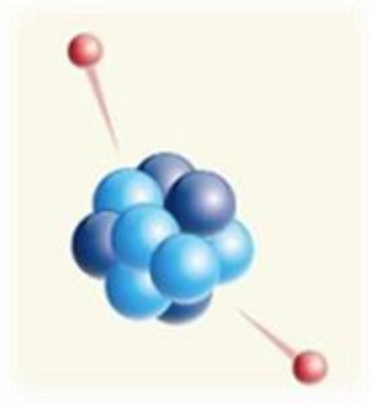


Shielding and Outer Detectors

Teena Vallivilayil John

Neutrinoless double beta decay search in Xe-next-generation experiment workshop

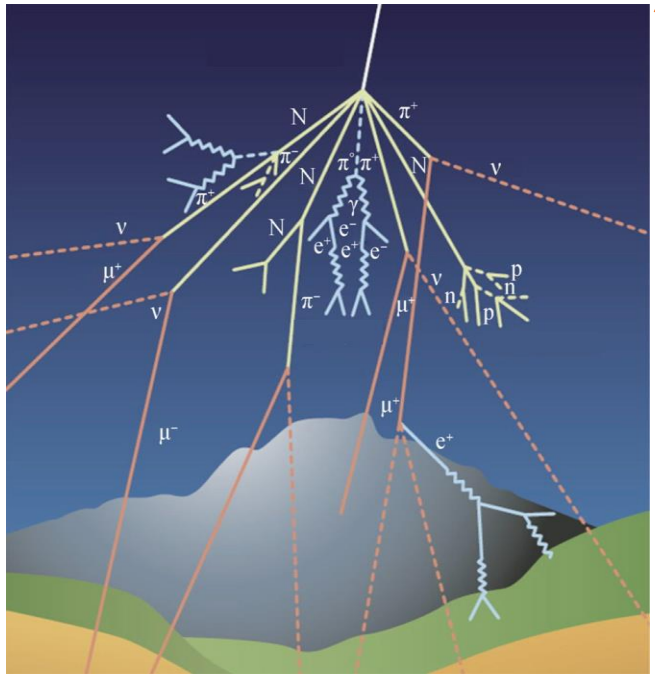
LaurentianUniversity
UniversitéLaurentienne

nEXO

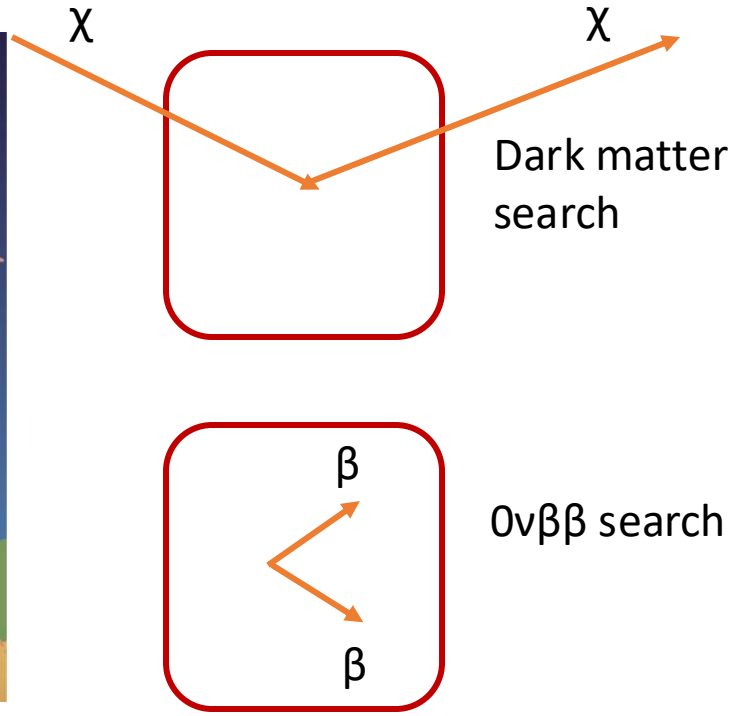
Carleton University

Rare event searches and background

- Looking for rare events
- Backgrounds affect the sensitivity
- Requires low background
- Muon flux at sea level : 1 μ/(min cm^2) or 1440 μ/(d cm^2)



Cosmogenic background



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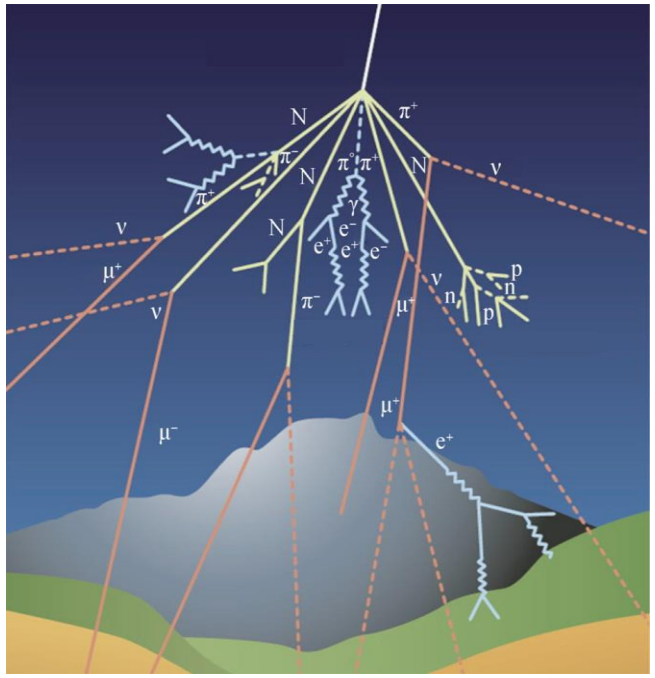

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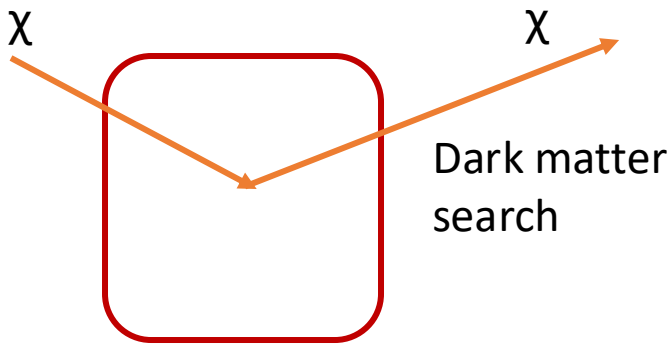
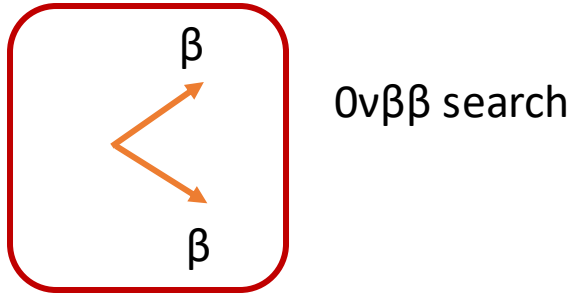
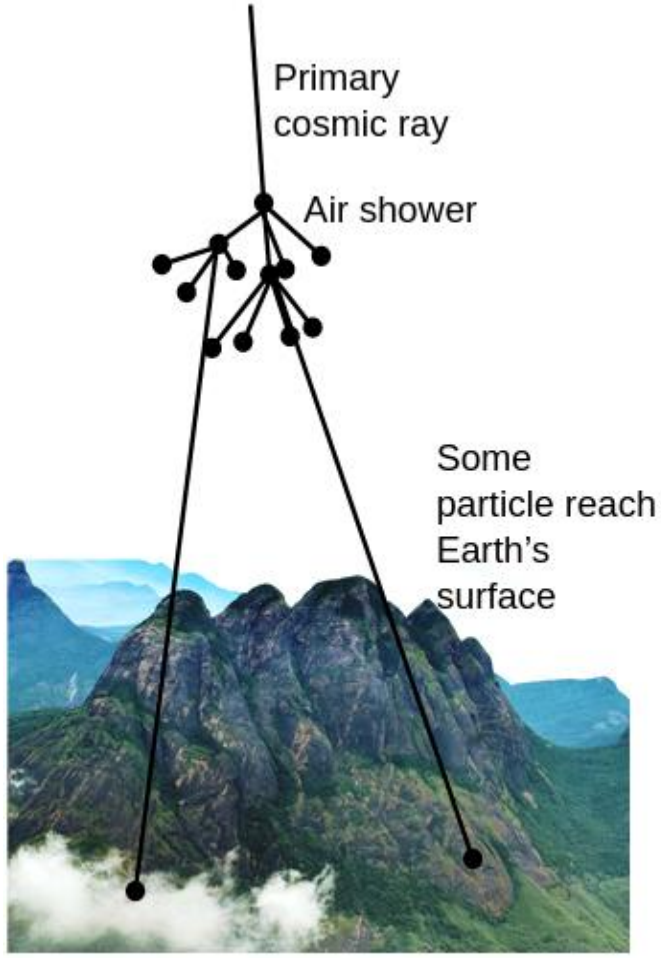




Cosmogenic background

- Prompt signals generated by muon interactions with the detector materials and its surrounding environment.
- Decay of cosmogenically activated radioisotopes.



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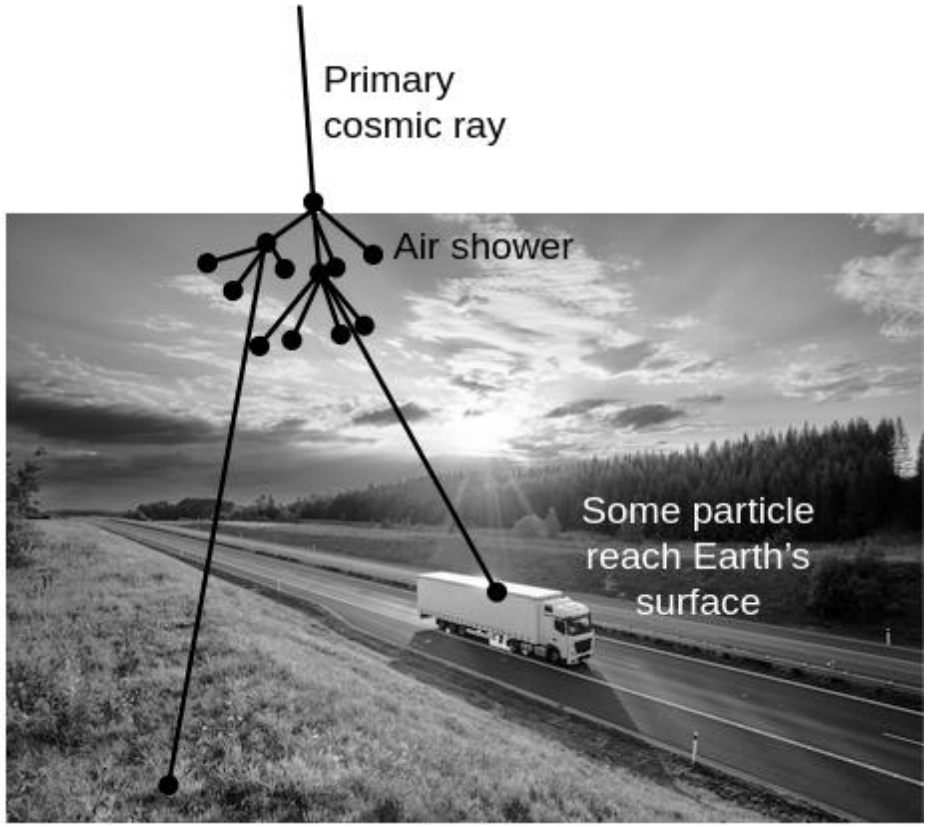

Cosmogenic background and mitigation strategies

- Prompt signals generated by muon interactions with the detector materials and its surrounding environment.
- Decay of cosmogenically activated radioisotopes.

- Underground laboratories
- Active muon veto

- Efficient transportation and storage plans

Cosmogenic background and mitigation strategies

- Prompt signals generated by muon interactions with the detector materials and its surrounding environment.
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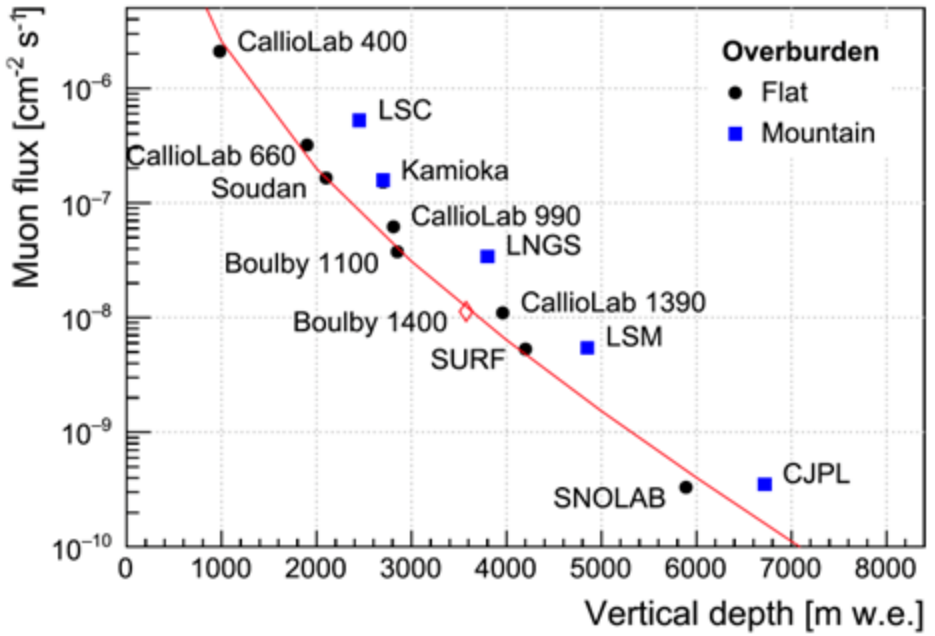
- **Underground laboratories**
- Active muon veto

- Efficient transportation and storage plans

Deep Underground Laboratories

- Suppress muon flux by 5 to 6 orders of magnitude
- Selecting the optimal underground site involves the experiment's depth requirements.
- Depth is usually measured in meter water equivalent (m.w.e.)



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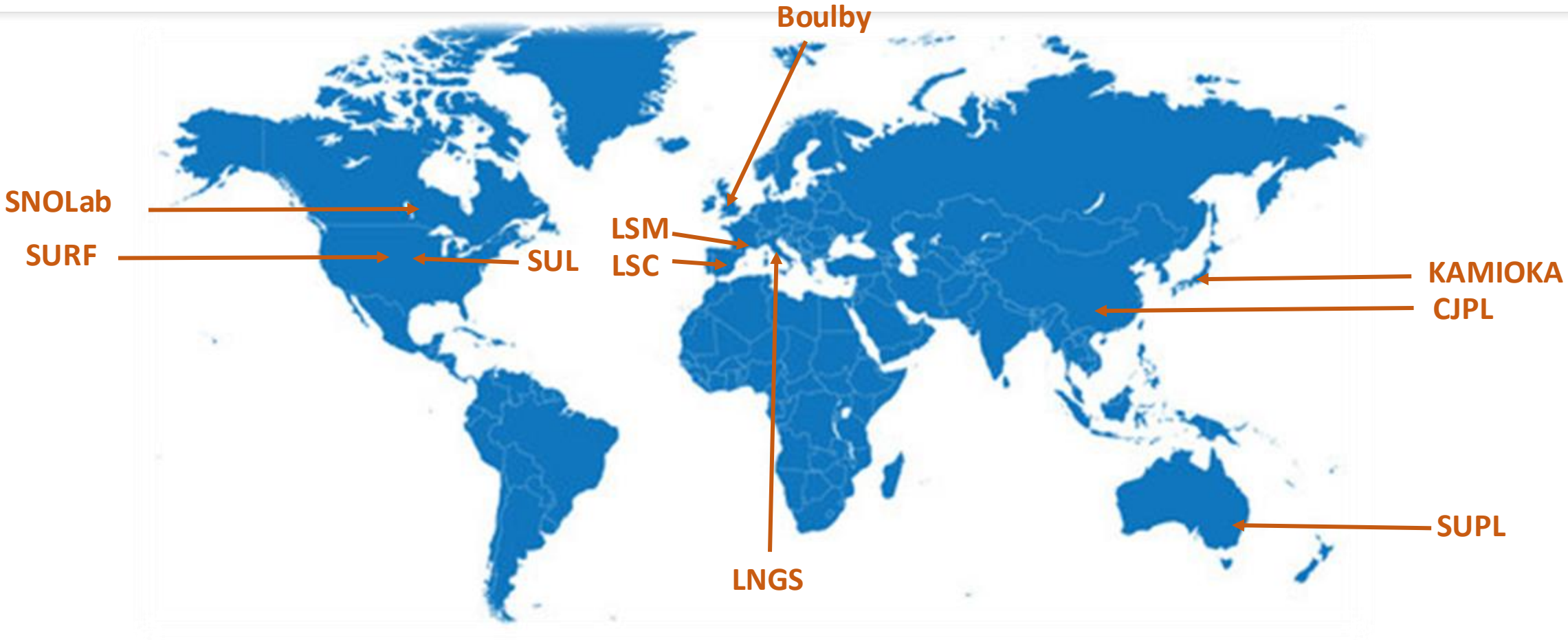
Deep Underground Laboratories



Cosmogenic background and mitigation strategies

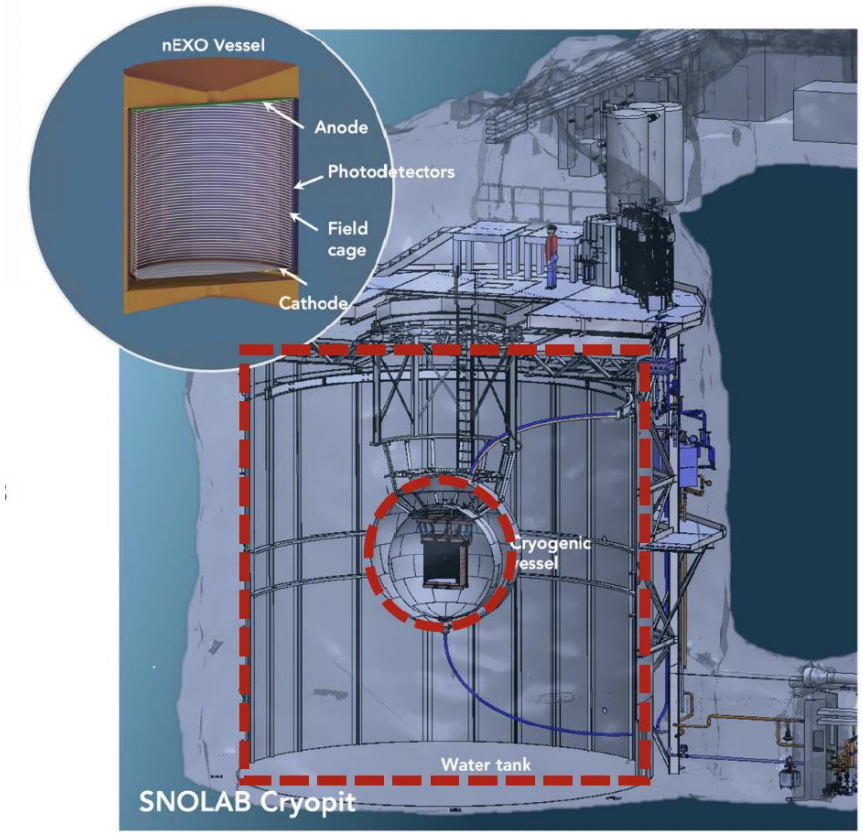
- Prompt signals generated by muon interactions with the detector materials and its surrounding environment.
- Decay of cosmogenically activated radioisotopes.

- Underground laboratories
- **Active muon veto**

- Efficient transportation and storage plans

Water Cherenkov Detector (WCD)

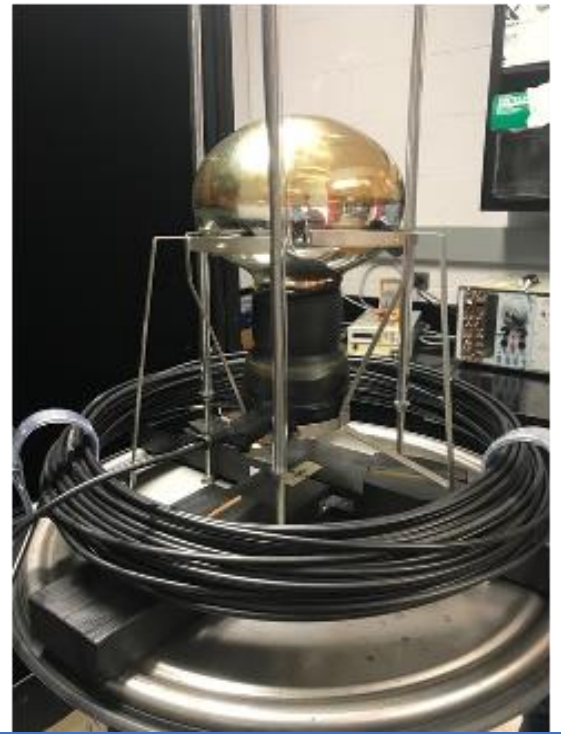
- Water tank instrumented with PMTs
- Passive shield from gammas and neutrons
- Muon veto
- Cost competitive
- Keep the radon concentration in water less than 10 mBq/m^3



Schematic diagram of nEXO

Cherenkov Detector

- Cherenkov spectrum peaks at UV range
- Reflective surface helps to reduce the number of PMTs
- Limiting factors
  - Reduced light yield
  - Need a higher energy threshold
  - Biological growth can influence the water transparency and light scattering.



Daya Bay PMT attached to a test setup.
Taken from LU PMT test facility for nEXO

Plastic Scintillation Detector

- Scintillation panels around the detector
- Segmentation allows more channels
- Higher light yield
- Excellent timing resolution
- Expensive for large volumes

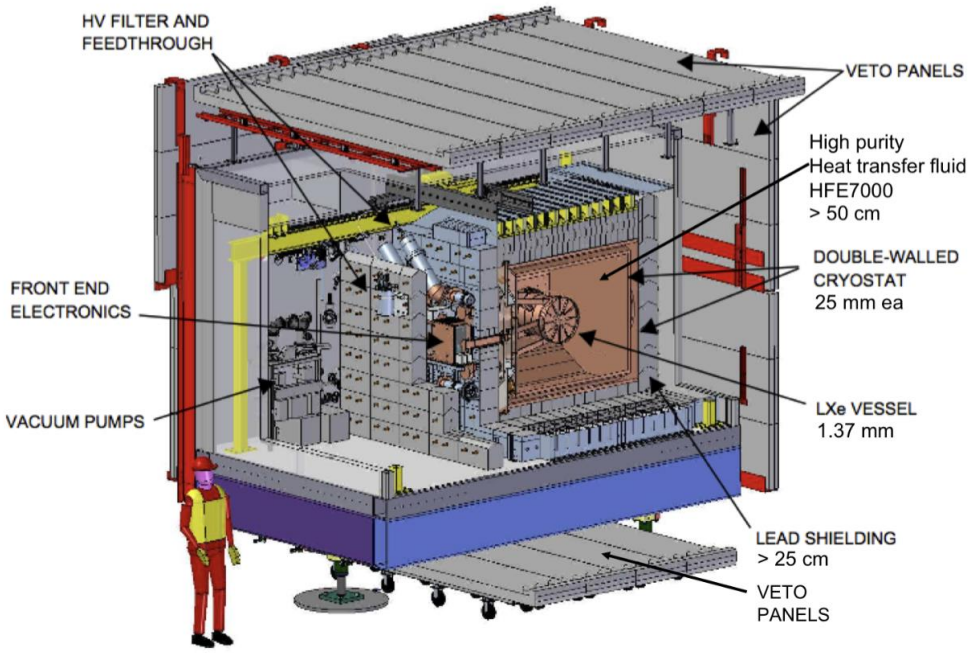
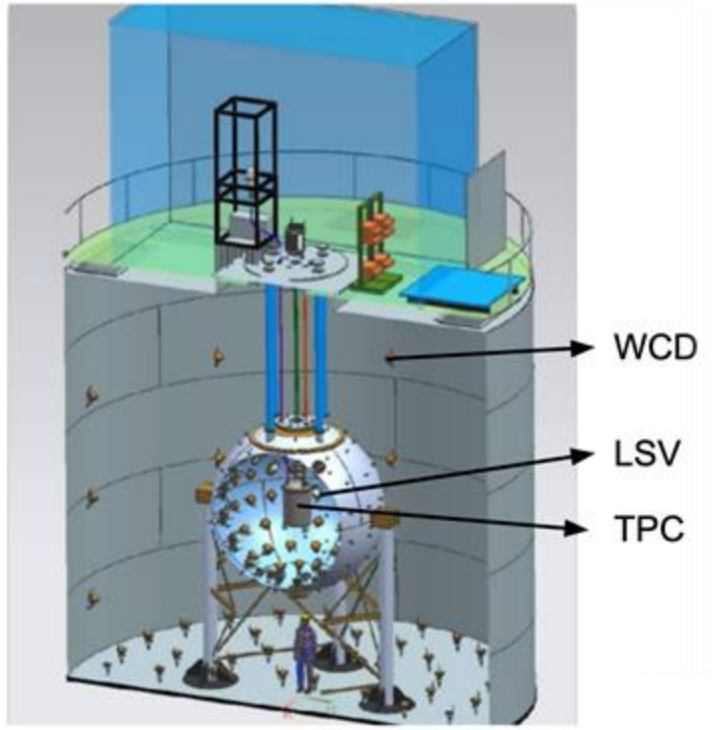


Illustration of EXO-200

Loaded Scintillation Detector

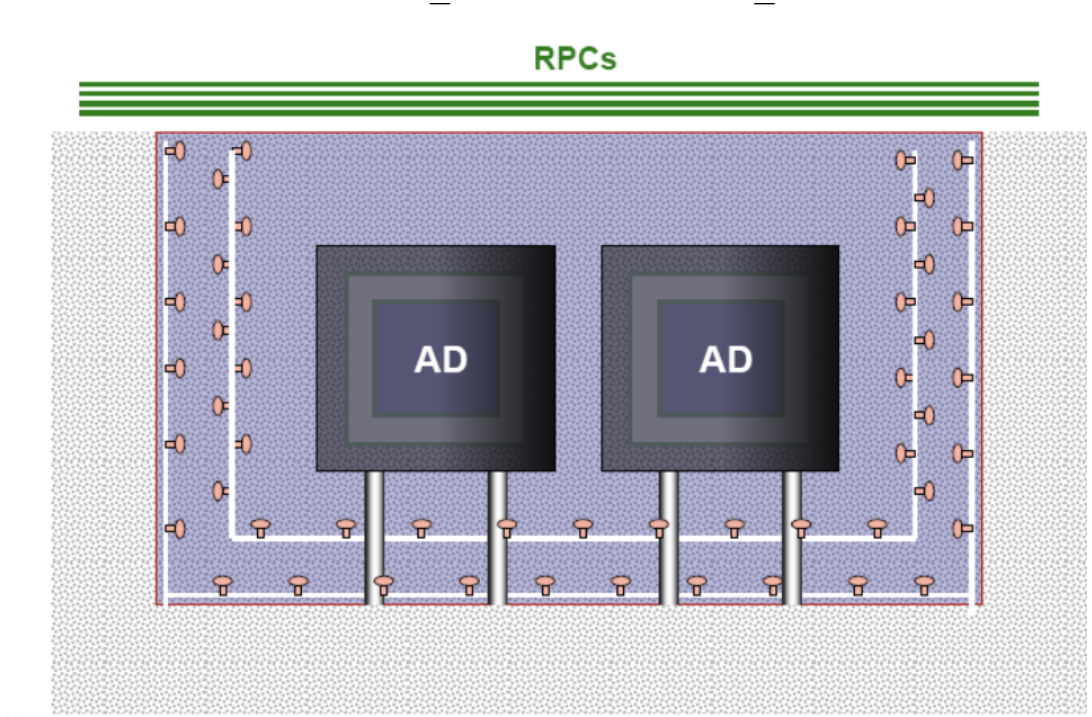
- Enhancement of neutron absorption possible with loaded scintillators
  - Boron (^{10}B)
  - Gadolinium (^{157}Gd)
  - Lithium (^{6}Li)
  - Cadmium (^{113}Cd)
- Limiting factors
  - Highly flammable
  - Toxic



Schematic diagram of DS-50

Resistive Plate Chamber (RPC)

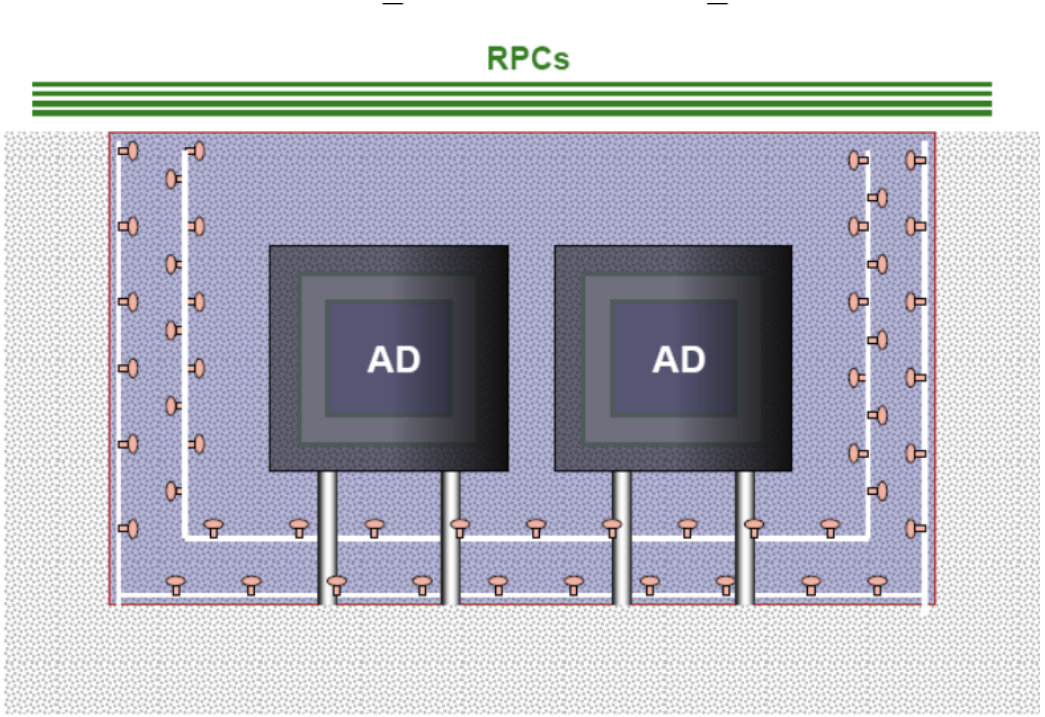
- Gaseous particle detectors
- Daya Bay experiment used RPC as one of its veto detectors
- Water pool is not sensitive to short track muons
- Provide independent and complementary muon information
- Provide muon directionality



Schematic diagram of DayaBay

Resistive Plate Chamber

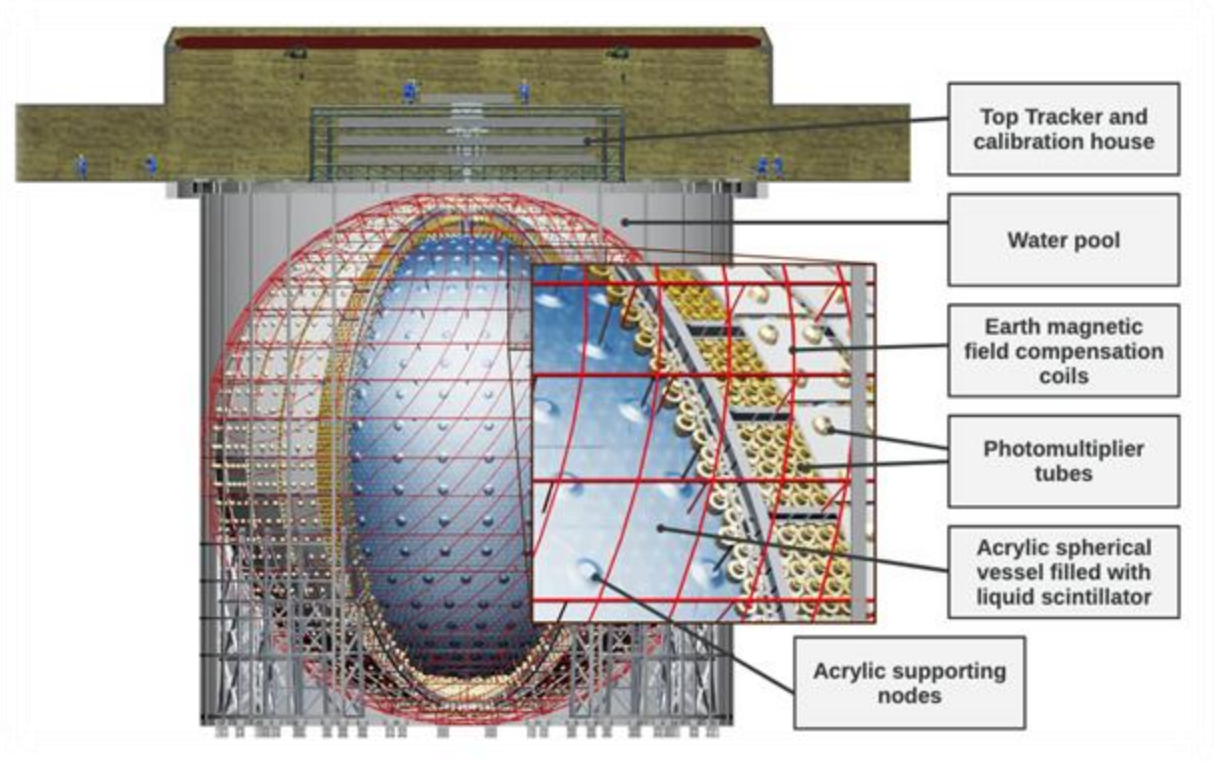
- Combined muon veto efficiency is at least 99.5%.
- Limiting factors
  - Requires high-voltage system and careful gas handling
  - Sensitive to temperature, humidity, and gas purity.
  - Aging effects from long-term operation.



Schematic diagram of DayaBay

Top Tracker

- Plastic scintillator trackers
- Provide independent muon information to help muon tagging and track reconstruction.



Schematic diagram of JUNO

Conclusions

- Cosmogenic backgrounds are a major concern for rare event searches.
- Underground labs suppress cosmogenic backgrounds to an order of 5 to 6.
- Water Cherenkov detector provides great flexibility in modifying the size and shape of the central detector.
- Scintillator detectors has higher light yield
- Resistive plate chamber, and top trackers along with water Cherenkov can improve the muon detection efficiency
- Efficient transportation and storage plans

Thank you