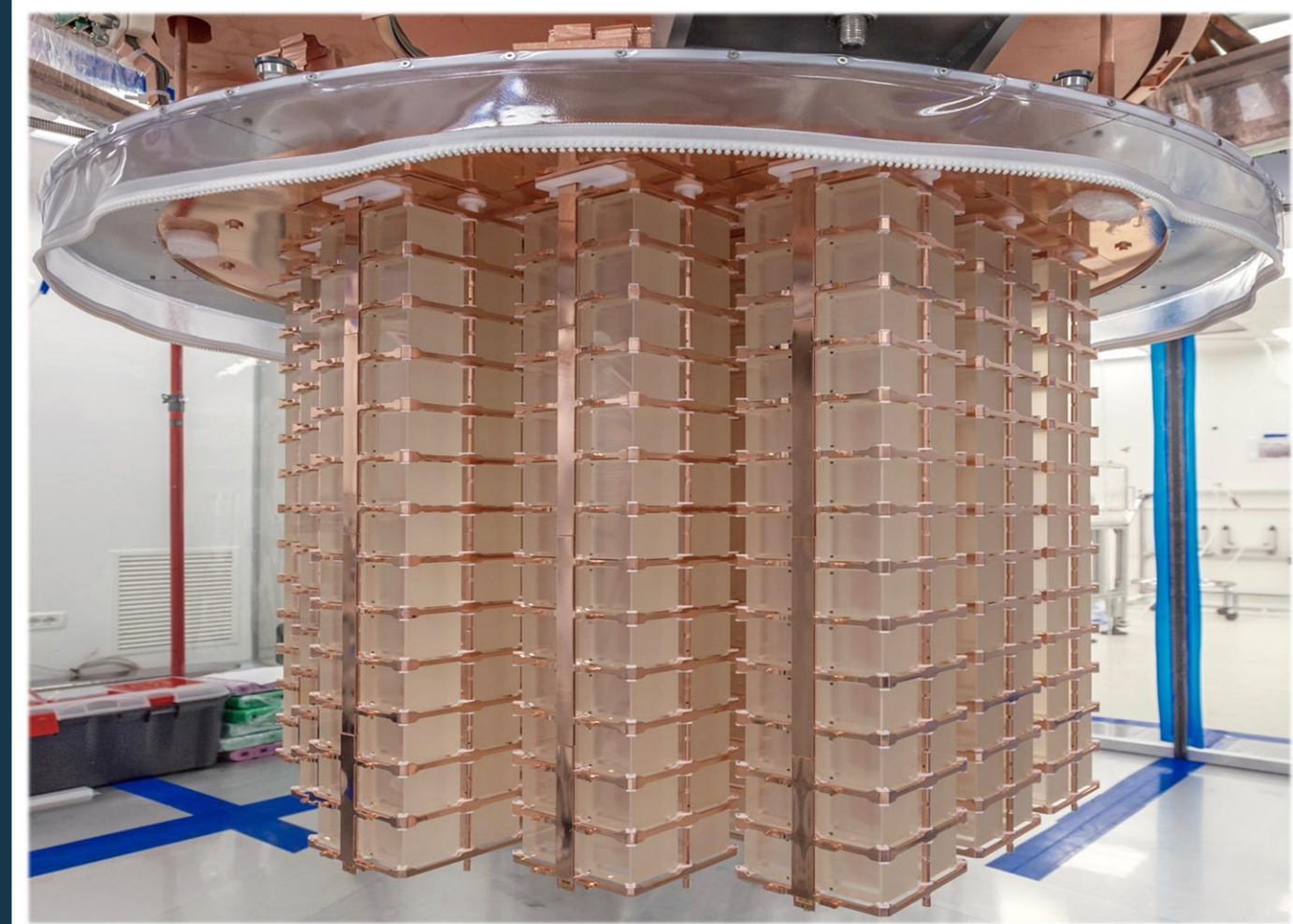


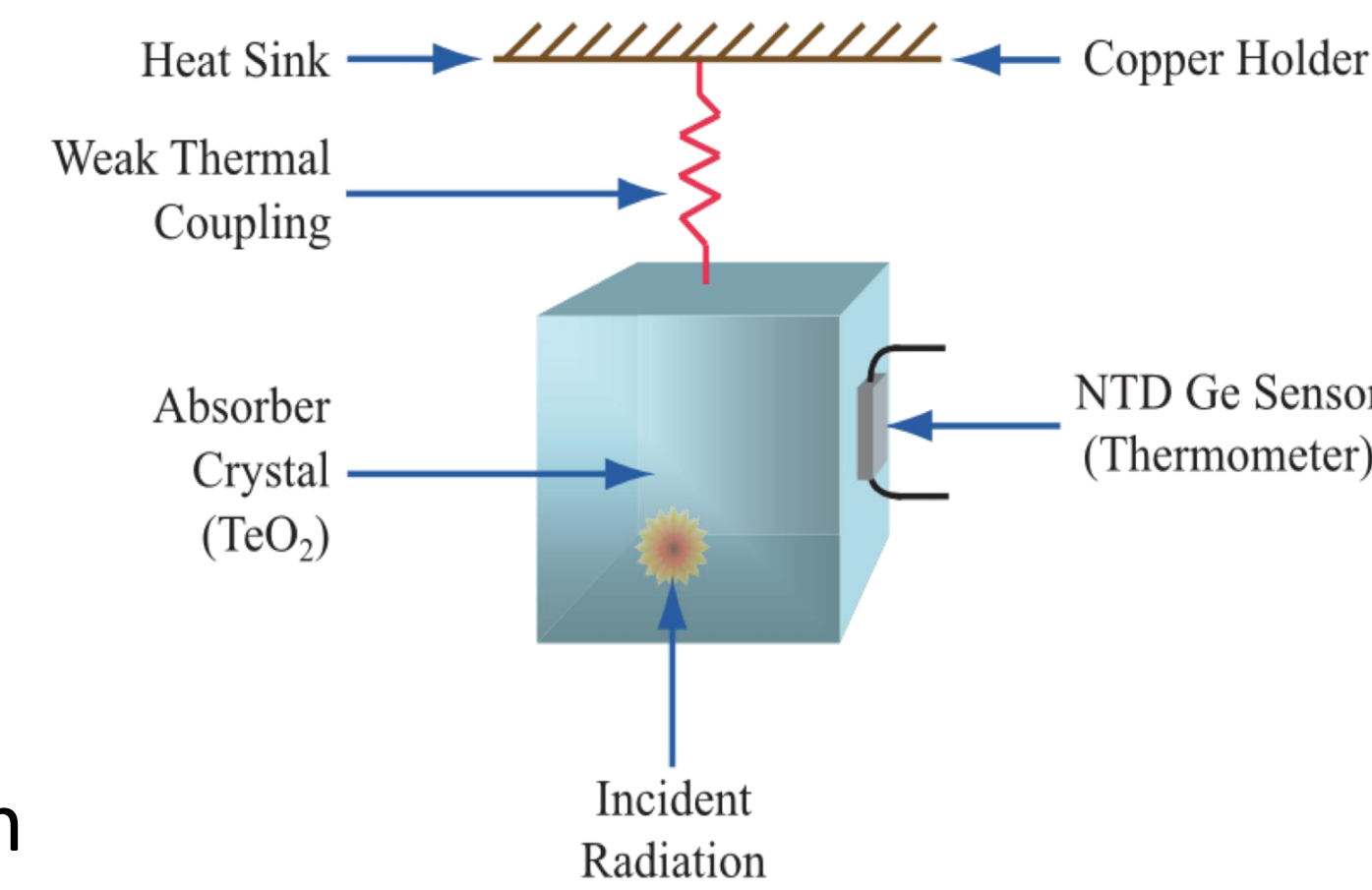
## -- INTRODUCTION --

### Cryogenic Underground Observatory for Rare Events

- Primarily a search for neutrinoless double beta decay for  $^{130}\text{Te}$

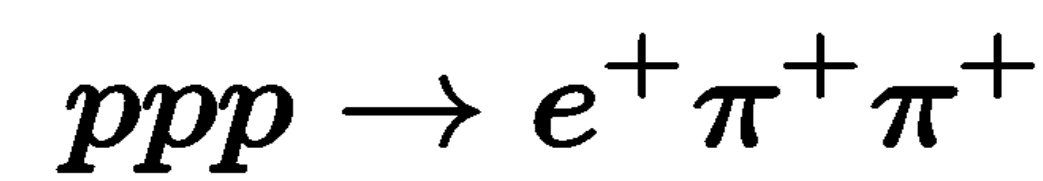


- Located in Hall A of Laboratory Nazionali del Gran Sasso
  - ~3600 m.w.e. of overburden
  - ~ $10^6$  reduction in muon backgrounds
- Bolometric approach; **Source=Detector**
- Tightly spaced crystals allow for coincidences to be exploited
- See poster #224 for more details; "Latest Results from the CUORE experiment"



## -- TRI-NUCLEON DECAY --

- Conservation of baryon number not guaranteed
- Violation of baryon number conservation essential for matter anti-matter asymmetry (Sakharov conditions)
- Proton decay\* best probe yet; **nucleon decay modes** also promising
- Model† proposed to utilize  $Z_6$  symmetry forbids  $\Delta B=1$  and  $\Delta B=2$  decays, allows  $\Delta B=3$



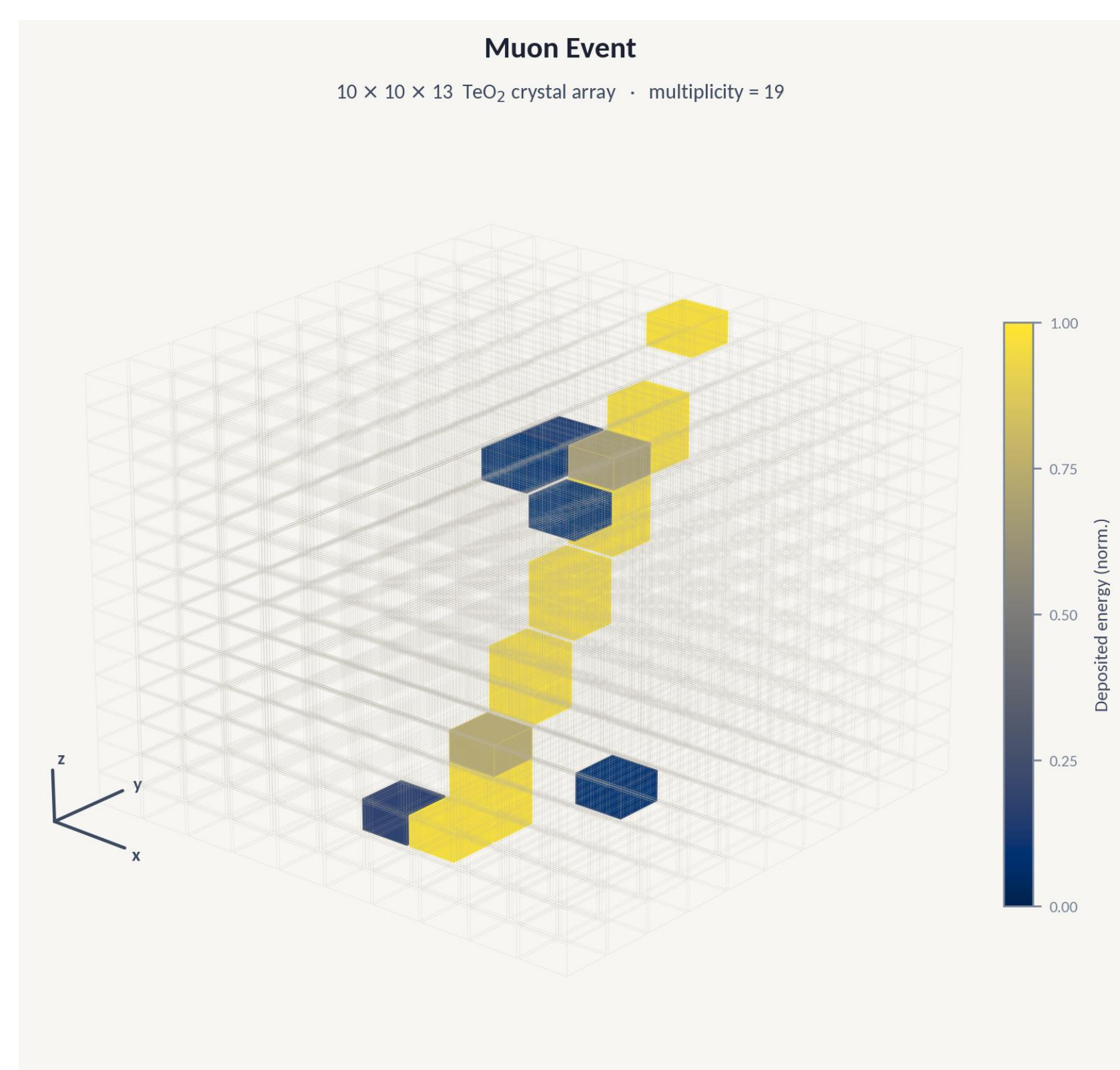
$$I_R^3 + L_i + L_j - 2L_k$$

$$I_R^3 = Y - (B - L)/2$$

$L_i$ :  $i^{\text{th}}$  family lepton number,  $i \neq j \neq k$

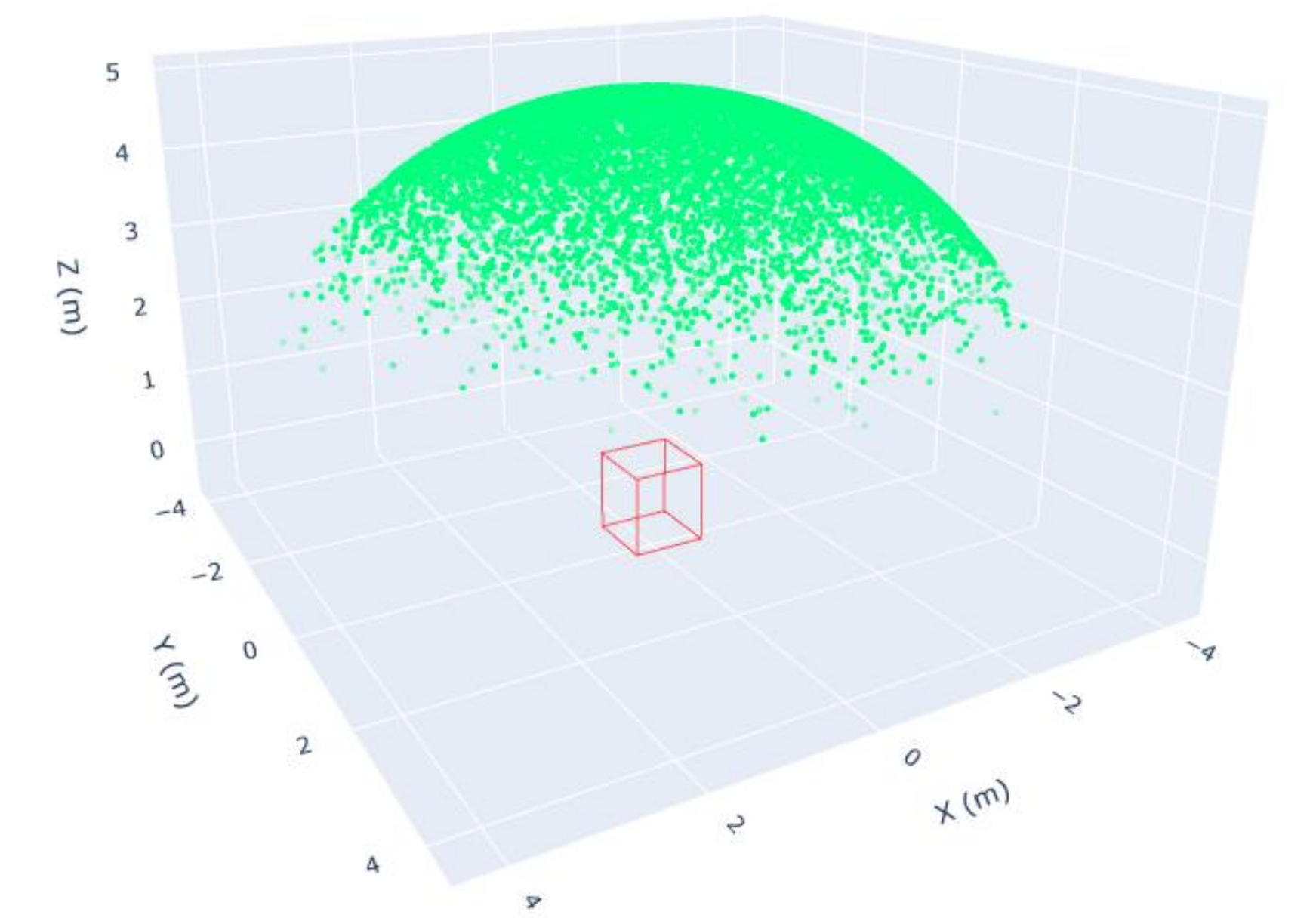
## -- DECAY SIGNATURE --

- Tri-proton decay in  $^{130}\text{Te}$  produces  $^{127}\text{In}$ , and charged particles carrying **2.7 GeV**
- Energy deposited in detector in the form of **high multiplicity** events with diffuse topology
- Primary background is **Muons**; track-like topology



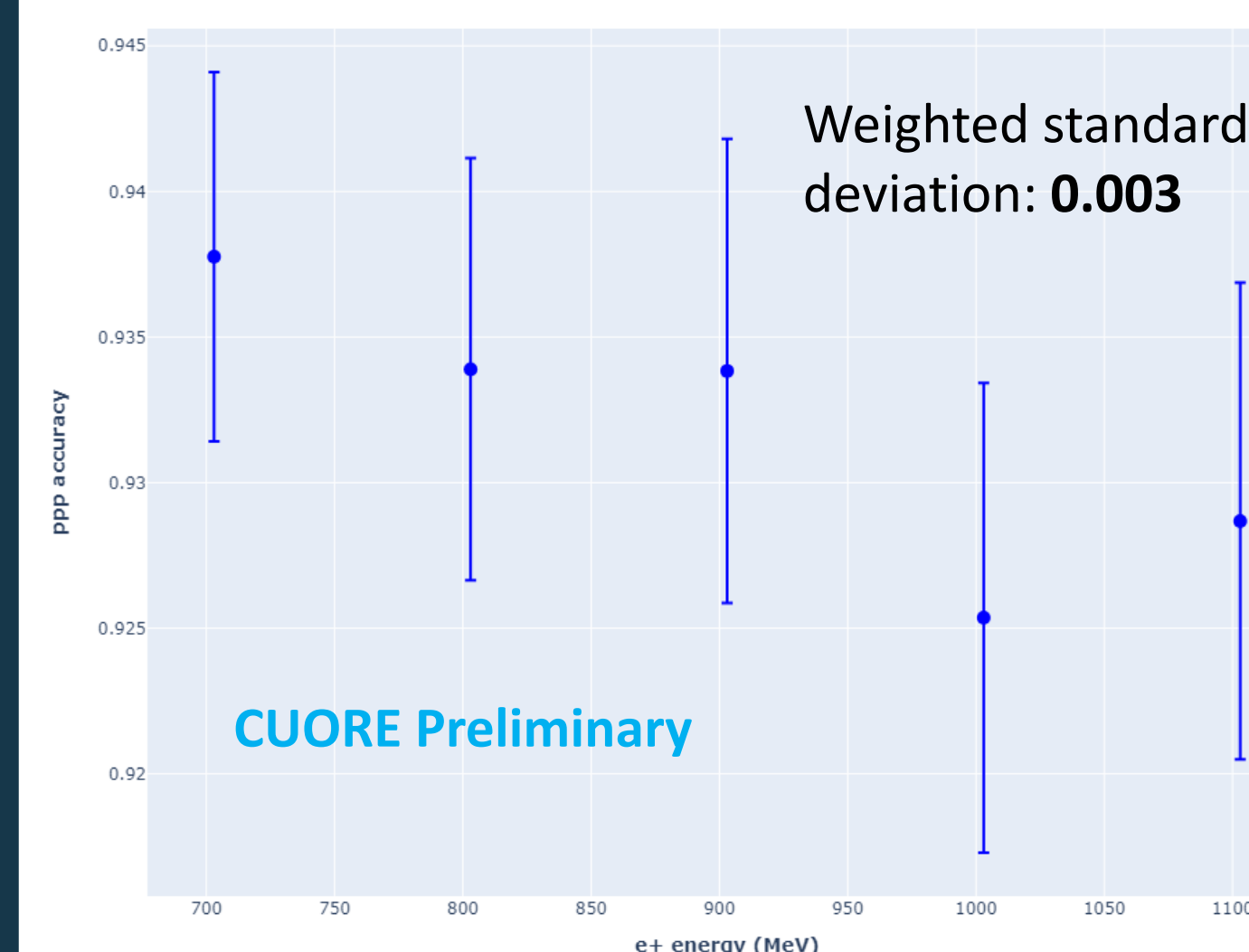
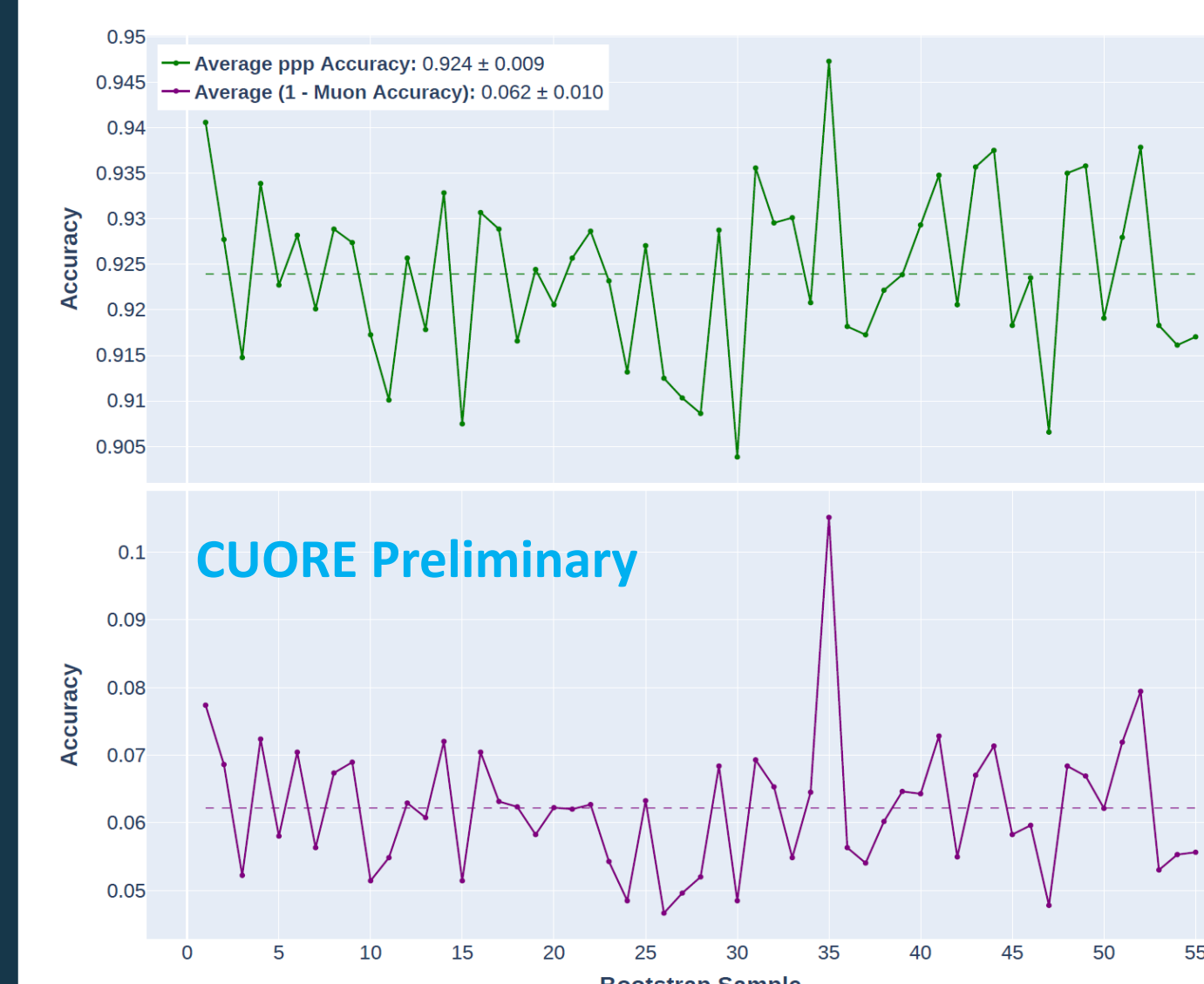
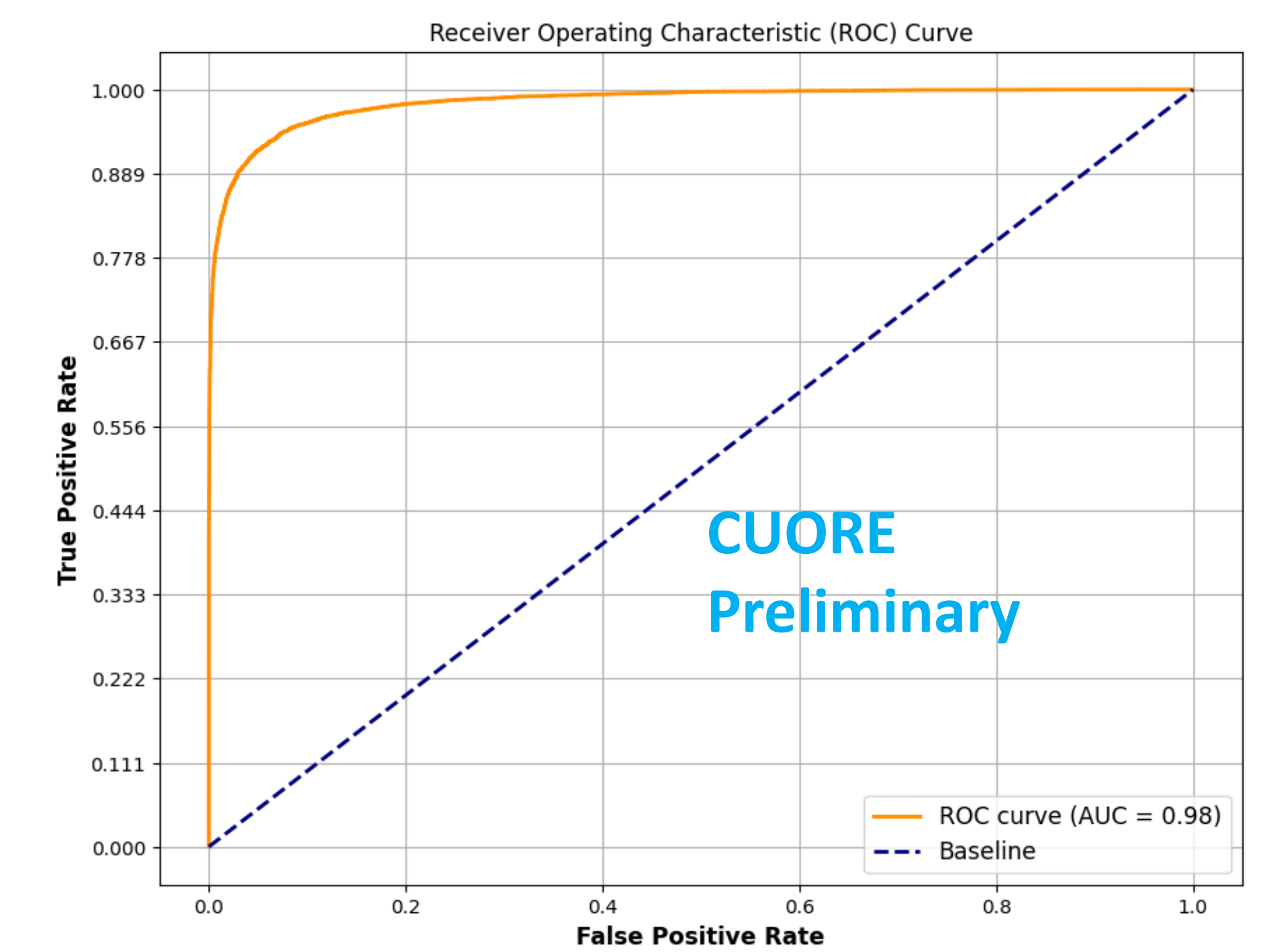
## -- SEARCH ALGORITHM --

- Potential to discriminate between events based on energy distribution and event topology
- Convolutional Neural Network** good candidate for classification algorithm
  - Excellent at extracting spatial information with translational invariance
  - Relatively lightweight: 50k parameters
- Training Data**
  - PPP decays:
    - Randomly split **2.7 GeV** among the decay products
  - Muon events:
    - Generated in MC on a **5 m** hemisphere with measured LNGS muon distributions

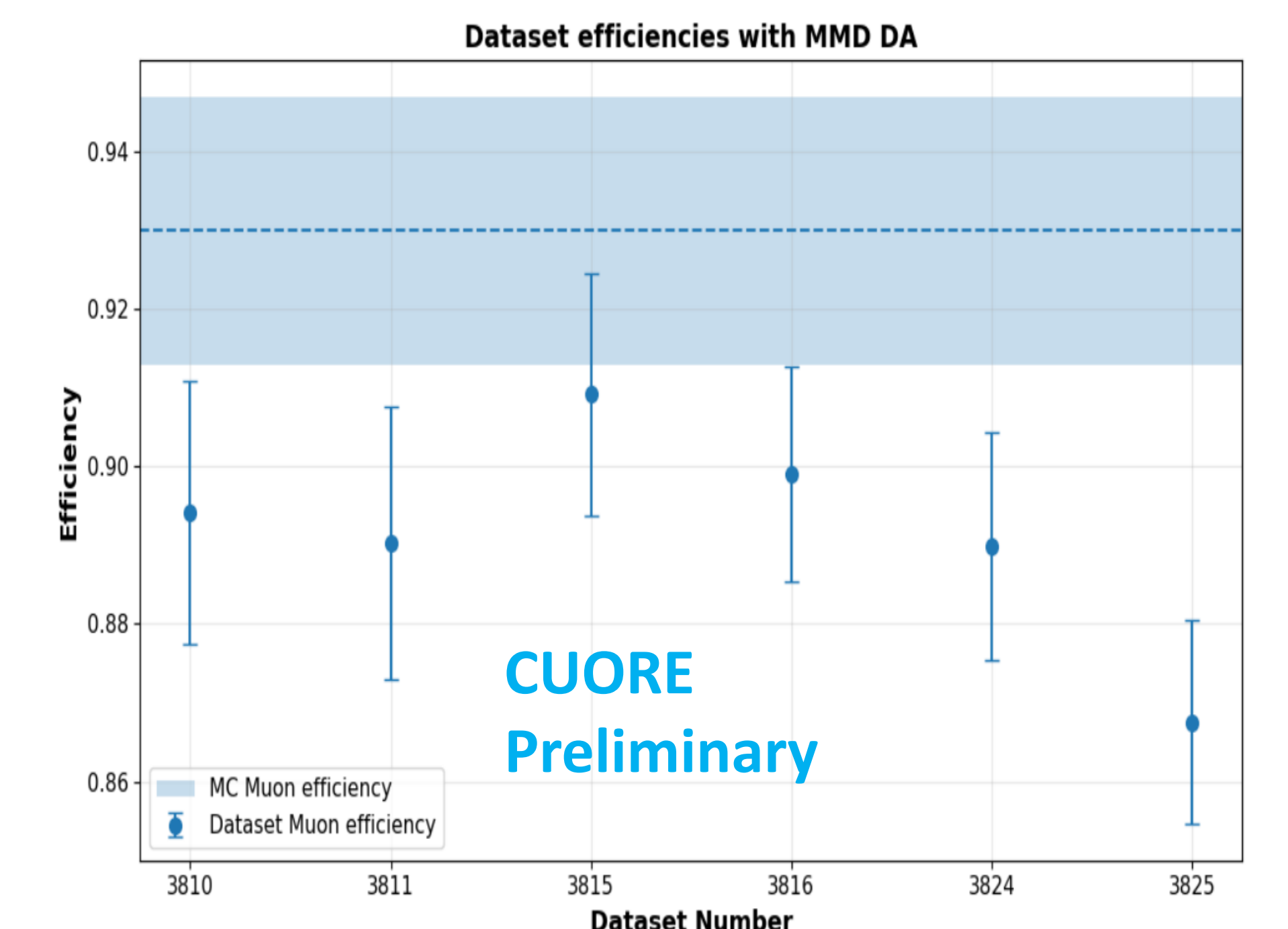


## -- RESULTS --

- 3D CNN trained on simulations performs well
  - Signal Efficiency: **~93%**
  - Background Efficiency: **~94%**
- Statistical uncertainty estimated using **bootstrapping technique**
- Statistical uncertainty
  - 3P accuracy: **0.9%**
  - Muon accuracy: **1.0%**
- Systematic uncertainty originating from 3P energy split: **0.3%**



- Discrepancy observed when model tested on data
  - Employed Maximum Mean Discrepancy based **Domain adaptation**
  - Prepared augmented, unlabeled dataset to align performance of model with data
- Improvement in accuracy discrepancy by **~20%**



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\*[Phys. Rev. D 102, 112011](https://doi.org/10.1103/PhysRevD.102.112011)

†K.S. Babu et al. <https://doi.org/10.1016/j.physletb.2003.07.036>