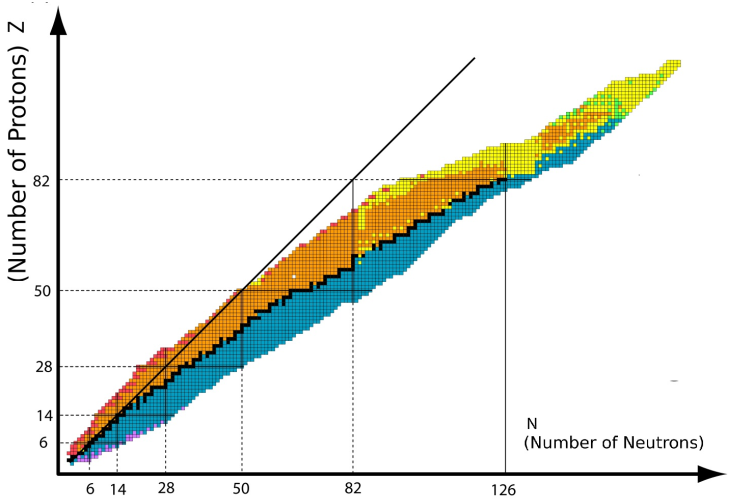
Electromagnetic Dipole Strength distribution in ^{124,128,132,134}Xe below the neutron separation energy

Ralph Massarczyk

Helmholtz-Zentrum Dresden-Rossendorf

02.10.2013

Overview



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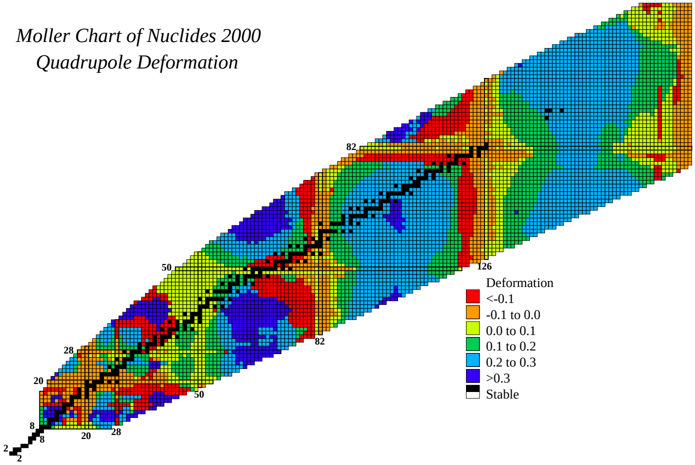
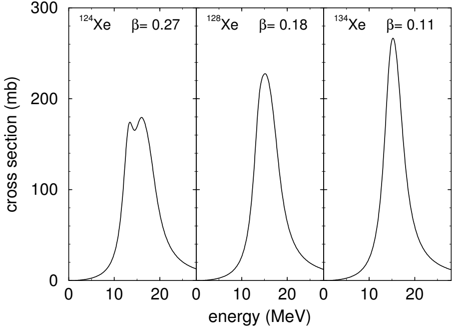


How effects nuclear deformation nuclear reactions ?

A closer view



- deformation changes shape of the Giant Dipole Resonance
- different parameterizations available

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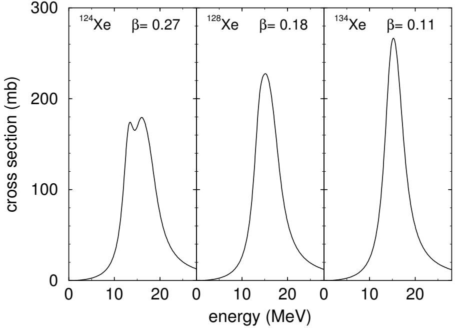

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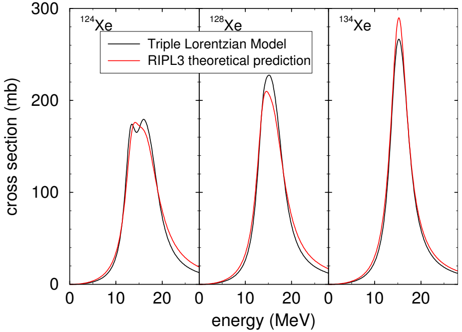

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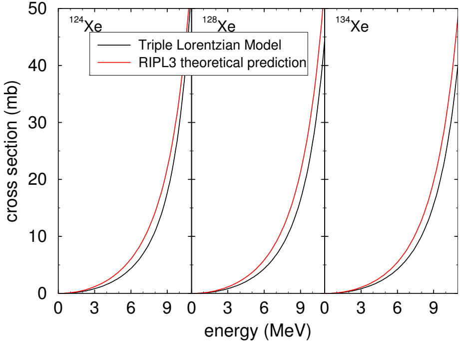

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Idea of the measurements

photo-absorption cross-section vs. strength function

$$f^J_{0\lambda XL} = 26 \cdot 10^{-8} \frac{\overline{\sigma}^J_{0\alpha XL}(E_\gamma)}{g_J E_\gamma^{2L-1}} (MeV)^{-(2L+1)}$$

σ	f
• is what we can measure • starts from ground state • often includes E1, M1, E2 transitions as well as (γ,γ'), (γ,n) and other reactions (γ,X)	• is needed to describe deexcitations of excited states • splits up in E1, M1, E2 ... • should be independent from excitation energy, spin, parity, excitation mechanism • **an idea based on statistical assumptions**

A short why-to-visit the energy region below the threshold

- interesting for a lot of nuclear reactions
- cross-over from a system dominated from single states to a statistical dominated system
- new resonances (pygmy, M1, soft pole), new picture of nuclear matter ?
- *fascinating how small scale effects can change big things*

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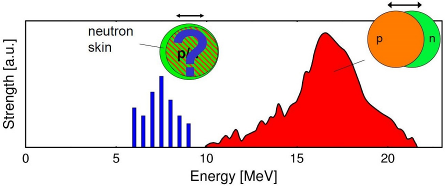

[1]

[1] figure by D.Savran

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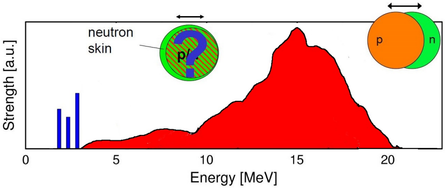

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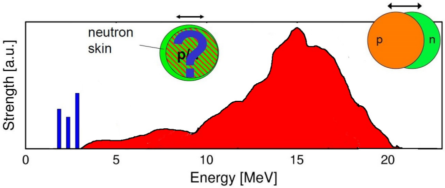

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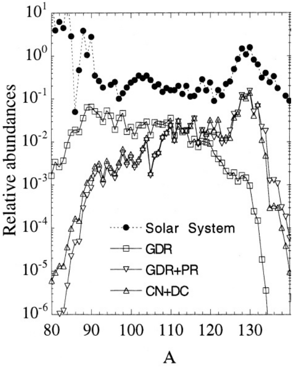

[2]

[2] S.Goriely Phys. Lett. B 436 (1998) 10–18

Why a series of measurements

- measure the photo-absorption cross section in a chain of stable isotopes
- recently published results of chain with neutron number N = 50 [1]
- What happens if neutron excess and nuclear deformation go in different directions ?
- measurements of Xenon isotopes ⇔ learn something about the **general behavior**

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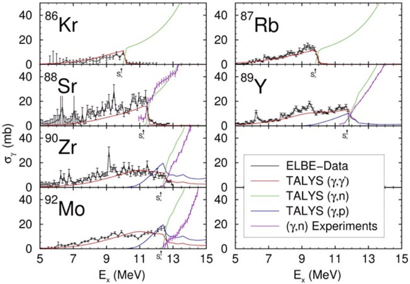

[1] R. Schwengner PRC 87 (2013) 024306

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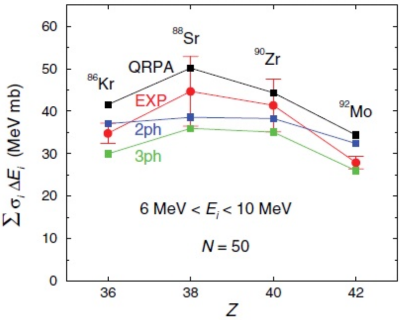

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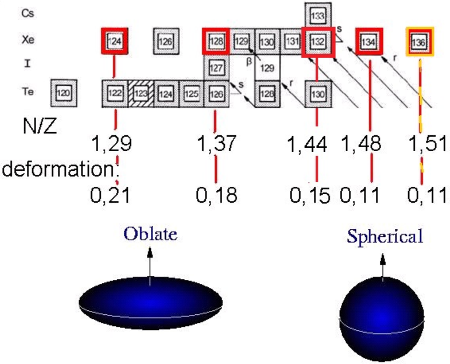

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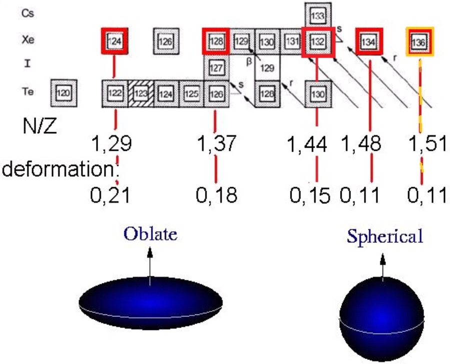

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pro and cons of Xenon

Pro and Contra

- **noble** gas
- interesting for reactor physics acts as the most important reactor poison - ^{135}Xe(n,γ)
- ^{129}Xe/^{130}Xe, ^{136}Xe/^{130}Xe ratios important in solar system studies and planetary differentiation

- rarest not radioactive element on earth
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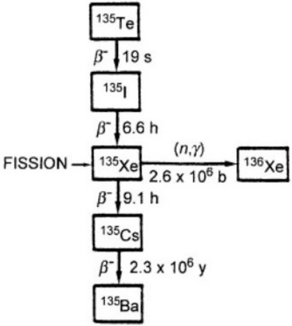

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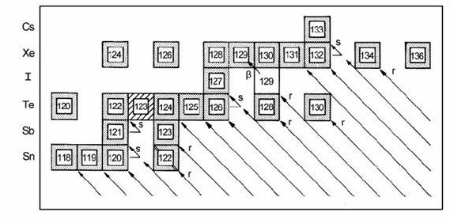

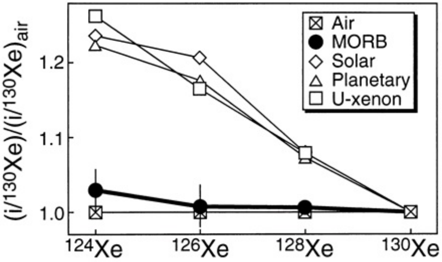

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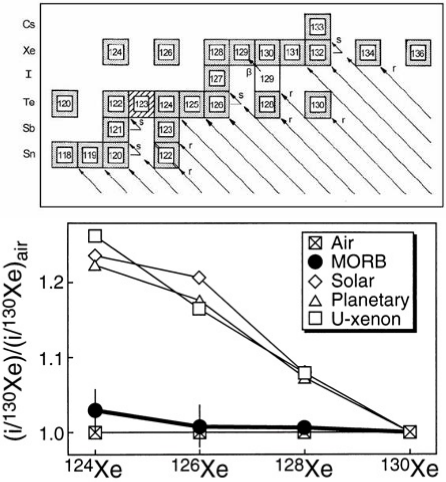

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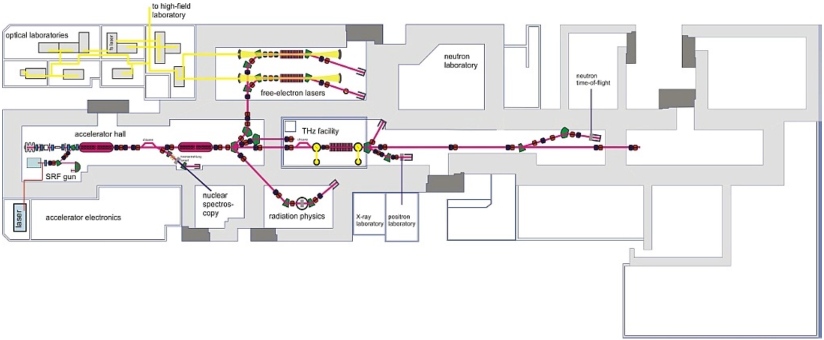
Sites

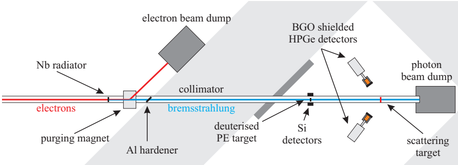
The (new) **ELBE** at Dresden



Electron Linac for secondary radiation purposes
(*neutrons,positrons, FEL, activation experiments,* ***bremsstrahlung***)

Sites

- photon excitation at the bremsstrahlung setup at the electron accelerator ELBE
- electron energies from 5 to 20 MeV with up to 1mA
- electron beam on thin niobium foil produces bremsstrahlung
- setup contains high purity Germanium detectors with BGO shielding
- empty target measurements necessary



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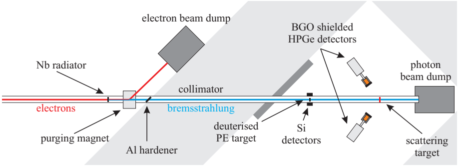

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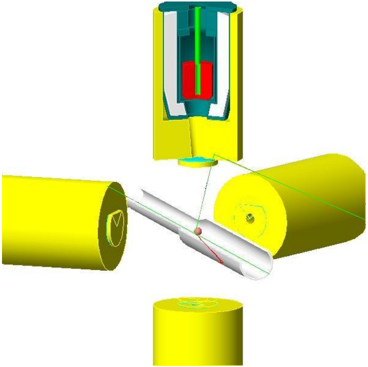
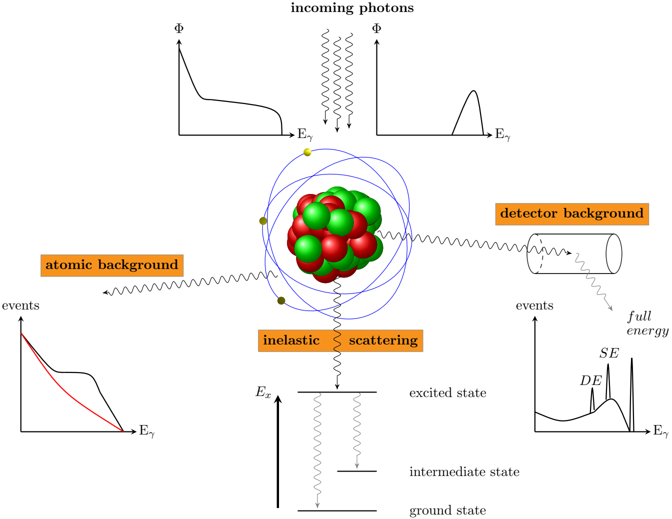
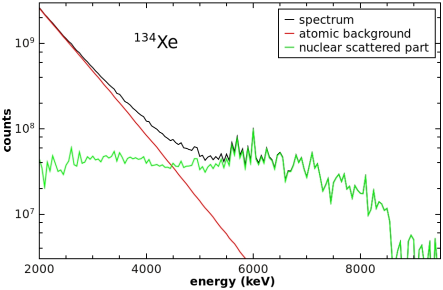


A walk through the analysis



A continuum analysis



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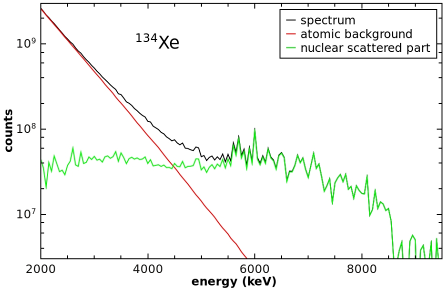

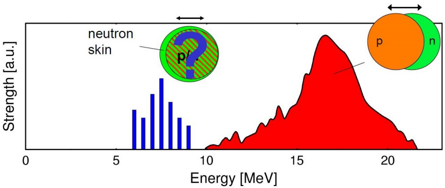

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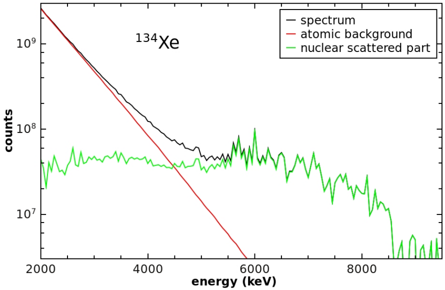

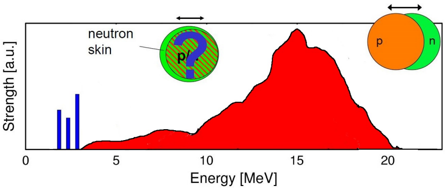

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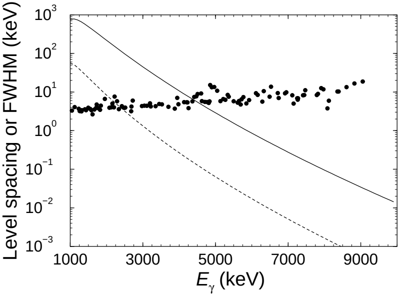

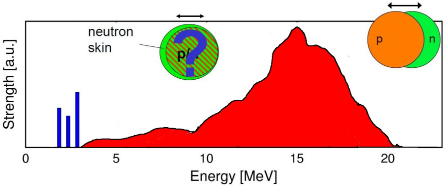

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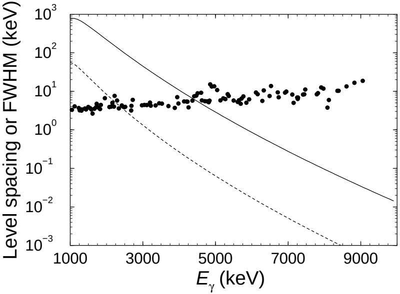

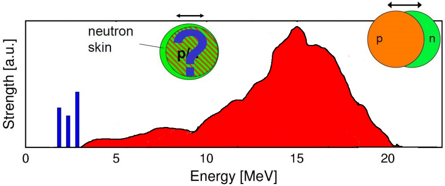

continuum analysis...

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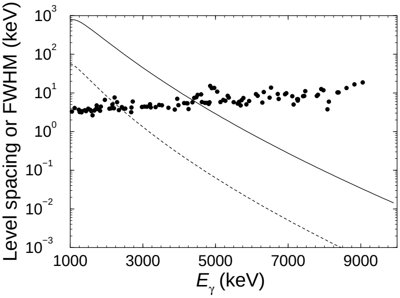

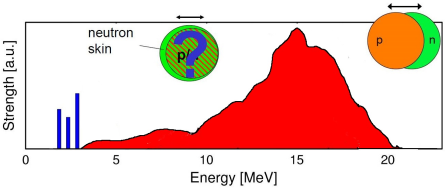

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... standard tool in (n,γ) analysis (e.g. Two-Step-Cascades)

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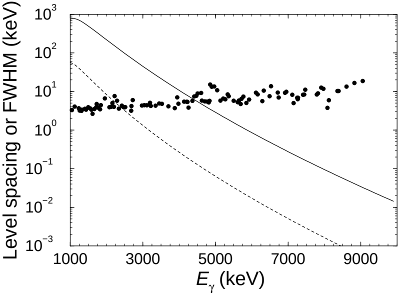

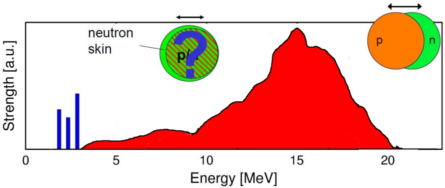

continuum analysis...

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... but not in nuclear resonance fluorescence experiments

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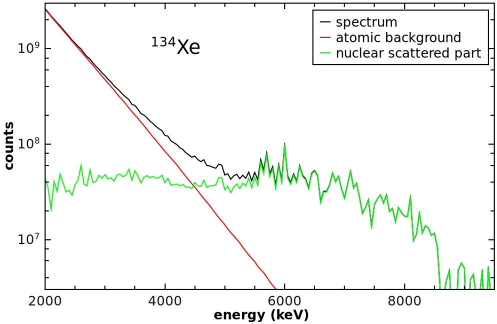
Correction of inelastic scattering

- Correction of inelastic scattered events and branching
- Calculation and subtraction with γDEX [1], [2]
- **Self-consistent:** Input PSF is Output PSF



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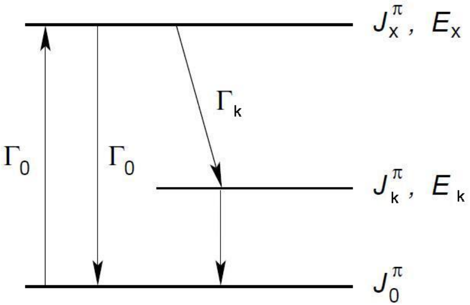

[1] G. Schramm PRC 85 (2012) 014311

[2] R. Massarczyk PRC 87 (2013) 044306

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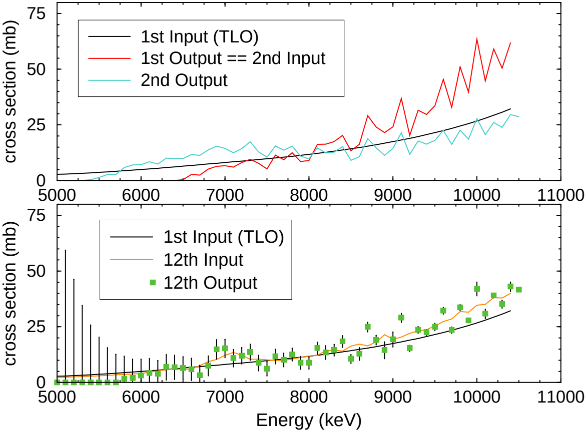

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γDEX

- based on the idea of DICEBOX [1]
- first step: scheme of levels $\Longrightarrow$ scheme of energy bins [2], [3]
- second step: remove the random numbers, by distributions, mean values, deviations and covariances

[1] F. Bečvář NIM A 417 (1998) 434

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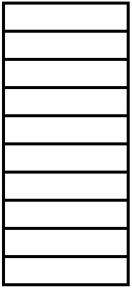
γDEX 2.0

change computer time to computer power !

new calculation method:



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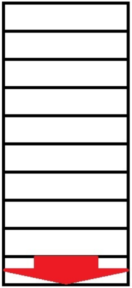

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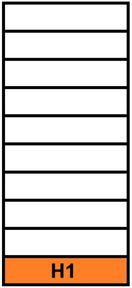

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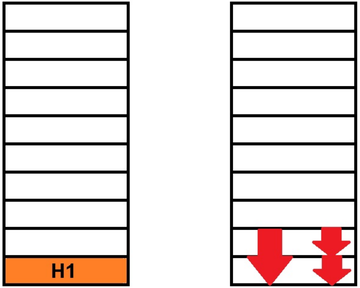

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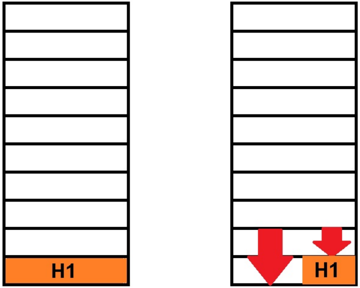

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- define Histogram of $1st$ bin:

$$H_1 = \delta(E_1)$$

- define Histogram of $2nd$ bin:

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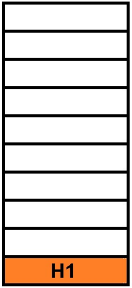

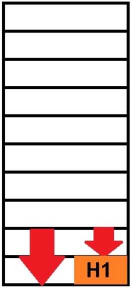

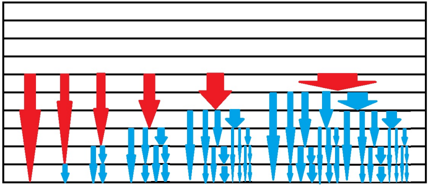

γDEX 2.0

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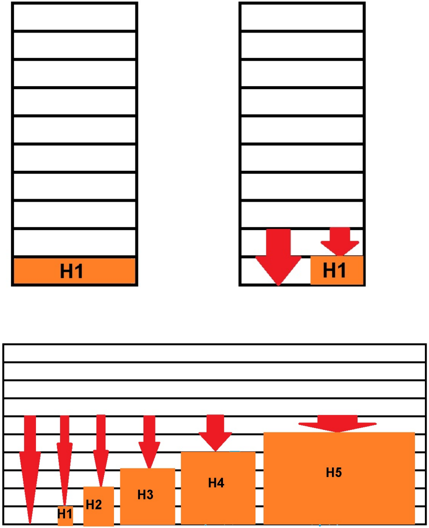

γDEX 2.0

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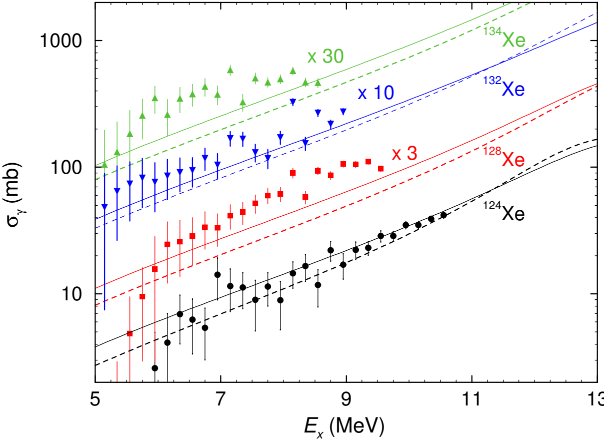
Advantages

- TIME...TIME...TIME, calculation within a minute
- Test with different model combinations

HZDR
HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

results

- Complete dipole strength below the neutron separation energy in gas targets



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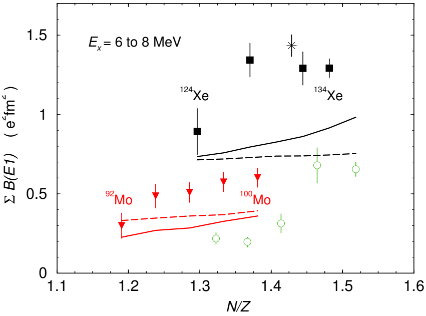
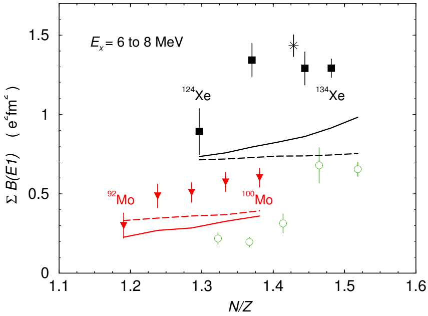
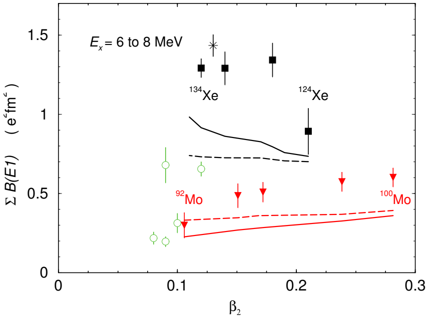
Integrated Strength below the neutron separation energy



Comparison of Xenon (black) Molybdenum (red) and N=82 results (green), TLO Prediction (dashed) and QRPA (red)

Integrated Strength below the neutron separation energy





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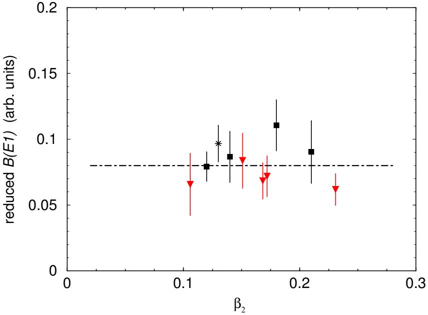
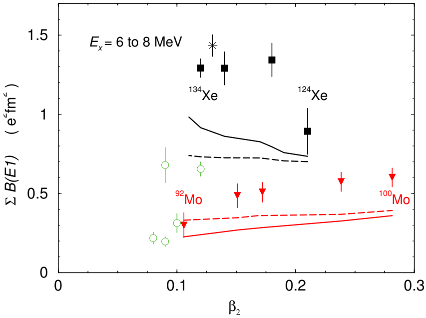
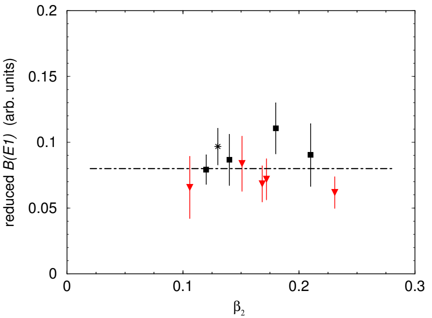


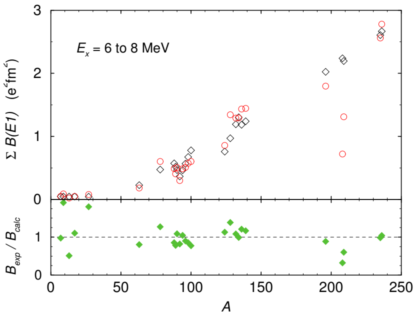


Comparison of Xenon (black) Molybdenum (red) and N=82 results (green), TLO Prediction (dashed) and QRPA (red)

Normalization of the strength to the Thomas-Reiche-Kuhn Sum Rule

Integrated Strength below the neutron separation energy





Comparison of Xenon (black) Molybdenum (red) and N=82 results (green), TLO Prediction (dashed) and QRPA (red)

N/Z effect dominating → Global parametrization

$$\sum_{6-8\mathrm{MeV}} B(E1) \approx 0.08\frac{NZ}{A}\left(\frac{N}{Z}-1\right)$$

Conclusions

- determination of dipole strength functions below the neutron separation energy
- we are able to measure gaseous targets
- fast reaction code γDEX for correction
- dominating N/Z effect
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Outlook

- analysis of HIγS Data
- work with γDEX in (n,γ) experiments at GEELINA and Budapest

Announcement

The 15^{th} International Symposium on
Capture Gamma-Ray Spectroscopy and Related Topics (CGS15)
will take place in Dresden, Germany,
from **August 25 to August 29, 2014**.

We are looking forward to seeing you there.