$\nu 0p_{1/2} - \nu 0p_{3/2}$ spin-orbit splitting in ^{20}O

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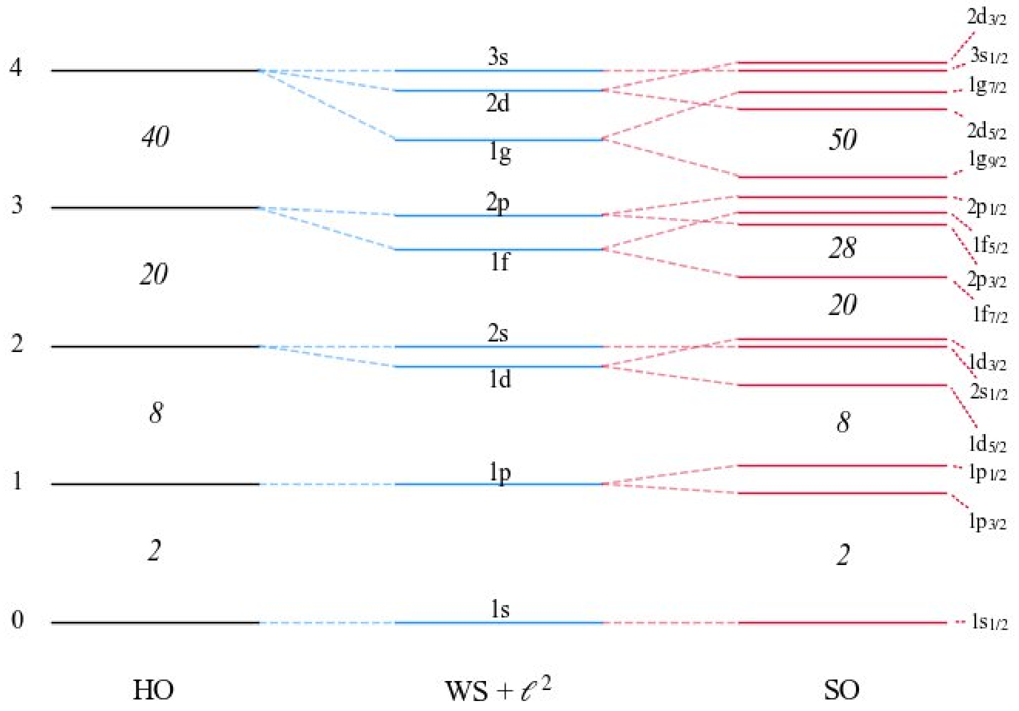
IGFAE-USC, GANIL and LPC-Caen

EuNPC 2025 - Caen

A recap on the SO splitting

Introduced by M. Goeppert-Mayer, reproduces magic numbers for stable nuclei.



SO splitting is mainly a surface effect:

$$V_{SO} = -\frac{1}{\hbar^2} V_{so} (\vec{l} \cdot \vec{s}) \left(\frac{1}{r} \frac{dV}{dr} \right)$$

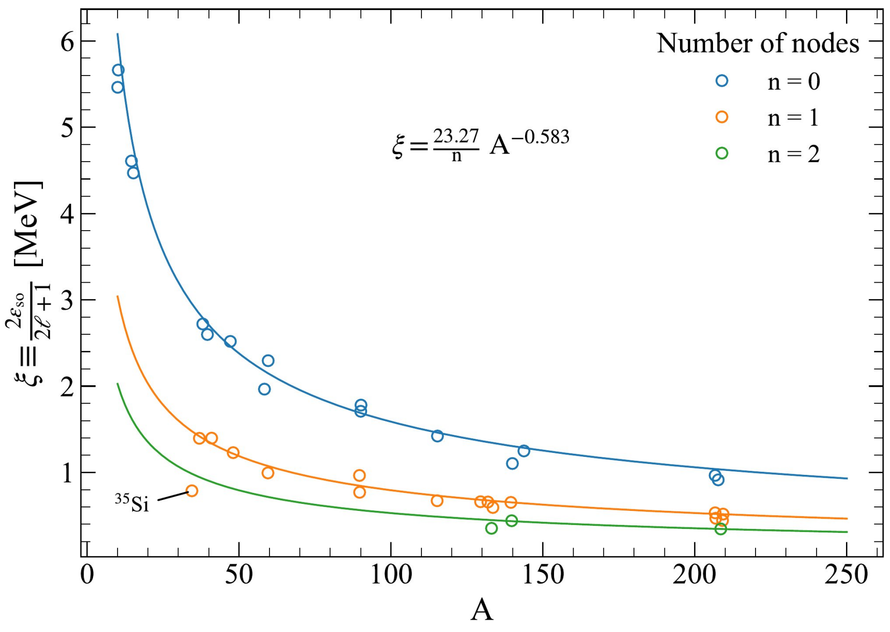
which yields a l-depending gap:

$$\Delta_{so} = \frac{\hbar^2}{2}(2\ell + 1)\xi$$

⇒ Expected to evolve towards more exotic nuclei, where surface blurs

A recap on the SO splitting

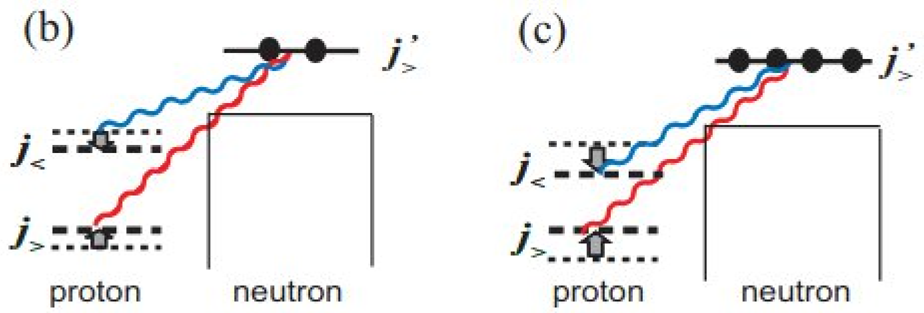
G .Mairle *et al.* (PLB 304 (1993)) found systematic trends easily parametrizable.



Proton-neutron interactions drive **shell evolution**

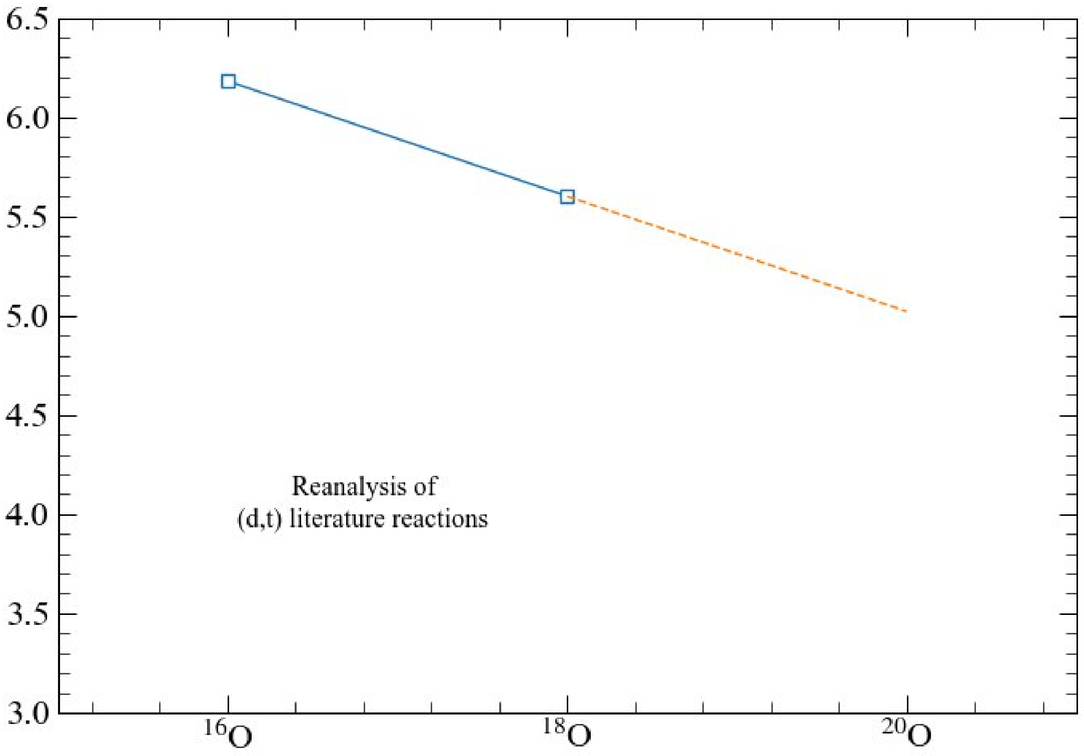
Deviations from the trend are found due to:

- Loosely bound orbitals
- Nuclear matter depletion (^{35}Si?)
- Role of **tensor force**



SO gap for Z = 8 isotopes

Evolution of the SO gap is plotted below for neutron-rich O isotopes.



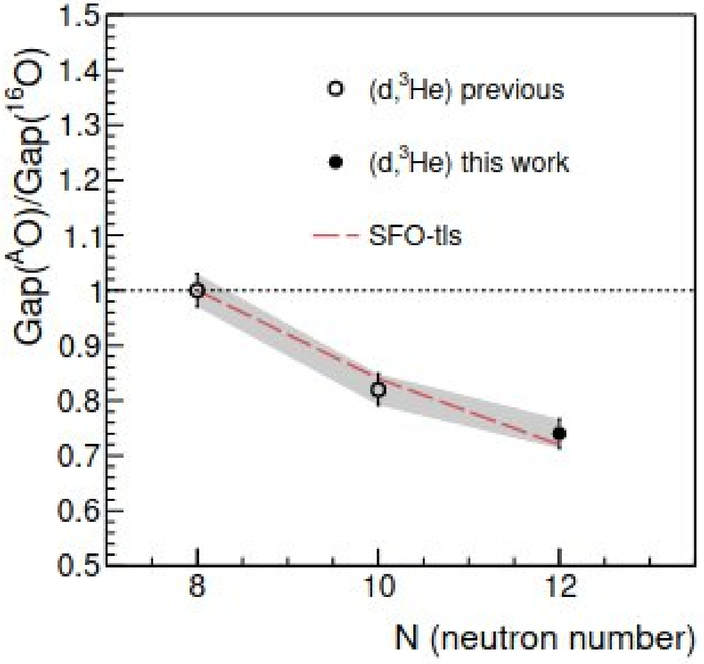
Will ^{20}O follow the trend?

Could be determine the *pn* tensor contribution?

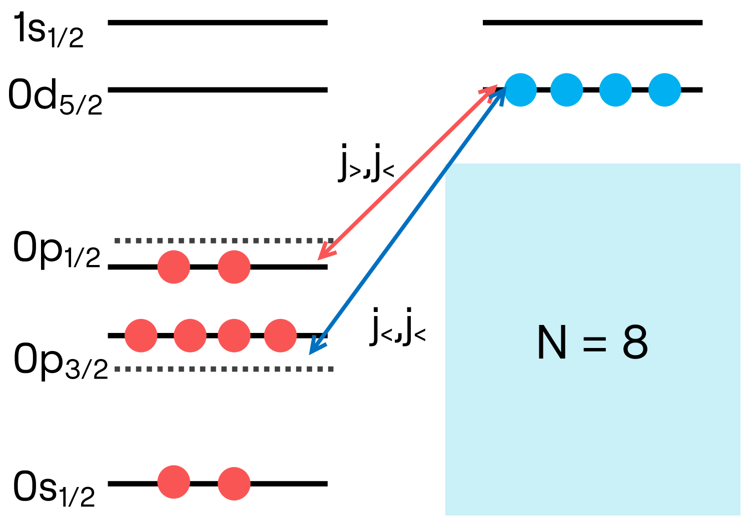
Physics case

E796 to measure **transfer** reactions probing single-particle occupancies in ^{20}O.

1. Proton removal $^{20}O(d,^{3}He)^{19}N$ to investigate persistence of Z = 6



J. Lois-Fuentes, PhD thesis (2023)



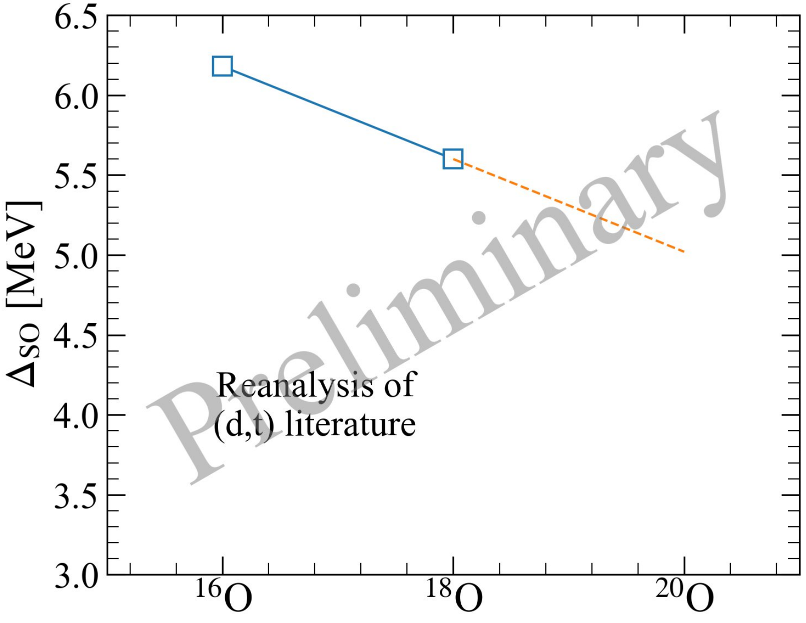
Schematic view of tensor interaction in ^{20}O

Tensor V_{pn} reduces Z = 6 gap as neutrons are added to $\nu 0d_{5/2}$

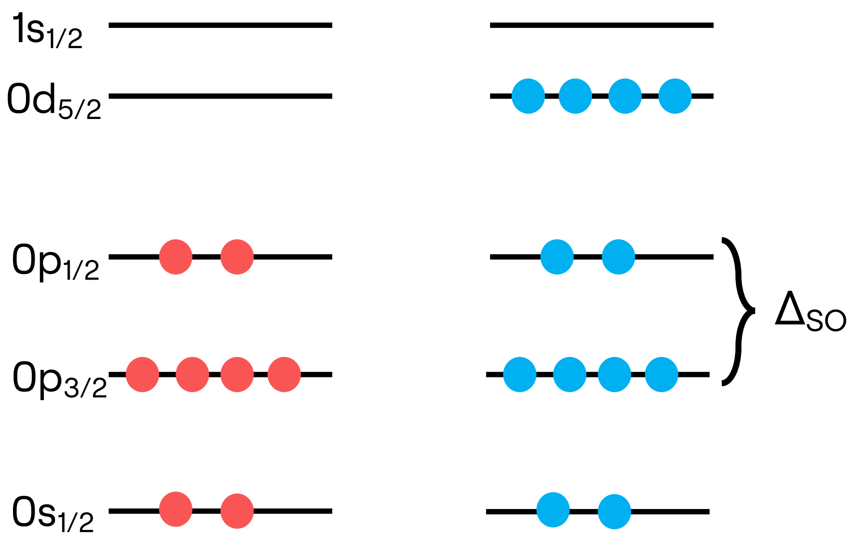
Physics case

E796 to measure **transfer** reactions probing single-particle occupancies in ^{20}O.

2. Neutron removal $^{20}O(d,t)^{19}O$ to extract N = 6 SO gap



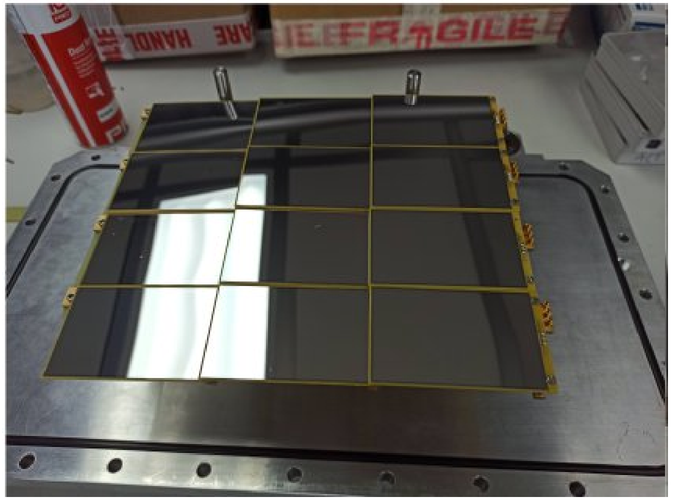
Reanalyis of previous data



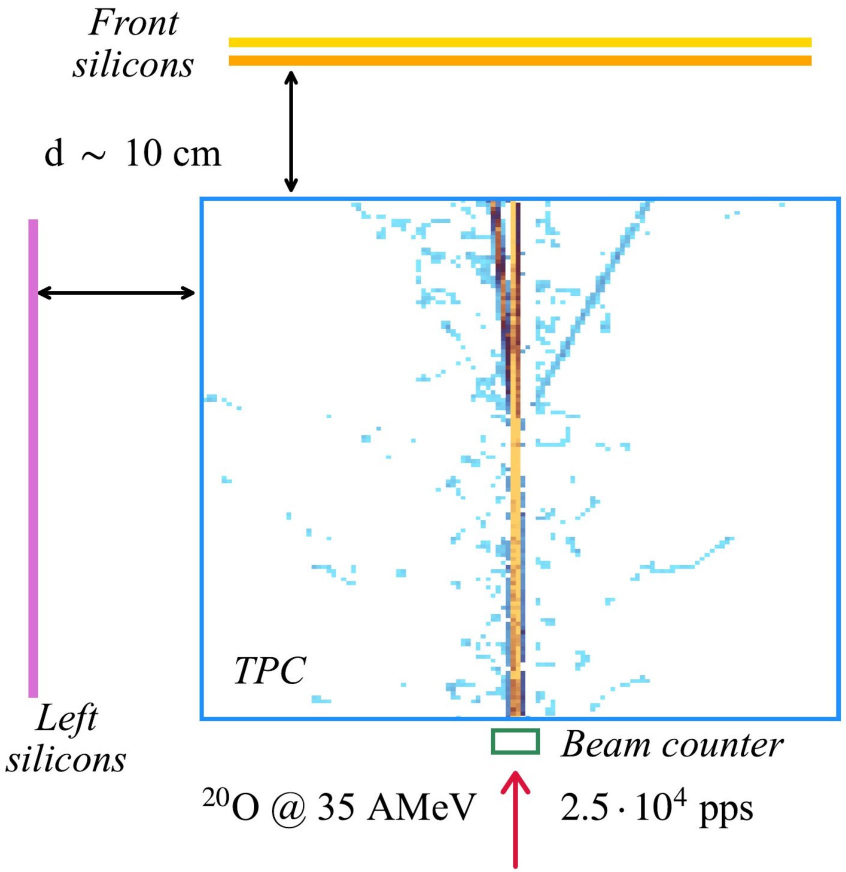
IPSM of ^{20}**O**

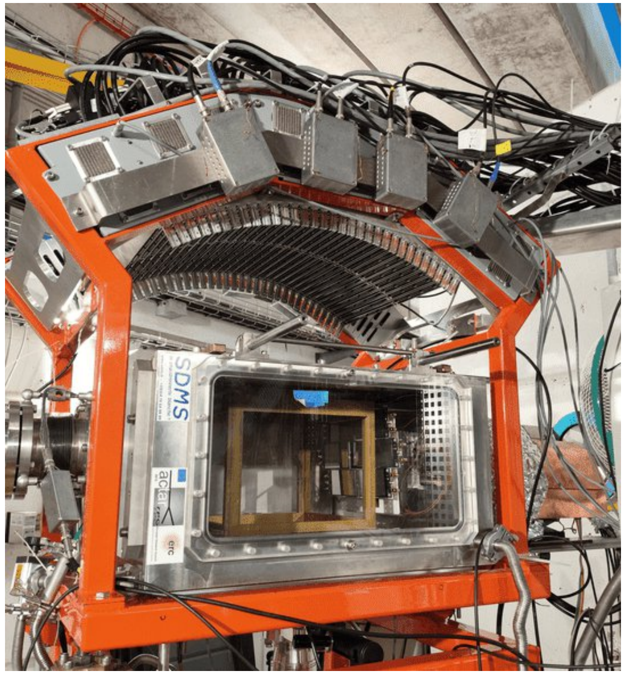
Experimental setup

E796 @ LISE in 2022. First transfer experiment with ACTAR TPC!



Silicon sizes:
80 x 50 x 0.5 mm^3

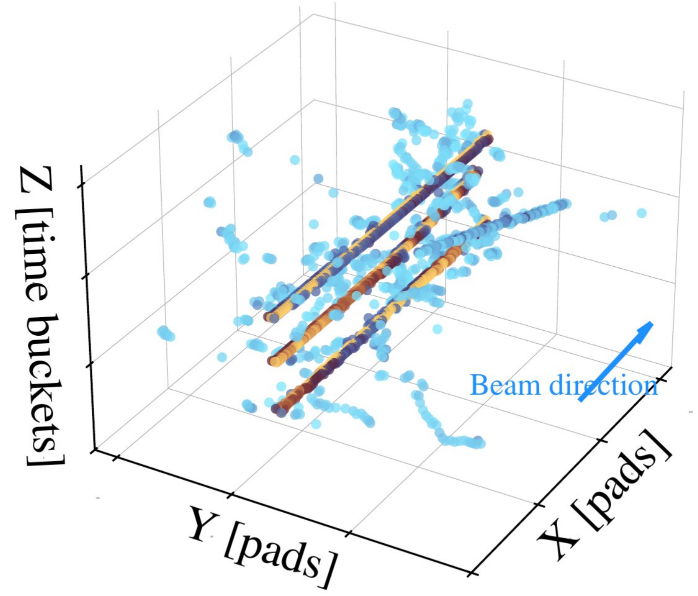


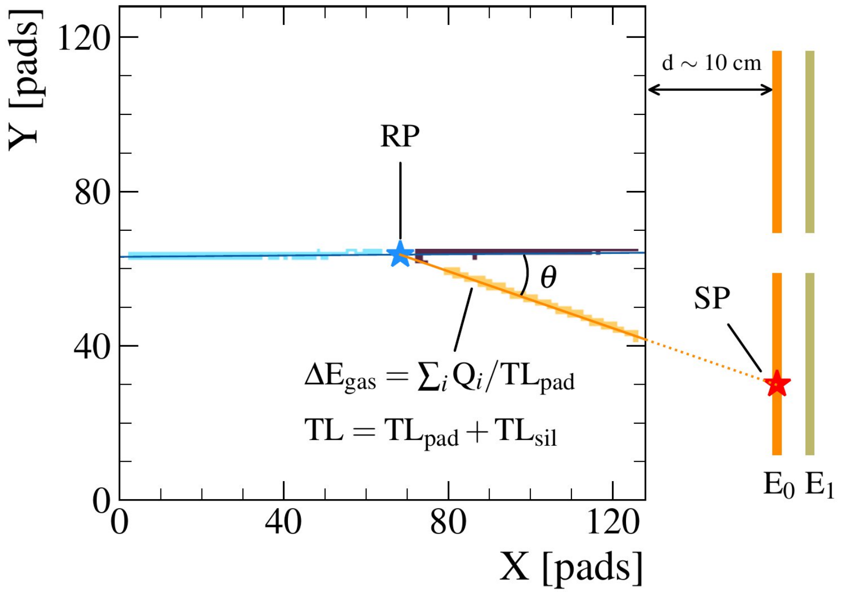


Gas mixture:
90% D_2 + 10 % iC_4H_{10}
at 952 mbar

A window to the analysis

Intricate analysis to extract reactions of interest out of noisy data.





Unique advantages from the TPC:

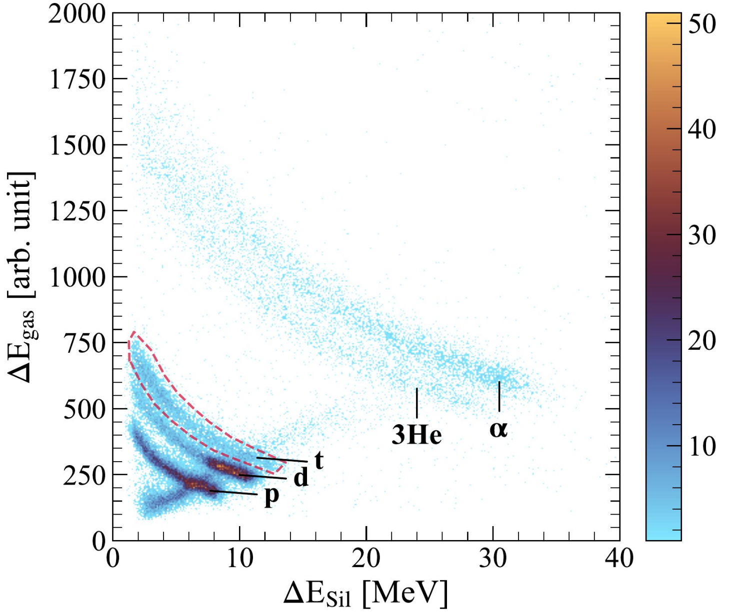
- Precise **vertex** determination
- Improved ΔE corrections

- Factor 10 in target number
- Implicit PID with ΔE_{gas}

A window to the analysis

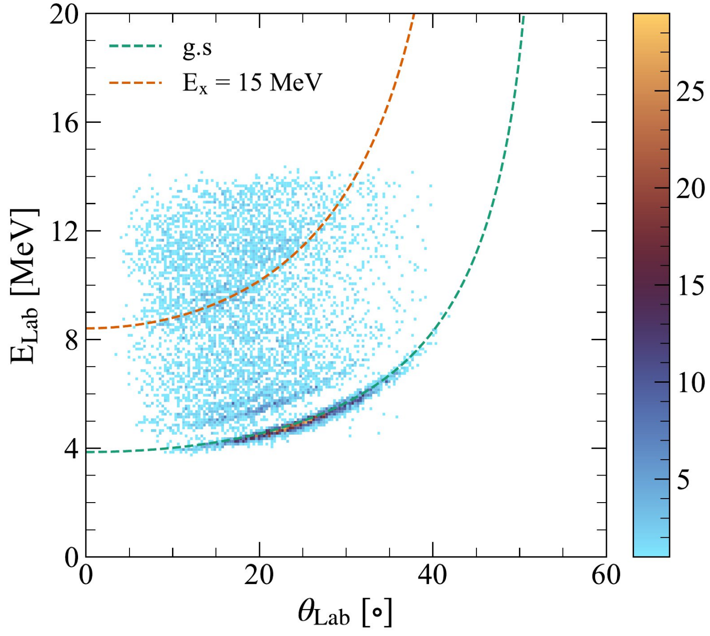
Two steps are needed after a binary reaction has been identified.

1. PID of tritons by plotting ΔE_{gas} vs ΔE_{Sil}

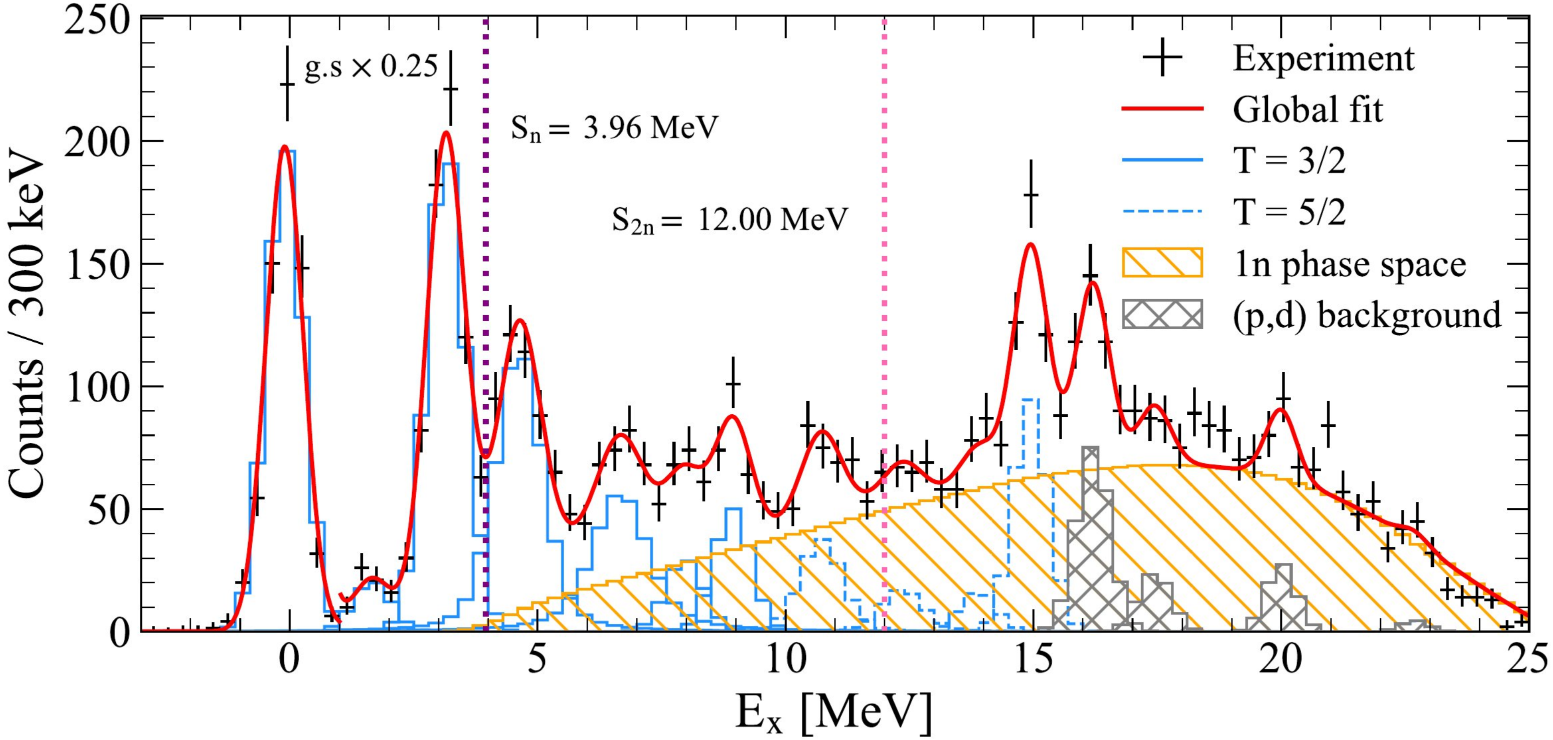


Masked punch-through to 2nd front layer

2. E_x reconstructed by the **missing-mass** technique



Results: E_x spectrum

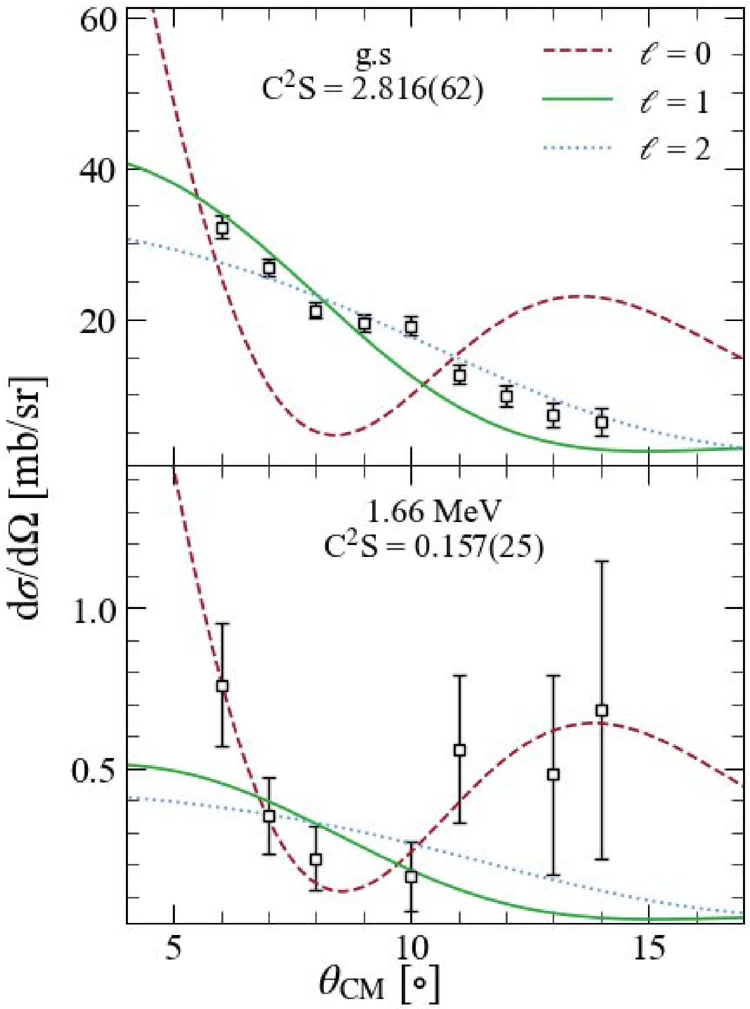


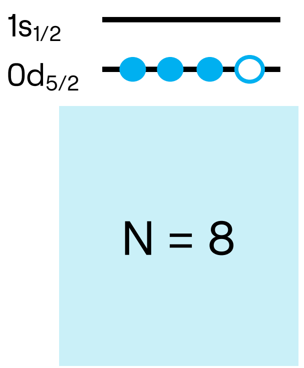
Negligible 2n phase space contribution

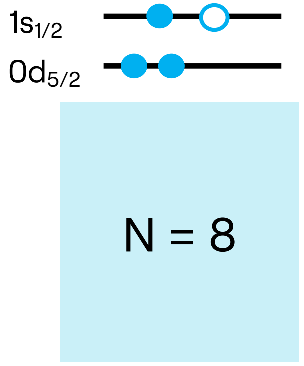
- 11 observed states
- At E_x > 15 MeV (p,d) contamination appears

- Isospin *T* = 3/2 and 5/2
- Assigned based on $^{20}O(d,^{3}He)^{19}N$

Results: cross-sections





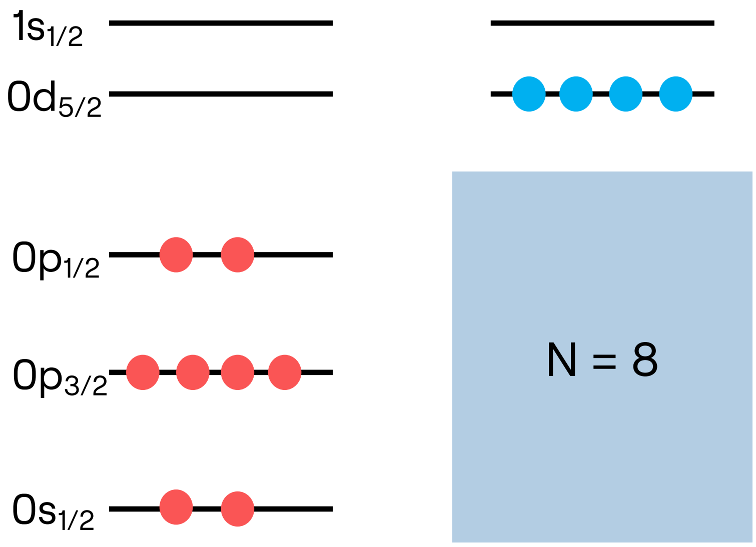


DBWA with Fresco

- OMP:
  - ^{20}O + d: Daehnick
  - ^{19}O + t: Pang
- ⟨ d | t ⟩ from ab-initio GFMC
- ⟨ ^{20}O | ^{19}O ⟩ from standard WS

- g.s: $5/2^+$, taking up 71% of the occupation
- 1st: $1/2^+$, with 8% of $1s_{1/2}$ occupancy

A window to the analysis



Grazas!

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