The NEXT experiment

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On behalf of the NEXT collaboration

DBD11 — November 2011

NEXT Collaboration

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

LBNL • Texas A&M• John Hopkins

CEA (Saclay)

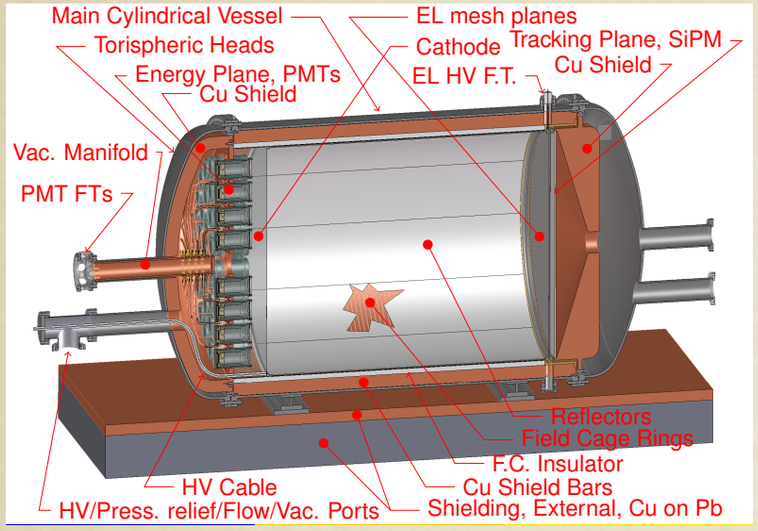
U. Coimbra • U. Aveiro

JINR (Dubna)

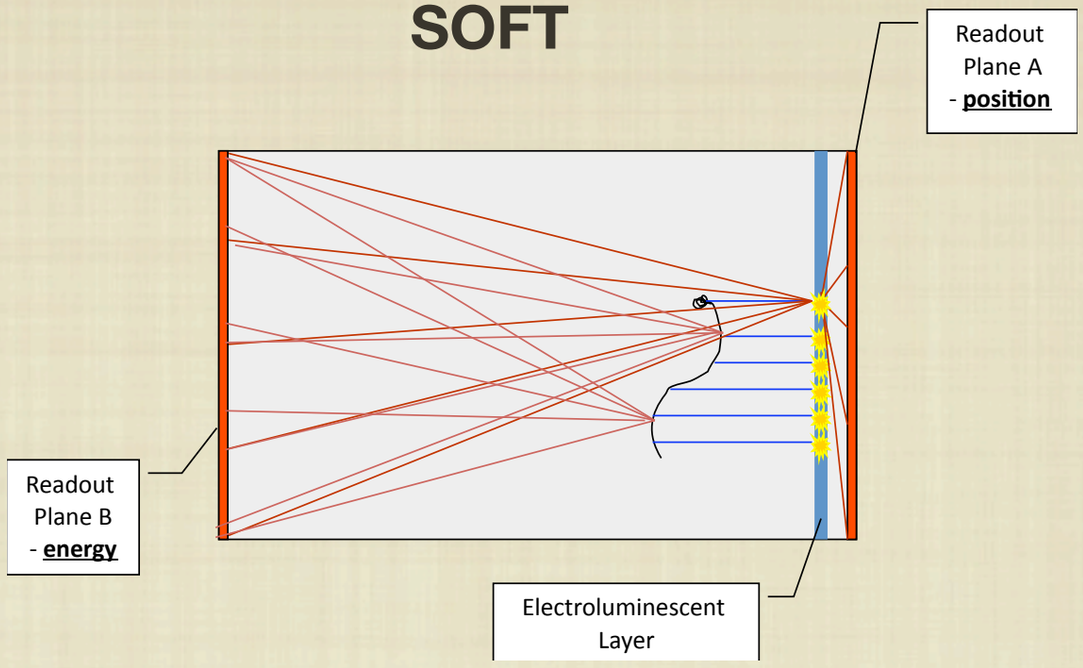
UAN (Bogotá)

NEXT concept

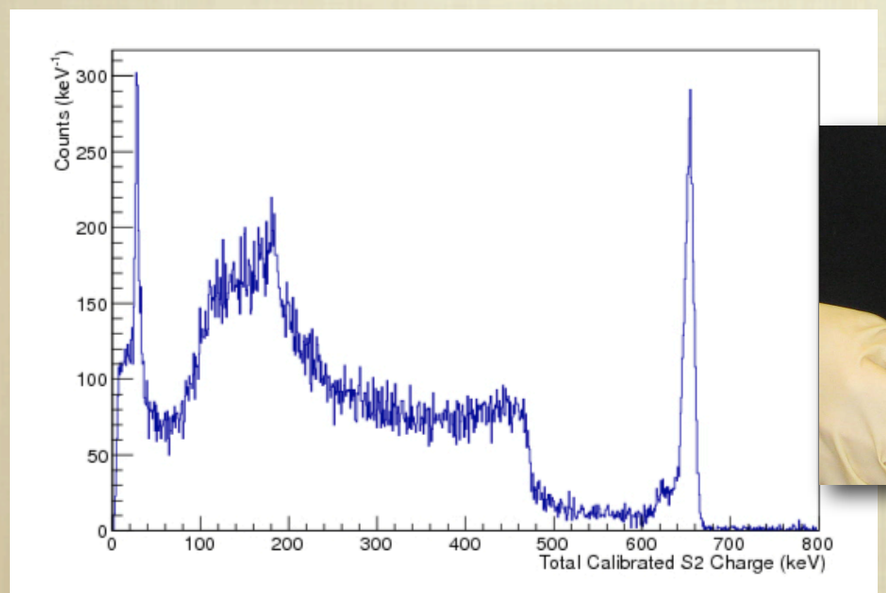
HPGXe

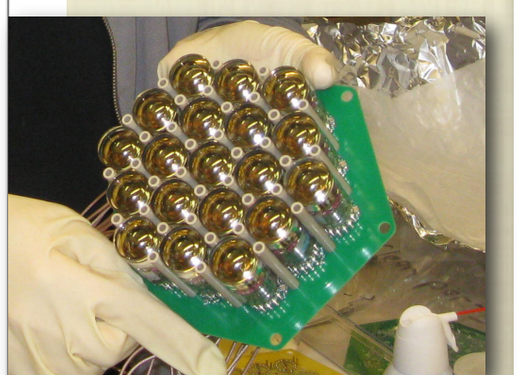


SOFT

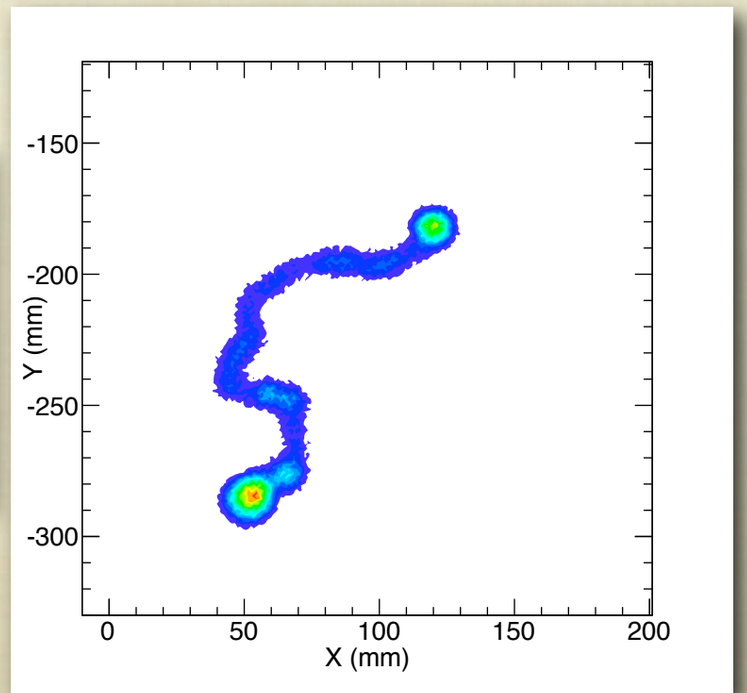


Energy resolution

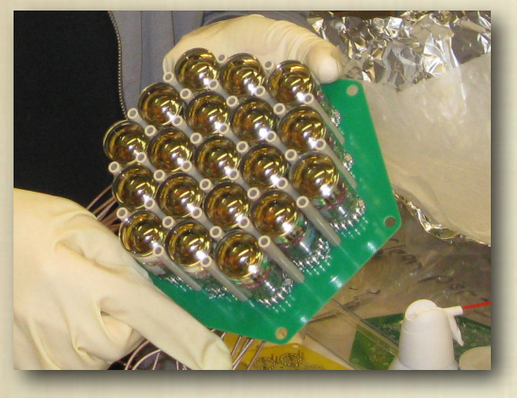


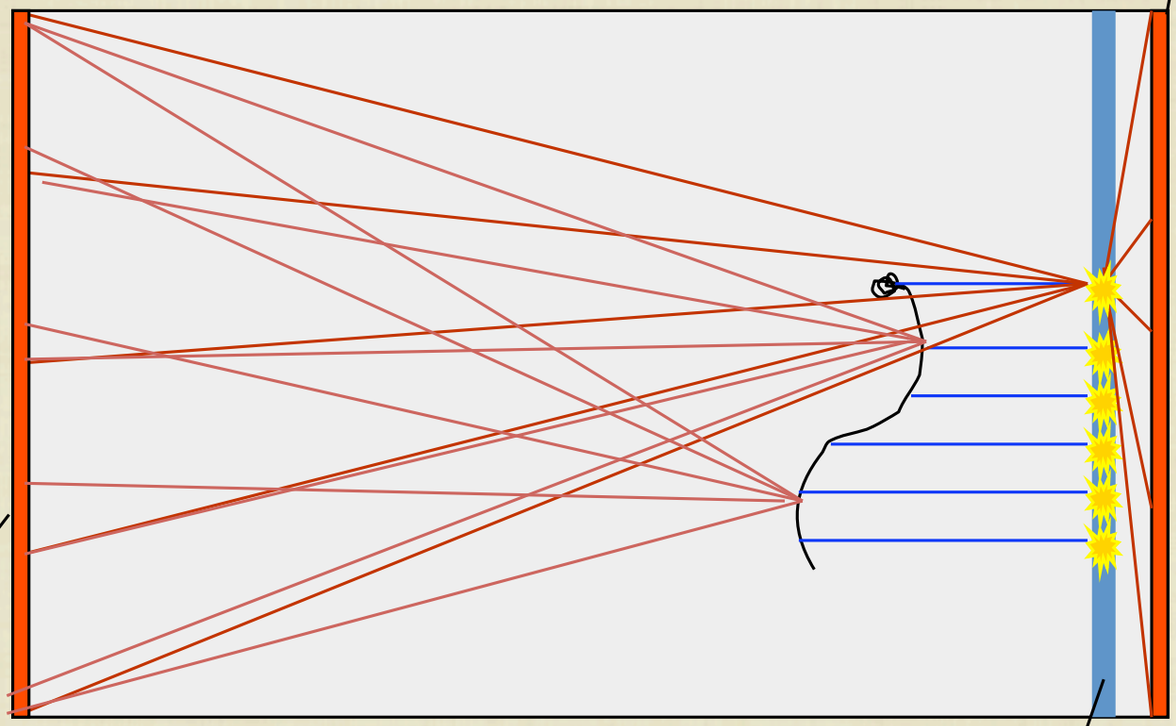


Topological signature

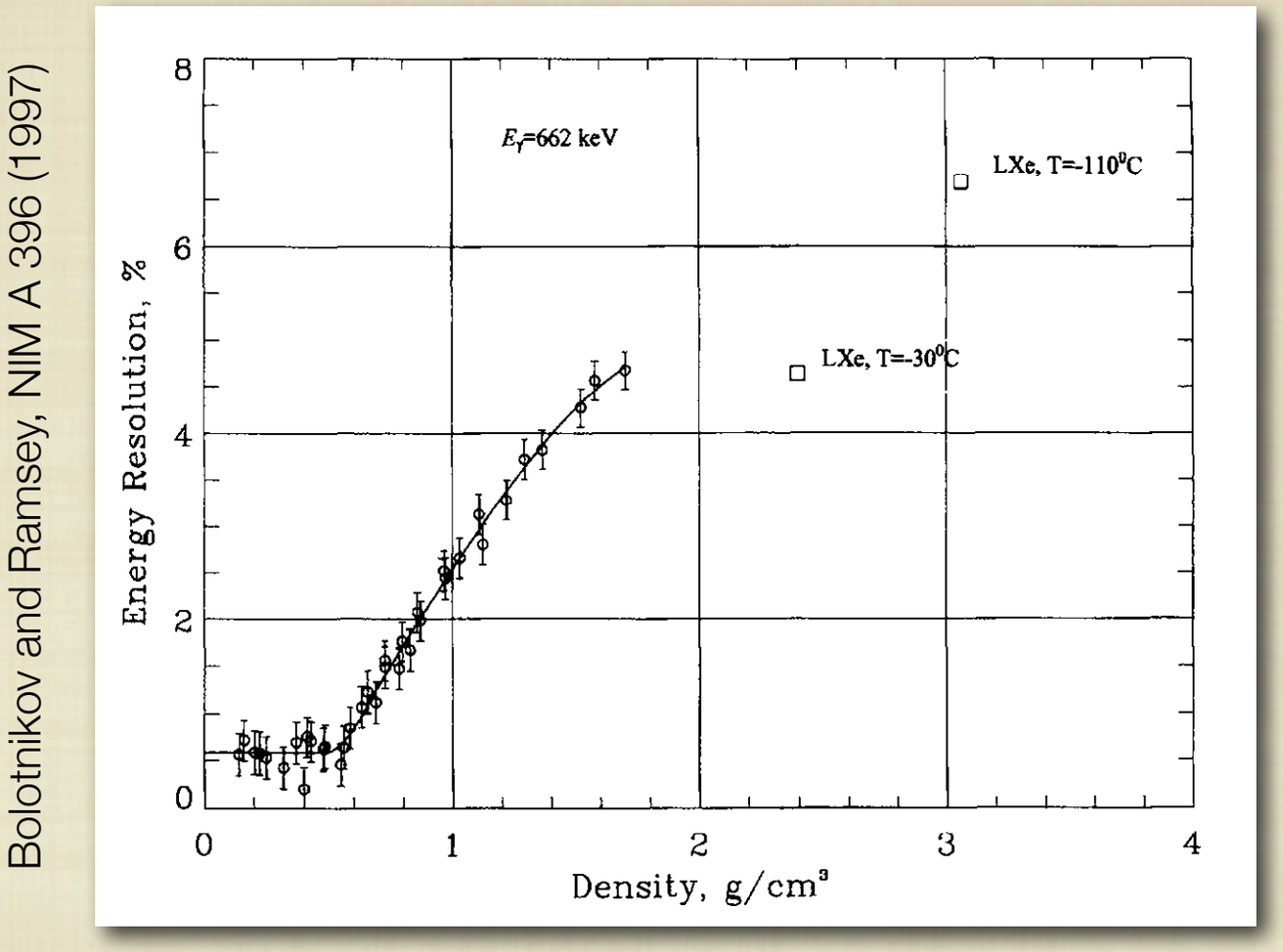


The SOFT concept





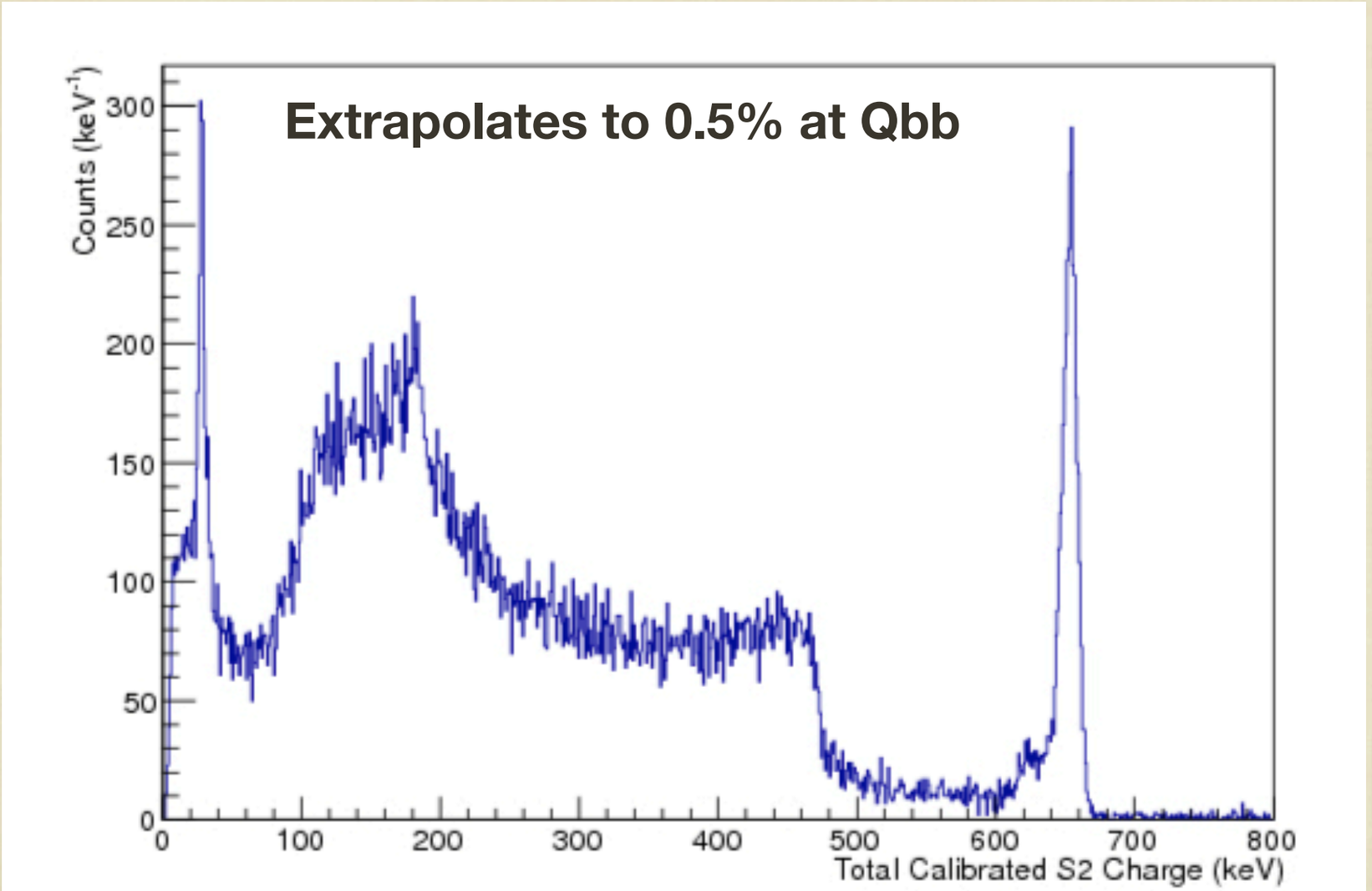
Energy resolution in HPXe



- Intrinsic resolution (Fano factor) at $Q_{\beta\beta}$ (2458 keV): 3×10^{-3} FWHM.
- Achieved in NEXT large prototypes: 5×10^{-3} FWHM.
- NEXT target: 0.5% FWHM appears feasible.

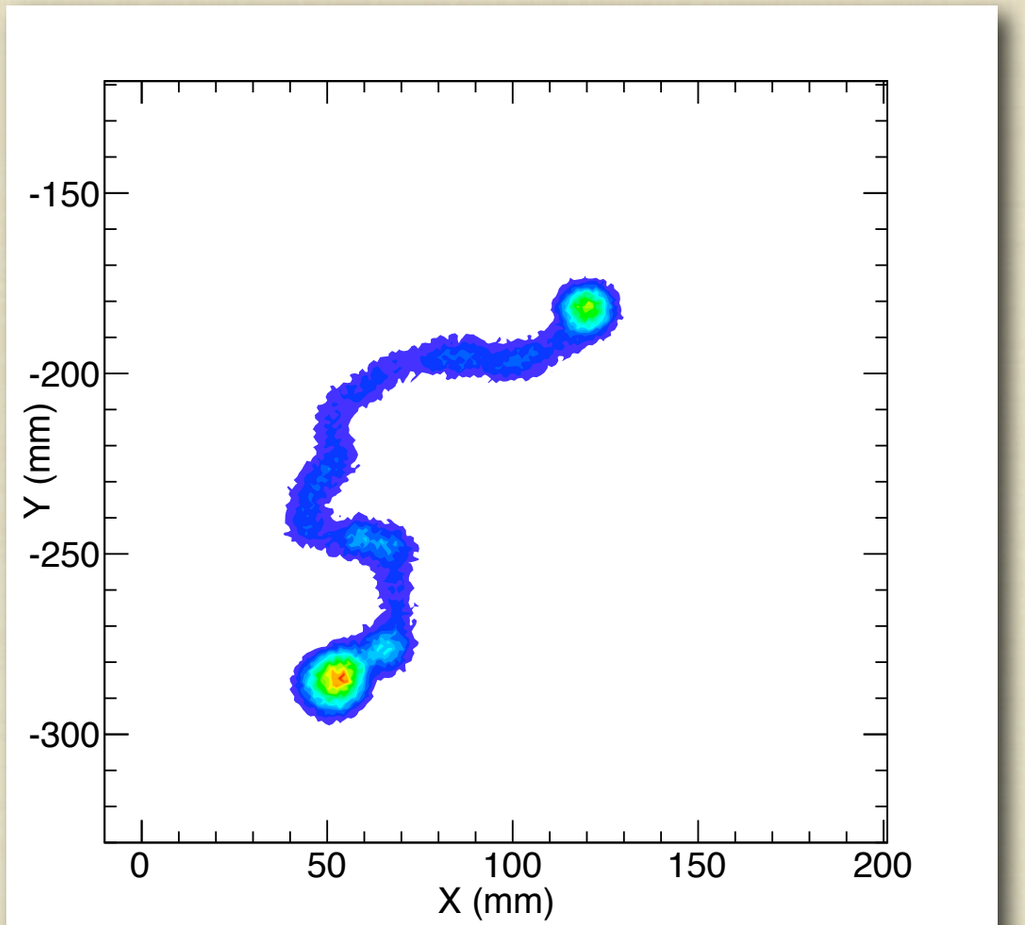
Energy resolution

Energy resolution of 1 % FWHM at 662 keV measured by NEXT-DBDM



Full energy spectrum for a Cs-137 calibration source.
Resolution is quite stable against pressure, drift field (0.3-2 kV/cm) and EL (2.0-3.5 kV/cm bar), but careful calibration and monitoring needed.

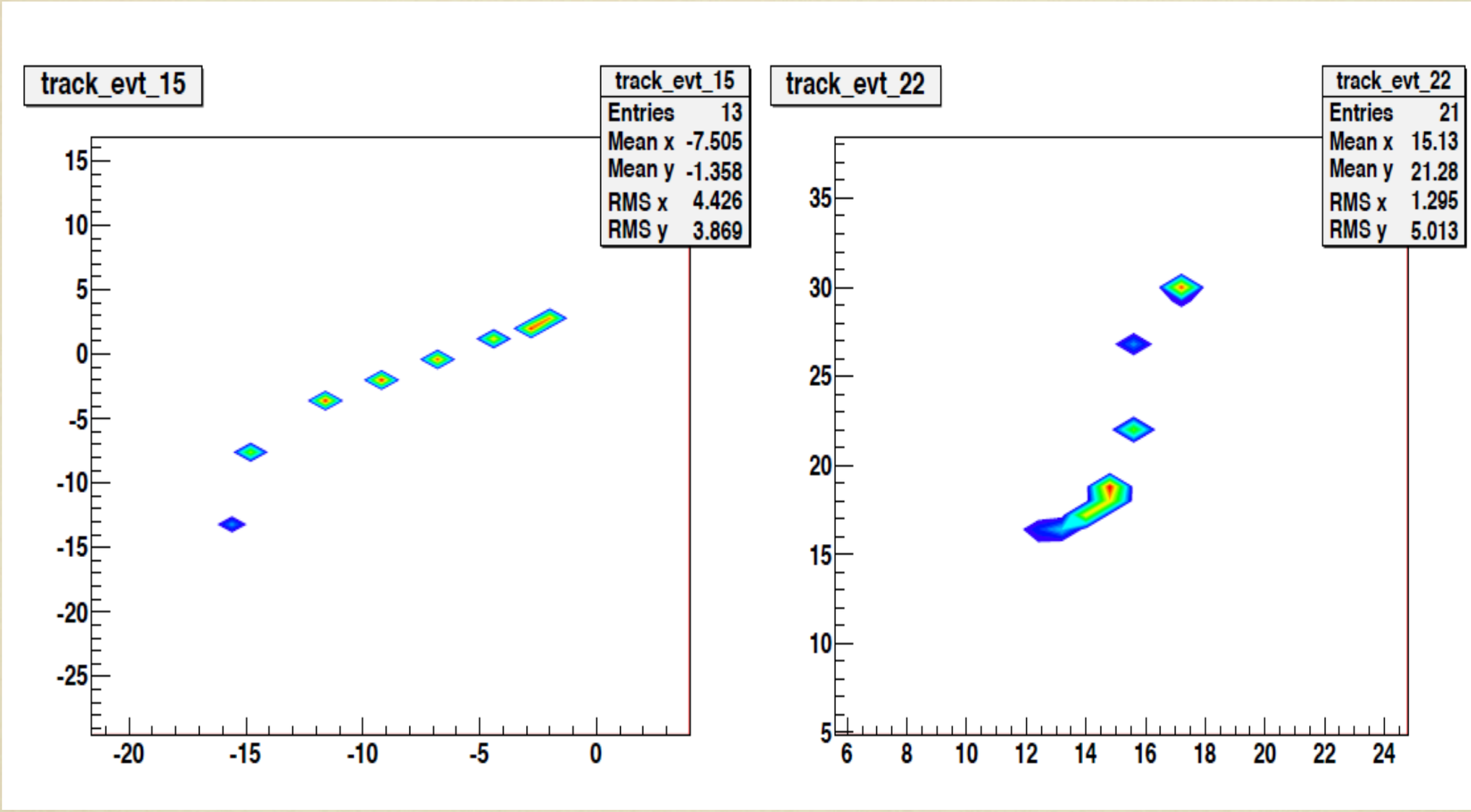
Tracking in HPXe



Electrons travel on average ~15 cm each. Clear topological signature. Electrons behave as MIPs except near the endpoints (*blobs*).

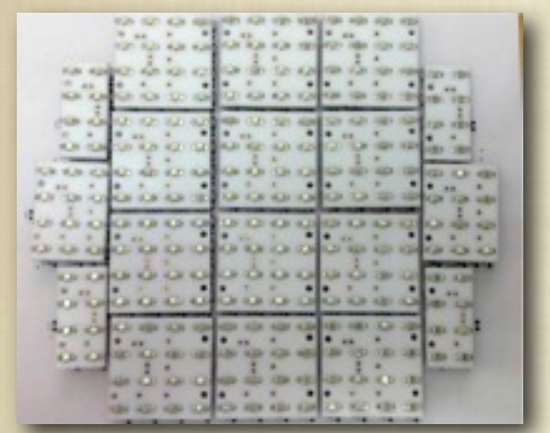
Topological signature

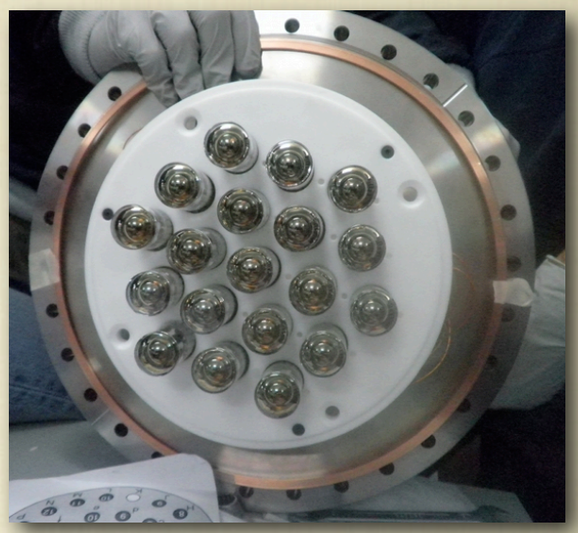
Tracks reconstructed at 662 keV by NEXT-DEMO



Single blobs clearly visible at the end of the track

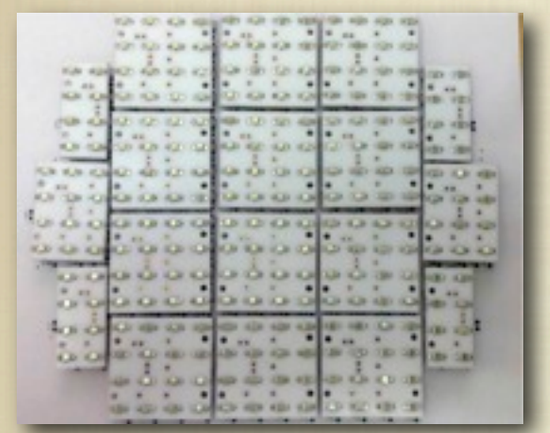
Detection process

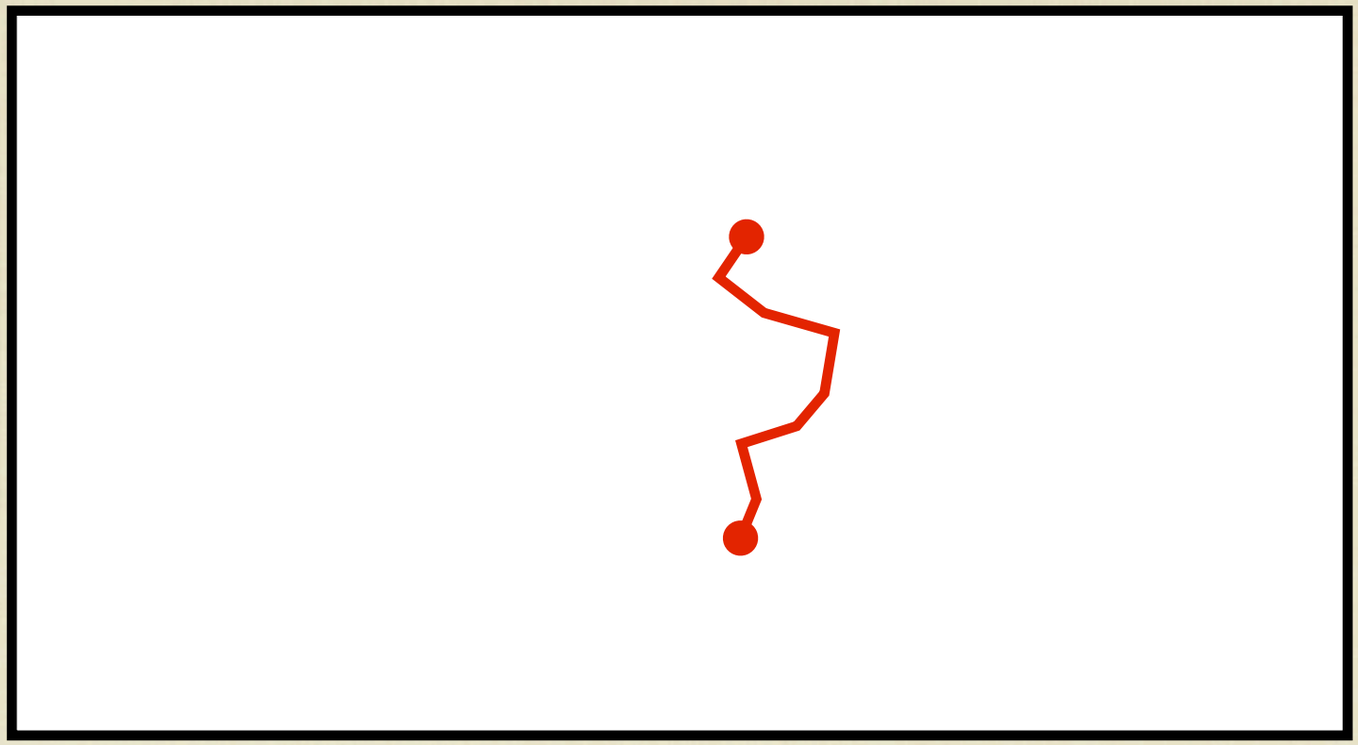


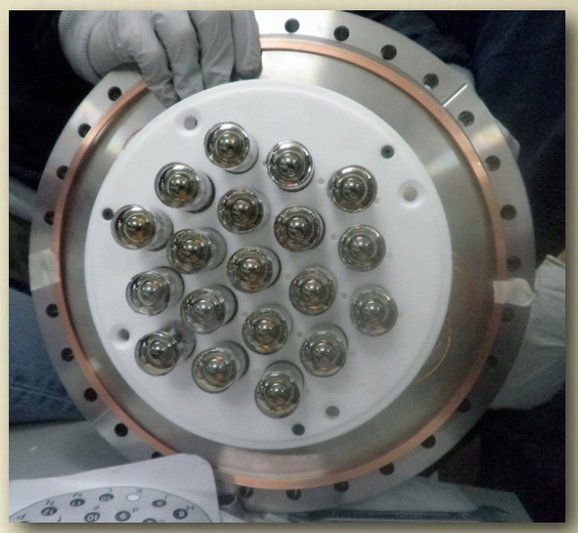


- Cylindrical TPC filled with highly enriched (>90%) ^{136}Xe gas at 15 bar pressure.
- TPC walls lined with material highly reflective.
- Signals read by photosensors
- Baseline detector with ~100-150 kg mass (2 m^3): NEXT-100.

Detection process

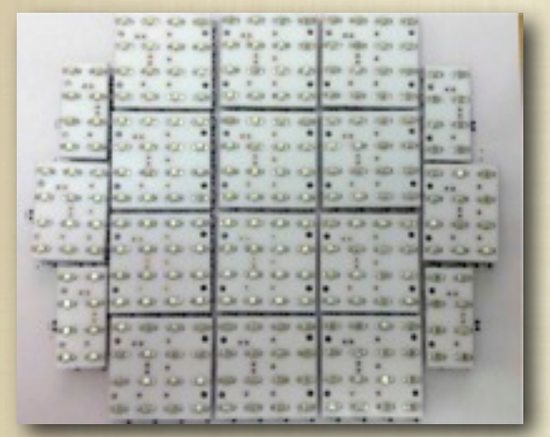


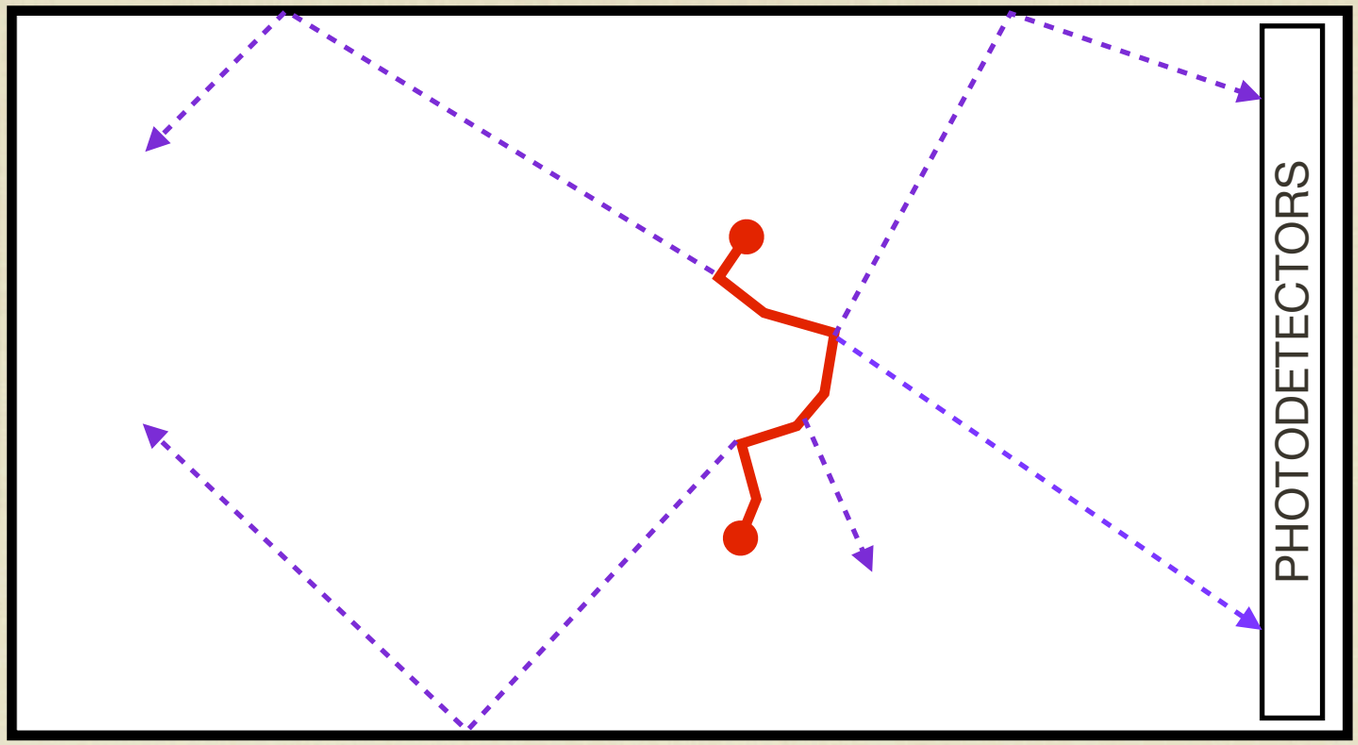


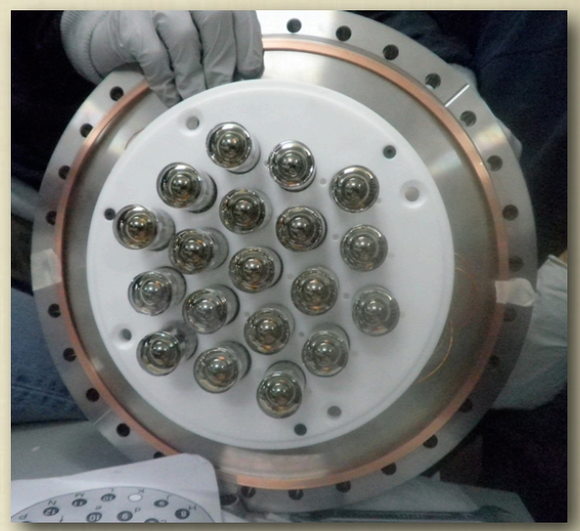


- A ^{136}Xe isotope decays emitting the two electrons.
- They propagate through the HPXe ionizing and exciting its atoms.

Detection process

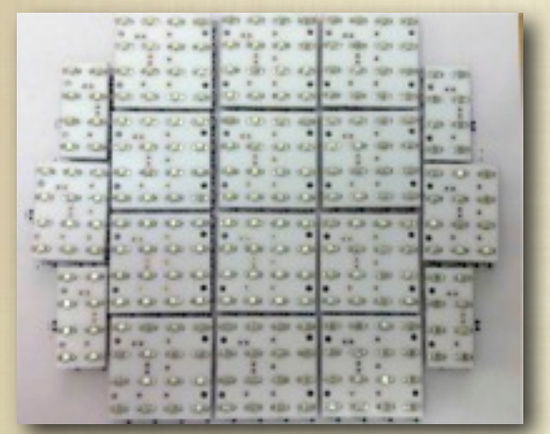


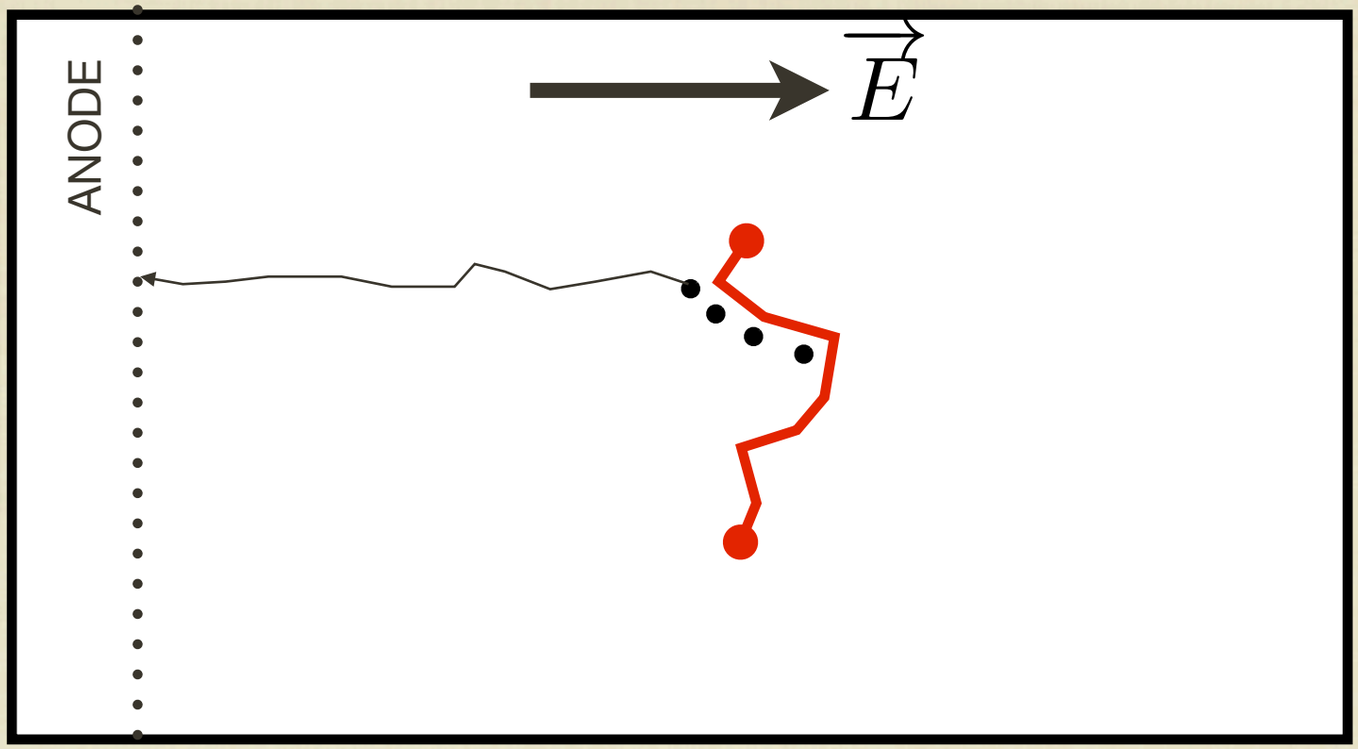


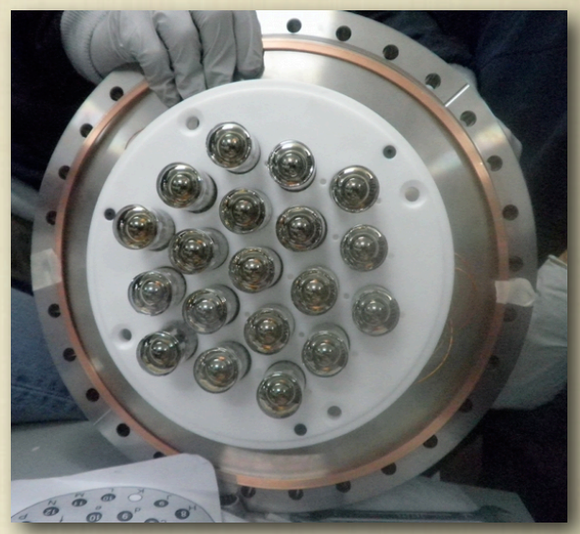


- Prompt primary scintillation light emission in VUV (~175 nm). About 100 eV needed to create a primary scintillation photon.
- Detect faint signal via sensitive photo-detectors (PMTs) behind transparent cathode.
- Determine t_0 and therefore event position along drift.

Detection process

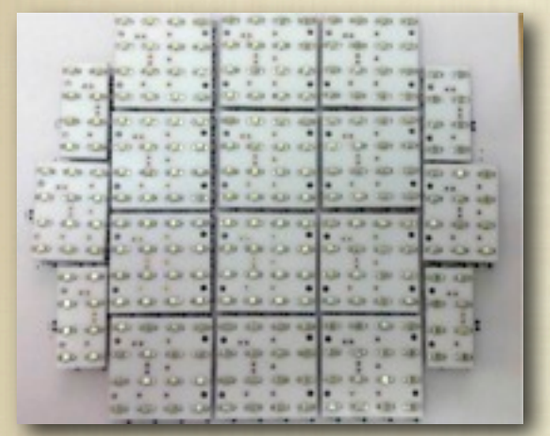


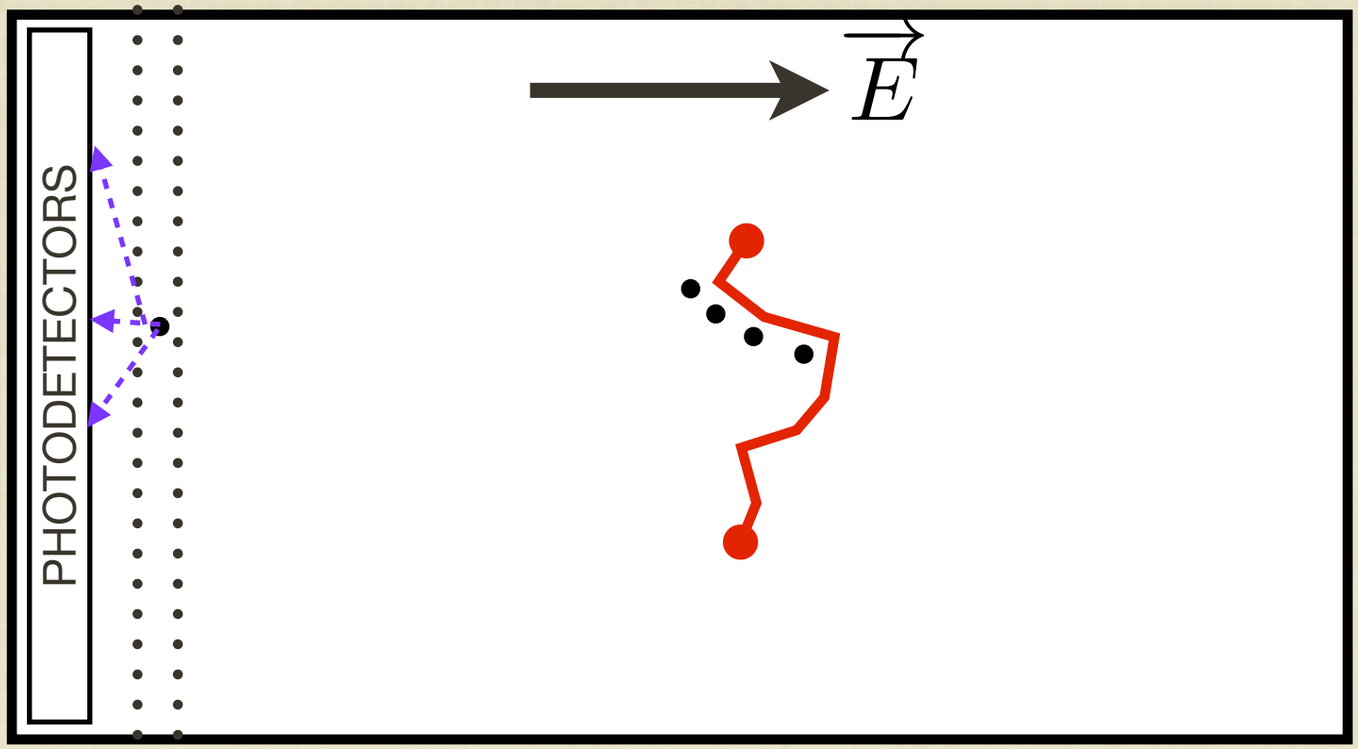


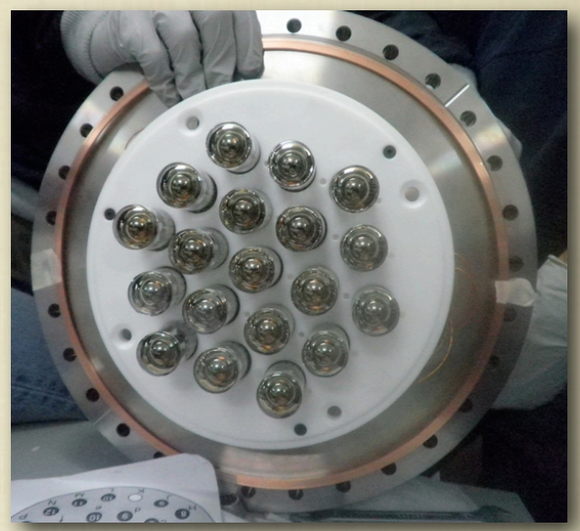


- Create ionization charge in Xe: ~25 eV to create one electron-ion pair.
- Electrons drift toward anode with velocity ~1 mm/us in a ~0.5 kV/cm electric drift.
- At 10 bar pressure, non-negligible diffusion: 9 mm/√m transverse, 4 mm/√m longitudinal).

Detection process

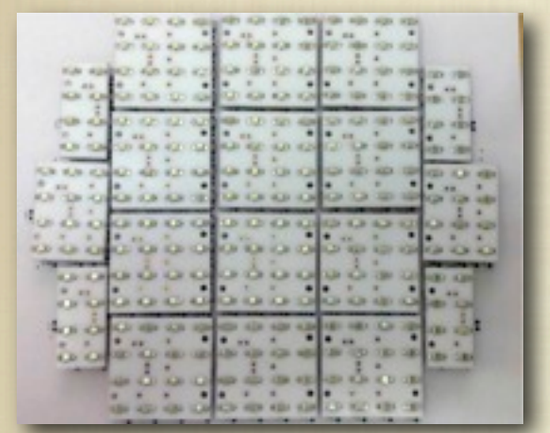


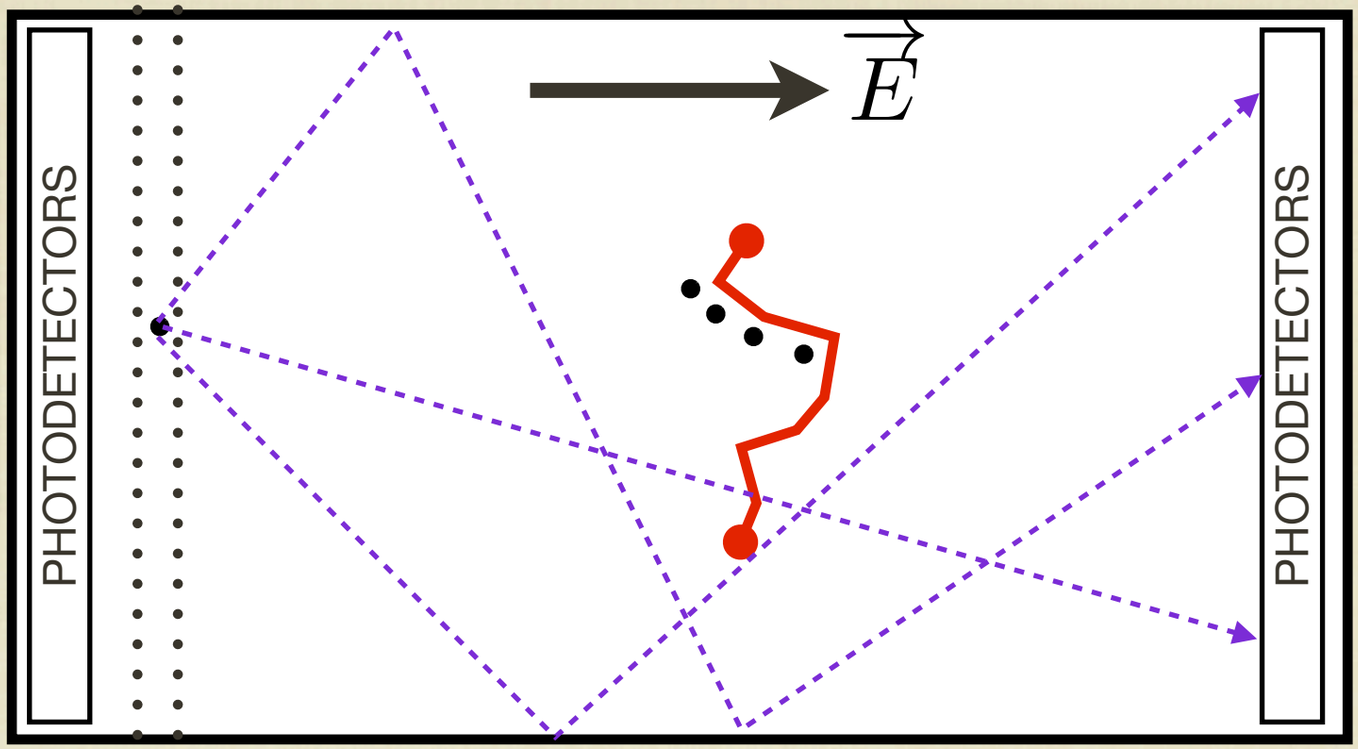


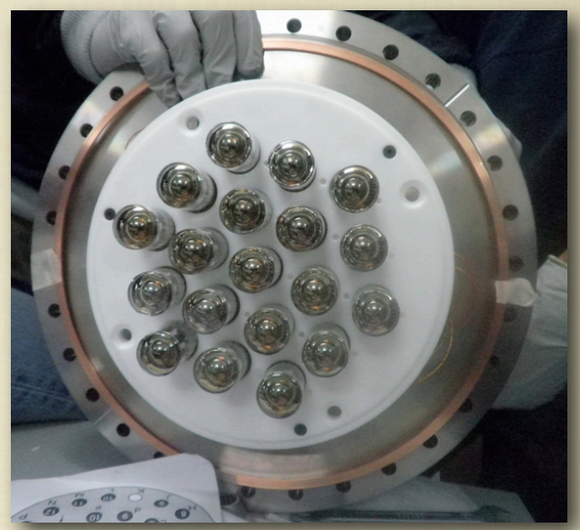


- Additional grid in front of anode creates ~0.5 mm thick region of more intense field: E/p ~4 kV/cm/bar.
- Secondary scintillation light (electroluminescence) created in between grids by atomic de-excitation, with very linear gain of order 10^3 and over a ~2us interval.
- Finely segmented photo-detector plane (MPPCs) just behind anode performs “tracking”.

Detection process

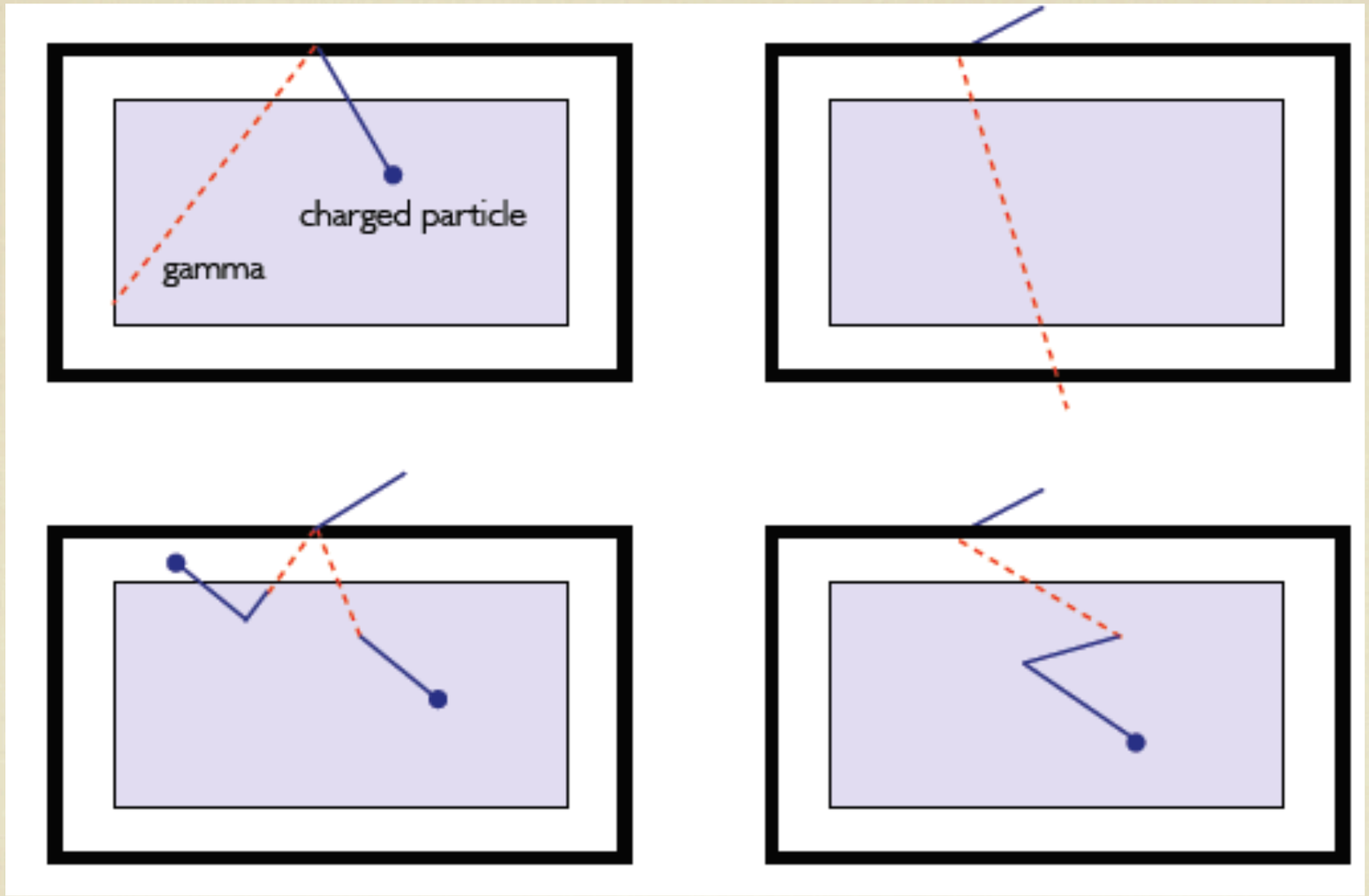






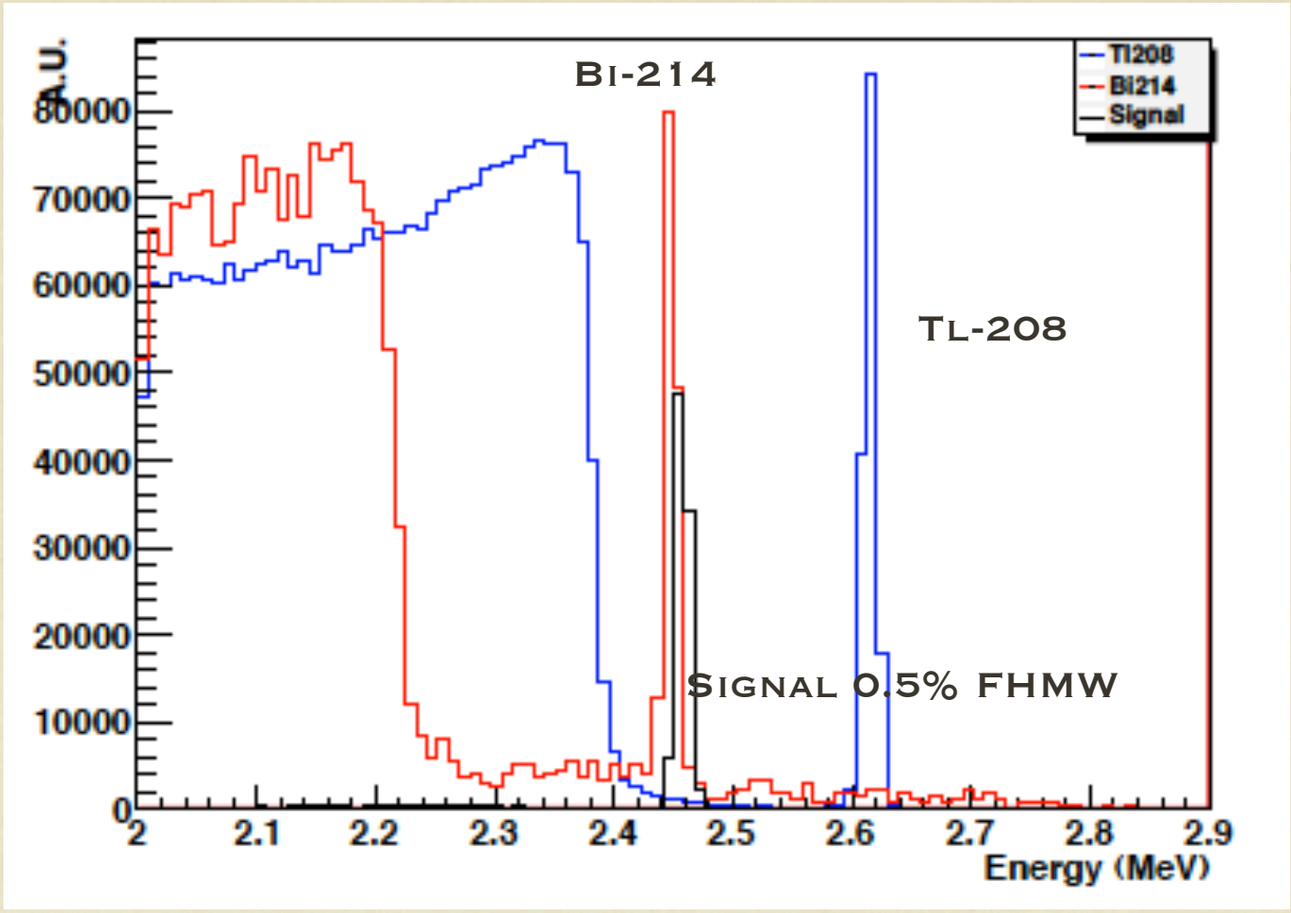
- Electroluminescence, emitted isotropically, also reaches cathode.
- Same array of photo-detectors used for t_0 measurement is also used for accurate calorimetry.

Backgrounds



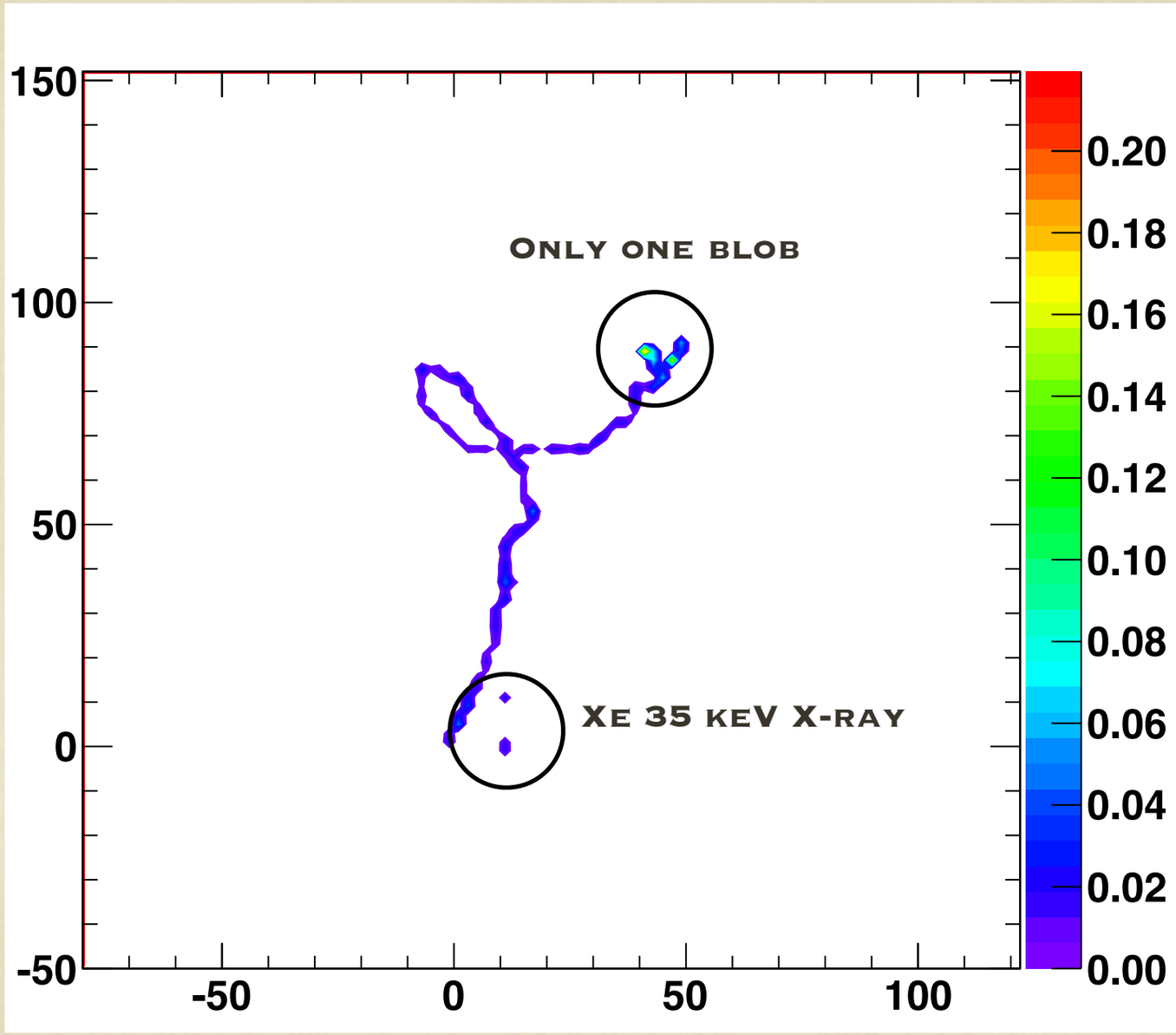
- The only relevant background for NEXT are gammas from Bi-214 and TI-208.
- 3D reconstruction of event suppresses most background events including identification of 30 keV X-rays from Xe de-excitation.

The Xe landscape



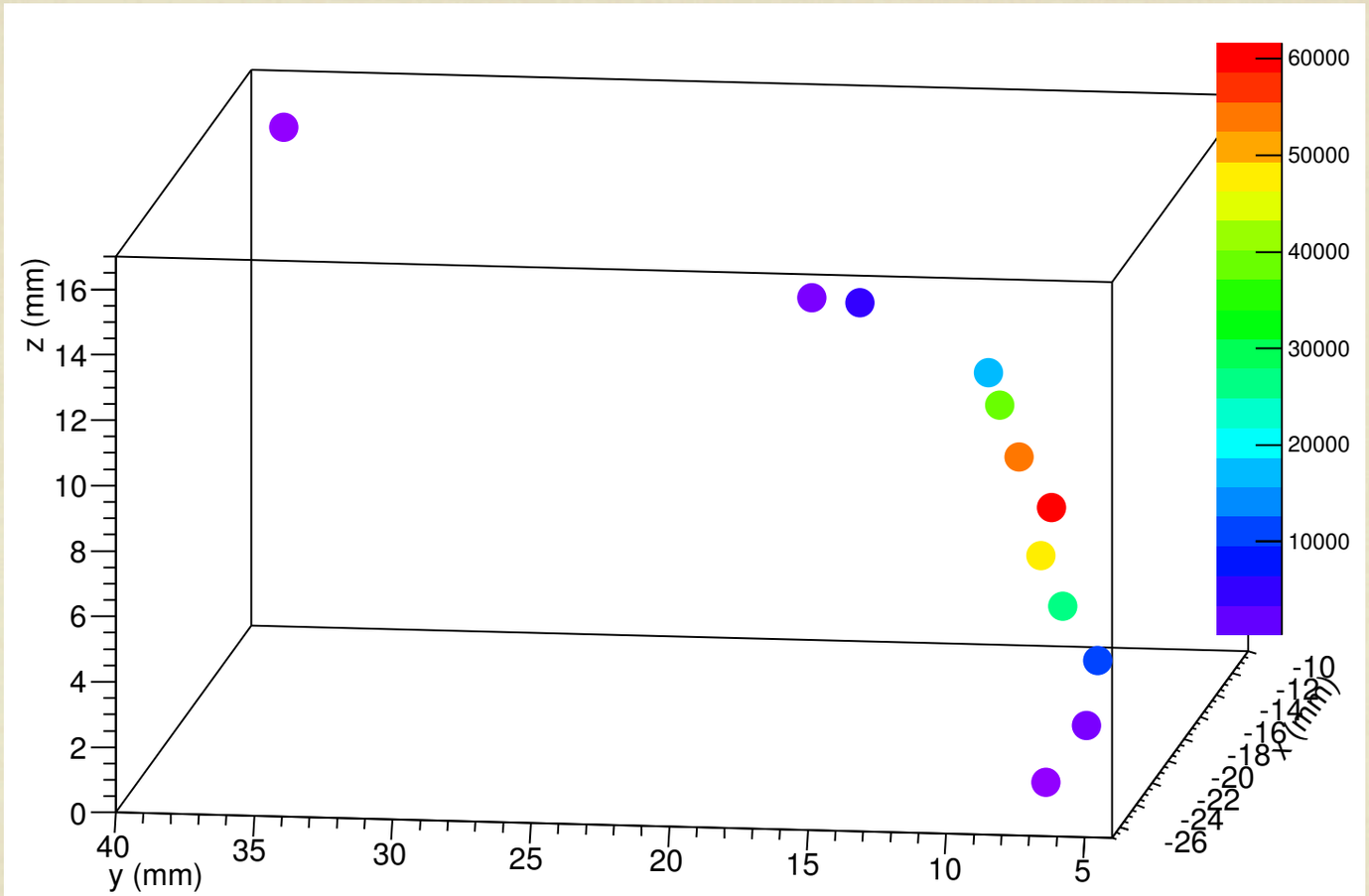
- Bi-214 line very close to Xe Qbb.
- Energy resolution (and radiopurity) are essential to separate signal from background.
- But extra handles become a must

Topological signature



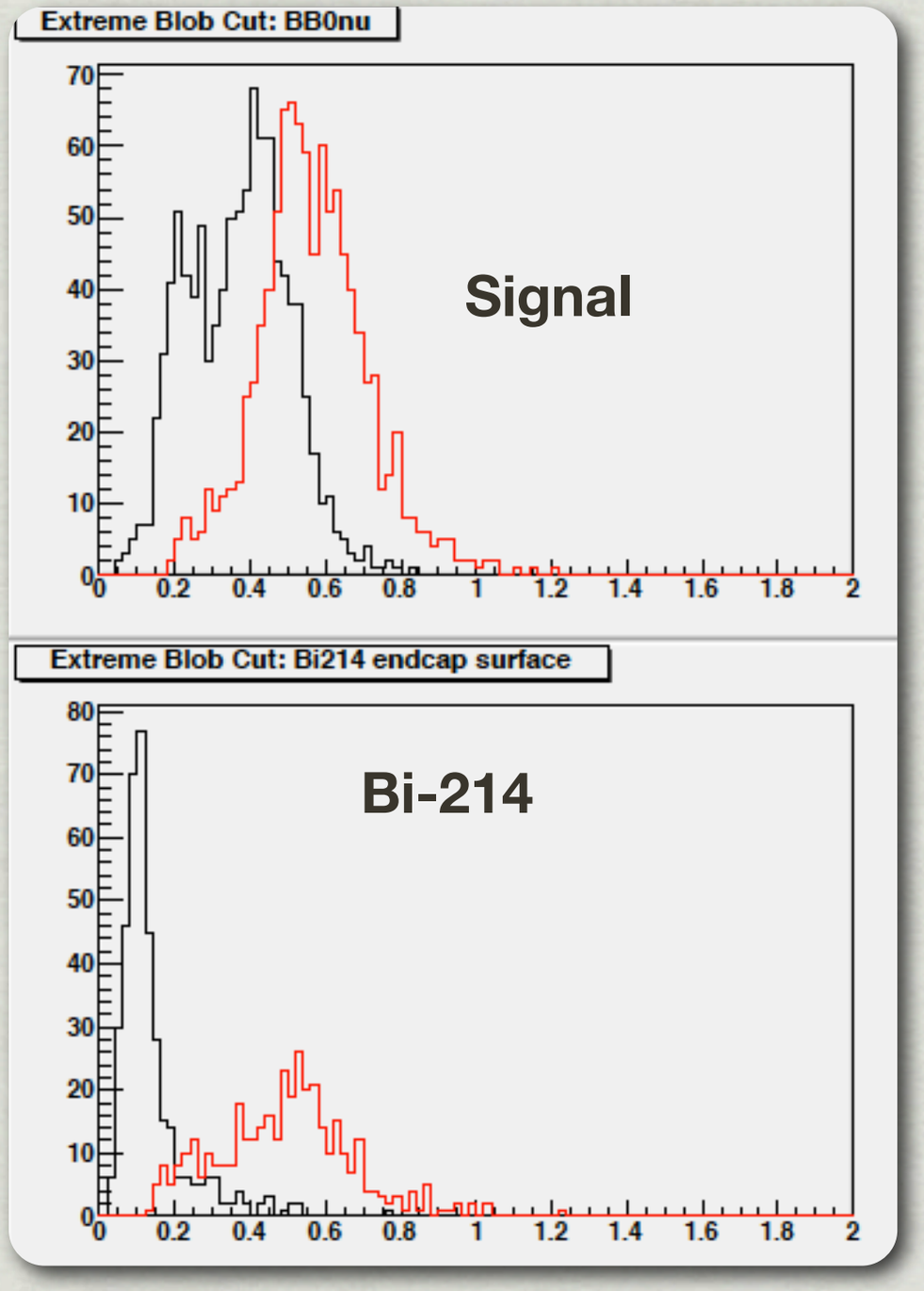
Monte Carlo bkgnd event from Bi-214

Topological signature



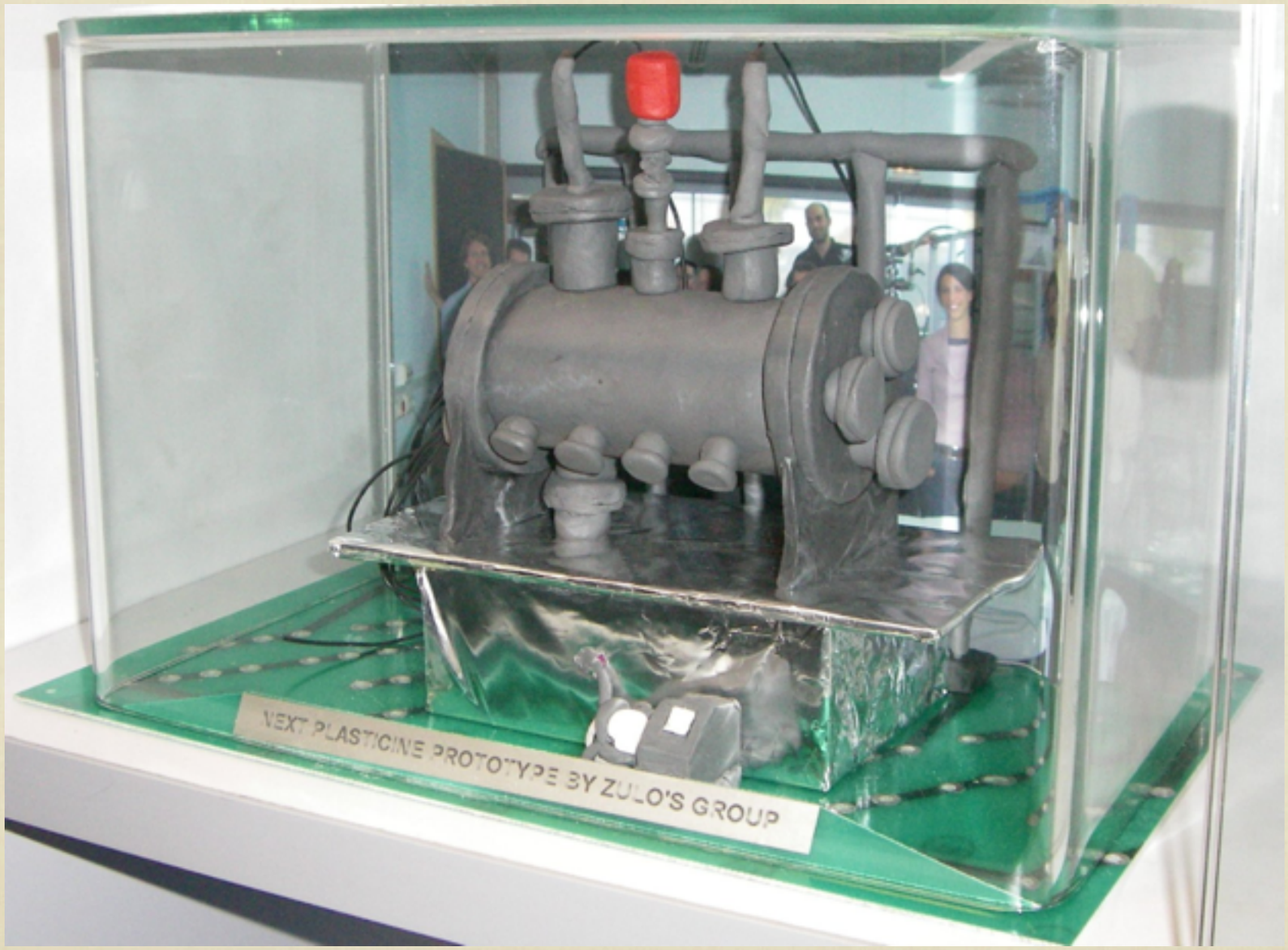
NEXT-DEMO event from Na-22 with X-ray

EXTREME BLOB CUT

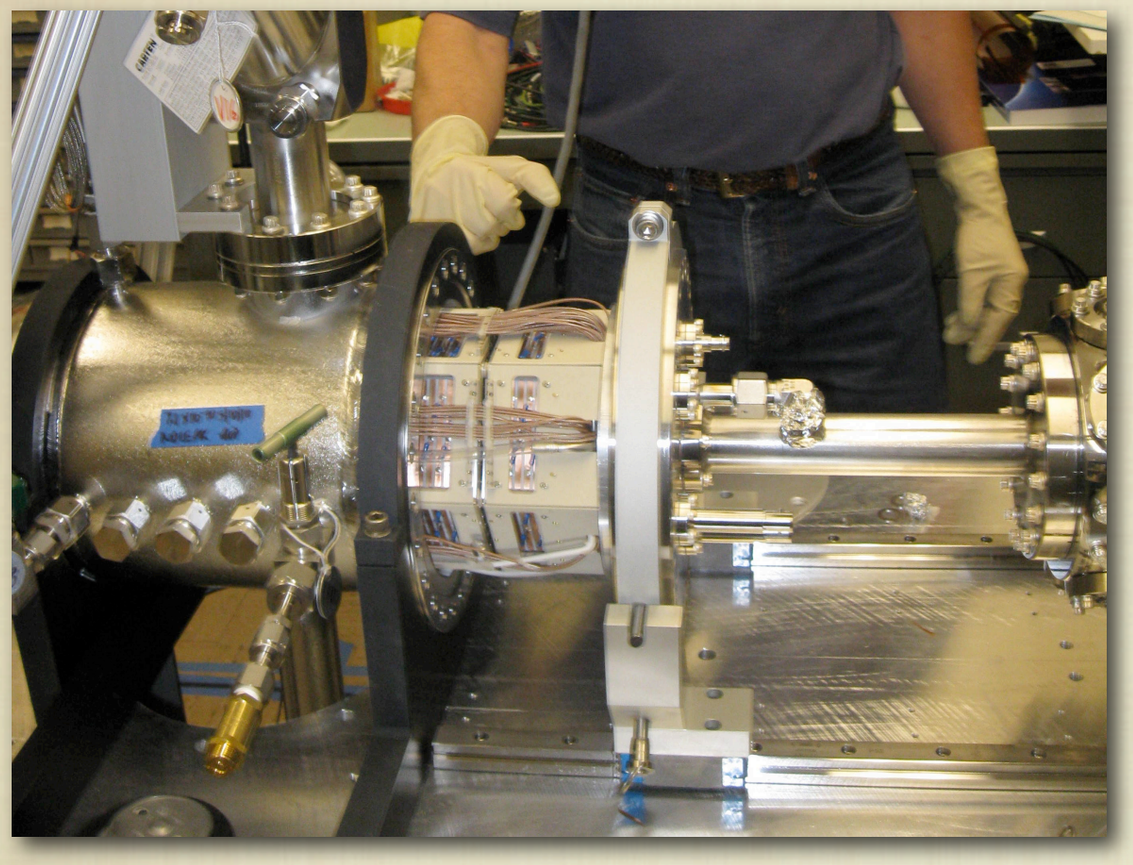


- Good rejection factor (1/10) with very high signal efficiency (>80%)
- Or higher rejection factors (1/50 or better) at higher efficiency cost (50% or lower)

Prototypes



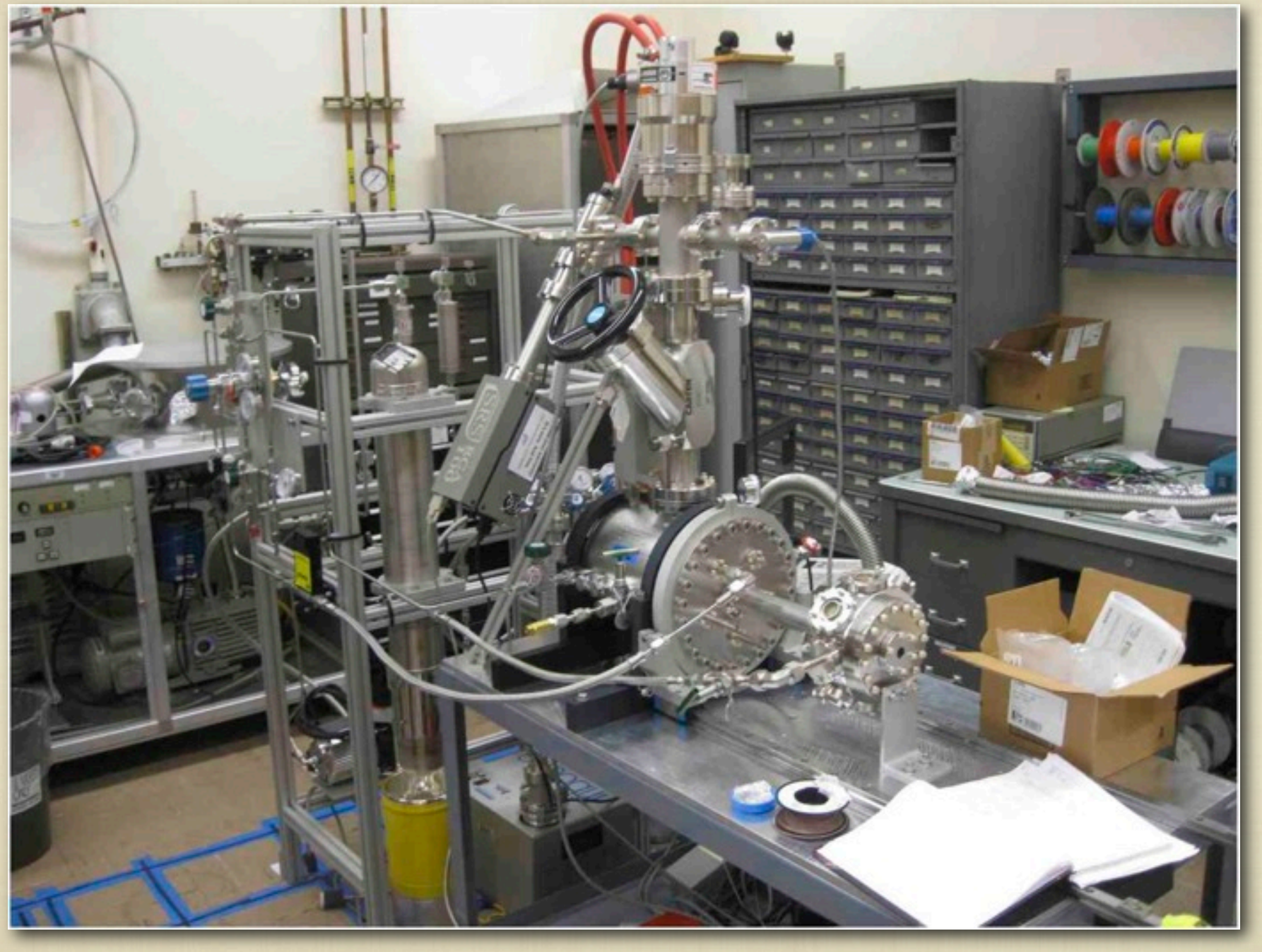
EL prototypes



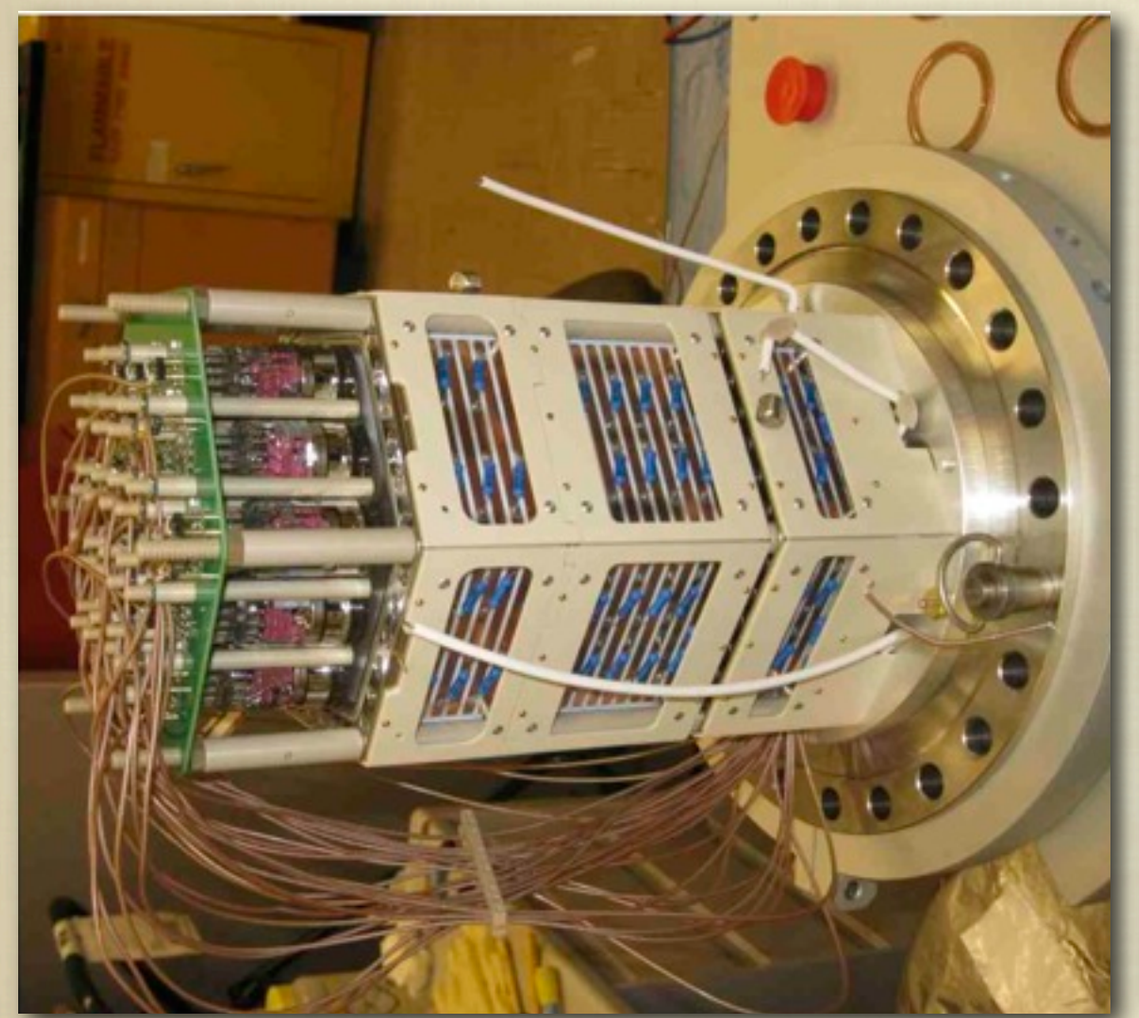
NEXT-DBDM
Energy resolution in HPXe
Possible application to DM searches

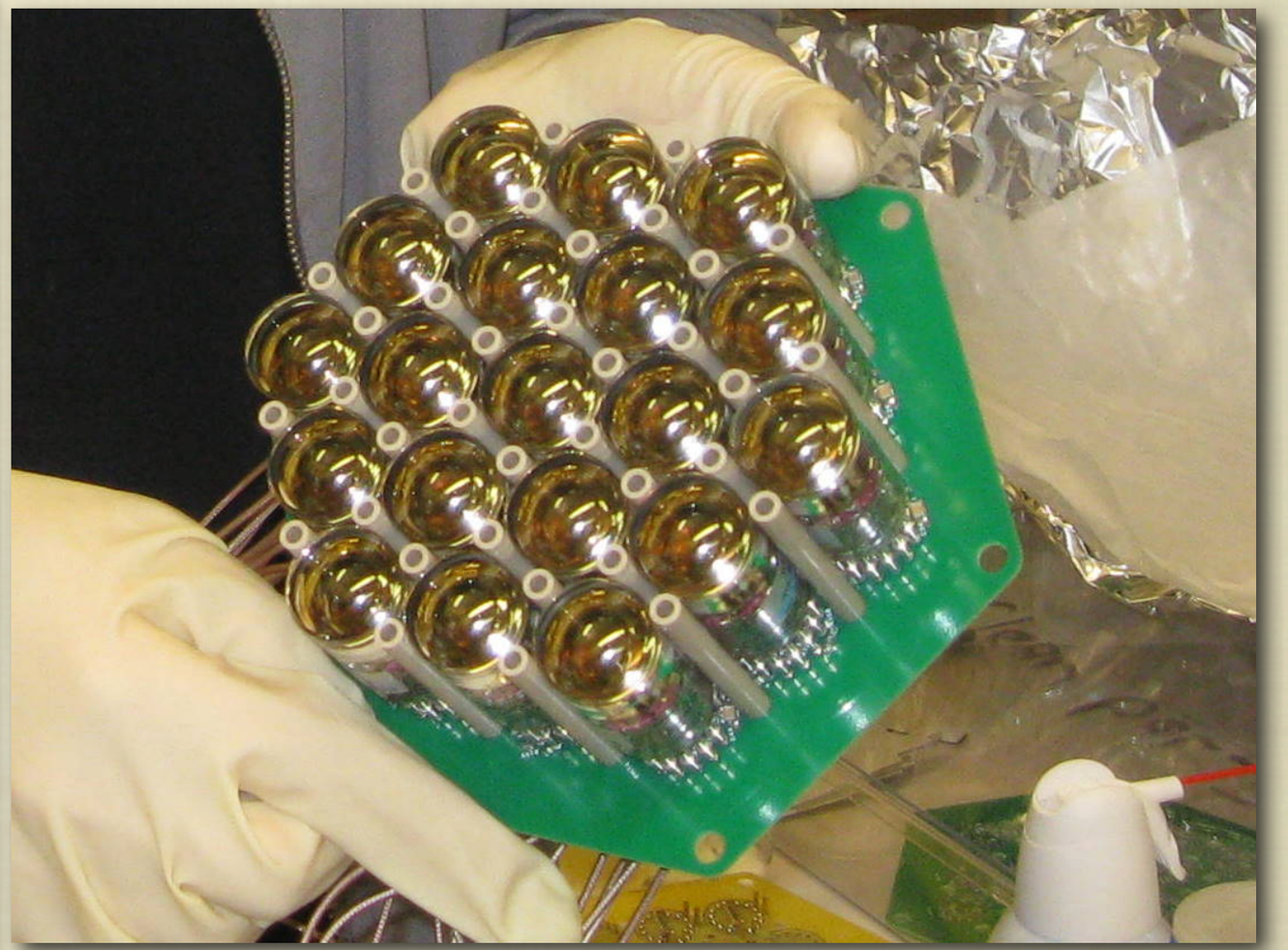
NEXT-DEMO
NEXT detector concept

NEXT-DBDM

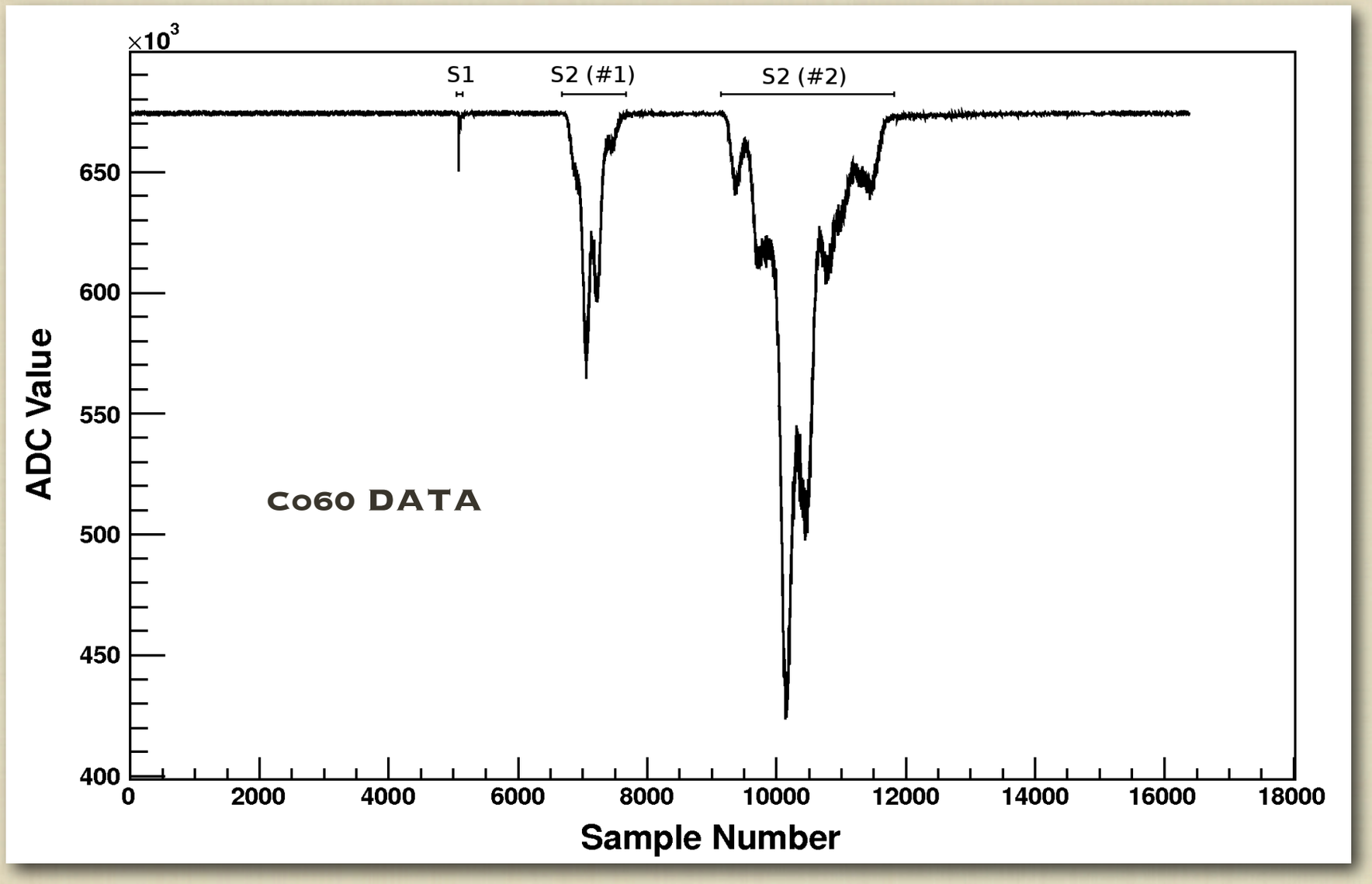


NEXT-DBDM



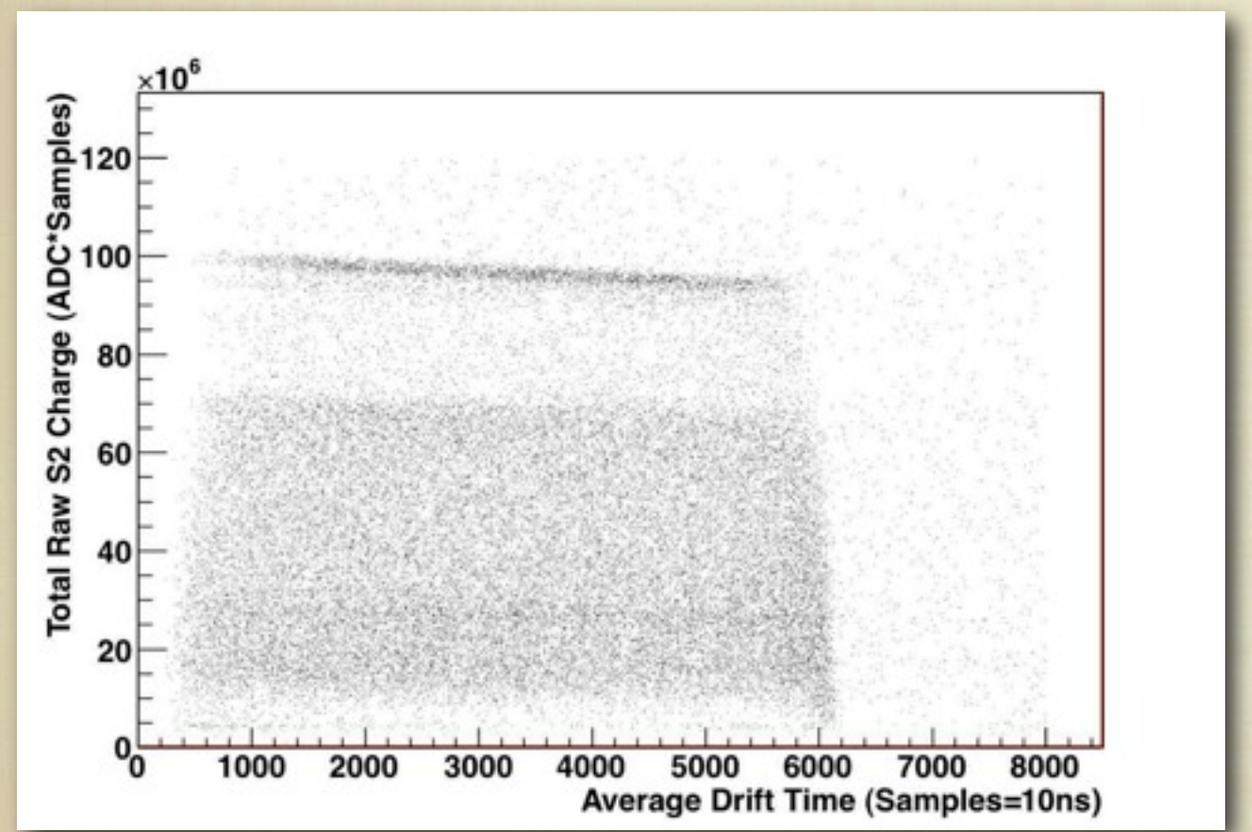


NEXT-DBDM

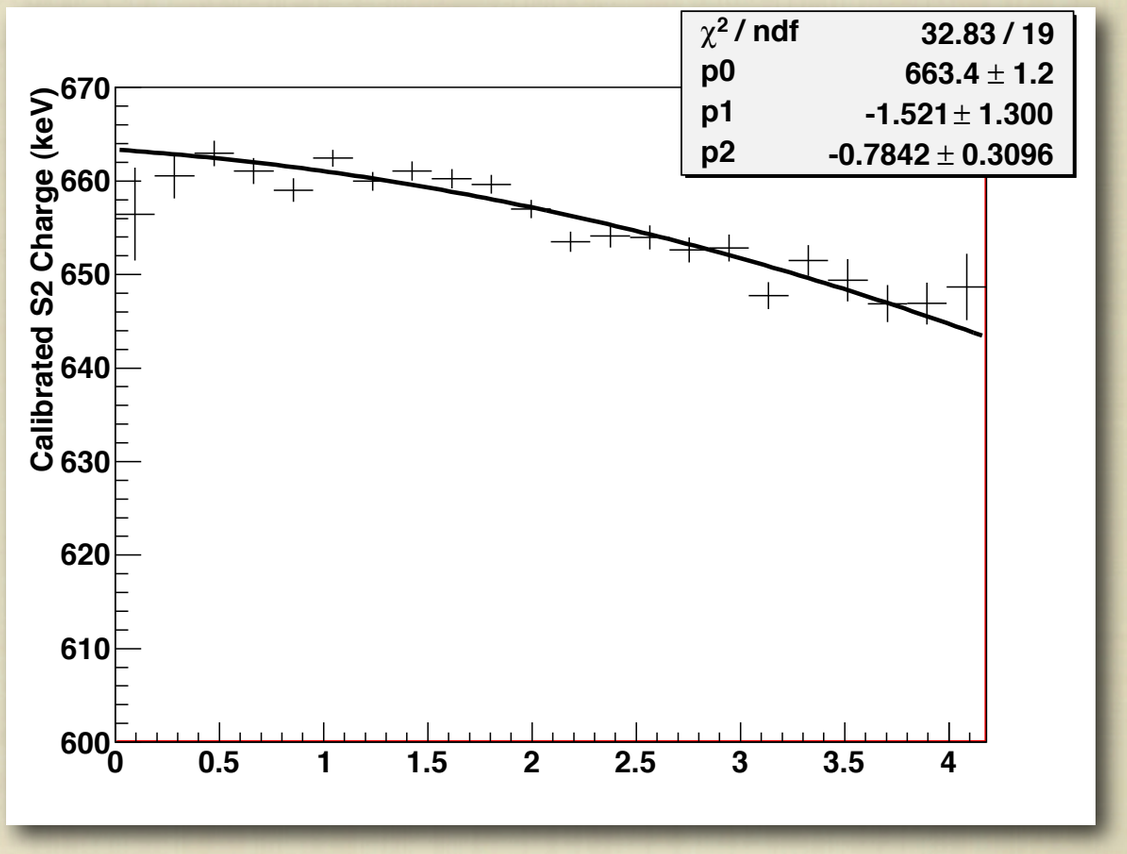


Very clean waveforms. Both scintillation (S1) and ionization (S2) signals clearly visible.

Analysis corrections



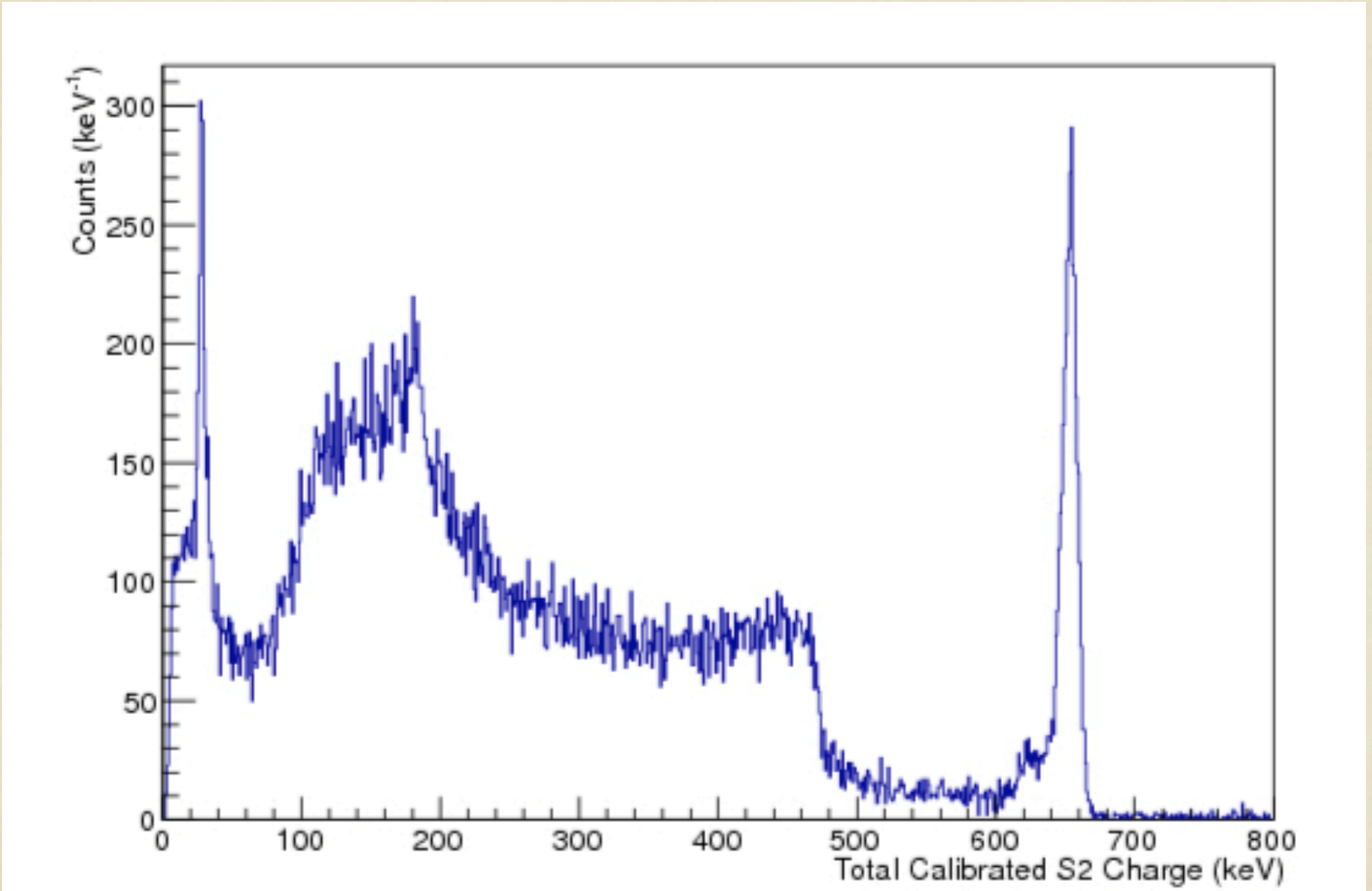
Long electron lifetime (>4 ms) in the gas.



Radial dependence (solid angle) of collected light easily corrected.

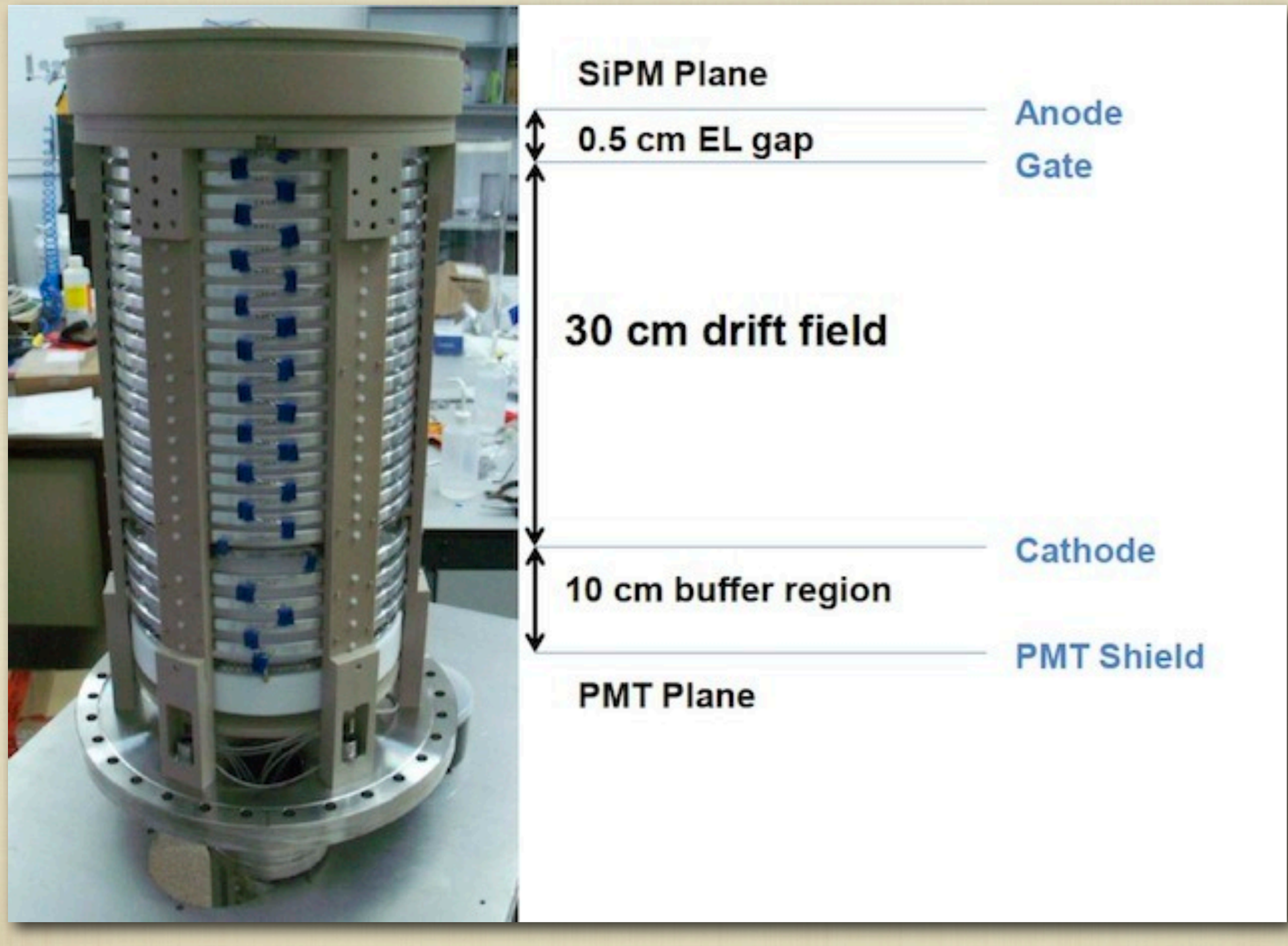
NEXT-DBDM

Energy resolution of 1 % FWHM at 662 keV!



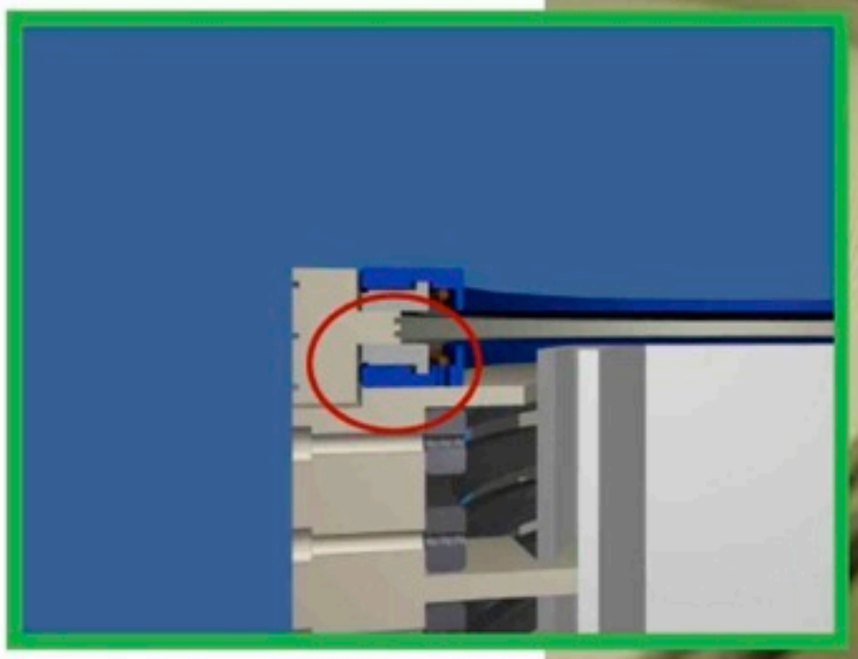
Full energy spectrum for a Cs-137 calibration source.
Data taken at 15 bar, drift field of 0.7 kV/cm and EL gain of 2 kV/cm/bar.

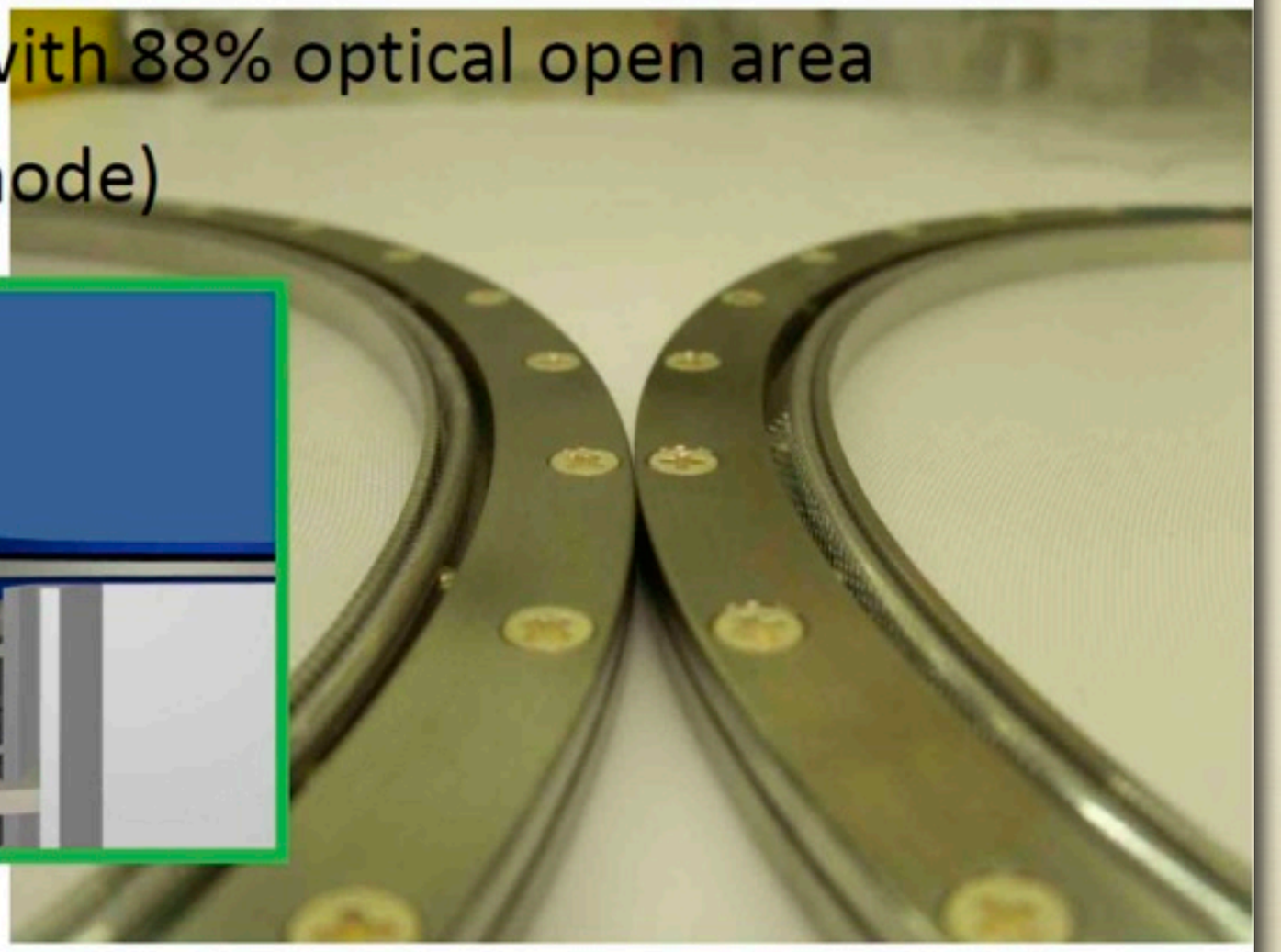
NEXT-DEMO


SiPM Plane
Anode
0.5 cm EL gap
Gate
30 cm drift field
Cathode
10 cm buffer region
PMT Shield
PMT Plane

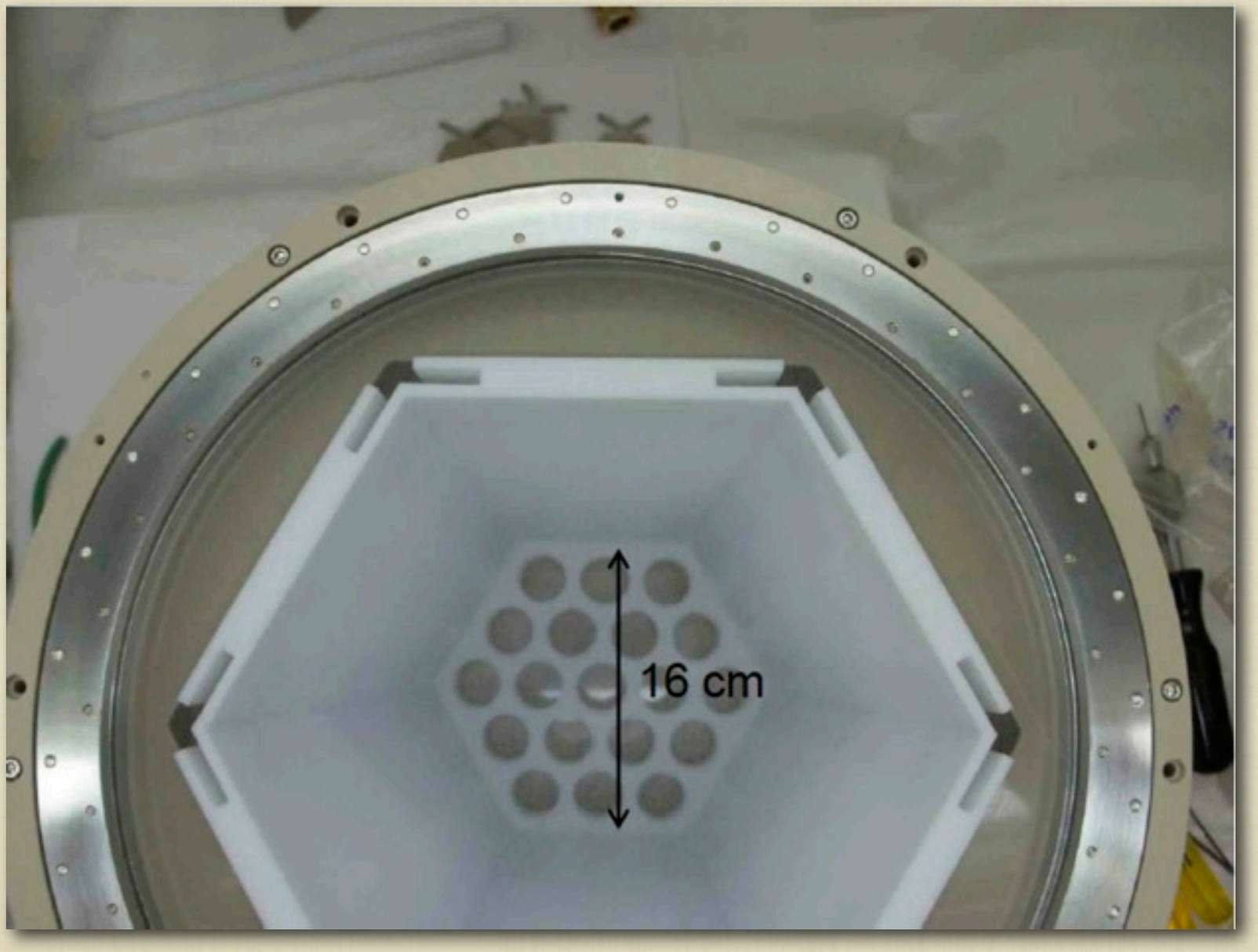
NEXT-DEMO

- Mesh grids with 88% optical open area (gate and anode)

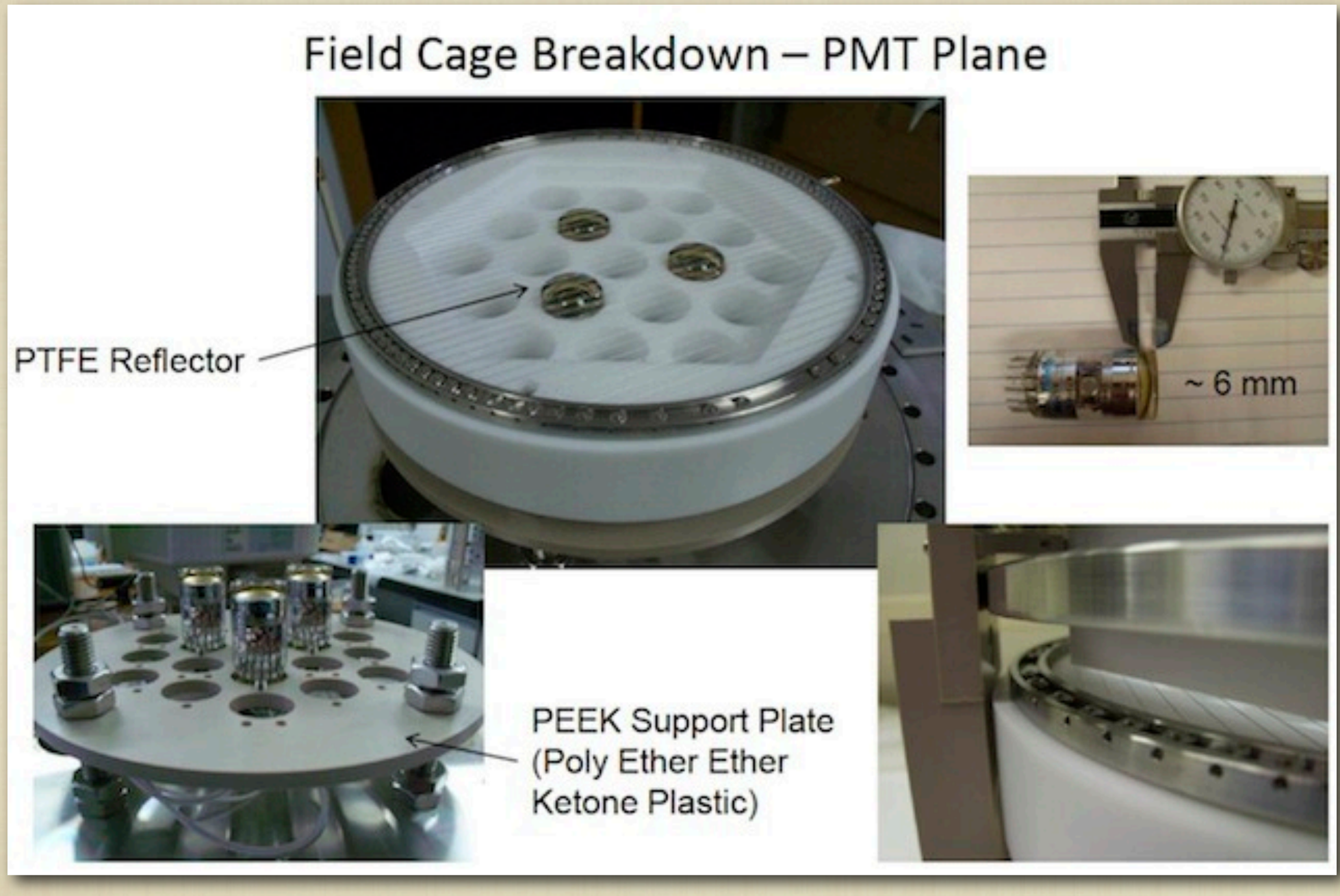




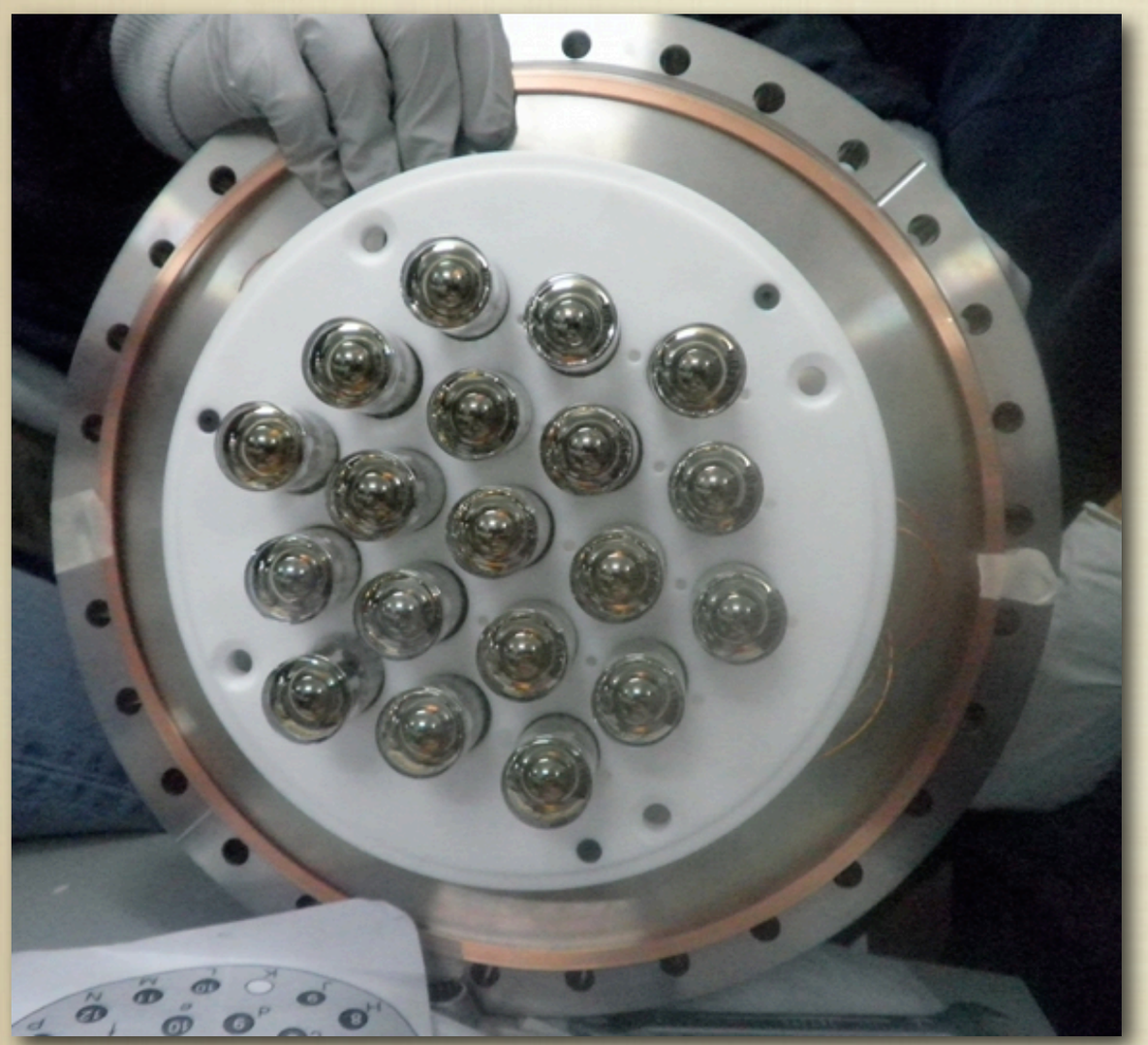
NEXT-DEMO

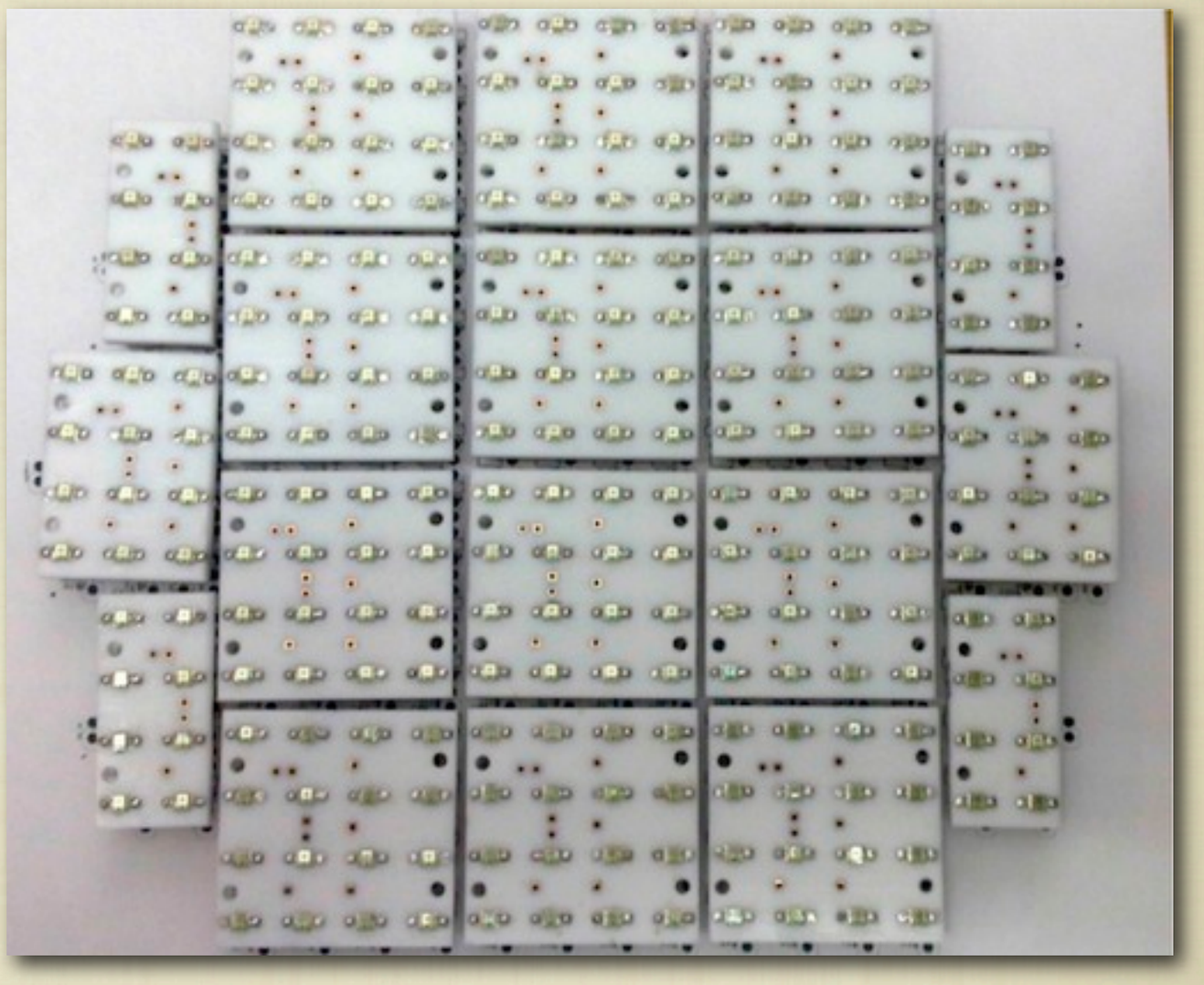


NEXT-DEMO

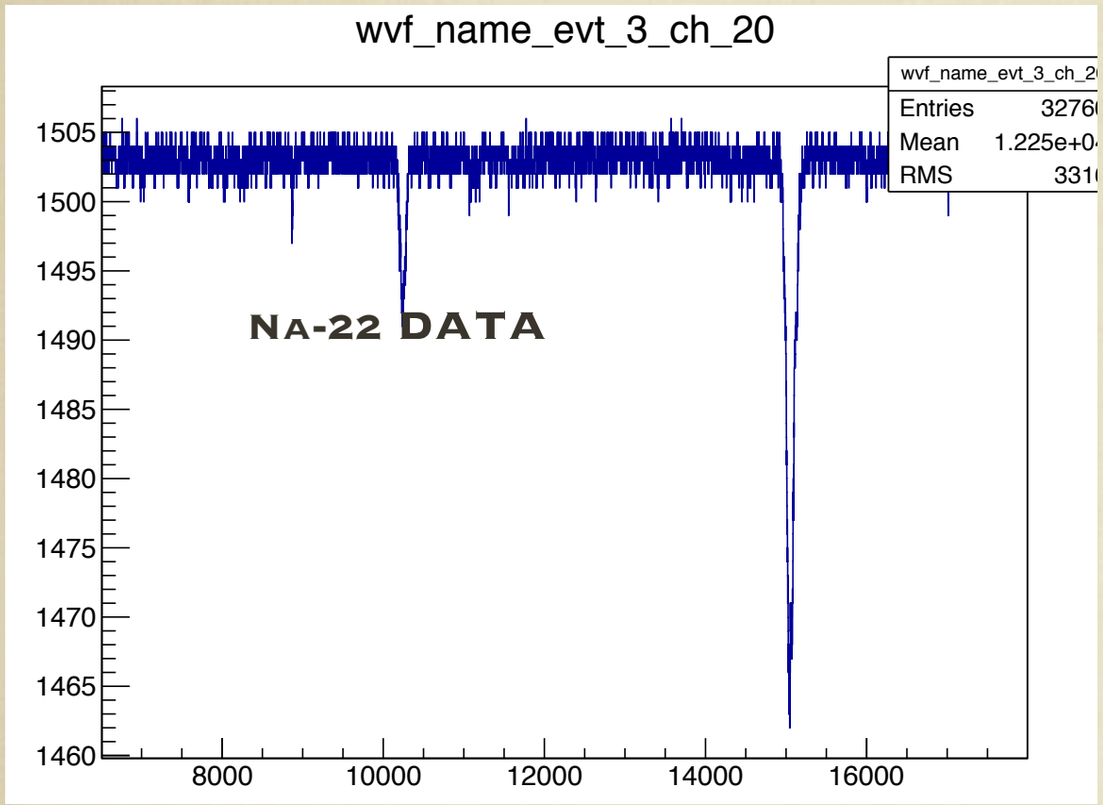

Field Cage Breakdown – PMT Plane
PTFE Reflector
~ 6 mm
PEEK Support Plate
(Poly Ether Ether
Ketone Plastic)

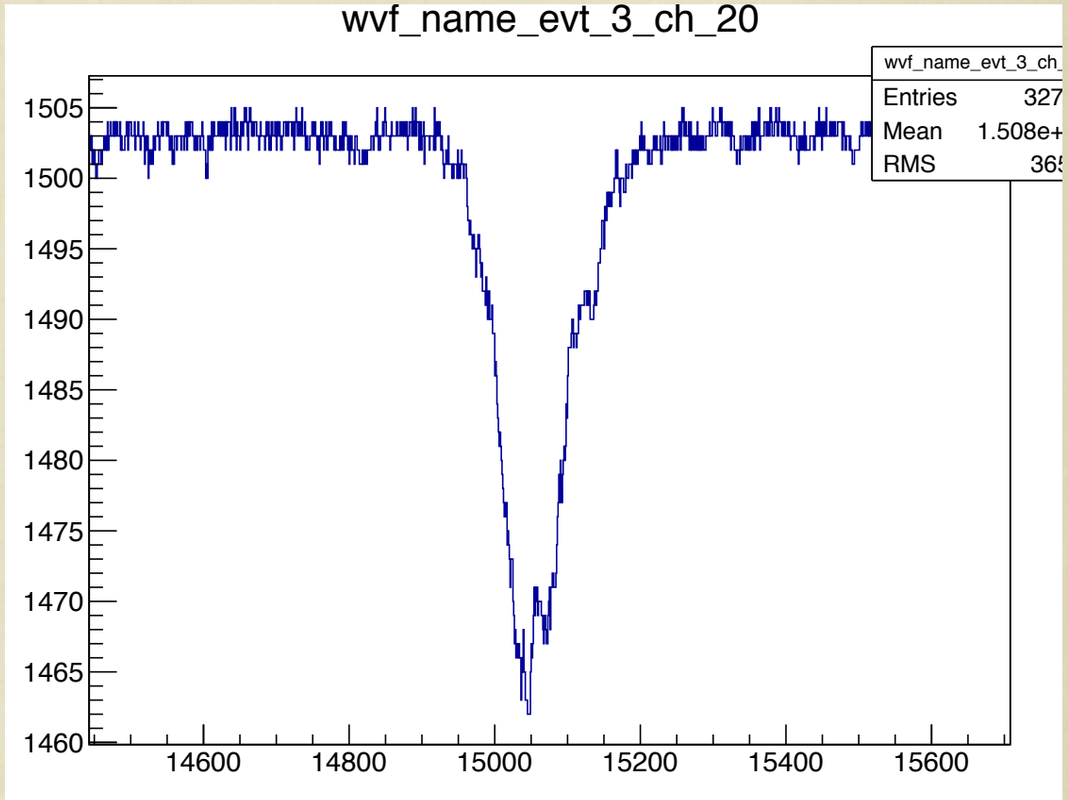
NEXT-DEMO





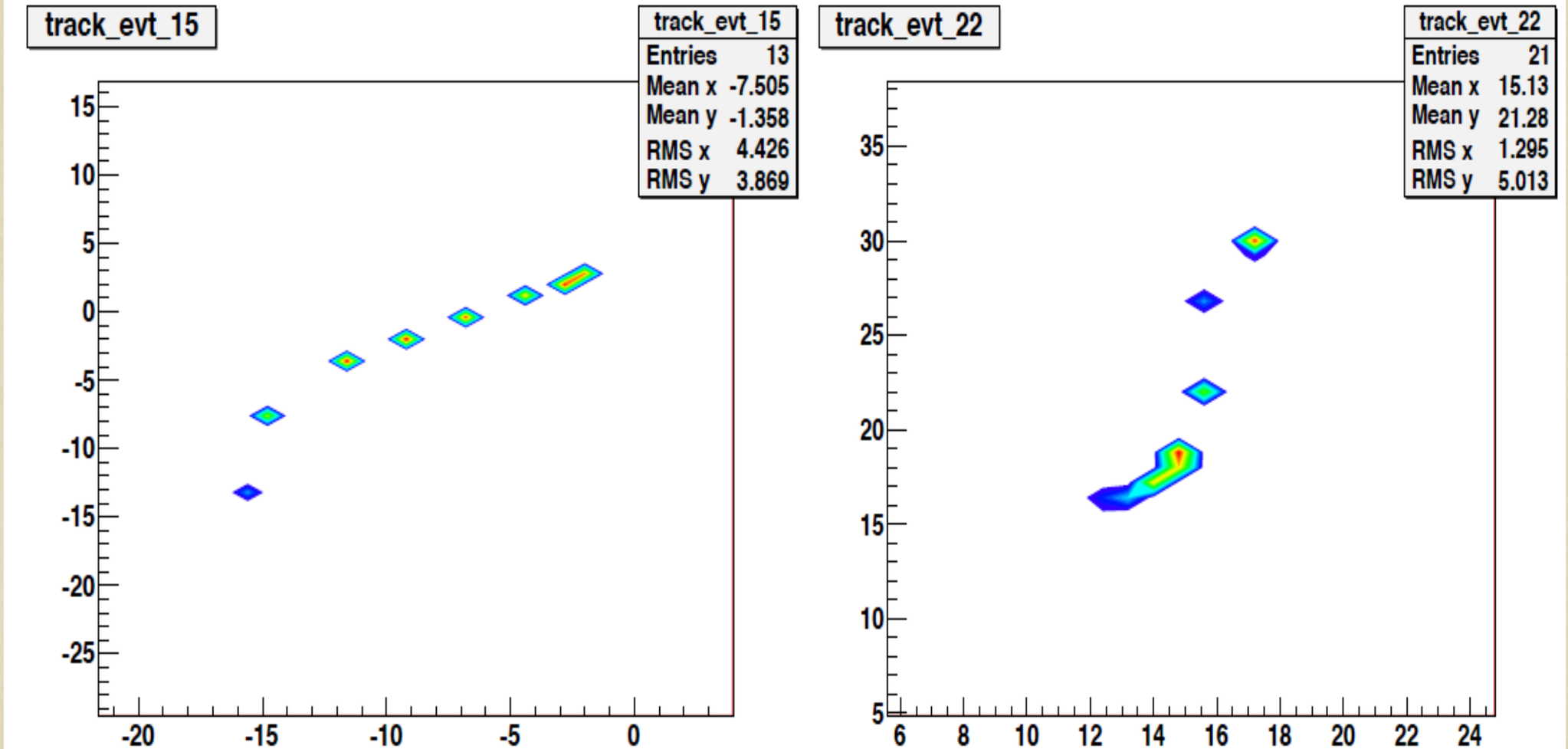
NEXT-DEMO





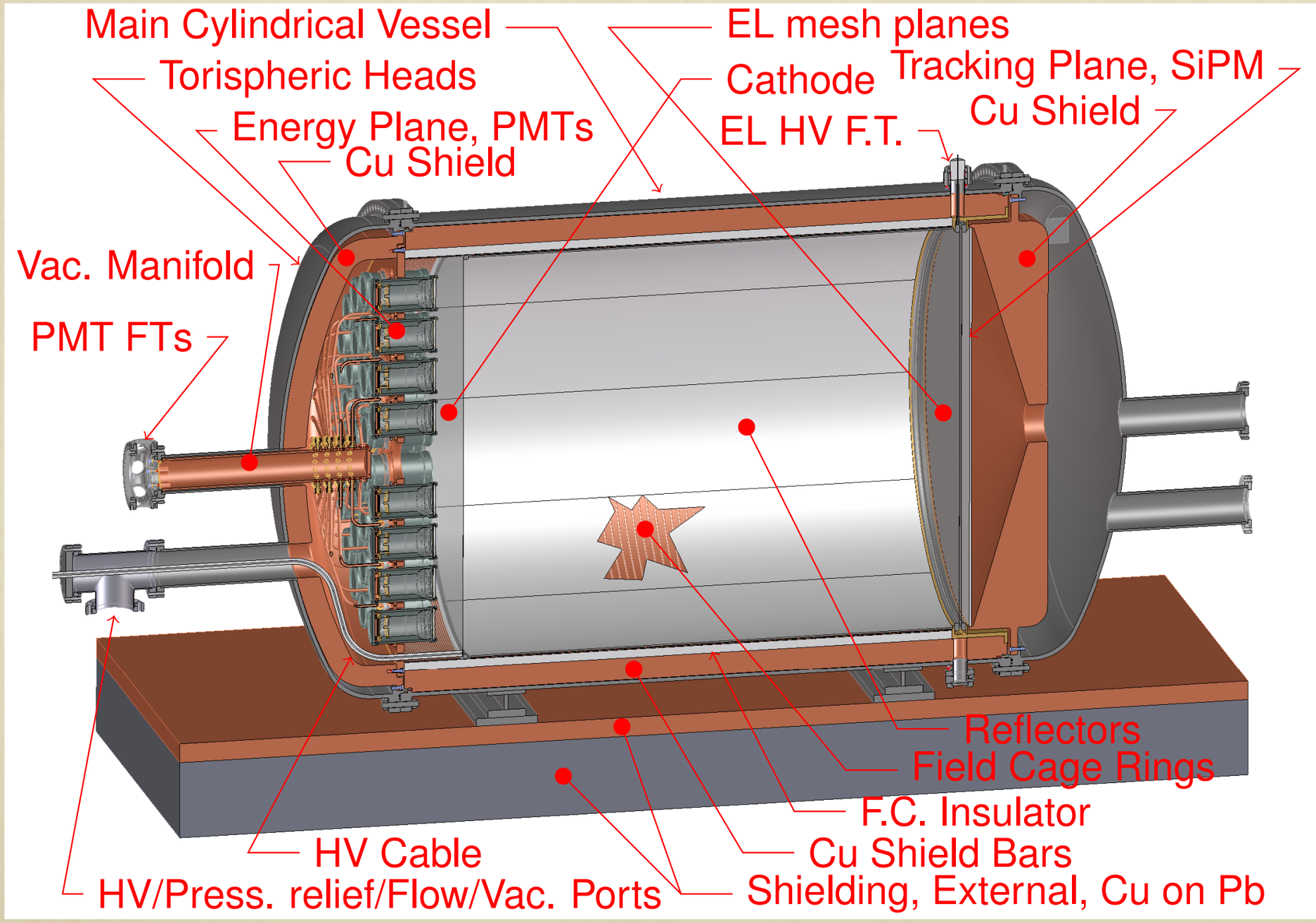
S1, S2 and S2 due to X ray clearly visible

NEXT-DEMO

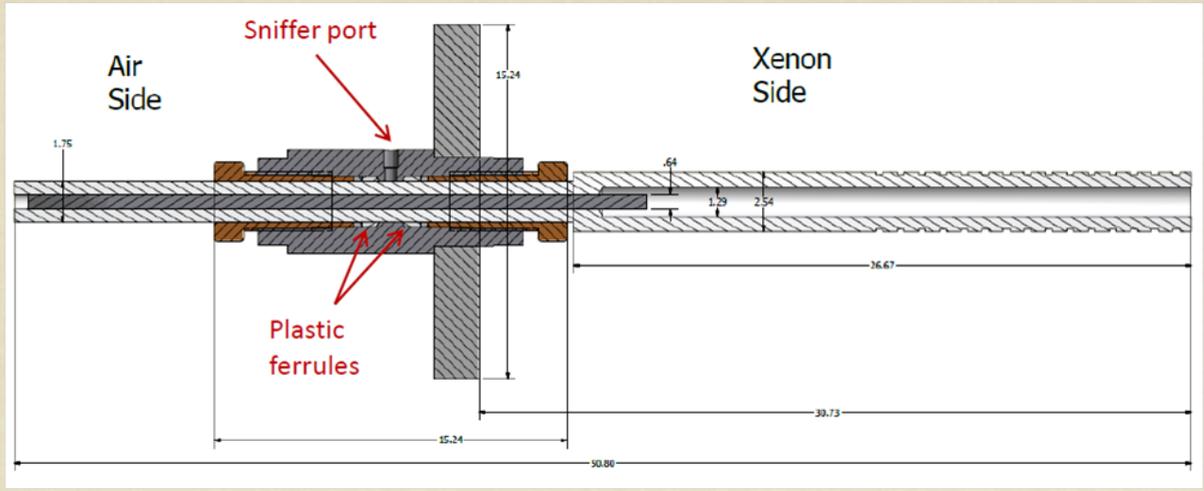


Reconstructed electrons from Cs-137 source.

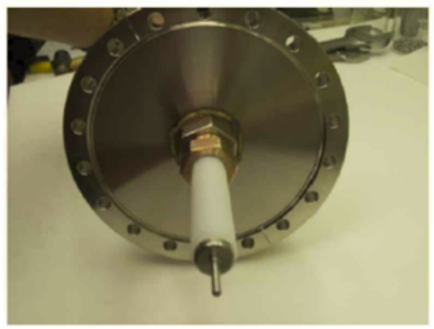
NEXT-100

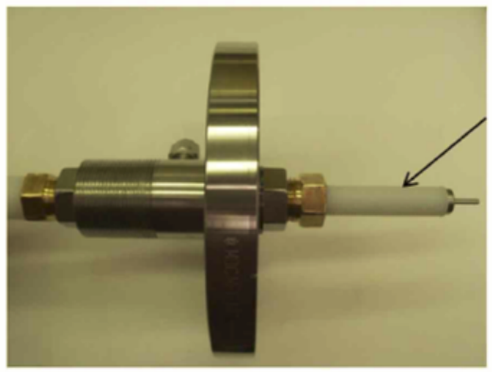

Main Cylindrical Vessel
Torispheric Heads
Energy Plane, PMTs
Cu Shield
Vac. Manifold
PMT FTs
EL mesh planes
Cathode
EL HV F.T.
Tracking Plane, SiPM
Cu Shield
Reflectors
Field Cage Rings
F.C. Insulator
Cu Shield Bars
Shielding, External, Cu on Pb
HV Cable
HV/Press. relief/Flow/Vac. Ports

HV

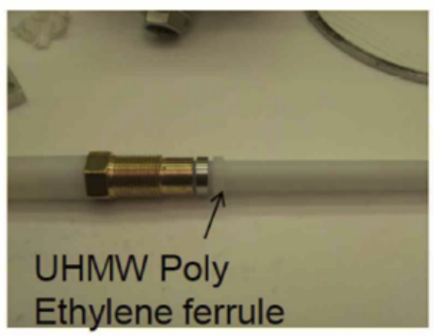


HVFT Design

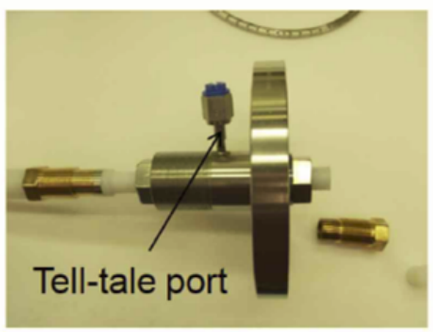




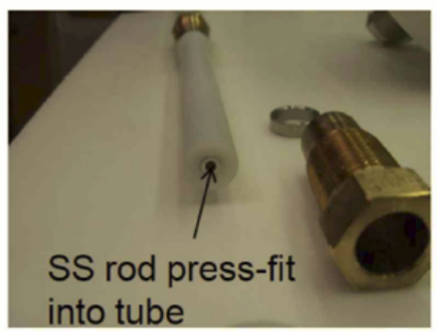
Tefzel tube
(κ=1800 V/mil)



UHMW Poly
Ethylene ferrule

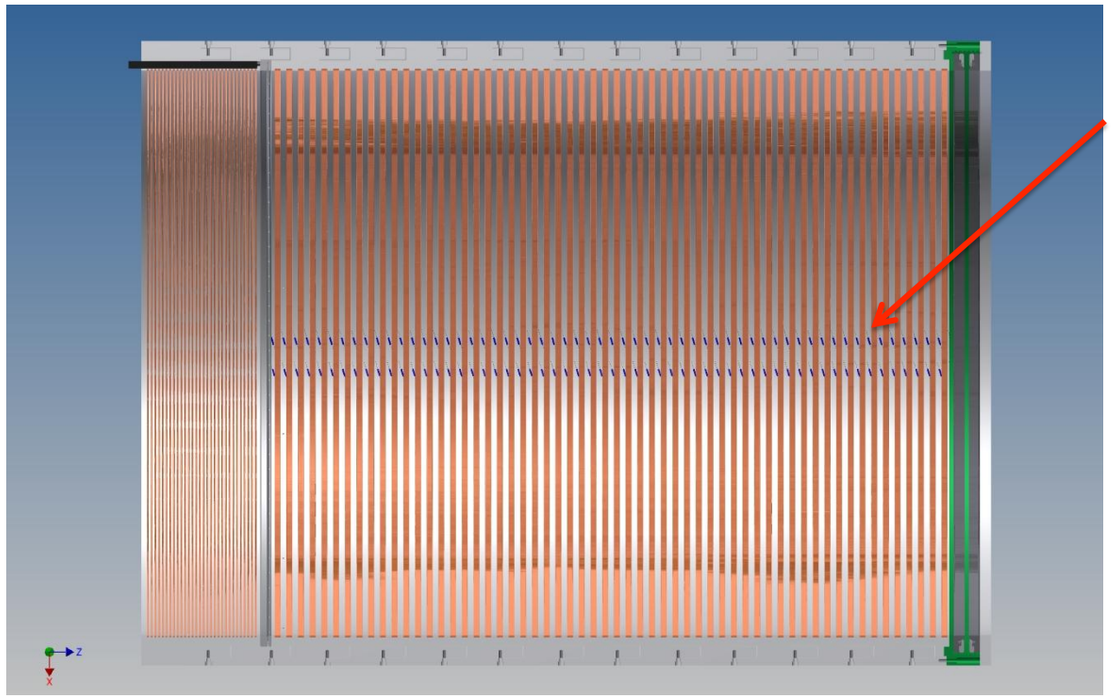


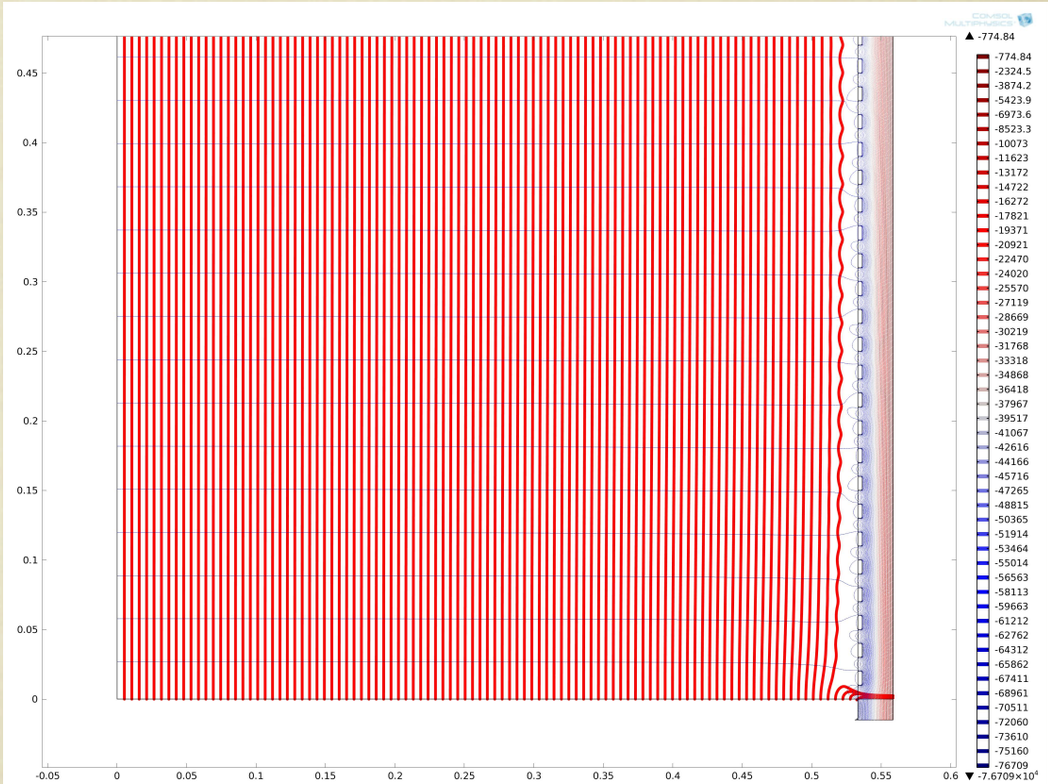
Tell-tale port



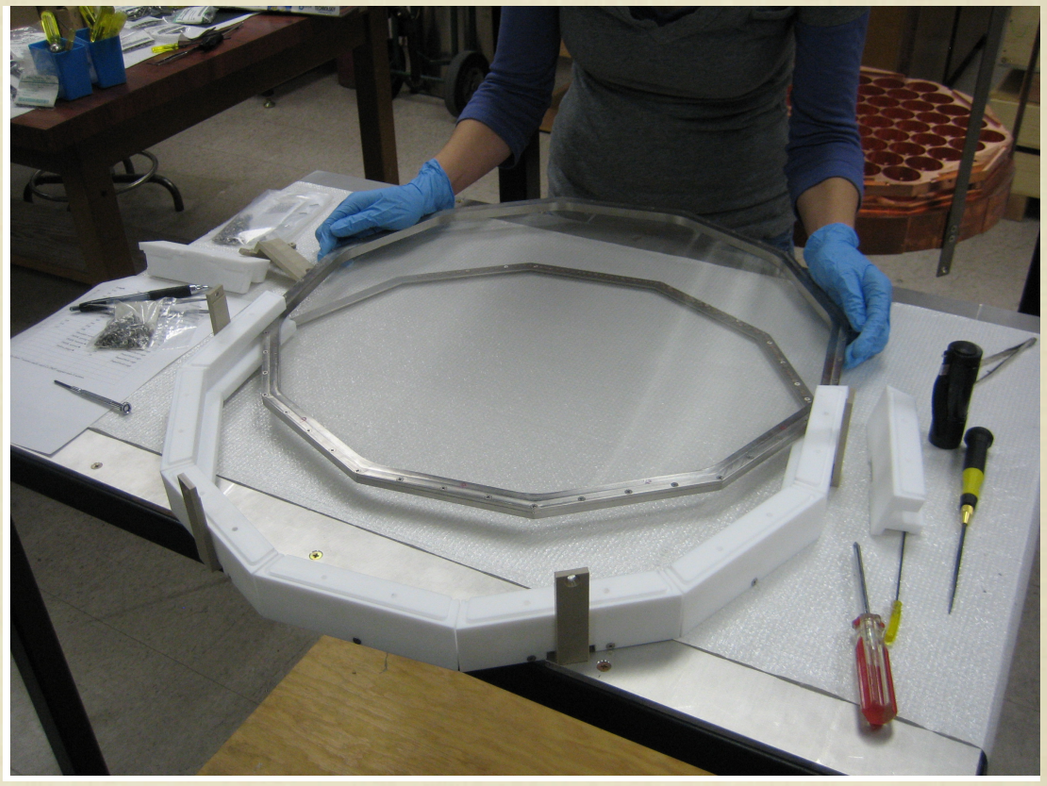
SS rod press-fit
into tube

Field Cage

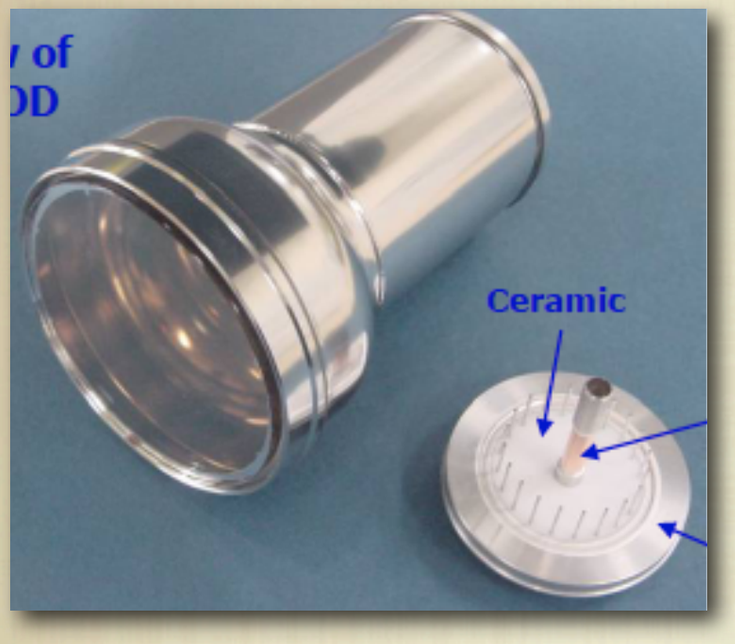

Dual resister
Divider chain


▲ -774.84
-774.84
-2324.5
-3874.2
-5423.9
-6973.6
-8523.3
-10073
-11623
-13172
-14722
-16272
-17821
-19371
-20921
-22470
-24020
-25570
-27119
-28669
-30219
-31768
-33318
-34868
-36418
-37967
-39517
-41067
-42616
-44166
-45716
-47265
-48815
-50365
-51914
-53464
-55014
-56563
-58113
-59663
-61212
-62762
-64312
-65862
-67411
-68961
-70511
-72060
-73610
-75160
-76709
▼ -7.6709×10⁴
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6

EL Grids

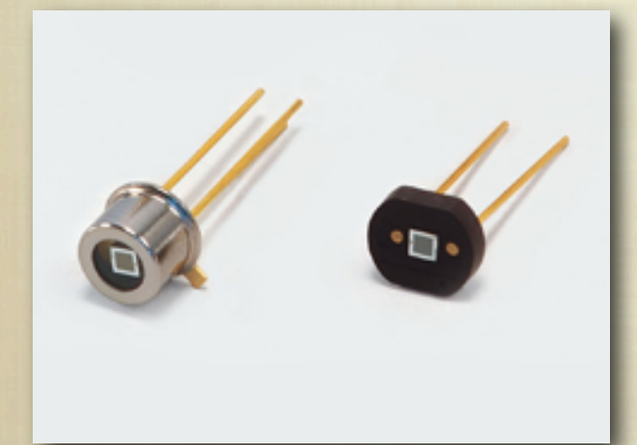


NEXT-100 sensors



PMTs for calorimetry and start-of-event

- Excellent charge resolution and linearity, single-pe detection, large dynamic range, etc.
- Favorite candidate: Hamamatsu R1141MOD.
- No. channels ~60.



MPPCs for tracking:

- Fine pixelization (~1cm pitch), low cost, some energy information.
- No. channels ~7500

R11410-10

RI Level for R11410MOD

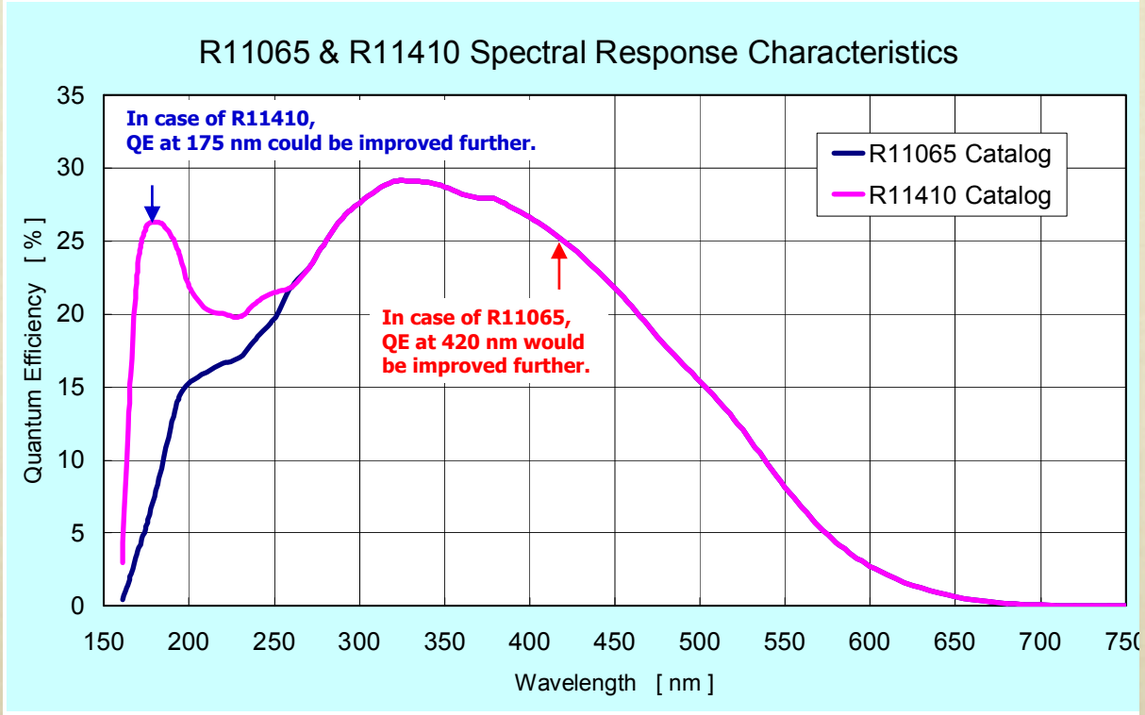
Estimated RI level

< Unit : mBq/PMT >

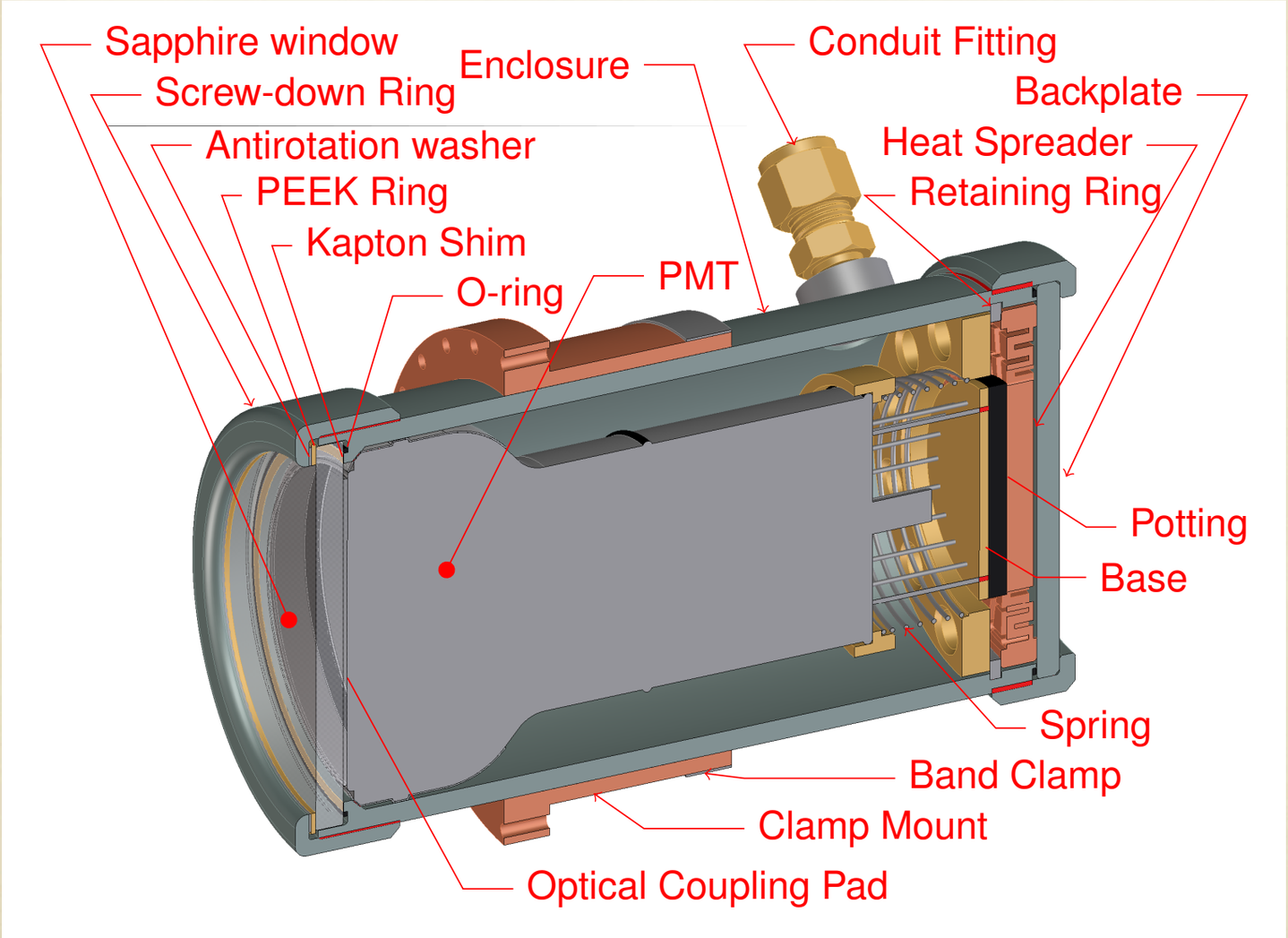
Materials	Weight (g)	40K	U	Th	Co60	Sub Total
Quartz Faceplate	35	0.0	0.2	0.4	0.1	0.7
Metal Bulb	95	5.7	2.9	1.0	3.5	13.1
Stem (ceramic)	25	0.0	0.0	0.7	5.5	6.2
Insulating Plates	16	0.0	0.1	0.2	0.0	0.3
Electrodes	31	0.0	0.1	0.0	0.0	0.1
Total	202	5.7	3.3	2.3	9.1	20.4

Expected RI level : 10~30 mBq/PMT

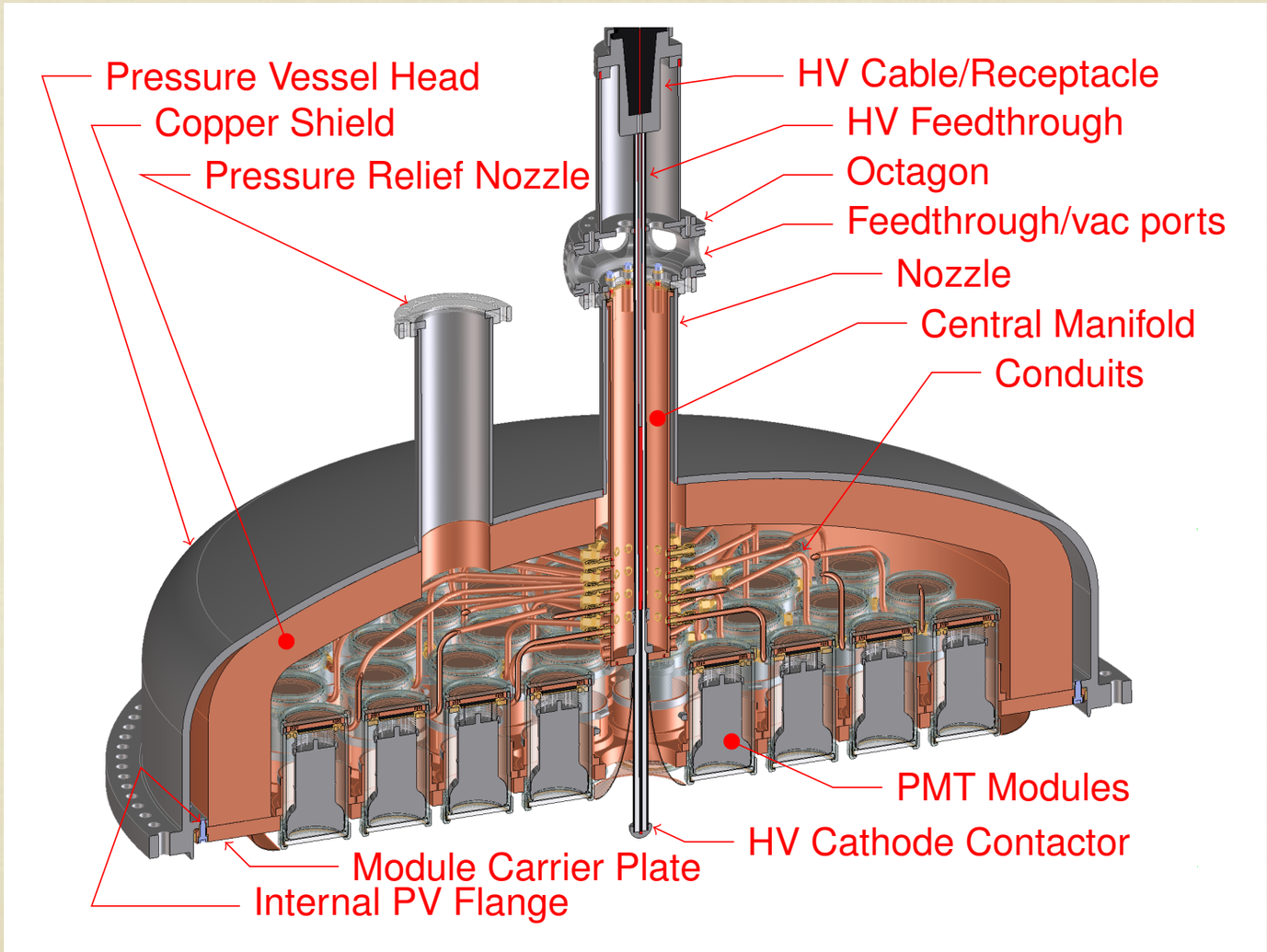
Typical QE Curve



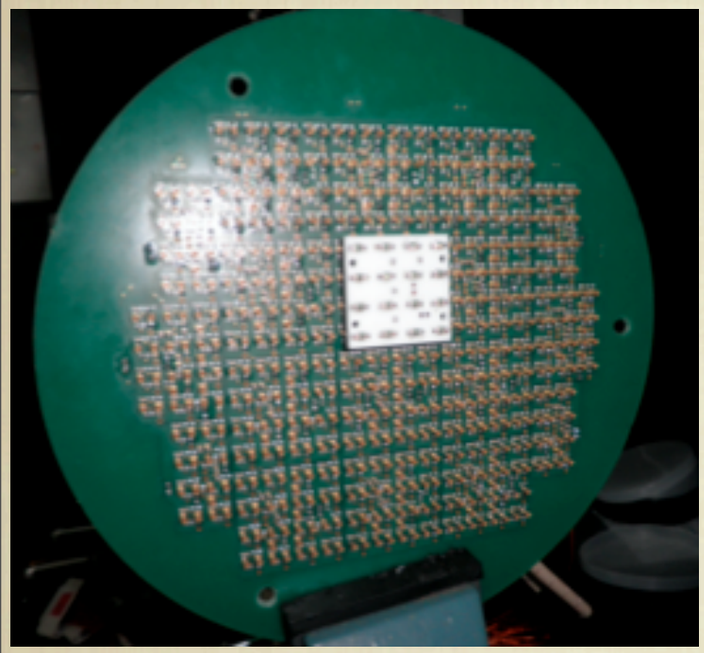
PMT can

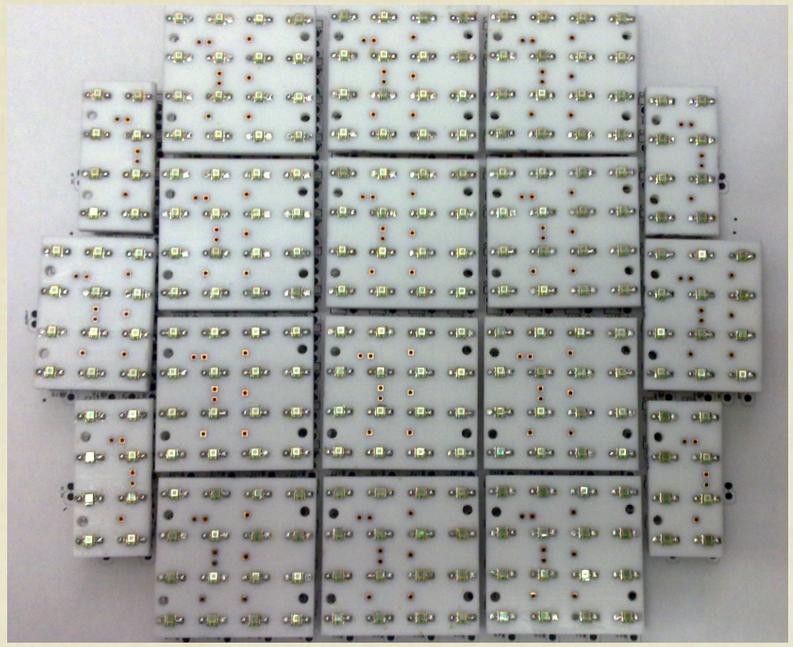

Sapphire window
Screw-down Ring
Antirotation washer
PEEK Ring
Kapton Shim
O-ring
Enclosure
PMT
Conduit Fitting
Backplate
Heat Spreader
Retaining Ring
Potting
Base
Spring
Band Clamp
Clamp Mount
Optical Coupling Pad

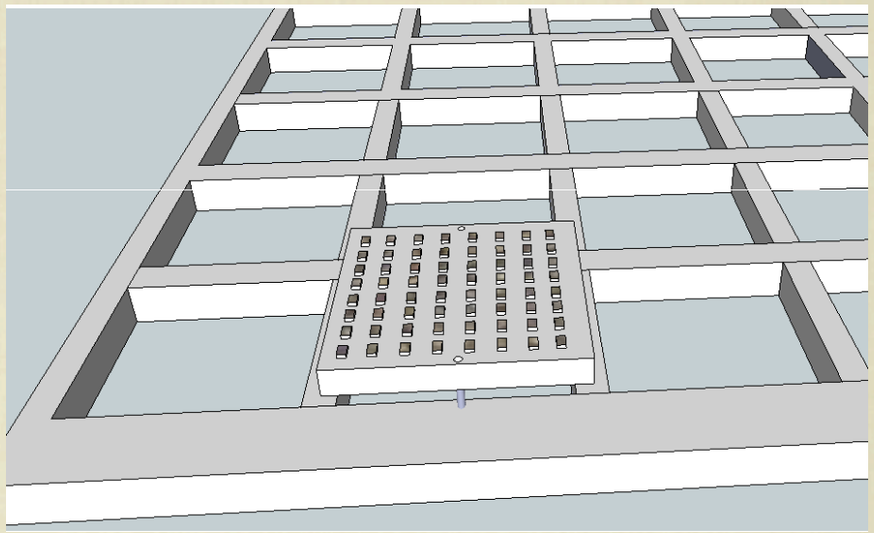
PMT plane

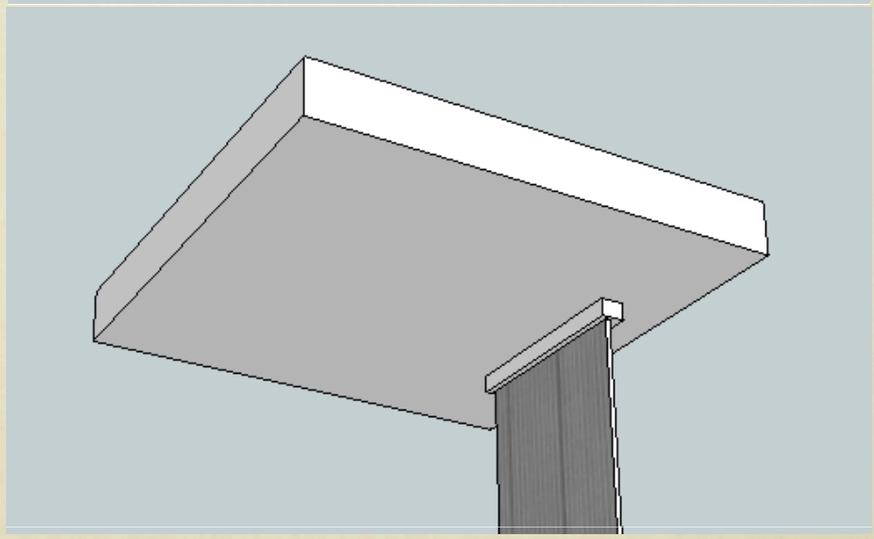

Pressure Vessel Head
Copper Shield
Pressure Relief Nozzle
HV Cable/Receptacle
HV Feedthrough
Octagon
Feedthrough/vac ports
Nozzle
Central Manifold
Conduits
PMT Modules
HV Cathode Contactor
Module Carrier Plate
Internal PV Flange

SiPM plane

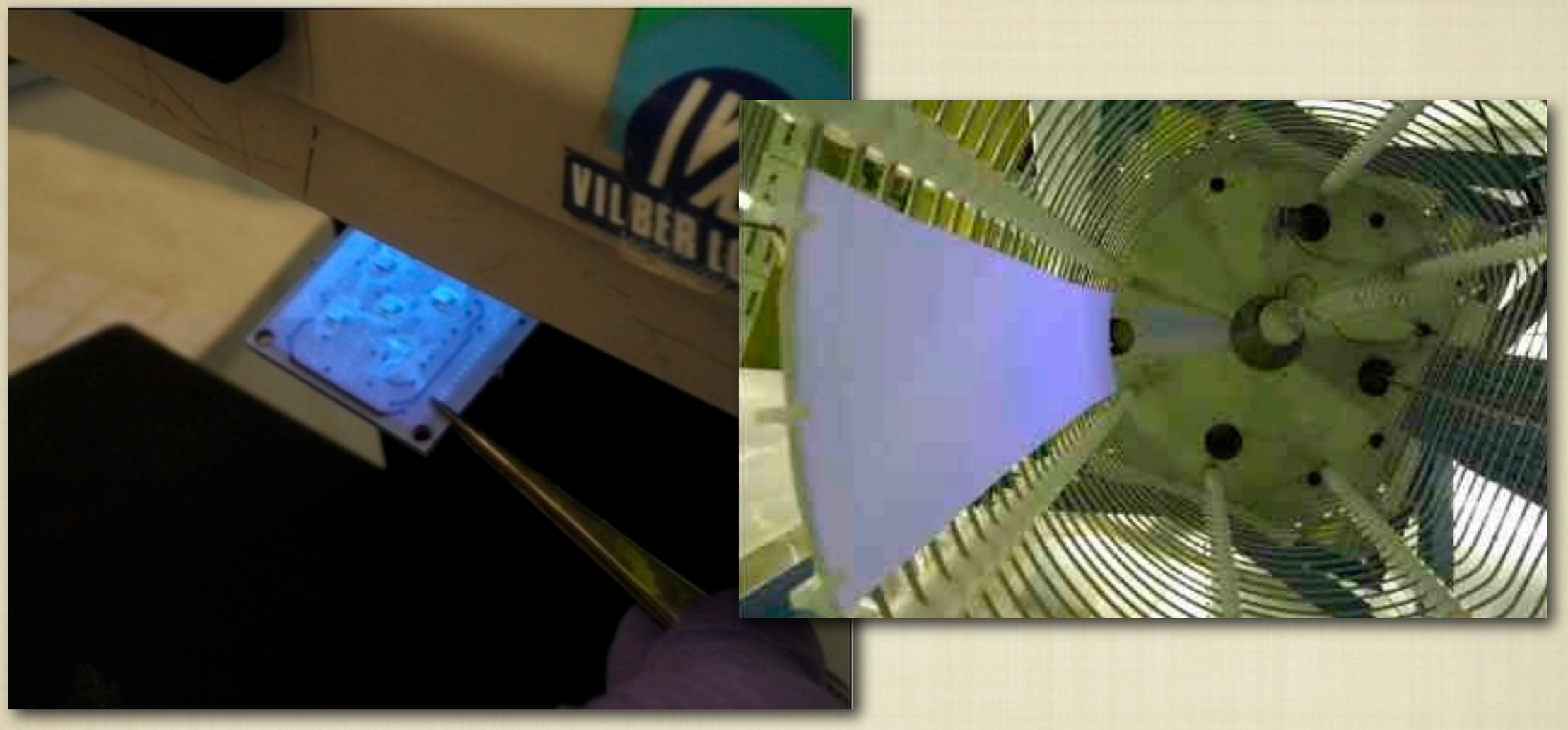






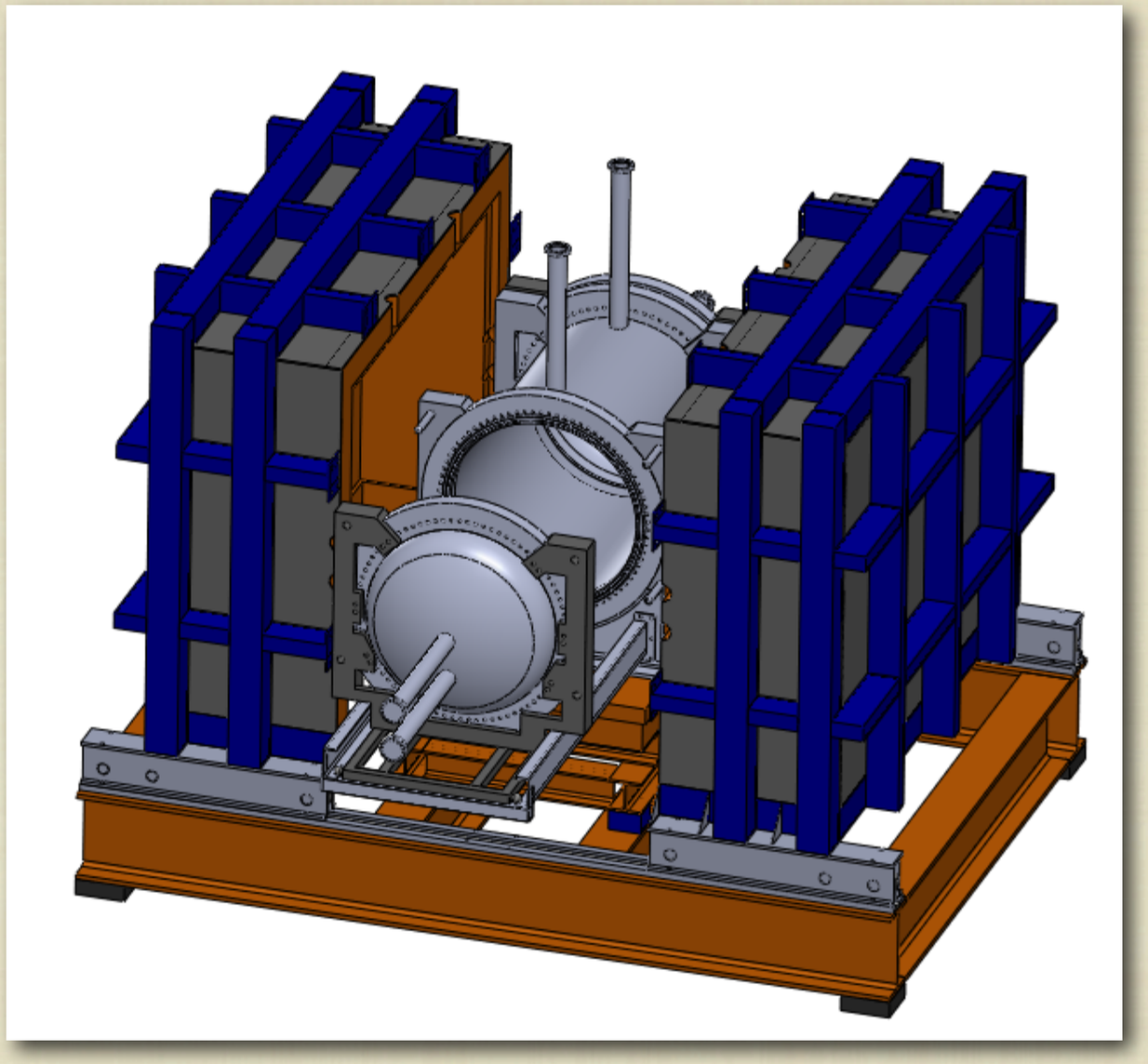


NEXT-100: WLS



Coating of sensors and reflectors with a WLS (TPB) to improve light collection.

NEXT-100: shielding



Shielding design completed.
Construction starts early january

NEXT-100: xenon

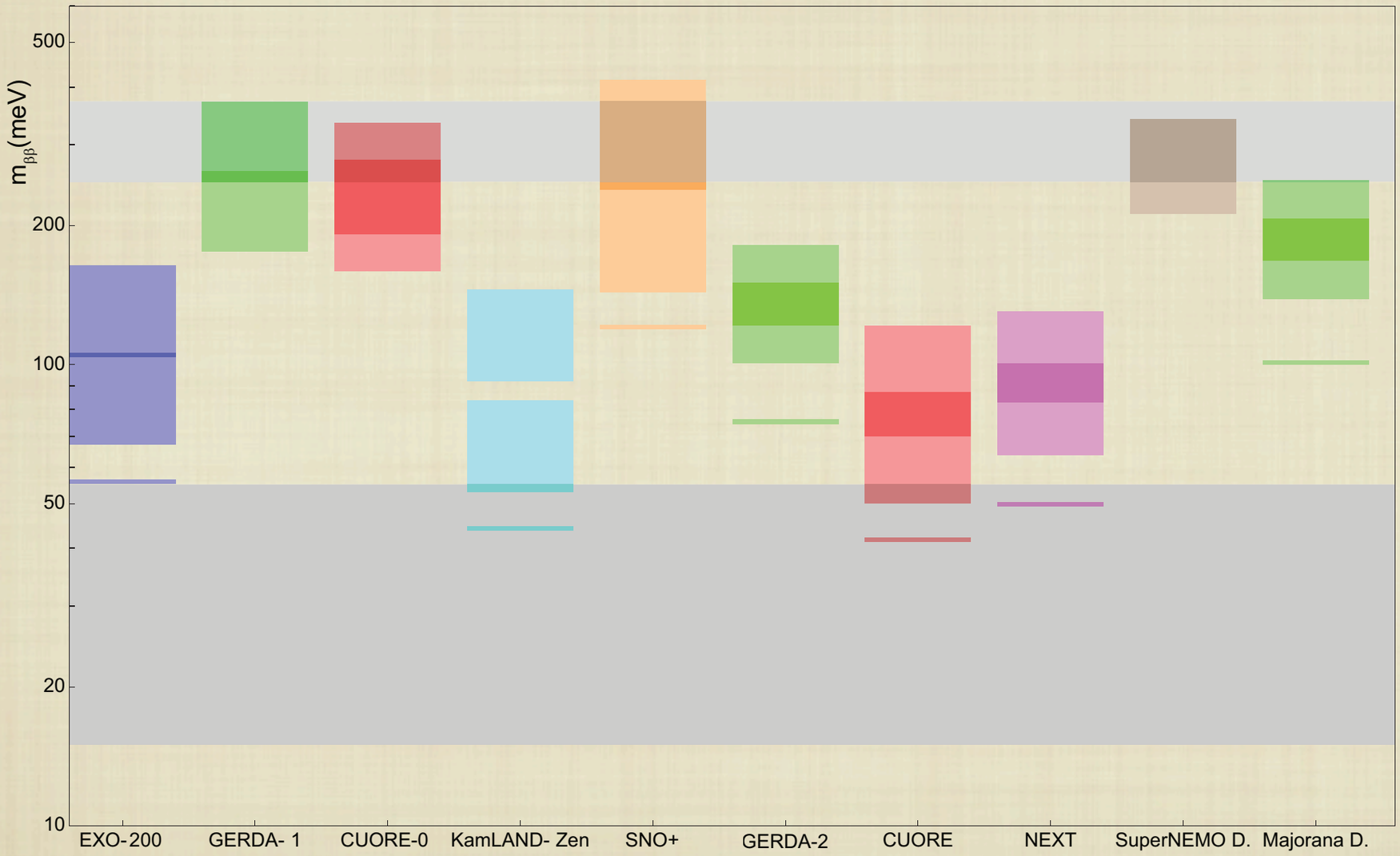
100 kg of enriched xenon (and 100 of depleted) already procured, and waiting at the LSC.

NEXT-100 performance

	Signal	^{214}Bi	^{208}Tl
1 track cut	0.48	6.0×10^{-5}	2.4×10^{-3}
ROI	0.33	2.2×10^{-6}	1.9×10^{-6}
Topological cut	0.25	1.9×10^{-7}	1.8×10^{-7}

Rejection Potential	$\sim 10^{-7}$
Background	2.0×10^{-4} counts/keV/kg/yr

NEXT-100 sensitivity



NEXT-100 schedule

- TDR in December, 2011
- Construction and commissioning of shielding and gas system (January 2012—June 2012).
- Complete design of pressure vessel and manufacture (Sept 2011—Sept 2012).
- Construction and characterization of detector planes (Second half 2012).
- Construction of field cage and HV system (Second half 2012).
- Commissioning of the NEXT-100 detector at the LSC (early 2013).
- Running in 2014

Summary

- NEXT is a new-generation double beta decay experiments, lead by Spanish and American groups, and to be installed at the Laboratorio Subterráneo de Canfranc (Spain).
- Marries two old instrumental concepts (TPCs and EL) in a novel approach, providing very good energy resolution and tracking for background rejection.
- A crash R&D program has produced to EL prototypes which have already demonstrated the feasibility of the idea.
- Technical design of the NEXT-100 detector essentially completed.
- Pushing ahed on a very thigh schedule to be running in 2014.
- Hoping to be there on time!

ありがとう
ございます