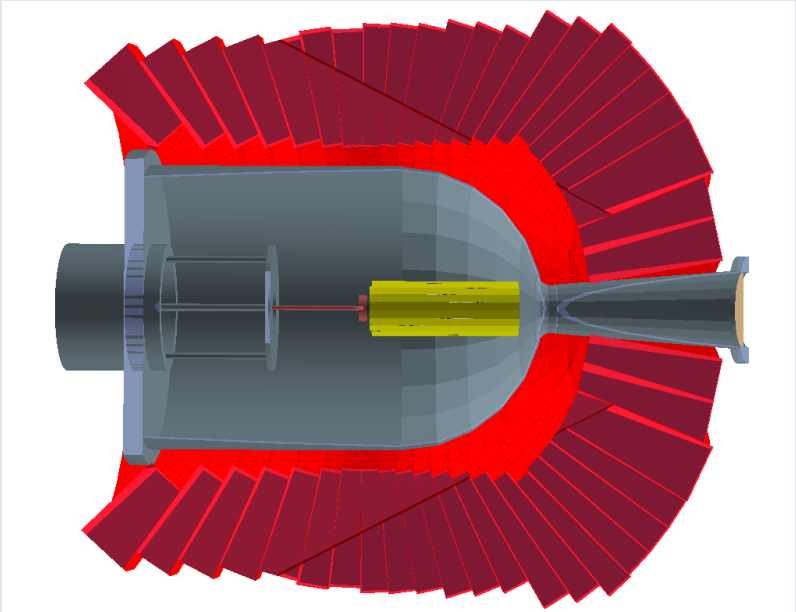
Update of the ALPIDE Si-tracker simulations for studies with quasi-free scattering reactions



José Luis Rodríguez-Sánchez
University of Coruña & USC
23rd 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
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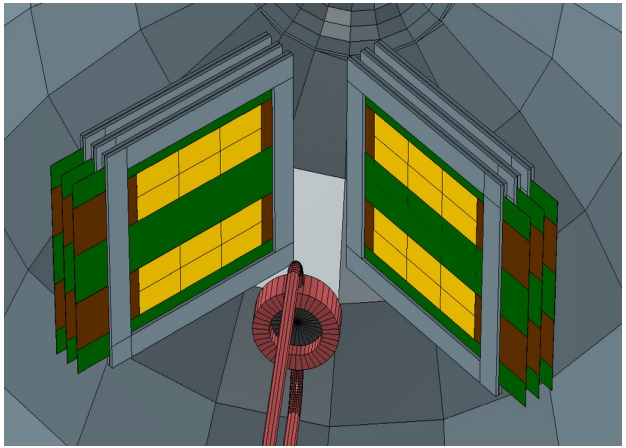
R3B Si-tracker configurations

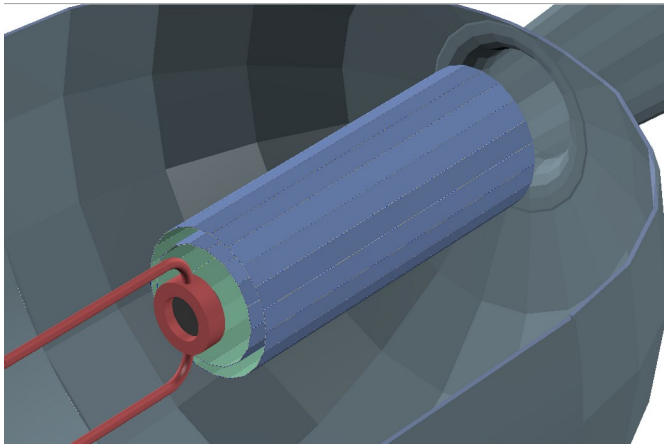
Stage I



Two arms
- 3 planes each
- 18 sensors per plane

2024

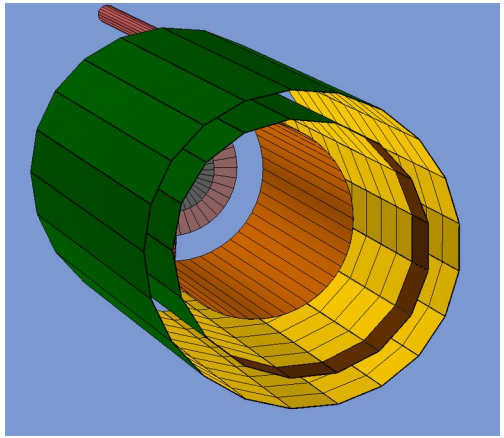
Stage II



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

2026/2028

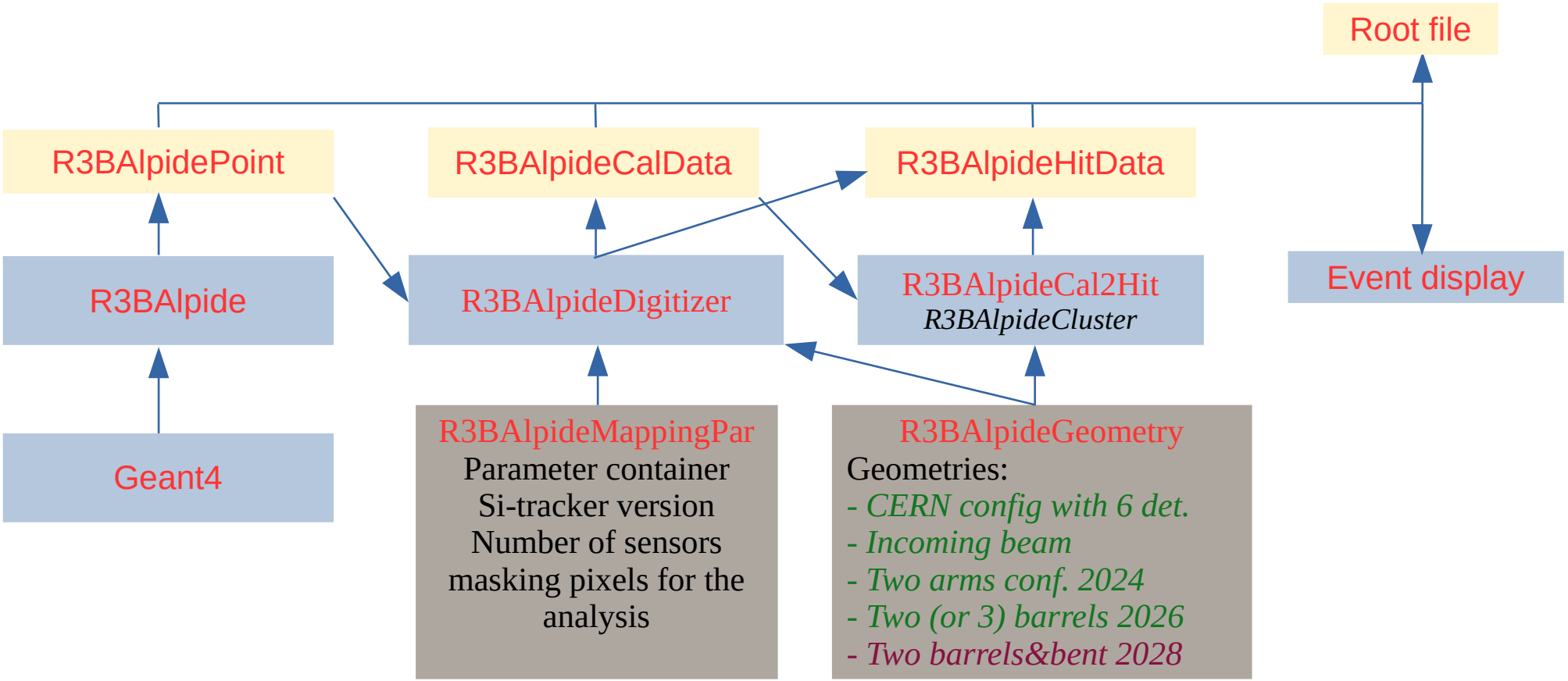
Stage III



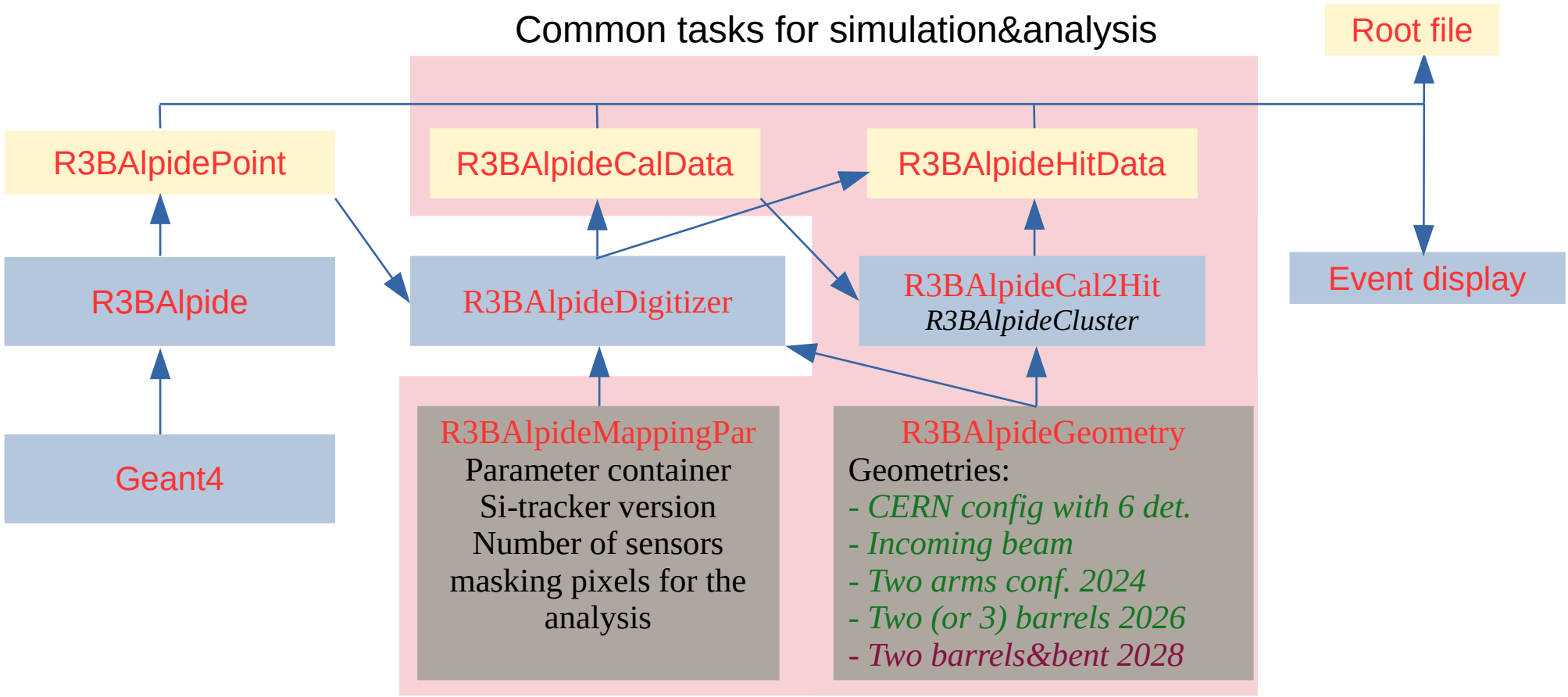
Three (one bent) **barrels**
- 17/21 multi-Flex modules
- 9 sensors per module
- Barrel with bent Si-sensors

2029/...

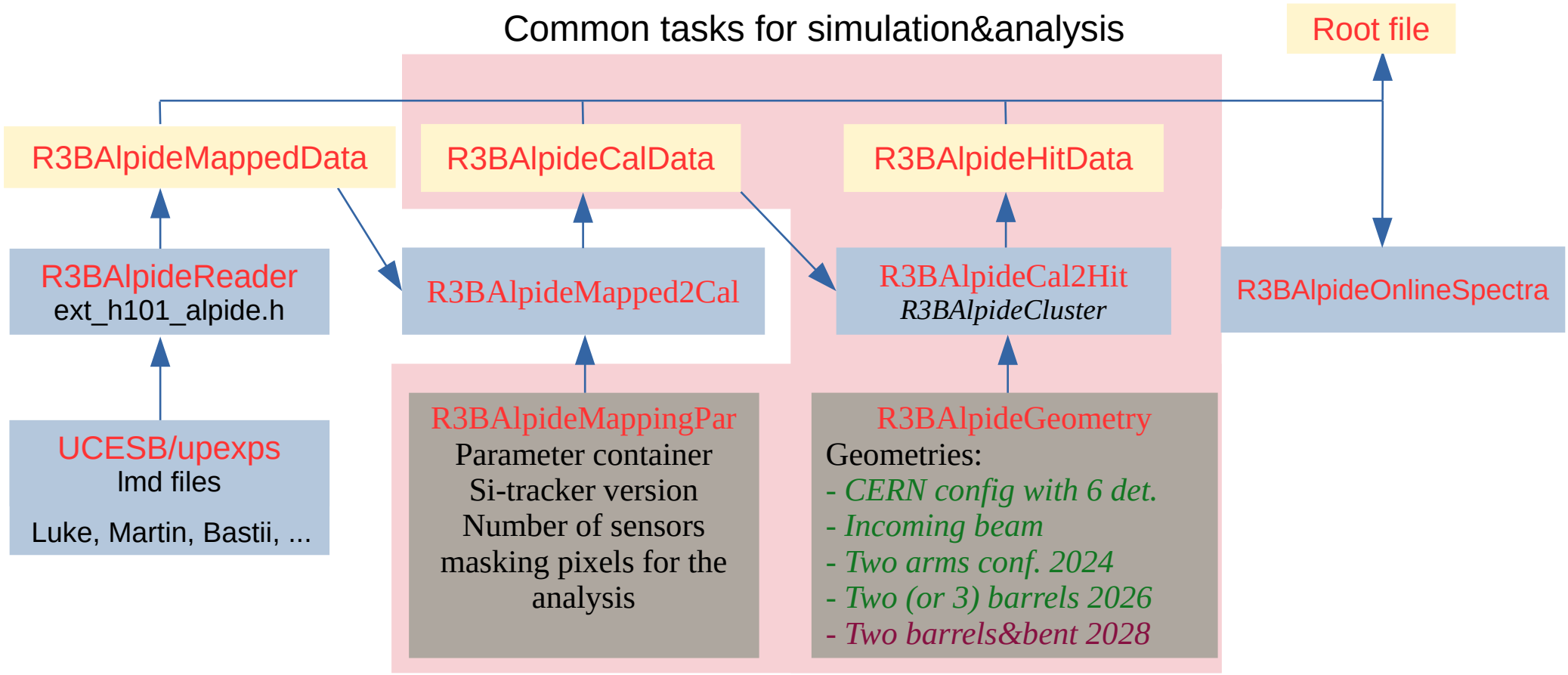
R3BRoot workflow for ALPIDE simulations



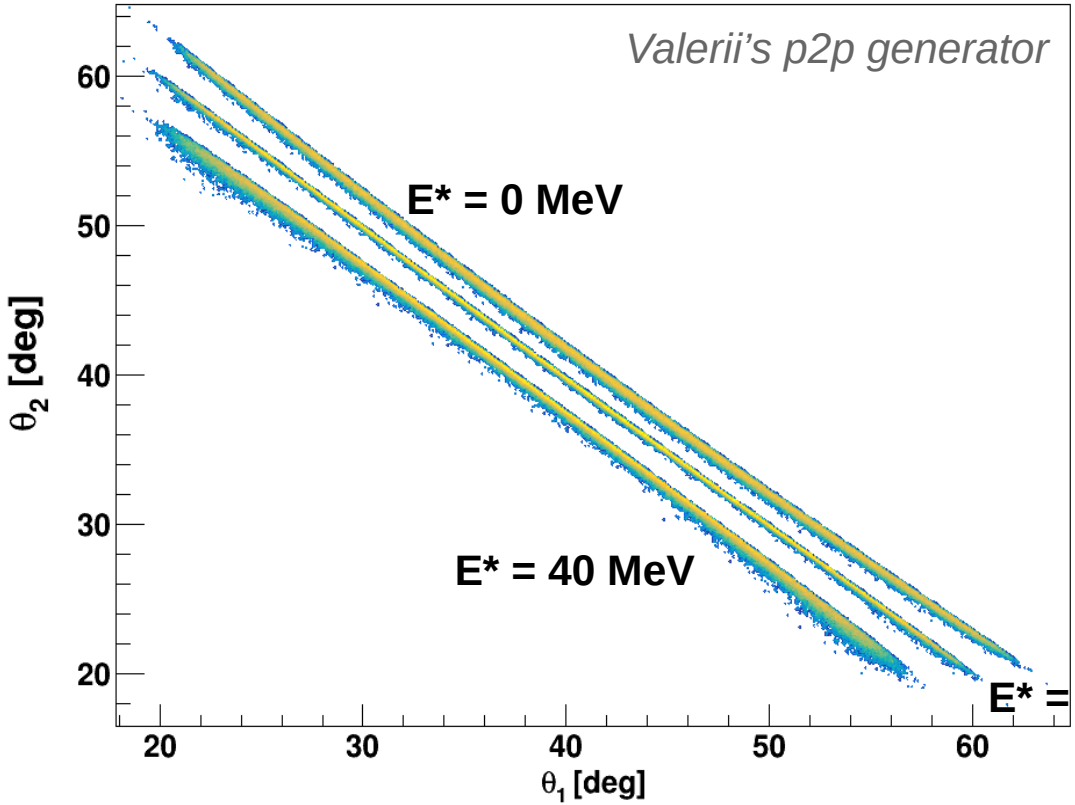
R3BRoot workflow for ALPIDE simulations



R3BRoot workflow for ALPIDE data analysis



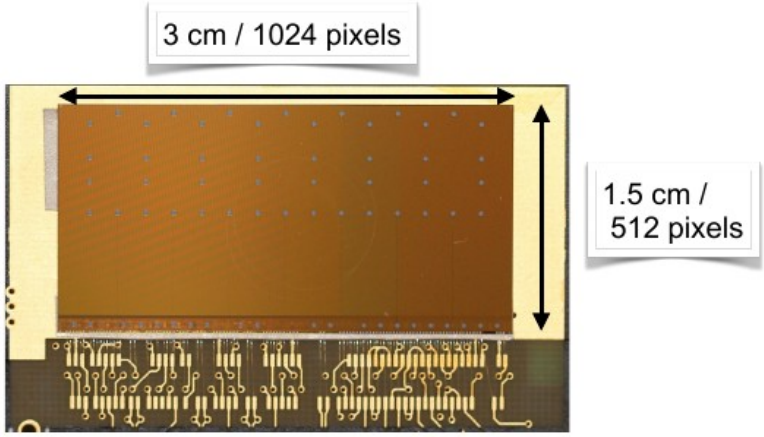
(p,2p) events for three excitation energies: 0, 20 and 40 MeV



- Energy of **500 MeV/u**
- Geant4 propagation based on the option EMZ (the most realistic!)

ALPIDE(ALice PIxel DEtector) sensor

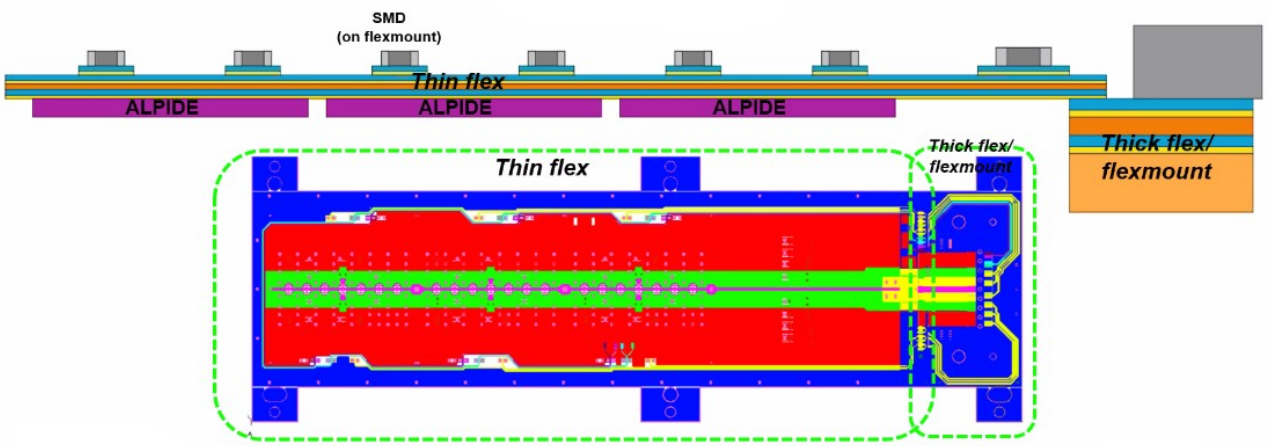
Parameter	Requirement	ALPIDE
Spatial resolution (μm) sigma	≈ 5	≈ 5
Integration time (μs)	< 30	< 10
Fake-hit rate (/ pixel / event)	$< 10^{-6}$	$<< 10^{-6}$
Detection efficiency	> 99%	>>99%
Power consumption (mW / cm^2)	< 100	< 40
Total Ionising Dose (TID) (krad)	> 270 (IB) > 10 (OB)	OK
Non-Ionising Energy Loss (NIEL) ($1\ MeV\ n_{eq} / cm^2$)	$> 1.7x10^{12}$	OK



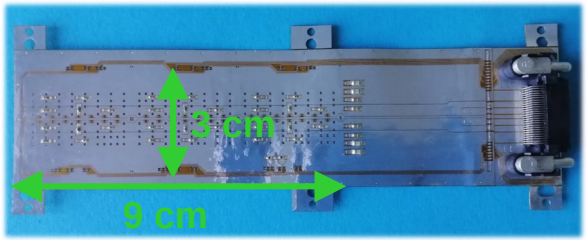
ALPIDE die on carrier card

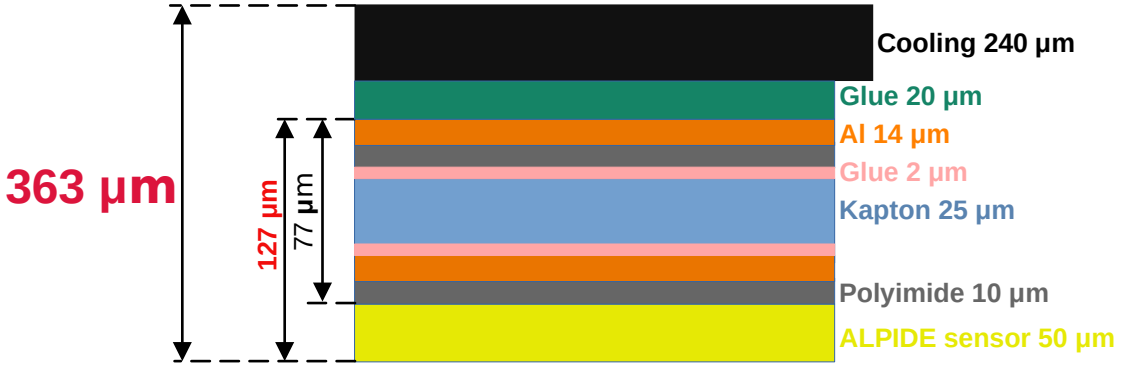
Thickness of 50 μm

Two arms configuration (2024): Multi-Flex board with 6 sensors

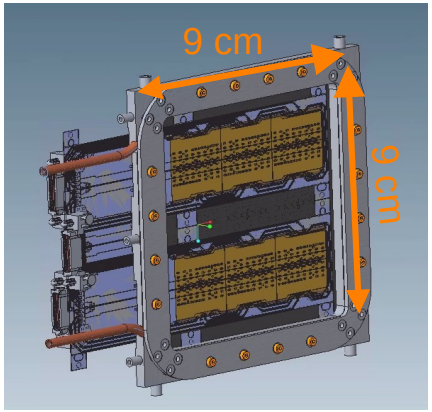


6 Flex boards at GSI



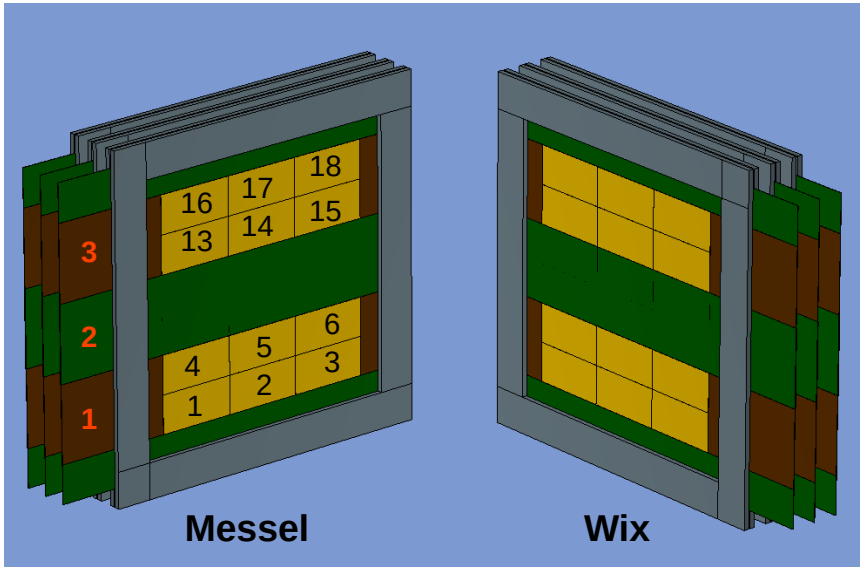


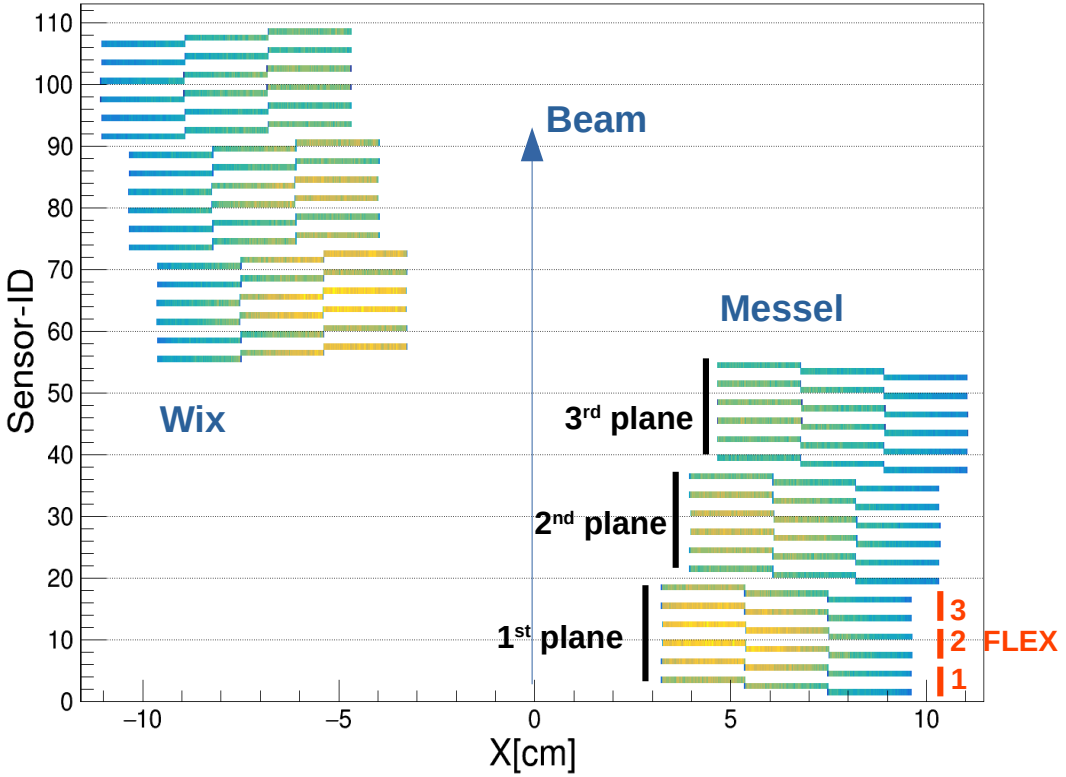
Tracking station with 3 multi-flex



Two arms configuration (2024)

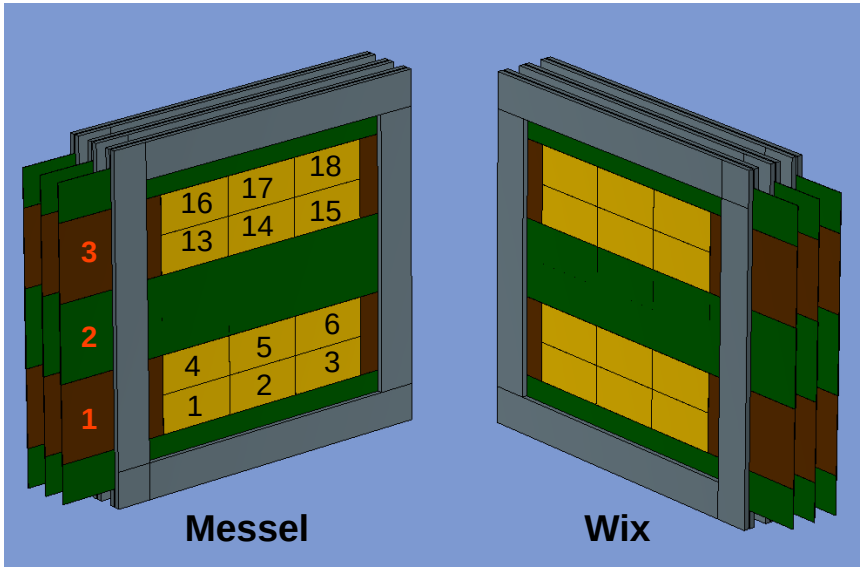
Two arms with **108 ALPIDE sensors** in total



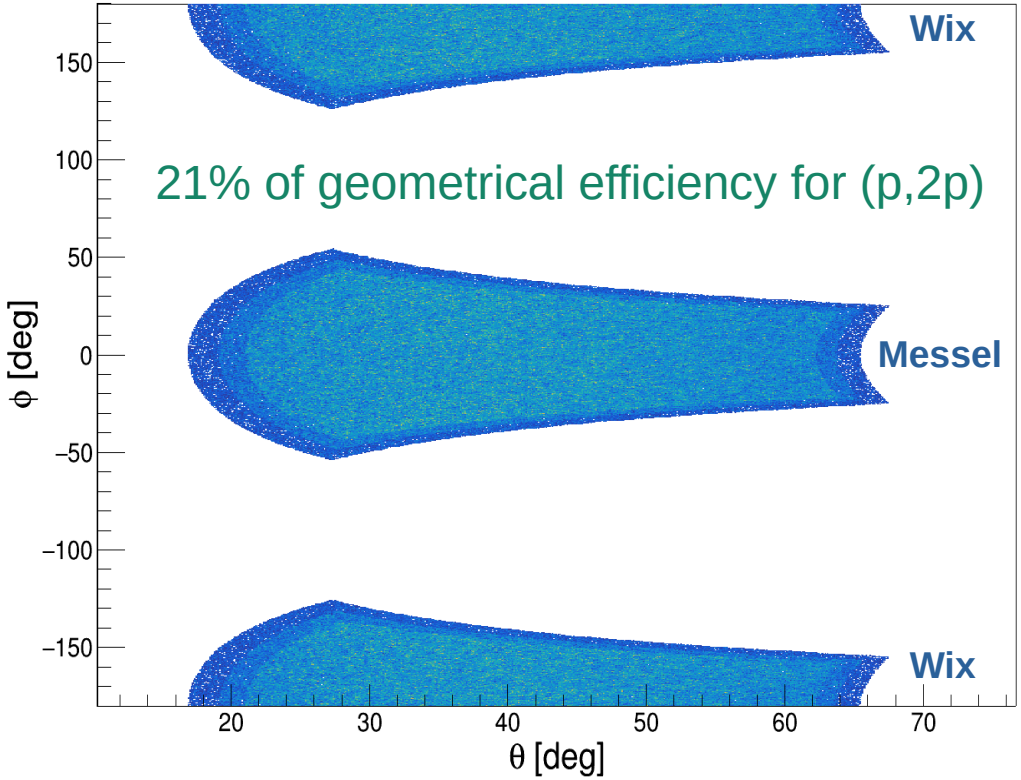


Two arms configuration (2024)

Two arms with **108 ALPIDE sensors** in total



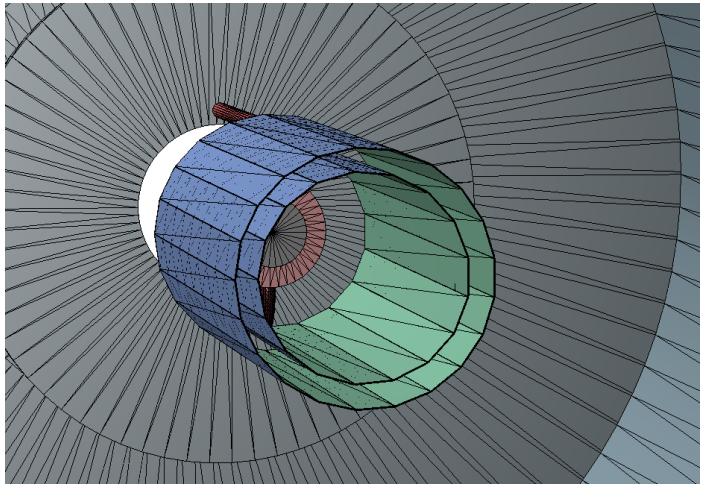
Angular distribution covered by the two arms

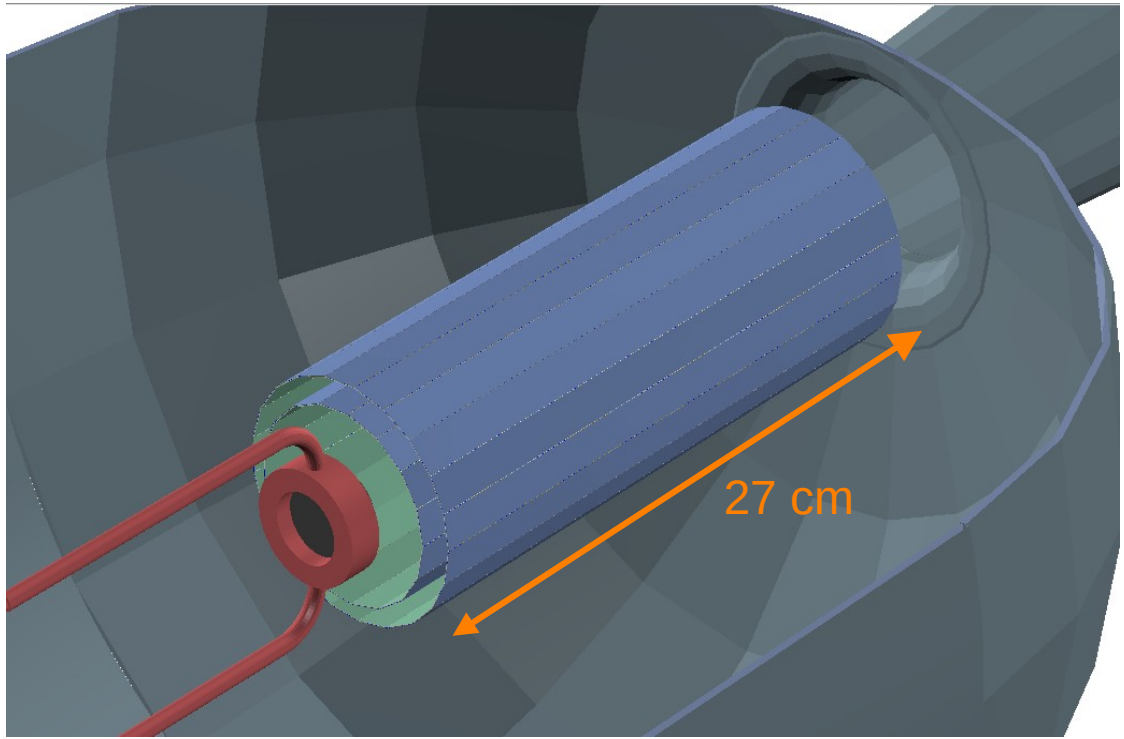


Two barrels configuration (2026/2027)

Two barrels (ideal case) made of 38 multi-Flex boards with **342** ALPIDE sensors in total

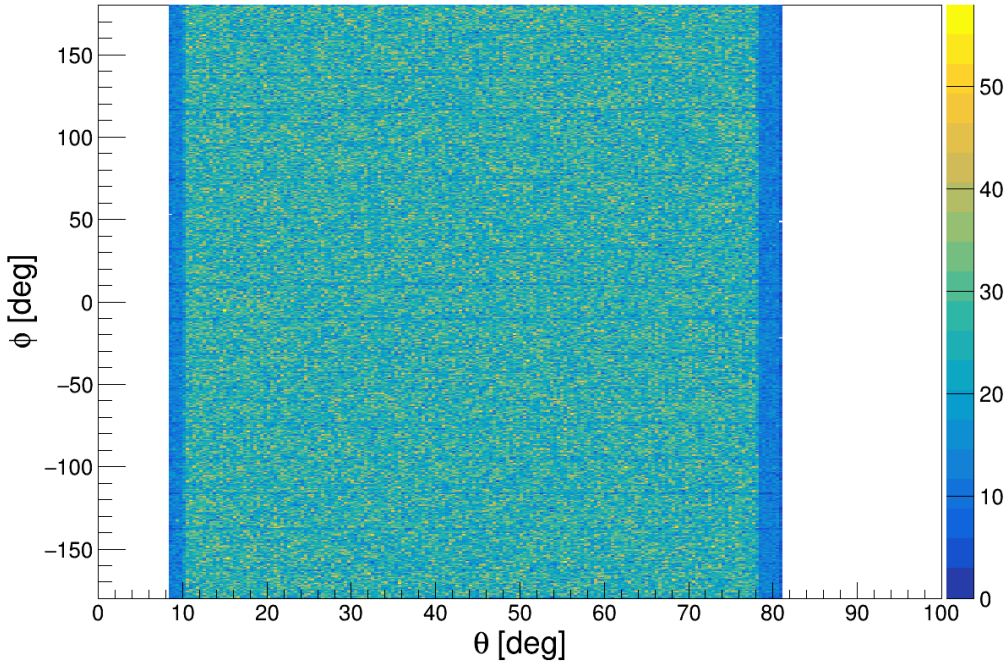
- Inner barrel
  17 multi-Flex boards x 9 sensors
- Outer barrel
  21 multi-Flex boards x 9 sensors

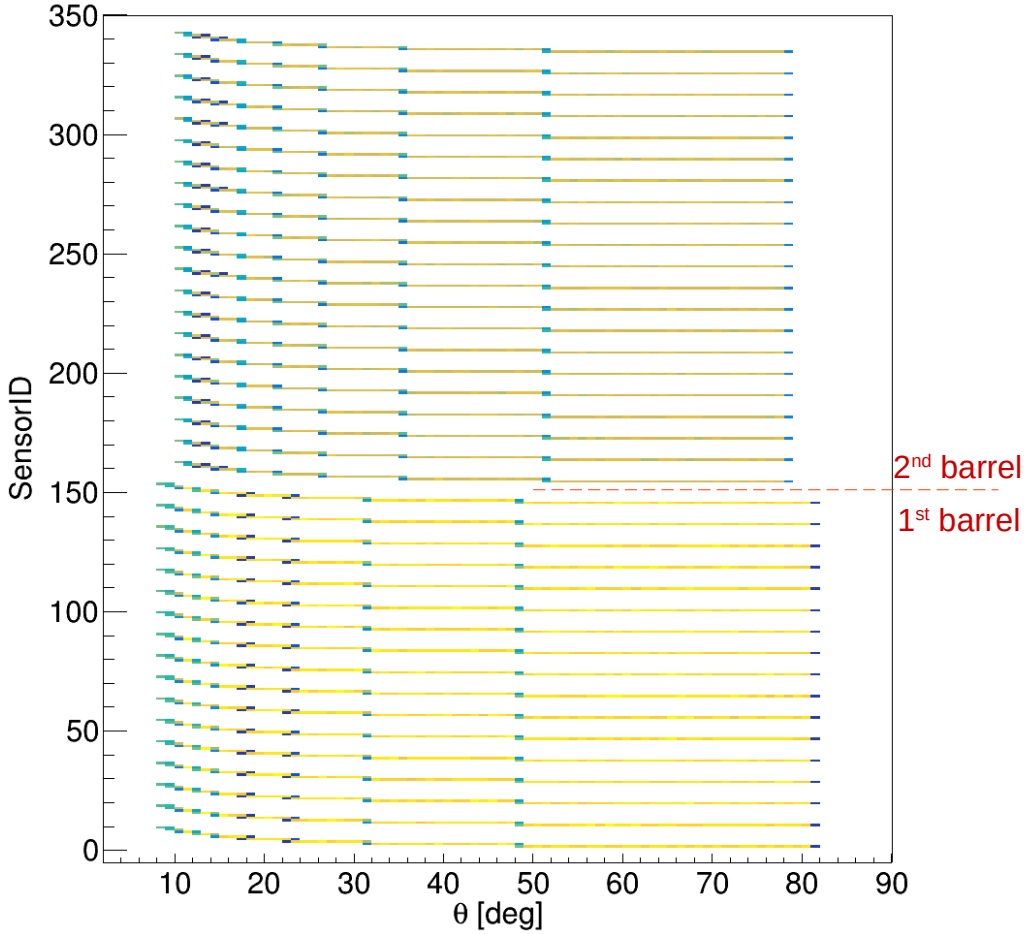




Two barrels configuration (2026/2027)

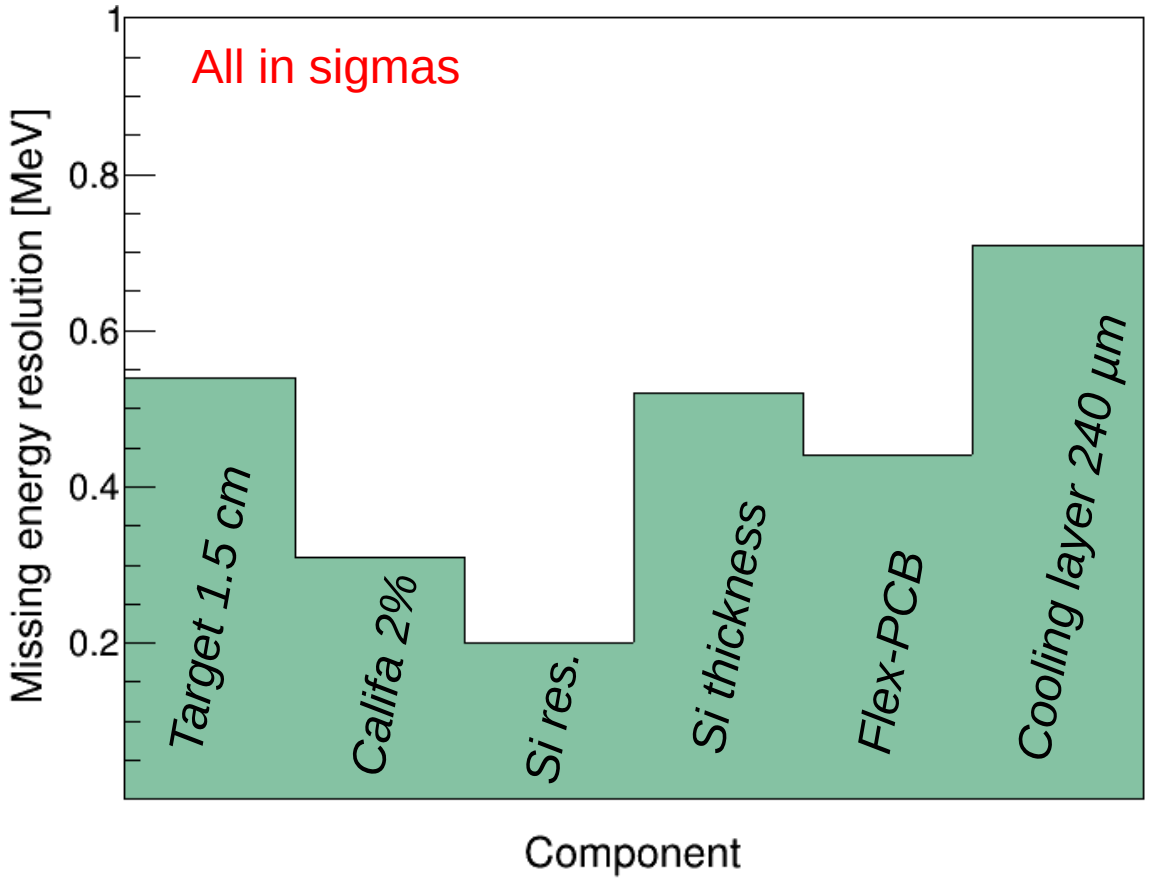
Angular distributions





86% of geometrical efficiency for (p,2p)

Two arms configuration (2024): Missing mass resolution



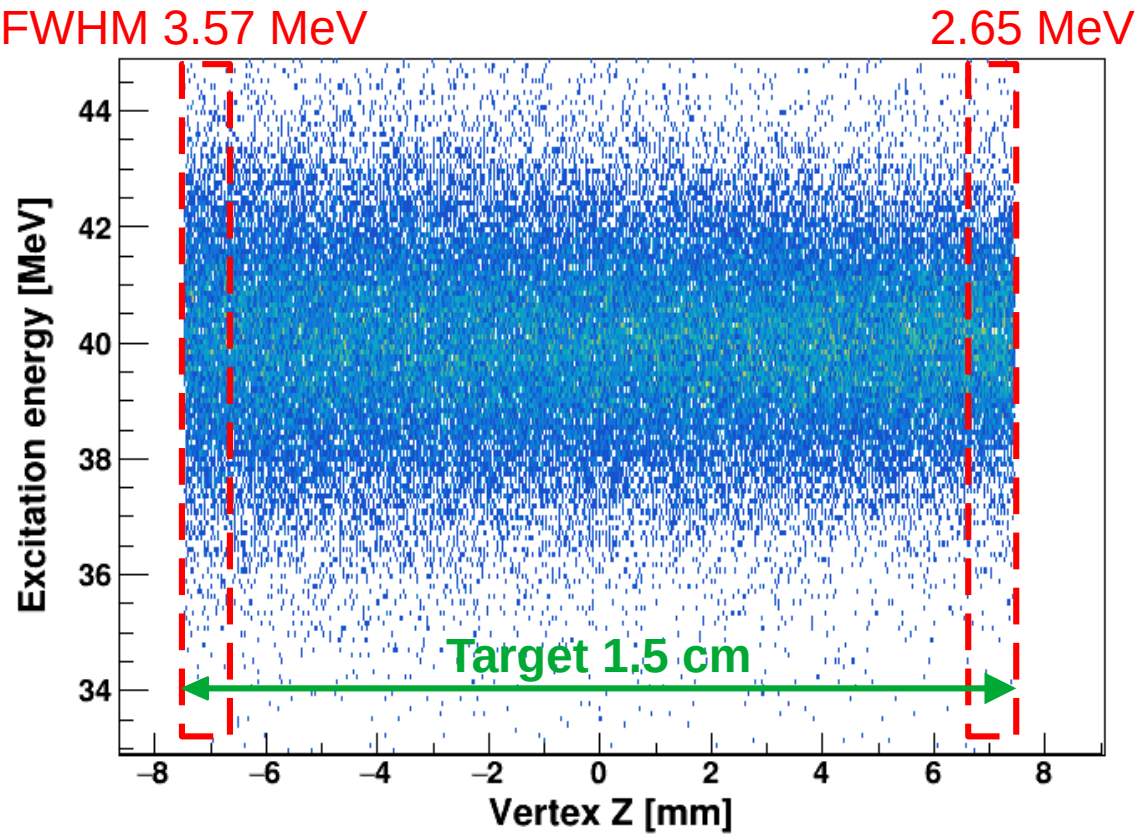
The main contribution to the missing mass comes from the cooling layer

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): Excitation energy resolutions

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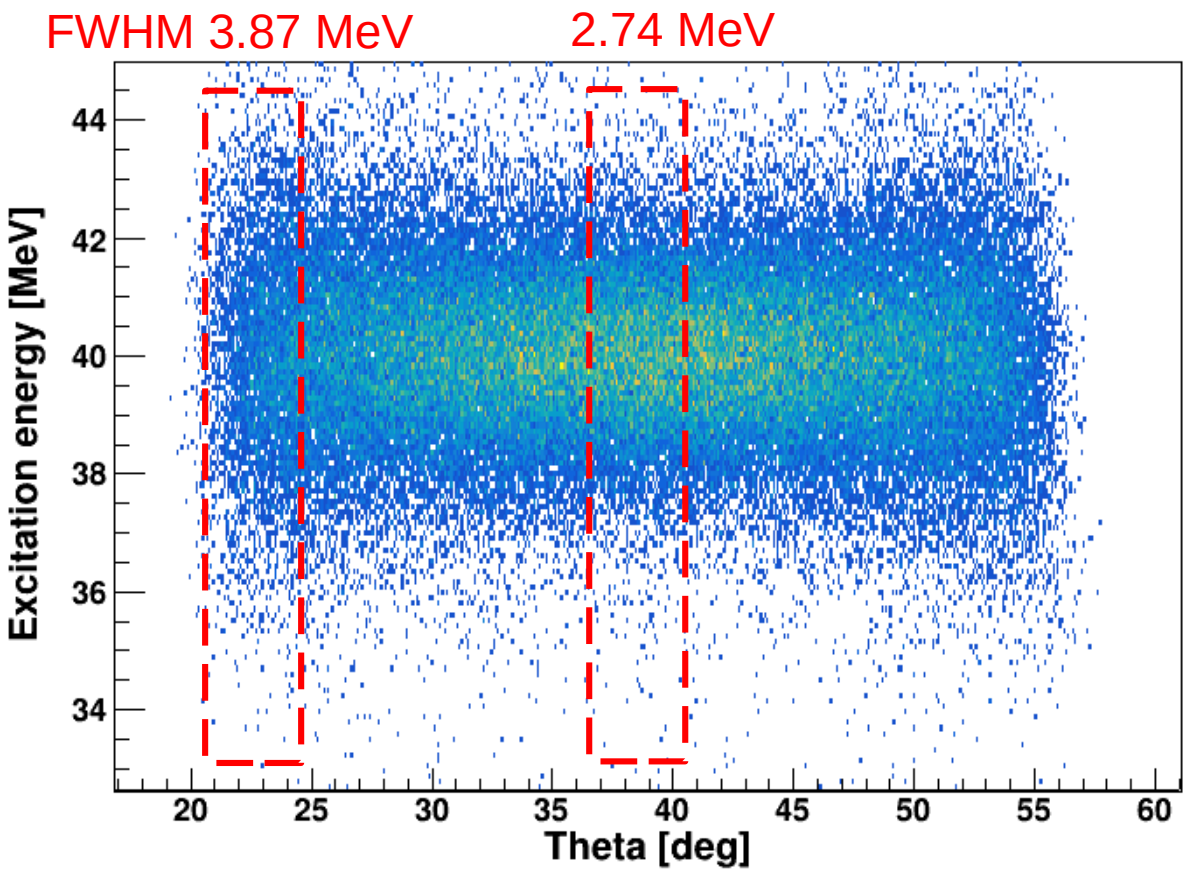
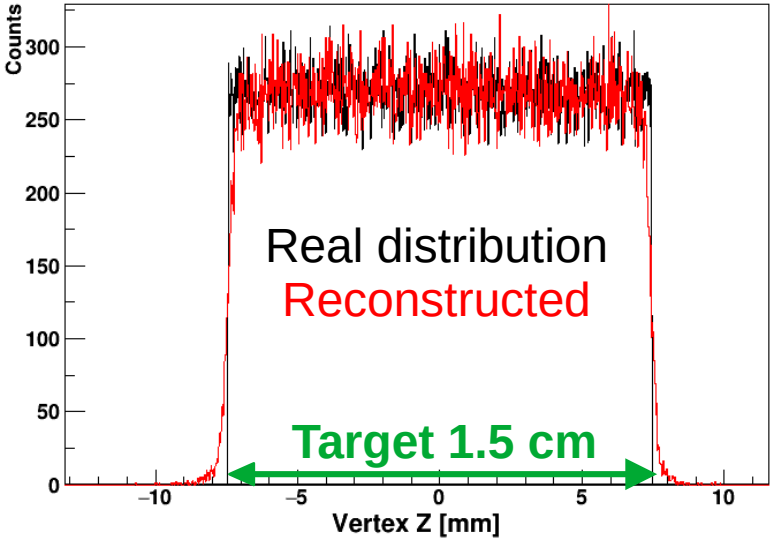
Dependence on theta



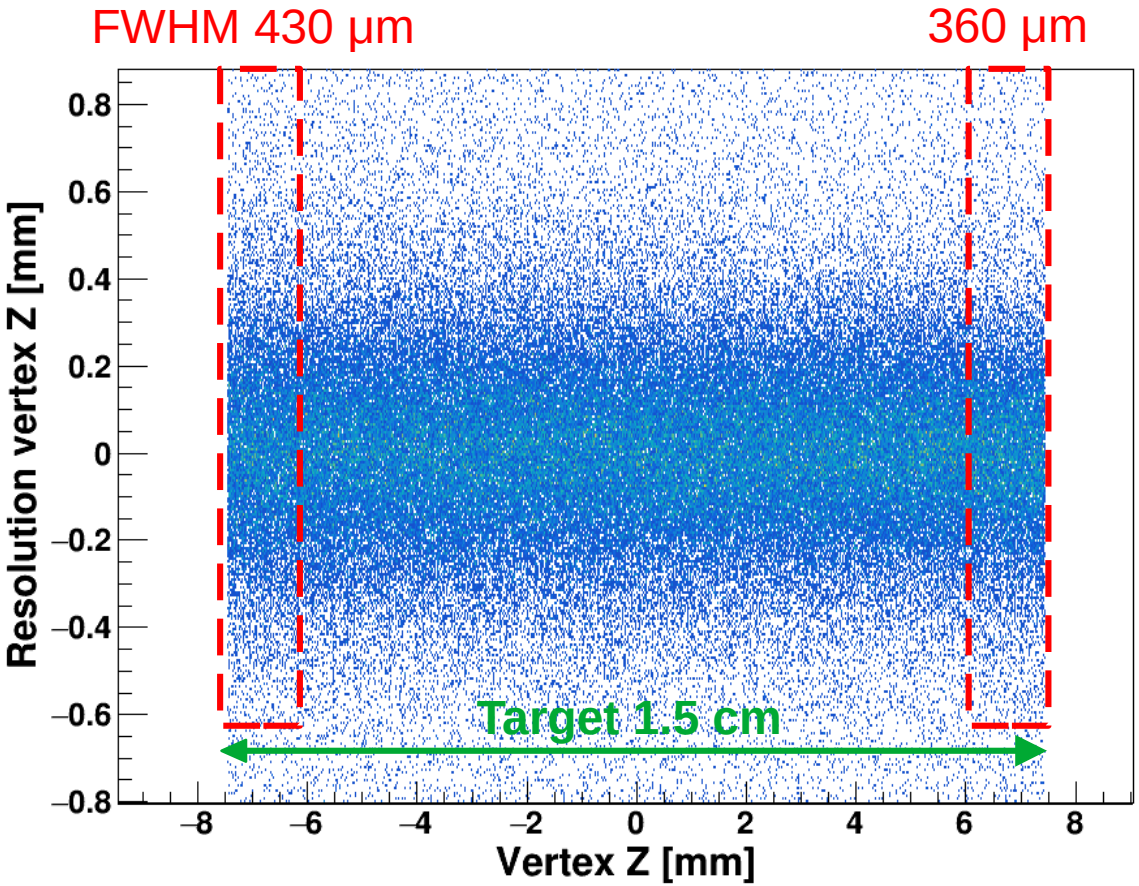
Two arms configuration (2024): Vertex reconstruction

Vertex resolution dependence on Z

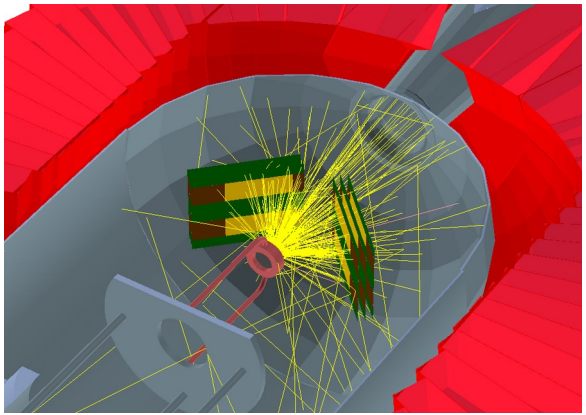
Vertex resolution is calculated as
$\Delta z = Z_{reconstructed} - Z_{real}$



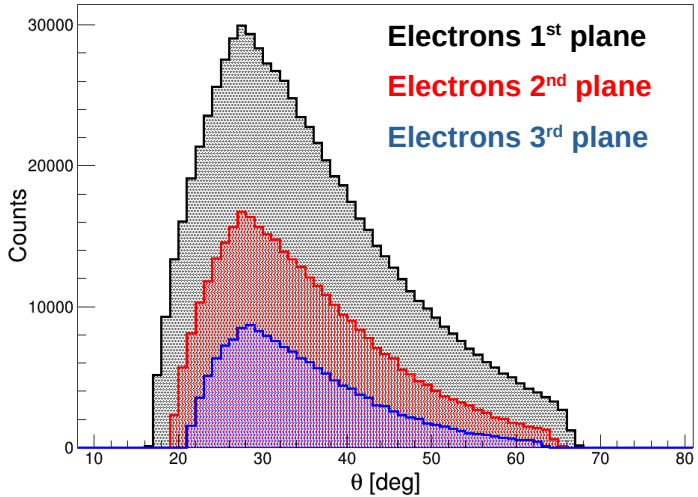
Average resolution **390 µm** (FWHM)

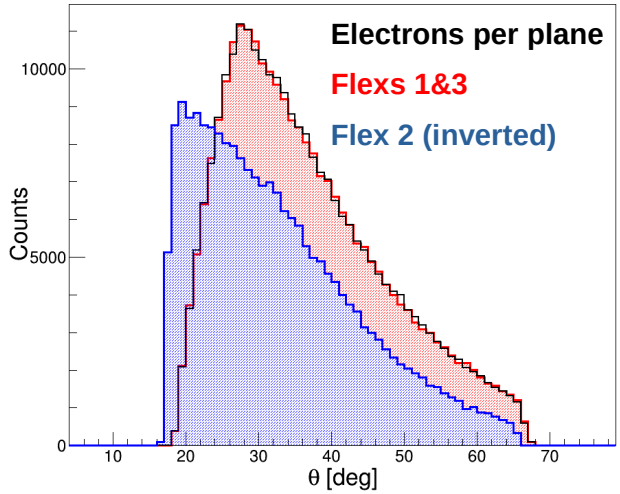


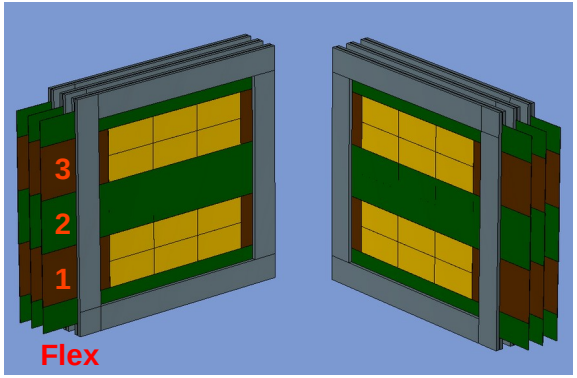
Attenuation of δ-electrons: Two arms



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

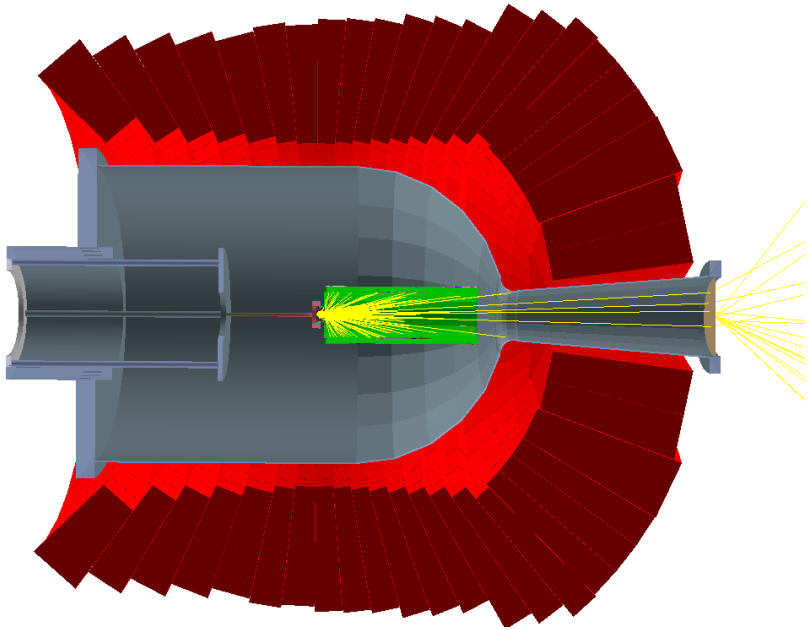




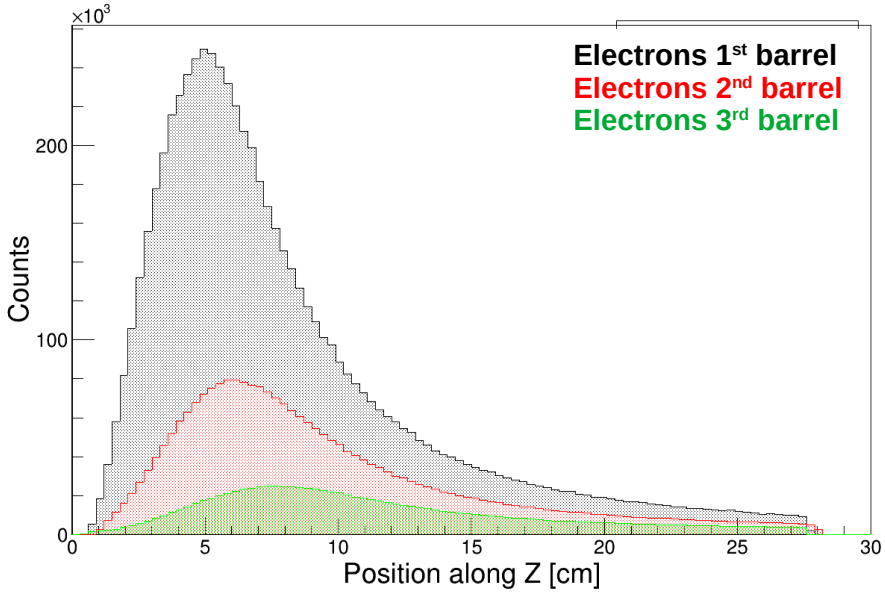


Attenuation	%
1st plane	50
1st and 2nd planes	79
Inverted flex	19

Attenuation of δ-electrons: Barrels



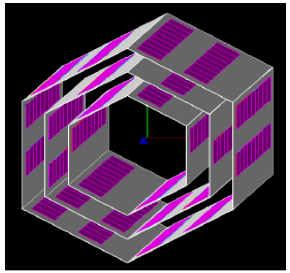
Beam of ^{238}U @ 500MeV/u



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

Conclusions & Perspectives

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



- Implementation of new TRT configurations

- Upgrade the existing analysis code (online)

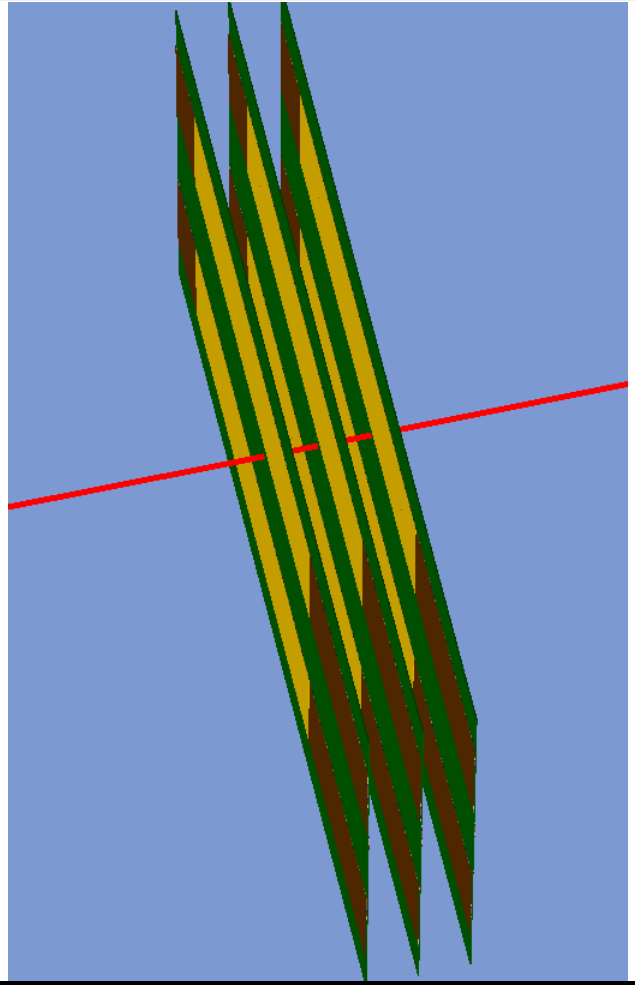
- Test at Jülich:

- 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

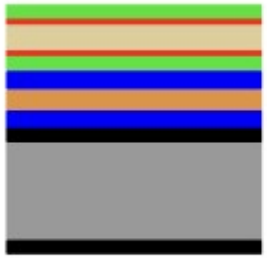
Two arms

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

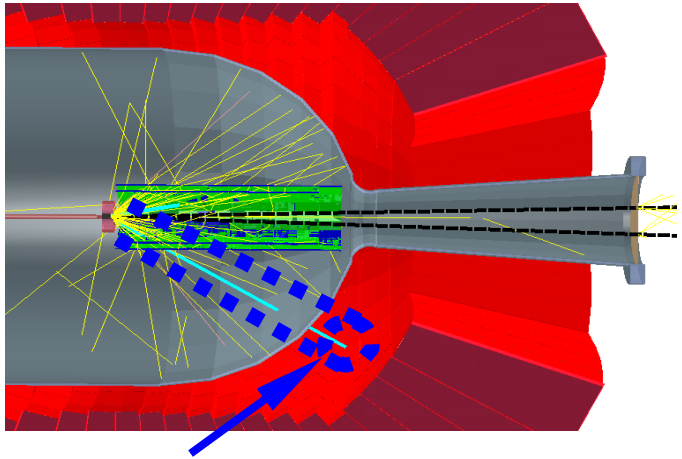
Figure 4.5: The stack of ALPIDE layers, as defined in the simulations

Total thickness **565 um**

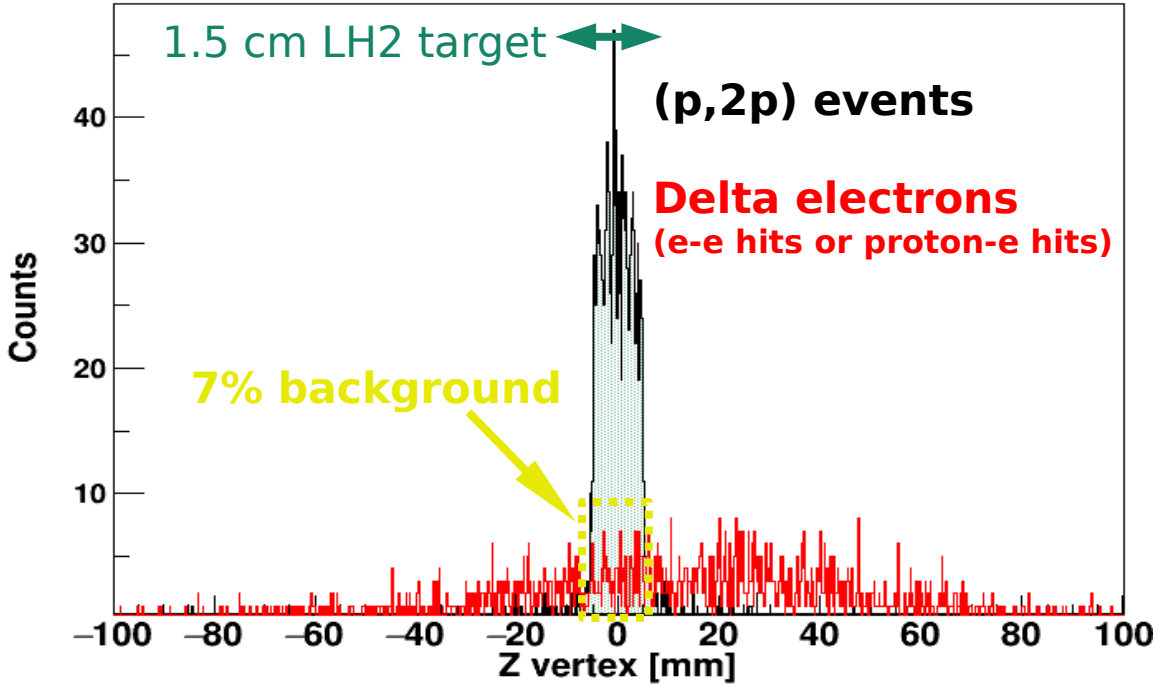
280 um of cooling layers (inner part of the barrel) before the ALPIDE sensors

Resolution in missing mass **~ 2.85 MeV**

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



CALIFA selection in theta and Phi (±4º) to constrain the angular range for barrels



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