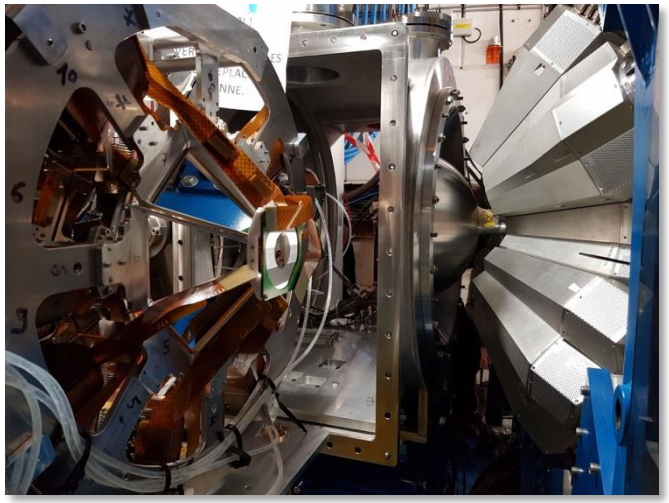
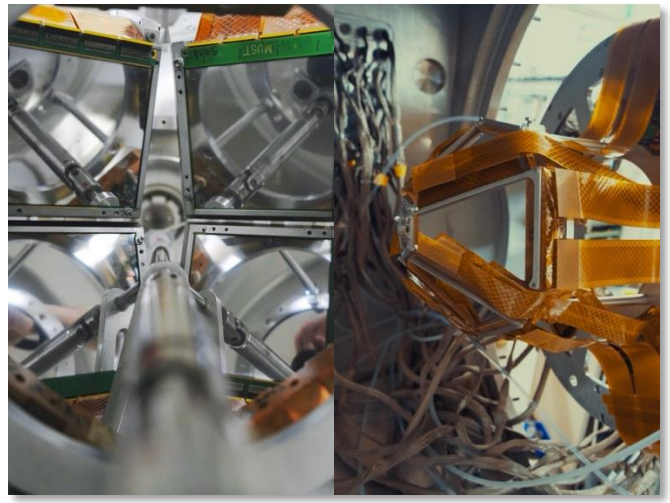
MUGAST and GRIT at GANIL



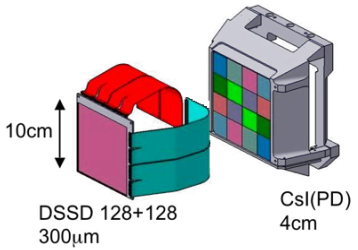


First ASTRANUCAP Workshop 2024

Girard-Alcindor Valérian - IJCLab

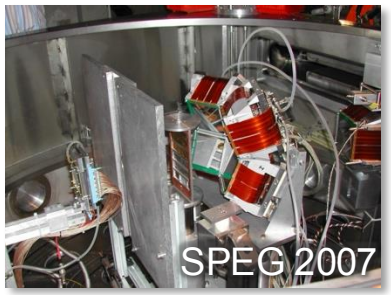
Presentation of MUST2/MUGAST

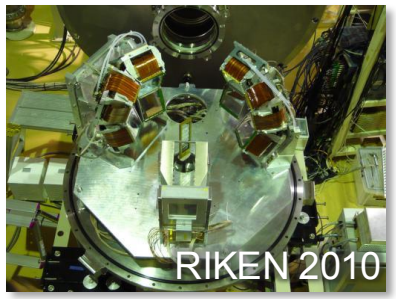
Presentation of MUST2/MUGAST



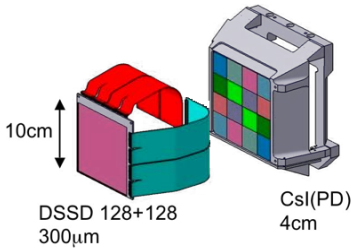
MUST2:

- 300 µm Si detector
- 4x4 CsI crystals
- Up to 8 telescopes
- In use since: 2007





Presentation of MUST2/MUGAST



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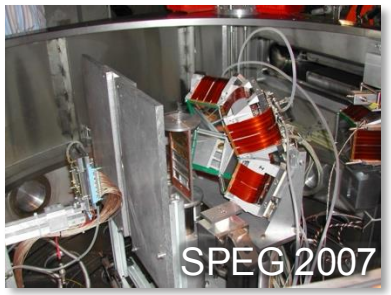
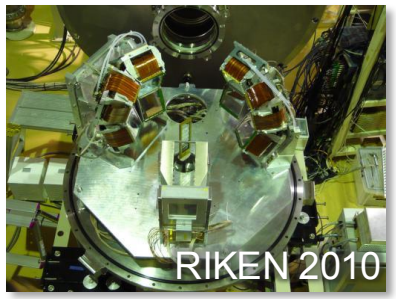
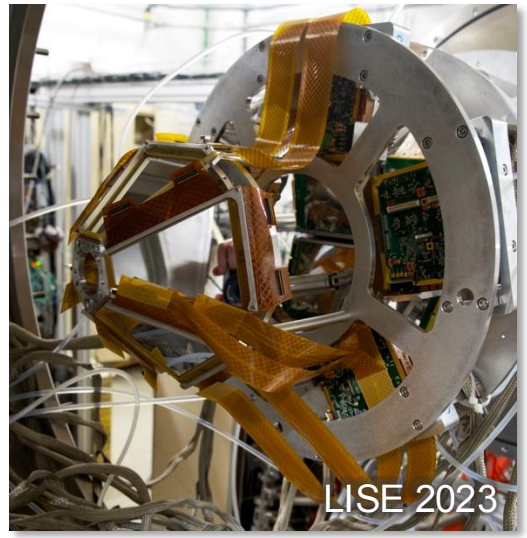




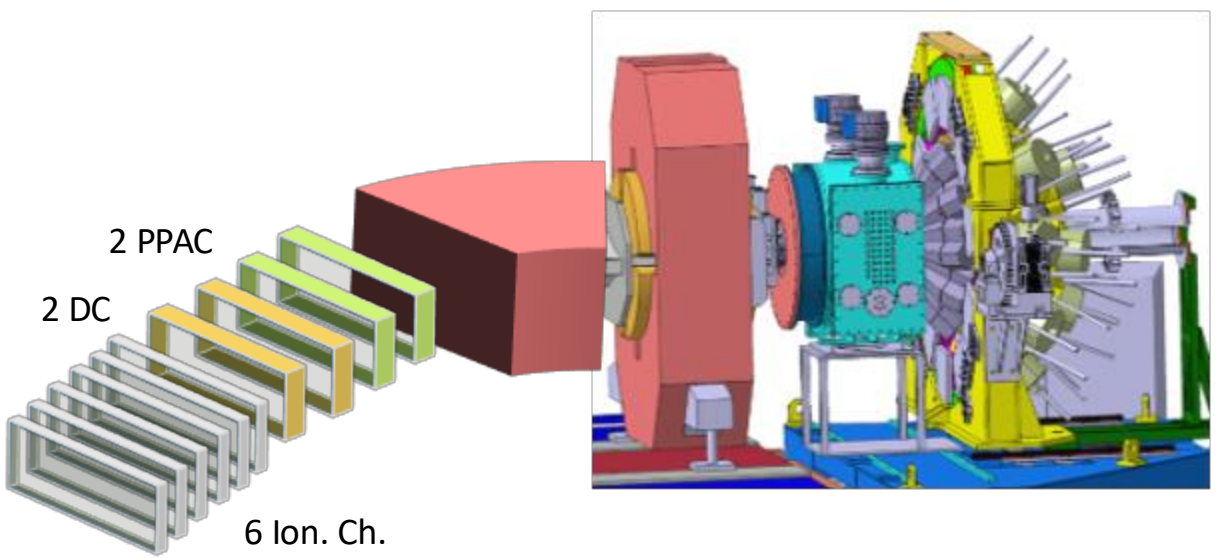


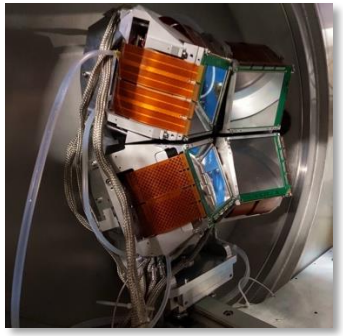
MUGAST:

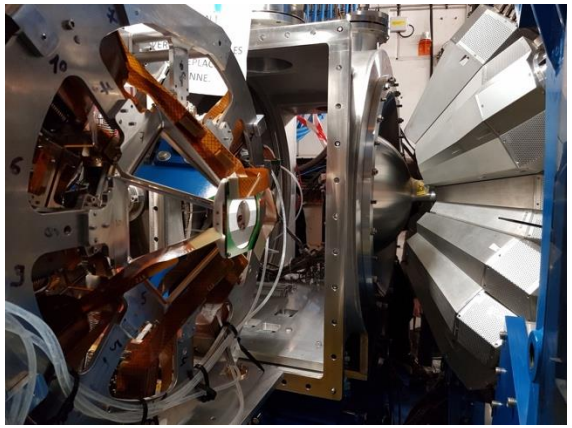
- First step toward the next generation Si detector: GRIT
- 4 MUST2 telescopes (forward)
- 5 - 7 trapezoid-shape 500 µm DSSD (backward)
- 1 annular DSSSD (backward)
- 2 square shape 500 µm DSSD + a 1.5 mm DSSD or 1 MUST2 (90°)
- In use at GANIL since: 2019 ISOL + Fragmentation beam

MUGAST/VAMOS/AGATA Campaign

MUGAST-VAMOS-AGATA: 2019 - 2021



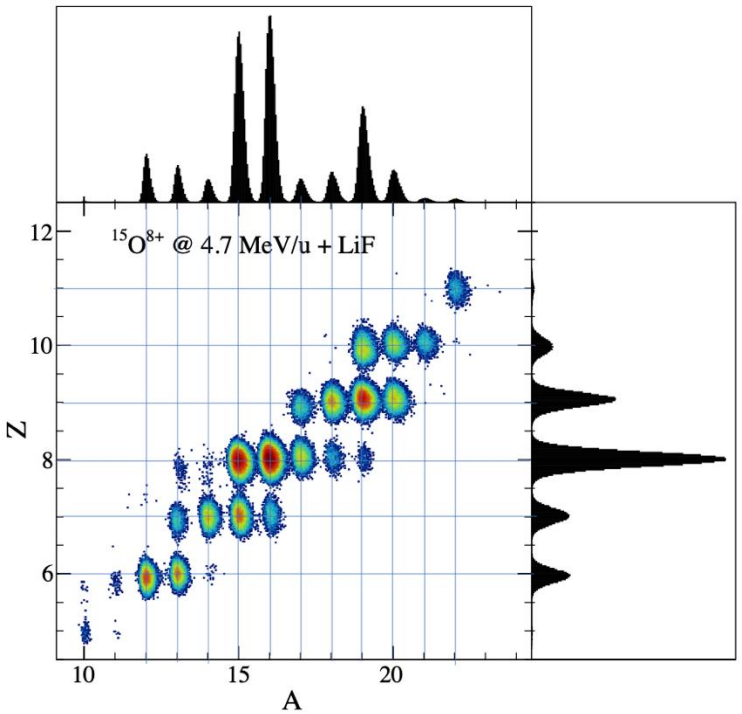




- 0º Detection: VAMOS
- AGATA Ge y-ray spectrometer
- 4 MUST2 telescopes (forward)
- 5-7 trapezoidal DSSD + 1 Annular DSSD (backward)
- 2 Square DSSD or 1 MUST2 at 90º
- Cryogenic-target compatible

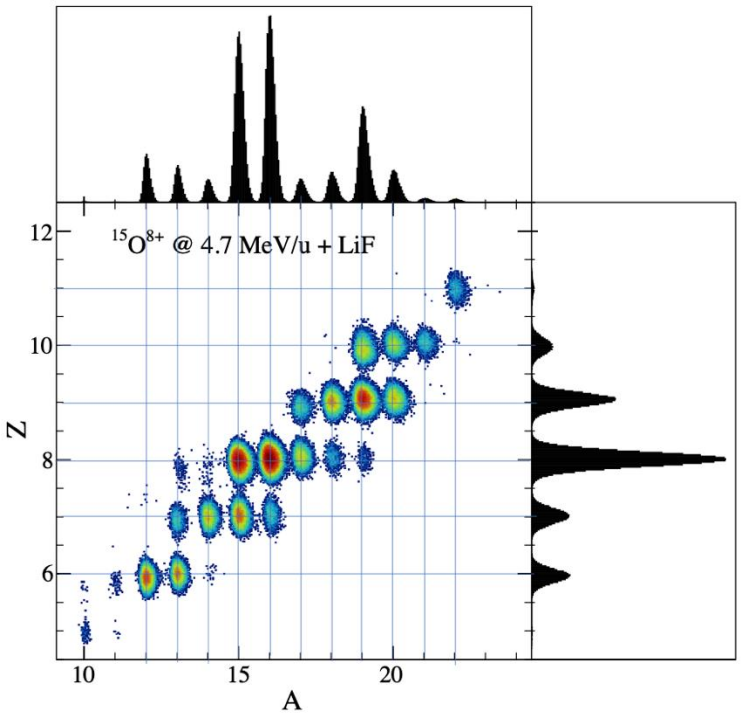
- 5 experiments (2019-2021)
  - Shell-model
  - Drip-line
  - Nuclear astrophysics

“Heavy” fragments PID in VAMOS:

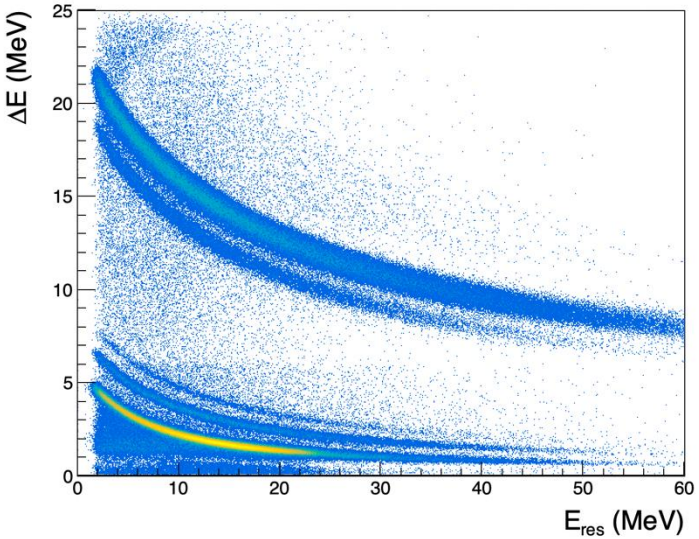


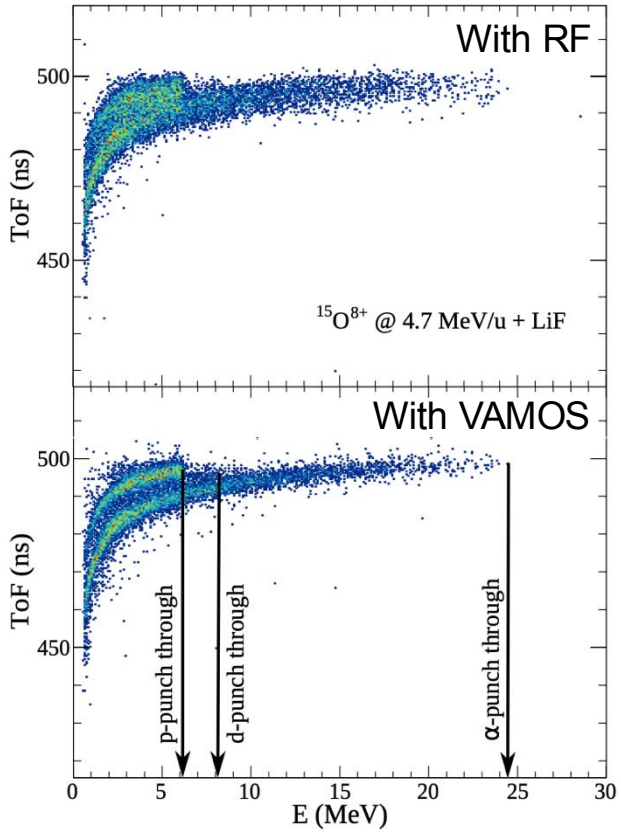
M. Assié Volume 1014, 21 October 2021, 165743

"Heavy" fragments PID in VAMOS:



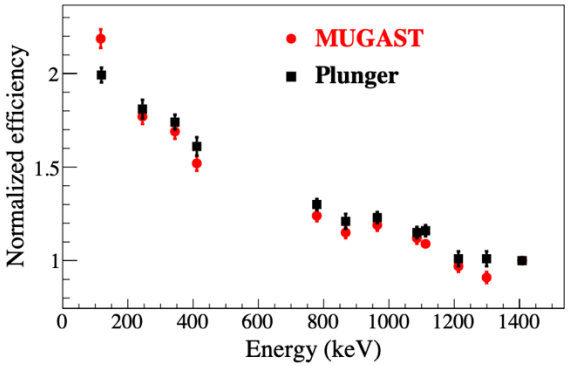
Light particles PID in MUGAST:



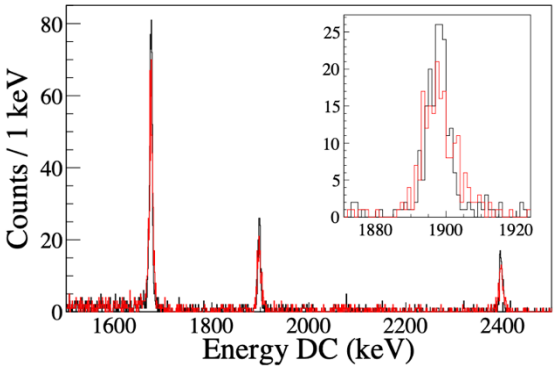


M. Assié Volume 1014, 21 October 2021, 165743

Efficiency MUGAST = plunger:



10.2 keV -> 7.1 KeV (FWHM):



M. Assié Volume 1014, 21 October 2021, 165743

MUGAST-VAMOS-AGATA: 2019 - 2021

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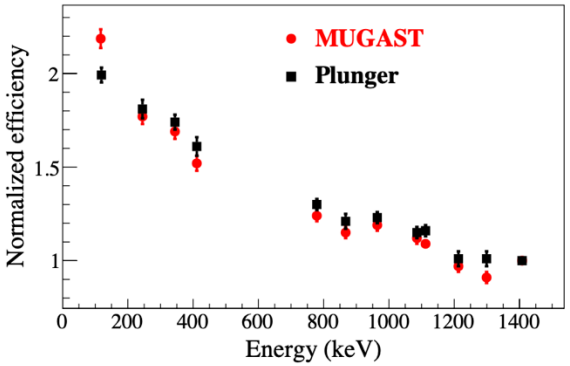

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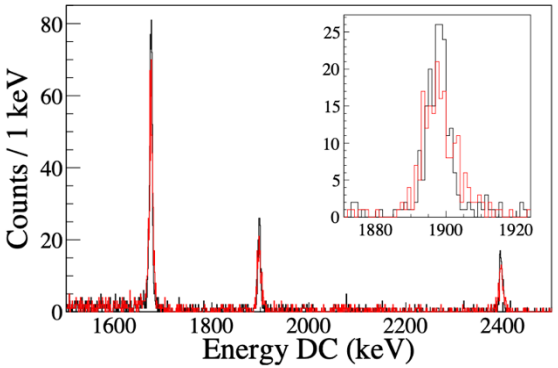
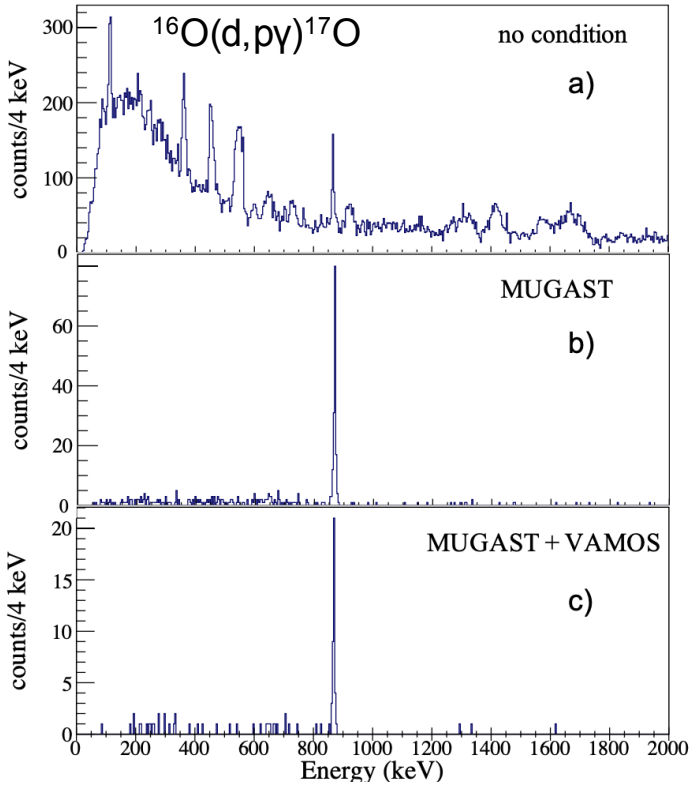


M. Assié Volume 1014, 21 October 2021, 165743

Excellent background reduction:



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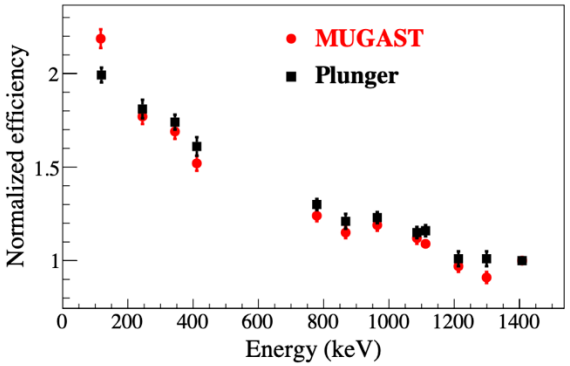

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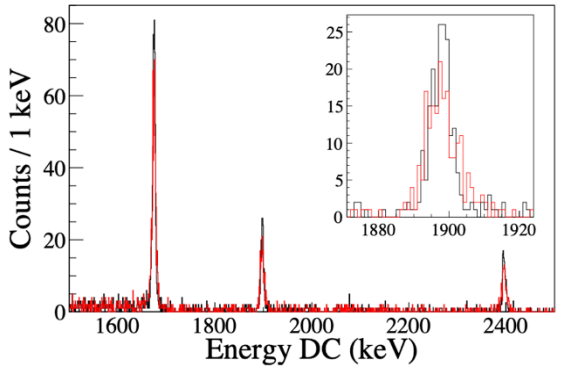

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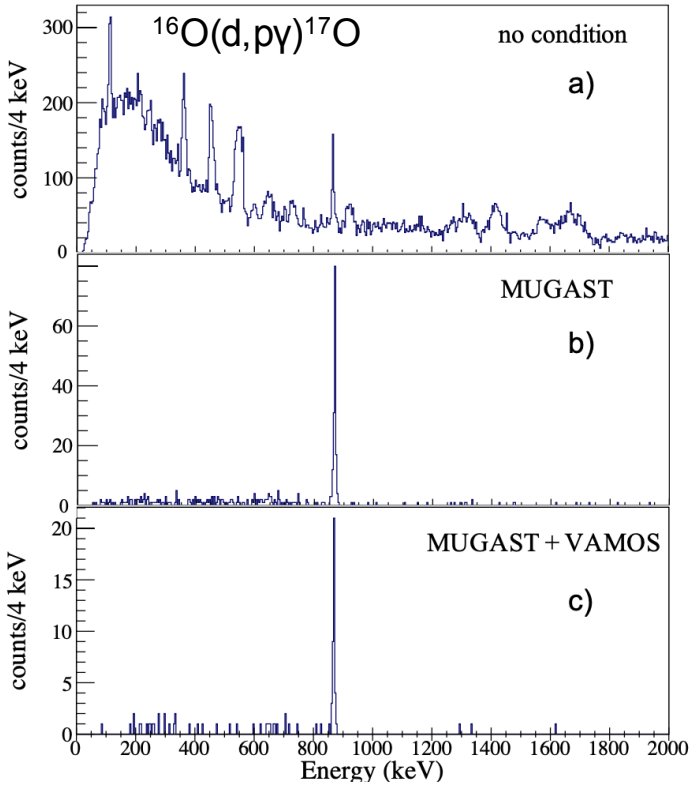
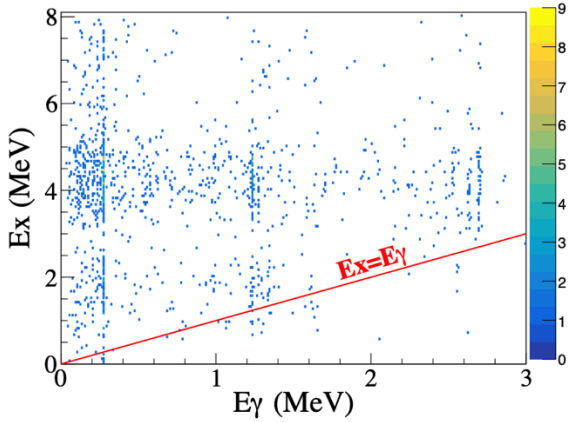


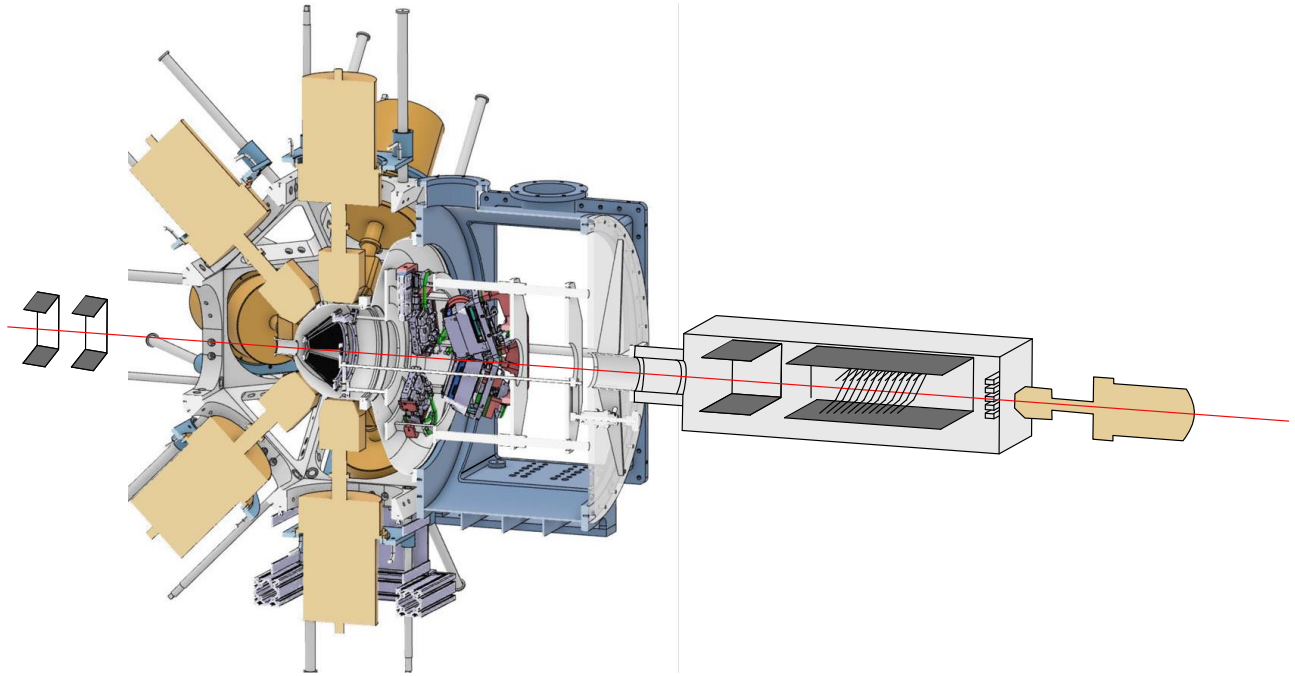
Missing mass + gamma spectroscopy:



The new LISE campaign: 2023-2026?

MUGAST@LISE campaign 2023-2026?

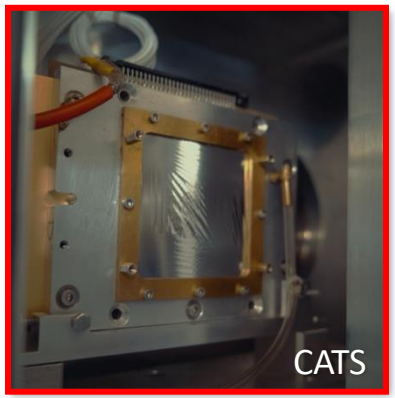
Setup:

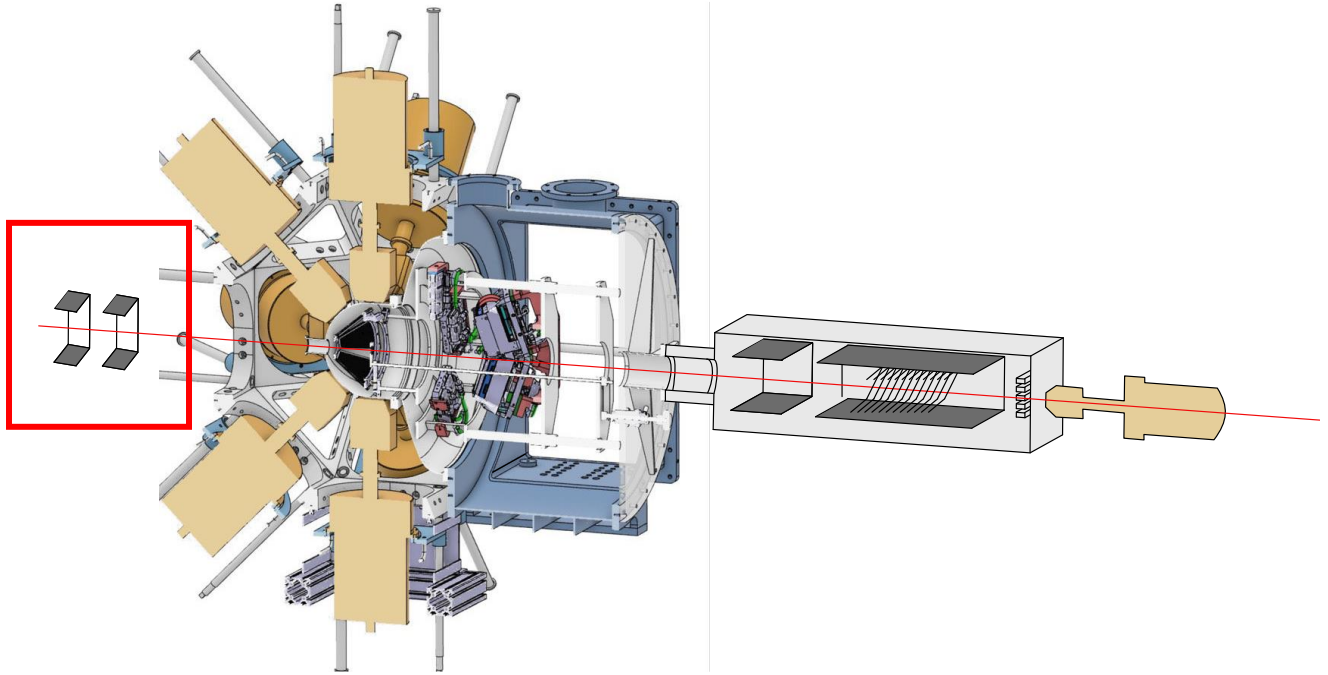


MUGAST@LISE campaign 2023-2026?

Setup:

- CATS beam tracker





MUGAST@LISE campaign 2023-2026?

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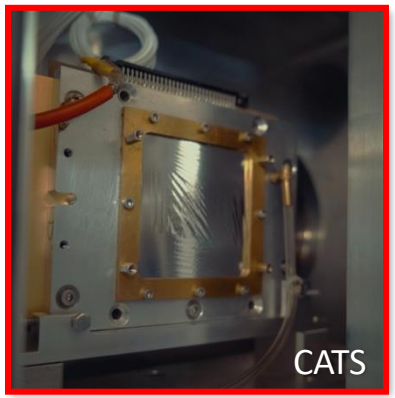
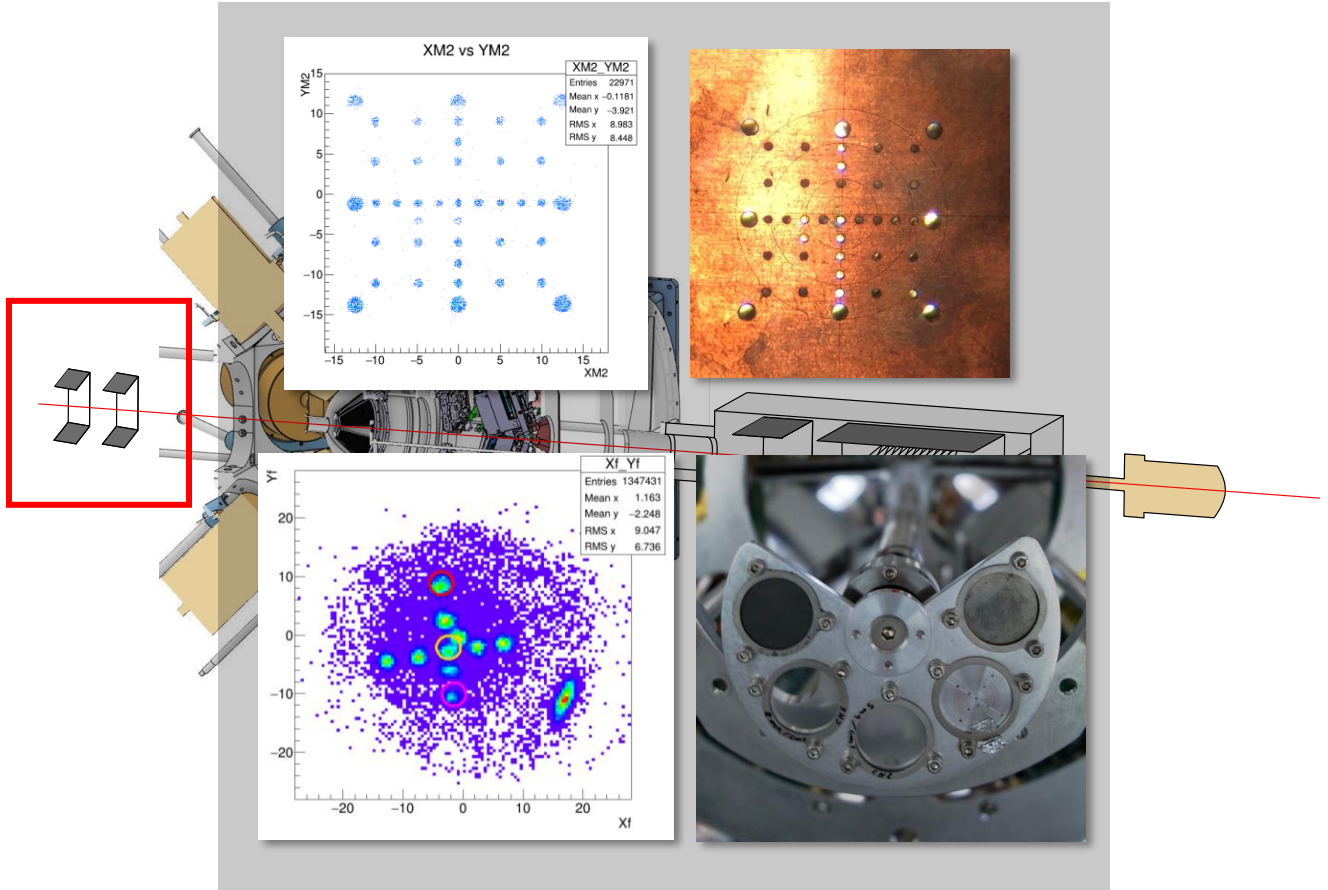


Mask on CATS:



MUGAST@LISE campaign 2023-2026?

Setup:

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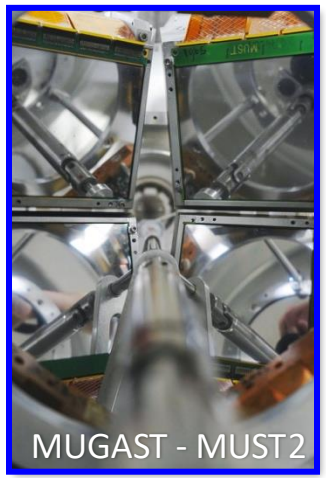
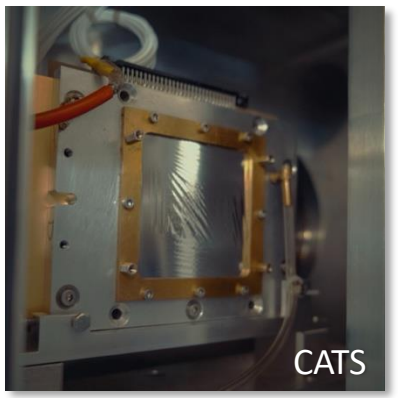
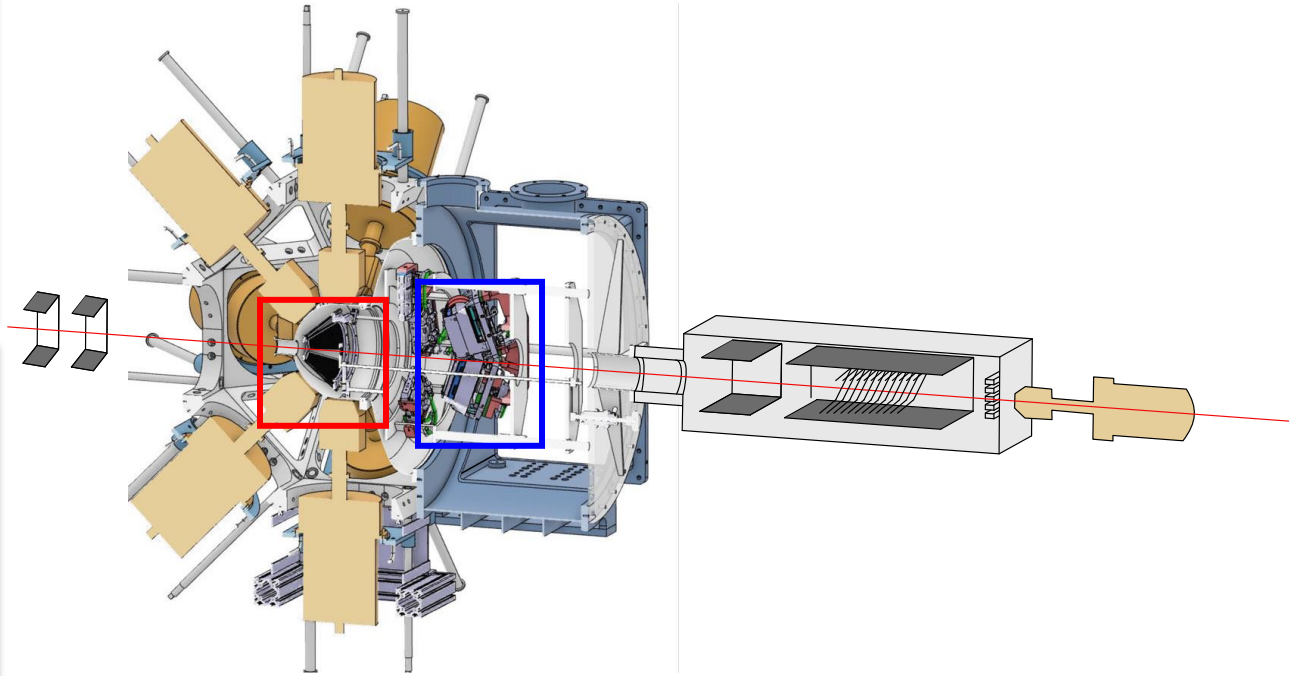
- 5 trapezoidal DSSD (backward)
- 4 MUST2 telescopes (forward)
  - 300 um DSSSD
  - CsI crystals







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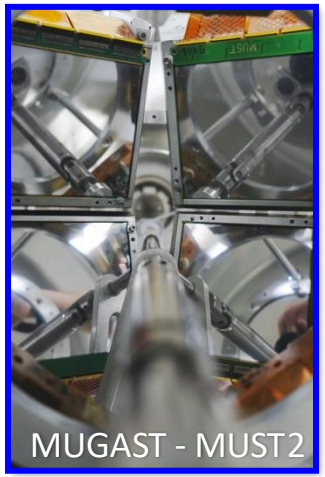

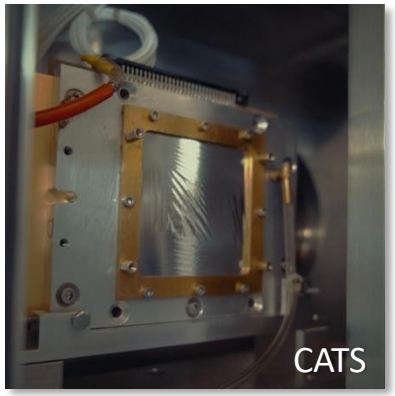

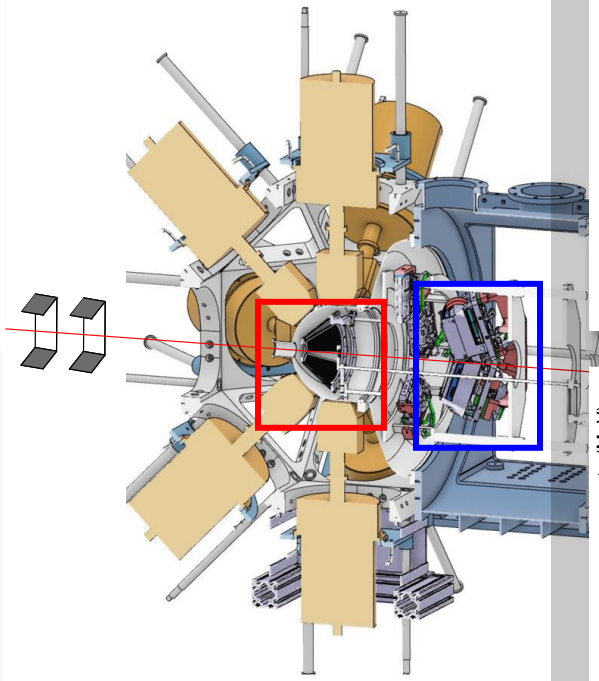

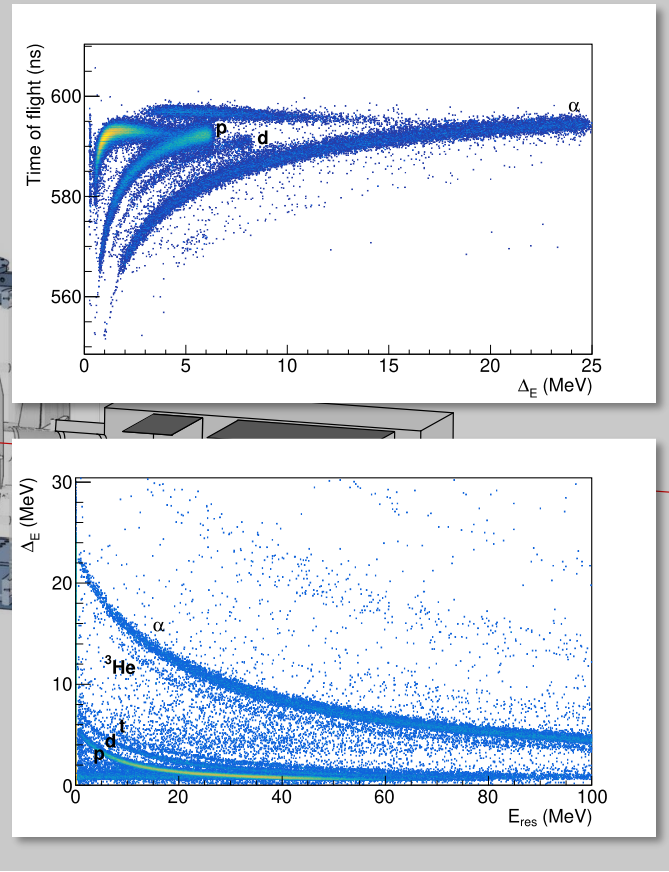

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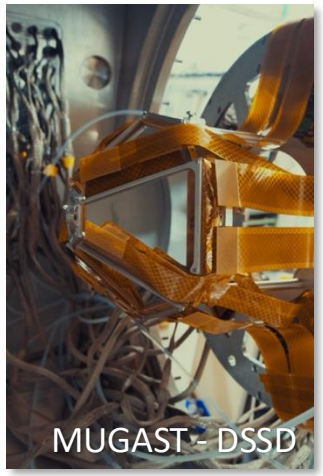

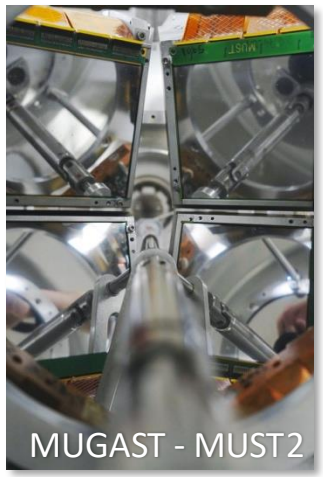

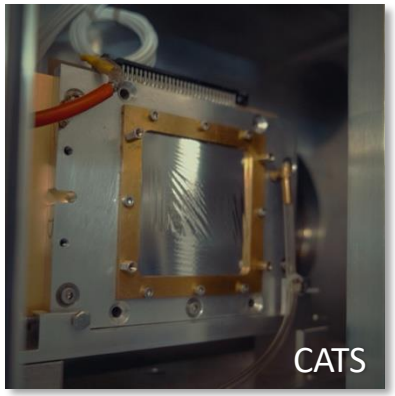

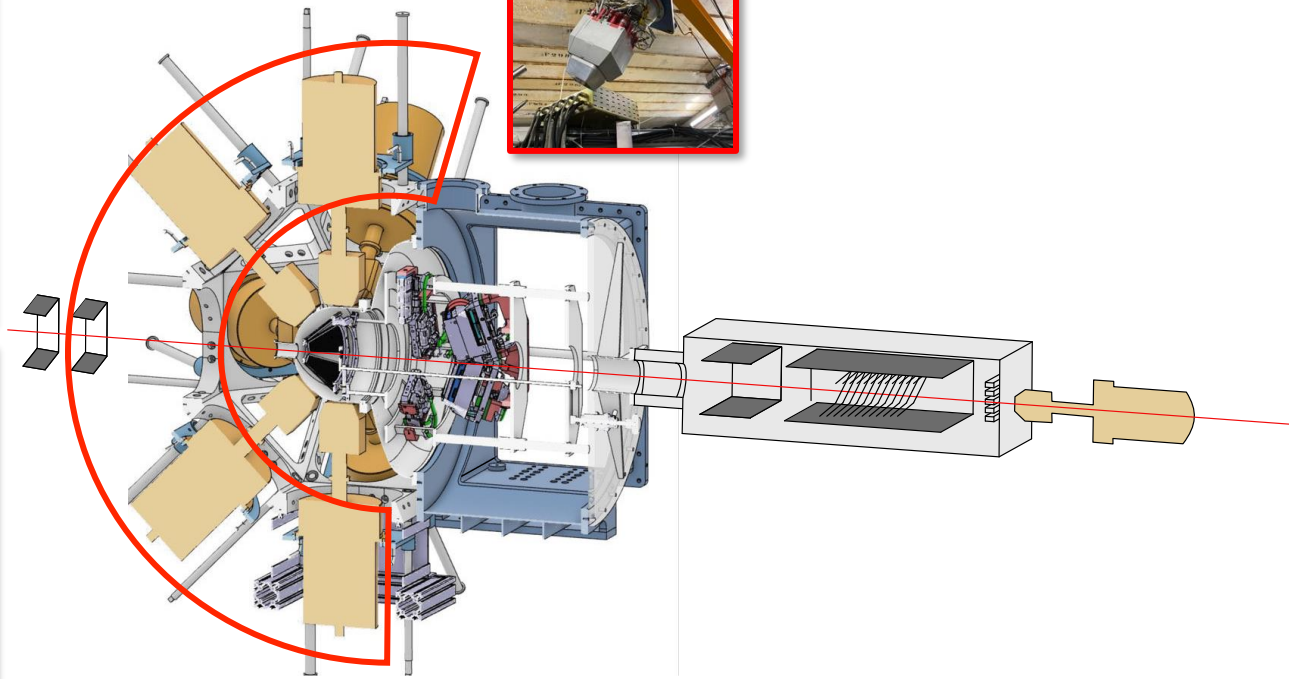

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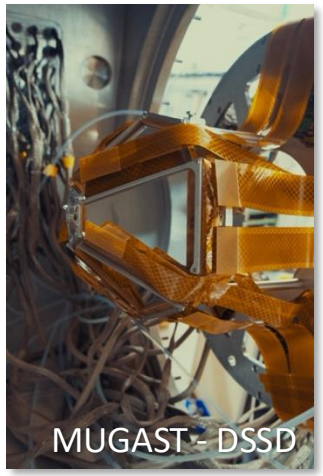
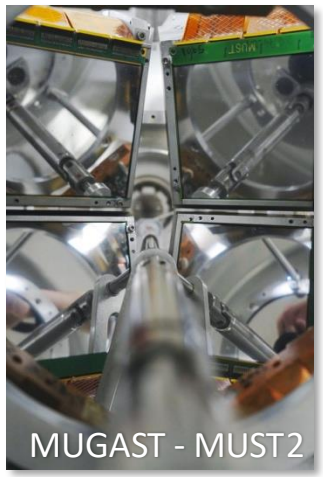
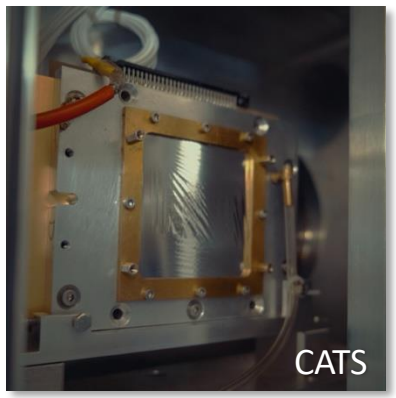
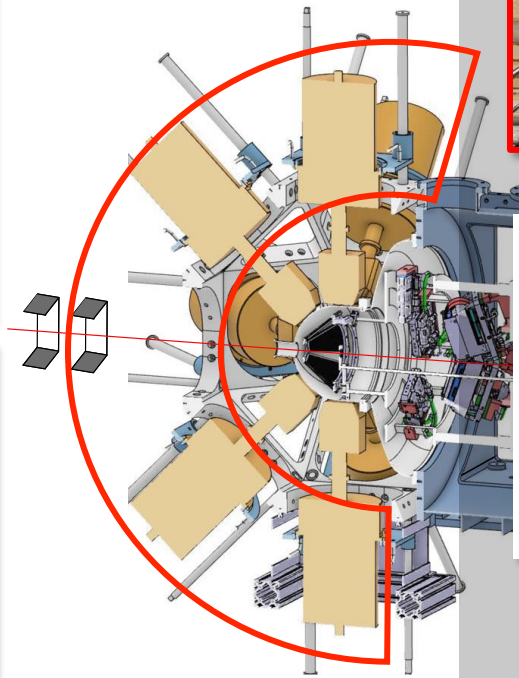
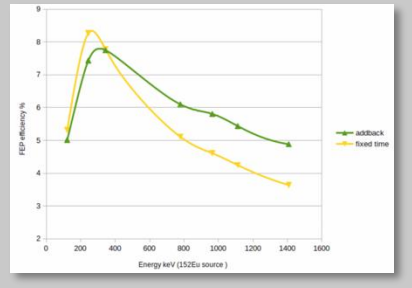


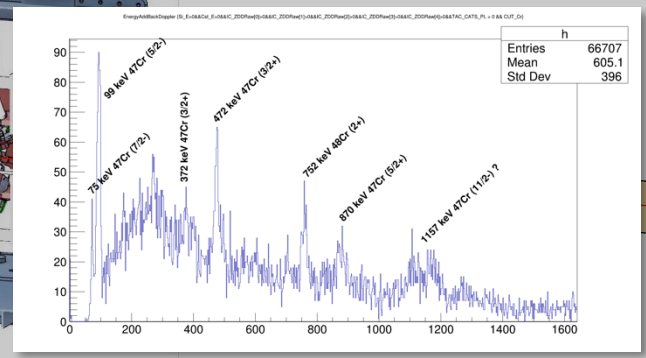








Courtesy of Ozgë Aktas



Example of online add-back doppler corrected spectra

MUGAST@LISE campaign 2023-2026?

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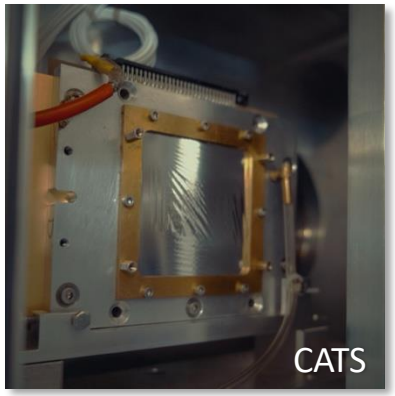
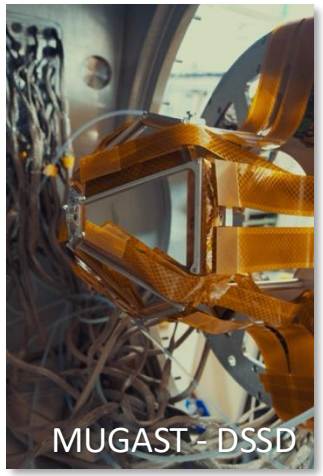
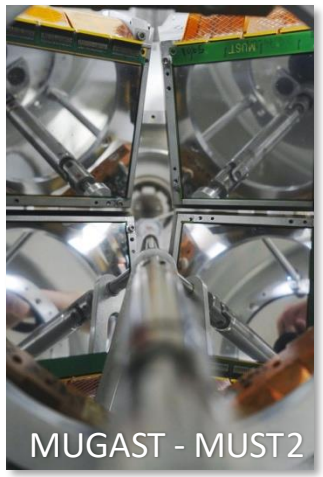
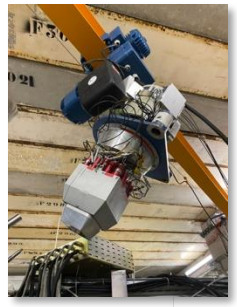
- Exogam Ge y-ray spectrometer
- 0° Detection: ZDD from LISE
  - Drift chamber (DC)
  - Ionization chamber (IC)
  - Plastic detector
  - Exogam









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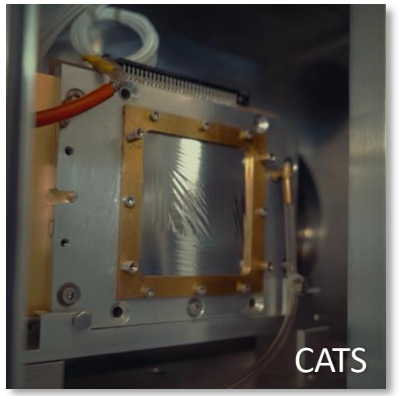
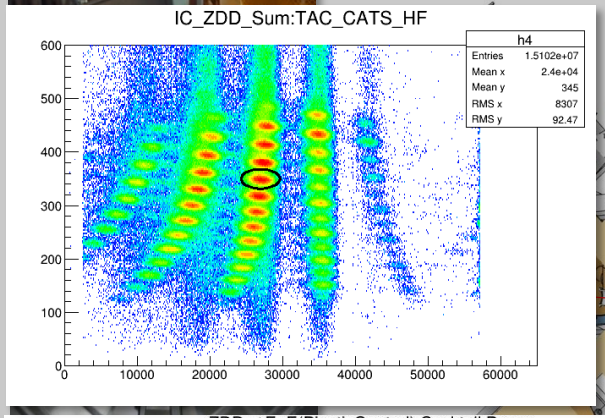
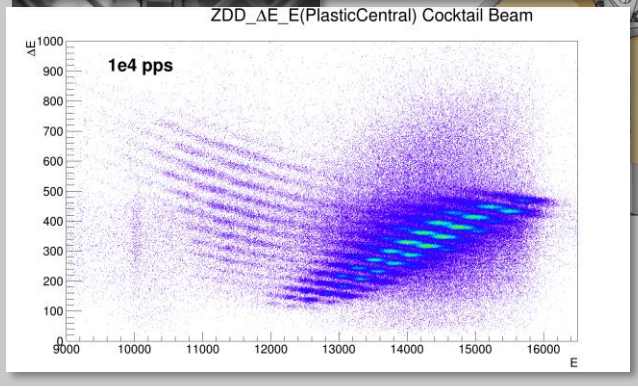
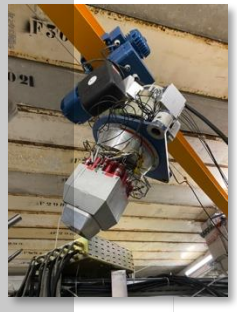


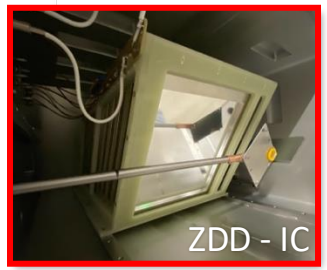
Damage to the central plastic

- No ΔE-E
- identification ΔE-ToF







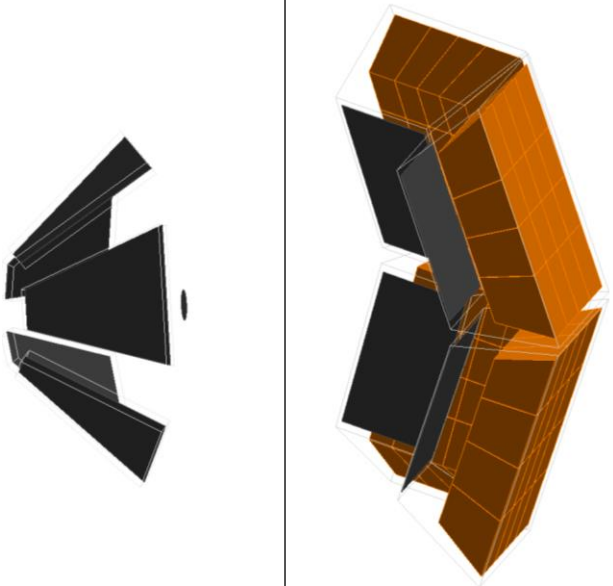


MUGAST@LISE2023

SO-splitting around the N = 40/50 shell gap

S. Koyama and O. Sorlin, Postdoc: Ozgë Aktas:

- Beam : ^{68}Ni at 18 MeV/u and 40 MeV/u, 10^5 pps, 80% purity
- Target : CH_2 5 mg/cm^2 and CD_2 0.5 mg/cm^2
- Reaction studied: ^{68}Ni(p, d)^{67}Ni, ^{68}Ni(d, p)^{69}Ni
- Topic: SO splitting and N=40/50 shell gap



Courtesy of O. Aktas

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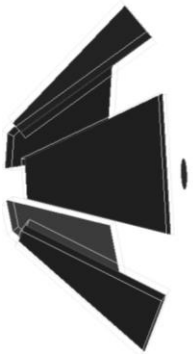

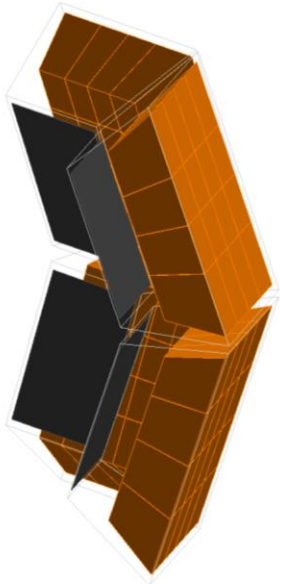

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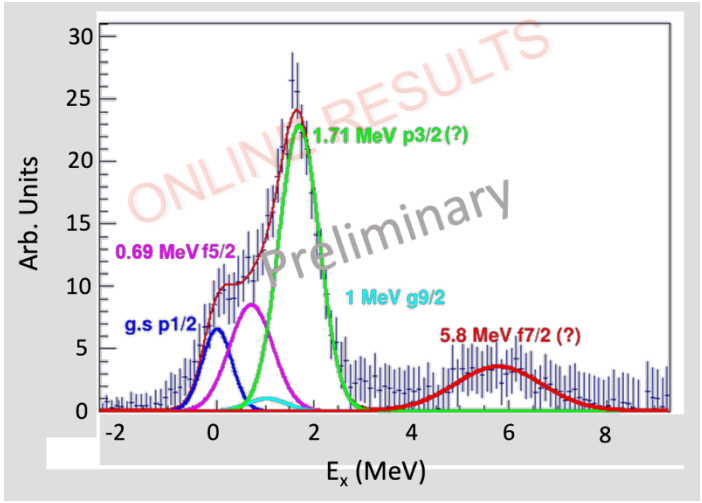

- $f_{5/2} - f_{7/2}$ SO splitting
- $p_{1/2} - p_{3/2}$ SO splitting
- Partial filling of the $g_{9/2}$ orbital

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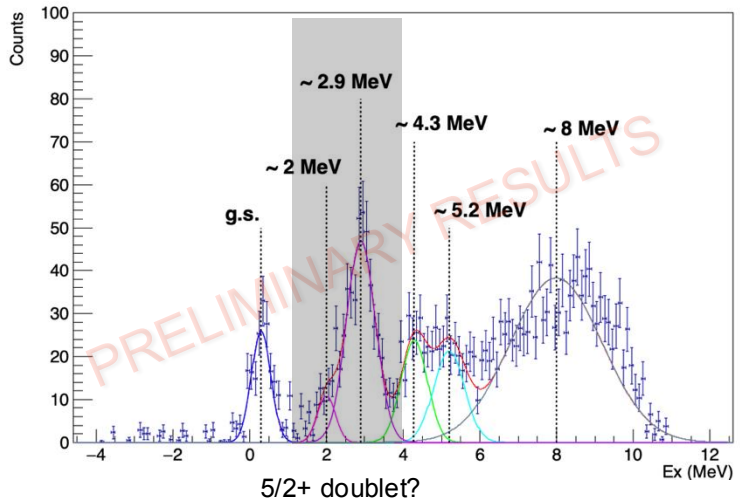
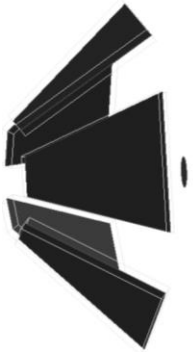
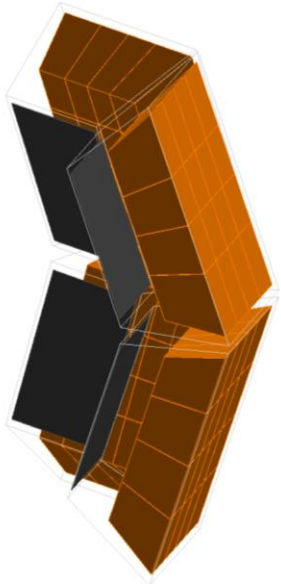


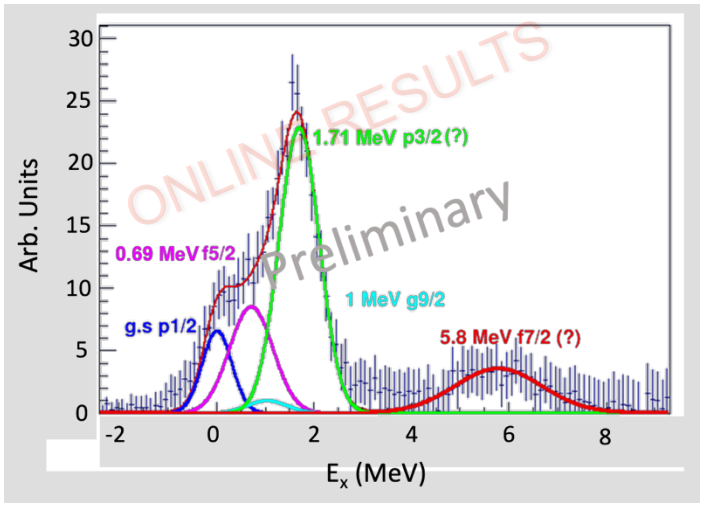
5/2+ doublet?





- $g_{9/2} - d_{5/2}$ spacing
- $g_{9/2} - g_{7/2}$ SO splitting ?
- Hint of the expected 5/2+ doublet?

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



- $f_{5/2} - f_{7/2}$ SO splitting
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Courtesy of O. Aktas

Two-nucleon transfer: $^{48}Cr(p,^{3}He)^{46}V$

M. Assié, PhD: Hugo Jacob

- Beam : ^{48}Cr at 30 MeV/u, 2×10^{5} pps, 95% purity
- Target : CH_2 5 mg/cm^2
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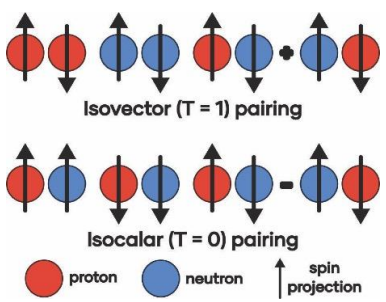
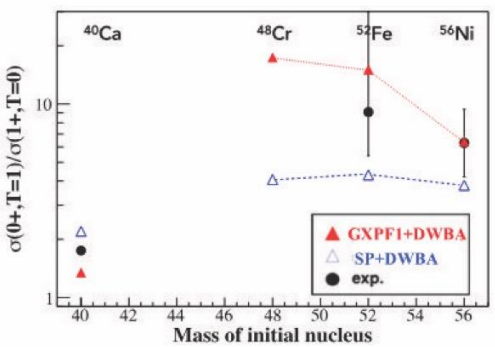
- Topic: Influence of deformation on neutron-proton pairing





- Study competition between p-n and like-particle pairing in N=Z nuclei
- Deformation of ^{48}Cr could imply reduced T=0 pairing contribution
- $(p,^{3}He)$ transfer reaction rules allow population of both 0+ and 1+ channels to measure $\sigma(0+)/\sigma(1+)$ ratio

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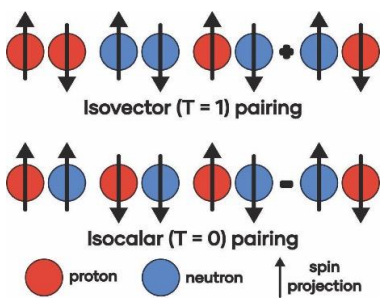

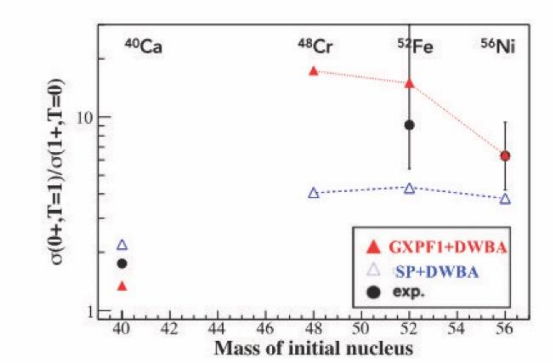

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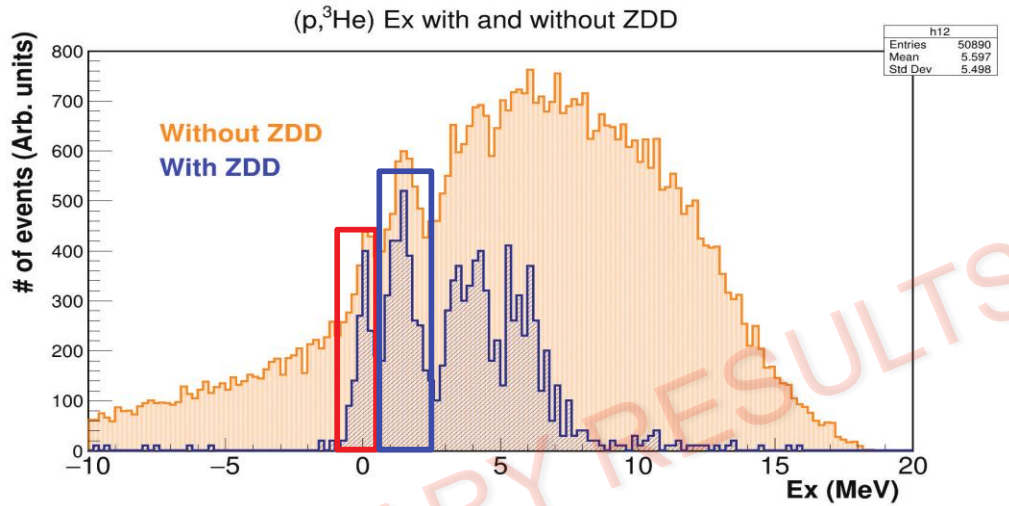

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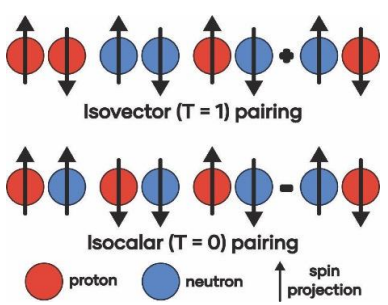

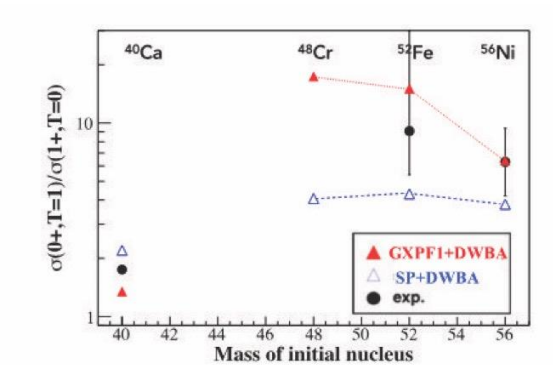

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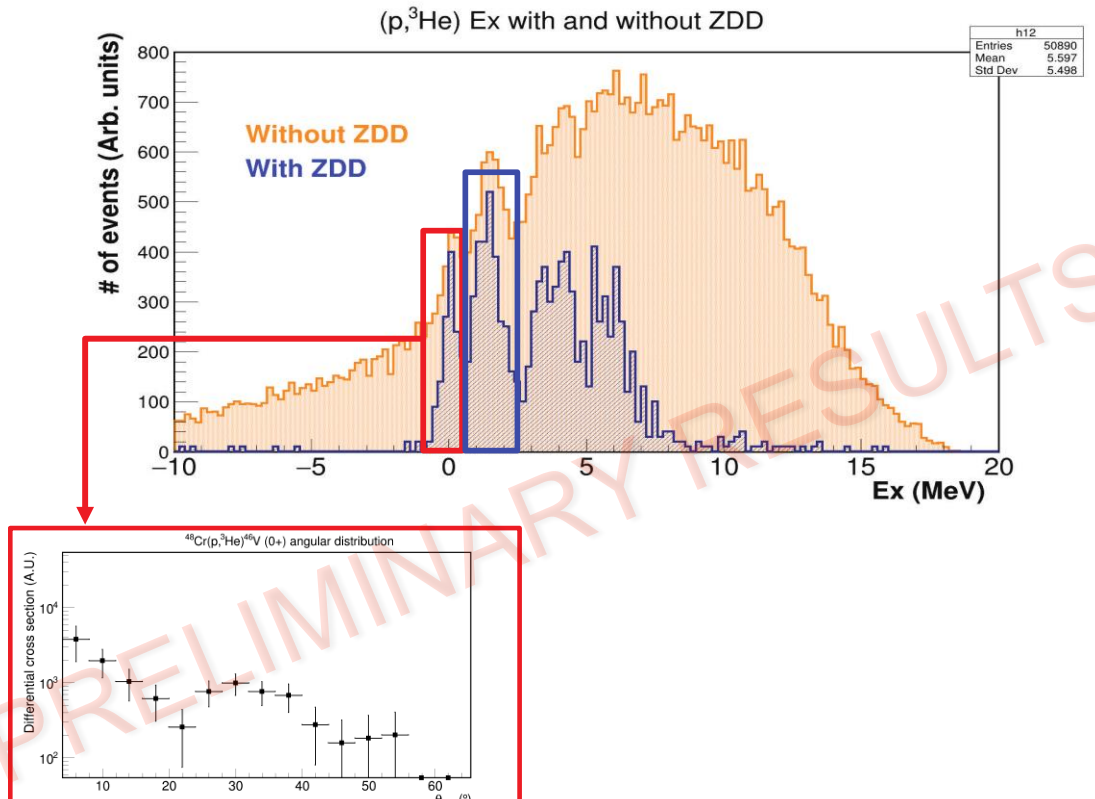

- Consistent with l = 0
- DWBA calculation on the way

Courtesy of H. Jacob

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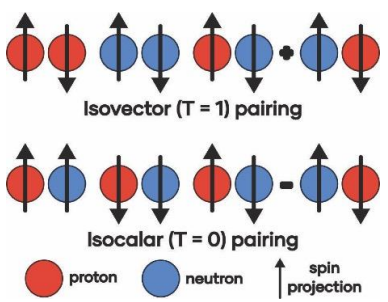

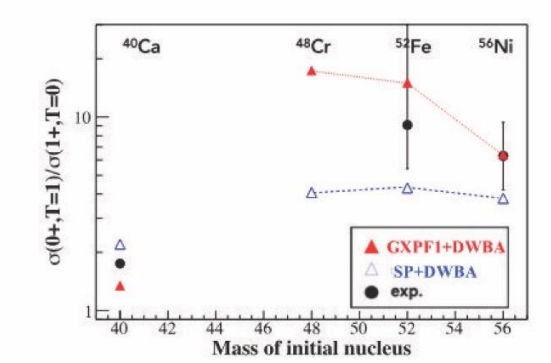

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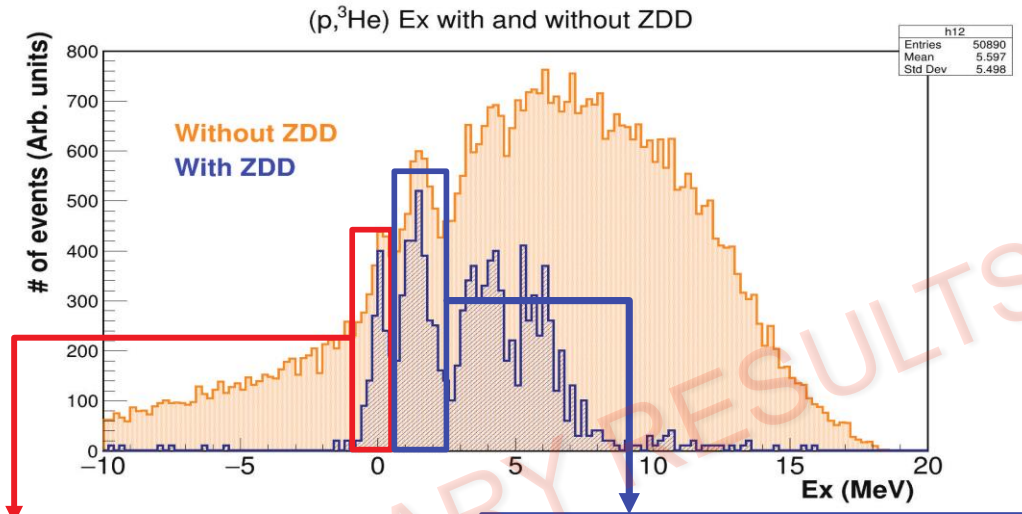

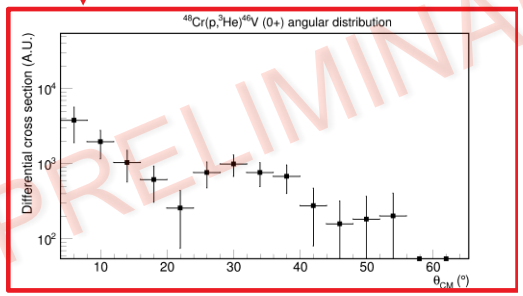

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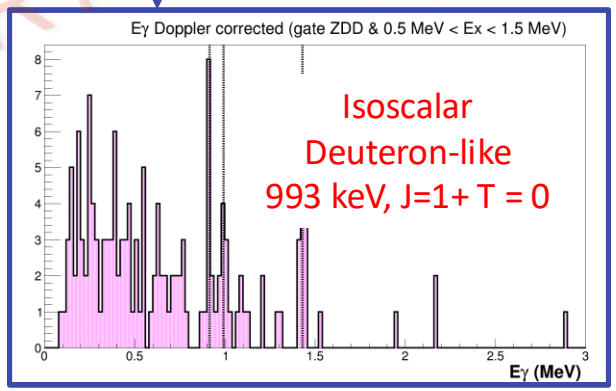

1+ peak clearly visible!

Courtesy of H. Jacob

MUGAST@LISE2024

Evolution of the neutron $1d_{3/2}$-$1d_{5/2}$ spin-orbit splitting in N = 19 isotones and Fermi surface in ^{34}Si

F. Galtarossa, PhD: Raquel Nicolás De Álamano:

- Beam : ^{34}Si
- Target : CH_2 5 mg/cm^2
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- Topic: SO splitting and Fermi surface in ^{34}Si

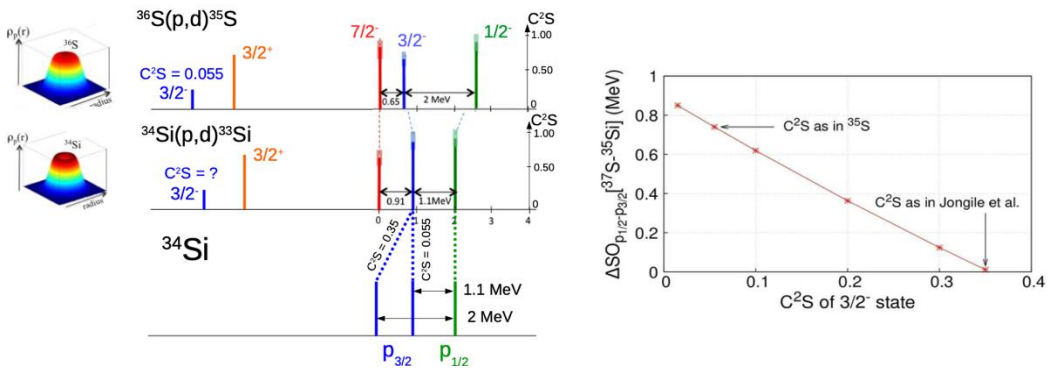

FIG. 3: Pictorial representation (left) and graphic (right) of the predicted variation of the difference between the $\nu p_{1/2}$-$\nu p_{3/2}$ SO splitting in ^{37}S and in ^{35}Si as a function of the C^{2}S of the $3/2^-$ state at 1.981 MeV in ^{33}Si.

Courtesy of R. Nicolás De Álamano

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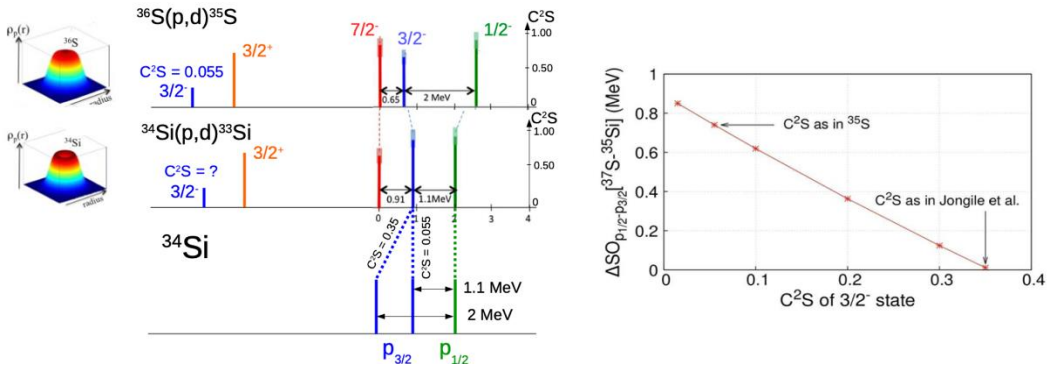

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The experiment failed:

- Hardware DAQ issue (20/30% efficiency only)
- Issue with CATS validation
- Late discovery of both issues ~ 7.5 UT lost (mostly ^{36}S)
- 2.5 UT of good data then accelerator failure

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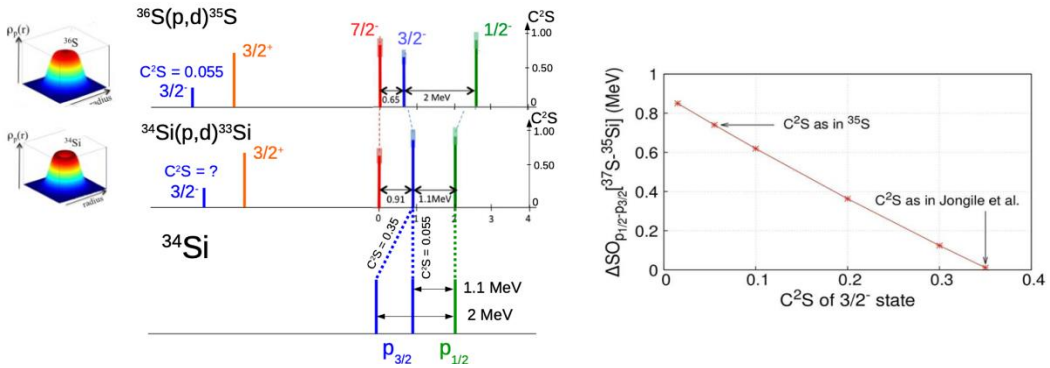

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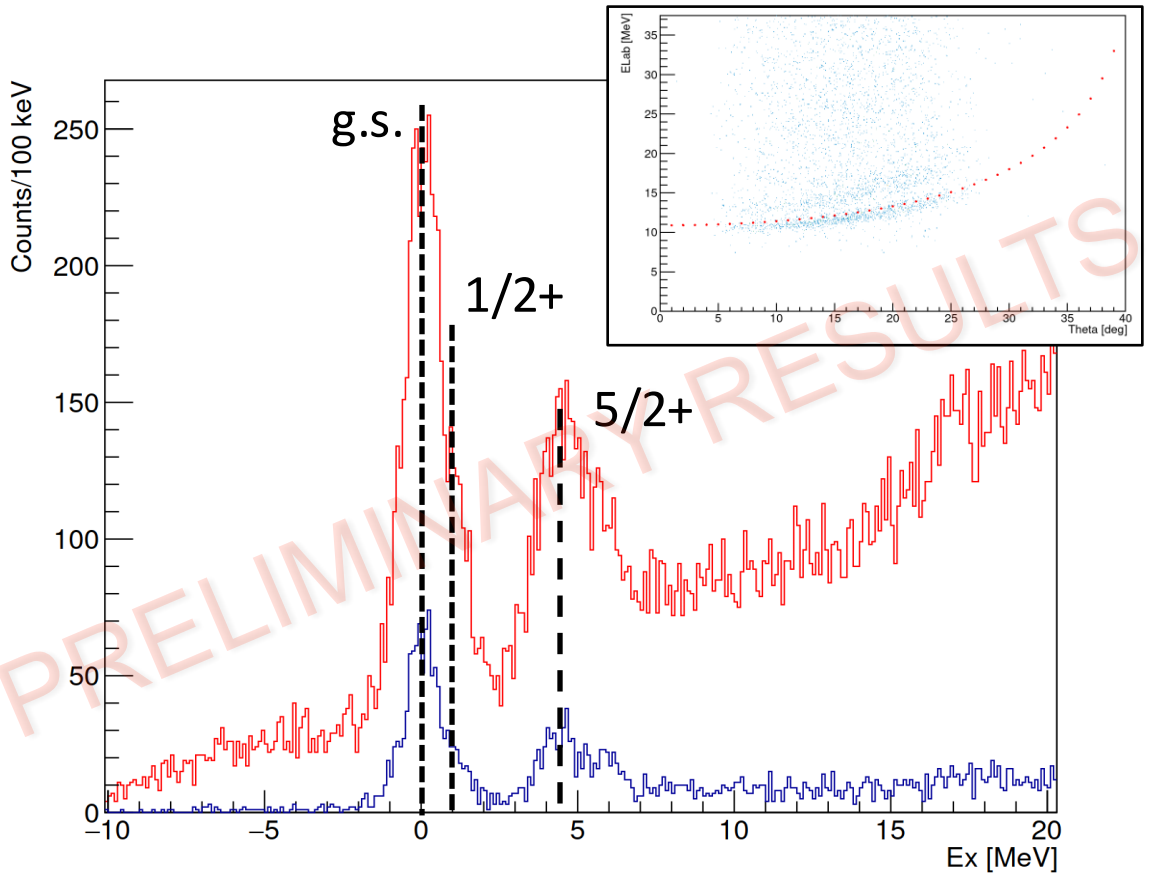


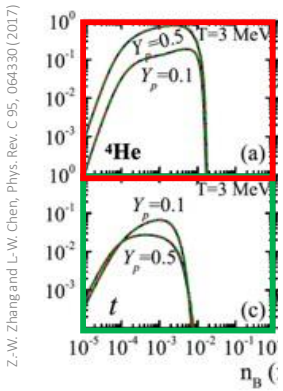
Encouraging preliminary results -> Rescheduled next year!

Courtesy of R. Nicolás De Álamano

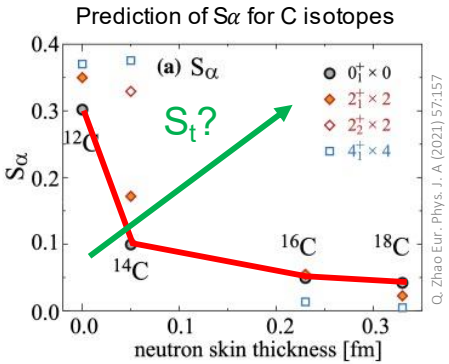
Cluster structure of the ground state of light exotic nuclei beyond alpha-clustering

VGA, D. Beaumel, PhD: Tania Zanatta Martínez:

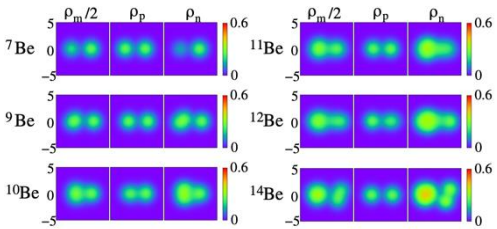
- Beam : ^{10,12}Be
- Target : CH_2 5 mg/cm^2, CH_2 5 mg/cm^2
- Reaction studied : ^{10,12}Be(p, α), ^{10}Be(d,^{6}Li)
- Topic: Triton clustering in light exotic nuclei



Z.-W. Zhang and L.-W. Chen, Phys. Rev. C 95, 064330 (2017)



Q. Zhao Eur. Phys. J. A (2021) 57:157



g.s. of Be isotopes are well described by 2 α clusters.

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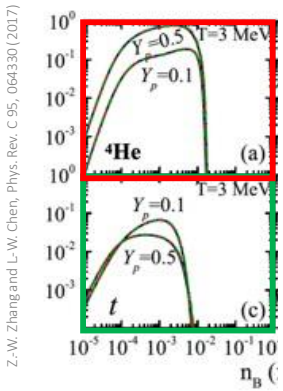

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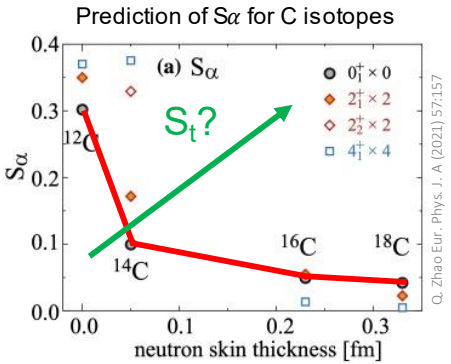

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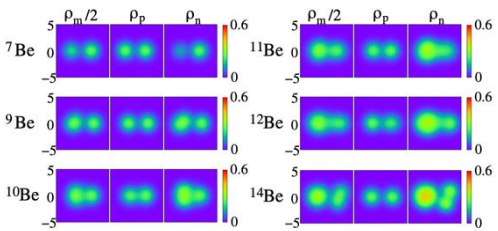

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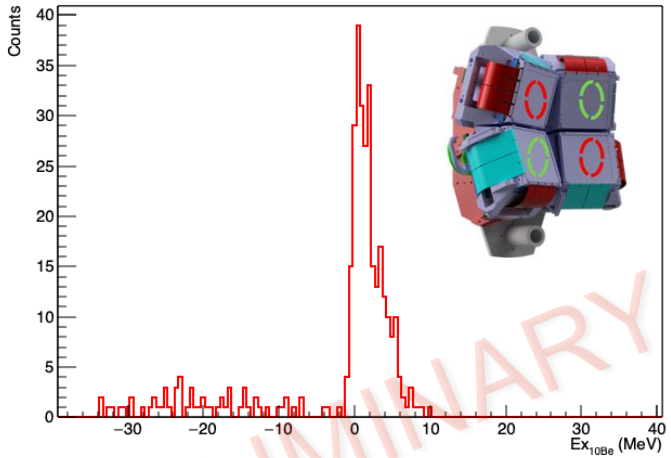
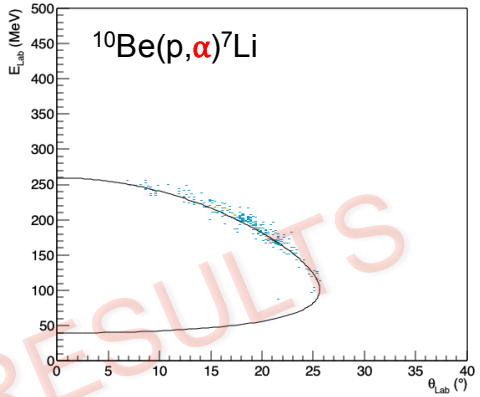
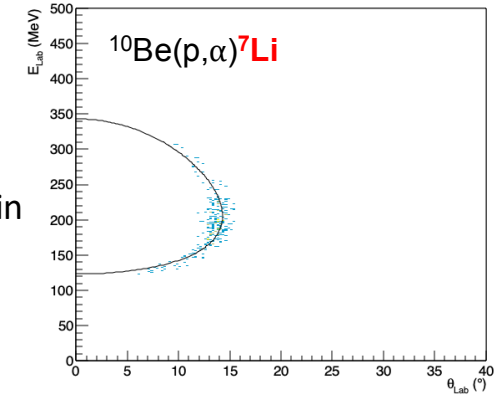
^{10}Be(p,α)^{7}Li:







Using energy correlation and φ gate we obtain nearly background free Ex and kinematics…

Next step is the analysis of:

- ^{12}Be(p,α)^{9}Li
- ^{10}Be(d,^{6}Li)^{6}He

Courtesy of T. Zanatta Martínez

MUGAST@LISE: Upcoming experiments

C. Diget, N. De Séreville: (To be scheduled)

Determining the thermonuclear ^{18}Ne(α,p)^{21}Na reaction rate by measurement of the ^{7}Li(^{18}Ne,t)^{22}Mg(p)^{21}Na reaction

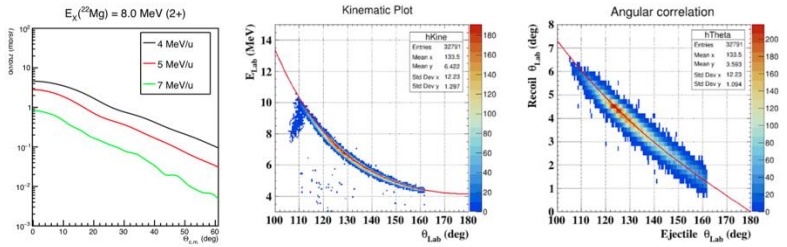
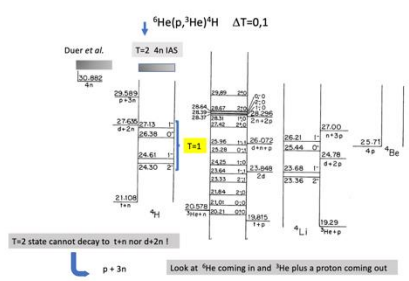
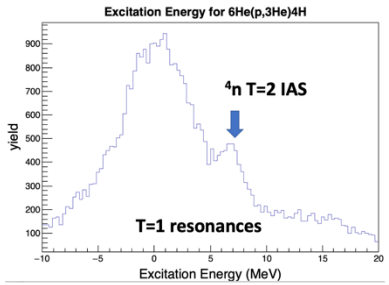


Figure 1: Differential cross section for 2+ state with $C^2S = 1$ (left); triton kinematics for ^{22}Mg resonance (middle); and heavy-ion (^{22}Mg) angle against triton angle (right).

A. Machiavelli, M. Assié: (To be scheduled)

The tetra-neutron Isobaric Analog State in ^{4}H : The case for the ^{6}He(p,^{3}He) reaction





F. Galtarossa: (To be re-scheduled)

Evolution of the neutron $1d_{3/2}$-$1d_{5/2}$ spin-orbit splitting in N = 19 isotones and Fermi surface in ^{34}Si

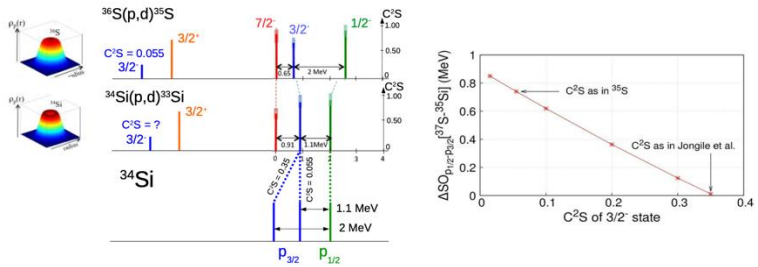
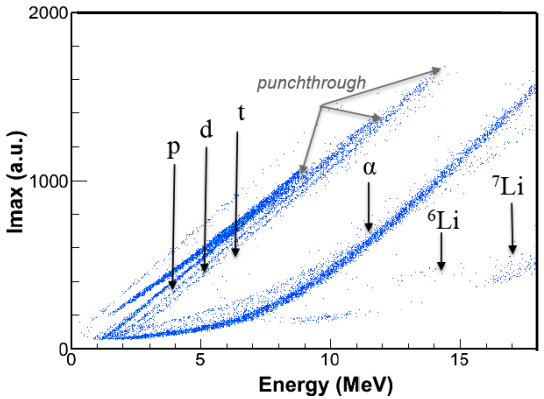


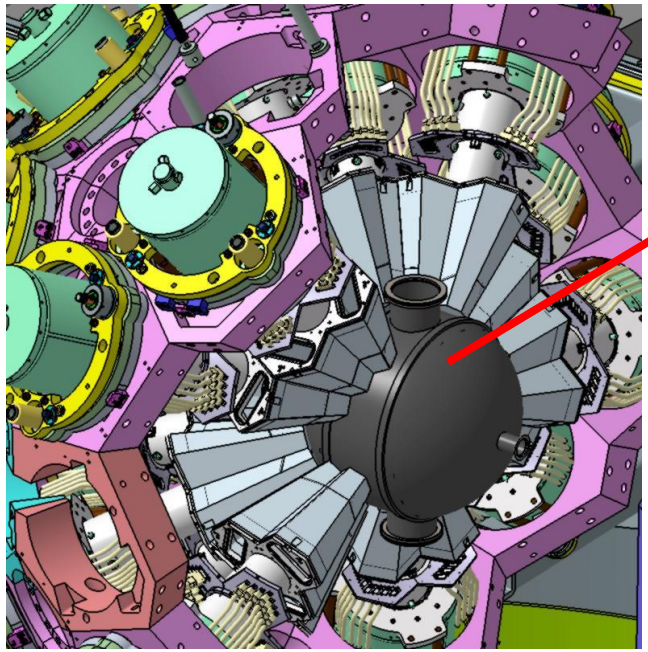
FIG. 3: Pictorial representation (left) and graphic (right) of the predicted variation of the difference between the $\nu p_{1/2}$-$\nu p_{3/2}$ SO splitting in ^{37}S and in ^{35}Si as a function of the C^2S of the $3/2^-$ state at 1.981 MeV in ^{33}Si.

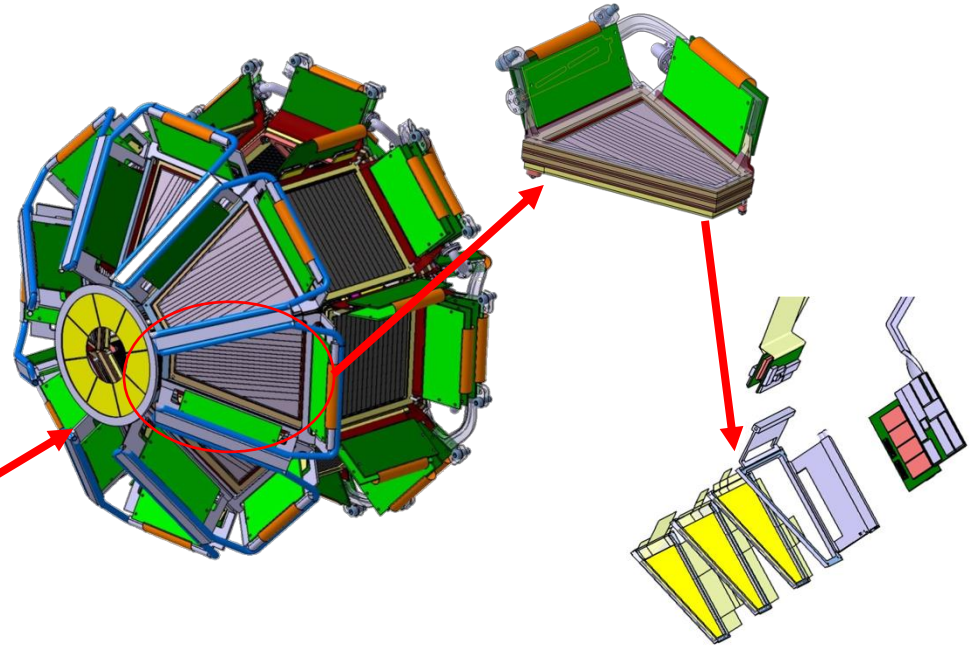
GRIT-AGATA-VAMOS @GANIL (2029-?)

GRIT: **G**ranularity, **R**esolution, **I**dentification and **T**ransparency

- ~4π silicon detector
- Coupled to AGATA
- Missing mass
- With PSA identification

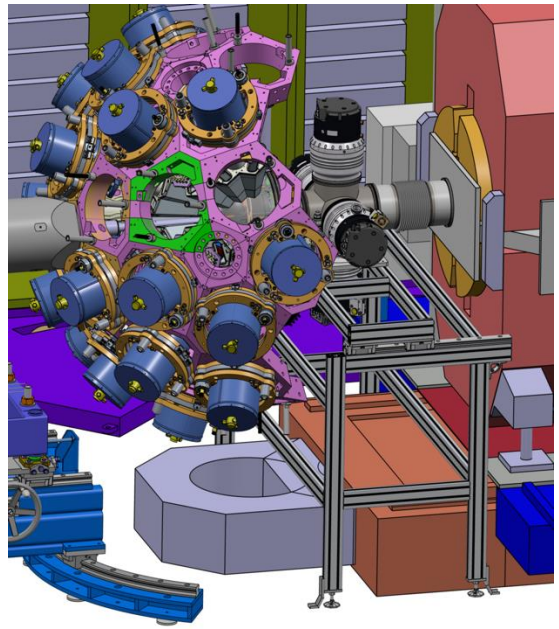


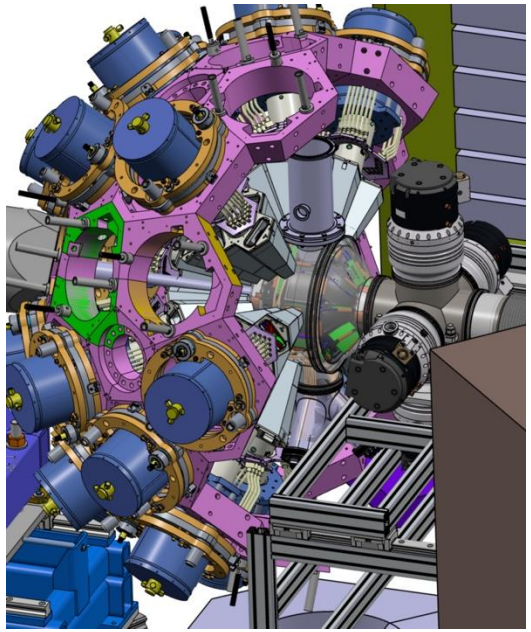




Integration challenge:

- GRIT is inside the 450 mm sphere of AGATA
  - 90 electronics card
  - 24 silicon detectors





2nd of October 2024 – ASC meeting

To stay at LNL until mid 2028 to complete the zero-degree campaign.

Move to GANIL to start the campaign in March 2029 to have (at least) two campaigns with a minimum of 100UT per year dedicated to AGATA.

Formal decision on location after 2030 to be decided in 2027 once more information on SPES beams and FAIR timescales/funding become available.

DECISION: AGREED

Discussions about mechanical integration are ongoing

Most likely a “Small”-GRIT version first:

- Forward?
- Backward?
- Mixed?

To define the best GRIT geometry, the physics cases should decide:

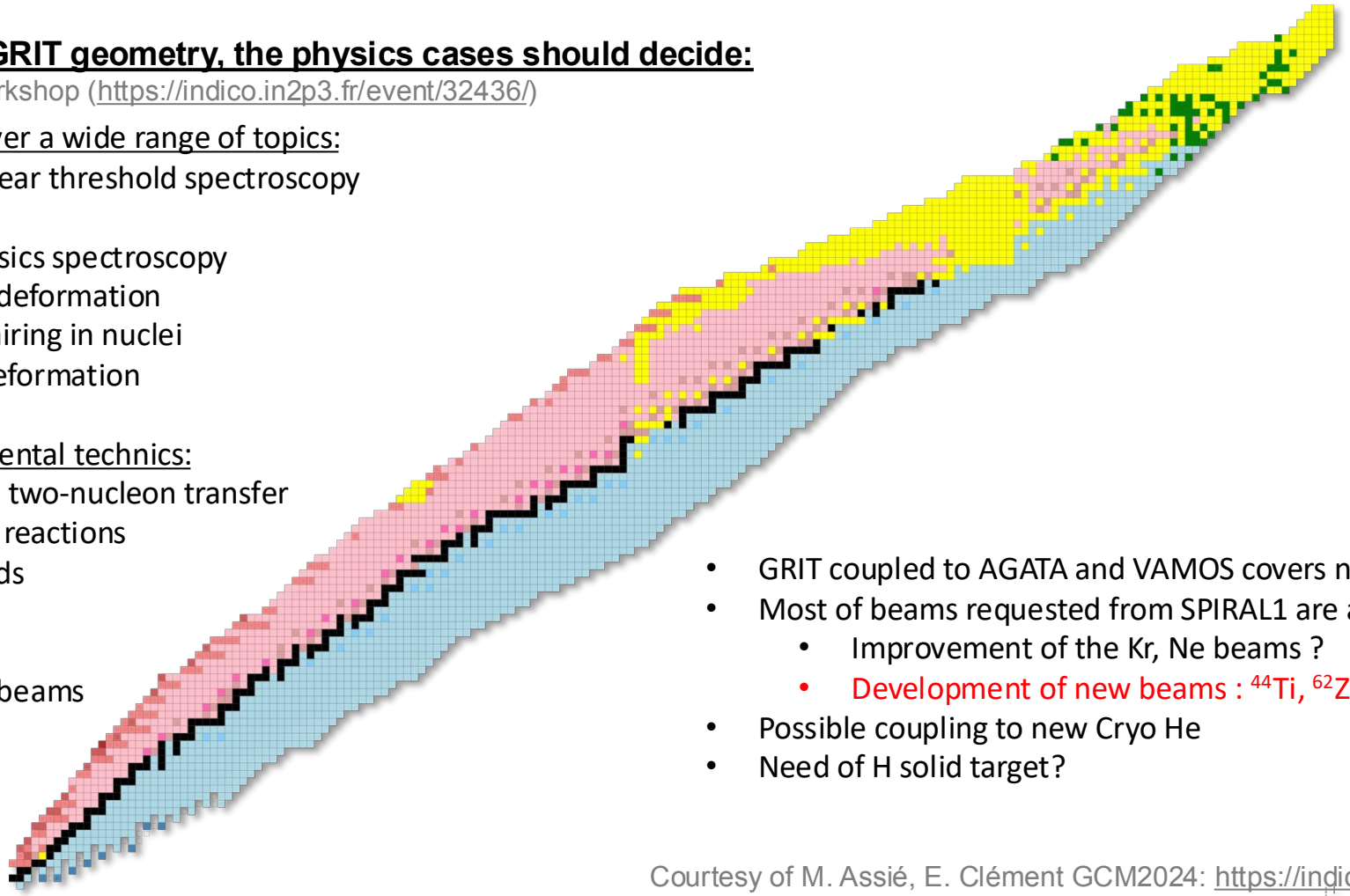
See: Agata@Ganil.2 workshop (https://indico.in2p3.fr/event/32436/)

The physics cases cover a wide range of topics:

- Resonance and near threshold spectroscopy
- Ab-initio testing
- Nuclear astrophysics spectroscopy
- Study of nuclear deformation
- Clustering and pairing in nuclei
- SHE and hyper-deformation

with various experimental technics:

- One-nucleon and two-nucleon transfer
- Charge exchange reactions
- Surrogate methods
- DSAM + transfer
- Coulex or fusion
- MNT with heavy beams



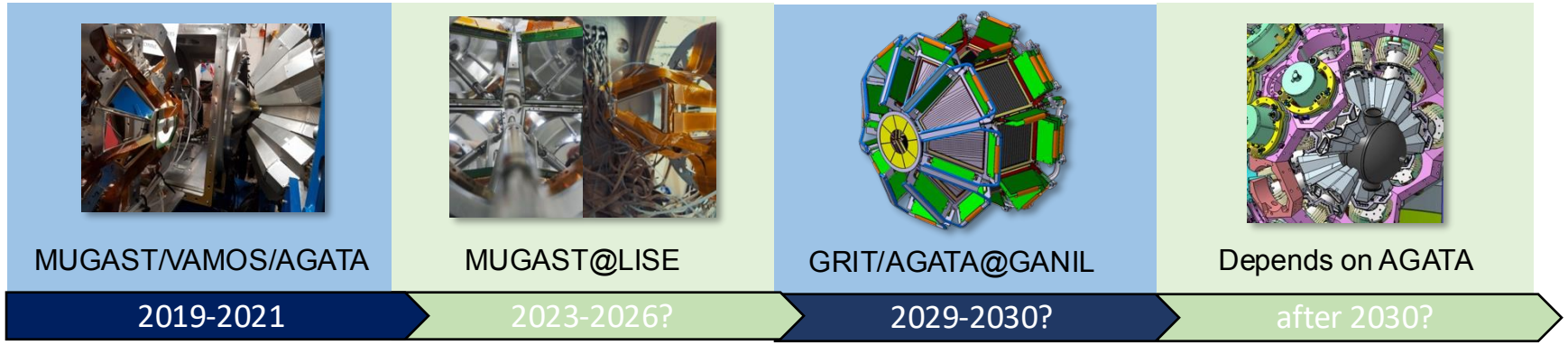
- GRIT coupled to AGATA and VAMOS covers nearly all physics cases
- Most of beams requested from SPIRAL1 are already available
  - Improvement of the Kr, Ne beams ?
  - Development of new beams : ^{44}Ti, ^{62}Zn, ^{13}O, ^{55}Co, ^{56,57}Ni
- Possible coupling to new Cryo He
- Need of H solid target?

Courtesy of M. Assié, E. Clément GCM2024: https://indico.in2p3.fr/event/31236/

Conclusion

Strength of combining light-particle + gamma-ray + Residue detection:

- Measuring nearly all the particles is very powerful
- Nearly background free excitation energy spectra, and gamma spectroscopy studies
- A tool to study a broad range of topics (shell-model, astrophysics, drip-line…)
- There is more to come!!
  - 3+ experiments in GANIL
  - GRIT/VAMOS/AGATA@GANIL in 2029!



Thank you for your attention!

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