Recent results on the Pygmy Dipole Resonance studied via hadronic probes at intermediate energy

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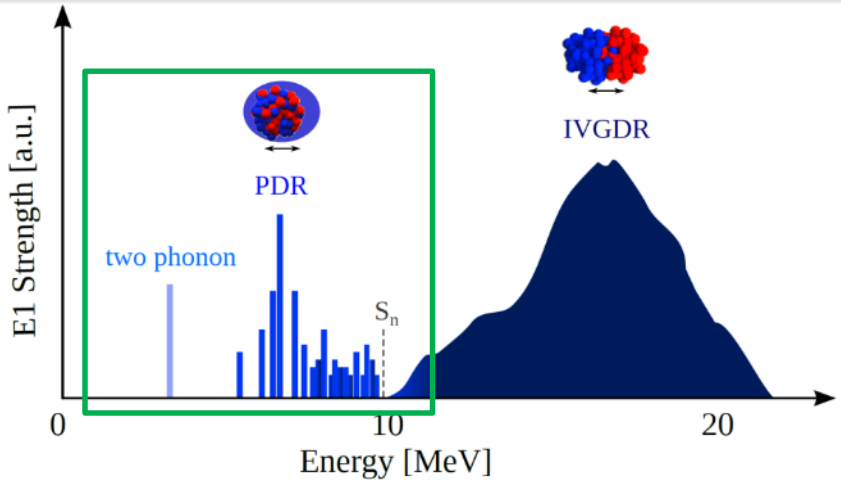
Outline

- Introduction
- The particle-γ coincidence method
- The Pygmy Dipole Resonance in ^{140}Ce studied via (p,p$'\gamma$)
- Summary and outlook

Introduction



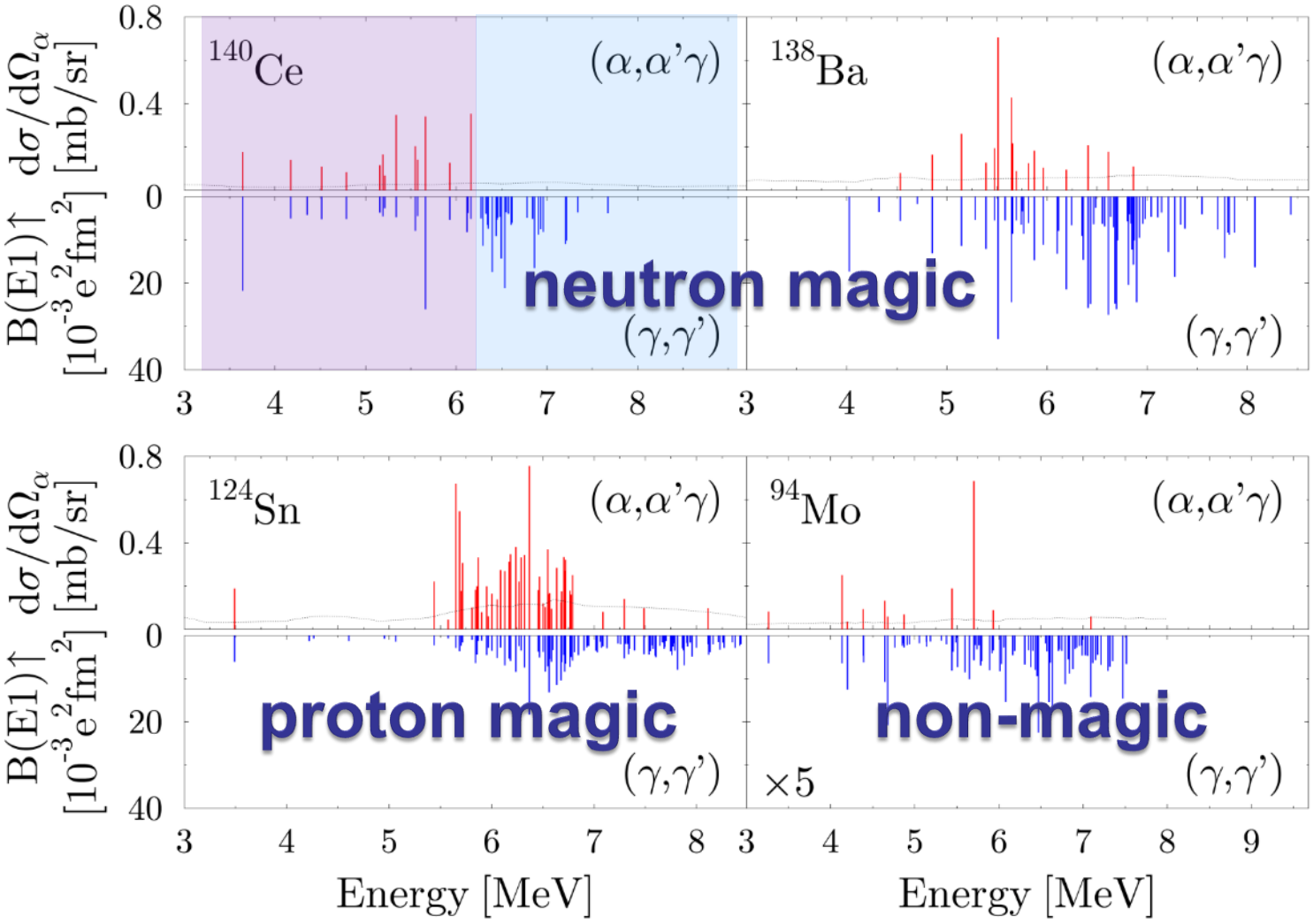
Probing the structure of low-lying E1 strength?

D. Savran., T. Aumann, and A. Zilges, Prog. Part. Nucl. Phys. **70** (2013) 210

Probe	Interaction (dominant)	Location of interaction	Character of interaction (dominant)
Photon	Electromagnetic	Whole nucleus	Isovector
α particle[1]	Hadronic* *at intermediate energies (≈ 20-100 MeV/u)	Surface	Isoscalar
Proton[2]			
^{17}O[3]			

[1] D. Savran et al., Phys. Rev. Lett. **97** (2006) 172502
[2] V. Derya, PhD thesis, Universität zu Köln (2014)
[3] F.C.L. Crespi et al., Phys. Rev. Lett. **113** (2014) 012501

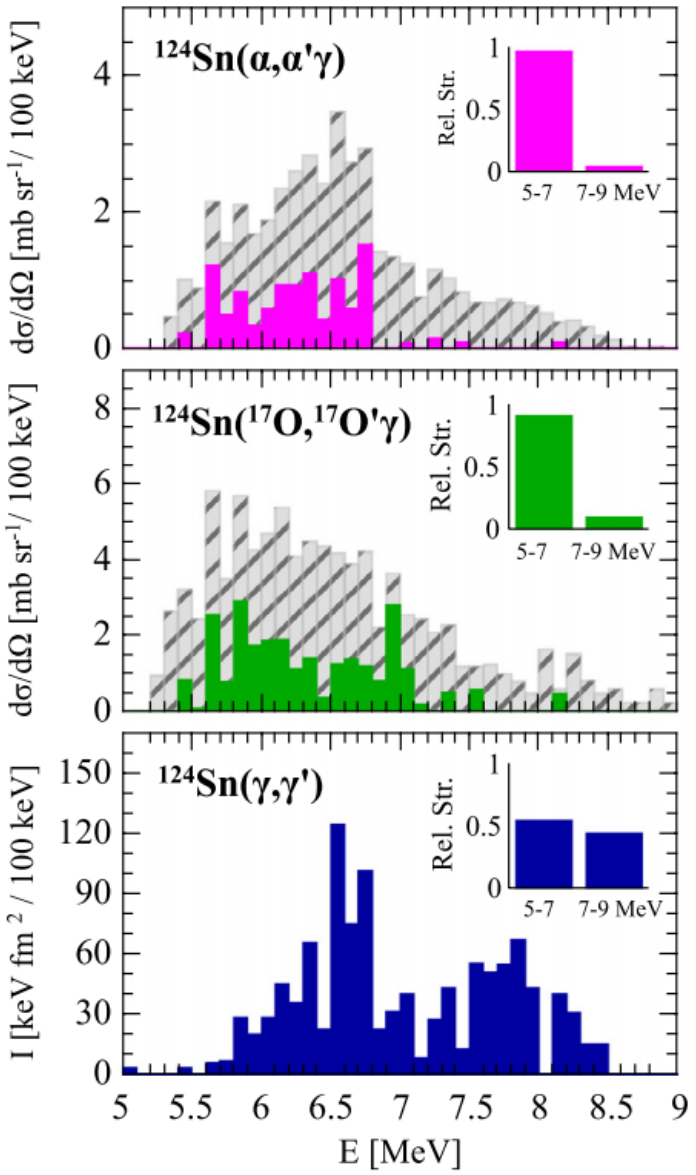
Systematic study in (α,α′γ) and (γ,γ′) experiments



D. Savran et al., Phys. Rev. Lett. **97** (2006) 172502
J. Endres, E. Litvinova et al., Phys. Rev. Lett. **105** (2010) 212503

J. Endres et al., Phys. Rev. C **80** (2009) 034302
V. Derya et al., Nucl. Phys. A **906** (2013) 94

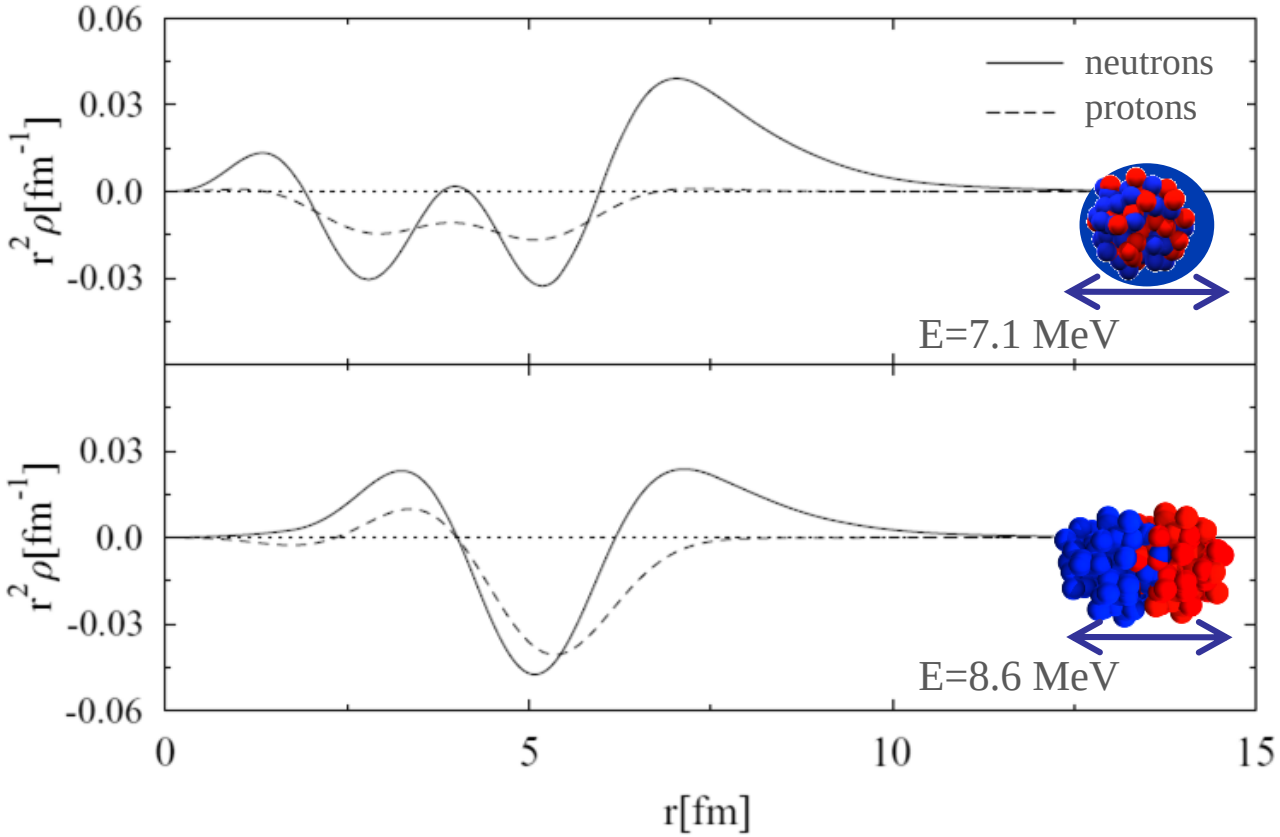
$^{124}Sn(^{17}O,^{17}O'\gamma)$ at 20 MeV/u



- Recent experiment at Legnaro National Laboratories in Italy
- ΔE-E silicon telescopes and AGATA demonstrator
- "The data are in remarkable agreement with a previous experiment using the $(\alpha,\alpha'\gamma)$ inelastic scattering reaction."
  L. Pellegri et al., Phys. Lett. B **738** (2014) 519

Interpretation of the splitting

Transition densities for two RQTBA states in ^{124}Sn



- In phase
- Large neutron contribution at the surface

- Slightly out of phase
- Enhanced proton contribution

- Low-lying state: Typical PDR state
- High-lying state: Transitional towards the GDR

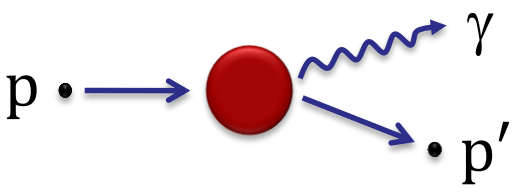
J. Endres, E. Litvinova et al., Phys. Rev. C **85** (2012) 064331

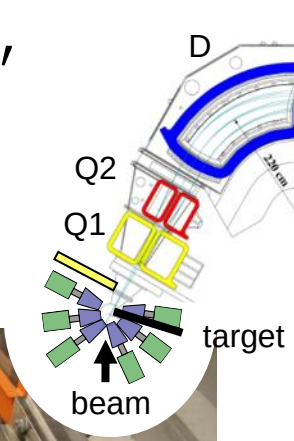
Similar conclusions in
N. Tsoneva et al., Phys. Rev. C **77** (2008) 024321

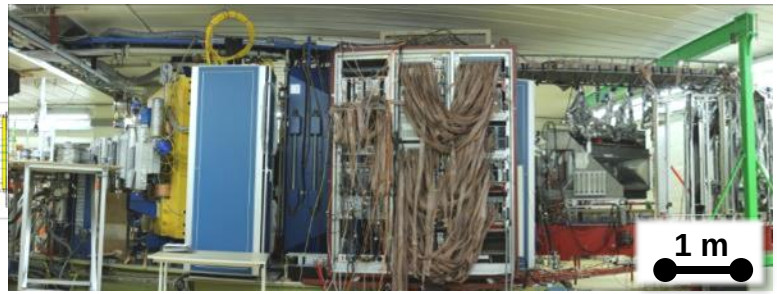
Particle-γ coincidence method

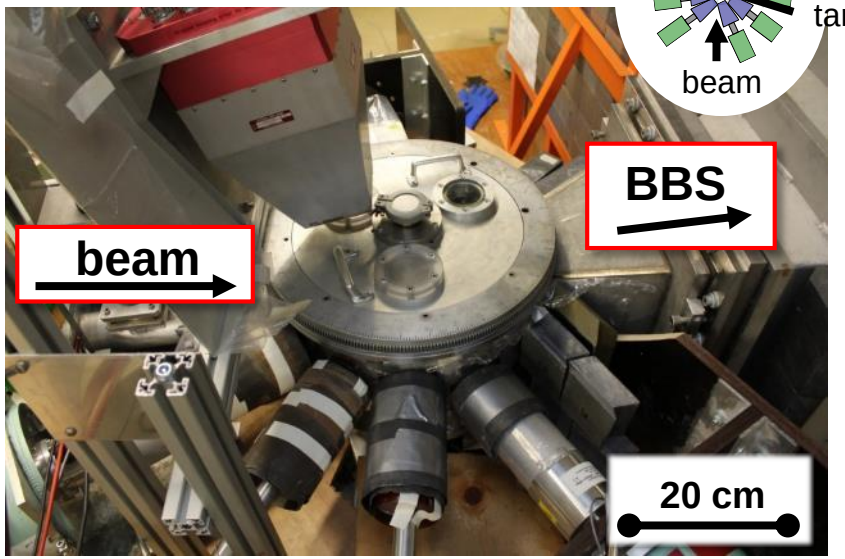
- Reaction: Inelastic particle scattering at intermediate energy performed at KVI Groningen

Big-Bite Spectrometer @ ≈ 3-6°







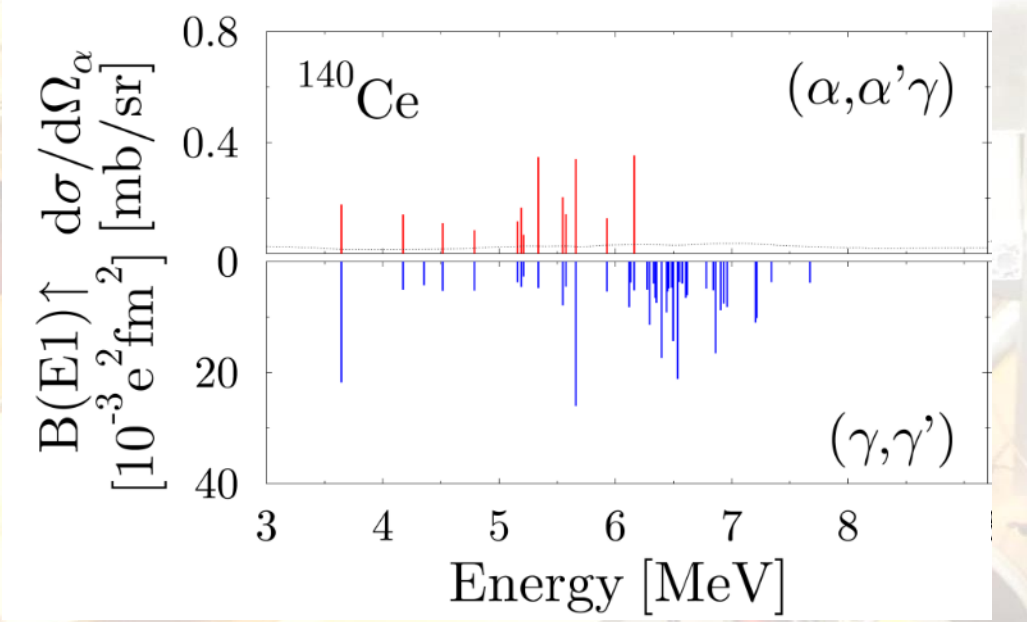


High-resolution HPGe-detector array

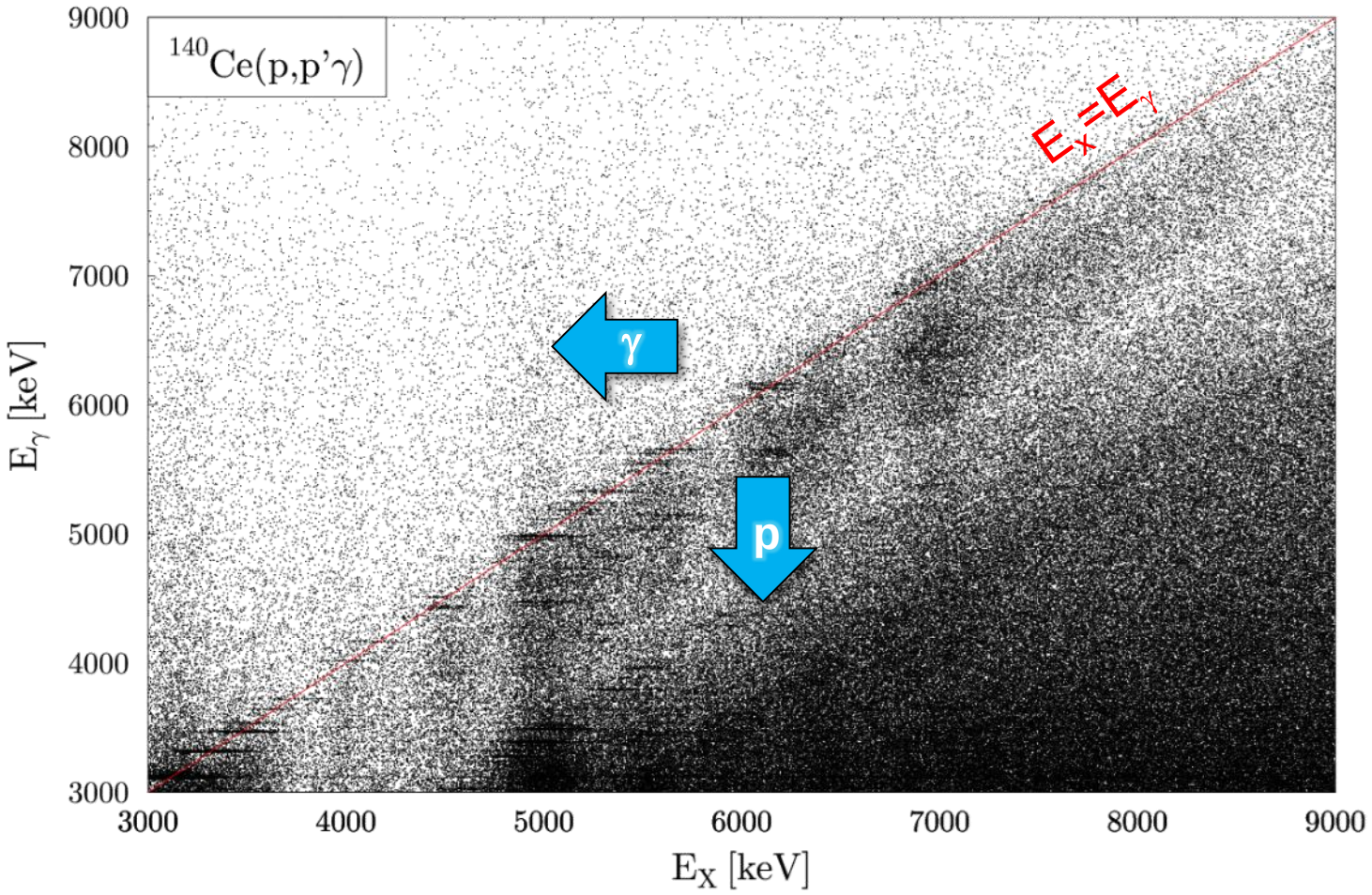
D. Savran et al., Nucl. Instr. Meth. A **564** (2006) 267

First ^{140}Ce(p,p′γ) experiment

- Beam energy: 80 MeV
- Central BBS angle: 6°
- 8 HPGe detectors
- Target enrichment: 99.72 %

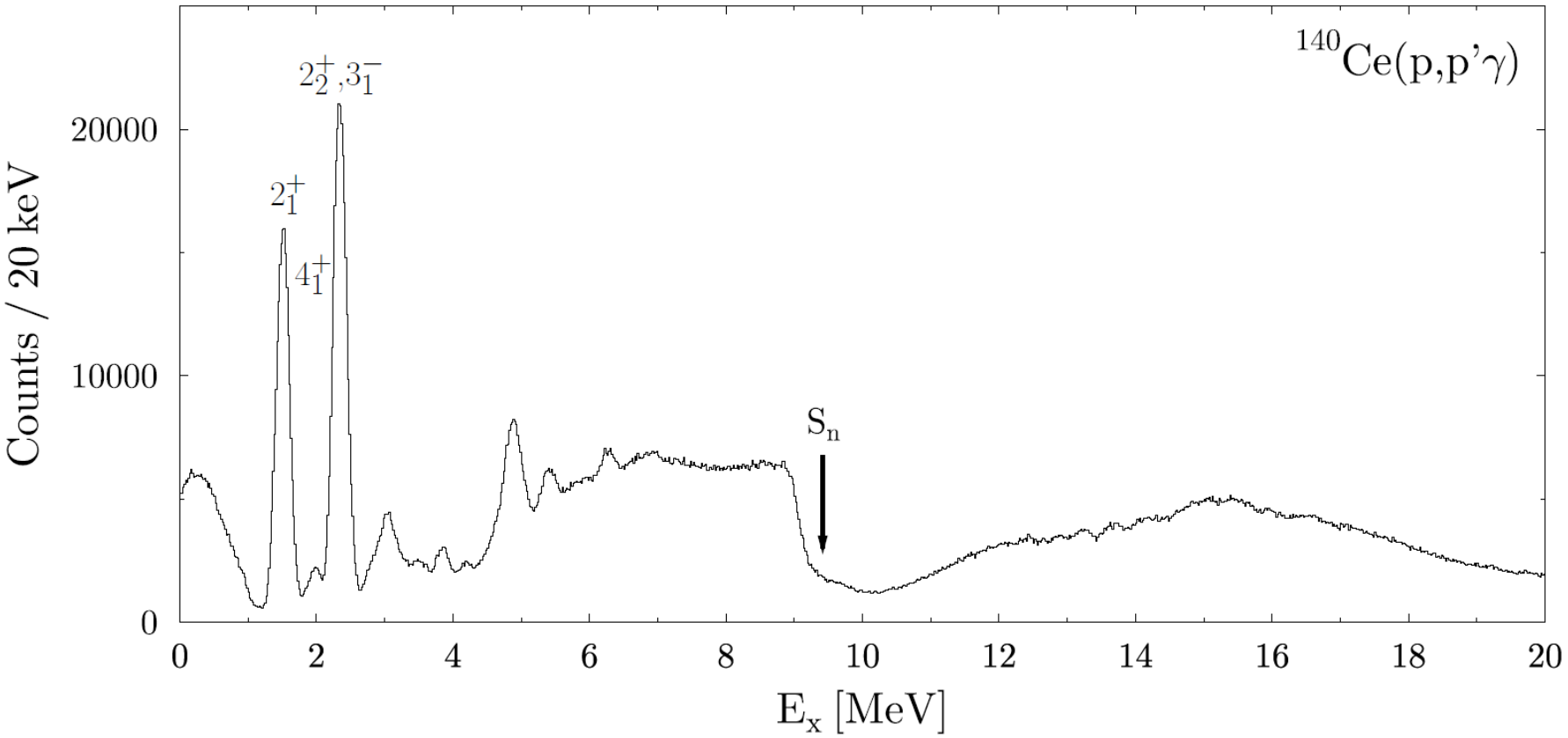


p-γ coincidence matrix



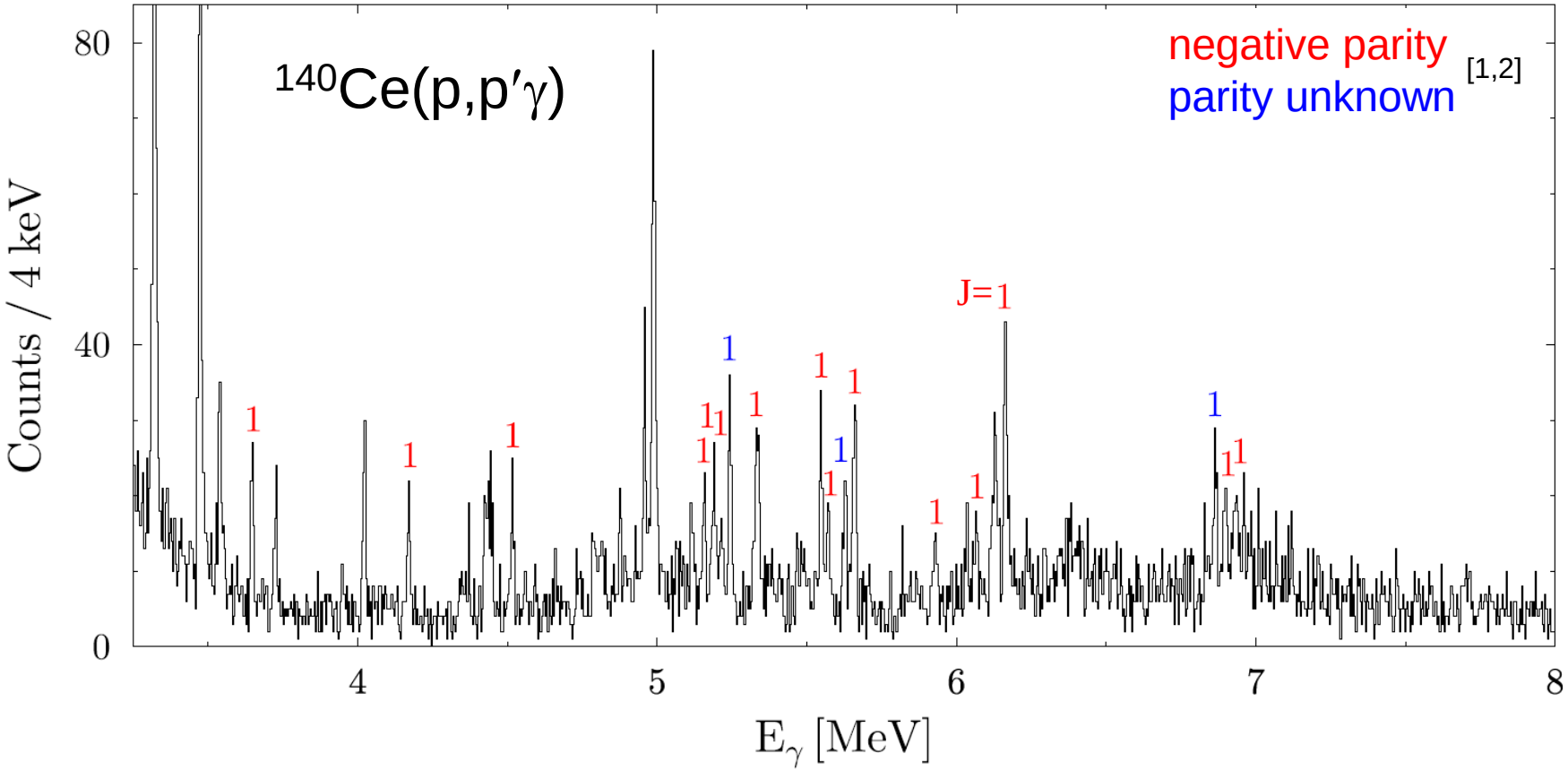
- Energy spectra through projection
- Selecting transitions by setting gates

Excitation-energy spectrum



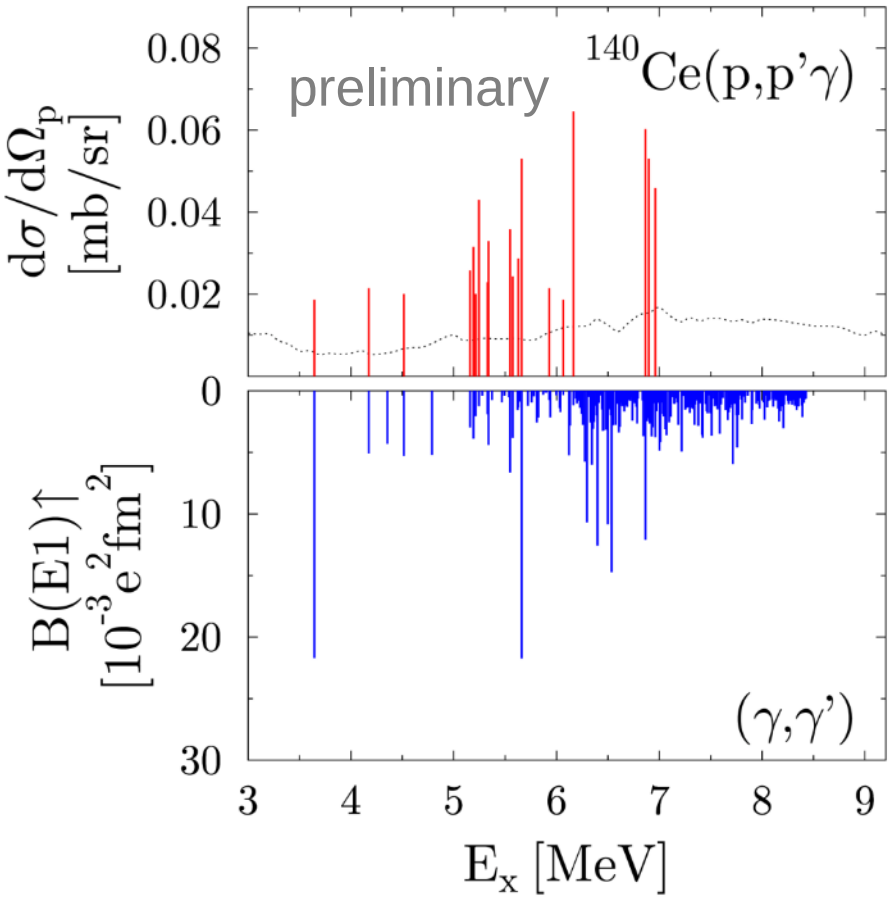
γ-ray spectrum

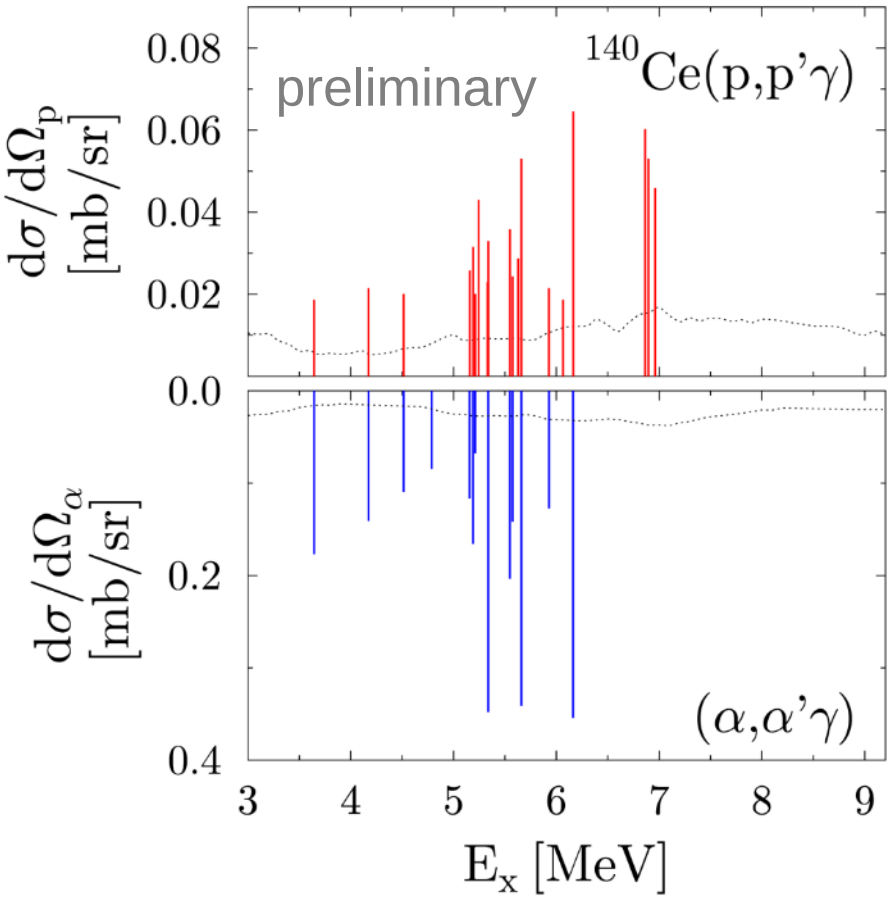
Ground-state transitions $E_x=E_\gamma$



[1] D. Savran et al., Phys. Rev. Lett. **97** (2006) 172502
[2] B. Löher, PhD thesis, Universität Mainz (2014)

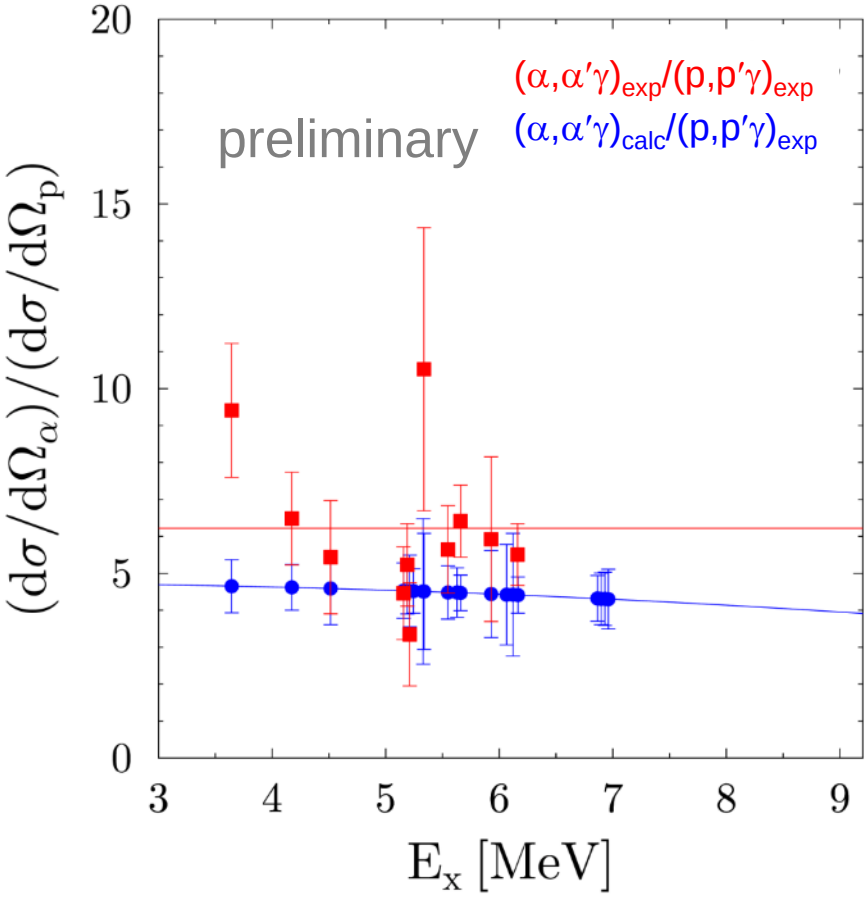
Cross sections for ^{140}Ce(p,p′γ)

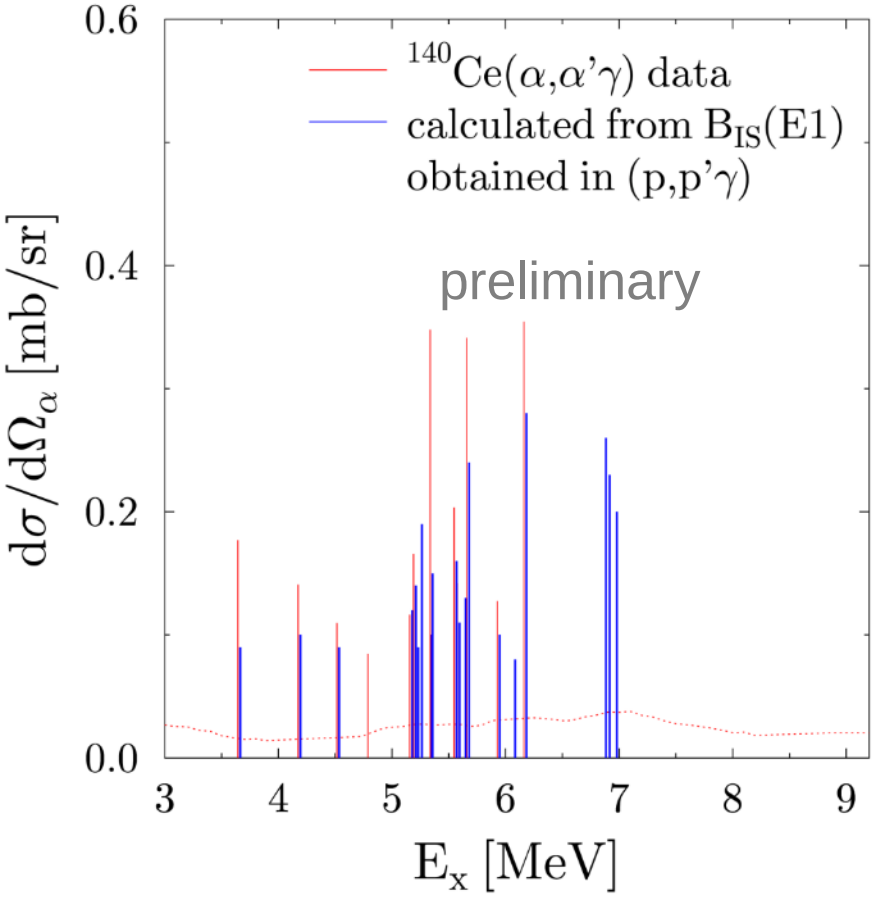




- Order of magnitude smaller cross sections
- General excitation behavior similar

Comparison of ^{140}Ce(α,α′γ) and ^{140}Ce(p,p′γ)





- Ratio of cross sections almost constant
- Fair reproduction with DWBA conversion

Summary and Outlook

The Pygmy Dipole Resonance in ^{140}Ce

- First ^{140}Ce(p,p′γ) experiment at intermediate energy
- General excitation behavior in (α,α′γ) and (p,p′γ) is similar
- Proton-scattering cross sections order of magnitude smaller than α-scattering cross sections

Character of PDR in light, deformed, exotic nuclei?

- RIKEN: (α,α′γ) experiments in inverse kinematics on radioactive and stable nuclei (^{128,132}Sn measured in 2014)
- iThemba LABS and CAGRA@RCNP: (α,α′γ) and (p,p′γ) experiments on stable nuclei

Collaboration

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