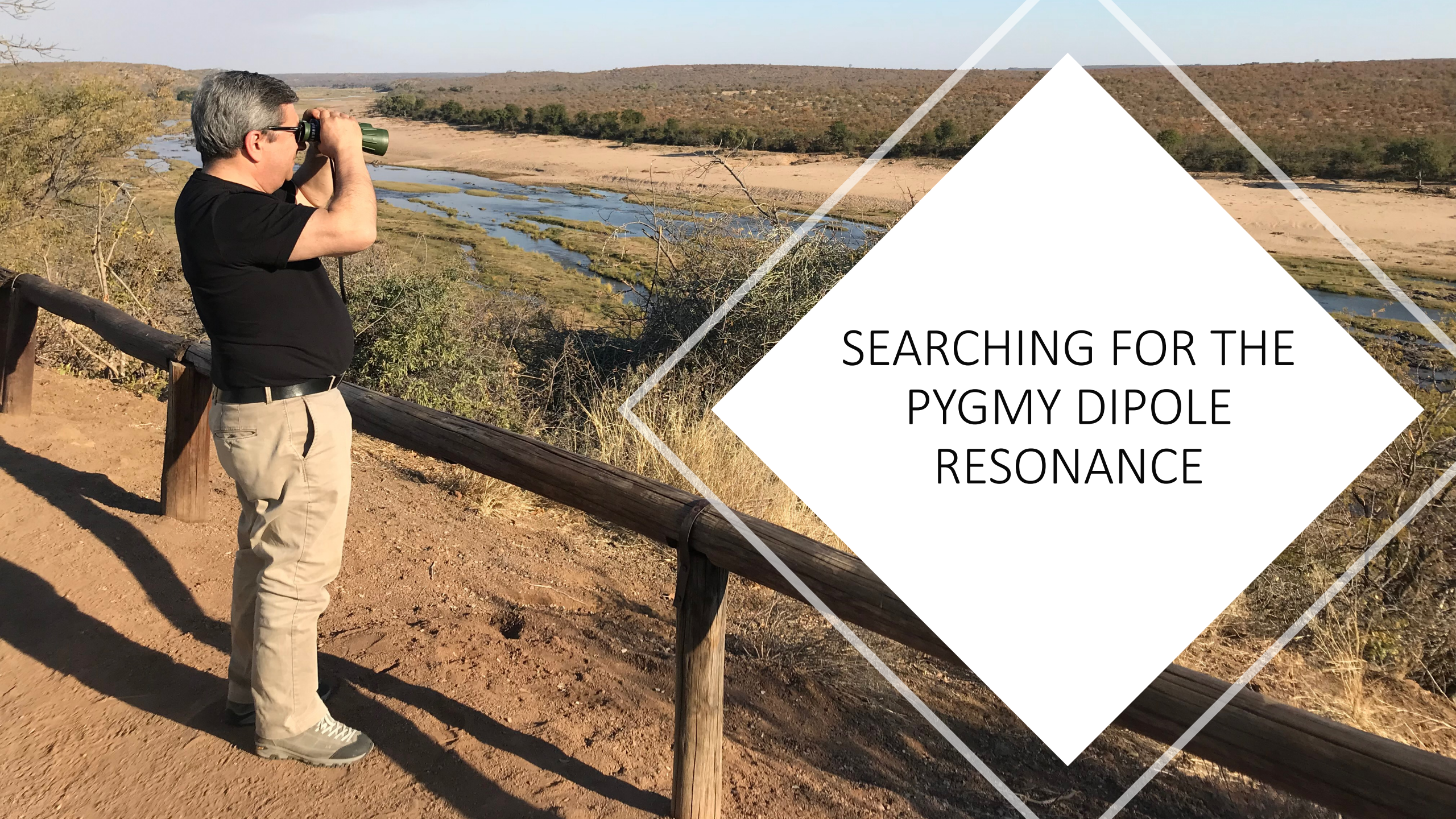
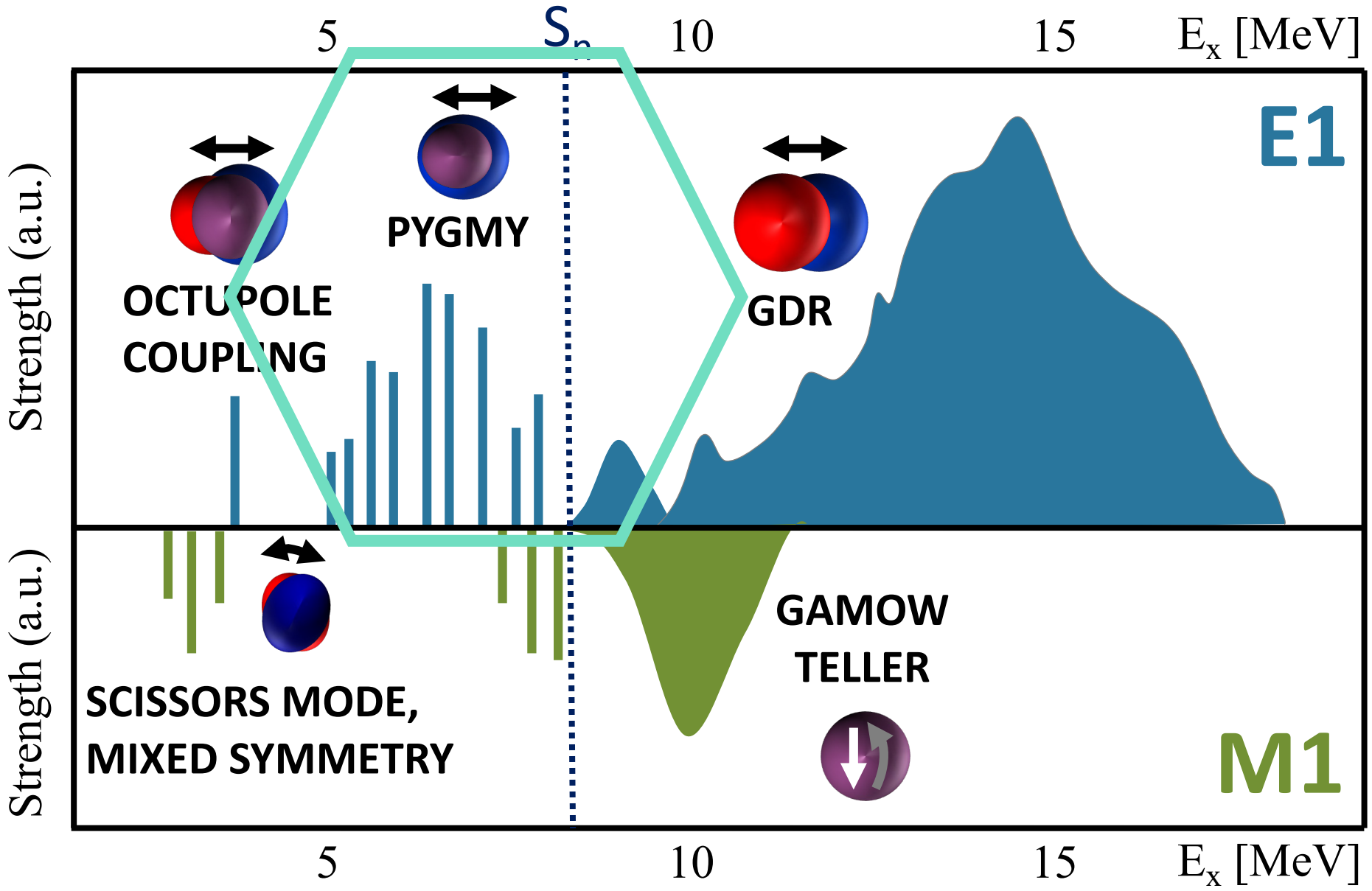
SEARCHING FOR THE PYGMY DIPOLE RESONANCE

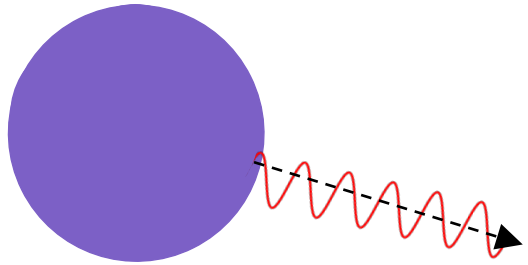
L.Pellegri – WITS & iThemba LABS

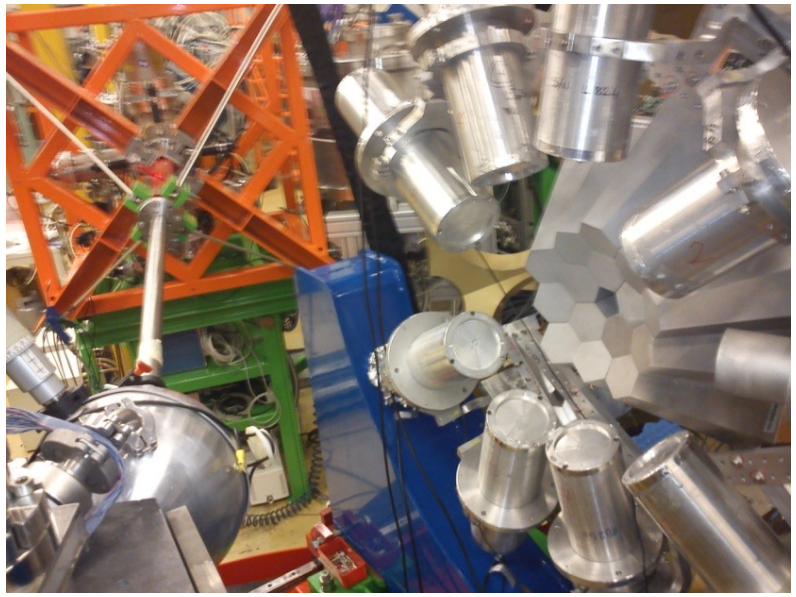


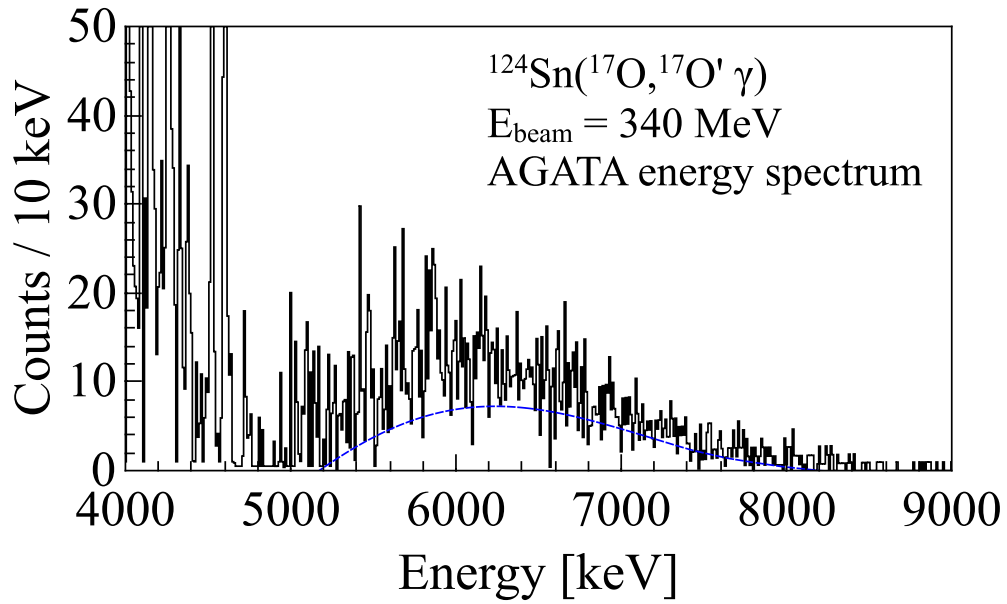
SEARCHING FOR THE PYGMY DIPOLE RESONANCE

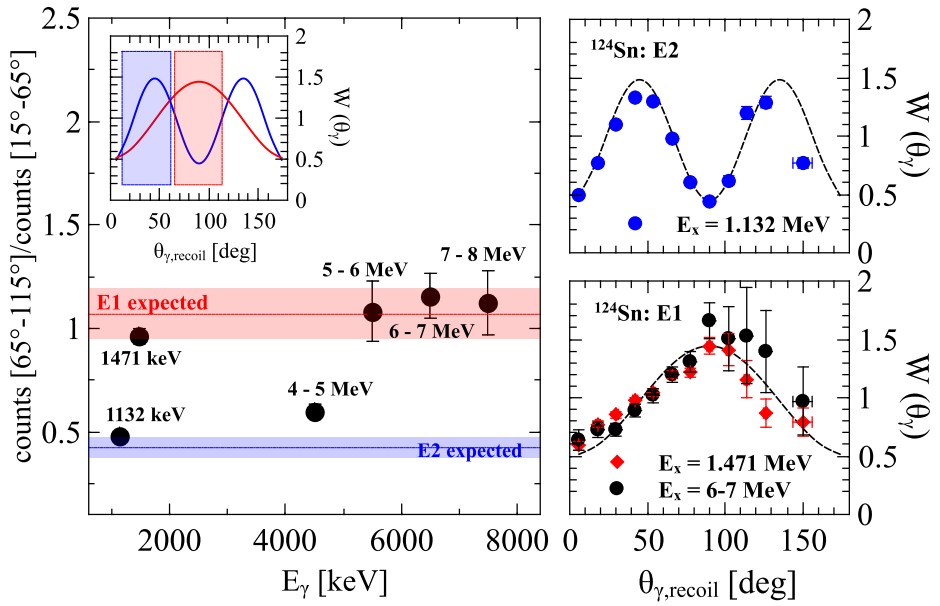

5
S_n
10
15
E_x [MeV]
E1
PYGMY
OCTUPOLE
COUPLING
GDR
Strength (a.u.)
Strength (a.u.)
GAMOW
TELLER
SCISSORS MODE,
MIXED SYMMETRY
M1
5
10
15
E_x [MeV]

It was the year 2010…

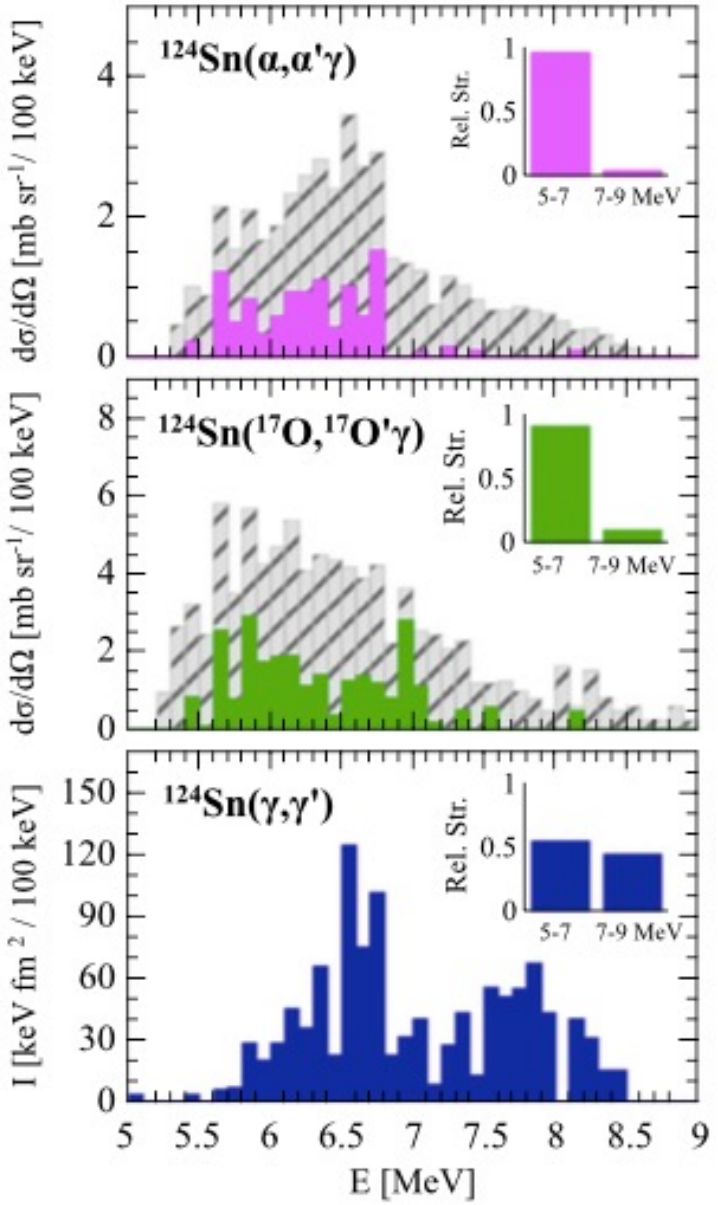








L. Pellegri et al. - Phys Lett B 738 (2014) 519–523



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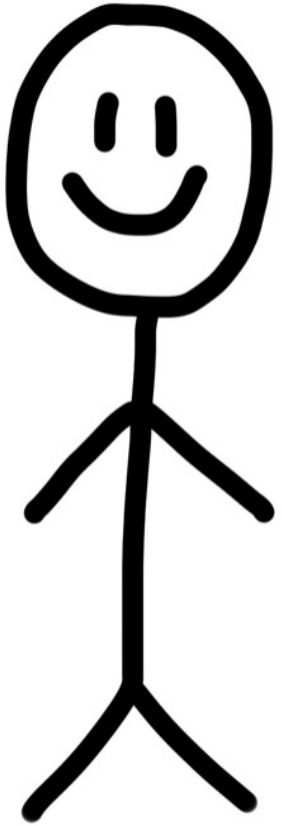
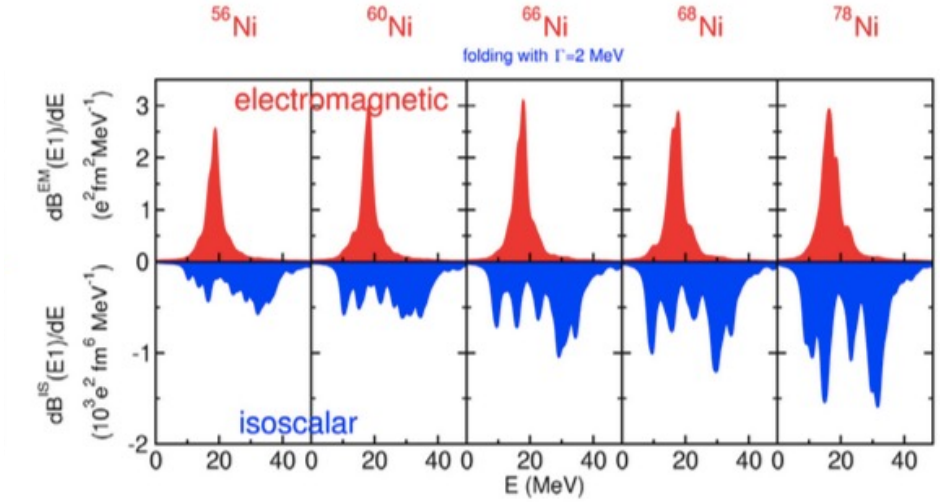
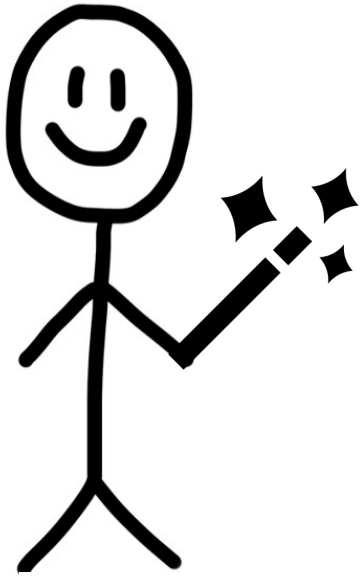
Dr Edoardo G. Lanza

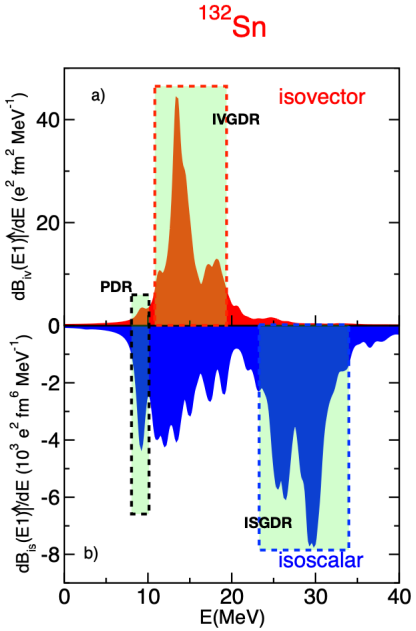


Dr Edoardo G. Lanza

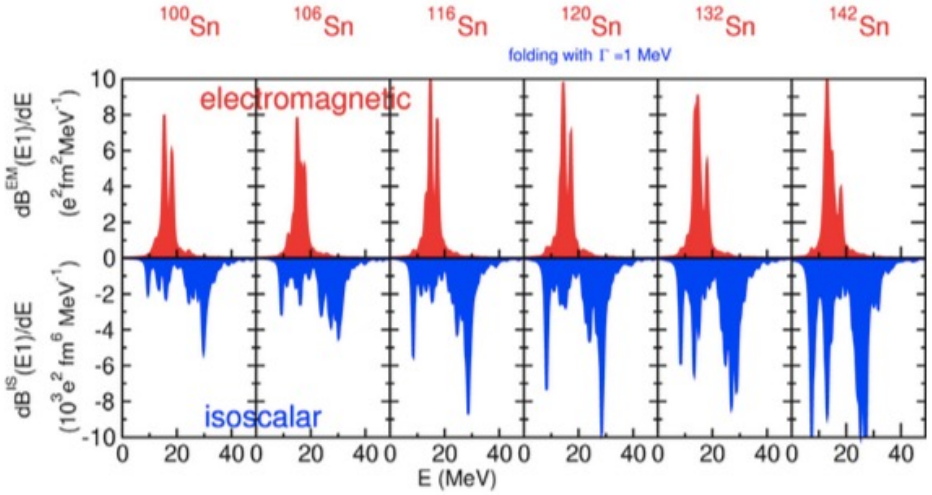
Theoretical Interpretation

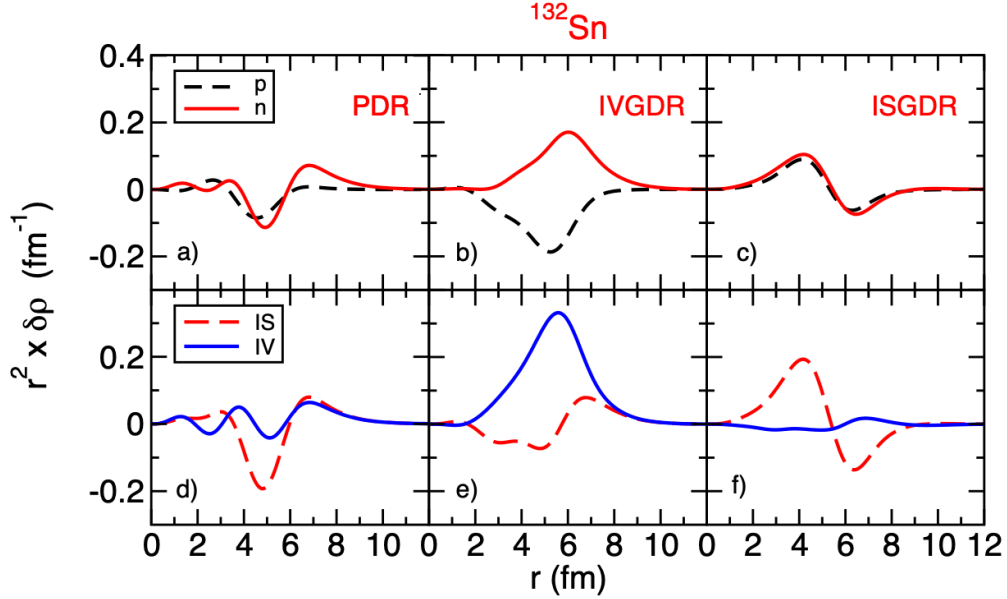






Presence of low-lying strength in both isovector and isoscalar responses
IV strength develops with increasing neutron number





A. Bracco, E.G. Lanza and A. Tamii, Prog Part Nucl Phys 106 (2019) 360

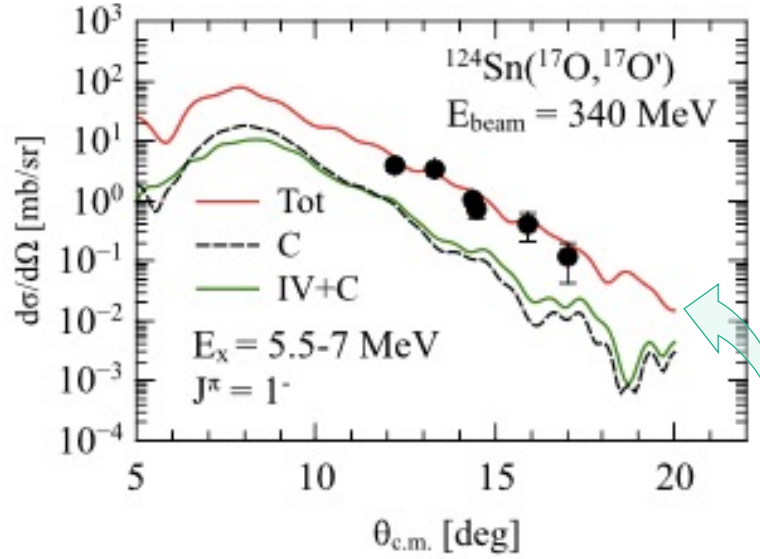
E.G. Lanza and A. Vitturi, arXiv:2202.07589v1

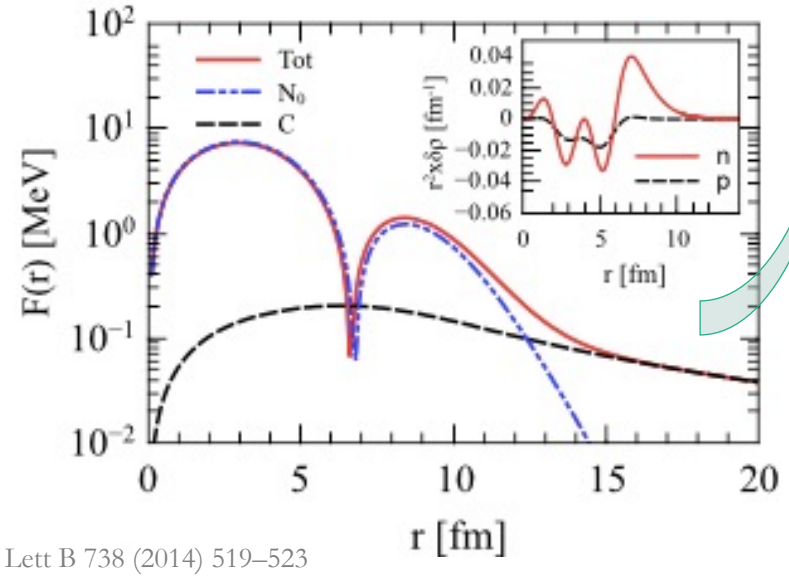
^{124}Sn+^{17}O: Cross sections for the Pygmy states

DWBA with **standard form factor** using the B(E1) measured in electromagnetic excitation → **account only for the 10% of the measured yield, very similar to only coulomb contribution**

The nuclear contribution to the excitation process is important and it has to be included in the cross section calculations in a proper way.

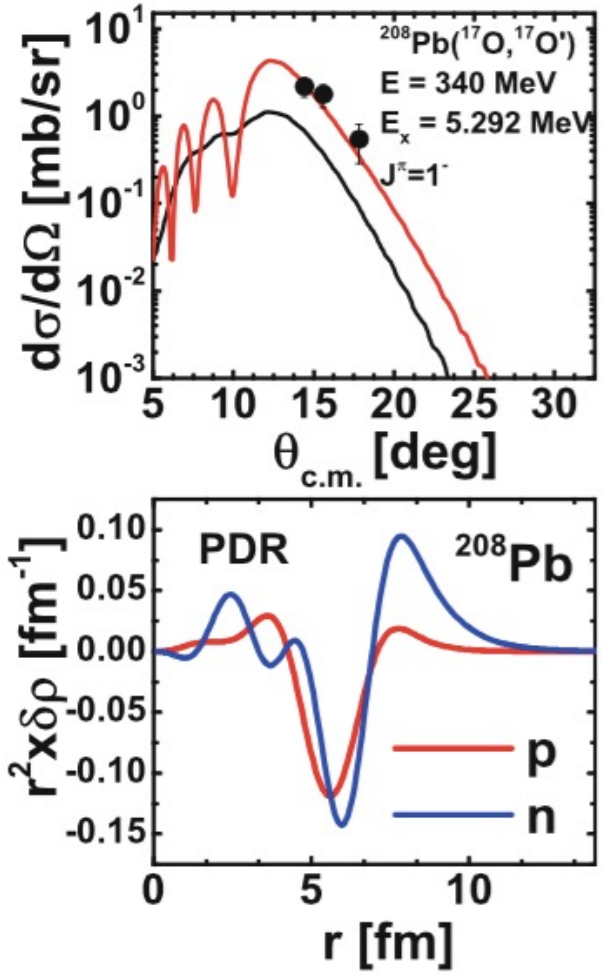
DWBA calculation performed using a **microscopic form factor based on the transition density** obtained with a microscopic model (RQTBA)



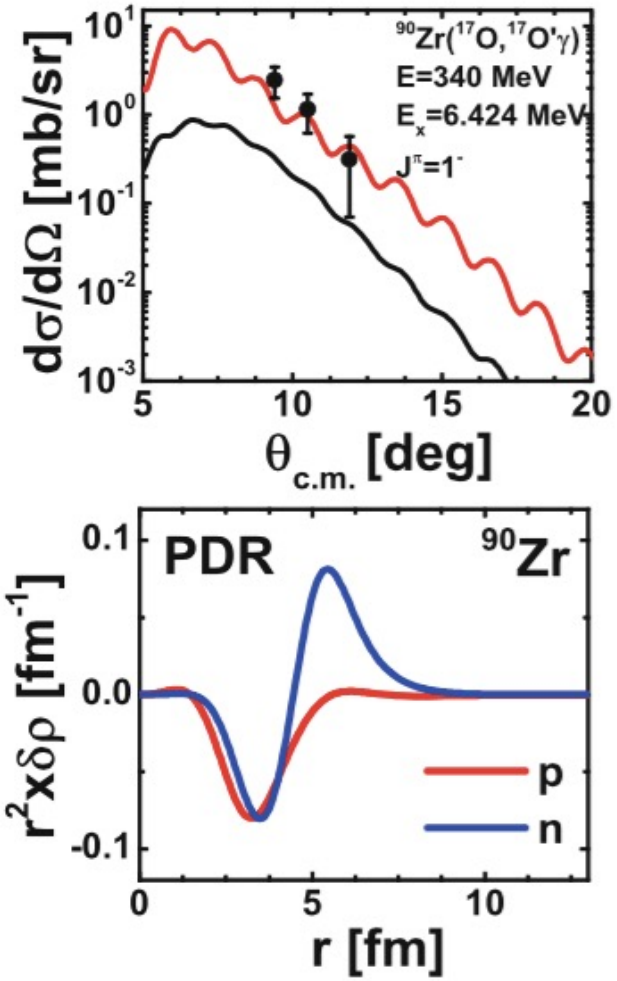


L. Pellegri et al. - Phys Lett B 738 (2014) 519–523

^{208}Pb and ^{90}Zr: Cross sections for the Pygmy states



F.C.L. Crespi et al., Phys Rev. Lett. **113**, 012501 (2014)



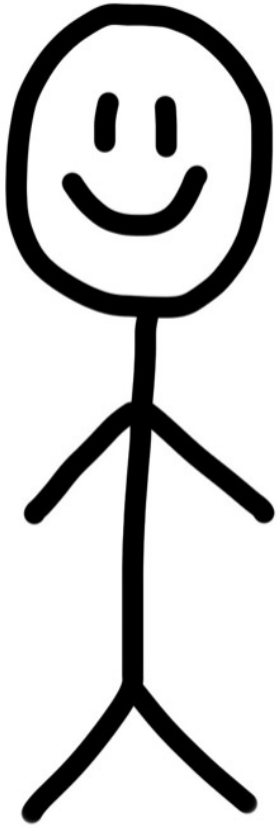
F.C.L. Crespi et al., Phys Rev. C **91**, 024323 (2015)

NN2015

12th INTERNATIONAL CONFERENCE ON NUCLEUS-NUCLEUS COLLISIONS

June 21-26, 2015, Catania, Italy

Dr Edoardo G. Lanza



Pygmy Dipole Resonance – what we learned

- **Observed in several neutron-rich nuclei** below and above neutron separation energy;
- **Few % of the electric dipole strength;**
- **Mixed isospin nature**
- **Astrophysical implications**: r-process nucleosynthesis and EoS
- Satisfactory description of PDR with microscopic self-consistent mean field models.
- Coupling of increasing complexity (2p-2h, 3p-3h …) configurations produce a fragmentation of the dipole strength comparable to the one observed in the experimental data
- **All the models predict TD with strong neutron contribution at the surface**

Open questions

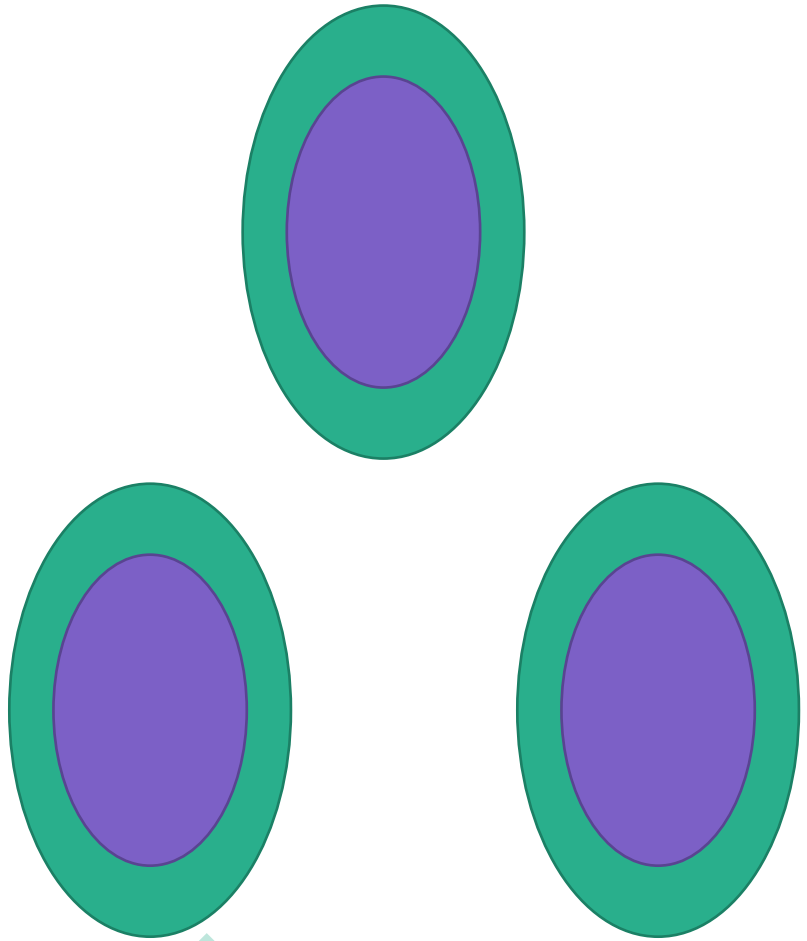
- Systematic correlation of PDR with basic properties of nuclei?
- Which states do belong to the PDR?
- What is the Role of deformation?
- Are the pygmy states collective or single particle excitations?
- Which is the interplay between the isoscalar and isovector contributions, especially above particle emission threshold?
- Are there PDR-type excitation in other multipolarities?
- …

The search continues..

Complication of otherwise simple matters…

- Goldhaber-Teller model:

DEFORMATION

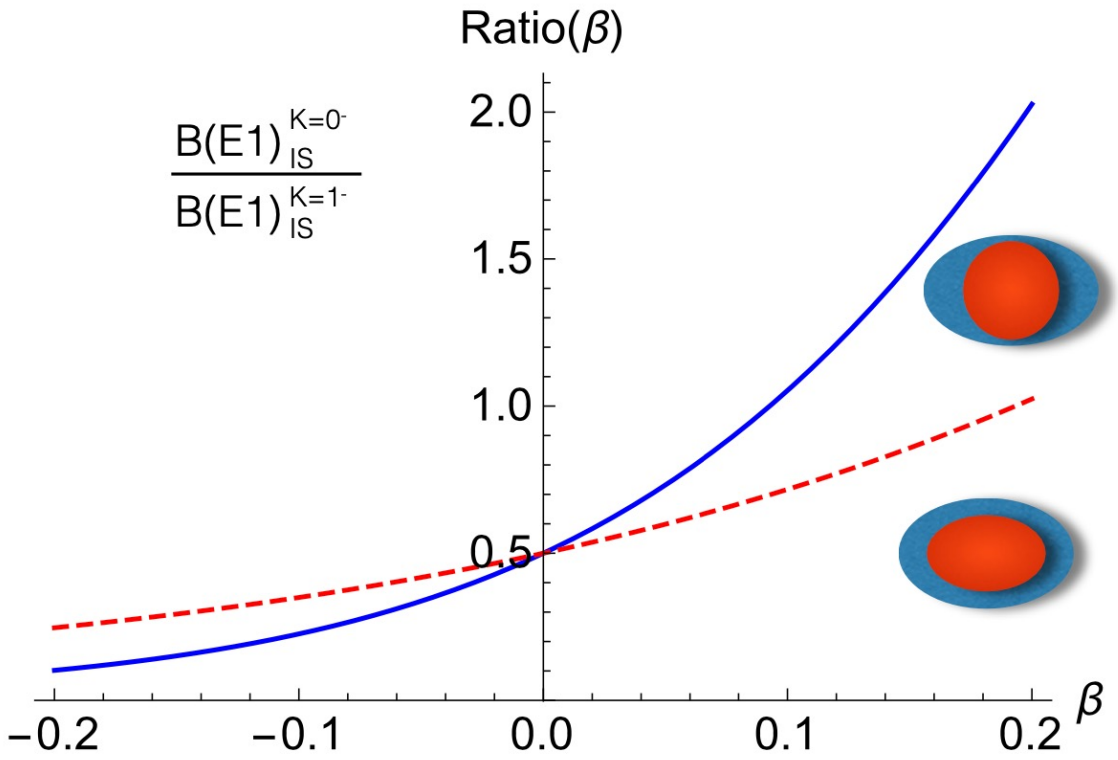


PDR in Deformed Nuclei

- Goldhaber-Teller model:

→ For the isoscalar response and prolate nuclei the isoscalar strength distribution reinforces the K=0 response with respect to the K = 1.

→ This dominance is further enhanced as the core approaches sphericity.



M. Faccioli, J.A. Lay, A. Vitturi, M.V. Andrés, E.G. Lanza work

PDR in Deformed Nuclei

Microscopic theories give contradictory answers:

- Relativistic Hartree-Bogoliubov (RHB) mean field plus a relativistic QRPA microscopic calculations

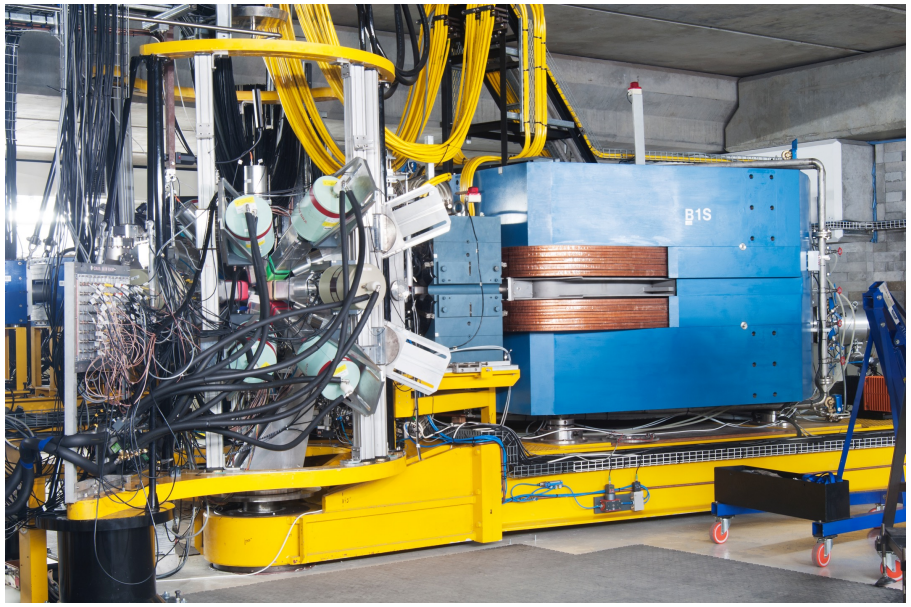
→the deformation quenches the isovector dipole response in the low-lying energy region

- HFB plus QRPA with Skyrme interactions

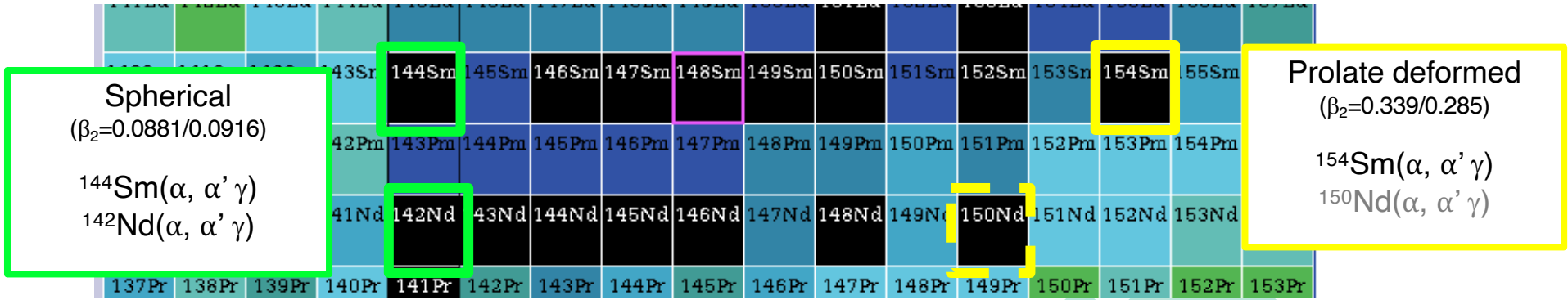
→ enhancement of the summed low lying dipole strength

→ The isoscalar response shows a separation between K=0 and K=1 components which is similar to what happens for the IVGDR of deformed nuclei

PDR in Deformed Nuclei



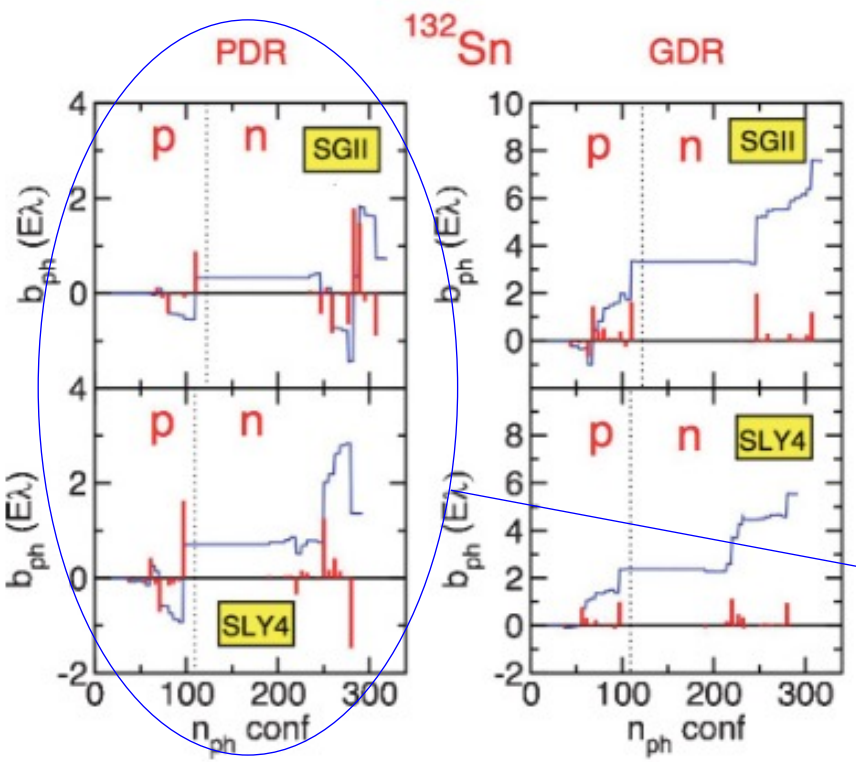
Experiment performed at iThemba LABS - Comparison with theoretical interpretation on going …

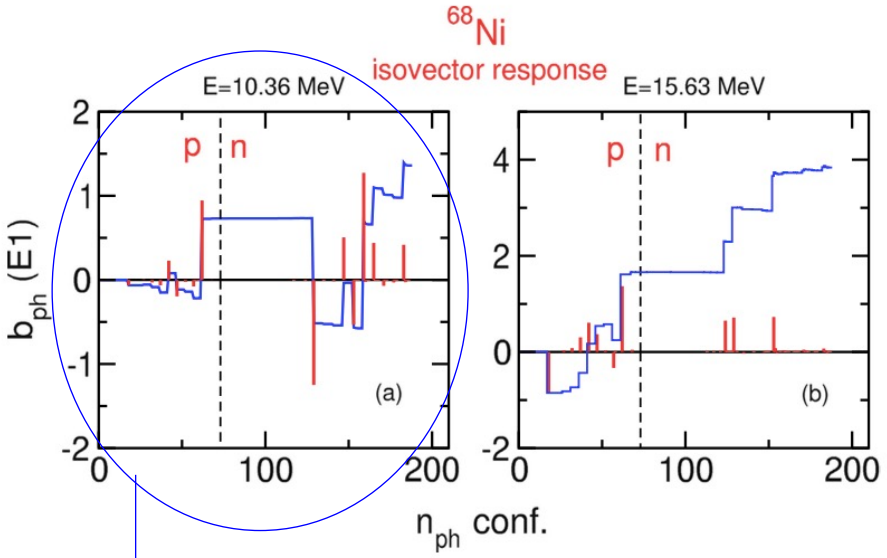


PDR property

SINGLE PARTICLE

PDR property





Contributions from several configurations but strong cancellations → small B(E1)

States cannot be considered collective but not even single p-h configuration

Collectivity:

1. number of particle-hole components entering in the RPA wave function with an appreciable weight.
2. Coherence

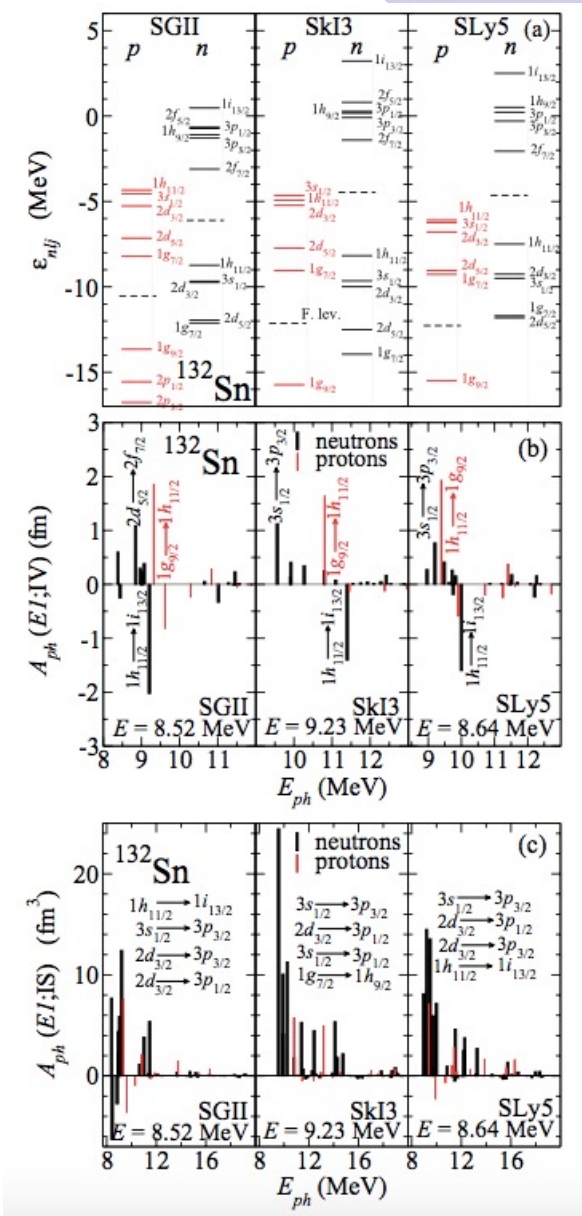
$$B(E\lambda) = \left| \sum_{ph} b_{ph}(E\lambda) \right|^2 = \left| \sum_{ph} \left(X^{\nu}_{ph} - Y^{\nu}_{ph} \right) T^{\lambda}_{ph} \right|^2$$

E. G. Lanza et al. Physical Review C 79, 054615 (2009)

PDR property

Study of Isoscalar and Isovector response:
IV → only a few in number + destructive interference
IS → mainly neutron transitions + add coherently

Low-energy isoscalar dipole response can be considered as a collective mode in all studied models, the PDS cannot

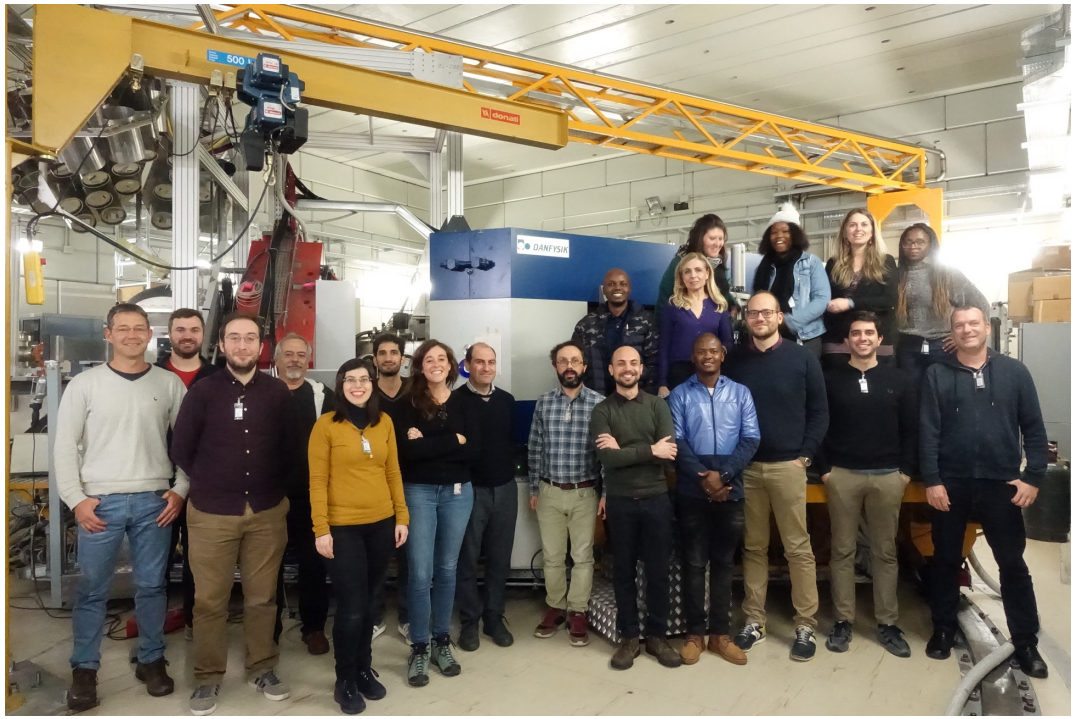


X. Roca-Maza et al. Physical Review C **85**, 024601 (2012)

PDR property

Transfer reactions on 208Pb, 120Sn and **96Mo (performed with MAGNEX at INFN-LNS)** were used to investigate the PDR with probes that enhance the single particle response.

COMPARISON WITH EXPERIMENTAL DATA NON-TRIVIAL but we are working on it ☺



PDR with transfer reaction experiment at MAGNEX – INFN-LNS
PhD project of T.C. Khumalo (Wits & iThemba LABS)

NOT ONLY NUCLEAR PHYSICS

MY FAVORITE CHEFS 🇮🇹

CONGRATULATIONS ON YOUR BRILLIANT CAREER (SO FAR!!)

To many more collaborations together and...
Many more PIZZAS