



Muon Neutrino - Charged Current Event Selection From The *NOvA* Prototype Detector's Data



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On behalf of the *NOvA* collaboration

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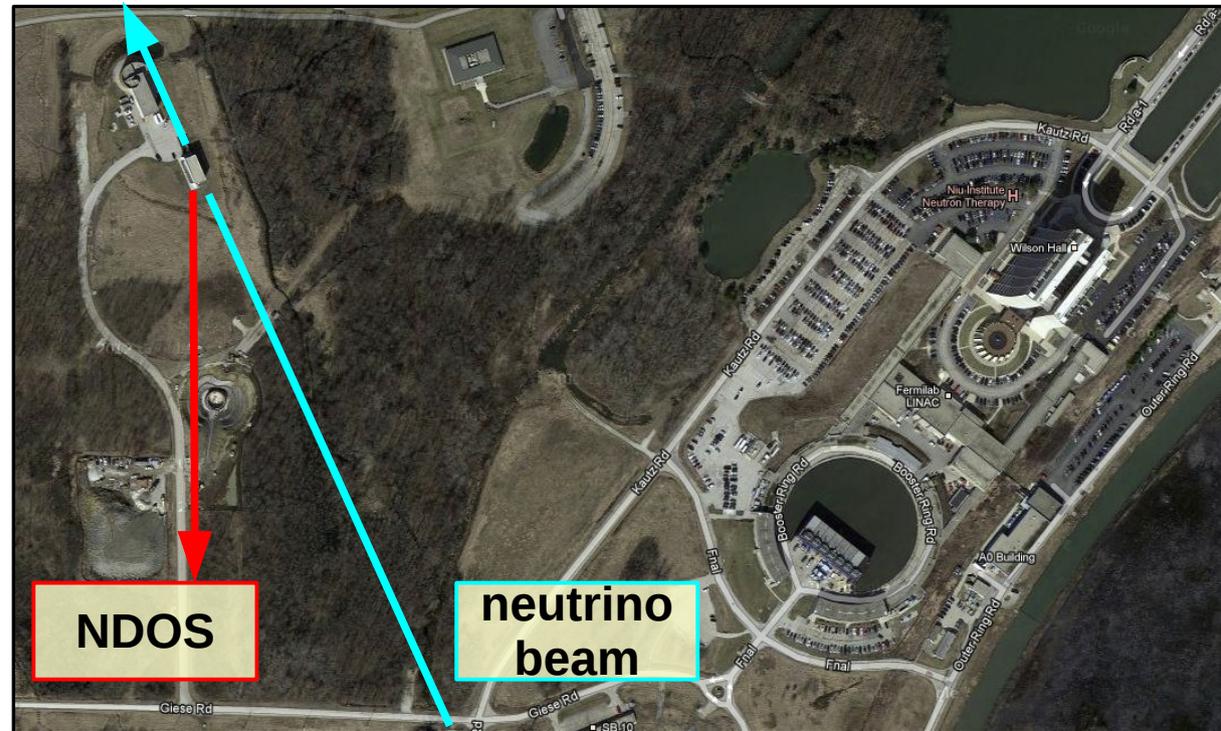
April 14th, 2013
APS Meeting
Denver, CO



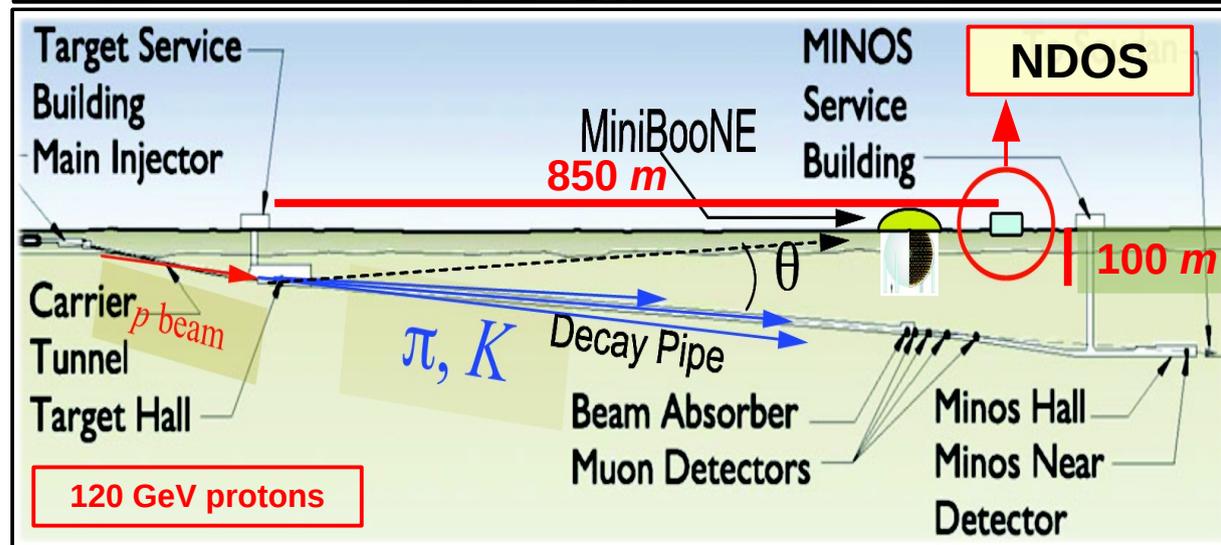
NOvA

N_{ear} D_{etector} O_{n the} S_{urface}

- NOvA built a prototype detector (NDOS) on the surface, at *Fermilab*, to test the experiment's various concepts, and collect real neutrino data.



- **NDOS:**
 - Recorded neutrinos from *Fermilab's Main Injector Proton Beam*.
 - $\theta \sim 110$ mrad off the beam's axis.

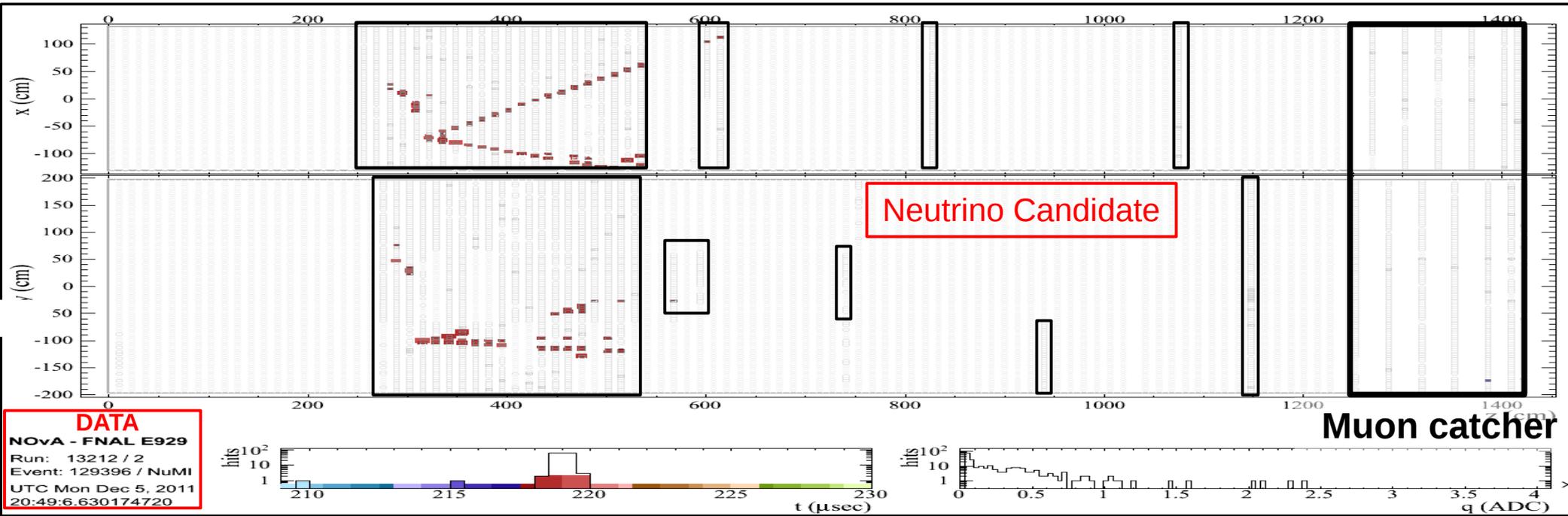
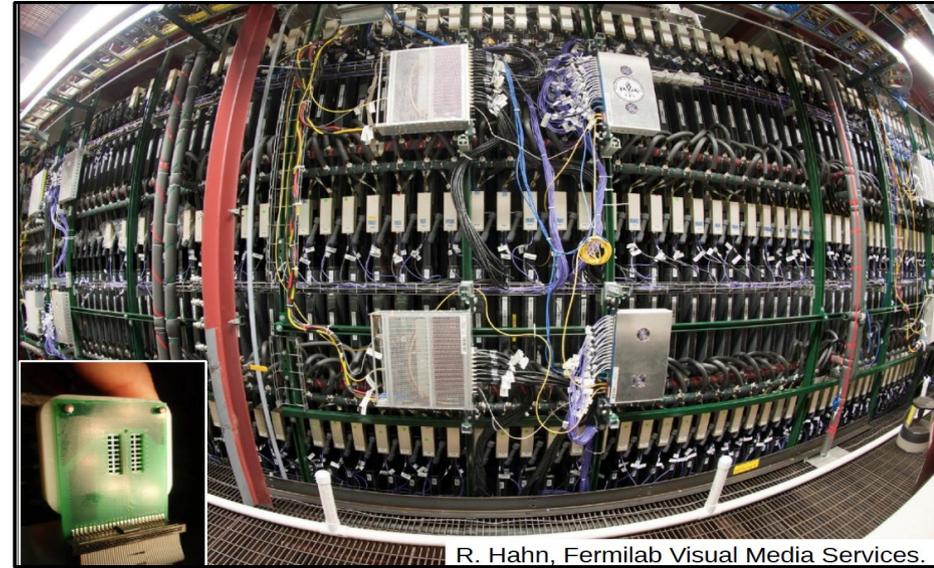


NOvA

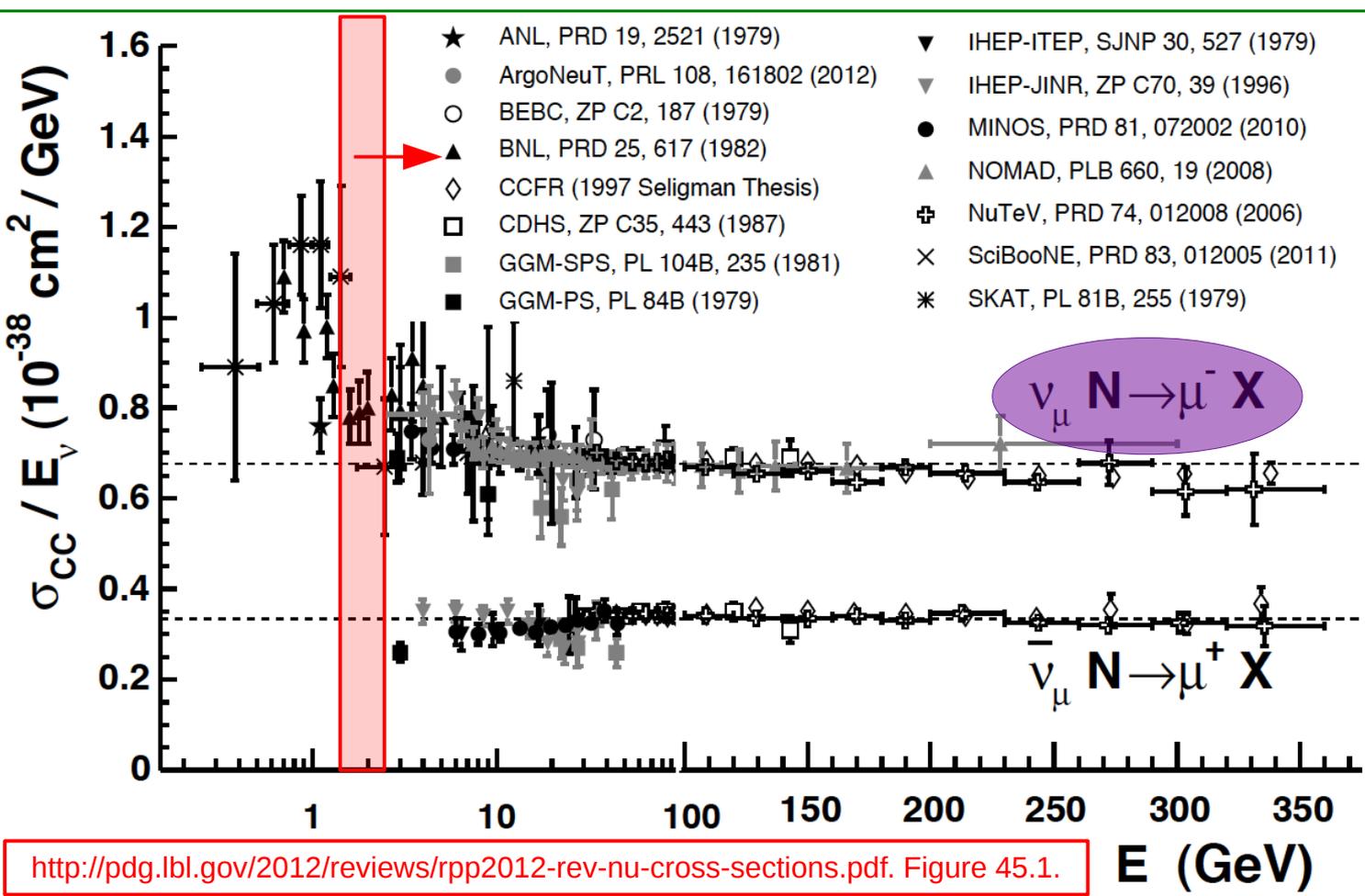
Near Detector On the Surface

- **NDOS:**

- 220 ton.
- Has 15000 Cells, ~ 1/3 instrumented.
- Analysis data: 10/2011 - 04/2012.
- Recorded ~ 10^{20} Protons On Target.
- Expected Neutrino candidates: ~ 500.



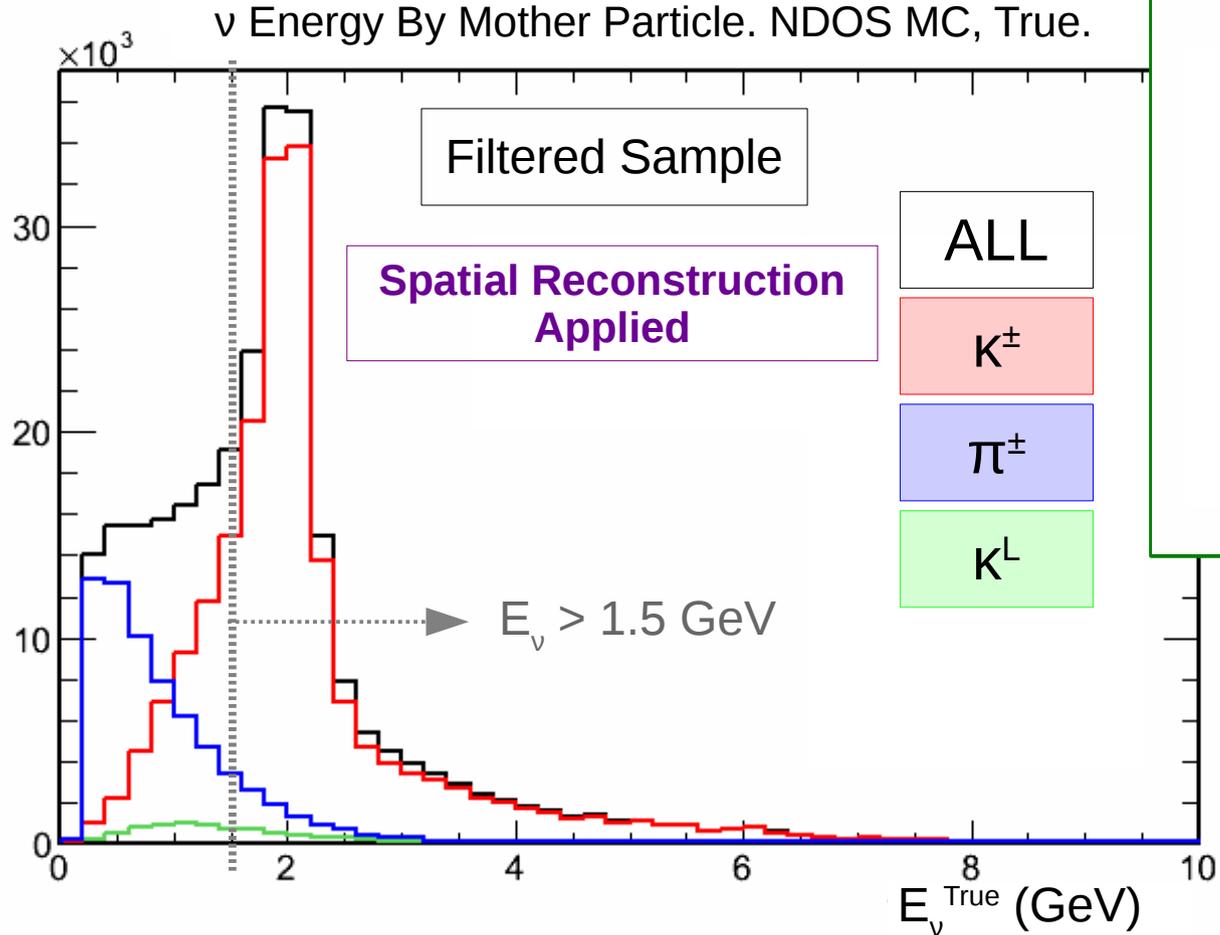
- Measure the inclusive cross section of charged current ν_μ for energies ~ 2 GeV.



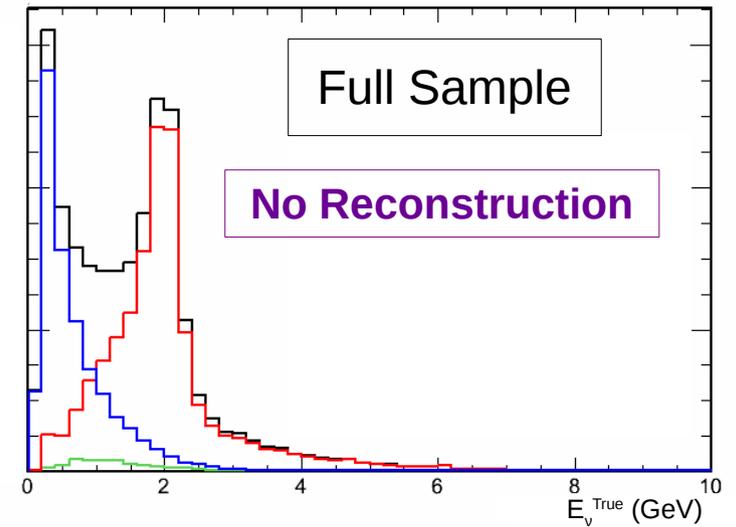
- **BNL measurement:**
 - $\sim 10\%$ uncertainty.
 - Deuterium nuclei.

• Not much data exist in this region.

- **NDOS measurement:**
 - Carbon nuclei.
 - Add a significant data point to the region of interest.



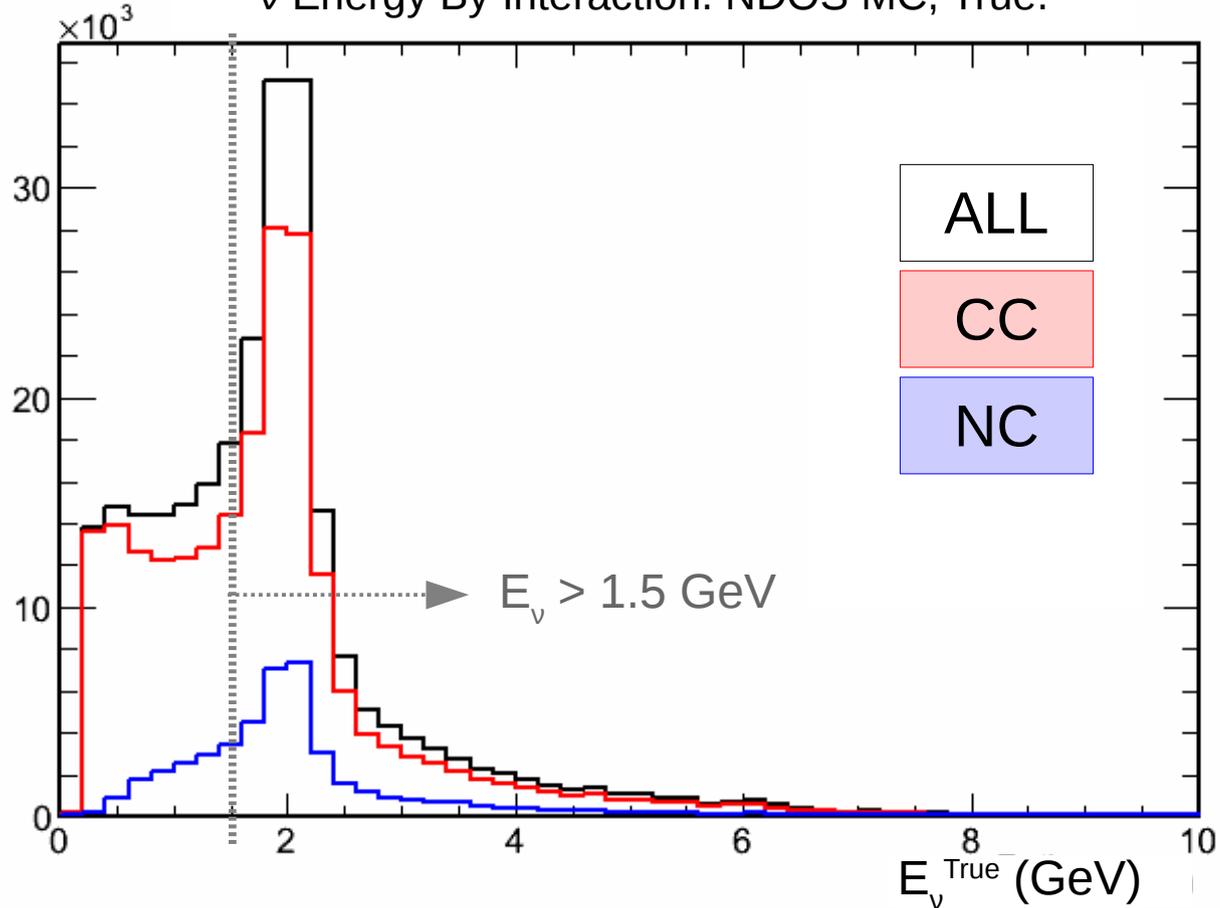
ν Energy By Mother Particle. NDOS MC, True.



$$\frac{\pi^{1.5 \text{ GeV} \rightarrow}}{K^{1.5 \text{ GeV} \rightarrow}} = 0.08$$

- ν 's come from the decays of K^\pm and π^\pm .
- *Track* reconstruction efficiency is low for low energy ν 's.
- $E > 1.5 \text{ GeV}$ ensures a high purity sample of ν 's from K^\pm .

ν Energy By Interaction. NDOS MC, True.



$$\frac{NC^{all}}{CC^{all}} = 0.22$$

$$\frac{NC^{1.5 \text{ GeV} \rightarrow}}{CC^{1.5 \text{ GeV} \rightarrow}} = 0.26$$

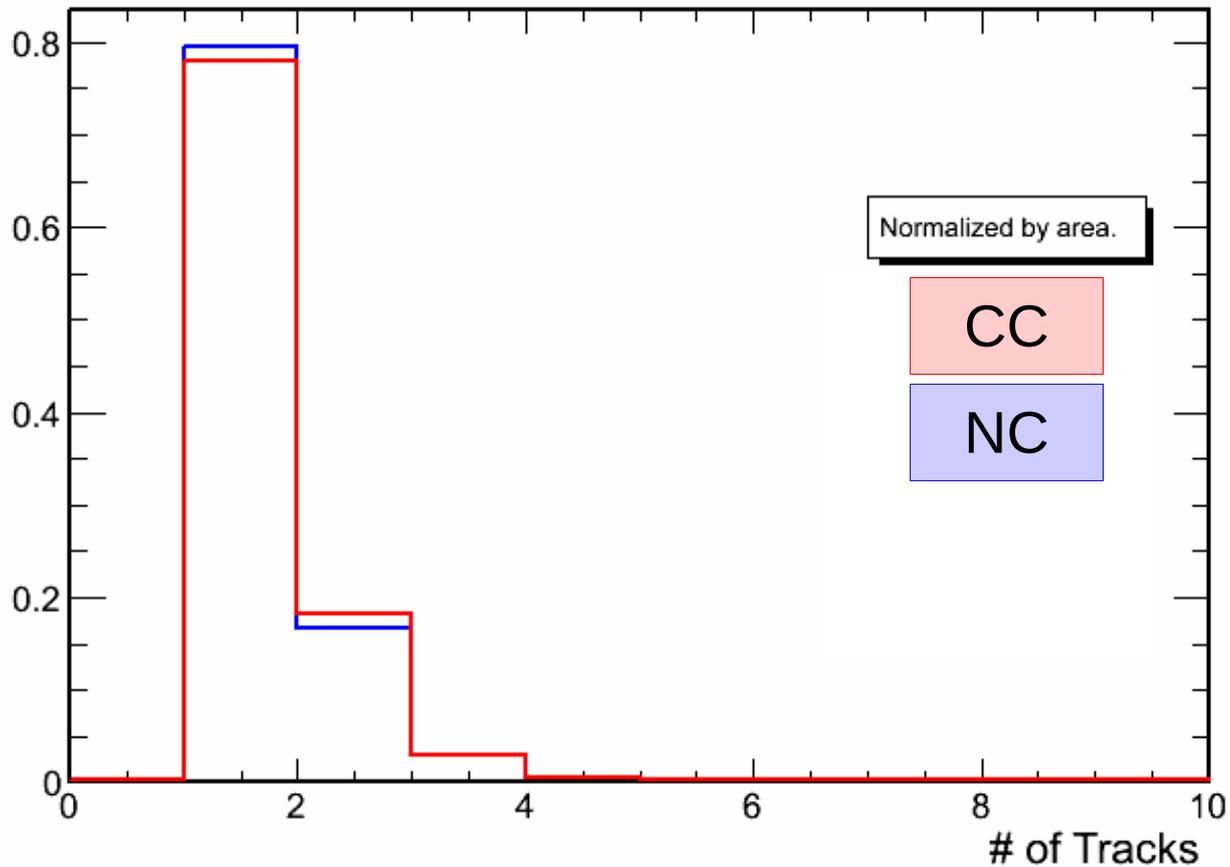
High deposited energy
reduces background

- **CC**: signal.
- **NC**: background.
- Finding methods to distinguish signal from background is a work in progress.

TRACK MULTIPLICITY

CC & NC

Number of Tracks per Event. NDOS MC.



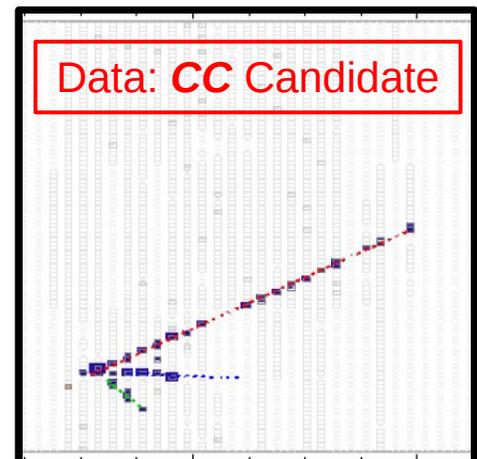
$$\frac{CC^{One\ Trk}}{CC^{All}} = 0.78$$

$$\frac{NC^{One\ Trk}}{NC^{All}} = 0.8$$

$$\frac{CC^{Two\ Trk}}{CC^{All}} = 0.18$$

$$\frac{NC^{Two\ Trk}}{NC^{All}} = 0.16$$

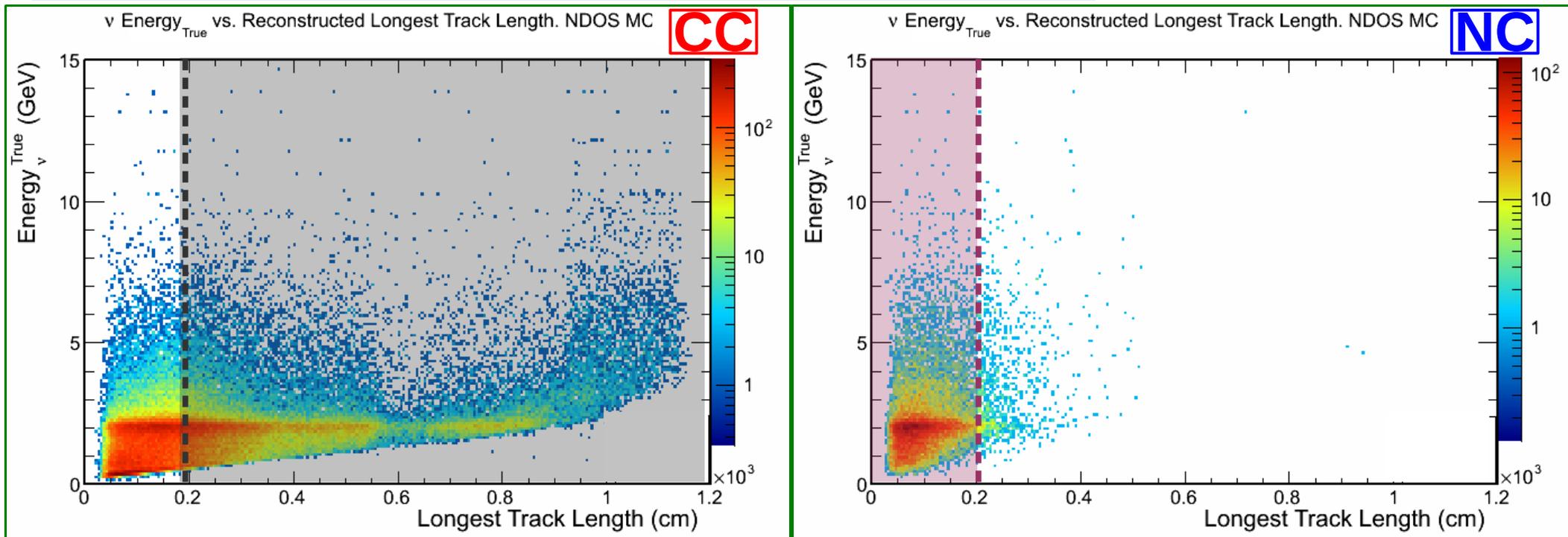
Data: CC Candidate



- A large fraction of the reconstructed events have one reconstructed *Track*.
- Both interactions have the similar *Track Multiplicity*.
- The longest *Track* per event becomes an important object of study.

ν ENERGY vs TRACK LENGTH

CC & NC



• Longest Track length, L :

- $L > 200$ cm:
 - Ensures a high purity CC sample.
- $L < 200$ cm:
 - How to separate the CC from the NC event?

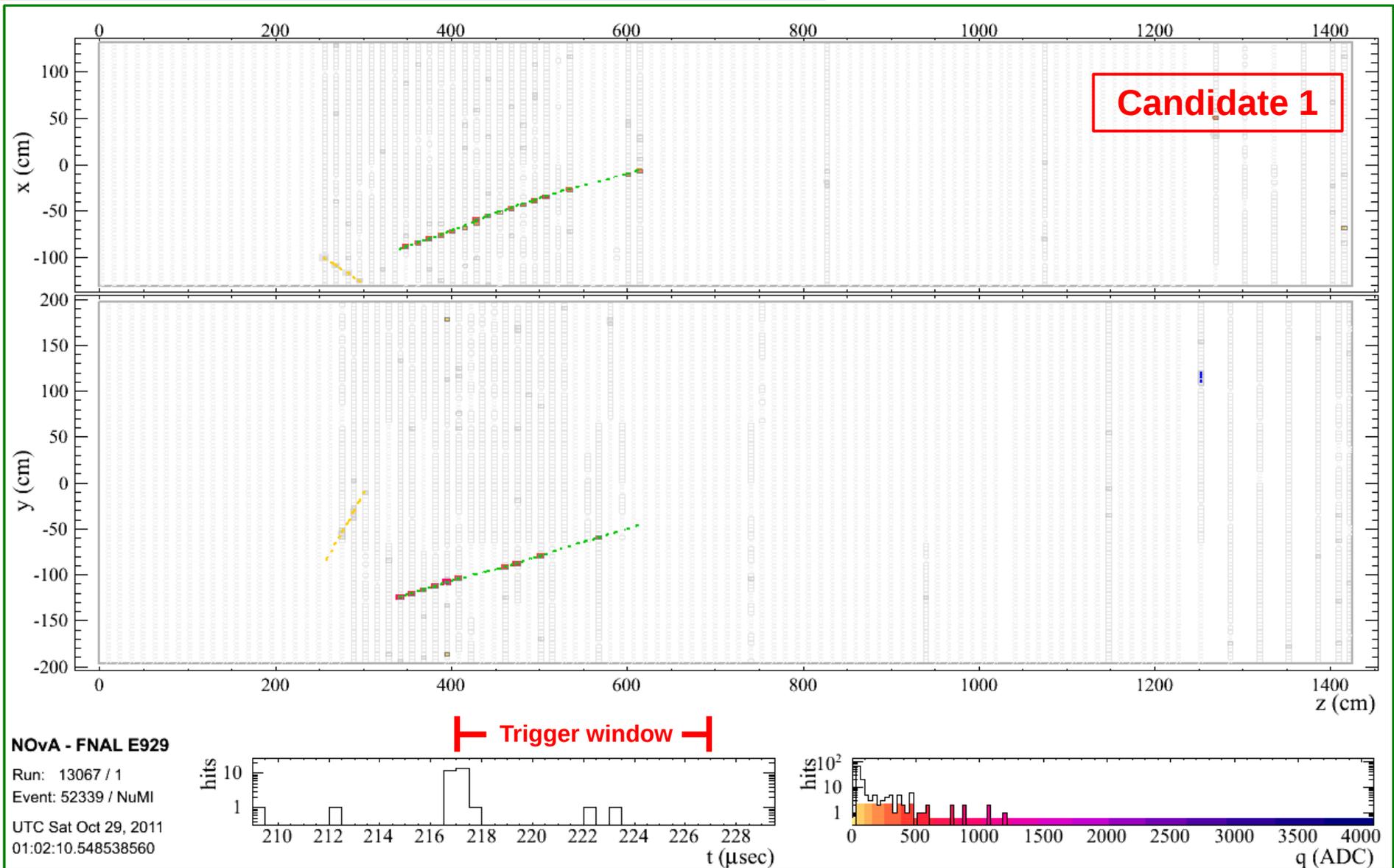
$$\frac{NC_{200\text{cm} \rightarrow}}{CC_{200\text{cm} \rightarrow}} = 0.04$$

$$\frac{NC_{\leftarrow 200\text{cm}}}{CC_{\leftarrow 200\text{cm}}} = 0.17$$

$$\frac{CC_{200\text{cm} \rightarrow}}{CC_{All}} = 0.42$$

SAMPLE EVENTS, DATA

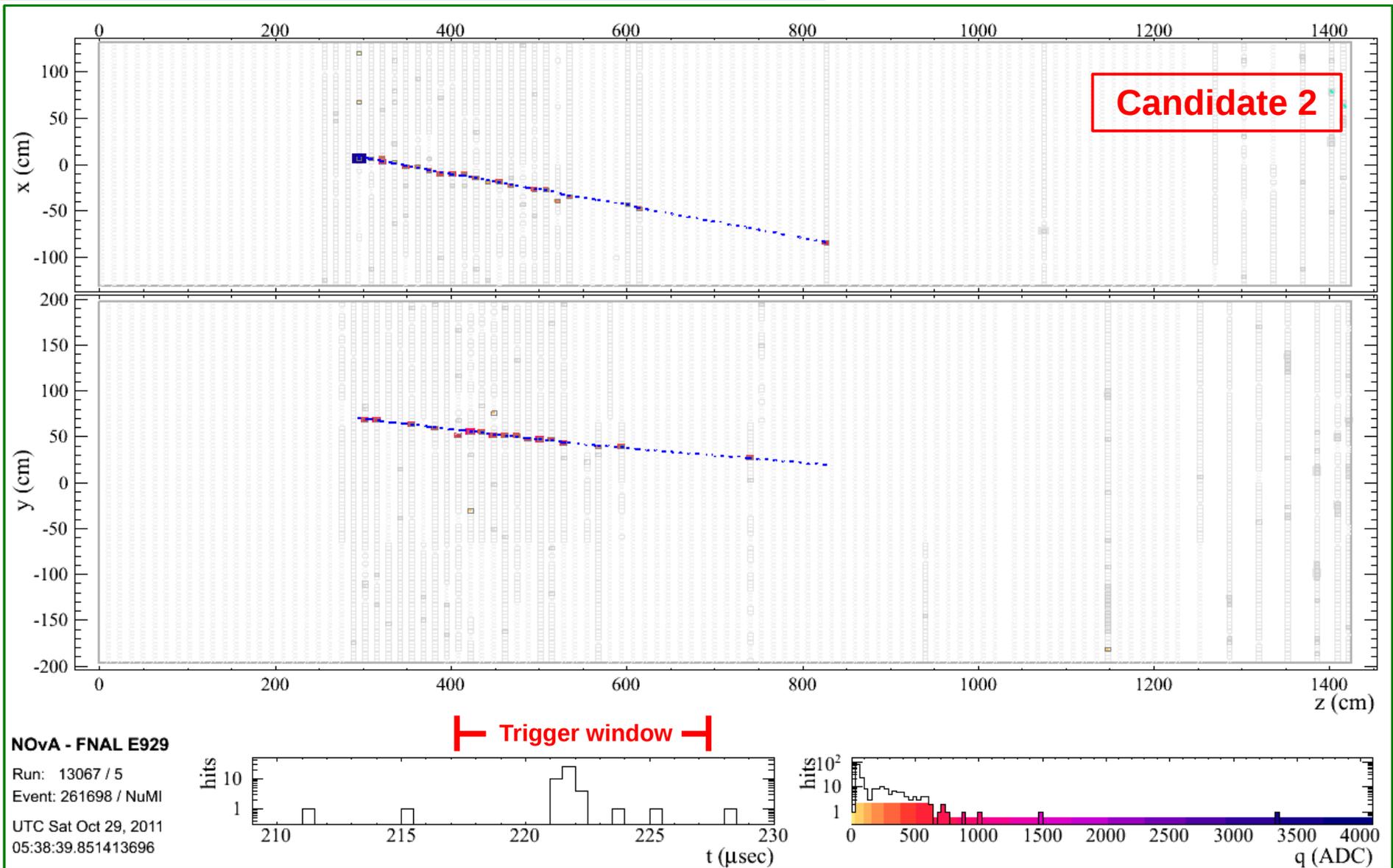
CC



- By means of the L cut, this is a CC candidate.

SAMPLE EVENTS, DATA

CC



- By means of the L cut, this is another CC candidate.

- dE/dX : Mean energy deposition in matter per unit length.

$$dE/dx: \mu \approx \pi$$

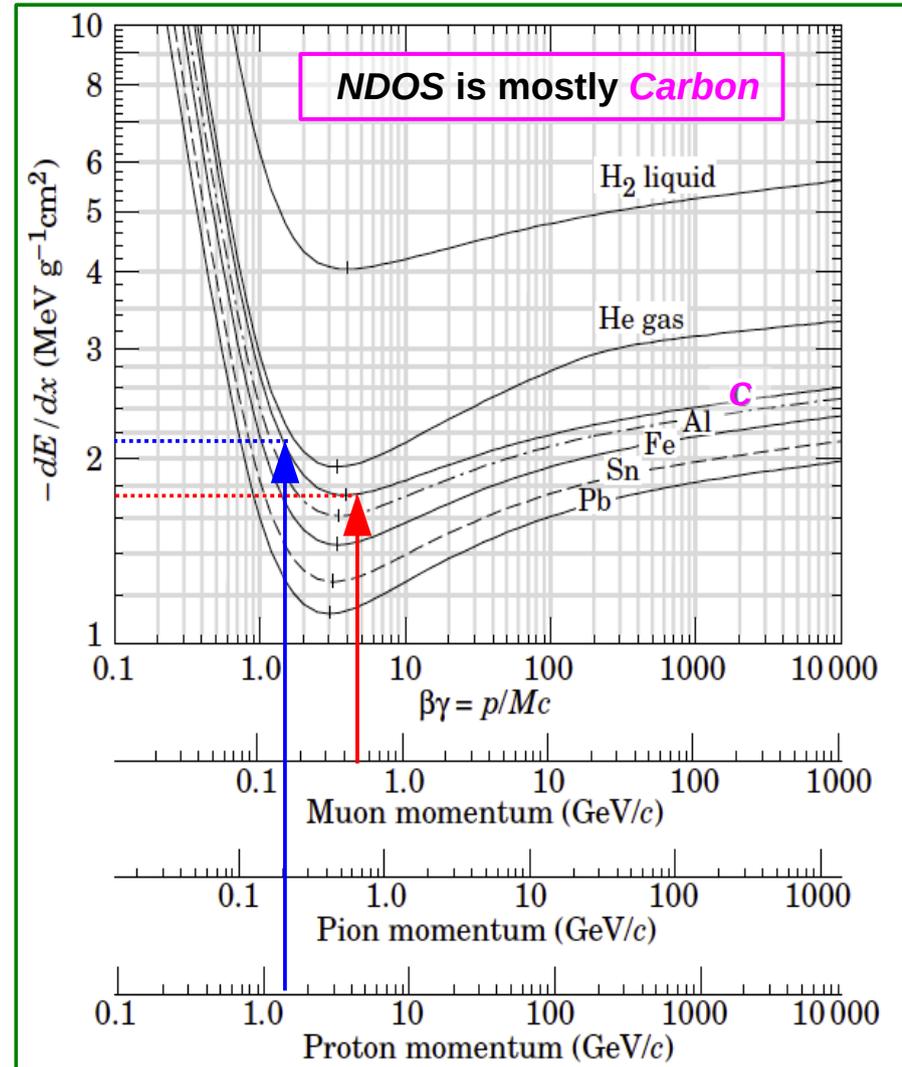
$$dE/dx: \mu \neq p$$

$$L = 200 \text{ cm:}$$

$$p_\mu \sim 0.5 \text{ GeV}/c$$

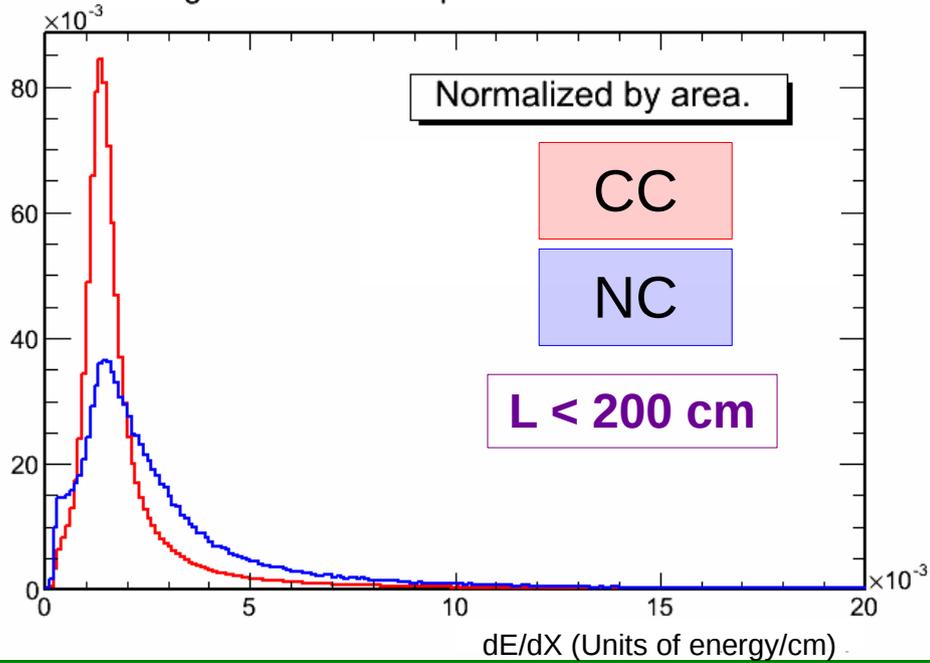
$$p_p \sim 1.5 \text{ GeV}/c$$

- Are these differences noticeable in this partially instrumented NDOS?

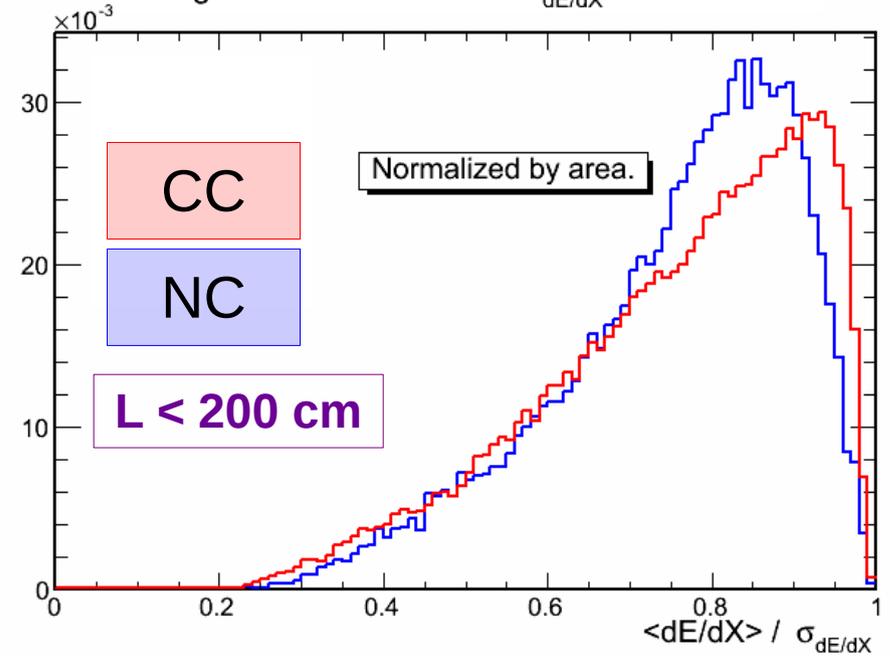


<http://pdg.lbl.gov/2011/reviews/rpp2011-rev-passage-particles-matter.pdf>. Figures: 27.2.

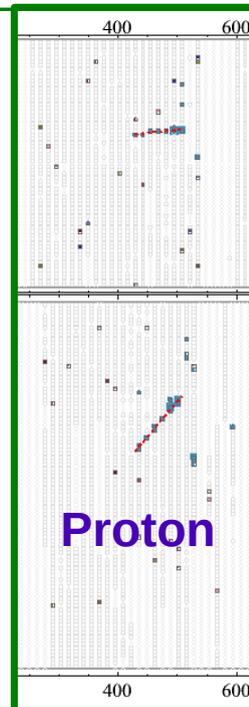
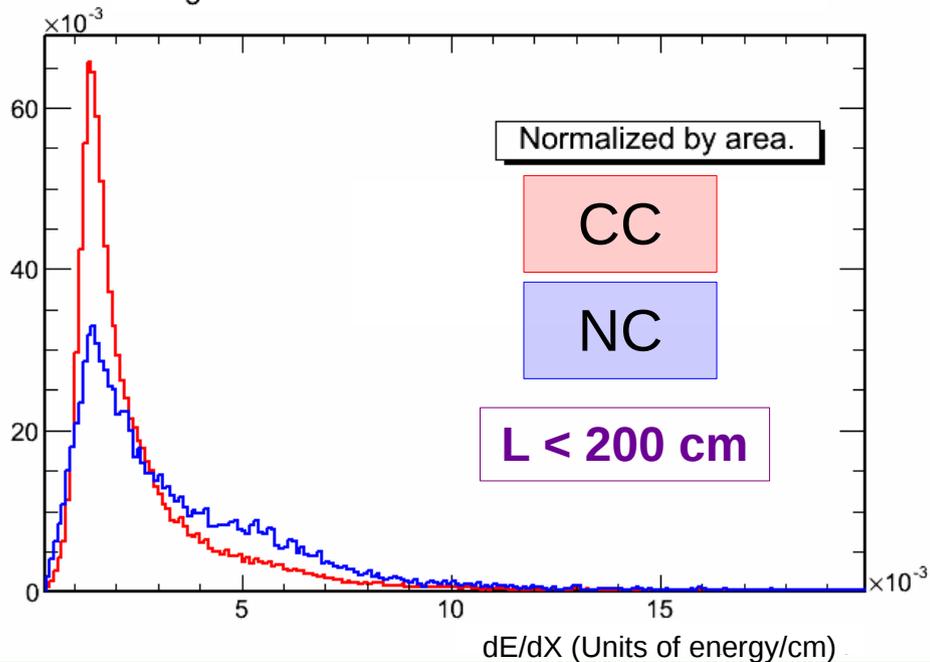
Longest Track dE/dX per Cell. NDOS MC.



Longest Track $\langle dE/dX \rangle / \sigma_{dE/dX}$. NDOS MC.



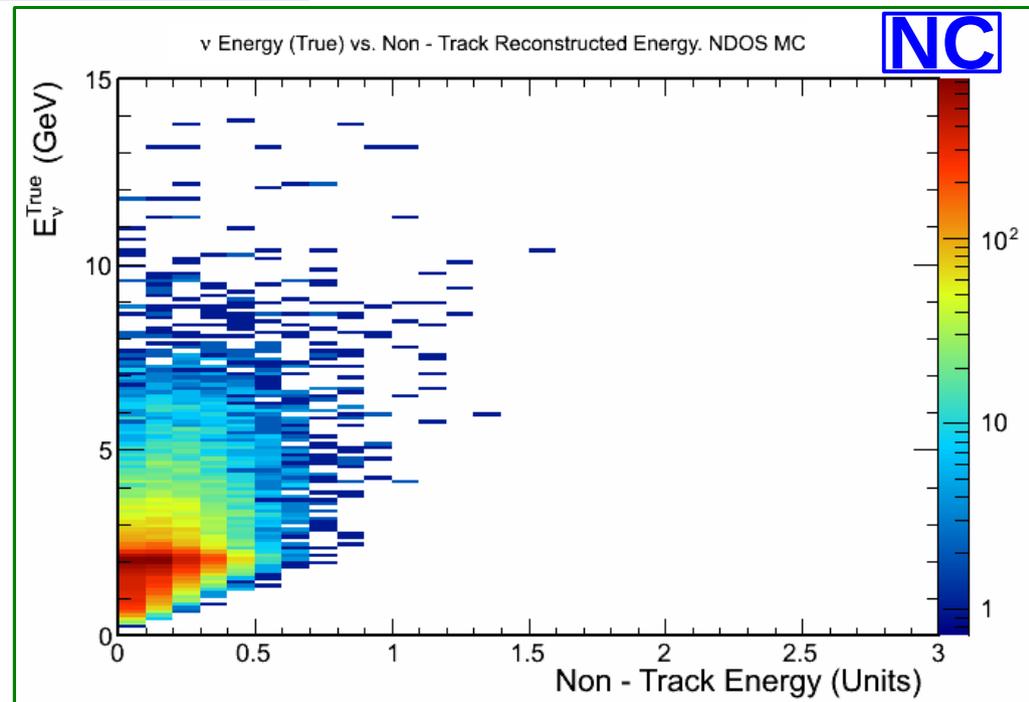
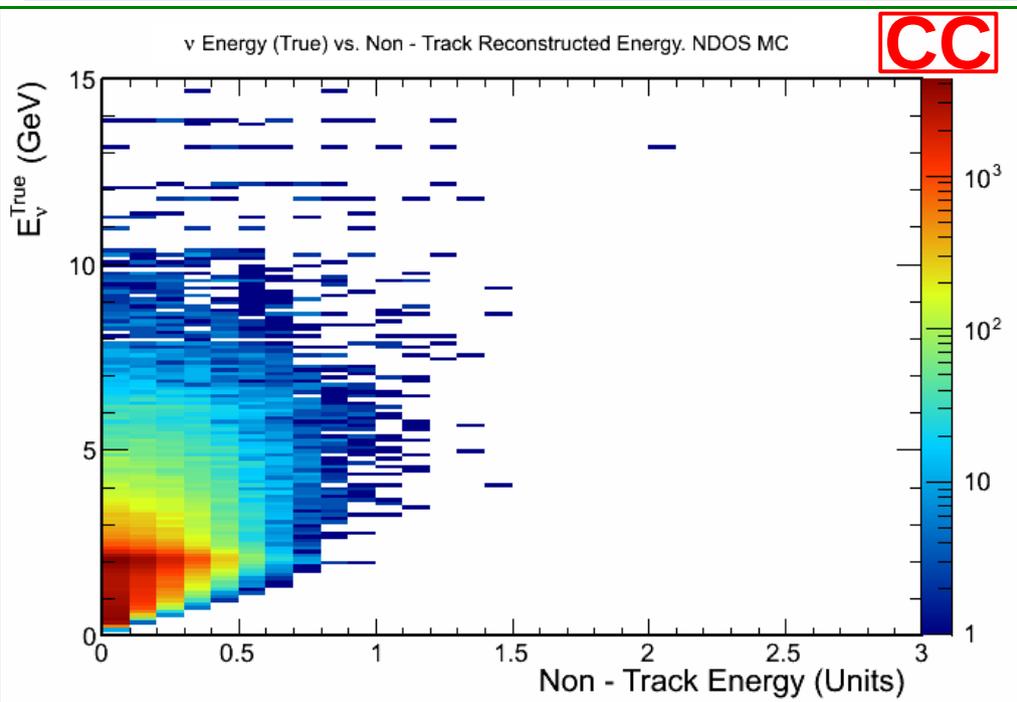
Longest Track dE/dX Last Three Cells. NDOS MC.



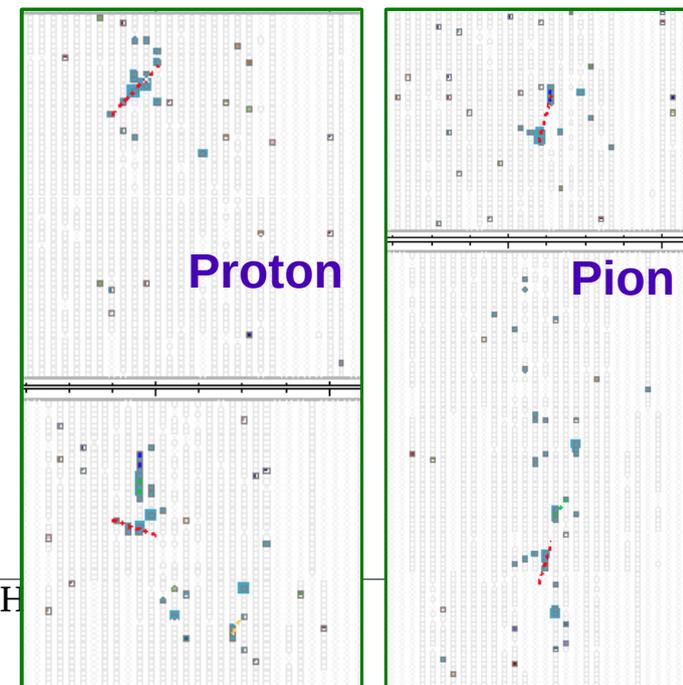
- Three different ways of using the dE/dX concept.
- Not as good discriminators as L to separate NC from CC .

(ν vs NON TRACK) ENERGY

CC & NC

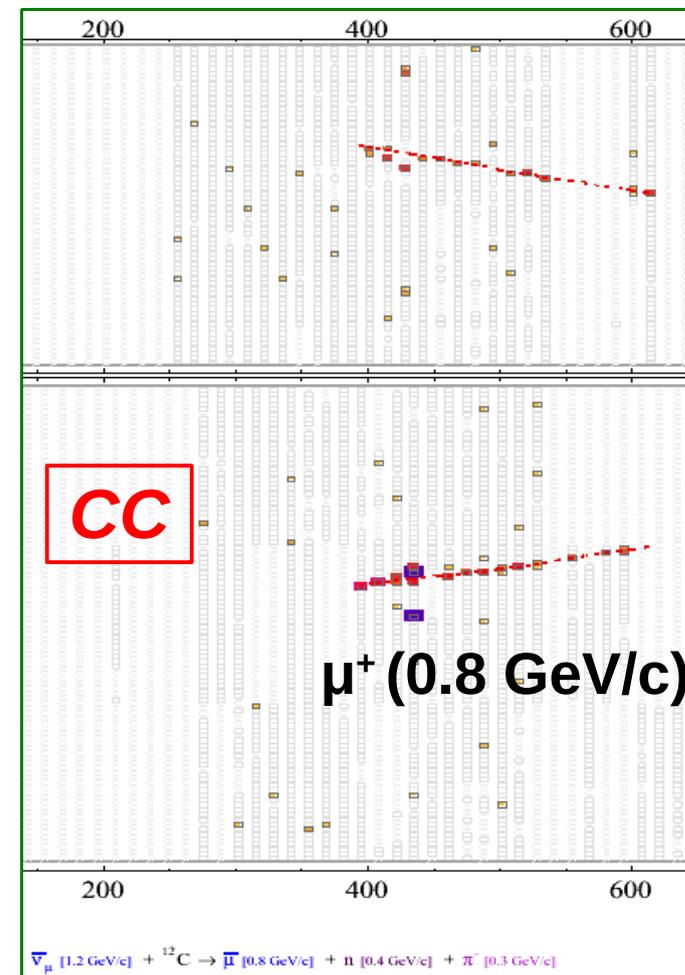
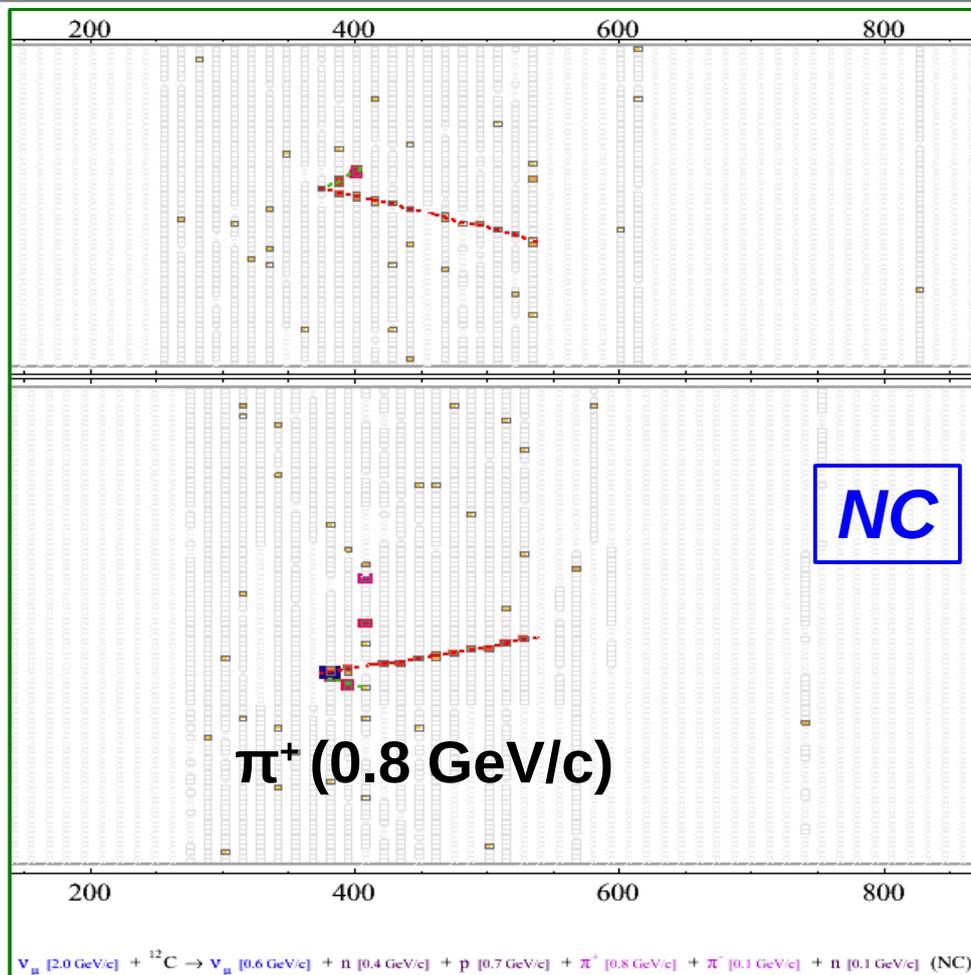


- The energy deposited in *Cells* that are not part of reconstructed *Tracks* is presented in the horizontal axis.
- Both interactions have similar scatter plot.
 - Not good for background rejection.



SAMPLE EVENTS, MC

CC & NC



- The study continues to find ways to differentiate the **NC** background from the **CC** signal, or reduce it to an acceptable minimum. **work in progress**
- $L < 200 \text{ cm}$: **NC** background = 17%. Current value.
- Aim: **NC** background = 10%.

CONCLUSION

- The *NDOS* data are under investigation to produce a v_{μ} cross section measurement.
- Long *Track* length will:
 - Dramatically reduce the *NC* background.
- For short *Track* length:
 - The dE/dX concept has not been useful yet to separate *NC* background from *CC* signal.
- *CC* event selection is a work in progress.
 - Improvement to the current results will come.



THANK YOU!

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