On the nature of the low-energy E1 strength in the unstable nucleus ^{68}Ni

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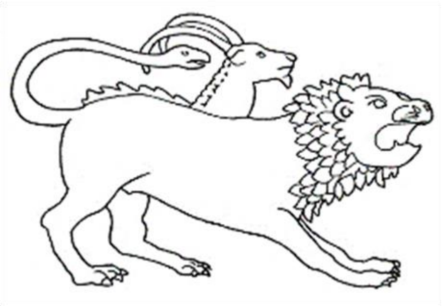
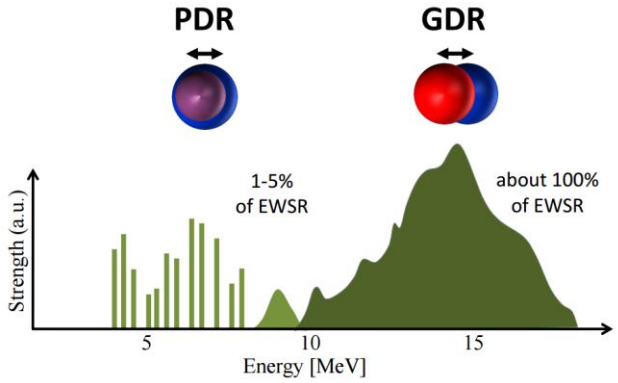
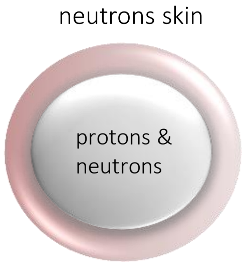
On behalf of
CHIMERA-NEWCHIM Collaboration



Pygmy Dipole Resonance



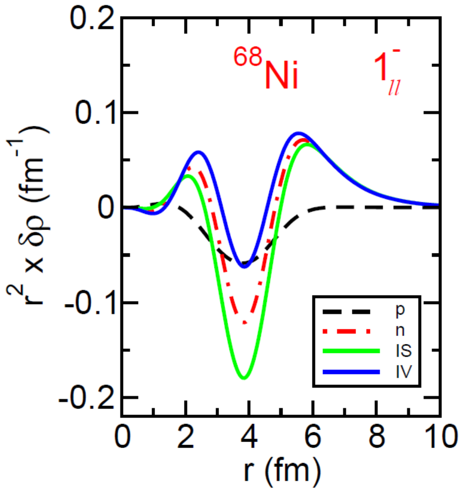


N=Z saturated core against neutron skin

Klimkiewicz et al., Phys. Rev. C 76, 051603 (R) (2007)

J. Piekarewicz et al., Phys. Rev. C 73 044325 (2006)

- Neutrons and protons transition densities are in phase inside the nucleus, and at the surface only the neutron part survives→ theoretical definition of the Pygmy Dipole Resonance (PDR)
- At the interior the isoscalar part is much more pronounced than the isovector one, at the surface both have almost the same strength:



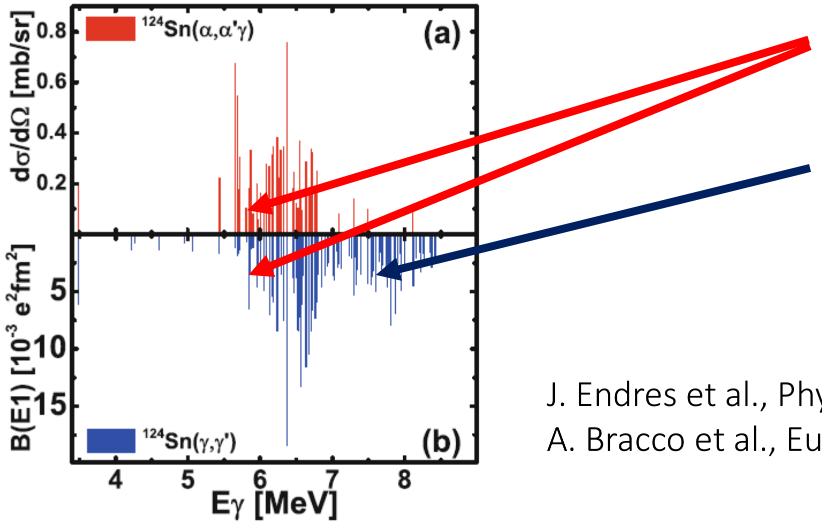
Isovector probe

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

Isoscalar probe

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

Experiments performed on stable and unstable (N. Nakatsuka et al., Phys. Lett. B 768 (2017) 387–392) nuclei below the neutron emission threshold reveal a property known as isospin splitting:



- Only the low energy region of the PDR is populated by both isoscalar and isovector probes
- The higher part is excited via electromagnetic interaction

J. Endres et al., Phys. Rev. C 85, (2012) 064331
A. Bracco et al., Eur. Phys. J A 51 (2015) 99

It is interesting to investigate the PDR in the region above the neutron emission threshold and for unstable nuclei

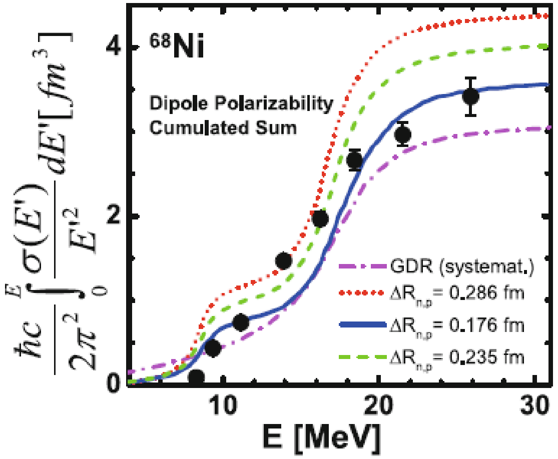
^{132}Sn + ^{208}Pb → P. Adrich et al., Phys. Rev. Lett. 95, 132501 (2005)
^{68}Ni + Au → O. Wieland et al., Phys. Rev. Lett. 102, 092502 (2009)
^{68}Ni + Pb → D. M. Rossi et al., Phys. Rev. Lett. 111 242503 (2013)

^{68}Ni + ^{12}C (75 μm) @ 28A MeV → N.S. Martorana, G. Cardella, E.G. Lanza et al.

There are two important aspects related with this “new excitation mode”:

- Its influence on reactions rates in the astrophysical r-process which synthesizes approximately 50 % of the elements heavier that iron.

- The link of the PDR to the size of the neutron-skin:
    - The neutron skin of neutron rich nuclei is directly related to the equation of state (EOS) of asymmetric matter.
    - The density dependence of the symmetry energy governs the neutron skin in nuclei as well as the radius of neutron stars.



A. Bracco et al., Eur. Phys. J A 51 (2015) 99

D. M. Rossi et al., Phys. Rev. Lett. 111 242503 (2013)

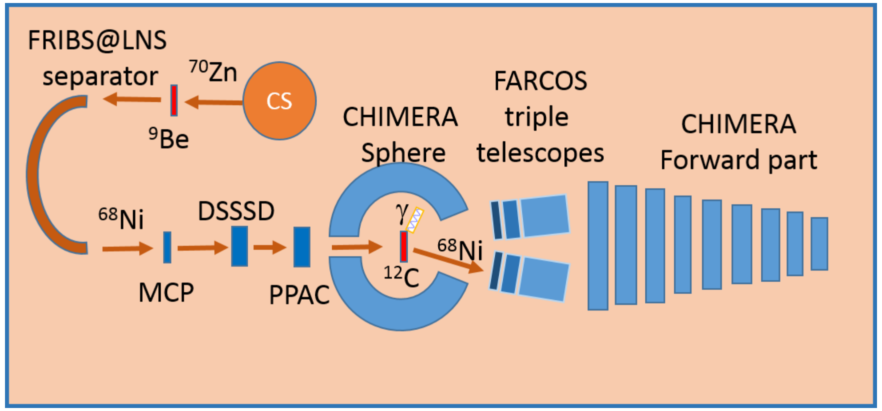
A. Bracco et al., Eur. Phys. J A 51 (2015) 99

Table 1. Dipole polarizability, strength of the pygmy states and the deduced neutron skin radii.

Nucleus	α_D (fm^3/e^2)	PDR (% of EWSR)	Δr_{np} (fm)	Ref.
^{68}Ni	–	5(1.5)	0.200(15)	[20]
^{68}Ni	3.40(23)	–	0.17(2)	[5]
^{120}Sn	8.93(36)	–	0.148(34)	[23]
^{132}Sn	–	4(3)	0.258(24)	[20]
^{208}Pb	20.1(6)	–	$0.156^{+0.025}_{-0.021}$	[7]

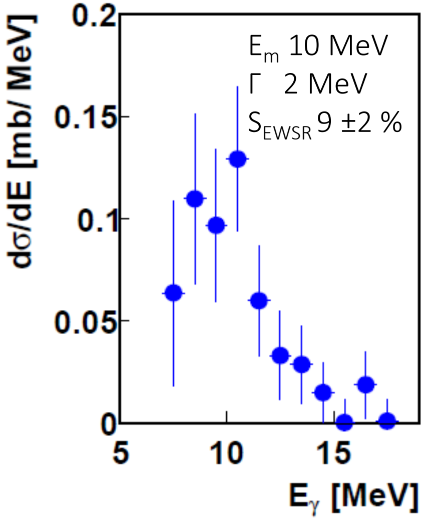
^{68}Ni + ^{12}C @28A MeV N.S. Martorana, G. Cardella, E.G. Lanza et al.

First measurement of the isoscalar excitation above the neutron emission threshold of the Pygmy Dipole Resonance in ^{68}Ni

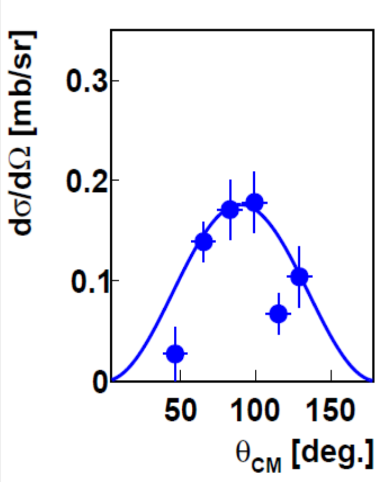


- Exotic beam produced using the FRIBs at INFN-LNS
- ^{70}Zn primary beam accelerated by CS @ 40 A MeV
- ^{70}Zn + ^{9}Be → production of the exotic beam
- Standard tagging system → MCP + DSSSD
- Multidetectors CHIMERA & FARCOS

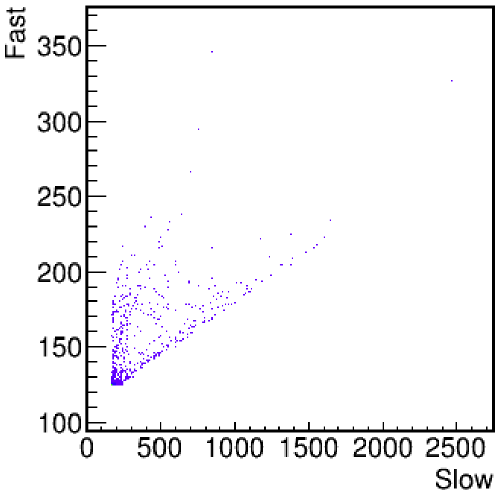
γ-decay channel of the PDR → N.S. Martorana et al., in press in PLB

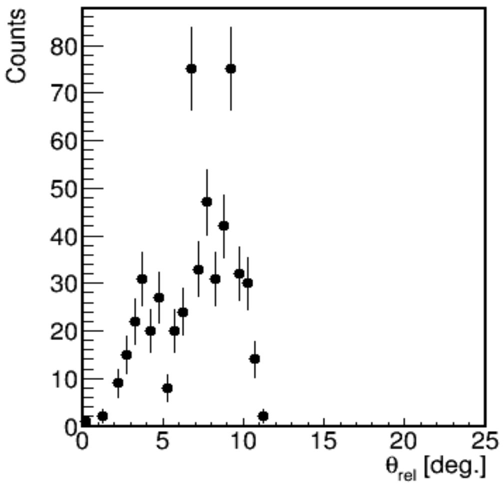


E1 character of the transition



n-decay channel of the PDR → Preliminary results





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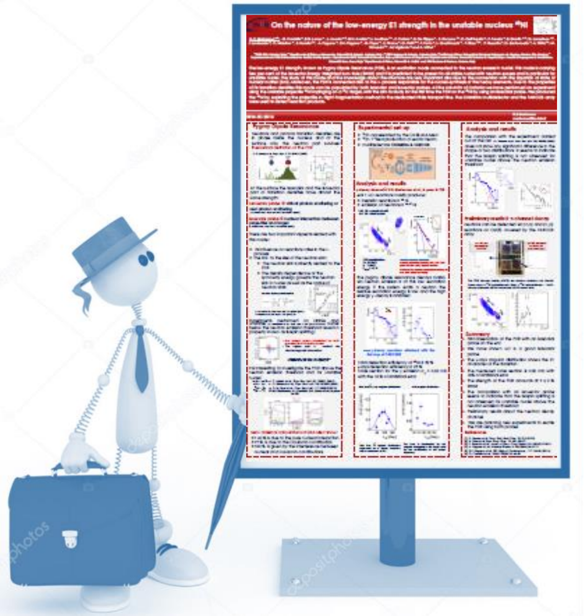

Thank you for your attention