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

Ralph Massarczyk

Helmholtz-Zentrum Dresden-Rossendorf

29.05.2013

Outlook

my original idea

- introduction
- experiment
- my results
- other results

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Outlook

Oh oh I got 40 minutes talk...

- ~~introduction~~
- ~~experiment~~
- ~~my results~~
- ~~other results~~

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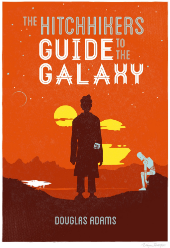
Outlook

Outlook

new idea

My Hitchhiker's Guide to a PhD in nuclear physics ...
...trails and off the beaten track



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My Hitchhiker's Guide to a PhD in nuclear physics ...
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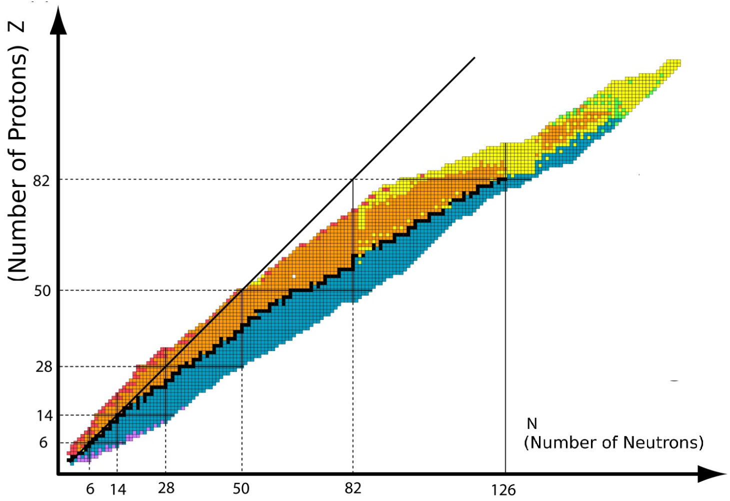
How would such a book look like?

Part I - Maps and Overview



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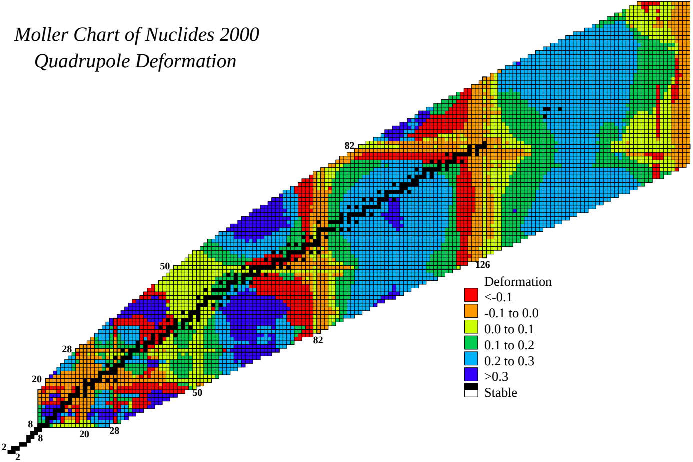
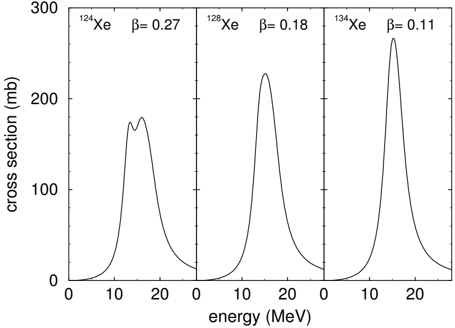


How effects nuclear deformation nuclear reactions ?

Part Ib - A closer view



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

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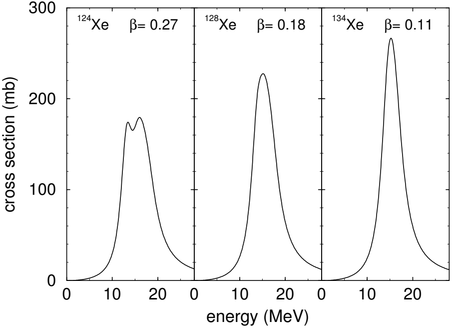

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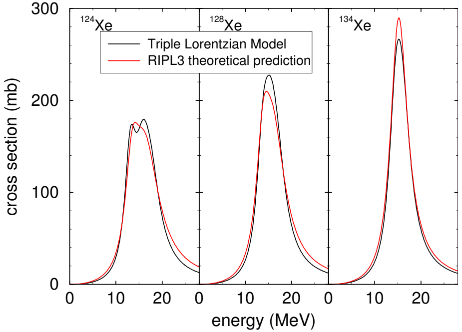

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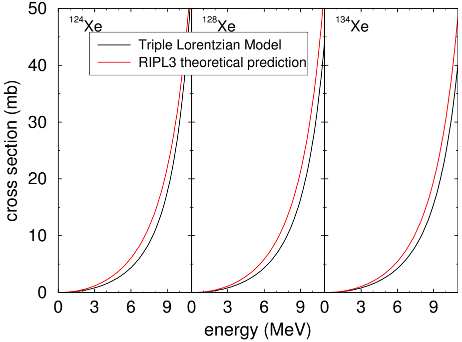

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Part Ic - some background

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 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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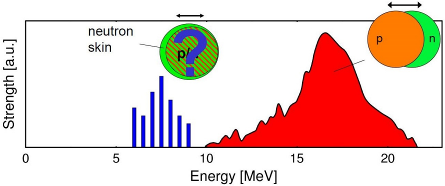

[1]

[1] figure by D.Savran

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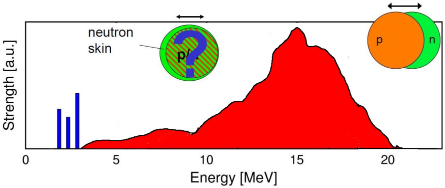

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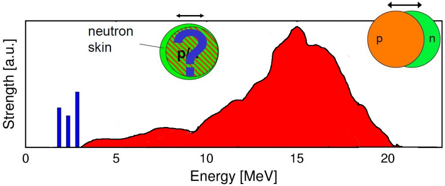

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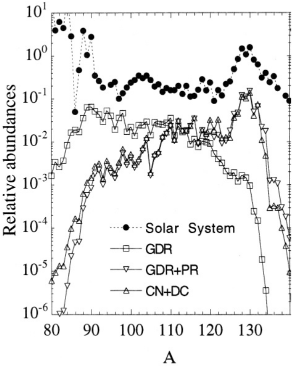

[2]

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

My personal walking tour

- 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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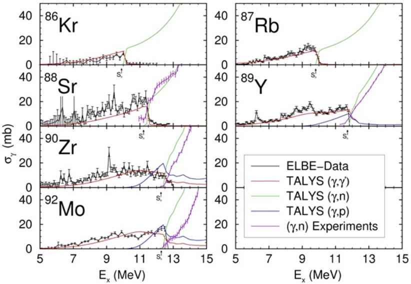

[1] R. Schwengner PRC 87 (2013) 024306

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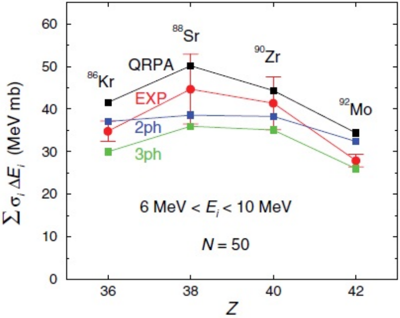

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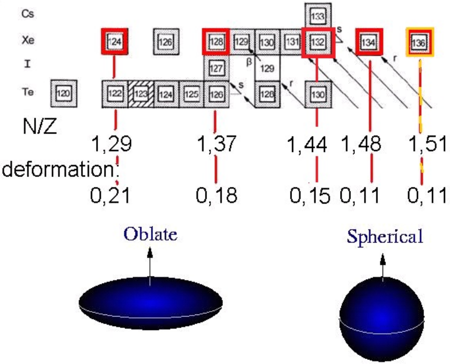

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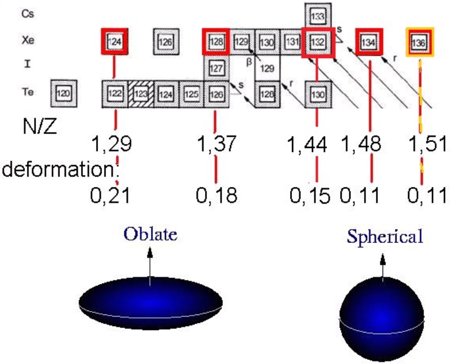

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pro and cons of Xenon

Pro and Contra

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

- rarest not radioactive element on earth
- noble **gas**

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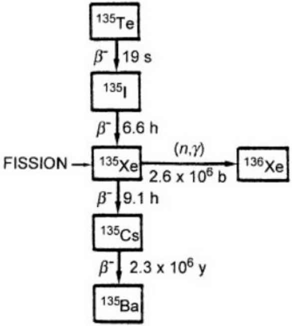

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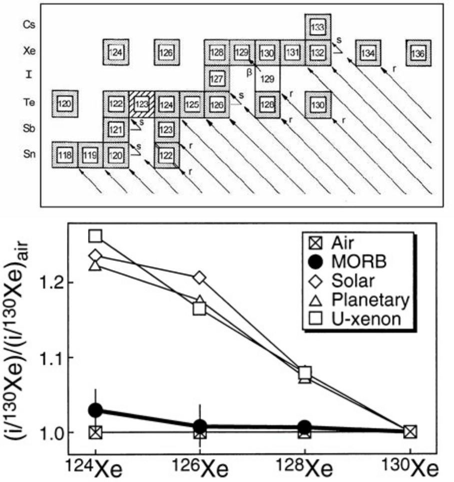

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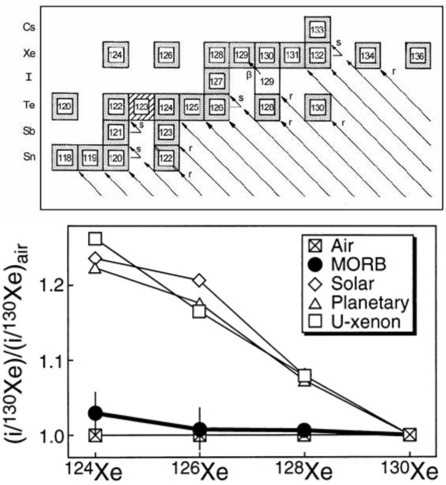

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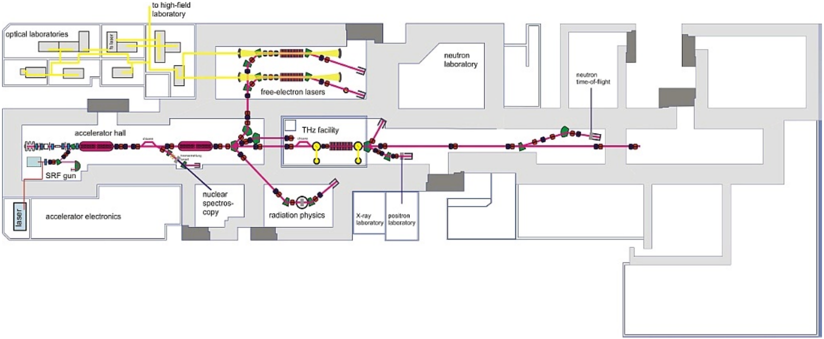
Part II - Sites

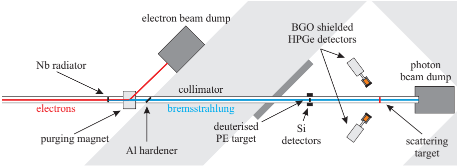
The (new) **ELBE** at Dresden



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

Part II - 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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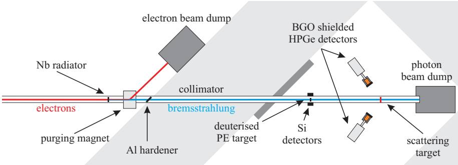

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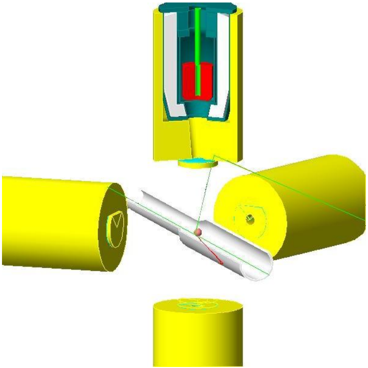
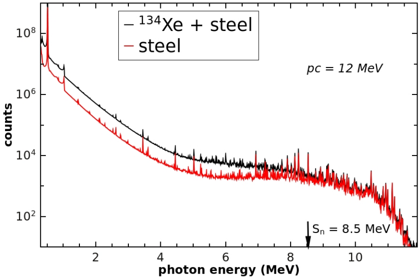


Part III - A walk through the analysis

- subtraction of the background from target container
- correction for efficiency and deconvolution of detector response (GEANT4) [1]
- subtraction of atomic background



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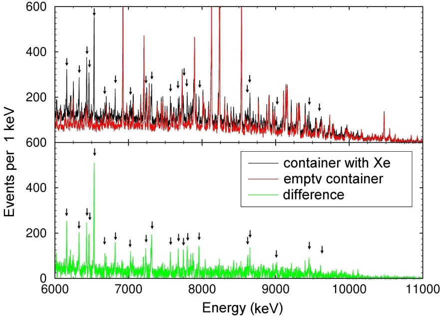

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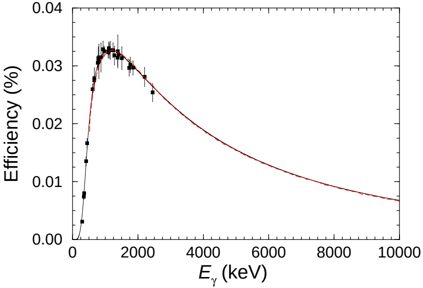

[1] R. Massarczyk PRC 86 (2012) 014319

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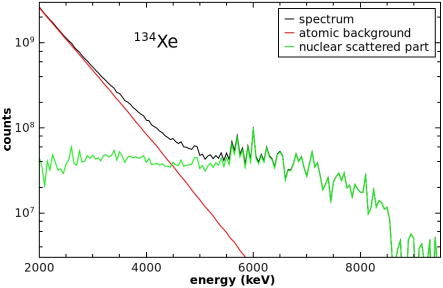

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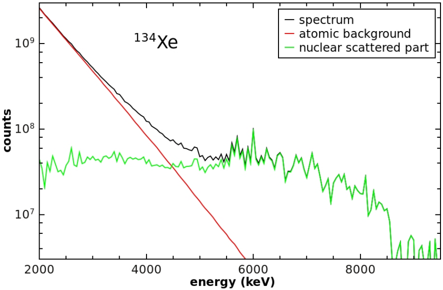
beaten track and an alternative way to go



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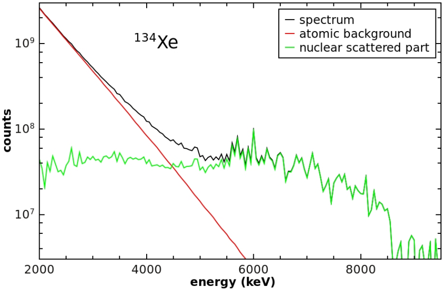

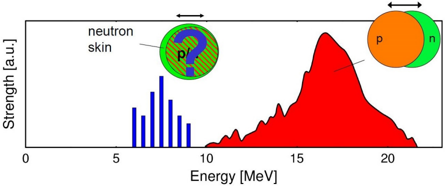

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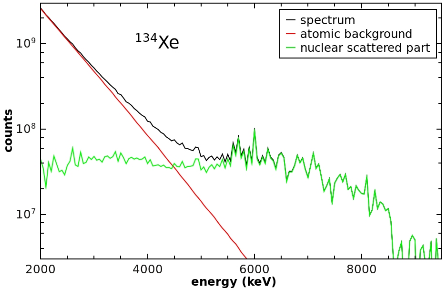

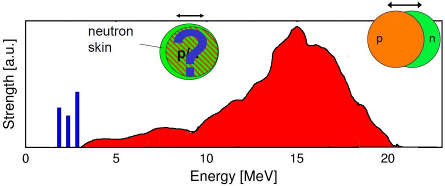

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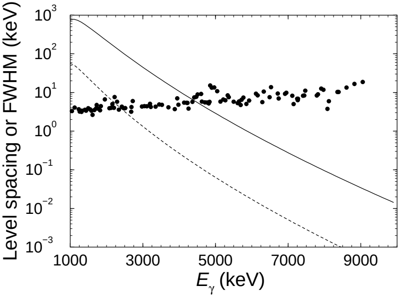

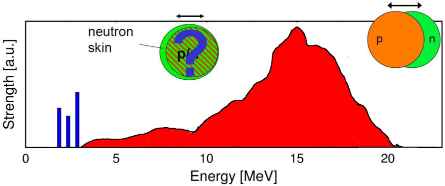

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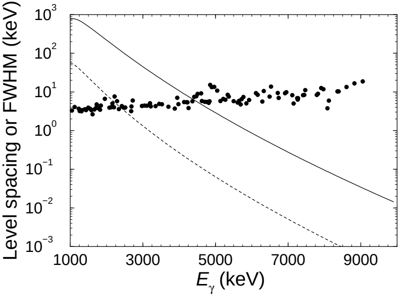
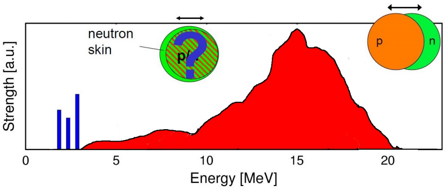
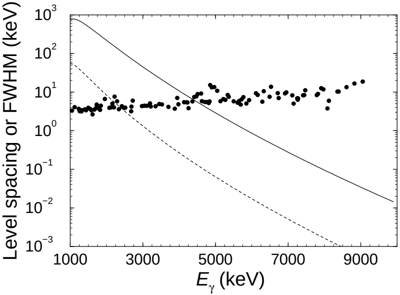
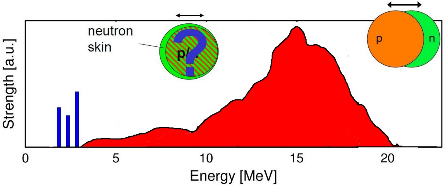




continuum analysis...

beaten track and an alternative way to go





continuum analysis...

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

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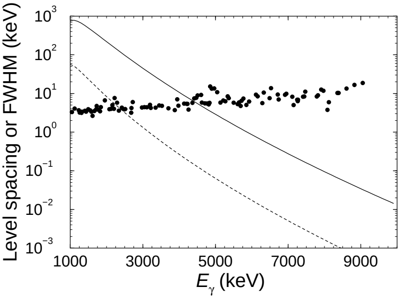

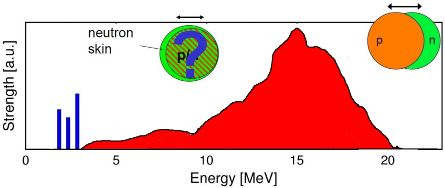

continuum analysis...

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

... but not in nuclear resonance fluorescence experiments

beaten track and an alternative way to go

In this continuum of unresolvable states ...

In this continuum of unresolvable (not overlapping) states ...

beaten track and an alternative way to go

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... we have distributions for strength and level densities, their means, their deviations ...

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In this continuum of unresolvable (not overlapping) states ...

... we have distributions for strength and level densities, their means, their deviations ...

... Why do we still use random numbers and waste computational power ?

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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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[2] T. Kawano Journal of Nucl. Science and Tech. 47 (2010) 462
[3] G. Schramm PRC 85 (2012) 014311

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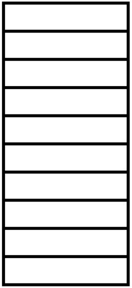
change computer time to computer power !

new calculation method:



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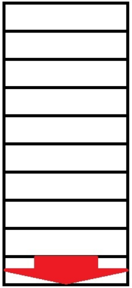
$H_1 = \delta(E_1)$



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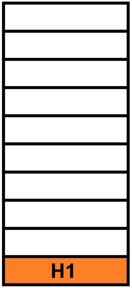

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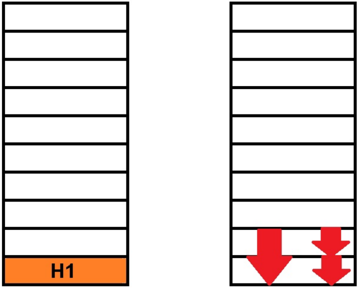
- define Histogram of $2nd$ bin:

$H_2 = \frac{\Gamma_{2\to 0}}{\Gamma_{tot}}\delta(E_2) + \frac{\Gamma_{2\to 1}}{\Gamma_{tot}}H_1$



γDEX 2.0 - off the beaten path

change computer time to computer power !

new calculation method:

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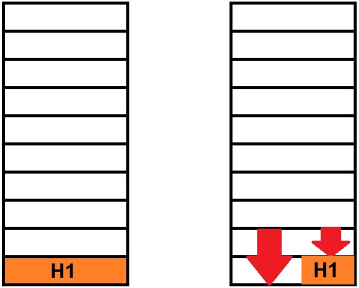

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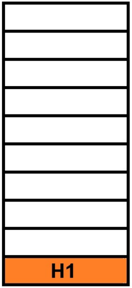

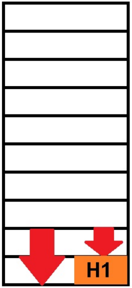

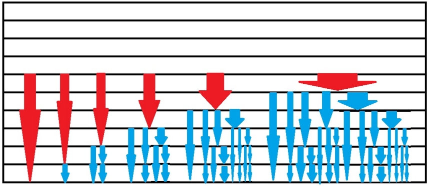

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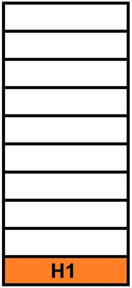

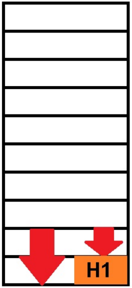

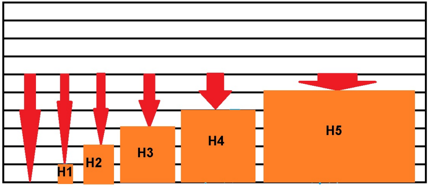

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Problems

- Uncertainty propagation much more complicated
- statistical assumption not true for low energies

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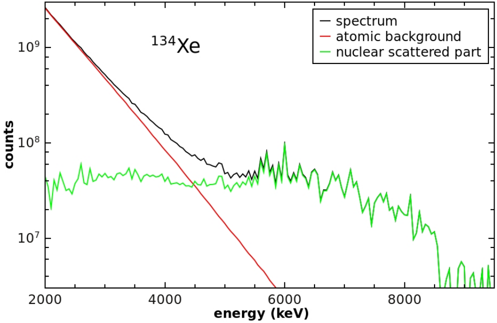
Advantages

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

Back to the experiment

- 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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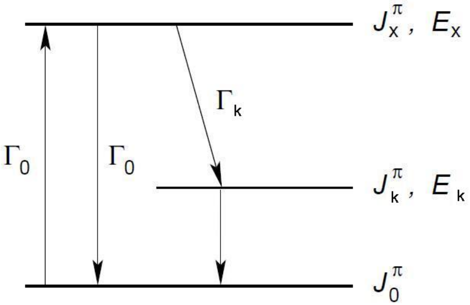

[1] G. Schramm PRC 85 (2012) 014311
[2] R. Massarczyk PRC 87 (2013) 044306

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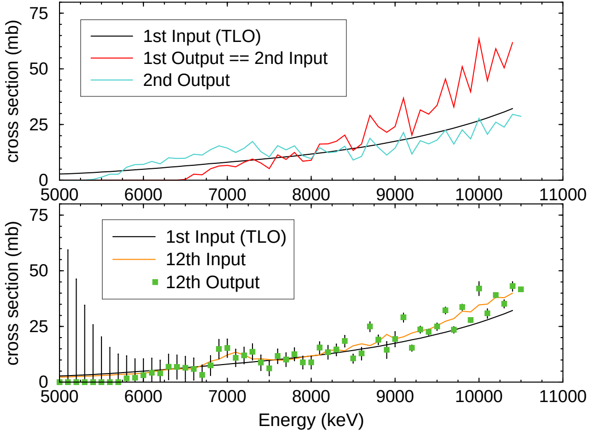

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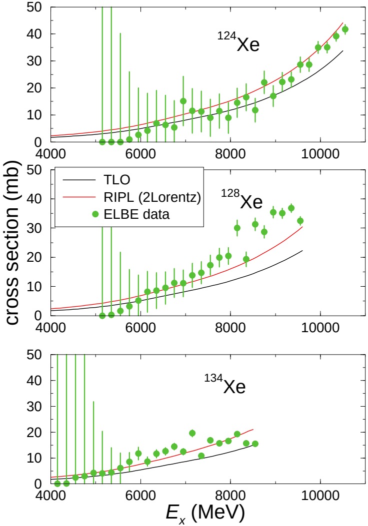
last chapter - results

- Complete dipole strength below the neutron separation energy in gas targets
- QRPA calculations performed [1]



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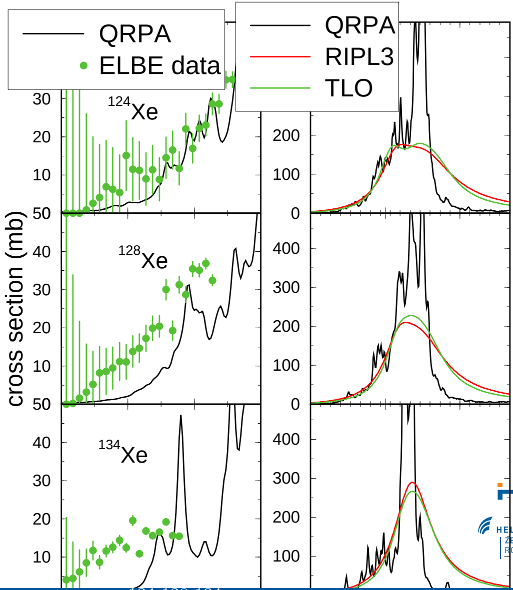
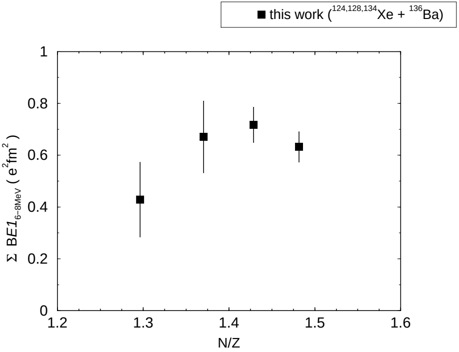


results and theory

- Deviation to other results [1]
- Follows the trend of theory in N/Z plot, extra strength observed



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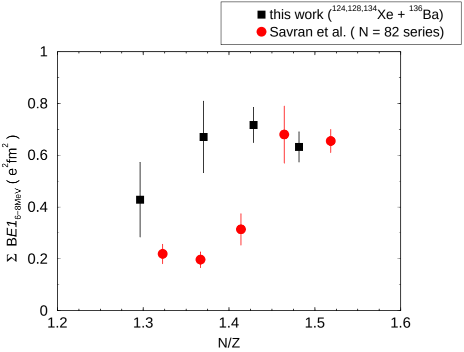

[1] D. Savran PRL 100 (2008) 232501

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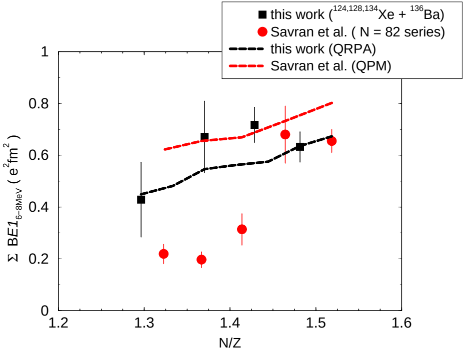

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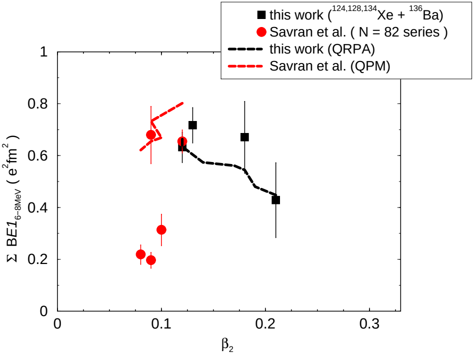

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results and theory

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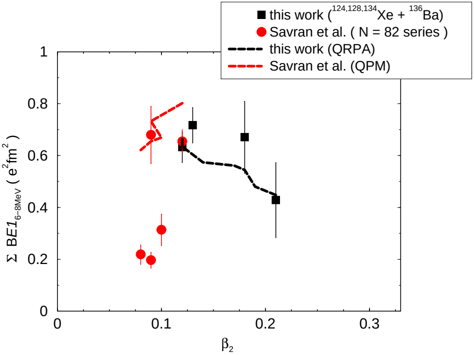
extra strength (pygmy resonance ?)...

... seems to be more dependent on (triaxial) deformation than known so far.



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Conclusions

- determination of dipole strength functions below the neutron separation energy
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Outlook

- additional measurement on ^{130}Xe
- analysis of HIγS Data
- additional work with γDEX in (n,γ) experiments at GEELINA

Thank you for your attention.

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

one last slide

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.