



AND INSTRUMENTATION PHYSICS

May 22-26, 2017 BEIJING CHINA

TIPP'17

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| ihep.ac. | .cn, tipp2017@ihep.ac.cn |

AIR LIQUIDE

XEMIS: LIQUID XENON COMPTON CAMERA FOR 3y IMAGING

Yajing XING, IMT Atlantique 23 May 2017 @Beijing, China



Cancéropôle

MICRHAU

XEMIS: XEnon Medical Imaging System



Motivation: Personalized Medicine

↔ Concept: Low activity medical imaging

 \hookrightarrow Principles: 3γ imaging & Liquid xenon Compton camera



Outline



- 3γ imaging technique
- XEMIS1: R&D prototype ------
- XEMIS2: small animal imaging
- Summary





Principle of the 37 Compton Imaging



- Direct 3D location of the radioactive source
- Administered activity reduction &/or shorter scan times



□ Radioisotope (β^+ , γ) emitter in quasi-coincidence:

$$\hookrightarrow \ ^{44}Sc - \left[\begin{array}{c} \beta^{+} \left(E_{max} = 1.472 \ MeV \right) \\ \gamma \left(E_{0} = 1.157 \ MeV \right) \\ T_{1/2} = 4 \ h \end{array} \right]$$

- Position of the source:
 - \hookrightarrow Line of Response (LOR) & Compton Cone
- \Box γ direction reconstruction :
 - $\stackrel{\leftrightarrow}{\textrm{ kinematics }} \cos \theta = 1 \ + \ m_e c^2 \bigg(\frac{1}{E_{\gamma}} \ \ \frac{1}{E_1} \bigg)$
 - $\begin{array}{l} \hookrightarrow \\ \text{Spatial Resolution} \\ & \hookrightarrow \\ \text{Energy Resolution} \\ & \hookrightarrow \\ \text{Opening angle } \theta \end{array}$

XEMiS1: R&D prototype



LXe Time Projection Chamber (TPC)



XEMIS1: Ionization Signal Readout

v



IDeF-X Asics

Developed for CdTe @ IrFU (Gevin et al. 2006) Adapted by Subatech for LXe



Ultra-low noise front-end electronics

Noise < 100 e⁻ (at LXe Temp)

511 keV (@1 kV/cm) ⇒ 27200 e-

Ionization signals of 64 pixels



XEMIS1: Ionization results@511 keV (1 kV/cm)



Drift time resolution: ~ 50 ns DOI resolution: ~ 100 μm



MC simulation of primary electron trajectory



XEMIS1: Ionization results @511 keV





Resolution along the LOR



- Angular resolution limited by active area of XEMIS1
- XEMIS₂ is the key

Motivation!



XEMIS2: Complete simulation with Geant4

0.25

0.2

0.1

Efficiency





Detectable Event Fraction



XEMIS2 expected image 20 kBq, 20 mns



Reconstructed image



Quite uniform response of the detector!

XEMIS2: cryogenic commissioning

ReStoX : **Re**covery and **Sto**rage system of **X**enon

Xenon cryogenics of XEMIS₂ :

- ✓ compact (210 kg capacity)
- ✓ safe (from RT to -110°C)

✓ powerfull (up to 10 kW) ✓ ultra clean (ppb impurities lvl)

Installation in HOSPITAL

ubatech

Expectation, observation and prediction for ReStoX warm-up test











XEMIS2: cryogenic commissioning



Assisted Gravity Recovering









XEMIS2: DAQ for Ionization



20480 pix

Challenge: continuous read-out with negligible dead-time **Goal :** record on disc 10⁴ charge and time signals/pixel/s



IDeF-X HD LXe Imaging Detector Front-end IRFU - SUBATECH



XTRACT Xemis TPC Readout for Acquisition of Charge and Time

13 May 22, 2017 Yajing XING - TIPP2017@Beijing



- \checkmark 3 γ imaging will be a new medical modality thanks to LXe
- ✓ It involves lots of technologies and innovations for the camera design
- ✓ XEMIS covers initial TRLs inside a scope compatible with Fundamental Research frame
- Expected image qualities are very promising:

- very low activity in the FOV

- good spatial resolution in all the FOV

- fast scan of all the FOV

★ XEMIS2: The first LXe camera will be installed in a hospital

★ LXe technology is scalable: design of large total-body camera could be investigated.



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ac.cn, tipp2017@ihep.ac.cn

Zhen An Lia (Cahri) (IHEZ China) (An USTC, Chan Nick Vas Balck, Malch Nethendra), Claristan Boltz, Charlan Werny Of Stockholm, Sweden | Margan Hamen, CLBM, Switzerfault | Tols, HHEZ China | Jacoban Jing, HHER China | Bay Larses, SLAC, USA | Tot Lia, Fernikah, USA Yimog Lia, Trajaka University, China | Parcik Le Du, IPM, France | Nilo Netfold, CEBN, Switzerland | Martin Purchka, BSL, USA | Tot Statistical Constraints HERZ China | Grag Woods, BNLT, USA | Data Organ; HERZ China | Grag Woods, BNLT, USA | Data Organ; HERZ China | Grag China | Jack Organ; HERZ China | Grag China | Jack Organ; LOCAL ORG ANIZING: COMMIT DEEL China | Fadin QJ, HHEZ China | Jack Organ; Jia (China Serrary, HHEZ China | Jack Organ; Jian (China Serrary), HHEZ China | Jack Organ; Jian (Leib Serrary), HHEZ China | Jack Orga

Thank you for your listening

Any questions?

