MINOS Run Plan and Protons

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Nov. 11, 2004

Overview

- MINOS Running and Proton Request
  - I will not cover this in any depth due to time limitations… But it was all presented one year ago:
  - http://www.fnal.gov/directorate/program_planning/Dec2003PACPublic/MINOS_Presentation.pdf
- Short-term run plan and issues

A Brief Reminder

Proposal for a Five Year Run Plan for MINOS

The MINOS Collaboration

May 30, 2003

Abstract

In this document, we outline MINOS physics capabilities under three different integrated proton intensity scenarios (7.4×10^{20}, 16×10^{20} and 25×10^{20} protons on target). We propose a five year run, starting early in 2005, and show that the physics reach of the experiment is significantly enhanced as the total number of delivered protons increases. The highest intensity scenario, which appears feasible based on recent studies, will offer particularly strong oscillation measurement capabilities, including an excellent sensitivity for discovery of a small admixture of ν_μ to ν_e oscillation. The purpose of this document is to request that the laboratory prepare a specific plan of investment in proton intensity to achieve the physics goals outlined herein.

- In May 2003, the MINOS Collaboration submitted a proposal for a 5 year run plan which through both extended running and investments in proton intensity would result in more total protons on target than the original “proposal number” (which we argue is no longer relevant… let’s move on).
- There is an “easy part” and a “hard part” for the lab in this request:
  - Easy part: Agree that MINOS will run for 5 years. We request this decision. We believe that MINOS results will remain the most relevant in the world throughout this running period (and maybe beyond?)
  - Hard part: Come up with a plan to deliver more protons. There is thinking in the direction of more protons, but no clear plan.

The APS Study and MINOS

MINOS: The NuMI beamline will be complete late in 2004 and MINOS beam operations will begin. This U.S.-based experiment will offer precision measurements of oscillation parameters and extension in sensitivity to ν_e appearance. The sensitivity of MINOS depends on the number of protons that can be delivered. Investments in the Main Injector proton intensity will be important to best exploit the investment in MINOS and extend its discovery reach. We endorse such investment.

Our recommendations for a strong future U.S. neutrino physics program are predicated on fully capitalizing on our investments in the current program. The present program includes the longest baseline neutrino beam and a high-flux short baseline beam, both in the U.S. Elsewhere, American scientists and support are contributing in important ways to the burgeoning world program in neutrino physics, including a long-base-

Four issues deserve special mention:

1. Support for continued increases of proton intensity for Fermilab neutrino experiments, as is necessary for the present experiments to meet their physics goals.

My own (Gu)estimate of Protons on Target

- In the initial running period, anticipate that the protons per cycle will range from about 1.0e13 to 1.5e13.
- This gives the following expected range for protons on target:
  - For analyses by June: 0.2-0.35e20
  - Up to the 2005 shutdown: 0.5-0.8e20
  - By April 2006 (for summer 2006 conference presentations): 1.3-2.0e20
  - Following years add:
    - 2006 2.4e20
    - 2007 2.8e20
    - 2008 3.0e20
    - 2009 3.5e20
    - Total 13.7e20

Note: Each year runs April-April

Developing MINOS Run Plan for 2005

- NuMI beam commissioning first. Then…
- LE neutrinos 88%
  - Main running mode. Most useful for accumulation of statistics relevant to the expected oscillation signals.
- HE neutrinos/anti-neutrinos 3%
  - Provides useful near detector data for beam/cross section systematic checks.
- ME neutrinos 4%
- Horn Off 3%
- “Intentional” low intensity 2%
  - Provides data for understanding any possible event overlap effects in the near detector.
  - Probably comes for free!
- We should be able to switch between these running conditions in negligible amounts of time. Odd horn running conditions spread over a few blocks in several months.
- Sanity check: Plan to “open the CC spectrum box” in September.

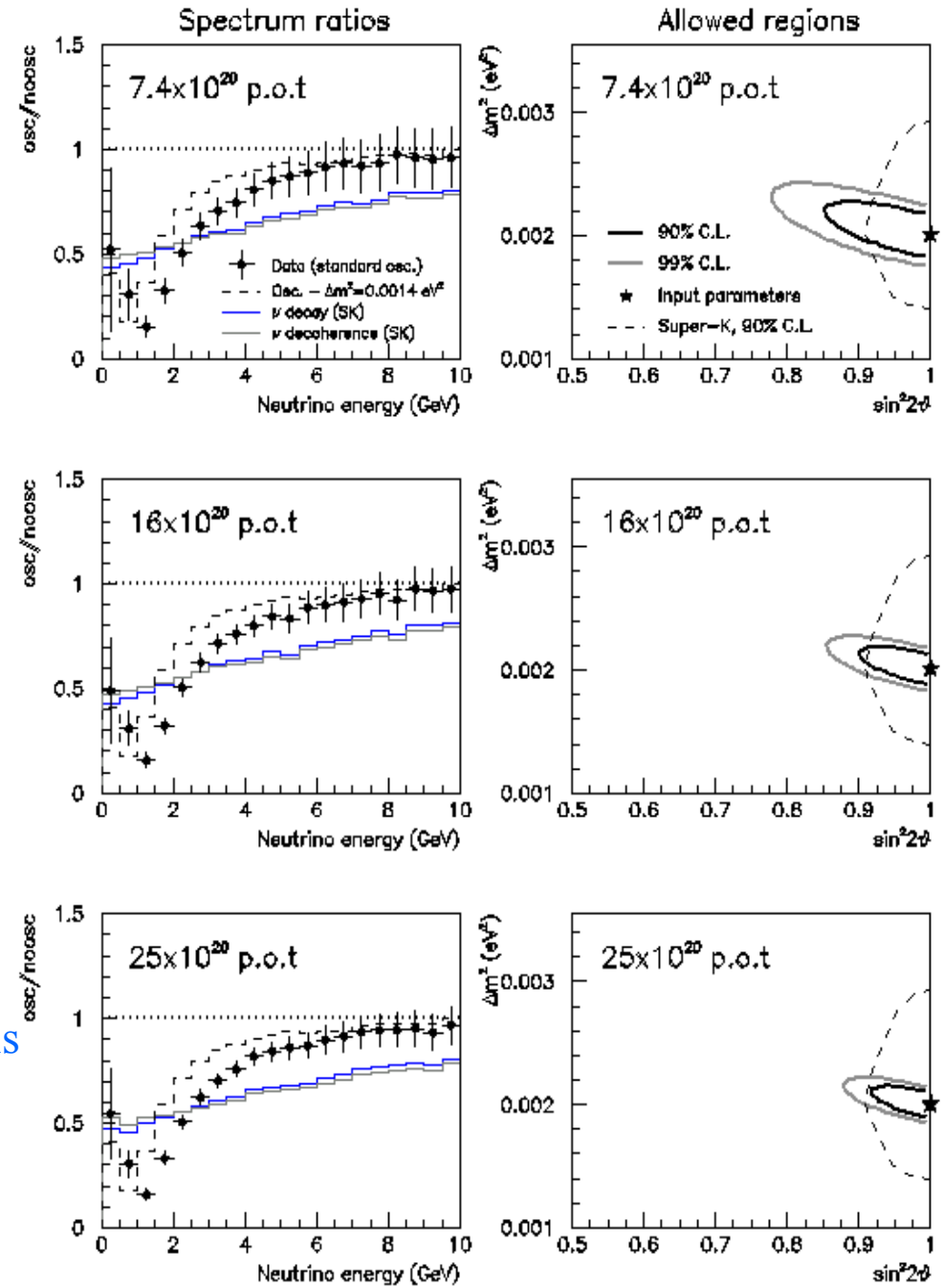
Measurement of Oscillations in MINOS

For $\Delta m^2 = 0.0020\ eV^2$, $\sin^2 2\theta = 1.0$

Plots on the left: Oscillated/unoscillated ratio of number of ν_μ CC events in the far detector vs $E_{observed}$

Plots on the right: MINOS 90% and 99% CL allowed oscillation parameter space for the Super-K best fit point.

Note: the MINOS 1σ measurement of Δm^2 is about 3-6% depending on the central value and number of protons. Compare to T2K in 5 years of running error of 2.5%, if T2K has the intermediate detector.

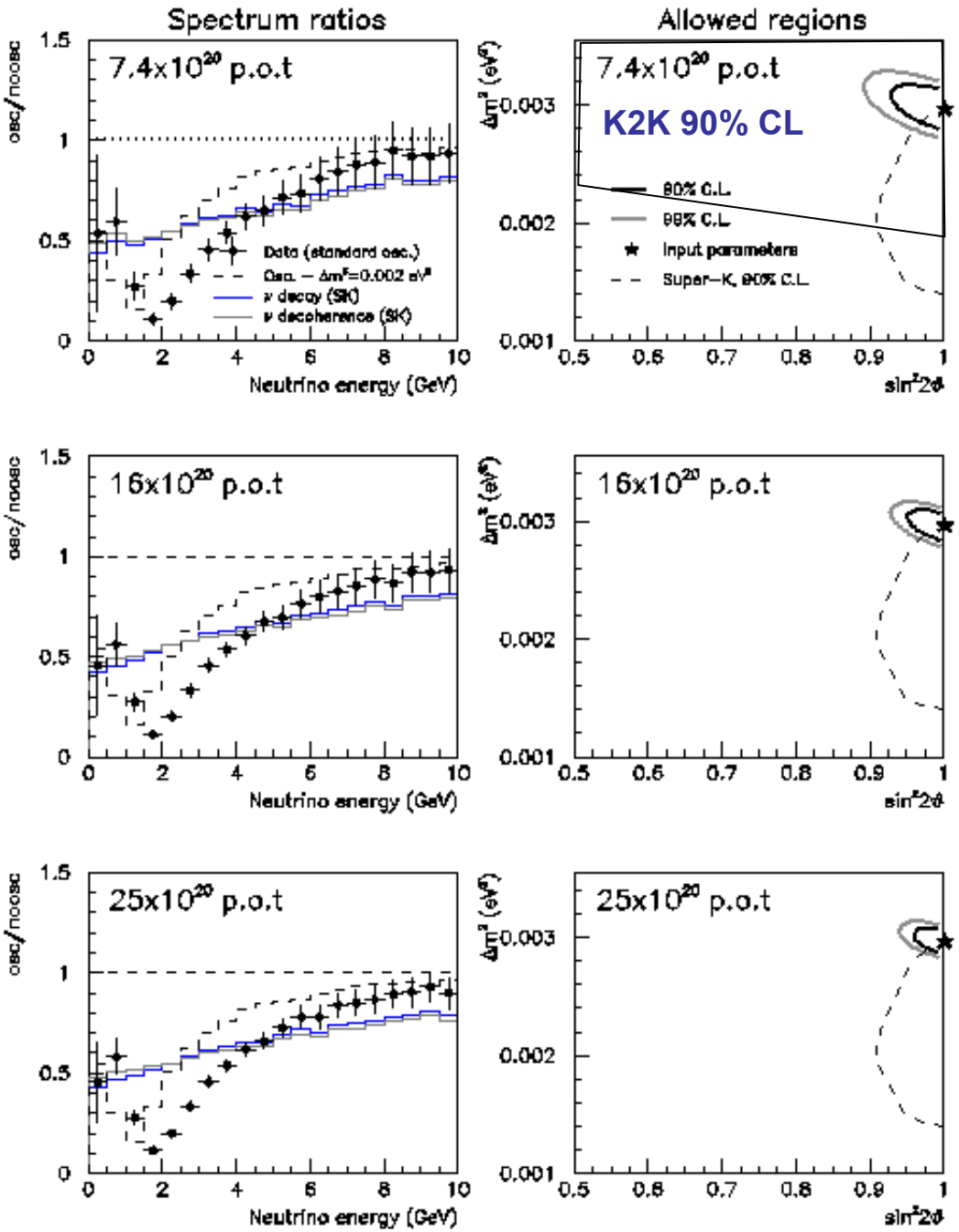


Measurement of Oscillations in MINOS

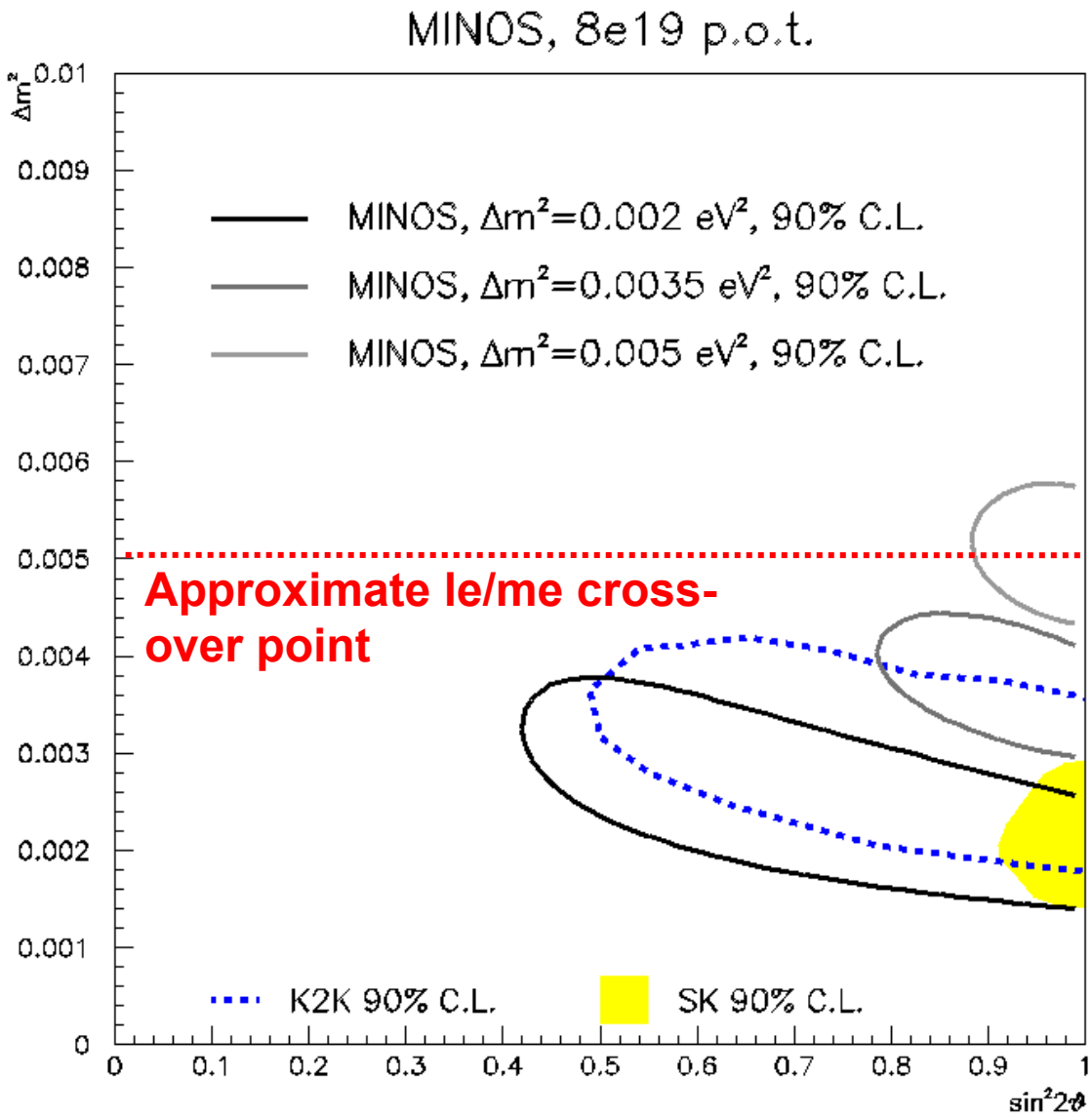
For $\Delta m^2 = 0.0030\ eV^2$, $\sin^2 2\theta = 1.0$

Plots on the left: Oscillated/unoscillated ratio of number of ν_μ CC events in the far detector vs $E_{observed}$

Plots on the right: MINOS 90% and 99% CL allowed oscillation parameter space for the Super-K best fit point.



Beam Energy "Sanity Check"



If Δm^2 is sufficiently large, running with the low energy beam will be non-optimal.

We wish to make an "early as practical" check that we are in fact using the optimum beam.

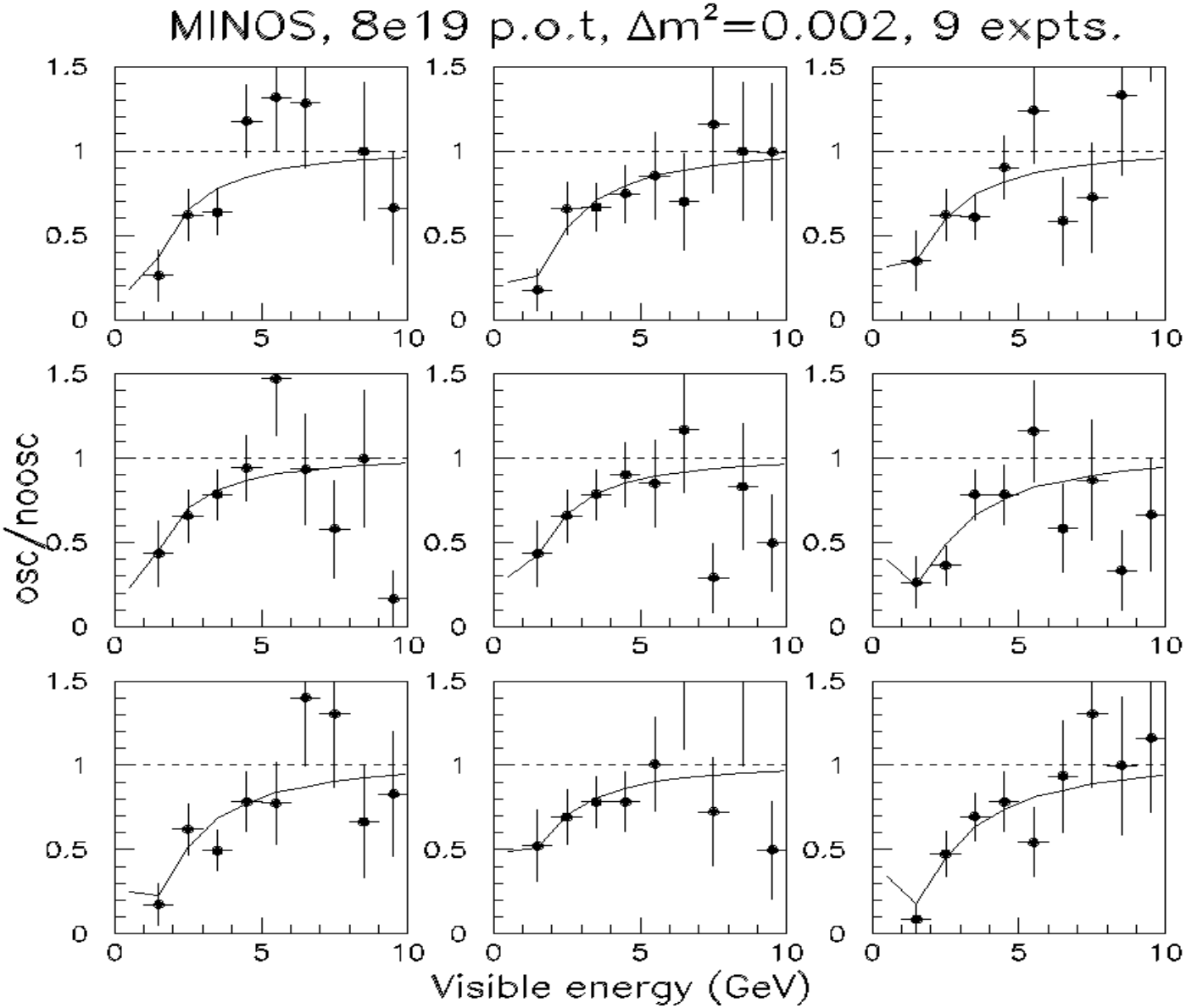
Roughly, we expect this should be possible by the 2005 shutdown.

NB: K2K best-fit outside physical region

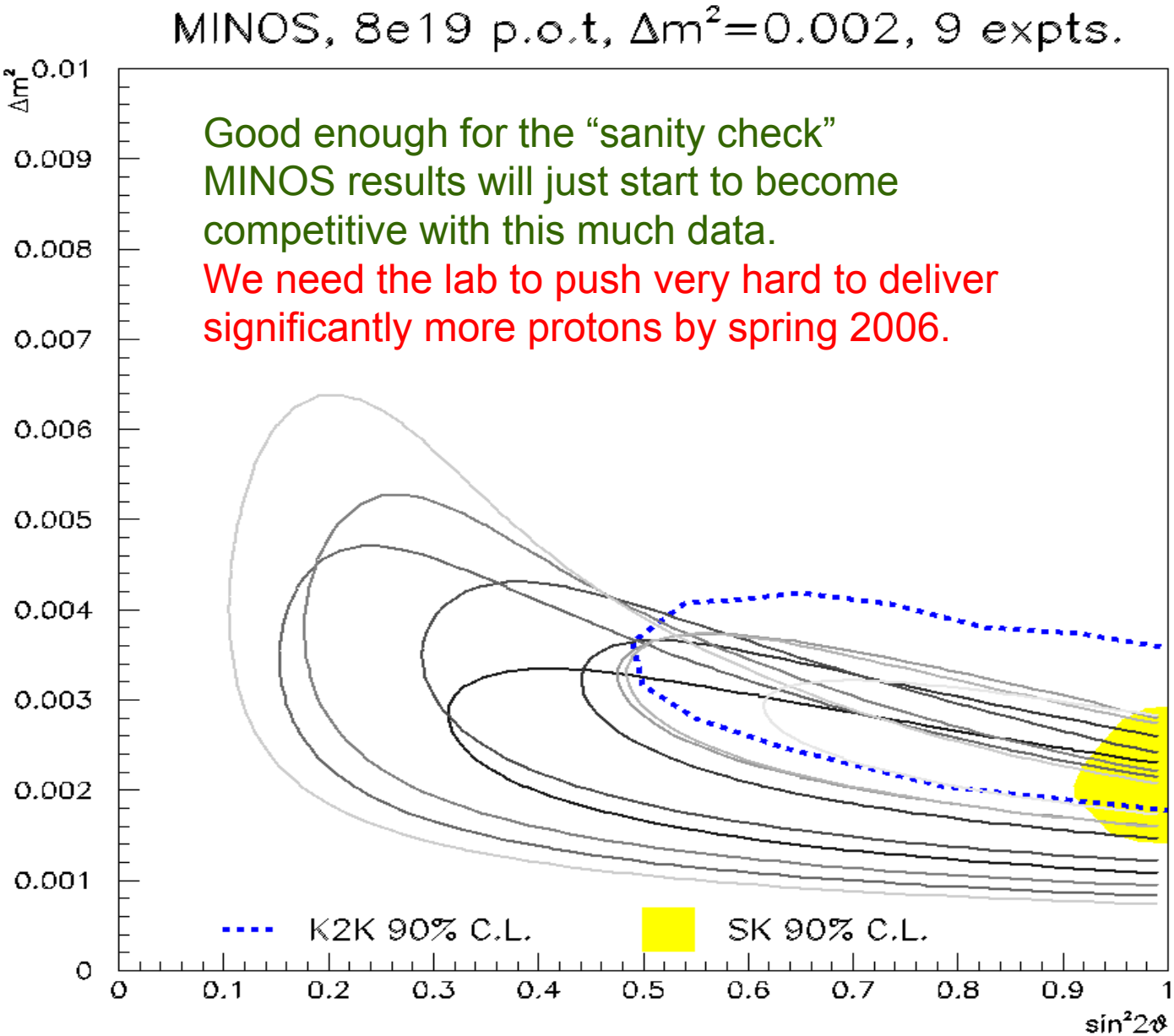
Nine Sample "Early Experiments"

Points: data

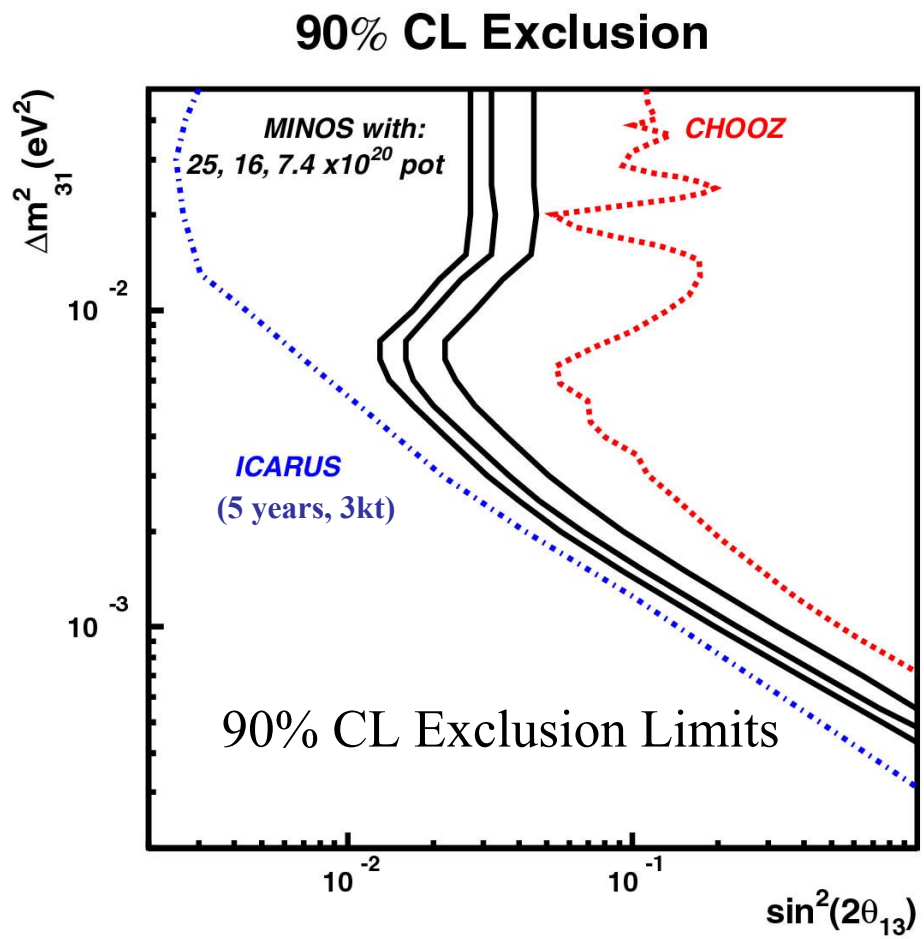
Lines: best-fit MC

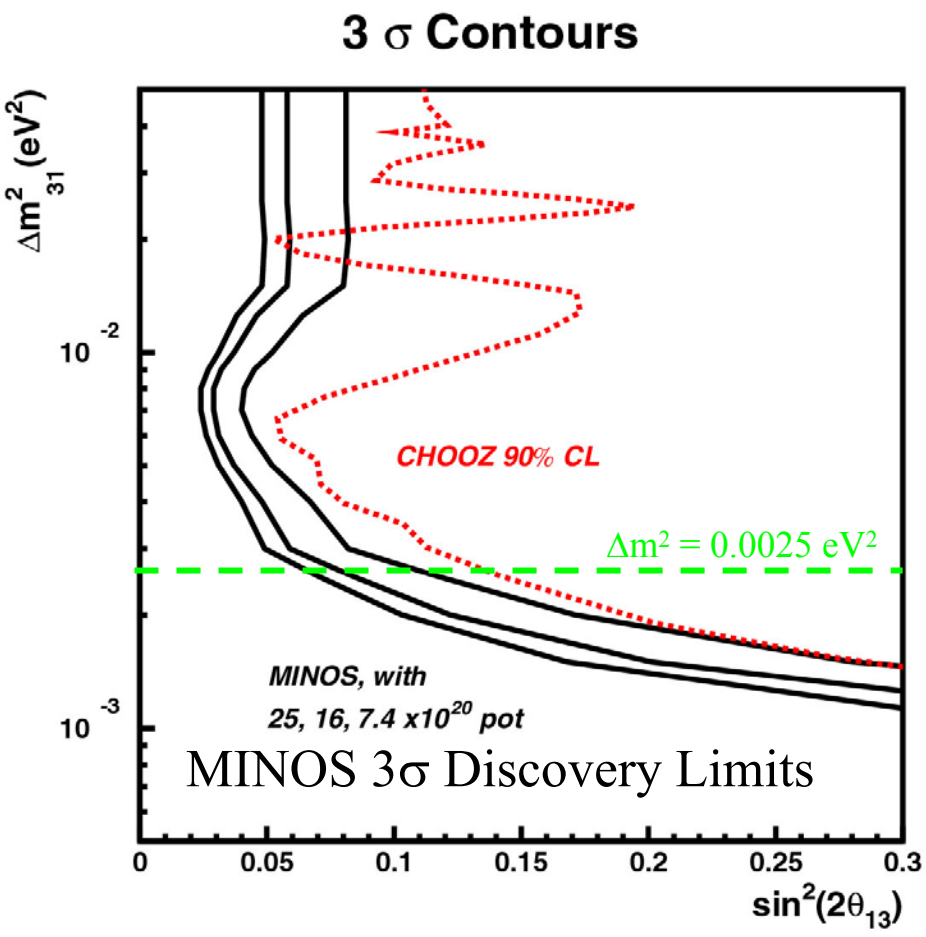


Nine Sample "Early Experiments"



Appearance of Electrons





- Depending on the protons on target, MINOS can cover up to about half of the remaining "linear" parameter space for ν_e appearance with 3σ discovery potential. Protons!

Summary

- The MINOS Detectors and Collaboration are *really* ready to go with beam running.
- The commissioning of NuMI is imminent.
  - We appreciate the effort the lab has made in getting to this point!
- Protons on target is by far the most important issue for MINOS now. We need as many protons as possible as soon as possible.
  - In order to provide better measurement of Δm^2 as soon as possible (requires a good effort to accomplish by spring 2006)
  - MINOS can cover half the remaining "linear" parameter space for ν_e appearance with 3σ discovery potential with a significant boost in proton intensity.
- We are prepared to run for 5 years. We request that this become the lab plan.
- We are developing a detailed scenario for running conditions:
    - Default is running with the low energy neutrino beam all the time once NuMI is commissioned.
    - A "sanity check" in summer 2005 on beam energy looks feasible and advisable. If the shutdown stays put, that seems the right time (assuming the protons are delivered).

Fermilab Schedules

2004-5 Fermilab Accelerator Experiments Schedule

This Schedule will be updated regularly, as plans change.

Calendar Year		2004			2005		
Tevatron Collider		CDF & Dzero	CDF & Dzero		CDF & Dzero		BTeV / CDF & Dzero
Neutrino Program	B	MiniBooNE	MiniBooNE		MiniBooNE	OPEN	OPEN
	MI		MINOS		MINOS		MINOS
Meson 120	MT	Test Beam	Test Beam		Test Beam		Test Beam
	MC		E907/MIPP		E907/MIPP		OPEN

Draft 2006-9 Fermilab Accelerator Experiments Schedule

Revised Annually - This Version from March, 2004.

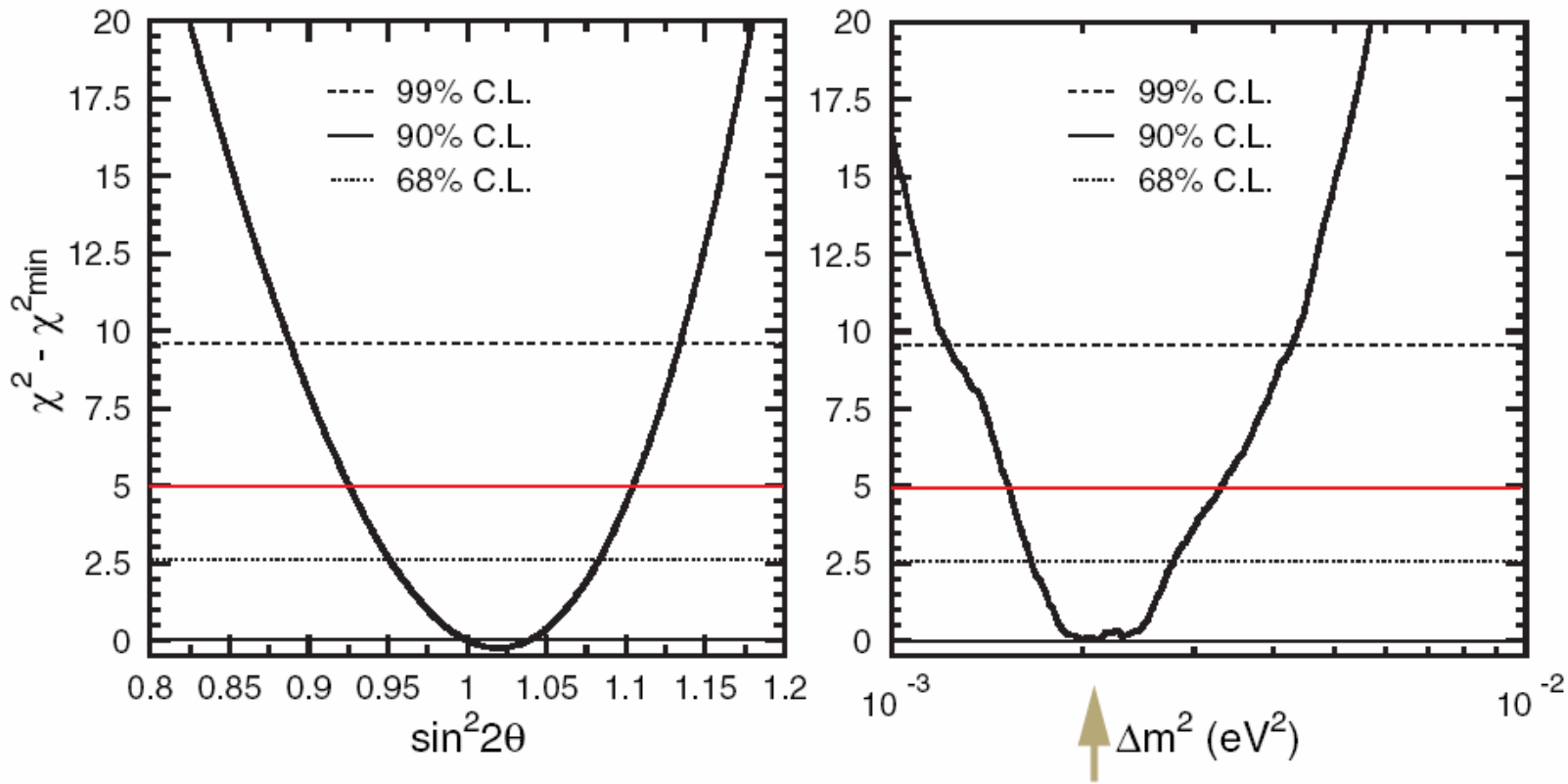
Calendar Year		2006	2007	2008	2009	
Tevatron Collider		BTeV / CDF & D0	BTeV / CDF & D0	BTeV / CDF & D0	BTeV / CDF & D0	BTeV / Open
Neutrino Program	B	OPEN	OPEN	OPEN	OPEN	OPEN
	MI	MINOS	MINOS	MINOS	MINOS / OPEN	OPEN
Meson 120	MT	TestBeam	TestBeam	TestBeam	TestBeam	TB
	MC	OPEN	OPEN	E906#	E906#	E906#
	ME	OPEN	OPEN	OPEN	E921*	E921*

- Running is scheduled for ~42 weeks per year.
  - This corresponds to ~0.9×10^7 MI cycles with 2.0 s cycle
- We should get around 20-24 weeks of good running before the 2005 shutdown.

MINOS Operations Plan

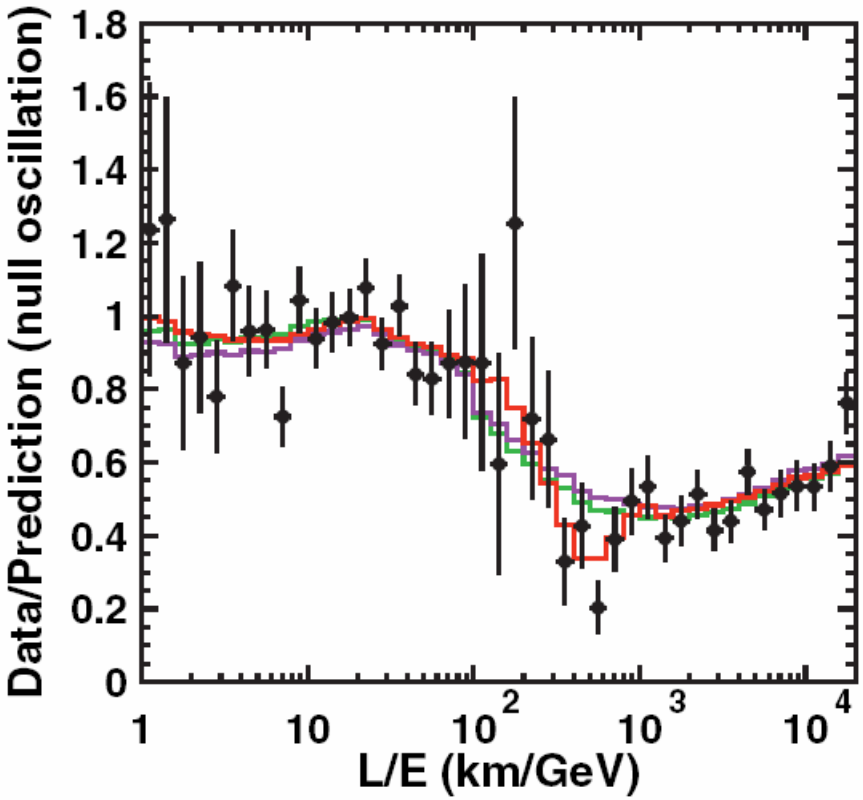
- MINOS collaborators will be on shift 24/7 during periods of Main Injector operation. The 12th floor control room will be the main center of MINOS operations and shifts.
- The MINOS detectors are ready to go! With a bit of coordination, we anticipate downtime of the MINOS far detector not correlated with accelerator downtime will be <1%.
- The Far Detector will be manned by the Mine Crew and some physicist shifters during the day. At night, Mine Crew experts and hoist operators (state park employees) are on call with anticipated 90 minute response time for underground access.
- We have appointed a first Run Coordinator, Rob Plunkett, who will be responsible for coordination of MINOS running and daily interactions with Fermilab operations groups.
- MINOS shift workers will monitor detector and beamline operations and data quality. In general, experts will be called in for any actual hardware interventions. The NuMI beamline will be run by the Main Control Room operations staff.
- Offline reconstruction is ready to proceed approximately in real time as data is acquired. However, the first pass of reconstruction will almost certainly not be the final pass due to continued development of reconstruction code. In general, we plan on blind physics analyses.

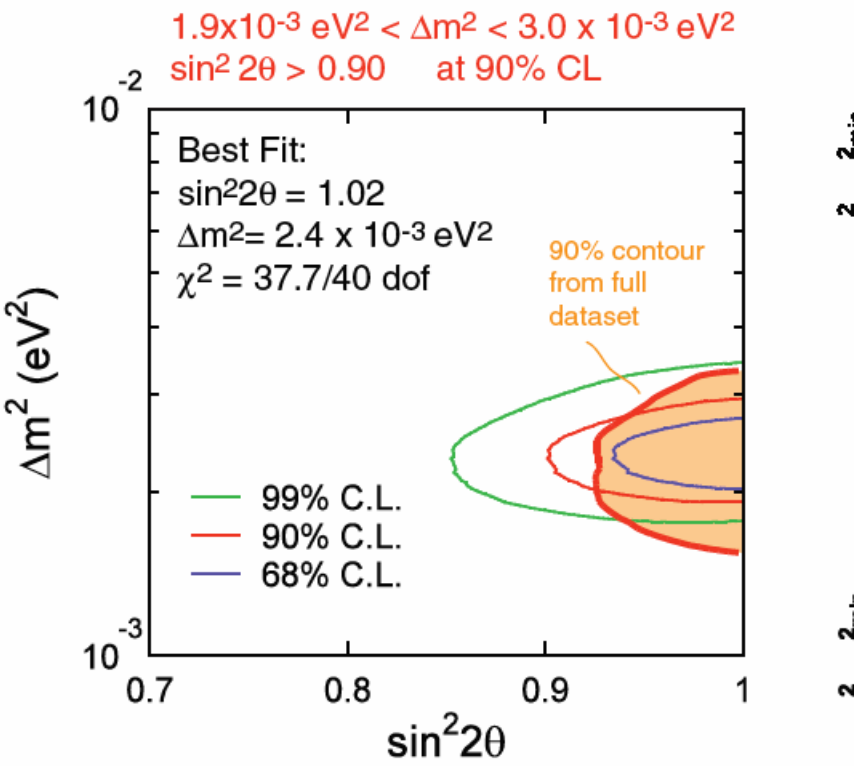
Global Fit Results from Super-Kamiokande



$\Delta\chi^2$ shape is rather flat and uneven between 2.0-2.5 x 10^{-3} eV^2

L/E Analysis from Super-Kamiokande

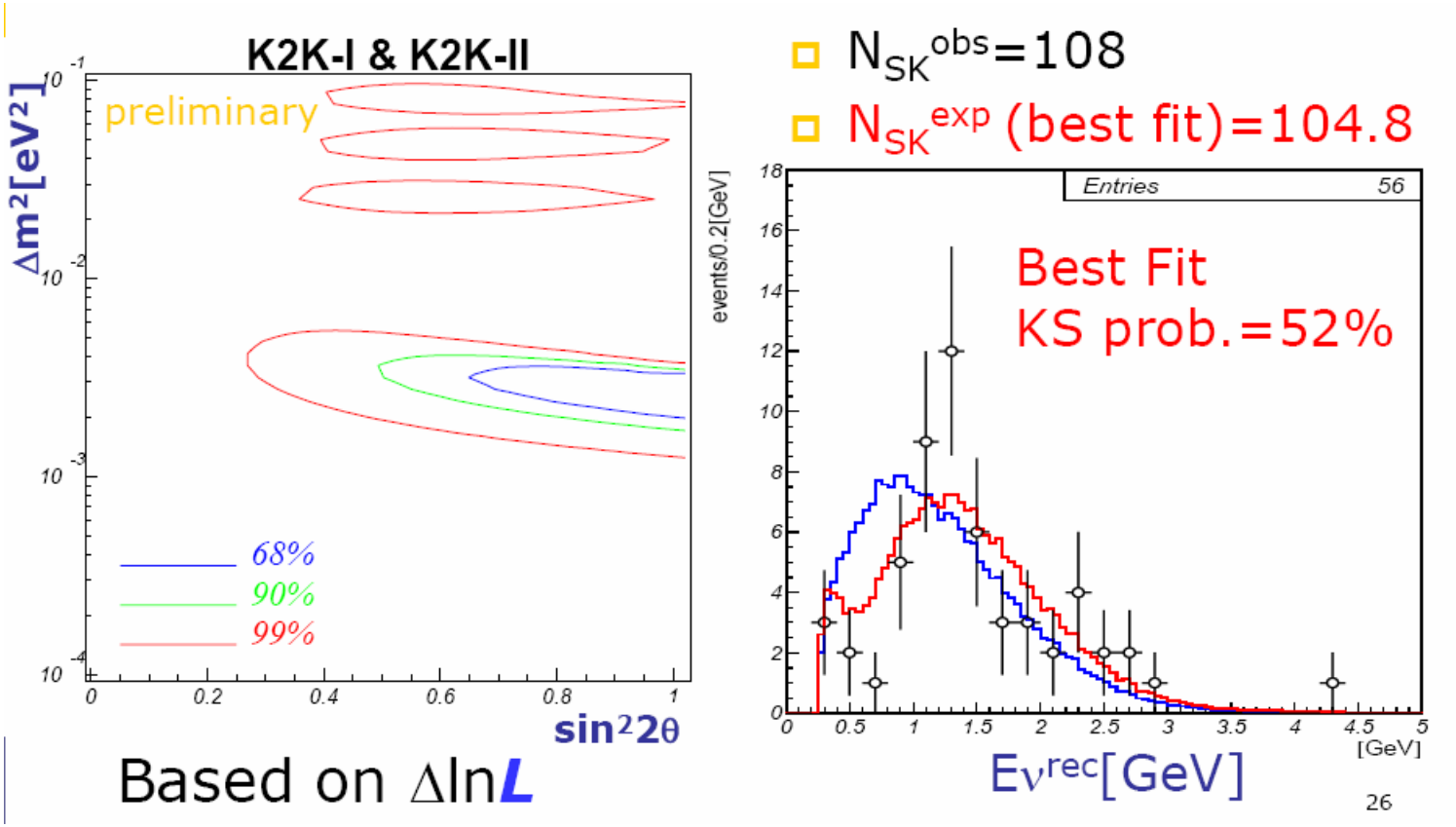




Strong constraint on minimum value of Δm2 with data sub-sample (not independent of course) no use of upward muons (cf. full dataset analysis)

Note: The alternate model curves shown here are for the same models as shown on the MINOS CC energy spectrum plots.

Results from K2K



Best fit: $\Delta m^2 = 2.7 \times 10^{-3}$ eV^2, $\sin^2 2\theta_{23} = 1.0$
Note that actual best fit mixing parameter >1.0 due to "anomalously large" variation vs energy.