Trends in neutron single-particle levels in N=51 isotones

D.K.Sharp[1], S.J.Freeman[1], J.P.Schiffer[2], B.B.Back[2], T.Bloxham[3], J.A.Clark[2], C.M.Deibel[2,4], A.Heinz[5], C.M.Hoffman[2], A.M.Howard[1], B.P.Kay[2], J.C.Lighthall[2,6], S.T.Marley[2,6], A.J.Mitchell[1], P.D.Parker[5], J.S.Thomas[1] and A.H.Wuosmaa[6].

[1]*University of Manchester, UK*

[2]*Physics Division, Argonne National Laboratory, USA,*

[3]*Lawrence Berkeley Laboratory, USA,*

[4]*Joint Institute for Nuclear Astrophysics, Michigan State University, USA,*

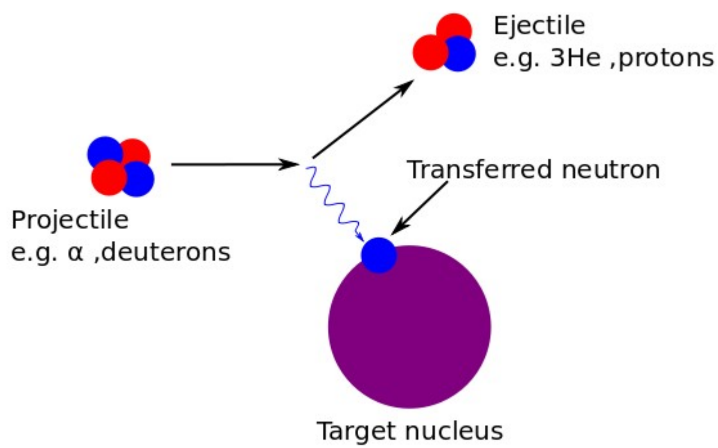
[5]*A.W.Wright Nuclear Structure Laboratory, Yale University, USA,*

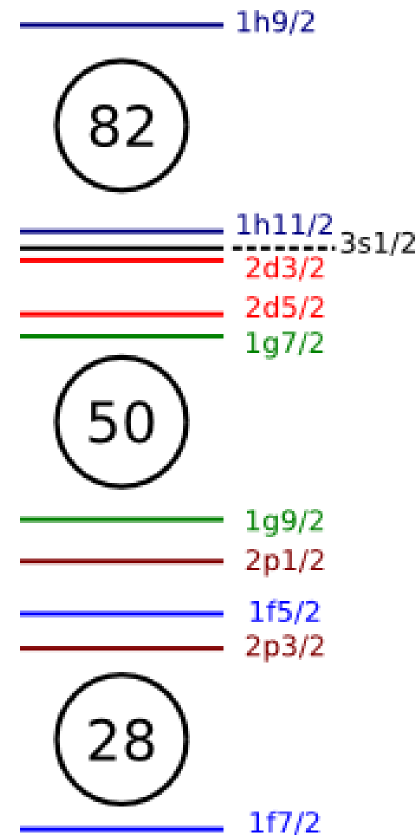
[6]*Western Michigan University, USA.*

Evolution of single-particle states

Investigating trends in energies of $\nu h_{11/2}$ and $\nu g_{7/2}$ in N=51 nuclei as part of ongoing study.

Populating states in nuclei with Z=36-42. Filling the *fp*-shell and then the $g_{9/2}$orbital.





Use **transfer reactions** to populate states of interest.

- Direct/single step processes
- Favoured population depends on kinematics of reaction

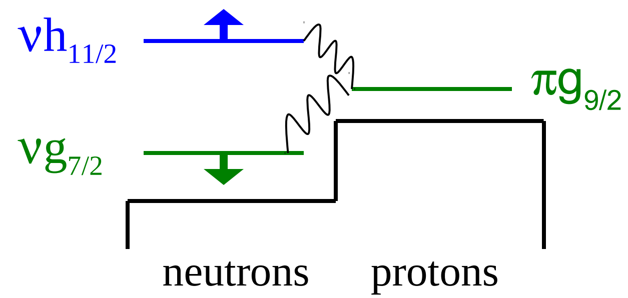
Need to measure **relative spectroscopic factors** in order to find the energy of the underlying state.

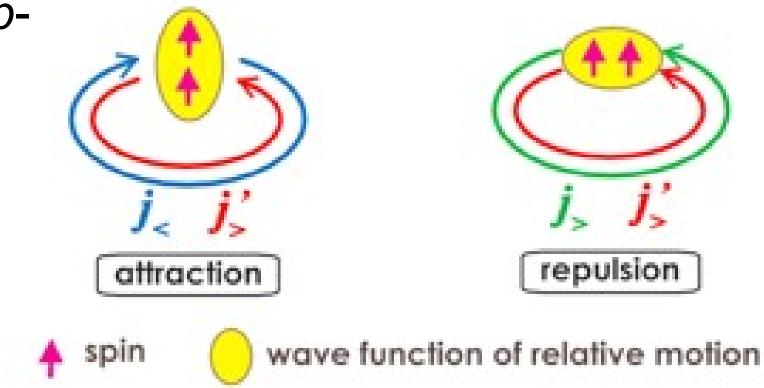
Motivation

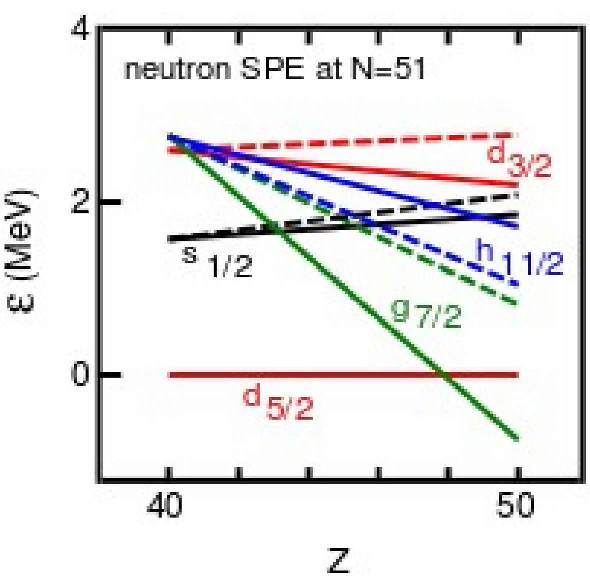
Are monopole shifts in single-particle energies driven by tensor interaction with protons?

Expect **increase** in separation of $\nu h_{11/2}$ and $\nu g_{7/2}$ neutron orbitals as $\pi g_{9/2}$ is filled.

Opposite effect expected in filling *fp*-shell.







Tensor interaction **attractive** for different $j_{<,>}$ - **raises** energy.

Repulsive for like $j_{>,>}$ or $j_{<,<}$ - **lowers** energy.

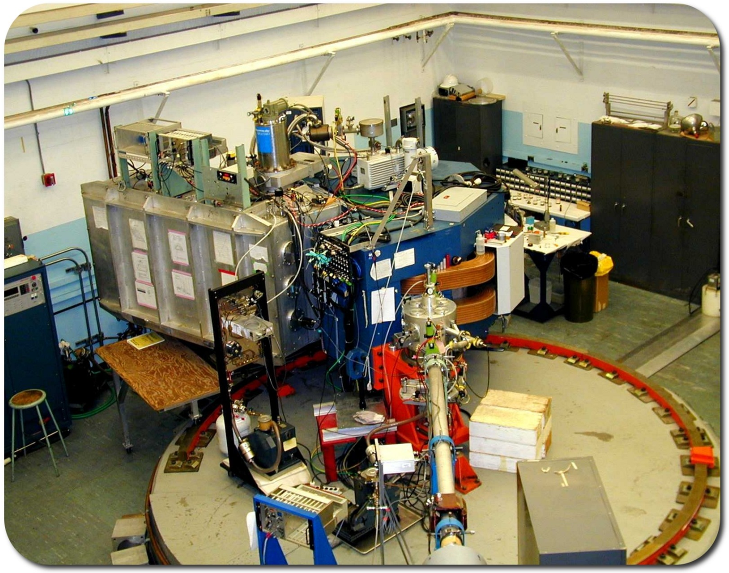
Otsuka et al. Phys. Rev. Lett. 104, 012501 (2010)

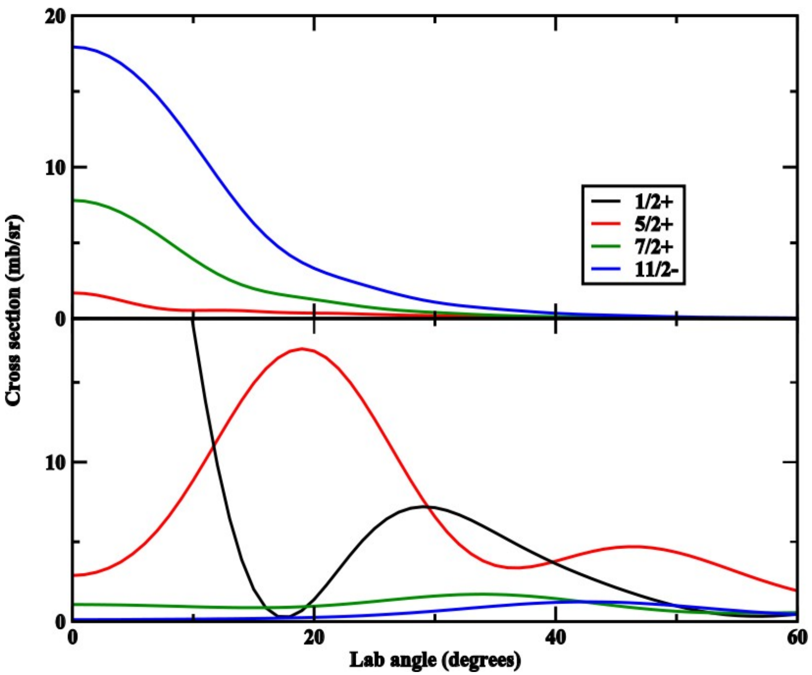
Single-particle transfer

Use DWBA to calculate predicted cross sections assuming S_{jl}=1.

$$S = \frac{\sigma_{\exp}}{\sigma_{ptolemy}}$$

Angles chosen to coincide with **peak cross sections** of l=0,2,4 and 5 angular distributions.





Beams produced by Tandem accelerator at A. W. Wright Nuclear Structure lab, Yale University.

Split-pole spectrograph momentum separates ejectiles and delivers them to the focal-plane detector.

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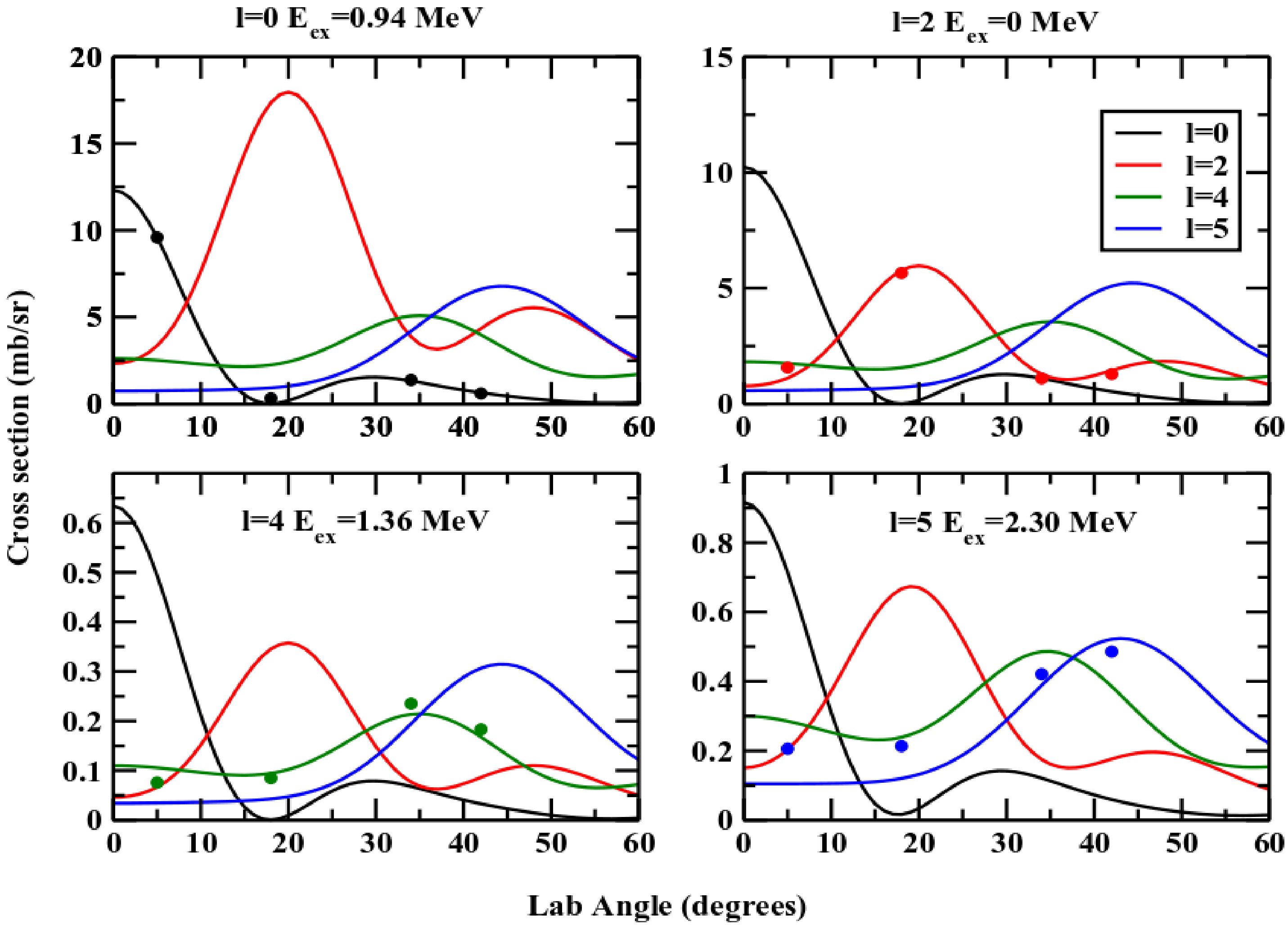
Spin-parity assignments, (d,p) distributions



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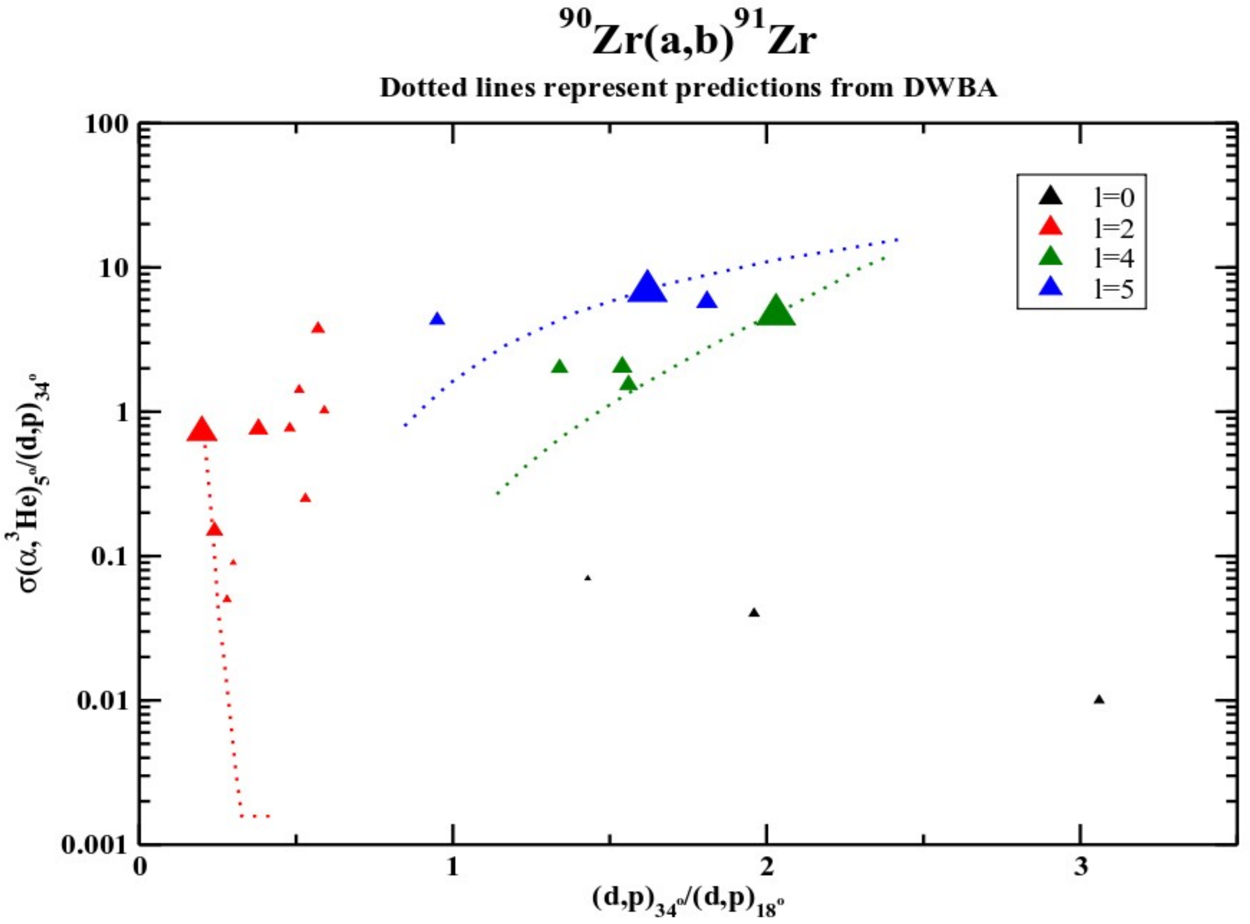
Spin-parity assignments, reaction ratios



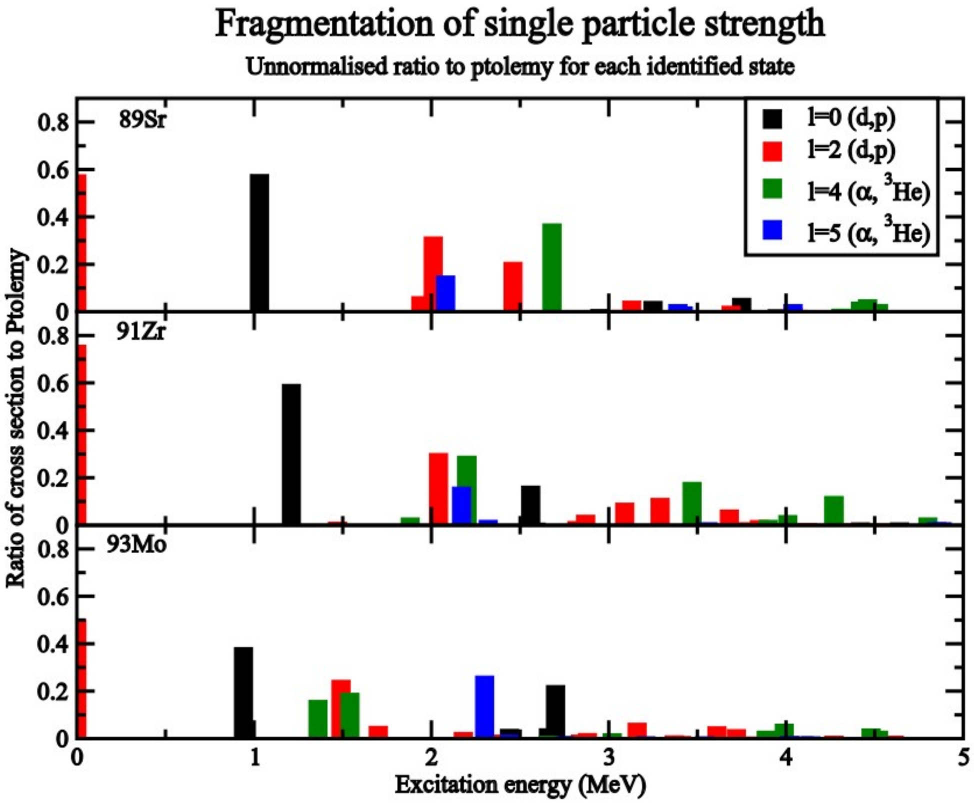
Spectroscopic factors

States have **high degree of fragmentation**.

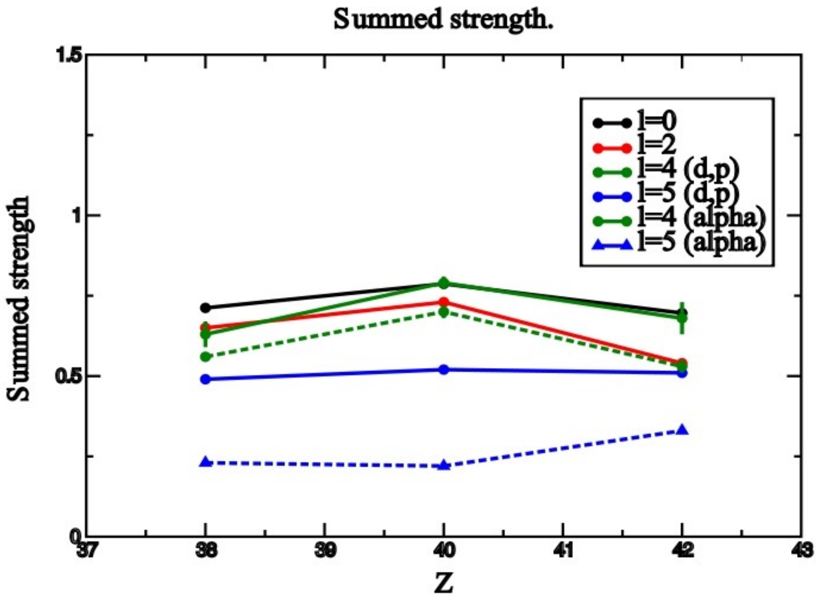
First excited state is not necessarily the strongest.

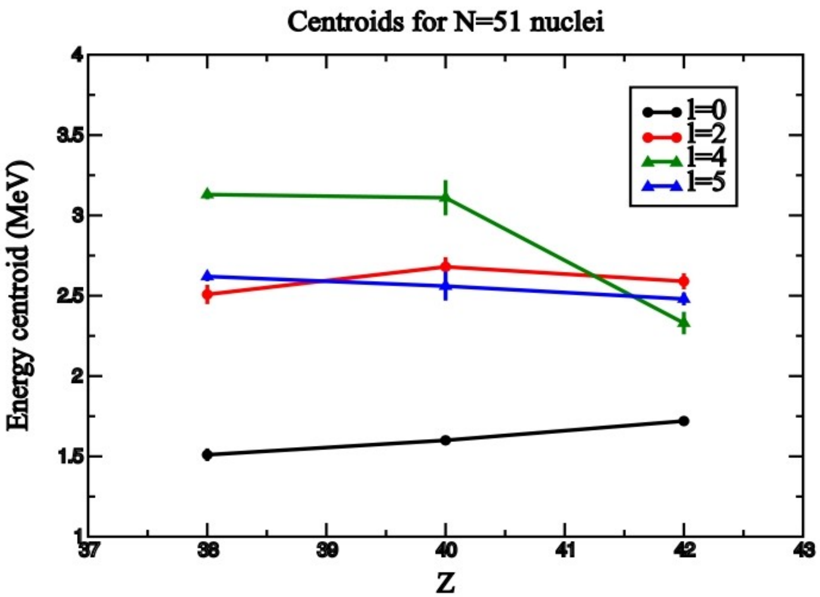
Need to calculate **centroid** of underlying single-particle level.

$$E = \frac{\Sigma \, NS_i E_i}{\Sigma \, NS_i}$$



Trends





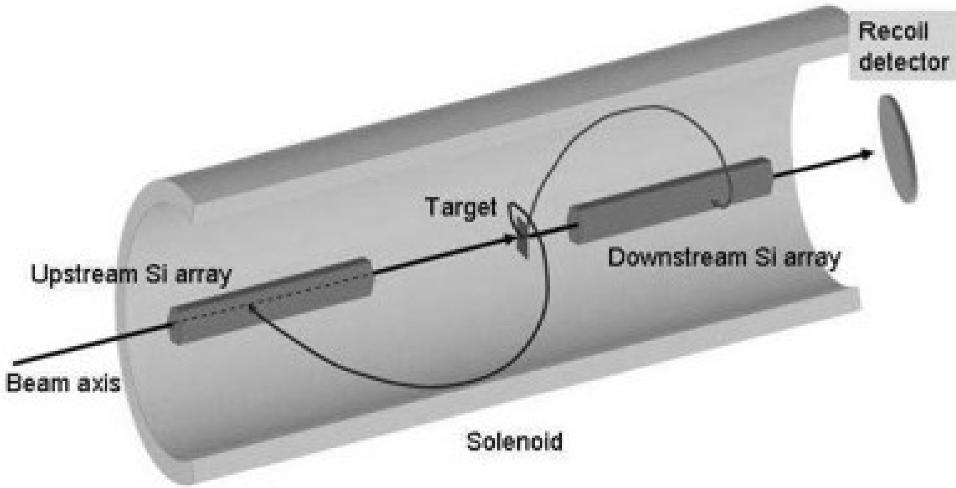
Summed strengths for l=0,2 and 4 are consistent.

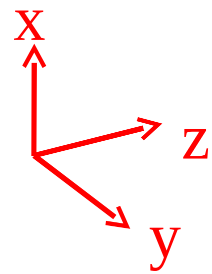
Missing l=5 strength.

Difference between l=4 and l=5 centroids increases as *fp*-shell is filled.

Sudden reduction in energy as $g_{9/2}$ level is filled.

Extending the region of interest - ^{87}Kr





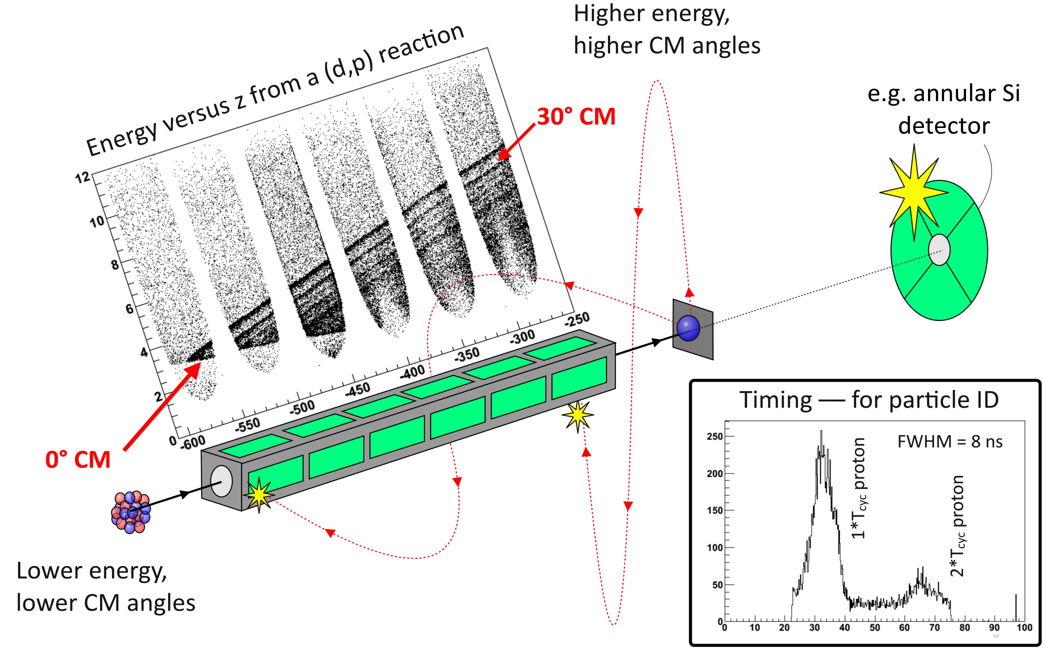
Measured quantities:

position Z

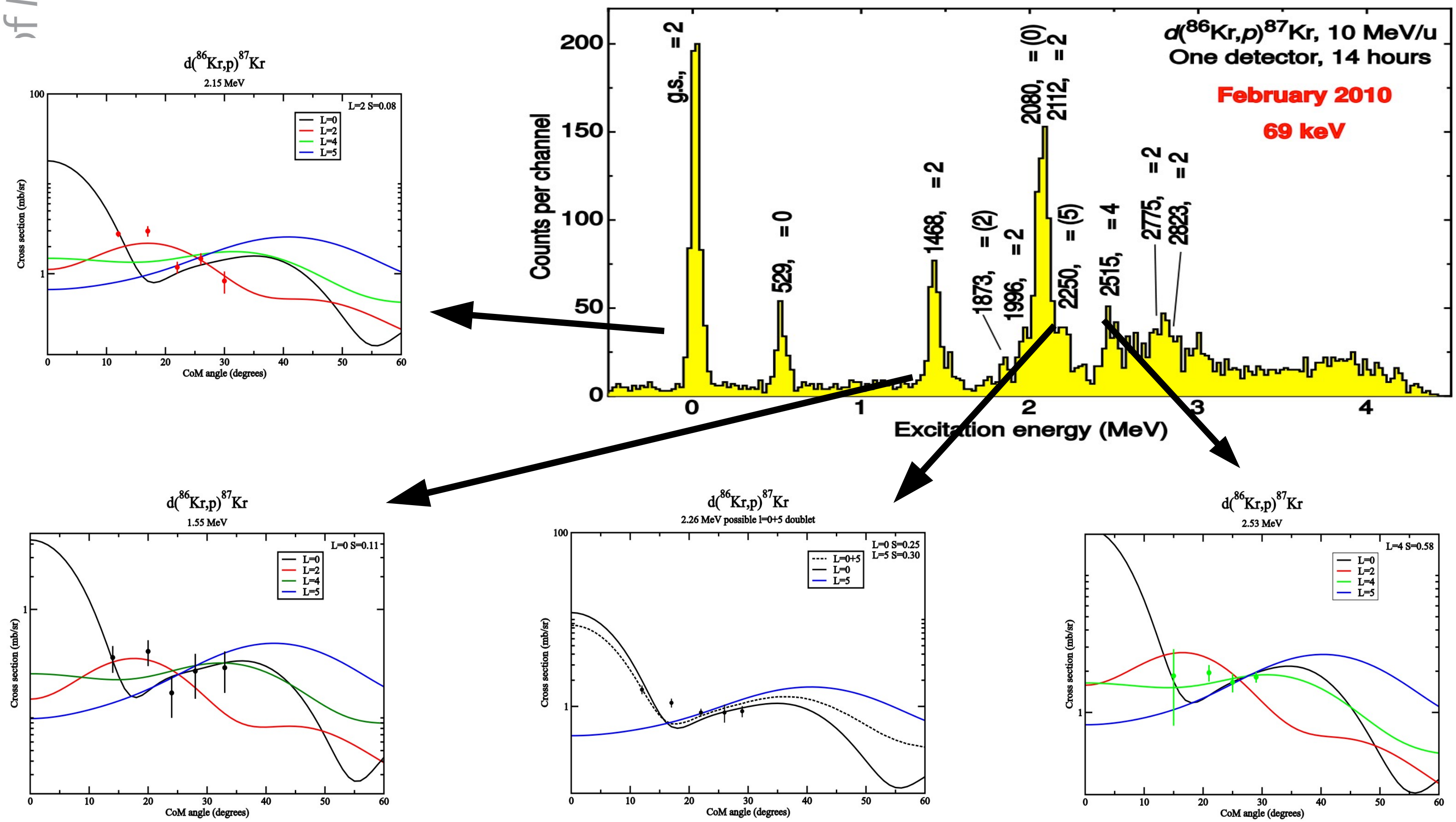
cyclotron period T_{cyc}

particle energy E_p

Light particles from reaction follow **helical** orbits, returning to the axis after one orbit where they are detected in position sensitive silicon detectors.



Helios – HELical Orbit Spectrometer



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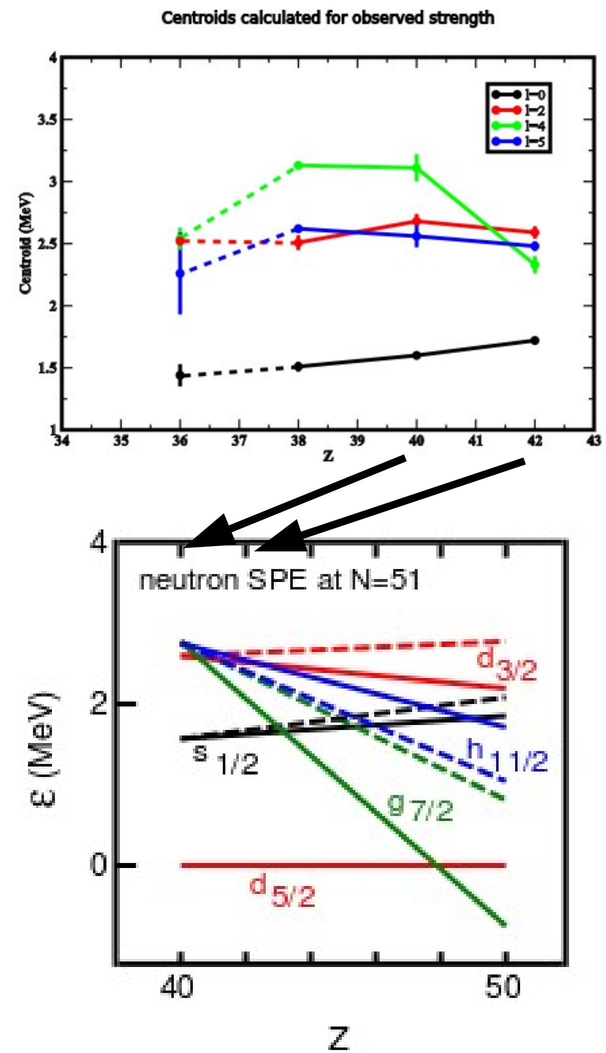
^{87}Kr Preliminary results

Table 1: Ratio of experimental cross sections to Ptolemy summary for ^{87}Kr

Ex	This work	S	Ex	Past work	S
0	2	0.38	0	2	0.56
0.52	0	0.55	0.529	0	0.46
1.46	2	0.07	1.468	2	0.23
1.55	0	0.11	1.570	(0,2)	
1.90	2	0.01	1.873	(2)	0.02
			1.996	2	0.09
2.01	(2,4)	(0.03,0.31)	2.080	(0)	0.18
2.11	2	0.09	2.112	2	0.30
2.15	2	0.08			
2.26	(0+5)	(0.25+0.30)	2.25	(5)	0.18
			2.277	(0)	0.03
2.40	4	0.10			
2.45	0	0.19			
2.53	4	0.58	2.515	4	0.49
2.61	(0,4)	(0.17,0.13)			
2.69	2	<0.01			
2.76	2	0.05	2.775	2	0.1
			2.823	2	0.11)
2.86	4	0.23			
2.94	2	0.02			
3.04	2	0.05	3.015	2	0.08
3.12	2	0.02			
3.20	2	0.02	3.223/3.237	(0+2)	



Summary

Populated states in ^{89}Sr, ^{91}Zr and ^{93}Mo using (d,p) and (α,^{3}He) reactions.

Extracted spectroscopic factors.

Trend for $\nu g_{7/2}$ states consistent with tensor force and possibly $\nu h_{11/2}$.

Work has been extended to include ^{87}Kr using inverse kinematics.

Need to investigate missing l=5 strength.