Study of ^{68}Ni by means of (d,p) and (p,d) transfer reactions

Prabhat Sharma

1st yr. PhD student

Outline

Introduction

Our Physics Case

Experimental Setup

Preliminary Results

(1) (d,p)

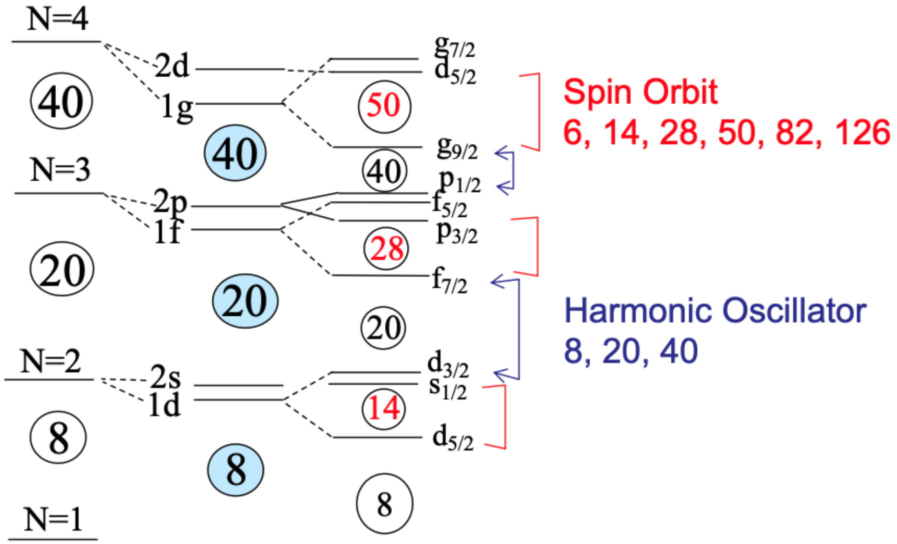
(2) (p,d)

Summary

~Özge Aktaş, former post-doc at GANIL

SO & HO magic numbers

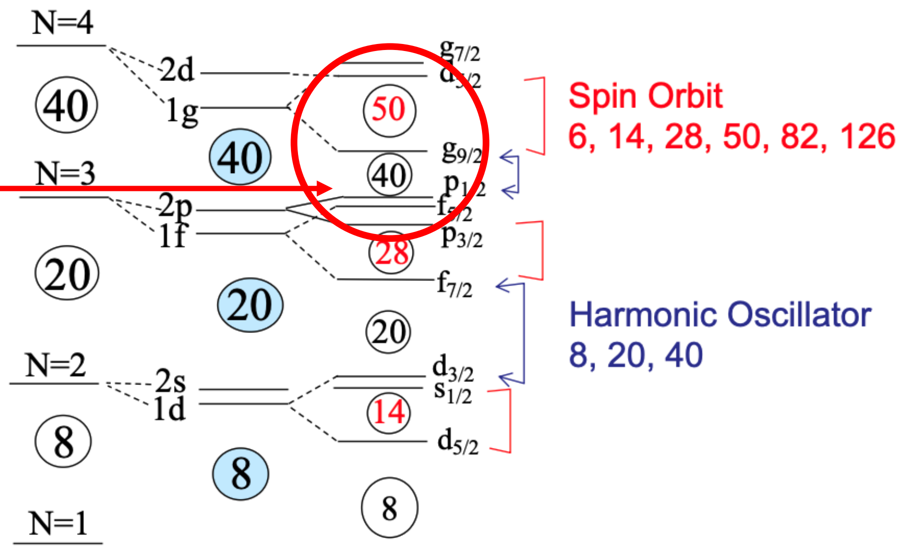
- The Spin Orbit coupling produces successfully the magic numbers.



SO & HO magic numbers

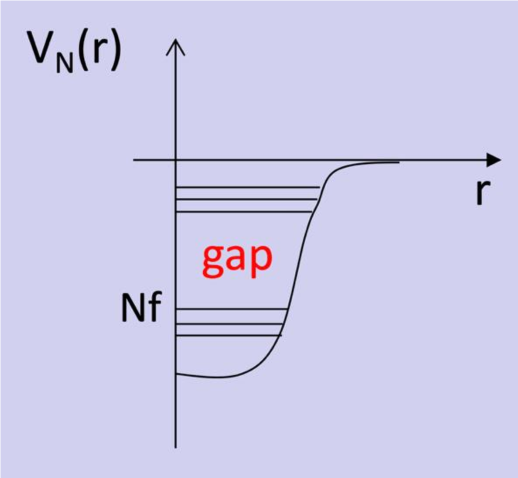
- The Spin Orbit coupling produces successfully the magic numbers.

- ^{68}Ni is at the verge of turning from HO shell gap (N=40) to SO shell gap (N=50).



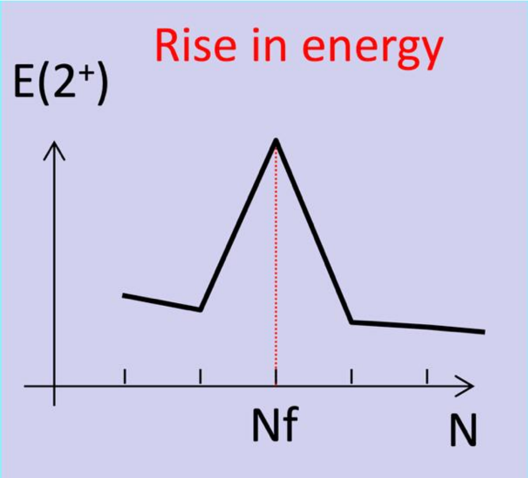
Magicity

- Characteristics of magicity:



Magicity: $E(2^+)$

- Characteristics of magicity:
    - A relatively higher $E(2^+)$ excitation energy.



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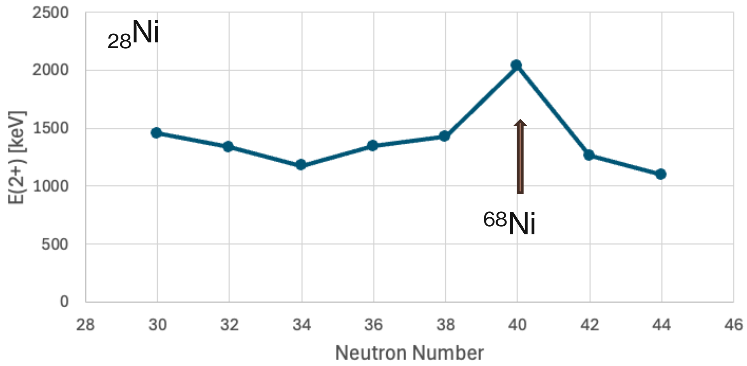

Magicity: B(E2)

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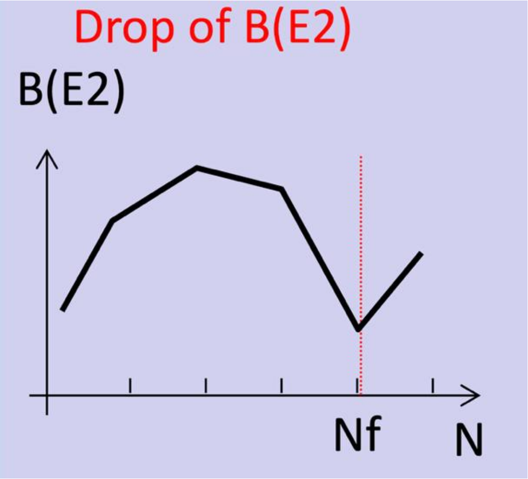
  - Drop in B(E2) value.



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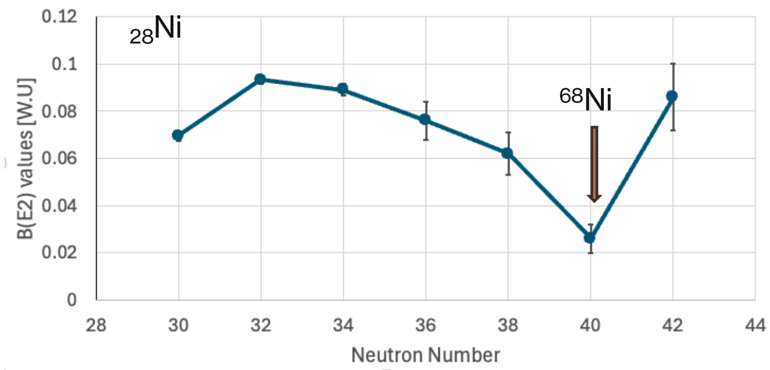

Magicity: Separation Energy

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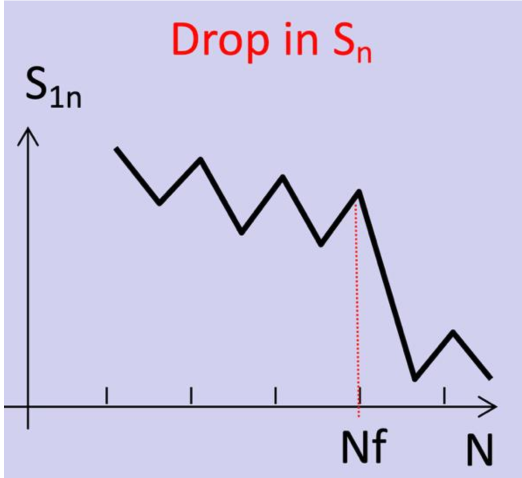
  - Drop in S_n.



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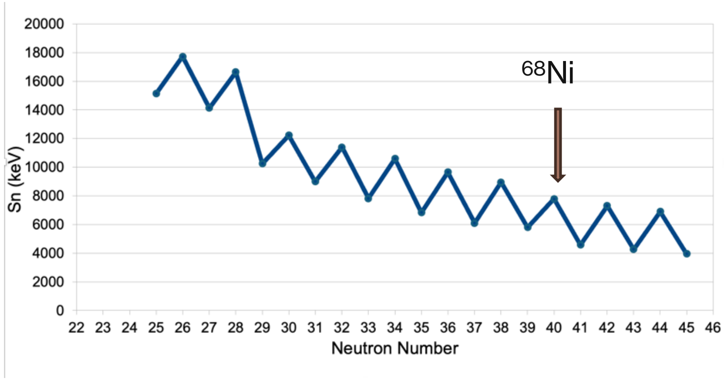

Magicity: Charge radius

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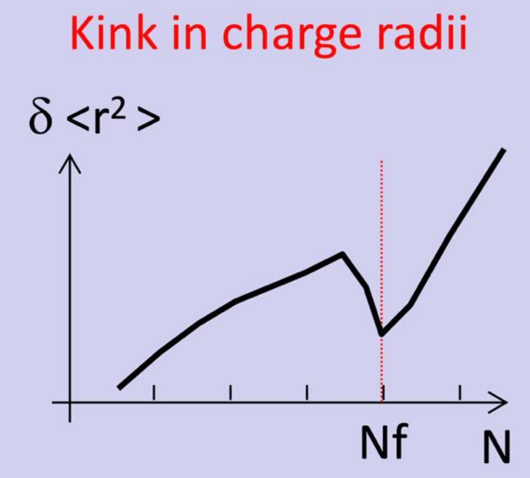

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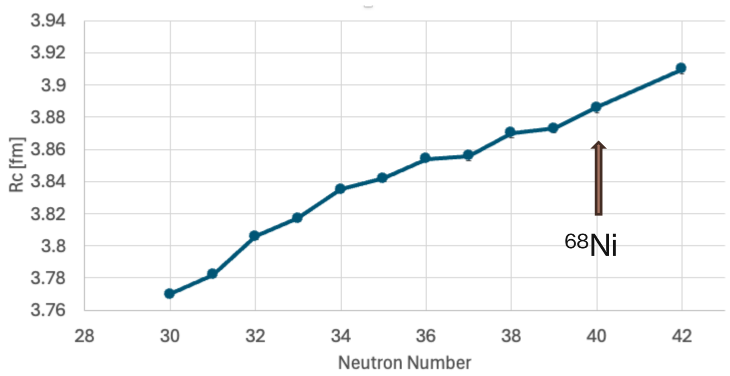

Magicity: Occupancy

- Characteristics of magicity:
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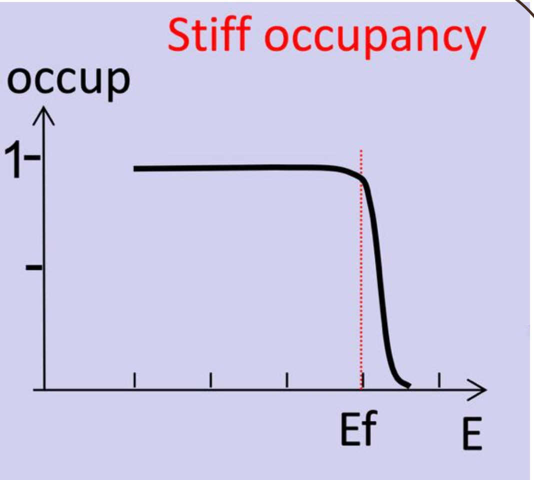

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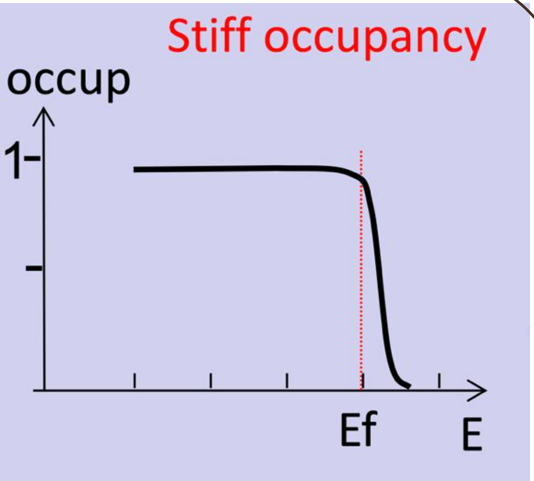
Becomes an important deciding factor



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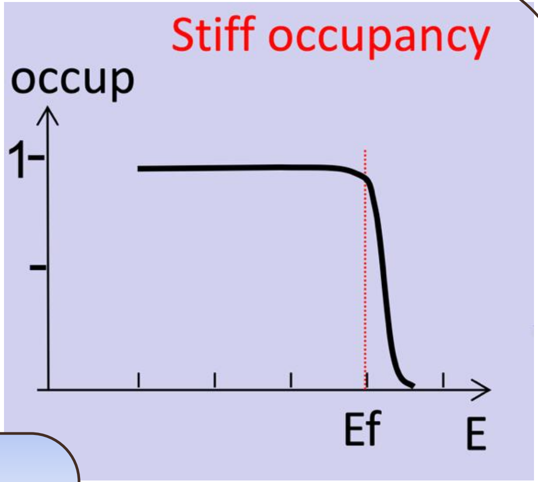
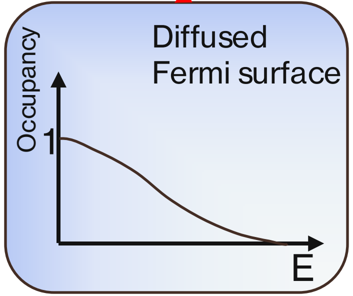
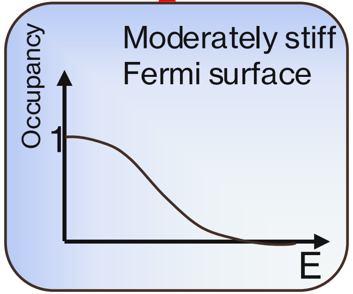
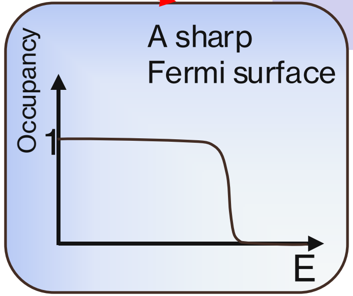


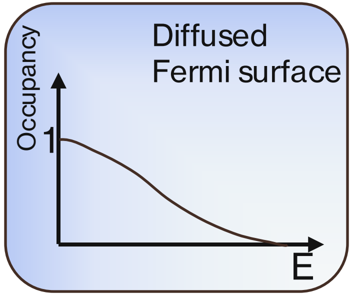




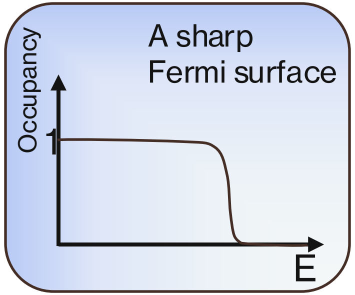


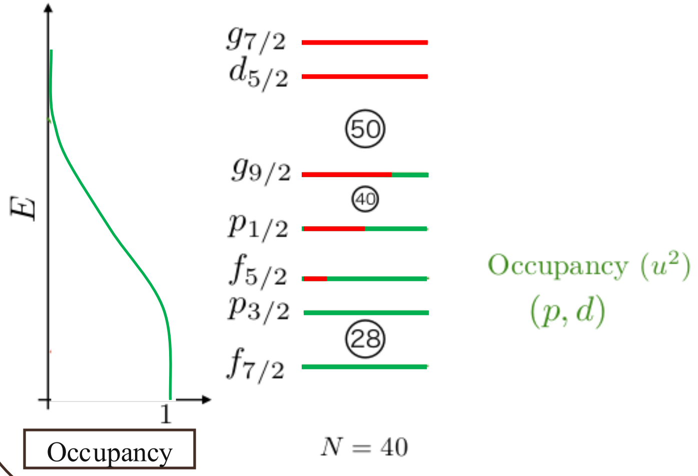
More Magic like

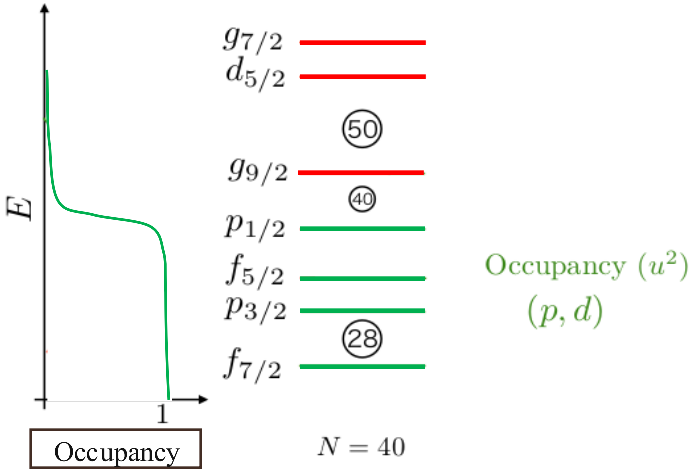
Sharpness of Fermi Surface



Comparison







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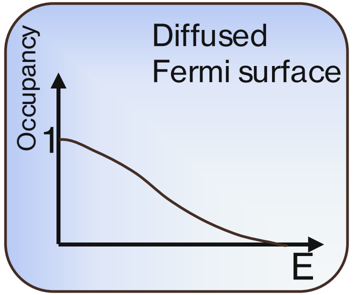
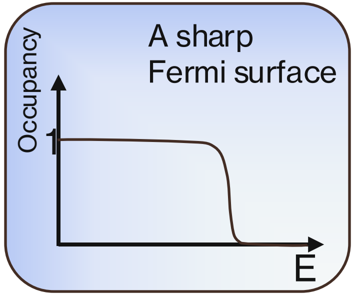
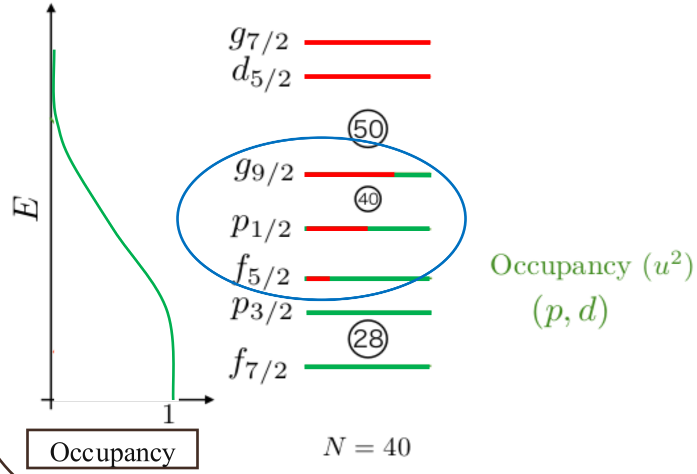
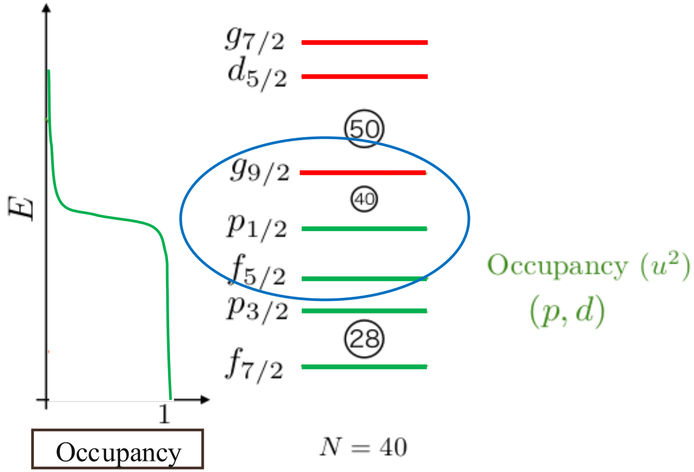


Orbitals in play: ^{68}Ni







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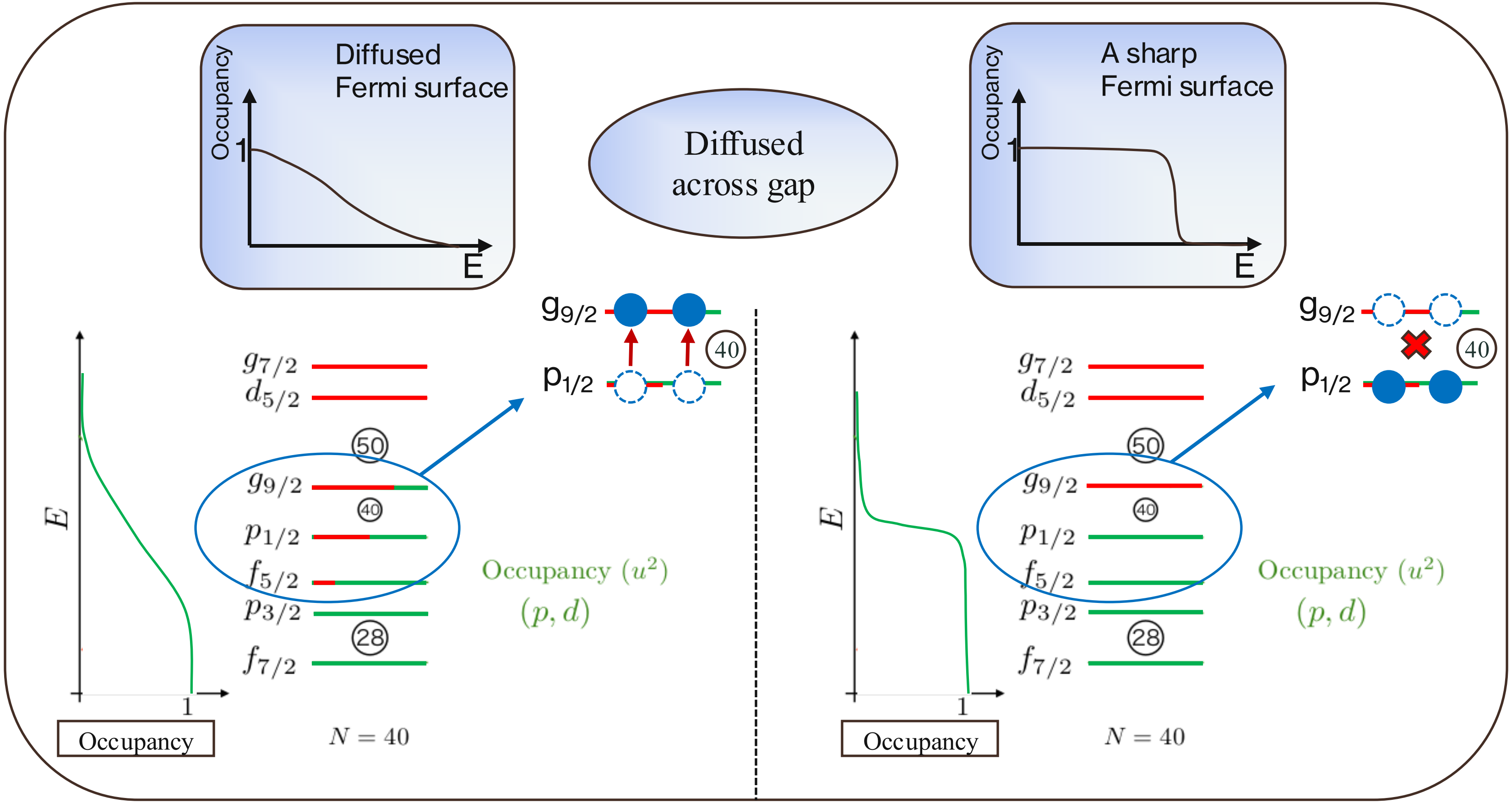
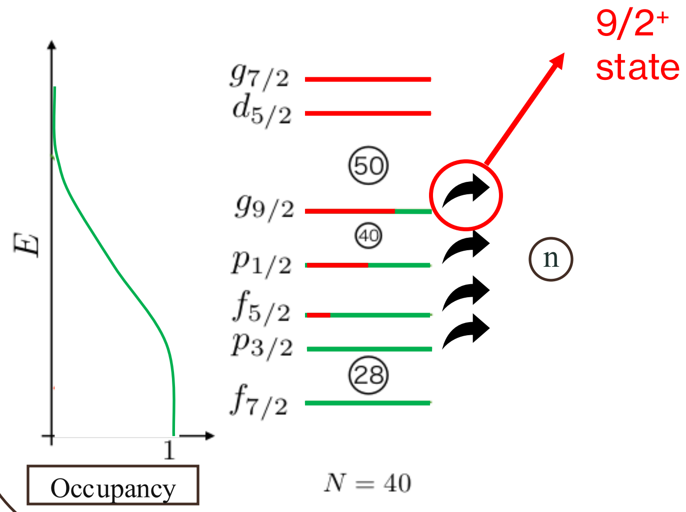
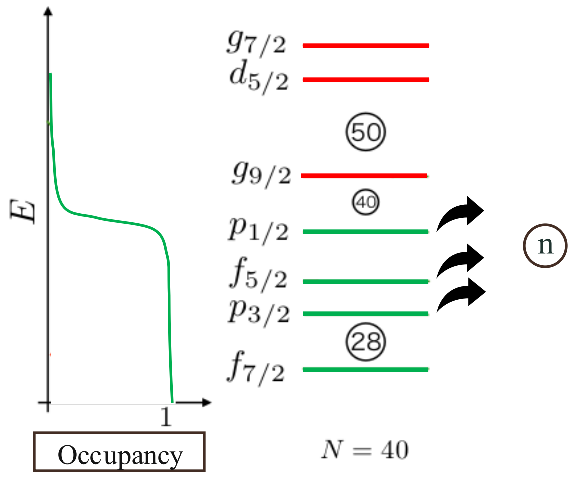


Neutron transfer: $^{68}Ni(p,d)^{67}Ni$

- Transfer reactions can help determine this occupancy.
- By removing a neutron, one can probe the occupancy of the $p_{1/2}$, $p_{3/2}$, and $f_{5/2}$. → ^{68}Ni (p,d) ^{67}Ni





Neutron transfer: ^{68}Ni(d,p)^{69}Ni

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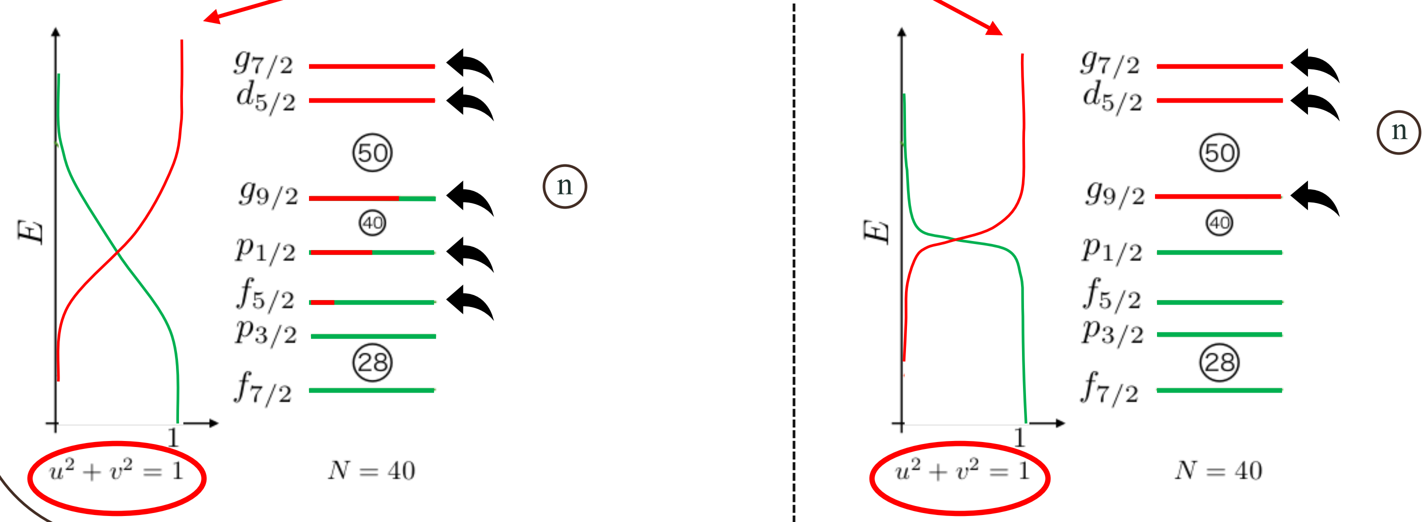
- By adding a neutron, one can probe the vacancy of $g_{9/2}$ and $d_{5/2}$ levels. → ^{68}Ni (d,p) ^{69}Ni



Our Physics Case

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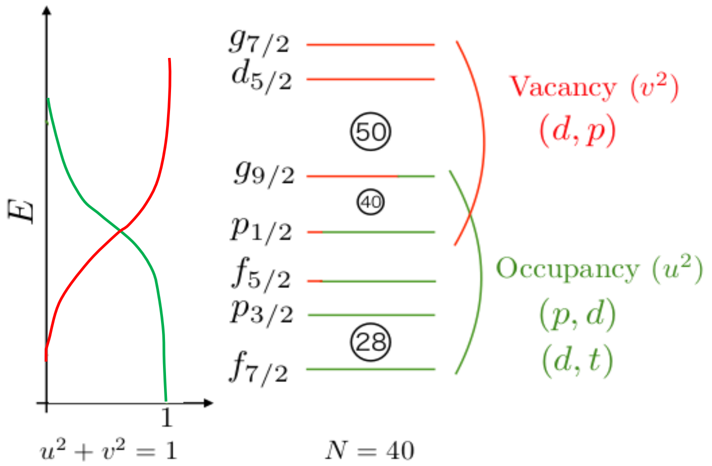
N = 50 Shell Gap

Given by $\langle E(d_{5/2})\rangle - \langle E(g_{9/2})\rangle$.

(d,p) → 69Ni:E*($d_{5/2}$) C^2S^+ → $\langle E(d_{5/2})\rangle$

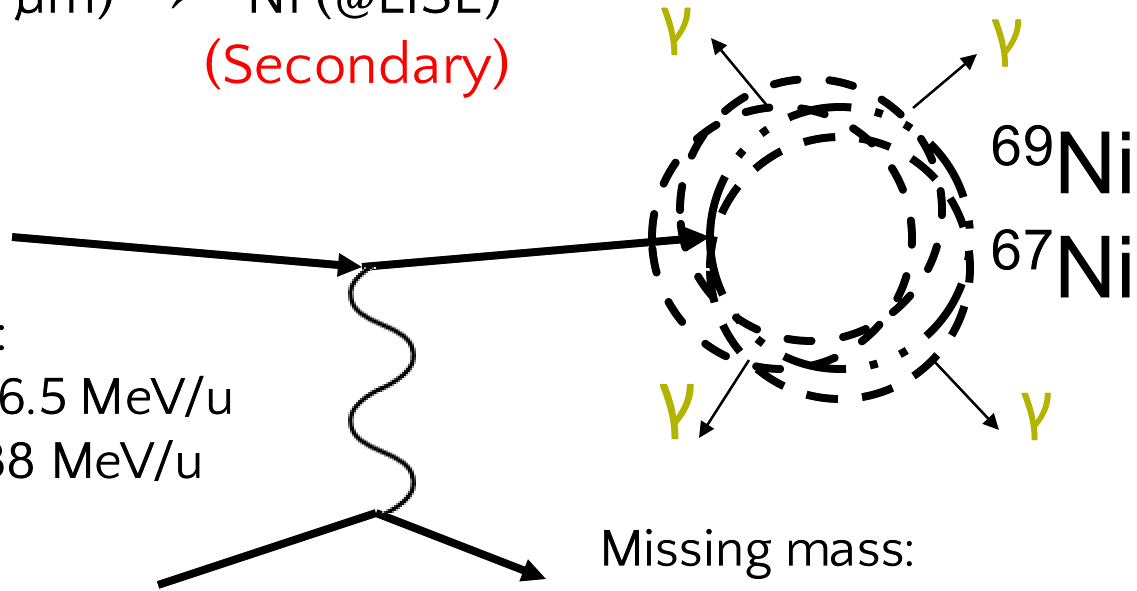
$$\left.\begin{array}{l}\text{(d,p)} \rightarrow {}^{69}\text{Ni:E}^*(g_{9/2})\ C^2S^+ \\ \text{(p,d)} \rightarrow {}^{67}\text{Ni:E}^*(g_{9/2})\ C^2S^-\end{array}\right\} \rightarrow \langle E(g_{9/2})\rangle$$



Experimental Setup

^{70}Zn (62 MeV) + ^{9}Be (500 µm) → ^{68}Ni (@LISE)
(Primary) (Secondary)

^{68}Ni



Beam @ LISE:
5x10^{4} pps, ~16.5 MeV/u
2x10^{5} pps, ~38 MeV/u

Targets:
CD_2 (0.5 mg / cm^2)
CH_2 (5 mg / cm^2)

Missing mass:
Proton, Deuteron, Triton

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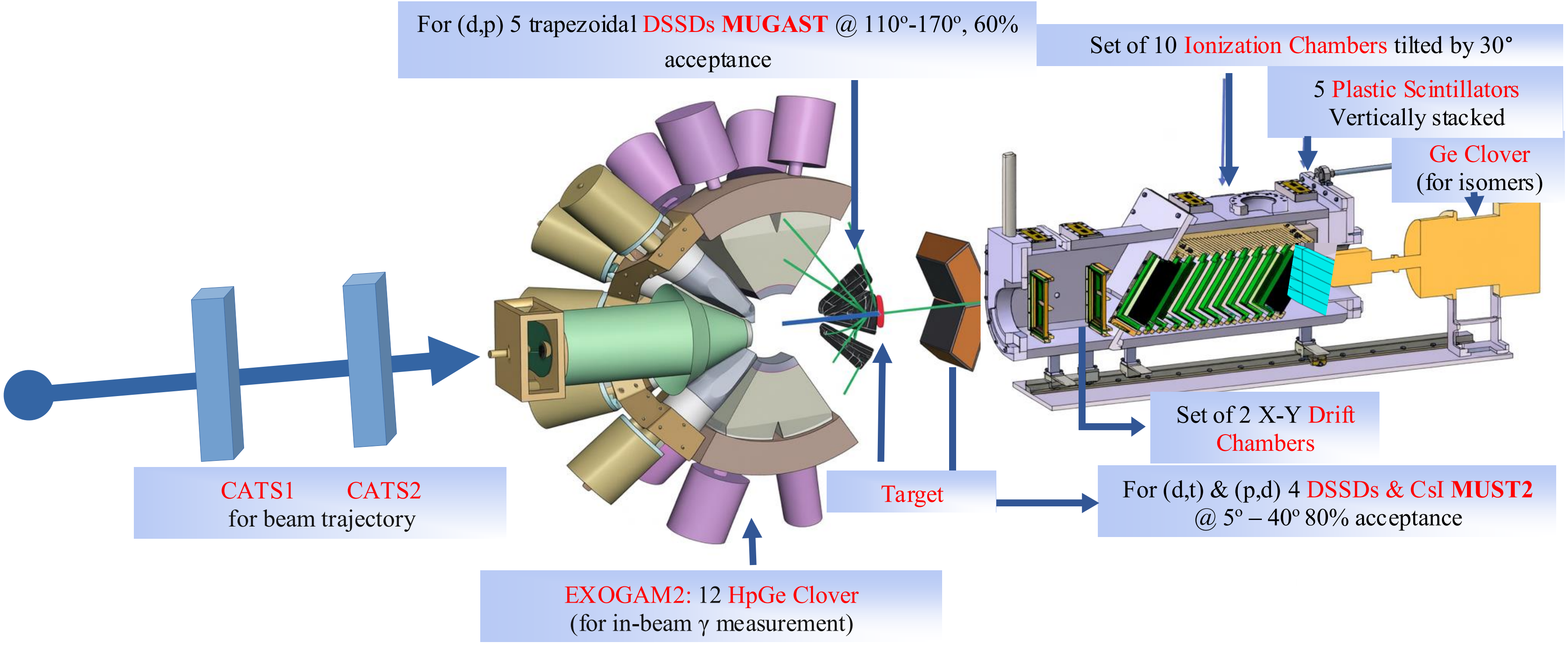


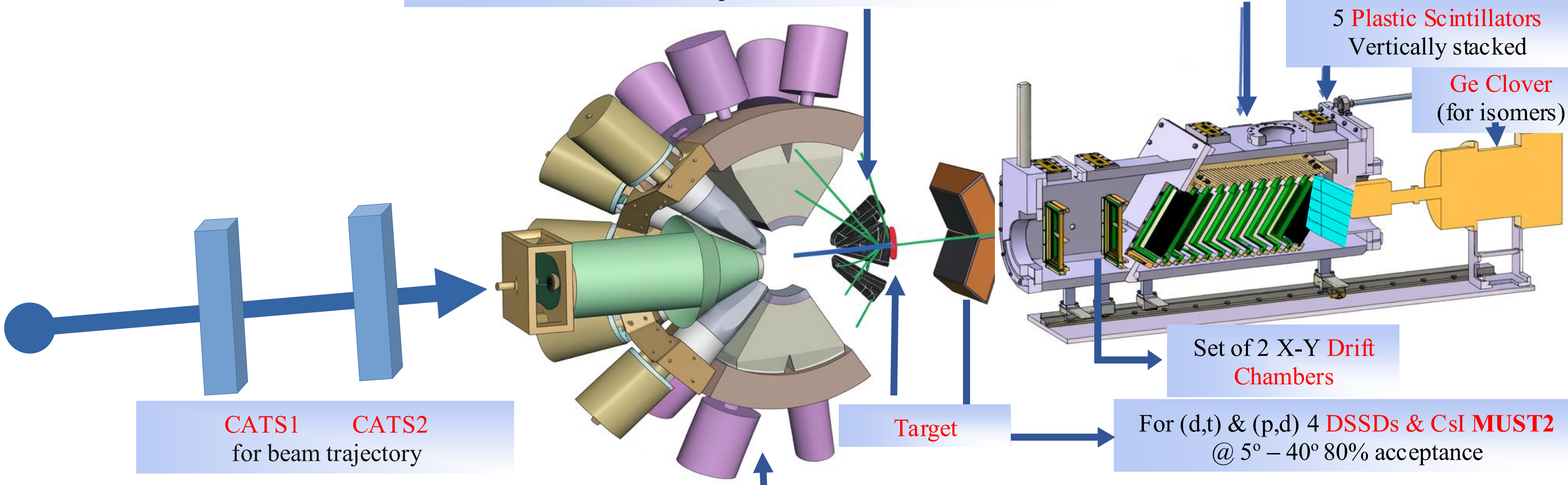
Experimental Setup

For (d,p) 5 trapezoidal DSSDs **MUGAST** @ 110º-170º, 60% acceptance

Set of 10 Ionization Chambers tilted by 30°

5 Plastic Scintillators
Vertically stacked

Ge Clover
(for isomers)



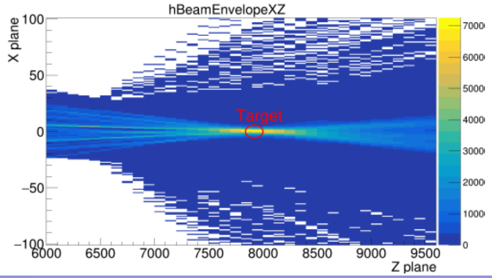
Set of 2 X-Y Drift Chambers

CATS1 CATS2
for beam trajectory

Target

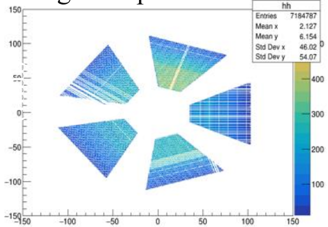
For (d,t) & (p,d) 4 DSSDs & CsI **MUST2** @ 5º – 40º 80% acceptance

EXOGAM2: 12 HpGe Clover
(for in-beam γ measurement)



Experimental Setup

Mugast impact construction



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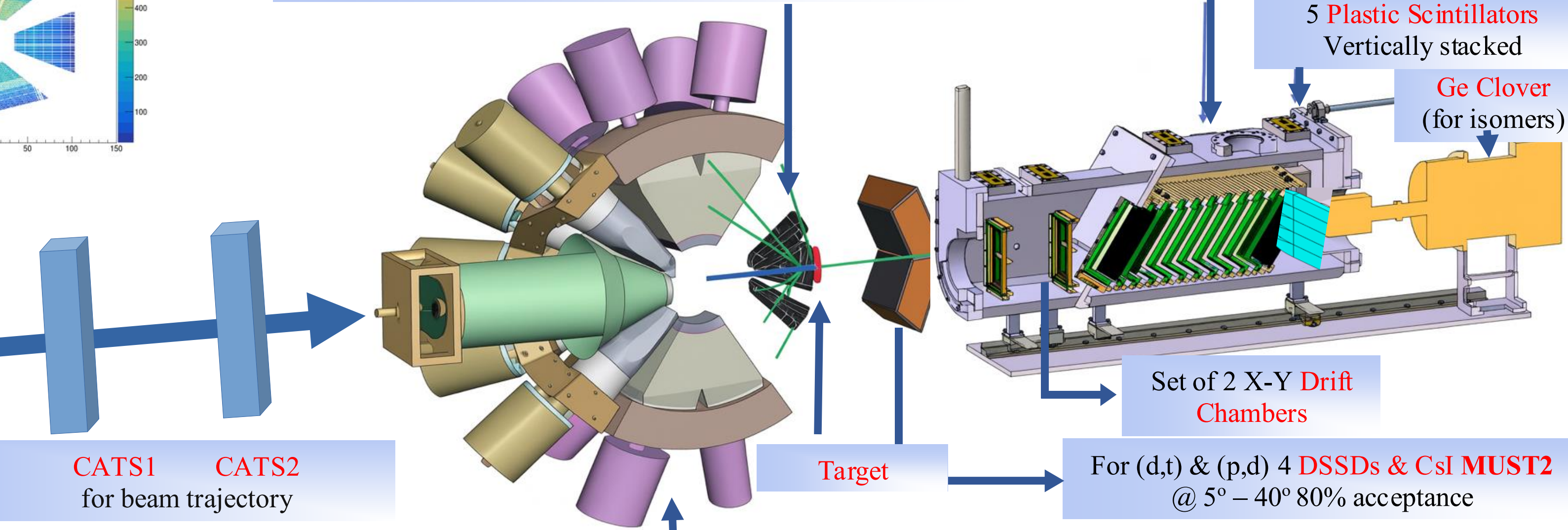

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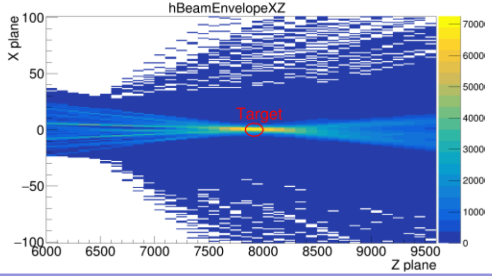

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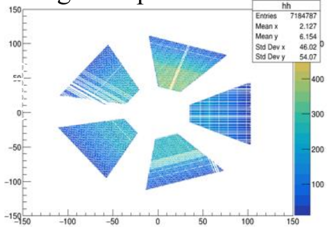

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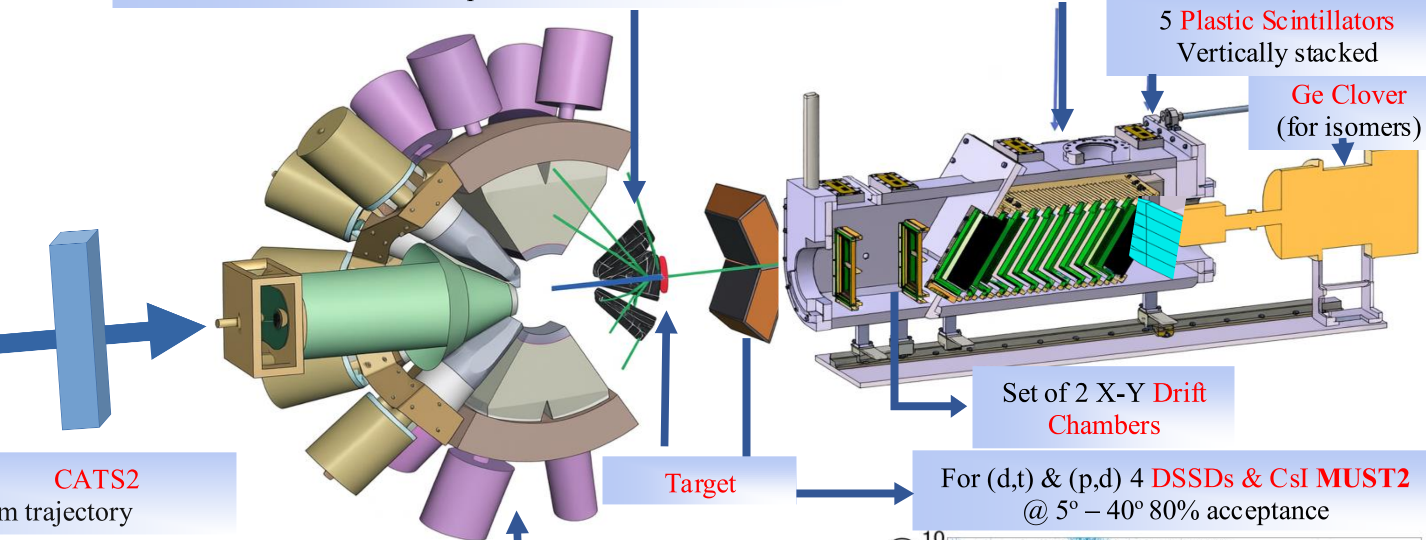

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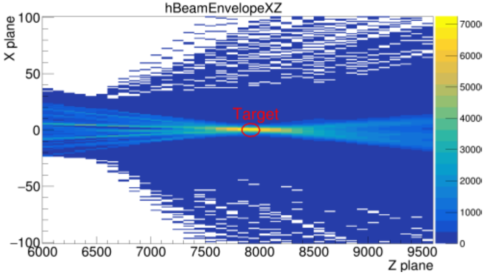

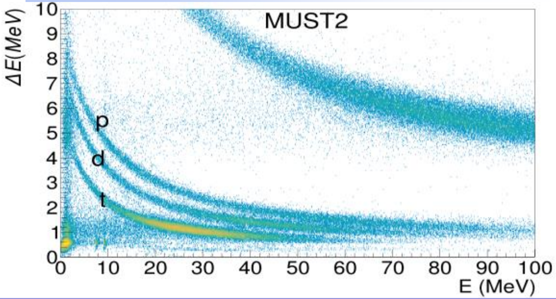

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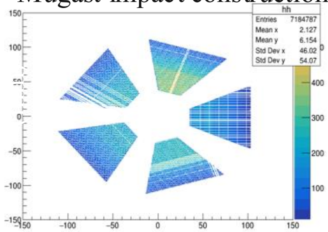

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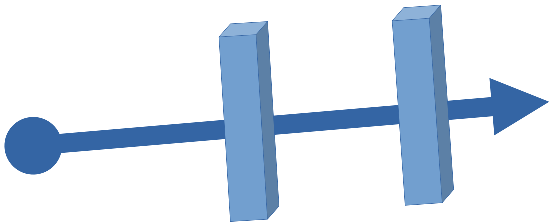

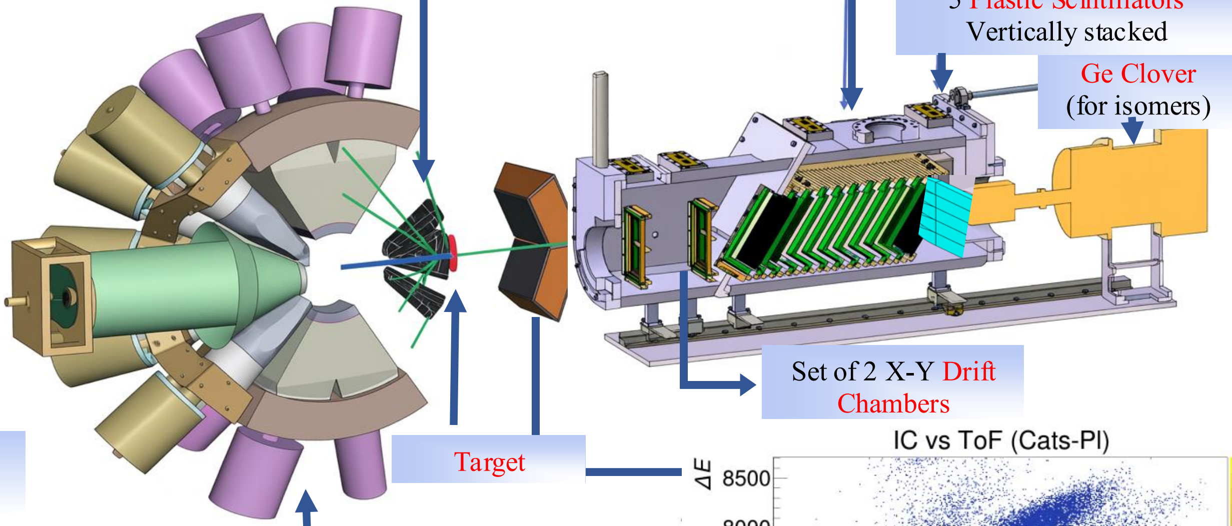

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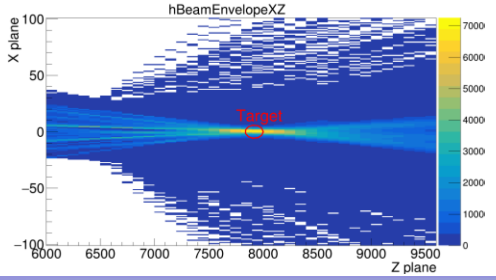

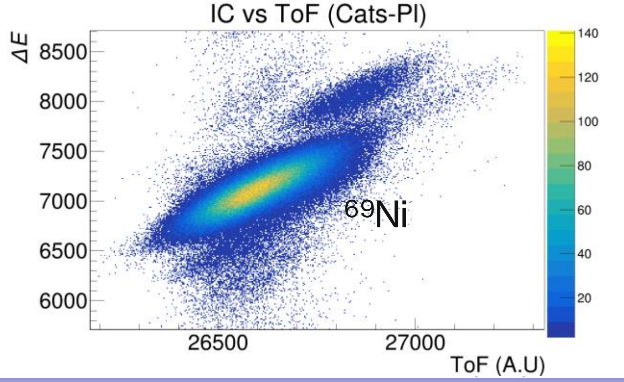

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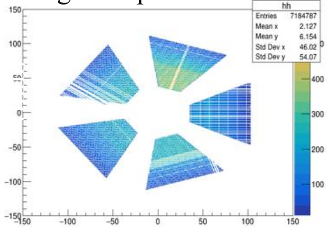

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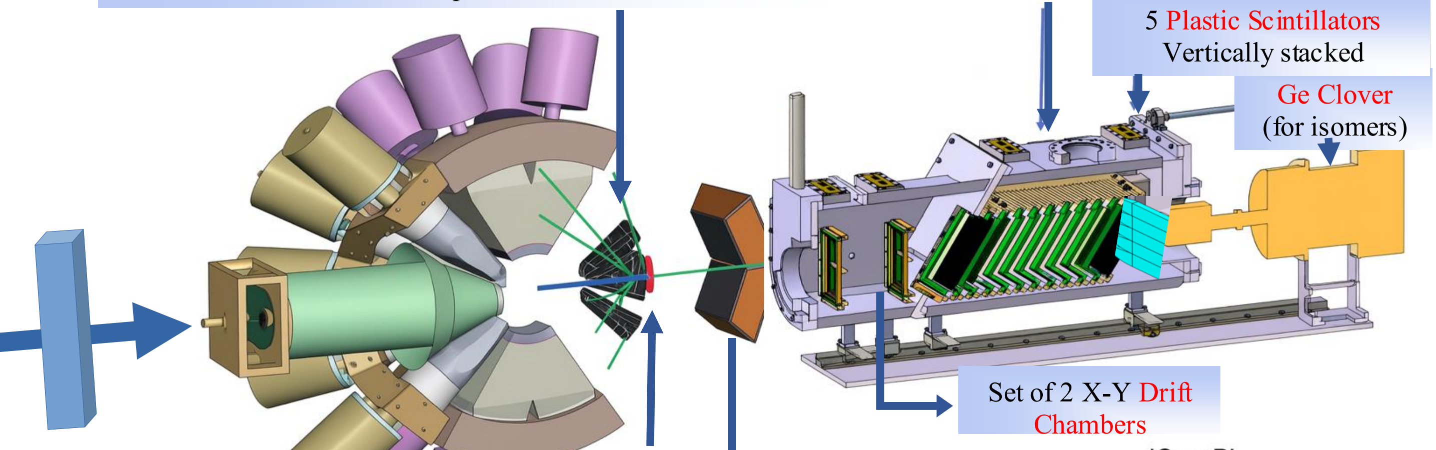

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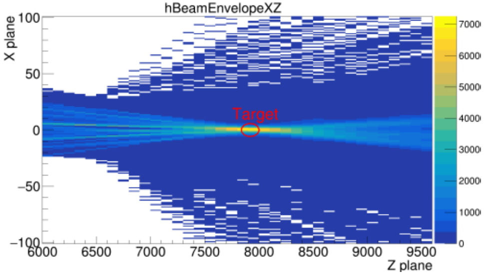

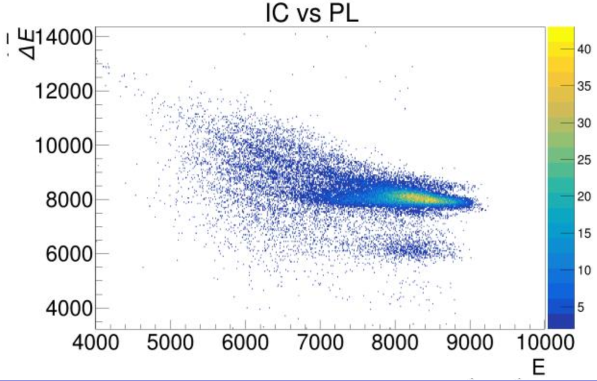

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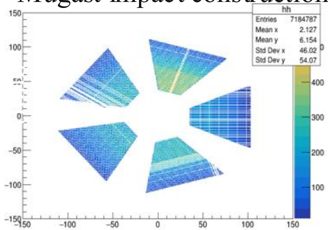

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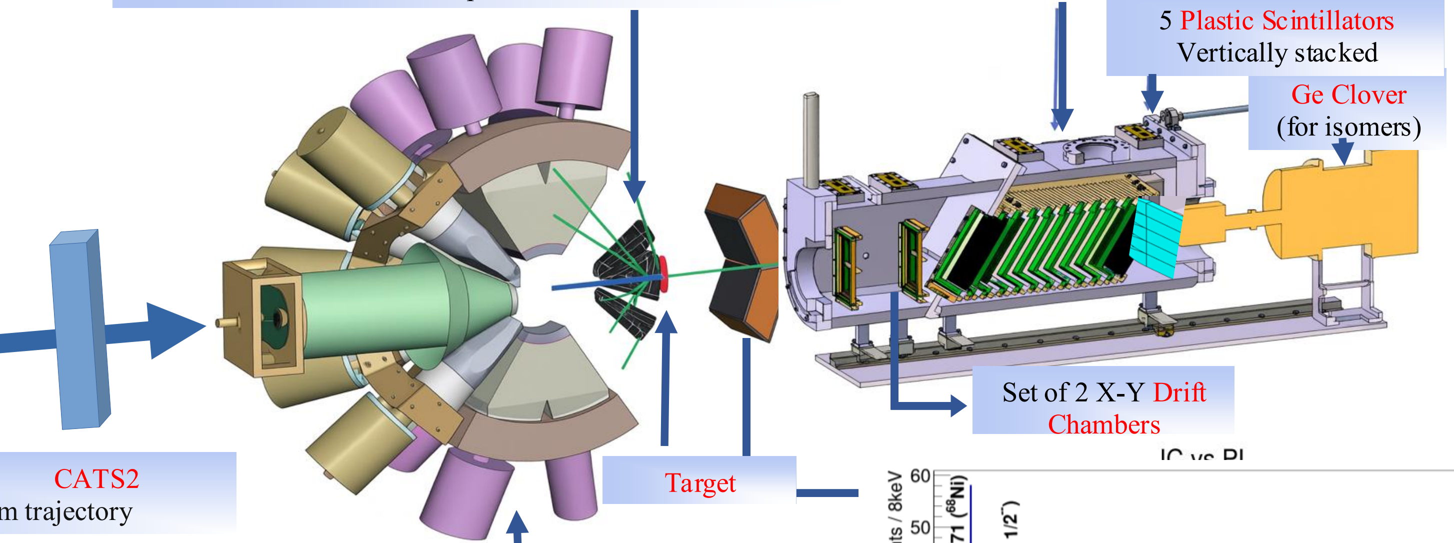

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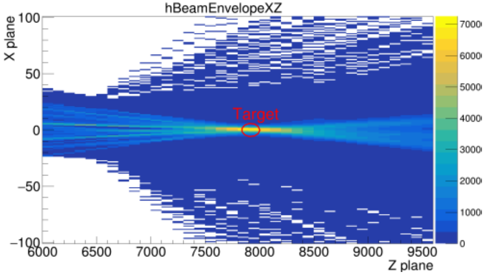
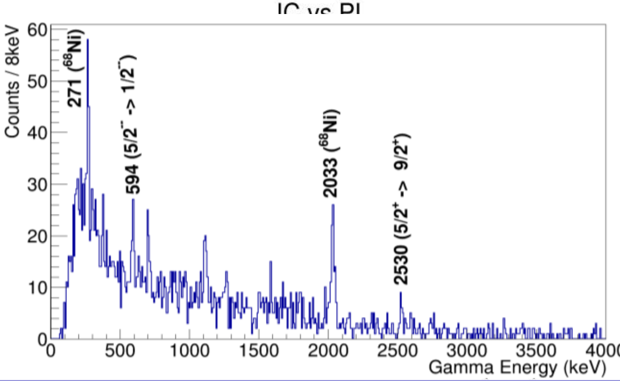
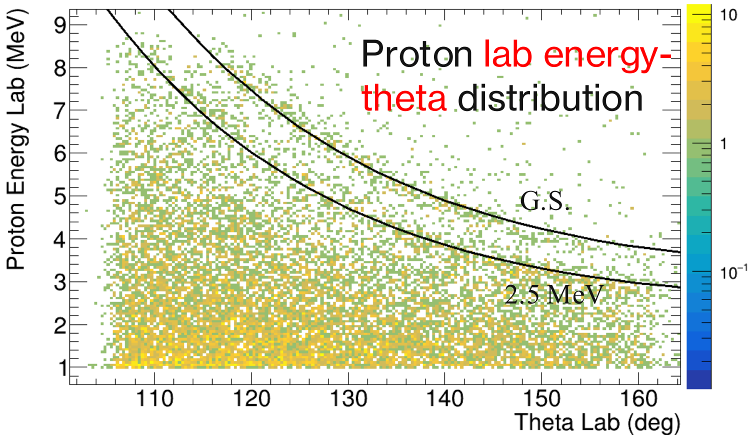




Preliminary Results (d,p)



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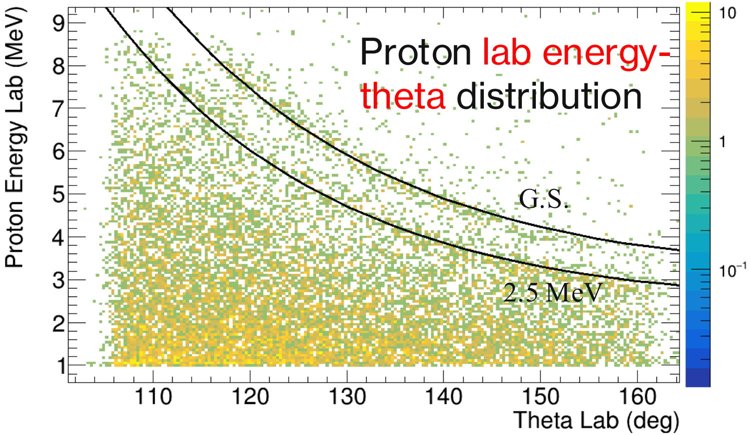

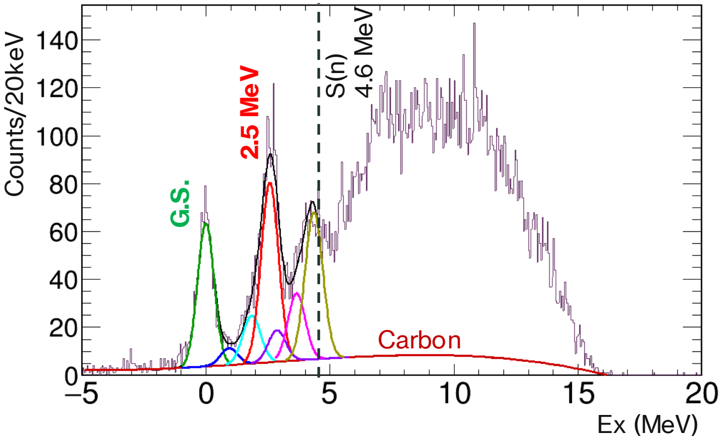

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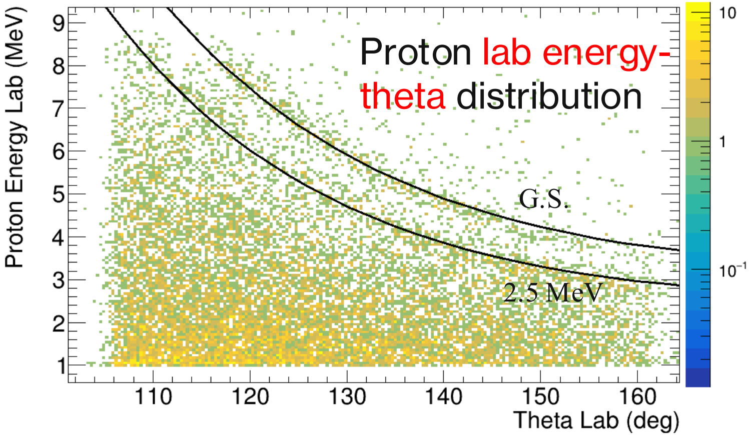

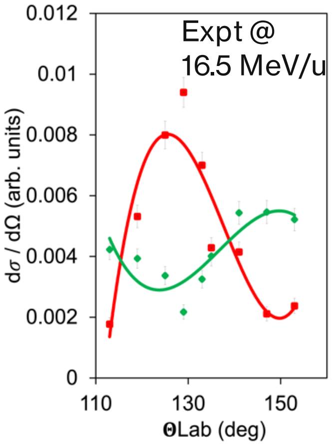

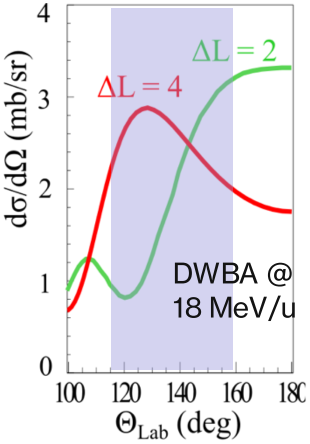

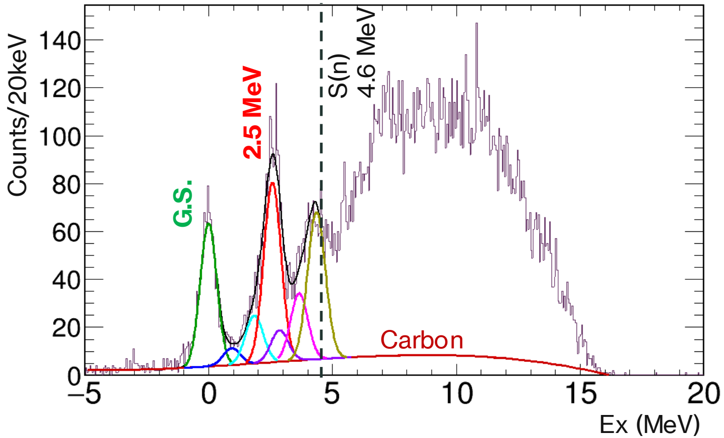

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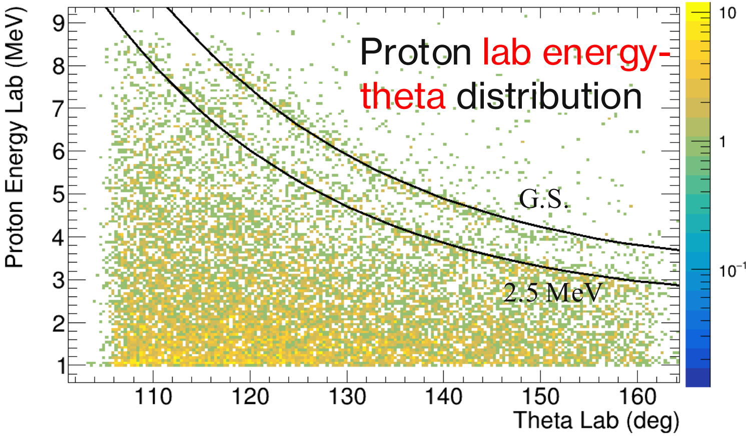

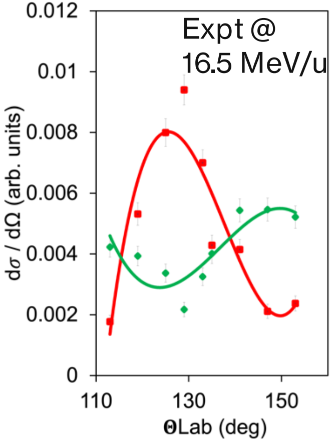

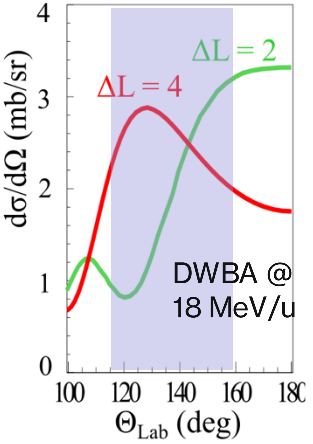

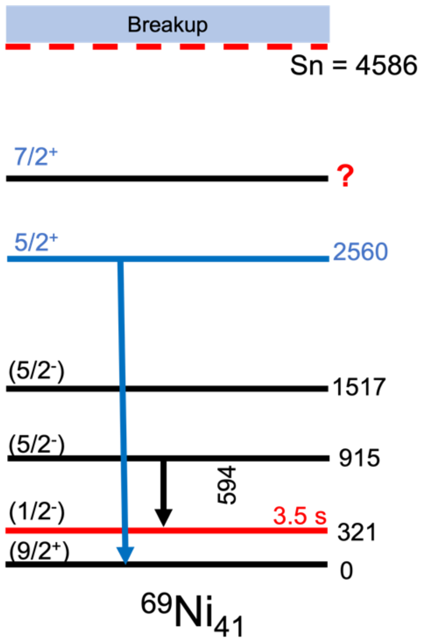

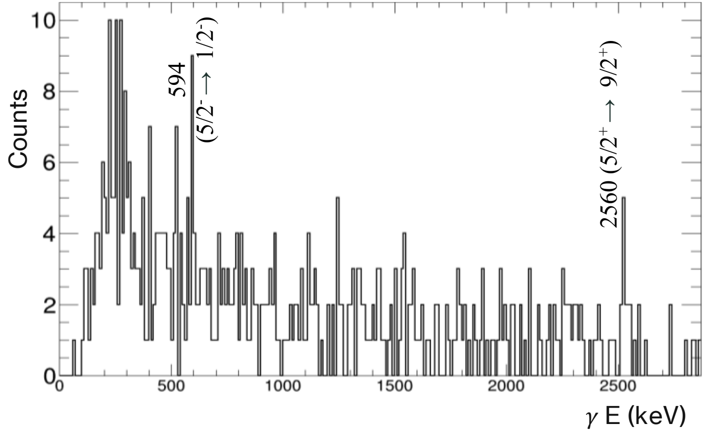

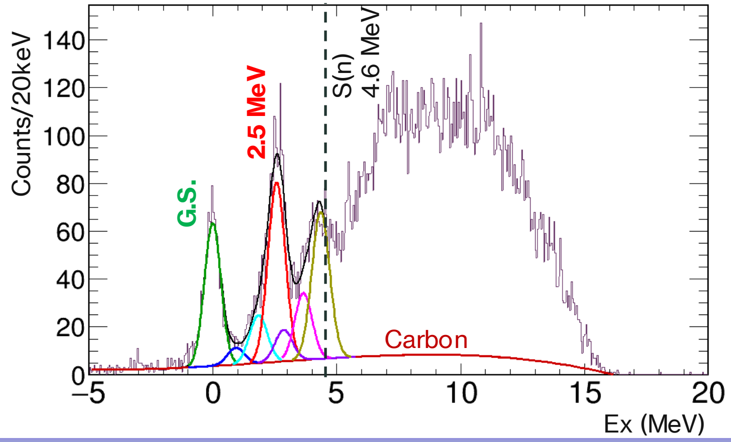

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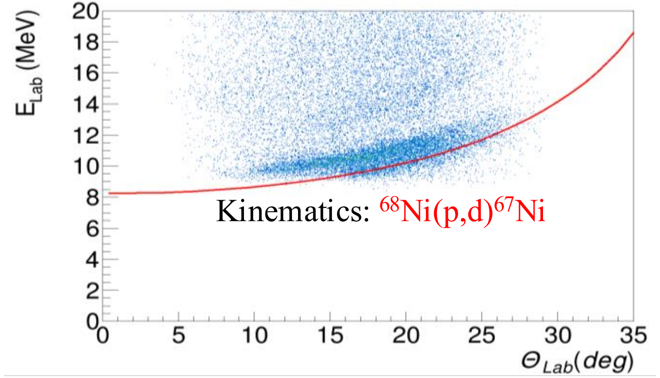

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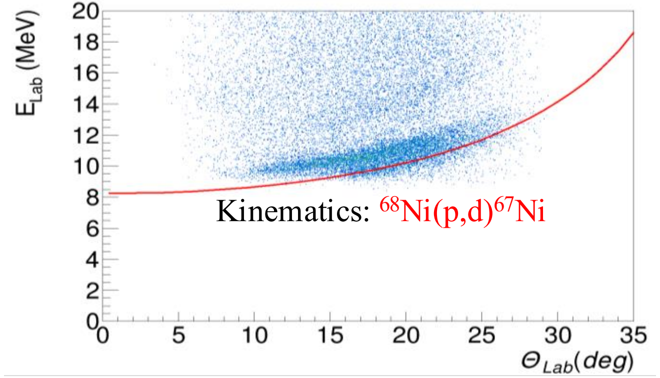

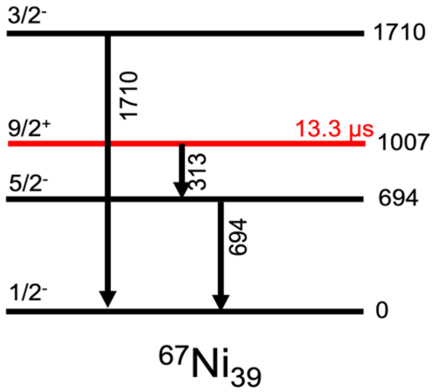

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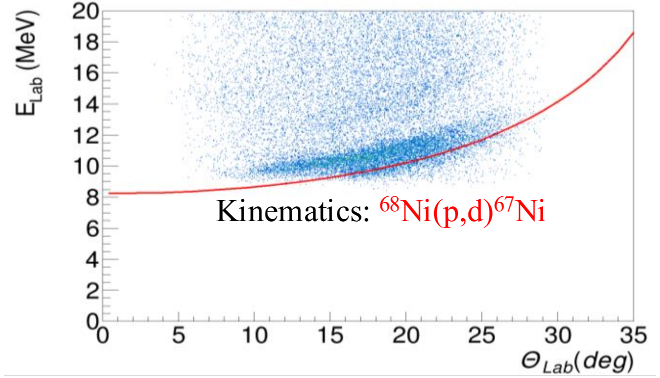
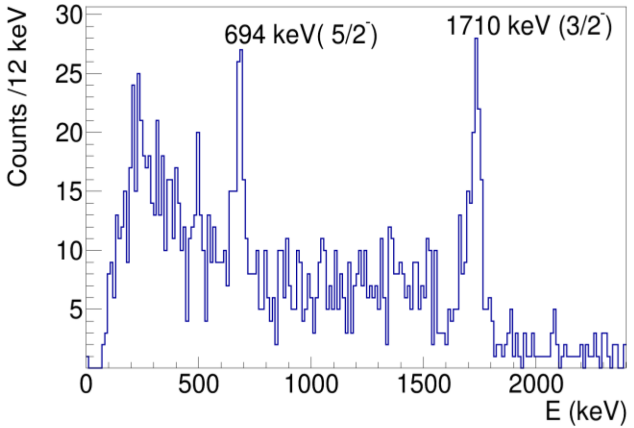
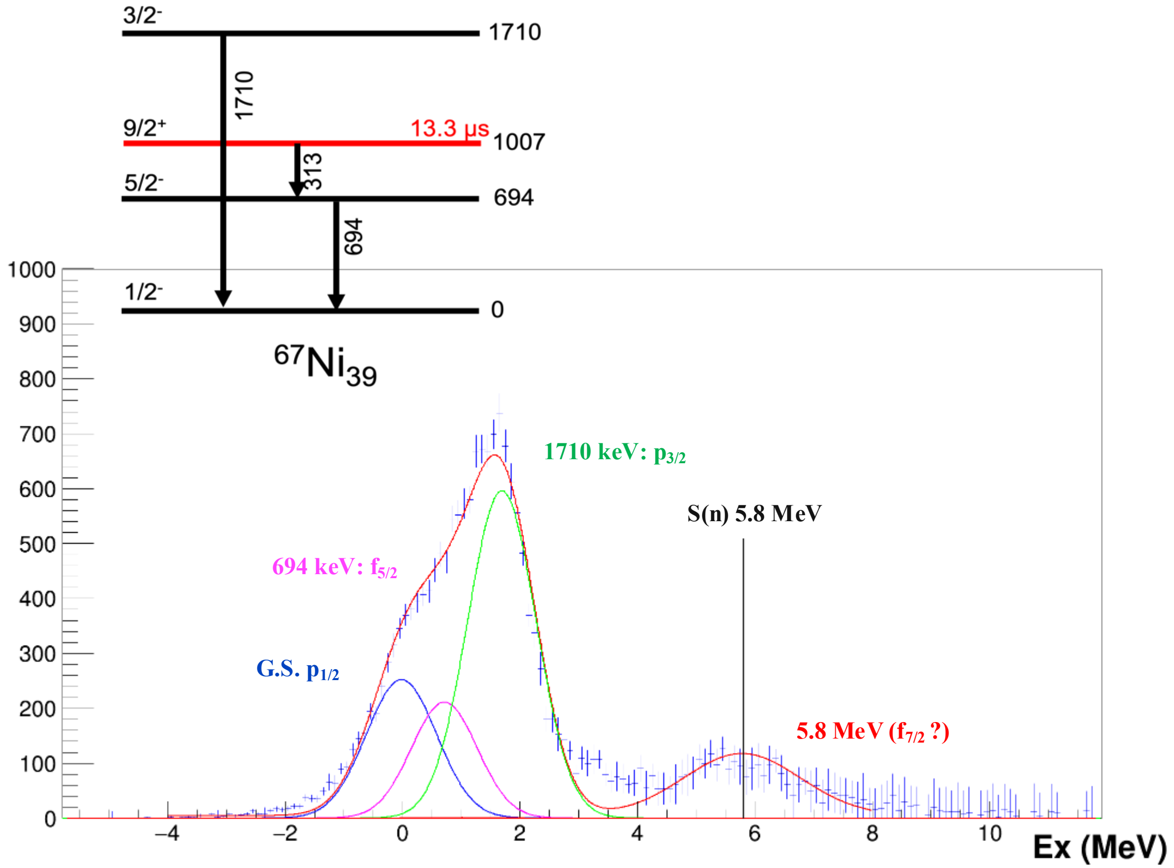






Summary

- We study ^{68}Ni with the aim:
    - To investigate the magicity at N = 40.
    - To evaluate the N = 50 shell gap.
    - The SO splitting of the p, f and possibly g orbitals.

- The $5/2^+$ state in ^{69}Ni at about 2.5 MeV decays directly to the $9/2^+$ ground state.
- The preliminary results for (p,d) shows promising data with clear $5/2^-$ and $3/2^-$ states.

- What remains to be done is:
    - All the remaining L-transfer angular distributions.
    - Use of Drift Chambers could allow to select 2-body reactions and suppress the BU component.
    - Analysis of the (p,d) part to complement the study of (d,p).

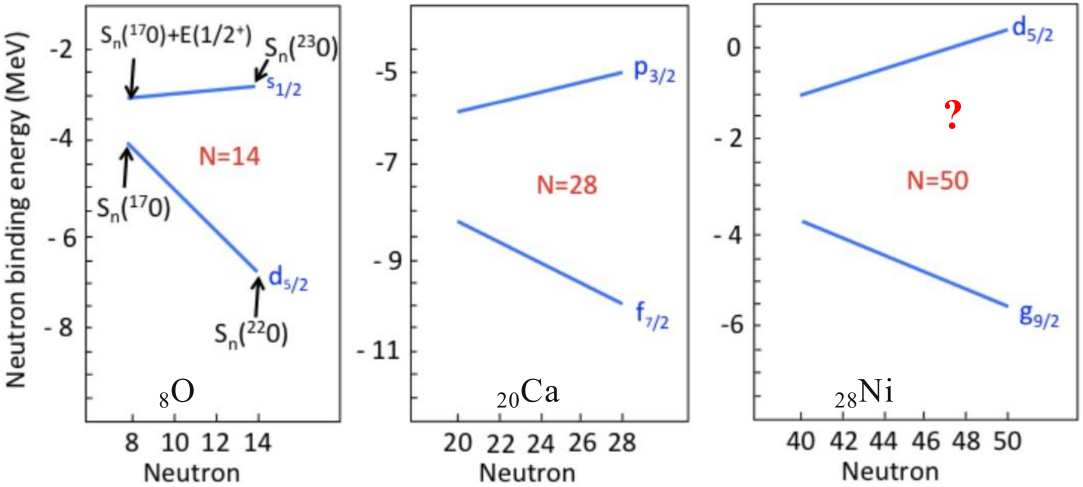
Thank you!

Özge Aktaş, Olivier Sorlin, S. Koyama, M. Assié[3], V. Girard-Alcindor[3],
H. Jacob[3], Q. Délignac[3], and MUGAST@LISE Collaboration

Backup Slides

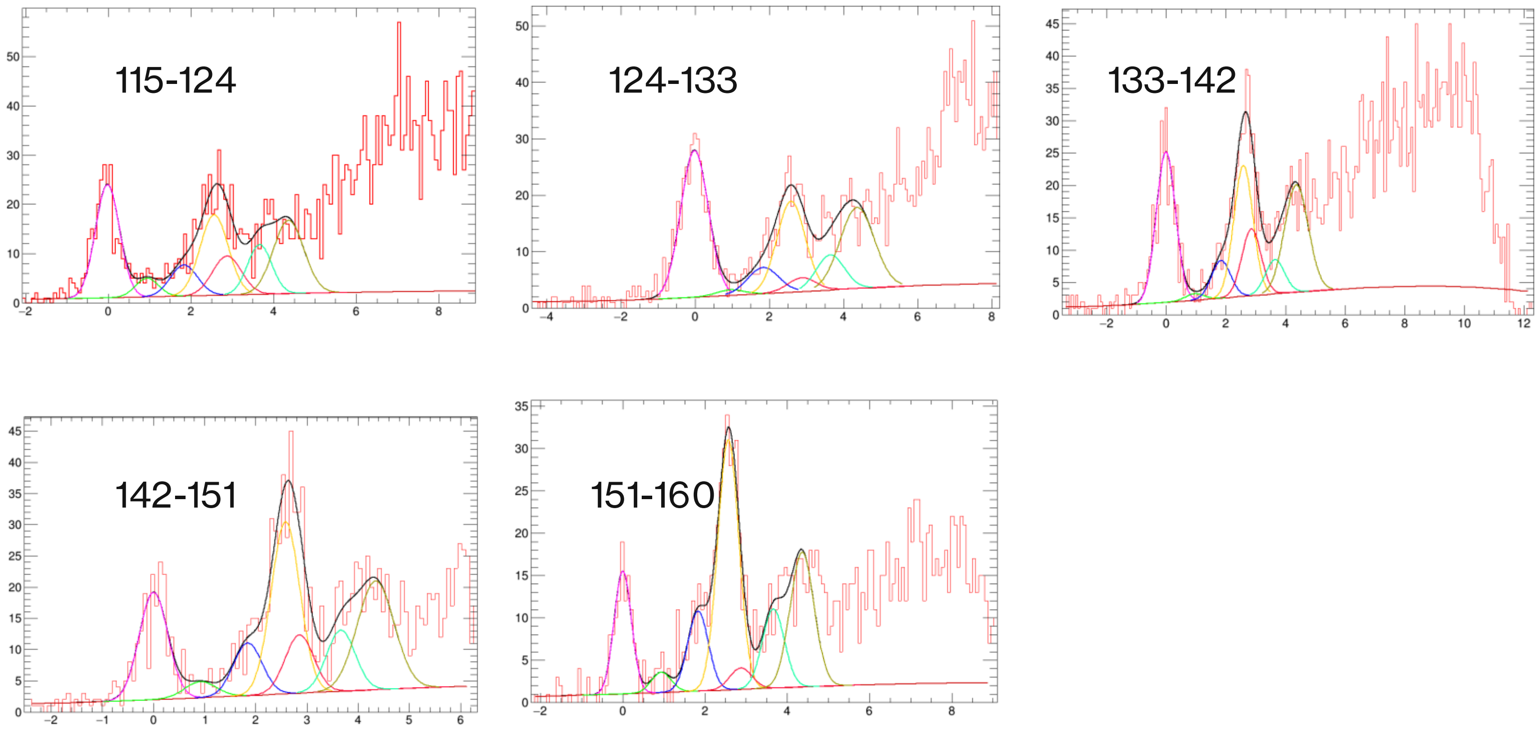
Our Physics Case

- Well known shell evolutions at N=14 in isotopic chains of $_{8}O$, N=28 in $_{20}Ca$.



O. Sorlin and M.G. Porquet, Phys. Scr. T152 014003

Our Physics Case



Our Physics Case

- At the same time, by means of neutron adding and removing reactions in ^{68}Ni, we get a unique access to the Spin-Orbit splittings of the pfg shells.
- These Spin-Orbit partners can be MeVs apart.
- It has been observed that the SO splitting scales with 2L+1 with approx. $A^{-2/3}$ trend and depends on the number of nodes n of radial wave-function.
- This sitting could be compared to other Ni isotopes and add another data point as another check for the validity of this trend.