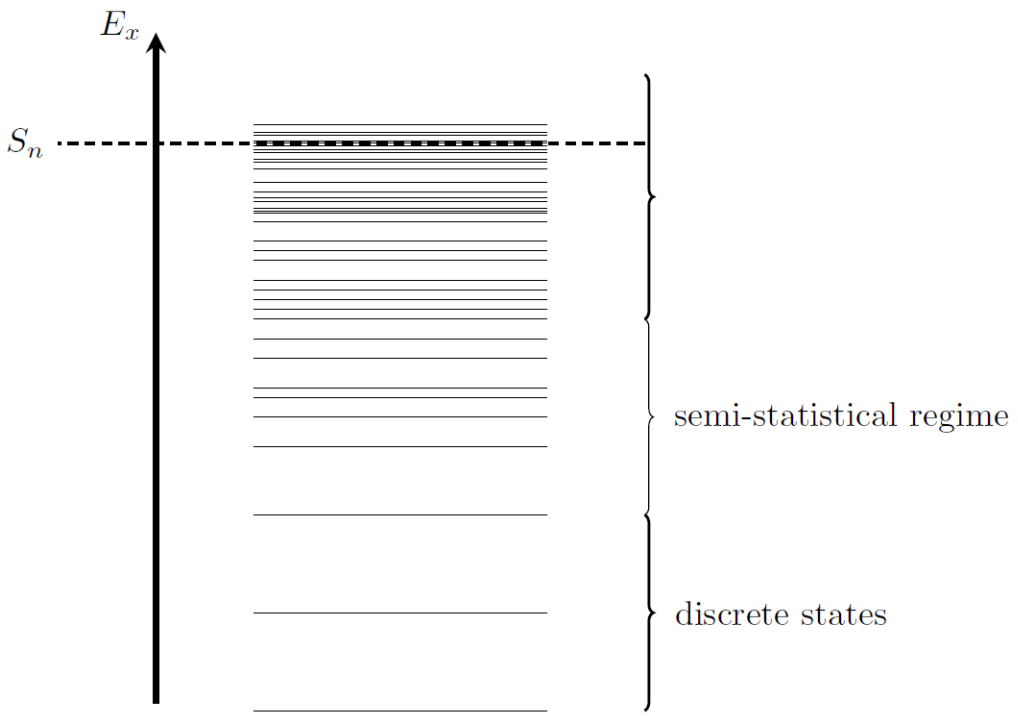
Investigation of dipole strength up to the neutron-separation energy at the ELBE accelerator

Ralph Massarczyk for the γELBE group

Nuclear levels at different excitation energies

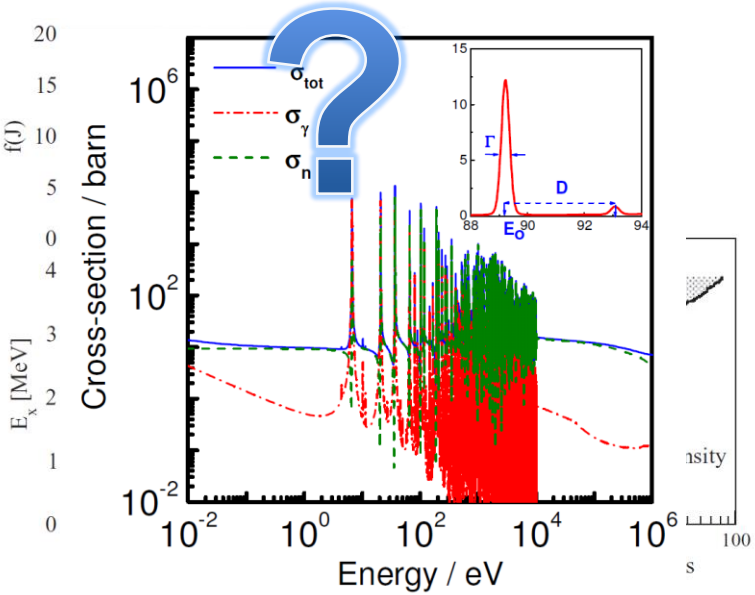


Steady separated states

Steady separated states in window

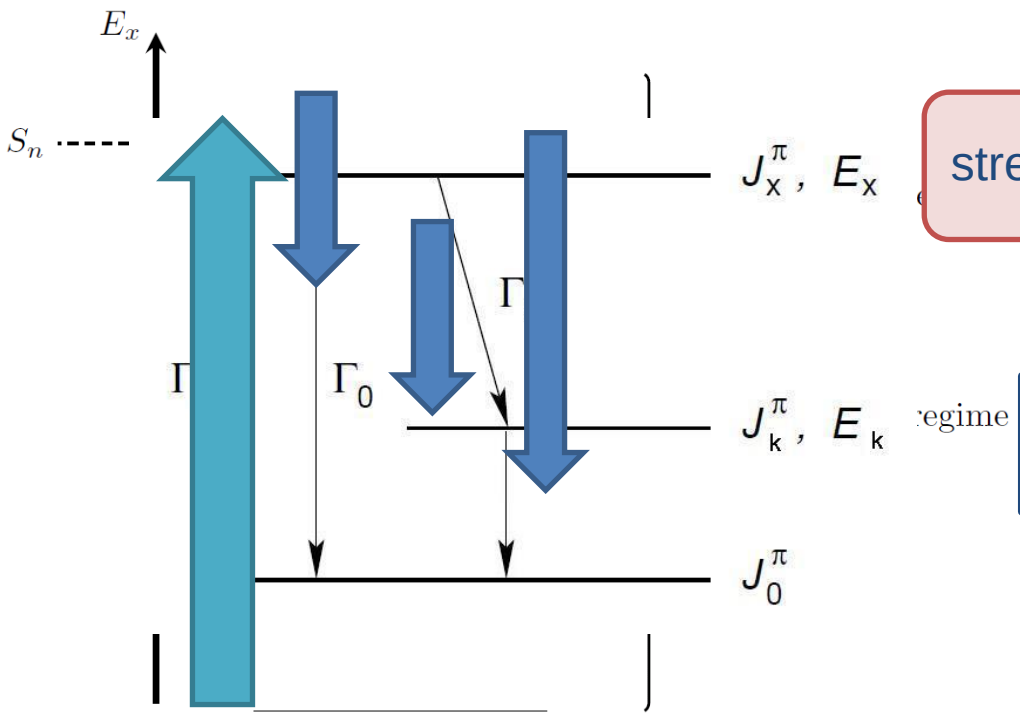
energy, (spins, parities),

(branchings, transition energies)



By Egidy et al. PRC 80, 054310 (2009)

Nuclear levels and how they are connected



strength function

transition energy

$f^{XL}(E_\gamma) \cdot E_\gamma^{2L+1}$

Transition widths play a role
in almost every nuclear reaction

level density

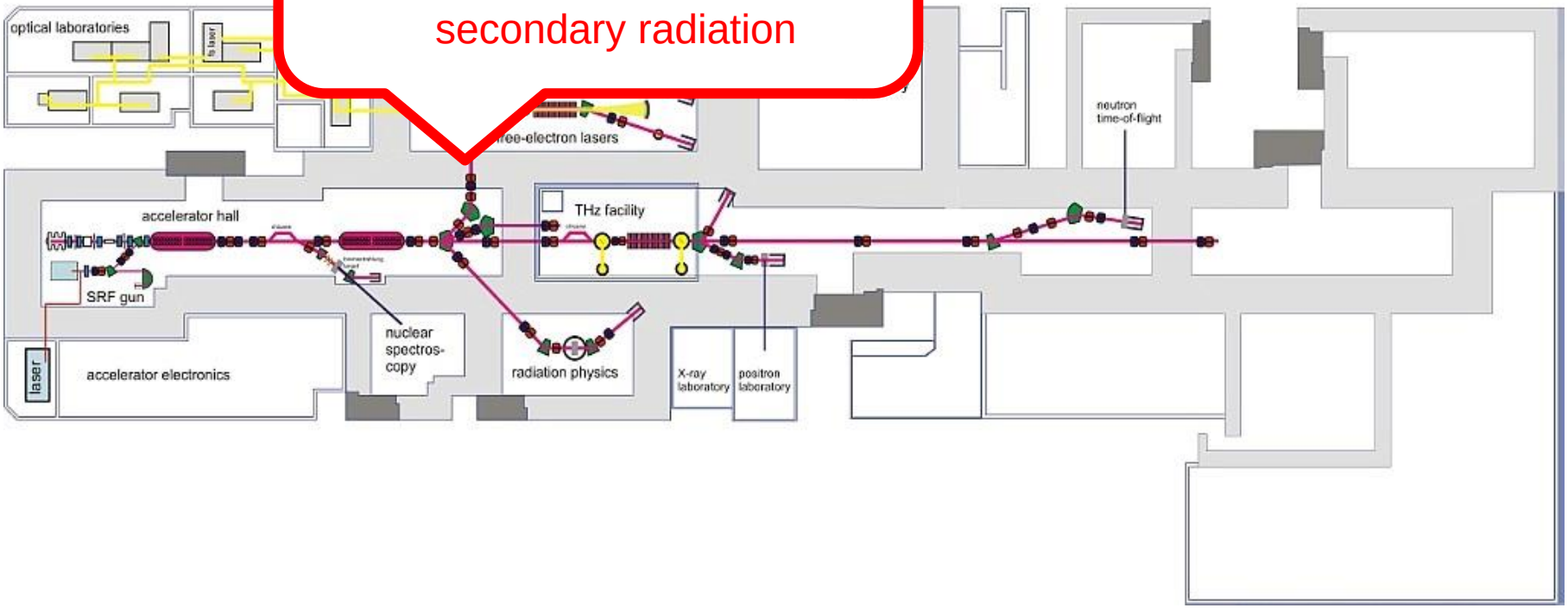
Measurement of the photo absorption crosss section

$$< \sigma_{abs} >= 3\pi^2\hbar^2c^2\, f_1\, E_x.$$

The (new) ELBE at Dresden

still an **E**lectron **L**inac with high **B**rilliance and low **E**mittance

Electrons
(E_{e-} < 40 MeV, I < *1* mA)
for
secondary radiation

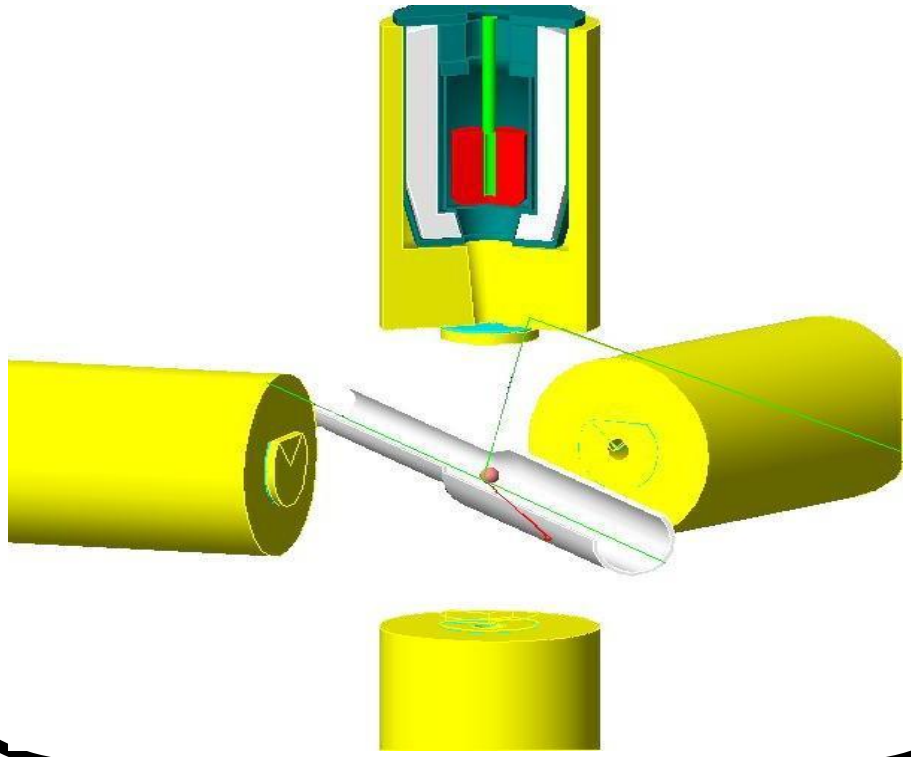


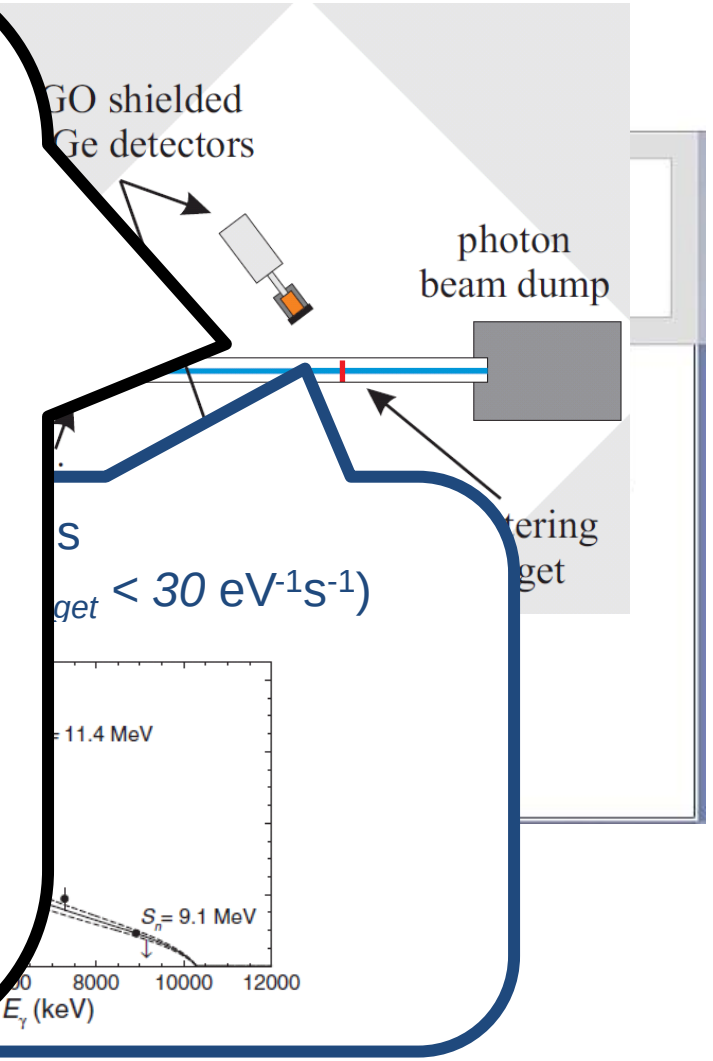
FEL LIGHT, neutrons, High Power Laser, Positrons, THz facility, **Bremsstrahlung**

Experiments at γELBE

4 HpGe Detectors (90° and 127°)

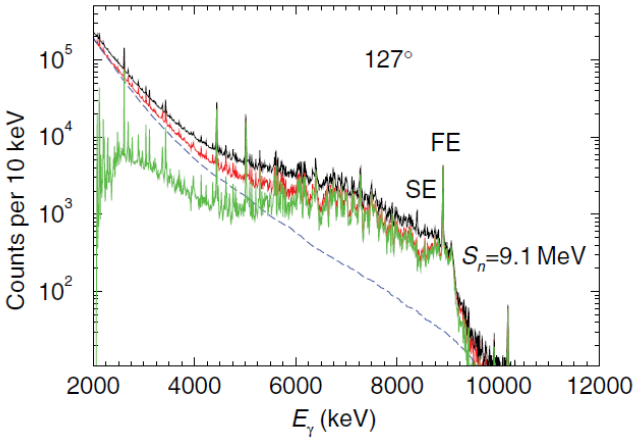
with BGO shields used as veto detectors

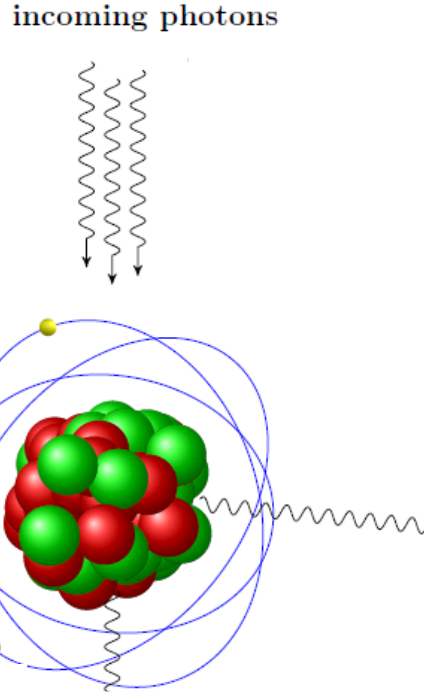


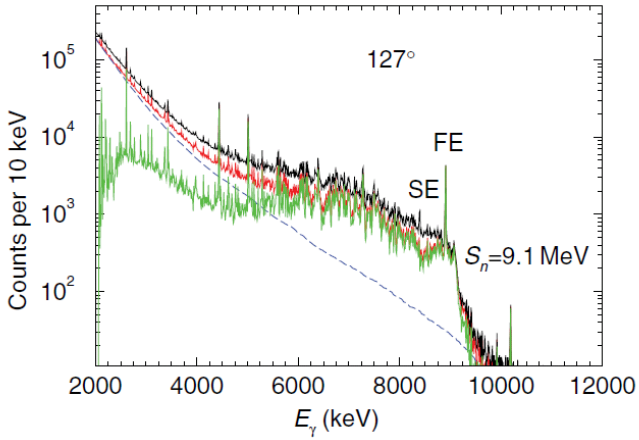


R. Schwengner *et al.*, NIM A **555**, 211 (2005)

Experiments at γELBE

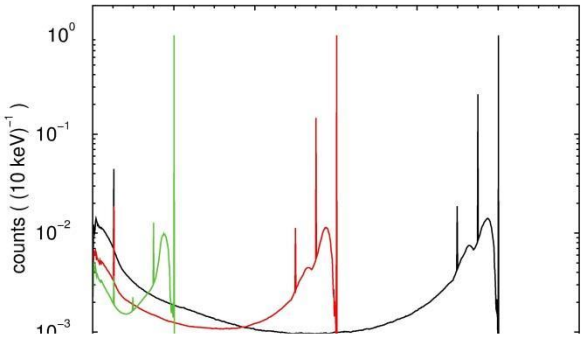


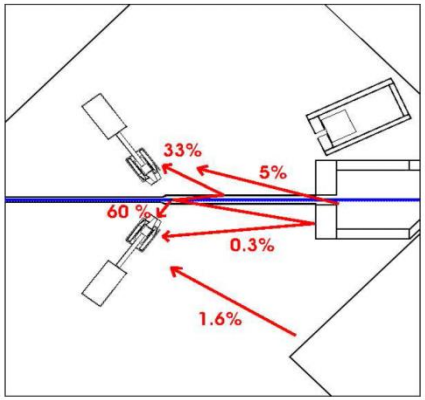




Unfolding of detector response and efficiency (GEANT4)

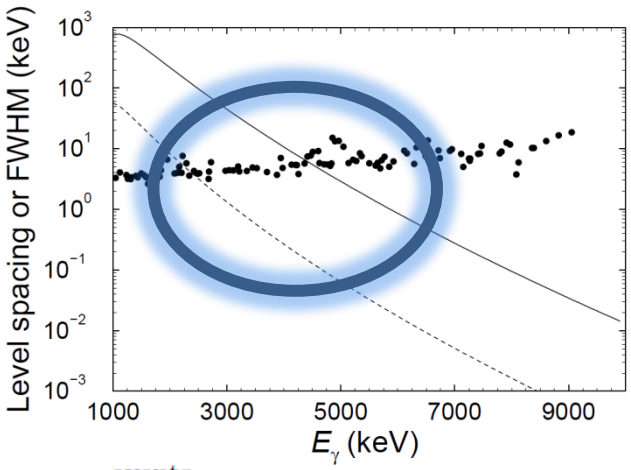
Subtraction of not nuclear scattered events (GEANT4)

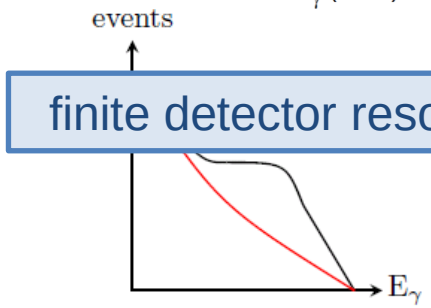




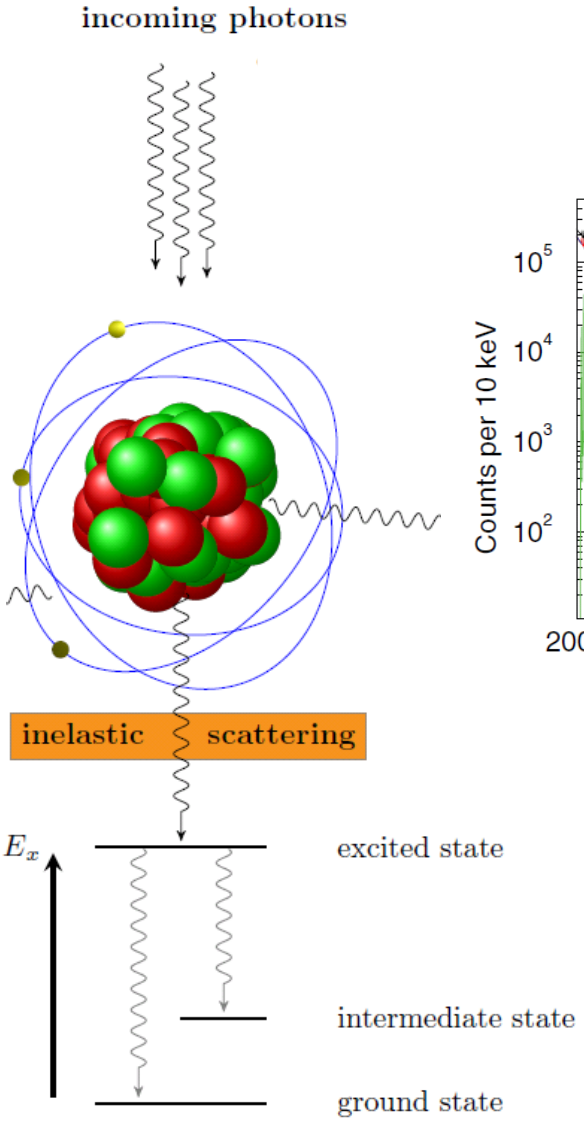
G. Rusev, PhD thesis

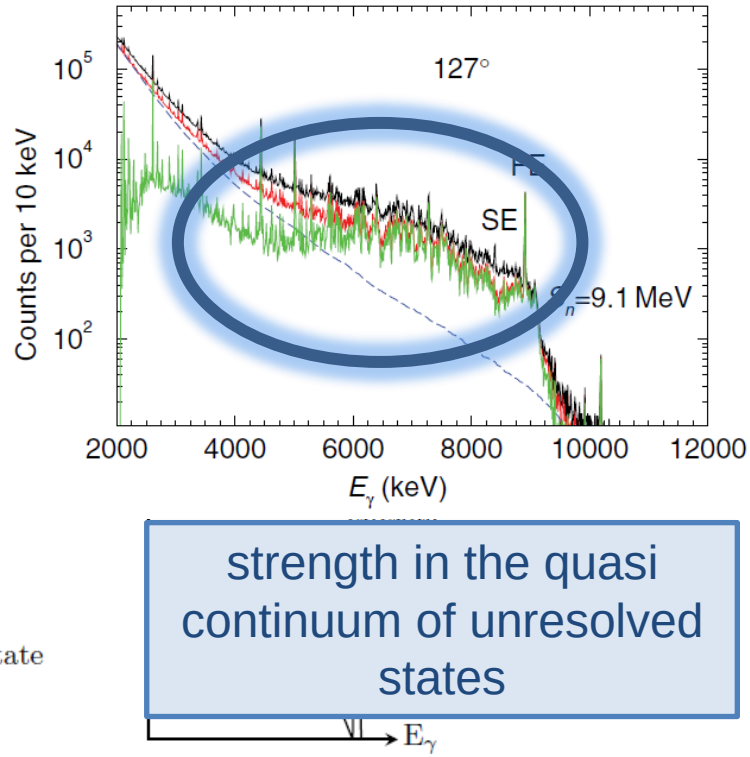
Experiments at γELBE





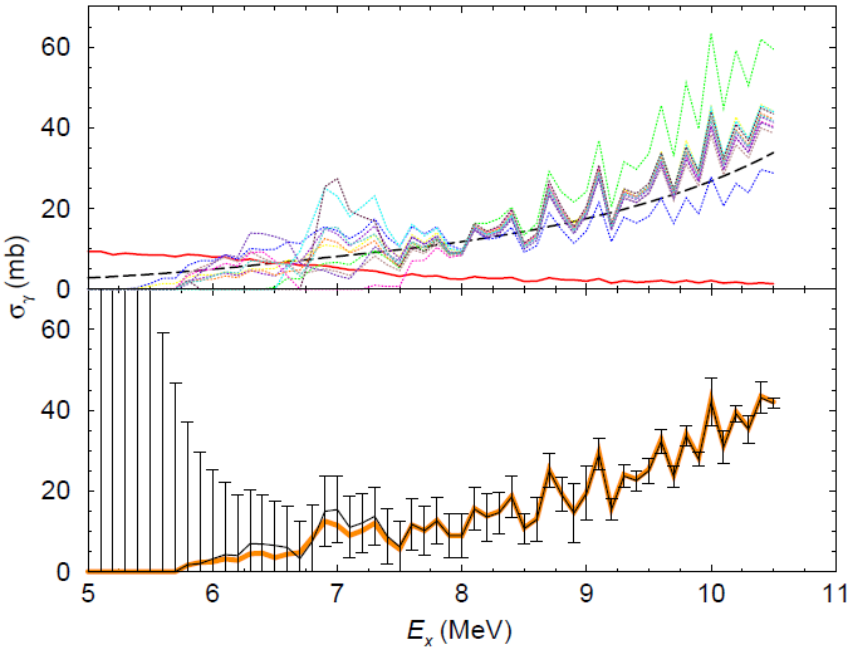
finite detector resolution





strength in the quasi continuum of unresolved states

Experiments at γELBE



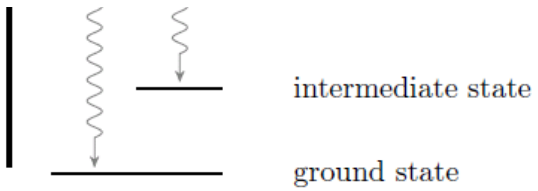
Strength function

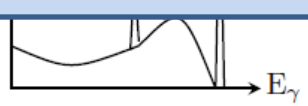
$$< \sigma_{abs} >= 3\pi^2\hbar^2c^2\, f_1\, E_x.$$

Iterative determination of the cross section

$$< \Gamma_{if}^{XL} >= \frac{f_{if}^{XL}(E_\gamma) \cdot E_\gamma^{2L+1}}{\varrho(E_i)}$$

Level density (constant temperature model)





G. Schramm *et al.*, PRC **85**, 014311 (2012), R. Massarczyk et al. PRC **87**, 044306 (2013)

Experiments at γELBE

Medium mass nuclei

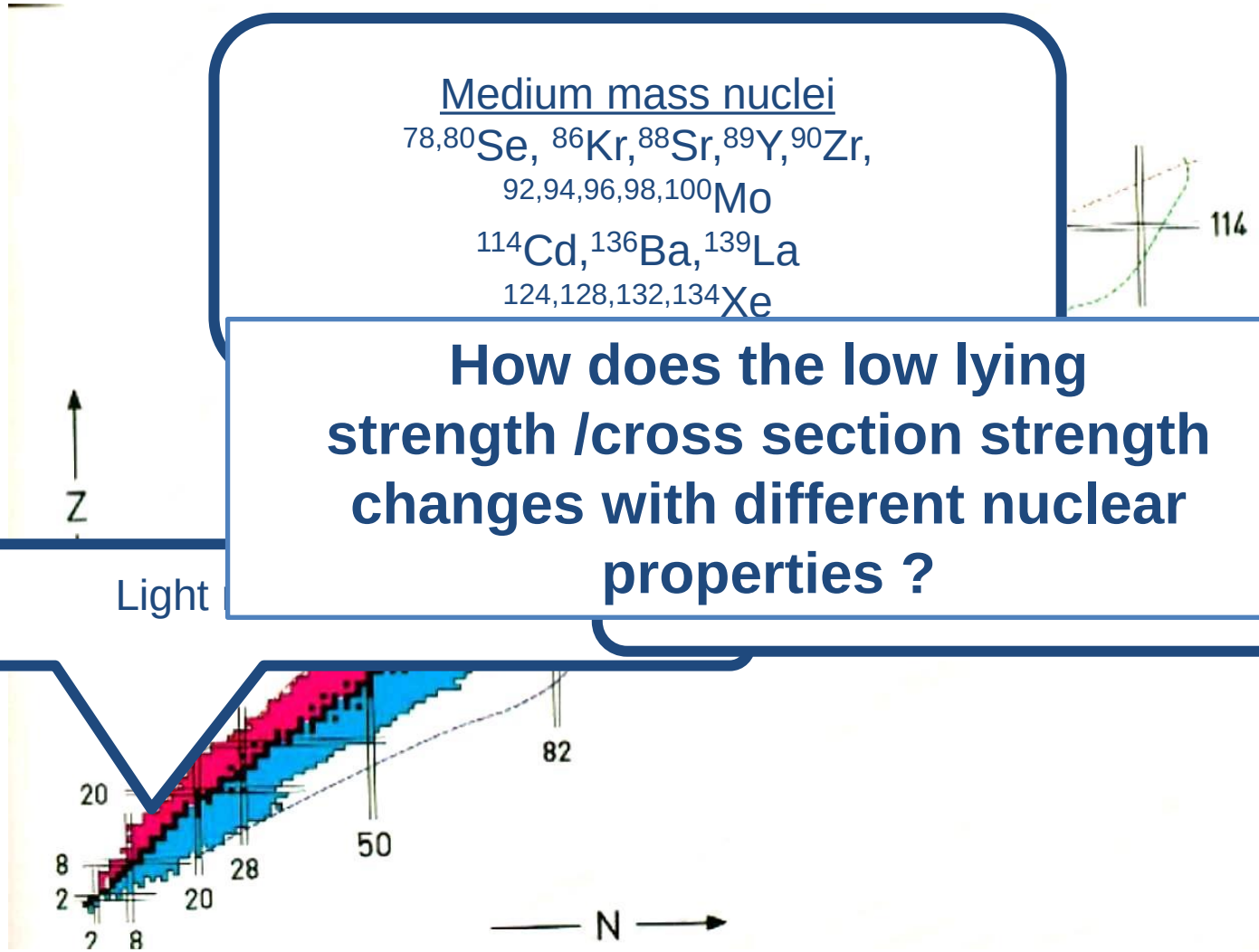
$^{78,80}Se$, ^{86}Kr,^{88}Sr,^{89}Y,^{90}Zr,

$^{92,94,96,98,100}Mo$

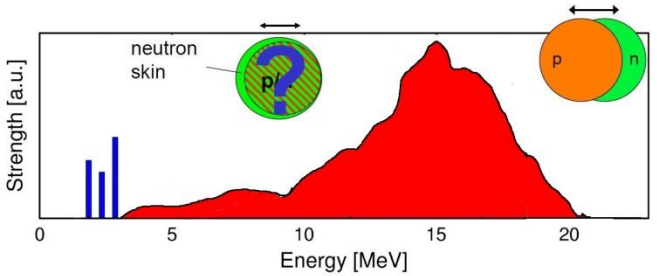
^{114}Cd,^{136}Ba,^{139}La

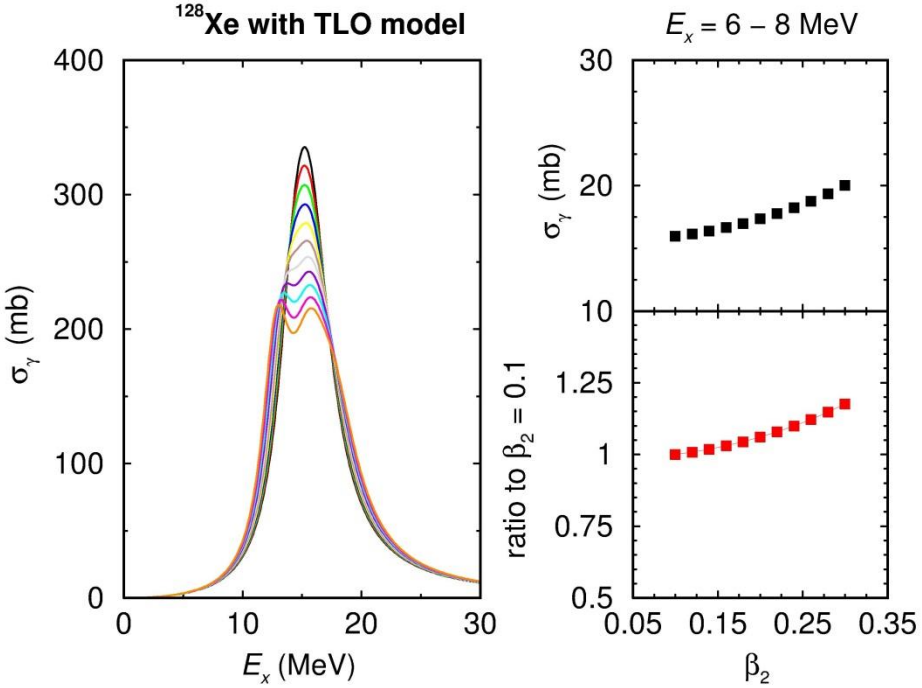
$^{124,128,132,134}Xe$

How does the low lying strength /cross section strength changes with different nuclear properties ?



Giant resonances and deformation

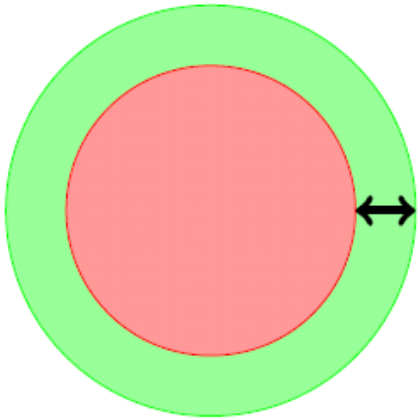




DEFORMATION SHIFTS STRENGTH TO LOWER ENERGIES

A. Junghans et al Physics Letters B 670 (2008) 200–204

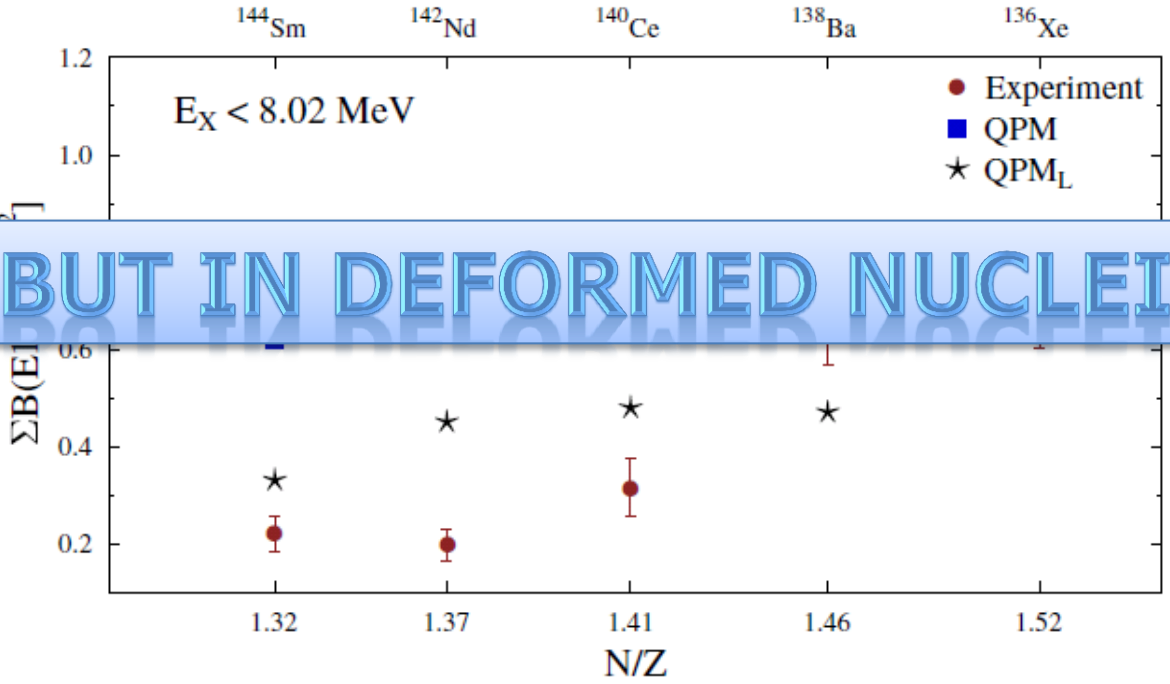
Pygmy resonances



Vibrating neutron skin

(6 MeV < E_γ < 9 MeV)

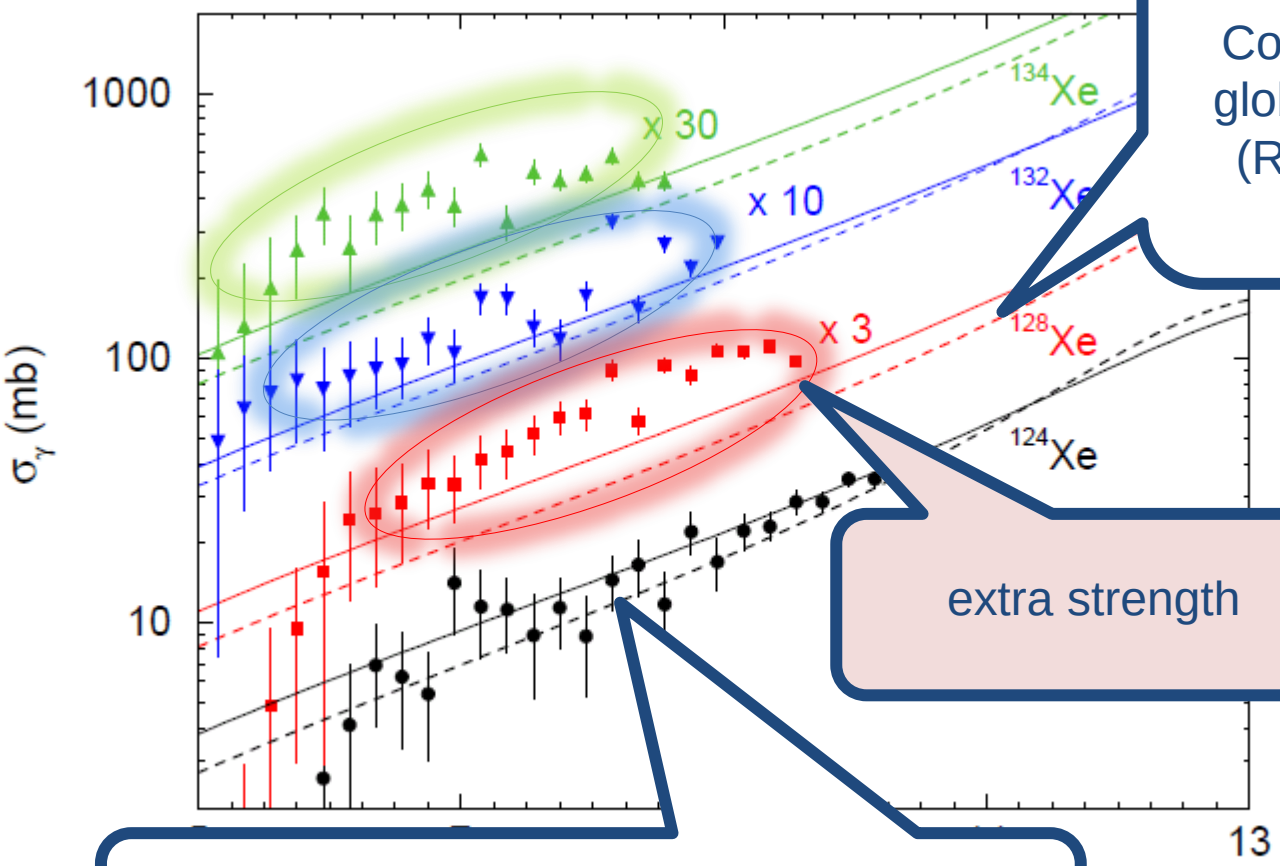
Should depend on **neutron excess**



BUT IN DEFORMED NUCLEI ???

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

Results γELBE



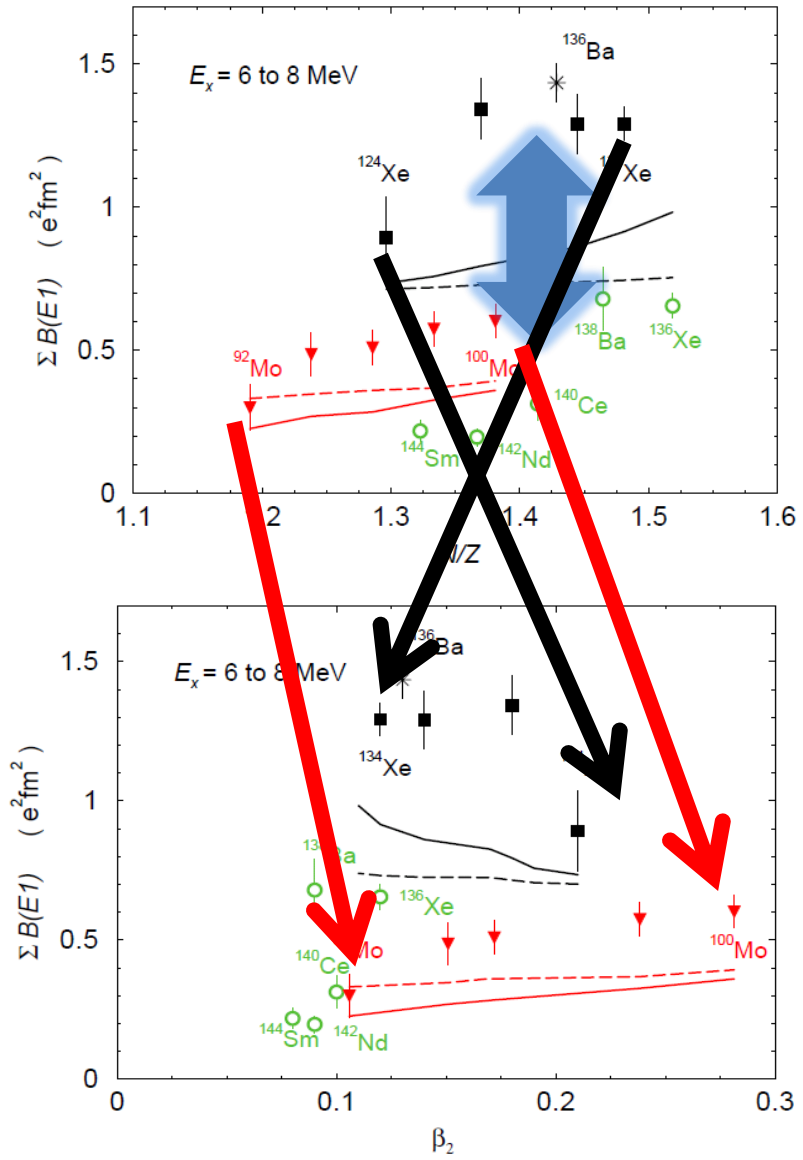
Comparison with global predictions (RIPL3 or TLO)

extra strength

Data from ELBE below the neutron separtion energy

R. Massarczyk et al. PRL 112, 072501 (2014)

Results γELBE – neutron excess vs. deformation



General increasing trend of strength with increasing **neutron excess** (also in TLO and QRPA)

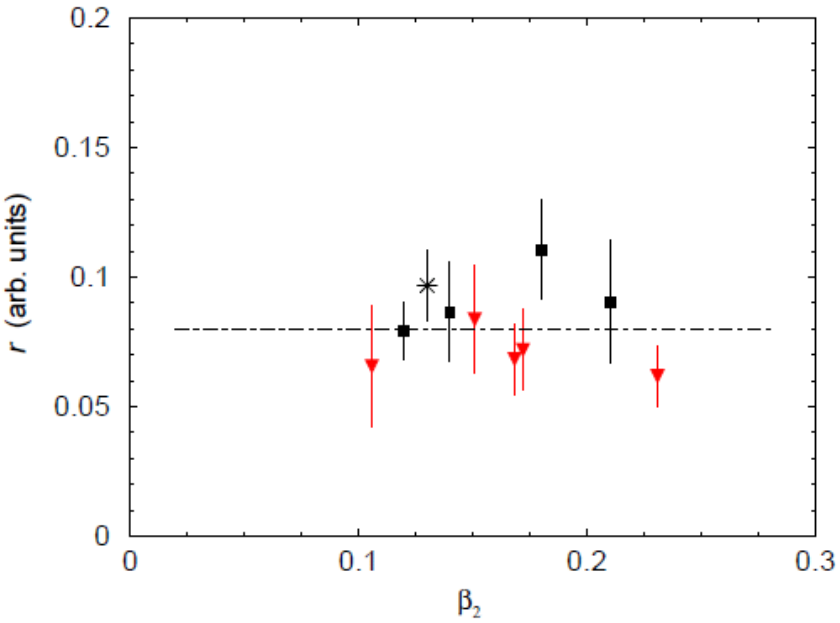
Full strength has to be taken into account

Inverse trend in Mo and Xe chain in **deformation**

NEUTRON EXCESS SEEMS TO DOMINATE

R. Massarczyk et al. PRL 112, 072501 (2014)

Results γELBE – neutron excess vs. deformation



Strength depends on :

Complete strength
(TRK sum rule)

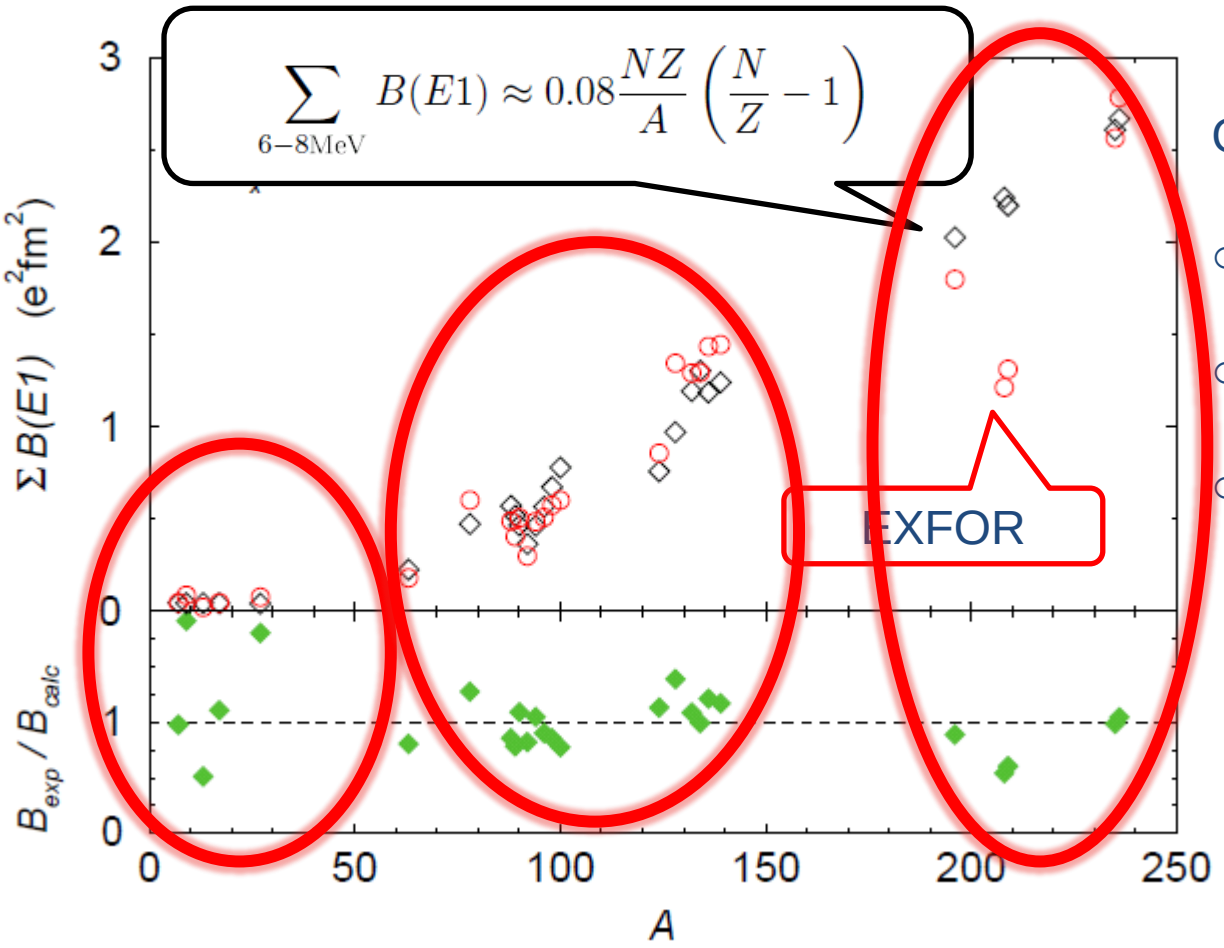
$$\sum_{6-8\mathrm{MeV}} B(E1) \sim \left(\frac{N}{Z}-1\right)$$

$$r = \sum B(E1)\left[\left(\frac{N}{Z}-1\right)\frac{NZ}{A}\right]^{-1}$$

Neutron excess

ONLY SMALL DEFORMATION DEPENDENCE

A global phenomena ?

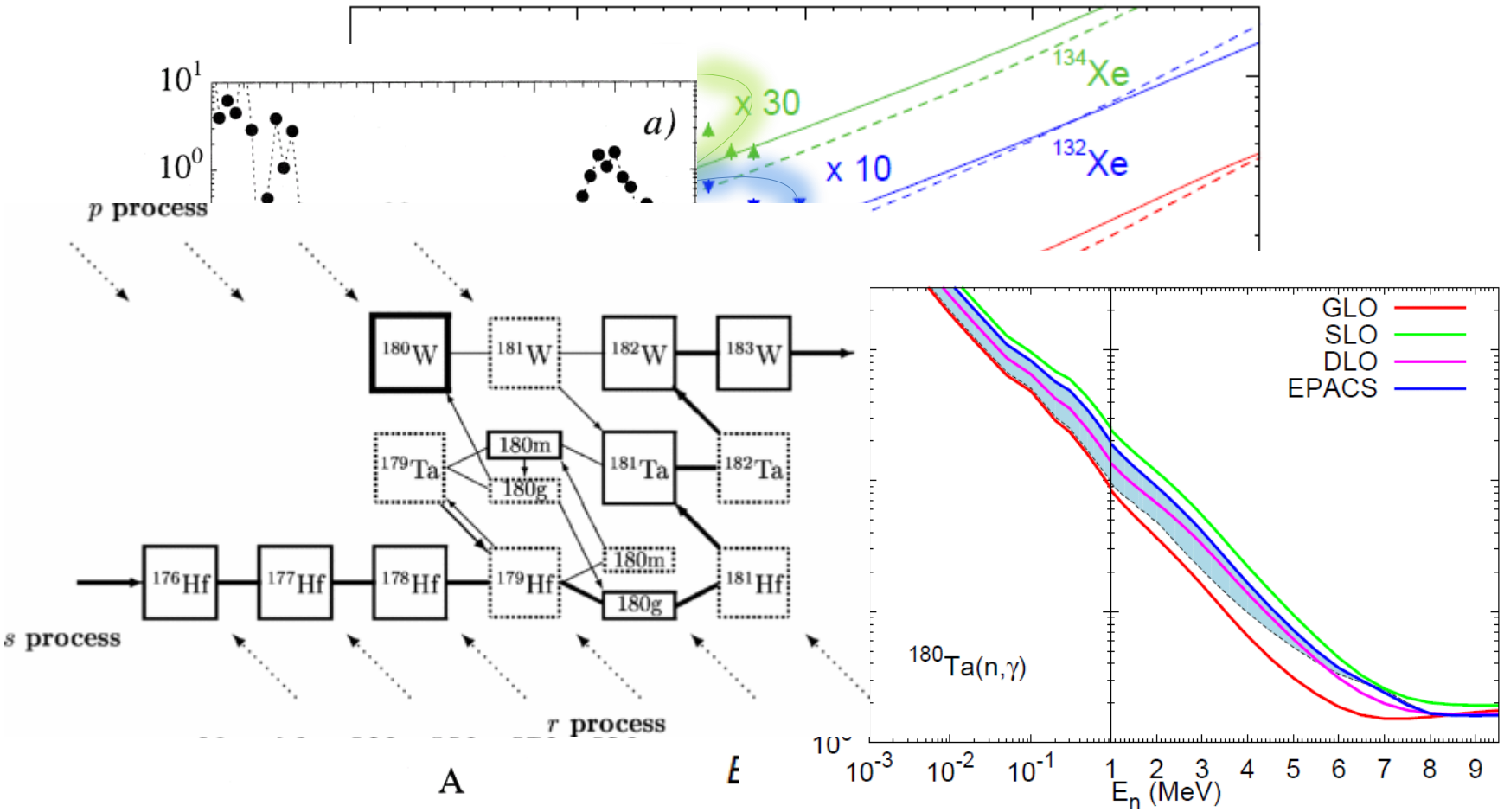


Good description for:

- (light nuclei)
- medium mass nuclei
- Heavy (deformed) nuclei

R. Massarczyk et al. PRL 112, 072501 (2014)

Results γELBE



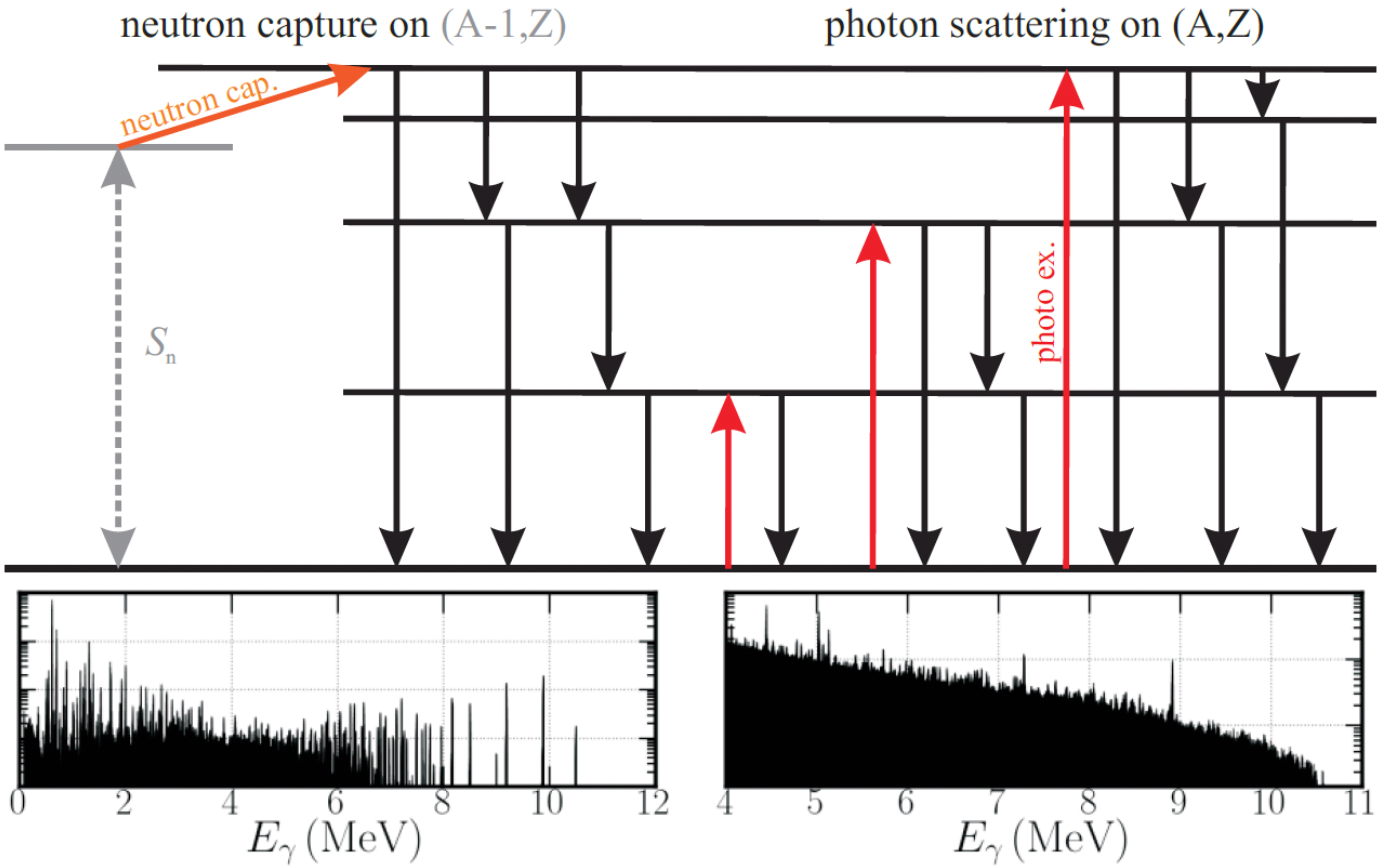
F. Käppeler et al. PRC 69, 015802 (2004)

A. Makinaga et al. PRC , sumbitted (2014)

Small changes can have a big impact on a large scale.

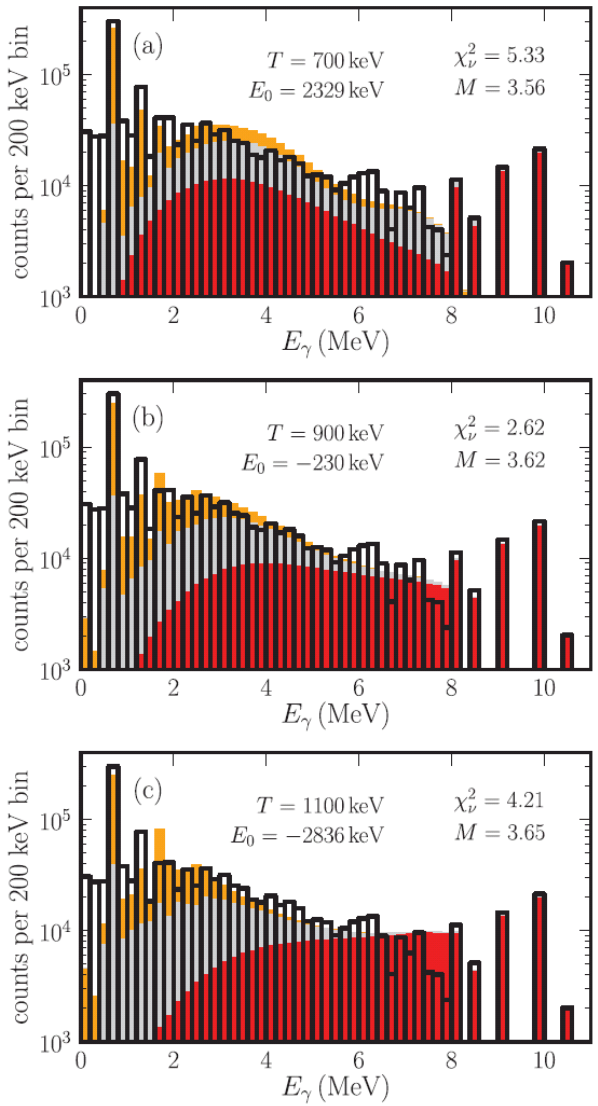
R. Massarczyk et al. PRL 112, 072501 (2014)

Results from ELBE for other reactions



Twin experiments in ^{77,78}Se, ^{113,114}Cd and ^{195,196}Pt

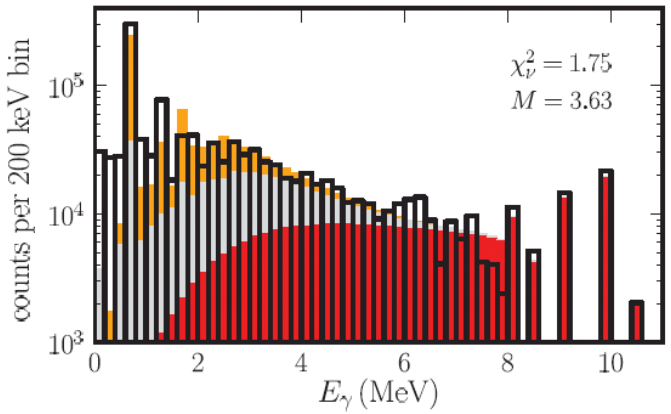
Results from ELBE for other reactions



$$< \Gamma_{if}^{XL} > = \frac{f_{if}^{XL}(E_\gamma) \cdot E_\gamma^{2L+1}}{\varrho(E_i)}$$

Test level density behavoirs

Combine experimental strength distribution



[78] Se: G. Schramm et al. PRC **85**, 014311 (2012)
[196] Pt: R. Massarczyk et al. PRC **87**, 044306 (2013)
[114] Cd: R. Massarczyk et al. PRC in preperation

Summary

- Measurements at ELBE
- Dipole strength up to the neutron separation energy
- Influence of neutron excess and nuclear deformation on low-lying strength
- Only minor influence of deformation on complete E1 strength

Thanks for your attention !

DFG

ERINDA
European Research Infrastructures for Nuclear Data Applications

HZDR