

Statistical Gamma-Ray Decay Studies at iThemba LABS

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Outline

- Brief overview of PSF and the problem of different measurements
- ^{74}Ge : PSF and PDR
- ^{95}Mo : γ -decay from neutron unbound states
- Concluding remarks.

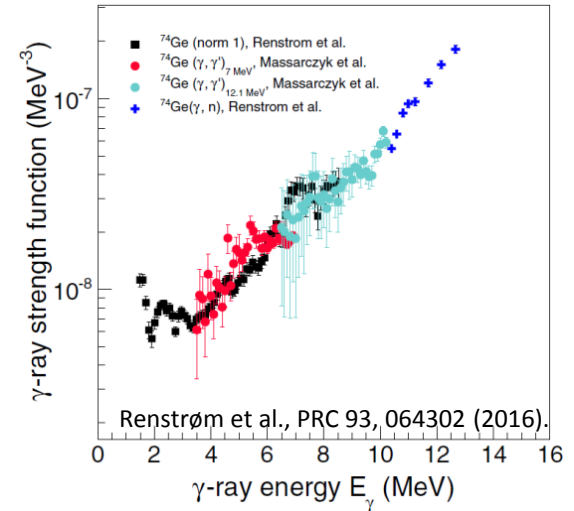
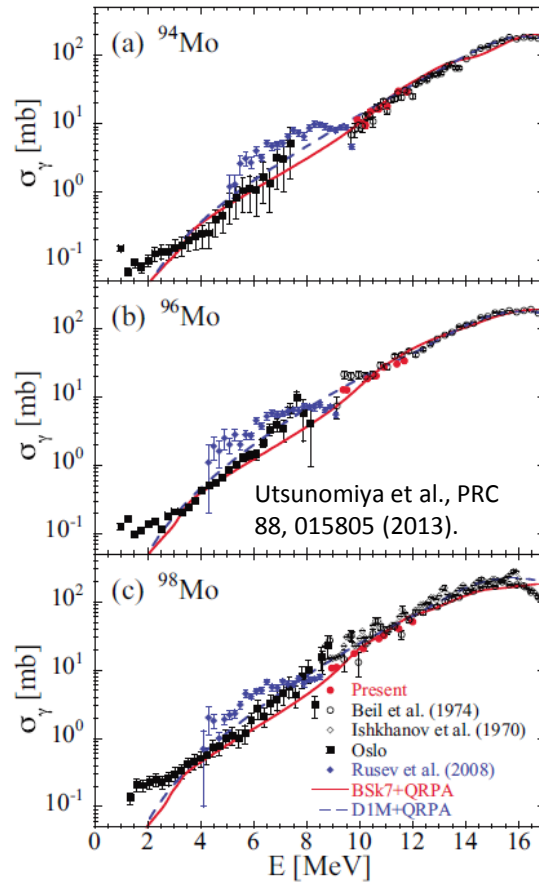
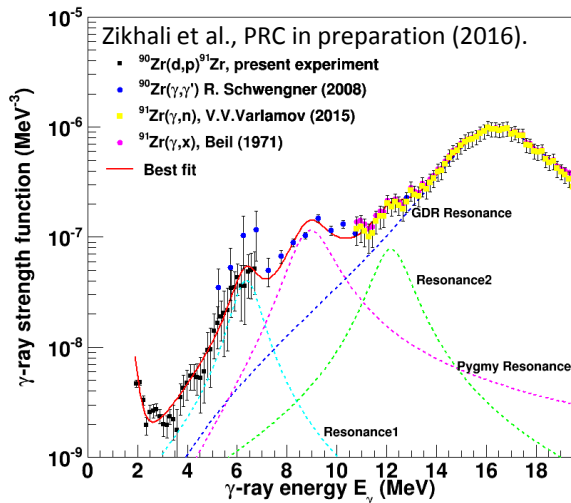
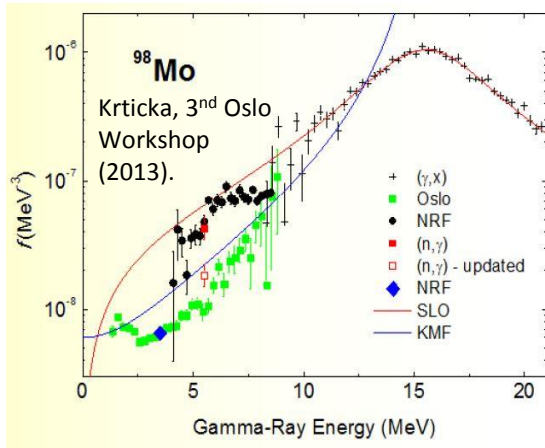


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Combining Data



- Inconsistencies between results from different methods.
- Sometimes things match.
- Why the differences?
- Confusing situation and not clear why.

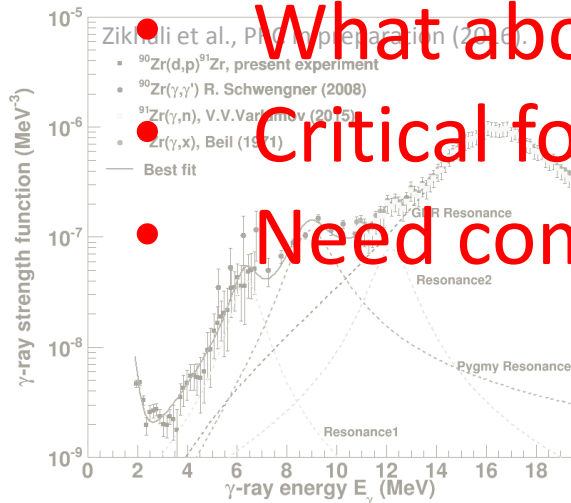
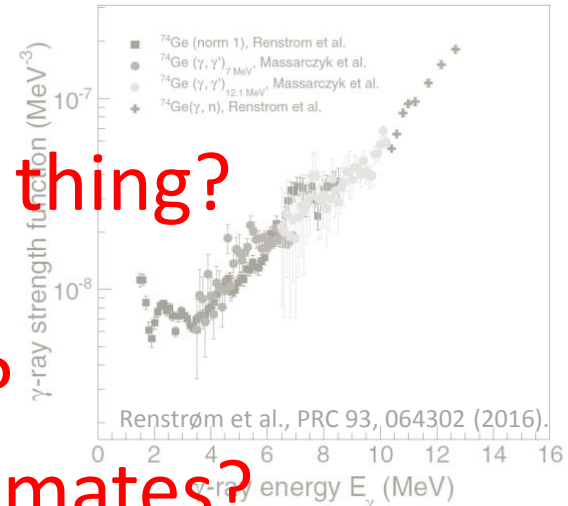
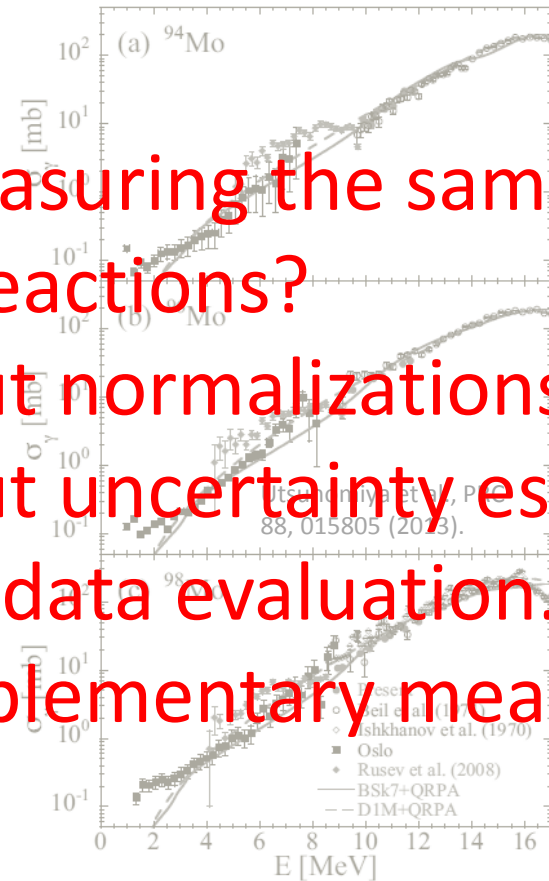
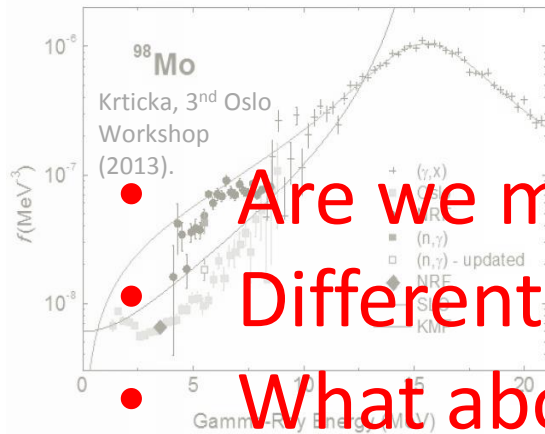


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Combining Data



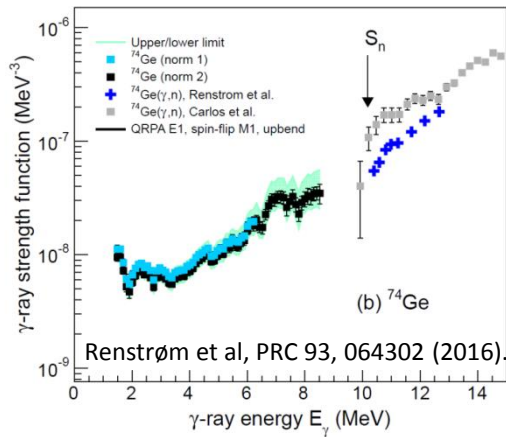
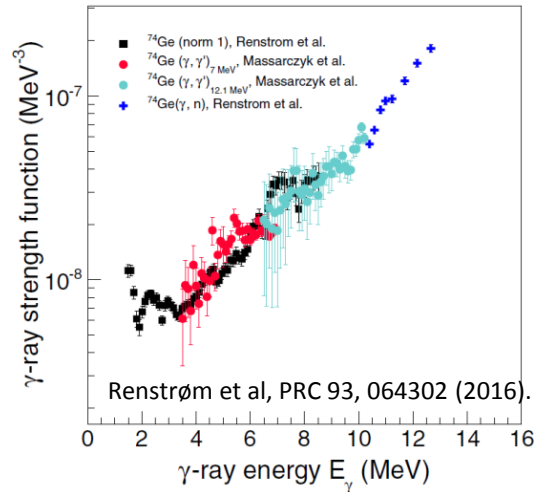
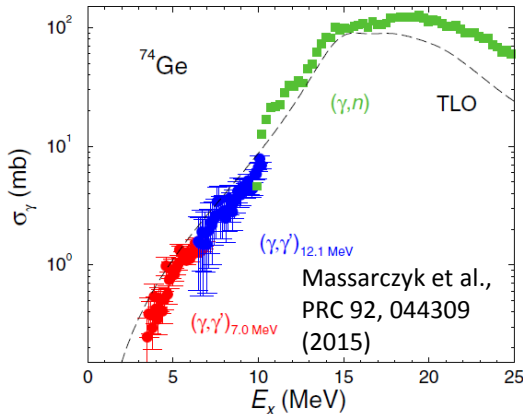
- Are we measuring the same thing?
- Different reactions?
- What about normalizations?
- What about uncertainty estimates?
- Critical for data evaluation.
- Need complementary measurements.

- Inconsistencies between results from different methods.
- Sometimes things match.
- Why the differences?
- Confusing situation and not clear why.

^{74}Ge : measurements

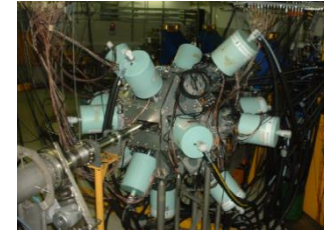
^{74}Ge : study nucleus in a series of measurements

- Use different beams on ^{74}Ge to populate states: p (LBNL), ^4He (iTLL), ^3He (UiO), γ (ELBE)
- Independent analyses performed.

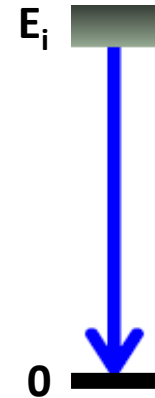
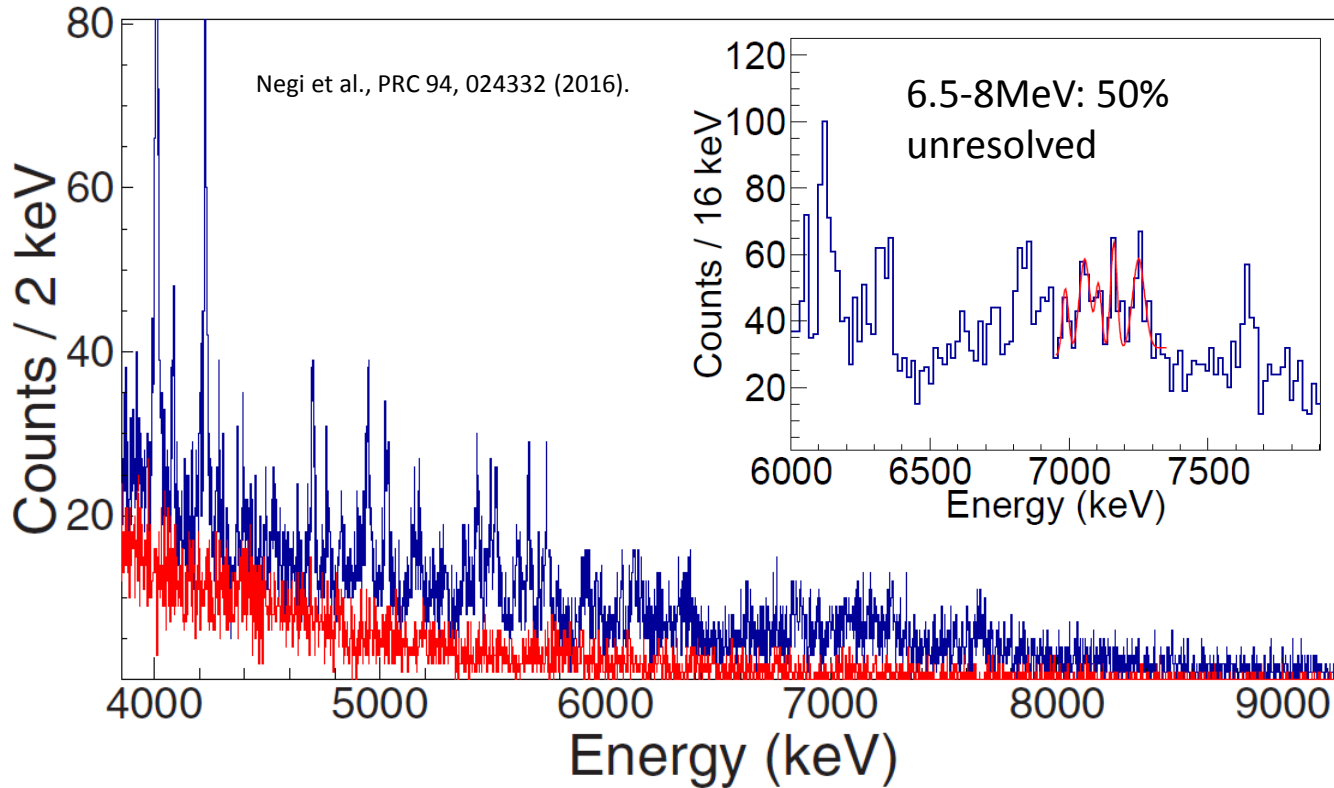


Is the structure at ~ 7 MeV real?
What is its origin?

Use high-resolution array:
silicon + clover (AFRODITE)
 $^{74}\text{Ge}(\alpha, \alpha'\gamma)$



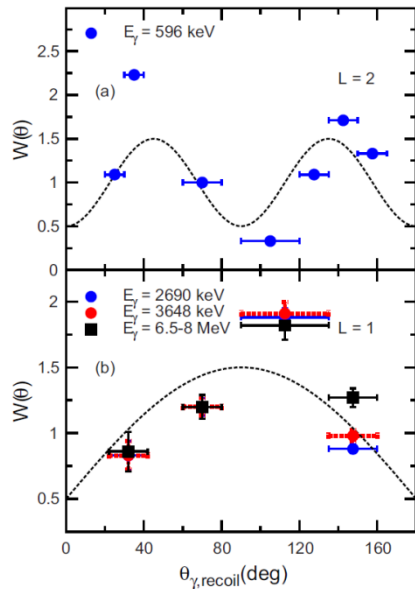
$^{74}\text{Ge}(\alpha, \alpha')$: One Step



Many transitions reported by Jung et al., Nucl. Phys. A 584, 103 (1995) and Massarczyk et al., PRC 92, 044309 (2015).

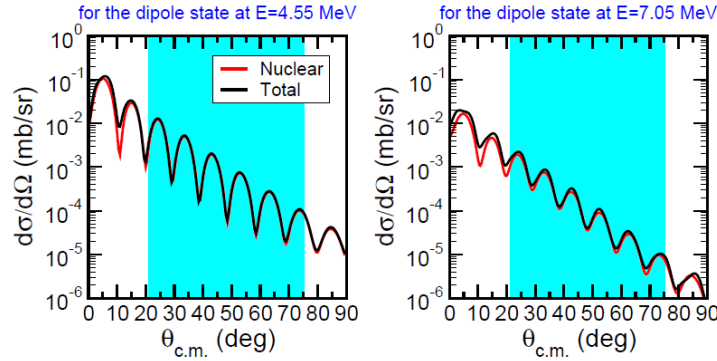
What is the nature of high-lying states? Coulomb or nuclear excitations?

Characterization of States

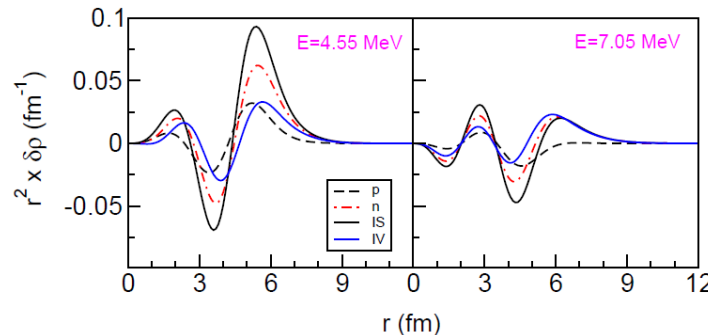


596-keV $l=2$ transition, compared to $l=1$ transitions from known 2690 and 3648-keV transitions and collection of states $6.5 < E_x < 8$ MeV. Dashed curves = theoretical angular distributions

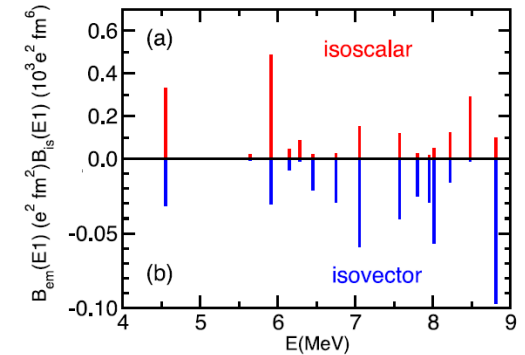
(α, α') = natural-parity states
 \rightarrow E1 transitions from states populated in nuclear interaction.



Cross sections from the Distorted Wave Born Approximation (DWUCK4). Microscopic transition densities from RQTBA used for DWBA -- E.G. Lanza and A. Vitturi



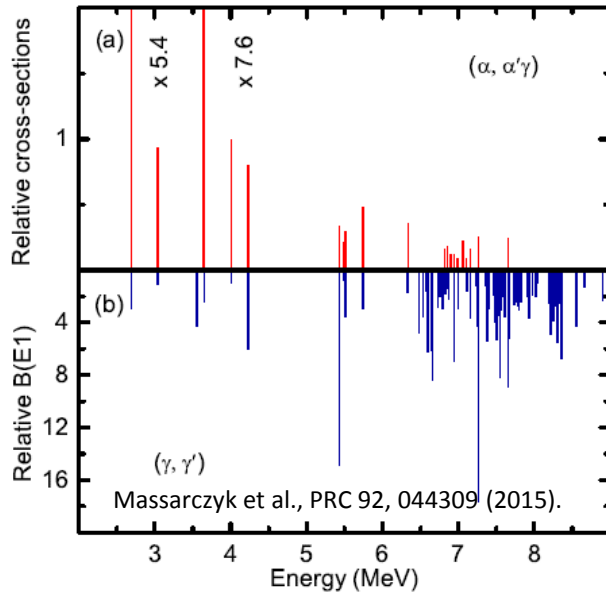
4.55 MeV: n and p transition densities in phase inside and at nuclear surface. Isoscalar transition density has pattern typical with a node close to nuclear surface.
 7.05 MeV: n and p transition densities in phase inside nucleus while surface region has contribution only from n, a behaviour typical of a pygmy dipole state.



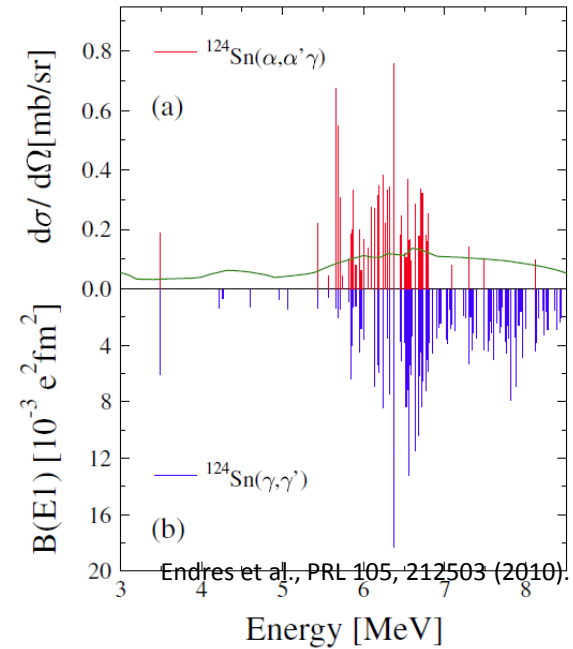
Reduced transition probabilities from Relativistic Quasiparticle Time Blocking Approximation (RQTBA) – E. Litvinova

Negi et al., PRC 94, 024332 (2016).

Comparison of (γ, γ') and (α, α') Results



3-5MeV strong IS weak IV.
 5-8MeV weak IS strong IV.
 At 6 to 9 MeV split into IS-IV
 mixed states at low energies
 and relatively pure IV states at
 higher energies.



Typical for PDR: 1) IS-IV mixed
 states at low energies 2)
 relatively pure IV states at
 higher energies.

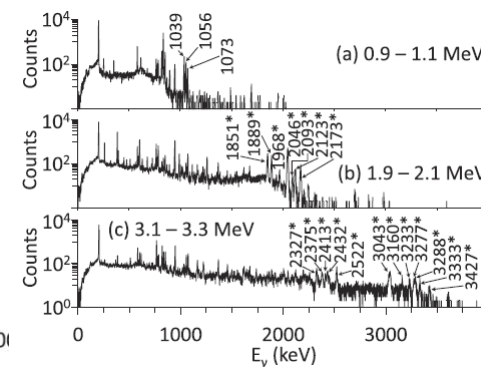
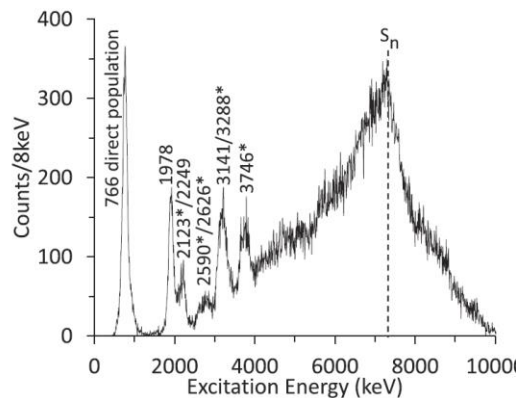
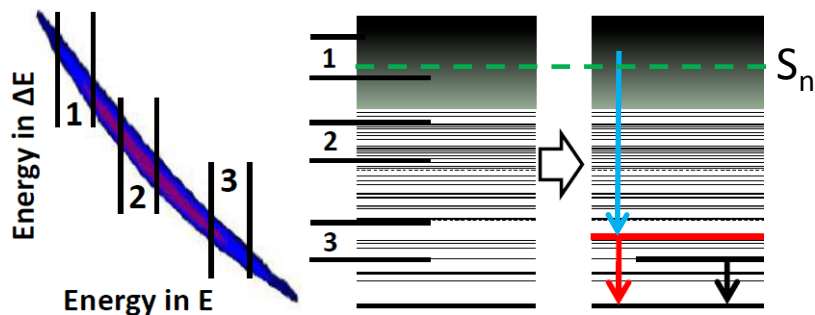
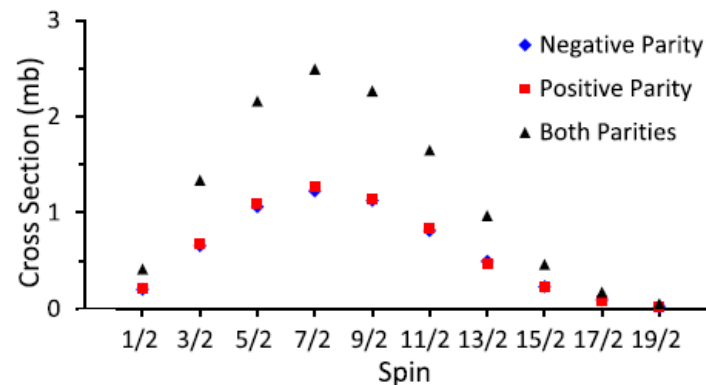
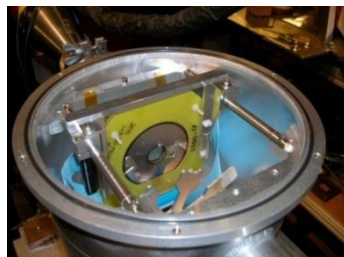
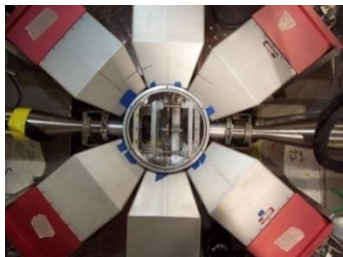
7 MeV peak exists and exhibits PDR characteristics.
 Combination of several approaches provides more complete picture

Negi et al., PRC 94, 024332 (2016).

^{95}Mo : γ -decay from neutron unbound states

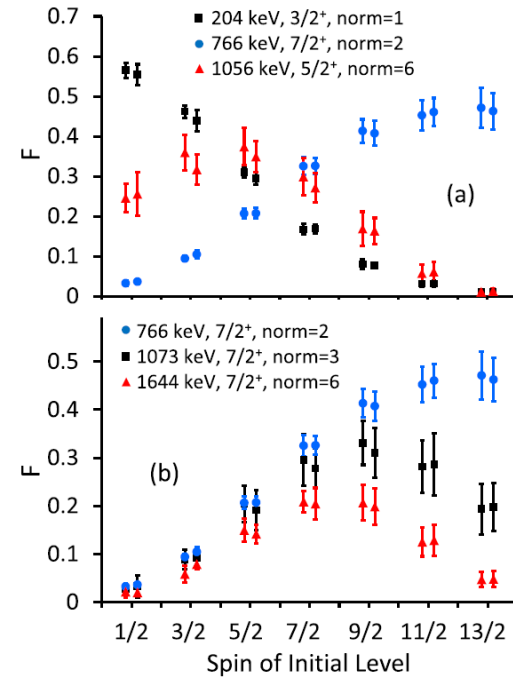
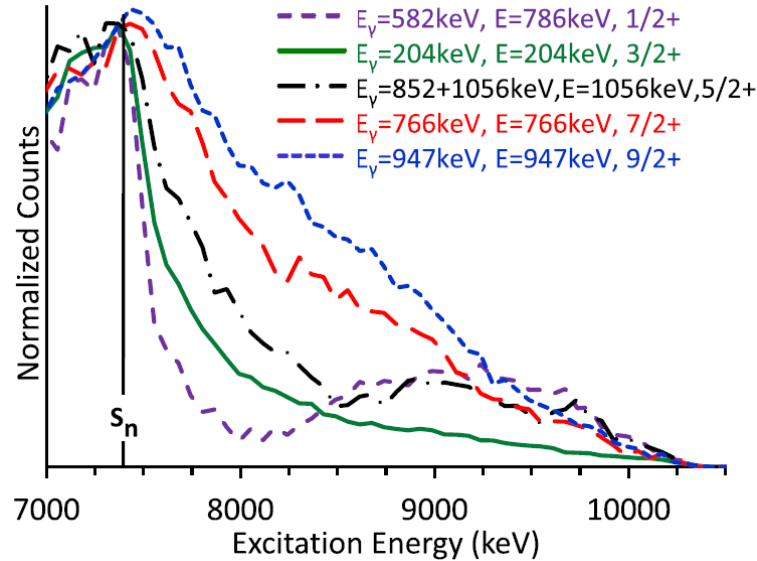
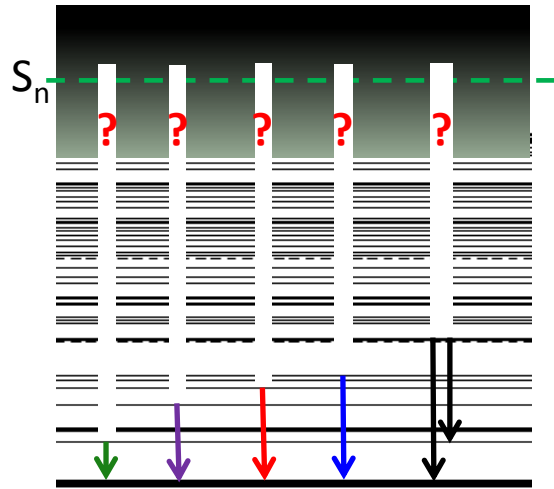
Spin dependence on gamma and neutron widths near S_n .

$^{94}\text{Mo}(d,p)^{95}\text{Mo}$ at 11 MeV



MW et al, PRC 93, 024303 (2016).

^{95}Mo : Spin Dependence at S_n



- Spin dependence of gamma and neutron emission probabilities.
- Angular momentum barrier has significant effect.
- Low-energy structure of $A-1$ nucleus important.
- “Memory” exists between S_n and low-lying states (low multiplicity 3-4 Sheets et al. PRC 76, 064317 (2007)).
- Can determine low-lying spins with this feature \rightarrow new spin determination method.
- It also provides insight into correction of low-energy (γ, n) data.

MW et al, PRC 93, 024303 (2016).

Conclusions

- i. Challenges remain when comparing different data.
- ii. Reaction and analysis dependence of results?
- iii. Challenges to the evaluation of different data.
- iv. ^{74}Ge and ^{95}Mo isotopes with many independent results.
- v. Need to identify more cases to co-ordinate specific measurements to completely understand the PSF.

^{74}Ge and ^{95}Mo Collaborators



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