Simulation tasks and plans for the megaton scale WC detector

C. Walter / Duke University

*Boston * BNL * Duke * LAPP * Maryland * Paris * Penn * Irvine*

Main Physics Goals

- Beam oscillation physics
- Proton decay
- Supernovae prompt + relic neutrinos

How can we optimize for each of these topics?
What are the detector requirements?
How much will each cost?

Some Questions

- What PMT Coverage is necessary?
  - Performance for Vertex / PID / track reconstruction
  - IMB: 5%, SK: 40% and 20%
- Size / Shape of the cavern
  - For PDK go as big as possible!
  - 300 kton fine for beam physics
- Do we need a veto?
  - SK/SNO: Yes
  - IMB: NO

Approaches in “First Year”

- You can use existing data and MC (e.g. from SK) and mask out tubes to try to understand how algorithms behave.
  - Realistic noise and light scattering but restricted to geometry and properties of existing detectors
- Use new MC to do studies.
  - Different cavern sizes cause more or less absorption/scattering.
  - Different tubes have different QM etc.
  - Different tube sizes can effect performance.

In the longer term a framework and simulation package which is used for physics studies will come out of this process.

What tools do we have?

SK Real Data
SK MC
T2K 2KM MC

SNO MC
RAT (SNO+, DeapClean)

Need more info for this list…

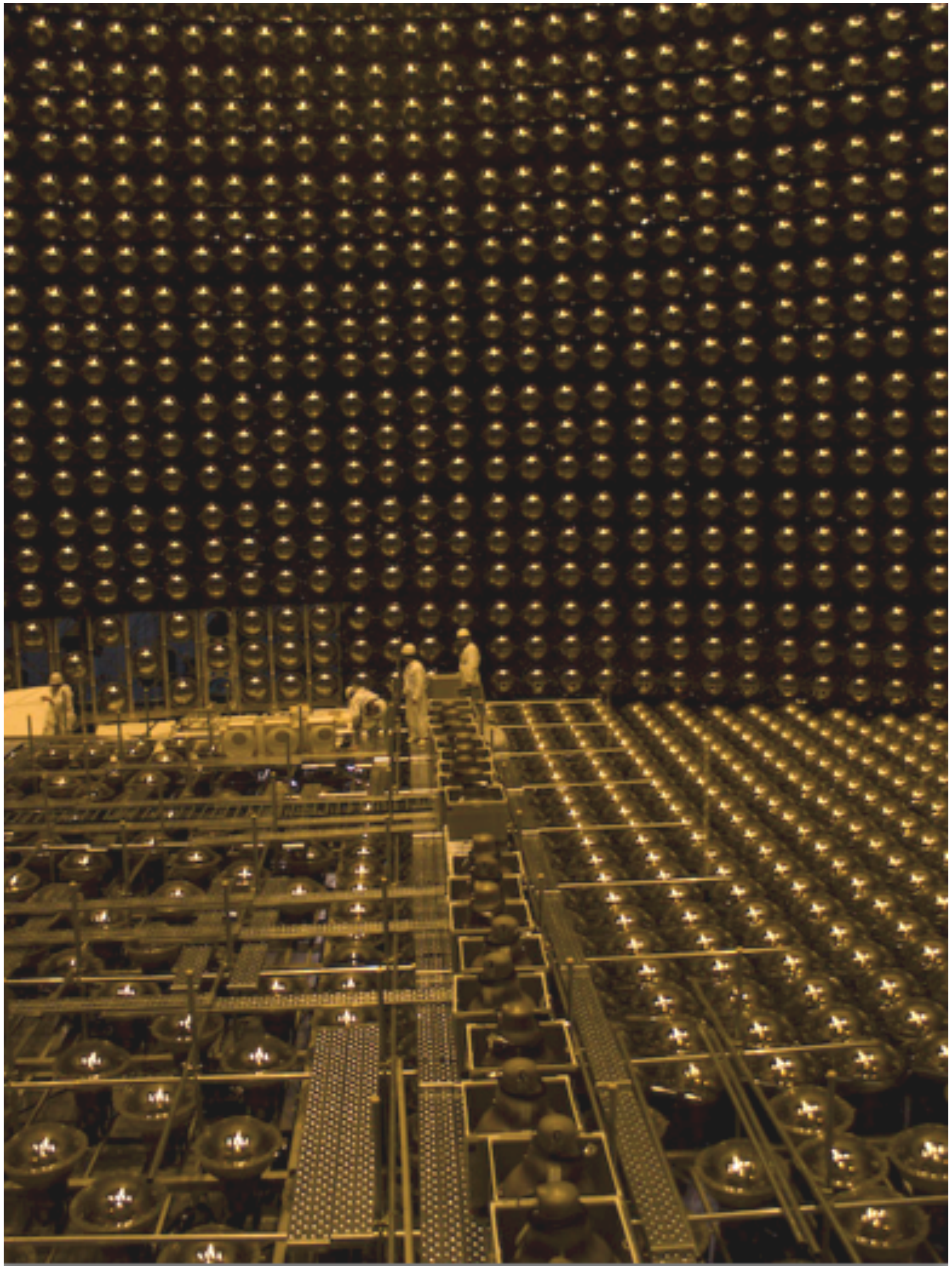
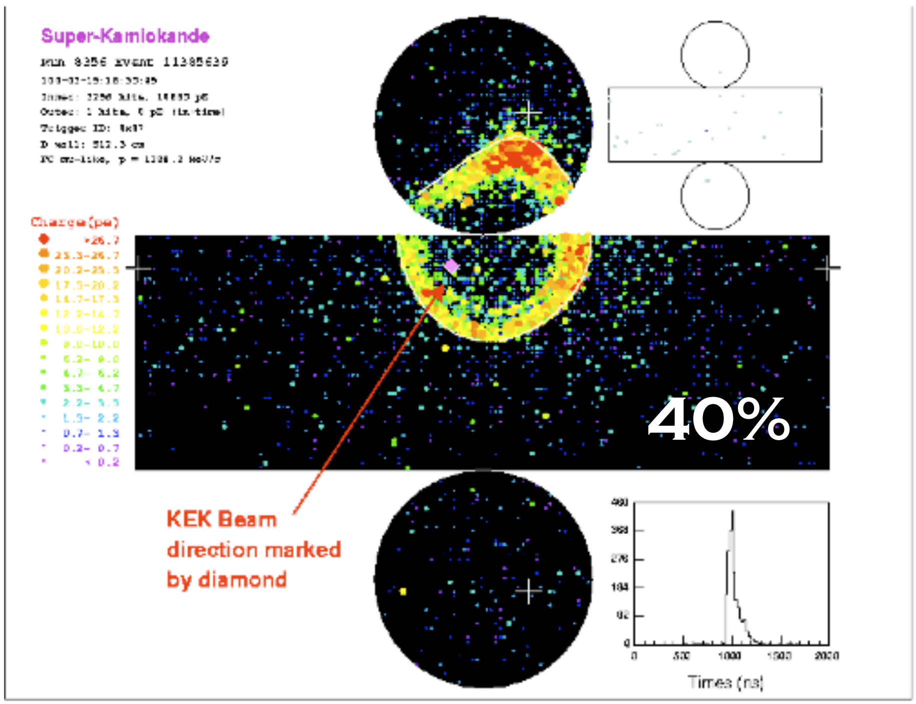
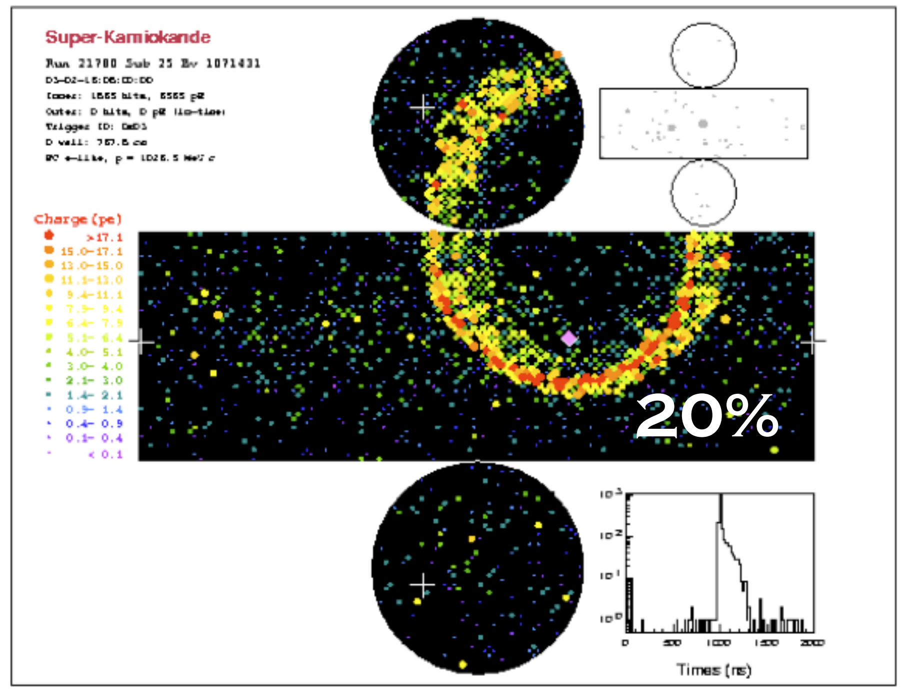


Photo of SK-III construction with both 40% and 20% coverage visible.

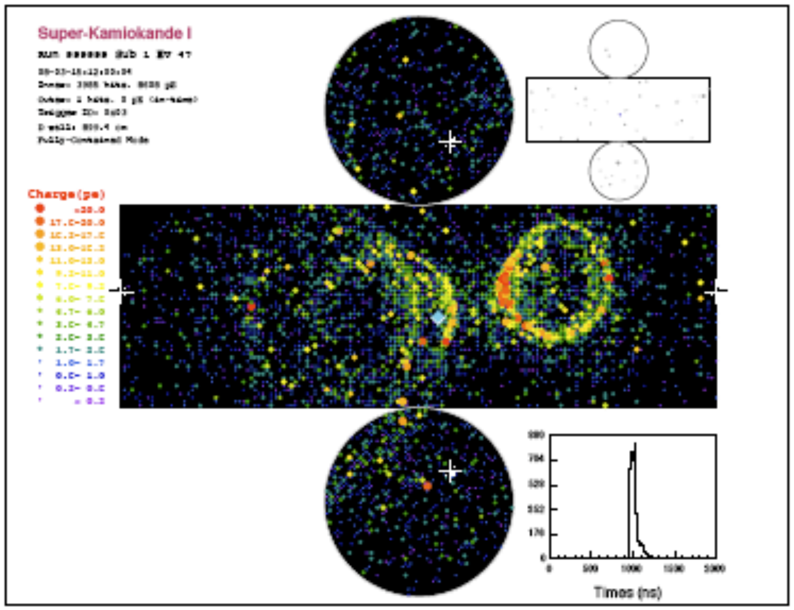
Data: 1 GeV neutrinos from a beam

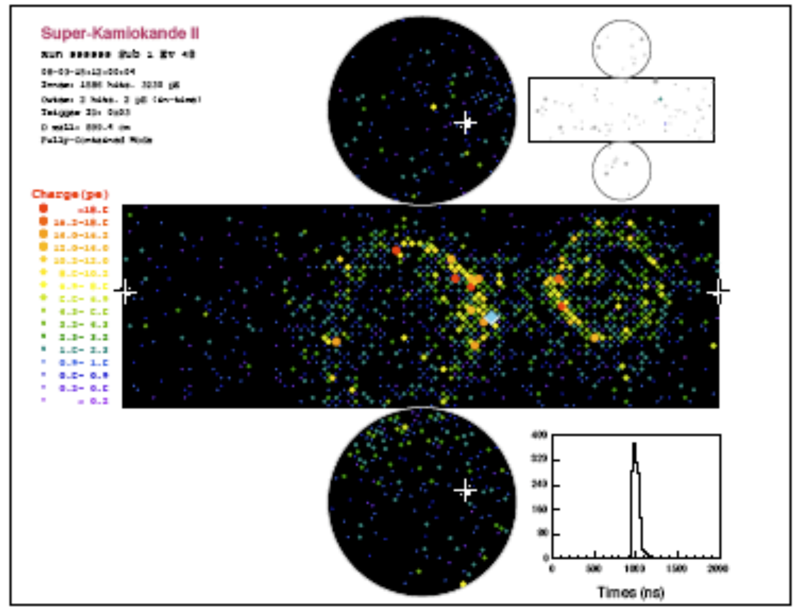
From K2K experience



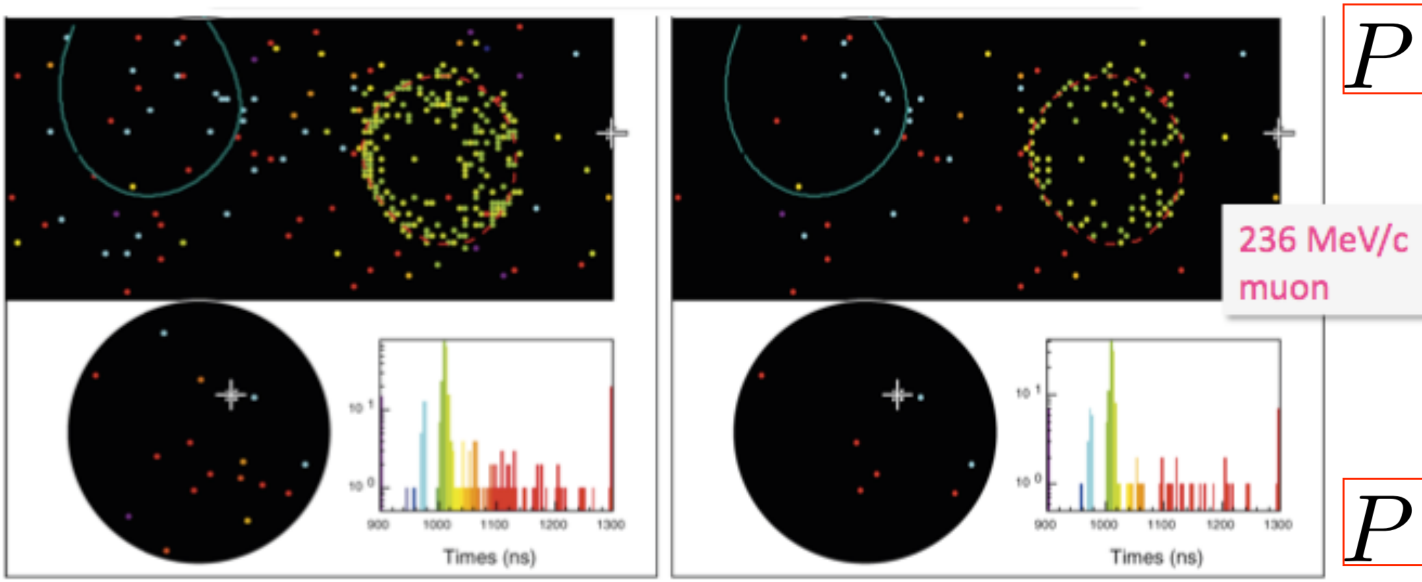


PDK MC: Multi-ring, or less energy is harder



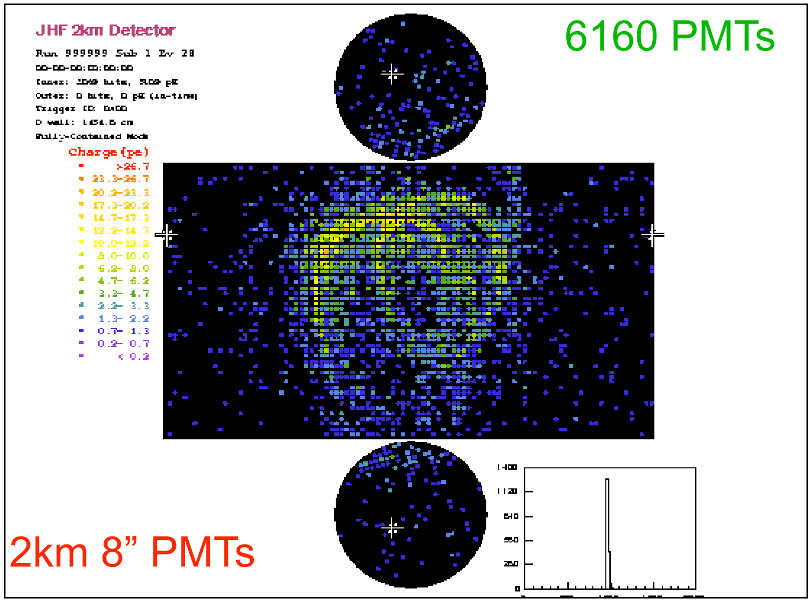


$$P \rightarrow e^{+}\pi^{0}$$

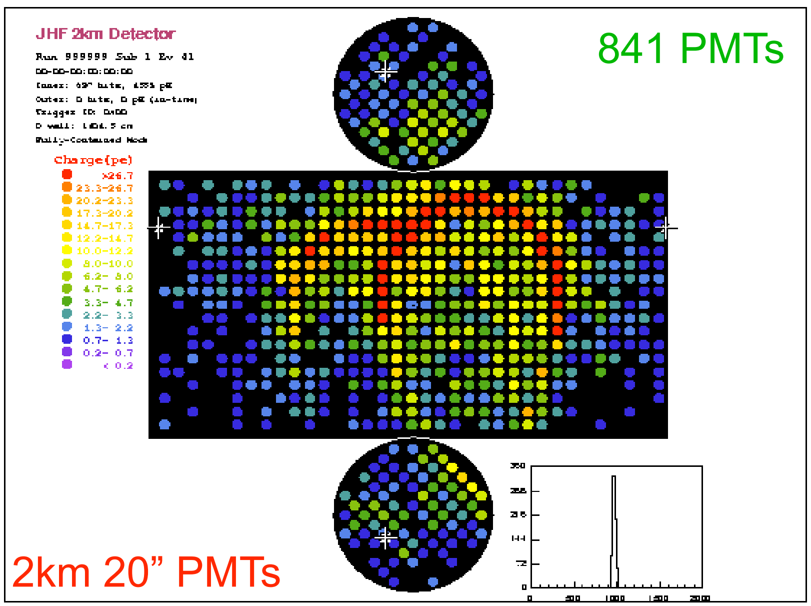


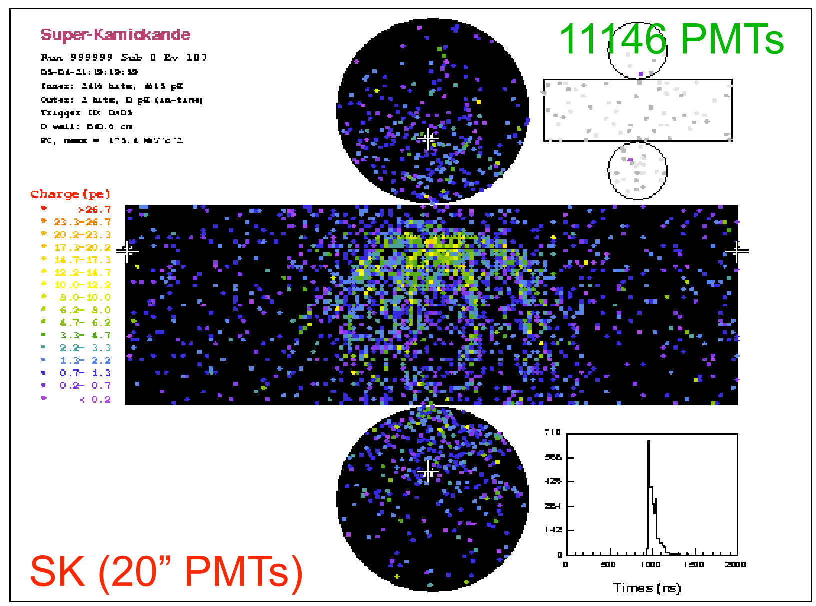
$$P \rightarrow K^{+}\nu$$

T2K MC: Comparison of pizero in GEANT4 8” and 20” 2KM WC and SK viewed with SK event display.



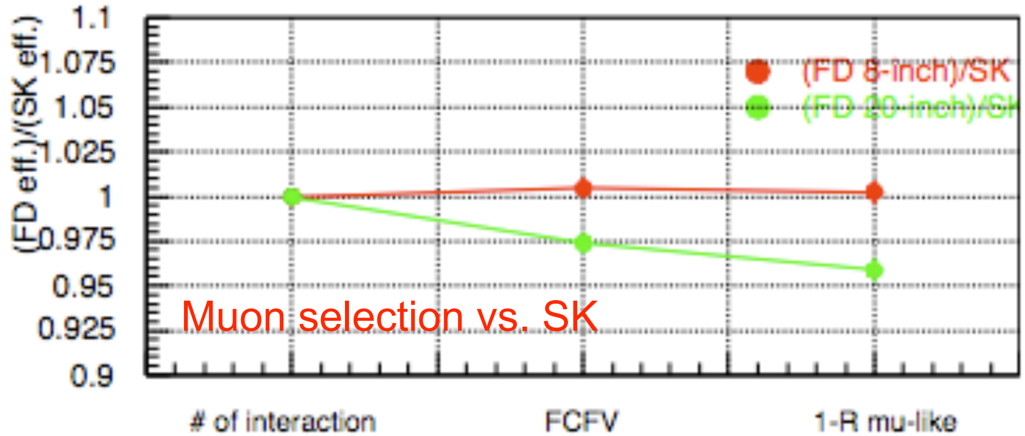
Also simulate 1kton at K2K
analyze data with modified SK tools and
compare with real neutrino data

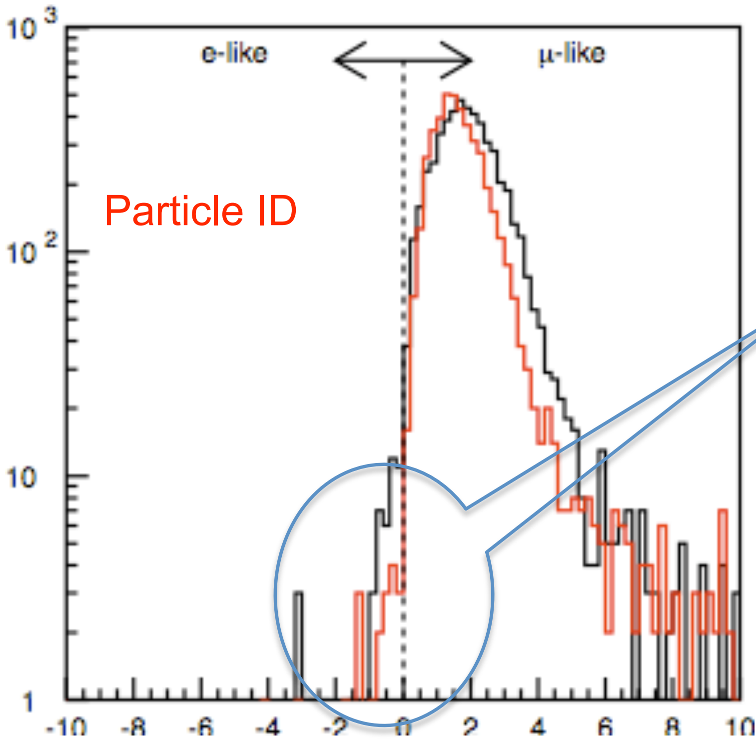




Examples from performance studies.

8” vs. 20” studies





Better mis-id performance with 8”

These sort of basic performance tests should be done to optimize a design. Don’t only check the output of a full physics analysis.

From Ed's NP08 talk

Comparison of 40% and 20% coverage

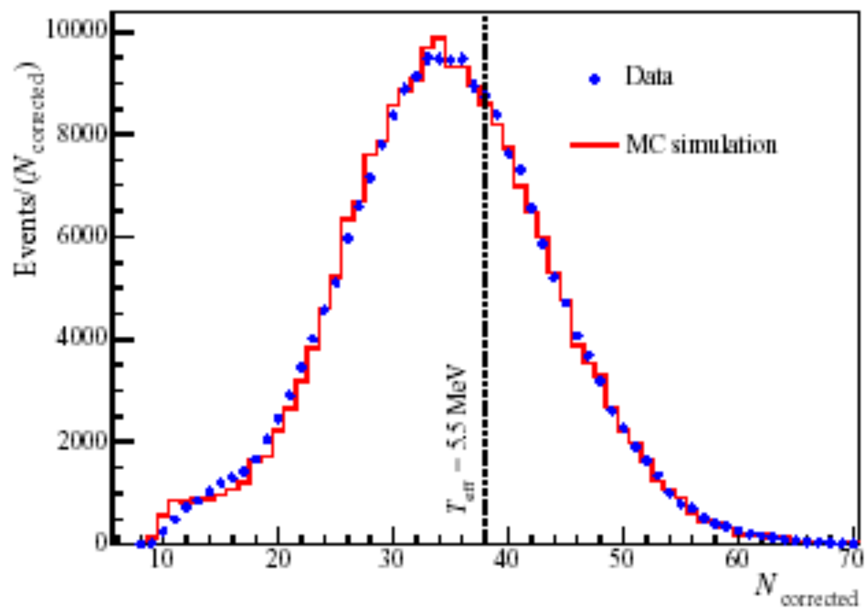
	Super-K I (40% coverage)	Super-K II (20% coverage)
Sub-GeV vertex resolution	26 cm (e-like) / 23 cm (μ-like)	30 cm (e-like) / 29 cm (μ-like)
Sub-GeV particle mis-ID	0.81% (e-like) / 0.70% (μ-like)	0.69% (e-like) / 0.96% (μ-like)
Sub-GeV momentum resolution	4.8% (e-like) / 2.5% (μ-like)	6.3% (e-like) / 4.0% (μ-like)
$p \rightarrow e^+\pi^0$ signal efficiency	45.0 ±1.3 ±6.7%	42.2 ±1.2 ±6.5%
$p \rightarrow e^+\pi^0$ background	0.4 (±35%) events/100kty	0.04 (±35%) events/100kty
$p \rightarrow K^+\nu$, γ tag signal efficiency	8.4±0.1 ±1.7%	4.7±0.1 ±1.0%
$p \rightarrow K^+\nu$, γ tag background	0.72 (±28%) events/100kty	1.4 (±30%) events/100kty
$p \rightarrow K^+\nu$, $\pi^+\pi^0$ signal efficiency	5.5 ±0.1 ±0.7%	5.7 ±0.1 ±0.4%
$p \rightarrow K^+\nu$, $\pi^+\pi^0$ background	0.59(±28%) events/100kty	1.0(±30%) events/100kty
T2K CCν_e likelihood effic.	83.7% (±0.1% stat)	84.8 %
T2K BG likelihood effic.	21.3 %	21.5 %

Preliminary numbers, for comparison purposes.
Final published efficiencies and BG may differ.

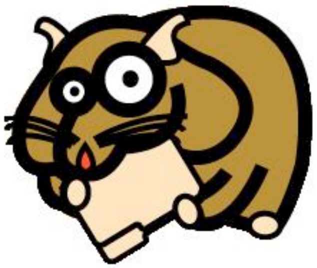
SNO Monte Carlo and Analysis

- Primarily FORTRAN and CERNLIB
- Detailed geometry all home brewed, tough to change
- All optics home brewed
- EGS4 for EM showers
- MCNP for neutrons
- FLUKA for hadrons
- HEPDB for detector constants database

Very well calibrated →



Josh Klein



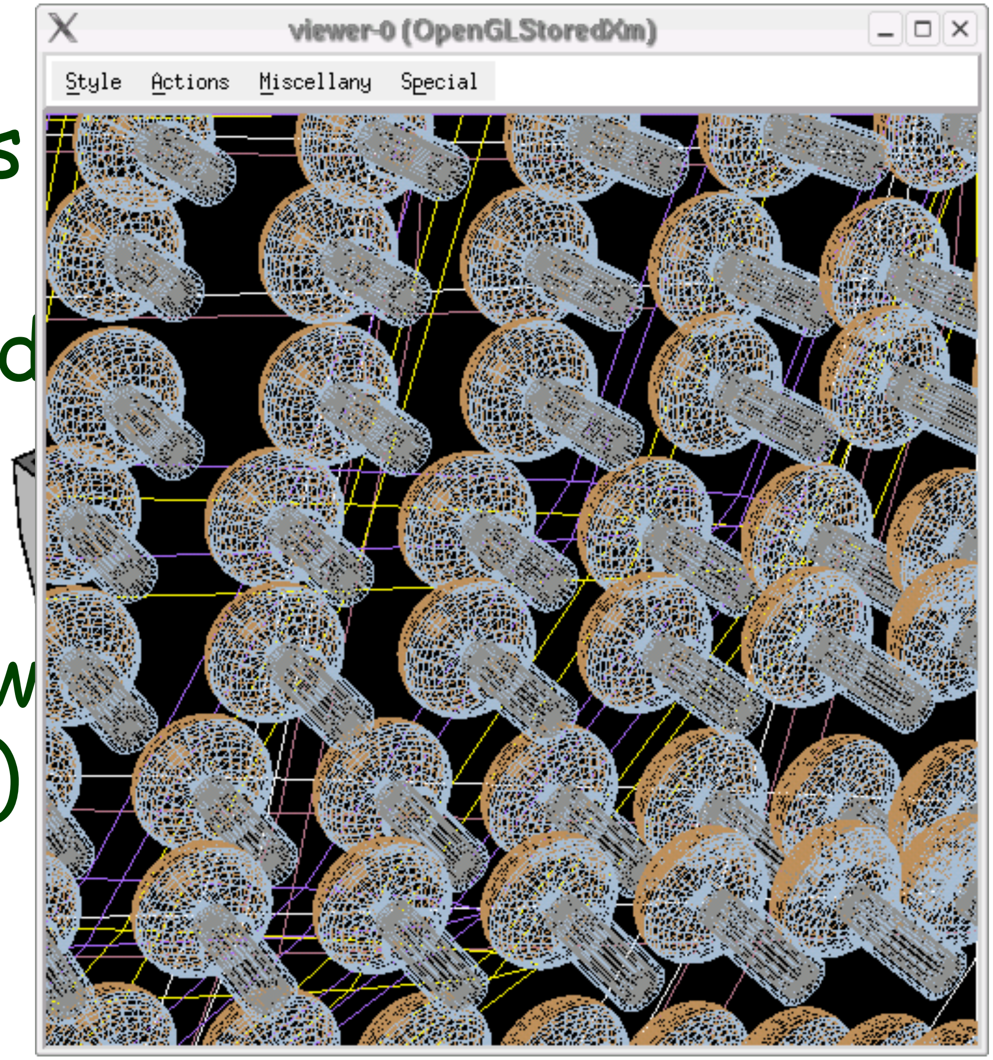
RAT Simulation and Analysis Tool

- Written by S. Seibert for Braidwood
- Now adopted by SNO+ and DEAP/CLEAN as simulation
- Relies on GEANT4, GLG4SIM (G. Horton-Smith), CLHEP,root
- Processor philosophy very similar to SNOMAN
- Data structure similar in design to SNOMAN

Josh Klein

Detector Geometry

- Detector materials and geometric construction loaded from RATDB
- User-editable without writing new code (within limits)
- Override parameters in macros



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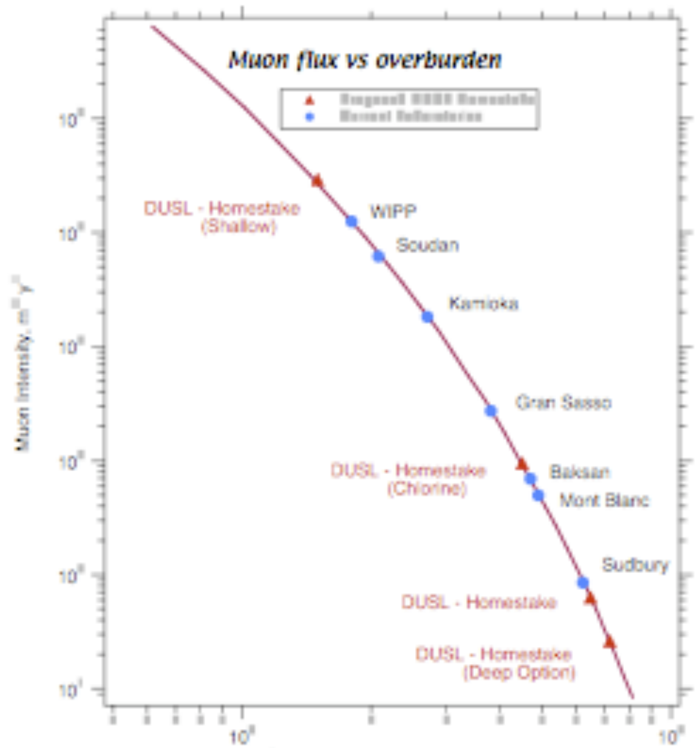
Info on veto

(do we need it?)



IMB Depth (1570 mwe) ~
Kamioka depth (2400 mwe) ~11,000 m^2/yr
DUSEL depth (4850 level) ~ 900 m^2/yr

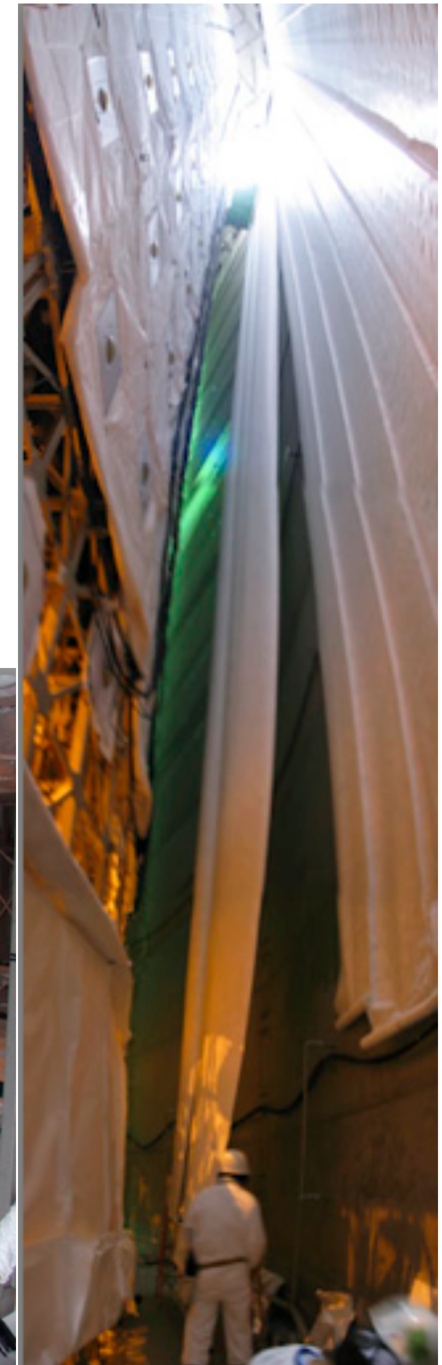
SK: 40m x 40m detector -> 3 hz muon rate.
SK Veto: ~ 1/10 the inner detector tubes. 8" tubes + wavelength shifter plates.
Atmospheric neutrino contamination: ~ 0.1 - 0.2%

IMB no veto: Although muon flux x10 SK, muon rate almost the same with ~ 15% of the neutrino rate because of detector size.

- Beam Physics (clearly not needed)
- PDK ?
- Low energy relic neutrinos (probably needed)
- No veto: cheaper/simpler + more mass.
- Veto: May give us access to some physics topics

CWW Opinion



Available Resources

- People
  - Scientists (SK, SNO, IceCube, Memphys)
  - Requested Postdocs (½ time DUSEL + ½ time other)
  - Request in S4 was 4 postdocs/yr
- Until we get S4 money we won't have postdocs to do work but the scientists can start meeting to understand the questions and baseline options.

Conclusions

- We have to start by addressing basic questions of size and coverage and geometry.
- We need to understand how different physics topics map onto these requirements.
- We should produce baseline numbers and costs for options associated with these physics topics (Ex: High Energy only, HE + Supernova).
- We need resources in order to do this work.