Prospects for the SNO combined 3-phase neutrino oscillation analysis

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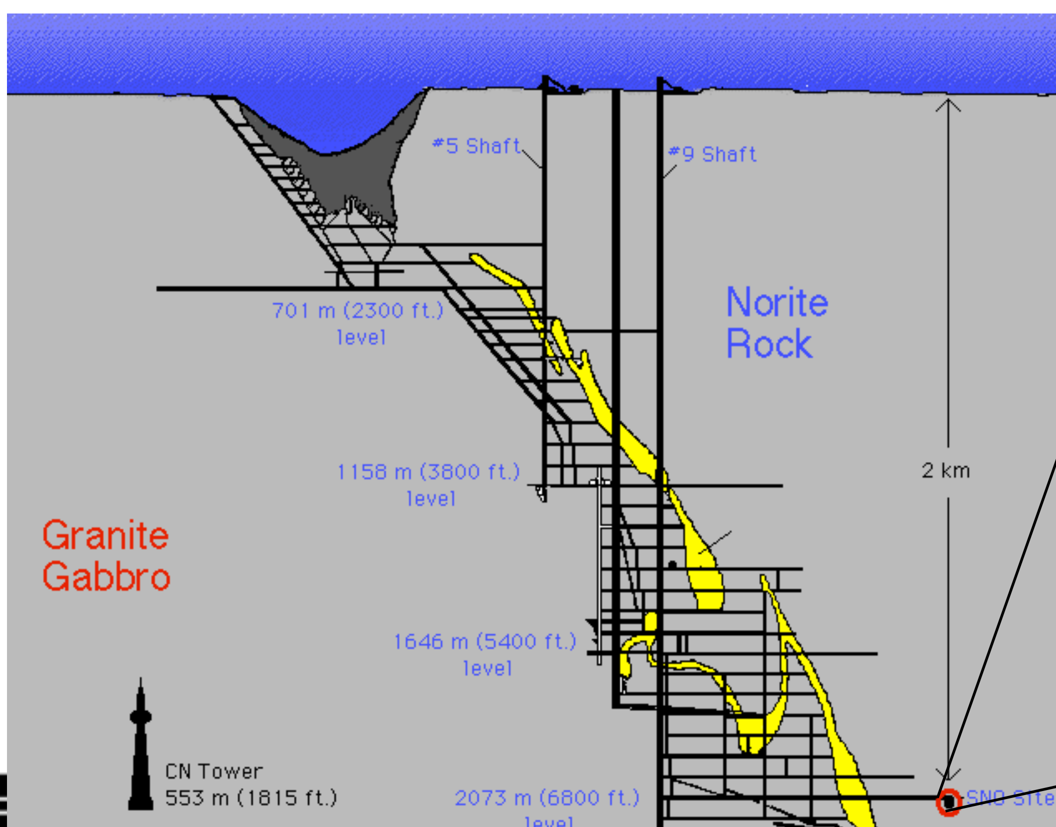
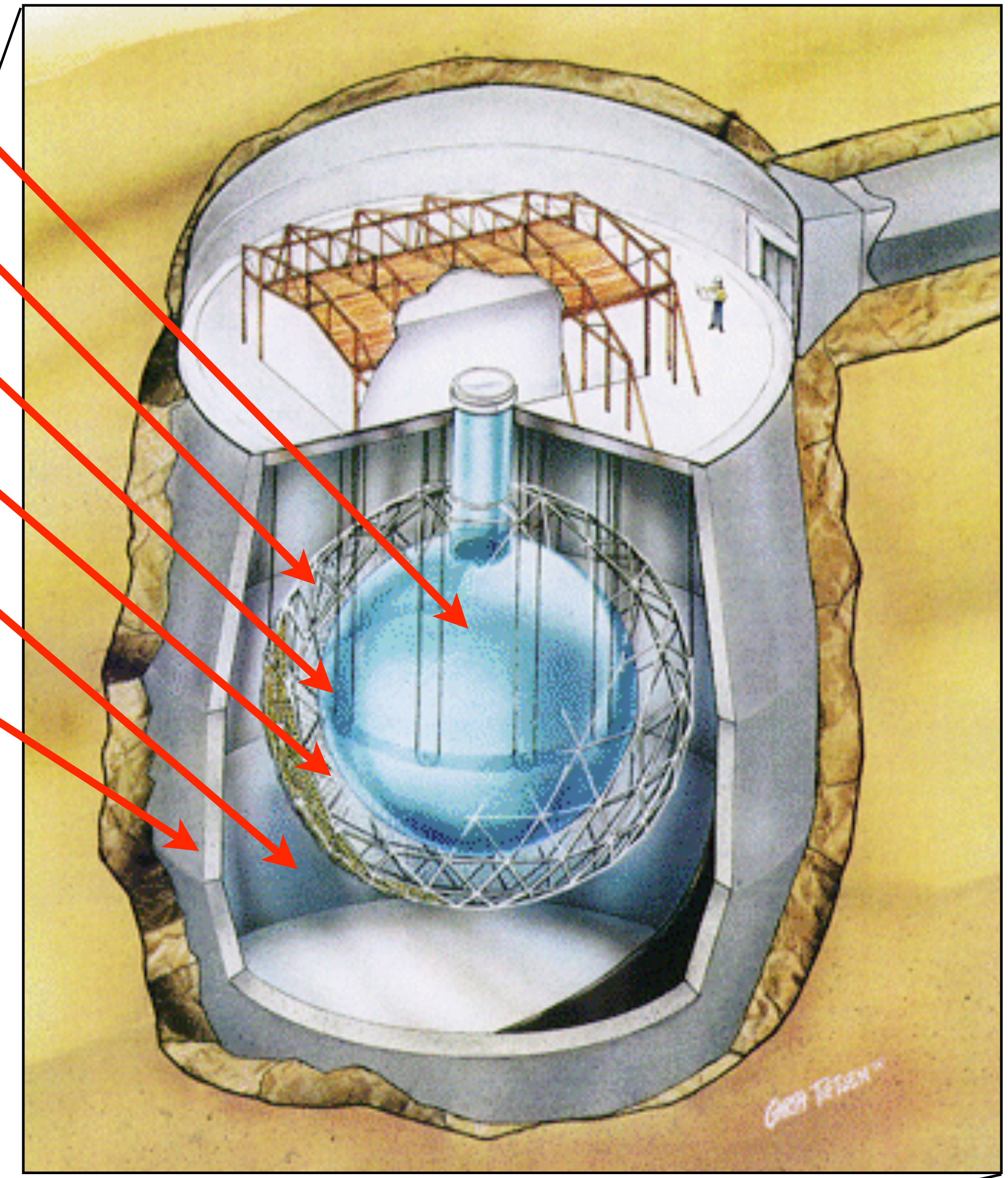
Outline

- Introduction
  - The SNO detector
- Previous results
- 3-phase combined analysis
- Oscillation analysis

Sudbury Neutrino Observatory (SNO)

- Heavy Water (D_2O): 1000 ton
- Support structure for 9500 PMTs (~54% coverage)
- Acrylic vessel (AV): 12m diameter
- Internal H_2O shielding: 1700ton
- External H_2O shielding: 5300ton
- Urylon liner: Radon seal

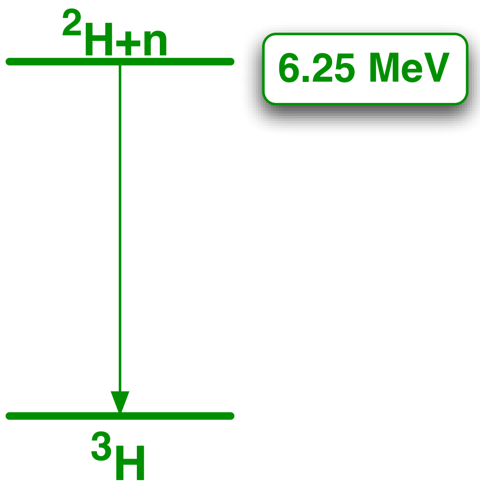


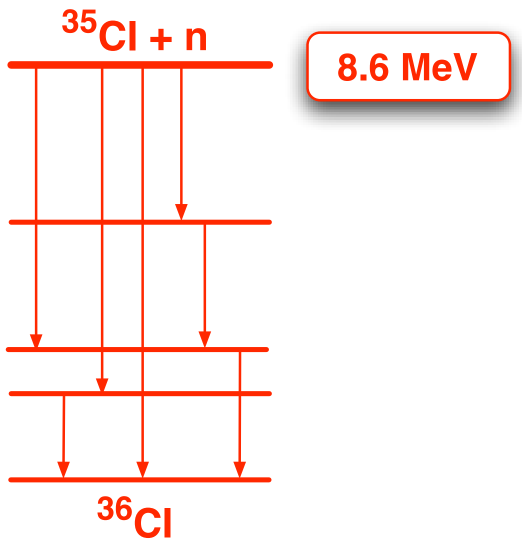


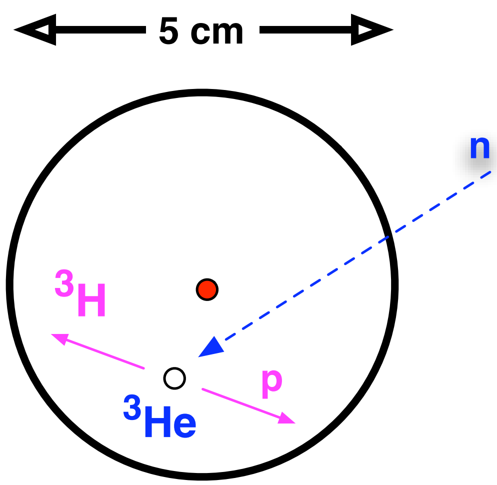
Creighton Mine, Sudbury, Canada
2039m depth
6000 mwe

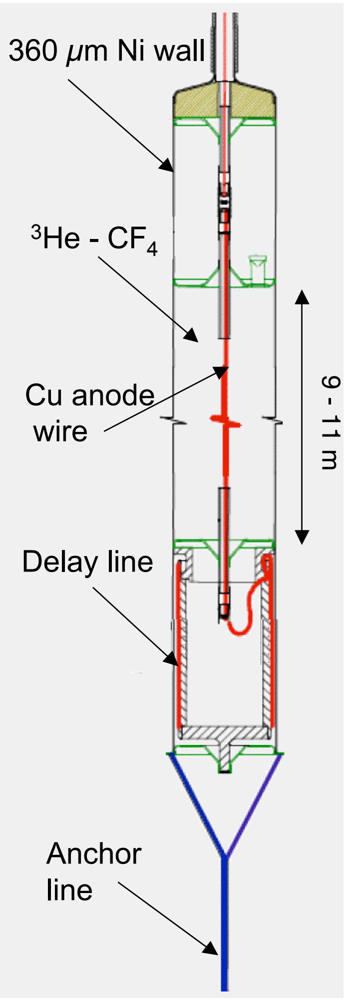
SNO program

Phase I (D_2O) Nov 99 - May 01	Phase II (salt) July 01 - Sep 03	Phase III (^3He) Nov 04 - Nov 06
	2t NaCl	40 proportional counters
$^2H(n,\gamma)^3H$	**$^{35}Cl(n, \gamma)^{36}Cl$**	**$^3He(n,p)^3H$**
σ=0.0005 b Single 6.25MeV γ	σ=44 b Multiple γ	σ=5330 b **p** and **^3H** independent readout
Good CC	**Enhanced NC**	**Event by event NC**

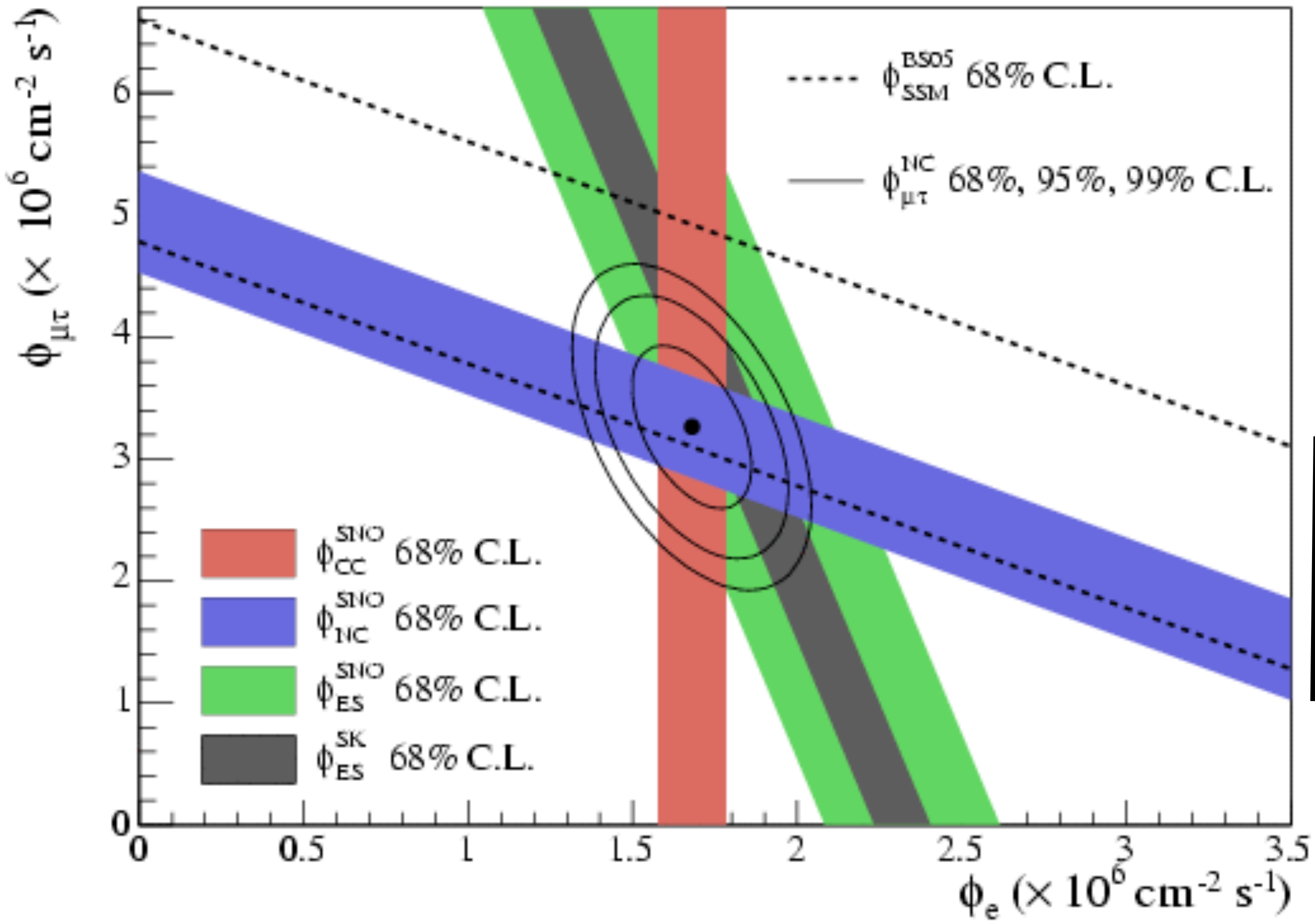








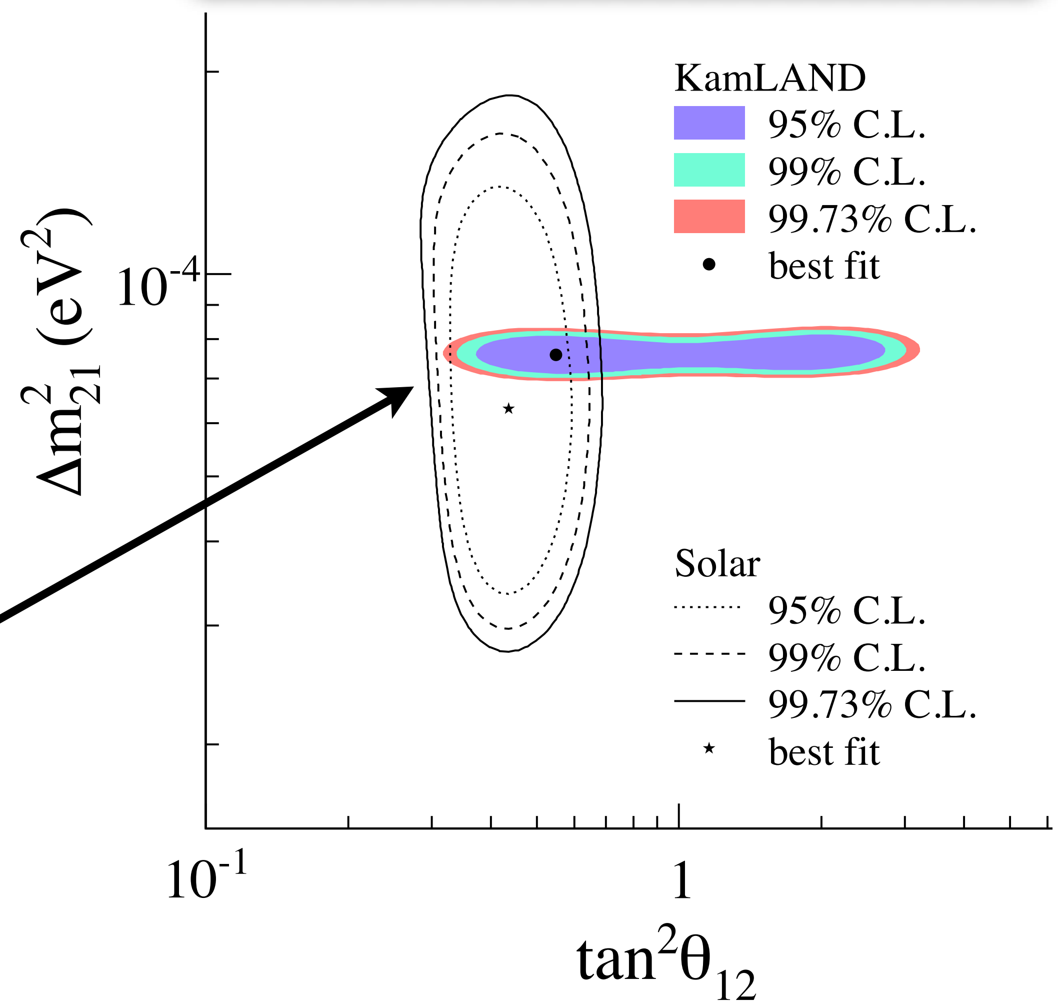
Overview of previous results



- Agreement with solar models

- Agreement with KamLAND

  (oscillations confirmed)



Upcoming analyses

- No more data, so what's new?
- Refinement of the analysis
  - Event reconstruction
  - Better Monte Carlo Simulations
  - Background cuts and estimations
- Analysis of combined phase I+II at 3.5MeV threshold
  - Talk by Hallin
- **Analysis of combined phases I+II+III**

Combined 3-phase analysis

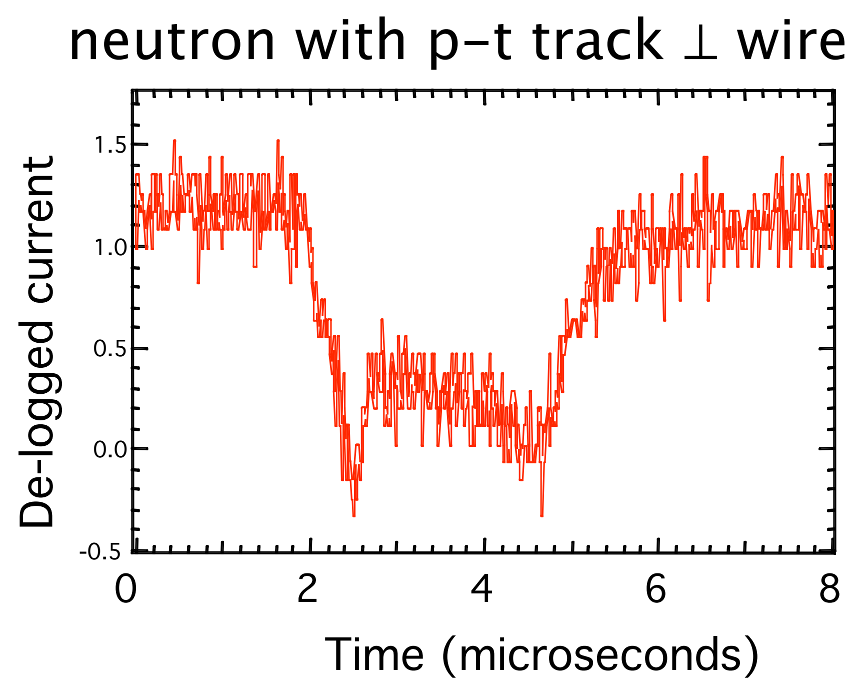
- Combine the data sets from 3 SNO phases
- Advantages
  - ~3 livetime years of data into a single data set (better statistics)
  - Analysis improvements lead to better systematics
    - Signals and error correlations are better handled by combining all data
  - Cross information from a specific phase with others
    - NCD phase enhanced NC measurement

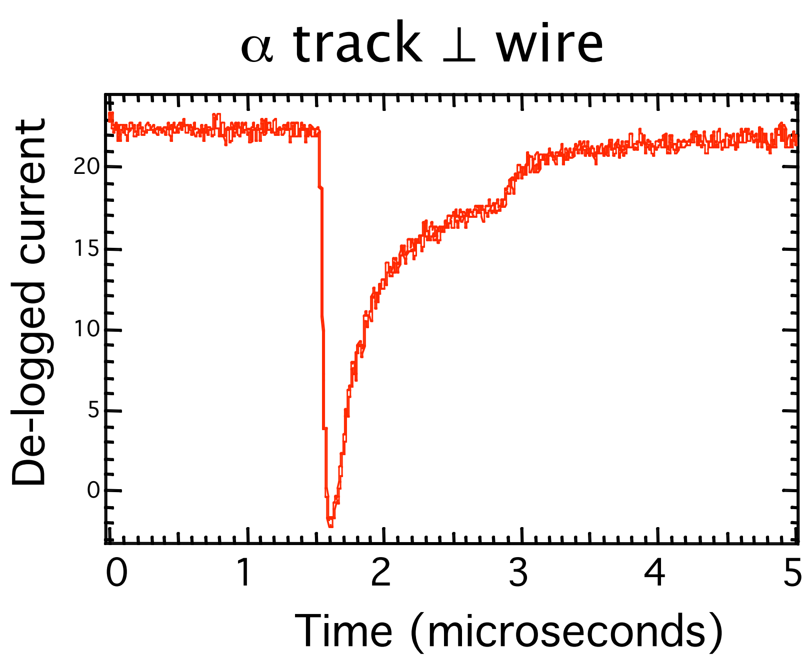
Combined 3-phase analysis

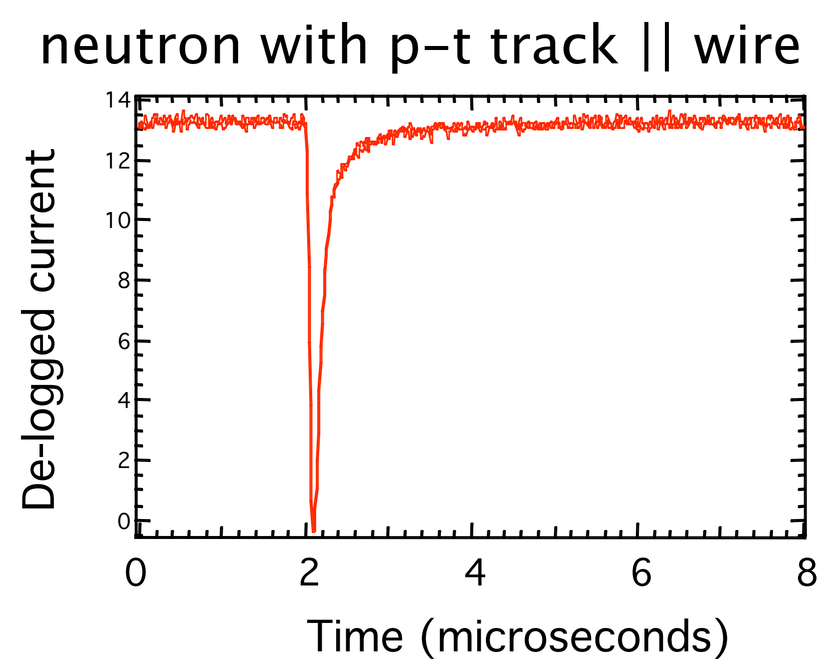
- NCD phase Pulse Shape Analysis (PSA) will be introduced as a constrain to NC

  - Event-by-event analysis of pulse shapes

  - Digitisation of pulse shapes for particle identification





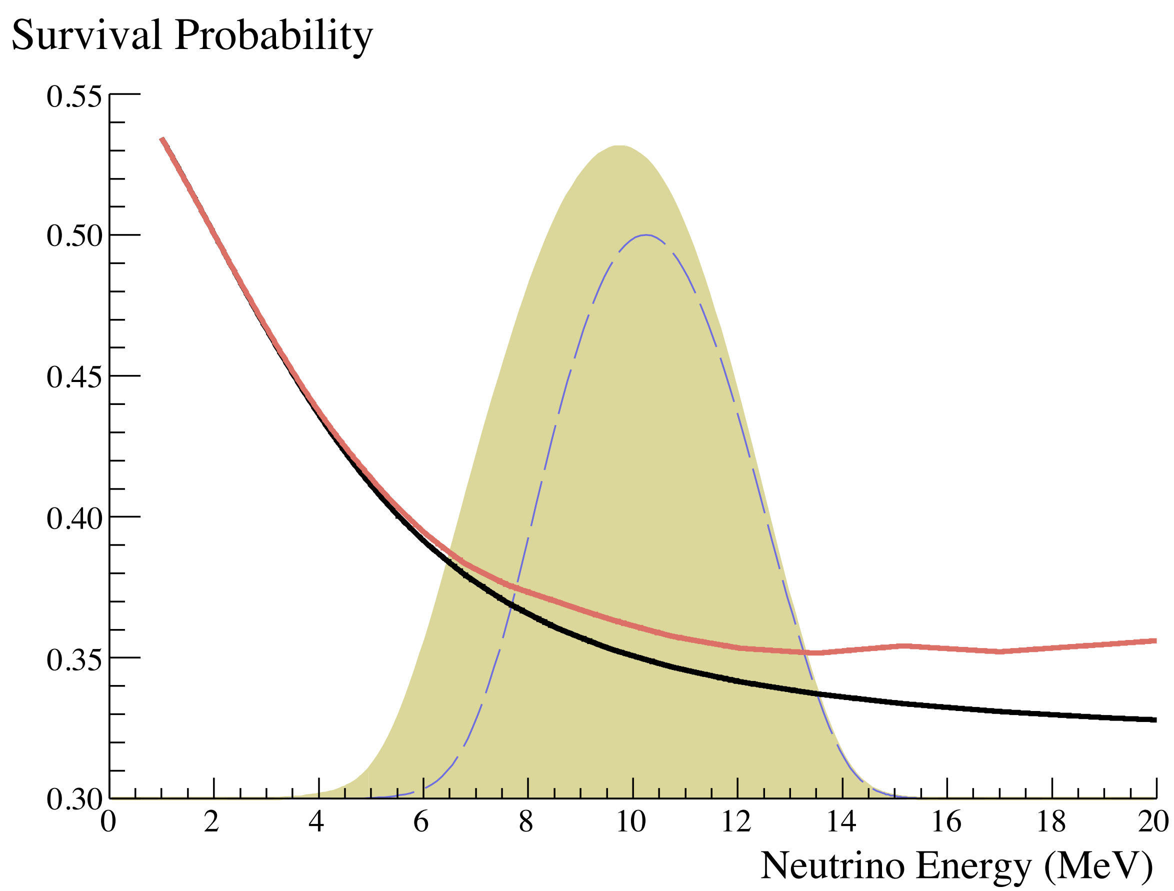


3-phase analysis

- Difficulties
  - “Traditional” effective energy unconstrained fit entangles neutrino physics with detector response
  - The energy response is considerably different between phases
    - In particular between phase III and others
- Solution:
  - Fit directly for the neutrino survival probability (P_{ee})

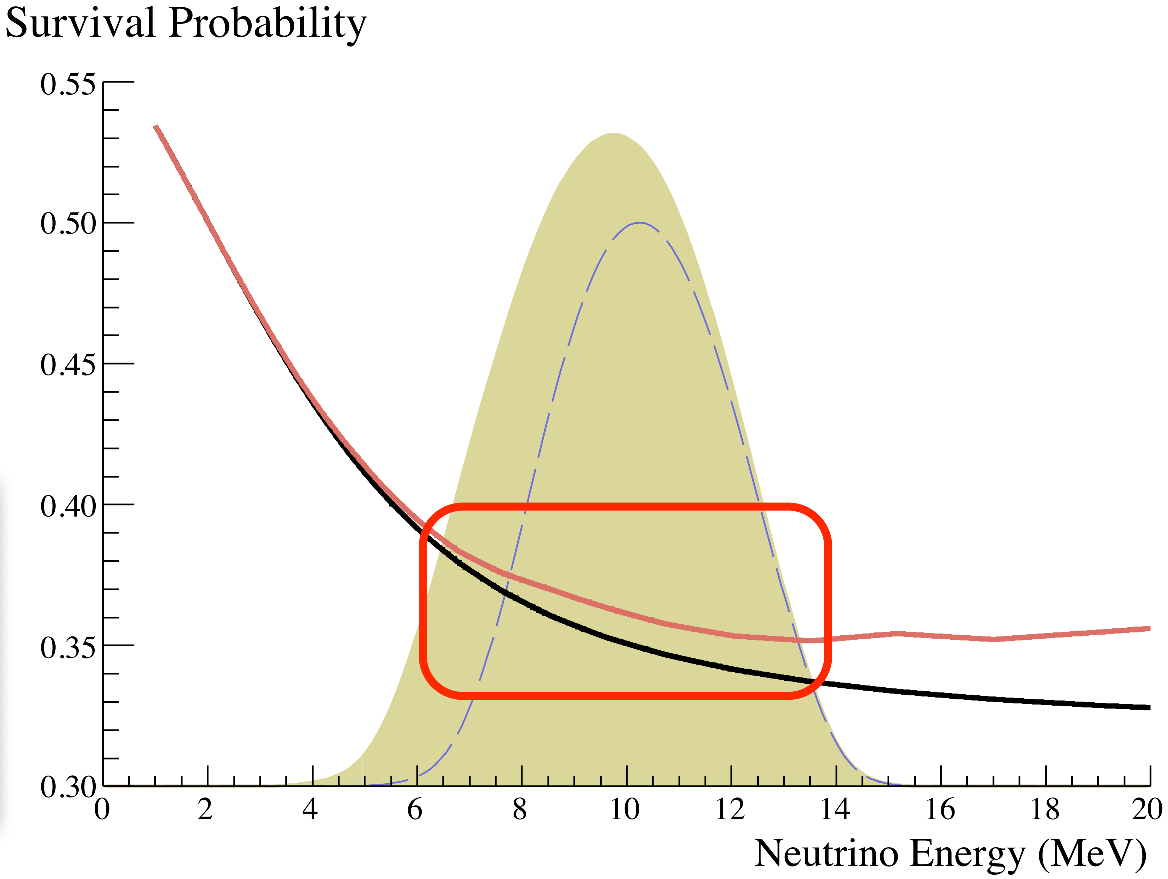
P_{ee} fit

- Standard SNO Signal Extraction with Energy, Isotropy, Radius and cos θ_{sun}
  - Free parameters
    - Total ^{8}B flux
    - Day & Asymmetry Survival probability coefficients
    - Background rates
    - Detector systematics
- Will work directly on neutrino energy
  - Common to all phases
  - Break phase correlations
  - Search directly for spectral distortion



Oscillation analysis

- Better understand the survival probability of solar neutrinos
  - Scale of Pee
- ^{8}B spectrum shape distortion
- Determine the mixing parameters generating the matter-enhanced effect (MSW)

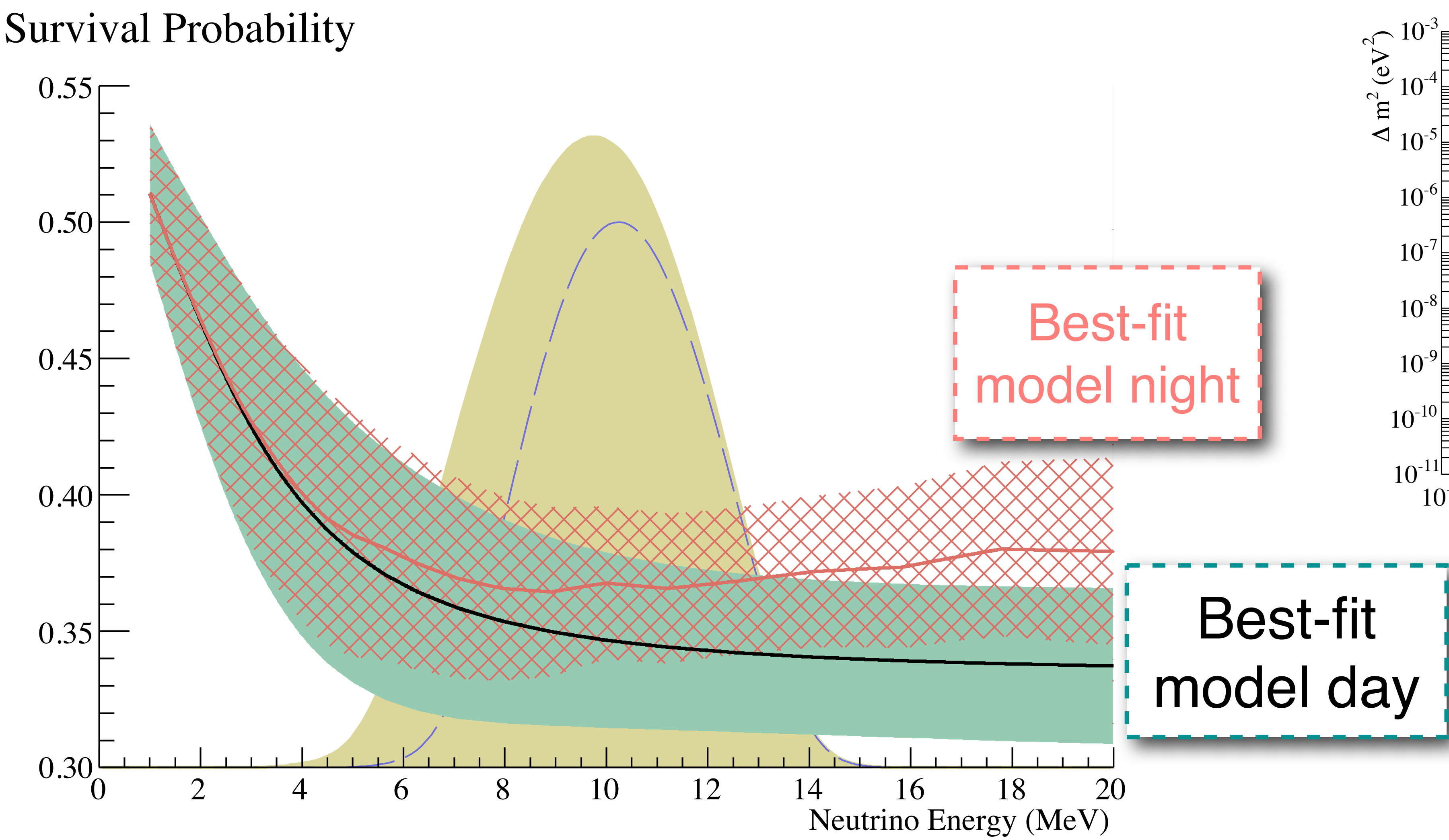


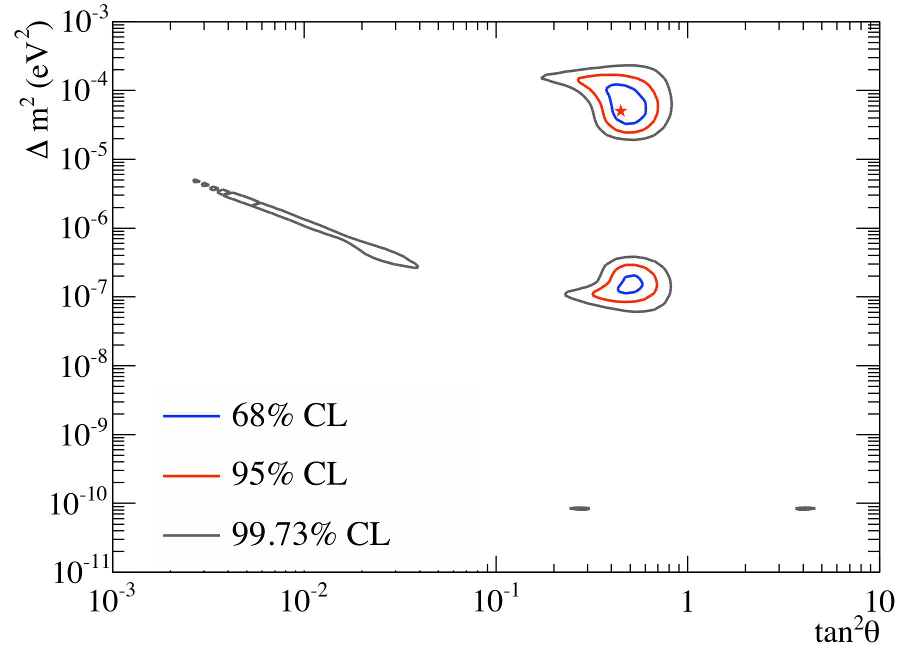
- Previous SNO data consistent with a flat Pee

Oscillation analysis (II)

- New questions introduced
  - Is there a distortion from a flat Pee?
  - Can we do better on the mixing parameters with a Pee curve?
  - Is the effective 2v parameterisation enough? By fixing θ_{13} are we artificially constraining θ_{12}?
    - Shall the residual discrepancy between experiments disappear by introducing θ_{13}?

Survival probability (Pee)





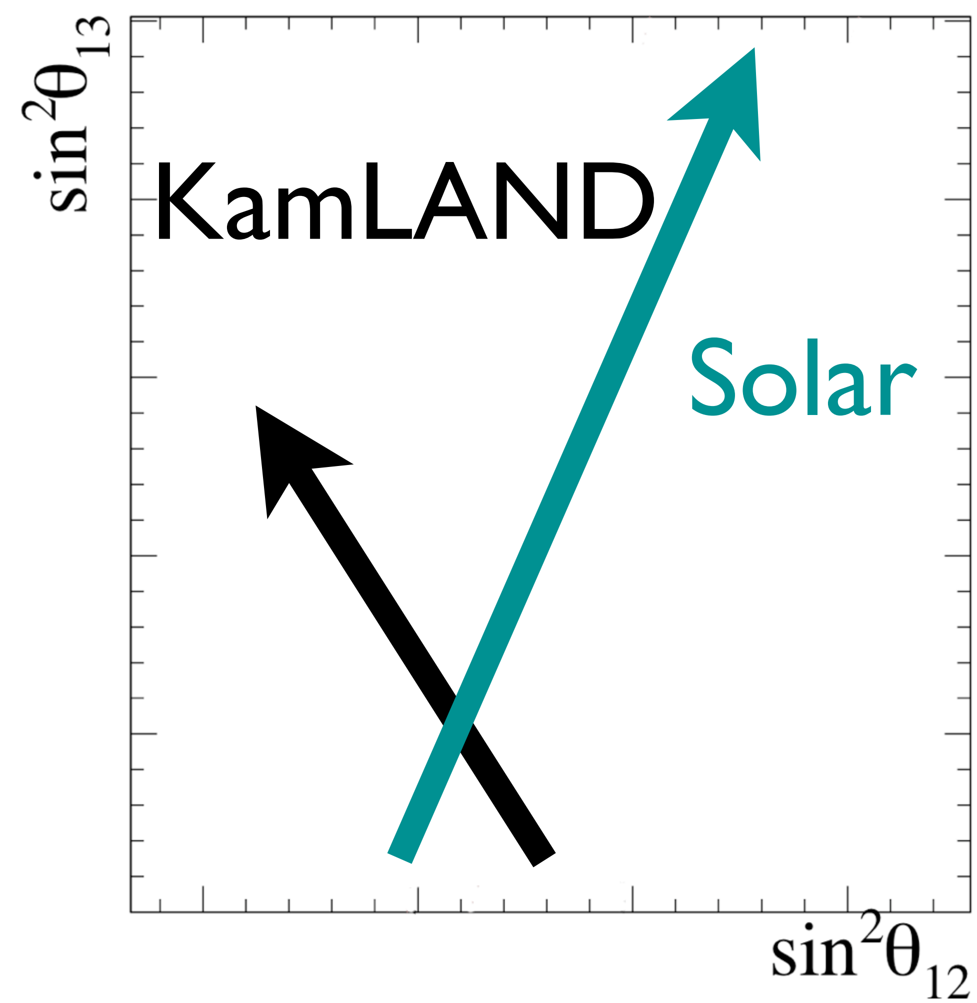
SNO salt phase

PRC 72, 055502 (2005)

- 68% CL model spread of Pee
  - With a common curve for all phases should yield a better result

3ν analysis (θ_{13})

- New precision results could push θ_{12} further away from KamLAND best fit
  - Hint of non-zero θ_{13}
    - KamLAND moves towards lower values of θ_{12}
    - SNO moves towards larger θ_{12}



- A 3ν oscillation analysis will be performed on SNO-only data
  - A 3ν global analysis will also be performed

Expected results

- SNO already provides a good constrain on θ_{12}
  - With the combination of 3 phases we expect to improve it
- Perform a 3v analysis
  - Any limit on θ_{13} will be propagated into a global analysis
- Search of a spectral distortion in Pee
  - Obtain an improved measurement of ^{8}B flux

Summary

- SNO data taking is over but the analysis continues strong
- 3-phase combined analysis output will be ^{8}B flux and energy-dependent survival probability
  - Moving from search physics to precision physics
- A 3ν analysis will be carried out
  - Can we get a better result by using Pee as input?
  - How significant could be a limit on θ_{13} ?
- Interesting results are coming soon...