Transfer reactions induced by ^{56}Ni: pairing and N=28 shell closure

Anastasia Georgiadou
Supervised by Marlène Assié

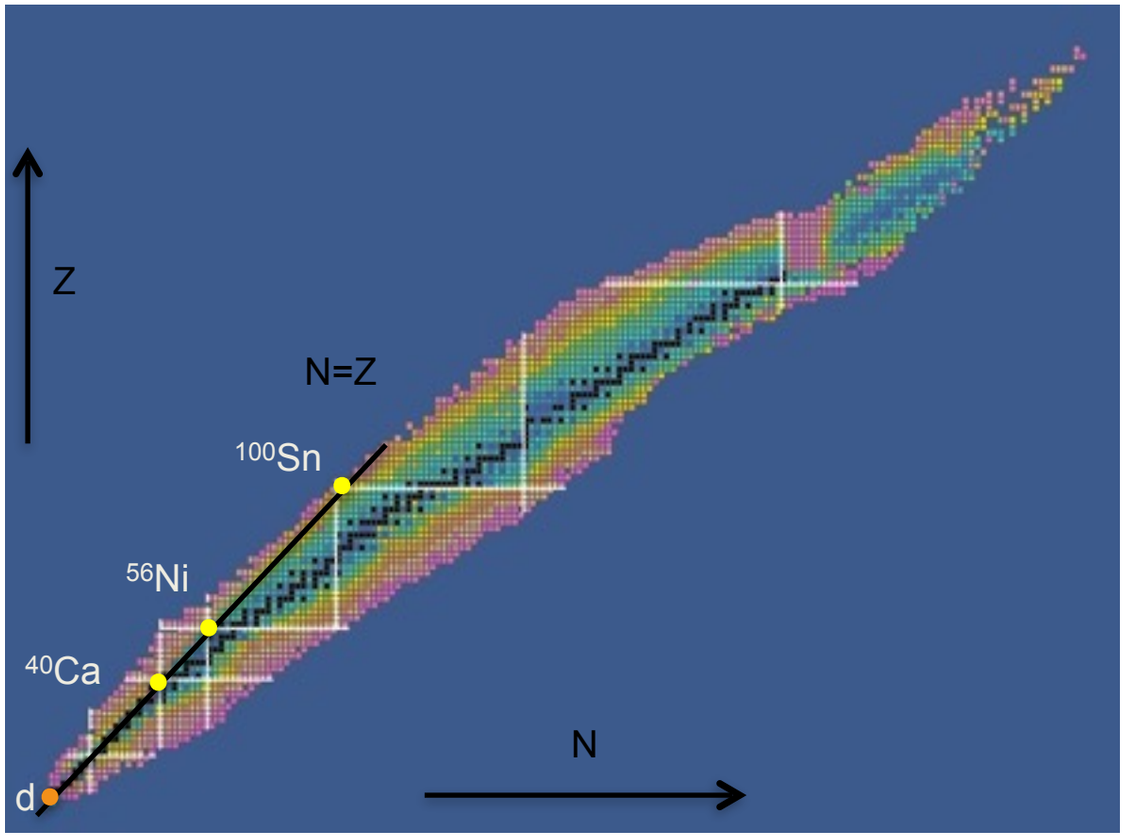
20th COLLOQUE GANIL

- ^{56}Ni: a doubly magic nucleus?
- N=28 shell closure
- Experimental set-up
- One neutron pick-up
- Perspectives: ^{56}Ni(d,p)^{57}Ni & ^{56}Ni (d,α) ^{54}Co

^{56}Ni: a doubly magic nucleus?

From Theory: n-p pairing may be important in N=Z nuclei with high J valence.^{56}Ni :the heaviest N=Z nucleus for which we can do transfer and study np pairing

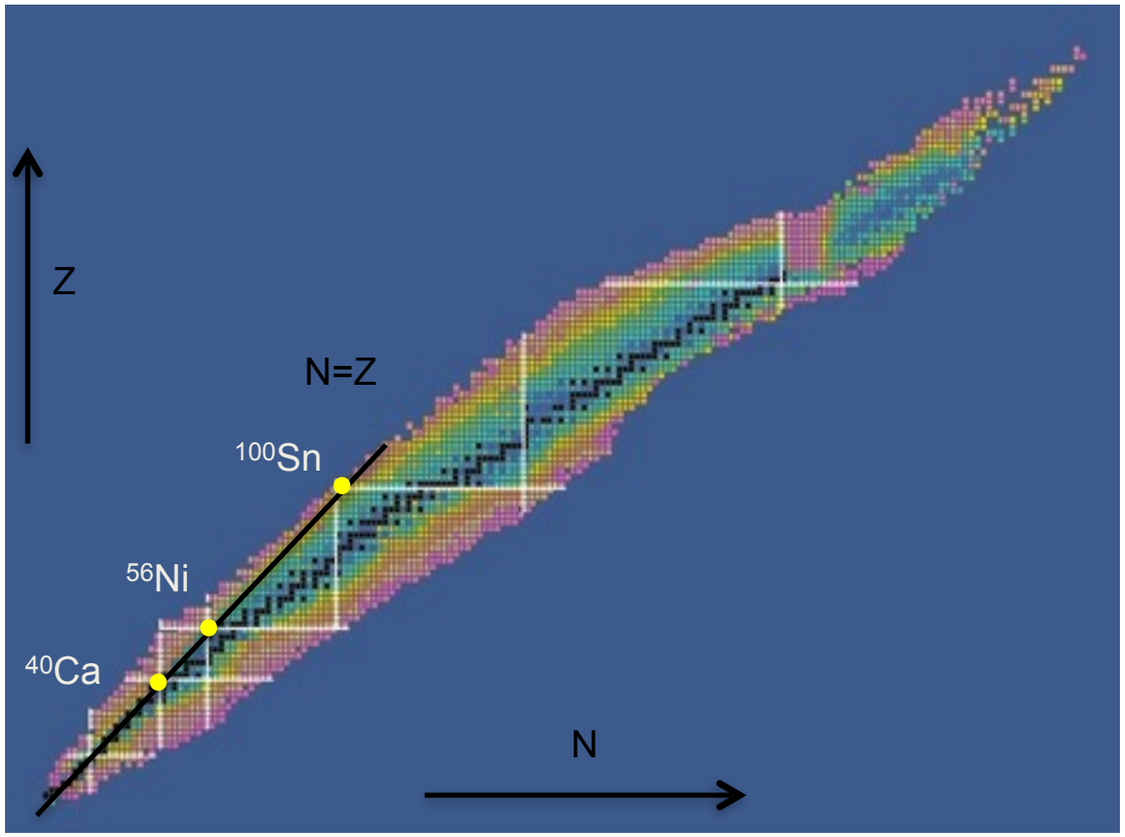
- For nuclei with N≠Z, nn and pp pairs are favoured.
- In the case of nuclei with N≈Z, n and p occupy the same shell model orbit.
- Large spatial overlap of the wave functions of proton and neutron in the f7/2 shell in ^{56}Ni



The double magicity of ^{56}Ni raises also the question what is the pairing at shell closure?

^{56}Ni: a doubly magic nucleus?

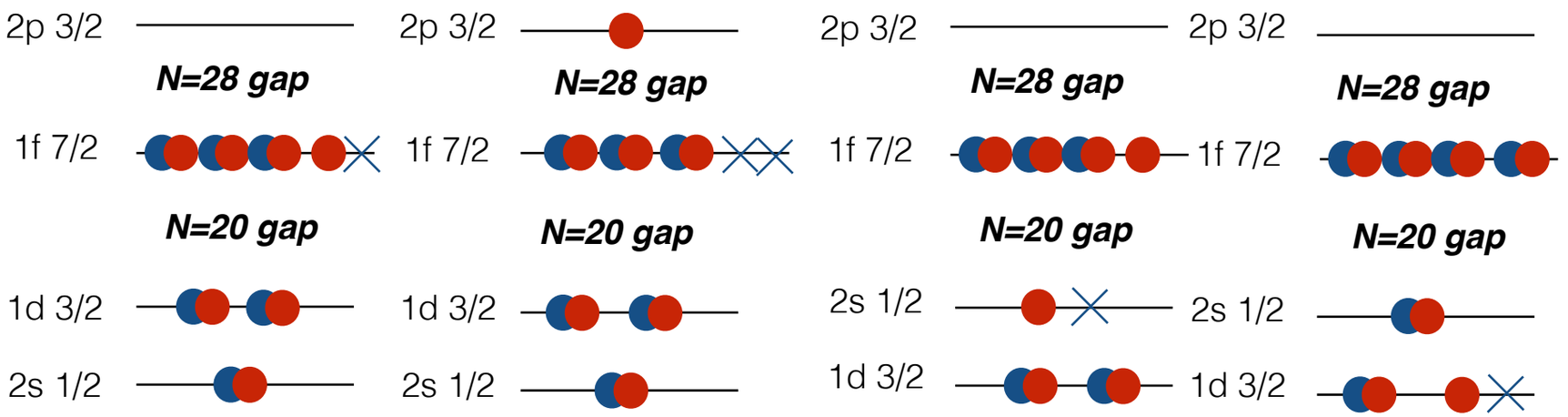
Doubly Magic nuclei with both proton and neutron number corresponding to closed shells have played a structuring role in nuclear physics.



That makes the shell structure of ^{56}Ni of great interest.

Extraction of the neutron SF, to do so we use single particle transfer reactions.

N=28 shell closure

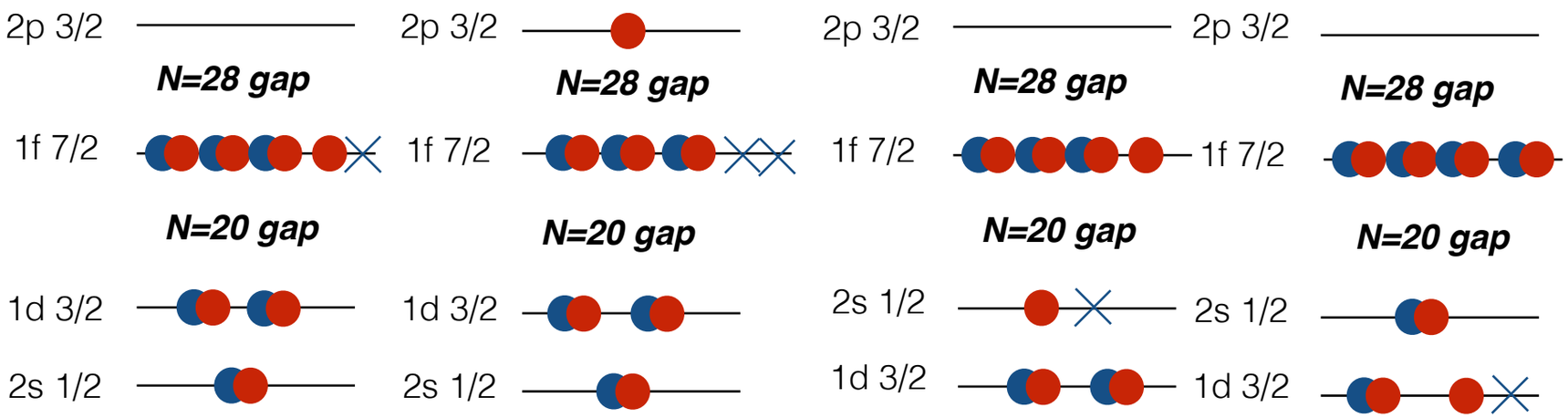


Ground State: f7/2	*1st Excited State: p3/2-*	*s1/2+*	*d3/2+*

neutrons ***protons***

"Holes" probed in N=27 isotones

N=28 shell closure



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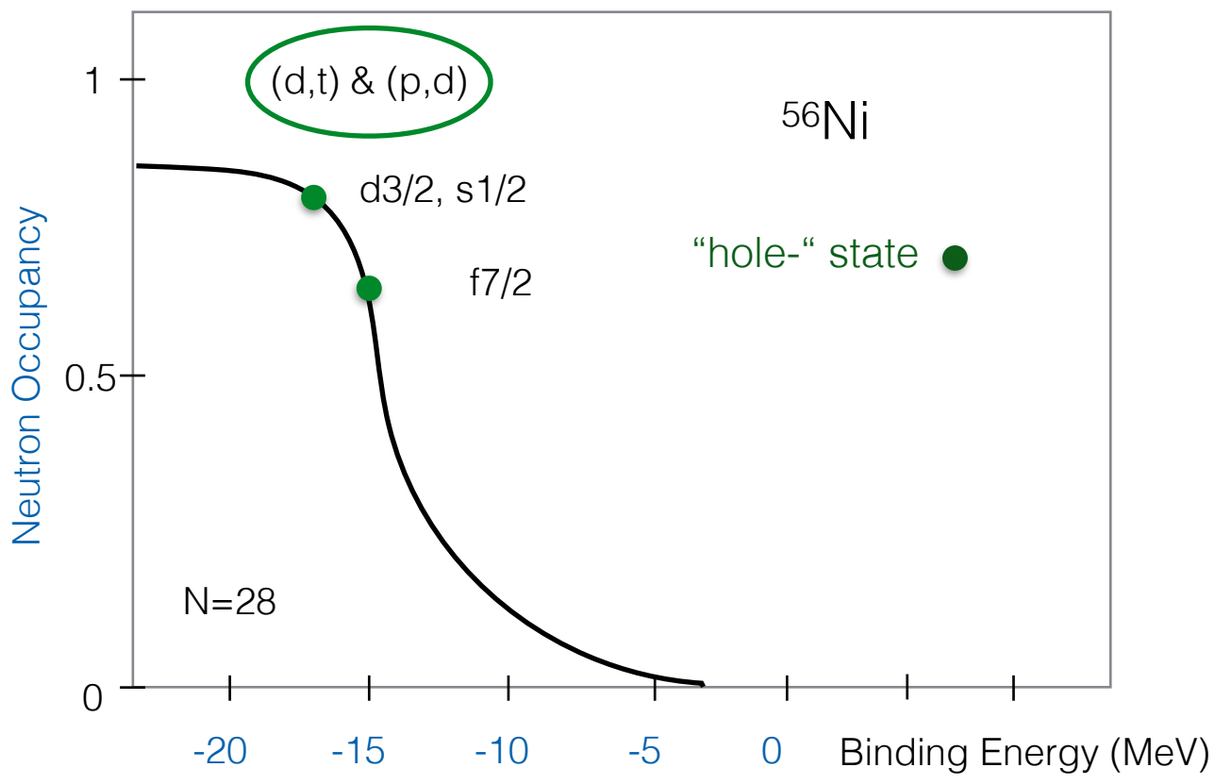
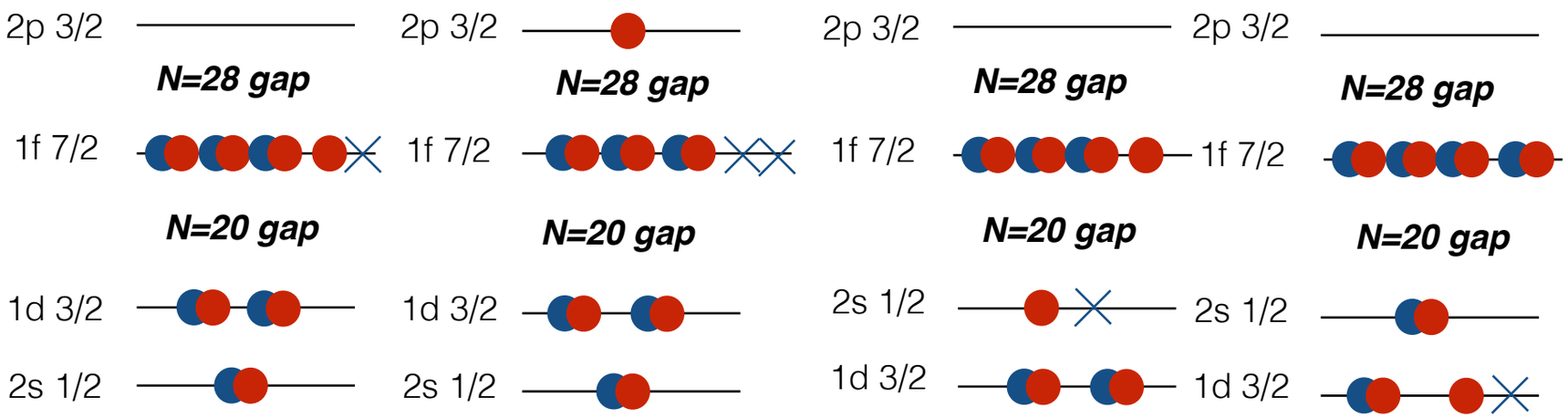


"Holes" probed in N=27 isotones

proton and neutron "Fermi surface" of ^{56}Ni

**Adapted from O.Sorlin*

N=28 shell closure



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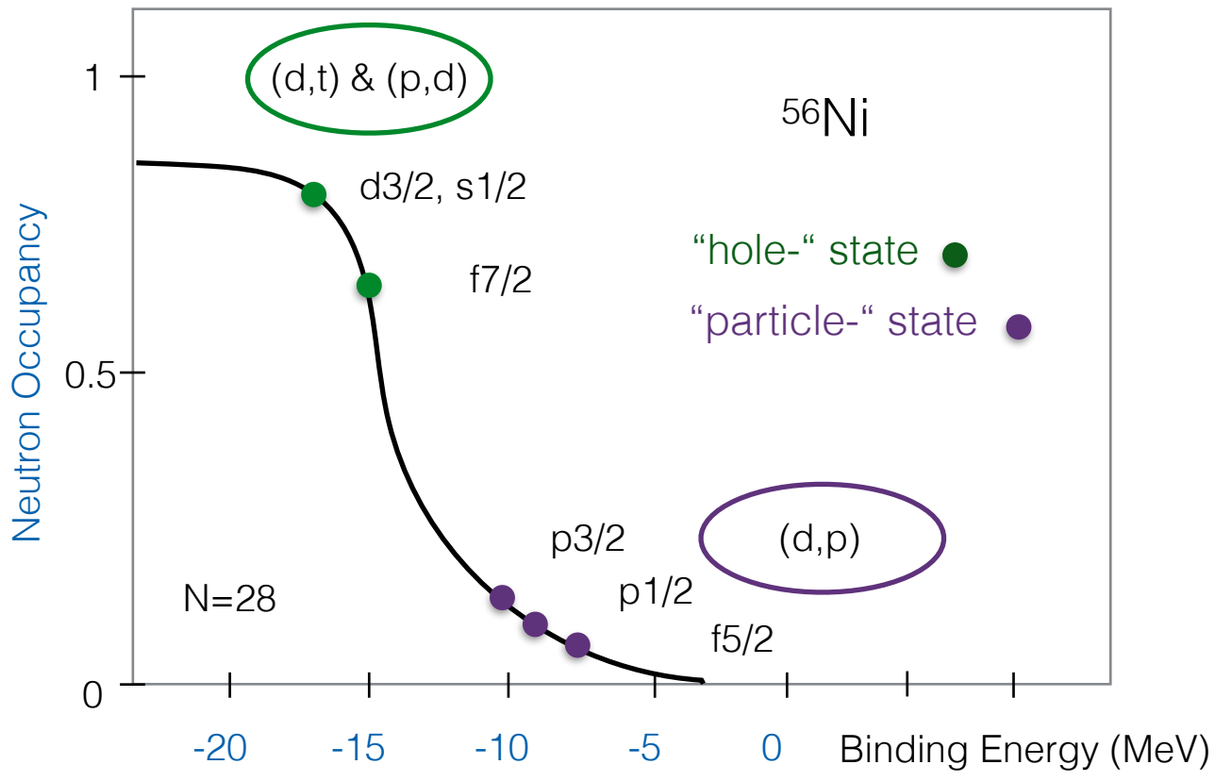

"Holes" probed in N=27 isotones

proton and neutron "Fermi surface" of ^{56}Ni

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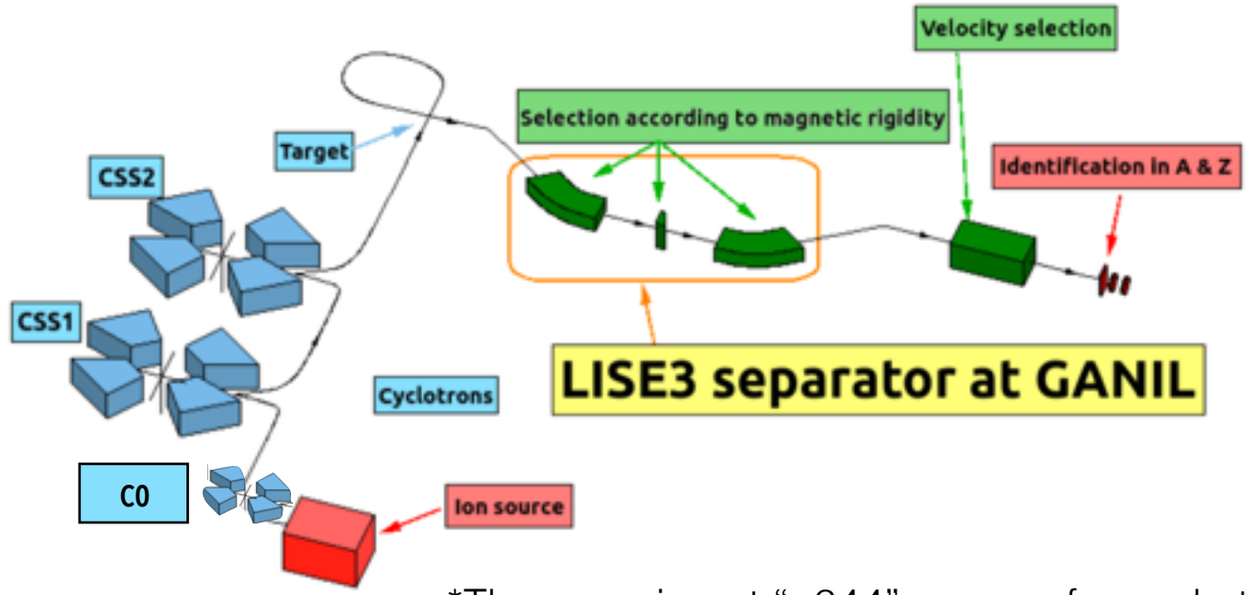
Experimental Set-up

Primary beam : ^{58}Ni at 74,5 A MeV

Rotating target (CLIM) : ^{12}C (1 mm)

Secondary beam : ^{56}Ni at 30A MeV



*The experiment “e644” was performed at GANIL,CAEN at Spring 2014.

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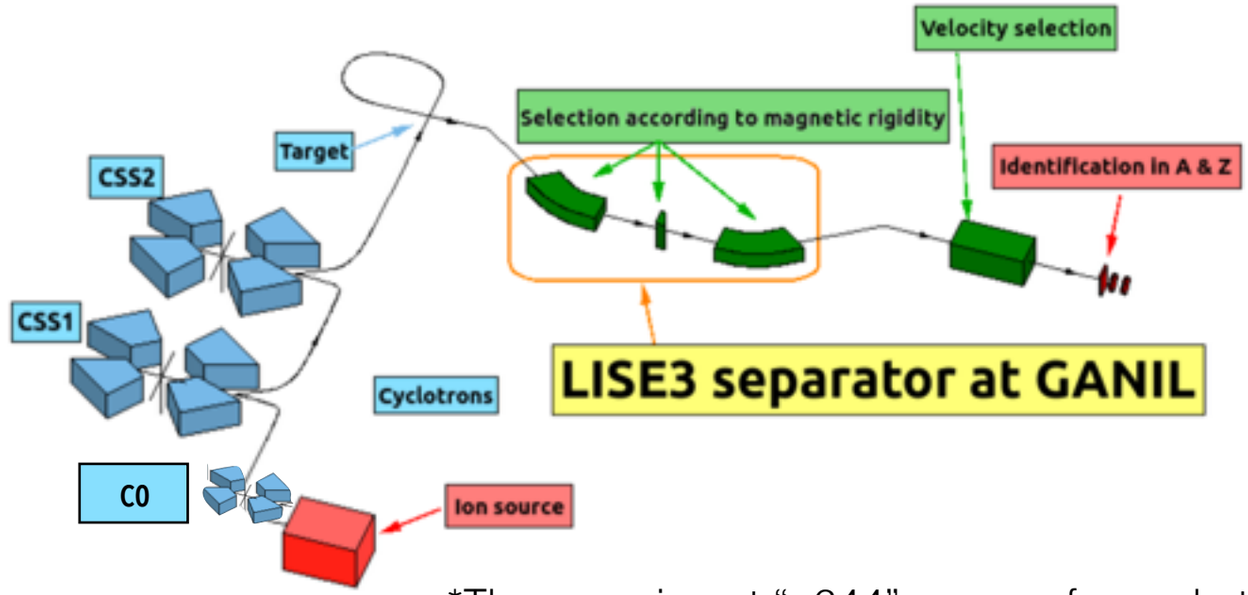

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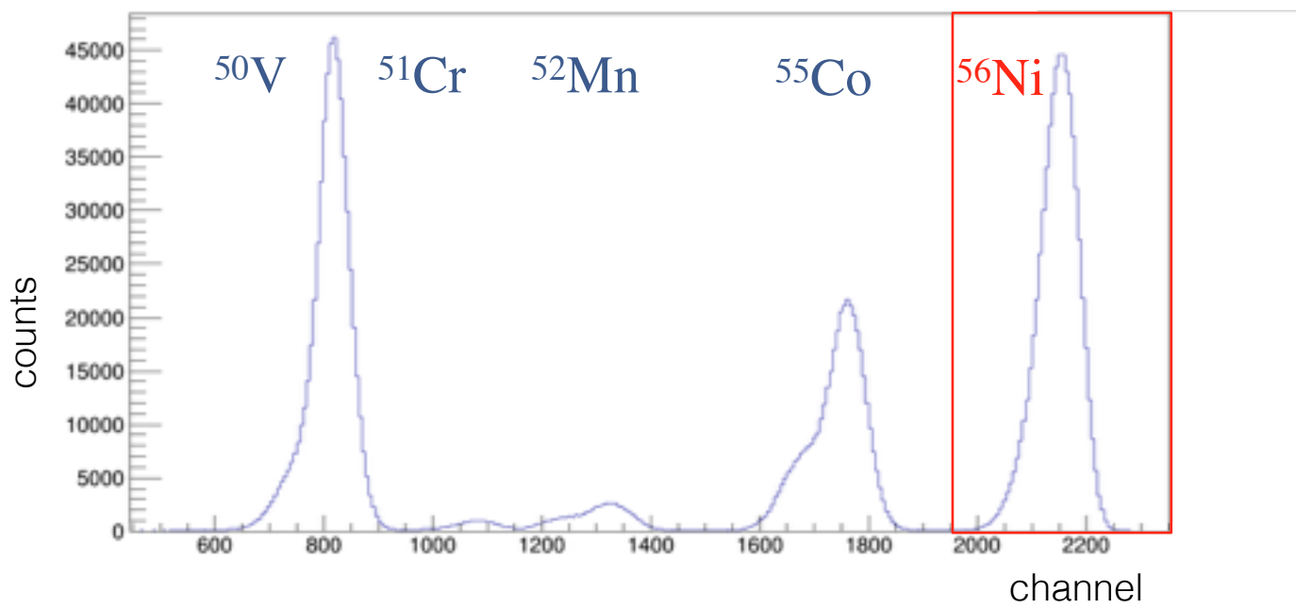
Beam Contaminants



ToF CATS1-HF

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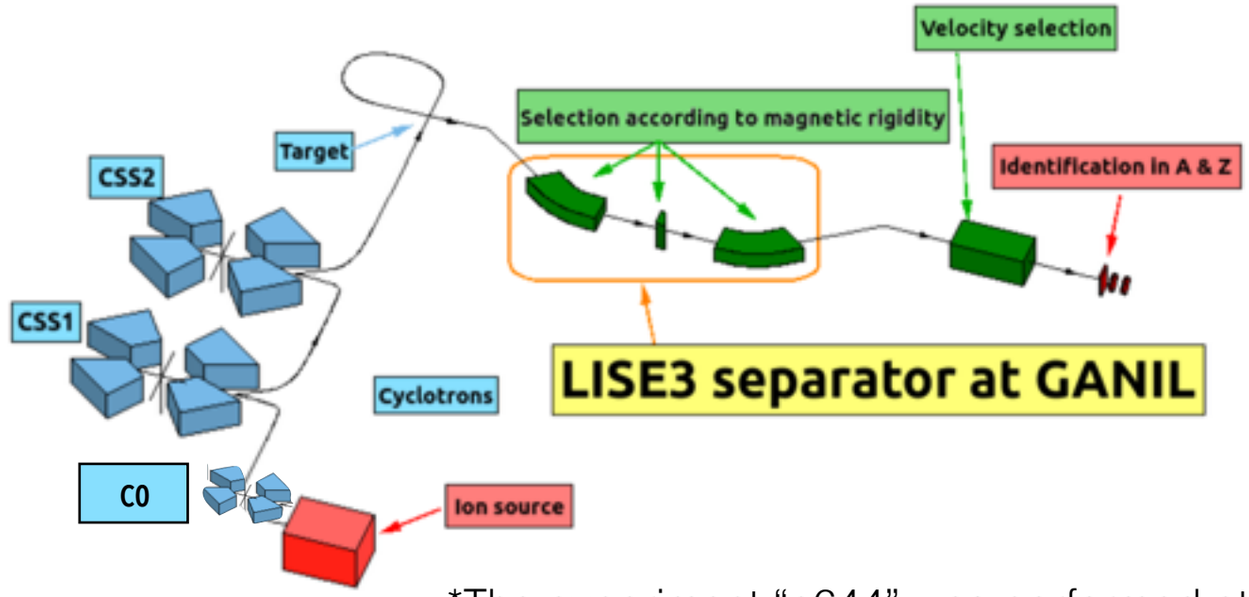

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^{56}Ni(p,^{3}He)^{54}Co

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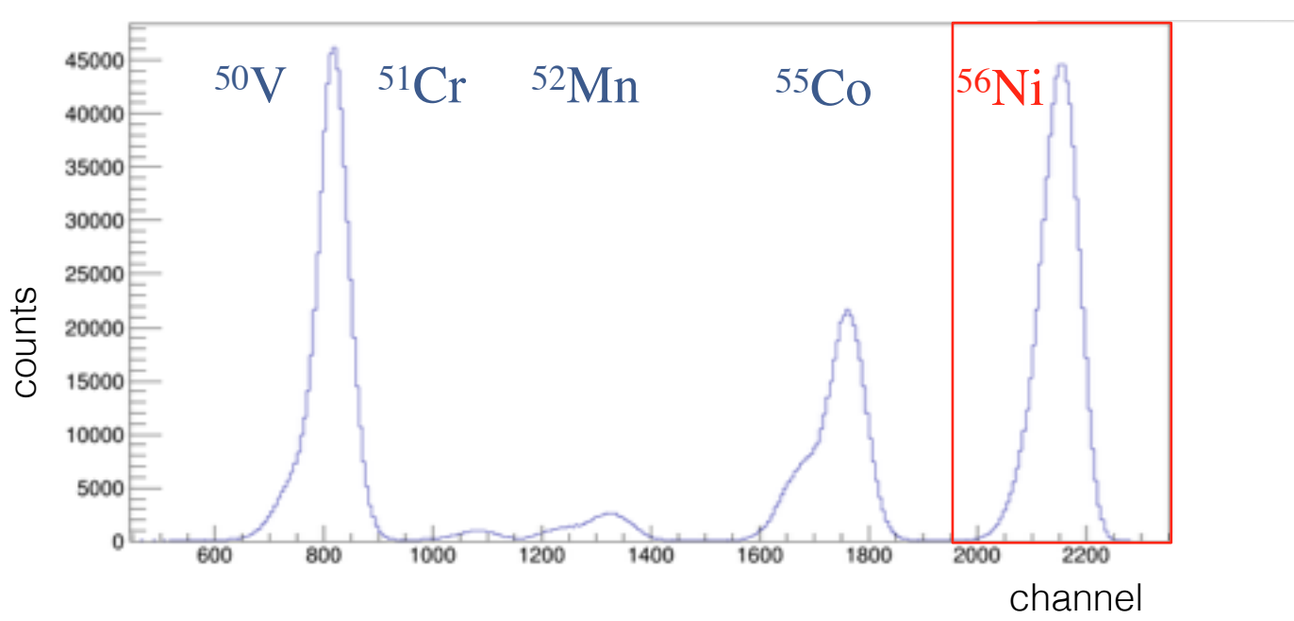

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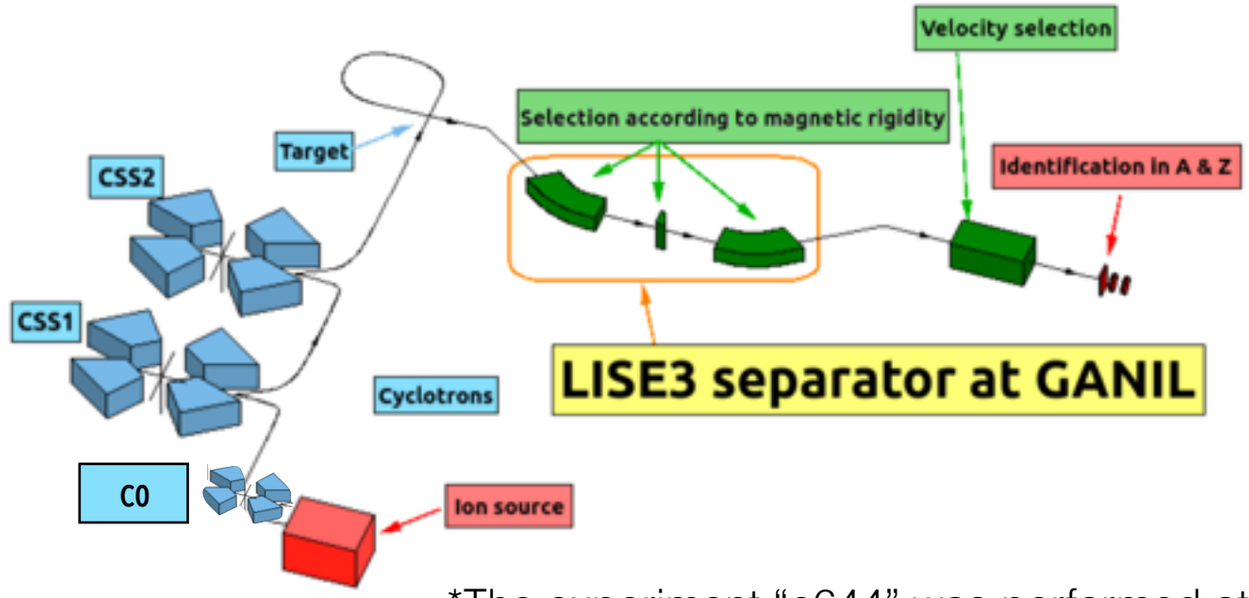

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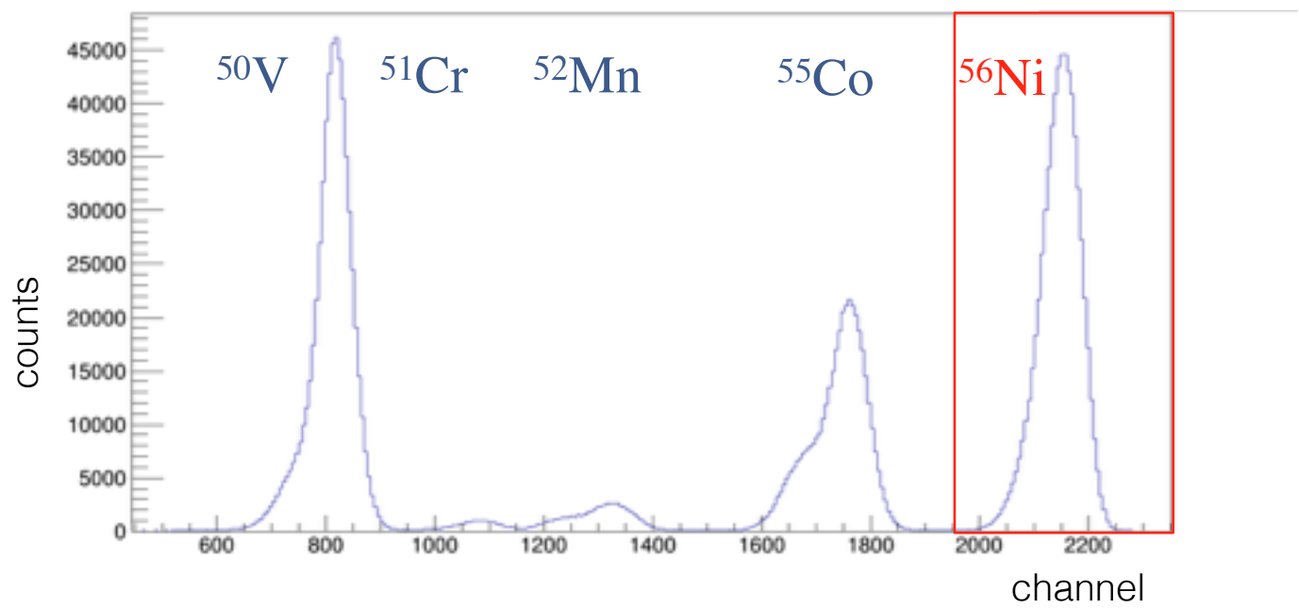

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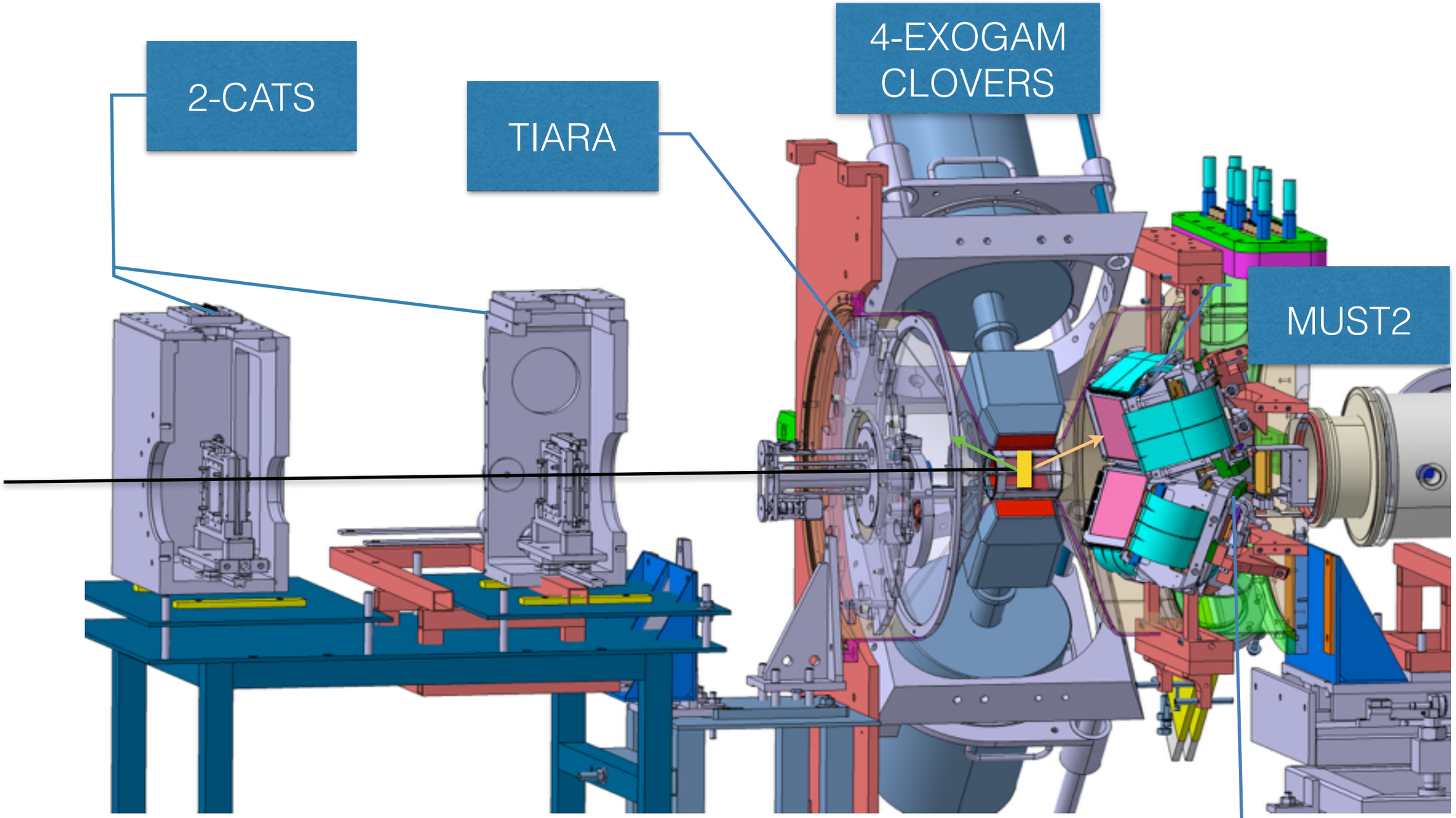
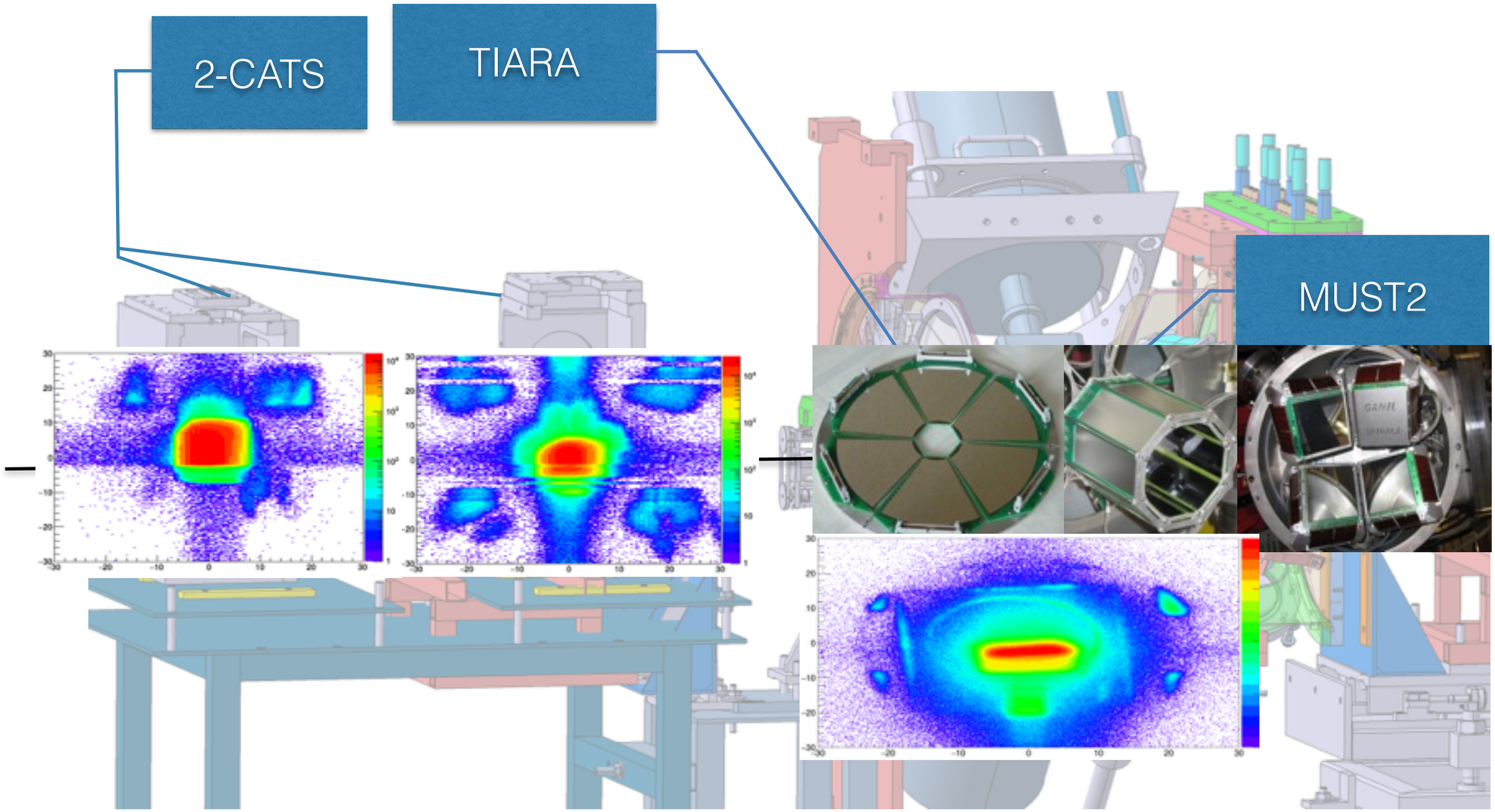


*Illustration by Emmanuel Rindel

Beam ^{56}Ni
tritons
protons

Targets: CH_2 CD_2

Experimental Set-up



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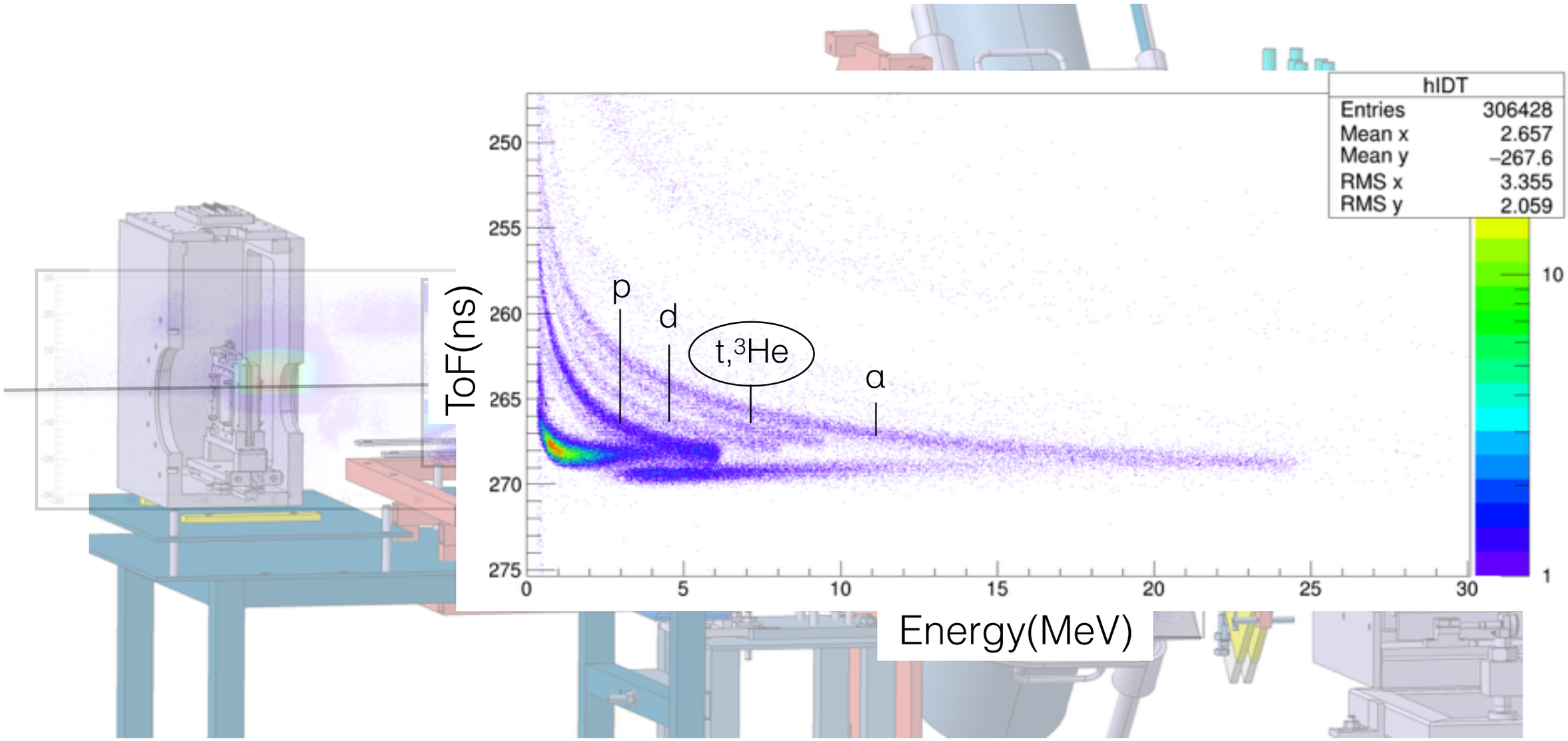
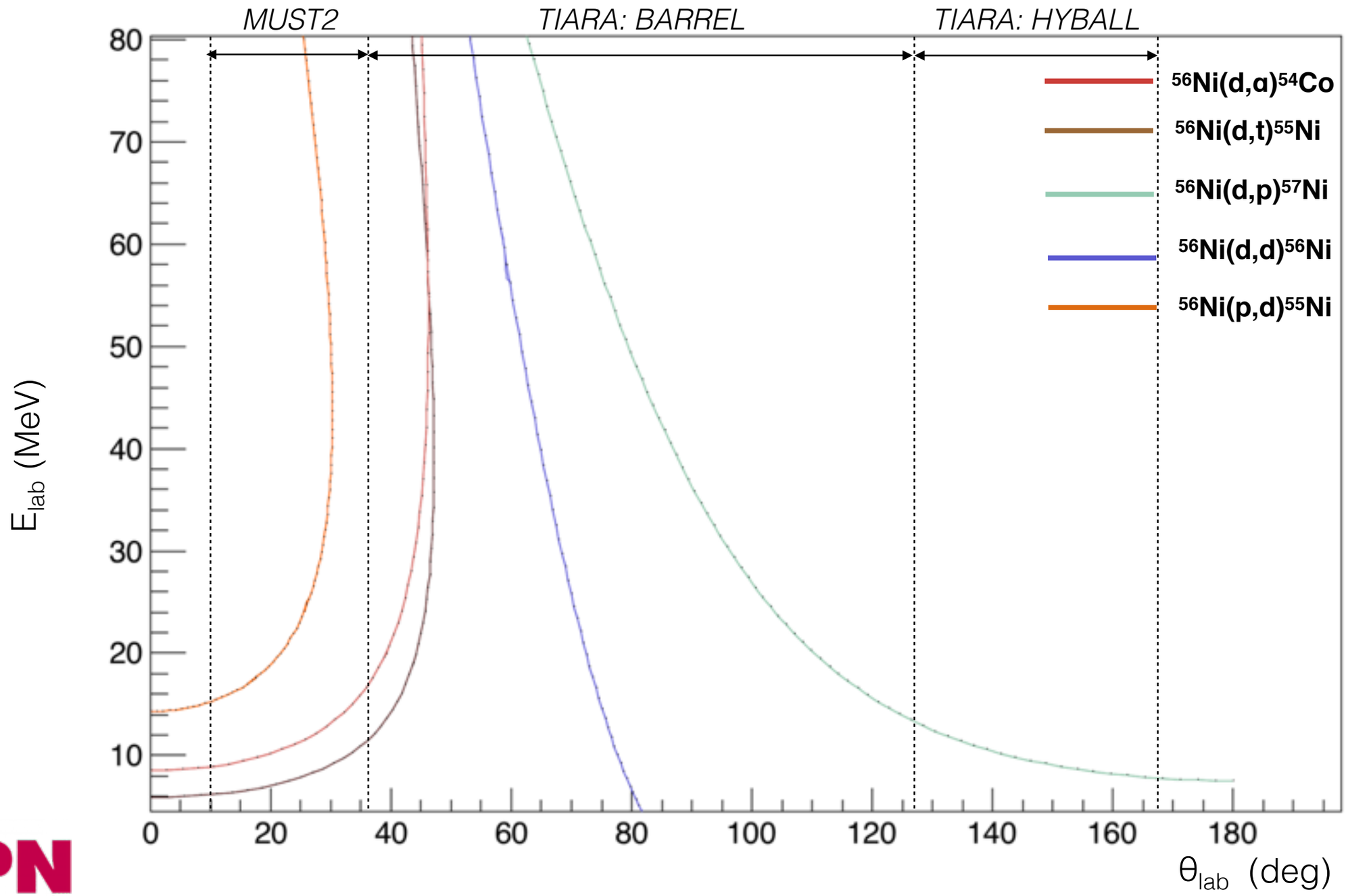


*Illustration by Emmanuel Rindel

Experimental Set-up

The reaction Kinematics



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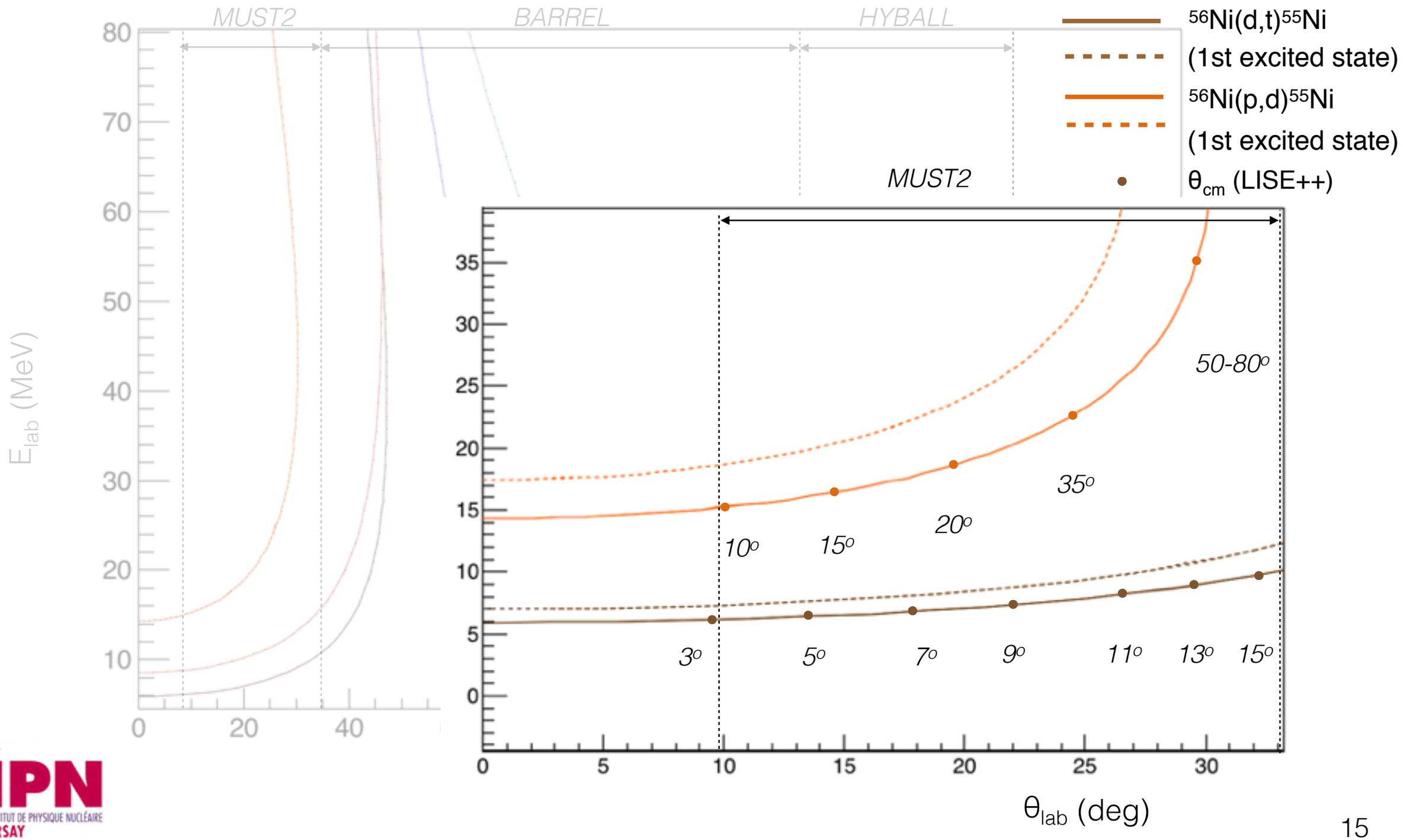
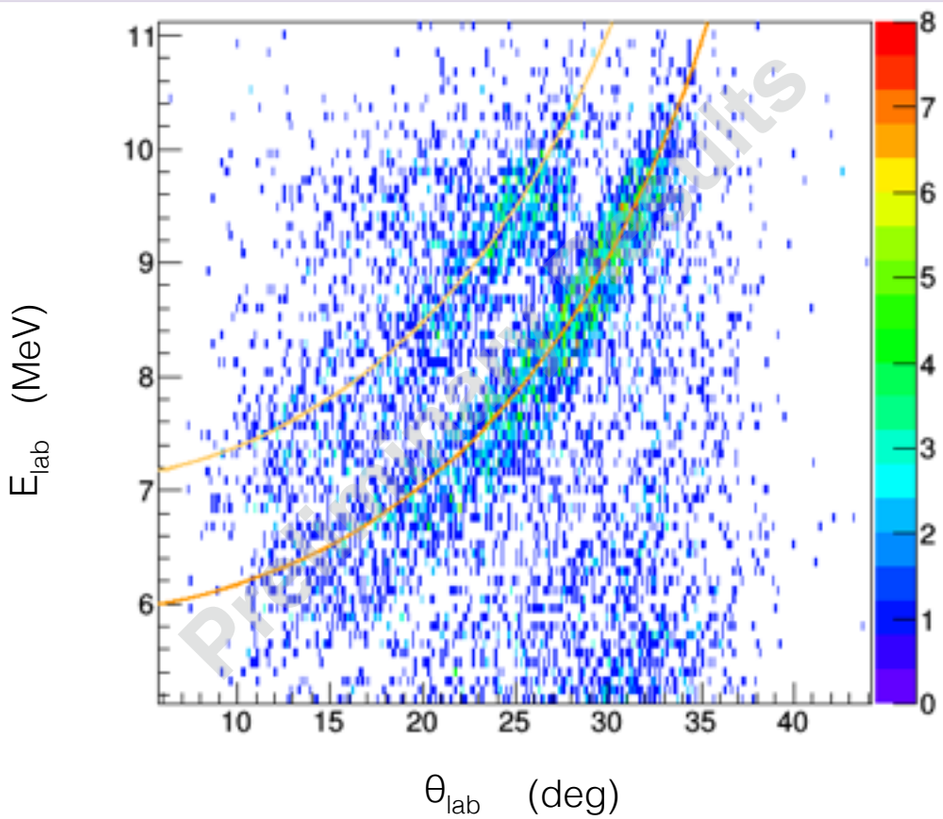


^{56}Ni(d,t)^{55}Ni



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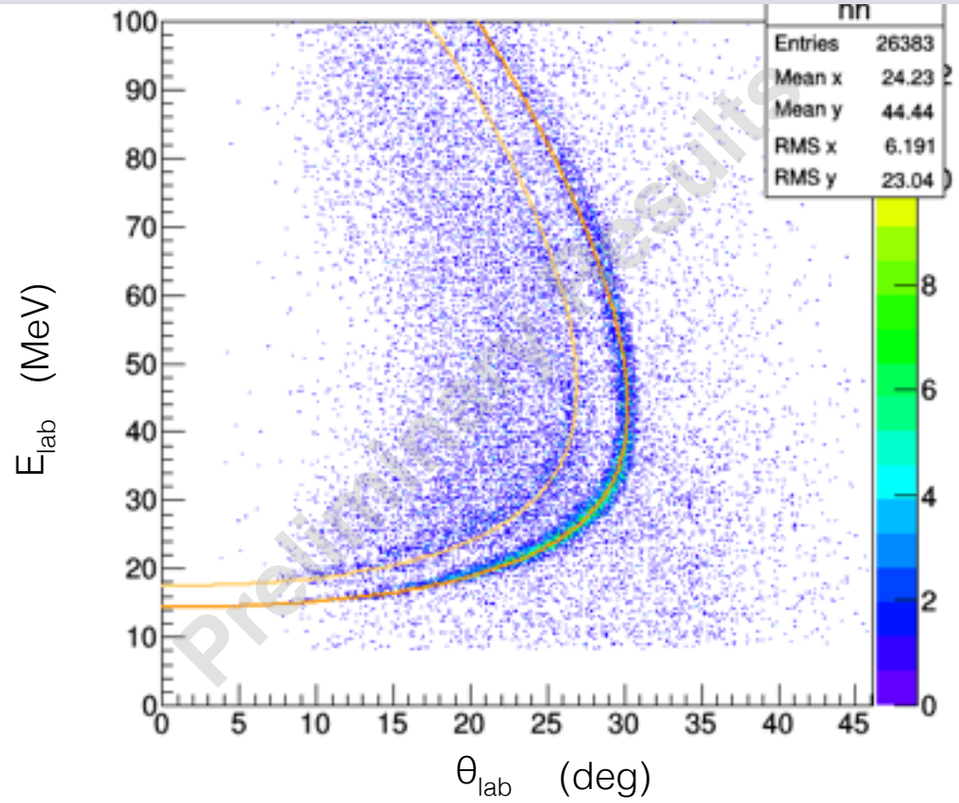

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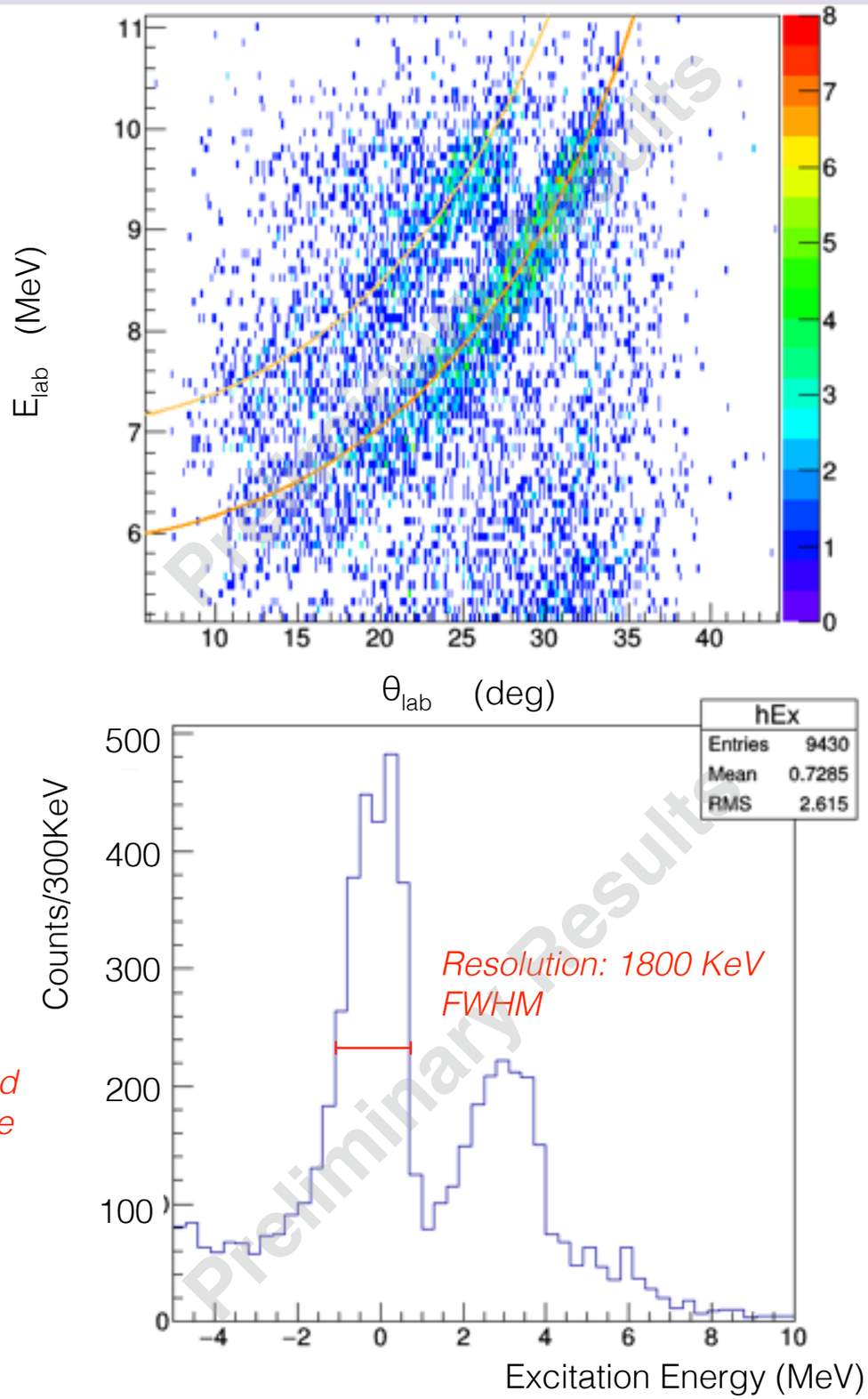
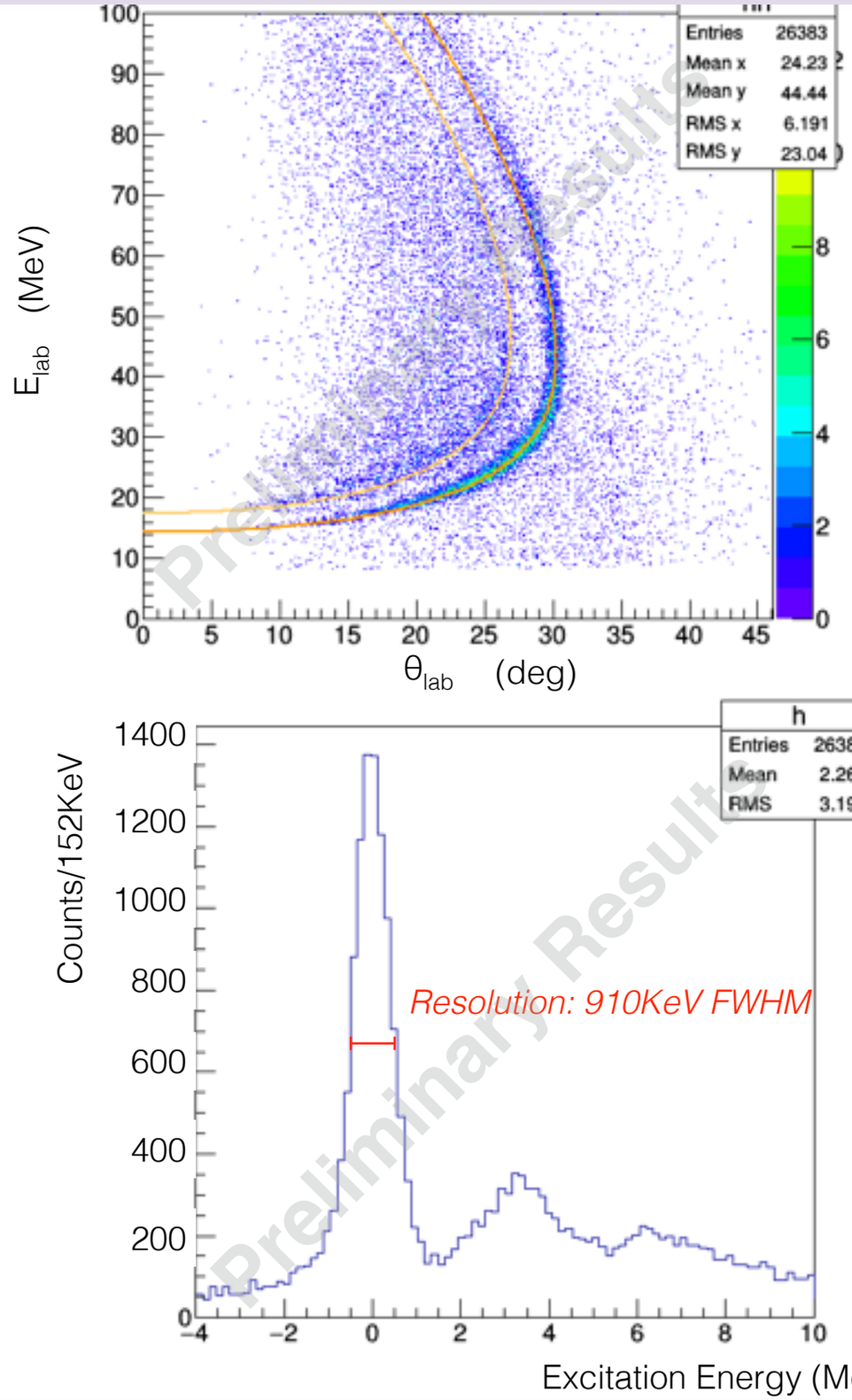


Resolution: In good agreement with the simulation!

^{56}Ni(p,d)^{55}Ni



$^{56}Ni(d,t)^{55}Ni$

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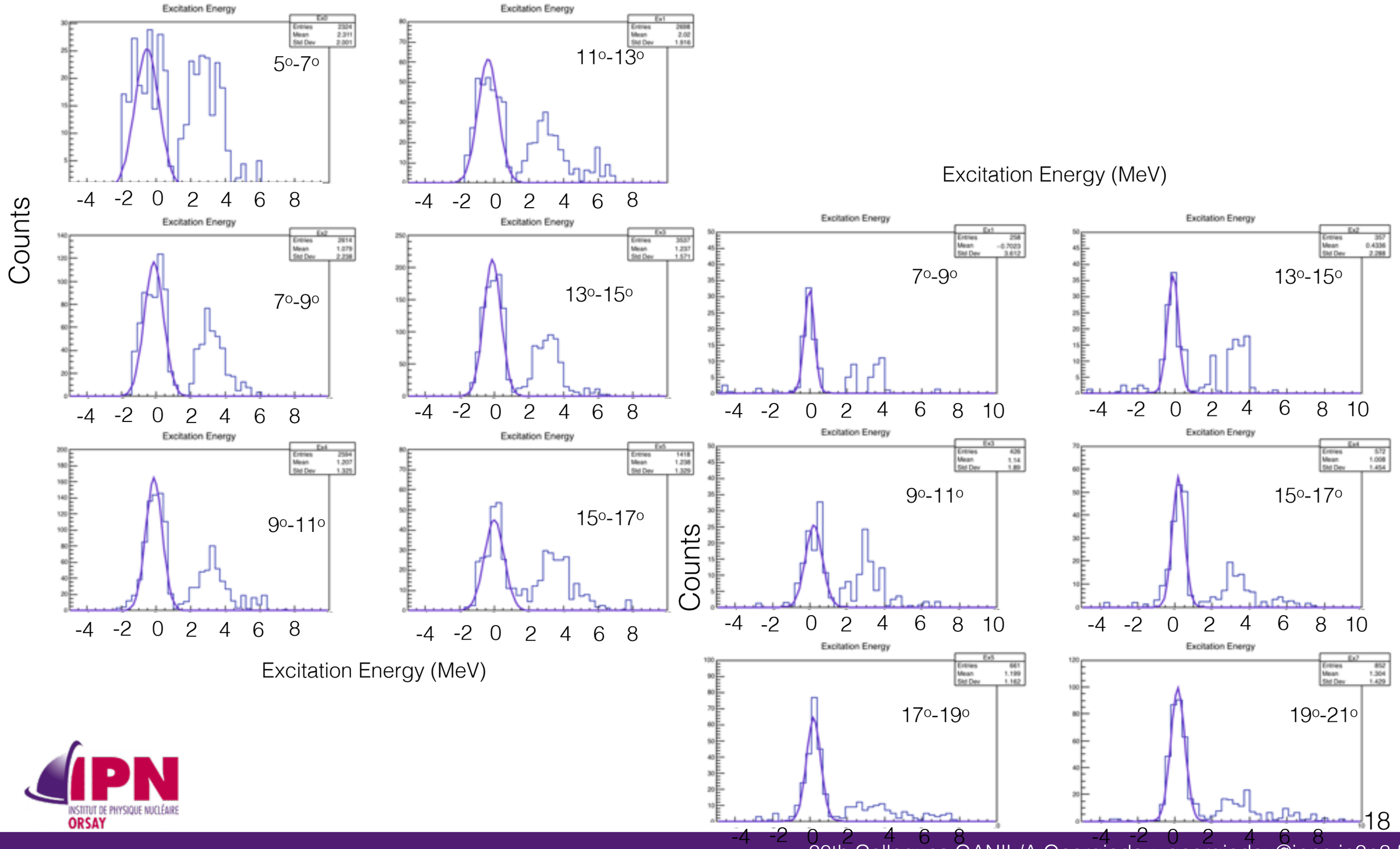
The excitation energy spectra in different angle in the centre of mass .



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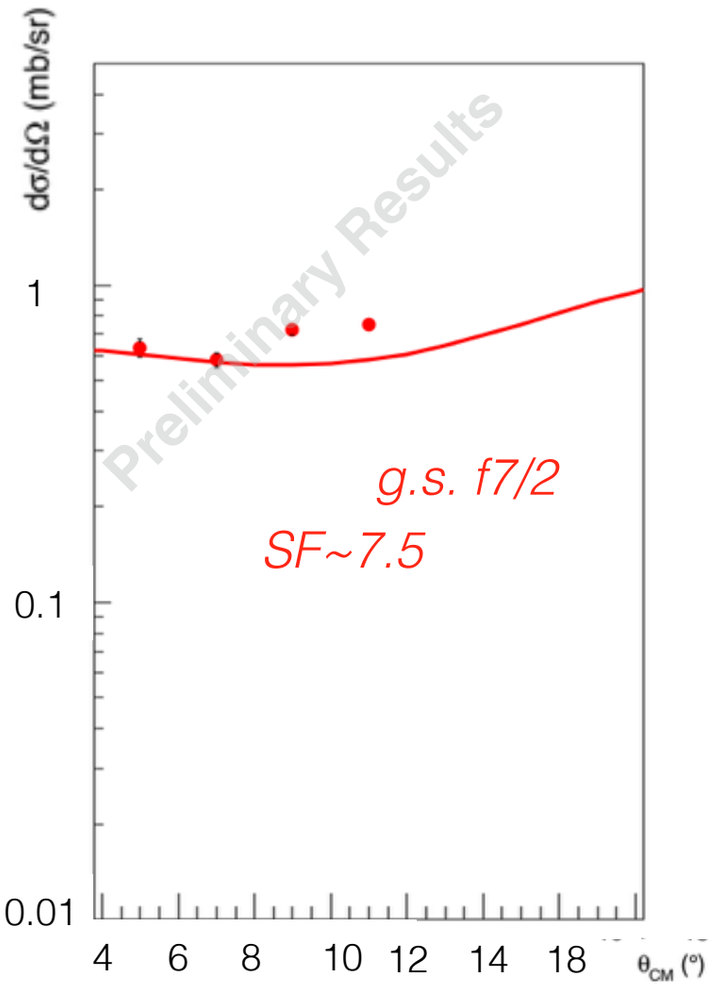
Differential cross-section for transfer reaction to gs and first excited state of ^{55}Ni



Calculation with DWBA: A.Georgiadou, J.Guillot

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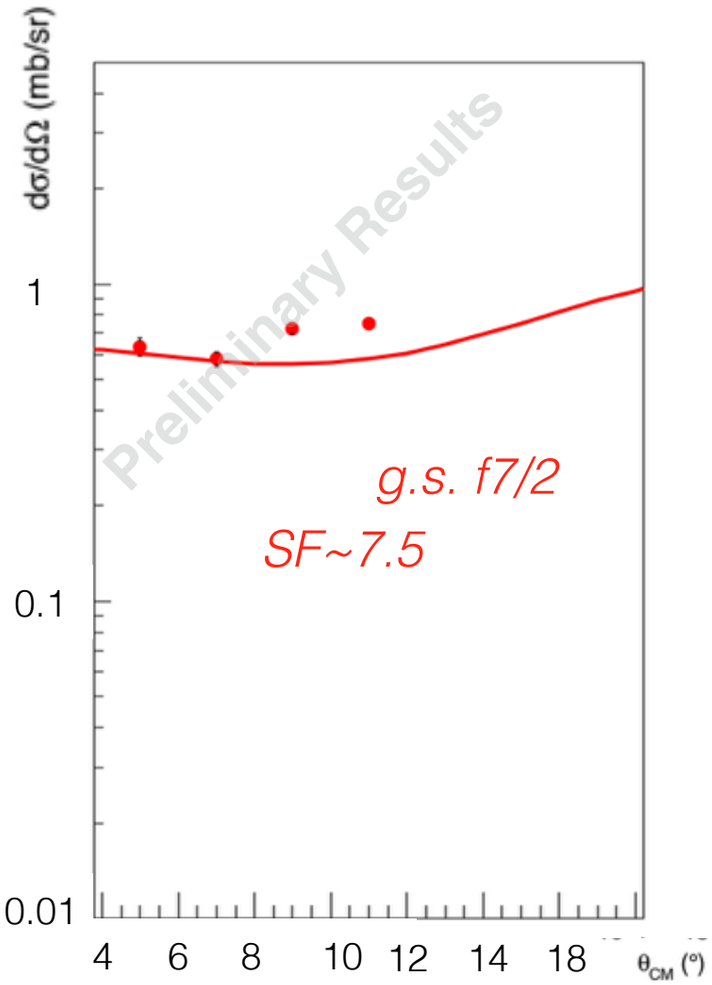

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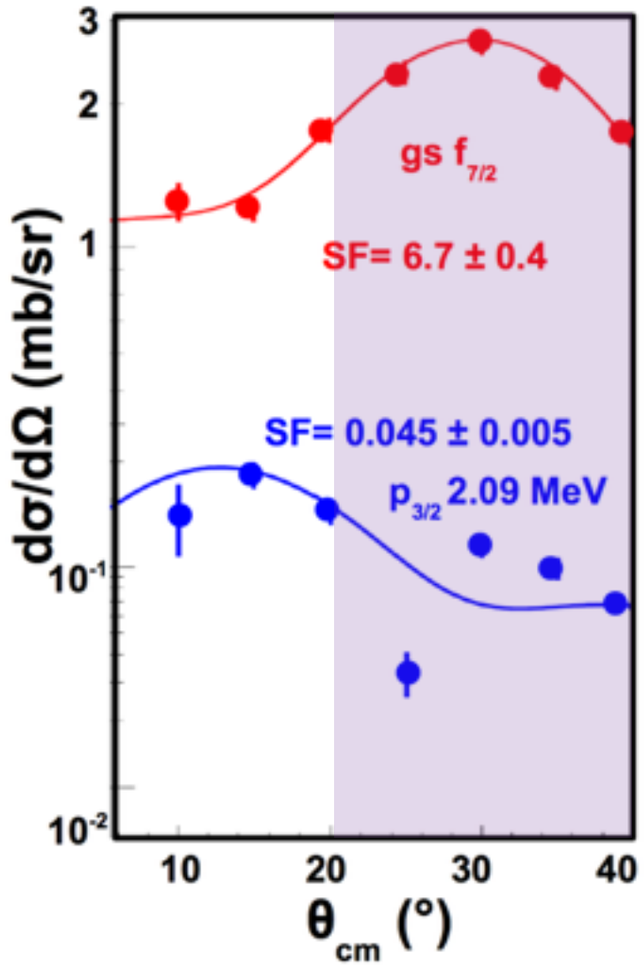

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**Benjamin Le Crom, Thesis,Université Paris-Saclay, 2016.*

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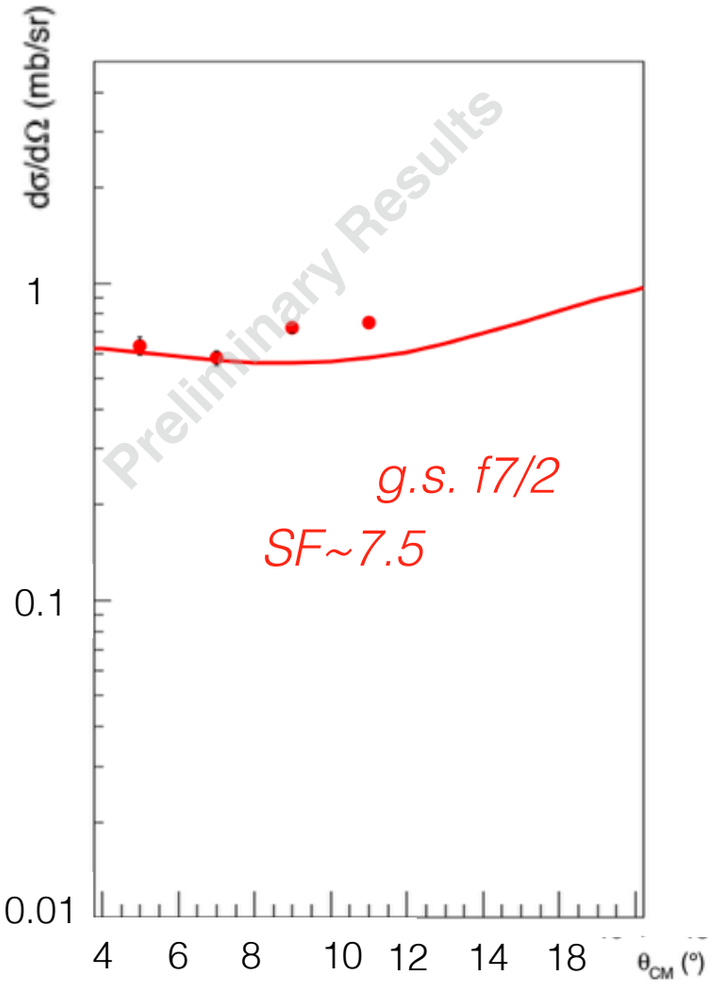

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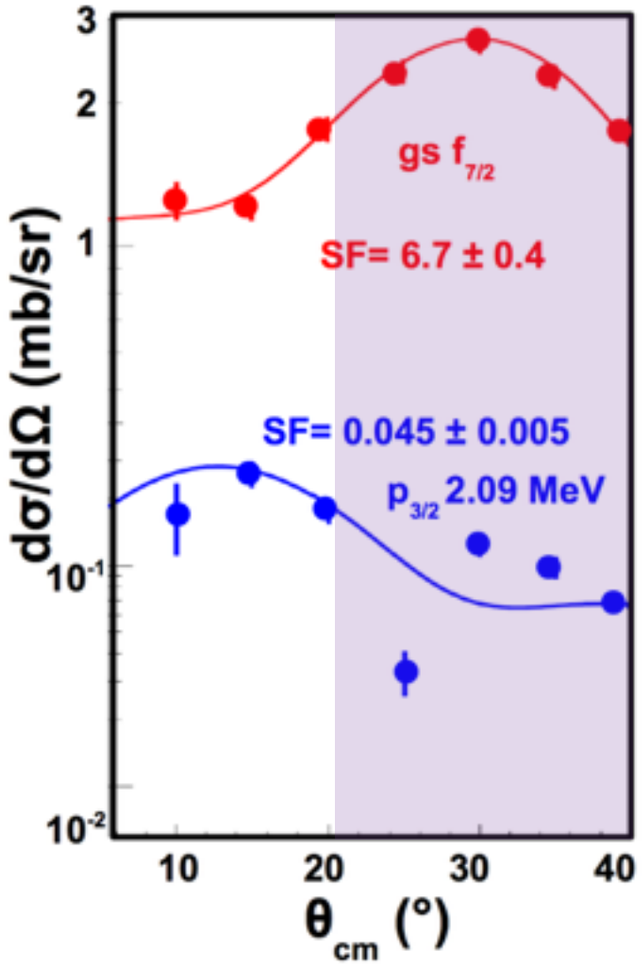

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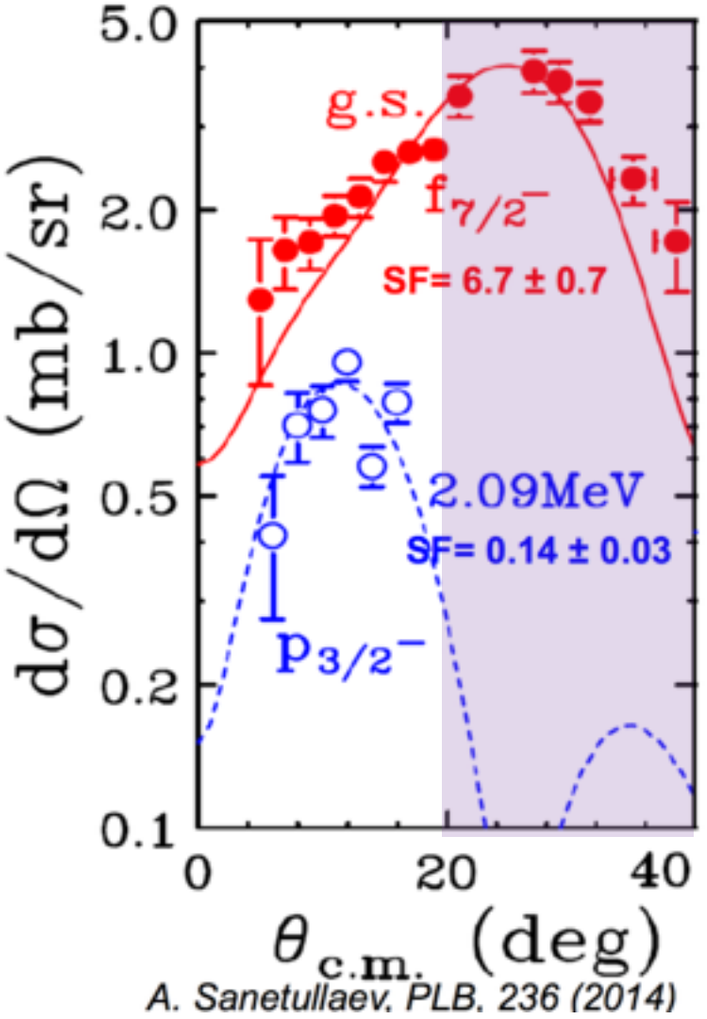
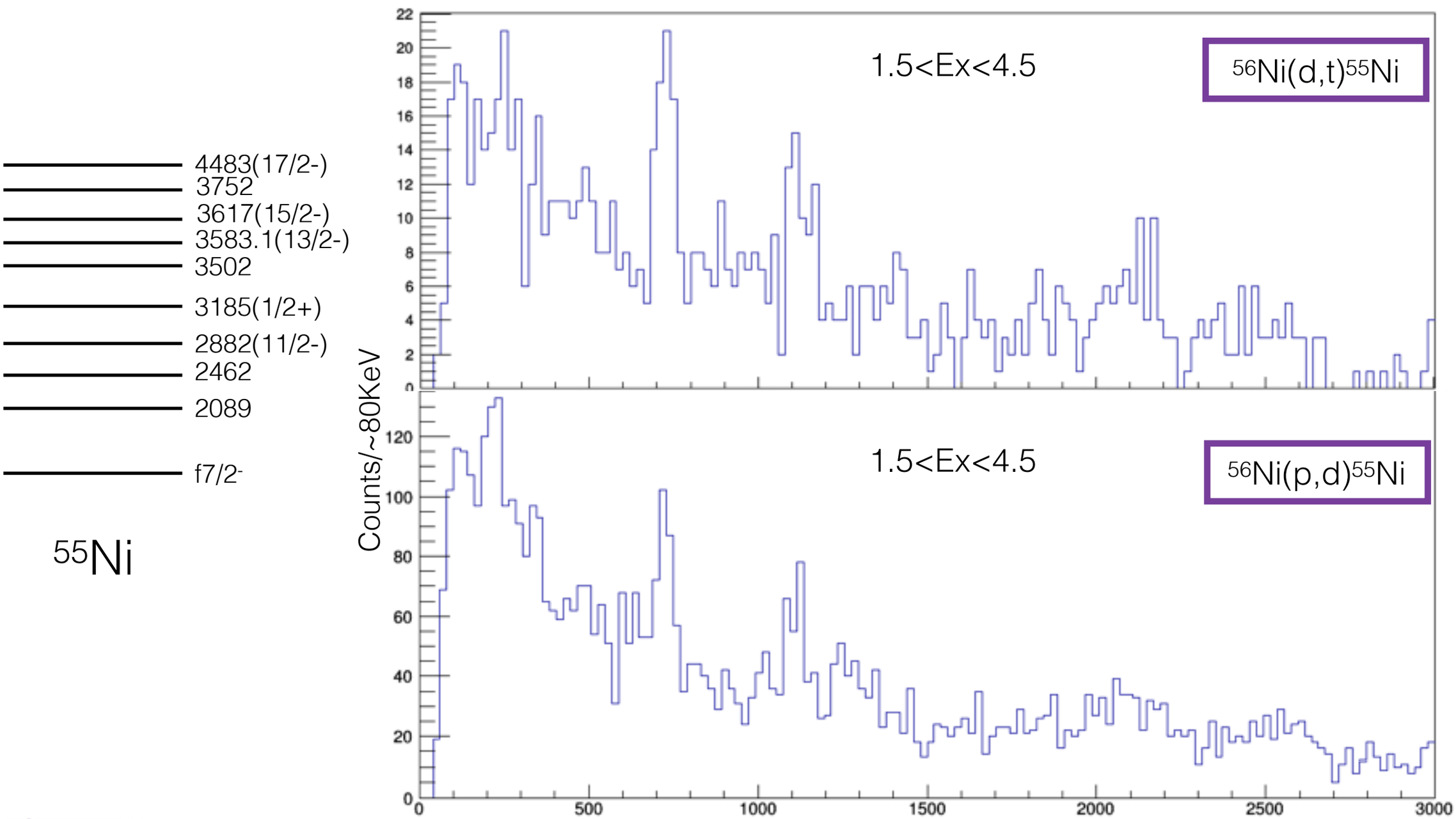


A. Sanetullaev. PLB. 236 (2014)

Particle-Gamma Coincidences



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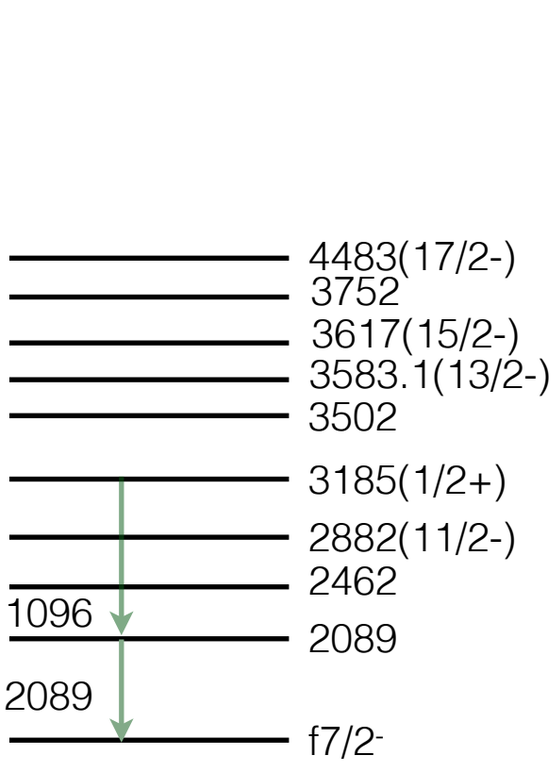
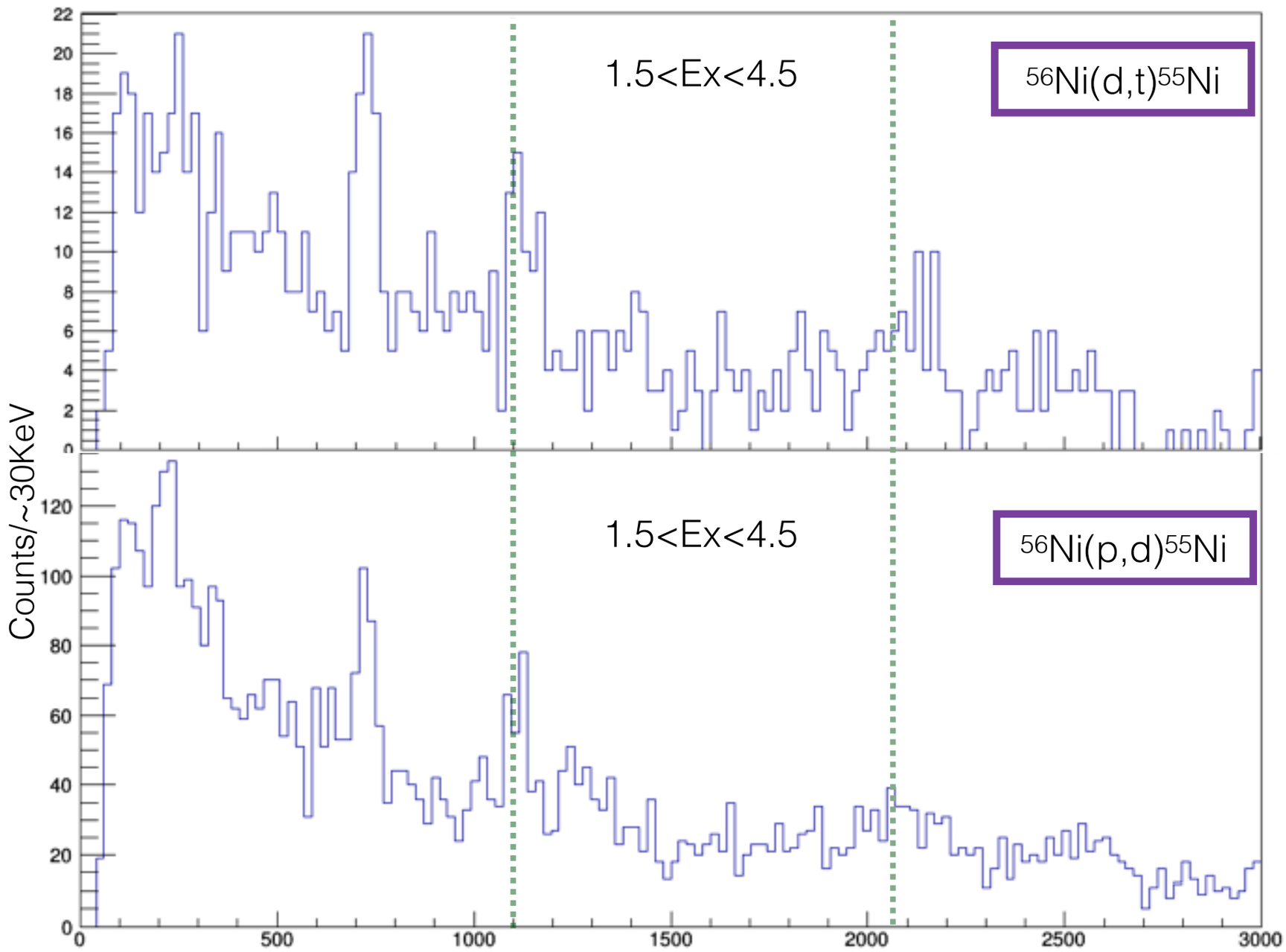


^{55}Ni



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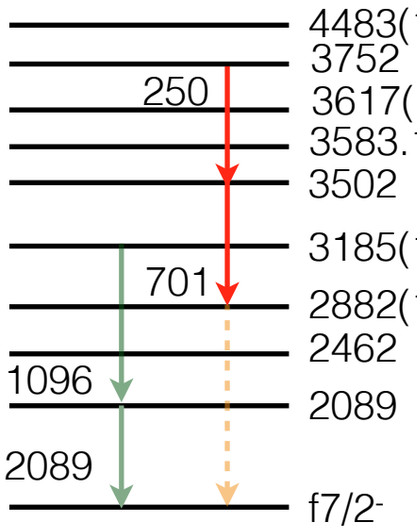

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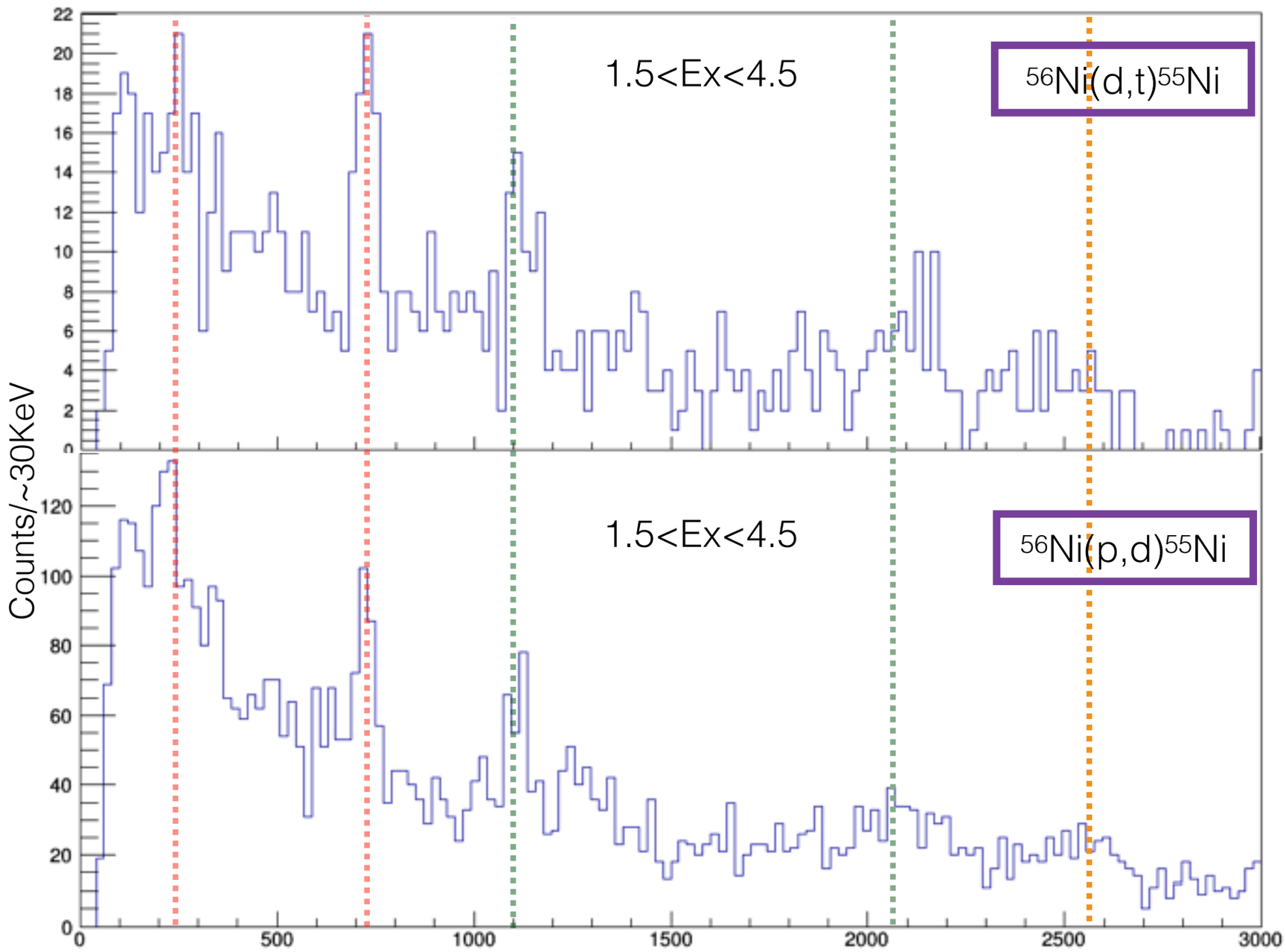

Perspectives: ^{56}Ni(d,p)^{57}Ni & ^{56}Ni (d,α)^{54}Co

- Conclude about the excited states of the (d,t) reaction by using the gamma-particle coincidences

- Analysis of the ^{56}Ni(d,p)^{57}Ni reaction

- Get the total cross section of the (d,α) for the study of the np pairing, completing the information about the strength of the isoscalar np pairing in ^{56}Ni.

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THANK YOU

ANASTASIA GEORGIADOU

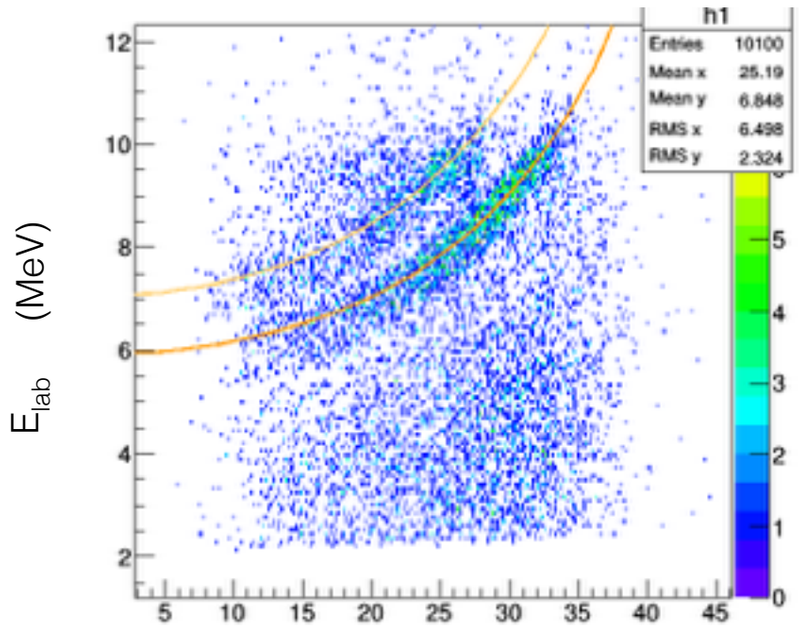
“E644 COLLABORATION”

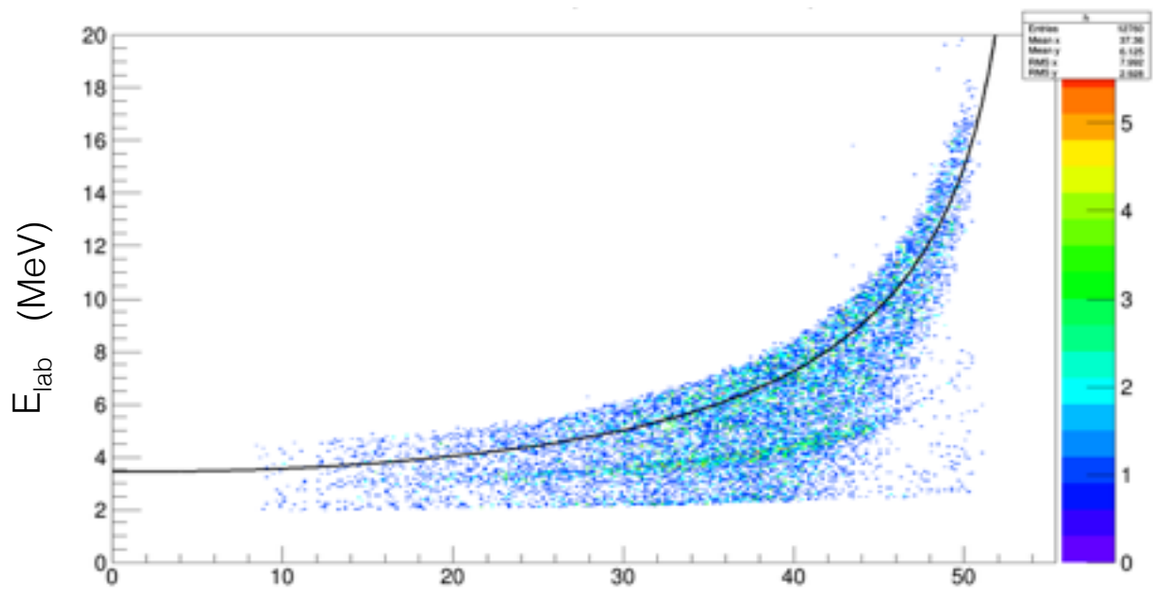
A. Georgiadou[a], M. Assié[a], Y. Blumenfeld[a], B. Le Crom[a], F. Flavigny [a],L. Achouri[b], M. Aouadi[b], B. Bastin[c], A. Benitez[d], R. Borcea[e], W. Catford[f], E. Clement[c], A. Corsi[g], G. Defrance[c], M-C. Delattre[a], F. Delaunay[b], N. De Séréville[a], Q. Deshayes[b], B. Fernandez[h], M. Fisichella[i], S. Franchoo[a], J. Gibelin[b], A. Gillibert[g], J. Guillot[a], F. Hammache[a], O. Kamalou[c], A. Knapton[f], V. Lapoux[g], S. Leblond[b], M. Marques[b], A. Matta[f], P. Morfouace[a], N. Orr[b], J. Pancin[c], X. Pereira[b,h], L. Perrot[a], E. Pollacco[g], D. Ramos[h], T. Roger[c], F. Rotaru[e], J-A. Scarpaci[j], M. Sénoville[g], O. Sorlin[c], M. Stanoiu[e], I. Stefan[a], D. Suzuki[a], J-C Thomas[c], M. Vandebrouck[c], G. Verde[a]

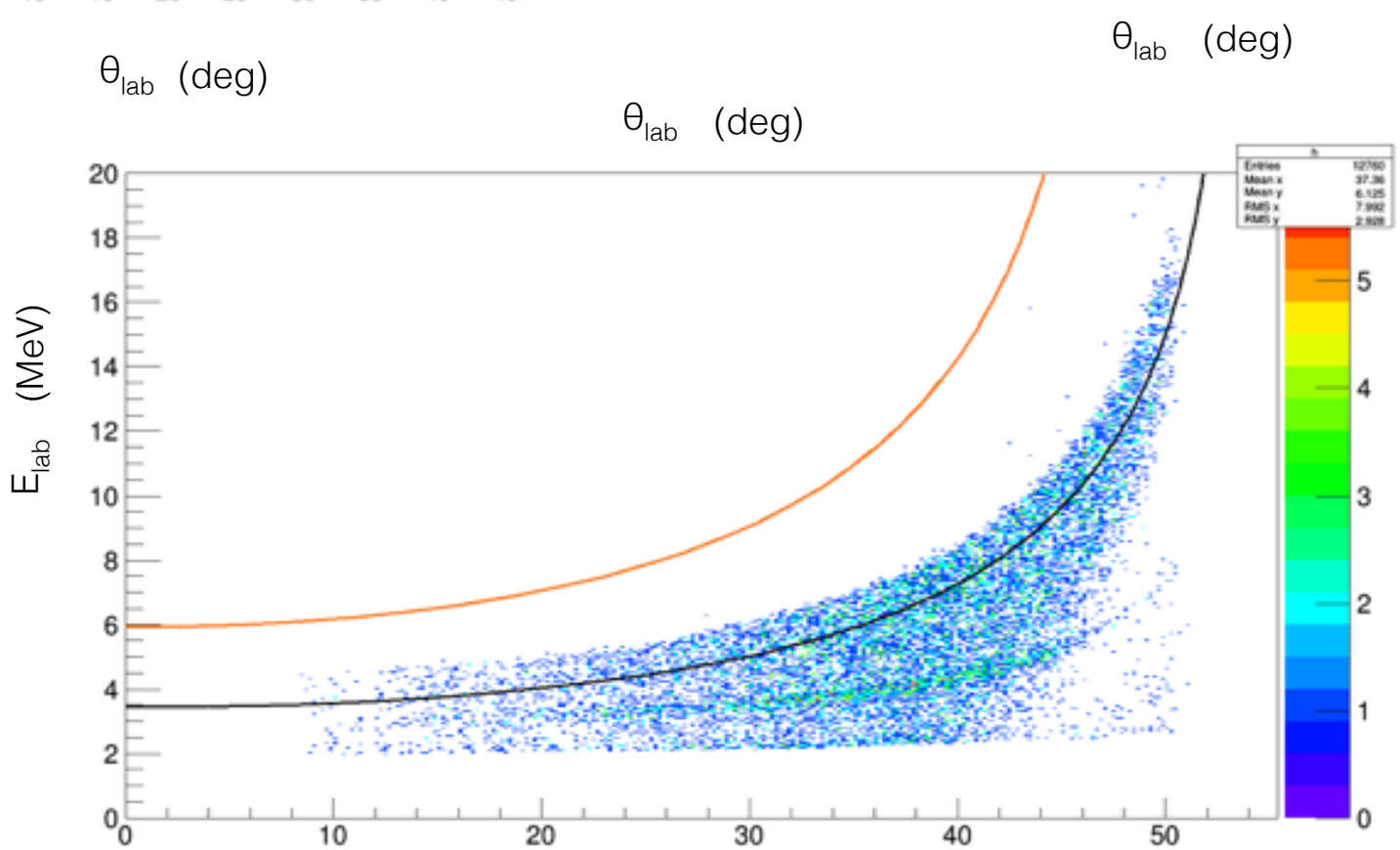
[a]Institut de Physique Nucléaire d'Orsay, Université Paris-Sud – CNRS/IN2P3, 91406 Orsay, France, [b]Laboratoire de Physique Corpusculaire de Caen, ENSICAEN – CNRS/IN2P3, 14050 Caen, France, [c]Grand Accélérateur National d'Ions Lourds, CEA/DSM – CNRS/IN2P3, 14076 Caen, France, [d]Centro de Física Nuclear da Universidade de Lisboa, 1649-003 Lisboa, Portugal, [e]Horia Hulubei National Institute of Physics and Nuclear Engineering, Măgurele, Romania, [f]Department of Physics, University of Surrey, Guildford GU2 5XH, United Kingdom, [g]Service de Physique Nucléaire, CEA-Saclay/IRFU, 91191 Gif-sur-Yvette, France, [h]Universidade de Santiago de Compostela, E-15782 Santiago de Compostela, Spain, [i]Laboratori Nazionali del Sud, Instituto Nazionale di Fisica Nucleare, Catania, Italy, [j]Centre de Sciences Nucléaires et Sciences de la Matière, Université Paris-Sud – CNRS/IN2P3, 91406 Orsay, France

$^{56}Ni(d,t)^{55}Ni$

$^{56}Ni(d,^{3}He)^{55}Co$







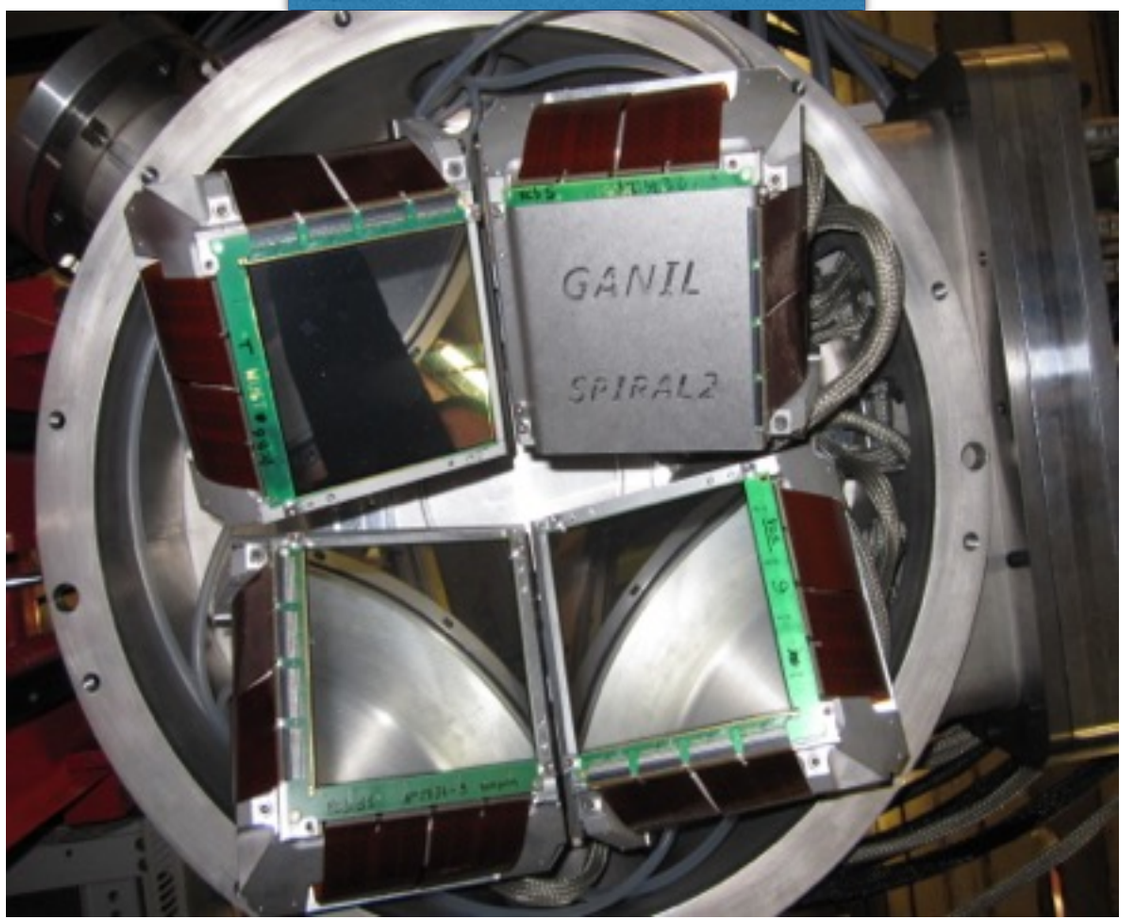
by Simulation

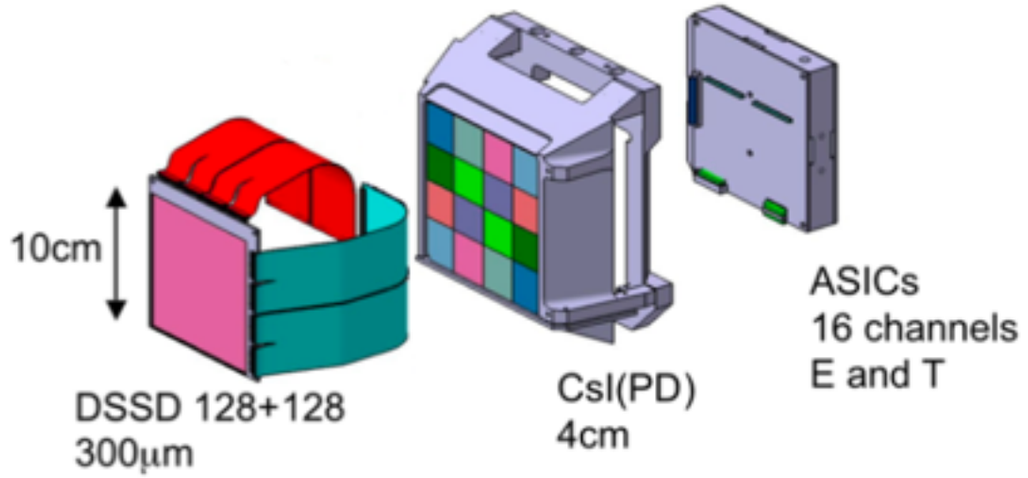
MUST2

^{56}Ni (d,^{4}He) ^{54}Co

^{56}Ni (d,t) ^{55}Co

MUST2





For the time calibration purposes a time calibrator module has been used. It generates a start and stop signal for each strip of the detector.

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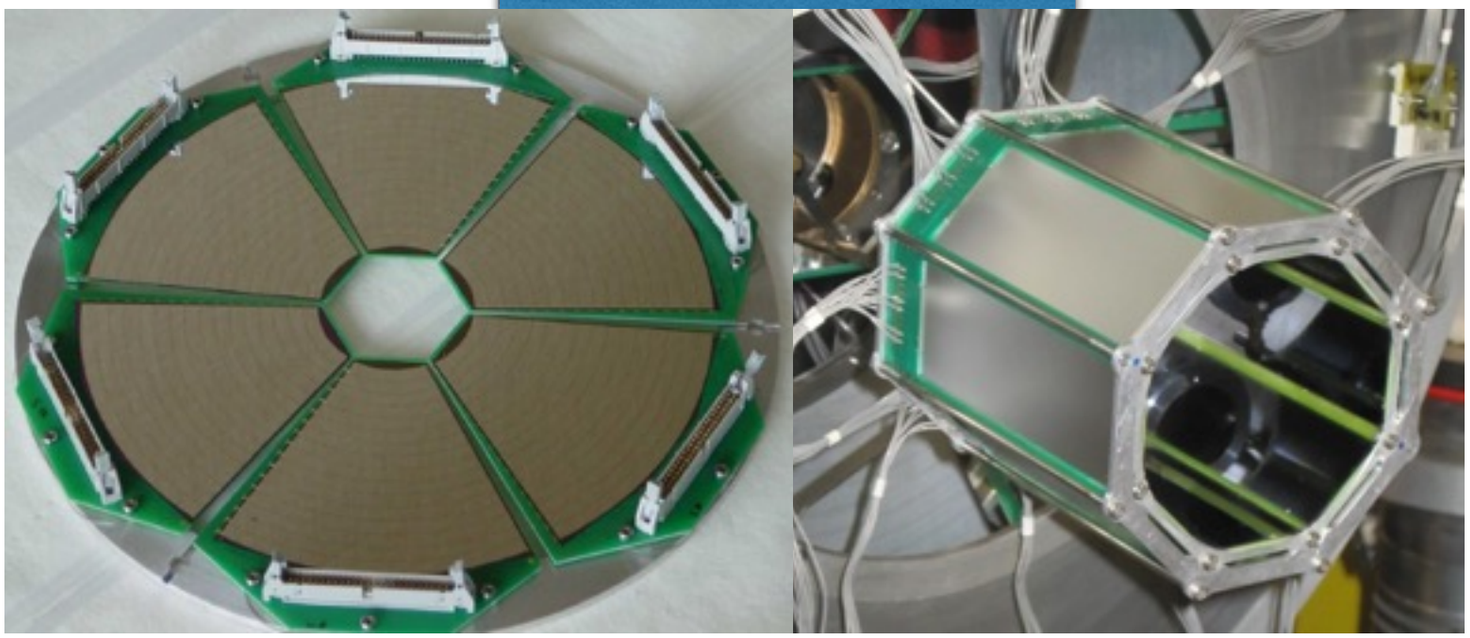
56Ni(d,p)57Ni

TIARA



TIARA(aka Transfer and Inelastic All-angle Reaction Array)
The SiHyBall annular detector (left) and the octagonal barrel (right).

BARREL

$^{56}Ni(d,d)^{56}Ni$

8 resistive charge division detectors

Thickness: 400 μm

HYBALL

$^{56}Ni(d,p)^{57}Ni$

6 individual wedge-shaped DSSSD

Thickness: 400 μm

Active surface segmented in 16 ring-shaped strings

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