NEXT-DEMO: a large electroluminescent TPC for double-beta decay search

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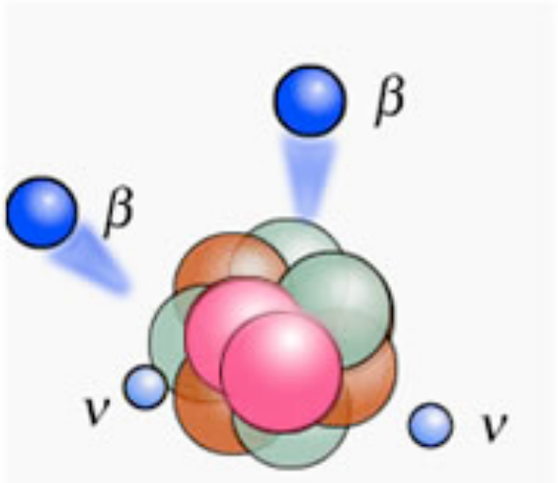
On behalf of the next *Collaboration*

Outline

- *Double beta decay*
- *The NEXT concept*
- *Detection process*
- *NEXT-DEMO prototype*
- *NEXT-100 Status*

Double Beta Decay

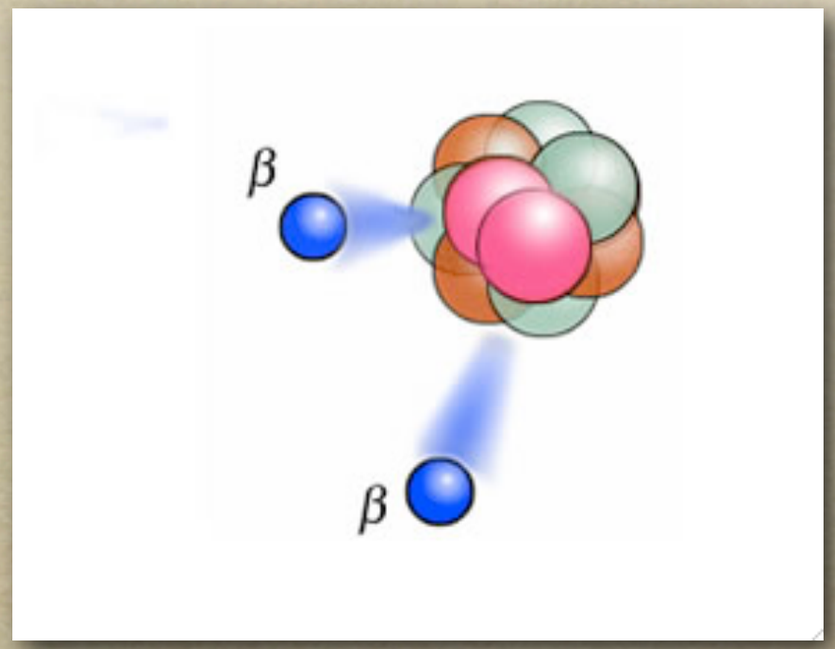


$\beta\beta 2\nu$

$$^{A}_{Z}X \rightarrow ^{A}_{Z+2}Y + 2e^{-} + 2\bar{\nu}_{e}$$

Allowed by Standard Model.
Measured in several nuclei.

$$T_{1/2} \sim 10^{18} - 10^{21}\ y$$



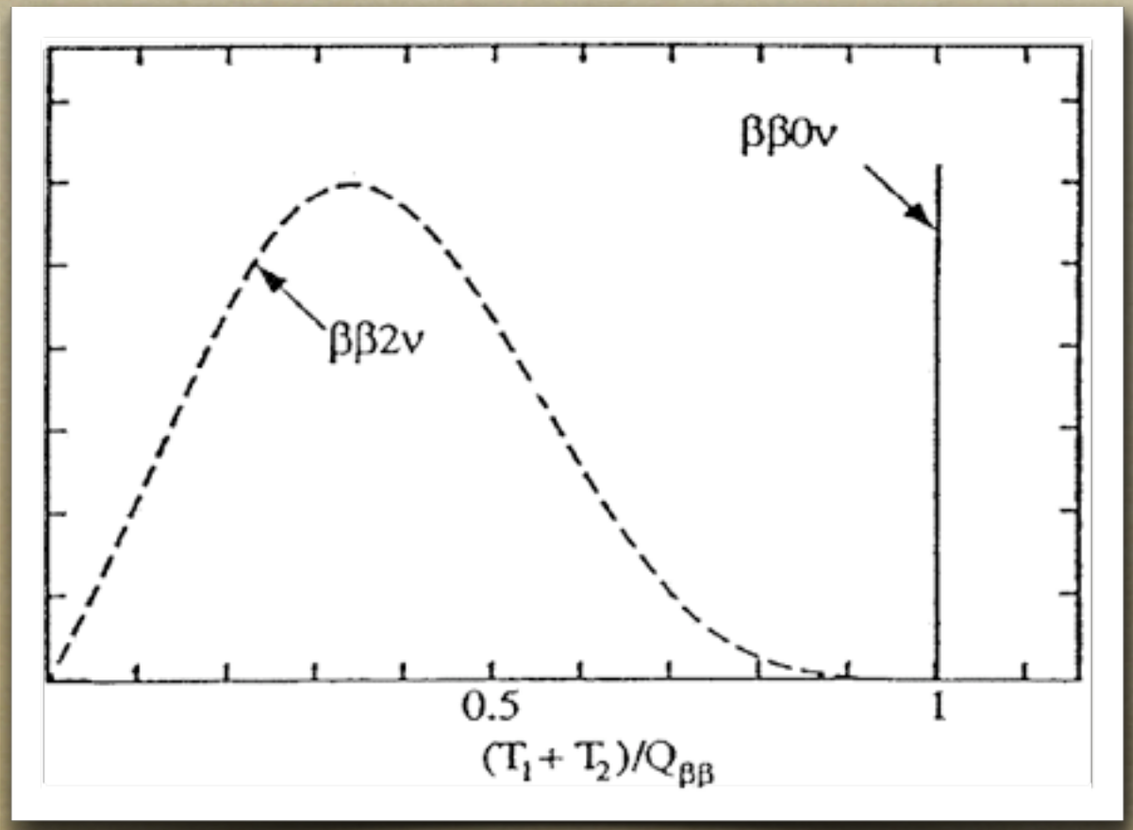
$\beta\beta 0\nu$

$$^{A}_{Z}X \rightarrow ^{A}_{Z+2}Y + 2e^{-}$$

Lepton number violating process.
Requires massive, Majorana neutrinos.

$$T_{1/2} > 10^{25}\ y$$

Neutrinoless Double Beta Decay Signature

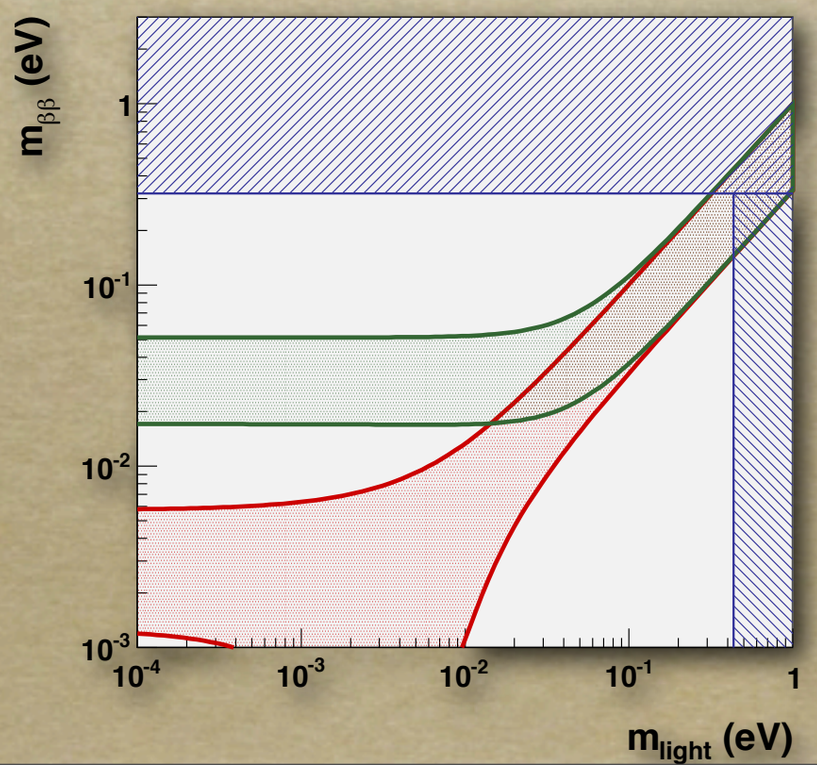


bb0v spectrum

$$T_{1/2} = \log 2 \, \frac{N_A \; Mt}{A \; N_{\beta\beta}}$$

$$(T^{0\nu}_{1/2})^{-1} = G^{0\nu}(Q, Z) \; |M^{0\nu}|^2 \; m^2_{\beta\beta}$$

$$m_{\beta\beta} = \left| \sum_i m_i U^2_{ei} \right|$$



Both energy resolution and background rejection is a must

The NEXT concept

A high-pressure gaseous Xenon, electroluminescent TPC.

The NEXT concept

- *Slow two-neutrino mode.* $T_{1/2} \sim 10^{21}\ y$
- *Easy to enrich and purify.*

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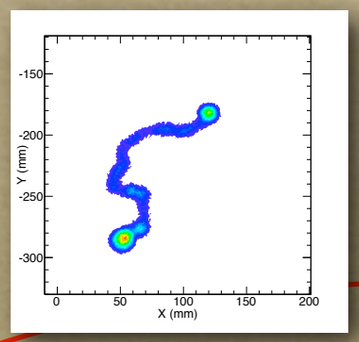

- *Topology information.*
- *Transparent to 2-3MeV gammas.*

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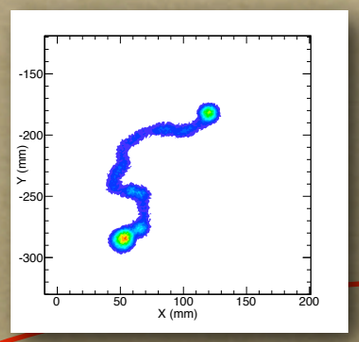

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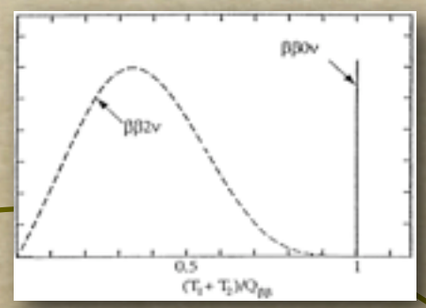
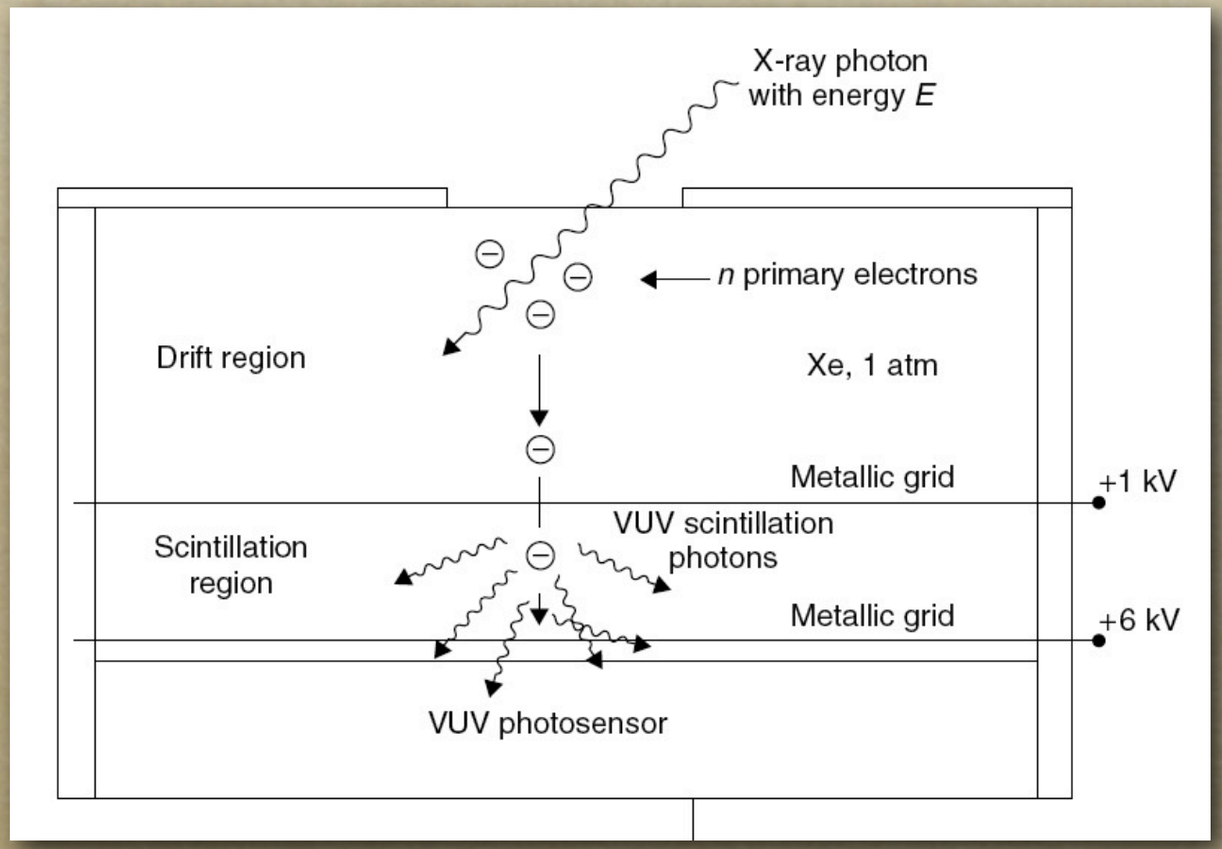
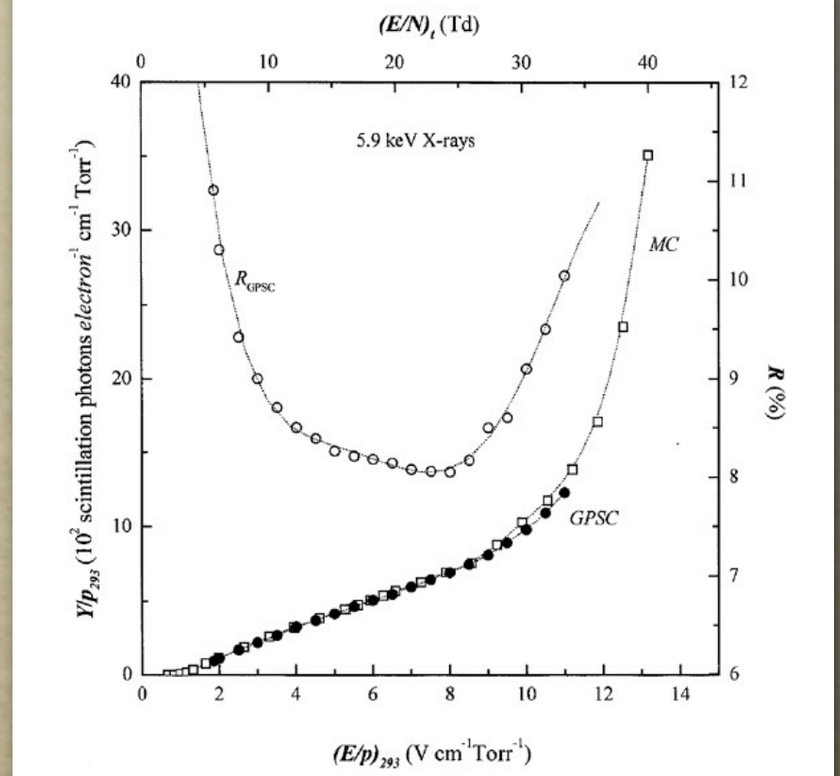


- Resolution <1%FWHM.
- Topology reconstruction without losing energy resolution.

Electroluminescence



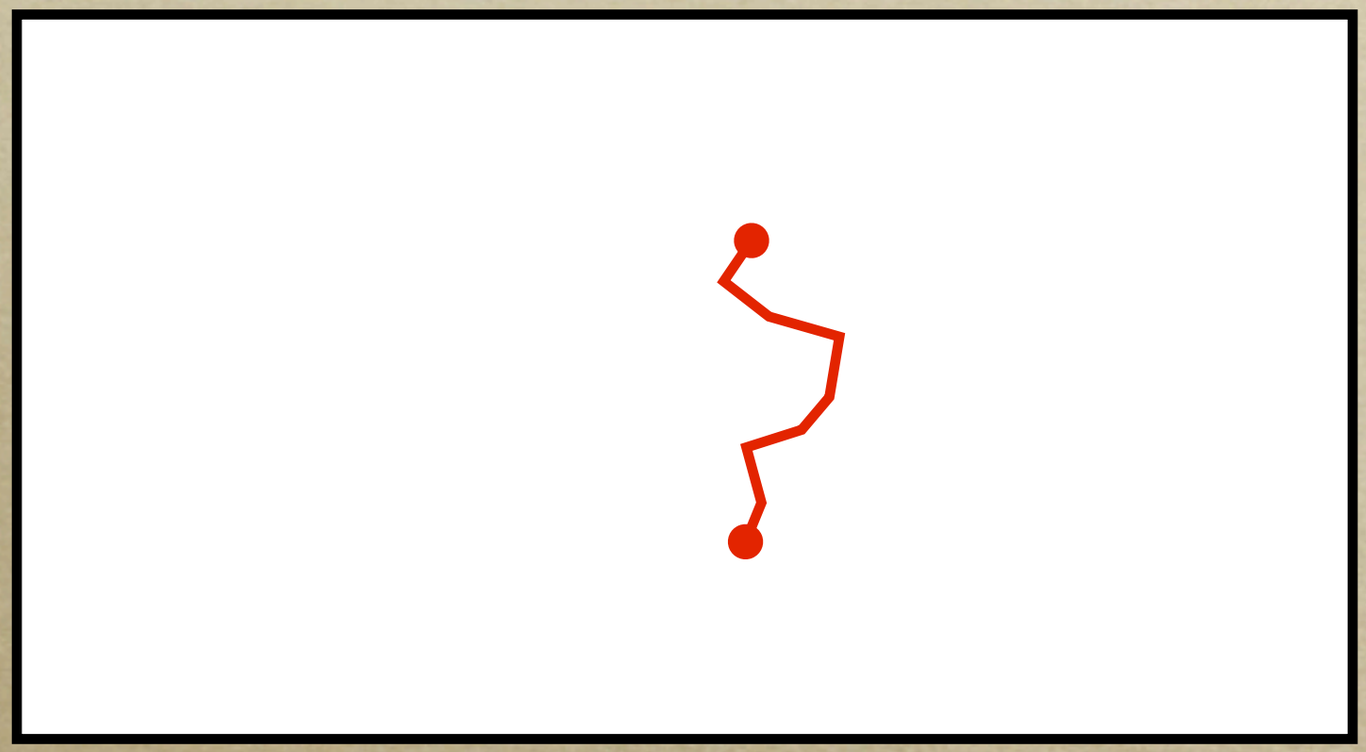


- *Emission of scintillation light after atom excitation by a charge accelerated by a moderately large (no charge gain) electric field.*
- *Linear process, huge gain, small statistical fluctuations.*
- *Used in NEXT to amplify the ionization signal.*

Detection process

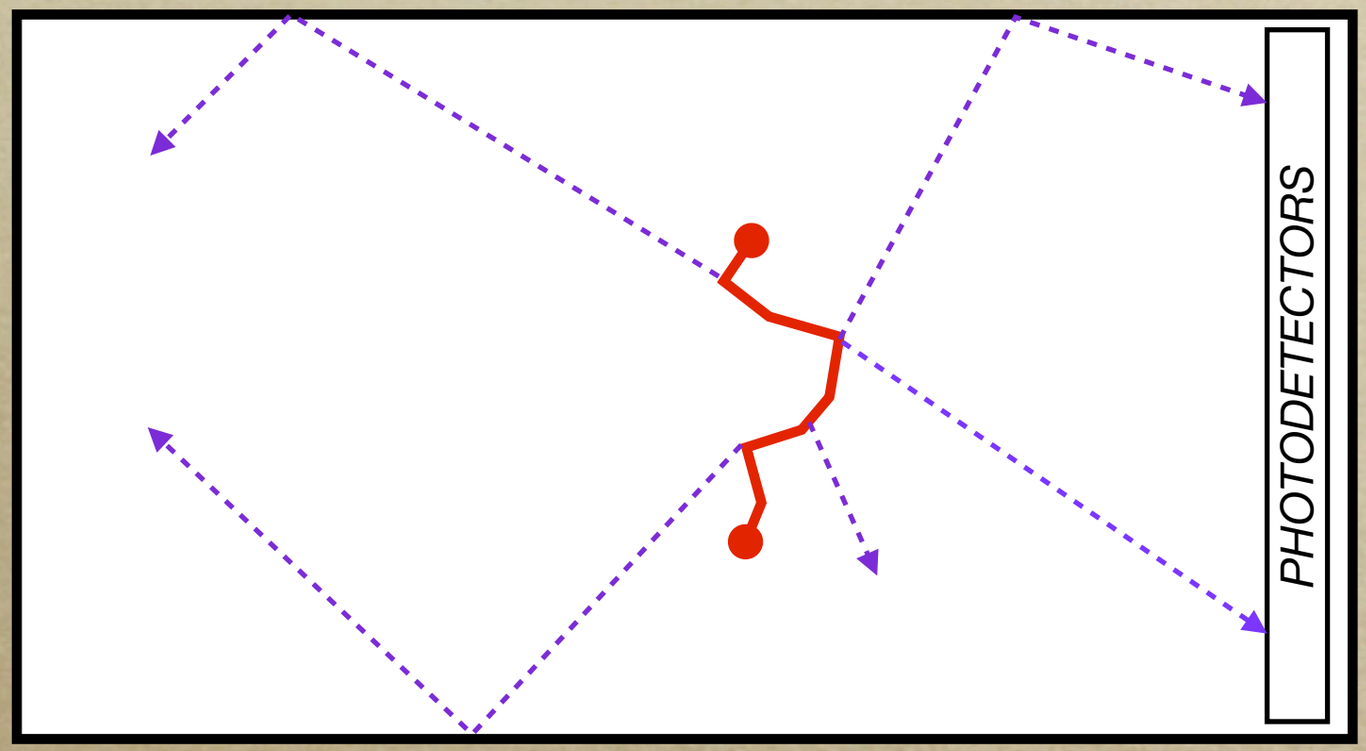
- *Cylindrical TPC filled with highly enriched (>90%) ^{136}Xe gas at 15 bar pressure.*
- *TPC walls lined with highly reflective material and coated with TPB improving light detection.*
- *Baseline detector with 100 - 150 kg fiducial mass (2 m^3): NEXT-100.*

Detection process



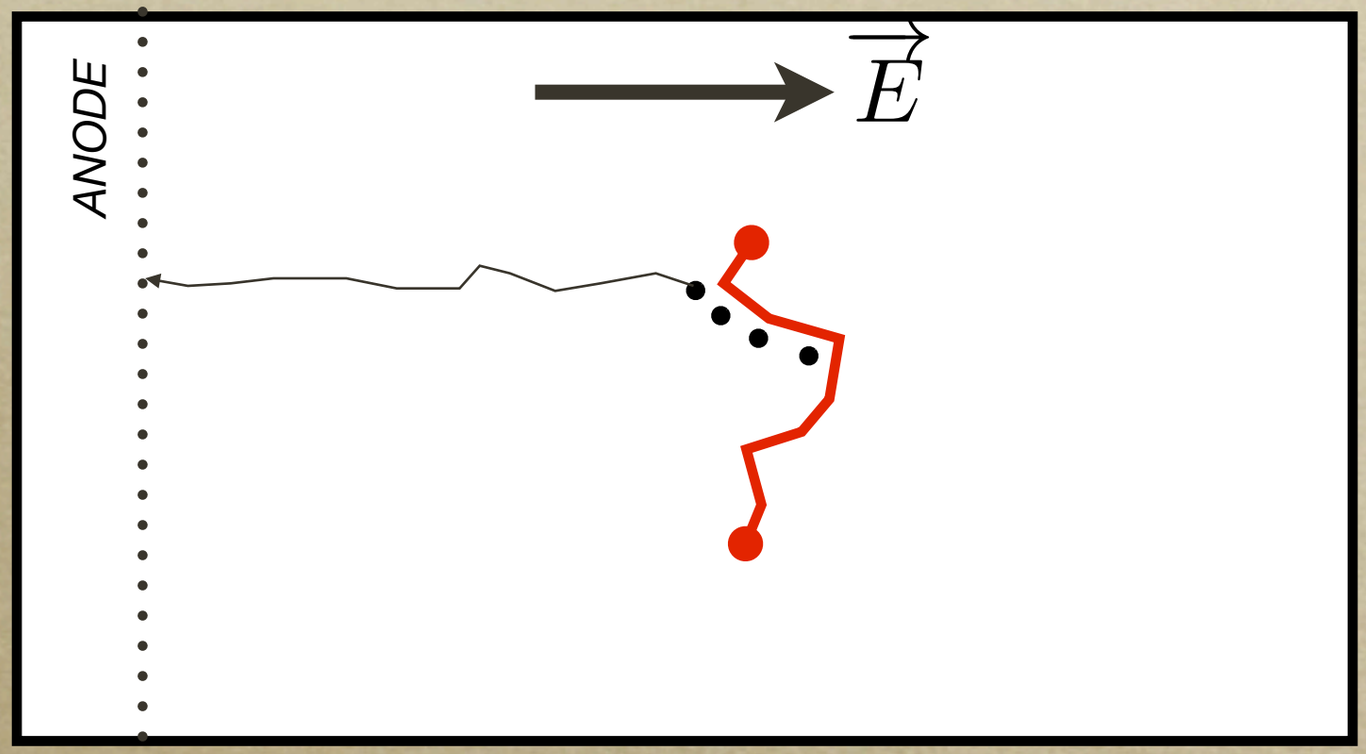
- *A ^{136}Xe isotope decays emitting the two electrons.*
- *They propagate through the HPXe ionizing and exciting its atoms.*

Detection process



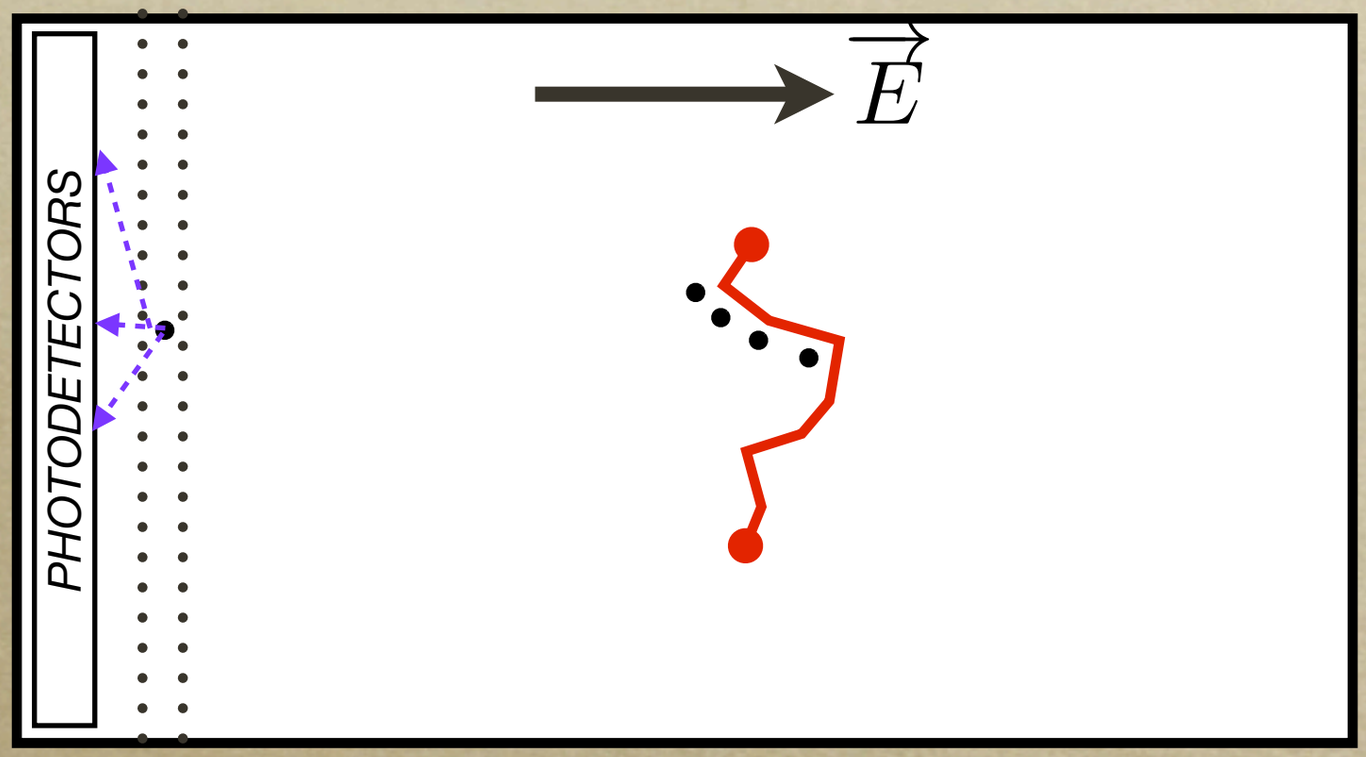
- *Prompt primary scintillation light emission in VUV (~175 nm). About 100 eV needed to create a primary scintillation photon.*
- *Detect faint signal via sensitive photo-detectors (PMTs) behind transparent cathode.*
- *Determine t_0 and therefore event position along drift.*

Detection process



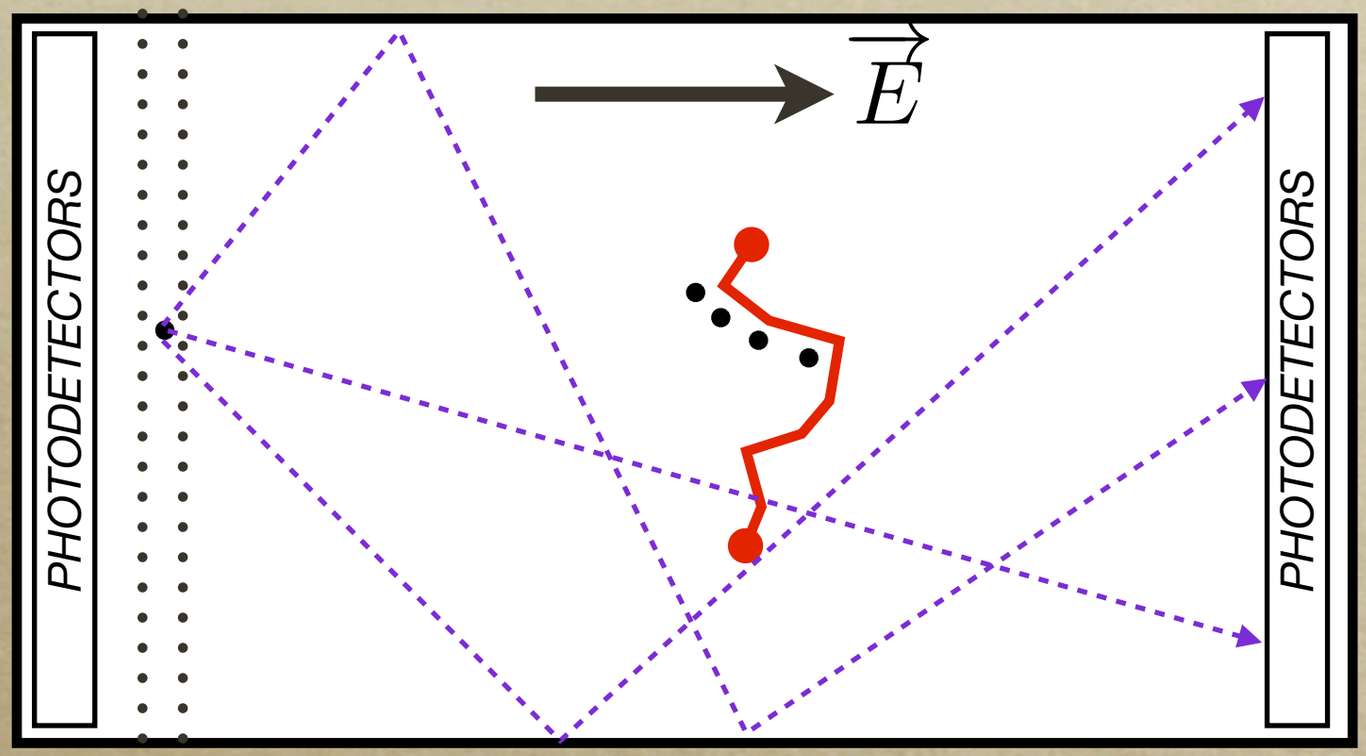
- *Create ionization charge in Xe: ~25 eV to create one electron-ion pair.*
- *Electrons drift toward anode with velocity ~1 mm/us in a ~0.3 kV/cm electric drift.*
- *At 10 bar pressure, non-negligible diffusion: 9 mm/√m transverse, 4 mm/√m longitudinal).*

Detection process



- *Additional grid in front of anode creates ~0.5 mm thick region of more intense field: E/p ~3 kV/cm/bar.*
- *Secondary scintillation light (electroluminescence) created in between grids by atomic de-excitation, with very linear gain of order 10^3 and over a ~2us interval.*
- *Finely segmented photo-detector plane (MPPCs) just behind anode performs "tracking".*

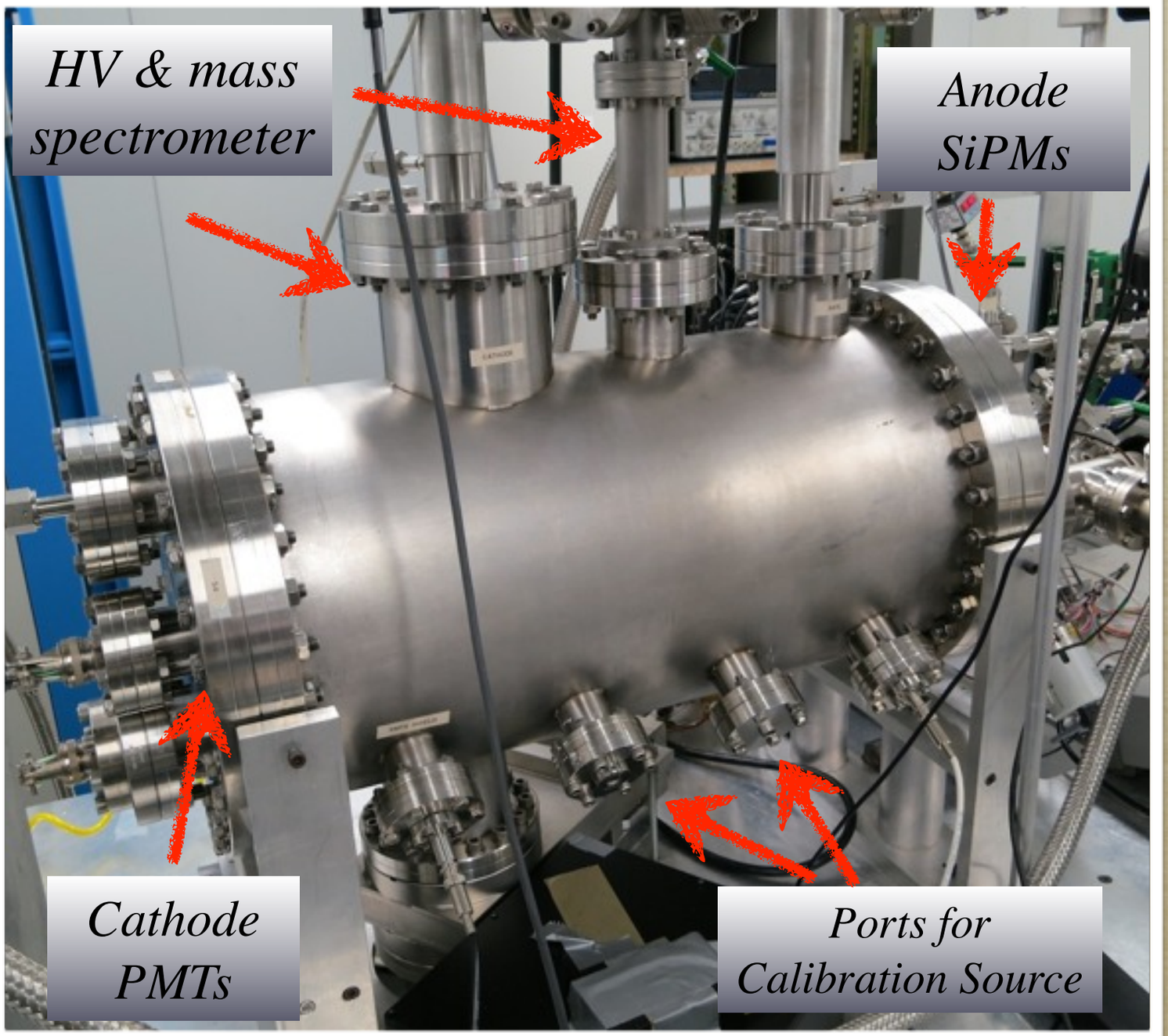
Detection process



- *Electroluminescence, emitted isotropically, also reaches cathode.*
- *Same array of photo-detectors used for t_0 measurement is also used for accurate calorimetry.*

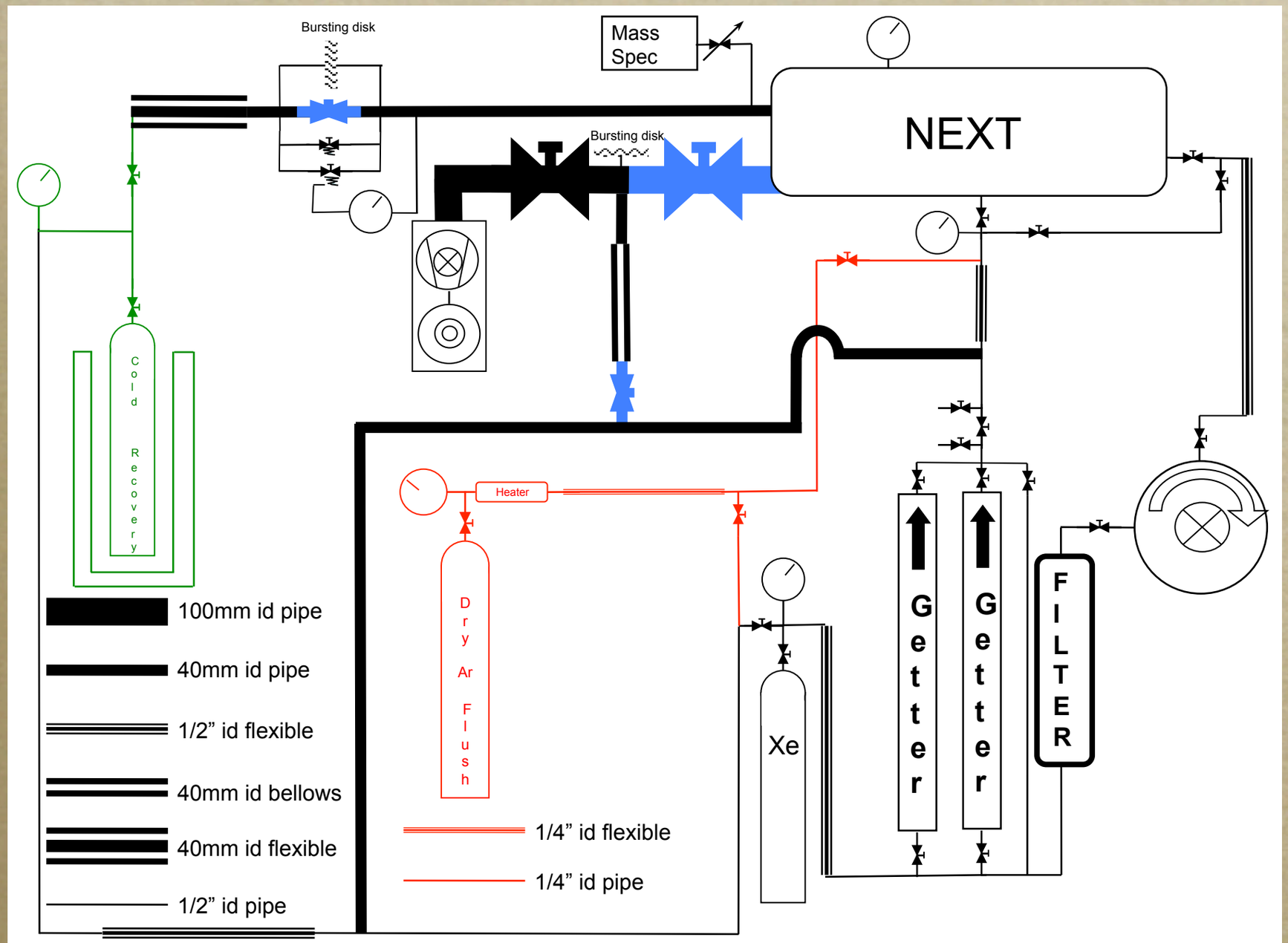
NEXT-DEMO Prototype

NEXT-DEMO: PRESSURE VESSEL



- *Designed at IFIC*
- *Stainless Steel*
  (Not radiopure)
- *30 cm diameter, 60 cm length*
- *Operational pressure: up to 15 bar*

NEXT-DEMO: GAS SYSTEM

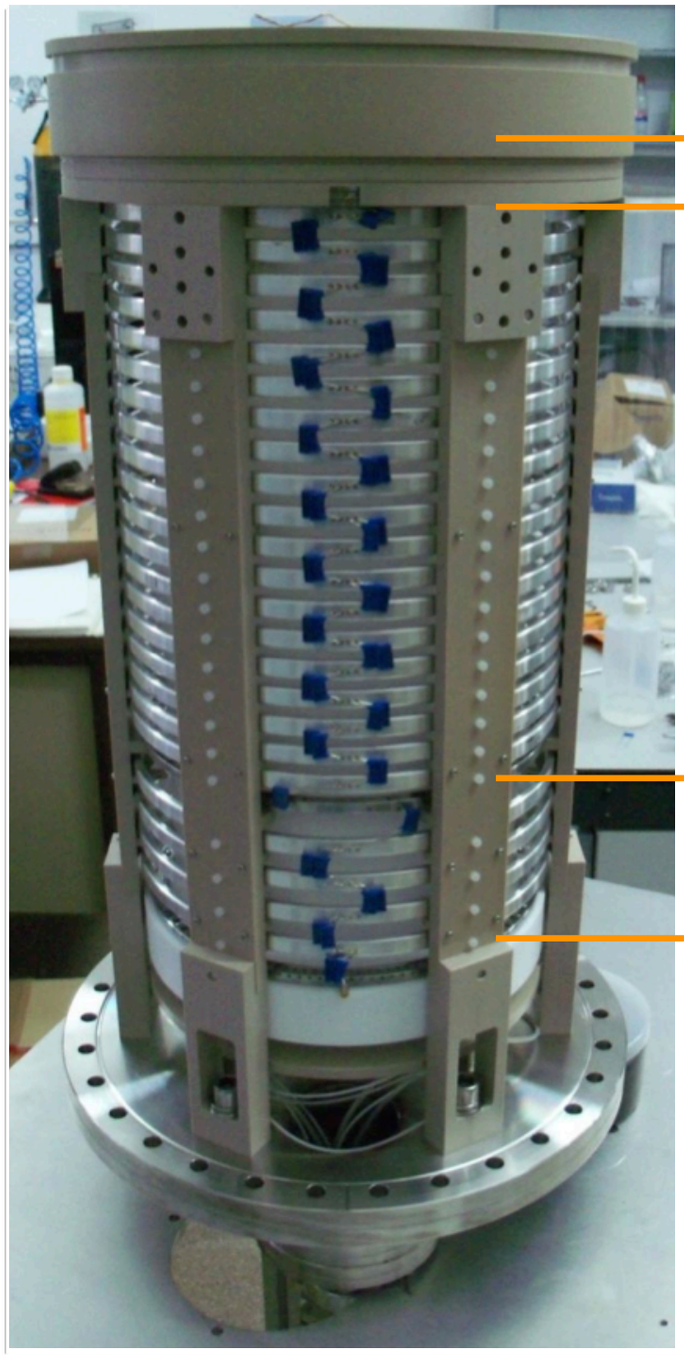


Schematic of the NEXT-DEMO gas system

Functions:

- ***Evacuation***
  ~10^{-7} mbar
- ***Pressurization***
  ~ up to 15 bar
- ***Recirculation***
  ~10l/min @ 10 bar
- ***Purification***
  ~ both room-temperature and hot getters

NEXT-DEMO: TIME PROJECTION CHAMBER



- *Designed and built by Texas A&M*
- *Gate and Anode:*
  88% open area meshes
- *Drift Region:*
  E ~ 0.3 KV/cm
- *EL Region:*
  E ~ (2 - 3) KV/cm/bar

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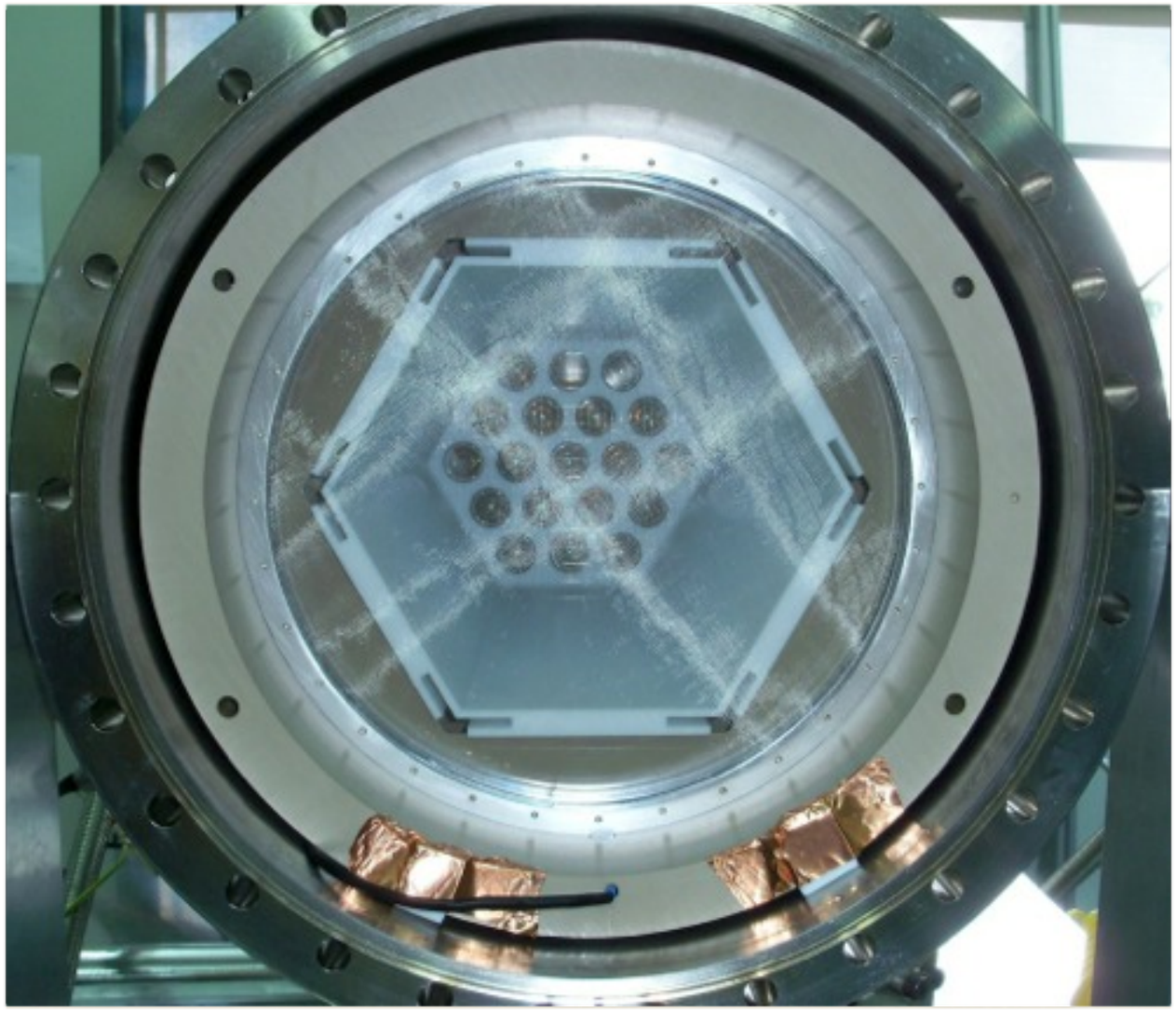
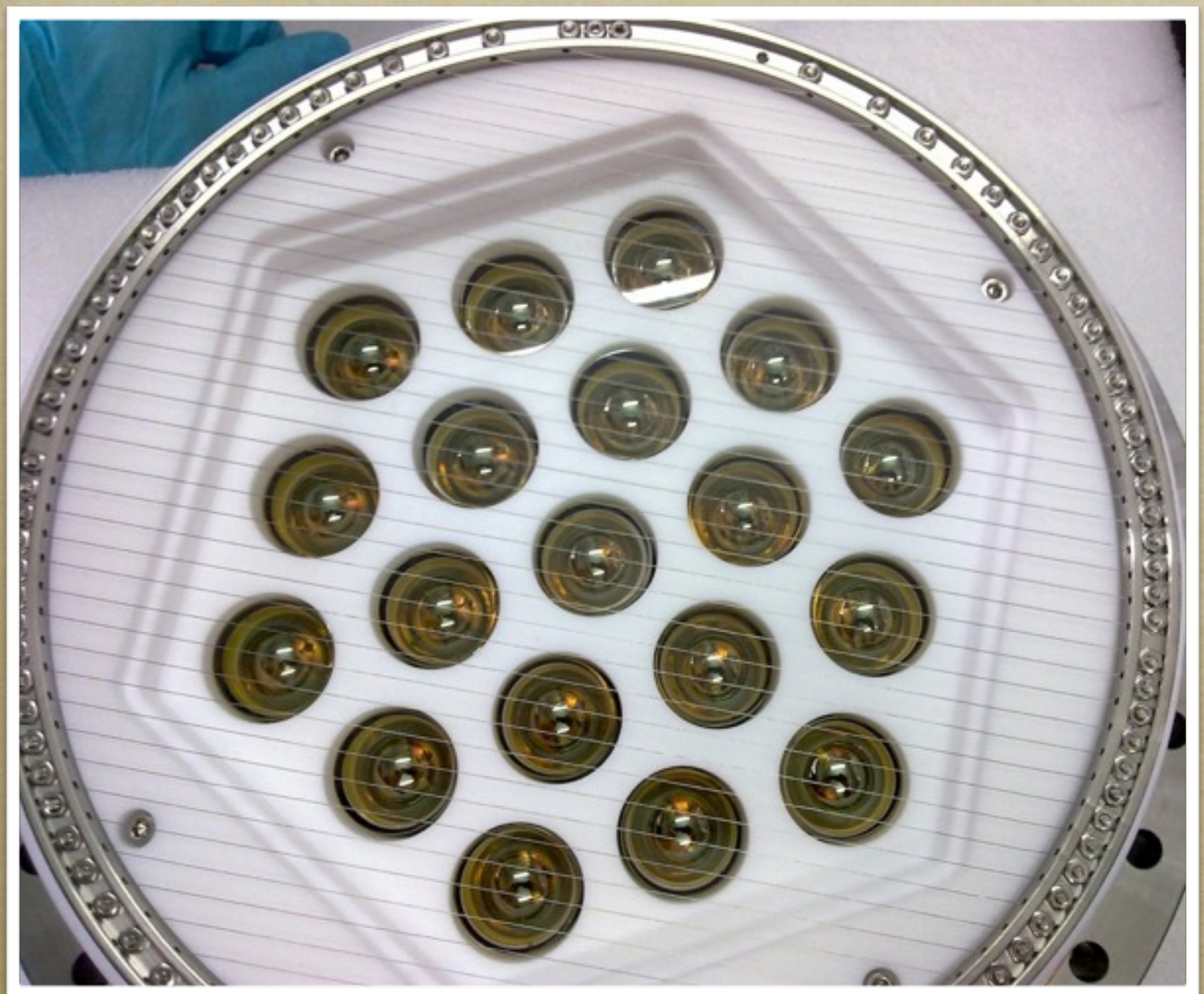


Light tube cross section

TPB coated to shift light to 430 nm

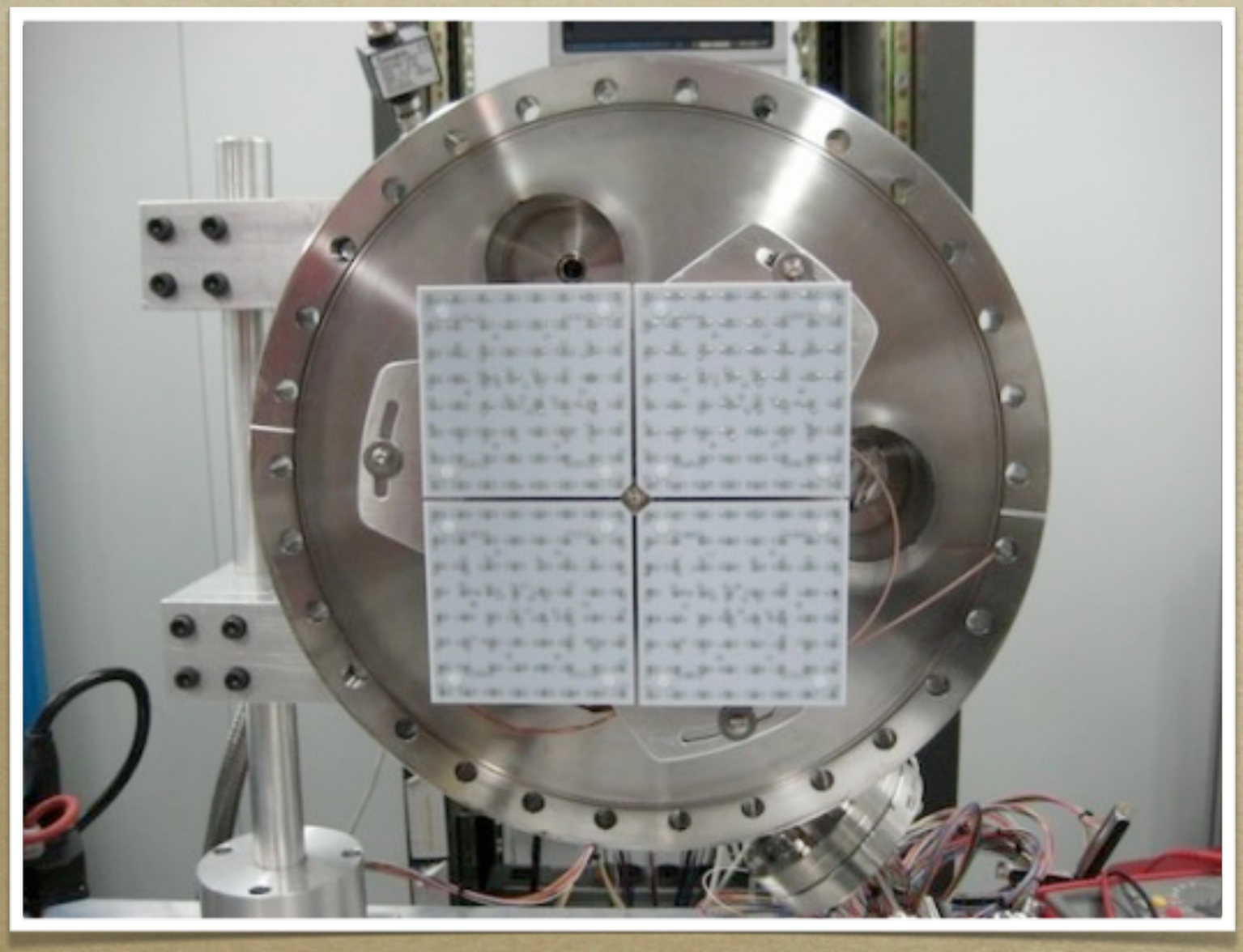
NEXT-DEMO: ENERGY PLANE



Energy Plane of NEXT-DEMO Prototype

- *19 PMTs*
  Hamamatsu R7378A
- *Pressure resistant*
  up to 20 bar
- *QE ~ 15%*
  VUV Region
- *Gain ~ $5 \cdot 10^6$*

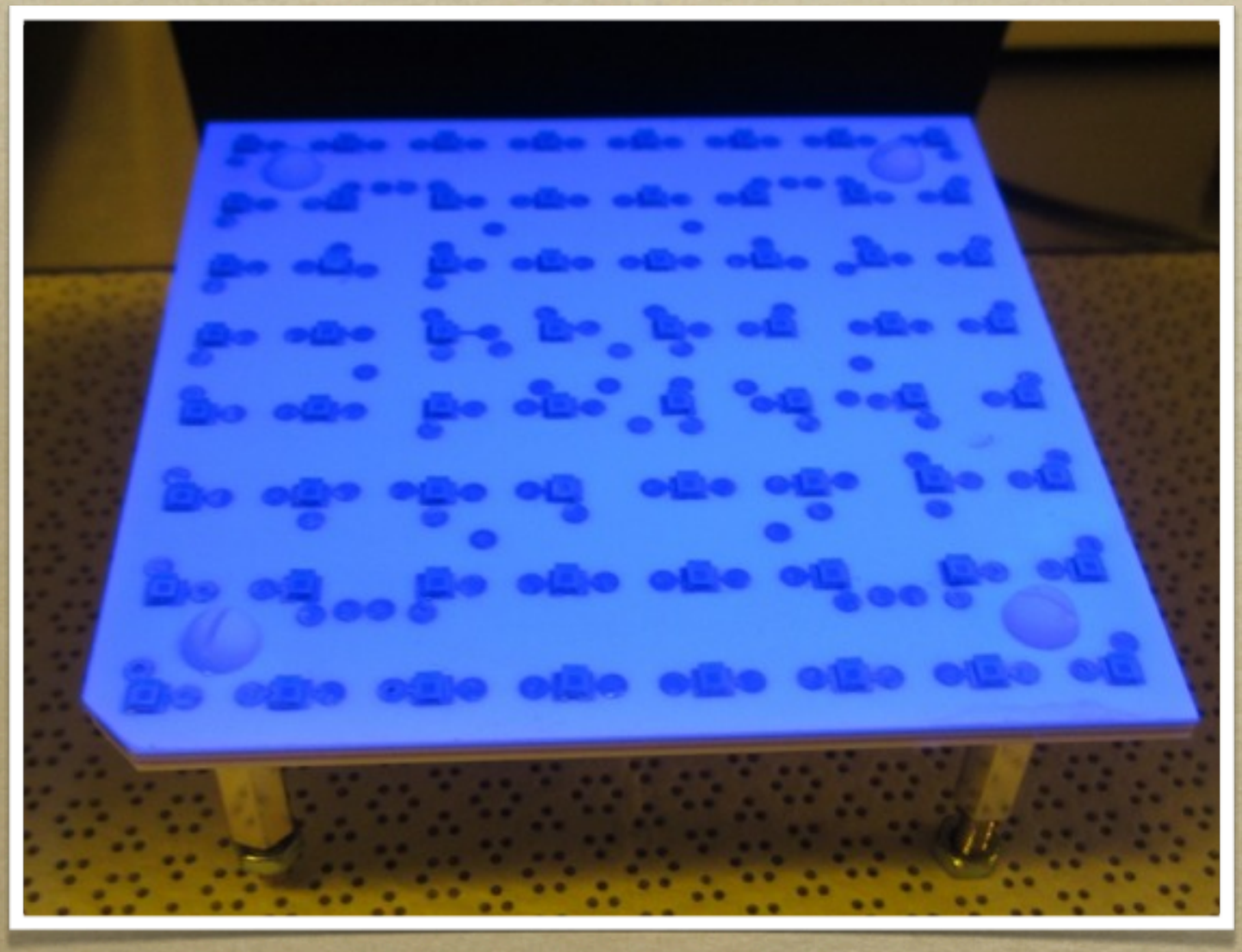
NEXT-DEMO: TRACKING PLANE



Tracking Plane formed by 4 Dice Boards

- *256 MPPCs Hamamatsu S10362-11-050P*
- *1 cm pitch*
- *Not sensitive to VUV*

NEXT-DEMO: TRACKING PLANE



Dice Board coated with TPB and illuminated with UV Lamp

- *Dice Board containing 64 MPPCs*
- *Sharing same bias voltage (common cathode)*
- *Spread in Gain < 4%*

NEXT-DEMO: READOUT SYSTEM

Front End used for Tracking Plane Readout

- *1 FEC for trigger*
- *3 FECs for PMTs*
- *2 FECs for SiPMs*

- *3 FEs for PMTs*
  ~24 Channels
- *16 FEs for SiPMs*
  ~256 Channels

developed by RD-51 Collaboration (SRS)

NEXT-DEMO: STATUS

- *Stable data taking during months of operation*
- *Lot of problems understood and solved.*

For more details attend to:

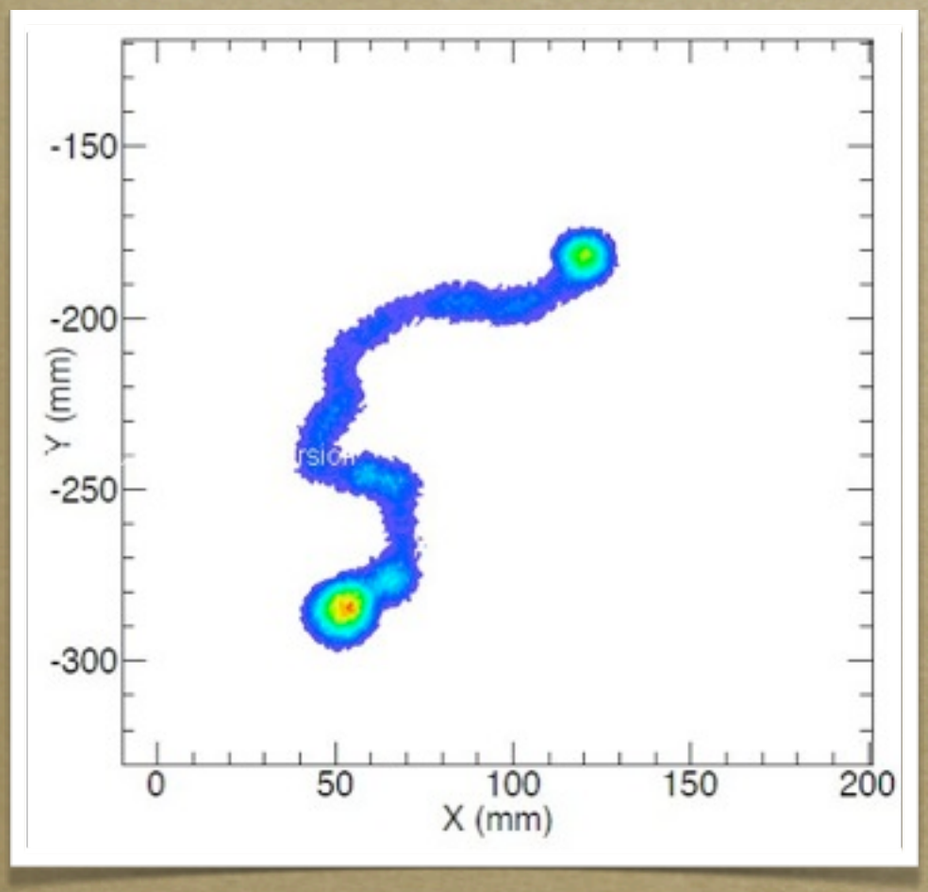
WG2 - Physics issues (14:00)
Operation and initial results of NEXT-DEMO TPC
F. Monrabal

NEXT - 100 Status

Working platform placed at Hall A at the LSC

- *Installation of first components has started*
- *NEXT-100 already under construction*
- *Commisioning expected for 2014*
- *Run with depleted/ enriched Xenon in 2015*

NEXT-DEMO: a large electroluminescent TPC for double-beta decay search



Thank you!!