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

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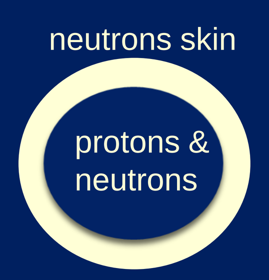
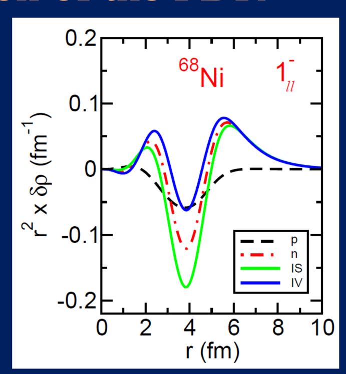
In the last years much attention has been devoted to the study of collective states in neutron-rich nuclei. In particular, the study of the Pygmy Dipole Resonance (PDR) is of remarkable interest. At the INFN-LNS of Catania we performed an experiment, in inverse kinematics using an unstable projectile ^{68}Ni on an isoscalar target ^{12}C, to study the PDR in the ^{68}Ni. The detector systems CHIMERA and FARCOS were used to detect both γ-rays and charged products. In the following we report the status of the experiment with the preliminary results.

Pygmy Dipole Resonance

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

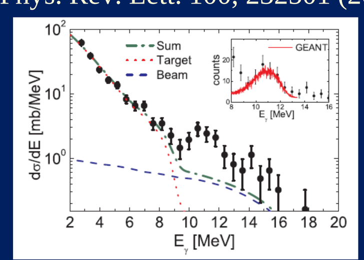




At the interior the isoscalar part is much more pronounced than that the isovector one, at the surface both have almost the same strength:

Isovector probe

PDR induced by virtual photon scattering or relativistic Coulomb excitation (D. Savran et al., Phys. Rev. Lett. 100, 232501 (2008))



Isoscalar probe

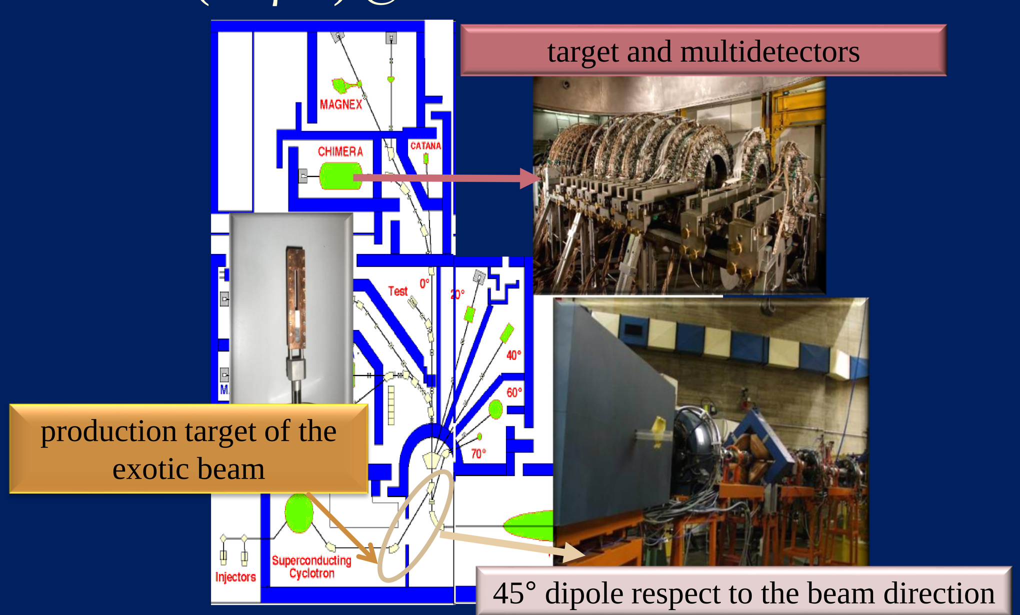
O. Wieland et al., Phys. Rev. Lett. 102, 092502 (2009)

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

Experimental set-up

nuclear collision:

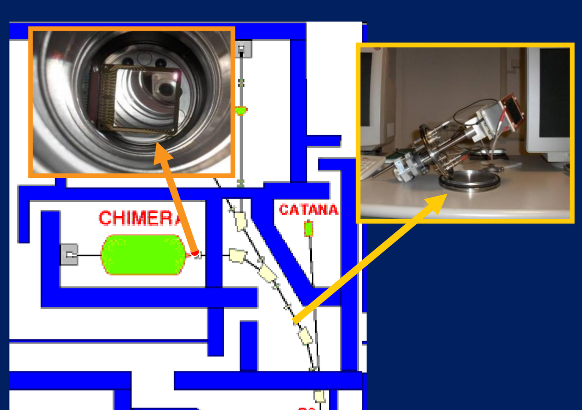
^{68}Ni+ ^{12}C (75 μm) @ 33 MeV A



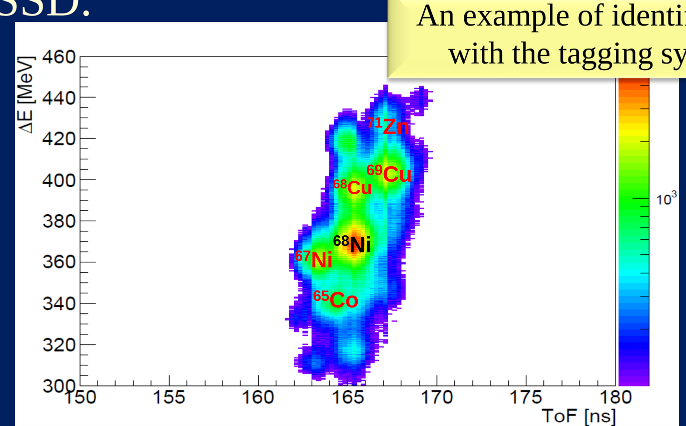
- ^{70}Zn @ 40 MeV A
- ^{70}Zn + ^{9}**Be**→production of exotic beam
- multidetectors **CHIMERA & FARCOS**

Standard tagging system→ MCP + DSSSD

(G. Cardella et al, Web of Conferences 117, 06008 (2016) NN2015)



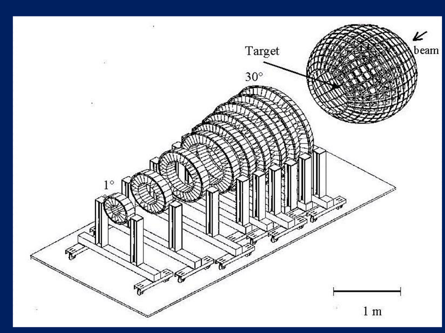
The identification of the particles is achieved by combining the energy loss in the DSSSD with the ToF information. The start of ToF is provided by the MCP. The stop is given by the signal delivered by the strips of the DSSSD.



An example of identification with the tagging system

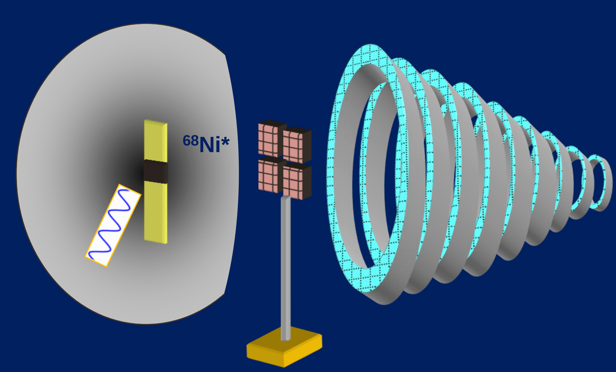
Experimental set-up

For studying the PDR we have to detect γ - rays in coincidence with ^{68}Ni→ CHIMERA and FARCOS



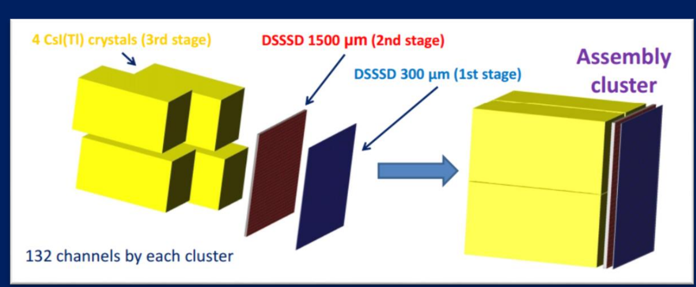
We can use the CsI(Tl) to detect γ rays

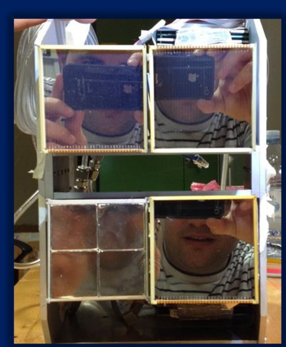
A . Pagano et al Nucl. Phys. A 734 (2004) 504



Experimental set-up

We detected ^{68}Ni and other heavy fragments by using FARCOS multidetector

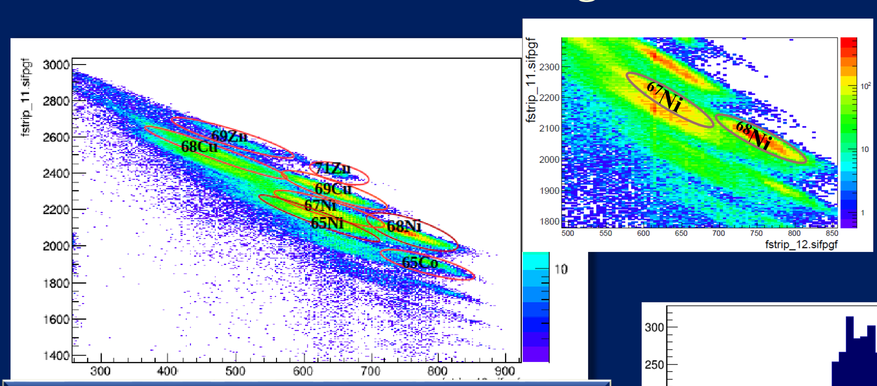




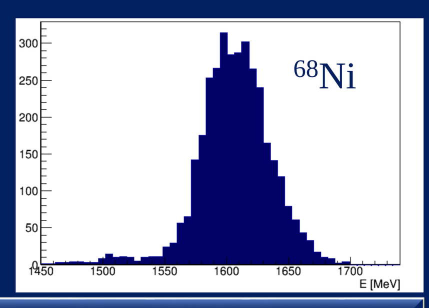
E.V. Pagano et al, EPJ Web Conf. 117, 10008 (2016) NN2015
L. Acosta et al. Journ. Phys. Ser. 730 (2016) 01 2001

Experimental set-up→ Results

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 were lost on the first two Silicon stages



Good mass identification also thanks to the cleaning effect of the fragment separator

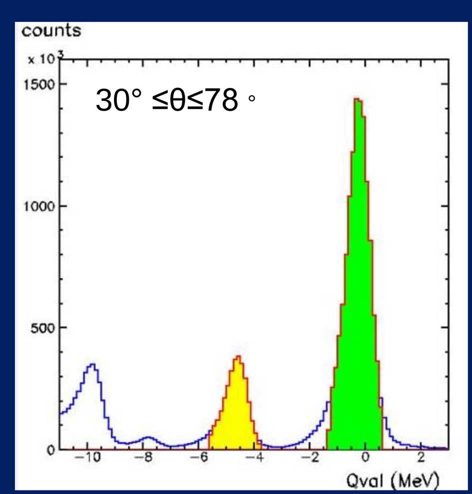


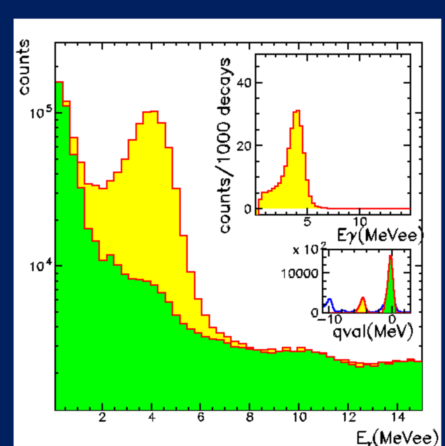
Energy spectrum of ^{68}Ni for a strip of FARCOS multidetector

Experimental set-up→ Results

γ calibration of CsI(Tl) of CHIMERA multidetector

p + ^{12}C reaction @ 24 MeV



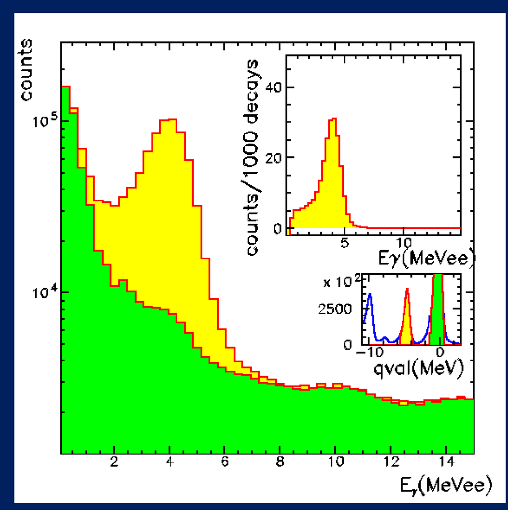


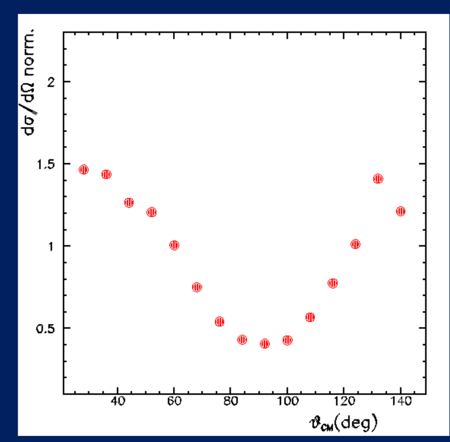
The background can be evaluated by collecting the same events, triggered by the detection of protons **elastically scattered**

Experimental set-up→ Results

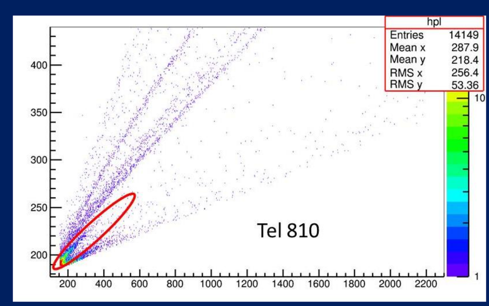
We verified that we can extract angular distributions from such events → very useful to understand the multipolarity of the emitted γ-rays obtaining information about the spin of the observed resonance.

(See also G. Cardella et al, Nuclear Instrument and Methods in Physics Research A799 (2015) 64-69)

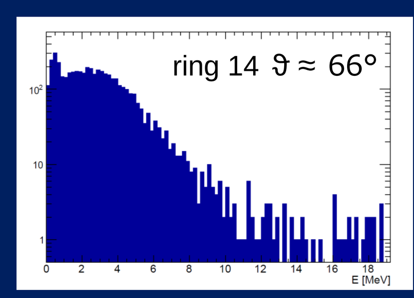


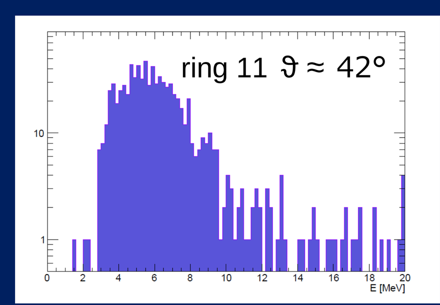


Experimental set-up→ Results



PSD of CsI(Tl) for the ring 14 (θ=66°) → we can see γ-rays discriminated by protons





Energy γ spectra in coincidence with the ^{68}Ni beam for the 14 ring and 11 ring→ ≈ 100 counts in the PDR region

Summary

- We have performed the first experiment in Catania for the search of the Pygmy Dipole Resonance with an isoscalar probe
- Calibration of experimental set up
- Mass Identification of ^{68}Ni and heavy fragments by using FARCOS multidetectors
- Preliminary coincidences between γ-rays and ^{68}Ni beam

Outlook

- Coincidences by including FARCOS multidetector
- Evaluation of PDR cross section
- Neutron detection by using the CsI(Tl) of CHIMERA covered by FARCOS→ both decay channels will be measured at the same time

References

[1] D. Savran et al, Prog. Part. Nucl. Phys. 70, 210 (2013)
[2] A. Bracco, F.C.L. Crespi and E.G. Lanza, Eur. Phys. J. A 51, 99 (2015)
[3] A. Klimkiewicz et al. (LAND-FRS Collaboration), Nucl. Phys. A 788, 145 (2007)
[4] E. G. Lanza et al, Phys. Rev. C 79, 054615 (2009)
[5] E. G. Lanza et al, Phys. Rev. C 84, 064602 (2011)
[6] N. Paar et al, Rep. Prog. Phys. C 70, 691 (2007) and references therein
[7] D. Savran et al, Phys. Rev. Lett. 100, 232501 (2008)
[8] P. Adrich et al. (LAND-FRS Collaboration), Phys. Rev. Lett. 95, 132501 (2005)

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