

Properties of the Pygmy Dipole Resonance

- Dipole strength in atomic nuclei
- Electric or magnetic?
- Pygmy or Giant?



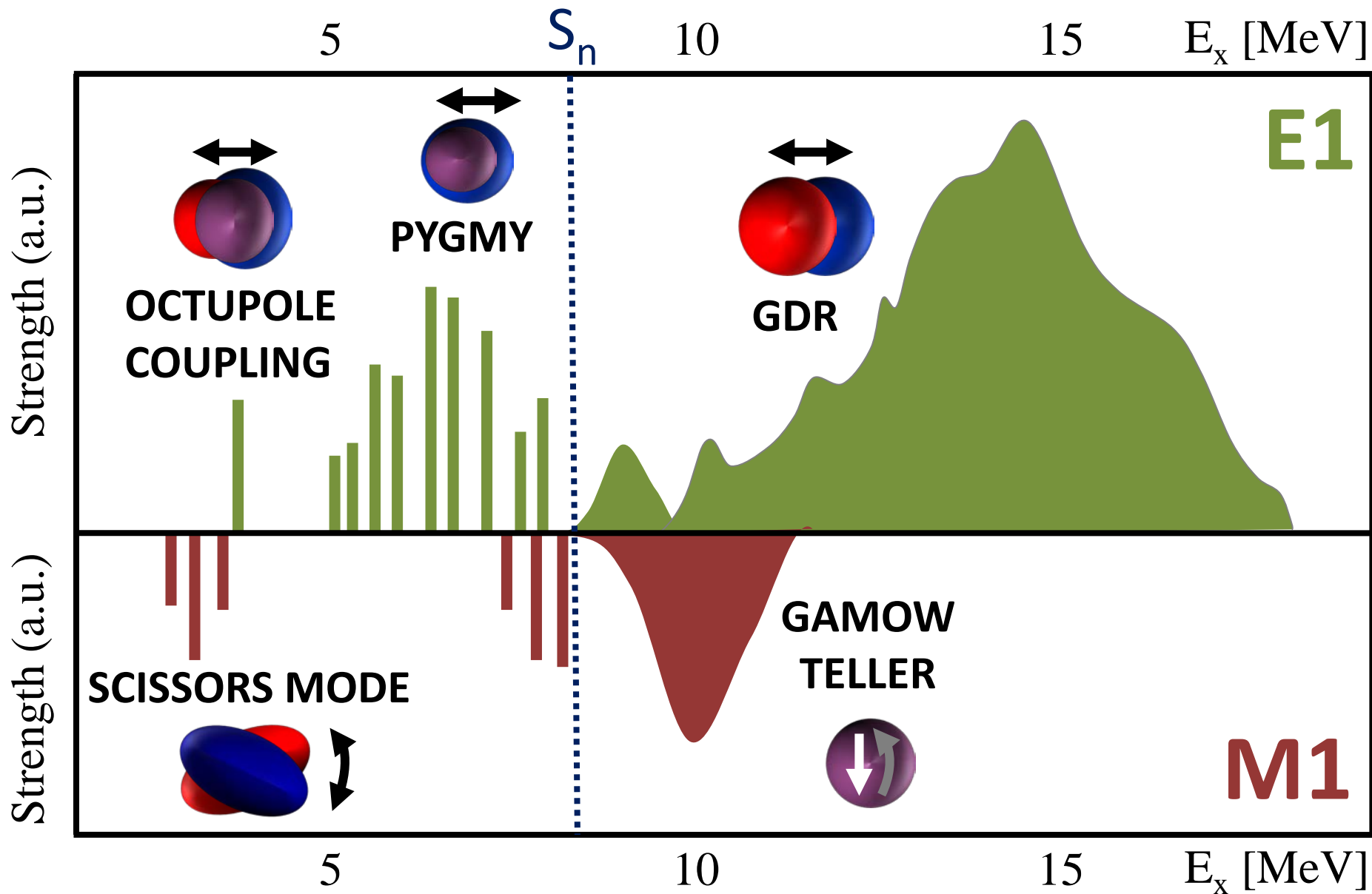
Andreas Zilges
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supported by: **DFG** (ZI 510/7-1, INST 216/544-1, and BCGS)

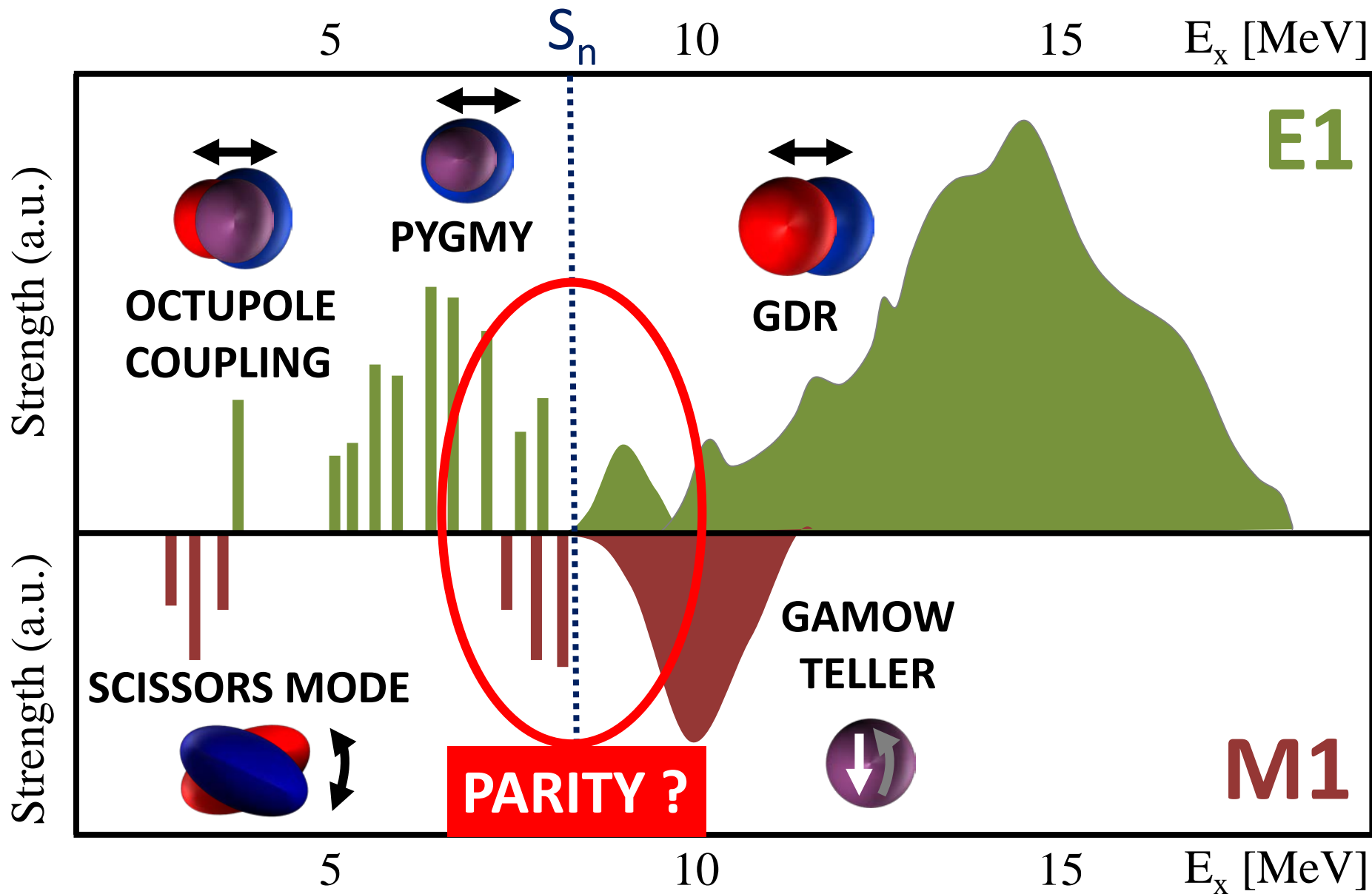


(05P2015 ELI-NP)

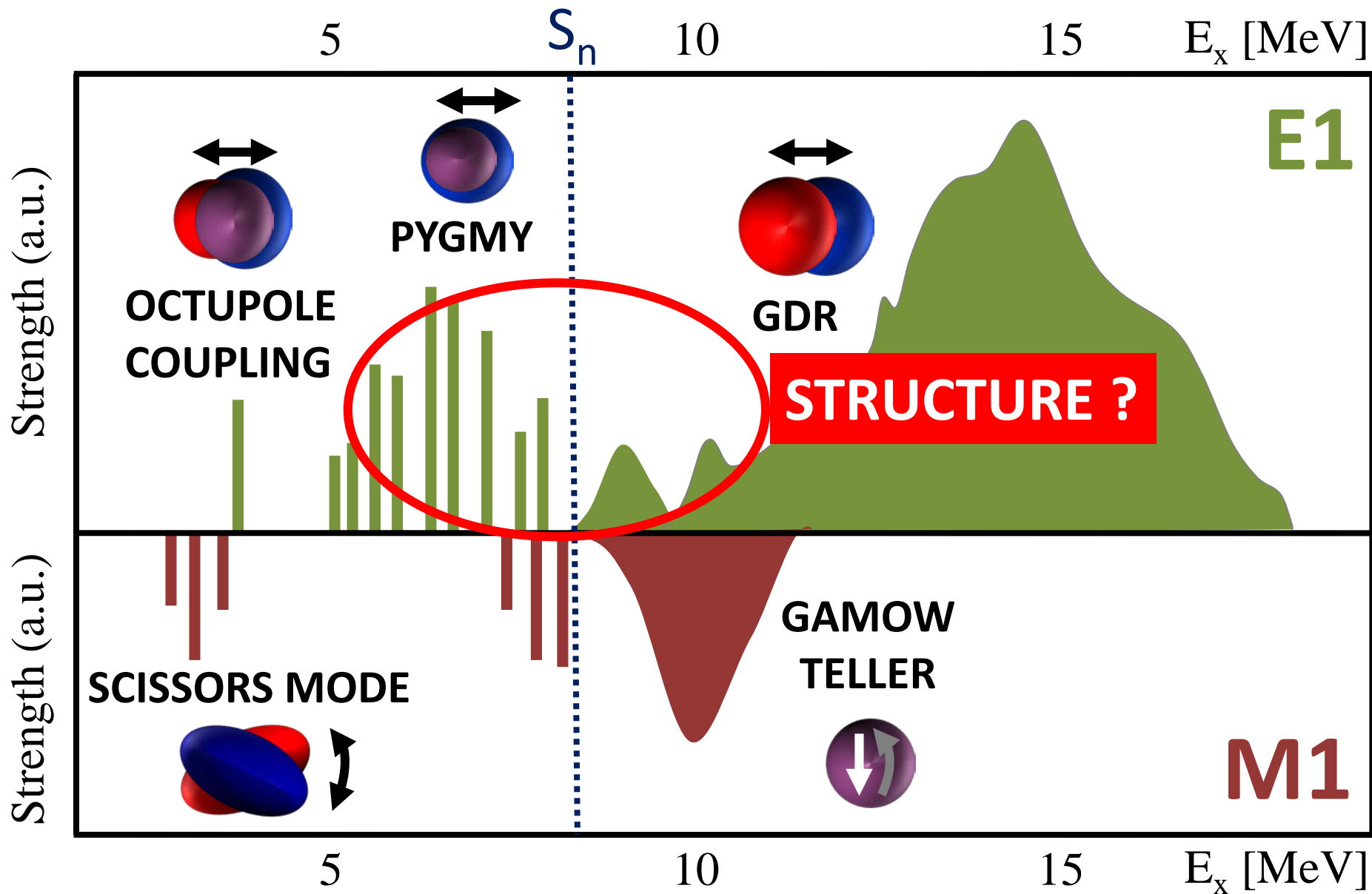
Dipole photoresponse of atomic nuclei



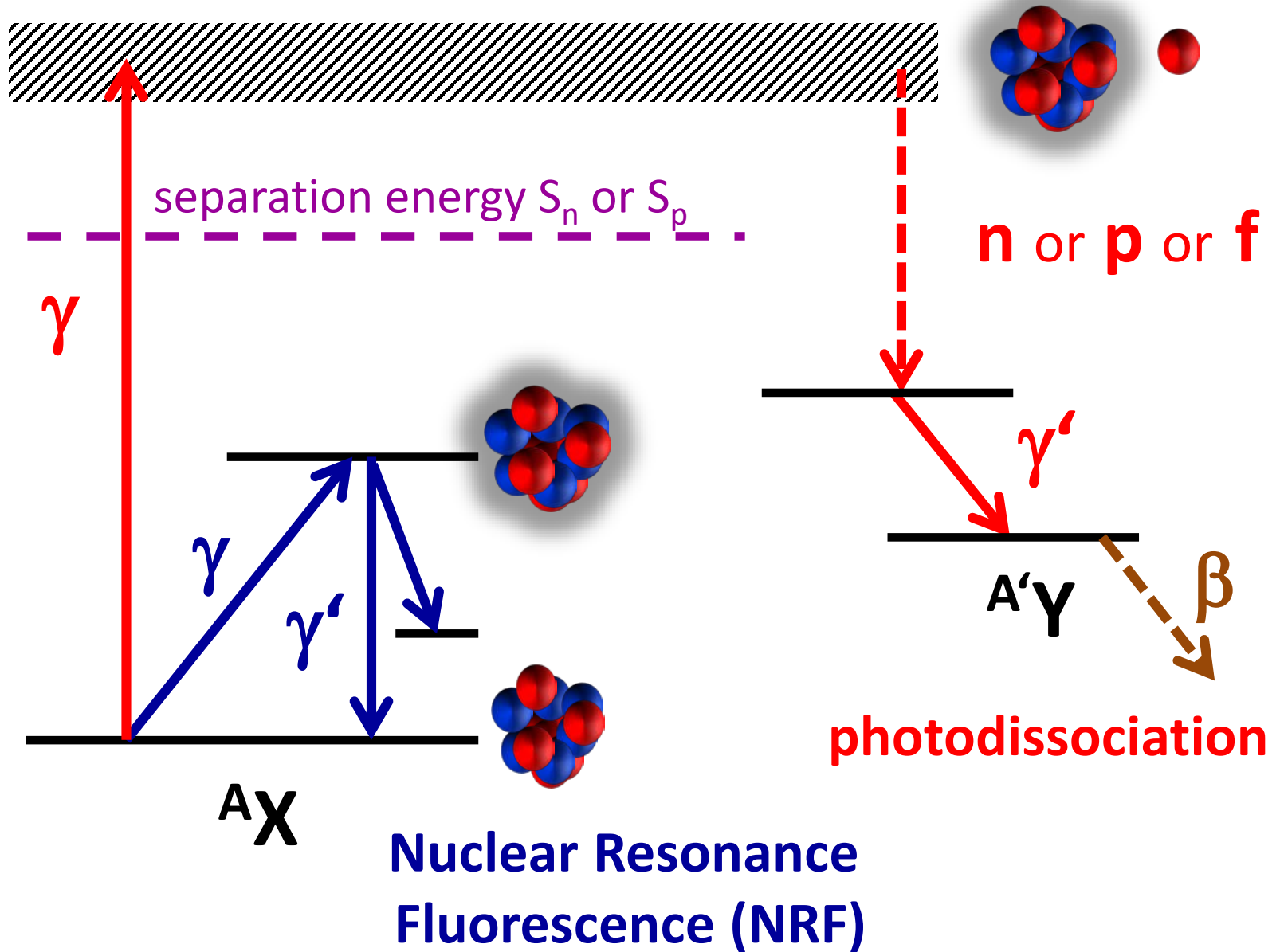
Dipole photoresponse of atomic nuclei



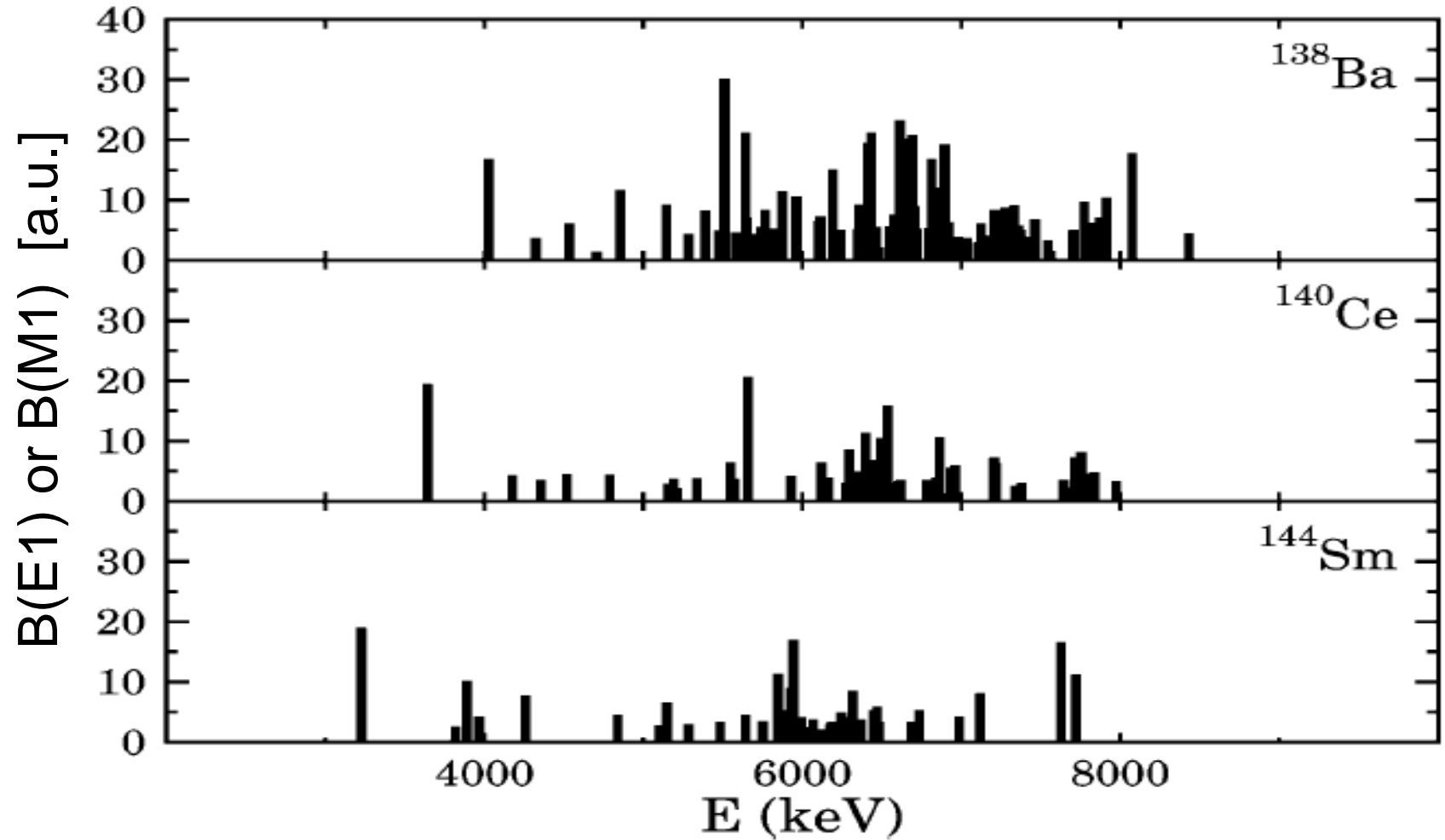
Dipole photoresponse of atomic nuclei



Photonuclear Reactions

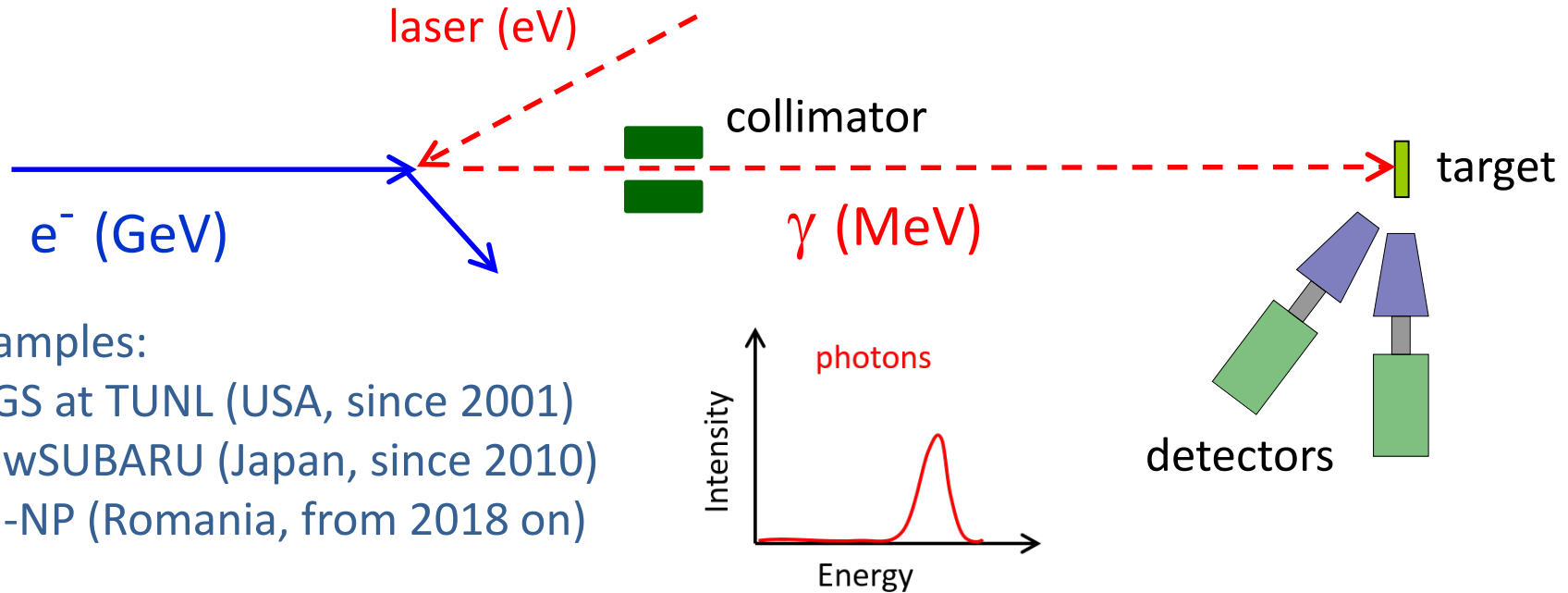


NRF using bremsstrahlung



NRF using monoenergetic photons

Laser Compton Backscattering (LCB)



Examples:

HIGS at TUNL (USA, since 2001)

NewSUBARU (Japan, since 2010)

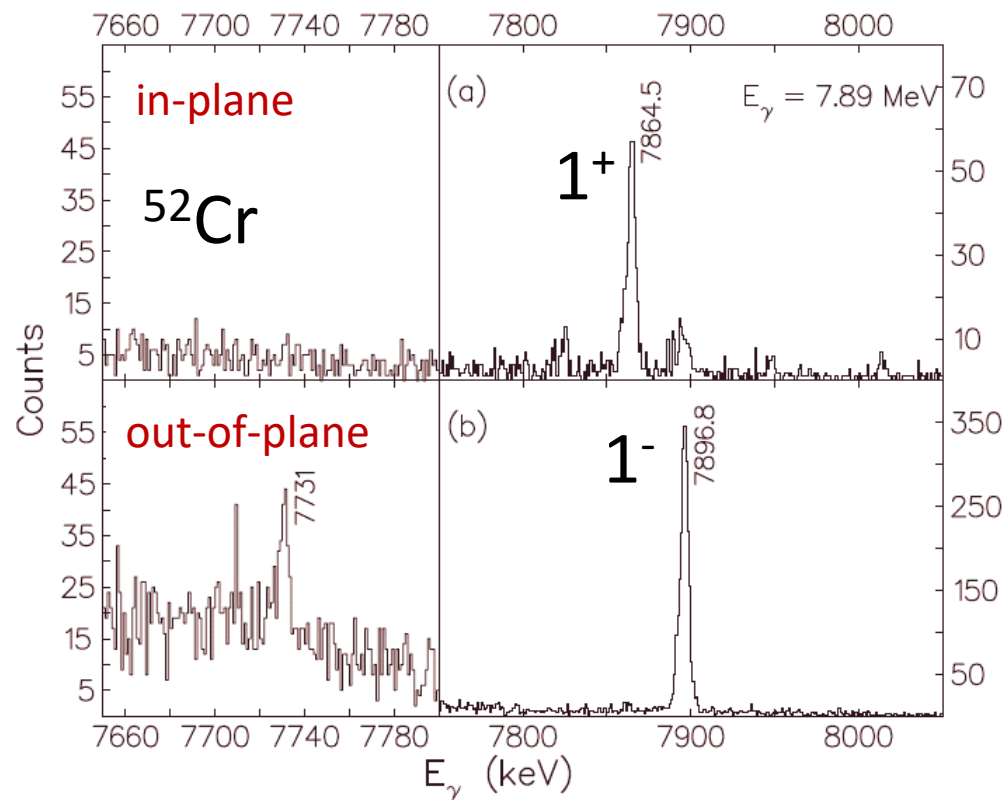
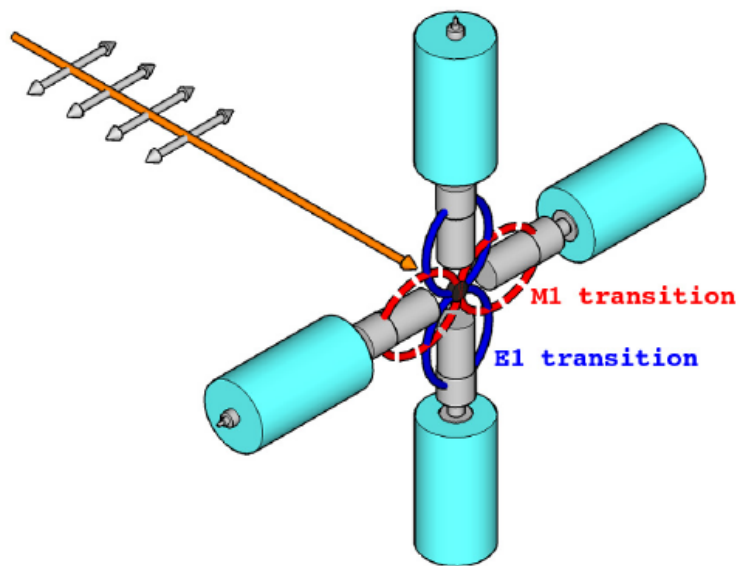
ELI-NP (Romania, from 2018 on)

- "monoenergetic" photon spectrum
- tunable energy
- polarized beam

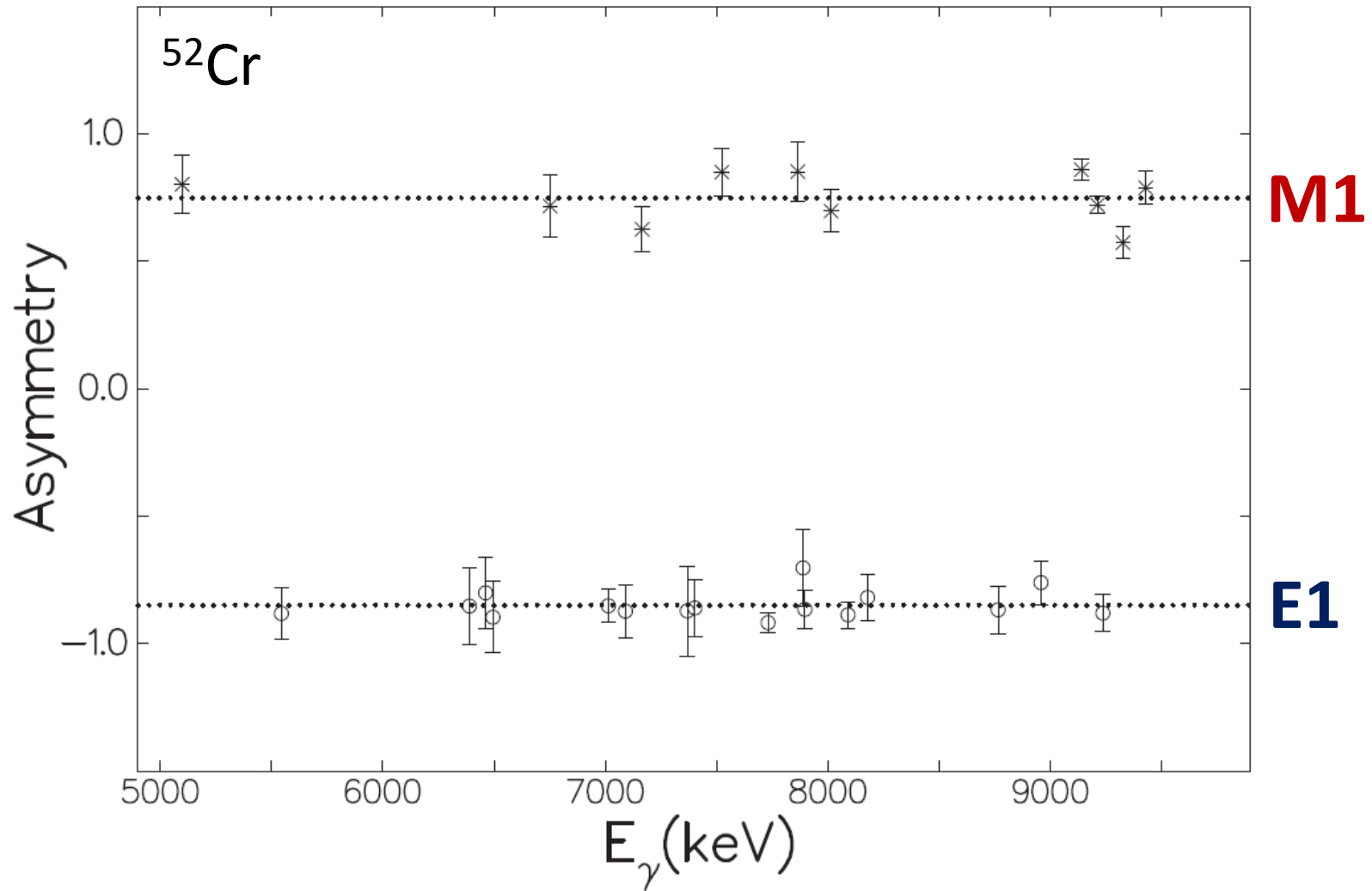
→ Nuclear Photonics

Parity determination with polarized photons

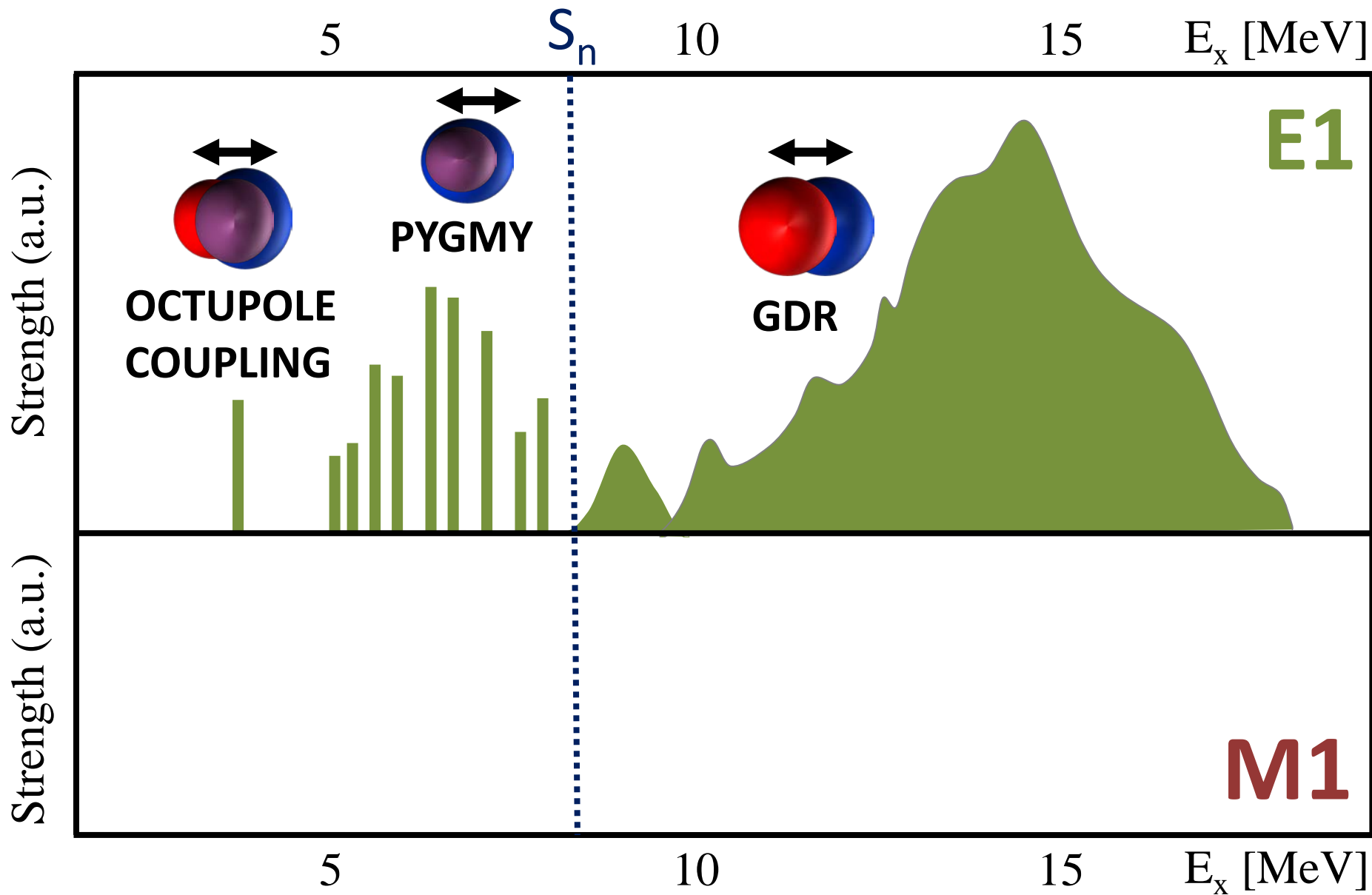
Measuring asymmetries of emitted photons:



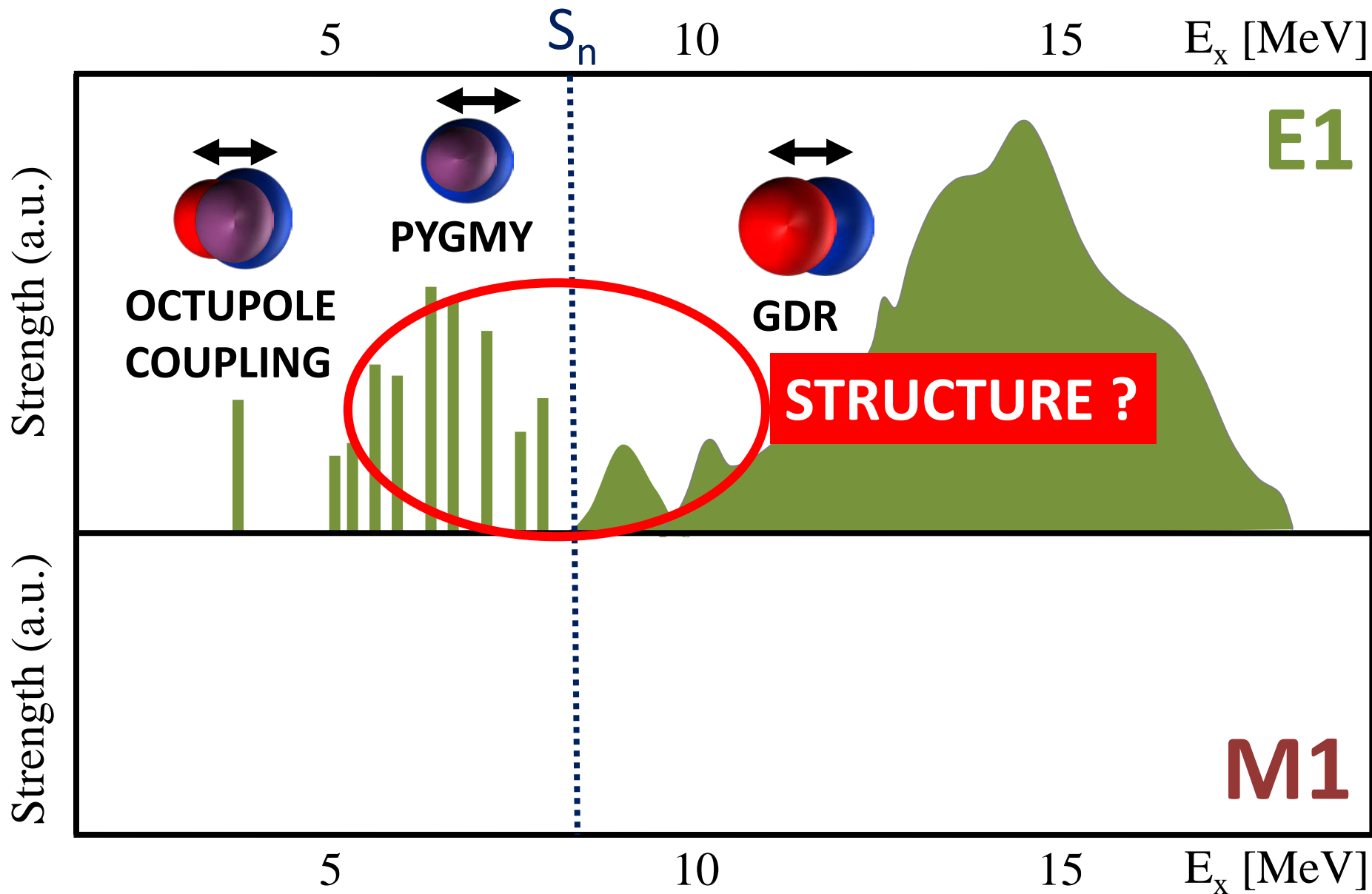
Polarized photons: A parity-meter



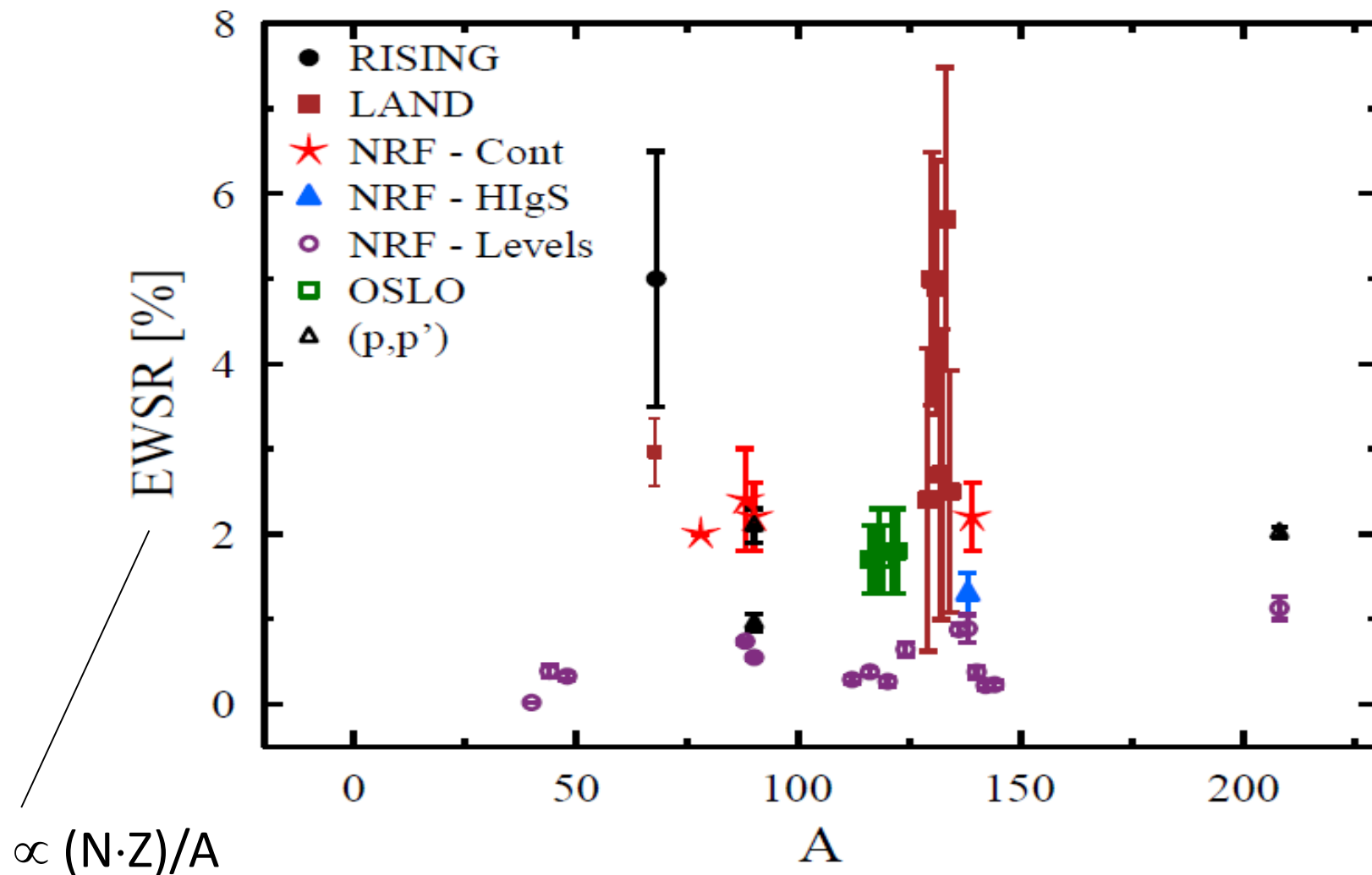
Dipole photoresponse of atomic nuclei



Dipole photoresponse of atomic nuclei



Summed B(E1) strength of "Pygmy" excitations



D. Savran, T. Aumann, and A. Zilges, PPNP 70 (2013) 210

Separation of Pygmy Dipole Resonance (PDR) from GDR

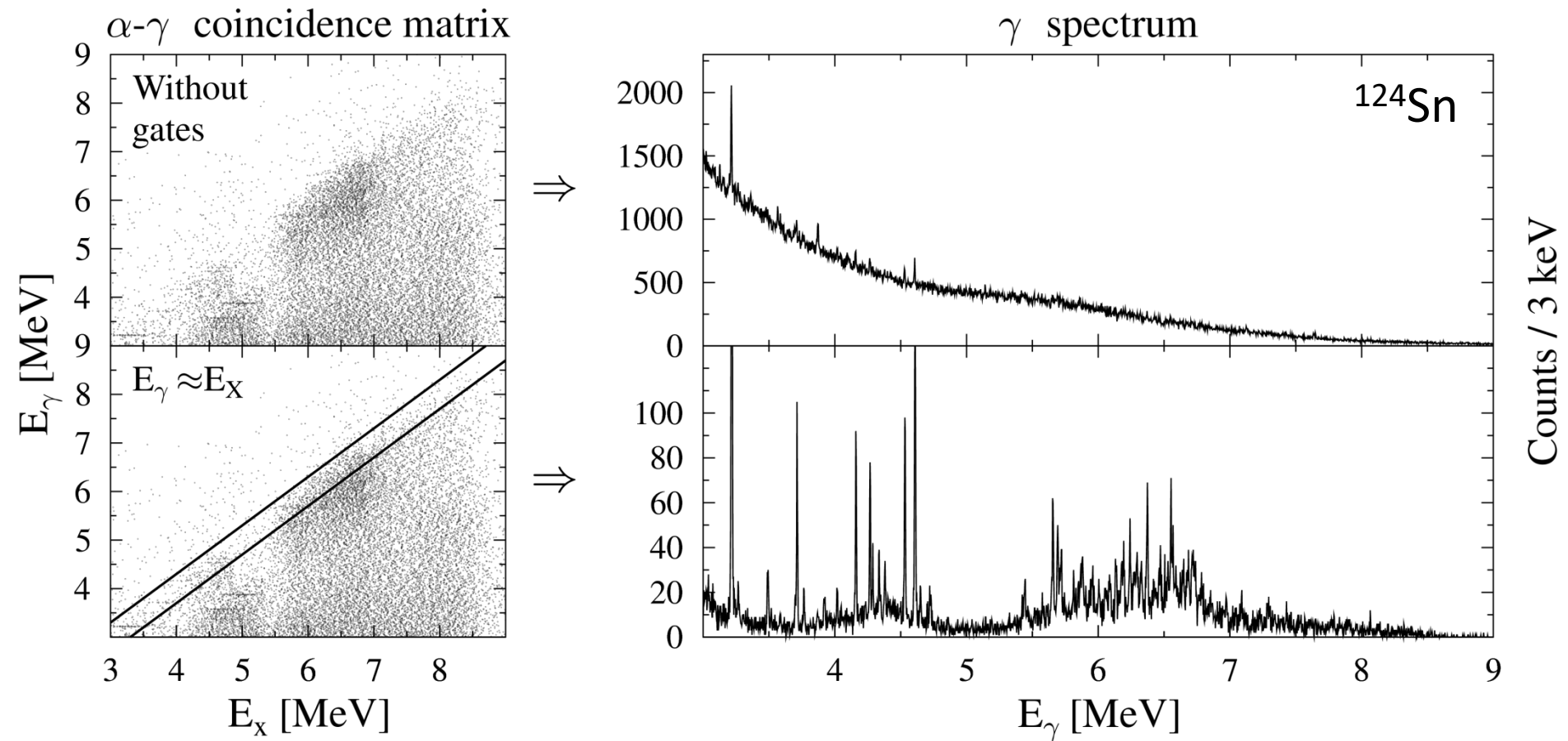
- **Response to isoscalar/isovector probes**
- **Decay to excited states**
- **Single-particle structure**

Testing the isospin structure: (γ, γ') vs. (α, α') or (p, p')

	(γ, γ') or Coulex	(α, α') @ 30 MeV/A or (p, p') @ 80 MeV/A
Interaction	electromagnetic	strong
Location of interaction	whole nucleus ($kR \ll 1$)	surface
Isospin	isovector E1 excitations	dominant isoscalar
Multipolarity	E1, M1, E2	E0, E1, E2, E3, ...

A coincident detection of the γ decay enhances the selectivity (and possibly the energy resolution) \rightarrow **$(\alpha, \alpha' \gamma)$ and $(p, p' \gamma)$**

Selectivity of $(\alpha, \alpha'\gamma)$ experiments

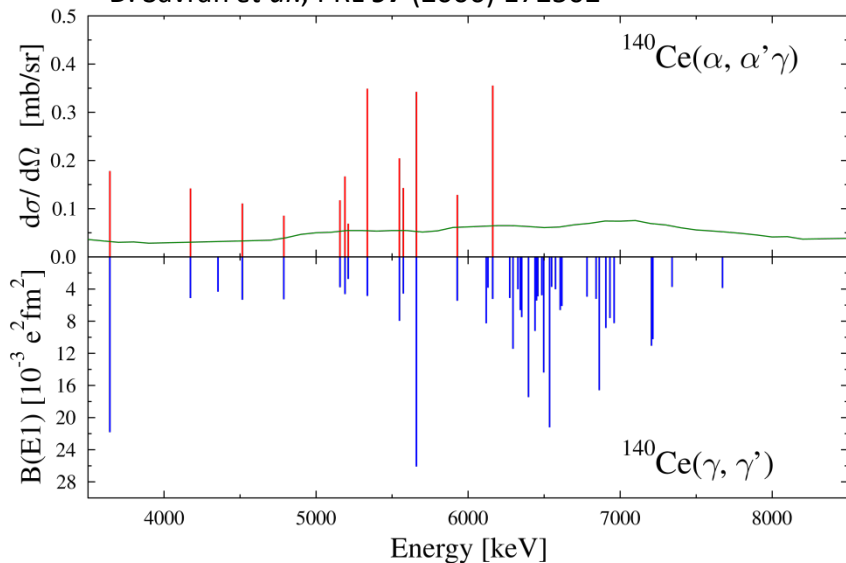


J. Endres et al., PRL **105** (2010) 112503

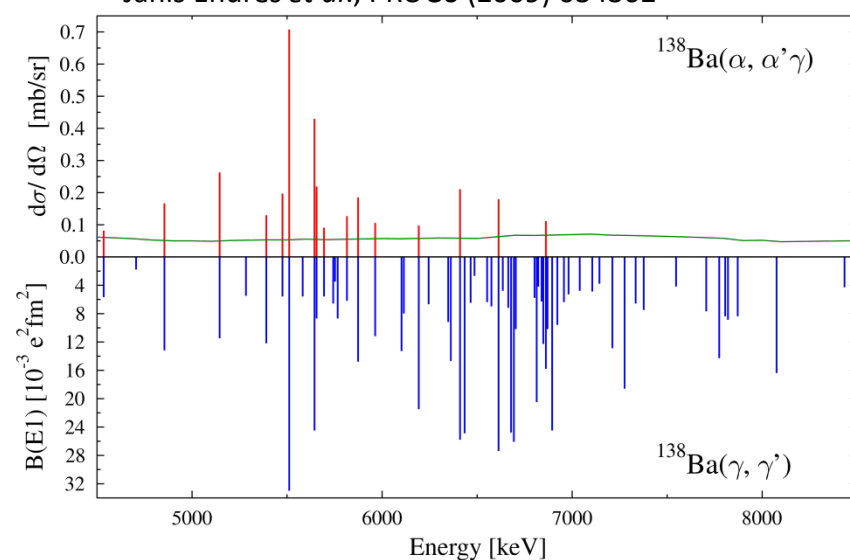
J. Endres et al., PRC **85** (2012) 064331

Splitting of strength: Experimental results

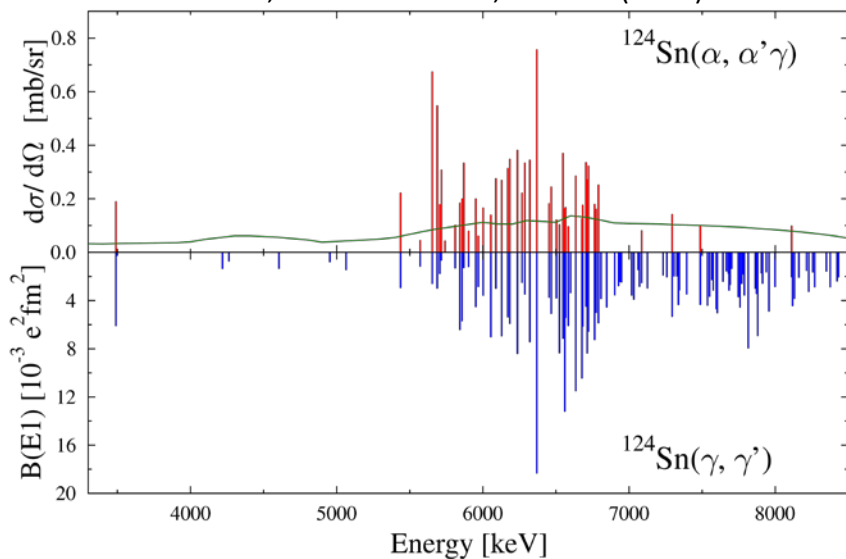
D. Savran *et al.*, PRL **97** (2006) 172502



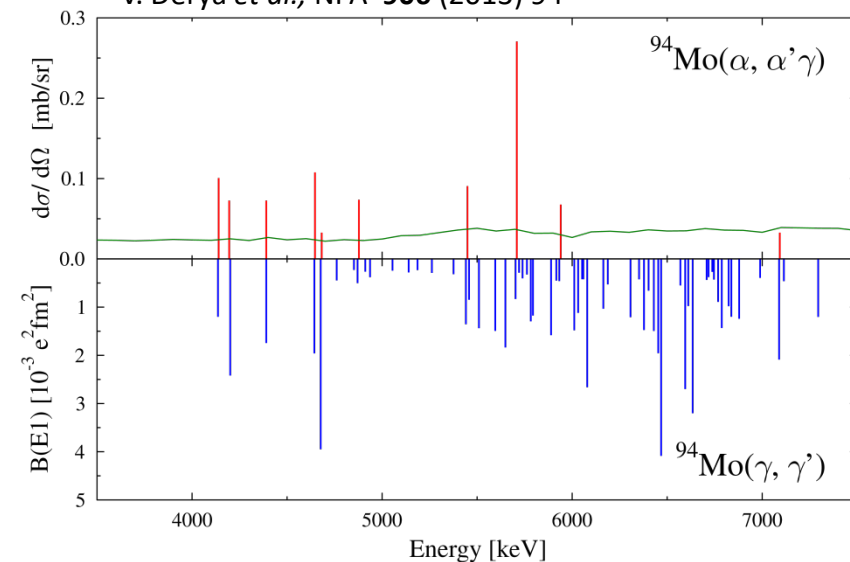
Janis Endres *et al.*, PRC **80** (2009) 034302



Janis Endres, E.Litvinova *et al.*, PRL **105** (2010) 212503

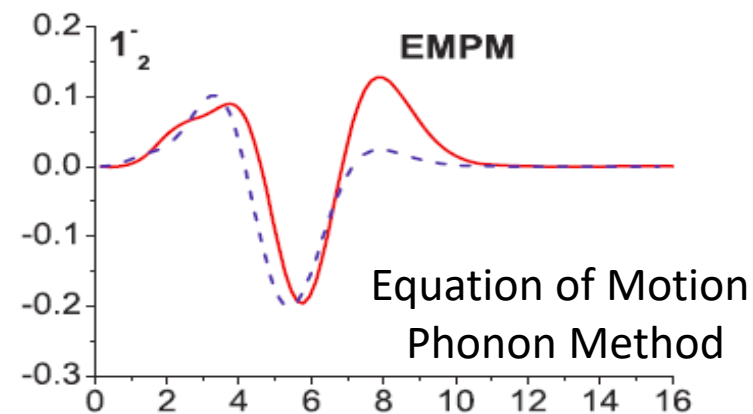
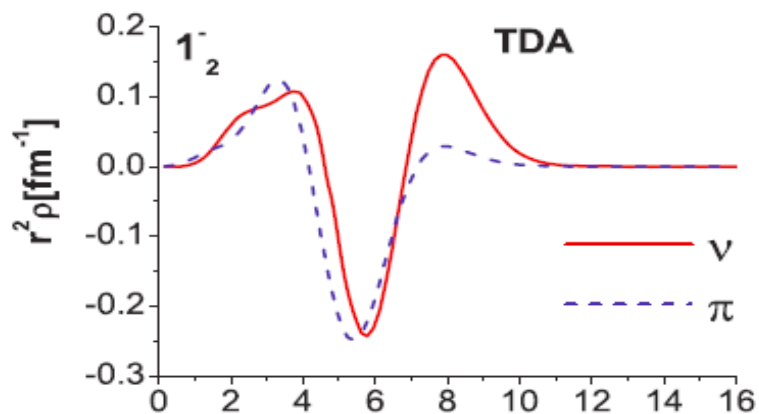


V. Derya *et al.*, NPA **906** (2013) 94

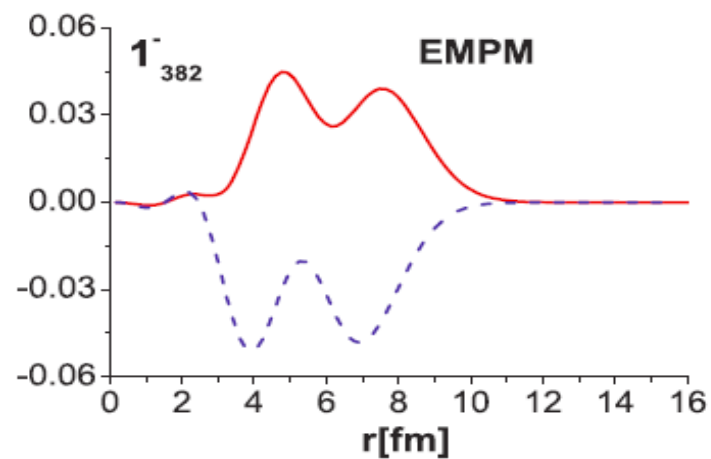
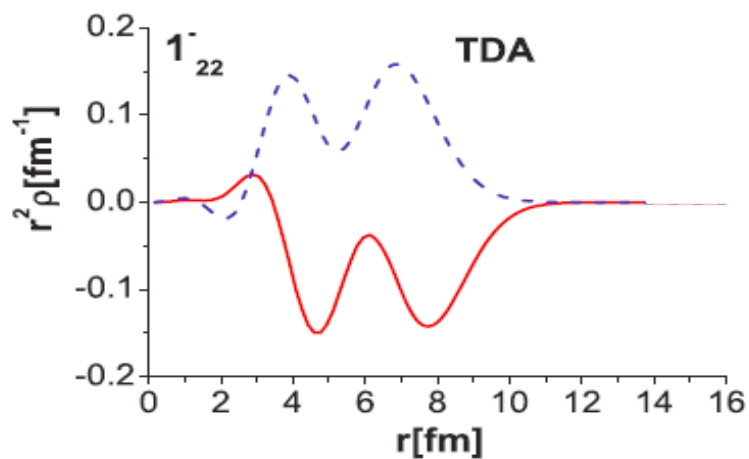


Transition densities for 1^- states in ^{208}Pb

PDR
region



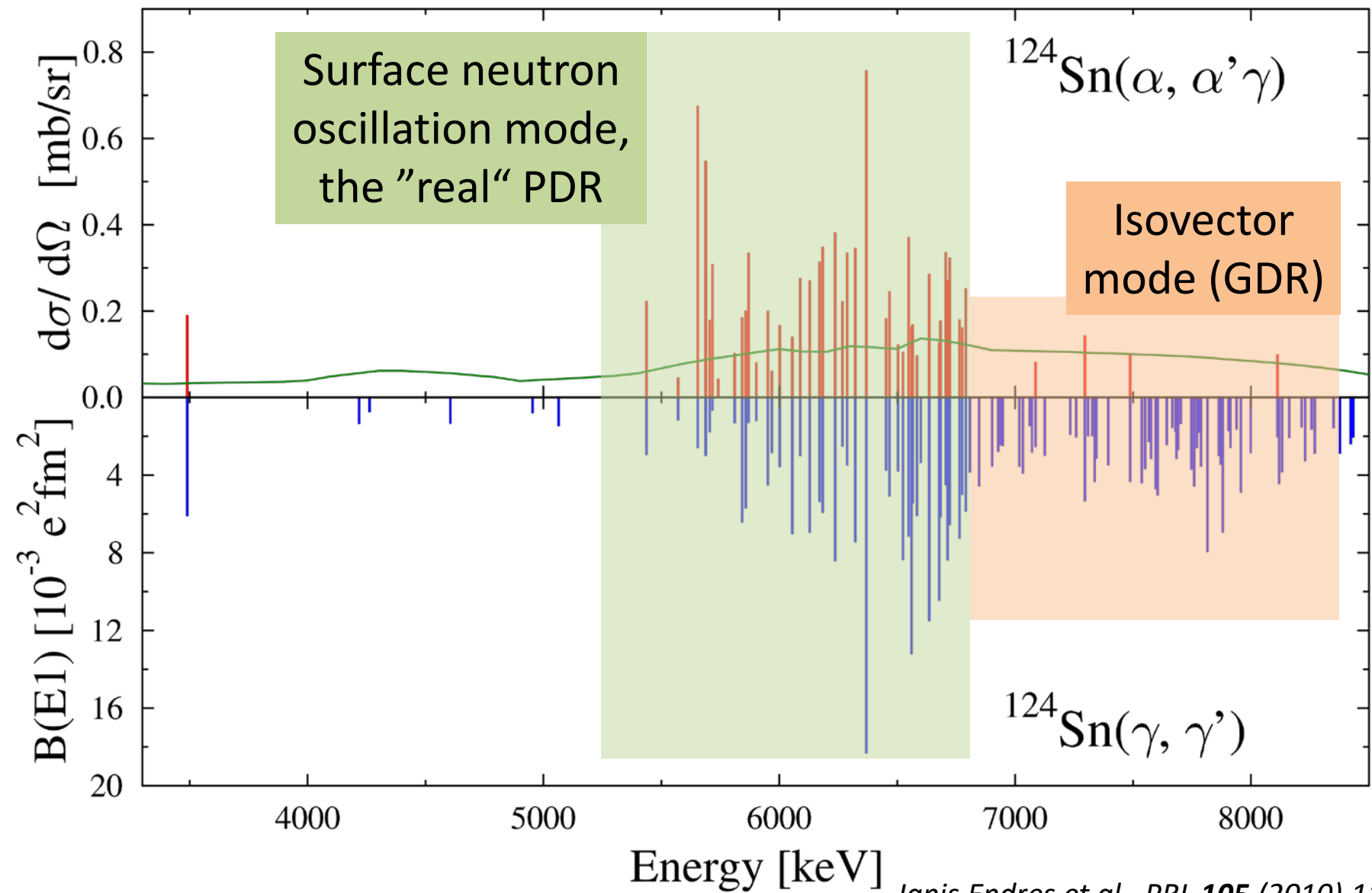
GDR
region



D. Bianco et al., PRC 86 (2012) 044327

similar results in RQTBA: E.G. Lanza et al., PRC 89 (2014) 041601

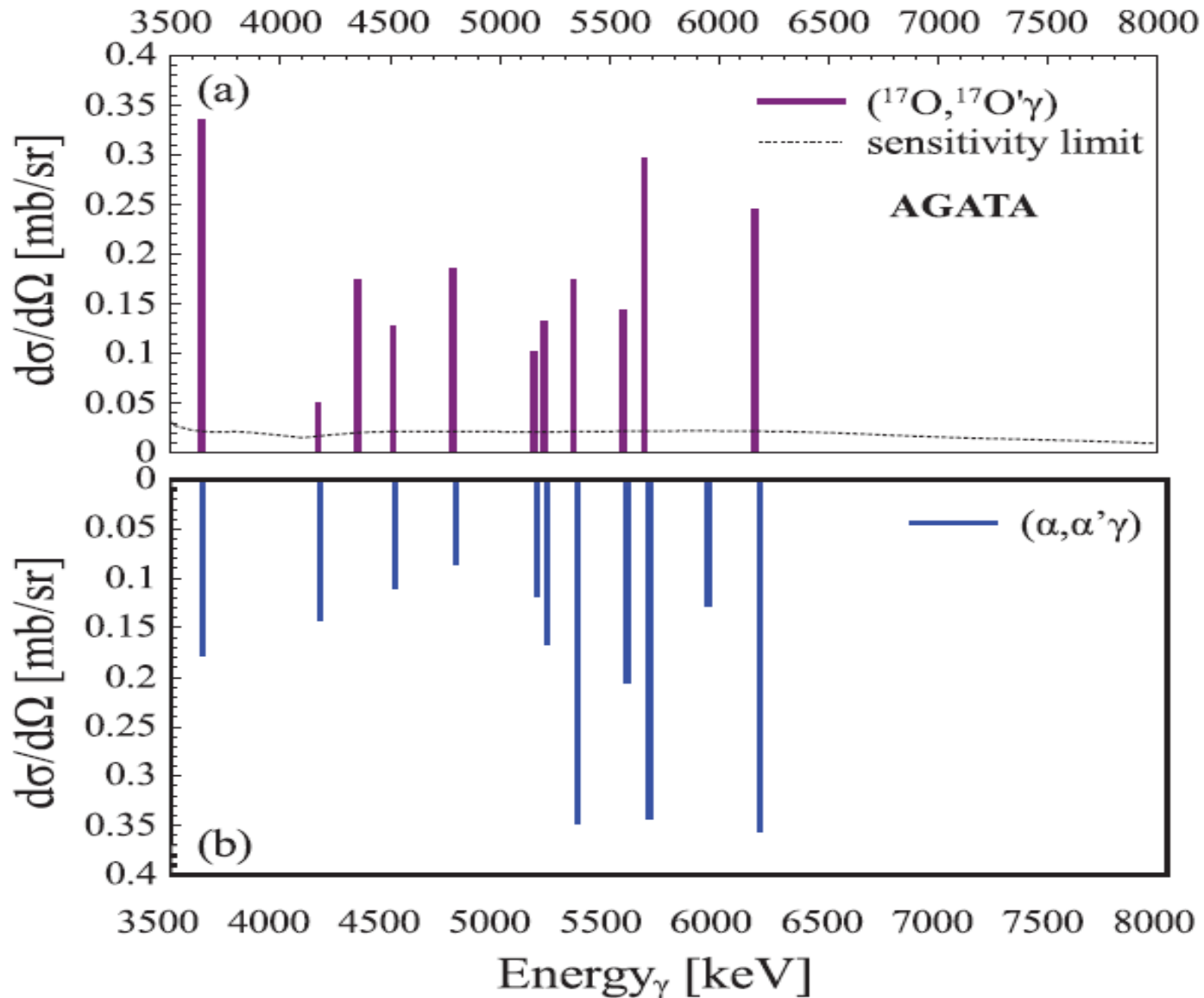
Splitting of the PDR: Interpretation from RQTBA



Janis Endres et al., PRL **105** (2010) 112503

Janis Endres et al., PRC **85** (2012) 064331

Result confirmed, e.g., in ($^{17}\text{O}, ^{17}\text{O}'\gamma$) on ^{140}Ce

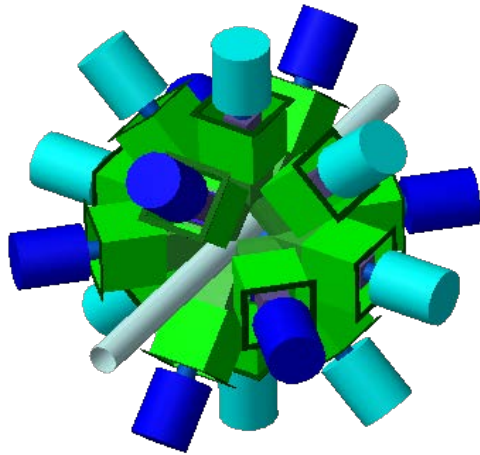


→ talk by O. Wieland

Isospin structure of the PDR in stable nuclei: The CAGRA campaign 2016 @ RCNP

$(\alpha, \alpha'\gamma)$ @ $E_\alpha = 130$ MeV and $(p, p'\gamma)$ @ $E_p = 80$ MeV
combining Grand Raiden spectrometer and
16 Compton suppressed HPGe Clover detectors

CAGRA



GRAND RAIDEN



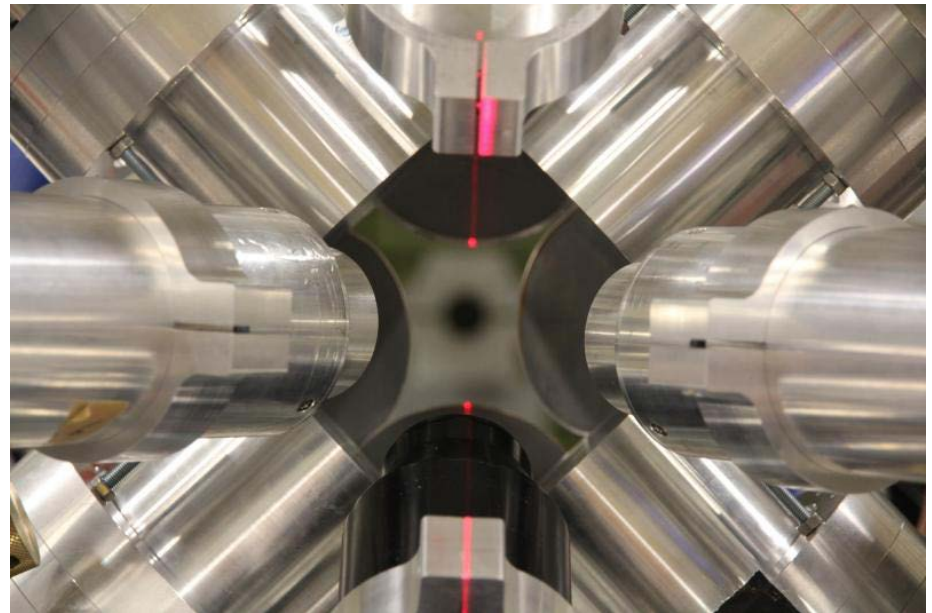
*Collaboration: Argonne – Cologne – KVI – Darmstadt – Milano – **Osaka** – NSCL*

Separation of Pygmy Dipole Resonance (PDR) from GDR

- Response to isoscalar/isovector probes
- **Decay to excited states**
- Single-particle structure

Decay pattern: γ^3 setup at HIGS

Combination of:
HPGe detectors (excellent energy resolution)
and **LaBr** detectors (high efficiency)



B. Löher, V. Derya et al., NIM A 723 (2013) 136



University
of Cologne



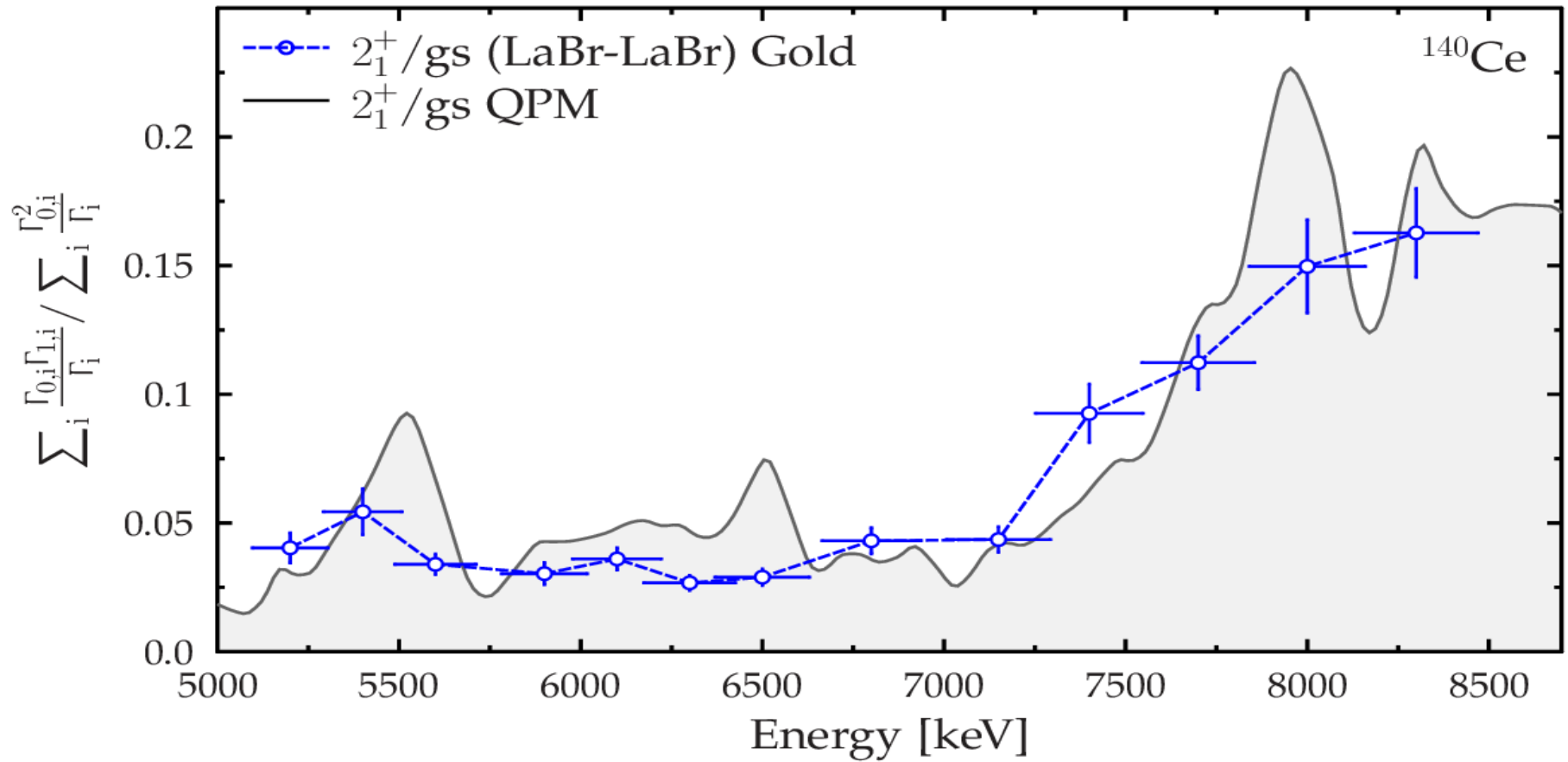
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UNIVERSITÄT
DARMSTADT



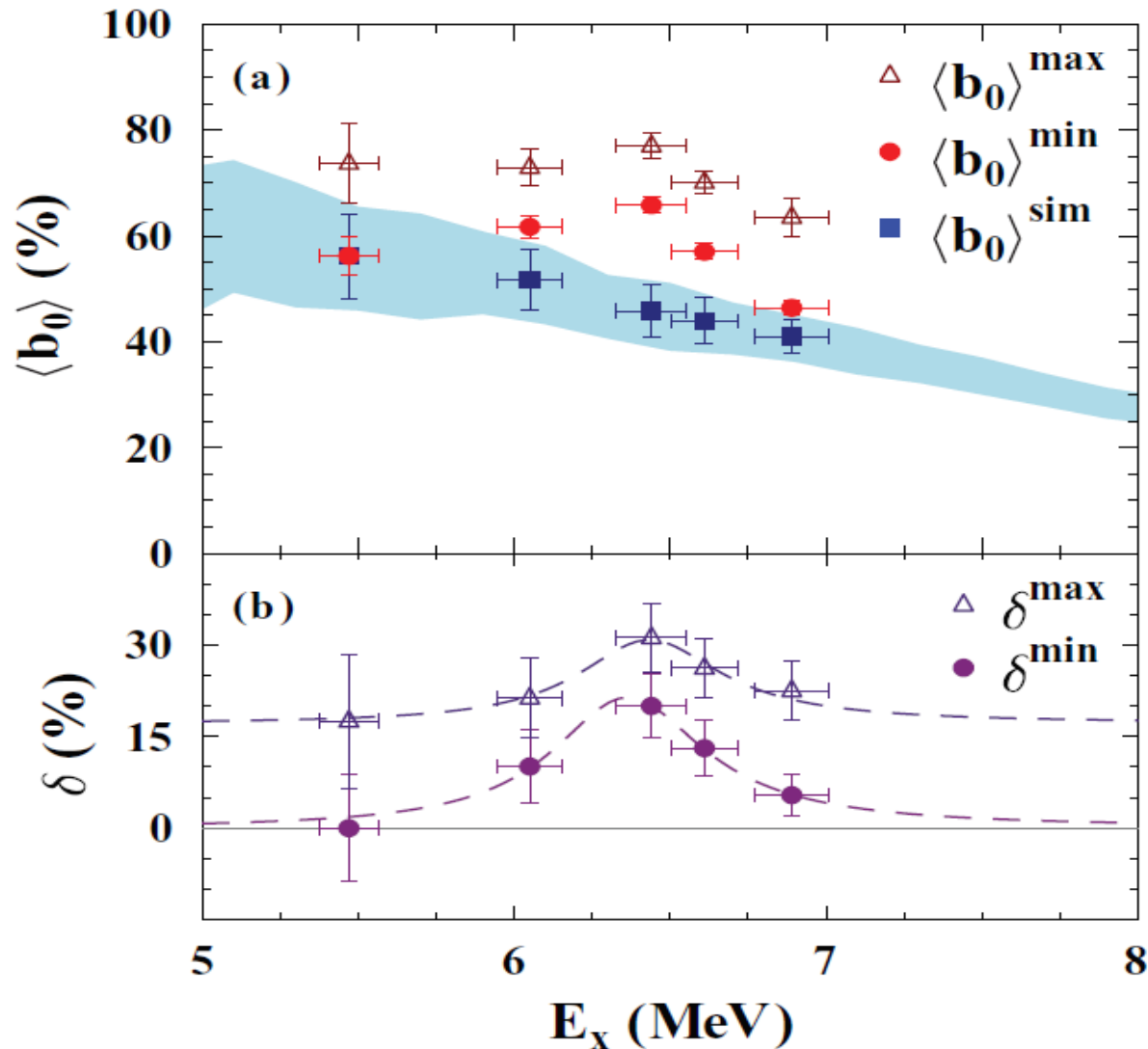
Yale University



Decay pattern of E1 excitations in ^{140}Ce



Decay pattern ^{94}Mo compared to DICEBOX

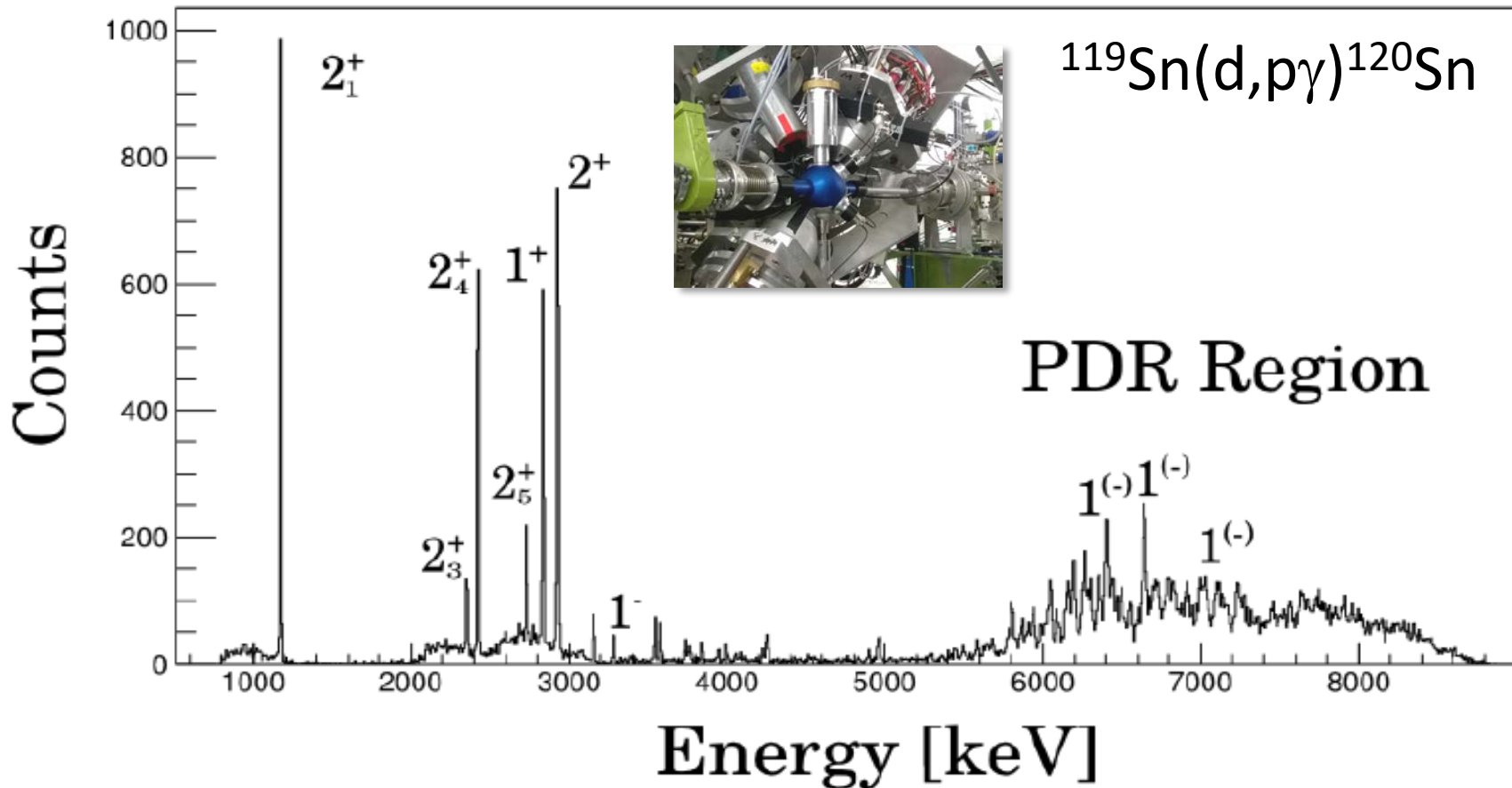


→ β decay: talk by M. Scheck

Separation of Pygmy Dipole Resonance (PDR) from GDR

- Response to isoscalar/isovector probes
- Decay to excited states
- **Single-particle structure**

Single-particle structure of the PDR: SONIC@HORUS, Cologne



S.G. Pickstone, M. Spieker, V. Derya, M. Weinert, J. Wilhelm, AZ

→ talk by M. Weinert

A new photon facility in Europe: ELI-NP @ Bucharest

A photon beam from laser Compton backscattering with:

- very high intensity (10^4 photons/(s·eV))
- narrow bandwidth (down to 0.5%)
- high degree of polarization (> 99%)
- small beam diameter (mm range)

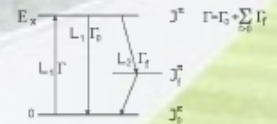
investment > 300 M€



Nuclear Resonance Fluorescence
Experiments
at ELI-NP

Technical Design Report

Separation threshold



Edited by

Andreas Zilges
Calin Alexandru Ur



Civil construction is finished

33.000 m² total:

- experimental areas
- guest house
- office spaces



Experiments start in 2018!



Properties of the Pygmy Dipole Resonance



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Bundesministerium
für Bildung
und Forschung

(05P2015 ELI-NP)