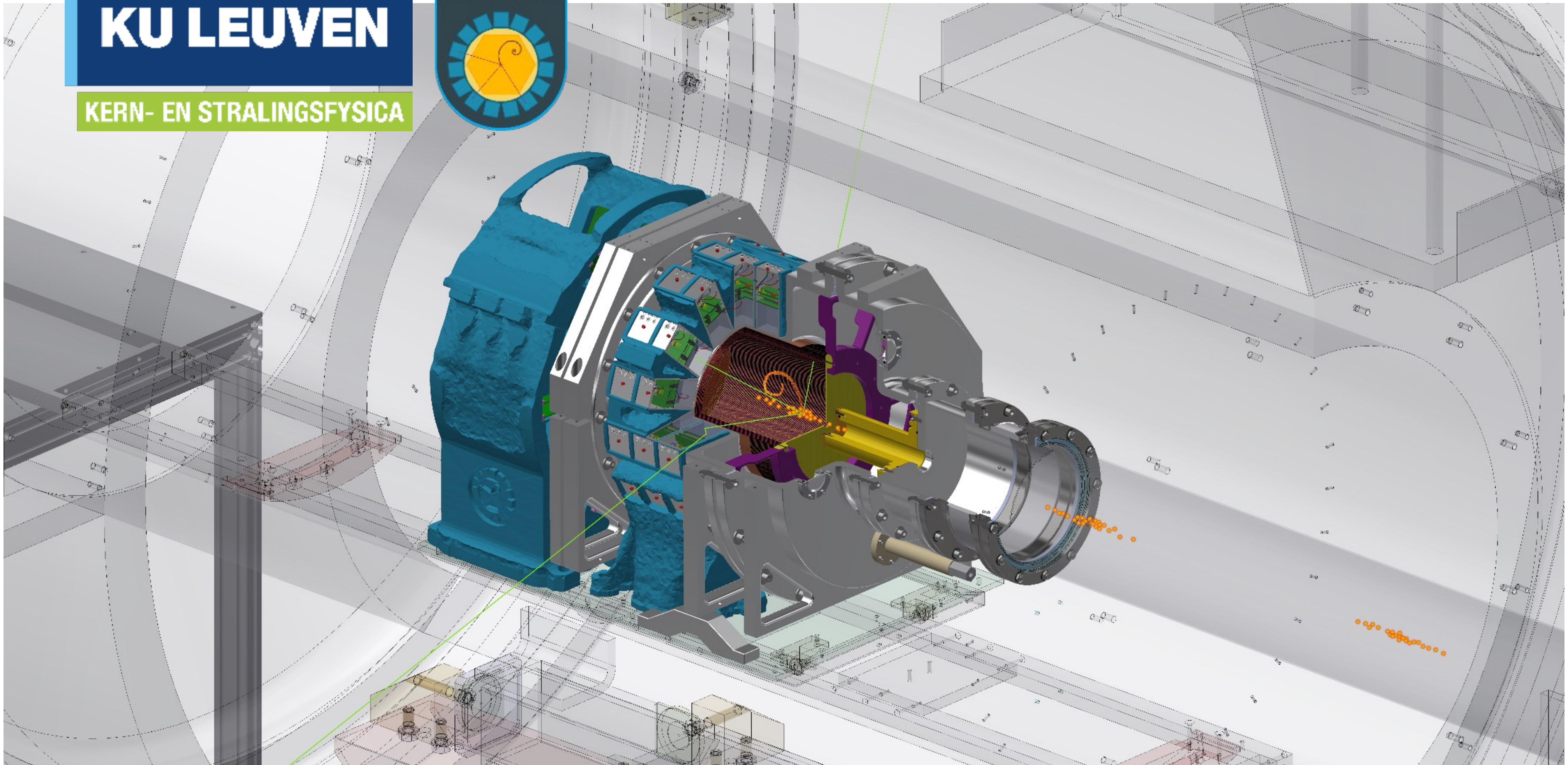


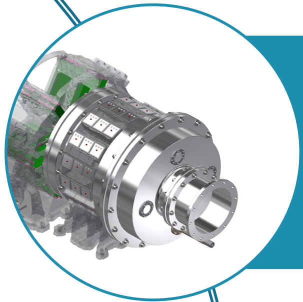
Performance of the SpecMAT active target in a strong magnetic field

Oleksii Poleshchuk

HIE-ISOLDE workshop

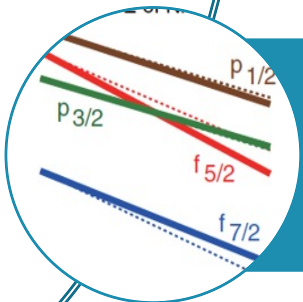
London, 24-26 May 2023

Outline



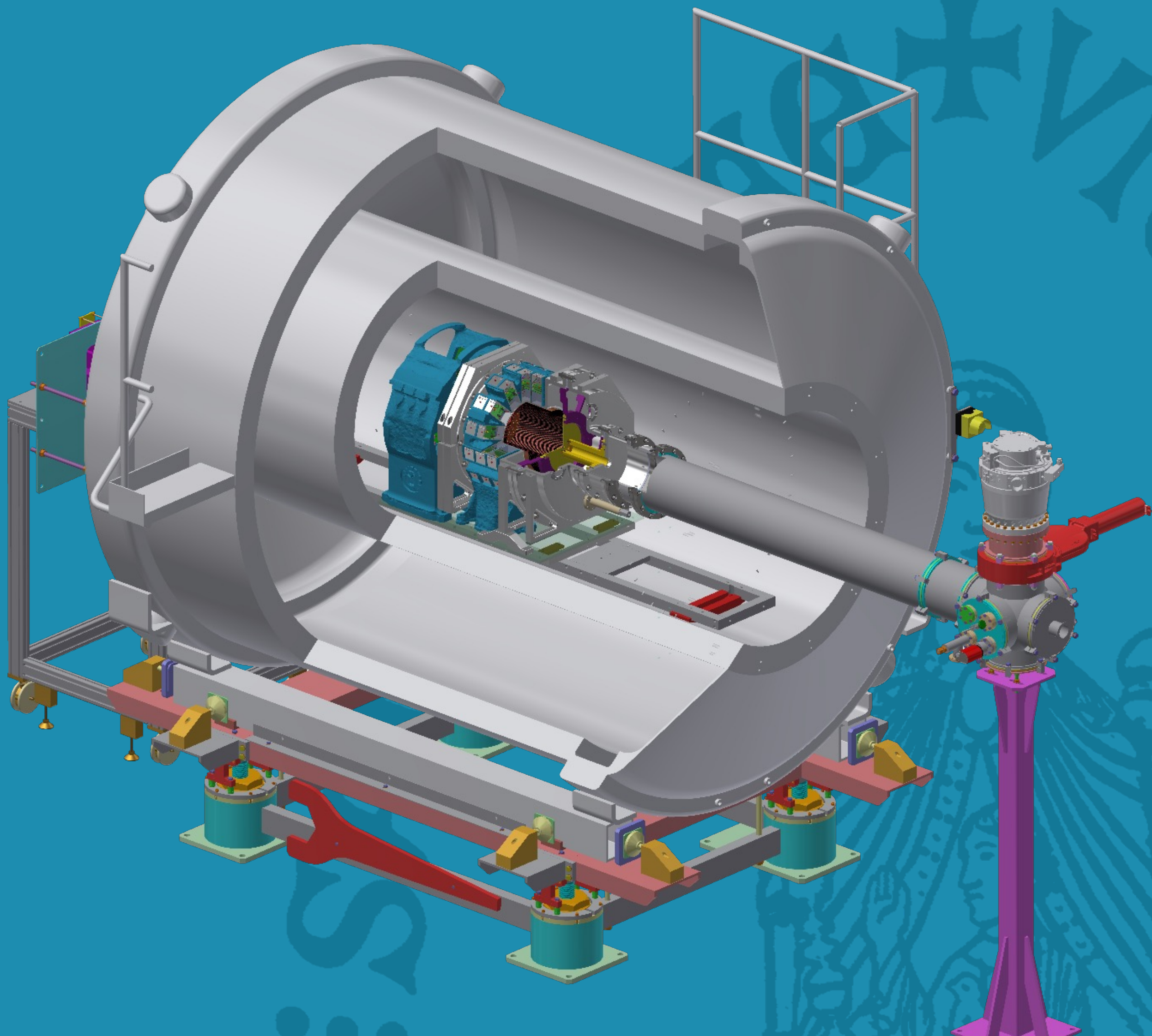
Motivation to build SpecMAT and its overview

Characterisation of the SpecMAT active target



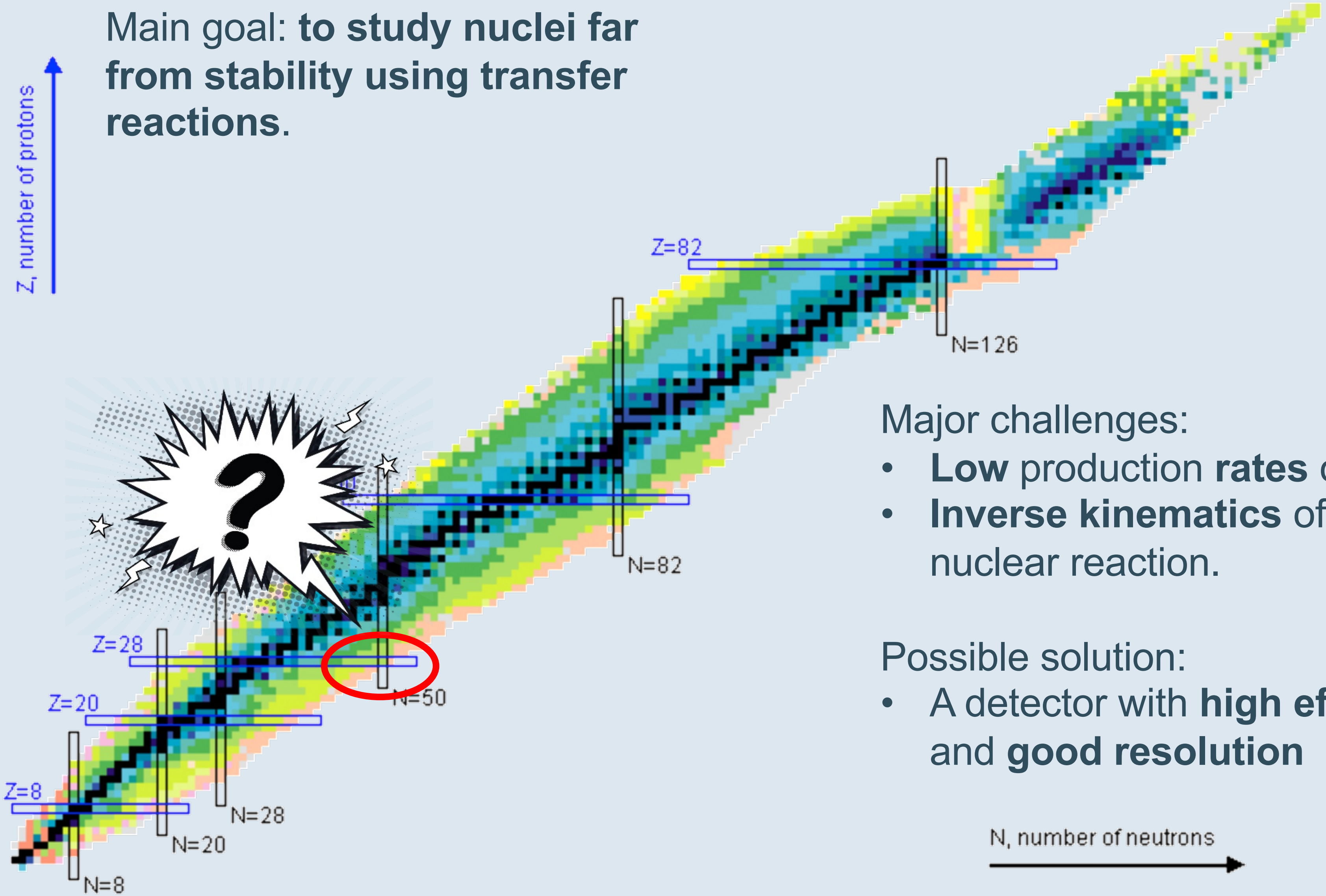
A (d,^{3}He) reaction for SpecMAT

Motivation and Overview



Physics motivation

Main goal: **to study nuclei far from stability using transfer reactions**.

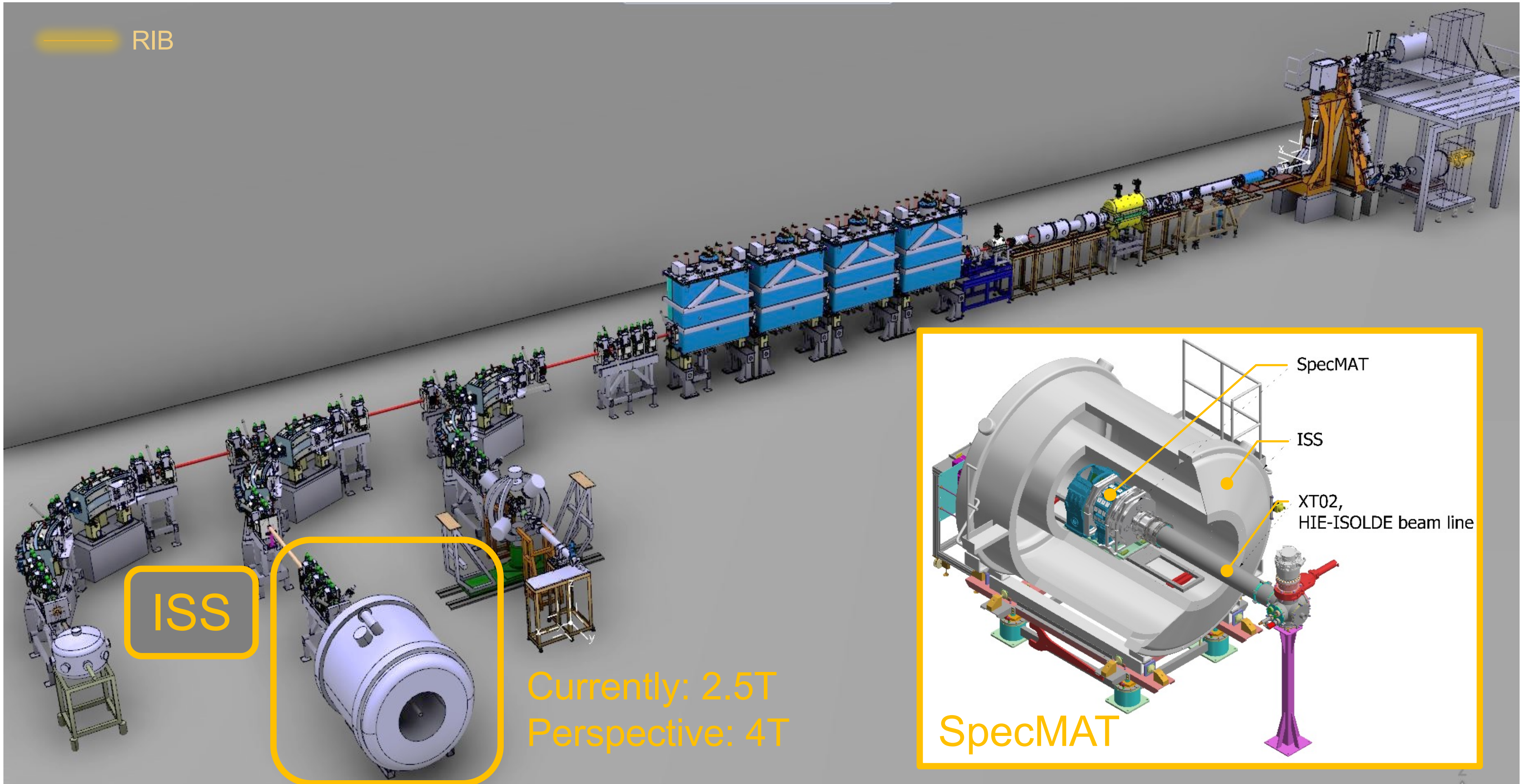


Major challenges:

- **Low** production **rates** of RIBs
- **Inverse kinematics** of the nuclear reaction.

Possible solution:

- A detector with **high efficiency** and **good resolution**



ISS = ISOLDE Solenoidal Spectrometer

SpecMAT

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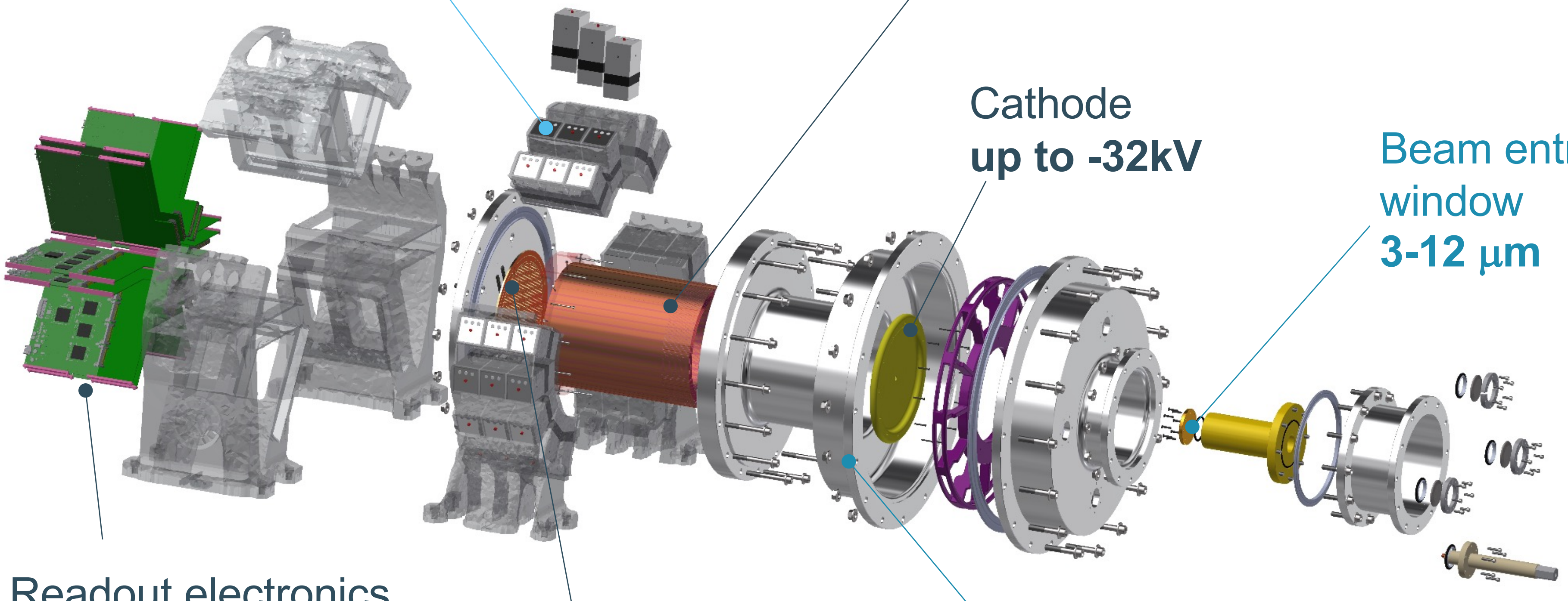
45 $CeBr_3$
48×48×48mm
scintillation
detectors
Field cage
homogeneous
electric field ~2%
Cathode
up to -32kV
Beam entrance
window
3-12 µm
Readout electronics
1-100MS/s 12bit
3072+256 channels
MICROMEGAS detector
2916 channels
Gas chamber
up to 1 atm
min wall thickness 3mm

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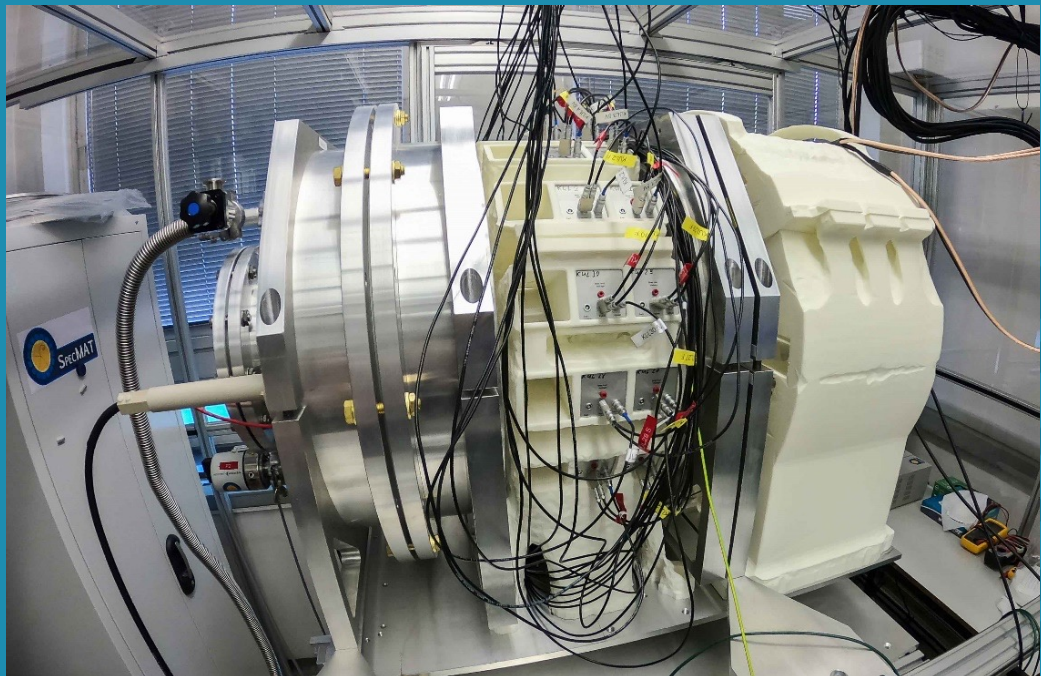
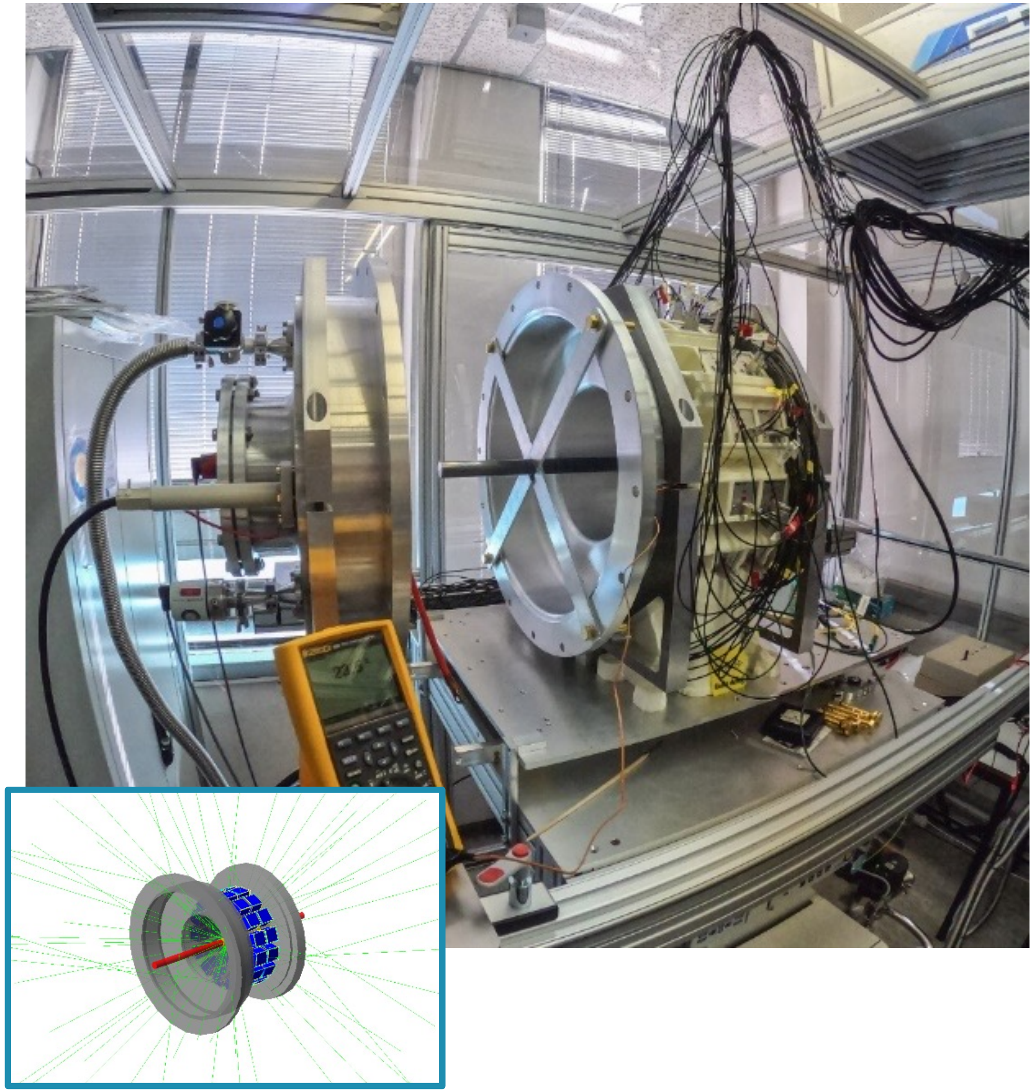
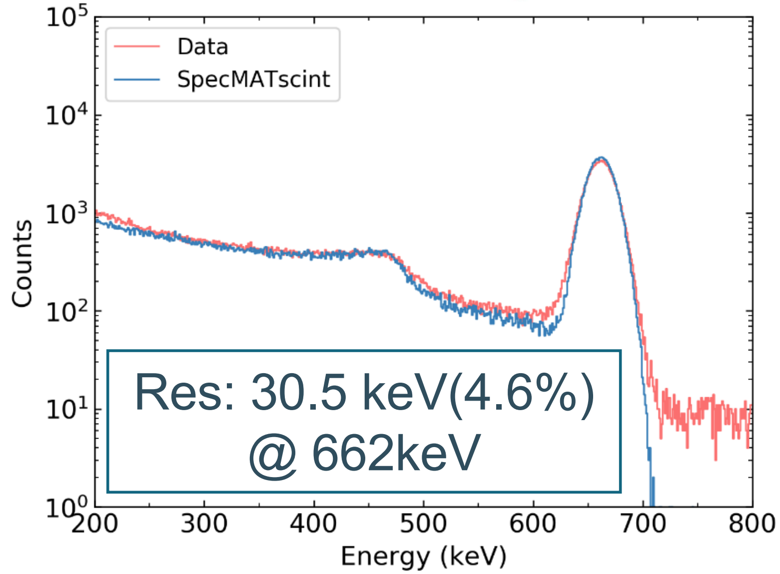
Characterisation of the SpecMAT active target

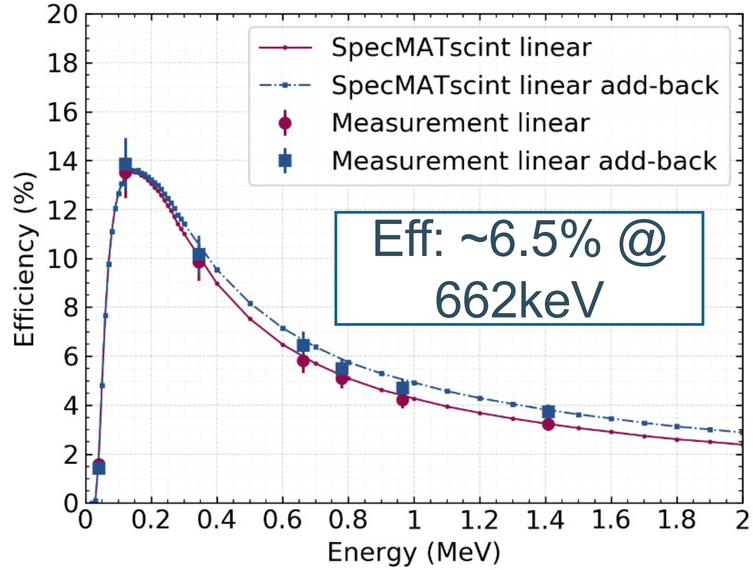


Characterisation of the array with 30 detectors, Measurement vs G4

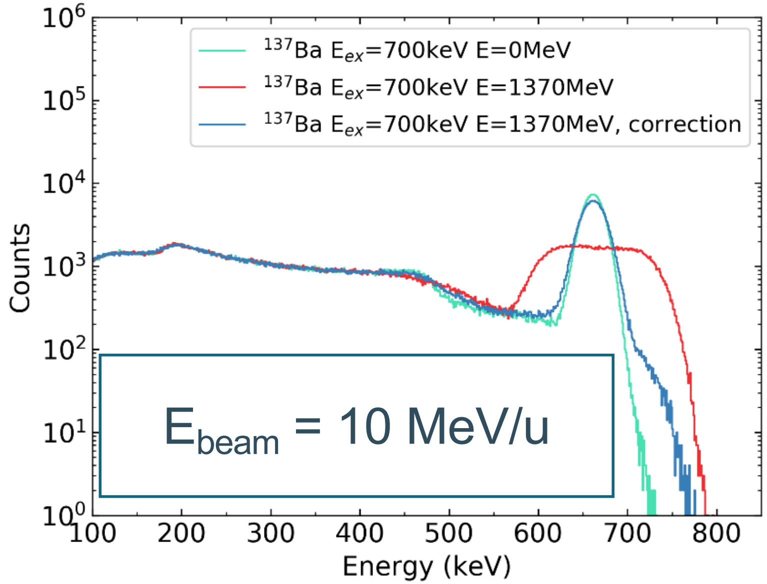


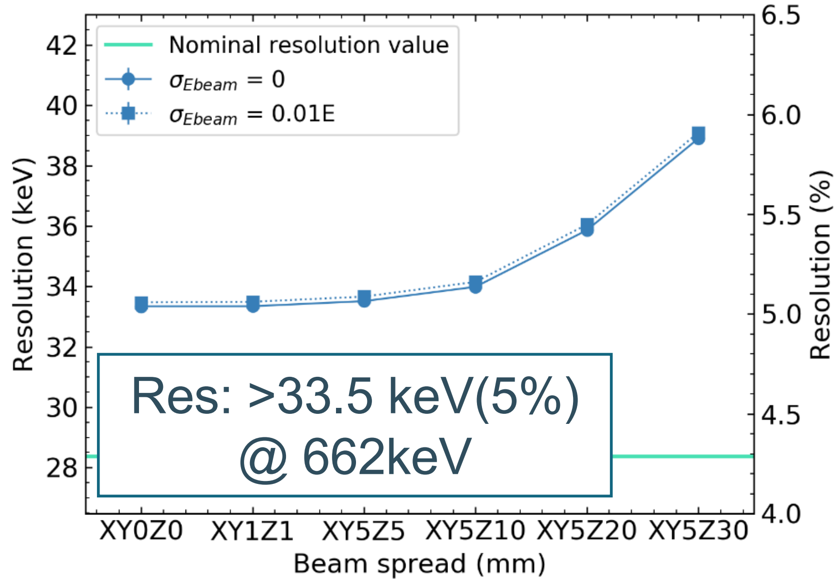


Linear source (Experimental condition)



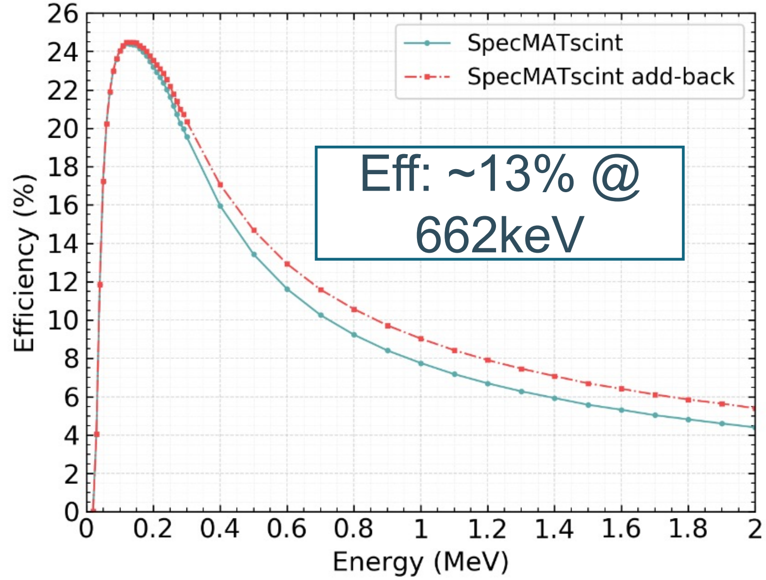
Characterisation of the array with 45 detectors, G4



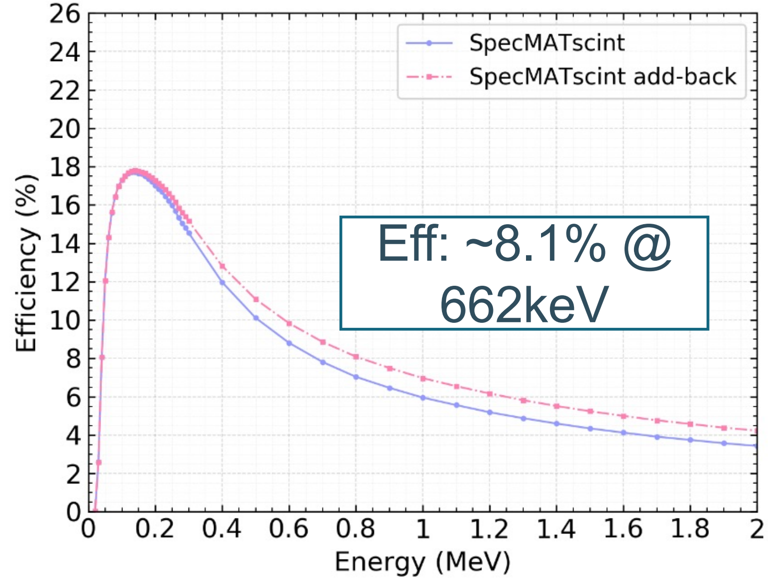


x45 $CeBr_3$ detectors

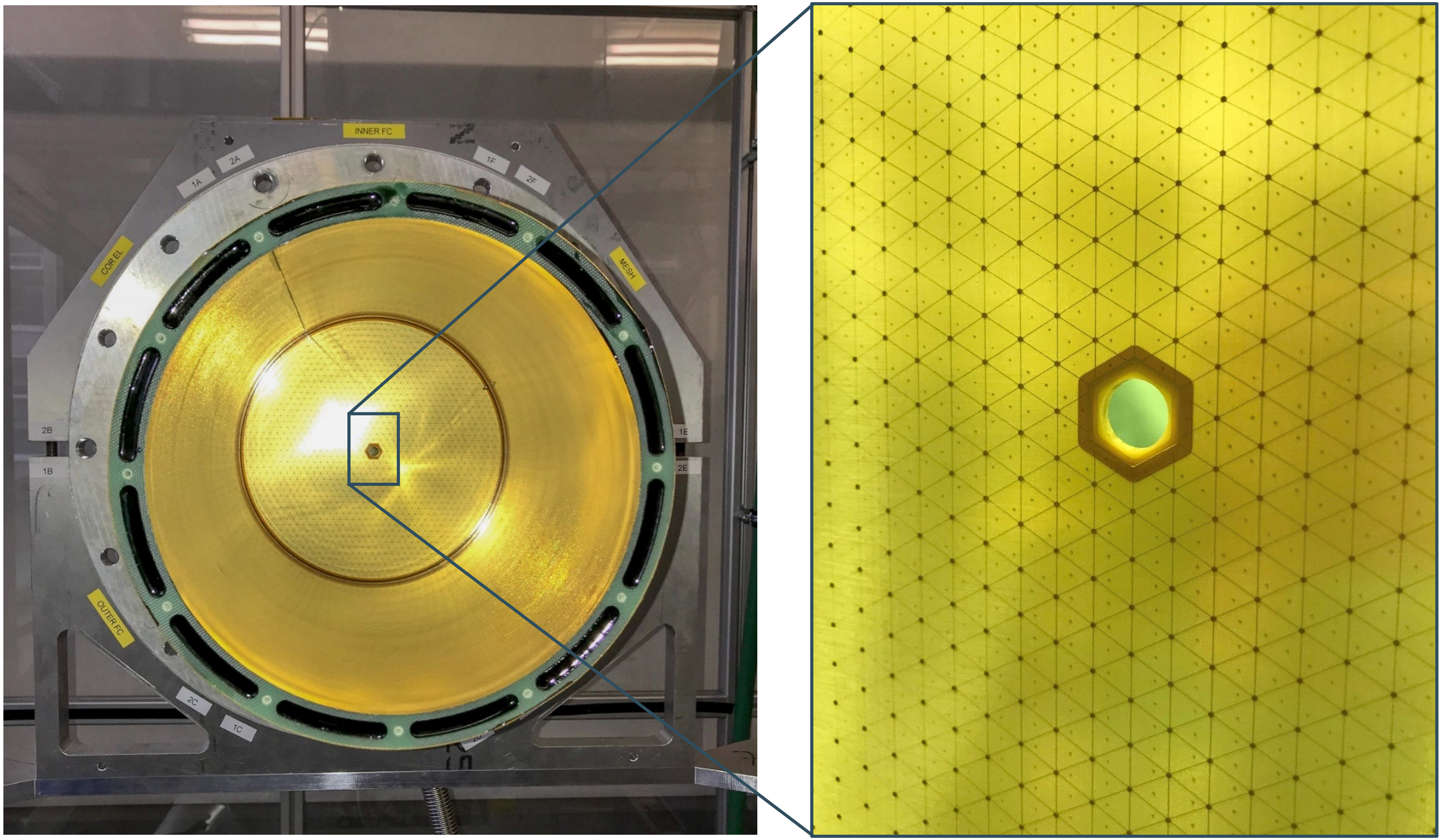
Point source



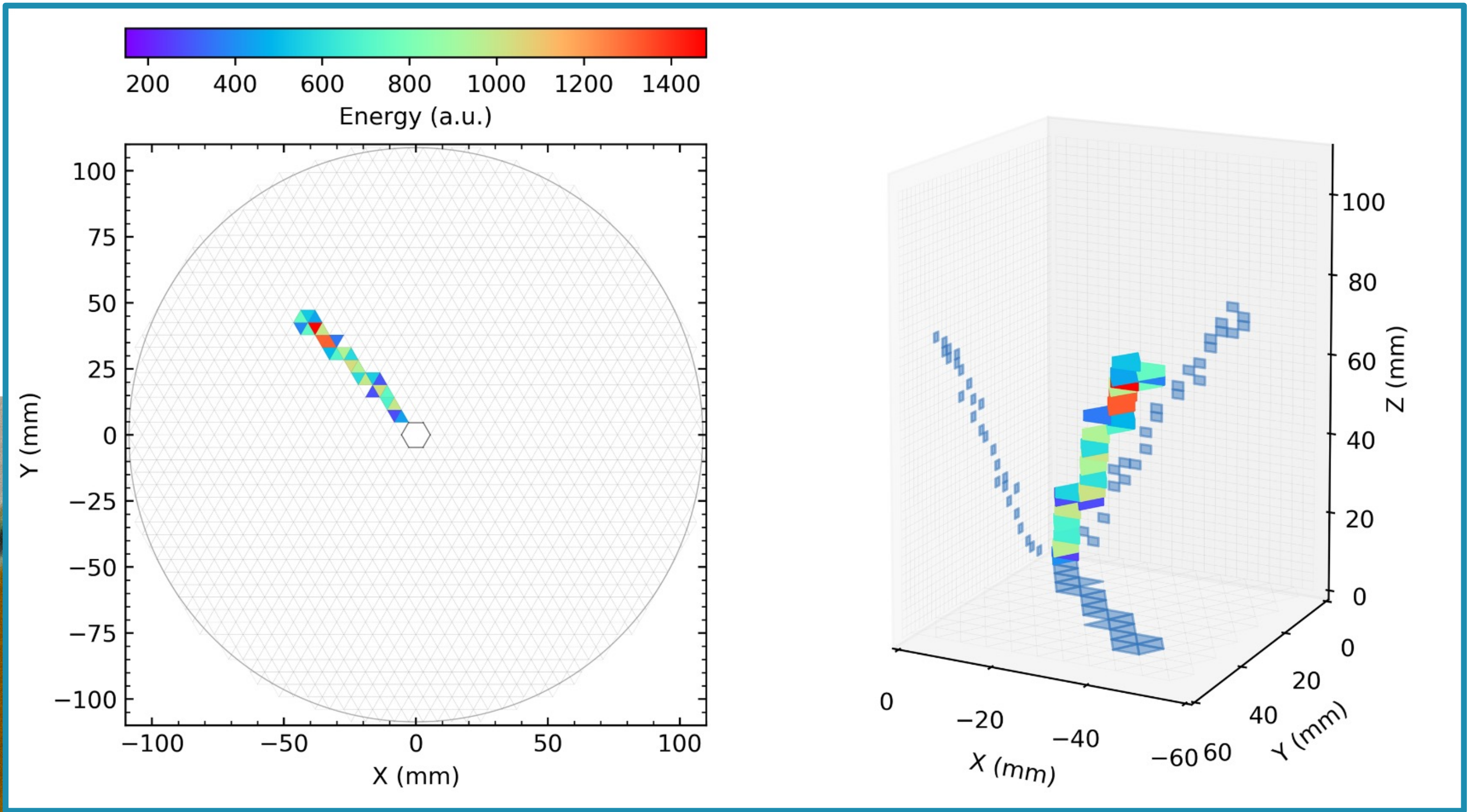
Linear source (Experimental condition)

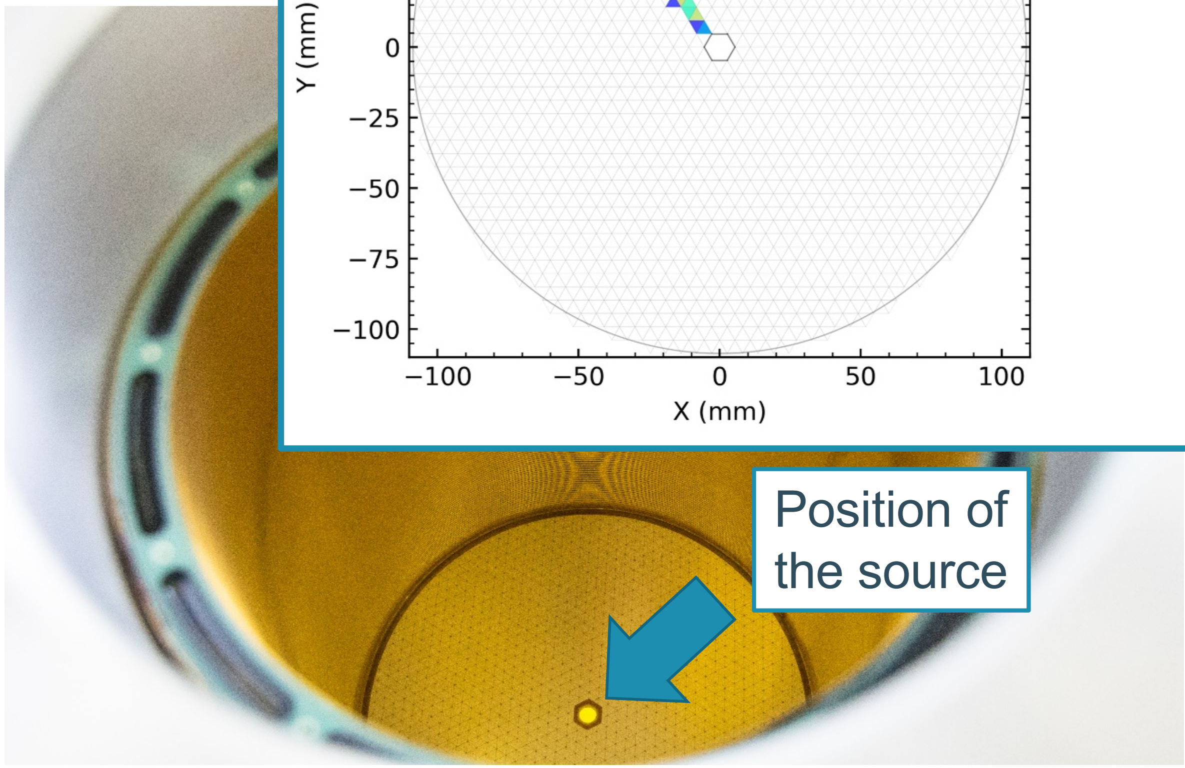


SpecMAT field cage

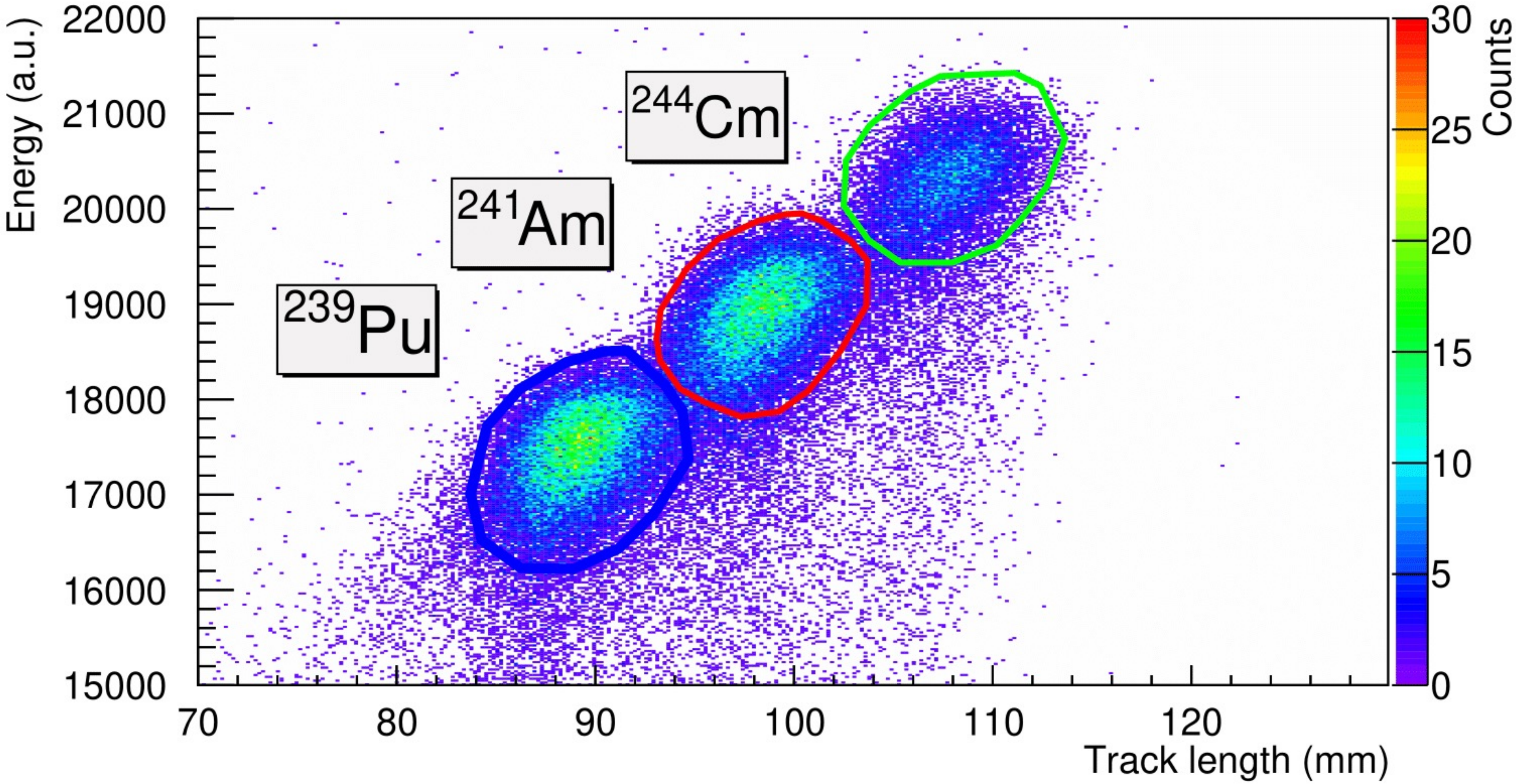


Measured α-particle track in Ar95%$CF_4$5% @ 0.4mbar

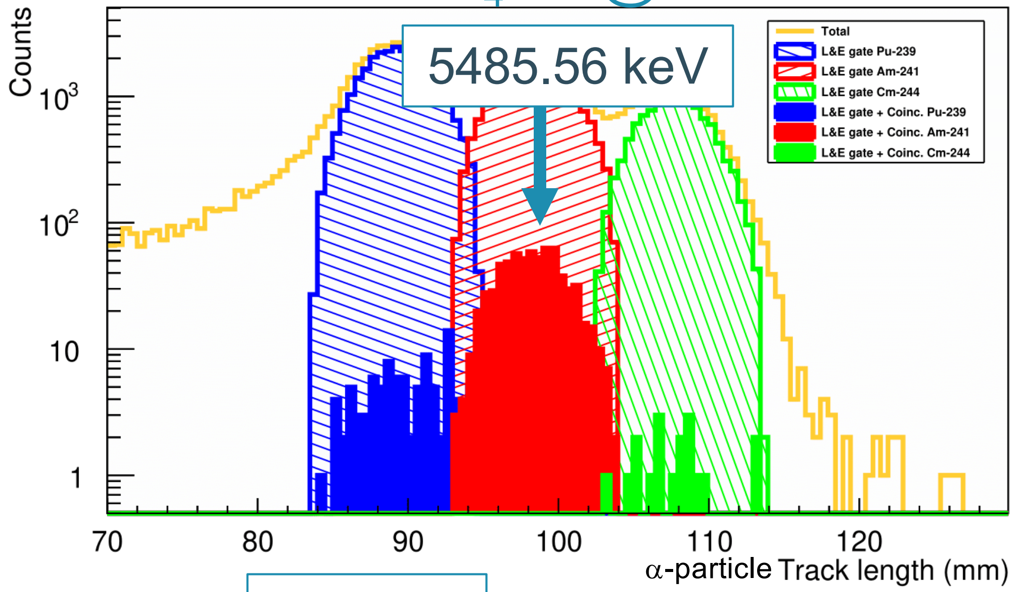


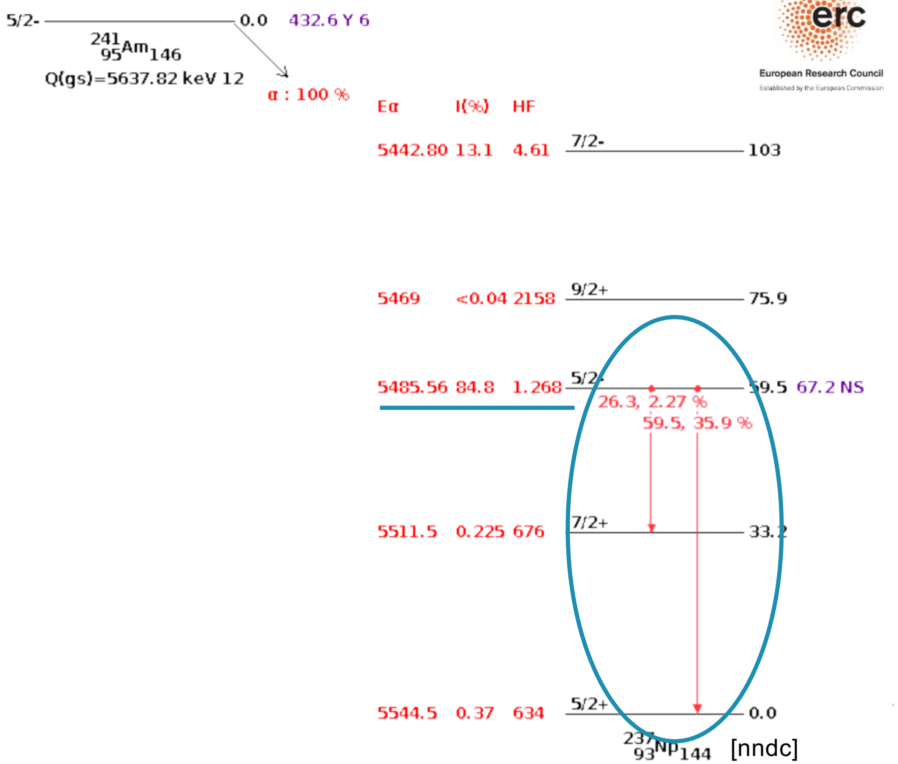


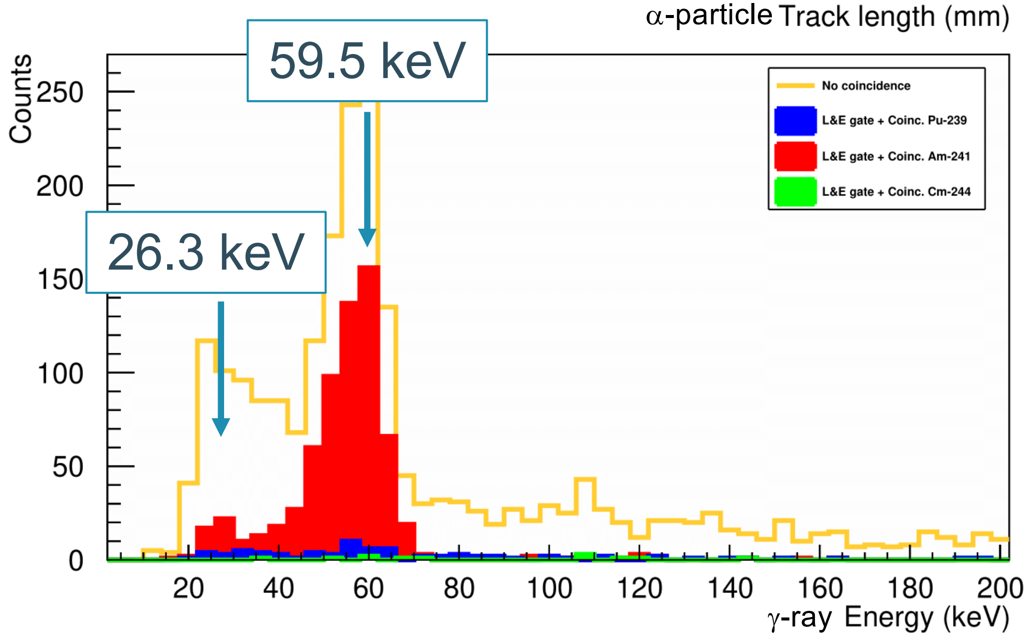
Measured α-particle spectra in $Ar95\%CF_45\%$ @ 0.4mbar

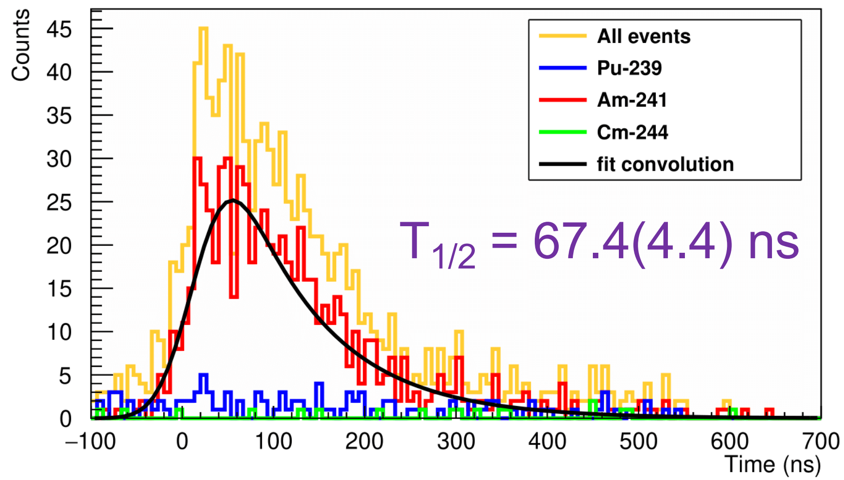


Measured α-γ correlation spectra in Ar95%$CF_4$5% @ 0.4mbar









O. Poleshchuk, R. Raabe, et.al., NIM A "The SpecMAT active target"
Volume 1015, 1 November 2021, 165765

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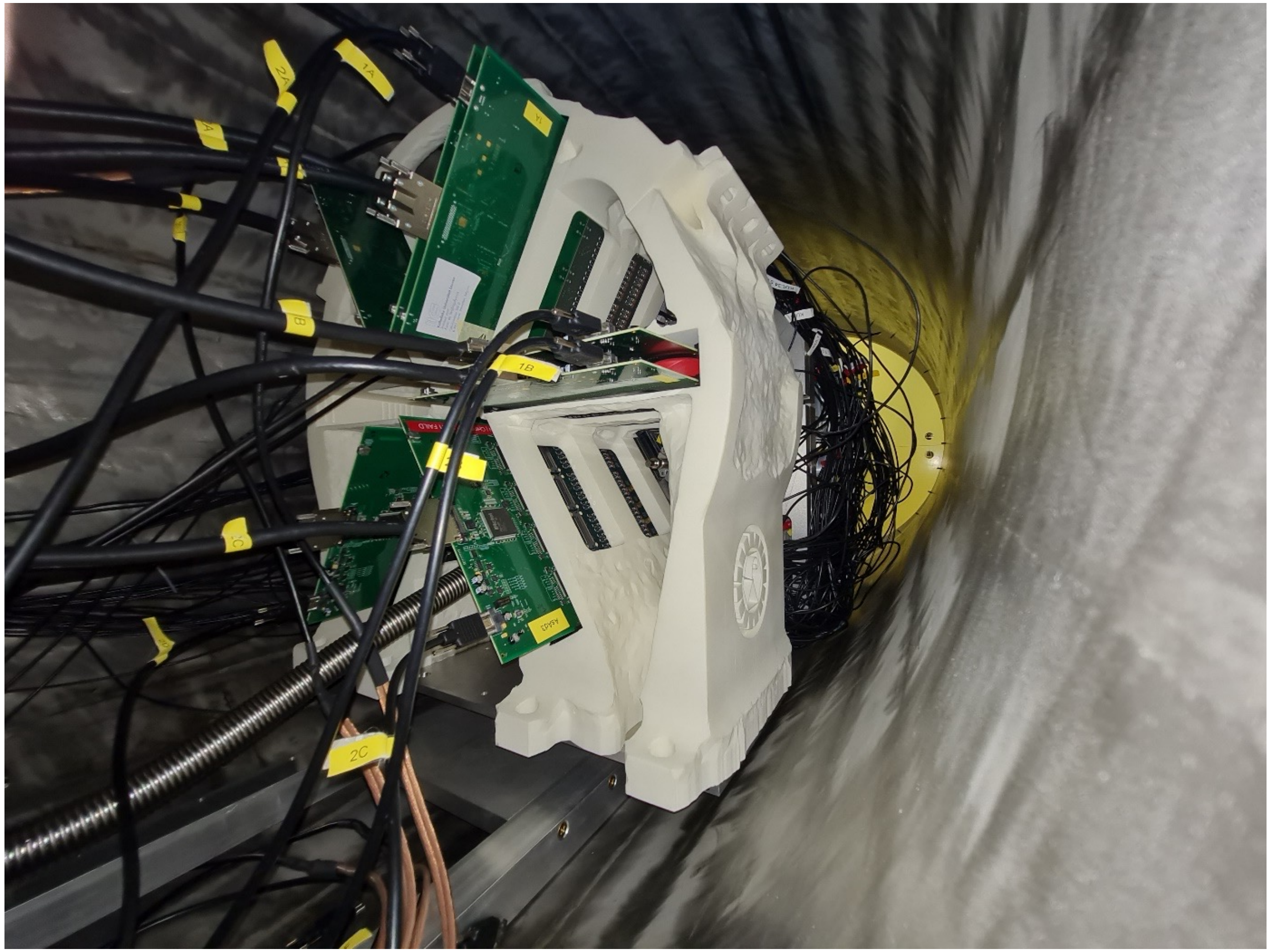
Tests of the SpecMAT active target in ISS

A 4-alpha source was used for the characterisation: ^{148}Gd, ^{239}Pu, ^{241}Am, ^{244}Cm

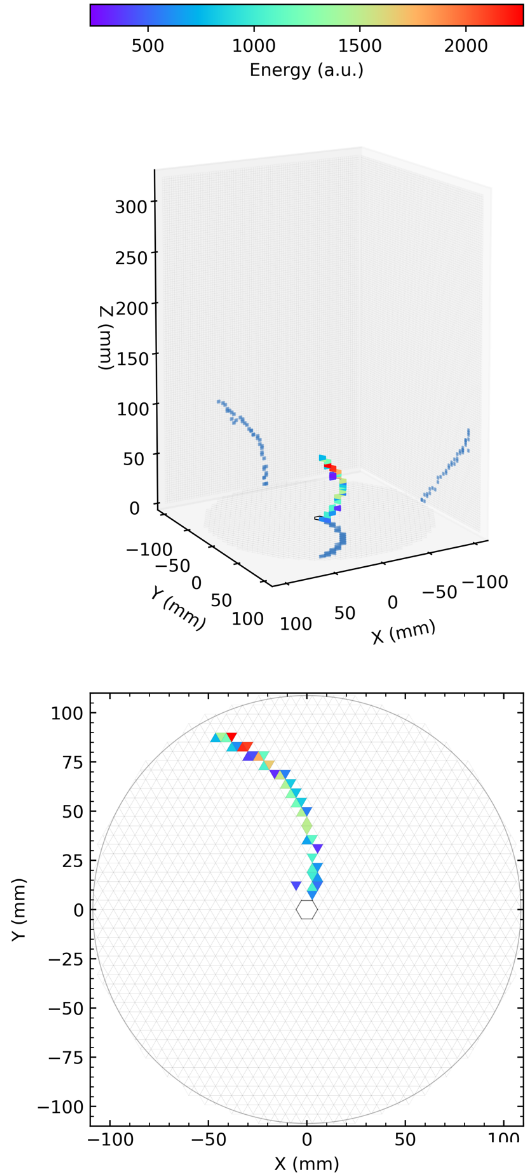
Detector configuration	Pressure of ArCF4(10%), mbar
3 sectors + scint. in 2.5T	100 / 250 / 350
3 sectors + scint. in 0T	

Pressure, mbar	^{148}Gd 3182 keV	^{239}Pu 5155 keV	^{241}Am 5488 keV	^{244}Cm 5805 keV
	Range, mm			
100	190	369.7	404.496	438.848
250	76.84	147.9	161.797	175.537
350	54.73	105.63	115.568	125.38

Tests of the SpecMAT active target in ISS



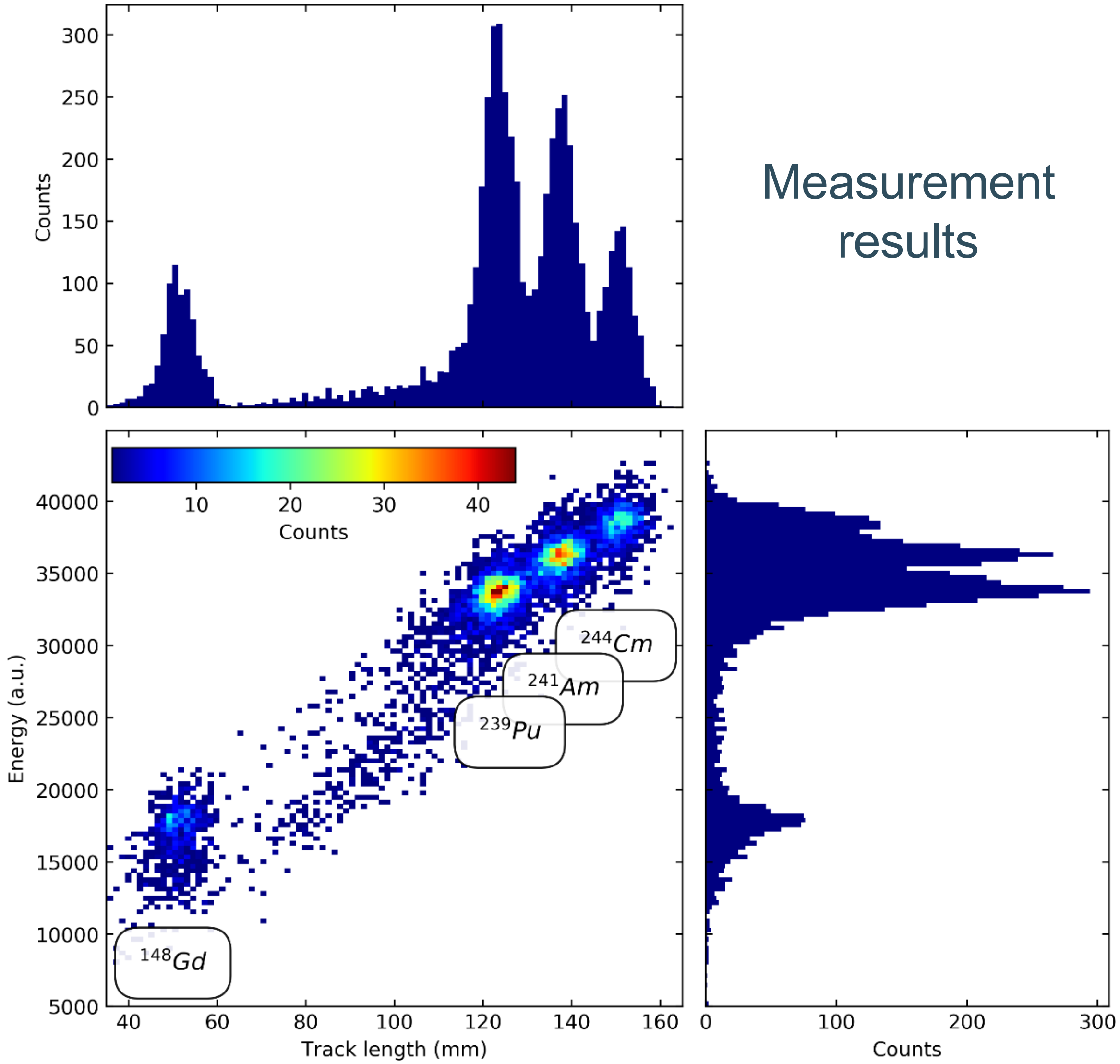
SpecMAT installed in ISS



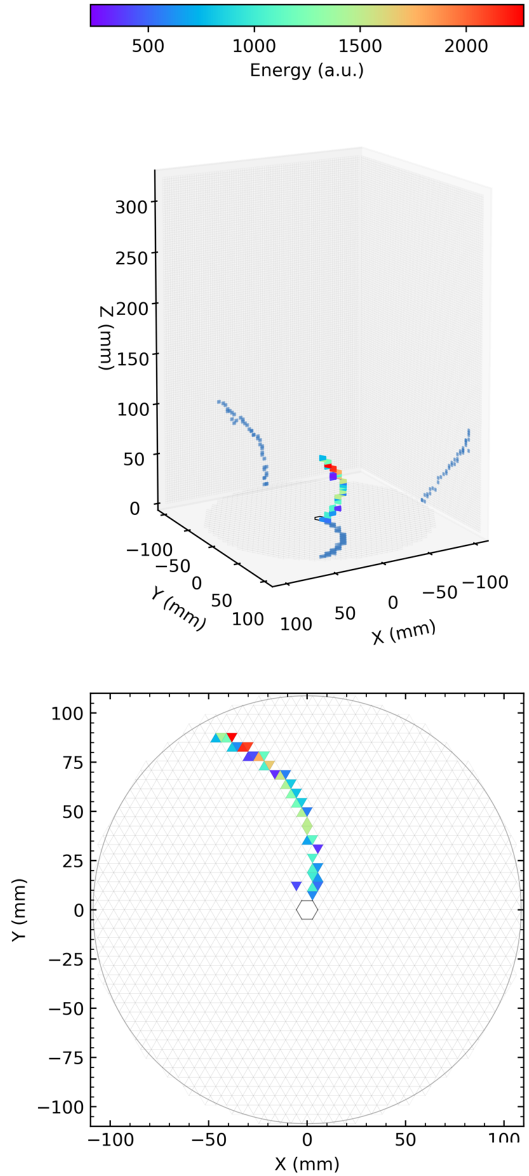
Measured α-particle track in B=2.5T

Tests of the SpecMAT active target in ISS

Comparison of the SpecMATscint G4 simulation
with preliminary analysis of the measurement
(Ar90%$CF_4$10% @ 250 mbar)



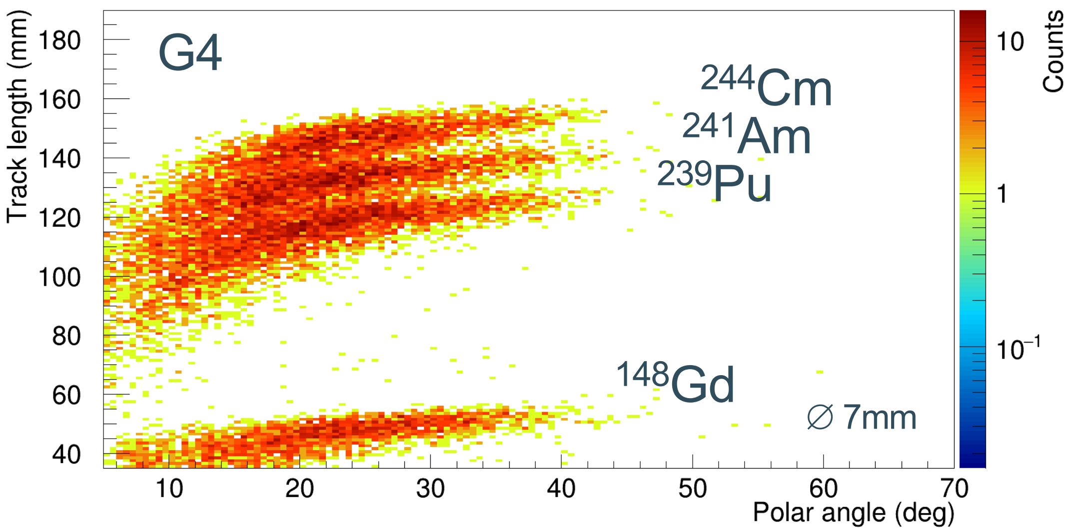
Measurement results

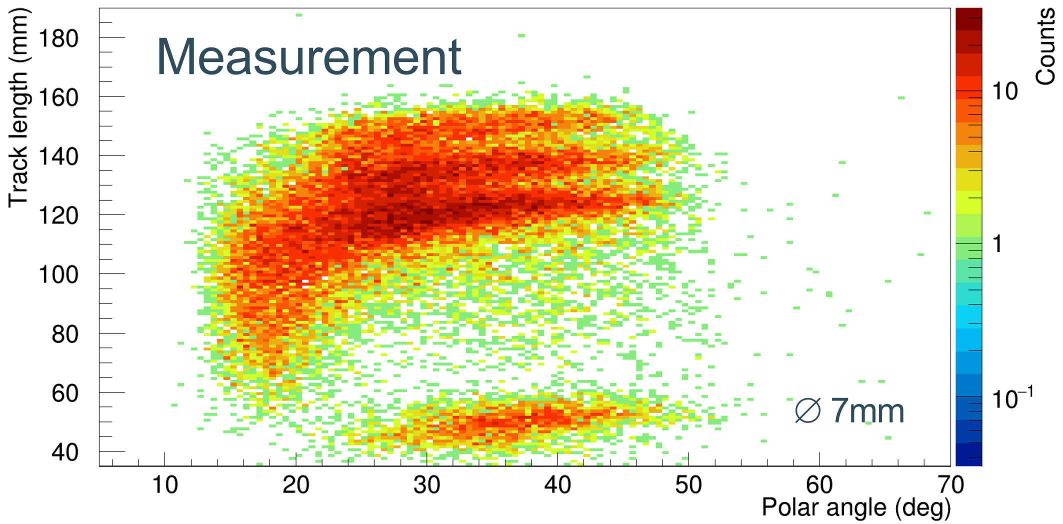


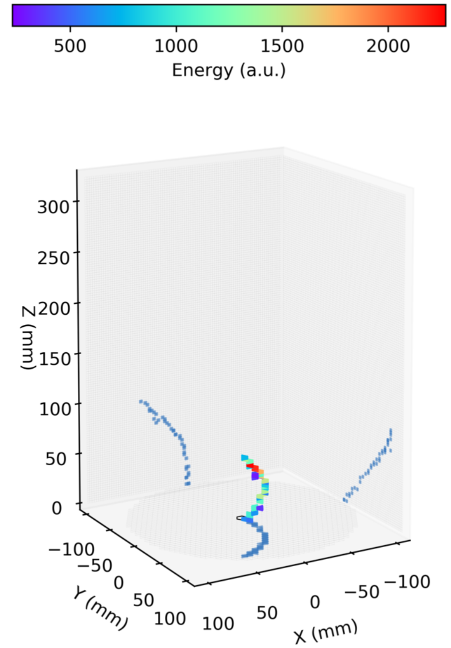
Measured α-particle track in B=2.5T

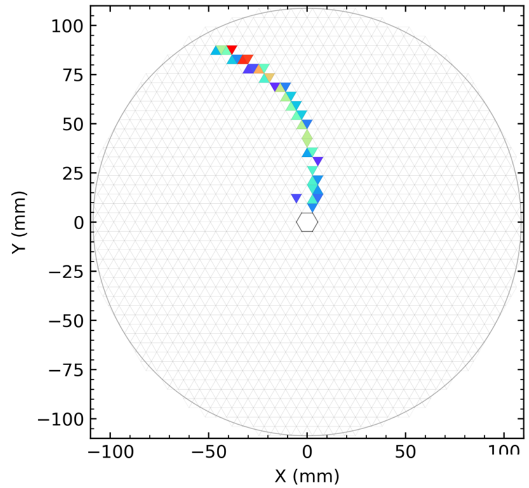
Tests of the SpecMAT active target in ISS

Comparison of the SpecMATscint G4 simulation with preliminary analysis of the measurement ($Ar90\%CF_4 10\%$ @ 250 mbar)





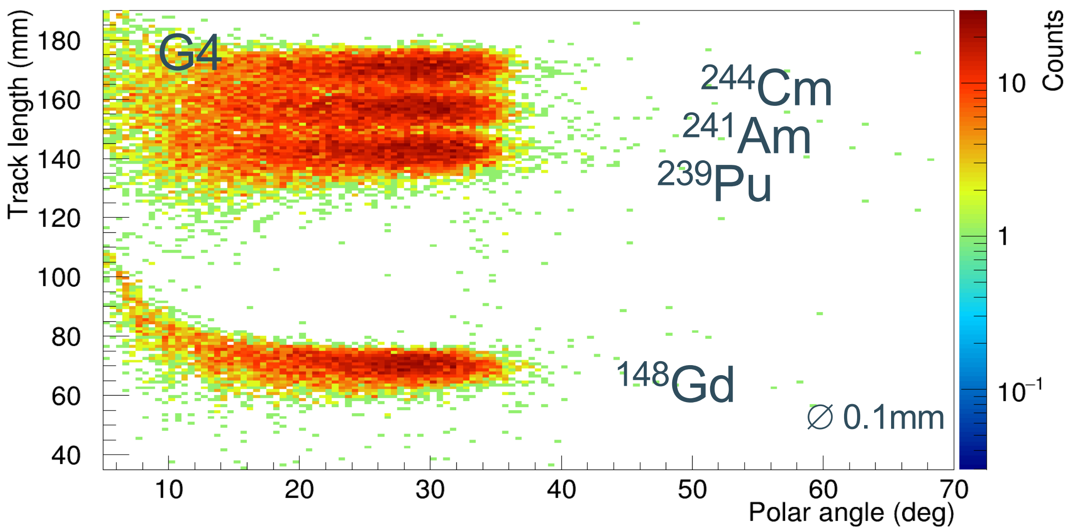


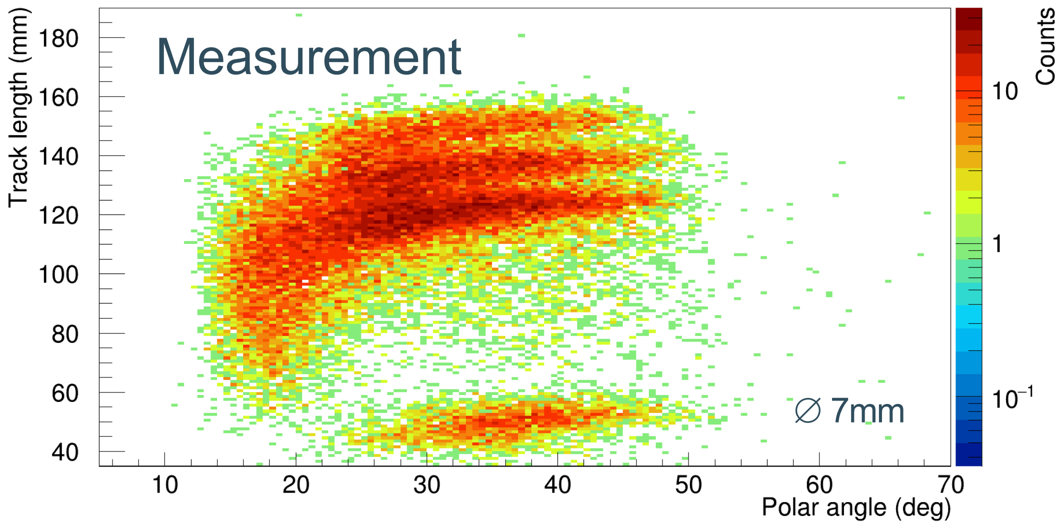


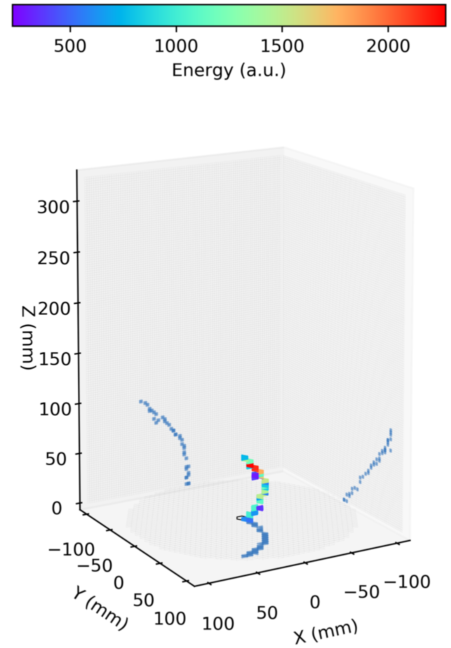
Measured α-particle track in B=2.5T

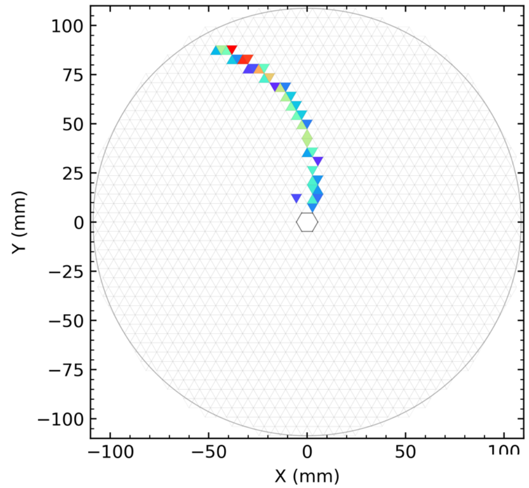
Tests of the SpecMAT active target in ISS

Comparison of the SpecMATscint G4 simulation with preliminary analysis of the measurement (Ar90%$CF_4$10% @ 250 mbar)





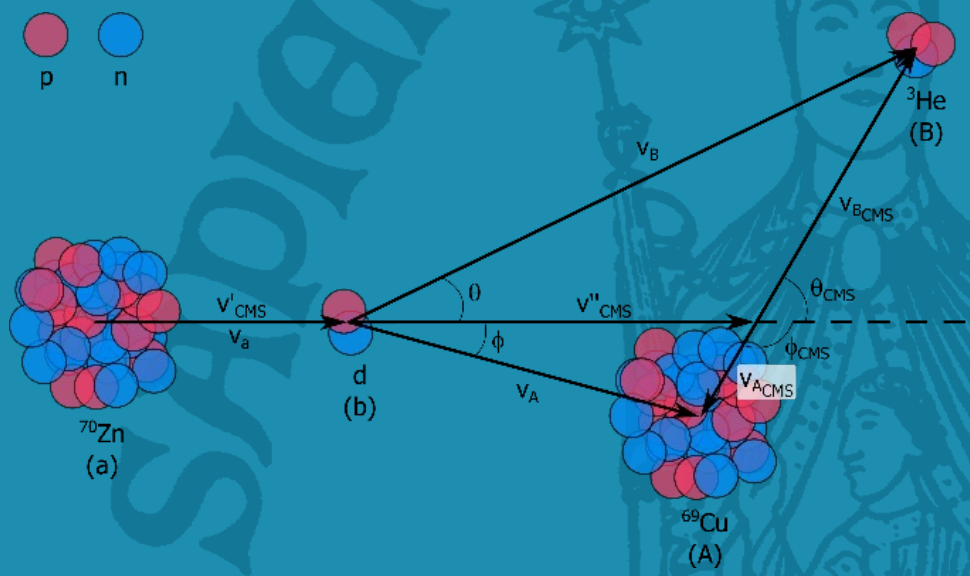




Measured α-particle track in B=2.5T

Physics perspectives

Simulation of a $^{70}Zn(d, ^{3}He)^{69}Cu$ reaction

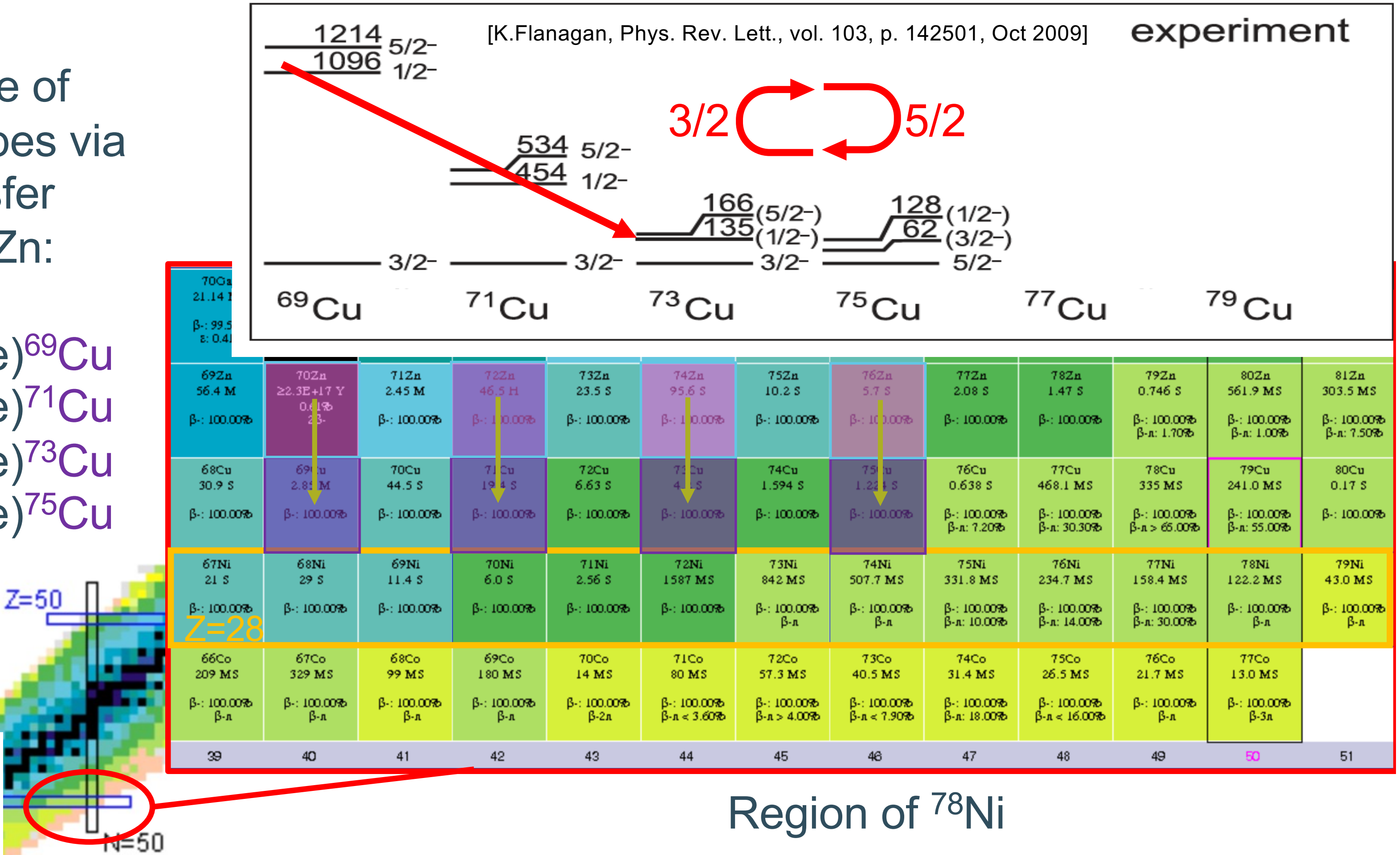


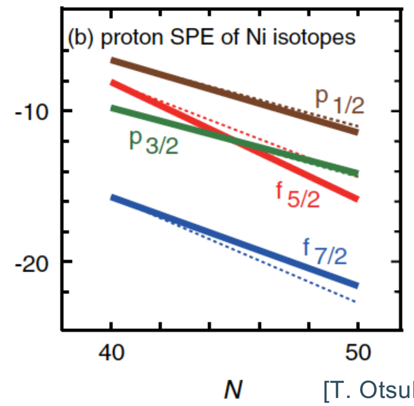
Physics case

Shell structure of odd Cu isotopes via nucleon transfer reactions on Zn:

Z, number of protons

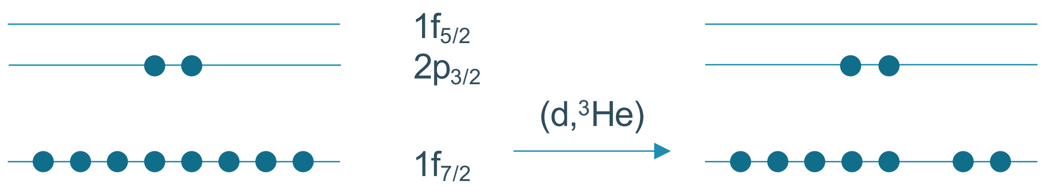
- $^{70}Zn(d,^{3}He)^{69}Cu$
- $^{72}Zn(d,^{3}He)^{71}Cu$
- $^{74}Zn(d,^{3}He)^{73}Cu$
- $^{76}Zn(d,^{3}He)^{75}Cu$





[T. Otsuka, *et al.*, PRL, 104, 012501 (2010)]

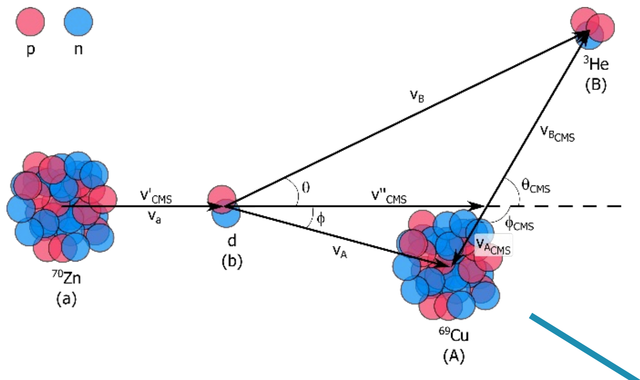
Region of ^{78}Ni

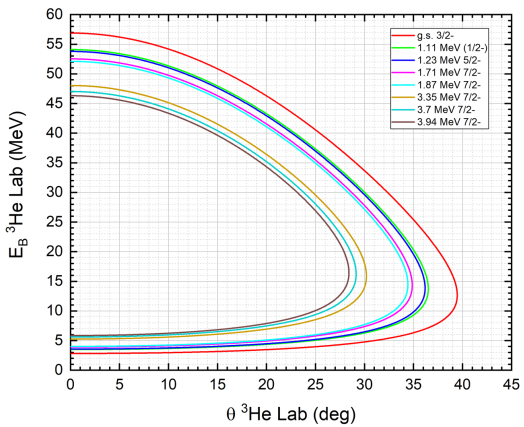


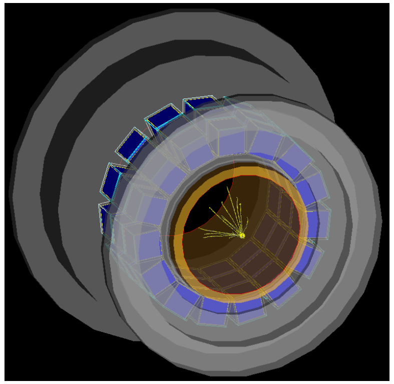
Protons in ^{72}Zn

Protons in ^{71}Cu*

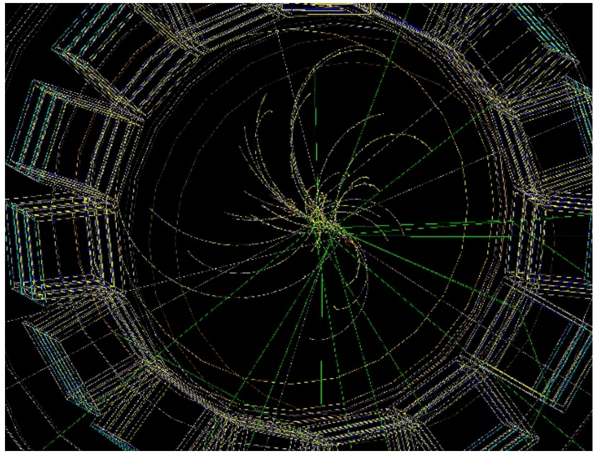
^{70}Zn(d, ^{3}He)^{69}Cu reaction simulation in G4 for SpecMAT

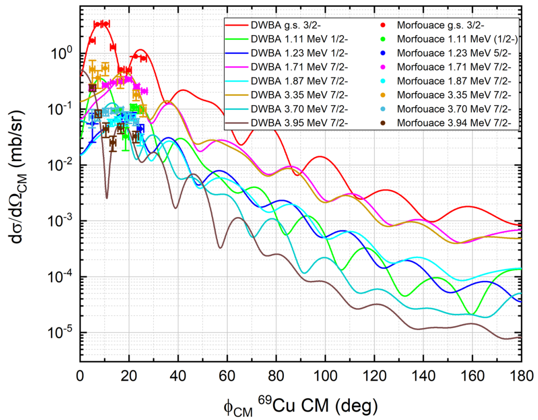






+ B-field = 4T





Cross section data from [P. Morfouace https://doi.org/10.1103/PhysRevC.93.064308], DWBA by J.C. Yang

Table 5.1: Estimated total cross section of the low-lying states in ^{69}Cu.

State	Energy (MeV)	Estimated σ_{tot} (mb)
$3/2^-$	g.s. 0	1.506
$(1/2^-)$	1.11	0.14
$5/2^-$	1.23	0.083
$7/2^-$	1.71	0.349
$7/2^-$	1.87	0.074
$7/2^-$	3.35	(0.387)
$7/2^-$	3.7	0.066
$7/2^-$	3.94	0.046

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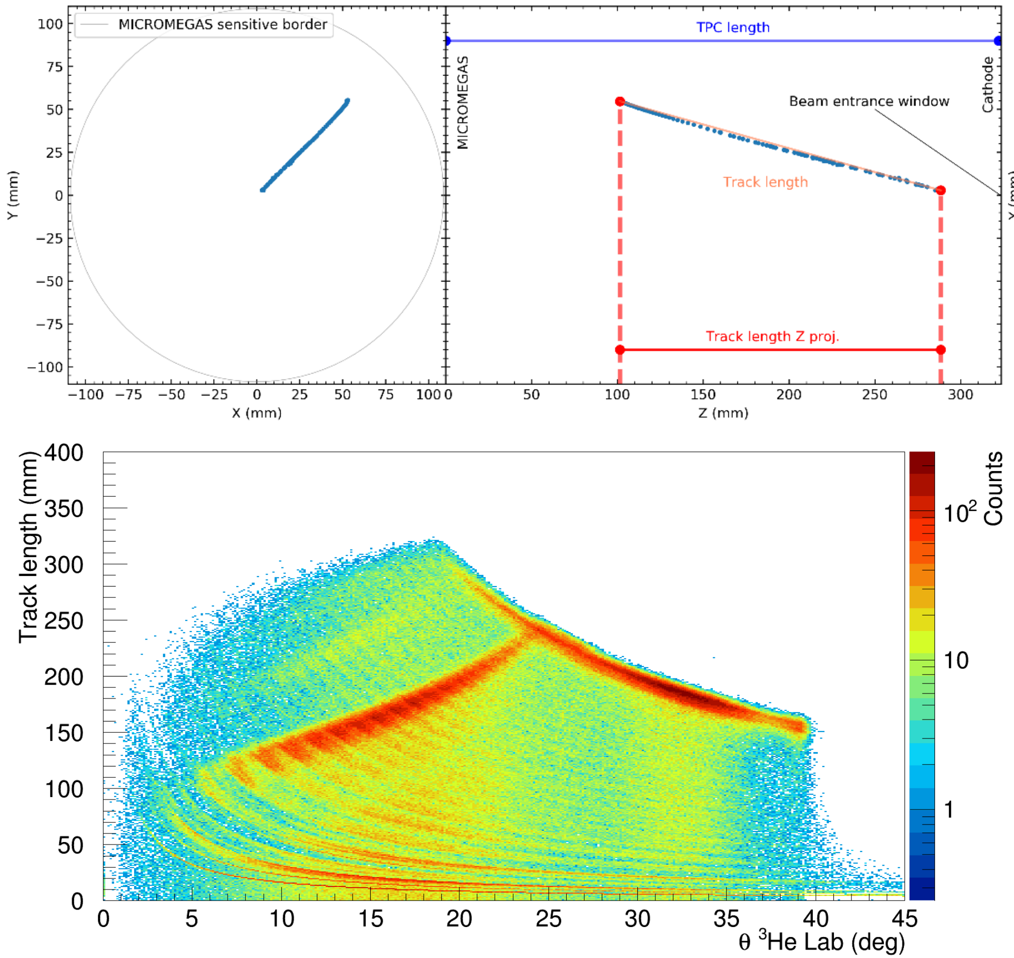
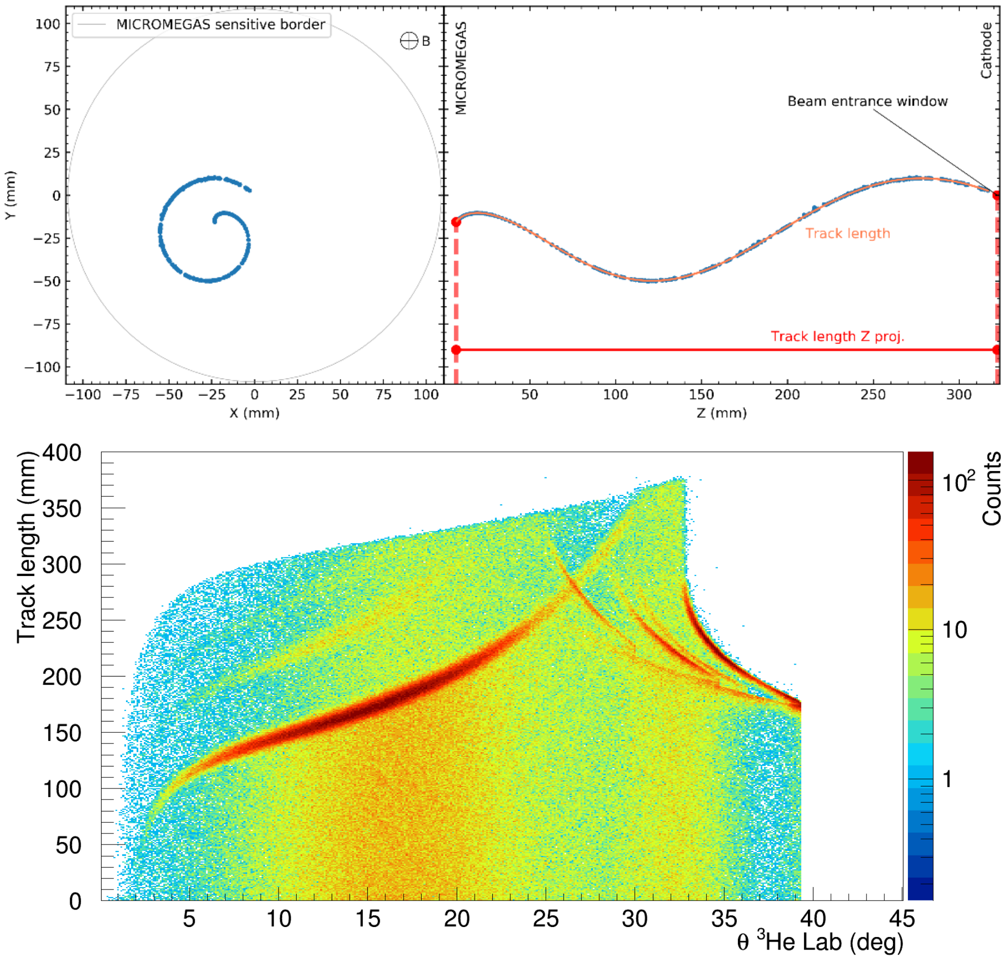
Analysis based on full-track length

0T with MICROMEGAS binning
Track parameters (θ, L) from fitting



4T no MICROMEGAS binning
Track parameters from G4



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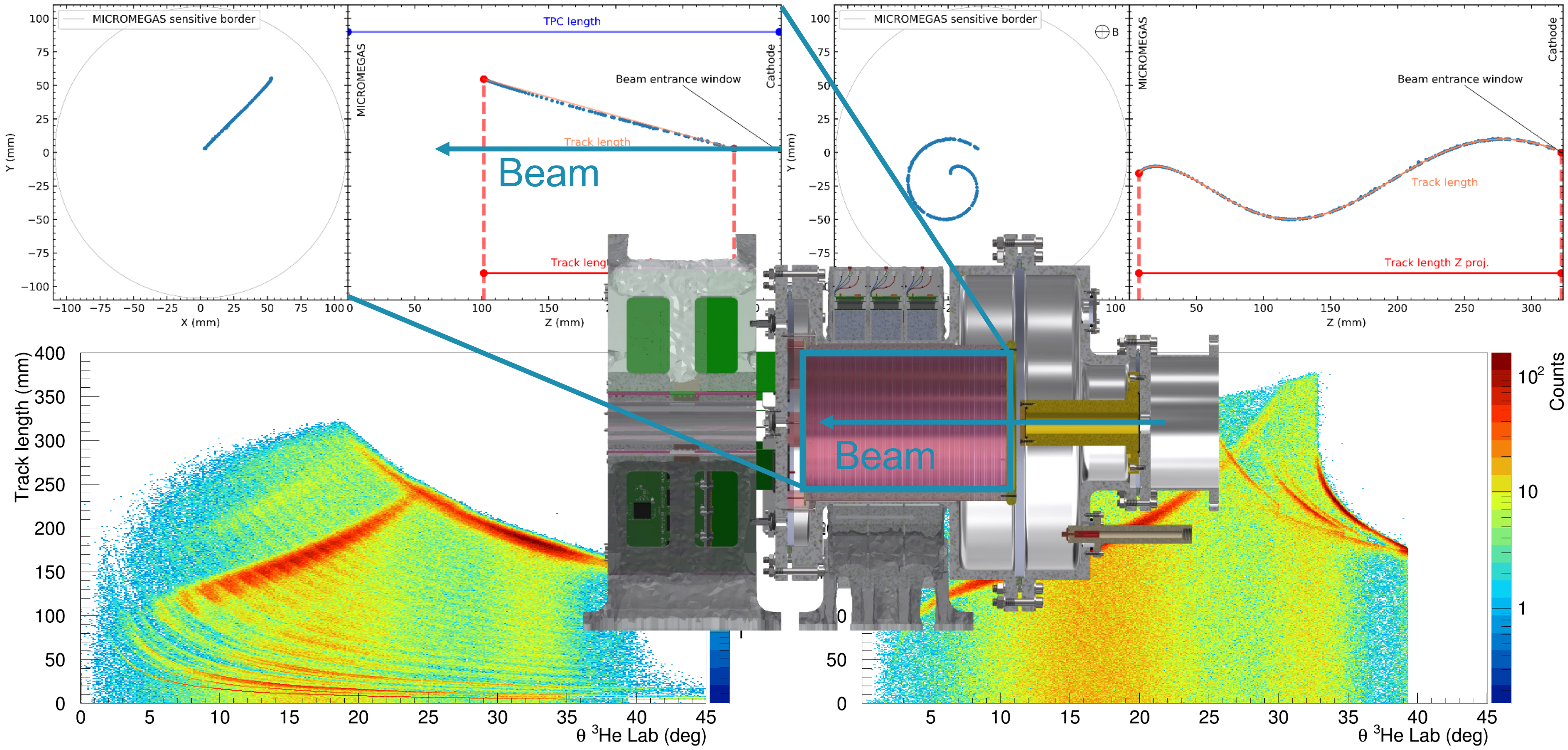
Analysis based on full-track length

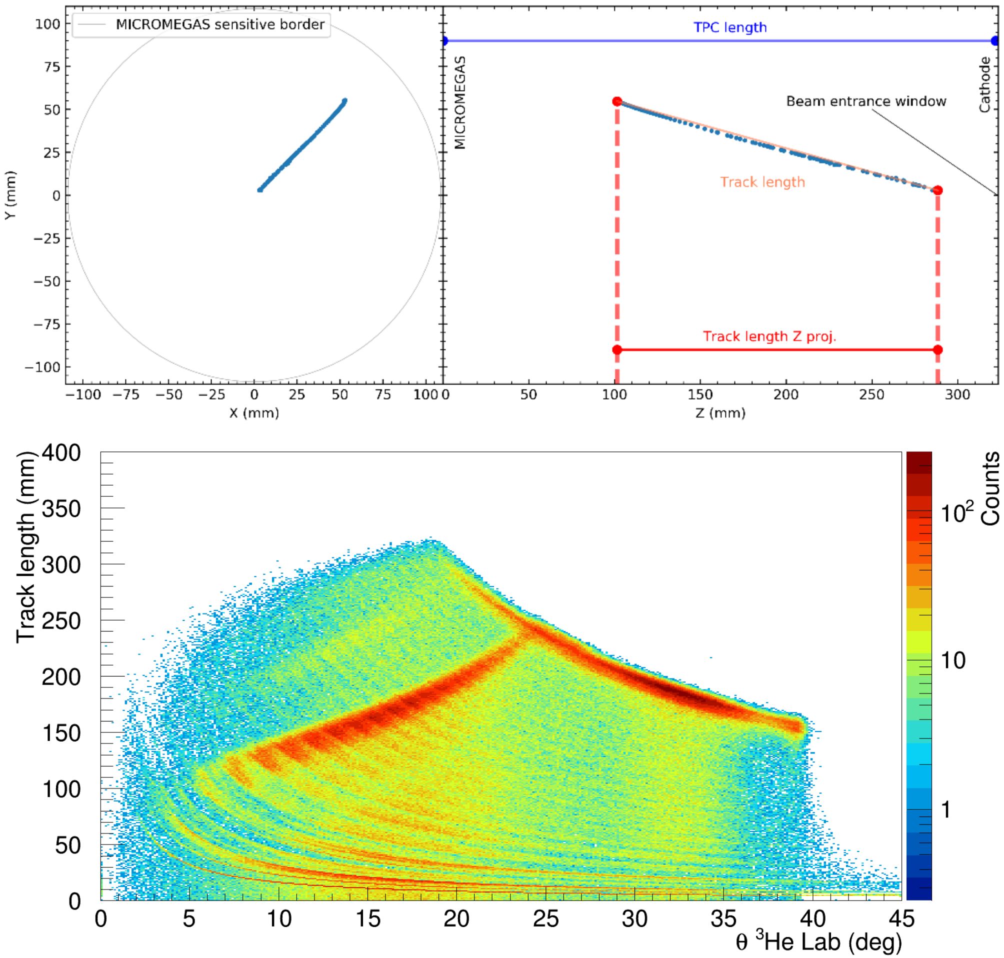
0T with MICROMEGAS binning
Track parameters (θ, L) from fitting

4T no MICROMEGAS binning
Track parameters from G4

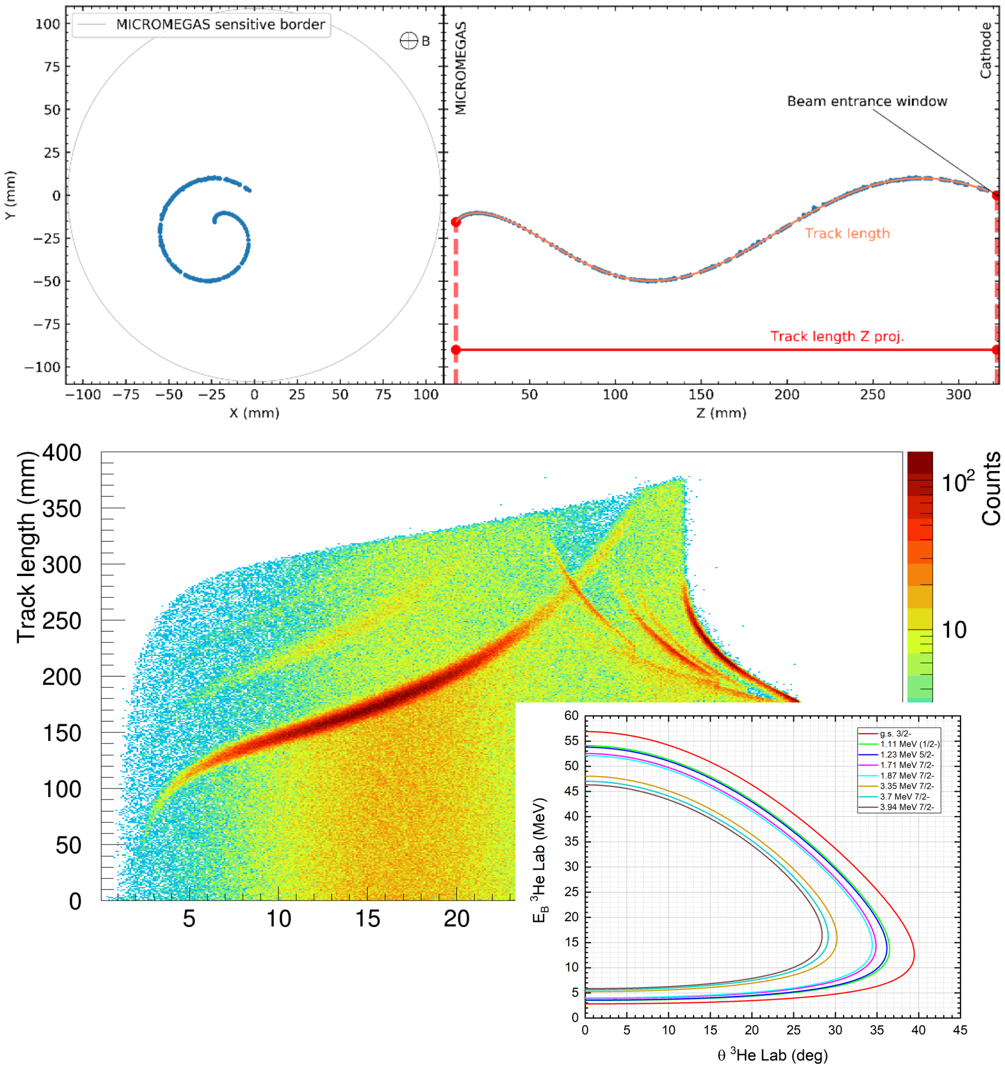


Analysis based on full-track length

0T with MICROMEGAS binning
Track parameters (θ, L) from fitting

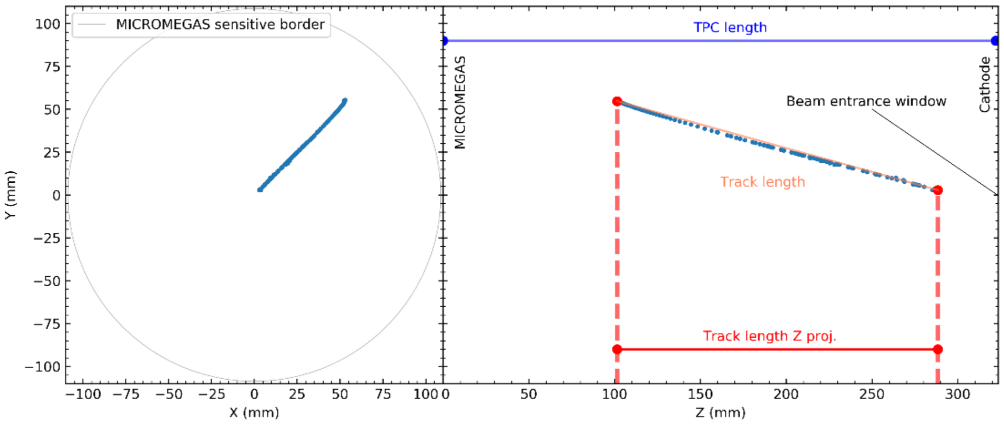


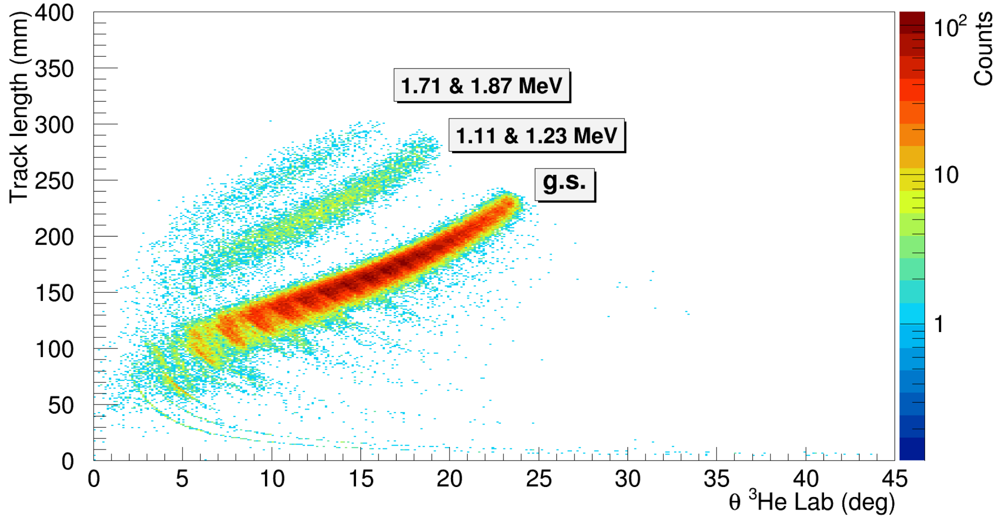
4T no MICROMEGAS binning
Track parameters from G4



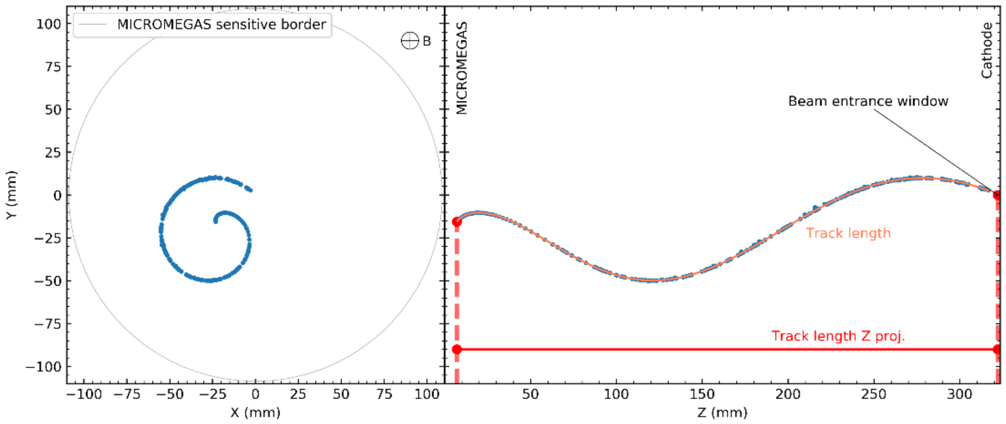
Analysis based on full-track length

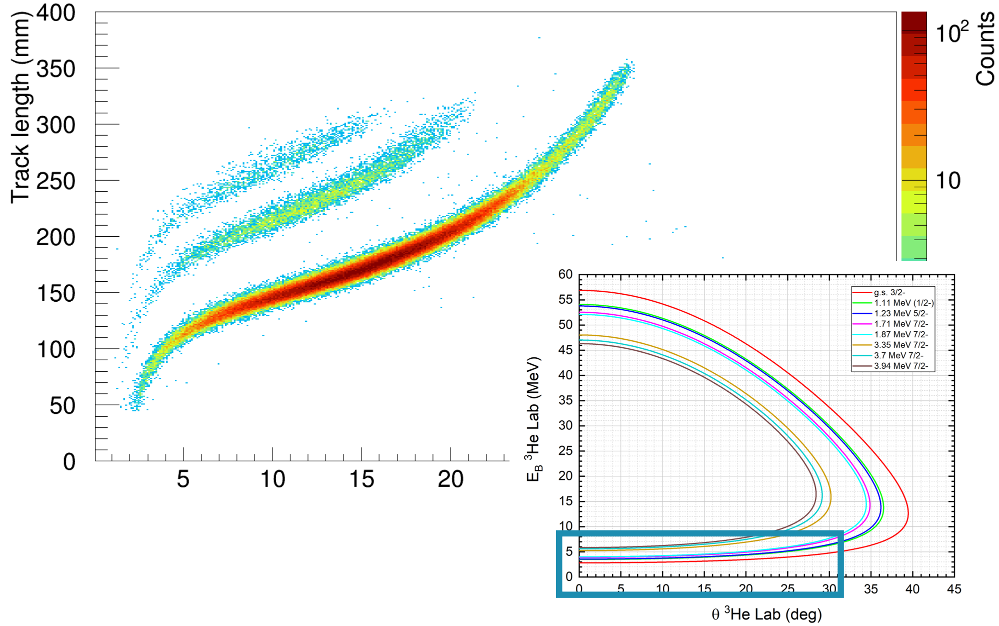
0T with MICROMEGAS binning



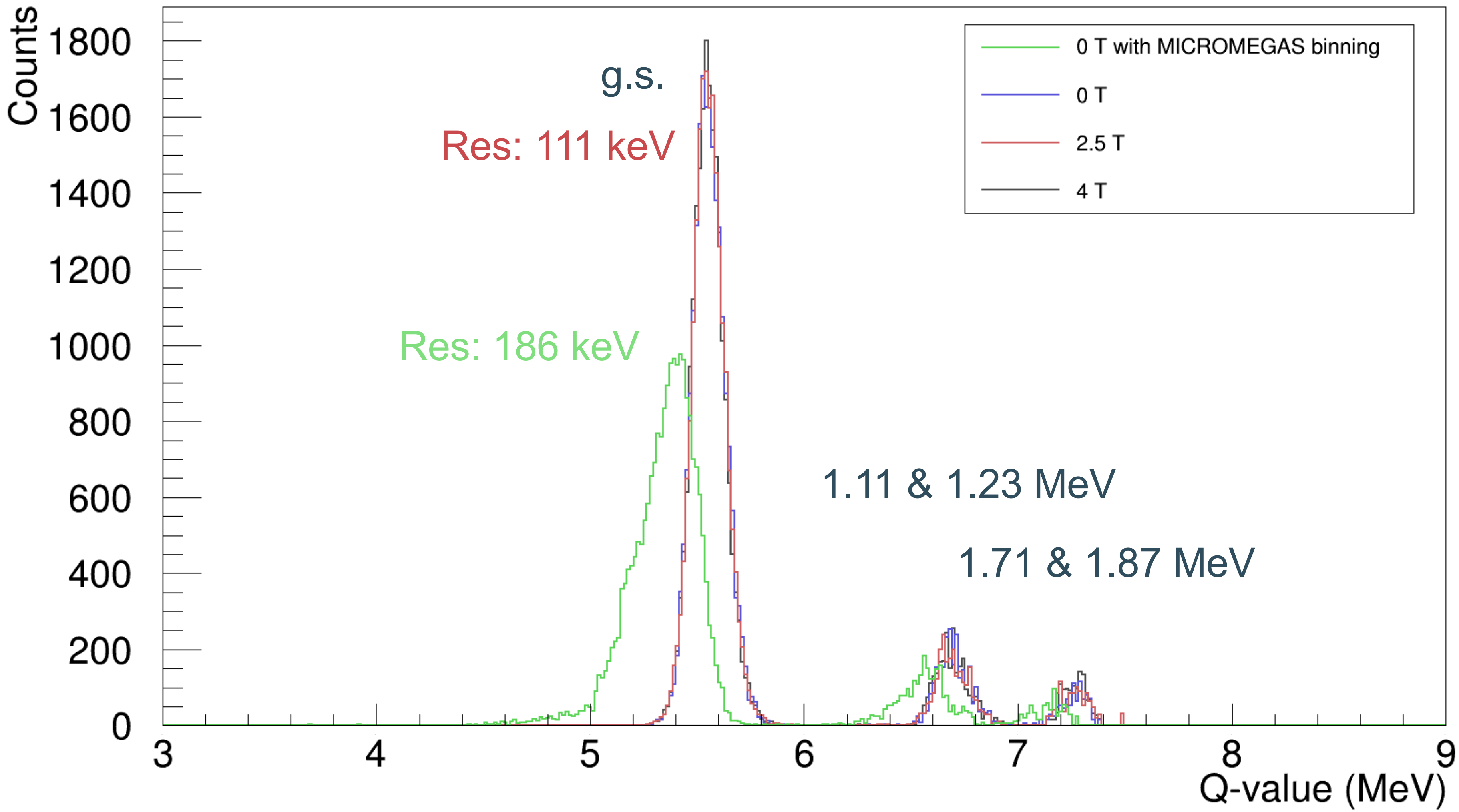


4T no MICROMEGAS binning

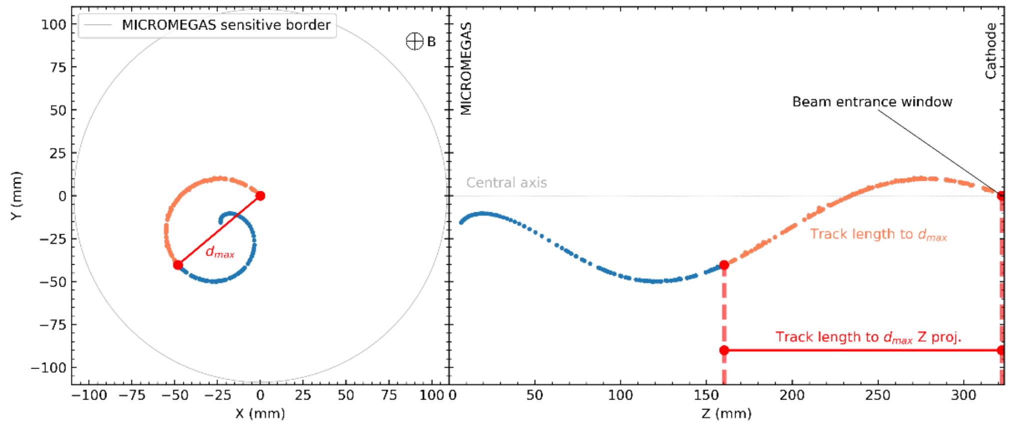


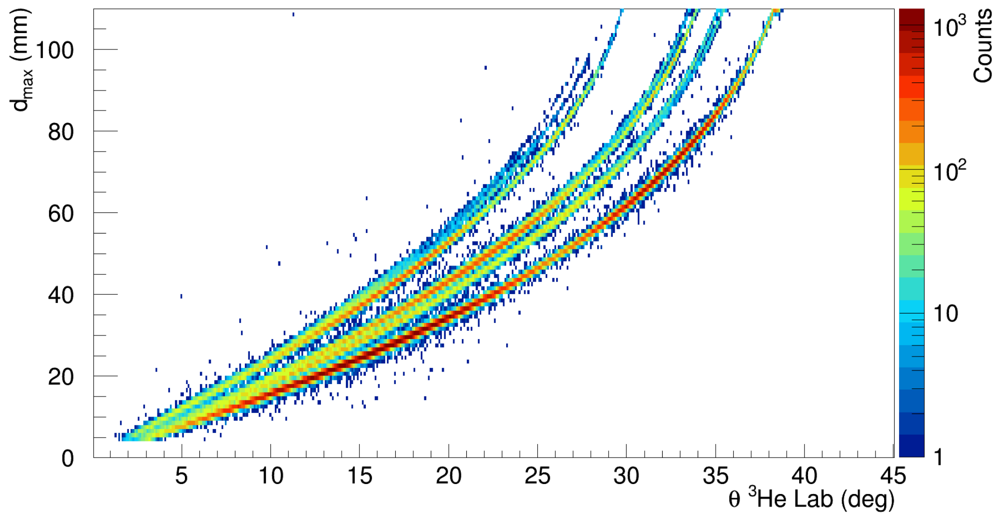


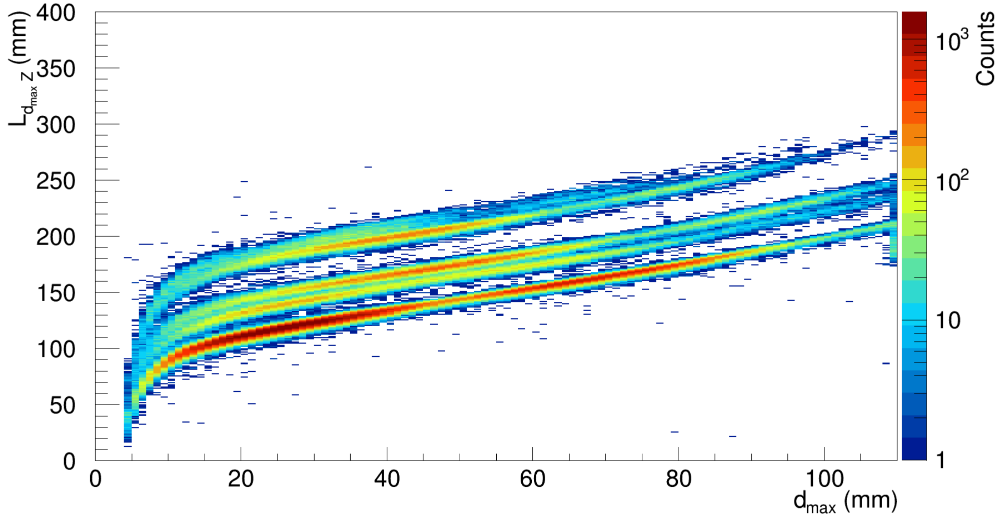
Analysis based on full-track length
Excitation spectra



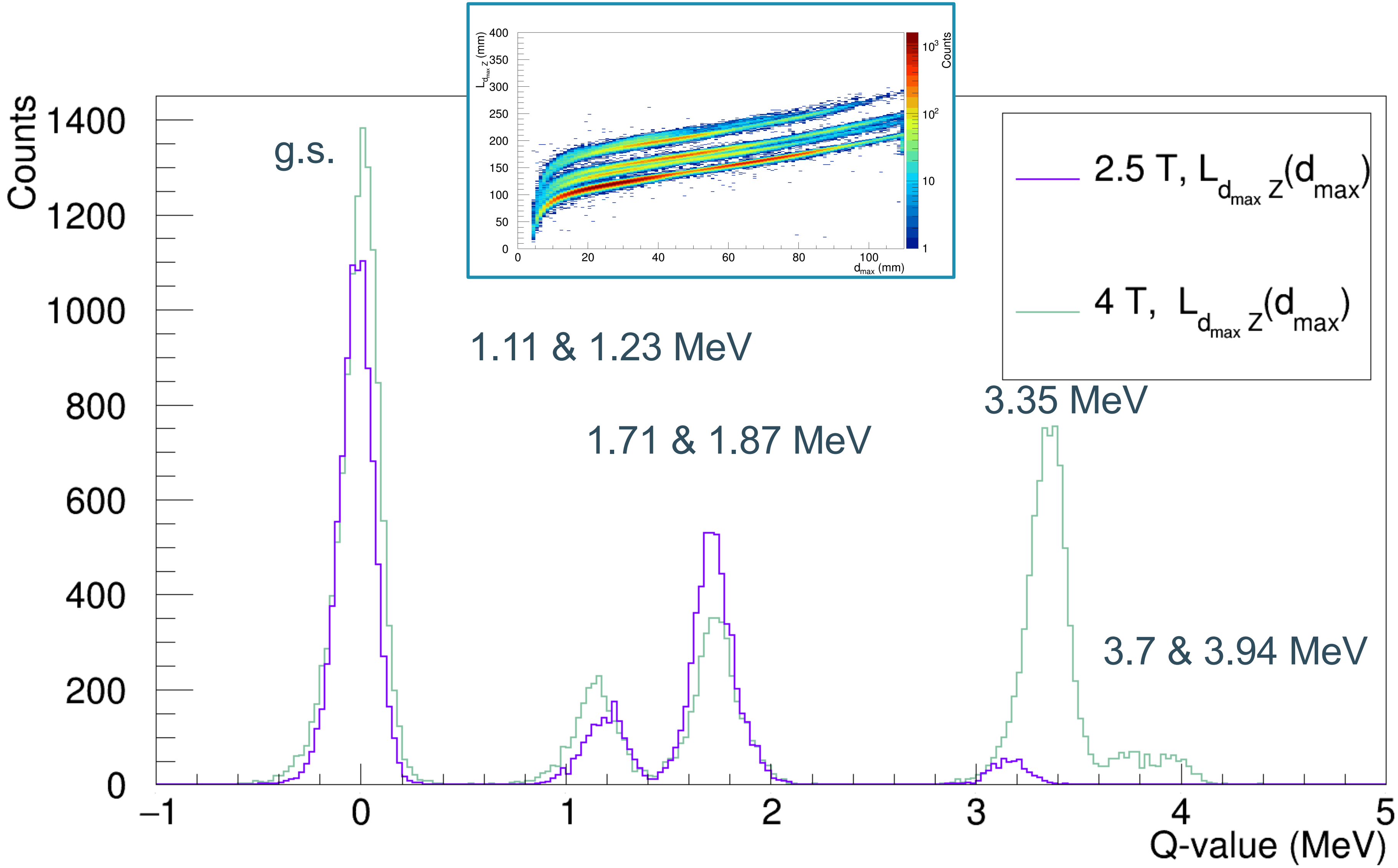
4T no MICROMEGAS binning



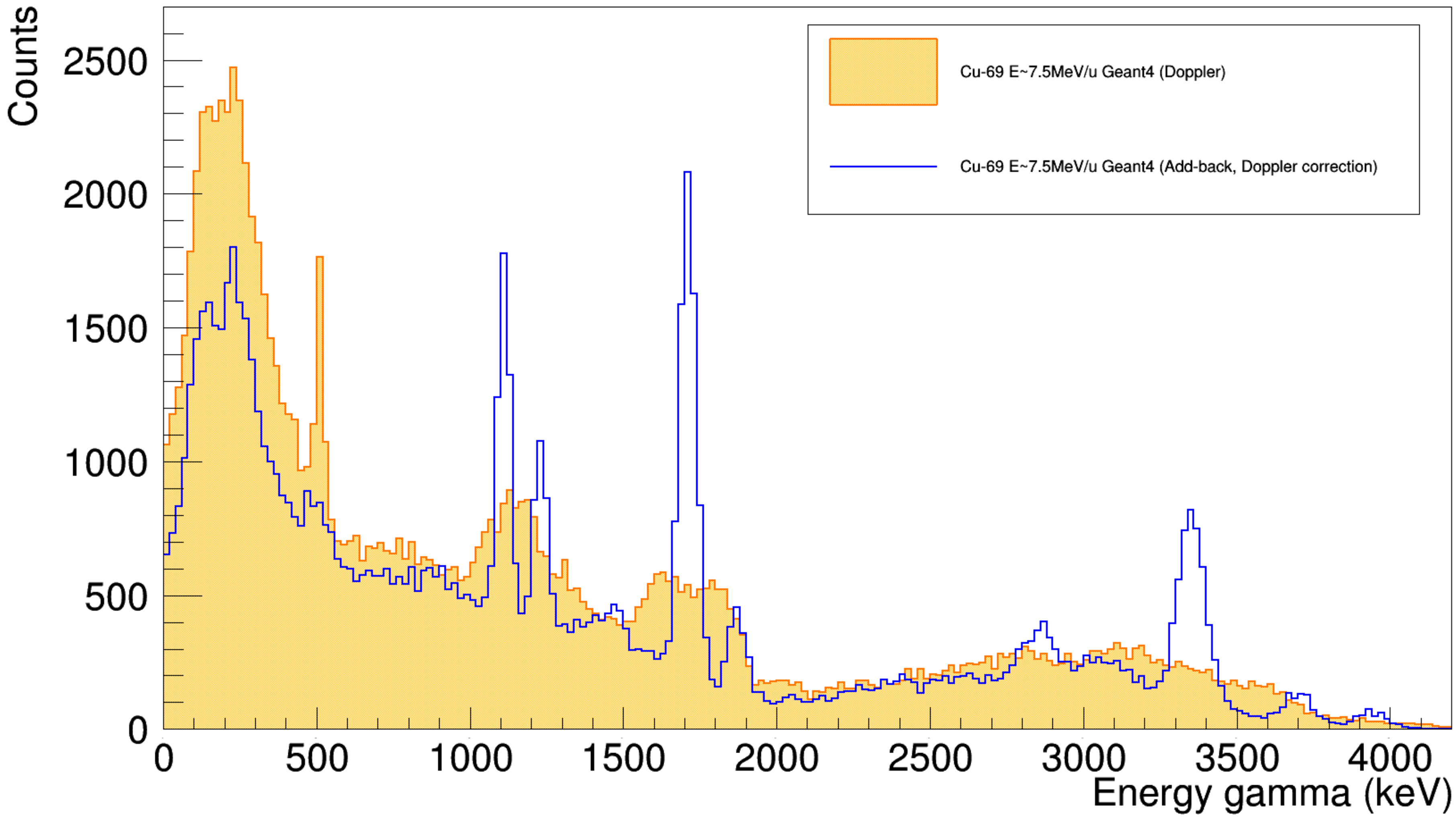




Excitation spectra obtained with the new analysis method



Analysis based on (full+partial)-track length
Gating on the gamma-ray spectrum



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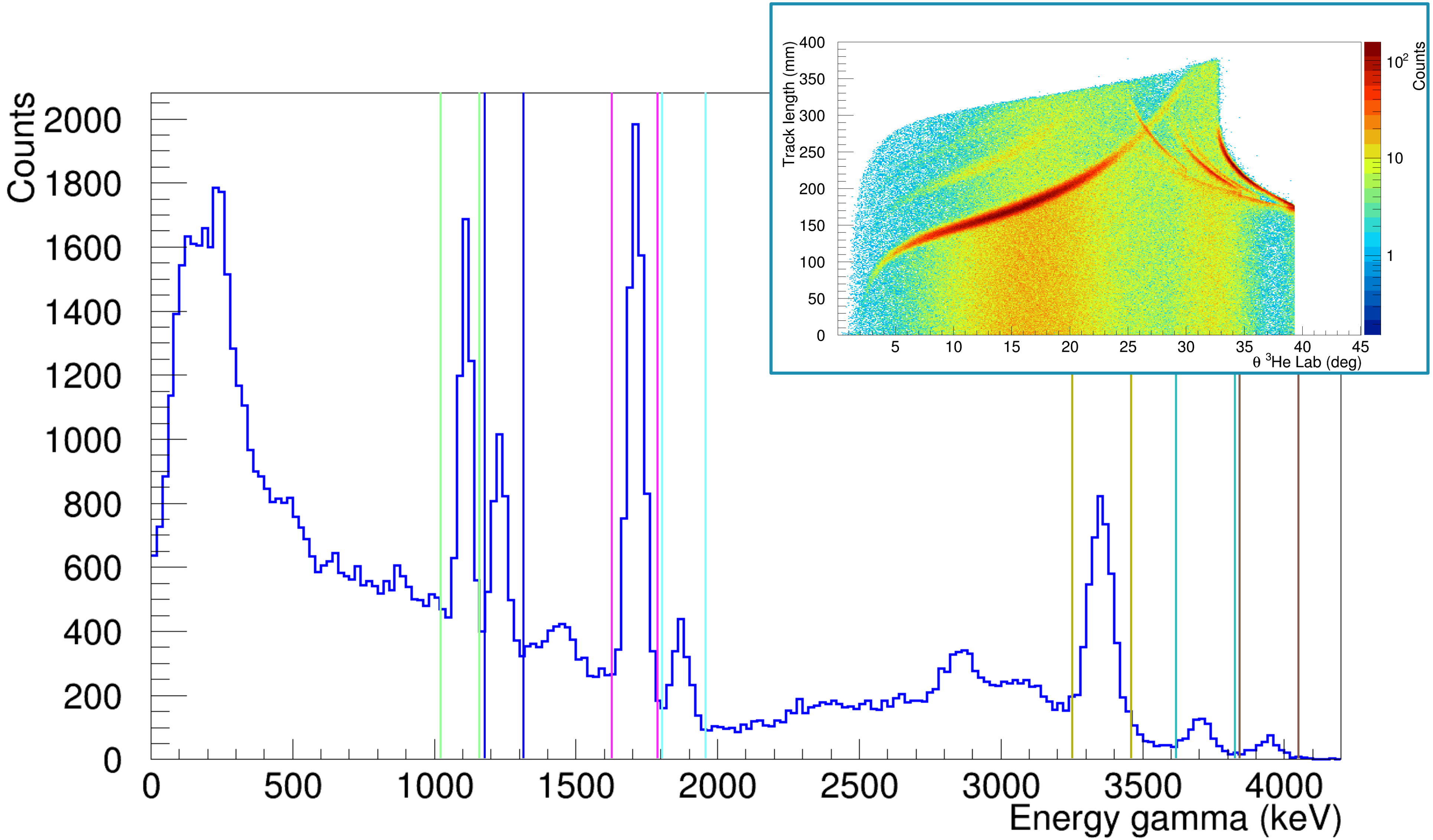
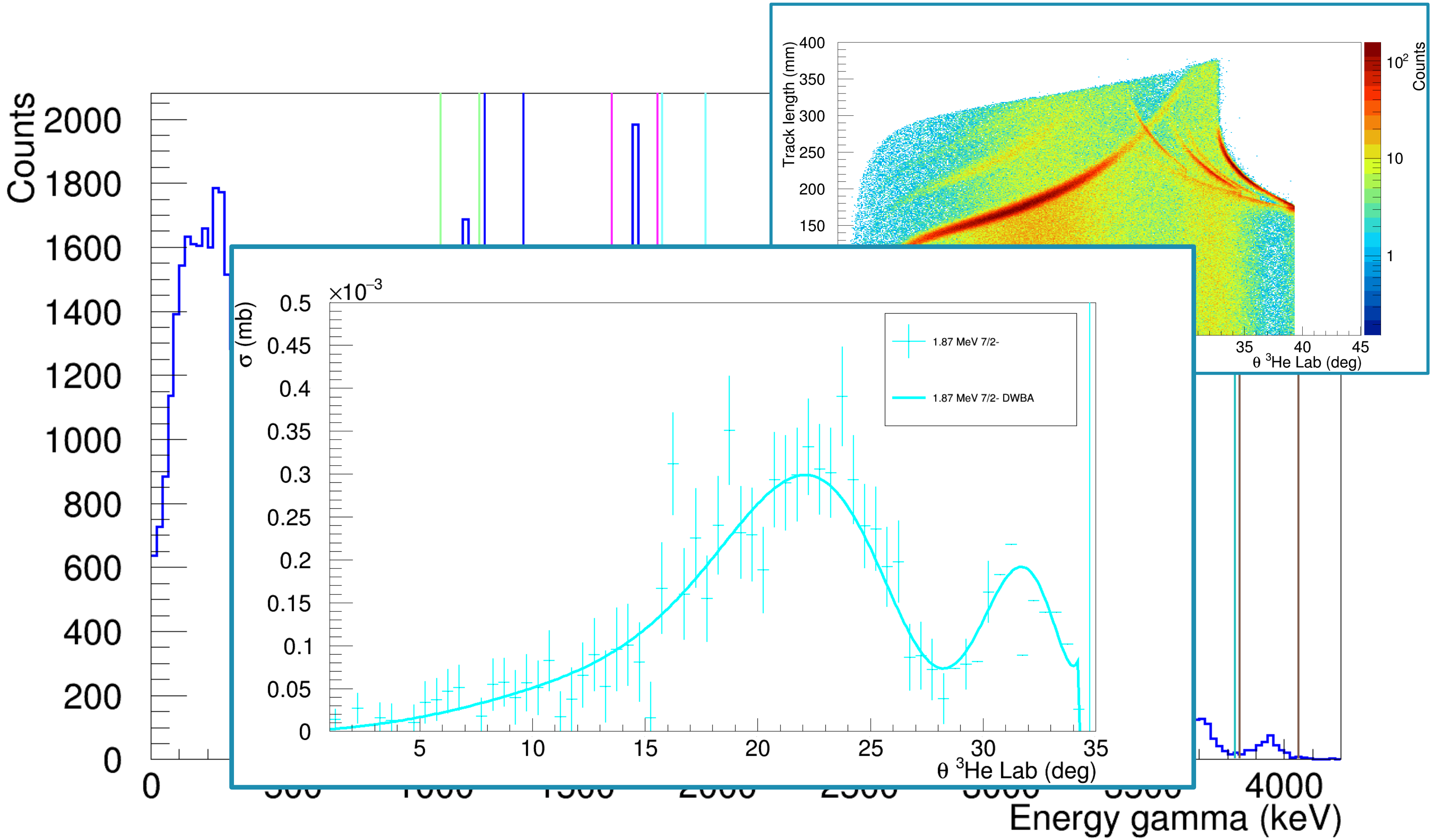
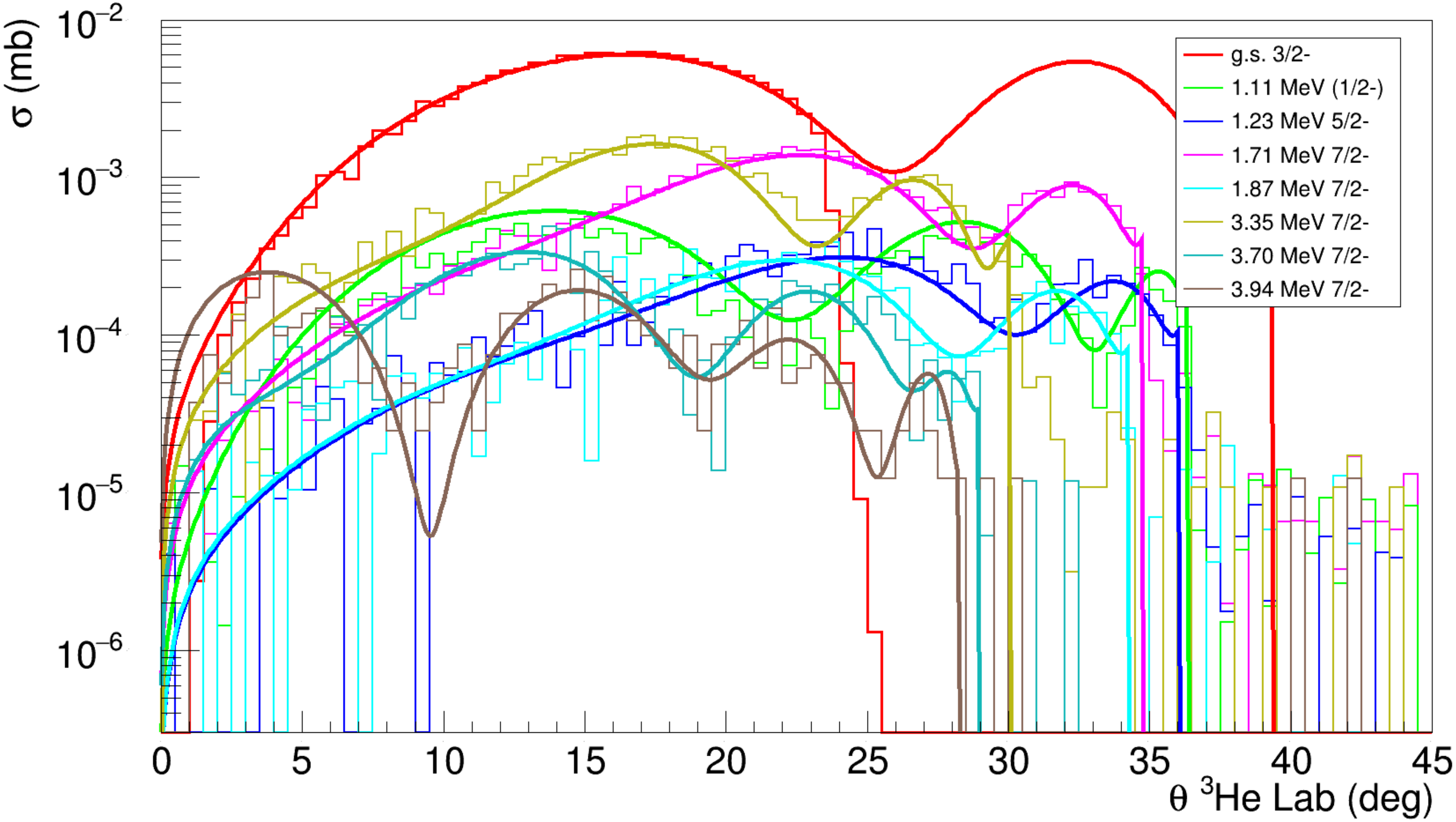
Analysis based on (full+partial)-track length
Gating on the gamma-ray spectrum



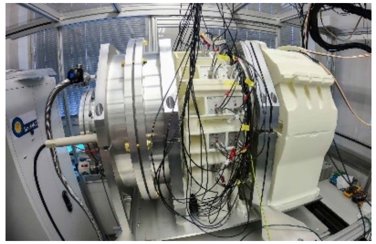
Analysis based on (full+partial)-track length
Gating on the gamma-ray spectrum

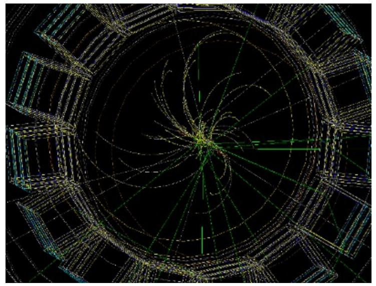


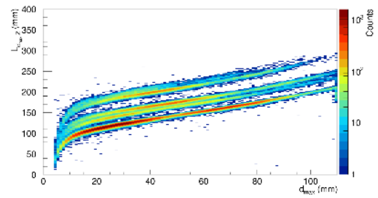
Analysis based on (full+partial)-track length
Gating on the gamma-ray spectrum



Summary







✓ The SpecMAT active target was designed, built and characterised.

✓ The detector was characterised in 0T and in 2.5T.

✓ An experimentally verified set of simulations was developed.

✓ A new fitting algorithm for spiral tracks was developed

✓ A novel analysis method of the spiral tracks was proposed.

✓ Online commissioning is planned for July 2023 with ^{22}Ne@7.5-10 MeV/u

KU LEUVEN

SpecMAT

Thank you for your attention!