The next way to neutrinoless double beta decay

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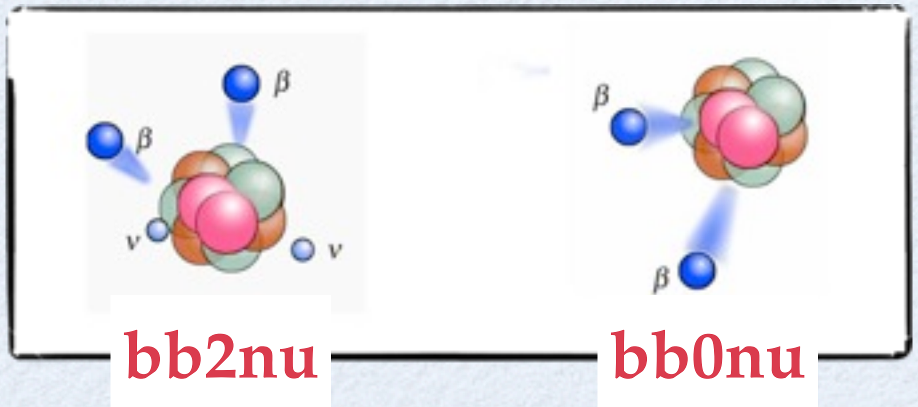
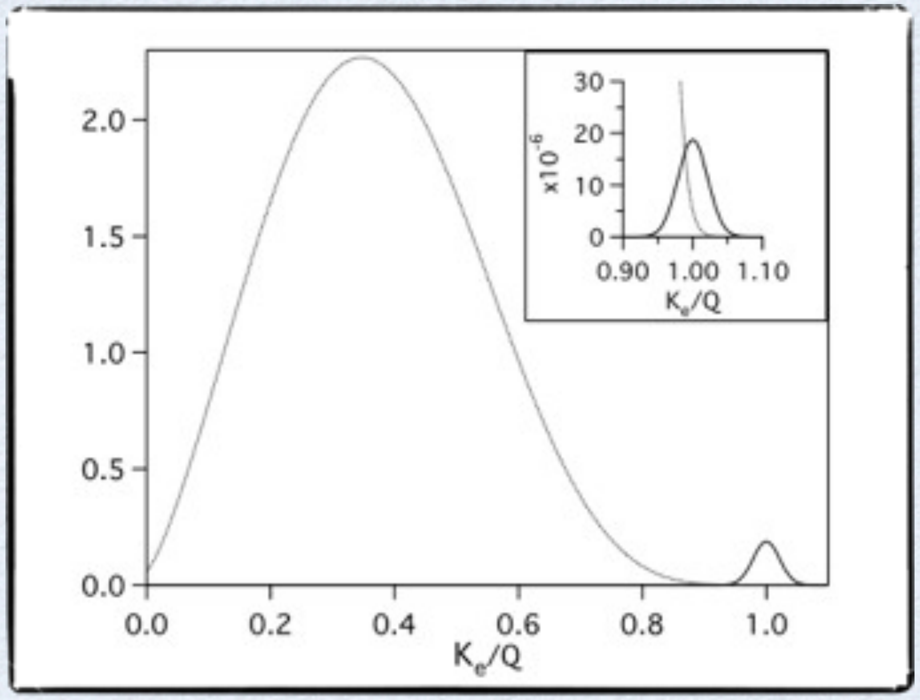
on behalf of the NEXT collaboration

IPAC 2013, 13-15 May , Madison, WI

The Race for Double Beta Decay





Energy distribution of the two electrons

Neutrinoless double beta decay is a unique signature of Majorana nature of neutrinos.

Signature: peak in the sum of the kinetic energies of the two electrons.

Essential requirements

- Energy resolution
- Background rejection

Challenging experiments

- Very slow decay rate (if any) -> large masses, ultra-pure materials

The Race for Double Beta Decay

136-Xe experiments (EXO and KamLAND-Zen) are leading the field: best limits on half-life, Klapdor claim (Ge-76) almost excluded

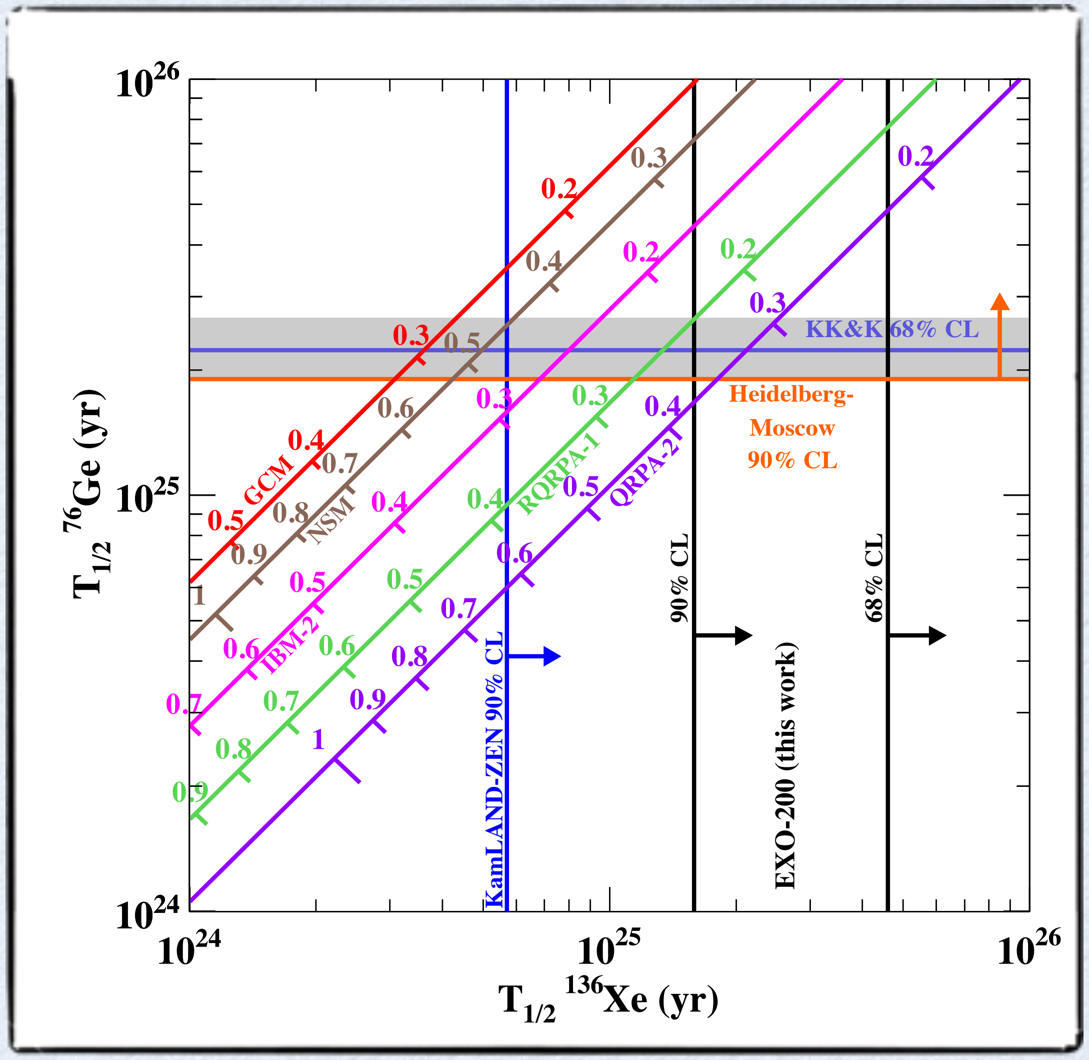
Why xenon?

SOURCE

• High Q-value (2.48 MeV), above most of background
• No long-lived radioactive isotopes
• Slow bb2nu mode

DETECTOR

• Possibility of building large experiments with very low background (currently, best limits in the field ~10^{-3} c/keV/kg/year): full active volume, possibility of fiducialization



The Race for Double Beta Decay

The next way: **high pressure gaseous** xenon

- Next Experiment with a Xenon TPC
- Small fluctuations in ionization (Fano factor ~0.15)
  -> better energy resolution than LXe (6-7 times)
- Visible electron tracks: possibility to use topology to reject background
- Cheap enrichment and scaling compared to other isotopes

Excellent for scaling to higher masses (~tons)

The NEXT collaboration

80 people, 5 different countries

THE NEXT COLLABORATION

80 PEOPLE, 5 DIFFERENT COUNTRIES

IFIC (Valencia), U. Zaragoza, U. Santiago de Compostela, U. Girona, U. Politécnica Valencia

U. Coimbra, U. Aveiro

LBNL, Texas A&M U., Iowa State U.

JINR (Dubna)

U. Antonio Nariño (Bogotá)

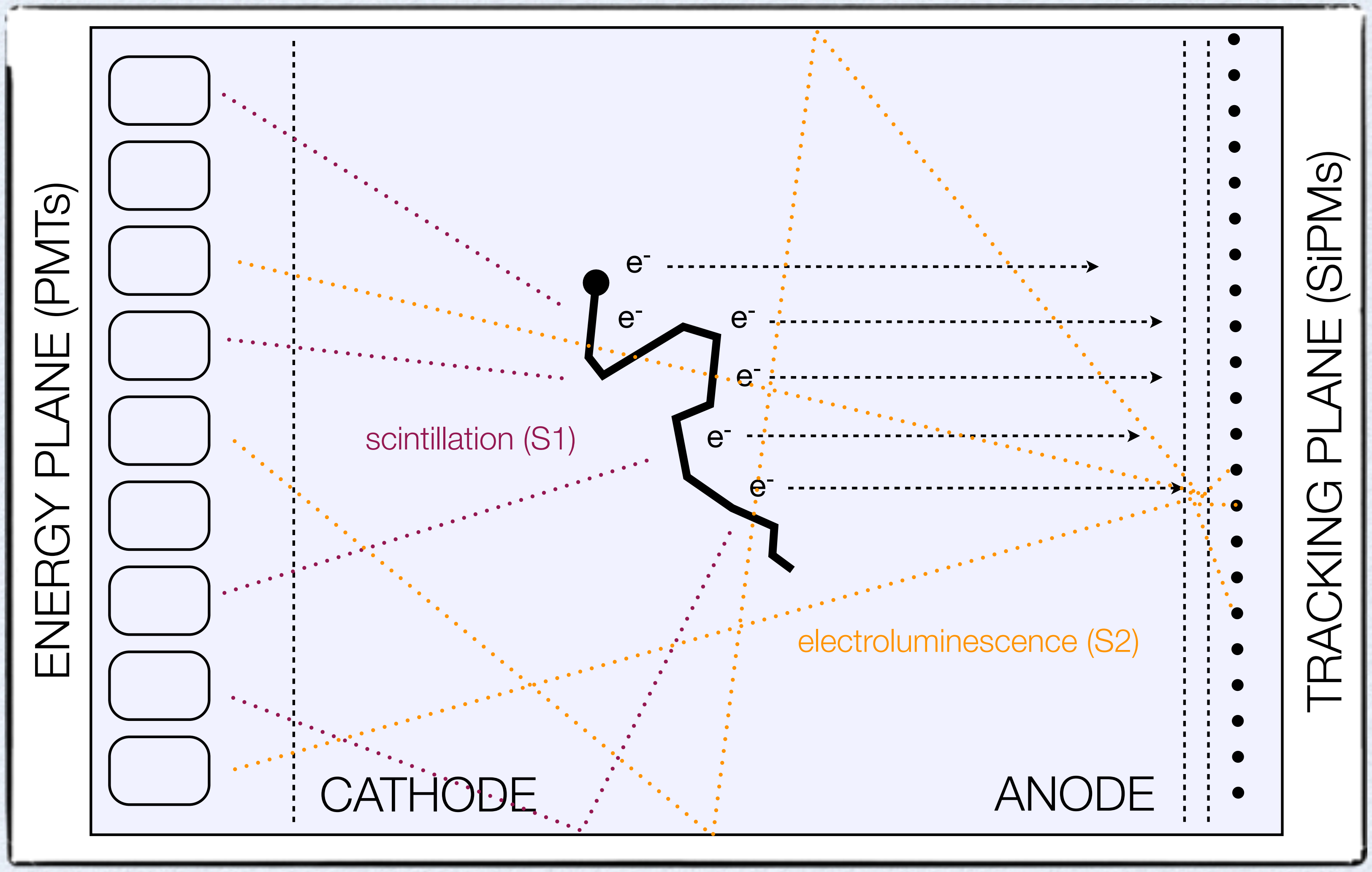
LSC

Laboratorio Subterráneo de Canfranc

NEXT-100 placed in the Underground Laboratory of Canfranc

A novel concept

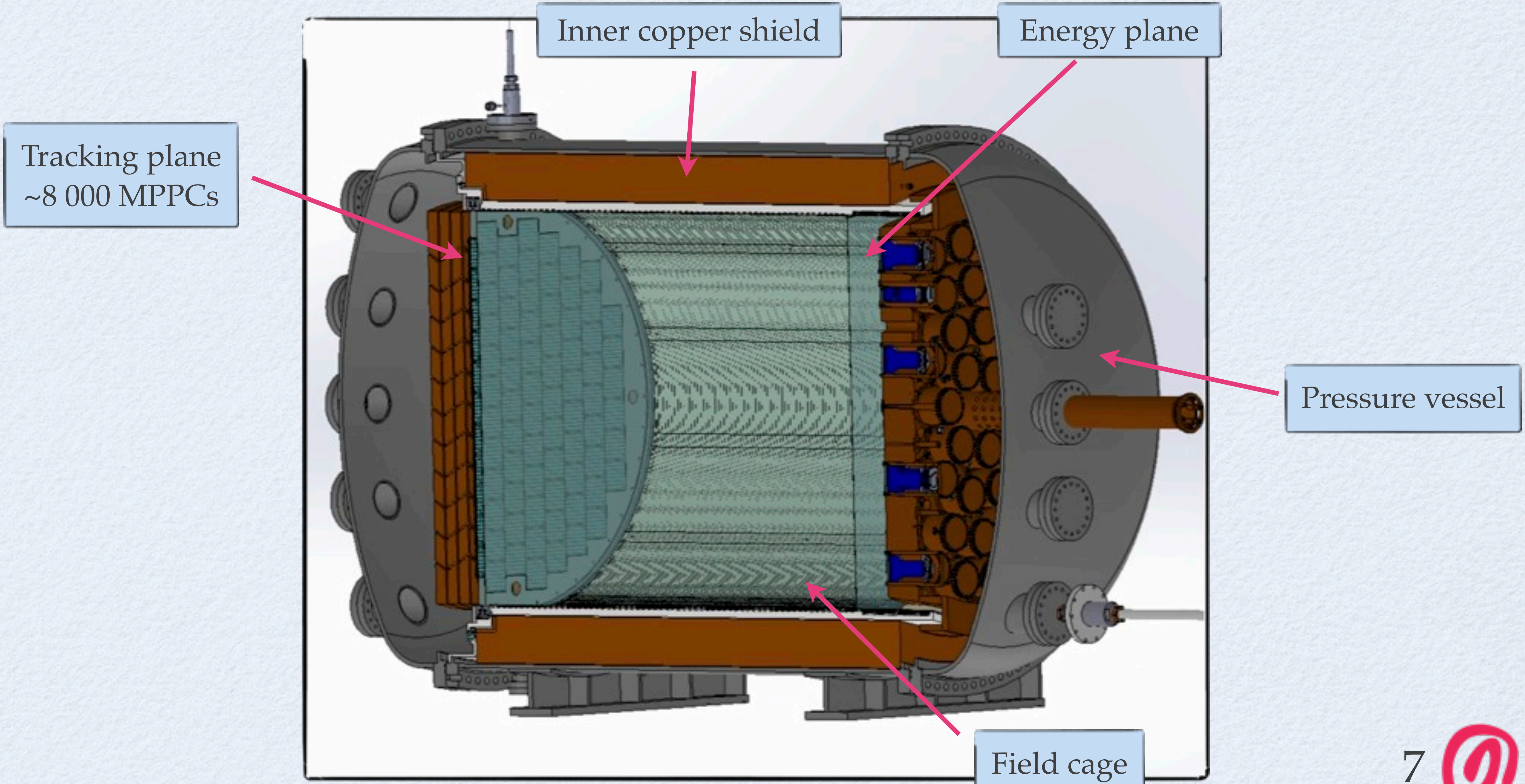
HPXe Time Projection Chamber + Electroluminescence for amplification



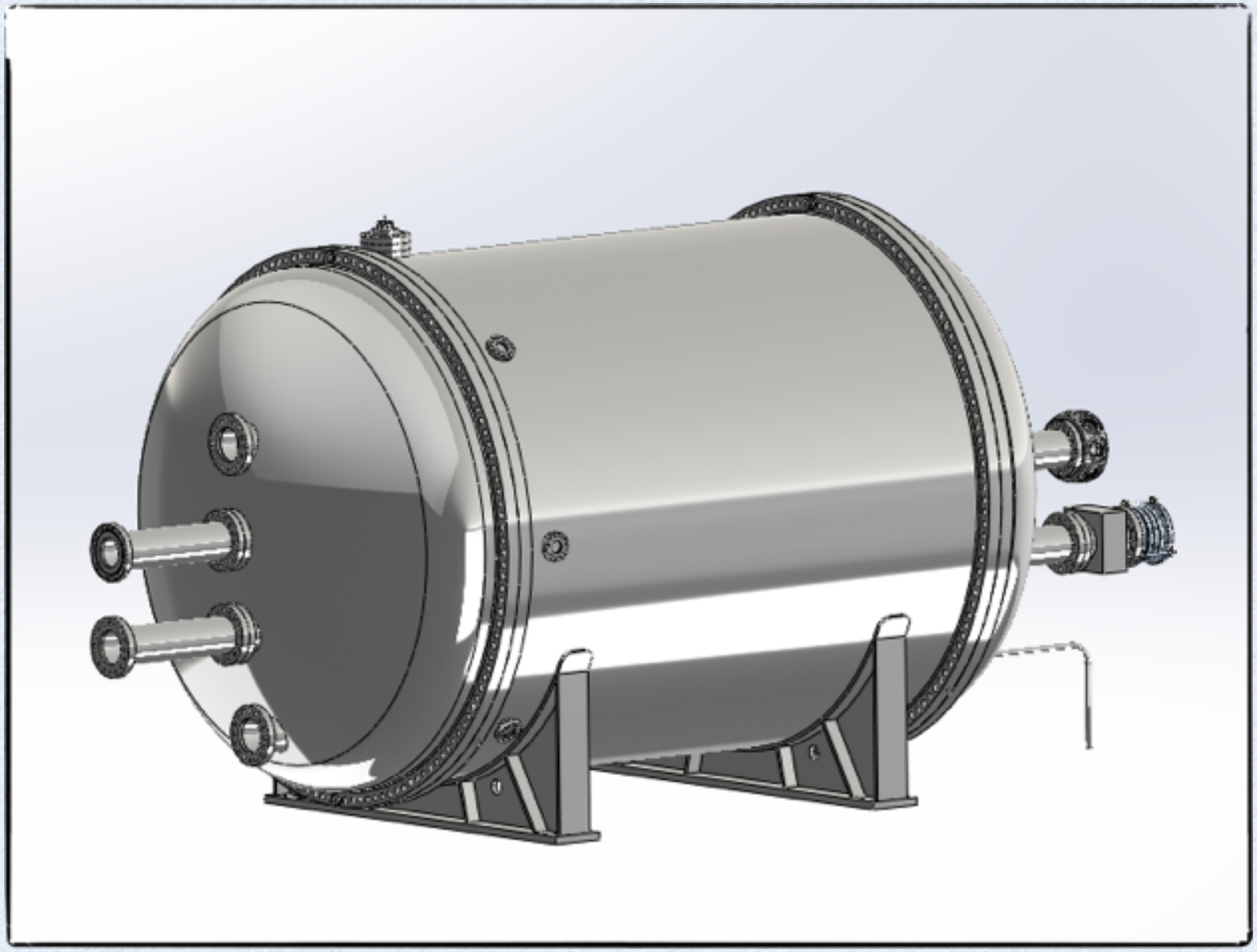
- Separated readouts for tracking and energy measurements
- Full 3-D reconstruction thanks to t0 + tracking plane
- Low fluctuations in EL gain -> better energy resolution

THE next EXPERIMENT

High pressure xenon, electroluminescent TPC, 100 kg, 15 atm

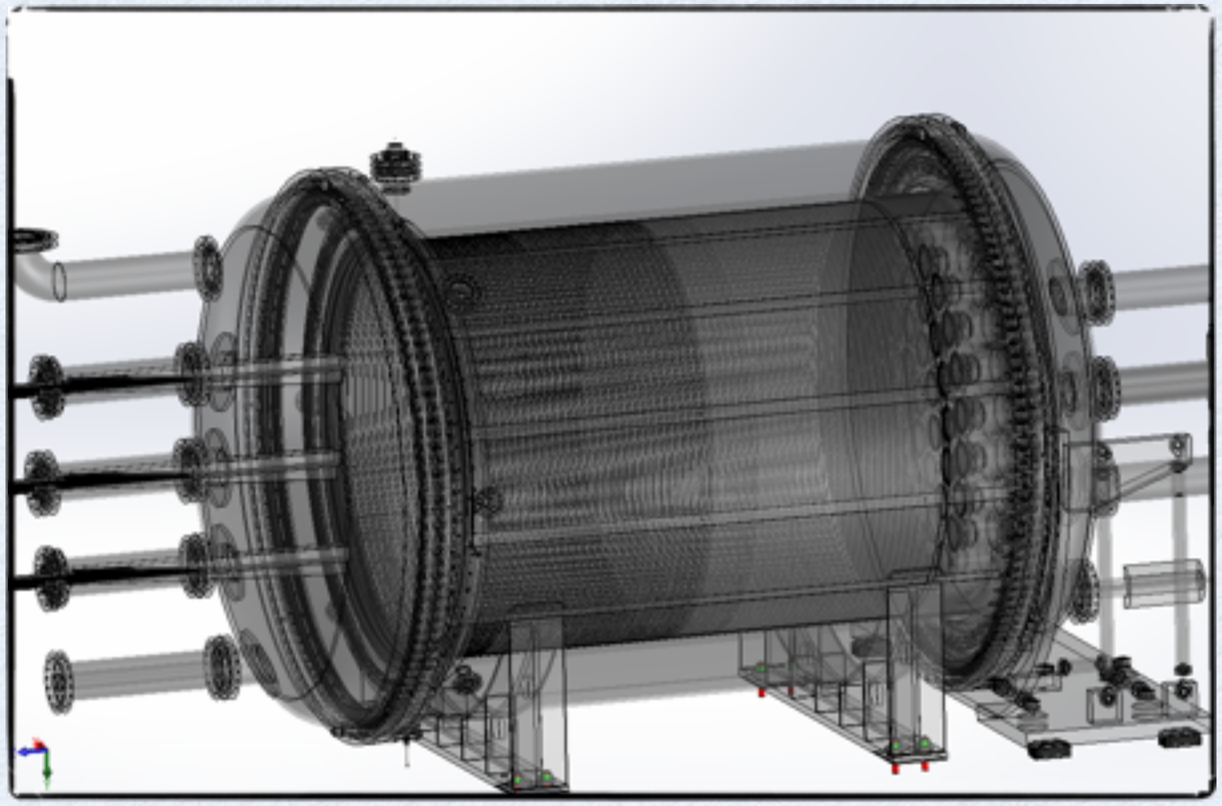


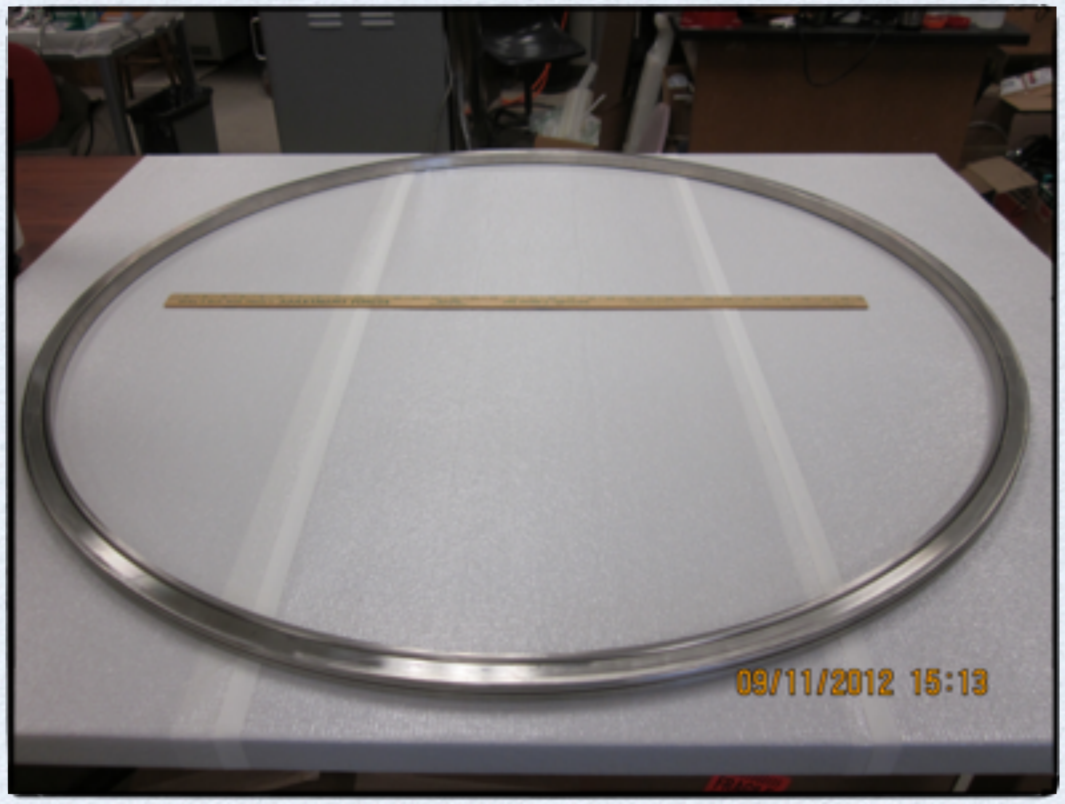
Pressure vessel



- 1 200 kg of stainless steel 316Ti alloy, very low activity
- 12 cm inner copper shield to block radiation from vessel of a factor of 100
- Currently being built by a company in Madrid

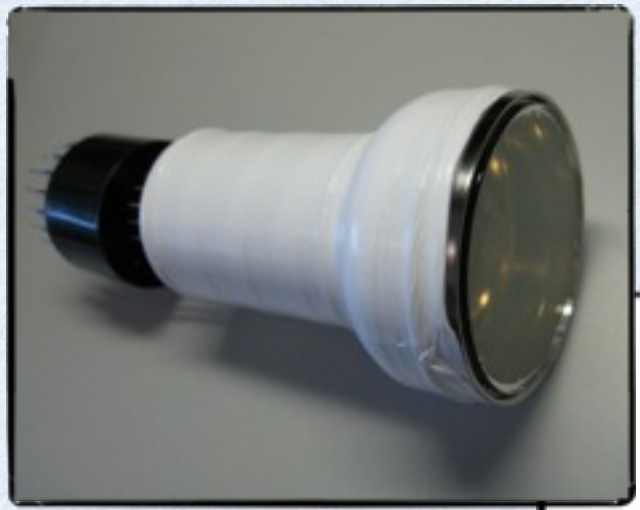
FIELD CAGE

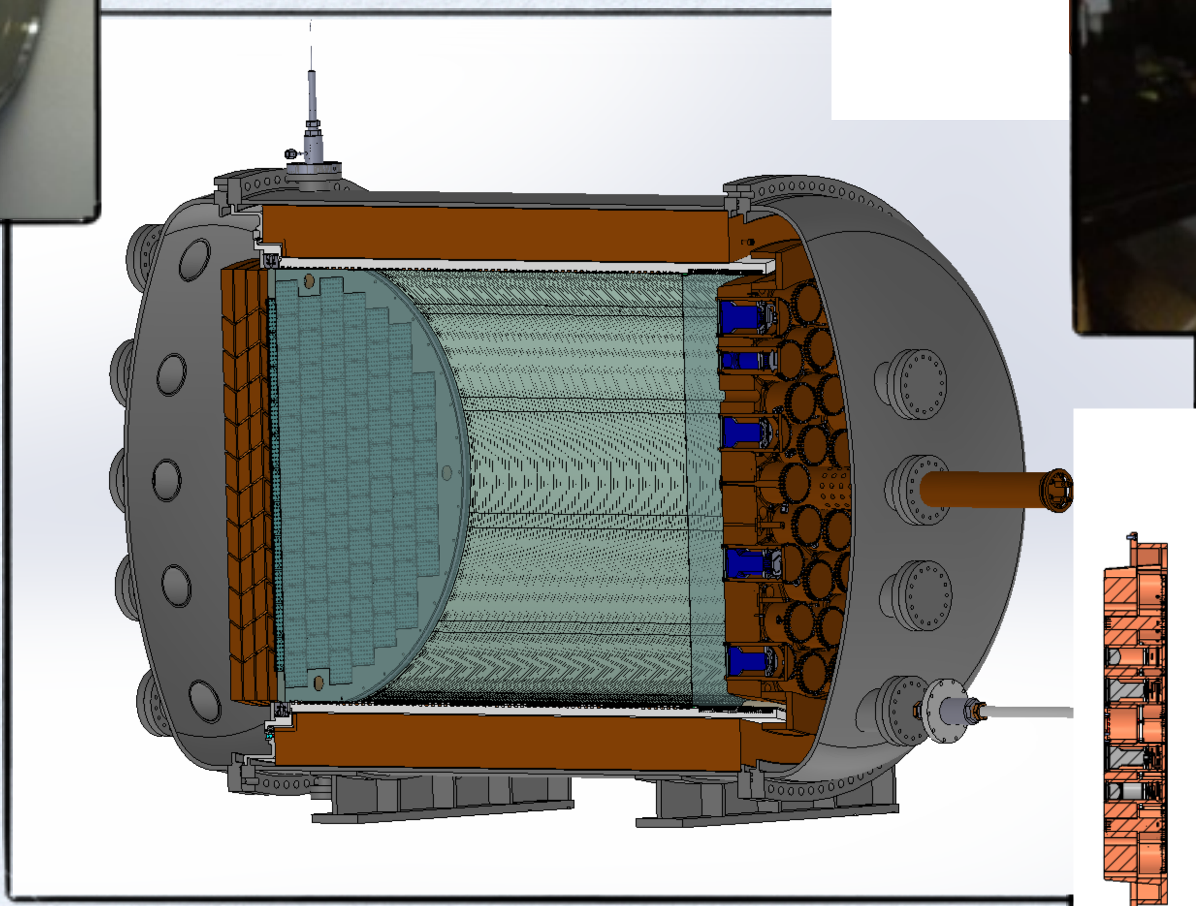


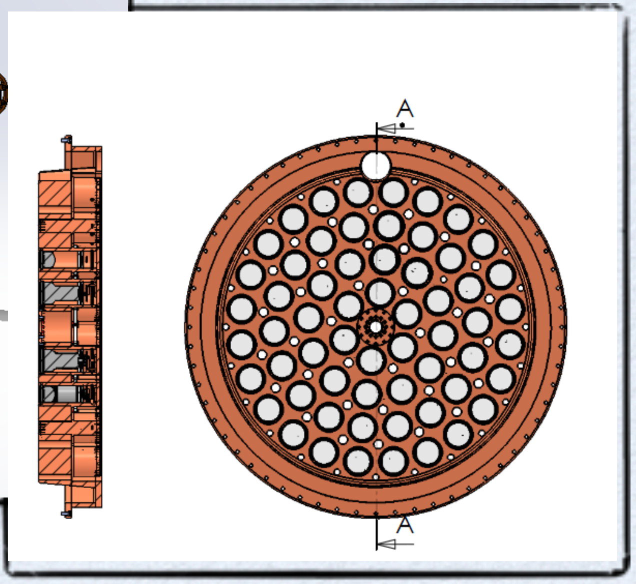


- High density polyethylene cylindrical shell insulating from the vessel
- Copper strips connected to low background resistors grade the high voltage
- Drift region: 130 cm long, 105 cm of diameter, EL region: 1 cm long
- Three wire meshes defining the two electric field zones, 88% transparency

ENERGY PLANE

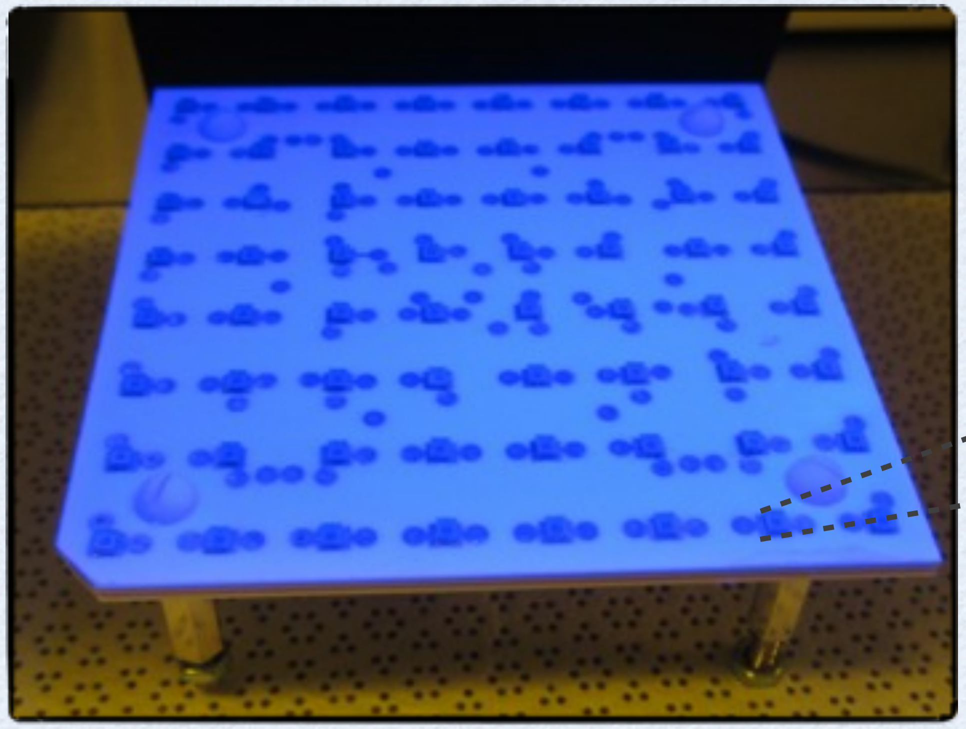


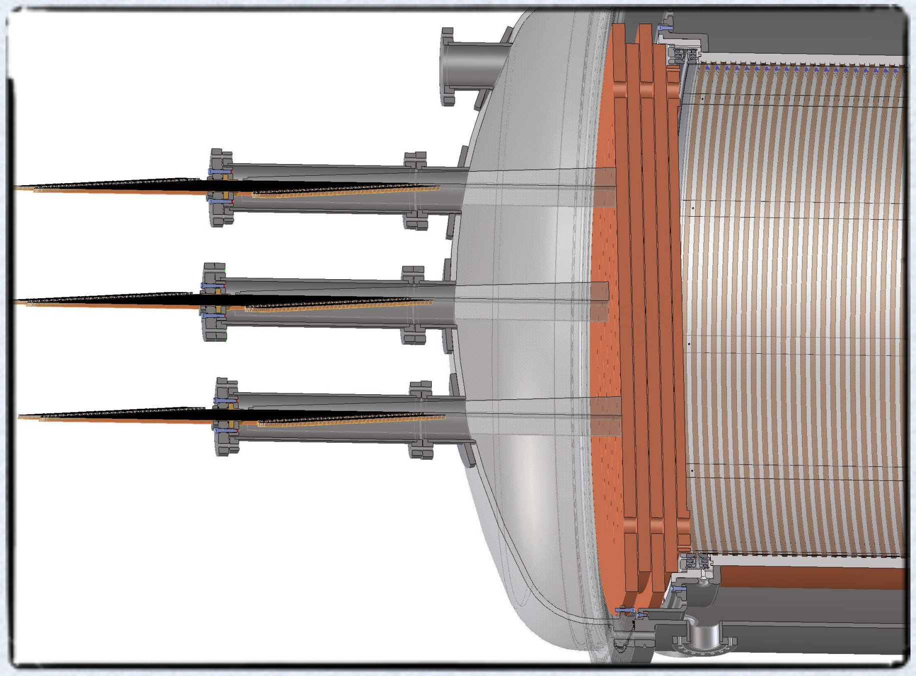




- 60 R11410-10 Hamamatsu PMTs, low radioactivity, 30% coverage
- Not withstanding high pressure -> copper cans needed, coupled to sapphire windows
- Currently under radioactivity screening at LSC

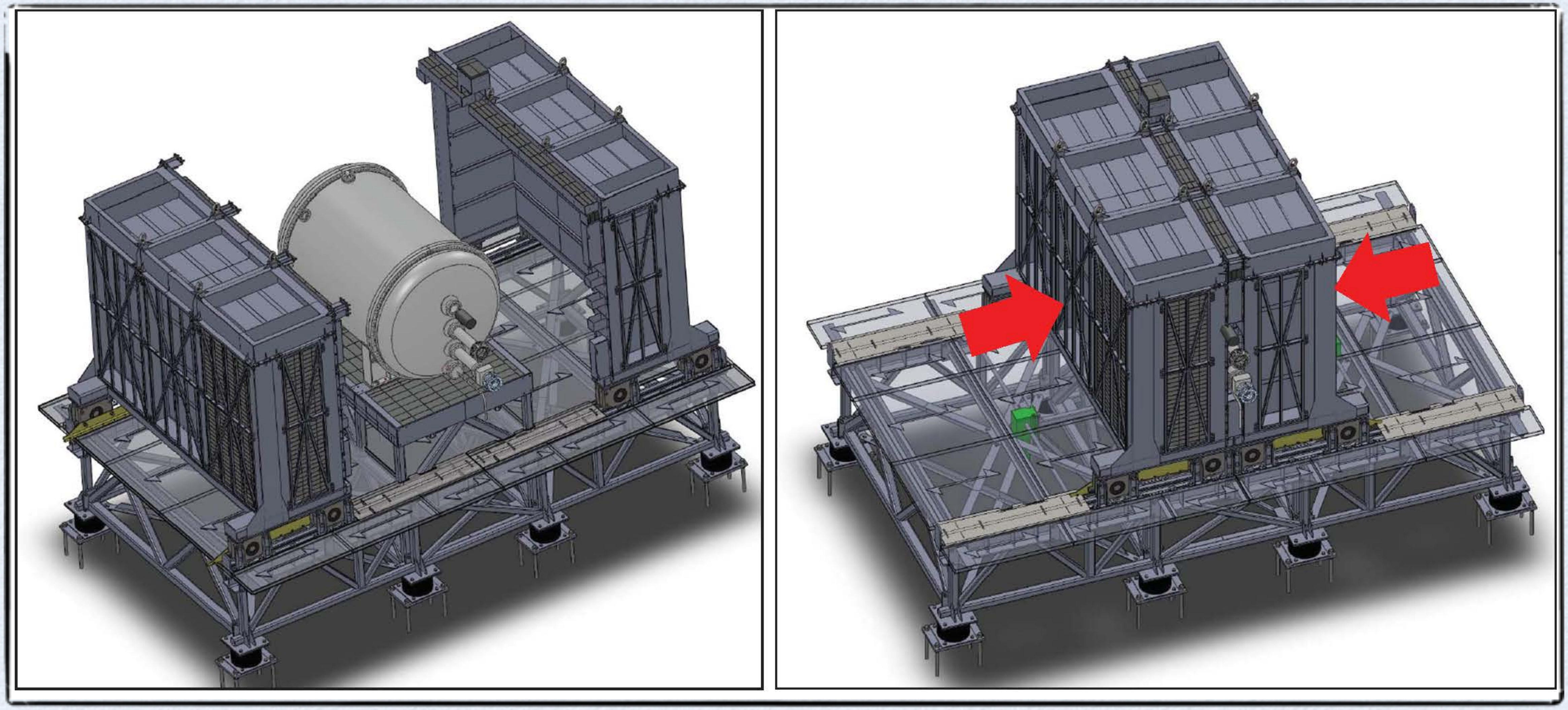
Tracking plane





- Multi Pixel Photon Counters (SiPM) S10362-11-050P, $1mm^2$ active area, 1 cm pitch
- Sensitive to blue light -> coated with wavelength shifter (TPB)
- Electronics outside the chamber -> custom-made feedthroughs to extract signal

Lead castle



- Lead castle made of 15-cm thick bricks provides passive shielding
- Mounted on a seismic platform, as well as the detector

THE next EXPERIMENT

Xenon

Working platform

Gas system

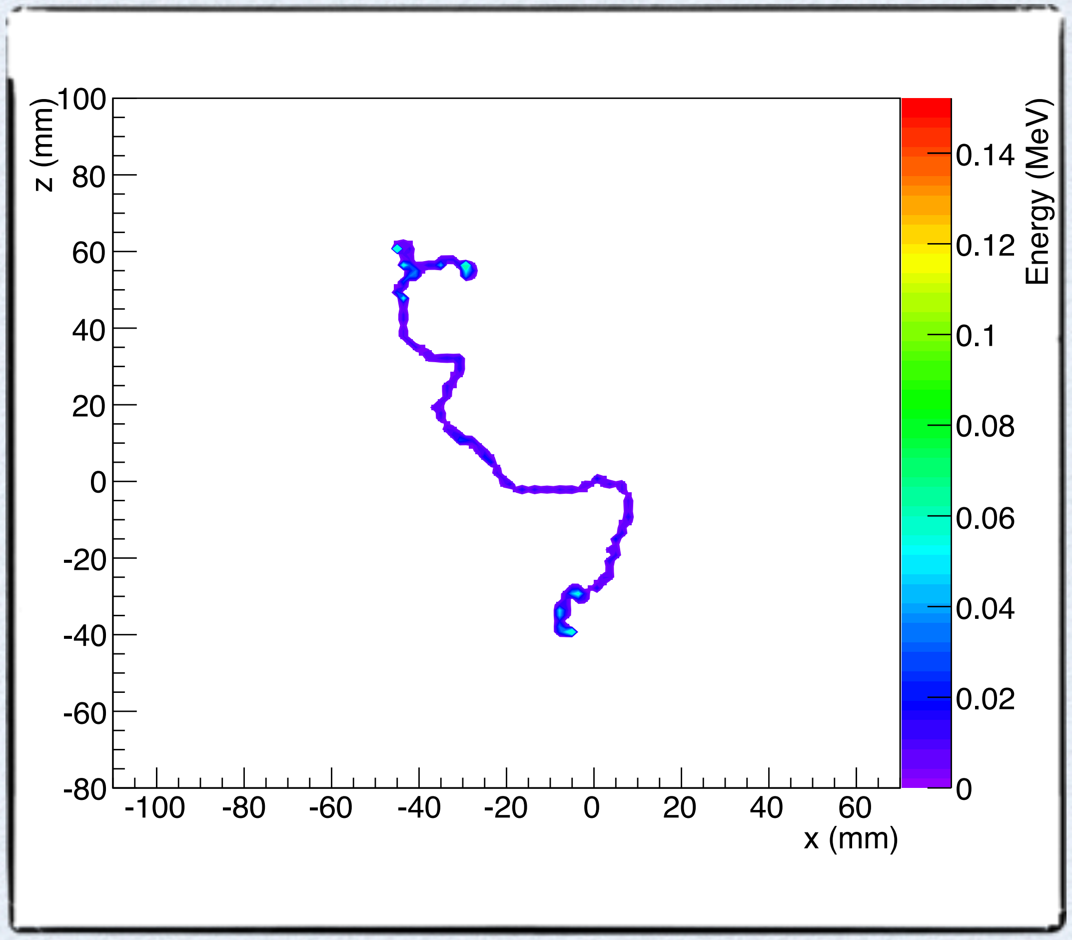
Ongoing construction at LSC

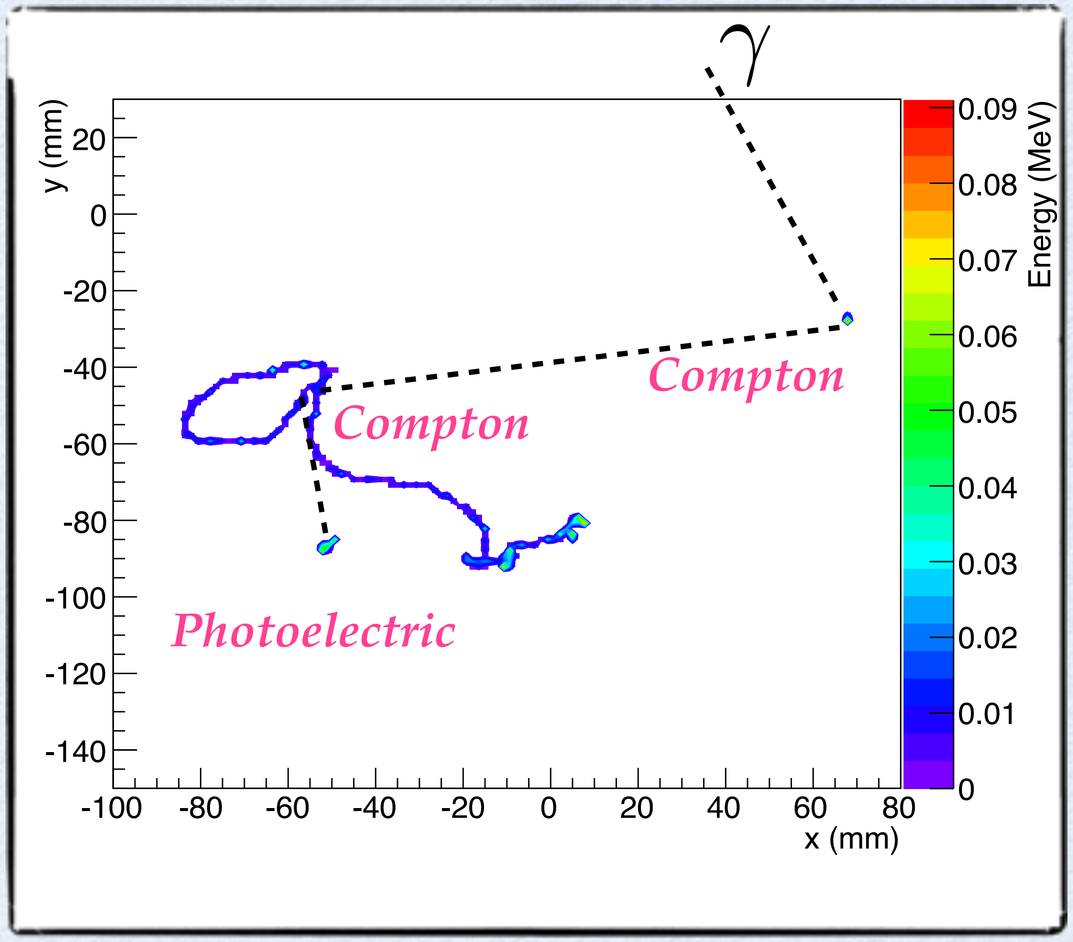
Sensitivity

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

- Efficiency mostly dominated by bremsstrahlung photons leaving the detector.
- Energy resolution expected to be better than 1% (based on results from prototypes, see Francesc's talk).
- 100 kg of Xe-136 ready at LSC.
- Relevant background due to high energy gammas from materials and rock. Possibility of topology discrimination.

Background Rejection





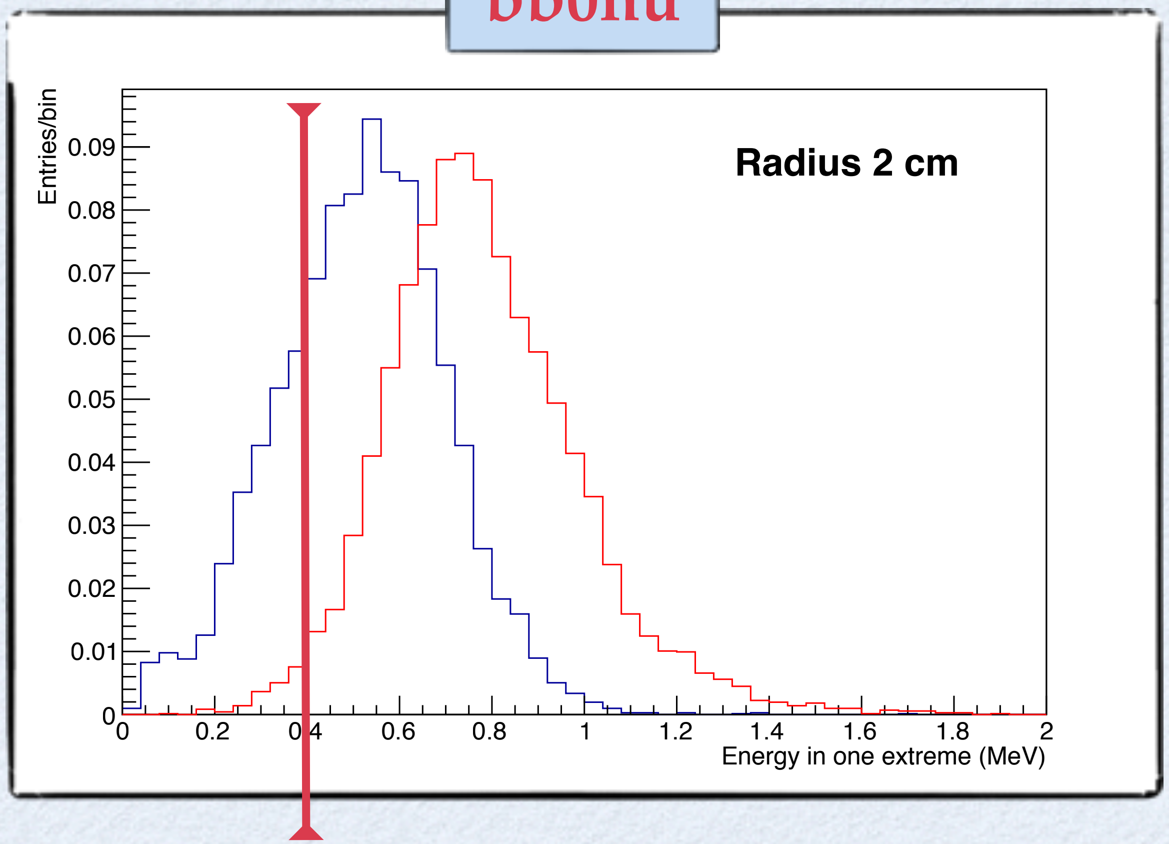
- Signal: spaghetti with two meatballs

- Background: more than one deposition, a blob at one end

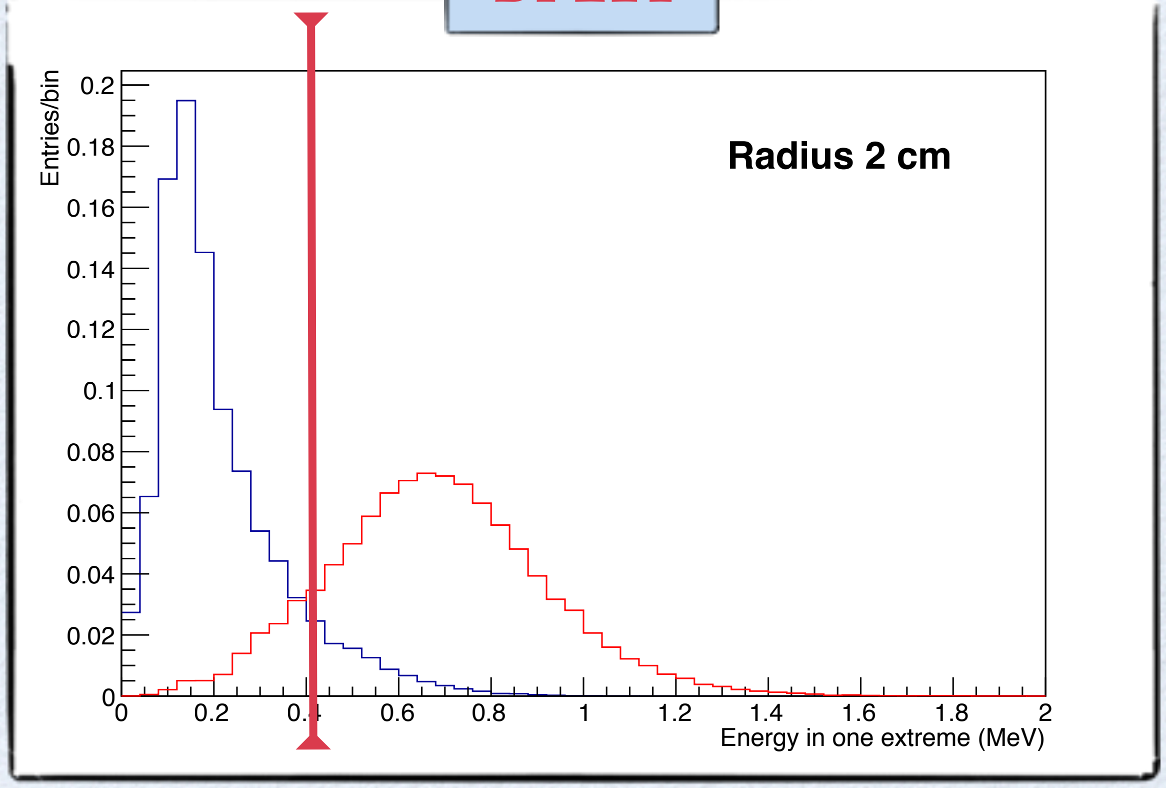
Background Rejection

- Most of background eliminated by fiducial veto, since external.
- High energy gammas from Tl208 and Bi214 mimic signal.
- First cut: one "long" track, zero isolated depositions.
- Final cut: minimum energy at both ends of the track.

bb0nu



Bi 214



75% signal efficiency, 10% background

Background Rejection

Screening campaign at LSC to measure the activity of the materials and detector components of NEXT

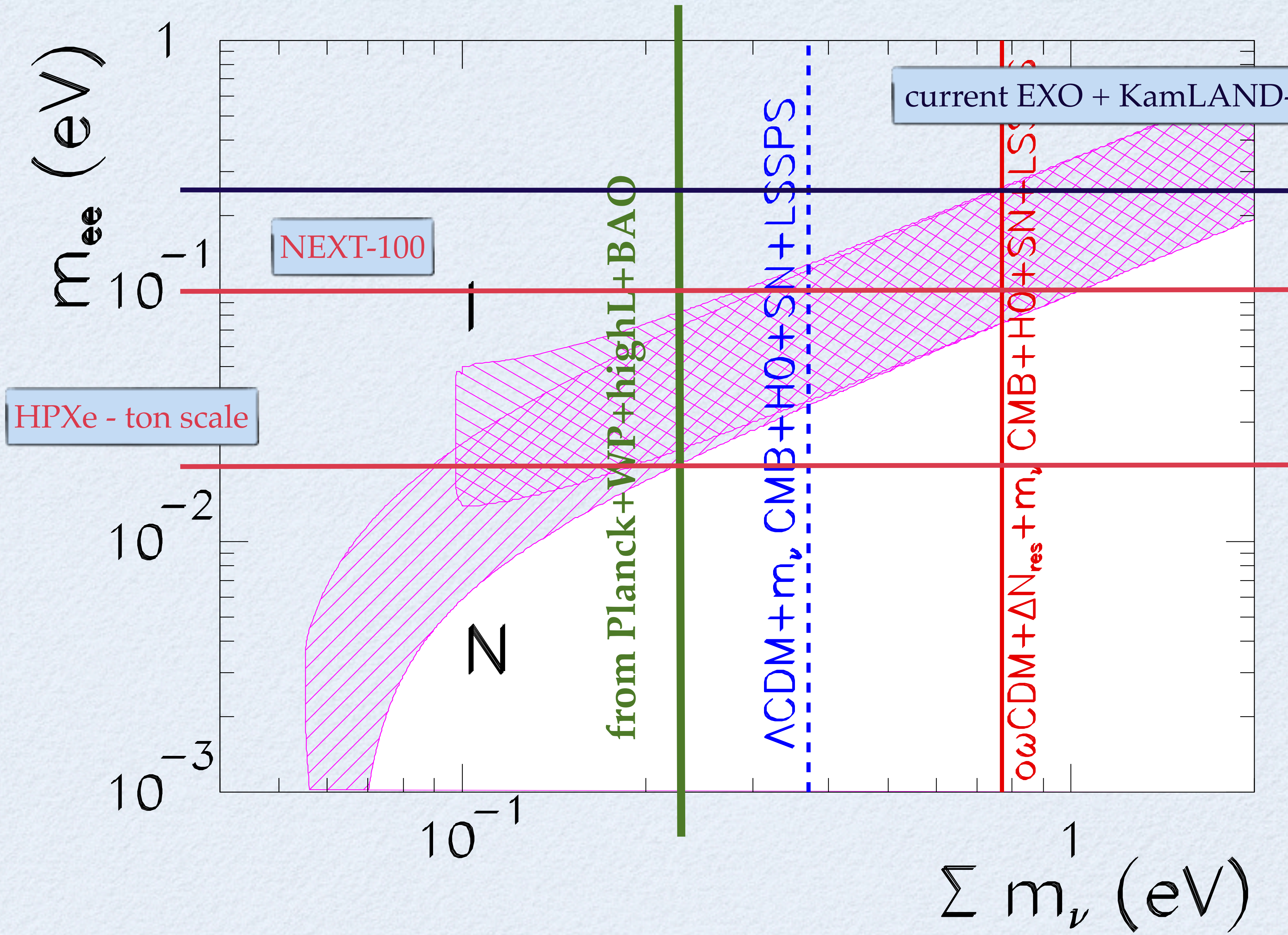
The NEXT collaboration, JINST 8 T01002 (2013)

Main contributions to background (c/keV/kg/year) from different components of NEXT-100

	Tl- 208	**Bi-214**
energy plane	3×10^{-5}	2×10^{-5}
tracking plane	2×10^{-4}	2×10^{-5}
pressure vessel	3×10^{-5}	2×10^{-6}
field cage	2×10^{-5}	2×10^{-5}

Total background estimation: **4×10^{-4}** c/keV/kg/year

SENSITIVITY



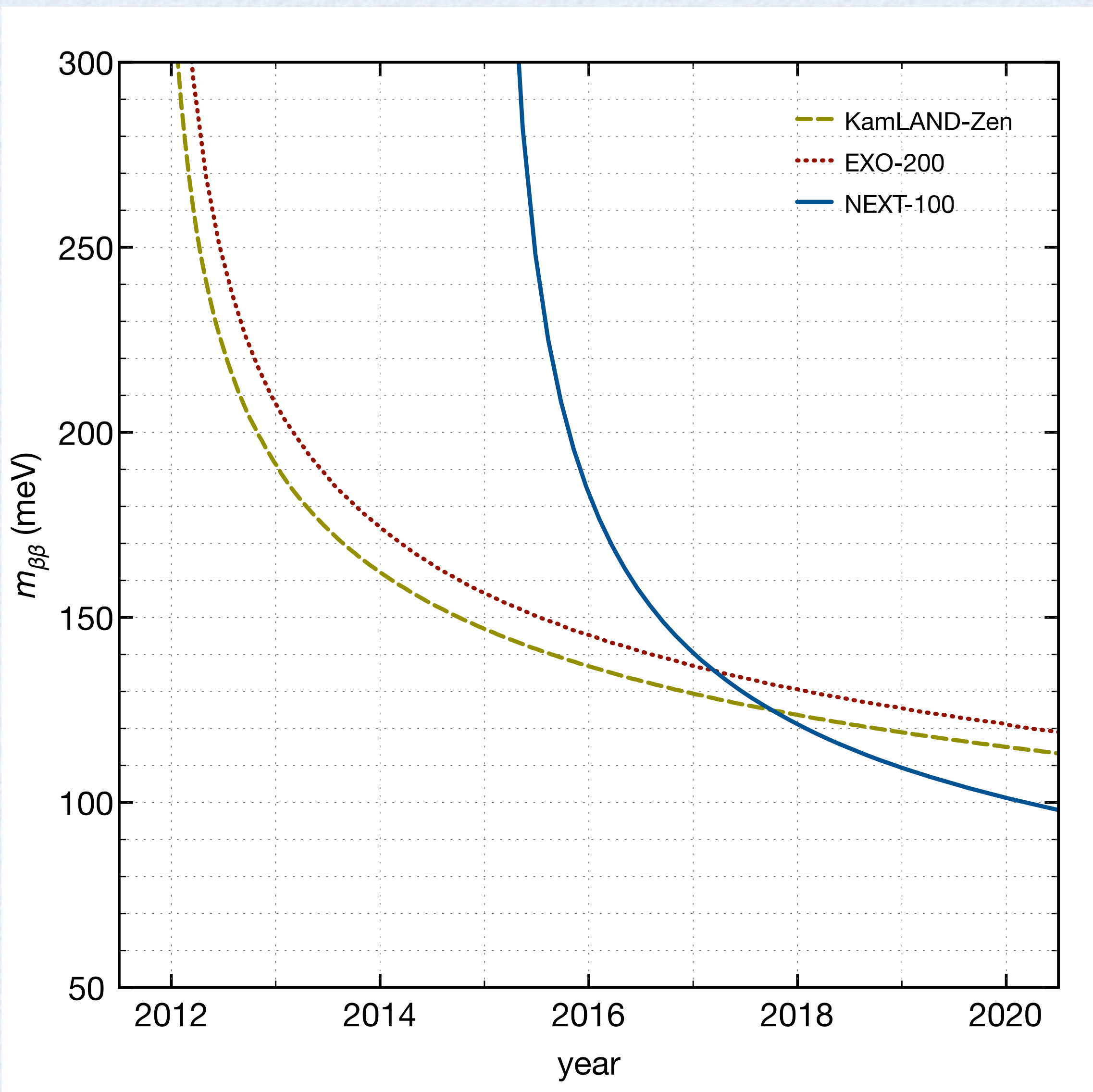
plot from M.C. González-García

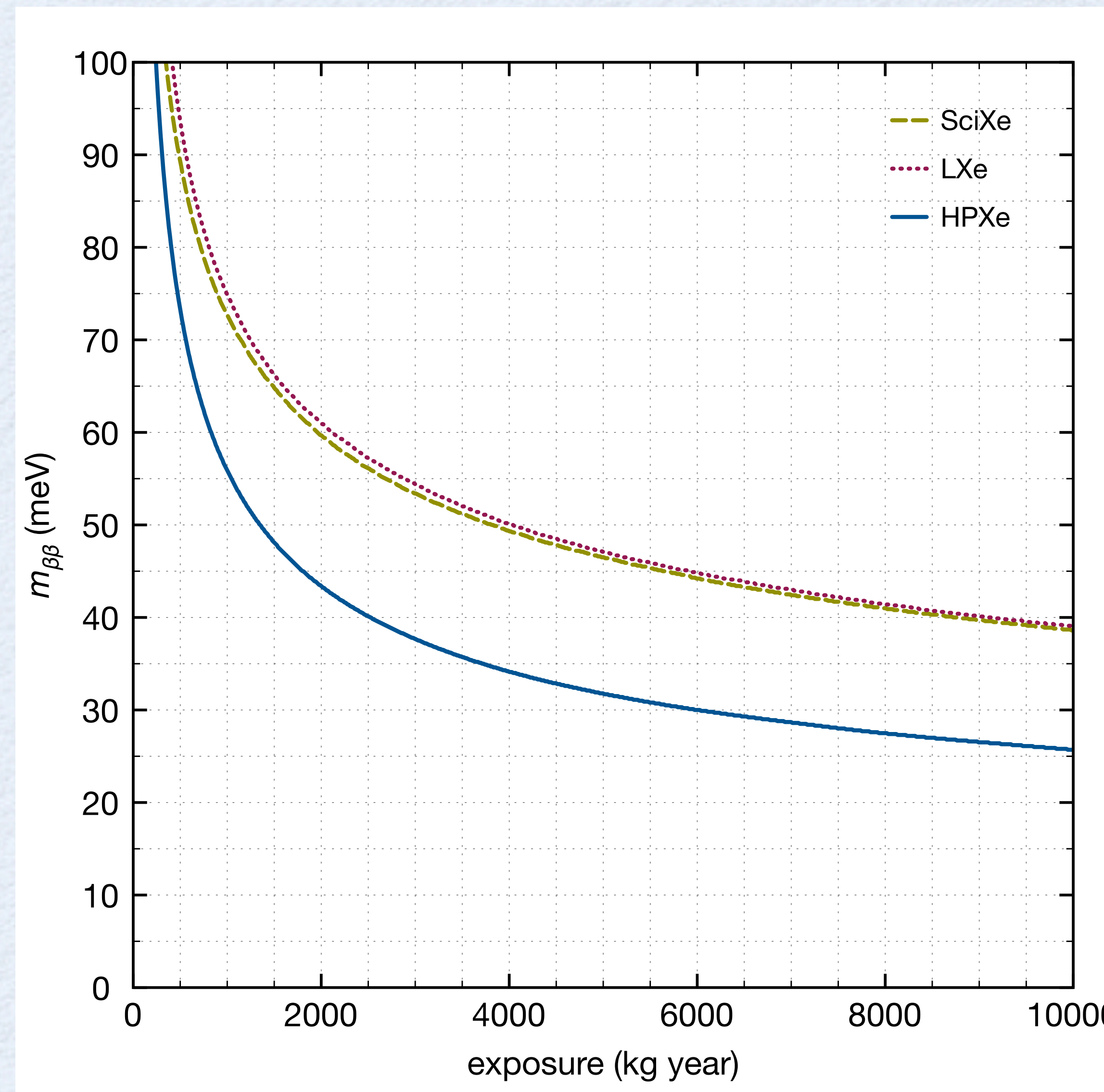
SUMMARY

- NEXT as a new way to neutrinoless double beta decay.
- After a successful prototyping phase, construction has started in Canfranc.
- Commissioning and calibration runs expected for 2014.
- Data taking with enriched xenon will start in 2015.

THANK YOU

BACKUP

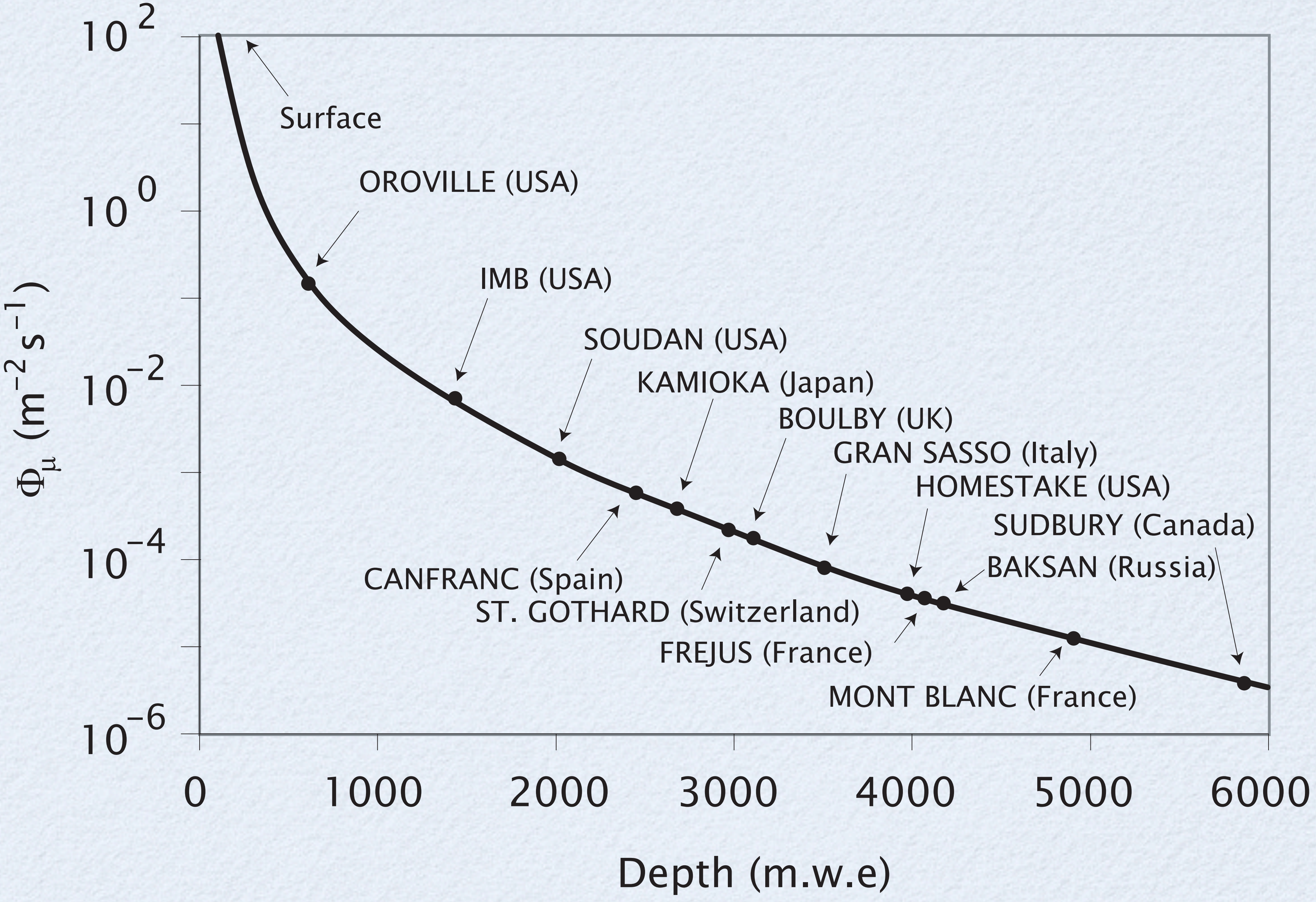




Experiment	M (kg)	f (%)	ε (%)	δE (% FWHM)	b (10^{-3} ckky)
EXO-200	110	0.81	0.56	4.0	1.5
KamLAND-Zen	330	0.91	0.42	9.9	1.0
NEXT-100	100	0.91	0.30	0.7	0.5

JCAP 1303 (2013) 043

BACKUP



10^2
10^0
10^{-2}
10^{-4}
10^{-6}
$\Phi_\mu\ (m^{-2}s^{-1})$
Surface
OROVILLE (USA)
IMB (USA)
SOUDAN (USA)
KAMIOKA (Japan)
BOULBY (UK)
GRAN SASSO (Italy)
HOMESTAKE (USA)
SUDBURY (Canada)
BAKSAN (Russia)
CANFRANC (Spain)
ST. GOTHARD (Switzerland)
FREJUS (France)
MONT BLANC (France)
0
1000
2000
3000
4000
5000
6000
Depth (m.w.e)