Photoresponse of atomic nuclei – Collective excitations and photodissociation

- **E1 strength in atomic nuclei**
- **Structure of the Pygmy Dipole Resonance**
- ~~**Some implications on nucleosynthesis**~~
- **Outlook**

Andreas Zilges
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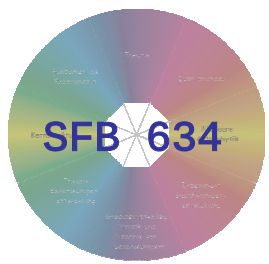
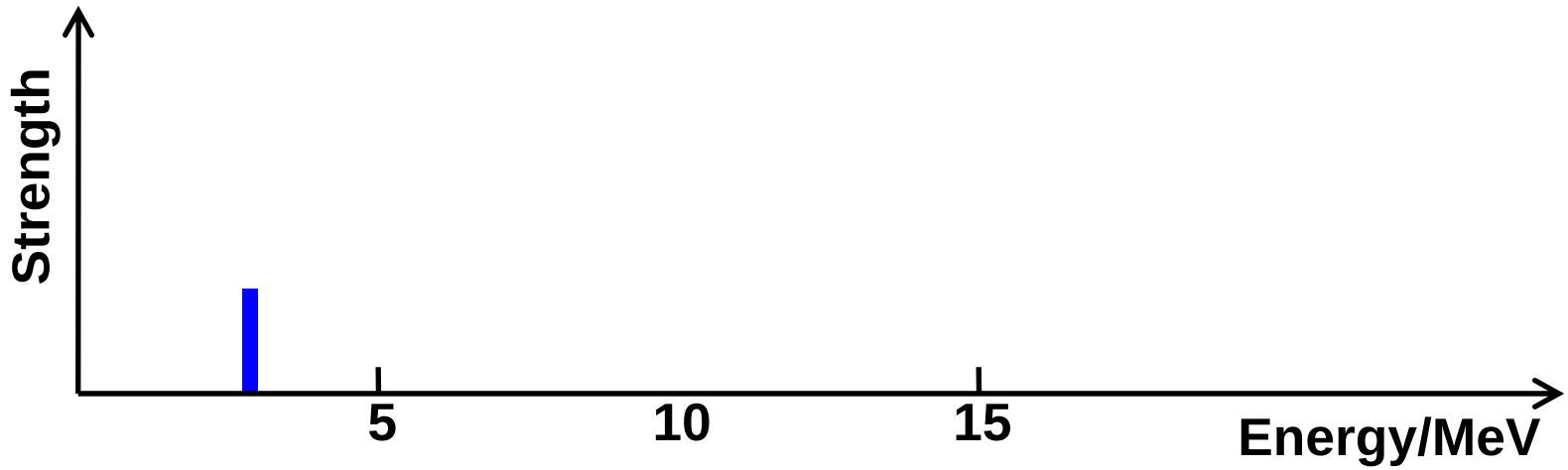


The photoresponse of atomic nuclei – E1 strength



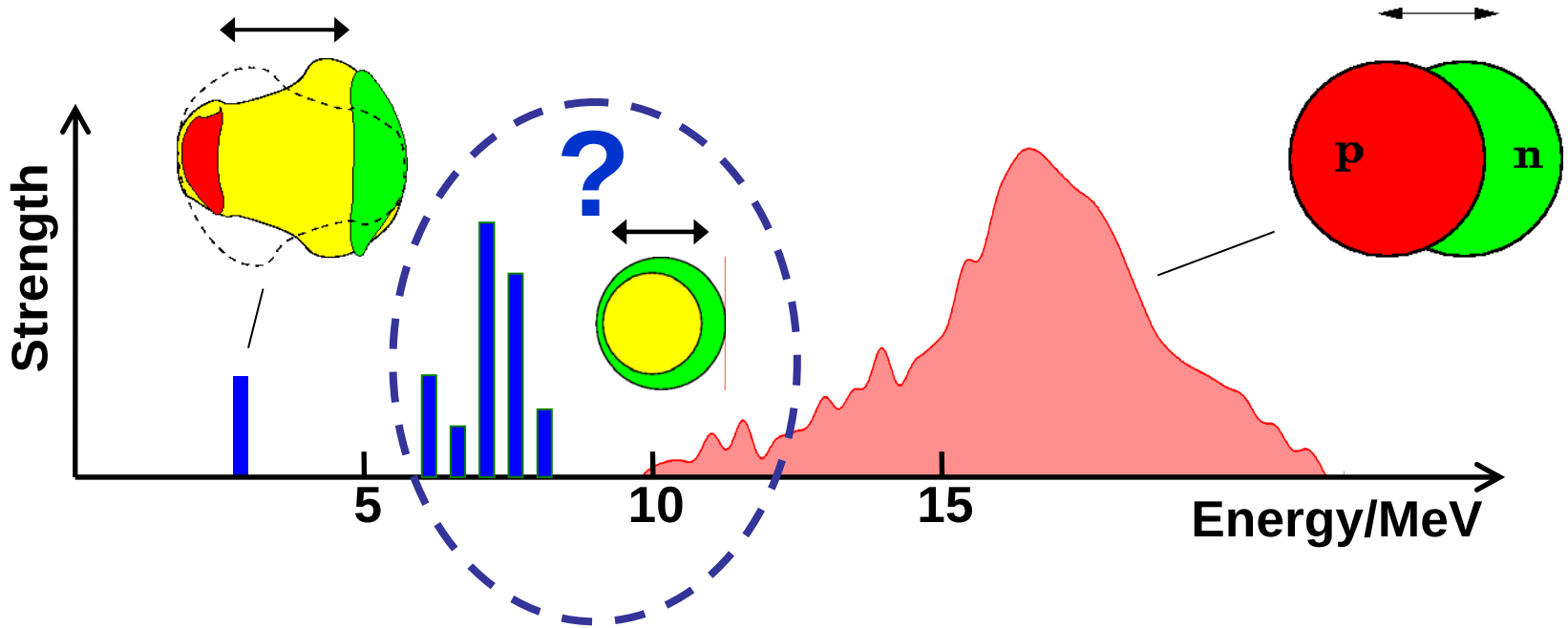
1^- excitation: E_x ~ 3 MeV, B(E1) ~ 10^{-2} W.u.

$2^+ \otimes 3^-$ two phonon excitation

„Yates quintuplet“

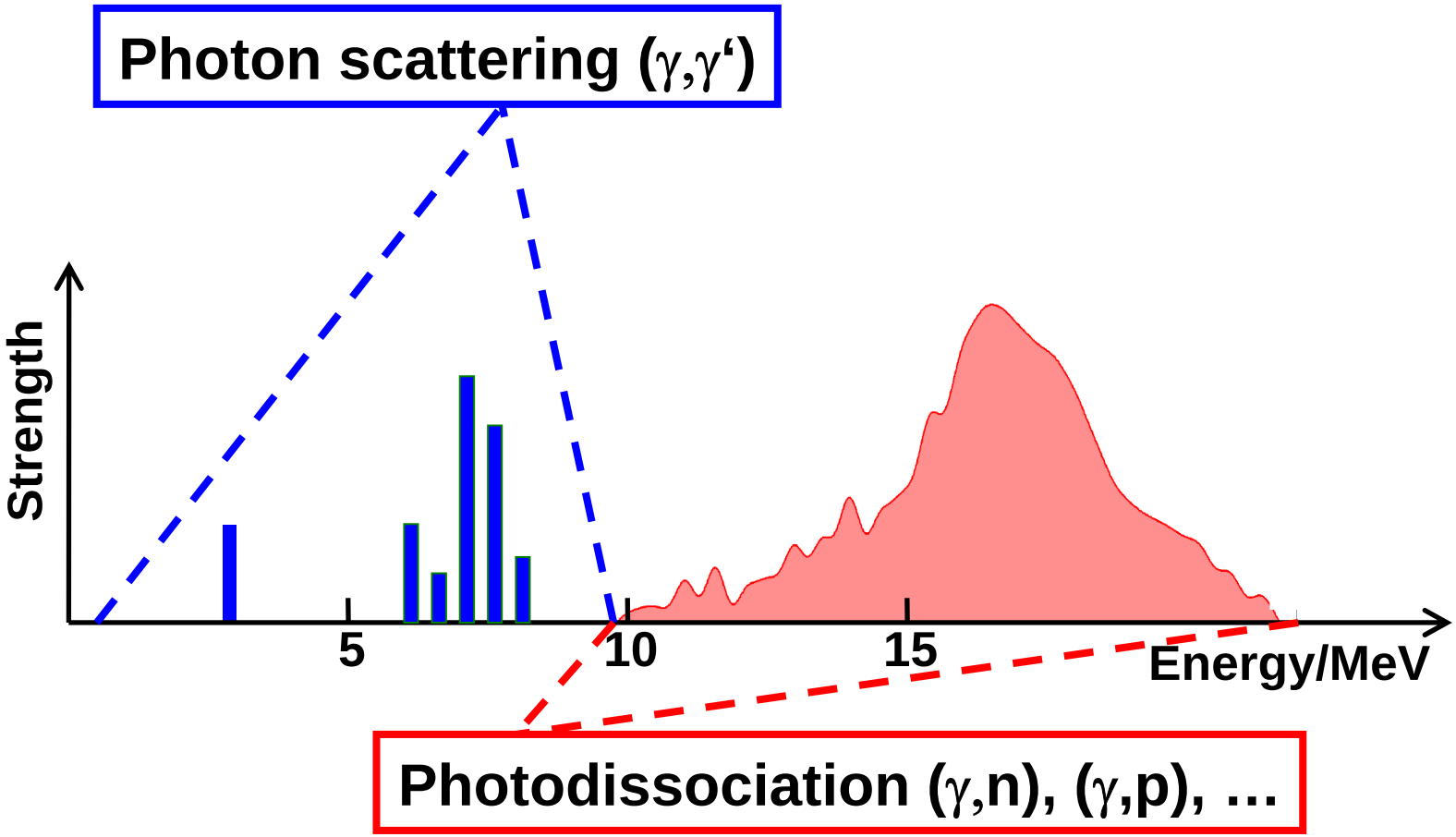
- S. W. Yates, J. Phys. G 31 (2005) S1339
- D. Bandyopadhyay et al., PRC 68 (2003) 014324
- P. E. Garrett et al., J. Phys. G 25 (1999) 823
- M. Babilon et al., PRC 65 (2002) 037303

The photoresponse of atomic nuclei – E1 strength



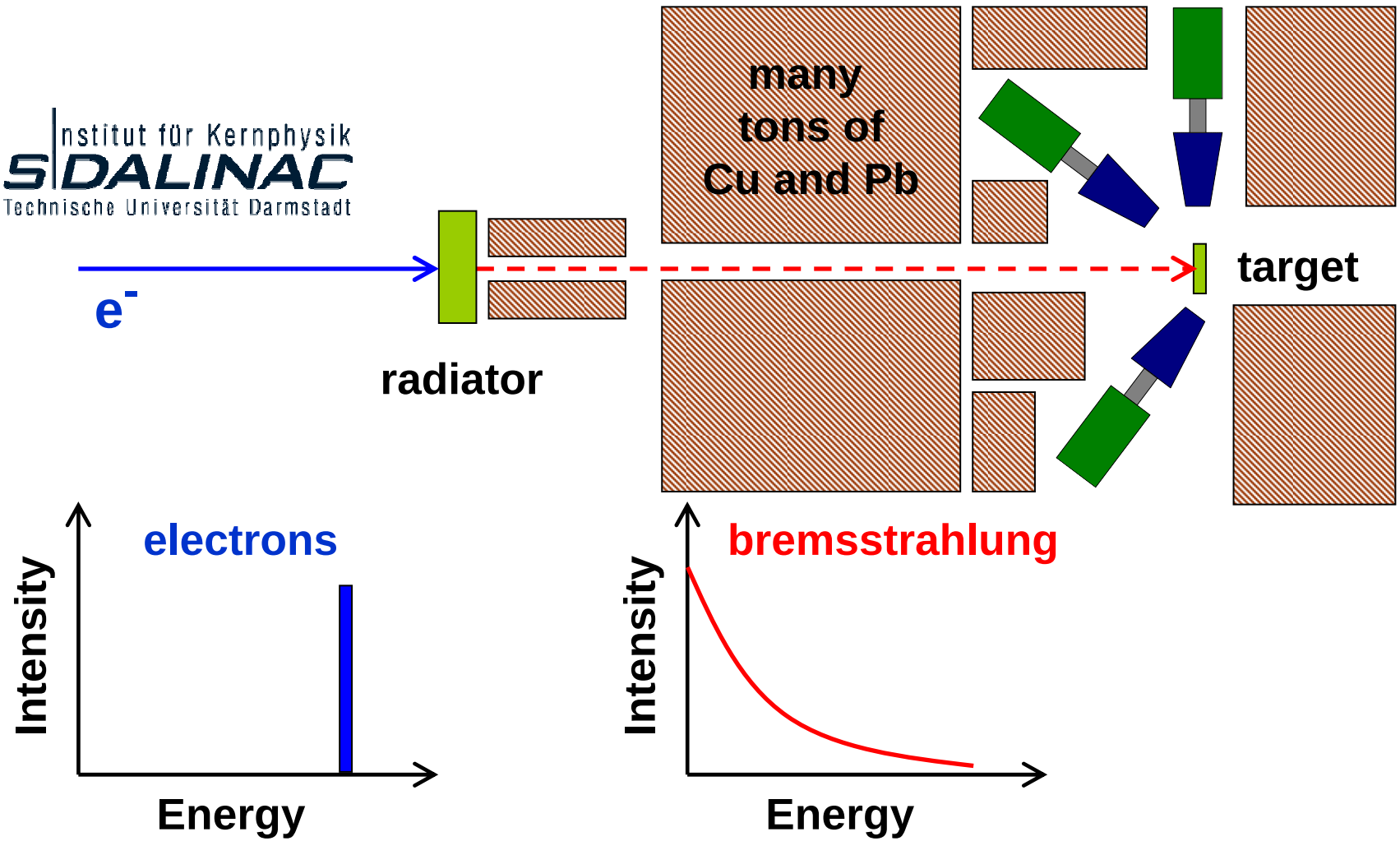
- **Two Phonon Excitation: E_x ~ 3 MeV, B(E1) ~ 10^{-2} W.u.**
- **Giant Dipole Resonance: E_x ~ 18 MeV, B(E1) ~ 10 W.u.**
- **Pygmy Dipole Resonance ?**
  - F. Iachello, PLB 160 (1985) 1
  - G. Colò et al., PLB 485 (2000) 362
  - D. Vretenar et al., PLB 487 (2000) 334

Measuring the photoresponse



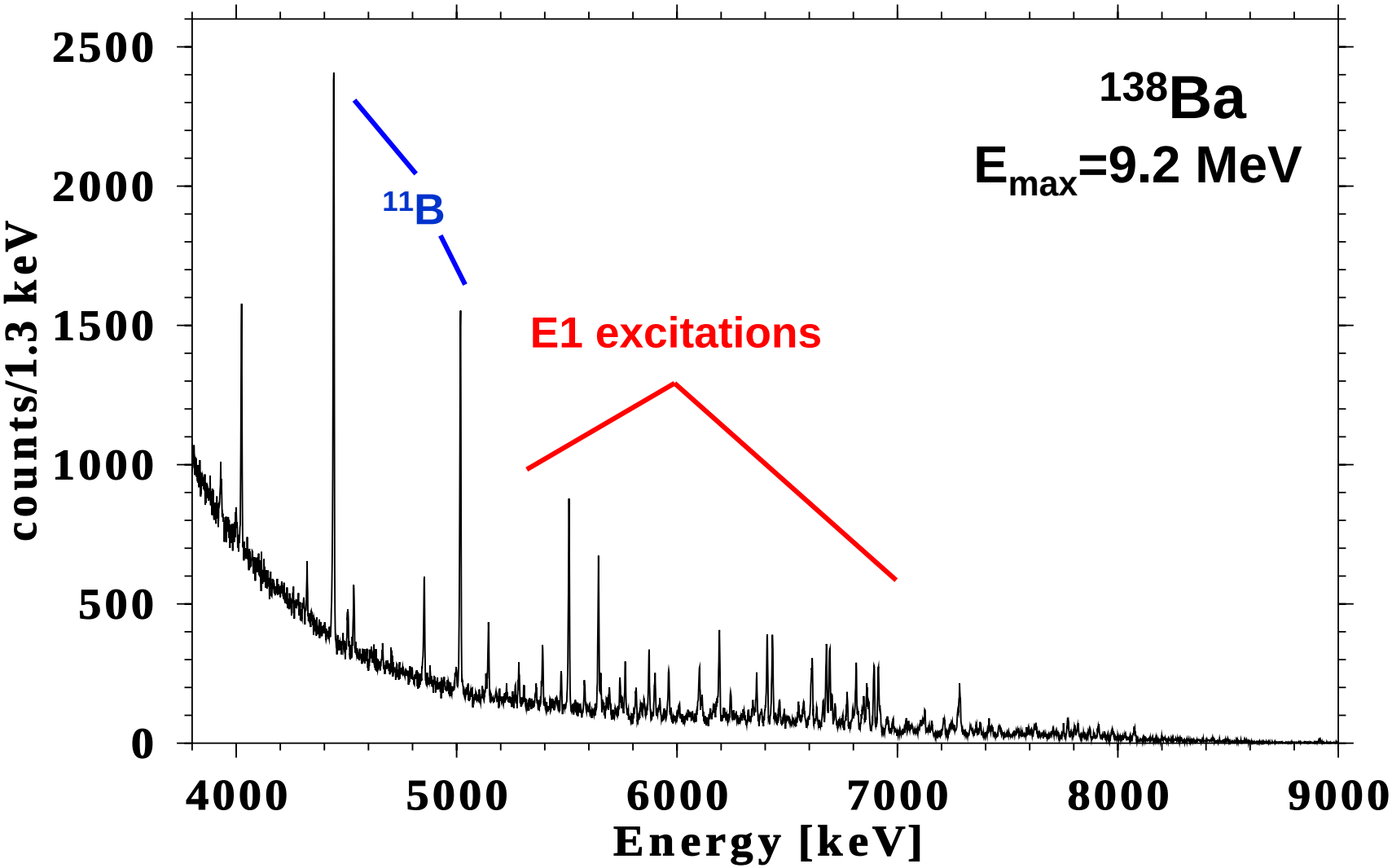
Real and virtual photons can be used for excitation!

Photoresponse below threshold of stable nuclei: Real Photon Scattering - NRF



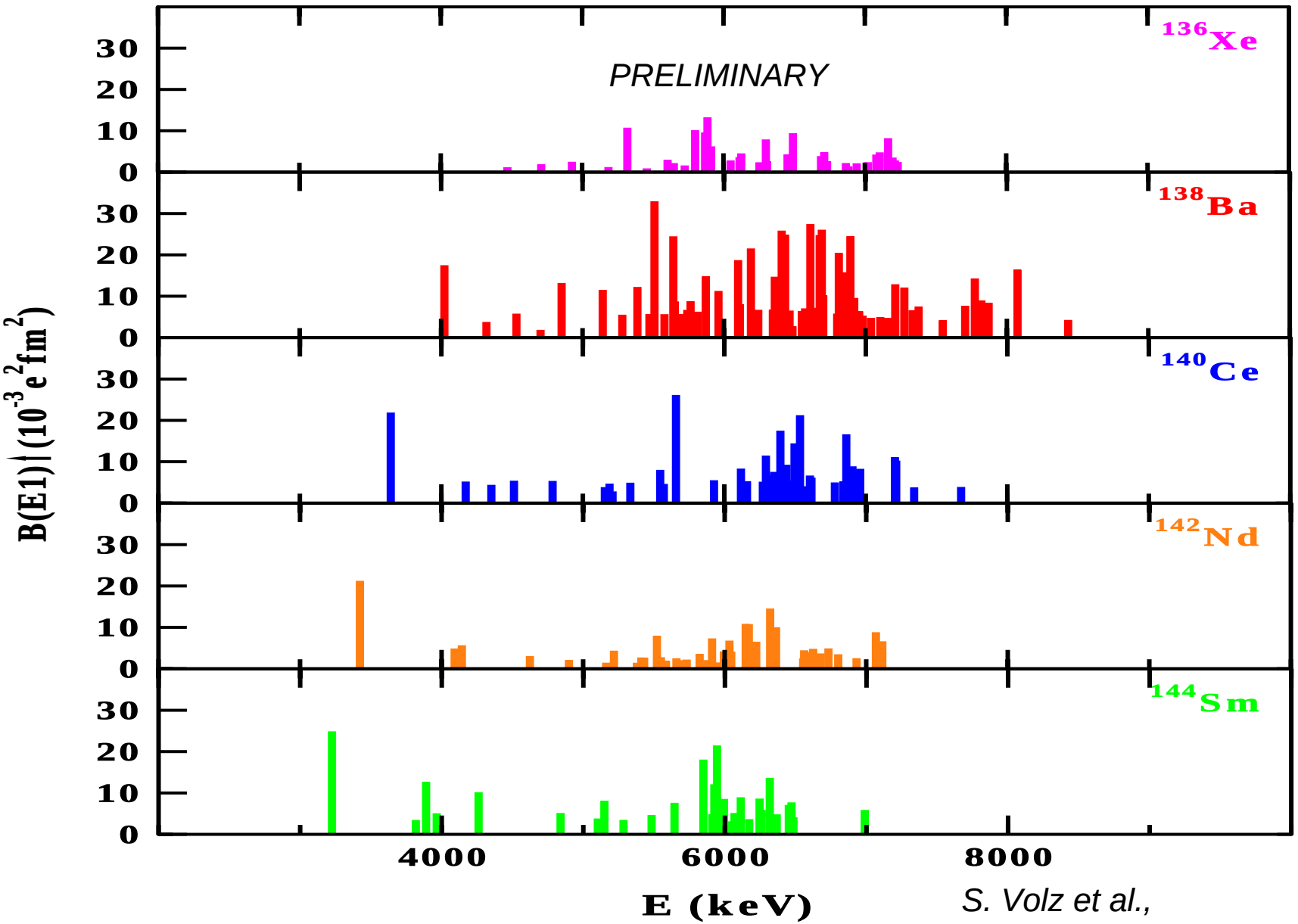
Review: U. Kneissl, H.H. Pitz, and A.Z., Prog. Part. Nucl. Phys. 37 (1996) 349

Photon scattering off ^{138}Ba



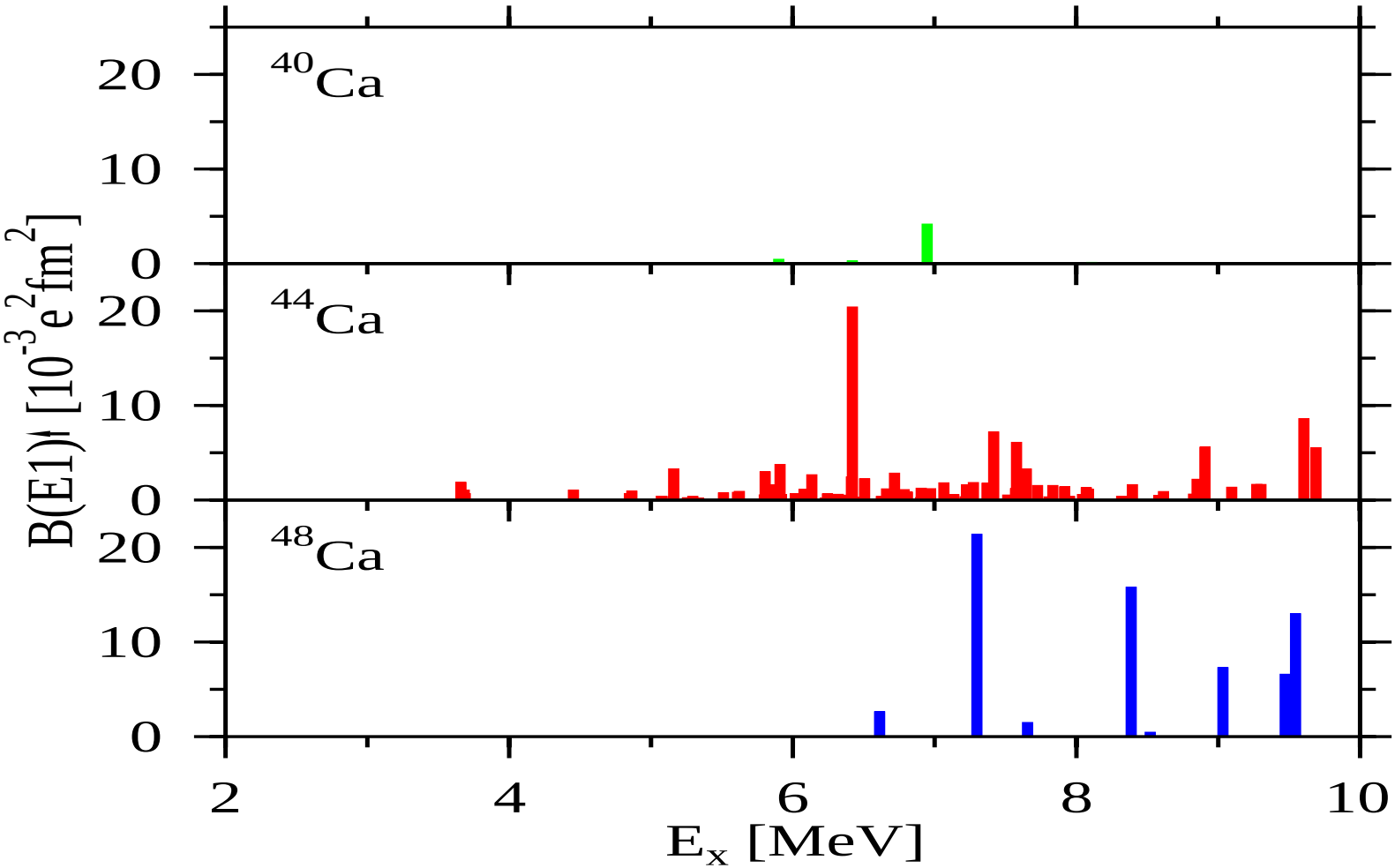
*A. Z. et al., Phys. Lett. B **542** (2002) 43*

E1 strength below threshold in N=82 nuclei



S. Volz et al.,
submitted to Nucl. Phys. A

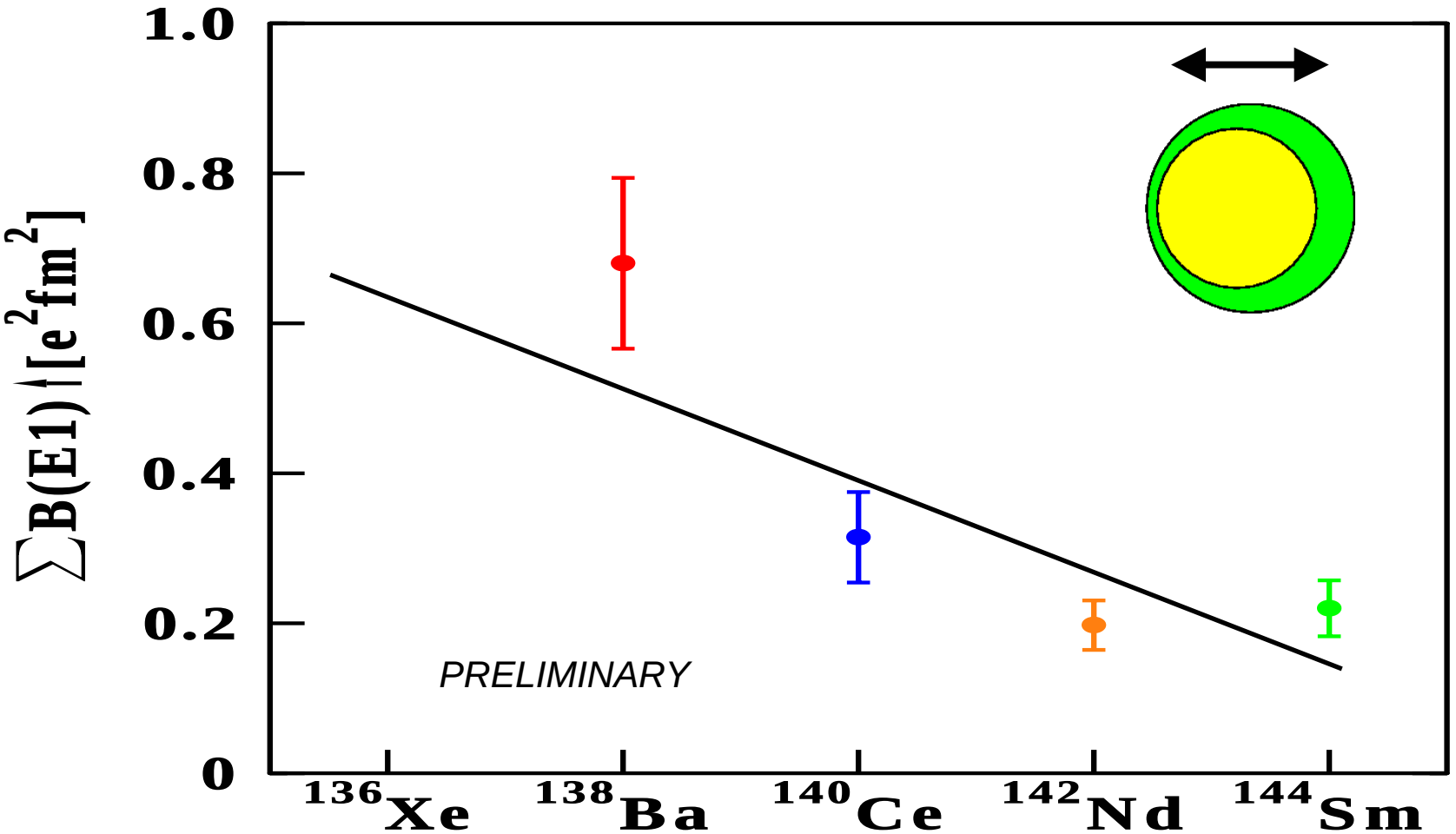
E1 strength distribution in Ca isotopes



*T. Hartmann et al., PRL **93** (2004) 192501,*
*PRC **65** (2002) 034301,*
*PRL **85** (2000) 274*

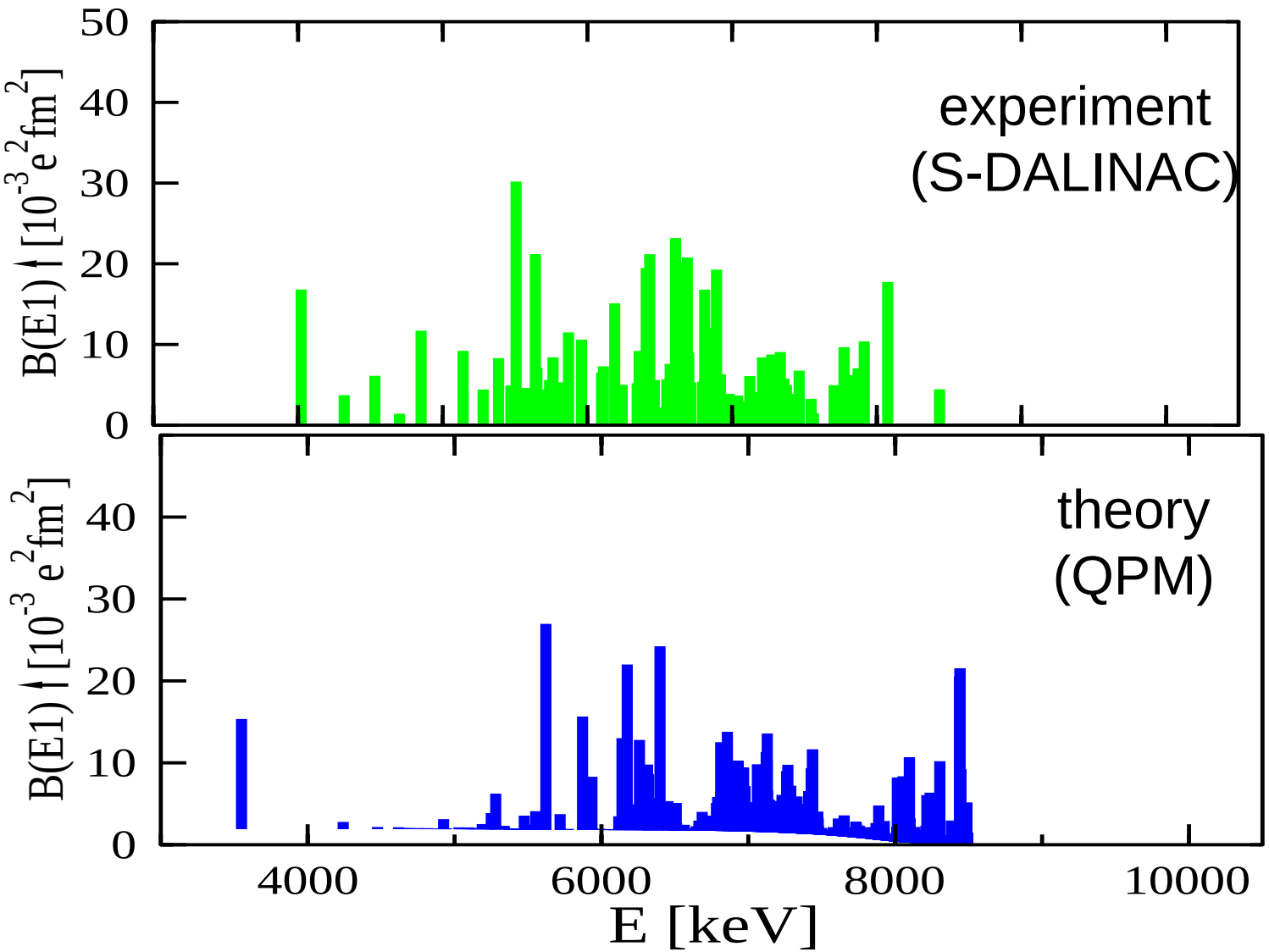
Sn nuclei: *K. Govaert et al.,*
*PRC **57** (1998) 2229*

E1 strength below 9 MeV in N=82 nuclei



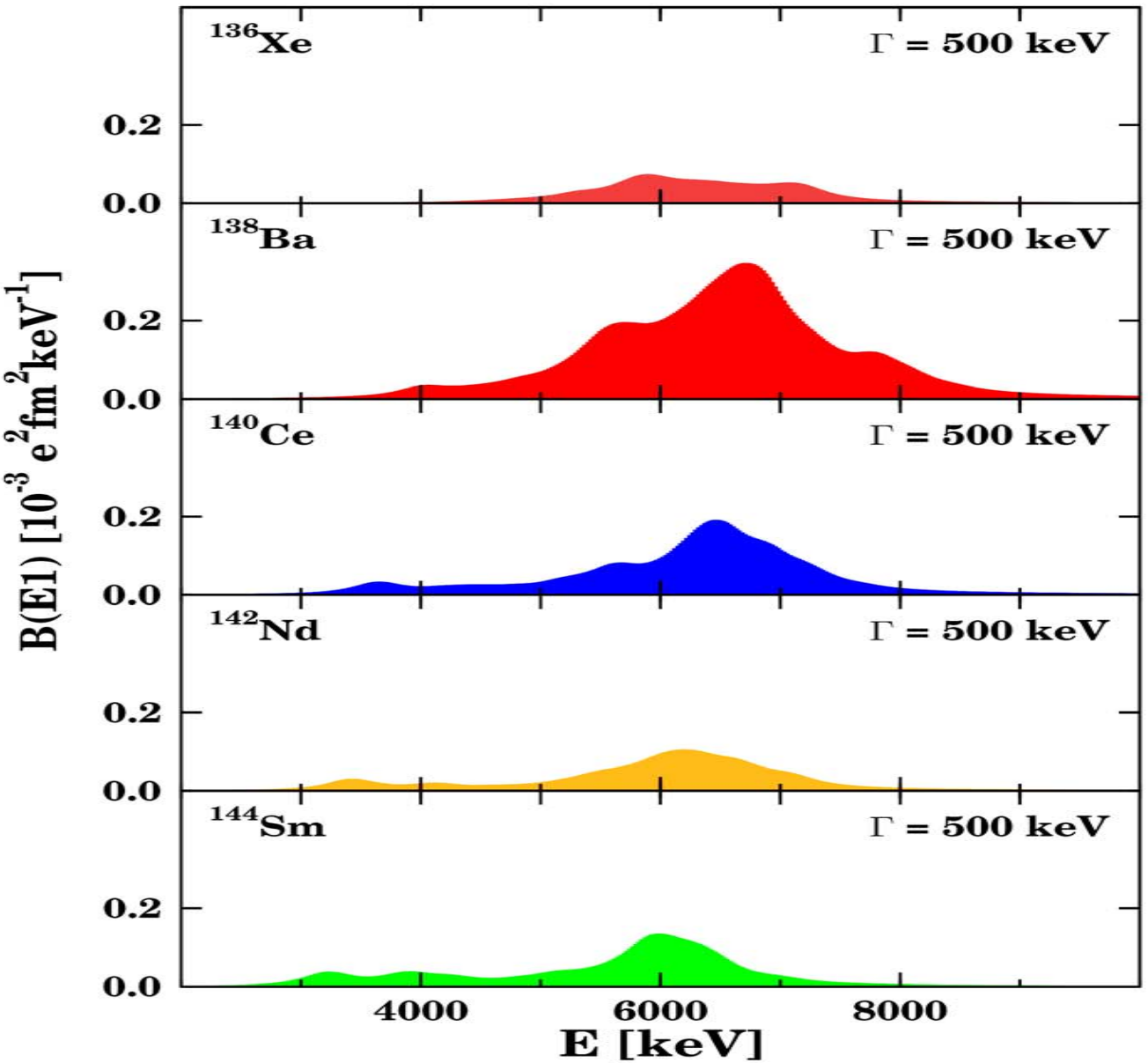
A.Z. et al., Prog. Part. Nucl. Phys. 55 (2005) 408
S. Volz et al., submitted to Nucl. Phys. A

QPM calculations for ^{138}Ba



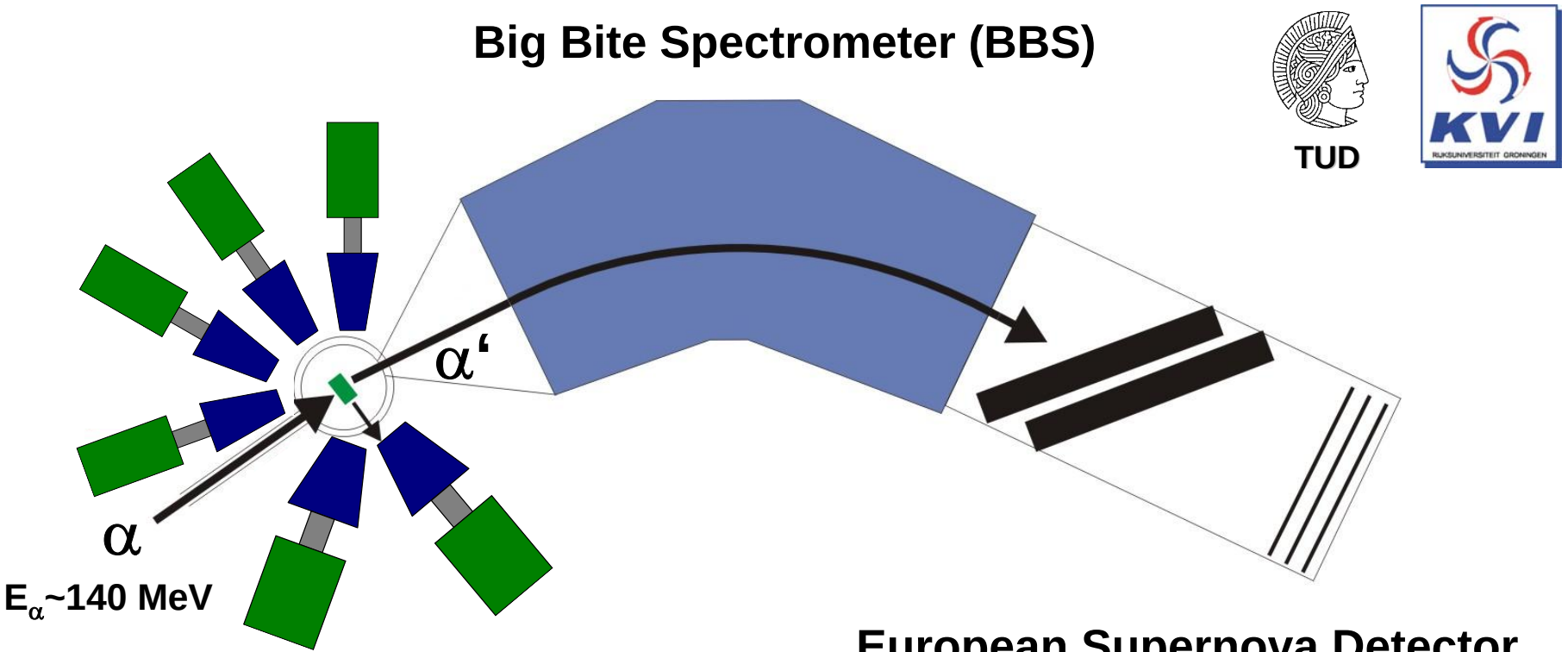
V. Ponomarev and J. Wambach

Substructure within the PDR ?



F. Iachello

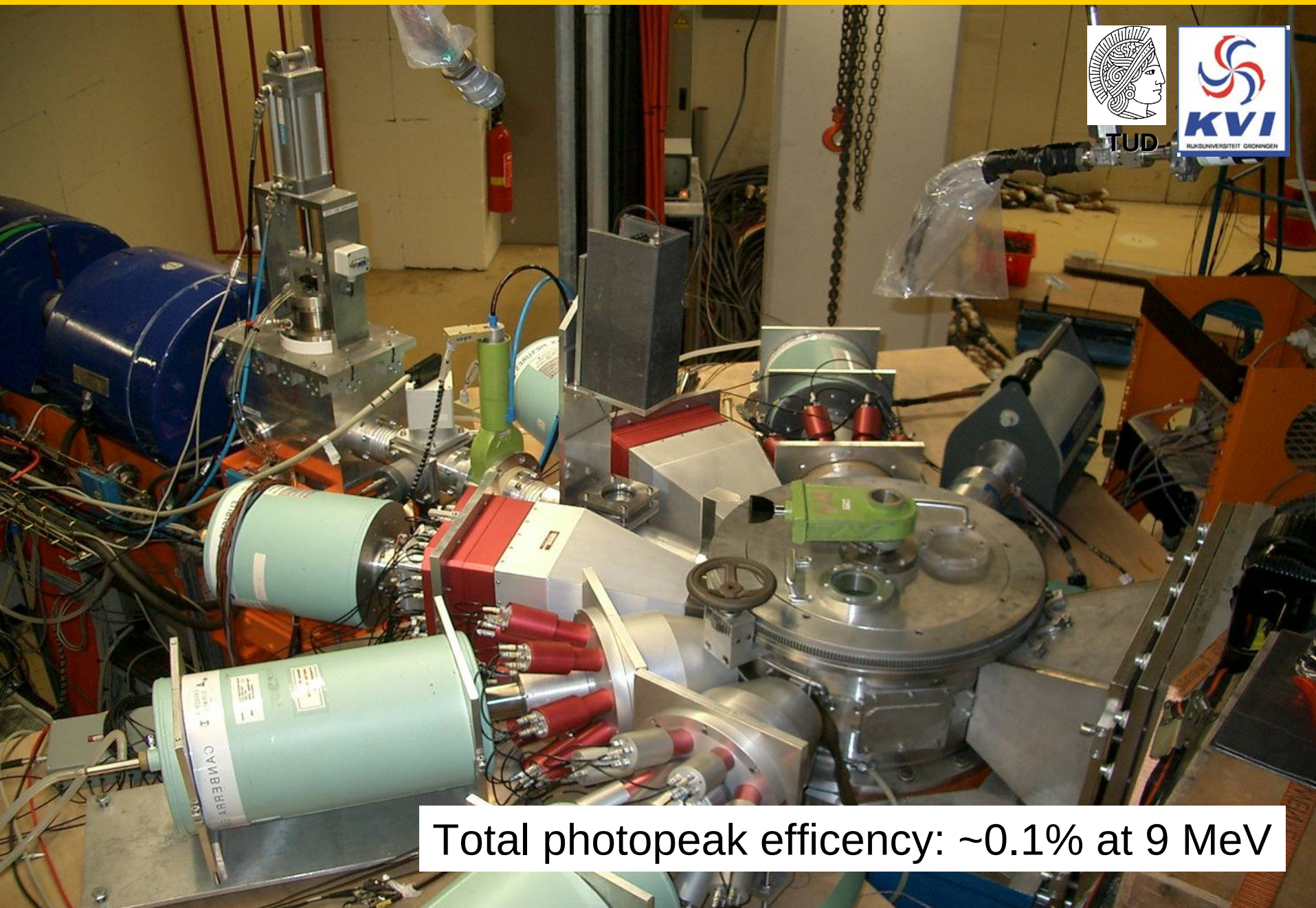
Investigating the PDR with α-particles



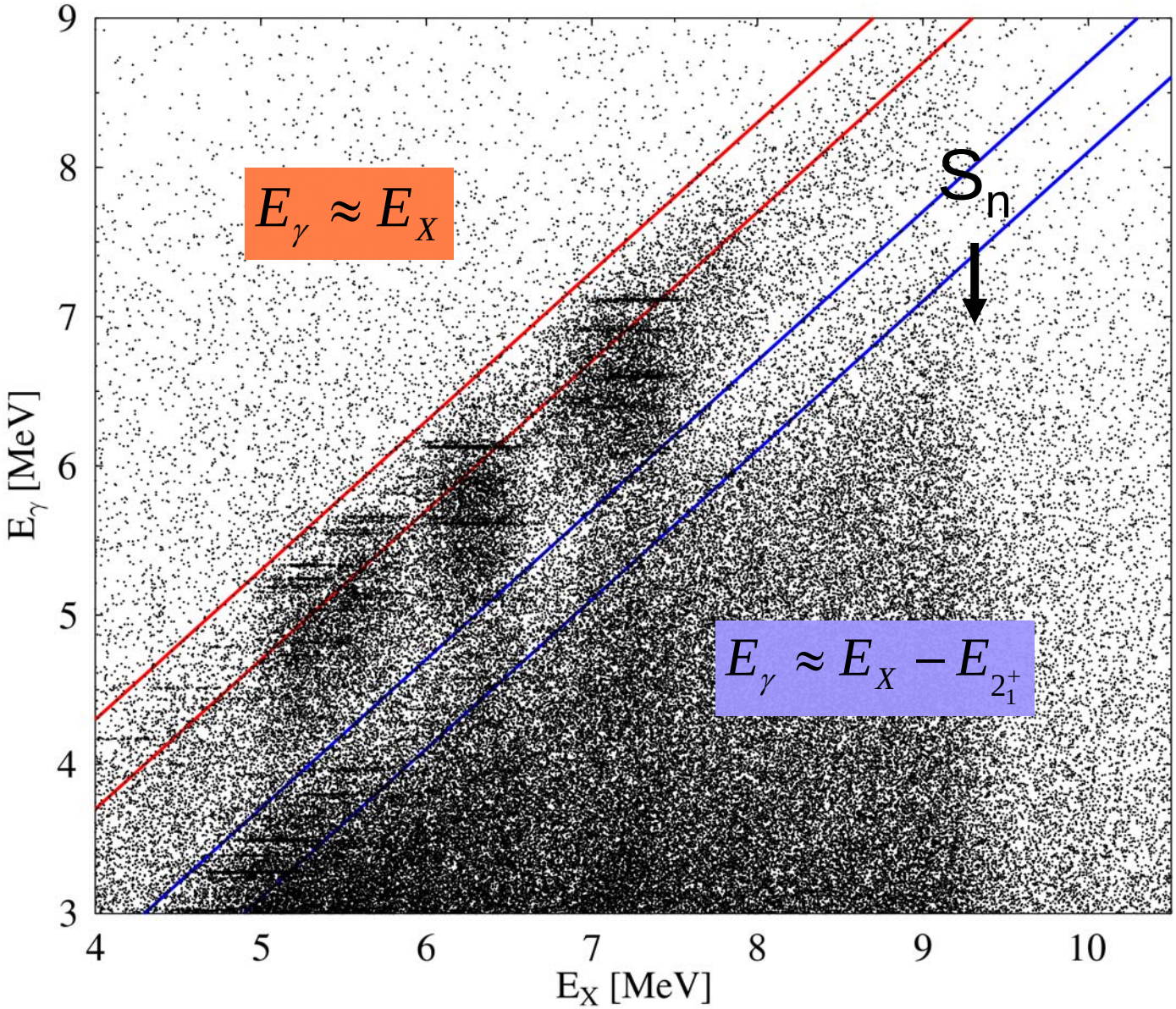
This setup combines isospin selectivity and skin sensitivity of α-particles with spin selectivity and energy resolution of γ-spectroscopy

D. Savran et al, submitted to NIM A

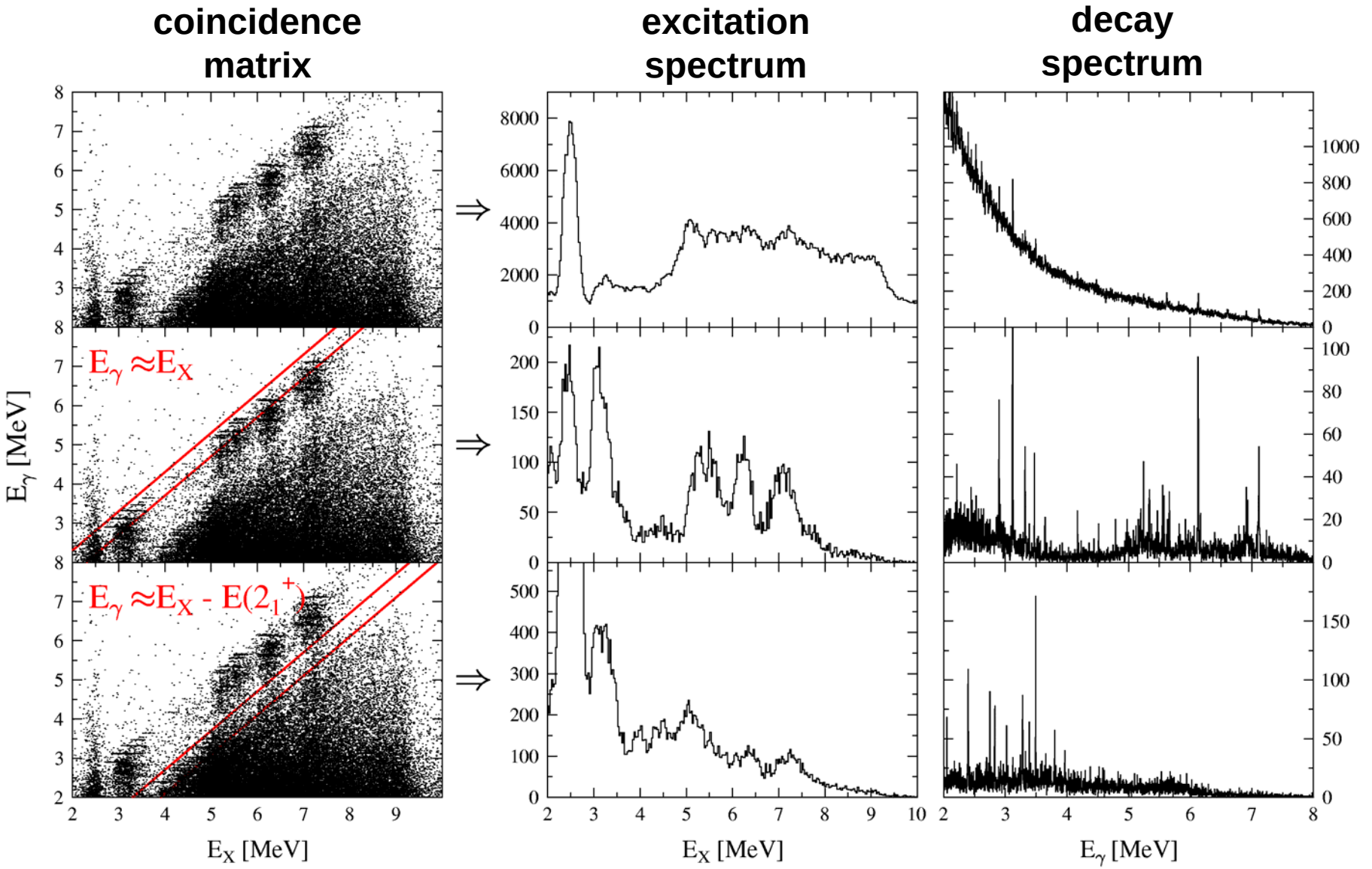
The new ISOSPIN setup at KVI



2D-energy matrix: (α,α'γ) on ^{140}Ce

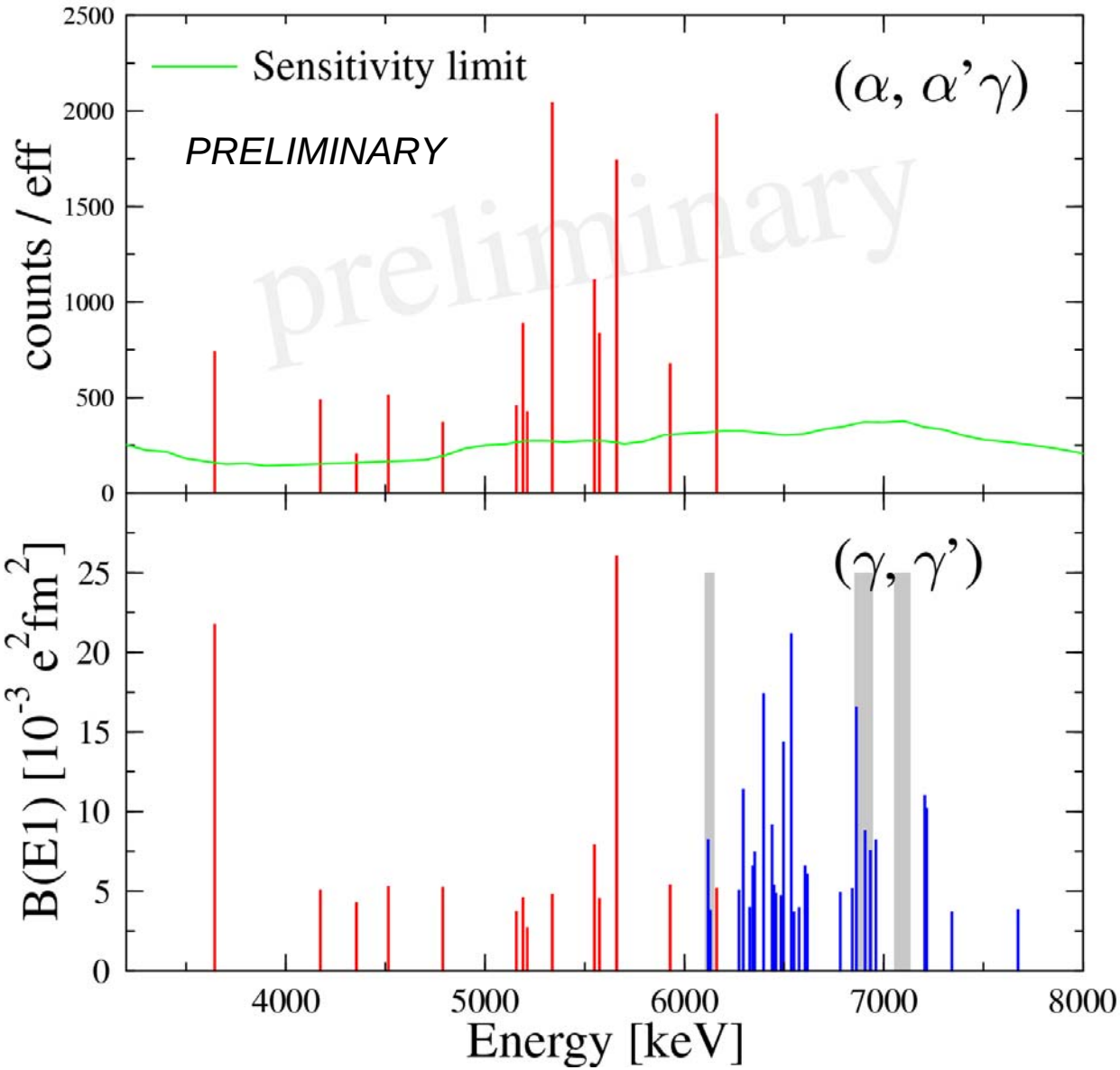


(α,α'γ) on ^{140}Ce - selectivity



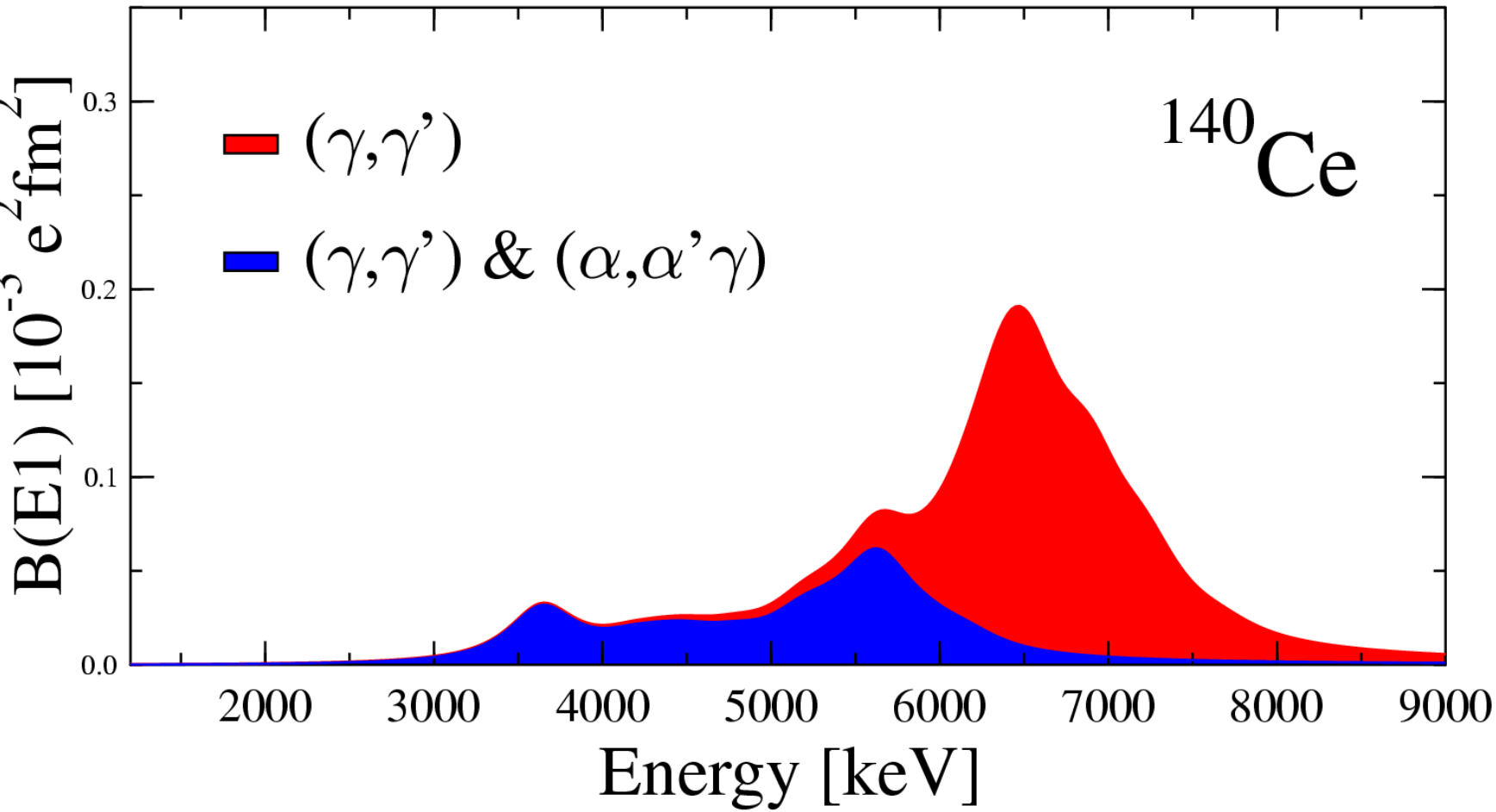
D. Savran et al, to be published

E1 strength in ^{140}Ce: $(\alpha,\alpha'\gamma)$ vs. (γ,γ')



Splitting of the GDR

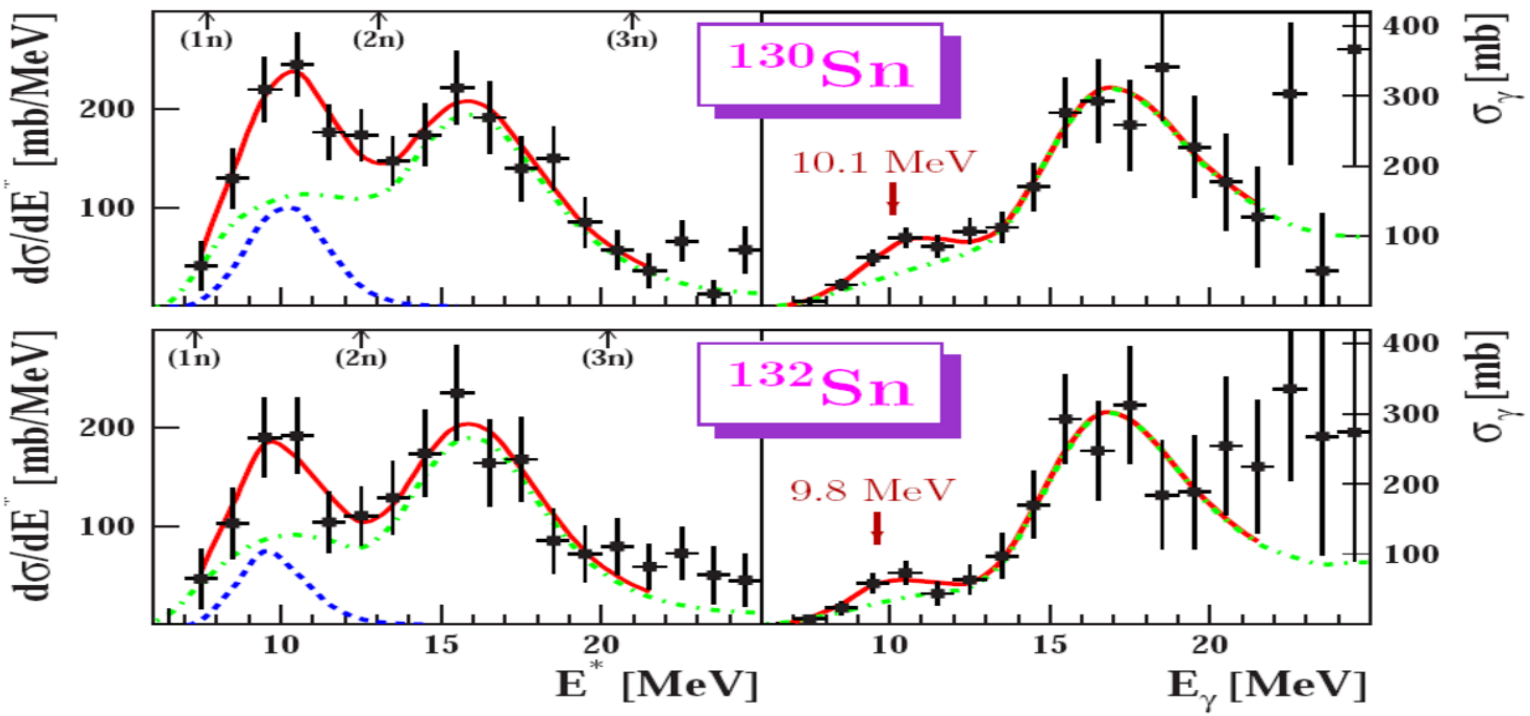
Strength distribution folded with Lorentzian, Γ = 300 keV



Summary

- An E1 resonance exhausting up to 1% of the EWSR is observed in all examined stable nuclei around about 7 MeV
- The strength seems to split up into two parts with different underlying isospin structure and/or different nuclear surface content
- More resonance like strength is found above the particle threshold in n-rich systems

E1 strength above threshold in exotic nuclei



Coulomb dissociation in inverse kinematics

P. Adrich et al., Phys. Rev. Lett. 95 (2005) 132501

(Results on ^{18,20}O: *E. Tryggestad et al., PRC 67 (2003) 064309)*

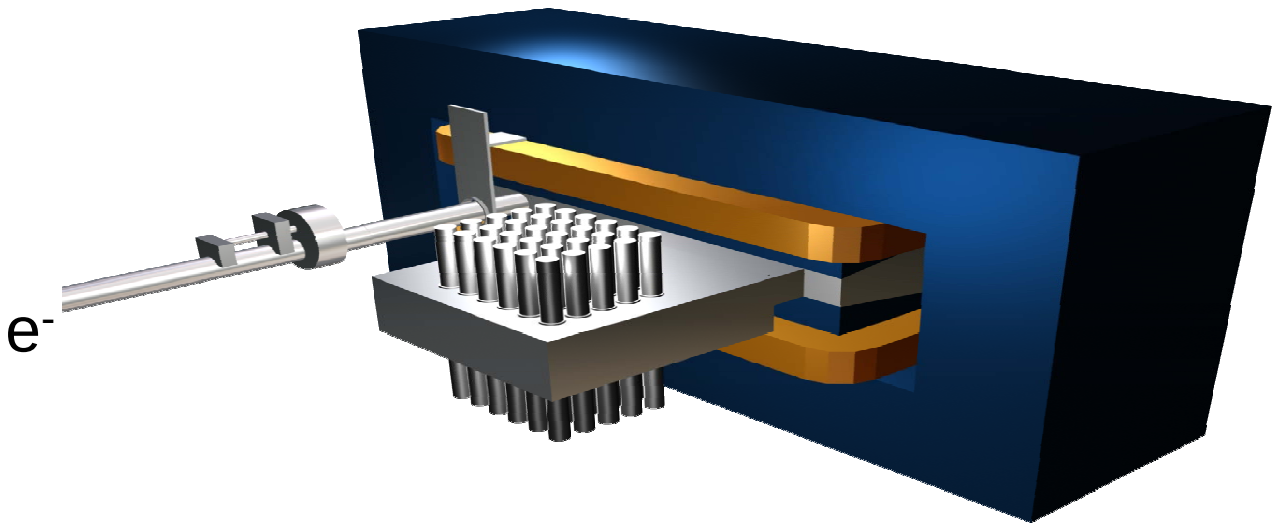
Summary

- An E1 resonance exhausting up to 1% of the EWSR is observed in all examined stable nuclei around about 7 MeV
- The strength seems to split up into two parts with different underlying isospin structure and/or different nuclear surface content
- More resonance like strength is found above the particle threshold in n-rich systems
- We do not understand the connection between the strength below and above the threshold and between the strength in stable and exotic nuclei

Connection to E1 strength above the threshold in stable nuclei

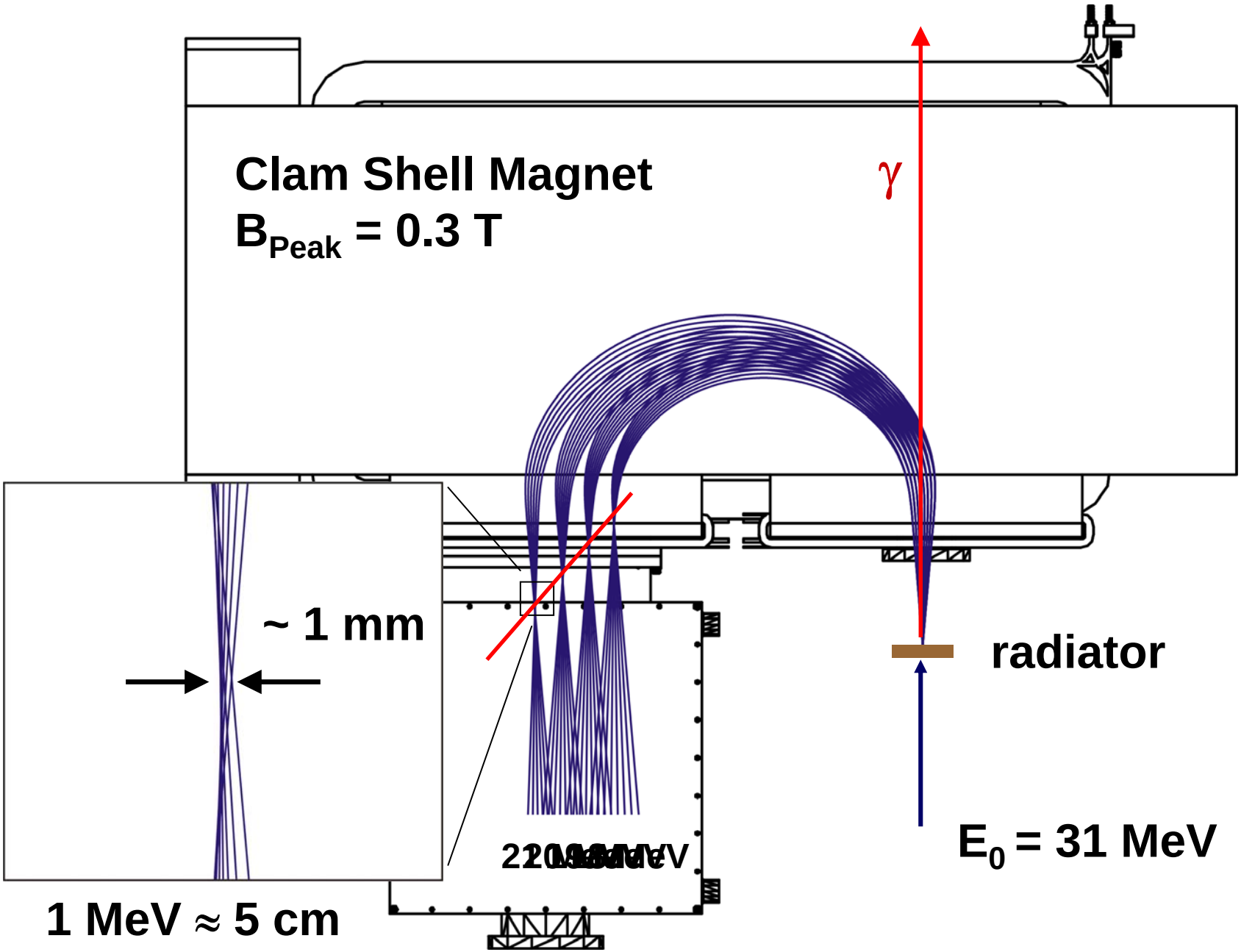
Low Energy Photon Tagger @ S-DALINAC

NiederEnergiePhotonenTagger



High resolution measurement ($\Delta E/E<0.25$ %) of photon induced reaction rates in the energy range 8 MeV < E_γ < 20 MeV

NEPTUN at S-DALINAC



NEPTUN at S-DALINAC

NEPTUN at S-DALINAC

NEPTUN will allow
high resolution measurements
above the particle threshold.

This is another clue for
a better understanding
of the photoresponse
of atomic nuclei.

The photoresponse of heavy nuclei – some implications on nucleosynthesis

M. Elvers, J. Endres, M. Fritzsche, J. Hasper, L. Kern, K. Lindenberg, S. Müller, D. Savran, C. Siegel, K. Sonnabend, S. Volz

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Supported by DFG *(SFB 634)*

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