Status of NEXT-DEMO optical tracking system

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On behalf of NEXT Collaboration

RD-51 mini-week

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Topics

- Brief introduction to NEXT-100 major experimental goals and detector concept
- NEXT-DEMO : the demonstrator
- First results

  Energy measurements (already published)

  Optical Tracking (preliminary results)
- Conclusions

Double beta decay with a HPGXe TPC

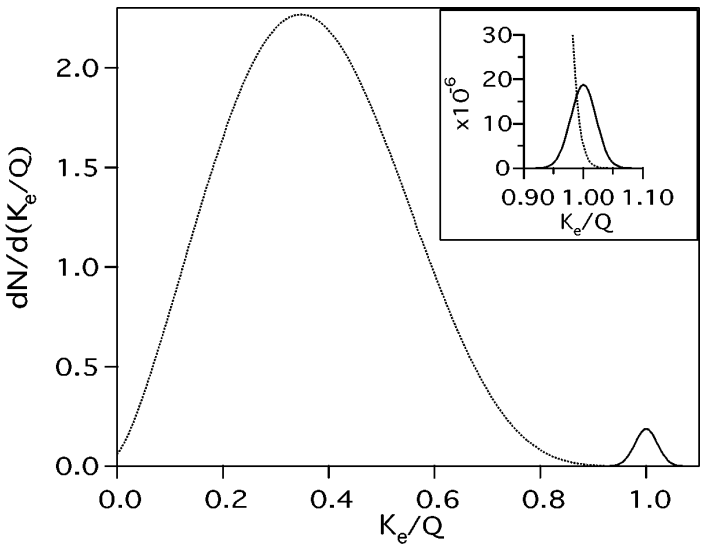
Xenon enriched with Xe-136 isotope is optimal as ββ source and detector medium,
large $Q_{\beta\beta}$ (2458 KeV)

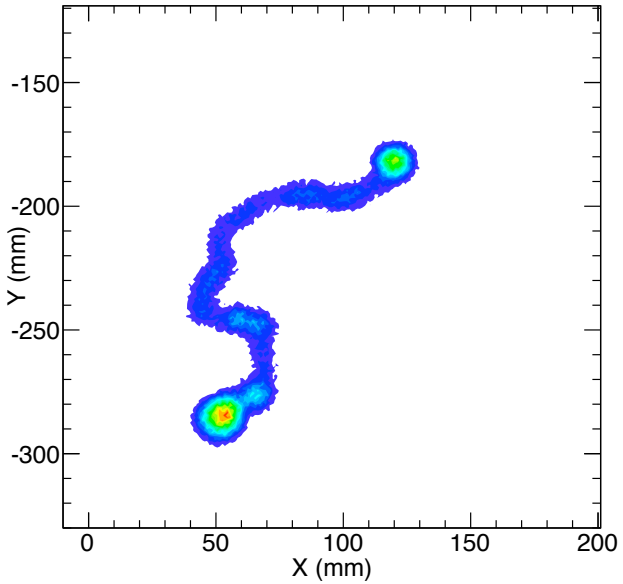
Gas phase at high pressure allows large isotope mass, small volume, tracking

NEXT major technological concerns :

Energy resolution is optimized using a proportional multiplication process of the primary ionizing electrons produced in the gas by the interaction of the charged particles -> **ELECTROLUMINESCENCE (EL)**

Background reduction is obtained by the selection of radio-pure materials and using the topological signature of the electron events -> **OPTICAL TRACKING READOUT using EL signals**



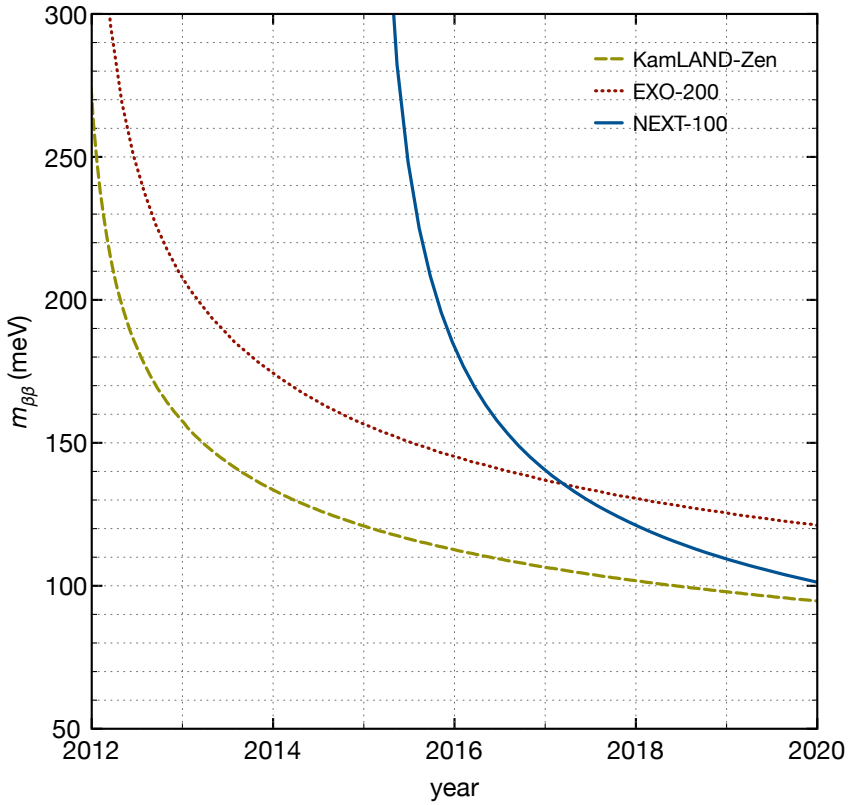


Double beta decay with a HPGXe TPC

The Sensitivity to the neutrino mass of different experimental techniques :

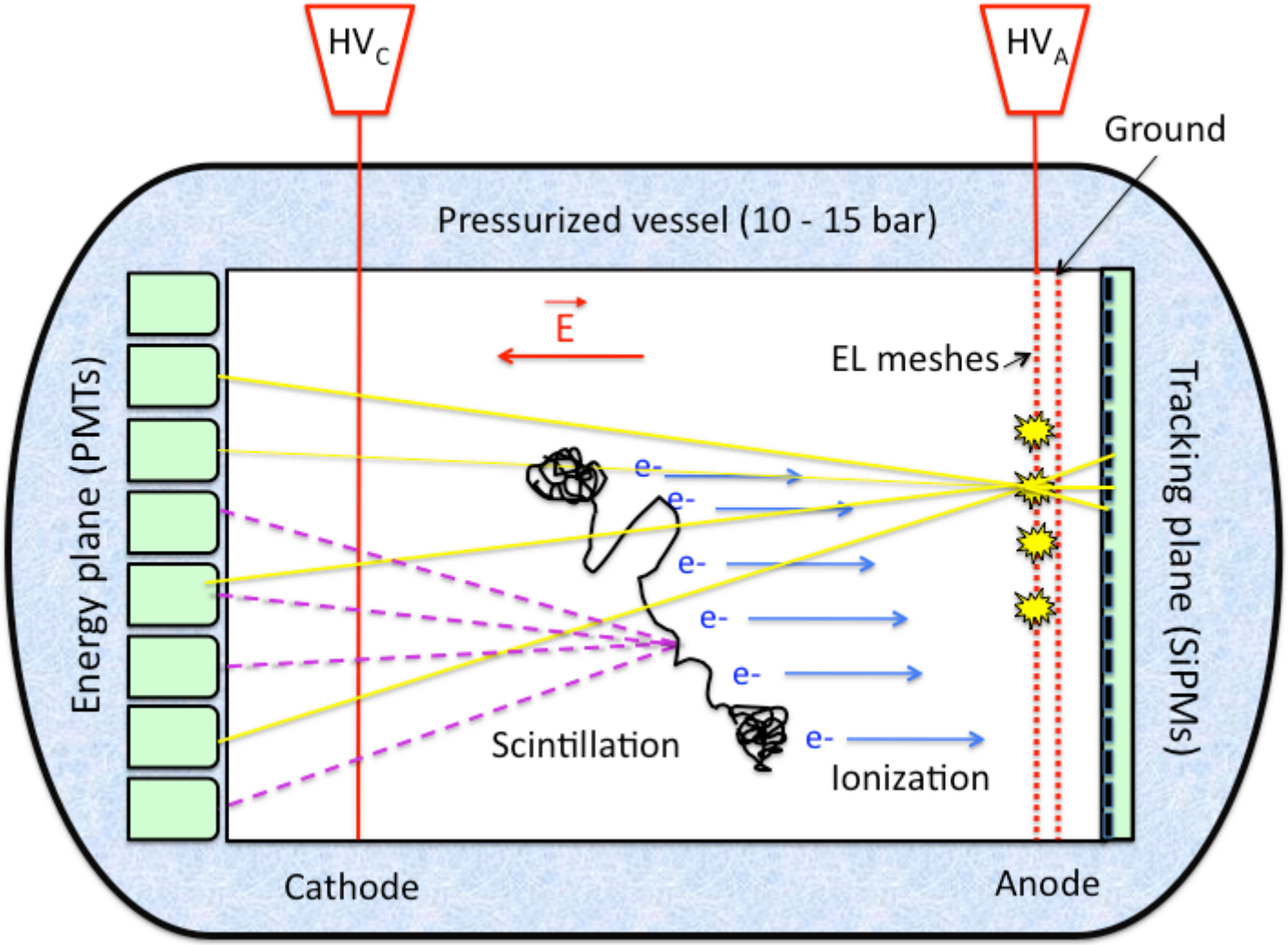
$$m_{\beta\beta} \propto \sqrt{1/\epsilon} \left(\frac{b\ \delta E}{M\ t} \right)^{1/4}$$

ε signal detection efficiency
δE energy resolution
t data taking time
M isotope mass
b background (counts /keV kilogram year)



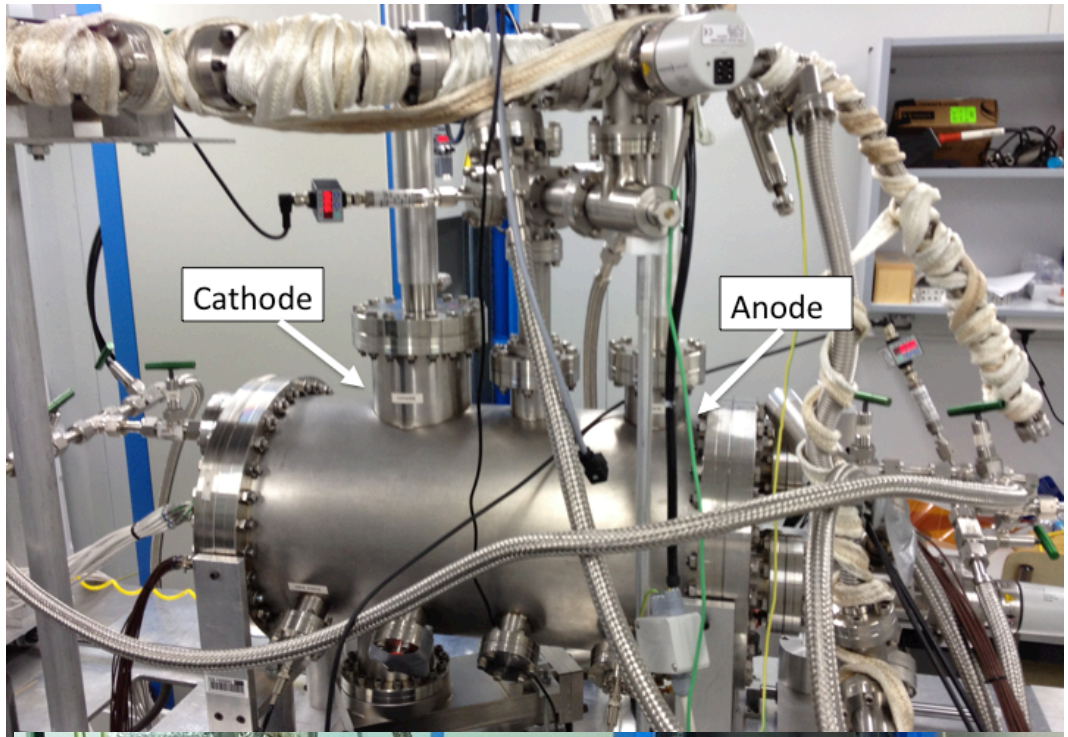
Experiment	M (kg)	ϵ (%)	δE (% FWHM)	b (10^{-3} ckky)
EXO-200	90	62	3.9	1.5
KamLAND-Zen	300	65	9.9	1.0
NEXT-100	90	25	0.7	0.5

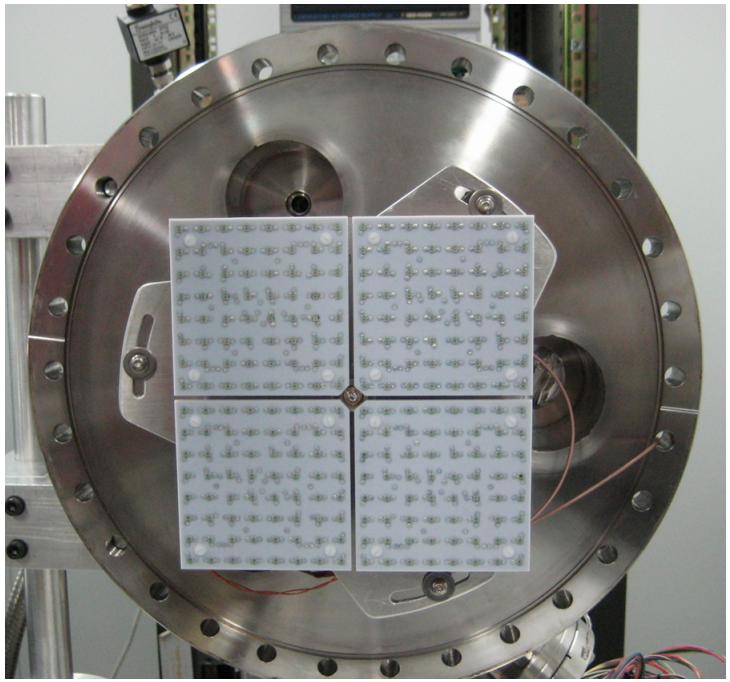
NEXT detector Concept



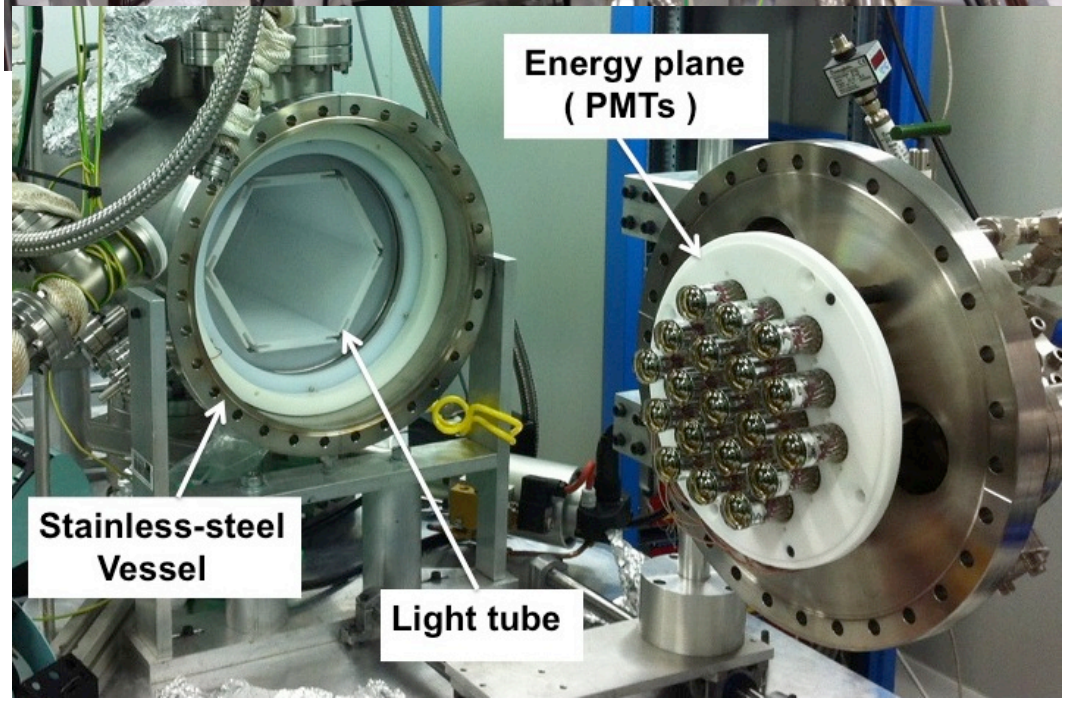
Primary scintillation (S1)
start-of-event signal

Secondary scintillation (S2)
Energy (PMTs) and tracking
(SiPMs) signals





Tracking plane (258 SiPMs), 1 cm pitch



NEXT-DEMO: the large NEXT-100 demonstrator

Presently in operation at IFIC

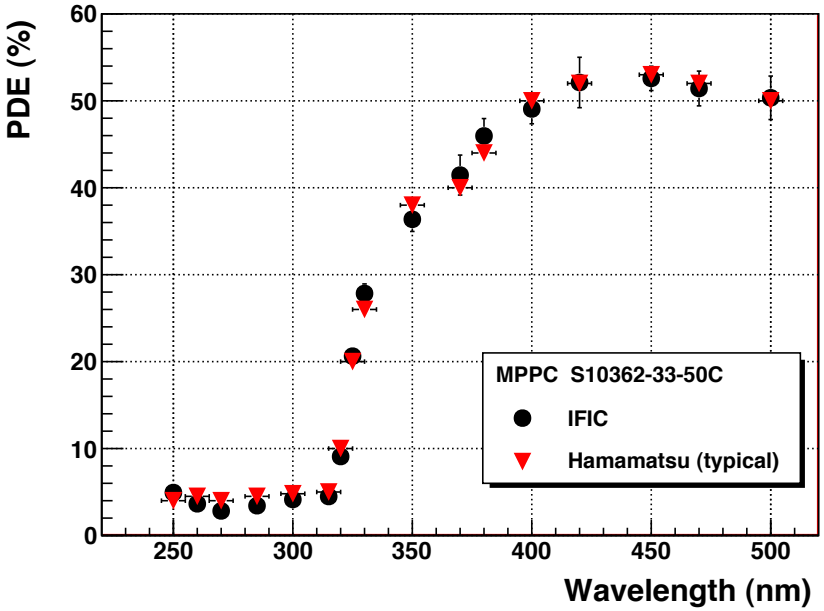
30 cm drift, 16 cm inner diameter, 1 kg of pure xenon at 10 bar pressure

Optical tracking with SiPMs

The necessity to perform an optical tracking in NEXT is driven by the requirement of an optimal resolution in the energy measurement obtained with the EL readout using Photosensors

SiPMs are best suited for optical tracking :

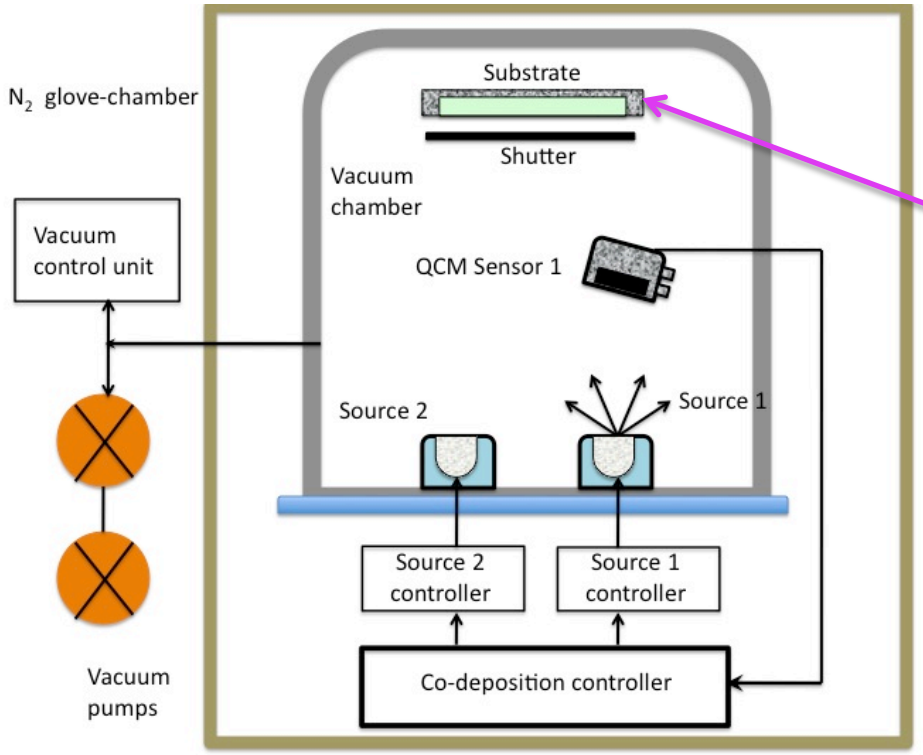
- Cost effective
- Low radioactive
- Small size (1 mm active area)
- High signal level (gain ~ 10^6)



- SiPMs are not sensitive to the xenon scintillation (~ 175 nm)
(see figure of Photon Detection Efficiency versus wavelength).

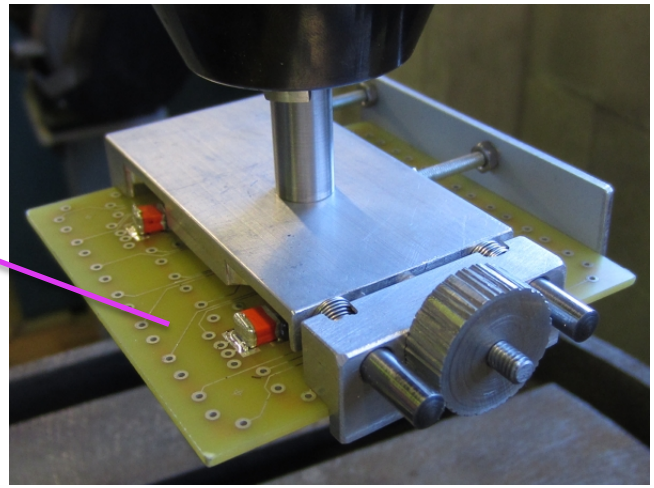
Coating with Tetraphenyl-butadienne (TPB) is used for shifting the VUV light to blue light

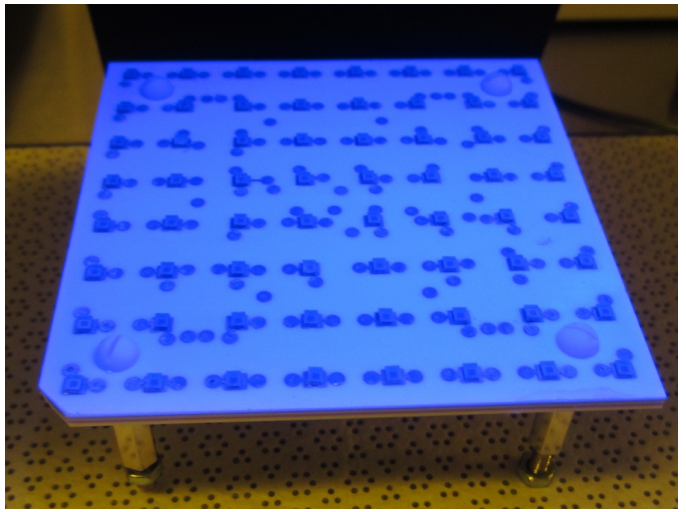
NEXT-DEMO SiPM boards



TPB coating setup

TPB thickness :
(130 ± 10) nm= 0.1 mg/cm^2

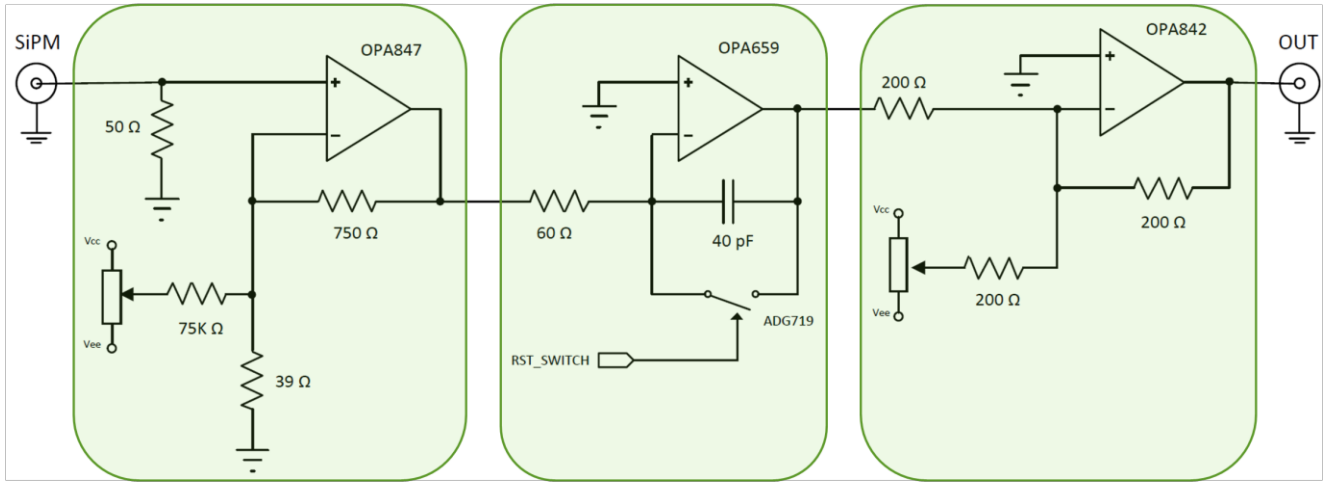




NEXT Dice board (64 SiPMs) coated with TPB
and illuminated with UV light (converted light is blue)

Summary of NEXT-DEMO FE&DAQ

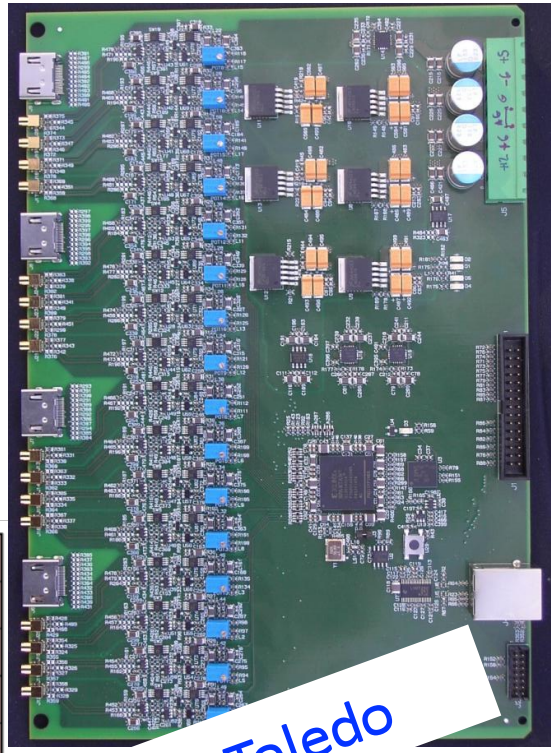
16-ch SiPM front-end board with amplifiers, gated integrators, ADCs and DTC interface to the FEC module

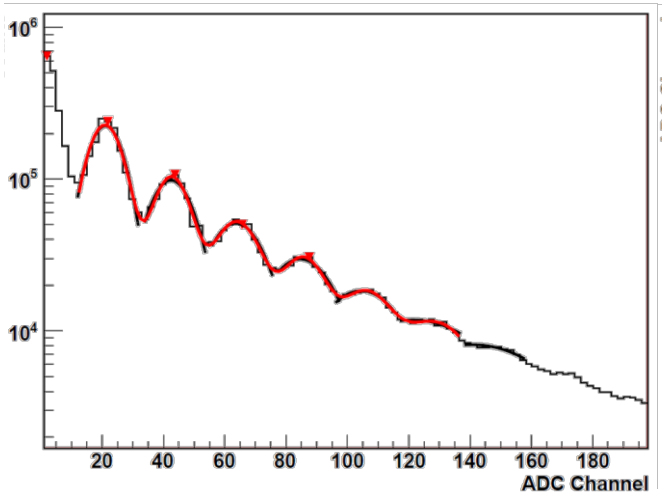


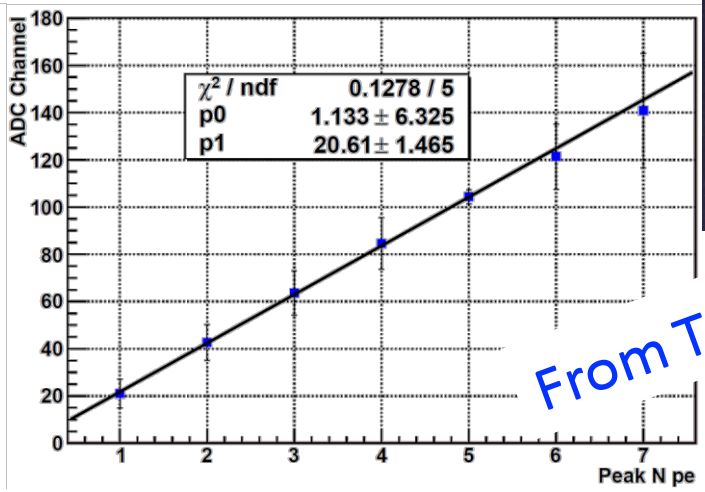
Stage 1: transimpedance amplifier + offset correction

Stage 2: gated integrator

Stage 3: inverter + offsset correction







From TALK by J.Toledo

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Recent results from NEXT-DEMO

Energy resolution

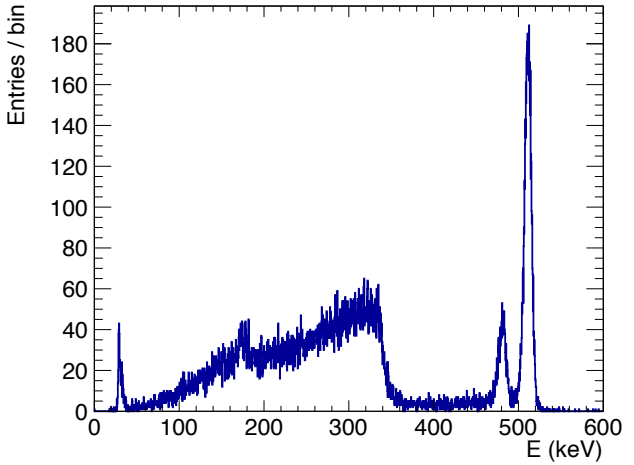
Na-22 radioactive source -> 500 keV gamma from positron annihilation
Located in a lateral port near the TPC cathode

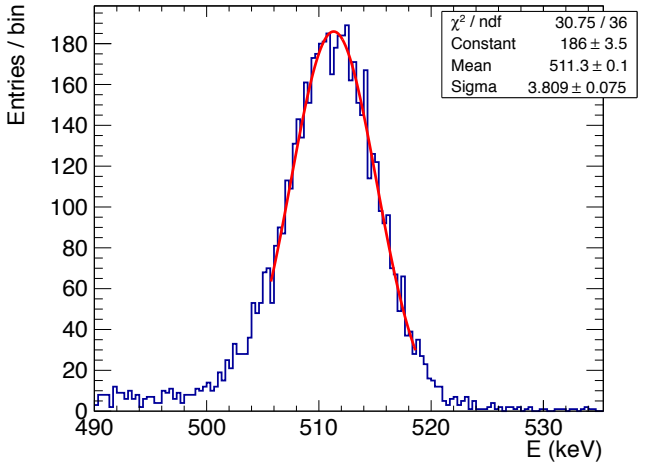
TPC operation conditions:
Cathode 32 kV, Anode 12 kV,
drift velocity : 600 V/cm
E/P : 2.4 kV/cm/bar

Energy resolution obtained after the different spatial corrections (definition of the fiducial volume, attachment, light losses):

1.75 % FWHM

→ 0.7 % FWHM extrapolated to $Q_{\beta\beta}$





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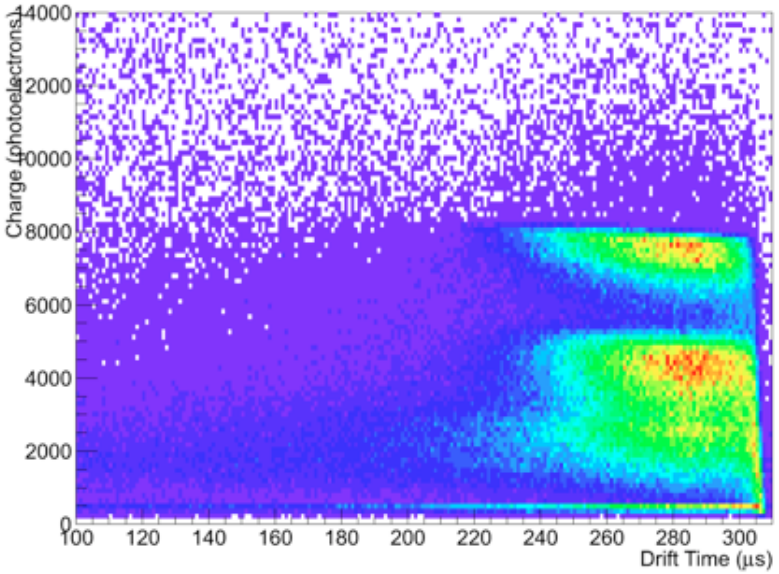
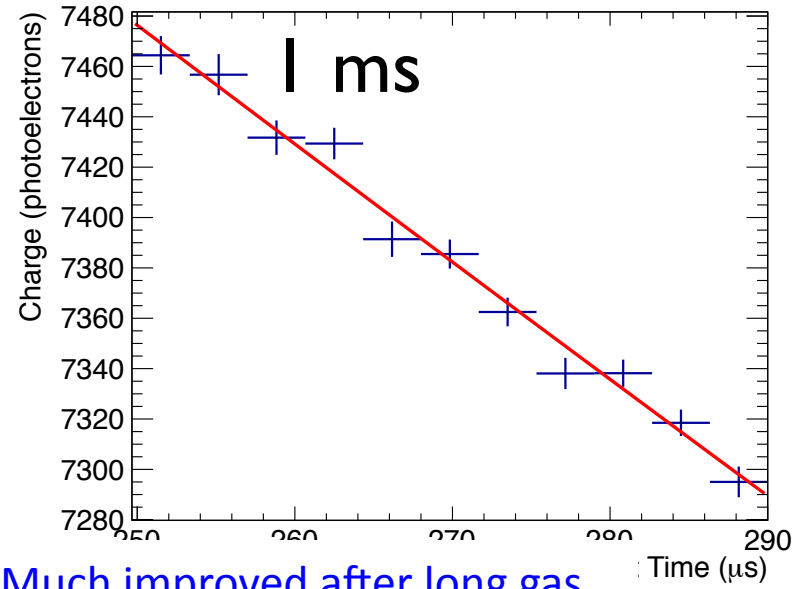
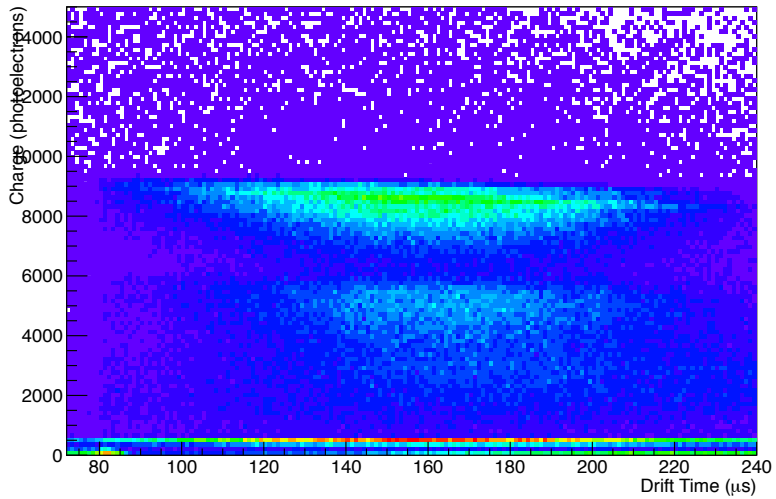
Geometrical corrections on the energy measurement

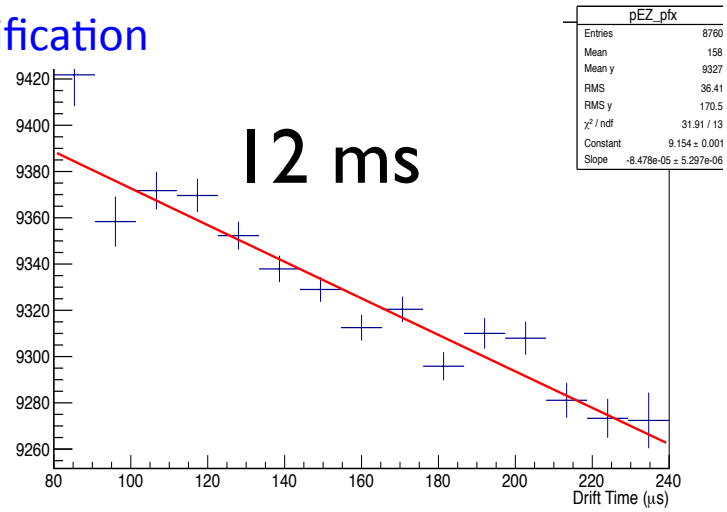
Electron life time



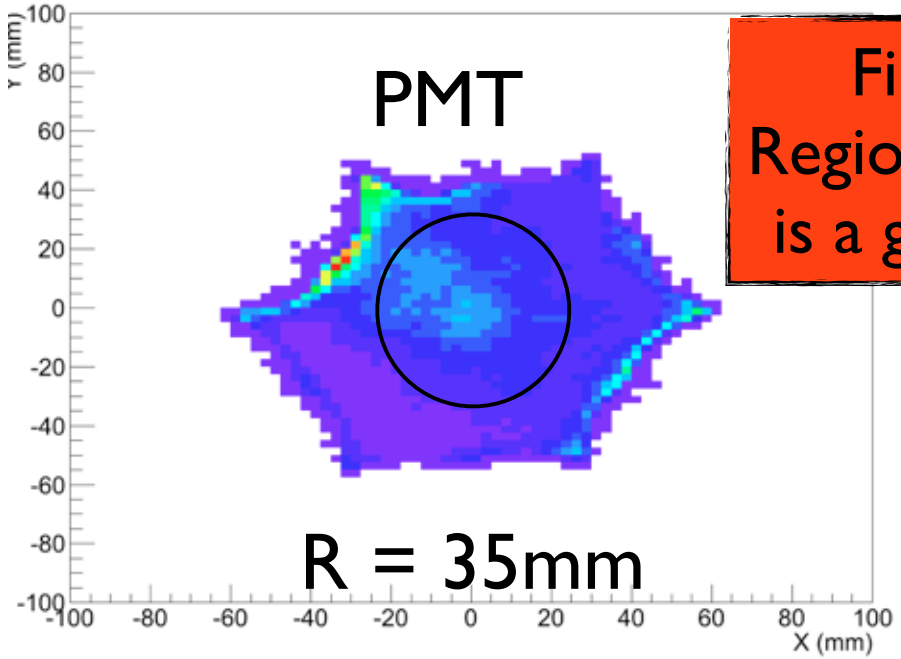


Much improved after long gas purification

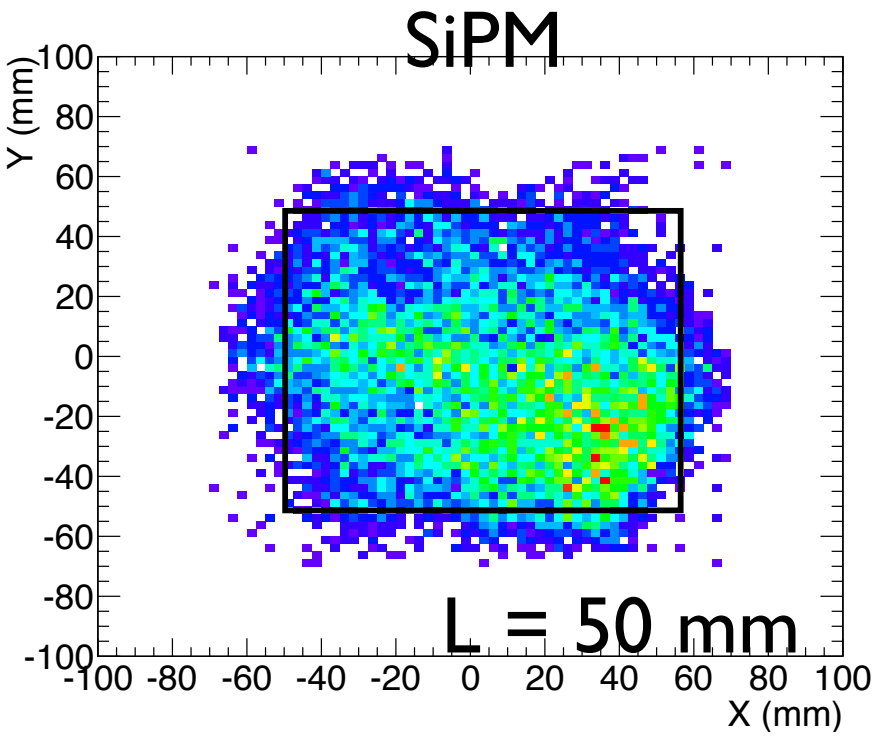




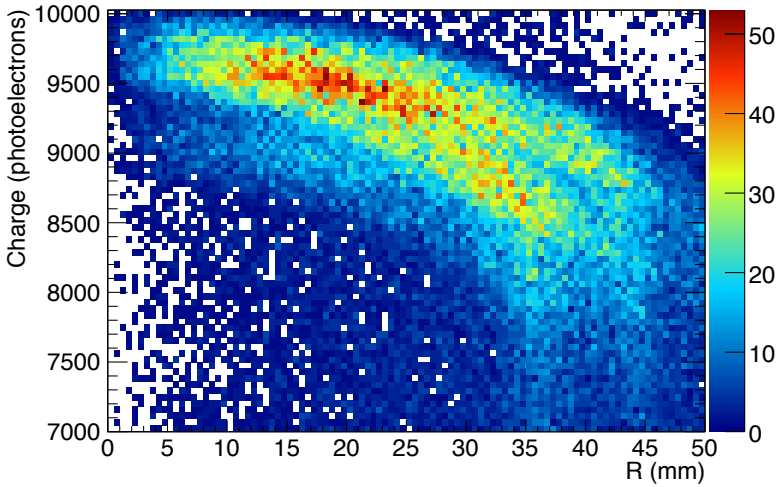
Fiducial volume

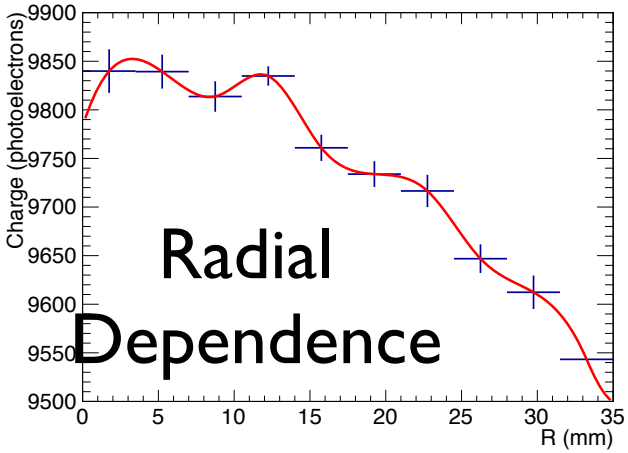


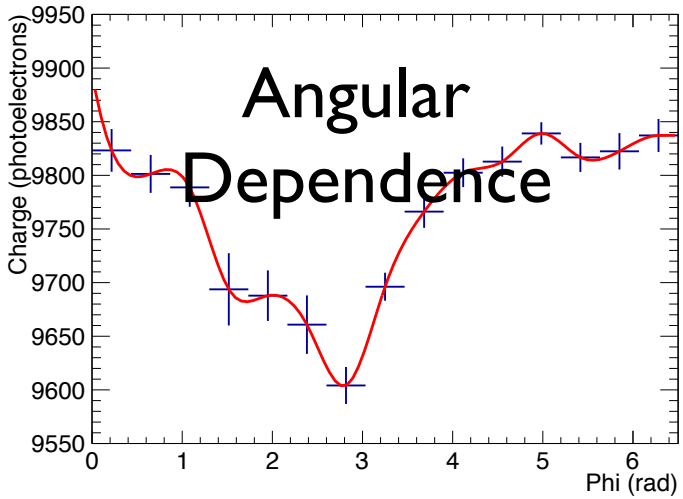
Fiducial Volume defined using MC.
Region where reconstructed XY position is a good estimator of the true position

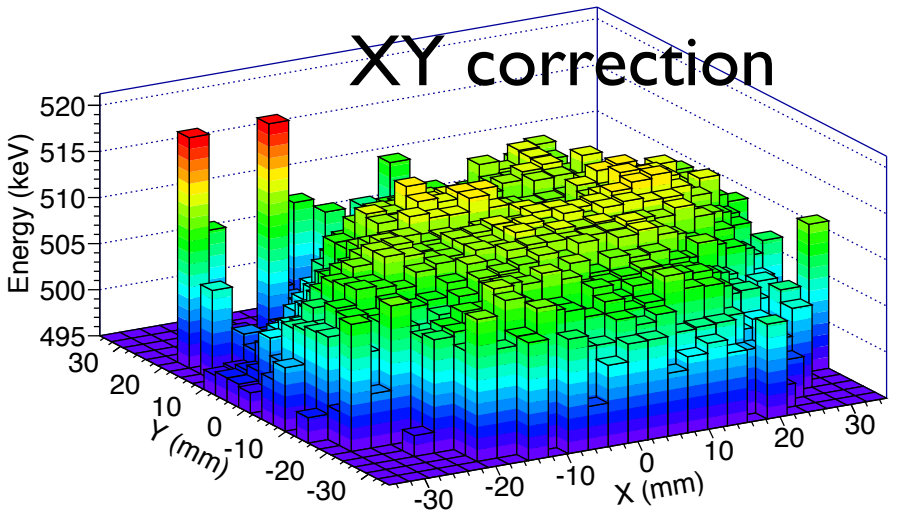


Geometrical corrections



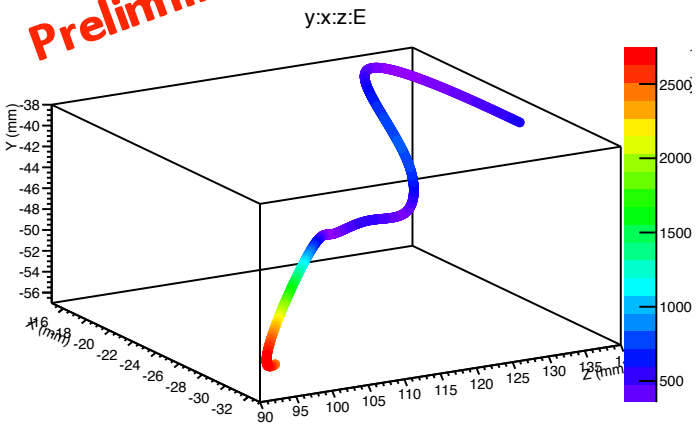


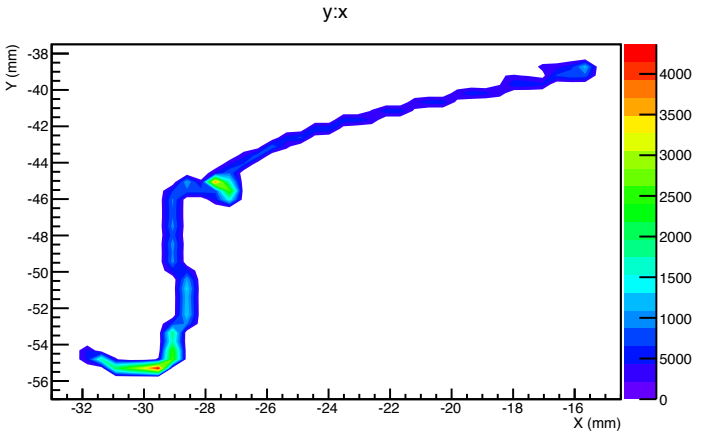


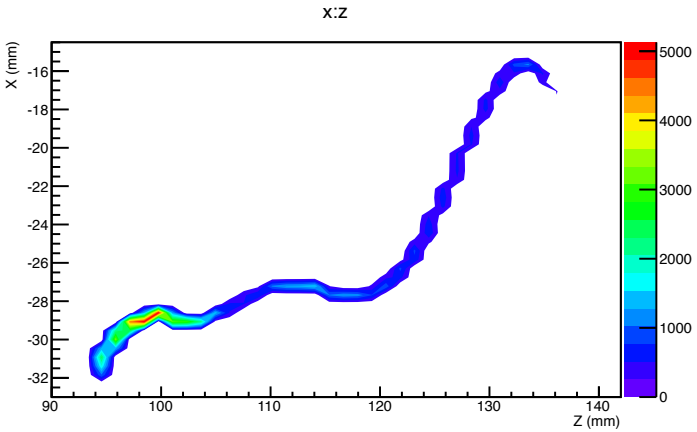


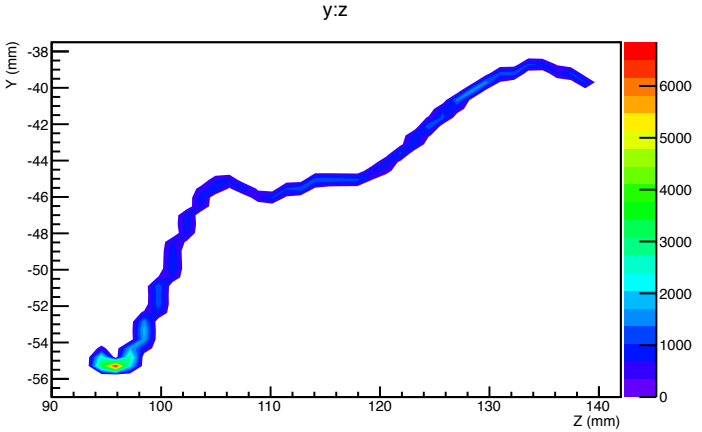
First tracks of 600 keV X-rays from Cs-137 source

Preliminary









Trigger :

4 coinc PMT signals

Thresh: 15-20 pes

Event Rate :

5 Hz
1 µs sampling

Each track point :

10 SiPMs with highest energy

Detector pperation conditions :

Cs-137 source located in the lateral side of the TPC perpendicular to the drift axis

Xenon gas pressure : 10 bar

Cathode : 25 kV, Anode: 10 KV, Drift velocity : 500 V/cm

E/P = 2kV/cm/bar

SiPMs calibration for tracks reconstruction:

SiPM Gains within a board have up to 4% dispersion due to the common bias of the 64 SiPMs. Individual Gain of SiPMs vs HV are determined off-line using a LED Operated in pulsed mode. Single photon response spectra are recorded for the gain measurements.

During operation in the TPC The SiPM signals are equalized using 30 keV X-rays.

30 keV X-rays occur everywhere in the TPC and are seen by the SiPMs over the tracking plane as point like events of equal energy which can be used for equalization of the SiPM signals.

Conclusions

- First tracks of 600 keV X-rays from Cs-137 radioactive source have been obtained with NEXT-DEMO optical tracking system based on SiPMs.

- A topological signature of the ranging out electrons are clearly seen with real data : a long track ended by a blob as already predicted by earlier simulations.

- The detector using the SRS electronics developed by the rd51 collaboration is operated in a very stable conditions and is well performing.

- Lots of data are presently being collected with different radioactive sources : Na-22, Co-60, Cs-137, and are being analyzed .