

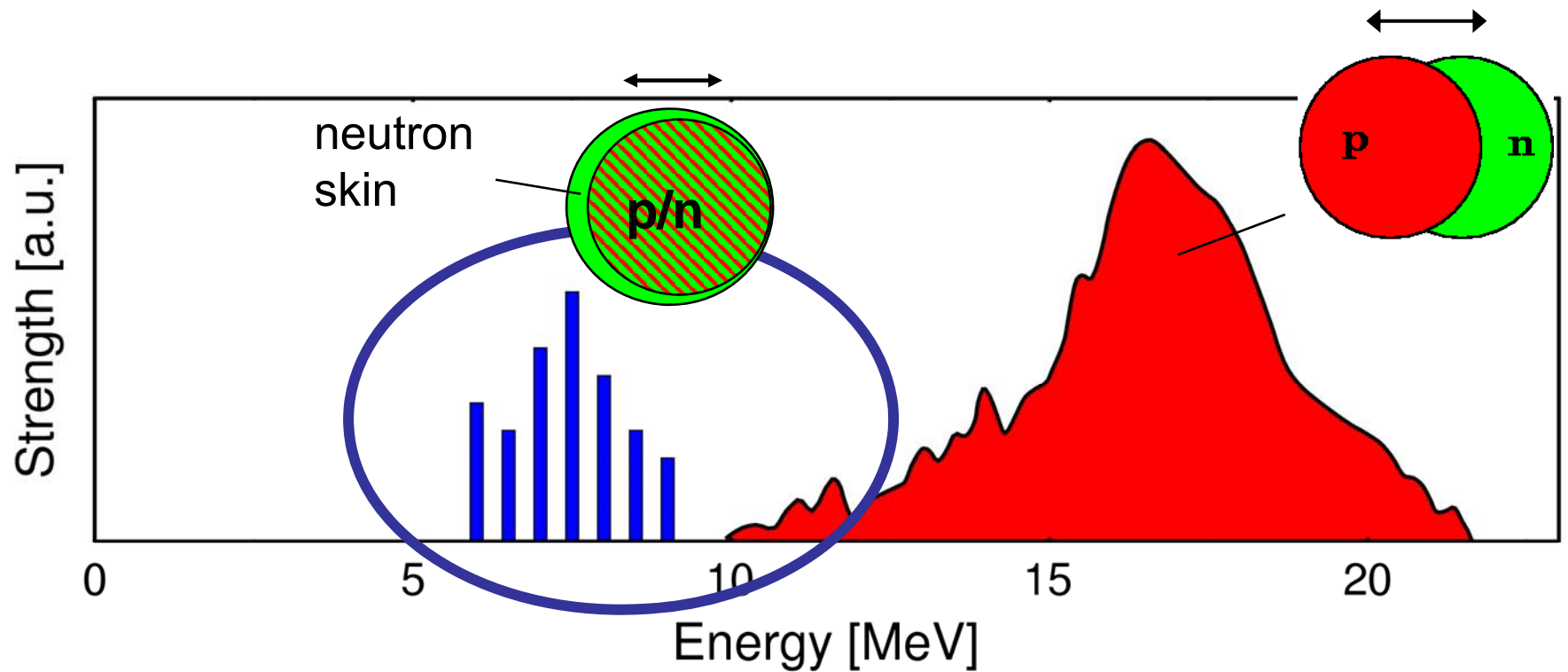
Systematic studies of the Pygmy Dipole Resonance by means of the $(\alpha, \alpha'\gamma)$ reaction

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S. Harissopulos, J. Hasper, R.-D. Herzberg, R. Krücken,
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Electric dipole strength in atomic nuclei

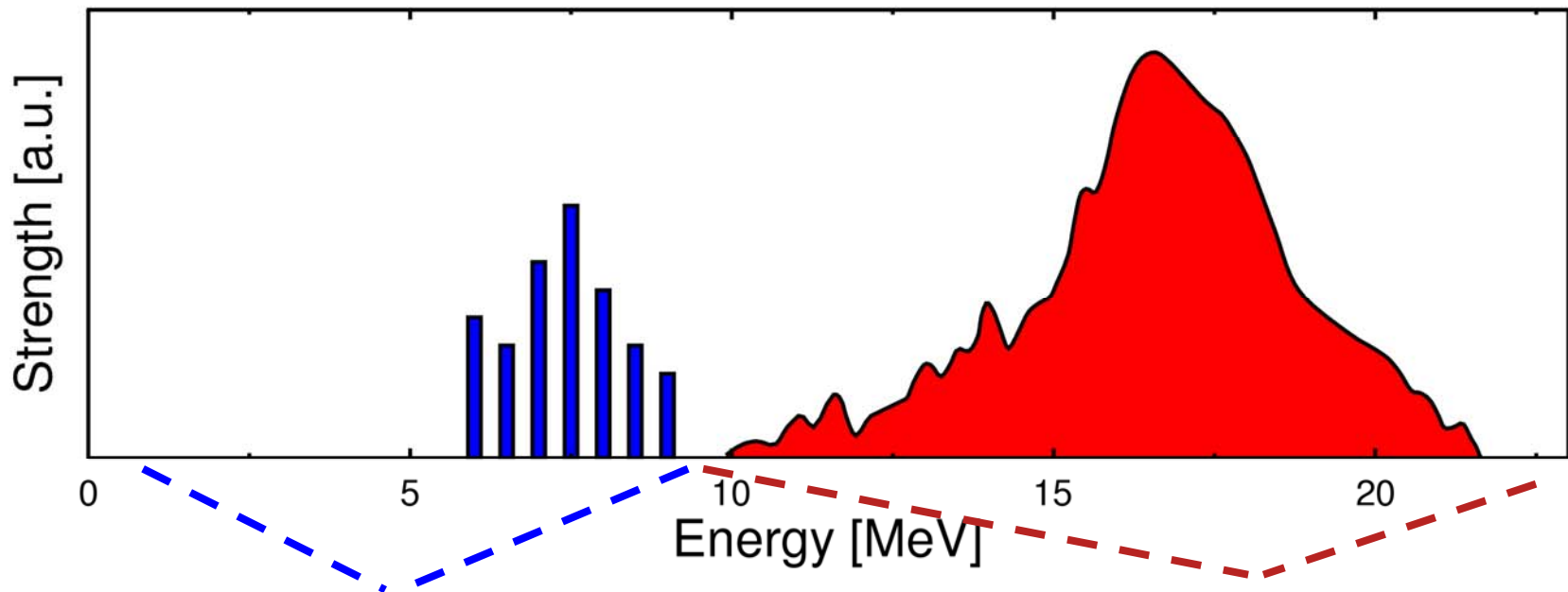


- **E1 Giant Dipole Resonance (GDR)**
- **E1 Pygmy Dipole Resonance (PDR)**

- How complete are strength measurements with photons?
 - Comparison of (γ, γ') experiments with QPM calculations
- Does the PDR show a strong N/Z dependence?
 - Systematic studies in (γ, γ')
- What is the real structure of the PDR?
 - Comparison of (γ, γ') and $(\alpha, \alpha' \gamma)$ experiments

Experiments with real photons

- High selectivity to dipole excitations
- Well-understood excitation mechanism

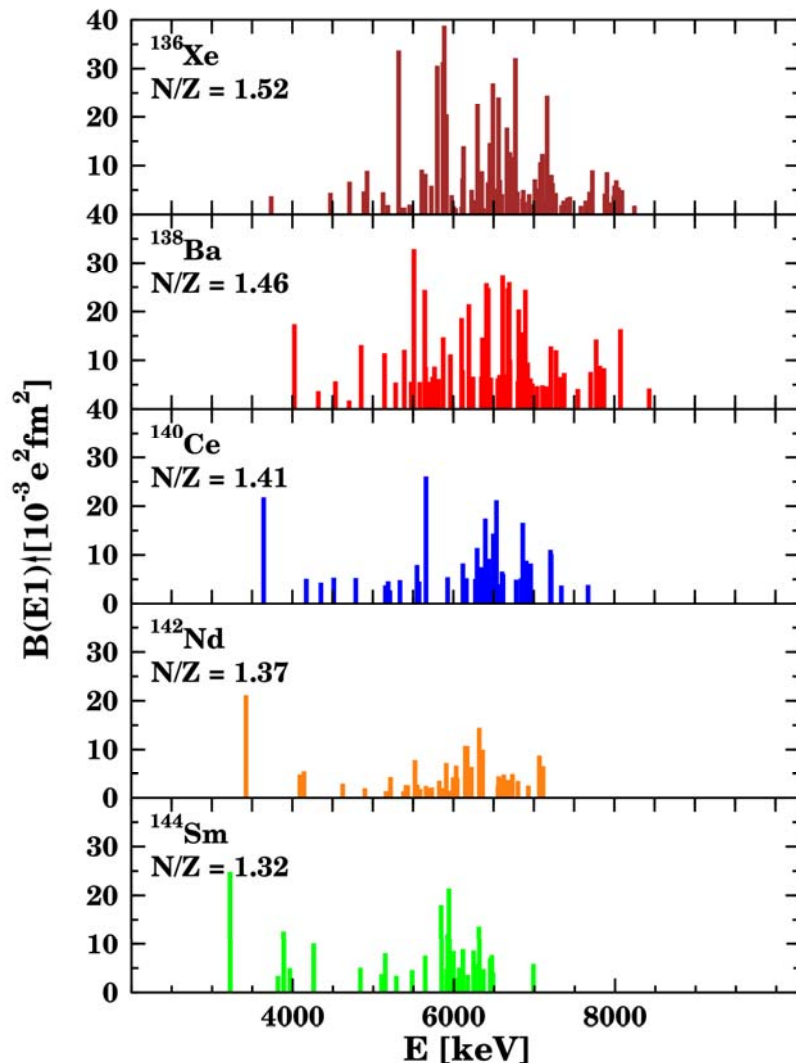


Photon scattering (γ, γ')

**Photodissociation
(γ, n), (γ, p), ...**

E1 strength in stable N=82 isotones

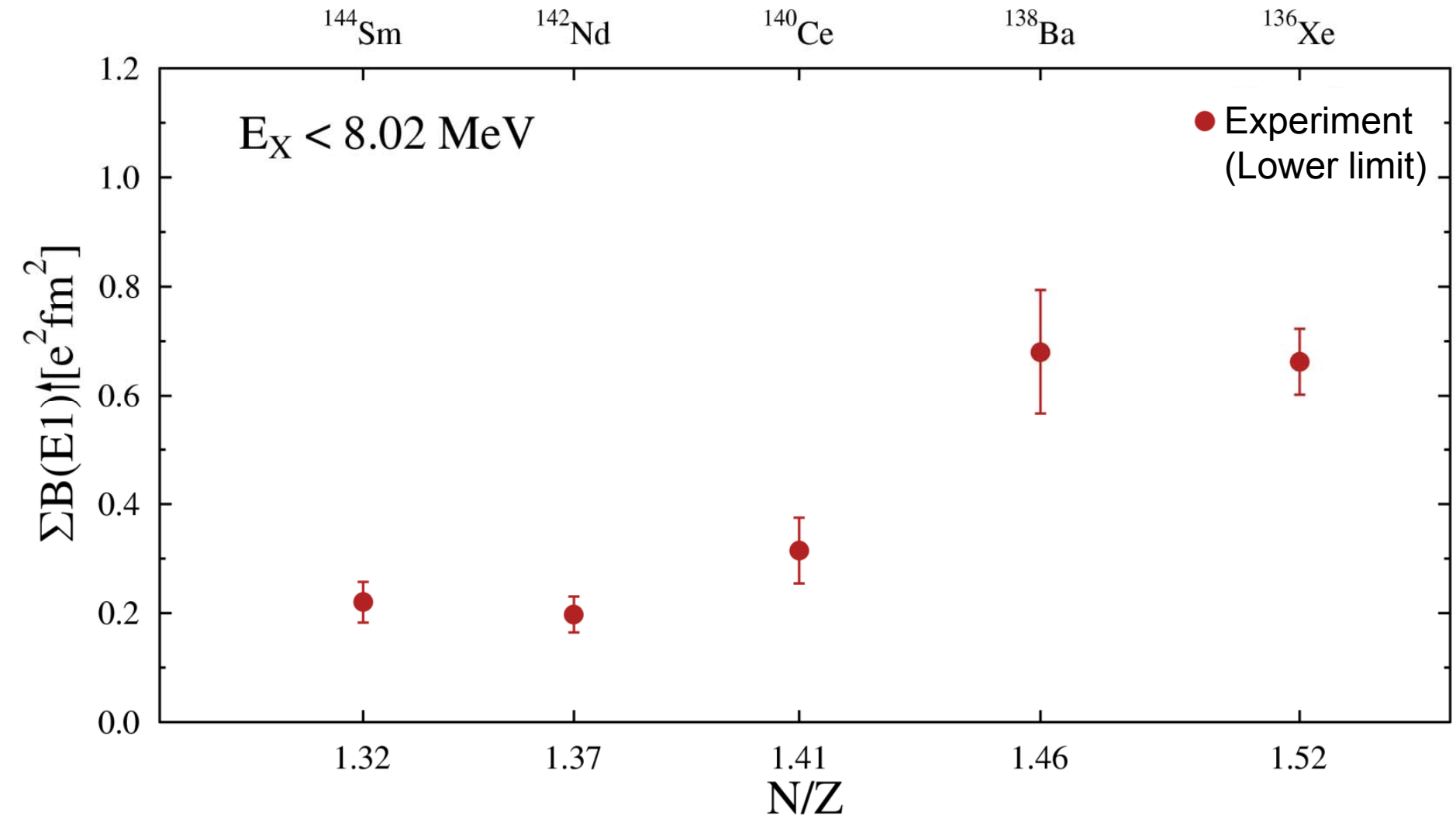
(γ, γ') @ S-DALINAC



- Strong fragmentation
- Concentration around 5.5 - 7.0 MeV
- Exhausts 1% of IVEWSR
- Scaling with N/Z

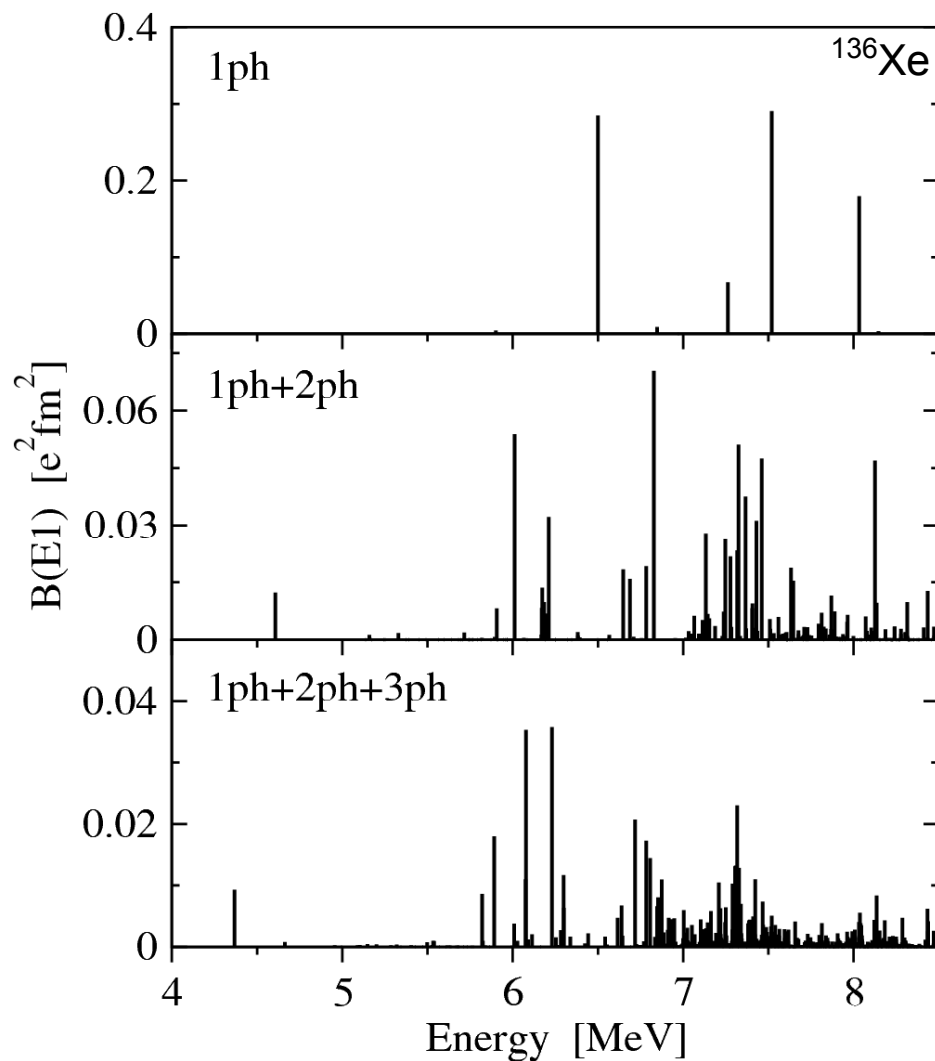
A. Zilges et al., Phys. Lett. B **542** (2002) 43
S. Volz et al., Nucl. Phys. **A779** (2006) 1
D. Savran et al., Phys. Rev. Lett **100** (2008) 232501

Integrated experimental B(E1) strength



D. Savran et al., PRL **100** (2008) 232501

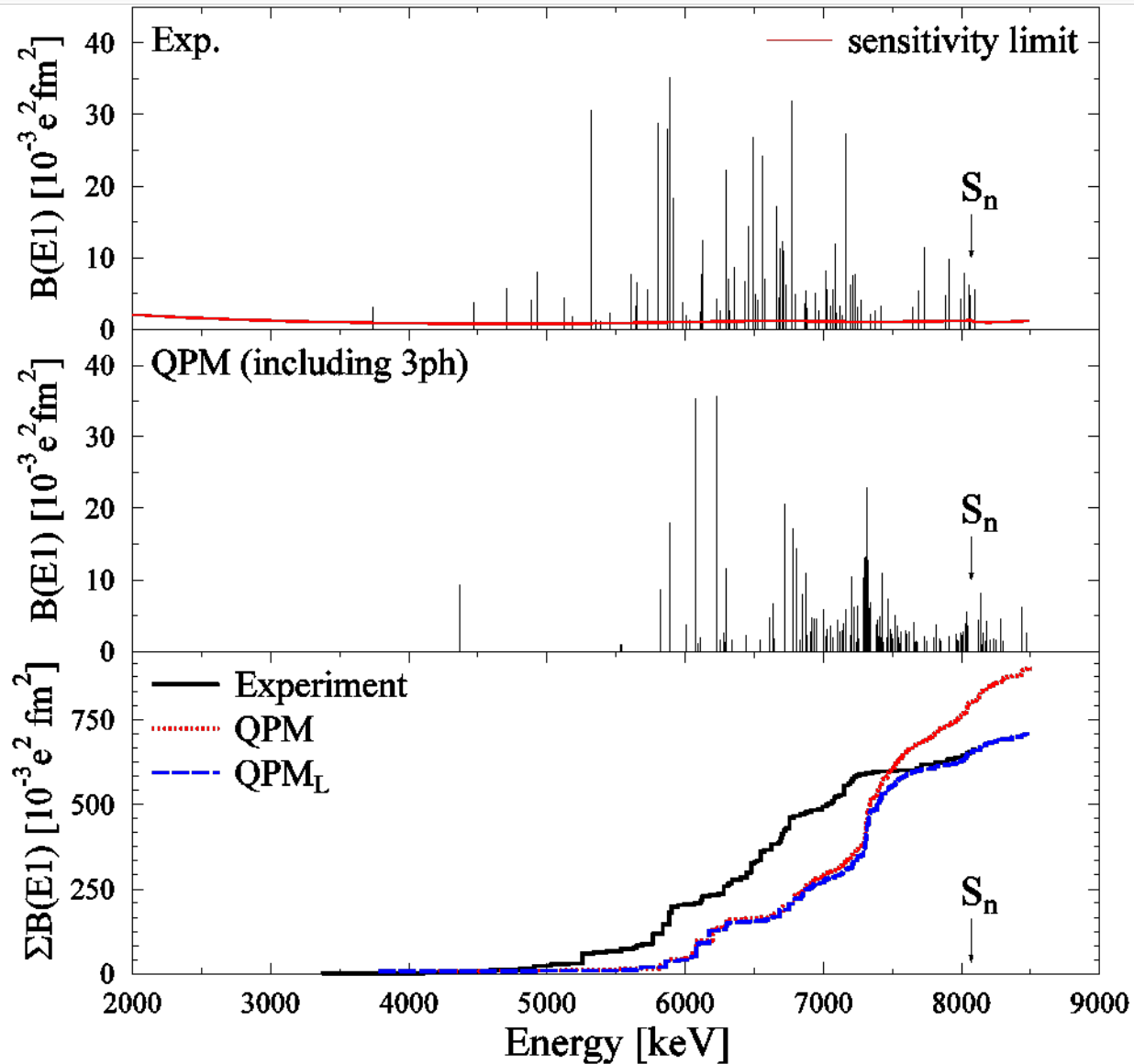
Fragmentation in QPM calculations



- B(E1) nearly completely carried by 1ph part
- Coupling to complex configuration produces fragmentation
- 1ph, 2ph, 3ph up to 8.5 MeV
⇒ Model space nearly complete up to 8.0 MeV

V. Yu. Ponomarev

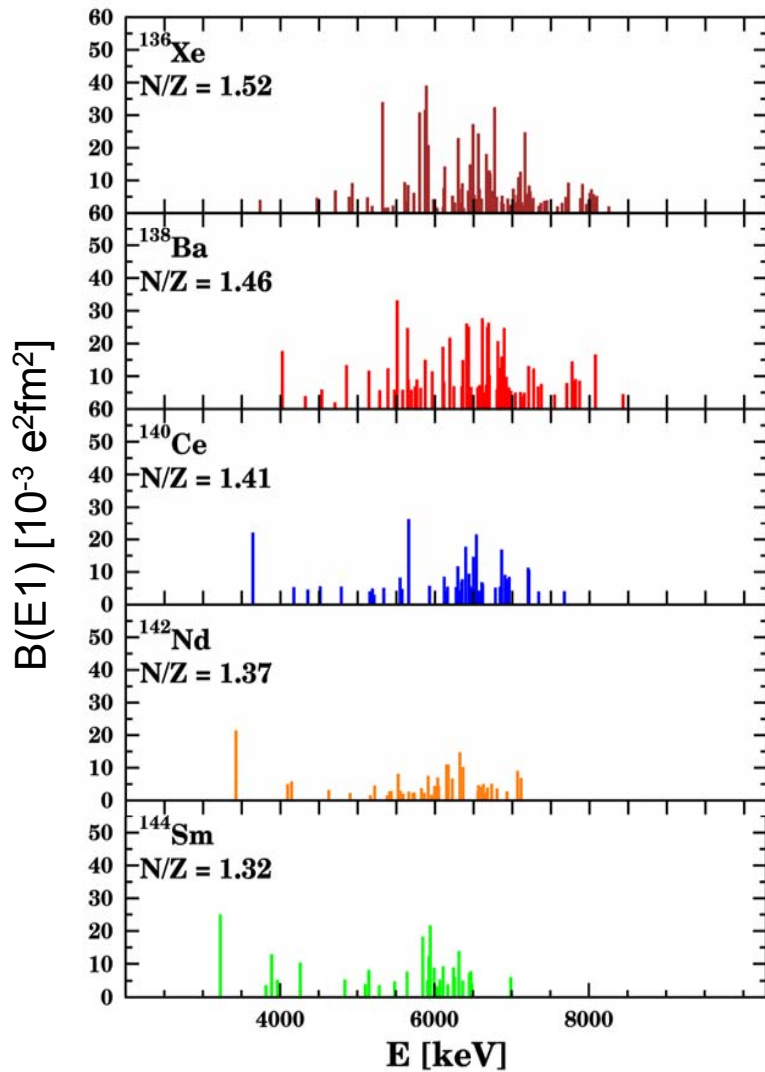
B(E1) strength distribution in ^{136}Xe



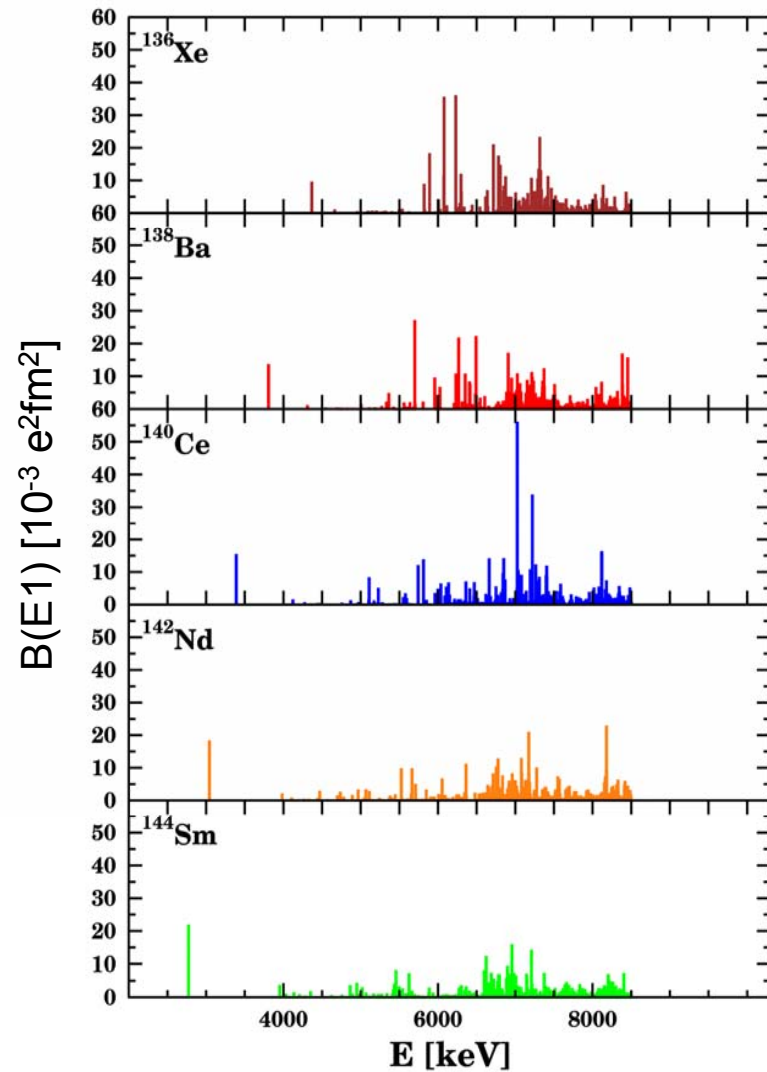
D. Savran et al., PRL **100** (2008) 232501

E1 strength in stable N=82 isotones

Experiment



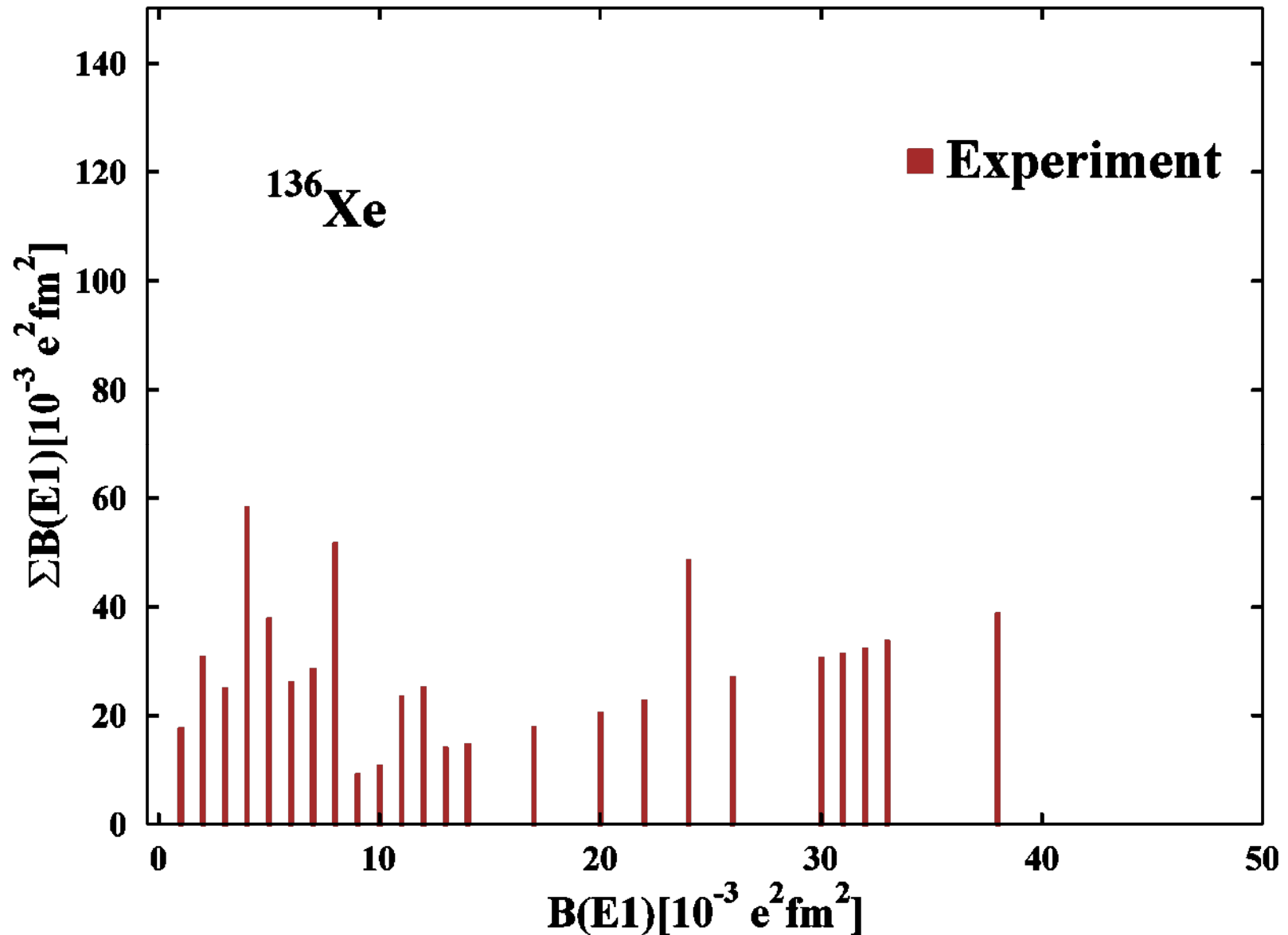
QPM



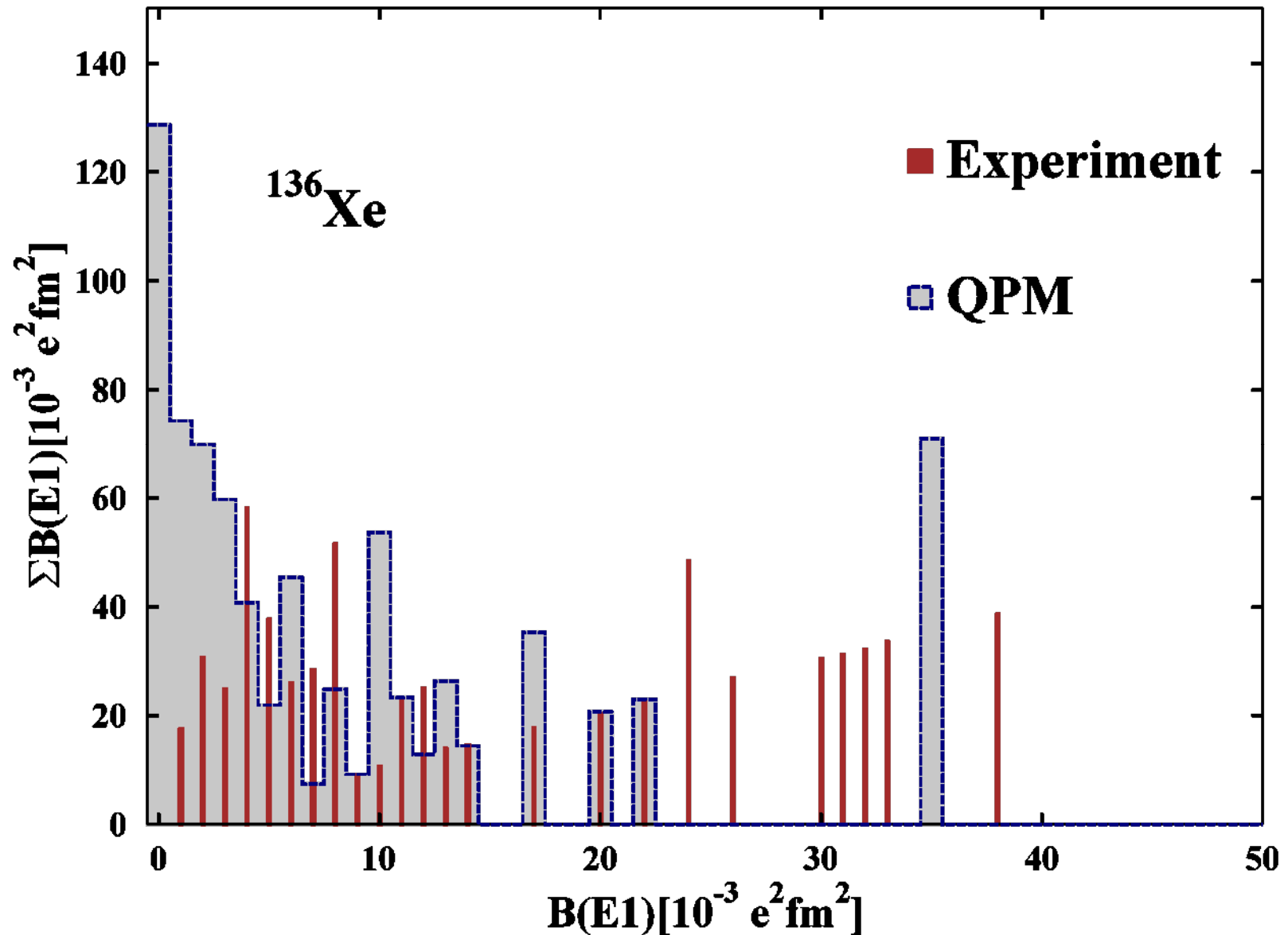
S. Volz et al., Nucl. Phys. **A779** (2006) 1

V. Yu. Ponomarev

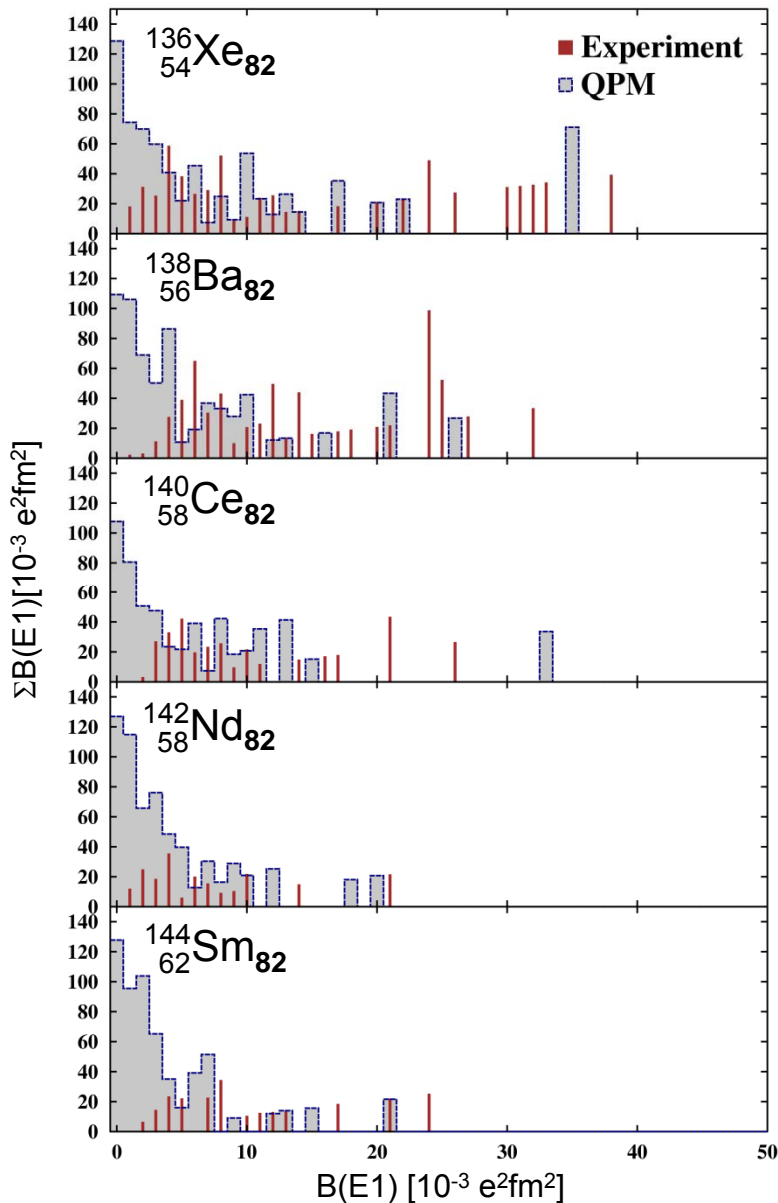
Fragmentation: Experiment vs. QPM



Fragmentation: Experiment vs. QPM



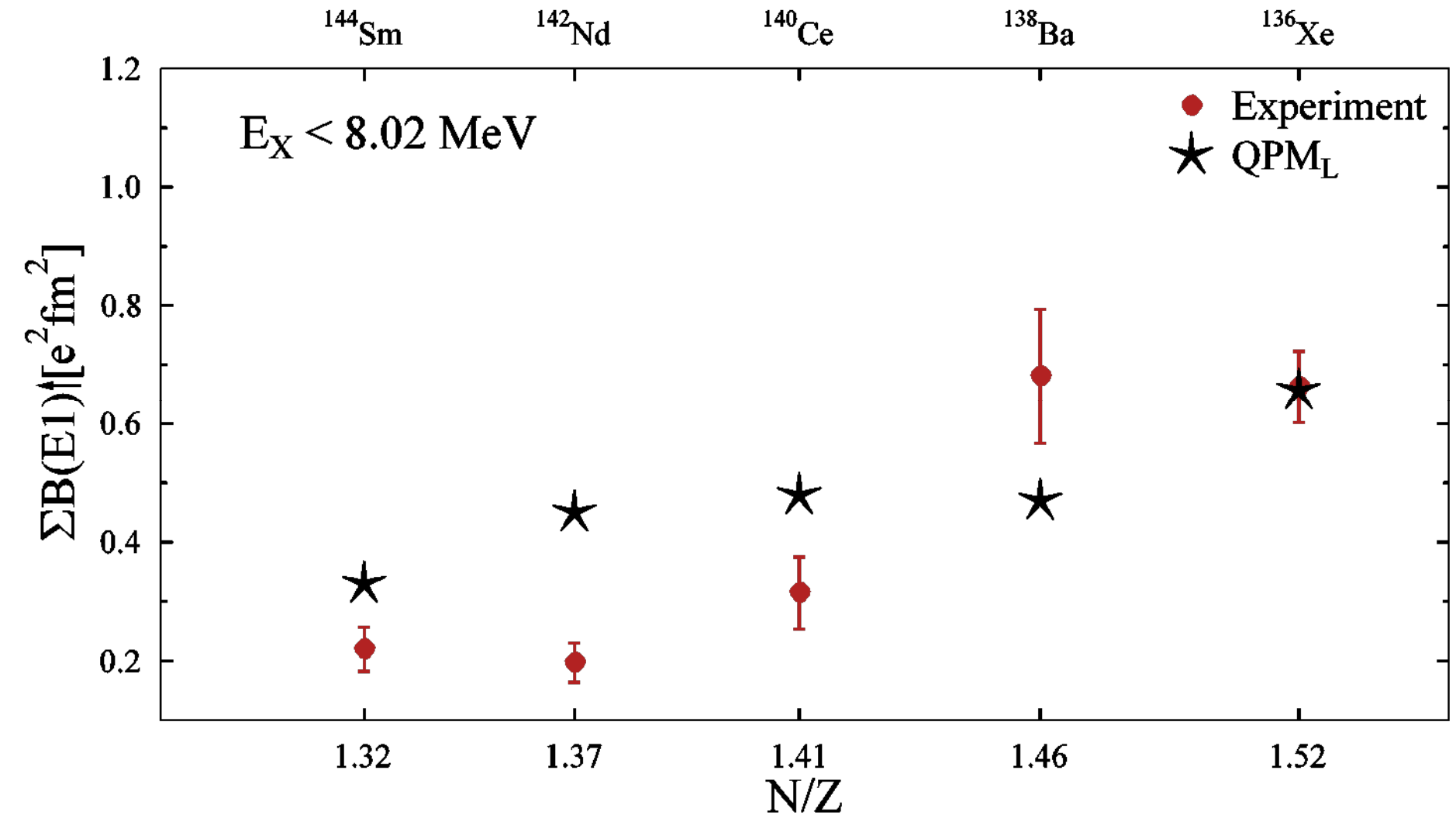
Fragmentation: Experiment vs. QPM



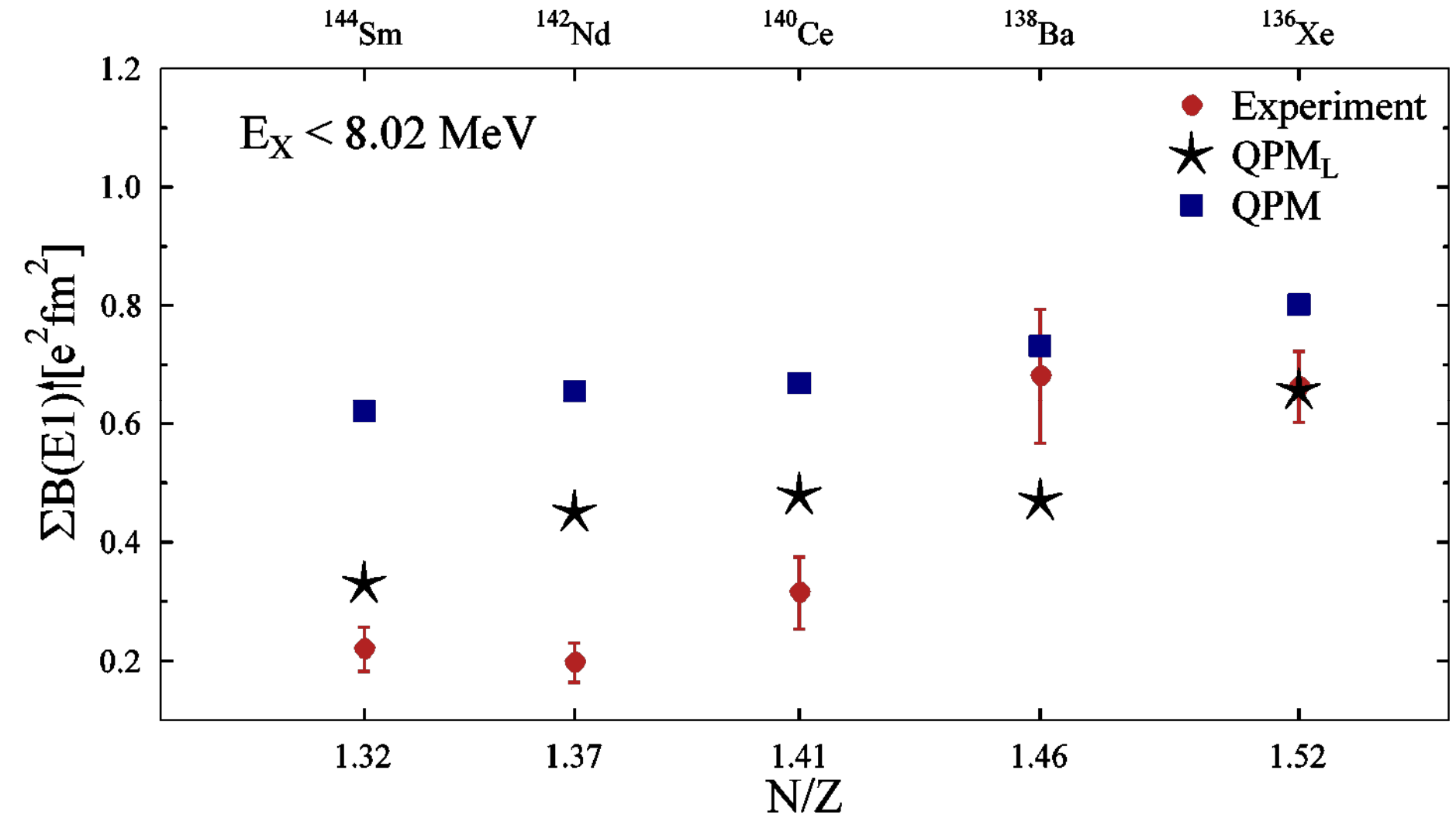
- Increasing fragmentation from ^{136}Xe to ^{144}Sm in experiment and QPM
- Total strength distributed on weaker states
- Impact of experimental sensitivity limit more important with increasing proton number

D. Savran et al., PRL **100** (2008) 232501

Integrated B(E1) strength



Integrated B(E1) strength



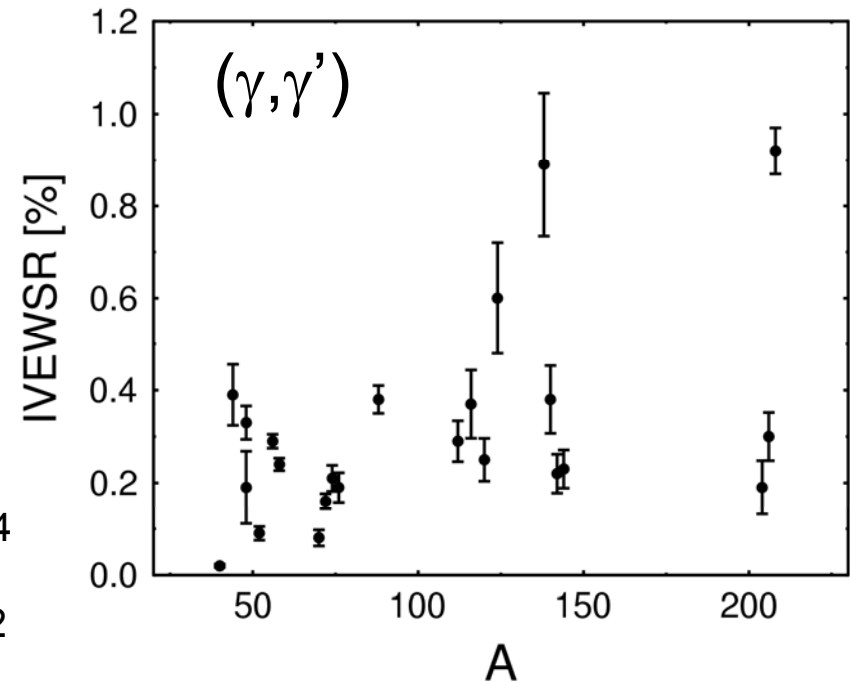
Pygmy Dipole Resonance

Experiment

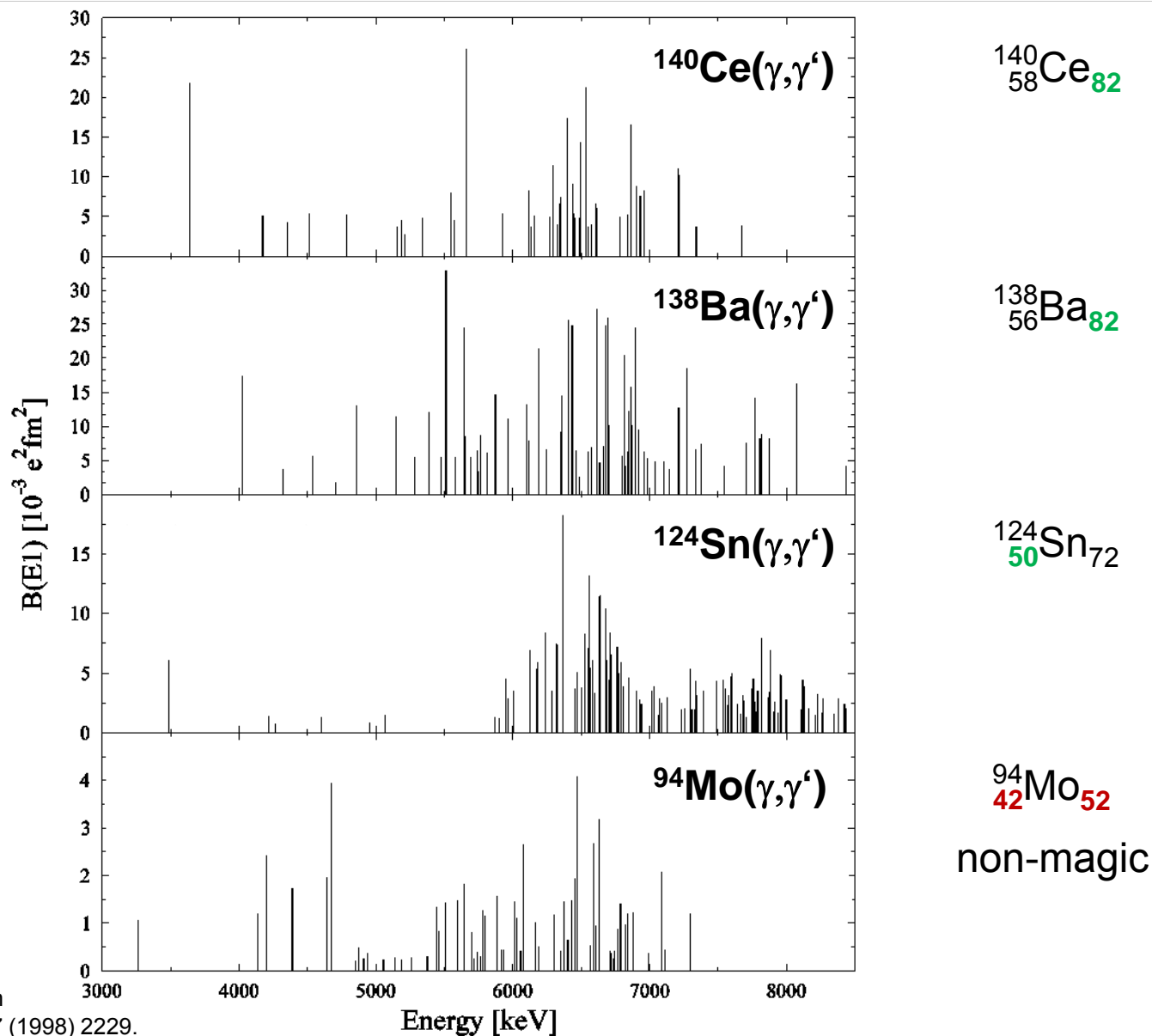
- K. Govaert et al., Phys. Rev. C **57** (1998) 2229
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Theory

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D. Sarchi, P.F. Bortignon, G. Colò, Phys. Lett. B **601** (2004) 27
S. Goriely, E. Khan, M. Samyn, Nucl. Phys. **A739** (2004) 331
N. Paar, T. Niksic, D. Vretenar, P. Ring, Phys. Lett. B **606**, (2005) 288
J. Terasaki, J. Engel, Phys. Rev. C **76** (2007) 044320
J. Liang, L. Cao, Z. Ma, Phys. Rev. C **75** (2007) 054320
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G. Tertychny, V. Tselyaev, S. Kamerdshiev, J. Speth, E. Litvinova et al., Phys. Lett. B **647** (2007) 104
N. Paar, D. Vretenar, E. Khan, G. Colò, Rep. Prog. Phys. **70** (2007) 691
N. Tsoneva, H. Lenske, Phys. Rev. C **77** (2008) 024321



E1 strength distribution in ^{140}Ce , ^{138}Ba , ^{124}Sn , and ^{94}Mo

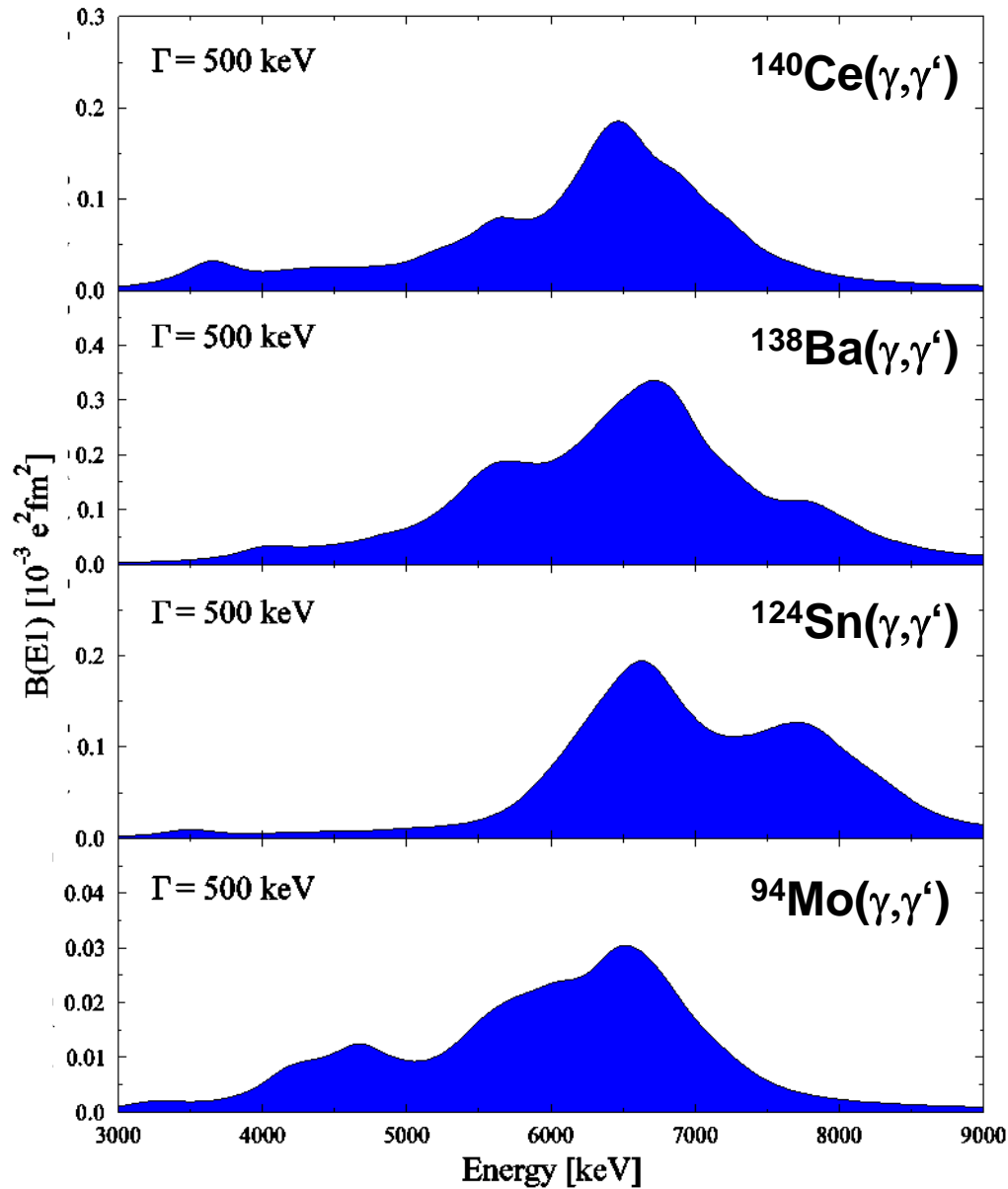


D. Savran, private communication

K. Govaert et al., Phys. Rev. C **57** (1998) 2229.

A. Zilges et al., Phys. Lett. B **542** (2002) 43

E1 strength distribution in ^{140}Ce , ^{138}Ba , ^{124}Sn , and ^{94}Mo



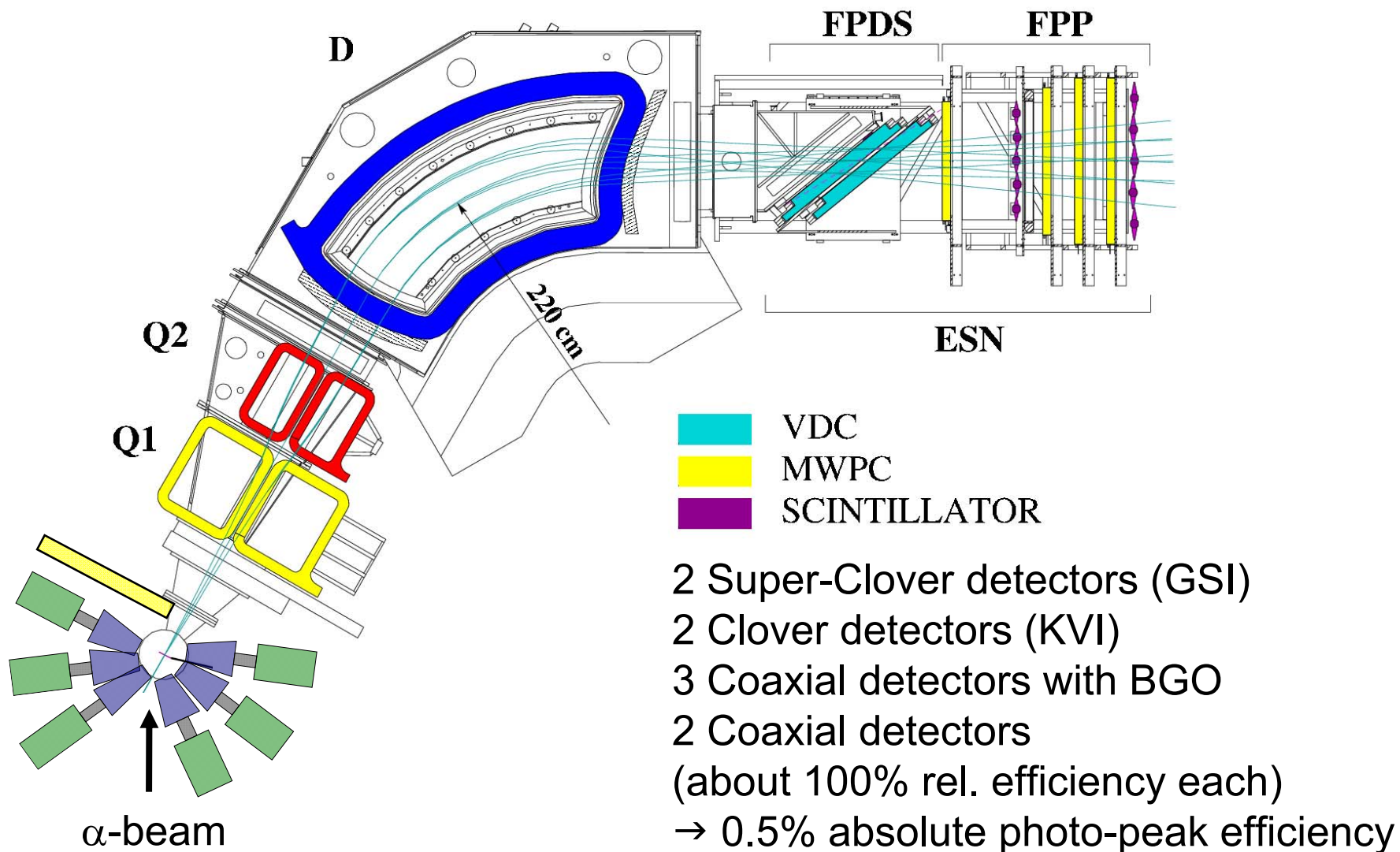
F. Iachello, private communication

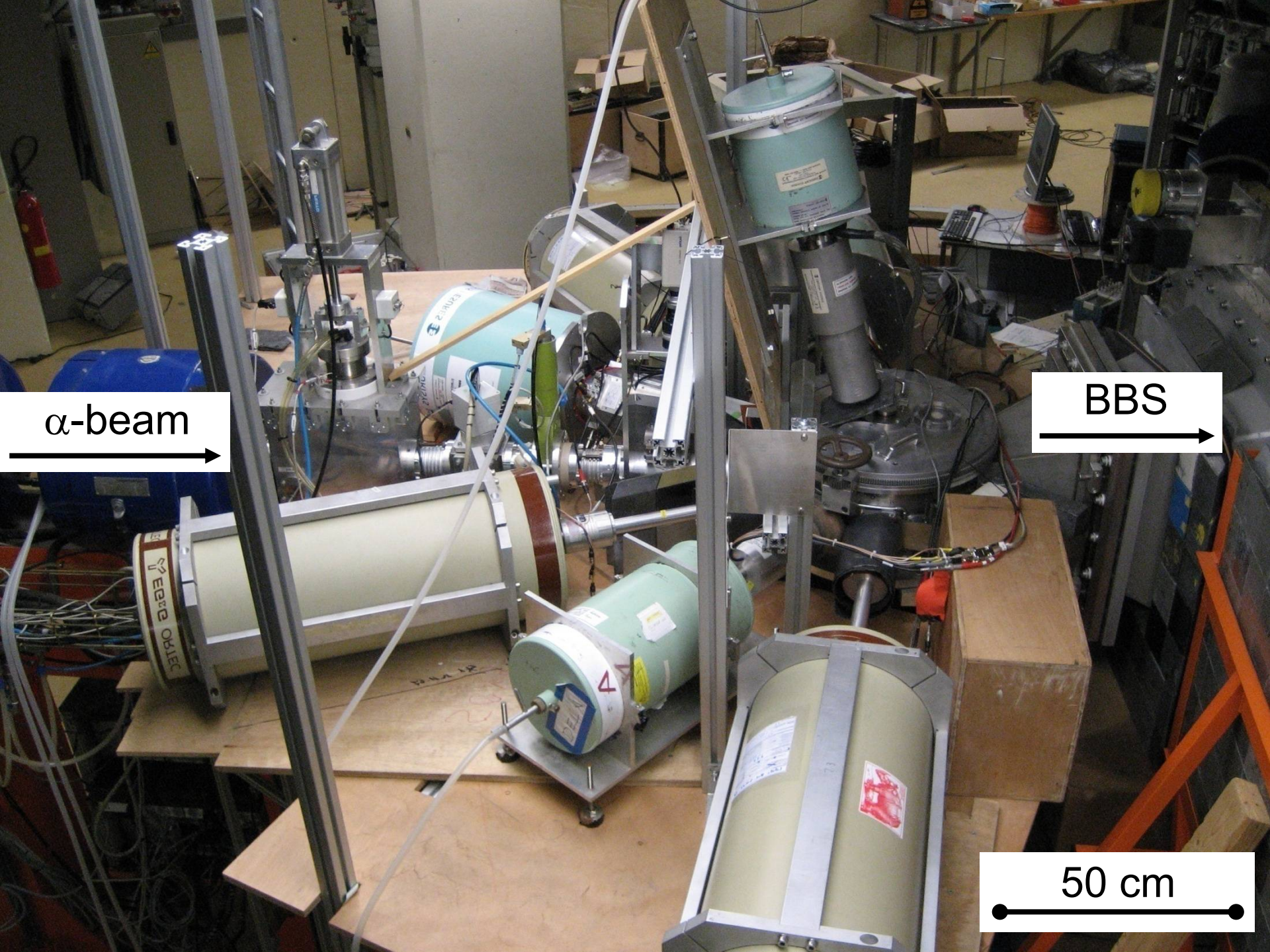
- Isoscalar probe
→ Further structure information
- Problem:
 - 30-100 keV energy resolution
No resolving of single excitations
 - Excitation of higher multipolarities
No separation from other excitations

⇒ **No detailed spectroscopy of PDR possible with (α, α')**

- Coincident measurement of γ -decay
⇒ $(\alpha, \alpha'\gamma)$
- Selection of decays to the ground state
⇒ **Selectivity to E1 decays**
T.D. Poelheken et al., Phys. Lett. B **278** (1992) 423
- Use of HPGe detectors
⇒ **High energy resolution**
D. Savran et al., Nucl. Instr. and Meth. A **564** (2006) 267
- Experimental parameters:
⇒ **$E_\alpha = 136$ MeV and forward angle**

Setup at KVI





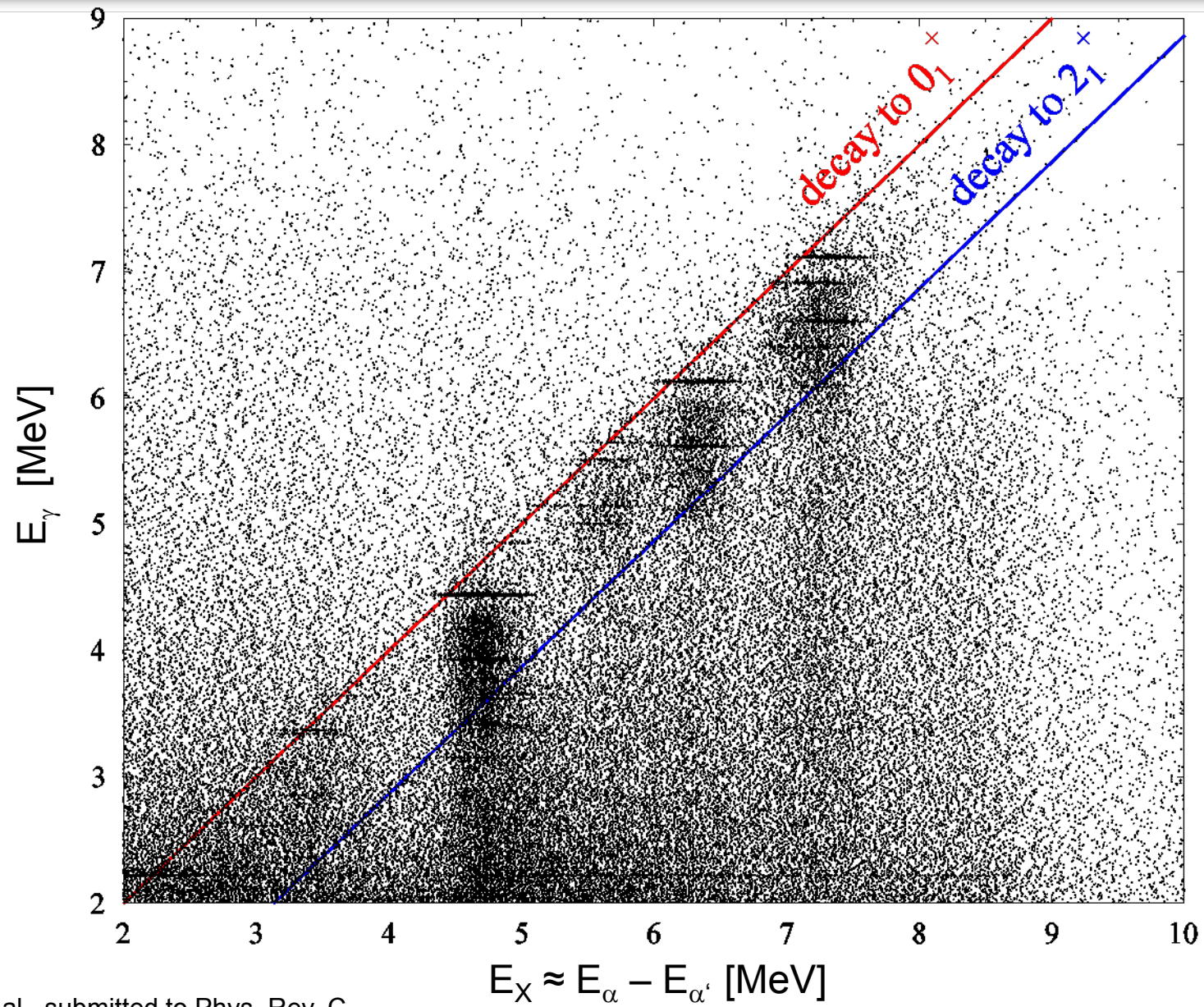
α -beam

BBS

50 cm

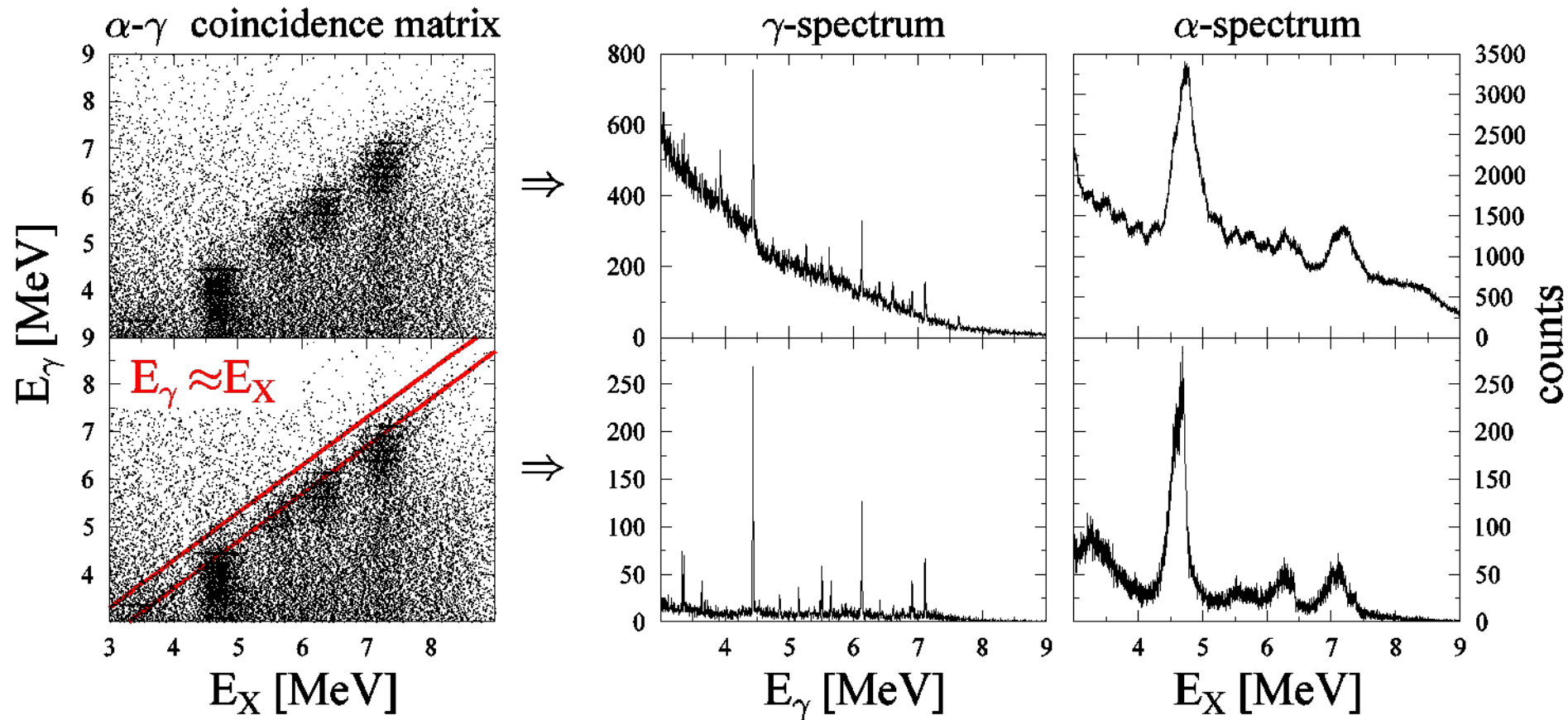


^{138}Ba -2d coincidence matrix

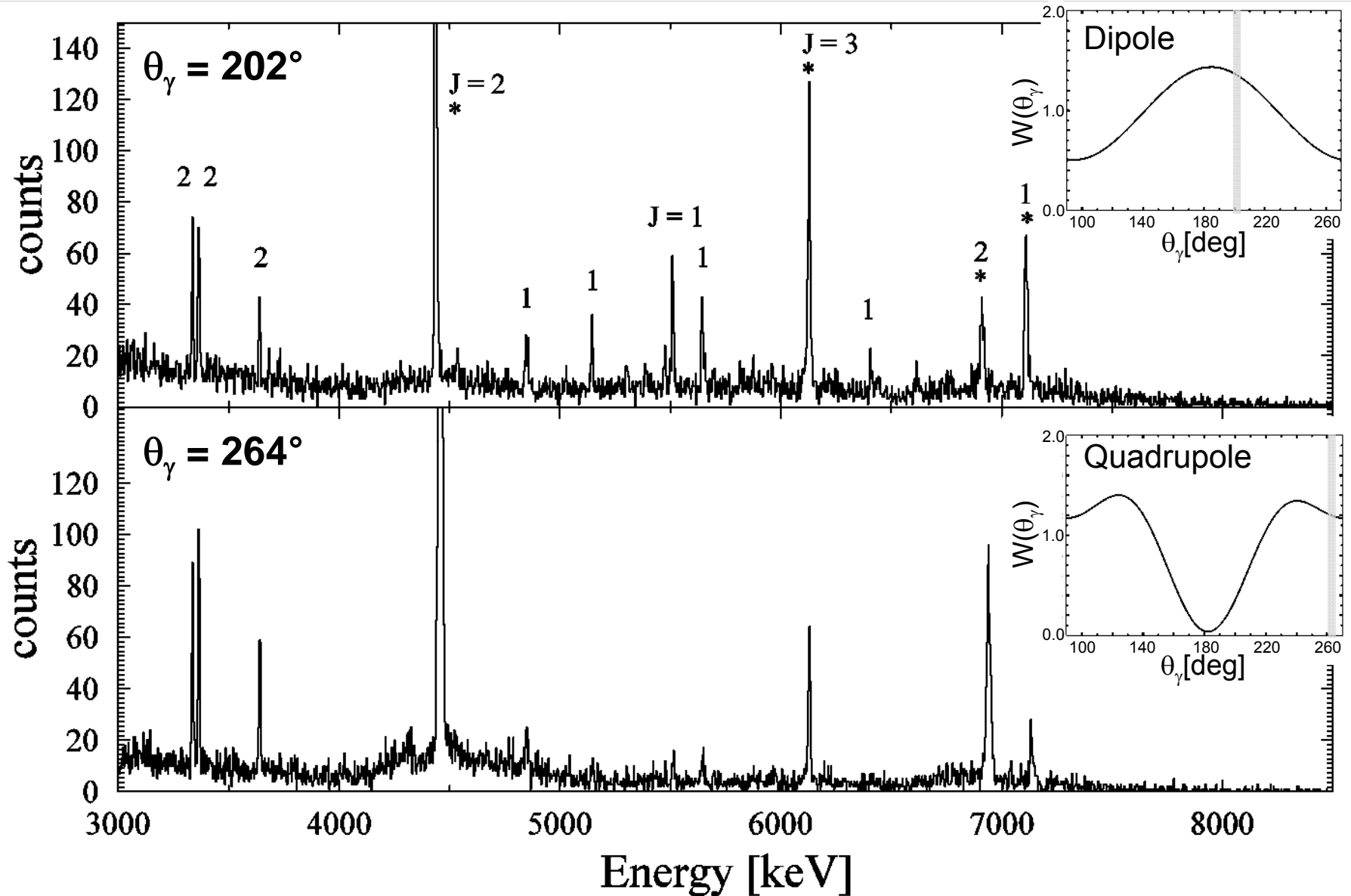


J. Endres et al., submitted to Phys. Rev. C

Selectivity in ^{138}Ba

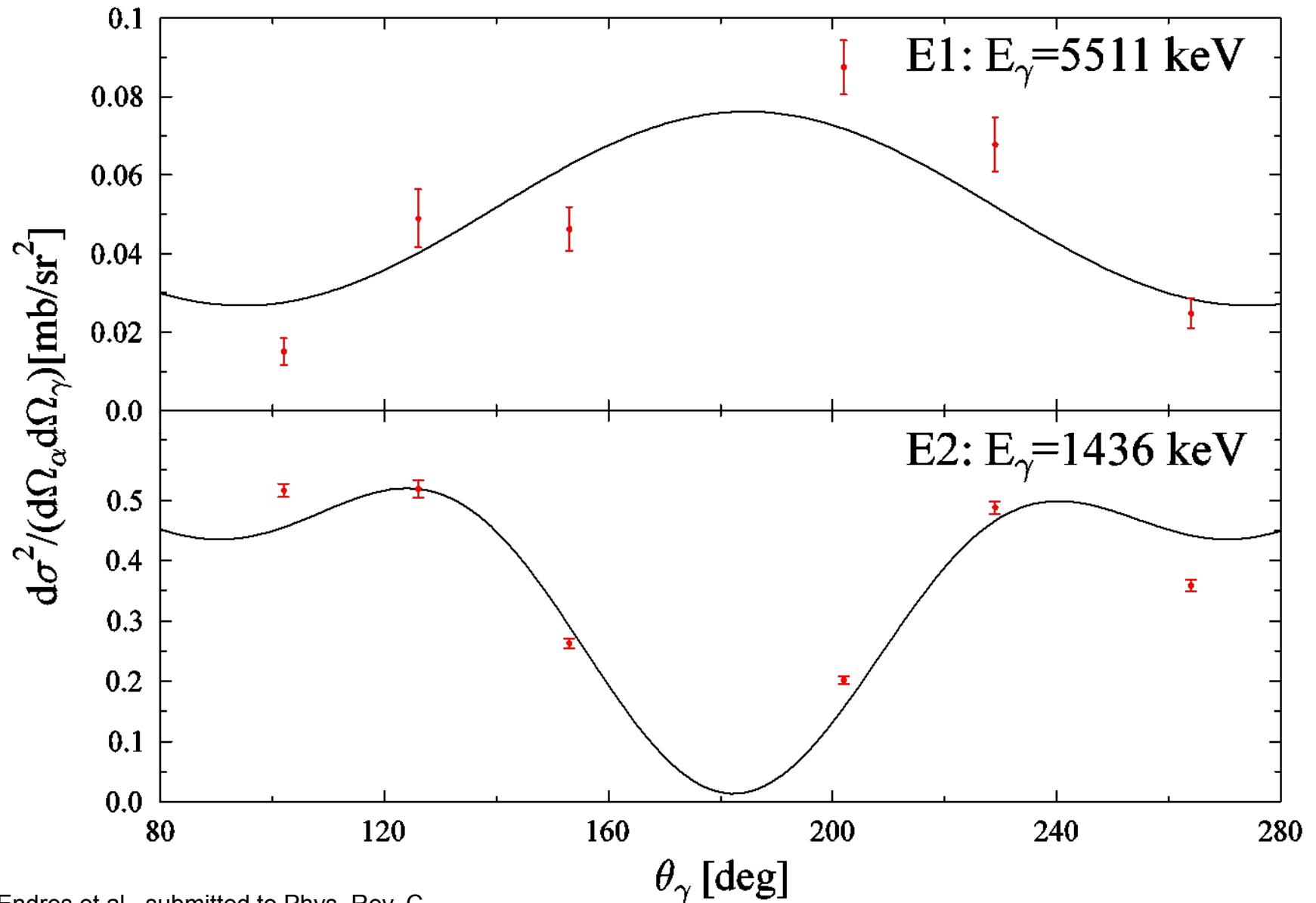


Multipole assignment with α - γ angular correlation



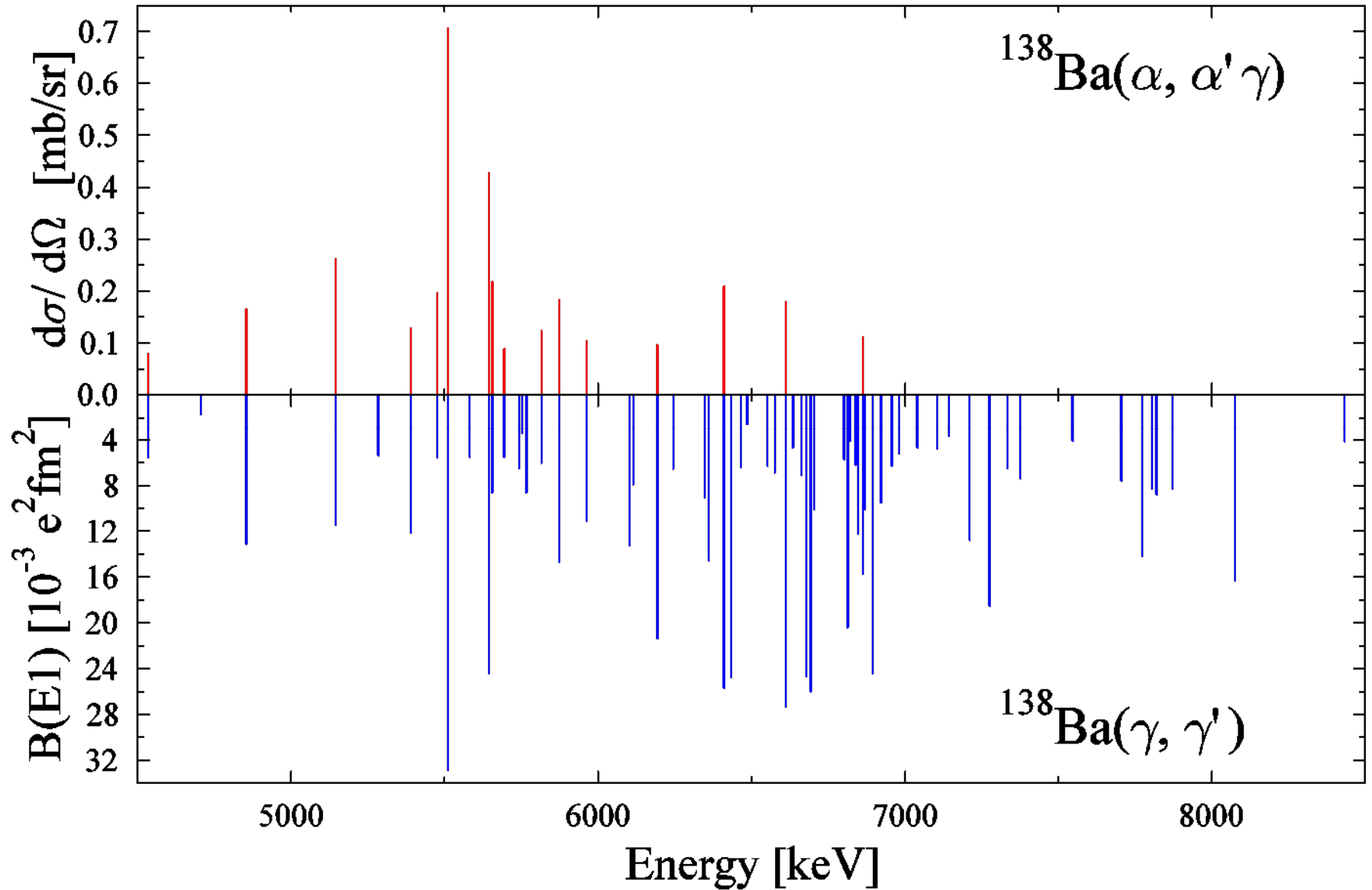
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Multipole assignment with α - γ angular correlation



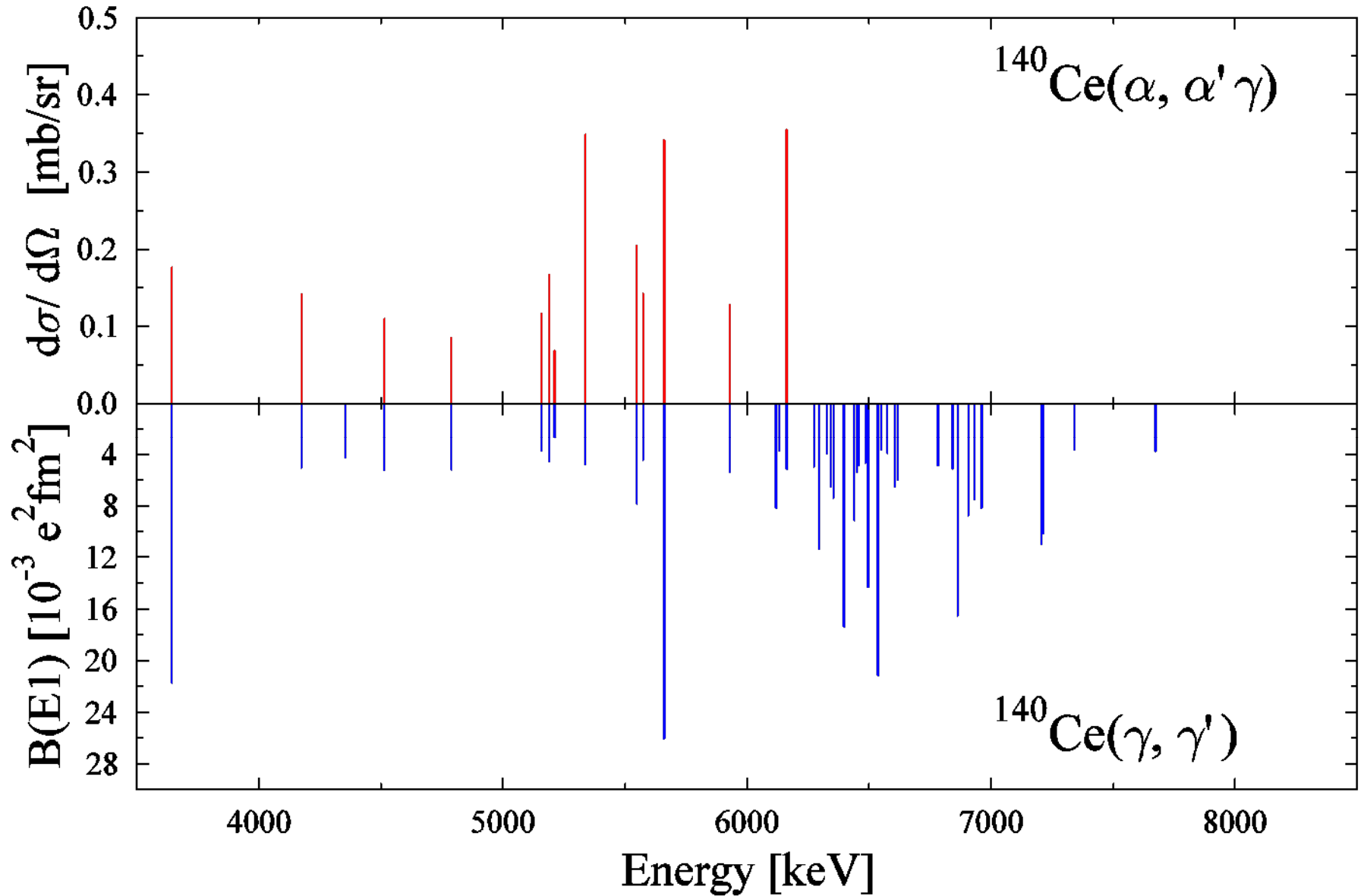
J. Endres et al., submitted to Phys. Rev. C

Comparison of $(\alpha, \alpha' \gamma)$ with (γ, γ') on ^{138}Ba



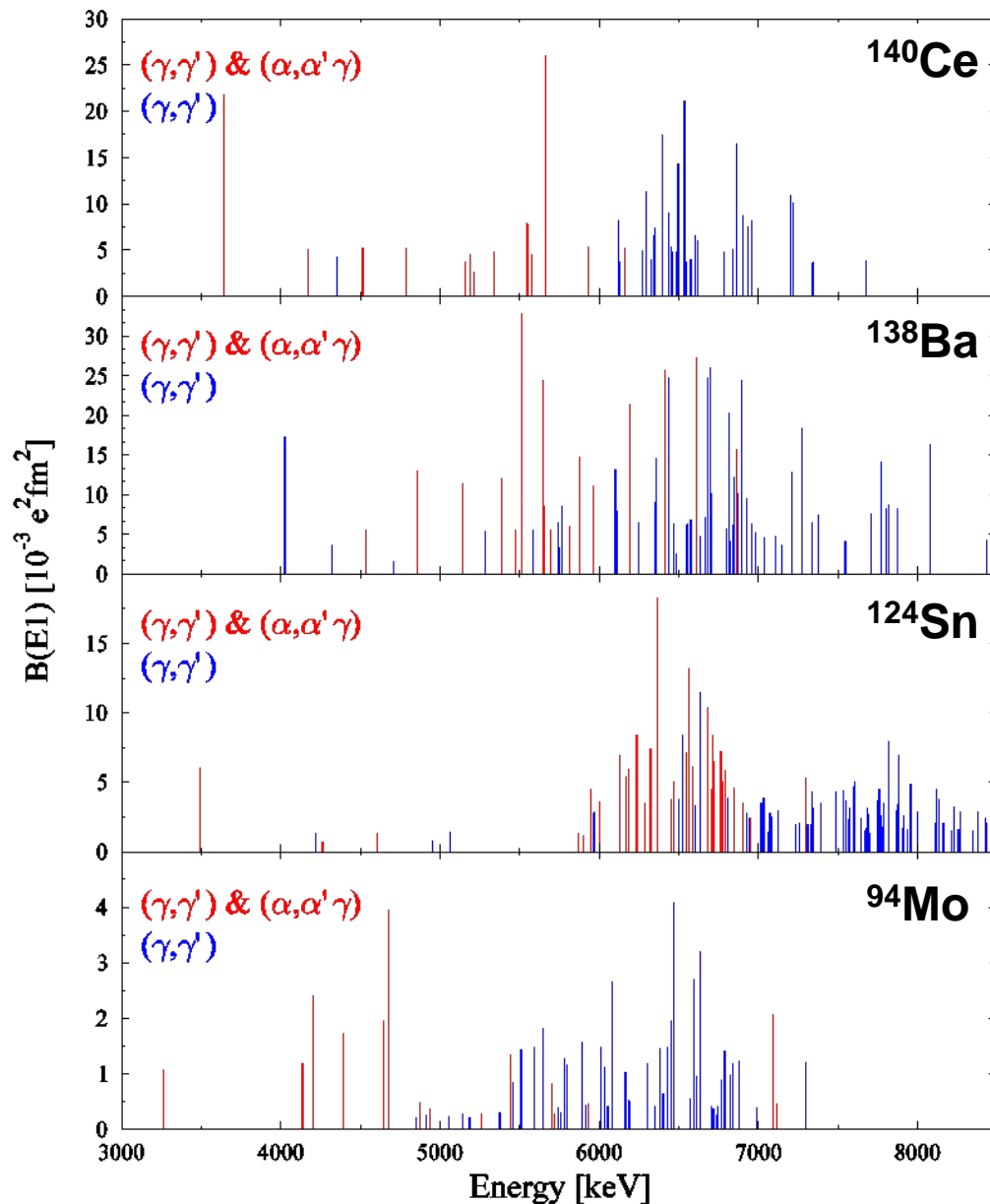
J. Endres et al., submitted to Phys. Rev. C

Comparison of $(\alpha, \alpha' \gamma)$ with (γ, γ') on ^{140}Ce



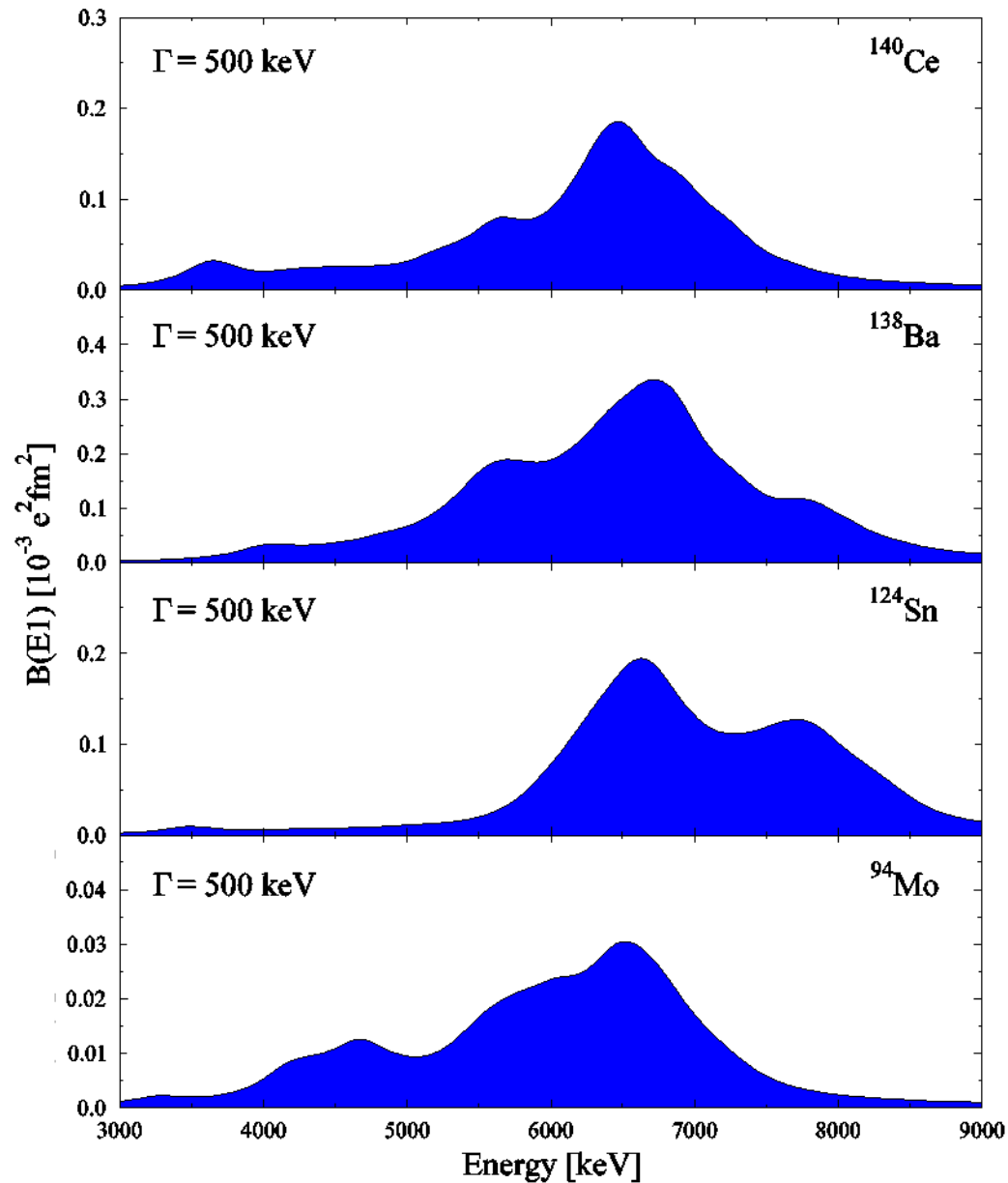
D. Savran et al., Phys. Rev. Lett. **97** (2006) 172502

E1 strength distribution in ^{140}Ce , ^{138}Ba , ^{124}Sn , and ^{94}Mo

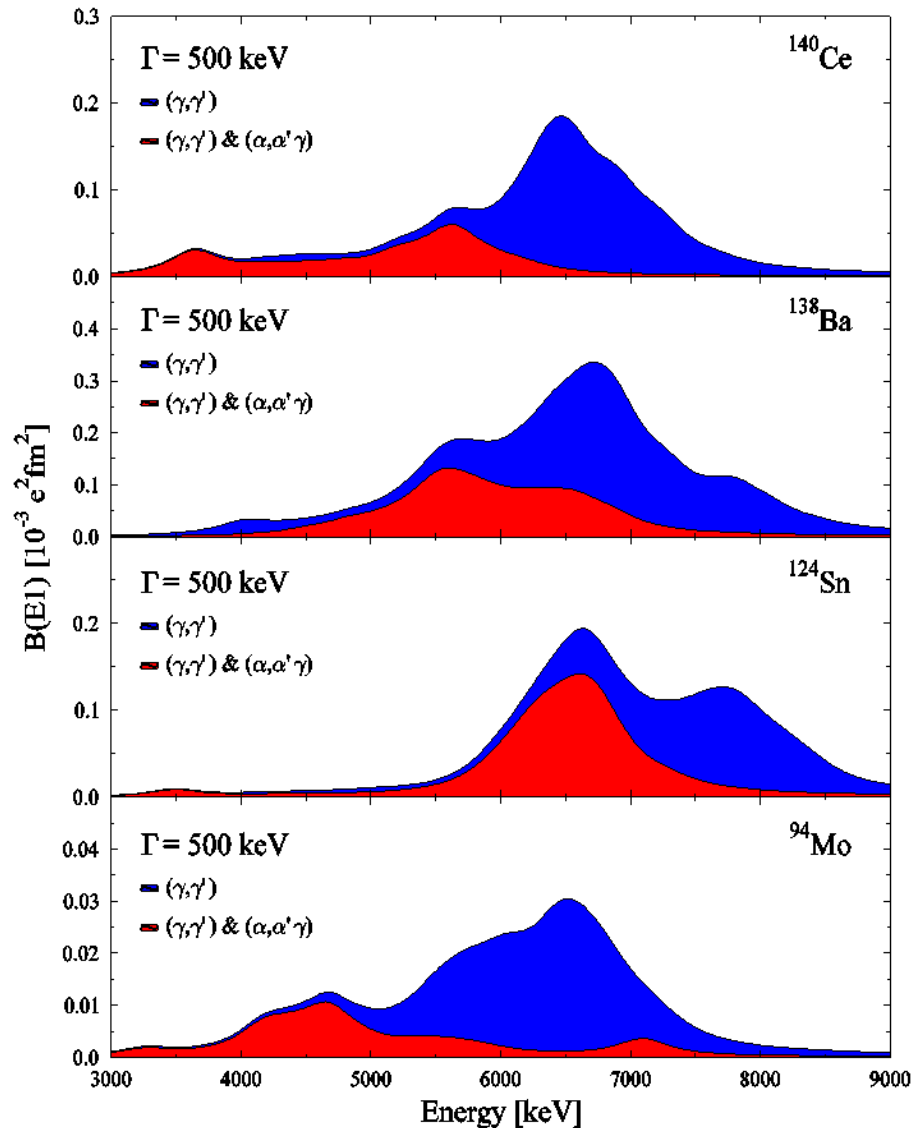


— (γ, γ') & $(\alpha, \alpha' \gamma)$
— (γ, γ') only

E1 strength distribution in ^{140}Ce , ^{138}Ba , ^{124}Sn , and ^{94}Mo



E1 strength distribution in ^{140}Ce , ^{138}Ba , ^{124}Sn , and ^{94}Mo



- Splitting of the PDR:
 - Two groups of states with different character

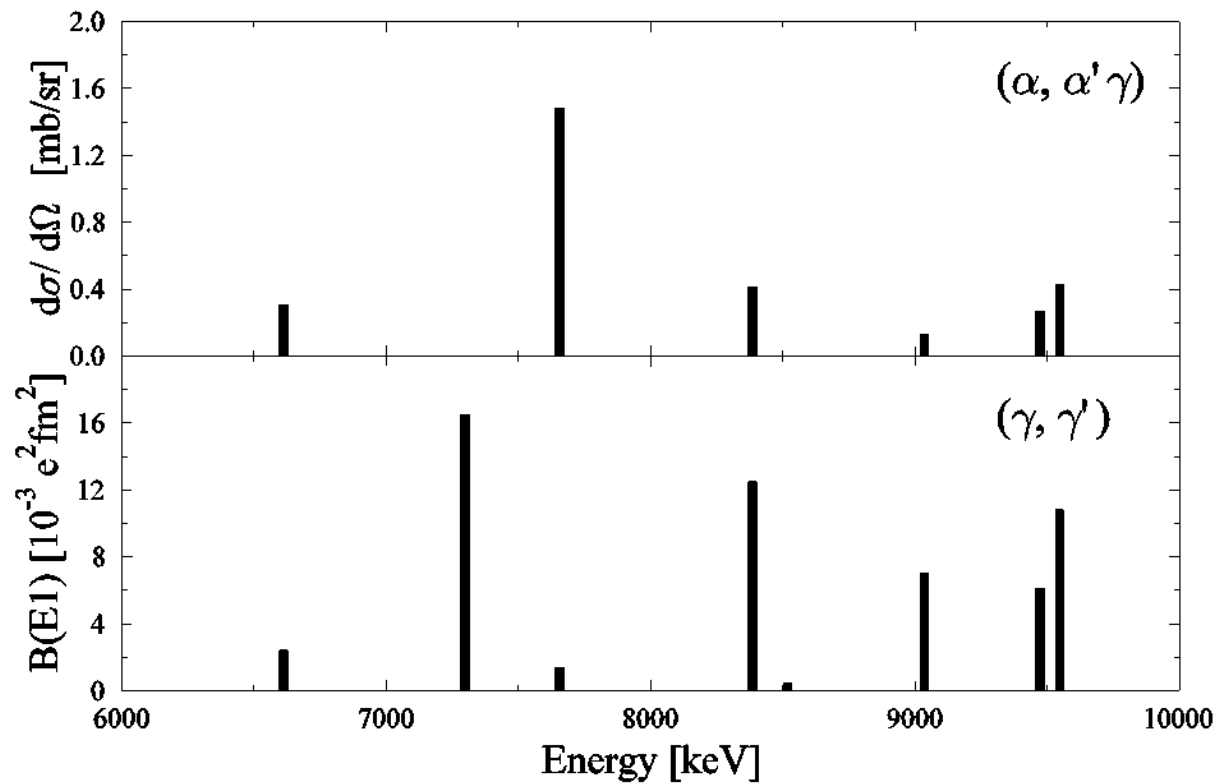
- Two different probes:
 - Isospin character
 - Interaction with nucleus

- Alpha clustering mode??

F. Iachello and A.D. Jackson, Phys. Lett. B **108** (1982) 151

- How complete are strength measurements with photons?
→ QPM calculations allow an estimation of the missing strength
- Does the PDR show a strong N/Z dependence?
→ QPM calculations show a slight dependence
- What is the real structure of the PDR?
→ Splitting of the PDR
- Complementary measurement
→ $^{140}\text{Ce}(p,p'\gamma)$

E1 strength distribution in ^{48}Ca



- Low level density
- Sensitivity up to 9.5 MeV
- Different pattern

- How complete are strength measurements with photons?
→ QPM calculations allow an estimation of the missing strength
- Does the PDR show a strong N/Z dependence?
→ QPM calculations show a slight dependence
- What is the real structure of the PDR?
→ Splitting of the PDR
- Complementary measurement
→ $^{140}\text{Ce}(p,p'\gamma)$
- Investigation of ^{48}Ca