PARTICLE PHYSICS JOINT LAB JAPAN - FRANCE

ECOLE DES MINES DE NANTES

cnrs IN2P3 Les deux infinis

UNIVERSITE DE NANTES

3γ Medical Imaging R&D with liquid xenon Compton telescope

Subatech

Wan-Ting Chen, Jean-Pierre Cussonneau, Samuel Duval, Jacob Lamblin, Eric Morteau, Patrick Le Ray, Tugdual Oger, JS Stutzmann, Dominique Thers
(Nantes)

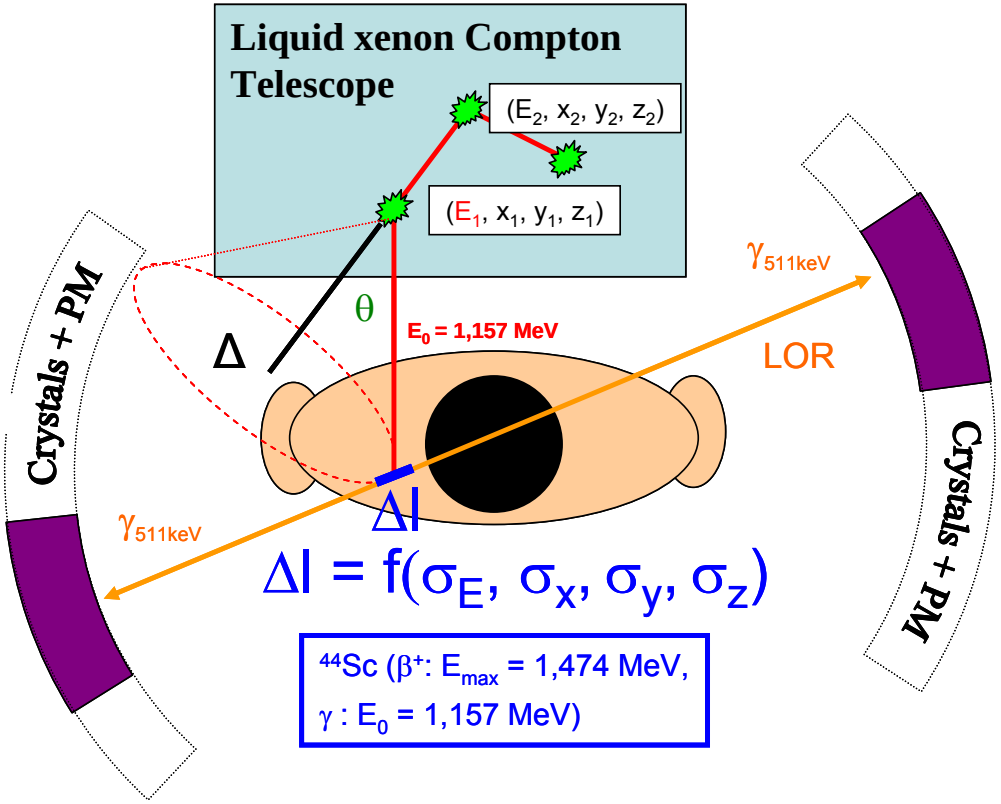
KEK 高エネルギー加速器研究機構

Toshiaki Tauchi, Tom Haruyama et al.
(Tsukuba)

Workshop FJPPL'10, 15-16 June 2010,
LAPP, Annecy-Le-Vieux, France

liquid xenon R&D: the 3γ imaging

- β+ γ (^{44}Sc) nuclide + Compton Telescope + PET = 3D reconstruction

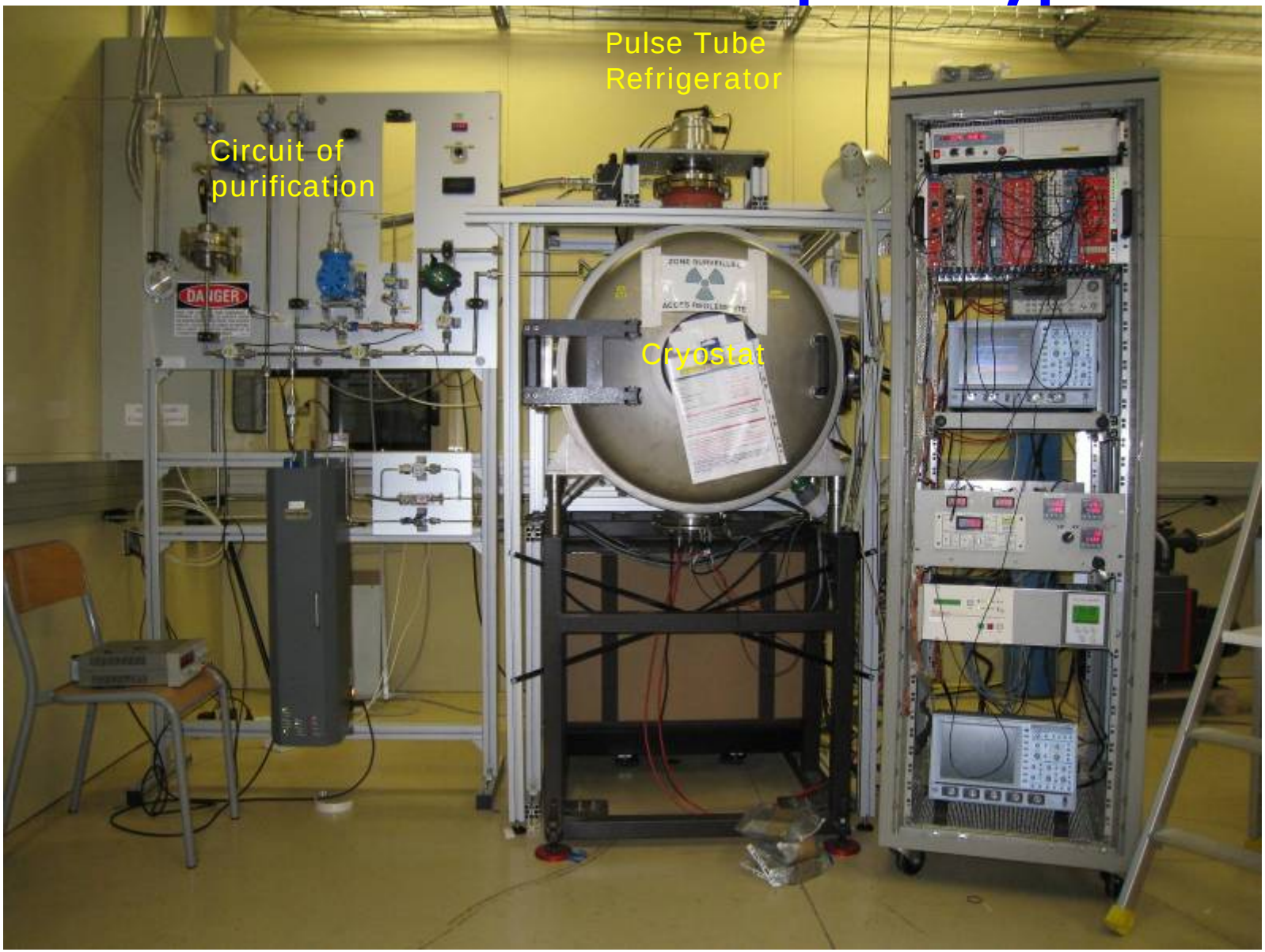


^{44}Sc produced @ ARRONAX

Ideal energy resolution
(of 511 keV γ-rays @E_{drift}=1 kV/cm):
~6.5%

⇒ Δl ~ 1-2 cm along the LOR targeted

XEMIS1 1st prototype



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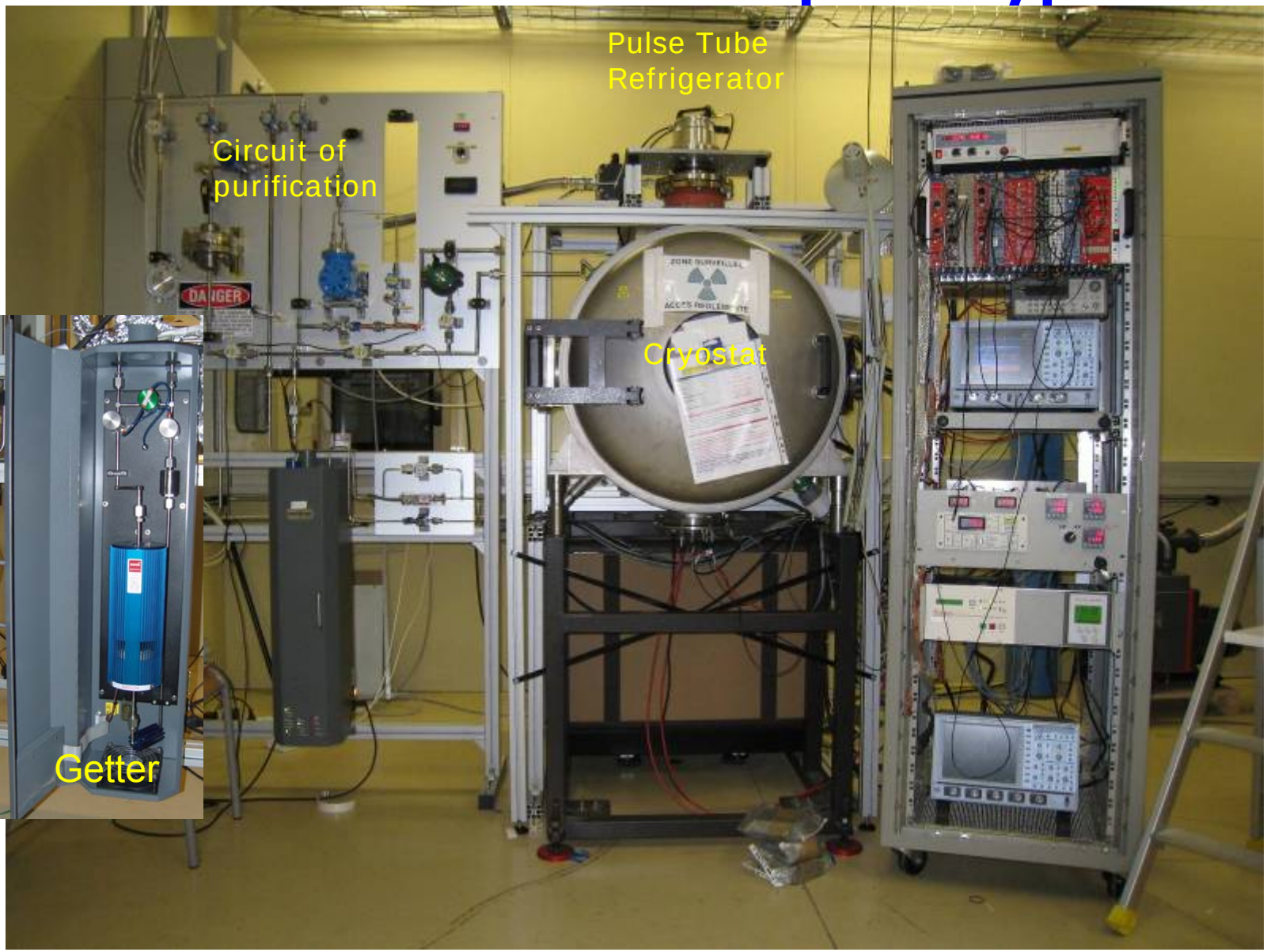

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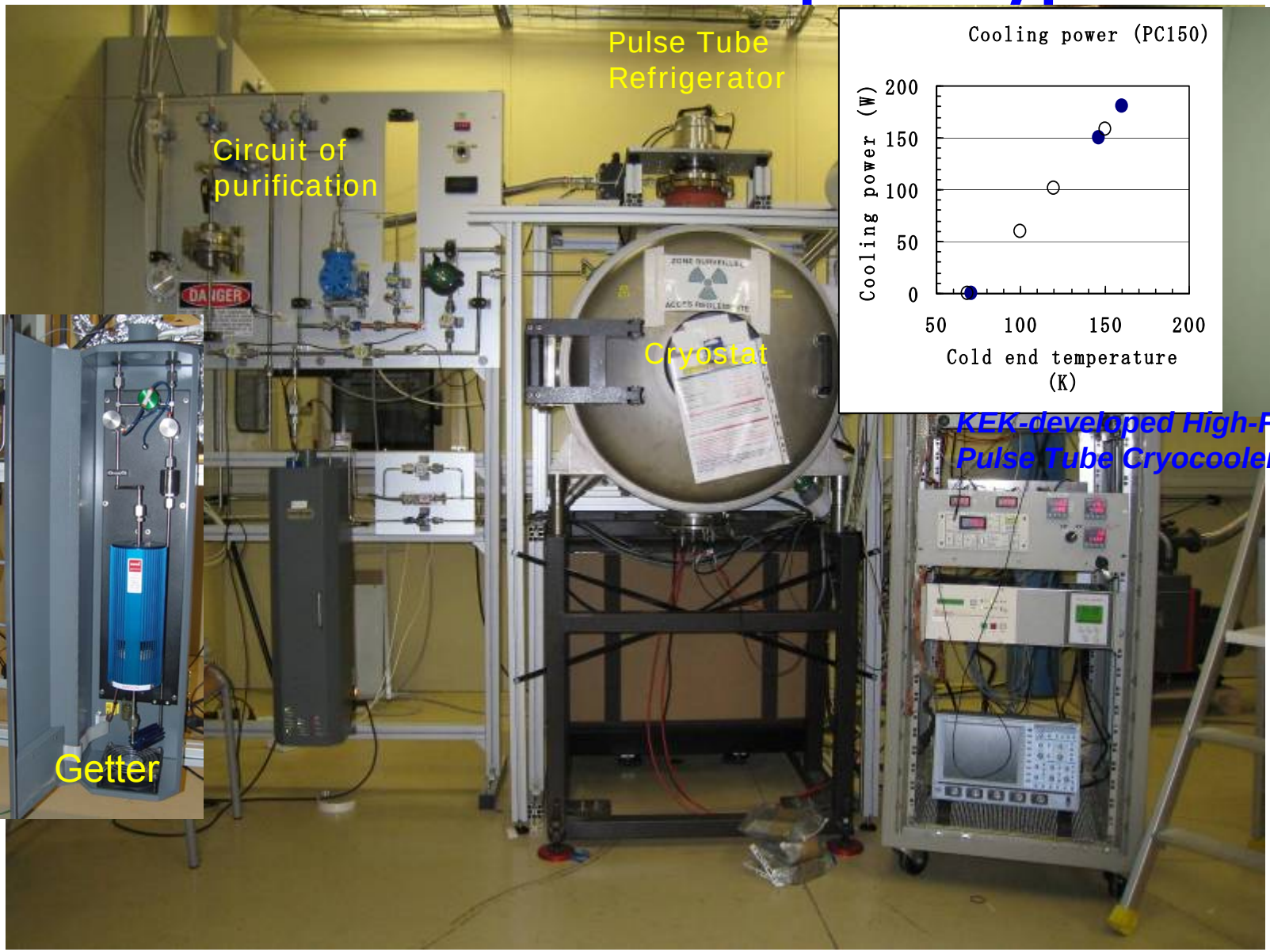
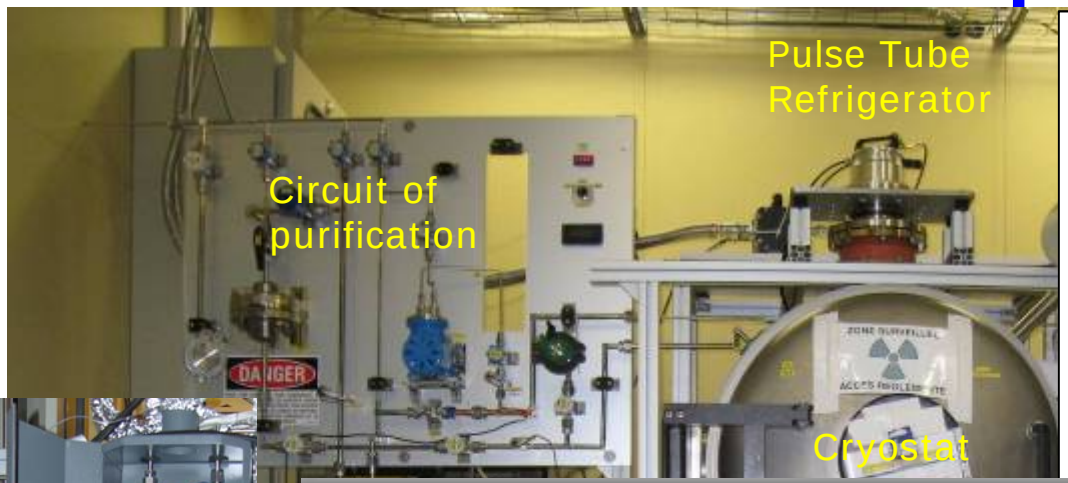
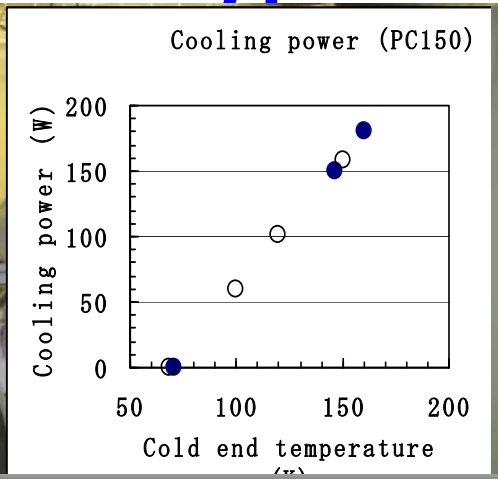
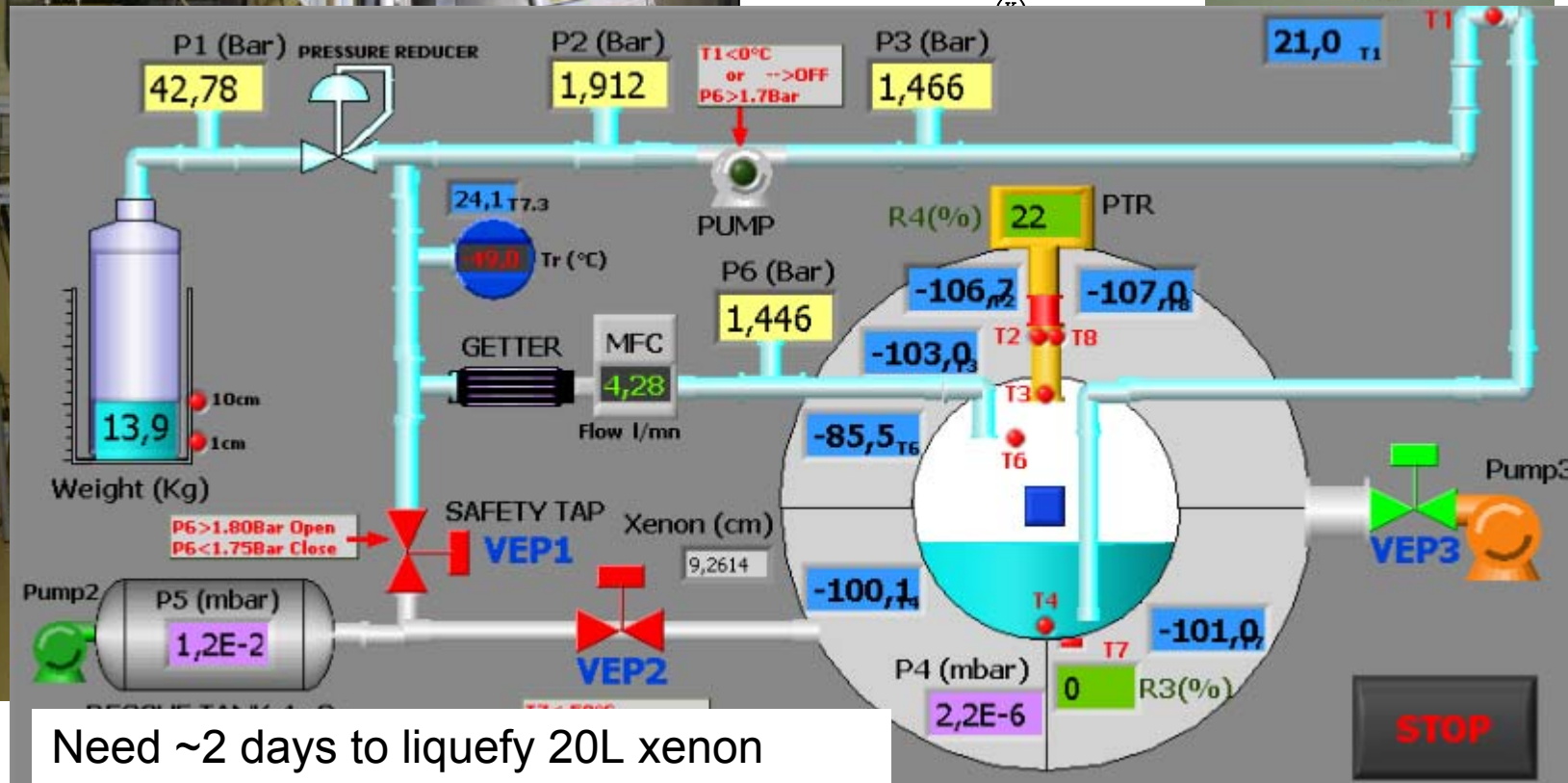


KEK-developed High-Power Pulse Tube Cryocooler

XEMIS1 1st prototype

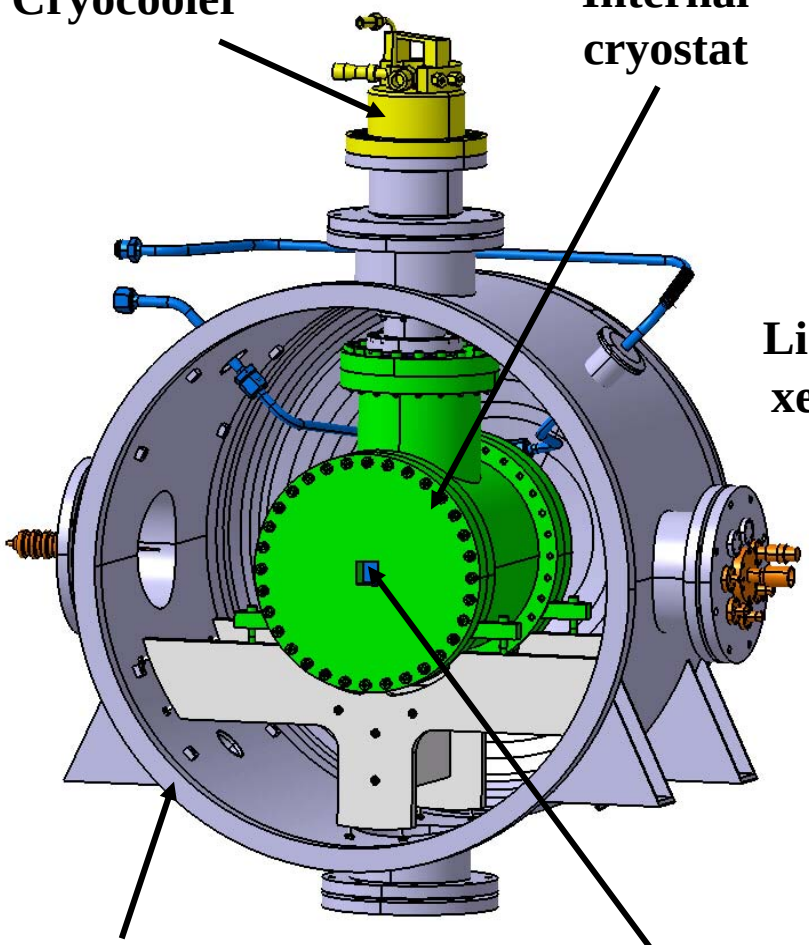


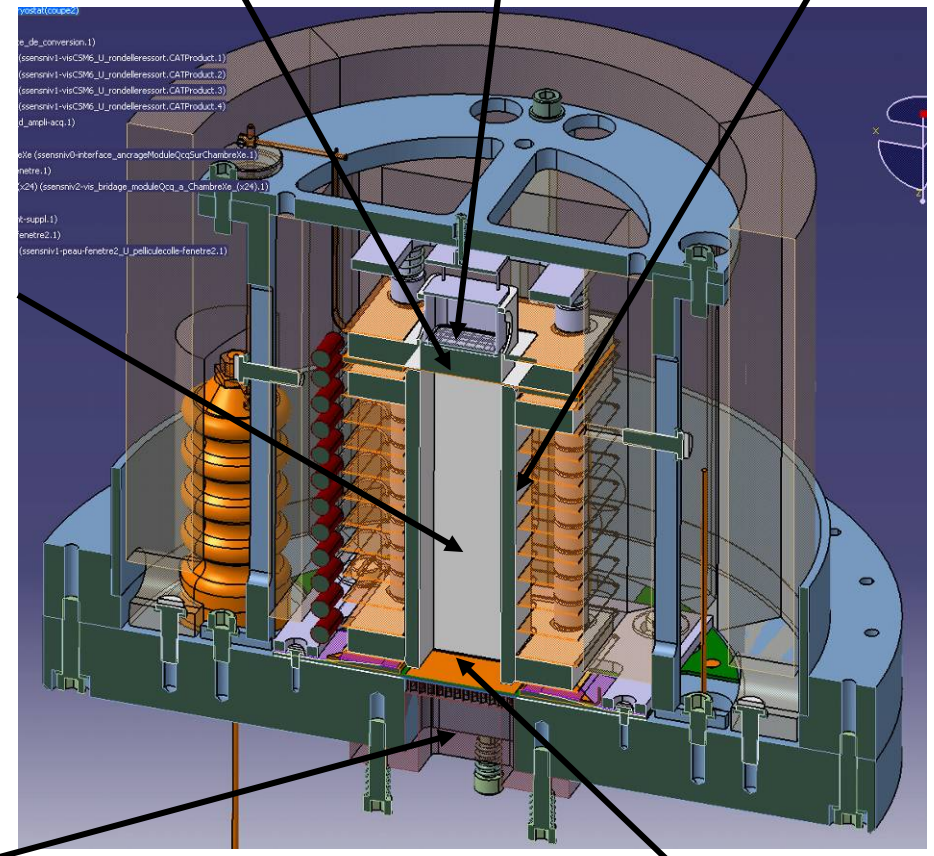




Need ~2 days to liquefy 20L xenon

XEMIS1 1st prototype





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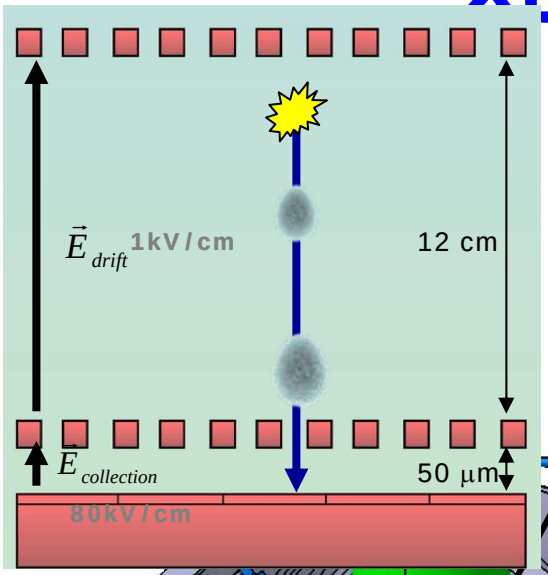
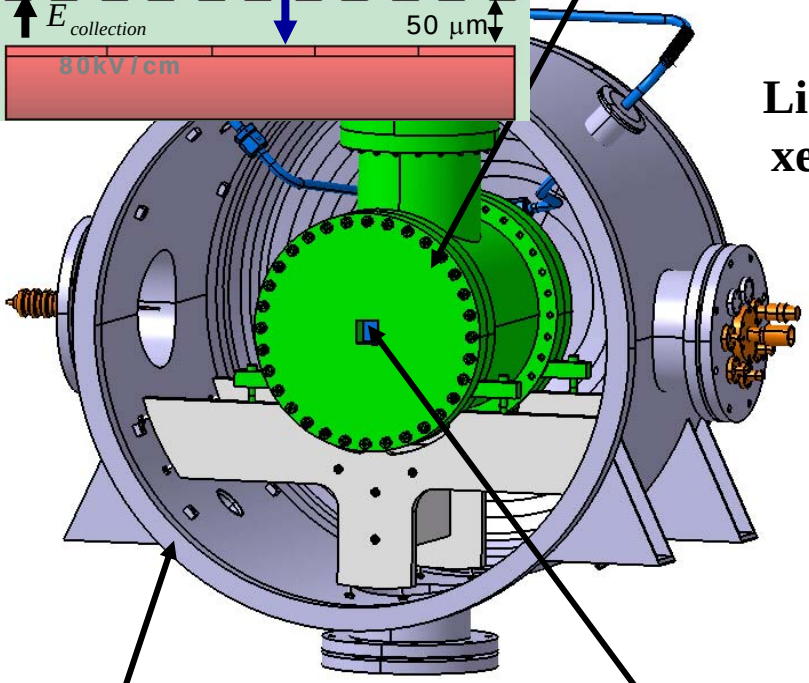




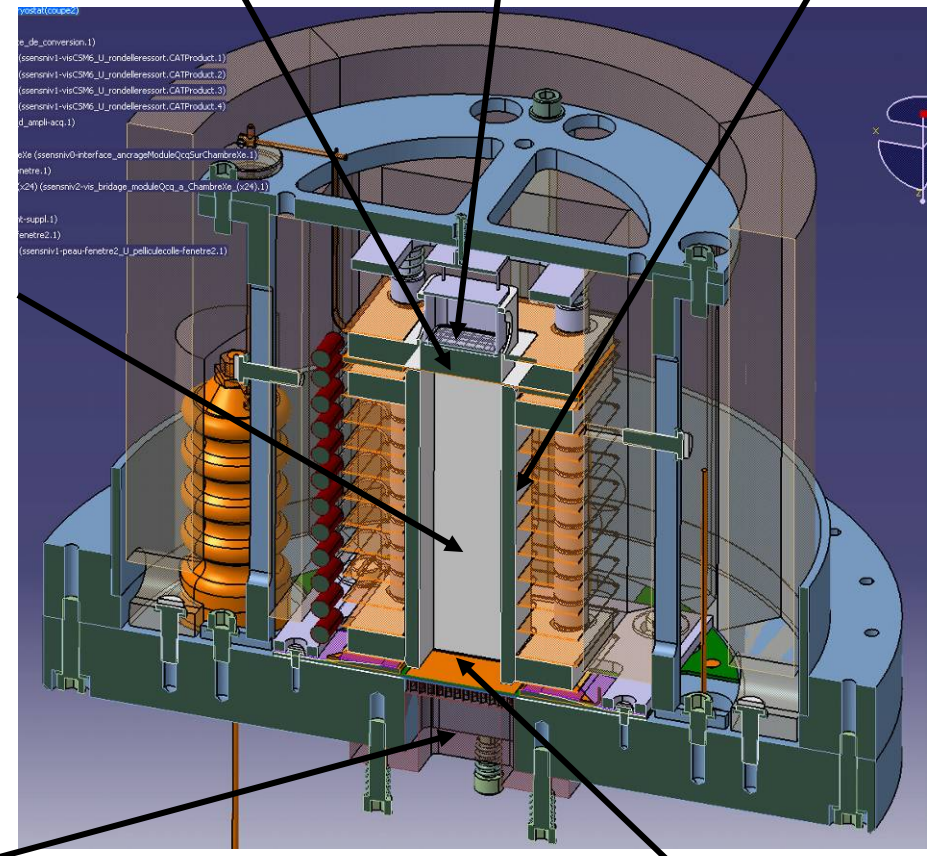
Internal cryostat

Cathode

PMT

Teflon

Liquid xenon

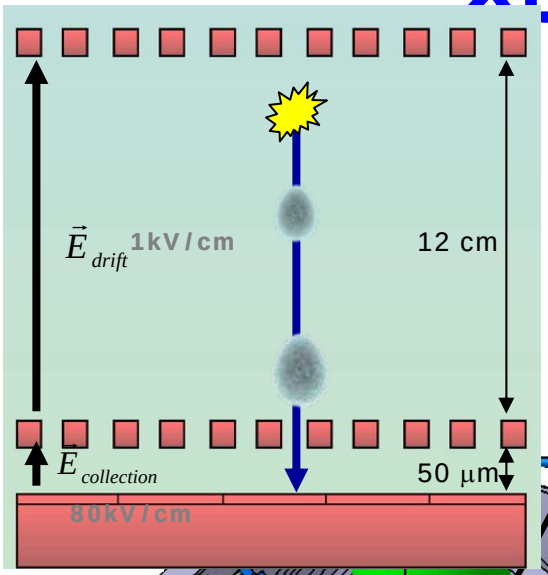


External cryostat

Entrance window

Micromeshes and Anode

XEMIS1 1st prototype



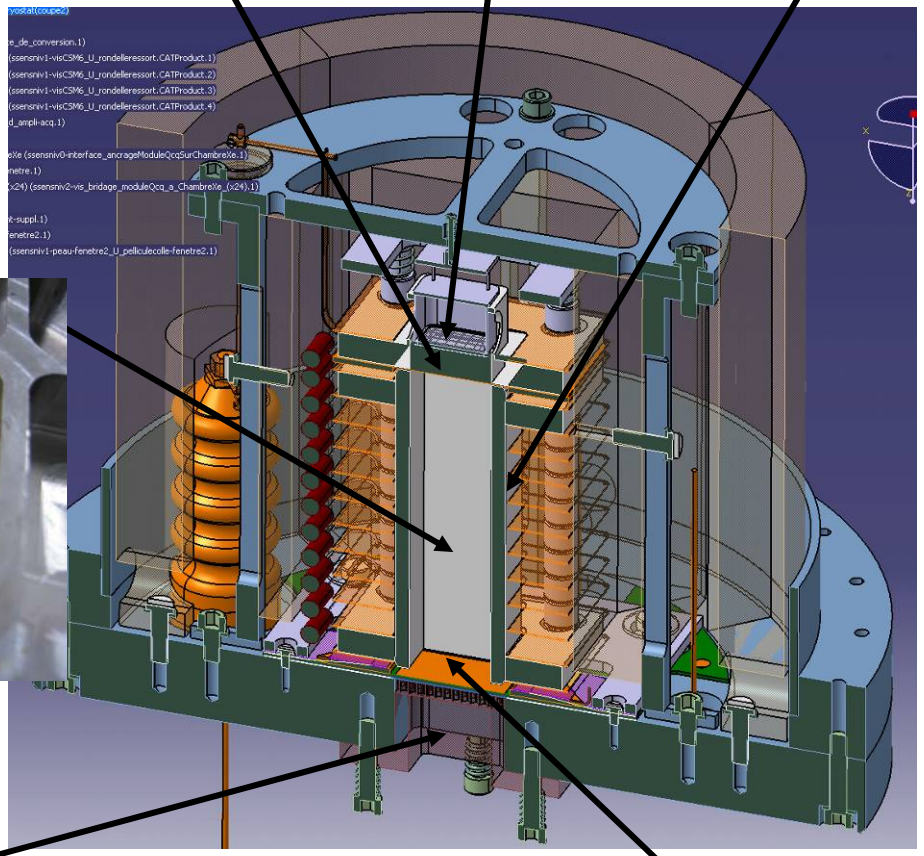
Internal cryostat

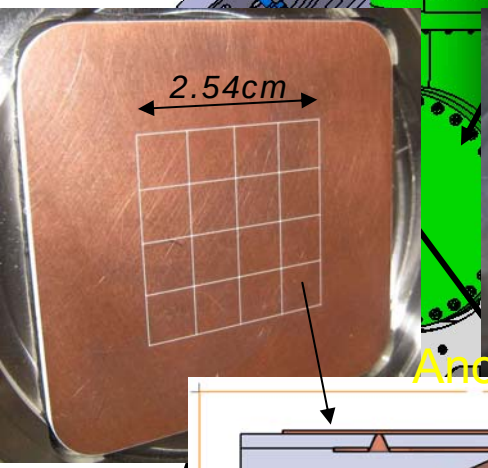
Cathode

PMT

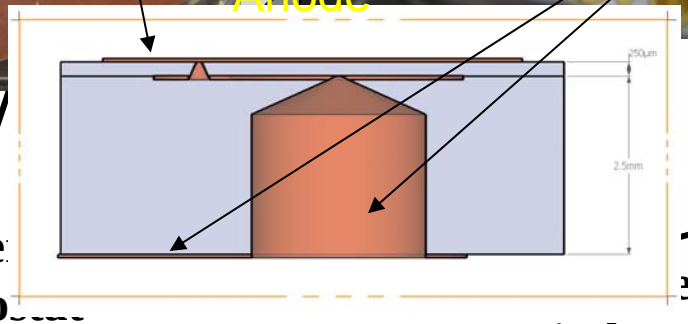
Teflon

Liquid





Anode

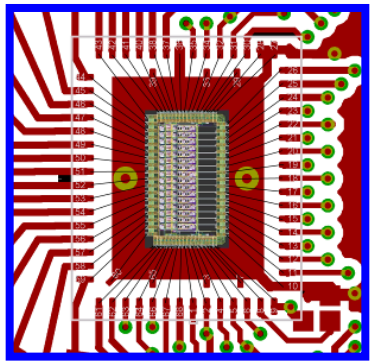


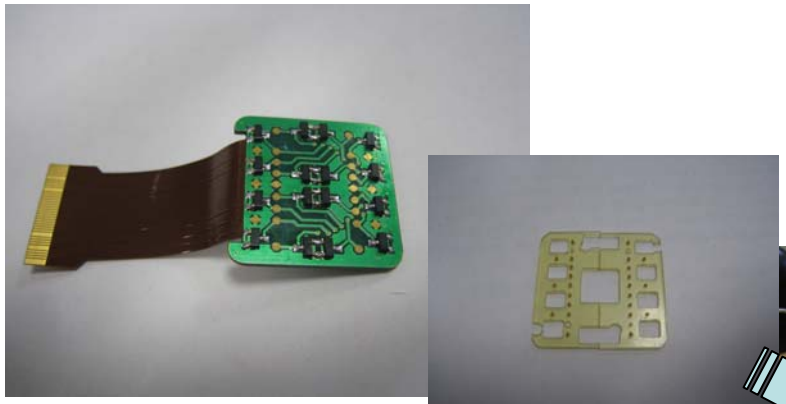
Micromeshes and Anode

window

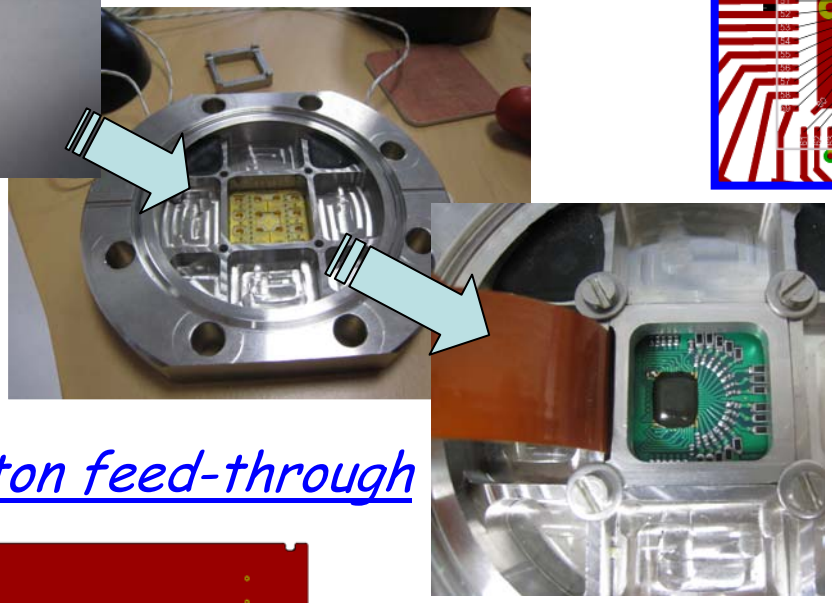
FE Electronics R&D for pixels read-out

IDEF-X 16 channelsAsics

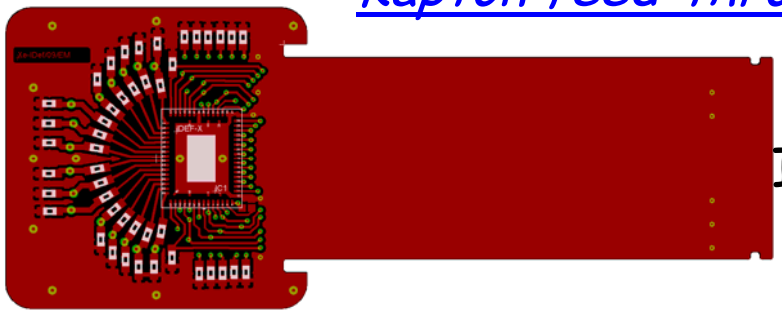




Flat - connectors



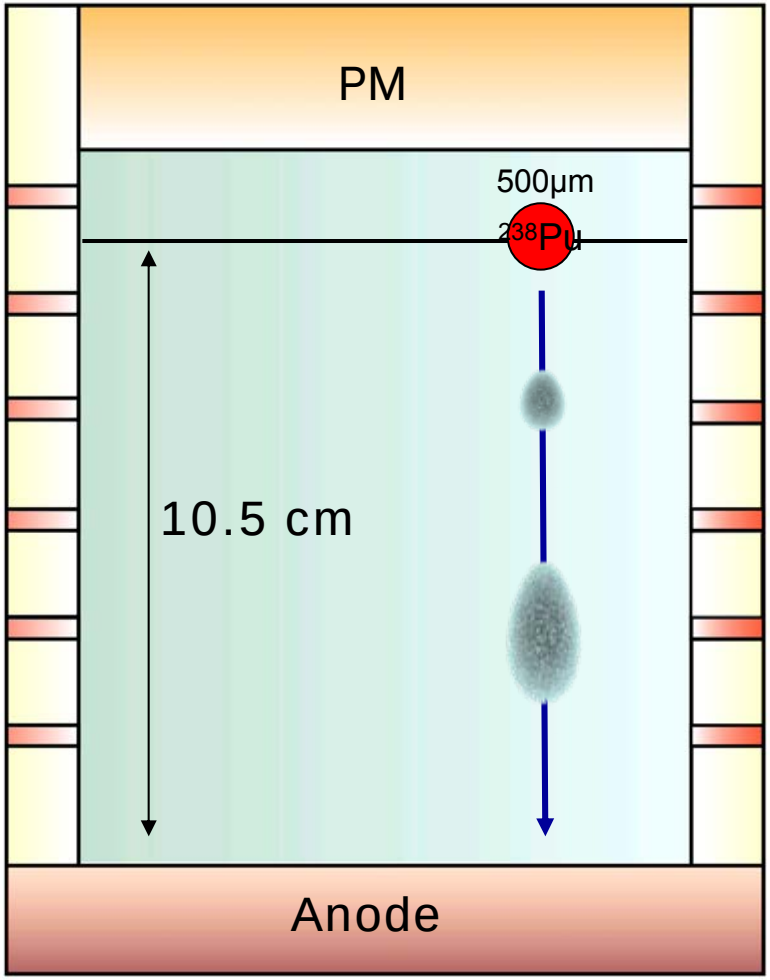
Kapton feed-through

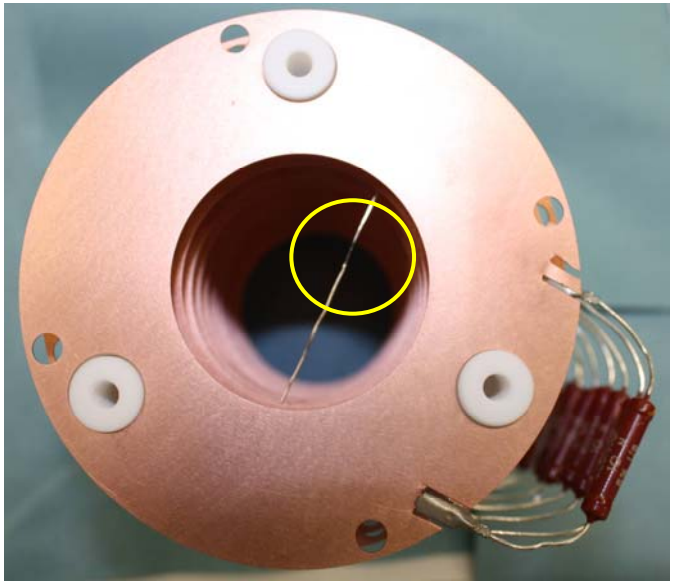


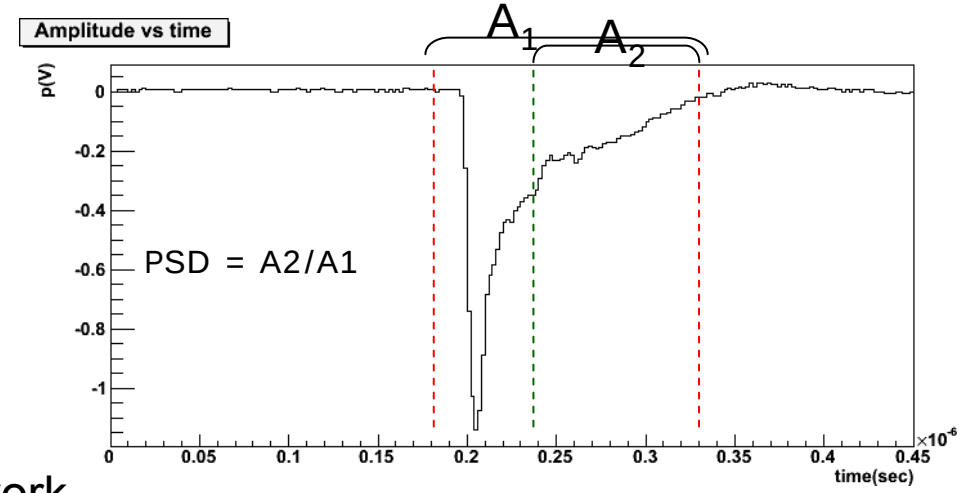
IDEF-X : ASIC developed for CdTe
@ CEA/IRFU

Noise ~ 200 e- at LXe temperature (165K)
(0.9% of e^--ion pairs created by 511keV gamma @ E_{drift}=1kV/cm)

Measurement of Z resolution

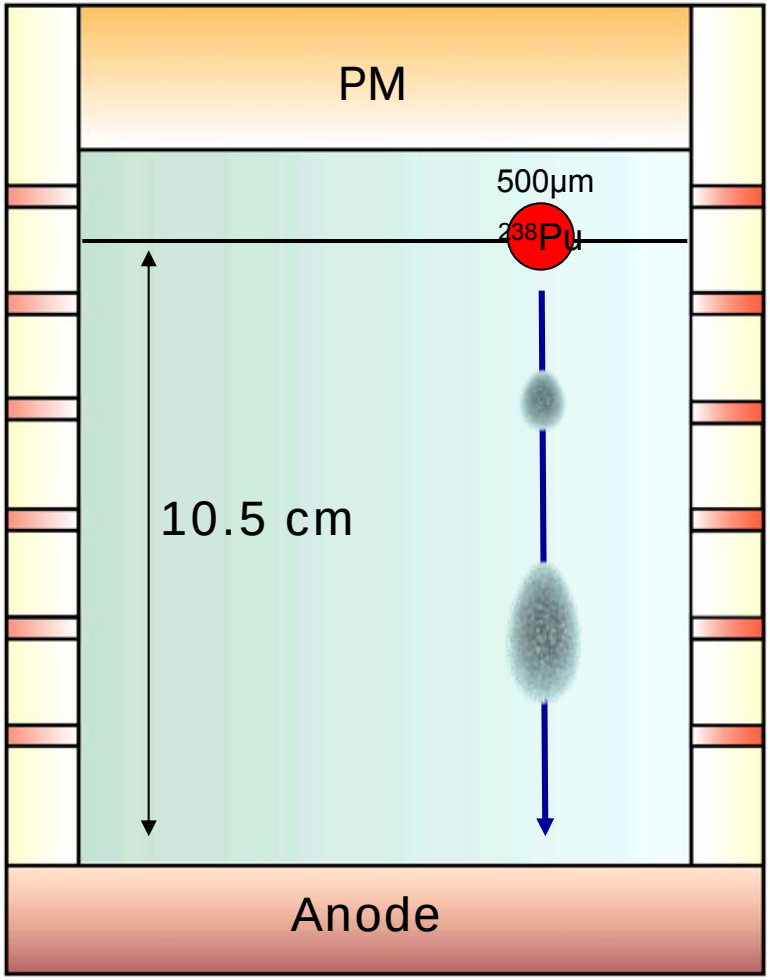


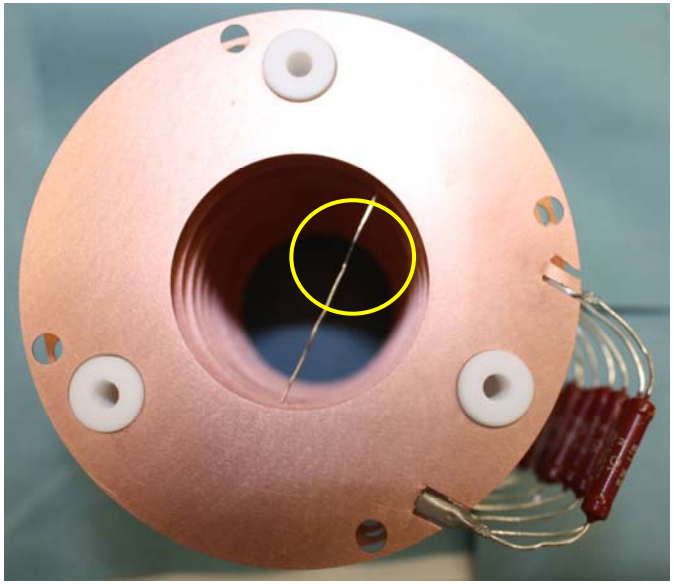


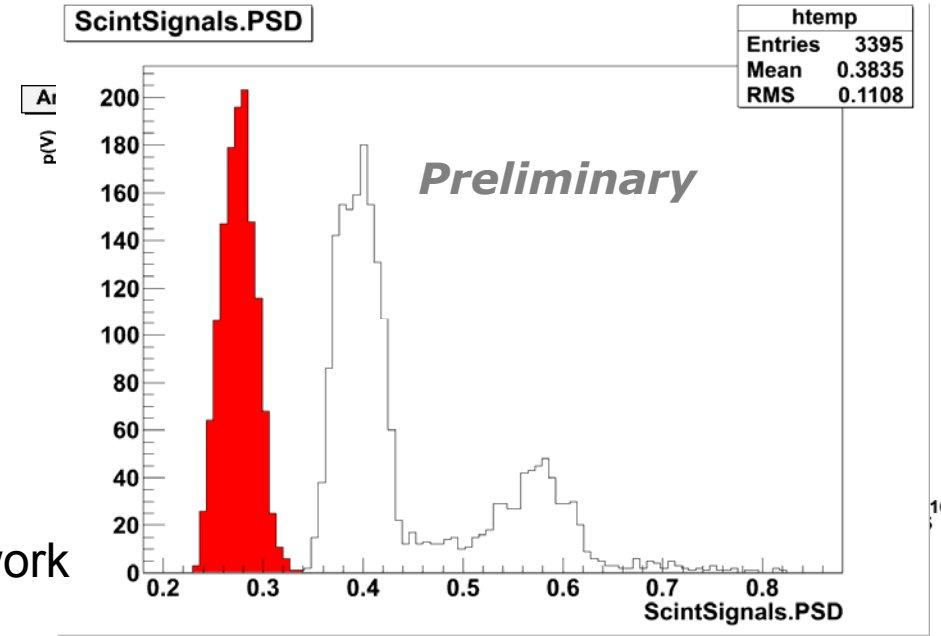


Fujii Yuki (KEK) also participated in this work

Measurement of Z resolution







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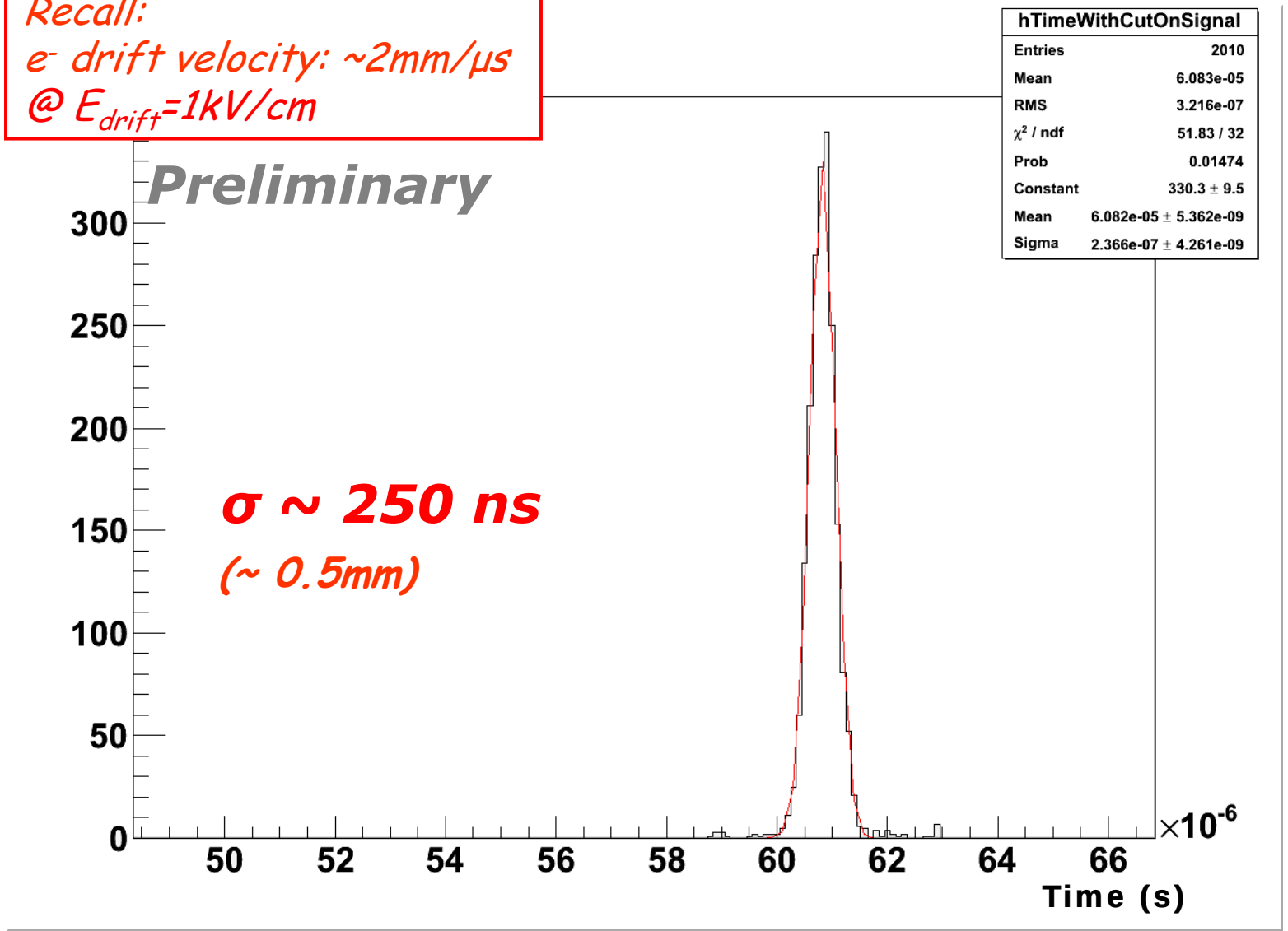
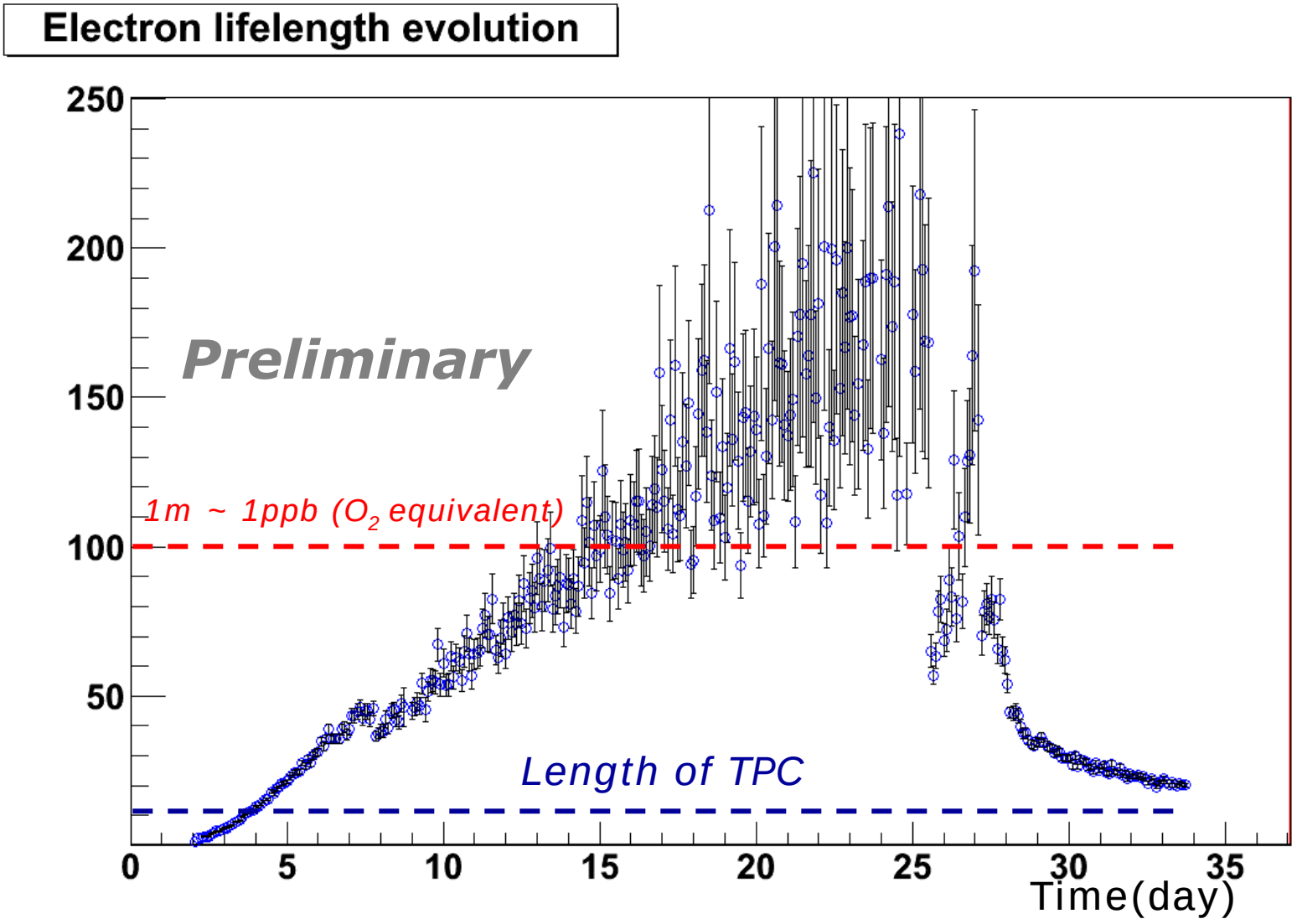
Z resolution

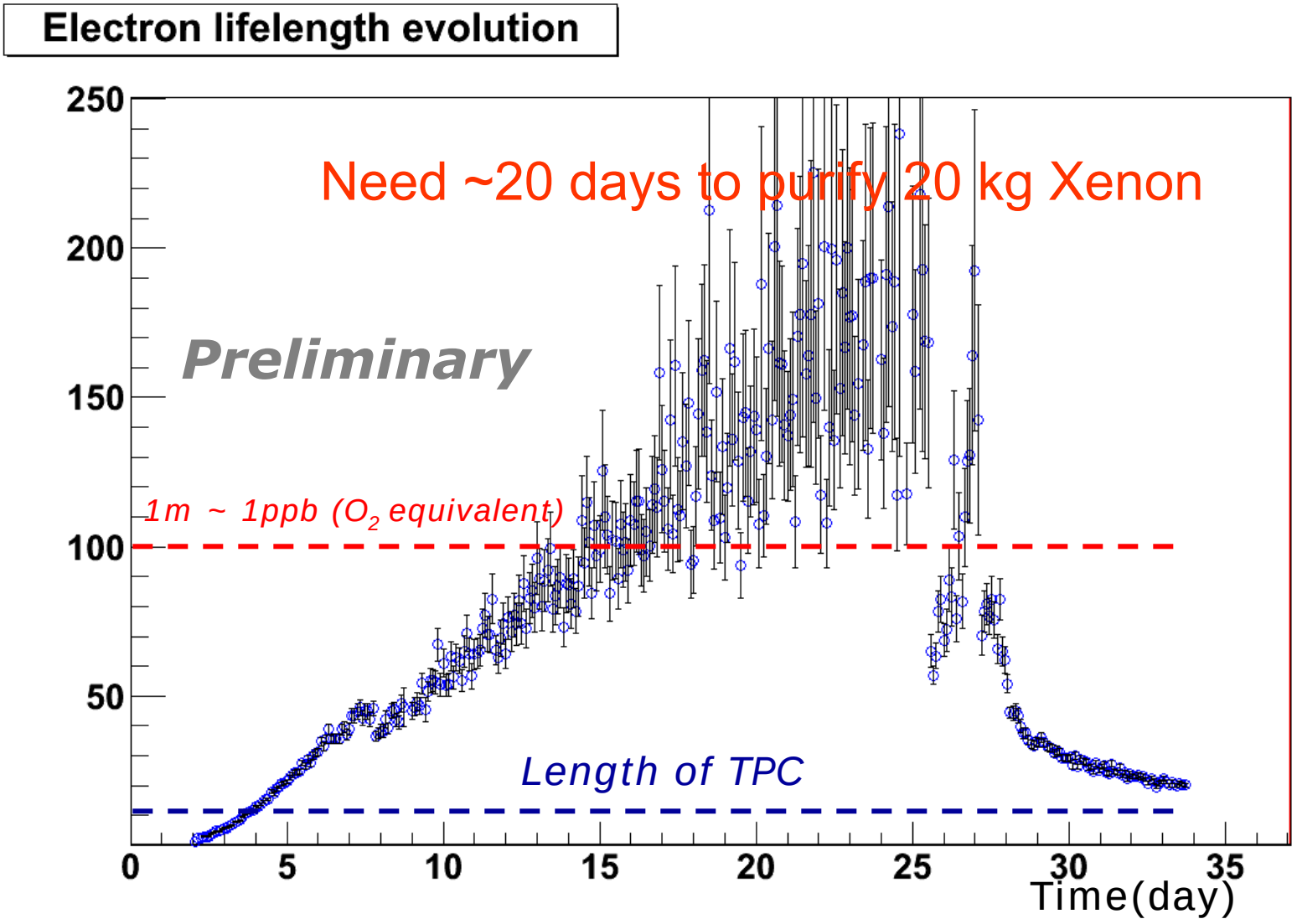
Recall:
e^- drift velocity: ~2mm/μs
@ E_{drift}=1kV/cm



Evolution of impurity



Evolution of impurity



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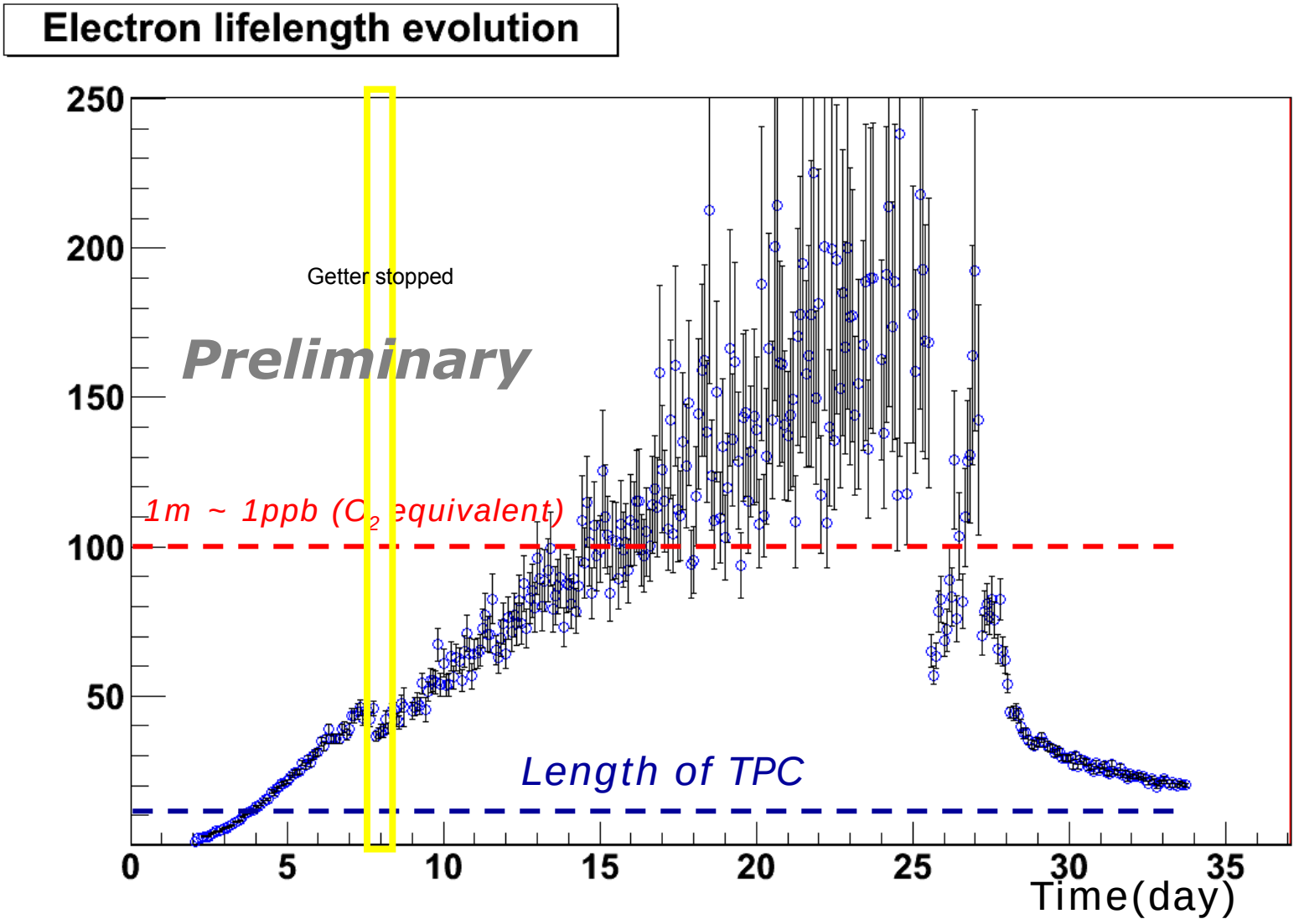

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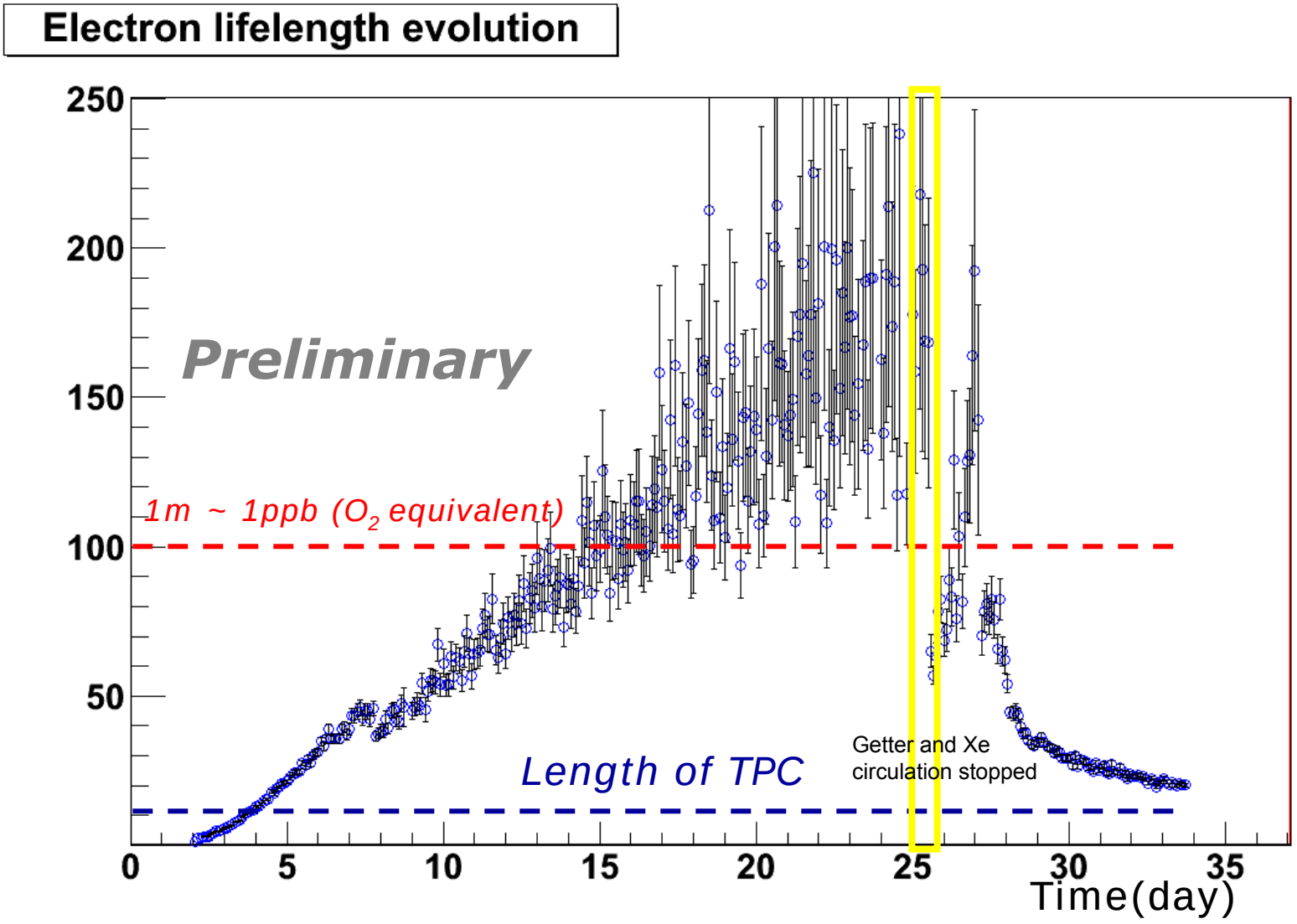
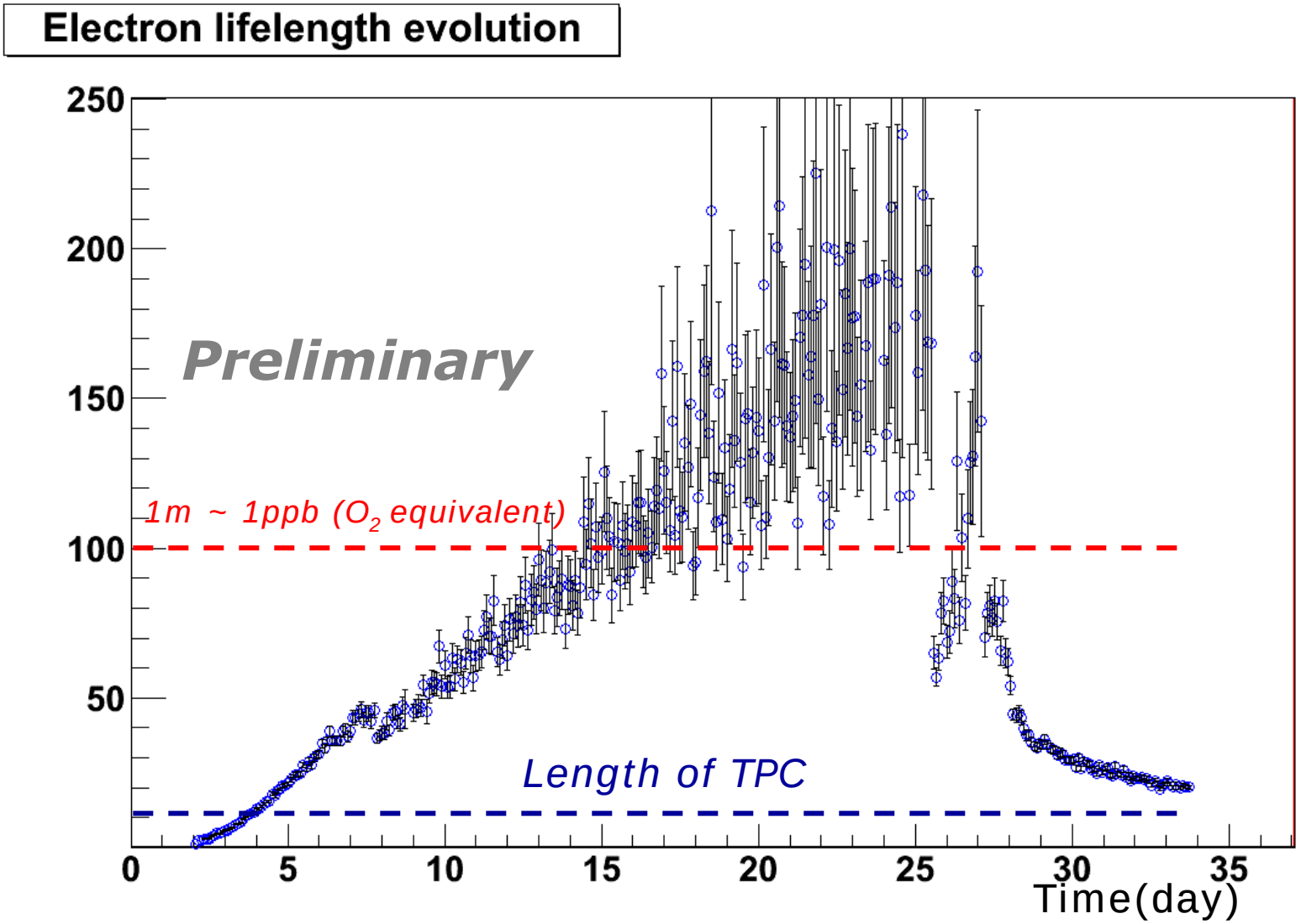


Evolution of impurity

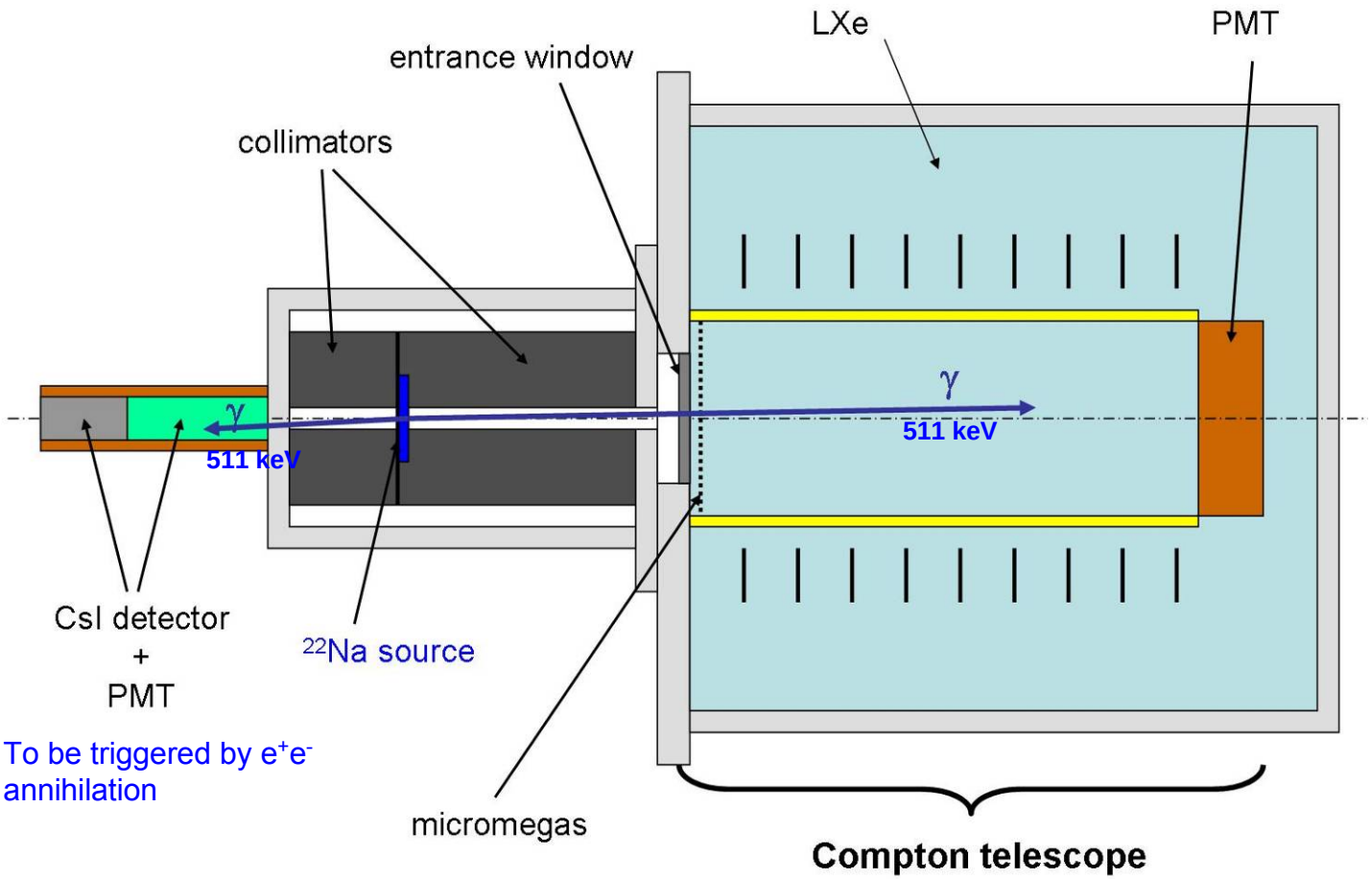


Stable purification and circulation is important to keep the purity of Xenon.

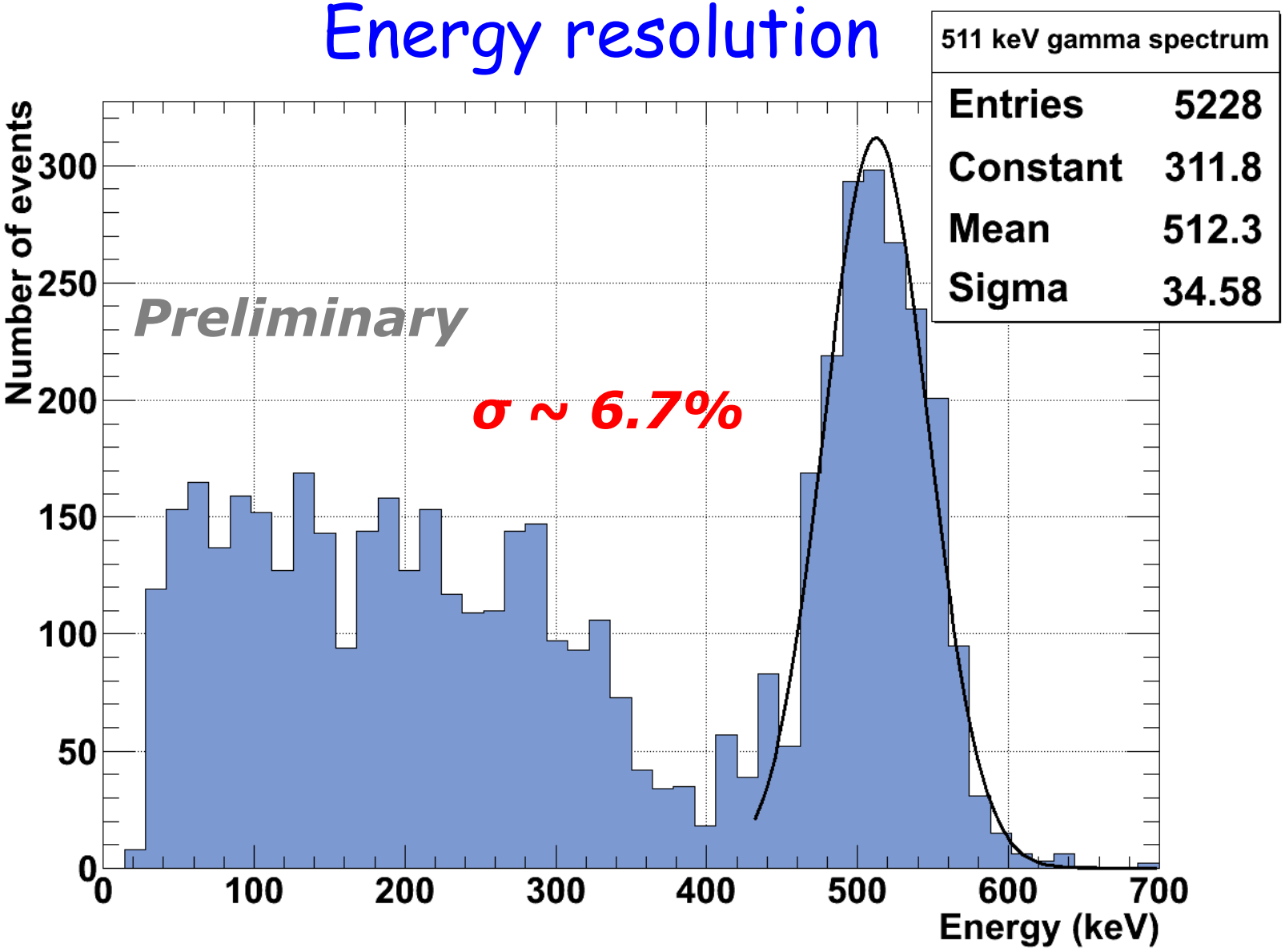
Measurement of energy resolution

Using ^{22}Na (emits β^+ and γ (1.257 MeV))

To measure the drift time and PSD

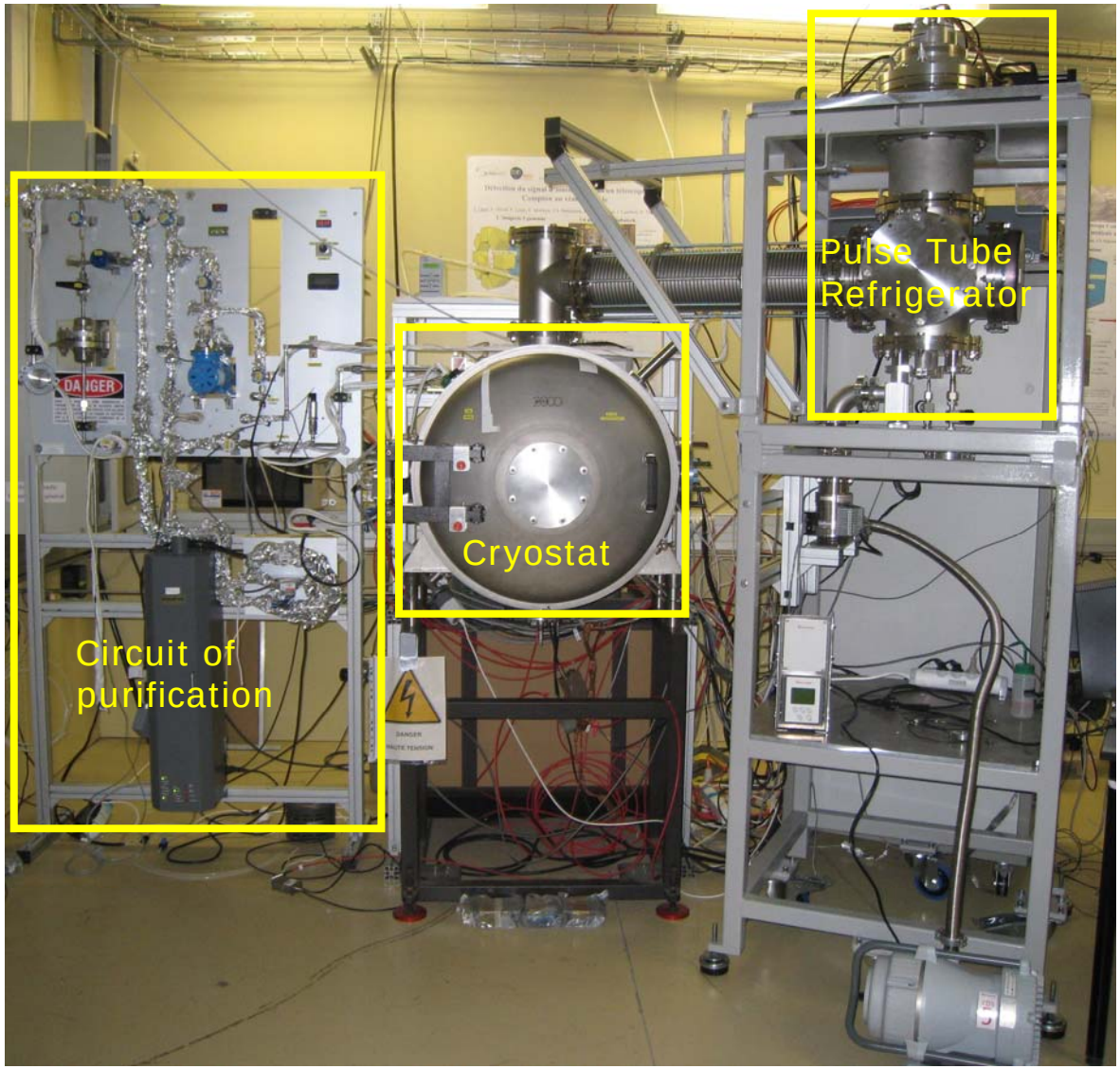


Energy resolution



Remind: ~6.5 % is dominated by liquid xenon

Modification of cryogenics



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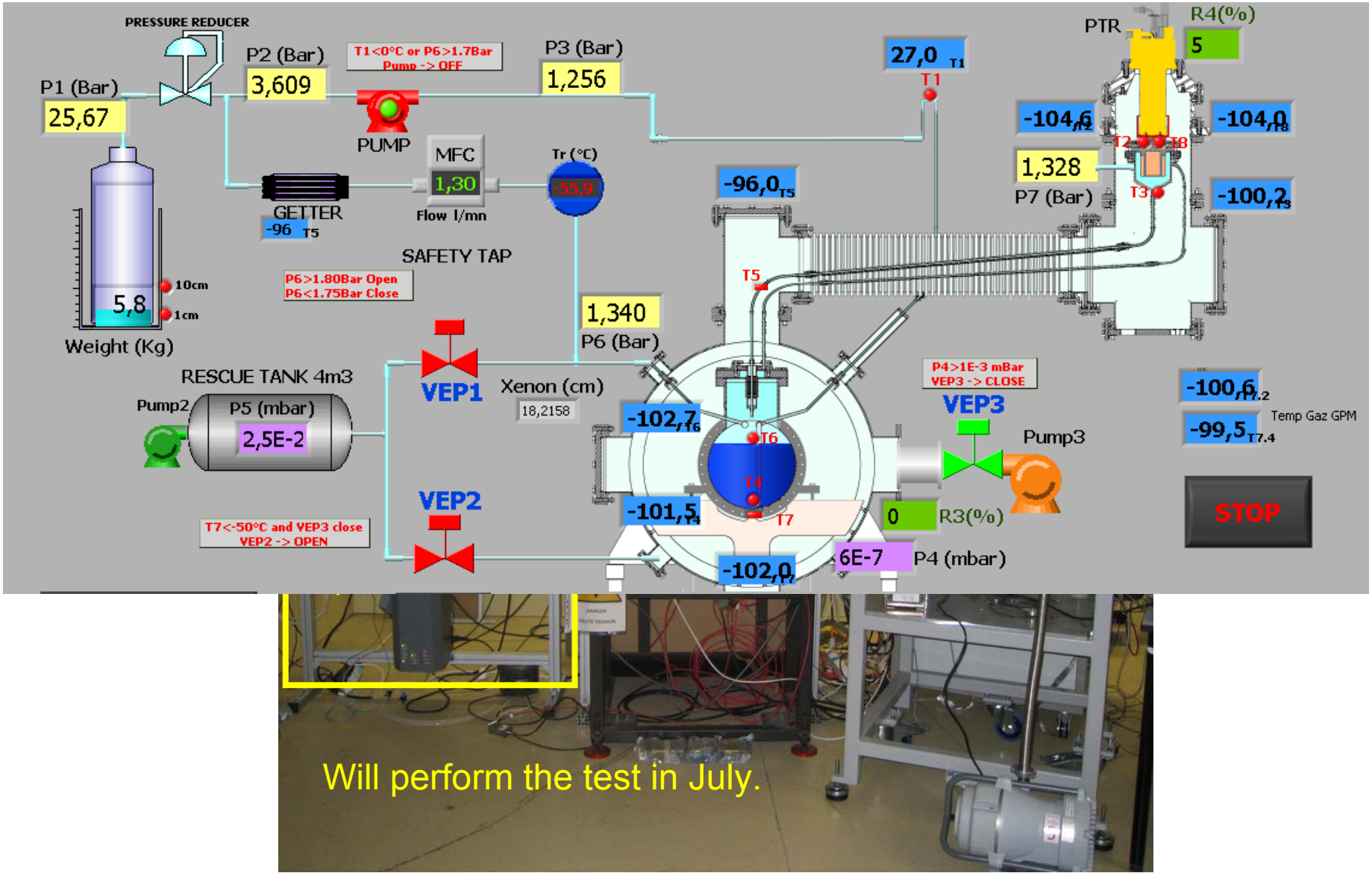

New xenon recovery system

- The LXe storage system
  - The idea is from MEG (done by Haruyama et al.)
  - Reduce the time to liquefy/purify the xenon
- Use heat exchanger
  - Save the heat loss
- Will make a prototype before the end of 2010
- Will be used in XENON-1T (dark matter experiment)

Plan for 3 years

	SUBATECH	KEK
First year 2010~2011	TPC R&D	R&D for basic property of TPC
Second year 2011~2012	Electronics R&D	R&D for advanced endcap
Third year 2012~2013	Pre-industrial prototype	TPC with ASIC FE chips at the endcap

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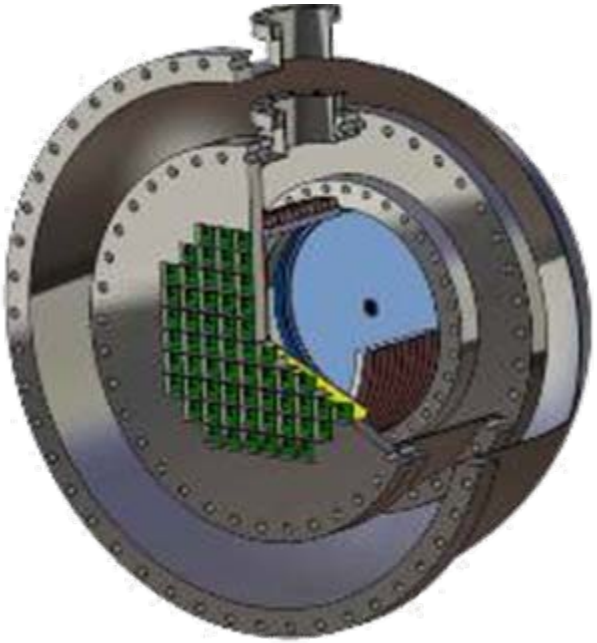

Xenon camera for small animal imaging

Cylindrical LXe TPC (Ø = 30 cm)

Plan for 3 years

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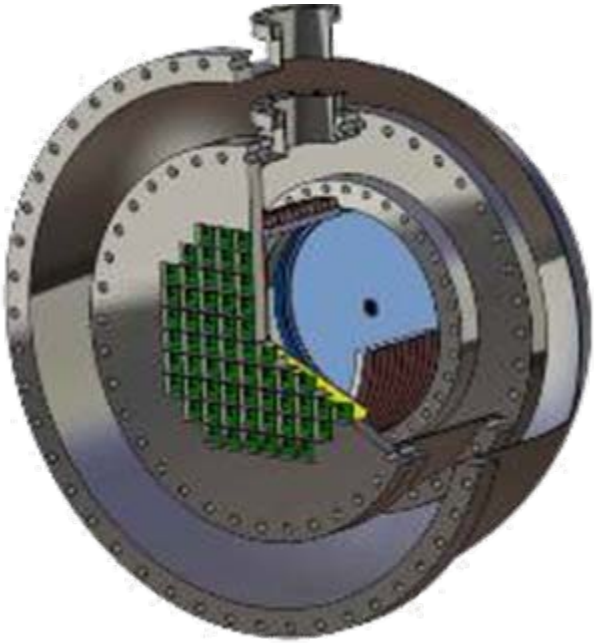


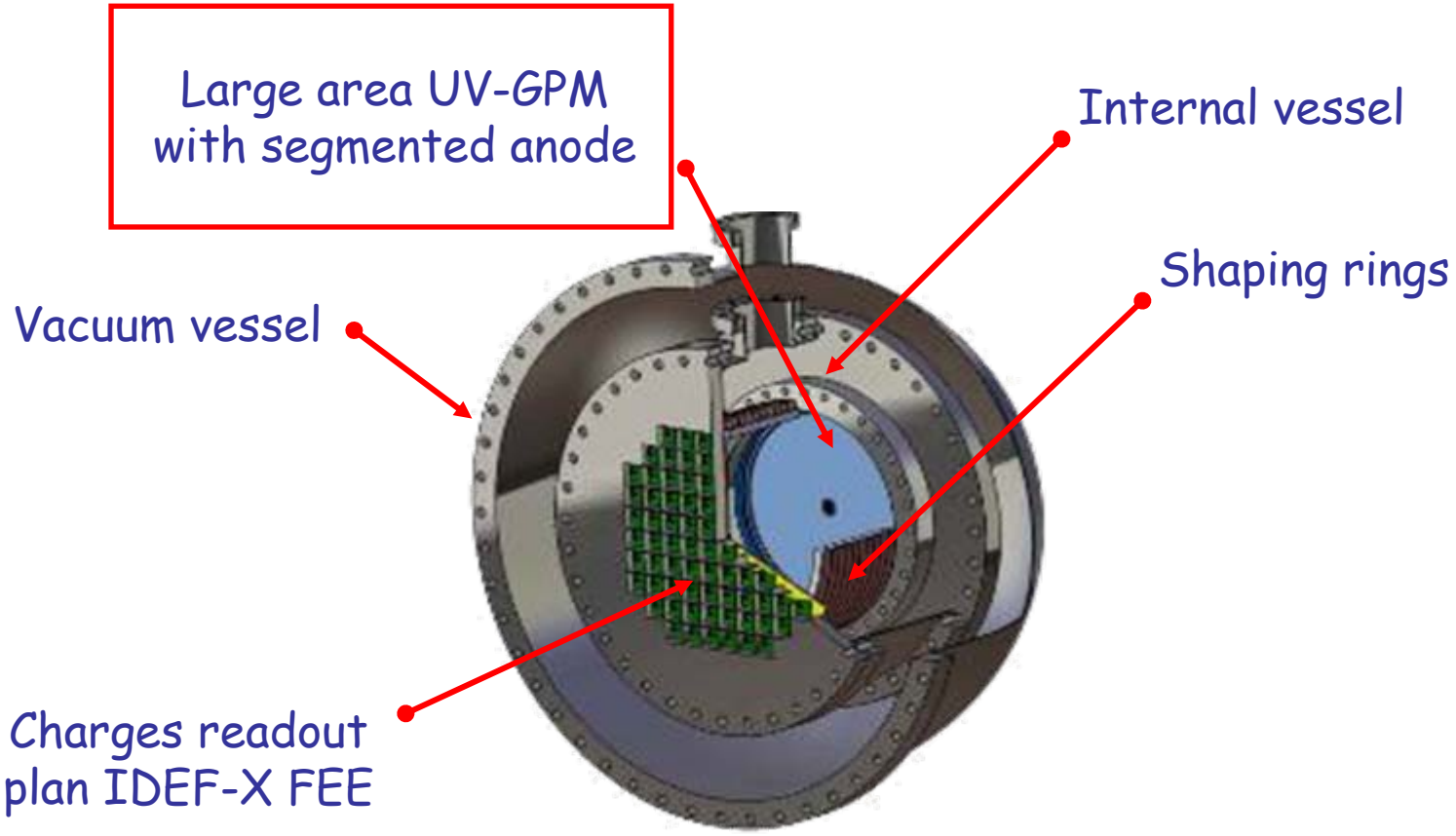
Xenon camera for small animal imaging
Cylindrical LXe TPC (Ø = 30 cm)

Thank you!

Backup pages

XEMIS2 2nd prototype

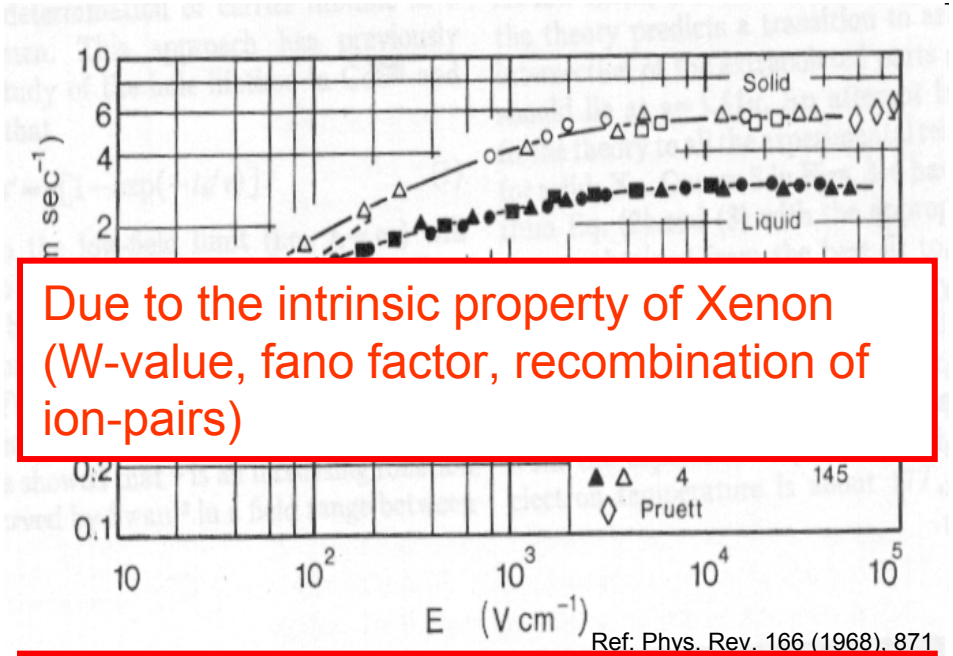
Xenon camera for small animal imaging



Cylindrical LXe TPC (Ø = 30 cm)

Introduction of liquid Xenon detector

- When the gamma / particle enter the liquid rare gas:
- Electron drift velocity (@E=1 kV/cm): 2mm/μs
- Ideal energy resolution (of 511 keV γ-rays @E=1 kV/cm): ~6.5%
- To make a nearly-ideal xenon detector, we need
  - High purity of xenon
  - Low noise from electronics /readout
  - Xenon recovery system



Ref: Phys. Rev. 166 (1968), 871

Due to the intrinsic property of Xenon (W-value, fano factor, recombination of ion-pairs)

Impurity may

✓Decrease the electron concentration

→Decrease electron lifetime

✓Absorb VUV photons

To keep the stable circulation, purification, and temperature