
Status of MiniBooNE

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The MiniBooNE Collaboration

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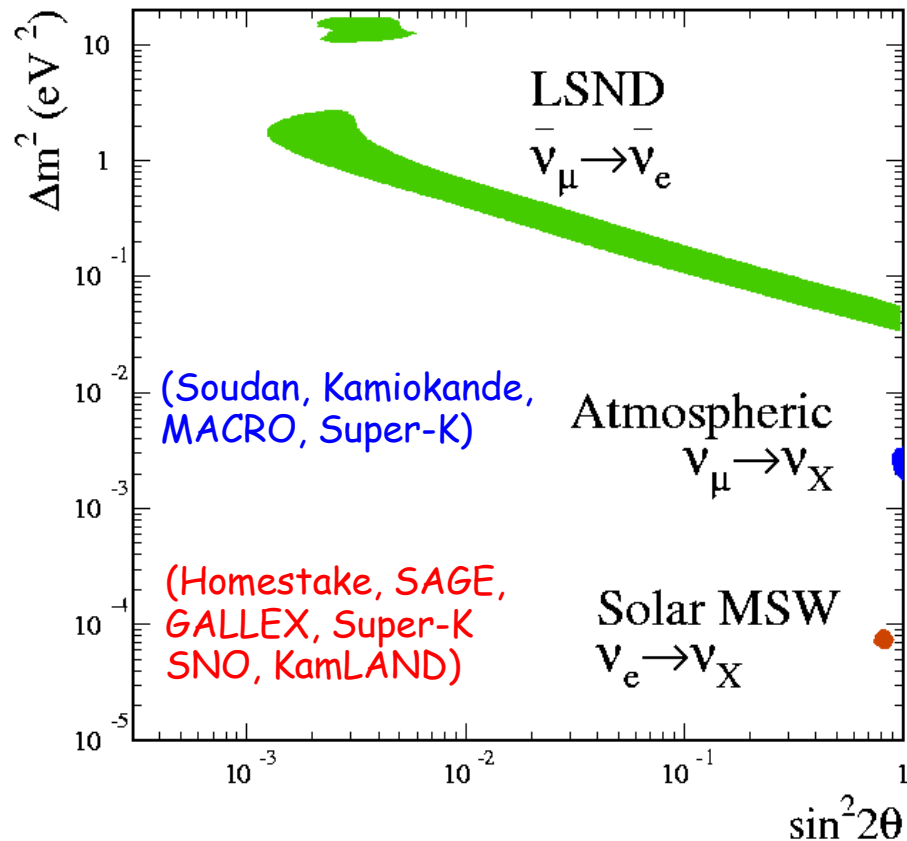
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Motivation for the Experiment - LSND

State of Oscillation Results



- Simplest model has three neutrino mass eigenstates, but...
- Data indicates 3 mass differences

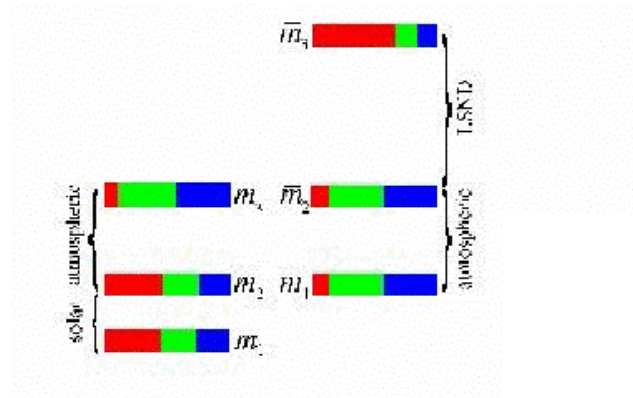
➤ $\Delta m^2_{\text{atm}} \sim 2-3 \times 10^{-3} \text{ eV}^2$

➤ $\Delta m^2_{\text{sol}} \sim 7 \times 10^{-5} \text{ eV}^2$

➤ $\Delta m^2_{\text{LSND}} \sim .1-10 \text{ eV}^2$

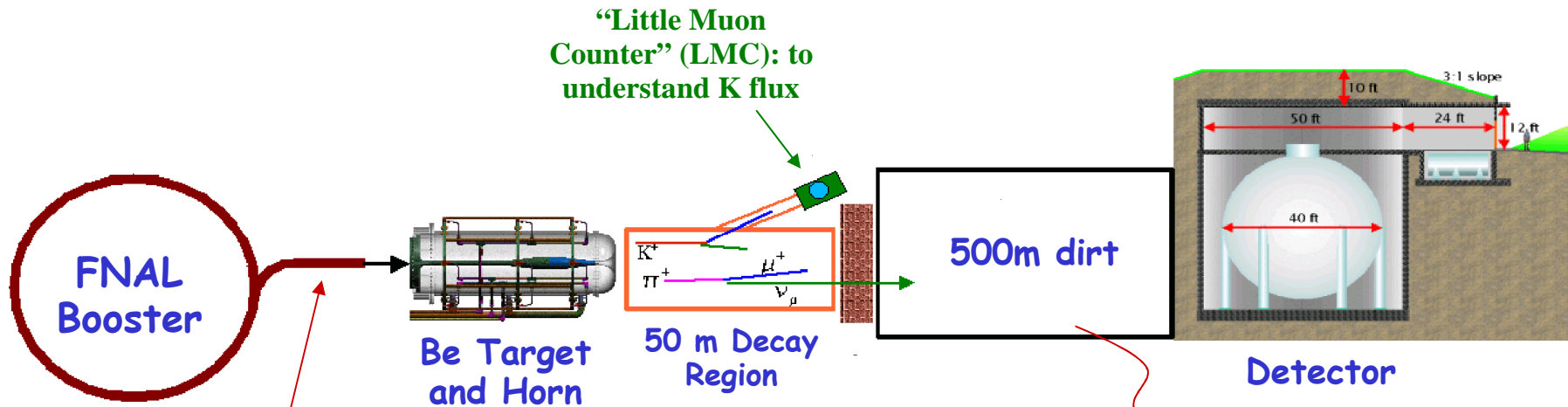
Possibilities

- 4 neutrinos?
 - We know from Z lineshape there are only 3 active flavors
 - Sterile?
- CPT Violation?

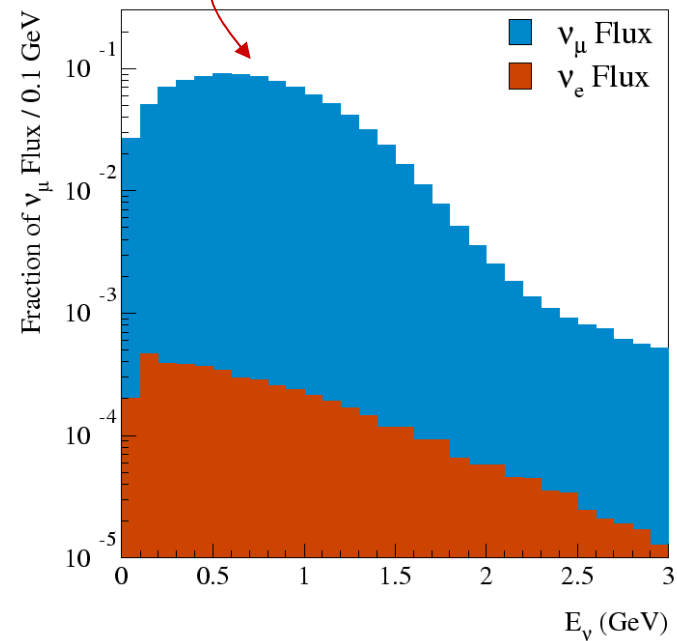


- LSND Wrong?
 - Must verify LSND Result -> MiniBooNE
 - Optimized for $L/E \sim 1$
 - Higher energy beam -> Different systematics than LSND
 - Proposed: 12/97
 - Began Construction: 10/99
 - Completed: 5/02
 - First Beam: 8/02

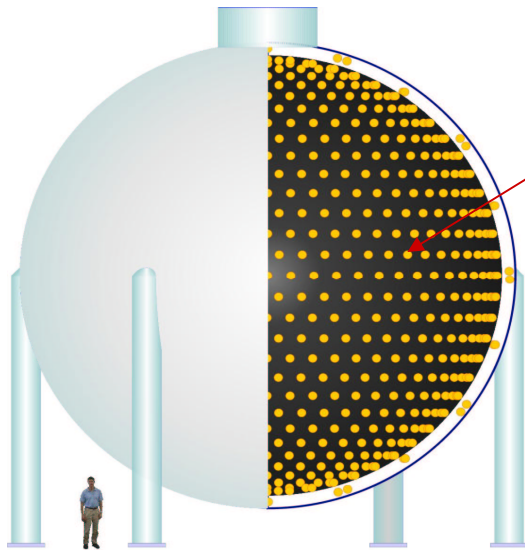
Neutrino Beam



- Proton flux $\sim 6E16$ p/hr (goal $9E16$ p/hr)
 - ~ 1 detected neutrino/minute
 - $L/E \sim 1$



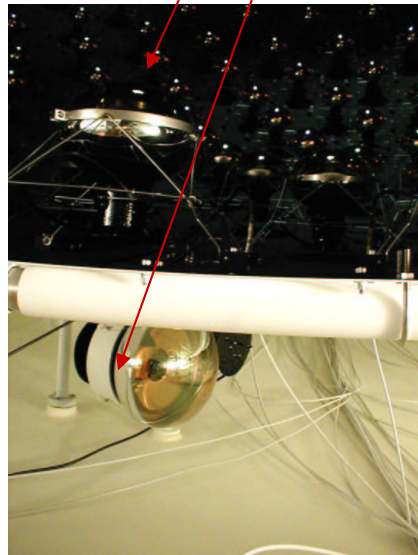
Detector



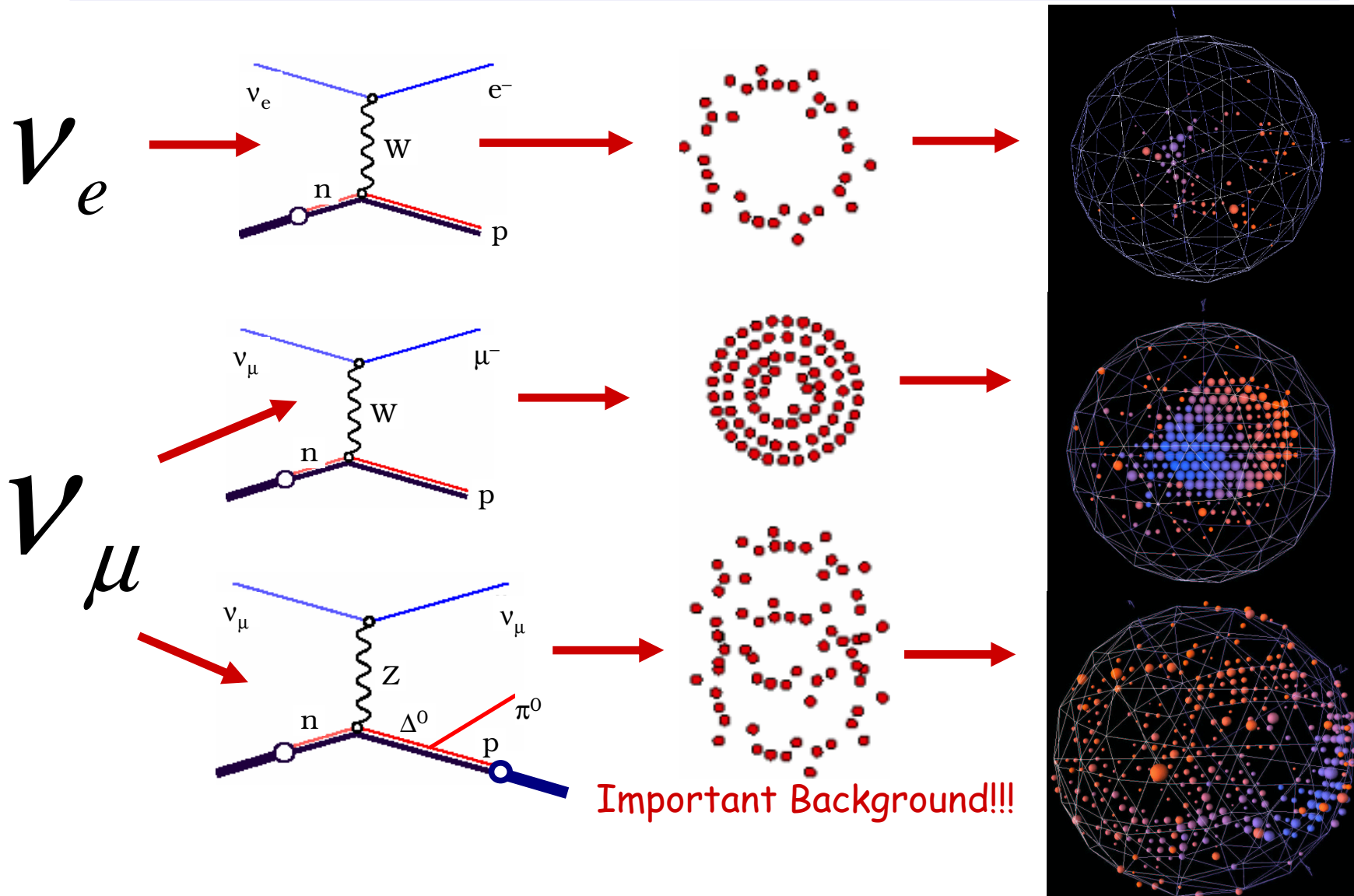
- 950,000 ℓ of pure mineral oil
- 1280 PMT's in inner region
- 240 PMT's outer veto region
- Light produced by Cerenkov radiation and scintillation

- Trigger:
 - All beam spills
 - Cosmic ray triggers
 - Laser/pulser triggers
 - Supernova trigger

Light barrier →

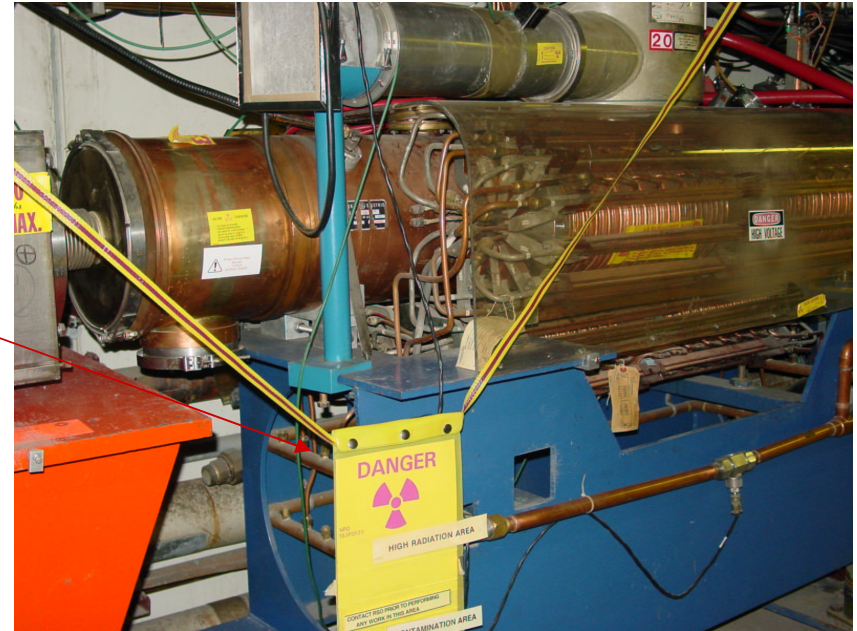


Neutrino Detection/Particle ID

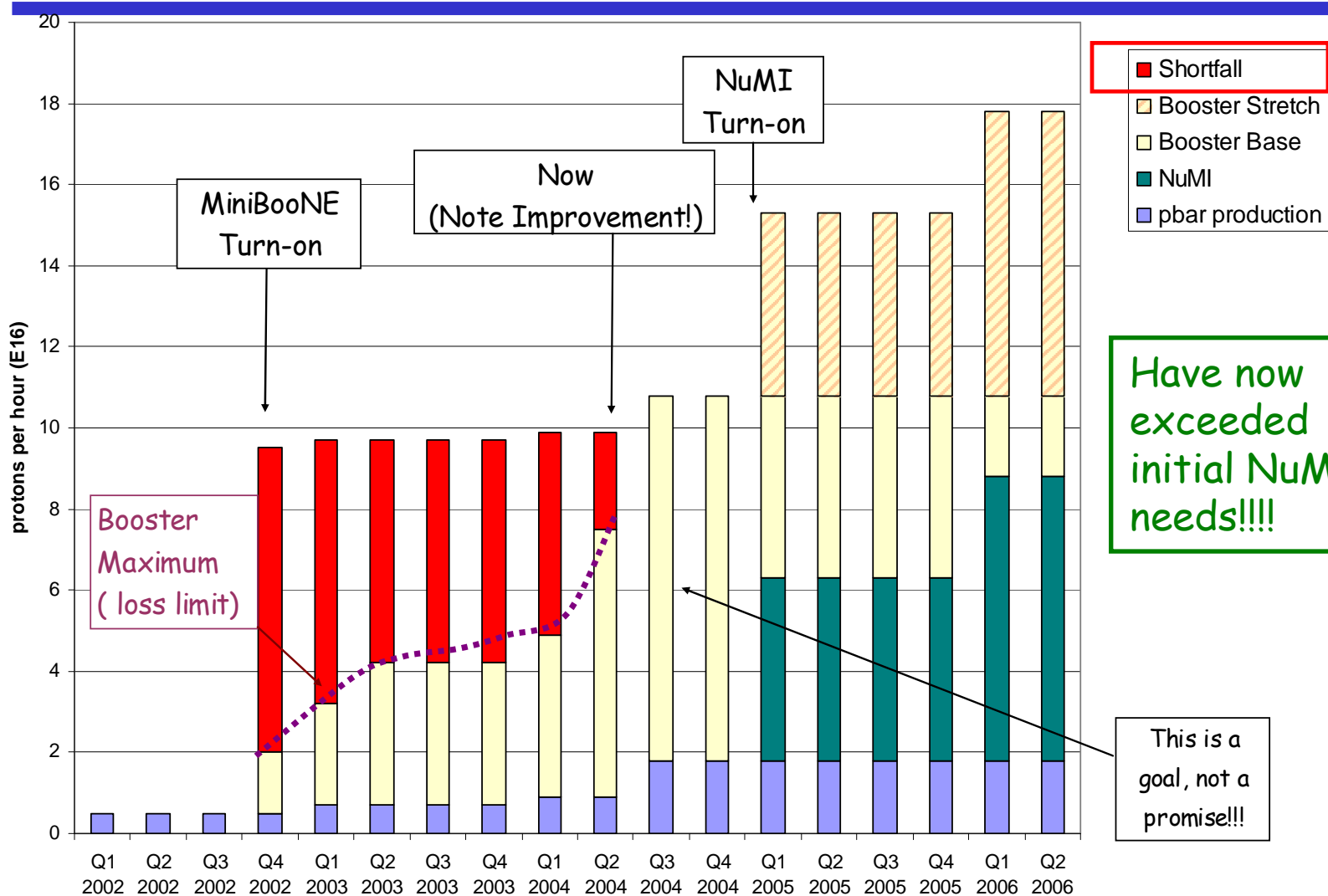


Delivering Protons

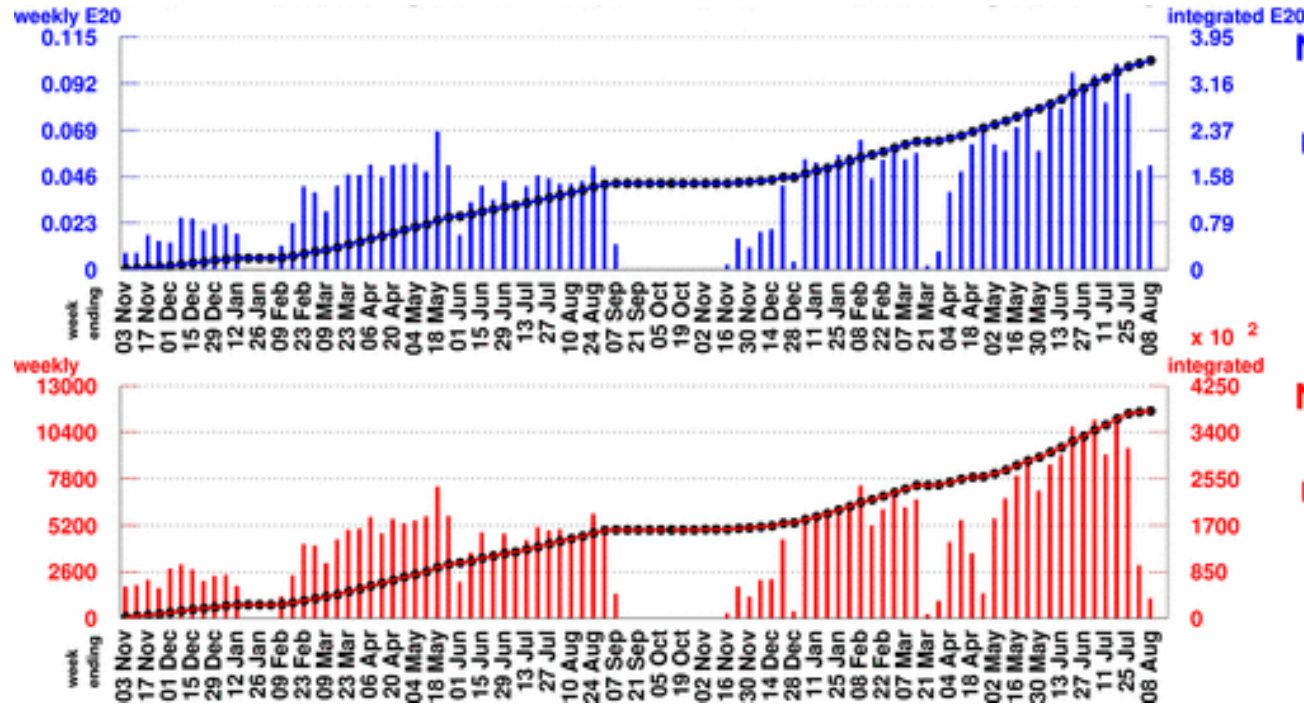
- Requirements of MiniBooNE greatly exceed the historical performance of the 30+ year old 8 GeV Booster, pushes...
 - Average repetition rate
 - Above ground radiation
 - Radiation damage and activation of accelerator components
- Intense Program to improve the Booster
 - Shielding
 - Loss monitoring and analysis
 - Lattice improvements (result of Beam Physics involvement)
 - Collimation system



Demands on Fermilab Proton Source



Beam Progress



Number of Protons on Target

To date: 3.5494 E20

Largest week: 0.1016 E20

Latest week: 0.0514 E20

Number of Neutrino Events

To date: 378499

Largest week: 11384

Latest week: 1088

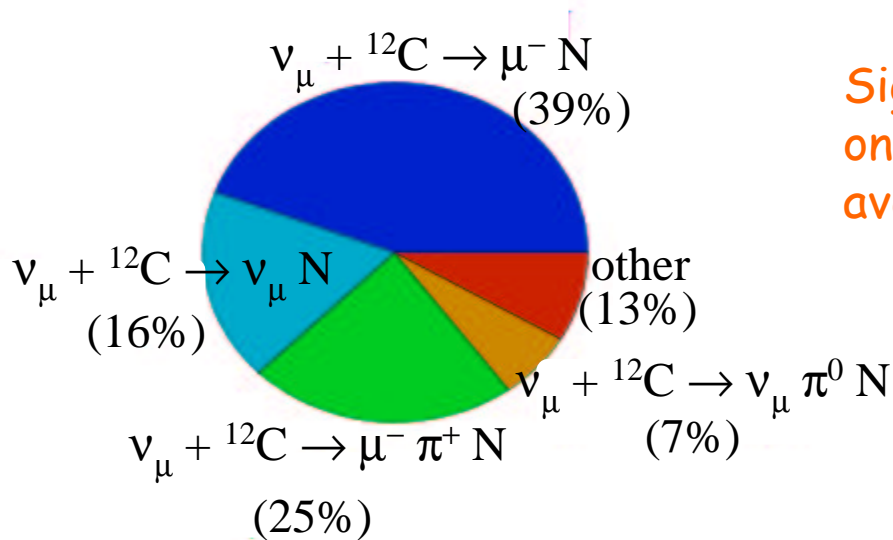
- To date: 3.5E20 protons on target
- Will collect at least 5E20
- Hope for 1E21

There are None So Blind...

- This is a difficult analysis, and there are many opportunities for unintentional bias
- Therefore, we consider a blind analysis essential
- General philosophy: **guilty until proven innocent**
- Events go "into the box" unless they are specifically tagged as being non-signal events, e.g.
 - **Muons**
 - **Single μ -like ring**
 - **Topological cuts**
 - **π^0**
 - **No Michel electron**
 - **Clear two-ring fit, both with $E > 40$ MeV**
- Will only look at remaining data when
 - **We have enough protons, AND**
 - **We are confident that we model the beam and detector well.**

Event Rates

ν_μ Reactions



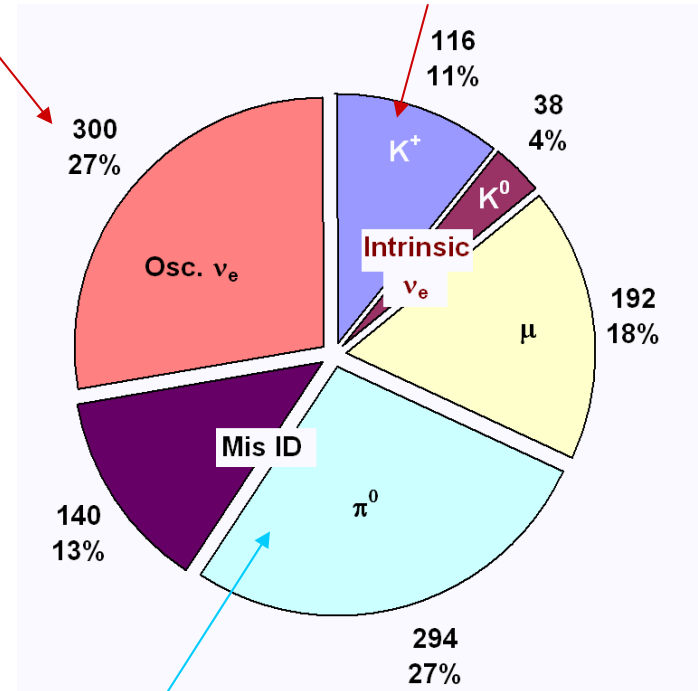
MC:

- Parametrized pBe interaction (our fit of BNL E910)
- GEANT4 model of target, horn, and beamline
- NUANCE MC of neutrino interaction
- Full hit-based MC of detector, including oil, PMT's etc.

Contributions to ν_e Signal

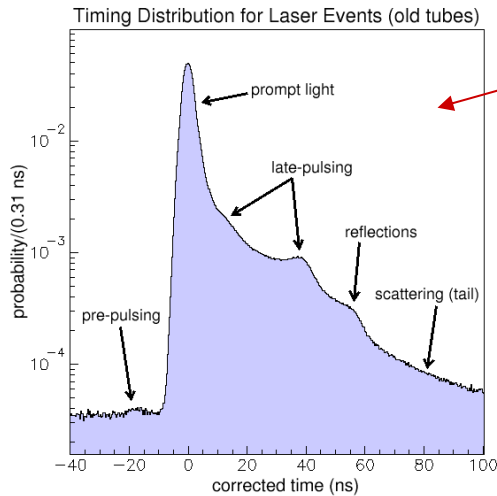
Signal: Based on LSND average

Hope LMC+HARP will help with K background



Can be constrained with data

Characterizing the Detector

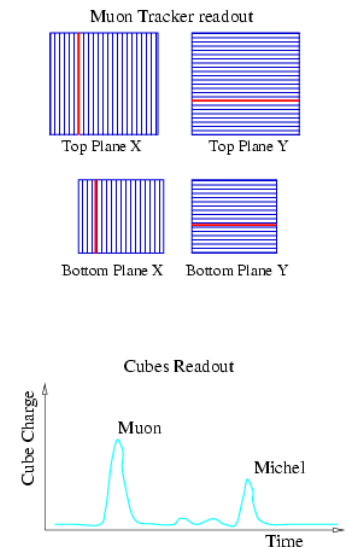
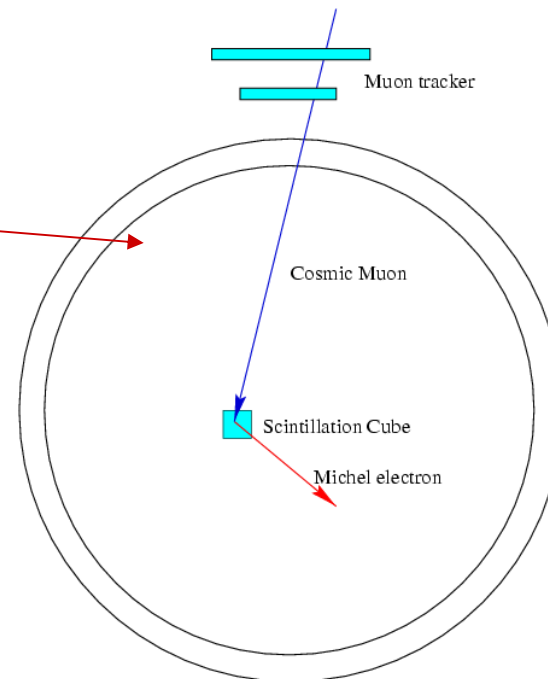


■ Laser Calibration

- Laser pulses illuminate one of 4 flasks which scatter light isotropically
- Used to understand PMT response

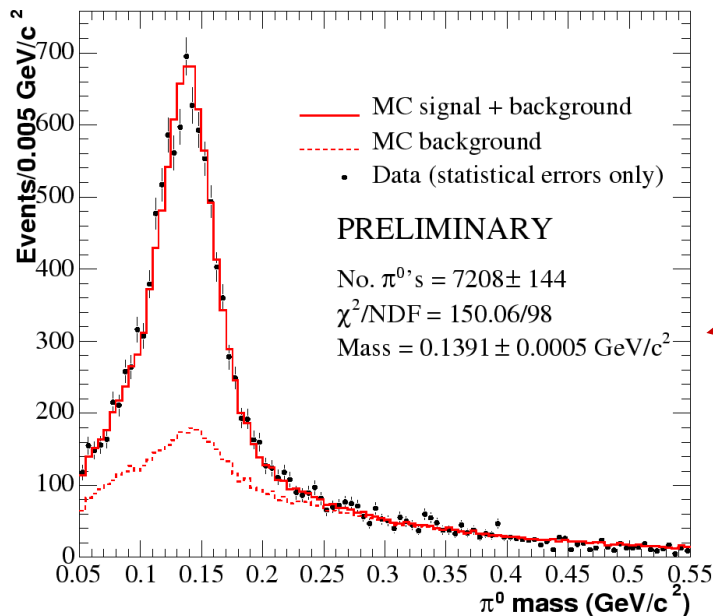
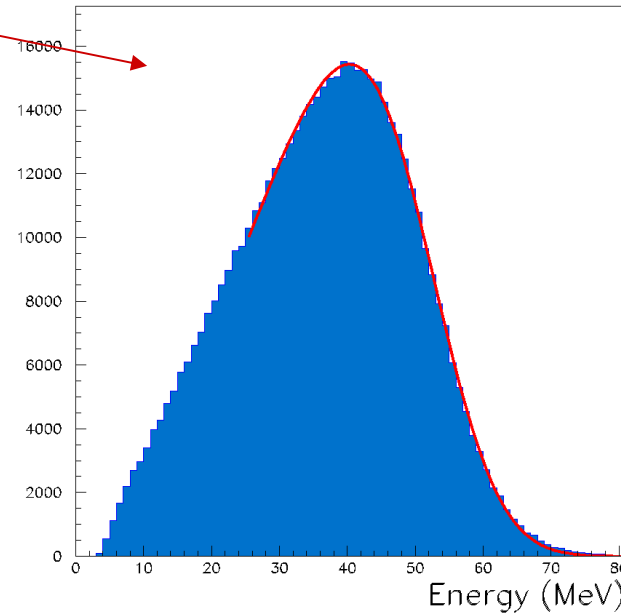
■ Cosmic Muons

- Muon Tracker used in conjunction with "cubes" to trigger on a particular endpoint (energy)
- Vital in understanding energy scale



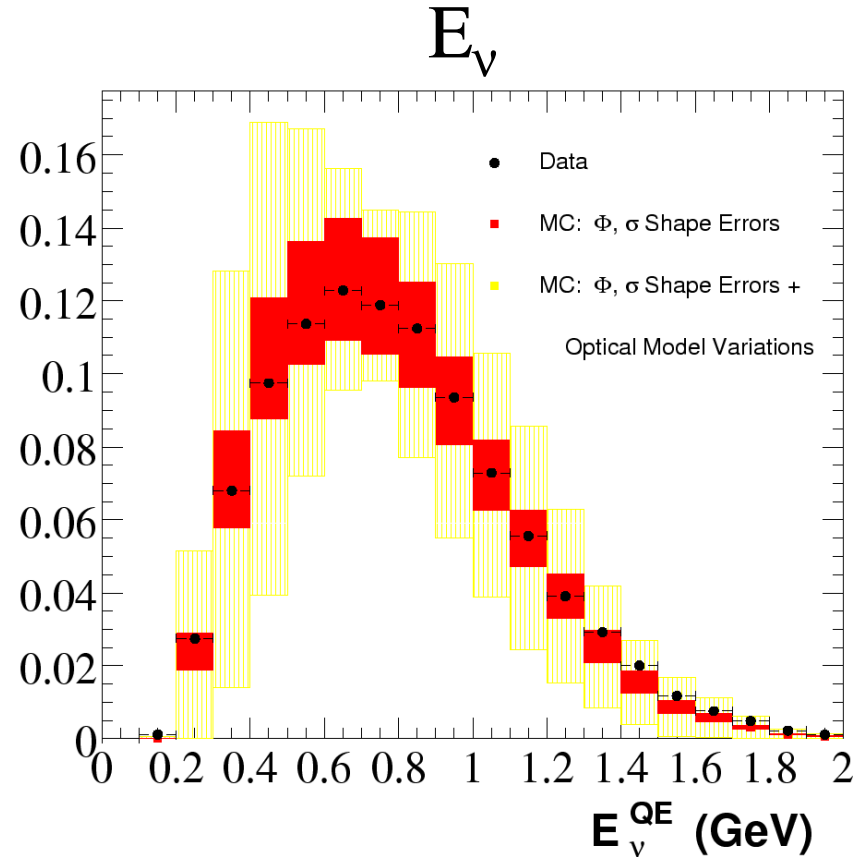
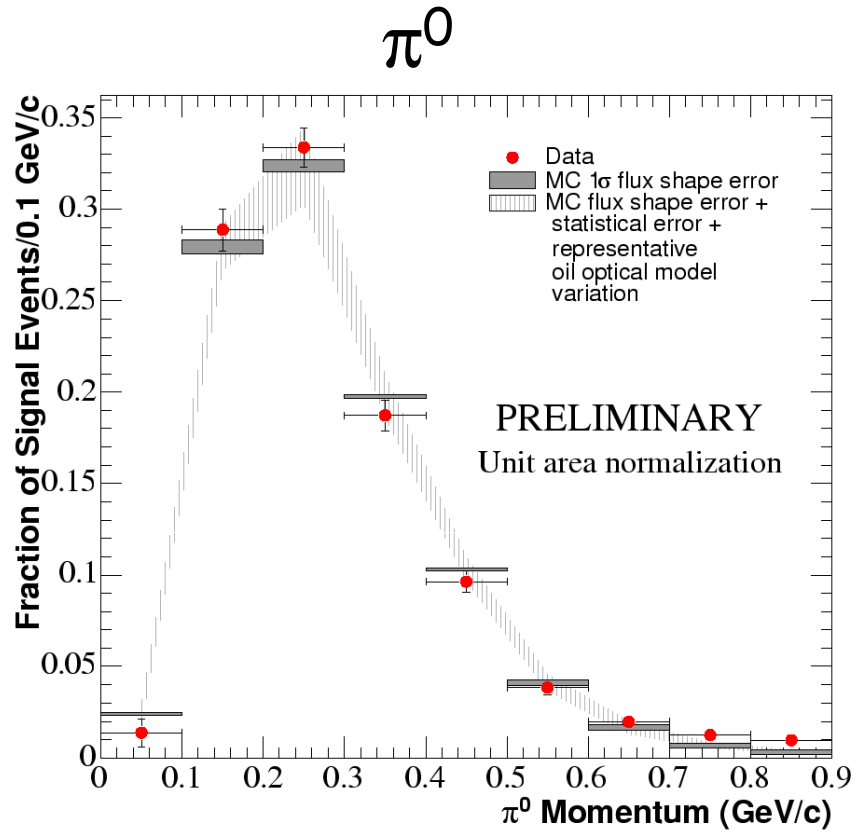
The Detector (cont'd)

- Electrons from muon decay (Michel electrons)
 - Vital for understanding signal events.

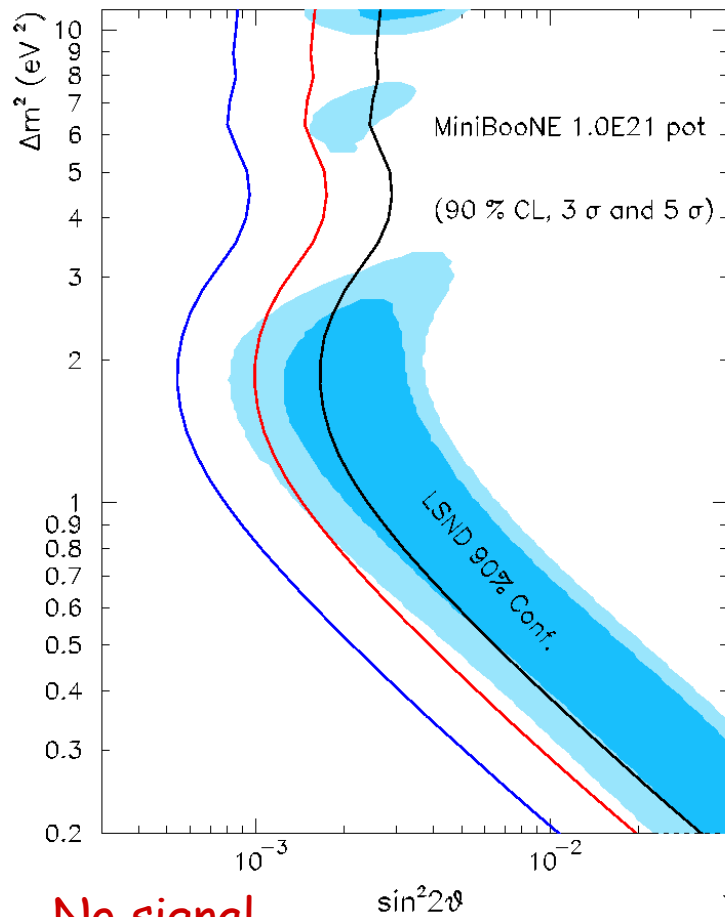


- π^0 Events
 - Help to understand higher energy ν_e
 - Help fix energy scale

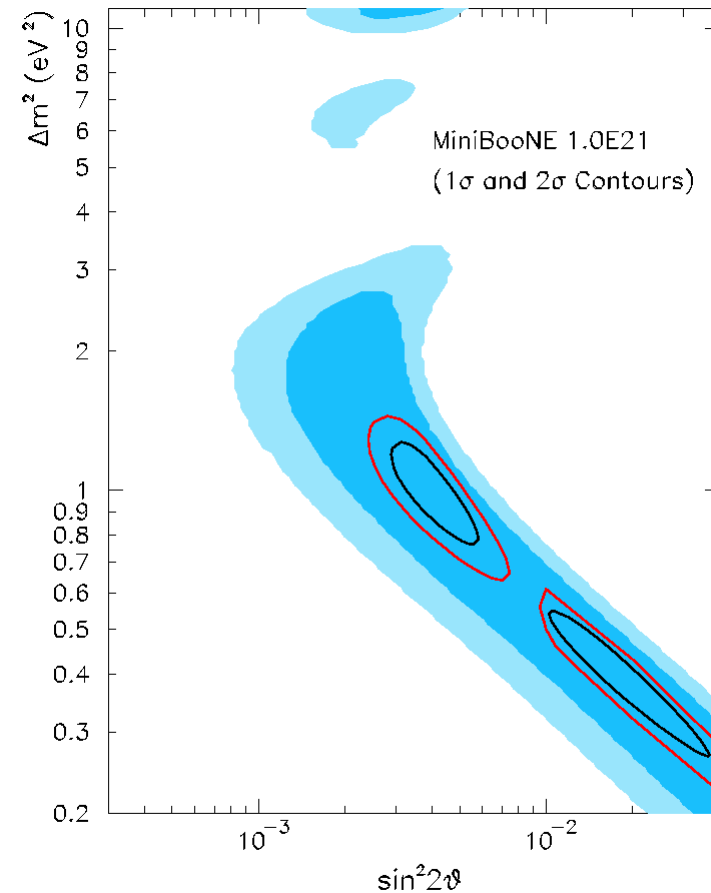
Understanding the Data: Examples



Experimental Sensitivity (1E21 POT)



- **No signal**
 - Can exclude most of LSND at 5 σ



- **Signal**
 - Can achieve good Δm^2 separation

Recent Developments with the Horn

- Horn currently has almost 100 million pulses
 - Designed for 200 million pulses (2 years @5 Hz)
 - Previous horn records .5Hz and 12M pulses
- March, 2004: Horn developed an internal water leak
 - Able to collect water and continue running
- July 24th, 2004: Horn began to ground-fault
 - ~600 Amps (out of 170,000) to ground
- Conclusion
 - Cannot safely run horn in this state.
 - Horn (way) too hot to repair.
 - Will run with horn OFF until Fall shutdown (starts August 23rd)
 - Useful for systematics
 - Will replace horn with a spare during shutdown.

Summary and Outlook

- MiniBooNE has collected $3.5E20$ protons
- The experiment has made impressive progress in understanding both the detector and the data.
- Fermilab is about to go into a 13 week shutdown, during which...
 - The MiniBooNE horn will be replaced.
 - Improvements will be made to the Booster, which should allow it to achieve the MiniBooNE intensity goals
- NuMI will start in early 2005, BUT MiniBooNE should be able to continue taking data, albeit at a reduced intensity
 - *We could not have said this a few months ago.*
 - $5E20$ proton by early 2005
 - $1E21$ somewhere between mid-2006 and mid-2007
- Will not release ν_e appearance result before $5E20$, but other physics along the way, e.g.
 - NC π^0 cross-section
 - ν_μ disappearance result