Tensor force fingerprints in ^{20}O: The quenching of the Z=6 gap

Juan Lois Fuentes

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XL Bienal RSEF - Sevilla - 20th July 2026

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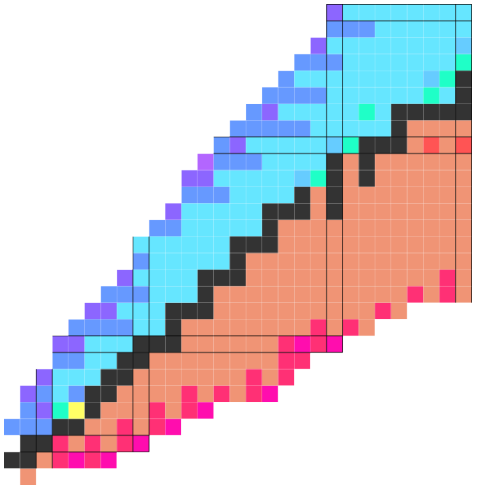
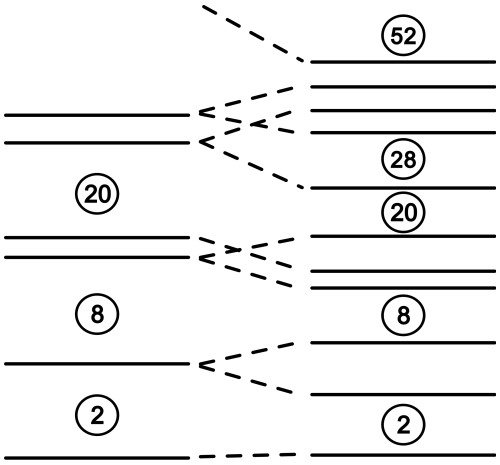
USC PhD | FRIB Postdoc | LPC Postdoc | LPC CRCN

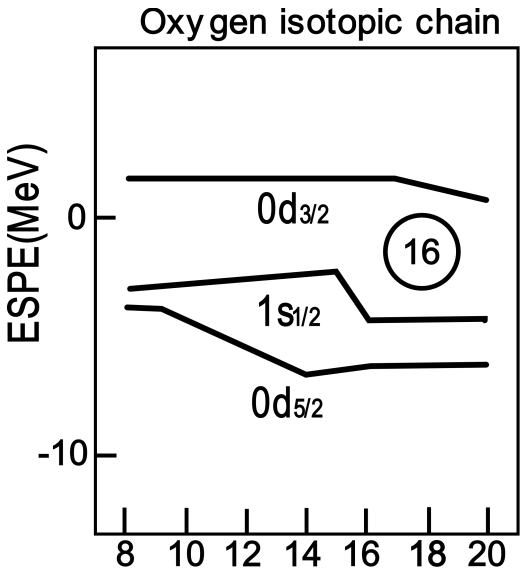
GANIL | Argonne NATIONAL LABORATORY | RIKEN NISHINA CENTER

How does the nucleus organize itself?



IPM



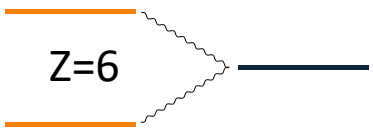


Interacting SM

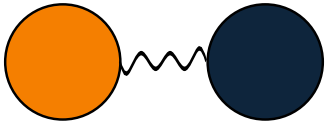
$H = H_0 + H_m + H_M$

Central Tensor LS

GAP evolution

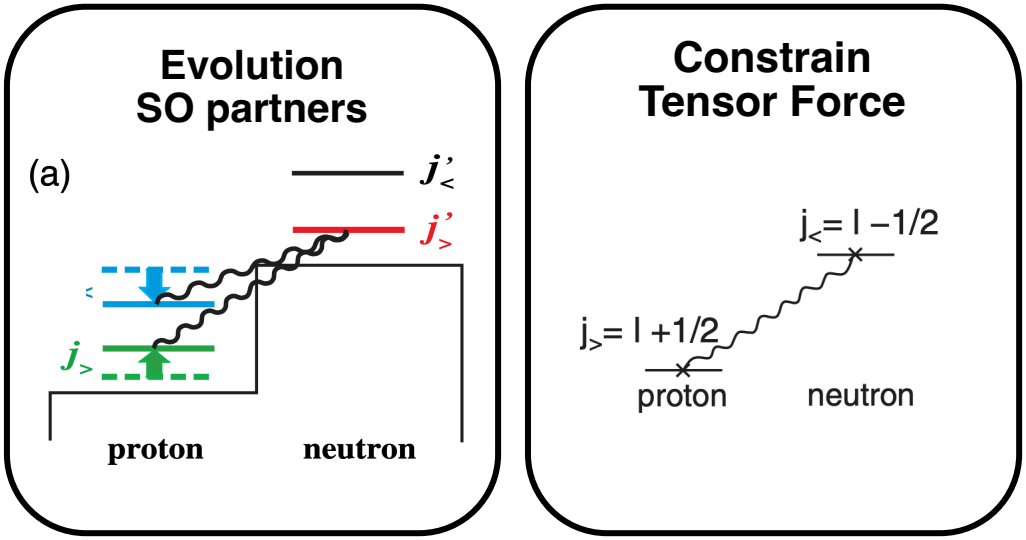


nucleon-nucleon interaction



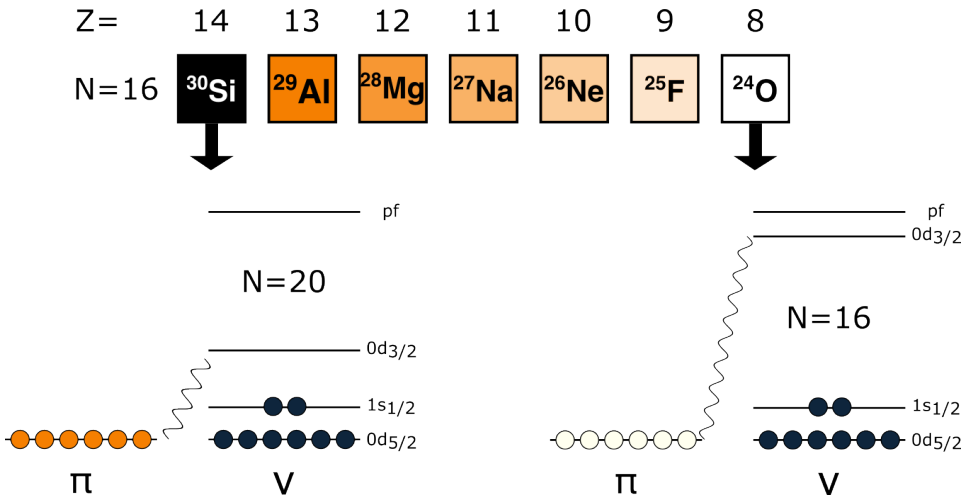
How can we constrain the tensor force?

Tensor for dominates evolution of SO partners.



N=16 Magicity in ^{24}O:

- Last bound Oxygen Isotope.



Tensor Force: The Controversy

Indirect measurements

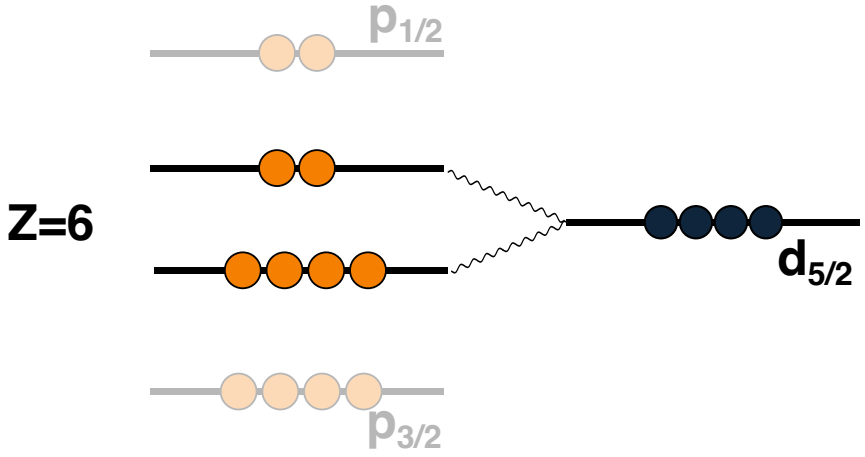
Surprise in the

N-rich Carbons!

Prevalent Z=6
- D.Tran et al. Nat. Com. 9 (2018)1594

Reduced Z=6
- I. Syndikus et al., PLB 809 (2020), 135748.

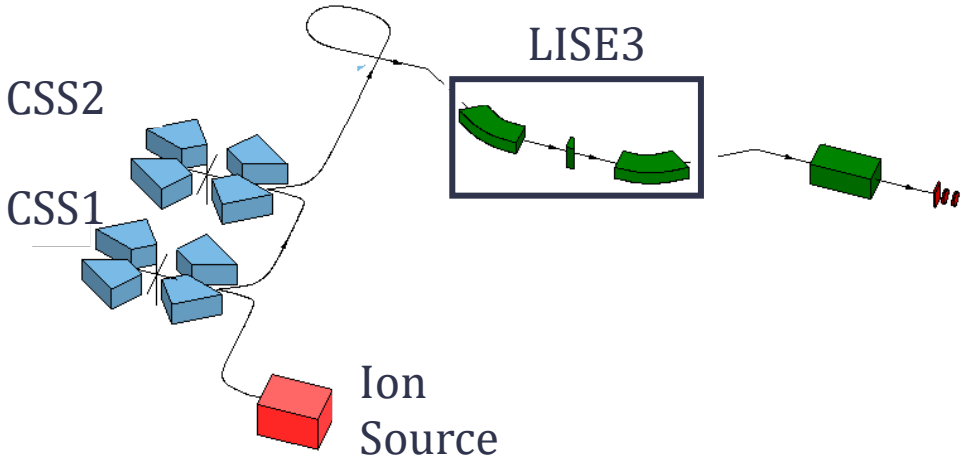
Tensor Force: Looking for direct evidence



Z=6 gap prevalence or reduction?

- Probing directly through direct reactions.
- $^{20}O(d,^{3}He)^{19}N$
- Removing protons from $0p_{1/2}$ and $0p_{3/2}$ -> Z=6 determination

^{20}O beam produced at GANIL



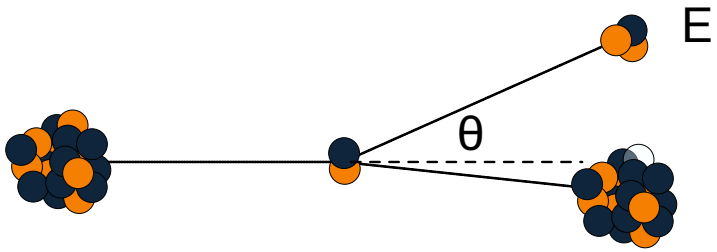
^{22}Ne Primary beam

^{20}O Produced by fragmentation at LISE

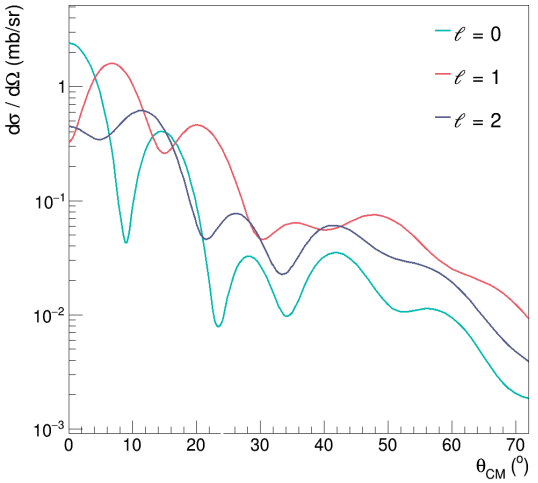
35 AMeV

100% purity

Inverse kinematics and Missing Mass



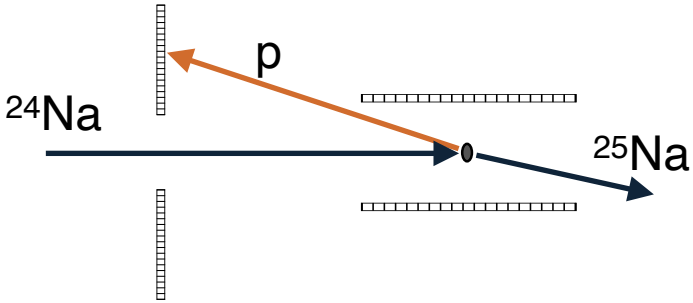
Light Particle: E,θ dσ/dΩ ⟩ E_x ℓ



Traditional experimental technique:

Solid Targets + Si Detectors:

- Thin CH/D_2 targets: ~1mg/cm^2
- Beam Intensity: > 10^5 pps



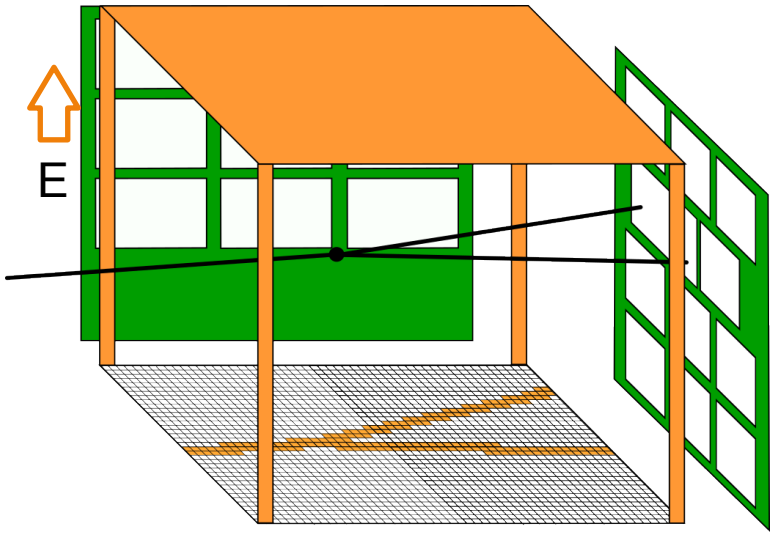
Active Target TPC: x10-100 Target Thickness

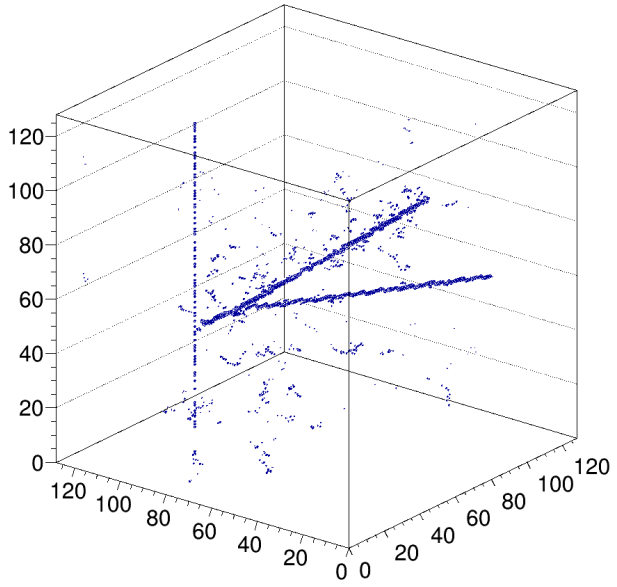
Active Target:

- Detection gas is also the target (D_2).

Time Projection Chamber:

- (X,Y) -> projection in Pad Plane
- Z -> Drift time





ACTAR TPC + Si Wall

- D_2 (90%)+ C_4H_{10} (10%) @ 1bar.
- N_{at} > 20 mg/cm² in eq. CH_2+CD_2.
- 500 um Si-PIN:E_{res} in the Si.
- ΔE measured in the gas

Promising technique… Why only few experiments?

Challenging PID:

- Complex PID $^{3/4}$He.

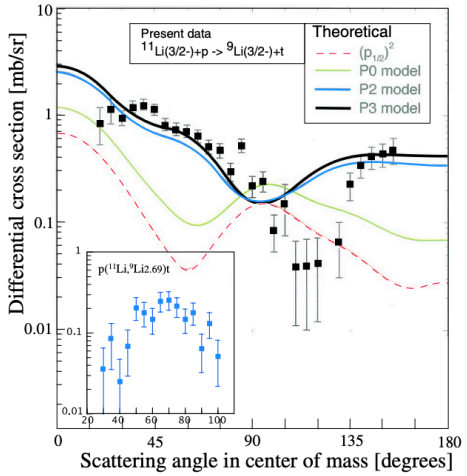
Challenging Event Reconstruction:

- Highly dependent on experimental conditions.

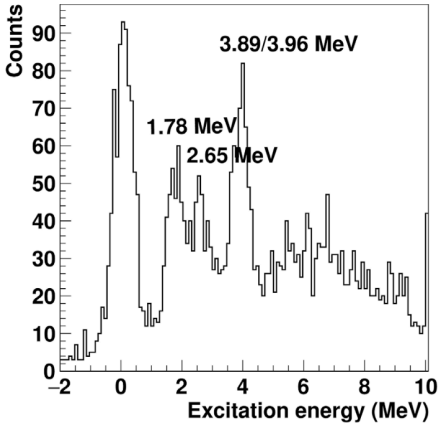
Study of systematics

- Complex analysis requires systematic analysis of different channels.

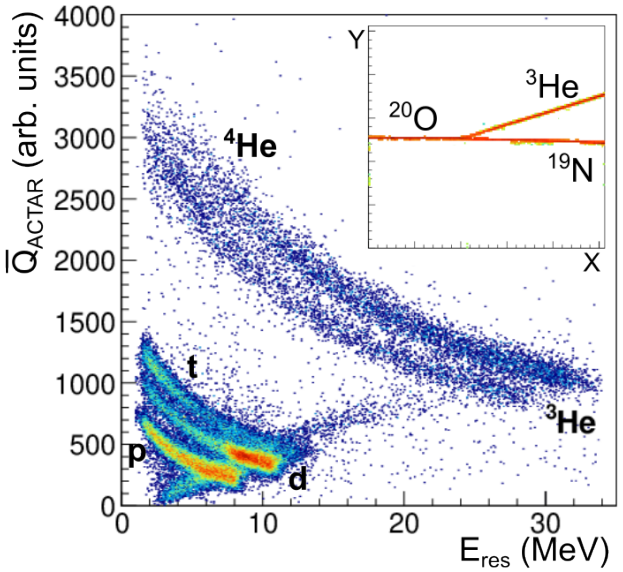
I.Tanihata et al PRL 100, 192502 (2008)

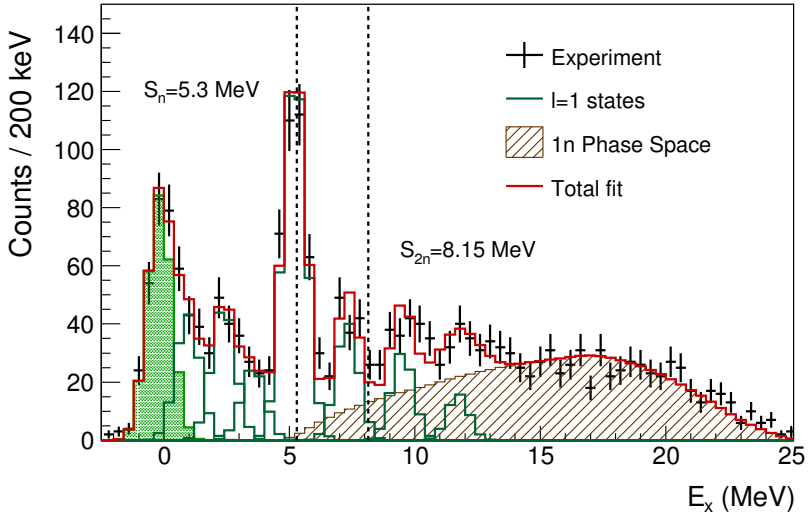


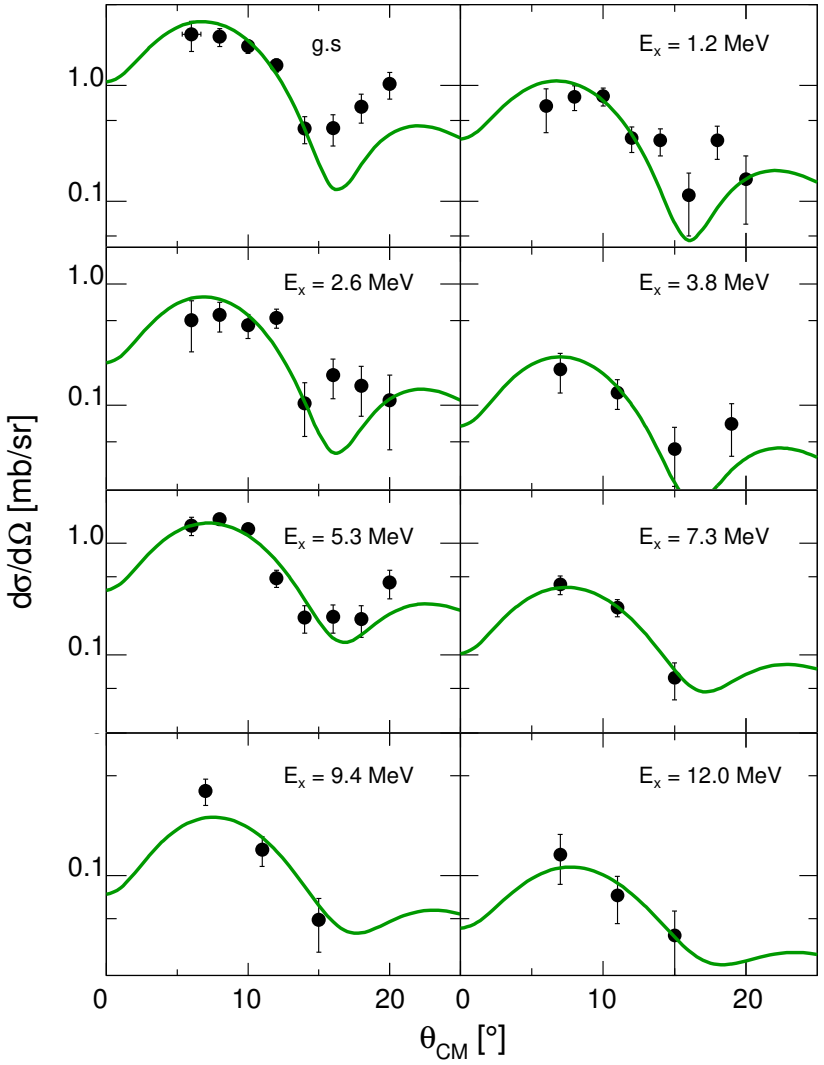
Y. Ayyad et al. Front. Phys., **24** (2025)



Transfer Reactions in ACTAR TPC:





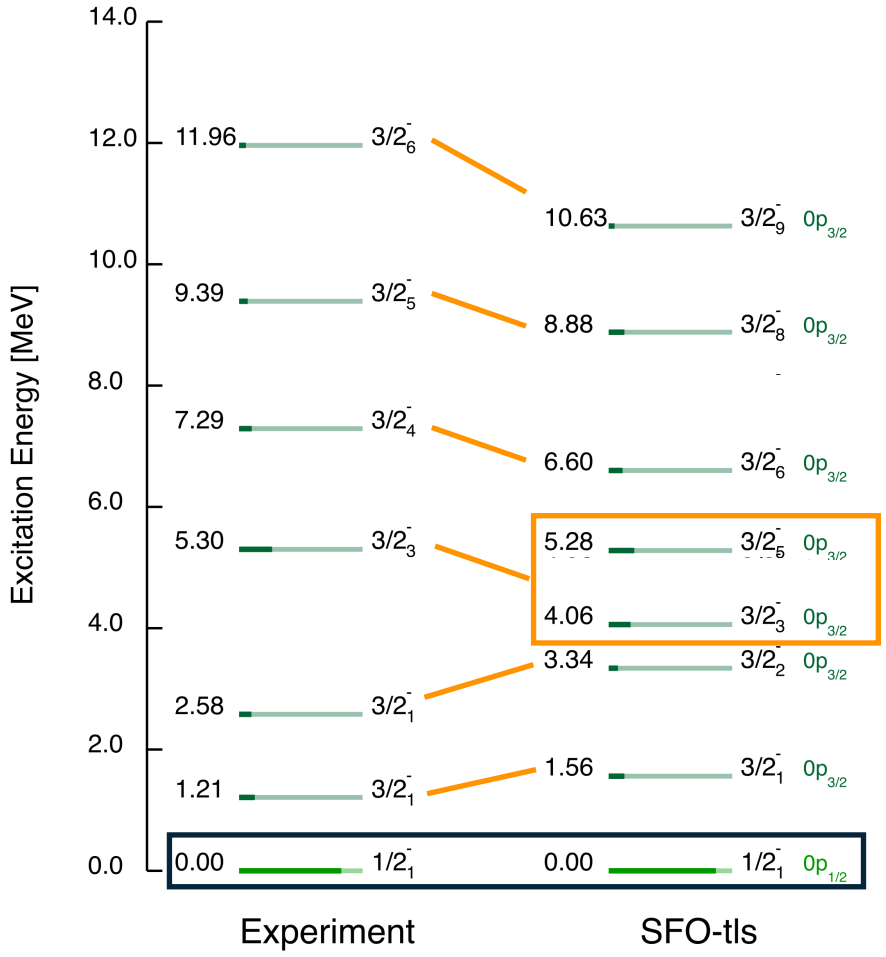


Experiment vs theory

G.S -> 0p$_{1/2}$
- Concentrated strength

Ex states -> All 0p$_{3/2}$
- Fairly good comparison.
- Main strength divided into two states

ΔSO^{exp} =5.30(14)(15) MeV
ΔSO^{th} =5.00 MeV

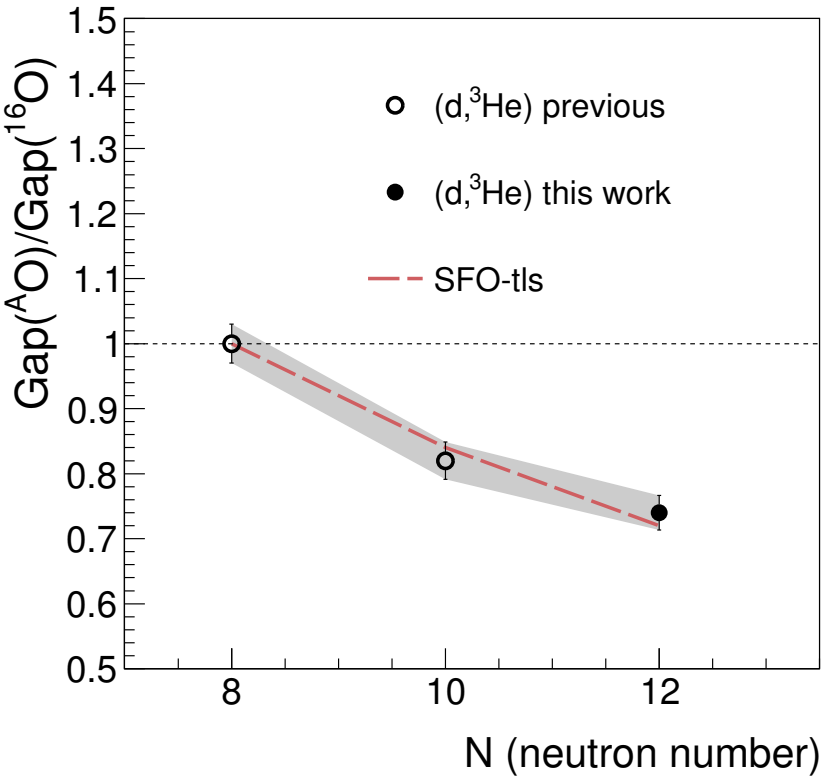


Results

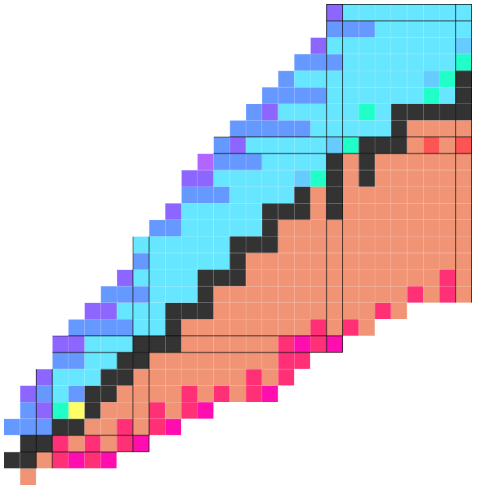
Z=6 Gap

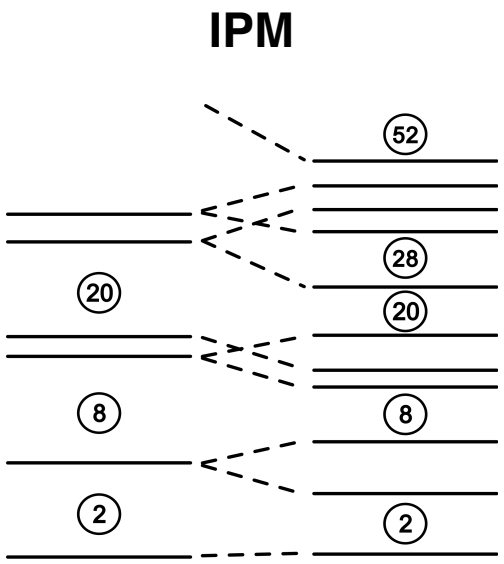
- Reduces 1.89 MeV from ^{16}O to ^{20}O.
- Spin-orbit decomposition shows tensor force is dominant term in this reduction.

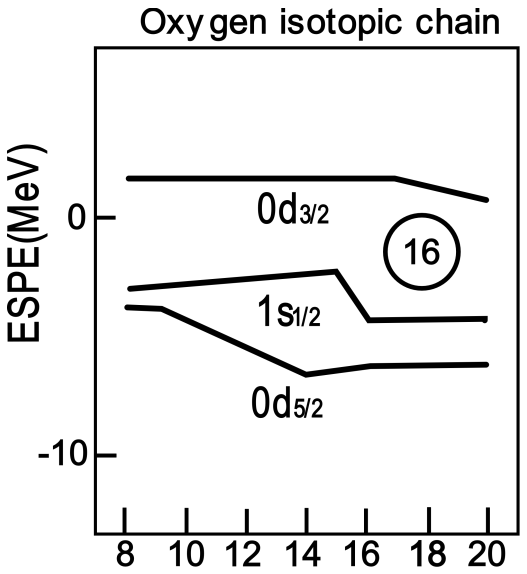
Experiment confirms depleted gap and directly links it with a tensor force effect.



How does the nucleus organize itself?



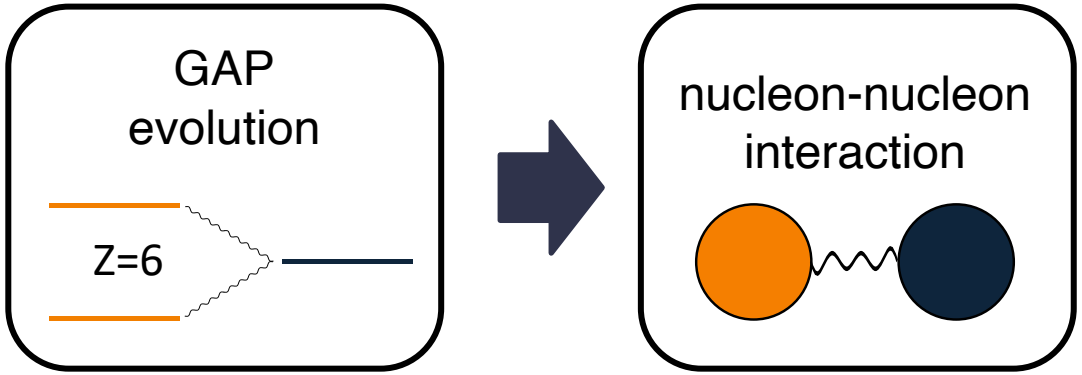




Interacting SM

$H = H_0 + H_m + H_M$

Central Tensor LS



How does ^{20}O organize itself?

95% Tensor Force

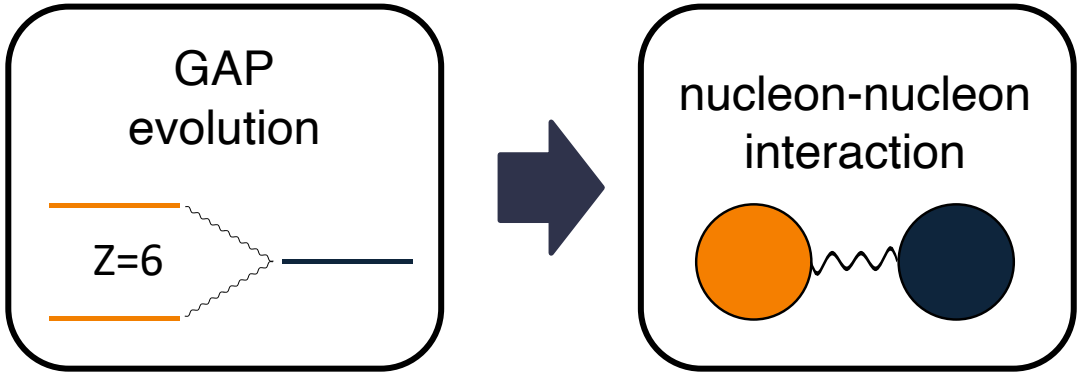
ΔSO =1.89 MeV

Tensor Explain region

Interacting SM

$H = H_0 + H_m + H_M$

Central Tensor LS



Thanks

Thanks to all the ACTAR TPC collaborators!

Thank you

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