



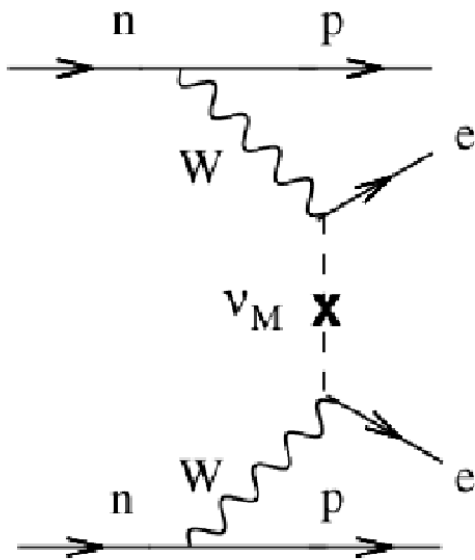
The Next Generation Neutrinoless Double- Beta Decay Experiment nEXO

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PASCOS 2016, Quy Nhon, Vietnam

Outline

- Motivation
- nEXO Concept Design
- The R&D Status
- Summary

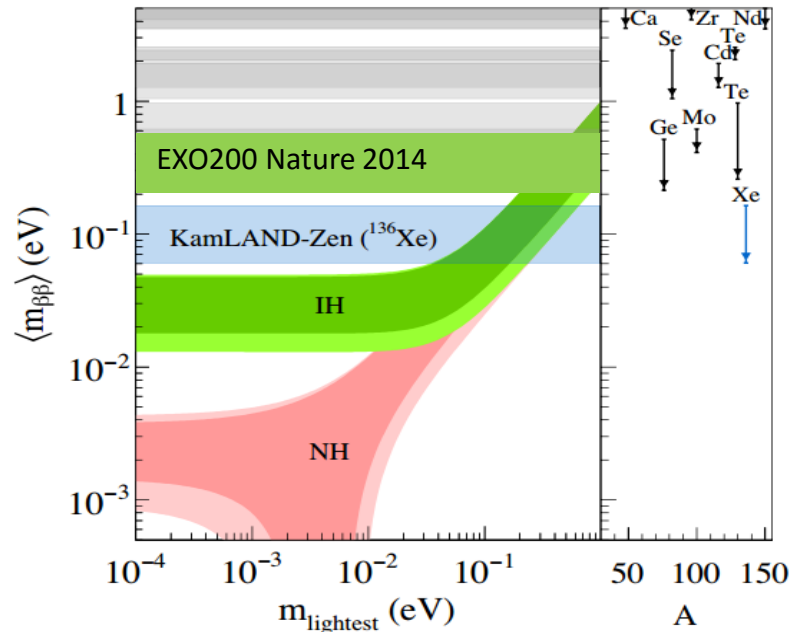
Search for $0\nu\beta\beta$ decay



Current half-life limit:

$>1.9 \times 10^{25}$ yr (90% CL) EXO200

$>1.07 \times 10^{26}$ yr (90% CL) KamLAND-Zen



- Neutrinos are Majorana Particles
- Demonstration of Lepton number violation

Basics requirement:

Low background, Large mass,

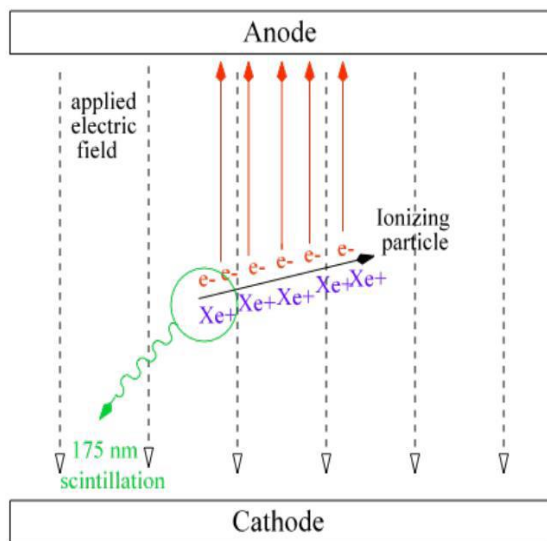
Good energy resolution, Good back ground rejection

Tone scale LXe TPC

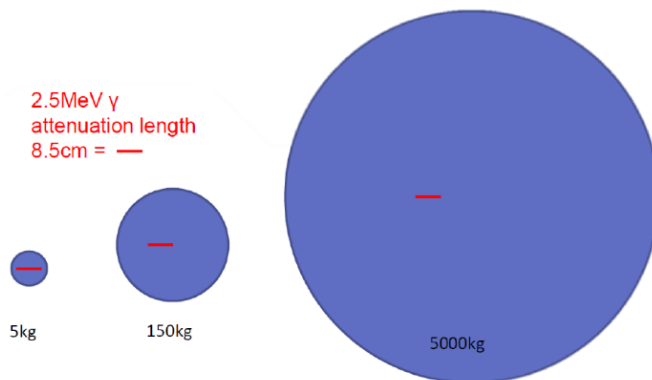
Candidate nuclei with $Q > 2$ MeV

Candidate Q Abund.
(MeV) (%)

$^{48}\text{Ca} \rightarrow ^{48}\text{Ti}$	4.271	0.187
$^{76}\text{Ge} \rightarrow ^{76}\text{Se}$	2.040	7.8
$^{82}\text{Se} \rightarrow ^{82}\text{Kr}$	2.995	9.2
$^{96}\text{Zr} \rightarrow ^{96}\text{Mo}$	3.350	2.8
$^{100}\text{Mo} \rightarrow ^{100}\text{Ru}$	3.034	9.6
$^{110}\text{Pd} \rightarrow ^{110}\text{Cd}$	2.013	11.8
$^{116}\text{Cd} \rightarrow ^{116}\text{Sn}$	2.802	7.5
$^{124}\text{Sn} \rightarrow ^{124}\text{Te}$	2.228	5.64
$^{130}\text{Te} \rightarrow ^{130}\text{Xe}$	2.533	34.5
$^{136}\text{Xe} \rightarrow ^{136}\text{Ba}$	2.479	8.9
$^{150}\text{Nd} \rightarrow ^{150}\text{Sm}$	3.367	5.6



TPC: 3D event reconstruction



Tone scale is Critical for background rejection

Advantage of Xe:

Easy to enrich: can be enriched to 80% relatively easily (better than growing crystals)

Easy to build Tone scale detector: Liquid, high density $3\text{g}/\text{cm}^3$

Low background ^{136}Xe :

Can be purified continuously, no long-life radioactive isotopes, Background rejection potentially by **Ba $^{++}$ tagging**

Advantage of TPC:

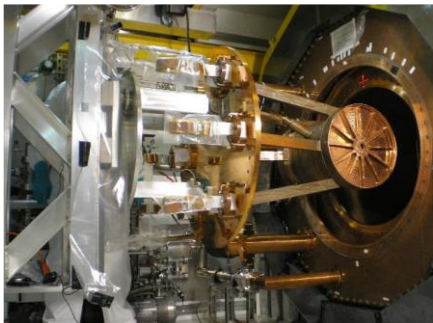
3D event reconstruction:

self shielding, SS selection and MS rejection

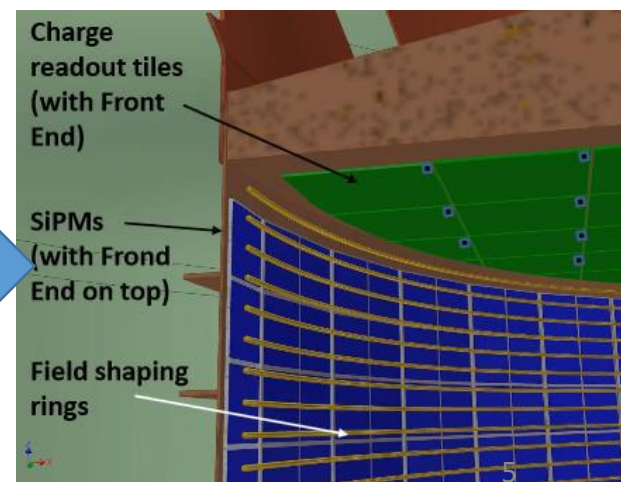
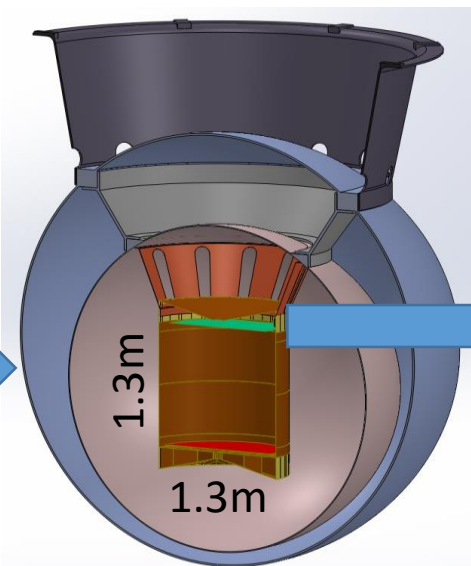
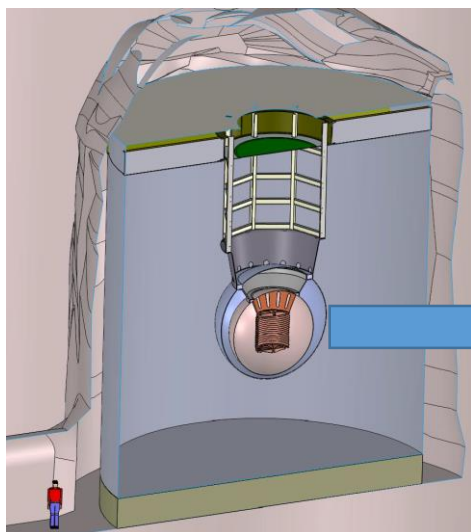
Energy resolution: using scintillation and charge anti-correlation

Next Generation: nEXO

EXO-200: 200kg liquid-Xe TPC



nEXO: 5-ton liquid Xe TPC with Ba tagging option (SNO lab cryopit)



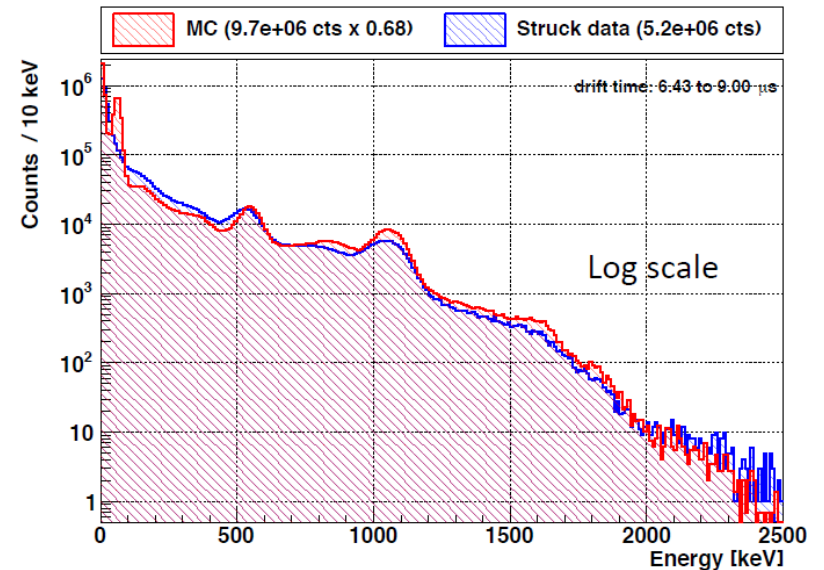
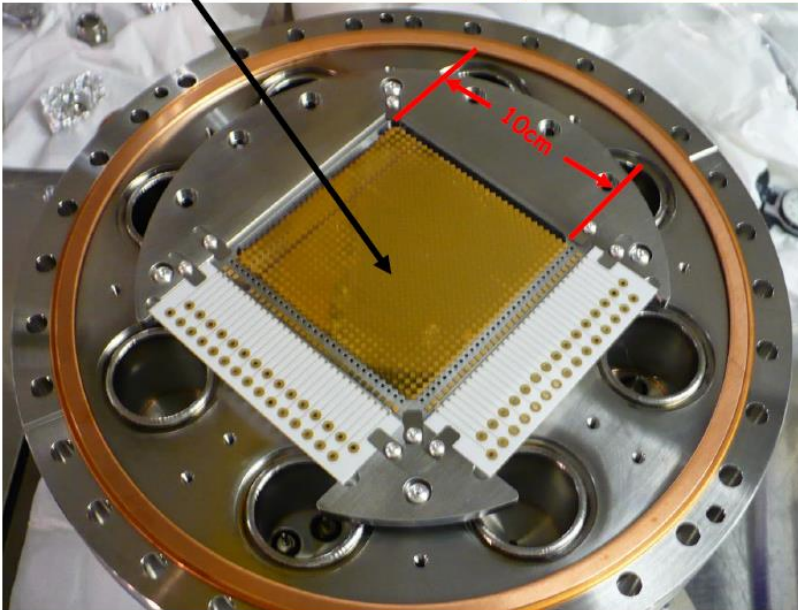
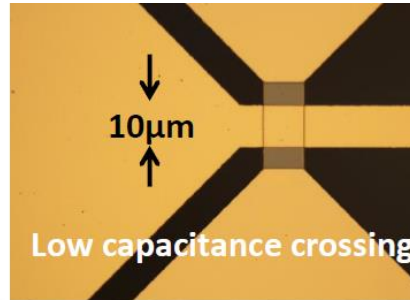
Detector concept design:

- 5 t liquid xenon TPC
- Possible location in SNOLab CryoPit (6010 mwe)
- SiPM for light detection
- Tiles for charge read out
- 3D event reconstruction
- Expected Energy Resolution of 1% at Q-value

Charge tiles

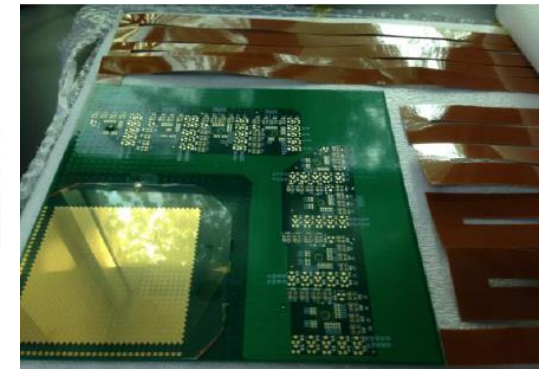
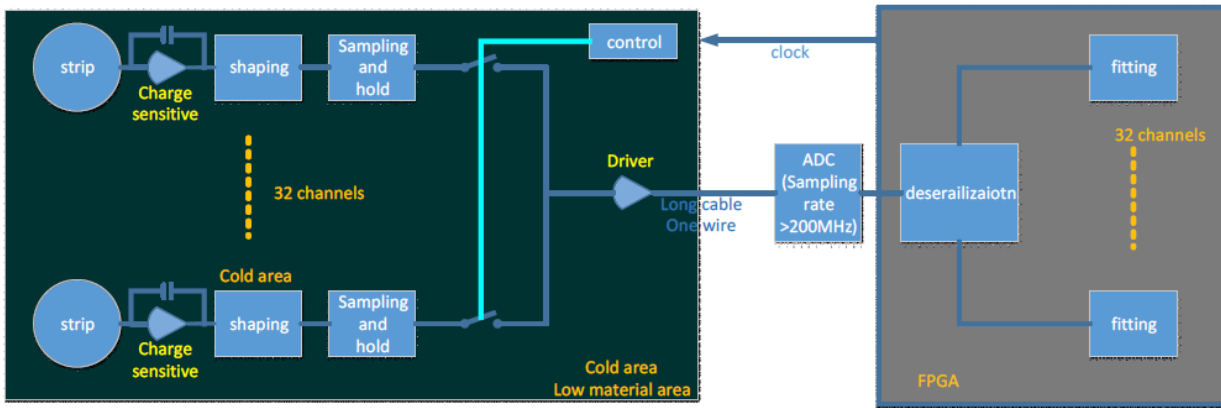
- 10 x 10cm² Prototype Tile
- Metallized strips on fused silica substrate
- 60 orthogonal channels (30 x 30)
- 3mm strip pitch
- Strip intersections isolated with SiO₂ layer
- Currently testing in LXe with a ²⁰⁷Bi source

IHEP/IME tile anode,
mounted to underside
of cell lid

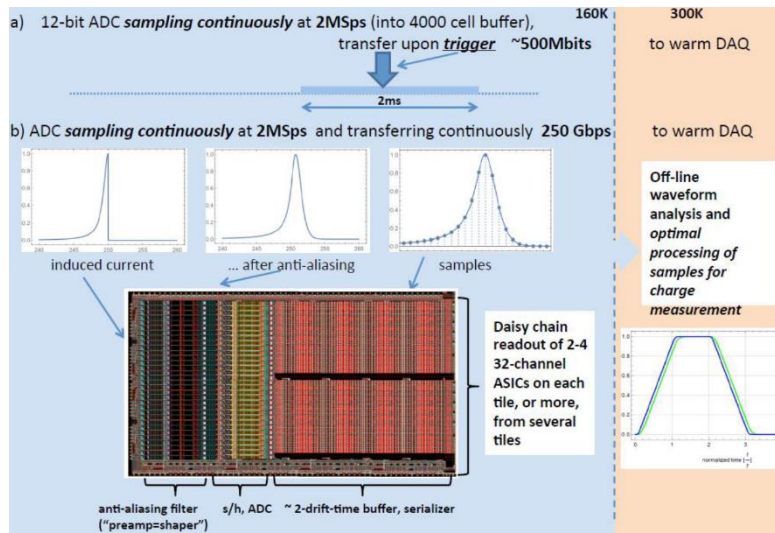


energy spectrum from an internal ²⁰⁷Bi
source ionization only

Charge readout

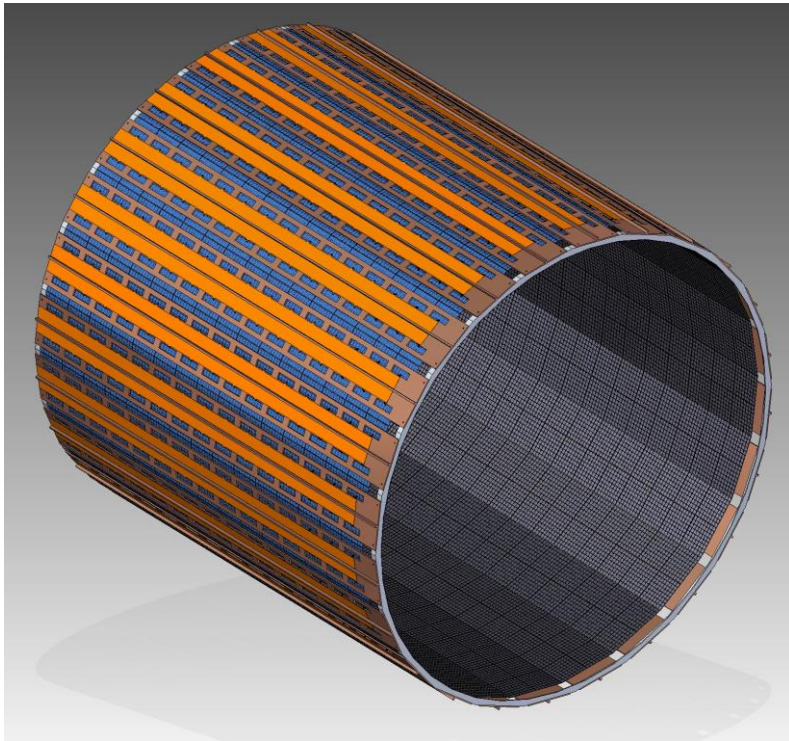


Series readout Low number of connections



LAr read out for nEXO

SiPM



Large area, order of 4 m²

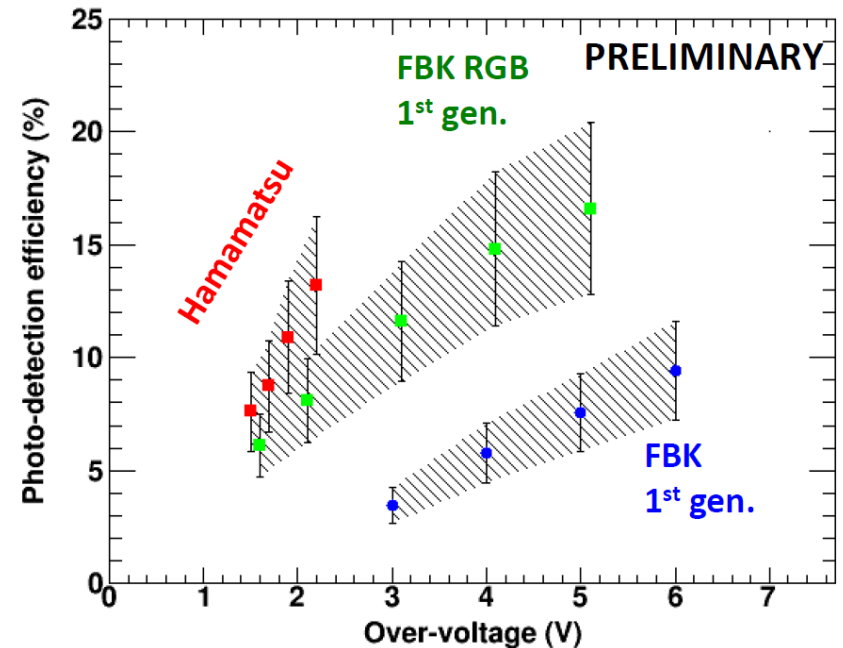
24 ladder staves

30 tiles per stave

84 mm x 84 mm tiles

VUV sensitive SiPMs

- Hamamatsu produces devices with QE= ~12% @ 175nm
- FBK “RGB” devices reach 15% QE with 7.7x7.7mm².

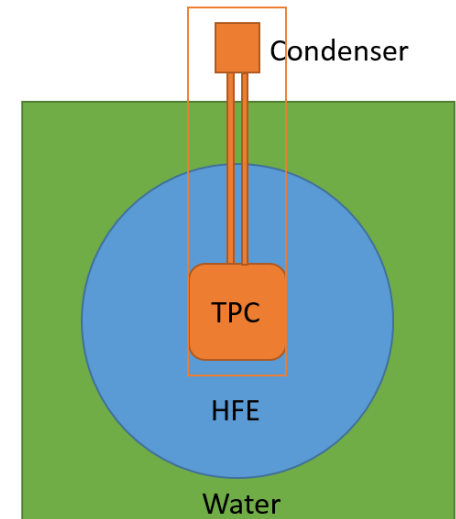
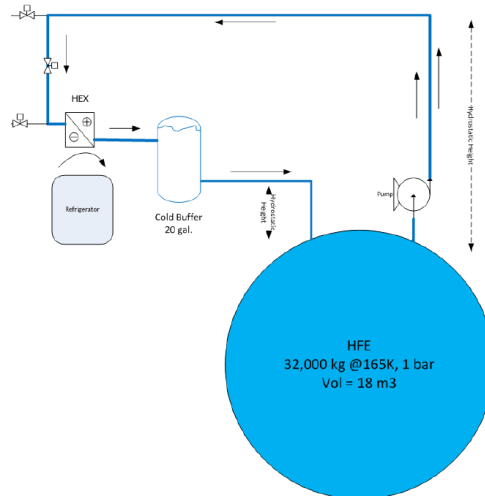
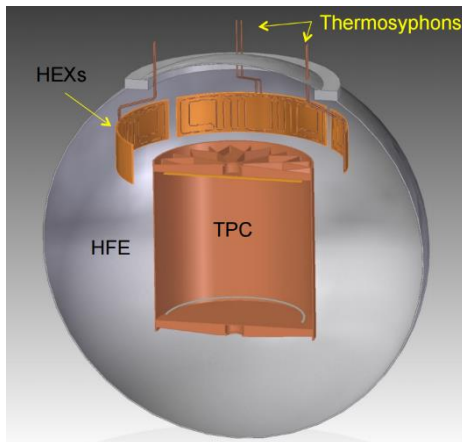
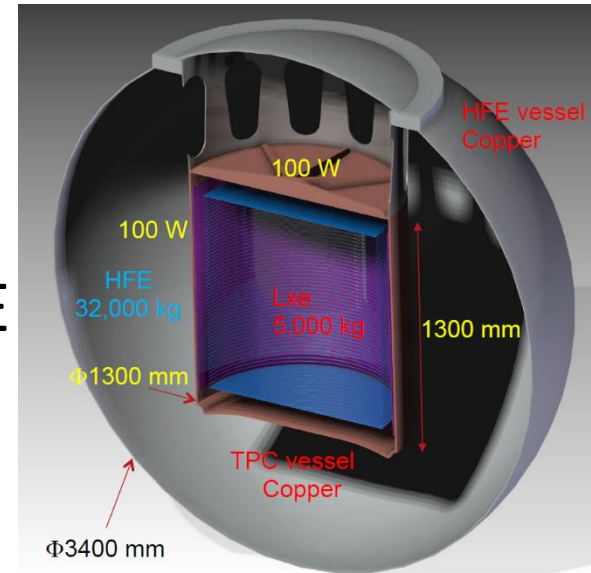


- Analog readout of SiPMs
- 3D SiPM readout

Cooling options

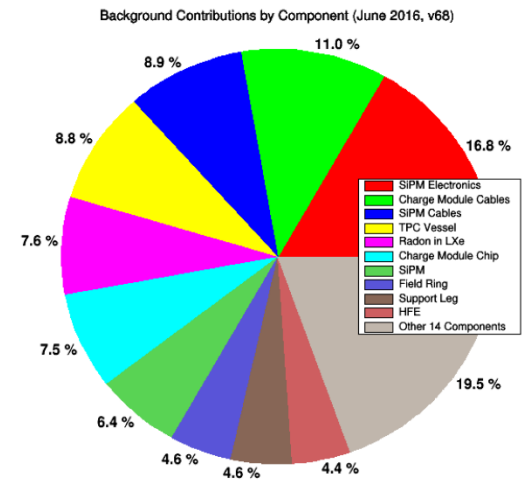
Total cold heat from RT to 165K: 7.25×10^9 J
 32T HFE, 5T Xenon, cryostat

- Thermosiphons with LN2 for the HFE
- Circulating cold HFE with pumps
- Thermosiphon directly on Xenon
- Hybrid solution



Background vs signal

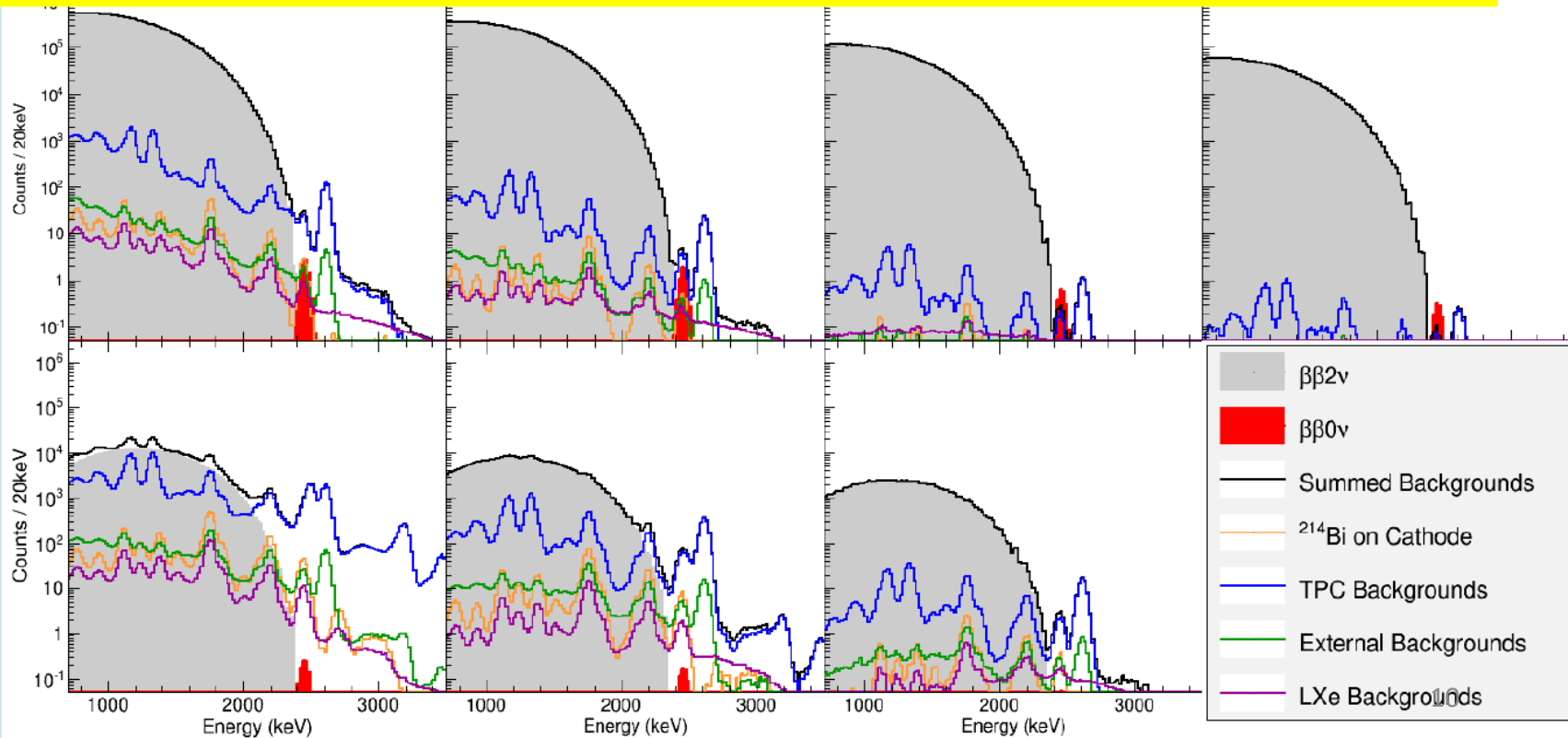
nEXO, 5 yr data, $0\nu\beta\beta$ @ $T_{1/2}=6.6 \times 10^{27}$ yr, projected backgrounds from subsets of the total volume



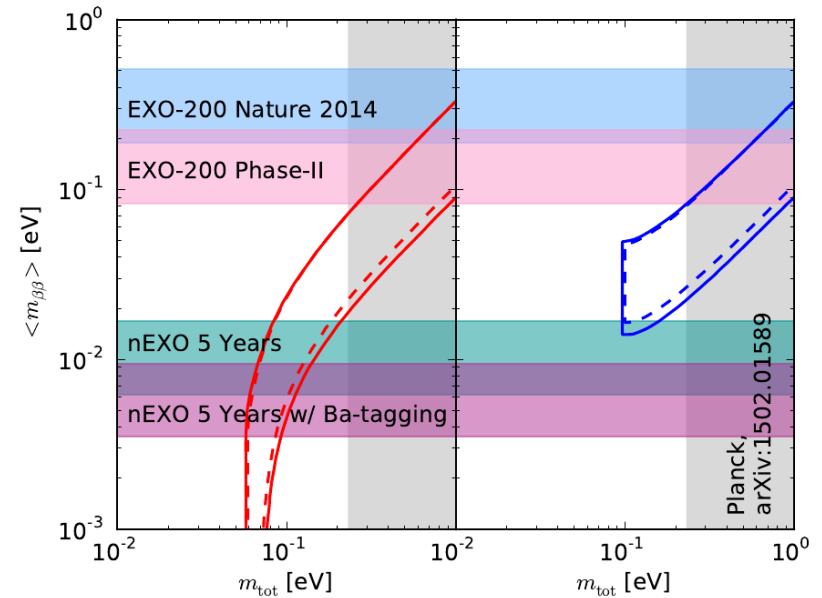
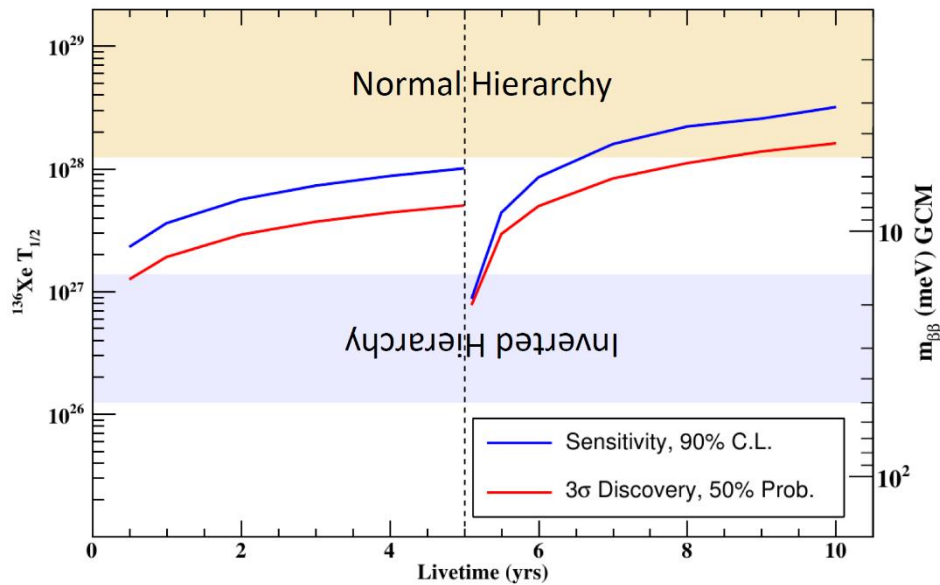
Fid. LXe Mass = 4780kg 3000kg 1000kg 500kg

SS

MS



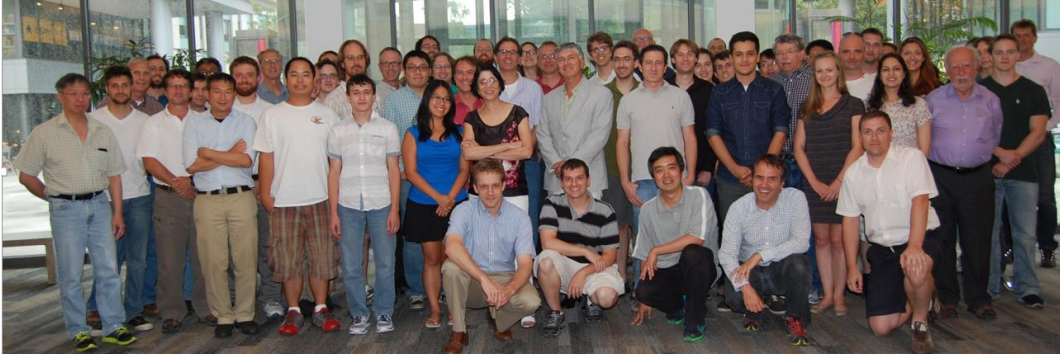
Sensitivity



- a half life sensitivity of $> 5 \times 10^{27}$ years
- cover the inverted neutrino mass hierarchy with 5 years of data

Summary

- nEXO is the next Generation $0\nu\beta\beta$ experiment
 - 5 tonne enriched LXe, 3D homogenous TPC, charge and light signal channels
- nEXO will allow for the full probing of the inverted mass hierarchy
- Lots of R&D work are underway



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The nEXO Collaboration

Thank you

