NEXT

Searching for the ββ0ν decay at the LSC

PANIC 2017 @ Beijing, China

Pau Novella (IFIC/CSIC)

On behalf of the NEXT collaboration

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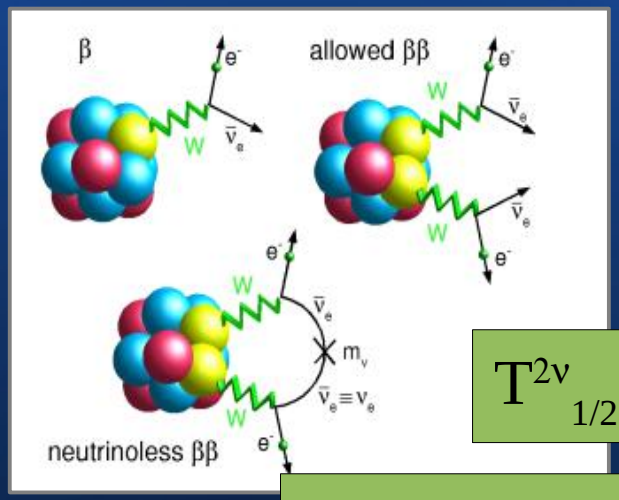
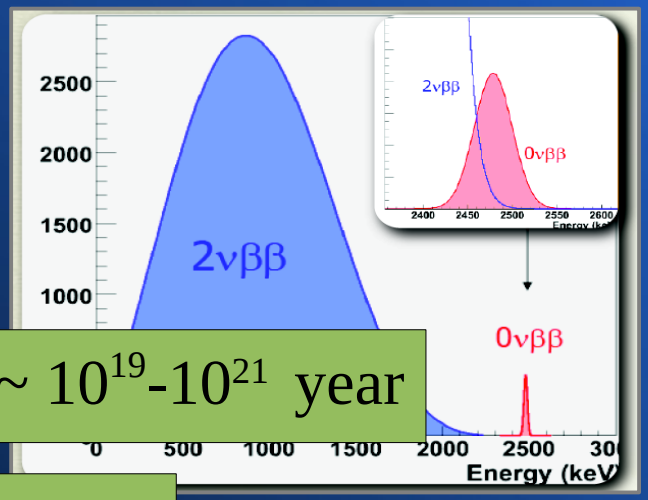
- Searching for the ββ0ν decay
- The NEXT TPC concept
- R&D: technology performance
- NEXT-NEW: physics @ LSC
- NEXT-100: the degenerate land
- Summary

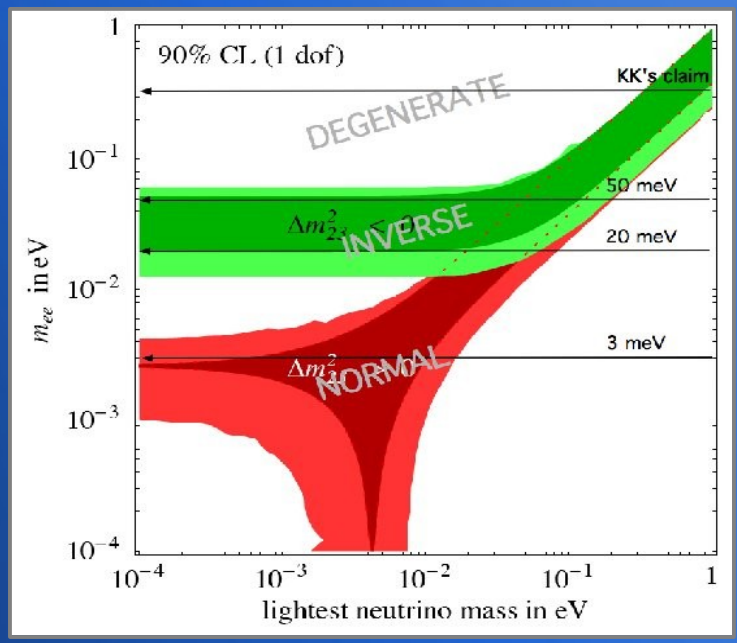
Searching for the ββ0ν decay





$T^{2\nu}_{1/2} \sim 10^{19}\text{-}10^{21}$ year

$T^{0\nu}_{1/2} > 10^{25}$ year



F. Feruglio et Al., Nucl. Phys. B 637 (2002)

Energy resolution

Background rejection

Scalability

ββ0ν experiment

NEXT

Calorimeters

Tracko-calos

Bolometers

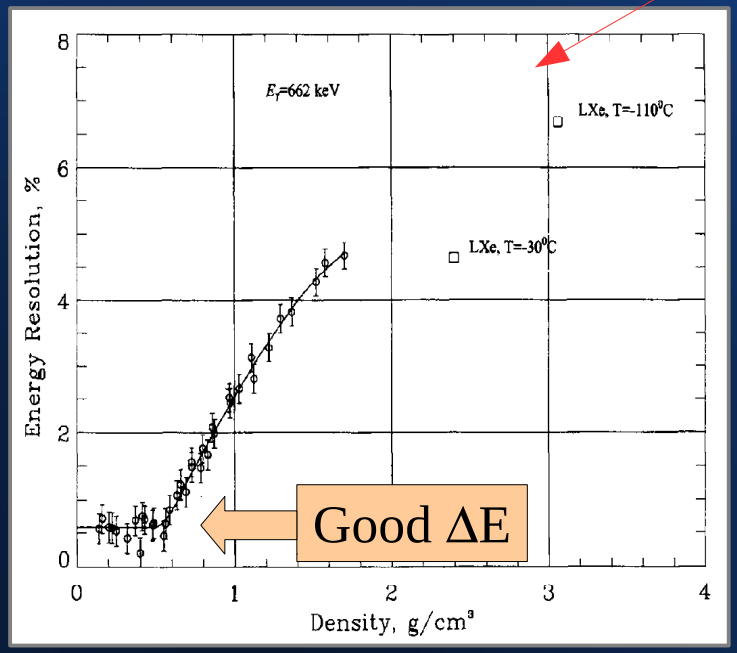
NEXT: HP Gas-Xe TPC

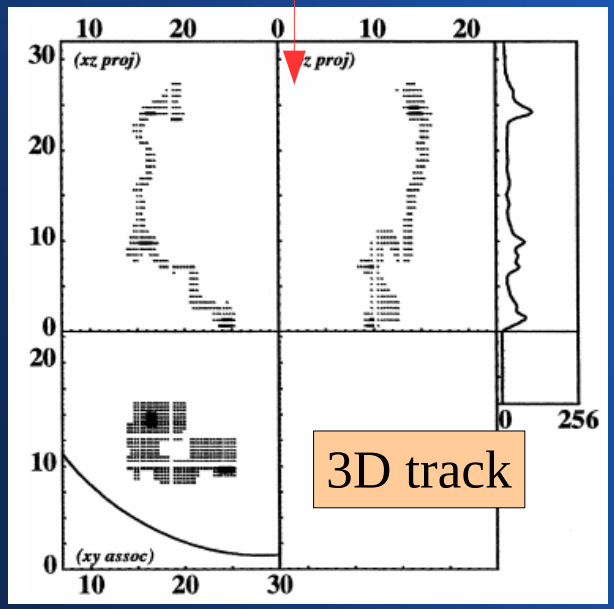
$$T_{1/2}^{-1} \propto a \cdot \epsilon \cdot \sqrt{\frac{Mt}{\Delta E \cdot B}}$$

^{136}Xe

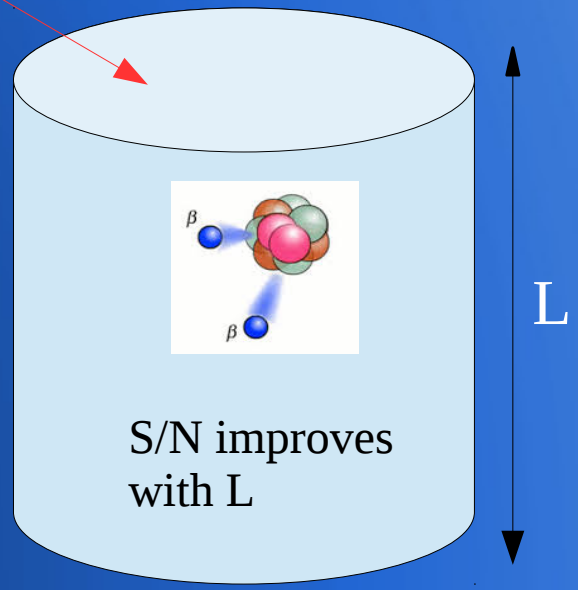
- $Q_{\beta\beta}$=2.48 MeV
- Scint/Ionization
- Cheap/Easy to enrich
- Long ββ2ν mode

Bolotnikov et Al. Nucl. Ins. Meth A 396 (1997)





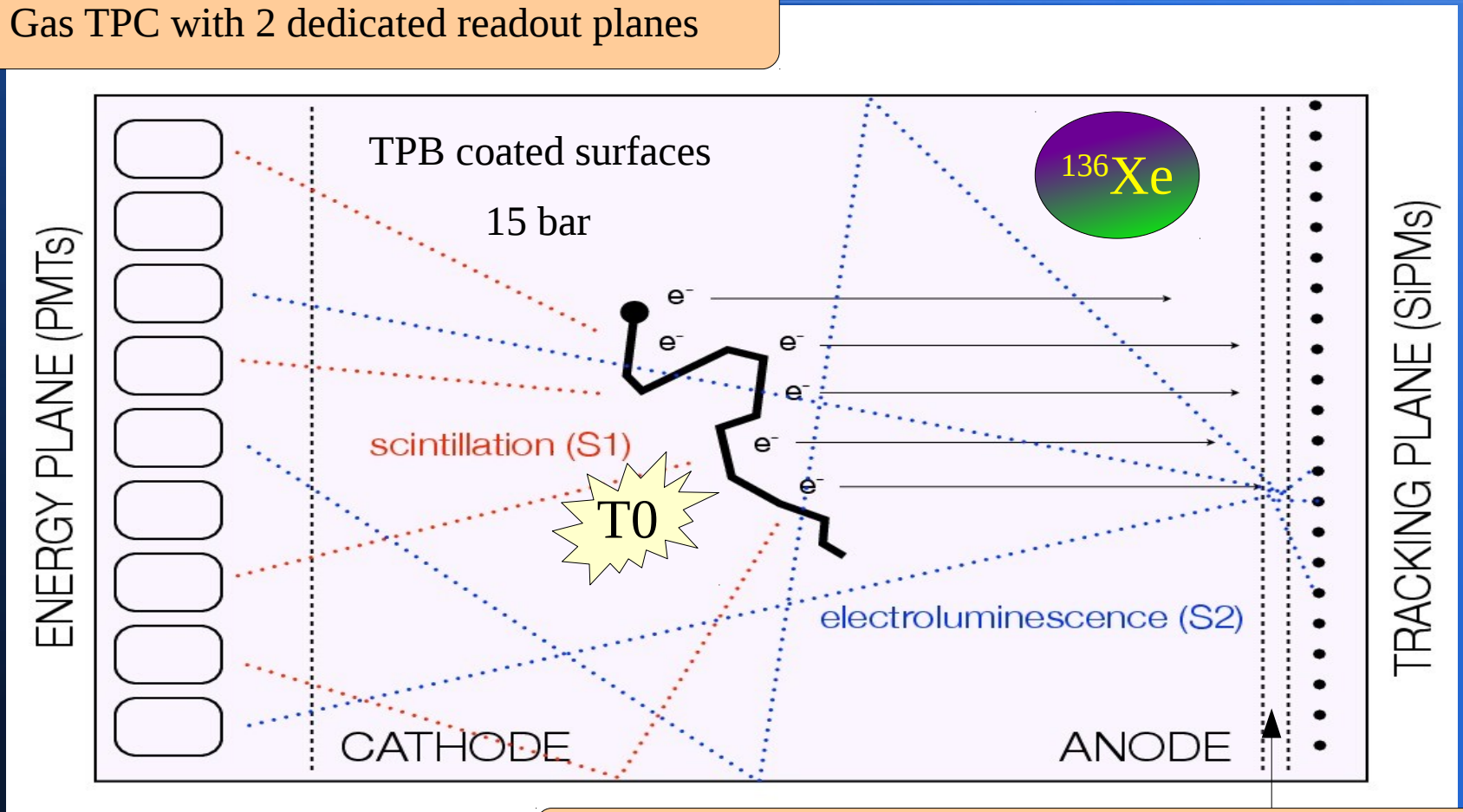
R. Luescher et al, PLB 434 (1998)



Source=Detector

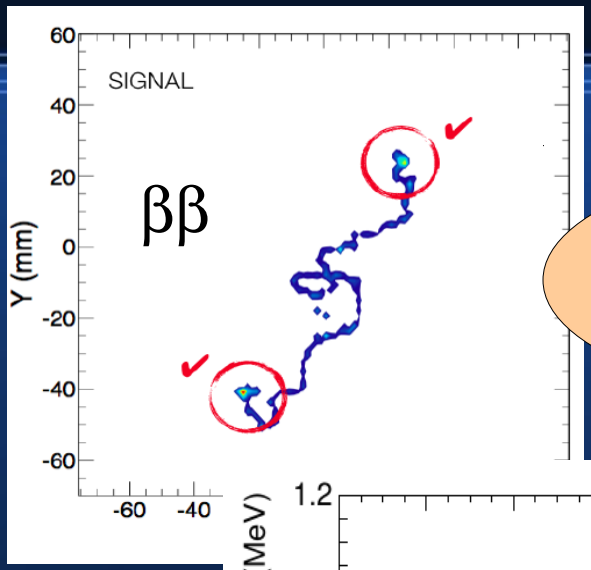
The TPC concept

Gas TPC with 2 dedicated readout planes

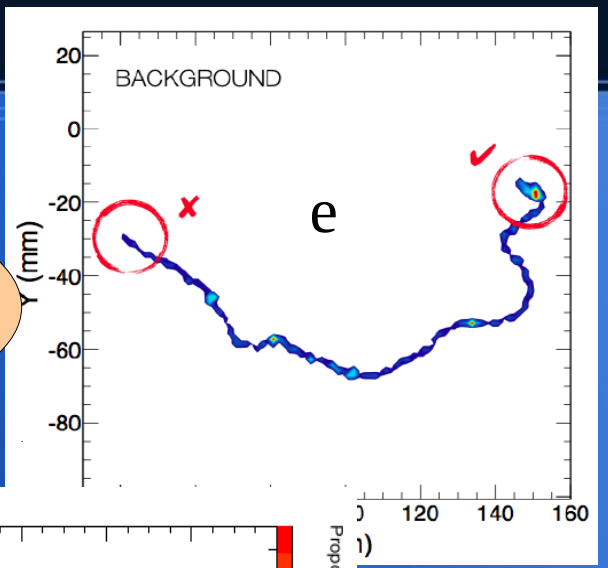


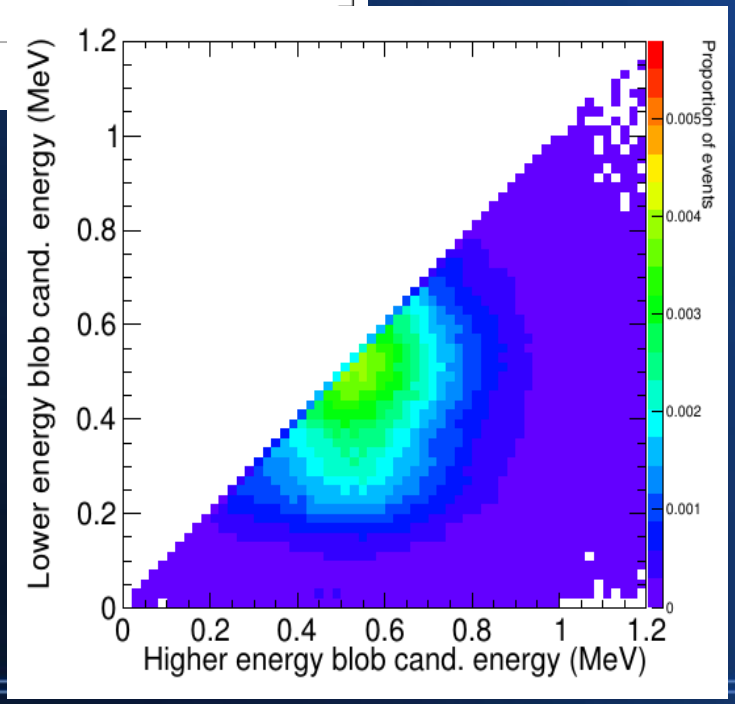
EL: linear gain, no avalanche fluctuations: optimize ΔE

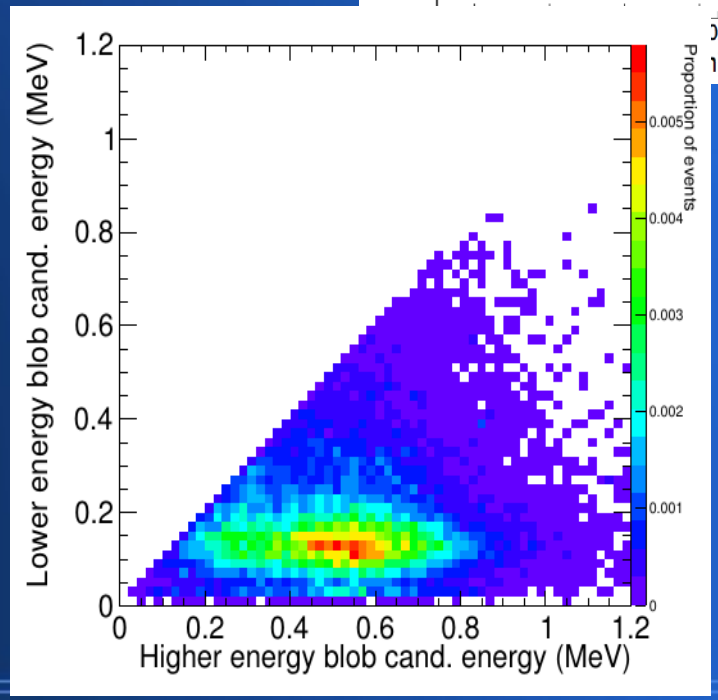
Fighting the non-ββ events



Powerful BG rejection:
track topology and dE/dx





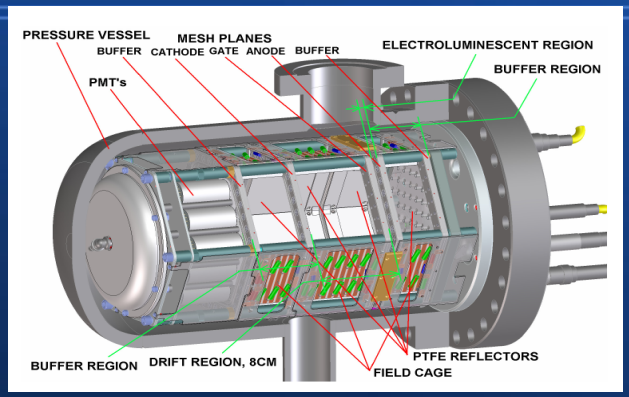


MC

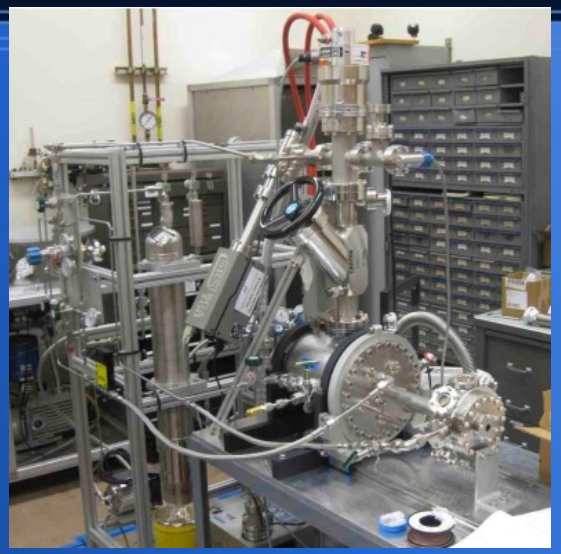
R&D: Proving the technology

2012-2014

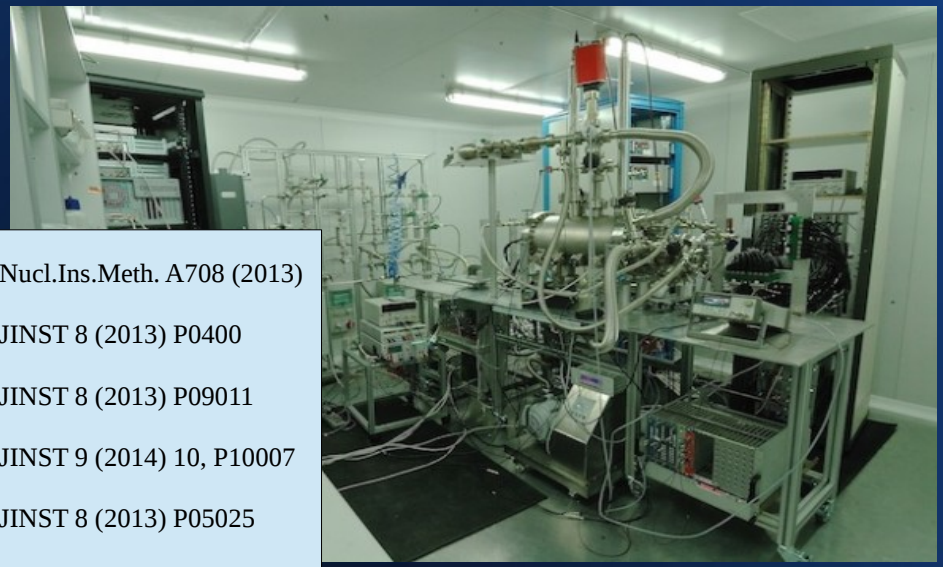
- The NEXT-DBDM @ LBL (1 kg Xe):



Gas Xe EL-TPC:
Energy resolution
(only PMTs)



- The NEXT-DEMO @ IFIC (1.5 kg Xe):



Nucl.Ins.Meth. A708 (2013)

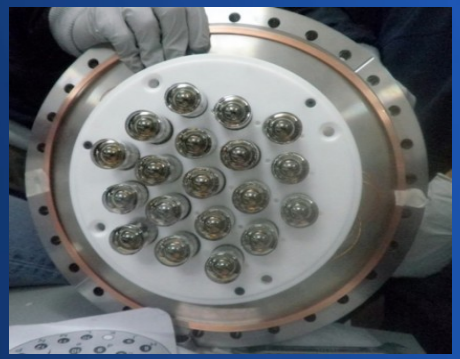
JINST 8 (2013) P0400

JINST 8 (2013) P09011

JINST 9 (2014) 10, P10007

JINST 8 (2013) P05025

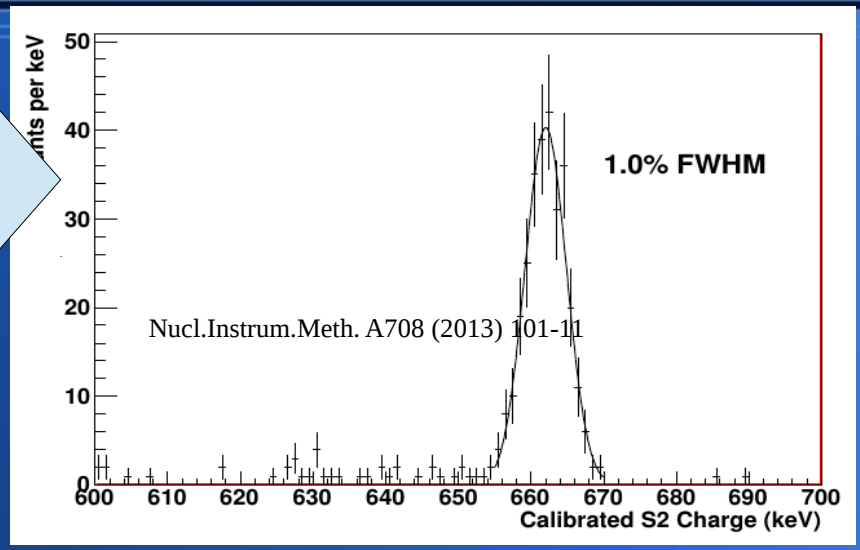
JINST 10 (2015) 03, P03025

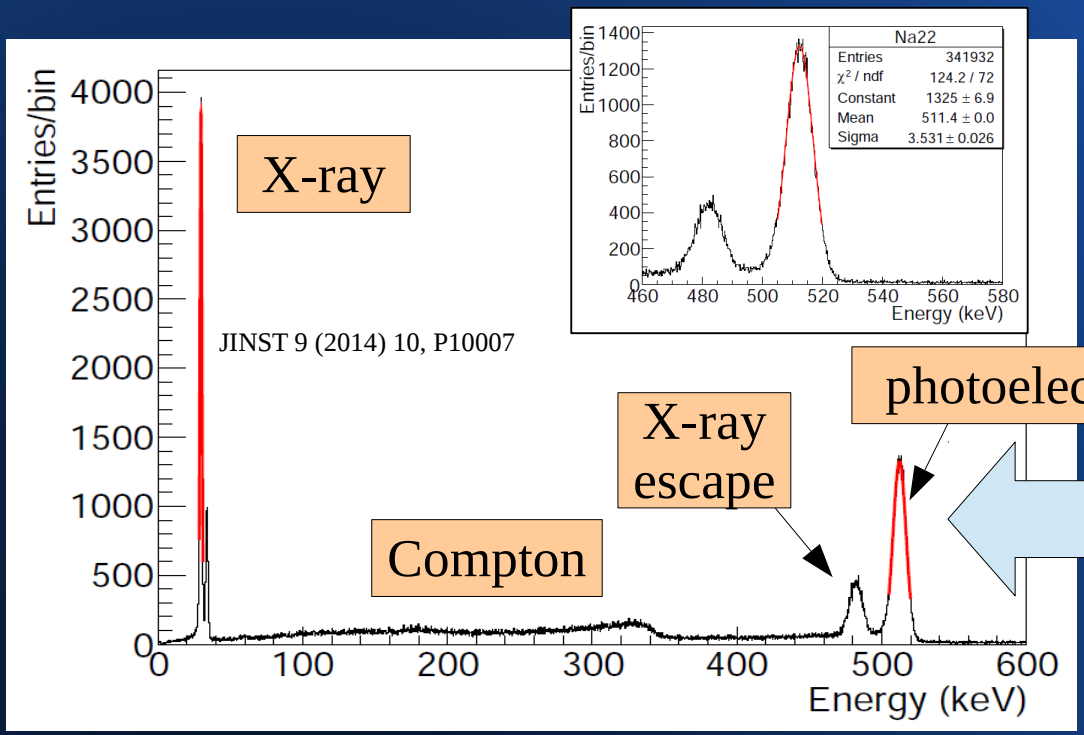


Complete prototype: PMT+SiPM

R&D: Energy Resolution

NEXT-DBDM: ^{137}Cs
1.0% FWHM @ 660 keV
0.5% FWHM @ $Q_{\beta\beta}$ of ^{136}Xe

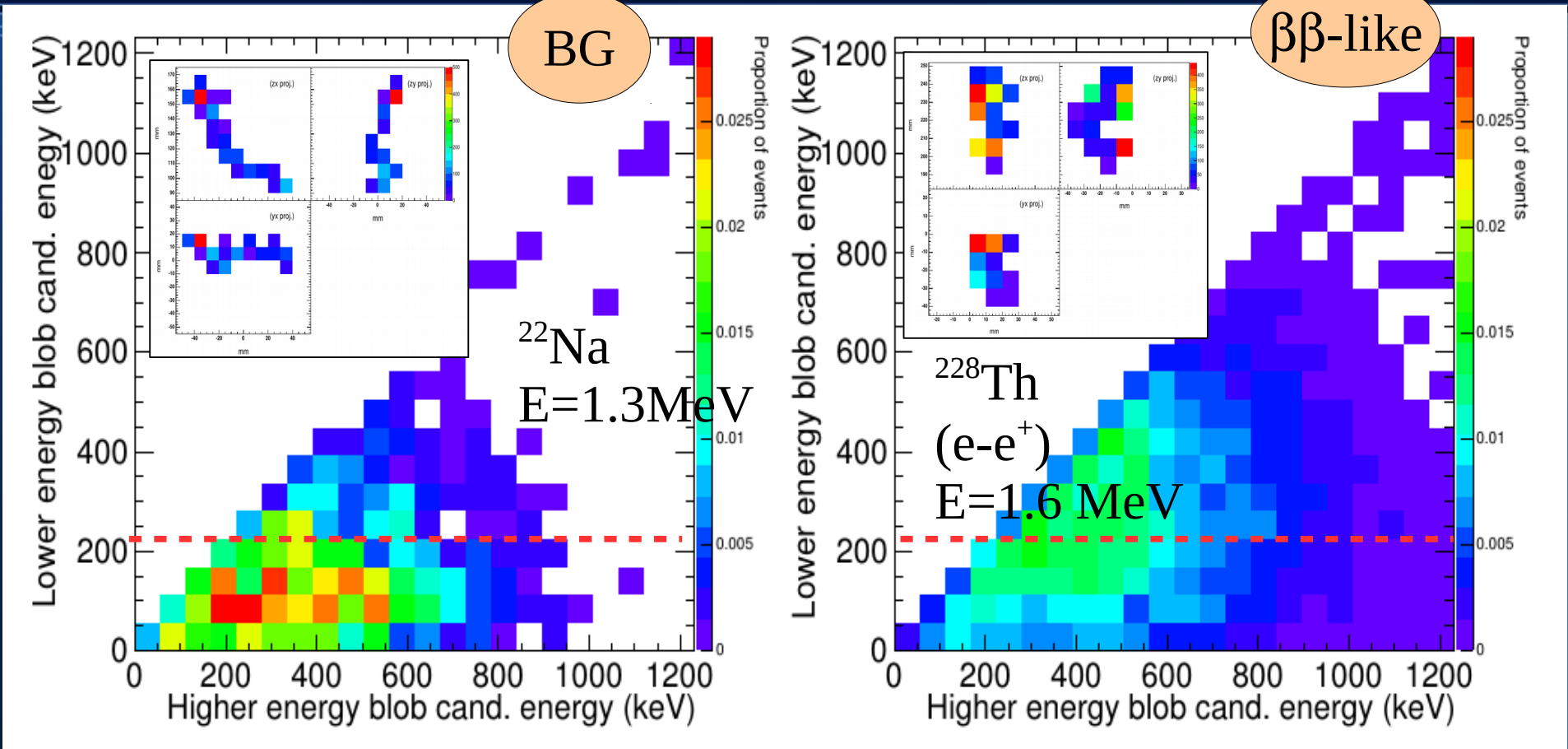




NEXT-DEMO: ^{22}Na
1.6% FWHM @ 511 keV
Over large fiducial volume
0.63% FWHM @ $Q_{\beta\beta}$ of ^{136}Xe

R&D: Event topology

- The NEXT-DEMO @ IFIC (1.5 kg Xe): arXiv:1507.05902



2e cut: ε_{Na}=24.13±1.4% (MC: 21.9%) ε_{Th}=66.7±0.6 % (MC: 65.9%)

BG rejection demonstrated

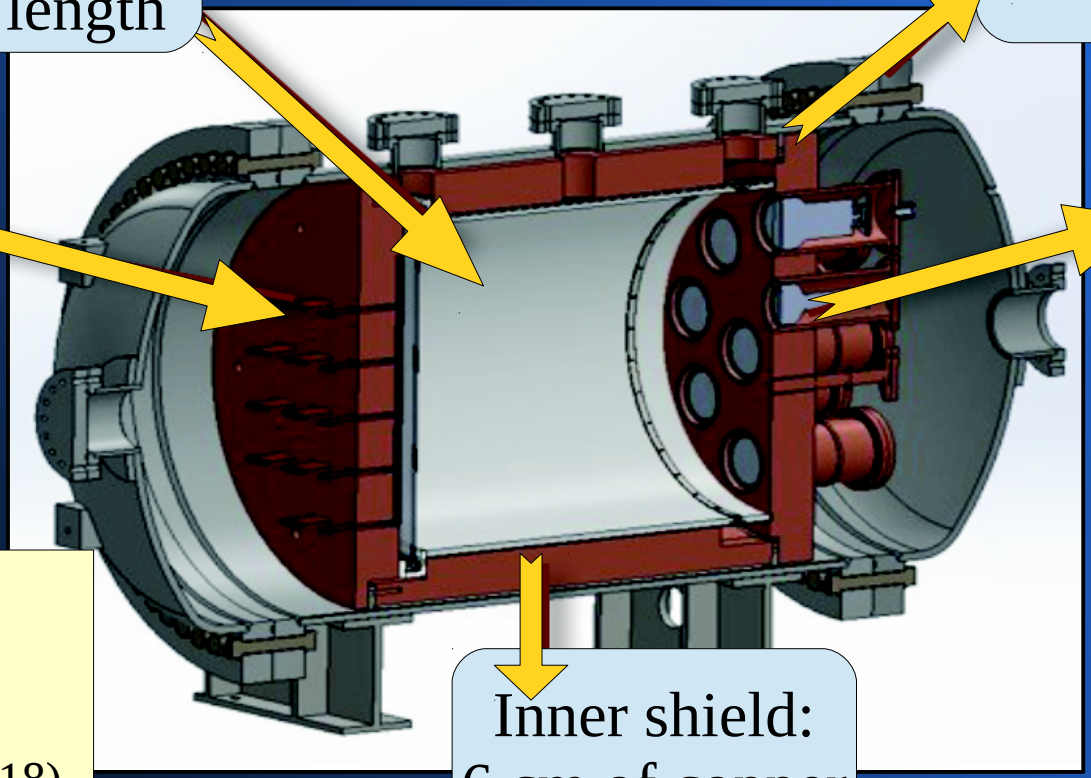
Monte Carlo validated

NEXT-NEW: Physics @ LSC

TPC:
5 kg active region
50 cm drift length

Pressure Vessel:
Steel, up to 30 bar

2015-2017



Tracking plane:
1792 SiPM
1 cm pitch

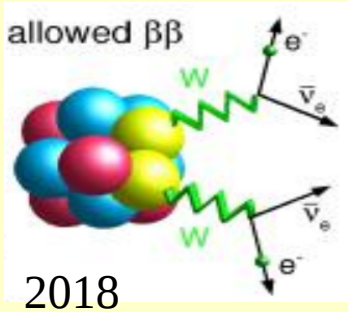
Energy Plane:
12 PMTs
30% coverage

Inner shield:
6 cm of copper

Physics program:

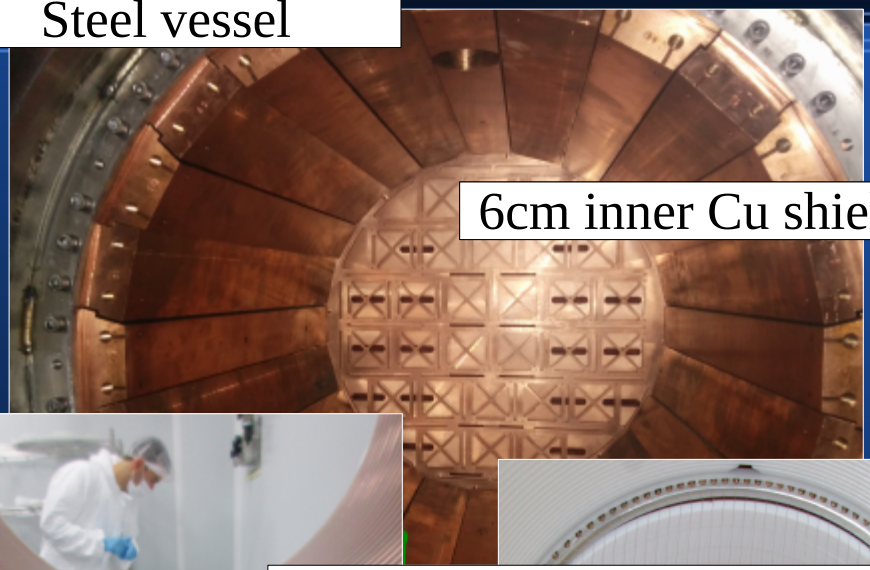
- ΔE=0.5% FWHM
- Event Topology
- Certify technology
- BG Measurement (2018)

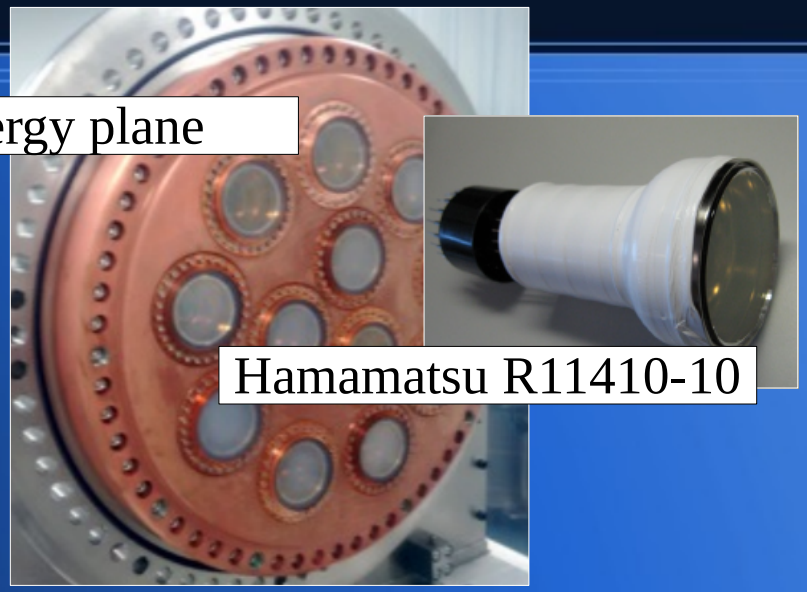
Ultimate goal:

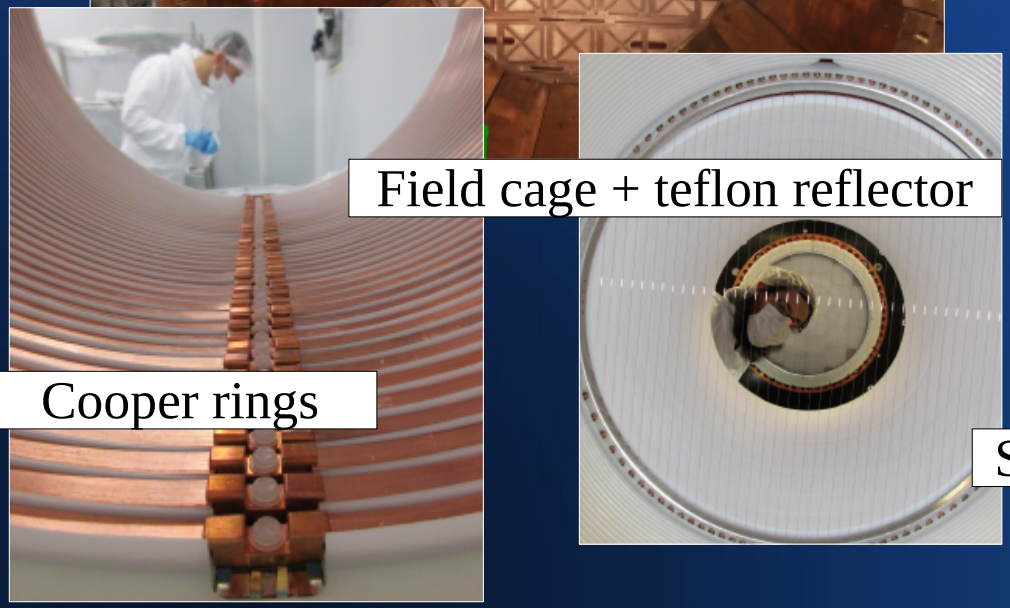


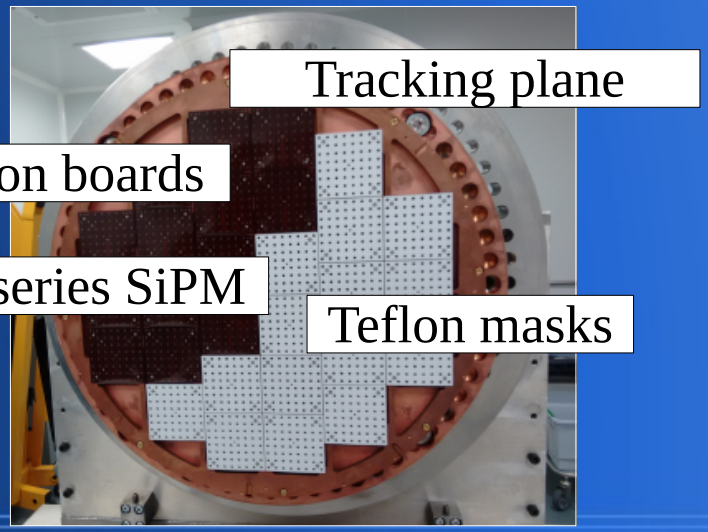
First phase of the NEXT-100 experiment

The NEW Detector









NEXT-NEW @ LSC

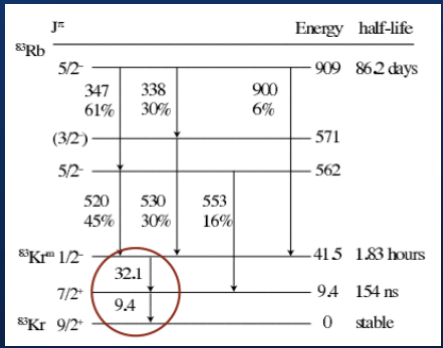
- Infrastructures: seismic platform, lead castle and gas system
- Xenon available: 100 kg of enriched ^{136}Xe and 100 kg of depleted Xe

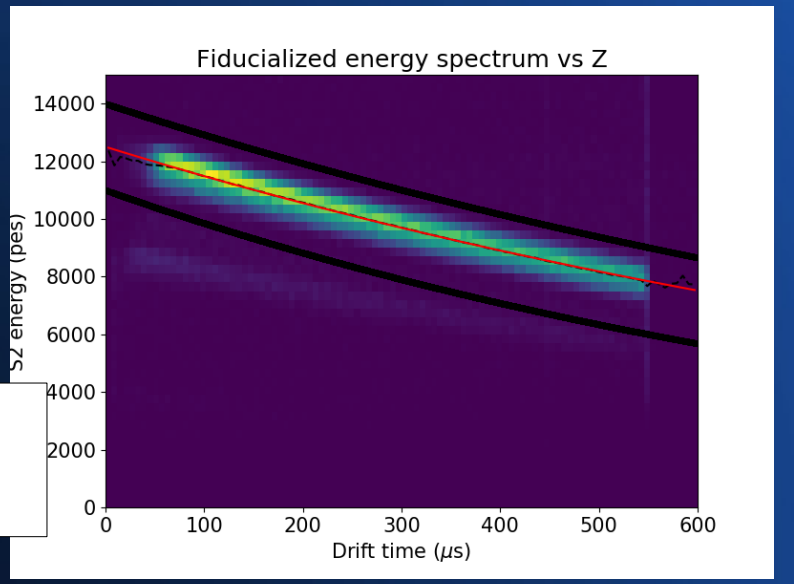
- NEW: installation/commissioning in 2015, stable operation since October 2016
- Calibration campaign @ 7 bar and ~2.5 kg of Xe: ^{83}Kr, ^{22}Na, ^{56}Co (^{137}Cs, ^{228}Th)
- 2017-2018: background and $\beta\beta2\nu$ measurements

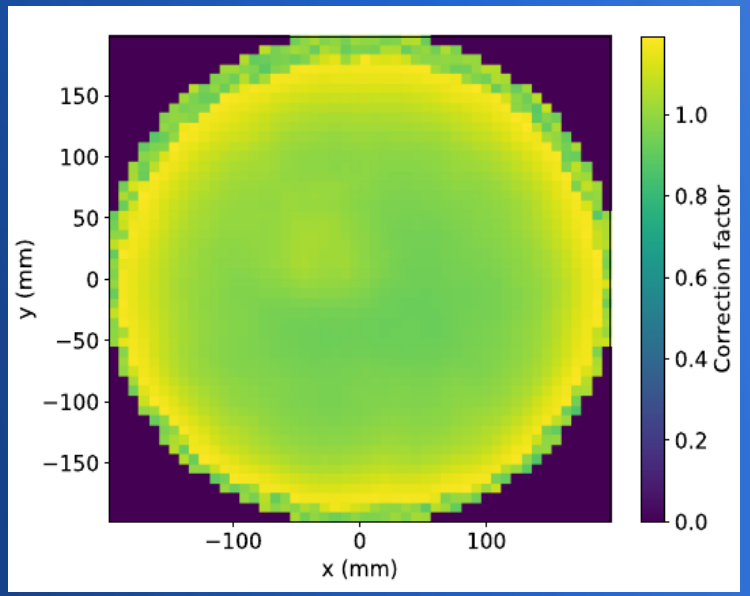
NEW Calibration: ^{83}Kr

- ^{83}Kr source
  - Point-like deposition of 41.5 keV
  - Gas uniformly distributed in volume

- Detector characterization
  - drift velocity (z reconstruction)
  - e- attachment (lifetime)
  - geometric corrections to energy





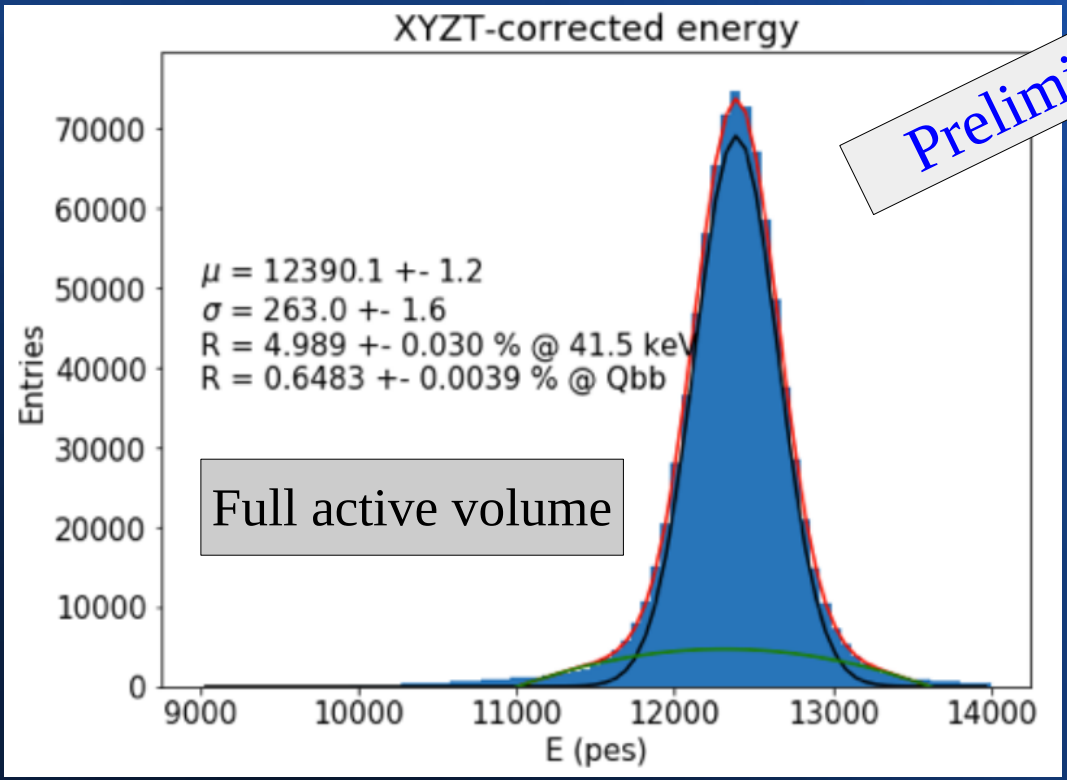


Lifetime: ~1.2 ms
Improving: ~3 ms

Light collection depends on the position of the event (solid angle effects and TPB inhomogeneities)

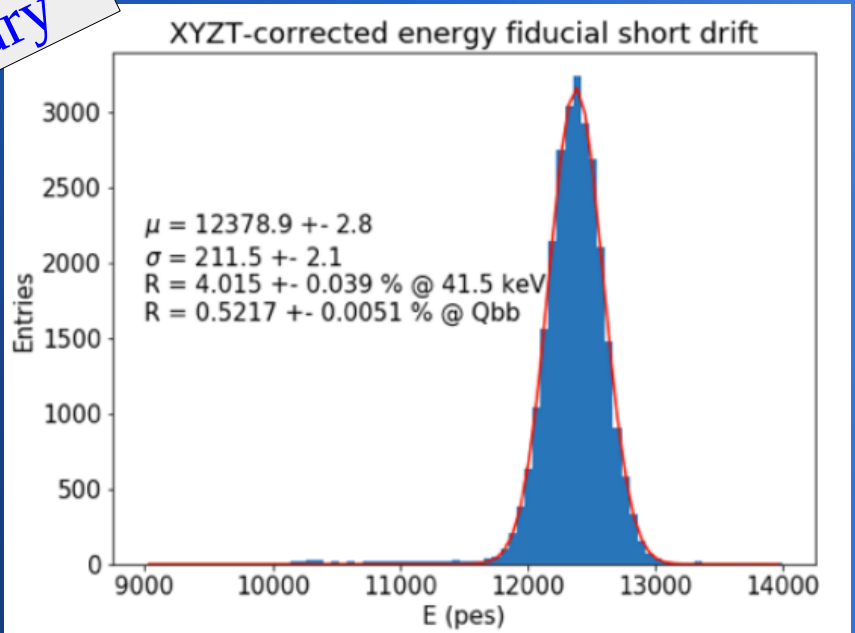
NEW Calibration: ^{83}Kr (II)

- Energy resolution measurement



Preliminary

Radius < 100 mm
Drift Time < 100 µs

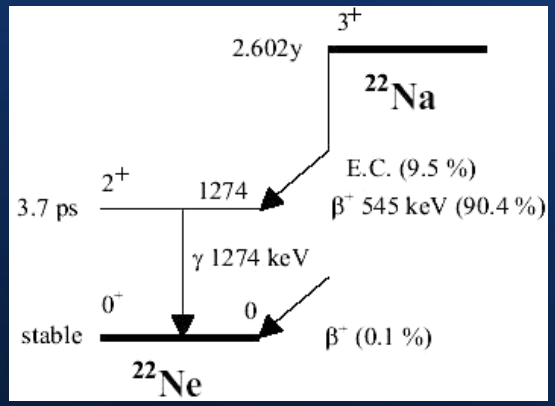


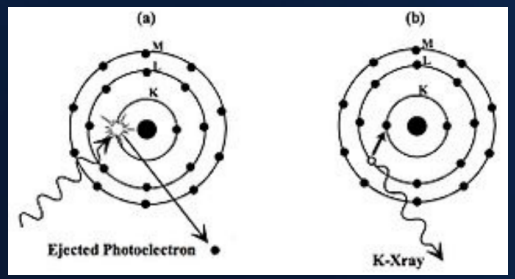
Room for improvement!

Resolution below 1% FWHM @ $Q_{\beta\beta}$ with √E extrapolation (target for NEXT-100)

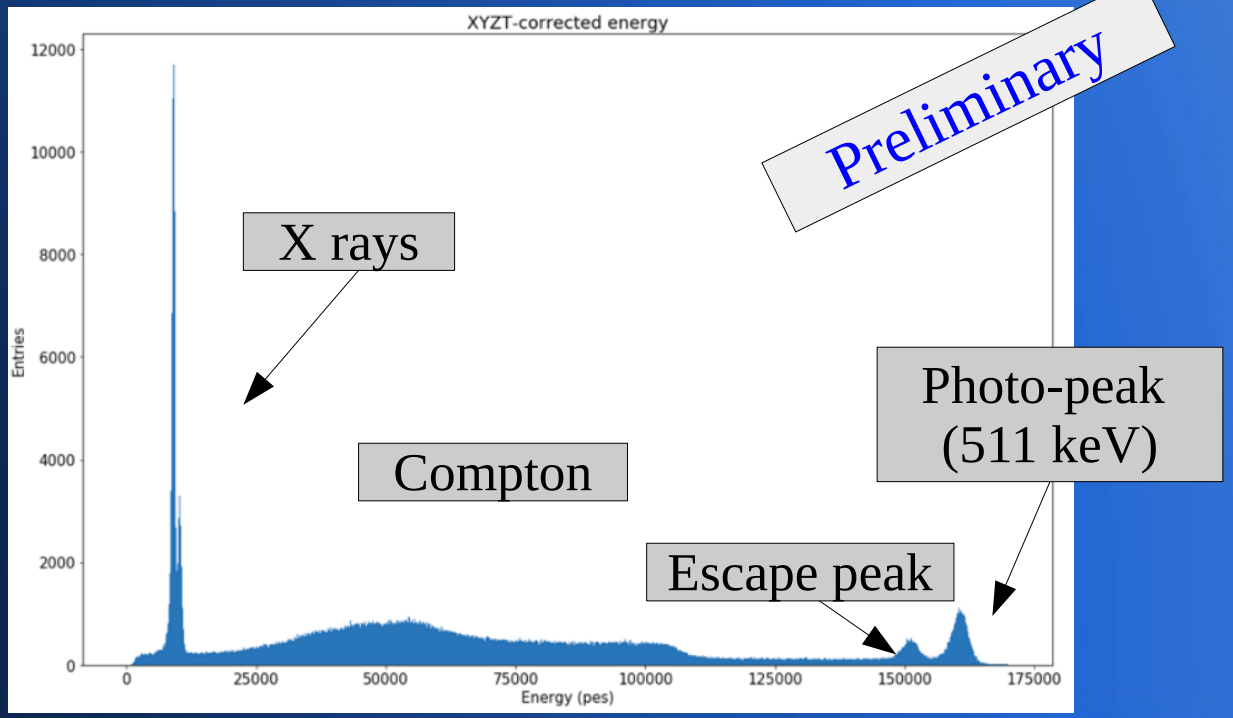
NEW Calibration: ^{22}Na

- ^{22}Na source:
  - Placed in axial and lateral vessel ports
  - X rays, Compton and photo-peak



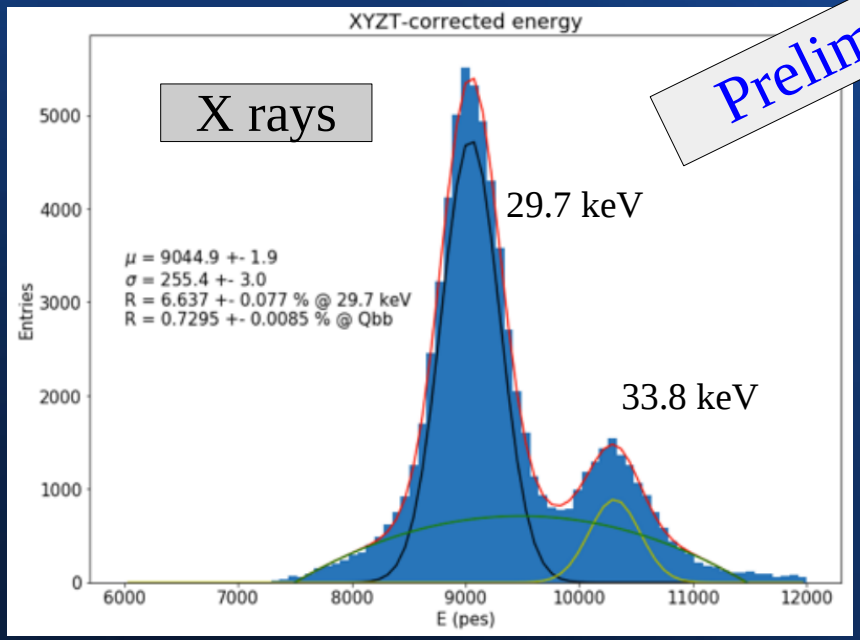


- Extended energy spectrum
  - Lifetime and Energy map (X-rays)
  - Non-point like depositions
  - E resolution vs energy

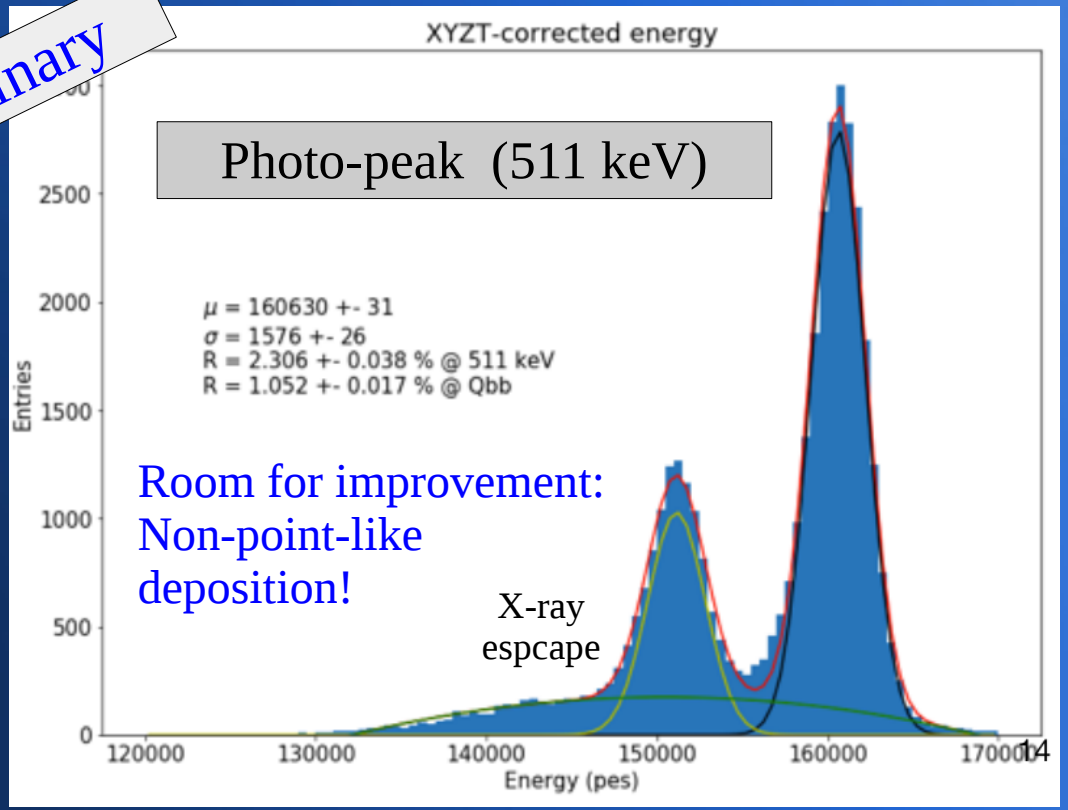


NEW Calibration: ^{22}Na (II)

- Energy resolution measurement



Preliminary

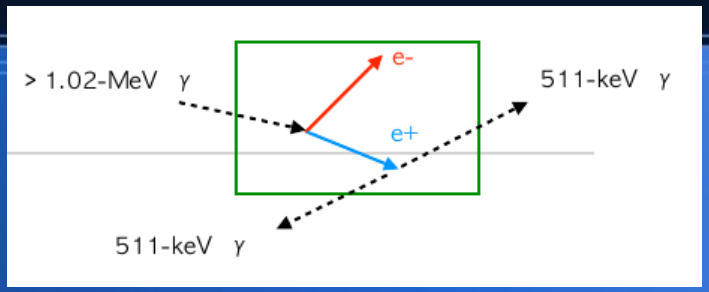


Consistent with ^{83}Kr results

Resolution below 1% FWHM @ $Q_{\beta\beta}$ with √E extrapolation (target for NEXT-100)

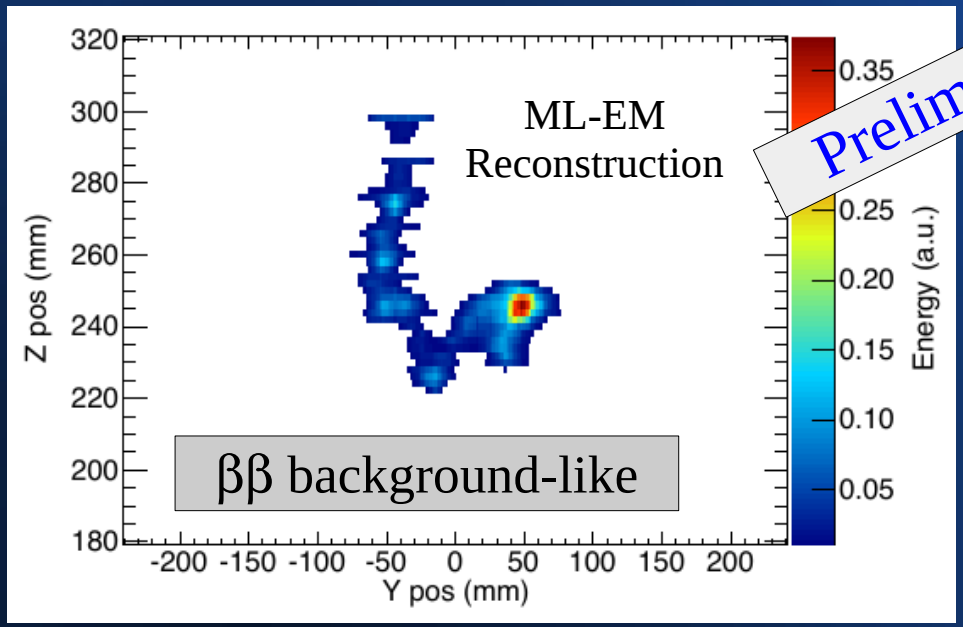
NEW Track Reconstruction

- ^{56}Co source:
  - Complex decay scheme, several gamma
  - Single e- peak and Compton: single blob
  - Pair production pear ~1.6 MeV: two blobs

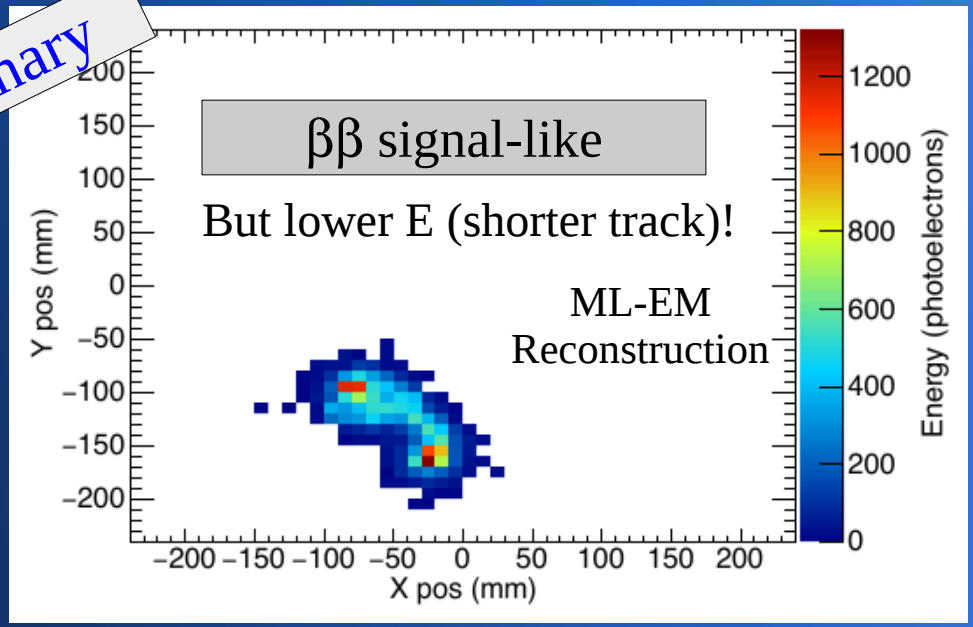


Single electron track

double electron track



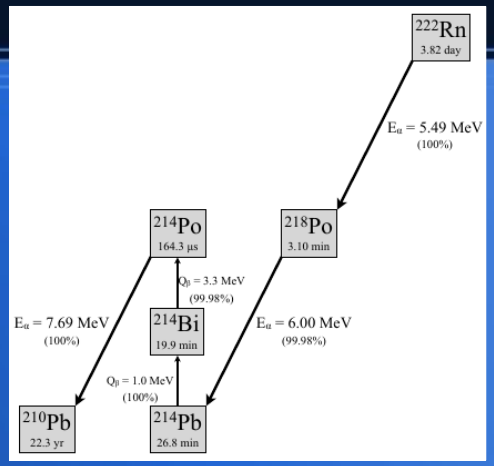
Preliminary

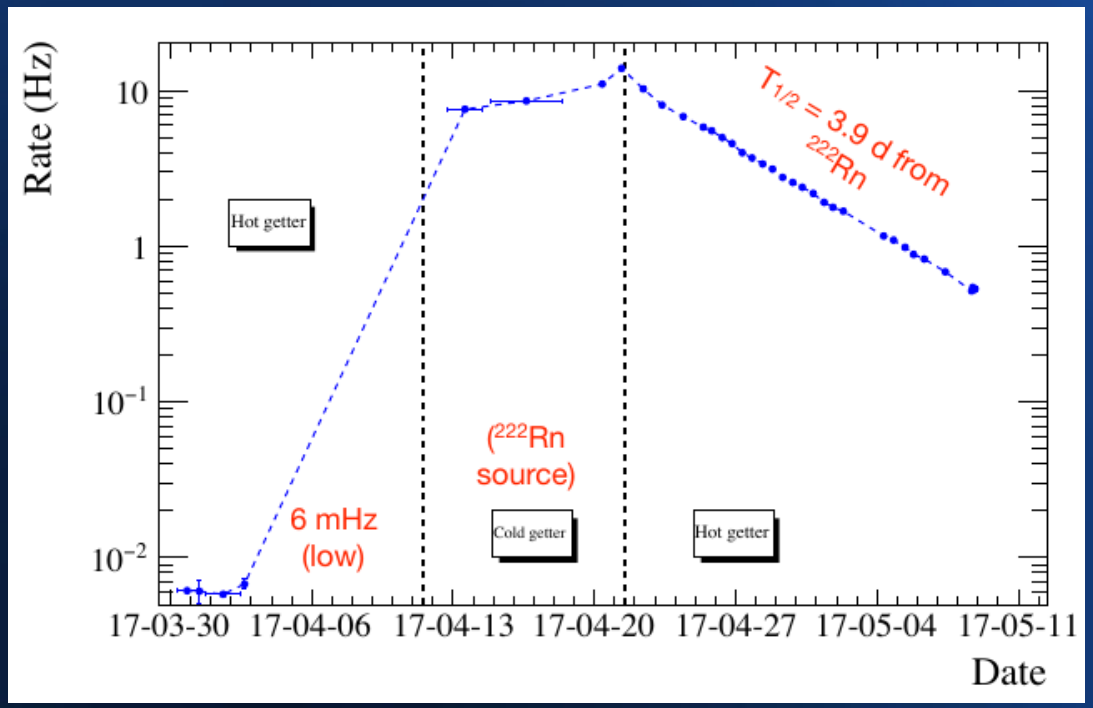


Different track reconstruction techniques being developed!

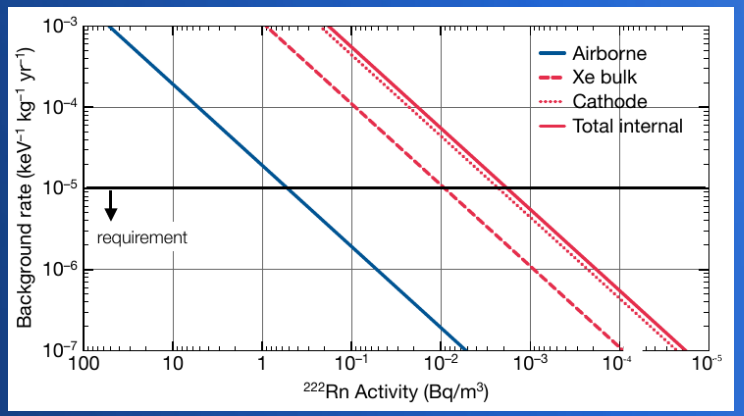
NEW Background: ^{222}Rn

- ^{222}Rn is present in the air and emanate from detector materials
- Its decay chain leads to ^{214}Bi, one of the main BGs in NEXT
- Alpha decays from decay chain used to monitor the Rn/Bi level





NEXT-100 requirement: $<10^{-4}$ counts/keV/kg/y



JHEP 1605 (2016) 159

^{222}Rn under control for NEXT-100!

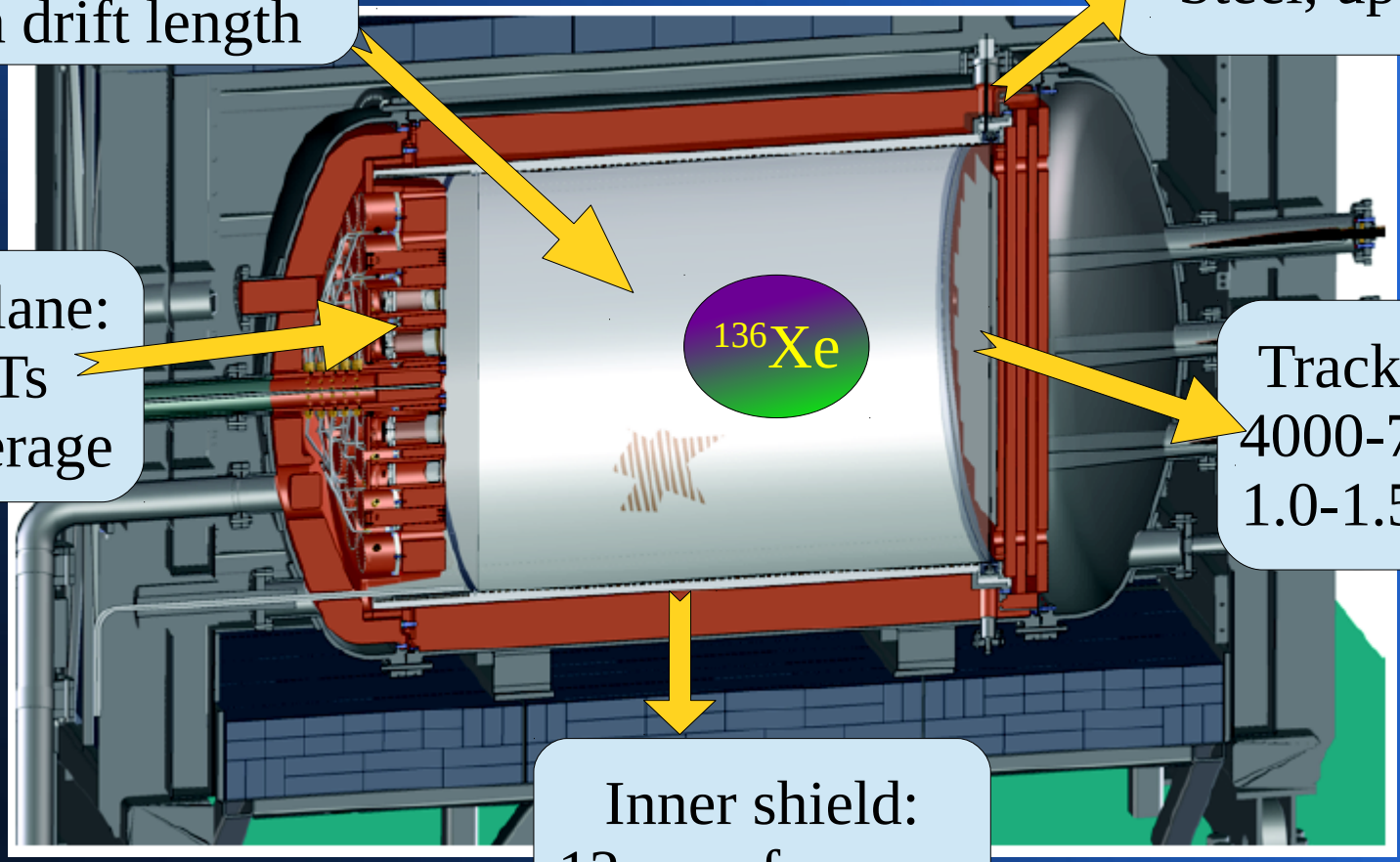
NEXT-100: the degenerate land

JINST 7 (2012) T06001

TPC:
100 kg active region
130 cm drift length

2019-2021

Pressure Vessel:
Steel, up to 15 bar

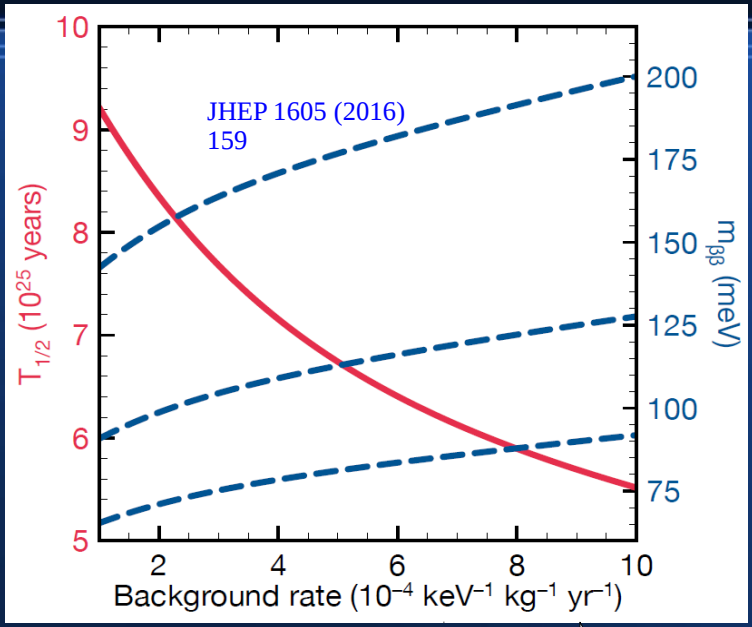


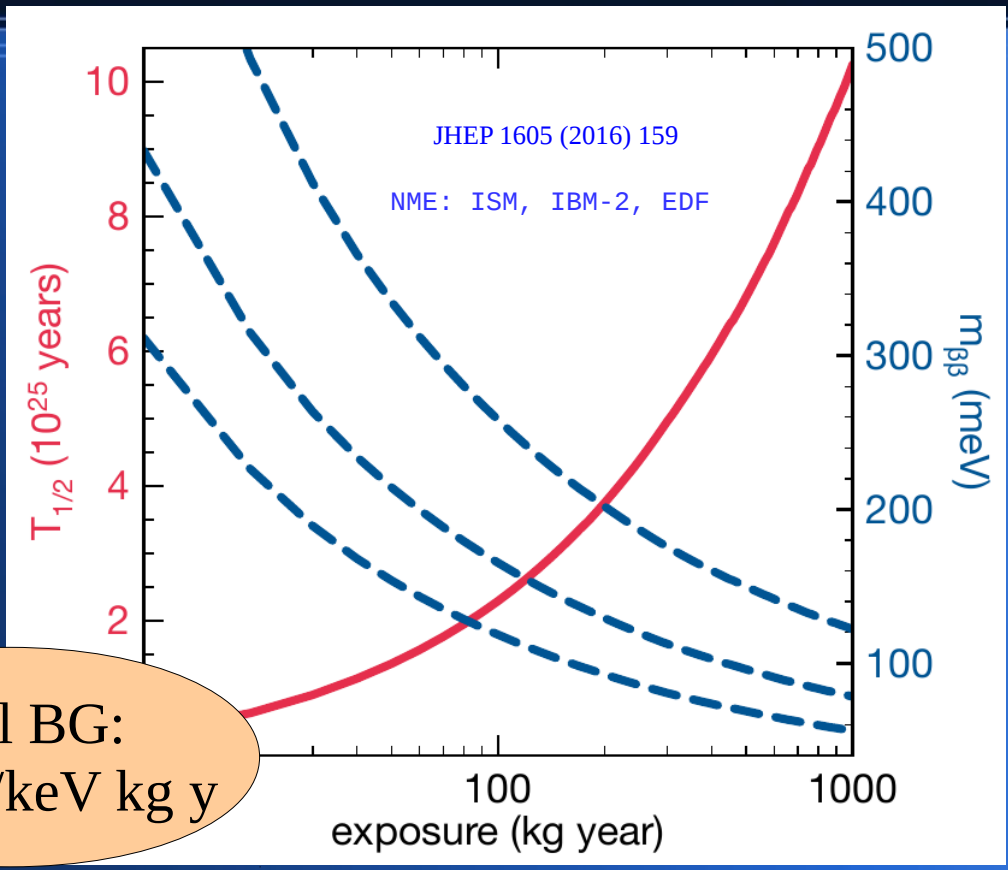
Energy Plane:
60 PMTs
30% coverage

Tracking plane:
4000-7000 SiPM
1.0-1.5 cm pitch

Inner shield:
12 cm of copper

Physics Case of NEXT-100





Radiopurity measurements

Background rejection factors

Total BG: 4×10^{-4} c/keV kg y

$m_{\beta\beta} < 100$ meV @ 90% CL (3 years of data)

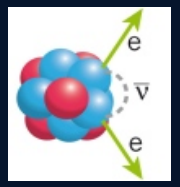
Radiopurity: JINST 8 (2013) T01002, JINST 10 (2015) 05, P05006

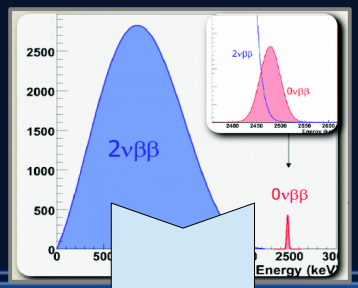
Sensitivity: JHEP 1605 (2016) 159

DNN BG rejection: JINST 12 (2017) no.01, T01004

Prove technology for ton-scale (+ gas additives, Ba tagging...)

Summary





Energy resolution

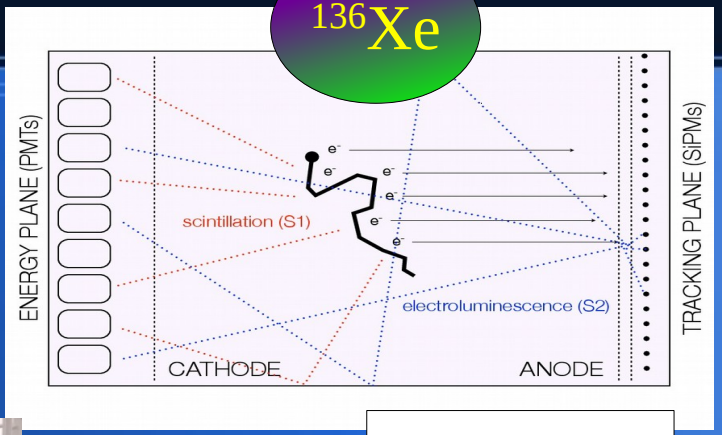
Background rejection

Scalability

next

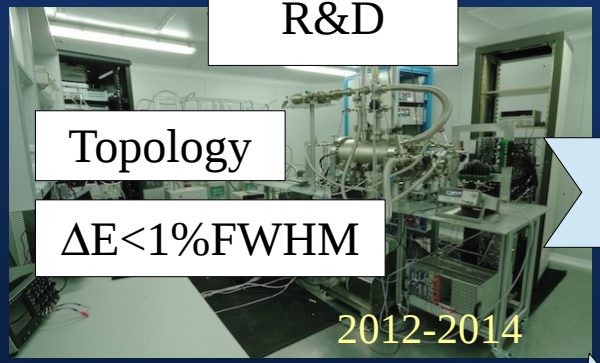
LSC
Laboratorio Subterráneo de Canfranc

^{136}Xe



Gas Xe TPC

R&D



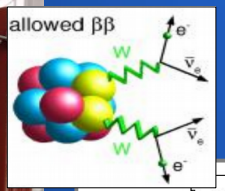
Topology

ΔE<1%FWHM

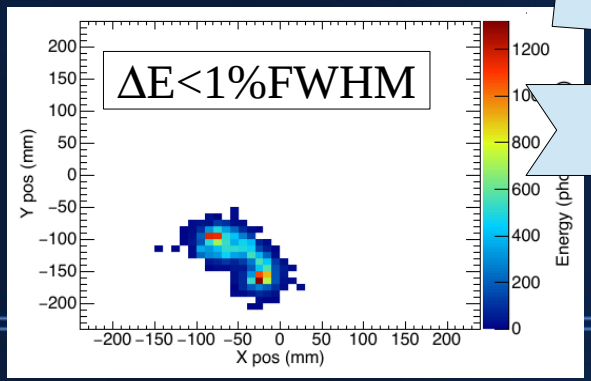
2012-2014

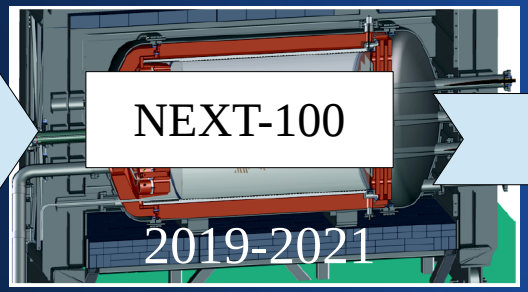
NEXT-NEW

Since 2016



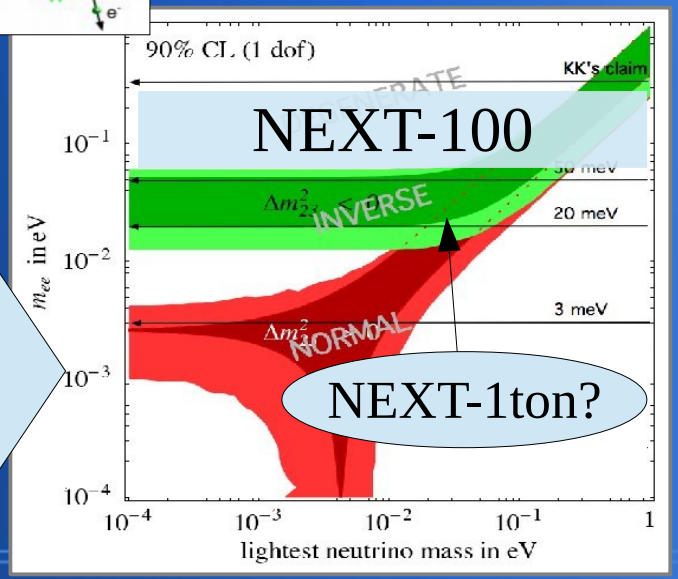
2018





NEXT-100

2019-2021



The NEXT Collaboration

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