Photon strength function modelling, status and perspectives.

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CNR*24

1- What is a Photon Strength Function ?

Photon Strength Function (PSF)
=
Gamma-ray Strength Function (GSF)

What is a Gamma-ray Strength Function ?

A

That's what metamorphoses Bruce Banner into the Hulk

Someone outside the nuclear community

C

It is a Talys code input.

Nuclear data and reaction community

B

It is proportional to the probability of gamma absorption

Nuclear spectroscopy community

D

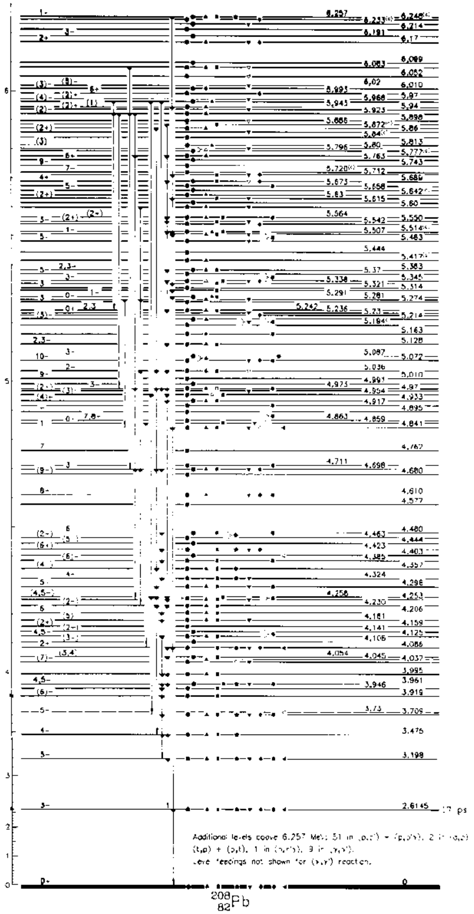
It is proportional to the probability of gamma emission.

Nuclear spectroscopy community

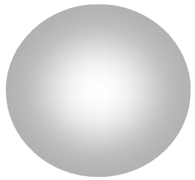
Why would a nucleus want to emit (or absorb) a gamma?

To decrease (or excite) from an excited state to another one.

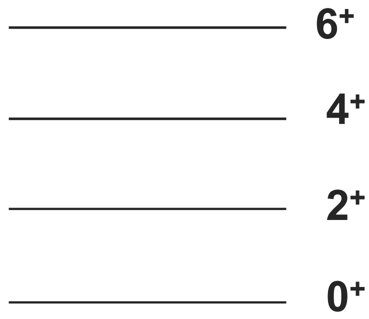
Global knowledge of nuclear excitations



Spherical nucleus — Vibrational spectra

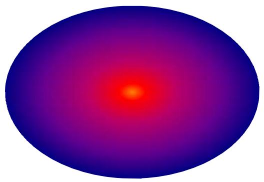


$E^* \propto J$



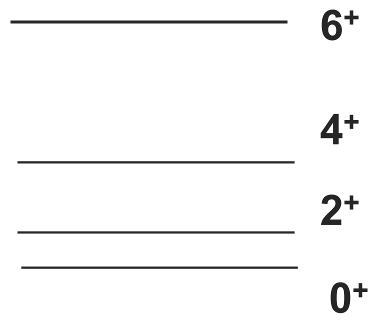
Oscillations around the ground state shape

Deformed nucleus — Rotational spectra



$E^* \propto J(J+1)$

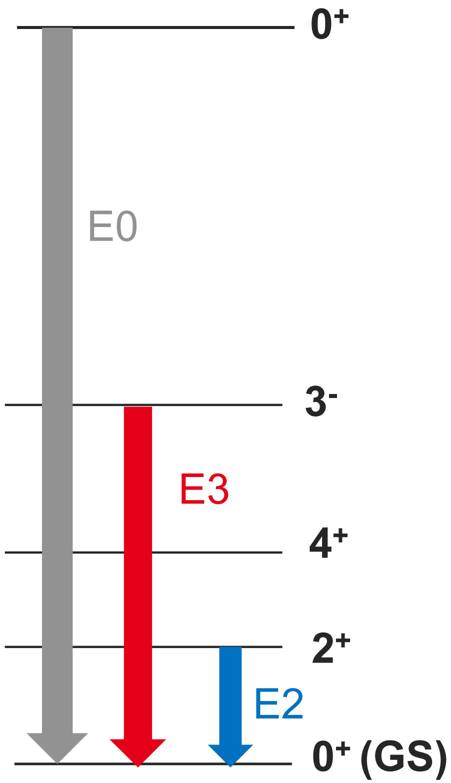
Frequency of the rotation

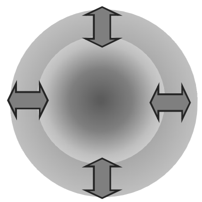


Electromagnetic excitations and shape oscillations

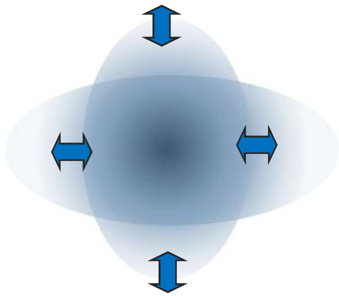
The multipole order L of the transition follows the selection rules: $|I_f - I_i| \leq L \leq I_f + I_i$

The parity of the transitions is given by: $\pi = (-)^{l}$ for electric
$\pi = (-)^{l+1}$ for magnetic

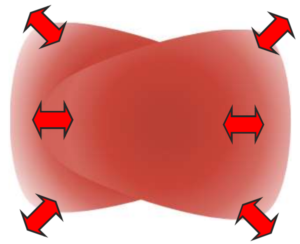




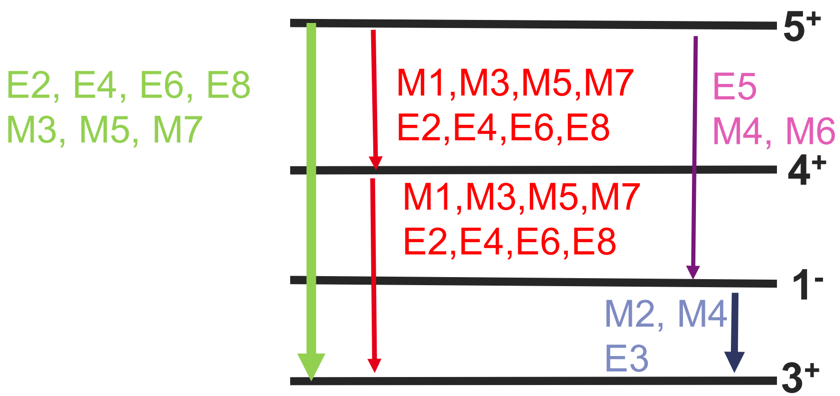
monopole



Quadrupole



Octupole



Electromagnetic excitations and shape oscillations

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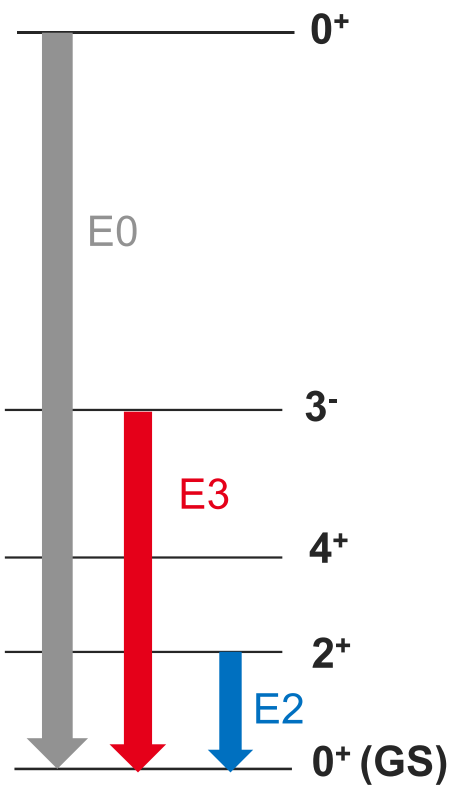
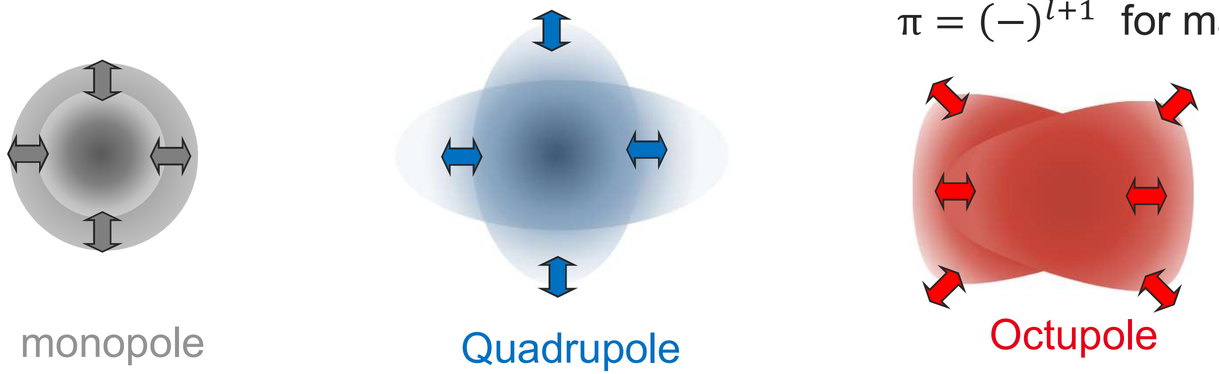
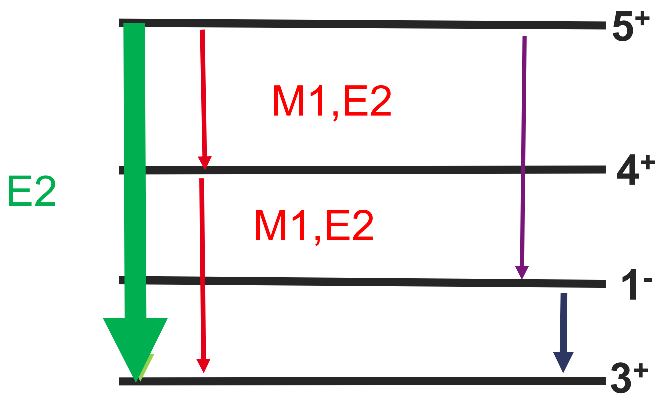
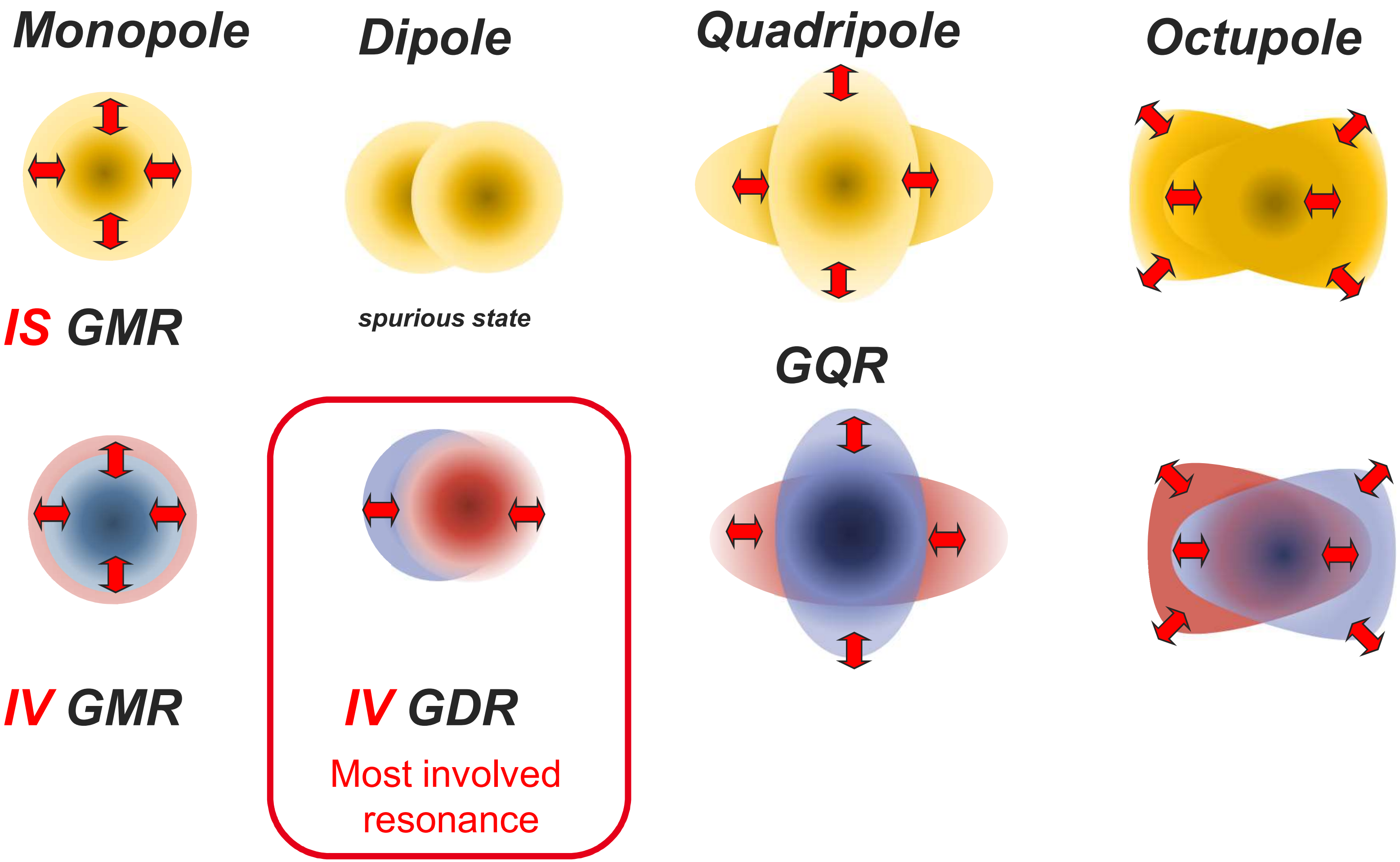






- The lowest multipolarity transition dominates the decay !
- Electric transitions are most probable than magnetic ones.

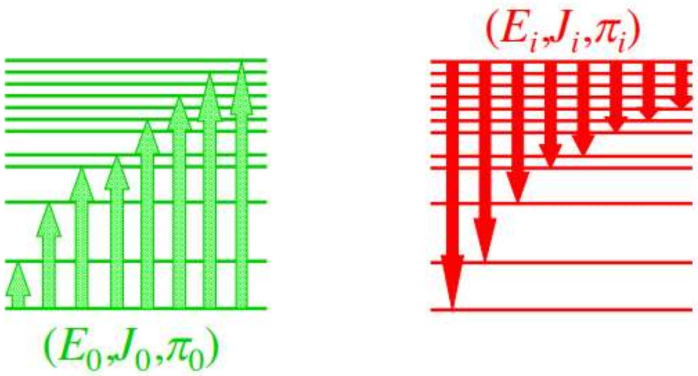
Electromagnetic excitations,
Isospin scalar versus isospin vector



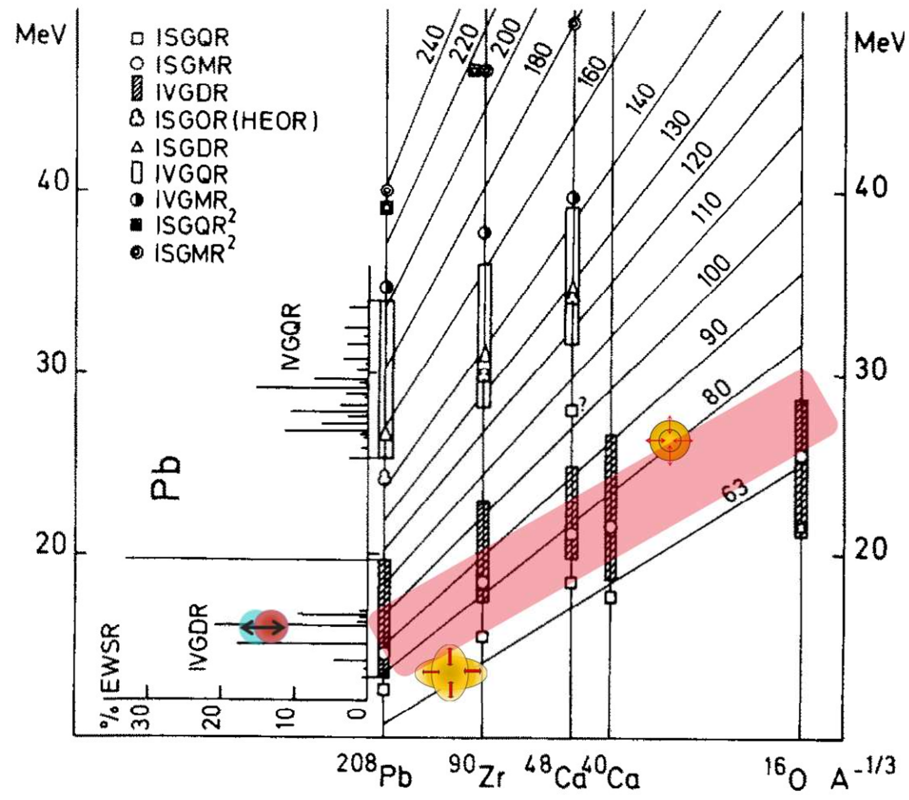
Assumptions and systematic behaviour

Brink hypothesis (1955): The downward strength function on each excited state is equal to the photo-excitation strength function on the GS

$$\overleftarrow{f}_{XL}(\varepsilon_\gamma) = \overrightarrow{f}_{XL}(\varepsilon_\gamma)$$



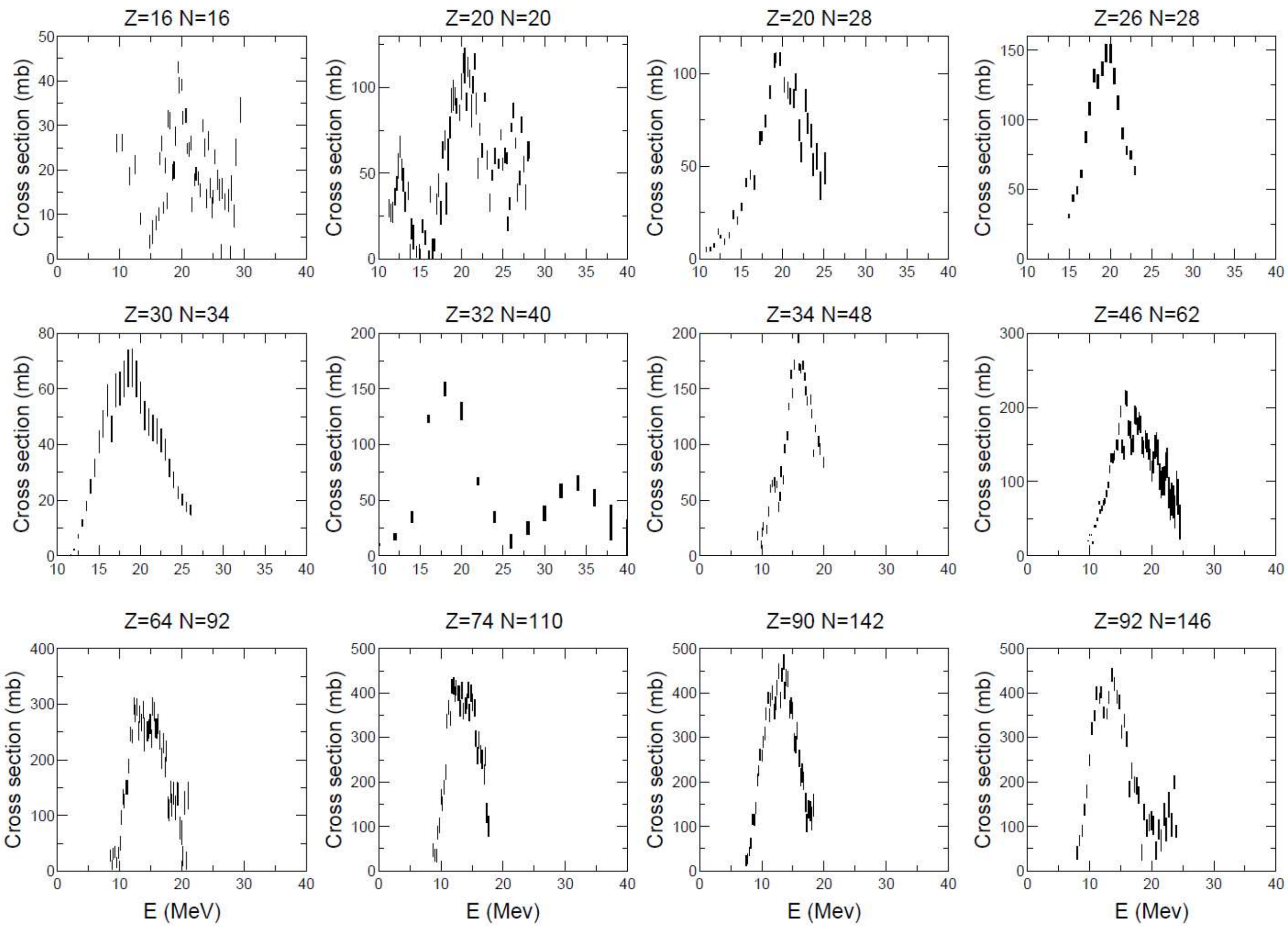
Reaction theory relates the γ-ray transmission coefficient for excited states to the ground state photoabsorption assuming the giant resonance to be built on each excited state, although γ-decay strength functions are expected to depend on the temperature T_f of the final states, which is a function of the excitation energy of de-excited nucleus E_f=E_i-ε_γ



J. Dechargé and L. Sips, NPA 407,1-28 (1983)

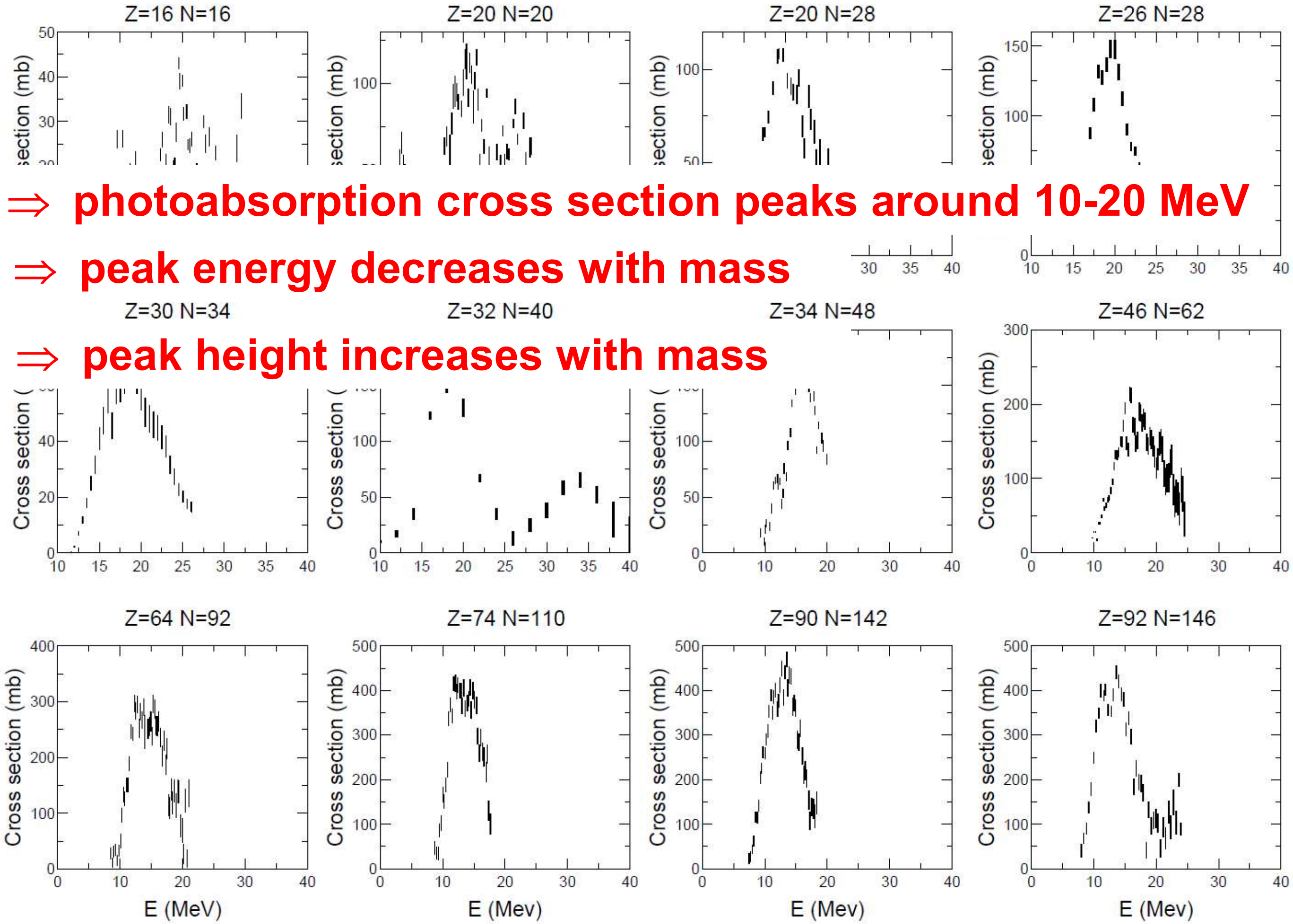
At first approximation, the gamma-ray strength function is mostly related to the dipole mode IVGDR (= γ absorption)

Gamma-ray strengths : qualitative aspects from photoabsorption



Courtesy of S.Hilaire

Gamma-ray strengths : qualitative aspects from photoabsorption



⇒ **photoabsorption cross section peaks around 10-20 MeV**

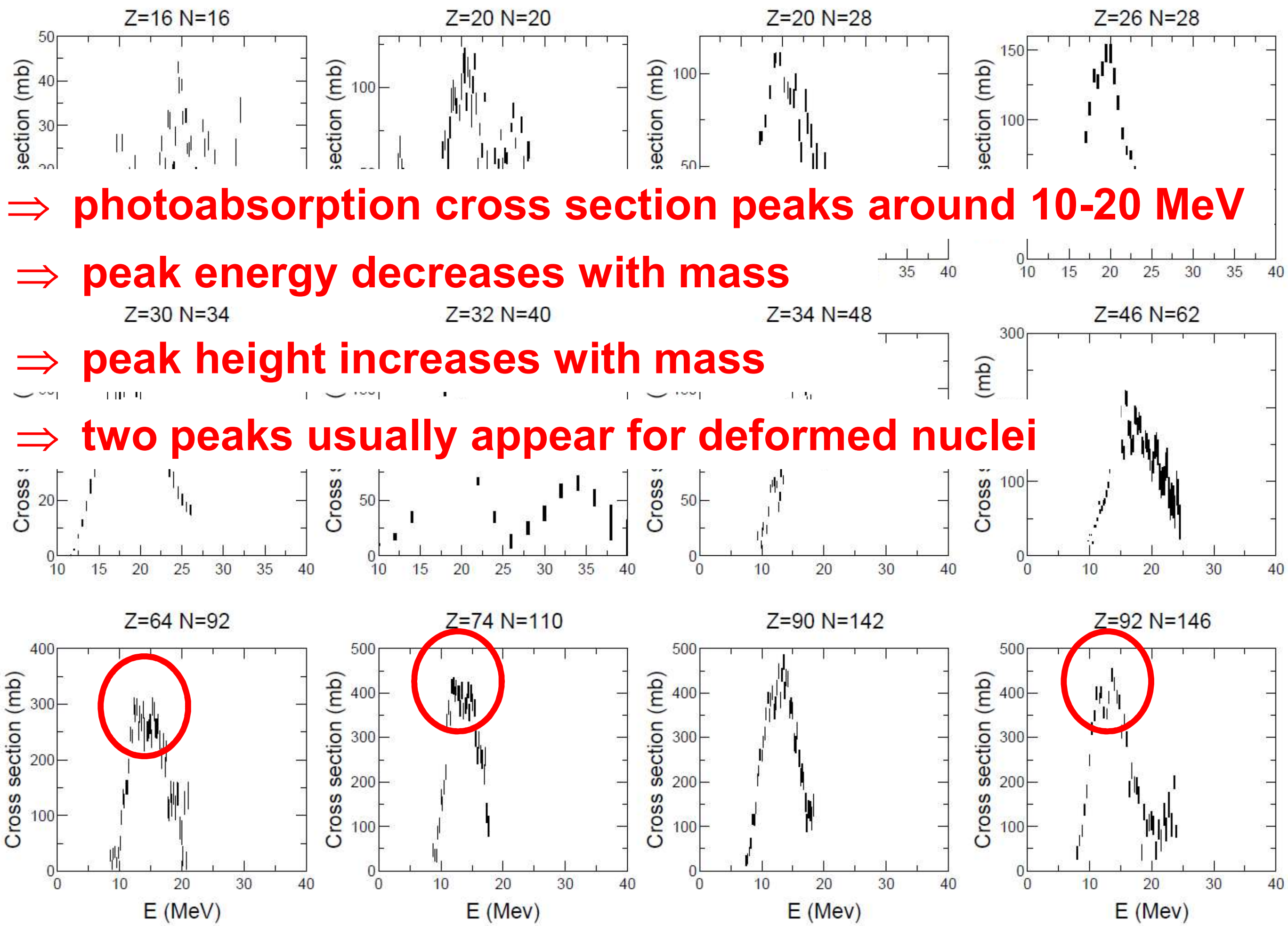
⇒ **peak energy decreases with mass**

⇒ **peak height increases with mass**

Courtesy of S.Hilaire

Gamma-ray strengths : qualitative aspects from photoabsorption

Courtesy of S.Hilaire

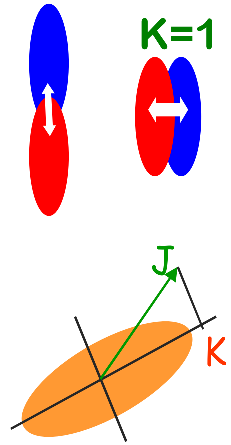


⇒ photoabsorption cross section peaks around 10-20 MeV

⇒ peak energy decreases with mass

⇒ peak height increases with mass

⇒ two peaks usually appear for deformed nuclei



2. Some Gamma-ray strength models

Focus on models able to provide systematics: input list of Talys code

Gamma-ray strength function = Talys input

Various options in Talys for various Gamma-ray strengths:

Phenomenological or analytic form

- strength = 1 : GLO model
- strength = 2 : SLO model
- strength = 3 : Skyrme-HFBCS + QRPA
- strength = 4 : Skyrme-HFB + QRPA
- strength = 5 : Hybrid model
- strength = 6 : *T*-dependent Skyrme-HFB + QRPA
- strength = 7 : *T*-dependent RMF-HFB + QRPA
- strength = 8 : Gogny-HFB + QRPA
- strength = 9 : SMLO
- strength =10 : T-dependent BSk27-HFB + QRPA

Gamma-ray strength function: some analytic forms

Standard Lorentzian (SLO)

[D.Brink. PhD Thesis(1955); P. Axel. PR 126(1962)]

$$\overleftarrow{f} = \overrightarrow{f} \sim \frac{E_\gamma \Gamma_r^2}{(E_\gamma^2 - E_r^2)^2 + E_\gamma \Gamma_r^2} \Rightarrow_{E_\gamma \to 0} 0$$

Explicit Brink hypothesis

Generalized Lorentzian (GLO)

[Kopecky & Uhl 1990]

$$f_{E1}(E_\gamma, T) = K_{E1}\left[\frac{E_\gamma \tilde{\Gamma}_{E1}(E_\gamma)}{(E_\gamma^2 - E_{E1}^2)^2 + E_\gamma^2 \tilde{\Gamma}_{E1}(E_\gamma)^2} + \frac{0.7\Gamma_{E1} 4\pi^2 T^2}{E_{E1}^3}\right]\sigma_{E1}\Gamma_{E1}$$

with $\tilde{\Gamma}_{E1}(E_\gamma) = \Gamma_{E1}\frac{E_\gamma^2 + 4\pi^2 T^2}{E_{E1}^2}$ and $T = \sqrt{\frac{E_n + S_n - \Delta - E_\gamma}{a(S_n)}}$

Here, the width depends on gamma energy and temperature which violates Brink hypothesis!

Gamma-ray strength function: some analytic forms

Standard Lorentzian (SLO)

Generalized Lorentzian (GLO)

Hybrid Model

[S. Goriely 1998]

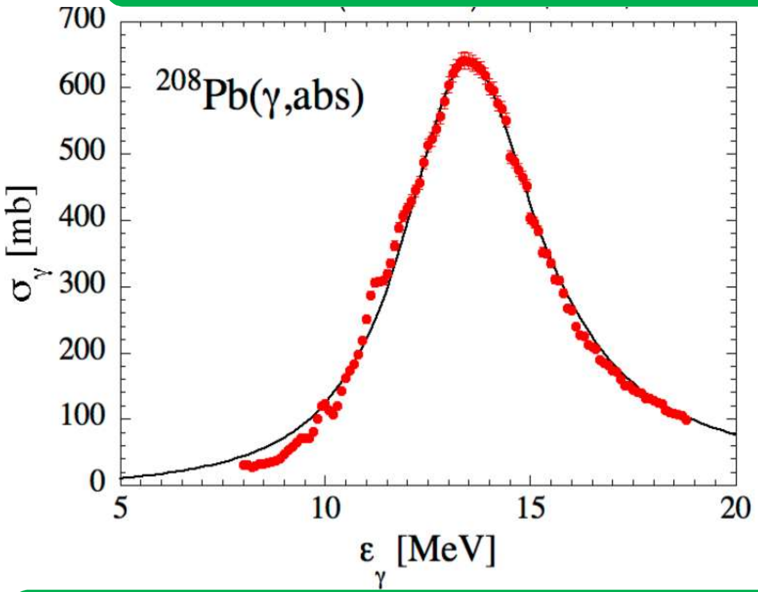
Similar to GLO for GDR with an improved description of the low energy GDR tail following the fermi liquid model of Kadmenskii et al (1987).

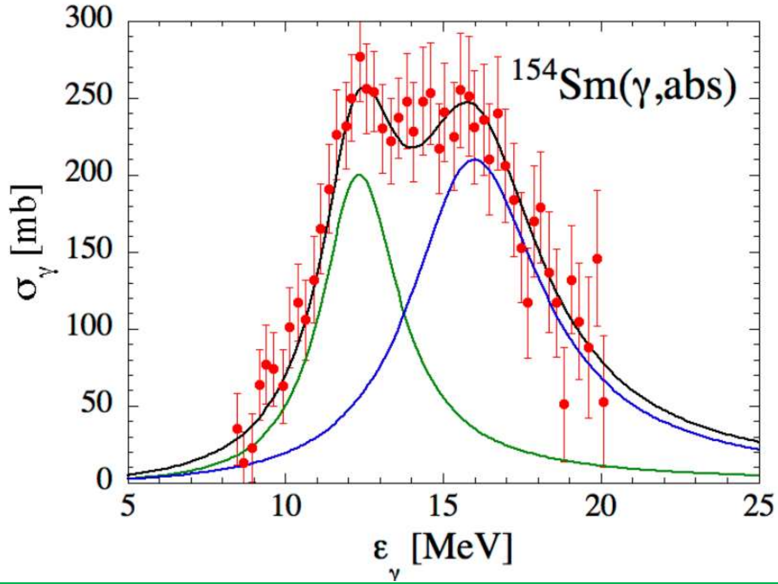
Gamma-ray strength function: some analytic forms

Standard Lorentzian (SLO)

Generalized Lorentzian (GLO)

Hybrid Model





For axially deformed nuclei, the GLO, SLO and Hybrid strength is split into 2 Lorentzians !

Gamma-ray strength function: some analytic forms

The Simplified M1 Lorentzian Model (SMLO) 2019

$$\overrightarrow{f_{M1}}(\varepsilon_\gamma) = \frac{1}{3\pi^2\hbar^2c^2}\sigma_{sc}\frac{\varepsilon_\gamma\,\Gamma_{sc}^2}{(\varepsilon_\gamma^2 - E_{sc}^2)^2 + \varepsilon_\gamma^2\Gamma_{sc}^2}$$

Scissors mode for deformed nuclei

$$+\frac{1}{3\pi^2\hbar^2c^2}\sigma_{sf}\frac{\varepsilon_\gamma\,\Gamma_{sf}^2}{(\varepsilon_\gamma^2 - E_{sf}^2)^2 + \varepsilon_\gamma^2\Gamma_{sf}^2}$$

Spin-Flip mode

where the SMLO M1 properties are inspired from the D1M+QRPA predictions

$$\overleftarrow{f_{M1}}(\varepsilon_\gamma) = \overrightarrow{f_{M1}}(\varepsilon_\gamma) + C\exp(-\eta\varepsilon_\gamma)$$

M1 upbend for de-excitation

where the upbend properties are inspired from the Shell Model predictions

$C = 3.5\ 10^{-8}\exp(-6\beta_2)\ \mathrm{MeV}^{-3}$

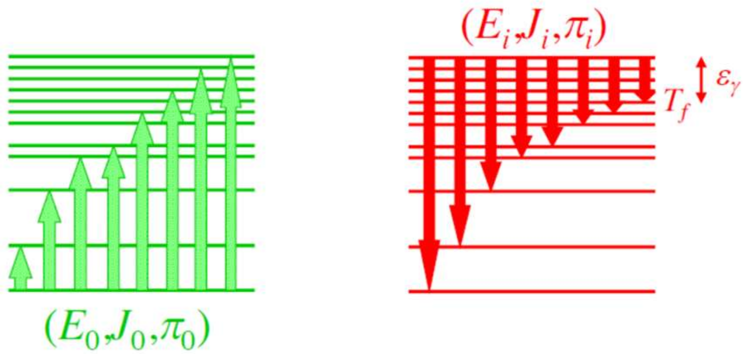
$\eta = 0.8$

Schwengner et al. 2017
Sieja 2017
Midtbø et al. 2018
...

Presence and impact of possible low-energy M1 upbend: Violation of the Brink Hypothesis!

$$\overleftarrow{f}_{E1}(\varepsilon_\gamma) \neq \overrightarrow{f}_{E1}(\varepsilon_\gamma)$$

$$\overleftarrow{f}_{E1} = \overleftarrow{f}_{E1}(\varepsilon_\gamma, T_f)$$



Gamma-ray strength function = Talys input

Various options in Talys for various Gamma-ray strengths:

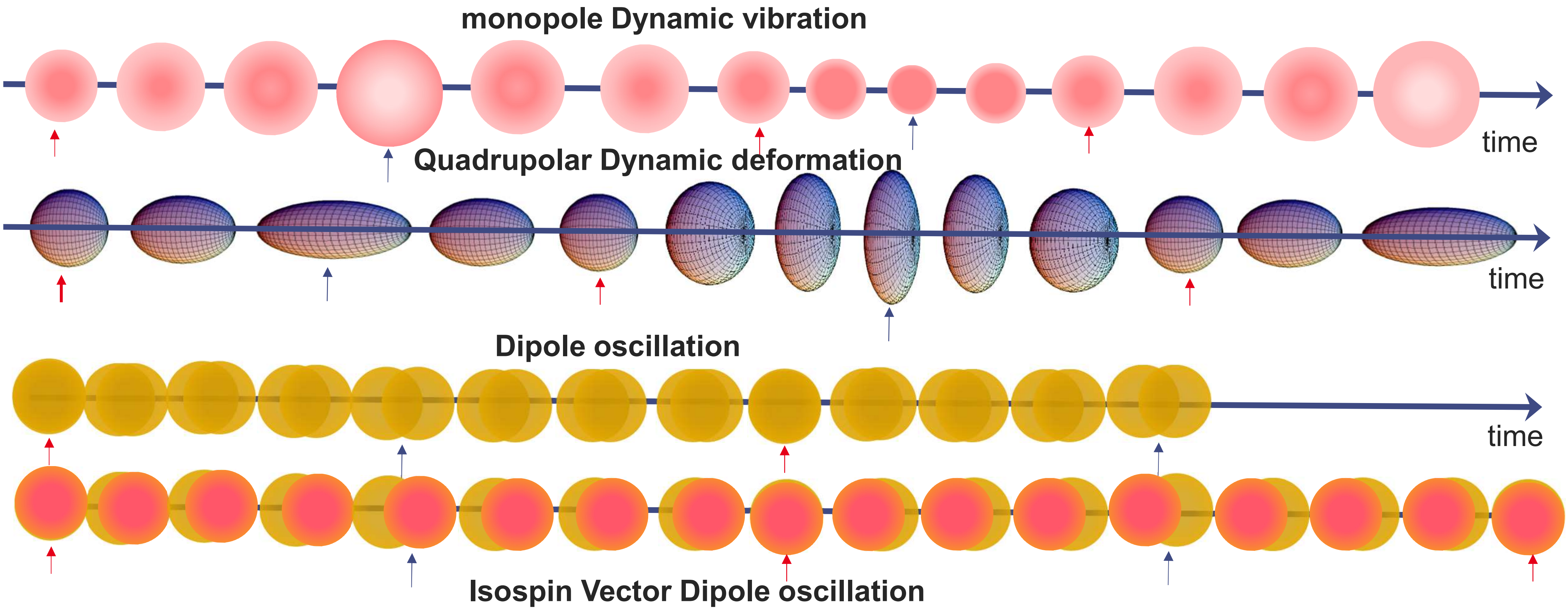
Contains microscopic ingredients

- strength = 1 : GLO model (Kopecky & Uhl 1990)
- strength = 2 : SLO model
- strength = 3 : Skyrme-HFBCS + QRPA
- strength = 4 : Skyrme-HFB + QRPA
- strength = 5 : Hybrid model
- strength = 6 : *T*-dependent Skyrme-HFB + QRPA
- strength = 7 : *T*-dependent RMF-HFB + QRPA
- strength = 8 : Gogny-HFB + QRPA
- strength = 9 : SMLO 2019
- strength =10 : T-dependent BSk27-HFB + QRPA

What is the standard QRPA approach ?

The (Q)RPA methods describe nuclear excited states for all multipoles and both parities, whatever the intrinsic deformation of the ground state.

Quadrupole, octupole and higher multipolarities can be obtained even on top of spherical shapes.

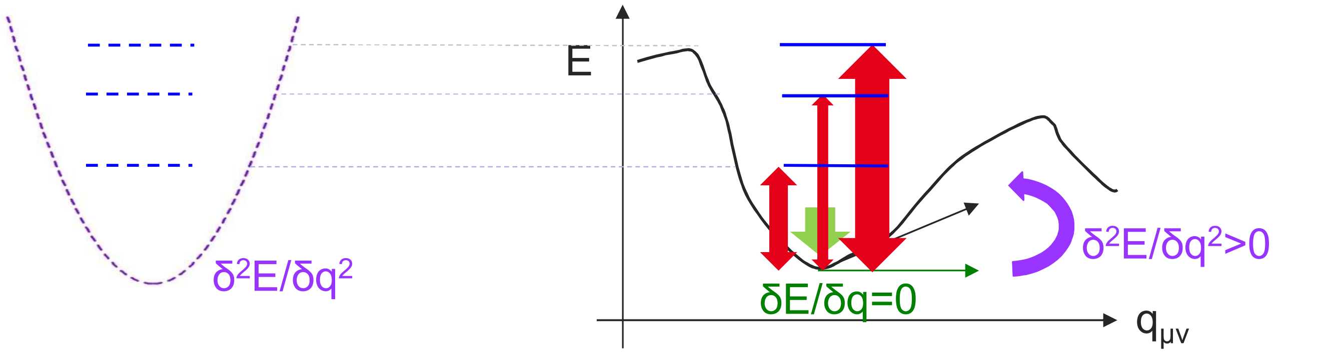


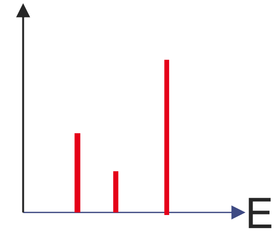
What is the standard QRPA approach ?

The (Q)RPA methods describe nuclear excited states for all multipoles and both parities whatever the intrinsic deformation of the ground state.

Main approximation:
Linear response, i.e. harmonic potential approximation

No rotational motion included even for deformed nuclei !





Generally, the discrete spectra is folded with a Lorentzian function

$$f_L(E, E_i, \gamma_i) = \frac{2}{\pi} \frac{\gamma_i E^2}{(E^2 - E_i^2)^2 + \gamma_i^2 E^2}$$

Most of the “RPA” based gamma strength function models impose the spherical invariance.
For deformed nuclei, phenomenological split of the IVGDR with SLO, GLO and hybrid recipe.

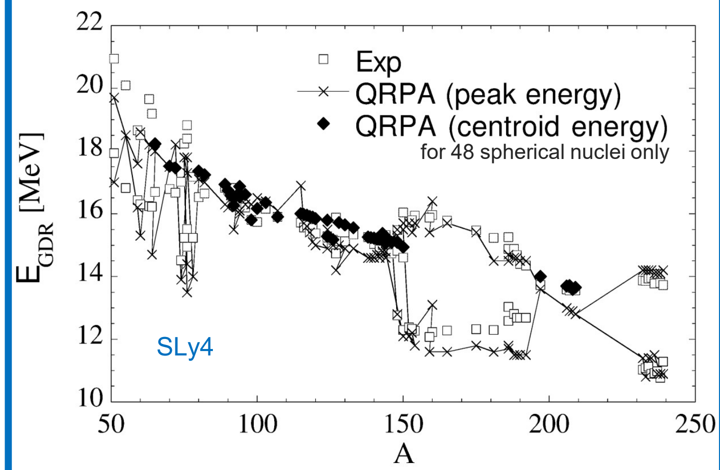
$$E^1_{\text{GDR}} + 2E^2_{\text{GDR}} = 3E_{\text{GDR}} \qquad E^2_{\text{GDR}}/E^1_{\text{GDR}} = 0.911\eta + 0.089$$

η being ratio between symmetry and perpendicular radii

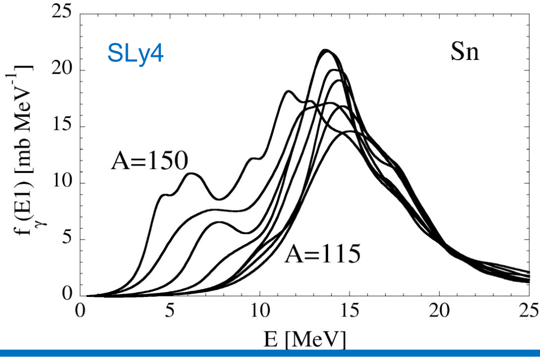
Microscopic systematic with “spherical” QRPA

QRPA based on HF + BCS

[S. Goriely and E. Khan, NPA706 (2002) 217-232]

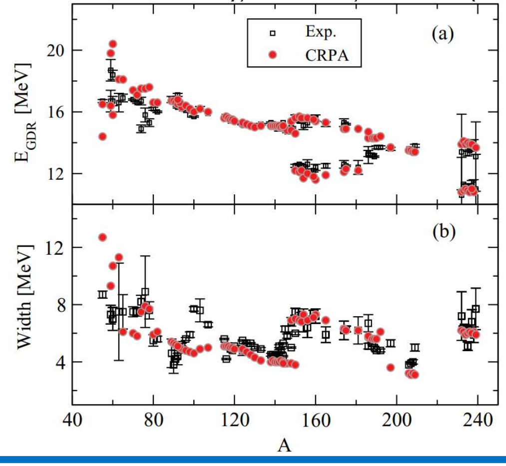


Microscopic input of PDR



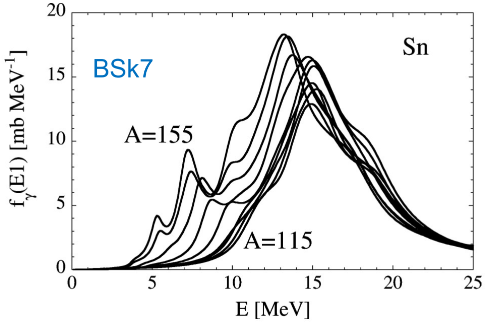
T-dependent RMF-HFB + QRPA

[I. Daoutidis and S. Goriely, PRC 86, 034328 (2012)]



QRPA based on HFB

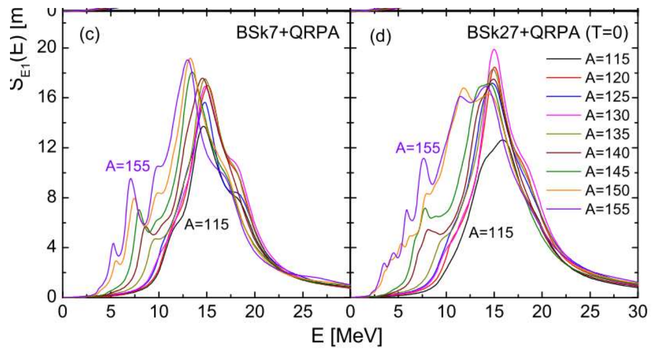
[S. Goriely, E. Khan,M. Samyn, NPA 739 (2004)331-352]



T-dependent Skyrme-HFB + QRPA
T-dependent BSk7-HFB+QRPA

The temperature effects are included in a phenomenological way in gamma strength function Γ(E,T)

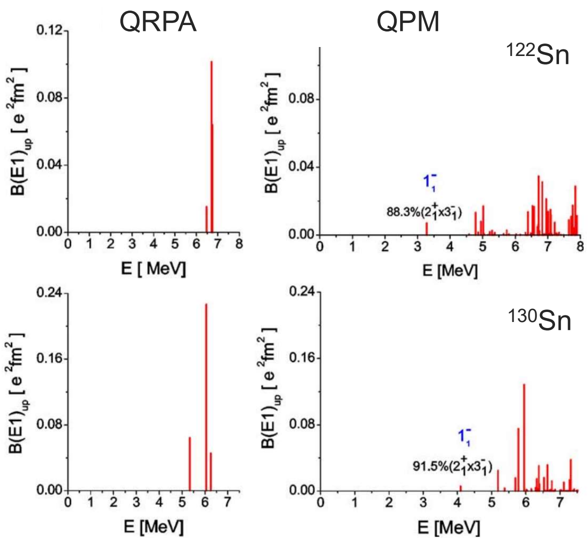
T-dependent BSk27-HFB + QRPA



[Y. Xu et al, PRC 104, 044301 (2021)]

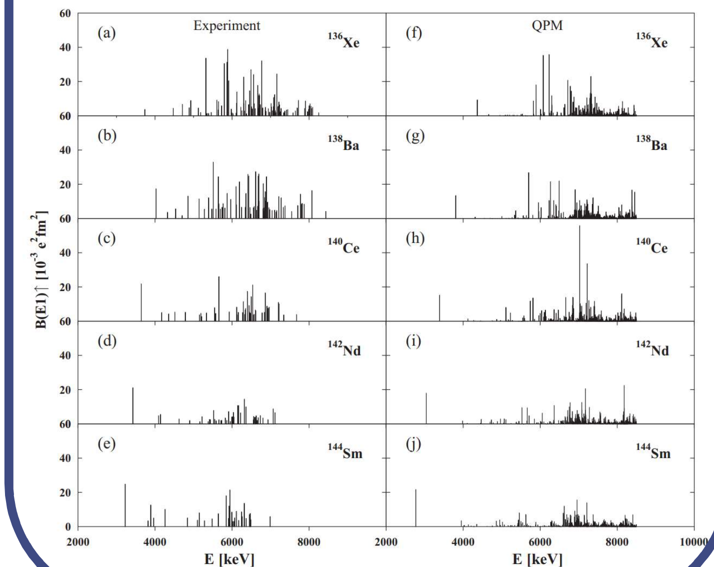
Other theoretical models applied to spherical isotopes or light nuclei

Quasiparticle– Phonon Model with HFB input



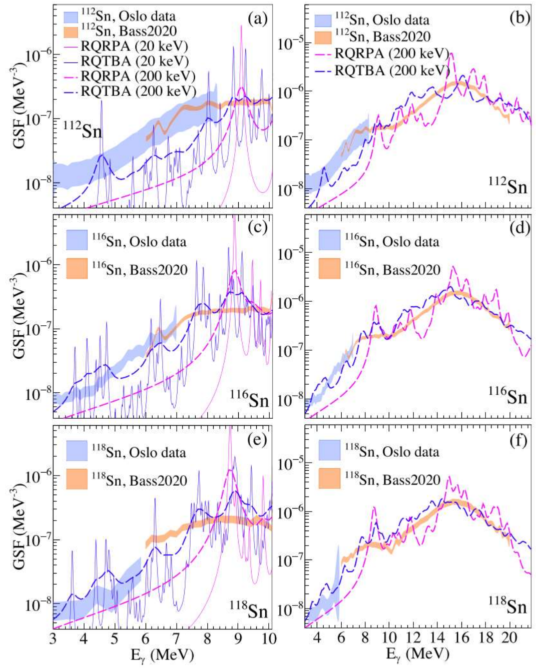
N. . Tsoneva et al, PLB 586 (2004) 213–218

QPM including complex configurations of up to three phonons



D. Savran et al,PRC84, 024326 (2011)

Ab initio-based Model

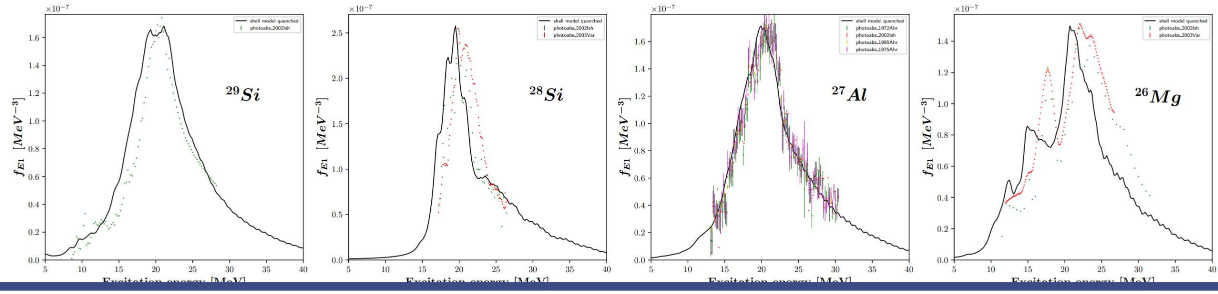


M. Markova et al,PRC 109, 054311 (2024)

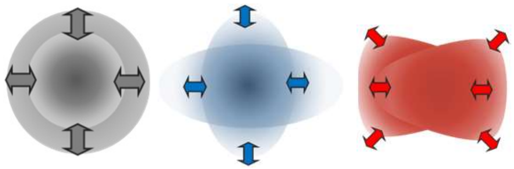
Shell Model Photo-Strength Functions

Oscar Le Noan (PhD) and Kamila Sieja

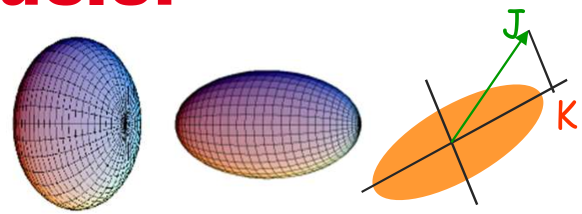
9th Workshop on Level Density and Gamma Strength, Olso 2024



QRPA approach for intrinsic deformed nuclei



Dynamic deformations versus intrinsic (static) ones



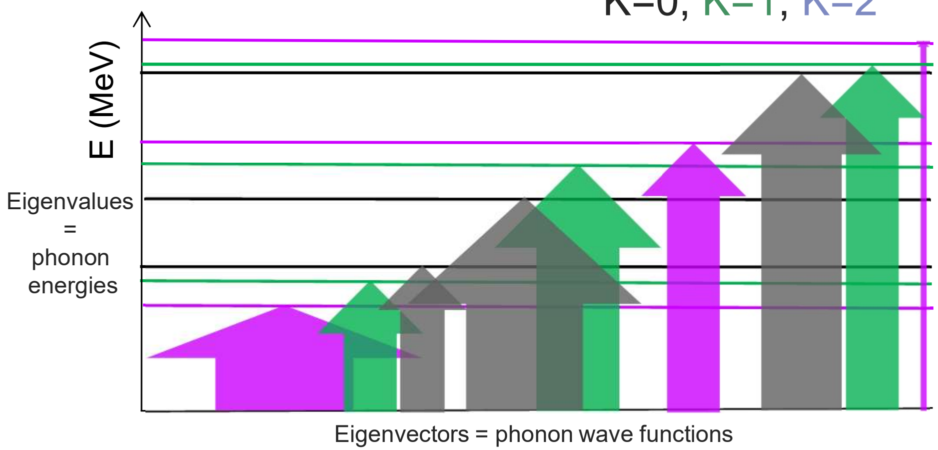
The axially-symmetric-deformed QRPA approach (ISAAC code) using matrix representation allows to provide excited state wave functions, excitation energies as well as transitions probabilities and densities from the GS to excited states and reverse.

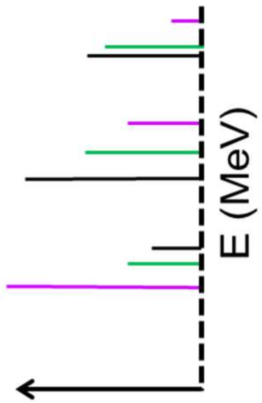
ISAAC describes excited states, transition probabilities for intrinsically deformed nuclei with axial symmetry.

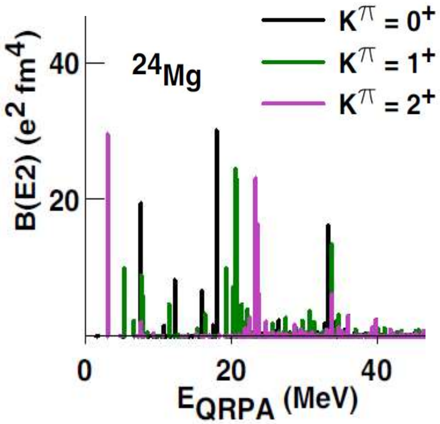
[S. Péru and M. Martini, Eur. Phys. J. A (2014) 50: 88]

And the results are:

K=0, K=1, K=2





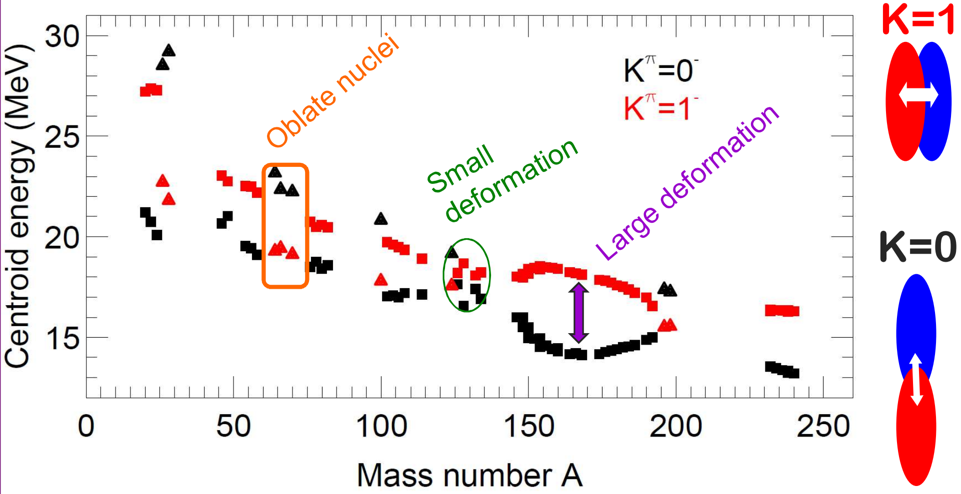


[S. Péru and H. Goutte, PRC77, 044313 (2008)]

D1M HFB+QRPA in axial symmetry applied to E1 and M1 strength

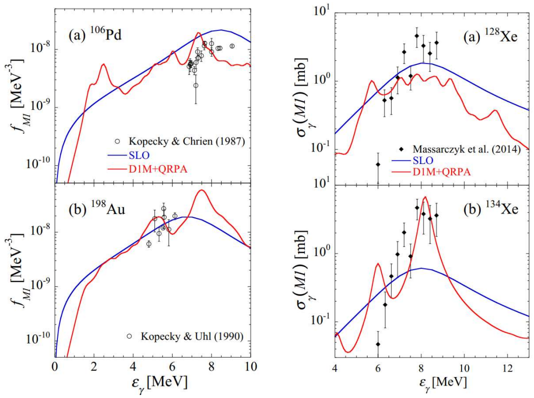
Magnetic and electric modes on the same footing

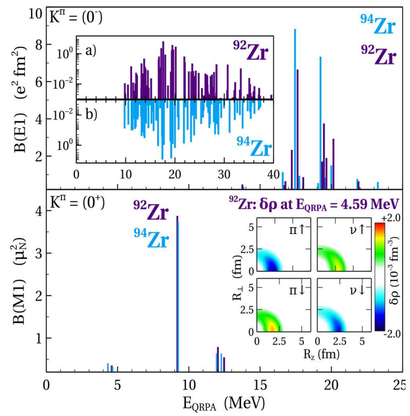
Impact of the deformation



[M. Martini et al, PRC 94, 014304 (2016)]

S. Goriely et al, PRC 94, 044306 (2016

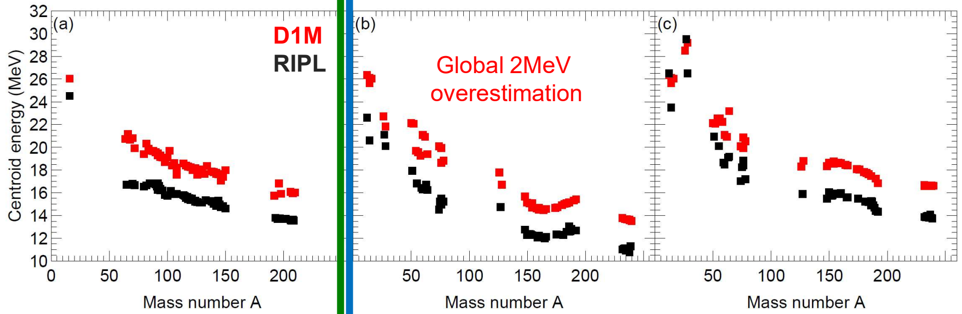


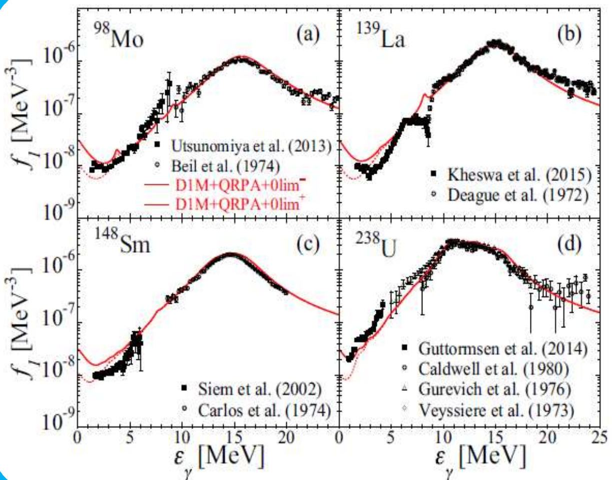


I.Deloncle et al, EPJA 53:170(2017)

Spherical nuclei
One Lorentzian in RIPL

Deformed nuclei
Two Lorentzians in RIPL





Gogny-HFB + QRPA

[S. Goriely et al, PRC98,014327 (2018)]

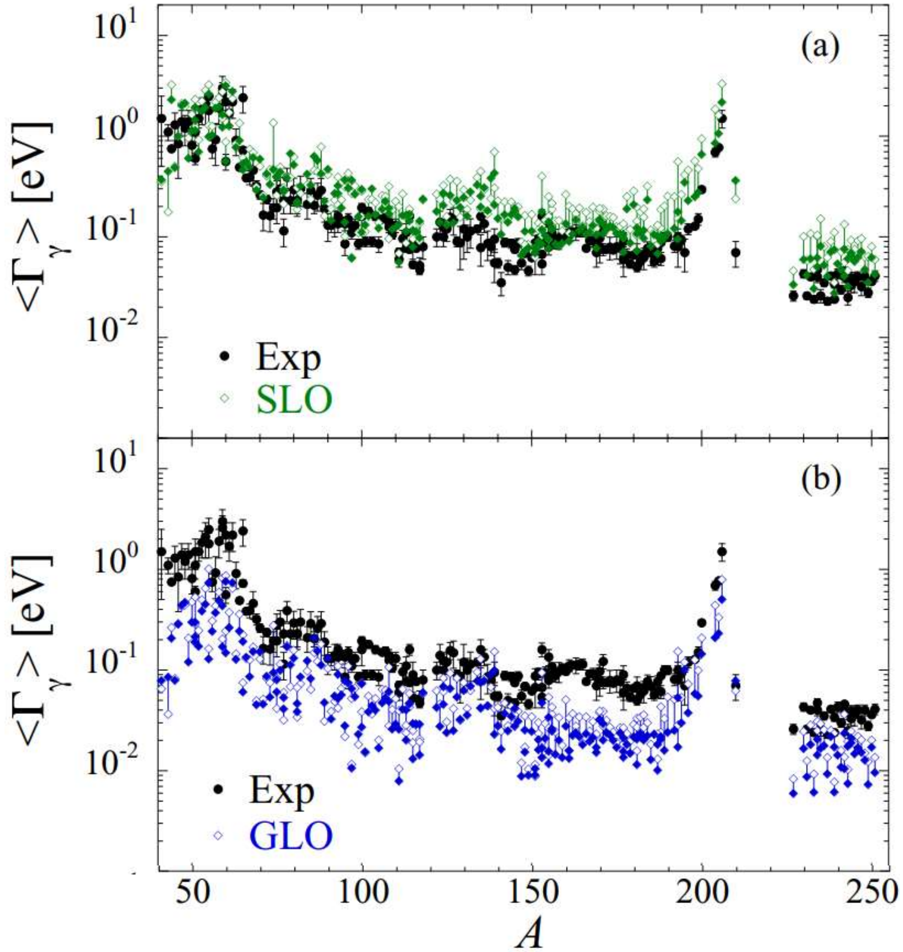
QRPA B(E1) and B(M1)

- Lorentzian folding
- shift in energy to fit data

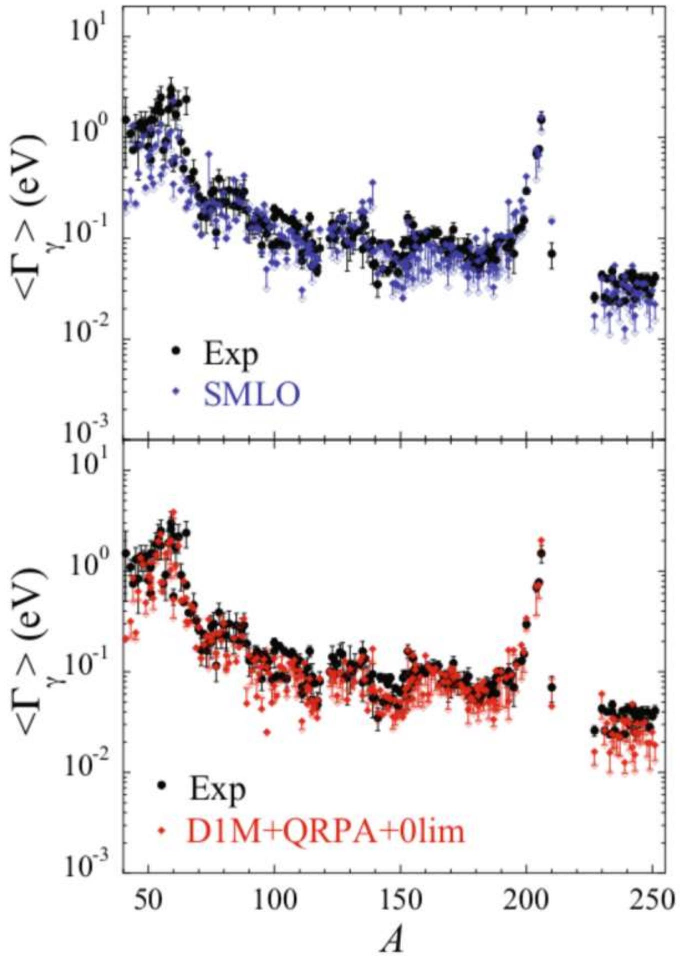
Phenomenological **upbend** inspired by shell model for the decay strength

Gamma-ray strengths: D1M(0lim) versus analytical

S. Goriely, S. Hilaire, S. Péru, and K. Sieja, PRC 98, 014327 (2018)



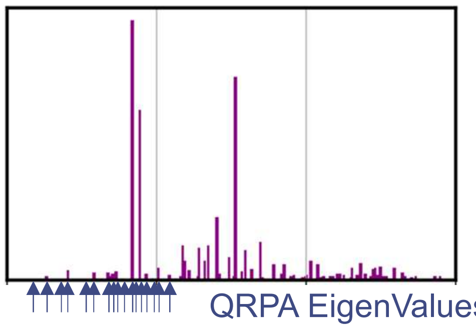
S. Goriely et al, EPJA (2019) 55: 172



Alternative resolution of QRPA equations

Full matrix filling and diagonalization

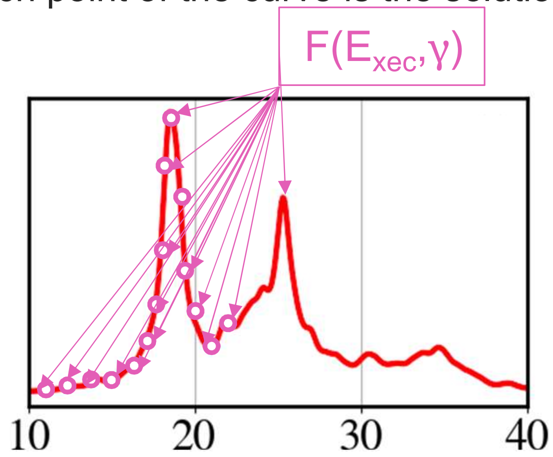
Both excitations energies and phonon wave functions are obtained as eigenvalues and eigenvectors.



Require optimized codes running on supercomputers to reduce the “human” computational time and to share the available cpu memory.

Finite amplitude method (FAM) :
Self-consistent Iterative process to provide multipolar smoothed response function

Each point of the curve is the solution of one QFAM run



Smearing dependent ! $\omega \rightarrow \omega + i\gamma/2$

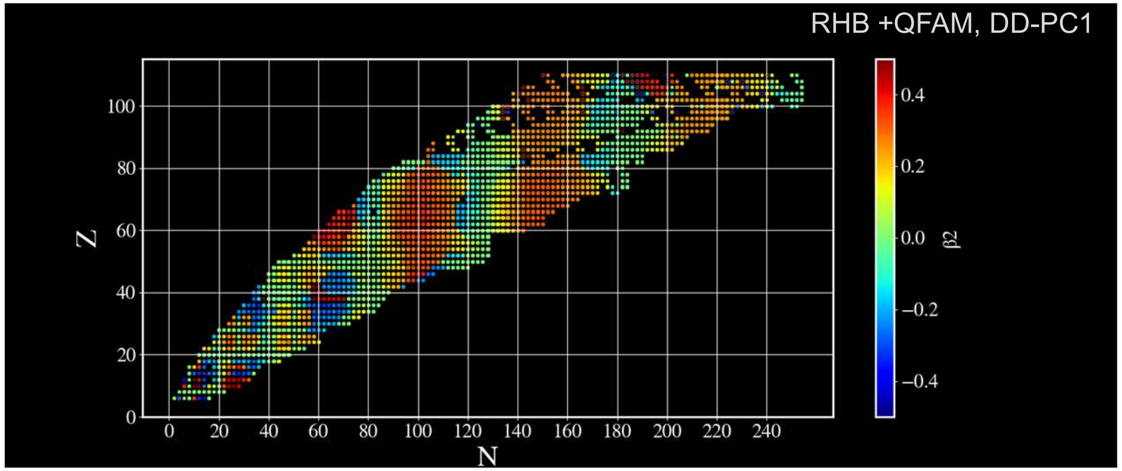
FAST production of multipolar response, but only the response. Eigen mode wave functions require additional treatment.

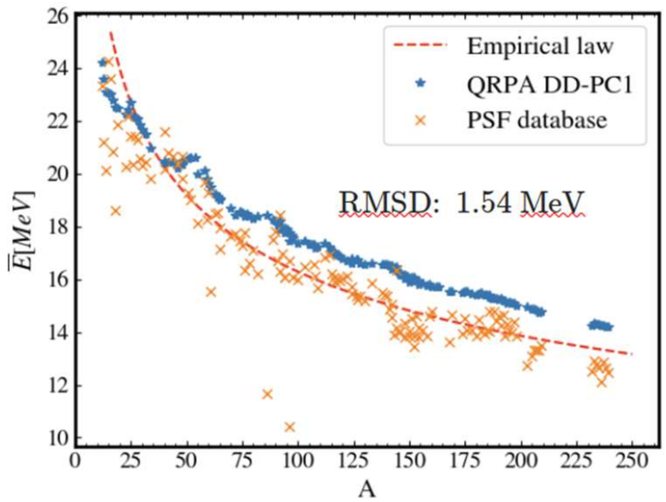
For non-iterative QFAM see the poster of Hirakazu Sasaki

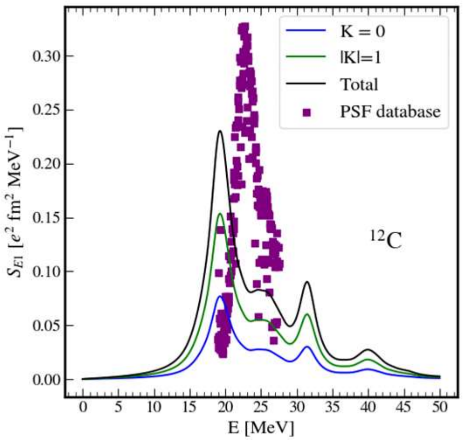
QFAM results

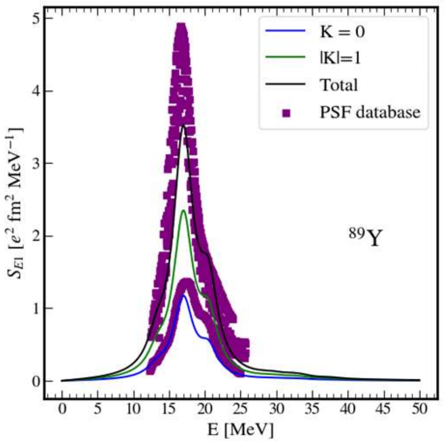
Luis Gonzalez-Miret Zaragoza, PhD Nov2024

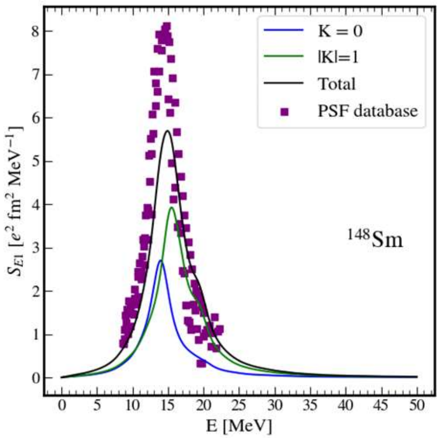
RHB +QFAM, DD-PC1 using the program DIRQFAM v2. 0.0 [Bjelčić, A., & Nikšić, T. (2023), *Computer Physics Communications*, *287*, 108689.]







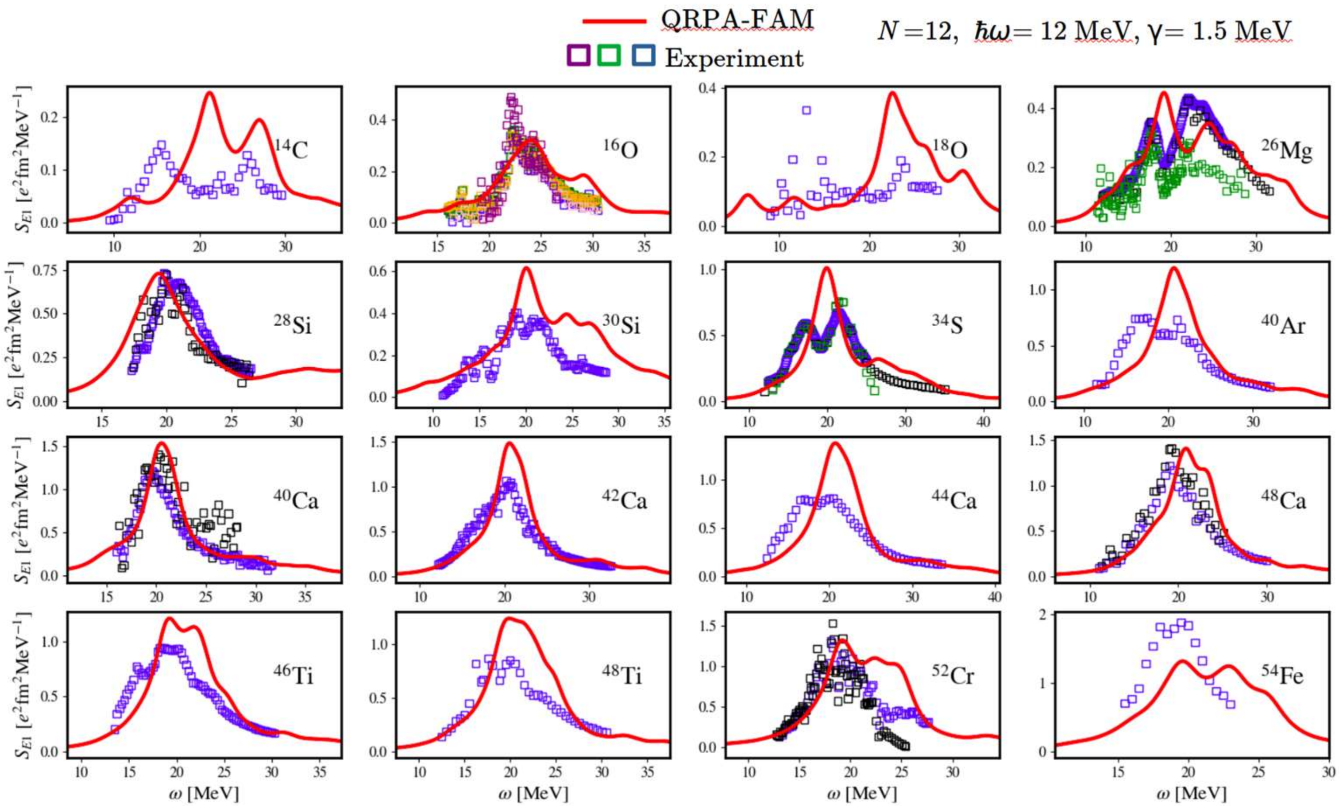




"Ab-initio" interaction: Chiral QFAM results

PAN@CEA collaboration

Luis Gonzalez-Miret Zaragoza, PhD Nov2024



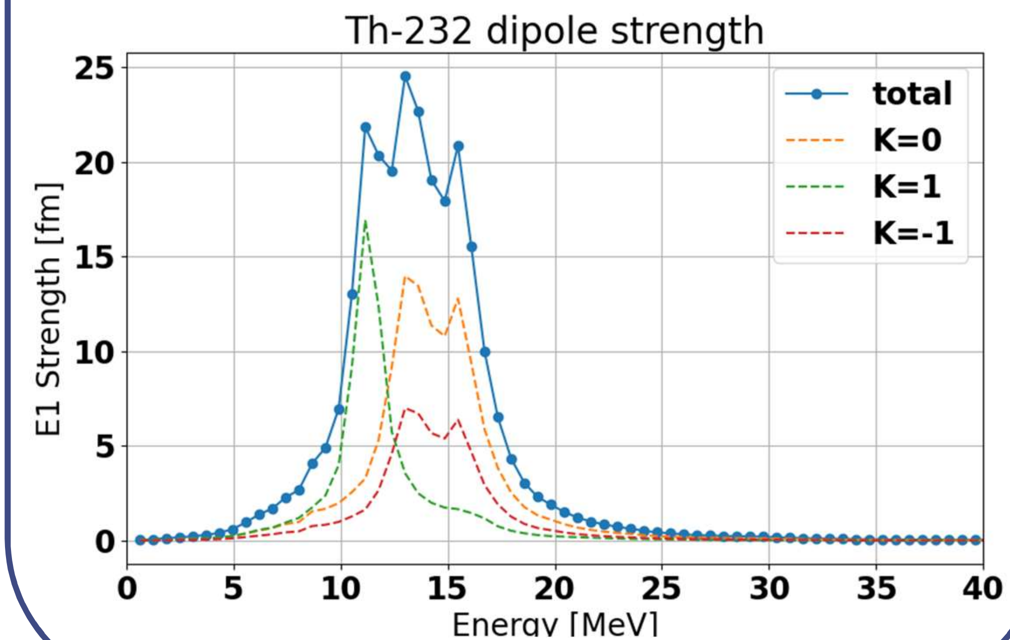
Chiral interaction: Hüther, T., Vobig, K., Hebeler, K., Machleidt, R., & Roth, R. (2020). Family of chiral two-plus three-nucleon interactions for accurate nuclear structure studies. Physics Letters B, 808, 135651.4

3-body to 2-body reduction method: Frosini, M., Duguet, T., Bally, B., Beaujeault-Taudière, Y., Ebran, J. P., & Somà, V. (2021). In-medium k-body reduction of n-body operators: A flexible symmetry-conserving approach based on the sole one-body density matrix. *The European Physical Journal A*, *57*(4), 151.

Time-Dependent Density Functional Theory

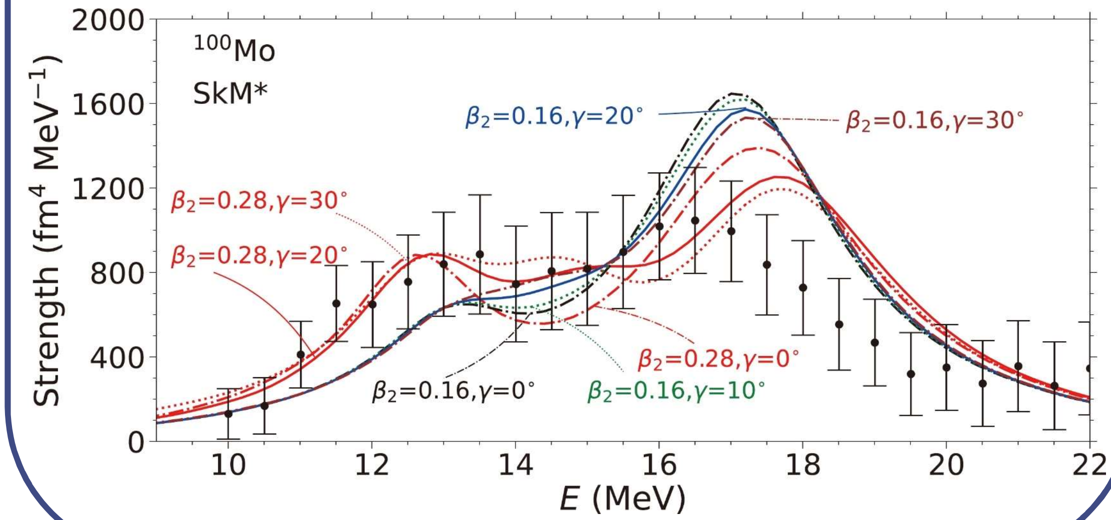
see the poster of Paul Stevenson

Heavy and deformed nuclei



Triaxial Mo isotope

Yue Shi and P. D. Stevenson
Chinese Physics C Vol. 47, No. 3 (2023) 034105

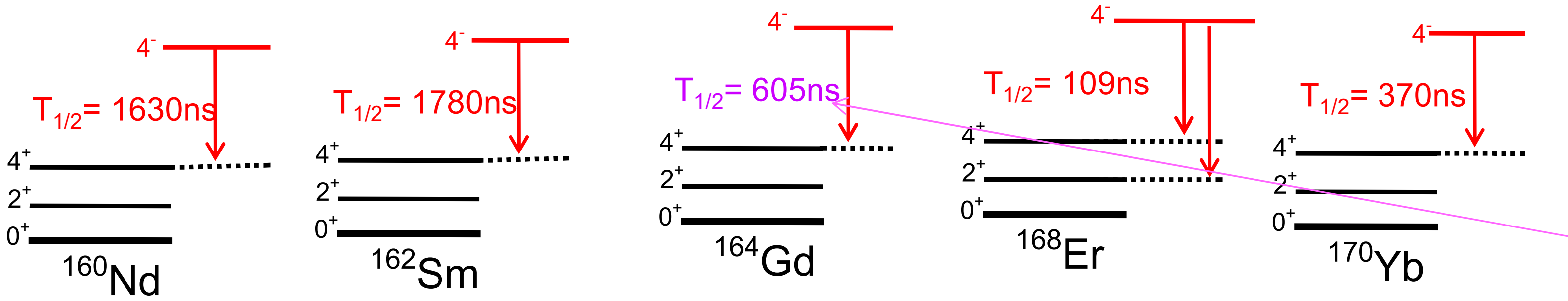


3. Unusual application of QRPA solutions

Description of J= 4^- isomers in N=100 isotones

5 minutes in the nuclear structure world …..

Unusual application: 4^- isomers in N=100 isotones

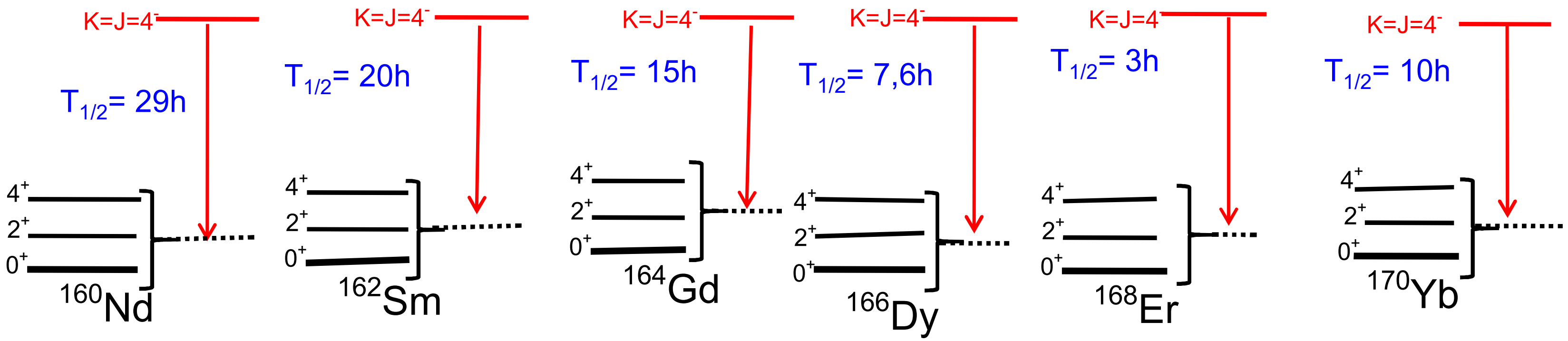


Experimental half-lives

Laurent Gaudefroy, CEA,DAM,DIF

Spontaneous fission of ^{252}Cf

The $4^- \rightarrow 4^+$ transition is expected to be E1



HFB+QRPA in axial symmetry with D1M Gogny force for $K^{\pi} = 4^-$

Only M4 and E5 transitions are allowed ← $\lambda \geq K=4$

What is the nature of these J=4 isomers?

Example : ^{162}Sm

$T_{1/2}$= 1780ns

J=4, $K^{\pi}=0^{-}$	J=4, K=1	J=4, K=2	J=4, K=3	J=4, K=4
B(E1) B(M2)	B(E1) B(M2)	B(E3) B(M2)	B(E3) B(M4)	B(E5) B(M4)
$T_{1/2} \approx$ 0,5 ps	$T_{1/2} \approx$ 300 ps	$T_{1/2} \approx$ 20 ns	$T_{1/2} \approx$ 700 μs	$T_{1/2} \approx$ 20 h

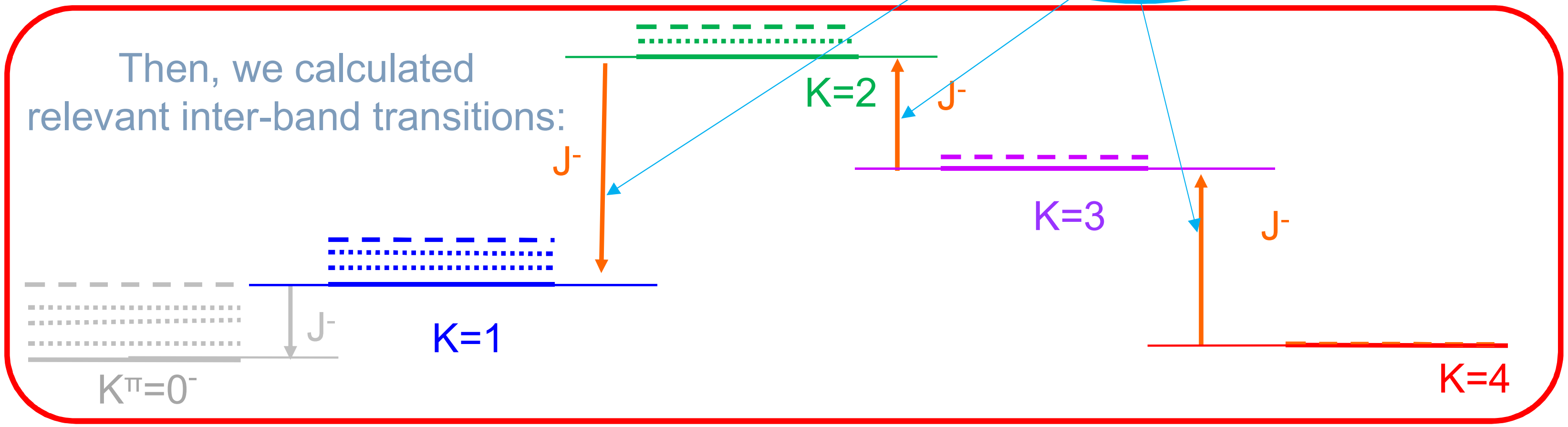
No calculated half-live reproduces the experimental one.
A very small K=1 component in the wave function would explain the observations.

There are 3 main mechanisms for K admixture :
F. G. Kondev, G.D. Dracoulis and T. Kibedi, ADNDT 103, 50 (2015)

- High level density
- Triaxial shape
- Mixing with Coriolis interaction

to fix it:

$$< K \,|\, H_c \,|\, K+1 >= -\frac{\hbar}{2I}\sqrt{(J-K)(J+K+1)}\,< K \,|\, j^- \,|\, K+1 >$$

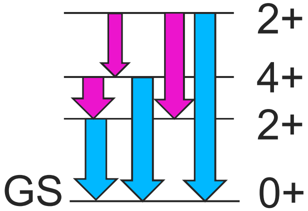


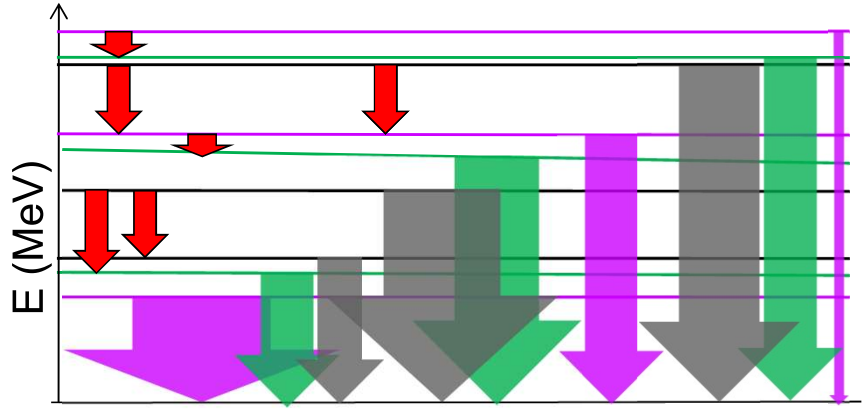
T ½ ns	^{160}Nd	^{162}Sm	^{164}Gd	^{166}Dy	^{168}Er	^{170}Yb	^{172}Hf
Exp.	1670(210)	1780(70)	605(30)	?	109(7)	370(15)	~1
QRPA	6970	11105	3980	285	365	260	1,5
QRPA/Exp.	4,17	6,24	6,57	?	3,35	0,703	1,5

L. Gaudefroy, S. Péru, et al, PRC97, 064317 (2018)

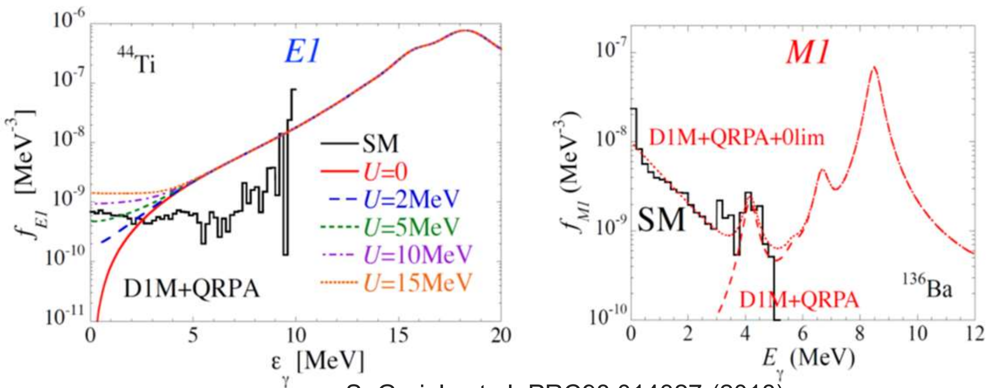
→ More transition probabilities are now available

Low energy spectroscopy
in spherical nuclei : $2^+_2 \rightarrow 2^+_1$
and $4^+_1 \rightarrow 2^+_1$ transition probabilities

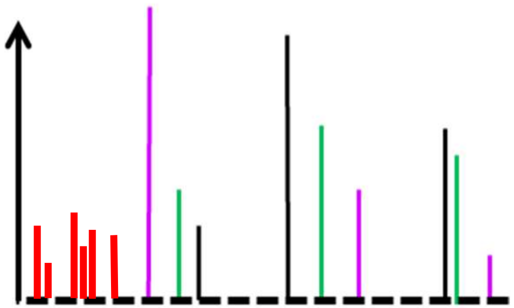




Theoretical description of « up-bend » :
increase of γ-ray strength function at low energy



S. Goriely et al, PRC98,014327 (2018)



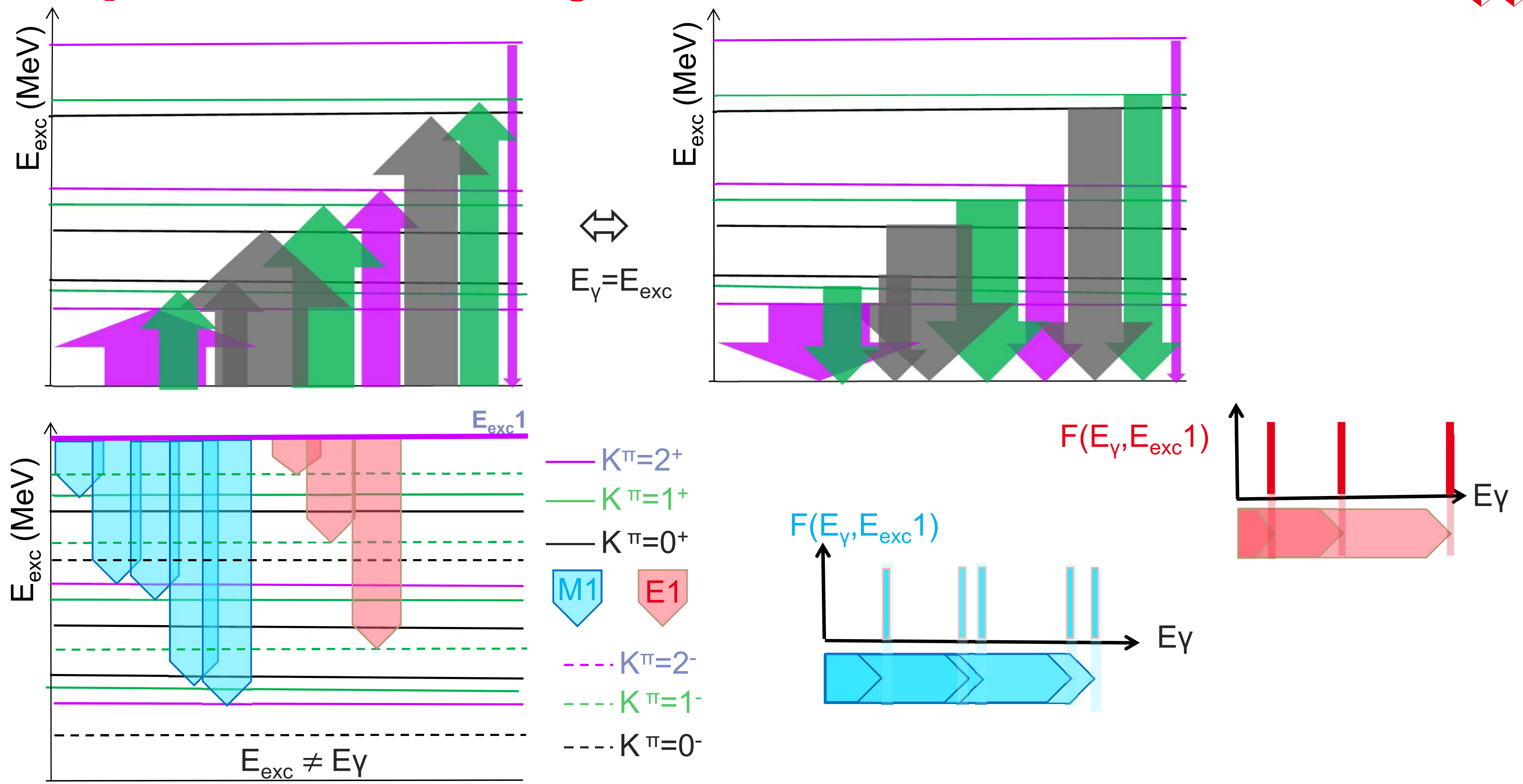
$E_\gamma \neq E_{exc}$

3. Some perspectives for γ-ray strength functions

Going back to the photon strength function definition !

Absorption versus decay

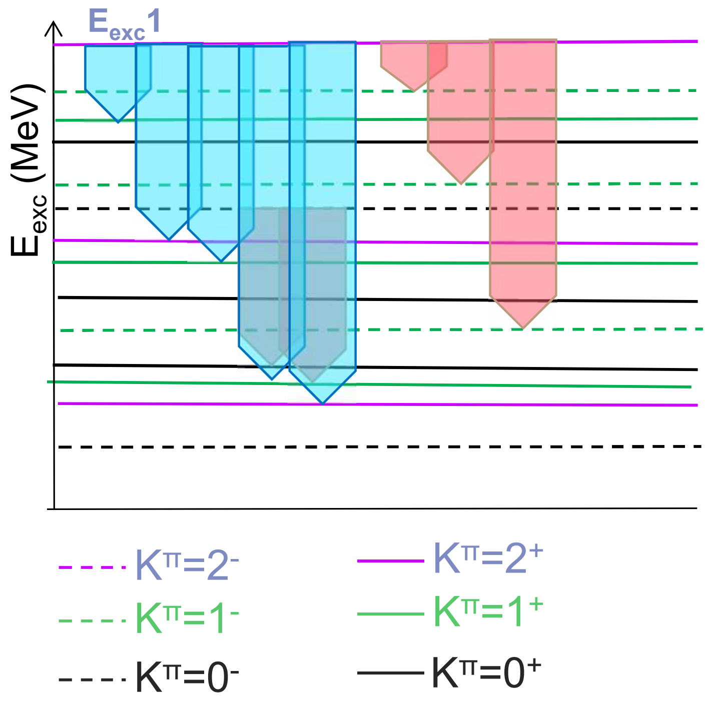
1/2

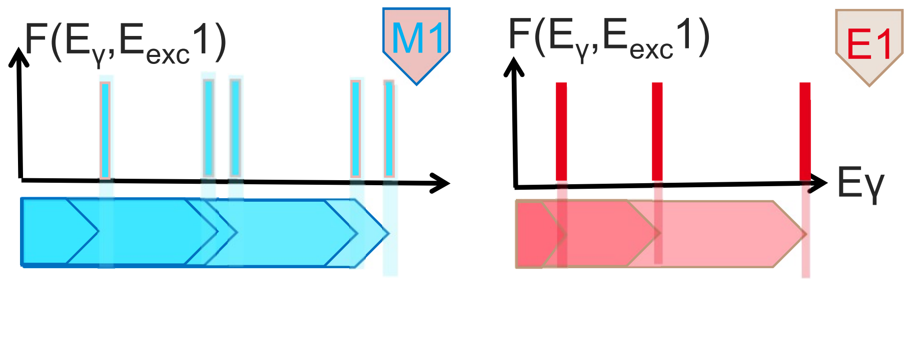


Absorption versus decay

2/2

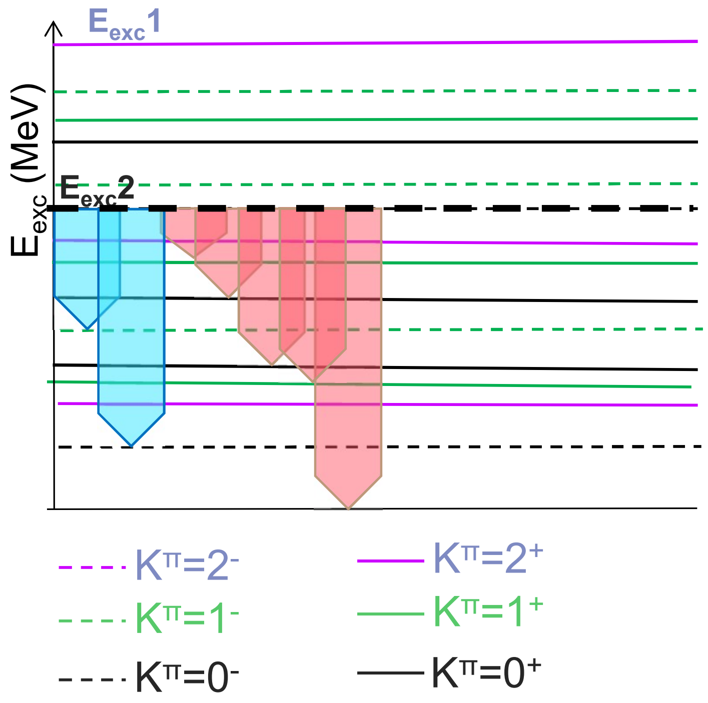
The γ-ray strength function depends on the excitation energy and on the level density

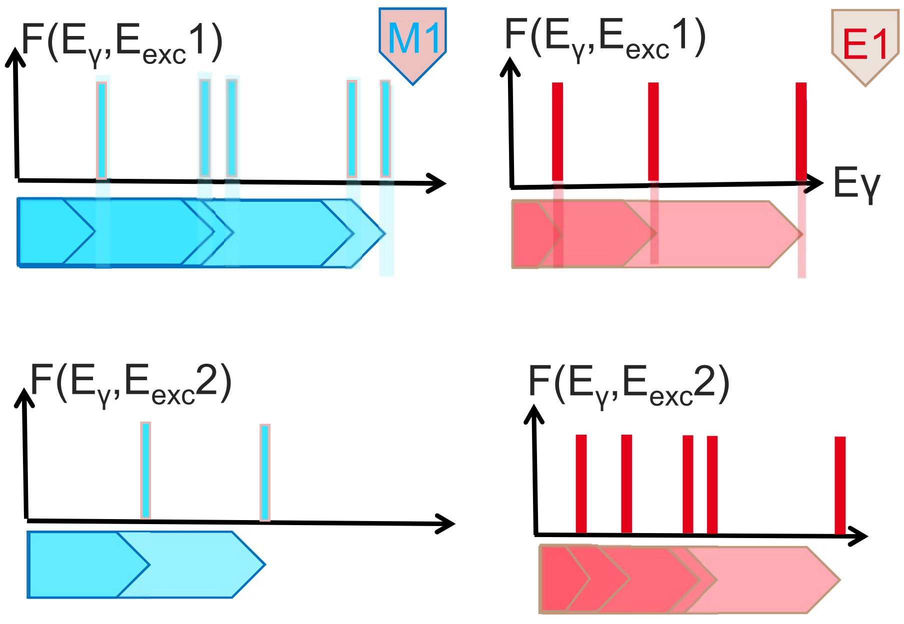




Absorption versus decay 2/2

The γ-ray strength function depends on the excitation energy and on the level density

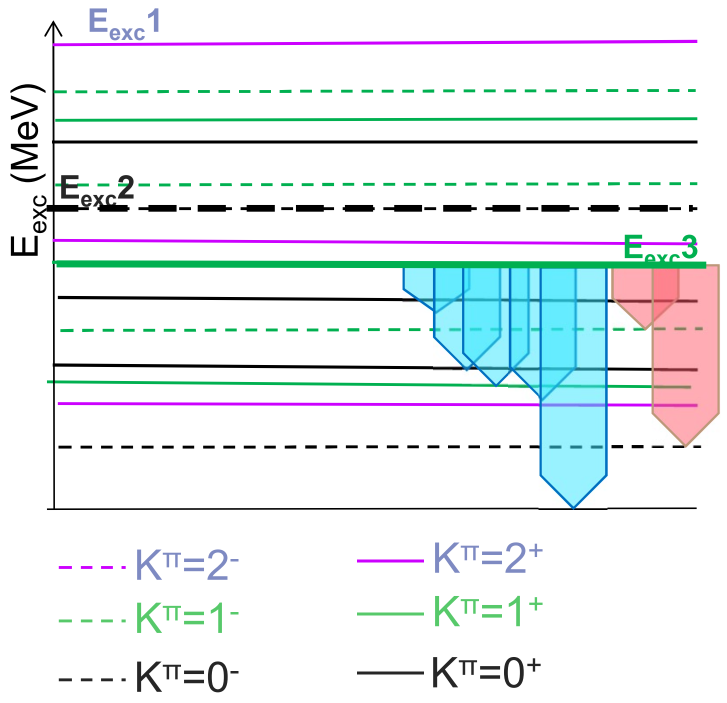


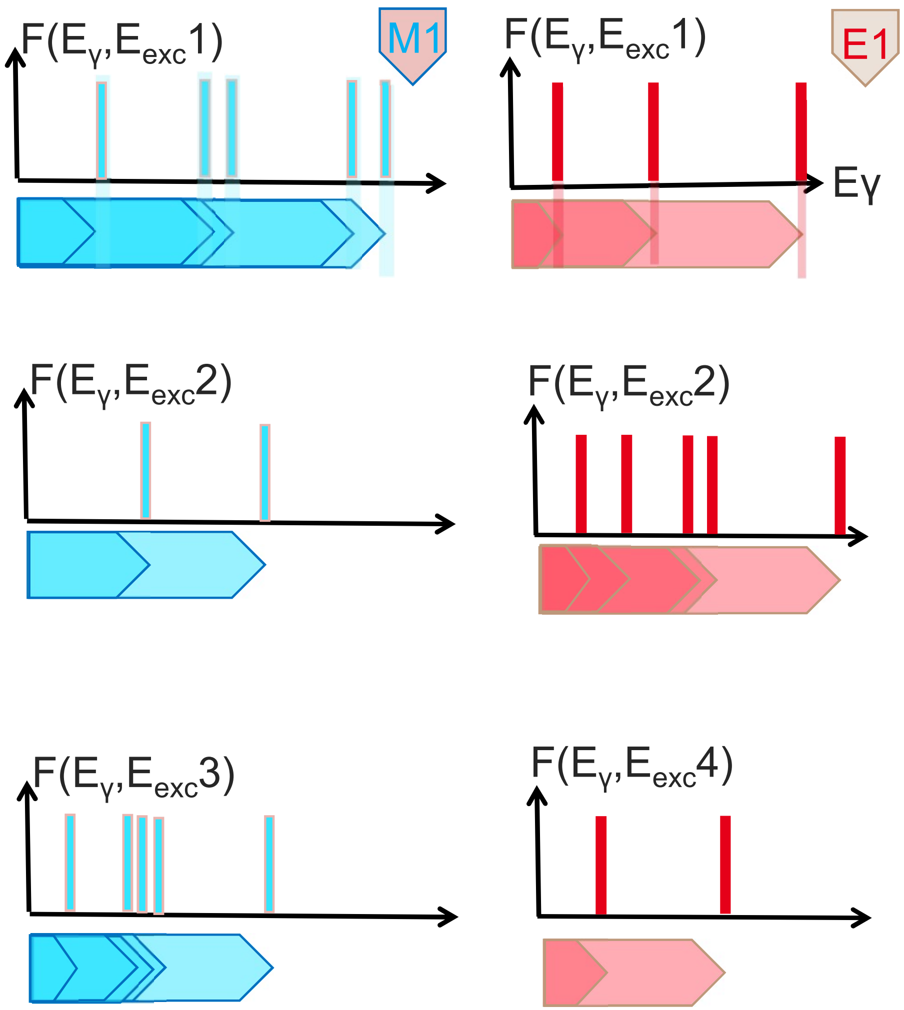


Absorption versus decay

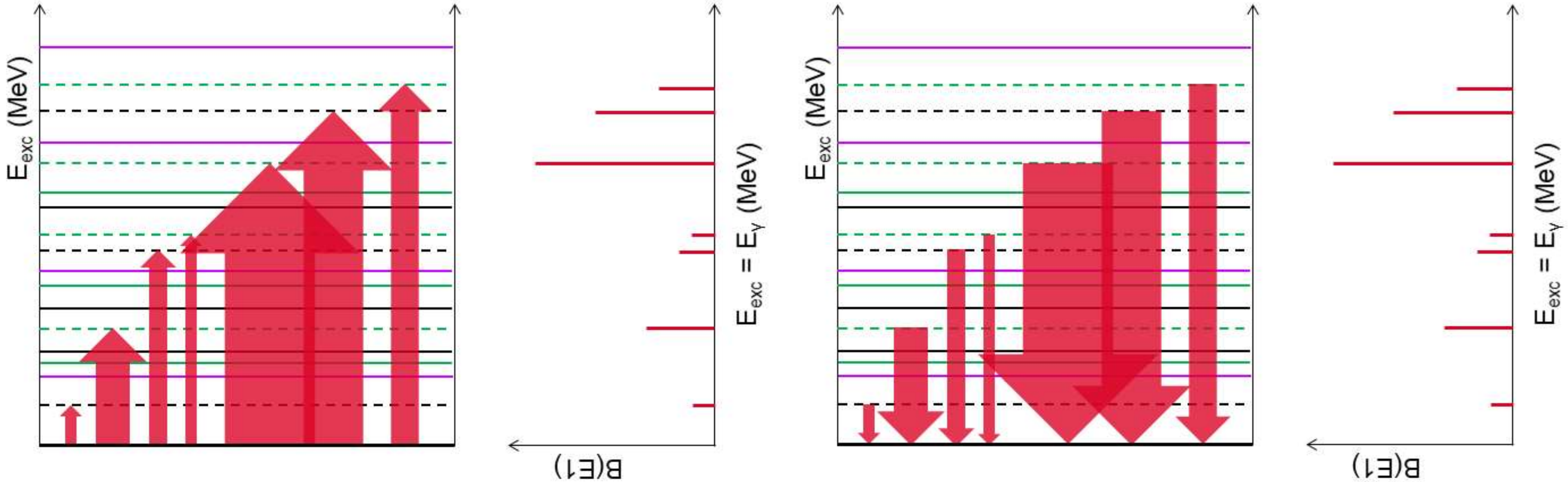
2/2

The γ-ray strength function depends on the excitation energy and on the level density

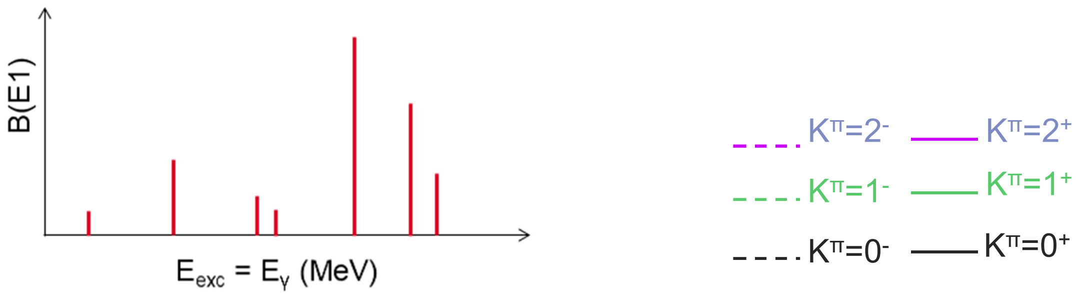


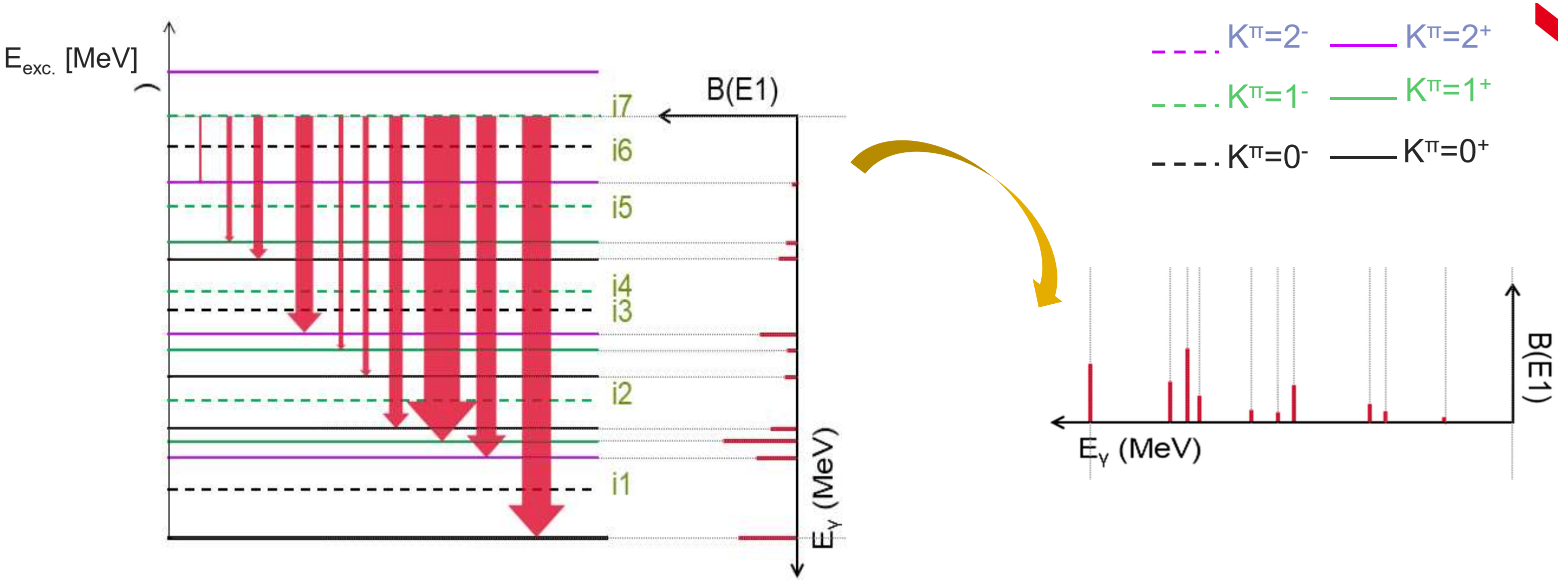


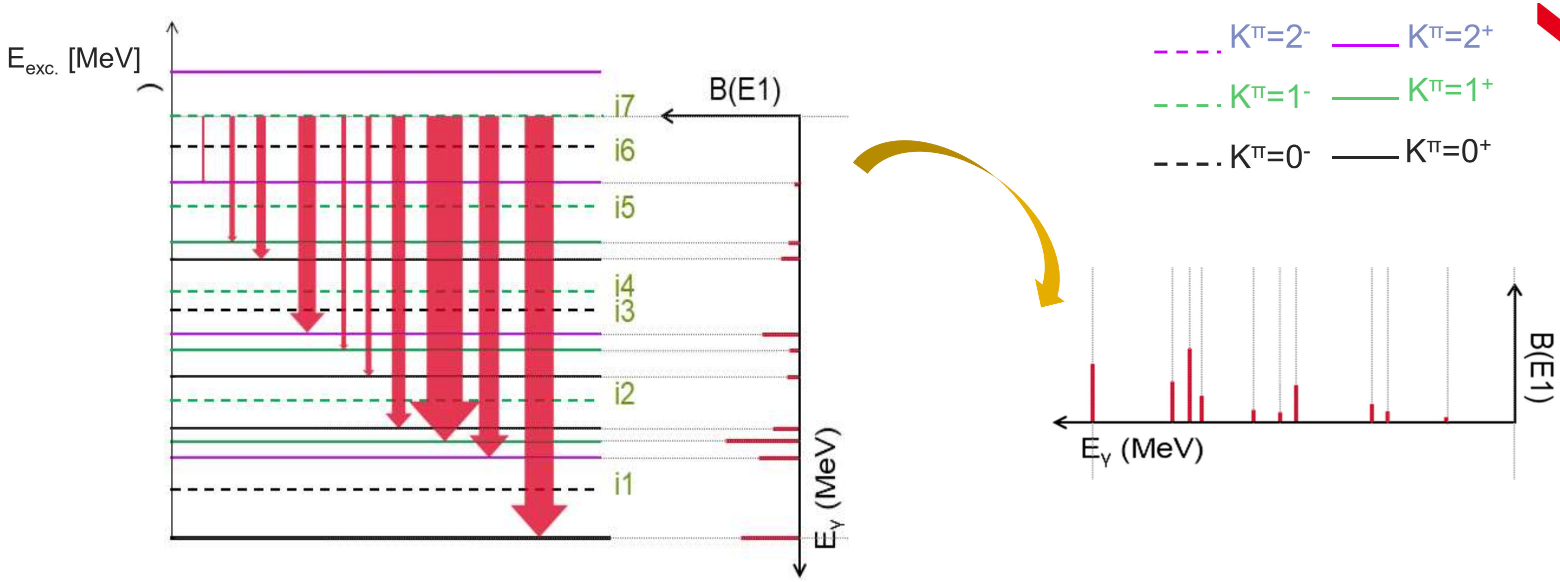
Absorption versus gamma decay, again...

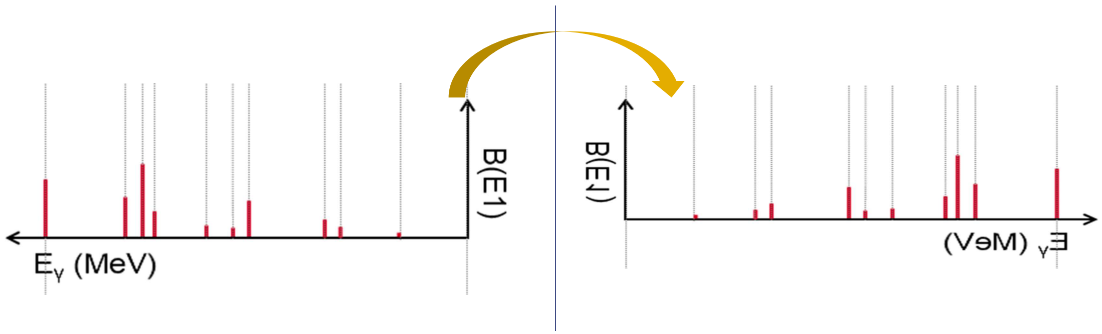


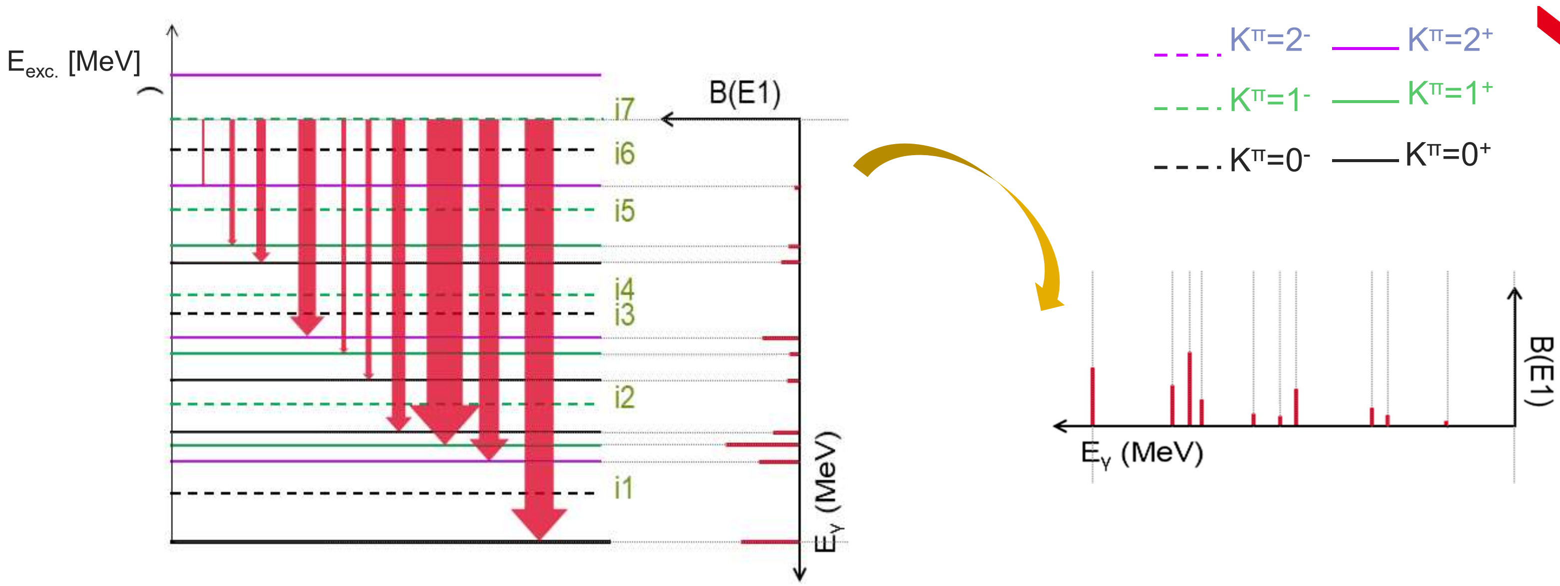
E emission γ = E excitation

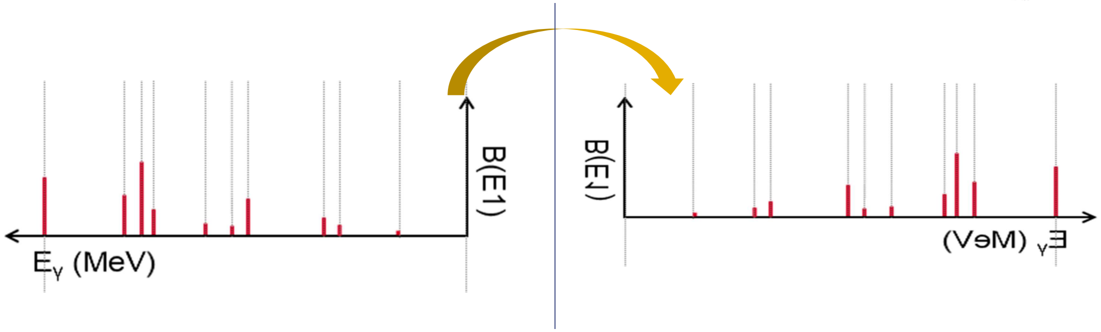


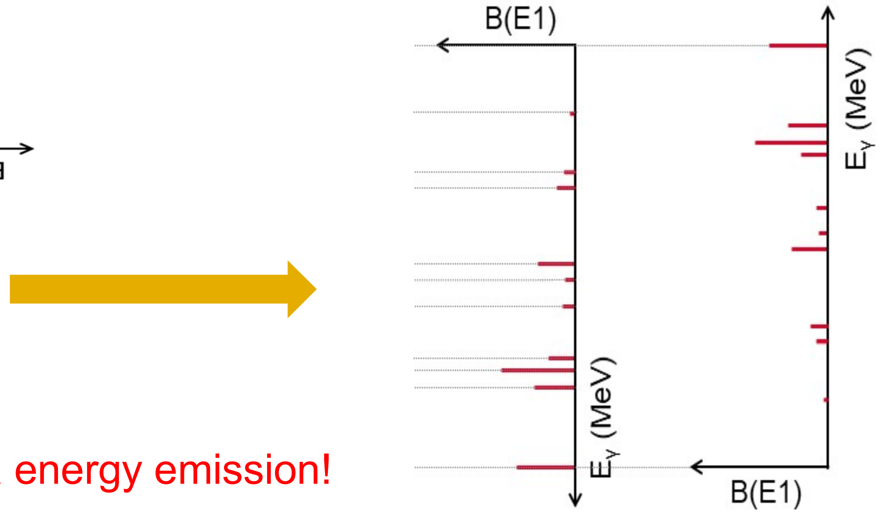

Kπ=2-
Kπ=2+
Kπ=1-
Kπ=1+
Kπ=0-
Kπ=0+
Eexc. [MeV]
B(E1)
i7
i6
i5
i4
i3
i2
i1
Eγ (MeV)
Eγ (MeV)
B(E1)


$E_{exc.}$ [MeV]
i7
i6
i5
i4
i3
i2
i1
B(E1)
E_γ (MeV)
$K^\pi=2^-$
$K^\pi=2^+$
$K^\pi=1^-$
$K^\pi=1^+$
$K^\pi=0^-$
$K^\pi=0^+$
B(E1)
E_γ (MeV)

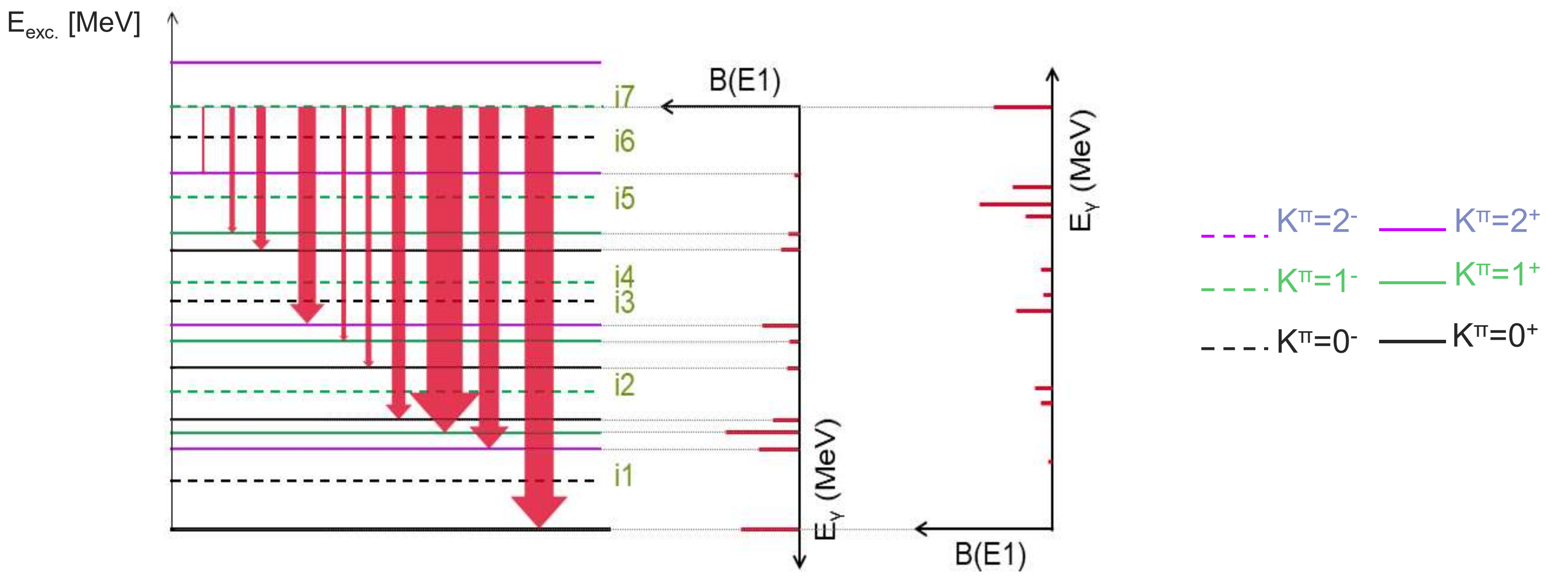

B(E1)
E_γ (MeV)



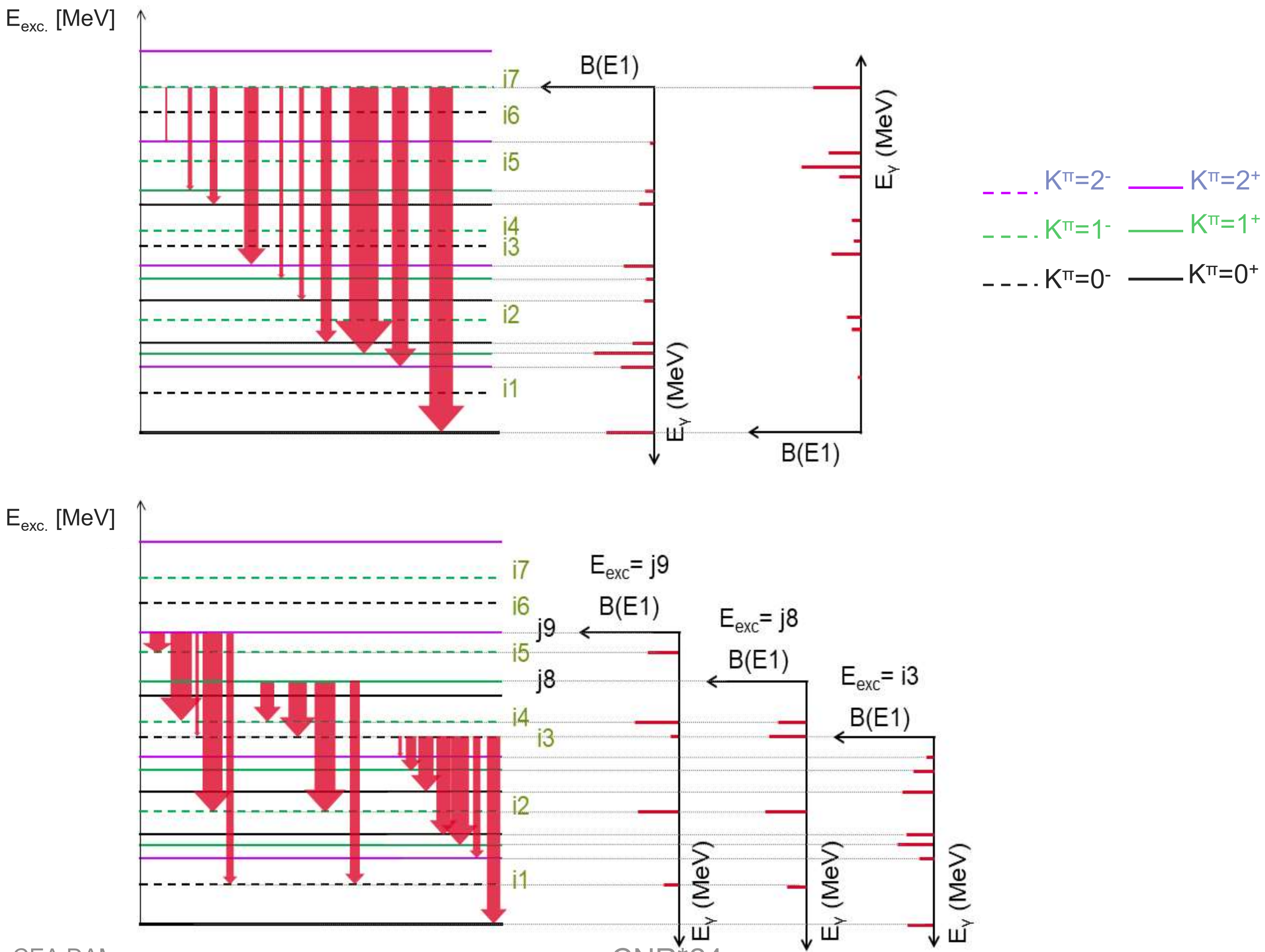




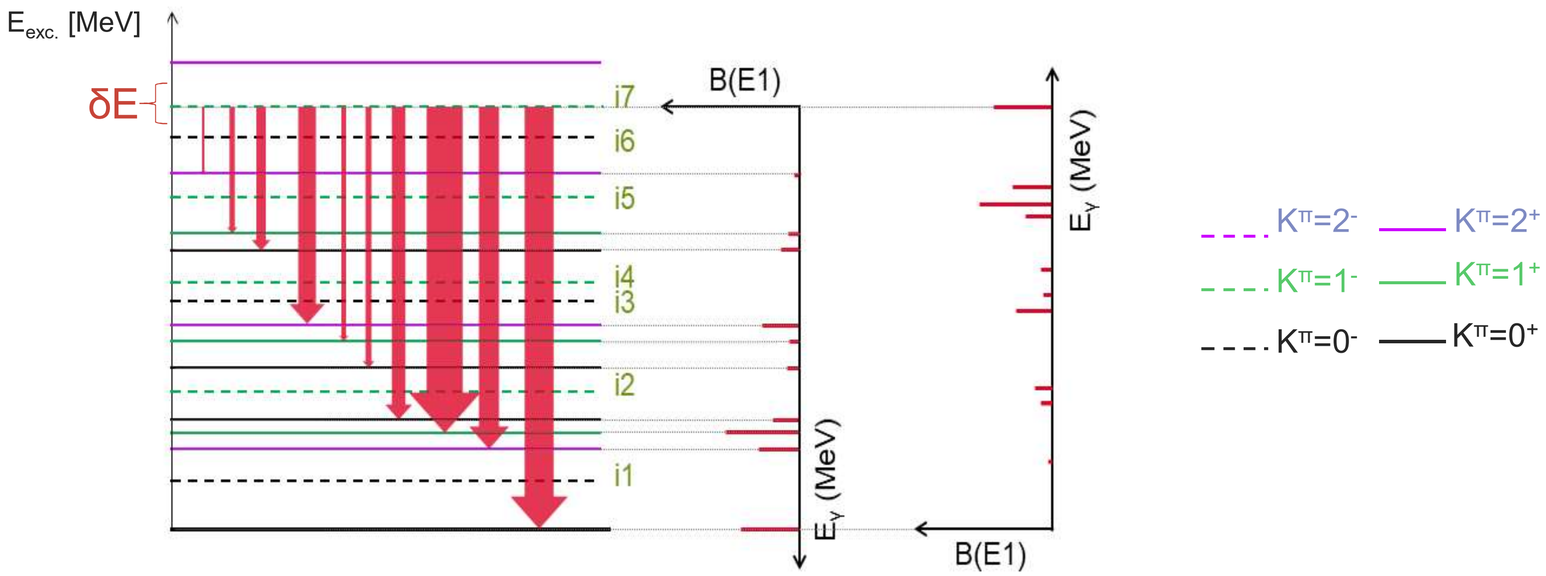
Low excitation energy states are seen at high gamma energy emission!

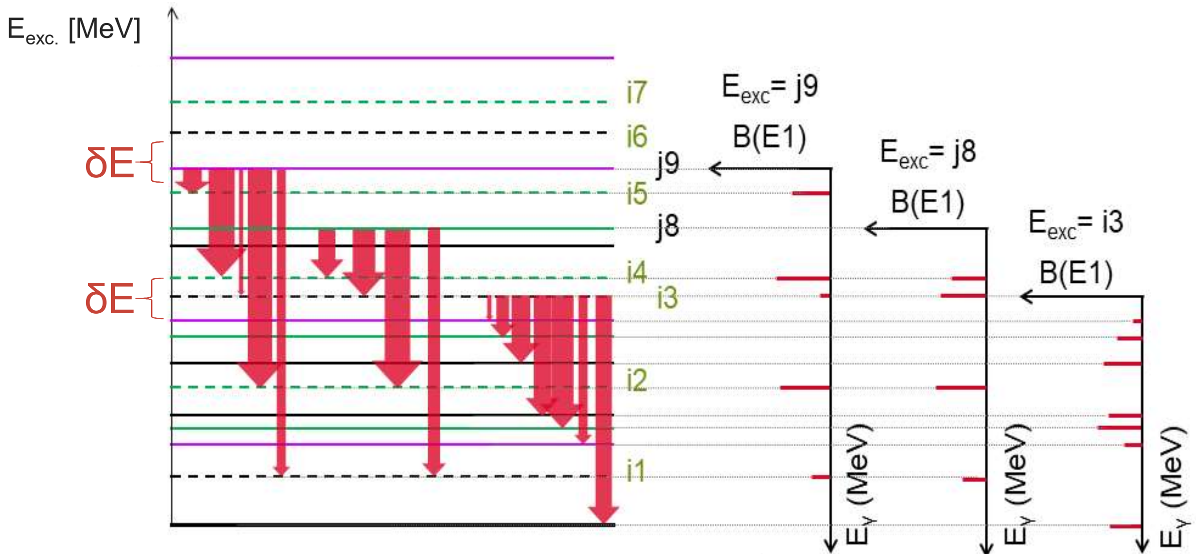


E_exc. [MeV]
i7
i6
i5
i4
i3
i2
i1
B(E1)
Eγ (MeV)
Eγ (MeV)
B(E1)
Kπ=2-
Kπ=2+
Kπ=1-
Kπ=1+
Kπ=0-
Kπ=0+



Eexc. [MeV]
i7
i6
i5
i4
i3
i2
i1
B(E1)
Eγ (MeV)
B(E1)
Eγ (MeV)
Kπ=2- Kπ=2+
Kπ=1- Kπ=1+
Kπ=0- Kπ=0+
Eexc. [MeV]
i7
i6
j9
i5
j8
i4
i3
i2
i1
Eexc= j9
B(E1)
Eexc= j8
B(E1)
Eexc= i3
B(E1)
Eγ (MeV)
Eγ (MeV)
Eγ (MeV)

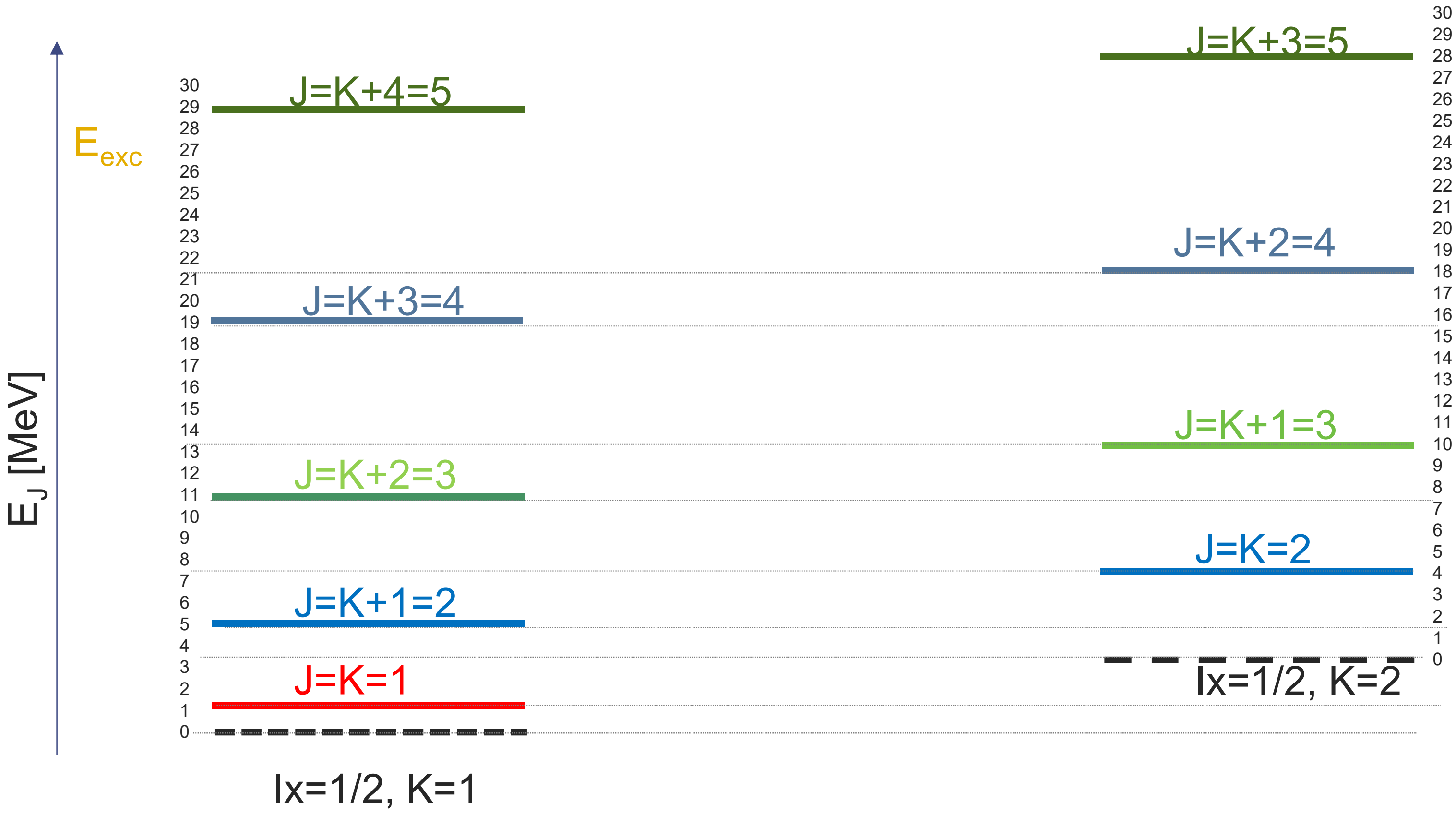

E$_{exc.}$ [MeV]
δE
i7
i6
i5
i4
i3
i2
i1
B(E1)
E$_γ$ (MeV)
E$_γ$ (MeV)
B(E1)
Kπ=2- Kπ=2+
Kπ=1- Kπ=1+
Kπ=0- Kπ=0+


E$_{exc.}$ [MeV]
δE
δE
i7
i6
j9
i5
j8
i4
i3
i2
i1
E$_{exc}$= j9
B(E1)
E$_{exc}$= j8
B(E1)
E$_{exc}$= i3
B(E1)
E$_γ$ (MeV)
E$_γ$ (MeV)
E$_γ$ (MeV)

Rotational bands in deformed nuclei

$$E_J = E_K + E_{rot} \text{ with } E_{rot} = \frac{J(J+1)-K^2}{2I_x(Z,N)}$$

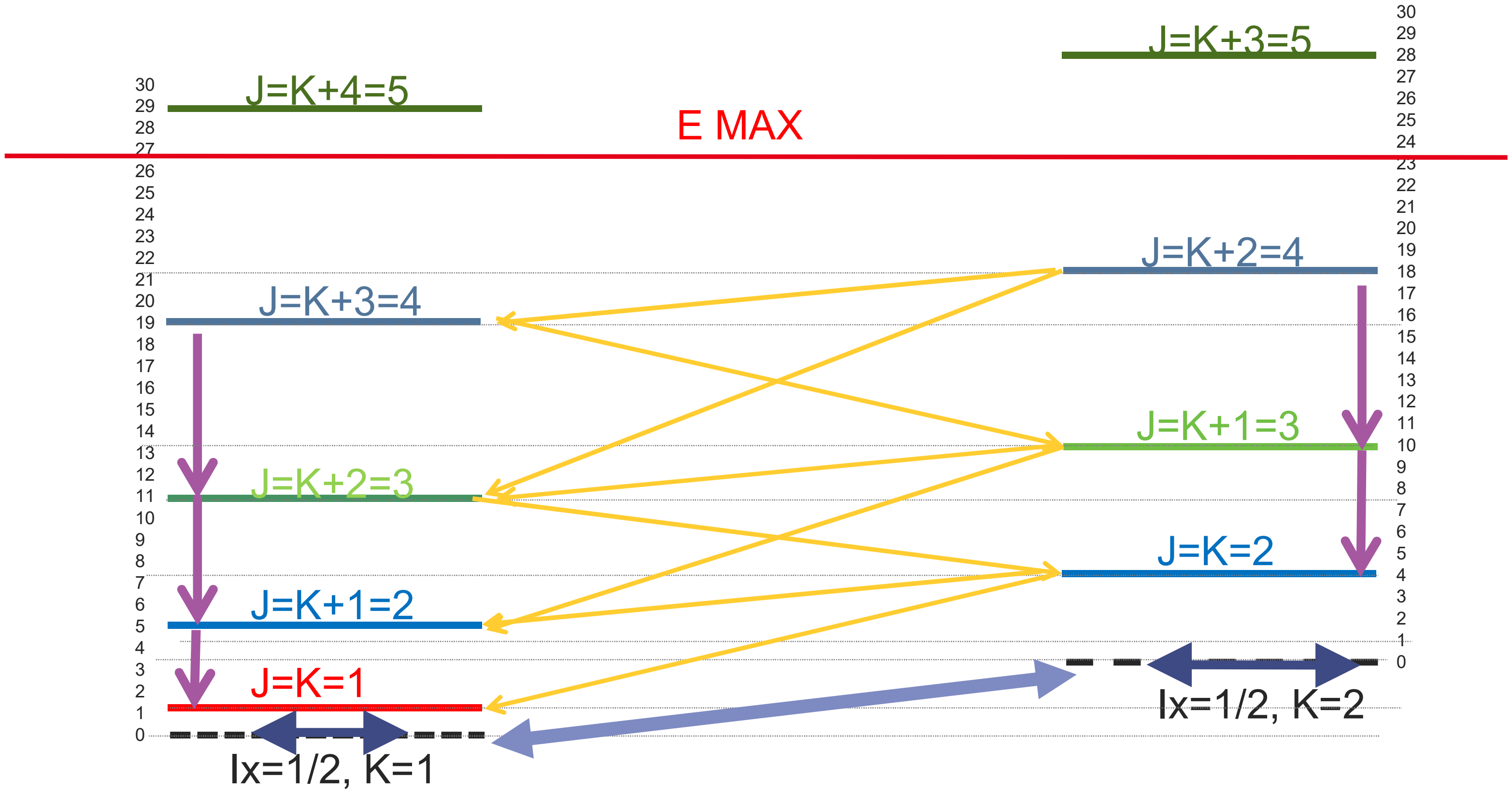
E_{exc} ≈ Temperature



Gamma emission in deformed nuclei

Intra band transition probability calculations

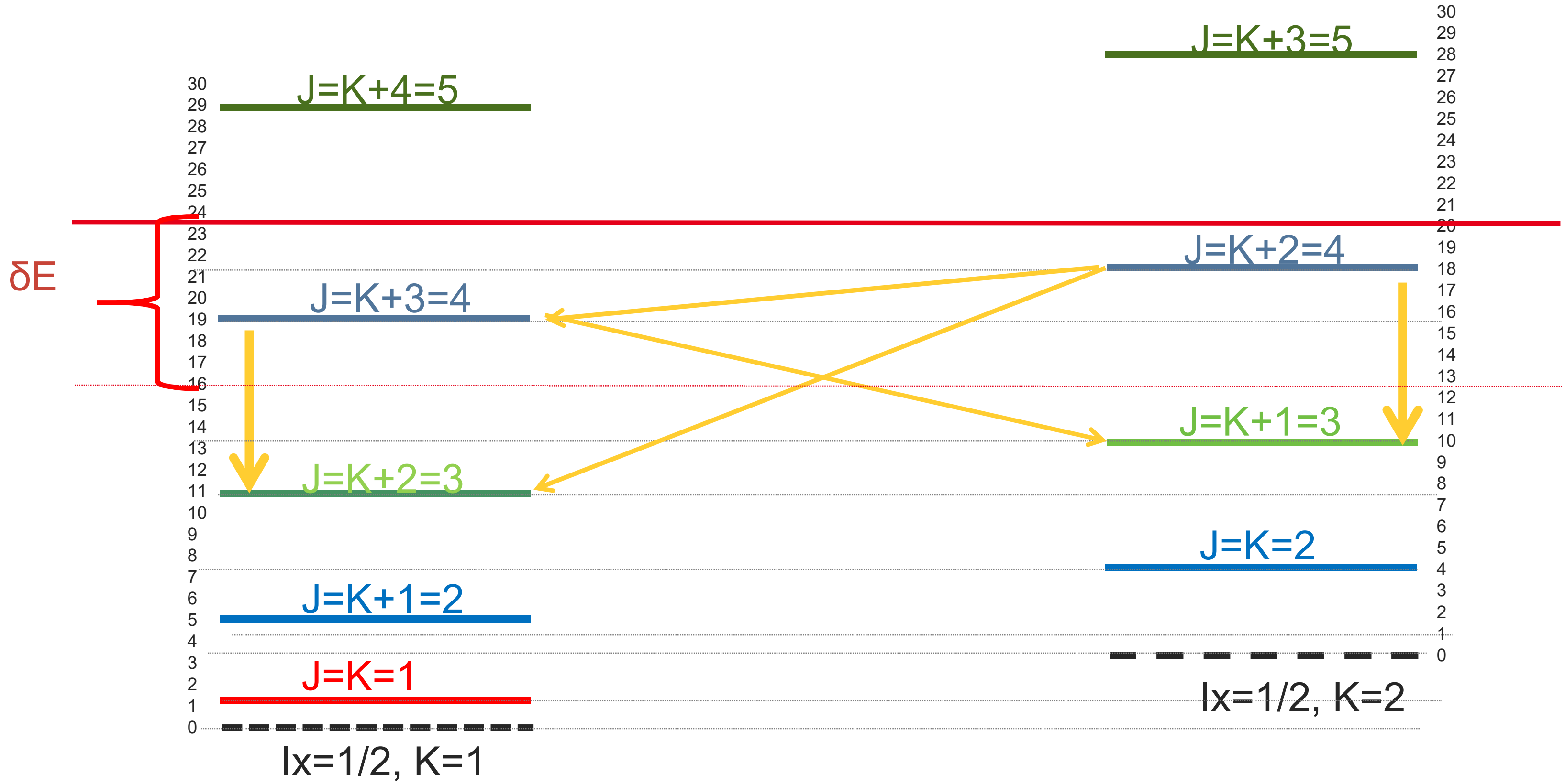
Inter band transition probability calculations



Gamma emission in deformed nuclei

Intra band transition probability calculations

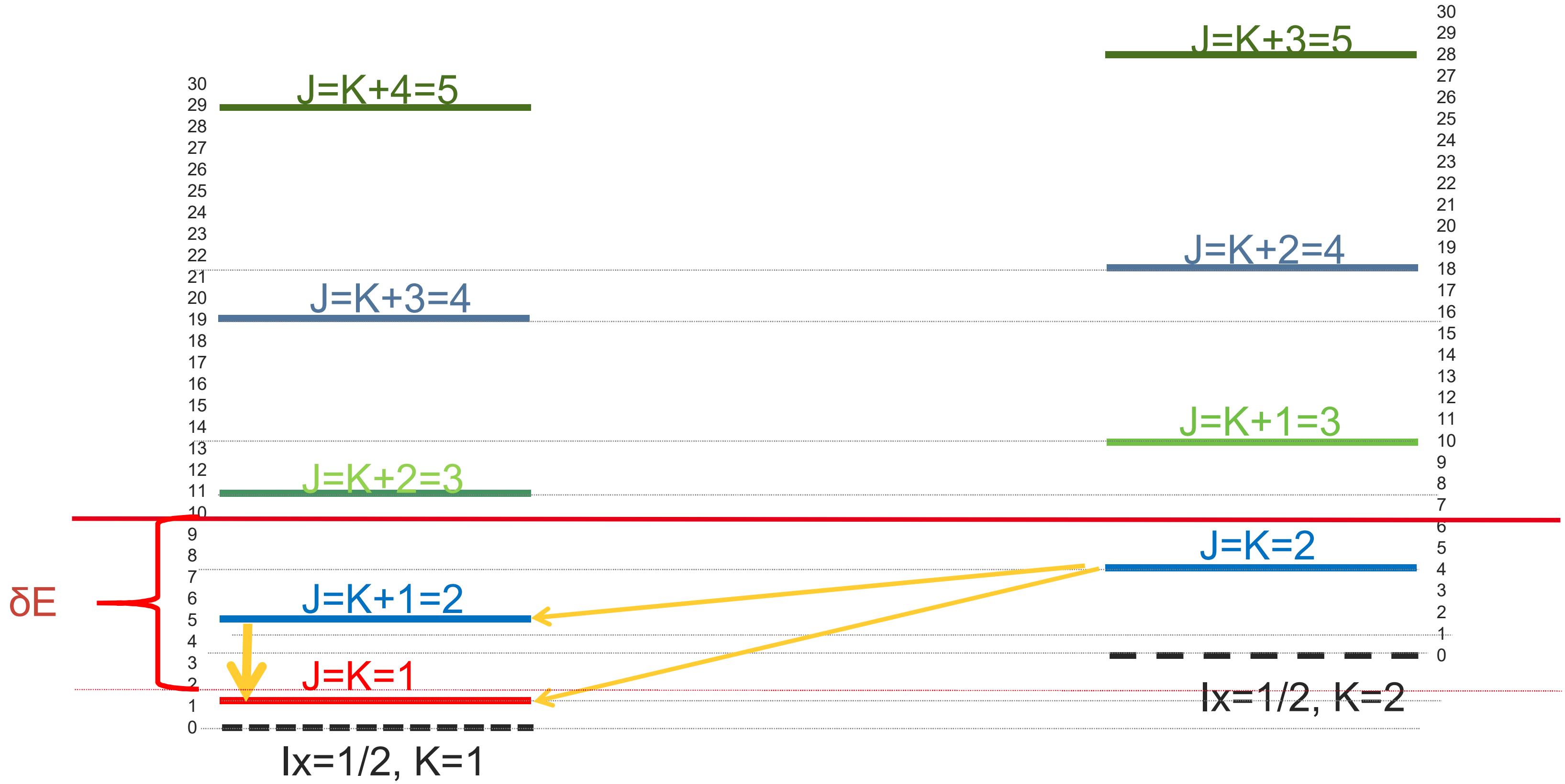
Inter band transition probability calculations

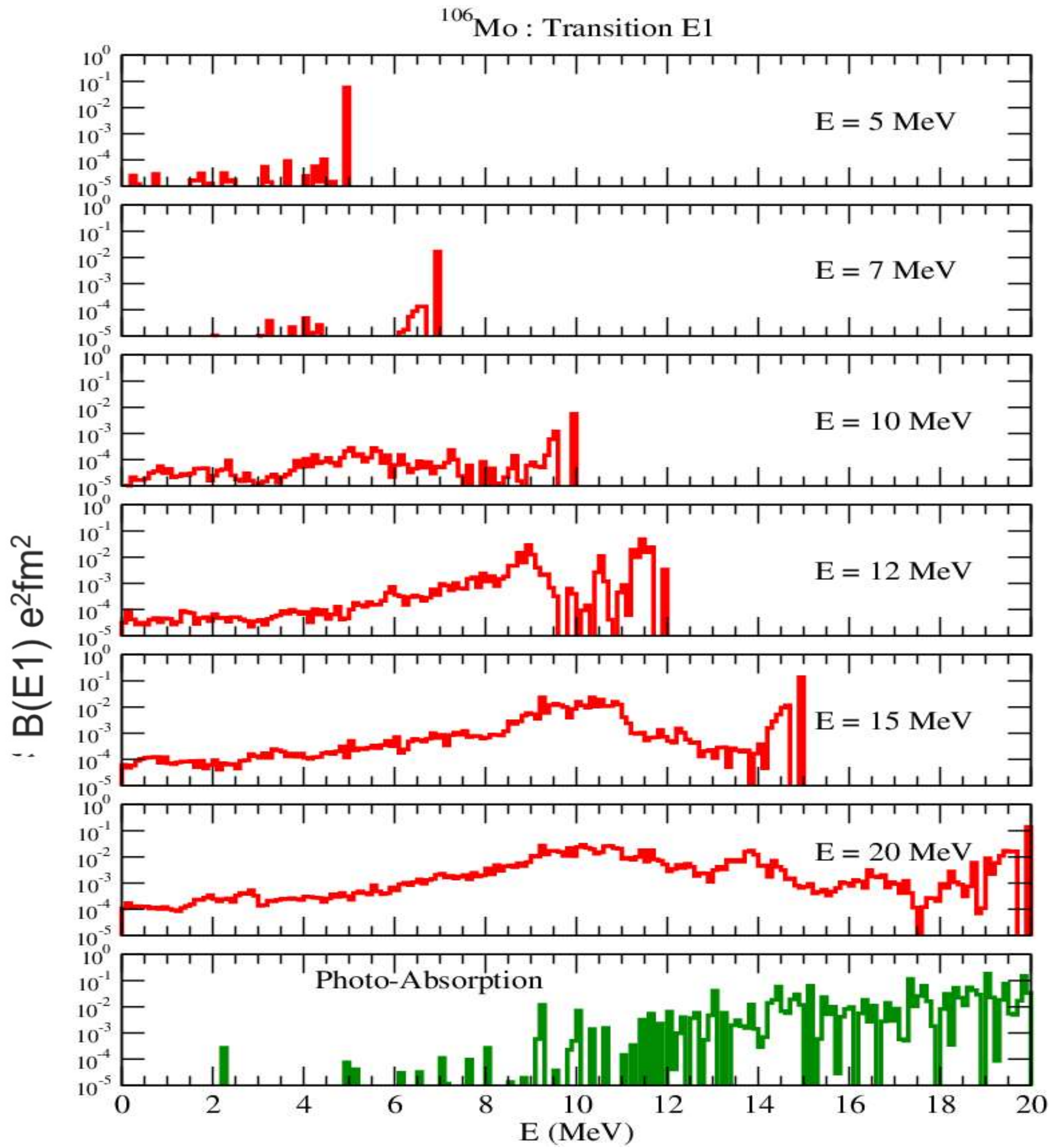


Gamma emission in deformed nuclei

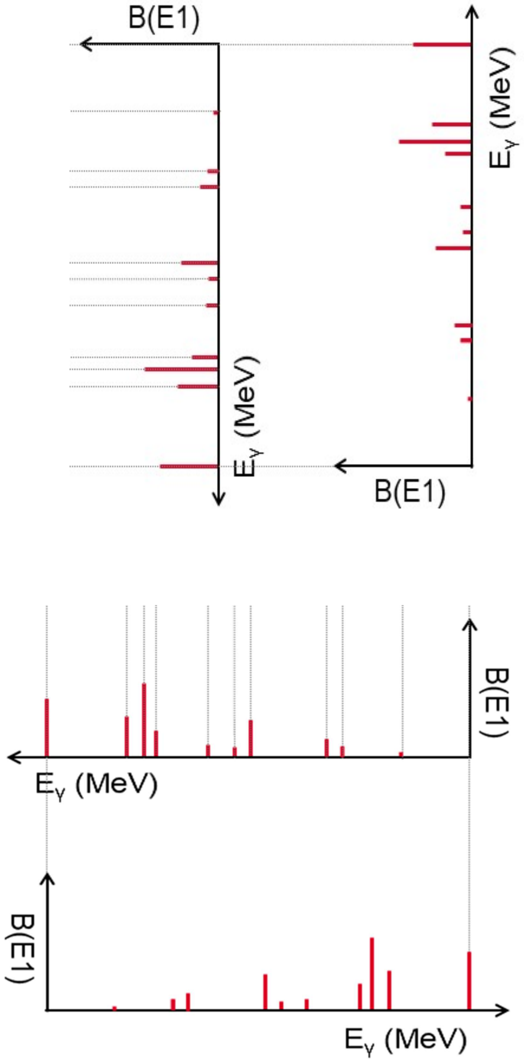
Intra band transition probability calculations

Inter band transition probability calculations

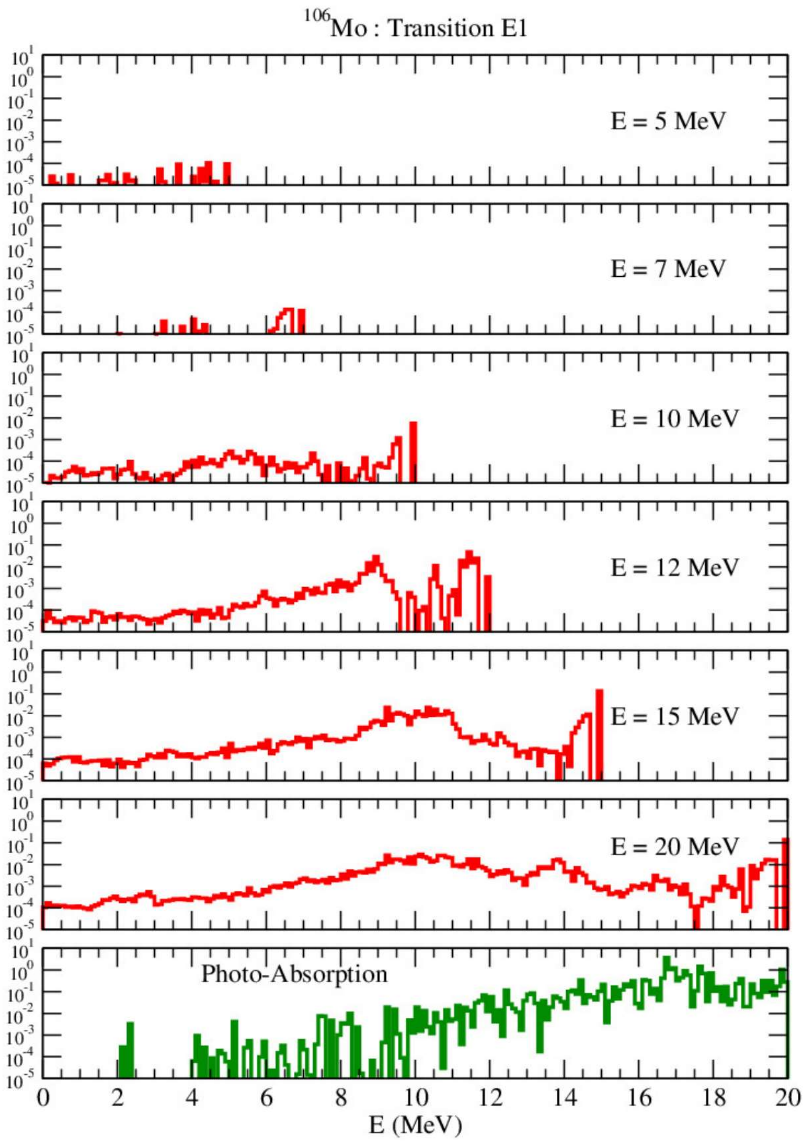


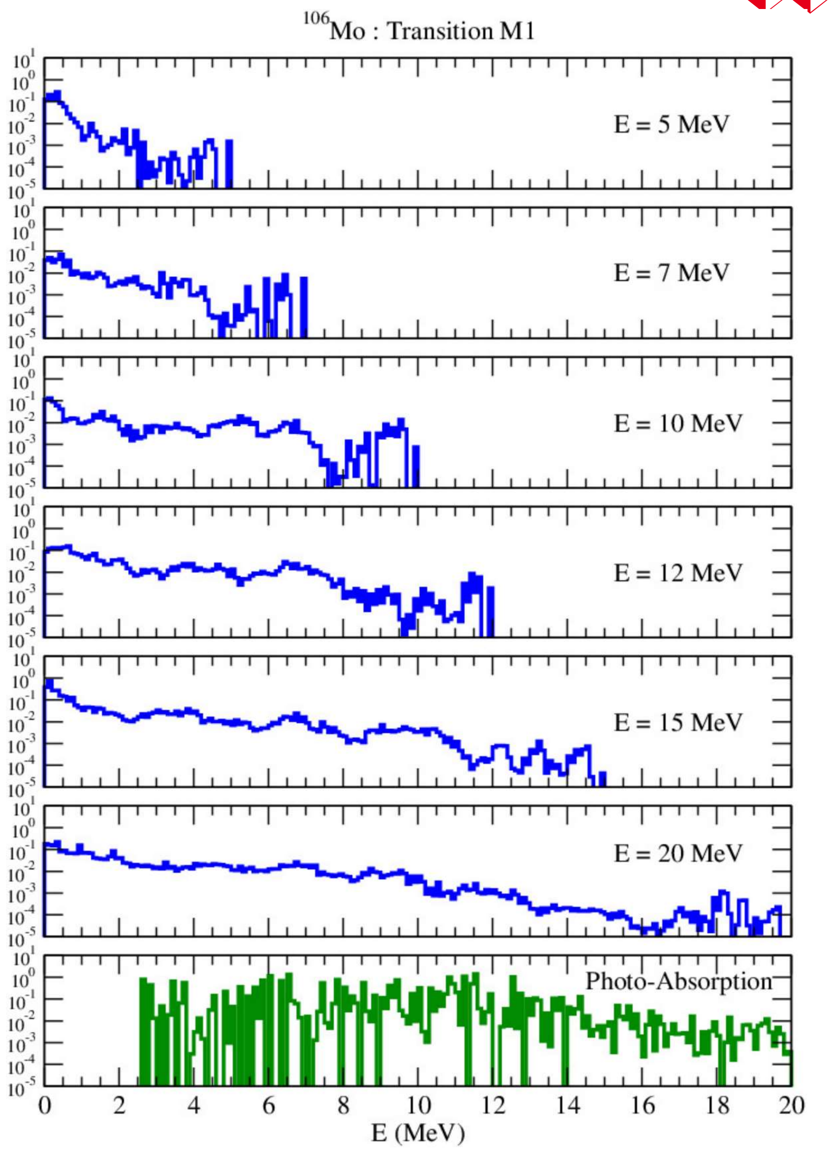


^{106}Mo : Transition E1
B(E1) e^{2}fm^2
E = 5 MeV
E = 7 MeV
E = 10 MeV
E = 12 MeV
E = 15 MeV
E = 20 MeV
Photo-Absorption
E (MeV)



B(E1)
E_γ (MeV)
B(E1)
E_γ (MeV)
E_γ (MeV)
B(E1)
B(E1)
E_γ (MeV)


^{106}Mo : Transition E1
E = 5 MeV
E = 7 MeV
E = 10 MeV
E = 12 MeV
E = 15 MeV
E = 20 MeV
Photo-Absorption
E (MeV)


^{106}Mo : Transition M1
E = 5 MeV
E = 7 MeV
E = 10 MeV
E = 12 MeV
E = 15 MeV
E = 20 MeV
Photo-Absorption
E (MeV)

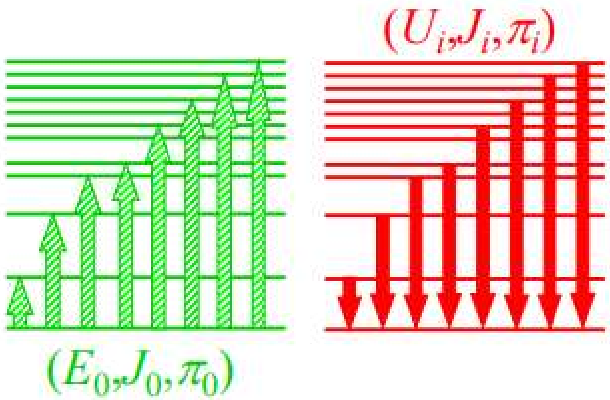
E1 Folding procedure

De-excitation PSF at an initial energy U_i

$$f_{XL}(E_\gamma,U_i)=\sum_{Ji,\pi i} f_{\text{conv}} <B(XL)>(E_\gamma,U_i,J_i,\pi_i)\ \rho(U_i,J_i,\pi_i)$$

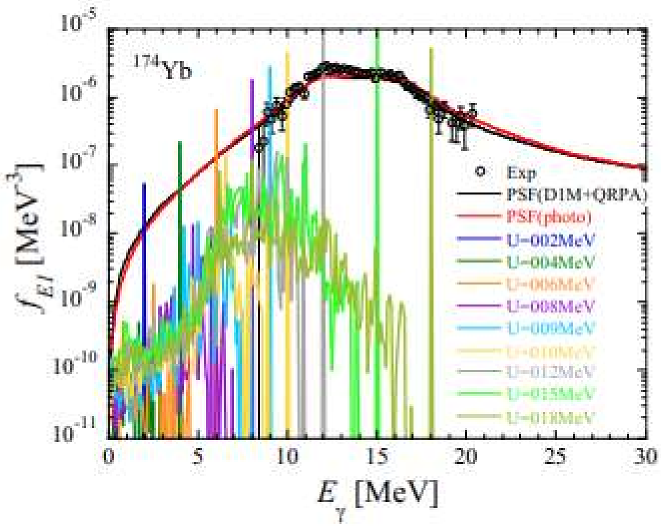
Reciprocity theorem

$$\overrightarrow{f_{XL}}(E_\gamma) = \overleftarrow{f_{XL}}(U_i, E_\gamma)$$



De-excitation PSF at $U_i=E_\gamma$
after folding should correspond
to the smooth (after folding)
photo-absorption PSF at E_γ

f_{E1} de-excitation PSF *before* folding



Courtesy of S.Goriely

E1 Folding procedure

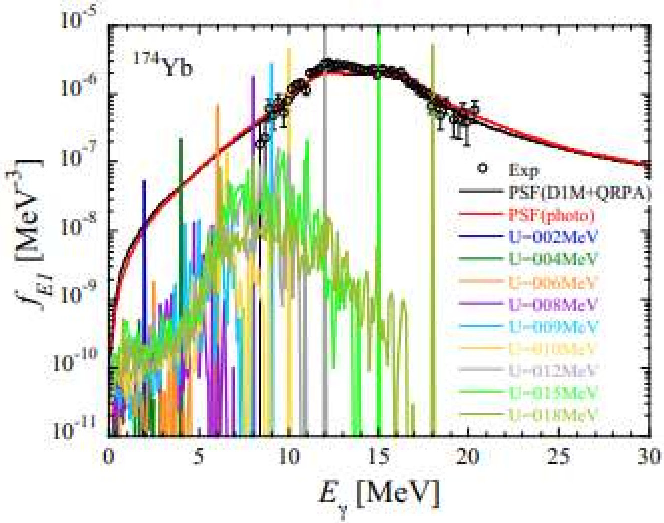
Preliminary results

Smooth de-excitation PSF at an initial energy U_i

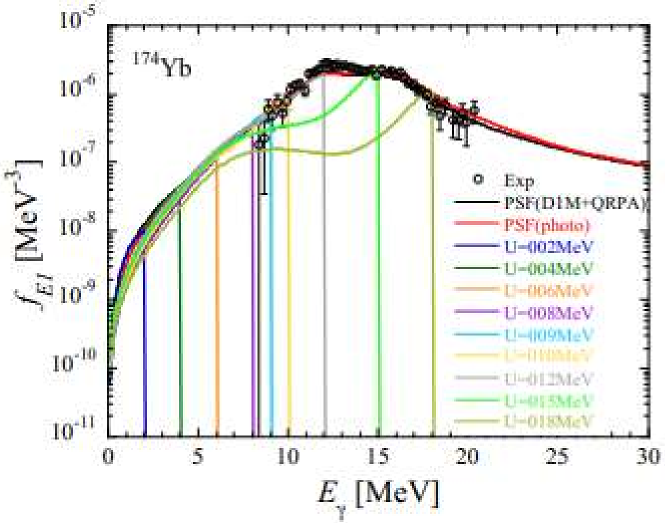
$$f_{E1}(E) = \int_{-\infty}^{+\infty} L(E,\omega) S_{E1}(\omega) d\omega \quad \text{with} \quad L(E,\omega) = \frac{1}{\pi\Gamma} \frac{\Gamma^2 E^2}{\left[E^2 - (\omega-\Delta)^2\right]^2 + \Gamma^2 E^2}$$

All QRPA energies shifted by $\Delta(\omega) \sim 0.14\ \omega$ $\Gamma(E1)=7-A/45$MeV

f_{E1} de-excitation PSF *before* folding

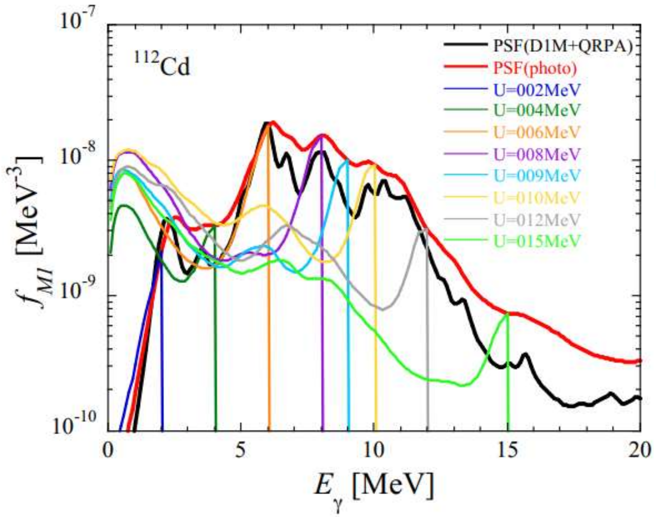


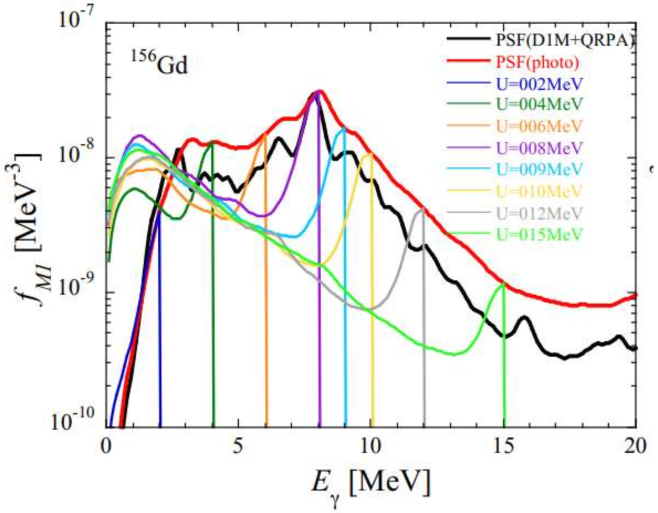
f_{E1} de-excitation PSF *after* folding



Negligible low-energy E1 enhancement

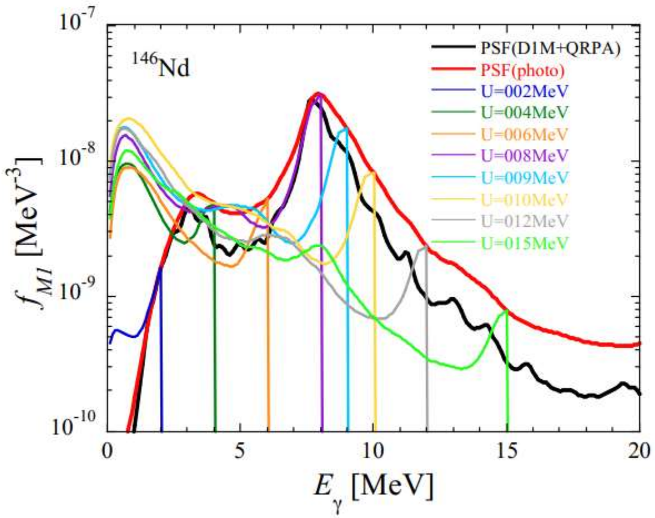
Courtesy of S.Goriely

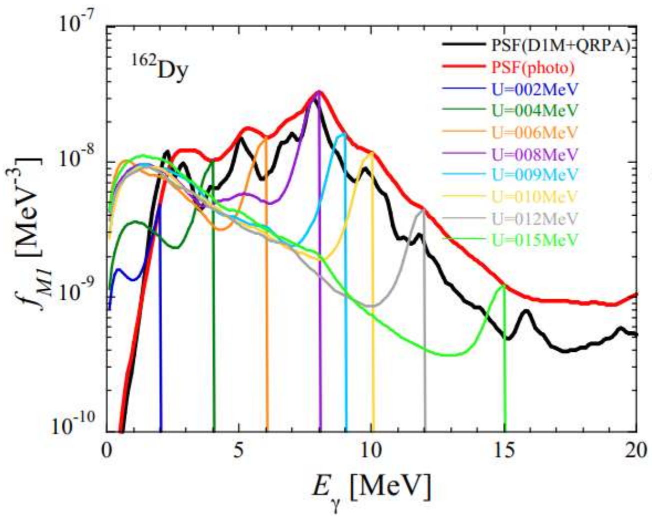


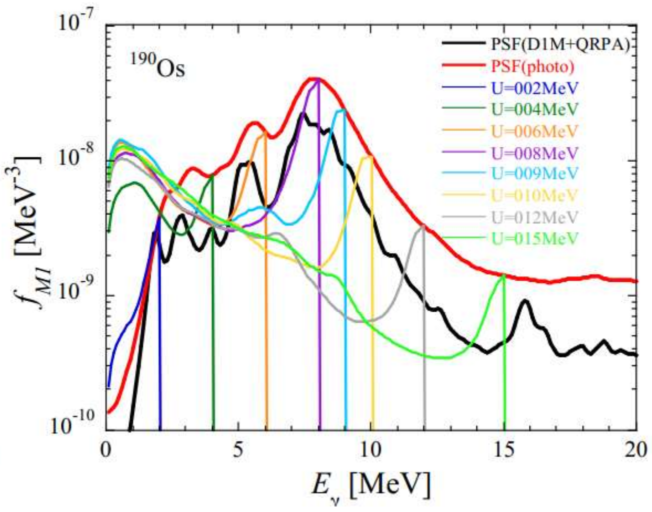


Preliminary results

Systematic low-energy enhancement of the M1 PSF

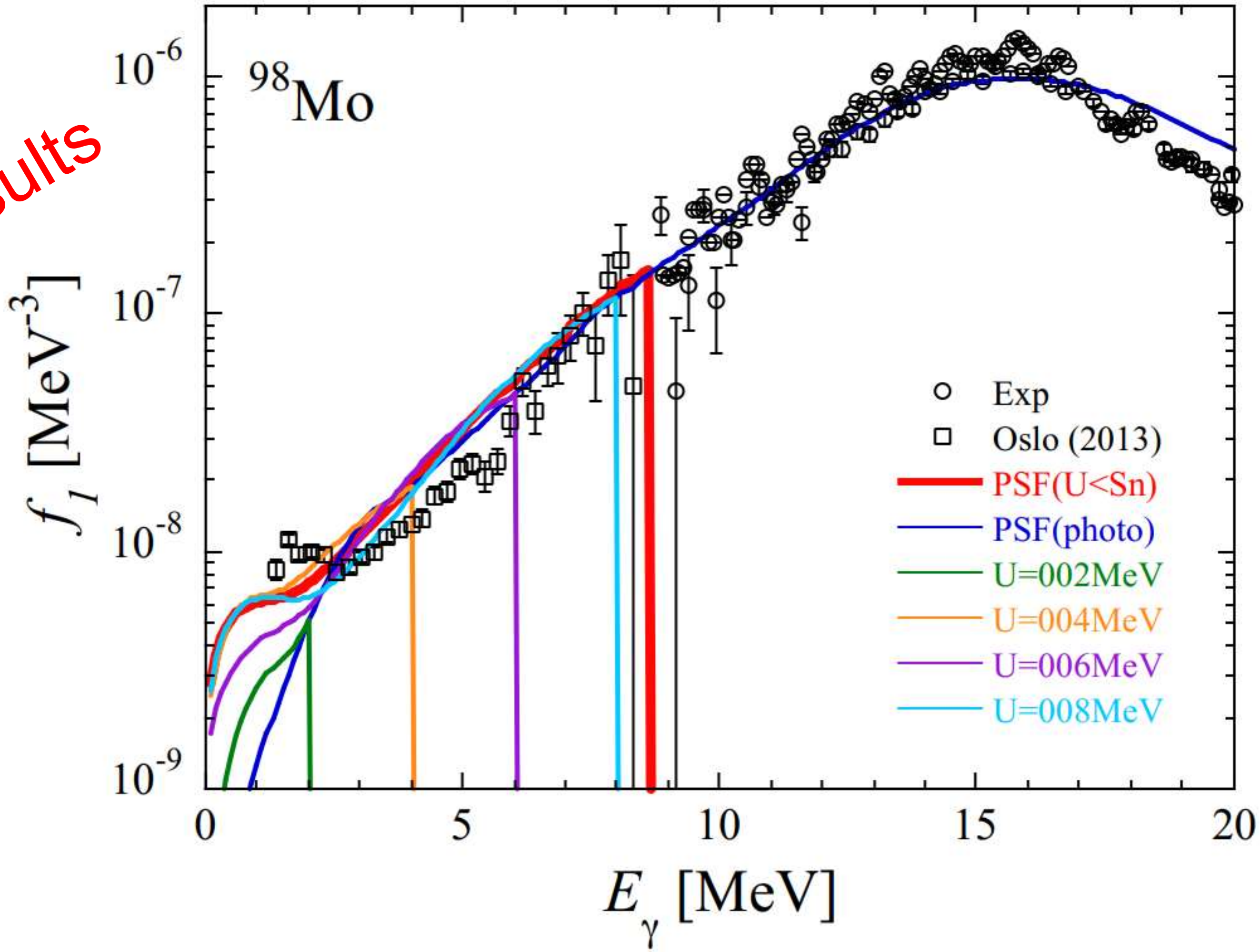






Comparison with Oslo data

Preliminary results



A little recap

- Microscopic ingredients improve the gamma-ray strength function models
- Many photo-absorption based on QRPA are obtained for various interactions.
- Beyond standard QRPA approaches are promising for future systematics (QPM, ab inito);

  Shell Model can be competitive for light systems;

  TDDFT cam provides photo absorption for many system up to heaviest and deformed ones.
- K mixing for isomer description: probabilities of transitions between QRPA excited states are needed.
- Intra-band and inter-band transition probabilities beyond standard QRPA are now accessible.
- work still in progress to improve γ-strength functions with microscopic inputs.

F(Eγ) ➔ F(Eγ, Ex) ➔ F(Eγ, Ex,δEx) ➔ F(Eγ, Ex, δEx, J, π)

Thanks for your attention