Relative Individual DOM Efficiency & Stopped Muon Prediction

Summary of Sofus Stray's project – 15/01/2021

Motivation

- DOM charge response in situ does not precisely match laboratory charge response
- Calibration of in situ charge response needed when simulating DOMs
- We want to calibrate Relative Individual DOM Efficiency (RIDE)

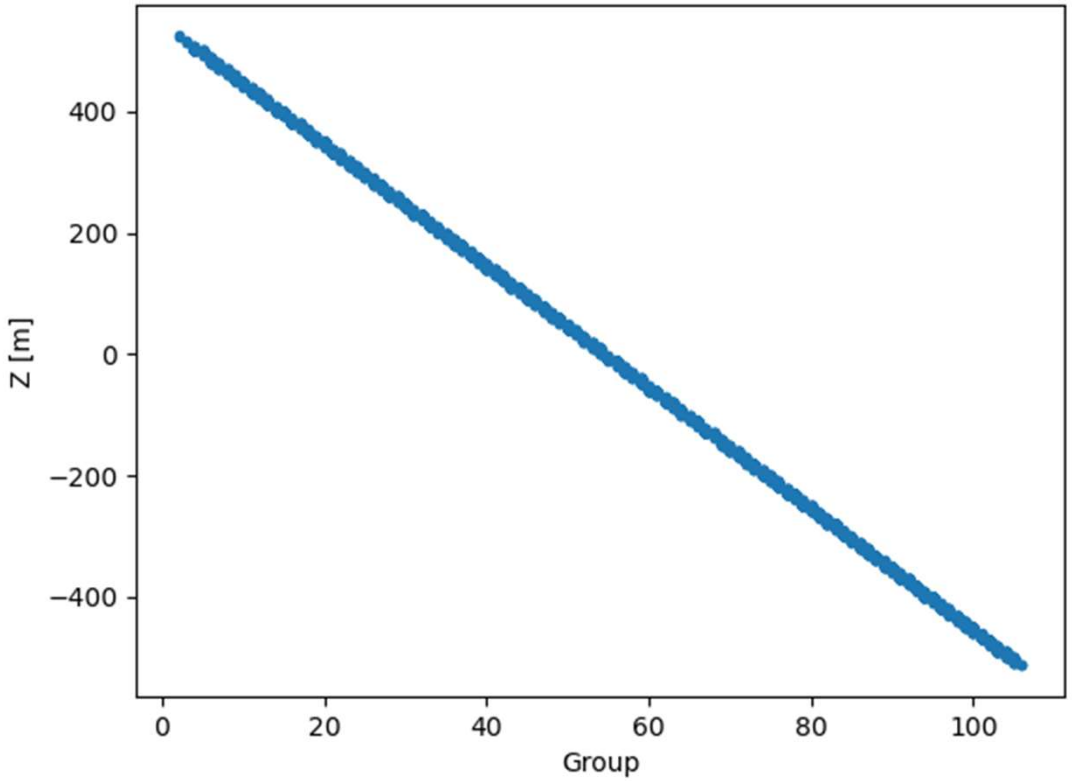
Motivation

- All DOMs in simulation currently use the same quantum efficiency
  - 1 for NQEs, 1.35 for HQEs
- Calibration compares these values to actual DOM measurements
- Previous presentation of this topic by Étienne Bourbeau

https://events.icecube.wisc.edu/event/100/contributions/522/attachments/36

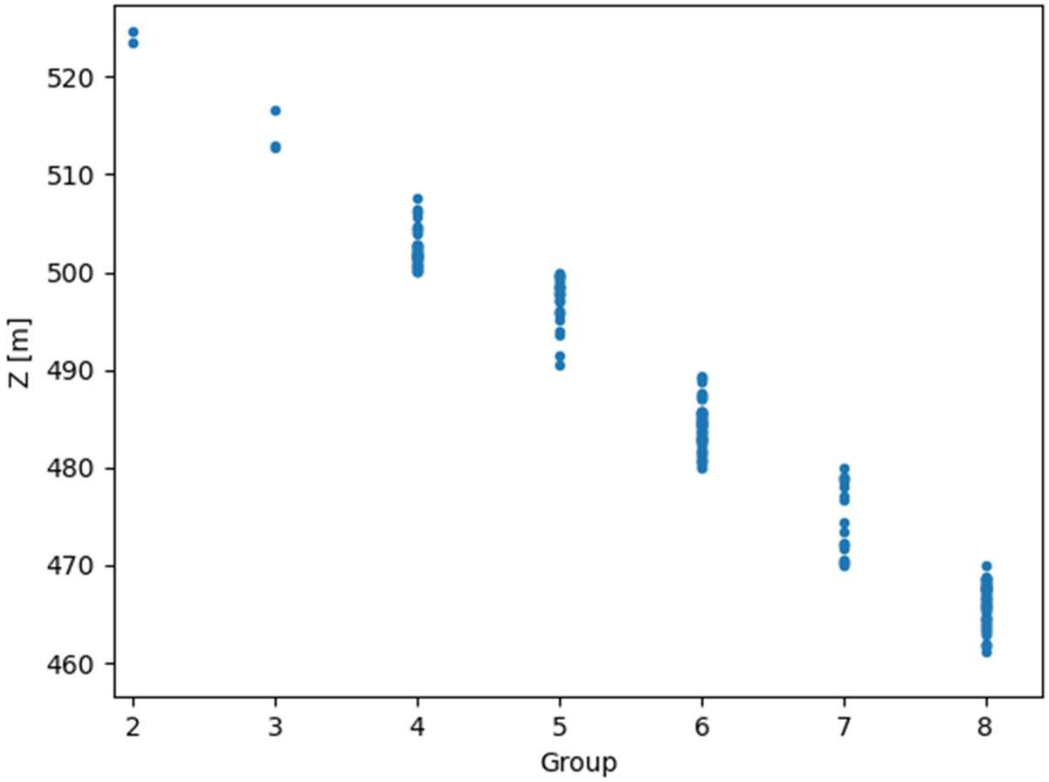
RIDE

- Relative Individual DOM Efficiency (RIDE) needs to be calibrated across DOMs
- We expect DOM charge responses to be similar in the same depth level
- Group DOMs into groups based on z-position



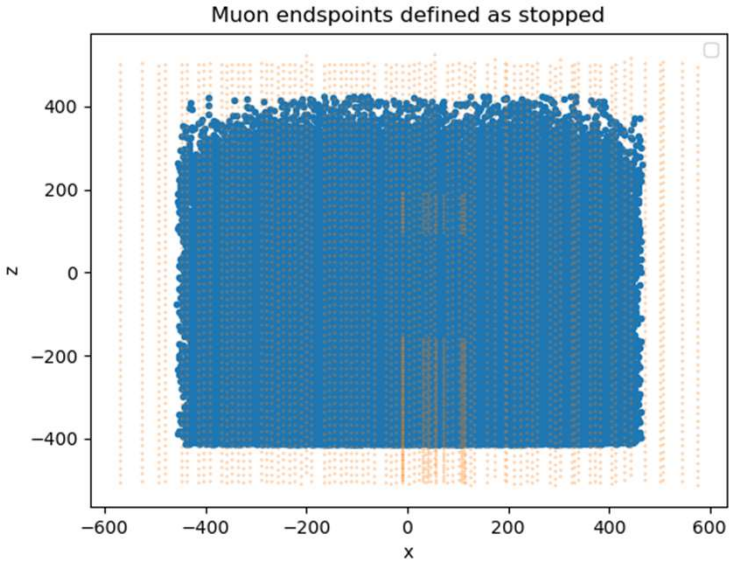
RIDE

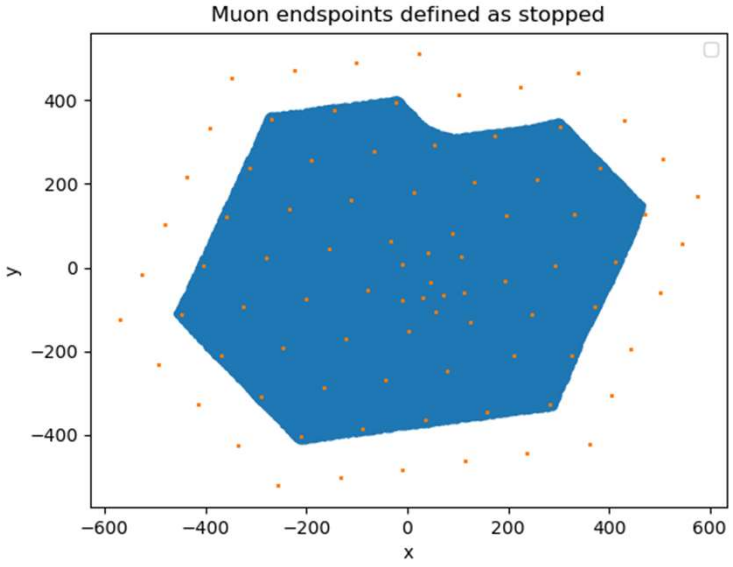
- Calculate mean charge of each DOM
- Divide each charge by the group's median
- $RIDE_i = \frac{\left(\frac{\sum_{events} q}{\sum_{events} hit}\right)_i}{\left(\frac{\sum_{events} q}{\sum_{even} \quad hit}\right)_{monitor}}$
- **Expectations: NQE DOMs have RIDE value of 1, HQE of 1.35**



Stopped Muons

- The RIDE assumption only works for well modelled particle sources
- In this study we focus on minimum ionizing muons
  - Known stopping point
  - Known energy
  - Constant light source
- We approximate minimum ionizing muons with muons that have stopped inside the detector

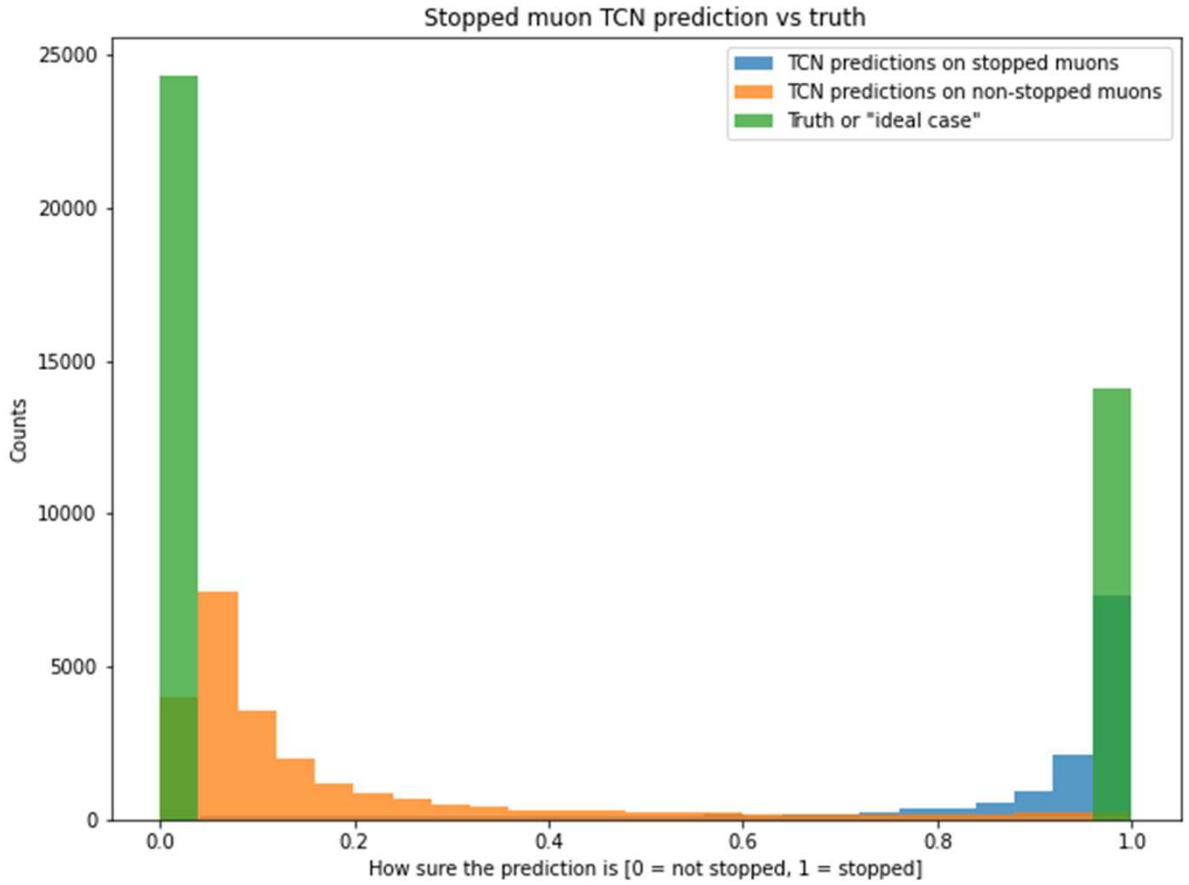




Temporal Convolutional Network - TCN

- Neural network implementation
- Use the position, charge, and time of each DOM to predict whether a muon is stopped

- Currently quite good results
- Unlikely to improve massively as neither increase in data nor change in NN architecture has an effect



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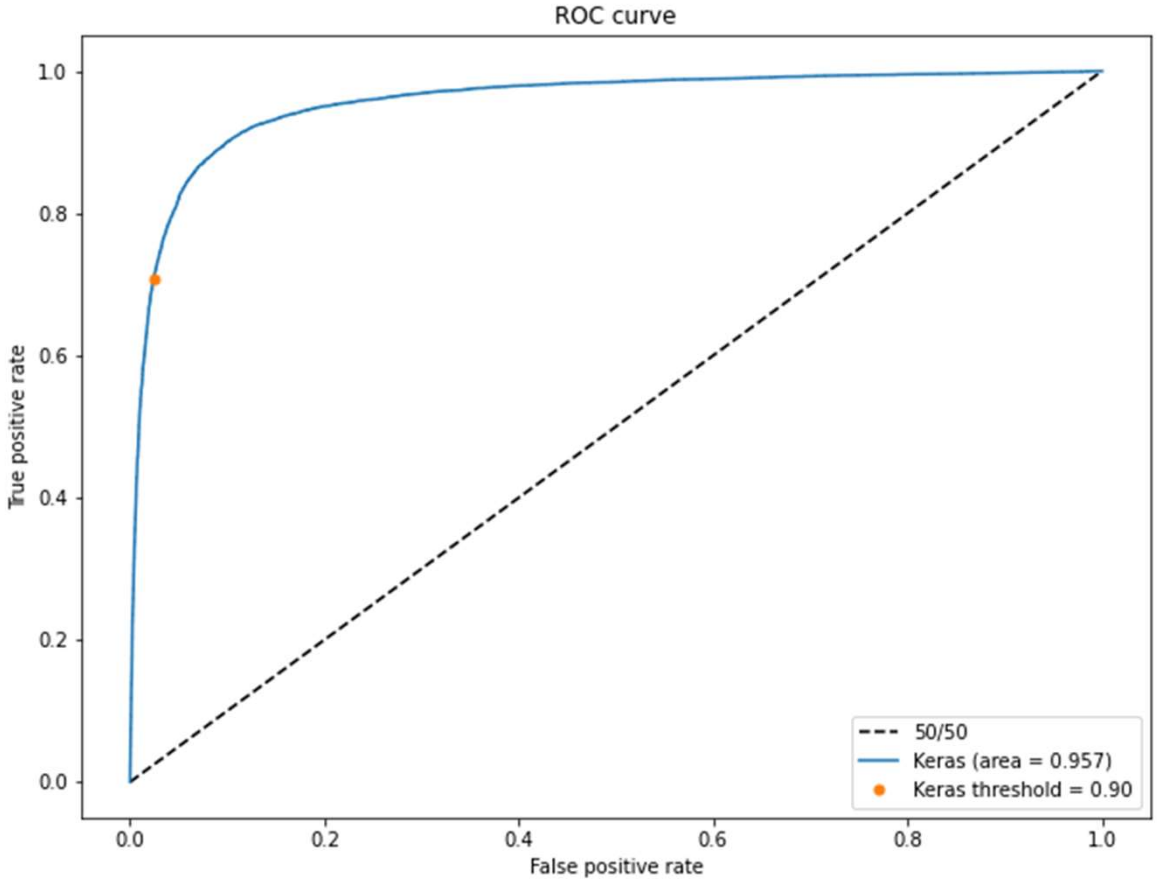
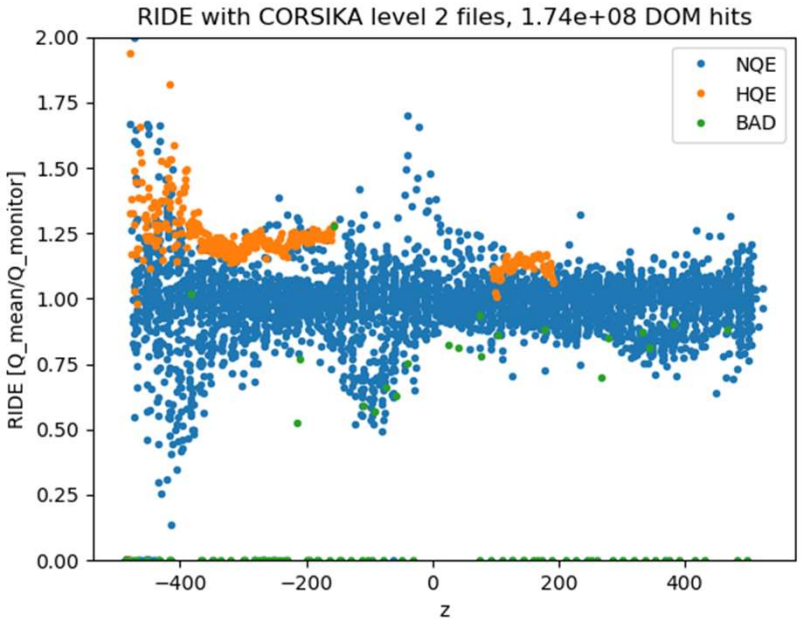


RIDE calculation

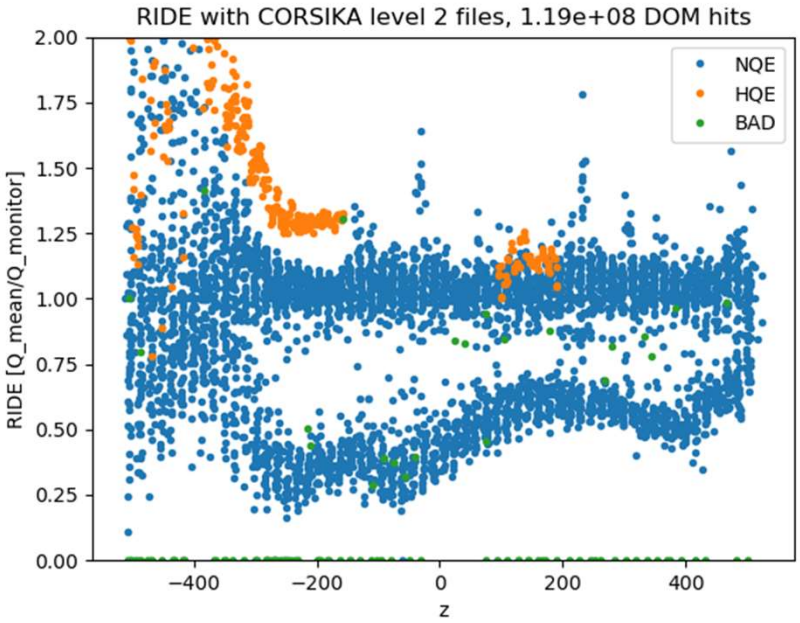
- Calculate RIDE from true stopped muon label and TCN prediction
- Compare results

RIDE calculation

True label

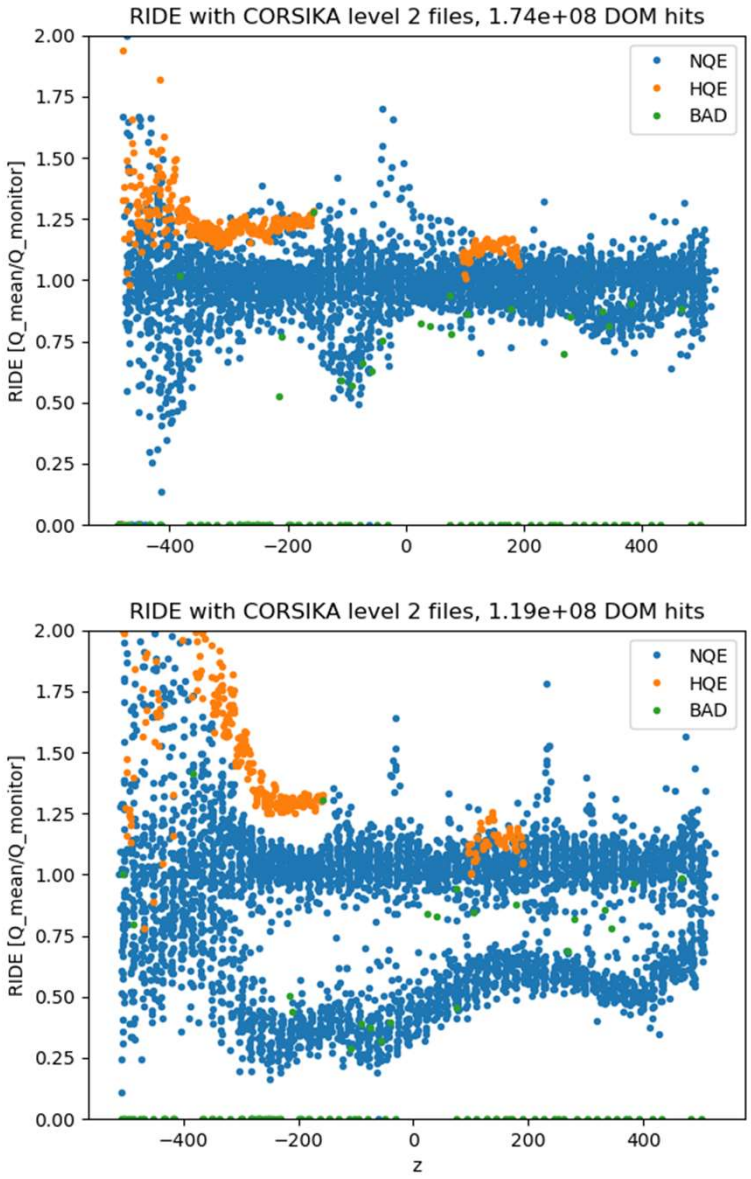


TCN prediction (threshold = 0.9)



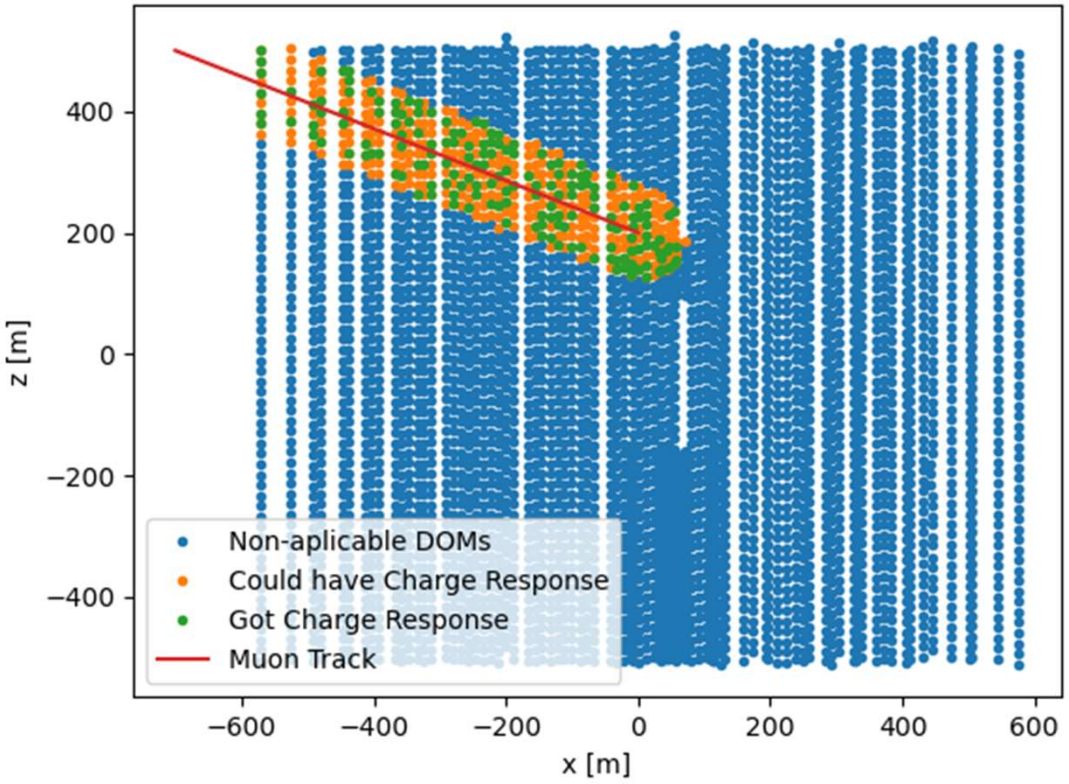
Ride Calculation

- Both label and TCN sees a generally higher RIDE value for HQE DOMs
- Label is a lot less chaotic
- TCN more clearly separates NQE and HQE DOMs in the ~-200 range
- TCN deals much worse with the bottom of the detector
- TCN has weird “gap”



Prediction on muon position

- Minimum ionizing part of stopped muon are roughly the last 200 meters
- Count DOMs within 75 meters of the stopping track
- **Need true value of stopped muon position from simulation – can this be predicted using TCN?**

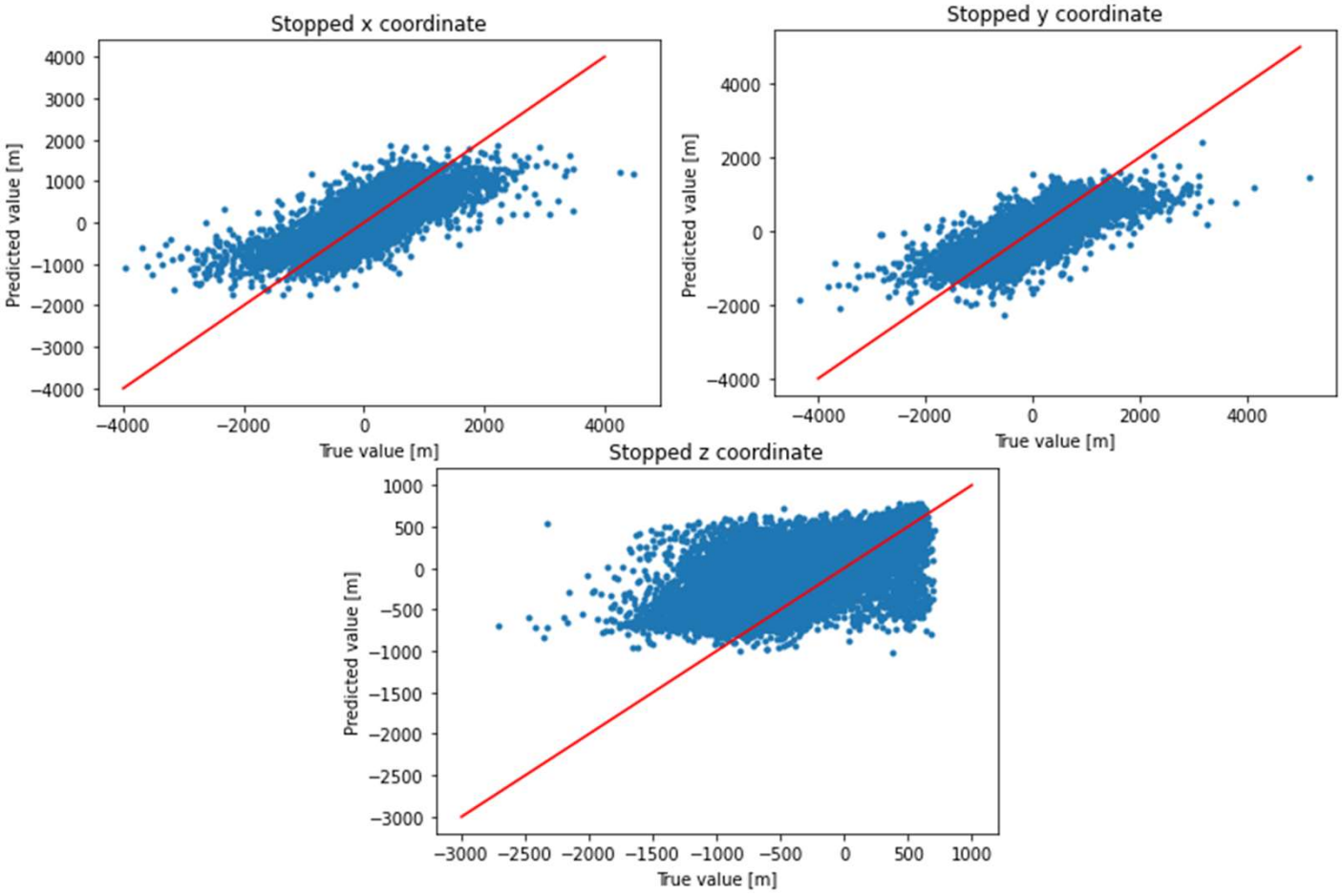


Initial muon position predictions

- Relatively much more complex than classification
- Needs to be somewhat precise

- Getting something that's not totally insane
- Still not good enough to replace truth variables
- Z-position especially bad

- Only initial results, could improve



Current plans

- Cooperating with James Mead
- Look into uncertainties
- Model RIDE values of each group as Gaussian
- Look into redefinition of a group
- Getting 2016 data to work

- Future plans:
  - Improve position and other stopping variables
  - Run on real data after simulation data is satisfactory
  - Compare performance