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Systematic studies of (p,t) reactions on the Er isotopes

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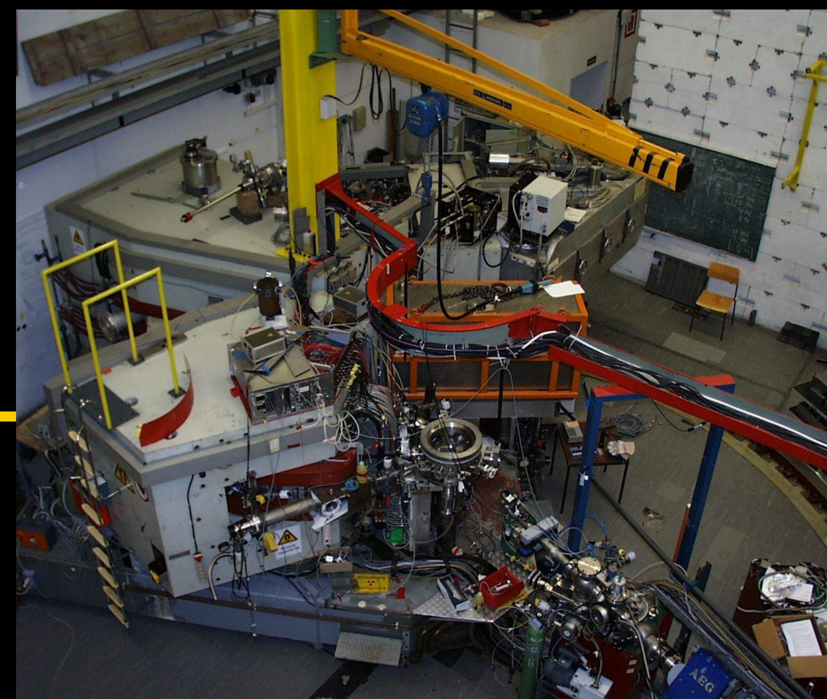
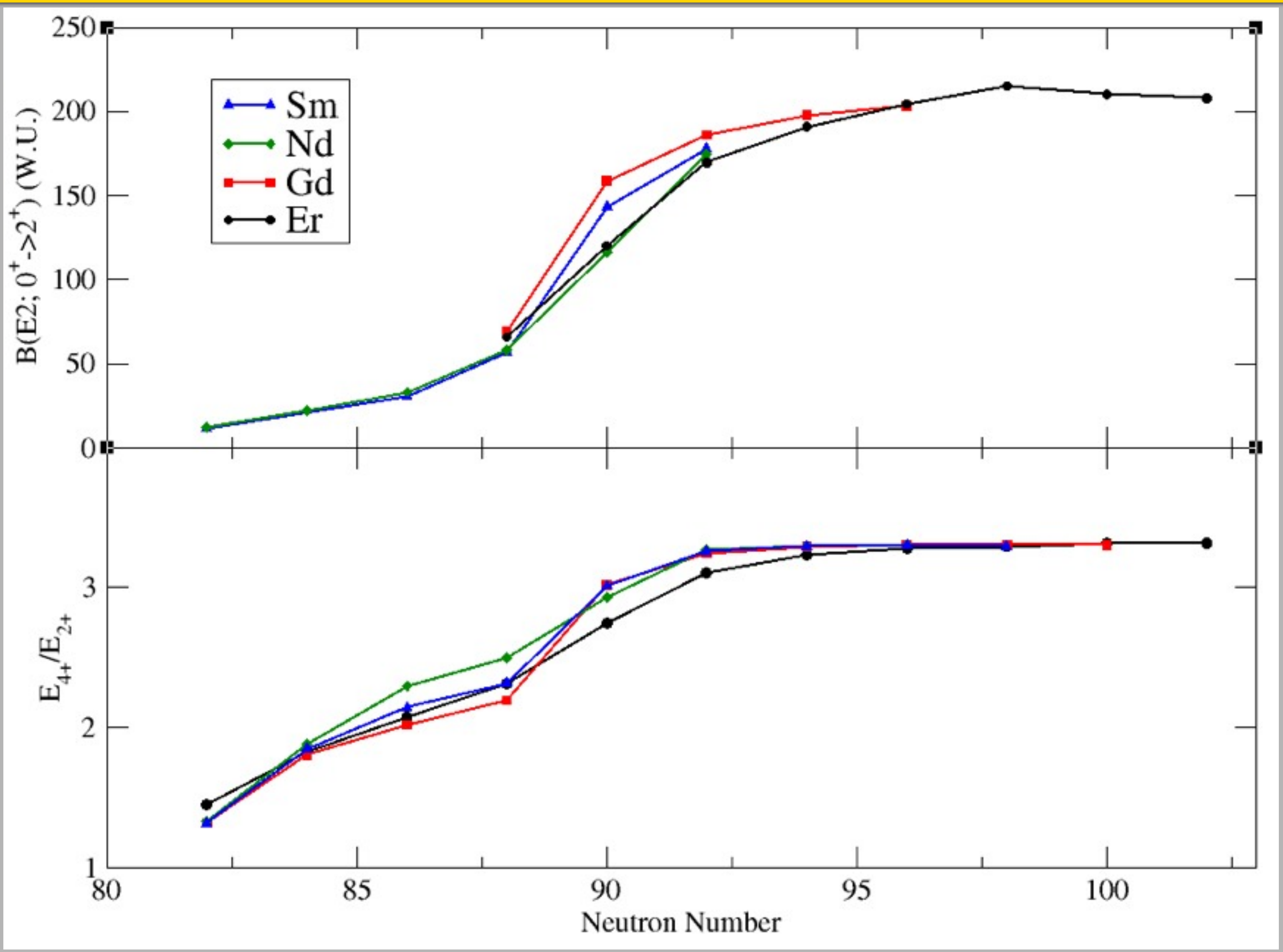
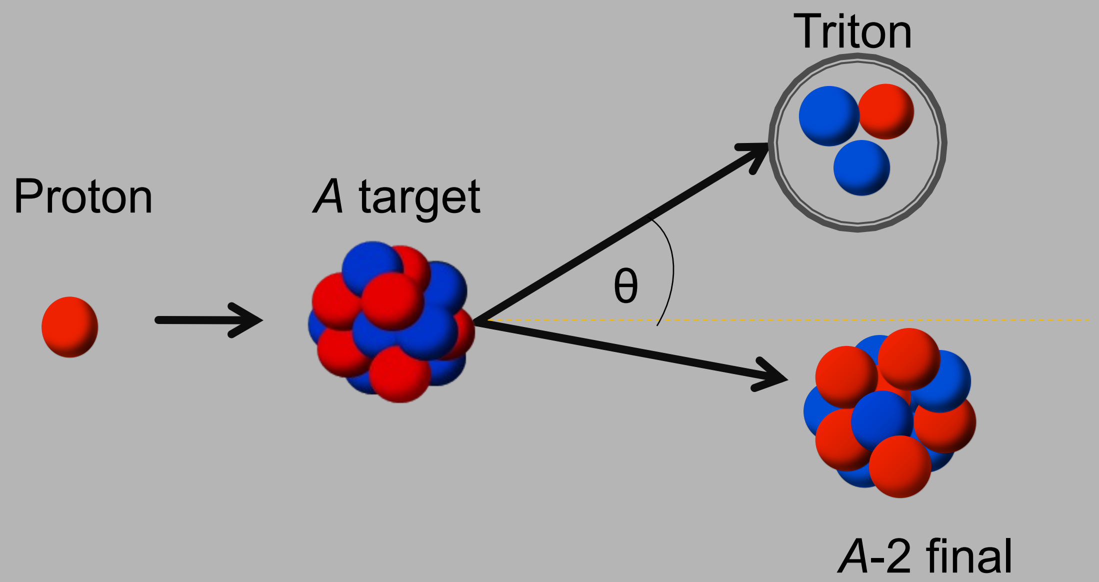


Physical observables undergoing rapid change at *N*=90



Two-neutron-transfer reaction cross sections: another important observable

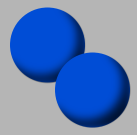


- **Pair transfer probes pairing components of wave functions**

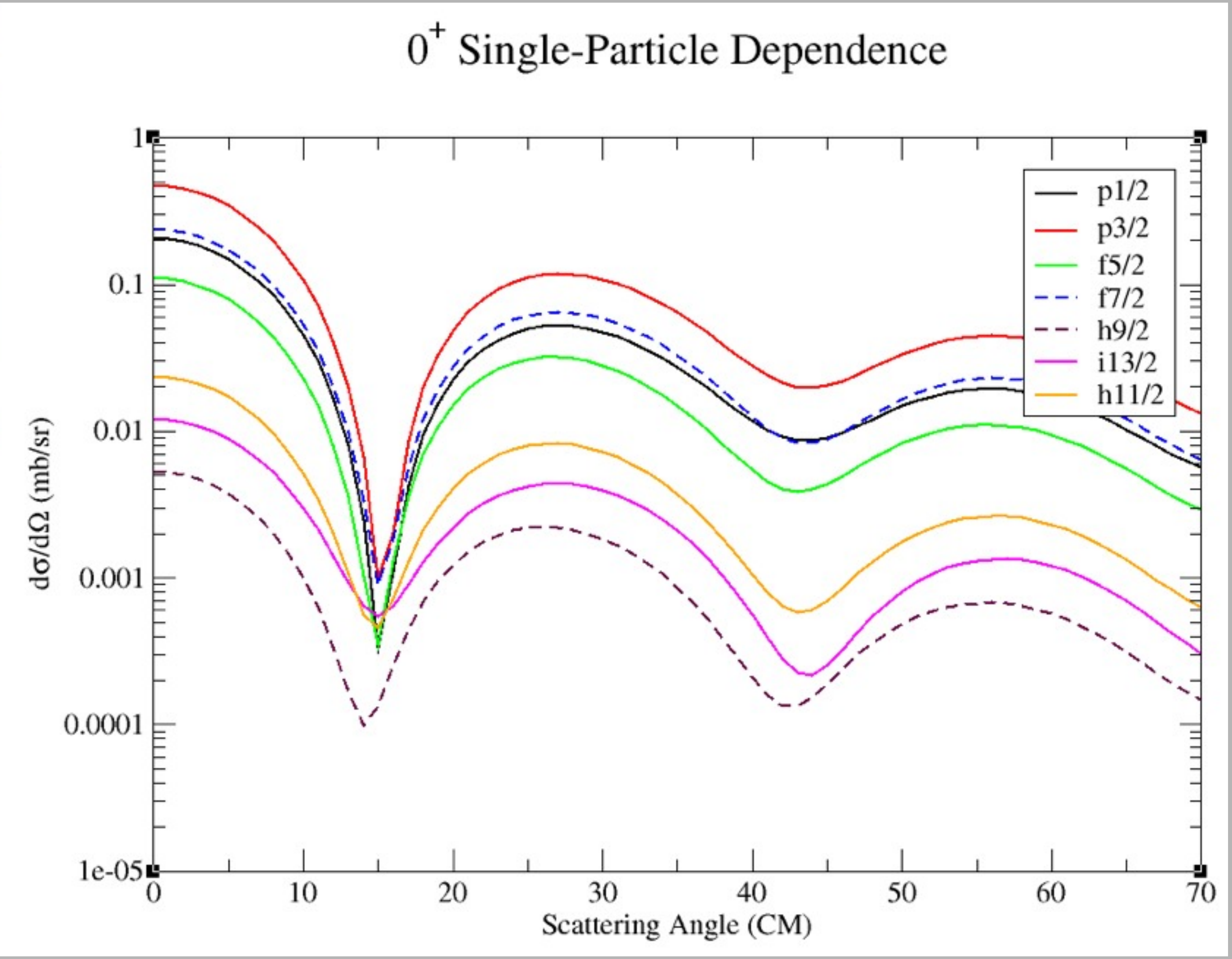
- **Spins of the neutrons generally couple to $S = s_1+s_2 = 0$, most states observed are natural parity ($J=L$)**

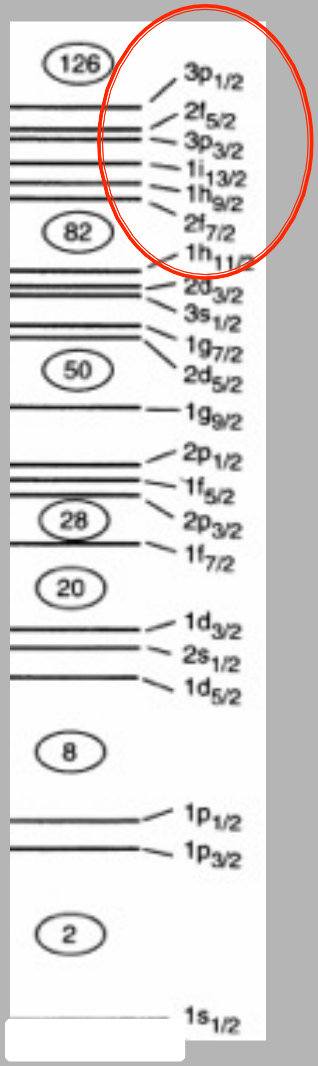
$$|L - S| < J < |L + S|$$

$$S = 0 \rightarrow J = L$$



Single-particle dependence of form factor: shape of angular distributions practically independent of *j* of transferred neutron





Relative population of 0^+ states

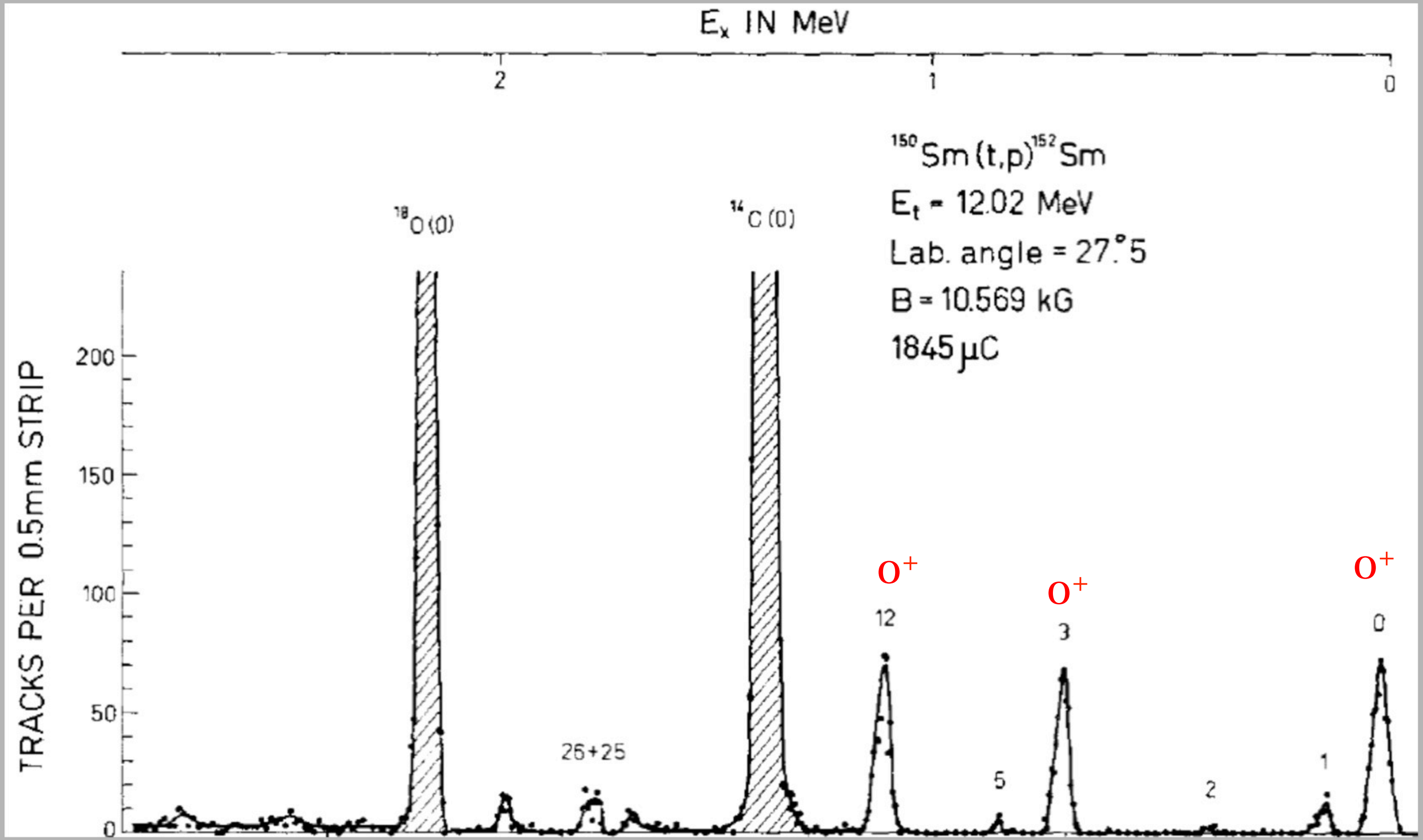
- Shape of angular distribution in two-nucleon transfer rather insensitive to individual *j* involved in pair transfer

- Ratio of excited 0^+ to gs cross sections normally expected to be on order of few% for 2 qp excitation

- 0^+ state cross section $\propto \left(\sum (a_i V_i^2)\right)^2$

- Relative population on order of 10% indicative of enhanced transition – a *collective pairing* transition – at least in conventional wisdom

Large two-neutron-transfer cross sections to excited 0^+ states observed at N=90



Large two-neutron-transfer cross sections to excited 0^+ states observed at N=90

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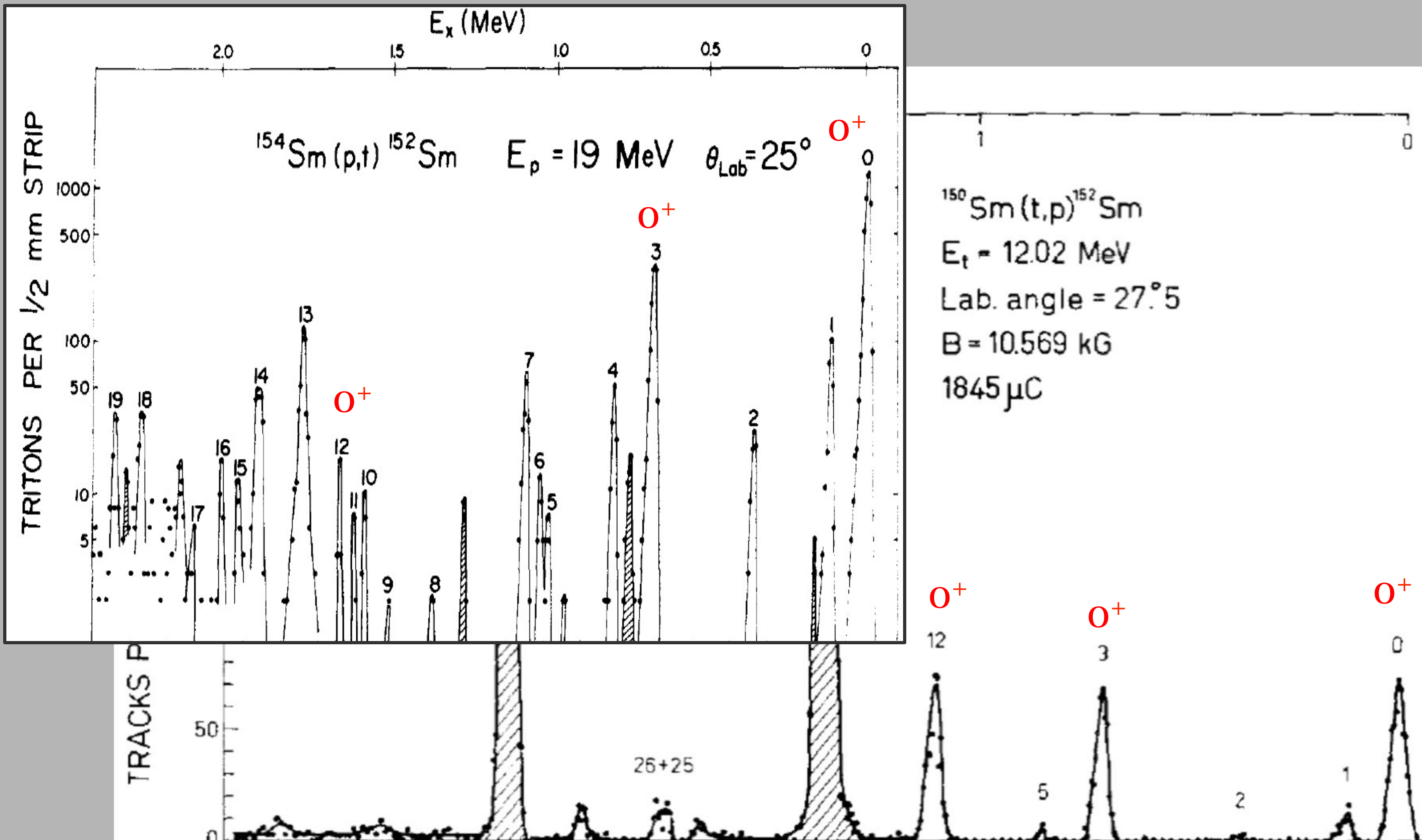
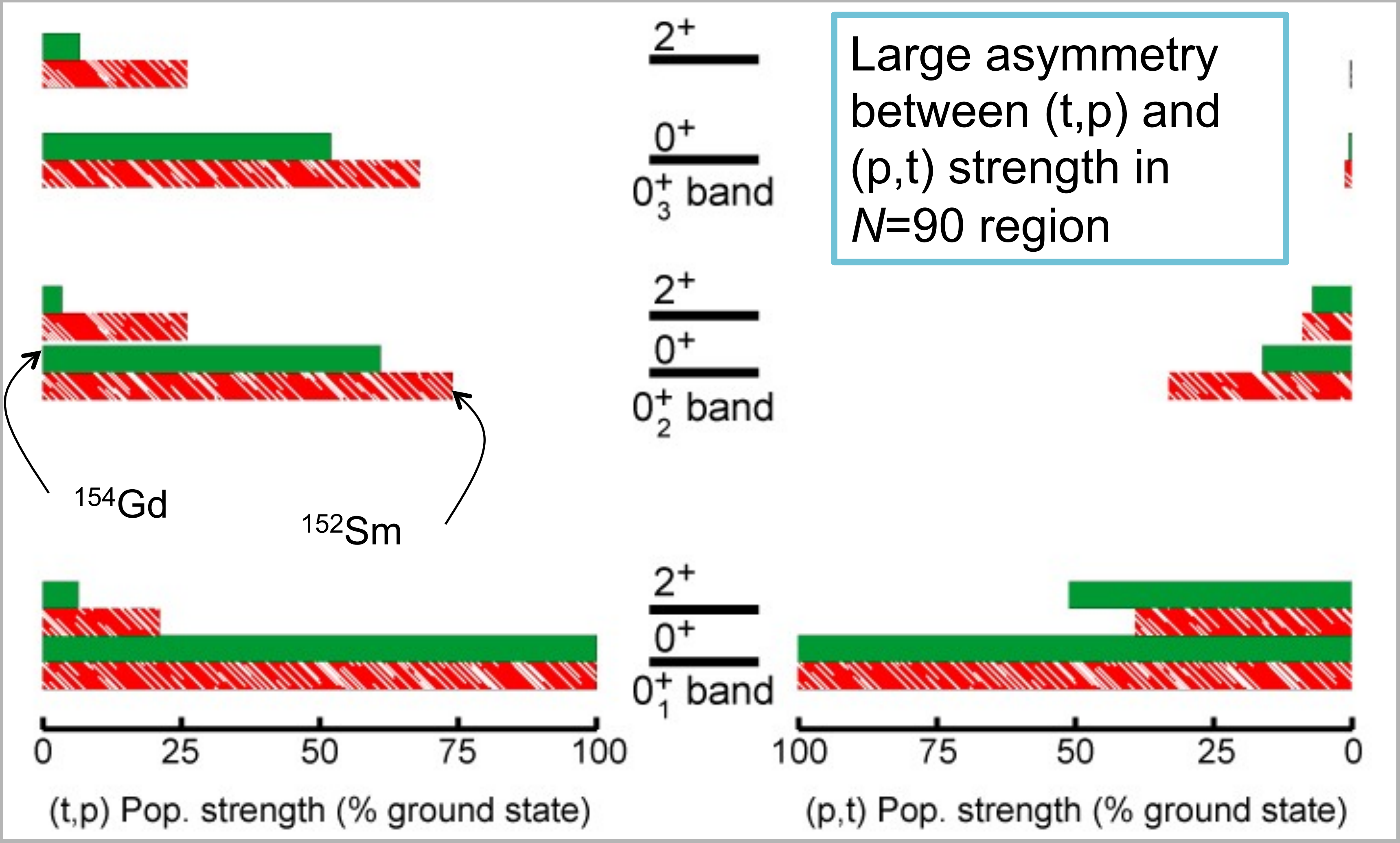


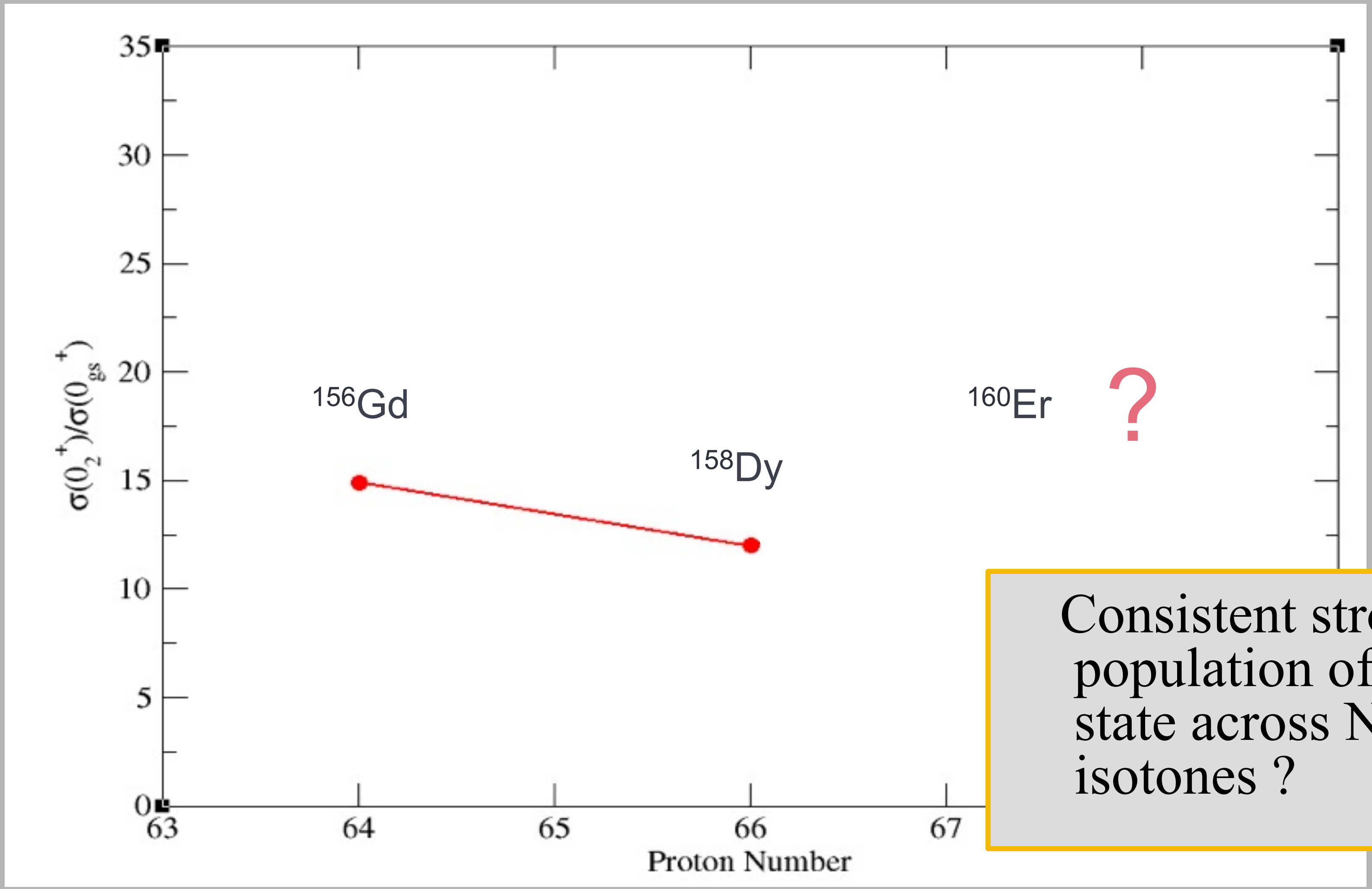
N=90 (t,p) and (p,t) strengths



Large asymmetry between (t,p) and (p,t) strength in *N*=90 region

Adapted from W. D. Kulp et al. PRC 71, 041303(R) (2005)

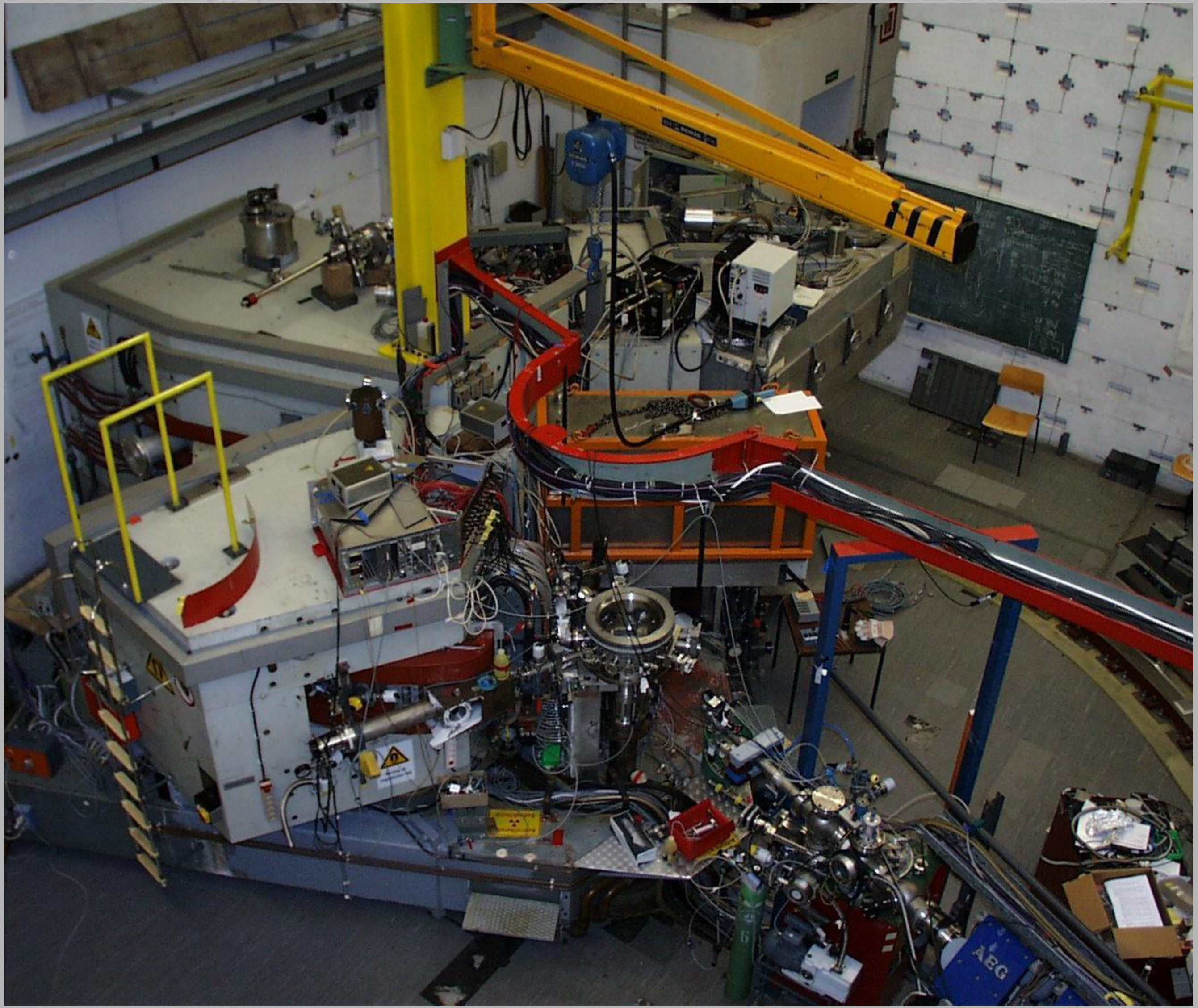
0_2^+ in *N*=92 isotones



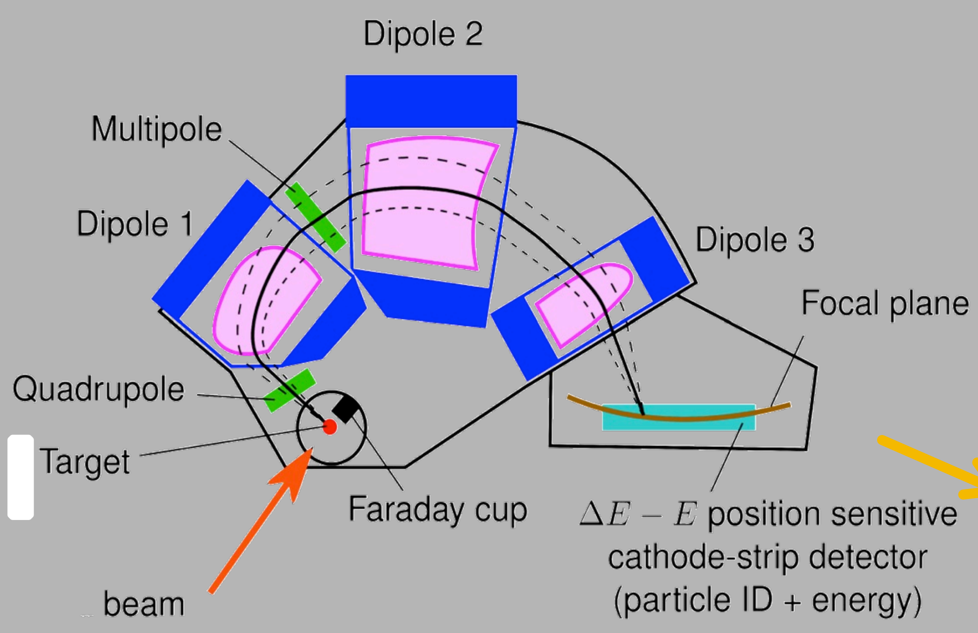
Consistent strong population of 0_2^+ state across N=92 isotones ?

Measurements using Q3D at MLL (Munich)

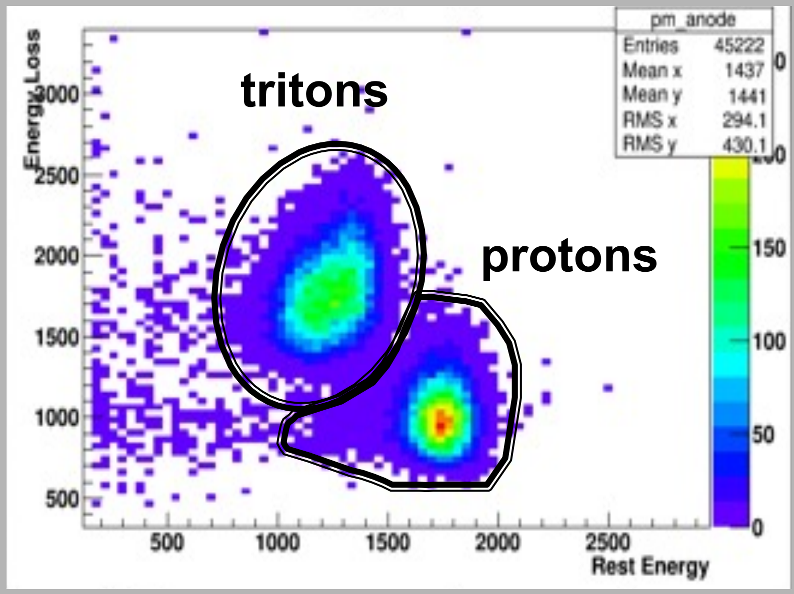
- **22-24 MeV proton beams up to 1 μA current**
- **Typical resolution ~ 8 keV FWHM**
- **Coverage up to ~ 2.4 – 3.2 MeV excitation energy**
- **Targets of ^{162}Er (natural abundance 0.14%) , ^{164}Er (1.6%) produced by running separated isotope through Florida State separator in 1960's**
  - **Resulting enrichment >99%**



Q3D Magnetic Spectrograph



- Q3D magnetic spectrograph momentum analyzes reaction ejectiles



- Focal plane detector allows for particle identification, and gives position along focal plane

$^{162}Er(p,t)^{160}Er$ spectrum

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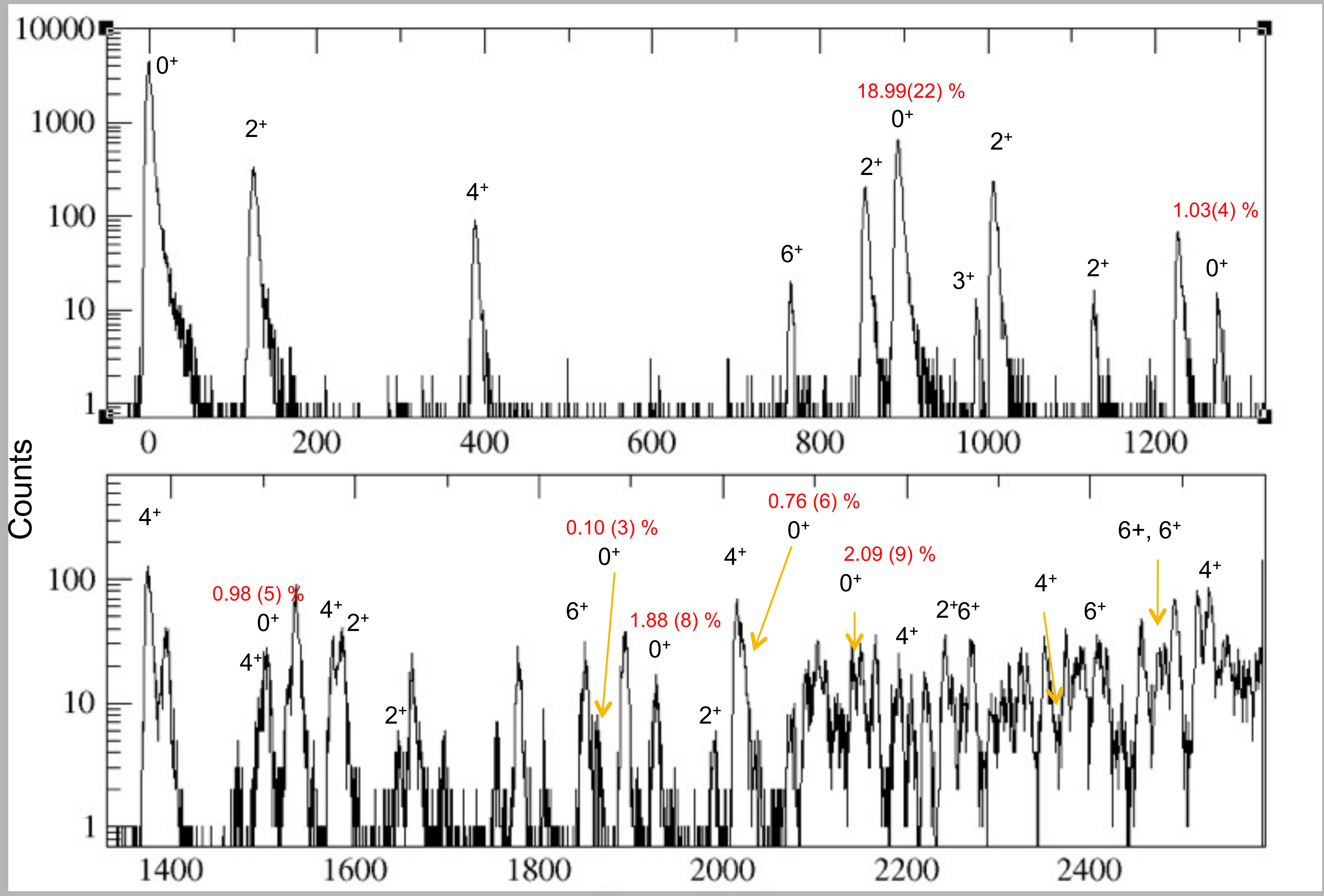
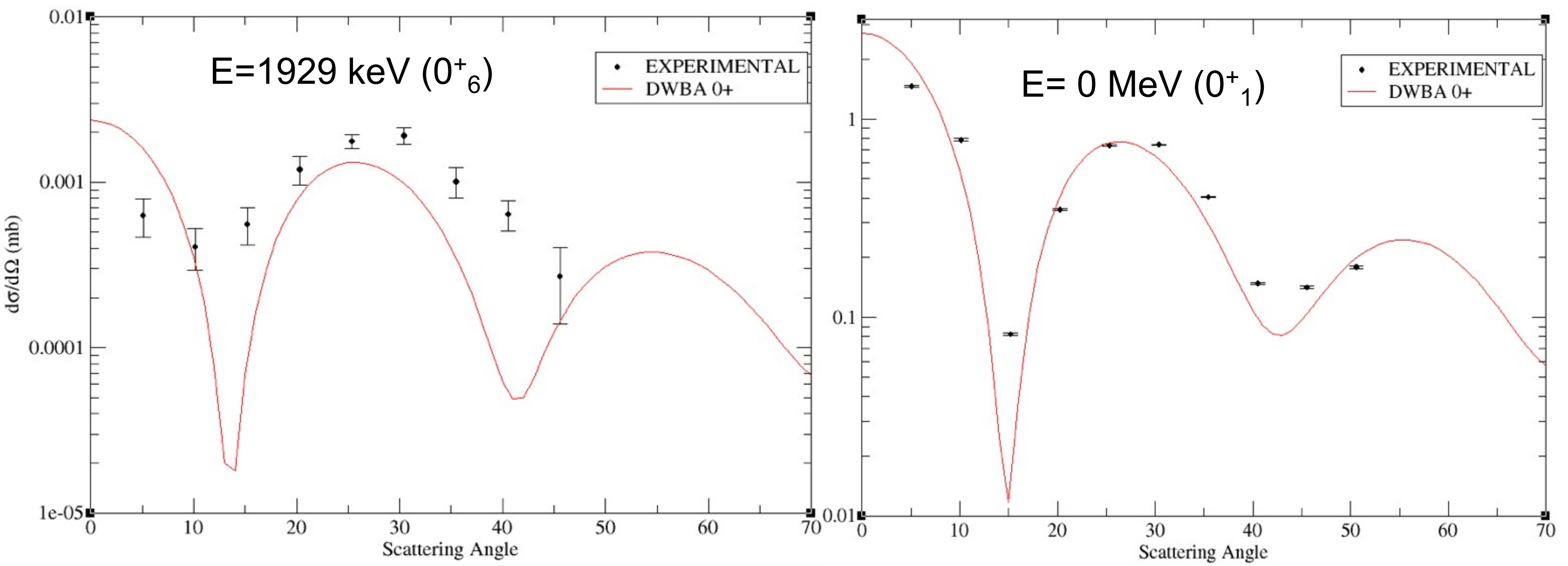


Relative Cross Section

$$\left(\frac{d\sigma}{d\Omega}\right)_{rel} = \frac{\left(\frac{d\sigma}{d\Omega}\right)^{lab}_{0^+_{ex}}}{\left(\frac{d\sigma}{d\Omega}\right)^{dwba}_{0^+_{ex}}} \Bigg/ \frac{\left(\frac{d\sigma}{d\Omega}\right)^{lab}_{0^+_{gs}}}{\left(\frac{d\sigma}{d\Omega}\right)^{dwba}_{0^+_{gs}}}$$

- **Ratio of Exp/DWBA cross sections will provide a Q-value correction for kinematics**



0_2^+ in *N*=92 isotones

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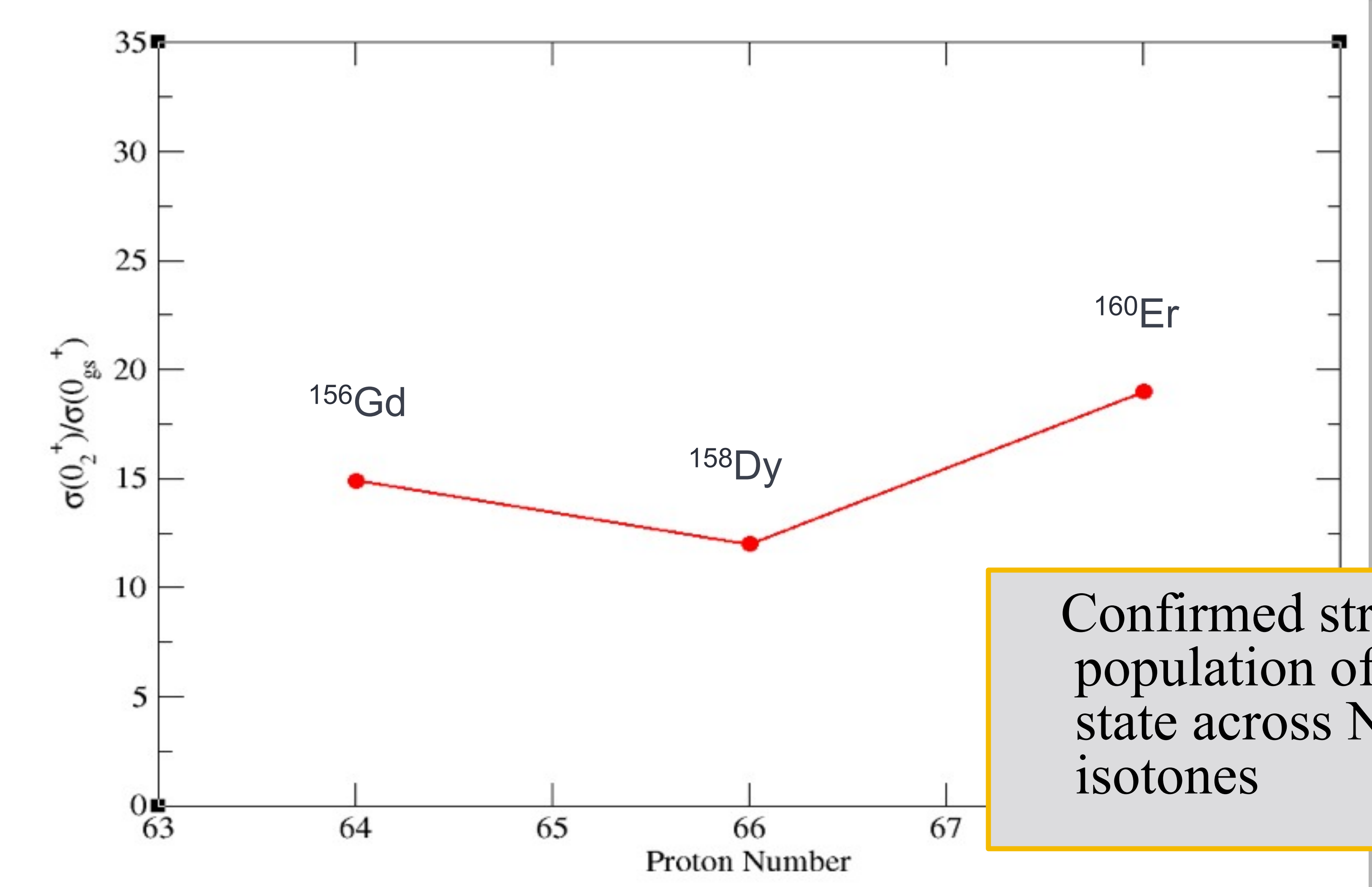
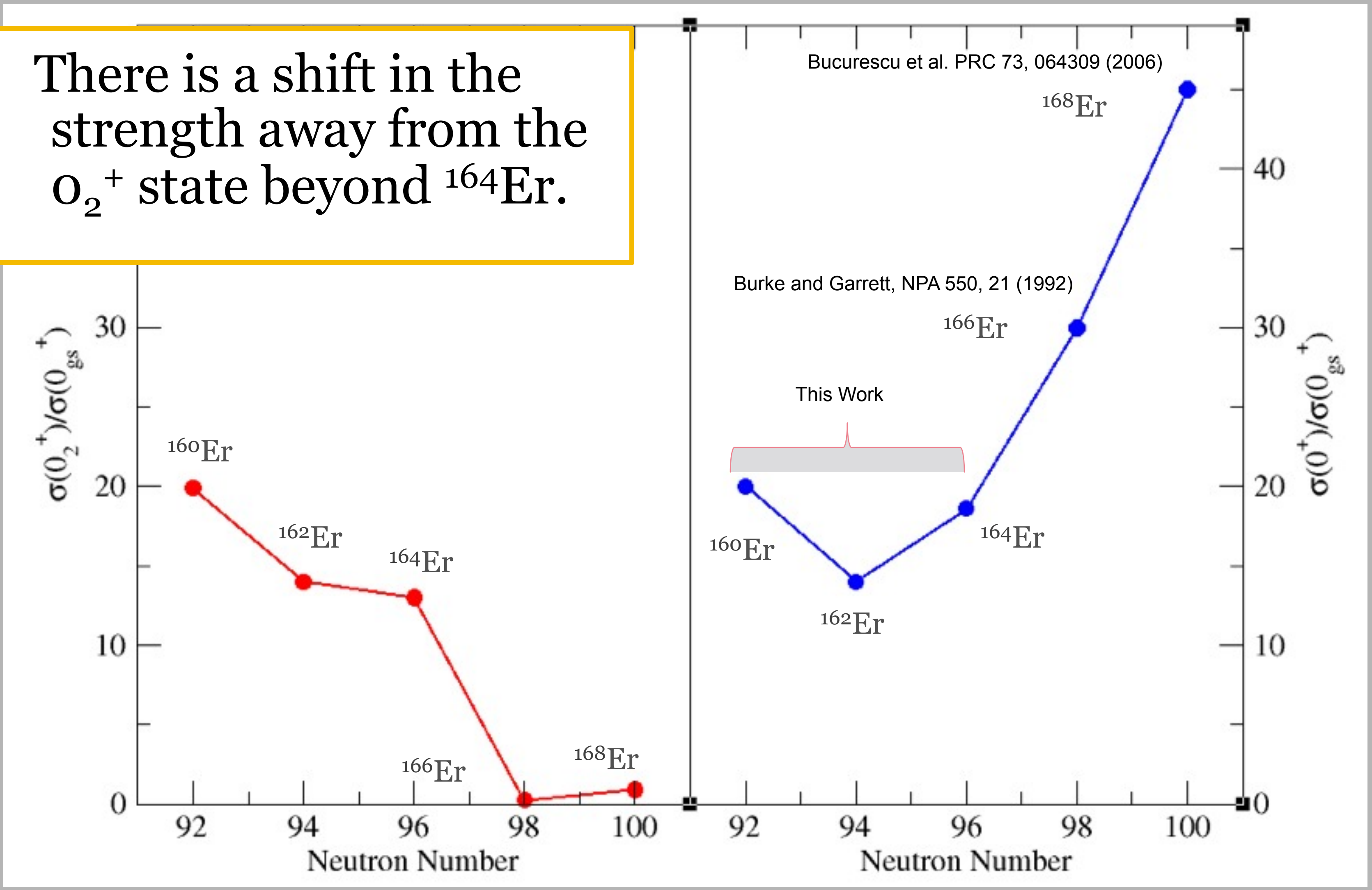


Confirmed strong population of 0_2^+ state across N=92 isotones

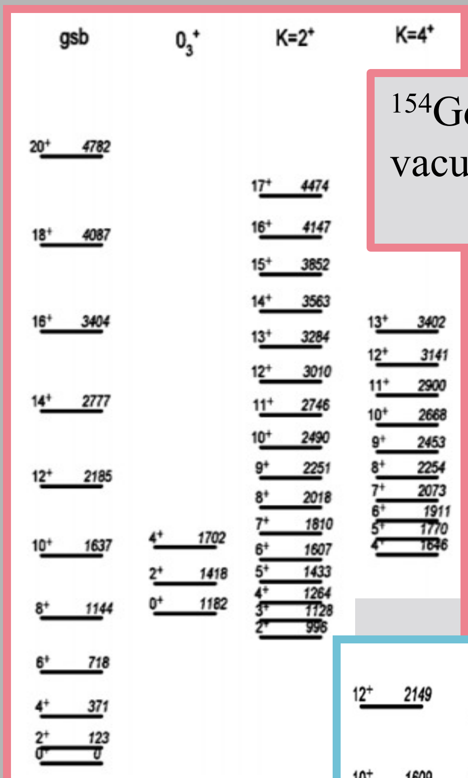
Consistent properties of 0_2^+ states points to common structure

Er isotopic trend in 0^+ states

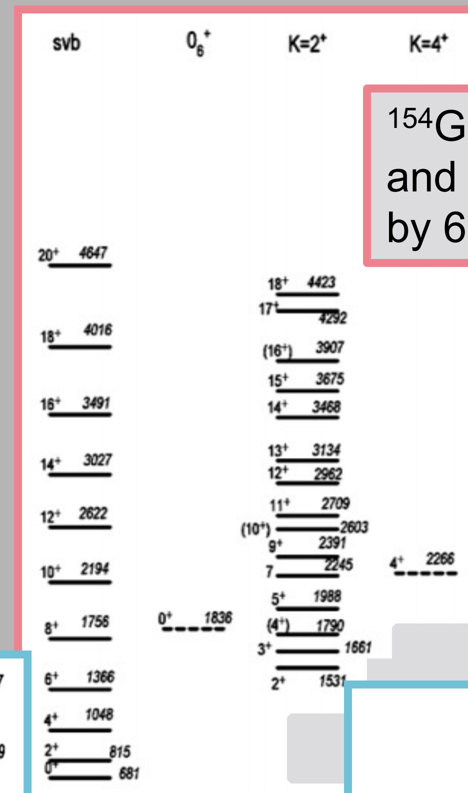
There is a shift in the strength away from the 0_2^+ state beyond ^{164}Er.



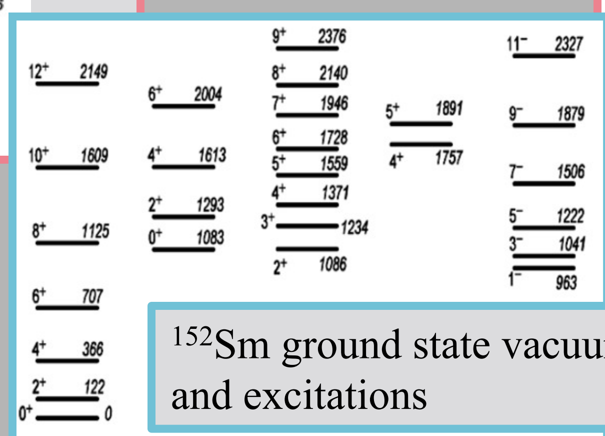
N=90 and the second vacuum state



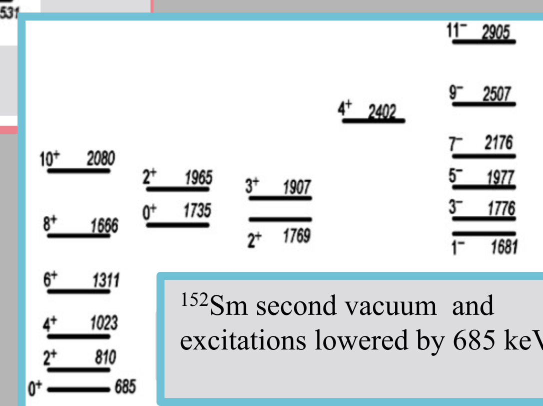
^{154}Gd ground state vacuum and excitations



^{154}Gd second vacuum and excitations lowered by 681 keV



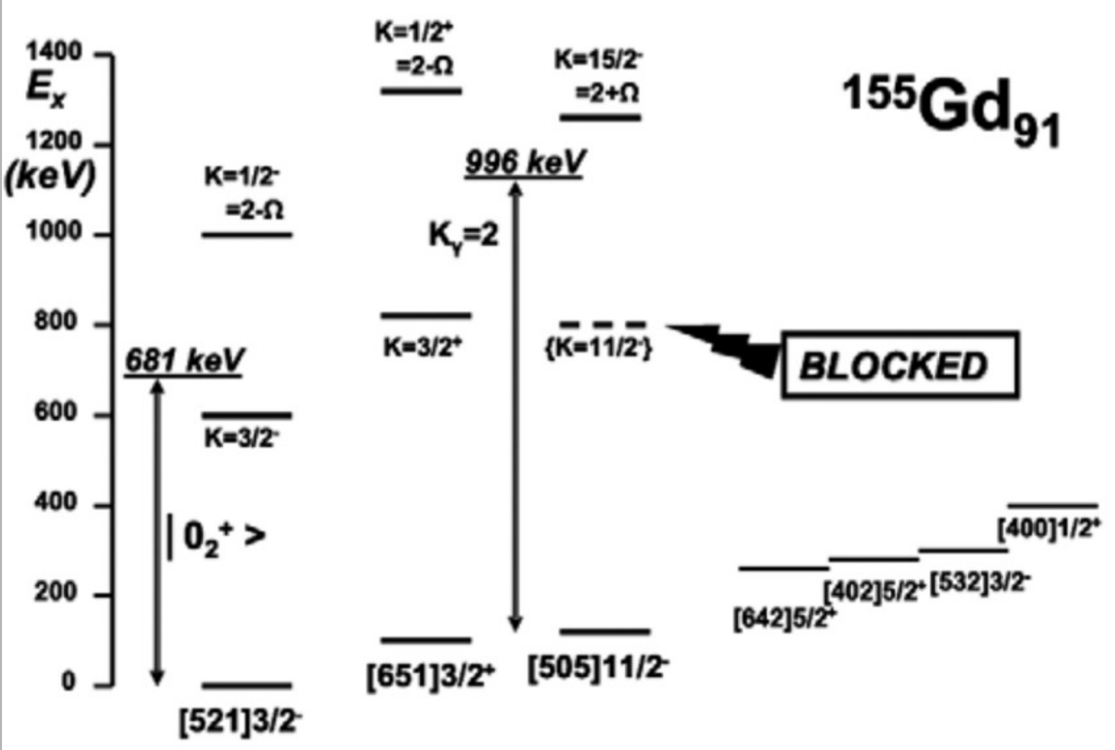
^{152}Sm ground state vacuum and excitations



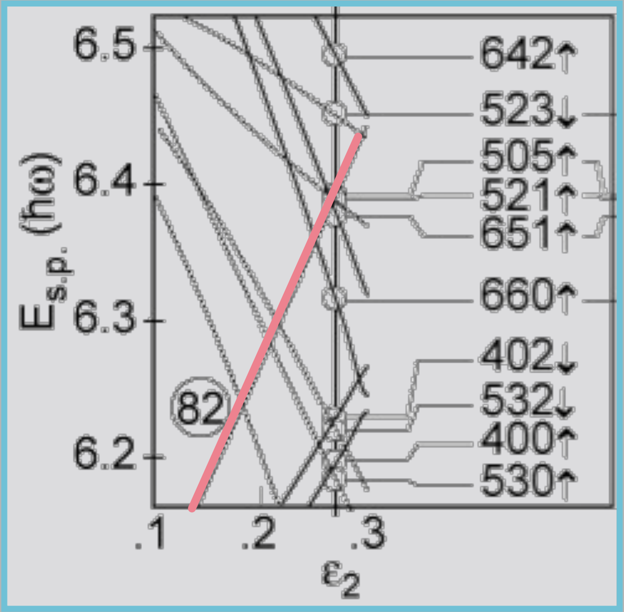
^{152}Sm second vacuum and excitations lowered by 685 keV

J.F. Sharpey-Schafer. Eur. Phys. J. A (2011) 47: 5

Blocked ν11/2 orbital in ^{155}Gd



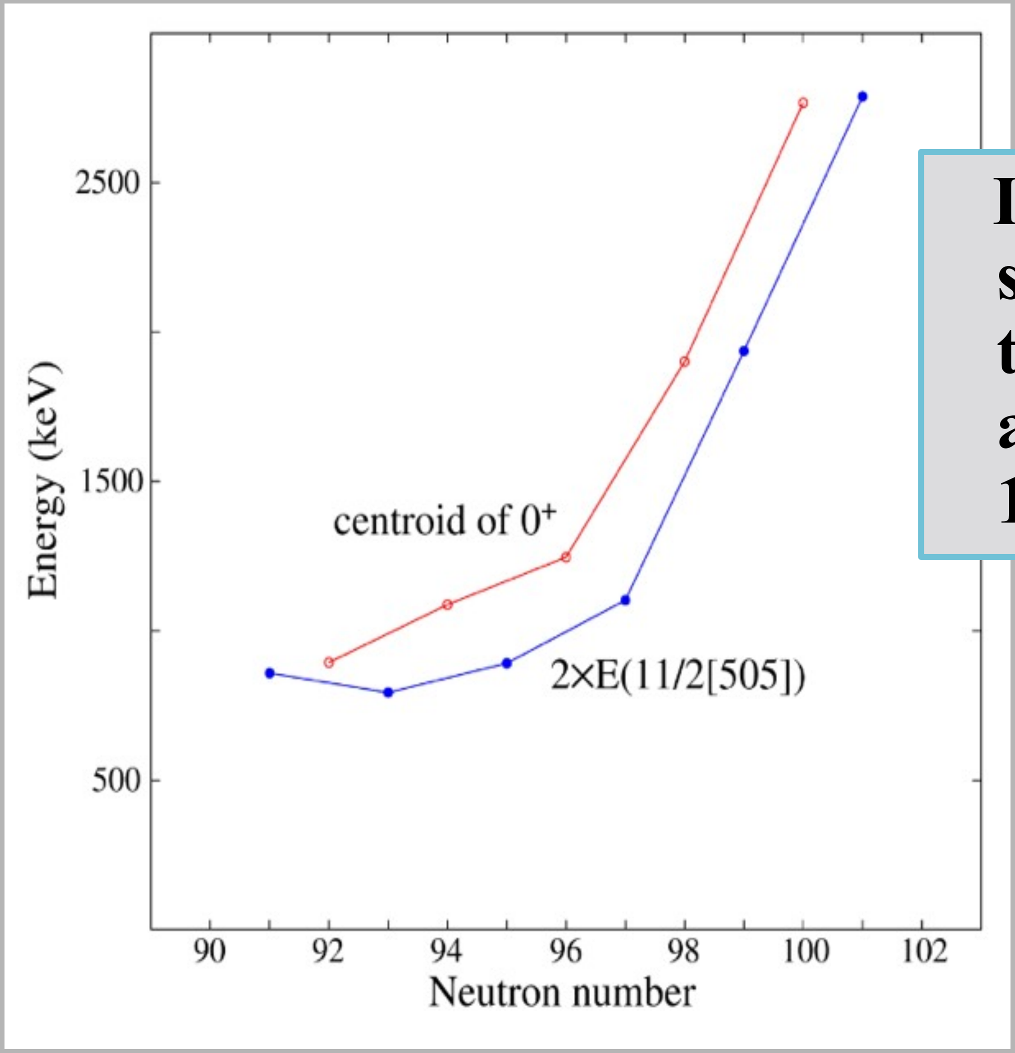
- The steeply up-sloping ν11/2[505] orbital is blocked in ^{155}Gd



ν11/2[505] believed to be a dominant configuration in the 0_2^+ state at *N*=90

J.F. Sharpey-Schafer. Eur. Phys. J. A (2011) **47**: 6

Similarity of energy centroid of 0^+ strength to ν11/2 orbital



Indication that the 0^+ strength tracks with the Fermi surface, and specifically the 11/2[505] orbital

Summary

- **The 0_2^+ state in *N*=92, 94, 96 Er possesses a high degree of coherence in its wave function evinced by the collective (*p*,*t*) transitions**
- **Appears to be very robust excitation across the *N*=92 isotones as well**
- **As Fermi level changes, the collective (p,t) transitions track with it, and become increasingly *fragmented but apparently stronger***
  - ***Indications that 11/2[505] playing a very important role***
- **Need spectroscopic data on excited 0^+ bands to fully characterize excitation**

Acknowledgments

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Transfer strength in N=90 region

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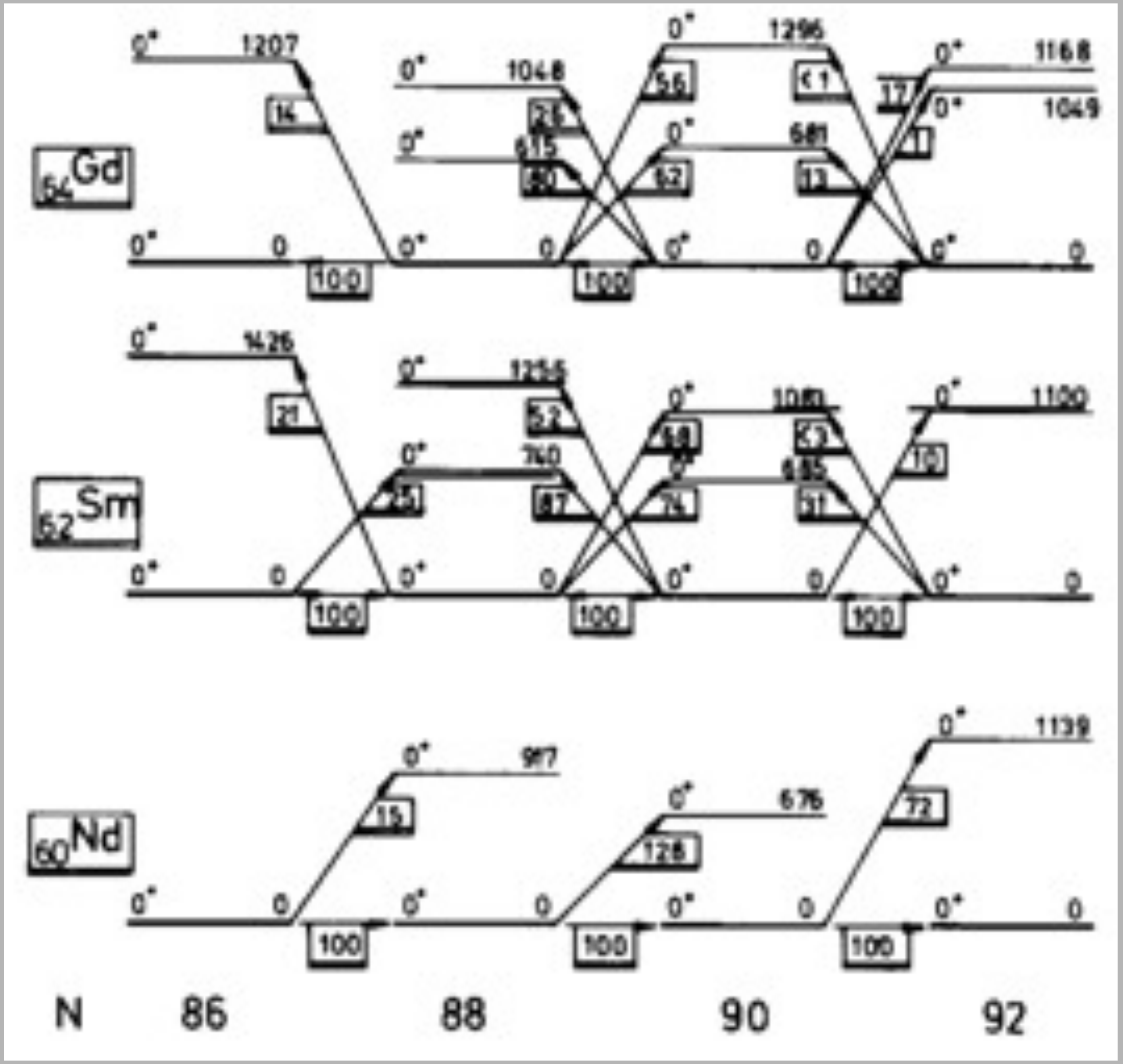

J.L. Wood et al. Phys. Rep. 215, Nos. 3 & 4 (1992)

- **Dominating GS→GS transition strengths until ^{152}Sm, ^{154}Gd**
- **For N<90 population to 0_2^+ and 0_3^+ strong**
- **For N>90 population only to 0_2^+ strong**