

# Neutrino-Nucleon Neutral Current Elastic Interactions in MiniBooNE

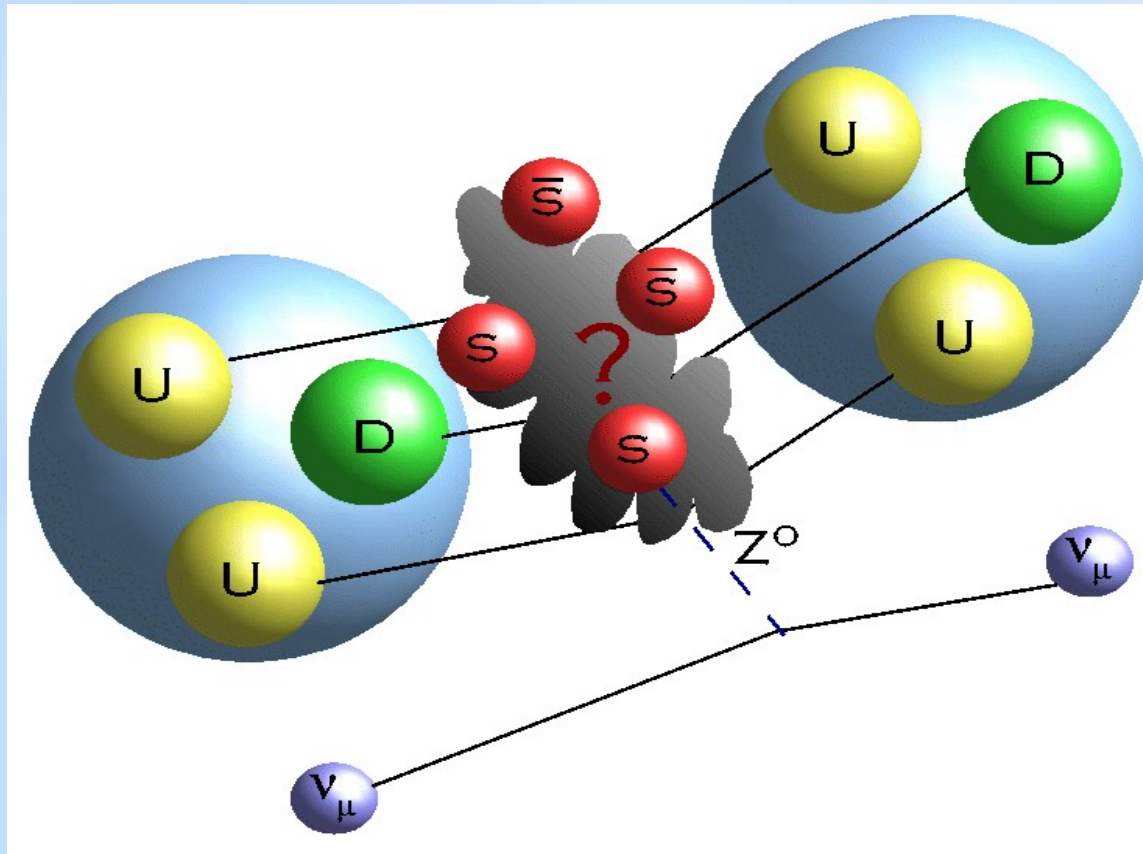


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*for the MiniBooNE collaboration*



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# What is “Neutral Current Elastic”?



Weak interactions mediated by the Z force carrier are called “neutral current”.

For neutrino-nucleon elastic scattering, the initial and final state particles are unchanged.

# Available world-wide neutrino NC Elastic data BNL E734

BNL E734 used 170-ton high-resolution target detector, comprised of 112 modules, each of which had 16 liquid scintillator cells

The beam was 26 GeV protons incident on a production target

BNL E734: PRD 35, 785 (1987)

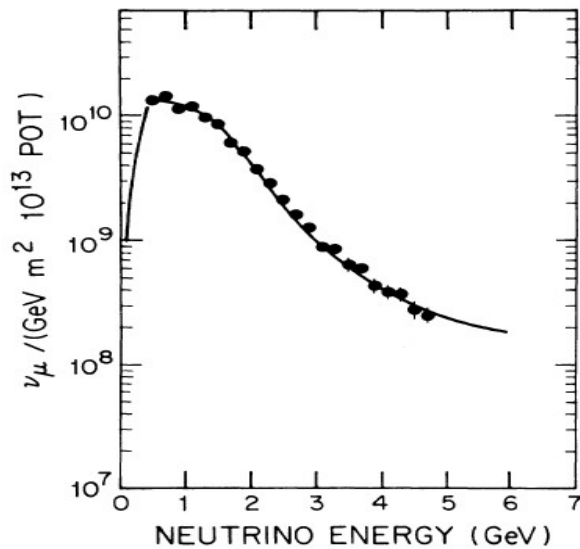
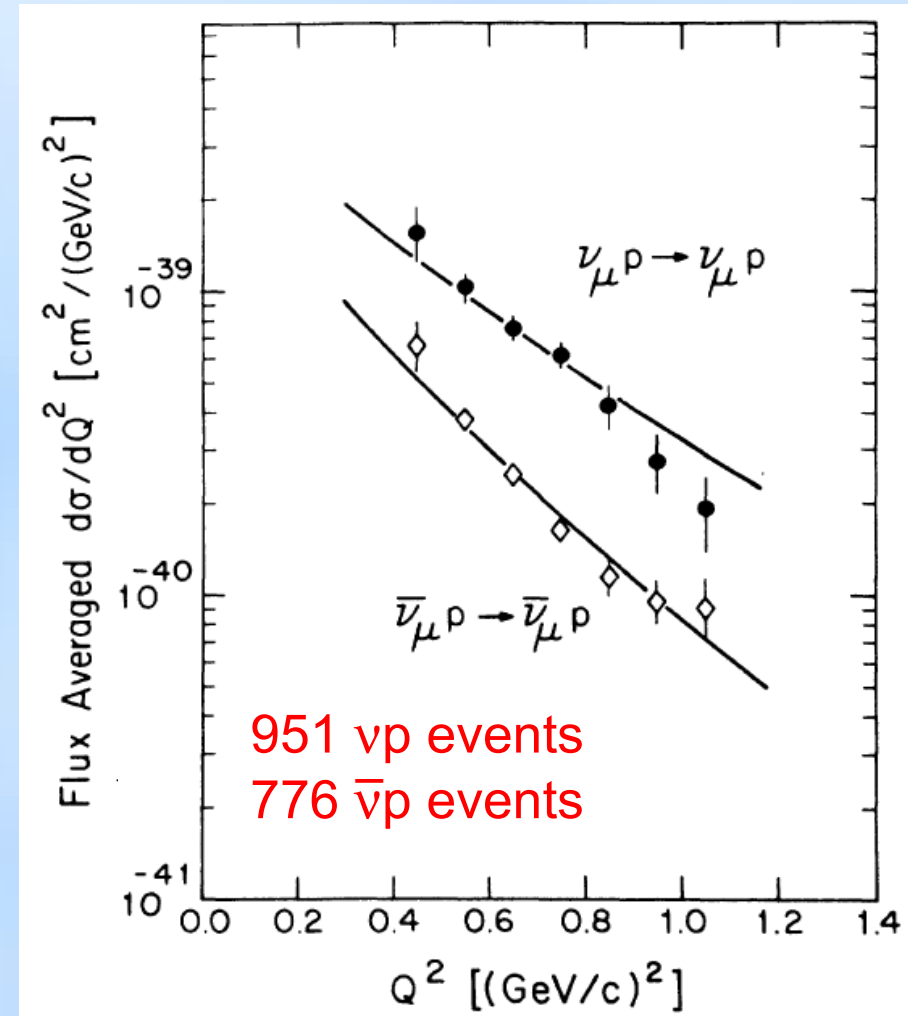
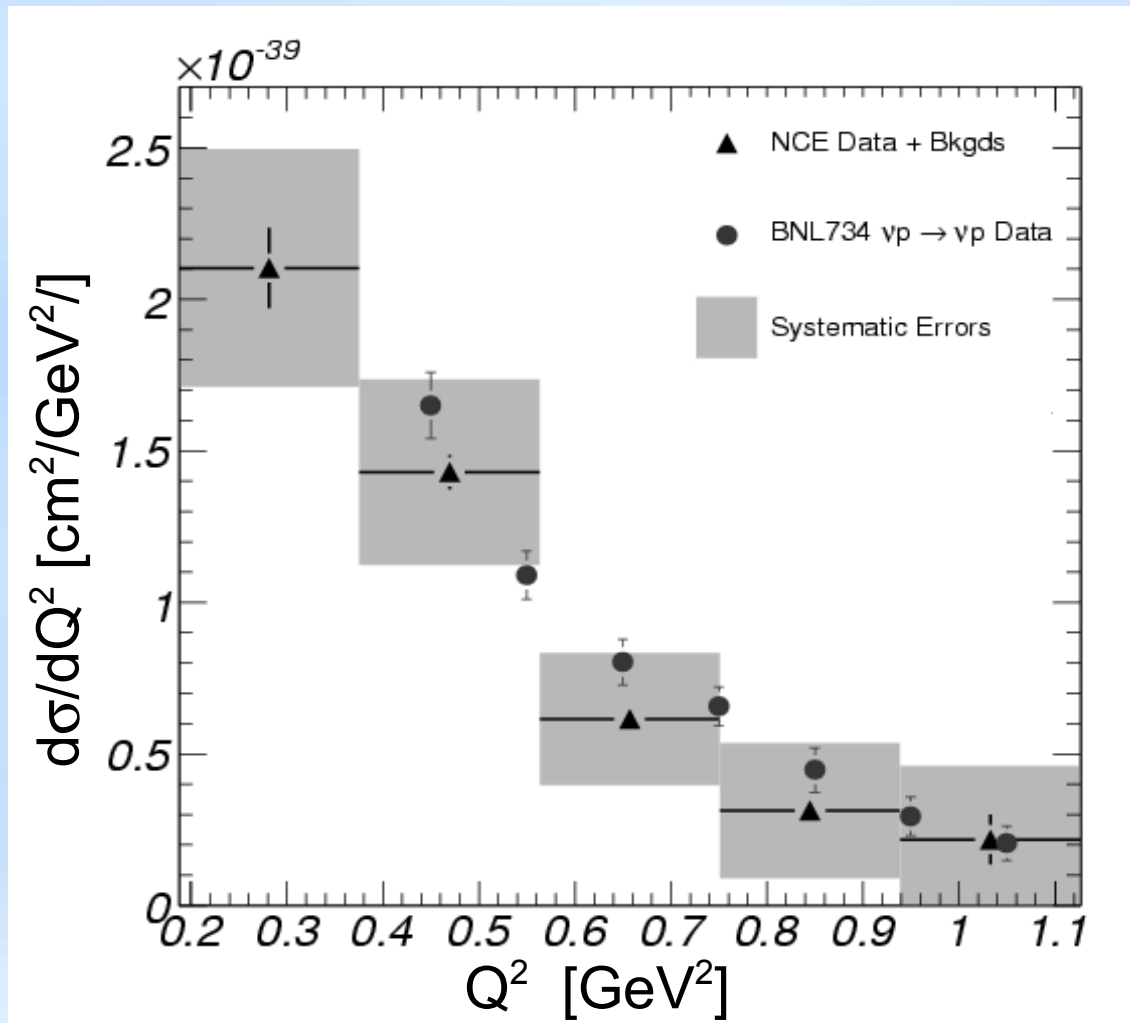


FIG. 2. The measured  $\nu_\mu$  flux. The error bars represent data from the reaction  $\nu_\mu n \rightarrow \mu^- p$ . The solid curve is a Monte Carlo beam flux calculation. Details of the flux measurement and Monte Carlo calculations are given in Ref. 19.



# BNL E734 $\nu p$ Elastic (1987) Data

## MiniBooNE Preliminary NC Elastic Flux-averaged Differential Cross-Section using 10% MiniBooNE data



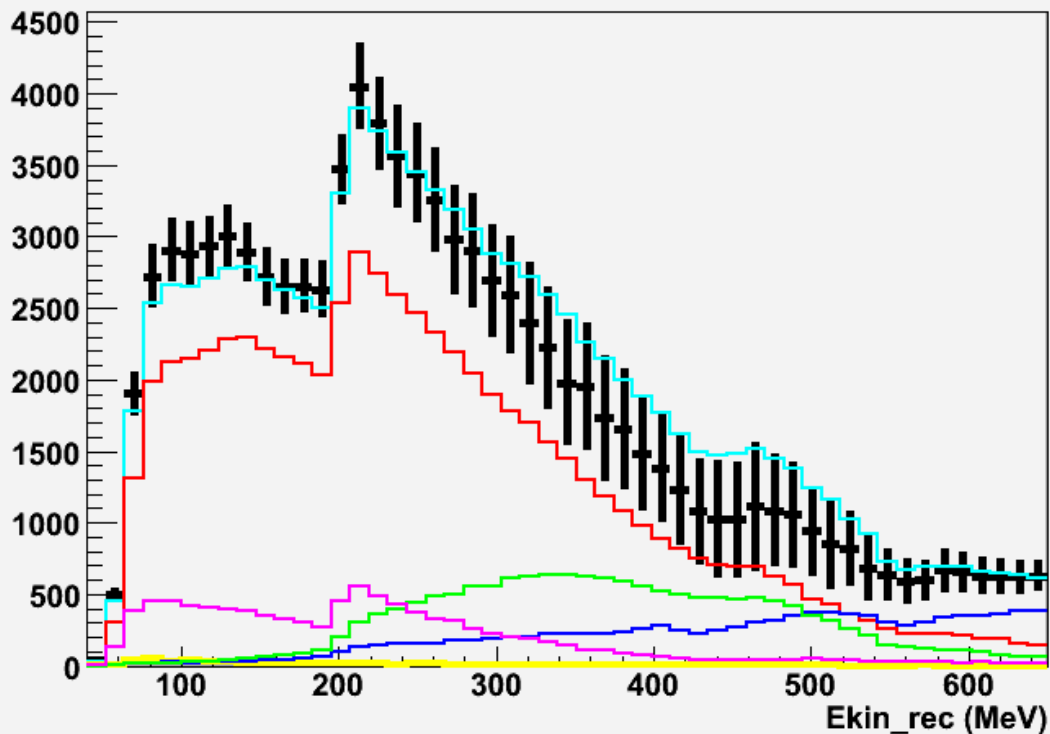
An early analysis, limited by oscillations analysis blindness requirement  
Ph.D. Thesis, Chris Cox, Indiana University (unpublished)

## NC elastic event selection:

- 1 subevent
  - Veto PMT hits < 6
  - Beam time window
  - Tank PMT hits > 24
  - Reconstructed energy < 650 MeV
  - Time likelihood ratio between proton and electron hypotheses
  - Fiducial volume = 
$$\begin{cases} R < 4.2\text{m} & \text{if } E_{\text{kin}_{\text{rec}}} < 200\text{MeV} \\ R < 5.0\text{m} & \text{if } E_{\text{kin}_{\text{rec}}} > 200\text{MeV} \end{cases}$$
- No decaying particles  
Remove cosmic rays  
Events in beam time  
Reconstructible events  
Ensures low visible energy
- Assures protons (removes beam unrelated Michel electrons)
- Removes dirt events, assures reconstructable events

Reconstructed energy spectrum

POT normalization



**Data**

Total Monte Carlo (RFG,  $M_A=1.23$  GeV)

NC elastic

Dirt

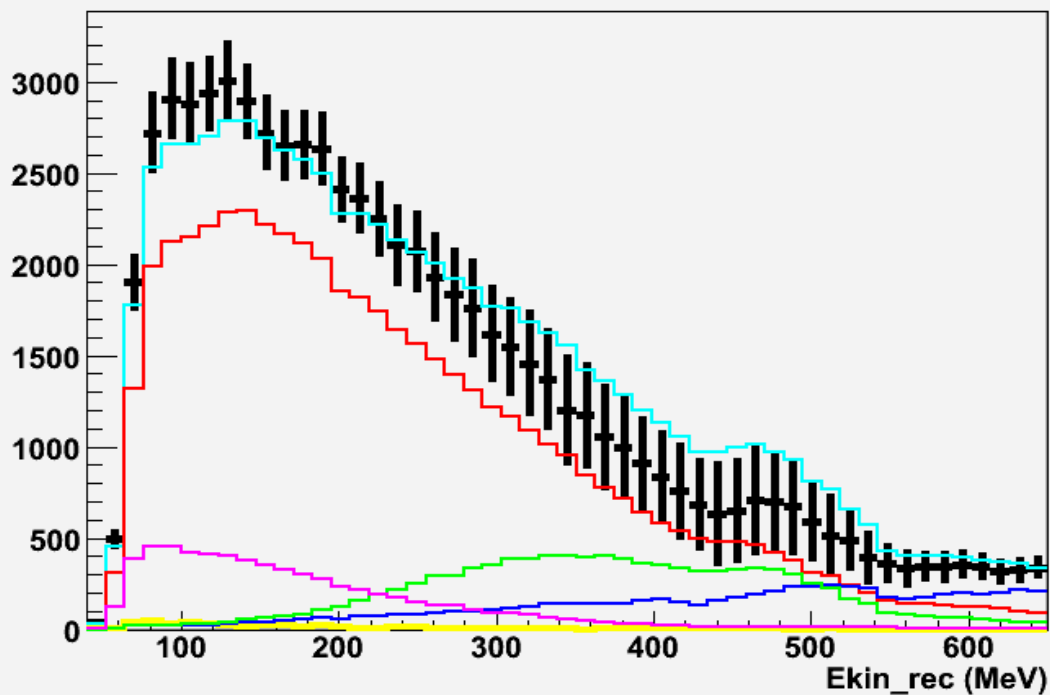
Irreducible

Beam unrelated

Other

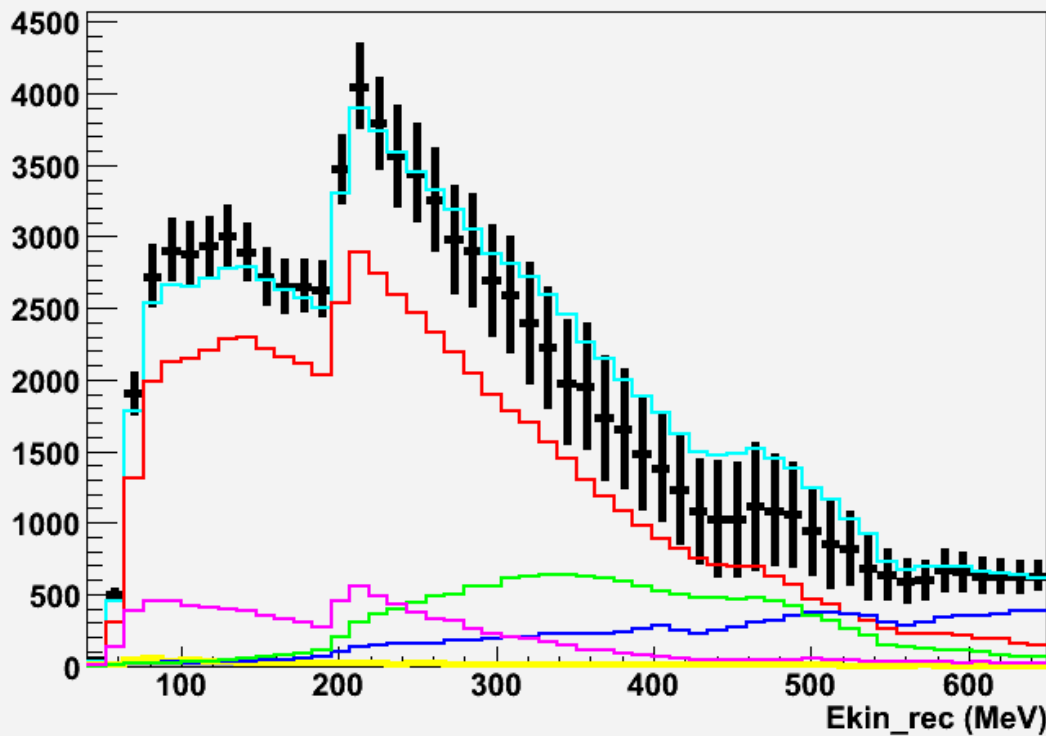
Data has 94.5K events for  $6.46 \cdot 10^{20}$  POT  
NCEL purity is 62%

Reconstructed energy spectrum,  $R < 4.2$  m



Reconstructed energy spectrum

POT normalization



**Data**

Total Monte Carlo (RFG,  $M_A=1.23$  GeV)

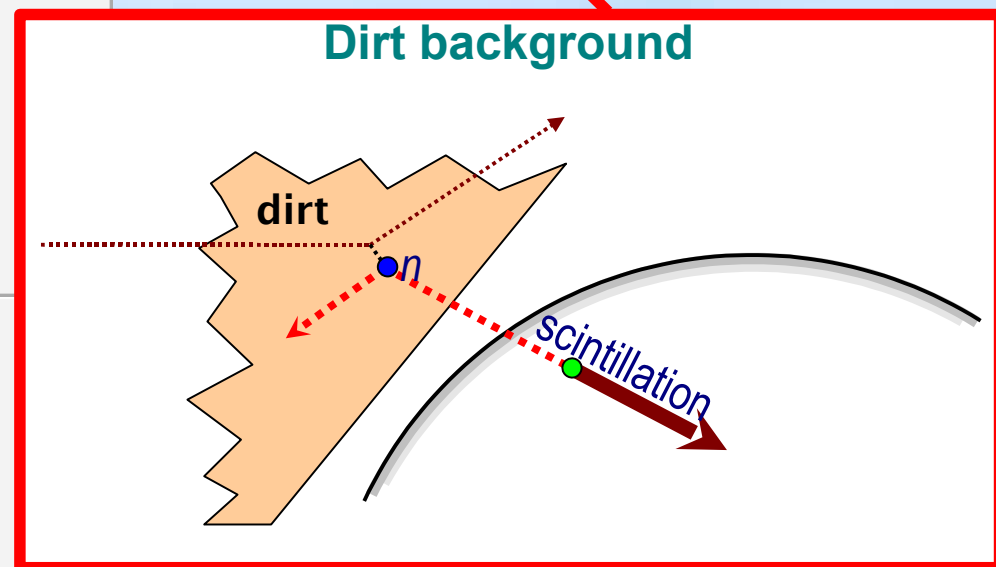
NC elastic

Dirt

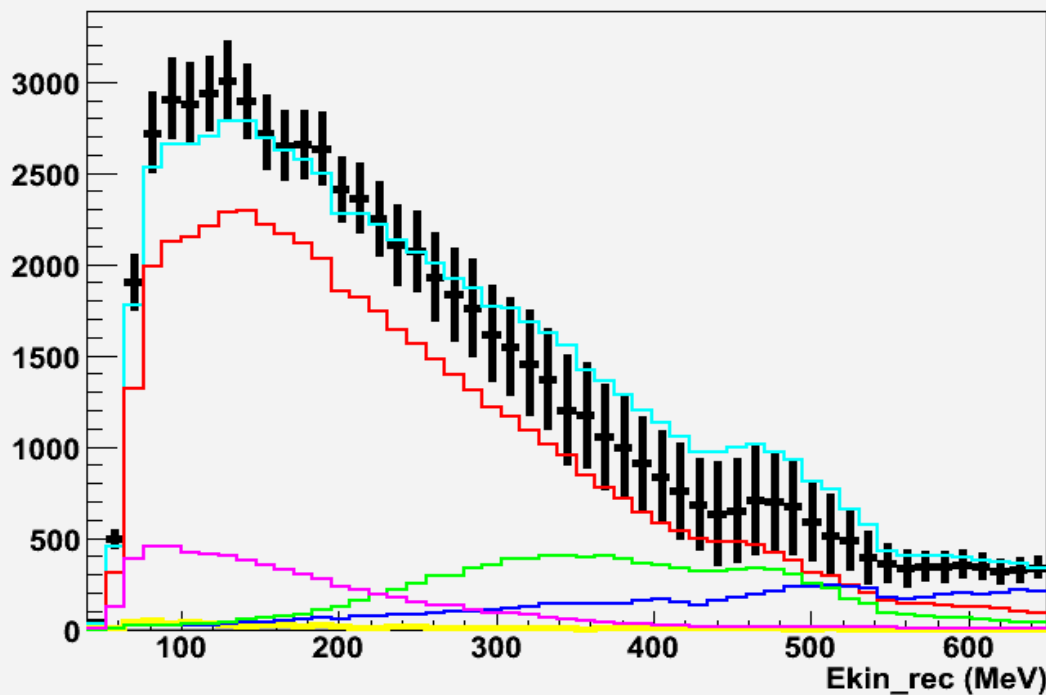
Irreducible

Beam unrelated

Other



Reconstructed energy spectrum,  $R < 4.2$  m

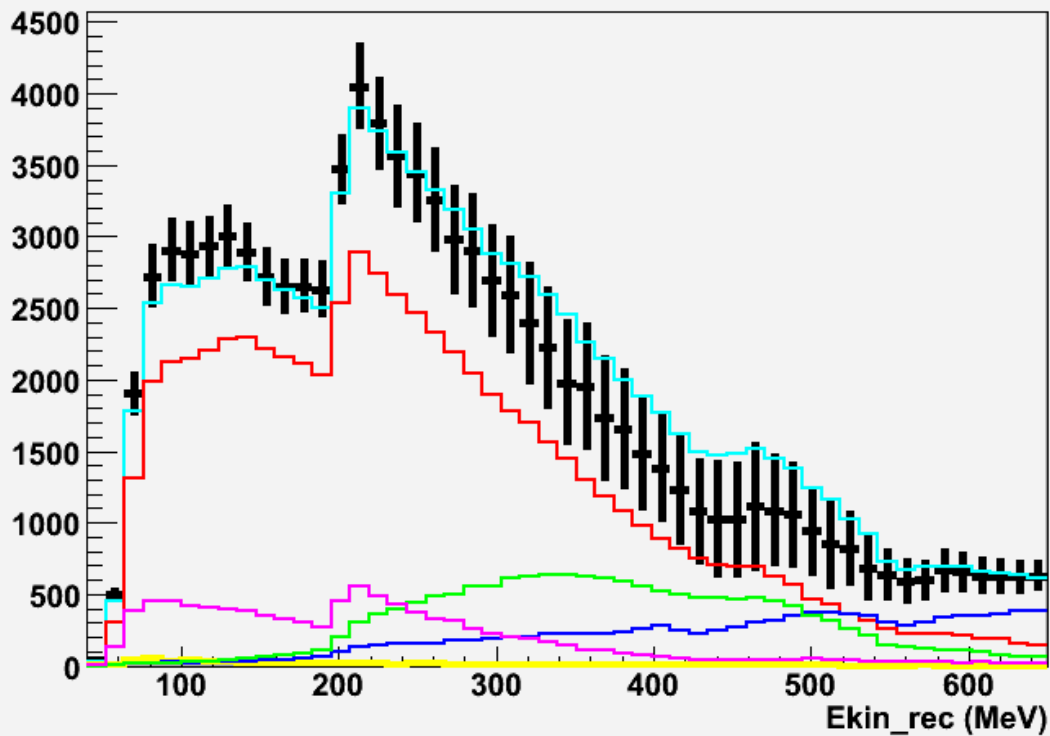


*Low energy background*



Reconstructed energy spectrum

POT normalization



Data

Total Monte Carlo (RFG,  $M_A = 1.23$  GeV)

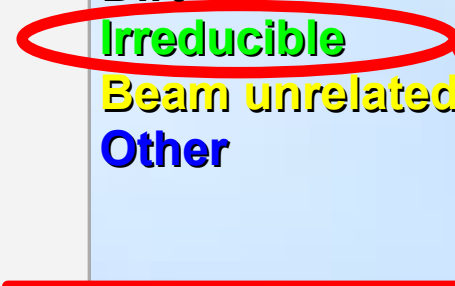
NC elastic

Dirt

Irreducible

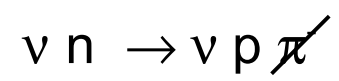
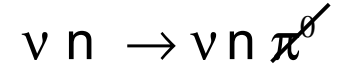
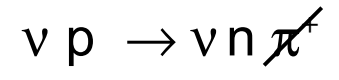
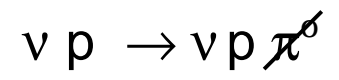
Beam unrelated

Other

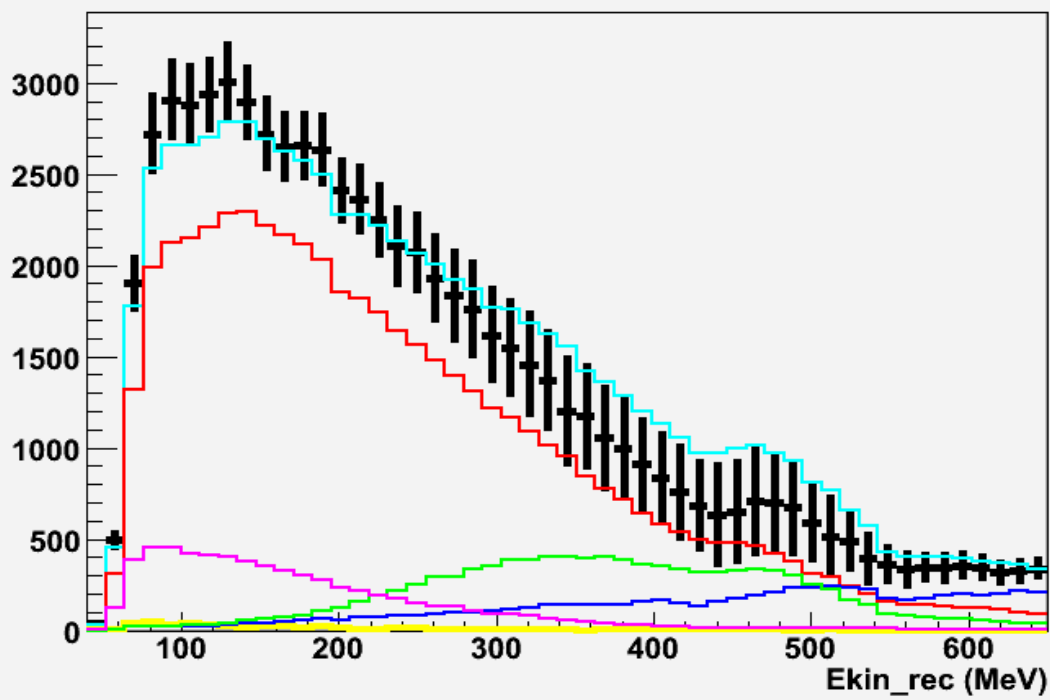


Irreducible background

(NC  $\pi$  channels with no pion in the final state)



Reconstructed energy spectrum,  $R < 4.2$  m

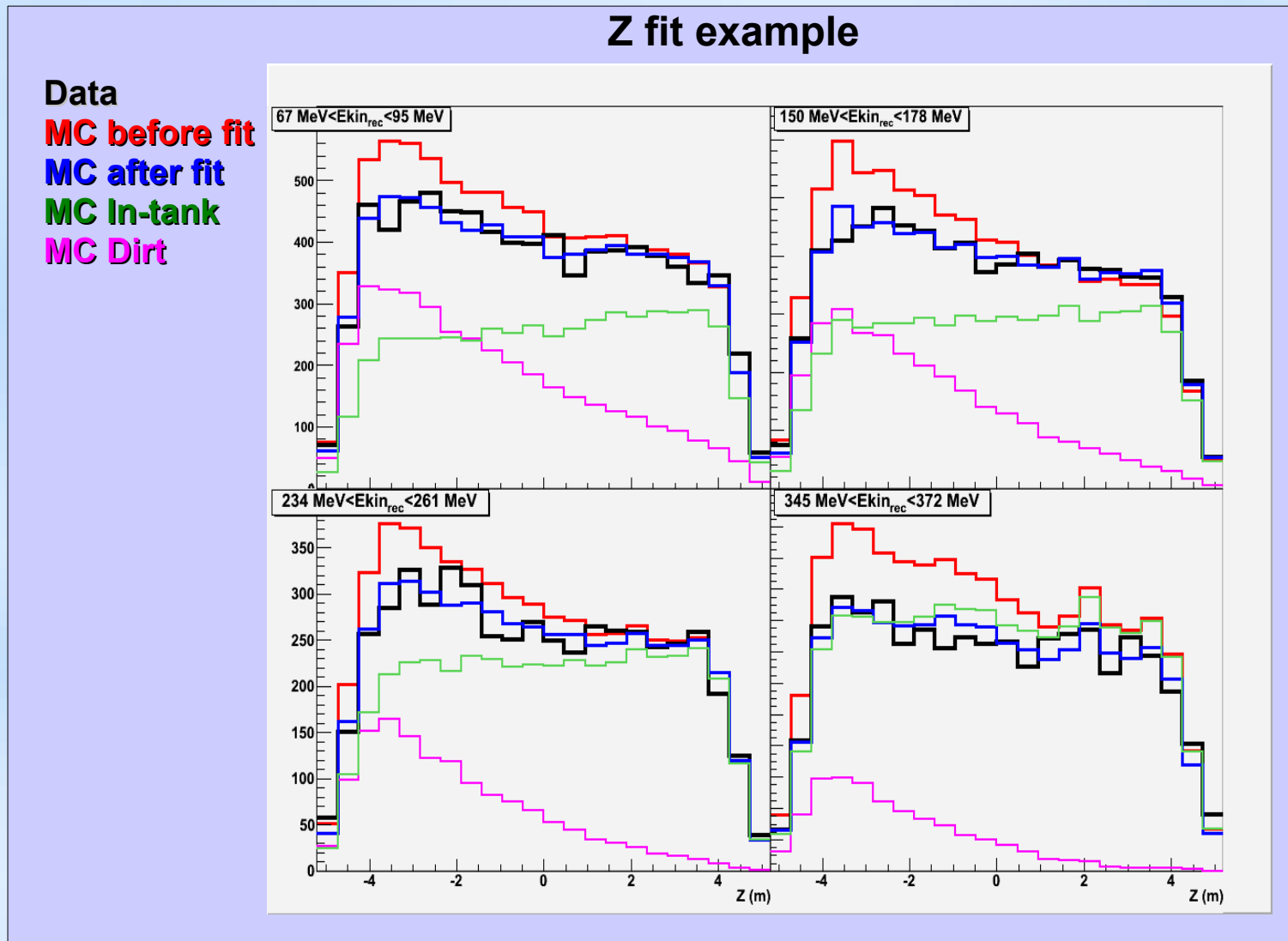


*Middle energy background*



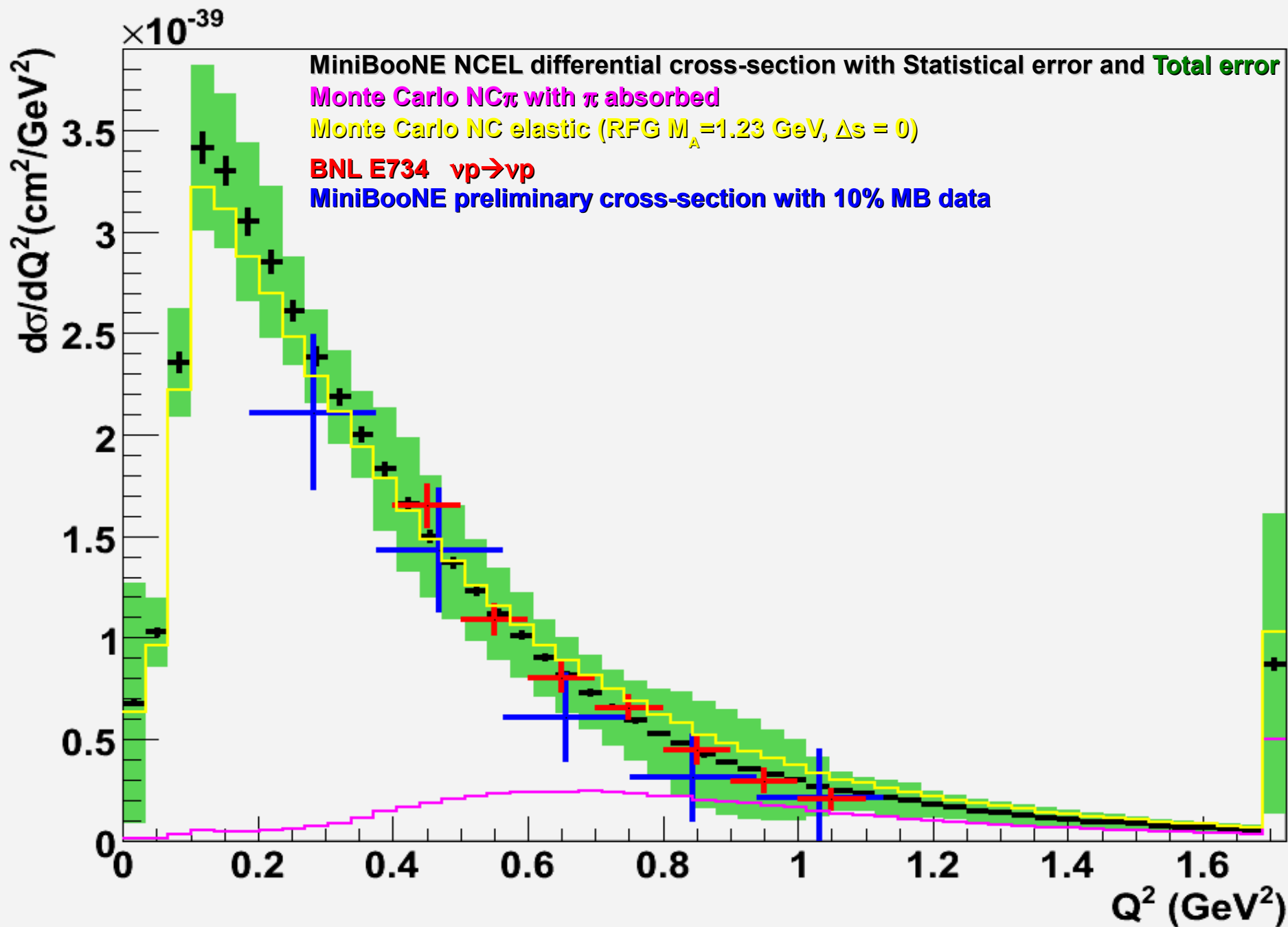
# Dirt background measurement

We have measure the dirt event energy spectrum by looking at the *dirt-enriched samples* and fitting **Z**, **R** and **Energy** distributions.



*The three fits agree with each other, and MC/Data in Z and R distributions agreement is good after the fit. We claim 10% error on the dirt measurement*

# Flux-averaged MiniBooNE NC elastic differential cross-section

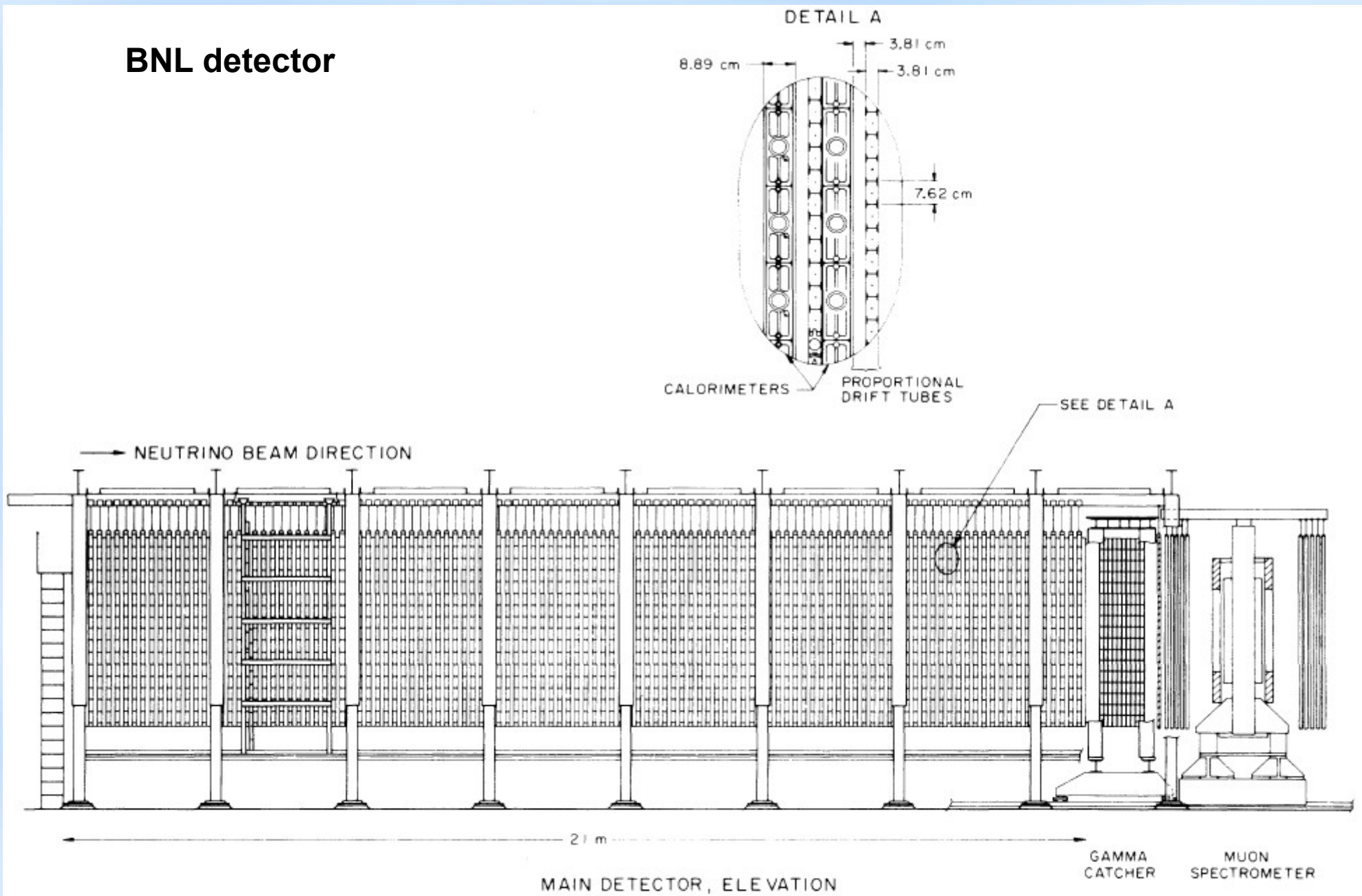


# Summary

- MiniBooNE has accumulated about 94.5K neutral-current neutrino interactions candidates in neutrino mode. We also now have the largest sample of antineutrino NC elastic interactions, that is yet to be analyzed.
- Since the early results, we have improved the analysis:
  - × using the new Proton fitter
  - × measured dirt backgrounds
  - × used 100% MiniBooNE datafor the latest NC elastic cross-section measurement, which have been shown.
- The paper is currently in preparation.
- We are working on the nuclear model parameters fits based on the NC elastic cross-section, axial vector mass ( $M_A$ ) and strange quark contribution to the nucleon spin ( $\Delta s$ )

# BACKUPS

# BNL detector



A schematic drawing of the BNL–Brown–KEK–Osaka–Pennsylvania–Stony Brook neutrino detector.

## Combined dirt correction

