INSTITUTO GALEGO DE FÍSICA DE ALTAS ENERXÍAS

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Quenching of spectroscopic factors in ^{10,12}Be transfer reactions

M. Lozano-González, A. Matta, B. Fernández-Domínguez,
F. Delaunay, J. Lois-Fuentes

USC-IGFAE and LPC-Caen

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AGENCIA ESTATAL DE INVESTIGACIÓN

EXCELENCIA MARÍA DE MAEZTU 2024-2029

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CENTROS

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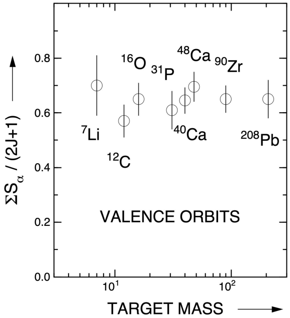
A recap on spectroscopic factors

Spectroscopic factors shed light on the occupancy of single-particle states:

$$\left.\frac{d\sigma}{d\Omega}\right|_{\text{exp}} = C^2 S \cdot \left.\frac{d\sigma}{d\Omega}\right|_{\text{s.p}}, \quad \sum C^2 S = (2j+1) \text{ in IPSM}$$

Experimentally:
Reduction of $\sim 65\,\%$!

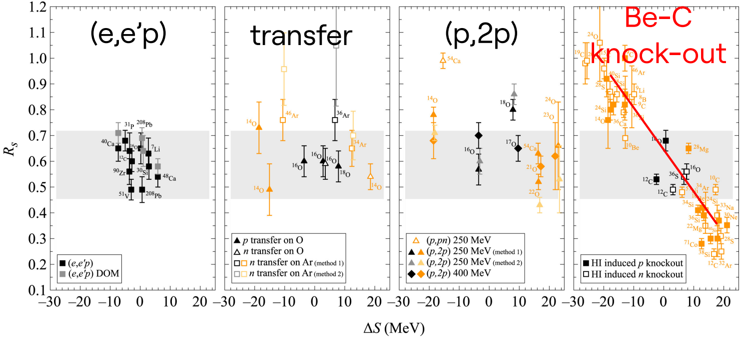
- **Short-range** correlations: tensor forces,...
- **Long-range**: vibrations, giant resonances,...



L. Lapikás, Nuclear Phys. A 553 (1993)

A long-standing puzzle

A trend with asymmetry energy $\Delta S \equiv \pm(S_p - S_n)$ is found depending on the experimental **probe**!

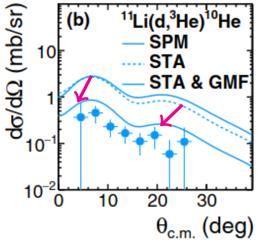


T. Aumann et al. Prog. Part. Nucl. Phys. 118 (2021)

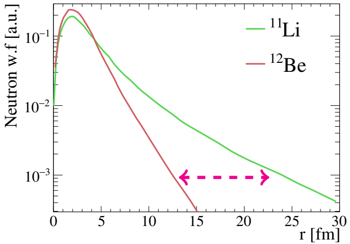
$\Rightarrow$ measure towards more exotic nuclei: $|\Delta S| \uparrow$

Importance of GMF

Towards exotic nuclei (loosely bound or halo), a ***geometrical mismatch factor*** emerges from the very different w.f. in the overlap:



A.Matta et al., Phys. Rev. C 92 (2015)



N. K. Timofeyuk, private communication (in E748 proposal)

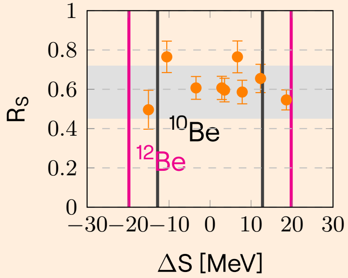
$\Rightarrow$ Need to correct C^2S by its value!

Physics case of E748

E748 @ GANIL back in 2017. Using ^{10,12}Be(d,t|^{3}He) reactions to:

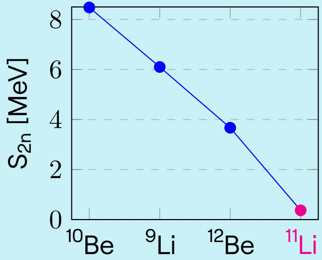
R_S and ΔS dependence:

- $\langle ^{10}\text{Be}|^{9}\text{Be, Li}\rangle$, $\Delta S = \mp 12.8$ MeV
- $\langle ^{12}\text{Be}|^{11}\text{Be, Li}\rangle$, $\Delta S = \mp 19.8$ MeV



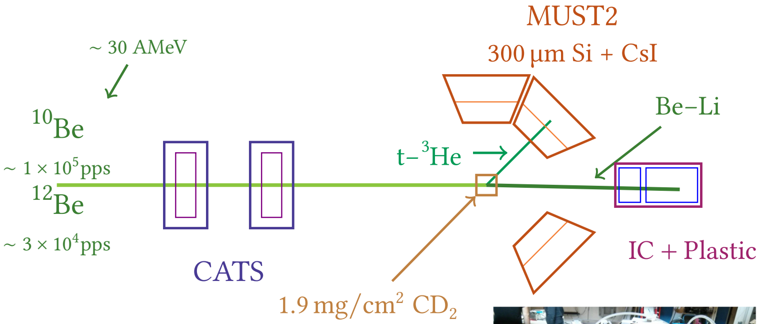
Explore effects of GMF:

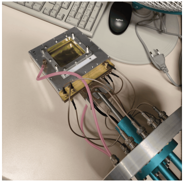
- $\left\langle ^{10}\text{Be}\middle|^{9}\text{Be, Li}\right\rangle$, GMF ~ 1
- $\left\langle ^{12}\text{Be}\middle|^{11}\text{Li}\right\rangle$, GMF $\sim 0.5?$

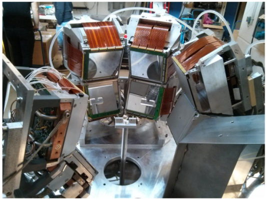


Experimental technique

Tradional solid target experiment @ LISE

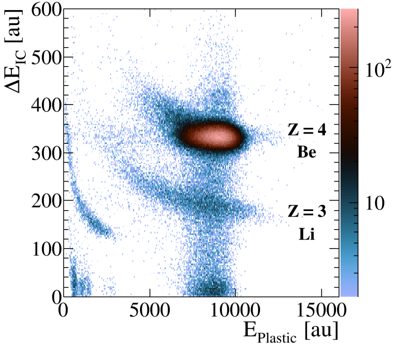




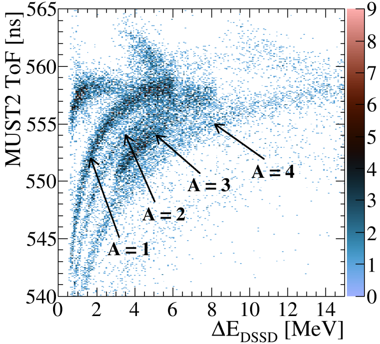


A glance at the analysis

1 **Heavy** ID at 0°



2 **Light** PID in DSSD

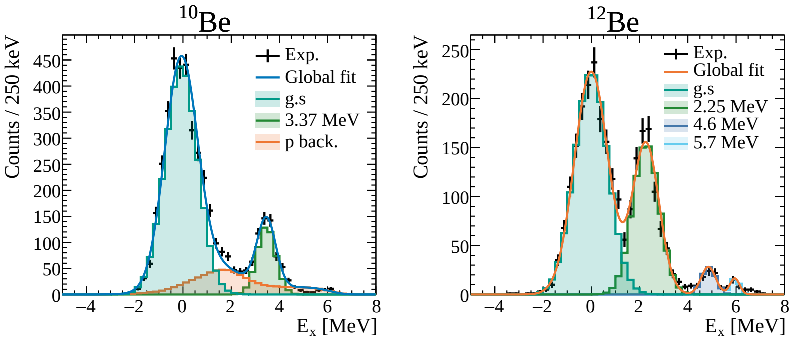


3 E_x from **missing mass technique**

$$E_{\text{beam}} + (E, \theta)_{\text{Lab}} \to E_x$$

Results: Elastic ^{10,12}Be(d,d)^{10,12}Be

The **ground state** sets our normalization!



First 2^+ is seen in both cases but not exploited yet!

Results: Elastic ^{10,12}Be(d,d)^{10,12}Be

Experimental cross-section formula:

$$\frac{d\sigma}{d\Omega} = \frac{N}{N_{\text{beam}} N_{\text{targets}} \epsilon \Delta\Omega} = \frac{N}{N_{\text{beam}} \alpha \epsilon_{\text{sim}} \Delta\Omega}$$

1 **Target thickness** not measured during experiment

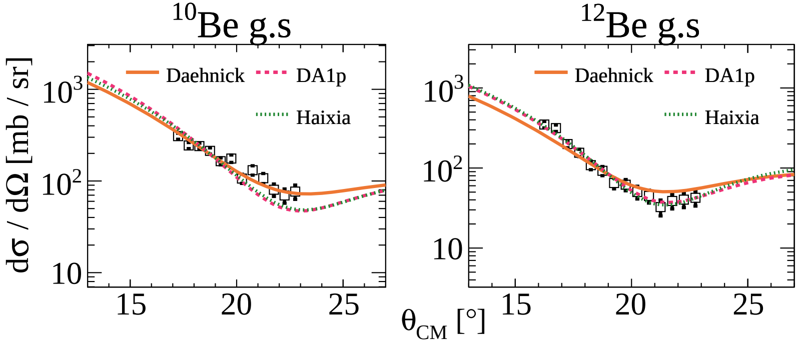
2 Missing intrinsic ZDD $\epsilon \sim 20\text{–}30\,\%$

Agglutination of unknown factors: $\alpha = N_{\text{targets}} \cdot \epsilon_{\text{instrinsic, ZDD}}$

α is determined from fits of theoretical cross-sections to data

Results: Elastic ^{10,12}Be(d,d)^{10,12}Be

The best OMP potentials can also be deduced from the fit quality.



^{10}Be + d: **Daehnick**

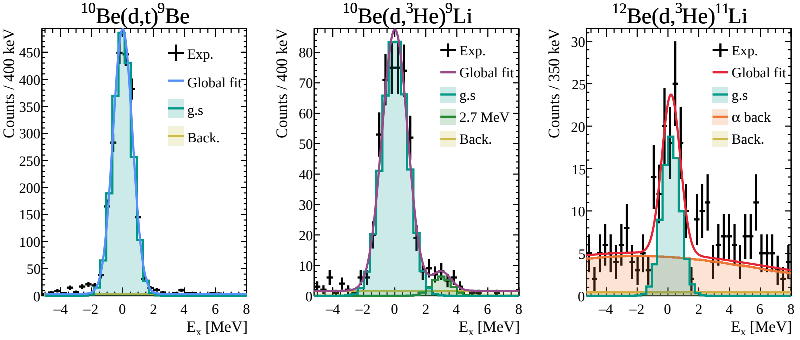
W. Daehnick et al. PRC 21 (1980)

^{12}Be + d: **Haixia**

H. Ann, C. Cai. PRC 73 (2006)

Results: transfer

The **ground states** of the heavy recoils are populated.



First state at 2.7 MeV of ^{9}Li is seen too! 🙂

Results: transfer

Fresco is employed to perform the **DWBA** calculations.

OMP

- In: set from elastic
- Out: HT1p

D. Y. Pang et al., PRC 91 (2015)

Light overlap

$\langle \mathrm{t}, {}^{3}\mathrm{He} | \mathrm{d} \otimes \mathrm{n,p} \rangle$

Accurate GFMC

I. Brida et al., PRC 84 (2011)

1 Heavy overlap

$\langle {}^{10,12}\mathrm{Be} | {}^{9,11}\mathrm{Be}, \mathrm{Li} \otimes \mathrm{n}, \mathrm{p} \rangle$

WS of *Standard Potential Model* (SPM)

$r_0 = 1.25$ fm, $a = 0.65$ fm

2 Heavy overlap

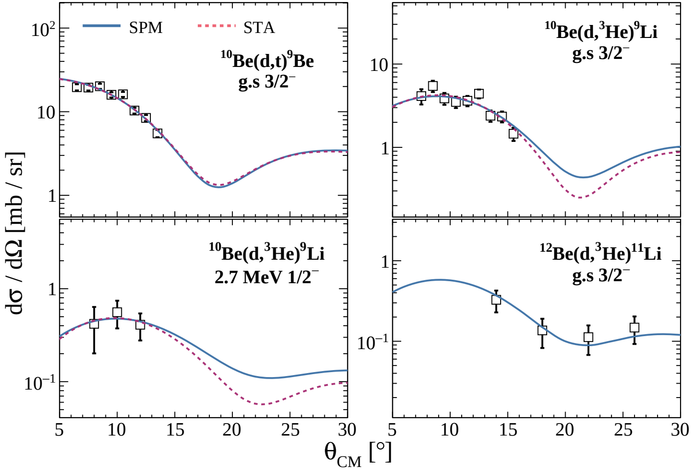
$\langle {}^{10,12}\mathrm{Be} | {}^{9,11}\mathrm{Be}, \mathrm{Li} \otimes \mathrm{n}, \mathrm{p} \rangle$

WS from novel *Source Term Approach* (STA)

N. Timofeyuk PRC 81 (2010)

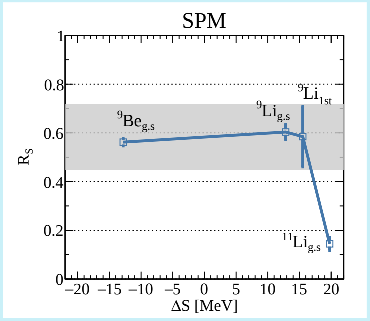
Results: transfer

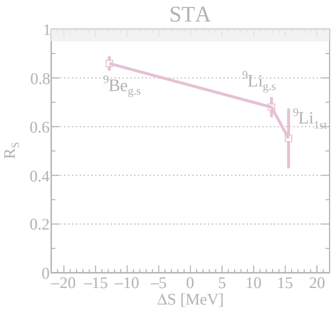
Angular distributions for all the states



Results: quenching factor

The reduction factor $R_S = C^2 S_{exp} / C^2 S_{theo}$ is computed:





SFO-tls interaction

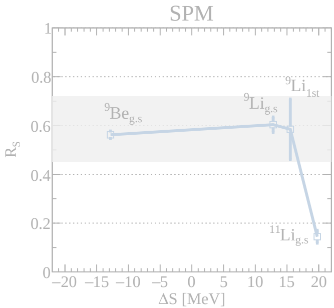
T. Suzuki, T. Otsuka PRC 78 (2008)

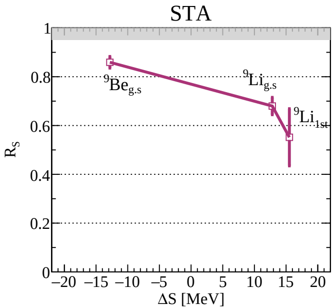
Compatible with current systematics 👍

^{11}Li requires GMF correction (pending)

Results: quenching factor

The reduction factor $R_S = C^2 S_{exp} / C^2 S_{theo}$ is computed:





$R_S = 1$
is expected now

Falls short in
modelling SRCs

Needs to be
extended to ^{11}Li

Conclusions

Angular distributions for ^{9}Be, ^{9}Li and ^{11}Li have been extracted and compared with DWBA

R_S for SPM agrees with literature, while STA still understimates NN correlations

^{11}Li needs correction for a major geometrical mismatch value

STA requires further developments to reach ^{11}Li

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  T. Roger
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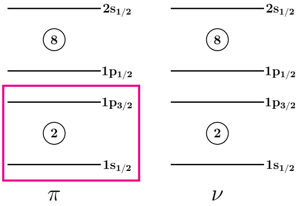
- Surrey:
  N. Timofeyuk

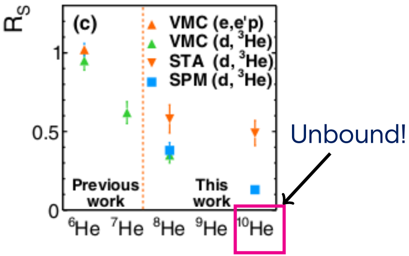
Backup

Status with light isotopes

Several experiments allowed for the extraction of C^2S with Li-induced (d, ^{3}He) reactions:

Explored region





A. Matta et al., Phys. Rev. C 92 (2015)

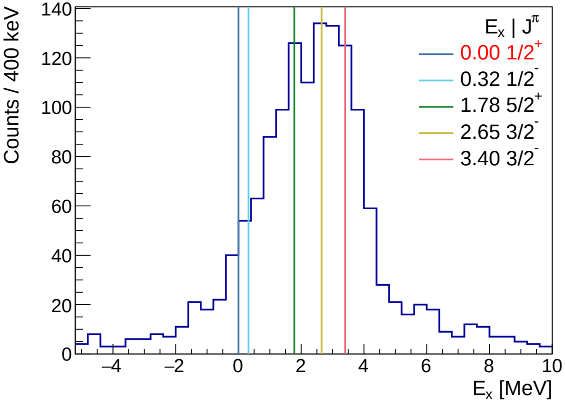
Several challenges in this region:

1 Dealing with **unbound** nuclei (^{10}He)

2 Many-body dynamics and/or core excitations

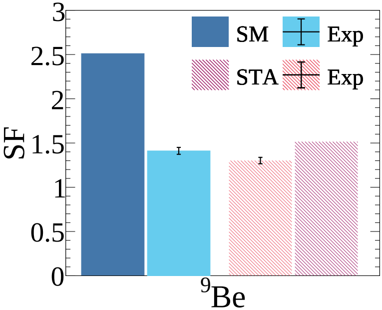
What happens with ^{11}Be?

It shows a strong inhibition of the ground state.



Impossible to disentangle excited states ☹

Results: $^{10}Be(d,t)^{9}Be$

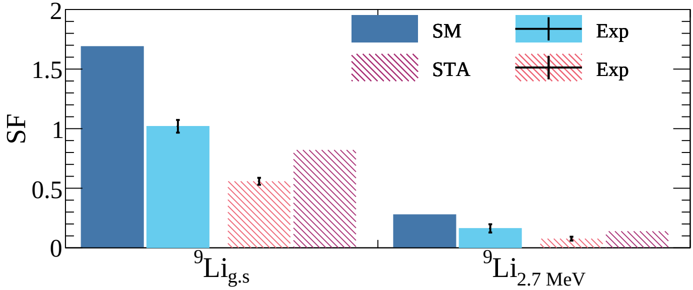


SM calculation using **SFO-tls** interaction

T. Suzuki, T. Otsuka PRC 78 (2008)

STA yields 40 % of SM value.
Better accord with exp values

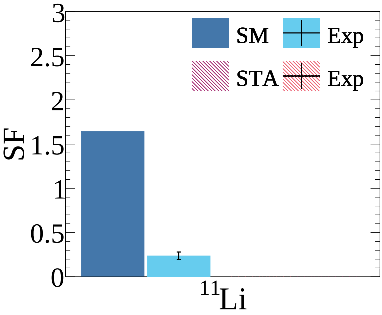
Results: $^{10}Be(d,^{3}He)^{9}Li$



Same significant differences SM–STA

Worse agreement within STA data
~ 40 % discrepancies

Results: $^{12}Be(d,^{3}He)^{11}Li$



Gigantic quenching, signature of **GMF** playing a role

No STA predictions yet 😕

Kinematical lines