The NEXT experiment to search for the neutrinoless double beta decay of Xe-136

F. Monrabal on behalf of the NEXT collaboration

University of Texas at Arlington

ICHEP2016CHICAGO

The NEXT Collaboration

IFIC Valencia • Zaragoza • Politécnica Valencia • Santiago de Compostela • Girona

• Texas A&M• Texas UTA

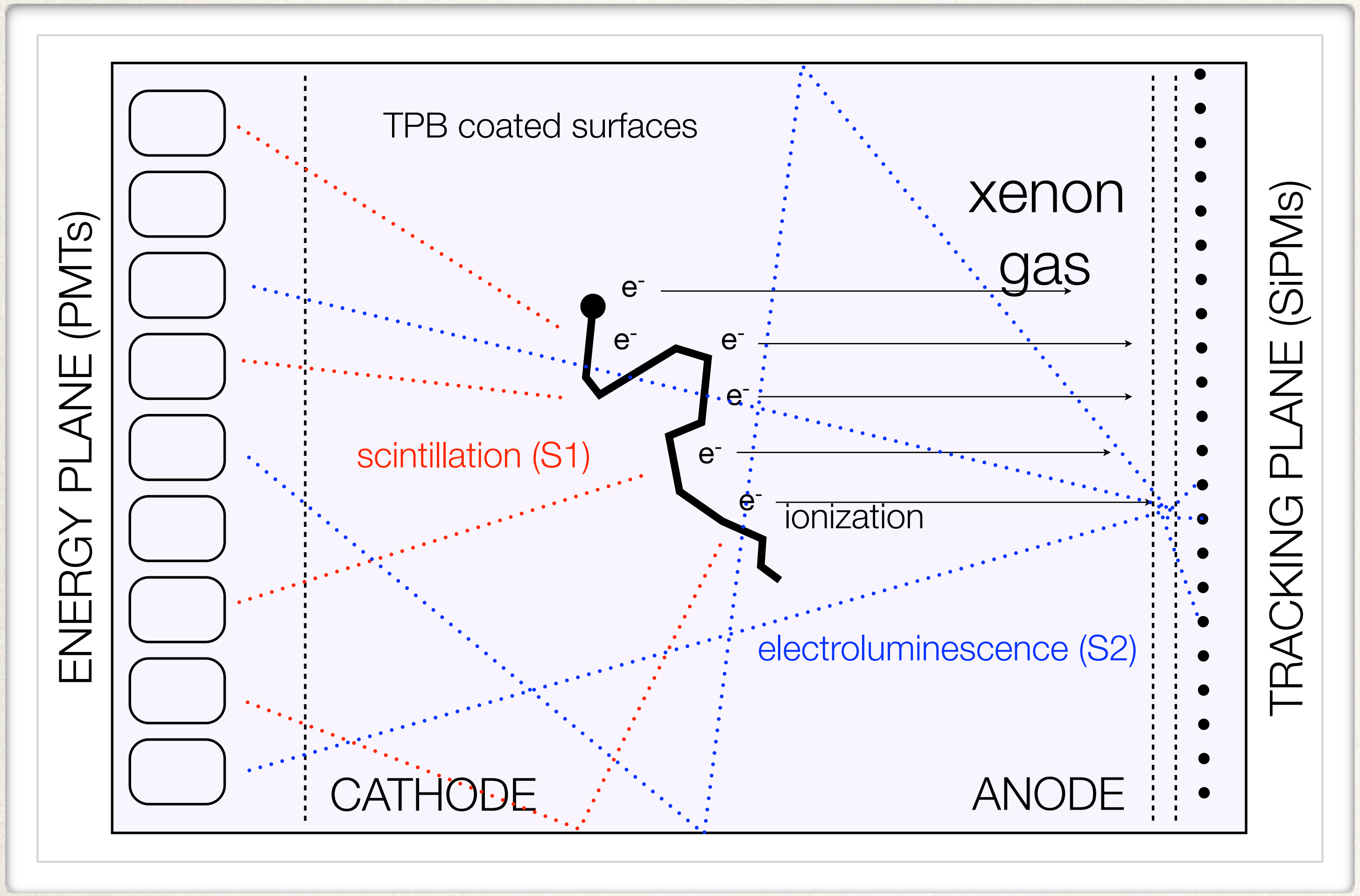
Coimbra • Aveiro

JINR

A. Nariño

co-spokespersons: D. Nygren (UTA) and J.J. Gomez-Cadenas (IFIC)

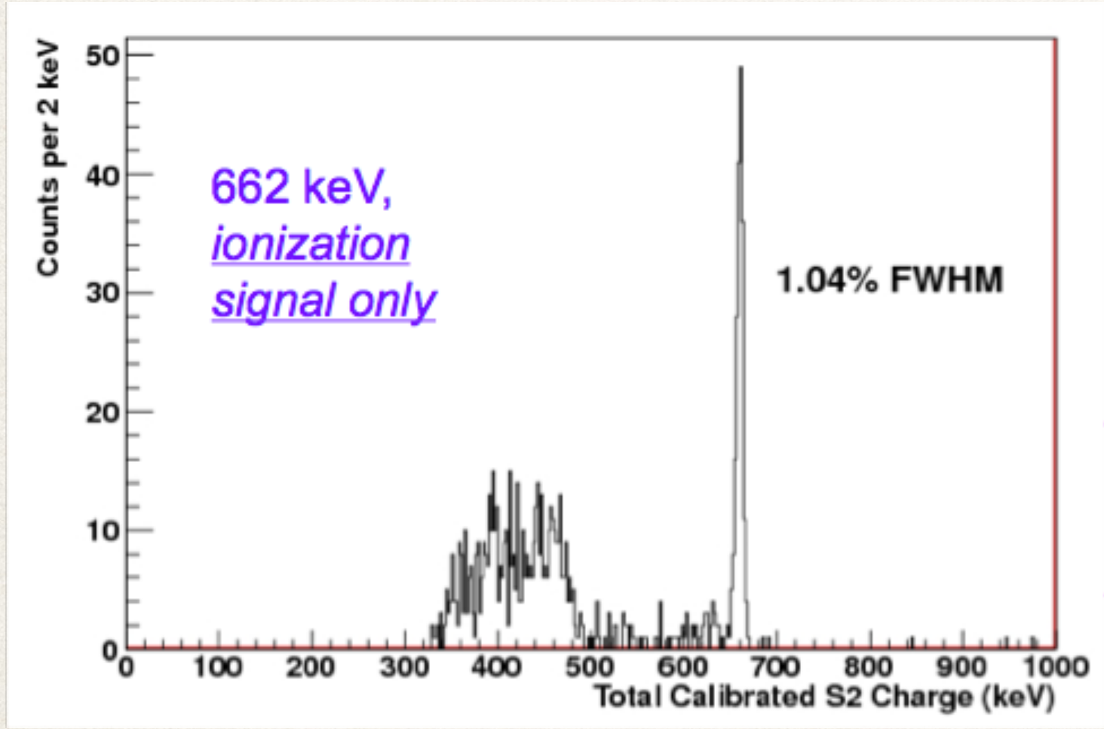
NEXT: An optical TPC



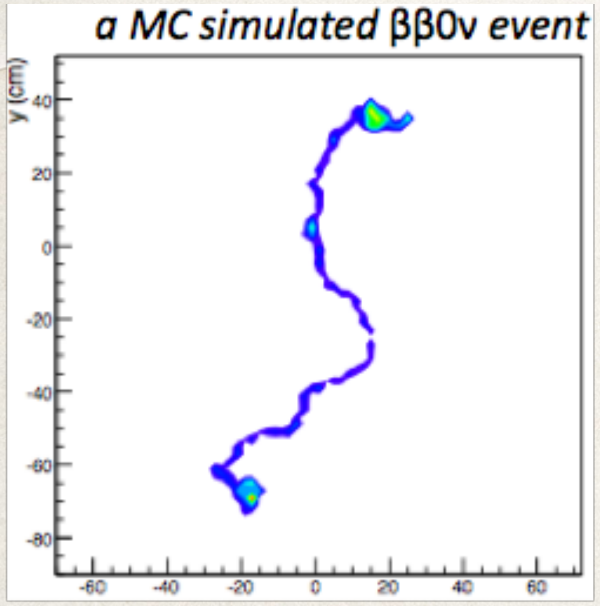
EL mode is essential to get linear gain, therefore avoiding avalanche fluctuations and fully exploiting the excellent Fano factor in gas (0.15)

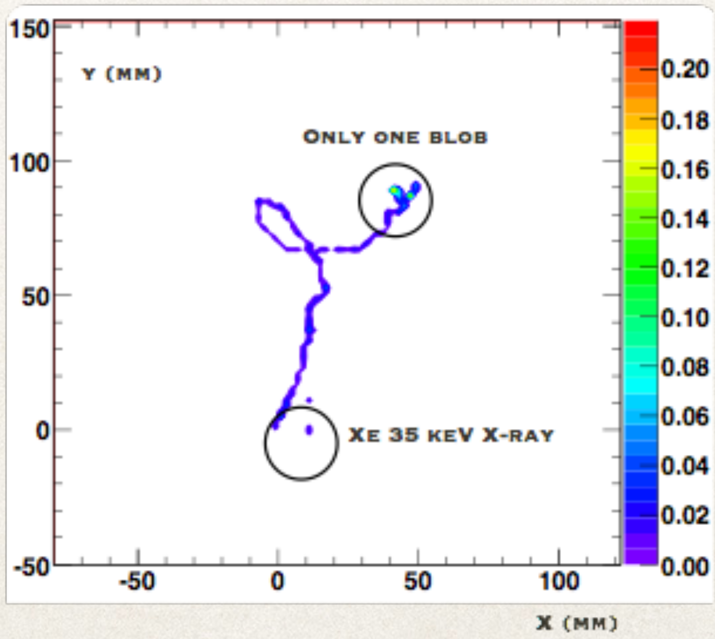
- High Pressure Xenon (HPXe) TPC operating in Electroluminescence (EL) mode.
- It is filled with Xenon enriched at 90% in Xe-136 (100 kg in stock) at a pressure of 15 bar.
- The event energy is integrated by a plane of radiopure PMTs located behind a transparent cathode (energy plane).
- PMTs also provide t0.
- The event topology is reconstructed by a plane of radiopure silicon pixels (MPPCs) (tracking plane).

NEXT: Salient features



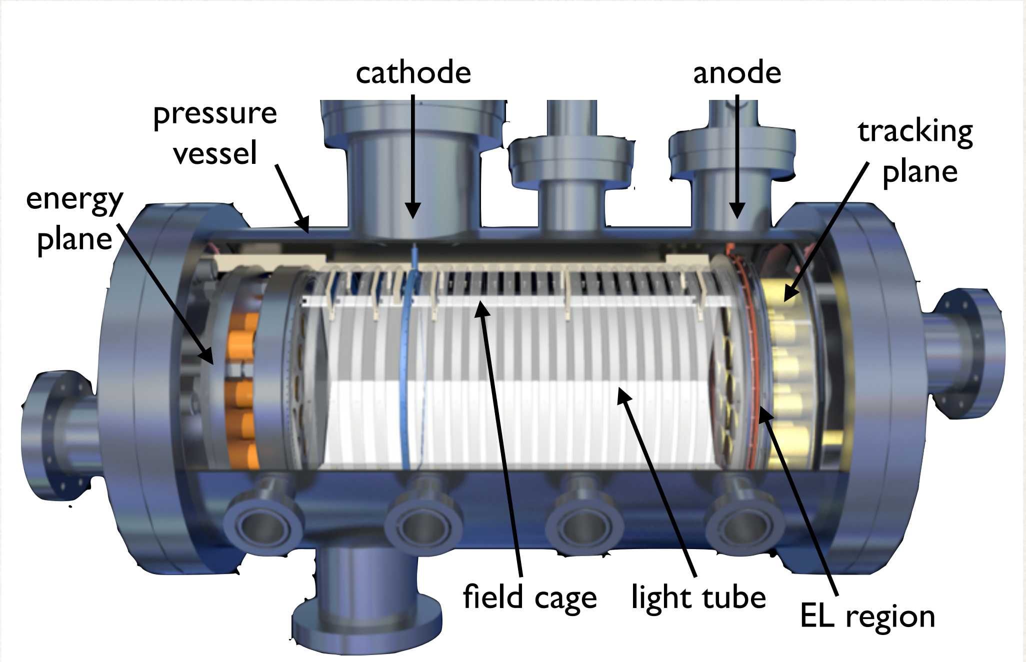
- Excellent resolution: 1% FWHM measured at 662 keV by NEXT prototypes, extrapolates to 0.5 % FWHM at Qbb.
- Topological signature (TPS), e.g. the ability to distinguish between signal ("double electrons") and background ("single electrons").
- Target = source. Fiducial region away from surfaces.
- Detector = Monolithic active mass.
- TPC: scalable. Economy of scale (S/N increases linearly with L)
- Xenon: the cheapest isotope to enrich in the market (NEXT owns 100 kg of enriched xenon).

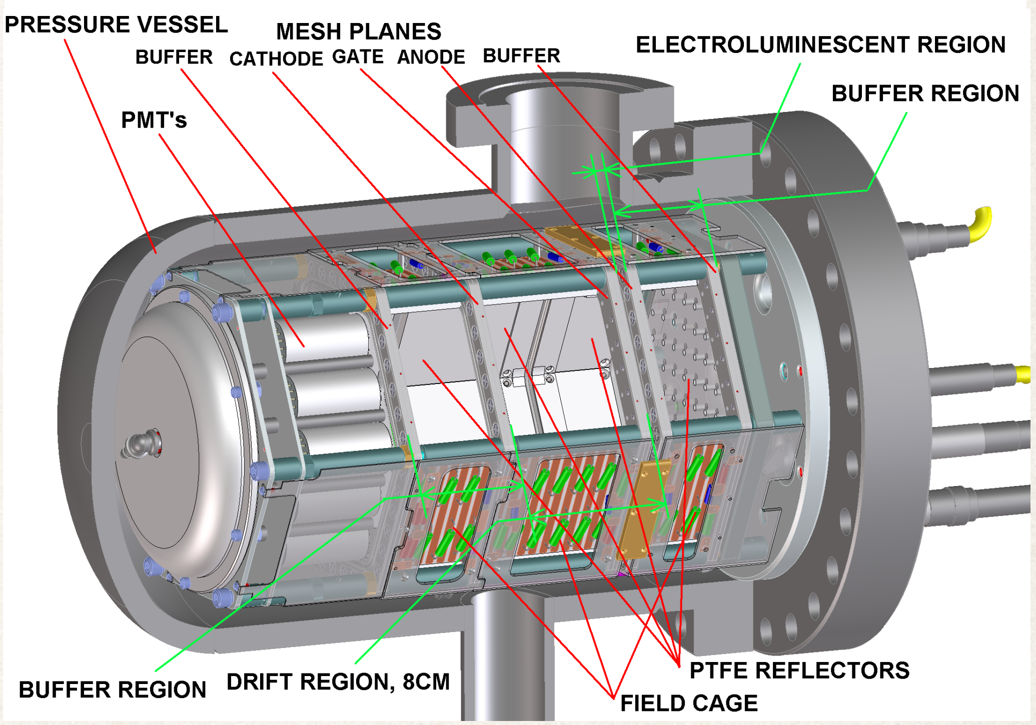




R&D: Up to 2014

- **NEXT-DEMO:**
  - ~1.5 kg natural xenon at 10 bar.
  - 19 1 inch PMTs behind cathode.
  - Array of 256 SiPMs behind anode.
  - Internal surfaces coated with TPB.
- **NEXT-DBDM:**
  - ~1 kg natural xenon at 10-15 bar.
  - 19 1 inch PMTs behind cathode.
  - Reflective plate behind anode

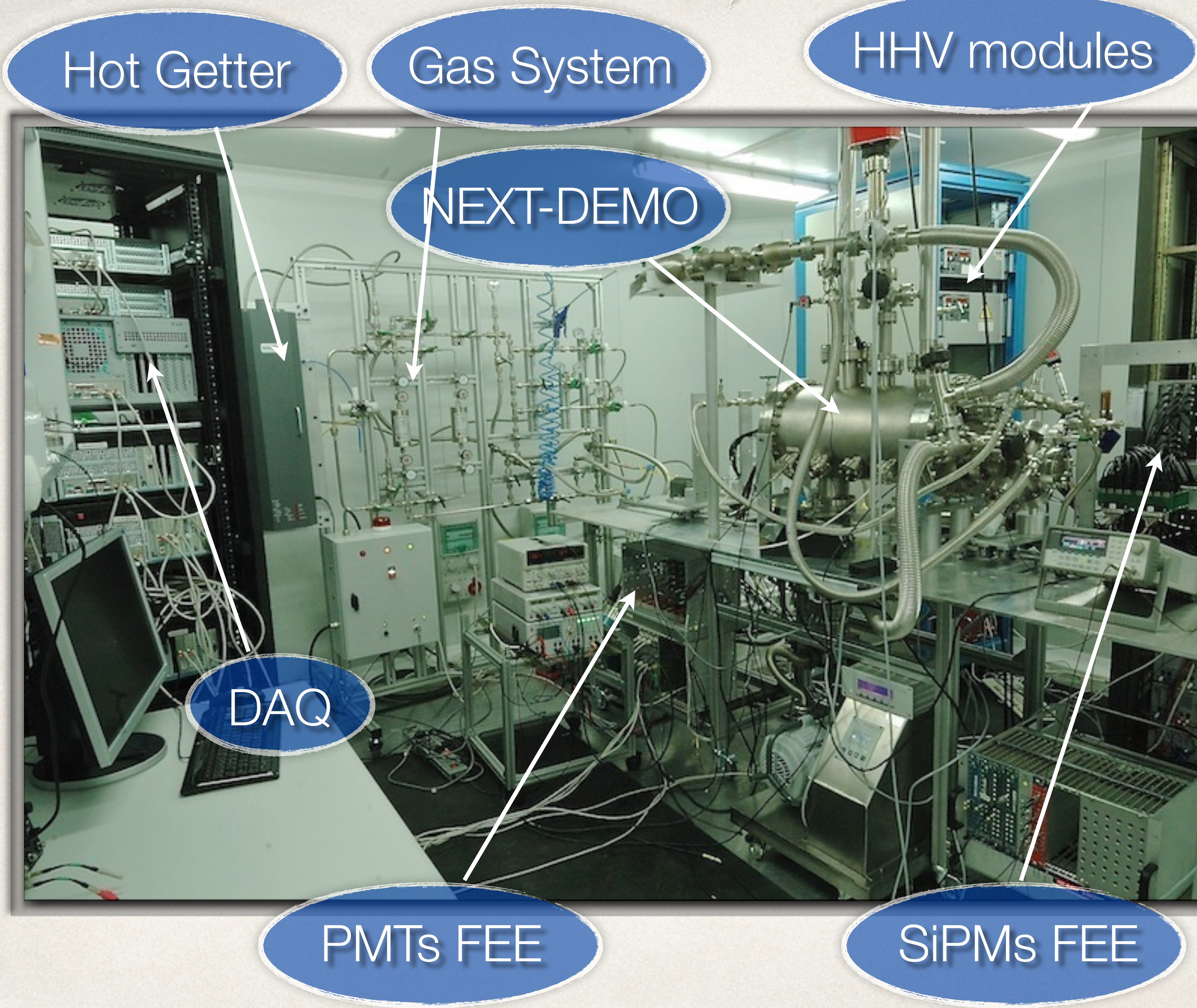


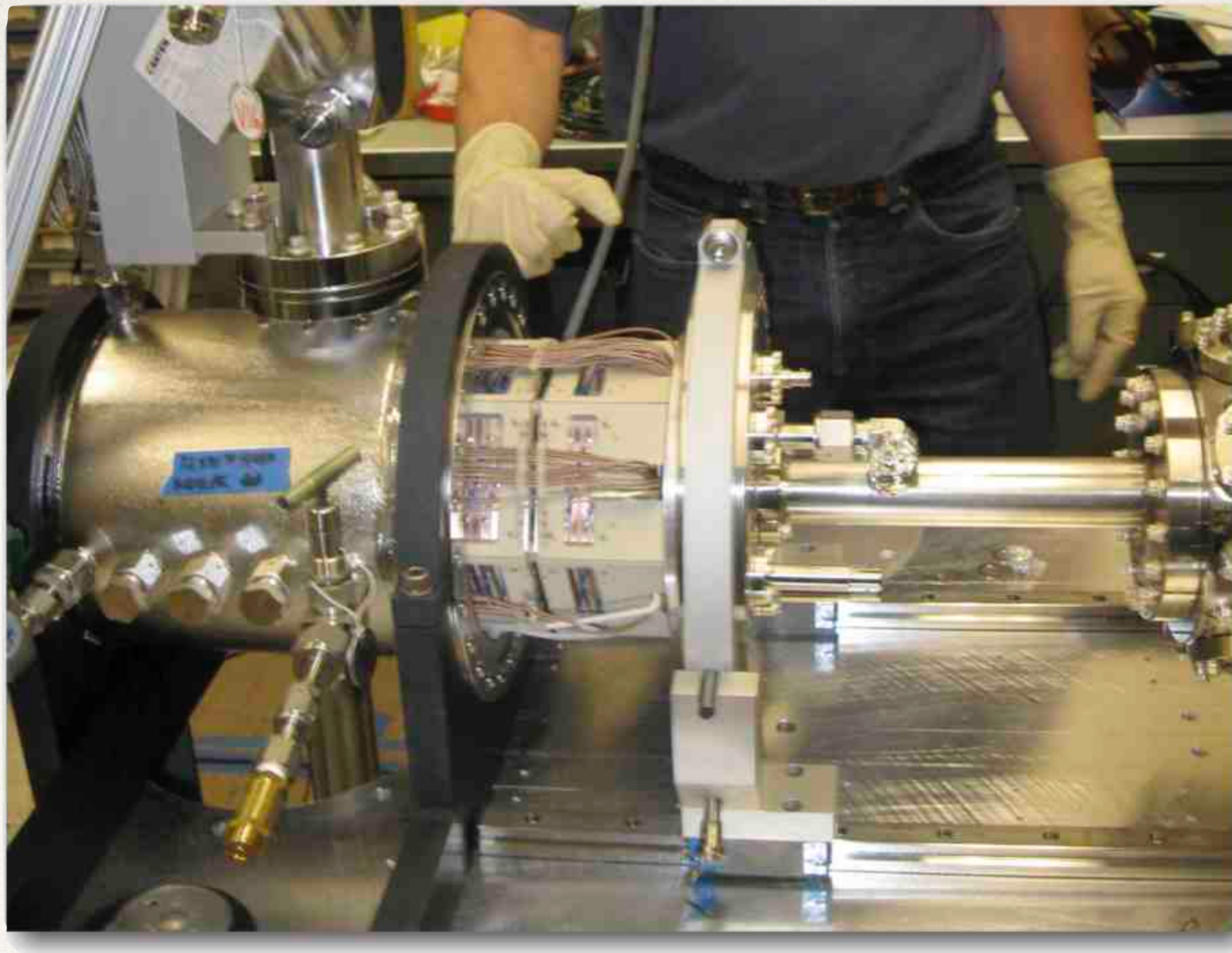


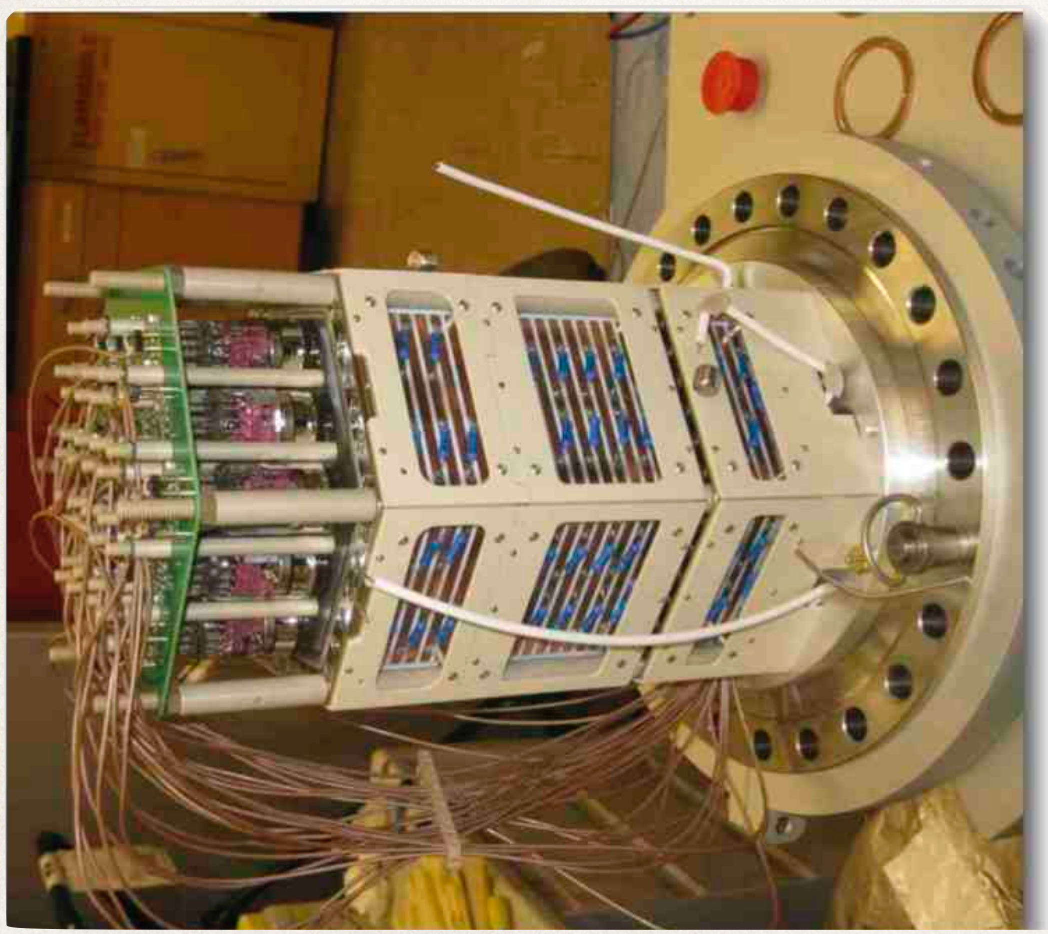
Simultaneous running to verify technology and physics for electron, alpha and nuclear recoil detection.

Nucl.Inst.Meth A708 (2013),
JINST 8 (2013) P04002
JINST 8 (2013) P09011,

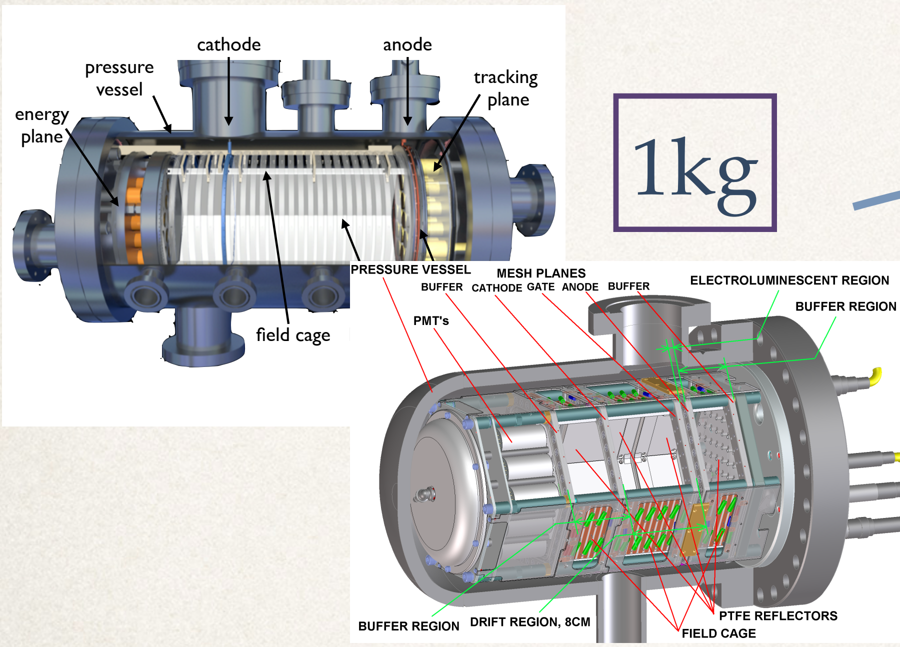
JINST 10 (2015) 03, P03025
Nucl.Inst.Meth A793 (2015)


Hot Getter
Gas System
HHV modules
NEXT-DEMO
DAQ
PMTs FEE
SiPMs FEE



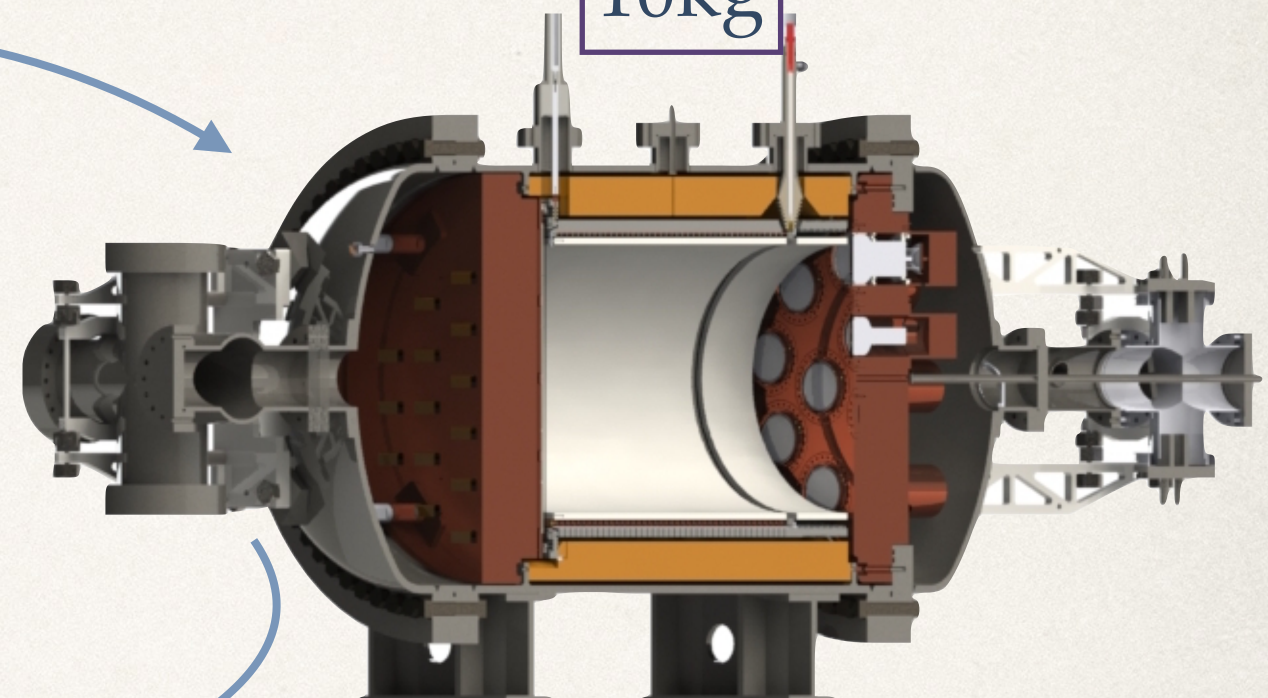


NEXT: The first stage (100 kg scale)

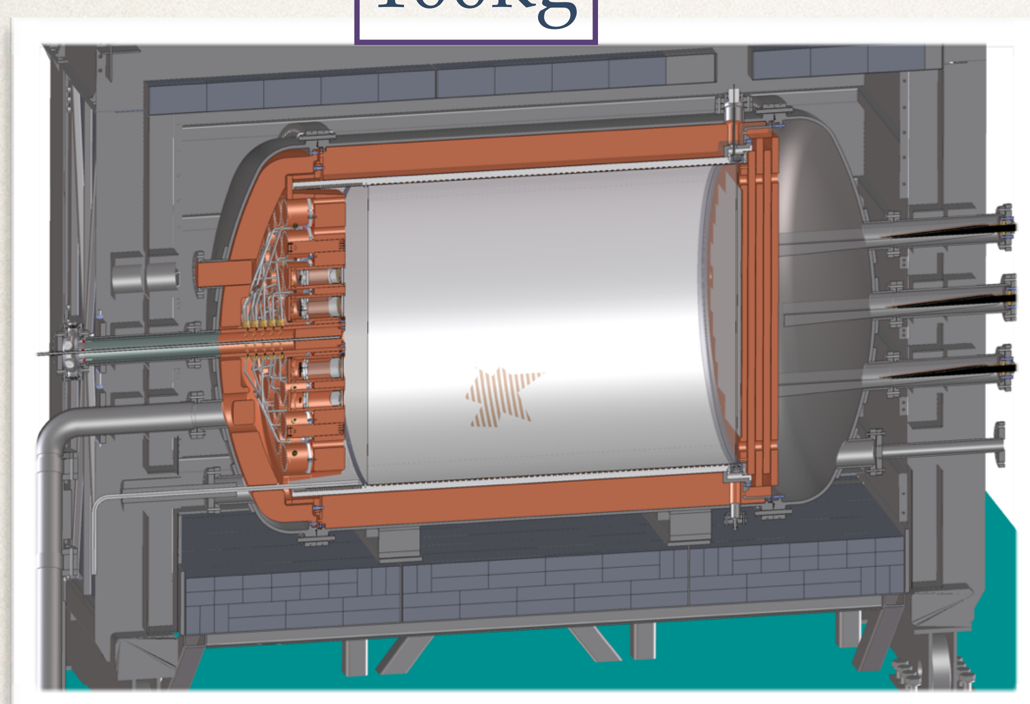


1kg

10kg



100kg



NEXT 1-tonne

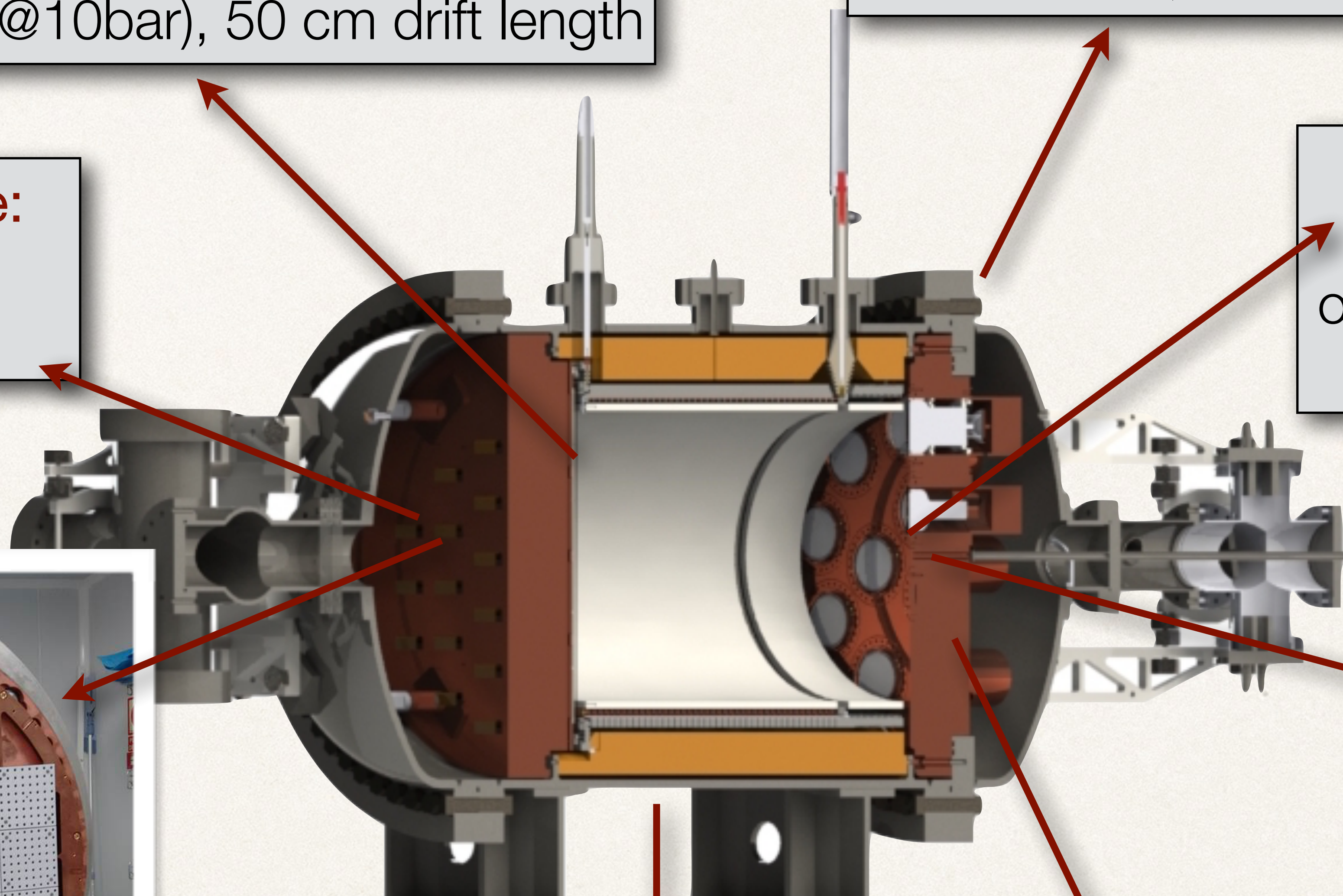
NEW (NEXT-WHITE) at a glance

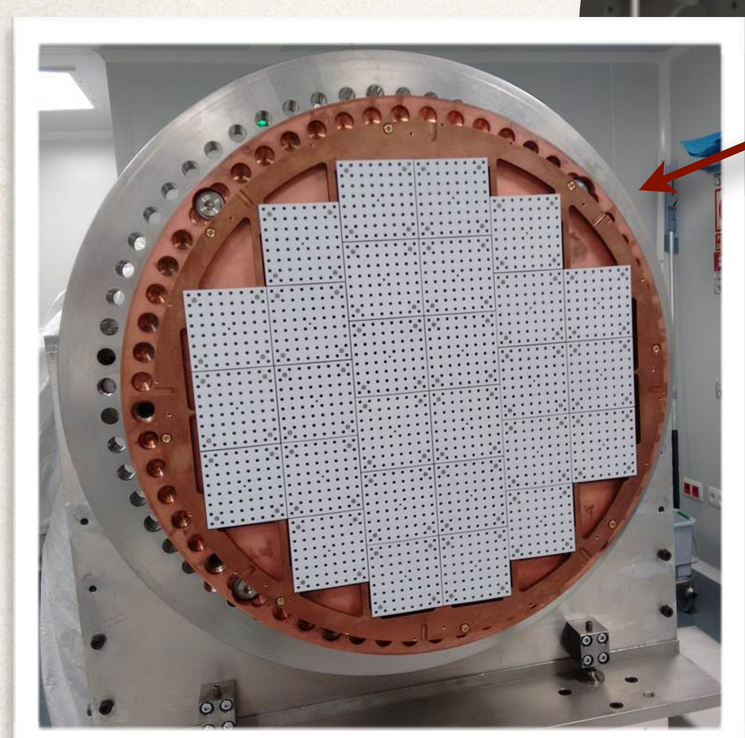
Time Projection Chamber:
10 kg active region(@10bar), 50 cm drift length

Pressure vessel:
316-Ti steel, 30 bar max pressure

Tracking plane:
1,800 SiPMs,
1 cm pitch

Energy plane:
12 PMTs,
operating at vacuum.
30% coverage

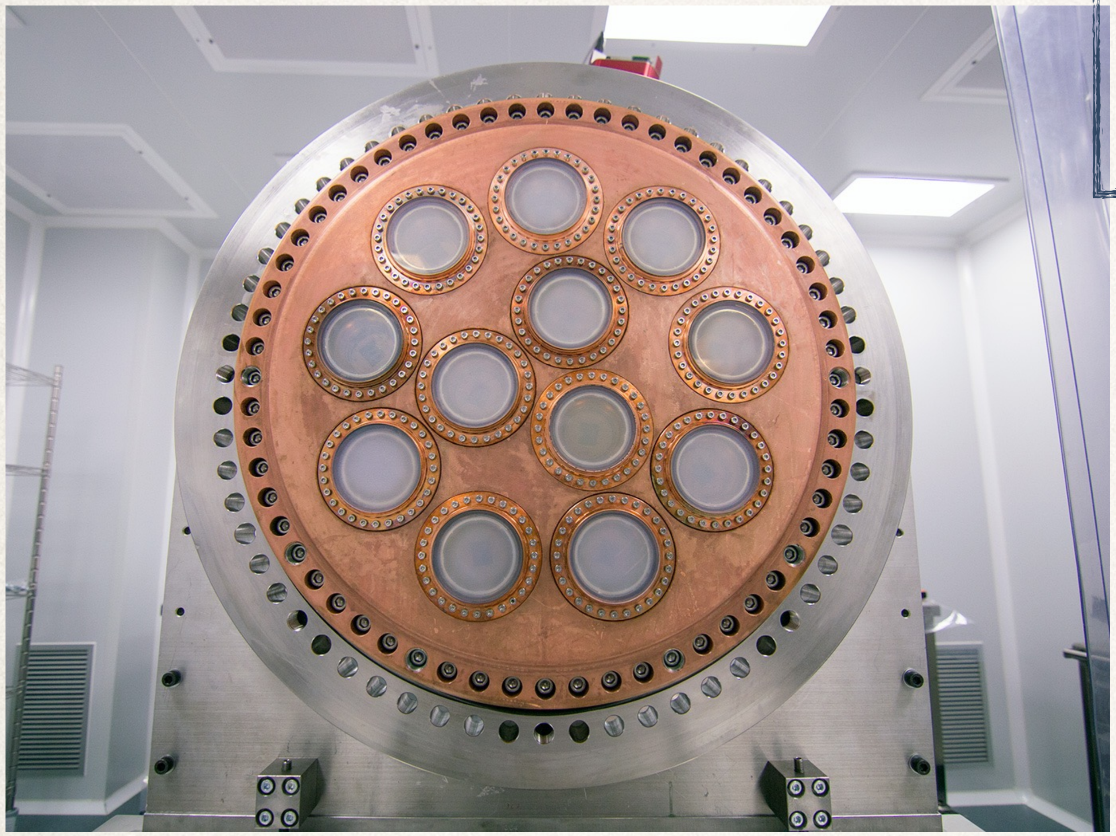




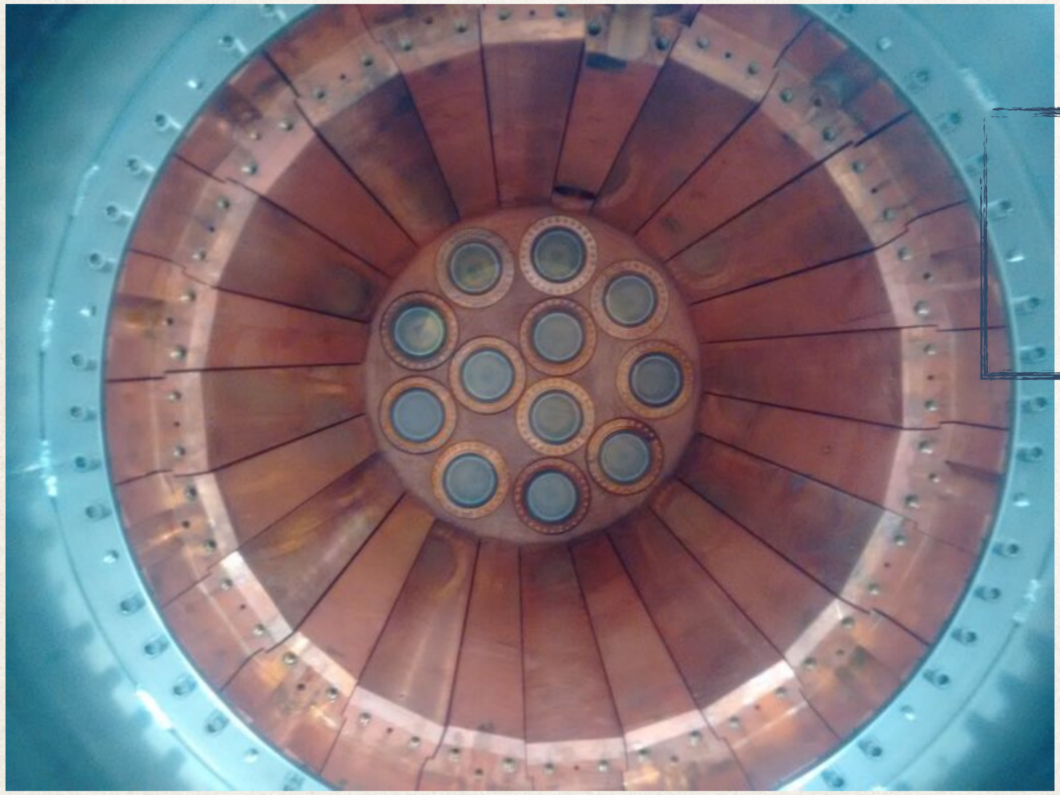
Inner shield:
copper, 6 cm thick

Mother can:
12 cm copper plate that
separates pressure from
vacuum and adds shielding.

Energy Plane



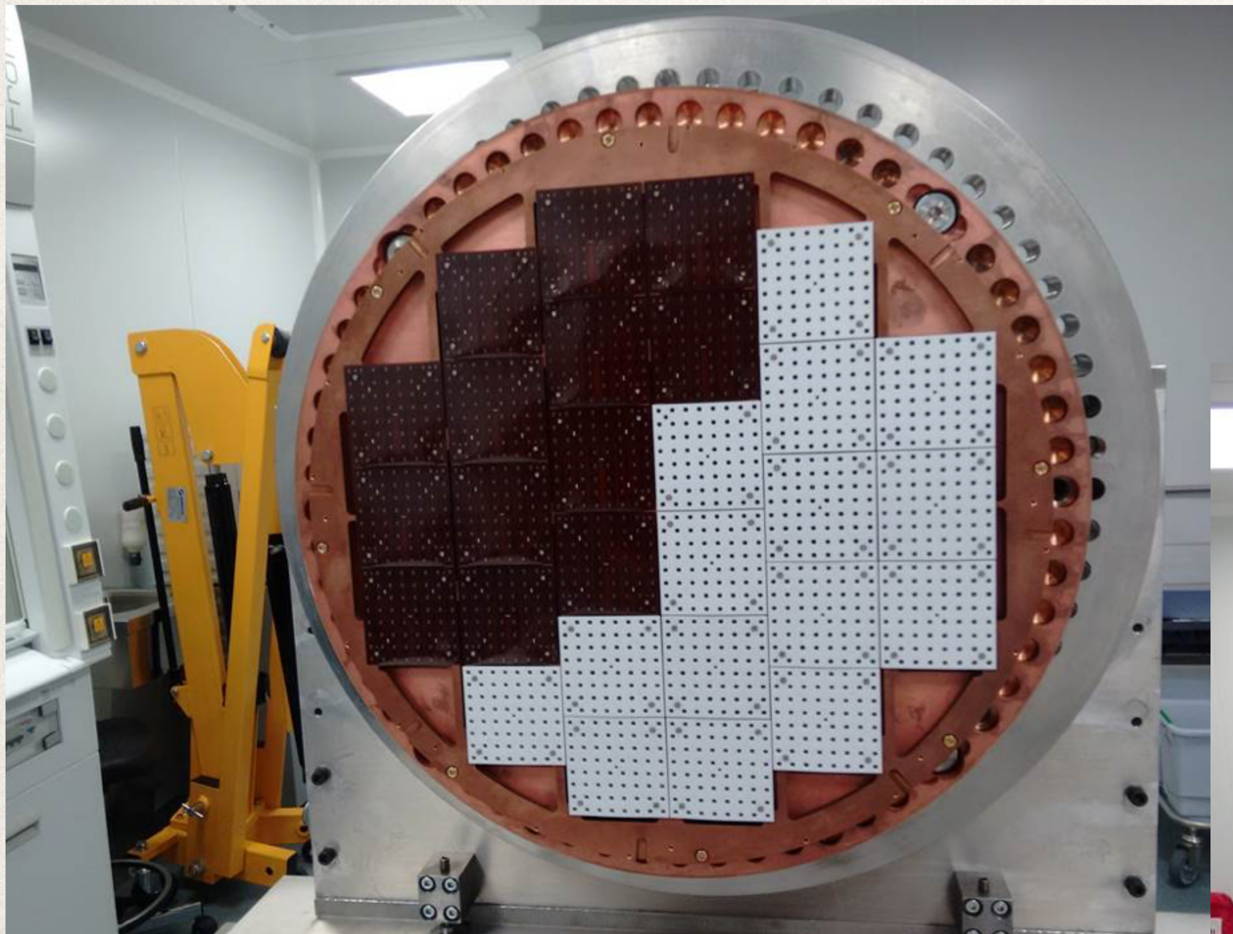
Energy plane mother can



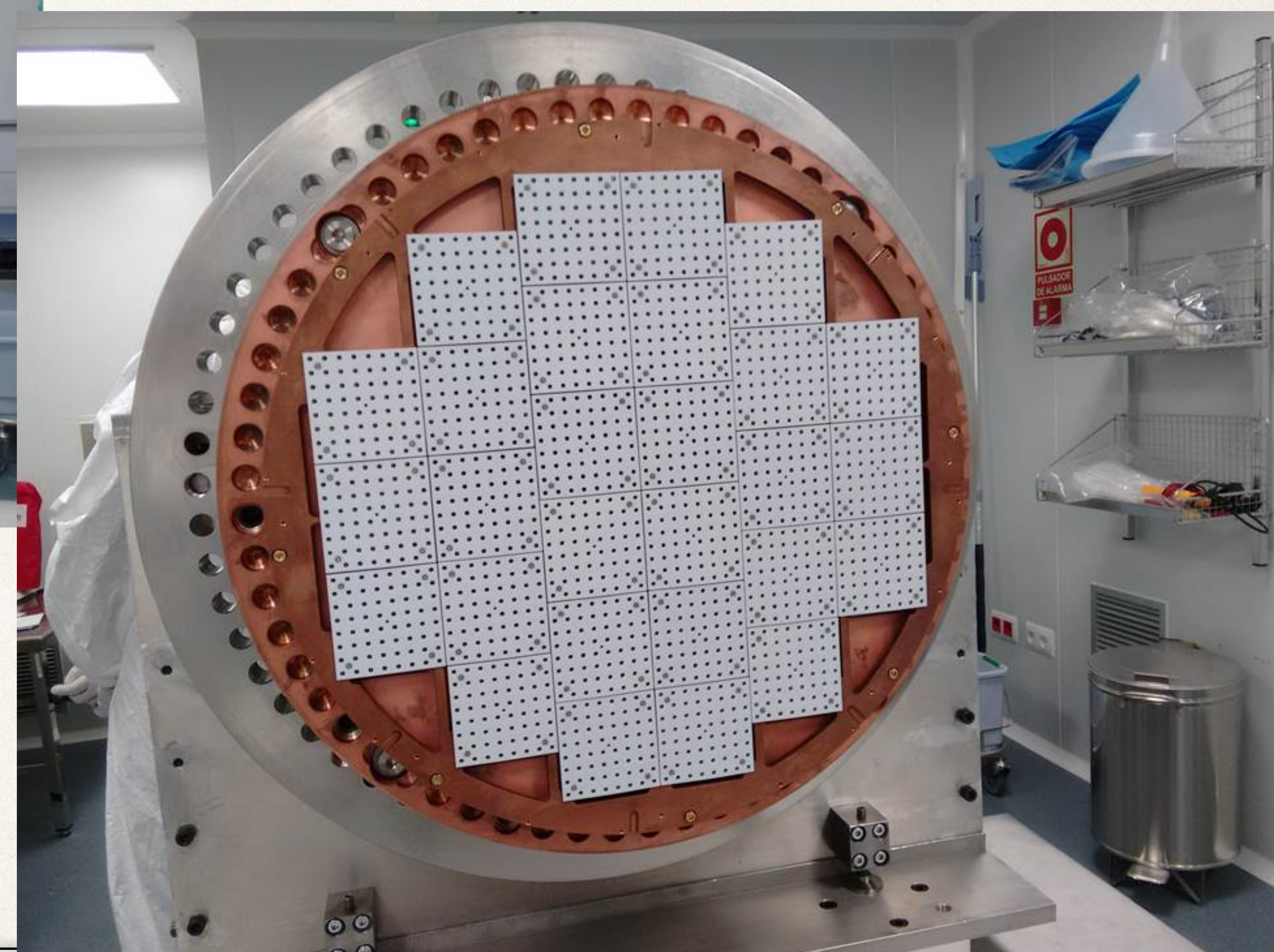
PMTs assembled

Enery plane installed.
PMTs calibrated.
First S1 and S2 signals in Ar detected.

Tracking plane



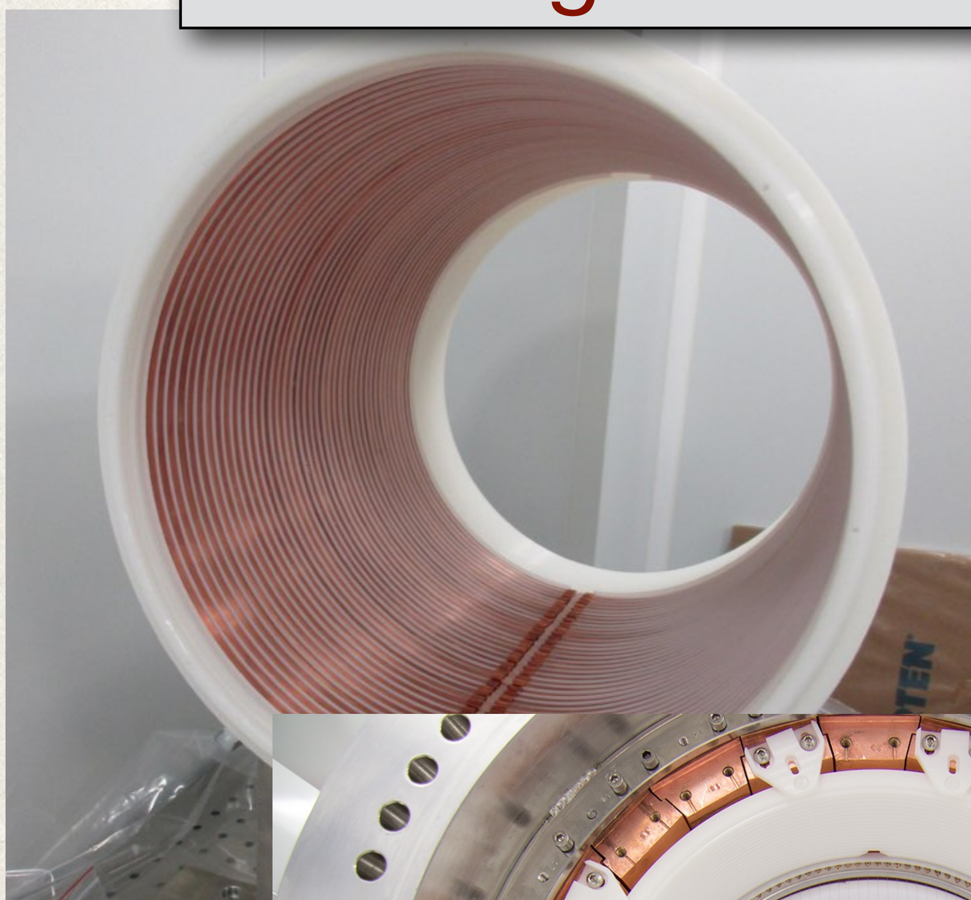
Tracking Plane with ~1800 SiPM
fully tested

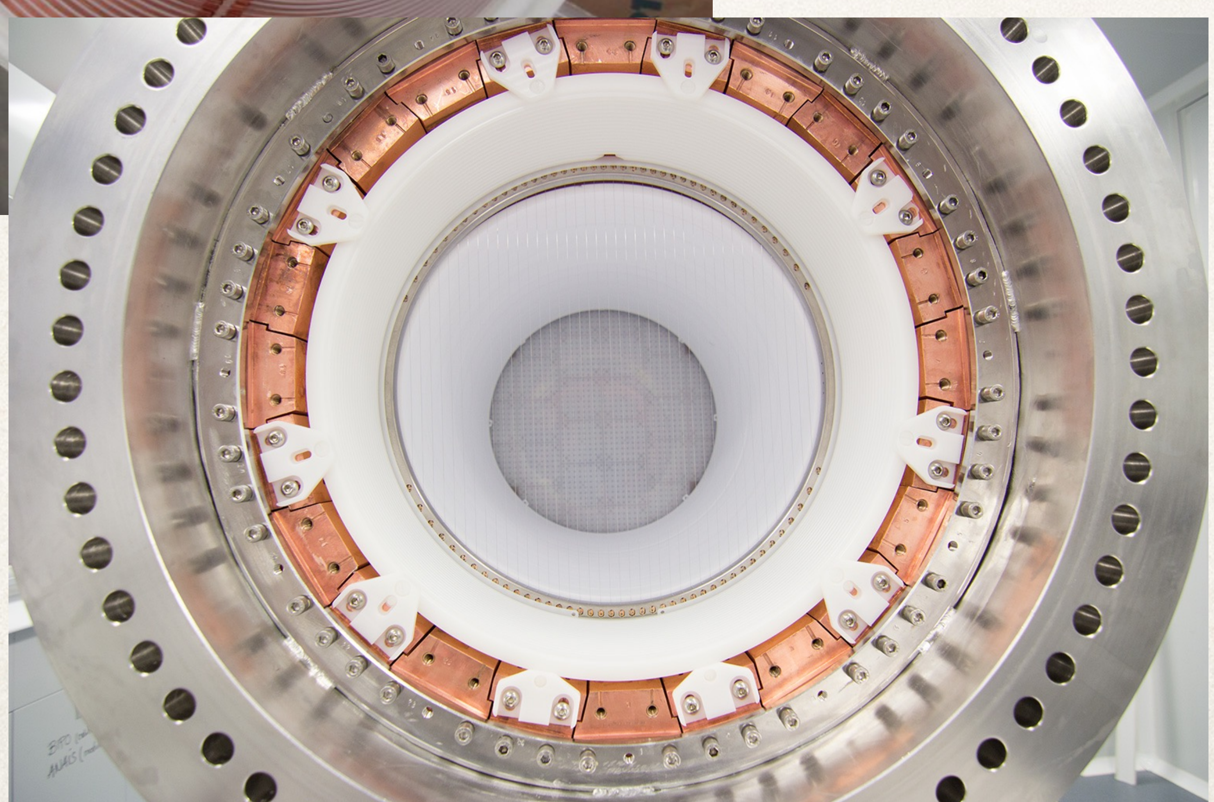


Tracking plane installed.
Boards covered with reflecting Teflon, to increase light ouptut.

Field Cage

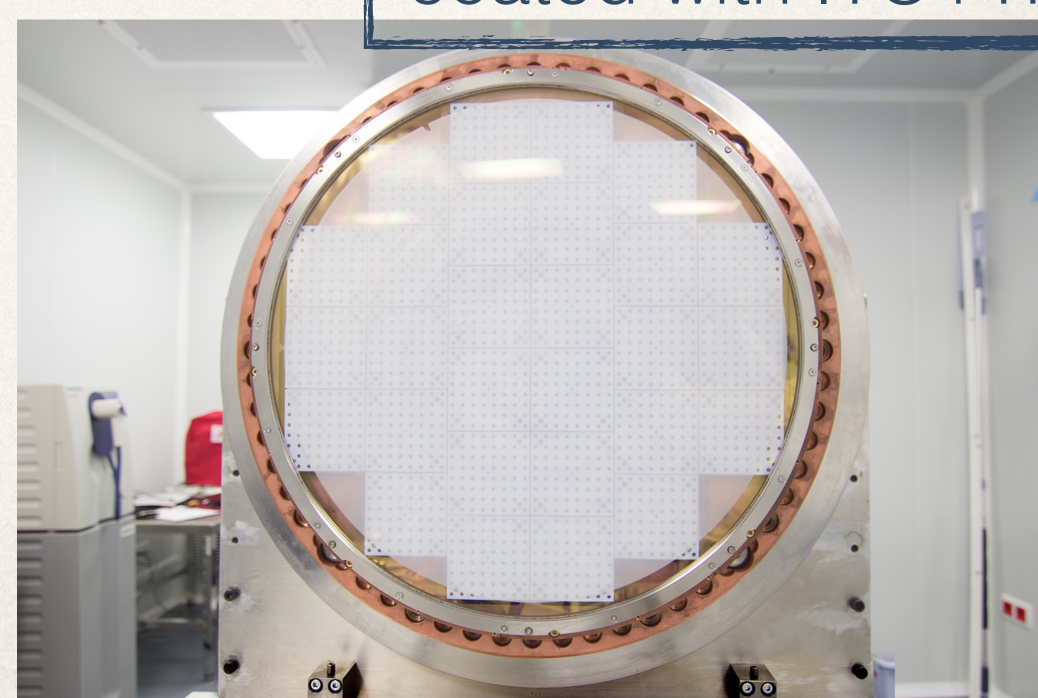
Field Cage installed



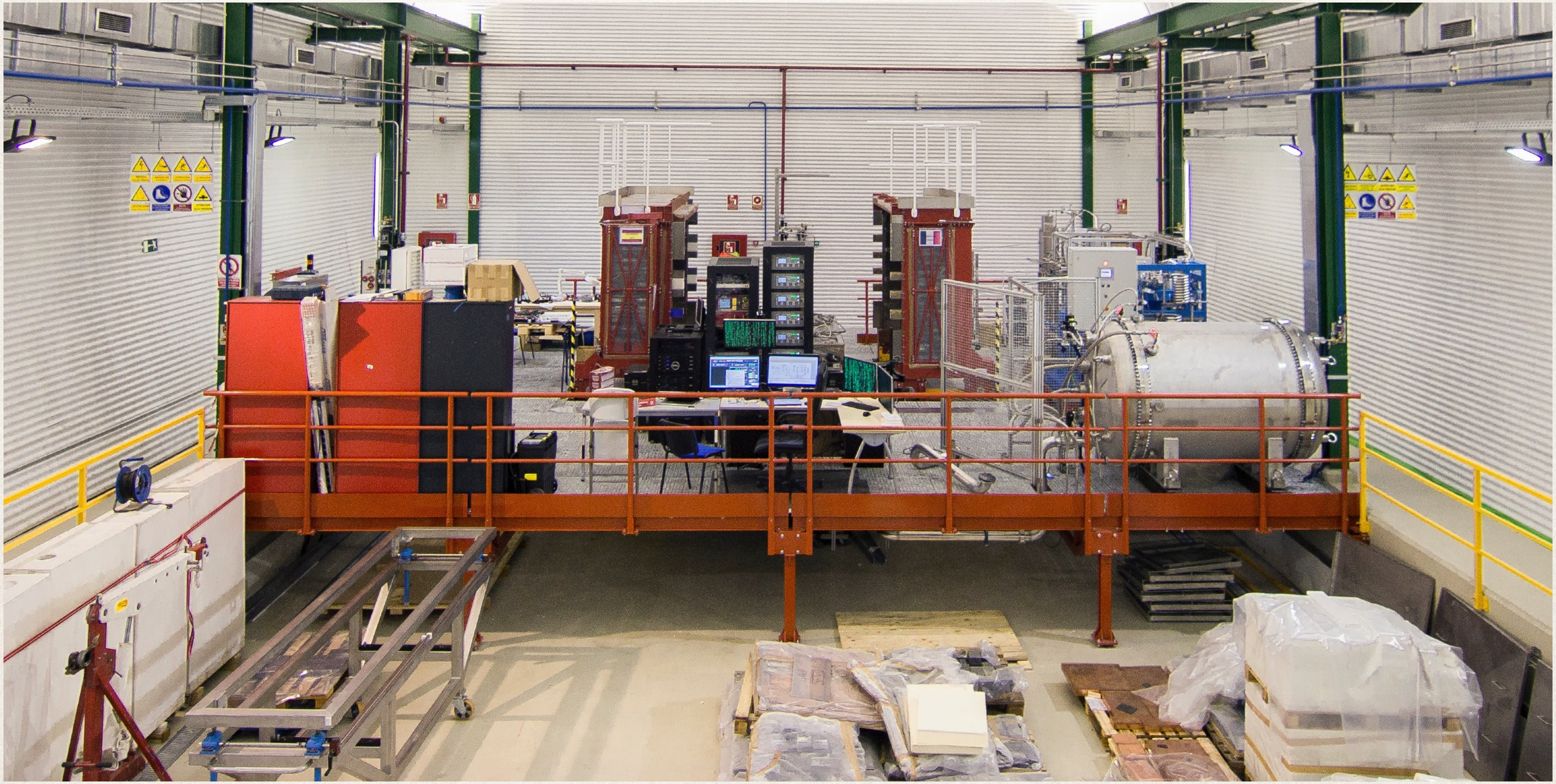


High Voltage Feedthroughs tested at 30kV in DEMO.

Anode quartz plate coated with ITO+TPB



Detector in the Canfranc Underground Laboratory



NEW Schedule

- Detector completed. Argon gas circulating now in system.
- Commissioning run (full detector): June-September: 2016
- Calibration run (energy resolution, topological signature: Fall 2016 (October-December).
- Physics run (background model, bb2nu): Q1-Q4 2017.

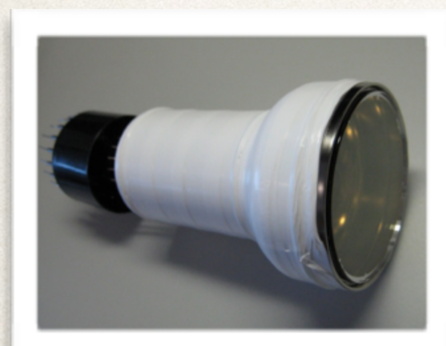
NEXT 100 kg detector at LSC: main features

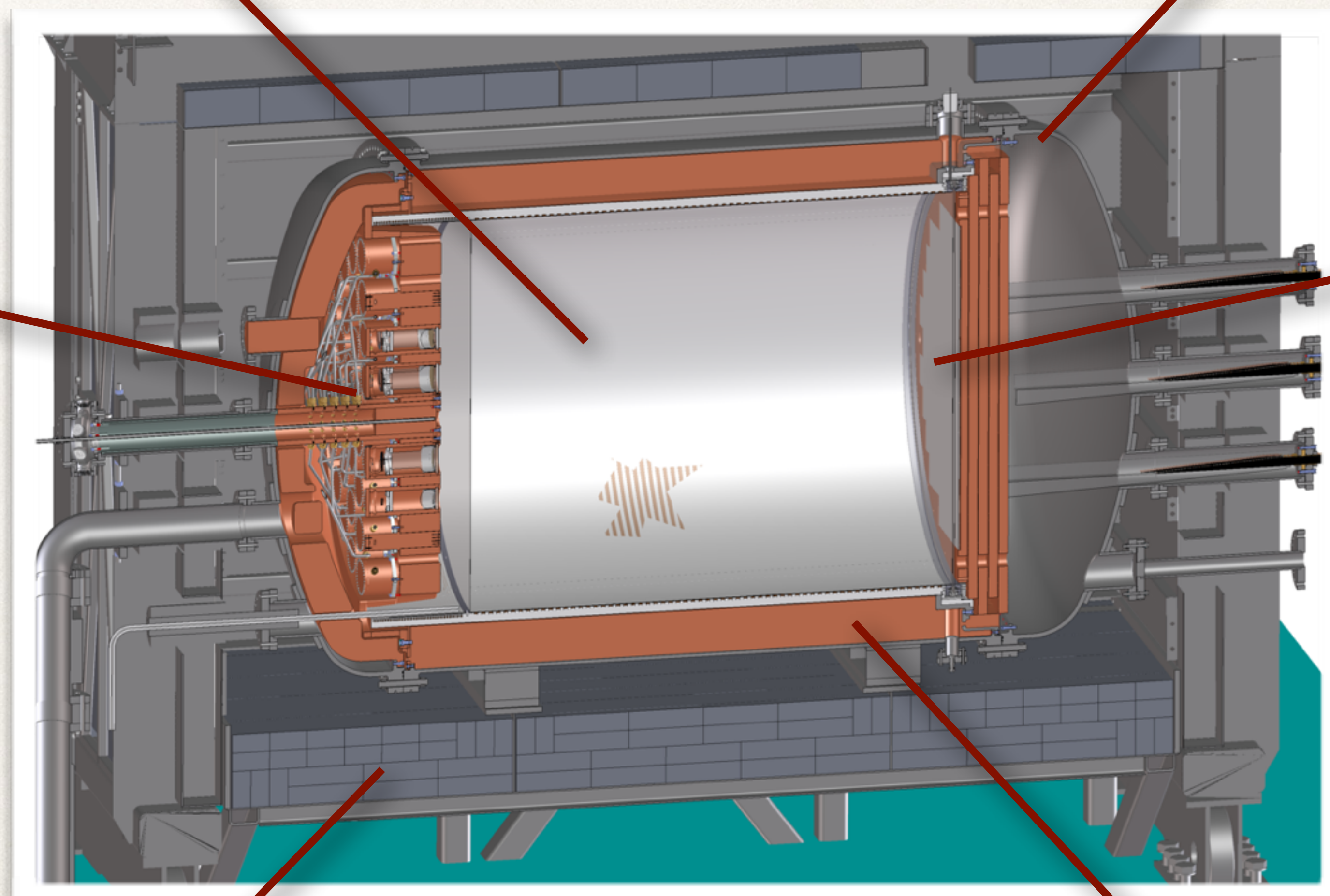
Time Projection Chamber:
100 kg active region, 130 cm drift length

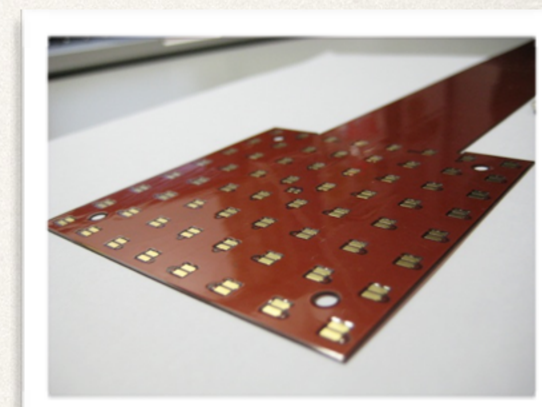
Pressure vessel:
stainless steel,15 bar max pressure

Energy plane:
60 PMTs,
30% coverage

Tracking plane:
7,000 SiPMs,
1 cm pitch



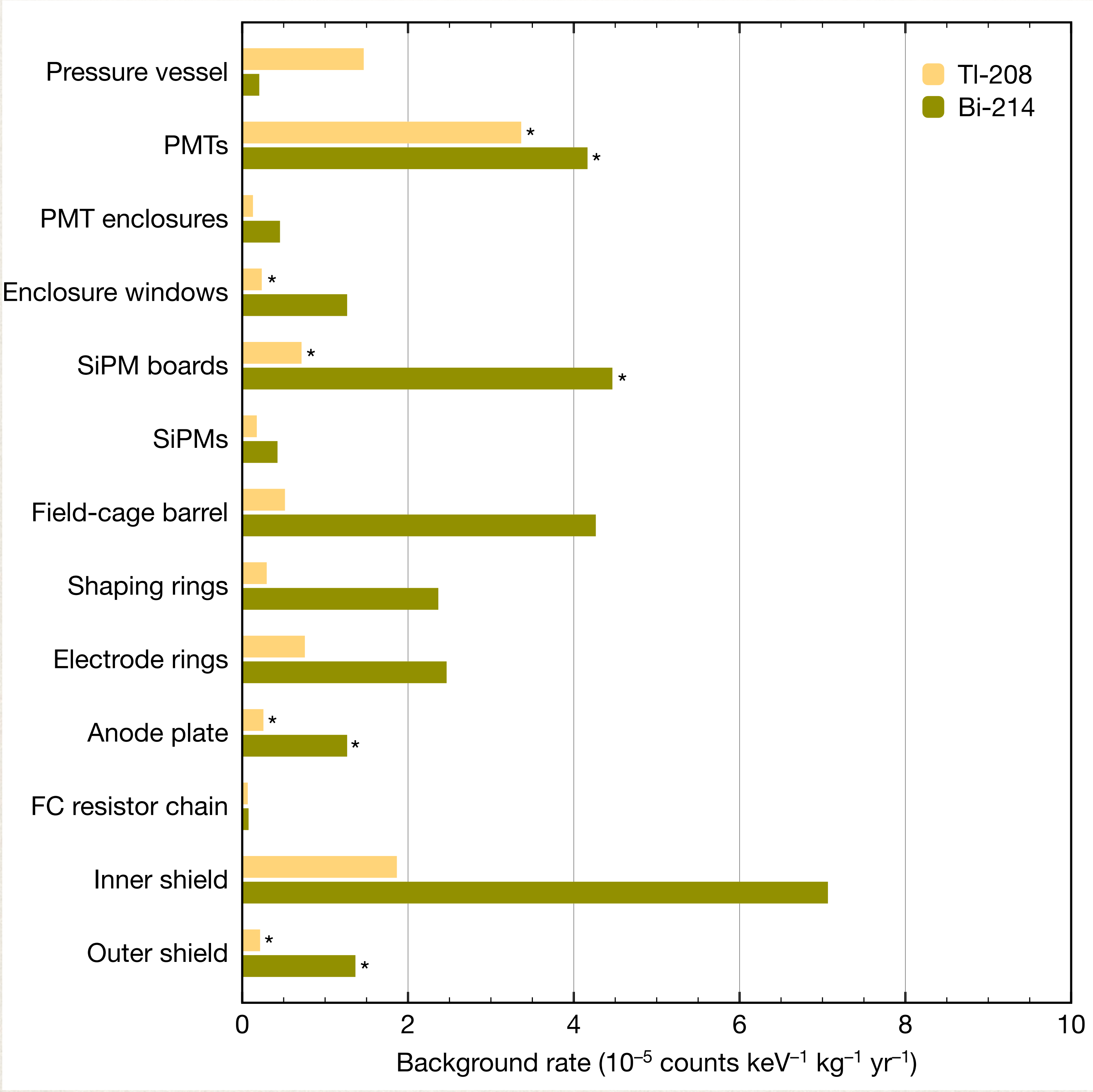




Outer shield:
lead, 20 cm thick

Inner shield:
copper, 12 cm thick

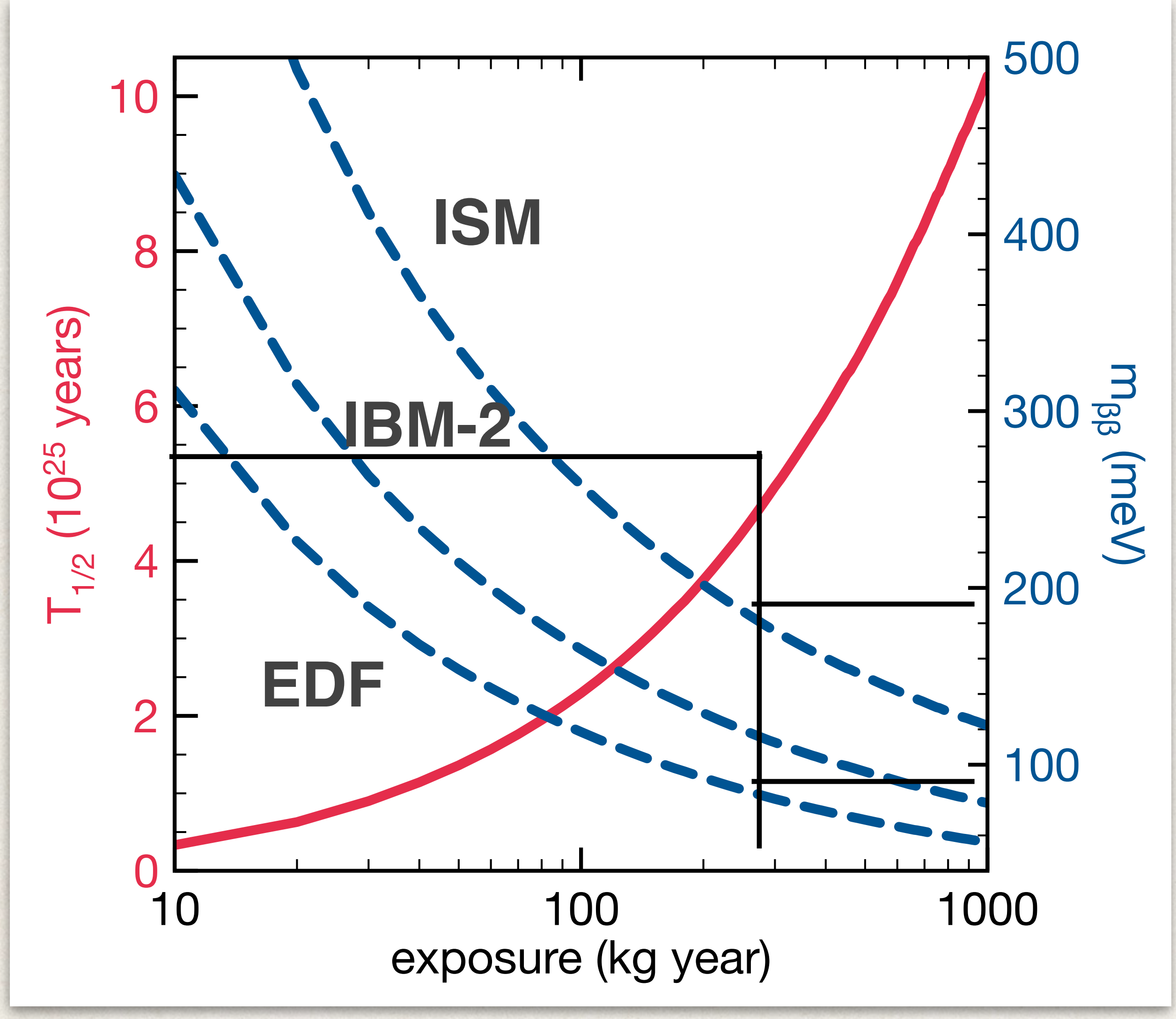
Background budget



- Expected background rate: 4 x 10^{-4} c/keV/kg/y
- Leading sources: PMTs and SiPM boards (KDBs), which contribute with equal amounts. PMTs + KDBs ~10^{-4} c/keV/kg/y in Bi-214
- Contribution of field cage and inner shield: only upper limits measured (taken as actual values, a conservative approach)

https://inspirehep.net/record/1407146

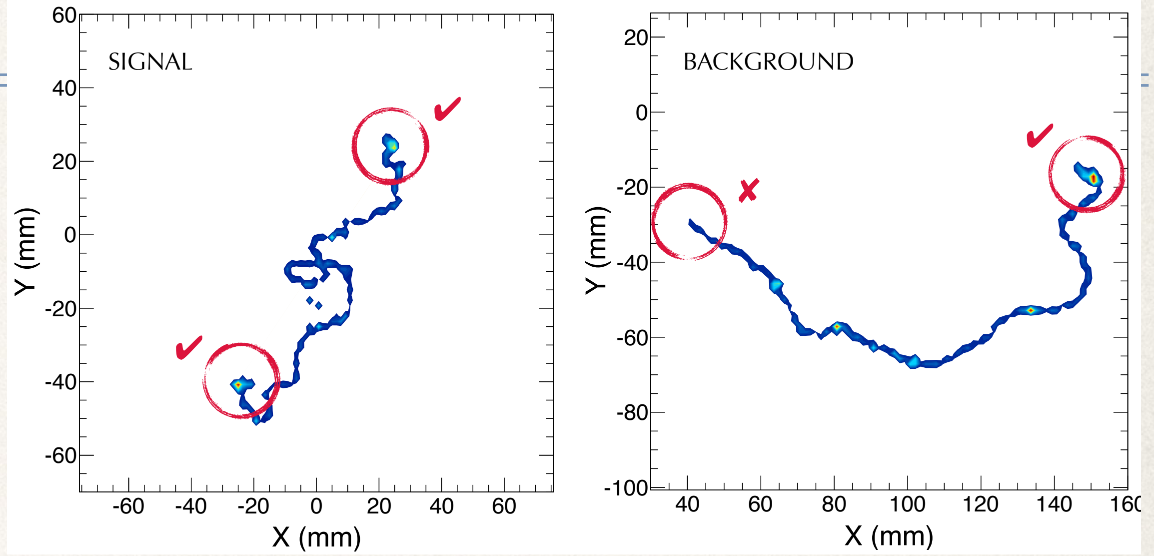
Sensitivity



- Expect 5 x 10^{25} y in 3 years run (2018-2020).
- mbb ~[90-180] meV depending on NME

Sensitivity of NEXT-100 to neutrinoless double beta decay
NEXT Collaboration (J. Martin-Albo (Valencia U., IFIC) *et al.*). Nov 30, 2015. 29 pp.
e-Print: **arXiv:1511.09246** **[physics.ins-det] | PDF**

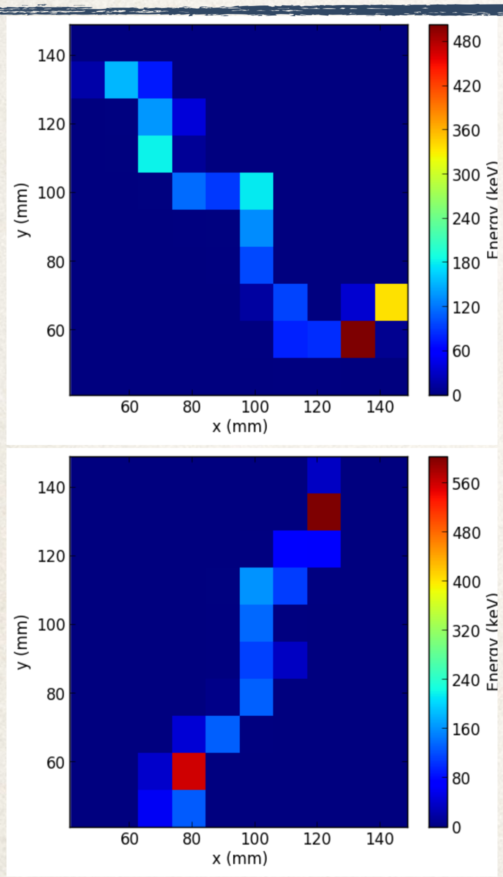
How to improve the background rejection?

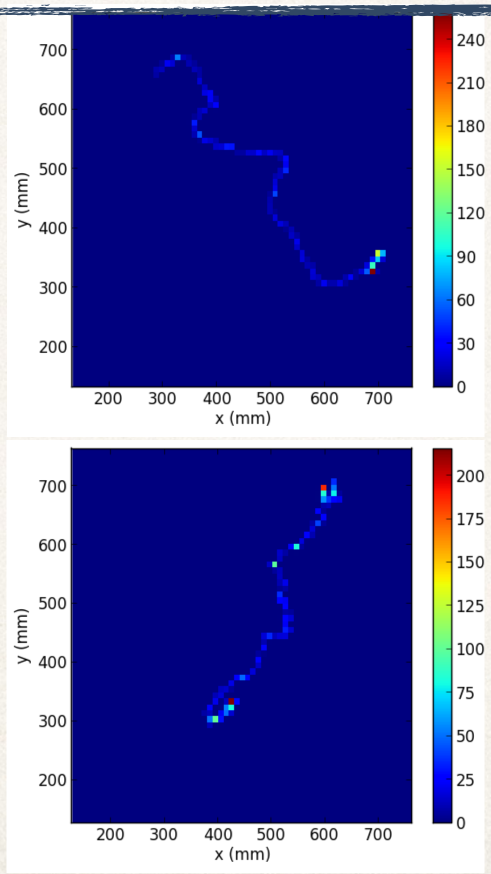


Effect of diffusion

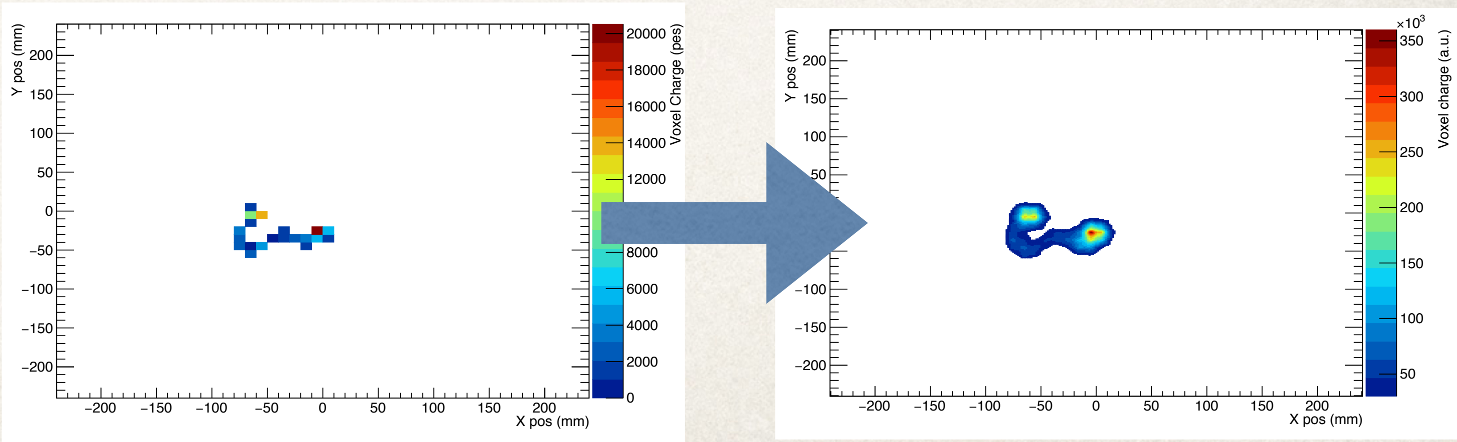
10mm voxels

2mm voxels



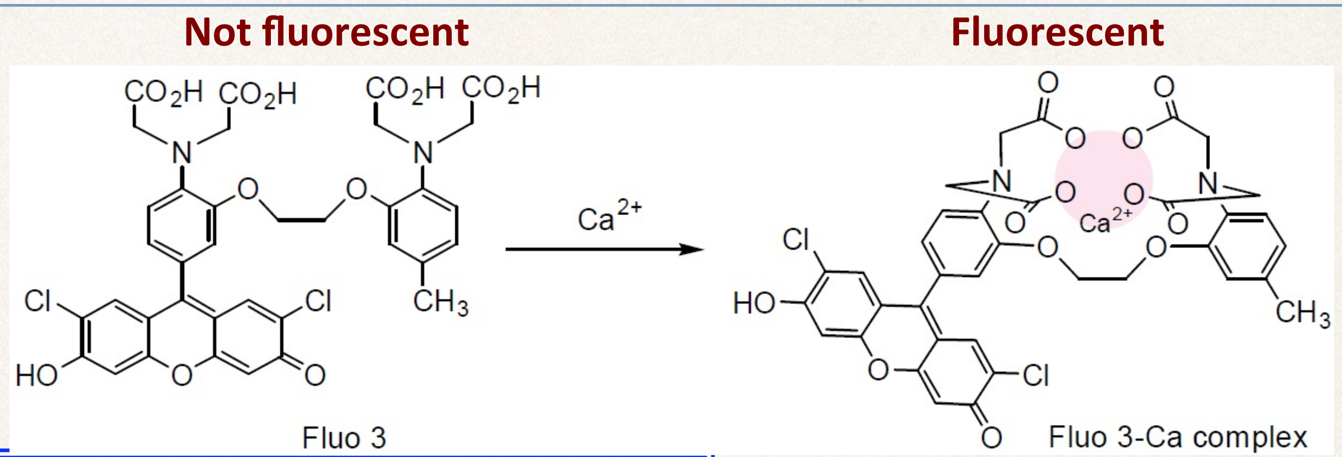


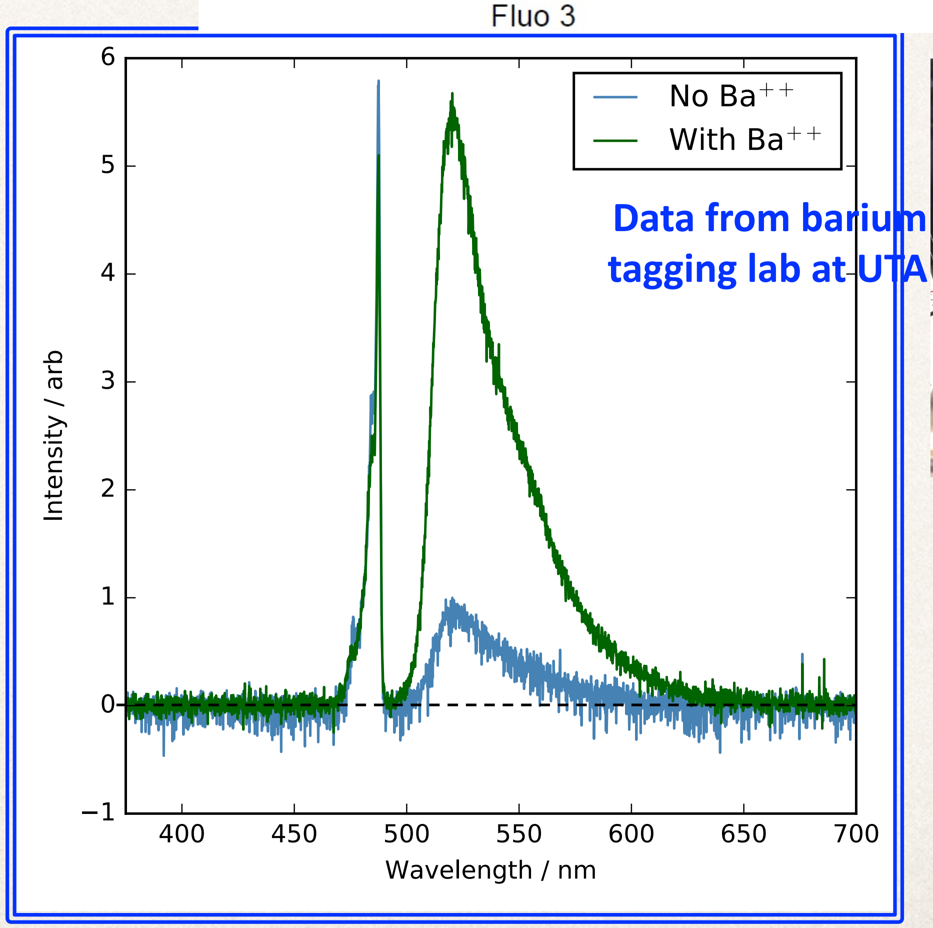
New reconstruction methods.
(See A.Simón poster)

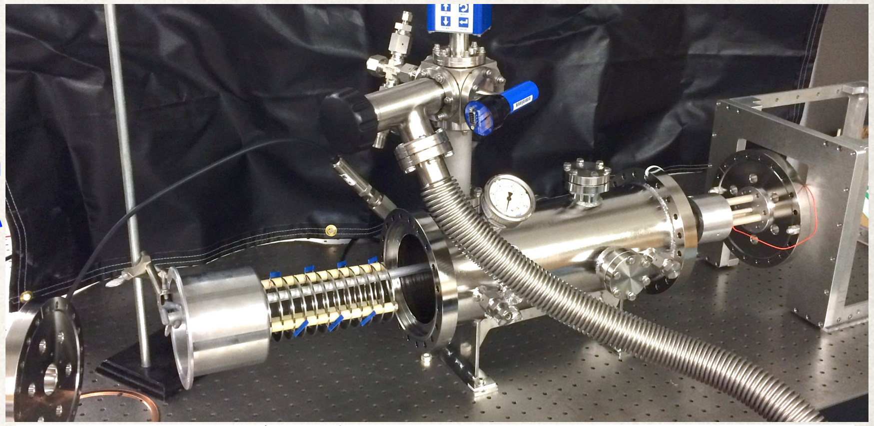


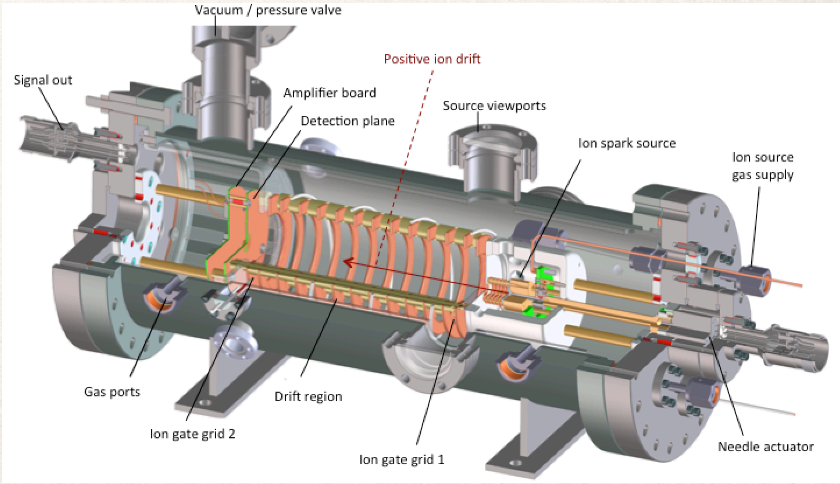
Single Molecule Fluorescent Imaging

- SMFI is a technique from biochemistry with demonstrated single-ion sensitivity.
- We are exploring its use in xenon gas for barium ion tagging
- If efficient barium tagging can be achieved, a zero background experiment can be realized.









For more info, see poster by B. Jones

Towards the ton scale

- TPCs extrapolate very well to large masses.
  - Symmetric detector. x2 in z.
  - Increasing the diameter will need some R&D to hold the HHV in the EL region with an homogeneous field.
- SiPM in both planes can reduce the background budget.
- Topological signature can get improved.
- Energy resolution may be improved (Fano factor = 0.15).
- Expected background rate $5 \cdot 10^{-5}$ c/keV/kg/y.
- Gas Xenon can provide a technique (SMFI) for a background free experiment.

Summary & Outlook

- R&D phase completed.
- Operation underground started.
- NEXT-100 will reach a sensitivity competitive with the best experiments in the 100kg scale.
- Excellent prospects for tonne scale scalability.