Collective Excitations close to the Particle Threshold

- **The photoresponse of atomic nuclei**
- **Experimental results**
- **Sources of electric dipole strength**
- **Outlook**

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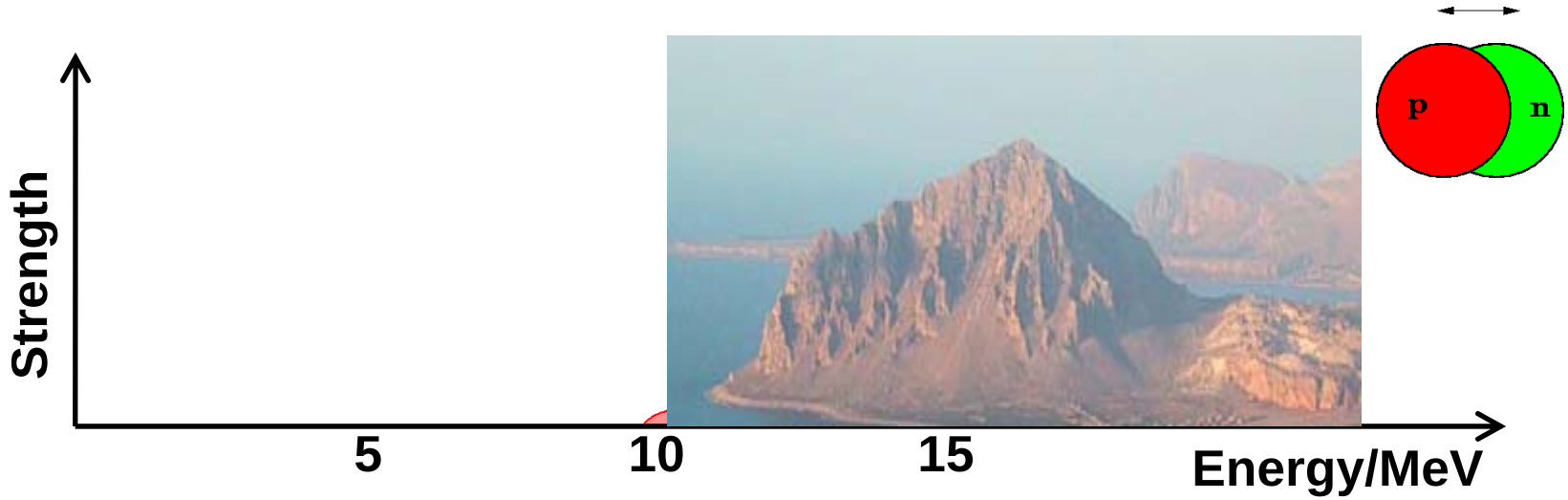
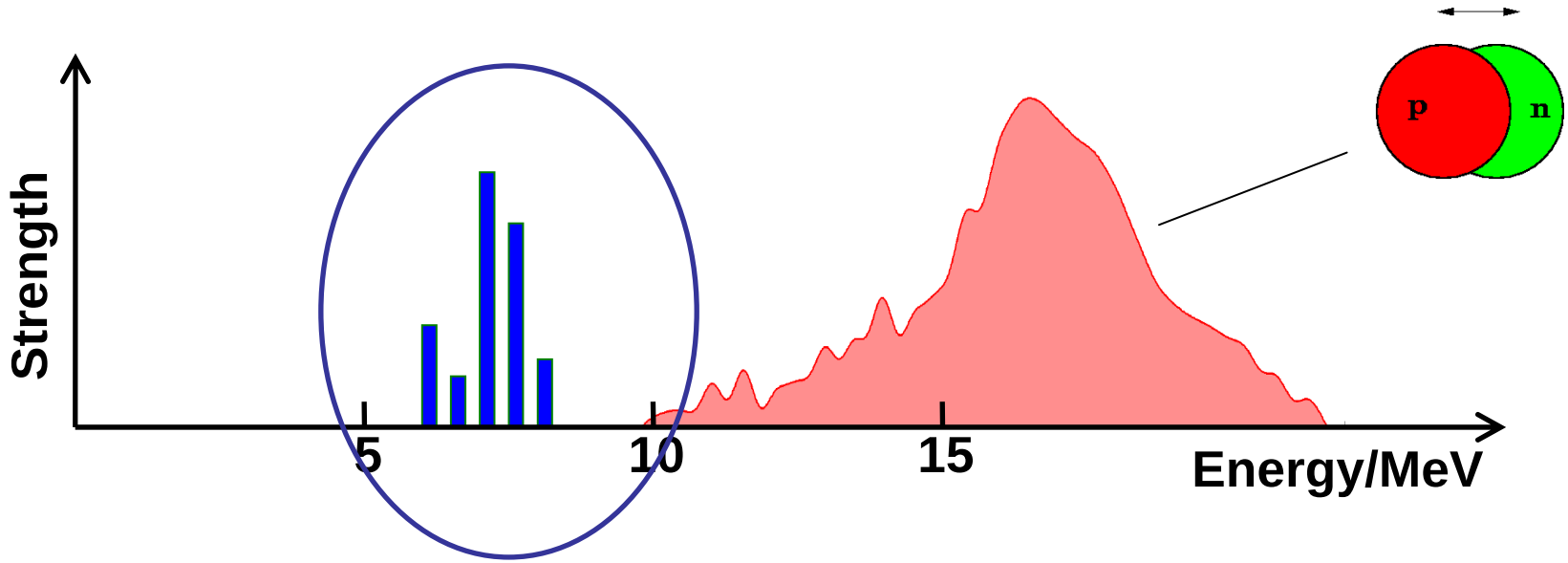
The photoresponse of atomic nuclei



Considerable E1 strength is predicted around the $1\hbar\omega$ region

The photoresponse of atomic nuclei



Considerable E1 strength is predicted around the $1\hbar\omega$ region

E1 Excitations around the Particle Threshold

- **1.) Nuclear structure phenomenon**

  Fundamental E1 mode below the GDR

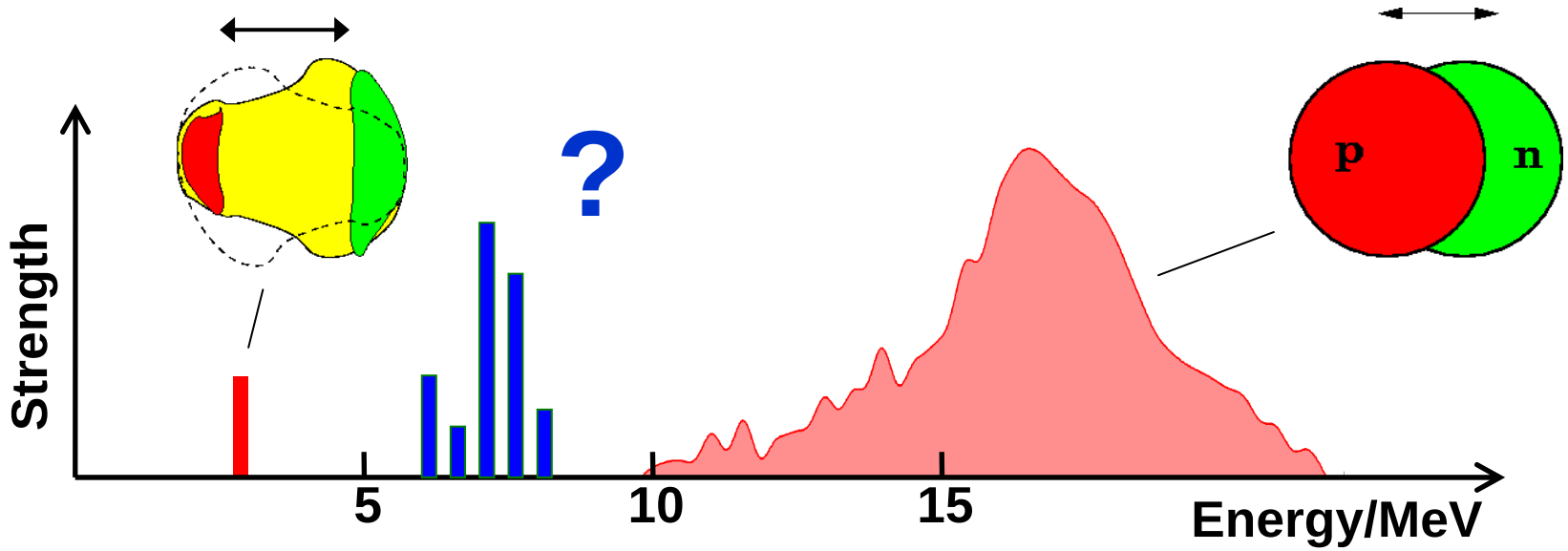
- **2.) Importance for understanding of exotic nuclei**

  E1 strength will be shifted to lower energies in neutron rich systems

- **3.) Impact on nucleosynthesis**

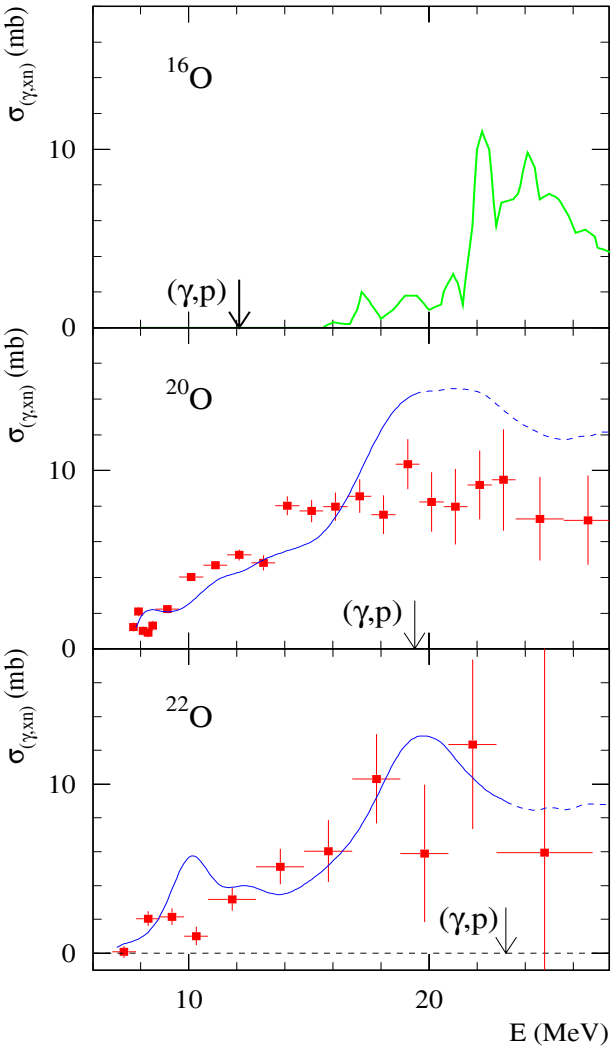
  Gamow window for photo-induced reactions in explosive stellar events

1.) Electric Dipole Strength in Nuclei

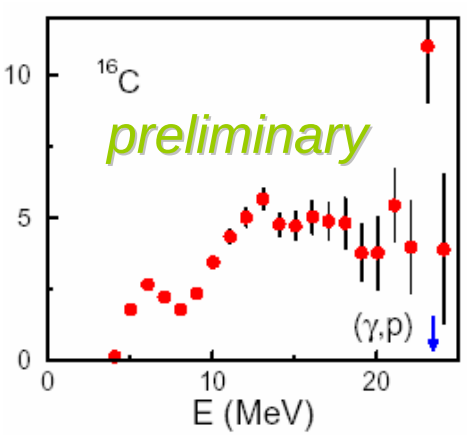


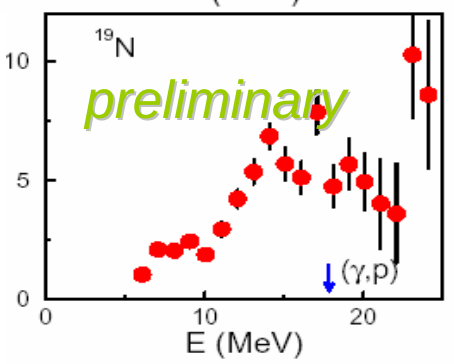
- **Two Phonon Excitation: E_x ~ 3 MeV, B(E1) ~ 10^{-3} W.u.**
- **Giant Dipole Resonance: E_x ~ 18 MeV, B(E1) ~ W.u.**
- **Pygmy Dipole Resonance ?**

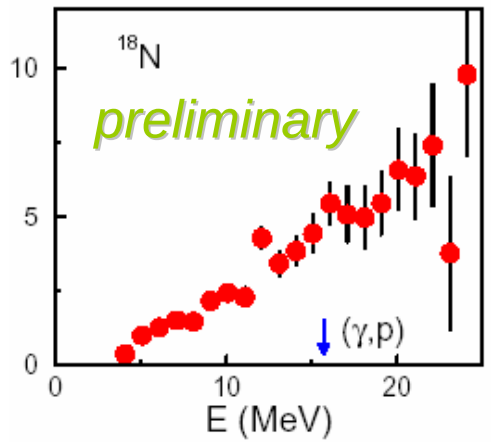
2.) E1 strength in exotic nuclei



T. Aumann et al., GSI



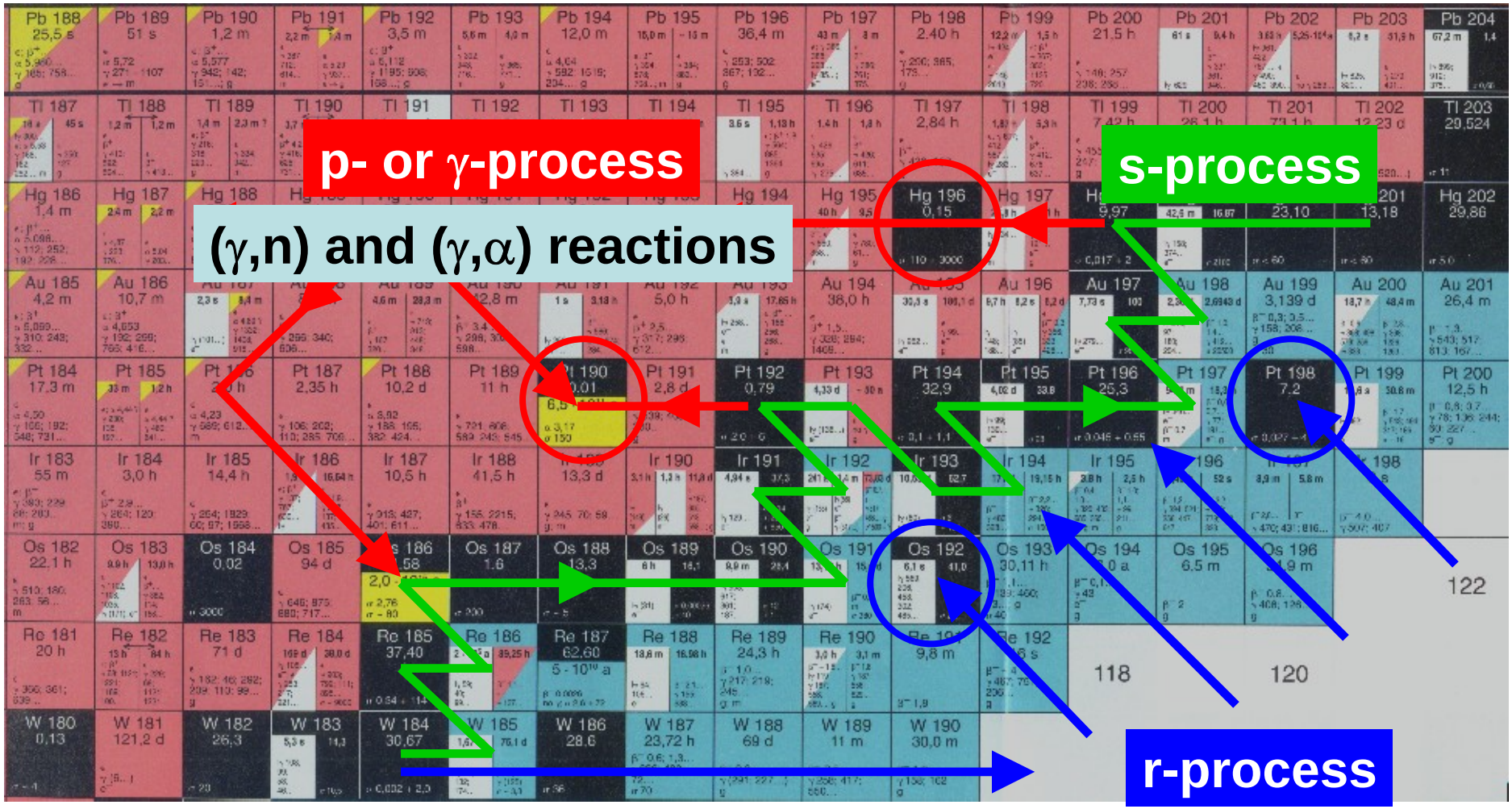




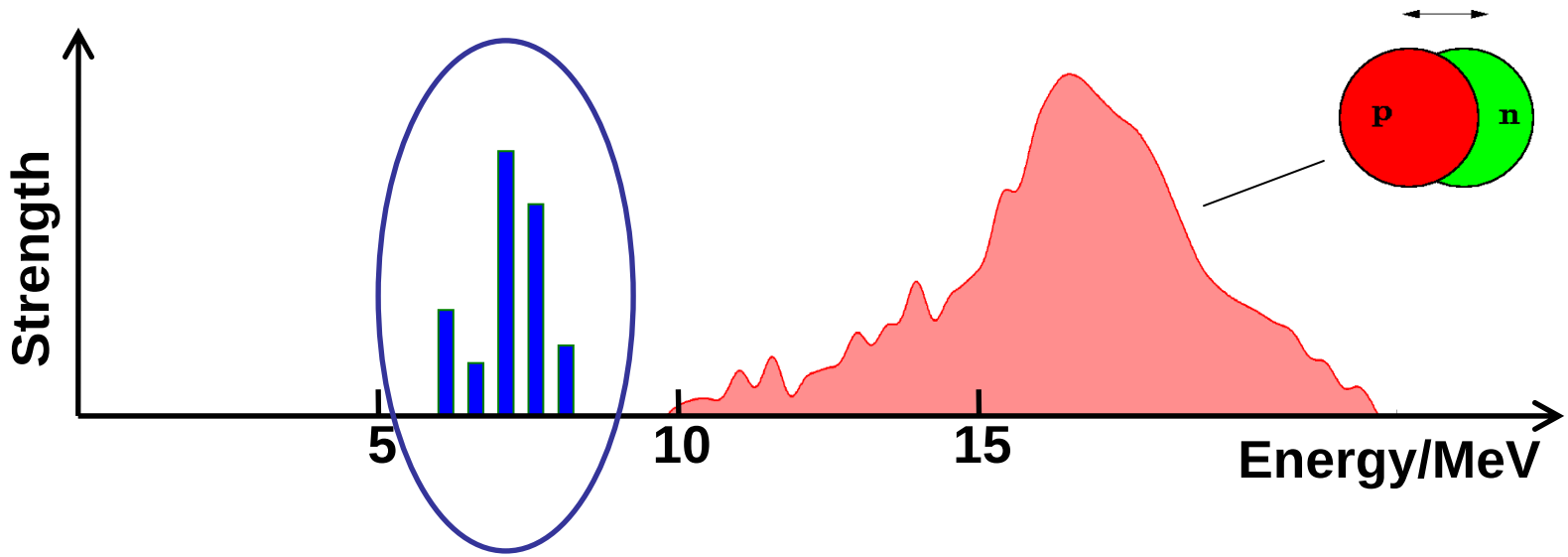
R. Palit, T. Aumann et al., Nucl. Phys. A 738(2004)45

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

3.) Impact on Nucleosynthesis



E1 Excitations around the Particle Threshold

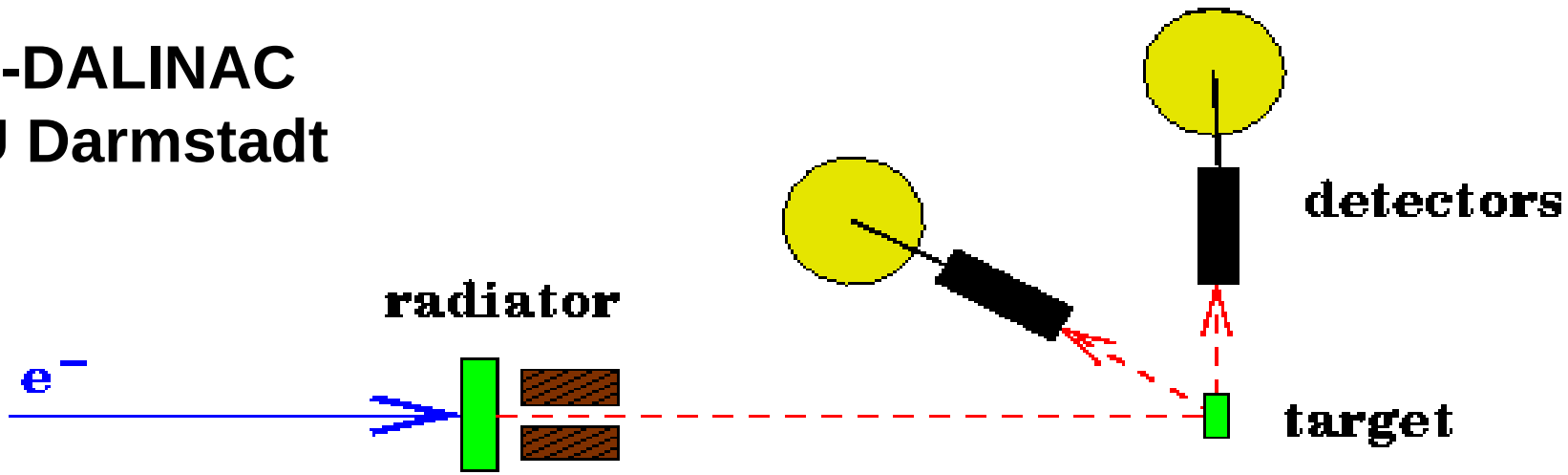


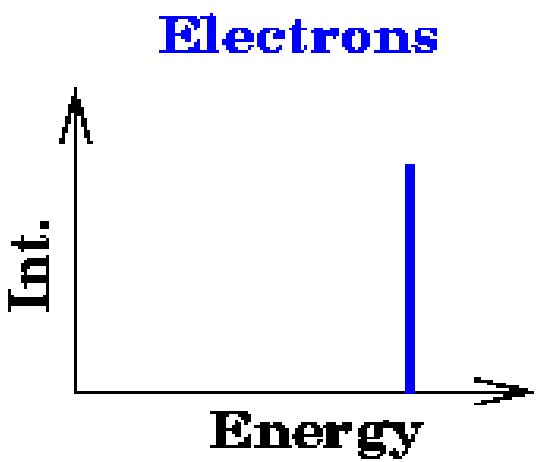
Experimental tool:

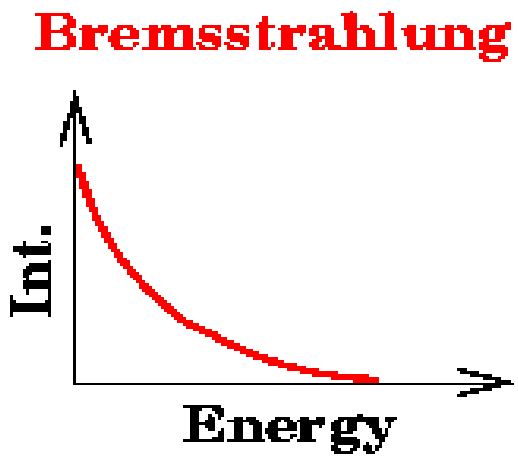
Photon Scattering
(Nuclear Resonance Fluorescence)

Photon Scattering
(Nuclear Resonance Fluorescence – NRF)

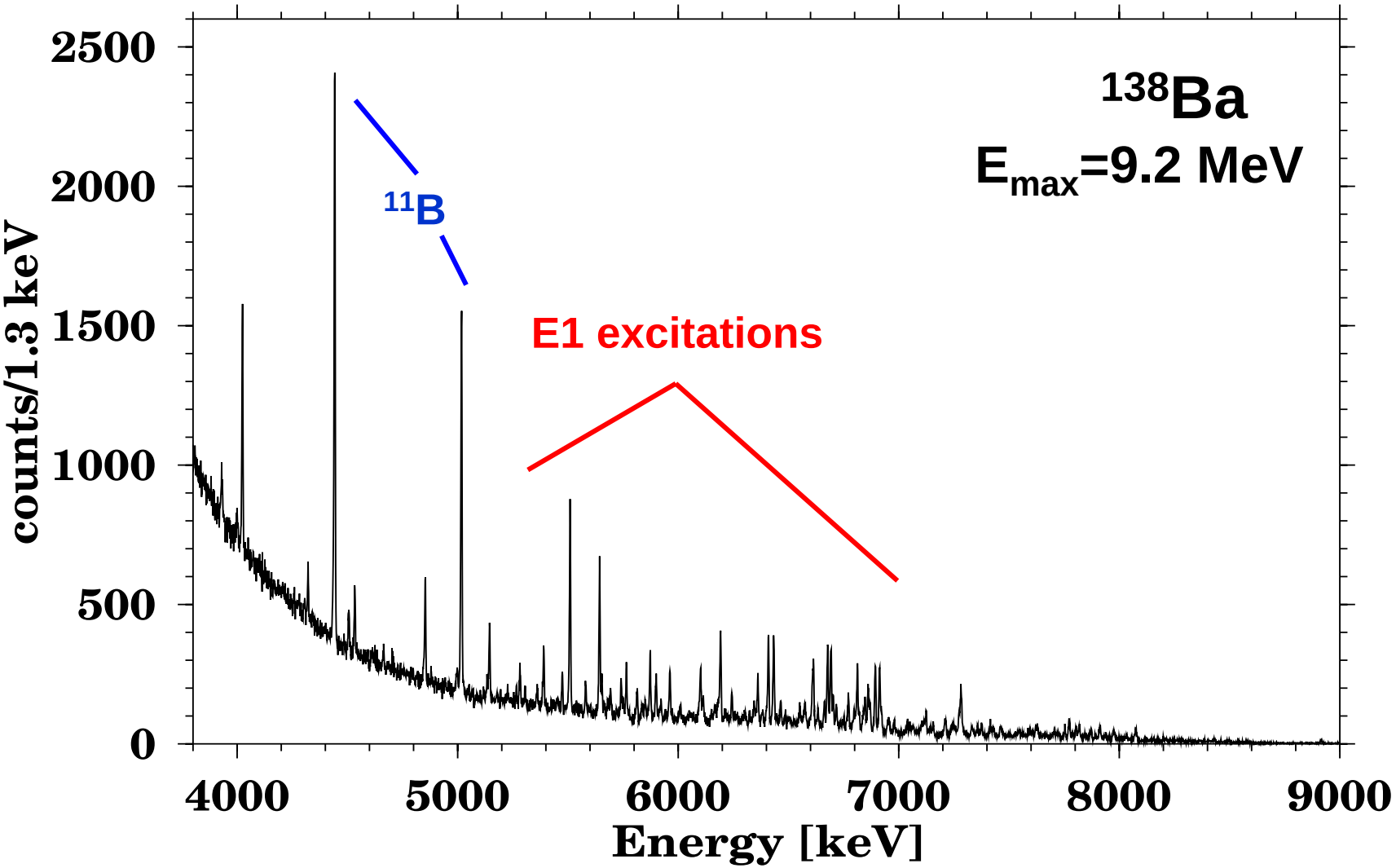
S-DALINAC
TU Darmstadt





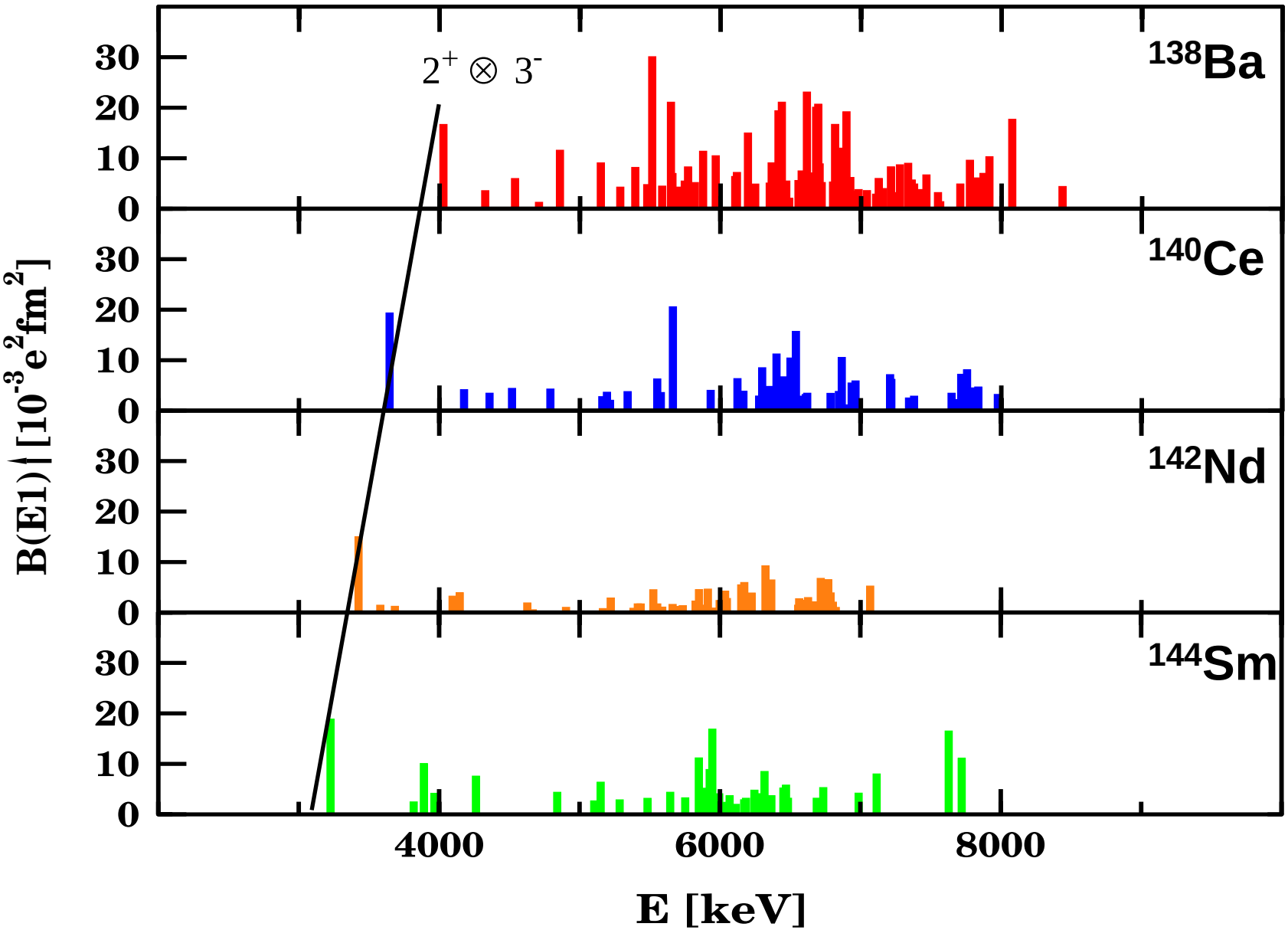


Photon scattering off ^{138}Ba

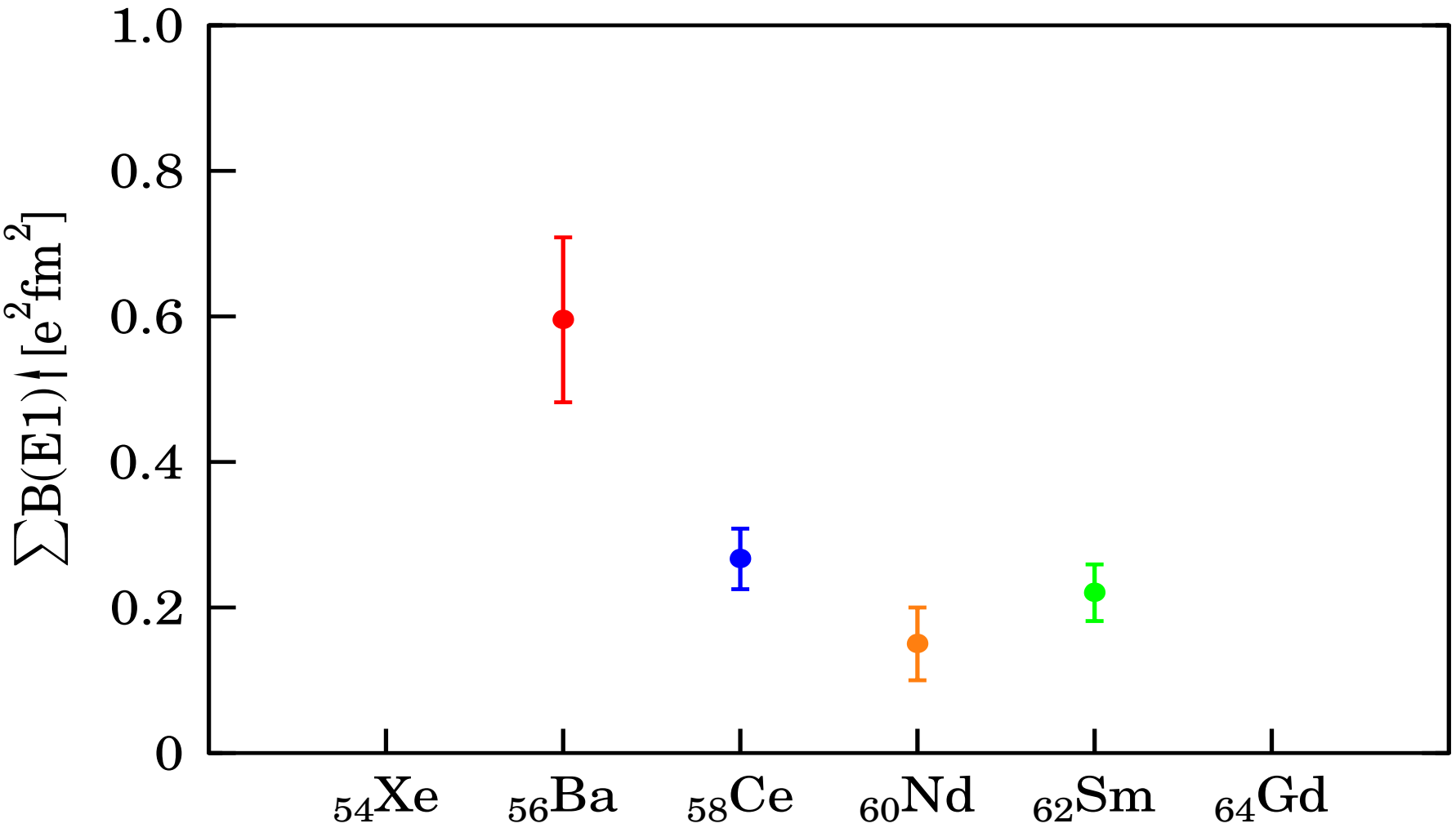


*A. Z. et al., Phys. Lett. B **542** (2002) 43*

E1 strength distribution in N=82 nuclei

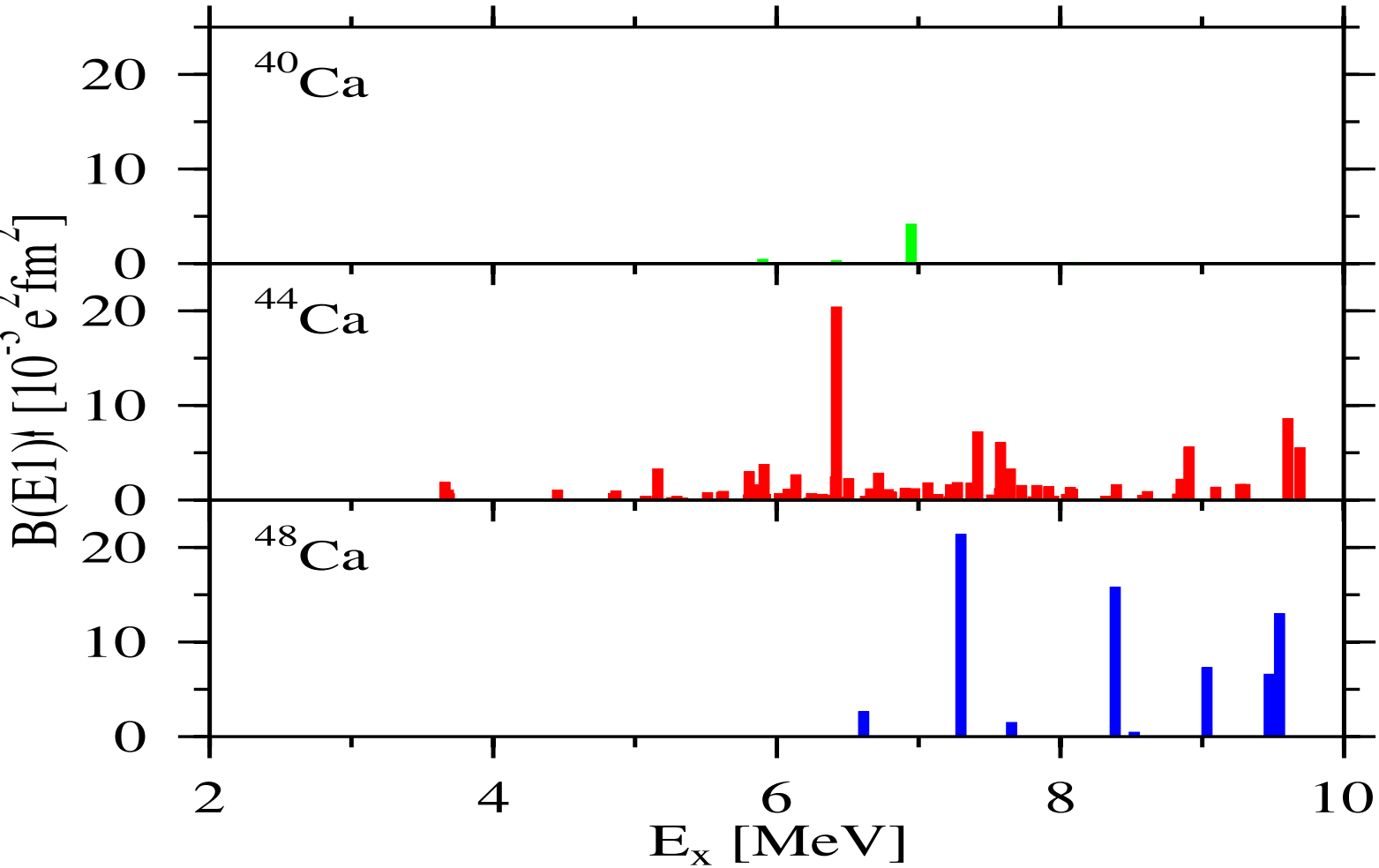


Summed E1 strength in N=82 nuclei



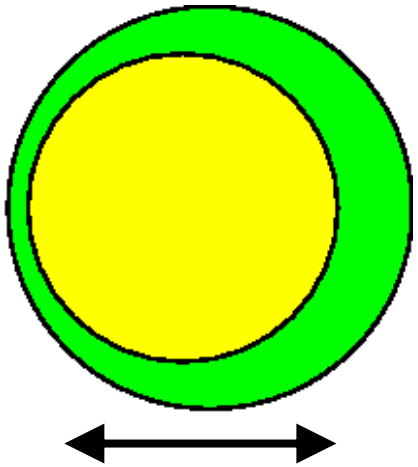
*A. Z. et al., Phys. Lett. B **542** (2002) 43, and*
S. Volz et al., to be published

E1 strength distribution in Ca isotopes



T. Hartmann et al., PRL, in press
*T. Hartmann et al., PRC **65** (2002) 034301*
*T. Hartmann et al., PRL **85** (2000) 274*

Neutron/proton „skin“ excitations

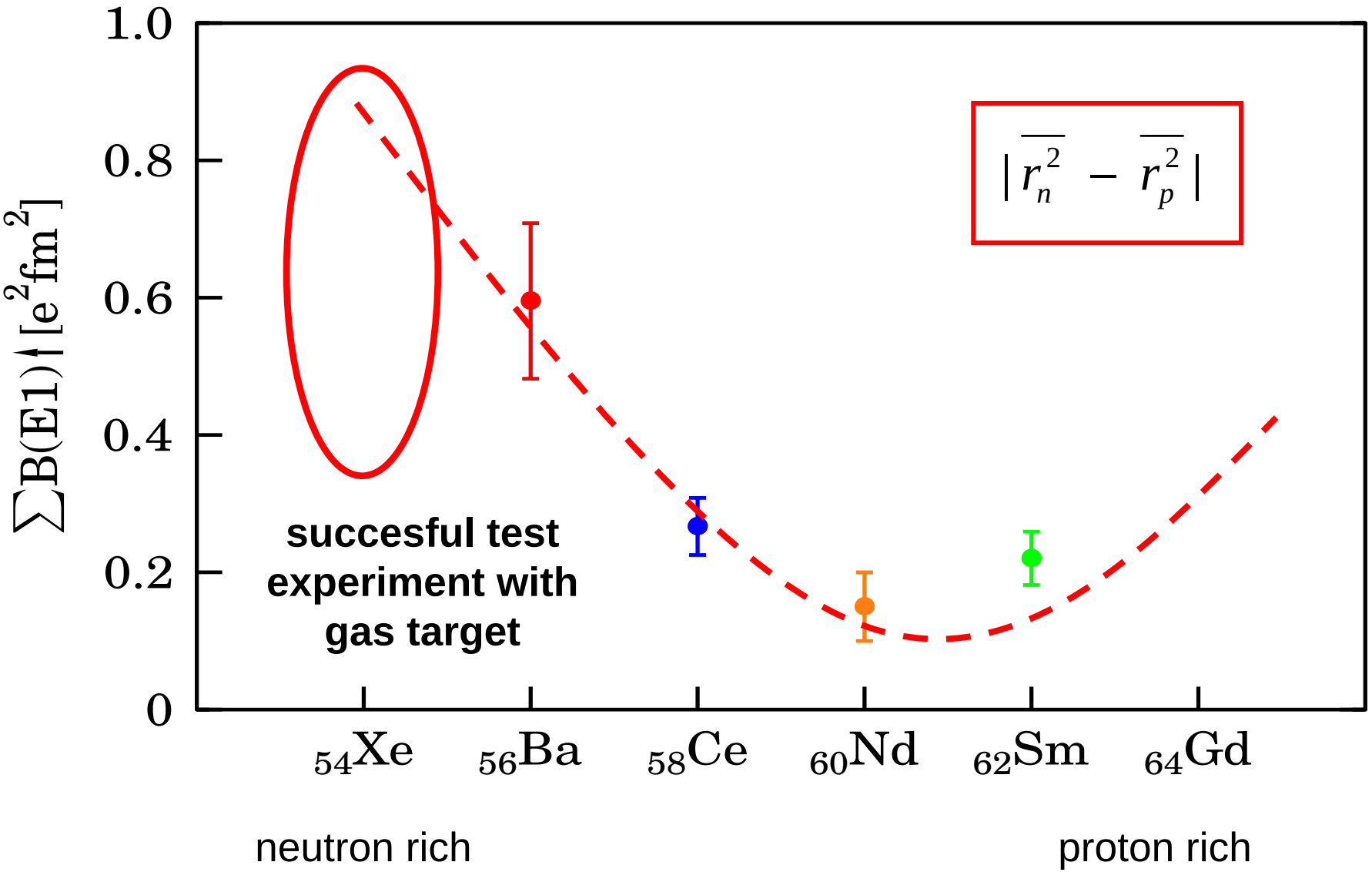


Oscillations of a neutron or proton rich periphery vs. the core leads to isovector E1 excitations

- Soft Dipole Mode in exotic nuclei
- Up to 1% of EWSR in some stable nuclei
- Located around 8 MeV in stable nuclei

*see e.g.: J. Chambers et al., Phys. Rev. C **50** (1994) R2671*
*P. van Isacker et al., Phys. Rev. C **45** (1992) R13*

Summed E1 strength in N=82 nuclei



Models generating E1 strength around the neutron threshold

- Relativistic RPA

  *D. Vretenar et al., Phys. Lett. B **487** (2000) 334*
  *D. Vretenar, N. Paar et al., Phys. Rev. C **65** (2002) 021301*

- Quasiparticle Phonon Model (QPM), QRPA

  *V. Ponomarev, J. Wambach et al., Phys. Rev. Lett. **89** (2002) 241*
  N. Tsoneva, H. Lenske et al., to be published

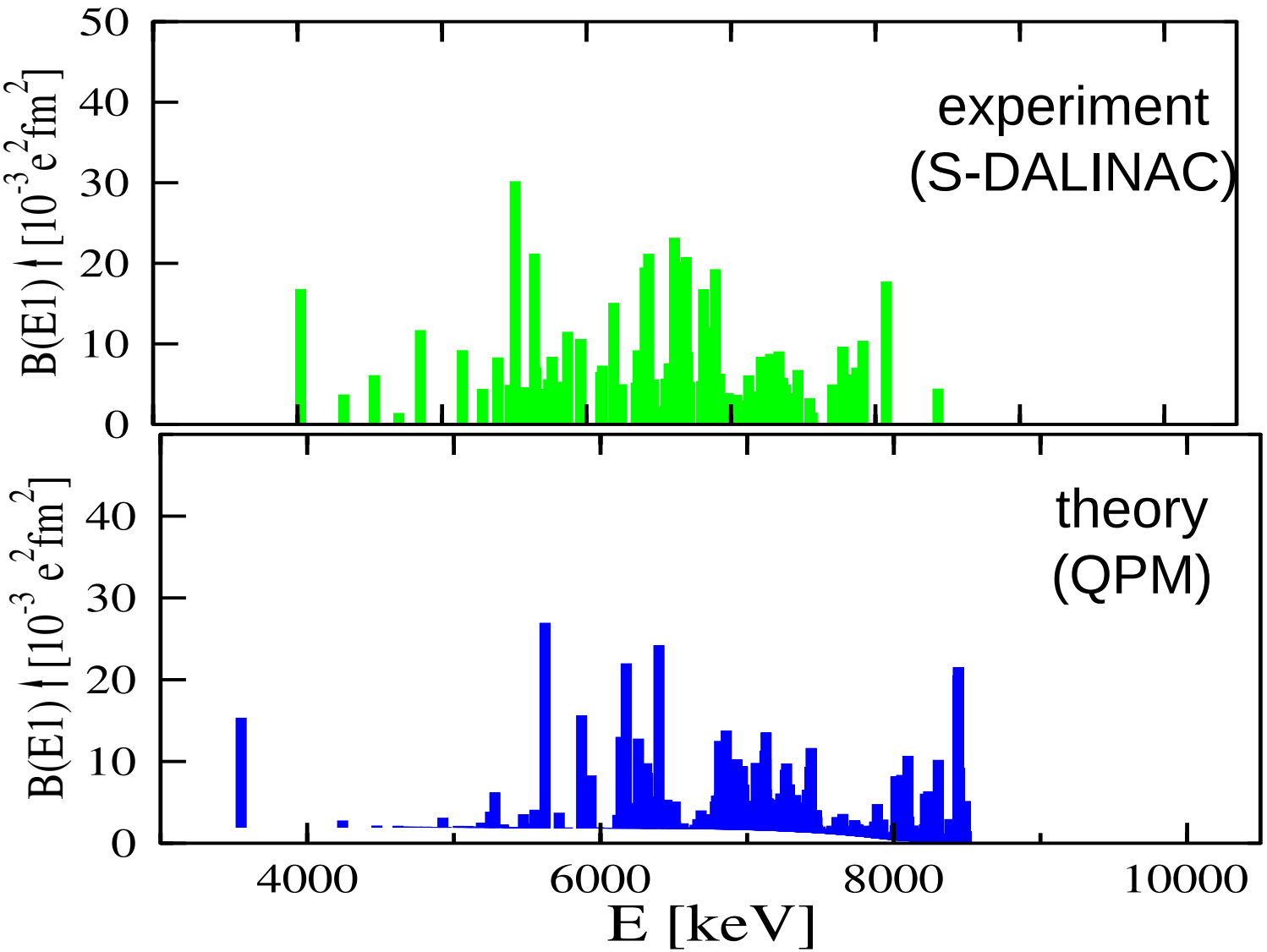
- QRPA with complex configurations, ETFFS

  *G. Colò, P.F. Bortignon et al., Phys. Lett. B **485** (2000) 362*
  T. Hartmann, E. Litvinova et al., Phys. Rev. Lett., in press

- Local Isospin Resonances

  *F. Iachello, Phys. Lett. B **160** (1985) 1*
  F. Iachello, priv. com. 2004

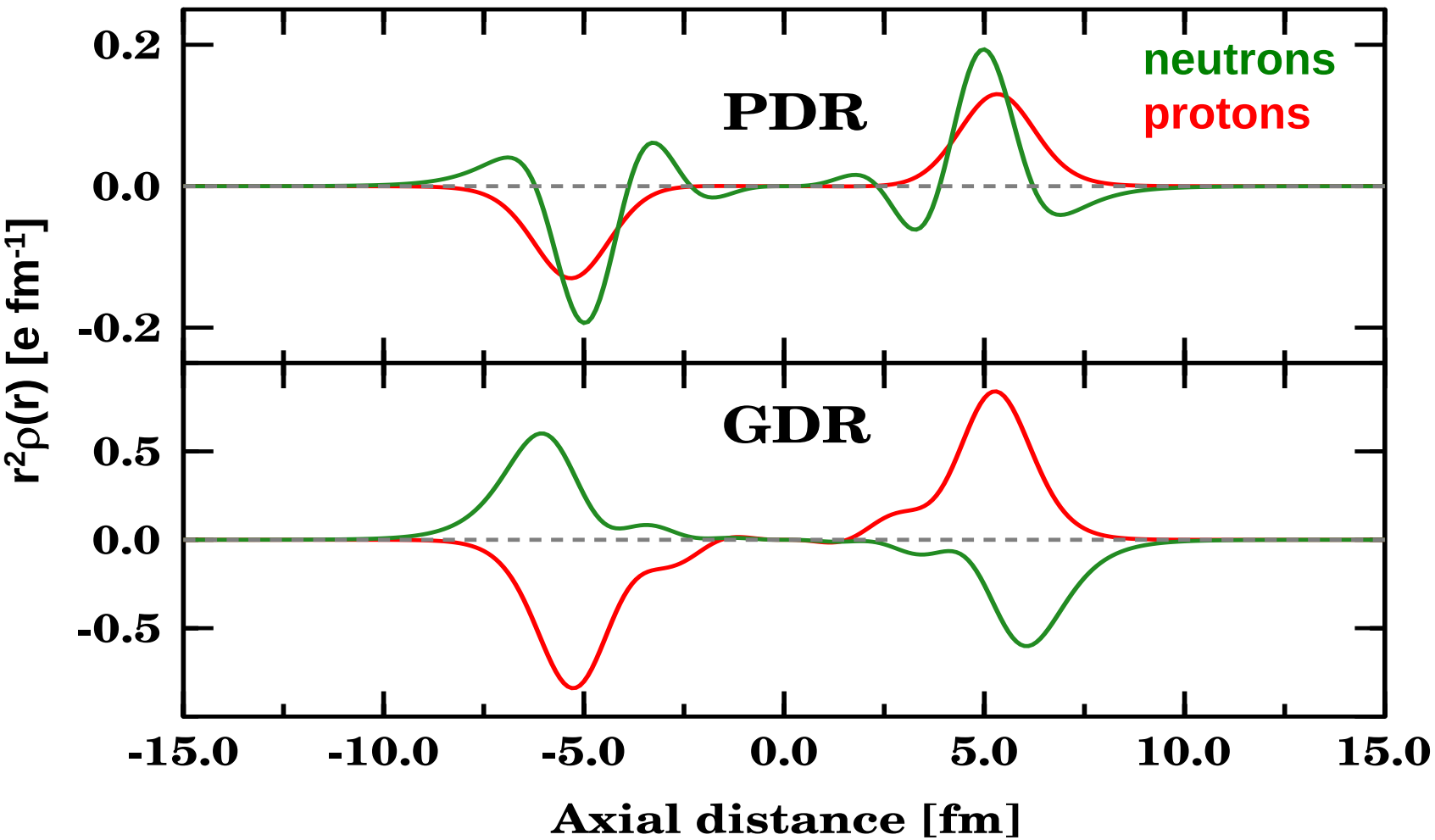
QPM calculations for ^{138}Ba



V. Ponomarev, J. Wambach et al., to be published

QPM calculations for ^{138}Ba

The E1 strength at 7 MeV is dominantly isoscalar



V. Ponomarev, J. Wambach et al., to be published

Summary

- An E1 resonance exhausting up to 1% of the EWSR is observed in all examined nuclei around about 7 MeV

- We still do not know its systematics. isospin character, decay pattern, a form factor

Outlook

- **Systematic strength measurements**

  [(γ,γ') and (γ,n) @ S-DALINAC]

- **Isospin character**

  [$(\alpha,\alpha'\gamma)$ @ KVI]

- **Branching ratios, parities**

  [$(\vec{\gamma},\gamma')$ @ HIγS, Duke University]

- **Form Factor**

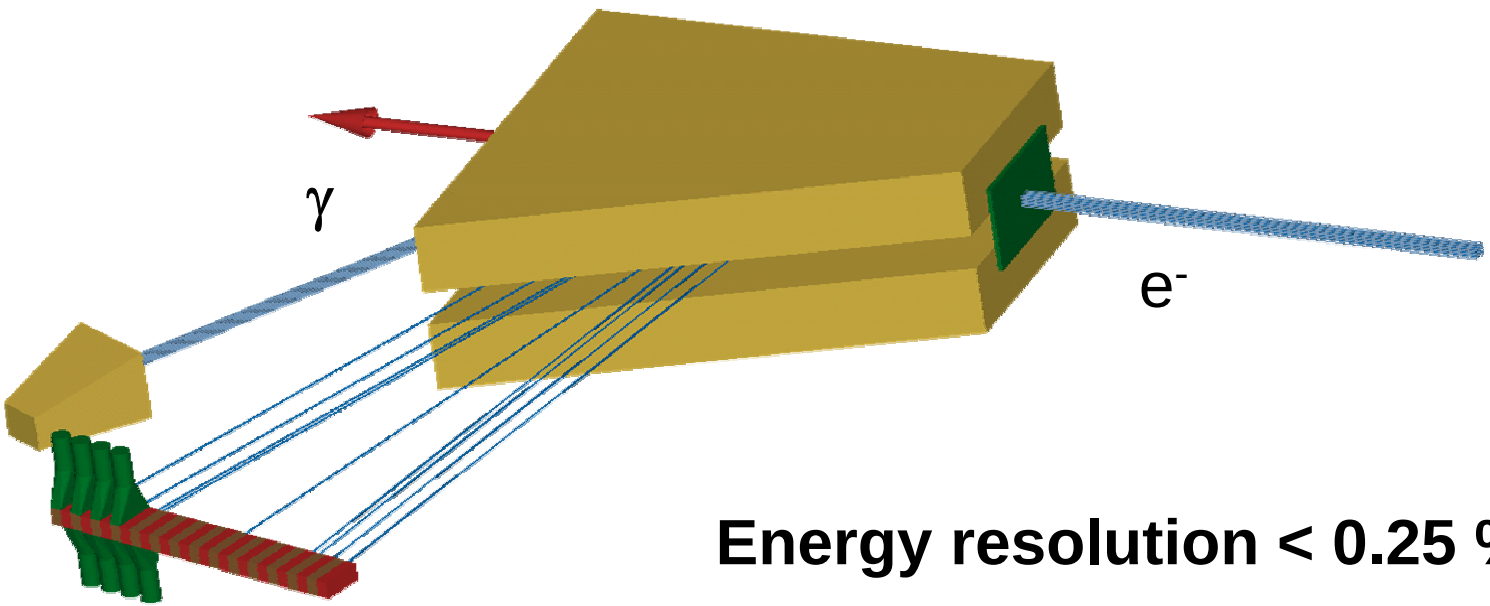
  [(e,e‘) @ S-DALINAC]

- **Improved model calculations**

  [Predictive power]

High resolution measurements above the particle threshold: The new tagger facility @ S-DALINAC

Production of a tagged photon beam in the energy range 5-20 MeV

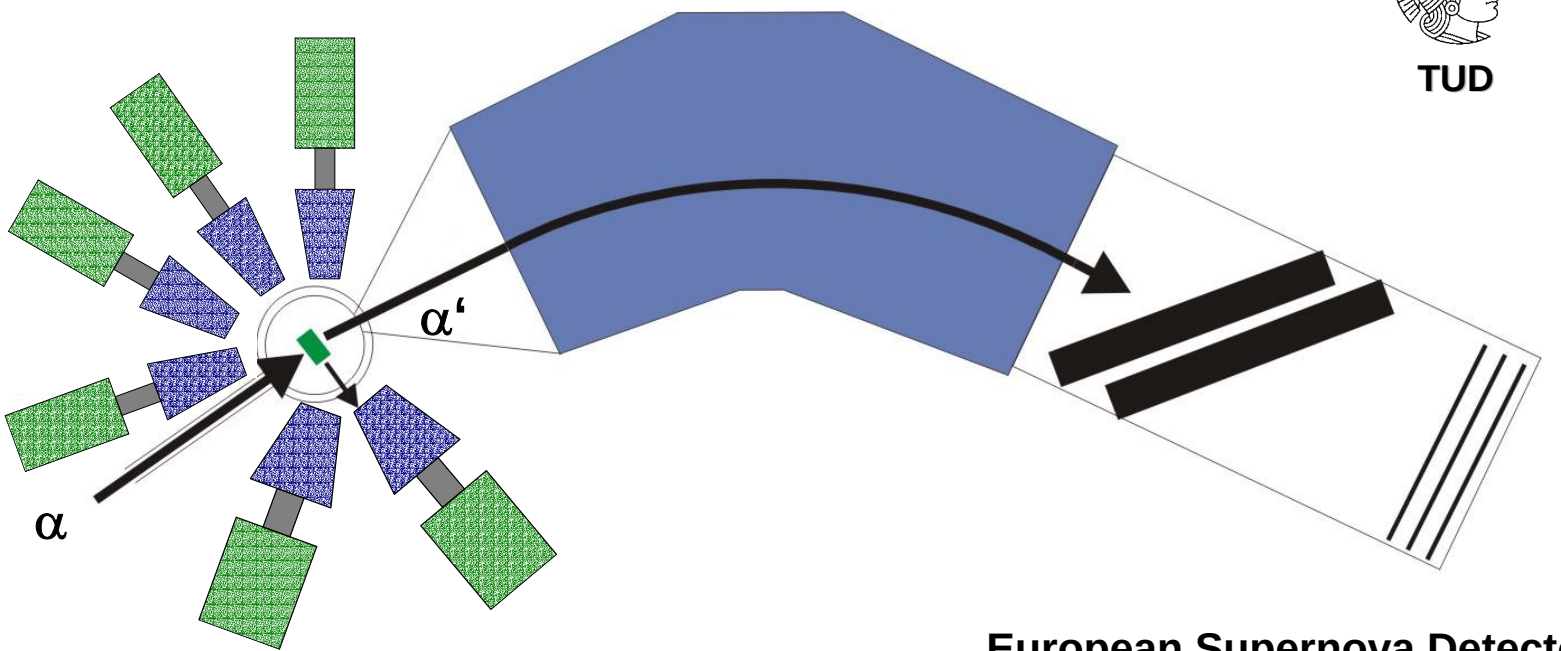


Energy resolution < 0.25 %

The new ISOSPIN-Meter at KVI

Big Bite Spectrometer (BBS)

TUD



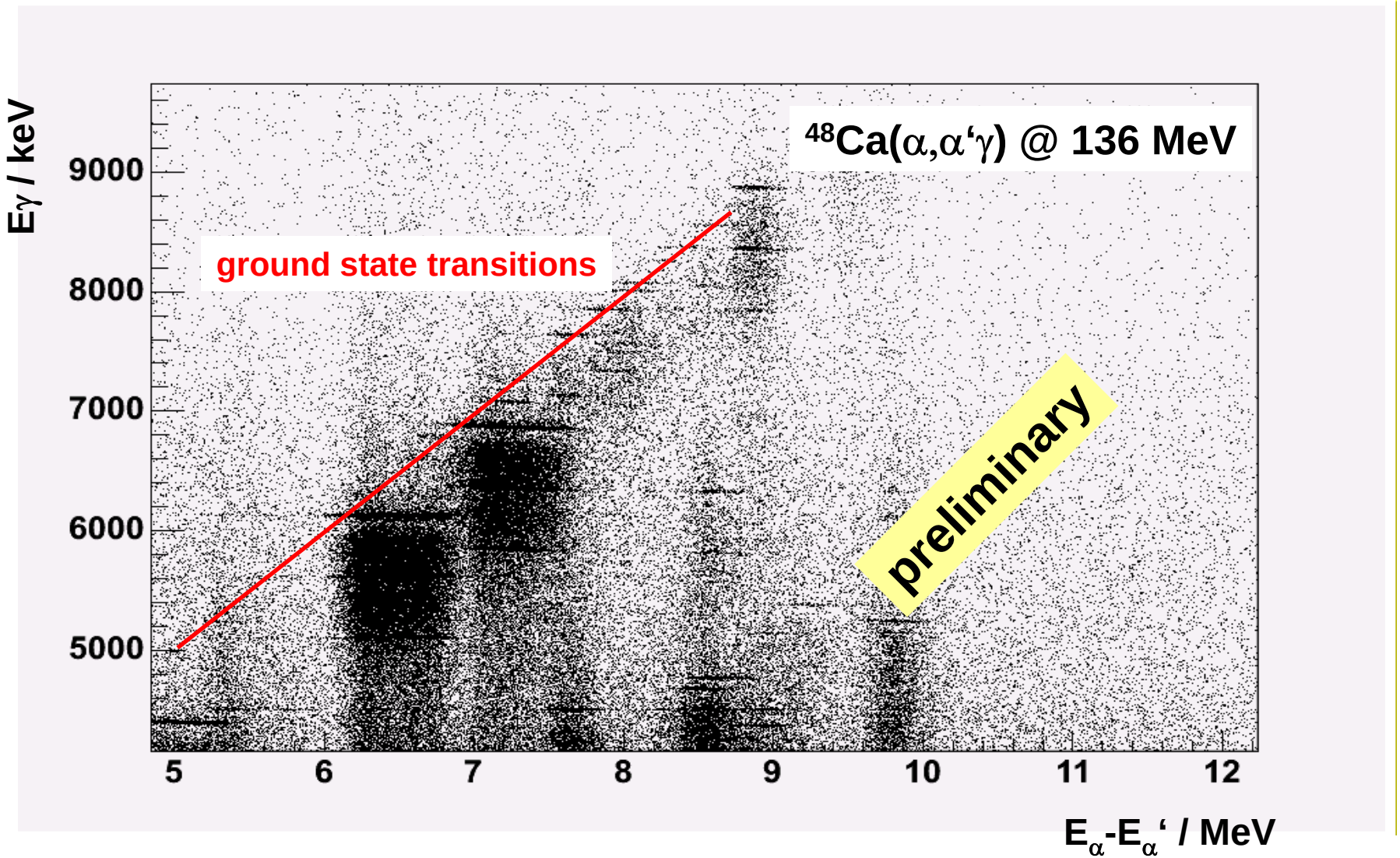
Ge detector array
for detection of γ decays

European Supernova Detector
for detection of α particles,
ΔE ~ 100-200 keV

This setup allows to determine the isospin character of bound states !

D. Savran, H.J. Wörtche, M. Harakeh, K. Ramspeck, A. van den Berg, A.Z.

The new ISOSPIN-Meter at KVI



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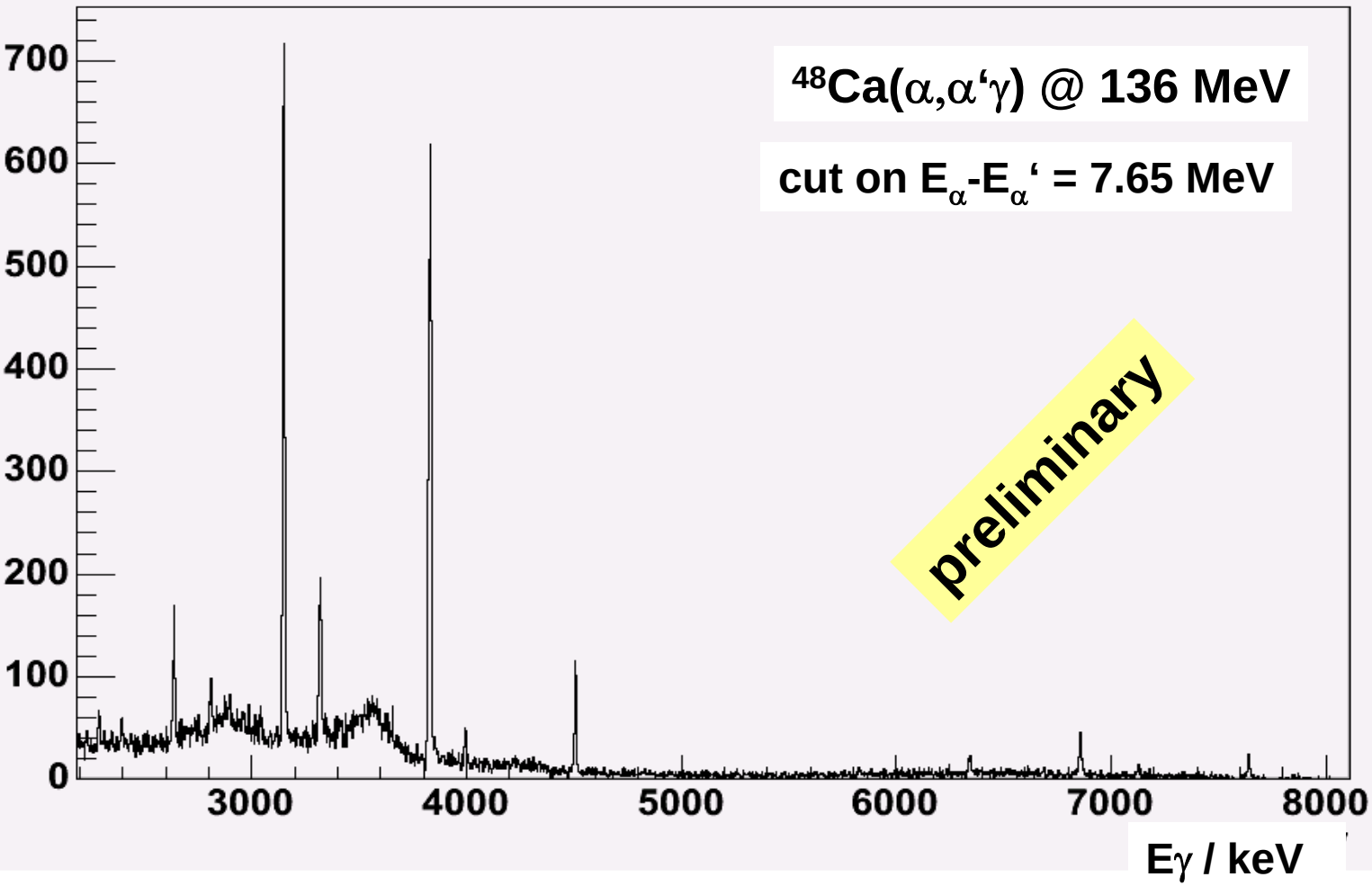

D. Savran, H.J. Wörtche, M. Harakeh, K. Ramspeck, A. van den Berg, A.Z.

Collective Excitations close to the Particle Threshold

M. Babilon, W. Bayer, D. Galaviz, J. Hasper, T. Hartmann, K. Lindenberg, S. Müller, K. Ramspeck, D. Savran, K. Sonnabend, S. Volz

(Institut für Kernphysik, TU Darmstadt)

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More information and references: www.zilges.de