



SciBooNE (E954) update

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Columbia University

Mar 27, 2008 PAC meeting at Fermilab

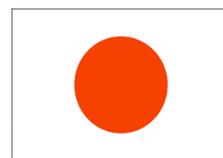
Outline

- SciBooNE experiment
 - Data taking status
 - Detectors
- Status of physics analyses
- Run plan
- Summary

SciBooNE Collaboration

- Universitat Autònoma de Barcelona
- University of Cincinnati
- University of Colorado, Boulder
- Columbia University
- Fermi National Accelerator Laboratory
- High Energy Accelerator Research Organization (KEK)
- Imperial College London
- Indiana University
- Institute for Cosmic Ray Research (ICRR)
- Kyoto University
- Los Alamos National Laboratory
- Louisiana State University
- Purdue University Calumet
- Università degli Studi di Roma "La Sapienza and INFN"
- Saint Mary's University of Minnesota
- Tokyo Institute of Technology
- Universidad de Valencia

5 countries 17 institutions



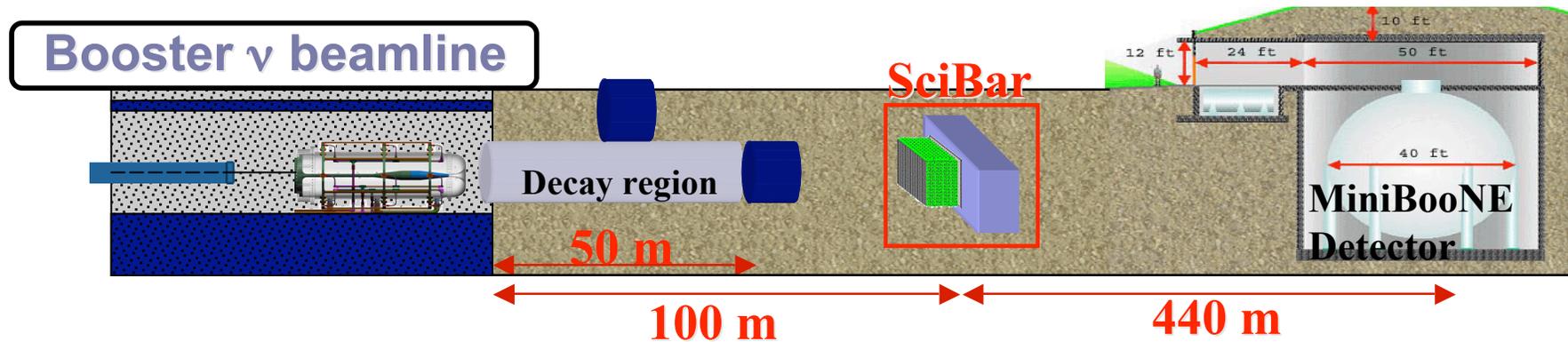
Spokespeople:

M.O. Wascko (Imperial), T. Nakaya (Kyoto)

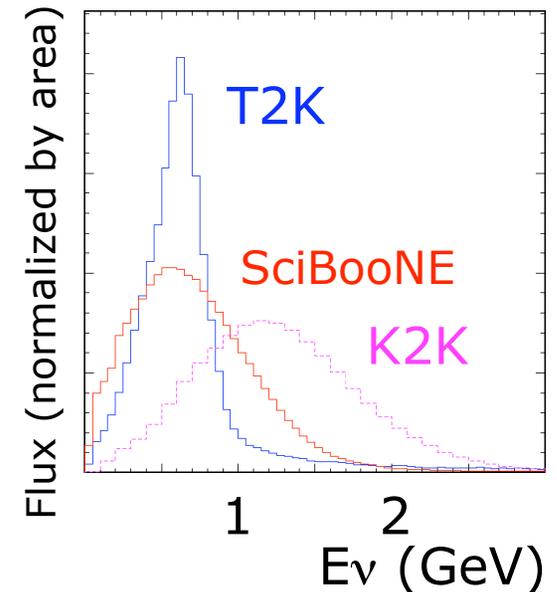
SciBooNE Experiment

SciBooNE Experiment

(K2K-SciBar detector at FNAL Booster Neutrino Beam line)

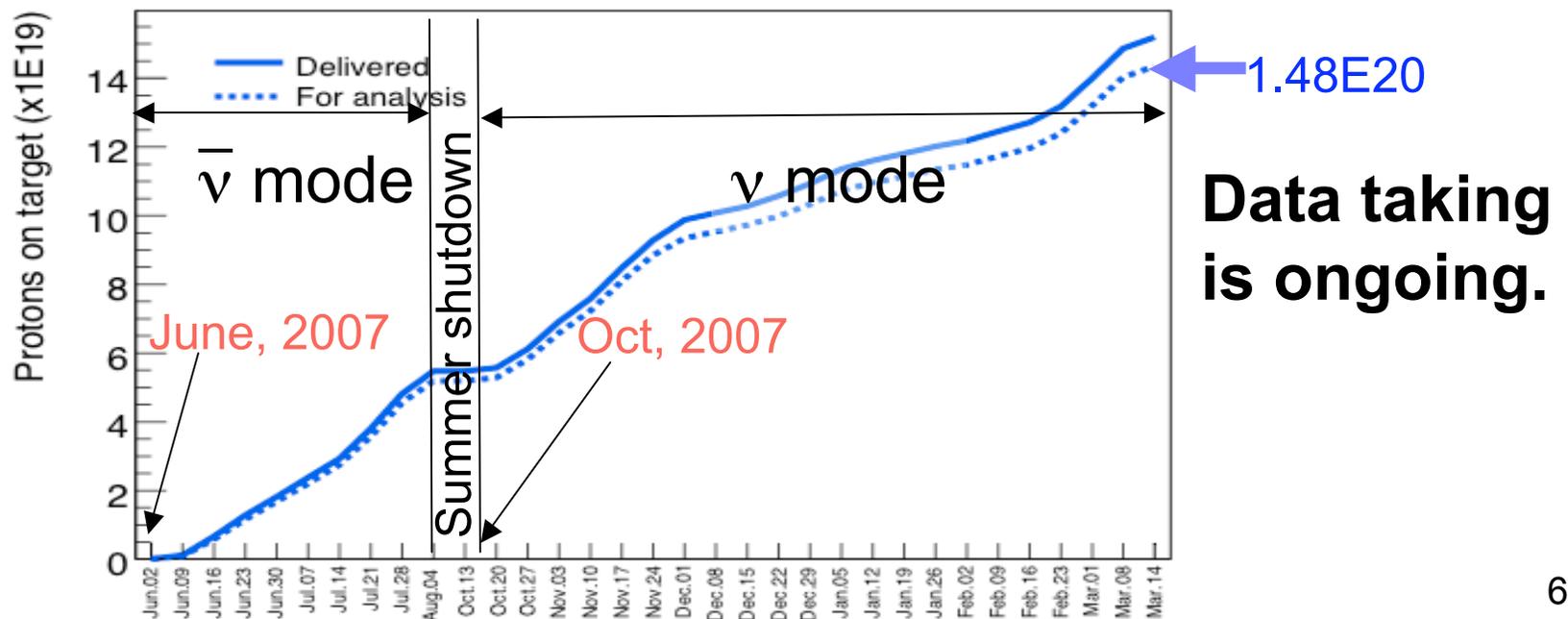


- Precision measurement of ν & $\bar{\nu}$ cross sections at ~ 1 GeV \leftarrow Important for T2K and other oscillation experiments
- **SciBar:**
 - Originally K2K-near detector
 - Shipped to FNAL
- **BNB: Intense & low energy ν beam**
 - E_ν good match to T2K
 - ν and $\bar{\nu}$ beam
- MiniBooNE near detector



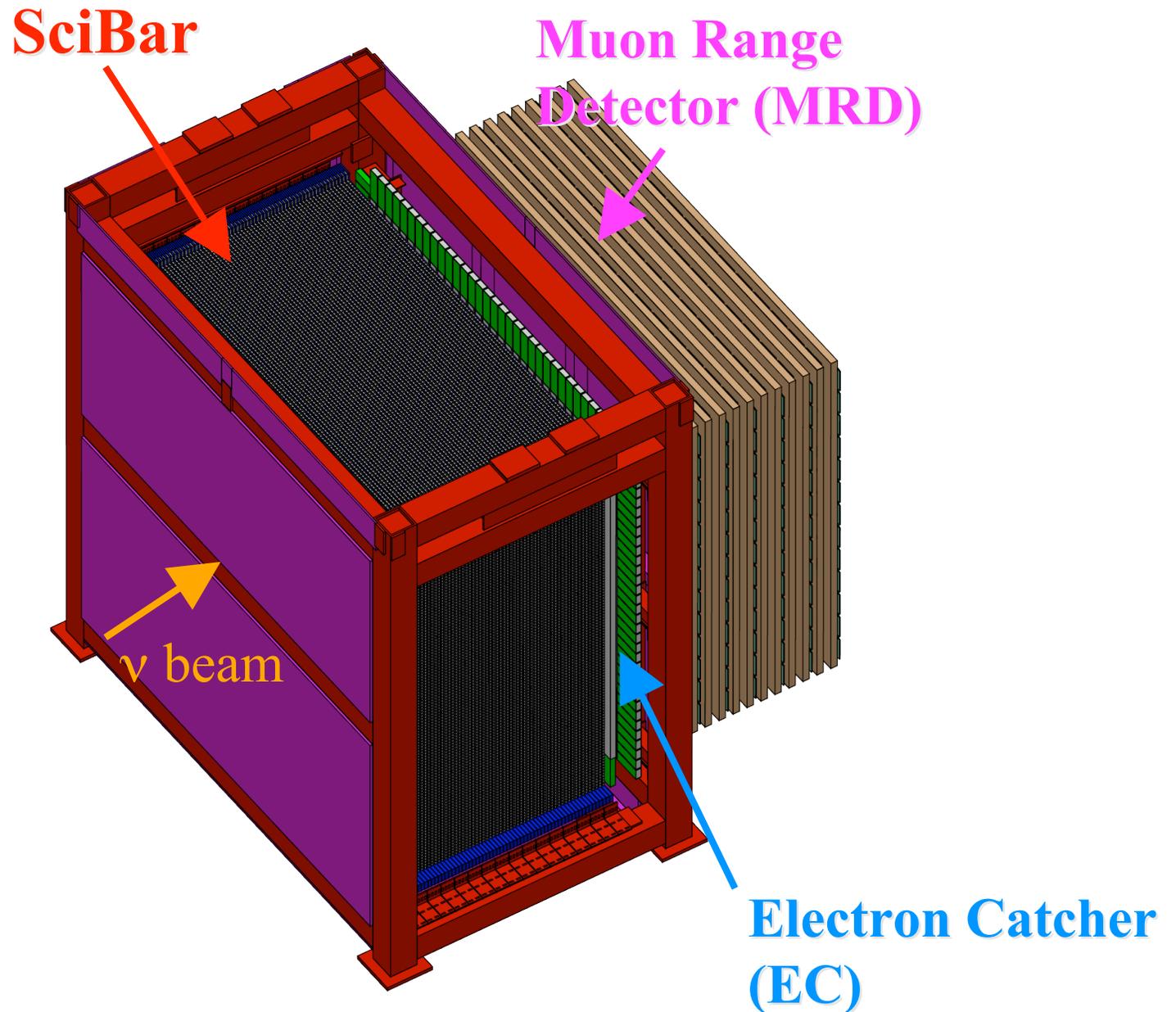
Data taking status

- Projected Protons On Target (POT): $2E20$
 - ~1 year run
- Total collected POT so far: $1.48E20$
 - ν : $9.4E19$ (goal: $1E20$)
 - $\bar{\nu}$: $5.4E19$ (goal: $1E20$)
- Averaged detector live time fraction: 94%



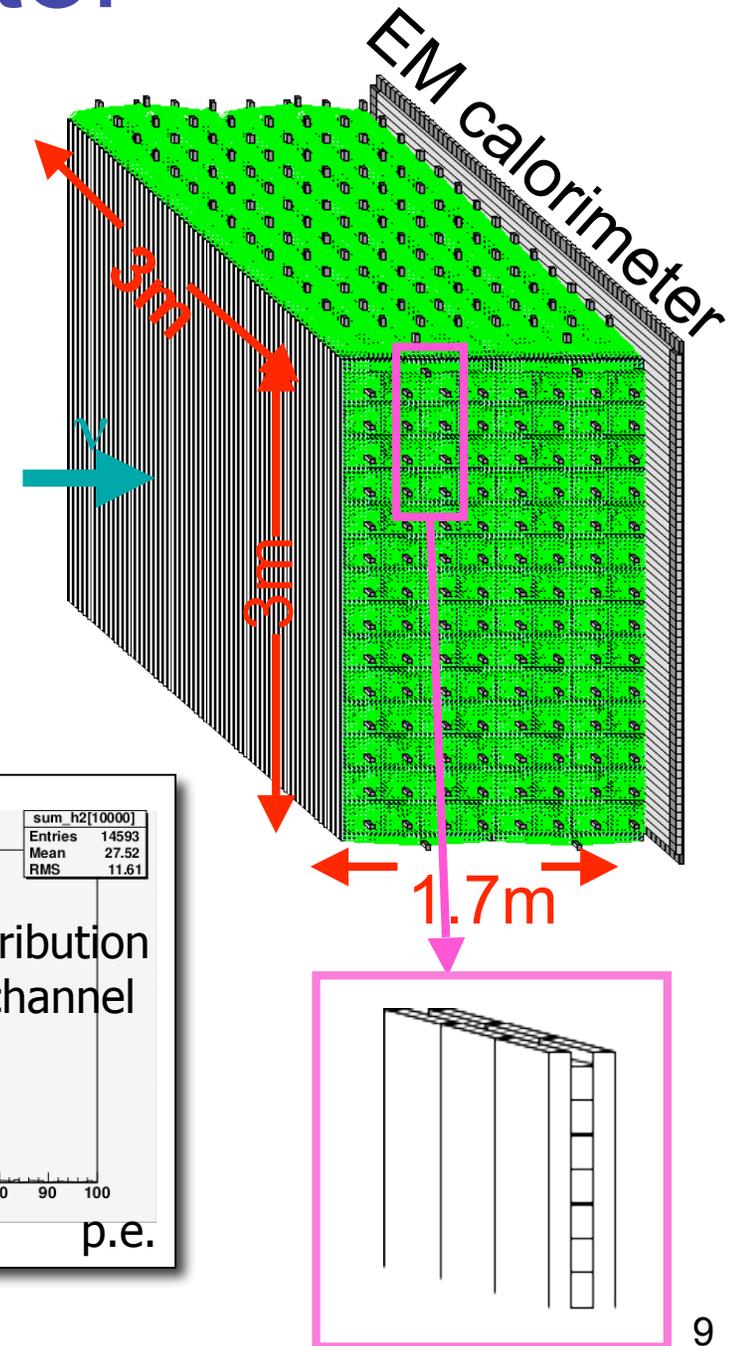
SciBooNE Detectors

SciBooNE Detectors



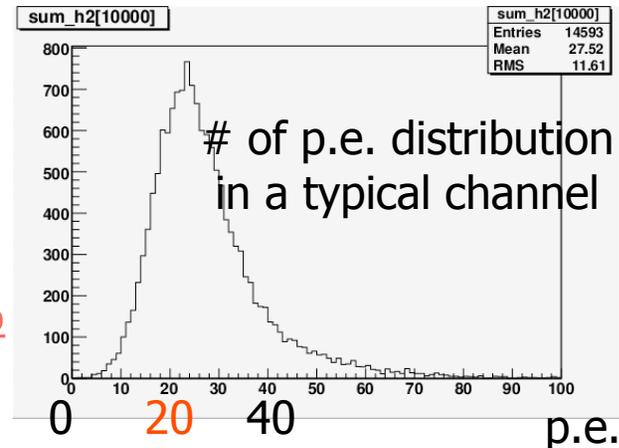
SciBar Detector

- Fully active target & tracking detector
 - Extruded scintillators with WLS fiber readout
 - $2.5 \times 1.3 \times 300 \text{ cm}^3$ cell
 - $\sim 15,000$ channels
- Total 15 tons, Fiducial volume: ~ 10 tons
- Distinguish a proton from a pion by dE/dx



Detector performance (SciBooNE cosmic ray data)

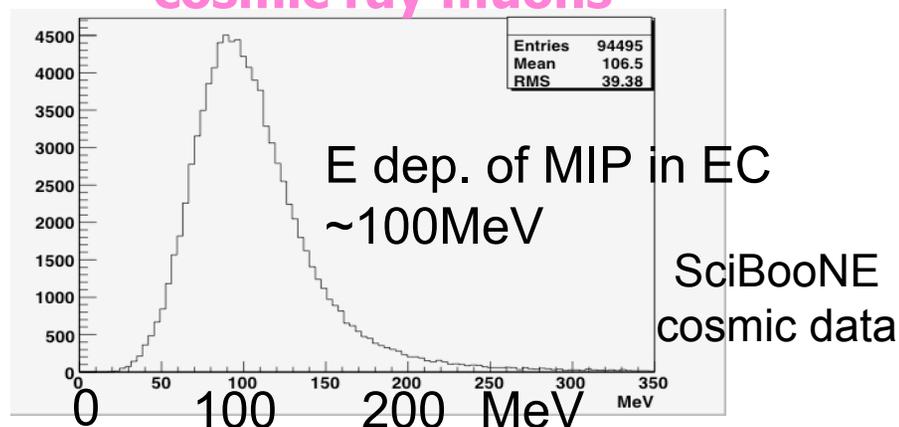
- Light yield for MIP:
 $\sim 20 \text{ p.e./ } 1.3\text{cm}$
- Hit finding efficiency; $\sim 99.9\%$



Electron Catcher (EC)

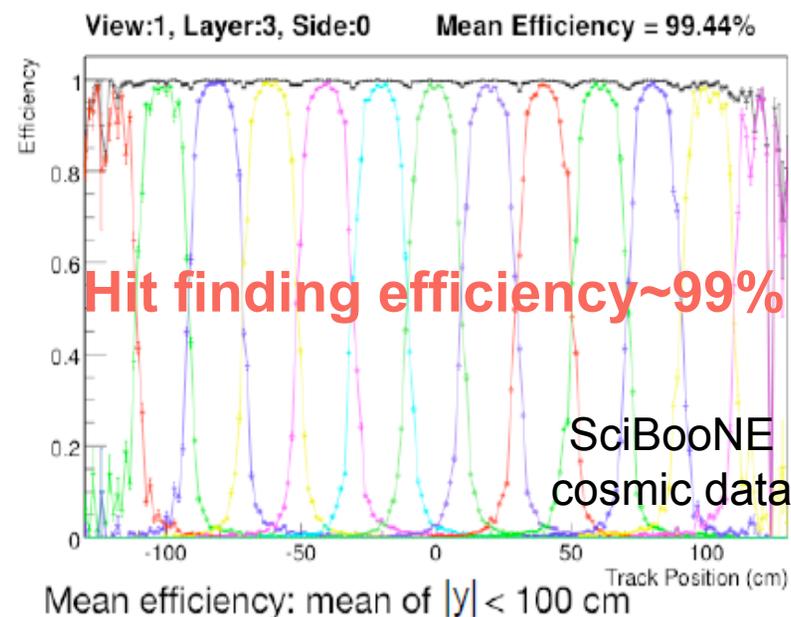
- EM calorimeter
- **Electron, gamma ID**
- 1mm **scintillation fibers** in the grooves of **lead foils**
- 2 planes (**total $11X_0$**)
- Expected resolution **$14\%/\sqrt{E}$**

dE/dx distribution for cosmic ray muons



Muon Range Detector (MRD)

- **Measure μ momentum with range**
 - momentum up to 1.2GeV/c
- **Iron Plate**
 - 2" thick x 12 planes
- **Scintillator Plane**
 - 13 planes alternating horizontal and vertical planes



Status of Analyses

- Neutrino data (no $\bar{\nu}$ data in this talk)
- $7.7E19$ POT is used
- **Preliminary results**
 - No systematic uncertainties yet
- MC sample: NEUT event generator
- All MC sample normalized by # of MRD match events (see later slides)

Physics Topics

Several analyses are in progress

- **C**harged **C**urrent
 - CC inclusive: Y. Nakajima (Japan)
 - CC-QE: J. Alcaraz (Spain), J. Walding (UK)
 - CC- $1\pi^+$: K. Hiraide (Japan)
 - CC- π^0 : J. Catala (Spain)
- **N**eutral **C**urrent
 - NC- π^0 : Y. Kurimoto (Japan)
 - NC-elastic: H. Takei (Japan)
- ν_μ disappearance: K. Mahn (US)

8 PhD students are working on analyses

(+ 2 already graduated; C. Mariani (PhD) and C. Giganti (graduate), (Italy))

Physics Topics

Several analyses are in progress

- **C**harged **C**urrent

- CC inclusive:

- CC-QE:

- CC- $1\pi^+$:

- CC- π^0 :

J. Catala (Spain)

→ Important for ν_μ disappearance

- **N**eutral **C**urrent

- NC- π^0 :

- NC-elastic:

H. Takei (Japan)

→ Important for ν_e appearance

- ν_μ disappearance: K. Mahn (US)

8 PhD students are working on analyses

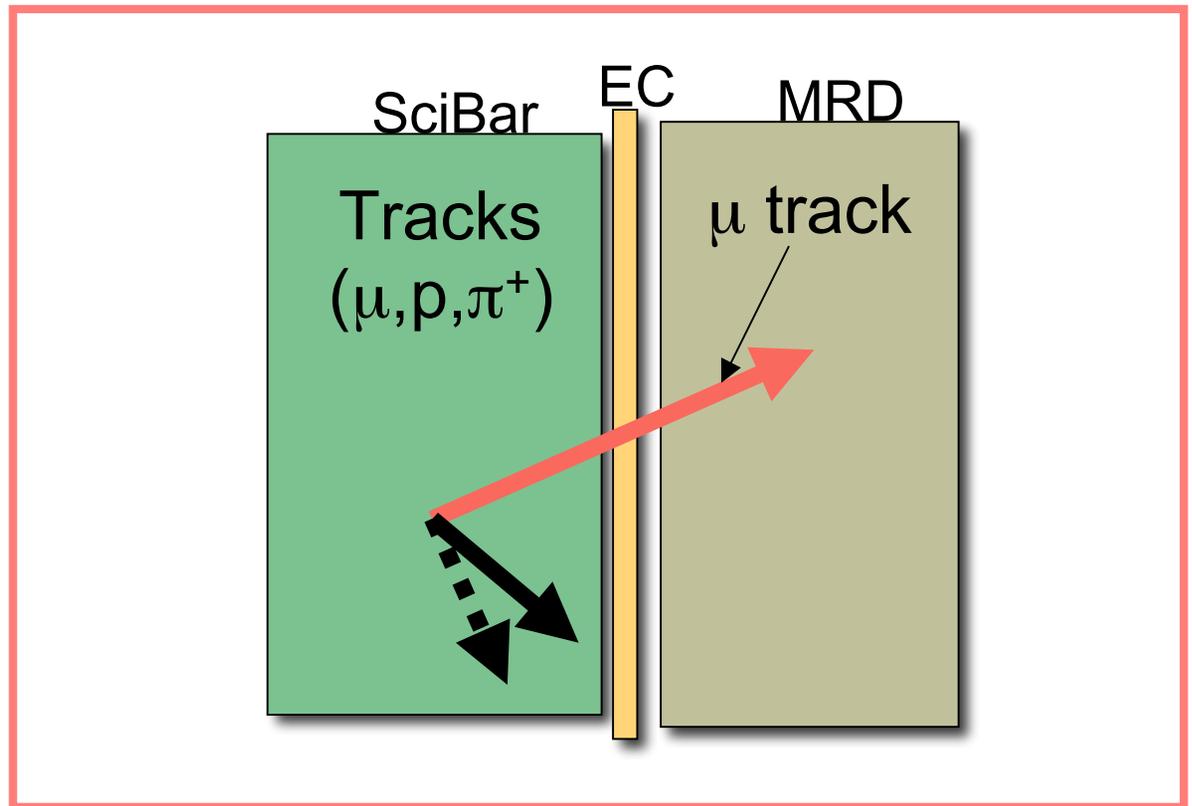
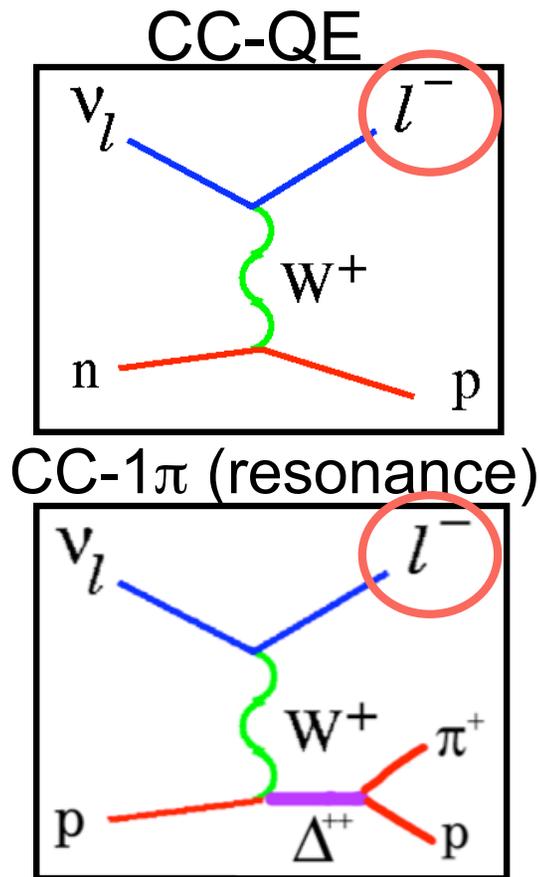
(+ 2 already graduated; C. Mariani (PhD) and C. Giganti (graduate), (Italy))

Charged Current analyses

- CC-inclusive, CC-QE, CC- $1\pi^+$

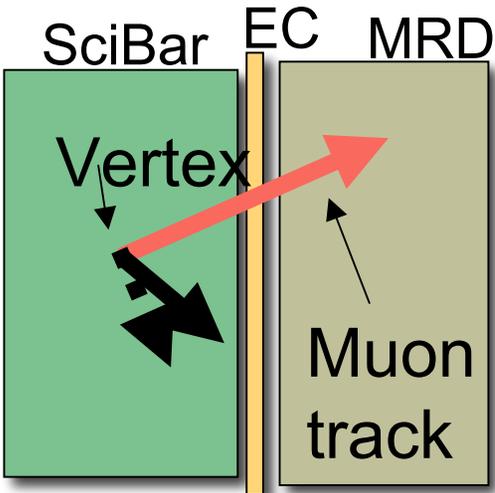
Signature of CC event at SciBooNE

- Muon = SciBar-MRD matched track

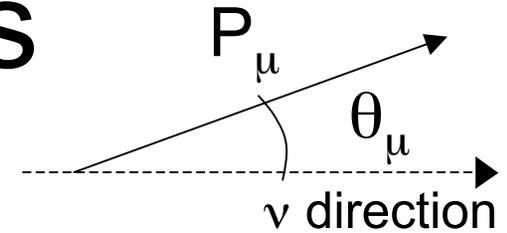


SciBar-MRD match sample:

- CC purity: 96%
- Cosmic ray background: <0.5%

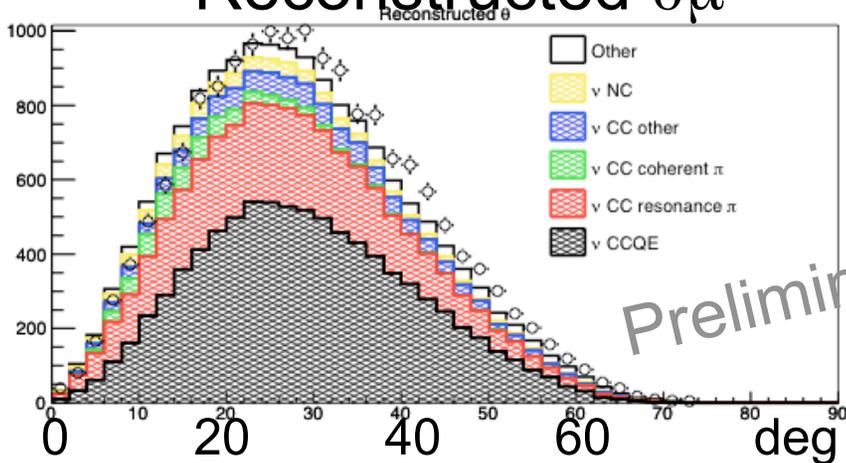


Muon distributions

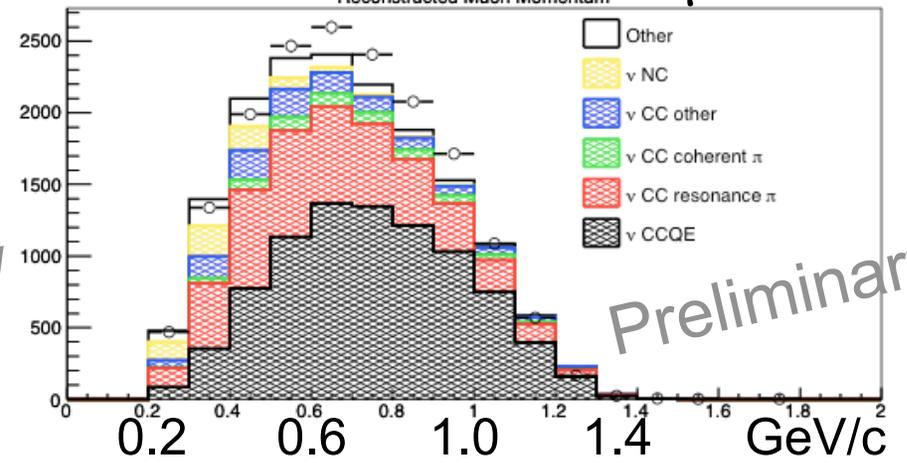


Sample: events μ stopped inside the MRD
 (MC samples: normalized by # of MRD match events)

Reconstructed θ_μ



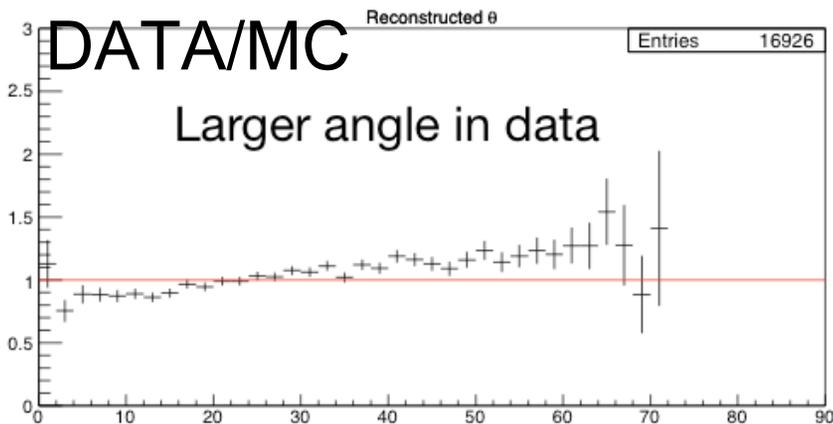
Reconstructed P_μ



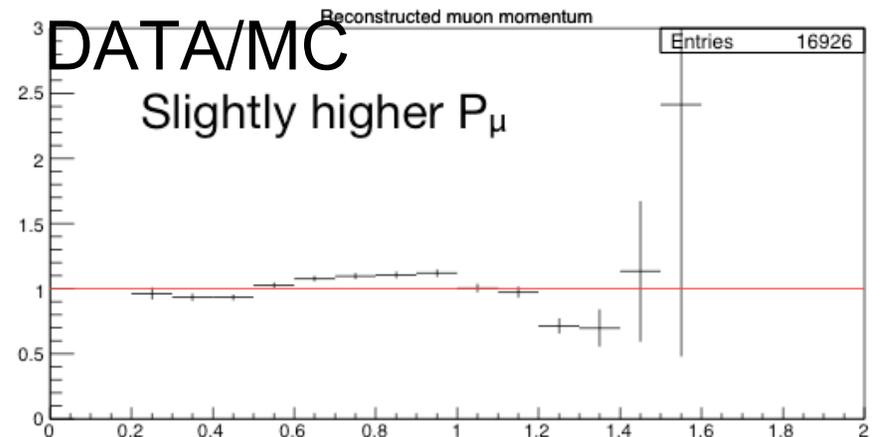
Preliminary

Preliminary

DATA/MC

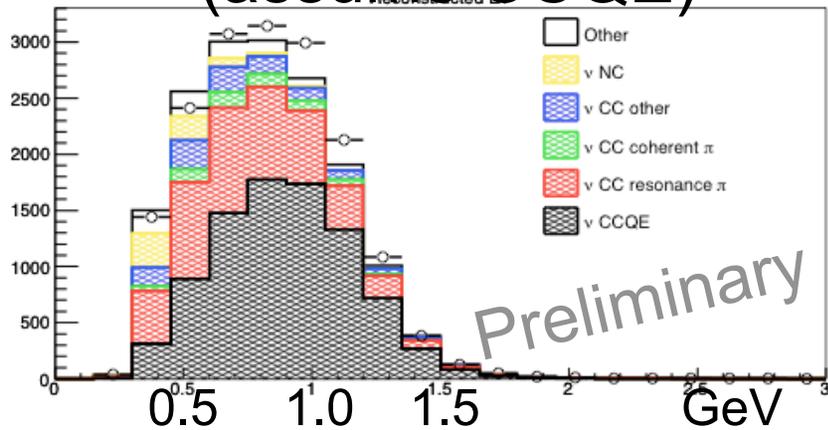


DATA/MC

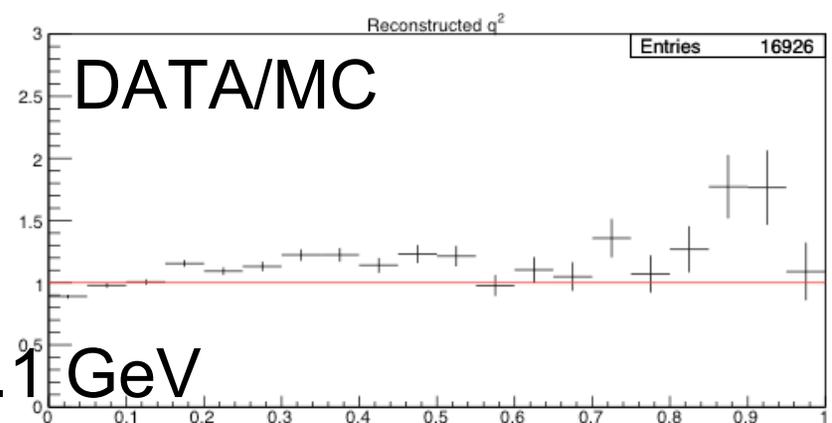
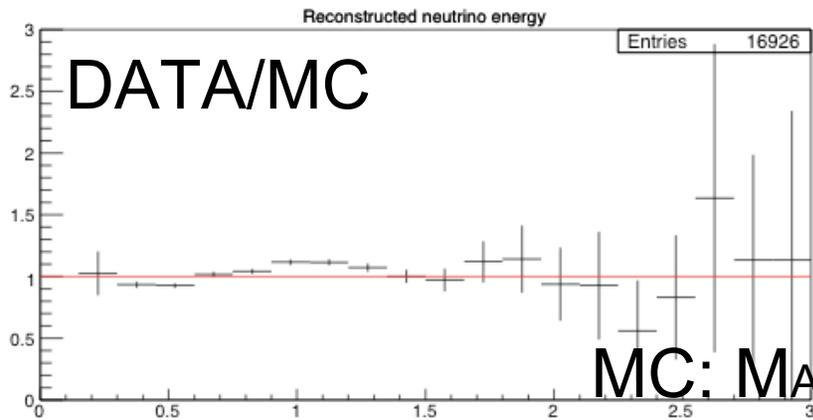
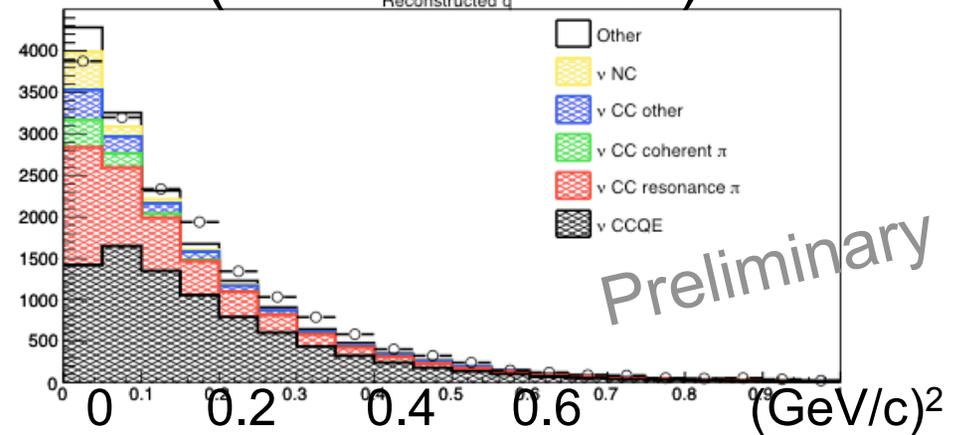


Event kinematics

Reconstructed E_ν
(assume CCQE)



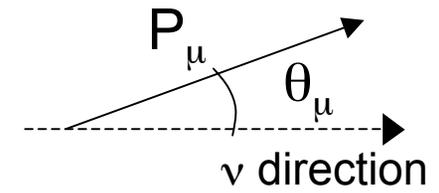
Reconstructed Q^2
(assume CCQE)



μ angle is important for ν energy reconstruction at SciBooNE (and T2K as well)

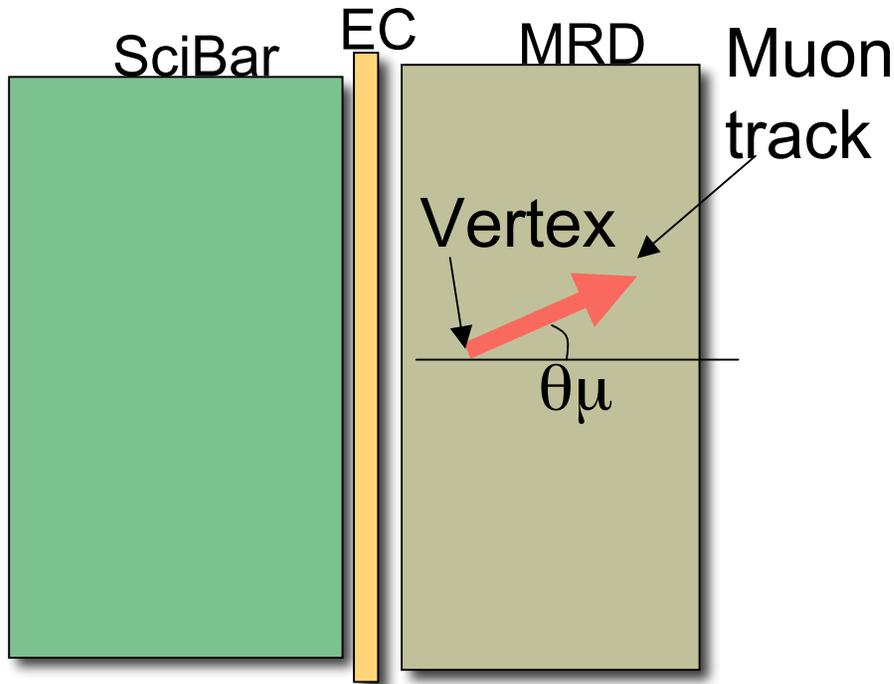
$$E_\nu^{rec} = \frac{m_n E_\mu - m_n^2 / 2}{m_n - E_\mu + P_\mu \cos \theta_\mu}$$

Assume CC-QE



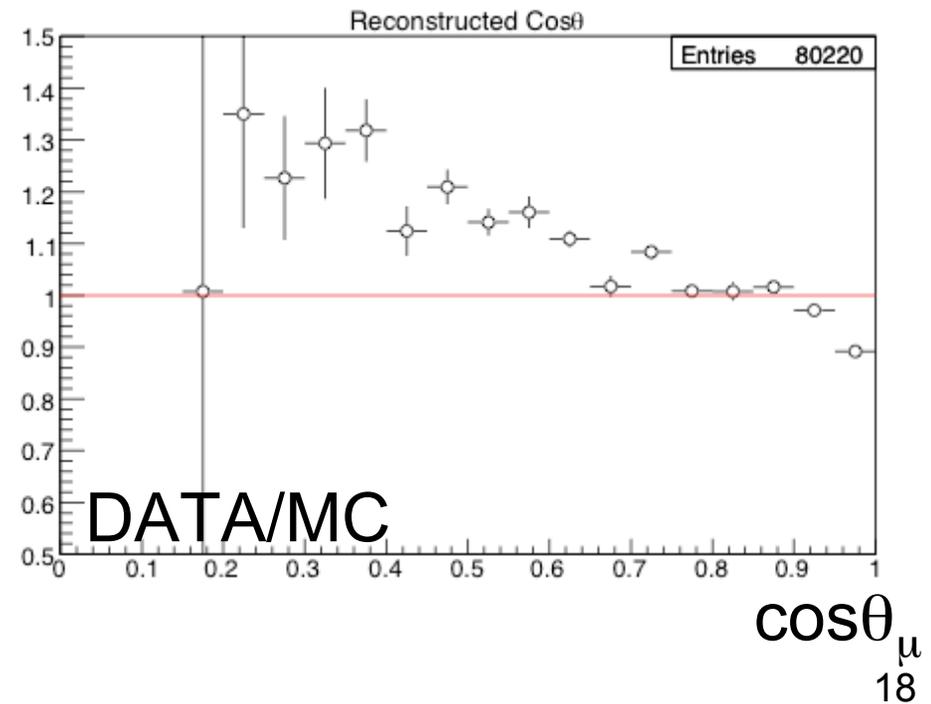
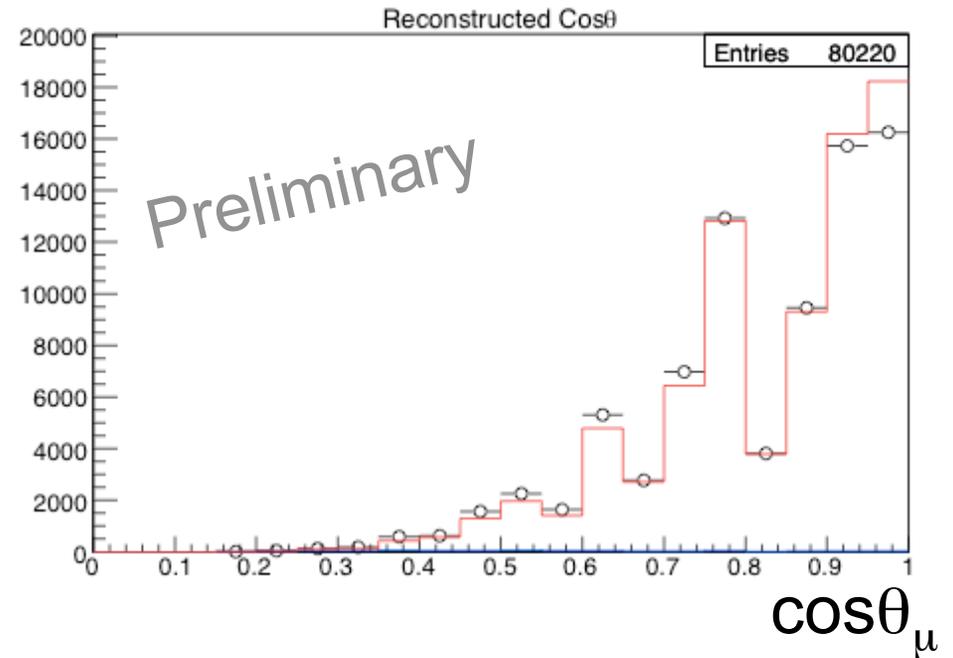
Independent Check on μ angle

- ν events inside MRD
- (SciBar not used for this sample)



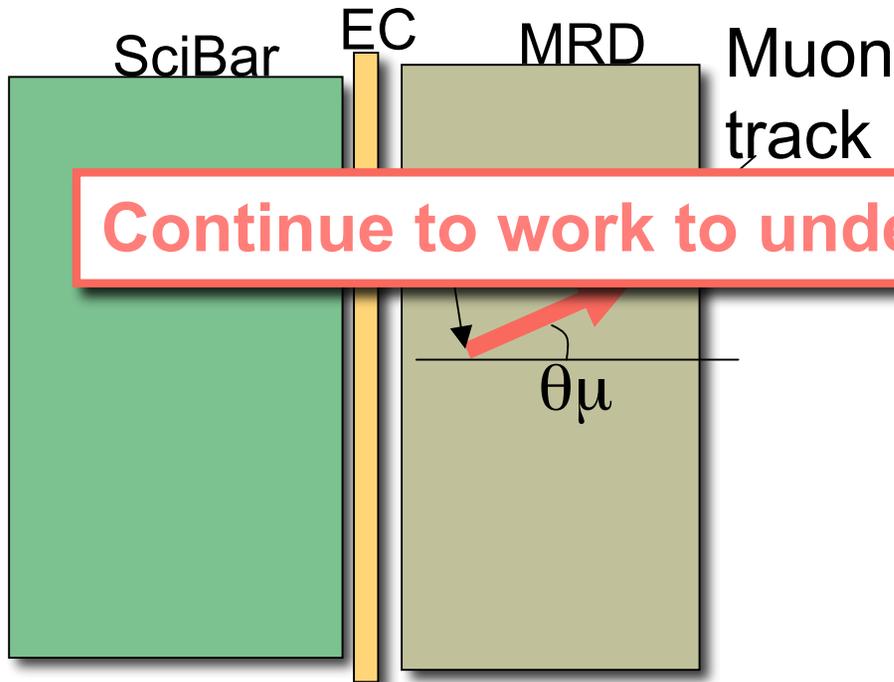
Data/MC disagreement is not caused by detector effect.

??Physics??



Independent Check on μ angle

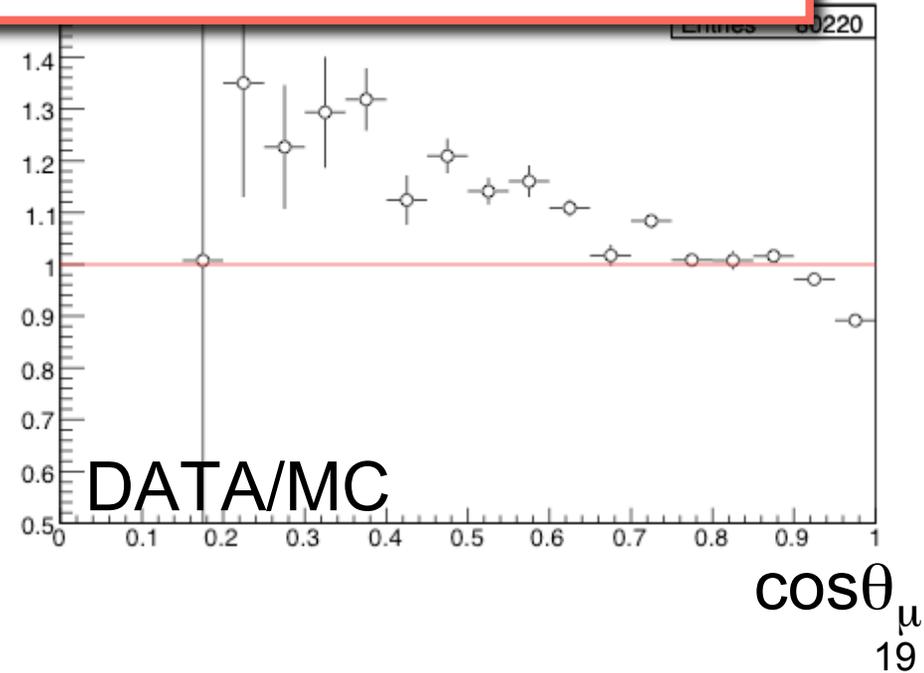
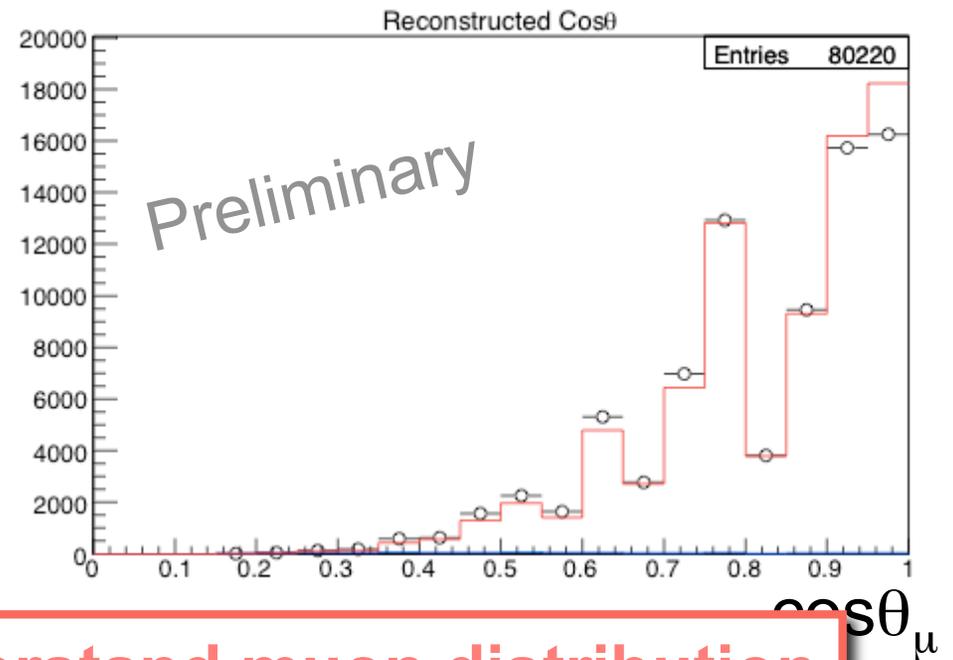
- ν events inside MRD
- (SciBar not used for this sample)



Continue to work to understand muon distribution

Data/MC disagreement is not caused by detector effect.

??Physics??



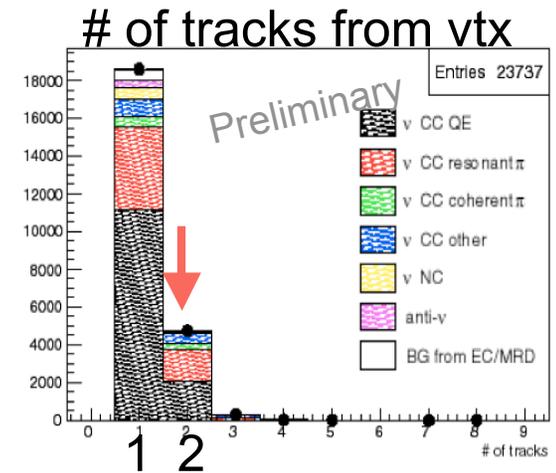
CC-QE and CC-nonQE

CC-QE and non-QE separation

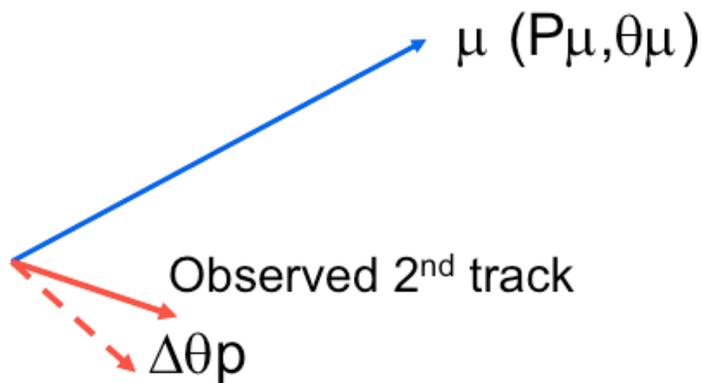
Sample: SciBar-MRD match event & 2 track

QE/non-QE separation by 2nd track kinematics.

$\Delta\theta_p$: Opening angle between observed 2nd track and expected proton track assuming CCQE.

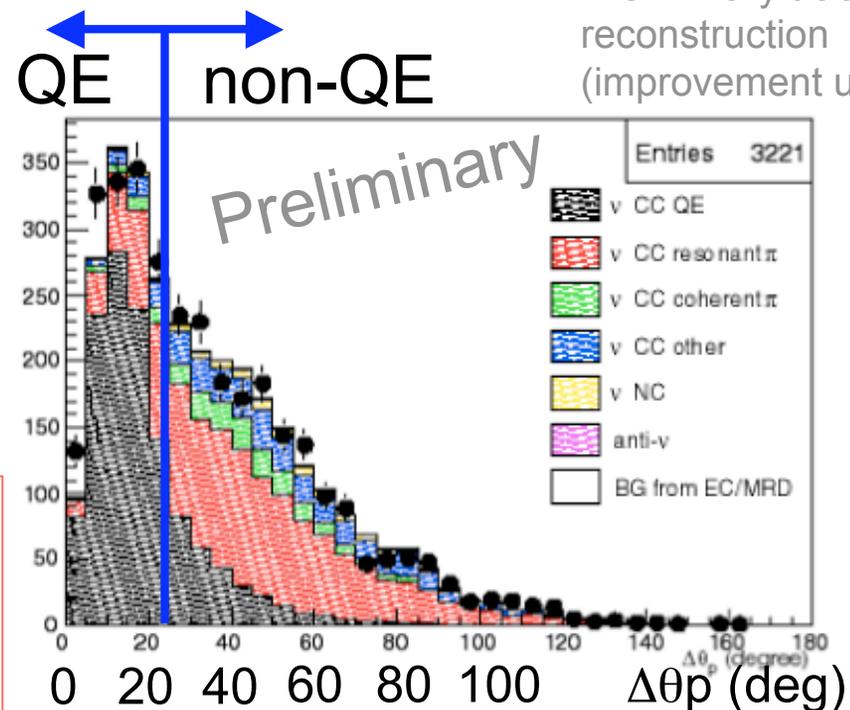


Preliminary track reconstruction (improvement underway)



QE sample (<25 deg)
Purity : 74%

Non-QE sample (>25 deg)
Purity : 84%



Muon distributions

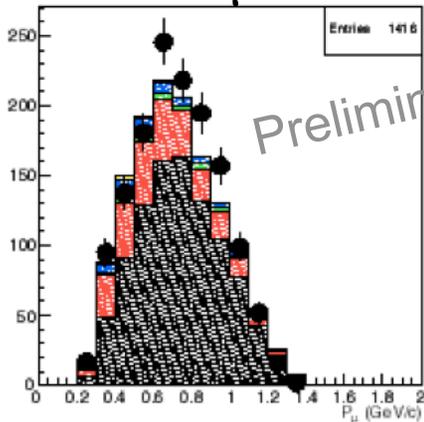
with QE and non-QE samples

- Data
- NC
- CC-multi π
- CC-coh π
- CC- $1\pi^+$
- CC-QE
- BG from EC/MRD

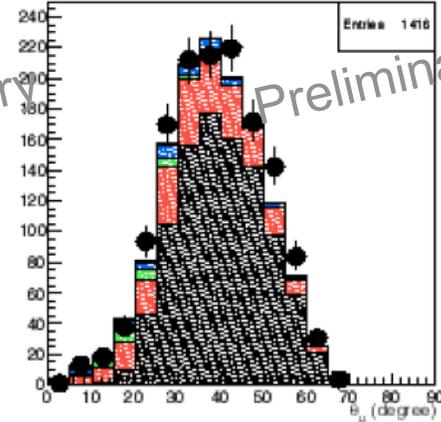
CC-QE

QE Purity: 74%

P_μ



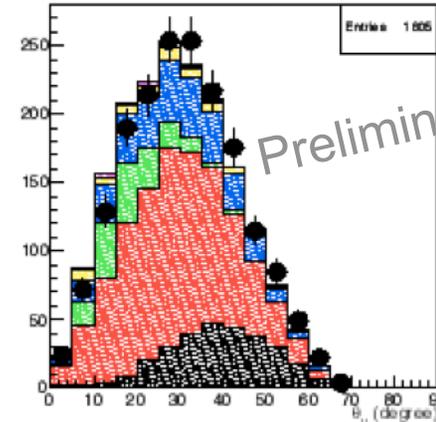
θ_μ



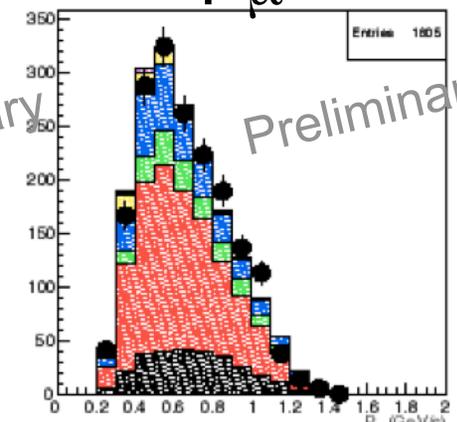
CC-nonQE

Non-QE Purity: 84%

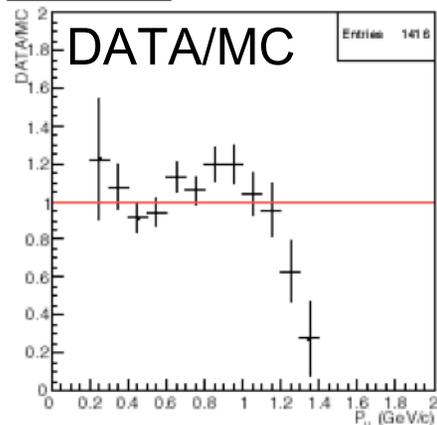
θ_μ



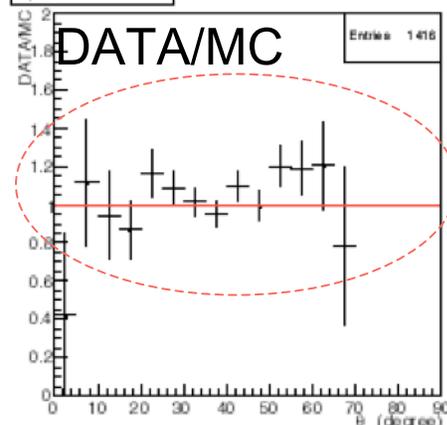
P_μ



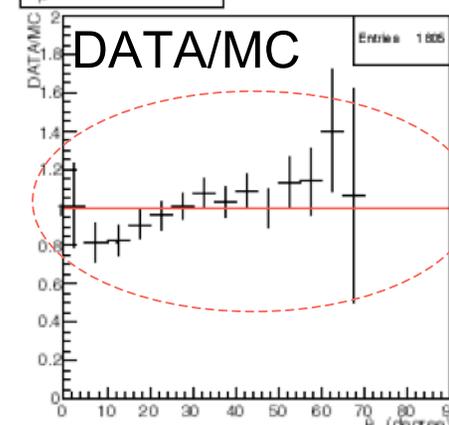
P_μ (2track QE)



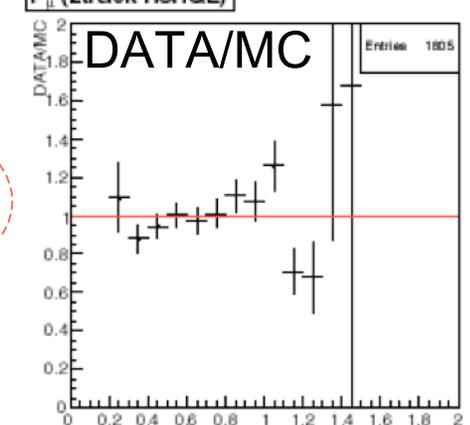
θ_μ (2track QE)



θ_μ (2track nonQE)



P_μ (2track nonQE)

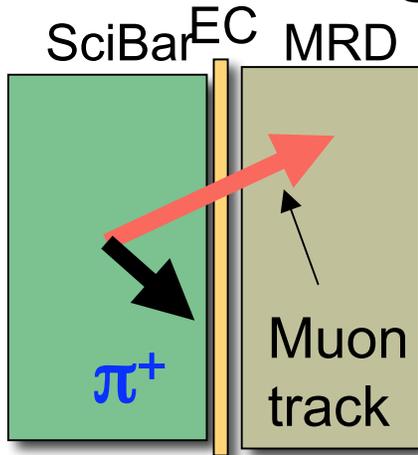


- μ angle discrepancy is due to non-QE events??

CC- $1\pi^+$ analysis

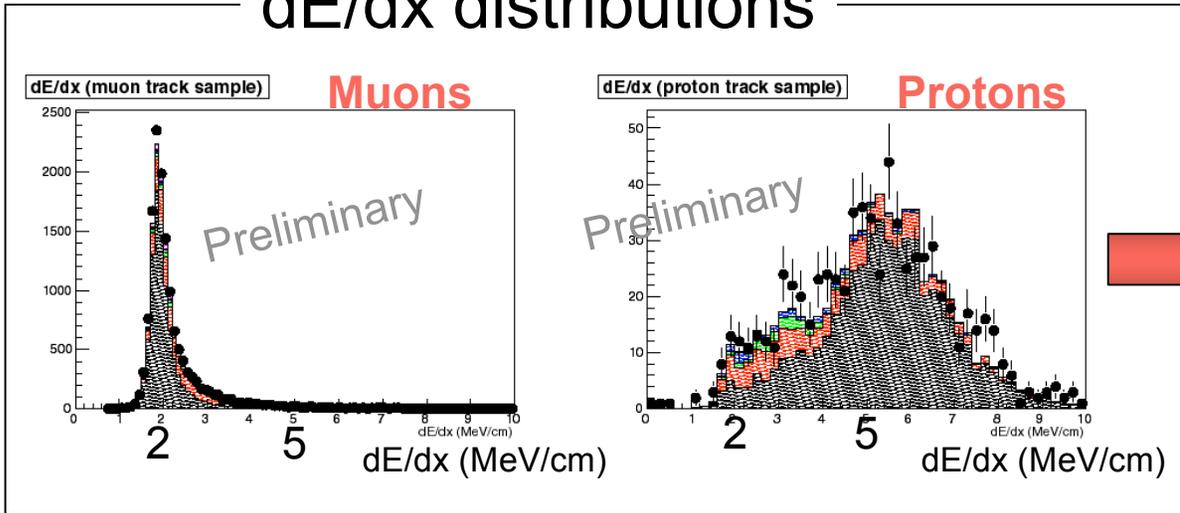
CC- $1\pi^+$ ($\nu+N \rightarrow \mu+\pi+N'$)

- Signature: muon + pion (2 MIP tracks)
Short proton track

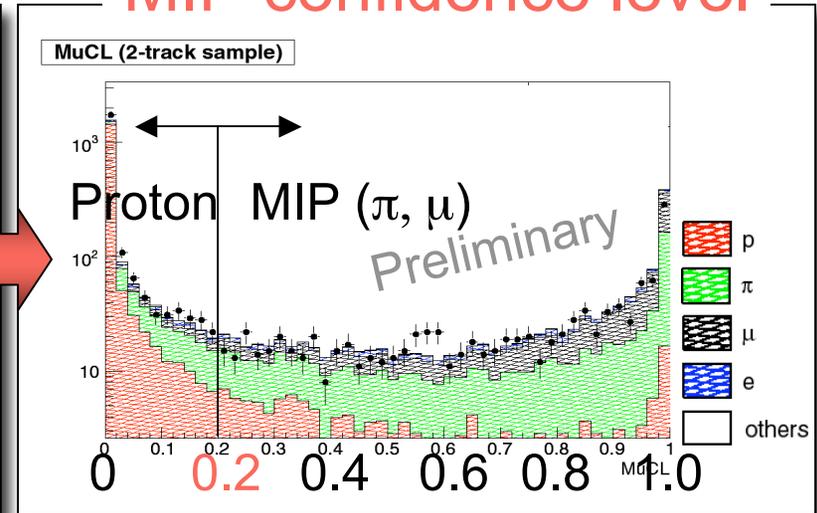


- Apply PID to 2nd track (π or p) of non-QE sample to separate CC- π from other interactions.

dE/dx distributions



MIP confidence level



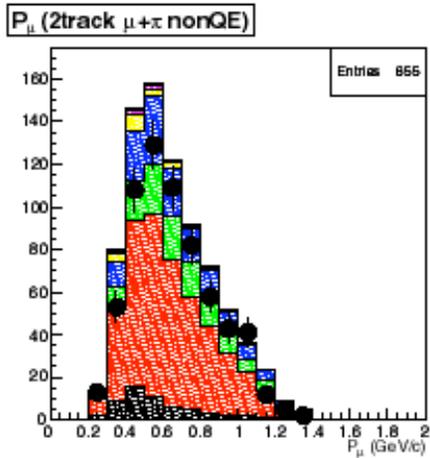
- Data
- CC- $1\pi^+$
- NC
- CC-QE
- CC-multi π
- BG from EC/MRD
- CC-coh π

Proton mis-ID as pion = 7.2%
(Pion track efficiency = 74%)

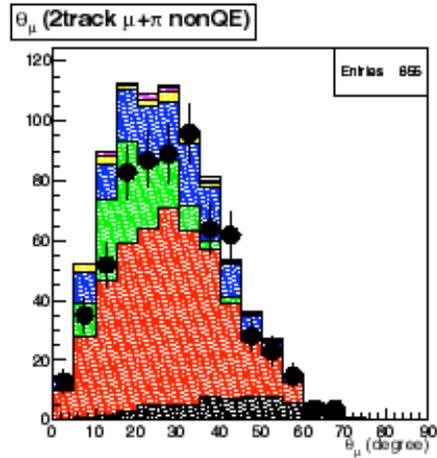
CC- $1\pi^+$ ($\nu+N \rightarrow \mu+\pi+N'$)

2track, $\mu+\pi$, non-QE-like

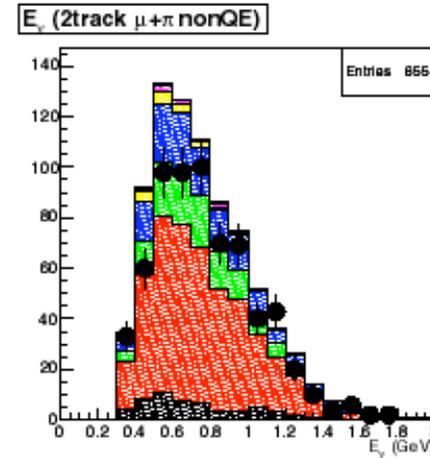
P_μ



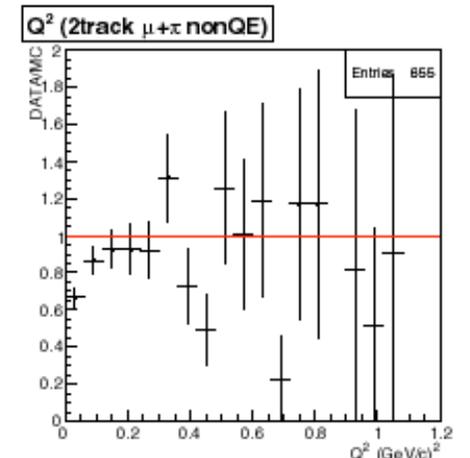
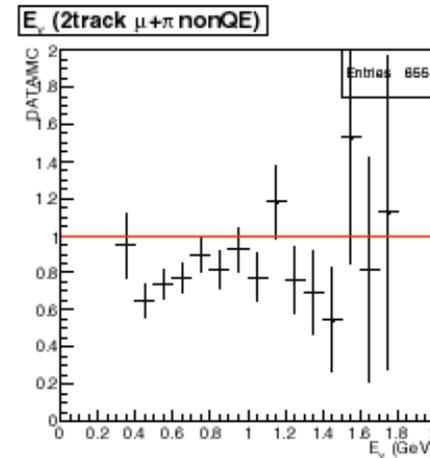
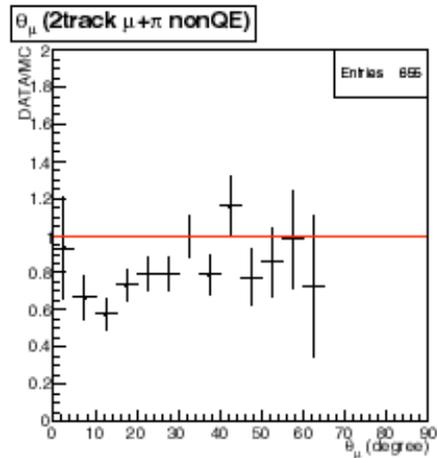
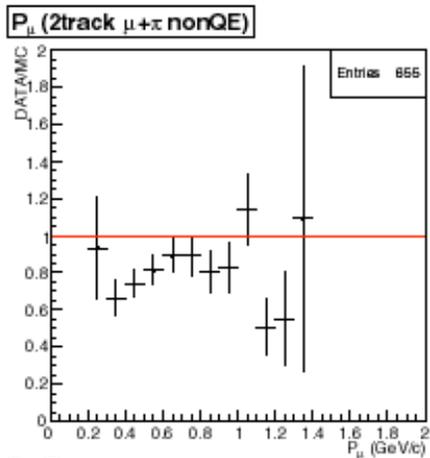
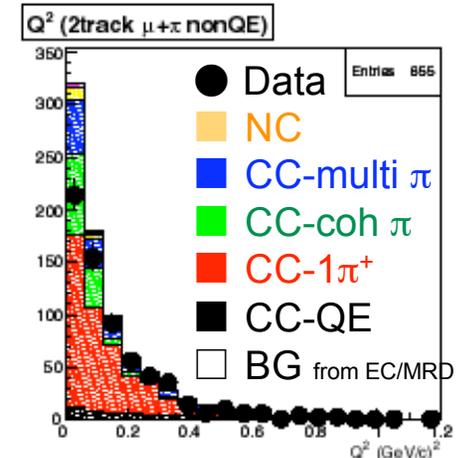
θ_μ



Reconstructed E_ν



Reconstructed Q^2



CC- 1π :

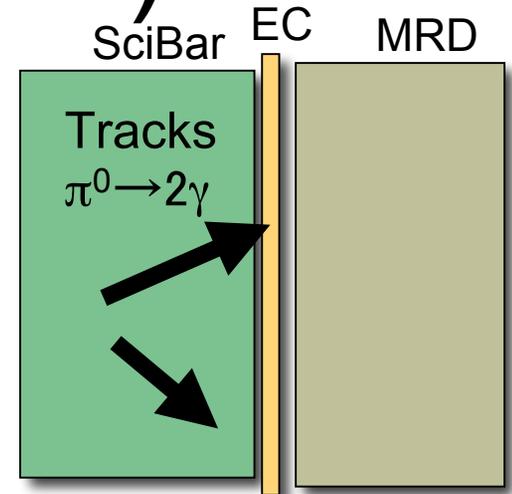
- CC-resonance π
- CC-coherent π
- CC-multi π

655 events,
CC- $1\pi^+$ Purity: 66% (MC)
(resonance)

Neutral Current Analysis

NC- π^0

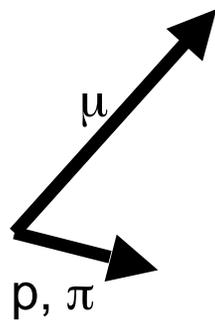
NC- π^0 ($\nu + N \rightarrow \nu + \pi^0 + N'$)



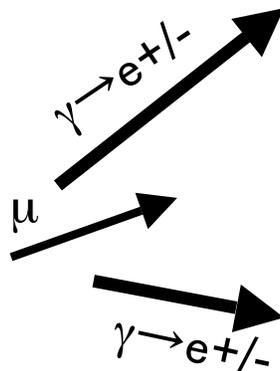
Event signature:

- No muon = No SciBar-MRD match track
- All tracks contained in SciBar

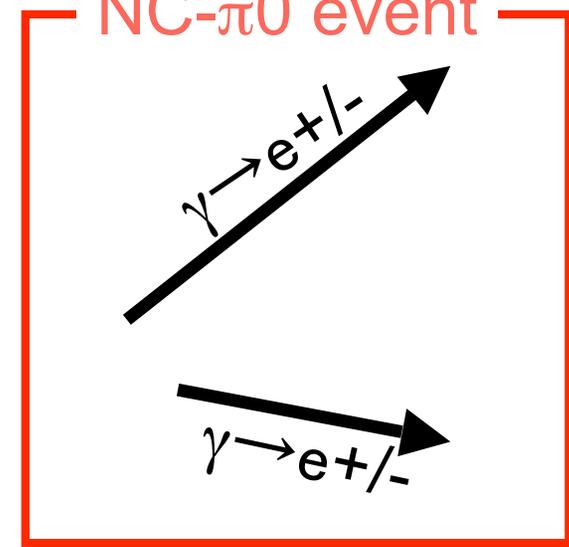
CC-event



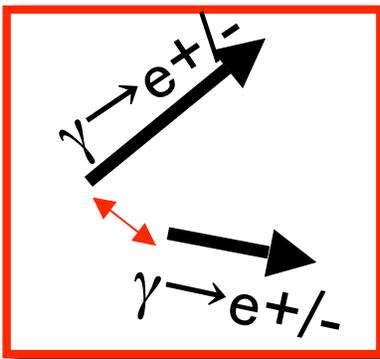
CC- π^0 event



NC- π^0 event



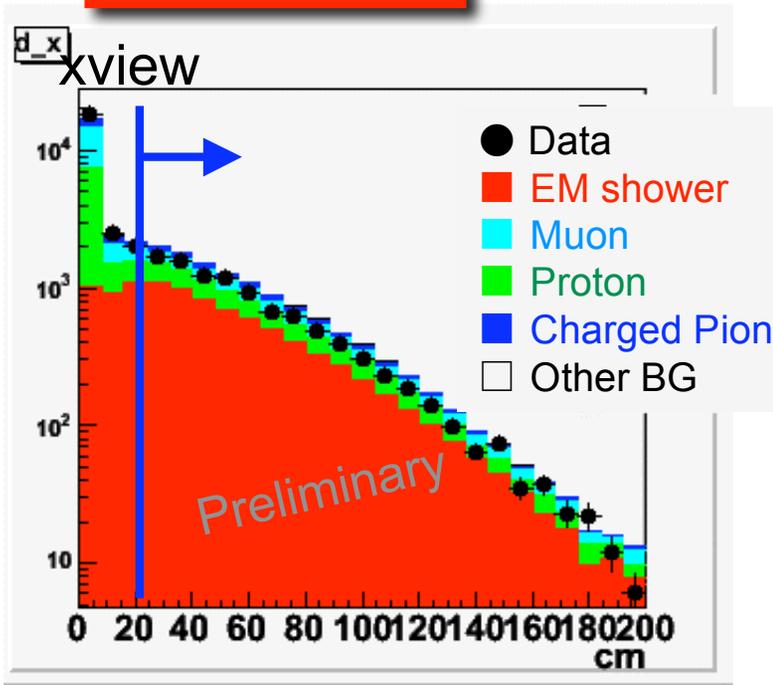
- In order to select NC- π^0
 - ➔ Chose: 2 isolated tracks
 - ➔ Reject: μ, π^+, ρ



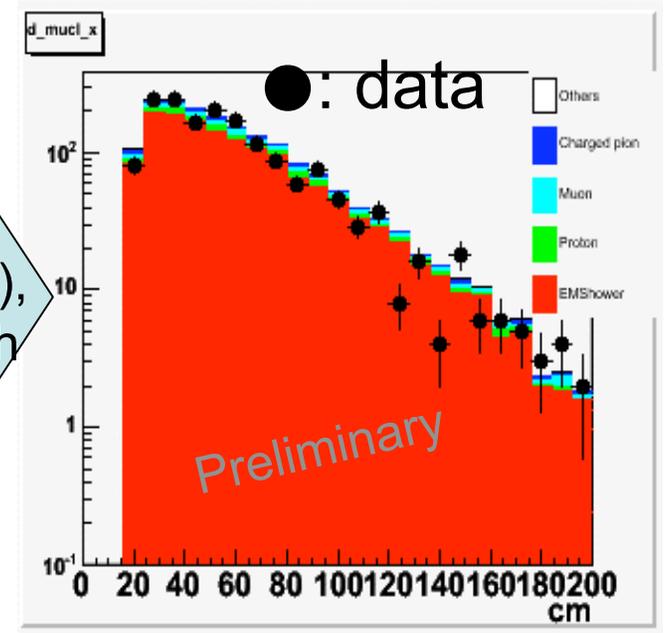
NC- π^0



846 events selected



Apply cuts:
Trk distance,
Muon (by Michel e),
Proton (by PID with
dE/dx)



Histo: MC

EMShower

NC π^0 (19%), CC π^0 (17%)

Proton (19%)

Muon (17%)

Histo: MC

EMShower

NC π^0 (47%), CC π^0 (12%)

Proton (7%)

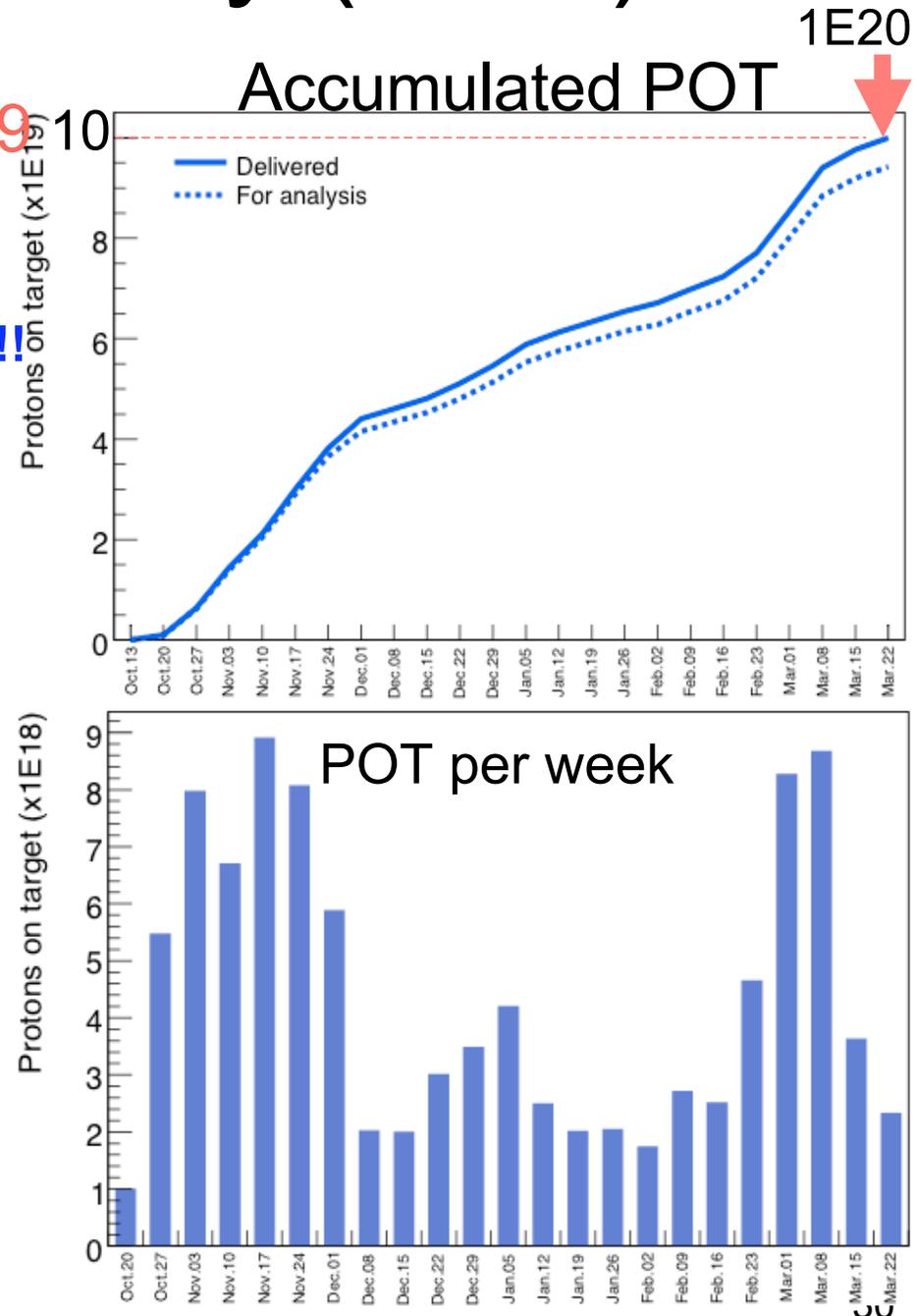
Muon (6%)

Run Plan

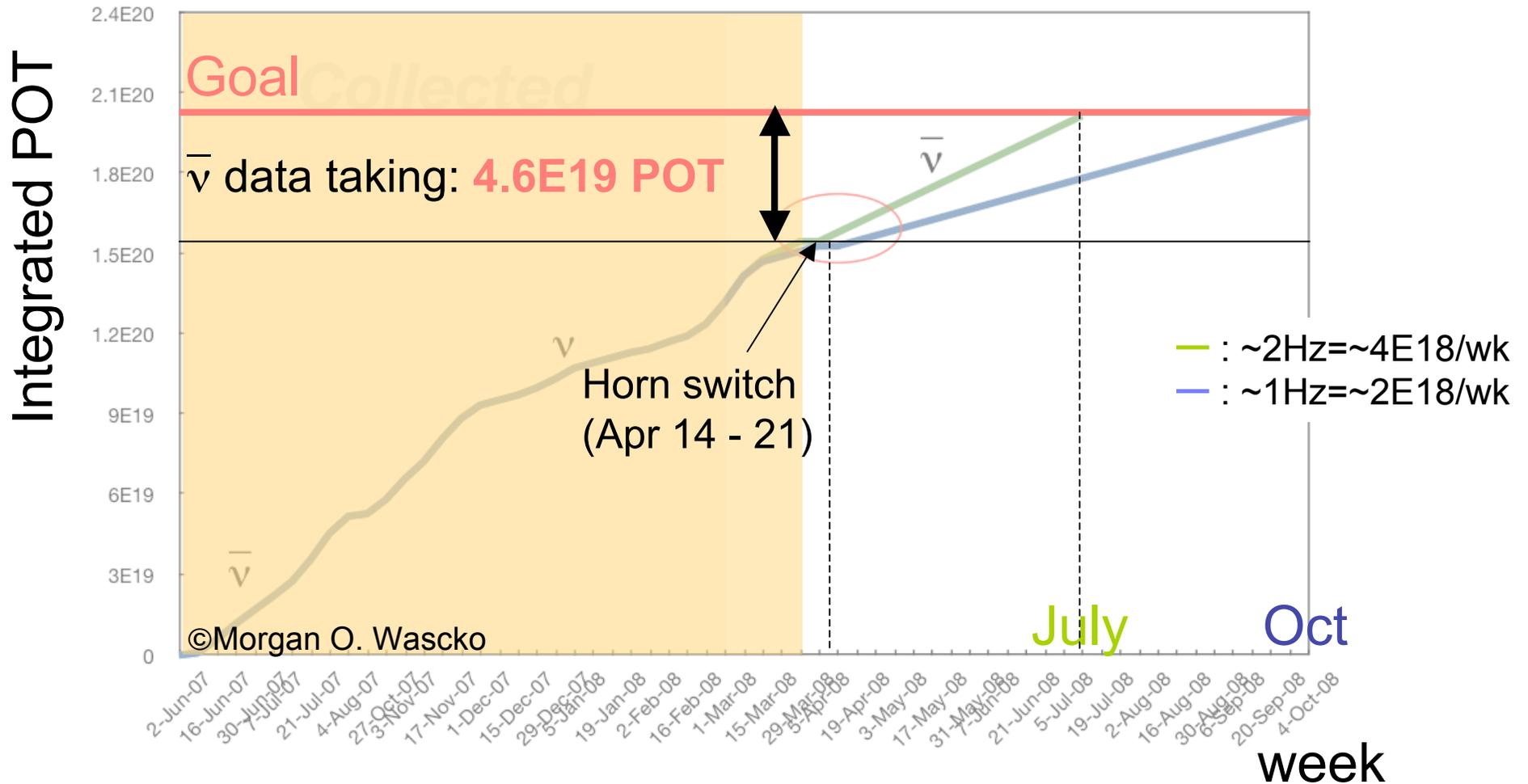
Switch Horn Polarity ($\nu \rightarrow \bar{\nu}$)

- Total POT so far (ν mode): **9.4E19** (at Mar 22)
 (Projected POT for ν : 1E20)
 - **Delivered POT: 1E20!** \leftarrow Thanks AD!!!
 - **For physics: $\sim 0.06E20$ left**
 - ν mode data taking complete before Apr 14

- **Will switch horn polarity April 14**
 - MiniBooNE spokespeople agreed to switch horn polarity on April 14.
 - BNB Machine Coordinator and Horn experts also agreed with the date.
 - Expected duration: ~ 1 week



$\bar{\nu}$ data taking and end of run



$\bar{\nu}$ data taking complete: → **October** (~ 6 months with $\sim 1\text{Hz}$)
 → **July** (~ 3 months with $\sim 2\text{Hz}$)

⊗ AD trying to send beam to BNB with 2Hz
 (but not clear yet)

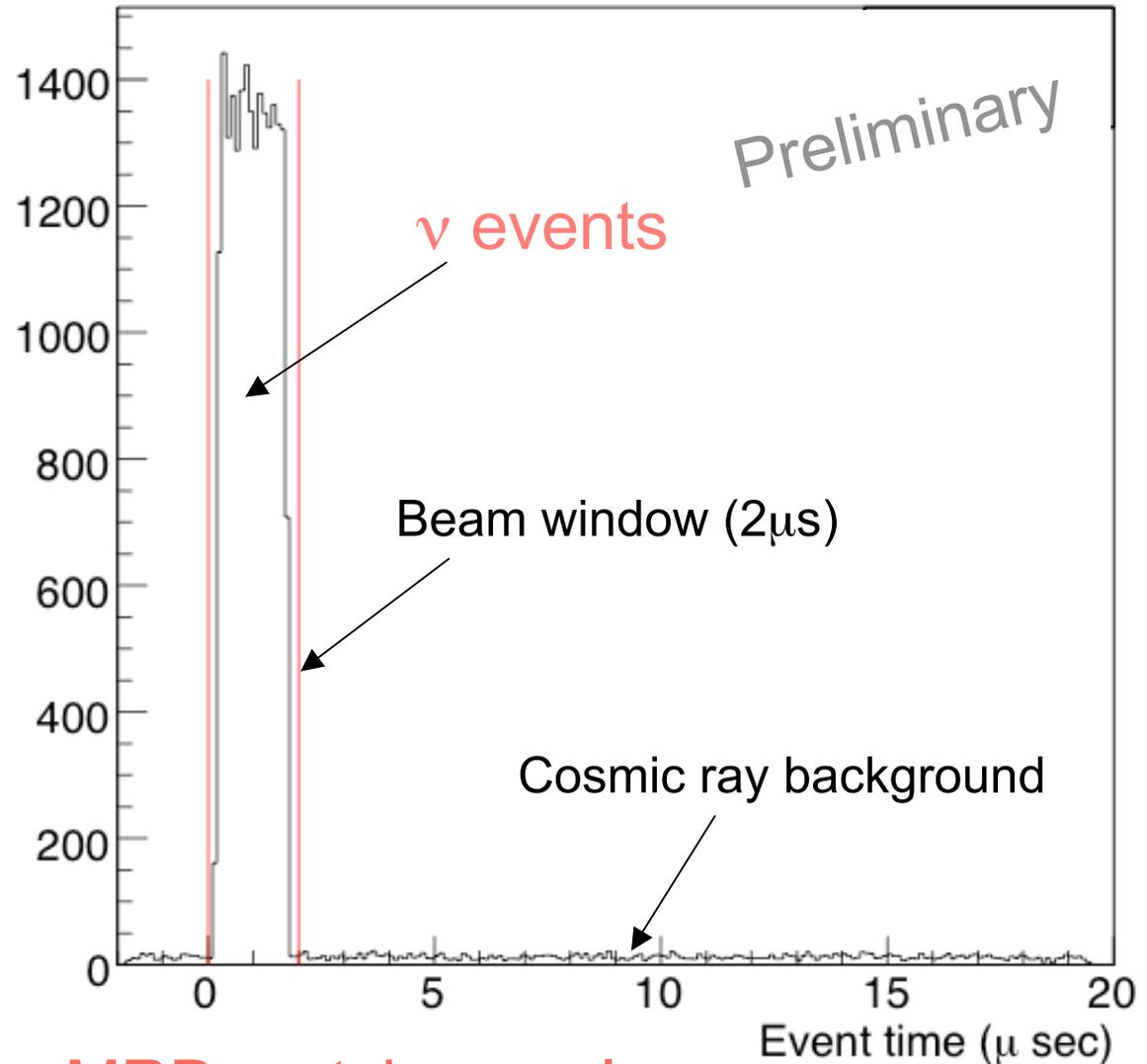
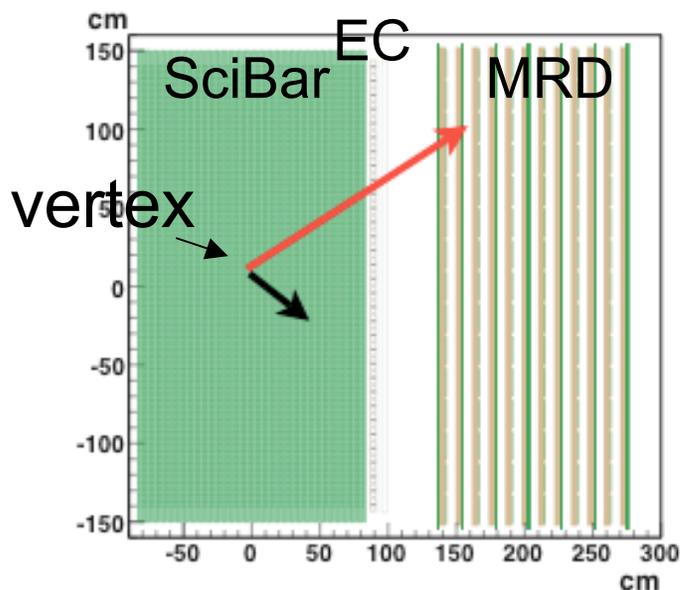
Summary

- **SciBooNE Experiment**
 - Precision measurement of ν and $\bar{\nu}$ cross section at $\sim 1\text{GeV}$
 - Data taking have been started June, 2007
 - Through Aug. 2007: Antineutrino mode
 - Started Oct. 2007: Neutrino mode
 - Data taking is going smoothly
- Run plan:
 - Horn polarity will be switched ($\nu \rightarrow \bar{\nu}$) on April 14.
 - Reach projected POT ($\nu + \bar{\nu}$: $2E20$) in this summer
 - Expected: in July with 2Hz or October with 1Hz
- Several physics analyses are in progress.
 - First results in this summer.

Backup

ν events timing distribution

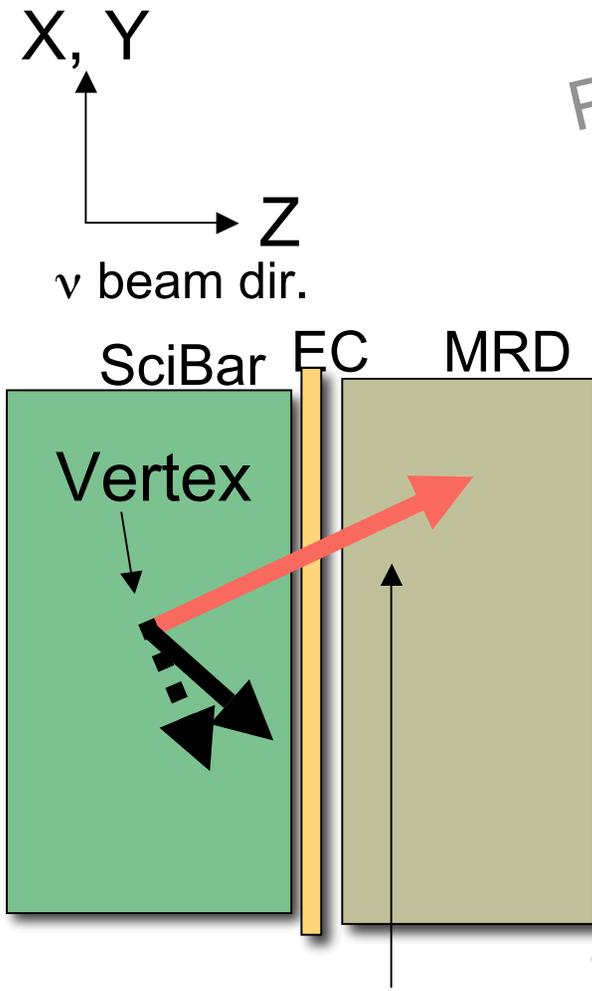
- Beam window: 2 μ sec (1.6 μ s beam spill)
- Requiring SciBar-MRD match, cosmic ray background <0.5%



SciBar-MRD match sample:
CC purity: 96%

Vertex and # of tracks

Sample: SciBar-MRD track matched event



SciBar-MRD
matched trk
(Muon track)

