

Recent Astroparticle and Beyond the Standard Model Results from MicroBooNE

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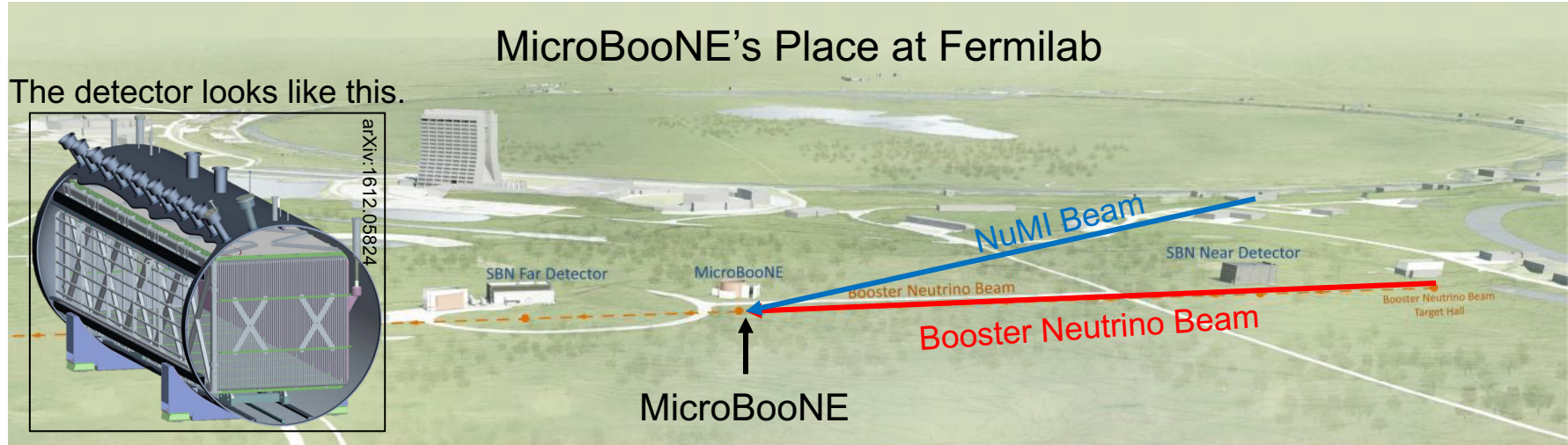
Rutgers University

For the MicroBooNE Collaboration

DPF 2021

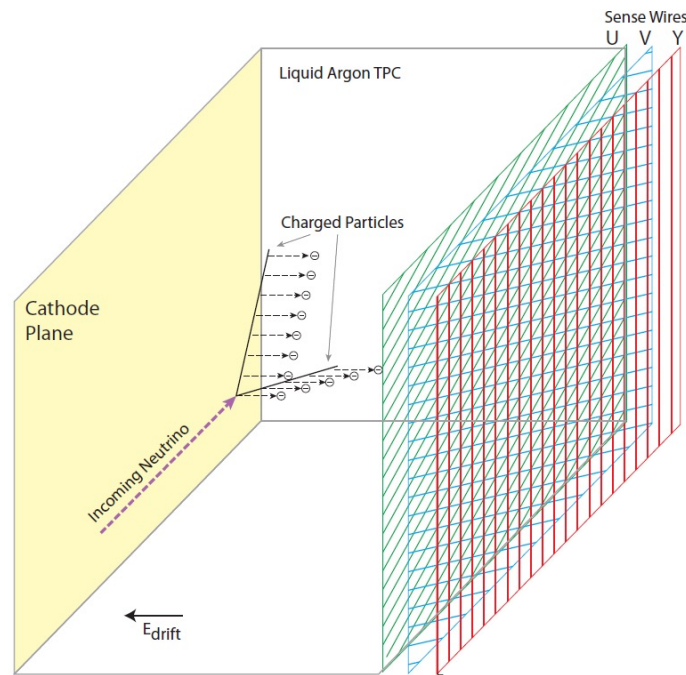
MicroBooNE

- 85-ton active mass Liquid Argon Time Projection Chamber (LArTPC)
- On-axis to the Booster Neutrino Beam at Fermilab (8 GeV protons)
- Off-axis to the Neutrinos at the Main Injector beam (120 GeV protons)
- Two beams = lots of BSM physics opportunities



LArTPC Technology

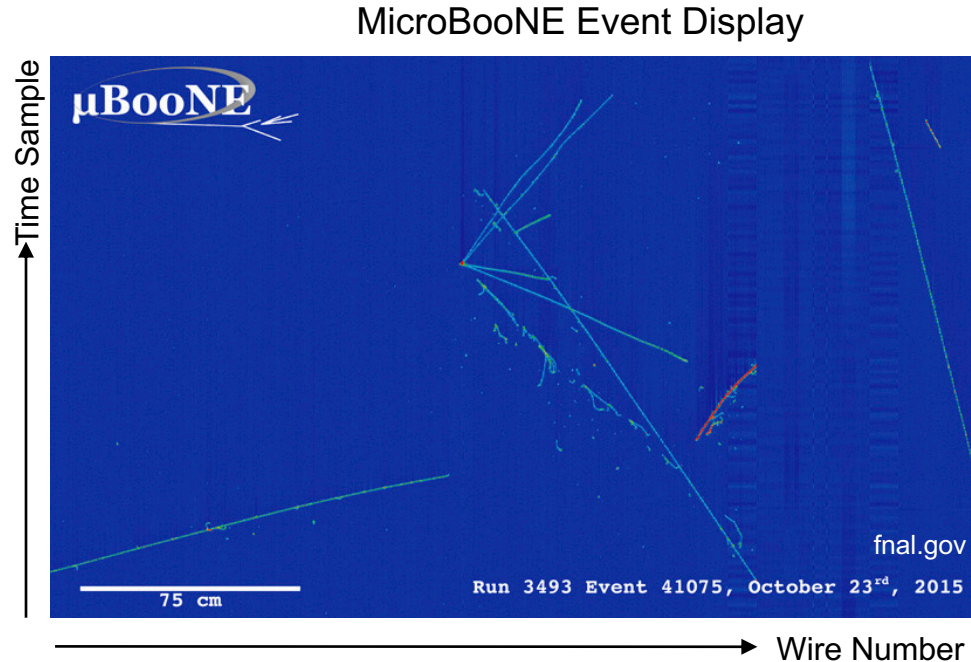
- LArTPCs offer excellent spatial resolution.
 - 3 mm for MicroBooNE
- As well as excellent calorimetry
- Electron-gamma separation
- Low thresholds
 - 100 keV for electrons
 - 21 MeV for protons
- LArTPCs are an excellent choice for astroparticle and Beyond the Standard Model studies.



JINST 12 (2017) 09, P09014
MicroBooNE's PMTs are not shown.

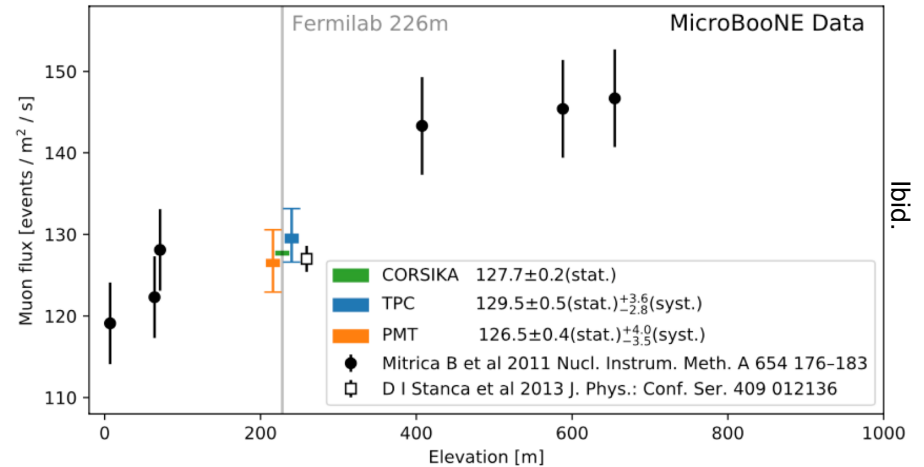
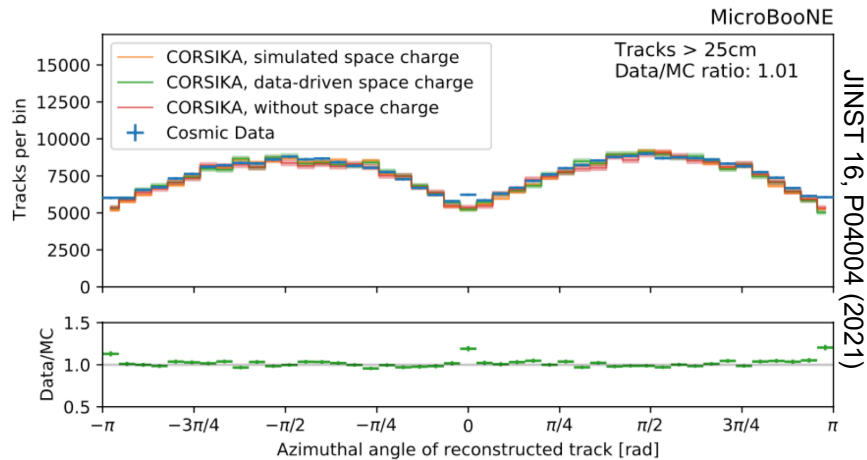
LArTPC Technology

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 - 3 mm for MicroBooNE
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Cosmic Ray Rate Measurement

- MicroBooNE has measured the rate of cosmic rays on the surface at Fermilab.
- Found good agreement with a CORSIKA simulation
- Useful for improving simulation and as input for future surface experiments at Fermilab (e.g. SBN program)

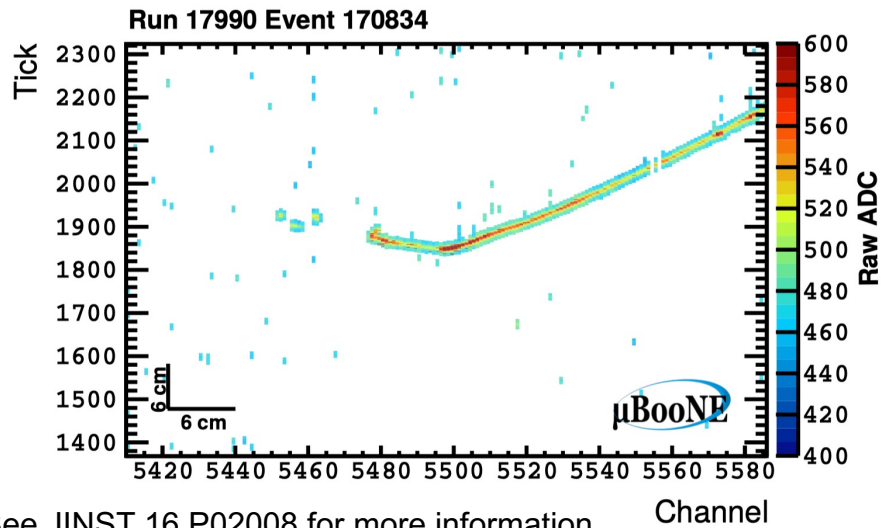


See JINST 16, P04004 (2021) for more information.

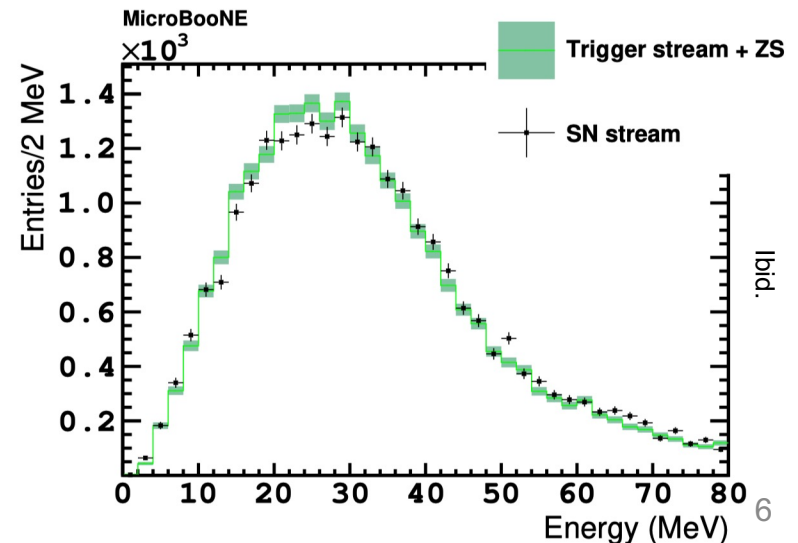
Supernova Neutrino Readout Stream

- Supernova neutrino detection requires a continuous readout stream.
- Problem: too much data GB/s (MicroBooNE) – TB/s (DUNE)
- Solution: zero suppress and compress the data
 - Compression factor: 80 (Huffman)

Event Display After Zero Suppression

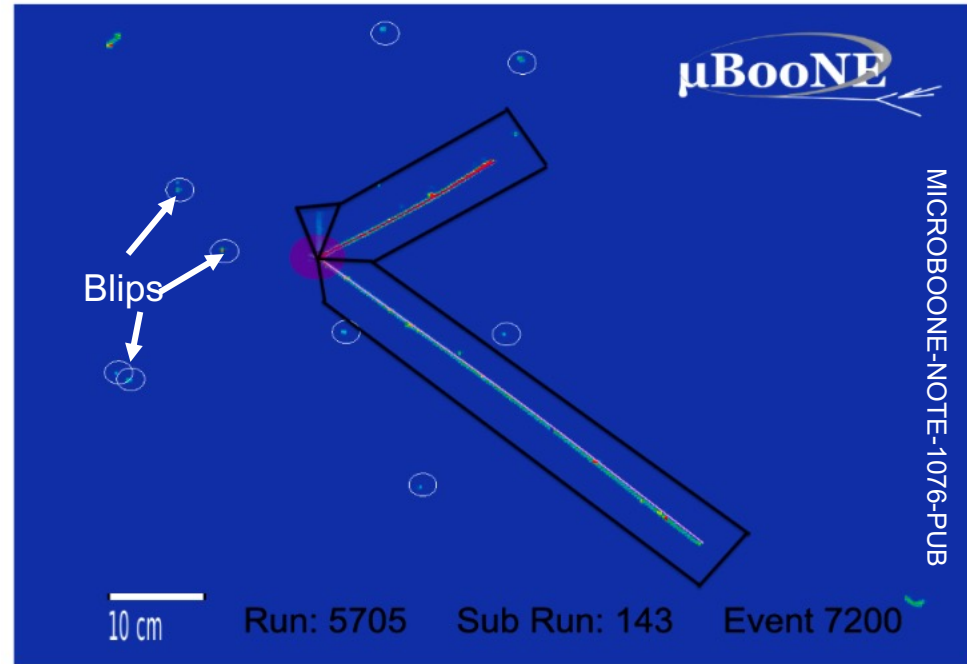


Reconstructed Michel Electron Spectrum



MeV-Scale Reconstruction

- Reconstructing MeV-scale activity is important for low-energy neutrino studies
 - e.g. supernova neutrinos, a major goal of DUNE
- Improved energy reconstruction and resolution by including de-excitation photons and neutrons
 - Appear as “blips”
- Algorithms have been developed for selecting and reconstructing activity as low as 100 keV.
 - Thresholds being lowered even further

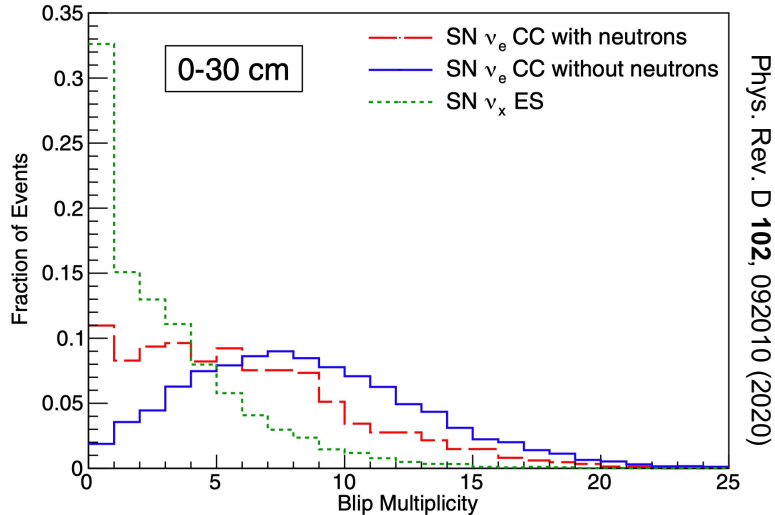


Event display of neutrino interaction with “blip” activity

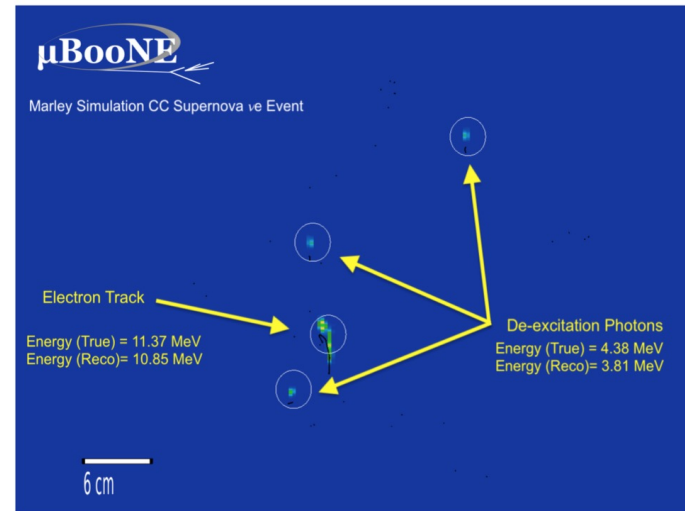
MeV-Scale Reconstruction Benefits

- Supernova neutrino interactions can be classified as CC absorption vs electron scattering (ES) based on amount of MeV-scale activity.
- As well as muon-pion separation
- Some BSM models require MeV-scale reconstruction (e.g. millicharged particles).

Blip Multiplicity For Supernova Neutrino Events

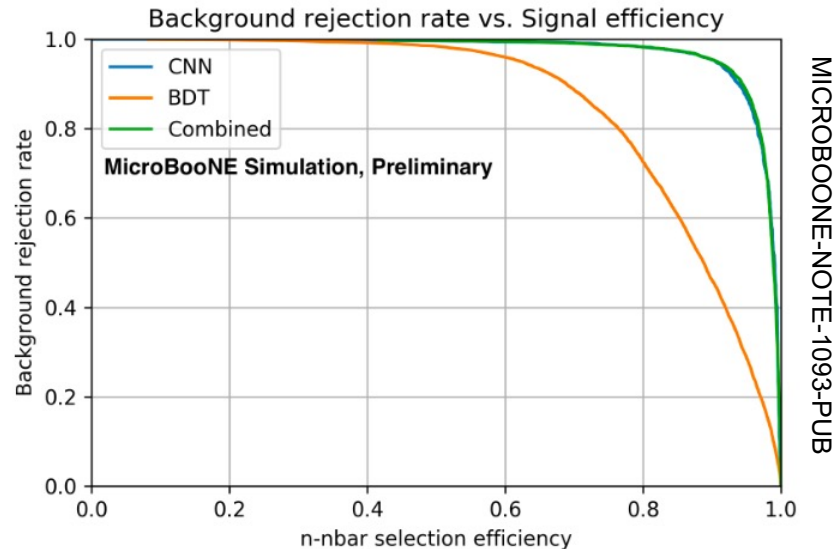
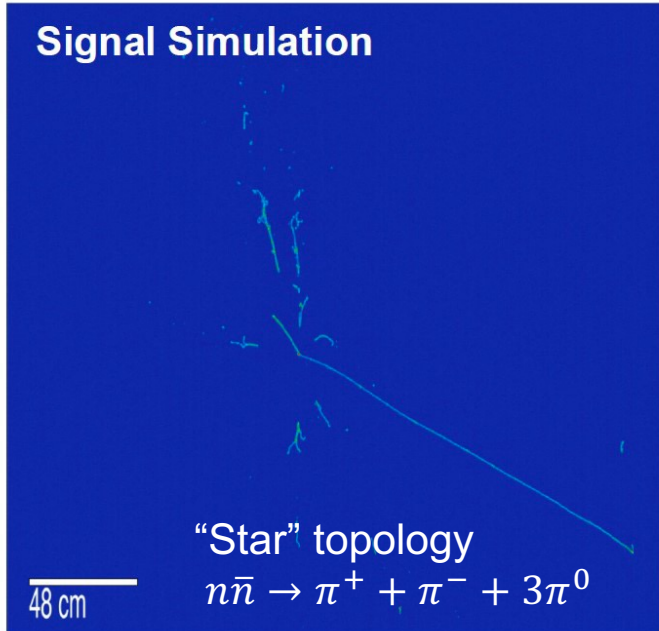


CC Absorption Event Display



Neutron-Antineutron Oscillation

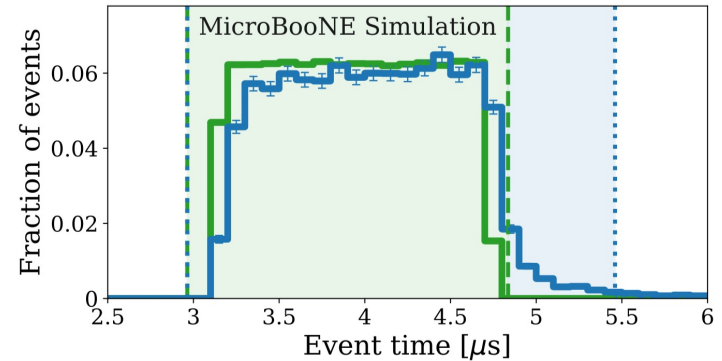
- MicroBooNE is developing techniques to search for neutron-antineutron oscillation, a baryon-number violating process.
- Using a convolutional neural network to identify signal
- Useful input for DUNE



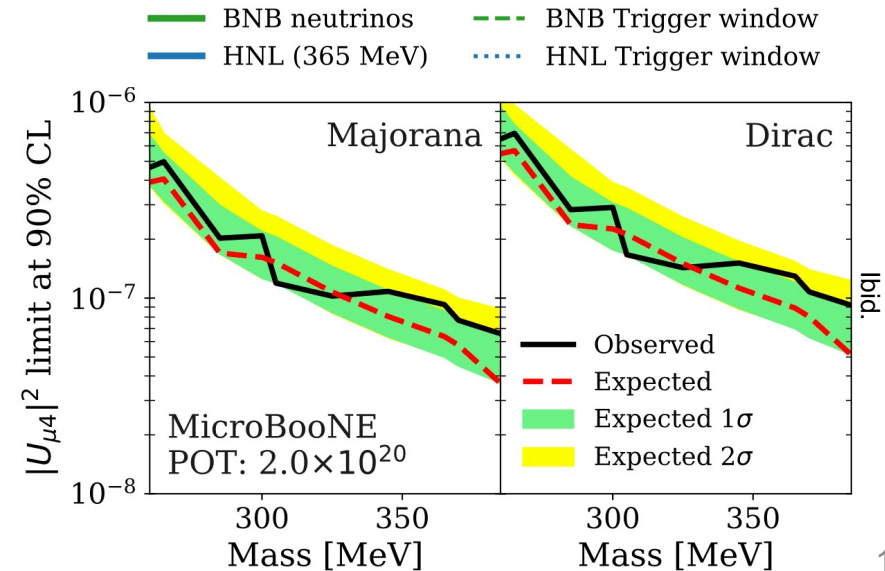
See MICROBOONE-NOTE-1093-PUB for more information.

Heavy Neutral Leptons

- Neutral leptons
 - Like neutrinos, but more massive
- Can be produced in the BNB
 - Requires use of late trigger window (top right)
- Arise from mixing with neutrinos
- Decay via SM weak interaction
- MicroBooNE has set limits for the $\mu + \pi$ decay mode.
- Currently exploring more decay modes and NuMI data



Phys. Rev. D 101, 052001

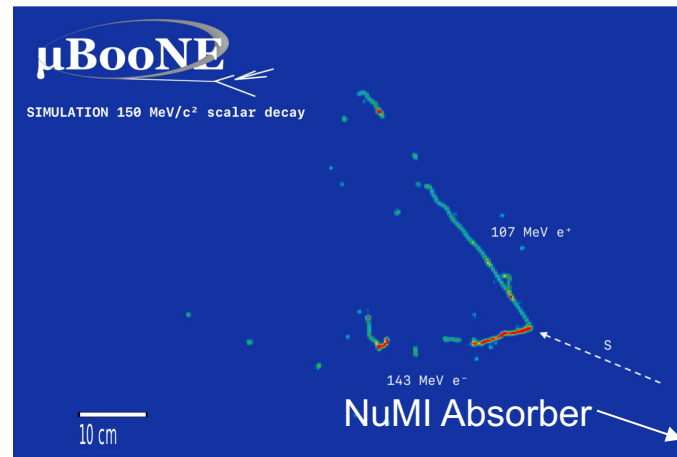


See Phys. Rev. D 101, 052001 for more information.

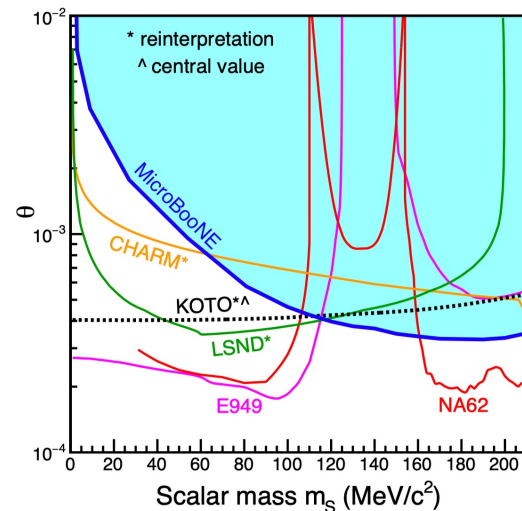
Higgs Portal Scalars

- Dark scalar which mixes with the Higgs
- Decays into l^+l^- or $\pi^+\pi^-$
- Possible explanation for the KOTO anomaly
 - Excess of $K_L^0 \rightarrow \pi^0 + \text{invisible}$ decays
- MicroBooNE has performed a search for e^+e^- decay.
 - Using KDAR from NuMI absorber
- Rules out Higgs Portal Scalar explanation to the KOTO anomaly

See arXiv: 2106.00568 for more information.



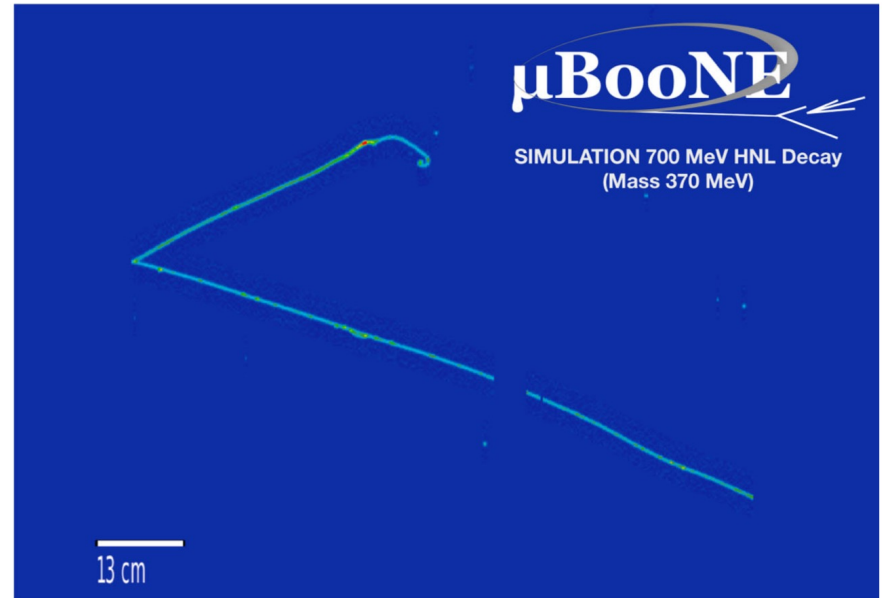
MICROBOONE-NOTE-1092-PUB



arXiv: 2106.00568

Summary

- MicroBooNE is an excellent detector for astroparticle and BSM studies.
- Over the past ~year, MicroBooNE has released several results in this domain
 - Supernova neutrino stream
 - Cosmic ray measurement
 - MeV-scale physics
 - Neutron-antineutron oscillation
 - Heavy neutral leptons search
 - Higgs portal scalar search
- More results are coming soon!



Simulated Heavy Neutral Lepton Decay