LEARNING FROM DATA: THE ZEN OF DEEP LEARNING IN KAMLAND

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LEARNING FROM DATA

Lectrure of Prof. Yaser Abu Mostafa, Caltech

Machine Learning is the field of study that gives computers the ability to learn without being explicitly programmed.

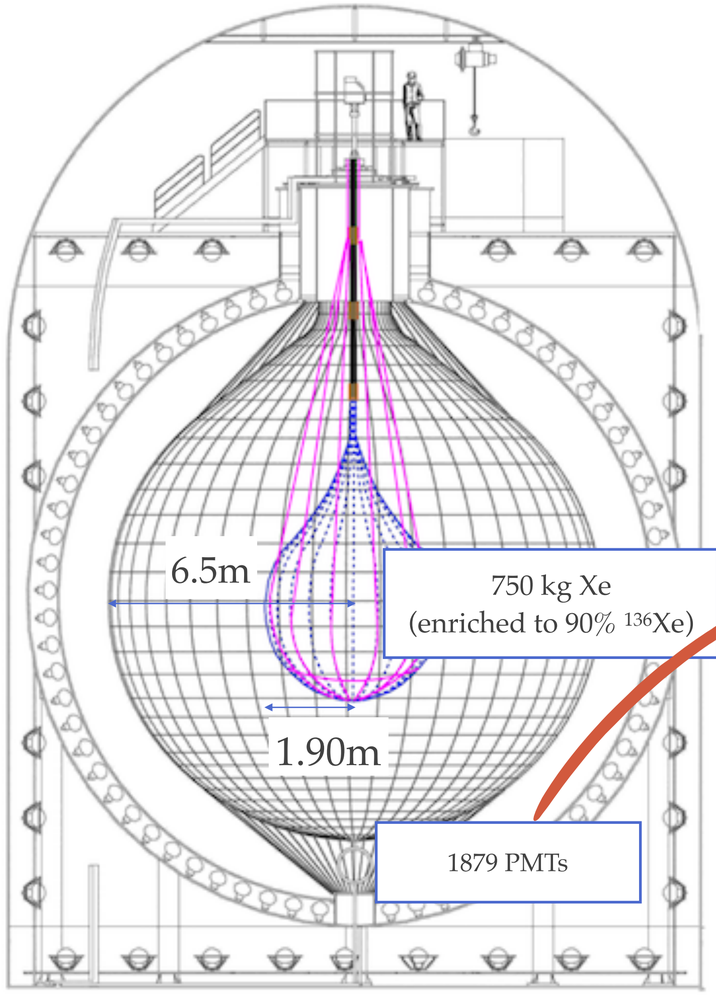
Arthur Samuel

First Phase: Learning physics from data

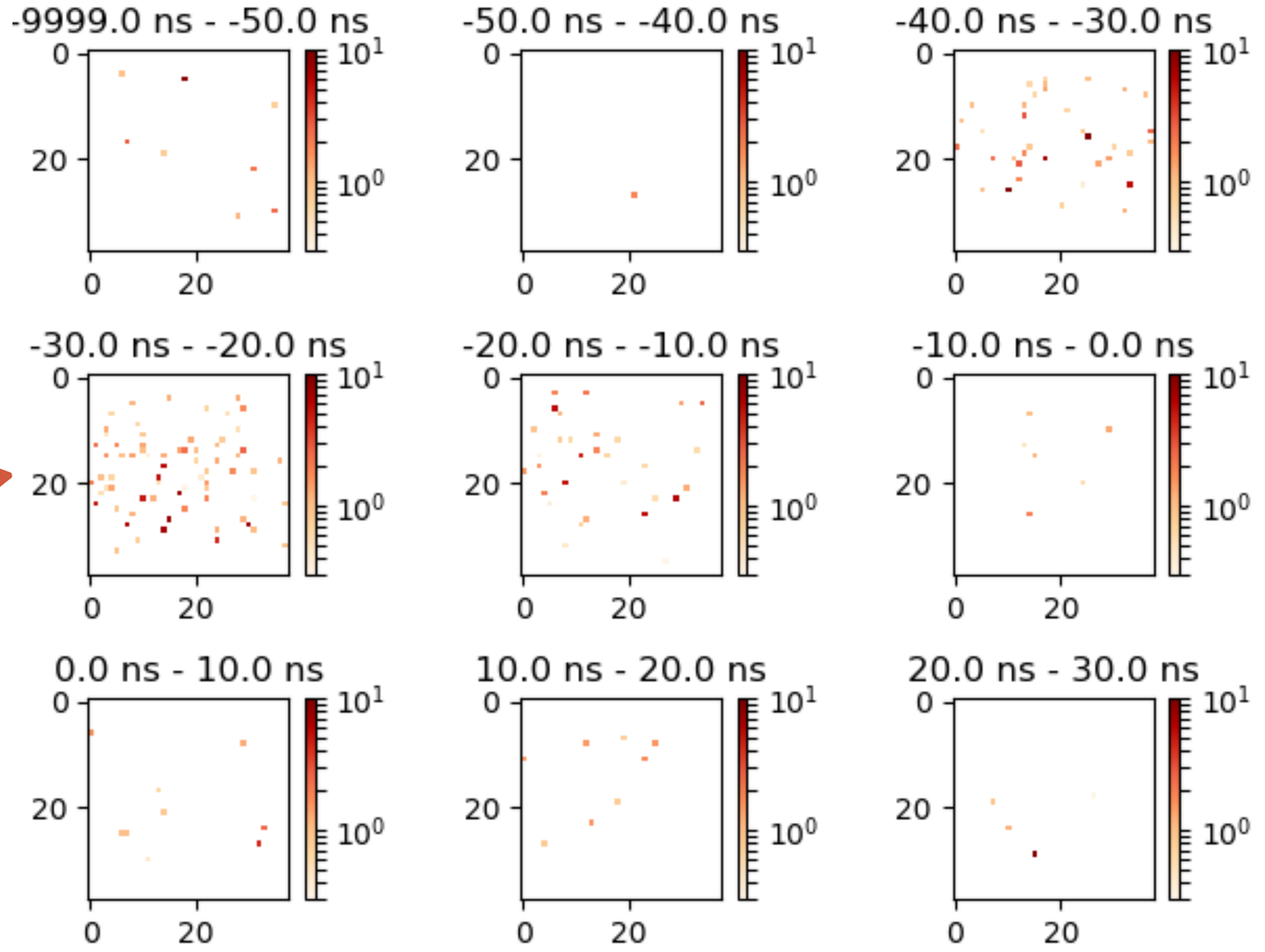
Second Phase: Speak the language of data

Third Phase: Let the data speak for itself

LEARNING PHYSICS FROM DATA



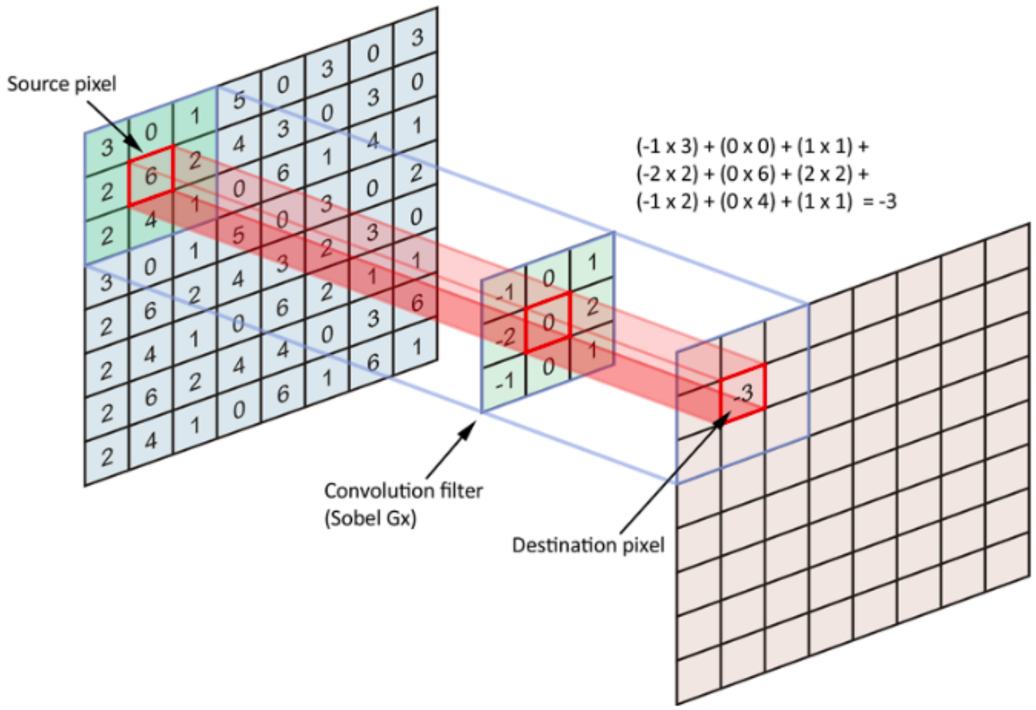
KamLAND-Zen 800 Experiment



θ-φ Hit Map

LEARNING PHYSICS FROM DATA

Convolutional Neural Network

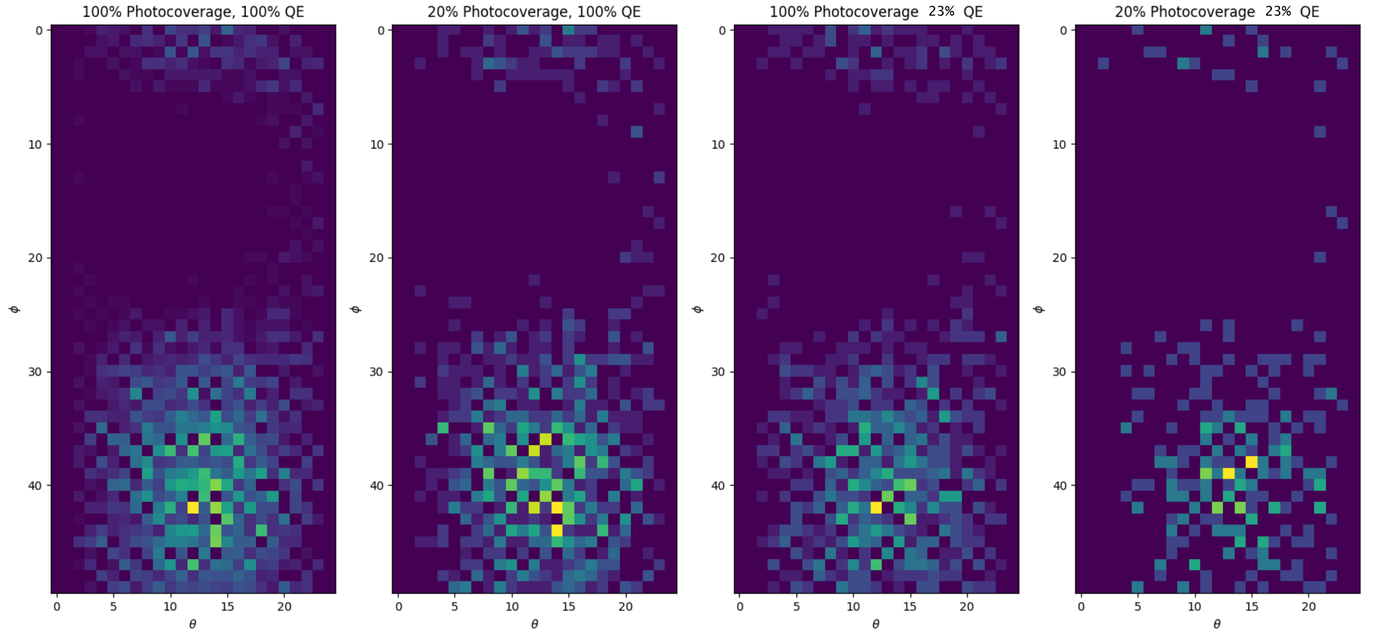


Free Code Camp

Modification of MC simulation with Pressure Parameter

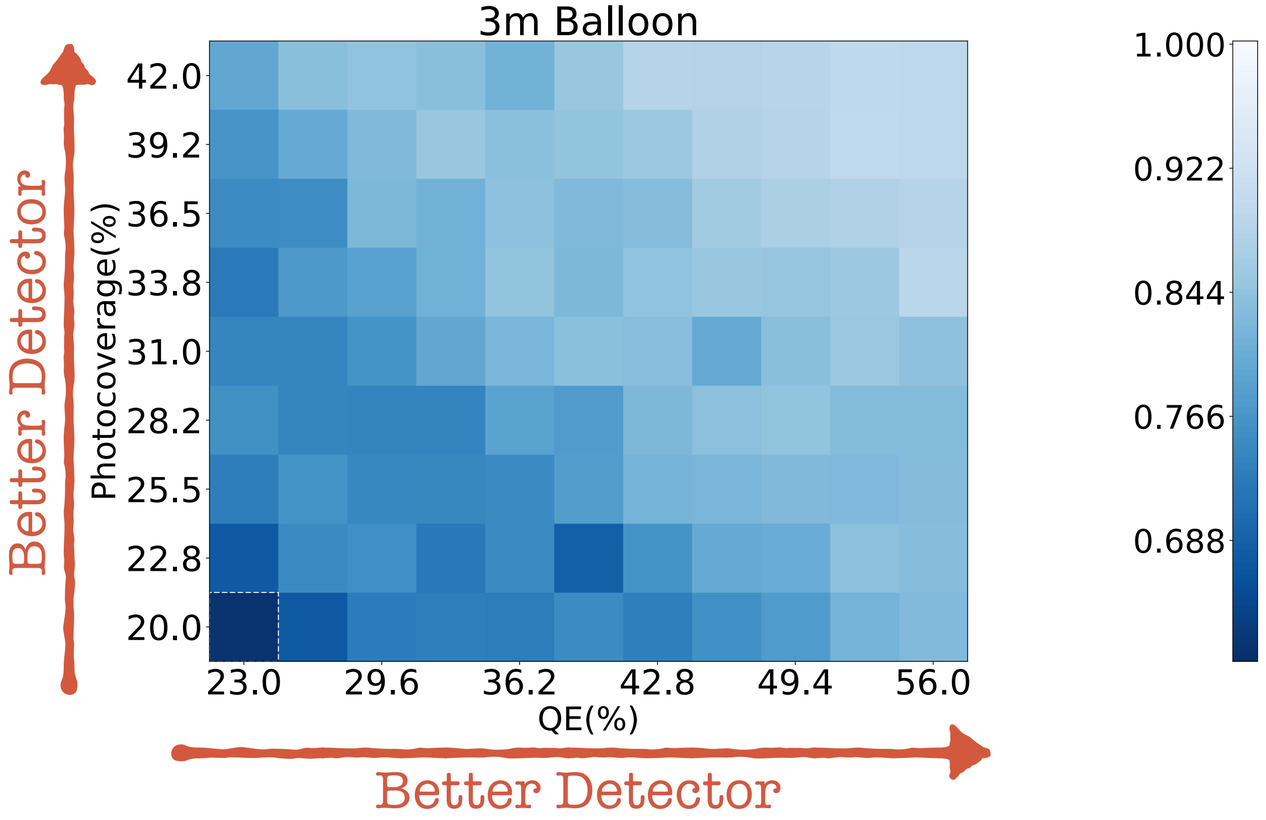
Perfect Detector

Realistic Detector
KamLAND-Zen Case



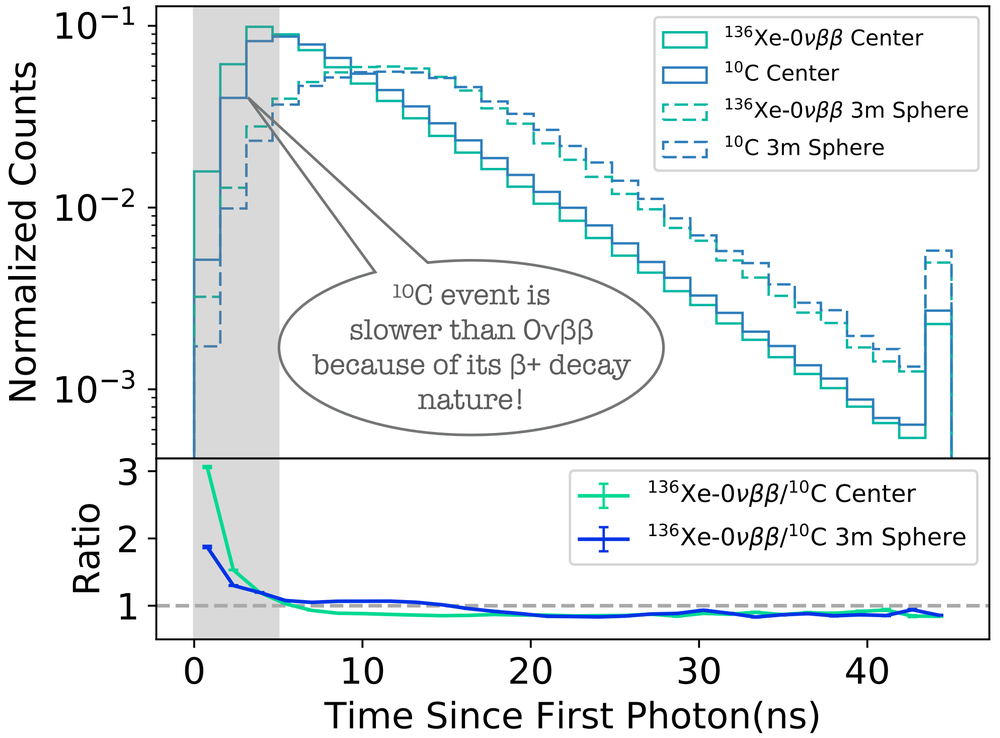
LEARNING PHYSICS FROM DATA

Signal(0νββ) vs Background(^{10}C) Pressure Map



Value in each box: Background rejection percentage at 90% signal acceptance

Origin of Classification Power



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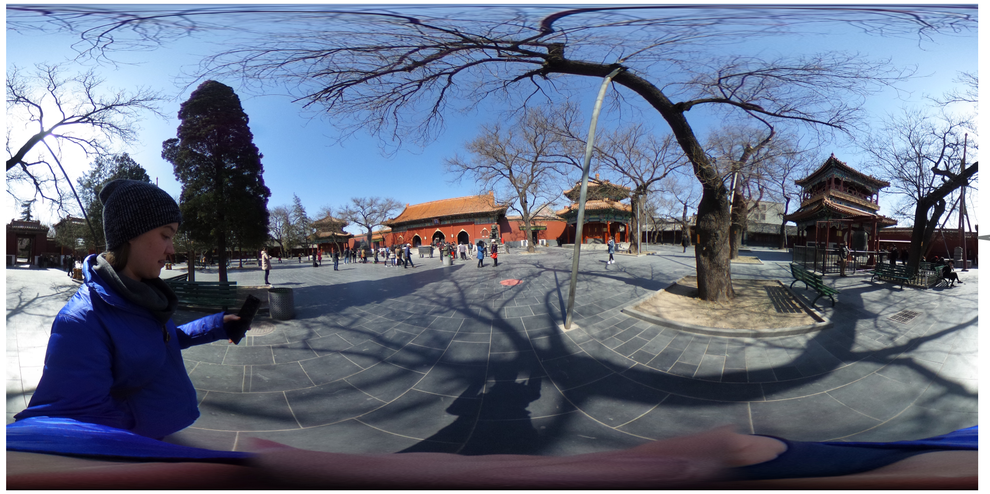
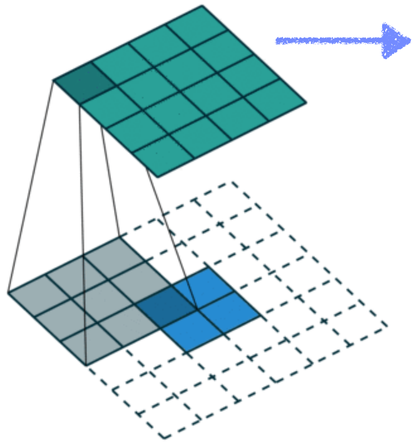
SPEAK THE LANGUAGE OF DATA



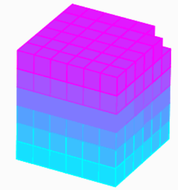
LATIS lab

- When opening up spherical image onto 2D θ-φ grid, image get distorted near the north/south pole.
- Normal CNN network cannot learn this distortion properly, because it does not incorporate the appropriate symmetry of spherical coordinate system.

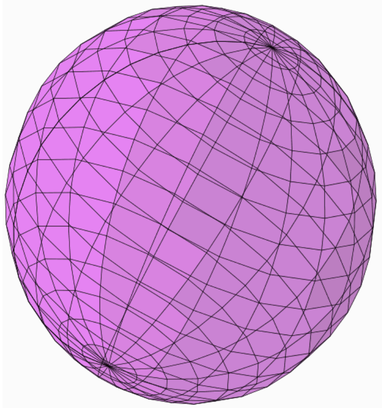
To speak the language of spherical input, we introduce Spherical CNN(Cohen et al.) to our network.



Extracted Feature

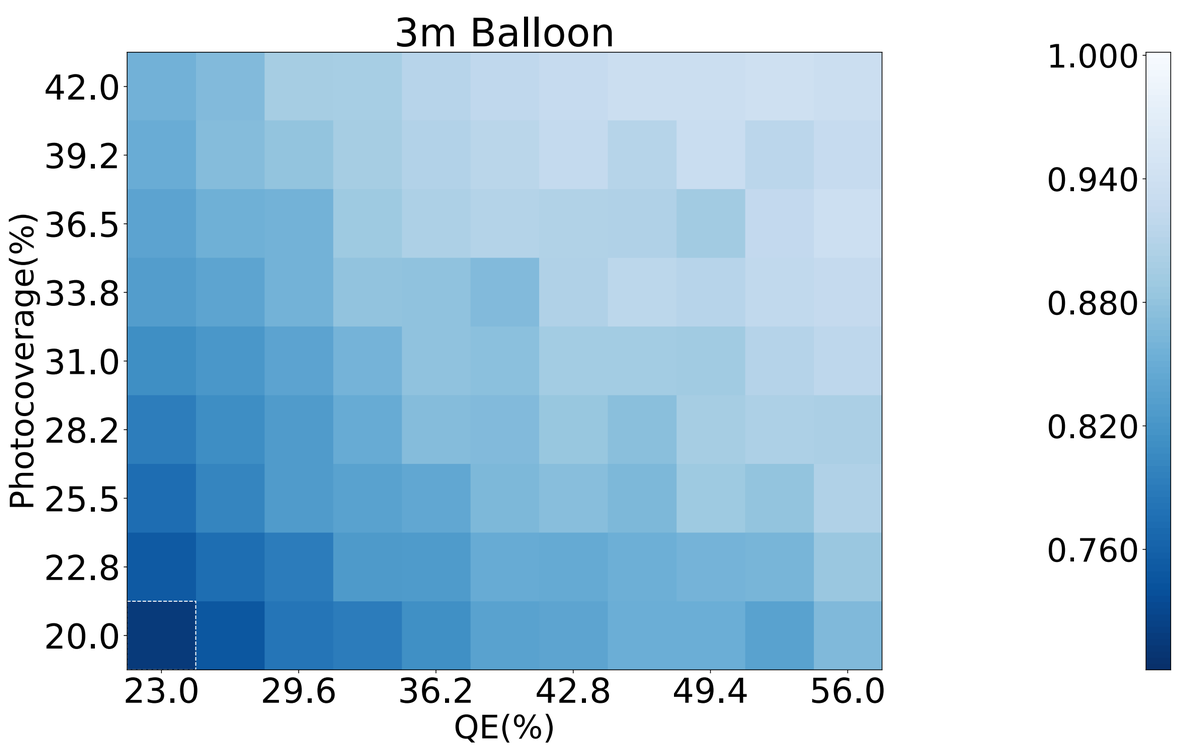


Image



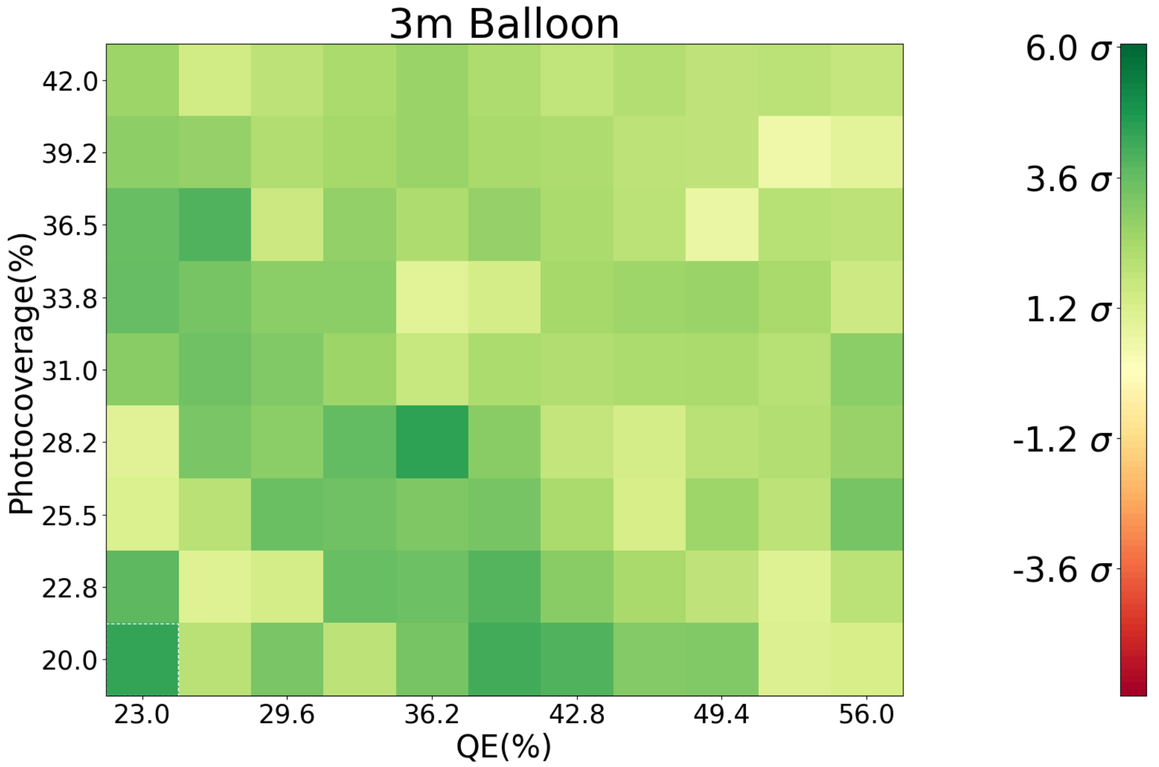
SPEAK THE LANGUAGE OF DATA

Spherical CNN Pressure Map



- Spherical CNN undergoes a much smoother transition from low to high pressure

Difference Map(SphCNN-CNN)

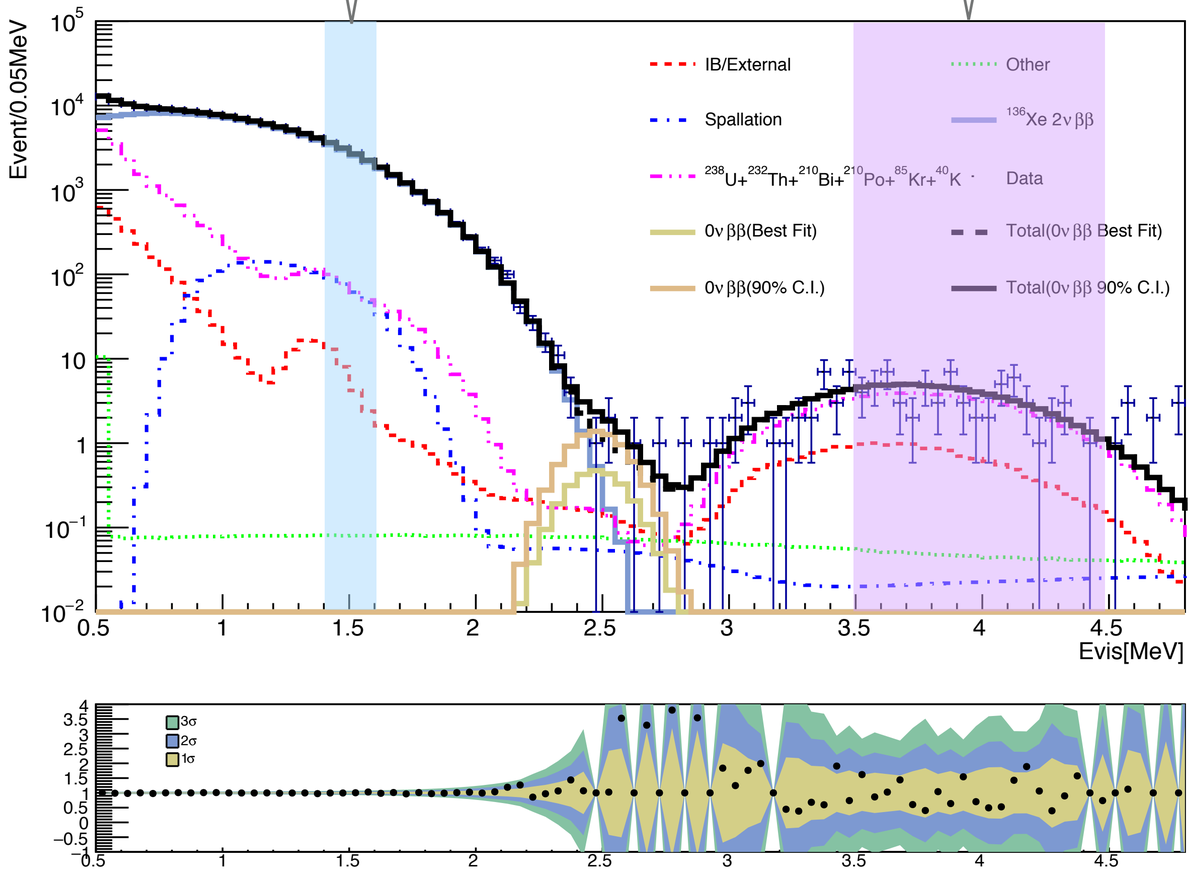


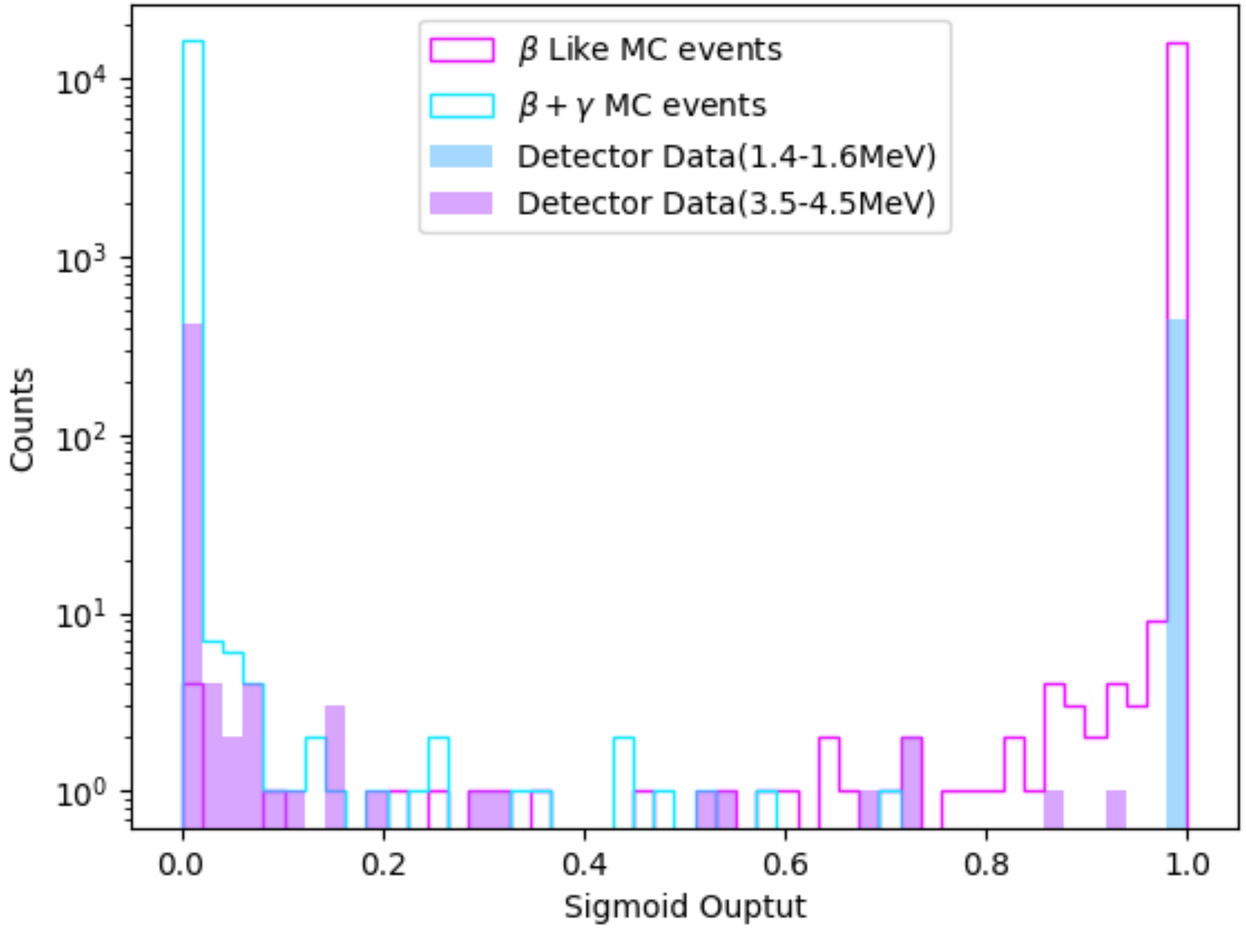
- Overall 2.4σ performance improvement
- 16% improvement for current KamLAND detector hardware

SPEAK THE LANGUAGE OF DATA

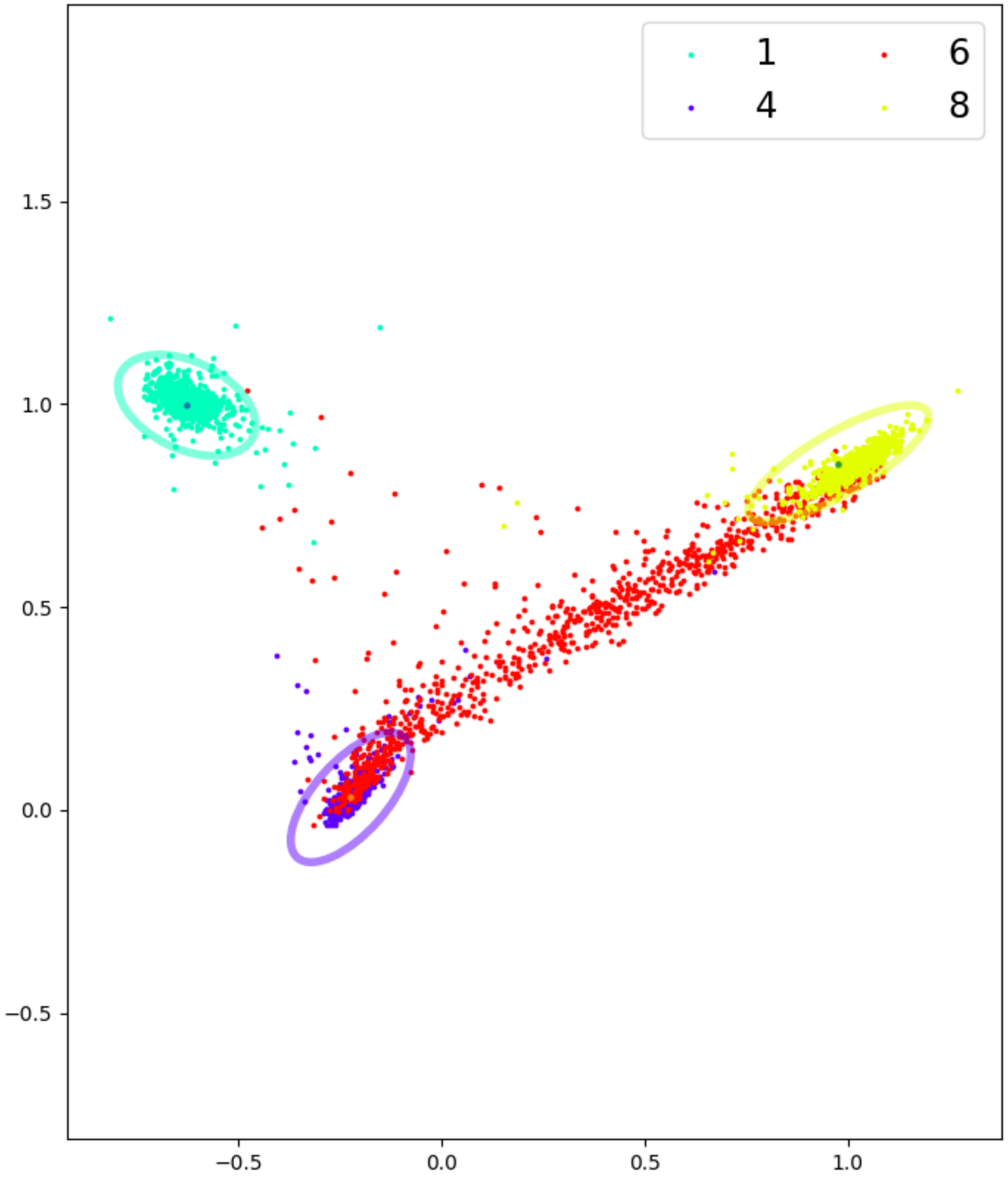
Mostly 2νββ events(β like)

Mostly ^{208}Tl decay events(β+γ)





Poster Sec. 3 #411



LET THE DATA SPEAK FOR ITSELF

- Traditional approach: training with MC, validate with data
- What if input data is NOT within the training MC sample?
  - Electronic noise events
- In that we, we need to let the data “speak” for itself
- Validate on MNIST dataset:
  - Trained on #1, 4, 8
  - PDF is obtained for each training class
  - Validate on #1, 4, 8, outlier #6
  - Outlier #6 is correctly isolated

THANK YOU FOR YOUR ATTENTION!

- **Learning physics from data:**
  - Normal CNN can efficiently classify backgrounds that are previously considered indistinguishable
    - 60% ^{10}C rejection while keeping 90% of $0\nu\beta\beta$ signal
  - The major classification power comes from the timing profile of events.
- **Speak the language of data:**
  - Incorporating correct symmetry into the machine can significantly boost its result
  - 16% increase with current KamLAND-Zen hardware
- **Let the data speak for itself:**
  - Achieve joint training with MC and data, with the proper handling of outlier events.