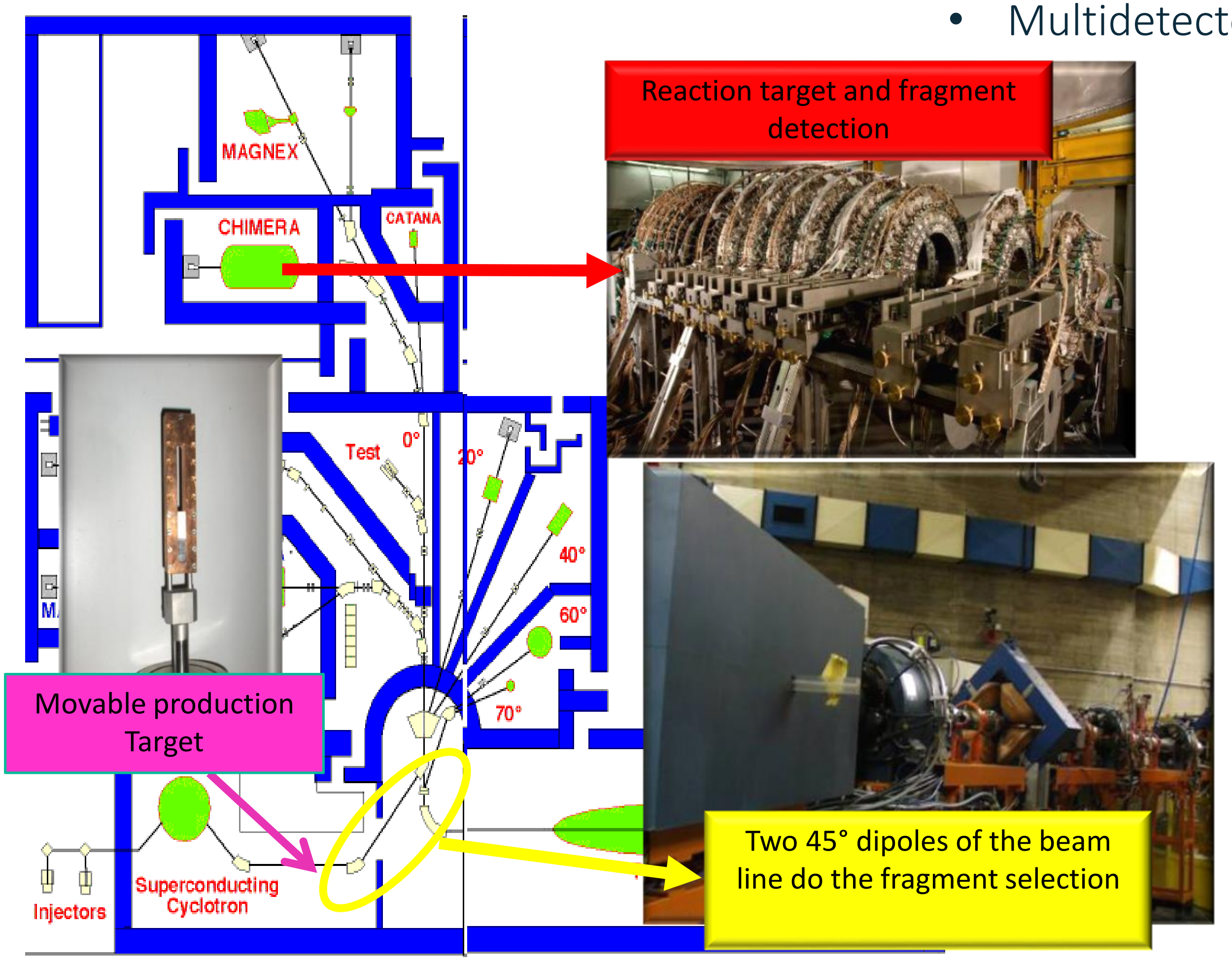
Isoscalar Probe

PDR can be induced by nuclear interaction between projectile and target (J. Endres et al., Phys. Rev. C **80**, 034302 (2009))

Experimental setup

Nuclear reaction studied:
^{68}Ni+ ^{12}C (75 µm) @ 33 MeV/nucleon

- ^{70}Zn @ 40 MeV/nucleon accelerated by CS
- ^{70}Zn + ^{9}Be→ exotic beam
- Multidetector CHIMERA & FARCOS



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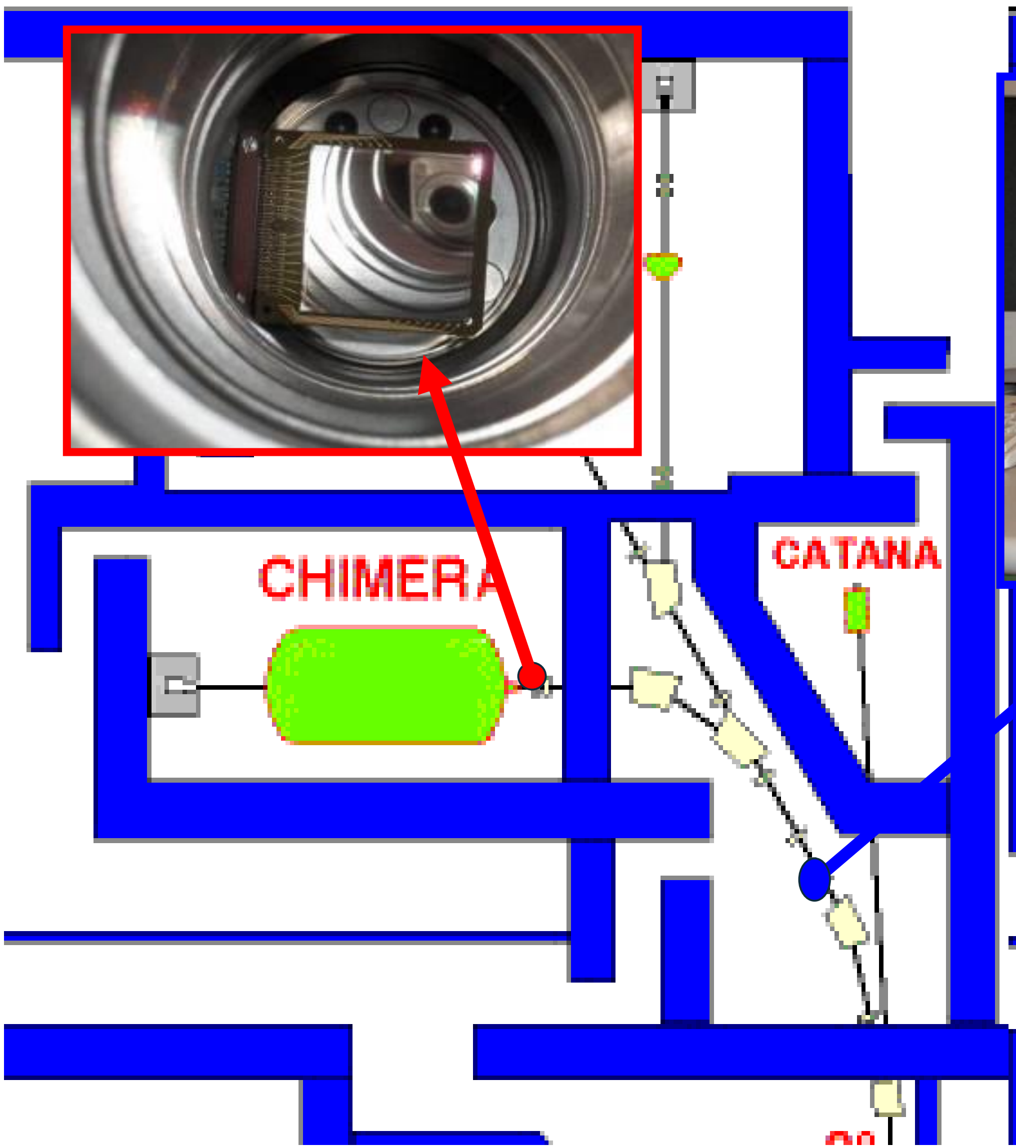
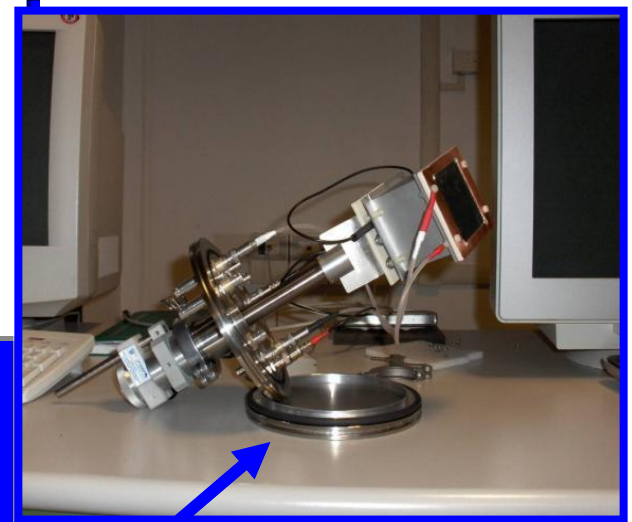
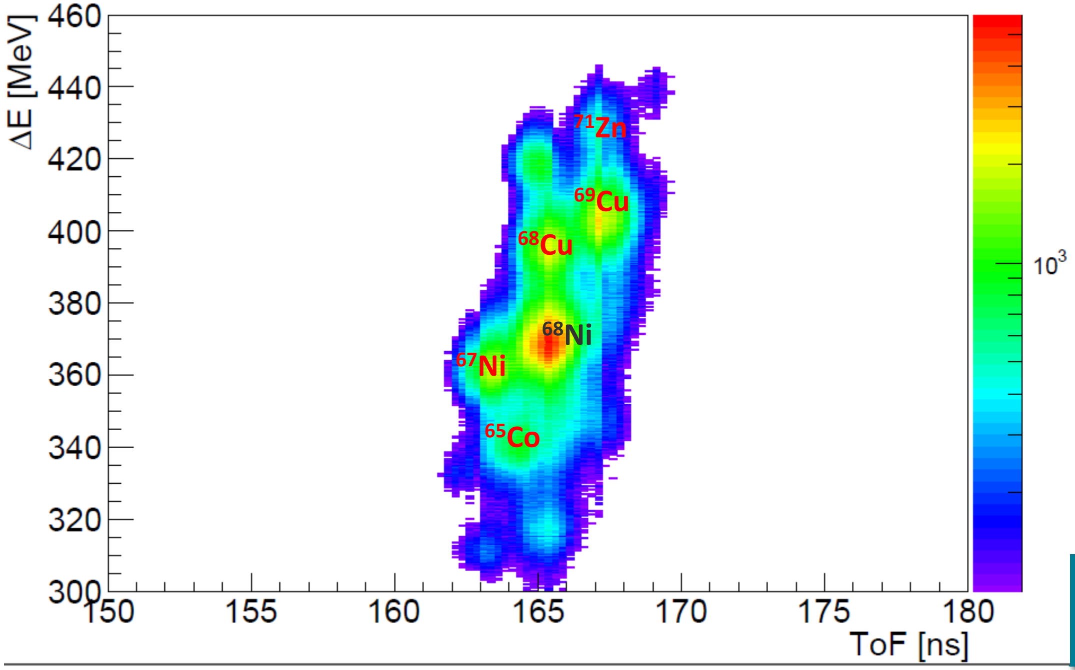




A tagging system (EPJ Web of Conferences 117, 06008 (2016) NN2015) was developed to identify event by event the isotopic composition of the produced exotic beam. This tagging system is based on use of a MCP (Micro-Channel Plate) and a 32x 32 strips DSSSD (Double Sided Silicon Strip Detector)

Experimental setup→ Preliminary results

The identification of the particles is achieved by combining the energy loss in the DSSSD with the Time of Flight information (ToF).
The start of this ToF measurement is provided by MCP mounted 13 m away from the DSSSD. The stop is given by the signal delivered by the strips of the DSSSD

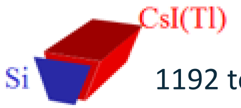


An example of the obtained identification scatter plot is shown in figure

Experimental setup→ CHIMERA multidetector

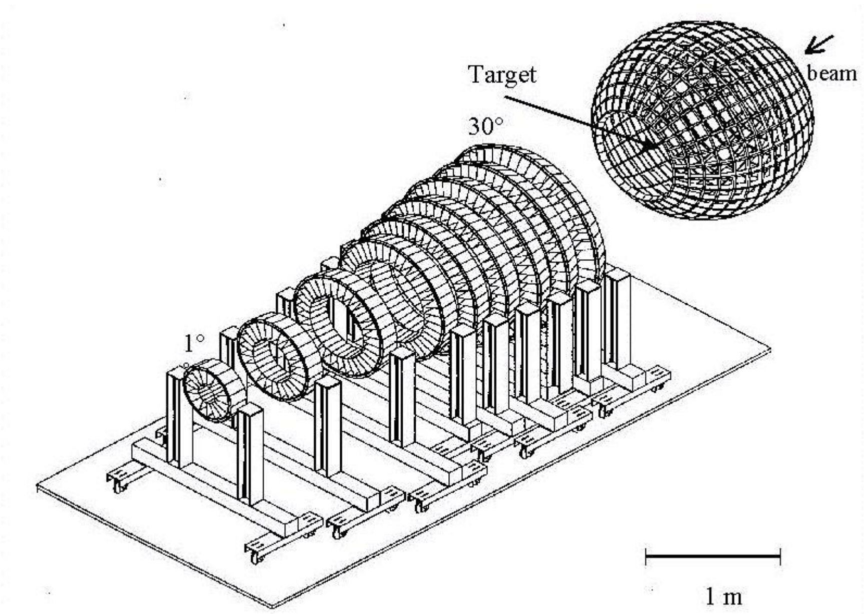
To study the Pygmy resonance we have to detect ɣ - rays in coincidence with ^{68}Ni→ CHIMERA (A.Pagano, Nuclear Physics News, 221(2012)25; A.Pagano et al Nucl.Phys. A 734 (2004) 504) and FARCOS (L. Acosta et al., EPJ Web of Conferences,31 ,0035 (2012)) detector

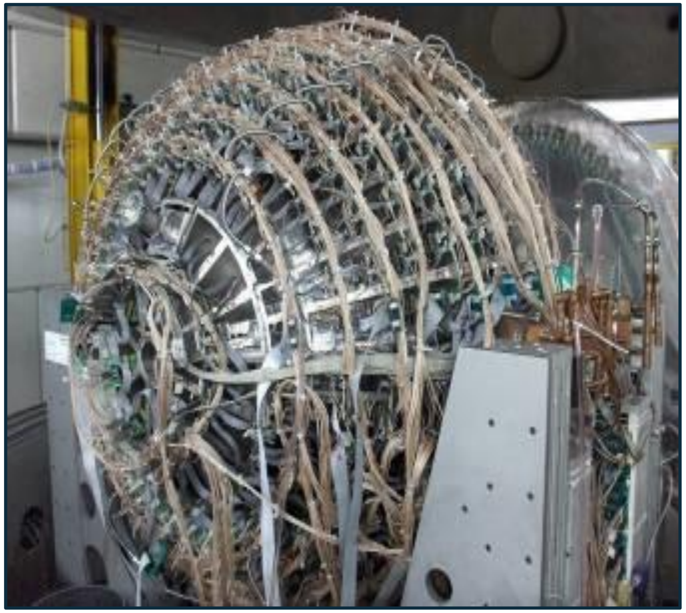
CHIMERA is composed by 1192 telescopes and it was born to the detect charged particles



1192 telescopes

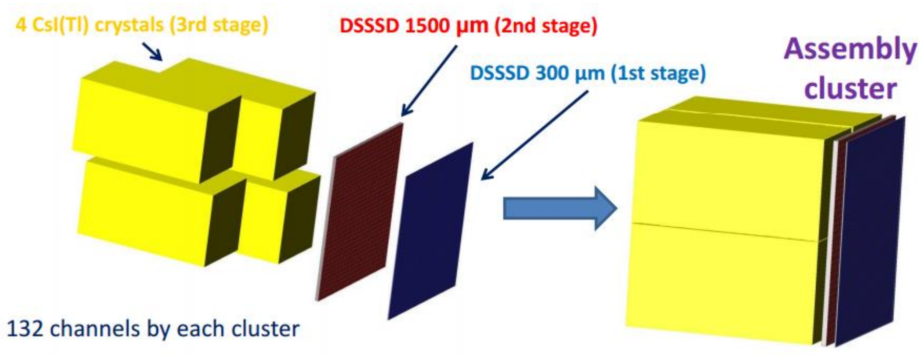
We can use the CsI(Tl) to detect ɣ rays



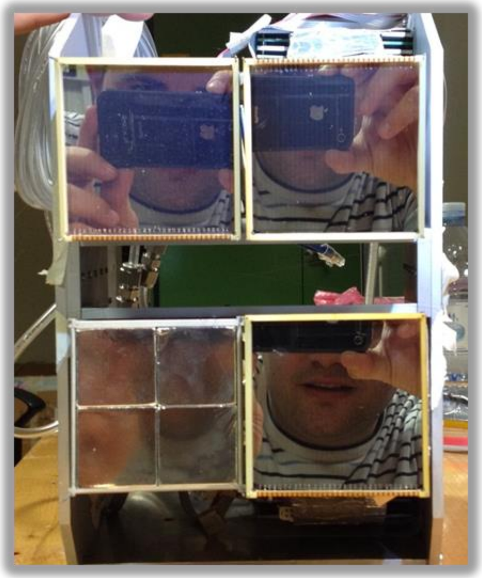


Experimental setup→ FARCOS multidetector

To detect the fragment of ^{68}Ni and also other fragments we use the FARCOS detector. This precise measurement, compared to the beam energy, is therefore a first constraint to the mass of the detected nuclei→ All the energy of Nickel ions will be lost on the first two Silicon stages

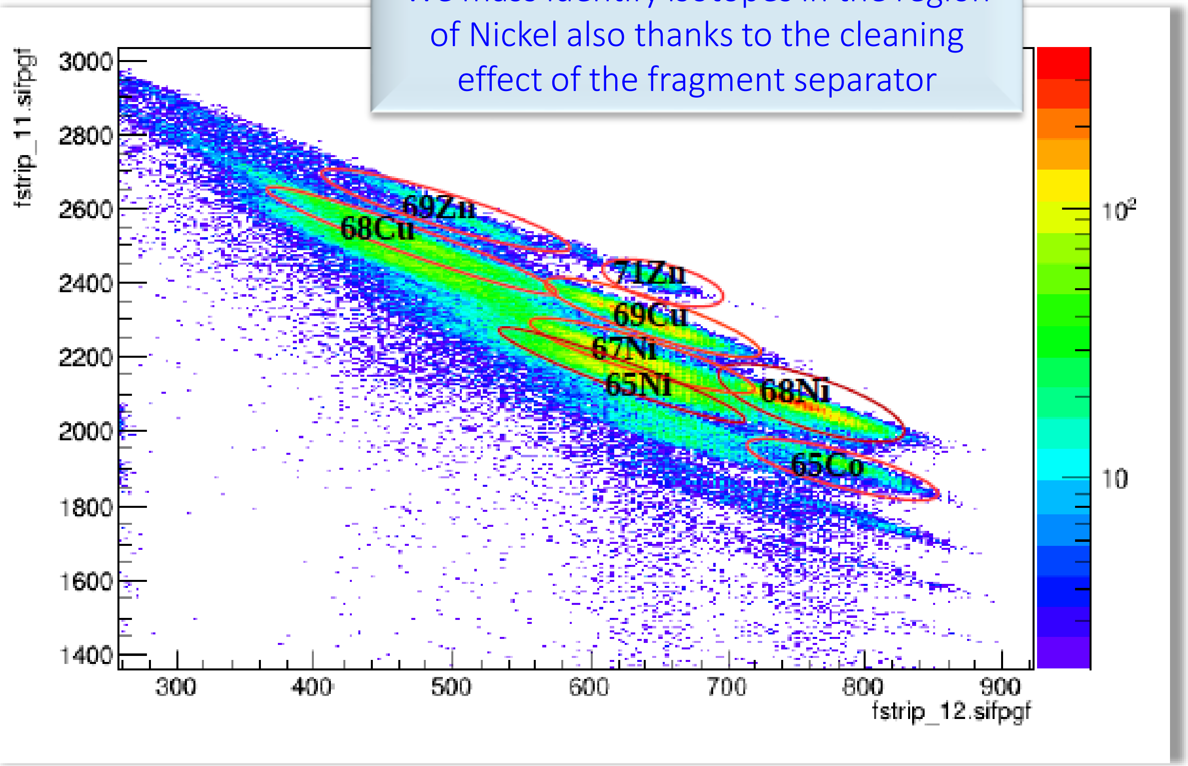


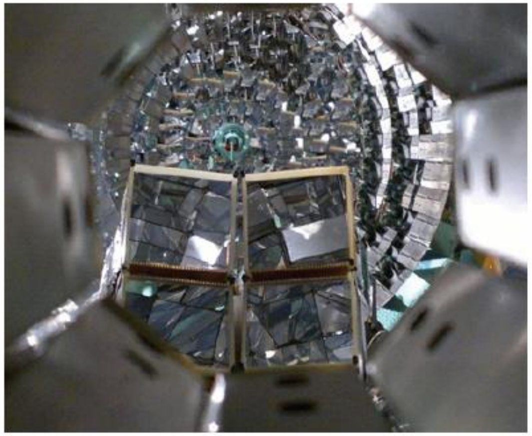
(L. Acosta et al., EPJ Web of Conferences,31 ,0035 (2012)

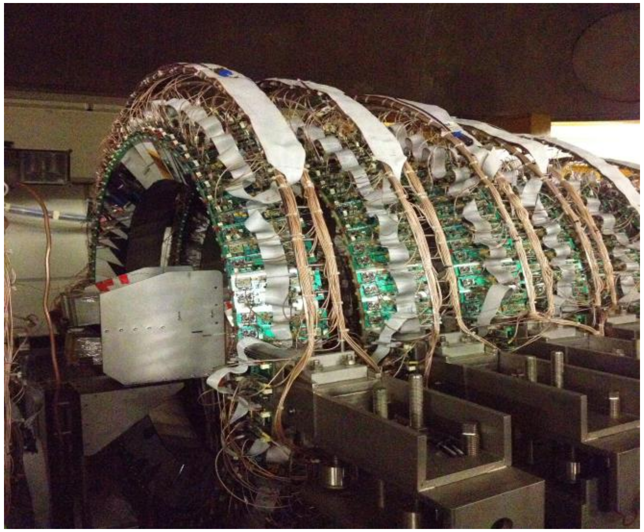


Preliminary results→ Mass Identification

We mass identify isotopes in the region of Nickel also thanks to the cleaning effect of the fragment separator



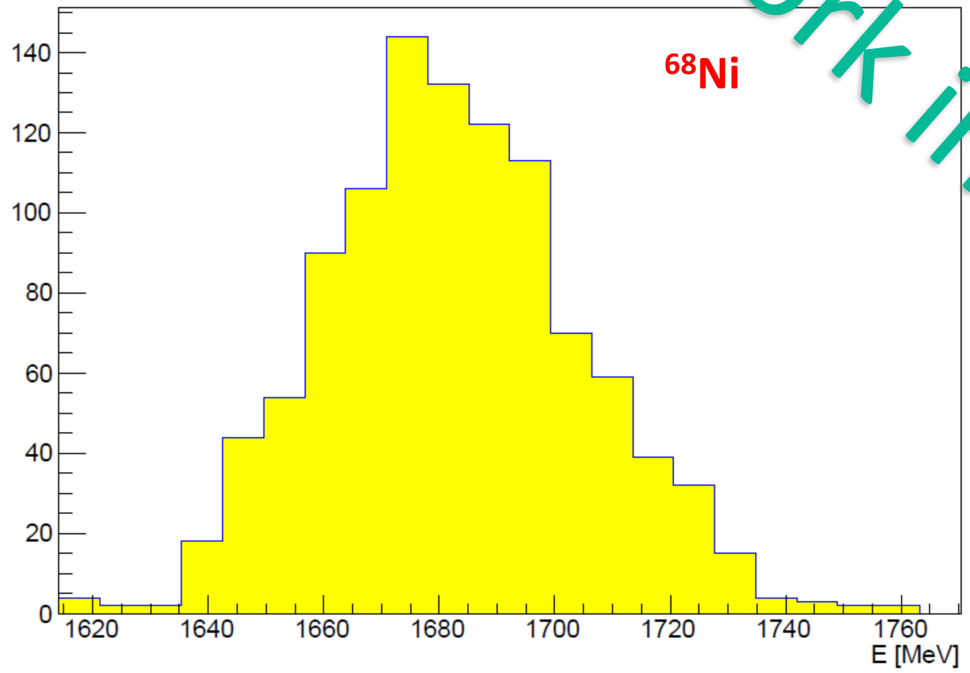




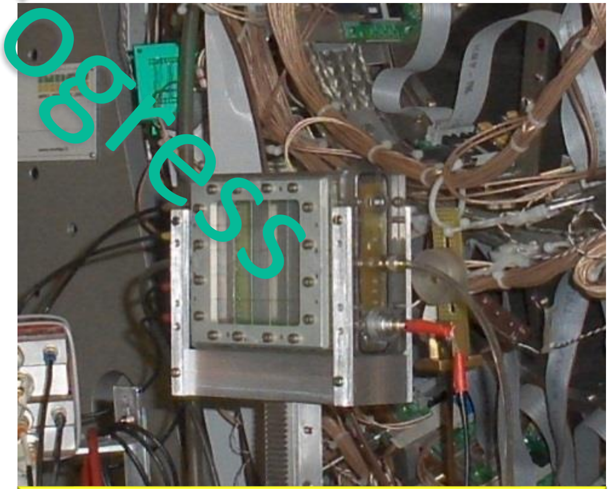
In figure we can see the different elements with the ΔE-ΔE plots on FARCOS

Preliminary results→ FARCOS energy calibration

Work in progress



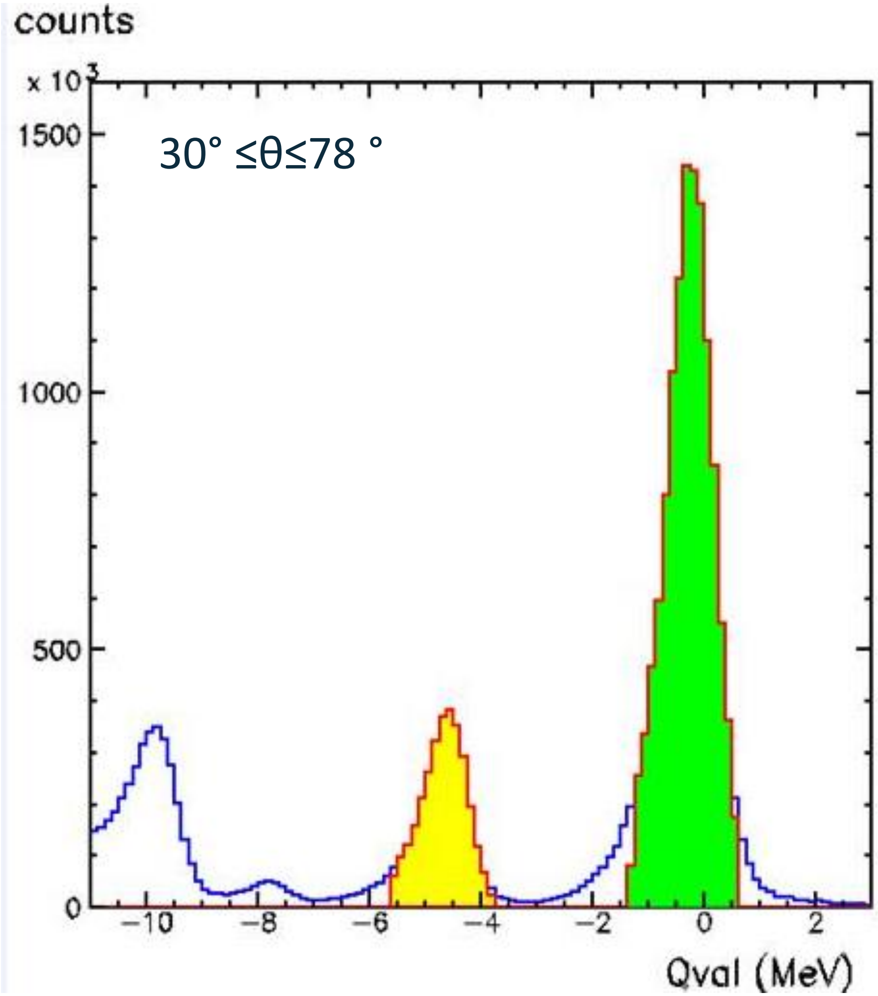
It is important to have a precise calibration on FARCOS→ We have to check the beam trajectory

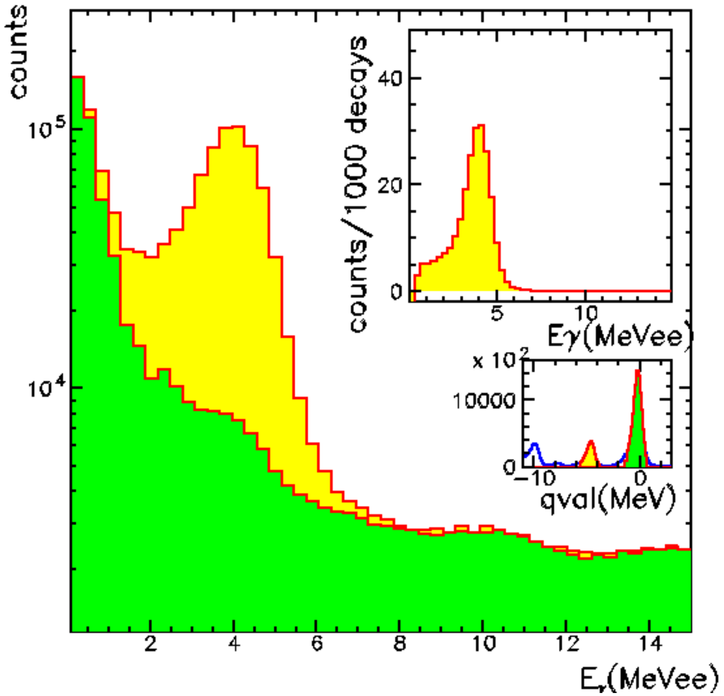


Position sensitive PPAC to measure trajectory

Preliminary results → ɣ ray calibration

We will get the Pygmy data after the ɣ calibration of detector → p+ ^{12}C @ 24 MeV

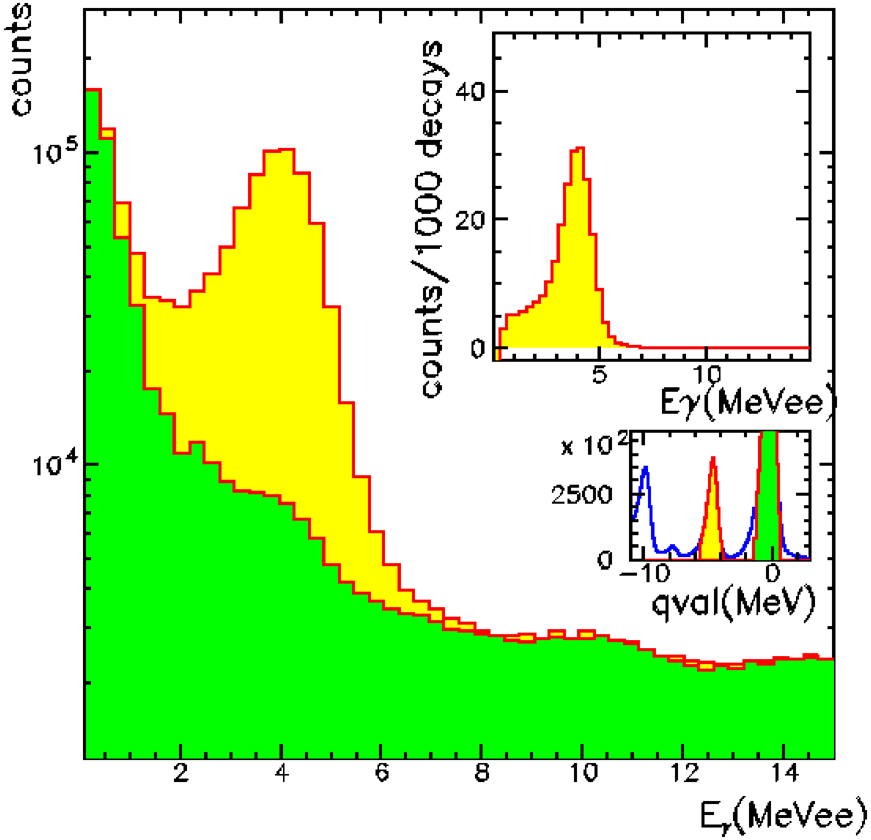


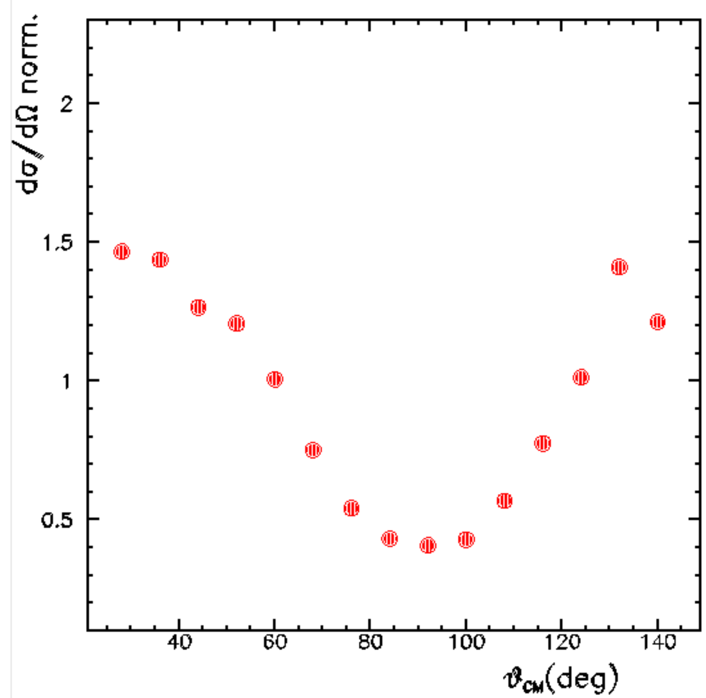


Background can be evaluated collecting the same events, triggered by the detection of protons from elastic scattering

Preliminary results→ ɣ ray calibration

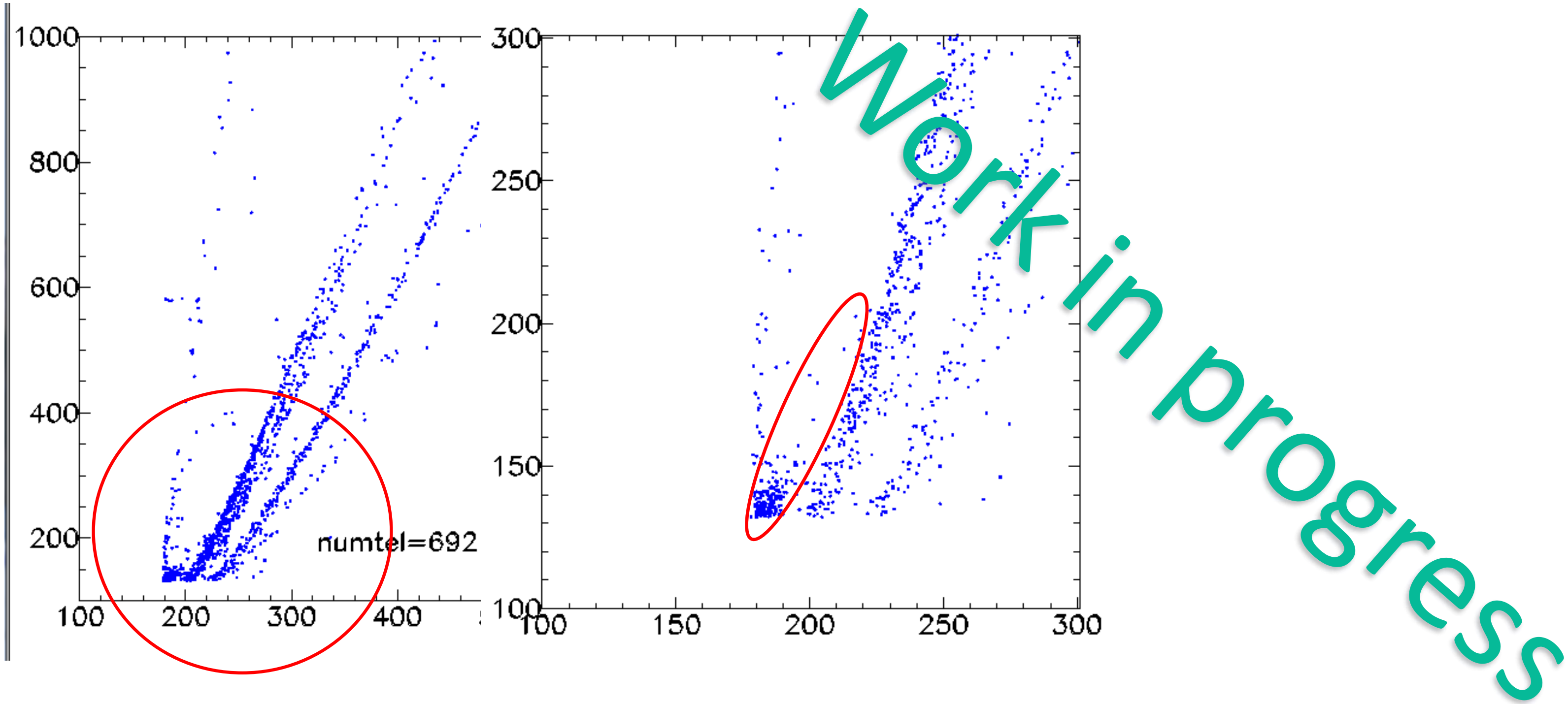
We have also verified that we can extract angular distributions from such events.
They are very useful to understand the multipolarity of the emitted γ-ray, so obtaining information about the spin of the observed resonance.
(See also G.Cardella et al, Nuclear Instrument and Methods in Physics Research A799 (2015))



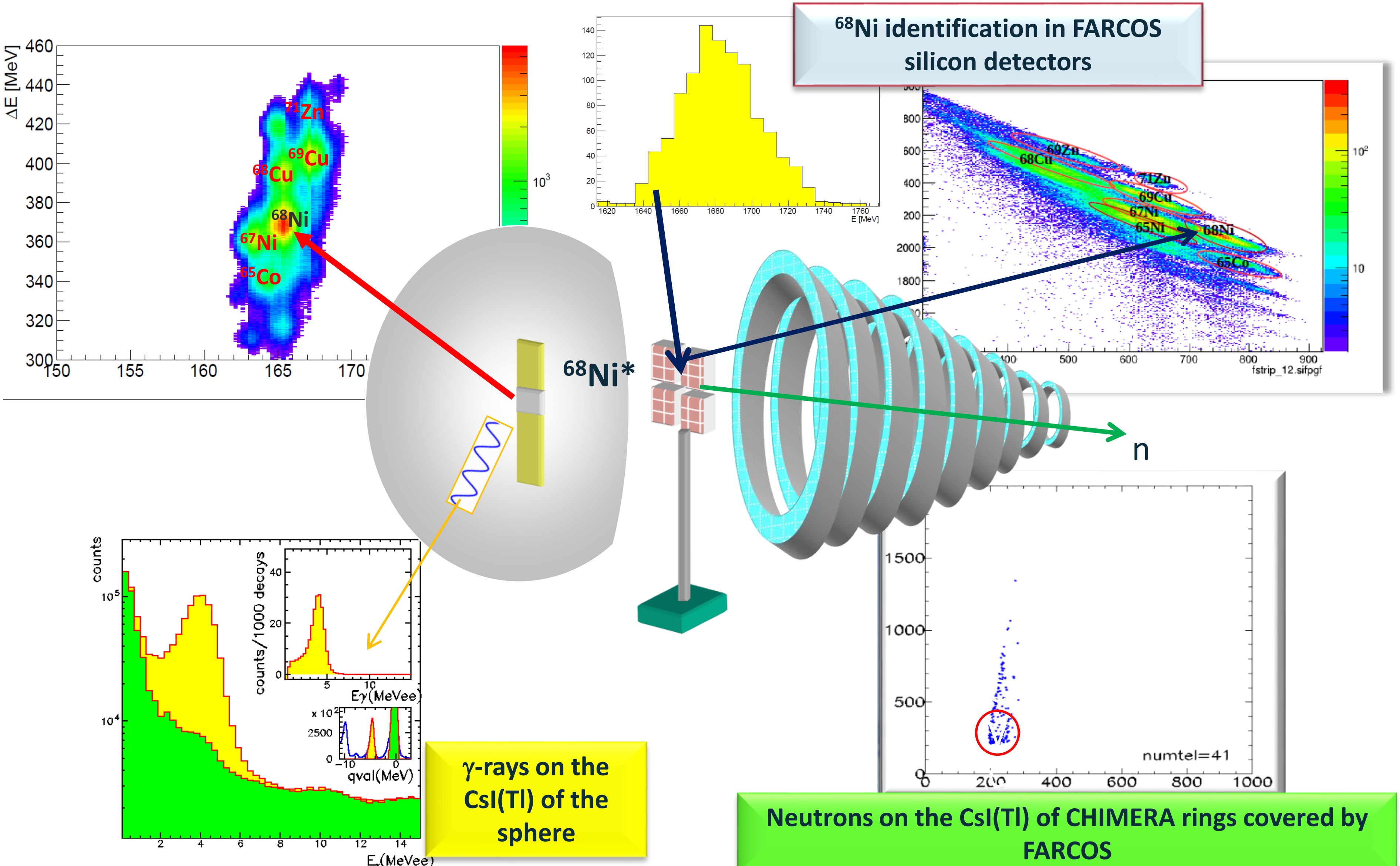


Preliminary results → ɣ ray identification

This is an example of fast-slow of a CsI(Tl) of ring 10 (θ=34°) - Zooming the low energy side we can see **ɣ**-rays discriminated by protons



Pygmy Dipole Resonance→ Preliminary results



Conclusions and Outlook

- We have performed the first experiment in Catania for the search of the Pygmy Dipole Resonance
- Calibration of experimental set up
- Mass Identification of ^{68}Ni
- Preliminary ɣ calibration

- Extension of calibration on all FARCOS
- Improvement of the ɣ identification with fast-slow method
- Forward angles of CHIMERA CsI(Tl) covered by FARCOS provided neutron detection

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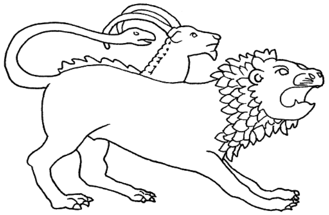
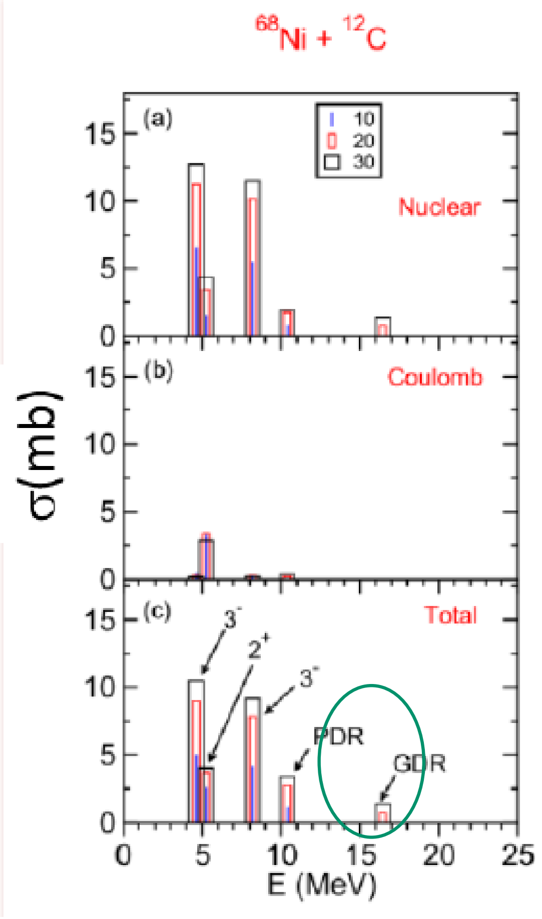


Thank you for your attention

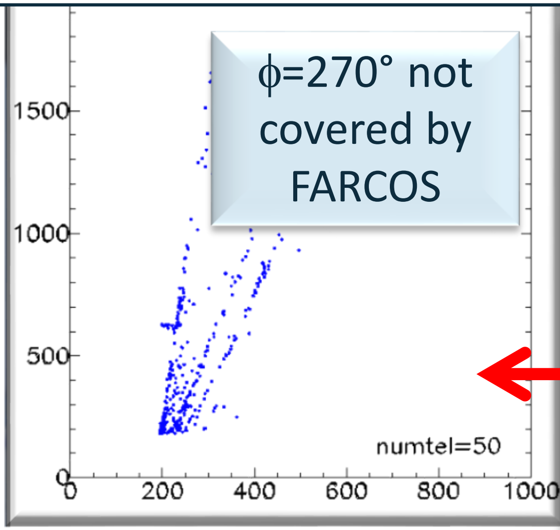
Pygmy Dipole Resonance

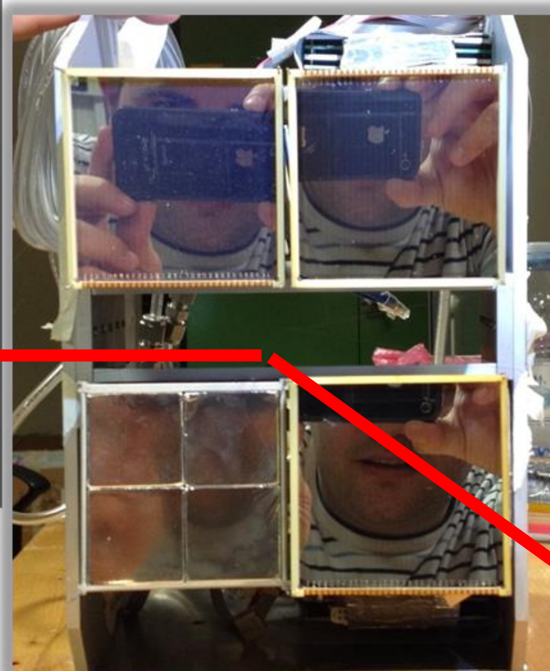
Our aim was to obtain information on PDR by excitation processes involving nuclear part of the interaction

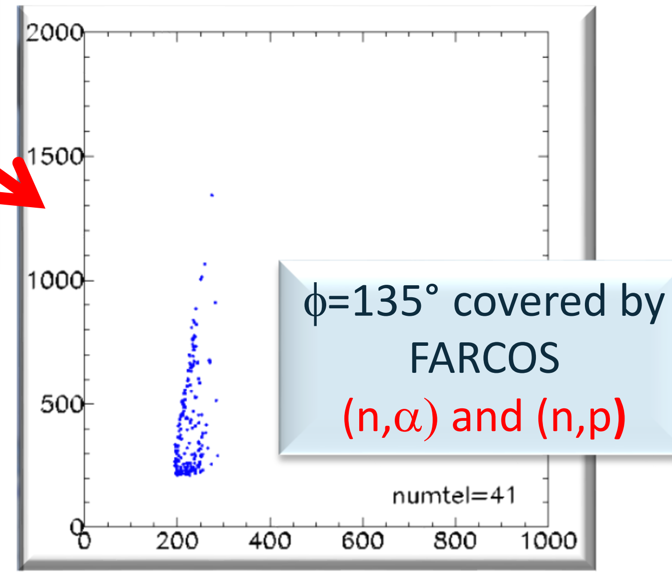


We can see the results for the nuclear Coulomb contributions as well as the total one are shown for three different incident energies (10,20, 30 MeV A). We can stress that although the Coulomb contribution for the PDR is very small a constructive interference is clearly shown in the lower frame

FARCOS cover some of the forward telescopes of CHIMERA neutrons can be detected via (n,α) and (n,p) reactions on CsI(Tl) producing alpha and proton lines







Efficiency for neutrons with beam energy of the order of 5% - Taking into account that Pygmy resonance decay mainly (>95%) via neutron decay we should have more n-^{67}Ni coincidences than ɣ-^{68}Ni coincidences - both decay channels will be measured at the same time