

# Search for a Low Energy Excess in MicroBooNE

Nicolò Foppiani - Harvard University  
On behalf of the MicroBooNE collaboration

54th Rencontres de Moriond EW - Young Scientist Forum  
March 20th, 2019

## Anomalies in Short Baseline Neutrino Oscillations

→ **Might hide sterile neutrinos -> new physics BSM**

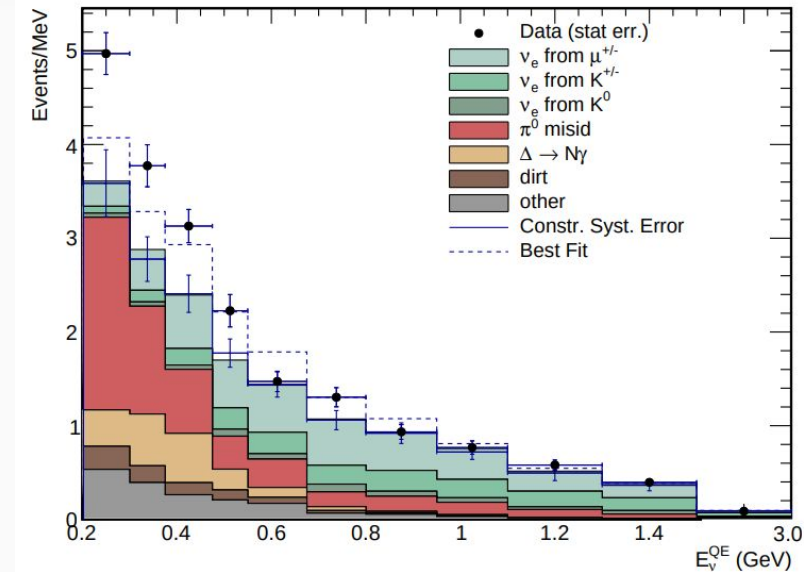
- LSND: **excess of EM-like** events

[Phys. Rev. D 64, 112007](#)

- MiniBooNE: similar **EM-like excess**

[Phys. Rev. Lett. 121, 221801](#)

- Could not distinguish electrons from photons
- MicroBooNE: LEE is the primary goal
  - Is there an excess?
  - Origin? Electron-like or photon-like?



# Neutrino anomalies and the Low Energy Excess

## Anomalies in Short Baseline Neutrino Oscillations

→ Might hide sterile neutrinos -> new physics BSM

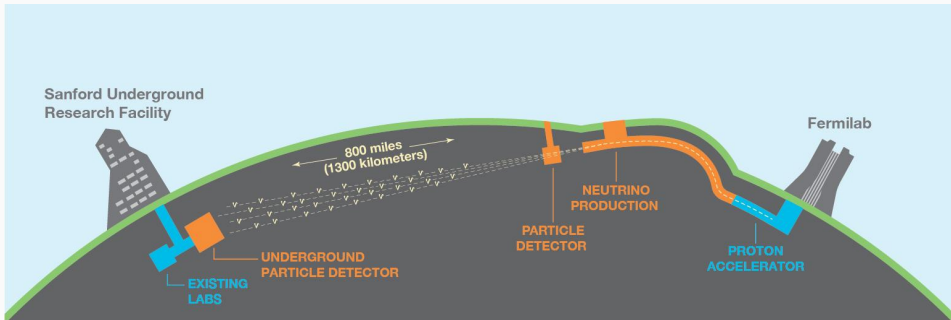
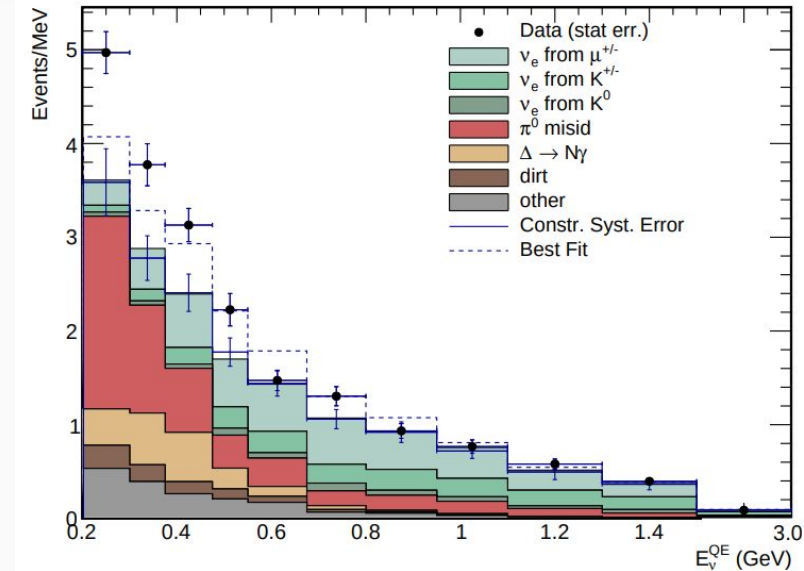
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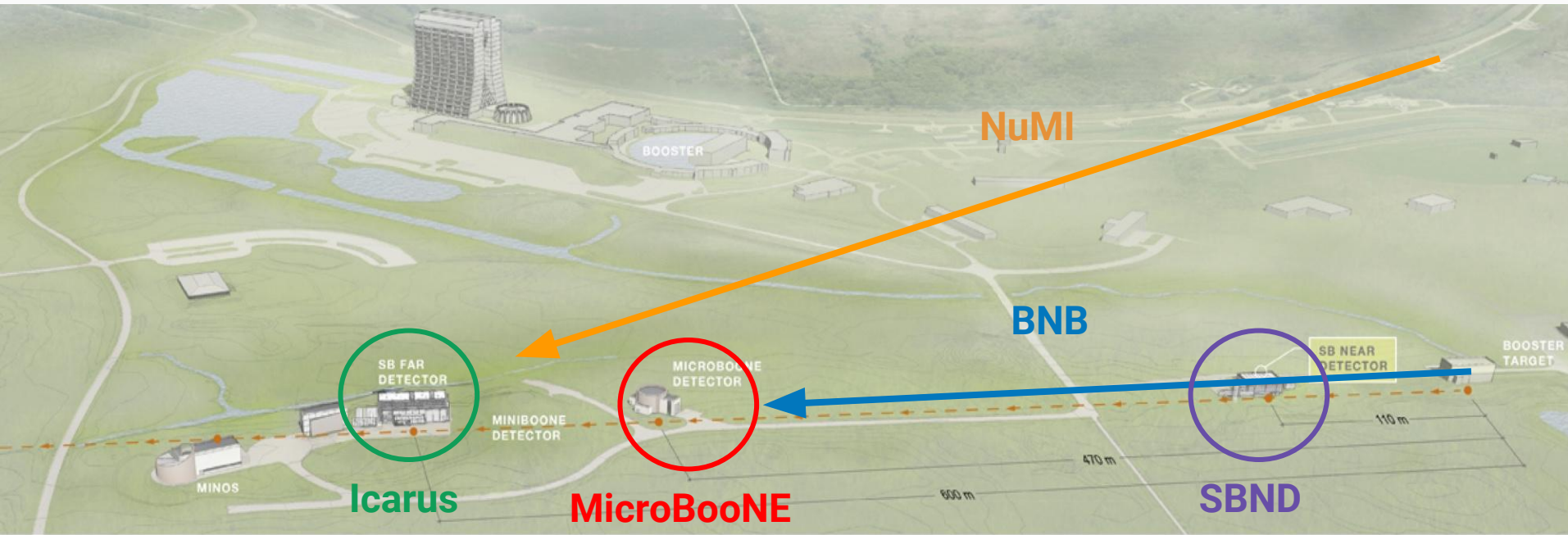
## Precision measurements of Cross Sections in liquid argon

- Improve understanding of nuclear physics in neutrino interactions
- Preparation for DUNE

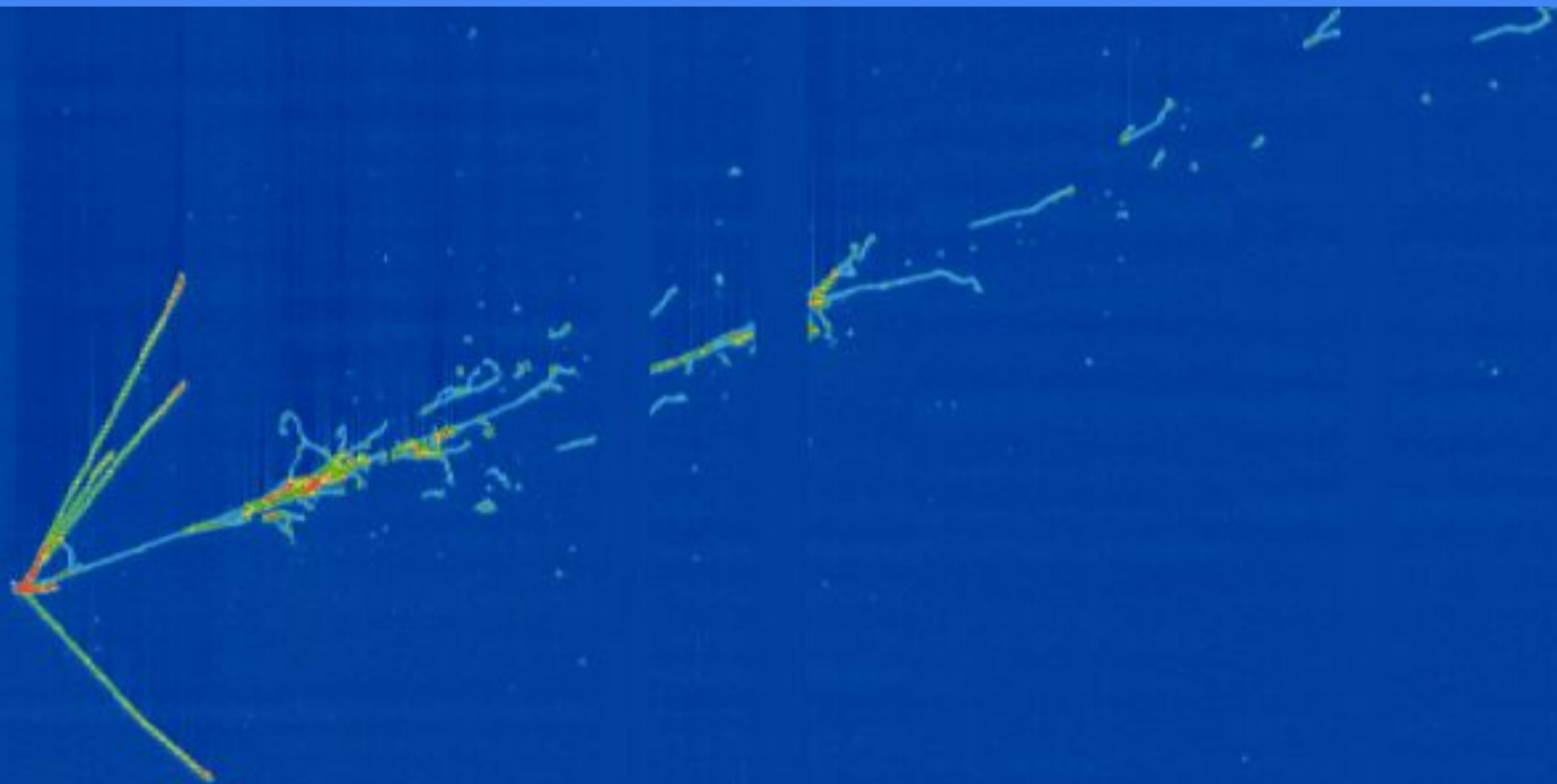
# Micro Booster Neutrino Experiment at Fermilab

Two beamlines:

- **BNB**: On axis, 480 m from the production point
  - For the main physics goals of MicroBooNE
  - The heart of the SBN programme, with SBND and Icarus
- **NuMI**: Off Axis (dedicated to  $\text{NO}\nu\text{A}$ ,  $\text{MINER}\nu\text{A}$ ,  $\text{MINOS}$ )
  - Complementary physics and cross checks



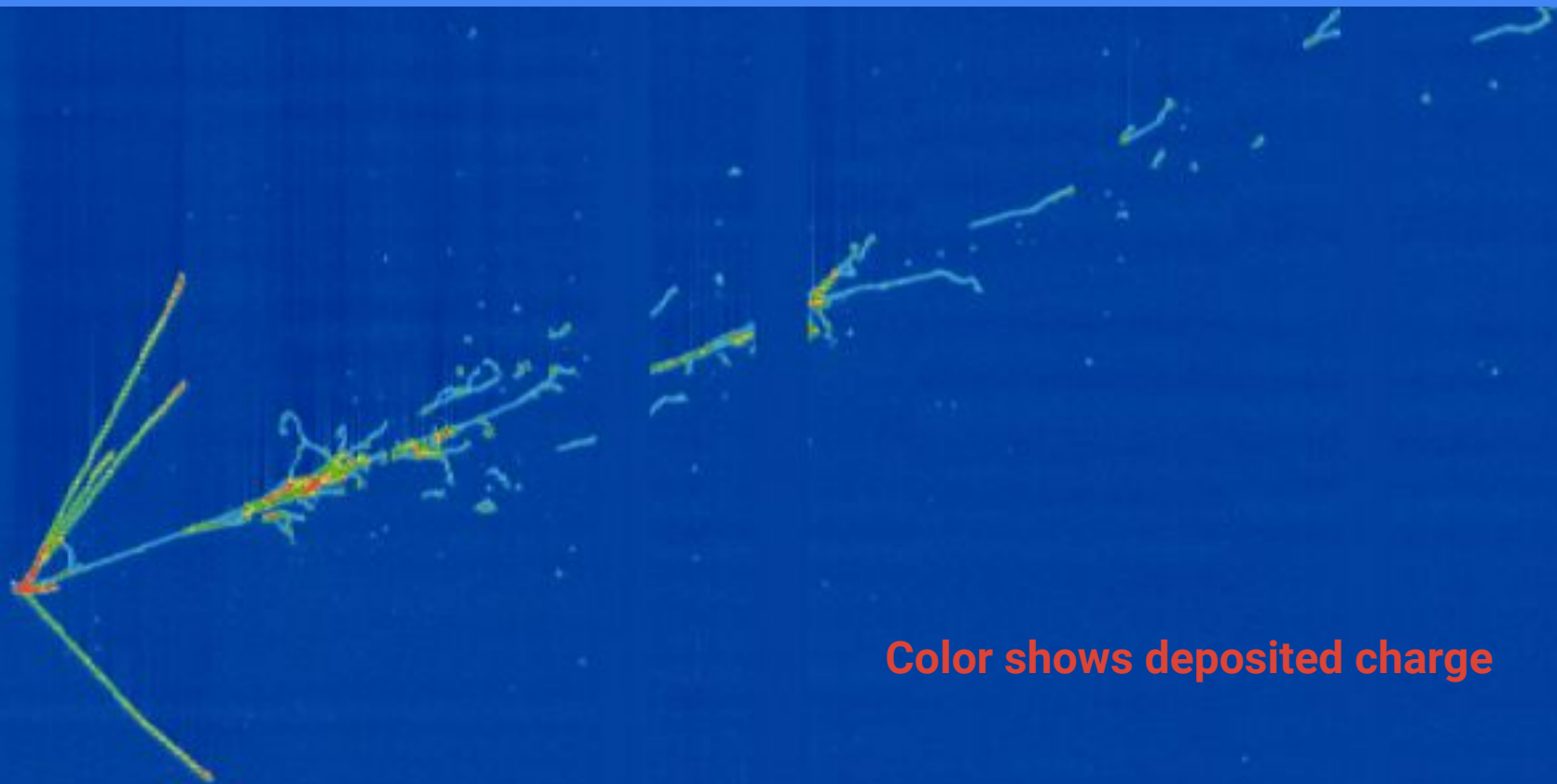
# A typical event



17 cm

NUMI DATA: RUN 10811, EVENT 2549. APRIL 9, 2017.

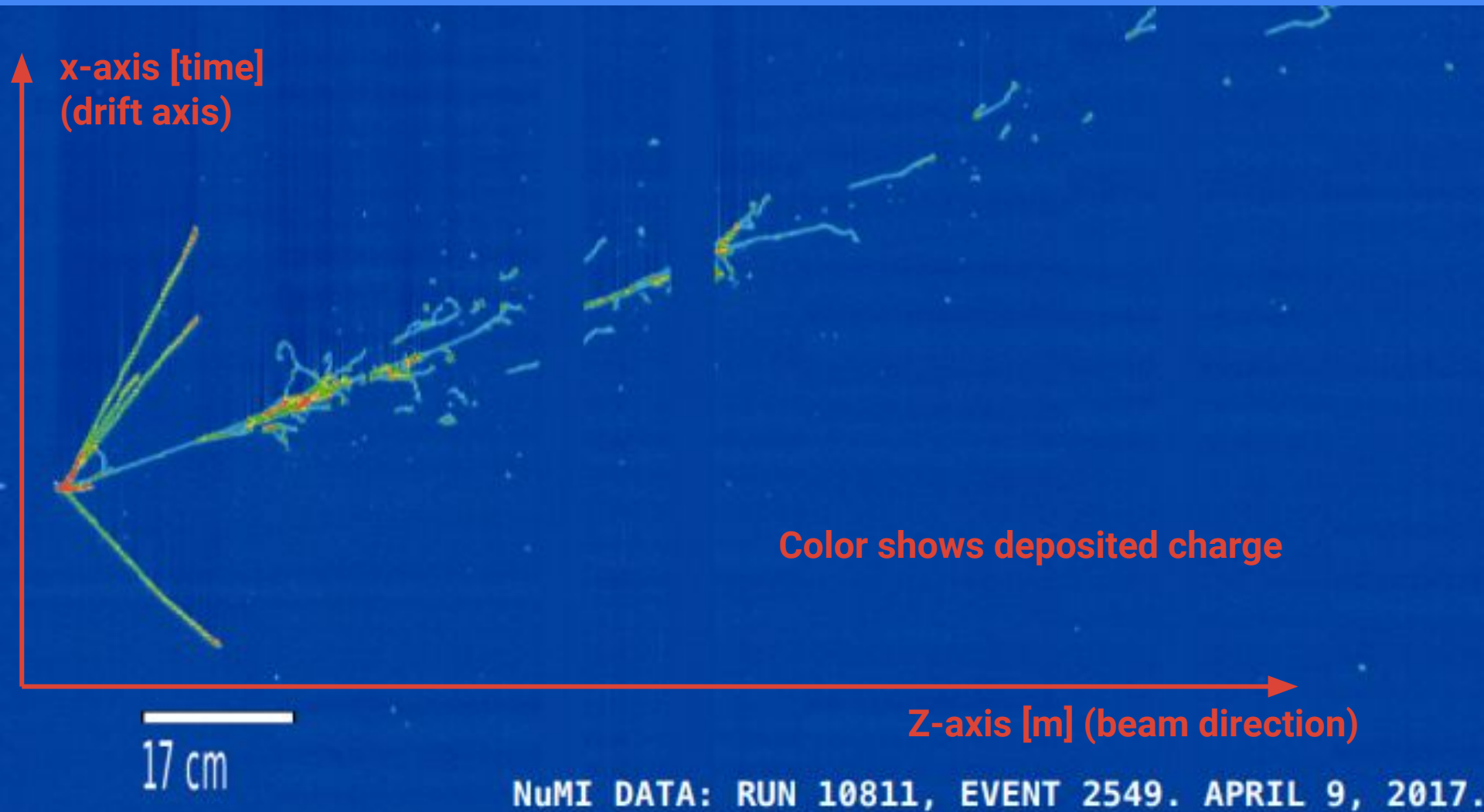
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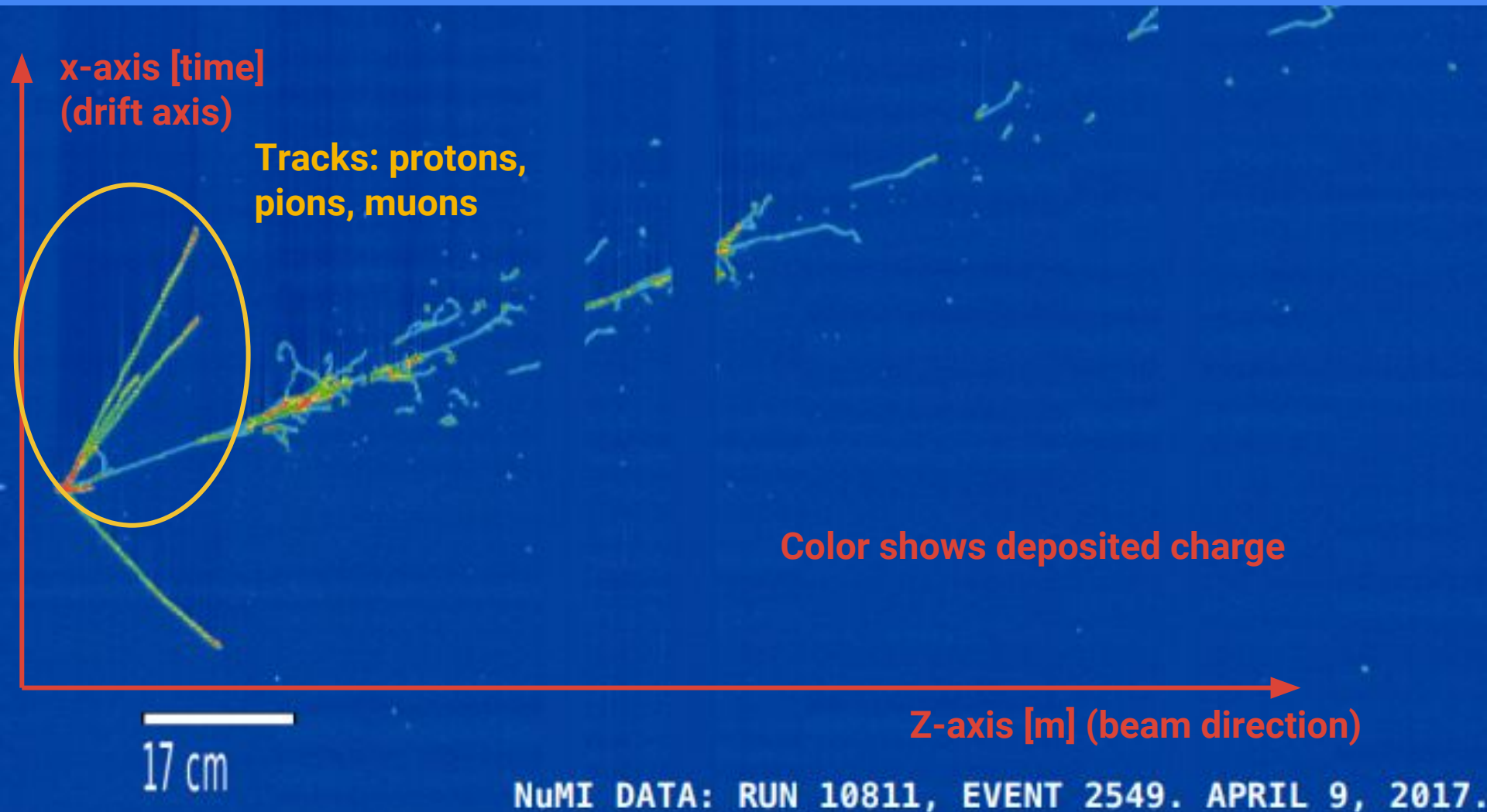
**Color shows deposited charge**

17 cm

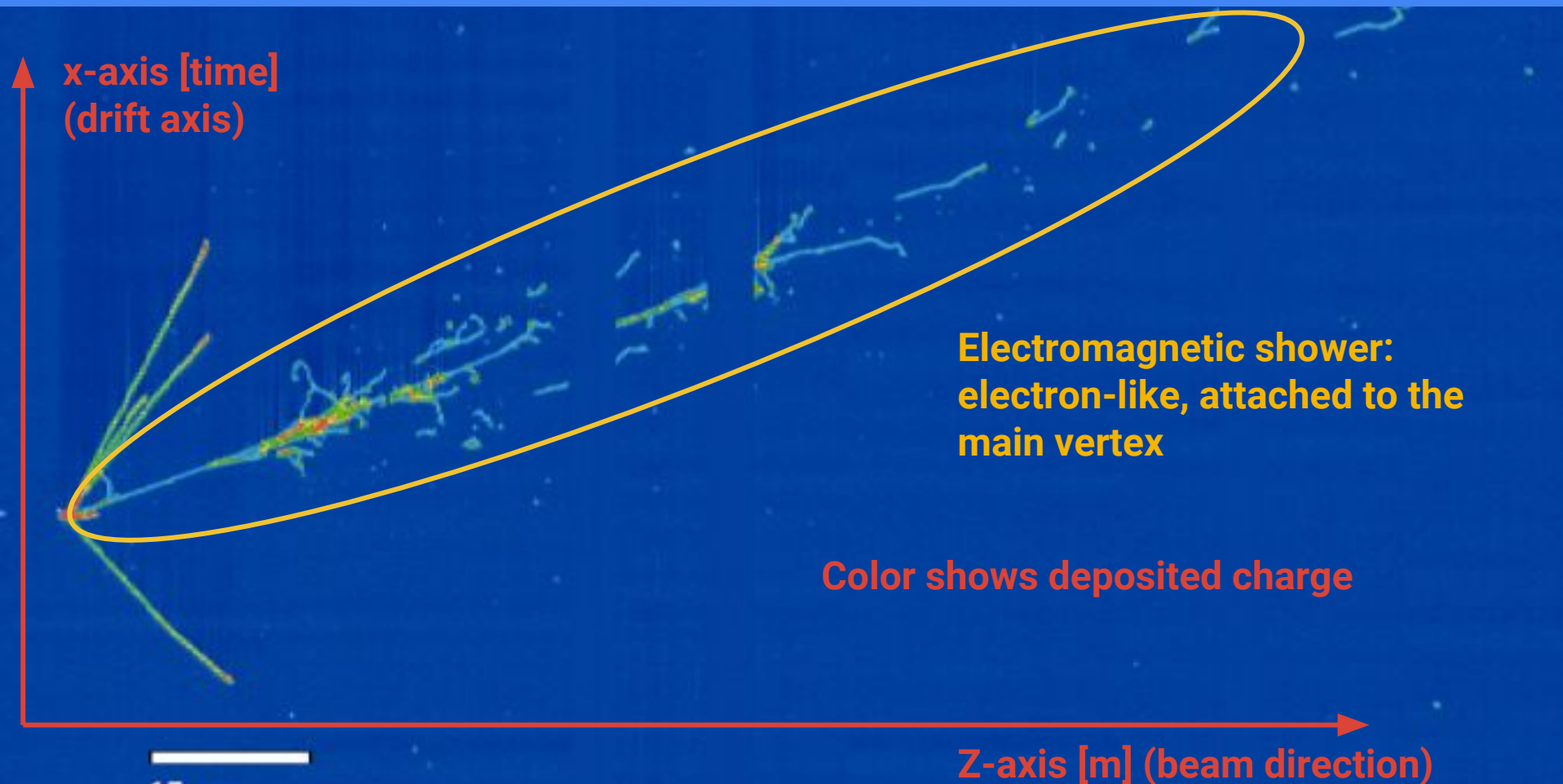
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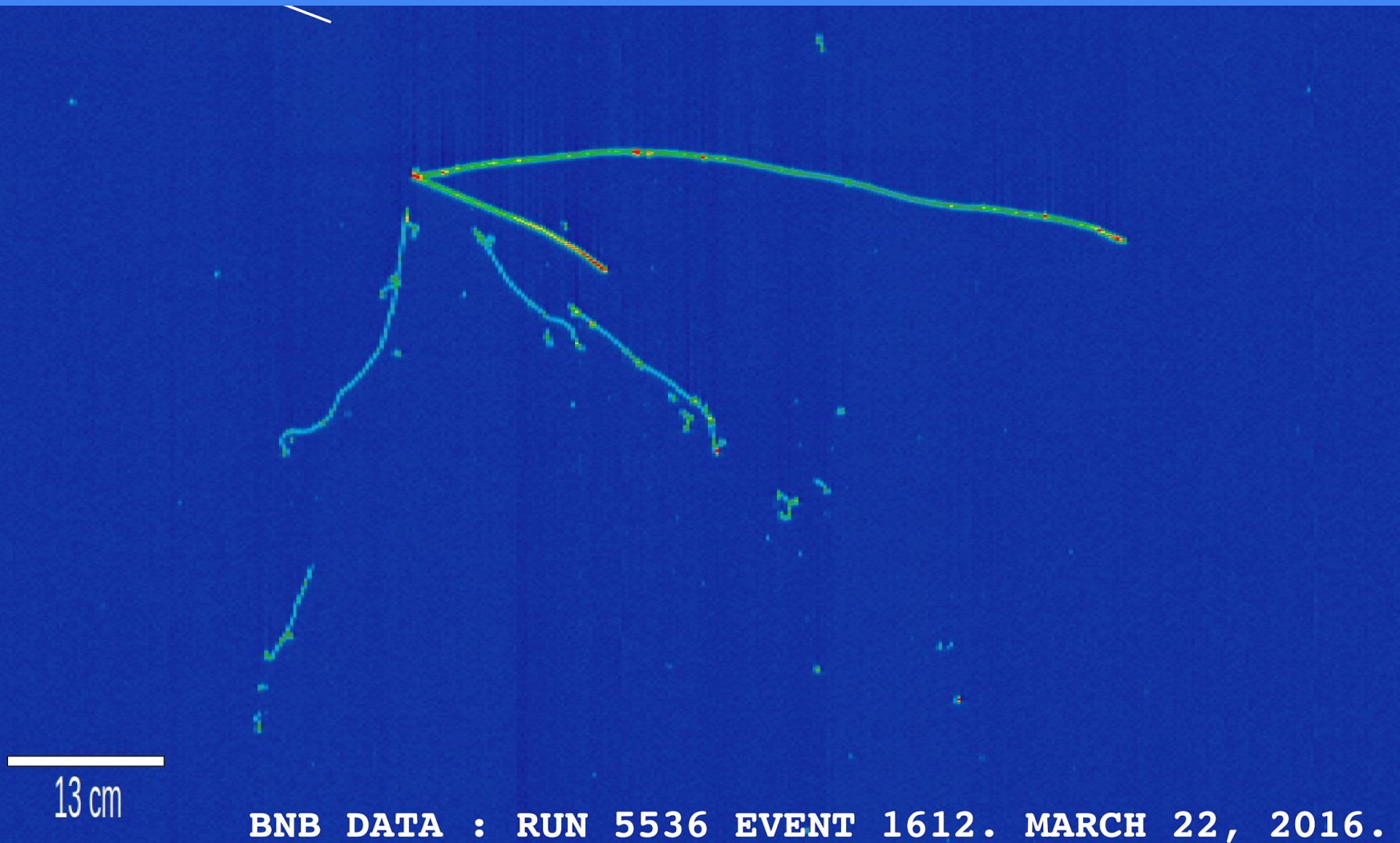


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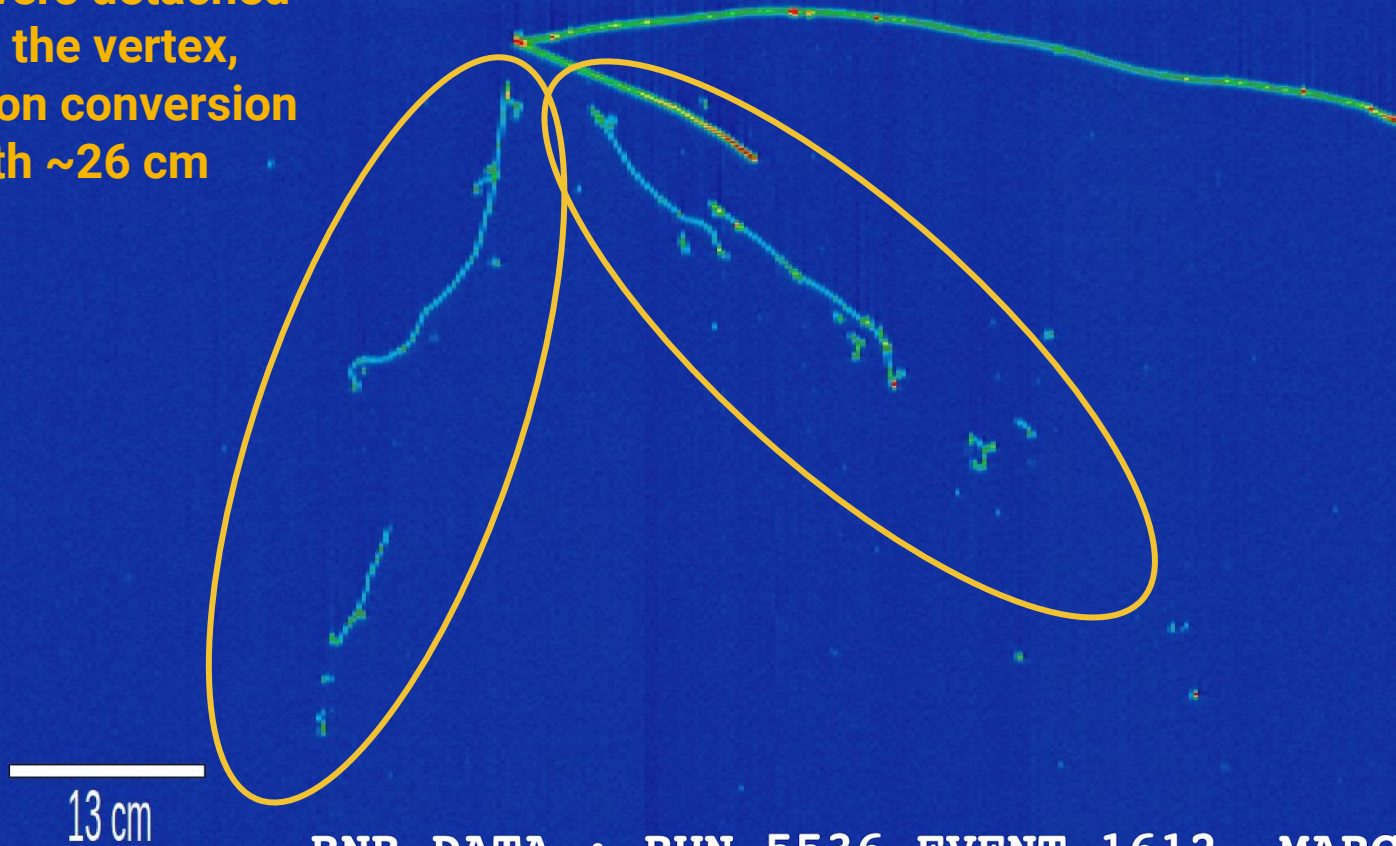
17 cm

# A typical $\pi_0 \rightarrow \gamma\gamma$ event



# A typical $\pi_0 \rightarrow \gamma\gamma$ event

Electromagnetic  
showers detached  
from the vertex,  
photon conversion  
length  $\sim 26$  cm

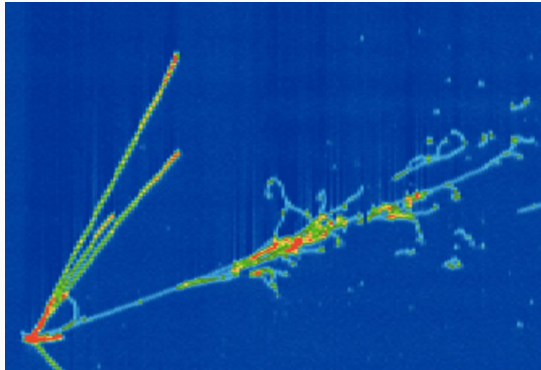


BNB DATA : RUN 5536 EVENT 1612. MARCH 22, 2016.



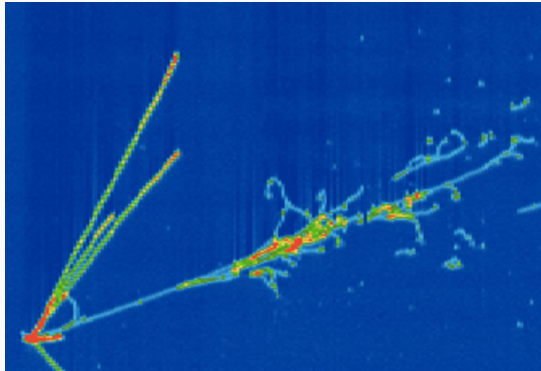
## Electron-like search:

- Shower attached to the vertex
- $dE/dx$  of one MIP particle at the start of the shower



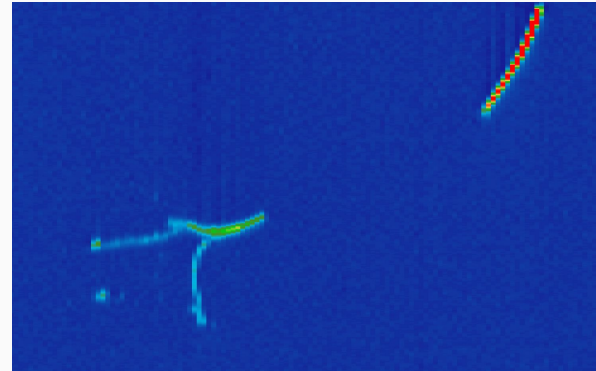
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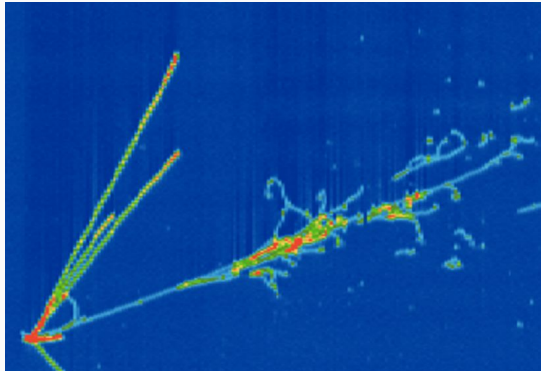
## Photon-like search:

- Shower detached from the vertex
- $dE/dx$  of two MIP particles at the start of the shower



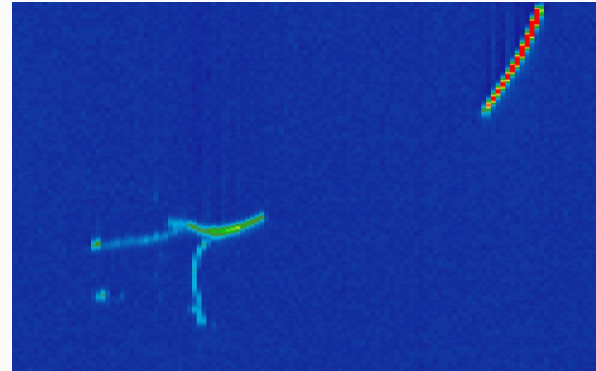
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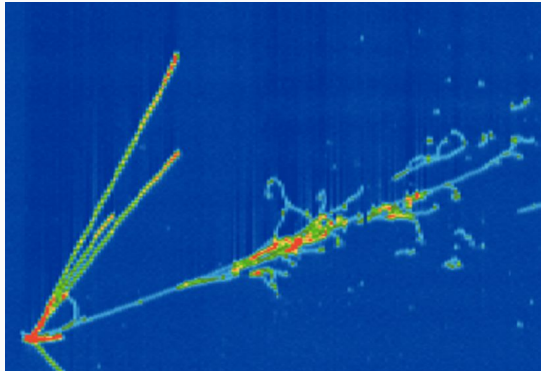
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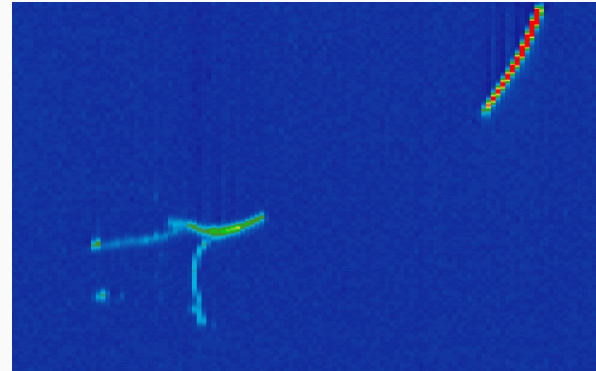
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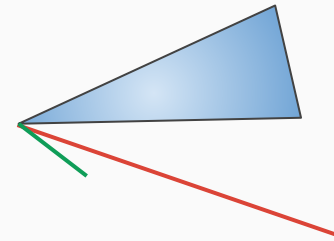
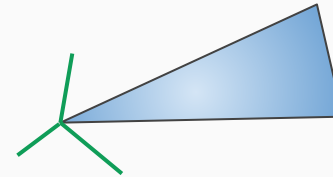
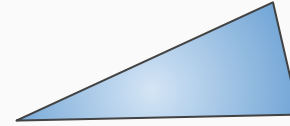
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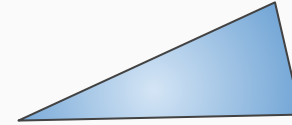
Some data ready to develop the analyses:

- Open data:  $4e19$  POT BNB ( $\sim 3.5\%$ ) and  $2.4e20$  POT NuMI (21%)
- Total data: about  $1.13e21$  POT BNB and  $1.6e21$  POT NuMI so far

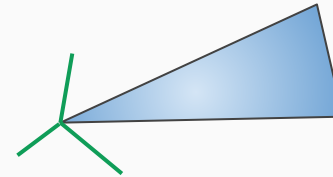
- **Only one electron:  $\nu_e$  CC  $0\pi 0p$** 
  - hardest to distinguish from single photon production
  
- **Additional protons:  $\nu_e$  CC  $0\pi Np$** 
  - Easier because additional tracks determine vertex
  - It is the channel in which the LEE has been observed
  
- **Additional pions:  $\nu_e$  CC  $M\pi Np$** 
  - Very complex events
  - Typically higher energies



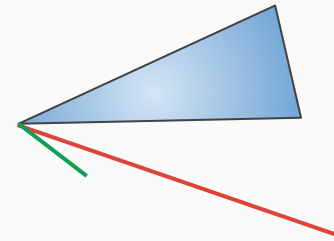
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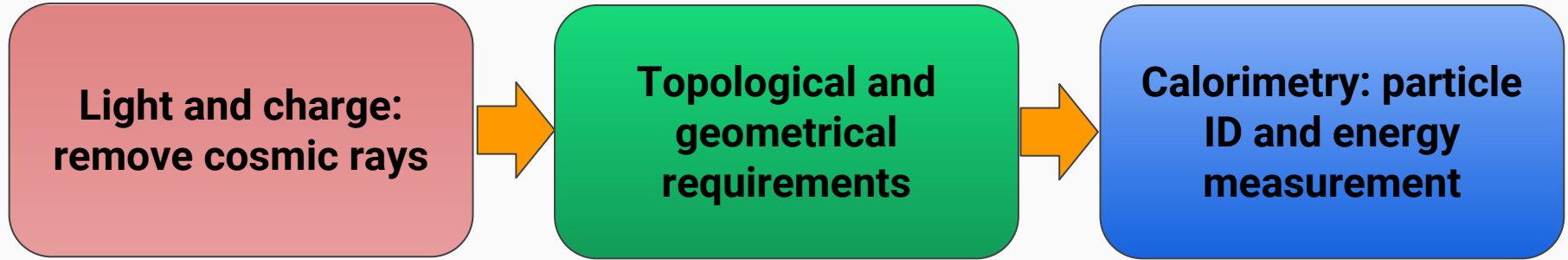


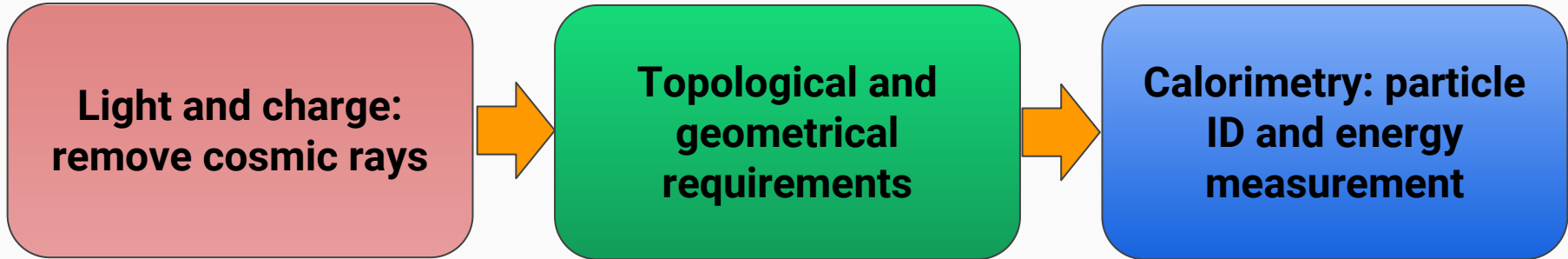
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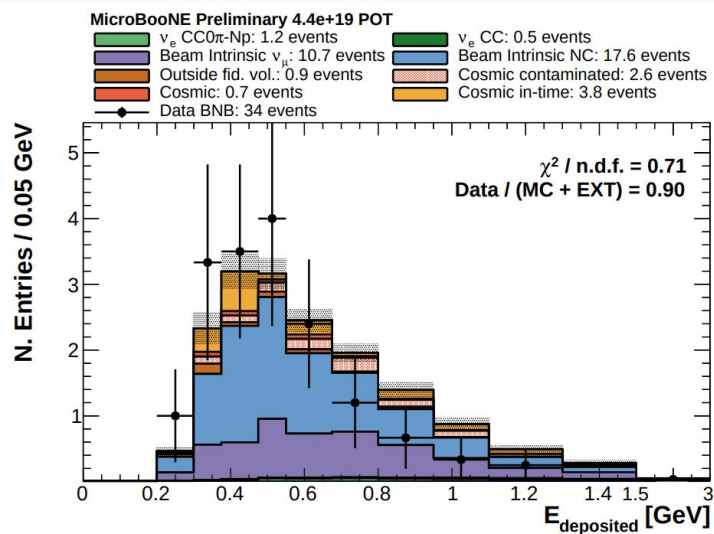




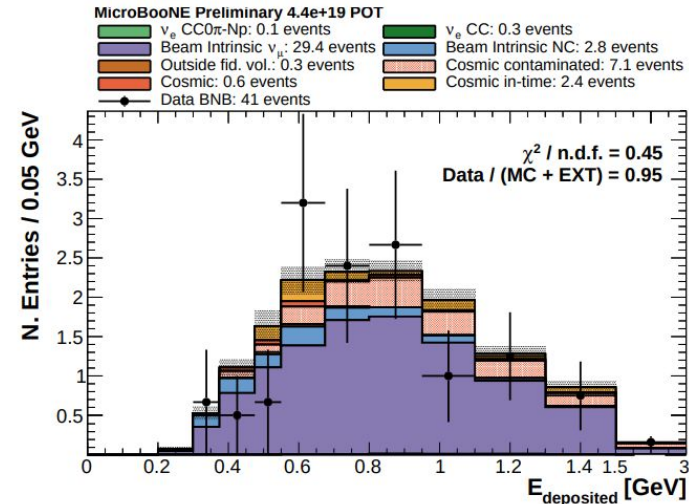


Cross check: two sidebands on 3.5% of the total BNB data

$NC\pi_0$   
enriched  
(photon  
enriched)  
sideband

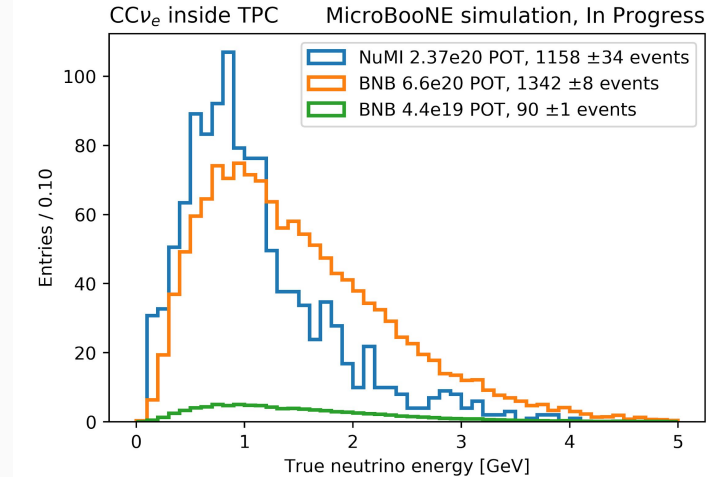


$\nu_\mu$  CC  
enriched  
sideband



Cross check the BNB analysis using NuMI

- As many  $\nu_e$  CC interactions as expected in the full BNB dataset
- Perfect to validate the analysis

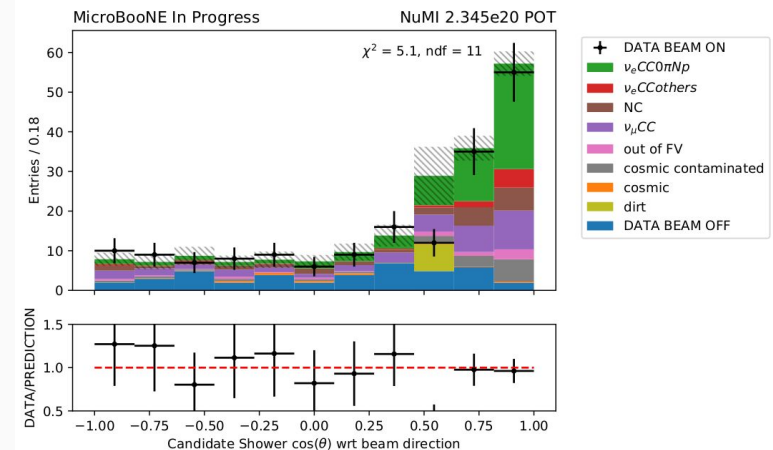
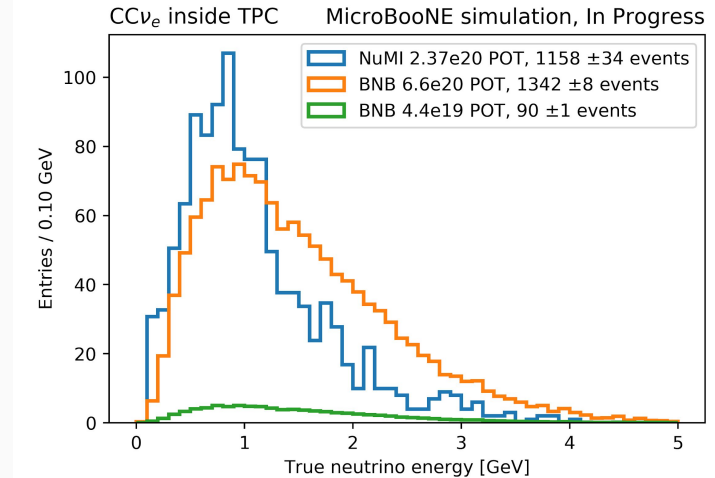


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$\cos(\theta)$  wrt NuMI beam direction:

- Cosmic rays: flat distribution
- Neutrinos: peak around 1
- Data/Monte Carlo agreement gives us confidence we can tune and cross check the LEE analysis

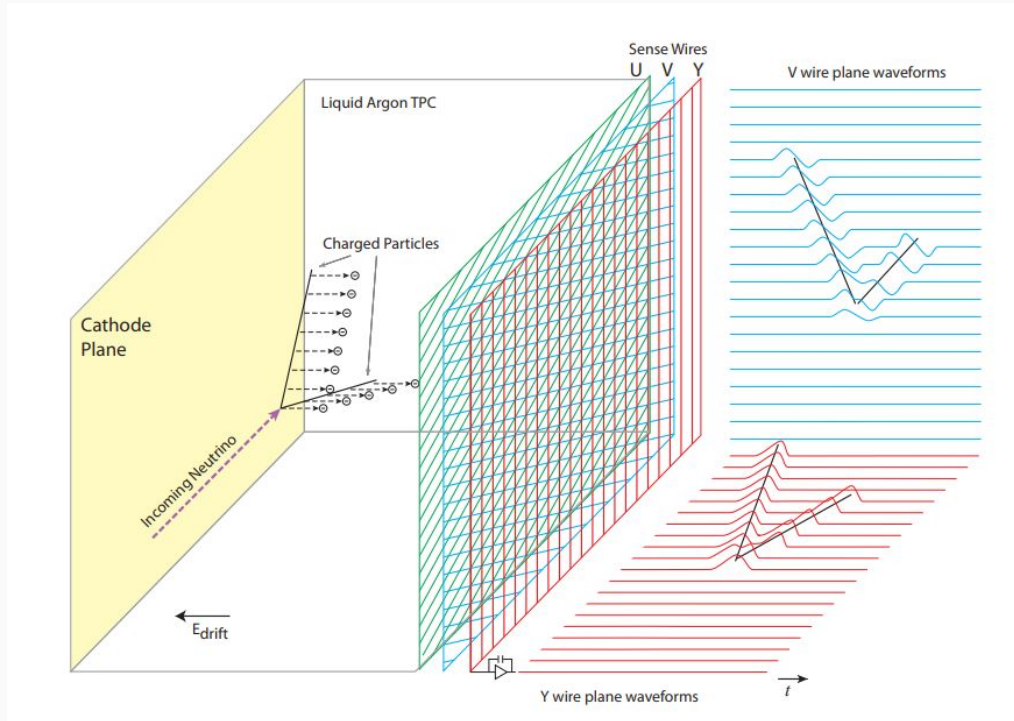


# Conclusions

- Exciting moment for MicroBooNE:
  - Collected a huge amount of data
  - Solid strategy and demonstration of the LEE analyses
- First Cross section measurements submitted for PRL publication
  - $CC\nu_{\mu} \pi_0$ : [MICROBOONE-NOTE-1032-PUB](#)
  - $CC\nu_{\mu}$  inclusive: [MICROBOONE-NOTE-1045-PUB](#)
- Strong demonstration of the LEE analysis strategies
  - Electron-like search BNB: [MICROBOONE-NOTE-1038-PUB](#)
  - Electron-like search NuMI: [MICROBOONE-NOTE-1054-PUB](#)
  - Photon-like search BNB: [MICROBOONE-NOTE-1041-PUB](#)

**Stay tuned: new results coming soon!**

BACKUP



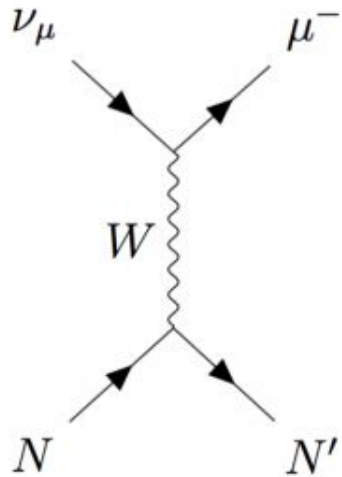
Two signals:

- Scintillation light, mainly for trigger and event selection
- TPC information: reconstruct the event, tracking and calorimetry

Typical neutrino energy  $\sim 1$  GeV

→ In this energy range interactions with the nuclei are predominant

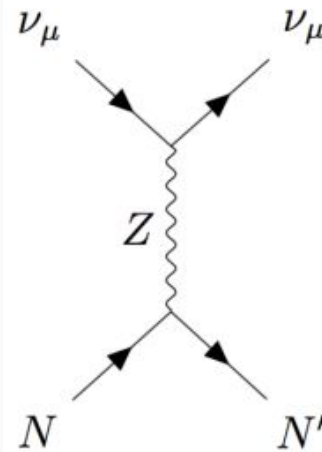
## Charged current interactions



Production of a lepton: clear exp signature.

Distinguish different flavours

## Neutral current interactions

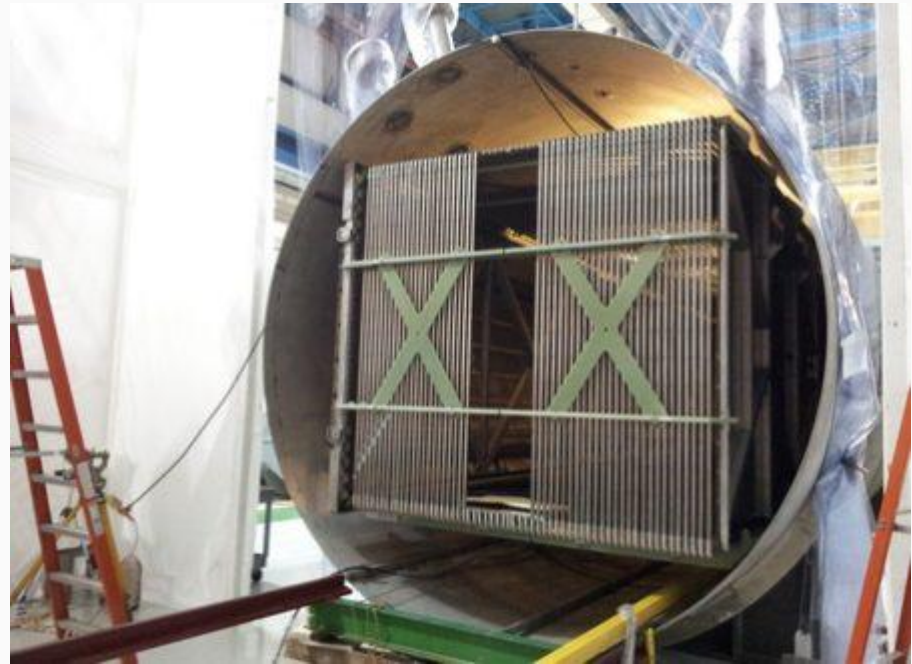


Only nucleus recoil, hard to detect.

No information about the flavour

For the LEE search -> need to distinguish the two flavours, only Charged Current (CC) are of interest!

# MicroBooNE during the construction



# Electron/photon separation using dE/dx

