# Proton Spectroscopic Factors from ($^{3}$He,d), (d,$^{3}$He), (d,n) Reactions

Rebecca Habas,

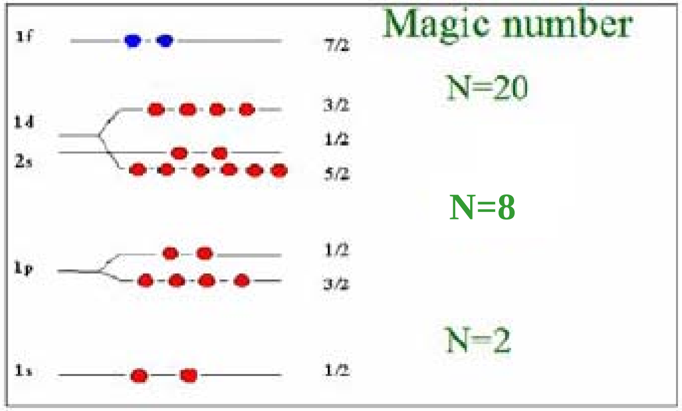
University of Rochester

Supervisor: Betty Tsang

Jenny Lee

# Physical Interpretation of the Spectroscopic Factor (SF)

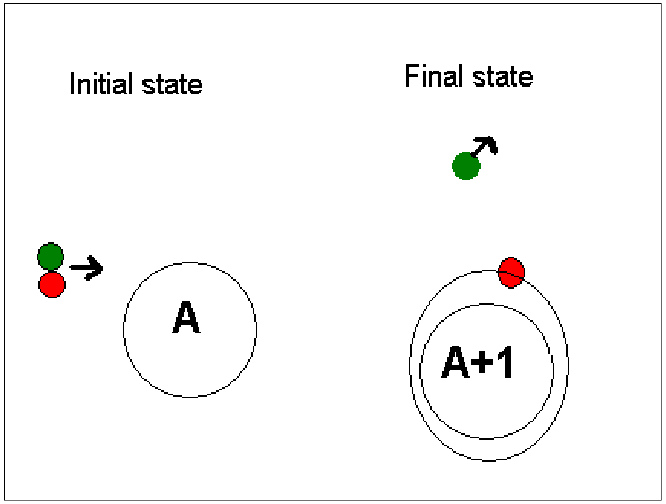
•The SF is a measure of how well one can describe the single particle nature of the valence nucleons.




In the Independent particle model (IPM), the SF represents how well the nucleus can be described as single particles plus a core.

$S_{\exp} = S_{SM}$ : Orbital description is accurate

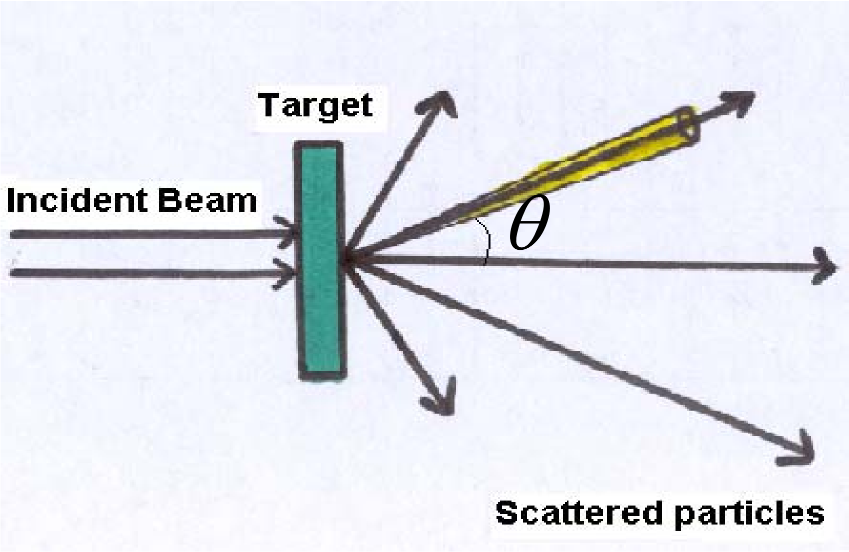
$S_{\exp} < S_{SM}$ : Valence nucleon occupies more than one orbit.

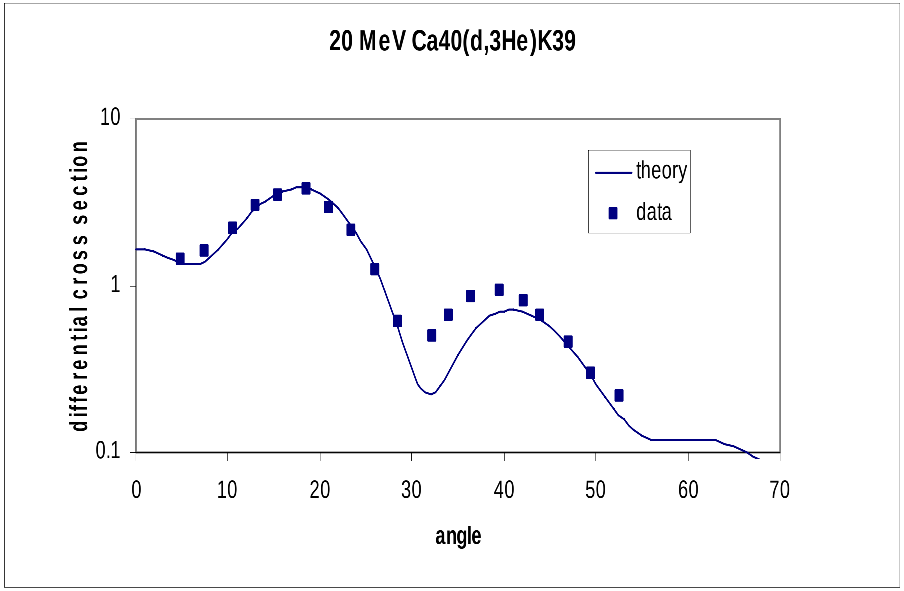


# Definition of experimental spectroscopic factor

- Experimental spectroscopic factor $S$ is the ratio of the experimental cross sections to the calculated cross sections

$$S = \frac{\sigma_{\exp}(\theta)}{\sigma_{\text{model}}(\theta)}$$



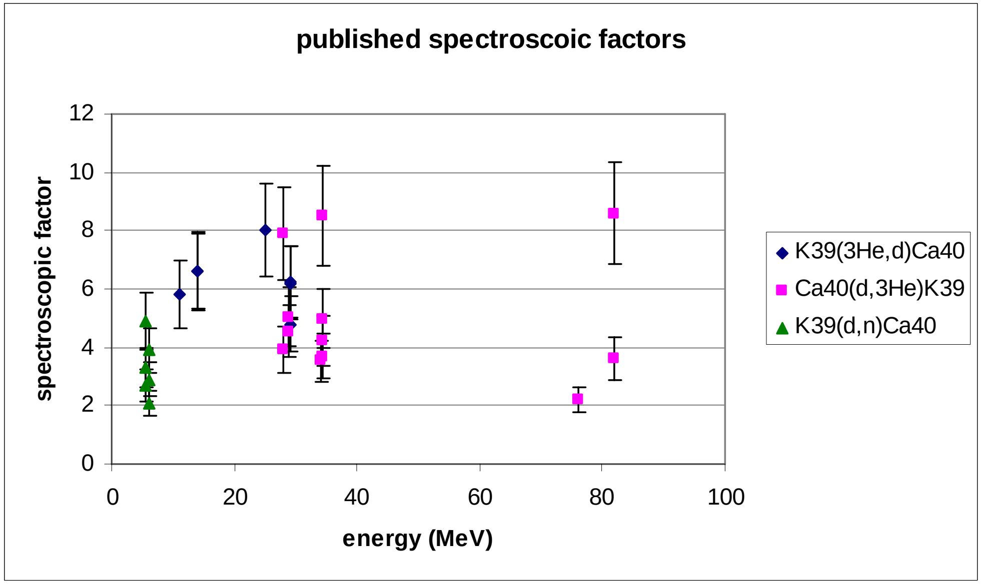
# Objective

- The literature shows a large fluctuation in published SF values

$^{39}K + d \longrightarrow n + {}^{40}Ca$

$^{39}K + {}^{3}He \rightarrow d + {}^{40}Ca$

$^{40}Ca + d \longrightarrow {}^{3}He + {}^{39}K$

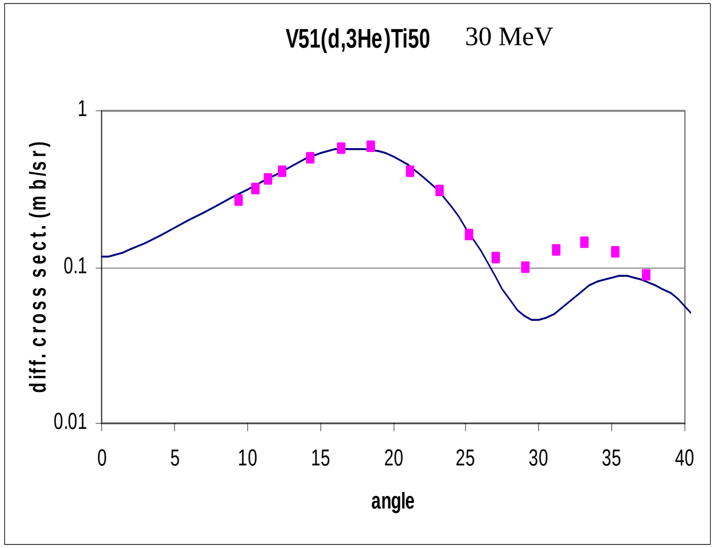



Our Proposal:

To extract spectroscopic factors by analyzing published angular distributions in a **systematic** and **consistent** manner.

# Analysis

- Digitize measurements of the angular distributions of ($^3$He,d), (d,$^3$He), and (d,n) single-nucleon transfer reactions.
- Restricted analysis to the first peak
- Studied the ground state to ground state transitions



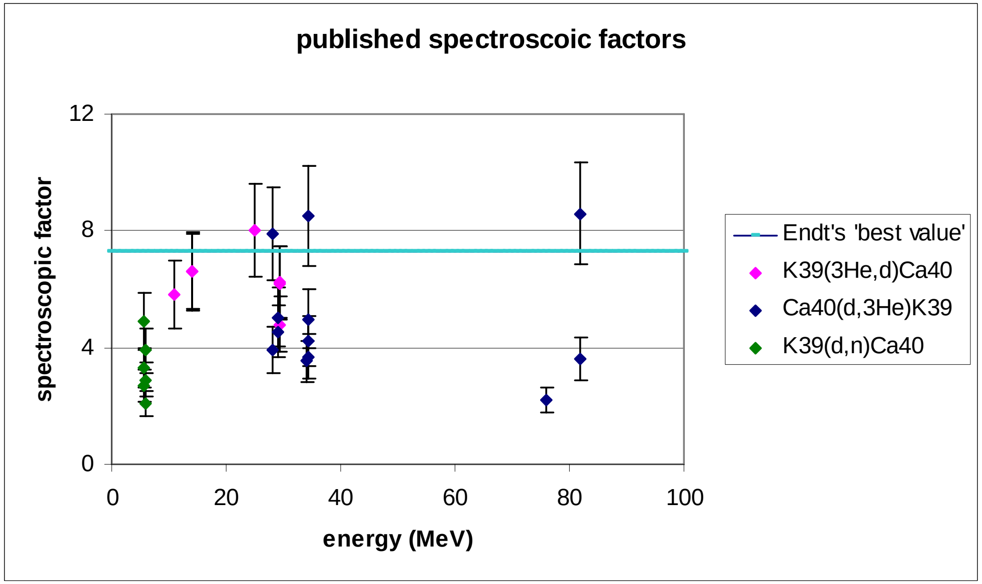

•To calculate the reaction model cross sections, we use the program TWOFNR, provided by Jeff Tostevin of University of Surrey. The model is based on the Distorted Wave Born Approximation with a consistent set of physical inputs.

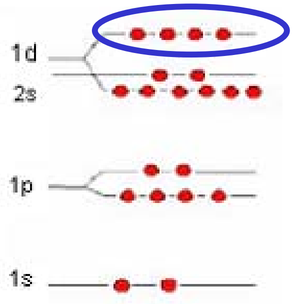
Apply this procedure to $^{12}$C, $^{13}$C, $^{15}$O, $^{16}$O, $^{31}$P, $^{32}$S, $^{34}$S, $^{40}$Ca, $^{42}$Ca, $^{51}$V, $^{90}$Zr, $^{92}$Zr, $^{206}$Pb, $^{208}$Pb, and others (44 in all)

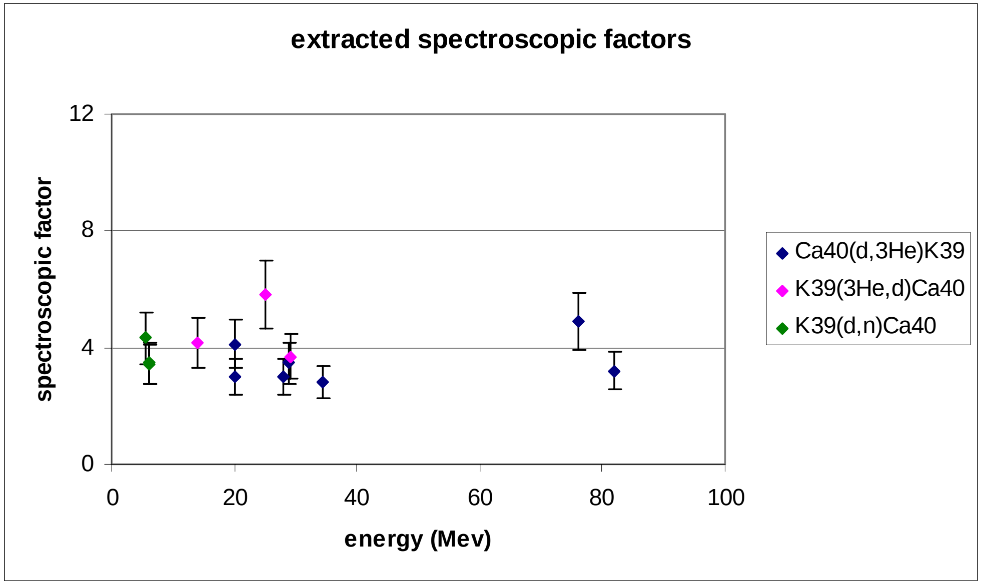
# Results

Our procedure gives more consistent values for the SF

Our best value for SF of $^{40}$Ca = 4.01 ± 20%



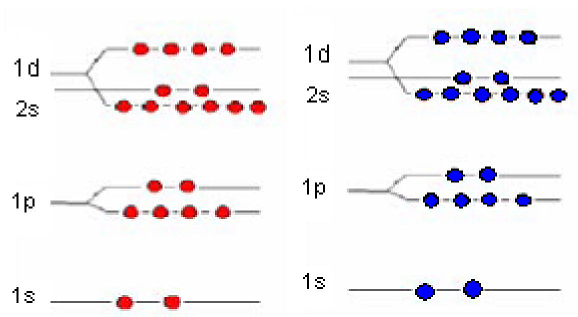



# Neutron and Proton Spectroscopic Factors

$^{40}$Ca

($^{3}$He,d)
(d,n) ⟵ $^{39}$K + p

(d,$^{3}$He)
(n,d) ⟵ $^{41}$K – p




protons neutrons

$^{39}$C + n ⟶ (d,p)

$^{41}$C – n ⟶ (p,d)

| (d,$^{3}$He) | ($^{3}$He,d) | (d,n) | <SF> | <SF>_n | <SF>/<SF>n |
|---|---|---|---|---|---|
| 3.63 | 4.73 | 3.67 | 4.01 | 4.3 | 0.933 |

# Comparison between Neutron and Proton SF

| Isotope | <SF> (d,$^{3}$He) | <SF> ($^{3}$He,d) | <SF> (d,n) | <SF> | <SF>_n | <SF>/<SF>n | $S_{SM}$ |
|---|---|---|---|---|---|---|---|
| C12 | 2.73 | 4.01 | 3.13 | 3.29 | 2.98 | 1.104 | 4 |
| O16 | 3.01 | 2.74 | 2.63 | 2.79 | 2.23 | 1.251 | 2 |
| S32 | 1.41 | 2.19 | 1.78 | 1.79 | 1.46 | 1.226 | 2 |
| Ca40 | 3.63 | 4.73 | 3.67 | 4.01 | 4.3 | 0.933 | 4 |

# Conclusions

- Extract p spectroscopic factors using a systematic approach for 12C, 16O, 32S, 40Ca….
- For N=Z nuclei, the proton spectroscopic factors are consistent with the neutron spectroscopic factors.
- Need further analysis to assign quantitative errors to each isotope.
- Would like to add (n,d) reaction to the list of reactions of (d,3He), (3He, d) and (d,n) studied.

# Input Parameters used in TWOFNR

| | DWBA |
|---|---|
| Neutron potential | Chapel-Hill [43] |
| Deuteron potential | Daehnick [45] (d,3He)<br>Adiabatic Potential with Chapel-Hill (d,n) |
| 3He potential | Bechetti-Greenlees |
| n-binding potential | Woods-Saxon<br>$r_0$ =1.25, a=0.65 |
| Hulthen finite range factor | 0.7457 (d,n)<br>0.7462 (d,3He) |
| Vertex constant $D_0^2$ | 15006.25 (d,n)<br>25600 (d,3He) |
| Non-Locality potentials | n 0.85; 3He 0.25;<br>d 0.54 (d,3He)<br>0.85 (d,n) |