

**nEXO** : a tonne-scale  
next-generation  
double-beta decay experiment

Design & Sensitivity

Ryan MacLellan

*on behalf of the* nEXO Collaboration

CAP Congress

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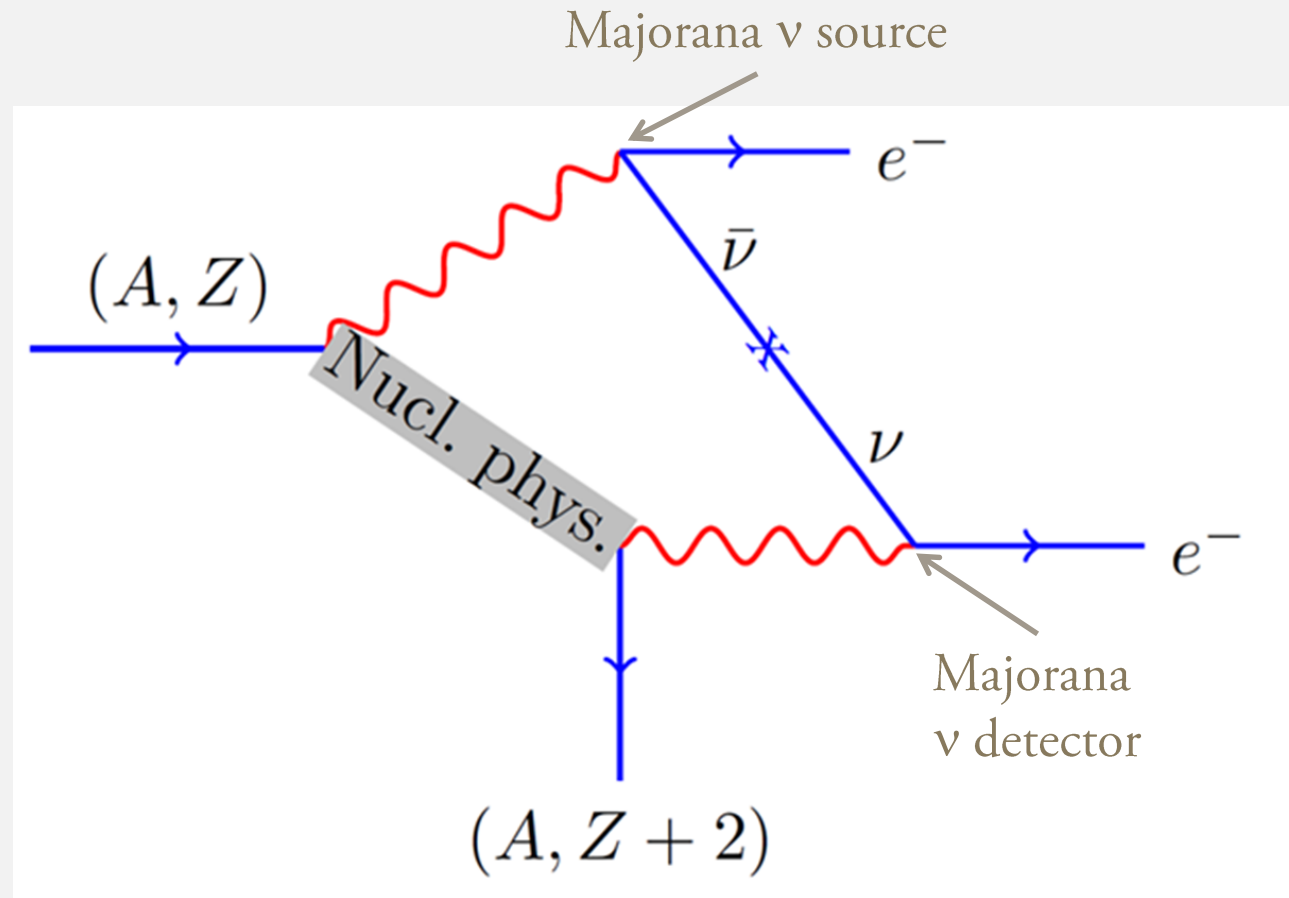
# Neutrinoless Double-Beta Decay

Discover of Majorana particles!

Probe mass mechanism at the  
GUT scale.

Probe key ingredient in  
generating the cosmic baryon  
asymmetry.

Not allowed by Standard Model  
Violation of lepton number conservation

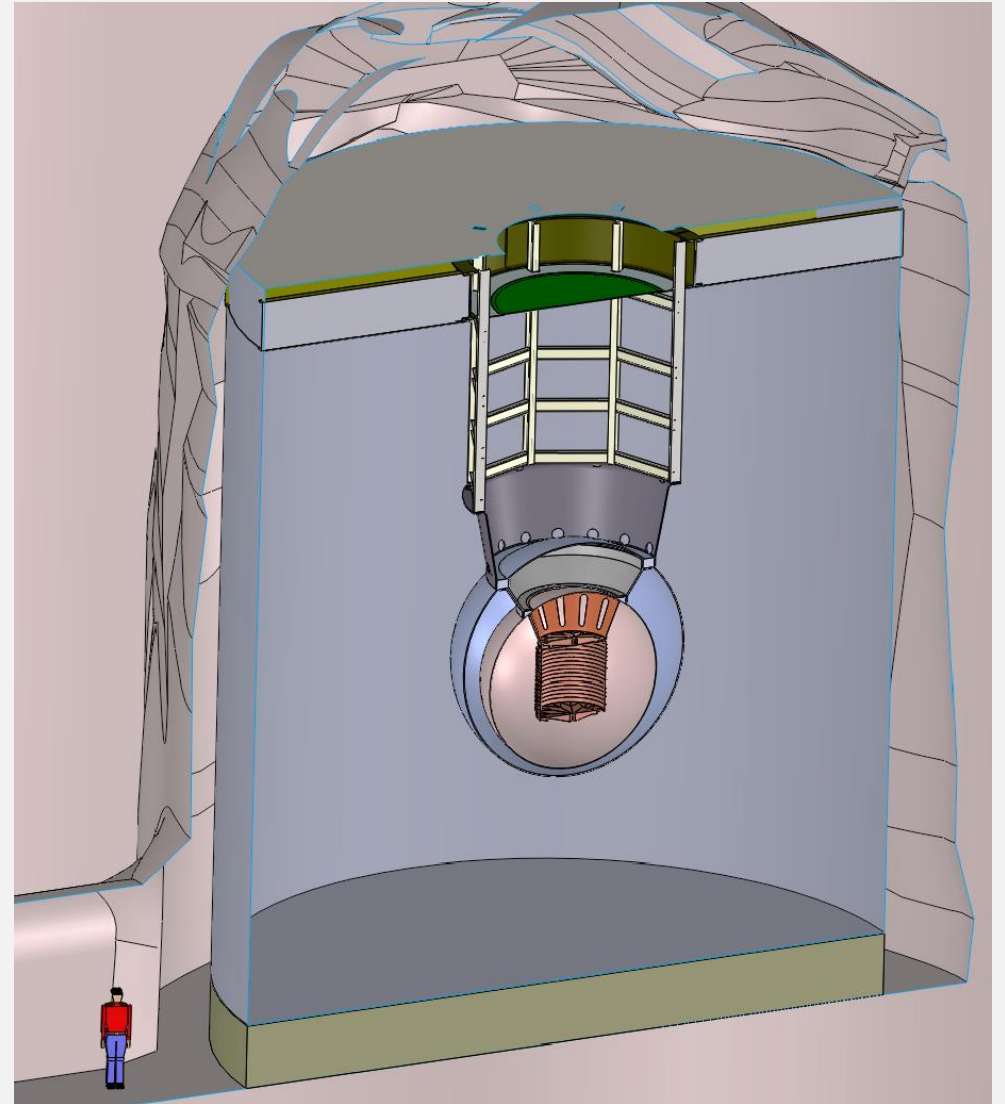


The EXO Program:  
Tonne-scale **nEXO** at **SNO LAB**

Depicted, here, in the cryopit

Projected sensitivity

$$t_{1/2}^{136\text{Xe}} \gtrsim 1 \times 10^{28} \text{ yr}$$



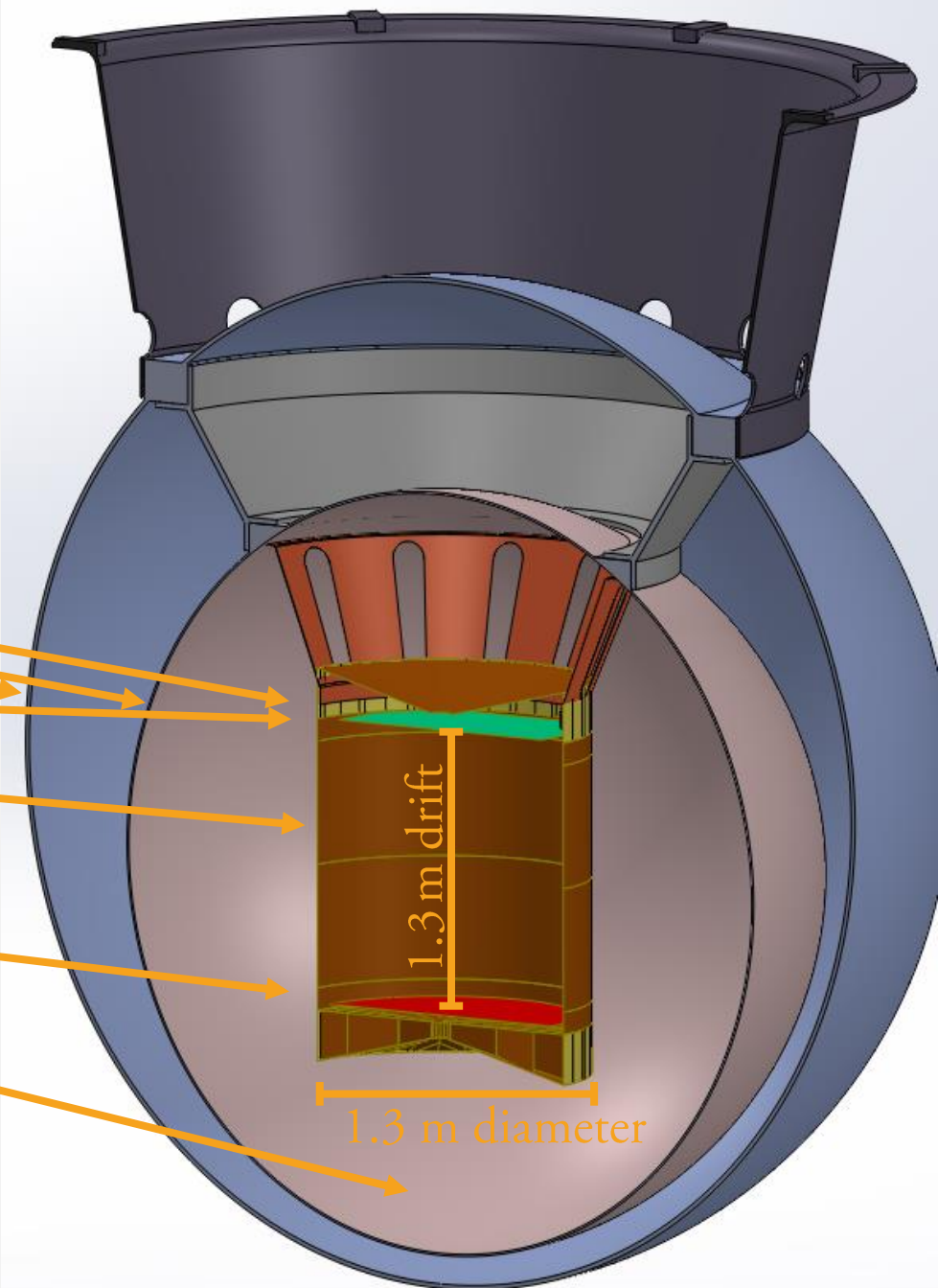


5 t Scale LXe

Absolutely...  
the wrong approach:  
30 EXO-200s!

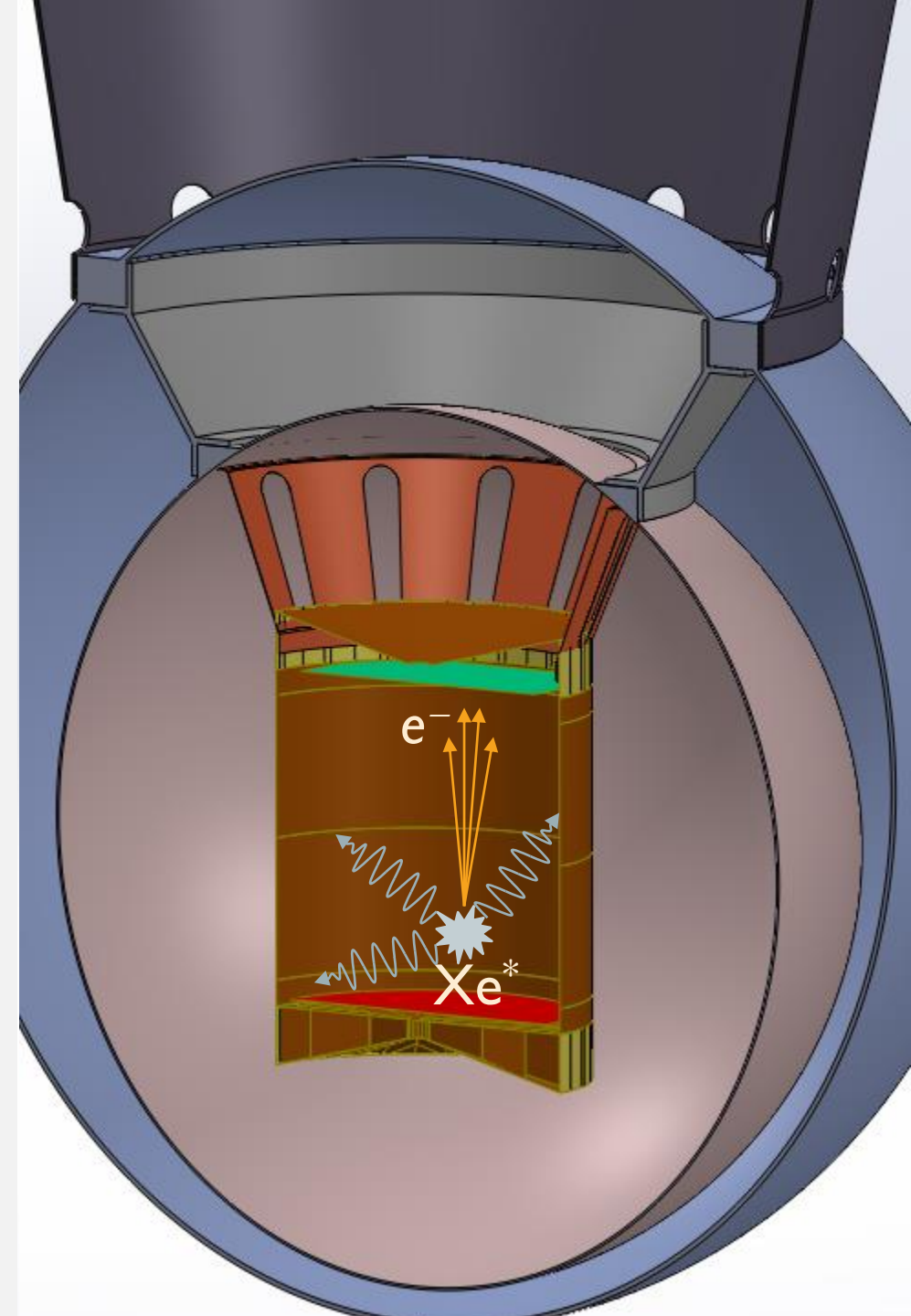
## 5 t Homogeneous nEXO Concept

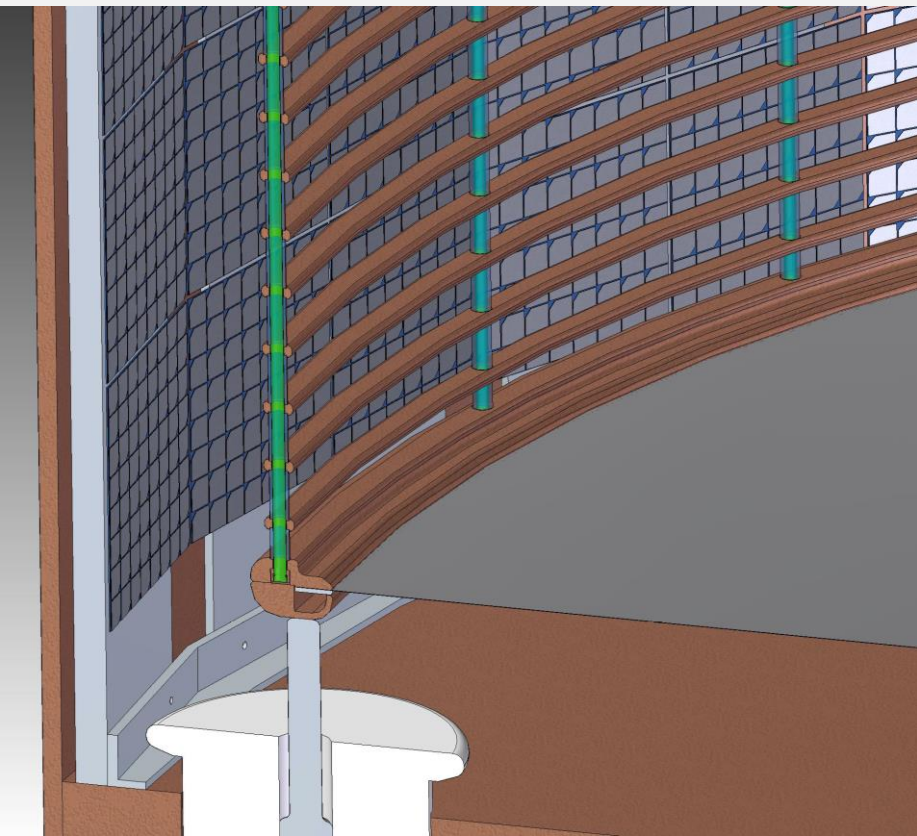
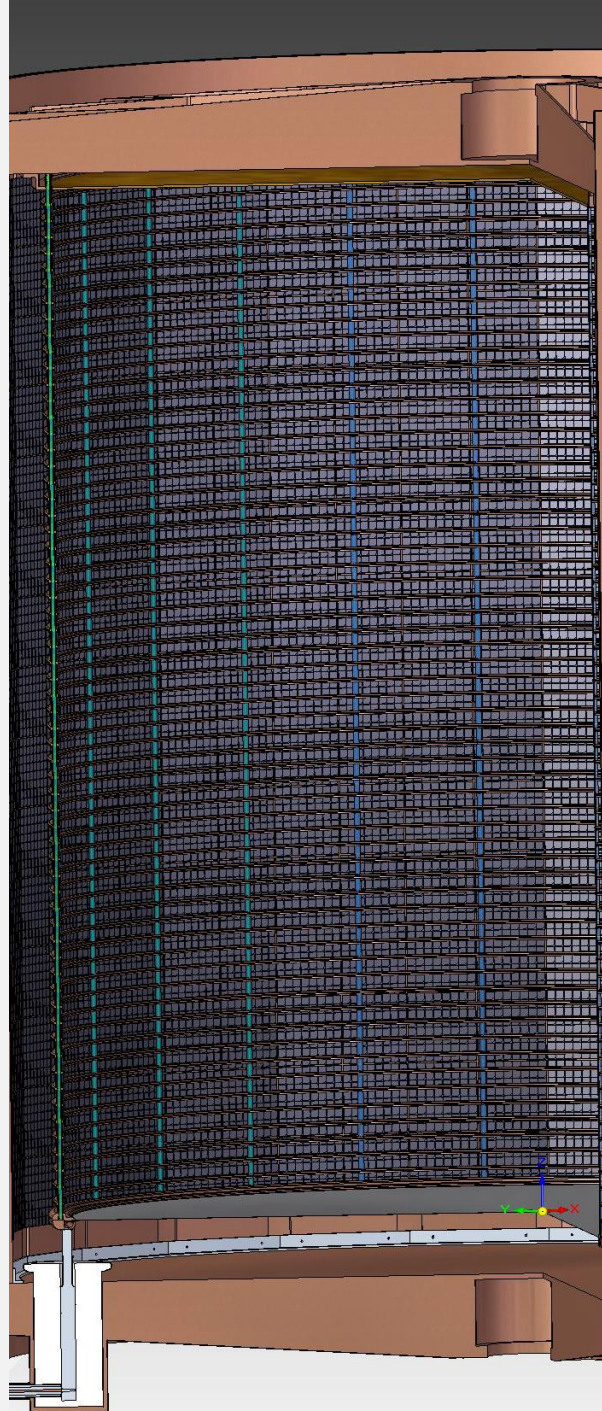
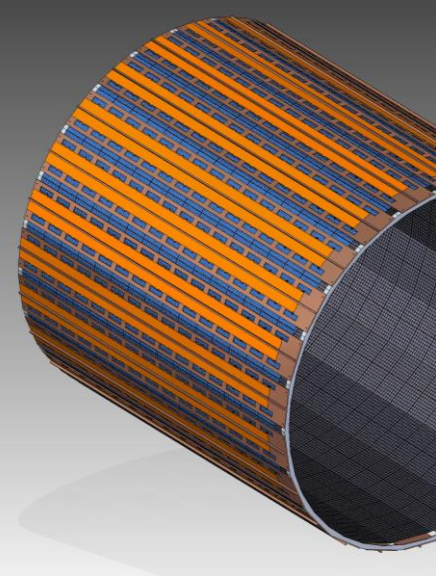
- Cold (in LXe) front end electronics.
- Spherical carbon fiber cryostat (lighter than copper).
- $(\sim 3\text{ mm})^2$  charge readout pads (anode).
- $4\text{ m}^2$  SiPM staves lining the inside of the barrel.
- Reflective cathode.
- Liquid cryogen (HFE-7000).
- 1.3 m diameter.
- 1.3 m maximum drift length.



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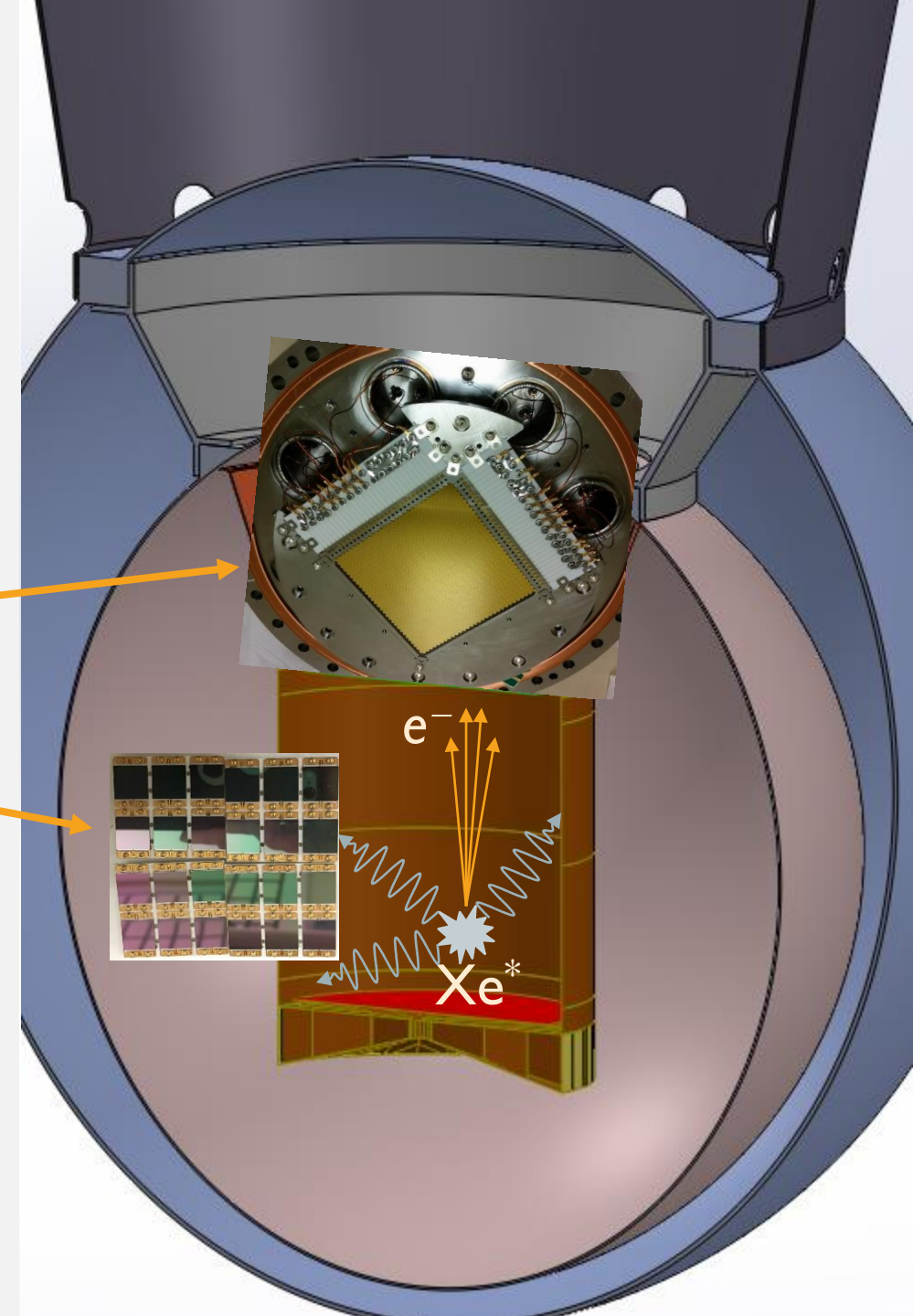
## Advanced TPC Model

- APDs to high gain SiPMs
- Increased photocathode coverage
- Reflective cathode



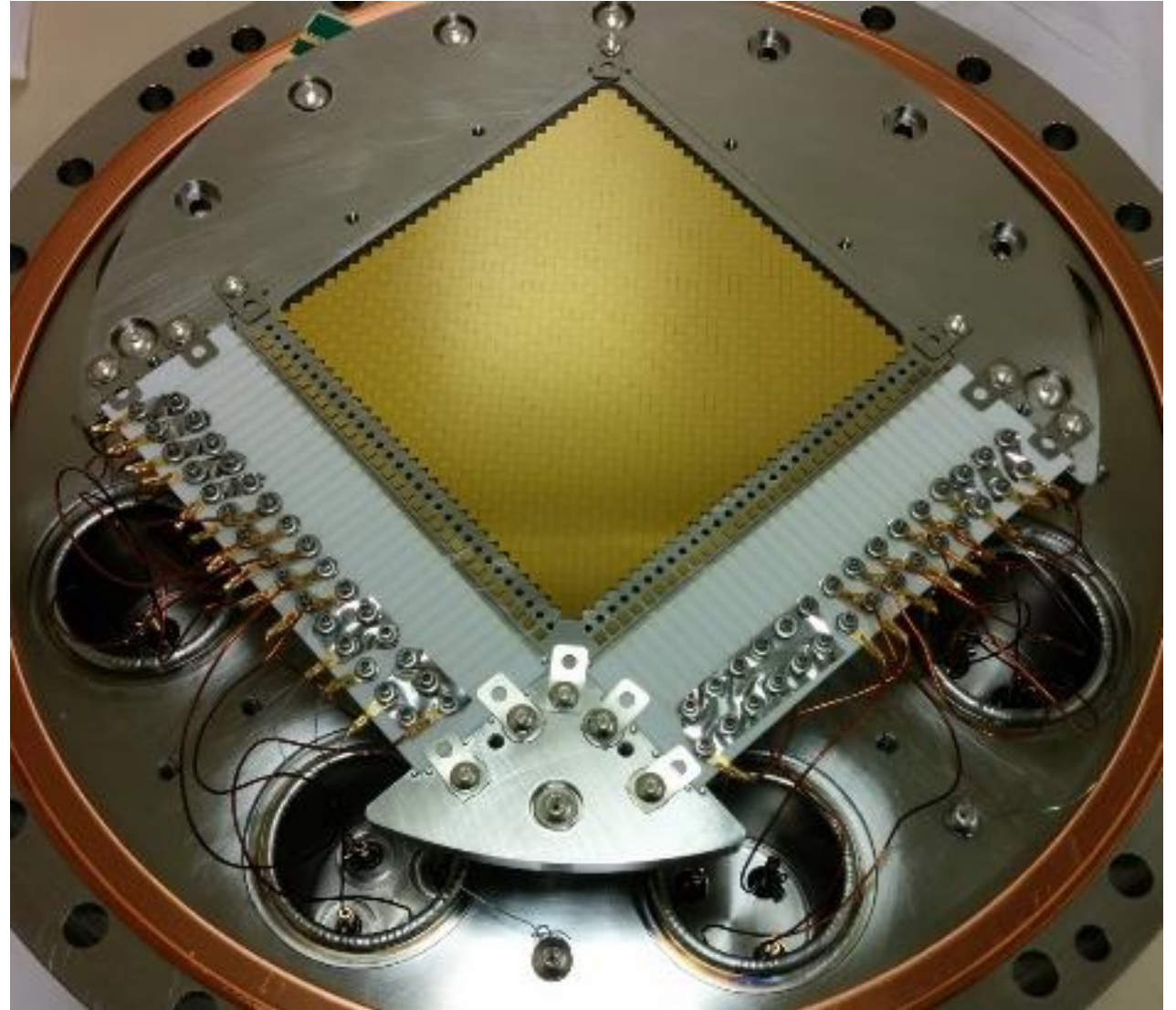
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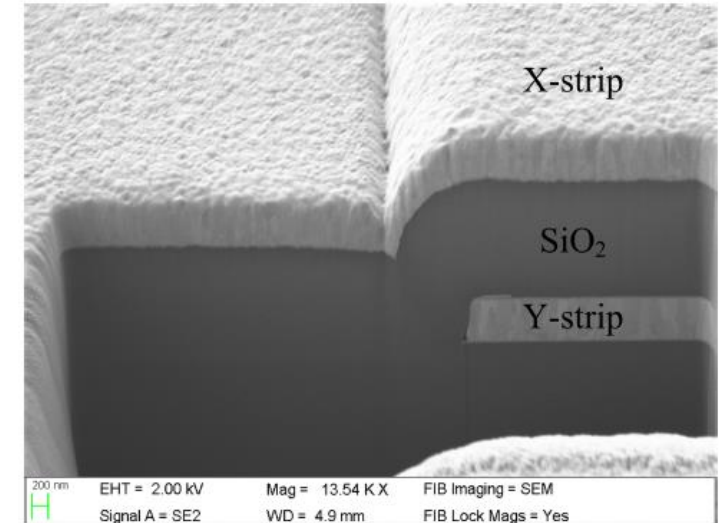
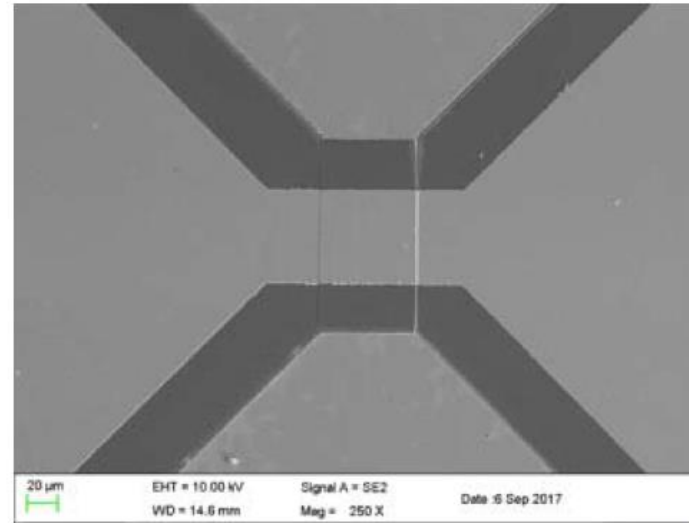
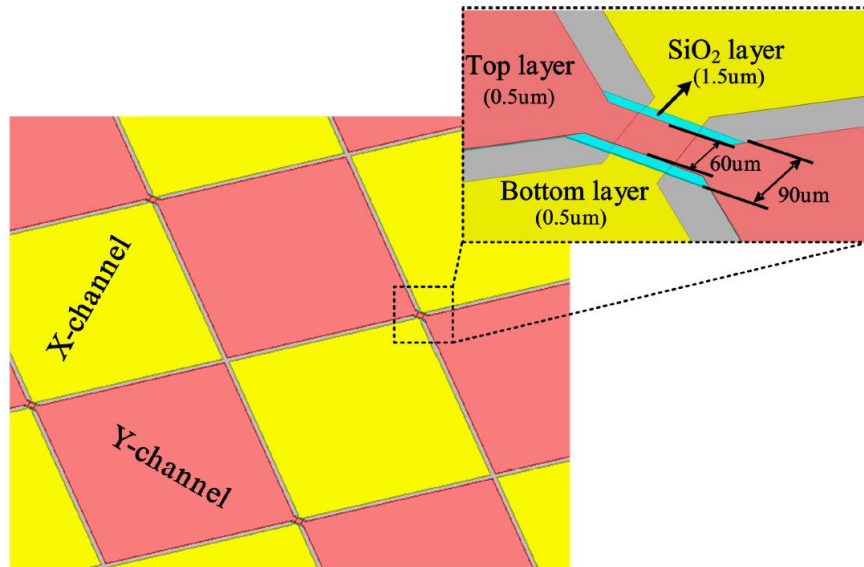


## Charge Readout Tiles

Crossed metallic strips on  
dielectric substrate

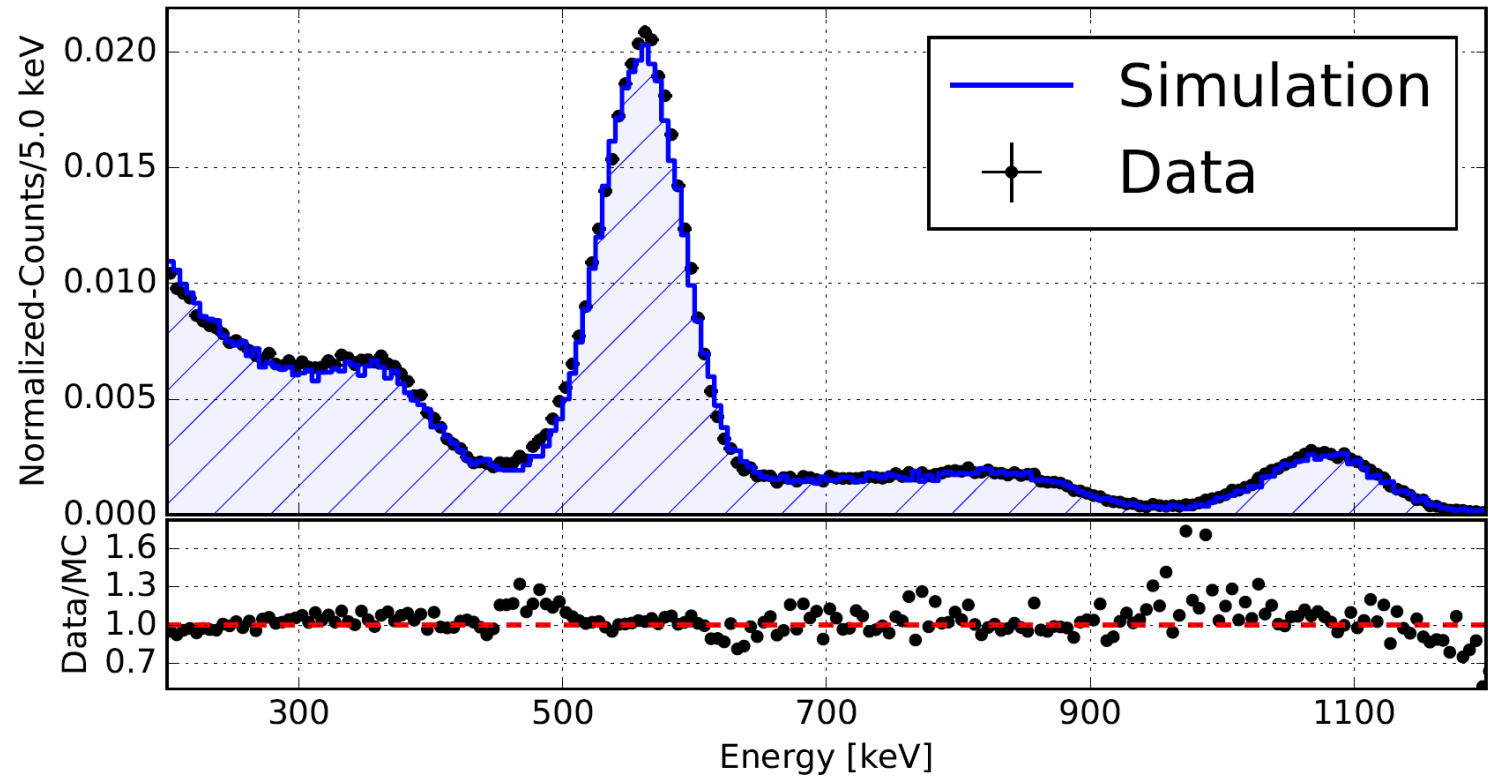
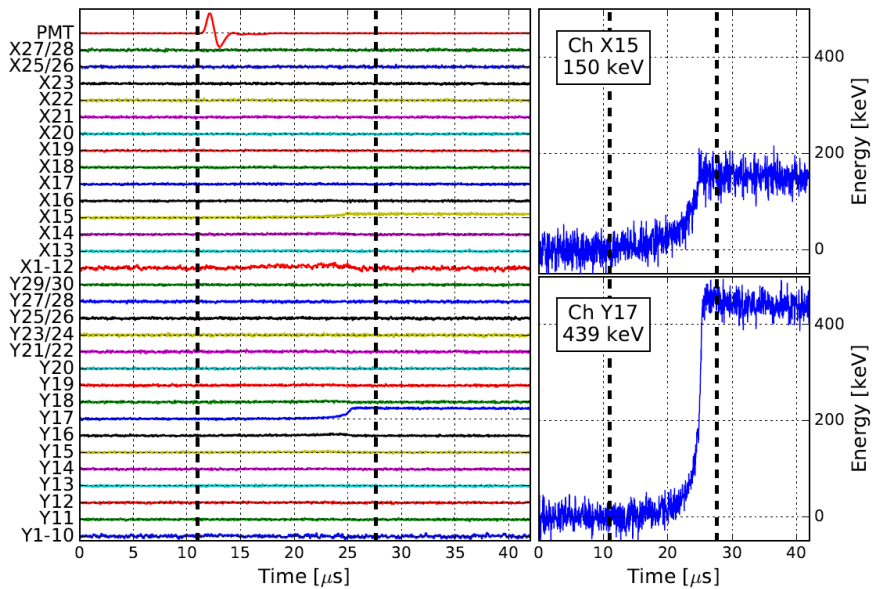


- Maximal pad coverage for minimal capacitance.
- 3mm center to center pitch.
- No Frisch grid.



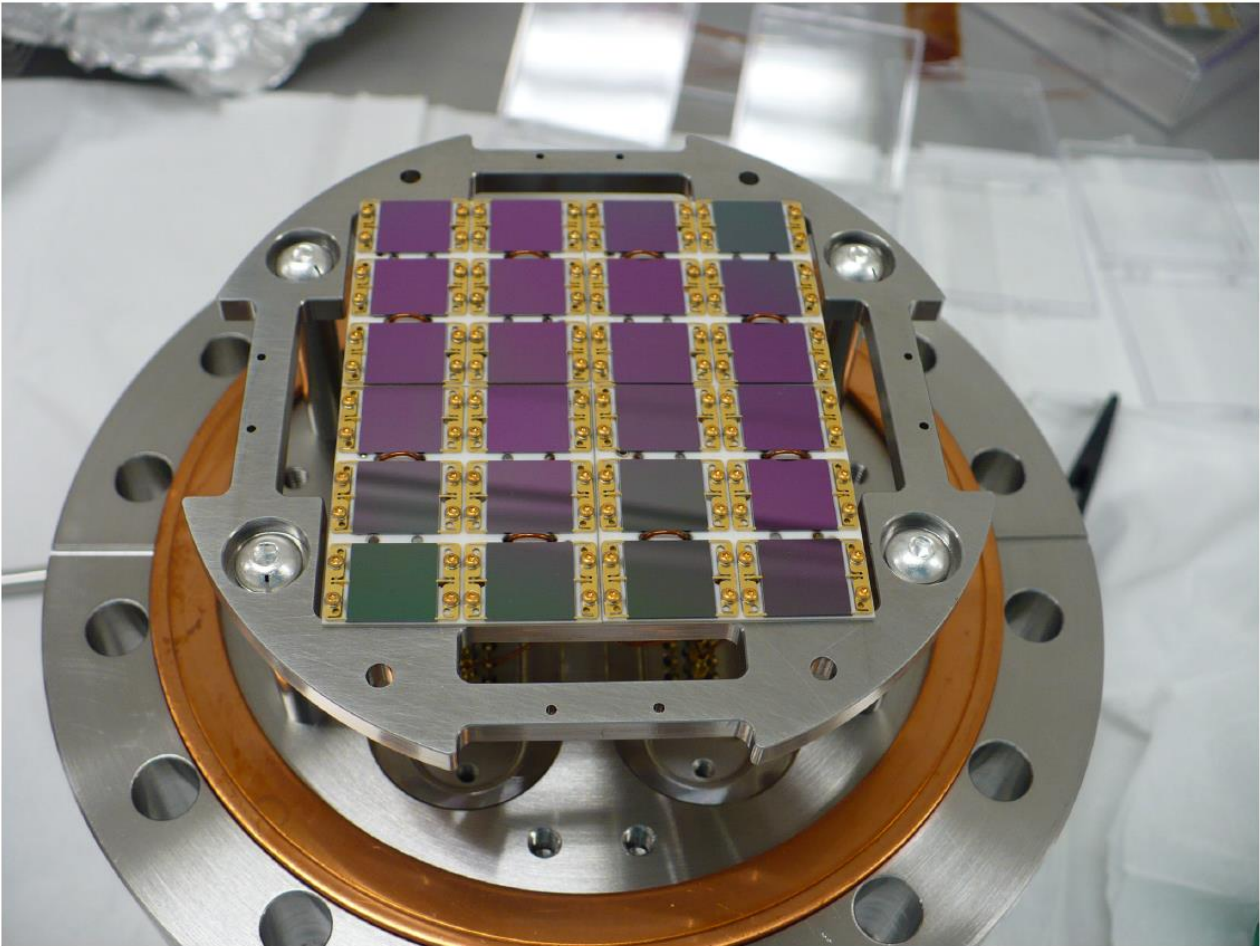
arXiv:1710.05109

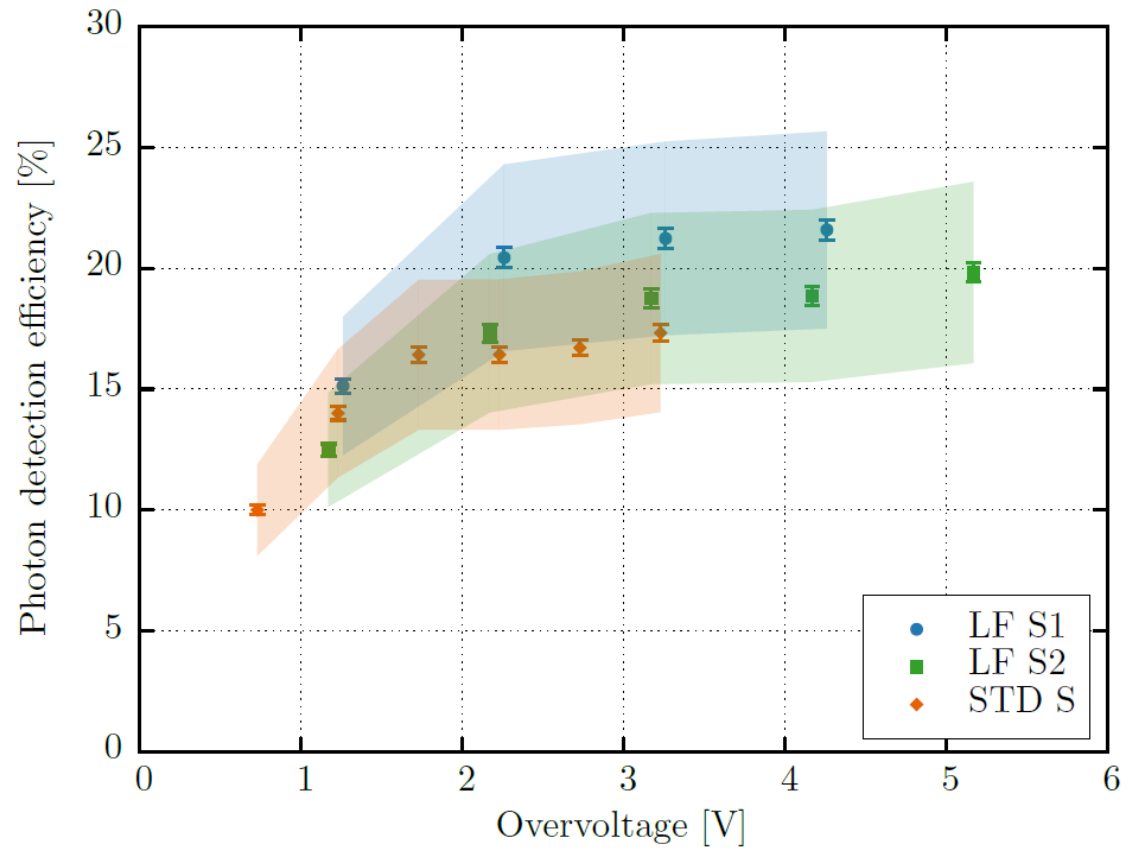
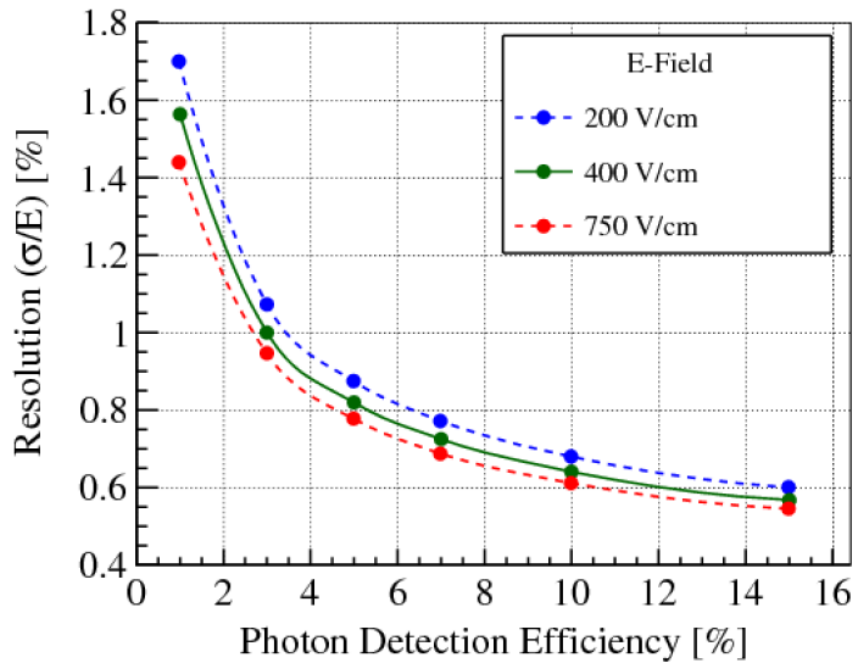
Charge only energy resolution:  
 $\sigma_E/E = 5.6\%$  at 570 keV  
(consistent with expectation)



arXiv:1710.05109

SiPM

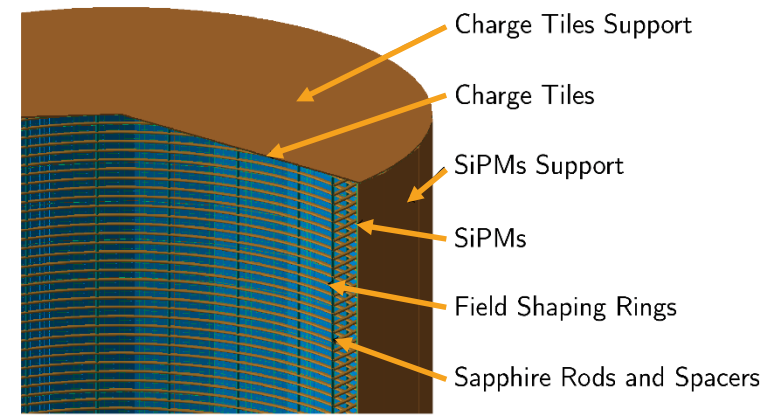
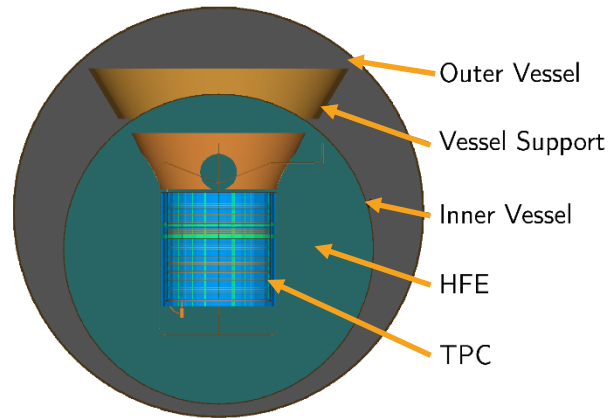




arXiv:1806.02220



nEXO has an official logo!



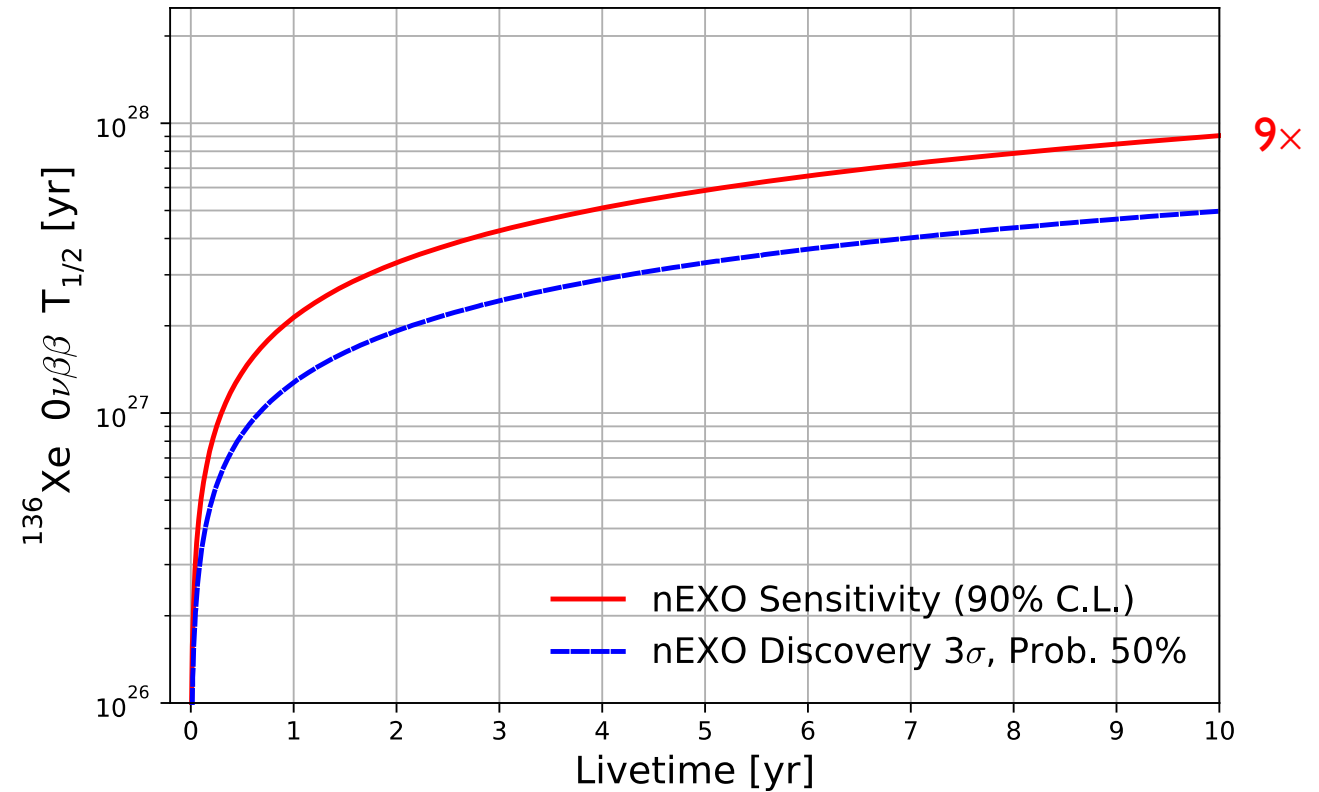
## nEXO Simulation



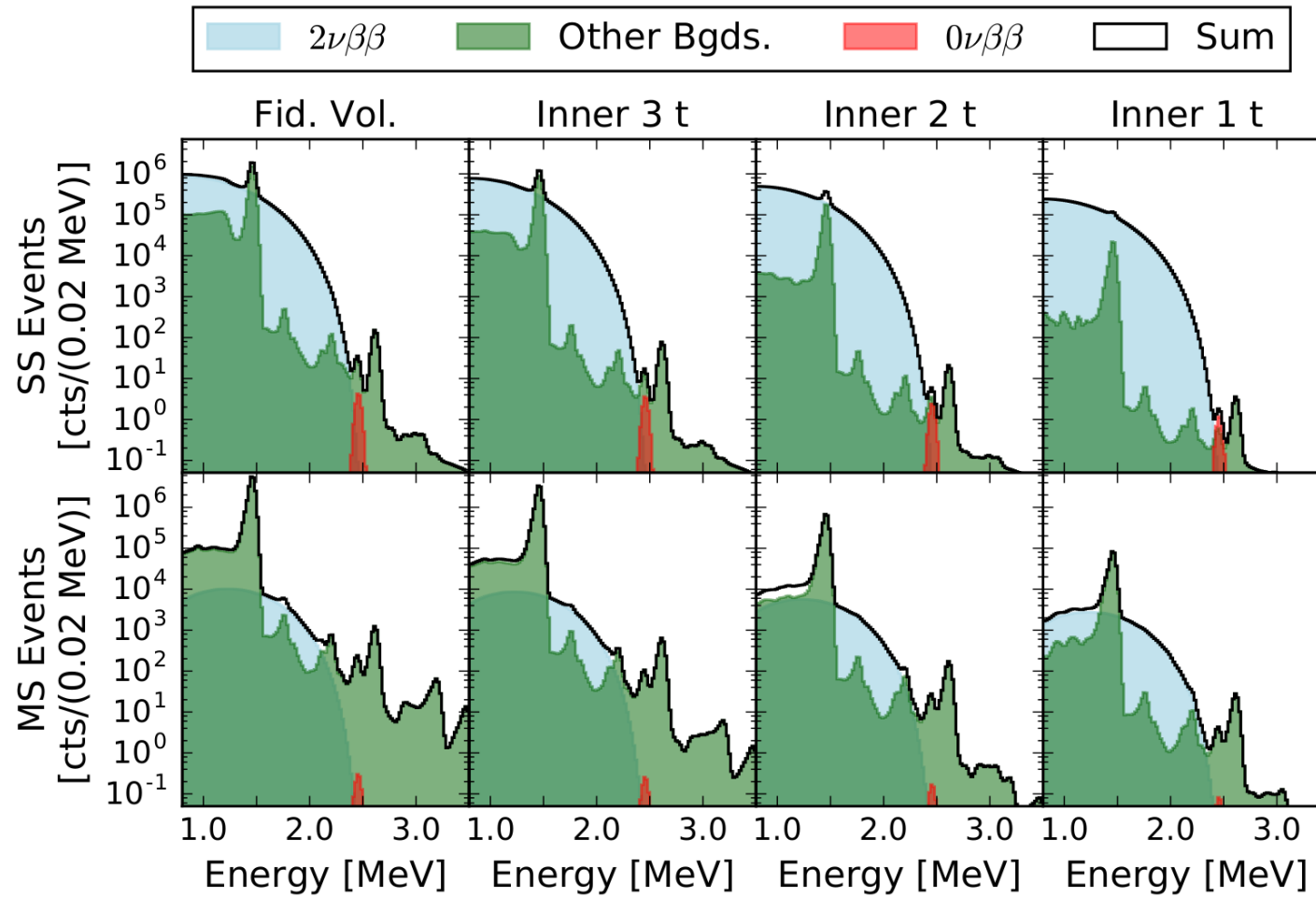
Baseline design that assumes:

- ONLY existing materials
- 1% energy resolution
- 2× improvement in SS/MS discrimination

nEXO  
Sensitivity  
and Discovery  
Potential

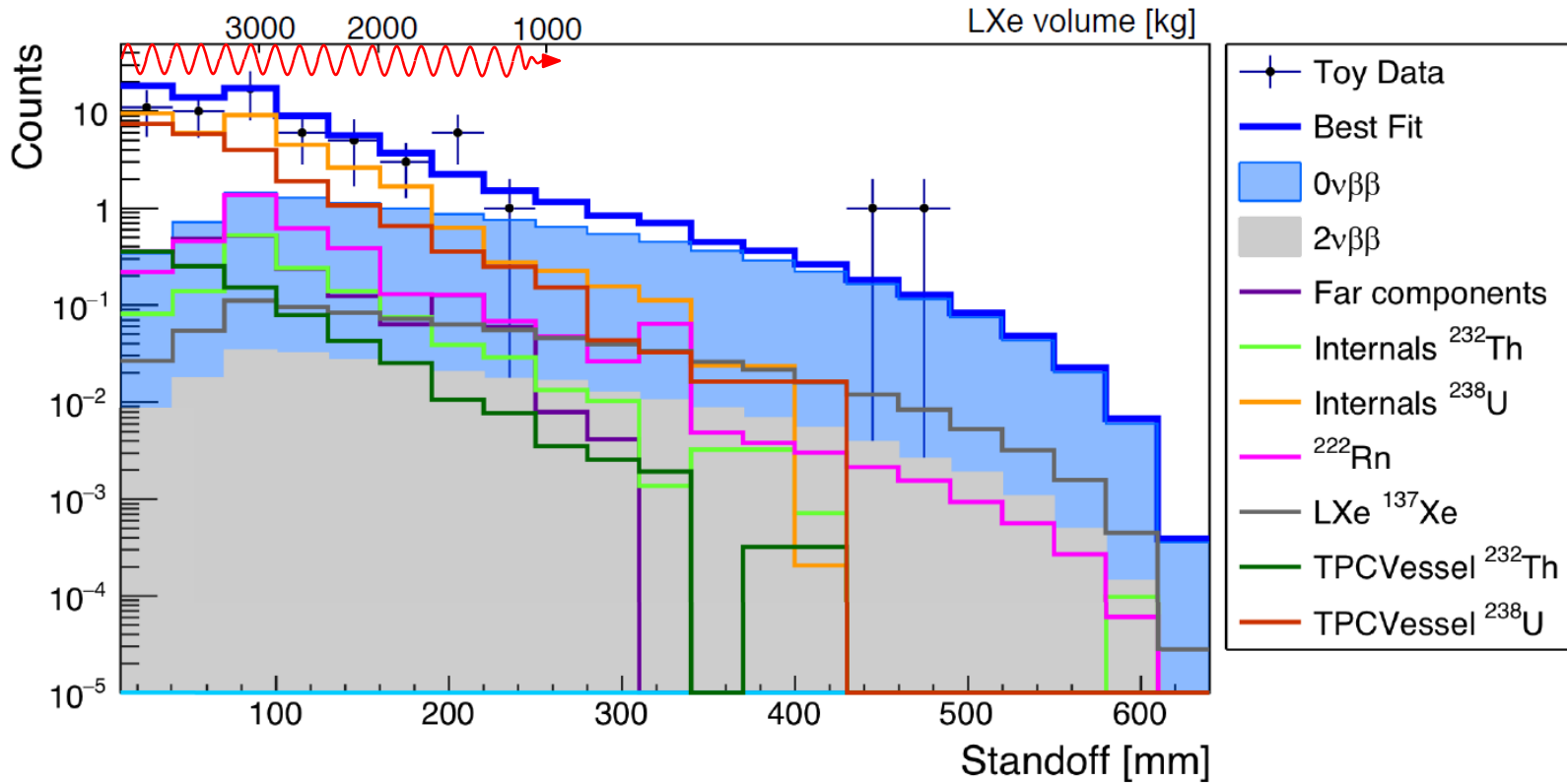


# RESULT: 10 Years of nEXO Expected Spectra



For 10y livetime  
and neutrinoless double  
beta decay half-life:  
 $t_{1/2} = 5 \times 10^{27} \text{ y}$

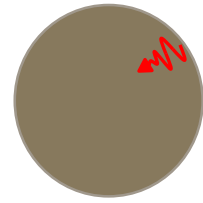
$\sim 7$  attenuation lengths for a 2.5 MeV  $\gamma$ -ray into reach center.



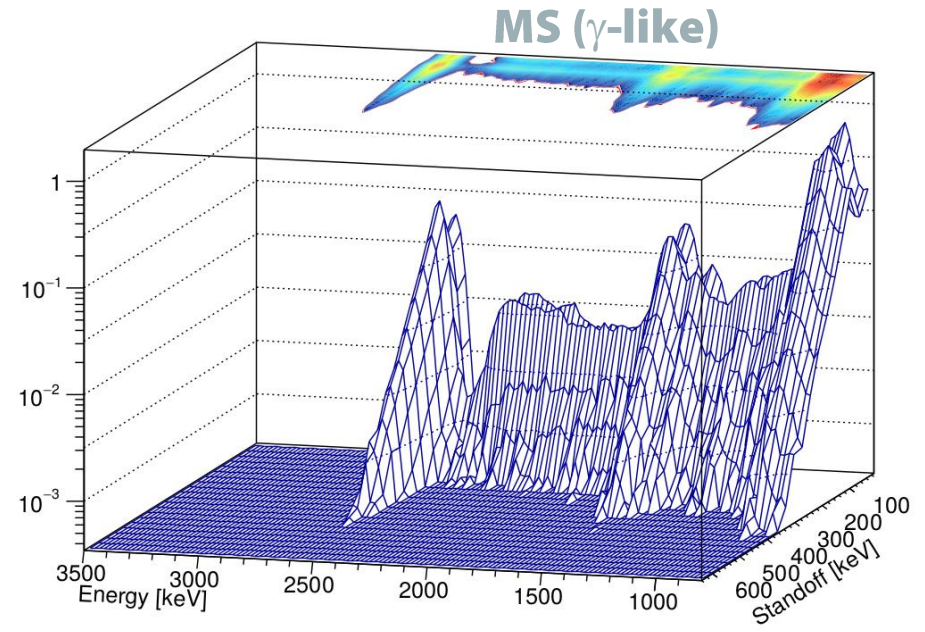
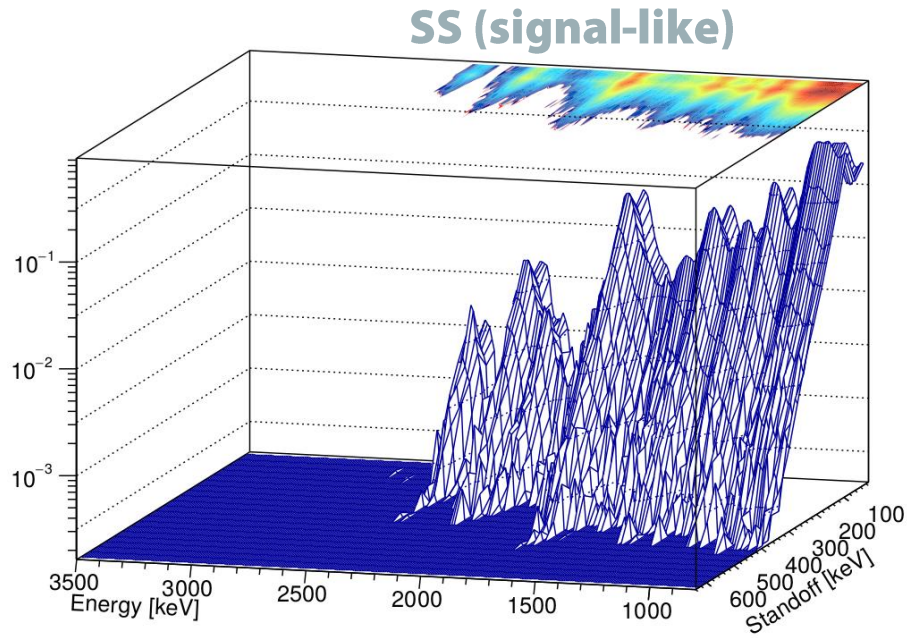
10 Years of nEXO

Standoff distribution  
around 2458 keV

2.5 MeV  $\gamma$ -ray attenuation length

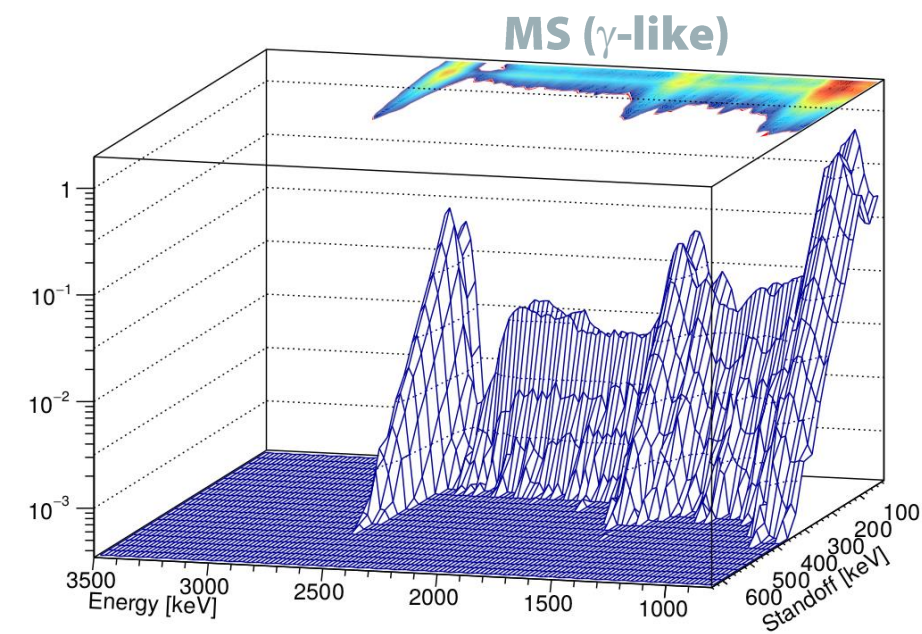
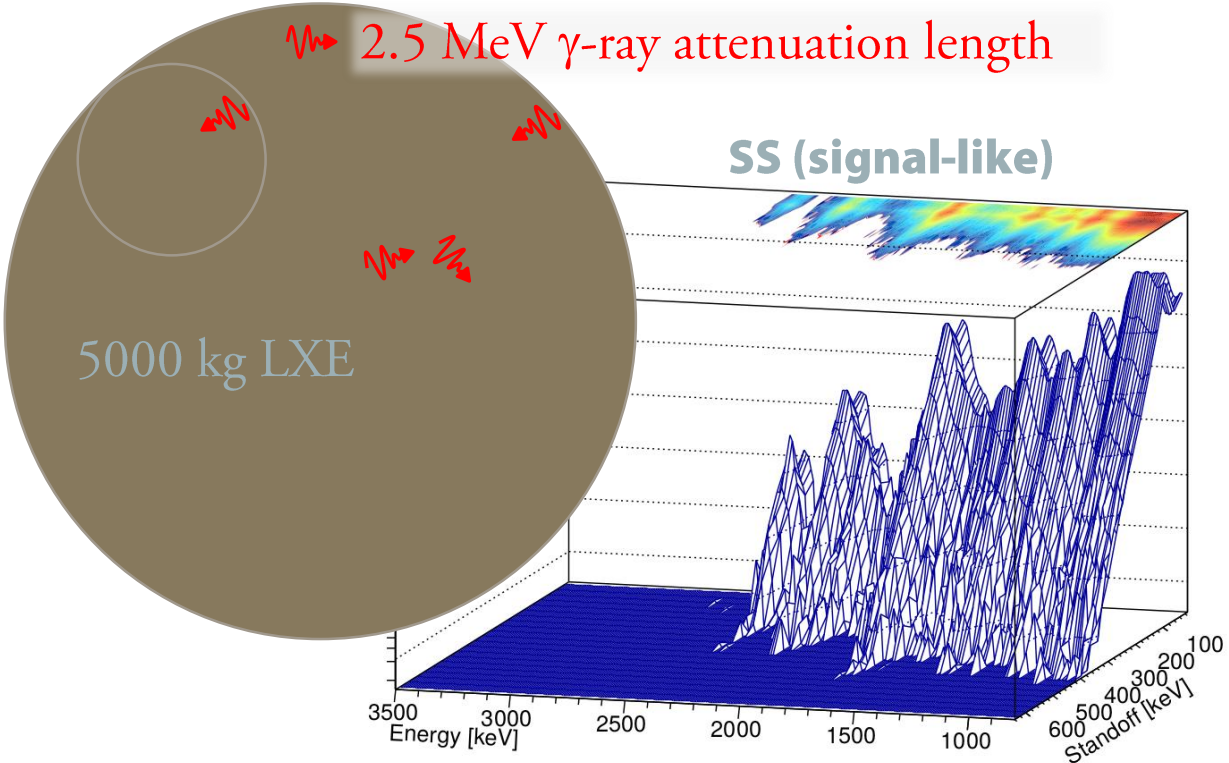


150 kg LXe



# 10 Years of nEXO

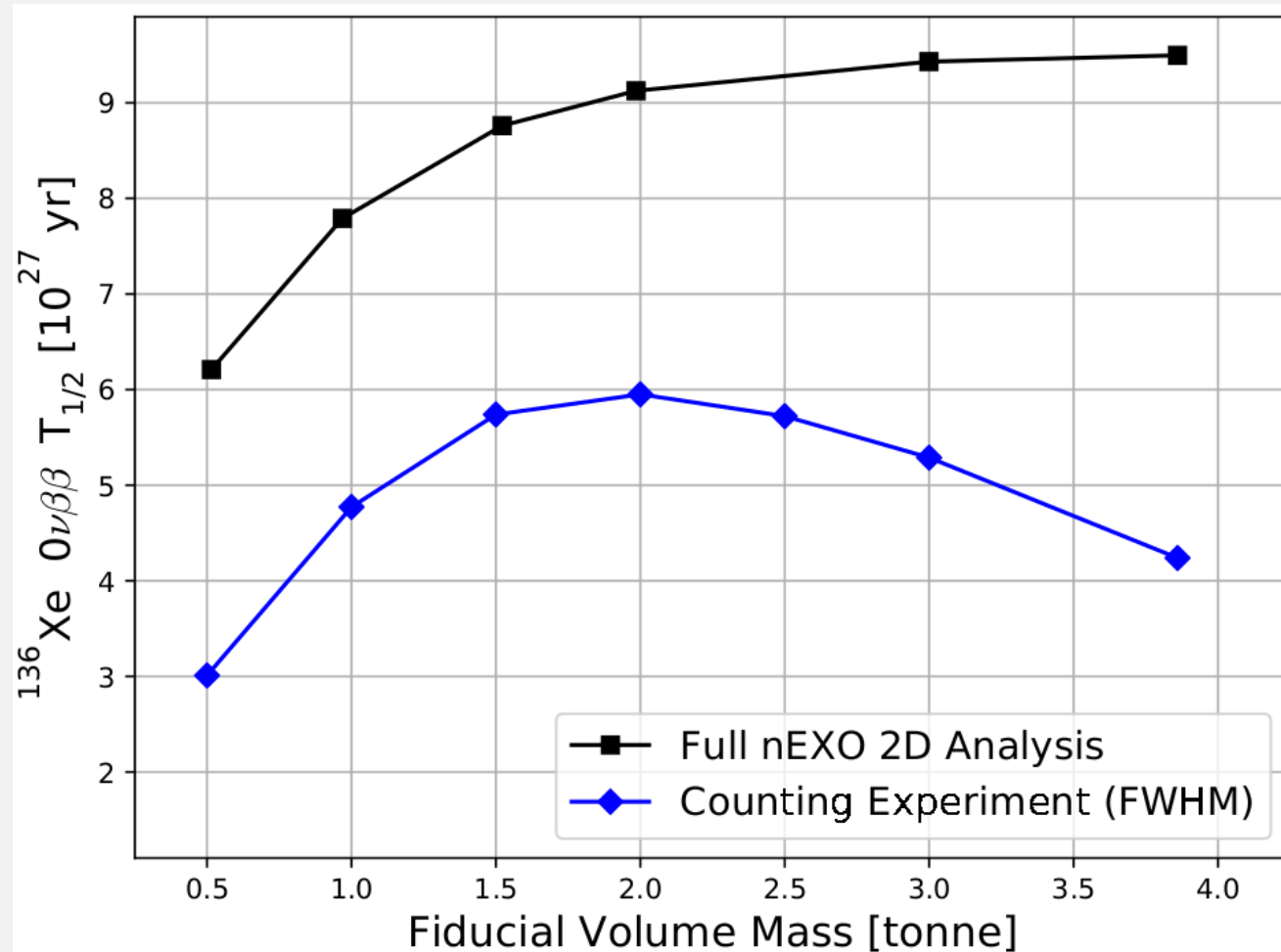
TPC vessel internals  $^{238}\text{U}$  and  $^{232}\text{Th}$  backgrounds



# 10 Years of nEXO

TPC vessel internals  $^{238}\text{U}$  and  $^{232}\text{Th}$  backgrounds

No Xenon  
Shield



## Summary

1. EXO-200 has demonstrated the power of a large and homogeneous LXe TPC.
2. Candidate materials of suitable radiopurity have all already been identified.
3. With 1% energy resolution, a factor of 2 improvement in MS discrimination a detailed detector model projects the sensitivity of nEXO to reach  $\sim 10^{28}$  yr (see for a detailed review).
4. R&D on all nEXO systems is progressing rapidly. An exhaustive review has recently been published in our pre-“Conceptual Design Report”.
5. Barium tagging effort (a possible upgrade to nEXO) producing exciting results.

nEXO  
Background-free  
Sensitivity

Within reach with  
barium tagging

