Some updates on theoretical PSF models

S. Goriely

- SMLO: phenomenological Lorentzian - E1 & M1
- D1M+QRPA+0lim: deformed Gogny QRPA with empirical corrections (energy shift, spreading width, M1 upbend)

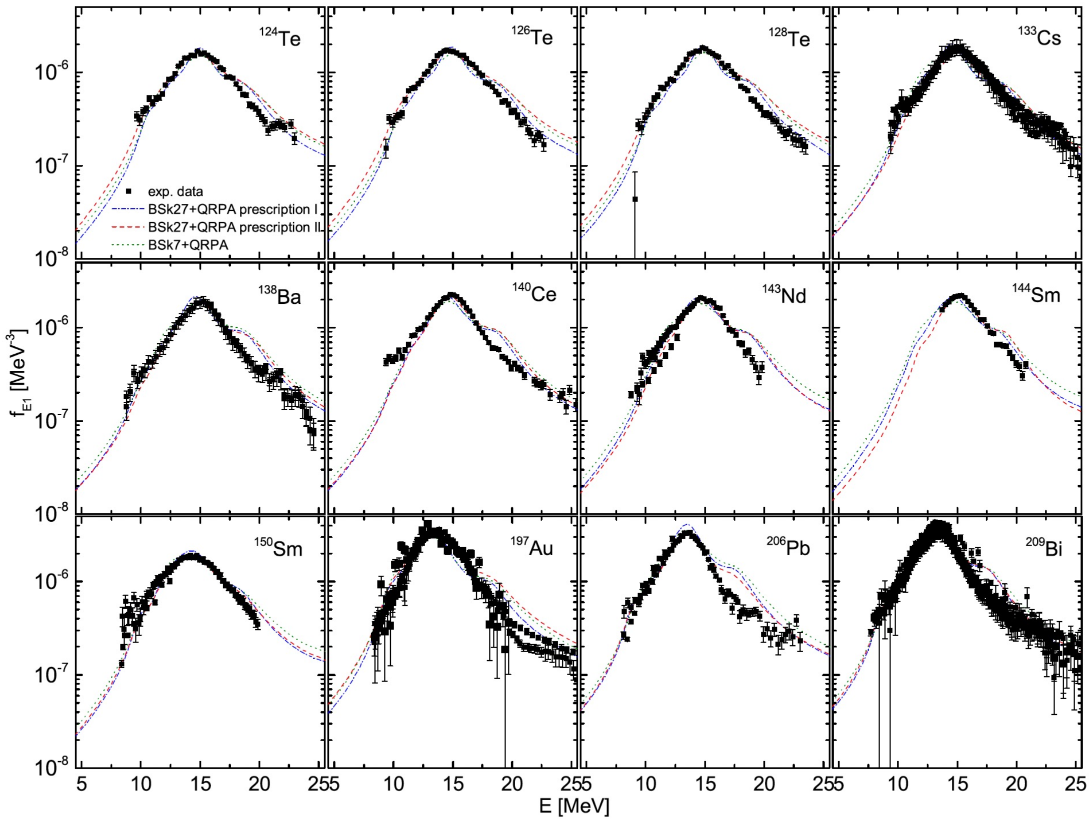
Since 2019, global models published:

- BSk27 + QRPA : spherical, E1 & M1 + empirical corrections (E1 deformation effects, M1 SM, M1 upbend)
- RQFAMz: RMF + QFAM (DD-PC1) – deformed, E1 – no M1
- Configuration Interaction Shell model - E1 - light nuclei

Spherical HFB+QRPA calculations of E1 & M1 PSF

Y. Xu, SG, E. Khan, PRC 104, 044301 (2021)

Comparison with E1 photodata (2021)

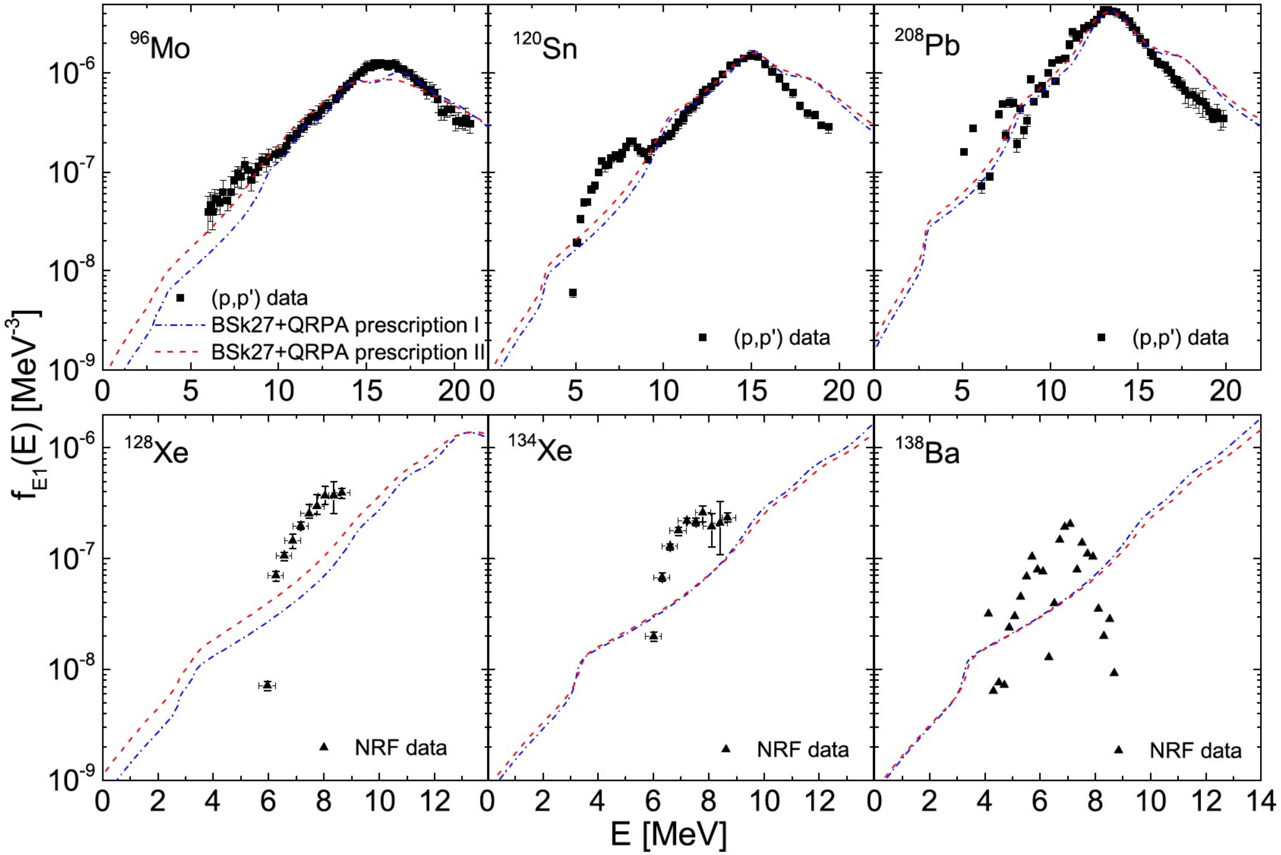


Phenomenological shift, spreading and deformation corrections

Spherical HFB+QRPA calculations of E1 & M1 PSF

Y. Xu, SG, E. Khan, PRC 104, 044301 (2021)

Comparison with E1 (p,p') (2021)



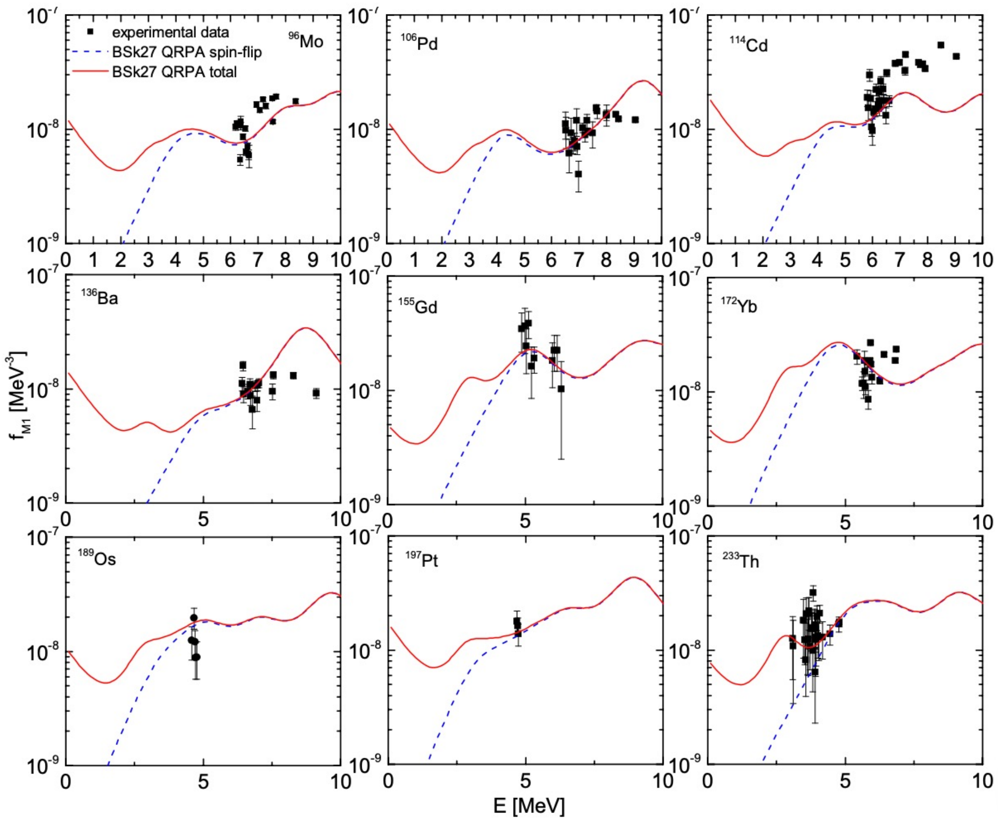
Phenomenological shift, spreading and deformation corrections

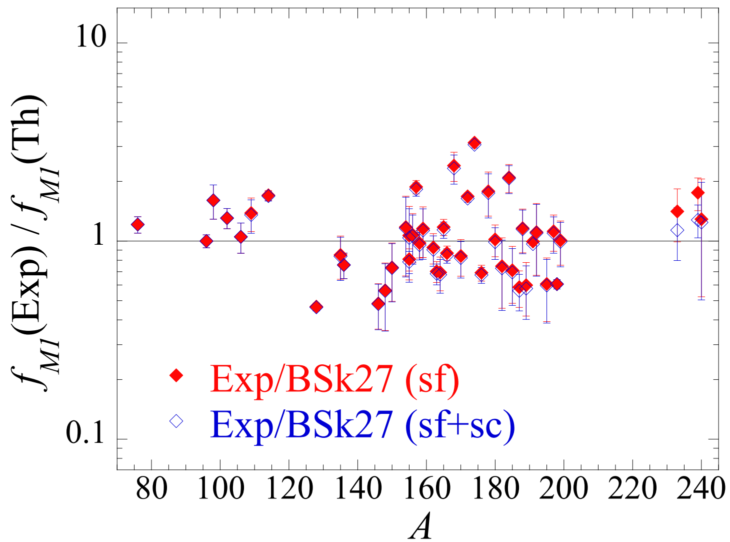
Spherical HFB+QRPA calculations of E1 & M1 PSF

Calculation of the M1 spin-flip PSF (2025) including phenomenological inclusion of M1 scissors mode (SMLO) and upbend (exp).

Y. Xu, SG, M. Krticka, E. Khan, PRC (2025) in press

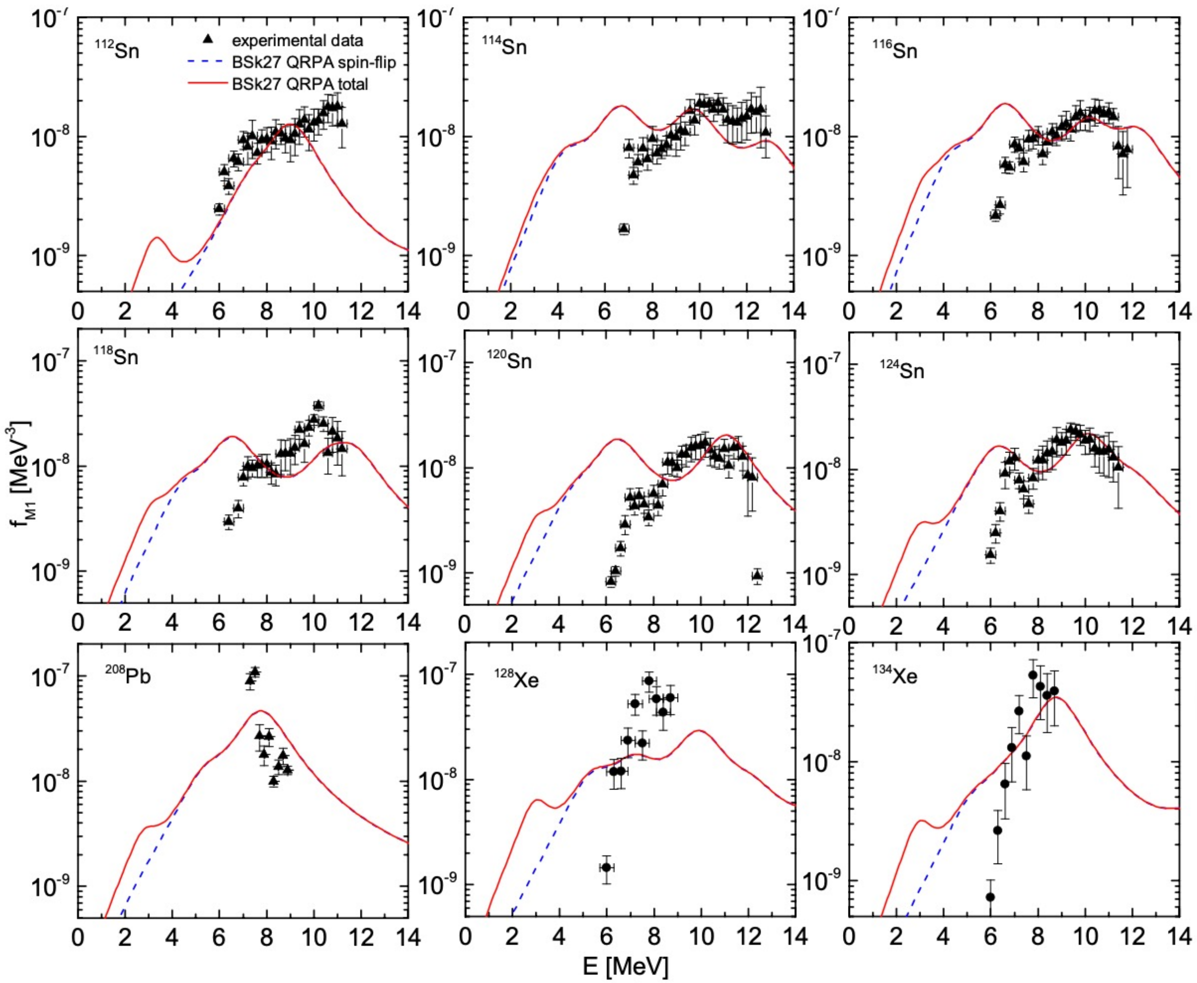
Comparison with M1 ARC data (2025)





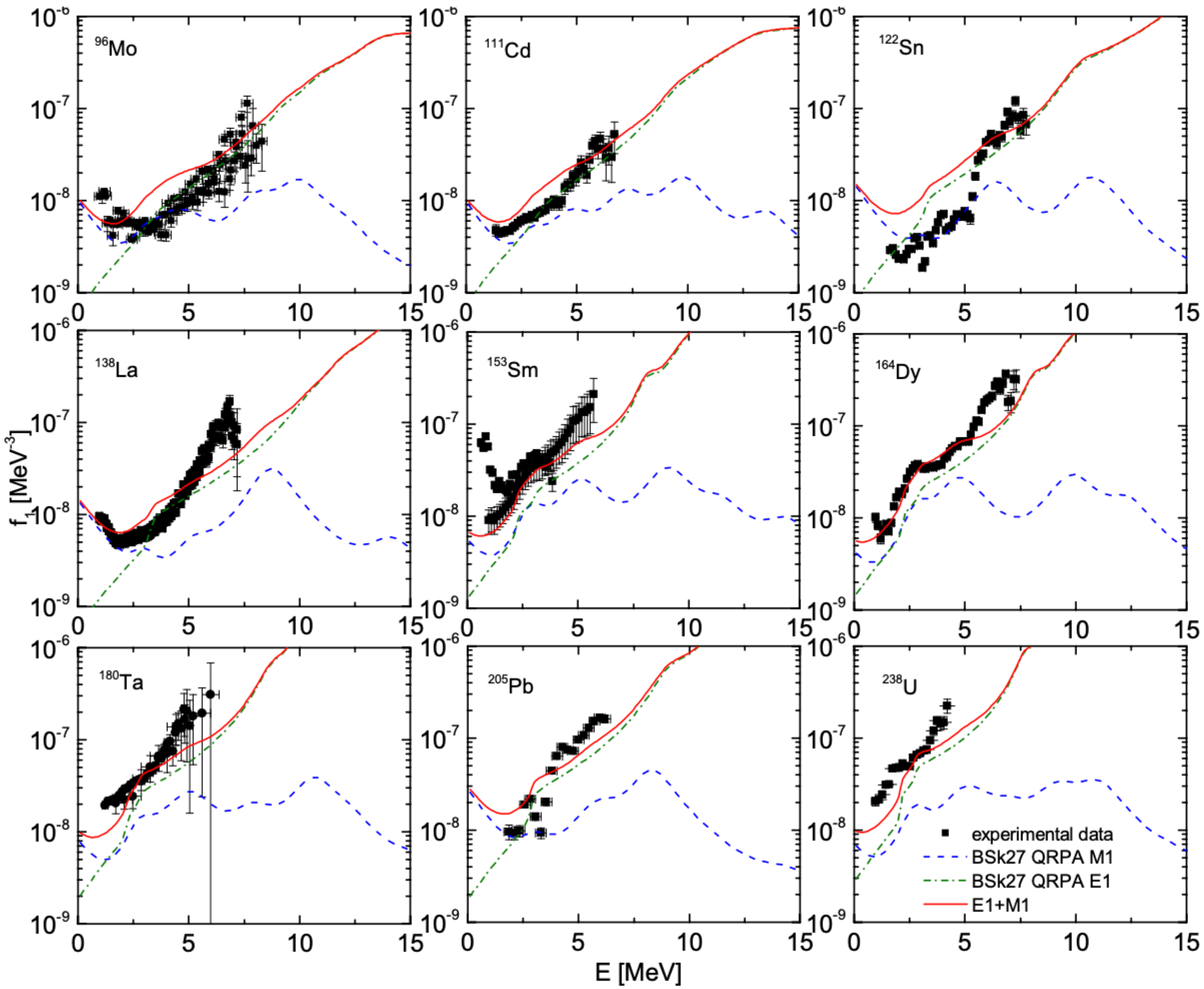
Spherical HFB+QRPA calculations of E1 & M1 PSF

Comparison with M1 (p,p') data



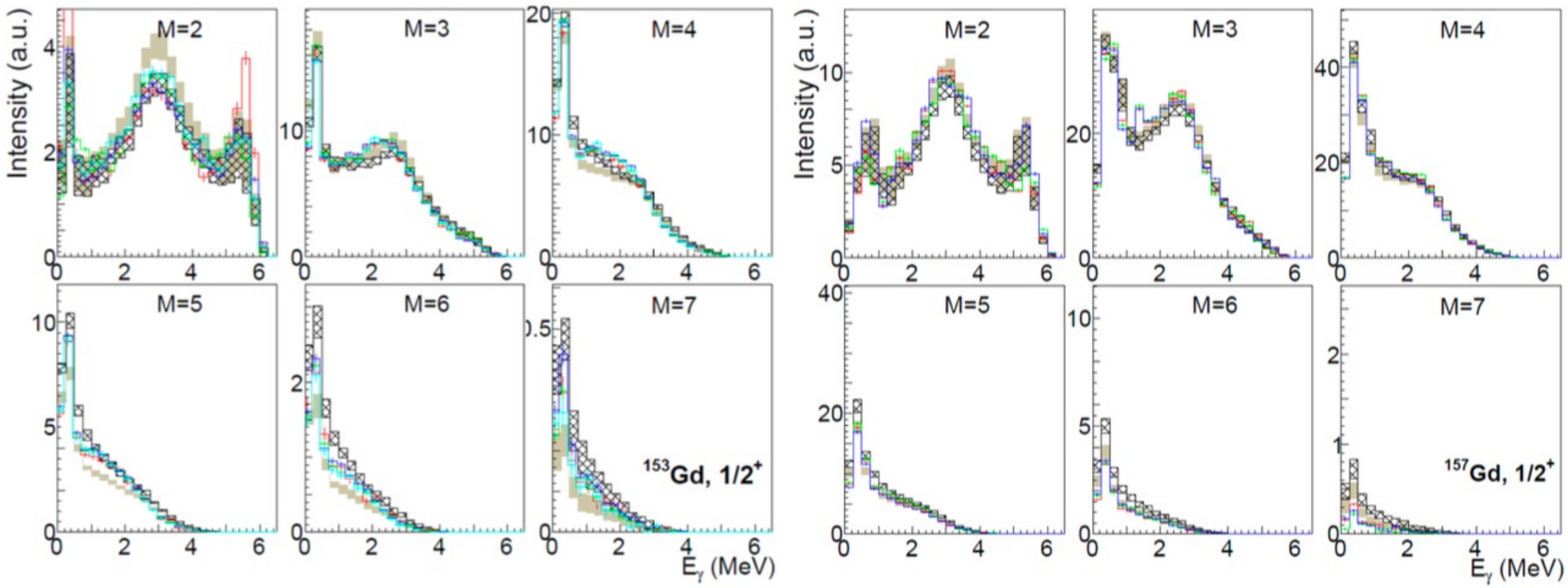
Spherical HFB+QRPA calculations of E1 & M1 PSF

Comparison with E1+M1 Oslo data



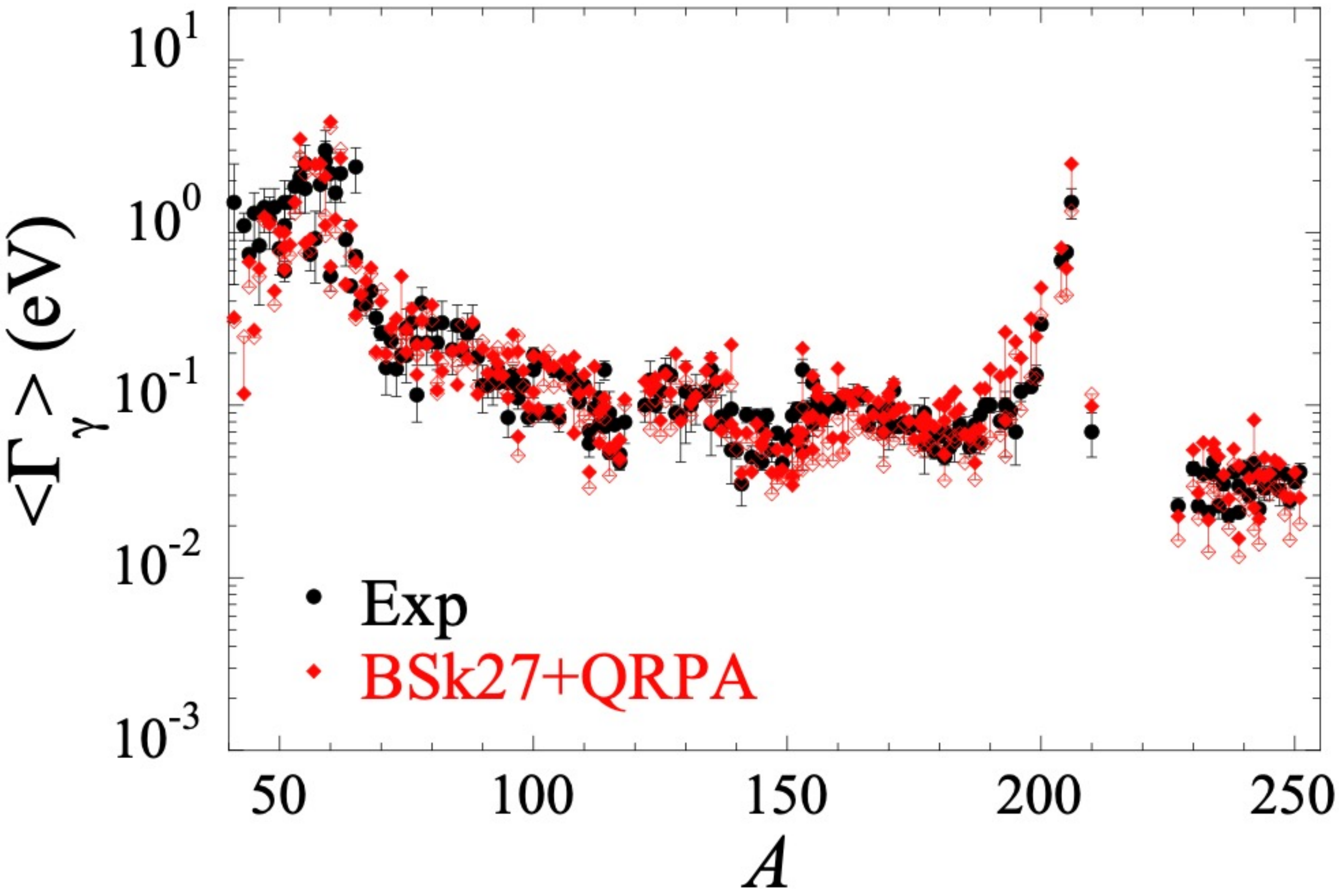
Spherical HFB+QRPA calculations of E1 & M1 PSF

Comparison with MSC data



Spherical HFB+QRPA calculations of E1 & M1 PSF

Comparison with <Γ_γ> data

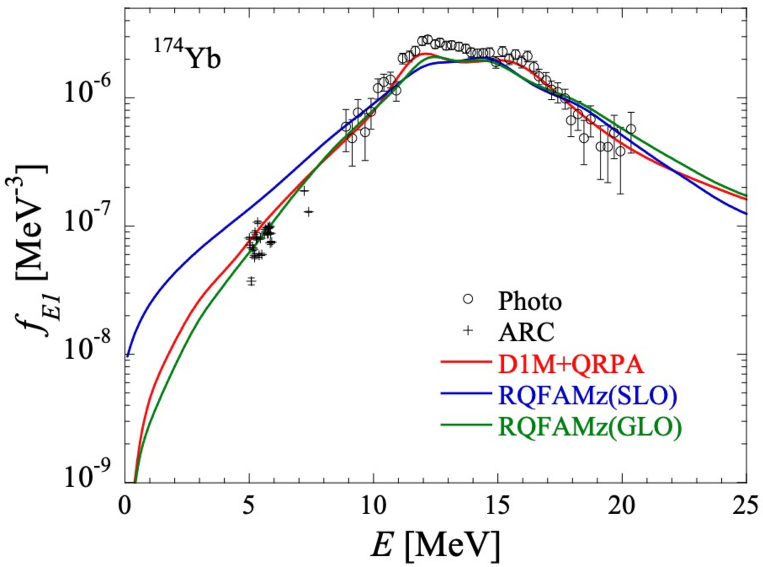


Deformed covariant energy density functional approach

Gonzalez-Miret Zaragoza, Ebran, SG, Hilaire, Khan, Péru (2025)

$$\Delta(A) = \begin{cases} 0.065A - 3.4,\ \text{MeV} & \text{for } A < 60 \\ 0.5\ \text{MeV}, & \text{otherwise.} \end{cases}$$

$$\Gamma(A) = \begin{cases} 4\ \text{MeV}, & A < 90, \\ 1.27 + 245/A\ \text{MeV}, & 90 \leq A \leq 200, \\ 2.5\ \text{MeV}, & A > 200. \end{cases}$$

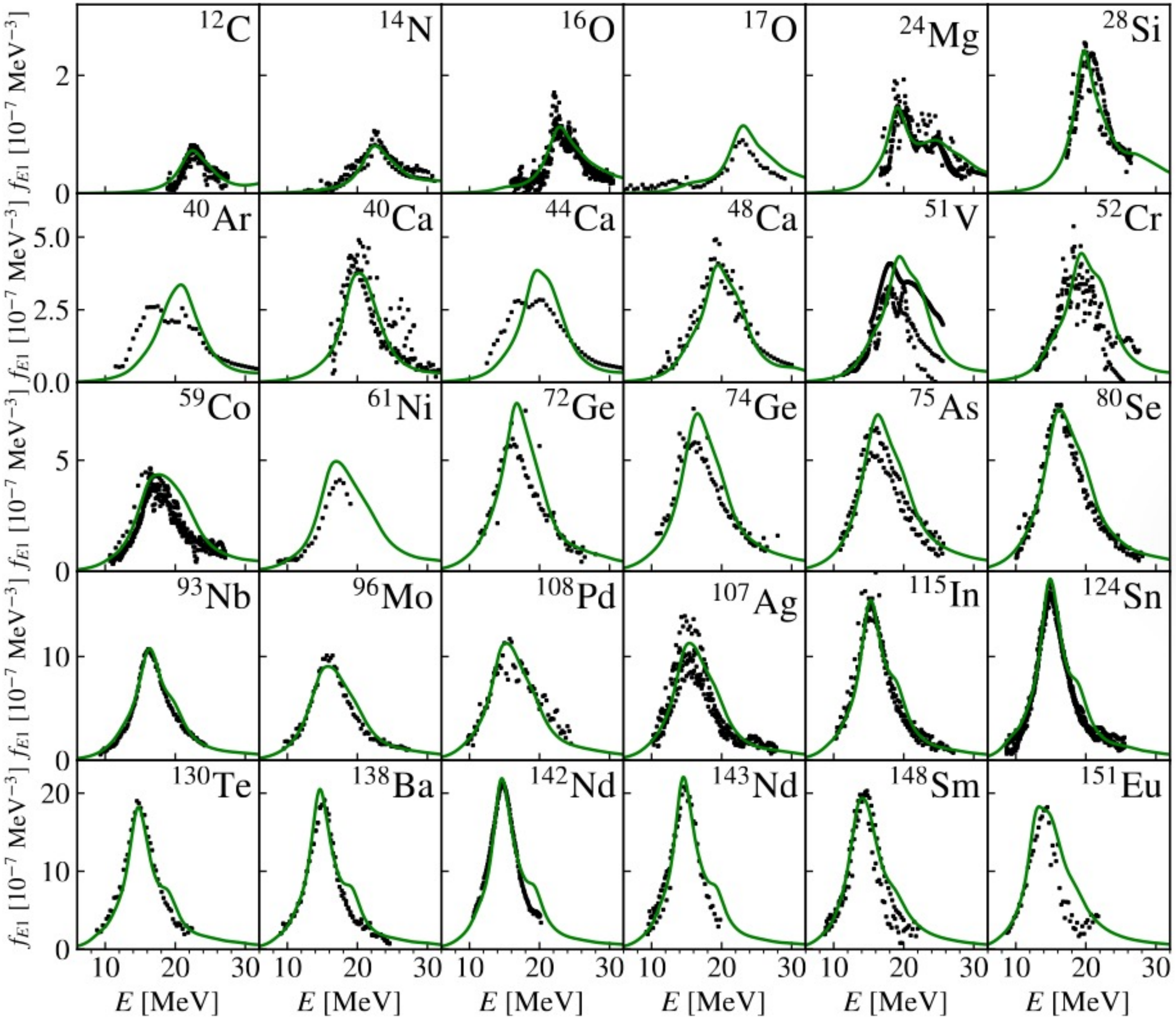


SLO vs GLO

Deformed covariant energy density functional approach

Gonzalez-Miret Zaragoza, Ebran, SG, Hilaire, Khan, Péru (2025)

RQFAMz

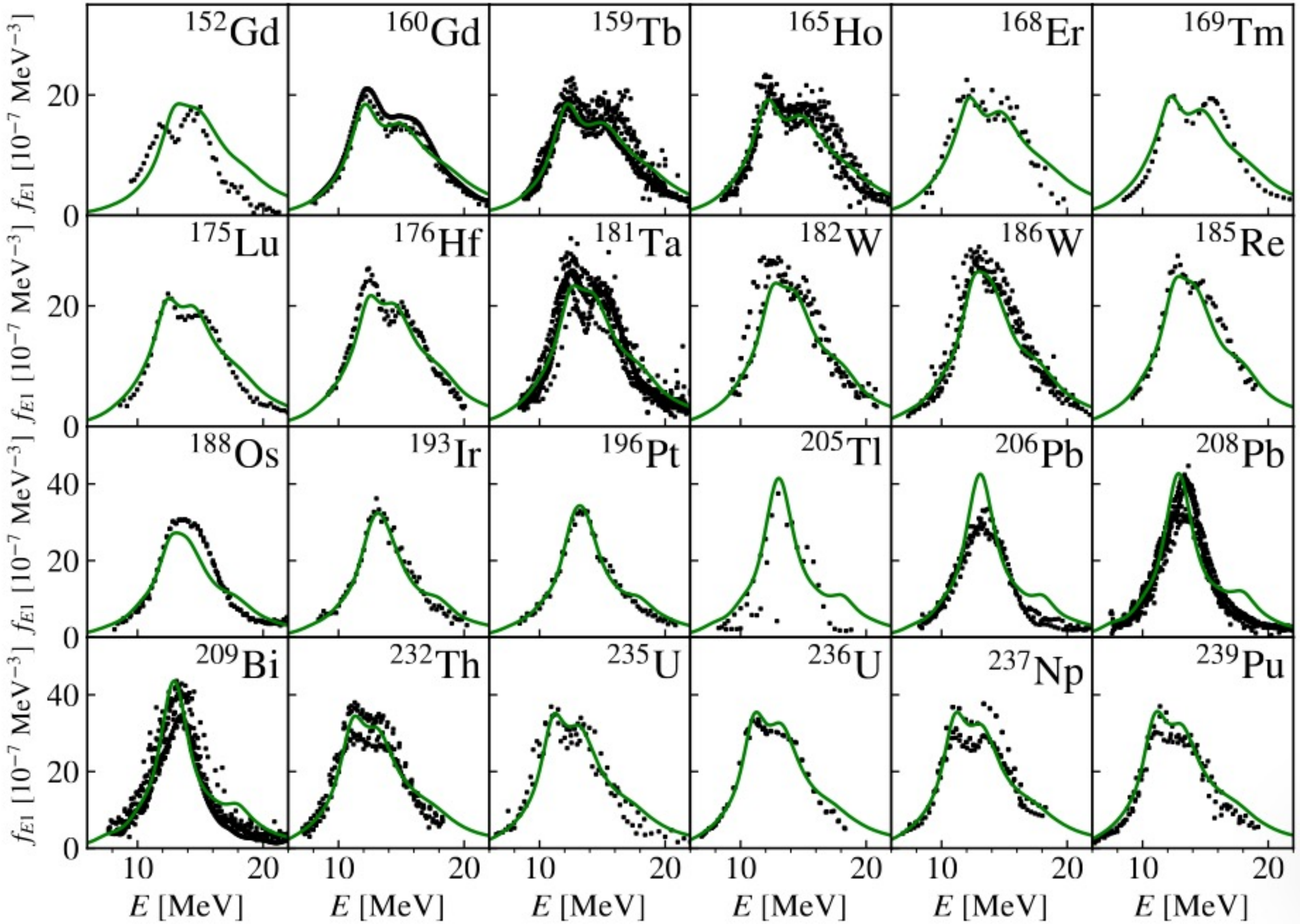


better on light nuclei than D1M+QRPA !

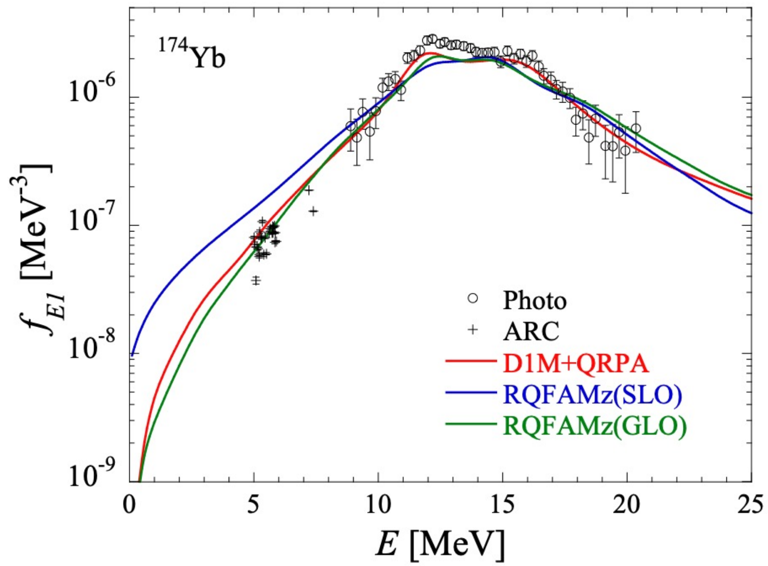
Deformed covariant energy density functional approach

Gonzalez-Miret Zaragoza, Ebran, SG, Hilaire, Khan, Péru (2025)

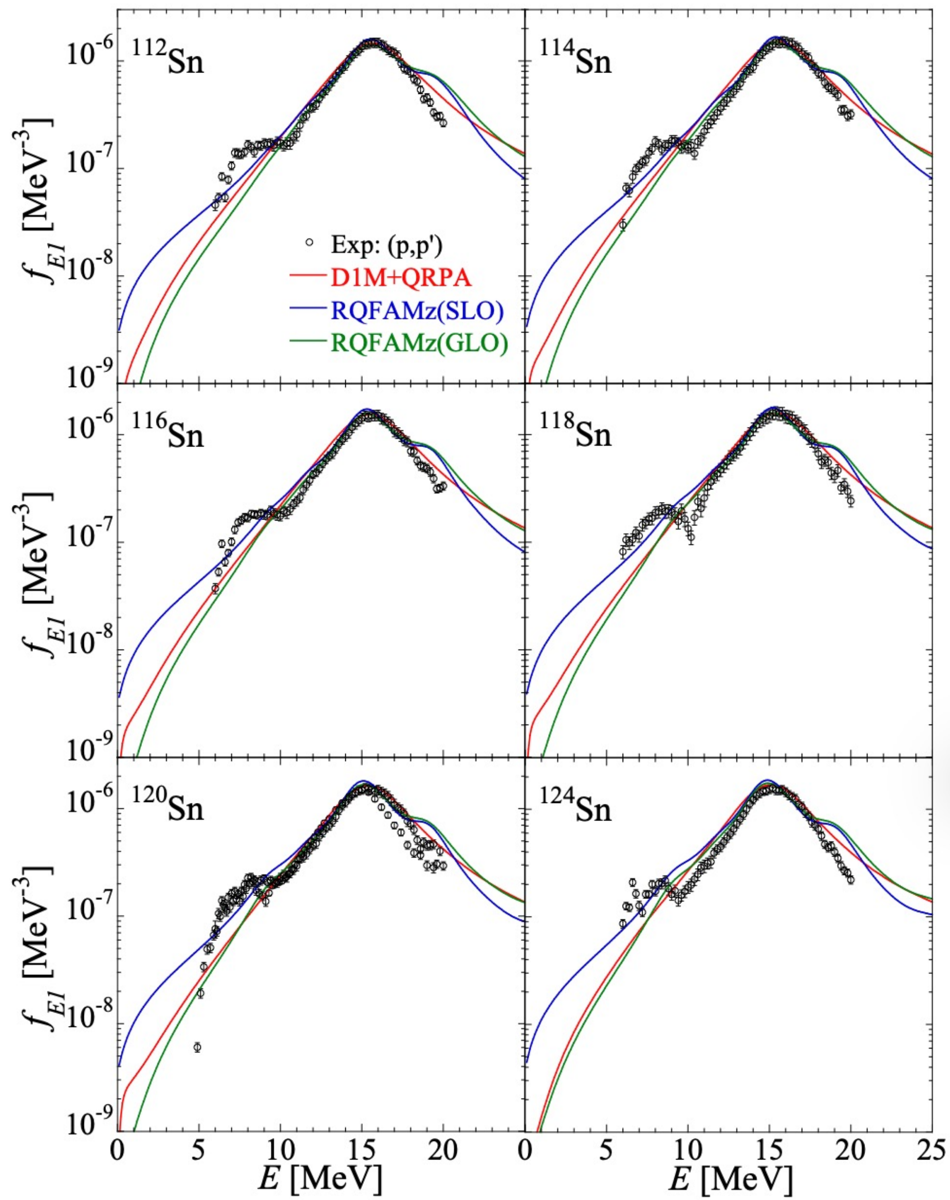
RQFAMz



better on actinides than D1M+QRPA !

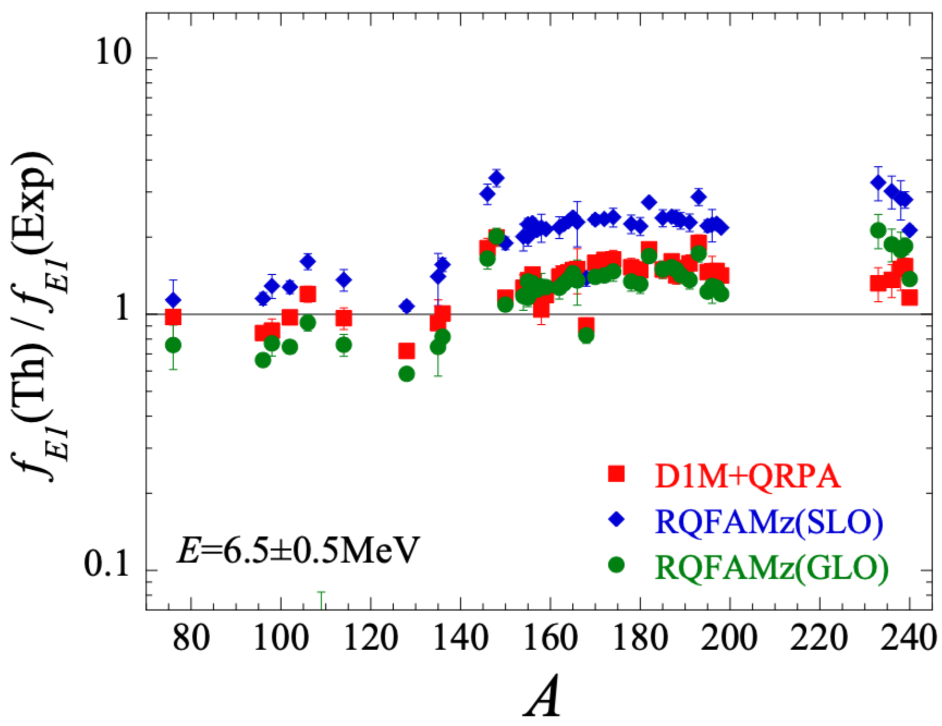


174Yb
Photo
ARC
D1M+QRPA
RQFAMz(SLO)
RQFAMz(GLO)
f_E1 [MeV^-3]
E [MeV]

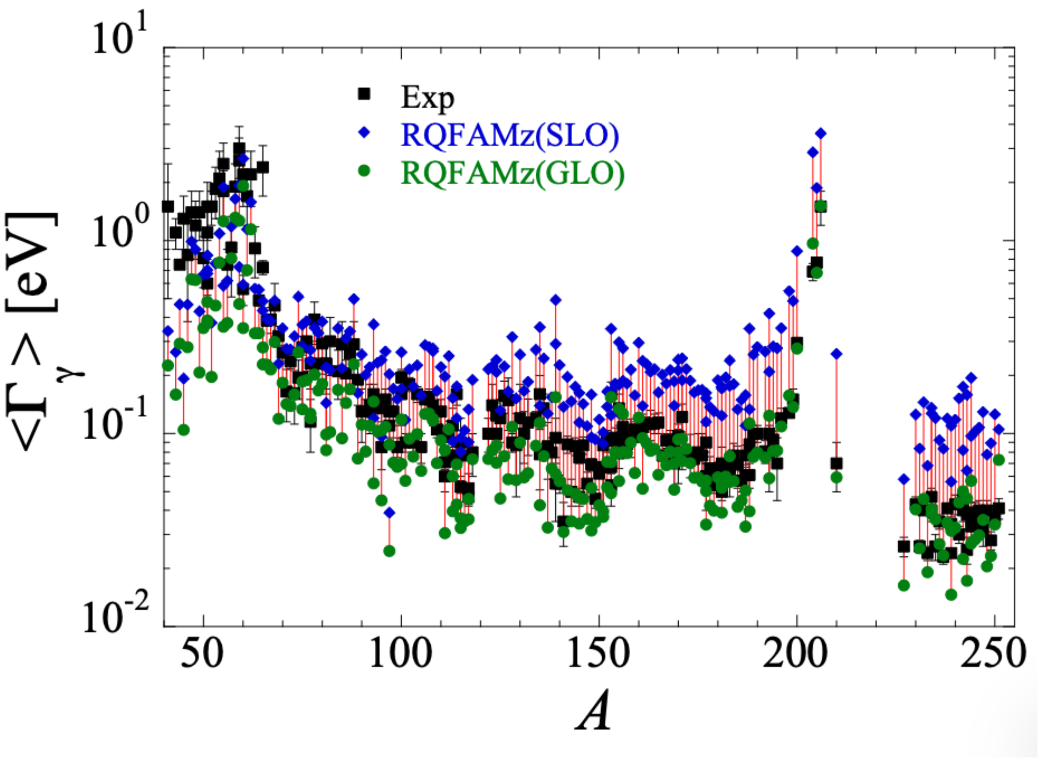


112Sn
114Sn
116Sn
118Sn
120Sn
124Sn
Exp: (p,p')
D1M+QRPA
RQFAMz(SLO)
RQFAMz(GLO)
f_E1 [MeV^-3]
E [MeV]

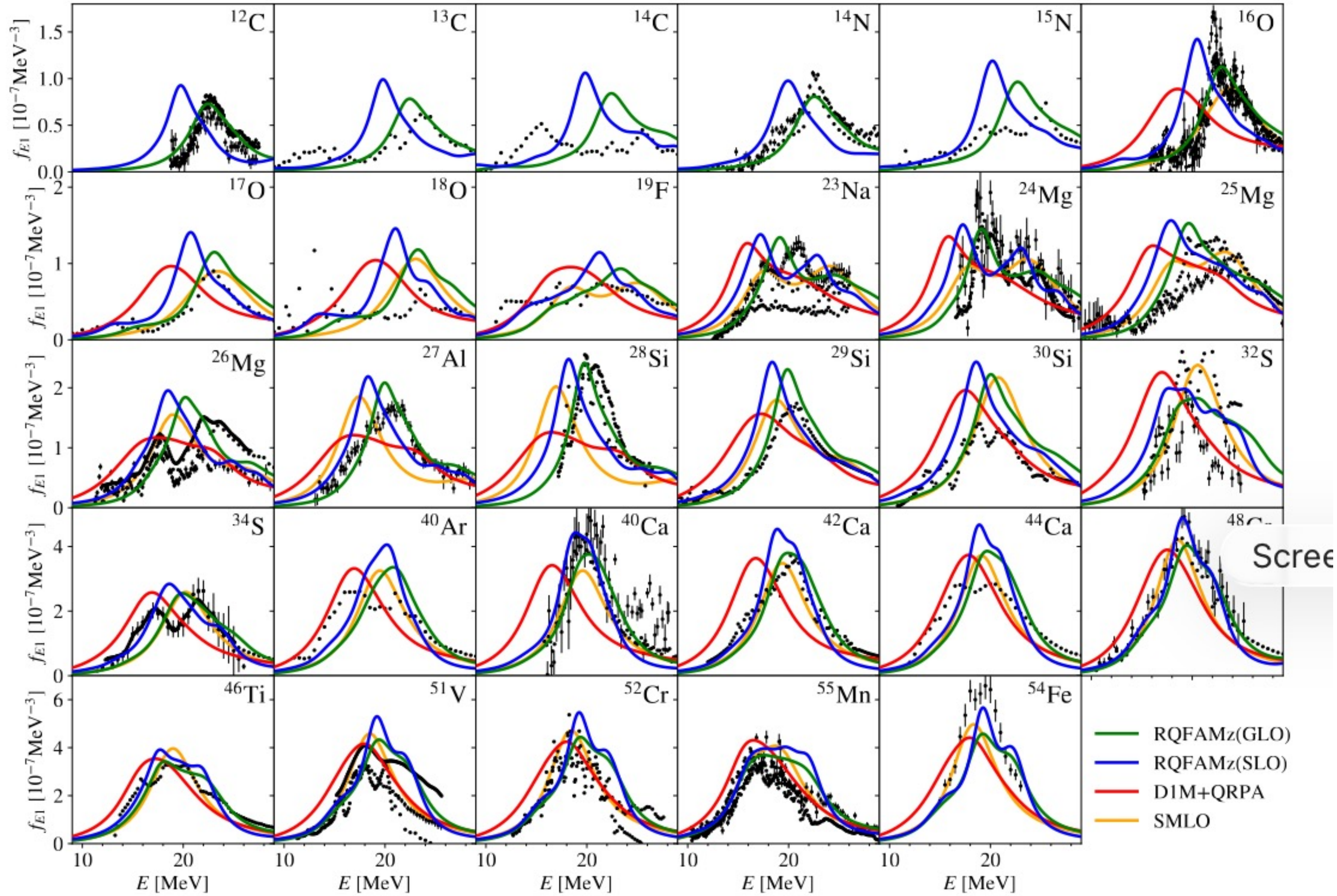
ARC data



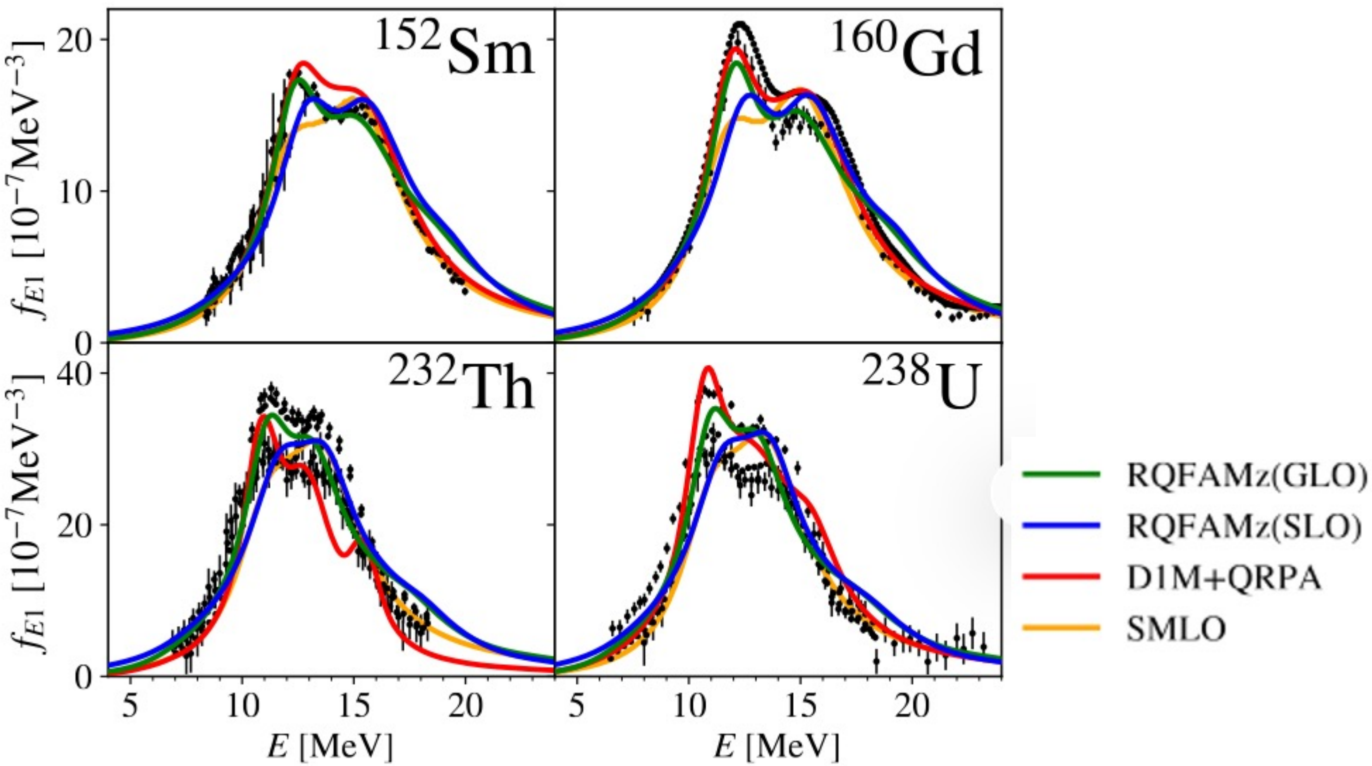
$<\Gamma_\gamma>$ data



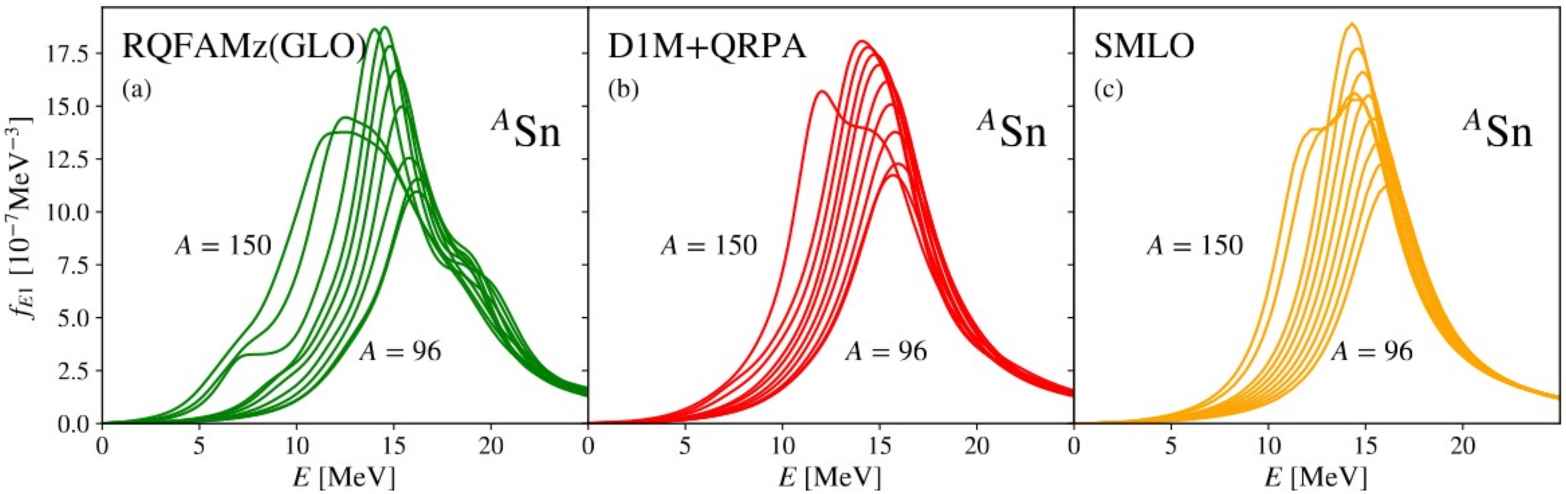
Comparison between different models for light A<56 nuclei



Comparison between different models for heavy deformed nuclei

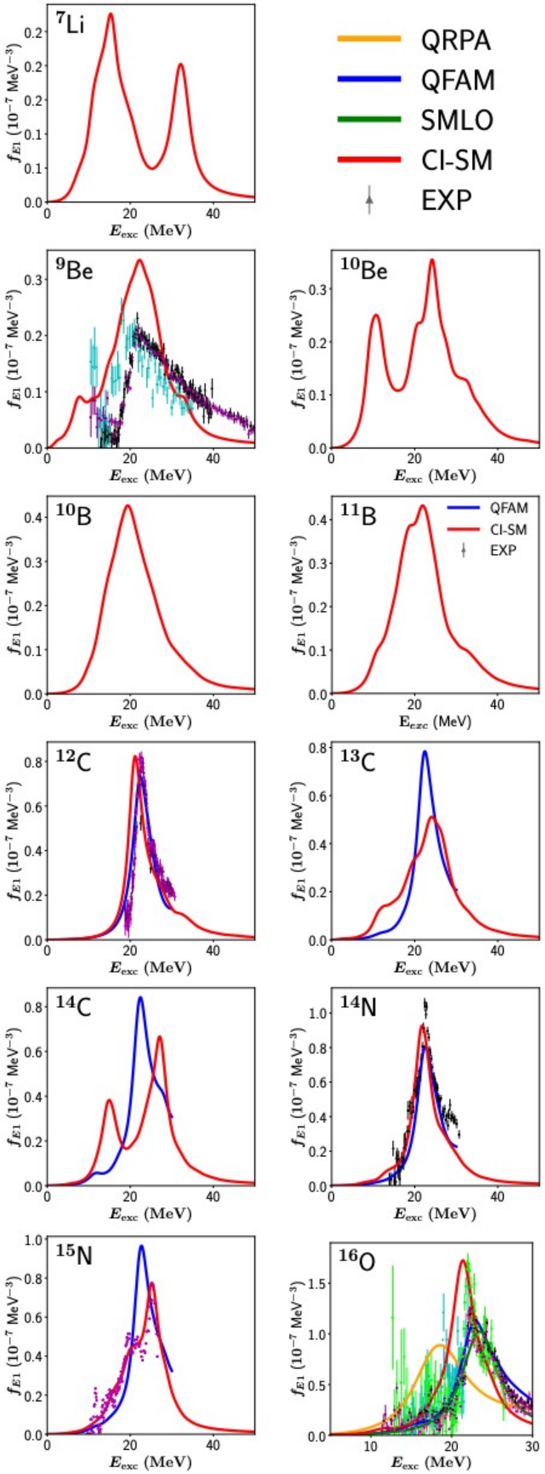


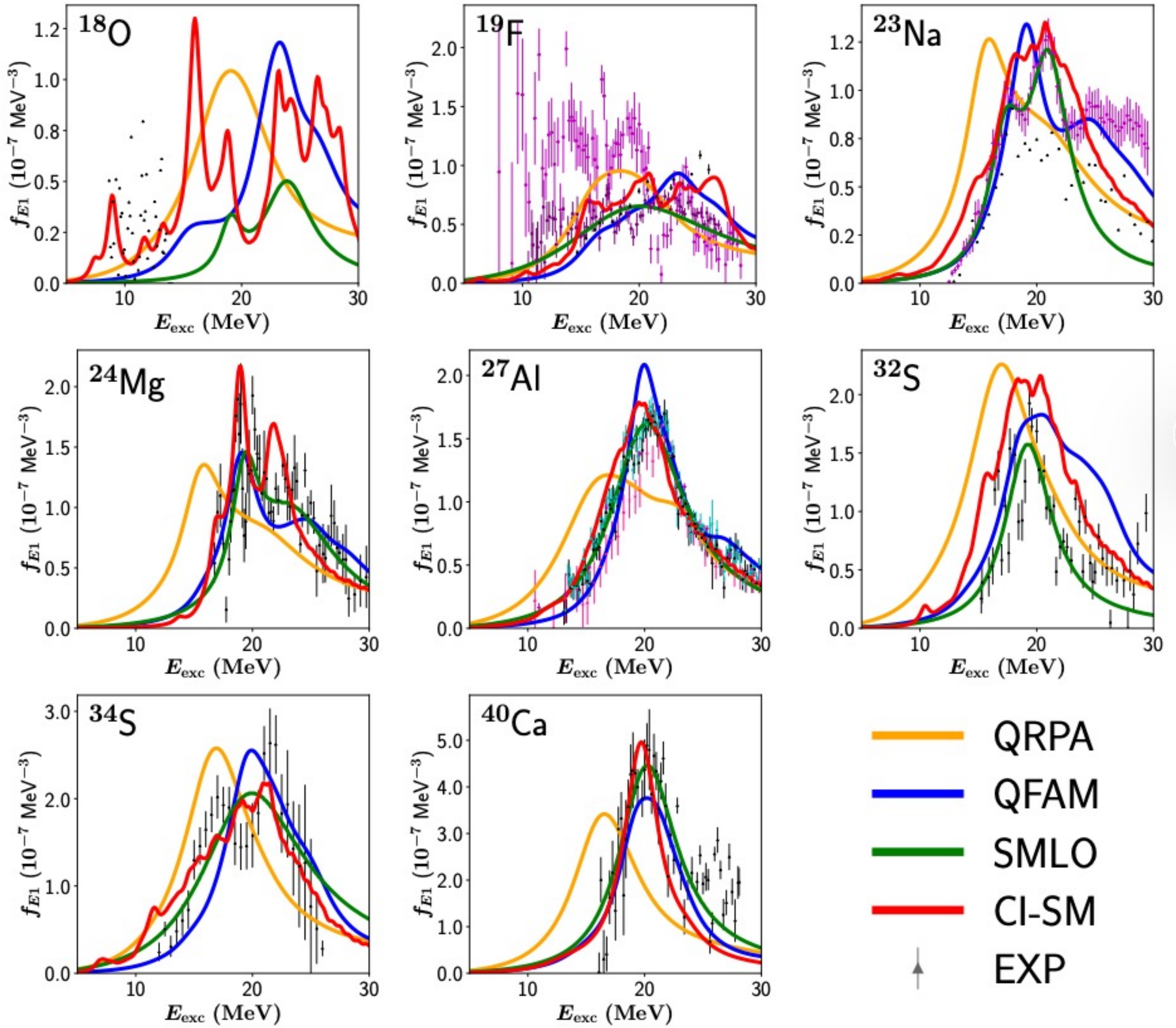
Comparison between different models for n-rich nuclei

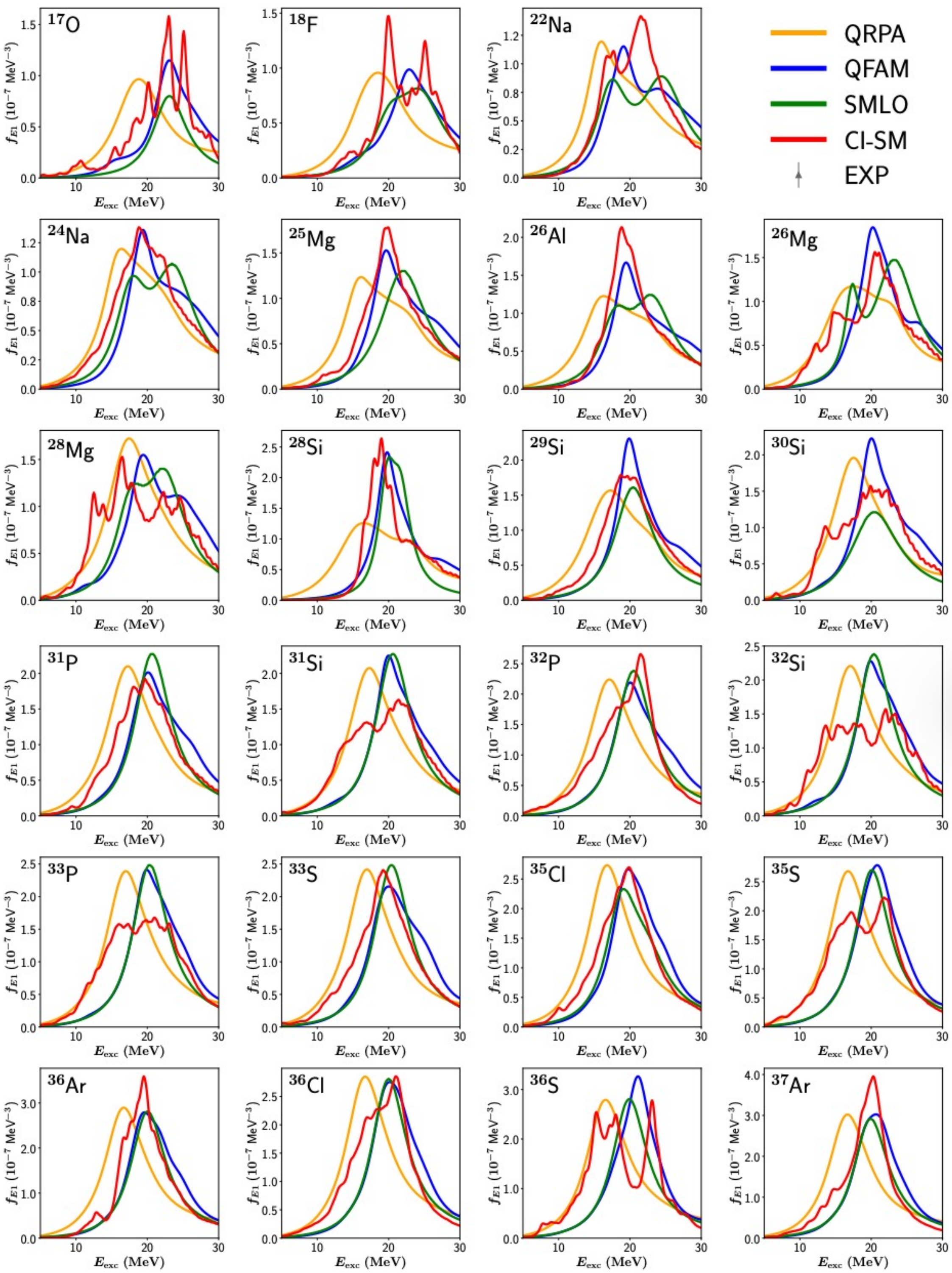


Configuration Interaction Shell Model

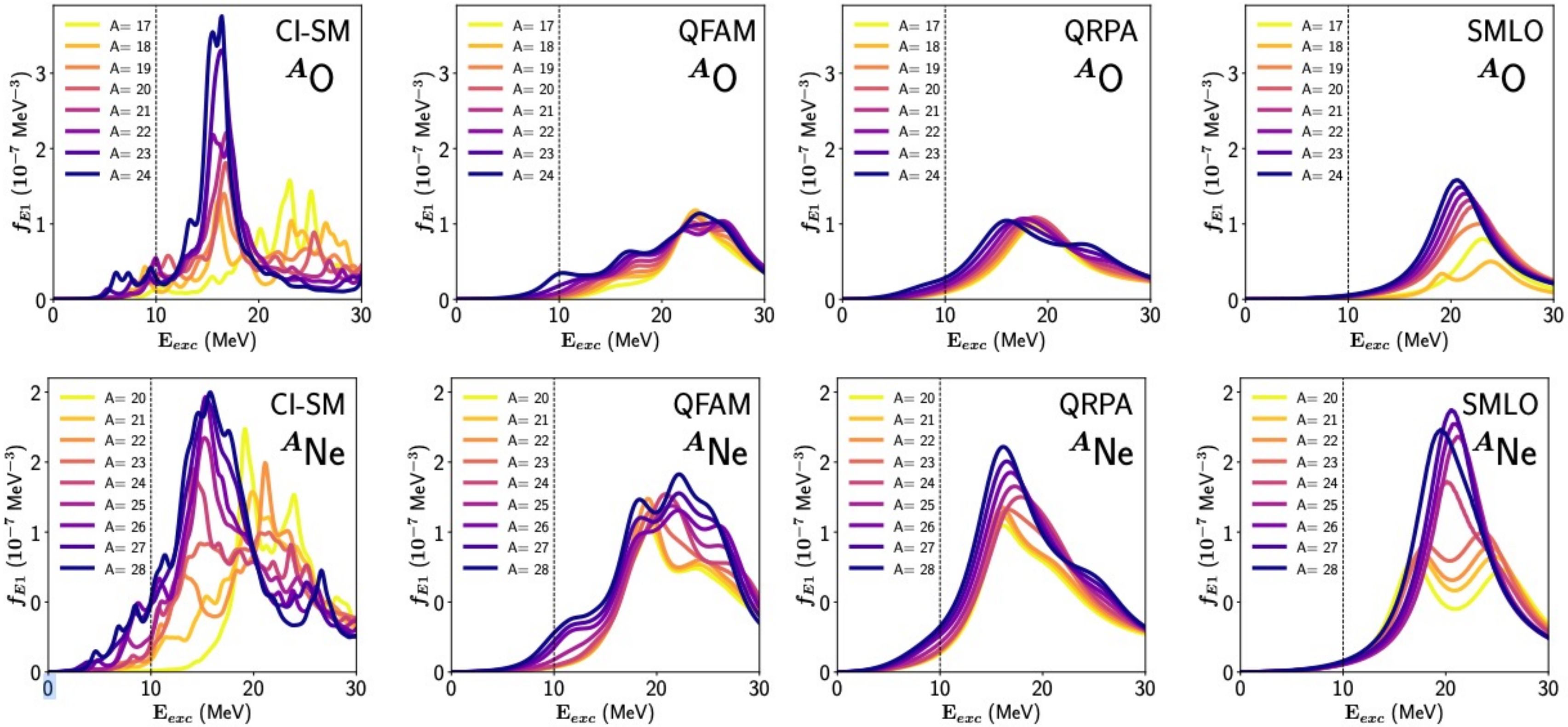
Le Noan, Sieja (2025)







QRPA
QFAM
SMLO
CI-SM
EXP
^{17}O
^{18}F
^{22}Na
^{24}Na
^{25}Mg
^{26}Al
^{26}Mg
^{28}Mg
^{28}Si
^{29}Si
^{30}Si
^{31}P
^{31}Si
^{32}P
^{32}Si
^{33}P
^{33}S
^{35}Cl
^{35}S
^{36}Ar
^{36}Cl
^{36}S
^{37}Ar
f_{E1} (10^{-7} MeV^{-3})
E_{exc} (MeV)



CI-SM
^{A}O
QFAM
^{A}O
QRPA
^{A}O
SMLO
^{A}O
A= 17
A= 18
A= 19
A= 20
A= 21
A= 22
A= 23
A= 24
CI-SM
^{A}Ne
QFAM
^{A}Ne
QRPA
^{A}Ne
SMLO
^{A}Ne
A= 20
A= 21
A= 22
A= 23
A= 24
A= 25
A= 26
A= 27
A= 28
f_{E1} (10^{-7} MeV^{-3})
$\mathbf{E}_{exc}$ (MeV)

“Validation” of the theoretical dipole Photon Strength Function on

1. Photodata in the GDR region (10-20MeV): E1 for ~159 nuclei
2. ARC/DRC data: $\varepsilon_\gamma \sim$ 5-8MeV; E1 & M1 for 88 nuclei
3. Oslo data: $\varepsilon_\gamma < S_n$; E1+M1 for 72 nuclei
4. NRF data: $\varepsilon_\gamma < S_n$; E1+M1 for 23 nuclei
5. ΣB(M1) scattering data: $\varepsilon_\gamma \sim$ 2-4MeV for ~47 nuclei
6. (p,γ) data: E1+M1 at $\varepsilon_\gamma \sim$ 5-10MeV for 22 nuclei ($A = 46 - 90$)
7. (p,p’) data for ^{96}Mo, ^{120}Sn, ^{208}Pb: E1& M1 at $\varepsilon_\gamma \sim$ 5-20MeV
8. MSC & MD spectra: E1+M1 for ~15 nuclei with ~4 J^π/nuc (NLD)
9. Neutron capture spectra: E1+M1 for 5 nuclei & diff J^π (NLD)
10. Average radiative width $<\Gamma_\gamma>$: $0 \leq \varepsilon_\gamma \leq S_n$ E1+M1 for ~230 nuc (NLD)
11. 30keV MACS $0 \leq \varepsilon_\gamma \leq S_n$ E1+M1 for ~240 nuc (NLD)

IAEA Reference Database developed within a recent CRP

(cf Talks of Wiedeking, Krticka, Schwengner, Utsunomiya)

“Validation” of the theoretical dipole Photon Strength Function on

Experimental data: 2024
324 unique nuclides (1071 datafiles) for all experimental methods

154 nuclides	Z = 2-94	(337 files)	Photonuclear
103 nuclides	Z = 21-94	(133 files)	**Oslo Methods**
58 nuclides	Z = 9-90	(137 files)	Thermal neutron capture
63 nuclides	Z = 9-94	(115 files)	Absolute Photonuclear
54 nuclides	Z = 33-94	(123 files)	Average Resonance Capture
52 nuclides	Z = 9-94	(99 files)	Discrete Resonance Capture
27 nuclides	Z = 26-82	(34 files)	**Nuclear Resonance Fluorescence**
22 nuclides	Z = 22-40	(37 files)	**Proton capture**
11 nuclides	Z = 26-66	(31 files)	**Ratio and Shape Method**
8 nuclides	Z = 42-82	(25 files)	**Proton scattering**

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