Characterization of NDBD detection effectiveness of LZ using CNN classification

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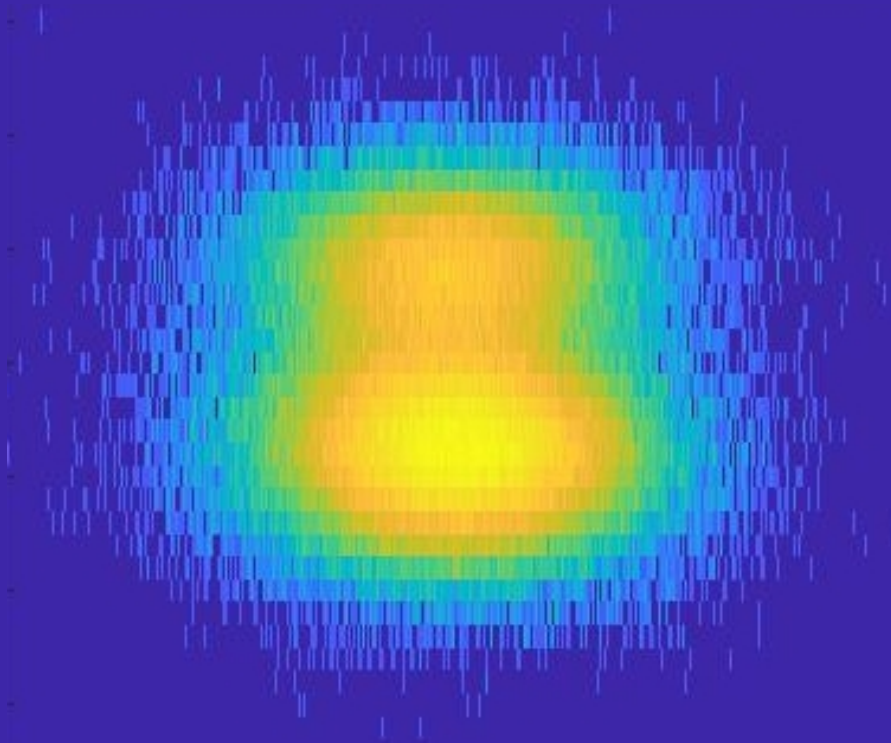

1st meeting of BigDataHEP - LIP
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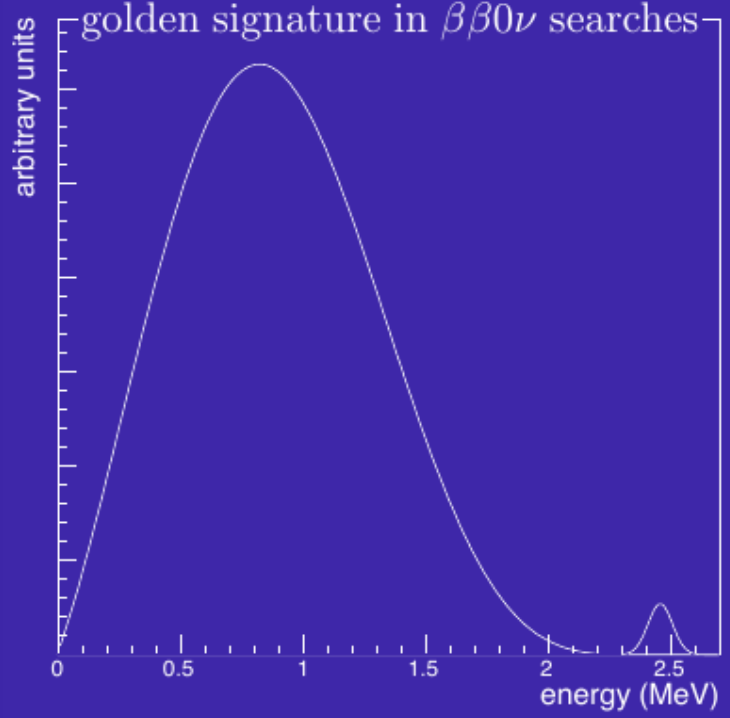
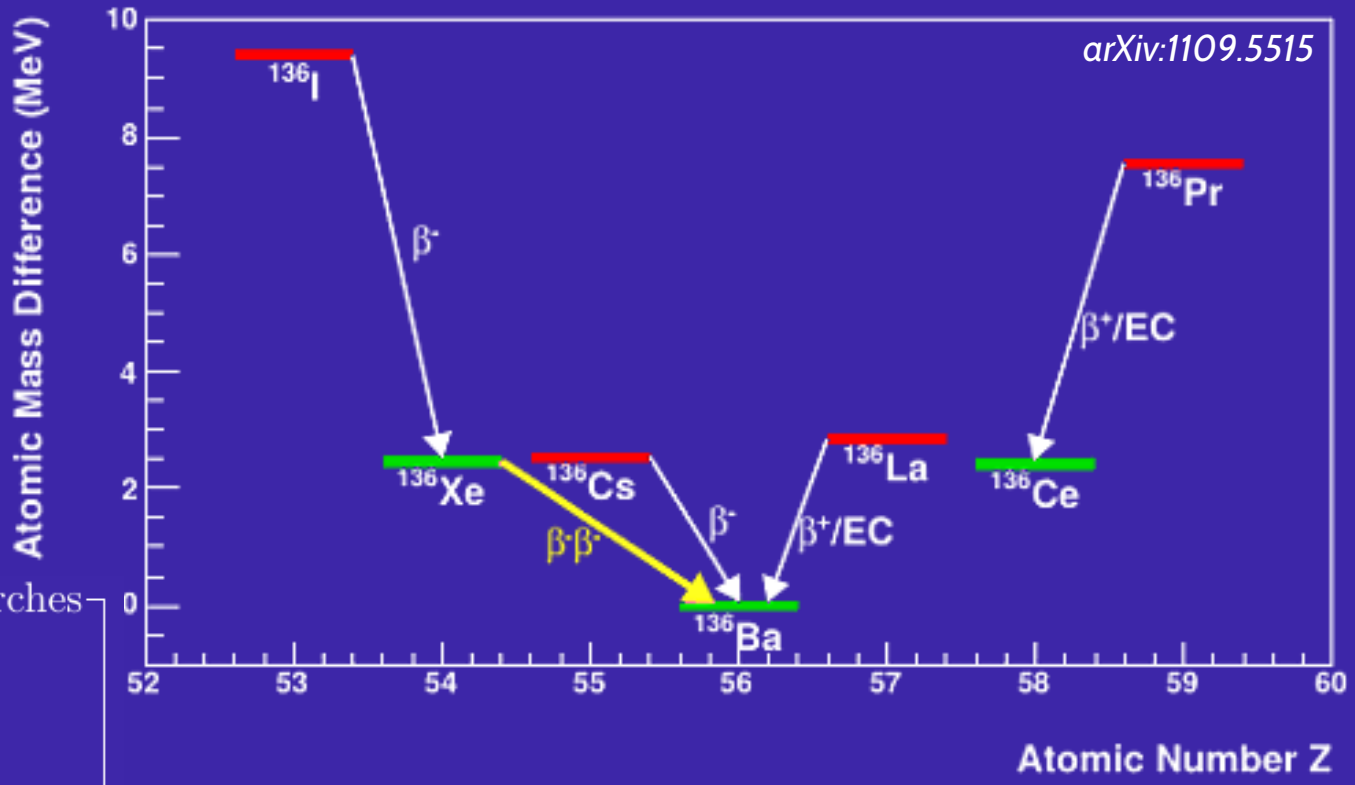
LIP

contents

Xe NDBD - mechanism



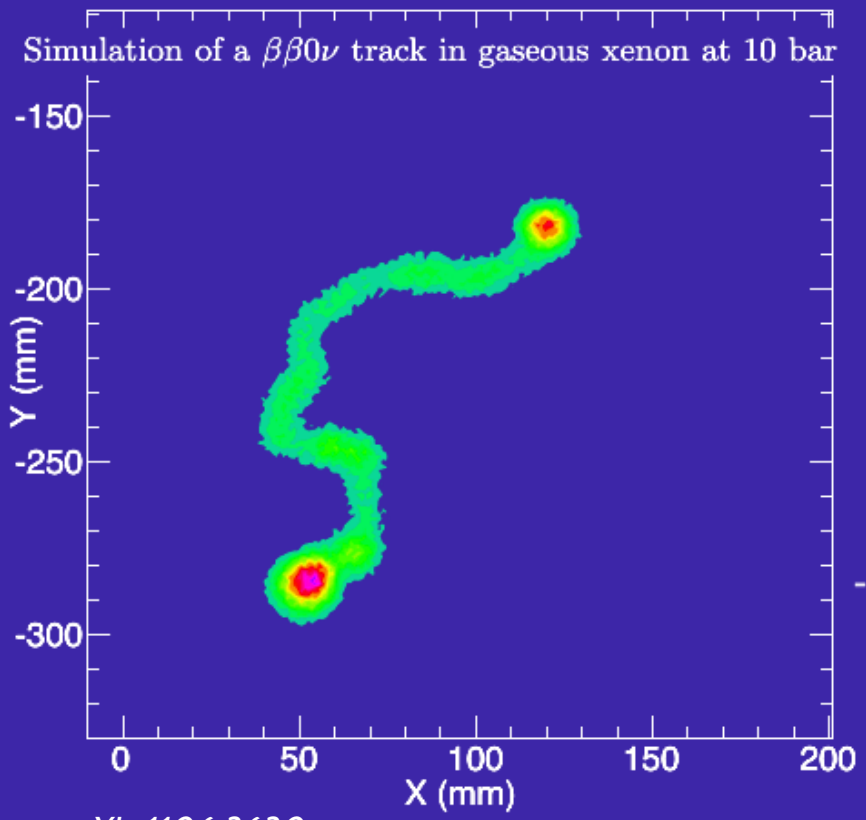
arXiv:1106.3630



- $T^{2\nu}_{1/2}$ for ^{136}Xe = 2.165 ± .075 x 10^{21} y [1]
- If Majorana ν : **NDBD possible**
- $T^{0\nu}_{1/2}$ for ^{136}Xe > 4.5 x 10^{23} y [2]
- $Q_{\beta\beta}$ = ~2.46 MeV

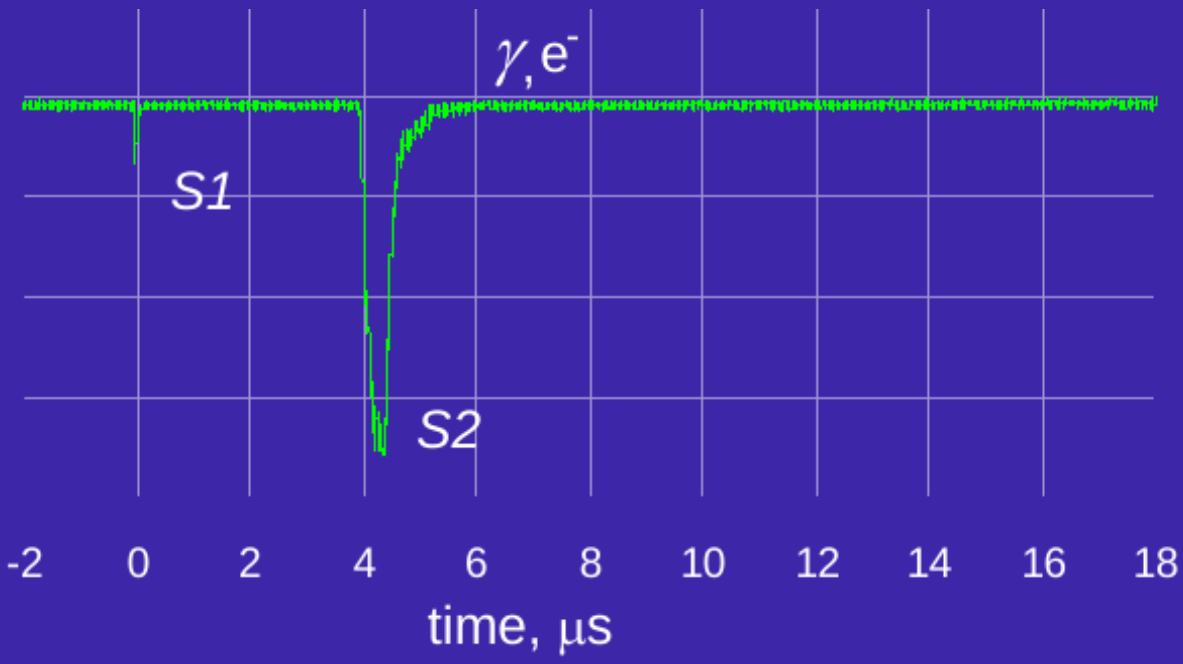
[1] Phys. Rev. C 89, 015502 (2014) , [2] Phys. Lett. B, 546 (2002) 23

Xe NDBD - characteristics



arXiv:1106.3630

arXiv:1207.2292



$(S2/S1)_{wimp} << (S2/S1)_{electron}$

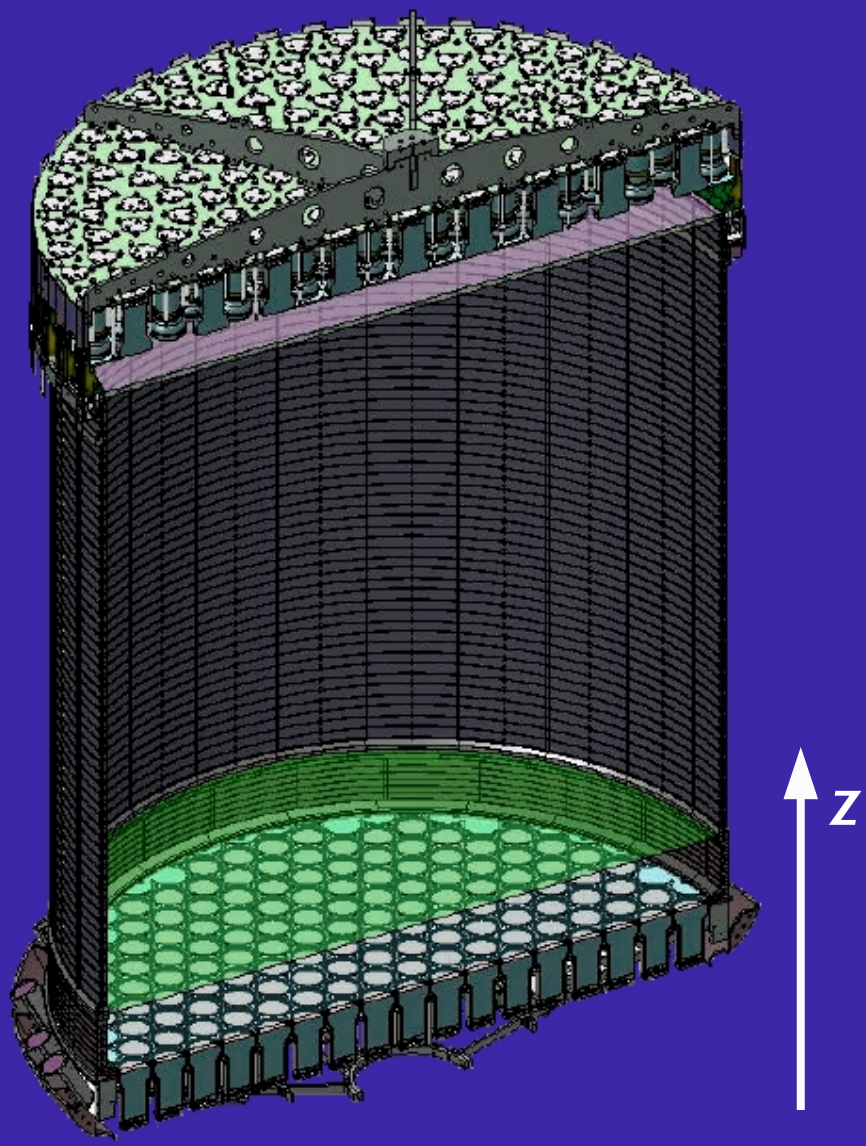
- *High and precise energy*
- *Topological signature (2 "blobs") affects S2*

NDBD in LZ - competitiveness

- *LZ uses natural LXe -> 8.857% ^{136}Xe*
- *apprx. DM fiducial LXe mass = 5.6t*
- *about 0.5t of ^{136}Xe, more than for any other experiment in the field*
- *25 keV energy resolution is competitive*
- *Maximum NDBD activity in LZ of 5.0 x 10^{3} y^{-1}*

Despite being optimized for low energy recoils from WIMPs, LZ still competitive at the energy ROI for NDBD

NDBD in LZ - challenges

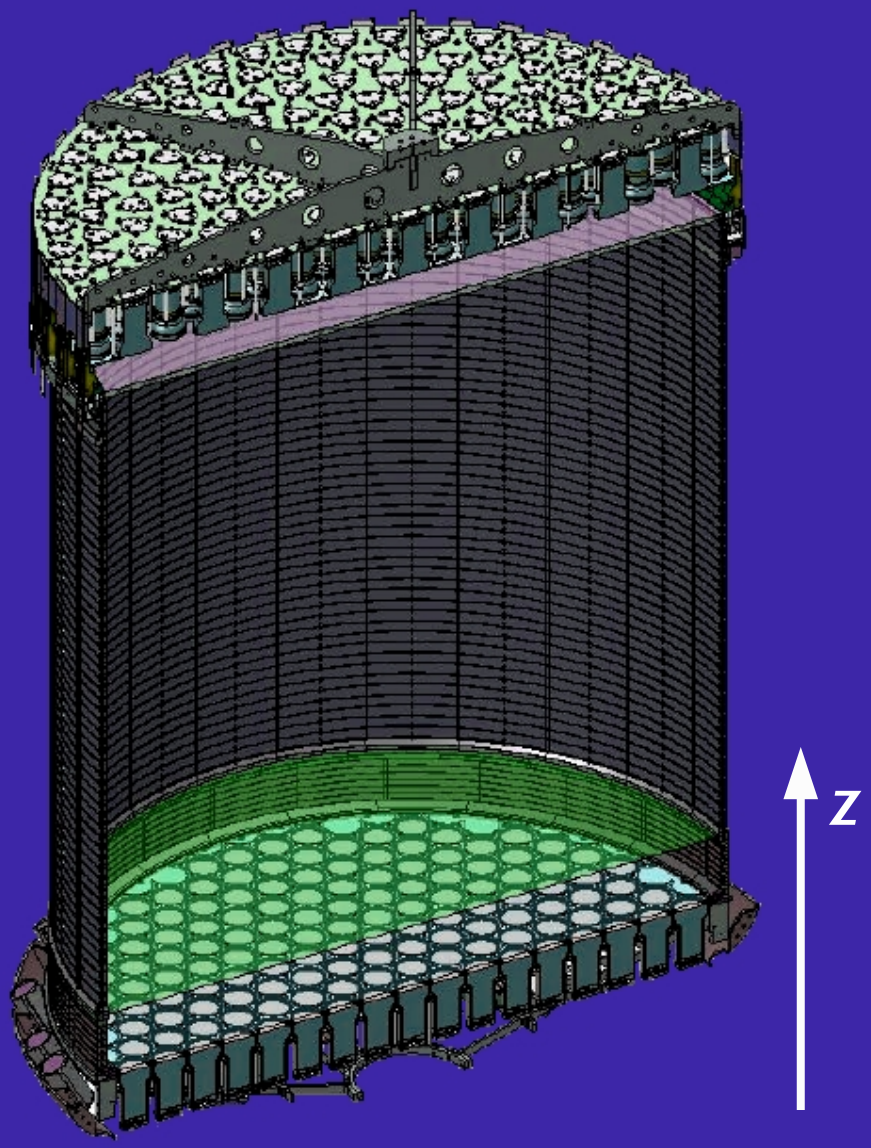


arXiv:1703.09144

- **LXe instead of gaseous Xe**
  - *Blobs close together (~6 mm)*
- **Diffusion**
  - *Loss of definition with depth*
- **False positives**
  - *Single electron 2.5 MeV events*
- **PMT array**
  - *PMT spacing limits xy reconstruction and resolution, as well as making the detectability depend on event orientation*

CNN can be advantageous because it examines input from an event holistically

Project Goals



arXiv:1703.09144

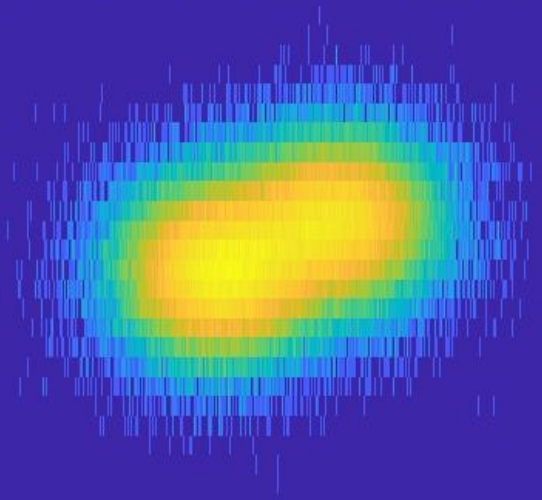
- Improve effectiveness of NDBD detection using discrimination methods
- Improve fiducial mass (depth)
- Reconstruction if possible

Method of Detection

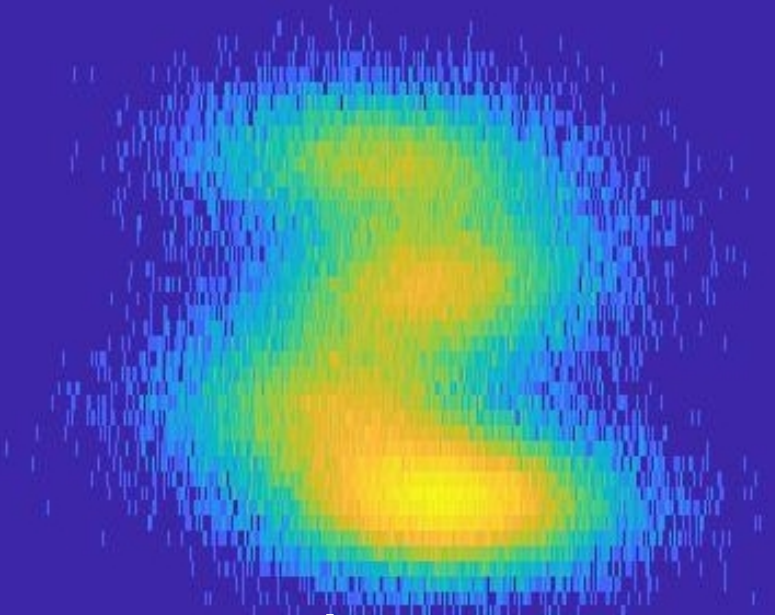
Two steps:

1) S2/S1 and energy windows

2) CNN binary classification



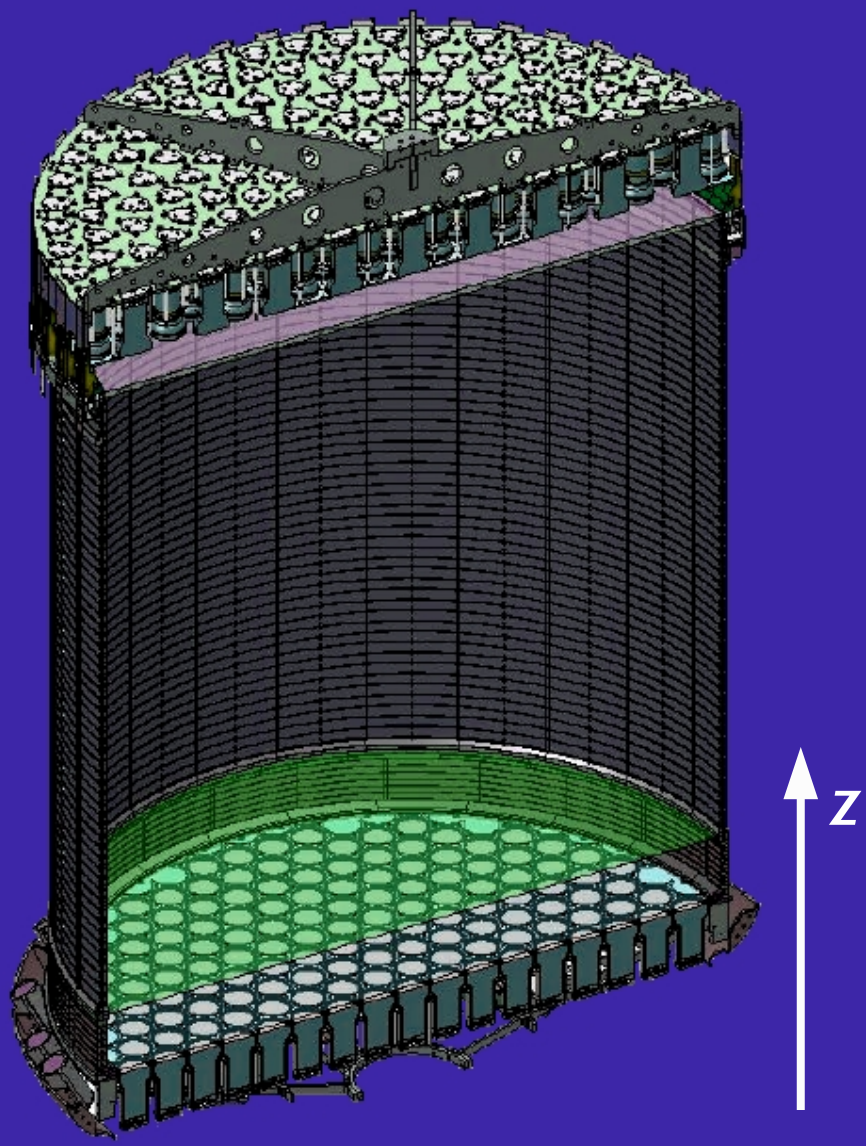
back-to-back NDBD electrons



single 2.5 MeV electron recoil *(background)*

(recoil electrons after 0.3 of TPC depth)

CNN Training Data



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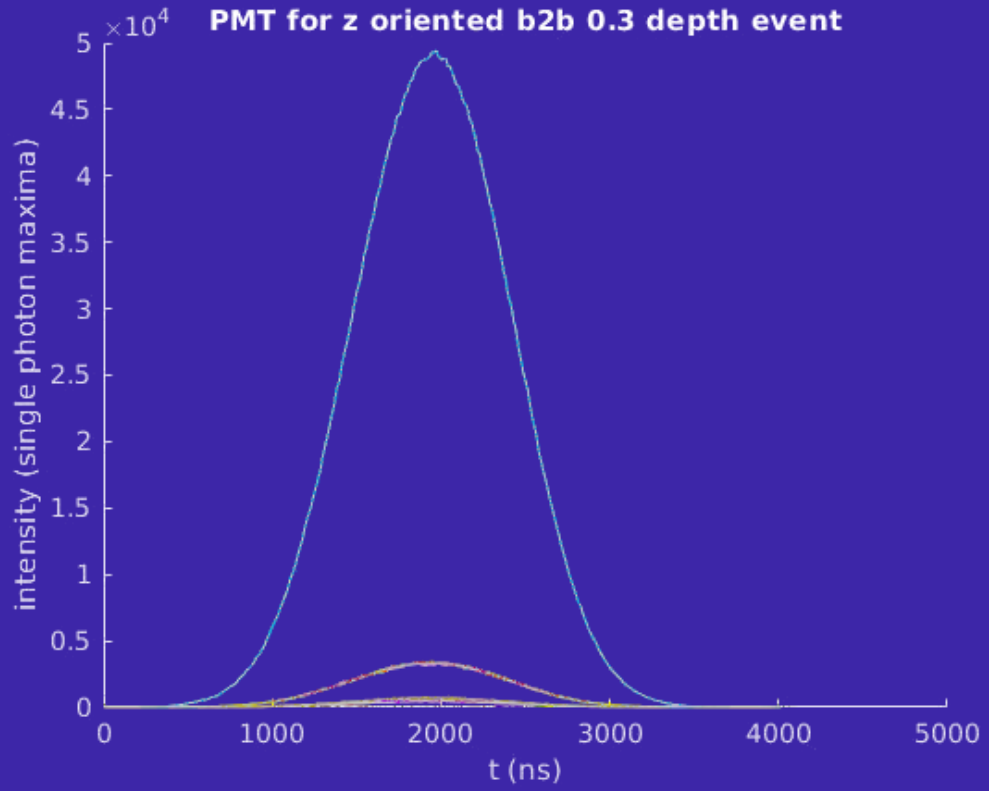
- **Recognize features by training with simulated samples representing ideal conditions first, then add complexity until realistic, finally use experimental data**
  - *event orientation*
  - *electric field*
  - *PMT configuration*

Current Status



- **Simulated waveforms are being generated under ideal conditions** *(uniform electric field in drift region, back to back z-oriented event).*
- **Currently implementing simulation into ANTS2, reducing simulation time.**

ANTS2 software package: https://github.com/andrmor/ANTS2

thank you.

NDBD in LZ - competitiveness

- LZ uses natural LXe -> 8.857% ^{136}Xe
- apprx. DM fiducial LXe mass = 5.6t

Experiment	$M_{\beta\beta}$ (t)	NDBD efficiency	Energy resoln. (keV)	Bgr/ROI (counts/y)
EXO-200	0.141	0.34	100	11 - 71
GERDA-1	0.0152	0.95	4.2	0.77 - 4.5
GERDA-2	0.0304	0.84	2	0.07 - 0.43
CUORE-0	0.0109	0.83	5	9.8 - 21.3
CUORE	0.206	0.83	5	37.1 - 134
KamLAND-ZEN	0.357	0.61	250	19.6 - 161
MAJORANA	0.0172	0.85	2	0.04 - 0.41
SNO+	0.044	0.50	220	87 - 680
NEXT	0.0892	0.33	18	0.32 - 1.6
SuperNEMO	0.007	0.28	130	0.55 - 5.5
LZ	**0.5**	???	**25**	???

Maximum NDBD activity in LZ of 5.0×10^3 y^{-1}