GOBIERNO DE ESPAÑA

MINISTERIO DE CIENCIA E INNOVACIÓN

CSIC

IFIC - INSTITUTO DE FISICA CORPUSCULAR

NEXT

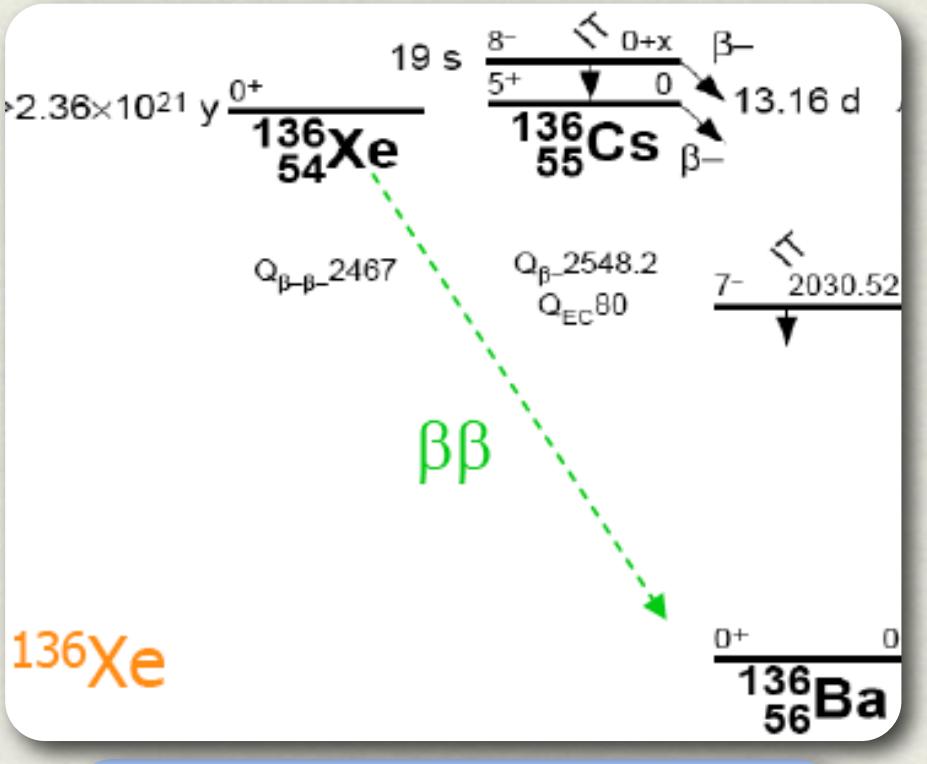
ELECTROLUMINESCENCE READOUT

Igor Liubarsky

Instituto de Fisica Corpuscular

CONTENTS

Neutrinoless Double β decay in ^{136}Xe Lifetime



$$T_{\beta\beta 2\nu} \sim 10^{18} - 10^{20}\, y$$

$$T_{\beta\beta 0\nu} \sim 10^{26} - 10^{27}\, y$$

0next

Neutrino Experiment
with a Xenon TPC

NEXT Collaboration

CIEMAT (Madrid) U. Girona IFAE (Barcelona) IFIC (Valencia)

U. Santiago U.P. Valencia U. Zaragoza

LBNL Texas A&M

CEA (Saclay)

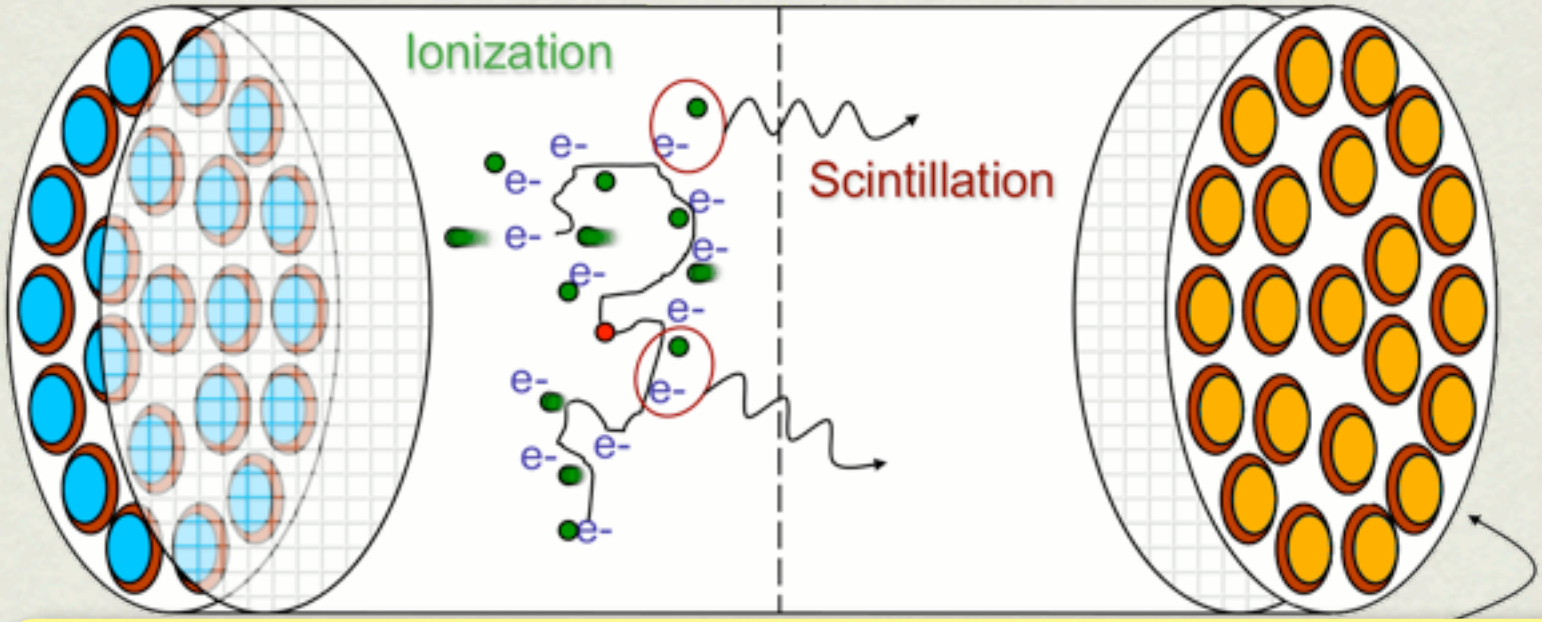
U. Coimbra U. Aveiro

JINR (Dubna)

UAN (Bogotá)

The NEXT concept

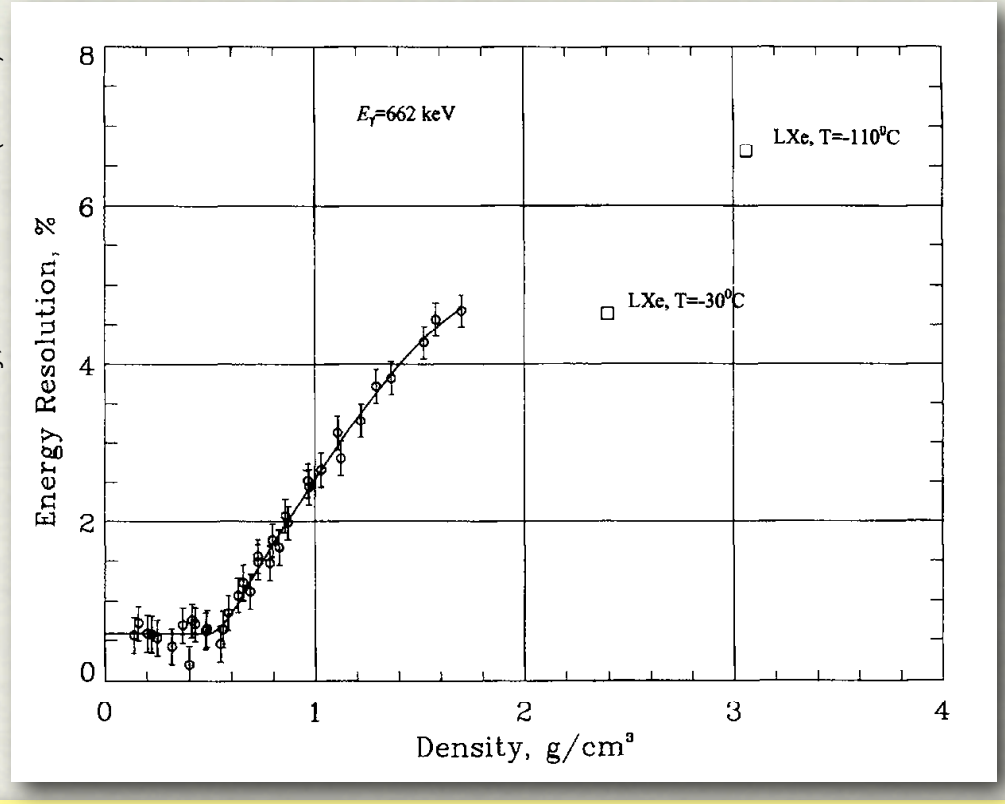
A high-pressure gaseous Xenon, electroluminescent TPC.



Ionisation and Scintillation in Xenon can be recorded in NEXT

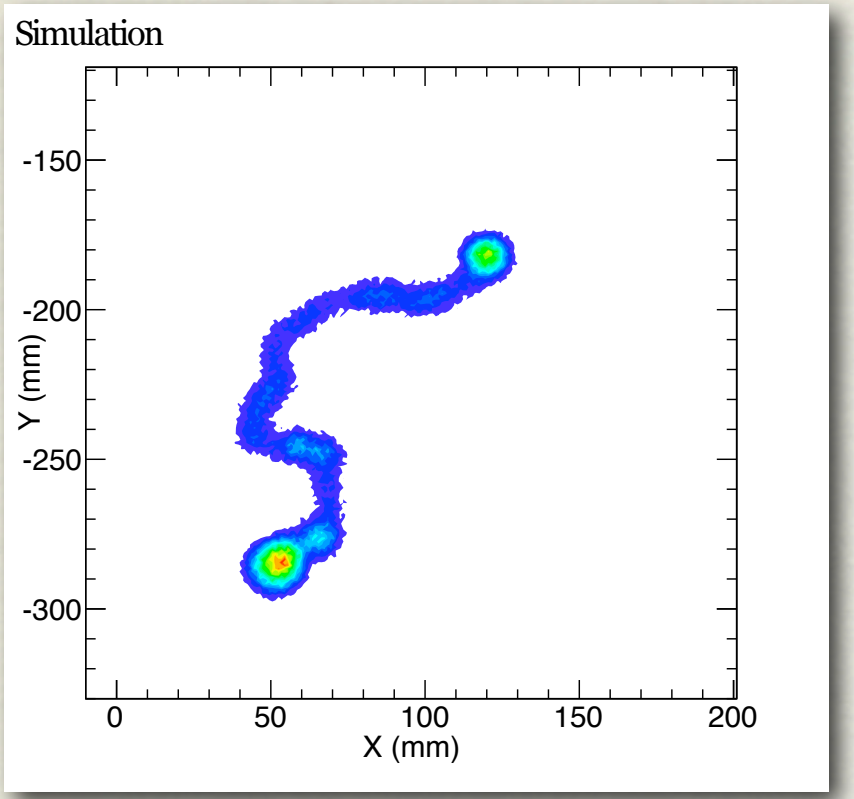
Energy resolution in High Pressure Xe

Bolotnikov and Ramsey, NIM A 396 (1997)



- Intrinsic resolution (Fano factor) at $Q_{\beta\beta}$ (2458 keV): 3×10^{-3} FWHM.
- Best experimental result: 4×10^{-3} FWHM.
- NEXT target: <1% FWHM.

Tracking in High Pressure Xe



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

Electrons travel on average ~15 cm each. Trajectories highly affected by multiple scattering. Electrons behave as MIPs except near the endpoints (*blobs*).

NEXT technology

High pressure chamber (10-20 bar)

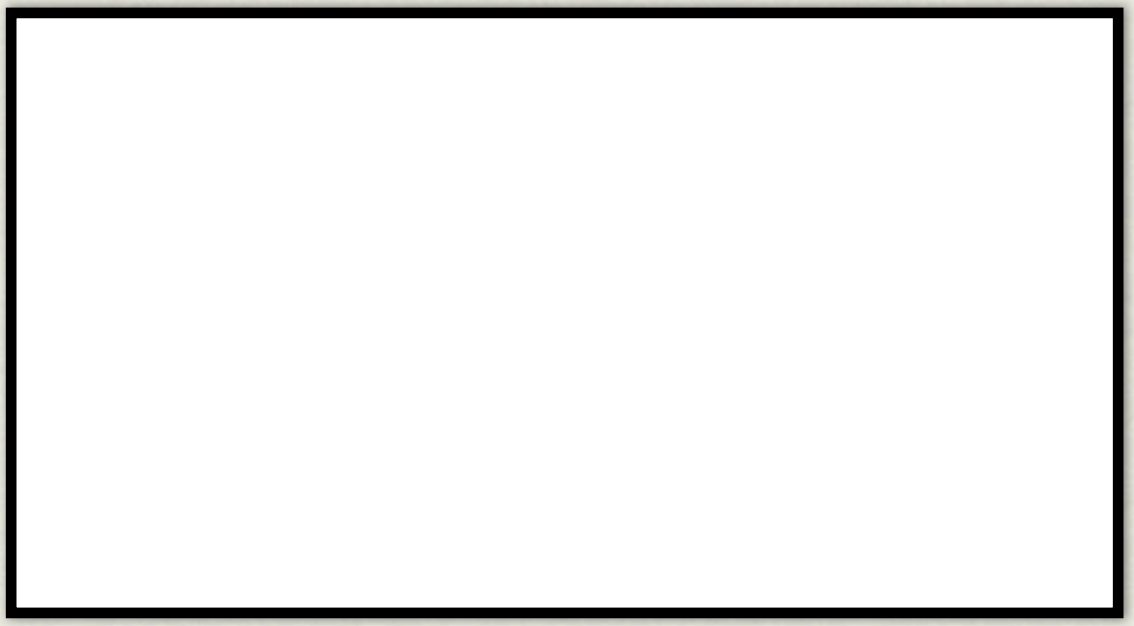
Achieve best possible energy resolution (~1% FWHM)

Topological signature

Mass: 100 kg of Xe-136 enriched at 90%

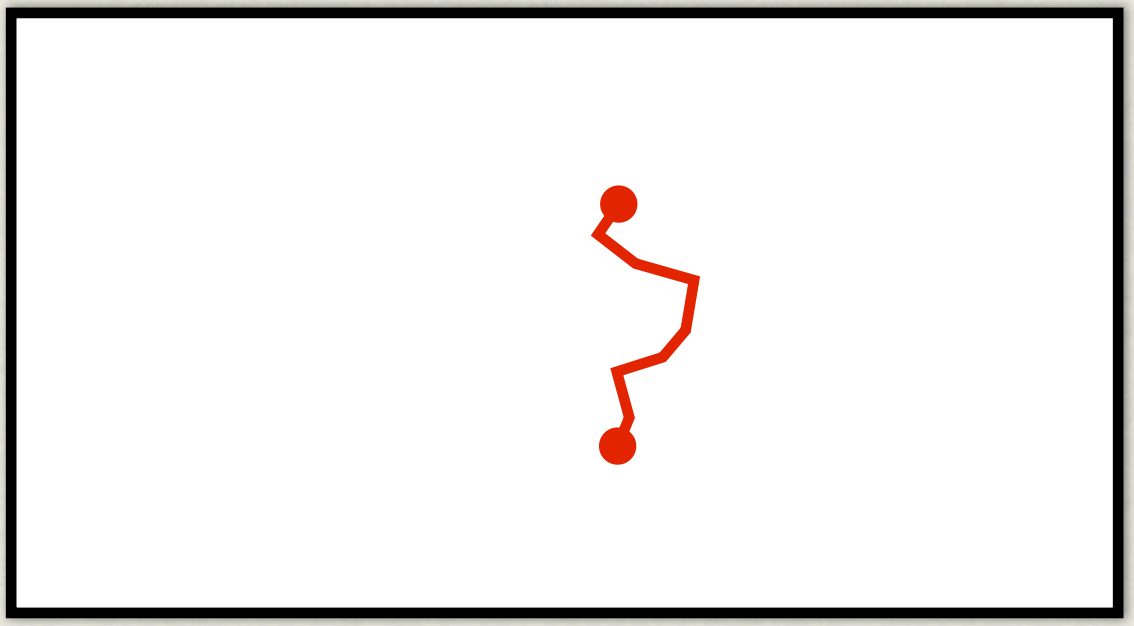
Electroluminescence TPC default technology

Signal Detection



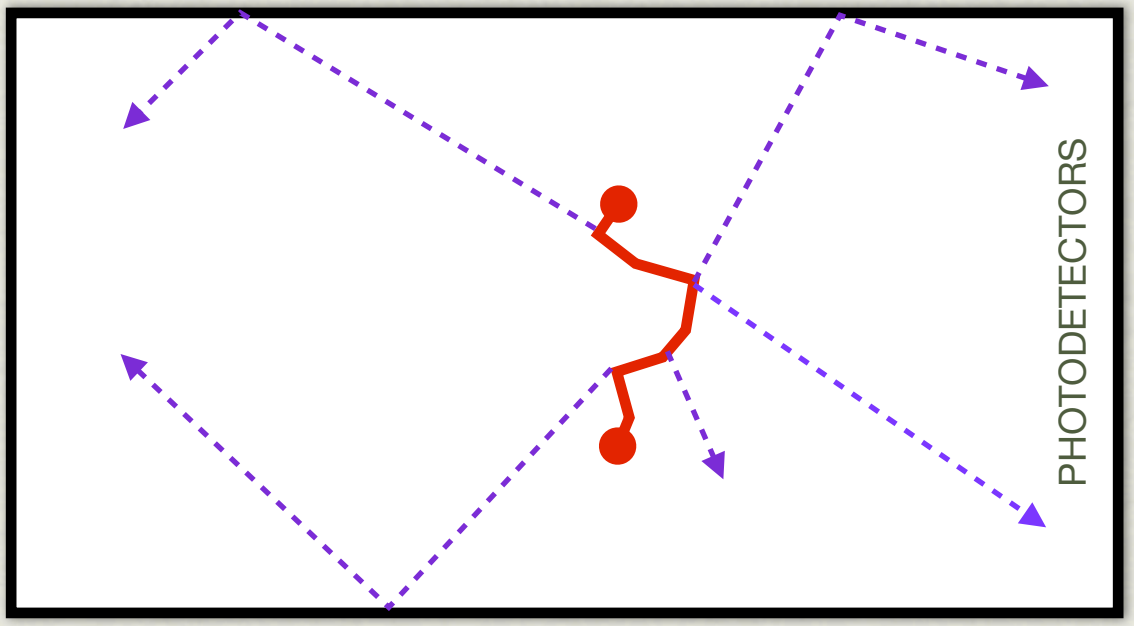
- TPC filled with highly enriched (>90%) ^{136}Xe gas at 10 bar pressure.
- Chamber walls lined with material highly reflective to UV light.
- Baseline detector with ~100 kg fiducial mass (2 m^3): NEXT-100.

Signal Detection



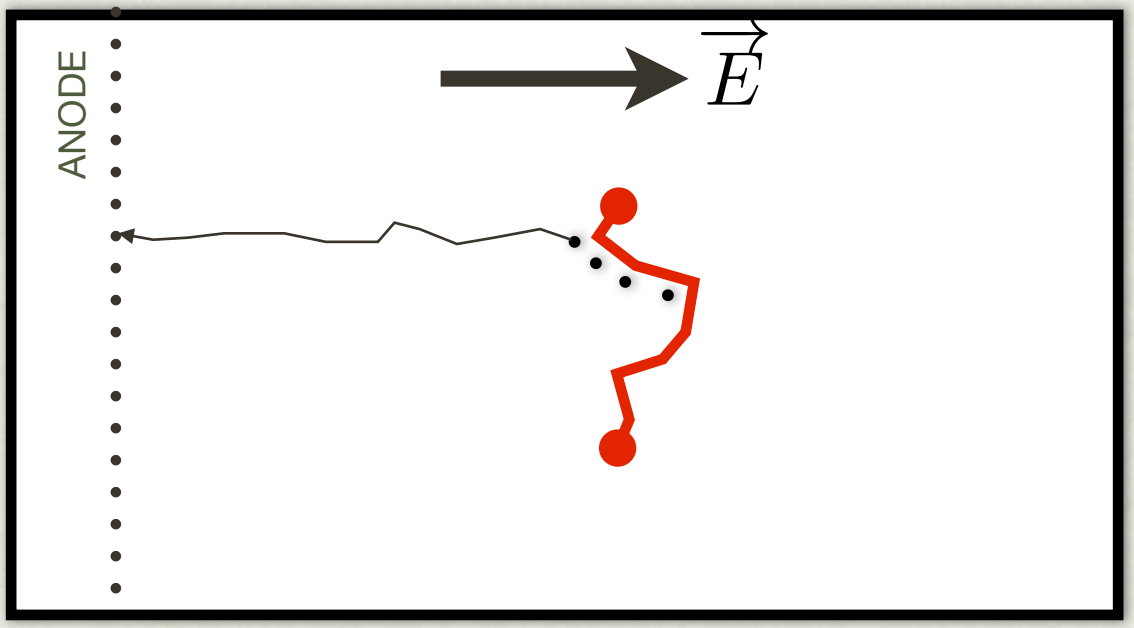
- A ^{136}Xe isotope decays emitting the two electrons.
- They propagate through the HPXe ionising and exciting its atoms.

Signal Detection



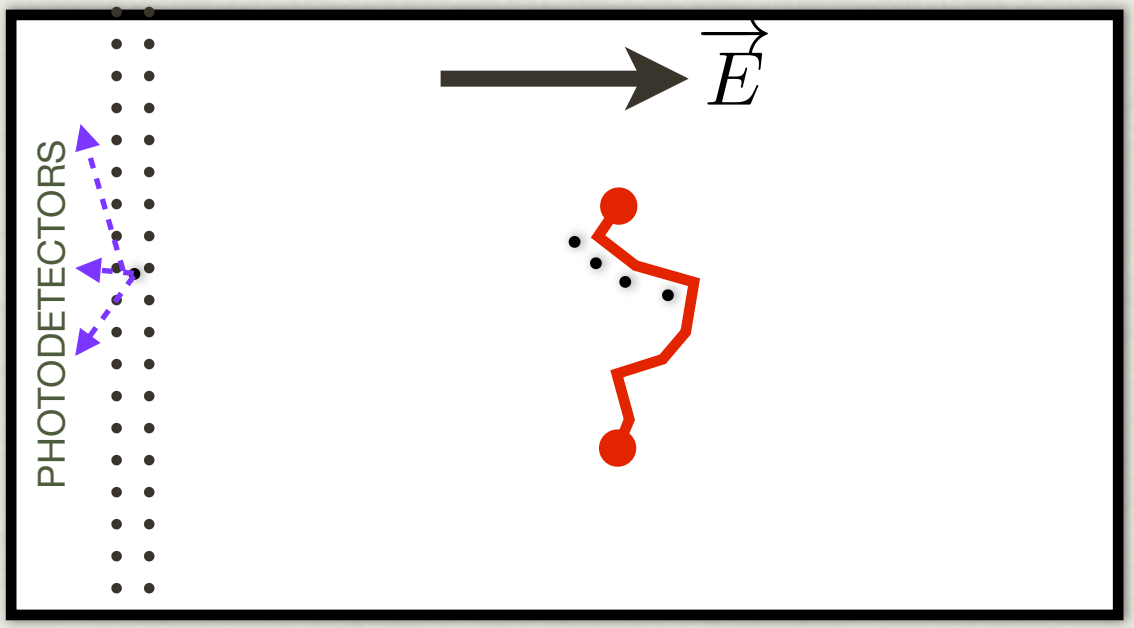
- Prompt primary scintillation light emission in VUV (~175 nm). About 100 eV needed to create a primary scintillation photon.
- Detect faint signal via sensitive photo-detectors (PMTs) behind transparent cathode.
- Determine t_0 and therefore event position along drift.

Signal Detection



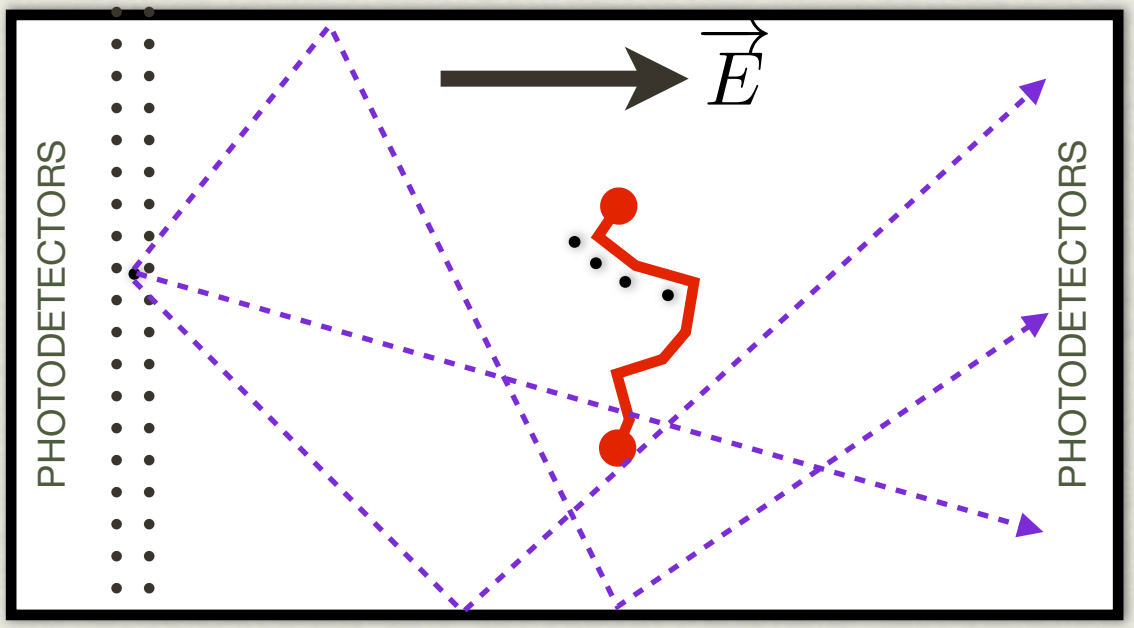
- Create ionisation charge in Xe: ~25 eV to create one electron-ion pair.
- Electrons drift toward anode with velocity ~1 mm/us in a ~1kV/cm electric drift.
- At 10 bar pressure, non-negligible diffusion: 9 mm/√m transverse, 4 mm/√m longitudinal).

Signal Detection



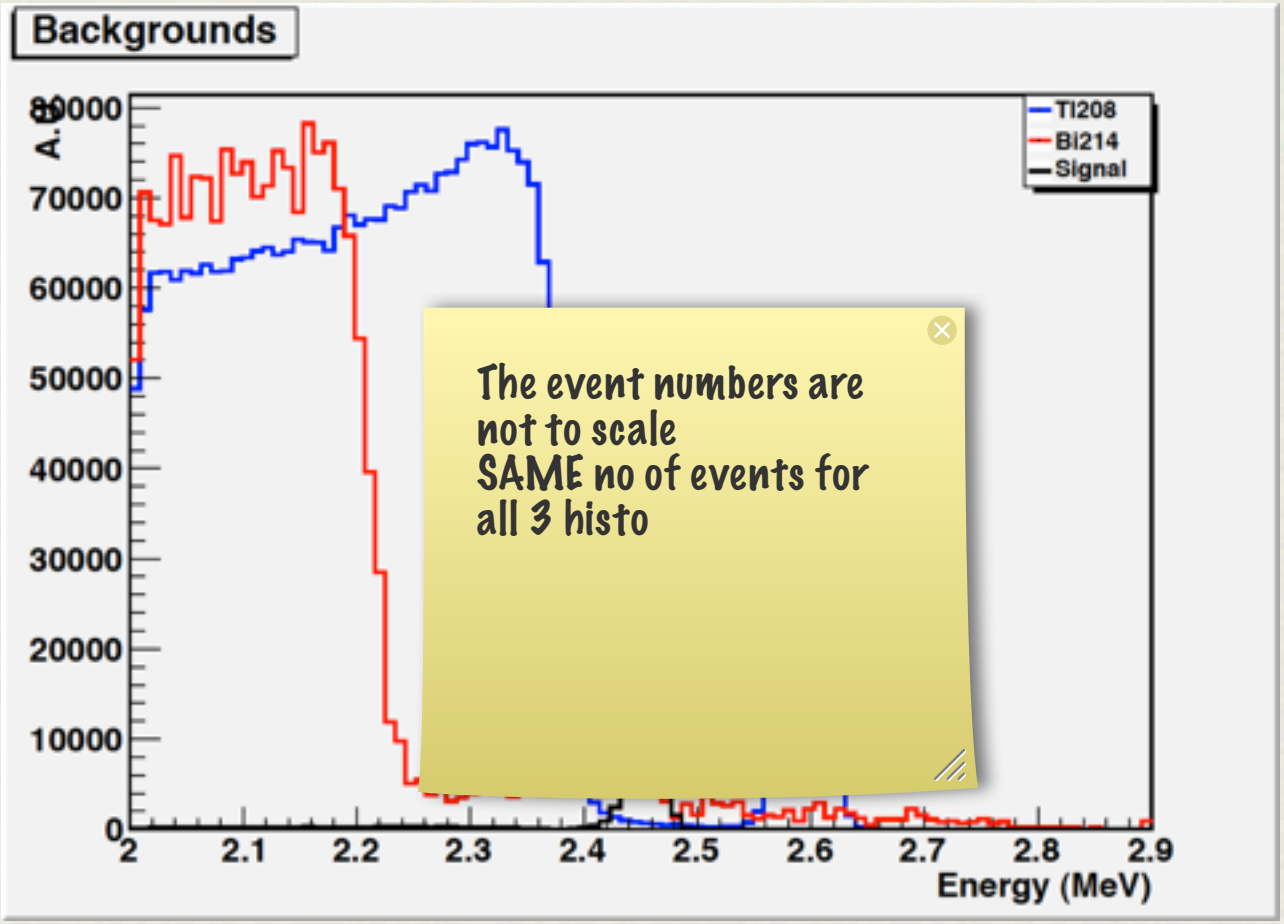
- Additional grid in front of anode creates ~0.5 mm thick region of more intense field: E/p ~4 kV/cm/bar.
- Secondary scintillation light (electroluminescence) created in between grids by atomic de-excitation, with very linear gain of order 10^3 and over a ~2us interval.
- Finely segmented photo-detector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

Signal Detection



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

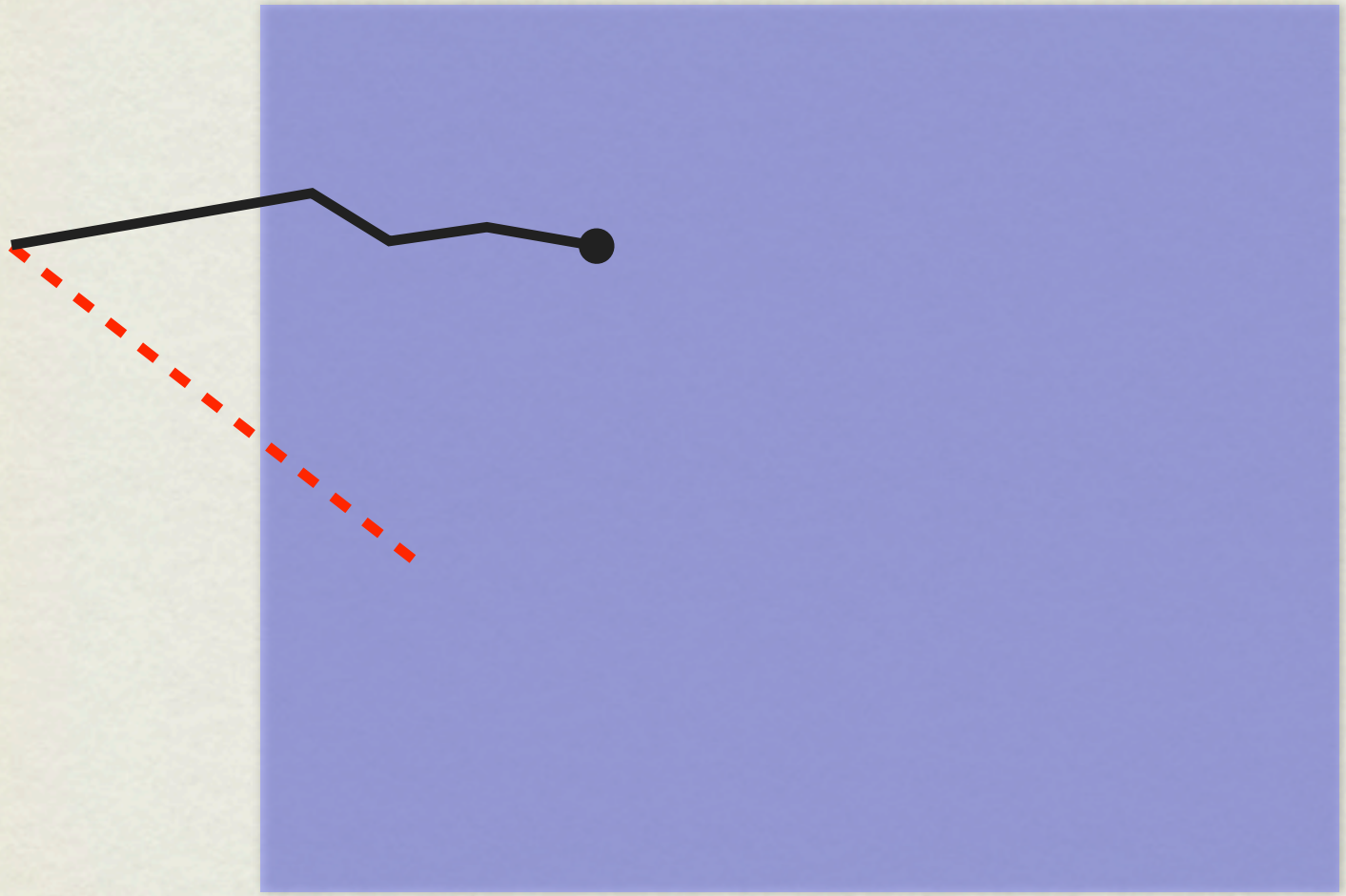
NEXT backgrounds



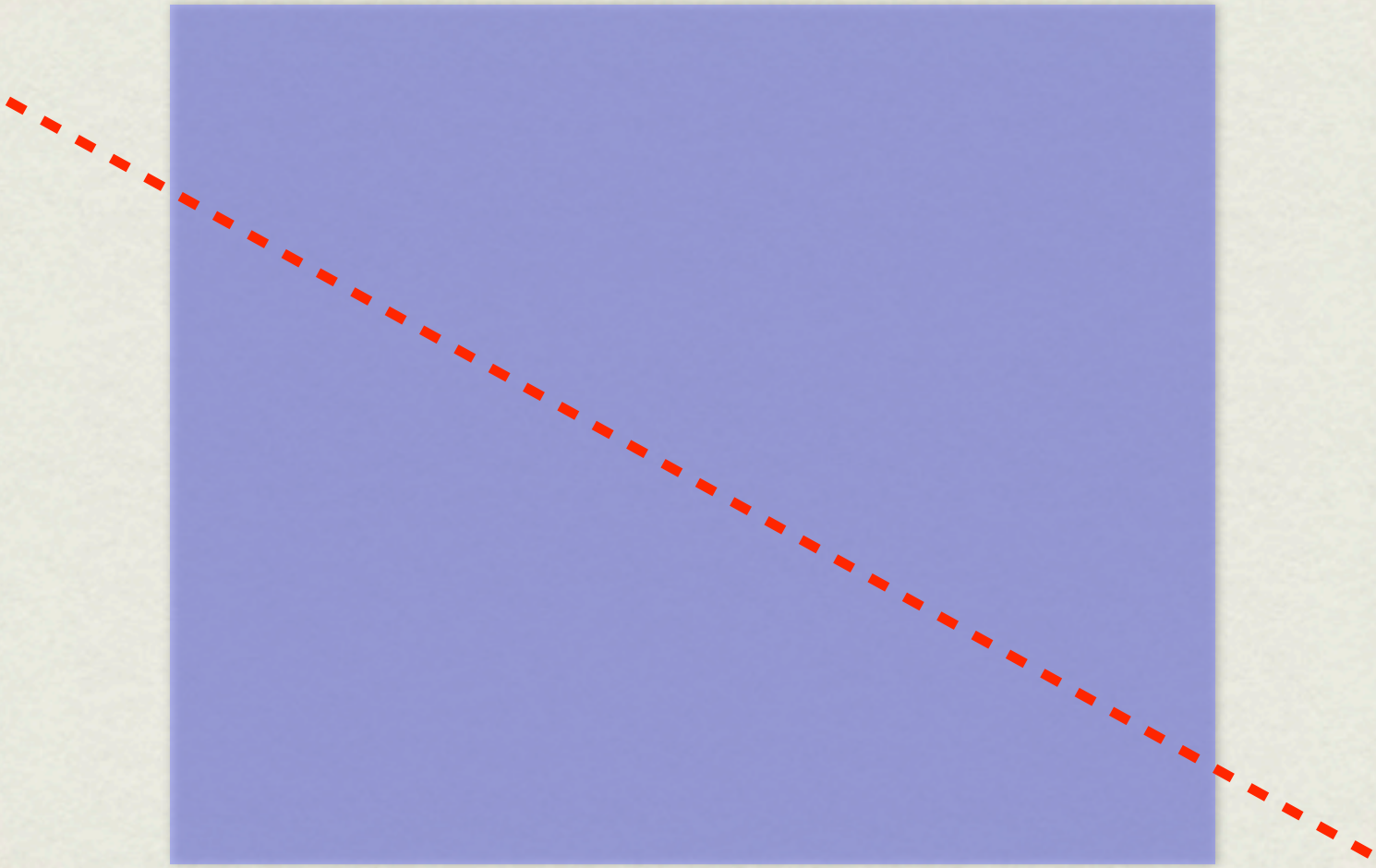
Two radioactive background sources in our Region of interest: ^{208}Tl and ^{214}Bi

Background Rejection

- Only gamma-generated electron tracks in the detector fiducial volume can become a background.
- Topological cuts and pattern recognition (single-electron track vs. two-electrons track) provide an overall 10^{-7} rejection factor.
- Selection efficiency for the signal of ~30%.

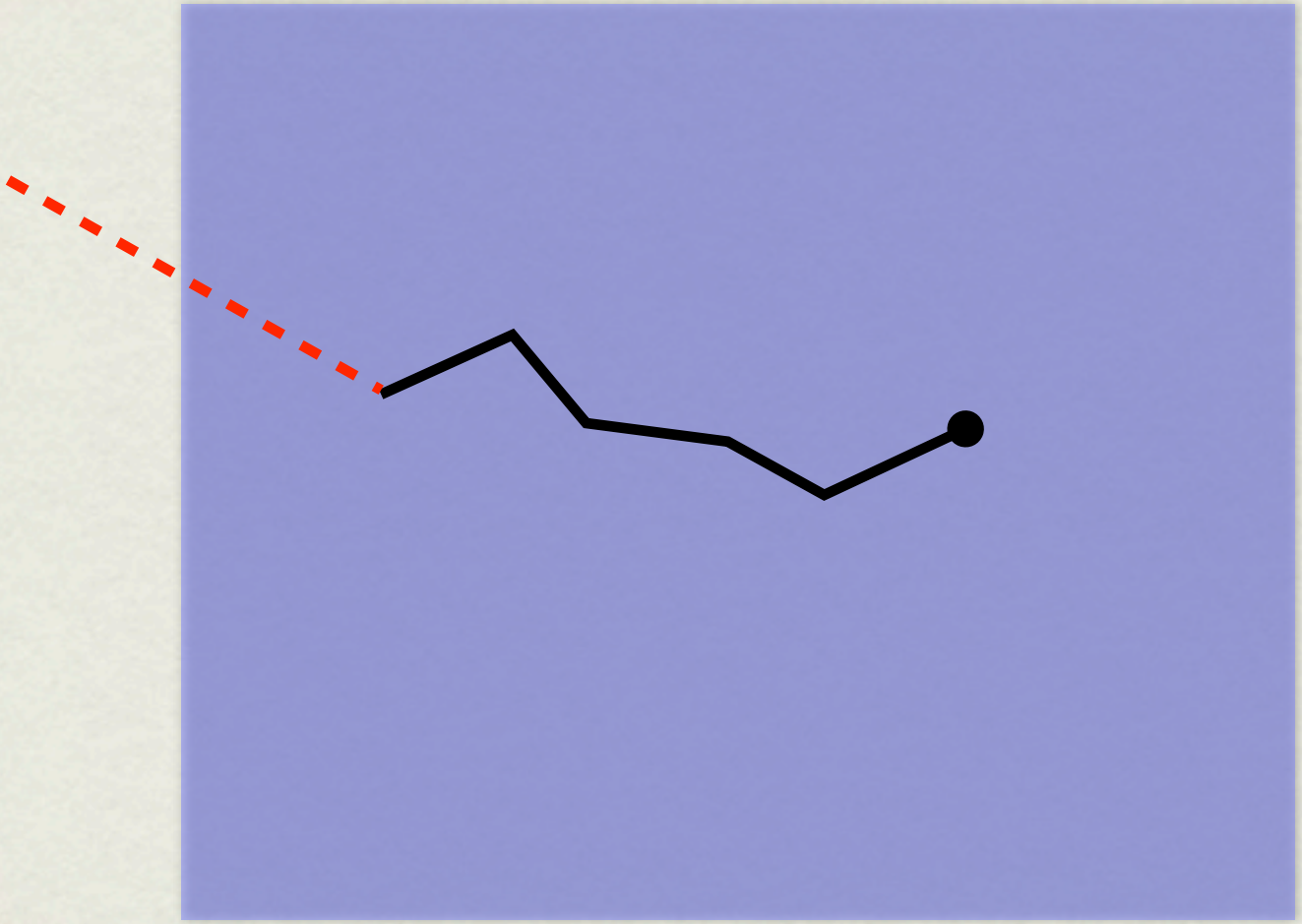


veto of charged backgrounds



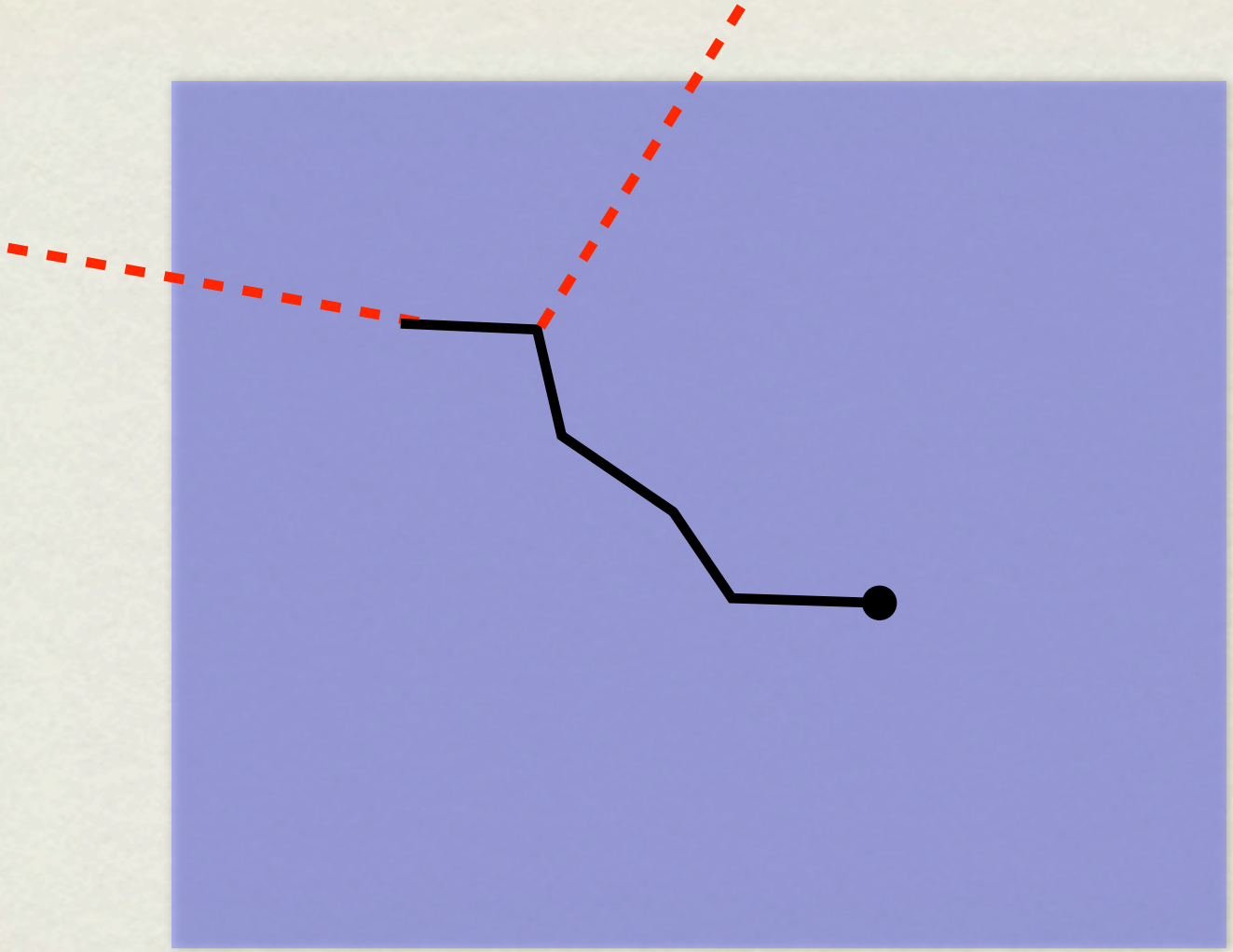
Gaseous Xe long attenuation length (>3 m at 10 bar) to high energy gammas.

photoelectric effect



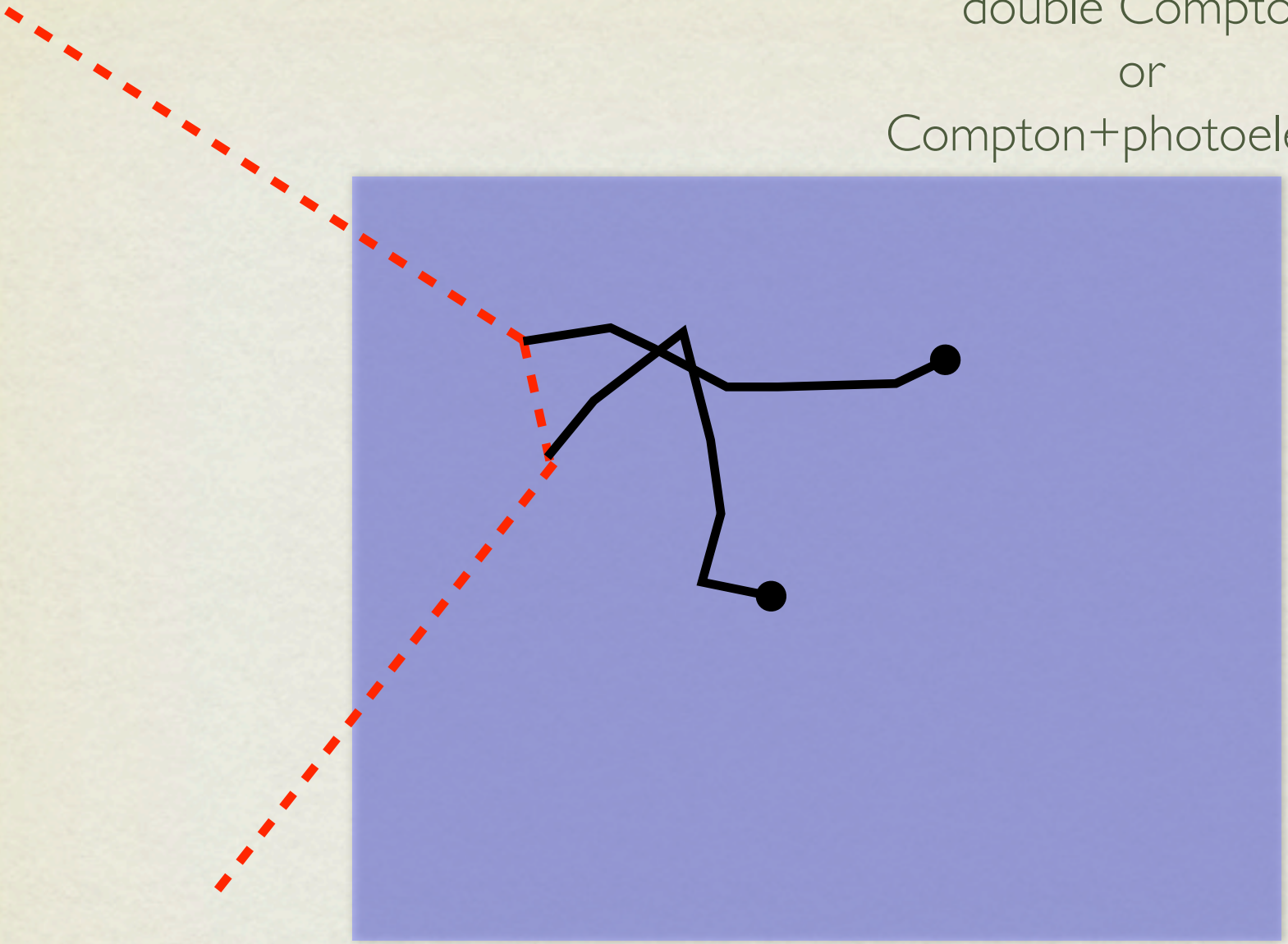
(gammas around Q)

photoelectric and bremsstrahlung



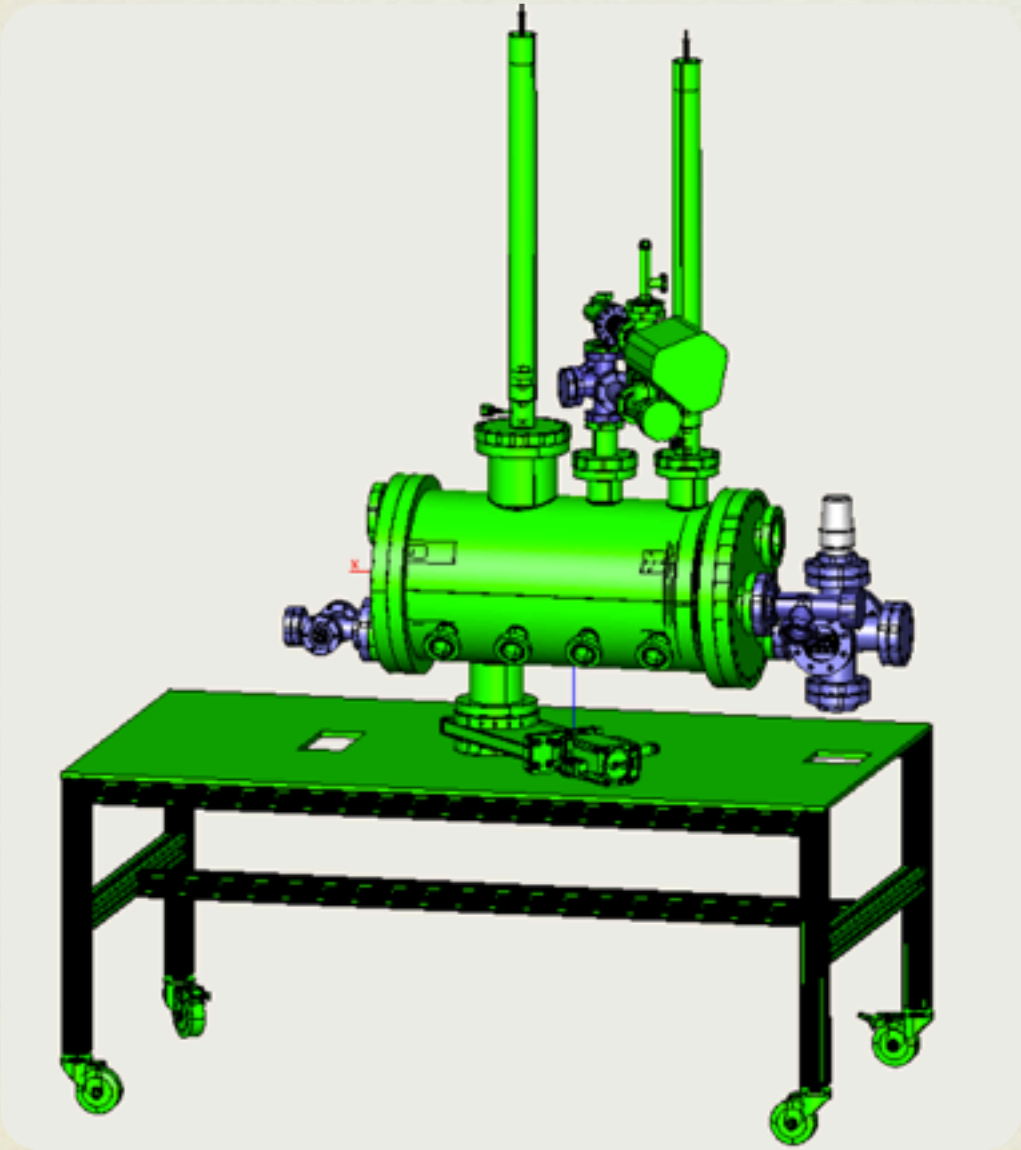
(gammas above Q)

double Compton
or
Compton+photoelectric



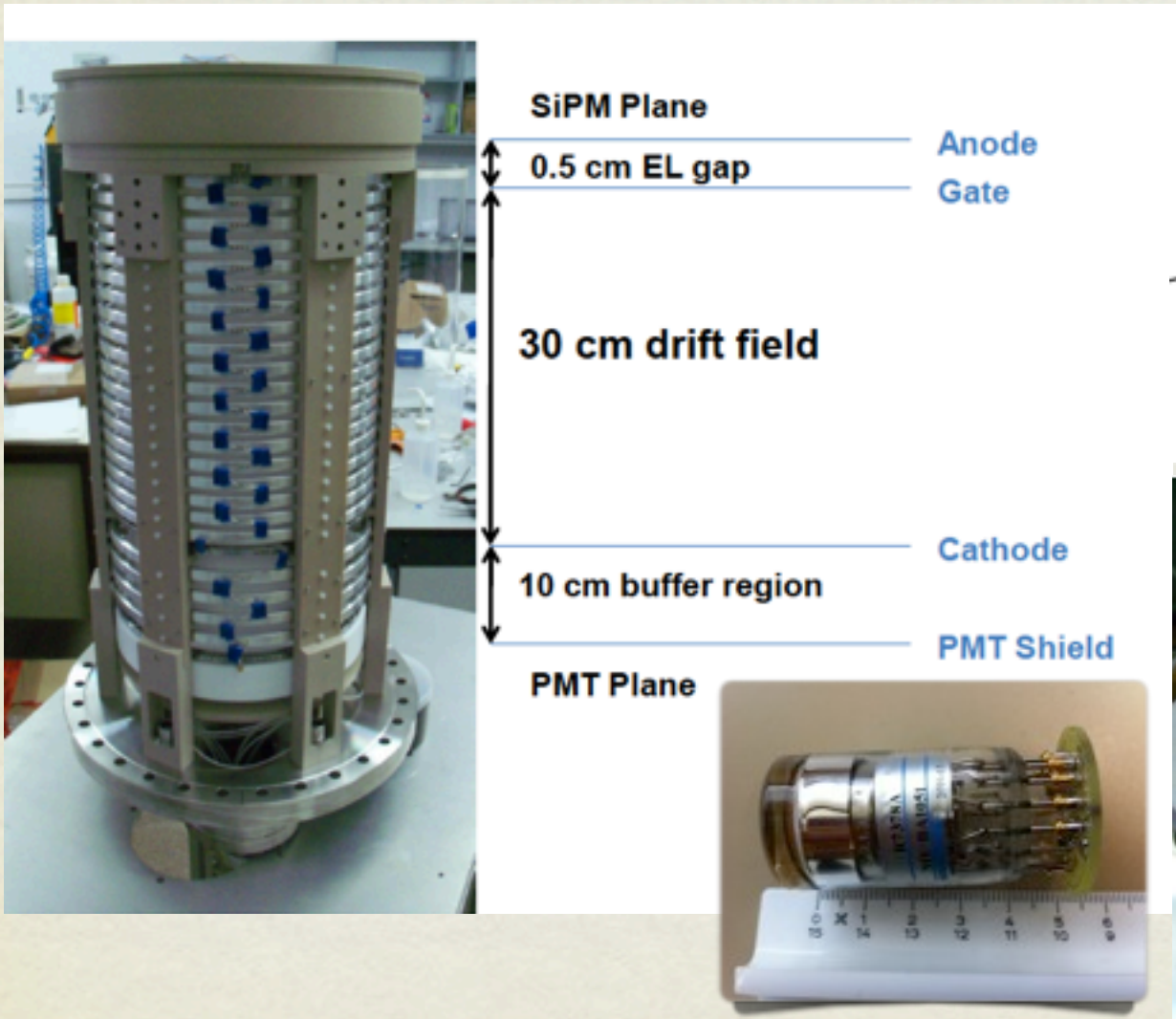
(gammas around and above Q)

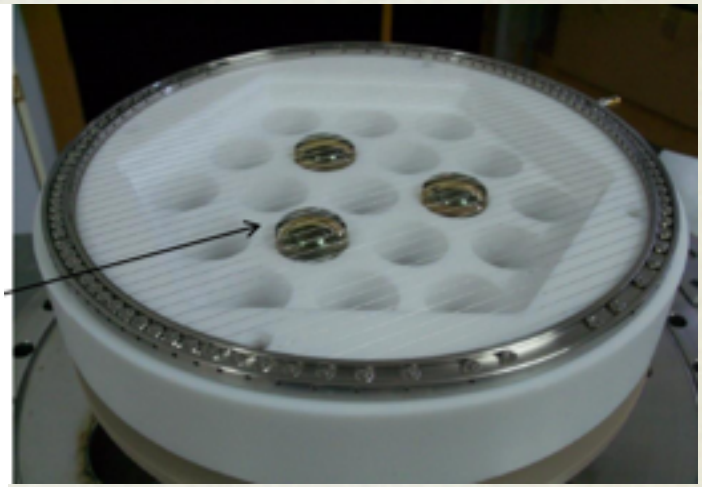
NEXT-1-EL

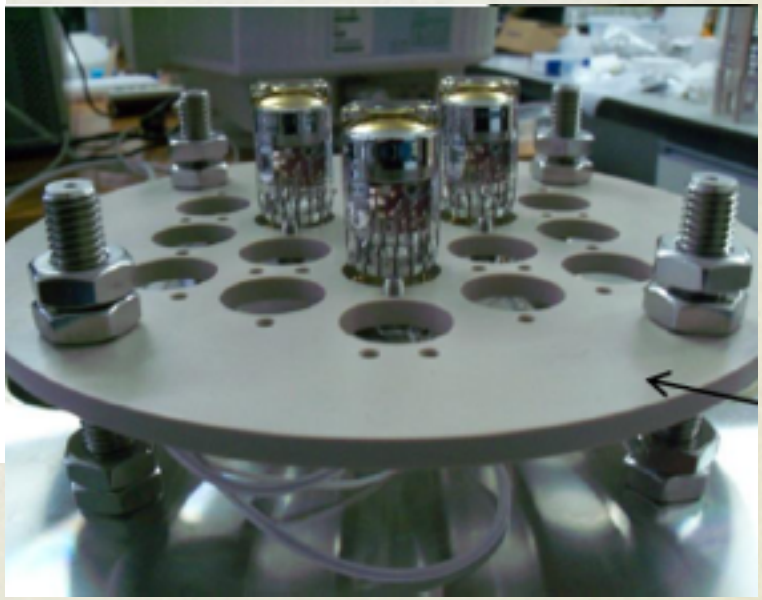


Presently :

The Largest Gaseous Xe Electroluminescence TPC



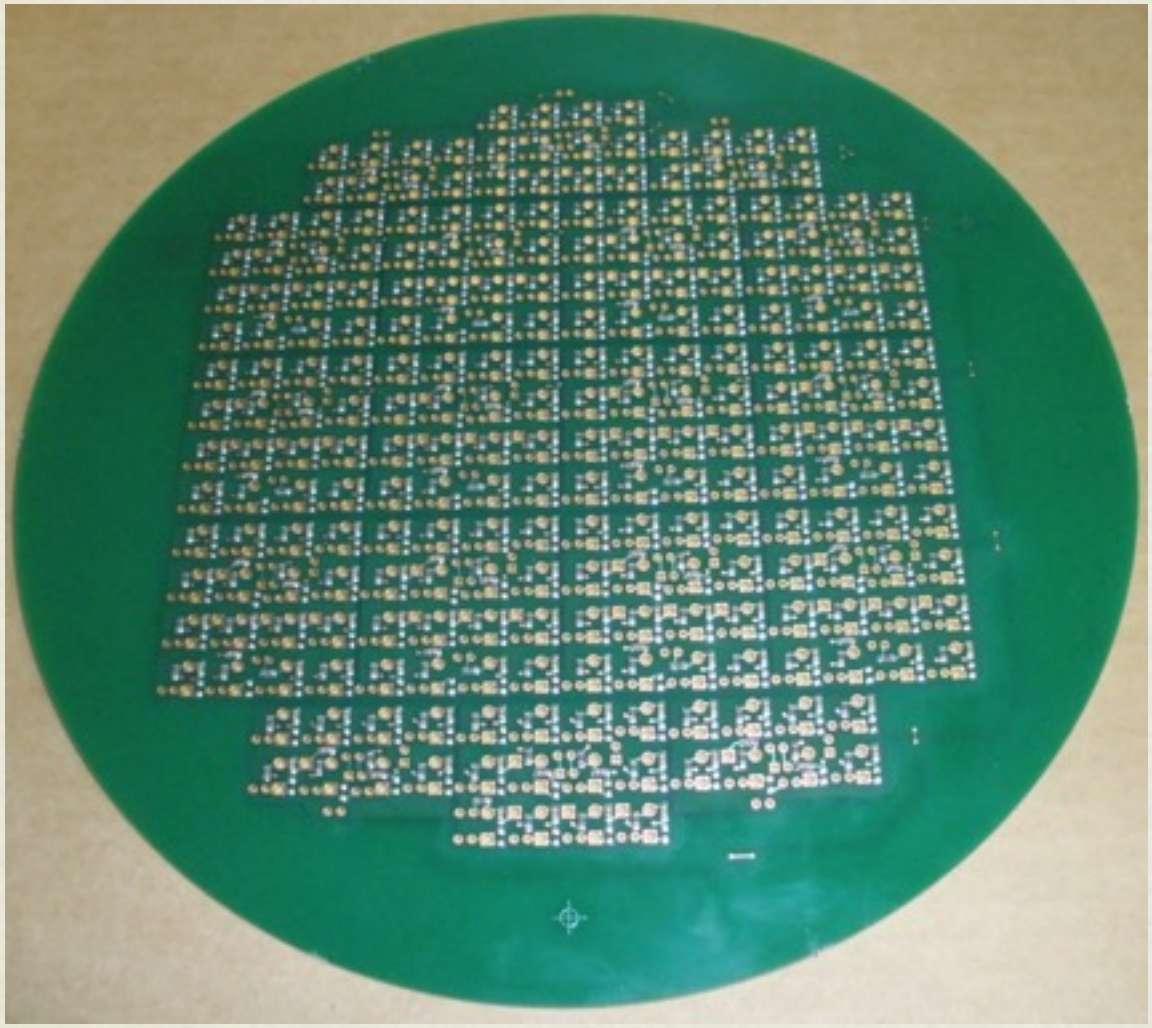


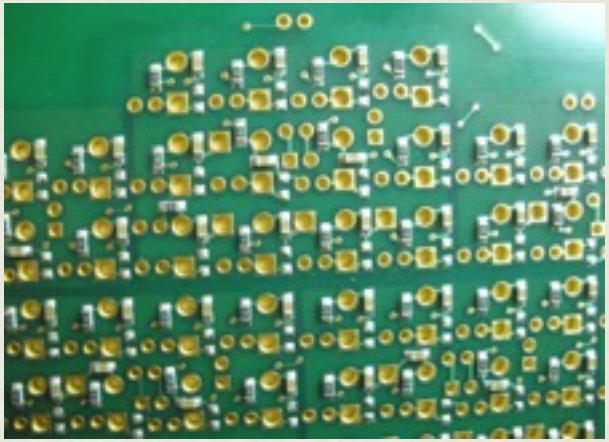


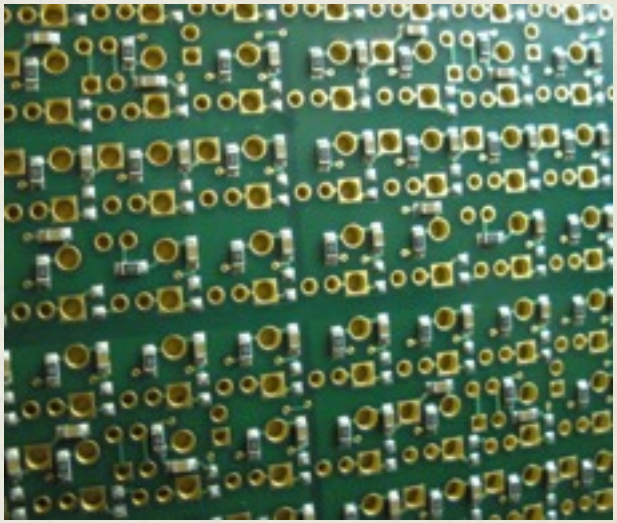
19 HAMAMATSU R7378A

Mock-up PMT x19

SiPM Plane



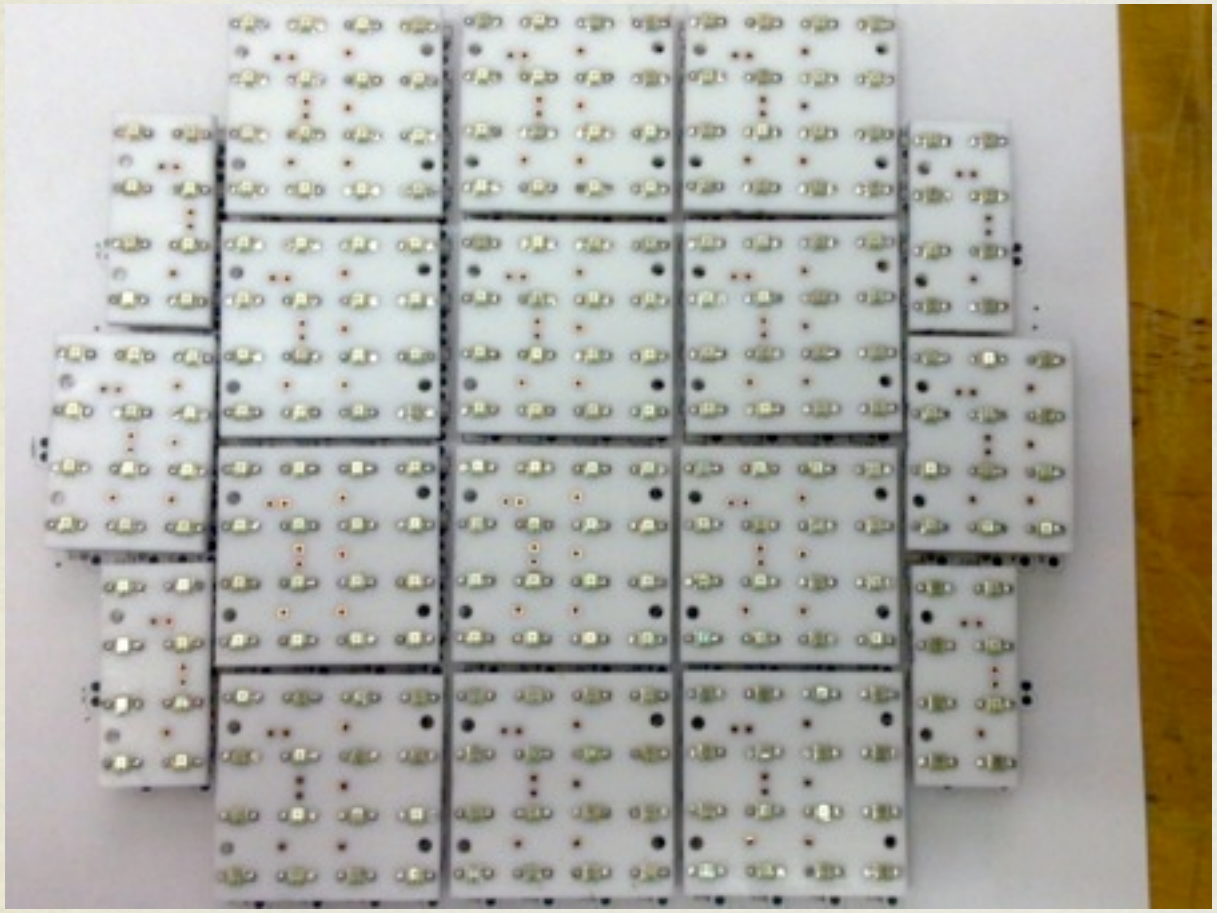




People Working

SiPM Plane

18 Daughter Boards



Selection of Si-PMs to have the minimum spread in gain.

12 Boards with 16 Si-PMs

2 Boards with 12 Si-PMs

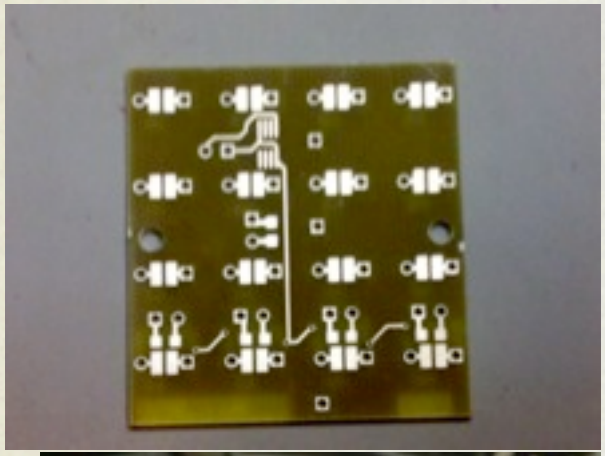
4 Boards with 8 Si-PMs

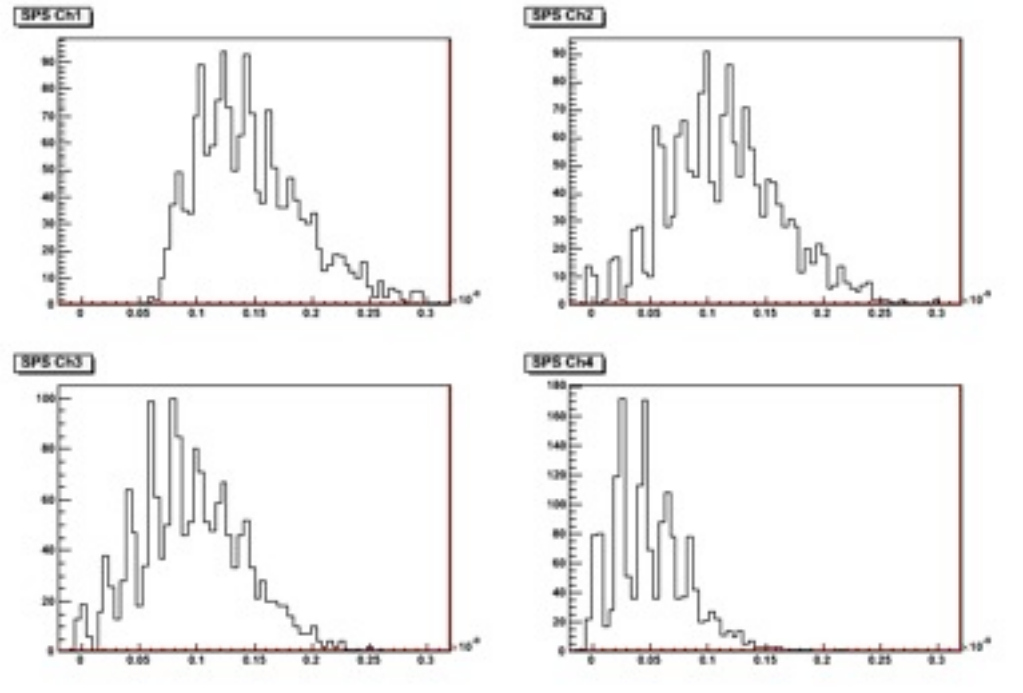
Daughterboard for temperature tests

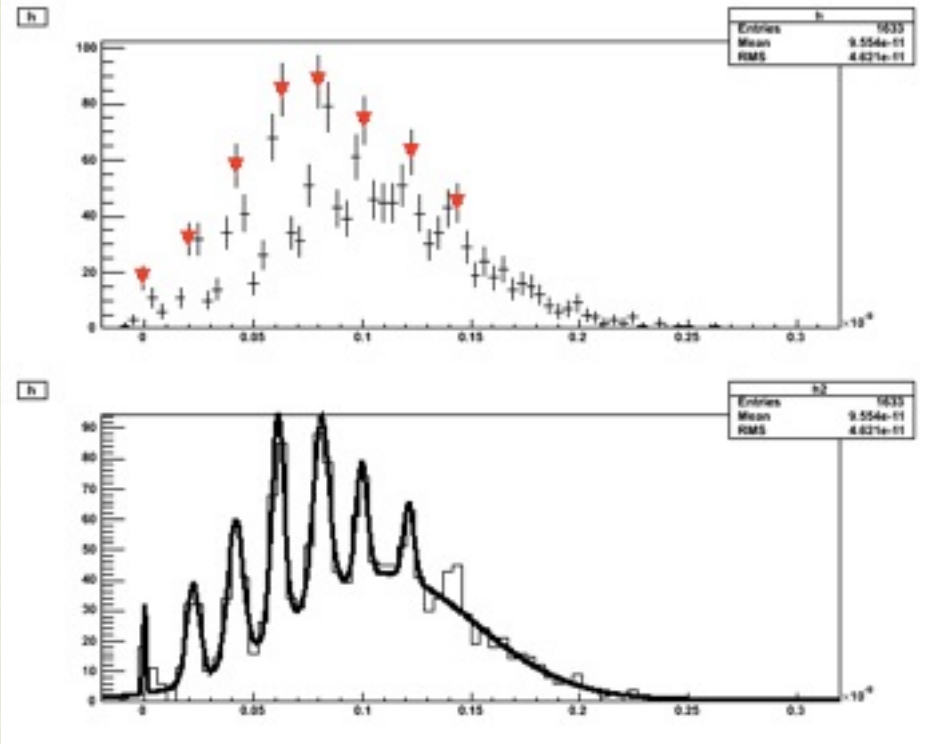
- Daughter board for temperature tests :

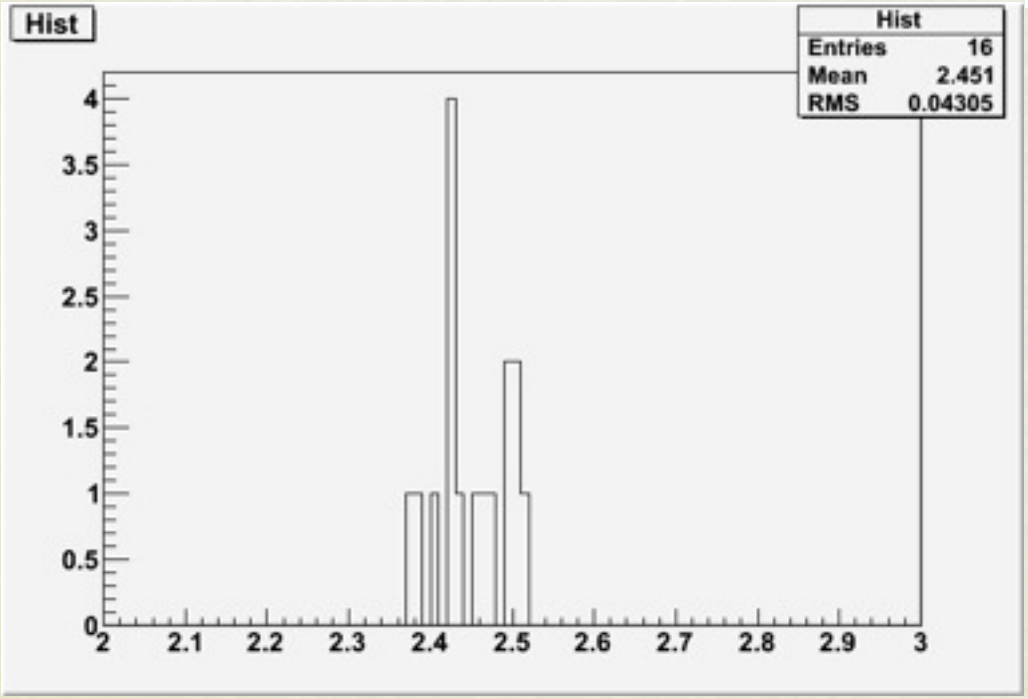
  - 5 temperatures sensors (DB18B20)

    - 5 thermocouples









Single Photon Spectrum of

each single Si-PMs

Spread in gain of each

Daughter Board

$$\text{Spread} = \frac{\text{RMS}}{\text{Mean}}$$

DBo № 1
Vop= 71,15 V
Gain = 2,457
Spread=1,83%

DBo № 2
Vop= 71,14 V
Gain = 2,439
Spread=1,90%

DBo № 3
Vop=71,18 V
Gain = 2,418
Spread=2,97%

DBo № 13
Vop= 71,1V
Gain = 2,268
Spread=2,00%

DBo № 16
Vop= 71,37V
Gain = 2,346
Spread=2,05%

DBo № 4
Vop= 71,16V
Gain = 2,367
Spread=3,58%

DBo № 5
Vop= 71,17V
Gain = 2,371
Spread=2,87%

DBo № 6
Vop= 71,19V
Gain = 2,354
Spread=1,70%

DBo № 15
Vop= 71,34V
Gain = 2,383
Spread=2,36%

DBo № 18
Vop= 71,32V
Gain = 2,344
Spread=1,59%

DBo № 7
Vop= 71,2V
Gain = 2,433
Spread=2,65%

DBo № 8
Vop= 71,21V
Gain = 2,379
Spread=2,35%

DBo № 9
Vop= 71,23V
Gain = 2,406
Spread=2,12%

DBo № 14
Vop= 71,13V
Gain = 2,409
Spread=2,50%

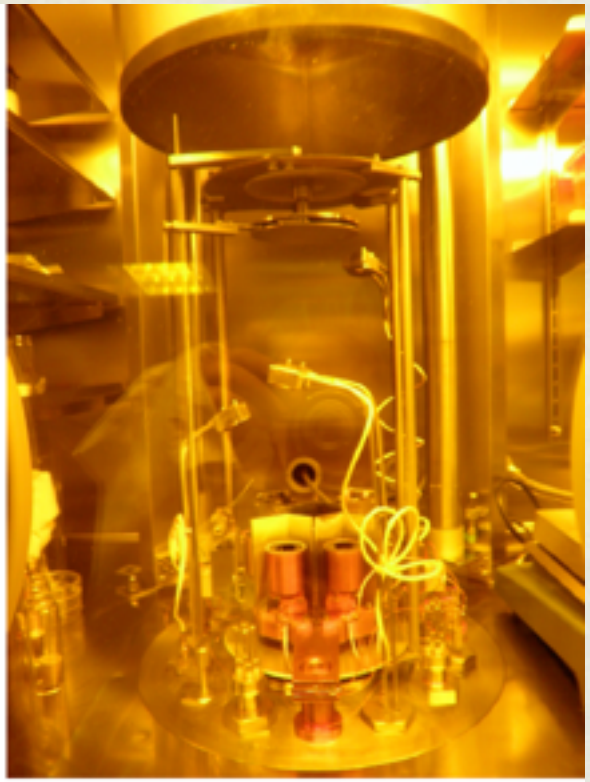
DBo № 17
Vop= 71,3V
Gain = 2,382
Spread=2,08%

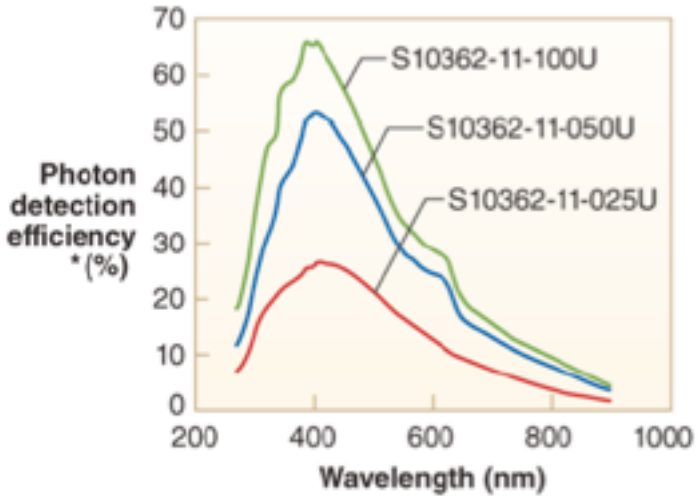
DBo № 10
Vop= 71,24V
Gain = 2,474
Spread=0,99%

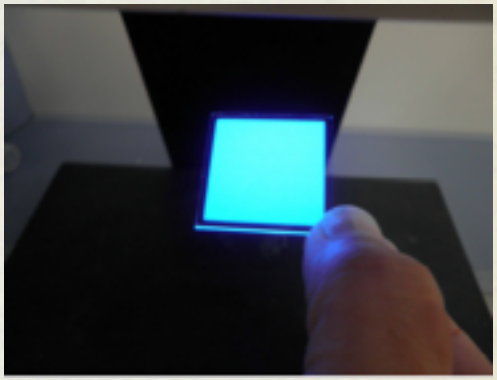
DBo № 11
Vop= 71,26V
Gain = 2,507
Spread=2,38%

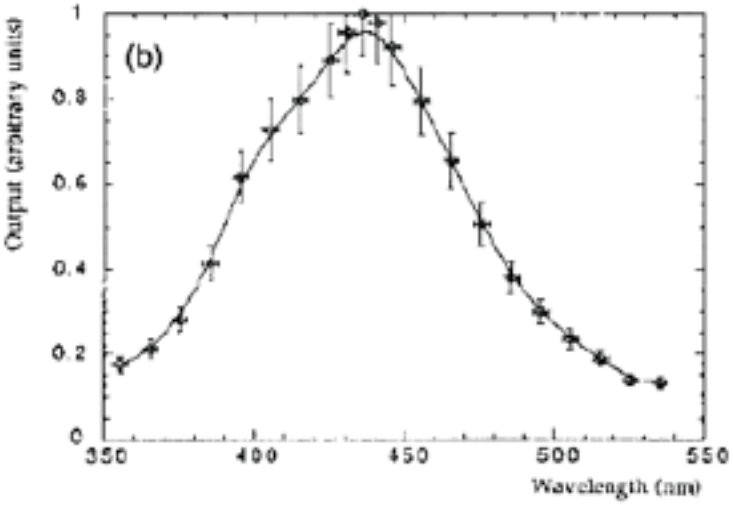
DBo № 12
Vop= 71,28V
Gain = 2,409
Spread=2,66%

Coating SiPMs



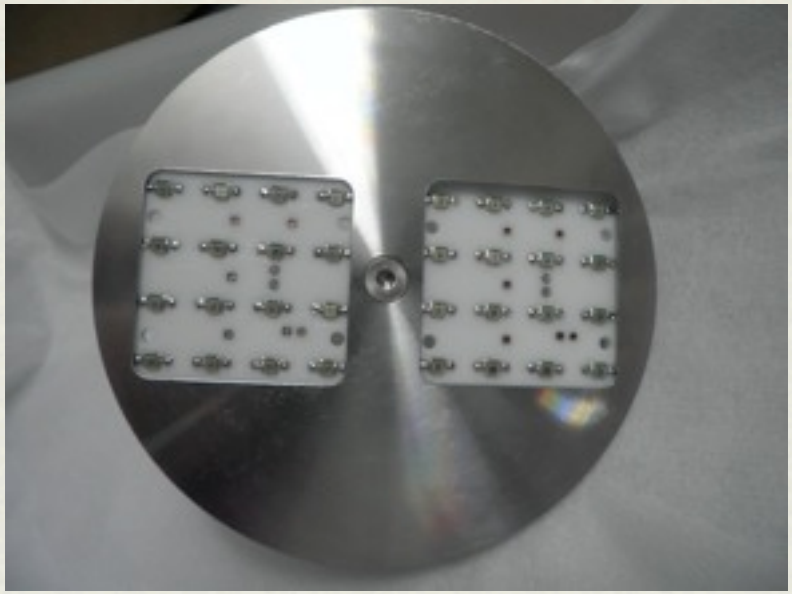


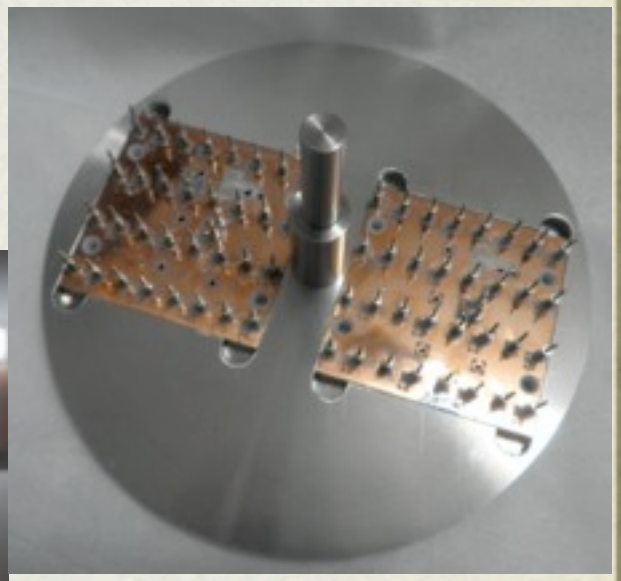


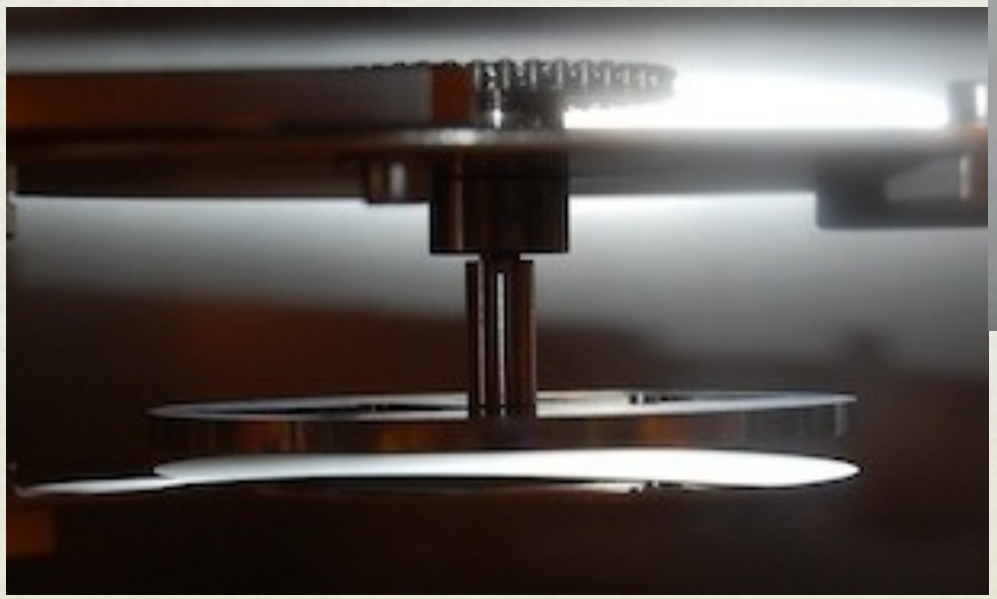


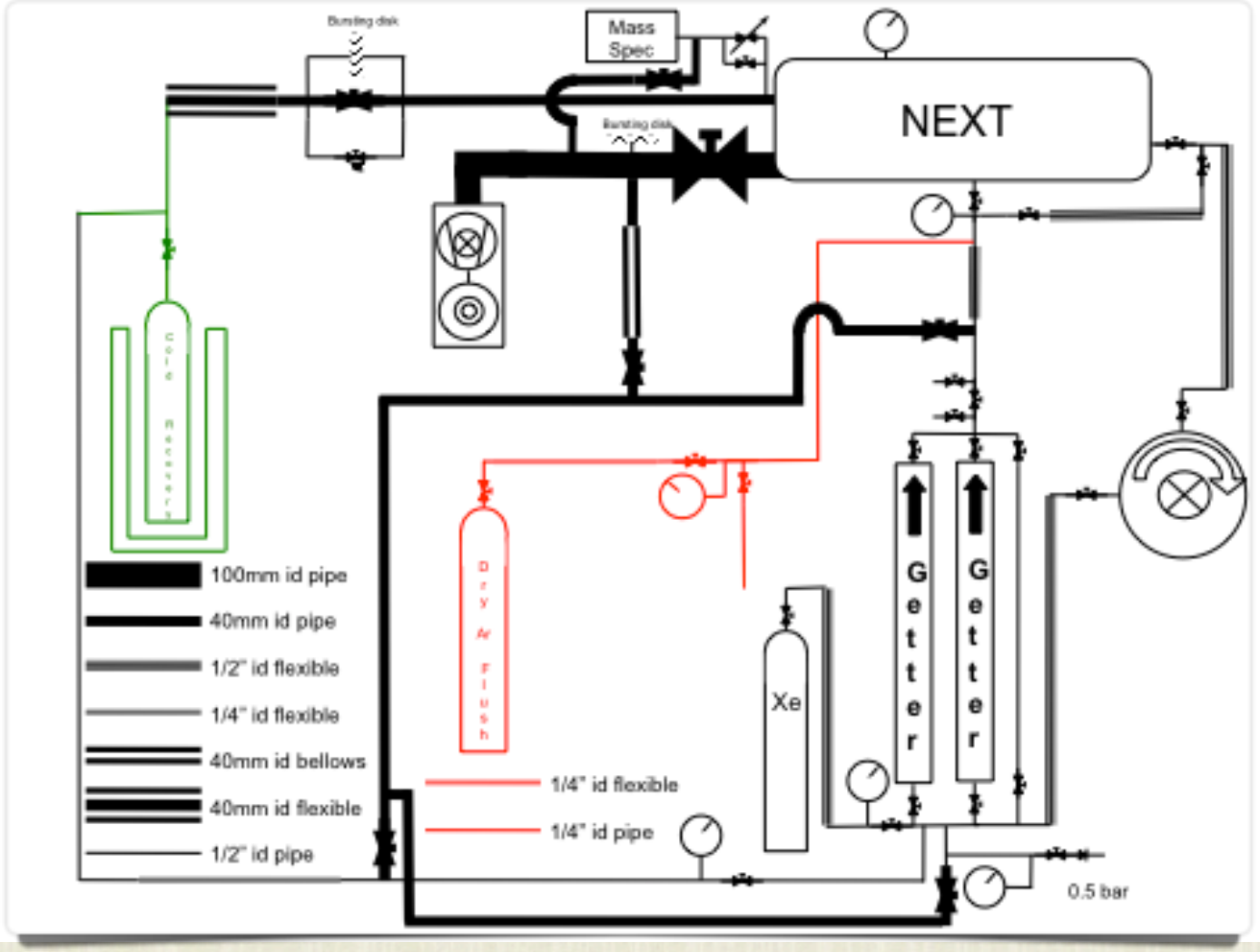
SiPMs are coated with TPB at ICMOL

SiPM Tetraphenyl-Butadiene (TPB)Coating



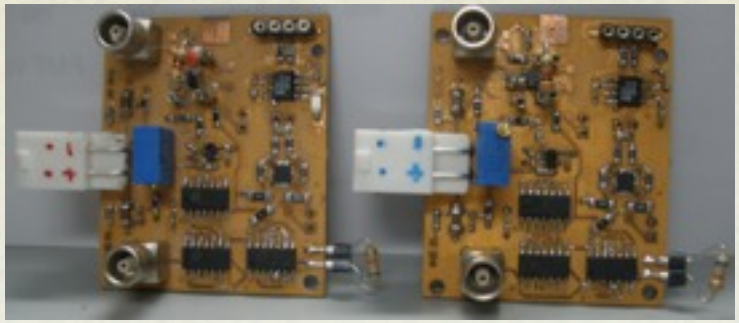






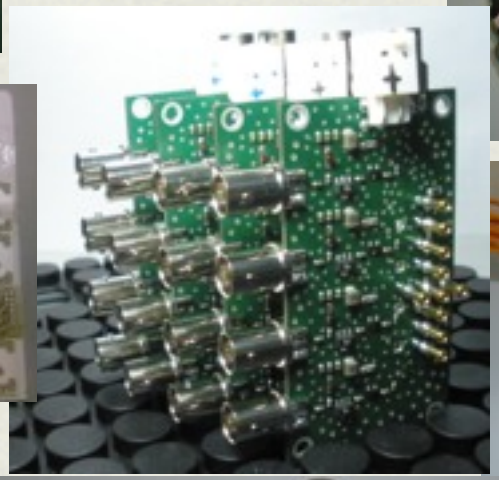
GAS SYSTEM SCHEMATIC

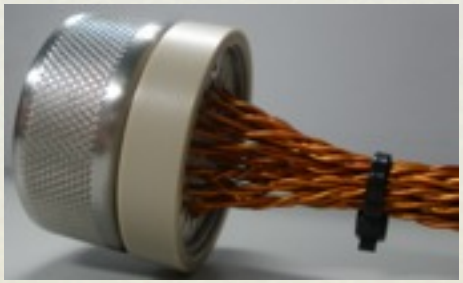
GAS SYSTEM IN THE LAB





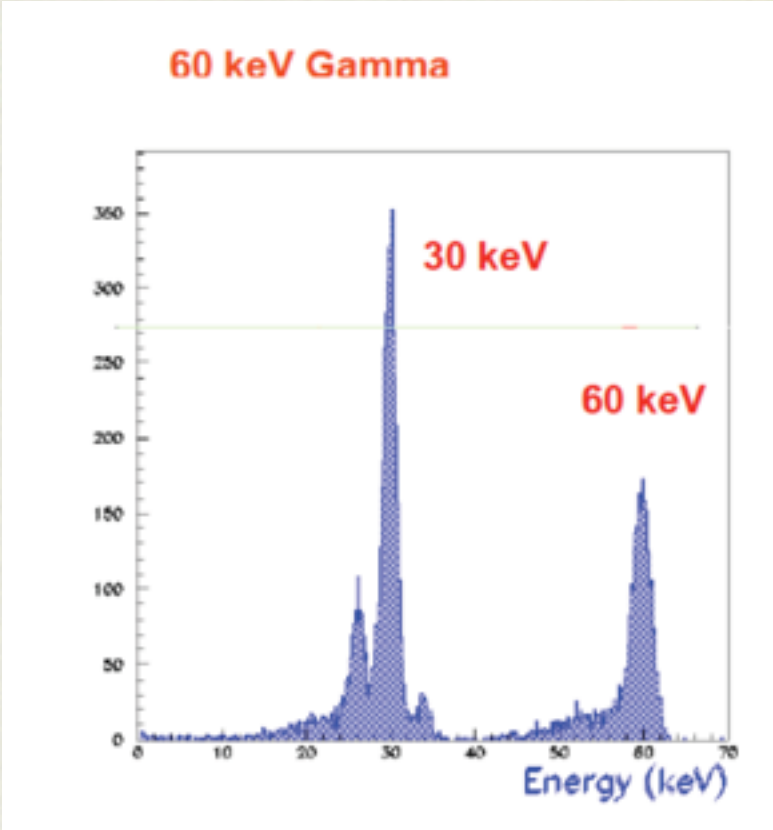

Other R&D Efforts

- NEXT 1 ELBL
- NEXT 1 MM
- APDs

In other talks

NEXT-1-ELBL

- Goals of 19-PMT: 10 liter, 10 to 20 Atm) system
  - Demonstrate energy resolution <1% FWHM for 511 keV
  - Measure E_{drift} dependence of energy resolution
- Gas System
- Field Cage / Light Pipe
- PMTs/DAQ
- Calibration sources / methods

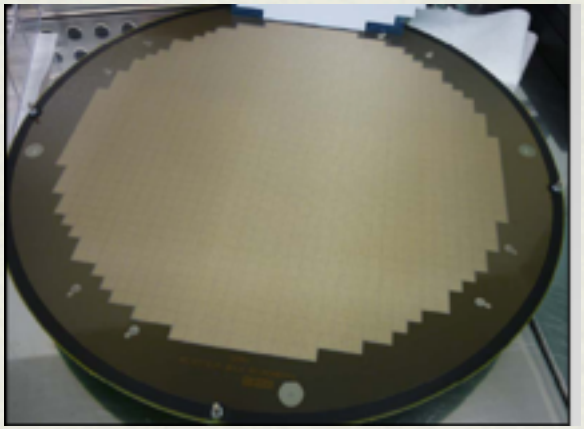


TAMU 7 PMT CHAMBER

Commissioning now

Data taking before the end of the year

NEXT-1-MM

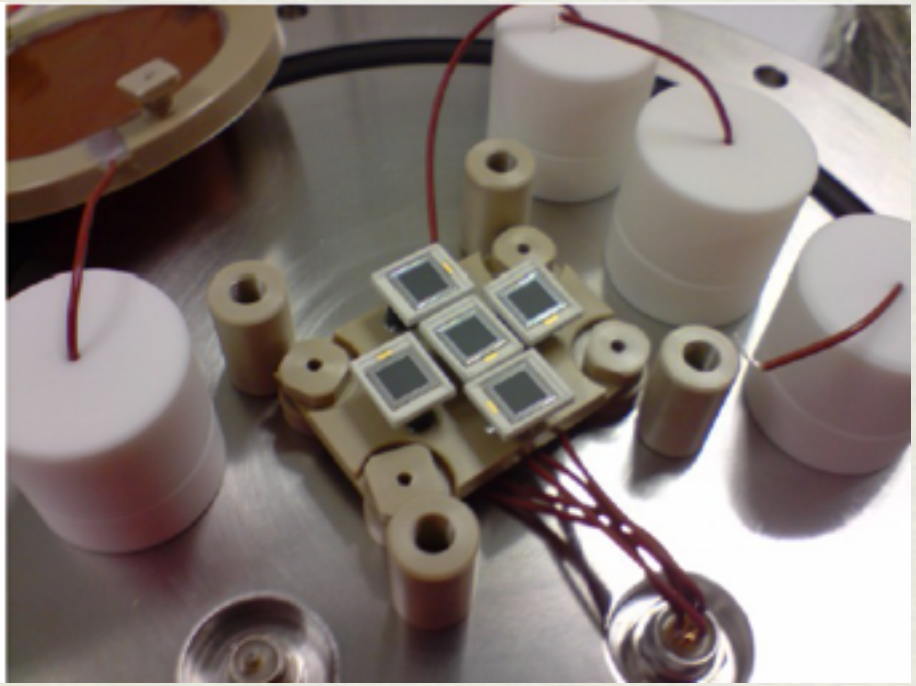


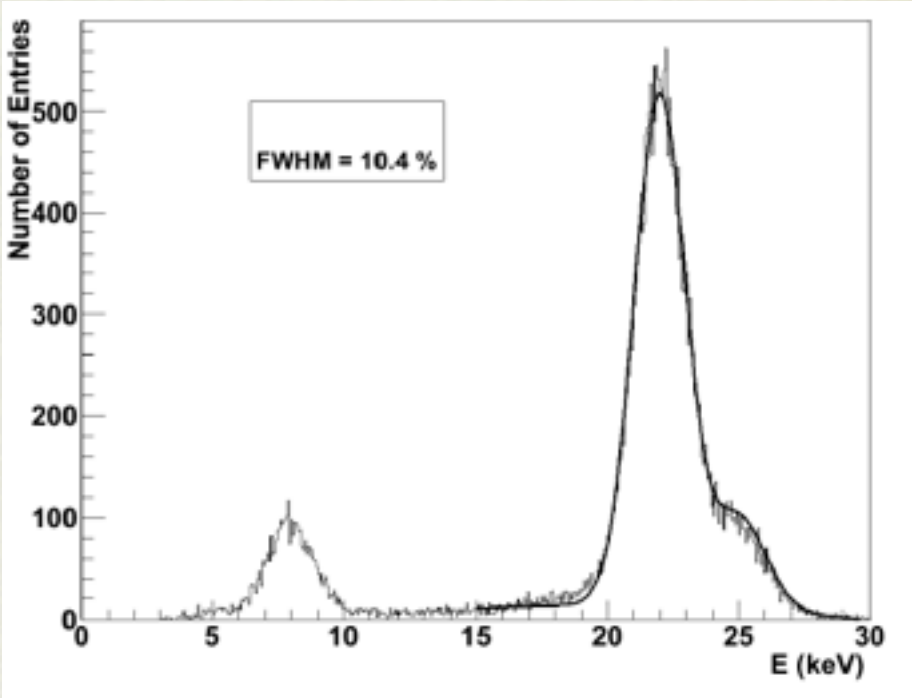
1152 pixels Bulk Micromegas, D ~30 cm

Soon to operate with MM micro-bulk

“Teflon and copper only” HV penetrators… very promising candidate for NEXT-100

APDs

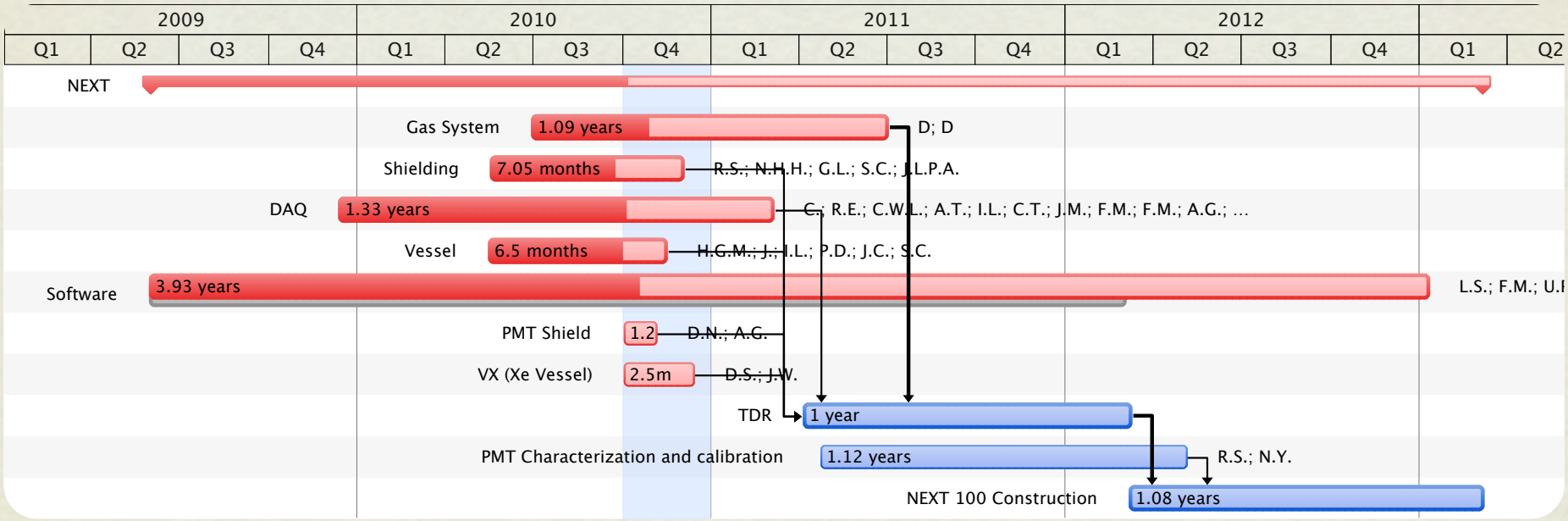




IFAE setup

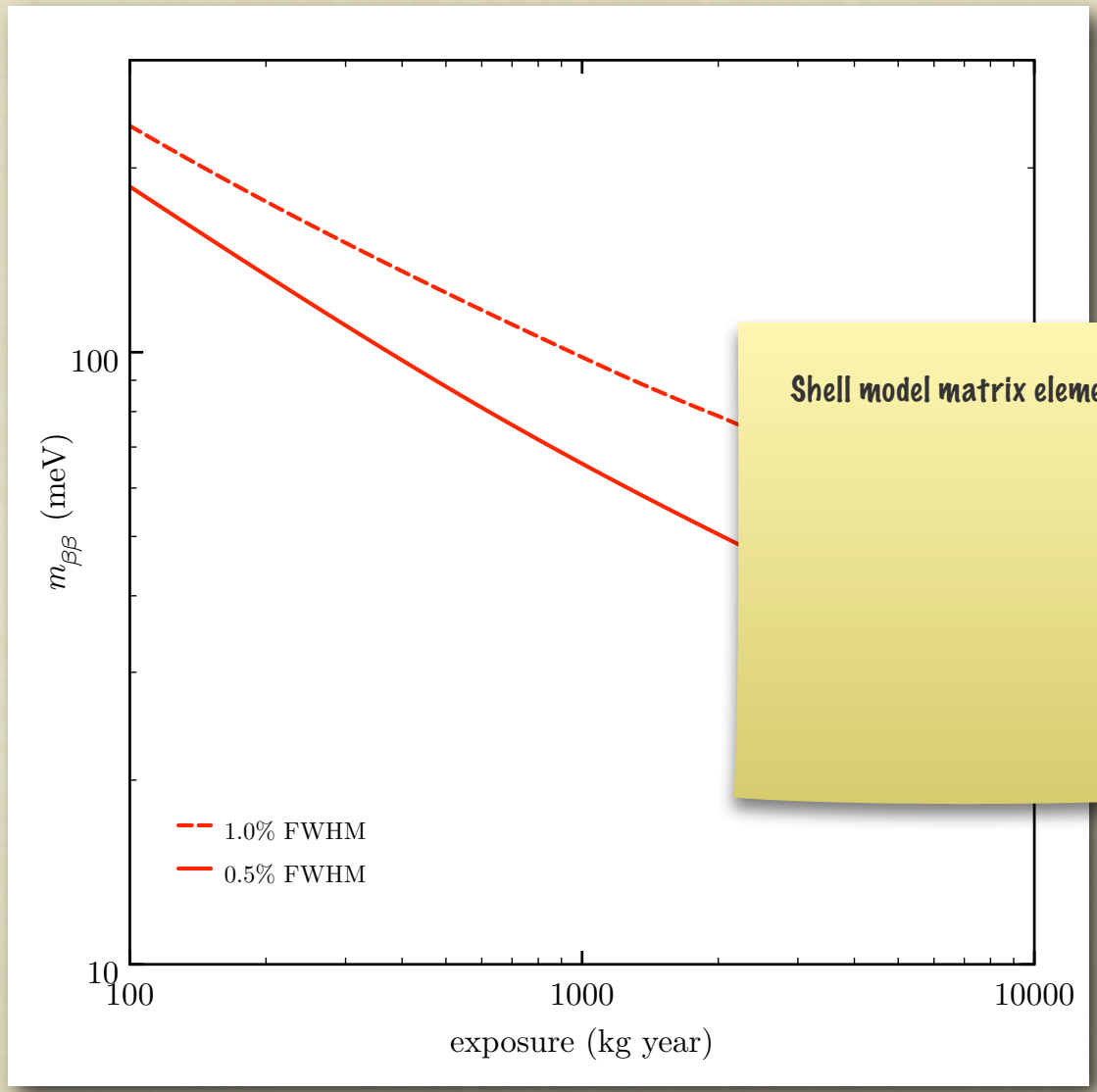
APDs show excellent energy resolution (~1% at Qbb)

Project Scheduling



Quo vadis?

Sensitivity of NEXT 100



Shell model matrix element

THE END