Nature of Pygmy Dipole Resonance in ^{74}Ge

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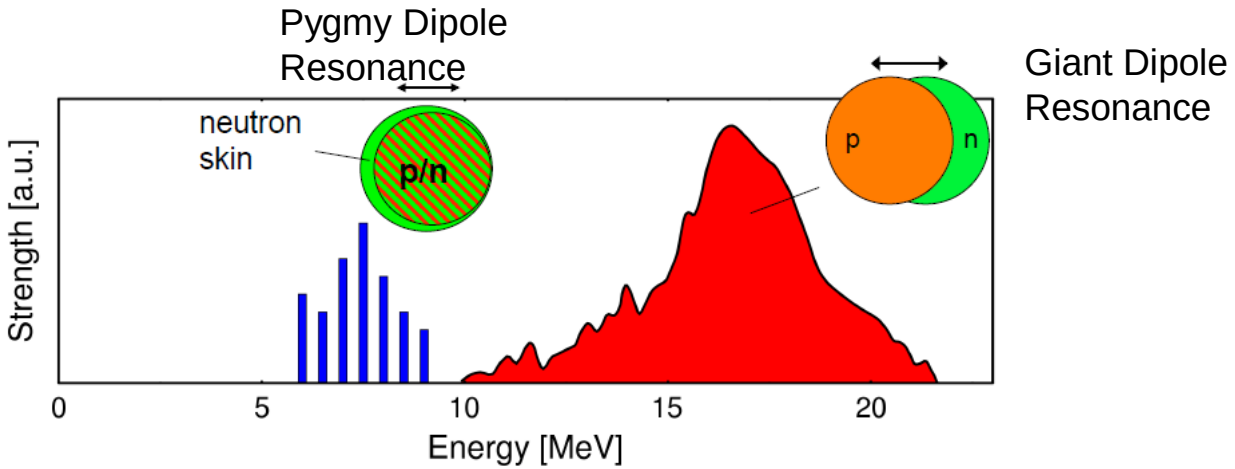
The Pygmy Dipole Resonance

Oscillation of neutron skin against the core



PDR : Open questions

- How collective it is ?
- Hoe does PDR depends on N/Z ?
- How PDR effects r-process nucleosynthesis ?
- Is ‘isospin-splitting’ a general phenomenon ?

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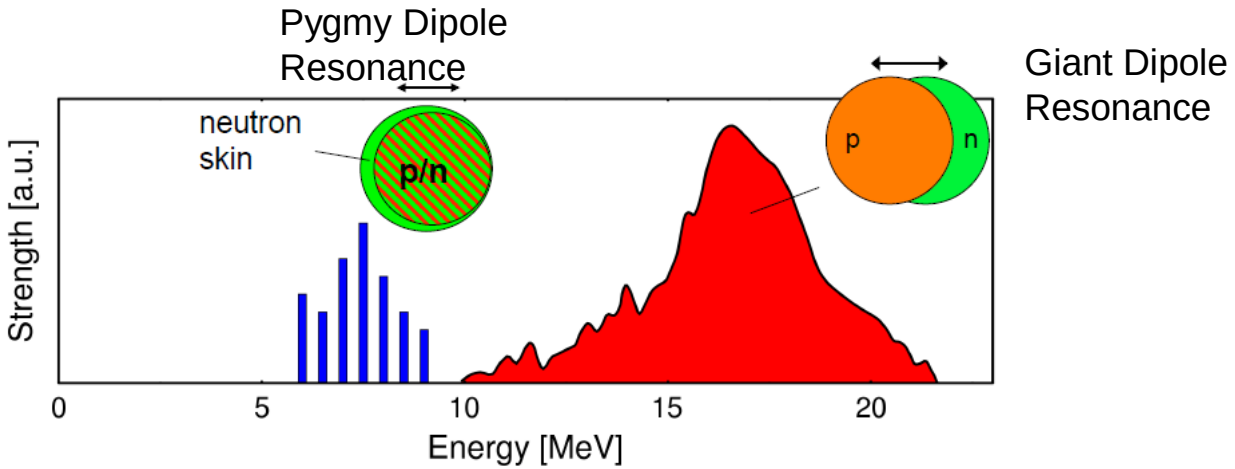

PDR : Open questions

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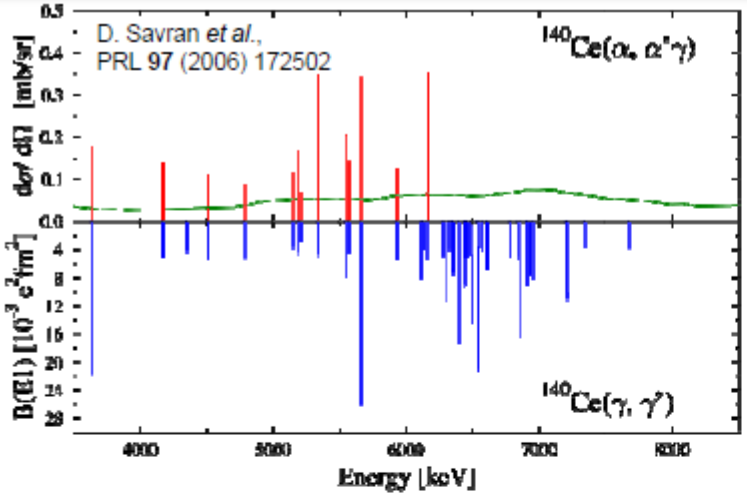
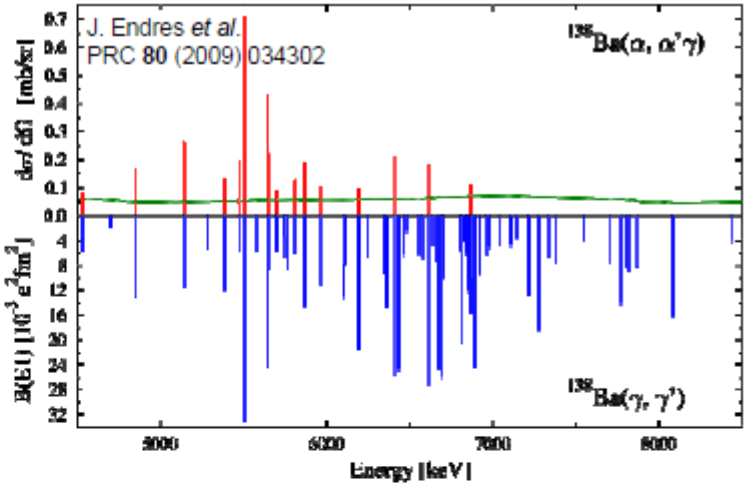
Use of complementary probes to reveal details of structure

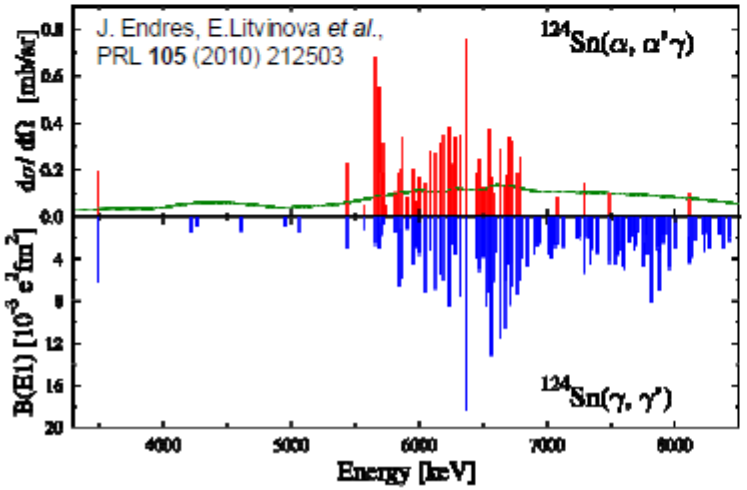
.

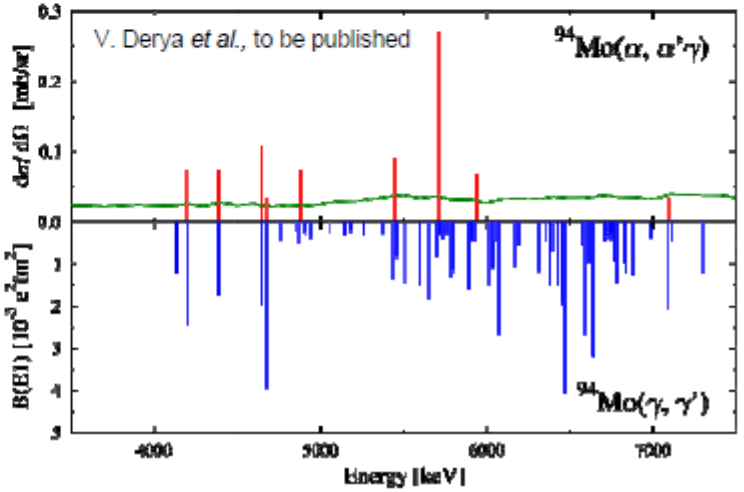
Photon scattering :	- dominant isovector excitation (for E1) - interaction with whole nucleus (kR << 1)
α scattering : (hadronic interaction)	- dominant isoscalar excitation - interaction dominant at the surface

Recent studies on E1 Strength distribution using $(\alpha, \alpha' \gamma)$ reaction

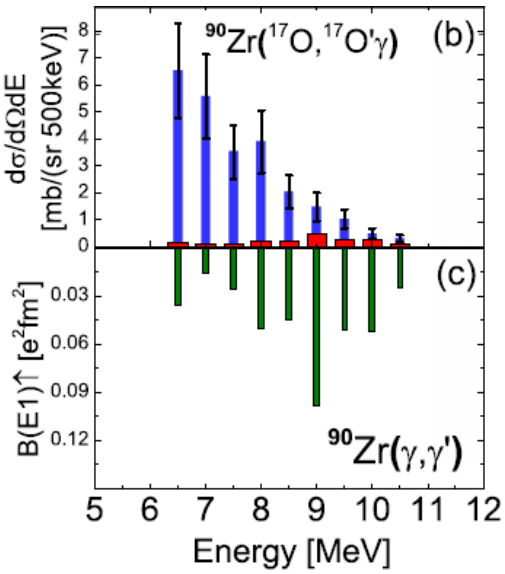




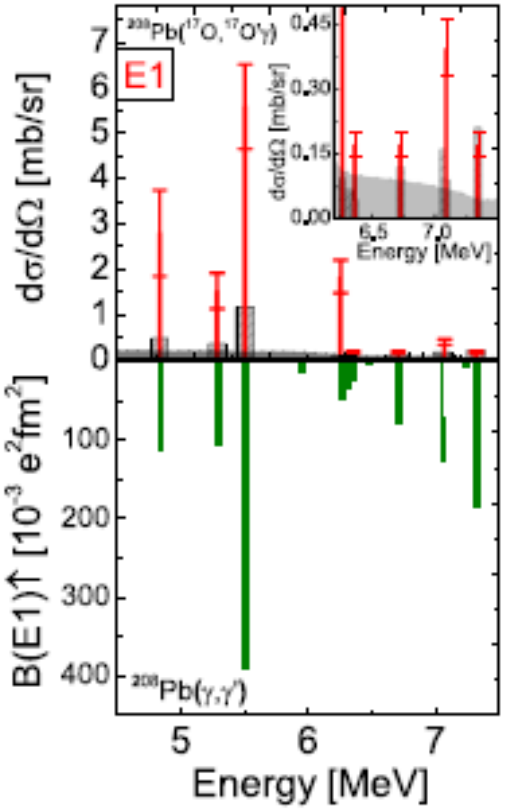




Recent studies on E1 Strength distribution using (H-Ion,H-Ion′γ) reaction



F.Crespi et al ., PRC 91, 024323 (2015)



^{208}Pb(^{17}O,^{17}O')^{208}Pb

F.Crespi et al ., PRL 113, 012501 (2014)

Scenario so far regarding studies with heavy ion scattering reactions

- Studies are limited to 130 mass region (except few cases) are done on nuclei with relatively larger N/Z asymmetry.
- Isospin -splitting is found in most of nuclei.

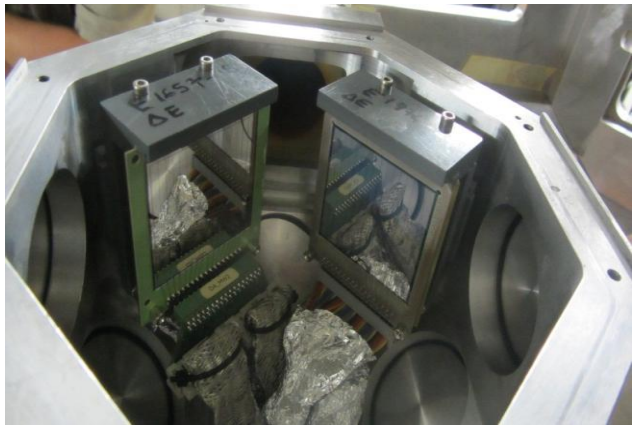
- Need for investigation in other mass regions (also in nuclei with lower N/Z asymmerty)

- Experimental effort was made to study low lying dipole states in 74Ge at iThemba LABS.

- N/Z = 1.32
- Weakly deformed prolate in its ground state

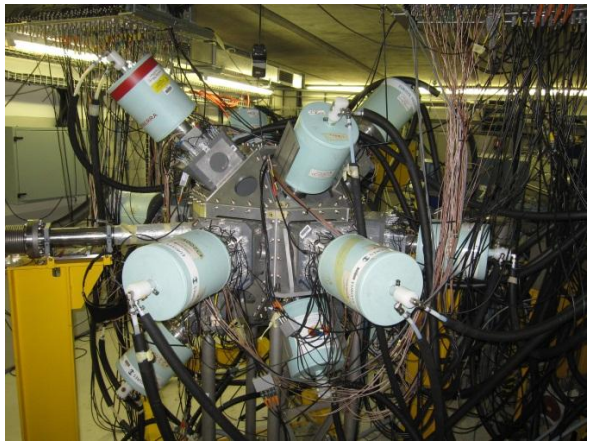
Experiment in new region

Population of excited states via inelastic scattering of ^{74}Ge using the following reaction ^{74}Ge(^{4}He, ^{4}He')^{74}Ge @ 48 MeV



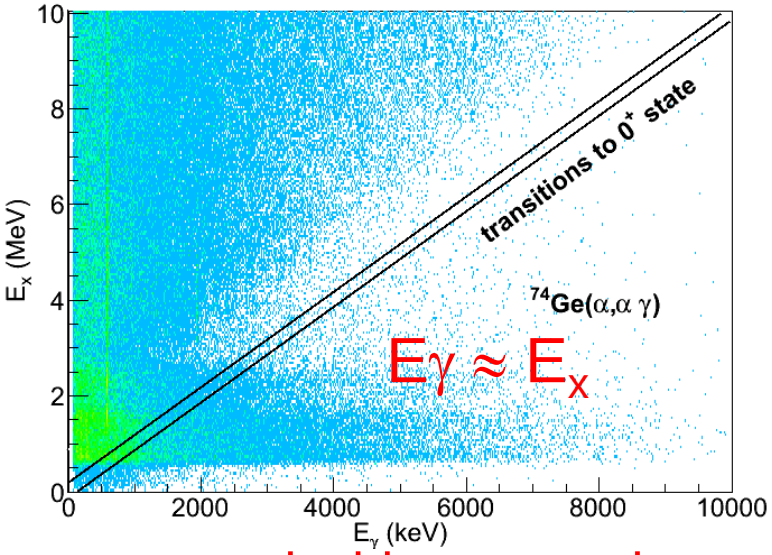
For the detection of
charged particles
Telescope counters
(Double sided) Silicon Strip Detectors
Two Counters
Thickness (ΔE) = 284 μm
Thickness (E) = 980 μm
At $\pm$ 45 degrees with respect to the beam axis

For the detection of γ-rays
HPGe detectors in Clover arrangement
Nine Clover detectors.
(AFRODITE Array at iThemba LABS)

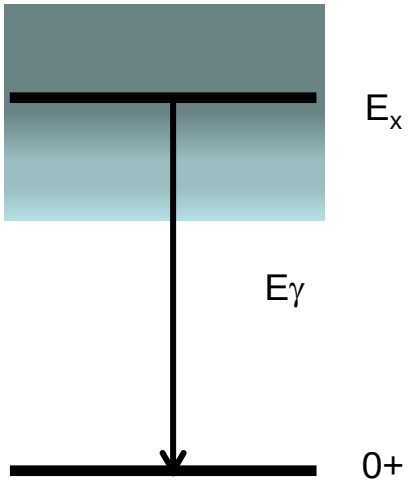


Experimental technique for the study of Pygmy dipole resonance

- Excitation energy of the system from the inelastically scattered alpha particles.
- Simultaneous detection of γ decaying to the ground state.

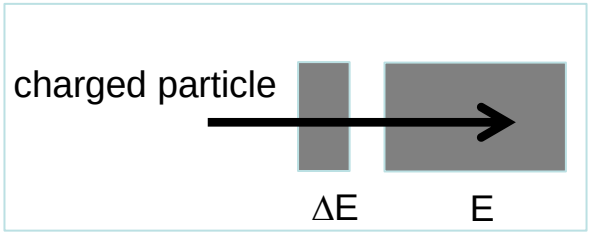


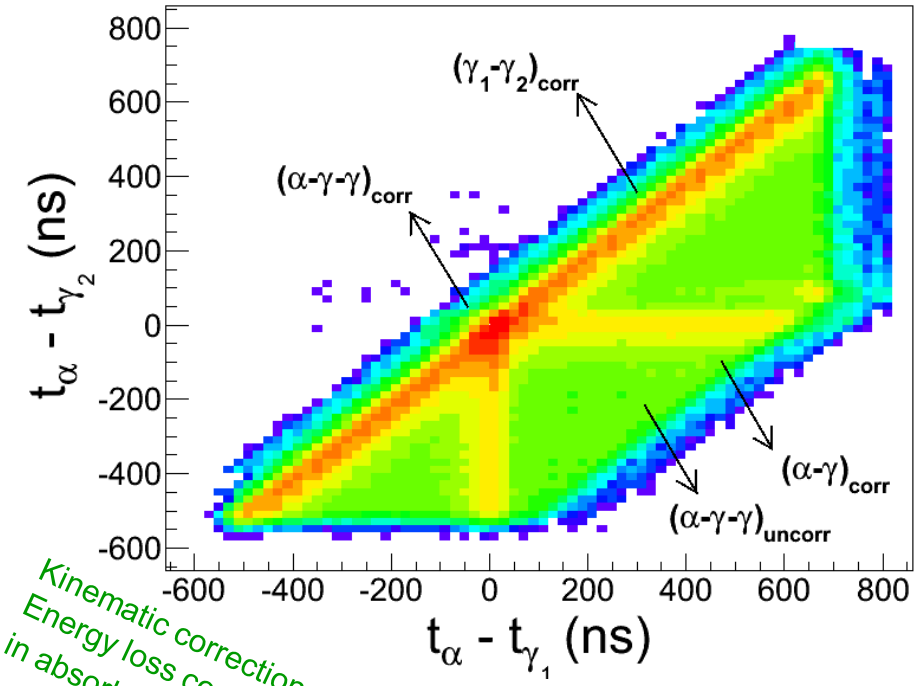
α – γ coincidence matrix



Excellent selection of $J^{\pi} = 1^{-}$ states
(for E_x > 5 MeV in even-even nucleus)

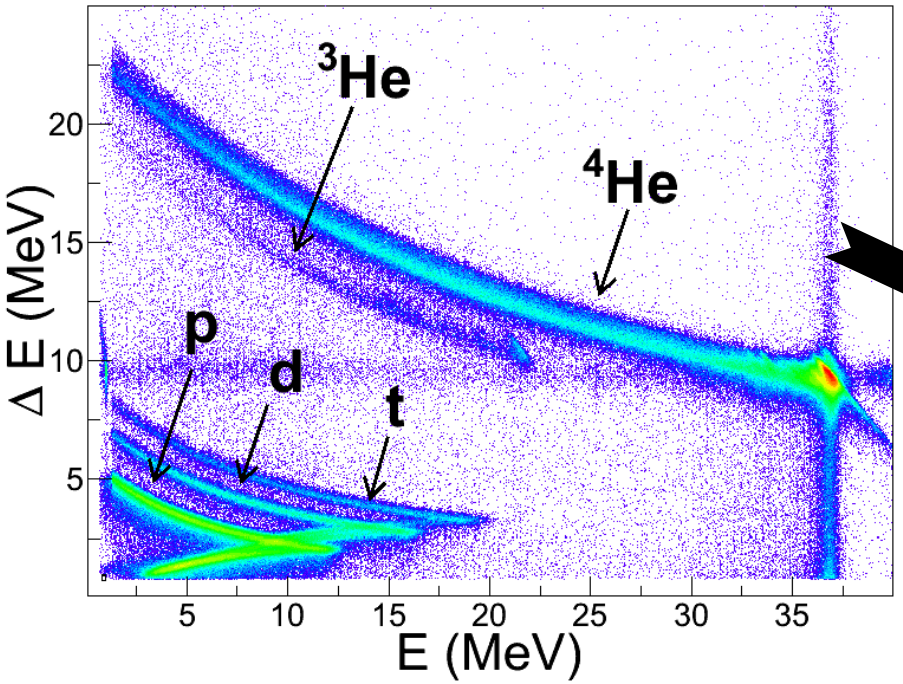
RESULTS



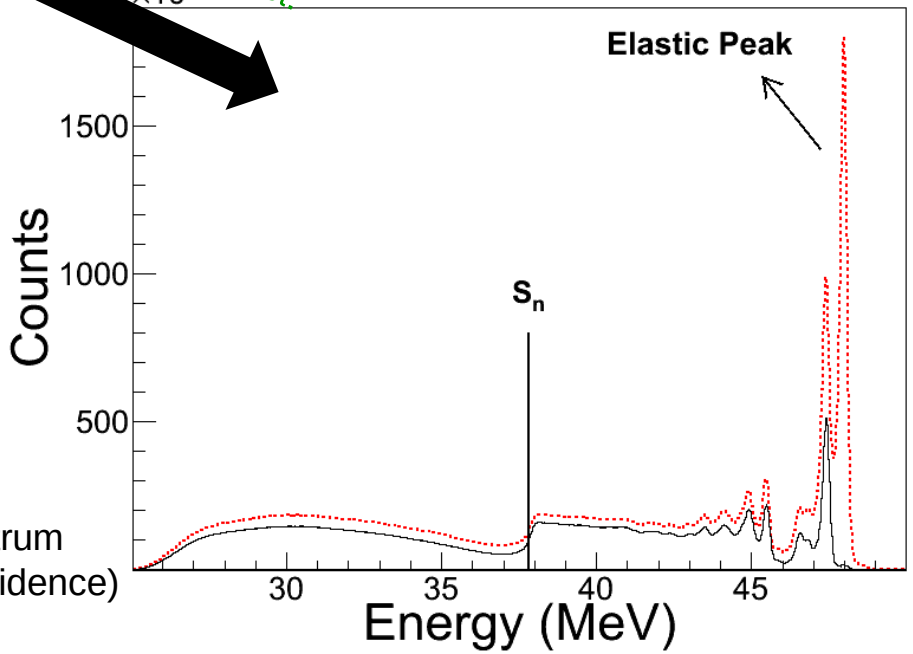


α-γ-γ timing relationship

Kinematic corrections.
Energy loss corrections
in absorbers and target.



Raw Particle Identification plot



α particle spectrum
(with γ in coincidence)

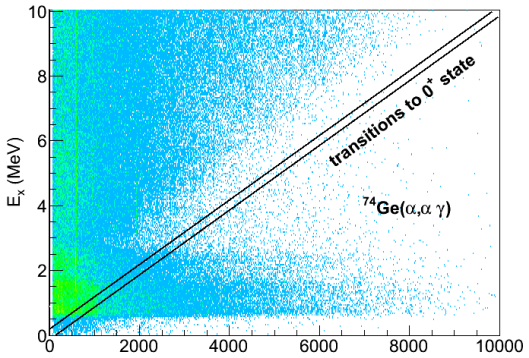
Red data are random events

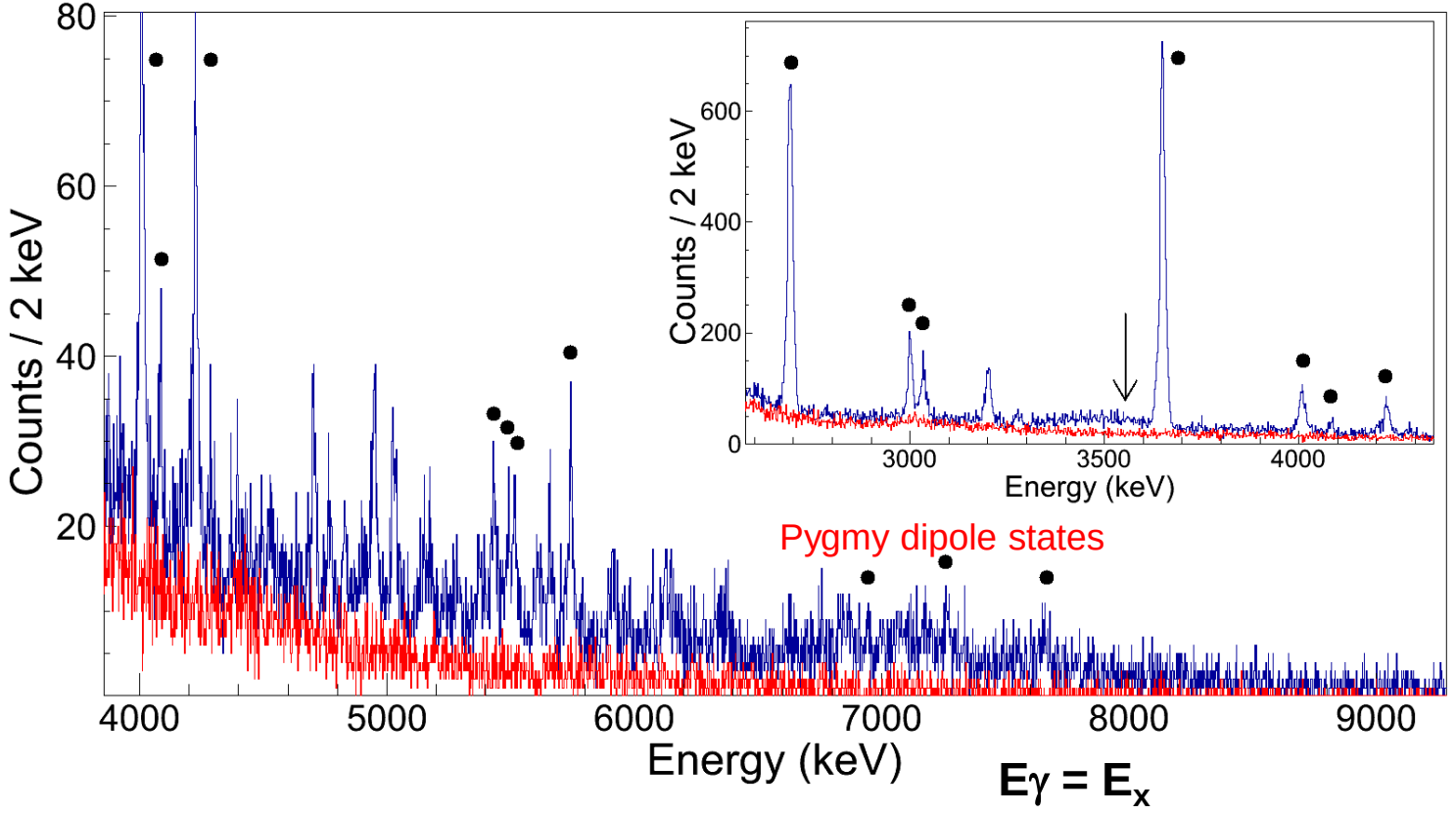
Blue data are after random subtraction

Energy resolution ~ 250 keV

RESULTS cont....

$| E_\alpha - E_\gamma | \; < \; 130$ keV



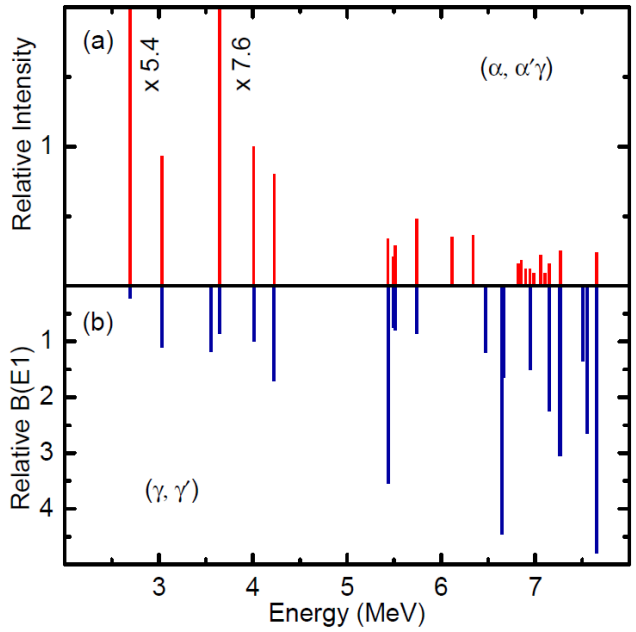


"●" represent known states from earlier works

"↓" indicate position of an absent transition observed in (γ , γ ') data

Comparison with (γ, γ')data

Experimental Results



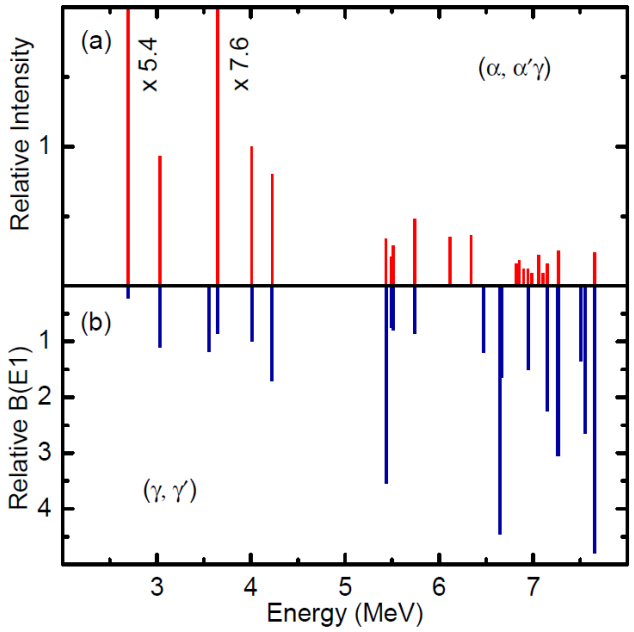
Observations :

- Relatively larger isoscalar contribution for states E < 5 MeV.
- Relatively larger isovector contribution for states E > 5 MeV .

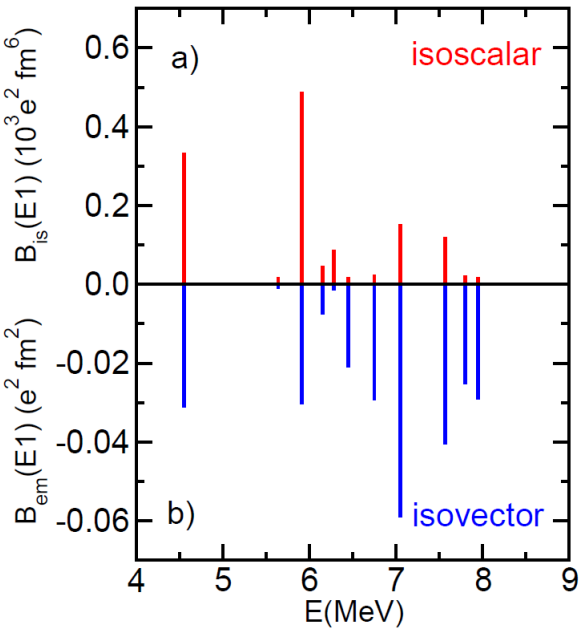
(γ,γ') data taken from A. Jung et al., Nucl. Phys. A 584 (1995) 103.

Comparison with (γ, γ')data

Experimental Results



Theoretical Calculations



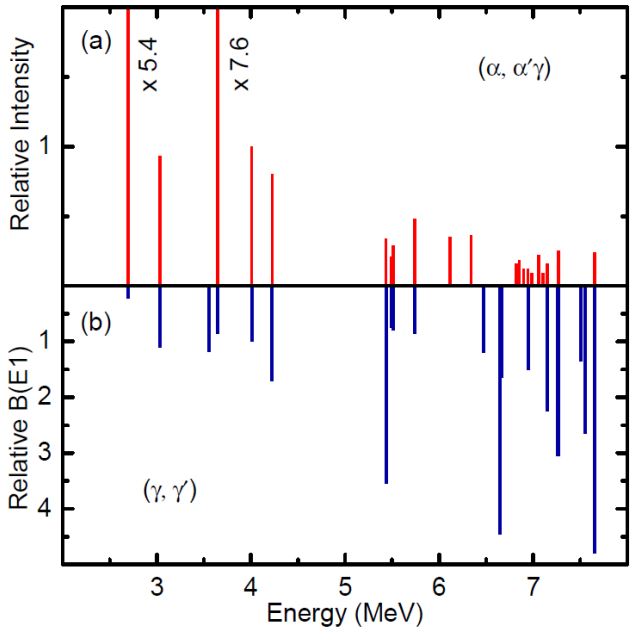
Theoretical calculations:

- RQTBA calculation.
- Qualitatively reproduces the trend of decreasing isoscalar strength with increasing excitation energy.

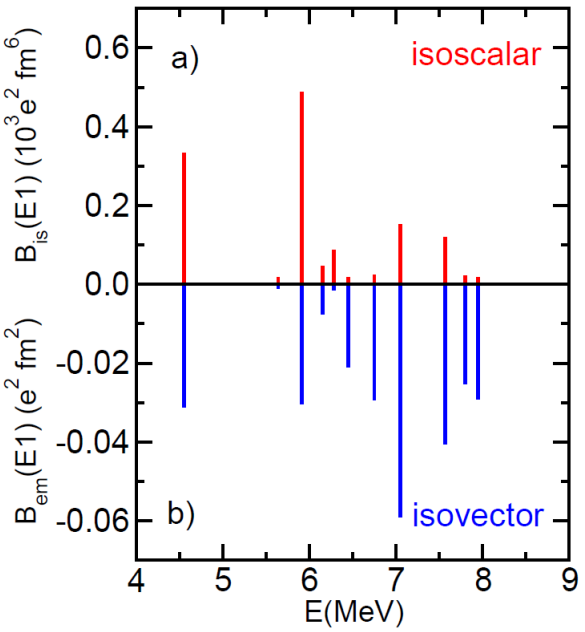
(γ,γ') data taken from A. Jung et al., Nucl. Phys. A 584 (1995) 103.

Comparison with (γ, γ')data

Experimental Results



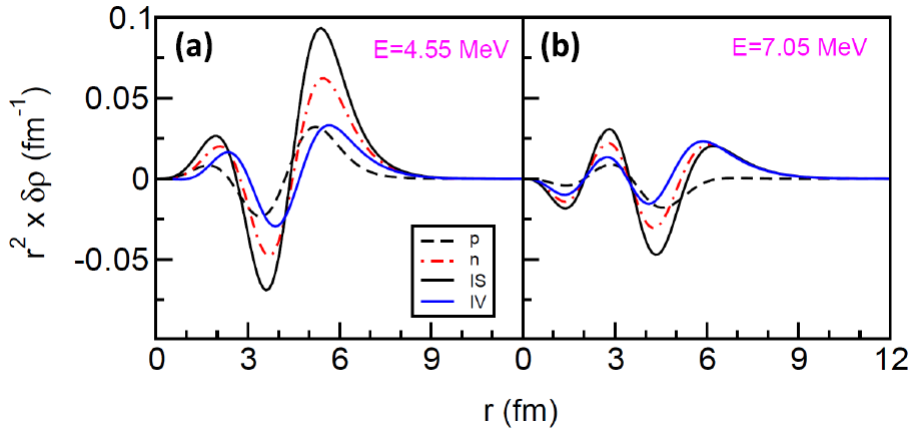
Theoretical Calculations



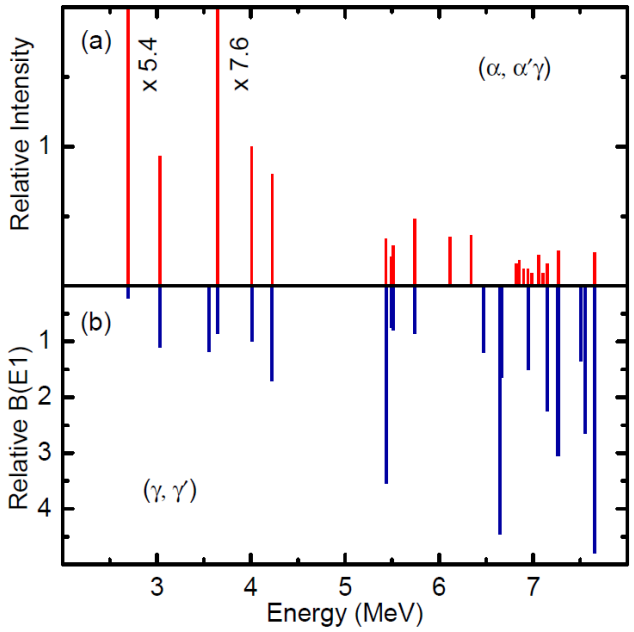
Theoretical calculations:

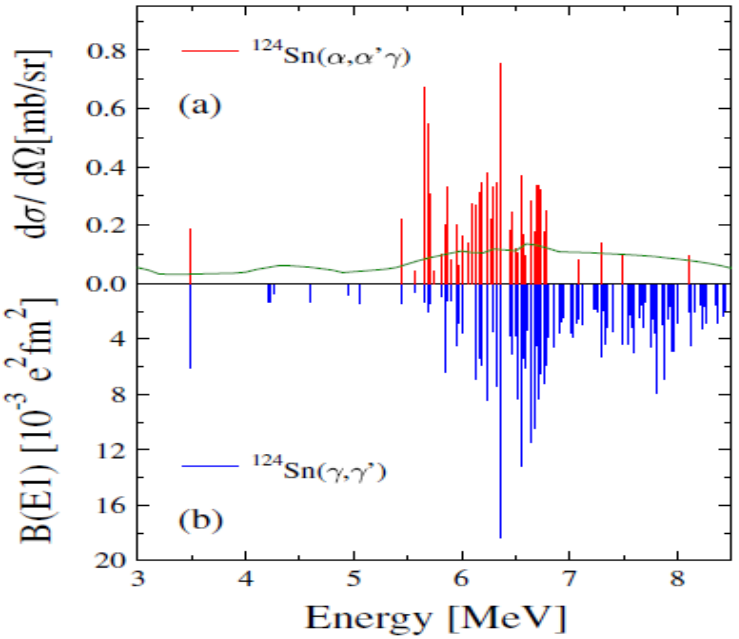
- RQTBA calculation.
- Qualitatively reproduces the trend of decreasing isoscalar strength with increasing excitation energy.

- Transition densities exhibit compressional mode at low energies and isospin mixed mode at higher energies



Comparison to earlier work with $(\alpha,\alpha'\gamma)$ reaction





J. Enders et al., PRL 105, 212503

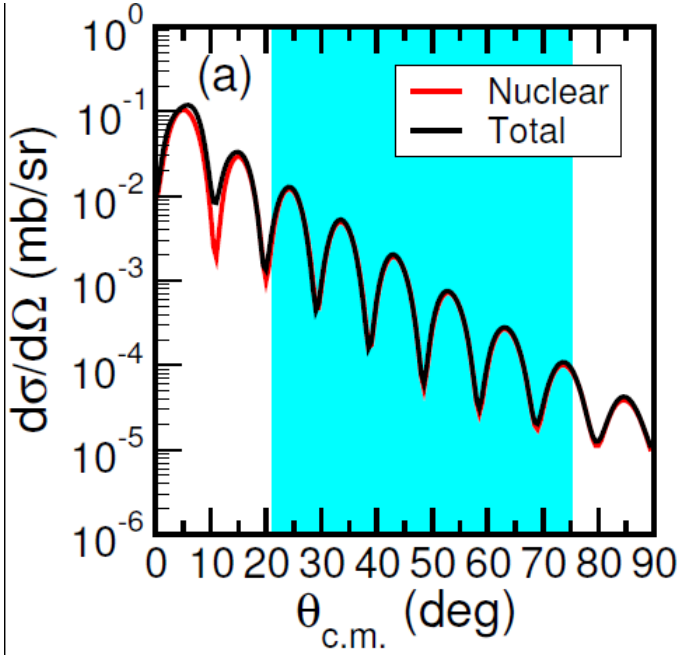
Observations:

- Stronger isoscalar response at low energies (E < 5 MeV) compared to earlier works.
- No isospin splitting in the pygmy region, i.e. 6 – 8 MeV.
- Isocalar response is same for dipole states in this energy region.

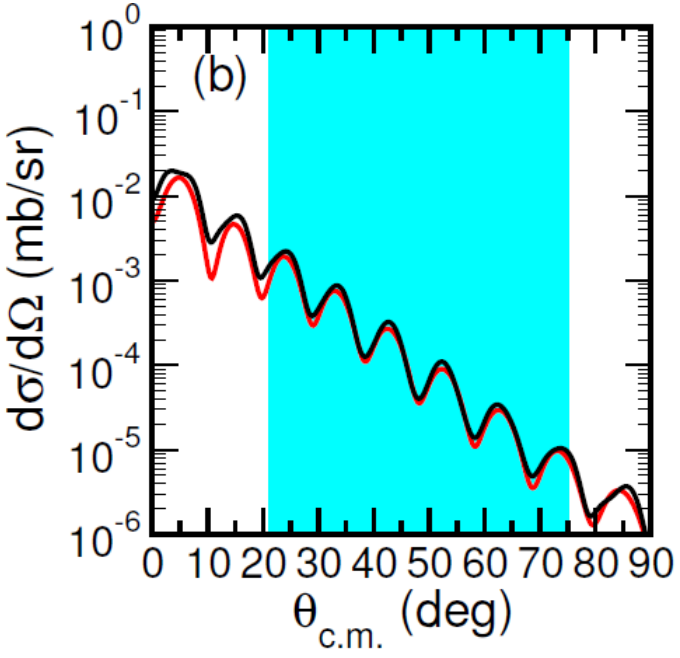
(γ,γ') data taken from A. Jung et al., Nucl. Phys. A 584 (1995) 103.

Contribution of Coulomb interaction

For dipole states at E = 4.55 MeV



For dipole states at E = 7.01 MeV

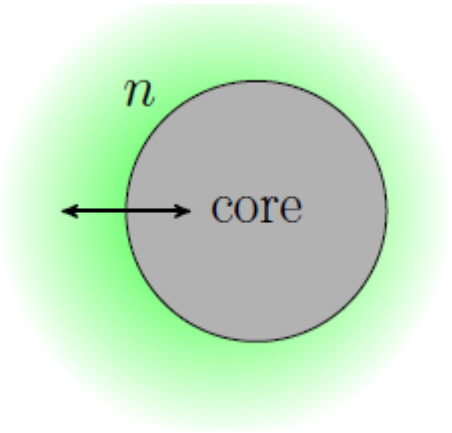


DWBA Calculations (DWUCK4 code)
Using microscopic transitions densities
from RQTBA calculations.

Negligible contribution from Coulomb interaction

Conclusions :

- Isospin splitting of PDR is not observed in ^{74}Ge
- Relatively large isoscalar components of dipole states at lower energies (E < 5 meV)
- α and γ interact differently with nucleus. (surface vs whole nucleus)
- Importance of complementary probe, alpha, in deducing information.



Collaboration

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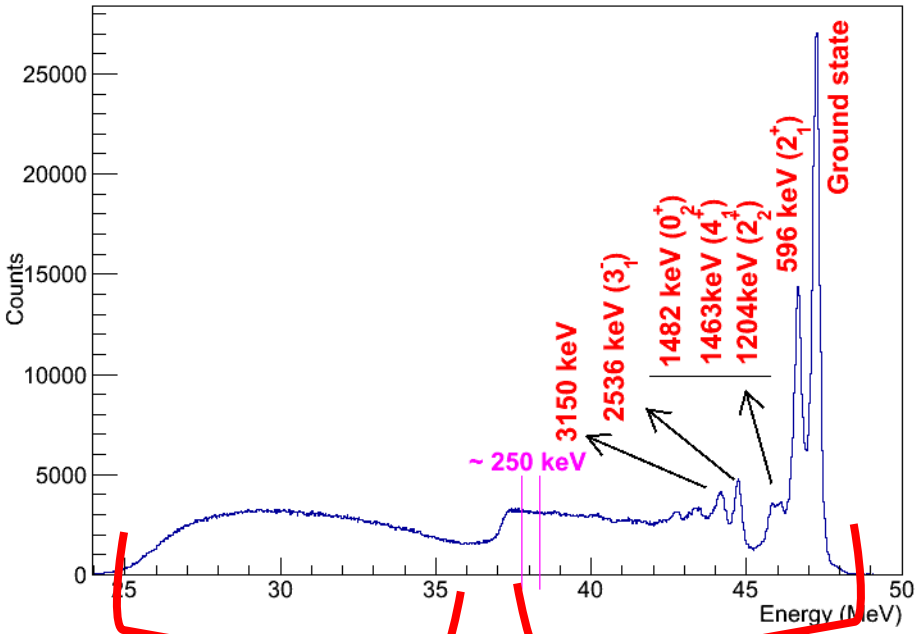
Thank You

RESULTS cont....

Particle Spectrum with α banana gate



γ-ray Spectrum