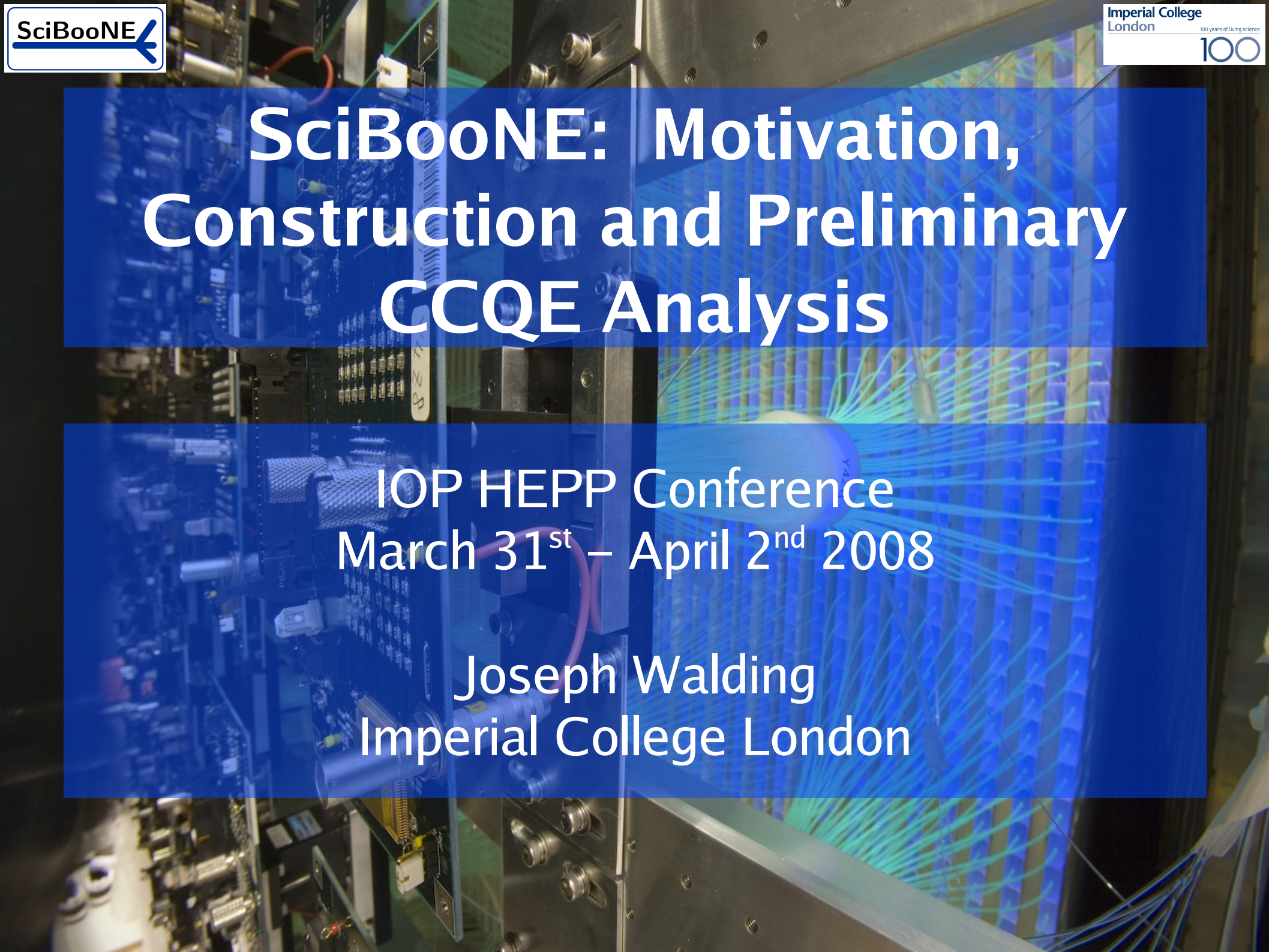


SciBooNE: Motivation, Construction and Preliminary CCQE Analysis

IOP HEPP Conference
March 31st – April 2nd 2008

Joseph Walding
Imperial College London

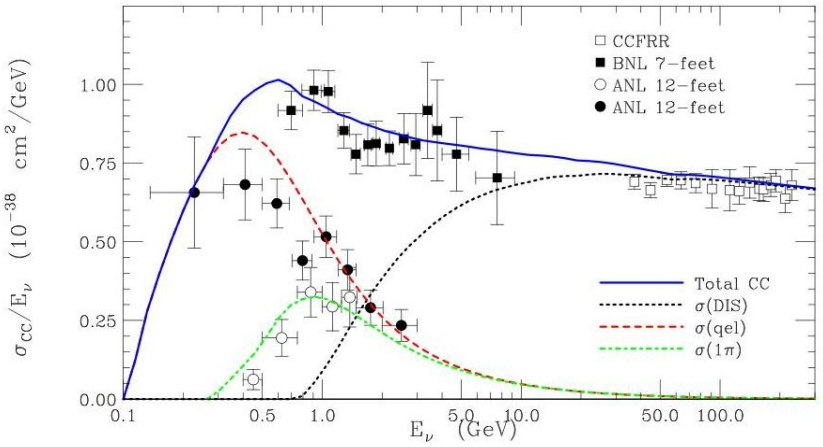
Outline

- Motivation for SciBooNE
- SciBooNE: The Detector
  - SciBar
  - Electron Catcher
  - Muon Range Detector
- Construction
- Data Targets
- Preliminary CCQE Analysis

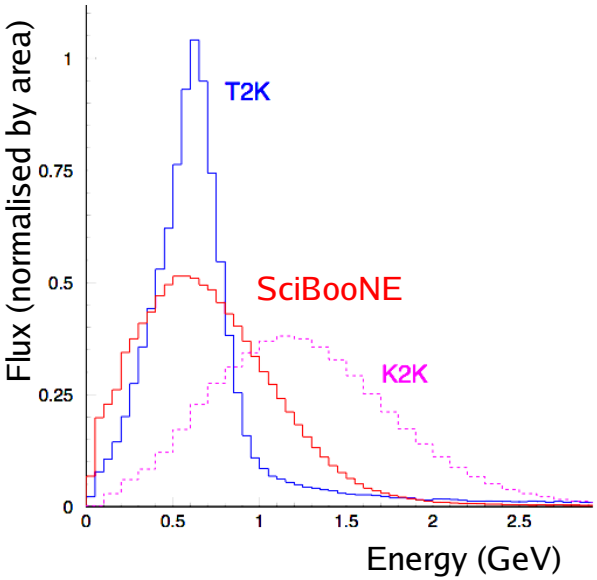
A selection of SciBooNE collaborators at the last collaboration meeting. March 2008

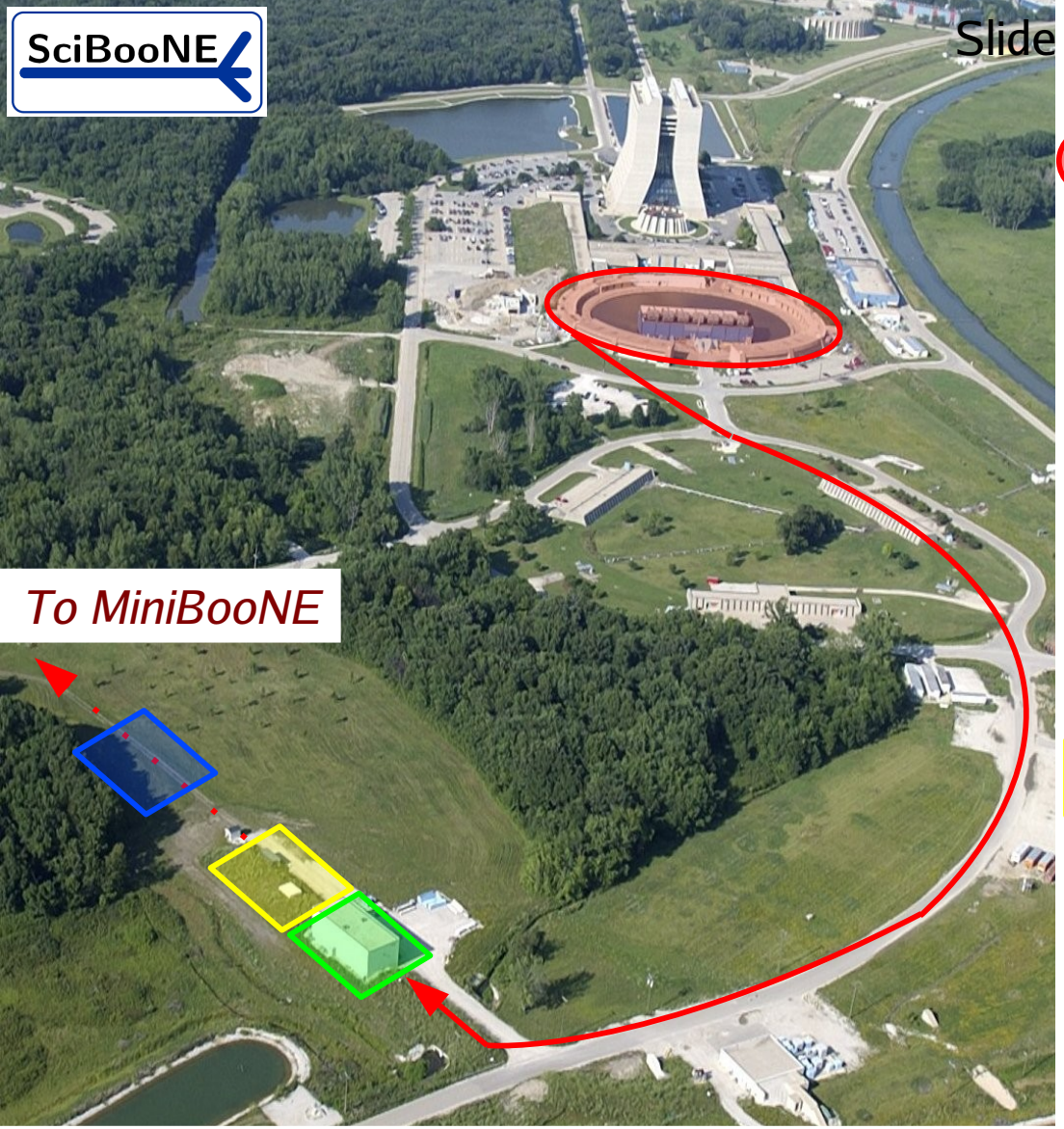
Motivation for SciBooNE

- SciBooNE: A 'ν' experiment at Fermilab
- Aim to measure sub-GeV ν_μ & $\bar{\nu}_\mu$ cross-sections
  - Few measurements in region, all low statistics (below right)
- T2K beam flux peak energy same as Booster neutrino beam (top right)
  - Measurement very useful for T2K
  - Independent data set
- SciBooNE also a MiniBooNE near detector
  - ν_e appearance/backgrounds
  - ν_μ disappearance/normalisation

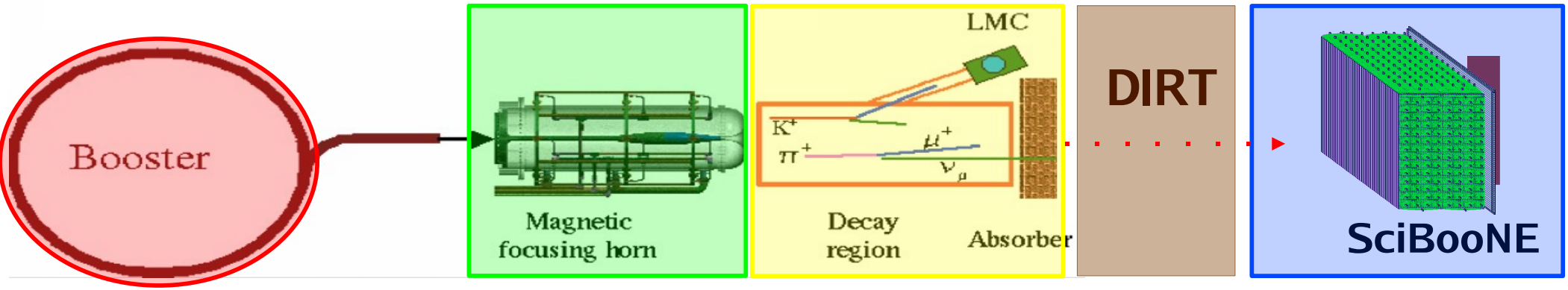


Lipari et al. arXiv:hep-ph/0207172



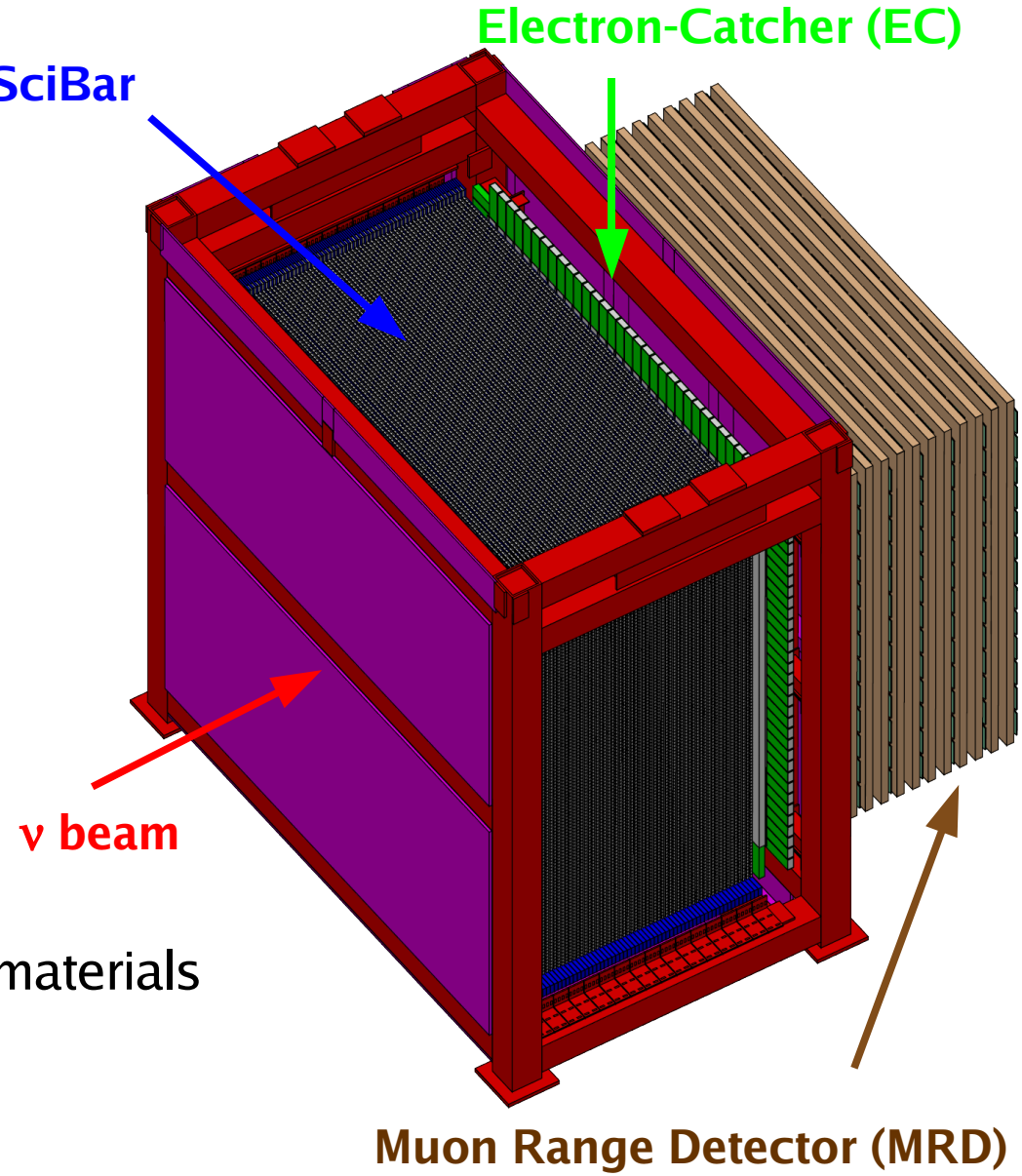


- **Booster Proton accelerator**
  - 8 GeV protons sent to target
- **Target Hall**
  - Beryllium target: 71cm long 1cm diameter
  - Resultant mesons focused with magnetic horn
  - Reversible horn polarity
- **50m decay volume**
  - Mesons decay to μ & ν_μ
  - Short decay pipe minimises $\mu \rightarrow \nu_e$ decay
- **SciBooNE located 50m from Absorber**



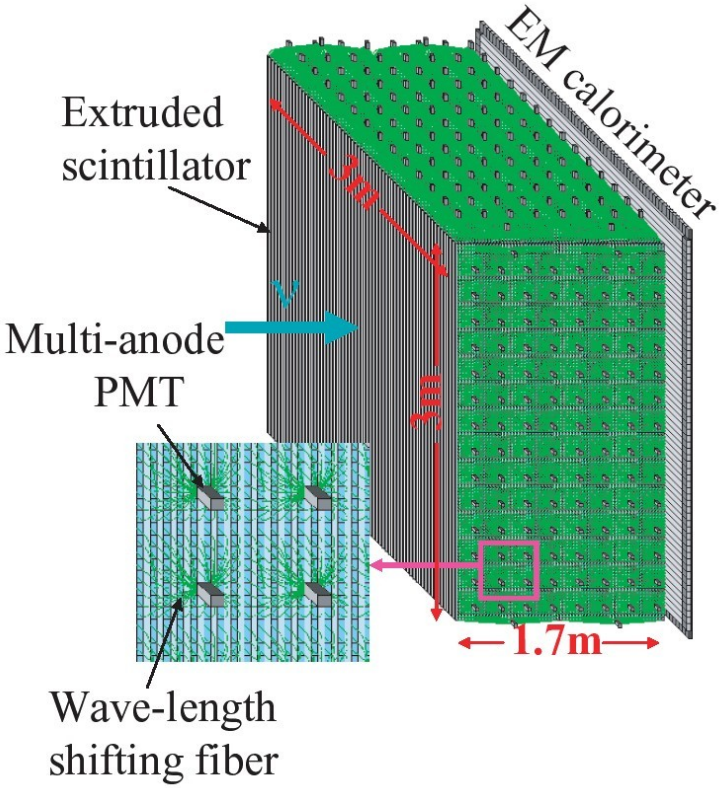
SciBooNE: The Detector

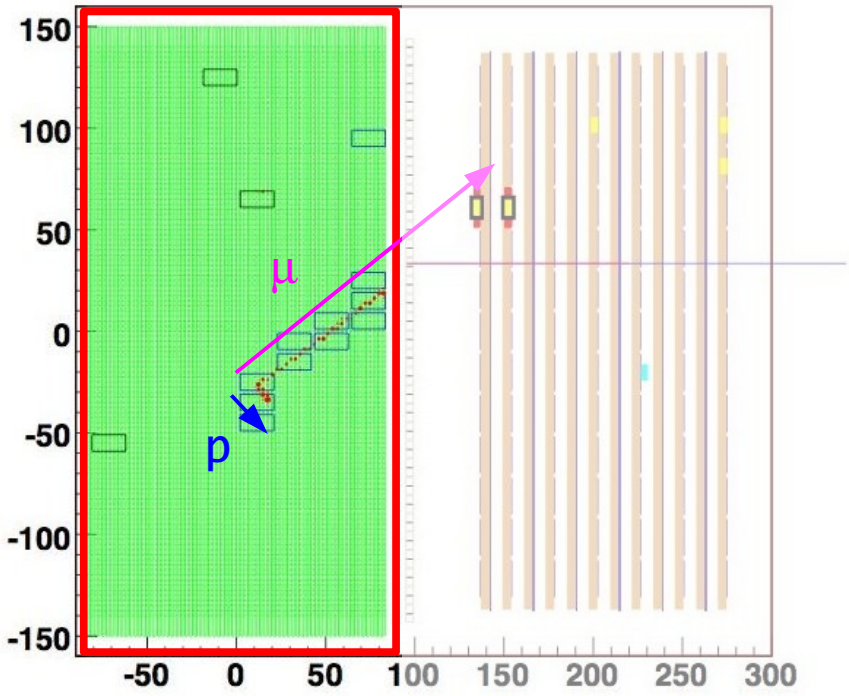
- SciBooNE consists of 3 sub-detectors
- **SciBar**
  - Used in K2K
  - Shipped from Japan to Fermilab
- **Electron-Catcher (EC)**
  - Used in CHORUS & K2K
  - Shipped from Japan to Fermilab
- **Muon Range Detector (MRD)**
  - 'New' detector built from recycled materials



SciBar

- Extruded scintillators
  - Wavelength-shifting (WLS) fibre readout
- Fully active detector
  - Scintillator is the neutrino target
- Total mass: 15 tons
  - Fiducial volume: ~10 tons
- Identify short tracks (>8cm)
- Distinguish a proton from a pion by dE/dx

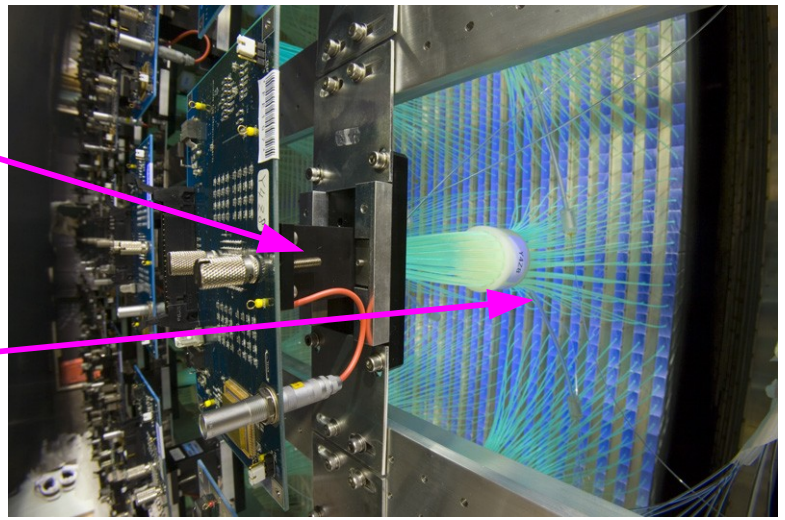




Typical CCQE event

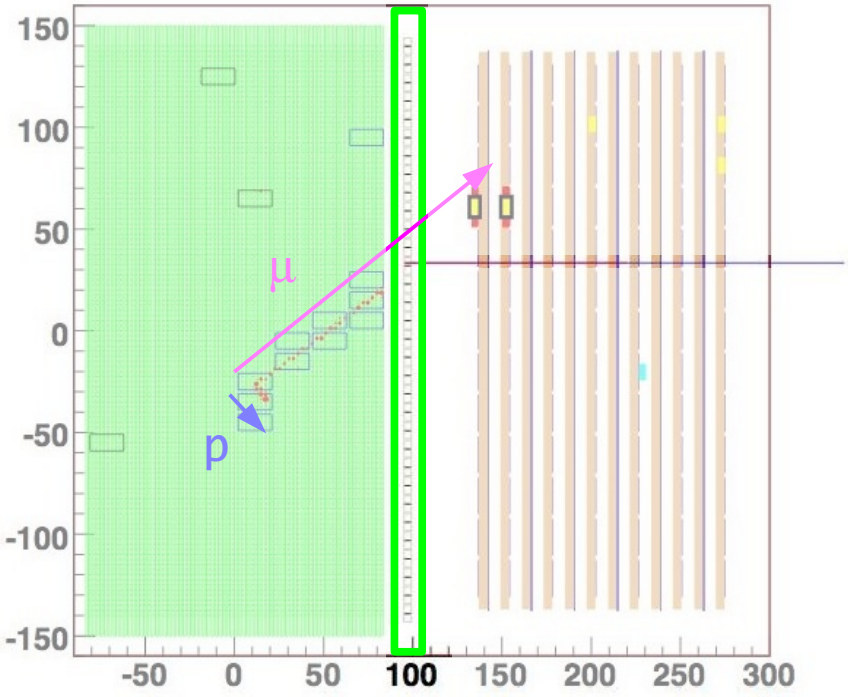
64 channel multi-anode PMT

WLS fibres

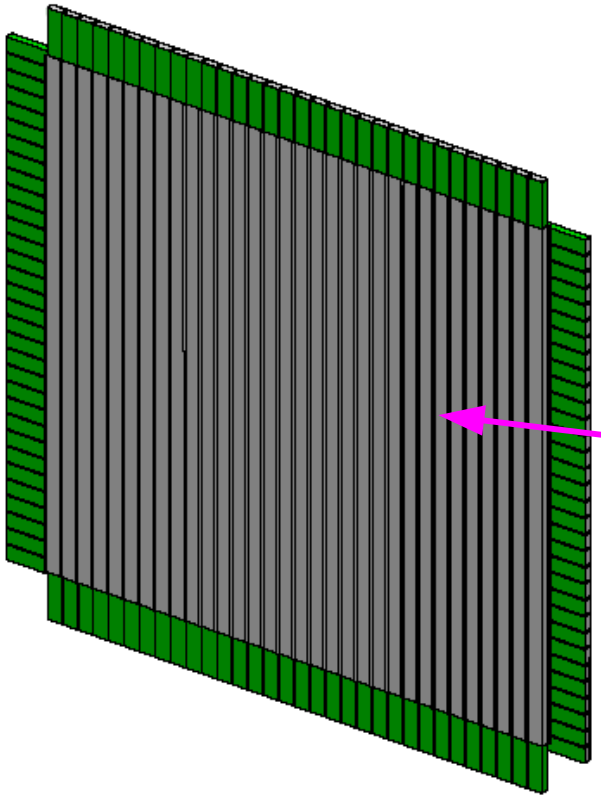


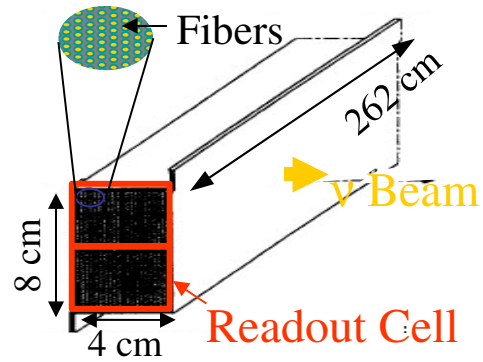
Electron-Catcher (EC)

- Gamma and electron identification (ν_e & π^0)
- "Spaghetti" calorimeter
- 2 planes (X & Y) ≡ $11X_0$



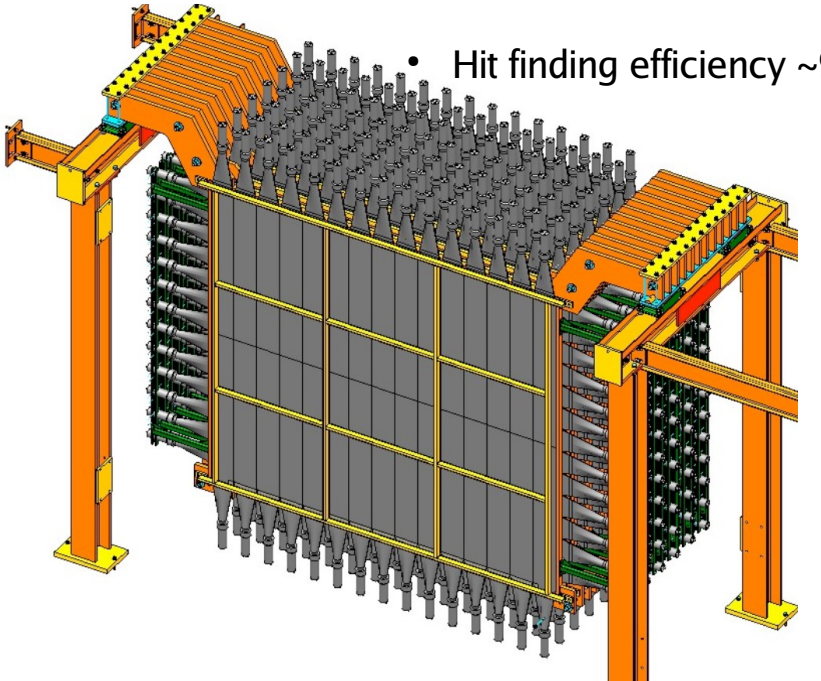
Typical CCQE event



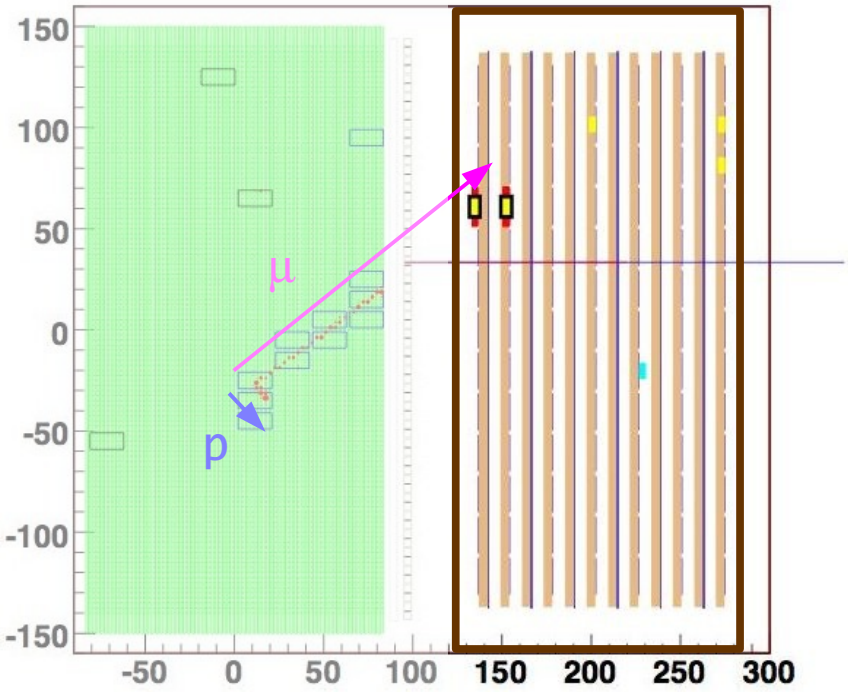


Muon Range Detector (MRD)

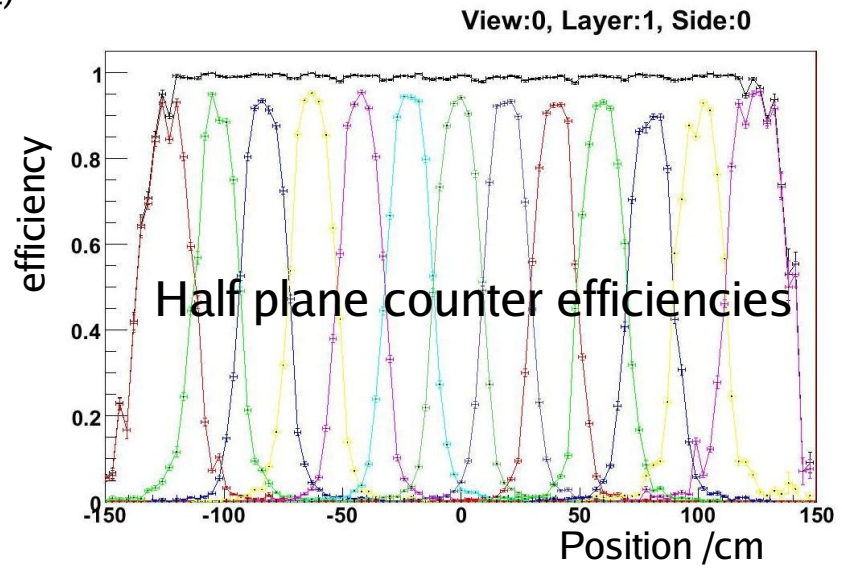
- The MRD reuses Fermilab materials
- Second-hand: Iron, scintillator, PMTs, electronics, signal cables and high voltage cables
- Ranging used to reconstruct muon energy
  - 13 alternating X & Y planes
  - 60cm iron total depth
  - MRD stops muons with momentum <1.2GeV/c
- Total ~ 55 tons
  - Large sample of CC events on iron



- Hit finding efficiency ~99% (see below right)



Typical CCQE event

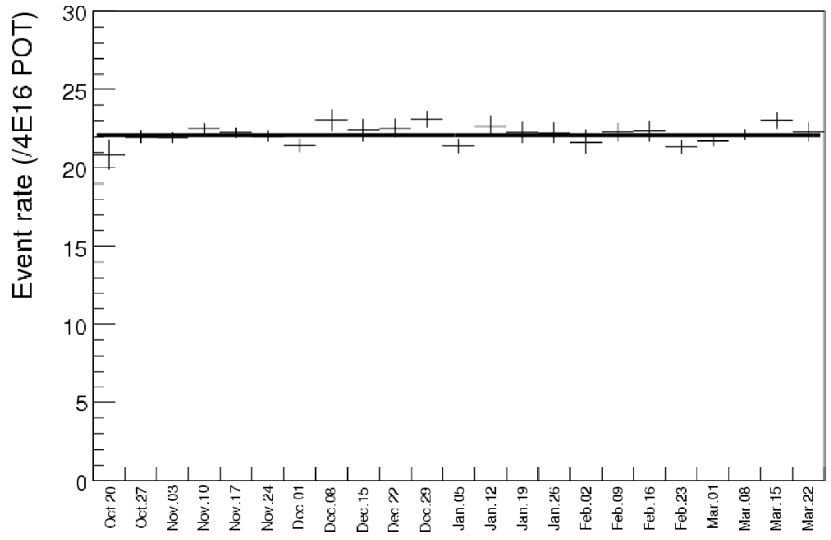


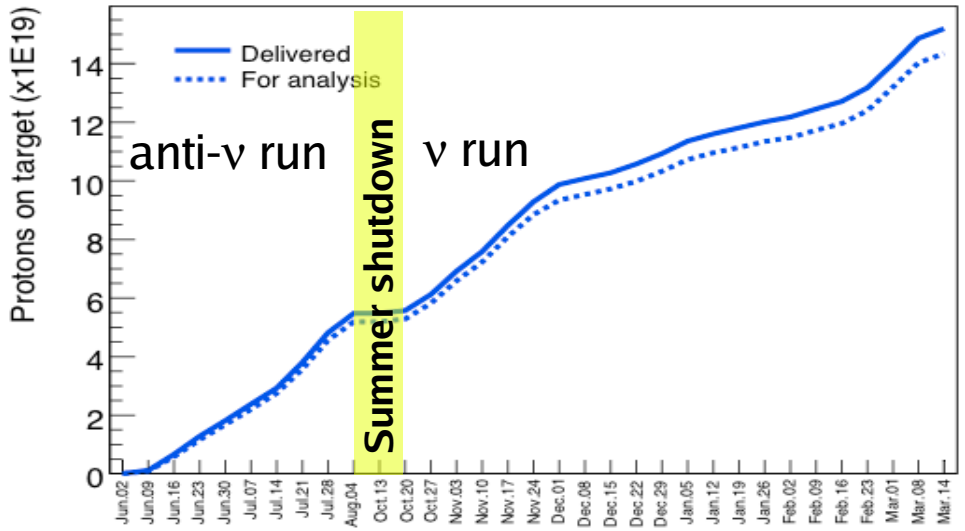
Construction

- SciBooNE Timeline
  - SciBooNE proposal Dec '05
  - MRD counter construction began June '06
  - SciBar & EC arrived at Fermilab July '06
  - Detector Assemblies completed March '07
  - Detectors moved to experiment hall April '07
  - anti-ν run began June '07
  - ν run began October '07
  - Completion of run by ~August '08

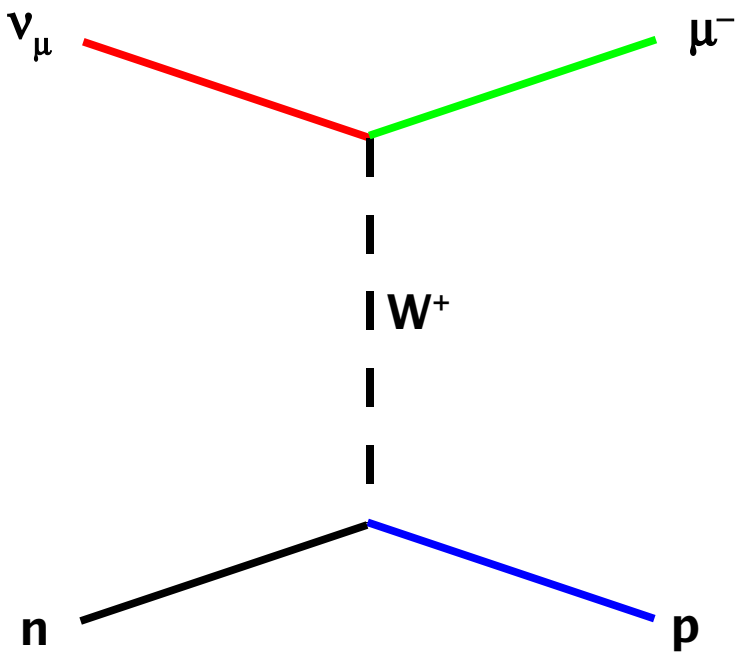
Data Targets

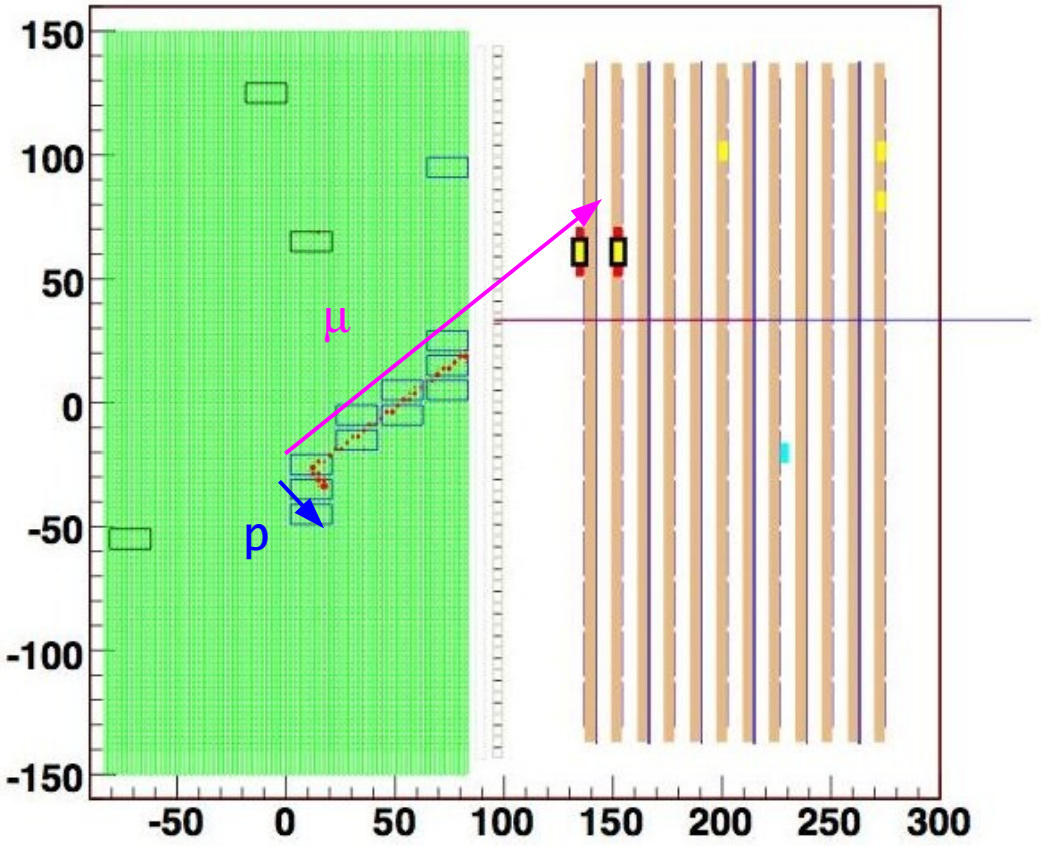
- Projected 2×10^{20} Protons on Target (POT)
- So far received 1.48×10^{20} POT
  - $\bar{\nu}$: 0.54×10^{20} (goal 1×10^{20})
  - ν: 0.94×10^{20} (goal 1×10^{20})
- Event rate/POT very stable
- Switch back to $\bar{\nu}$ mode in next month
- 94% average detector live time





Preliminary Charged Current Quasi-Elastic (CCQE) Analysis



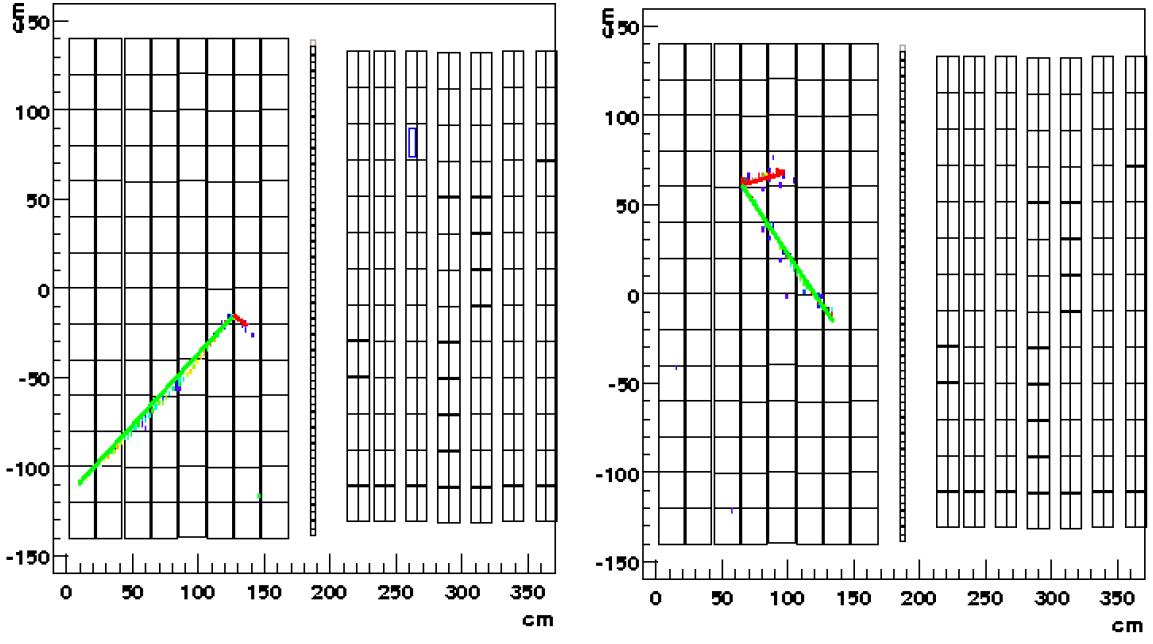


Typical CCQE event

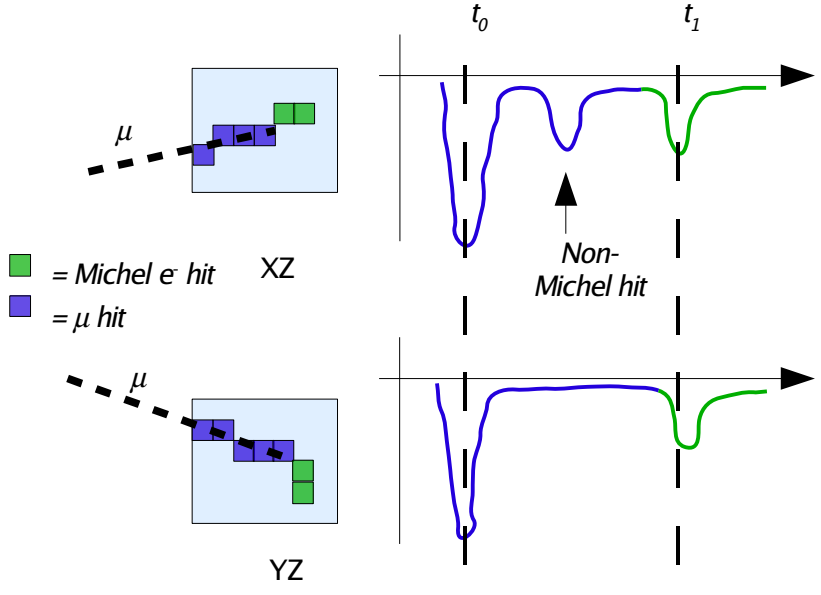
- Important: CCQE is process used for oscillation searches
- Clean process: ν energy easily reconstructed from μ

Preliminary CCQE Analysis

- 2 Charged Current Quasi-Elastic (CCQE) analyses in SciBooNE
  - MRD stopped muon
  - SciBar stopped muon (my analysis)
- Started looking at 2 track contained CCQE sample
  - Two types of 2 track CCQE events
    - Muon and Michel electron (below left)
    - Proton & muon (below right)

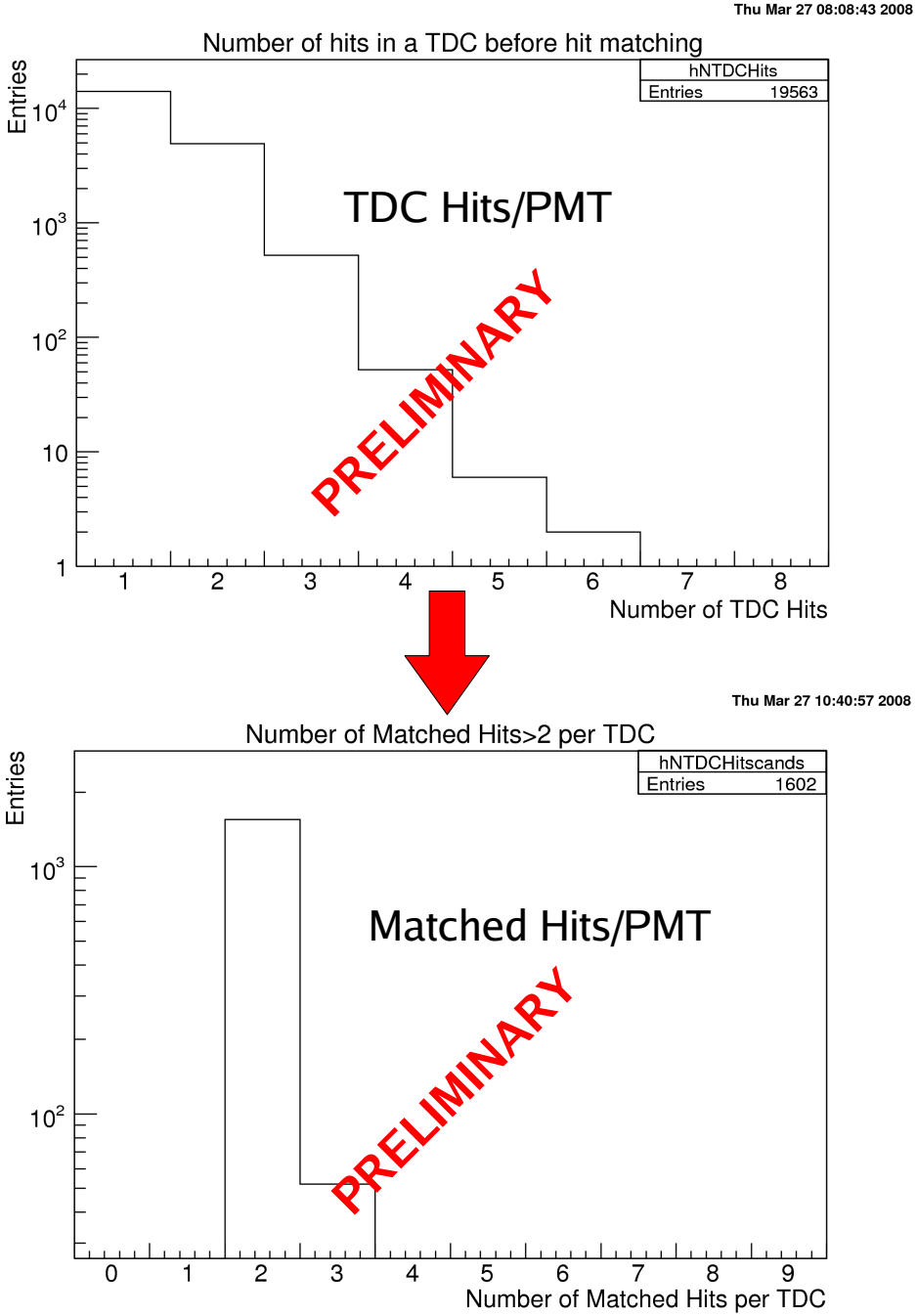


- SciBar stopped muons are tagged using Michel electrons
  - Identify Michel using timing information
  - Match hits using coincidence between top and side views to remove background hits (below)



Michel Coincidence

- 7.67x10^{19}POT ν data used
- No systematic errors shown
- For hits to be matched the coincidence time in both views <20ns
- This projection matching removes almost all non-Michel e$^-$ hits
- Remove some of the CC1π background by removing double Michel events

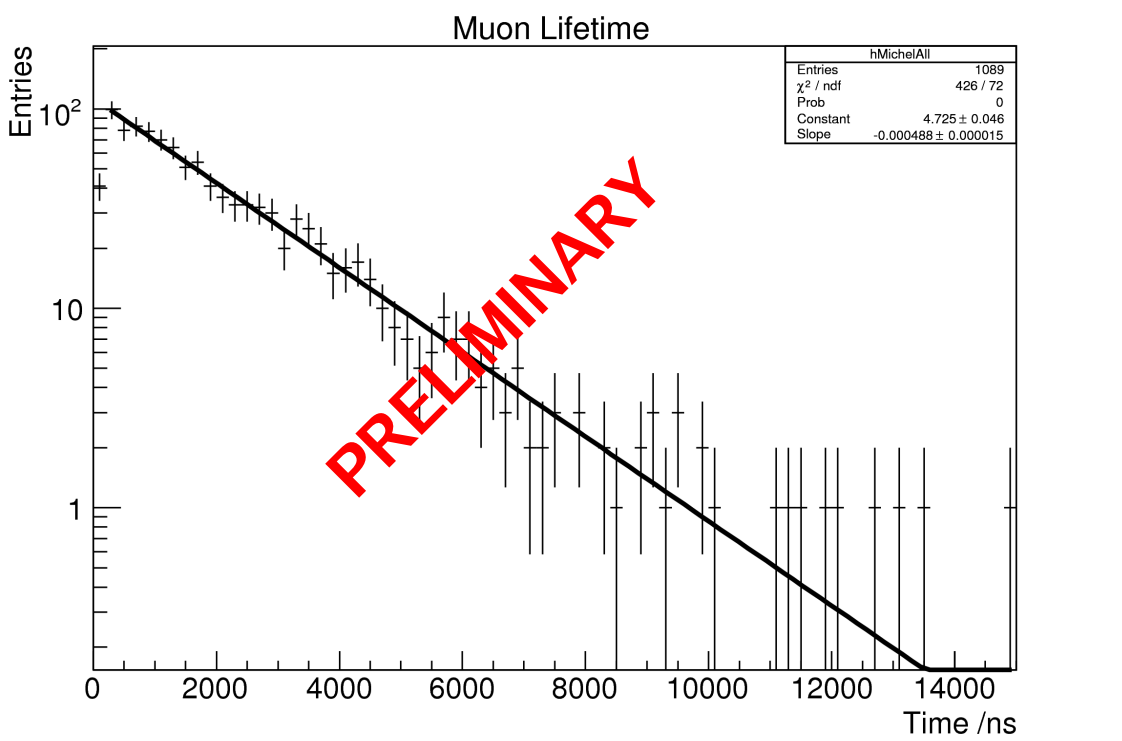


Muon Lifetime

- Muon lifetime
  - τ_μ = 2.049±0.060(stat)x10^{-6}s
  - c.f. 2.0263 ±0.0015x10^{-6}s*
  - Agrees with muon capture value

Suzuki et al. Phys. Rev C. 35 (1987) 2212-2224

- TDC deadtime 50-100ns
  - Fit starts from 100-200ns bin

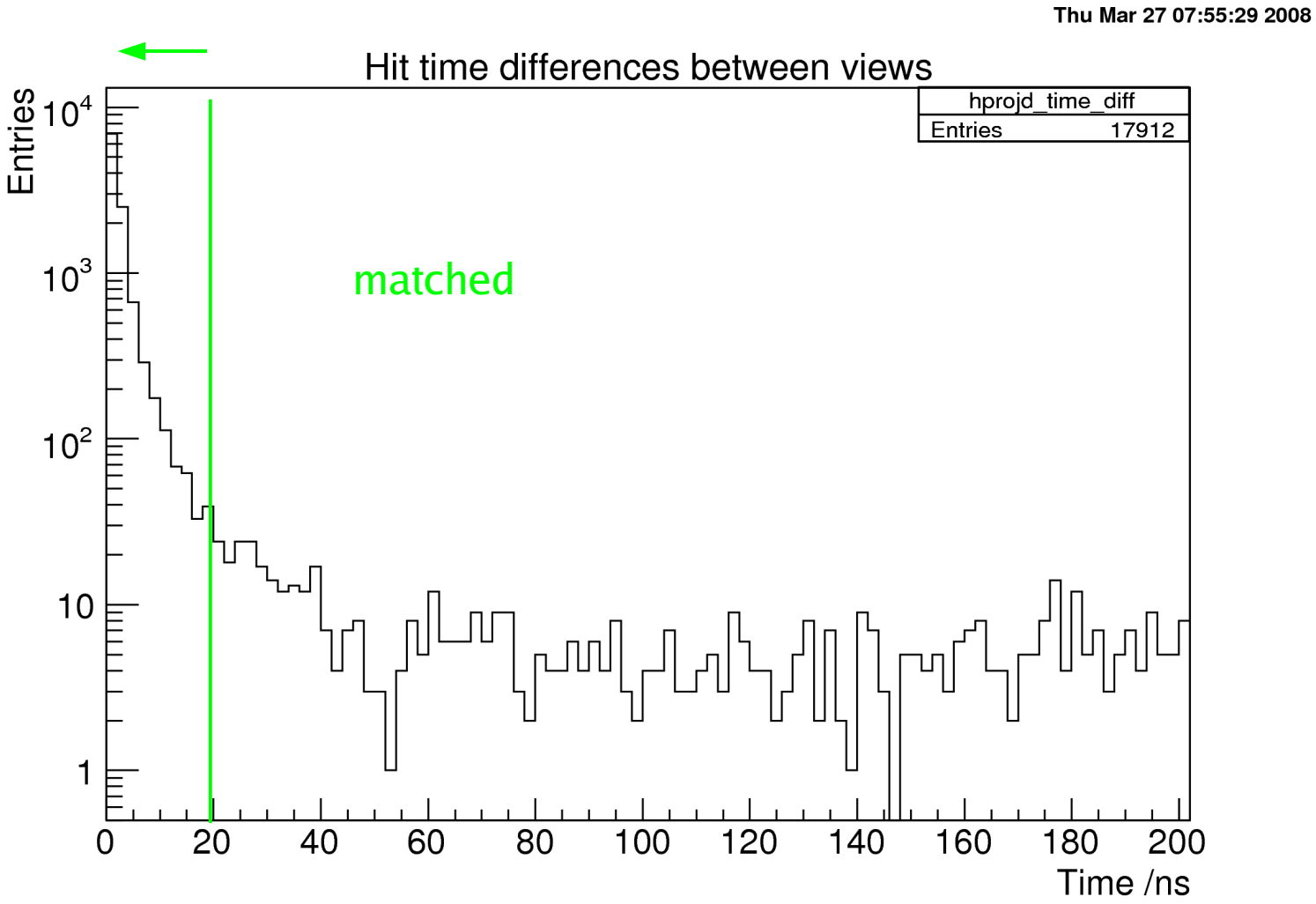


Summary

- SciBooNE is the new neutrino experiment at Fermilab
- Goal: To measure sub-GeV ν_μ & $\bar{\nu}_\mu$ cross-sections
- ¾ of all data already taken
- Contained muon CCQE analysis has been started
  - CCQE important for oscillation searches
  - Goal: Measure CCQE cross-section to ~10%

Backup Slides

View Matching



Breakdown of Interaction mode

Neutrino Run

Mode	#of ν_μ events
CCQE	38900
CC-1pi	23900
CC-coh	1200
CC-multi-pi	5300
NC-elastic	17400
NC-1pi	8600
NC-coh	700
NC-multi-pi	1700

Anti-neutrino Run

Mode	#of ν_μ-bar events	#of ν_μ events
CCQE	7500	3000
CC-1pi	2100	2000
CC-coh	500	90
CC-multi-pi	500	660
NC-elastic	2900	700
NC-1pi	1300	60
NC-coh	300	200
NC-multi-pi	130	1300

Events/10 tons/1x10^{20} POT

Slide courtesy of Katsuki Hiraide-san