MiniBooNE : Current Status

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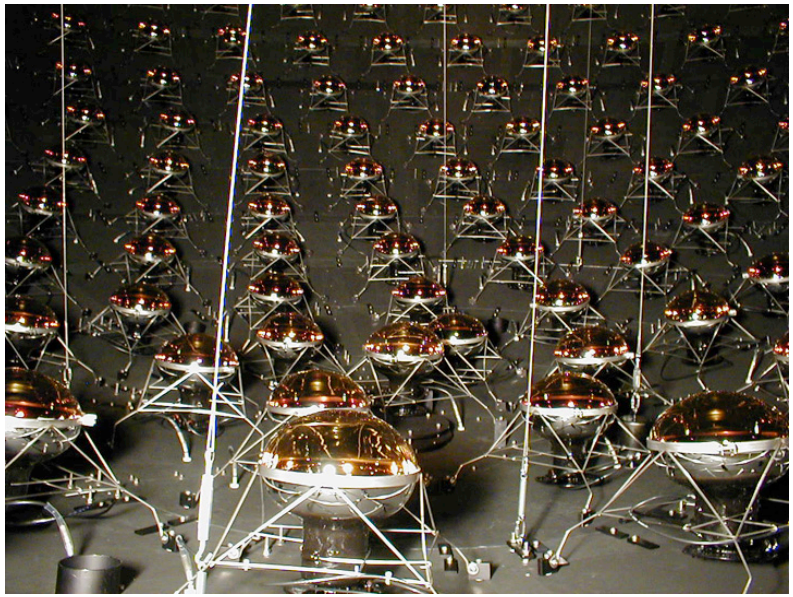
Outline

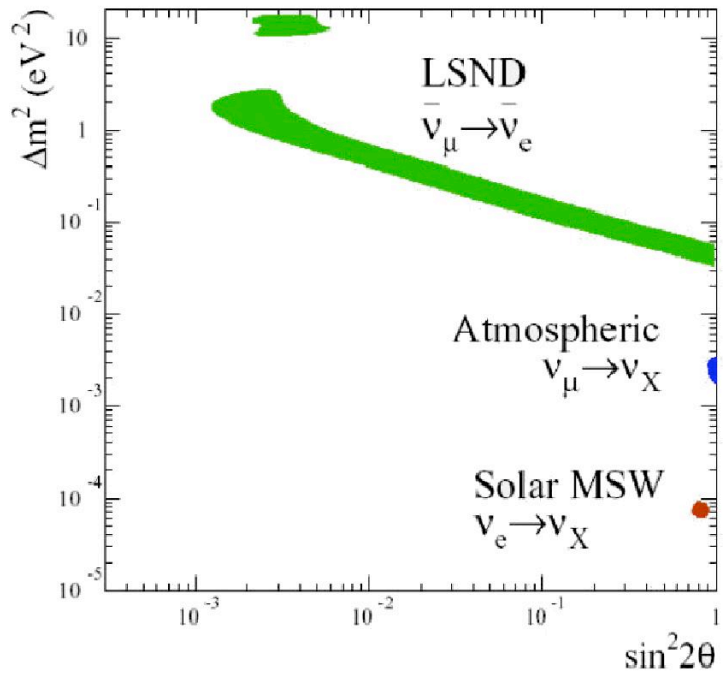
- Motivation
- MiniBooNE
  - ⇒ Beamline, Horn, Target, Tank
- Steps to Analysis
  - ⇒ Event Rate / Flux Predictions
  - ⇒ Calibrations
  - ⇒ PID
- Physics Updates
  - ⇒ ν_μ CCQE (see next talk)
  - ⇒ NC π^0
  - ⇒ NC Elastic
  - ⇒ Exotics searches
  - ⇒ Current oscillation sensitivity

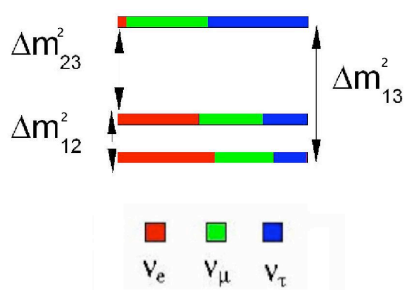


Current Oscillation Status

$P = \sin^2 2\theta \, \sin^2(1.27 \, \Delta m^2 \, L/E)$

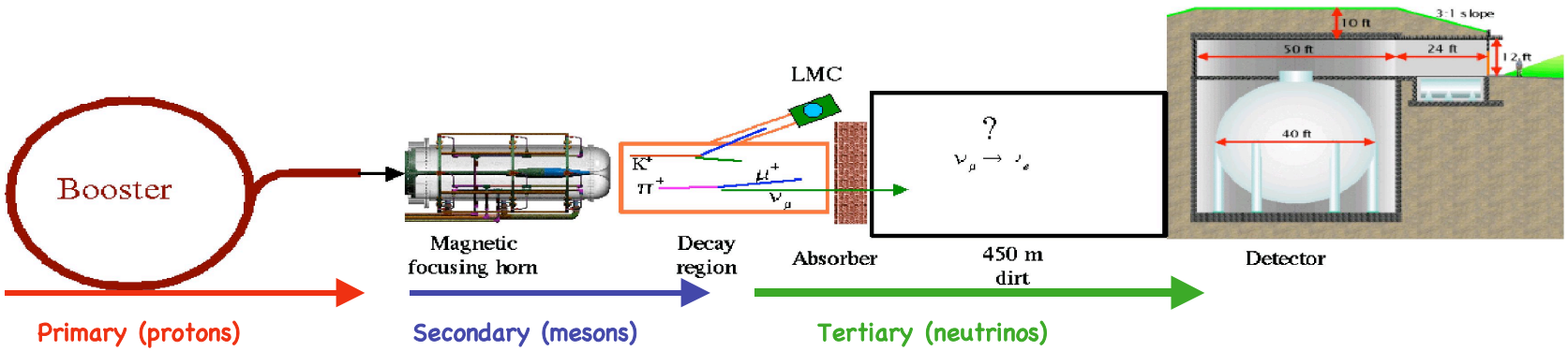
- Solar ν
  - ⇒ Deficit of ν_e from ⊙
  - ⇒ $\Delta m^2 \sim 8\times10^{-5}$ eV^2
- Atmospheric ν
  - ⇒ Zenith angle deficit of ν_μ
  - ⇒ $\Delta m^2 \sim 2\times10^{-3}$ eV^2
- LSND Result
  - ⇒ Excess of anti-ν_e in anti-ν_μ beam
  - ⇒ $\Delta m^2 \sim 0.1$ to 10 eV^2





Need ~same L/E, different systematics

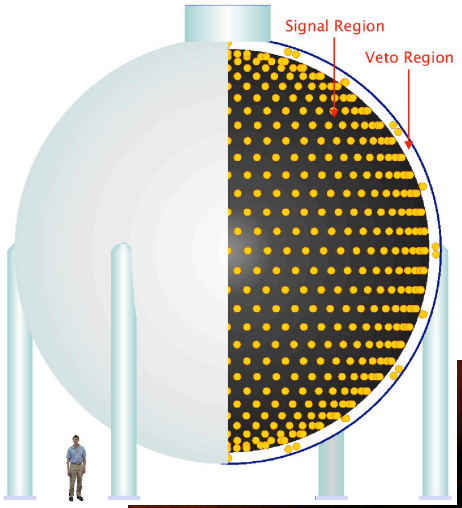
Beam, Horn, Target

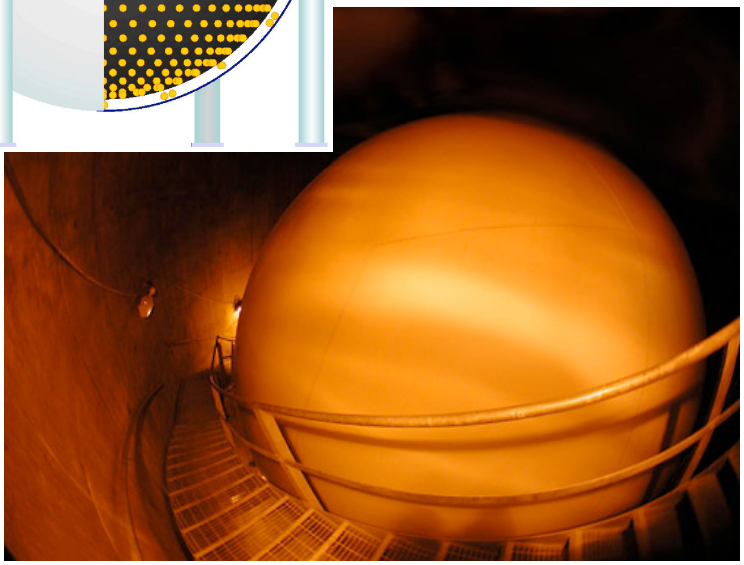


- 8 GeV proton beam
  - ⇒ 4×10^{12} protons/1.6 μs pulse, 5 Hz rate from Booster
  - ⇒ p + Be → mesons
- Mesons focused by magnetic horn
  - ⇒ focusing increases ν flux by factor of 6
  - ⇒ allow ν, anti-ν running
- Mesons → ν

MiniBooNE Detector

MiniBooNE Detector

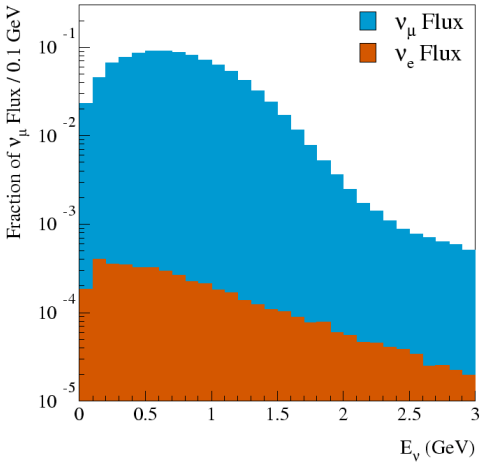


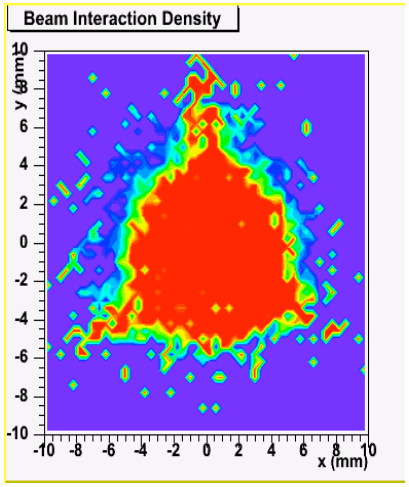


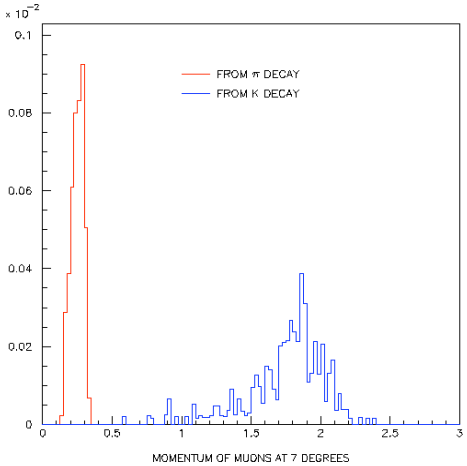
- 12 m diameter sphere
- Undoped mineral oil
- Two regions
  - ⇒ Inner light-tight region, 1280 pmts (10% coverage)
  - ⇒ Optically isolated outer veto-region, 240 pmts
- Signature
  - ⇒ Cerenkov and scintillation light

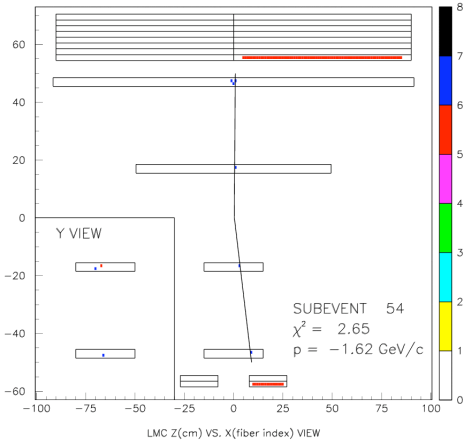
Event Rate/Flux Predictions

- ν_μ flux
  - ⇒ $\pi^+ \to \mu^+ \nu_\mu$
- Intrinsic ν_e flux
  - ⇒ From μ^+, K^+, K^0_L
  - ⇒ ~0.4% of ν_μ flux
  - ⇒ comparable to osc signal!
- E910
  - ⇒ π, K production @ 6, 12, 18 GeV w/thin Be target
- HARP
  - ⇒ π, K production @ 8 GeV w/ 5, 50, 100% λ thick Be target
- LMC spectrometer
  - ⇒ K decays produce wider angle μ than π decays
  - ⇒ scintillating fiber tracker



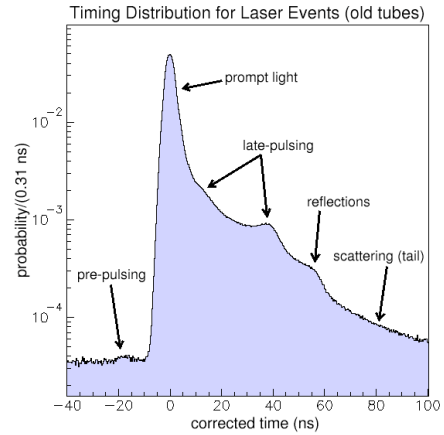


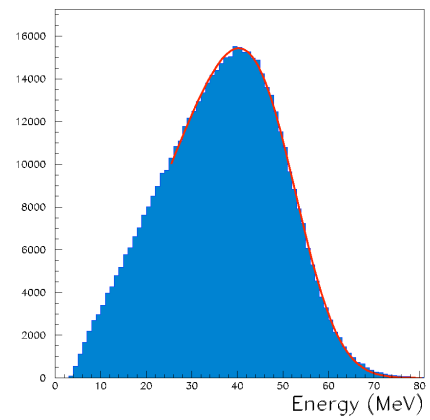


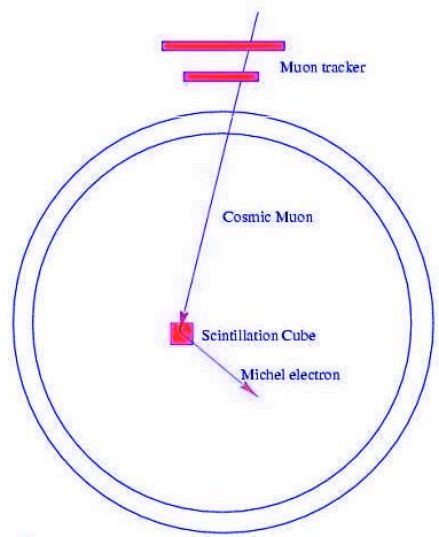


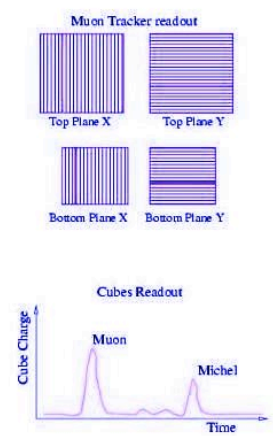
Calibrations

- Laser Flasks (4)
  - ⇒ Measure tube Q, timing response
  - ⇒ Change I = study PMT, oil
- Muon tracker
  - ⇒ Track dir + entry point = test track reconstruction in tank
- Cube System (7) (see next talk)
  - ⇒ Optically isolated scint. cubes
  - ⇒ + tracker = identify cosmic μ, michel ele of known position for E calibration
- Energy Calibrations
  - ⇒ Michel Electrons : fix detector E scale, 14.8% E reconstruction @ 50 MeV
  - ⇒ π^0 : mass peak, E scale and resolution at medium E



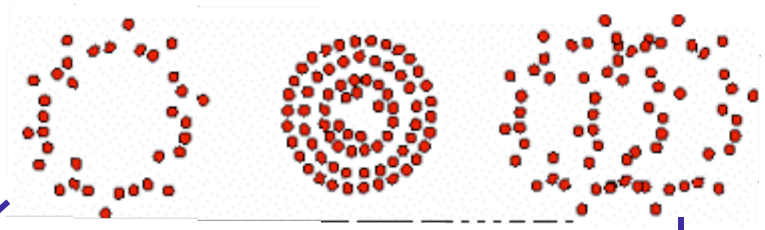




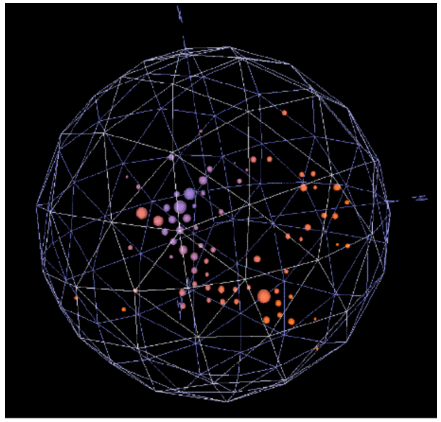


PID

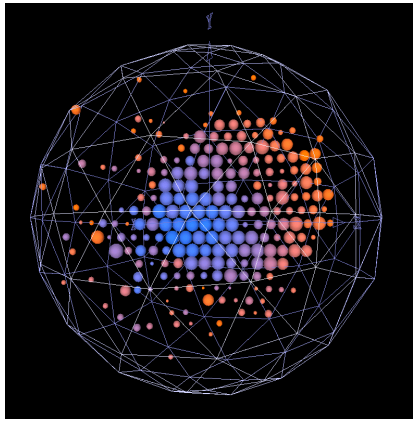
- Identify events using hit topology
- Exploring neural nets, boosting PIDs (publication in the works)



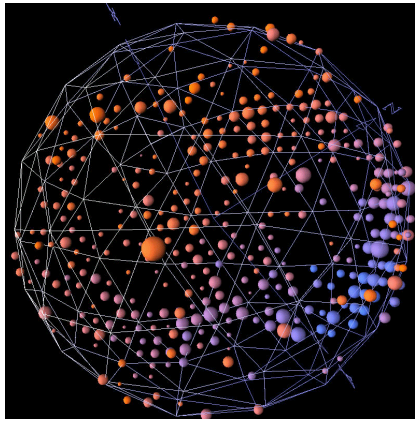
Michel e from μ decay



μ candidate



π^0 candidate

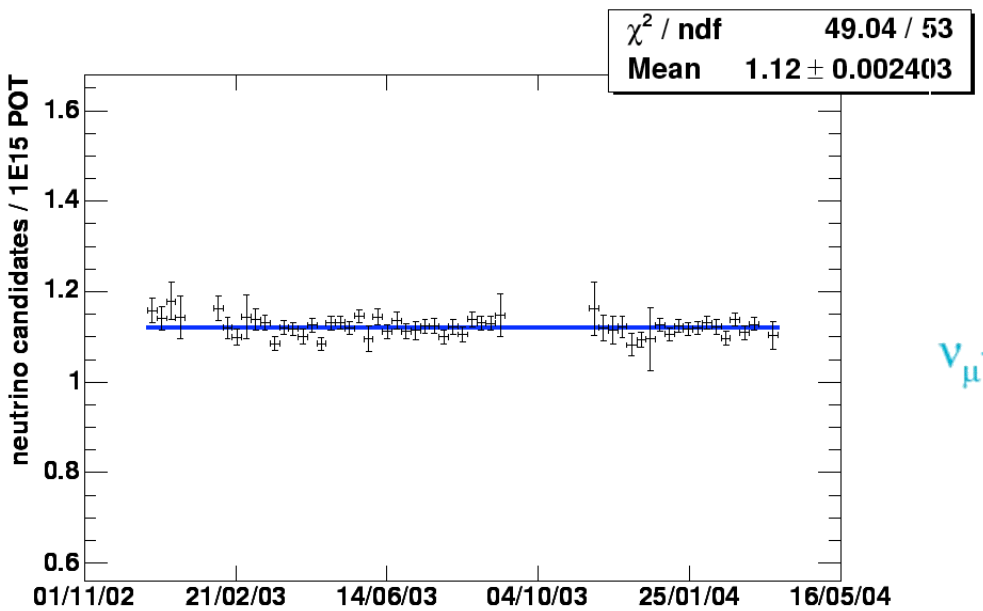


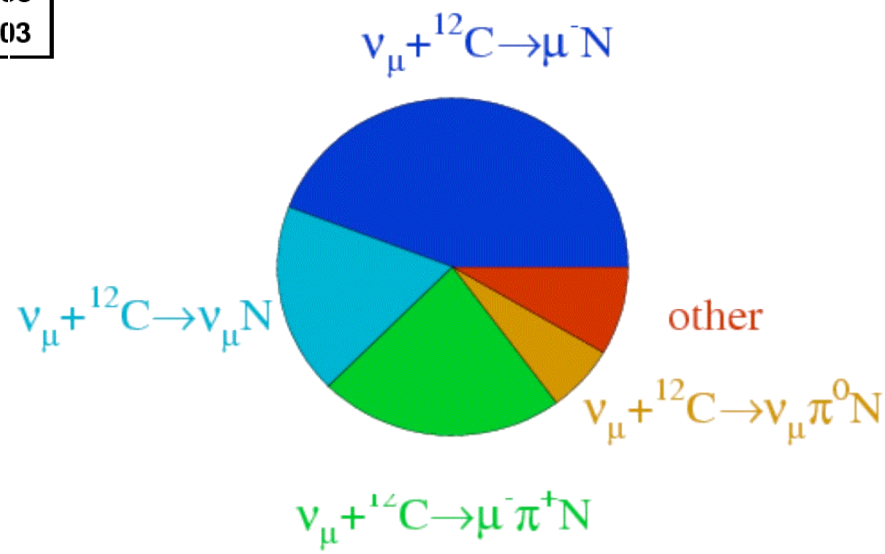
Physics Intro

- >380K neutrino events to date, > 1 million expected
- 148K CCQE
- 94K CC π^+

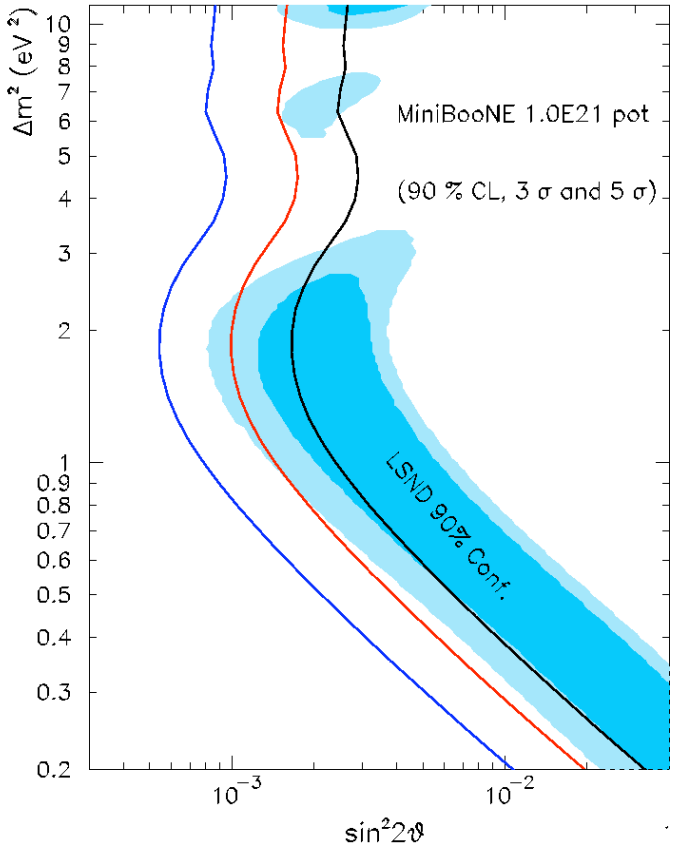
(see next talk)

- 60K NC Elastic
- 26K NC π^0

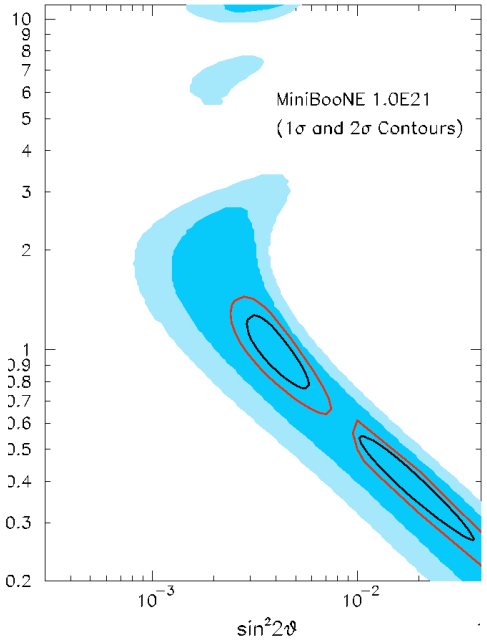




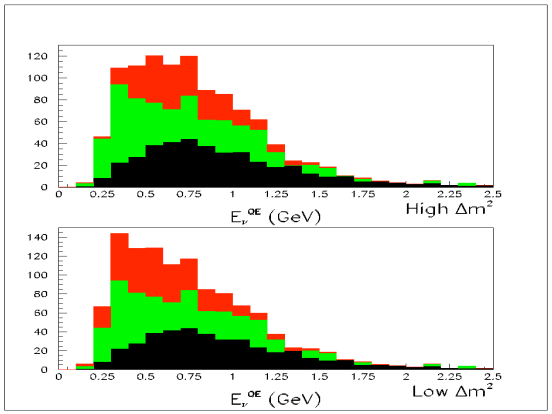
Appearance Sensitivity



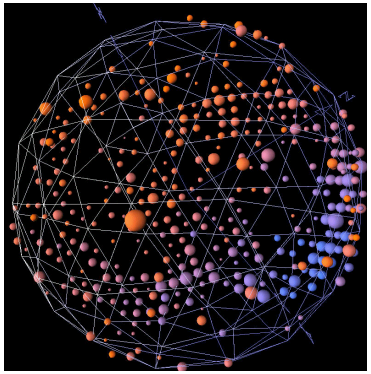
- Goal : fully explore LSND 90% conf. Region at 4-5 σ
- Need 10^{21} pot



signal, mis-id, intrinsic

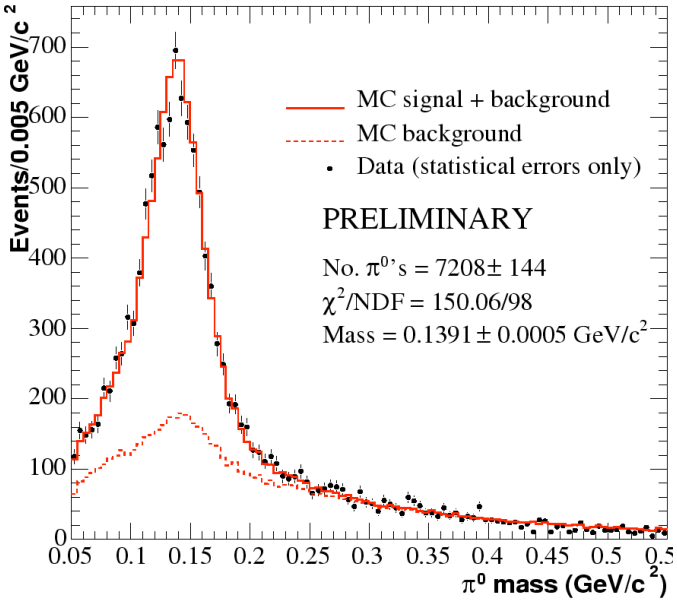


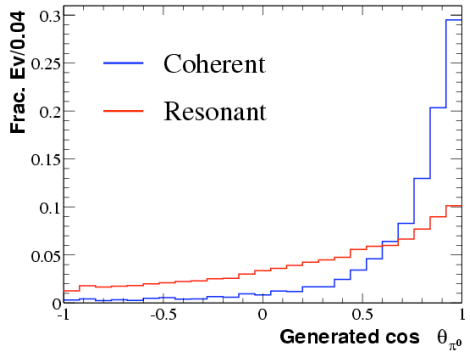
NC π^0

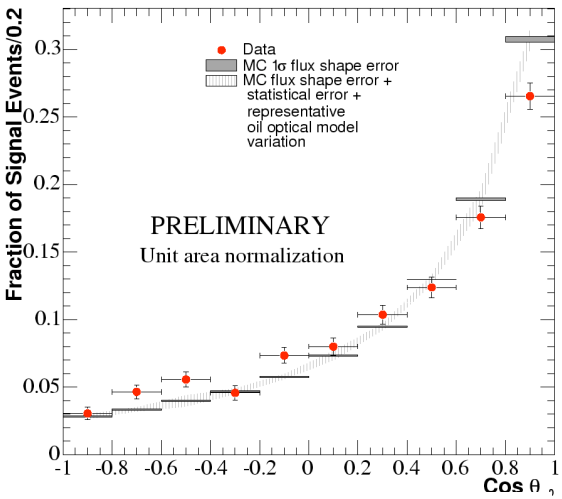


- Relevance
  - ⇒ Background to ν_e appearance (dominant mis-ID)
  - ⇒ σ : crucial for distinguishing $\nu_\mu \to \nu_\tau$, $\nu_\mu \to \nu_s$ in atm.
    - + angular distribution constrain mechanisms for NC π^0 production
- Event Selection
  - ⇒ No decay ele, 2 Cerenkov rings > 40 MeV each
  - ⇒ signal yield extracted from fit with bgd MC : fit assuming 2 rings
  - ⇒ Reconstruction : 55% sample purity with 42% efficiency
- Examine mass spectrum, kinematics
  - ⇒ Bin data in kin. quantities : π^0 momentum, E asymmetry, angle of π^0 relative to beam, extract binned yields
  - ⇒ Compare distributions to MC expectations

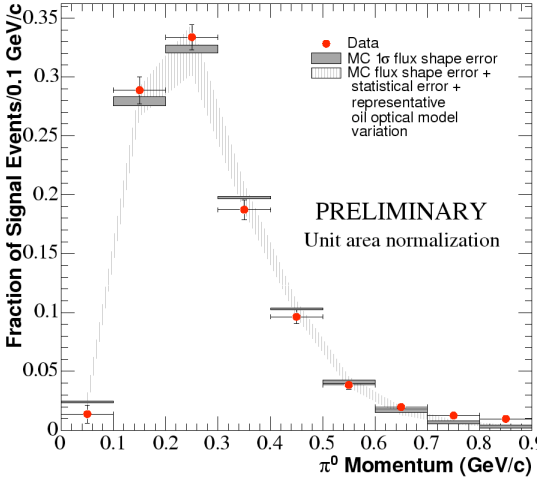
NC π^0







Errors are shape errors
Dark grey : flux errors
Light grey : optical model

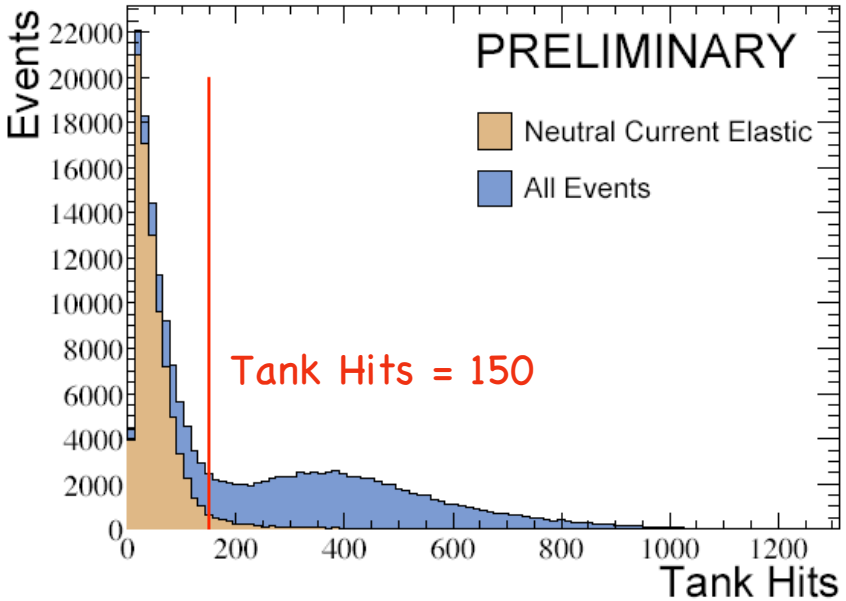


⇒ π^0 momentum = good data/mc agreement. Falloff at high p = due to flux falloff

⇒ Cos $\theta_{\pi 0}$ sensitive to production mechanism (coherent = forward, resonant = not so forward)

NC Elastic

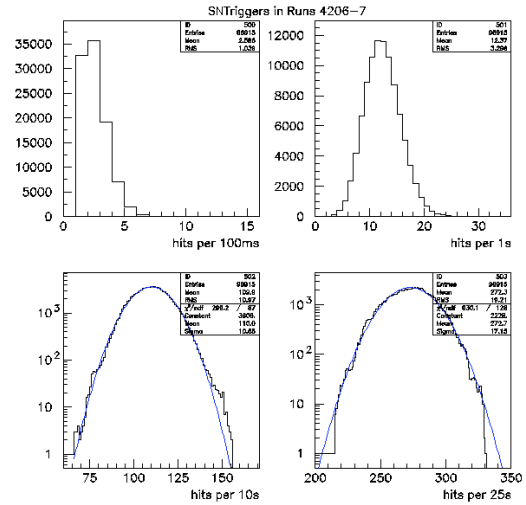
- Study scint. properties of oil, low E response of detector
  - ⇒ Reconstruct p energy from scint. light
- Measure σ (p+ν->p+ν)
  - ⇒ Help understand scint. light for ν_e osc analysis
- σ(NCE) / σ (CCQE)
  - ⇒ Measure Δs (component of proton spin carried by strange quarks)

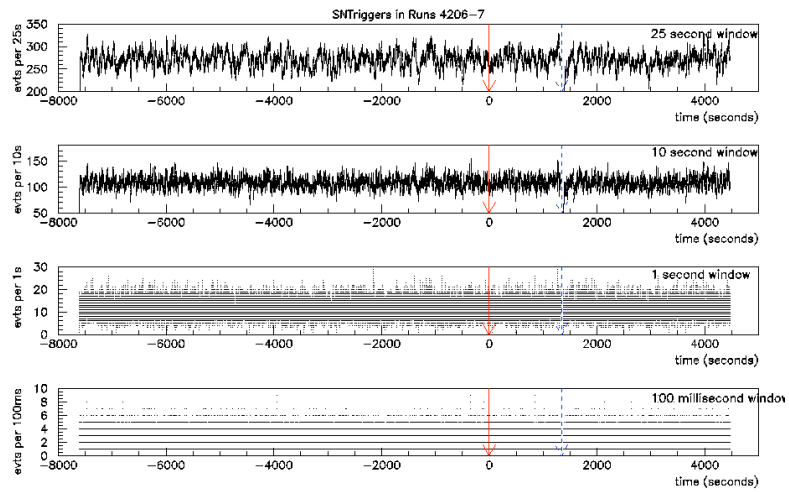


Tank hits < 150, veto < 6, 1 sub-event : ε = 70%, purity = 80%

Exotic Searches

- Muon magnetic moment search
  - ⇒ Massive $\nu \rightarrow \nu_R$, expect non-zero muon mag moment
  - ⇒ Need full dataset
- Rare particle searches
  - ⇒ Take advantage of beam structure
  - ⇒ Proton dribble monitor (if p between buckets, no search!)
- Astrophysics
  - ⇒ Supernova searches
    - Gamma Ray bursts (GRB 030329)
  - ⇒ Solar flare emission searches
  - ⇒ Gamma Ray bursts





Conclusions

- Accumulated ~35% of 10^{21} pot needed for 4-5 σ coverage of LSND
- Already have worlds largest ν dataset in 1 GeV range
- Reconstruction and analysis algos are working well :
  - ⇒ CCQE : compare with flux predictions, disappearance analysis – (see next talk)
  - ⇒ NC π^0 : measure cross section, analyze coherent contribution
  - ⇒ NC Elastic : measure ratio of cross sections vs Q^2
  - ⇒ CC π^+ : see next talk
- ν_e appearance analysis should be ready in time for 10^{21} pot (2005?)

Backup Slides

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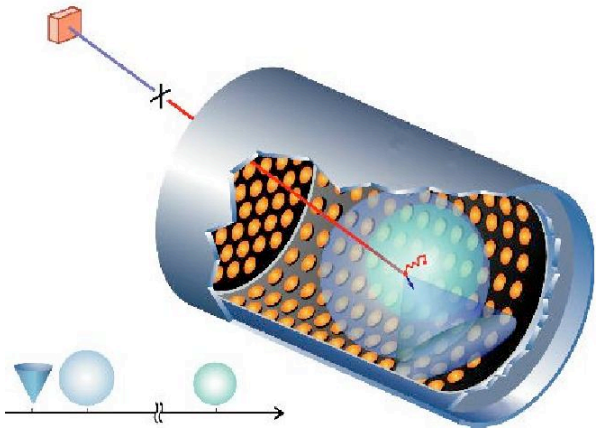
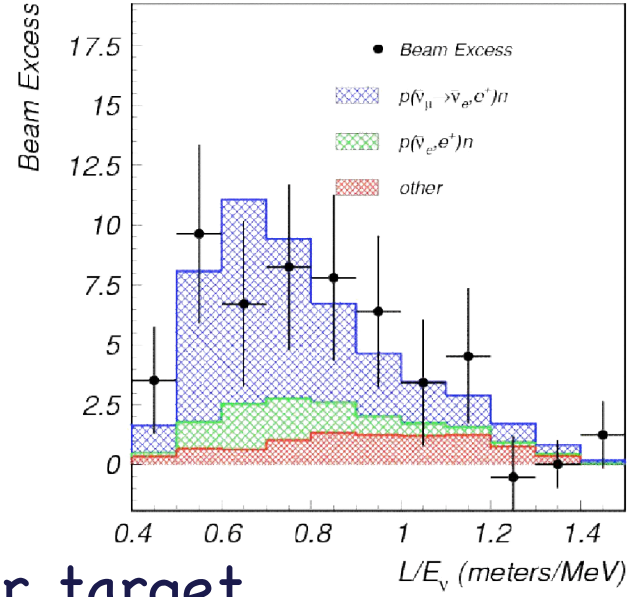
LSND





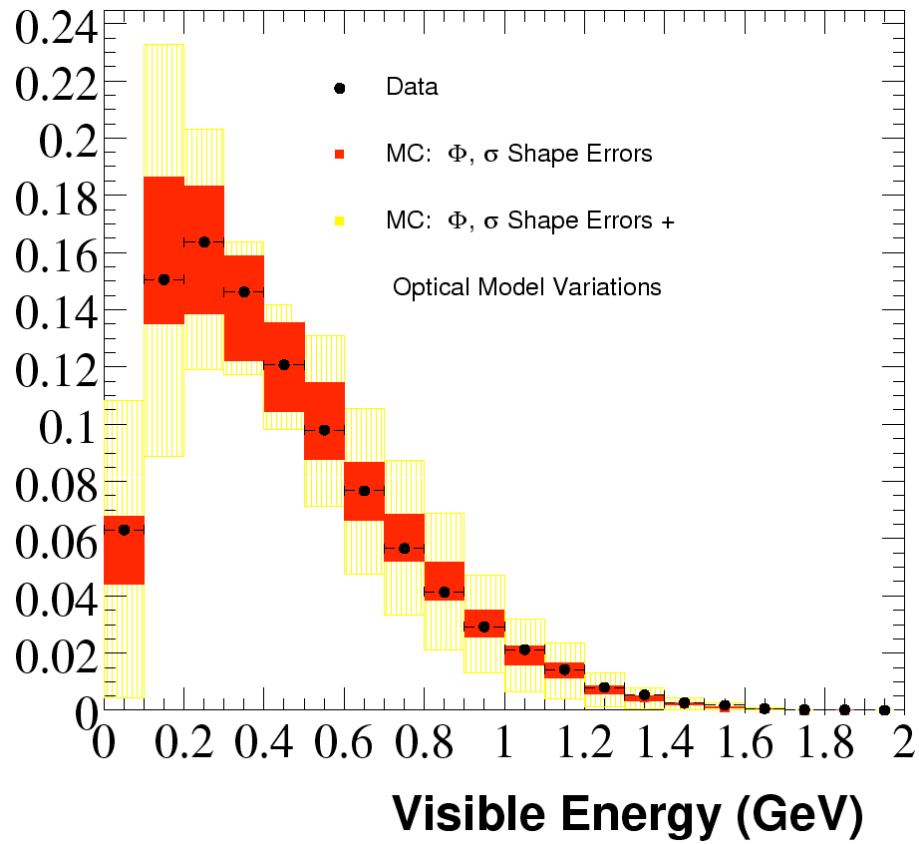
- 800 MeV proton beam -> water target
- 167 ton, liquid scintillator, 25% PMT coverage
- E ~ 20-53 MeV, L ~ 25 - 35 m (L/E ~ 1m/MeV)
- Measure osc. From DAR : P = 2.64±0.67±0.45 x 10^{-3}, see 4 sigma excess

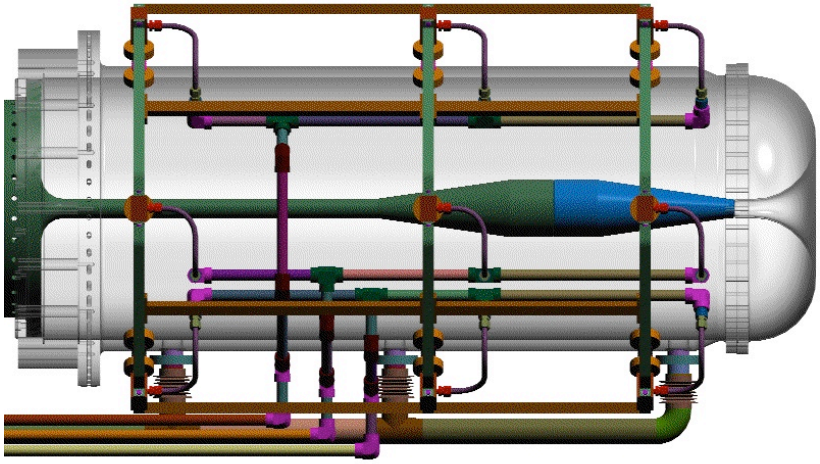
ν_μ CCQE Events

- Relevance
  - ⇒ Largest class of evts; use to validate flux, σ predictions
  - ⇒ Similar kin and cross section as ν_e signal in appearance
  - ⇒ Intrinsic ν_e bgd due to μ decay can be constrained
  - ⇒ Sensitive to ν_μ disappearance for Δm^2 ~0.1 - 10 eV^2
- Event Selection
  - ⇒ Use Fisher discriminant to isolate events with μ-like Cerenkov ring in final state
  - ⇒ 80% purity, 55% efficiency
- Preliminary comparisons between measured distributions and MC expectations
  - ⇒ Ex: Q^2 (sensitive to nuclear effects such as Pauli blocking, nuclear shadowing)

ν_μ CCQE Events

- Red error bands
  - ⇒ Flux errors
    - π^+ production, will be measured to 5% with HARP
  - ⇒ Cross section errors
    - CCQE from axial mass uncertainty, threshold effects, Pauli blocking
- Yellow variation bands
  - ⇒ Flux, Cross section, Optical Model variation
    - Optical model NOT 1 sigma, reflect current uncertainty on optical model parameters
- Data points
  - ⇒ ~ 50% of pot to date



Horn Update

- To date : World Record 96 M pulses!
- Ground fault observed on Friday, July 23
- Short found in either inner conductor or stripline attached to horn
  - ⇒ Horn must be replaced
- Spare horn already tested with 2 M pulses
  - ⇒ Installed during current shutdown