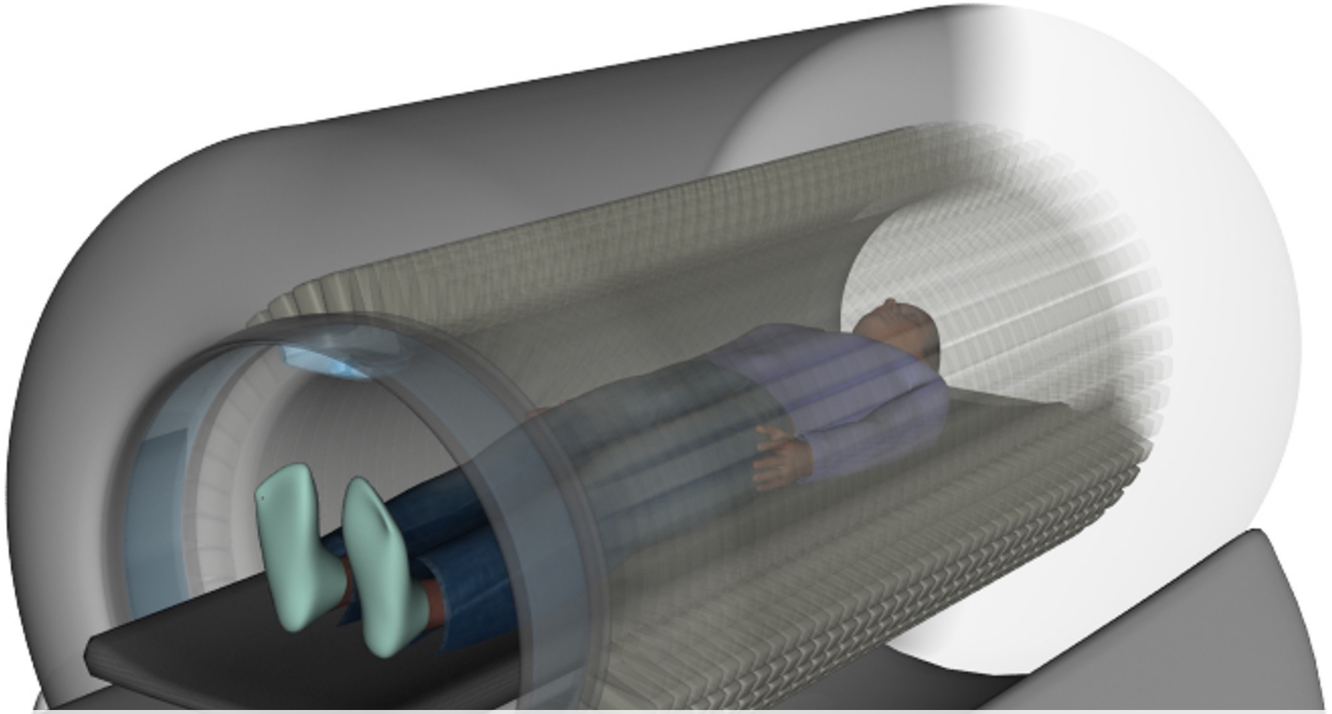
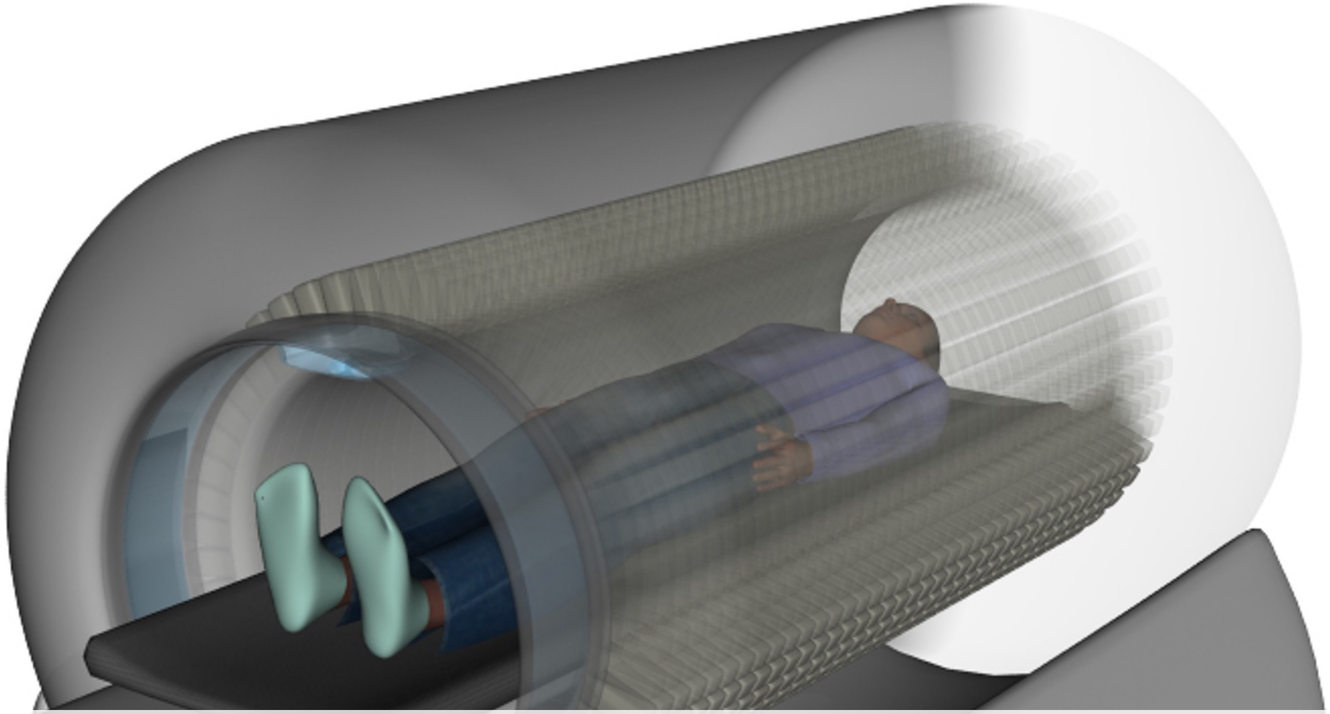


NOBLE LIQUID DETECTOR TECHNOLOGY

韩 柯 *HAN, Ke (SJTU)*



OTHER NL DETECTORS & APPLICATIONS

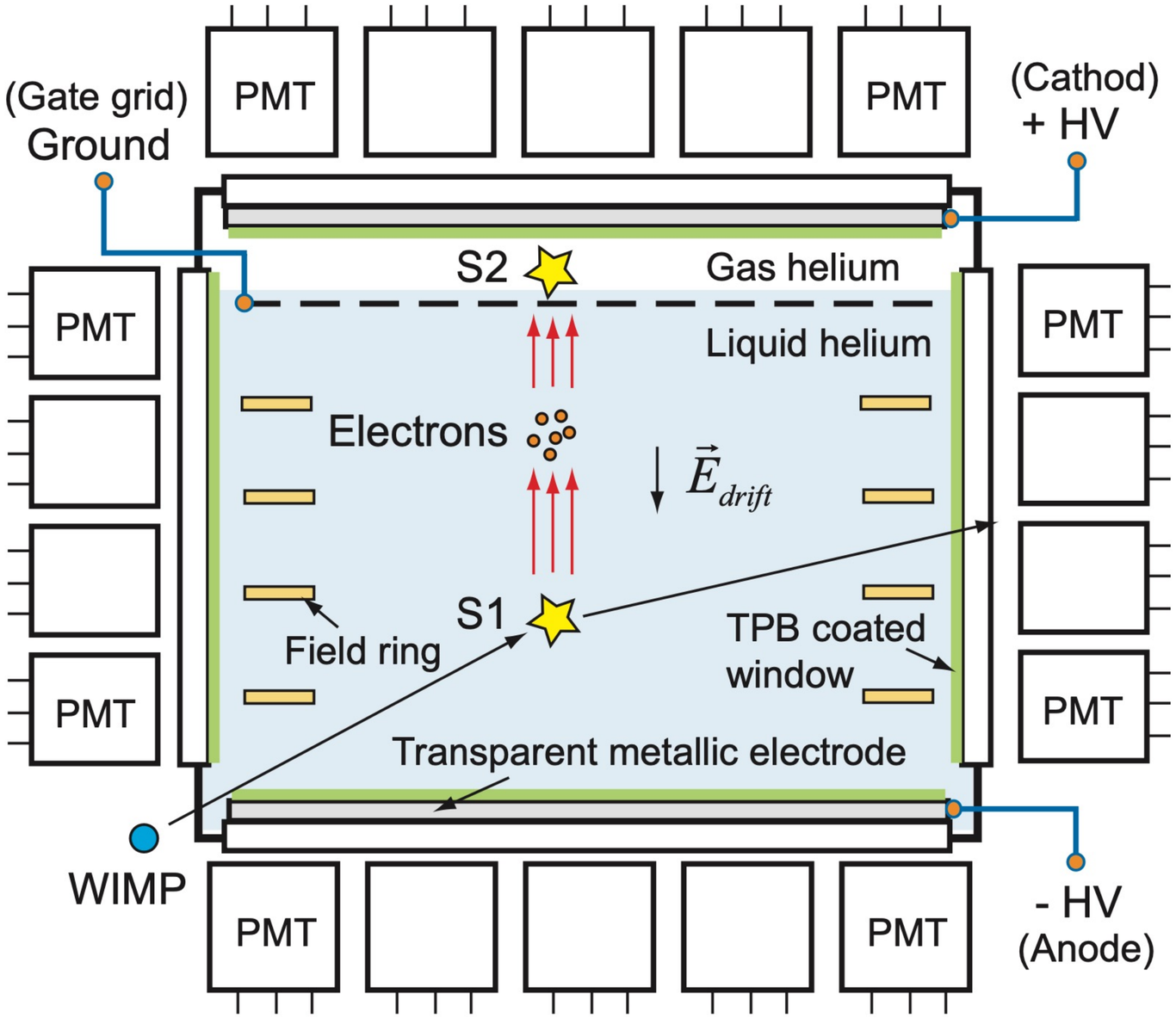
韩 柯 *HAN, Ke (SJTU)*

NOBLE LIQUIDS

	$_{2}$He	$_{10}$Ne	$_{18}$Ar	$_{36}$Kr	$_{54}$Xe
Isotopes	3, 4	20, 21, 22	36, 38, 40	78, 80, 82, 83, 84, 86	124, 126, 128, 129,130, 131, 132, 134, 136
Mol. Mass (g/mol)	4.0026	20.183	39.948	83.80	131.3
Abundance	✓✓	✓✓	✓✓✓	✓	✓
Boiling point @ 1ATM (K)	4.2 (^{4}He)	27.102	87.26	119.74	169
Liquid density (kg/m^3)	130 (4.2)	1204	1399	2413	3100
Gas density (kg/m^3)	0.1785	0.8881	1.7606	3.696	5.8971

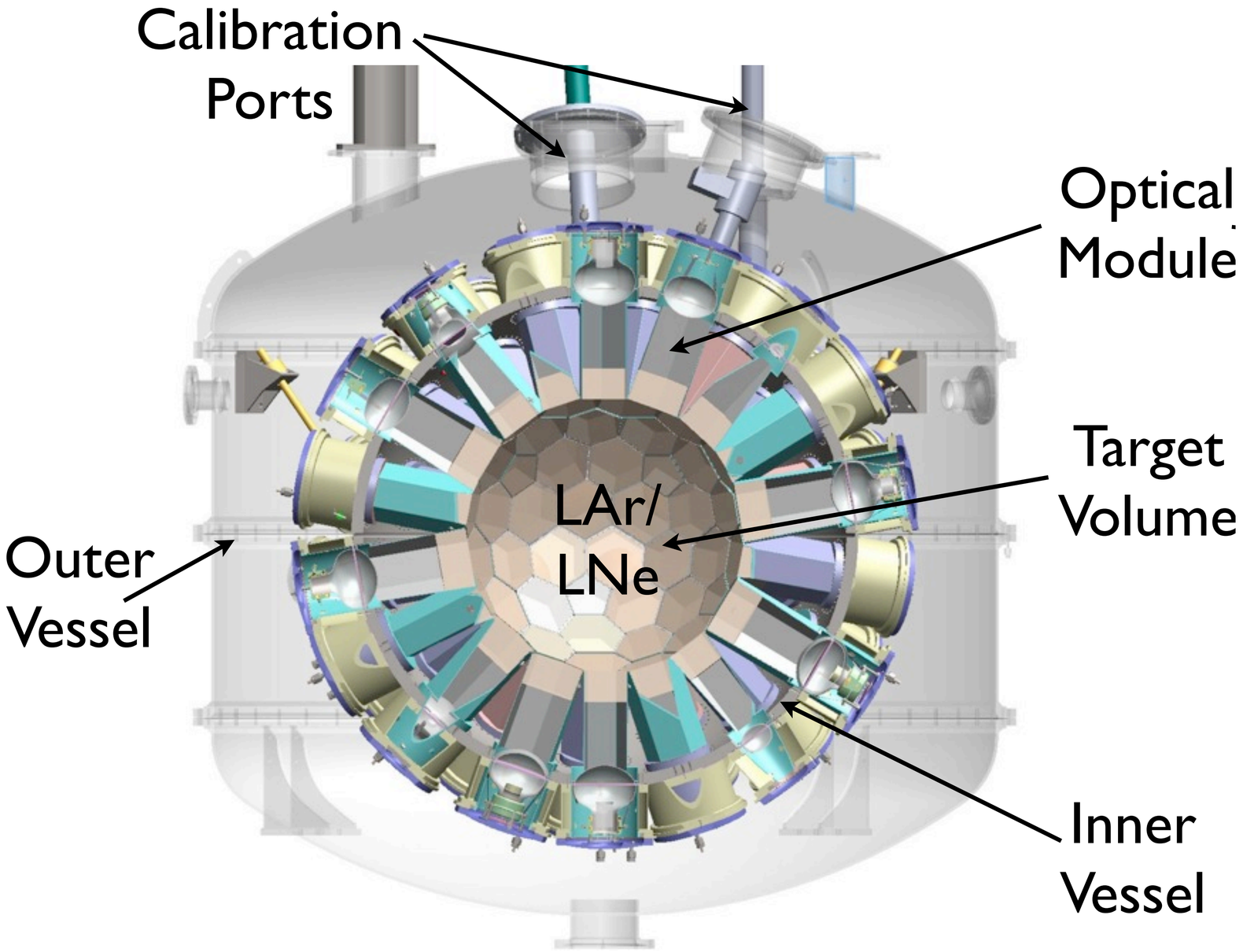
N_2 boiling point: 79K; NaI density 3890 kg/m^3

HELIUM TPC FOR DM DETECTION



- Favorable kinematic for light dark matter particle detection (Mass < 10 GeV)
- Cheaper than LXe
- S2 only with PSD proposal: ALETHEIA (CIAE, PKU)
- More proposals with superfluid Helium

arXiv:1302.0534

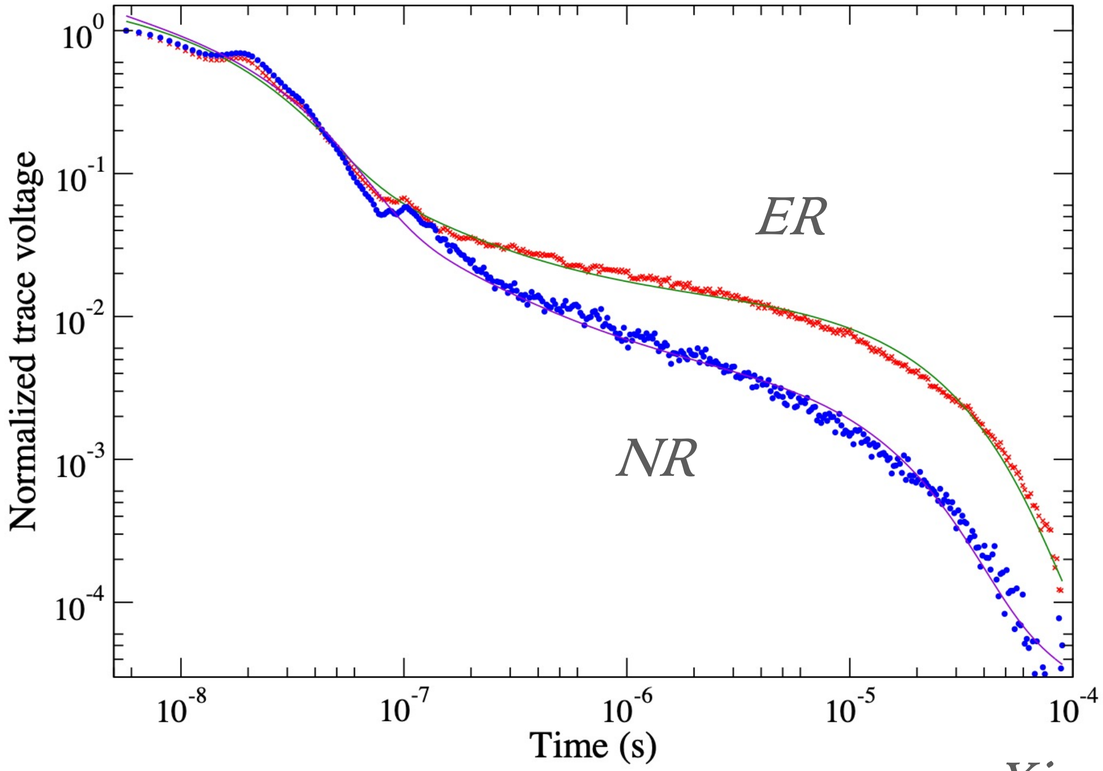


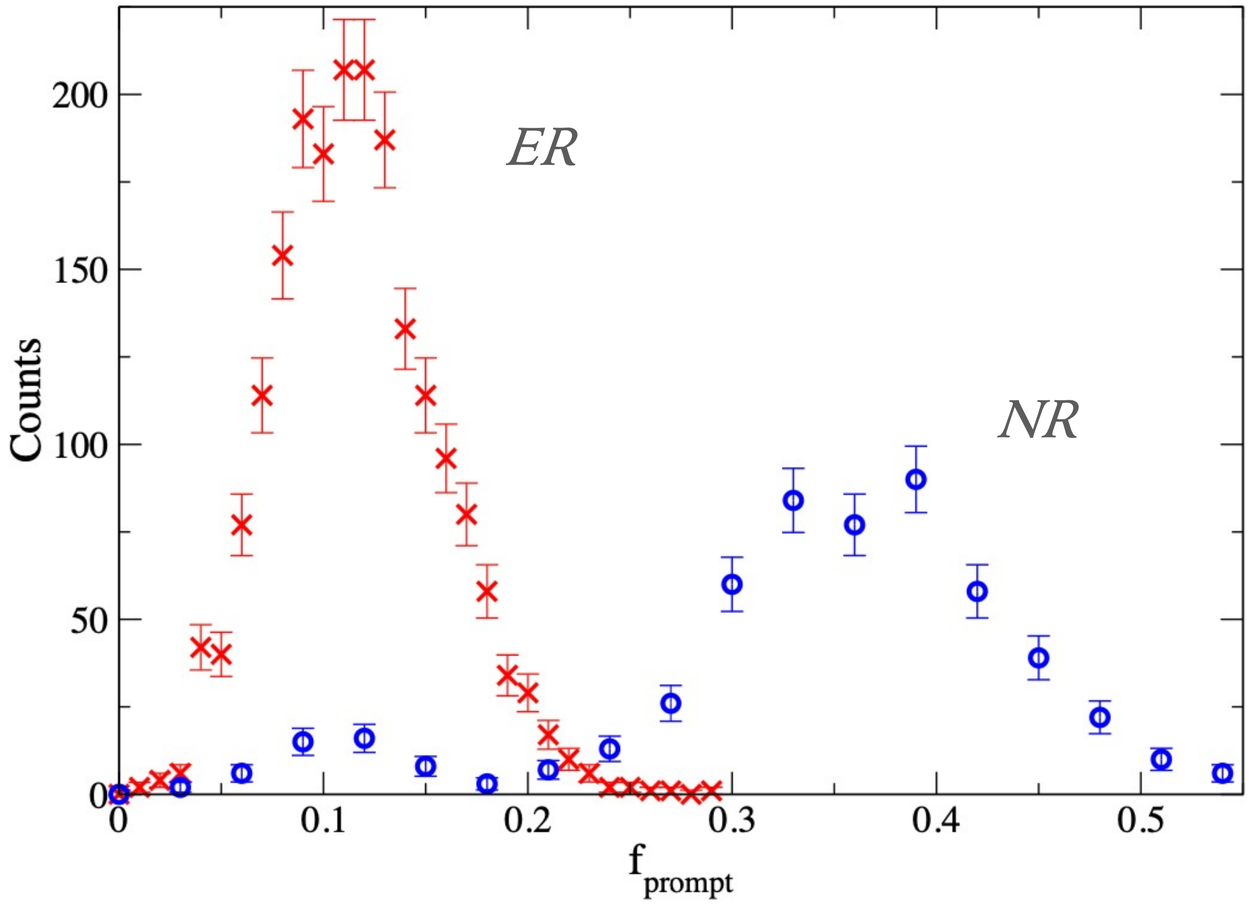
CLEAN

- Cryogenic Low-Energy Astrophysics with Neon
- CLEAN with neon would be more sensitive to lighter DM

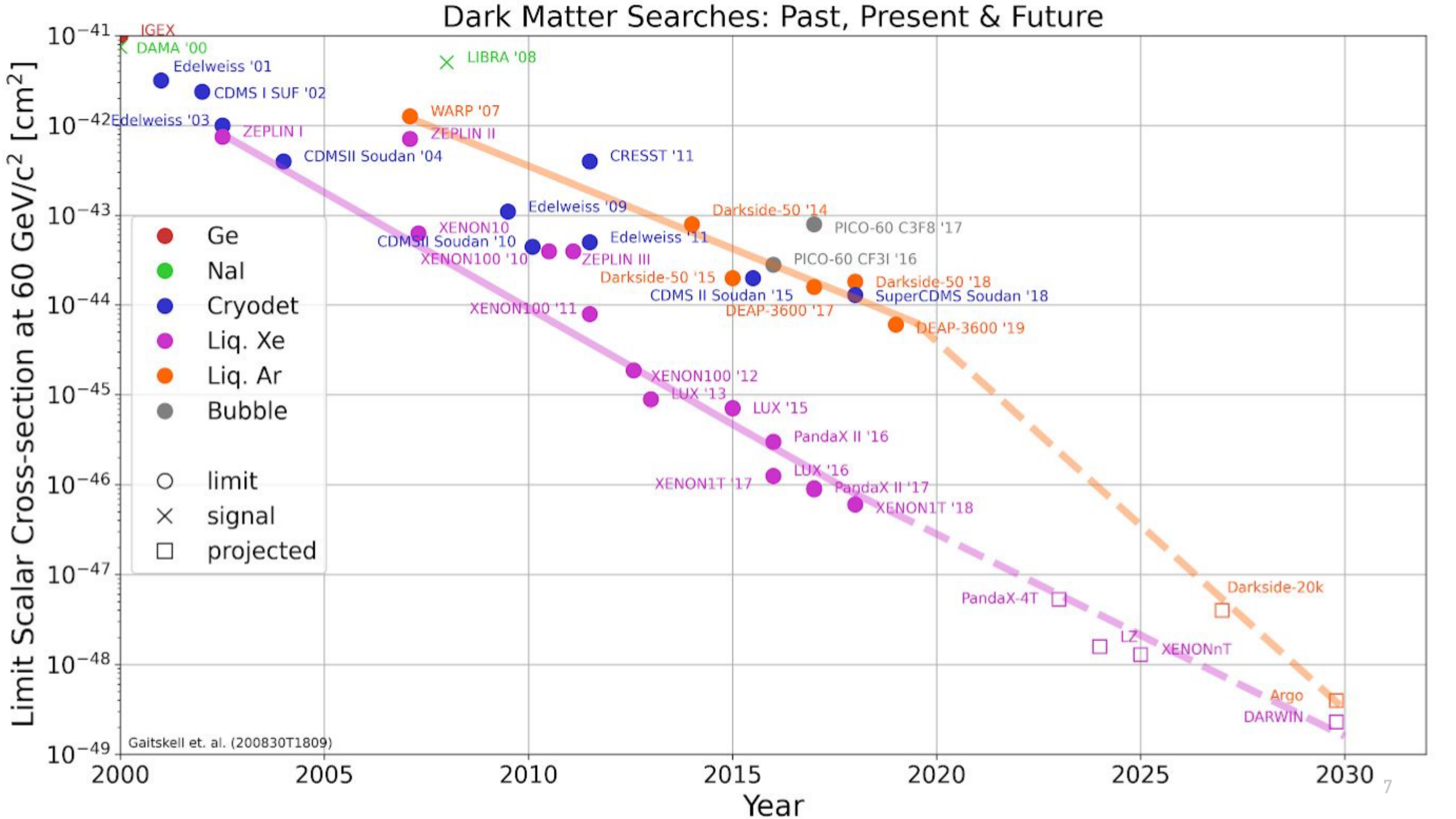
NEON FOR DM

- PSD in neon is not as good as hoped
- Discrimination of ~1/1000
  - $1/10^7$ for argon

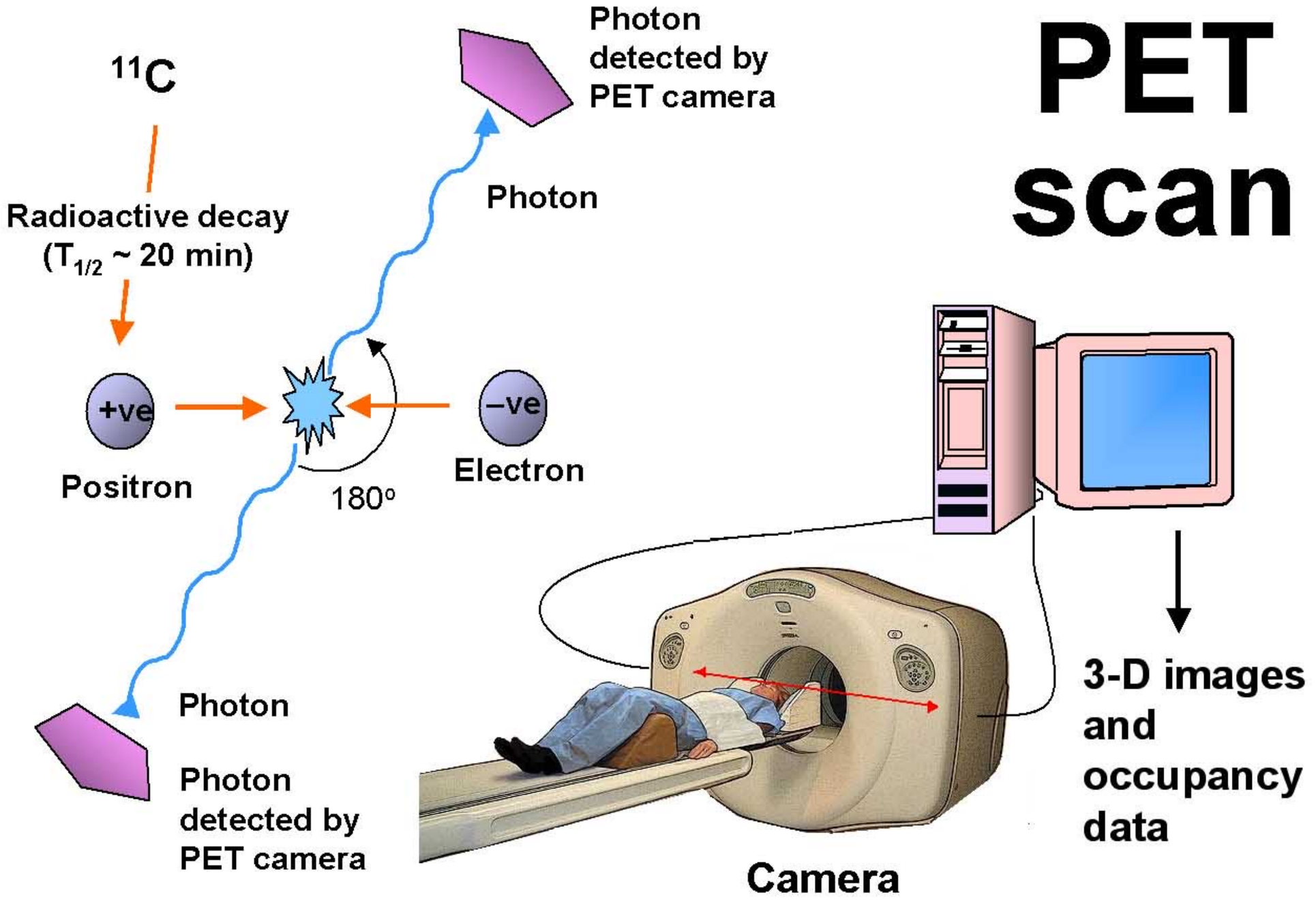


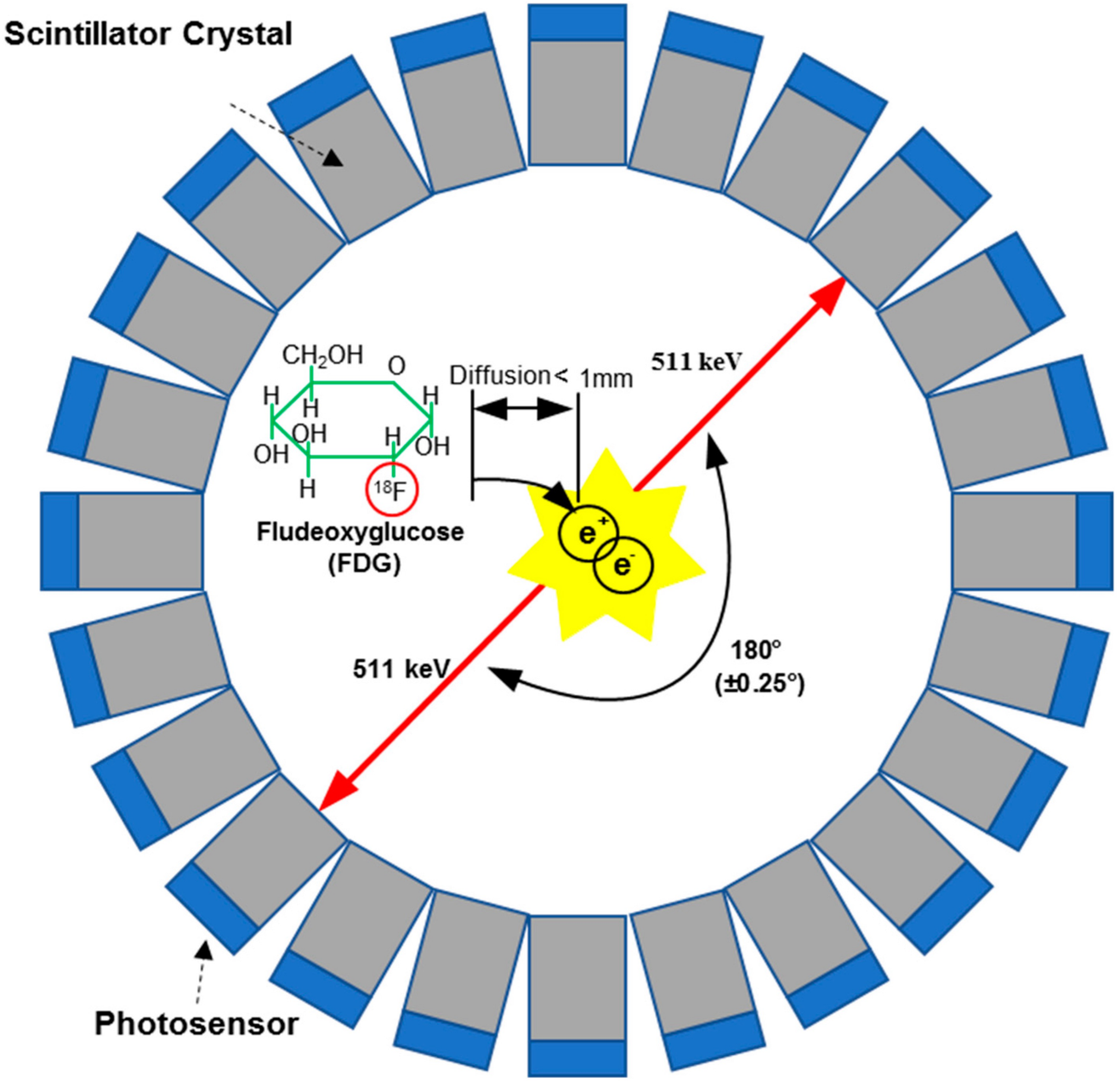


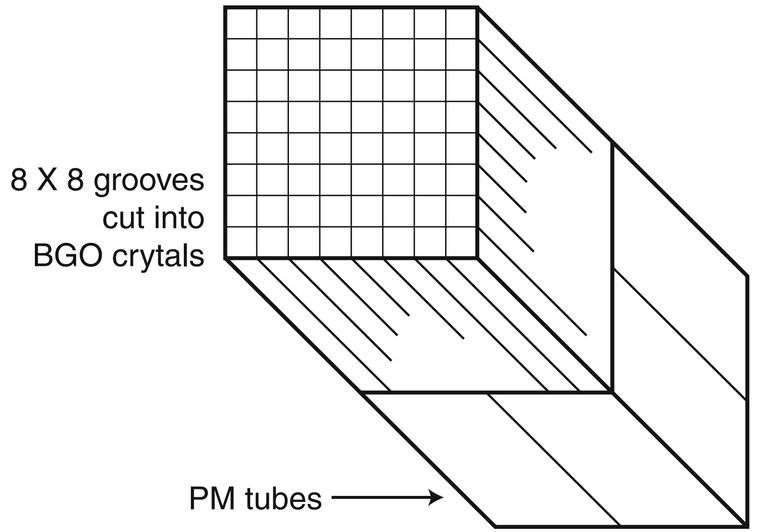
arXiv:0612108

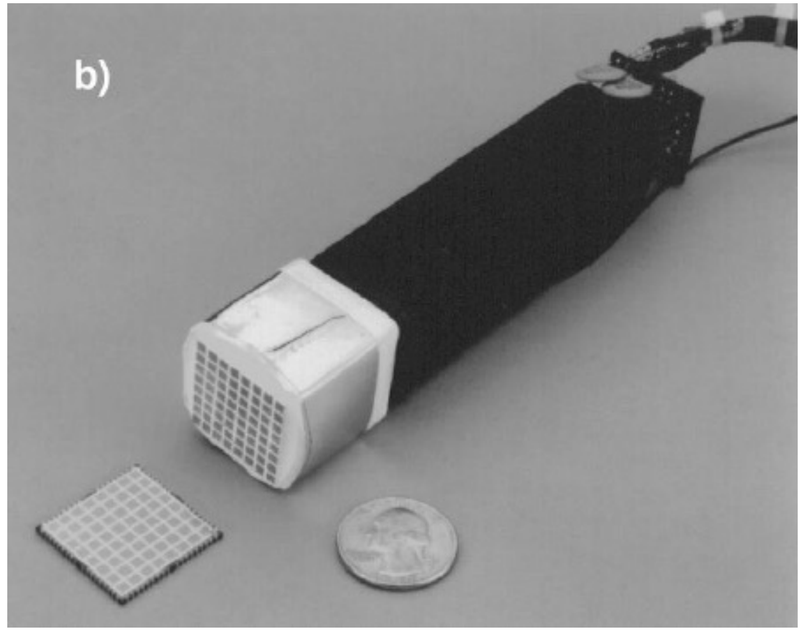

Dark Matter Searches: Past, Present & Future
Limit Scalar Cross-section at 60 GeV/c² [cm²]
Year
IGEX
DAMA '00
Edelweiss '01
CDMS I SUF '02
Edelweiss '03
ZEPLIN I
CDMSII Soudan '04
LIBRA '08
WARP '07
ZEPLIN II
CRESST '11
Edelweiss '09
XENON10
CDMSII Soudan '10
XENON100 '10
Edelweiss '11
ZEPLIN III
Darkside-50 '14
PICO-60 C3F8 '17
PICO-60 CF3I '16
Darkside-50 '15
CDMS II Soudan '15
DEAP-3600 '17
Darkside-50 '18
SuperCDMS Soudan '18
DEAP-3600 '19
XENON100 '11
XENON100 '12
LUX '13
LUX '15
PandaX II '16
LUX '16
XENON1T '17
PandaX II '17
XENON1T '18
PandaX-4T
Darkside-20k
LZ
XENONnT
Argo
DARWIN
Ge
NaI
Cryodet
Liq. Xe
Liq. Ar
Bubble
limit
signal
projected
Gaitskell et. al. (200830T1809)

PET scan


^{11}C
Radioactive decay
($T_{1/2}$ ~ 20 min)
+ve
Positron
180°
–ve
Electron
Photon
Photon detected by PET camera
Photon
Photon detected by PET camera
3-D images and occupancy data
Camera


Scintillator Crystal
CH2OH
O
H
H
H
OH
H
OH
OH
H
18F
Fludeoxyglucose
(FDG)
Diffusion < 1mm
511 keV
e+
e-
511 keV
180°
(±0.25°)
Photosensor


8 X 8 grooves
cut into
BGO crytals
PM tubes


b)

TOF-PET IN JAPAN (WASEDA)

- TOF-PET with PMTs on 5 sides
- A timing resolution (FWHM) of 552 ps was obtained. This value is affected by the time difference between interaction positions and PMTs at each interaction point. (260 ps at center)

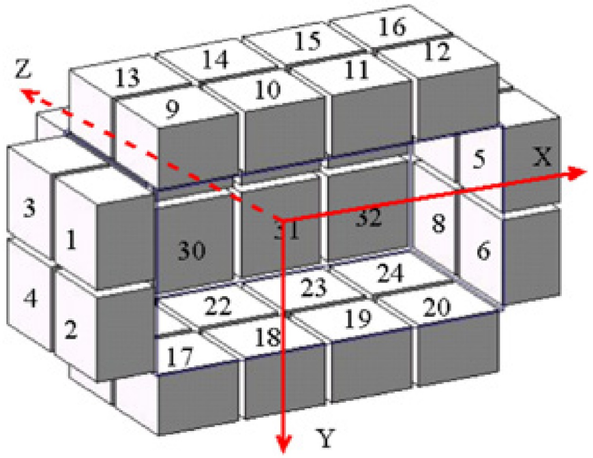


Fig. 2. Arrangements of 32 PMTs.

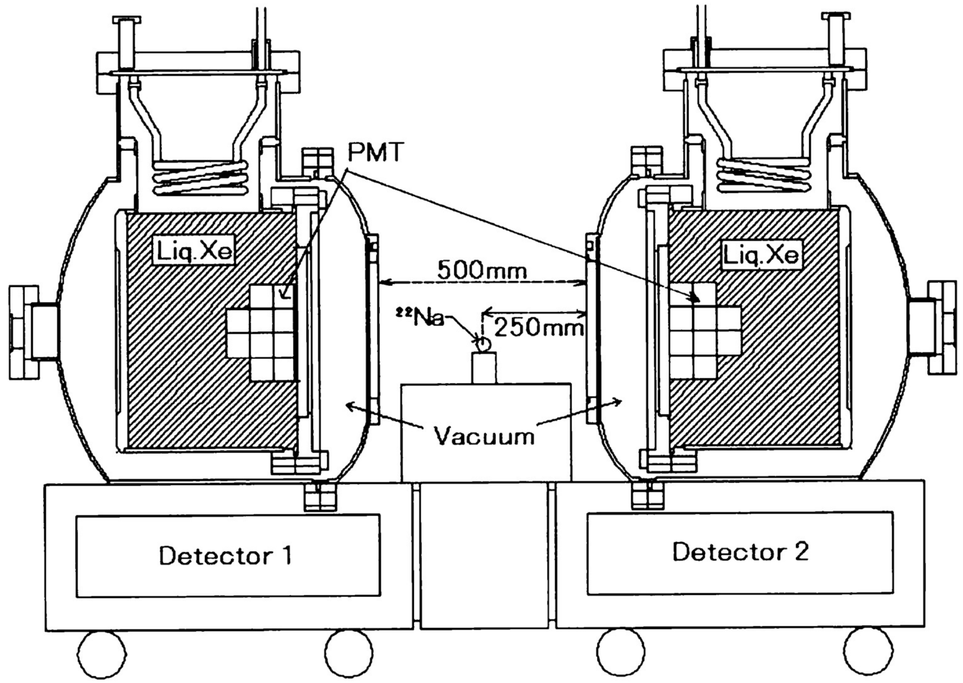
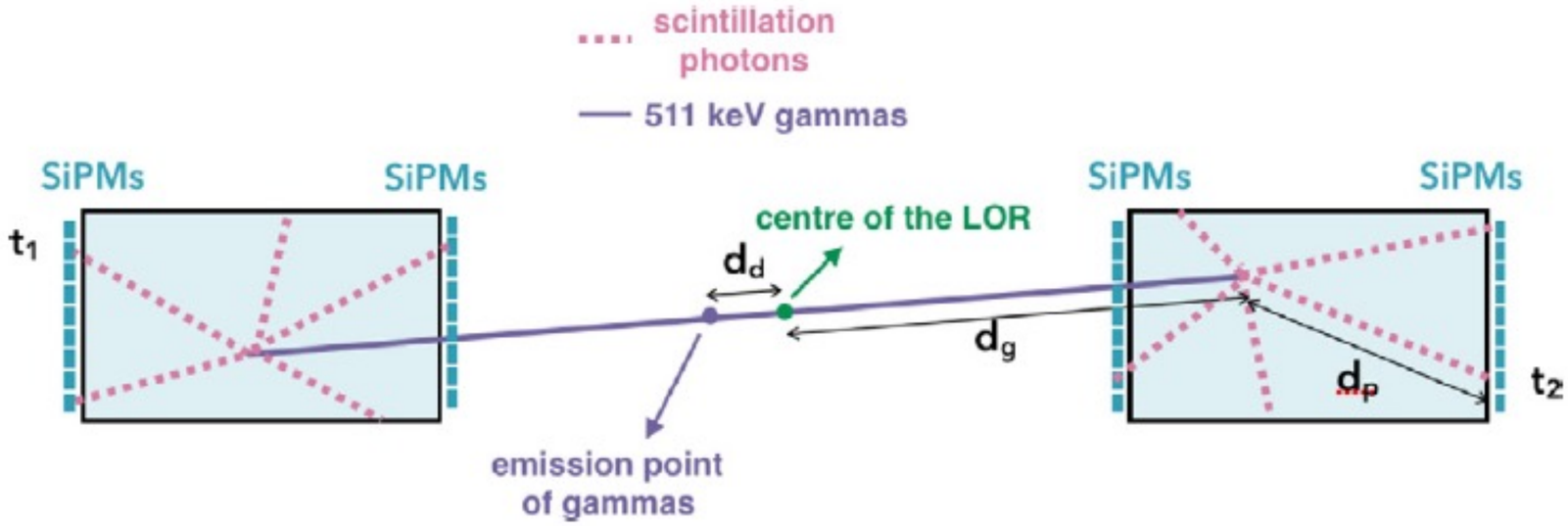


Fig. 4. Cross-sectional view of a prototype model consisting of a couple of liquid xenon scintillation chambers placed 70 cm apart.

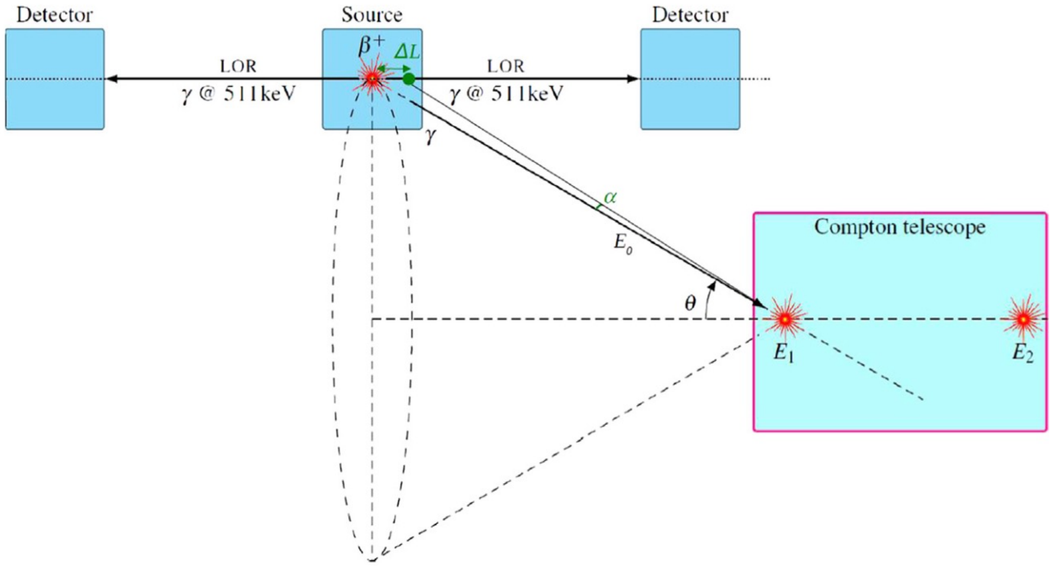
PETALO: TIME-OF-FLIGHT PET WITH LIQUID XENON

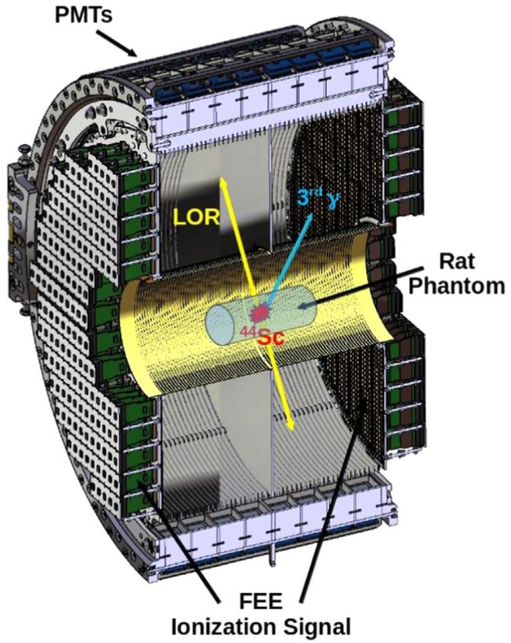
- PET scanners with Time-Of-Flight measurement, which combines a liquid xenon scintillating volume and SiPM as sensors.
  - No drifting, no ionization collection for fast timing
- Monte Carlo simulations point to a time resolution of 30-50 ps obtained using Cherenkov light
- Nuclear Inst. and Methods in Physics Research, A 958 (2020) 162397

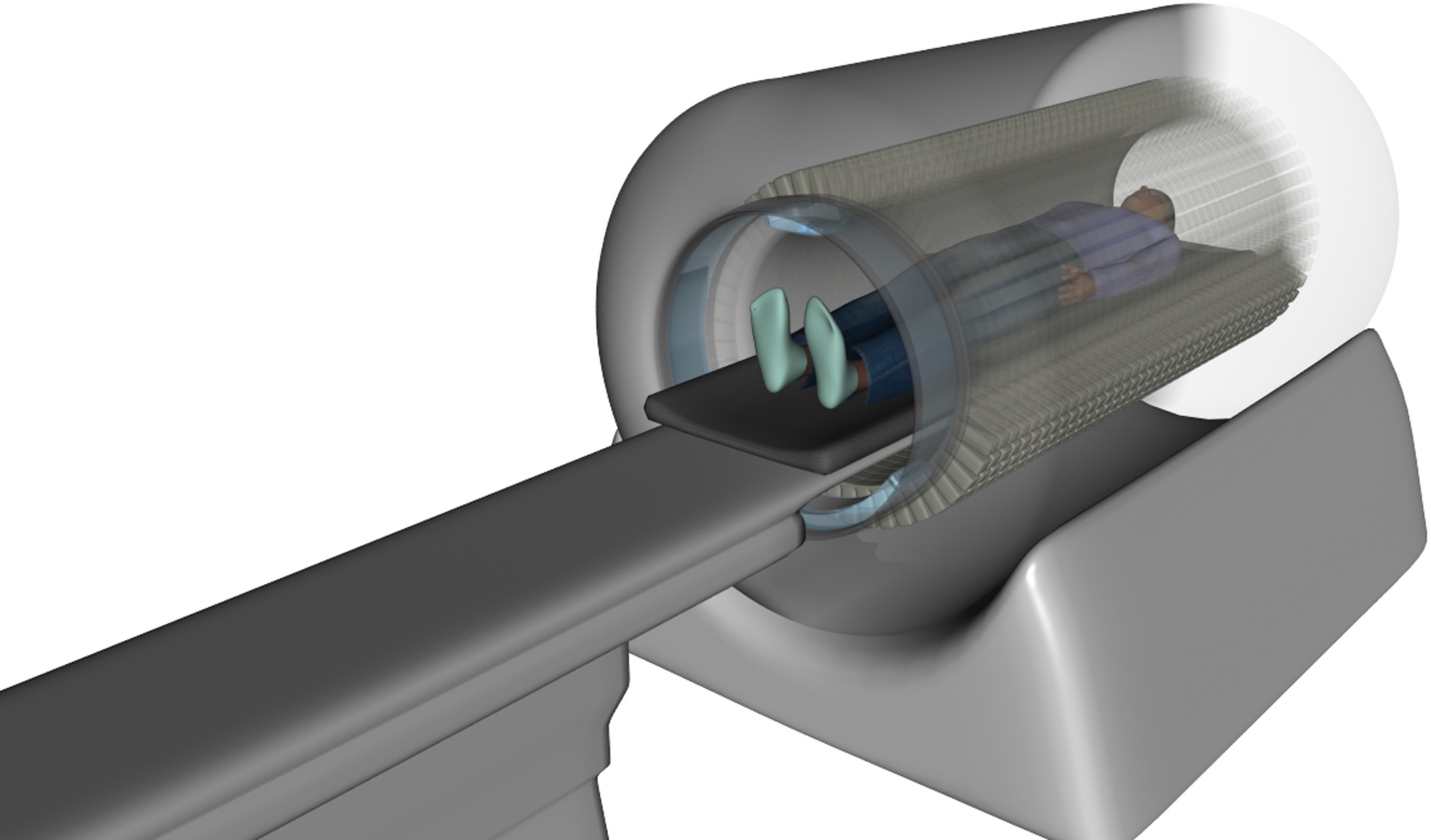


XEMIS: THREE-GAMMA IMAGING

- A specific radionuclide, ^{44}Sc, that emits a γ-ray (1.157 MeV) and a positron.
- TPC configuration: ionization and scintillation
- Gallego Manzano, L. *et al.* XEMIS: A liquid xenon detector for medical imaging. *NIMA* **787**, 89–93 (2015).







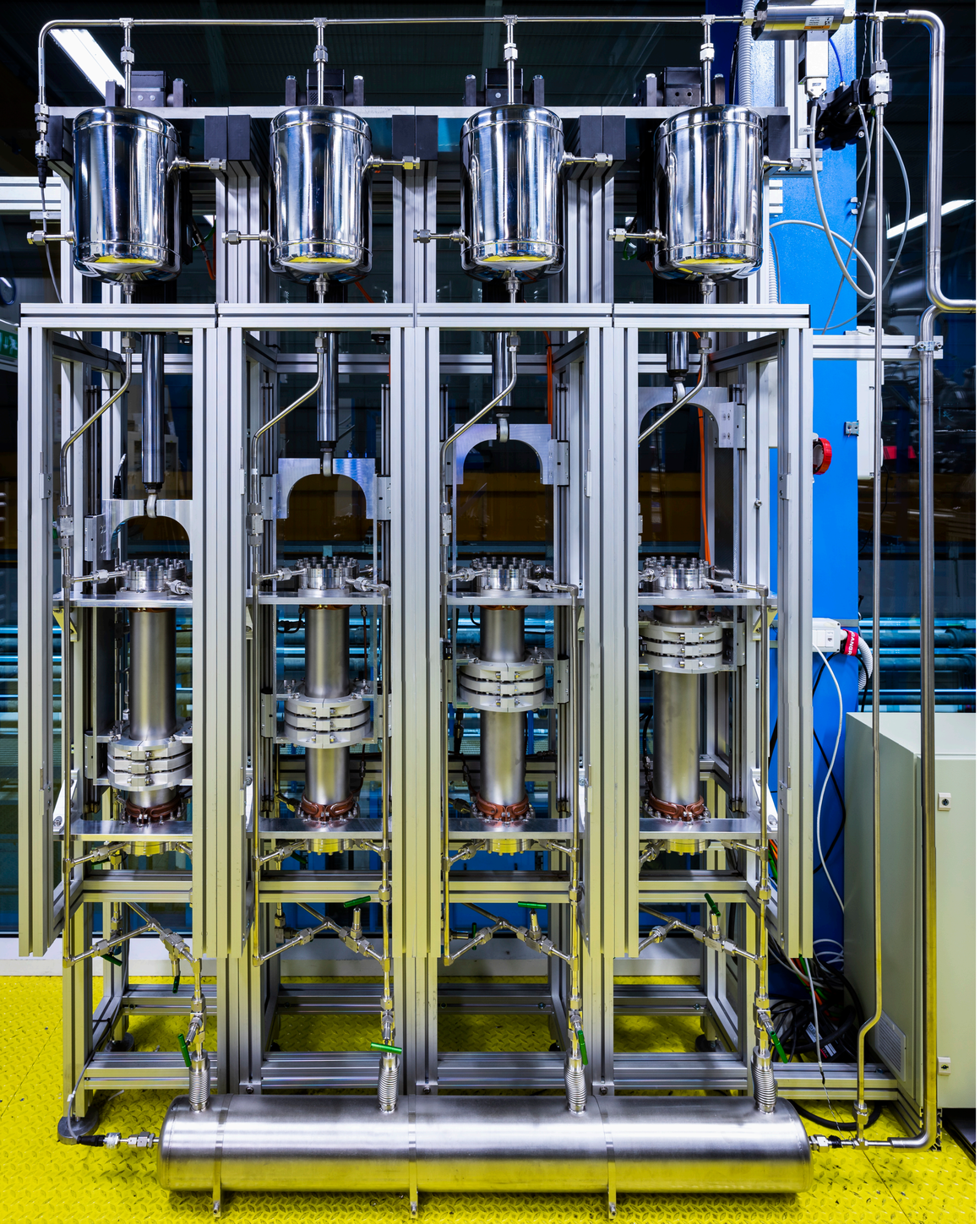
ENABLING TECHNOLOGY

GAS PURIFICATION SYSTEM

Get rid of water, oxygen, carbon dioxide, and hydrocarbons to maintain electron lifetime, a must for long drift length

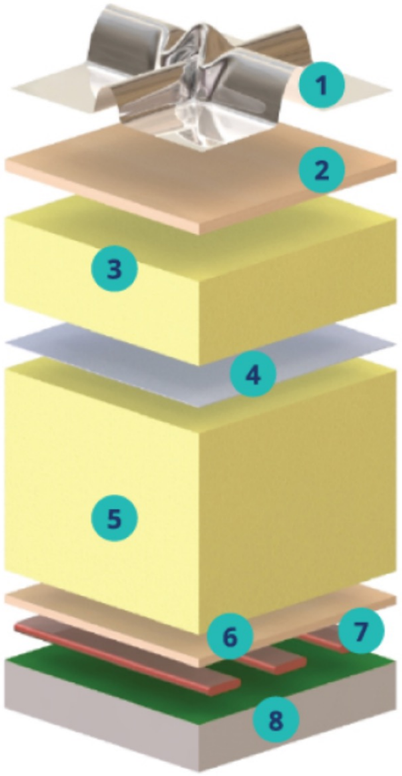
- Molecular sieves
- Silica gel
- Commercial getters

- Liquid purification



CLEAN FAST CIRCULATION

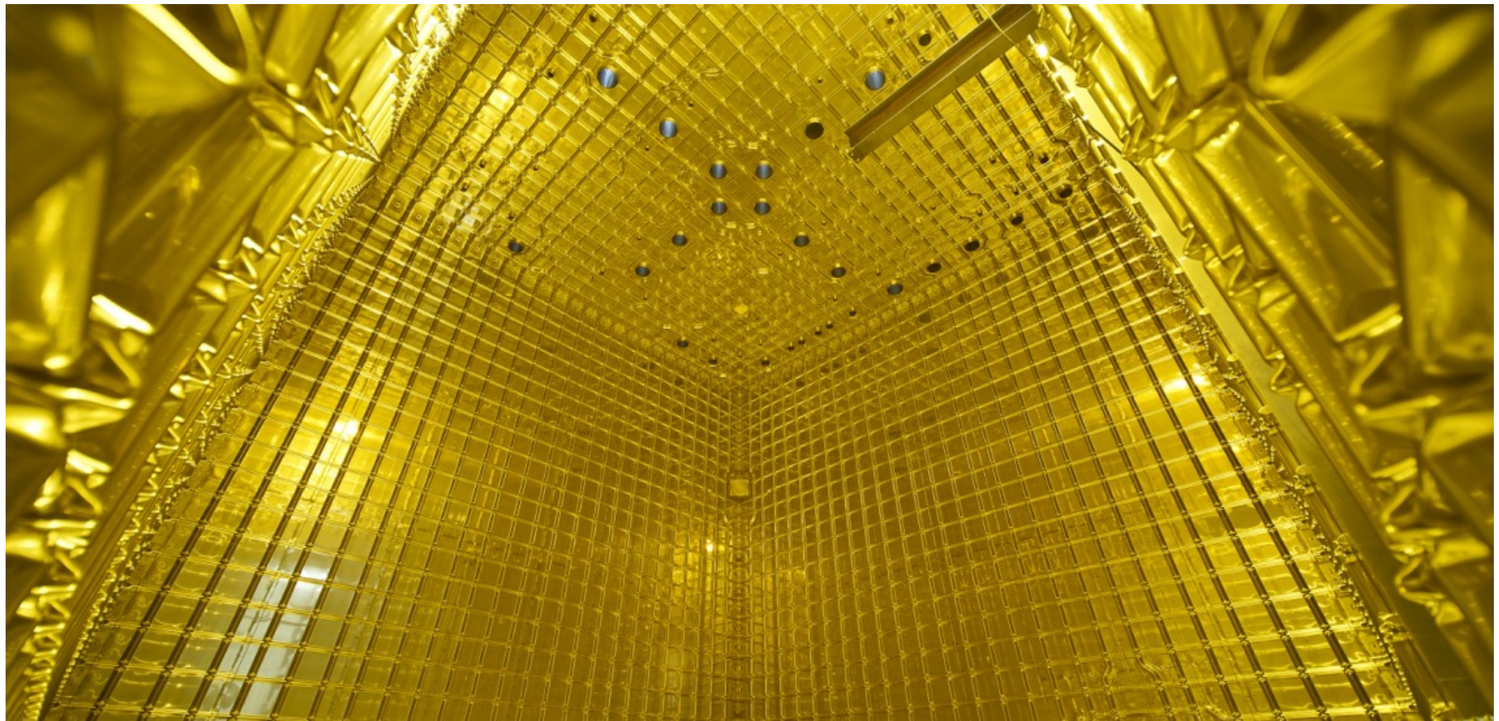
- Custom-designed and fabricated by XENONnT: 474 slpm



1. Stainless steel primary membrane
2. Plywood board
3. Reinforced polyurethane foam
4. Secondary barrier
5. Reinforced polyurethane foam
6. Plywood board
7. Bearing mastic
8. Steel structure with moisture barrier

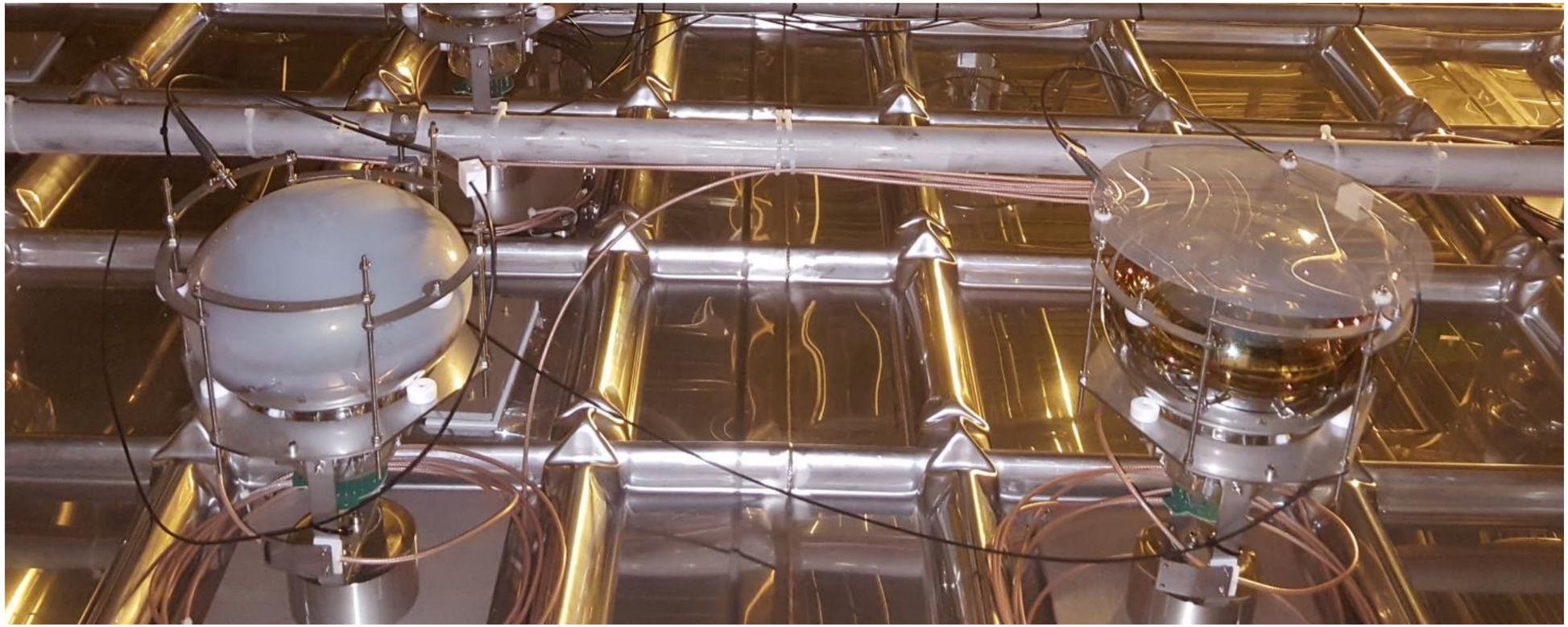
MEMBRANE CRYOSTAT TECHNOLOGY

- Widely used for Liquefied Natural Gas (LNG) transportation and storage
- over 100 vessels that now could be as large as 250,000 m^3 of volume
- DUNE adopted this.



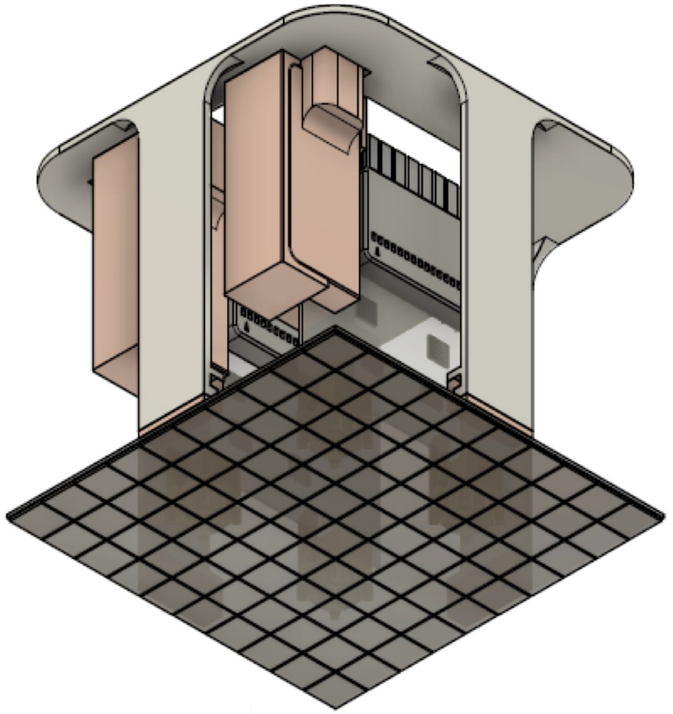
ARGON LIGHT WAVELENGTH SHIFTING

- TPB (Tetraphenyl butadiene) coating
- PEN (polyethylene naphthalate) film



(RADIOCLEAN) SENSITIVE PHOTOSENSORS IN VUV RANGE

- Always searching for high QE (@178 nm), low background, and extremely sensitive light sensors



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科学技术化

技术科学化

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道阻且长，行则将至；

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