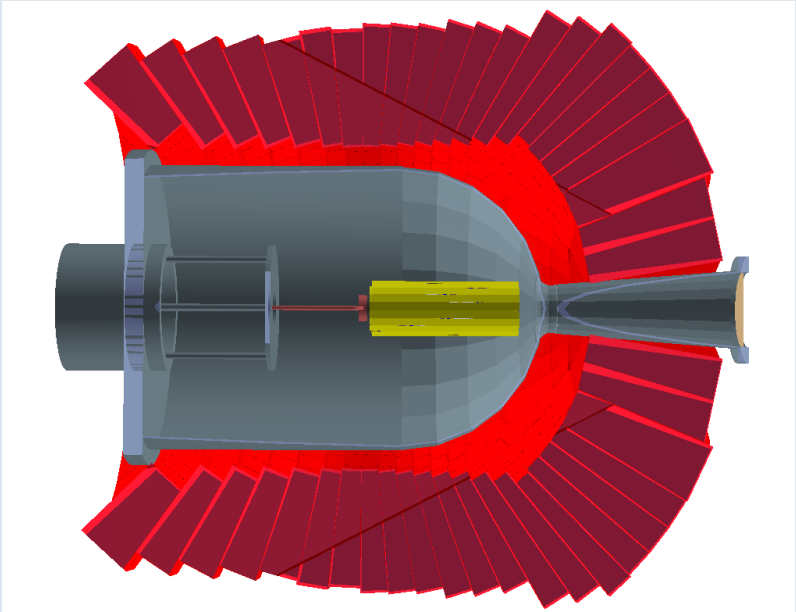
Update of the ALPIDE Si-tracker simulations for studies with quasi-free scattering reactions



José Luis Rodríguez-Sánchez

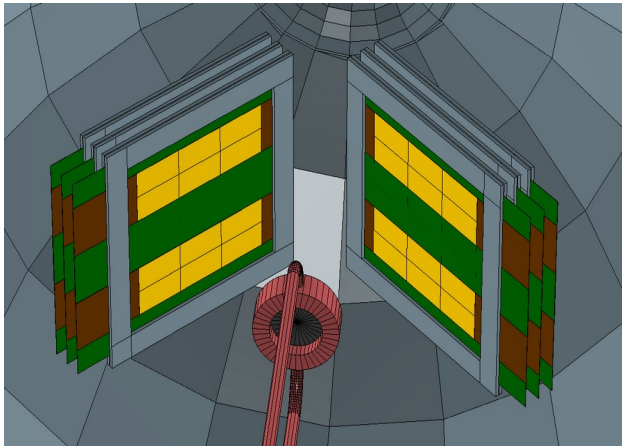
University of Coruña & USC

24th May 2023

MINISTERIO DE CIENCIA E INNOVACIÓN
Financiado por la Unión Europea NextGenerationEU
Plan de Recuperación, Transformación y Resiliencia
AGENCIA ESTATAL DE INVESTIGACIÓN
CITENI
USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA
UNIVERSIDADE DA CORUÑA

R³B Si-tracker configurations

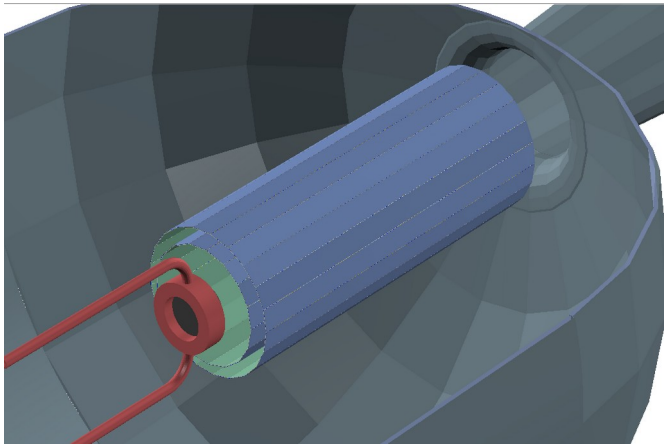
Stage I



Two arms
- 3 planes each
- 18 sensors per plane

2024

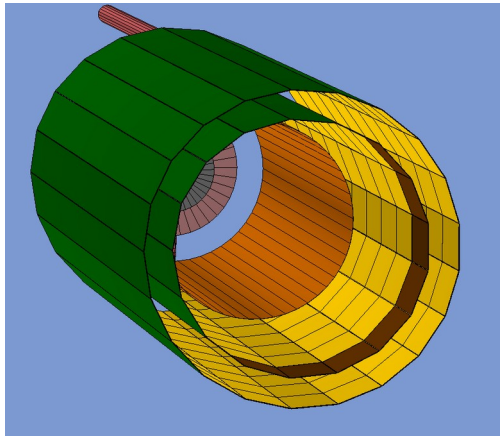
Stage II



Two/Three barrels *(ideal geo.)*
- 17/21 multi-Flex modules
- 9 sensors per module

2027/2028

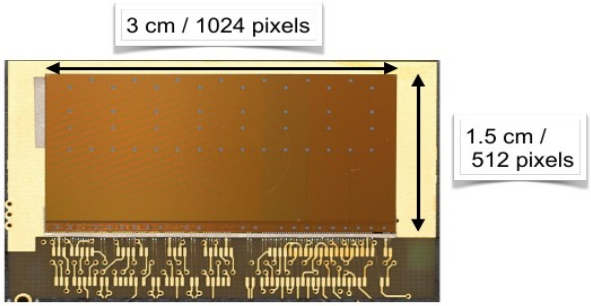
Stage III



Three (1st bent) **barrels**
- 17/21 multi-Flex modules
- 9 sensors per module
- Barrel with bent Si-sensors

2029/...

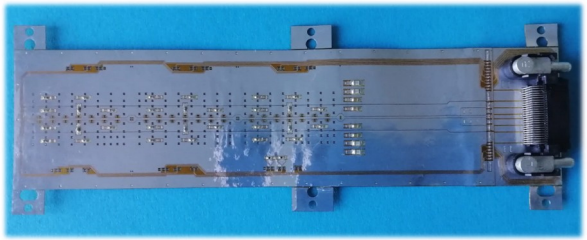
Tracking station for stage I: Two arms configuration



ALPIDE die on carrier card

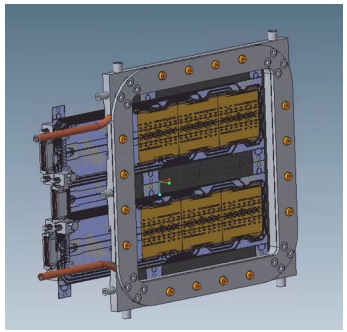
Thickness of 50 µm

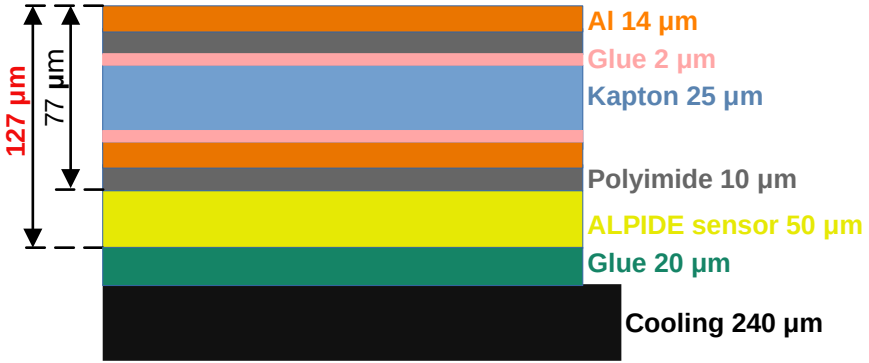
6 Flex boards at GSI: 3x9 cm^2



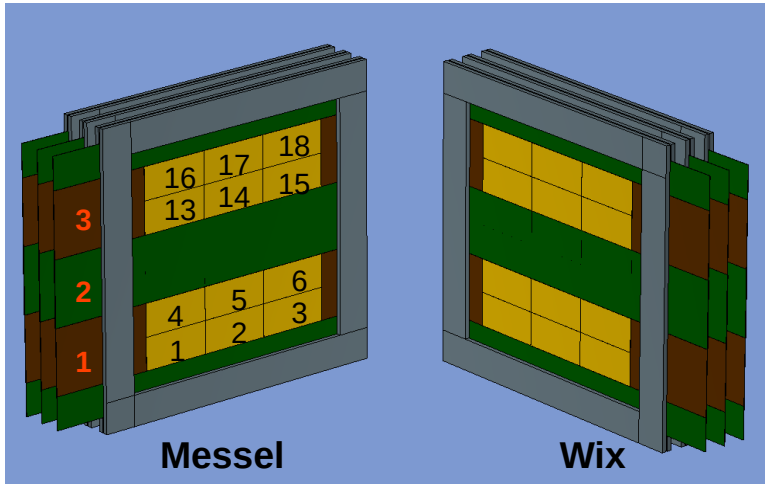
Thickness of 77 µm

Tracking station with 3 Flexes

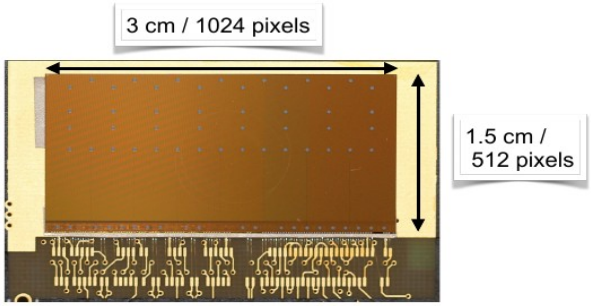




Thickness of 363 µm

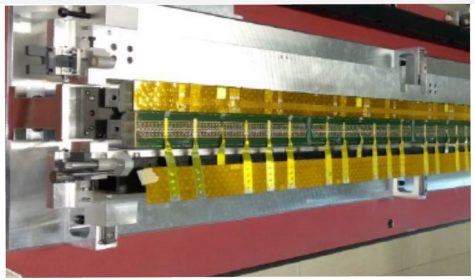


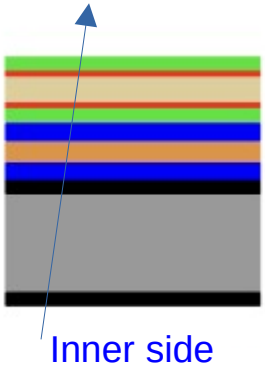
Tracking modules for stage II: Barrel configuration



ALPIDE die on carrier card

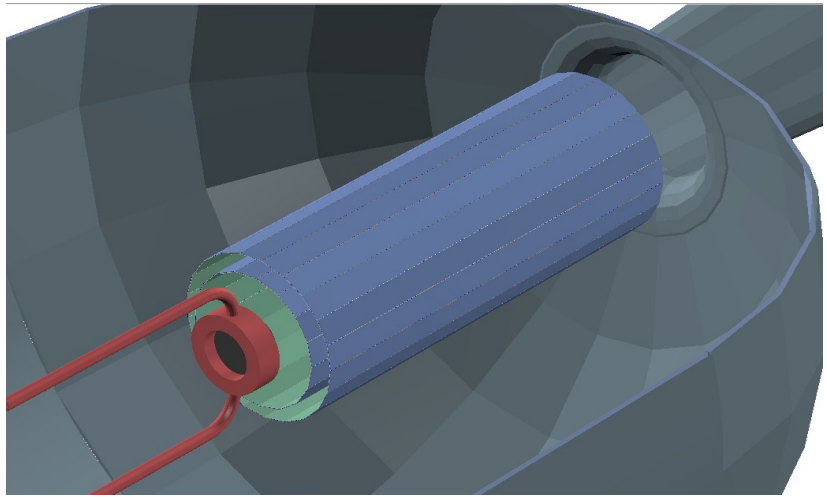
Thickness of 50 µm





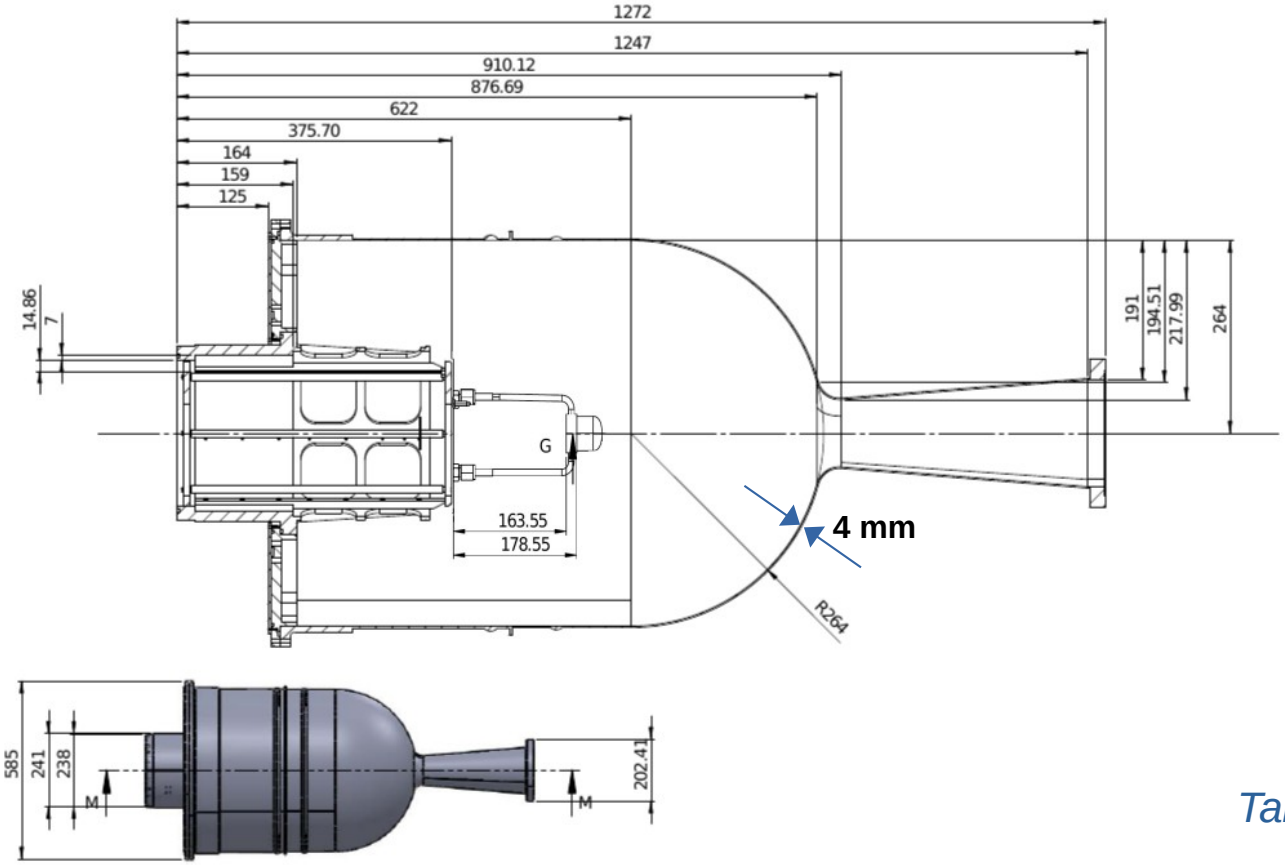
Layer	Thk (µm)	Composition	ρ (g/cm³)
Solder mask (2)	30	Epoxy (C_2H_2)	1.250
Conducting layers (2)	10	Al	2.699
Substrate	75	Kapton	1.420
Glue (2)	40	C	0.958
Chip	50	Si	2.328
C fleece (2)	20	C	0.400
Cold plate	240	C	1.583

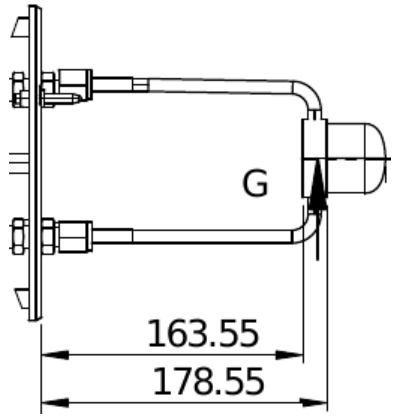
Thickness of 565 µm



Vacuum chamber

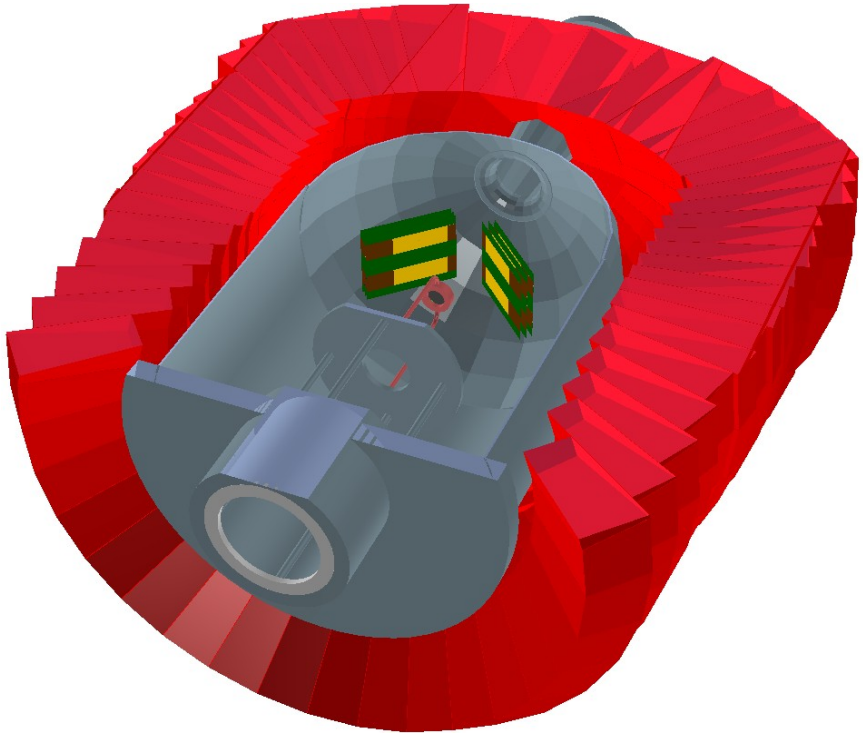
**Details from Enrique, Daniel & Anna*



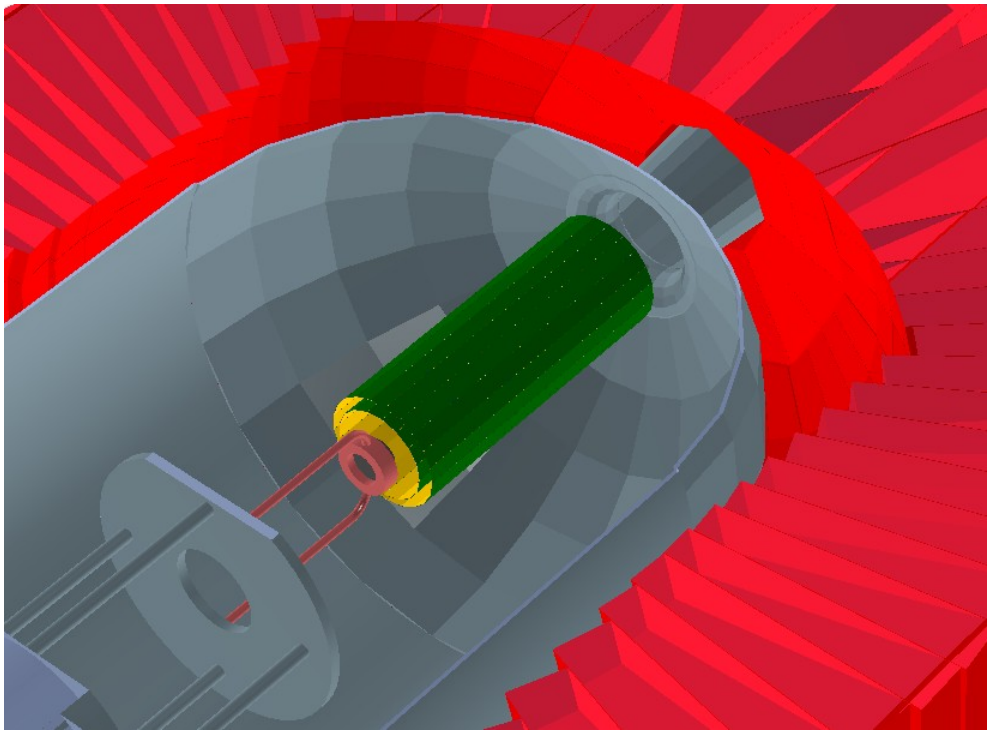


Target: 1.5 cm radius, 1.5 cm thick

Full geometries for stage I & II



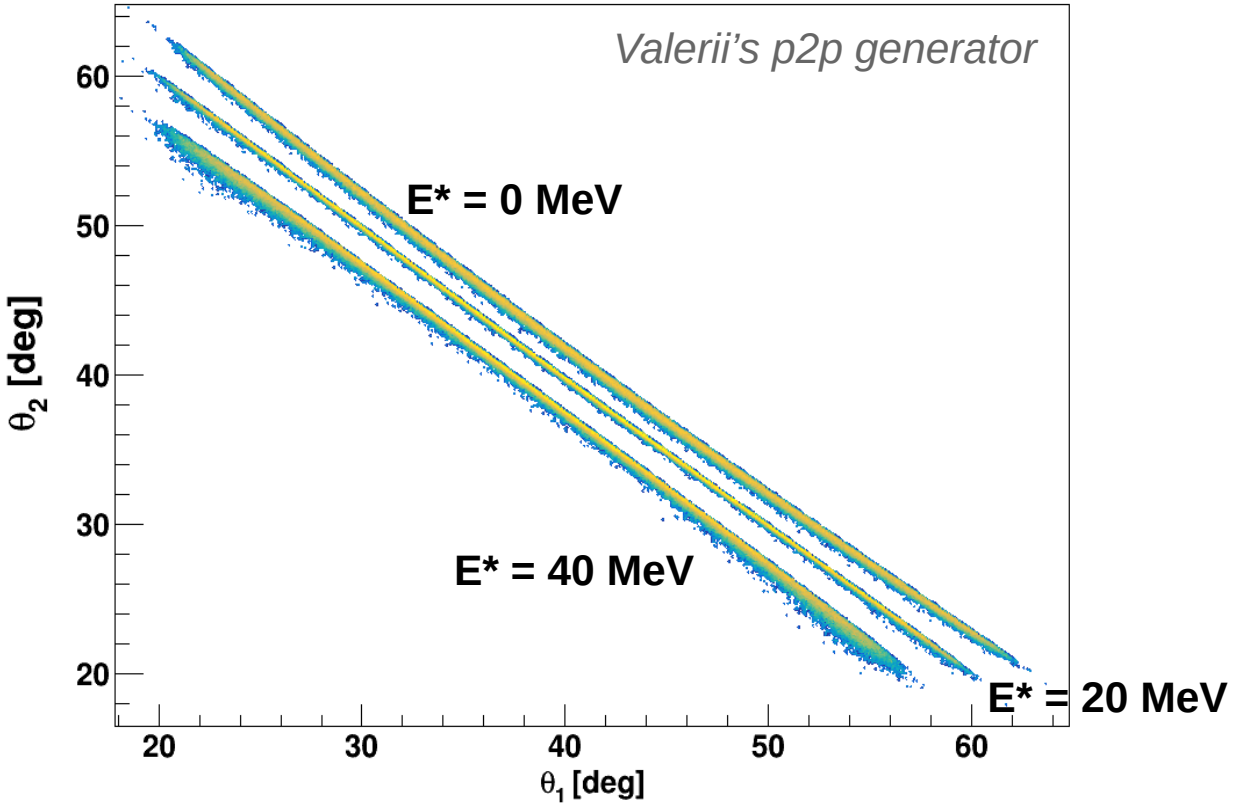
CALIFA: Hector's geometry 2021



Note for target: 1.5 cm radius, 1.5 cm thick

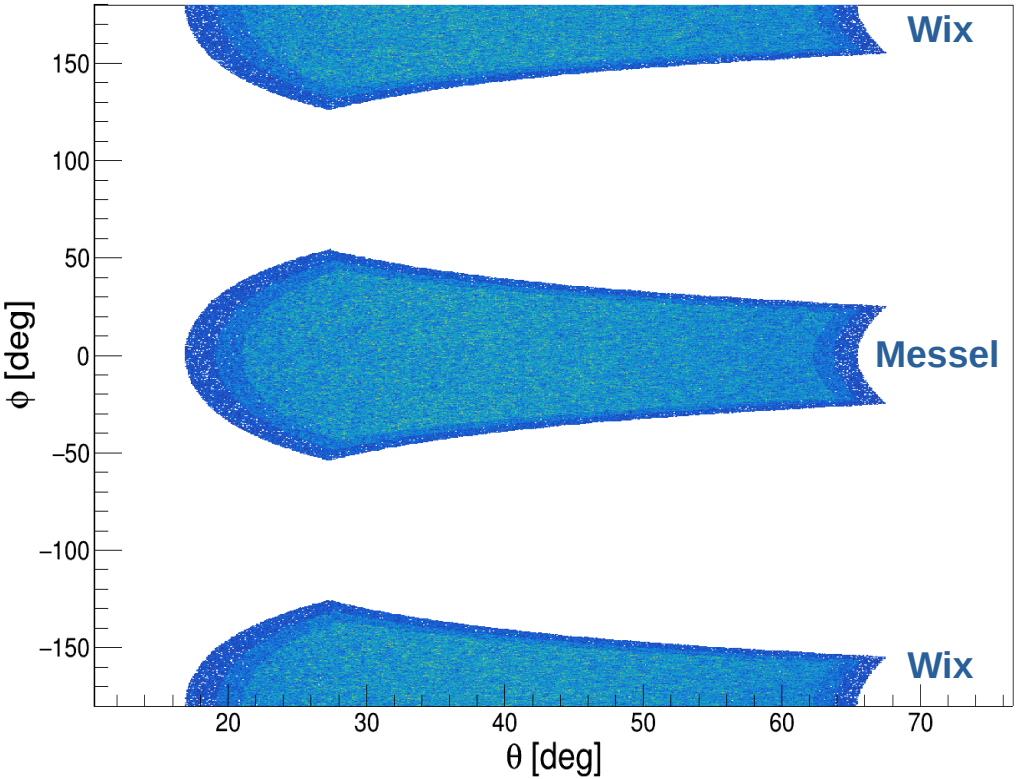
R3BRoot: (p,2p) event generator

(p,2p) events for three excitation energies: 0, 20 and 40 MeV, **at 500 MeV/u**



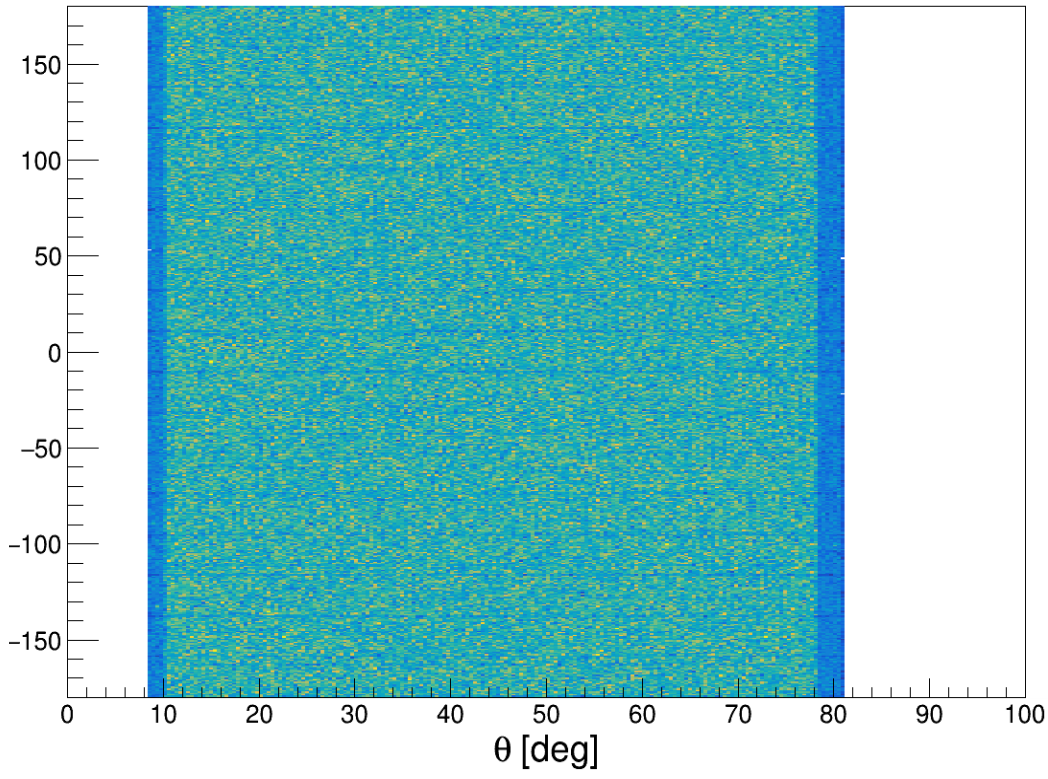
Comparison of **geometrical** efficiency

Two arms configuration



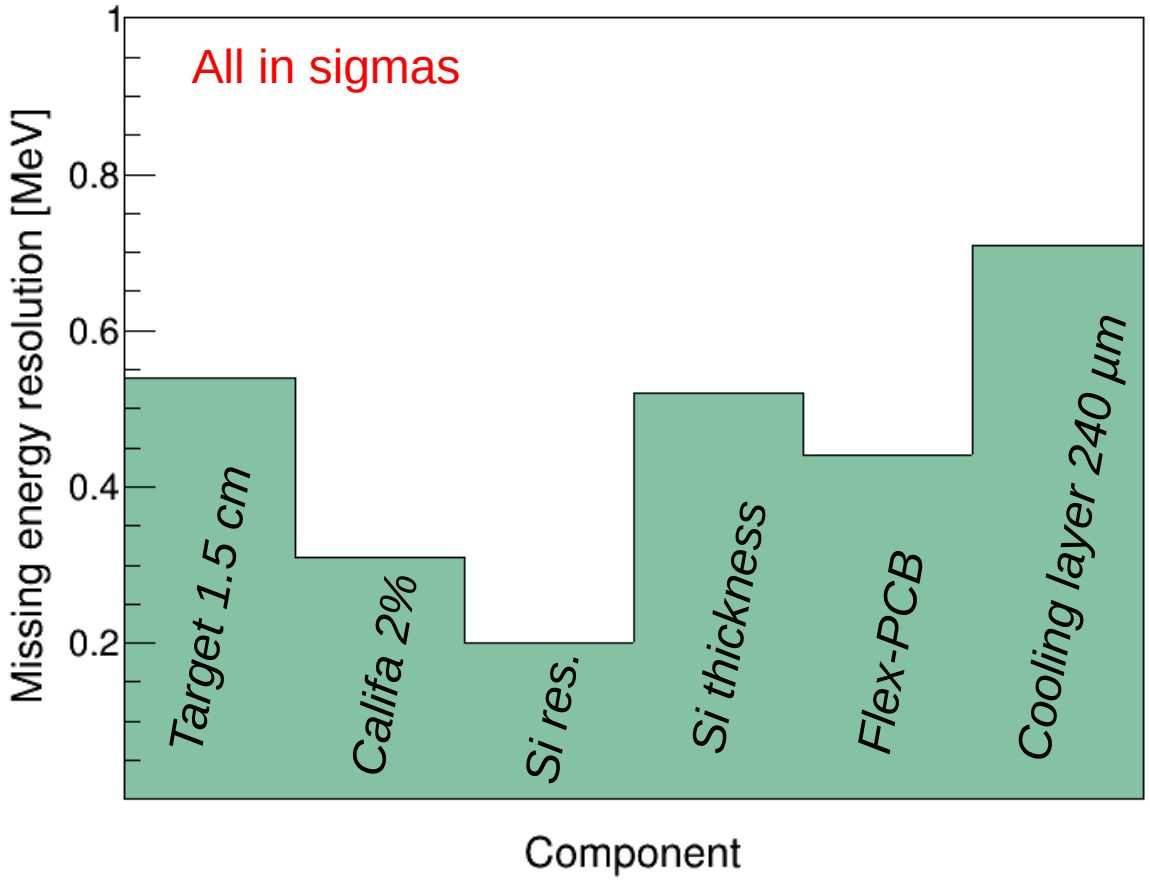
21% efficiency for (p,2p)

Barrel configuration



86% efficiency for (p,2p)

Two arms configuration (2024): Missing mass resolution



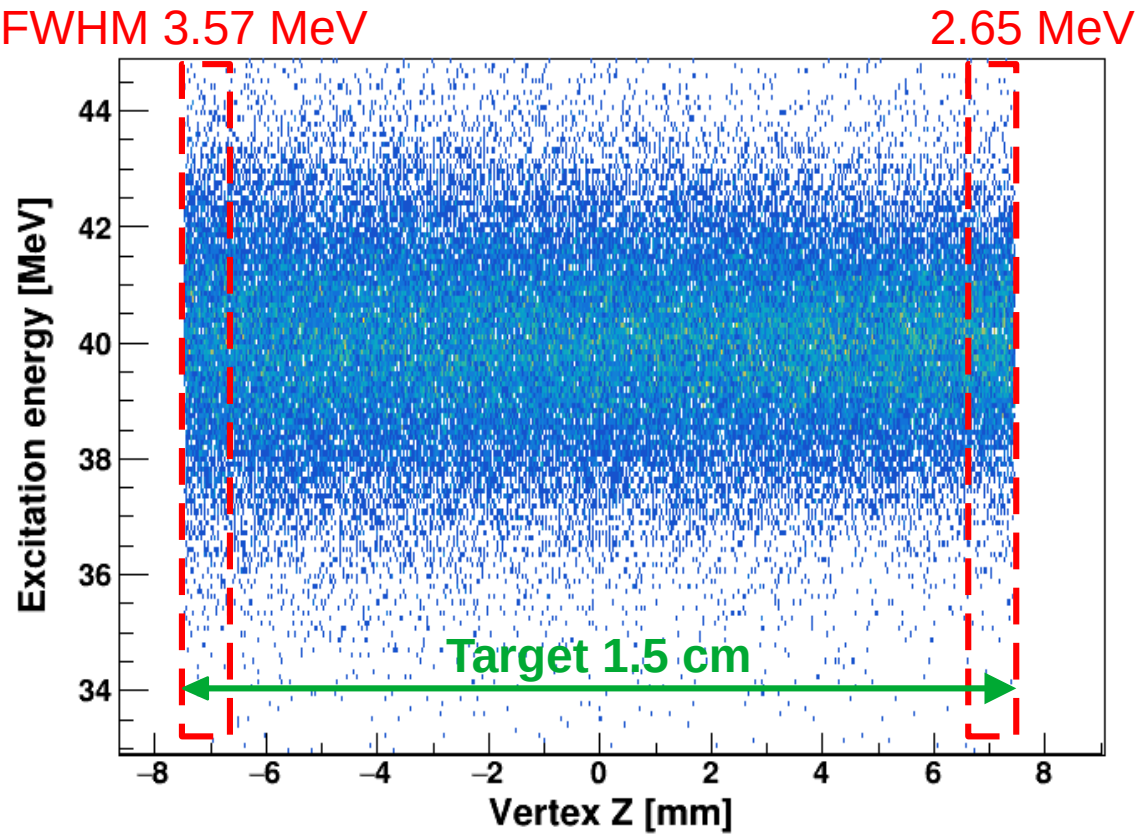
The main contribution to the missing mass comes from the cooling layer

Configuration	Resolution [MeV] (FWHM)
All componets	3.11

Note for target: 1.5 cm radius, 1.5 cm thick

Two arms configuration (2024): Excitation energy resolutions

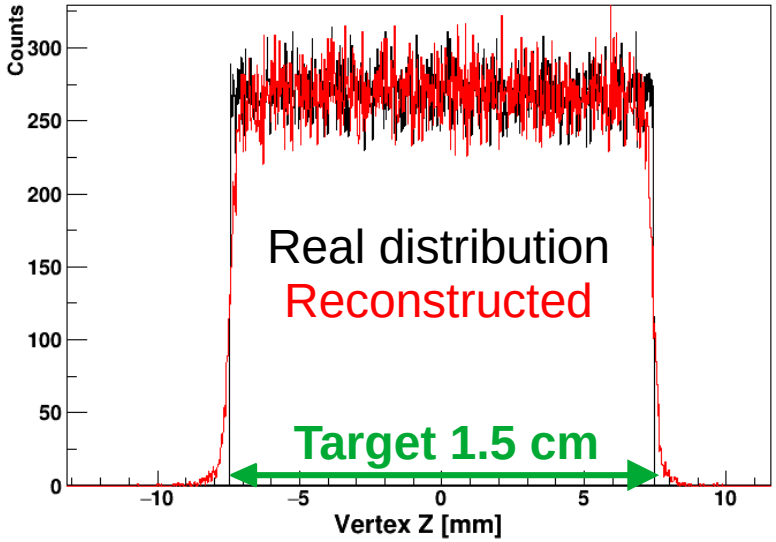
Dependence on vertex Z



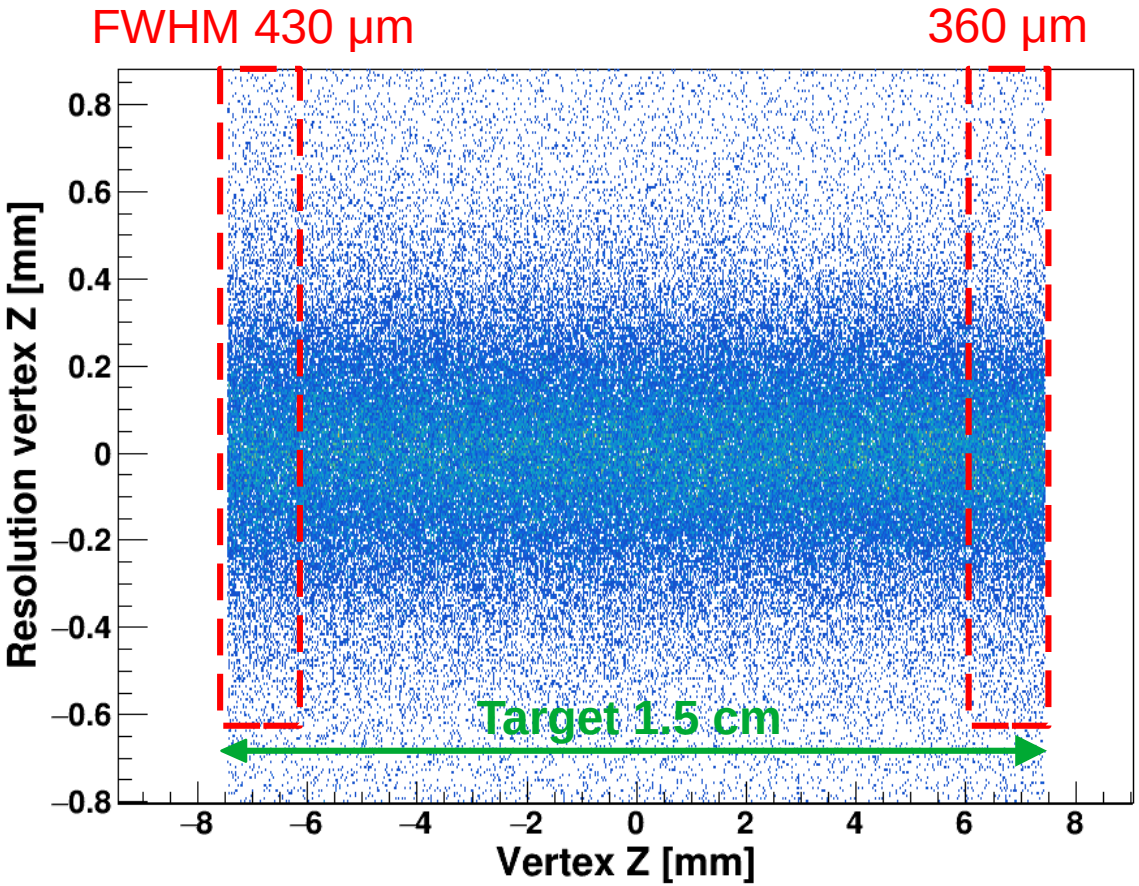
Two arms configuration (2024): Vertex reconstruction

Vertex resolution dependence on Z

Vertex resolution is calculated as
$\Delta z = Z_{reconstructed} - Z_{real}$

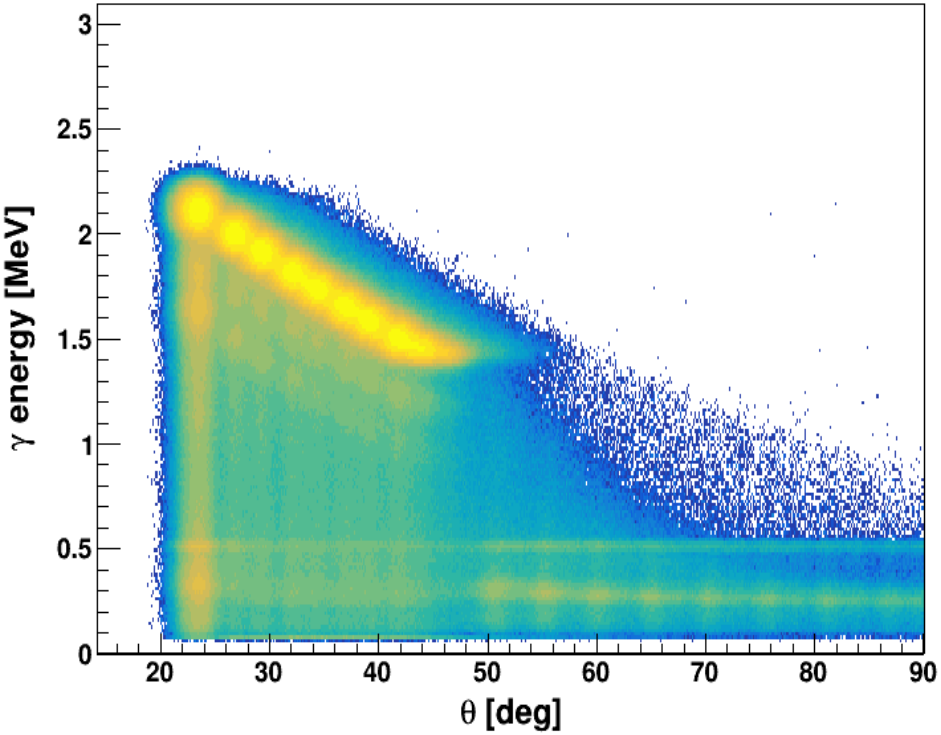


Average resolution **390 µm** (FWHM)



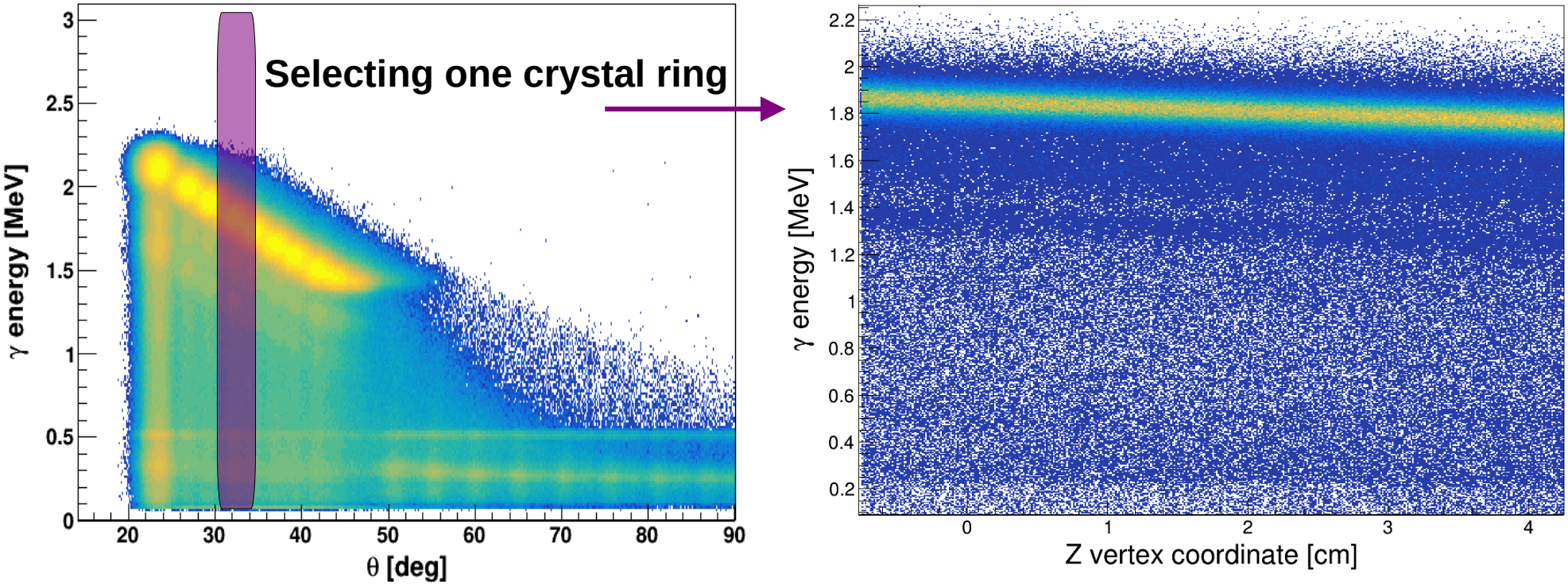
Doppler correction with ALPIDE tracking

Simulation of gammas with an energy of 1MeV emitted by fragments at 500 MeV/u



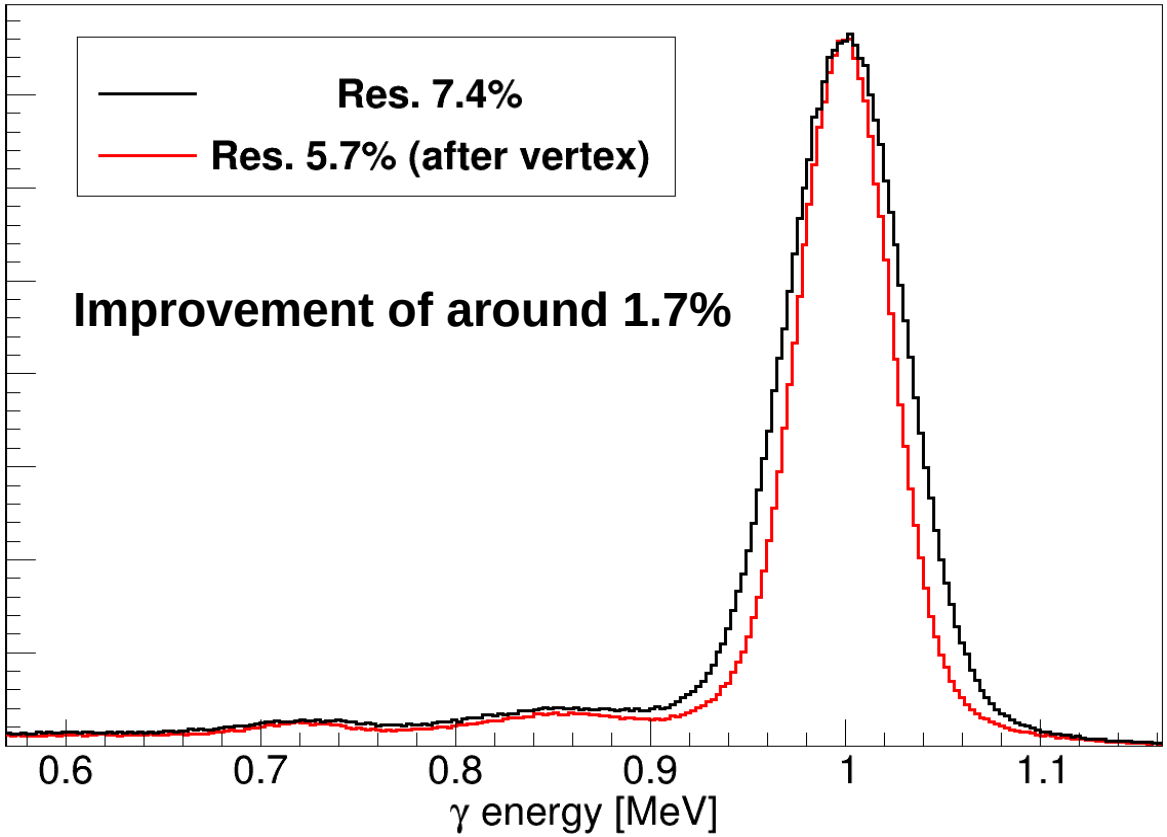
Doppler correction with ALPIDE tracking

Simulation of gammas with an energy of 1MeV emitted by fragments at 500 MeV/u

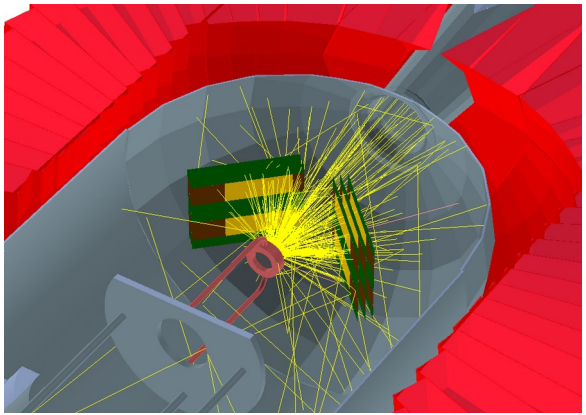


Doppler correction with ALPIDE tracking

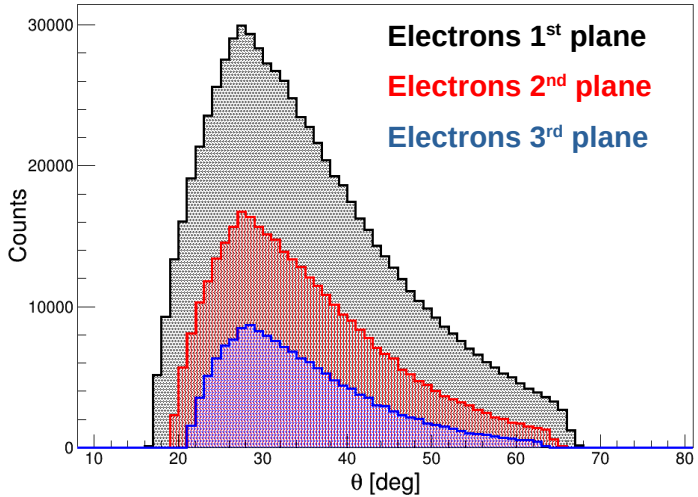
Simulation of gammas with an energy of 1MeV emitted by fragments at 500 MeV/u

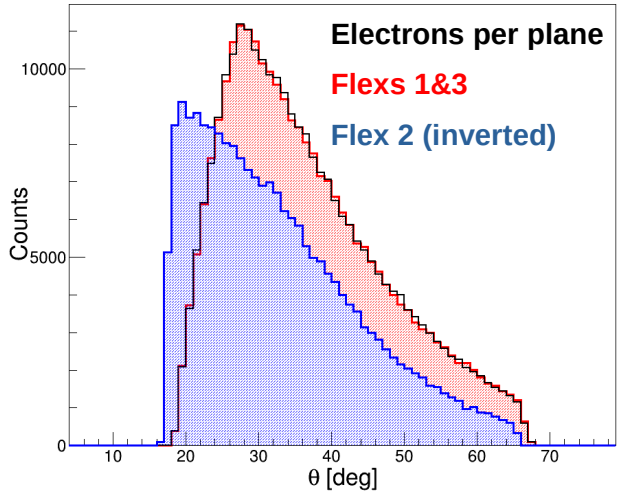


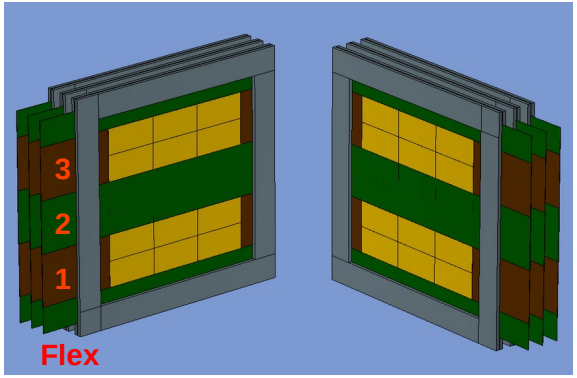
Attenuation of δ-electrons: Two arms



Beam of ^{238}U @ 500MeV/u

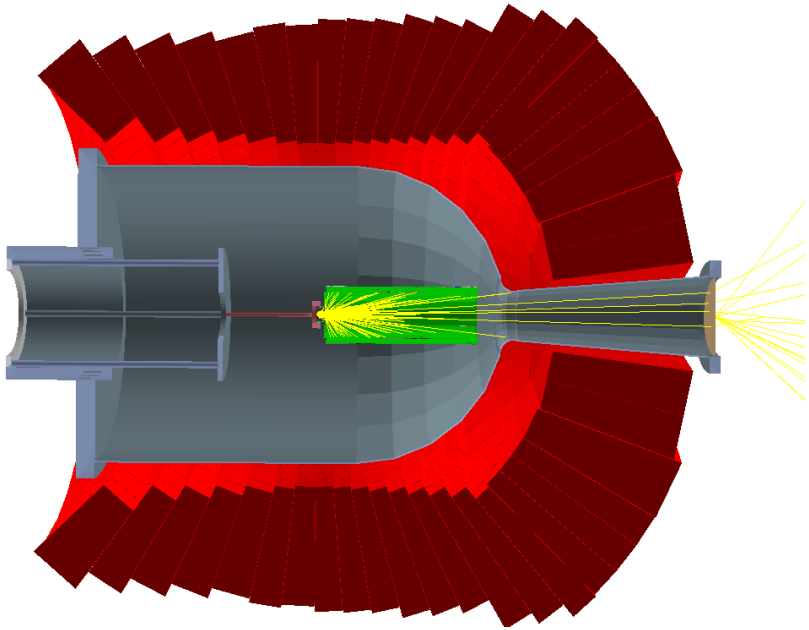




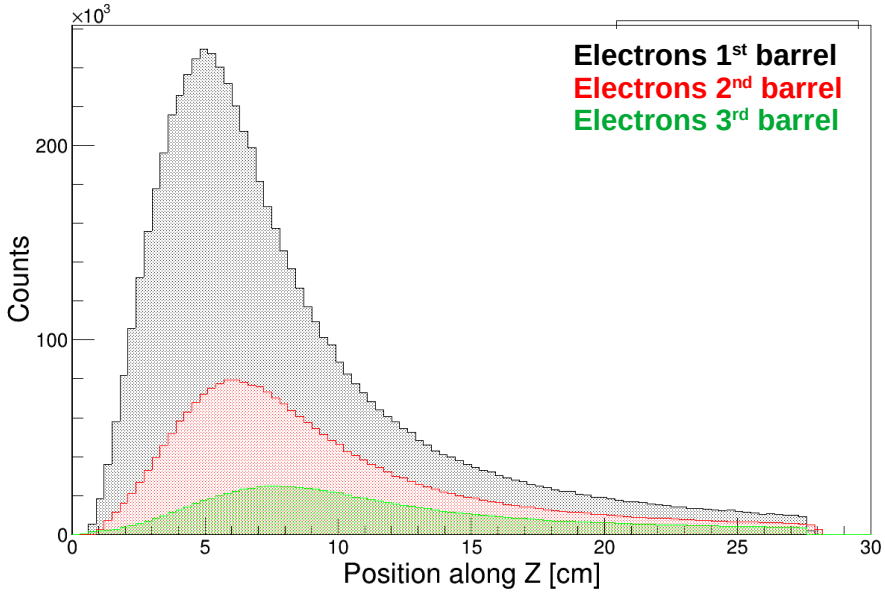


Attenuation	%
1st plane	50
1st and 2nd planes	79
Inverted flex	19

Attenuation of δ-electrons: Barrels



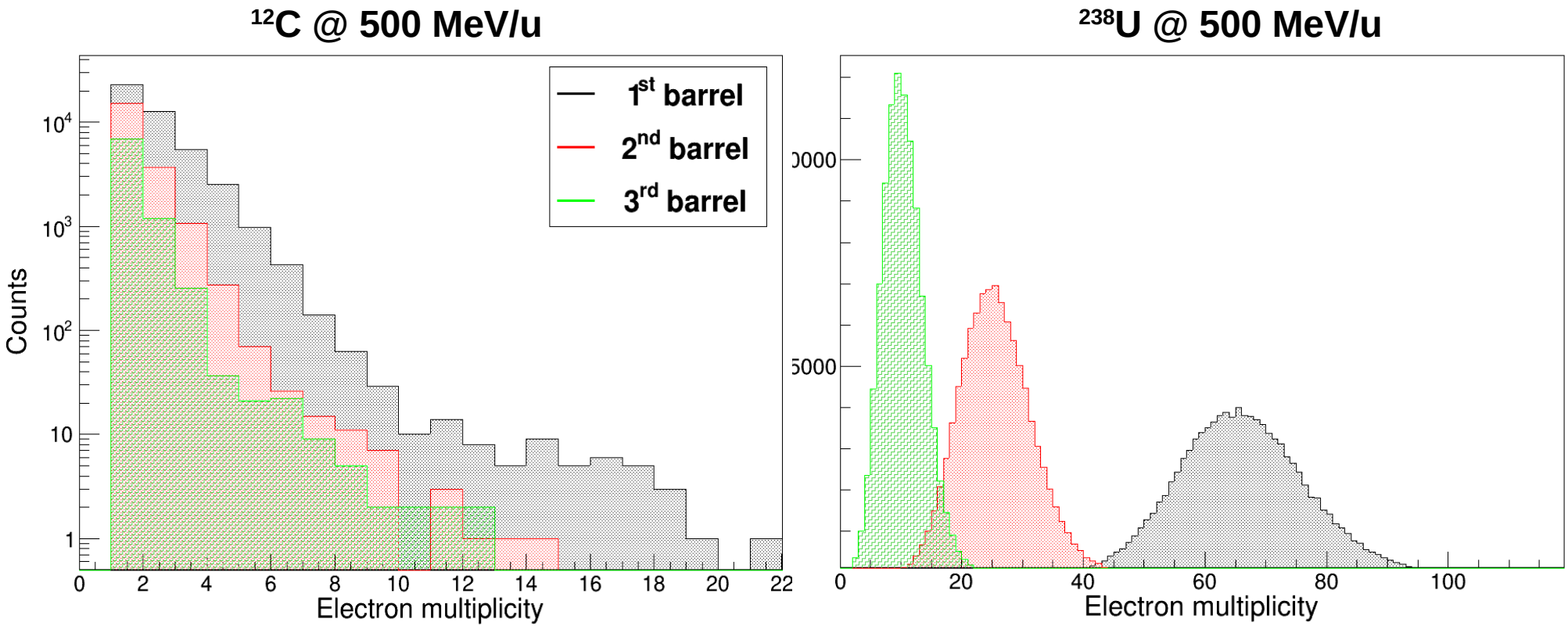
Beam of ^{238}U @ 500MeV/u



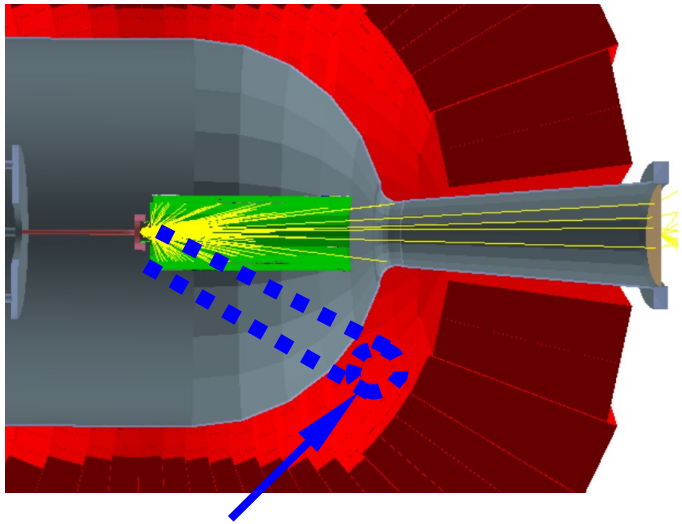
Attenuation	%
1st barrel	62
1st and 2nd barrels	85

δ-electron productions

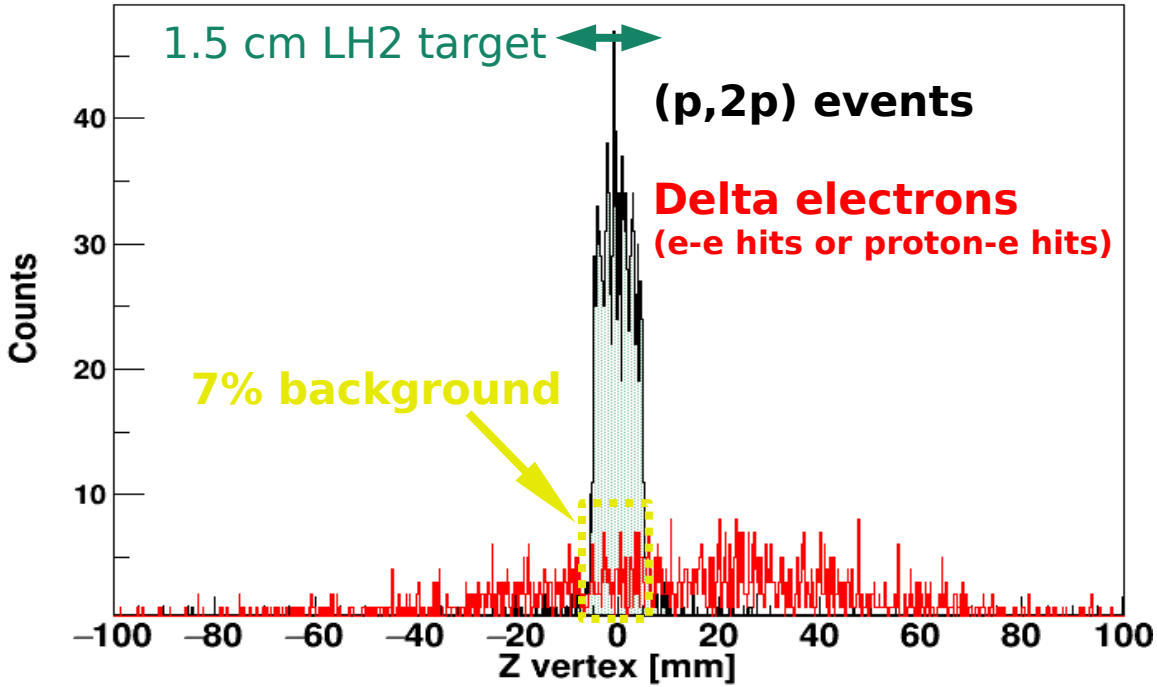
Expected δ-electron multiplicities in the barrel configuration



(p,2p)-reconstruction with δ-electrons



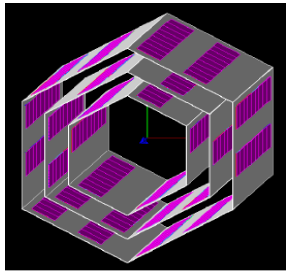
CALIFA selection in θ and φ (±5 deg) to constrain the angular range for barrels



In total, we recover **93 % of (p,2p) events**

Conclusions & Perspectives

Configuration	Resolution [MeV] (FWHM)	Tracking [μm] (FWHM)	(p,2p) efficiency* (%) [real geo.]
Two arms	2.65	360	~21[~18]
3 barrels (ALICE conf.)	2.85	370	~86 [~70]
3 barrels (1st bent)	**2.35**	**190**	**~86**



- Implementation of new TRT configurations in R3BRoot

- Upgrade the existing analysis code for online analysis

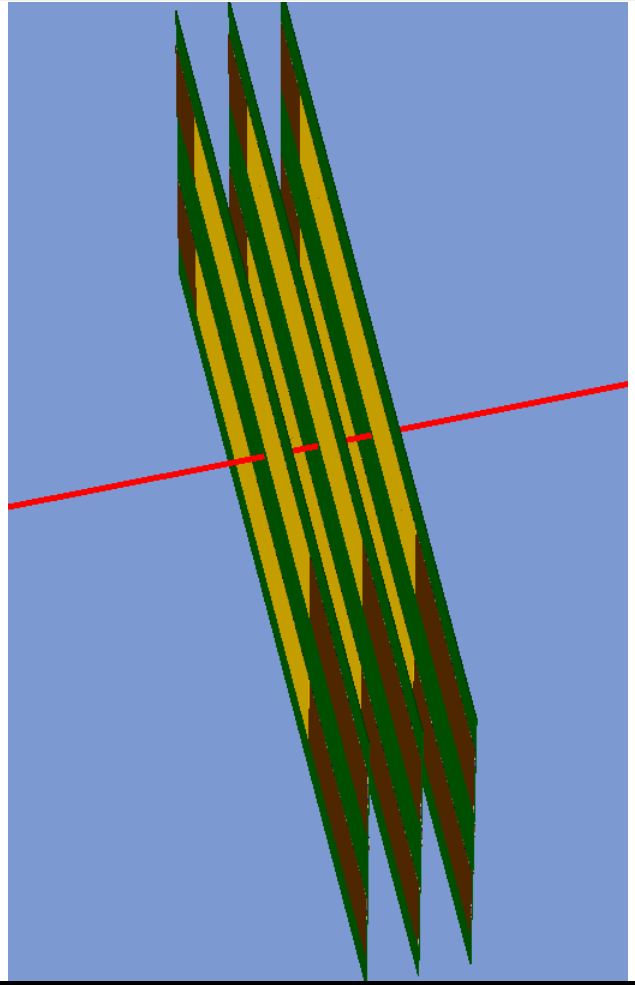
- Test at Jülich:

- Data analysis performance with *UCESB&R3BRoot*
- Position resolution and proton detection efficiency
- First reconstruction of (p,2p) reactions

* Geometrical efficiency

Thank you

Two arms configuration (2024): 2 or 3 planes?



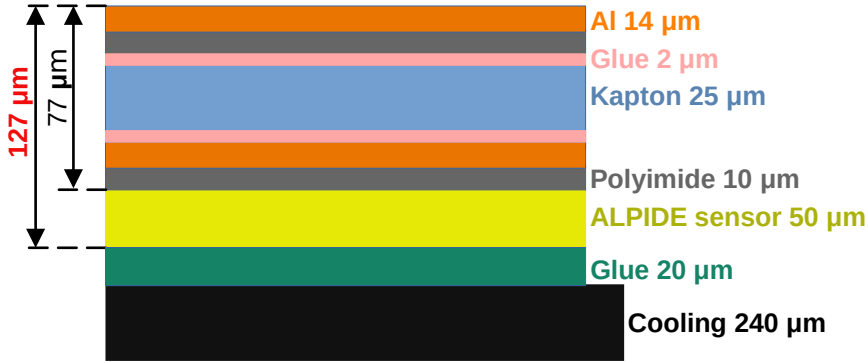
Missing energy reconstruction with 2 detector planes gives better results, this is because the straggling effects are larger than the ALPIDE position resolution

Configuration	Resolution [MeV] (FWHM)
2 planes per arm	**3.11**
3 planes per arm	3.31

Note for target: 1.5 cm radius, 1.5 cm thick

Comparison of modules and resolutions

Two arms

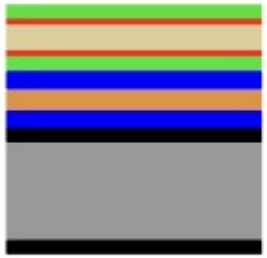


Total thickness **363 um**

No material before the ALPIDE sensors

Resolution in missing mass ~ **2.65 MeV**

Barrels



Layer	Thk (µm)	Composition	ρ (g/cm^3)
Solder mask (2)	30	Epoxy (C_2H_2)	1.250
Conducting layers (2)	10	Al	2.699
Substrate	75	Kapton	1.420
Glue (2)	40	C	0.958
Chip	50	Si	2.328
C fleece (2)	20	C	0.400
Cold plate	240	C	1.583

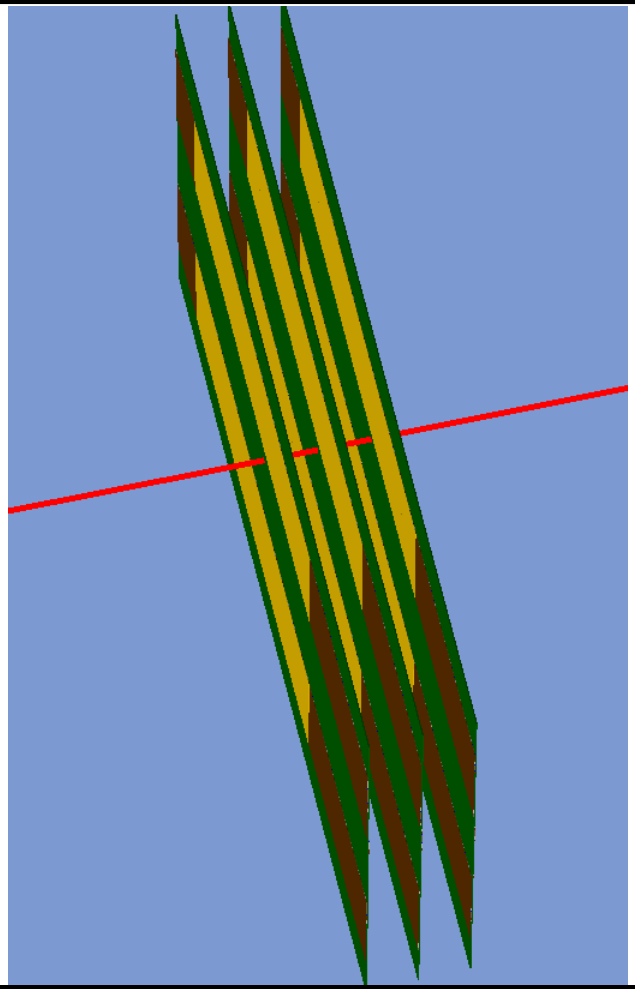
Figure 4.5: The stack of ALPIDE layers, as defined in the simulations

Total thickness **565 um**

280 um of cooling layers (inner part of the barrel) before the ALPIDE sensors

Resolution in missing mass **~ 2.85 MeV**

Two arms configuration (2024): 2 or 3 planes?



Missing energy reconstruction with 2 detector planes gives better results, this is because the straggling effects are larger than the ALPIDE position resolution

Configuration	Resolution [MeV] (FWHM)
2 planes per arm	**3.09**
3 planes per arm	3.31