

The XEMIS project, a three gamma imaging detector for medical Applications

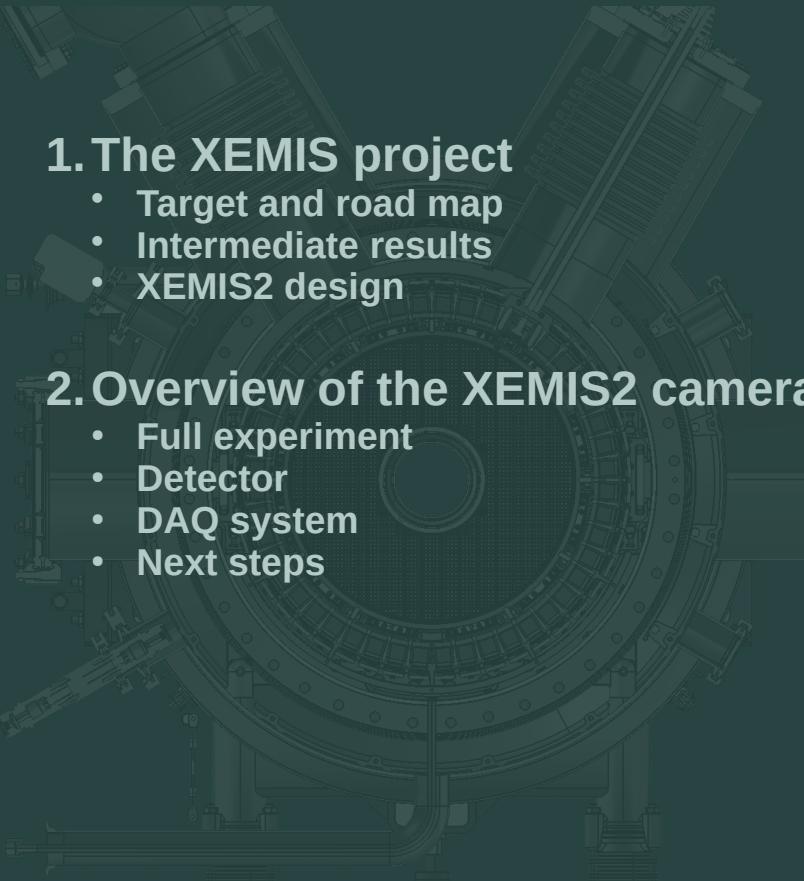
On behalf of the XEMIS team

1. The XEMIS project

- Target and road map
- Intermediate results
- XEMIS2 design

2. Overview of the XEMIS2 camera integration

- Full experiment
- Detector
- DAQ system
- Next steps





The XEMIS project

The XEnon Medical Imaging System (XEMIS) project

Target:

Build and proof that a functional, low activity (~ 20 kBq) and good resolution imaging system for human body is possible.

Technologies:

Liquid Xenon Compton Telescope
+
Three photons imaging

2010



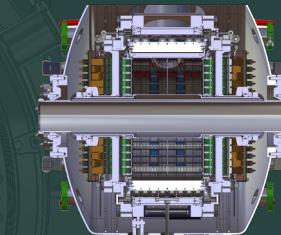
XEMIS1

R&D Prototype

30 kg
6 (12) cm
drift TPC

Done

2022



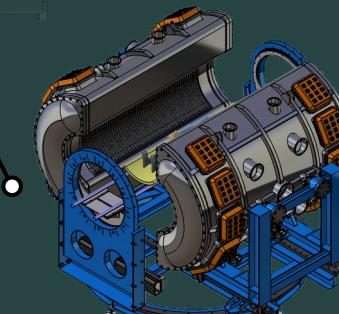
XEMIS2

Small animal imaging

200 kg
2 x 12 cm
drift TPC

Under installation at
Nantes CHU

Final goal



XEMIS3

Total body imaging
Hadron therapy
monitoring

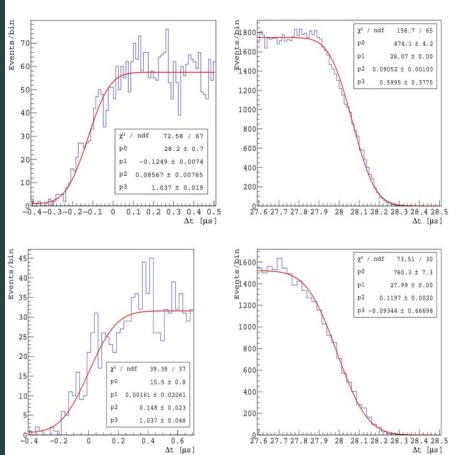
2 tons
2 m long
12 cm drift TPC

The XEMIS project: intermediate results

Y. Zing, "Studies and optimization of ionization signal measurement for the 3-gamma imaging XEMIS2 liquid xenon Compton camera", PhD thesis, HAL Id: tel-03373202, 2021.

Z resolution:

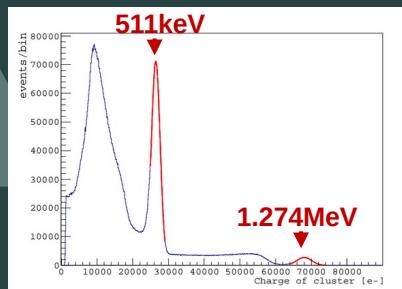
$\rightarrow \sigma(z) = 100 \mu\text{m}$ (for single scatter)



Energy resolution:

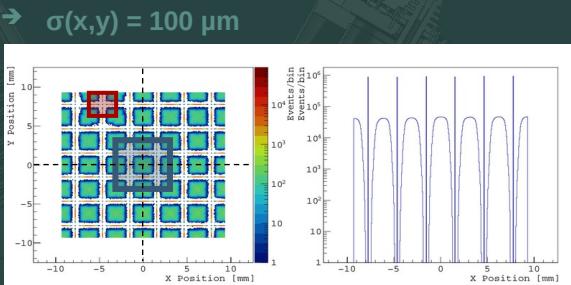
$\rightarrow \sigma(E) = 3.5 \%$

For $[^{22}\text{Na}$, single scatter, 2 kV.cm^{-1}]



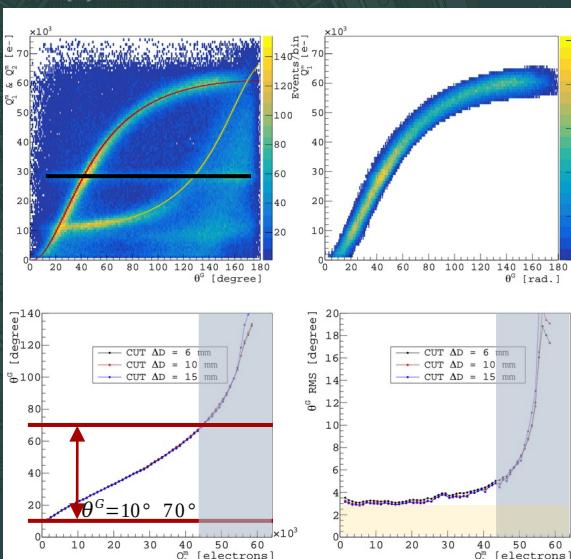
XY resolution:

$\rightarrow \sigma(x,y) = 100 \mu\text{m}$



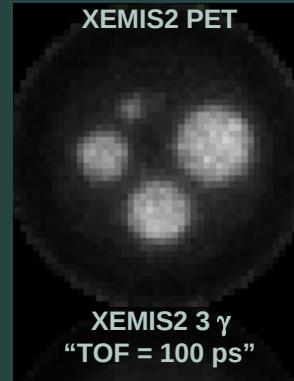
Angular resolution:

$\rightarrow \sigma(\theta) = 2^\circ$

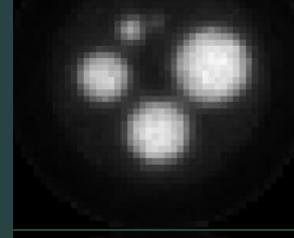


Reconstruction Algorithms:

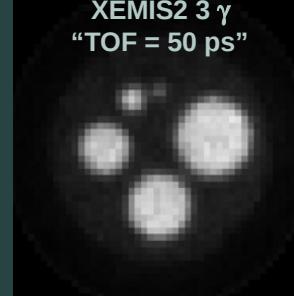
XEMIS2 PET



XEMIS2 3 γ
“TOF = 100 ps”



XEMIS2 3 γ
“TOF = 50 ps”

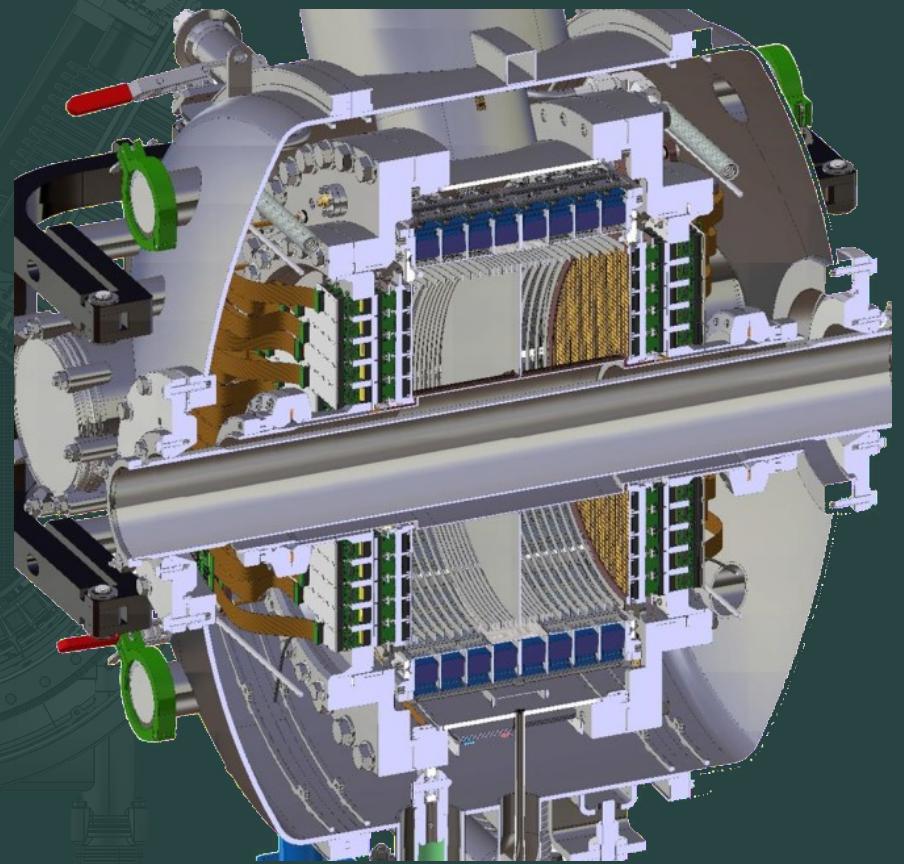


2, 4, 8, 10,
12 mm
radius hot
sphere
(^{44}Sc
contrast
15)

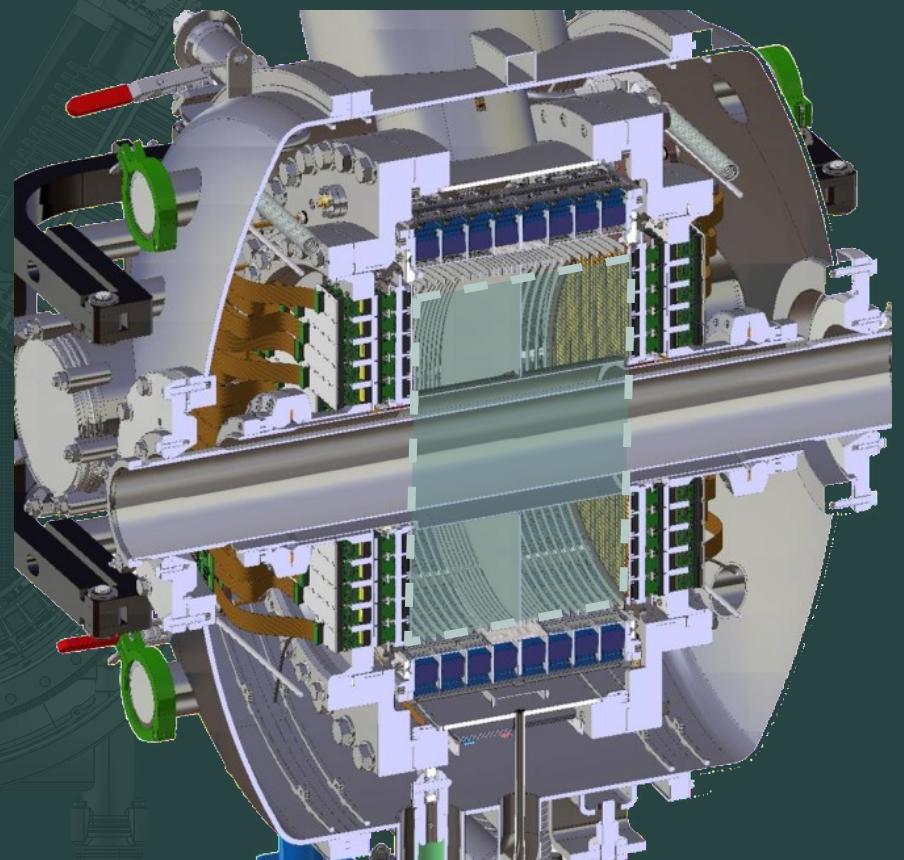


D. Giovagnoli et al., "A Pseudo-TOF Image Reconstruction Approach for Three-Gamma Small Animal Imaging," in IEEE Transactions on Radiation and Plasma Medical Sciences, vol. 5, no. 6, pp. 826-834, Nov. 2021.

- Double stainless-steel cryostat, vacuum and Al MLI thermal insulation
- 100 mm diameter central tube for mice (@ room atmosphere)
- 2 back-to-back TPC
- 1 shared central cathode
 - Sensitive detector
 - Cylindrical symmetry
 - External radius: 195 mm
 - Internal radius: 75 mm
 - Length: 240 mm
 - Volume: 24 L
 - 72 kg of LXe
 - Charge signal:
 - 2 x 10,000 anode pads
 - Pad surface: 3.0 x 3.0 mm²
 - Nominal pad voltage: ground
 - Light signal:
 - 64 (380) PMT, R7600
 - Sensitive area : 18 x 18 mm²
 - QE ~ 30% @ 175 nm



- Double stainless-steel cryostat, vacuum and Al MLI thermal insulation
- 100 mm diameter central tube for mice (@ room atmosphere)
- 2 back-to-back TPC
- 1 shared central cathode
 - Sensitive detector
 - Cylindrical symmetry
 - External radius: 195 mm
 - Internal radius: 75 mm
 - Length: 240 mm
 - Volume: 24 L
 - 72 kg of LXe
 - Charge signal:
 - 2 x 10,000 anode pads
 - Pad surface: 3.0 x 3.0 mm²
 - Nominal pad voltage: ground
 - Light signal:
 - 64 (380) PMT, R7600
 - Sensitive area : 18 x 18 mm²
 - QE ~ 30% @ 175 nm

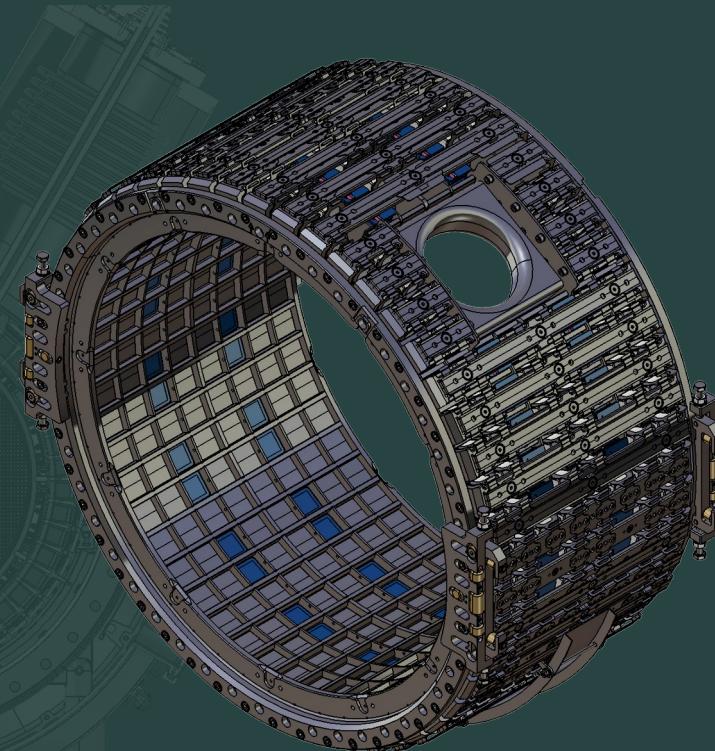


- Double stainless-steel cryostat, vacuum and Al MLI thermal insulation
- 100 mm diameter central tube for mice (@ room atmosphere)
- 2 back-to-back TPC
- 1 shared central cathode

- Sensitive detector
 - Cylindrical symmetry
 - External radius: 195 mm
 - Internal radius: 75 mm
 - Length: 240 mm
 - Volume: 24 L
 - 72 kg of LXe

- Charge signal:
 - 2 x 10,000 anode pads
 - Pad surface: 3.0 x 3.0 mm²
 - Nominal pad voltage: ground
- Light signal:
 - 64 (380) PMT, R7600
 - Sensitive area : 18 x 18 mm²
 - QE ~ 30% @ 175 nm

- Double stainless-steel cryostat, vacuum and Al MLI thermal insulation
- 100 mm diameter central tube for mice (@ room atmosphere)
- 2 back-to-back TPC
- 1 shared central cathode
 - Sensitive detector
 - Cylindrical symmetry
 - External radius: 195 mm
 - Internal radius: 75 mm
 - Length: 240 mm
 - Volume: 24 L
 - 72 kg of LXe
 - Charge signal:
 - 2 x 10,000 anode pads
 - Pad surface: 3.0 x 3.0 mm²
 - Nominal pad voltage: ground
 - Light signal:
 - 64 (380) PMT, R7600
 - Sensitive area : 18 x 18 mm²
 - QE ~ 30% @ 175 nm





Overview of the XEMIS2 camera integration

Overview of XEMIS2: full experiment



ReStoX: cooling

XEMIS2: camera

Light DAQ System

Overview of XEMIS2: full experiment



ReStoX: cooling

XEMIS2: camera

Light DAQ system

Overview of XEMIS2: full experiment



ReStoX: cooling

XEMIS2: camera

Light DAQ system

Overview of XEMIS2: full experiment



ReStoX: cooling

XEMIS2: camera

Light DAQ system

Overview of XEMIS2: circulation/cleaning system

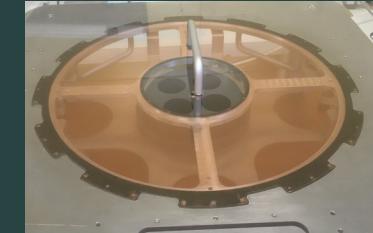


Overview of XEMIS2: detector

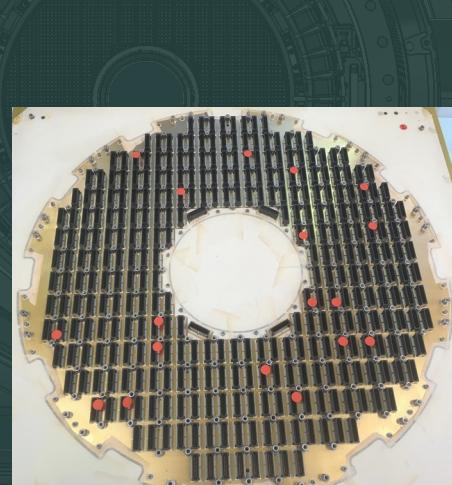
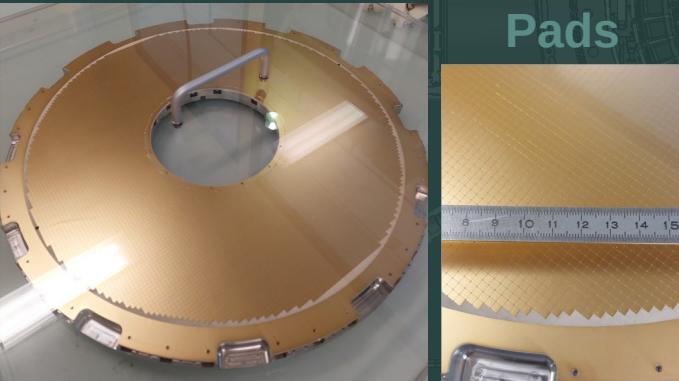
PMTs



Micro-mesh



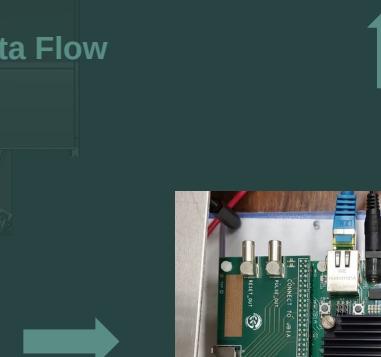
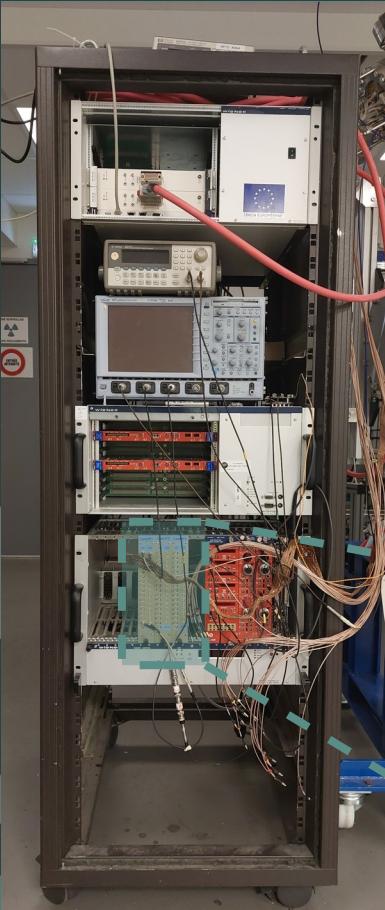
Pads



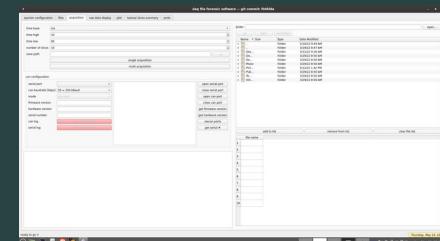
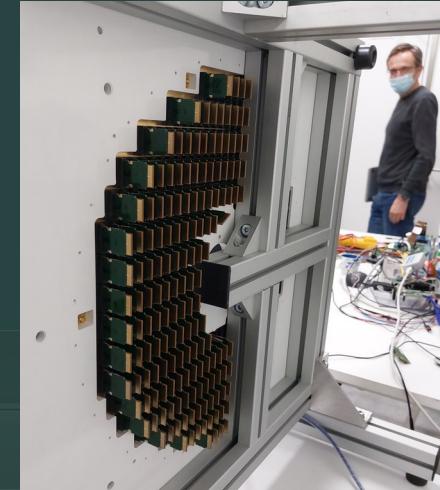
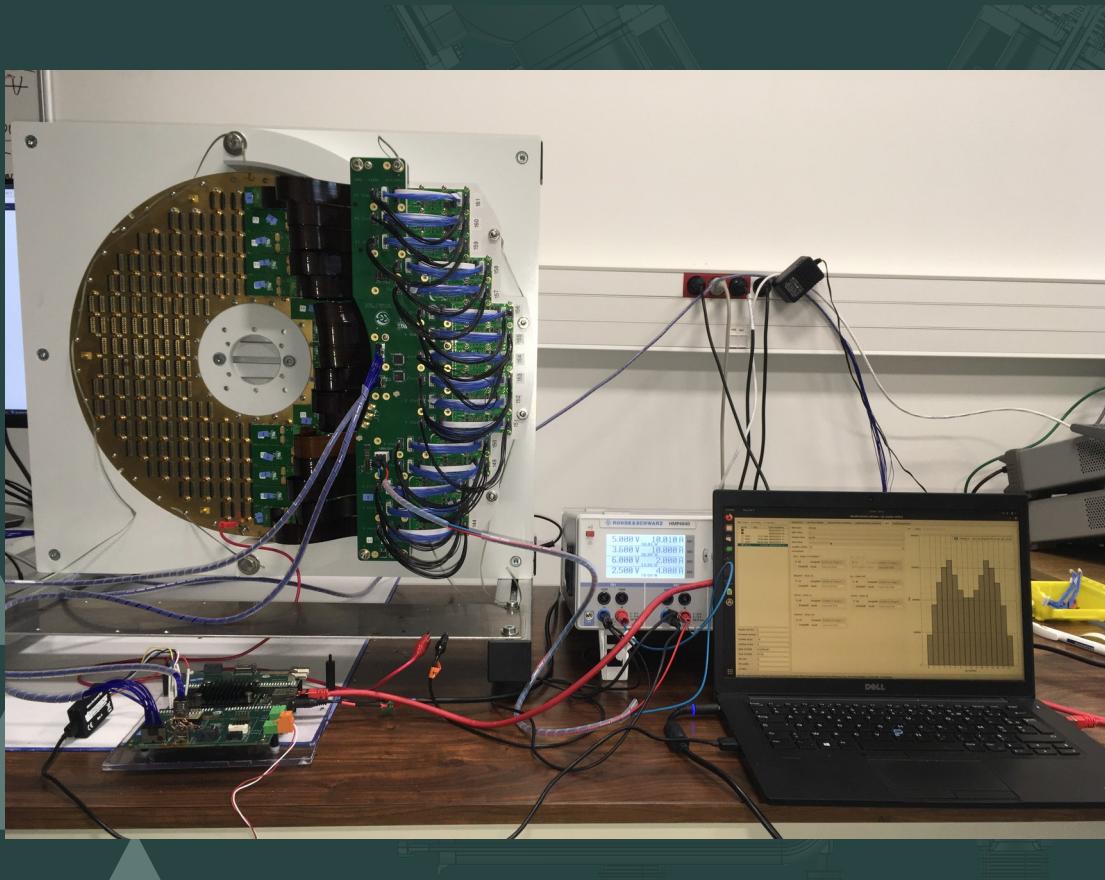
Inner tube



Overview of XEMIS2: light DAQ



Overview of XEMIS2: charge DAQ



- Finalized installation at Nantes University Hospital
- Commissioning the full experiment
- Start data acquisition and image reconstruction

Acknowledgment

Many thanks to all the XEMIS team that allow the realization of this work.

Thanks for the XeSAT international advisor committee, organizing committee, institutes and participants.