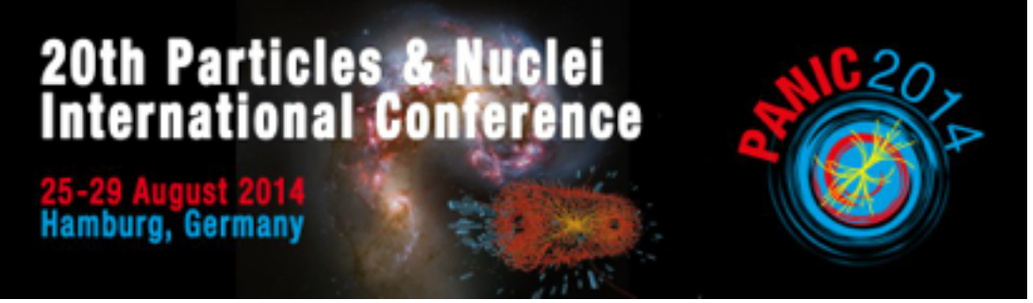



# The Hunt for neutrinoless double beta decay with the NEXT experiment

David Lorca

*On behalf of the next Collaboration*

European Research Council
Established by the European Commission

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

# Outlook

- *$\beta\beta0\nu$ experiment requirements*
- *The NEXT Concept*
- *NEXT-DEMO: R&D and Results*
- *NEXT-100*

# $\beta\beta0\nu$ experiment requirements

*Expected Decay Rate*

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

*Experimental Sensitivity*

$$T_{1/2} \propto a \cdot \epsilon \cdot \sqrt{\frac{M \cdot t}{\Delta E \cdot B}}$$

## *Main Experimental Requirements*

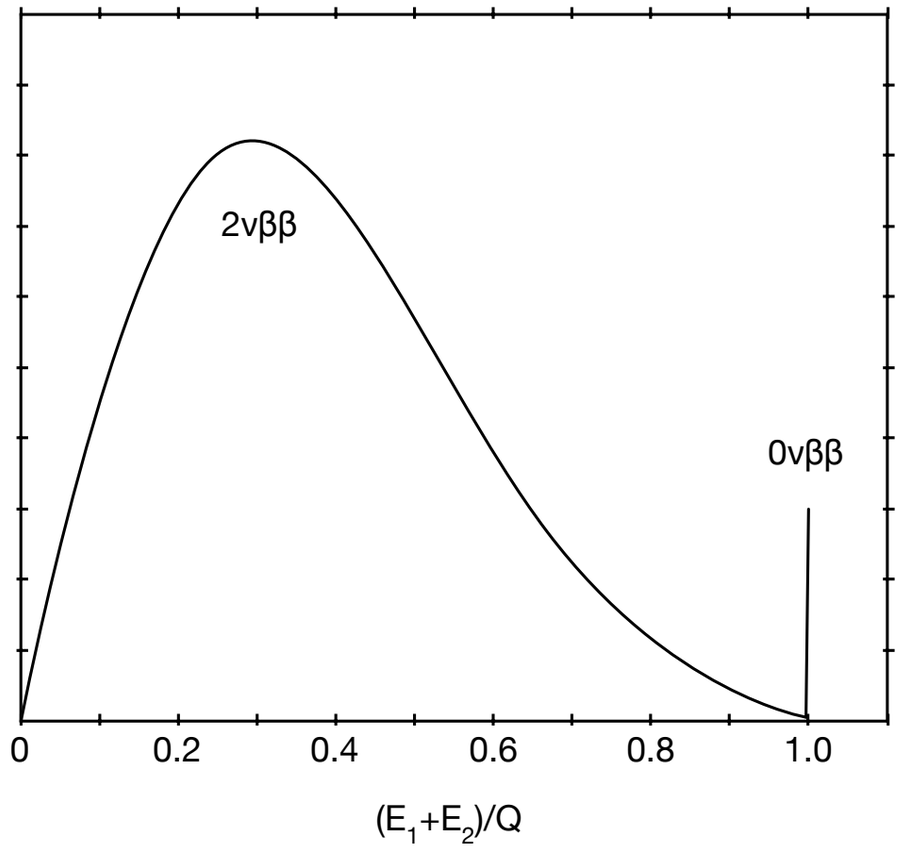
- *Energy Resolution*
- *Control of Backgrounds*
- *Scalability (Mass vs Cost)*

# $\beta\beta0\nu$ experiment requirements

$$T_{1/2} \propto a \cdot \epsilon \cdot \sqrt{\frac{M \cdot t}{\Delta E \cdot B}}$$

- ***Energy Resolution***

*selection of the appropriate technology to resolve $\beta\beta0\nu$ events from the continuous $\beta\beta2\nu$ mode and radioactive backgrounds*




*Neutrinoless double beta decay spectrum*

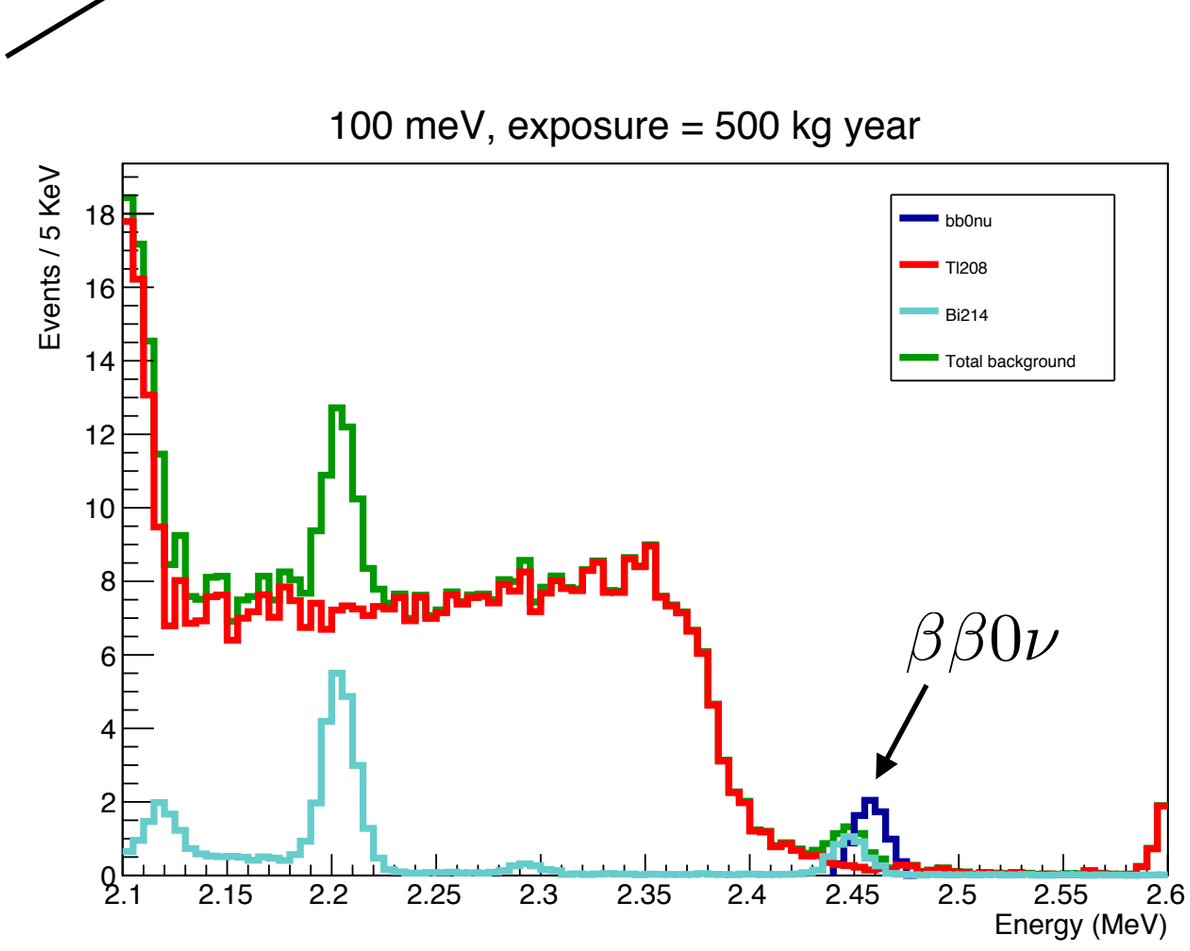
# $\beta\beta0\nu$ experiment requirements

$$T_{1/2} \propto a \cdot \epsilon \cdot \sqrt{\frac{M \cdot t}{\Delta E \cdot B}}$$

- ***Control of Backgrounds***

*(combined with ER)*

*Main background is natural radioactivity of detector components and surroundings*



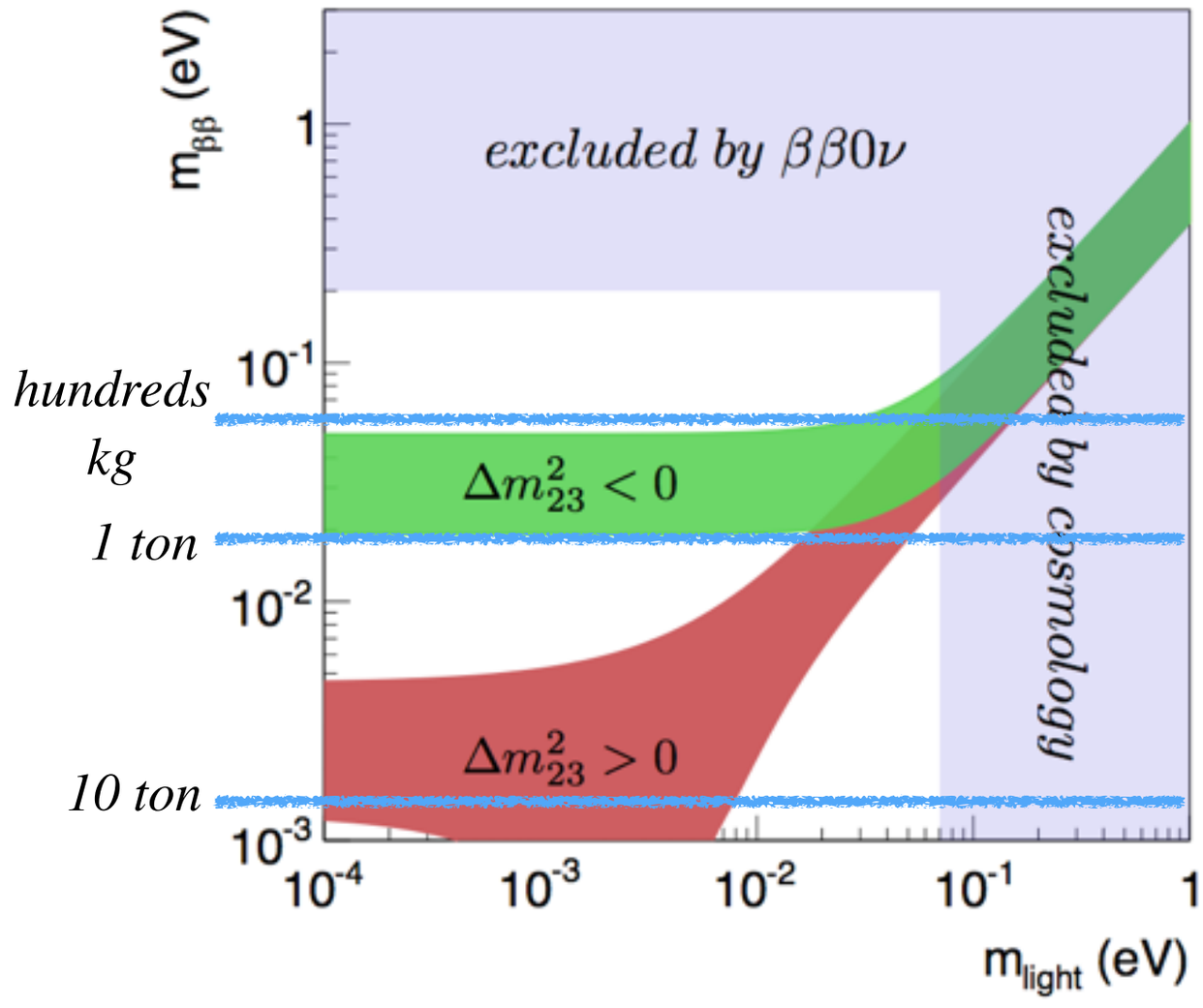
# $\beta\beta0\nu$ experiment requirements

$$T_{1/2} \propto a \cdot \epsilon \cdot \sqrt{\frac{M \cdot t}{\Delta E \cdot B}}$$

- ***Scalability***

***(Mass vs Cost)***

*New results have pushed down the $m_{\beta\beta}$ upper limit, creating the necessity to increase the detector mass up to the ton scale (for now)*



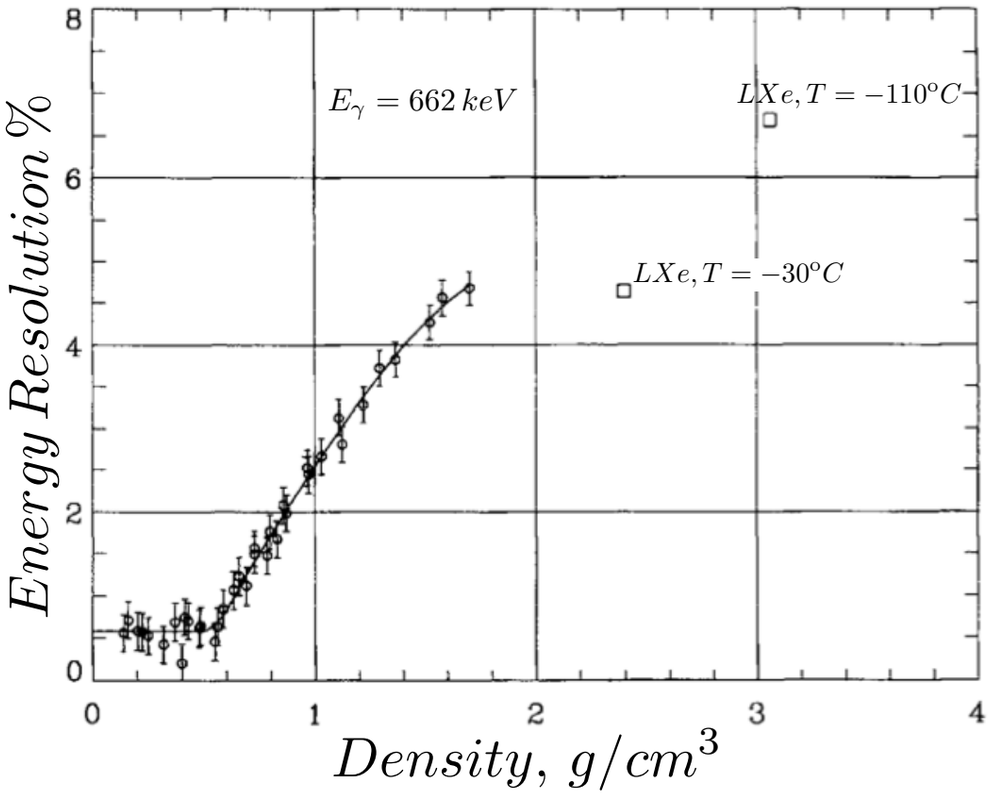
# The NEXT Concept

*NEXT, a high pressure gaseous Xenon TPC with EL amplification*

# The NEXT Concept

*NEXT, a high pressure gaseous Xenon TPC with EL amplification*

*Energy Resolution :*




*HPXe TPC combined with EL amplification provides excellent energy resolution*

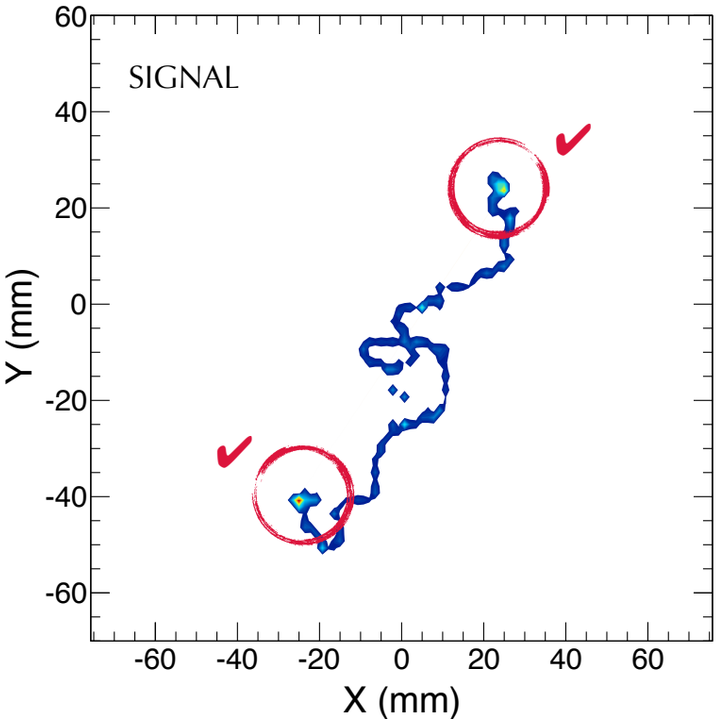
$$HPXe: \; Fano\,Factor = 0.15 \pm 0.02$$

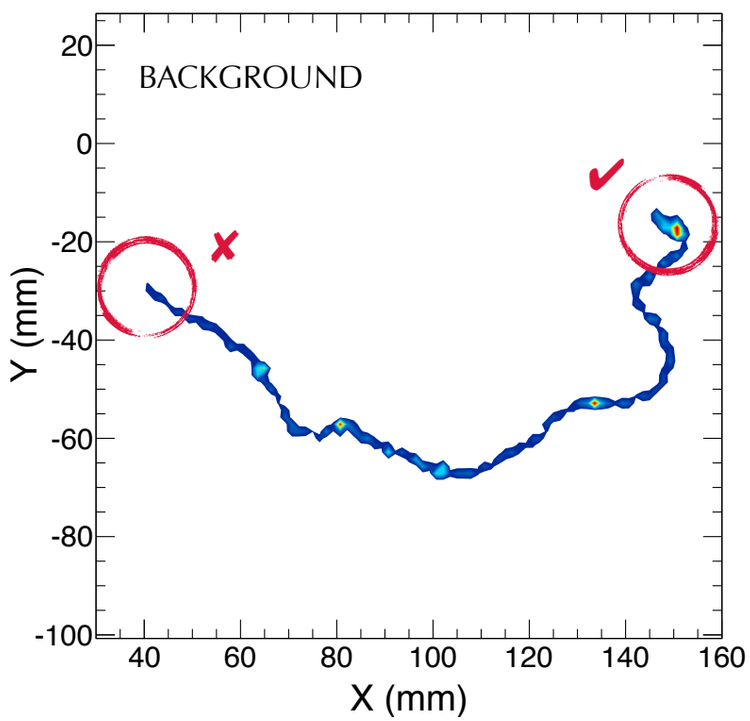
$$\Delta E < 1\,\%\; FWHM\; at\, 2458\, keV\; (Q_{\beta\beta})$$

# The NEXT Concept

*NEXT, a high pressure gaseous Xenon TPC with EL amplification*

## *Control of Background:*



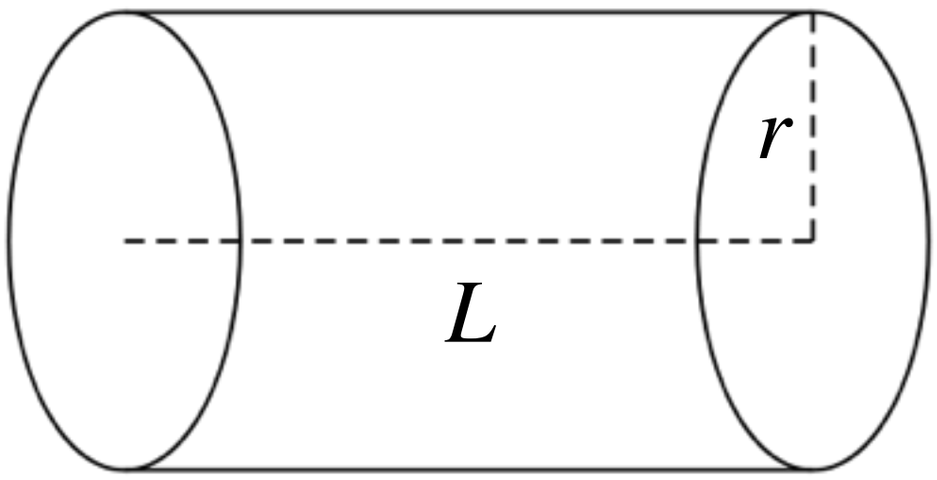

*HPXe provides topological reconstruction of the events*

- *Signal: a twisted track, 10 cm long, with two energy blobs at the end.*
- *Background: single electrons, 85% of the time accompanied by an X-ray.*

# The NEXT Concept

*NEXT, a high pressure gaseous Xenon TPC with EL amplification*

## *Scalability (Mass vs Cost)*

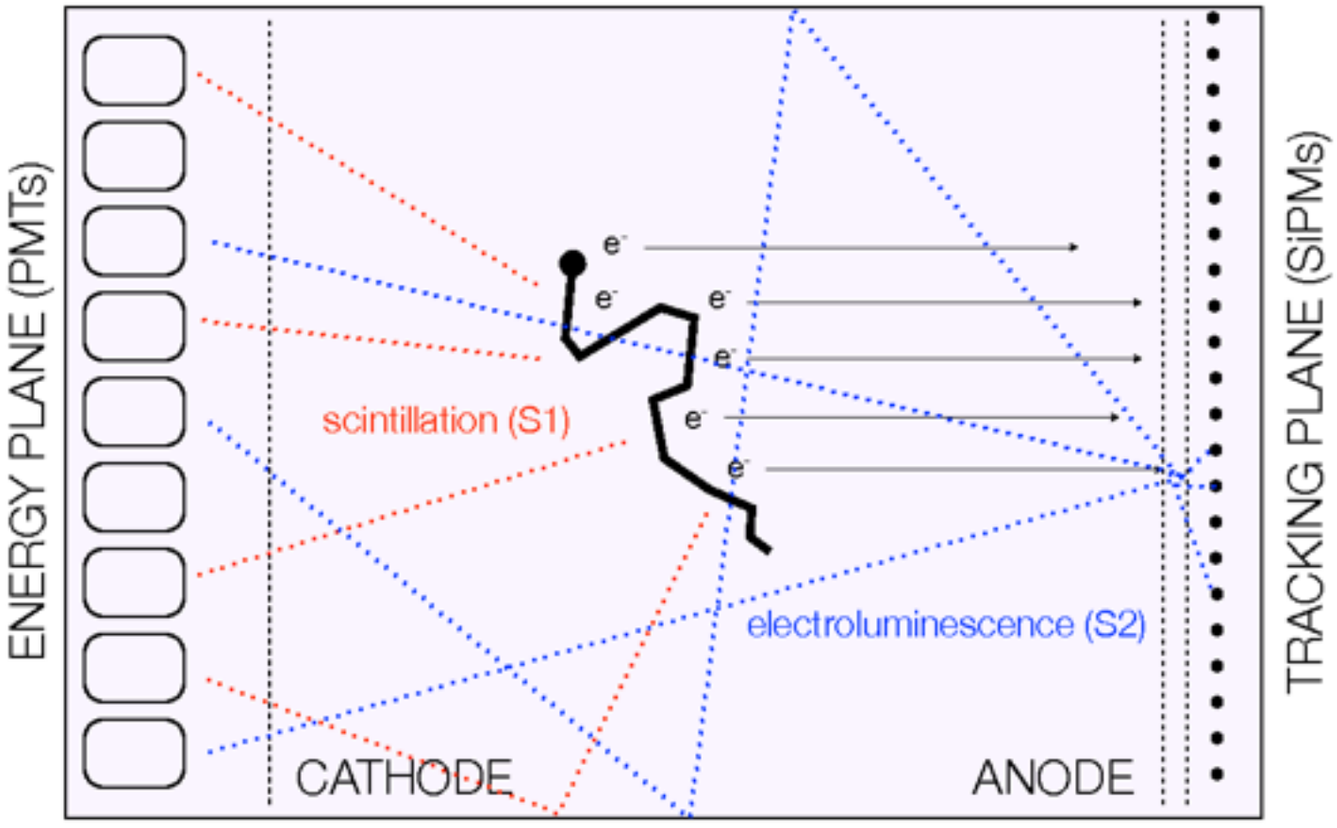



*Xenon is the cheapest and easiest to enrich of all $\beta\beta$ isotopes.*

*Doubling r&L* ➡ *S/N x2*

- *Source: increases by a factor 8*
- *Background: increases by a factor 4*

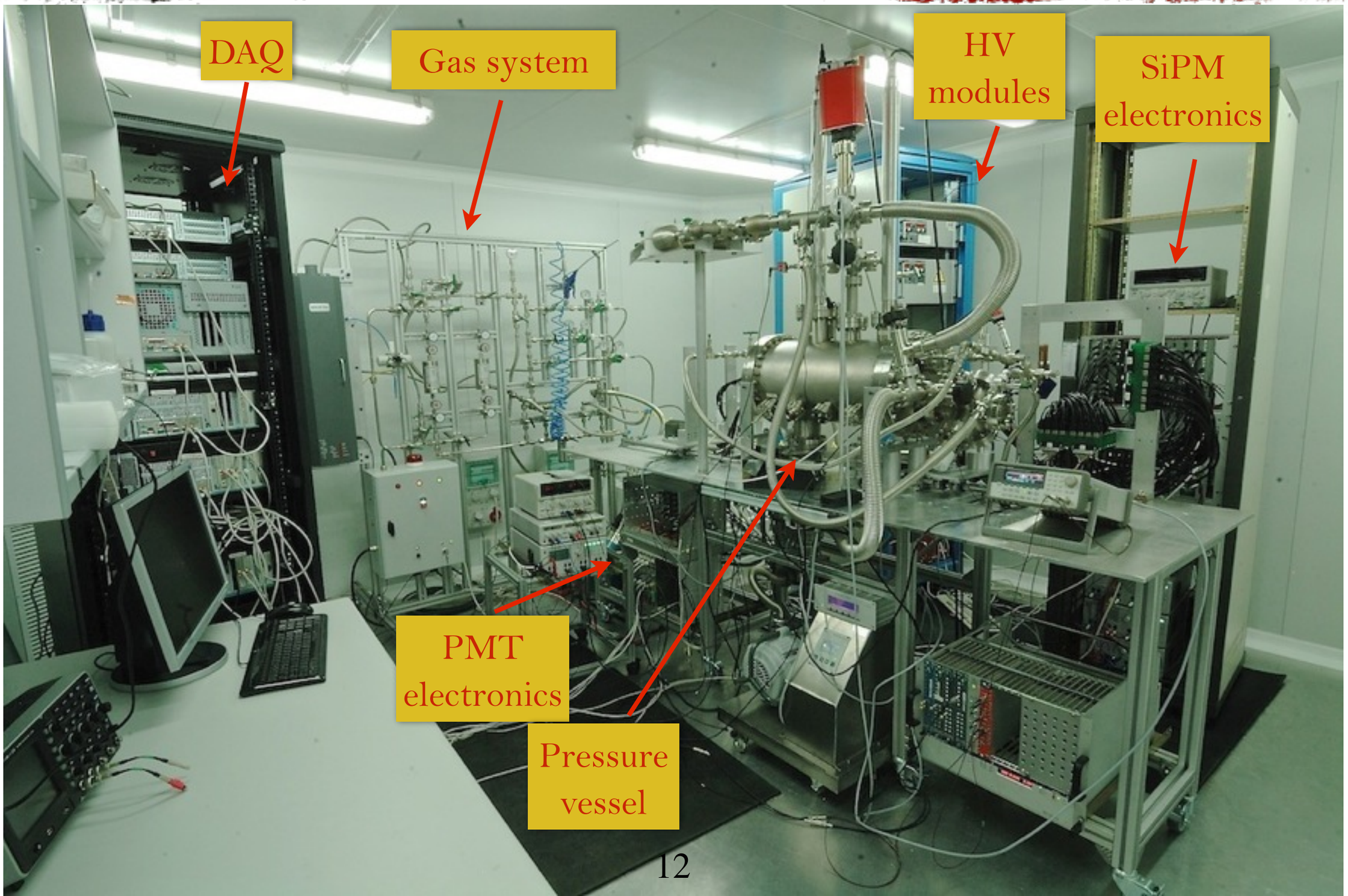
# *Detection Process*



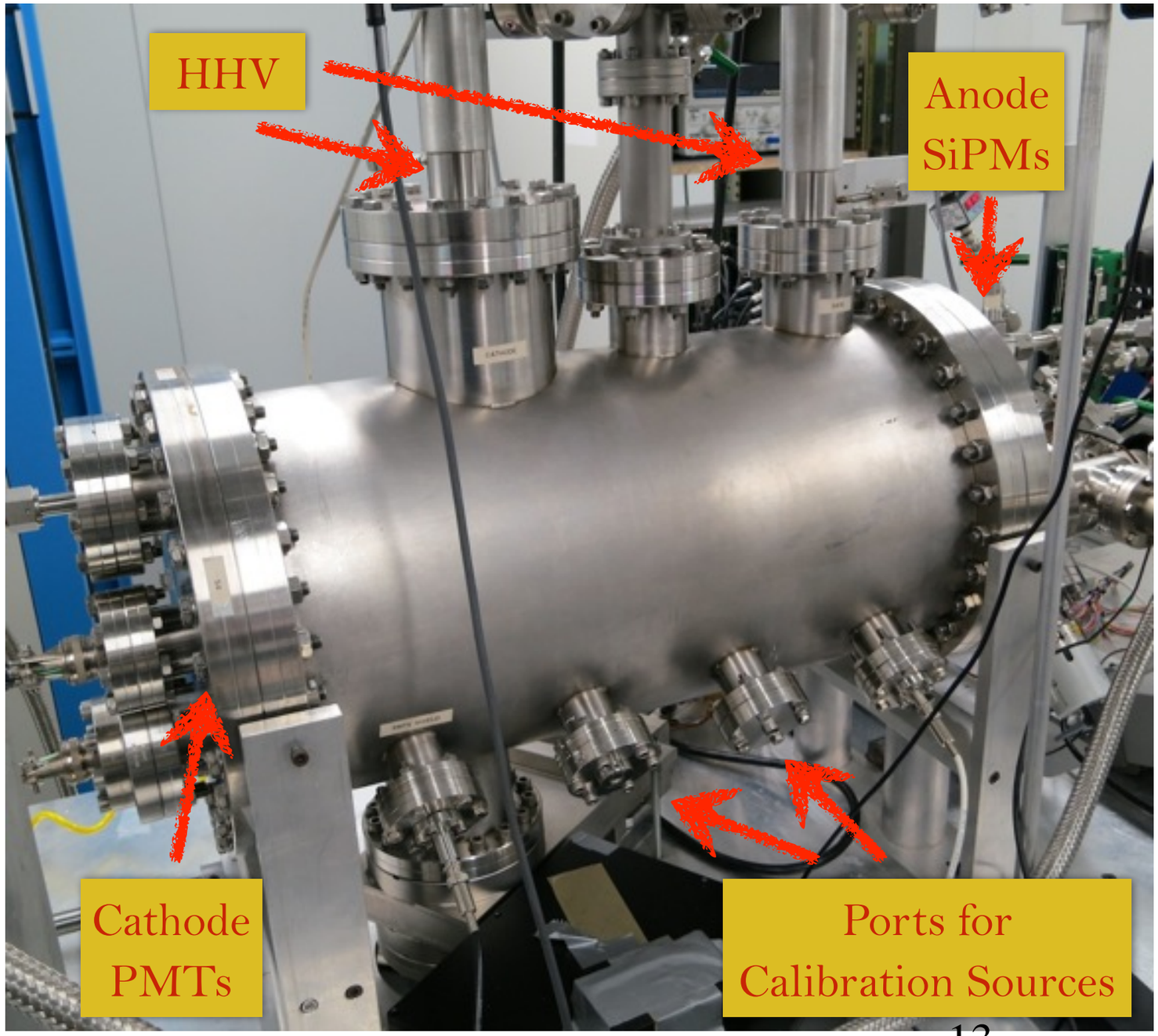

*EL amplification provides lineal gain, exploiting the excellent Fano factor in gas*

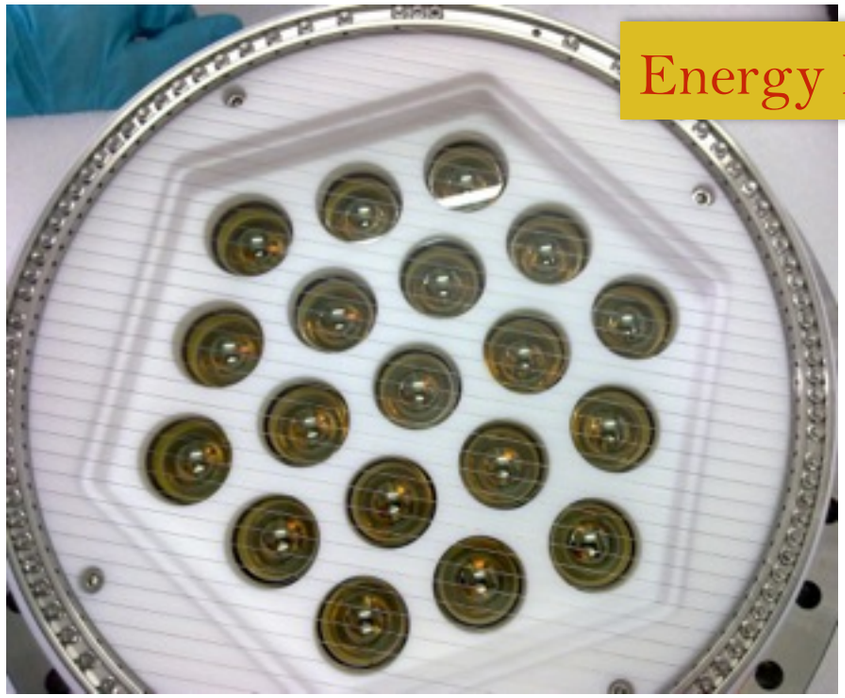
- *Charged particles propagate through Xenon ionizing and exciting its atoms.*
- *Calorimetry provided by a plane of PMTs located behind a transparent cathode (energy plane), with $t_0$.*
- *Event topology reconstructed by a plane of SiPMs (tracking plane).*

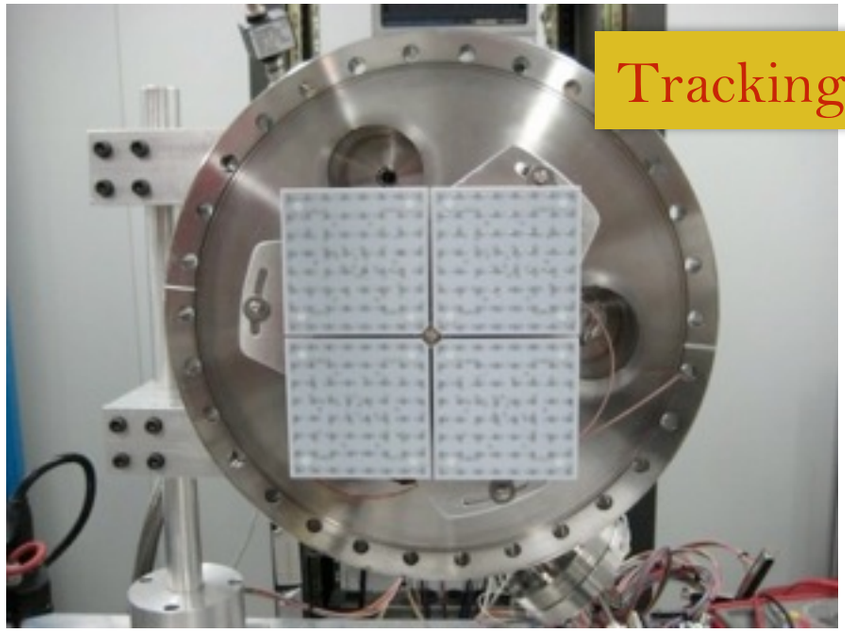
# *NEXT-DEMO at IFIC*



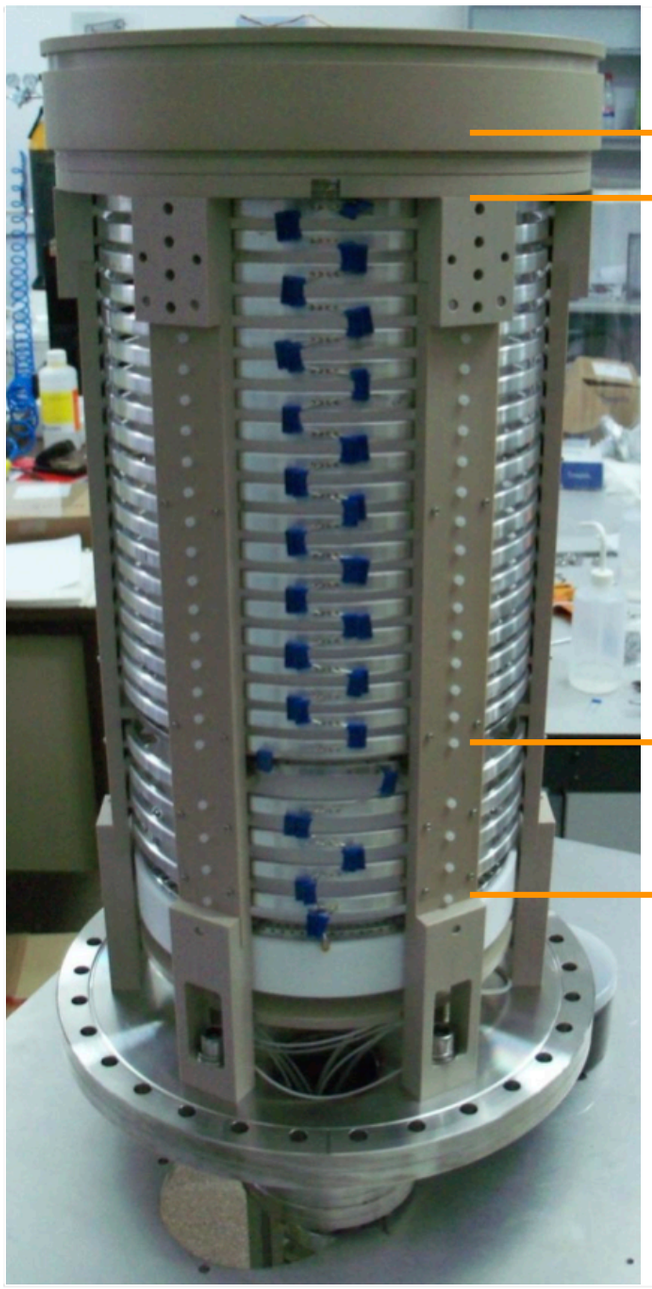
# Pressure Vessel and Detection Planes



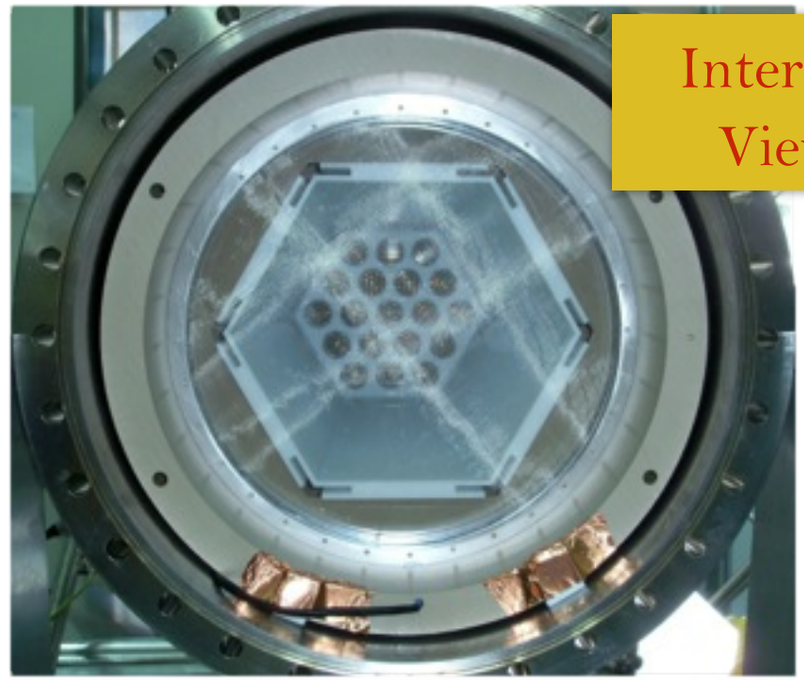



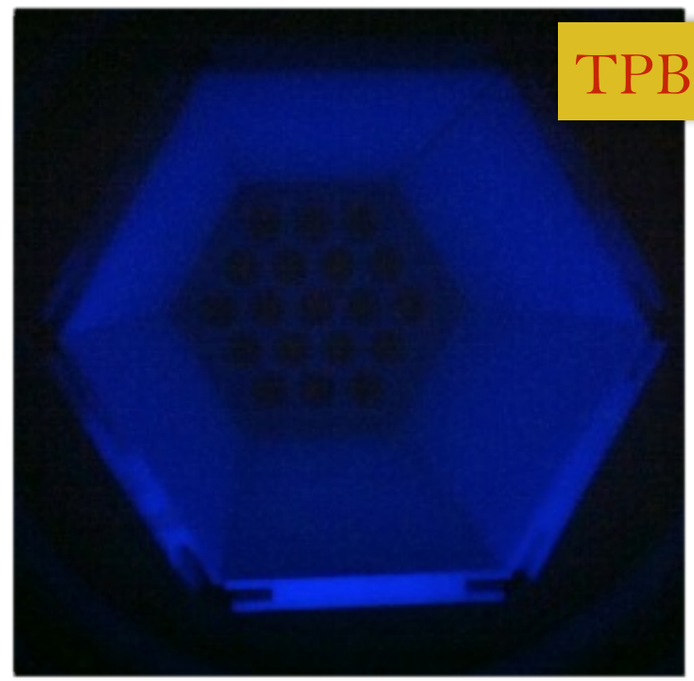
# Field Cage and Light Tube




NEXT-DEMO
Field Cage

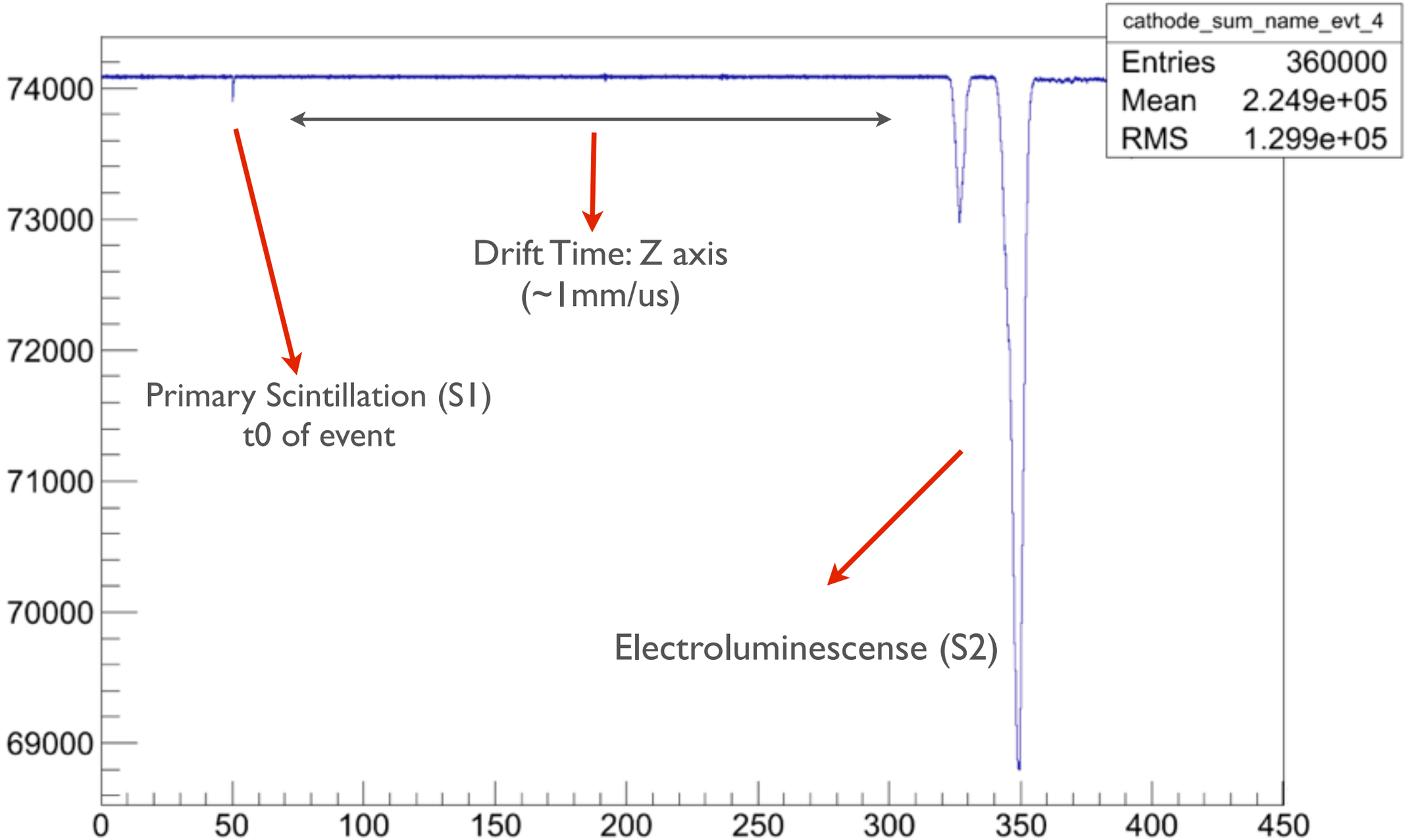


Internal
View

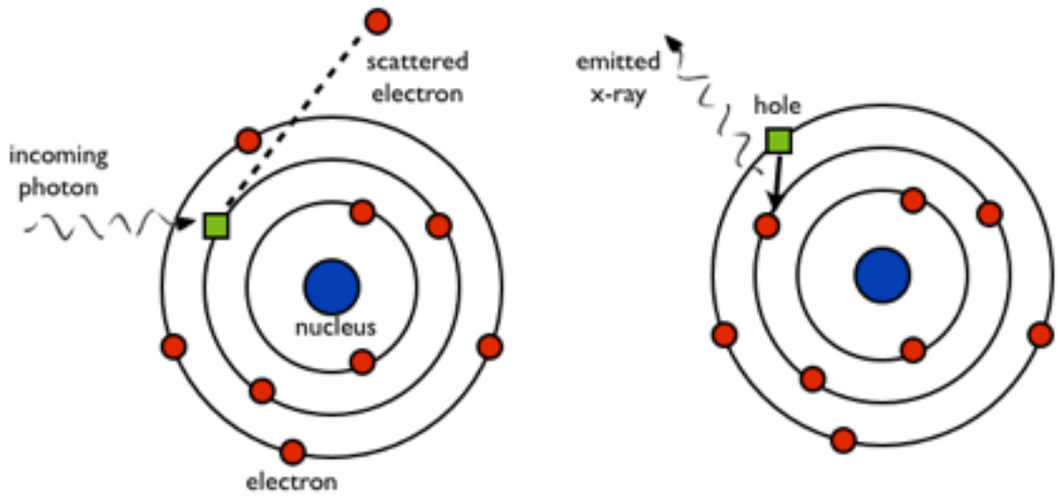


TPB Coated

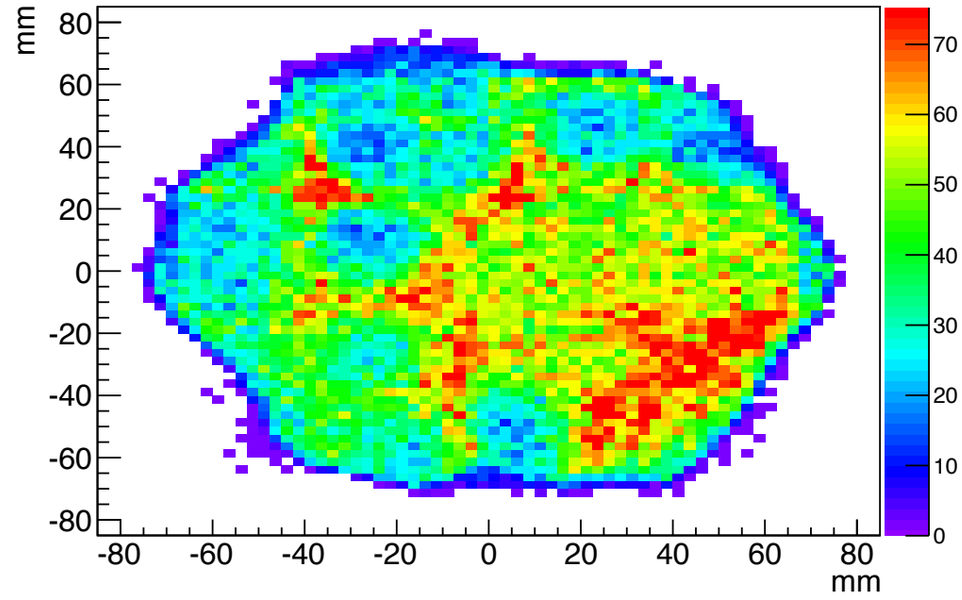
# Signals in NEXT-DEMO



# NEXT-DEMO NEW Results




X-ray production



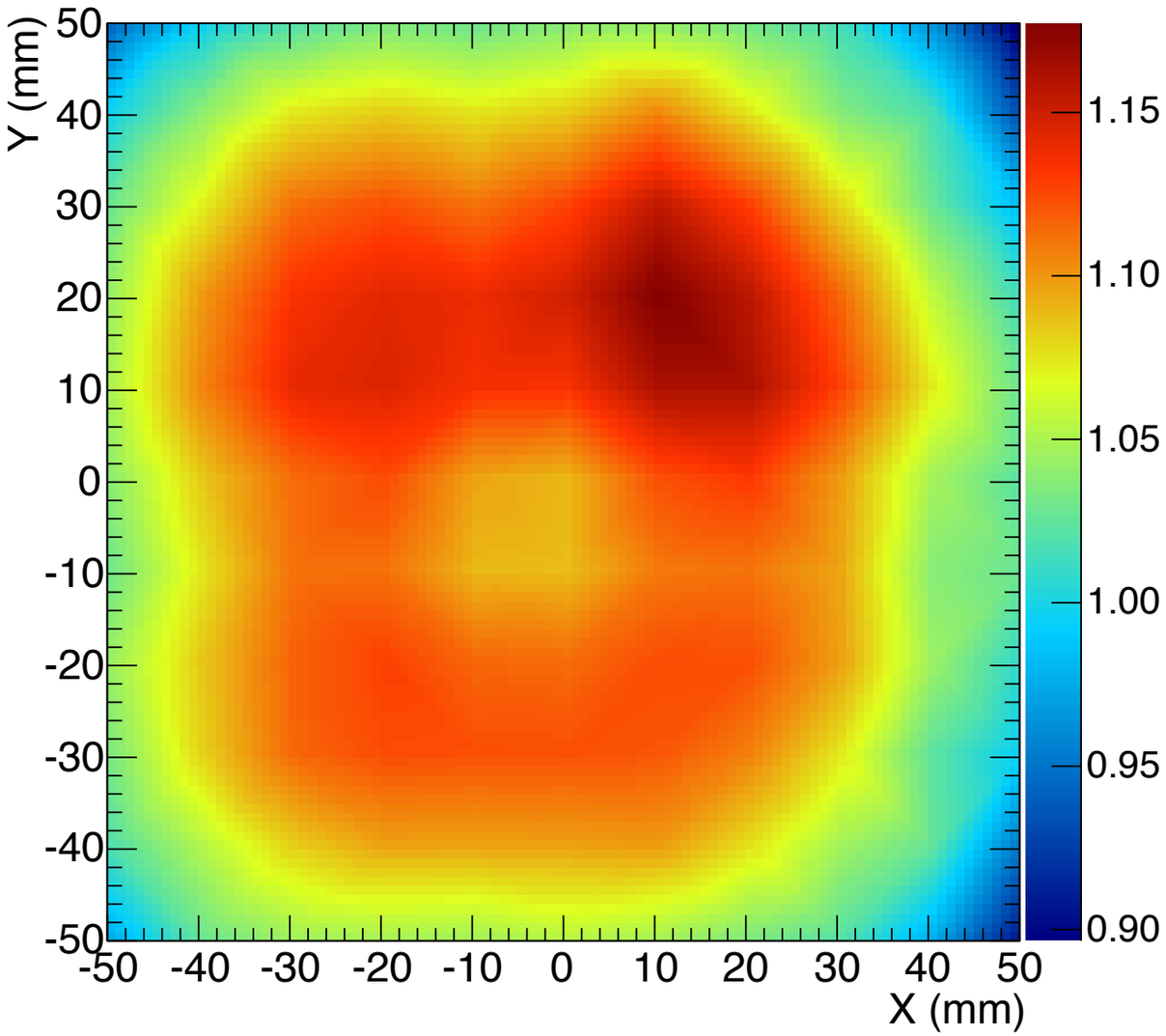

X-ray 2D distribution

X-ray energy deposition (~30 keV) used for calibration

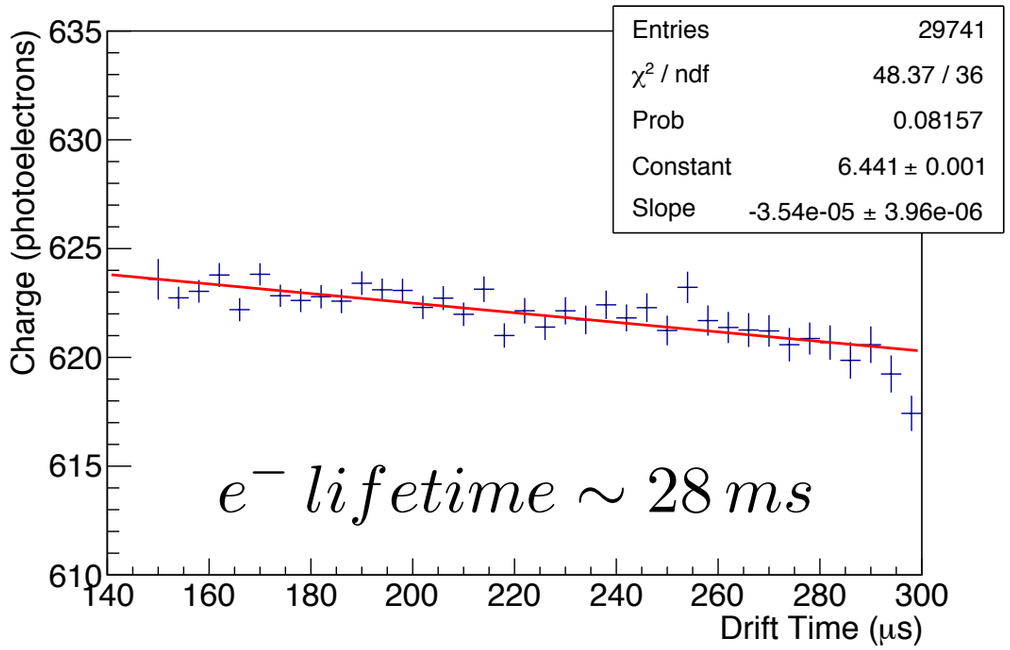
Distributed all over the volume

Point-like events, Range ~0.6 mm (10 bar)

# NEXT-DEMO NEW Results




*Two dimensional normalized response to X-ray depositions*



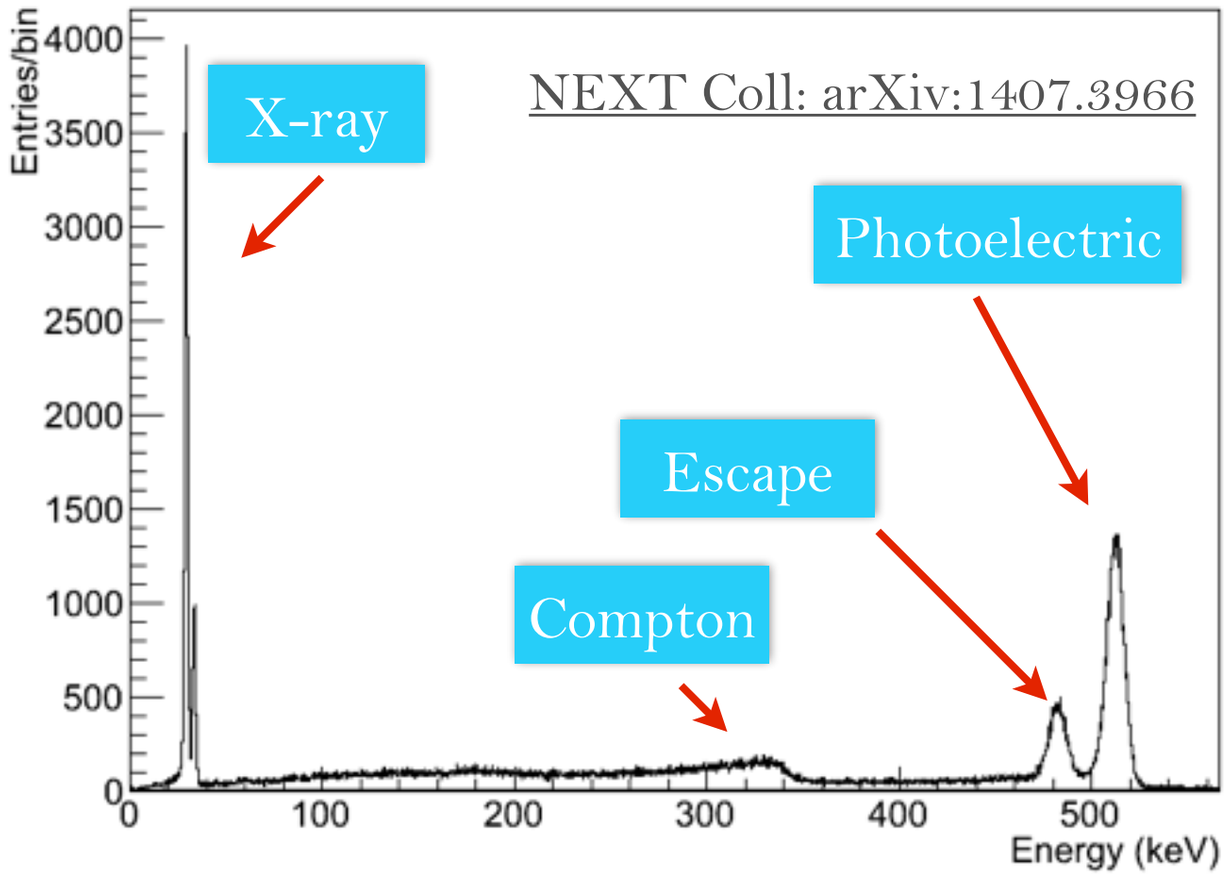

X-rays allow:

- ✦ Spatial calibration of the light tube.
- ✦ Electrons attachment correction.
- ✦ Temporal fluctuations correction in the EL generation.

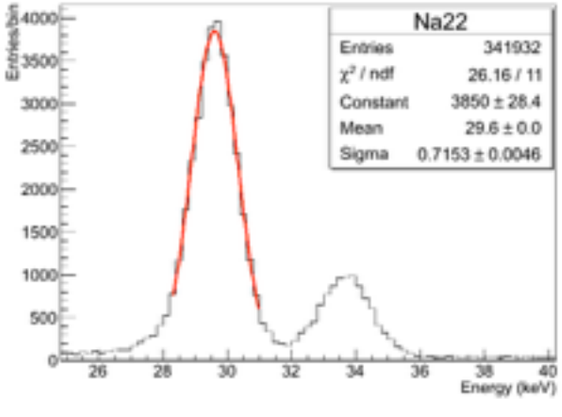
# NEXT-DEMO NEW Results

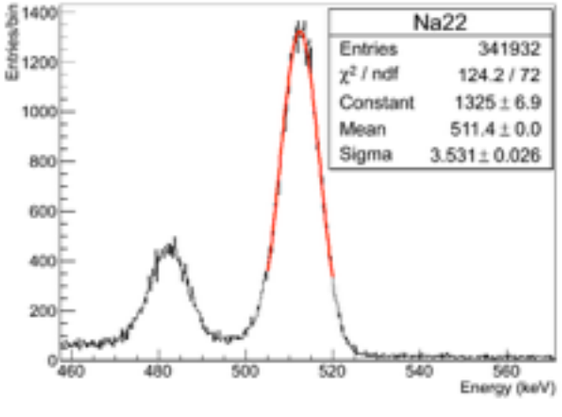
- 1.62 % FWHM energy resolution for 511 keV and 5.69% for 30 keV over a fiducial volume of 60x60x300 mm

- Extrapolate to 0.73% and 0.62% FHHM to the Qbb value

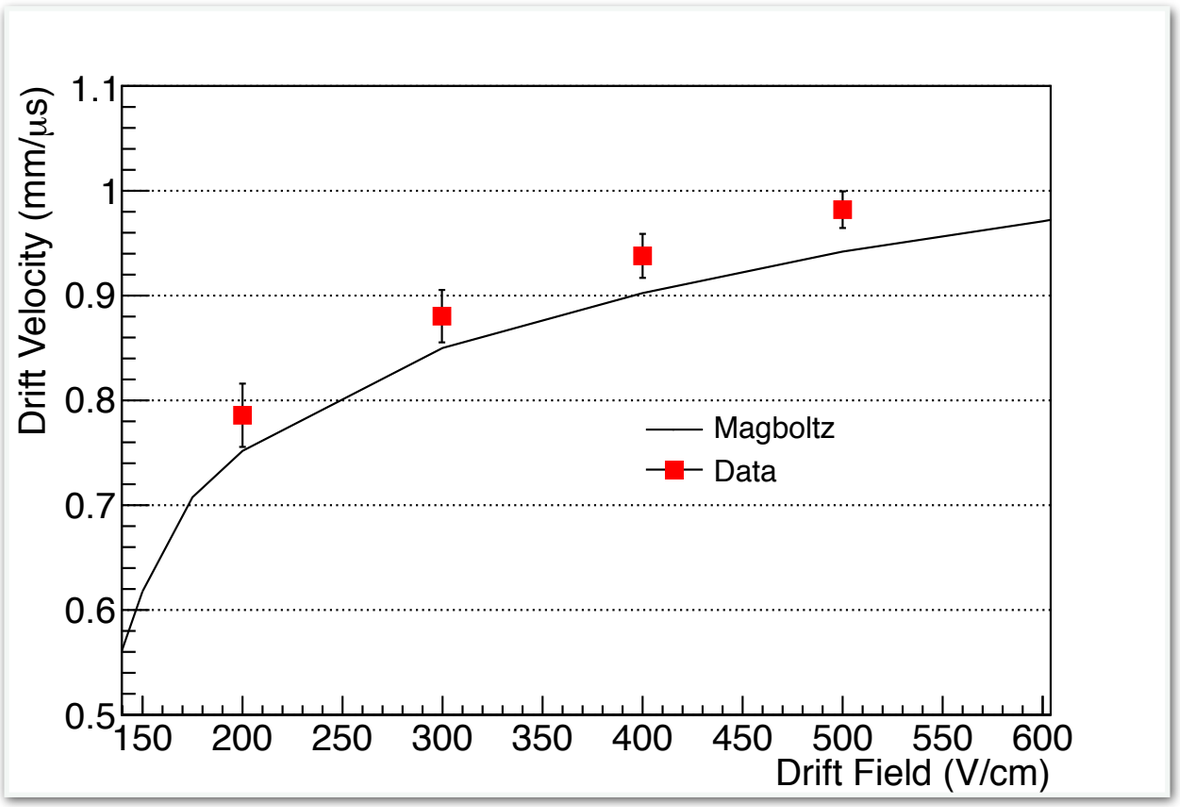



*Corrected Na-22 spectrum*

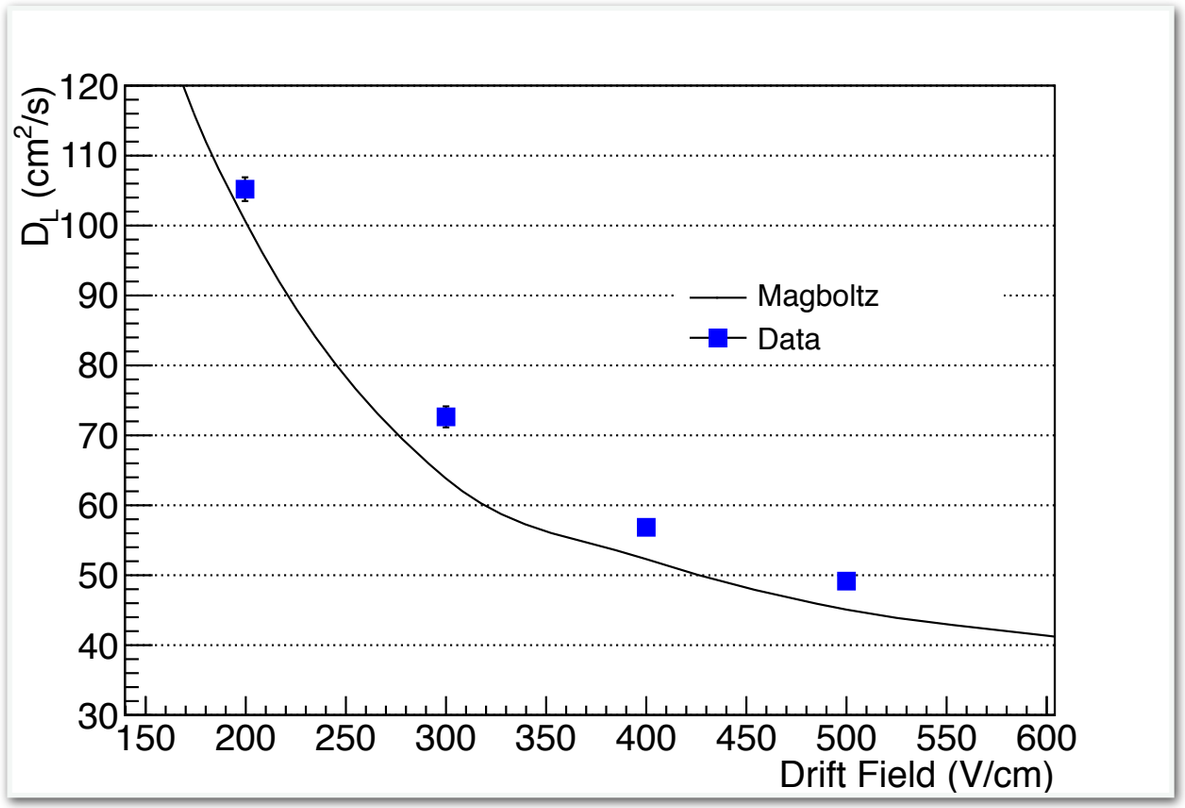


# NEXT-DEMO NEW Results



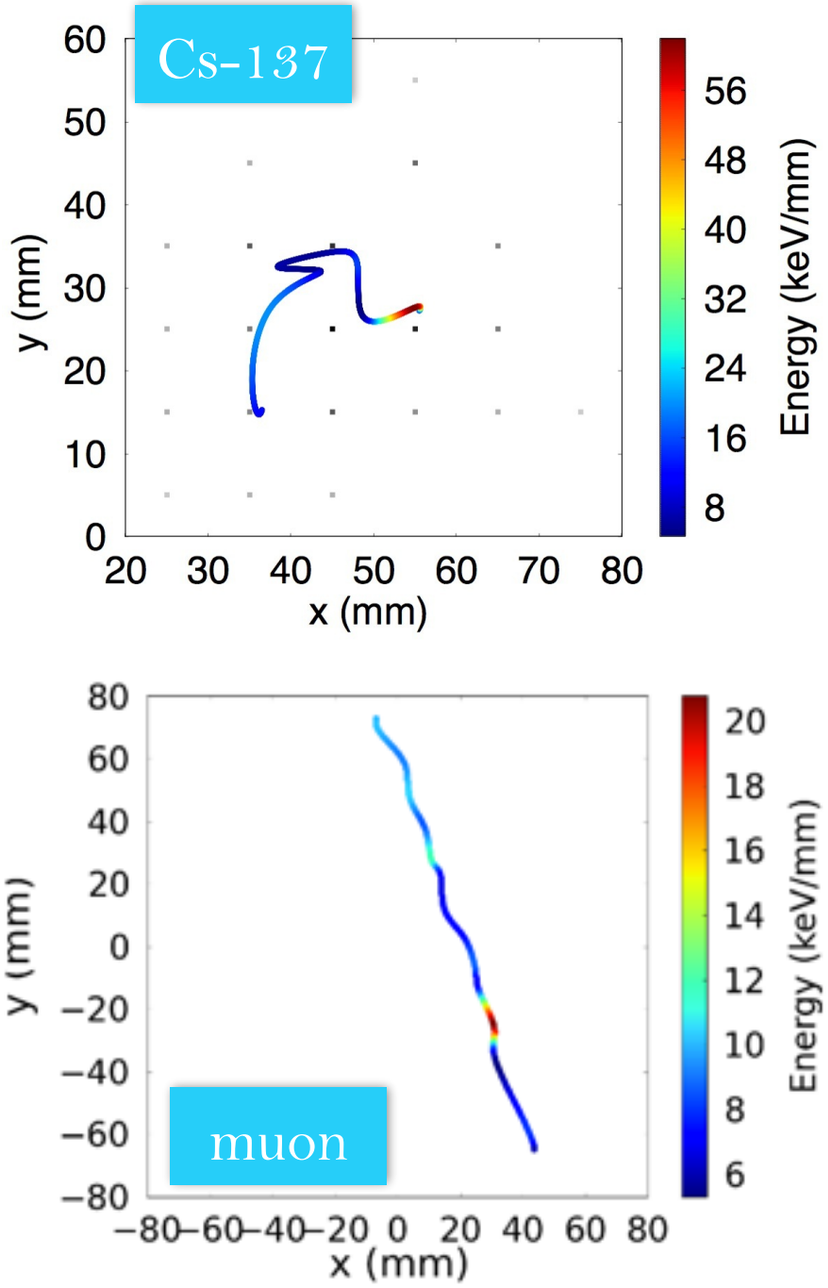

*Drift Velocity as a function of drift field*

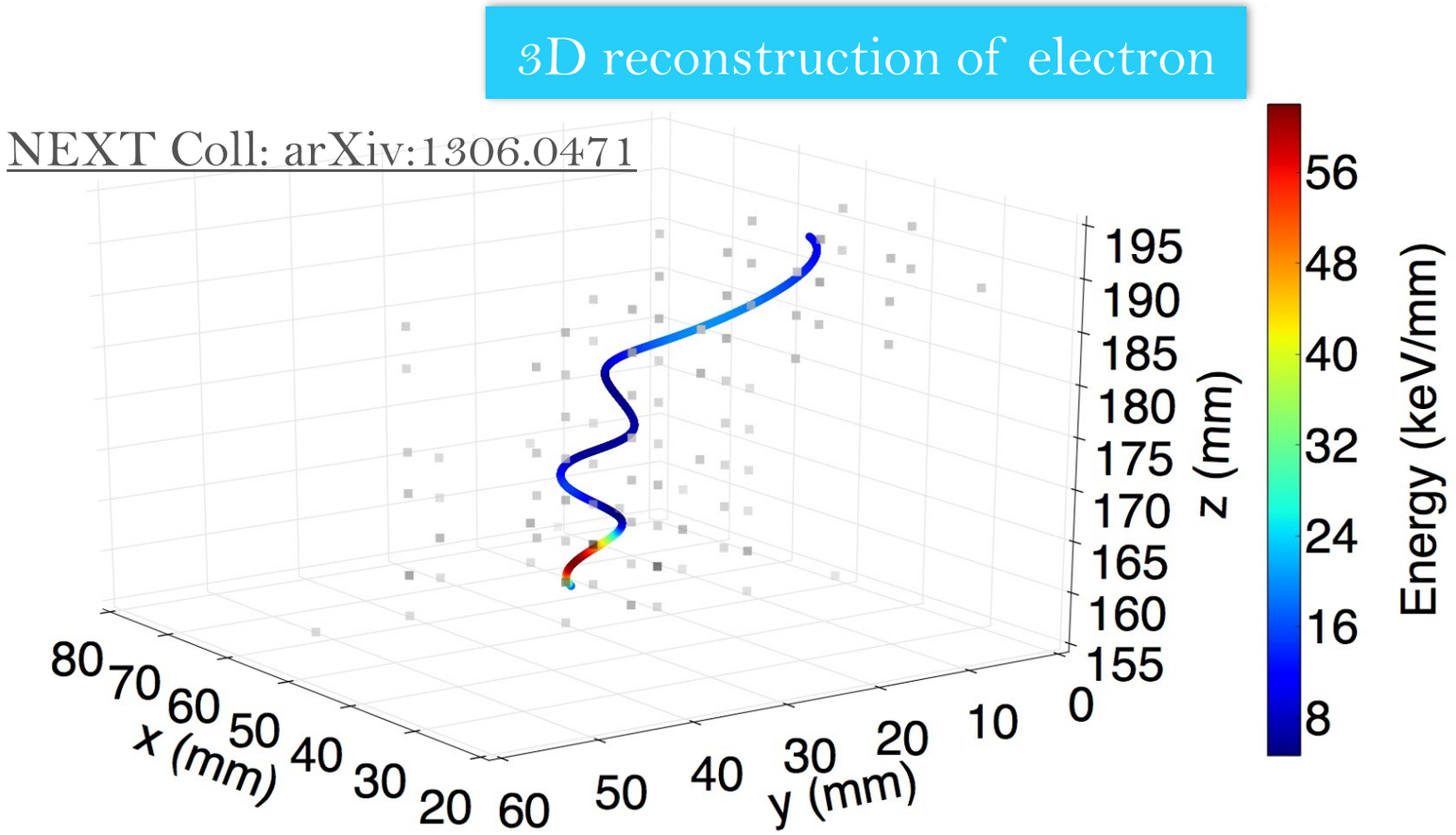



*Longitudinal diffusion coefficient vs drift field*

Point-like depositions allow the measurement of high pressure xenon properties such a drift velocities and longitudinal diffusion

# NEXT-DEMO Results



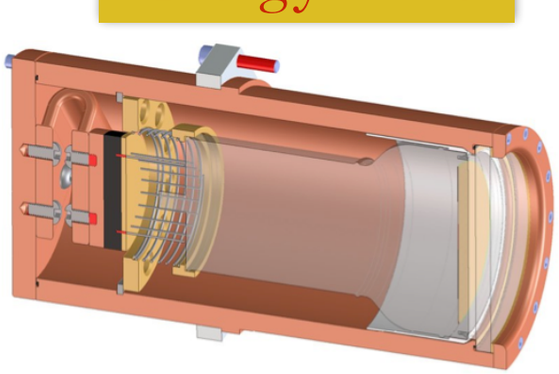



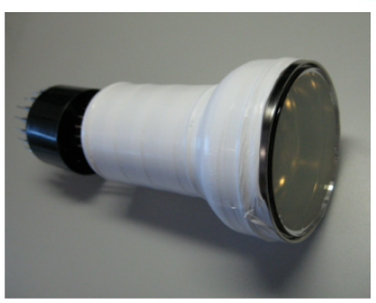

- *Tracking reconstruction of events*
- *Higher energy deposition at electron track end-point*

# NEXT-100

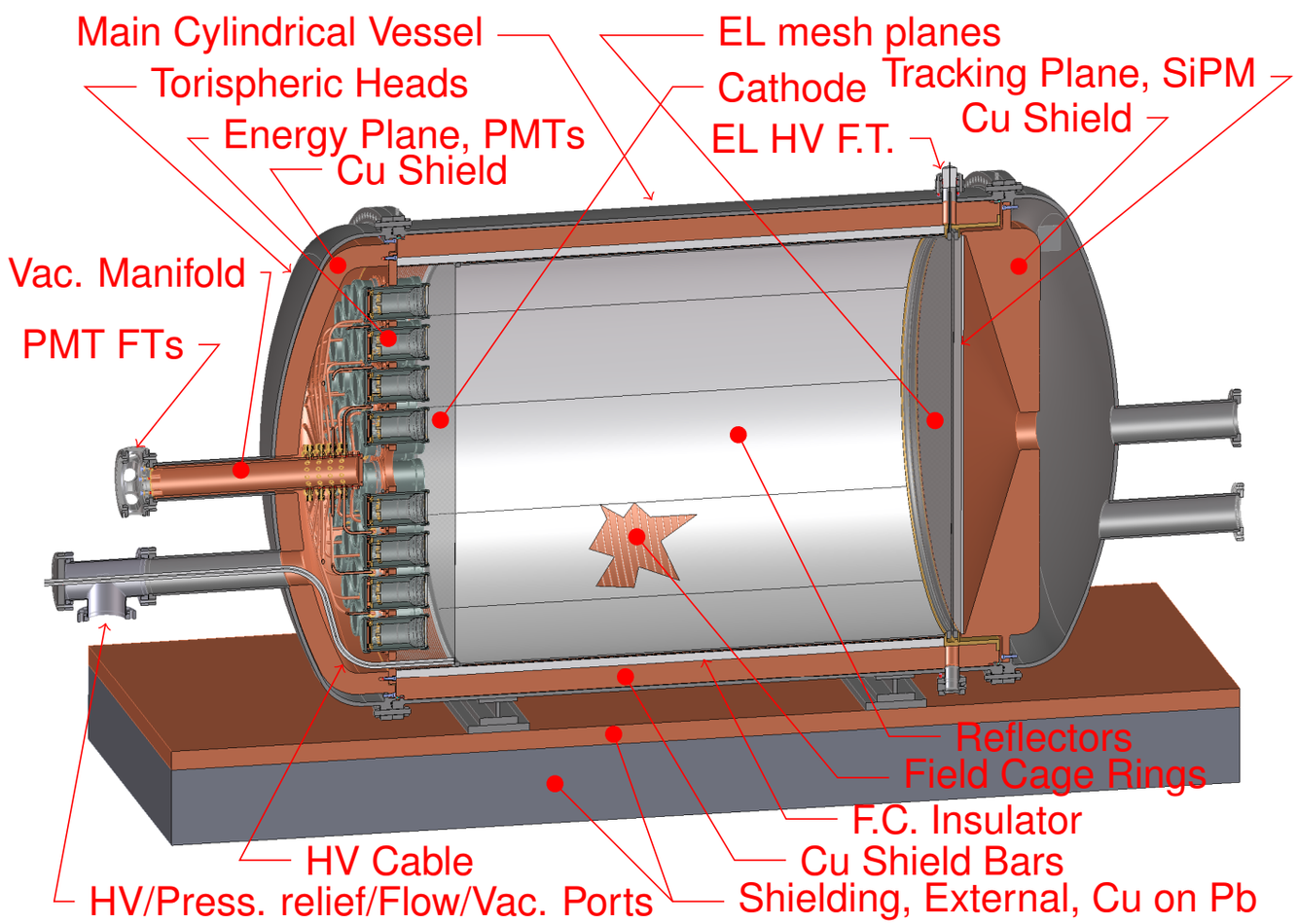
*HPXe TPC containing 100 kg of Xenon at 15 bar*

Energy Plane

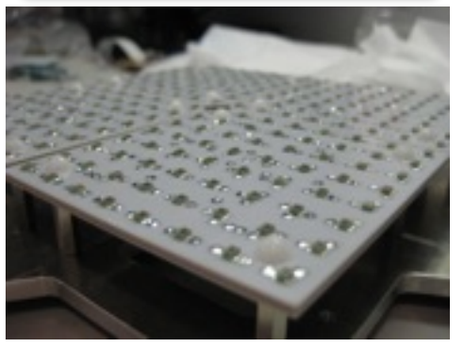




*60 PMTs*




Tracking Plane



*~7200 SiPMs*

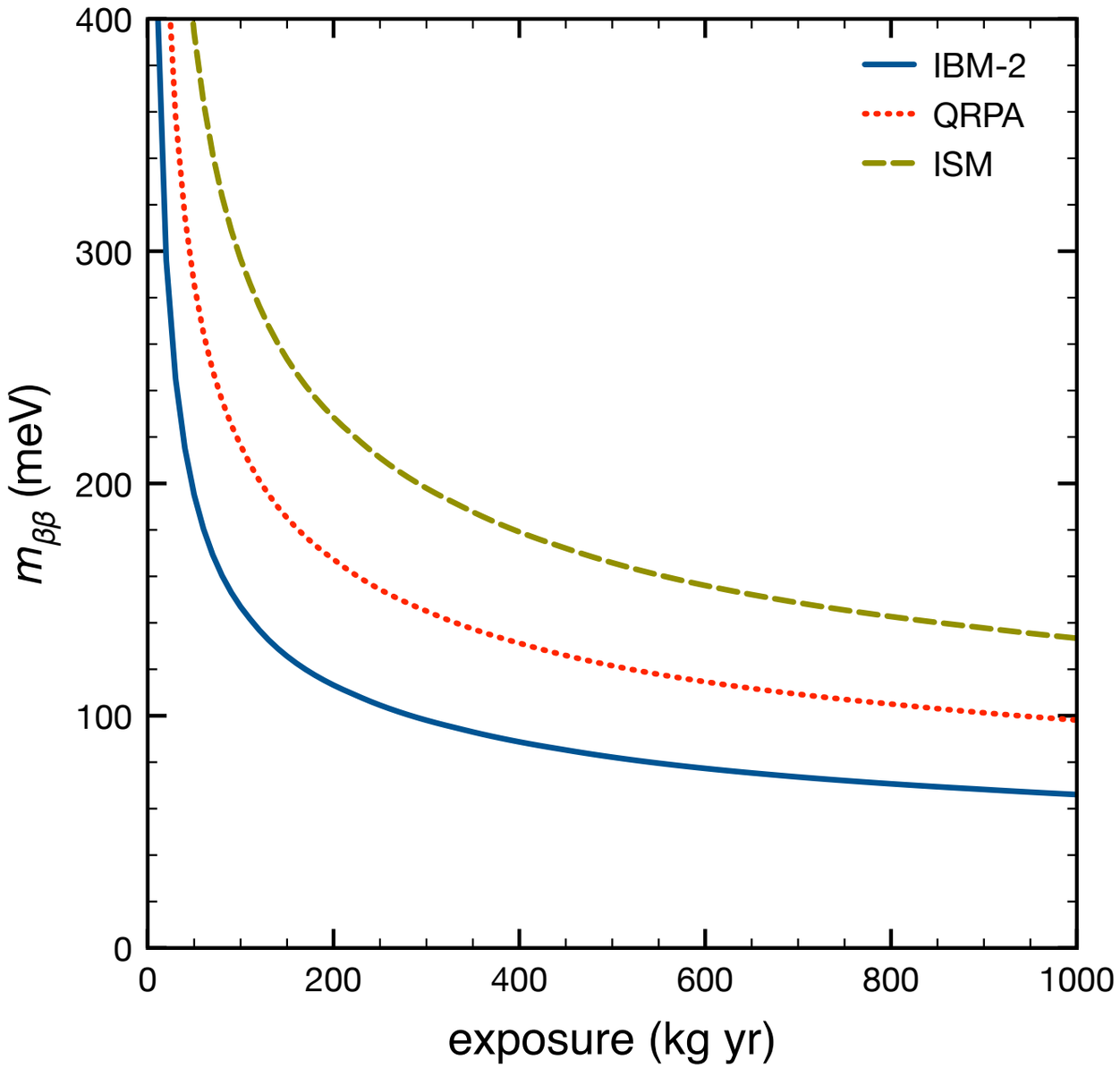
*Technical Design Report (TDR)*

NEXT Coll: arXiv:1202.0721

*Radiopurity Control*

NEXT Coll: arXiv:1211.3961

# NEXT-100




| | $\beta\beta0\nu$ | *Tl-208* | *Bi-214* |
|---|---|---|---|
| Fiducial E>2MeV | *67.86%* | *0.25%* | *0.01%* |
| ROI | *95.52%* | *8.99%* | *64.66%* |
| 1 track | *74.60%* | *1.86%* | *12.54%* |
| 2 blobs | *73.76%* | *9.60%* | *9.89%* |

| | |
|---|---|
| *Rejection* | $\sim 10^{-7}$ |
| *Total Background* | $5 \cdot 10^{-4}\, ckky$ |

$$m_{\beta\beta} \sim 100\, meV$$

# NEXT-100


*Platform for NEXT-100 at LSC*


Castle and seismic structure Video

*Status: Seismic platform, lead castle, gas system, emergency recovery system and vessel completed.*

*Schedule:*

- *2015: underground operations start with non-enriched Xenon*
- *2016-2020: physics with enriched Xenon (100 kg in stock)*

# SUMMARY

- *The NEXT concept satisfies the main requirements of a neutrinoless double beta decay experiment.*
- *NEXT-DEMO has demonstrated the main issues of such technology.*
- *NEXT-100 plans to explore sensitivities below 100 meV of neutrino mass.*
- *Possibility to scale up.*

# The NEXT Collaboration

IFIC (Valencia) • U. Santiago de Compostela • U. Politécnica Valencia • U. Zaragoza • U. A. Madrid • U. Girona

U. A. Nariño

LBNL • Texas A&M • Iowa State U.

U. Coimbra • U. Aveiro

JINR

*Neutrinoless Experiment with a Xenon TPC*