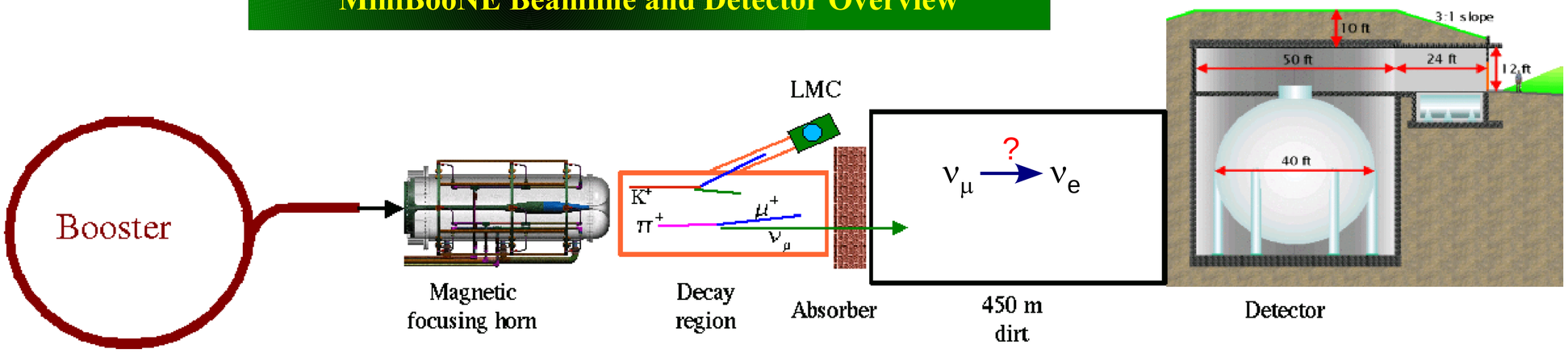
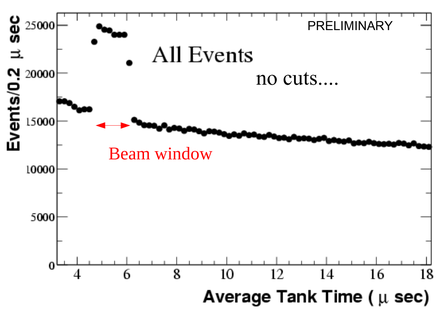
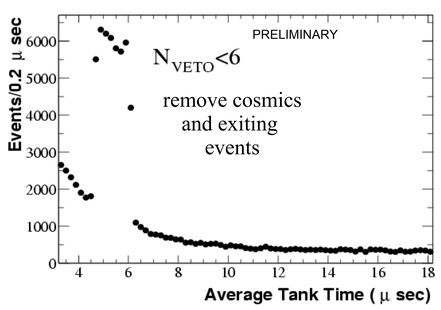
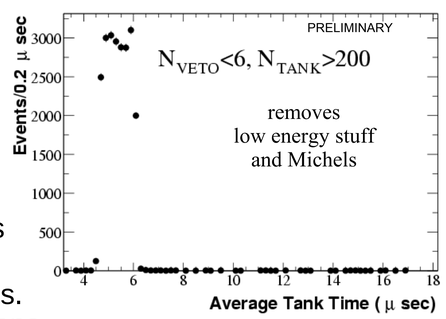
MiniBooNE Beamline and Detector Overview



Extracting ν Events

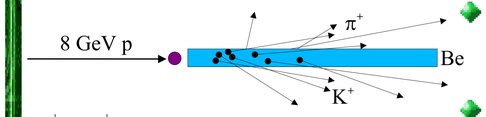






- Candidate neutrino events can be extracted using simple cuts.
- Once isolated, these events are fit to determine the Cerenkov/scintillation fraction and other properties. These measurables are then used in neural network and boosting PID algorithms.
- The systematic impact of uncertainties in the underlying MC are explored for:
  - Neutrino flux from target secondaries.
  - Cross sections for neutrino interactions in the detector.
  - Variations in the detector optical model.

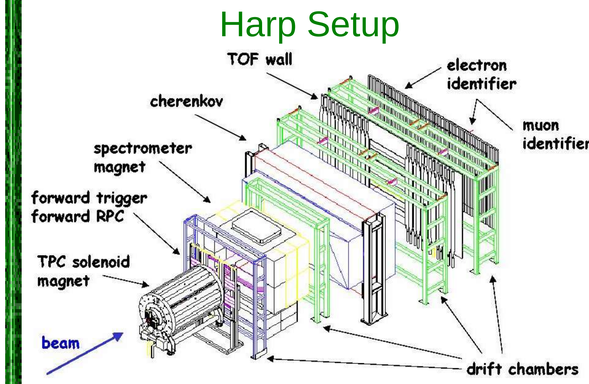
Determining the ν Flux

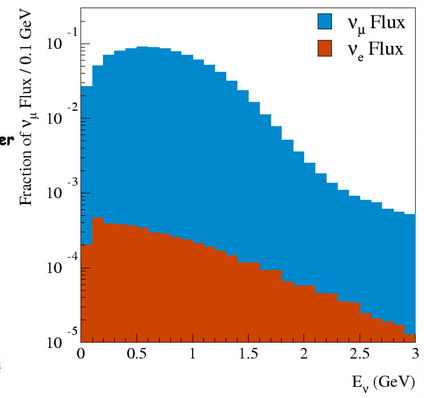


$\pi^+ \to \mu^+ + \nu_\mu$	source of ν_μ
$\to e^+ + \bar{\nu}_\mu + \nu_e$	source of ν_e background
$K^+ \to \mu^+ + \nu_\mu$	source of ν_μ
$K^+ \to \pi^0 + e^+ + \nu_e$	source of ν_e background
$K_L^0 \to \pi^- + e^+ + \nu_e$	source of ν_e background

- Knowing the production cross sections for mesons produced at the target is critical for determing the neutrino flux.
- In summer of 2002, the cross sections for an 8 GeV proton beam on Be were measured by the HARP experiment at CERN.
- MiniBooNE collaborators aided HARP and are now actively analyzing the data.
- Analysis results are expected soon.

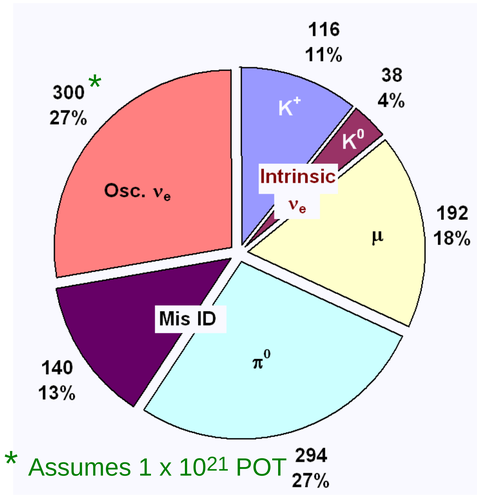
Harp Setup





Understanding Backgrounds

- After all of the analysis cuts, two types of backgrounds remain:
  - Intrinsic ν_e from K and μ decay.
  - Misidentified tank events.
- Many different methods exist for determining backgrounds to 5-10%



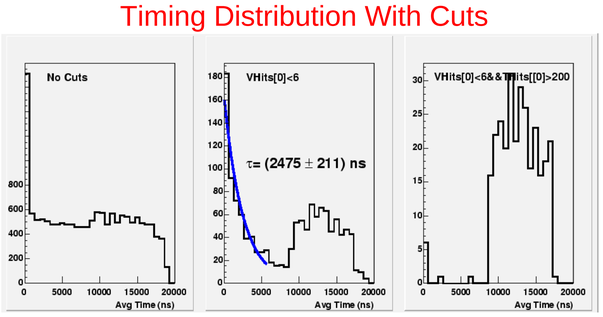
* Assumes 1 x 10^{21} POT

"Belt & Suspenders"	ν_e from kaons (10%)	ν_e from muons (5%)	μ misid (5%)	π^0 misid (5%)
HARP (& BNL910)	Be target kaon production cross section	Be target pion production cross section		
LMC	In-situ measure of kaon production			
antiν run	Significantly reduced kaon production		No muon capture	Significantly reduced production due to low E
change decay length by ½	rate remains constant	Reduced by factor of ¼		
muon tracker			Identified cosmic muon tracks	
muon cubes			Identified cosmic muon vertices	
cosmic michels			Insitu capture xsec measure	Michel e has typical E of soft π^0 photons
ν_μ events	Events at > 1.5 GeV	QE rate is prop. to pion flux	98% of stopped μ's tagged by michel	In-situ xsec measure -- 99% w/ 2 ring
K2K data				K2K xsec measure (We use K2K Nuance MC)

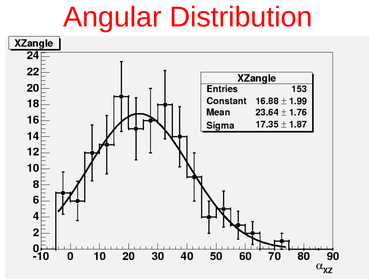
Events from the NuMI Beamline

- Neutrino events from the NuMI beamline and dump have been observed, making MiniBooNE the world's first off-axis detector.

Timing Distribution With Cuts

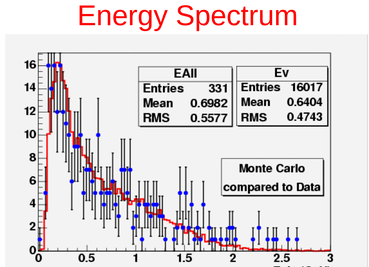


Angular Distribution

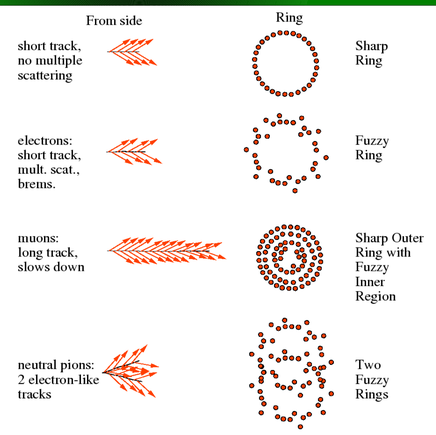


- MiniBooNE is 111 mrad off-axis from NuMI beamline and 740m from the NuMI target.
- Trigger is taken from NuMI extraction kicker.
- The beam spill contains 5 batches over 8μs
- Total predicted rate of 1.7x10^{-15} neutrino interactions per POT. By the shutdown, NuMI is expected to have 3x10^{19} POT.
- Sample will be useful for systematic checks of the PID and energy calibration.

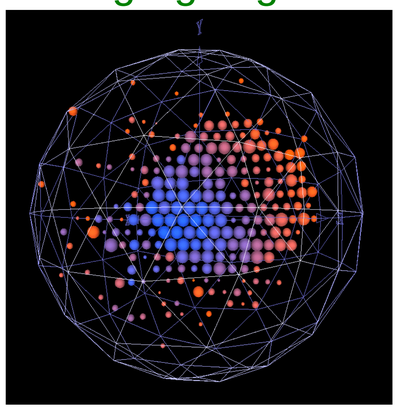
Energy Spectrum



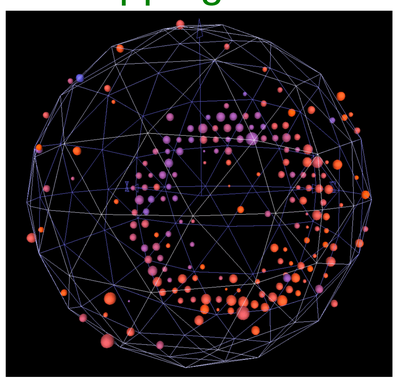
Event Topologies



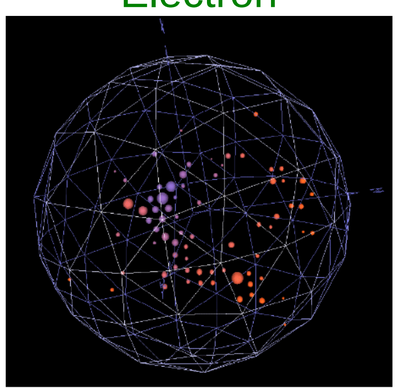
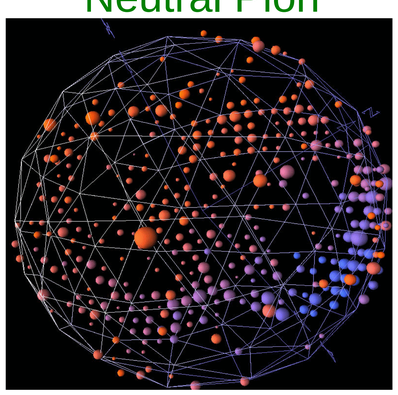
Through-going Muon



Stopping Muon



Electron



Neutral Pion