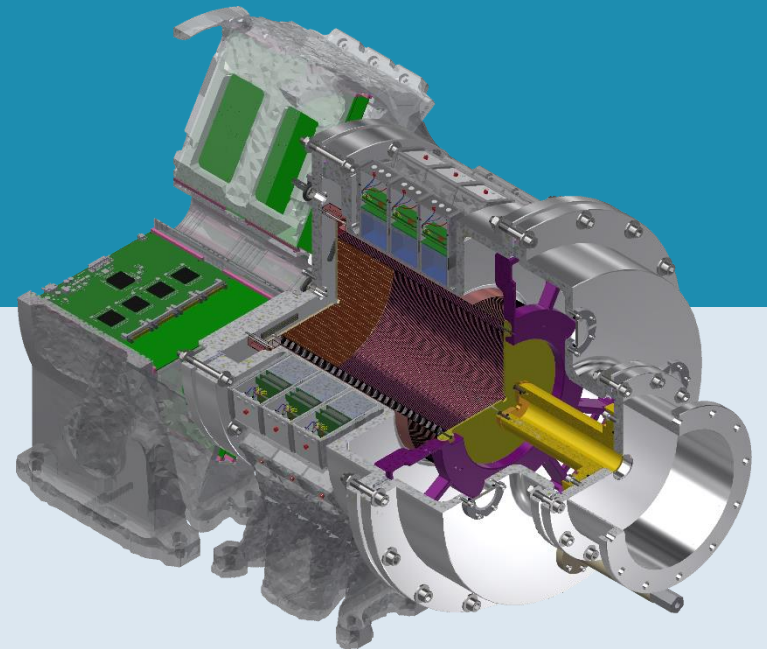


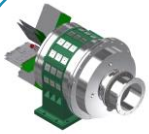
Development and construction of SpecMAT, the active target for transfer reactions in a strong homogenous magnetic field

Oleksii Poleshchuk

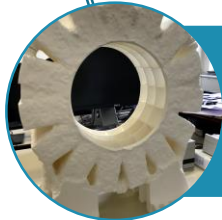
ISOLDE Solenoidal Spectrometer Workshop
Liverpool 2019



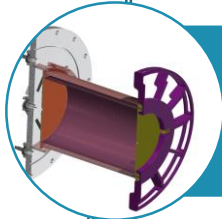
Outline



The SpecMAT active target



The scintillation array

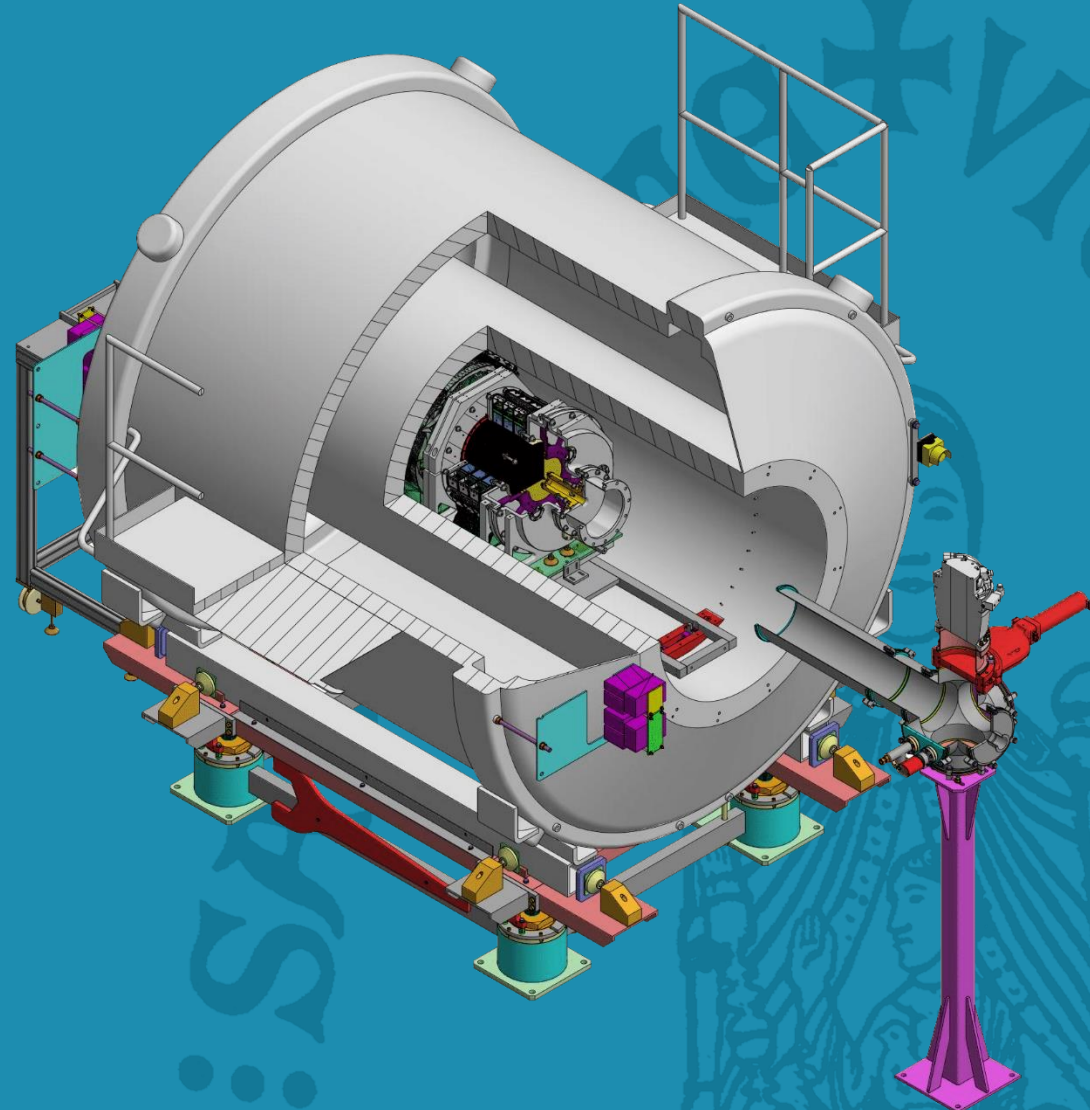


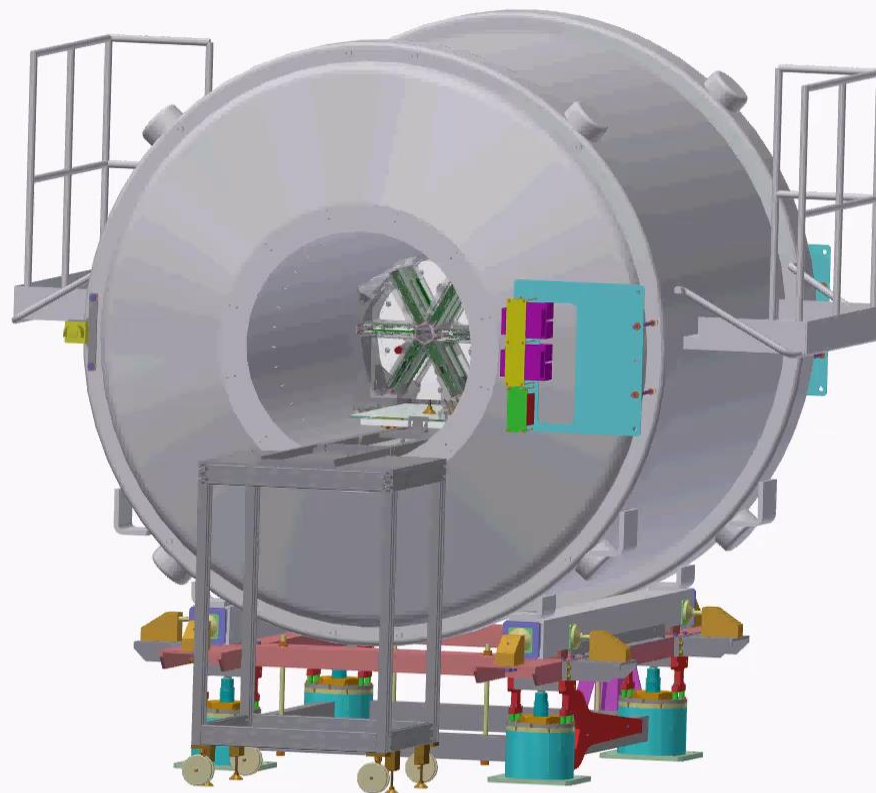
The active target



Characterisation of the detector

The SpecMAT active target





45 CeBr₃
48×48×48mm
scintillation
detectors

Field cage
homogeneous
electric field ~2%

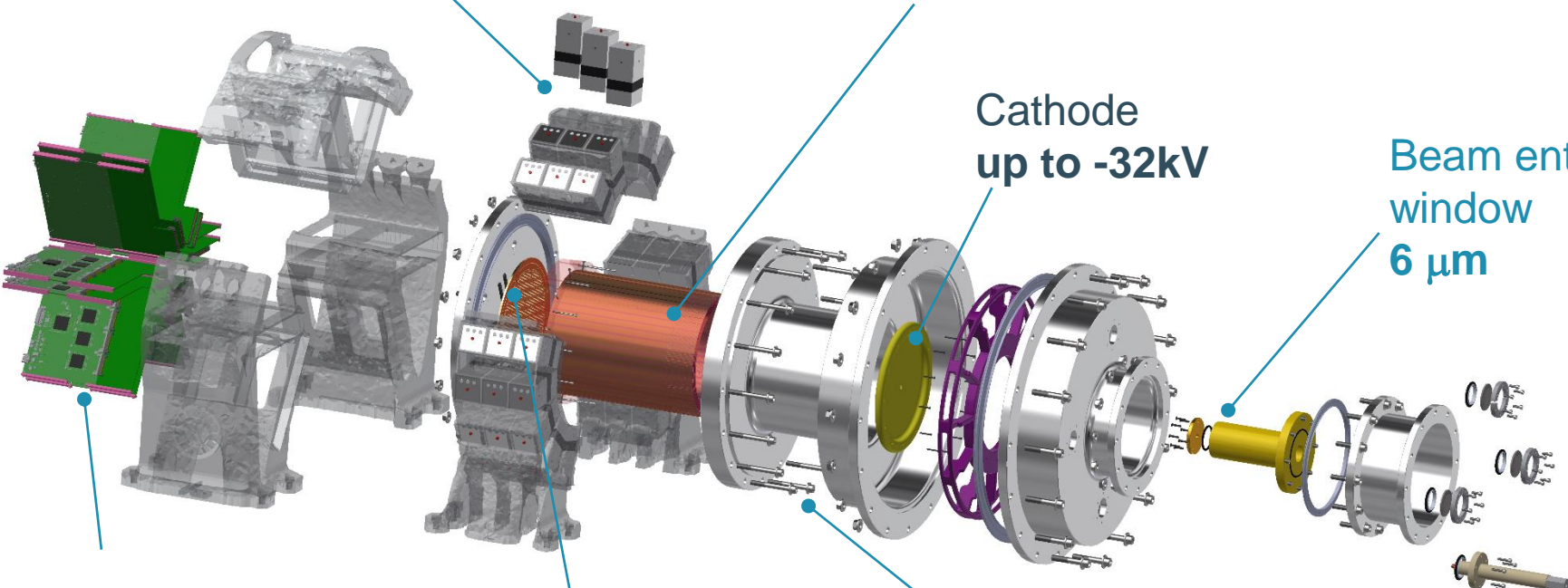
Cathode
up to -32kV

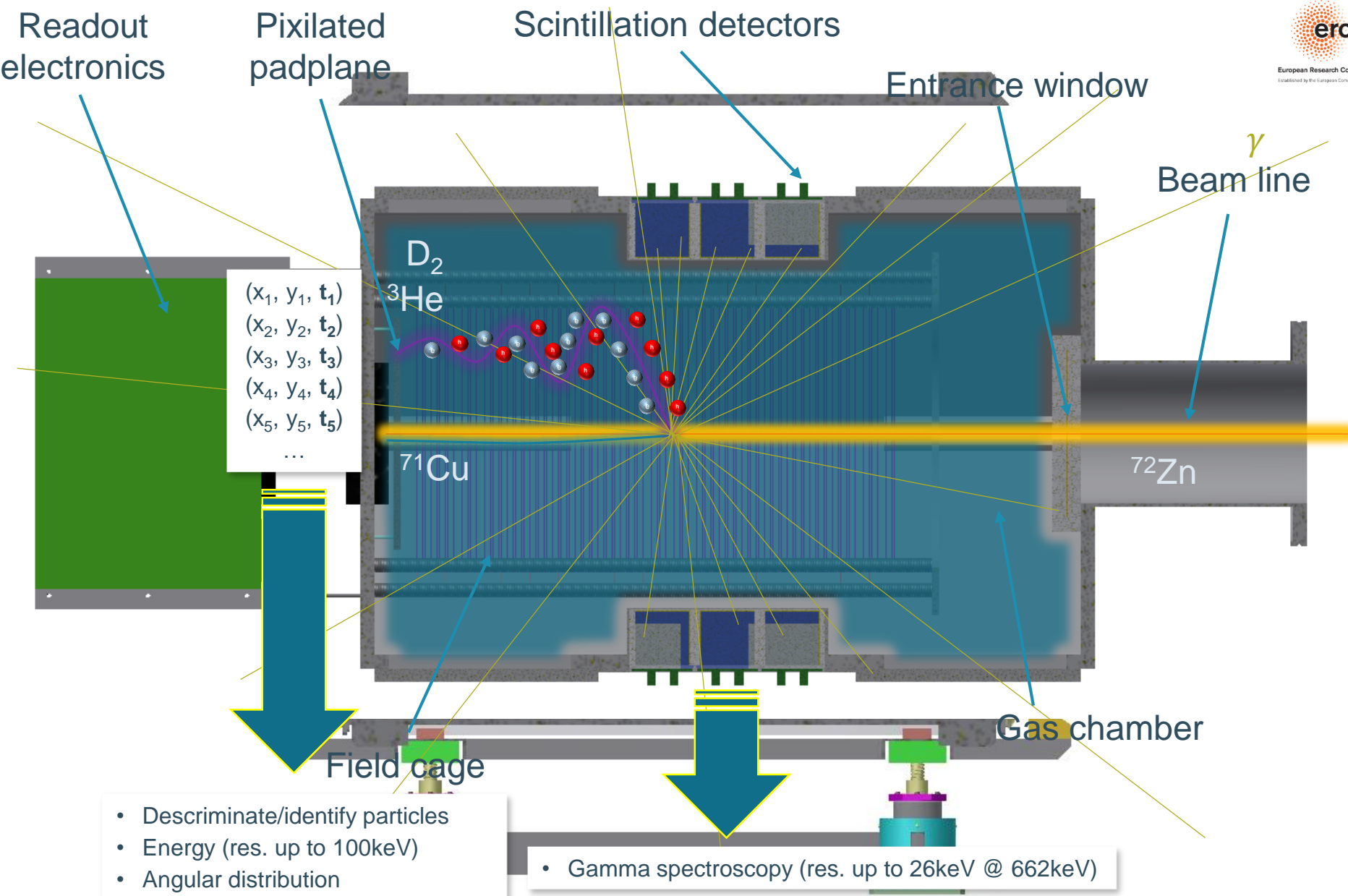
Beam entrance
window
6 μm

Readout electronics
100MS/s 12bit
~4096 channels

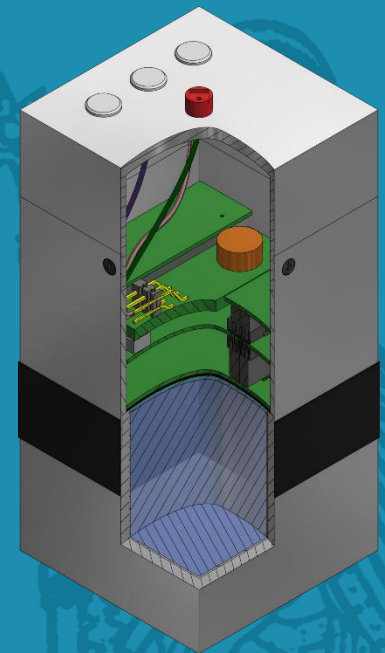
Pixelated pad plane
3072 channels

Gas chamber
up to 1 atm
min wall thickness 3mm





Choice, tests and development of gamma-ray detectors for SpecMAT



Choice of gamma-ray detectors

Operation in a magnetic field

- (NO Germanium detectors, scintillators + photo multiplier tubes ...)
- (Scintillators + Silicon photo multipliers)

Resolution – material

- (as good as possible)
- (LaBr₃:Ce, CeBr₃, CLLB, ...)

Detection efficiency – size

- Optimal limits are: $1\text{inch}^3 < V < 2\text{inch}^3$

Performance can be determined from laboratory tests

Estimation of the efficiency can be done via a simulation

Choice of gamma-ray detectors

Operation in a magnetic field

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Estimation of the efficiency can be done via a simulation

Detection efficiency – size

- Optimal limits are: $1\text{inch}^3 < V < 2\text{inch}^3$

Scintillation detectors test



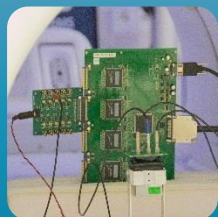
Test at GANIL (January 2016)

- B-field up to 1,7 T
- 1.5"x1.5"x1.5" cubic LaBr_3
- Analogue and Reduced GET electronics



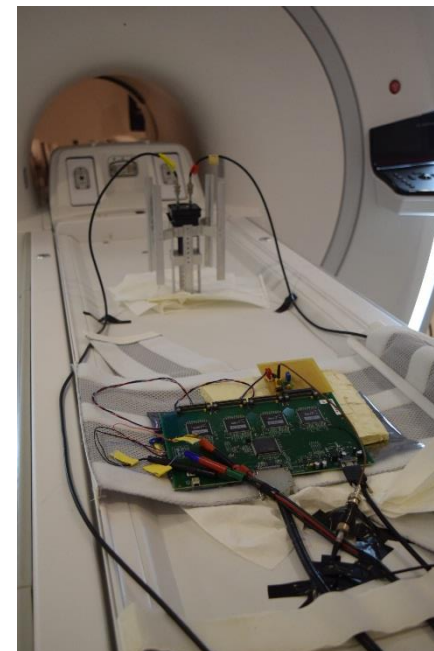
Test at UZ Leuven (August 2016)

- B-field up to 3 T
- 1.5"x1.5"x1.5" cubic $\text{LaBr}_3:\text{Ce}$ and CeBr_3
- Analogue, CAEN and Reduced GET electronics

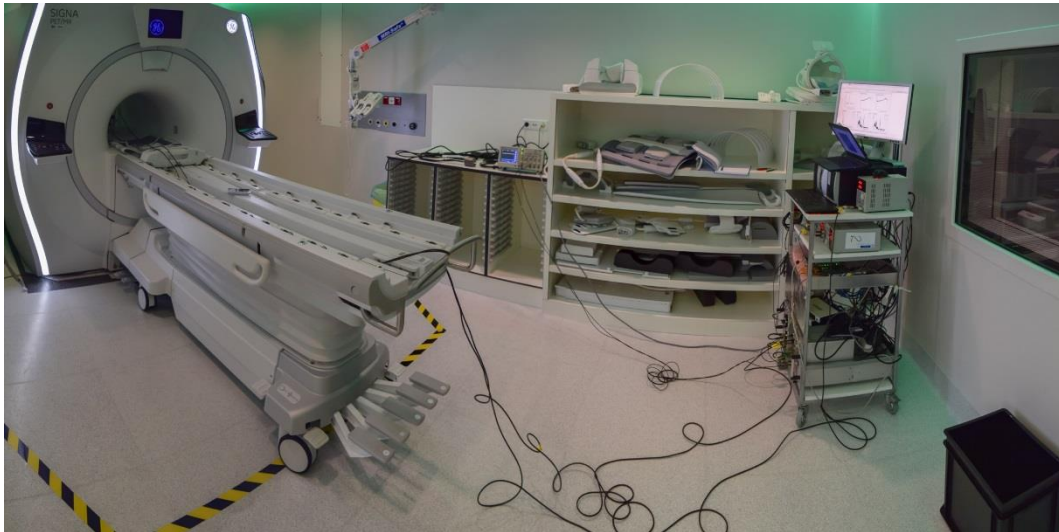


Test at UZ Leuven (August 2017)

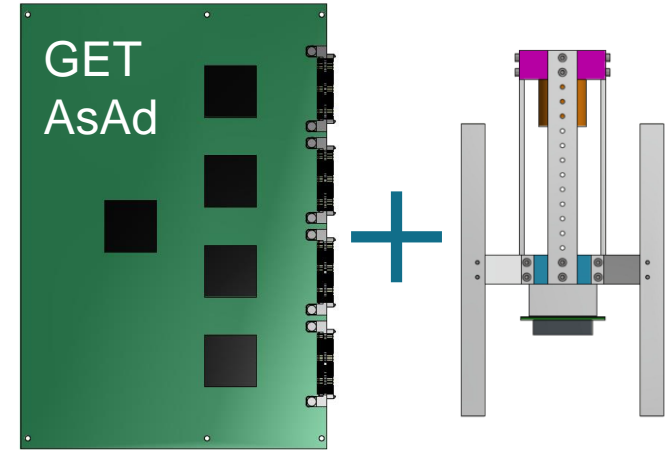
- B-field up to 3 T
- 1.5"x1.5"x1.5" cubic $\text{LaBr}_3:\text{Ce}$
- Analogue, CAEN and Full GET electronics



Detector and electronics tests in 3T magnetic field



B-field



	DAQ	Analogue	CAEN	GET	GET	GET
Detector	B-field	No field	No field	No field	AsAd in 3T parallel	AsAd in 3T perpendic
LaBr ₃ +SiPM	No field	2,94±0,01%	3,22±0,01%	3,85±0,03%	3,85±0,03%	3,82±0,03%
LaBr ₃ +SiPM	3T	2,97±0,01%	3,24±0,01%	3,88±0,01%	3,85±0,01%	3,84±0,01%

Measured resolution of LaBr₃:Ce detector @ **661,7keV** coupled to SensL J-series Silicon Photo Multiplier and 3 different DAQ systems in “no” magnetic field region (~0,001T) and in 3T magnetic field region.

Choice of gamma-ray detectors

Operation in a magnetic field

- (NO Germanium detectors, scintillators + photo multiplier tubes ...)
- (Scintillators + Silicon photo multipliers)

Resolution – material

- (as good as possible)
- (LaBr₃:Ce, CeBr₃, CLLB, ...)

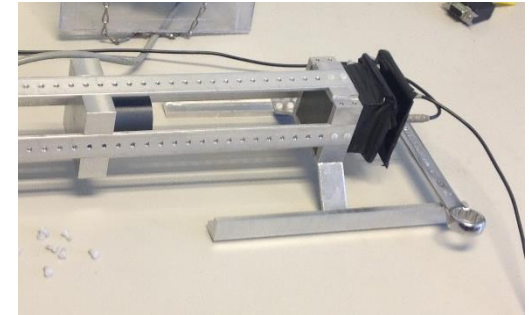
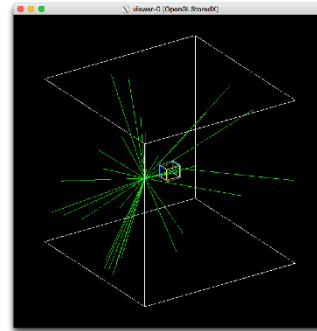
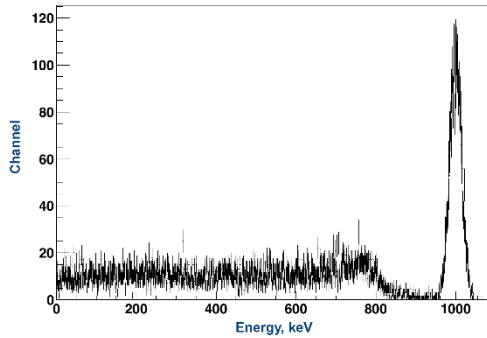
Detection efficiency – size

- Optimal limits are: $1\text{inch}^3 < V < 2\text{inch}^3$

Performance can be determined from laboratory tests

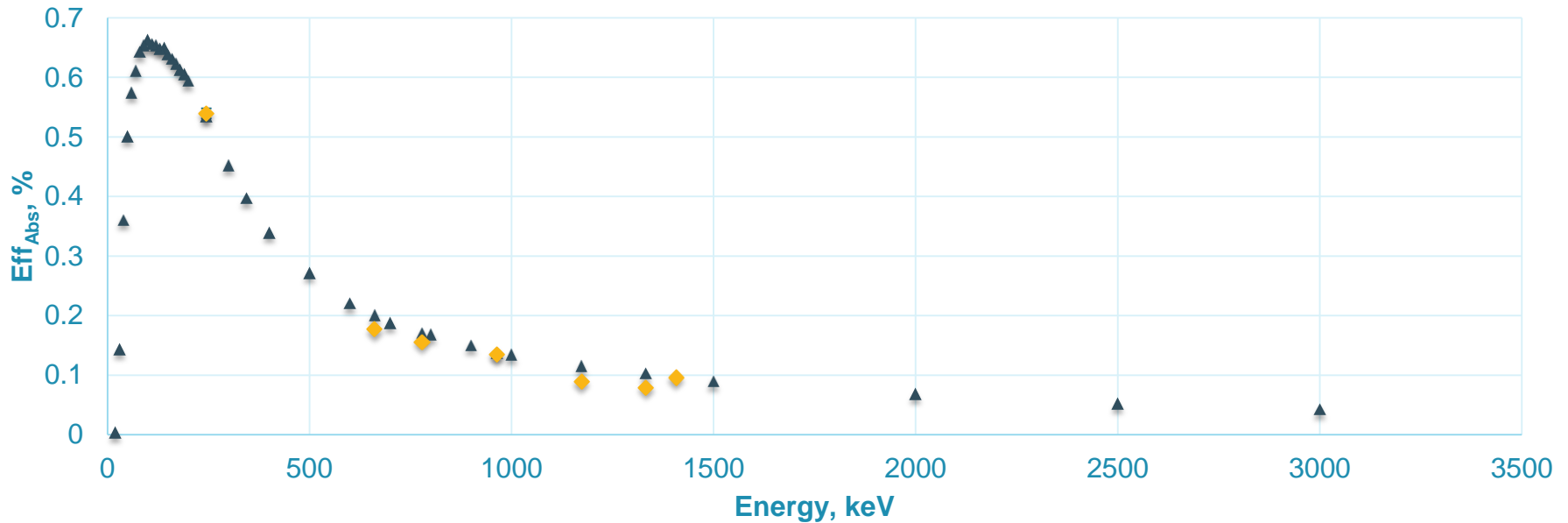
Estimation of the efficiency can be done via a simulation

Simulations of a scintillation detector in GEANT4

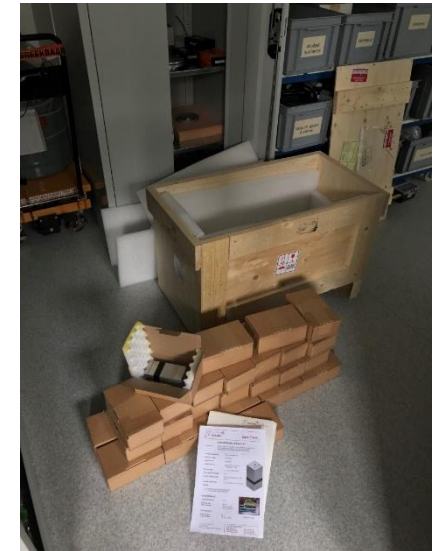
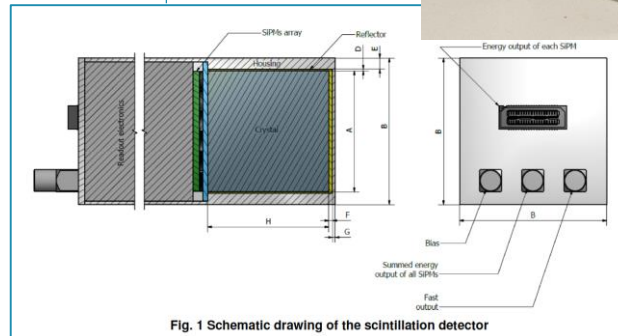
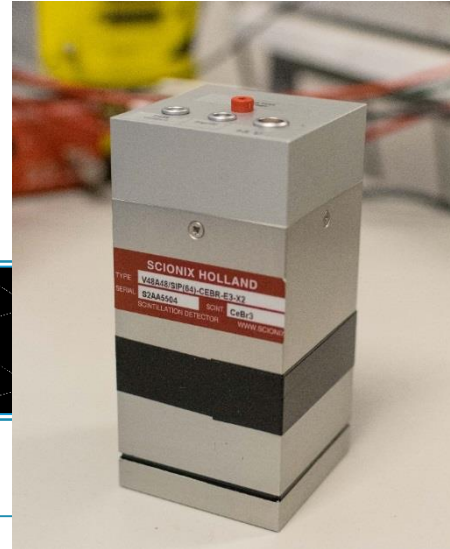
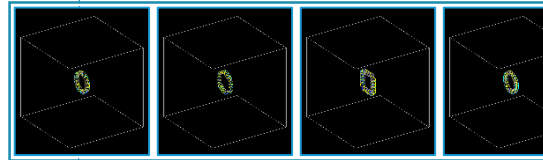
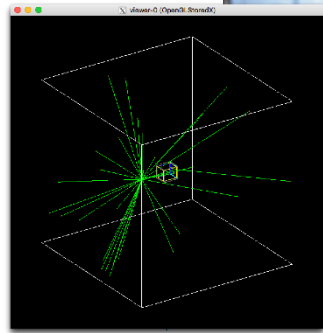
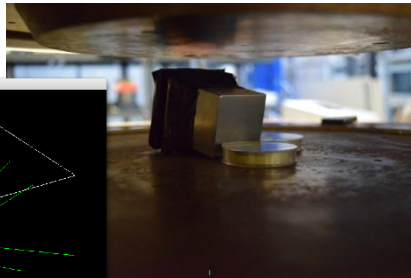


Our simulation is in a good agreement with experimentally measured Eff_{Abs} of 1,5"x1,5"x1,5" CeBr_3 crystal, 120 mm away from sources

▲ Sim ◆ Exp



Scintillation detectors for SpecMAT



G4 Sim

Tests in B-field

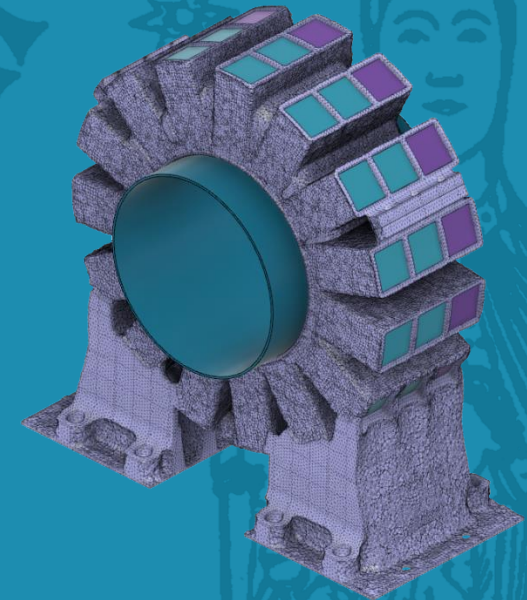
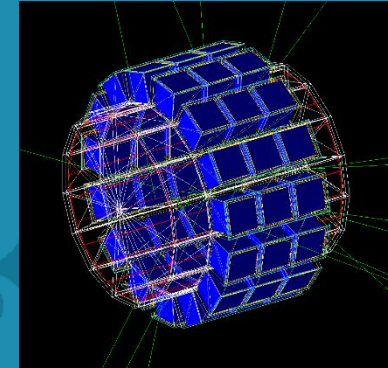
G4 Sim

Design

First prototype

30 detectors

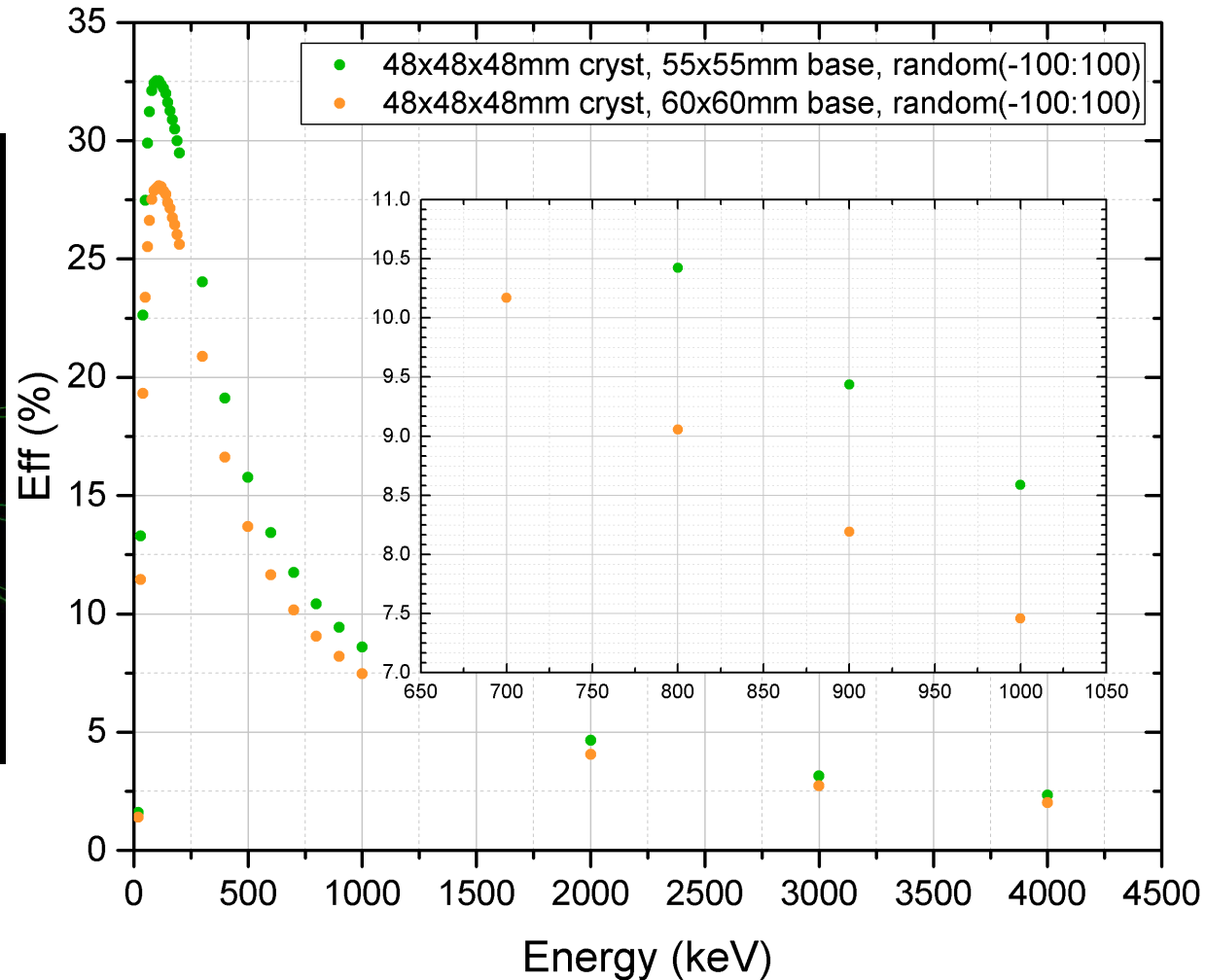
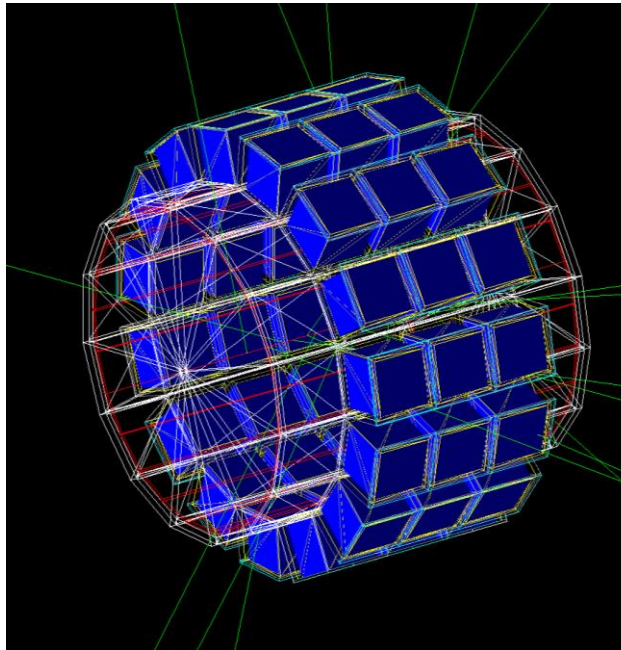
Development of the gamma- detection array



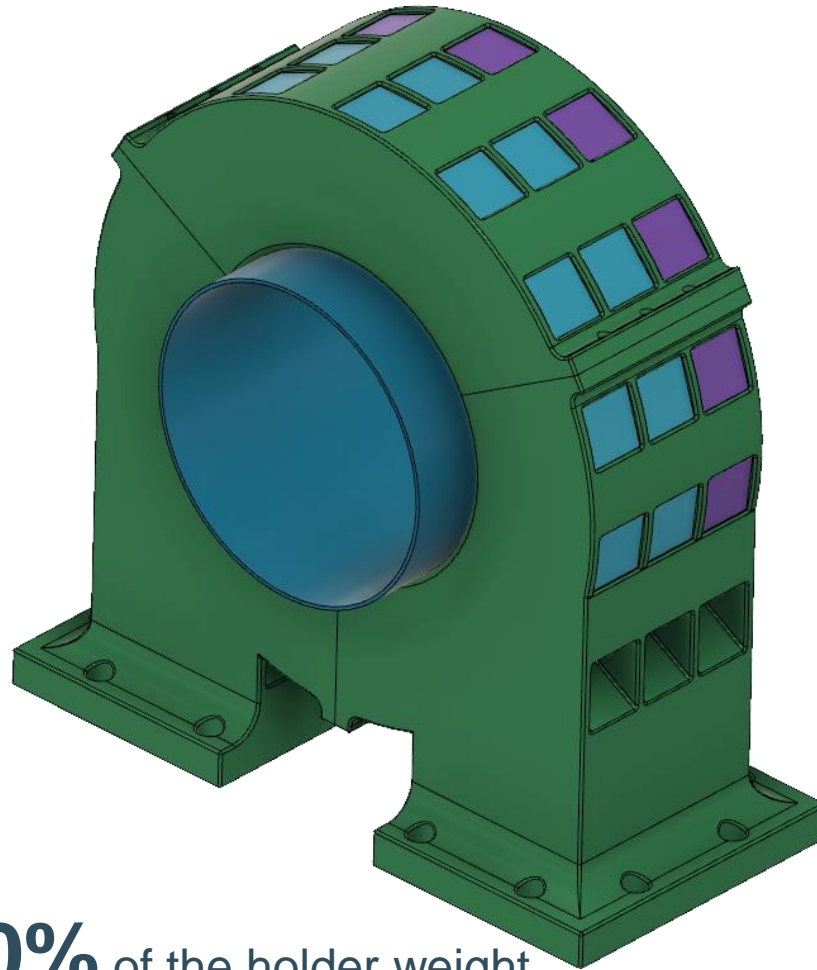
[From GENAT4 simulation to
generative design and 3D printing]

SpecMATscint, the GEANT4 simulation of the scintillation array

Efficiency of 45 CeBr_3 crystals arranged in an array



Generative design of the array holder



Reducing of up to **50%** of the holder weight

3D printing of the array holder

Test samples

The array

Original design

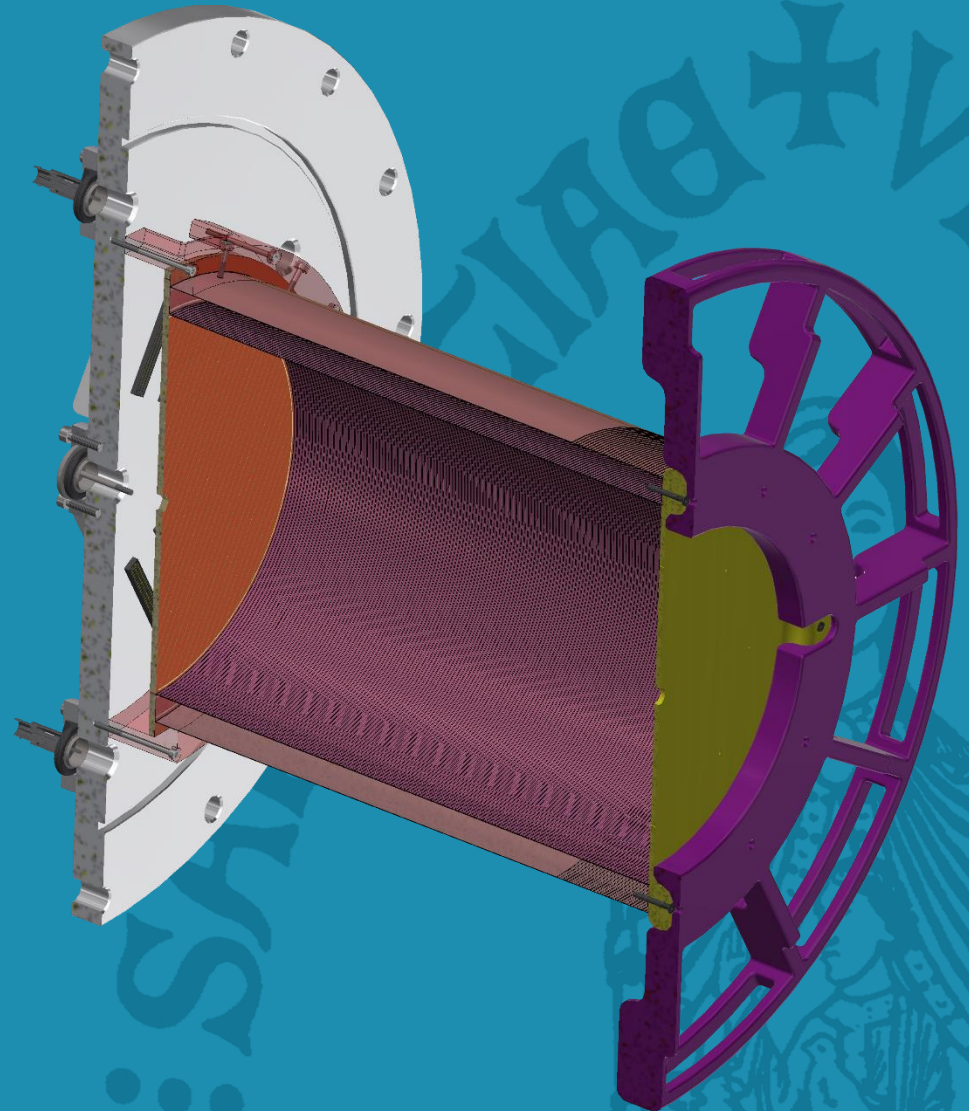


Generative design

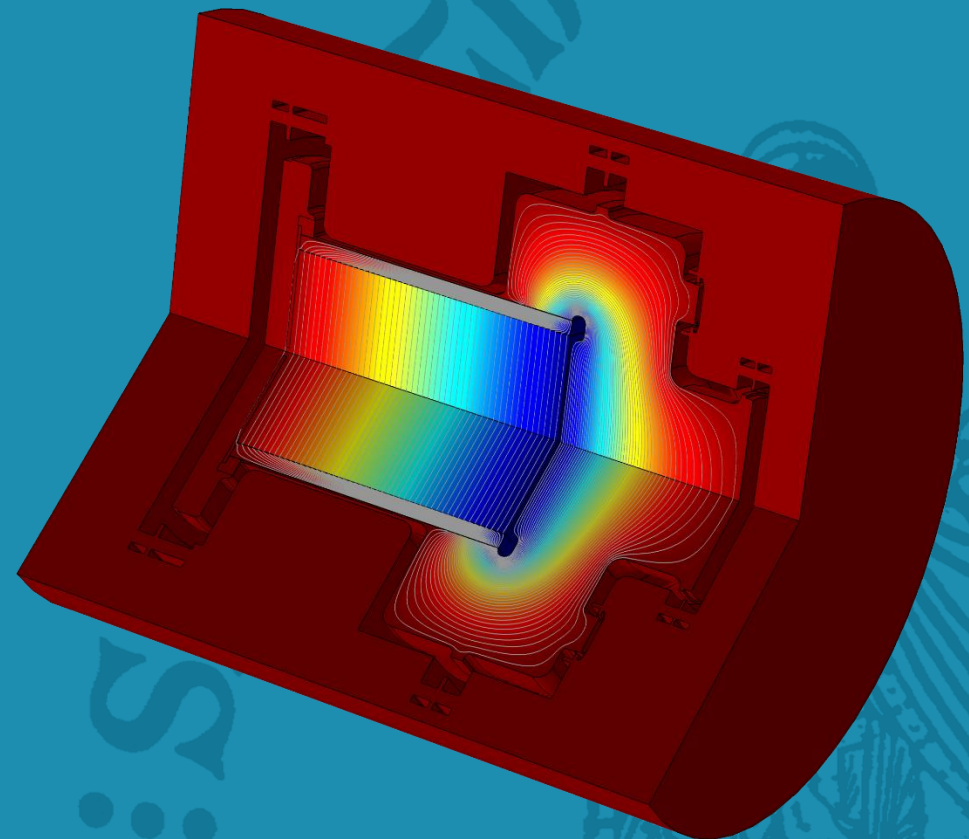


Reducing of up to **50%** of the holder weight

Development of the active target

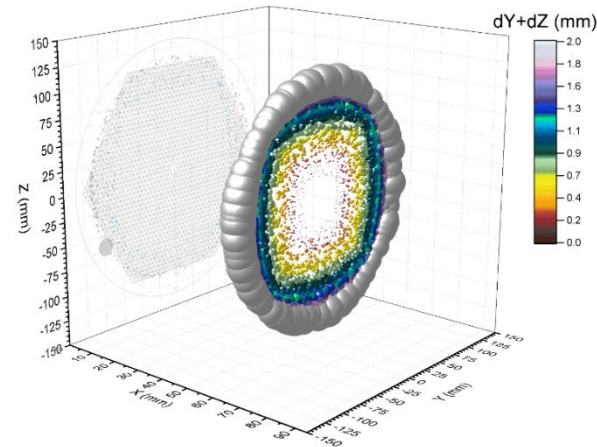
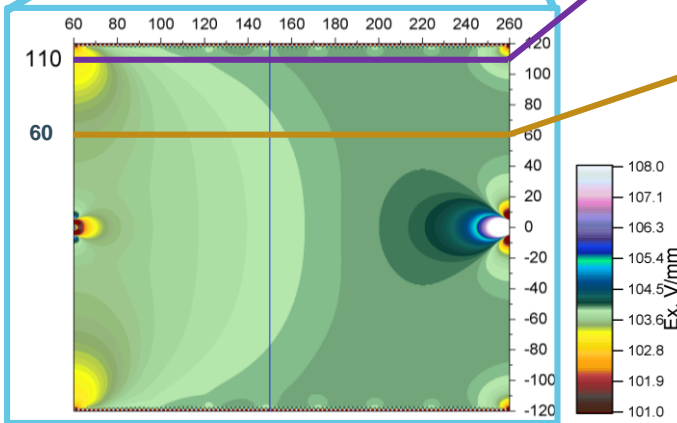
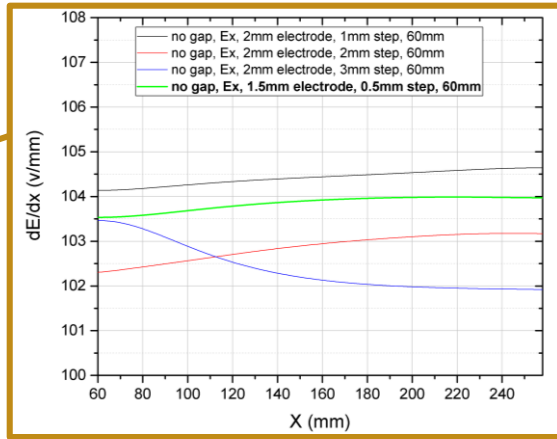
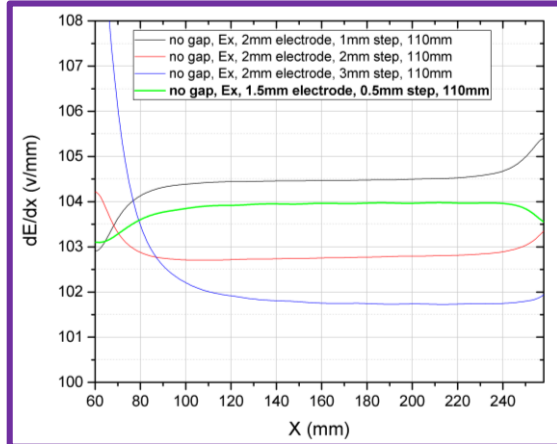
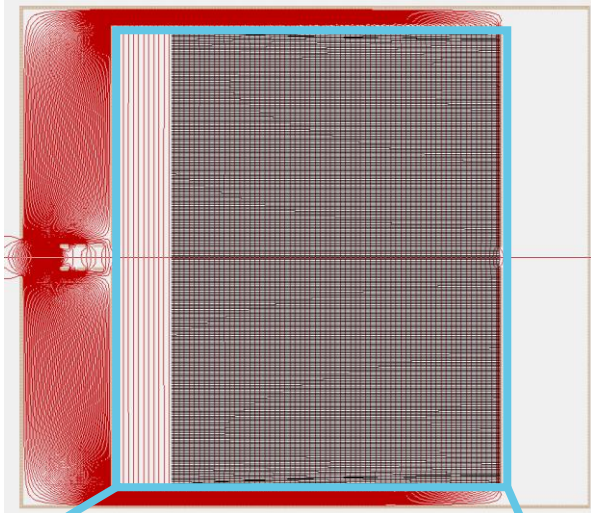


The SpecMAT Electric Field Cage

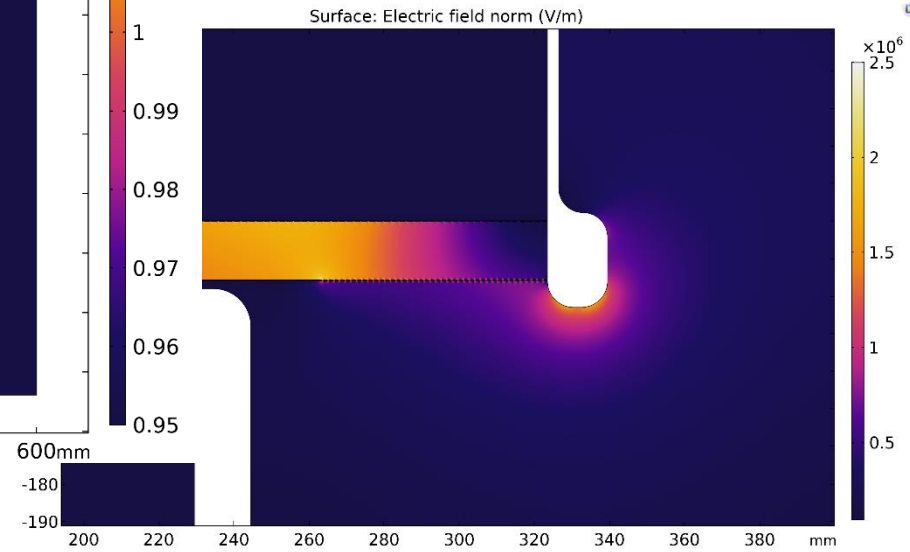
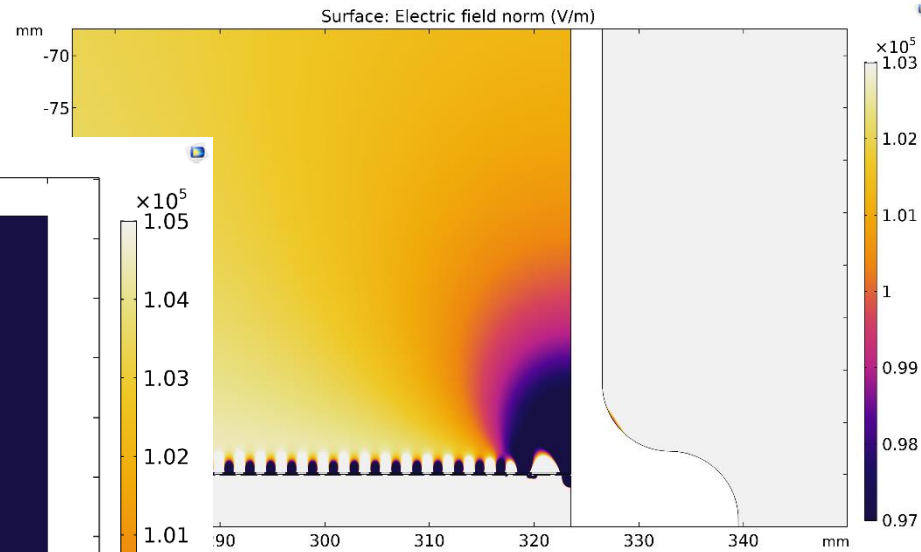
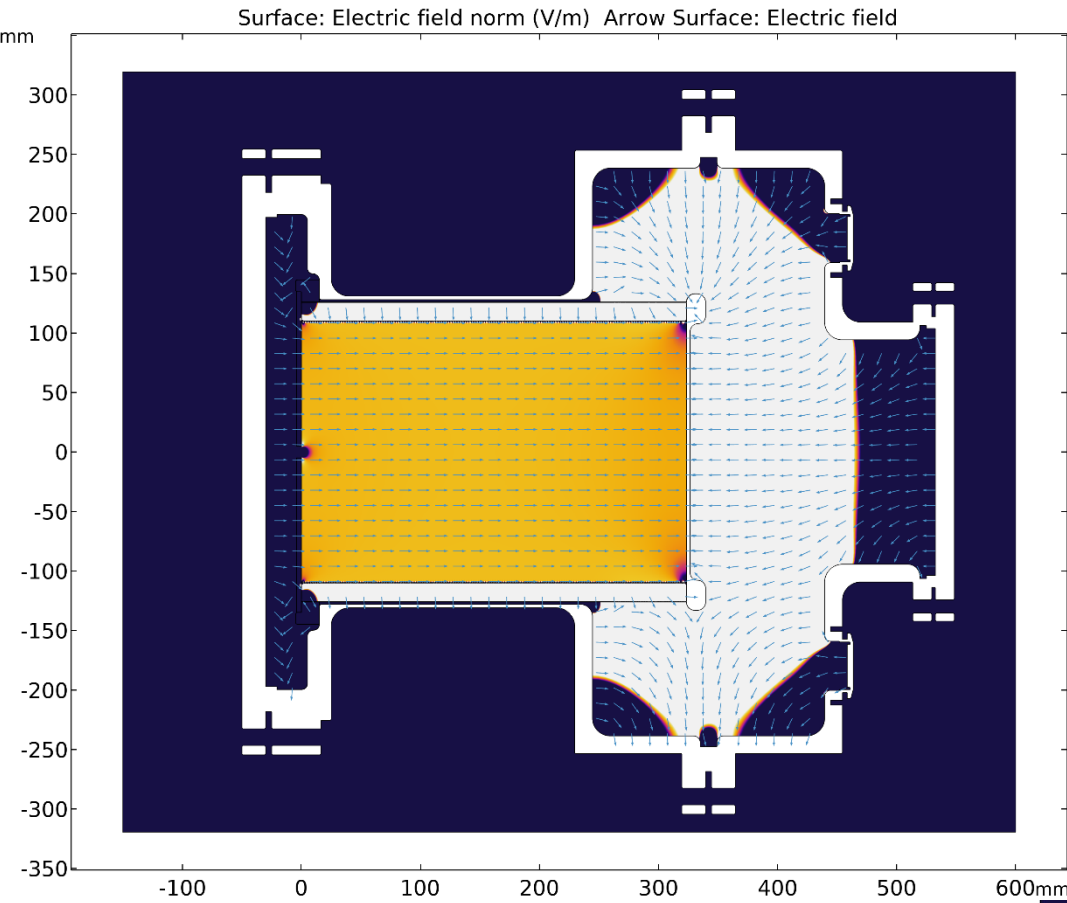


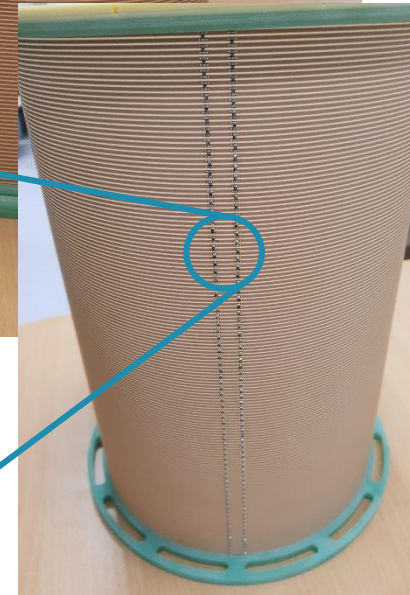
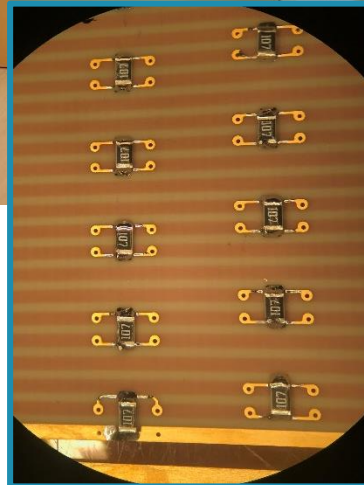
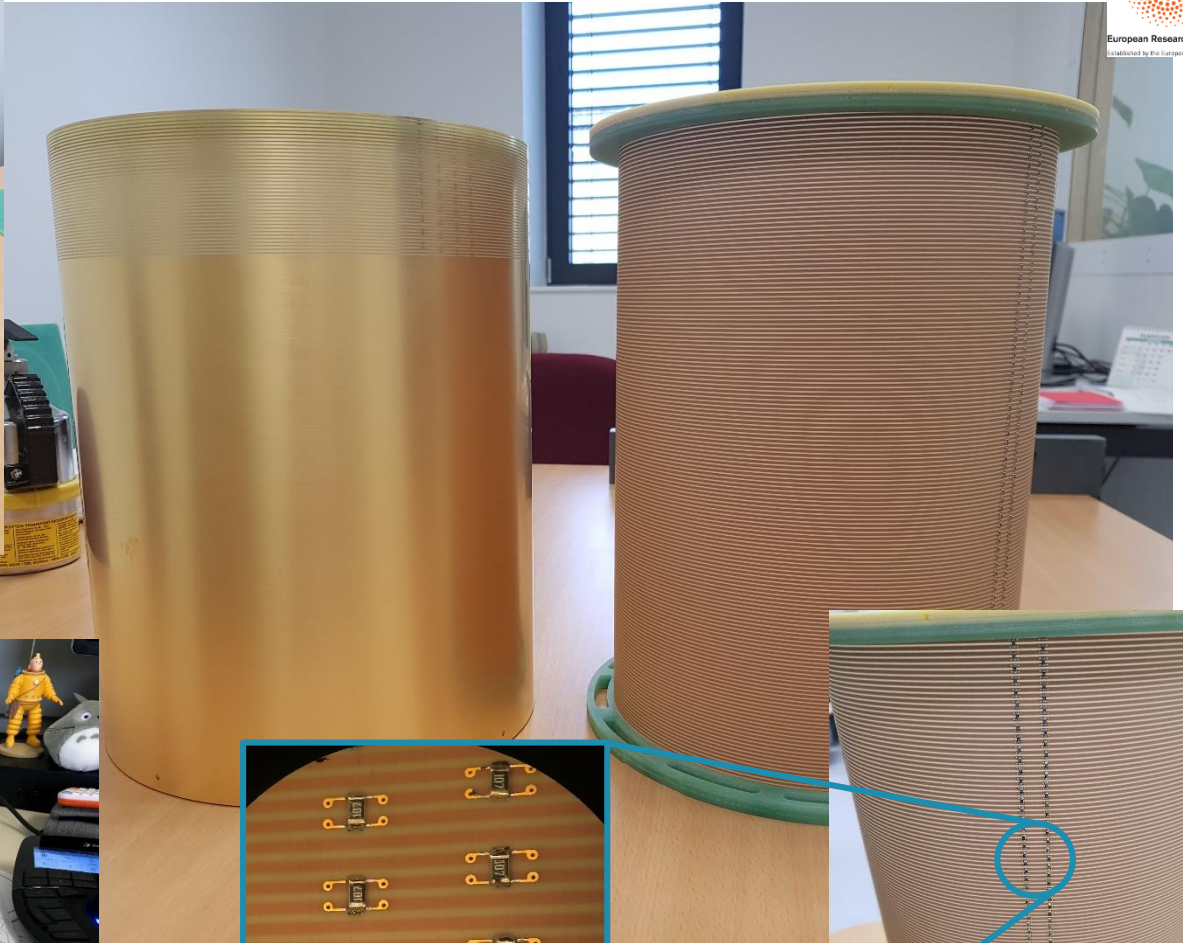
E-field

Electrodes shape & electron tracks simulation

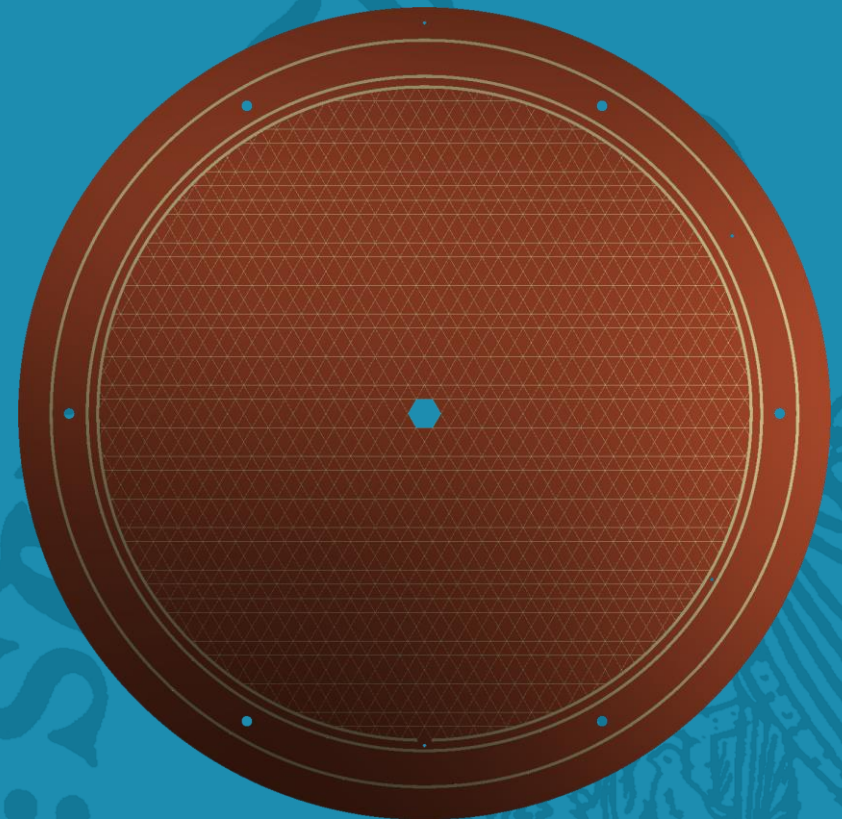


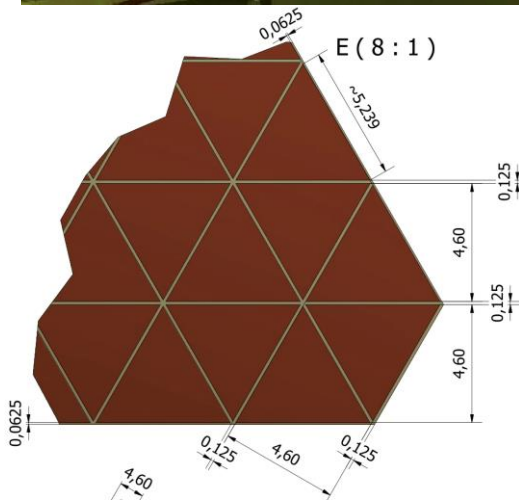
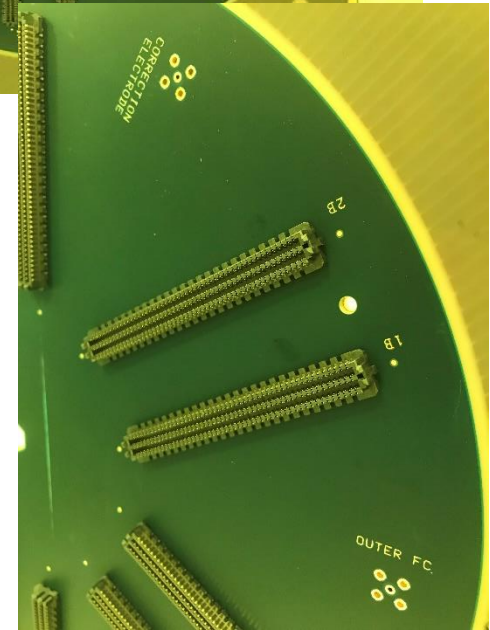
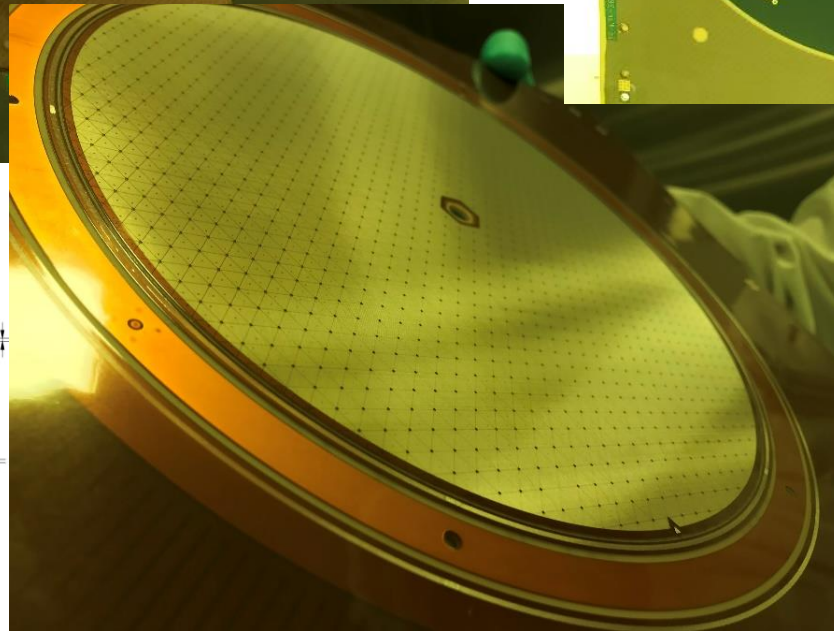
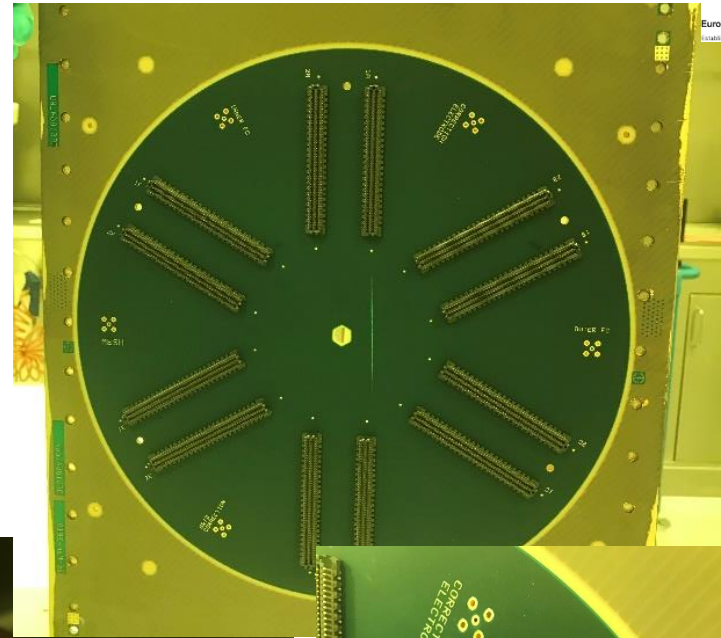
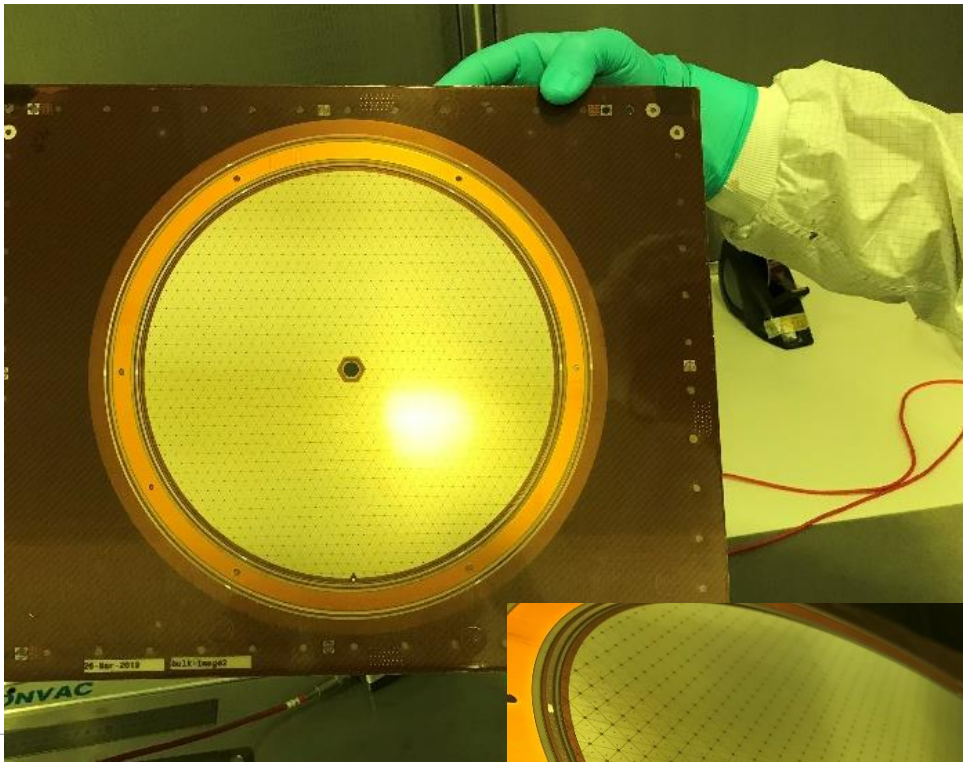
E-field Detailed geometry input



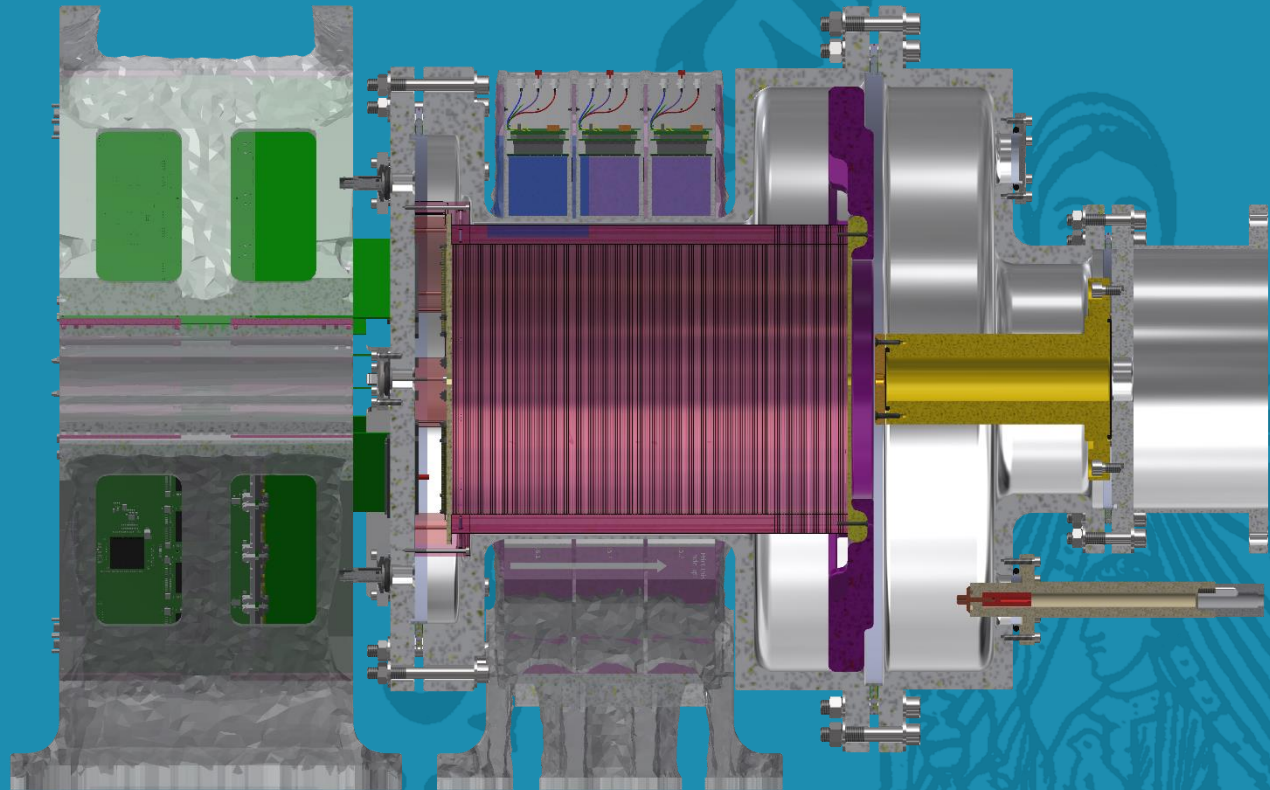


The SpecMAT gaseous detector
(a pixelated padplane based on the
Micromegas technology)

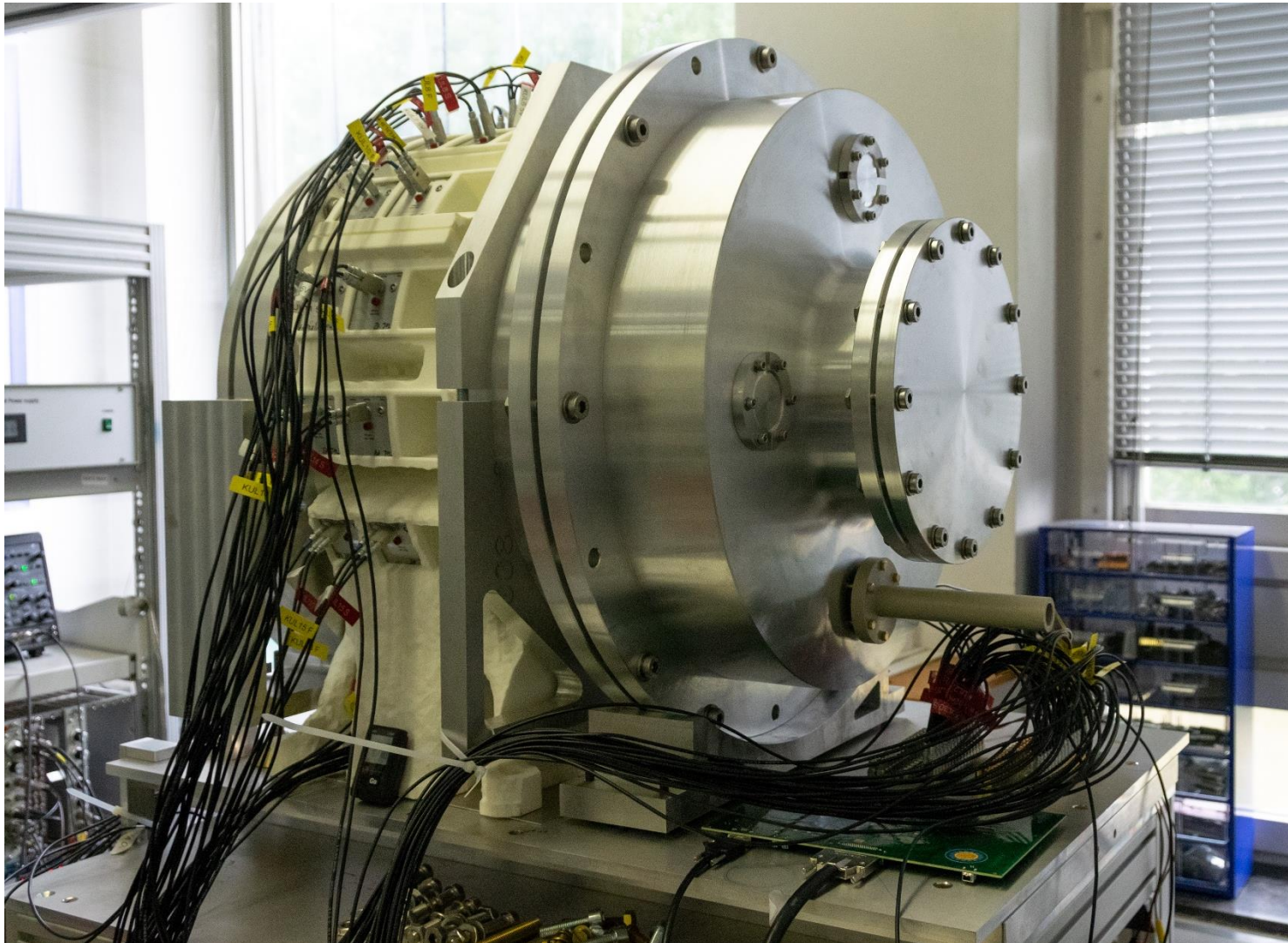




The SpecMAT active target



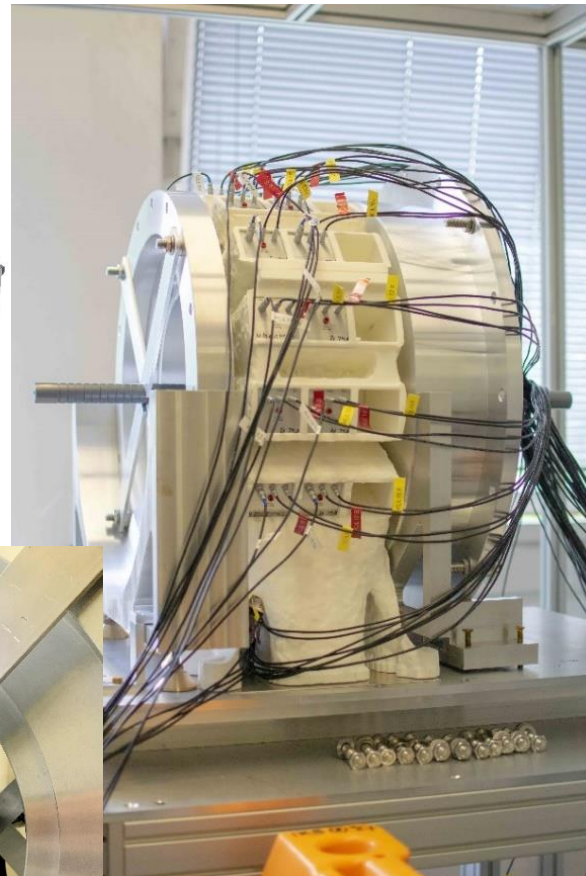
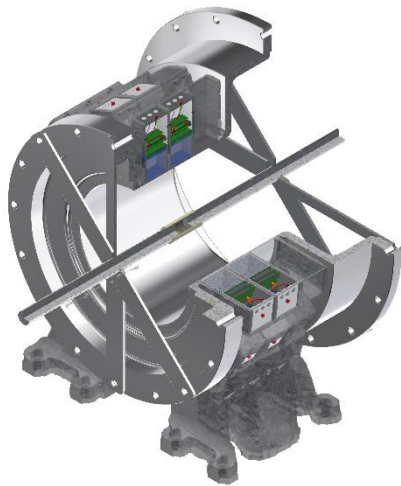
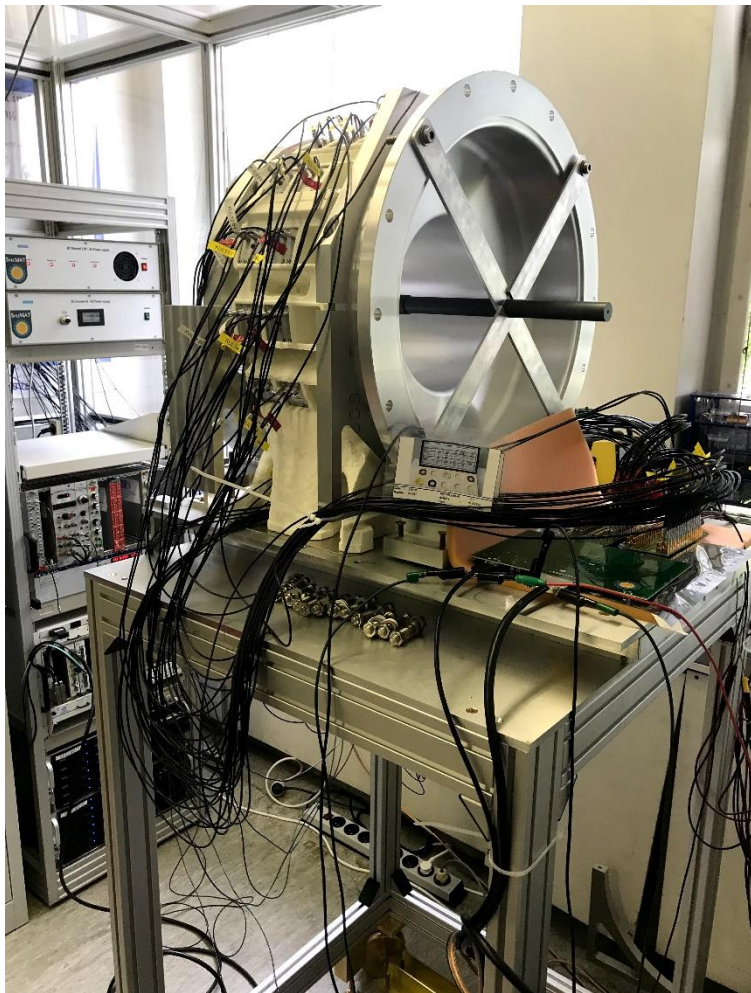
SpecMAT



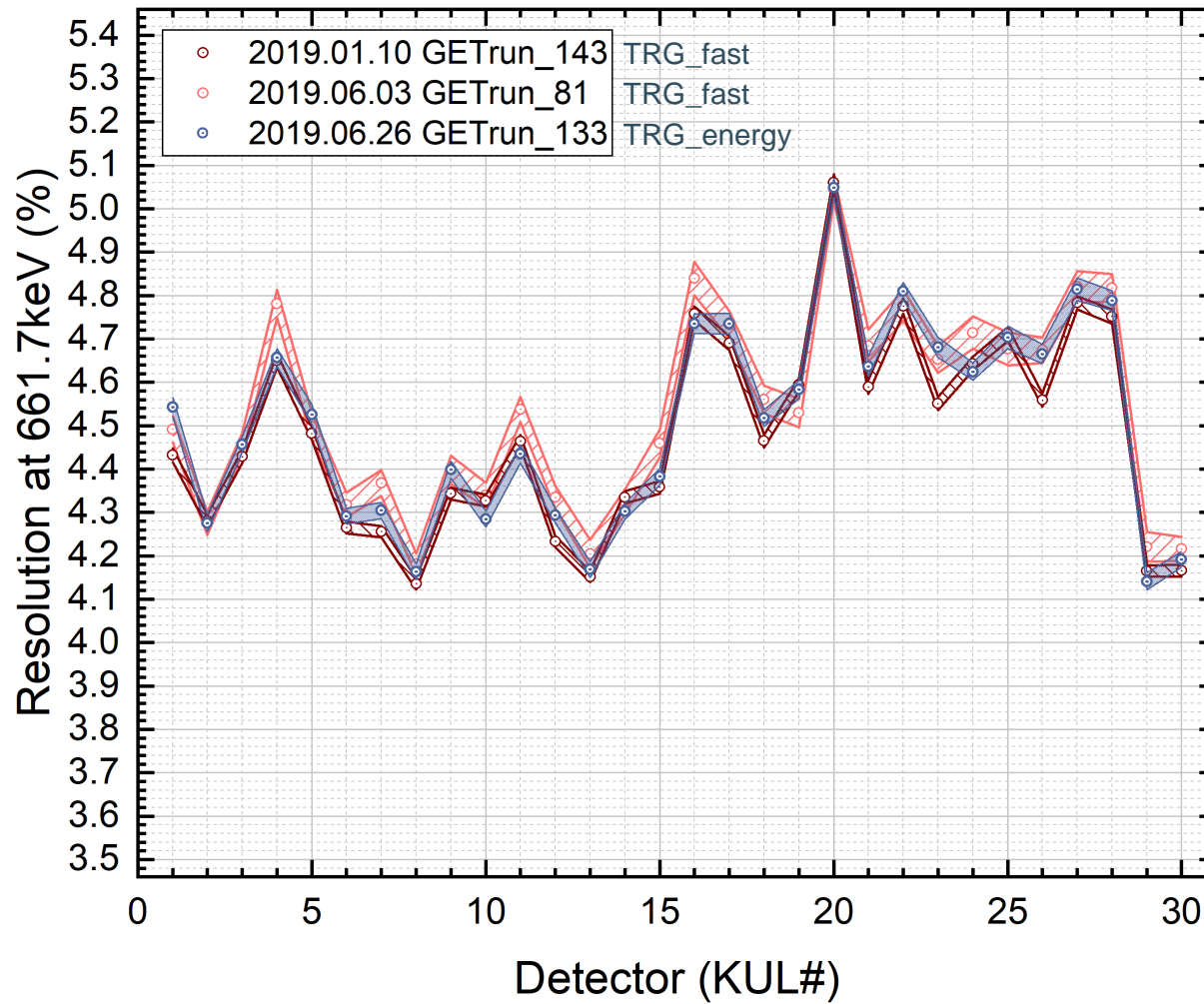
Characterisation of the scintillation array



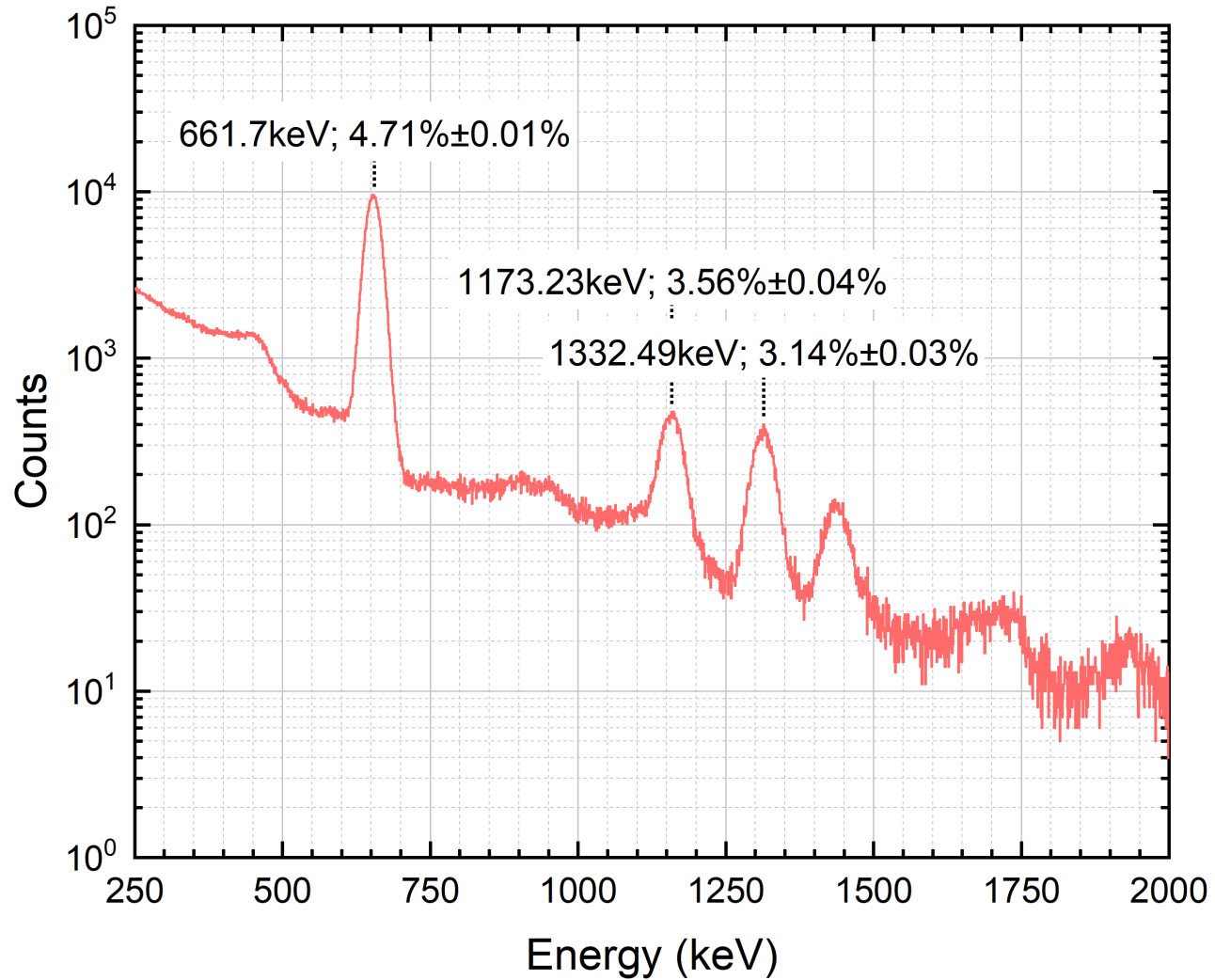
The setup



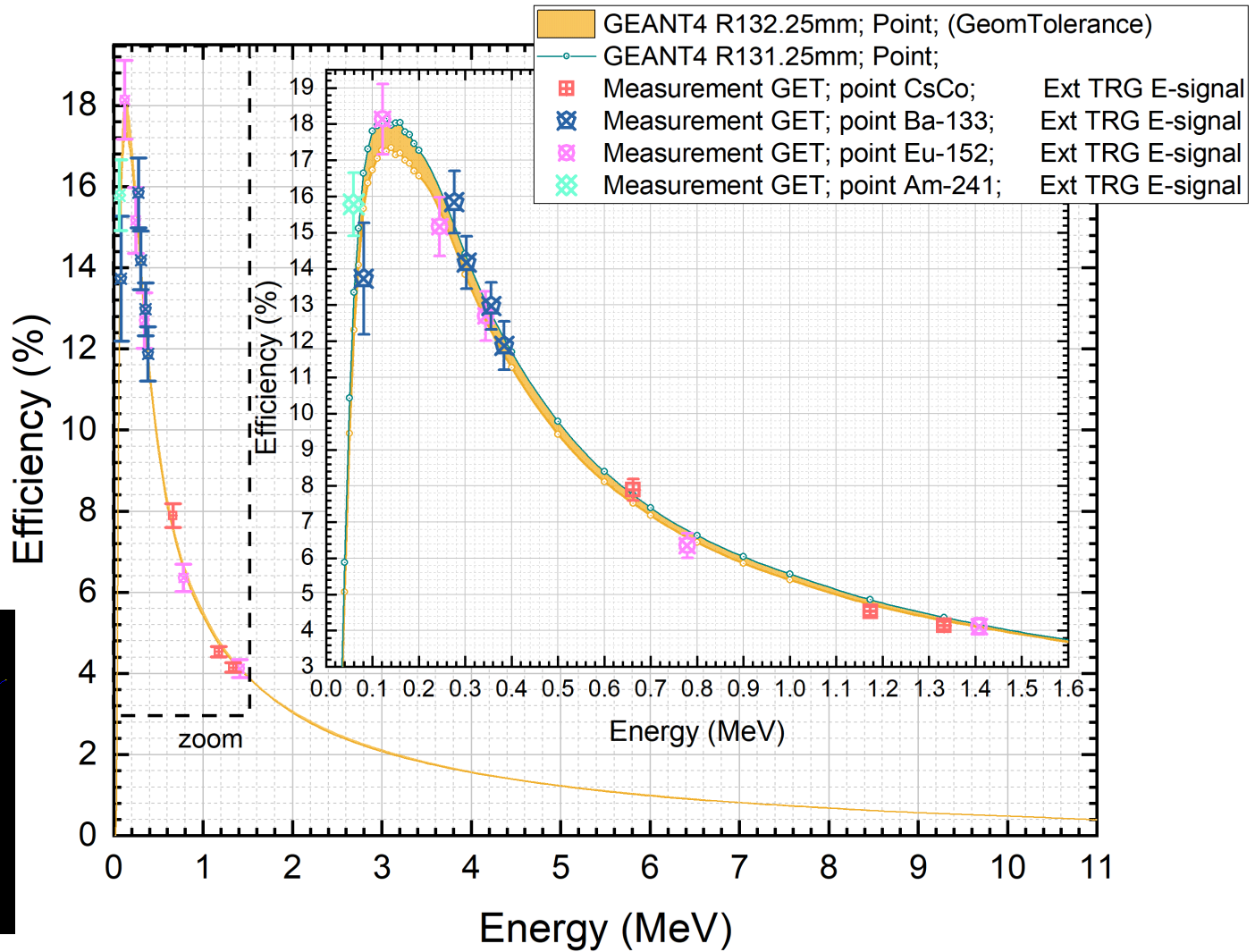
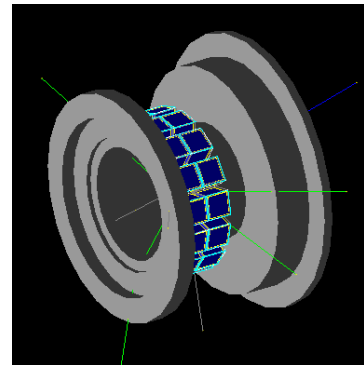
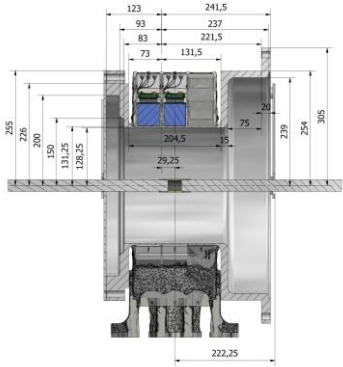
Resolution of the SpecMAT CeBr₃ detectors readout by GET



SpecMAT array, summed spectrum, ^{137}Cs and ^{60}Co



Photopeak Eff_{Abs} of the SpecMAT array, two rings (30 CeBr_3 detectors)



Thank you for your
attention!