

# Summary of the Sterile Neutrinos at the Crossroads Workshop

Jonathan Link

Virginia Tech

Pre-High Intensity Workshop, Fermilab

10/24/2011

# Workshop Objective

The goal of this workshop was to bring together experts in the various sub-disciplines – such as nuclear and particle theory and experiment, cosmology, and neutrino phenomenology – in order to critically review the evidence for and against sterile neutrinos and to discuss the need *or otherwise* to pursue dedicated new experiments and possibly new strategies.

# Workshop Program

## Monday 26 September 2011

- 09:00 - 10:30 Session 1  
Convener: Djordje Minic (Virginia Tech)
- 09:00 **Particle Theory Review 45'**  
Speaker: Paul Langacker (IAS, Princeton)
- 09:45 **Astrophysics Theory Review 45'**  
Speaker: Kevork Abazajian (University of California Irvine)
- 11:00 - 12:30 Session 2  
Convener: Gabriel Oribi Gann (University of Pennsylvania)
- 11:00 **LSND 35'**  
Speaker: William Louis (LANL)
- 11:35 **MiniBoONE 35'**  
Speaker: Geoff Mills (LANL)
- 12:10 **Bolometric Neutral Current Search 20'**  
Speaker: Joseph Formaggio (MIT)
- 14:00 - 15:30 Session 3  
Convener: Adam Bernstein (Livermore National Laboratory)
- 14:00 **Short Baseline Reactor Measurements 30'**  
Speaker: Yves Declais (IN2P3)
- 14:30 **Cumulated Beta Spectrum Measurement from Fission Products at ILL and FRM II 30'**  
Speaker: Klaus Schreckenbach (TU Muenchen)
- 15:00 **Nuclear Theory of Reactor Neutrino Fluxes 30'**  
Speaker: Petr Vogel (Caltech)
- 16:00 - 17:30 Session 4  
Convener: Robert McKeown (Jefferson Lab)
- 16:00 **Recent Re-evaluation of Reactor Neutrino Fluxes 45'**  
Speaker: David Lhuillier (CEA)
- 16:45 **Global Oscillation Fits 45'**  
Speaker: Thomas Schwetz-Mangold (MPK Heidelberg)

## Tuesday 27 September 2011

- 09:00 - 10:30 Session 5  
Convener: Werner Rodejohann (Max-Planck-Institut für Kernphysik)
- 09:00 **Sterile Neutrinos and CMB/LSS 30'**  
Speaker: Yvonne Wong (RWTH Aachen)
- 09:30 **Sterile Neutrinos and Supernova Nucleosynthesis 30'**  
Speaker: Rebecca Surman (Union College)
- 10:00 **Phenomenological Alternatives to Sterile Neutrinos 30'**  
Speaker: Gabriela Barenboim (U. of Valencia)
- 11:00 - 12:30 Session 6  
Convener: Georga Karagiorgi (Columbia University)
- 11:00 **Borexino Source Experiment 30'**  
Speaker: Gioacchino Ranucci (INFN Milano)
- 11:30 **51Cr Source Experiments 30'**  
Speaker: Jonathan Link (VirginiaTech)
- 12:00 **LENS Source Experiment 30'**  
Speaker: Ramaswamy Raghavan (Virginia Tech)

- 14:00 - 15:30 Session 7  
Convener: Karsten Heeger (University of Wisconsin-Madison)
- 14:00 **RENO 20'**  
Speaker: Yeongduk Kim (Sejong U.)
- 14:20 **Double Chooz 20'**  
Speaker: Jelena Maricic (Drexel U.)
- 14:40 **Daya Bay 20'**  
Speaker: Liang Zhan (IHEP Beijing)
- 15:00 **New Short Baseline Reactor Experiments 20'**  
Speaker: Nathaniel Bowden (LLNL)
- 16:00 - 17:30 Session 8  
Convener: Hamish Robertson (University of Washington)
- 16:00 **Atmospheric Neutrinos as a Probe of the Sterile Sector 20'**  
Speaker: Raj Gandhi (HCRI)
- 16:20 **IceCube Sterile Sensitivity 20'**  
Speaker: Soebur Razzaque (George Mason U.)
- 16:40 **MINOS 30'**  
Speaker: Alexandre Sousa (Harvard)
- 17:10 **Discussion on Prospects of Non-accelerator based Experiments 20'**
- 17:30 - 18:30 Posters Session

## Wednesday 28 September 2011

- 09:00 - 10:30 Session 9  
Convener: Wei Wang (College of William and Mary)
- 09:00 **Future Beam Experiments on Sterile Neutrinos 30'**  
Speaker: Roxanne Guenette (Yale University)
- 09:30 **Stopped Pion Beams 30'**  
Speaker: Gerry Garvey (LANL)
- 10:00 **Evidence from Particle Physics 30'**  
Speakers: William Louis (LANL), Concha Gonzalez-Garcia (U. of Barcelona)
- 11:00 - 12:30 Session 10  
Convener: Osamu Yasuda (Tokyo Metropolitan University)
- 11:00 **Evidence from Astrophysics 30'**  
Speaker: Gail McLaughlin (NCSU)
- 11:30 **Discussion 45'**
- 12:15 **Plans for a White Paper 15'**  
Speakers: Patrick Huber (Virginia Tech), Jonathan Link (VirginiaTech)
- 13:30 - 18:30 KURF Tour  
Convener: Bruce Vogelaar (Virginia Tech)

All talk slides can be viewed at:

<http://www.cpe.vt.edu/snac/>

# Theory and Phenomenology

## Monday 26 September 2011

- 09:00 - 10:30 Session 1  
Convener: Djordje Minic (Virginia Tech)
- 09:00 **Particle Theory Review 45'**  
Speaker: Paul Langacker (IAS, Princeton)
- 09:45 **Astrophysics Theory Review 45'**  
Speaker: Kevork Abazajian (University of California Irvine)
- 11:00 - 12:30 Session 2  
Convener: Gabriel Oribi Gann (University of Pennsylvania)
- 11:00 **LSND 35'**  
Speaker: William Louis (LANL)
- 11:35 **MiniBoONE 35'**  
Speaker: Geoff Mills (LANL)
- 12:10 **Bolometric Neutral Current Search 20'**  
Speaker: Joseph Formaggio (MIT)
- 14:00 - 15:30 Session 3  
Convener: Adam Bernstein (Livermore National Laboratory)
- 14:00 **Short Baseline Reactor Measurements 30'**  
Speaker: Yves Declais (IN2P3)
- 14:30 **Cumulated Beta Spectrum Measurement from Fission Products at ILL and FRM II 30'**  
Speaker: Klaus Schreckenbach (TU Muenchen)
- 15:00 **Nuclear Theory of Reactor Neutrino Fluxes 30'**  
Speaker: Petr Vogel (Caltech)
- 16:00 - 17:30 Session 4  
Convener: Robert McKeown (Jefferson Lab)
- 16:00 **Recent Re-evaluation of Reactor Neutrino Fluxes 45'**  
Speaker: David Lhuillier (CEA)
- 16:45 **Global Oscillation Fits 45'**  
Speaker: Thomas Schwetz-Mangold (MPK Heidelberg)

## Tuesday 27 September 2011

- 09:00 - 10:30 Session 5  
Convener: Werner Rodejohann (Max-Planck-Institut für Kernphysik)
- 09:00 **Sterile Neutrinos and CMB/LSS 30'**  
Speaker: Yvonne Wong (RWTH Aachen)
- 09:30 **Sterile Neutrinos and Supernova Nucleosynthesis 30'**  
Speaker: Rebecca Surman (Union College)
- 10:00 **Phenomenological Alternatives to Sterile Neutrinos 30'**  
Speaker: Gabriela Barenboim (U. of Valencia)
- 11:00 - 12:30 Session 6  
Convener: Georga Karagiorgi (Columbia University)
- 11:00 **Borexino Source Experiment 30'**  
Speaker: Gioacchino Ranucci (INFN Milano)
- 11:30 **51Cr Source Experiments 30'**  
Speaker: Jonathan Link (VirginiaTech)
- 12:00 **LENS Source Experiment 30'**  
Speaker: Ramaswamy Raghavan (Virginia Tech)

- 14:00 - 15:30 Session 7  
Convener: Karsten Heeger (University of Wisconsin-Madison)
- 14:00 **RENO 20'**  
Speaker: Yeongduk Kim (Sejong U.)
- 14:20 **Double Chooz 20'**  
Speaker: Jelena Maricic (Drexel U.)
- 14:40 **Daya Bay 20'**  
Speaker: Liang Zhan (IHEP Beijing)
- 15:00 **New Short Baseline Reactor Experiments 20'**  
Speaker: Nathaniel Bowden (LLNL)
- 16:00 - 17:30 Session 8  
Convener: Hamish Robertson (University of Washington)
- 16:00 **Atmospheric Neutrinos as a Probe of the Sterile Sector 20'**  
Speaker: Raj Gandhi (HCRI)
- 16:20 **IceCube Sterile Sensitivity 20'**  
Speaker: Soebur Razzaque (George Mason U.)
- 16:40 **MINOS 30'**  
Speaker: Alexandre Sousa (Harvard)
- 17:10 **Discussion on Prospects of Non-accelerator based Experiments 20'**
- 17:30 - 18:30 Posters Session

## Wednesday 28 September 2011

- 09:00 - 10:30 Session 9  
Convener: Wei Wang (College of William and Mary)
- 09:00 **Future Beam Experiments on Sterile Neutrinos 30'**  
Speaker: Roxanne Guenette (Yale University)
- 09:30 **Stopped Pion Beams 30'**  
Speaker: Gerry Garvey (LANL)
- 10:00 **Evidence from Particle Physics 30'**  
Speakers: William Louis (LANL), Concha Gonzalez-Garcia (U. of Barcelona)
- 11:00 - 12:30 Session 10  
Convener: Osamu Yasuda (Tokyo Metropolitan University)
- 11:00 **Evidence from Astrophysics 30'**  
Speaker: Gail McLaughlin (NCSU)
- 11:30 **Discussion 45'**
- 12:15 **Plans for a White Paper 15'**  
Speakers: Patrick Huber (Virginia Tech), Jonathan Link (VirginiaTech)
- 13:30 - 18:30 KURF Tour  
Convener: Bruce Vogelaar (Virginia Tech)

All talk slides can be viewed at:

<http://www.cpe.vt.edu/snac/>

# Theory and Phenomenology

## Conclusions

- Sterile neutrinos present in most theories
- LSND/MiniBooNE: need (small) active-sterile mixing (same helicity)
  - *Not* pure Majorana or Dirac, pseudo-Dirac, high-scale seesaw
  - The three miracles!
- Need mechanism for two types of small masses (usually Dirac and Majorana)
- Small masses from HDO, string instantons, large/warped extra dimensions
- Low-scale seesaw: Dirac and Majorana masses both suppressed by symmetries (mass-mixing relation)

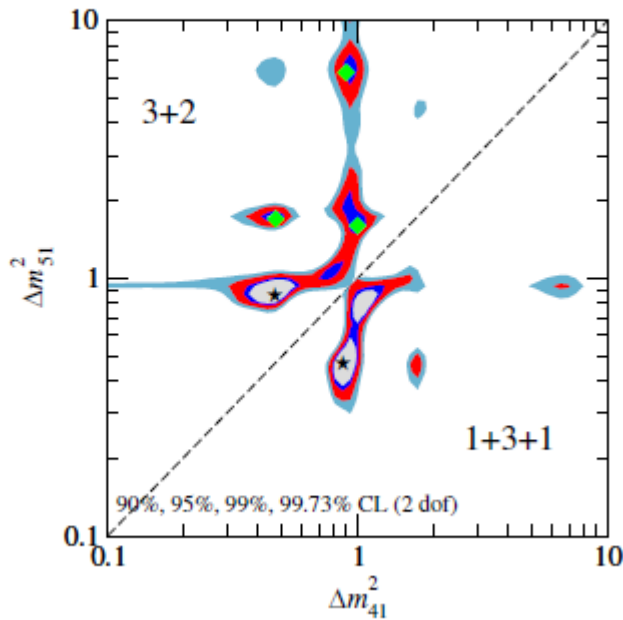
# Theory and Phenomenology

T. Schwetz

LSND+MB $\bar{\nu}$  versus rest  
global 3+1 fit

→ compatibility of less than  $10^{-5}$

3+2 global fit



There is severe tension in the 3+2 fit

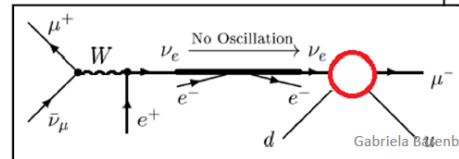
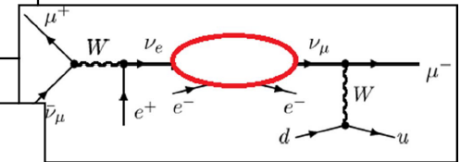
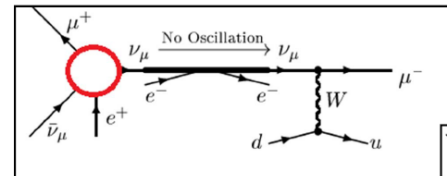
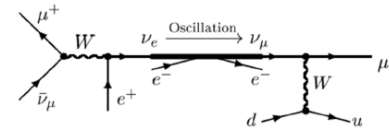
Gabriela Barenboim

## Alternatives to sterile neutrinos

Non standard neutrino interactions

CPT violation

Violations of Lorentz invariance



# Evidence from Particle Physics

## Monday 26 September 2011

- 09:00 - 10:30 Session 1  
Convener: Djordje Minic (Virginia Tech)
- 09:00 **Particle Theory Review 45'**  
Speaker: Paul Langacker (IAS, Princeton)
- 09:45 **Astrophysics Theory Review 45'**  
Speaker: Kevork Abazajian (University of California Irvine)
- 11:00 - 12:30 Session 2  
Convener: Gabriel Oribi Gann (University of Pennsylvania)
- 11:00 **LSND 35'**  
Speaker: William Louis (LANL)
- 11:35 **MiniBooNE 35'**  
Speaker: Geoff Mills (LANL)
- 12:10 **Bolometric Neutral Current Search 20'**  
Speaker: Joseph Formaggio (MIT)
- 14:00 - 15:30 Session 3  
Convener: Adam Bernstein (Livermore National Laboratory)
- 14:00 **Short Baseline Reactor Measurements 30'**  
Speaker: Yves Declais (IN2P3)
- 14:30 **Cumulated Beta Spectrum Measurement from Fission Products at ILL and FRM II 30'**  
Speaker: Klaus Schreckenbach (TU Muenchen)
- 15:00 **Nuclear Theory of Reactor Neutrino Fluxes 30'**  
Speaker: Petr Vogel (Caltech)
- 16:00 - 17:30 Session 4  
Convener: Robert McKeown (Jefferson Lab)
- 16:00 **Recent Re-evaluation of Reactor Neutrino Fluxes 45'**  
Speaker: David Lhuillier (CEA)
- 16:45 **Global Oscillation Fits 45'**  
Speaker: Thomas Schwetz-Mangold (MPK Heidelberg)

## Tuesday 27 September 2011

- 09:00 - 10:30 Session 5  
Convener: Werner Rodejohann (Max-Planck-Institut für Kernphysik)
- 09:00 **Sterile Neutrinos and CMB/LSS 30'**  
Speaker: Yvonne Wong (RWTH Aachen)
- 09:30 **Sterile Neutrinos and Supernova Nucleosynthesis 30'**  
Speaker: Rebecca Surman (Union College)
- 10:00 **Phenomenological Alternatives to Sterile Neutrinos 30'**  
Speaker: Gabriela Barenboim (U. of Valencia)
- 11:00 - 12:30 Session 6  
Convener: Georga Karagiorgi (Columbia University)
- 11:00 **Borexino Source Experiment 30'**  
Speaker: Gioacchino Ranucci (INFN Milano)
- 11:30 **51Cr Source Experiments 30'**  
Speaker: Jonathan Link (VirginiaTech)
- 12:00 **LENS Source Experiment 30'**  
Speaker: Ramaswamy Raghavan (Virginia Tech)

- 14:00 - 15:30 Session 7  
Convener: Karsten Heeger (University of Wisconsin-Madison)
- 14:00 **RENO 20'**  
Speaker: Yeongduk Kim (Sejong U.)
- 14:20 **Double Chooz 20'**  
Speaker: Jelena Maricic (Drexel U.)
- 14:40 **Daya Bay 20'**  
Speaker: Liang Zhan (IHEP Beijing)
- 15:00 **New Short Baseline Reactor Experiments 20'**  
Speaker: Nathaniel Bowden (LLNL)
- 16:00 - 17:30 Session 8  
Convener: Hamish Robertson (University of Washington)
- 16:00 **Atmospheric Neutrinos as a Probe of the Sterile Sector 20'**  
Speaker: Raj Gandhi (HCRI)
- 16:20 **IceCube Sterile Sensitivity 20'**  
Speaker: Soebur Razzaque (George Mason U.)
- 16:40 **MINOS 30'**  
Speaker: Alexandre Sousa (Harvard)
- 17:10 **Discussion on Prospects of Non-accelerator based Experiments 20'**
- 17:30 - 18:30 Posters Session

## Wednesday 28 September 2011

- 09:00 - 10:30 Session 9  
Convener: Wei Wang (College of William and Mary)
- 09:00 **Future Beam Experiments on Sterile Neutrinos 30'**  
Speaker: Roxanne Guenette (Yale University)
- 09:30 **Stopped Pion Beams 30'**  
Speaker: Gerry Garvey (LANL)
- 10:00 **Evidence from Particle Physics 30'**  
Speakers: William Louis (LANL), Concha Gonzalez-Garcia (U. of Barcelona)
- 11:00 - 12:30 Session 10  
Convener: Osamu Yasuda (Tokyo Metropolitan University)
- 11:00 **Evidence from Astrophysics 30'**  
Speaker: Gail McLaughlin (NCSU)
- 11:30 **Discussion 45'**
- 12:15 **Plans for a White Paper 15'**  
Speakers: Patrick Huber (Virginia Tech), Jonathan Link (VirginiaTech)
- 13:30 - 18:30 KURF Tour  
Convener: Bruce Vogelaar (Virginia Tech)

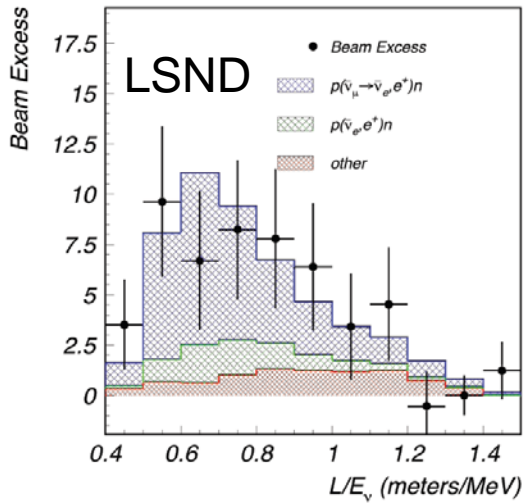
All talk slides can be viewed at:

<http://www.cpe.vt.edu/snac/>



# Evidence from Particle Physics

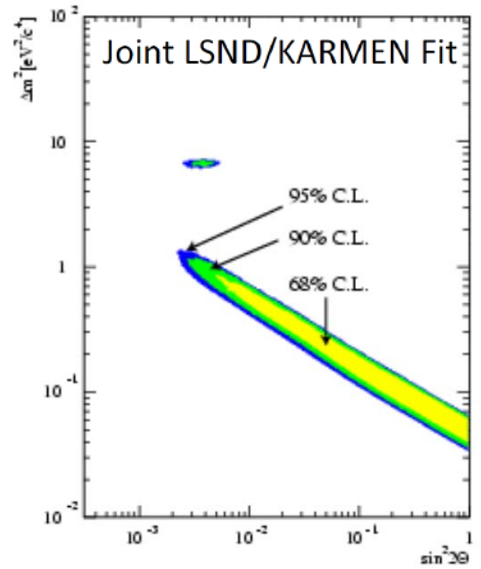
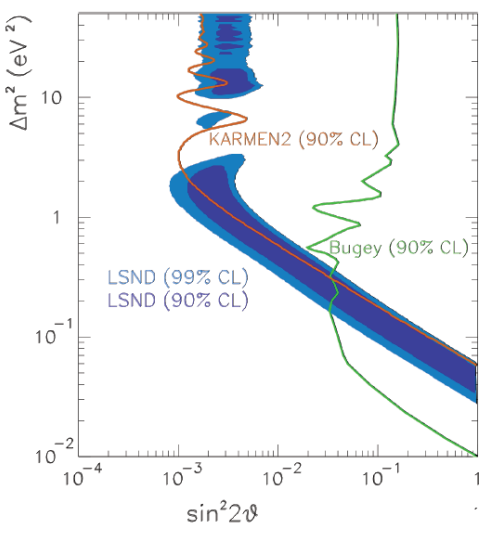
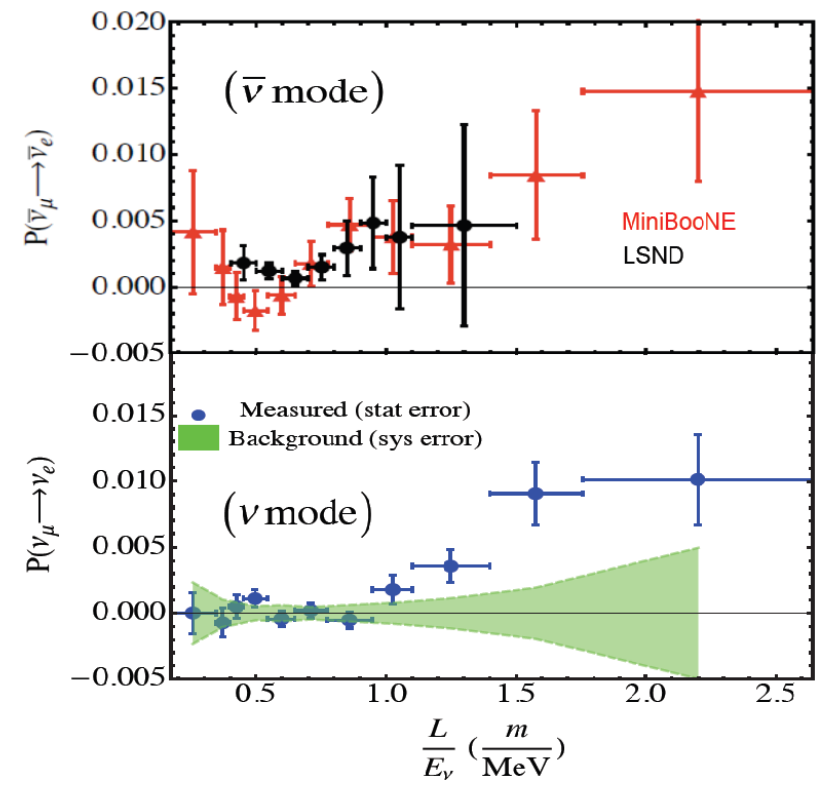
Bill Louis



Geoffrey Mills



Excesses in  $\nu_e$  ( $\sim 3 \sigma$ ) and  $\bar{\nu}_e$  ( $\sim 2.75 \sigma$ ) above background are emerging in both neutrino mode and antineutrino mode in MiniBooNE



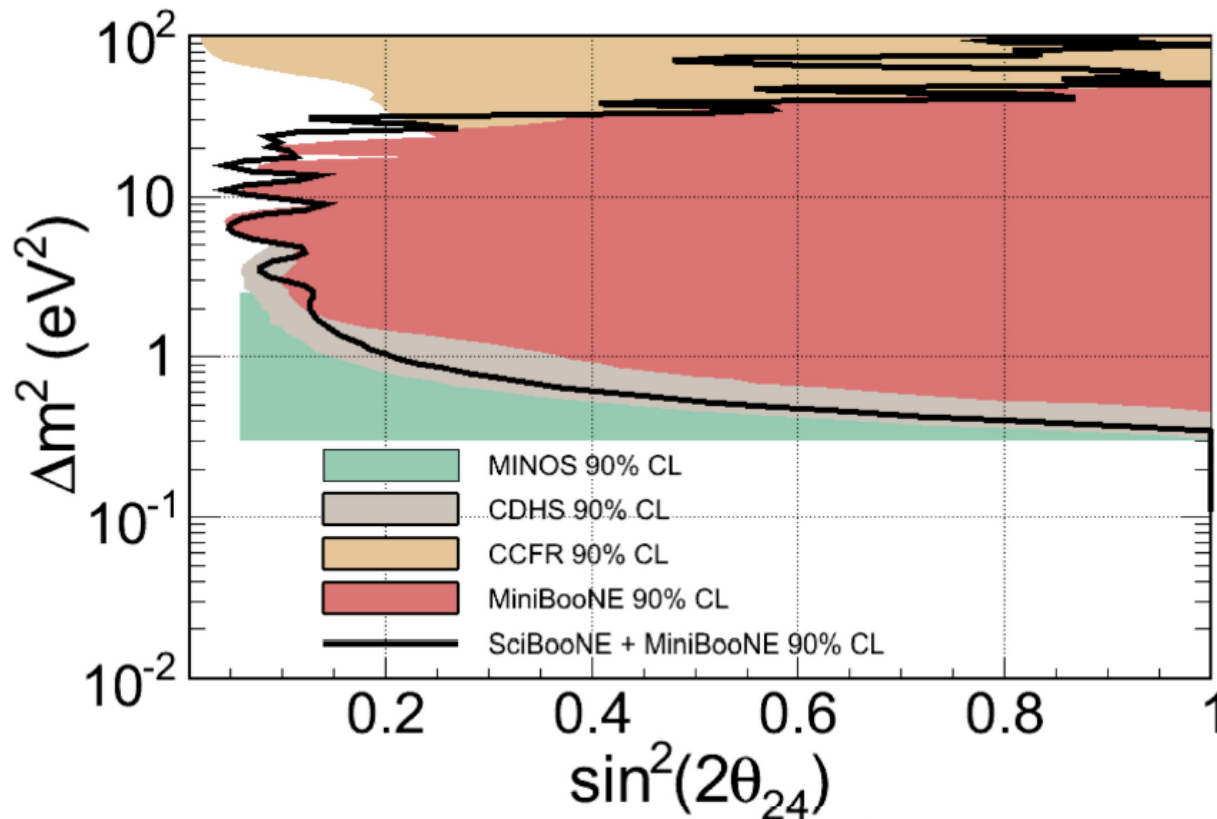


# Evidence from Particle Physics

Alexandre Sousa

MINOS Physics

Search for sterile neutrino mixing via neutral current disappearance



$\theta_{34} < 26^\circ$  ( $37^\circ \nu_e$ ) (90% C.L.)

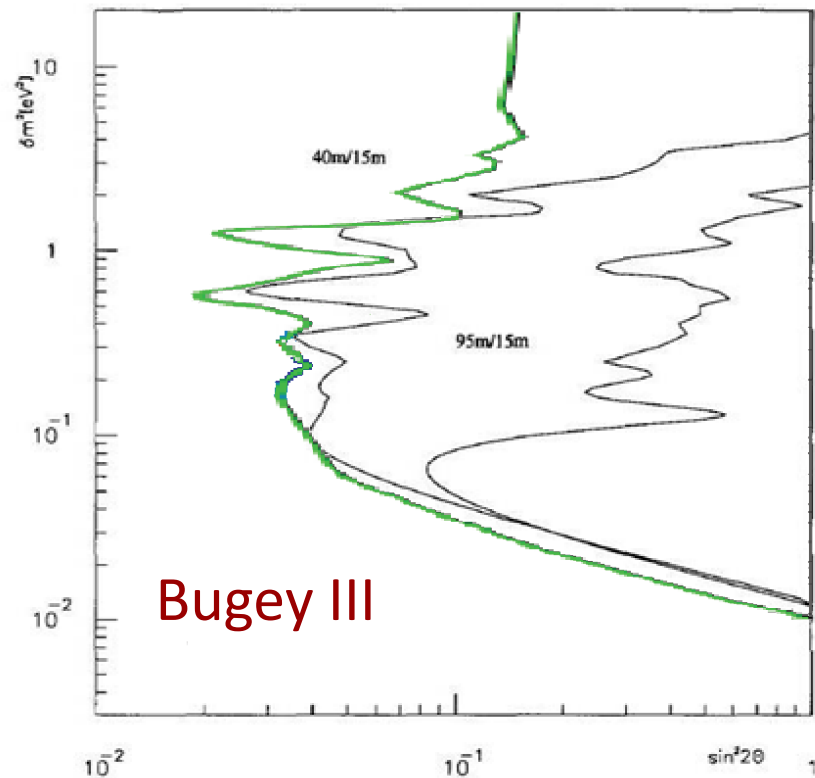
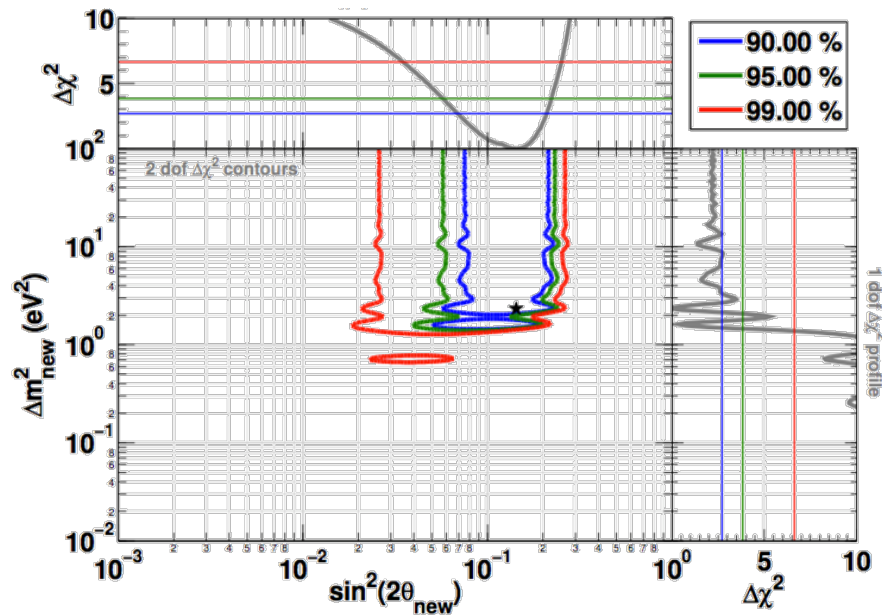
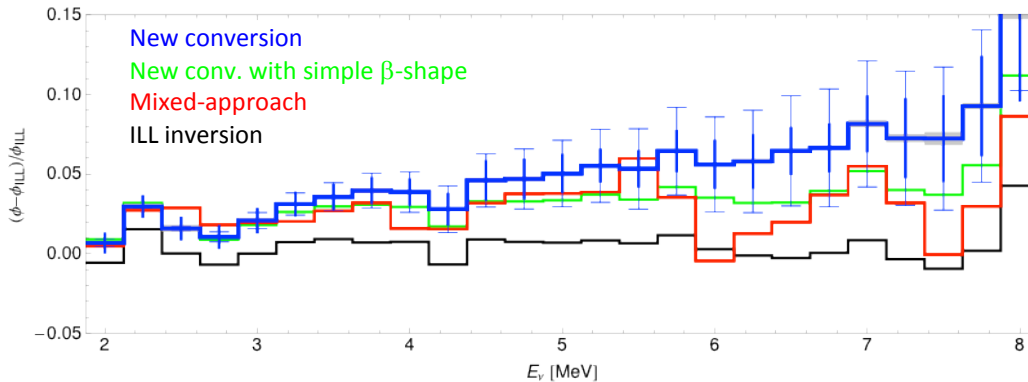
$\theta_{24} < 7^\circ$  ( $8^\circ \nu_e$ ) (90% C.L.)

# Evidence from Particle Physics

D. Lhuillier – CEA Saclay

## RECENT RE-EVALUATION OF REACTOR $\nu$ FLUX

Yves Déclais  
Short Baseline  
Reactor Experiments



# The Reactor Neutrino Flux Anomaly

## Monday 26 September 2011

- 09:00 - 10:30 Session 1  
Convener: Djordje Minic (Virginia Tech)
- 09:00 **Particle Theory Review 45'**  
Speaker: Paul Langacker (IAS, Princeton)
- 09:45 **Astrophysics Theory Review 45'**  
Speaker: Kevork Abazajian (University of California Irvine)

- 11:00 - 12:30 Session 2  
Convener: Gabriel Oribi Gann (University of Pennsylvania)
- 11:00 **LSND 35'**  
Speaker: William Louis (LANL)
- 11:35 **MiniBoONE 35'**  
Speaker: Geoff Mills (LANL)
- 12:10 **Bolometric Neutral Current Search 20'**  
Speaker: Joseph Formaggio (MIT)

- 14:00 - 15:30 Session 3  
Convener: Adam Bernstein (Livermore National Laboratory)
- 14:00 **Short Baseline Reactor Measurements 30'**  
Speaker: Yves Declais (IN2P3)
- 14:30 **Cumulated Beta Spectrum Measurement from Fission Products at ILL and FRM II 30'**  
Speaker: Klaus Schreckenbach (TU Muenchen)
- 15:00 **Nuclear Theory of Reactor Neutrino Fluxes 30'**  
Speaker: Petr Vogel (Caltech)

- 16:00 - 17:30 Session 4  
Convener: Robert McKeown (Jefferson Lab)
- 16:00 **Recent Re-evaluation of Reactor Neutrino Fluxes 45'**  
Speaker: David Lhuillier (CEA)
- 16:45 **Global Oscillation Fits 45'**  
Speaker: Thomas Schwetz-Mangold (MPK Heidelberg)

## Tuesday 27 September 2011

- 09:00 - 10:30 Session 5  
Convener: Werner Rodejohann (Max-Planck-Institut für Kernphysik)
- 09:00 **Sterile Neutrinos and CMB/LSS 30'**  
Speaker: Yvonne Wong (RWTH Aachen)
- 09:30 **Sterile Neutrinos and Supernova Nucleosynthesis 30'**  
Speaker: Rebecca Surman (Union College)
- 10:00 **Phenomenological Alternatives to Sterile Neutrinos 30'**  
Speaker: Gabriela Barenboim (U. of Valencia)

- 11:00 - 12:30 Session 6  
Convener: Georga Karagiorgi (Columbia University)
- 11:00 **Borexino Source Experiment 30'**  
Speaker: Gioacchino Ranucci (INFN Milano)
- 11:30 **51Cr Source Experiments 30'**  
Speaker: Jonathan Link (VirginiaTech)
- 12:00 **LENS Source Experiment 30'**  
Speaker: Ramaswamy Raghavan (Virginia Tech)

- 14:00 - 15:30 Session 7  
Convener: Karsten Heeger (University of Wisconsin-Madison)

- 14:00 **RENO 20'**  
Speaker: Yeongduk Kim (Sejong U.)
- 14:20 **Double Chooz 20'**  
Speaker: Jelena Maricic (Drexel U.)
- 14:40 **Daya Bay 20'**  
Speaker: Liang Zhan (IHEP Beijing)
- 15:00 **New Short Baseline Reactor Experiments 20'**  
Speaker: Nathaniel Bowden (LLNL)

- 16:00 - 17:30 Session 8  
Convener: Hamish Robertson (University of Washington)
- 16:00 **Atmospheric Neutrinos as a Probe of the Sterile Sector 20'**  
Speaker: Raj Gandhi (HCRI)
- 16:20 **IceCube Sterile Sensitivity 20'**  
Speaker: Soebur Razzaque (George Mason U.)
- 16:40 **MINOS 30'**  
Speaker: Alexandre Sousa (Harvard)
- 17:10 **Discussion on Prospects of Non-accelerator based Experiments 20'**

- 17:30 - 18:30 Posters Session

## Wednesday 28 September 2011

- 09:00 - 10:30 Session 9  
Convener: Wei Wang (College of William and Mary)
- 09:00 **Future Beam Experiments on Sterile Neutrinos 30'**  
Speaker: Roxanne Guenette (Yale University)
- 09:30 **Stopped Pion Beams 30'**  
Speaker: Gerry Garvey (LANL)
- 10:00 **Evidence from Particle Physics 30'**  
Speakers: William Louis (LANL), Concha Gonzalez-Garcia (U. of Barcelona)

- 11:00 - 12:30 Session 10  
Convener: Osamu Yasuda (Tokyo Metropolitan University)
- 11:00 **Evidence from Astrophysics 30'**  
Speaker: Gail McLaughlin (NCSU)
- 11:30 **Discussion 45'**
- 12:15 **Plans for a White Paper 15'**  
Speakers: Patrick Huber (Virginia Tech), Jonathan Link (VirginiaTech)

- 13:30 - 18:30 KURF Tour  
Convener: Bruce Vogelaar (Virginia Tech)

All talk slides can be viewed at:

<http://www.cpe.vt.edu/snac/>

# The Reactor Neutrino Flux Anomaly

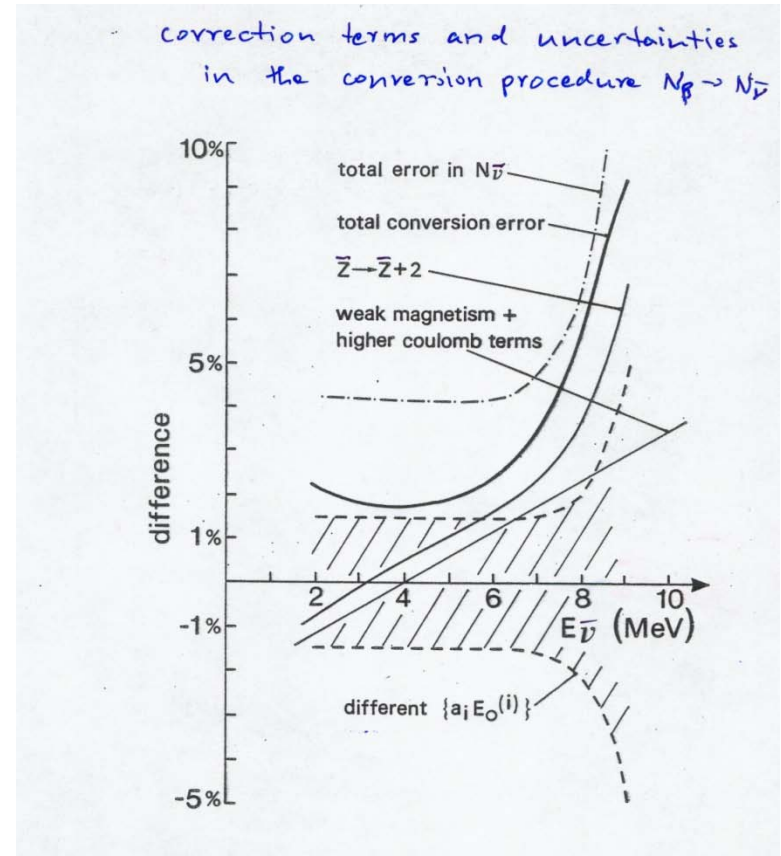
Klaus Schreckenbach

Cumulated beta spectrum measurements of fission products  
at ILL and FRM II

*How precisely do we know the antineutrino source spectrum from a nuclear reactor?*

## ➤ Conversion in antineutinos:

- **Beta shapes due to Z dependence well treated by new approach!**
- **uncertainty of weak magnetism term may be underestimated (see (b) P. Huber )**
- **previous conversion results changed by about the quoted uncertainty**



# The Reactor Neutrino Flux Anomaly

Petr Vogel

## Nuclear theory of reactor neutrino fluxes

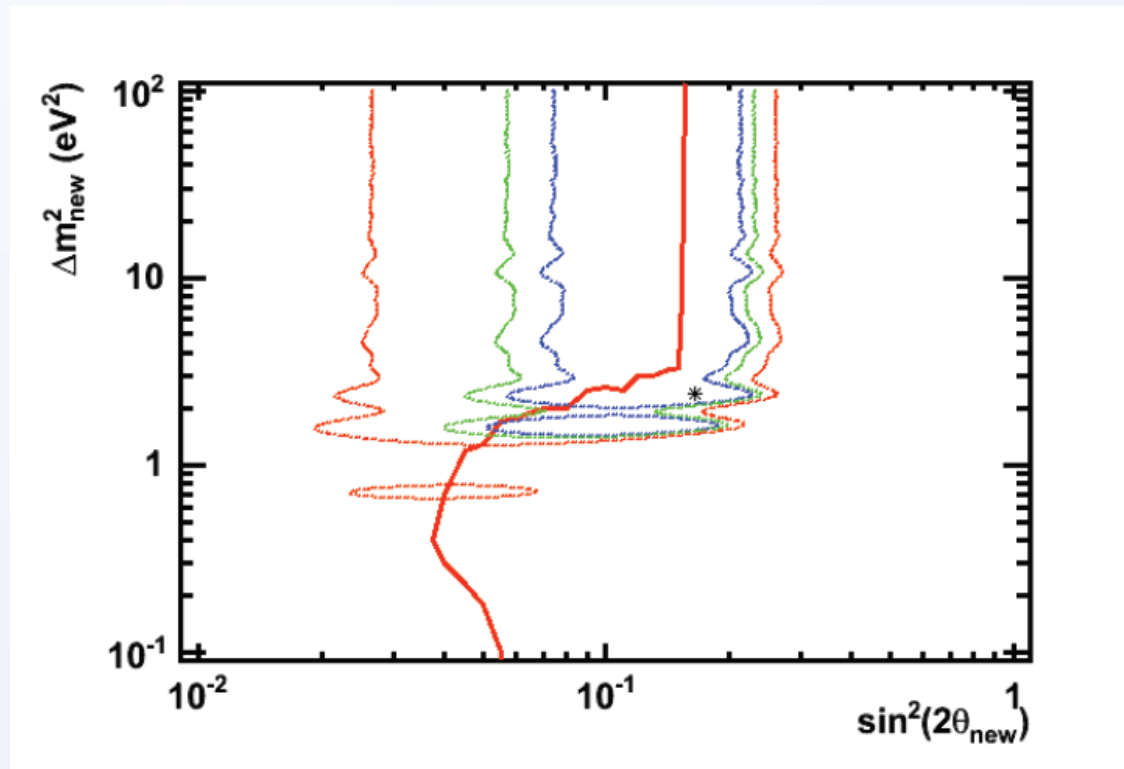
- 1) All evaluations of the reactor neutrino flux depend on two basic assumptions:
  - 1a) That the electron spectra measured at ILL by Schreckenbach et al. are correct (there is little doubt of that, even though the results were not independently confirmed).
  - 1b) That the spectrum shape of the individual  $\beta$  decays is well understood.
- 2) For the allowed  $\beta$  decays ( $\Delta I = 0, 1$ ,  $\Delta \pi = \text{no}$ ) the assumption 1b) is reasonably well fulfilled, even though the slope parameters  $A_{WM}$  and  $A_C$  have considerable uncertainty.
- 3) However, many transitions involve forbidden  $\beta$  decays since  $\Delta \pi = \text{yes}$  is often the case, there is an additional uncertainty involved. It is at present difficult to estimate how large it is, but simple examples suggest that it could be comparable to the stated uncertainty 2-3%.

# The Reactor Neutrino Flux Anomaly

Nathaniel Bowden

## Exclusion Estimates: Shape + Rate

- 150 days, 99% C.L.
- 4% Normalization, 1.5% Energy scale error, 8/1 Signal/Background





# Evidence from Astrophysics & Cosmology

## Monday 26 September 2011

- 09:00 - 10:30 **Session 1**  
Convener: Djordje Minic (Virginia Tech)
- 09:00 **Particle Theory Review 45'**  
Speaker: Paul Langacker (IAS, Princeton)
- 09:45 **Astrophysics Theory Review 45'**  
Speaker: Kevork Abazajian (University of California Irvine)
- 11:00 - 12:30 **Session 2**  
Convener: Gabriel Oribi Gann (University of Pennsylvania)
- 11:00 **LSND 35'**  
Speaker: William Louis (LANL)
- 11:35 **MiniBoONE 35'**  
Speaker: Geoff Mills (LANL)
- 12:10 **Bolometric Neutral Current Search 20'**  
Speaker: Joseph Formaggio (MIT)
- 14:00 - 15:30 **Session 3**  
Convener: Adam Bernstein (Livermore National Laboratory)
- 14:00 **Short Baseline Reactor Measurements 30'**  
Speaker: Yves Declais (IN2P3)
- 14:30 **Cumulated Beta Spectrum Measurement from Fission Products at ILL and FRM II 30'**  
Speaker: Klaus Schreckenbach (TU Muenchen)
- 15:00 **Nuclear Theory of Reactor Neutrino Fluxes 30'**  
Speaker: Petr Vogel (Caltech)
- 16:00 - 17:30 **Session 4**  
Convener: Robert McKeown (Jefferson Lab)
- 16:00 **Recent Re-evaluation of Reactor Neutrino Fluxes 45'**  
Speaker: David Lhuillier (CEA)
- 16:45 **Global Oscillation Fits 45'**  
Speaker: Thomas Schwetz-Mangold (MPK Heidelberg)

## Tuesday 27 September 2011

- 09:00 - 10:30 **Session 5**  
Convener: Werner Rodejohann (Max-Planck-Institut für Kernphysik)
- 09:00 **Sterile Neutrinos and CMB/LSS 30'**  
Speaker: Yvonne Wong (RWTH Aachen)
- 09:30 **Sterile Neutrinos and Supernova Nucleosynthesis 30'**  
Speaker: Rebecca Surman (Union College)
- 10:00 **Phenomenological Alternatives to Sterile Neutrinos 30'**  
Speaker: Gabriela Barenboim (U. of Valencia)
- 11:00 - 12:30 **Session 6**  
Convener: Georga Karagiorgi (Columbia University)
- 11:00 **Borexino Source Experiment 30'**  
Speaker: Gioacchino Ranucci (INFN Milano)
- 11:30 **51Cr Source Experiments 30'**  
Speaker: Jonathan Link (VirginiaTech)
- 12:00 **LENS Source Experiment 30'**  
Speaker: Ramaswamy Raghavan (Virginia Tech)

- 14:00 - 15:30 **Session 7**  
Convener: Karsten Heeger (University of Wisconsin-Madison)
- 14:00 **RENO 20'**  
Speaker: Yeongduk Kim (Sejong U.)
- 14:20 **Double Chooz 20'**  
Speaker: Jelena Maricic (Drexel U.)
- 14:40 **Daya Bay 20'**  
Speaker: Liang Zhan (IHEP Beijing)
- 15:00 **New Short Baseline Reactor Experiments 20'**  
Speaker: Nathaniel Bowden (LLNL)
- 16:00 - 17:30 **Session 8**  
Convener: Hamish Robertson (University of Washington)
- 16:00 **Atmospheric Neutrinos as a Probe of the Sterile Sector 20'**  
Speaker: Raj Gandhi (HCRI)
- 16:20 **IceCube Sterile Sensitivity 20'**  
Speaker: Soebur Razzaque (George Mason U.)
- 16:40 **MINOS 30'**  
Speaker: Alexandre Sousa (Harvard)
- 17:10 **Discussion on Prospects of Non-accelerator based Experiments 20'**
- 17:30 - 18:30 **Posters Session**

## Wednesday 28 September 2011

- 09:00 - 10:30 **Session 9**  
Convener: Wei Wang (College of William and Mary)
- 09:00 **Future Beam Experiments on Sterile Neutrinos 30'**  
Speaker: Roxanne Guenette (Yale University)
- 09:30 **Stopped Pion Beams 30'**  
Speaker: Gerry Garvey (LANL)
- 10:00 **Evidence from Particle Physics 30'**  
Speakers: William Louis (LANL), Concha Gonzalez-Garcia (U. of Barcelona)
- 11:00 - 12:30 **Session 10**  
Convener: Osamu Yasuda (Tokyo Metropolitan University)
- 11:00 **Evidence from Astrophysics 30'**  
Speaker: Gail McLaughlin (NCSU)
- 11:30 **Discussion 45'**
- 12:15 **Plans for a White Paper 15'**  
Speakers: Patrick Huber (Virginia Tech), Jonathan Link (VirginiaTech)
- 13:30 - 18:30 **KURF Tour**  
Convener: Bruce Vogelaar (Virginia Tech)

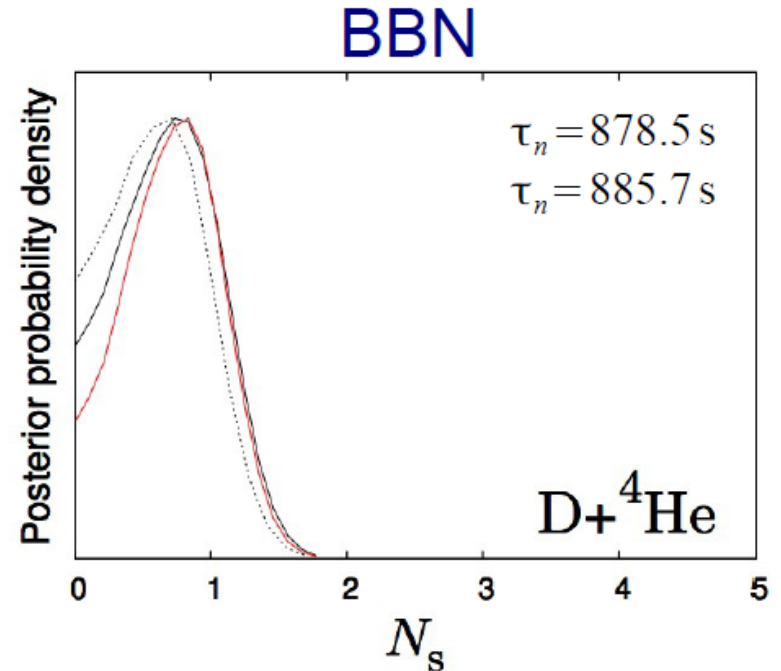
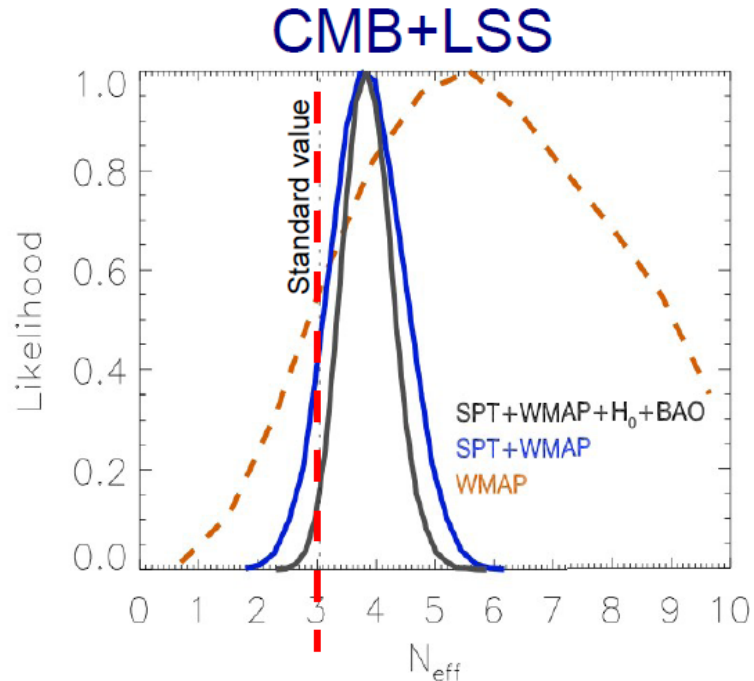
All talk slides can be viewed at:

<http://www.cpe.vt.edu/snac/>



# Evidence from Astrophysics & Cosmology

Yvonne Y. Y. Wong



- Current precision cosmological data show a preference for extra **relativistic degrees of freedom** (beyond 3 neutrinos).
- **Sterile neutrino** interpretation of reactor/MiniBooNE/LSND anomalies does not quite fit into the simplest picture though...
  - 3+2: **Too many** for BBN
  - 3+1, 3+2: **Too heavy** for CMB/LSS

# Evidence from Astrophysics & Cosmology

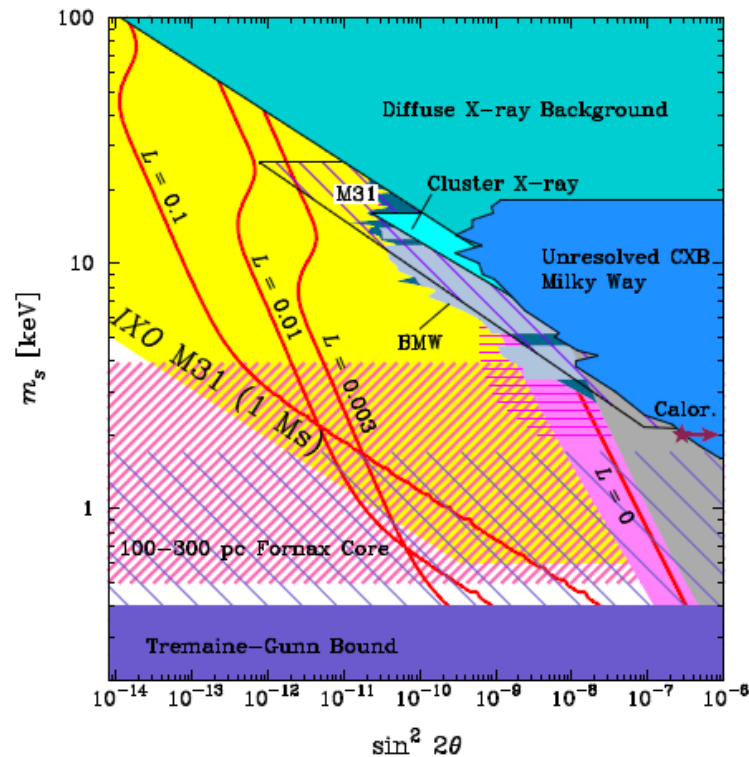
Other hints from the cosmos...

- r-process nucleosynthesis (talk by Rebecca Surman)
- KeV Steriles (talks by Kev Abazajian and Gail McLaughlin)

Pulsar kicks

Dark matter

Lyman  $\alpha$  forrest



Abazajian 2009

# Measurements at Atmospheric Experiments

## Monday 26 September 2011

- 09:00 - 10:30 Session 1  
Convener: Djordje Minic (Virginia Tech)
- 09:00 **Particle Theory Review 45'**  
Speaker: Paul Langacker (IAS, Princeton)
- 09:45 **Astrophysics Theory Review 45'**  
Speaker: Kevork Abazajian (University of California Irvine)
- 11:00 - 12:30 Session 2  
Convener: Gabriel Oribi Gann (University of Pennsylvania)
- 11:00 **LSND 35'**  
Speaker: William Louis (LANL)
- 11:35 **MiniBoONE 35'**  
Speaker: Geoff Mills (LANL)
- 12:10 **Bolometric Neutral Current Search 20'**  
Speaker: Joseph Formaggio (MIT)
- 14:00 - 15:30 Session 3  
Convener: Adam Bernstein (Livermore National Laboratory)
- 14:00 **Short Baseline Reactor Measurements 30'**  
Speaker: Yves Declais (IN2P3)
- 14:30 **Cumulated Beta Spectrum Measurement from Fission Products at ILL and FRM II 30'**  
Speaker: Klaus Schreckenbach (TU Muenchen)
- 15:00 **Nuclear Theory of Reactor Neutrino Fluxes 30'**  
Speaker: Petr Vogel (Caltech)
- 16:00 - 17:30 Session 4  
Convener: Robert McKeown (Jefferson Lab)
- 16:00 **Recent Re-evaluation of Reactor Neutrino Fluxes 45'**  
Speaker: David Lhuillier (CEA)
- 16:45 **Global Oscillation Fits 45'**  
Speaker: Thomas Schwetz-Mangold (MPK Heidelberg)

## Tuesday 27 September 2011

- 09:00 - 10:30 Session 5  
Convener: Werner Rodejohann (Max-Planck-Institut für Kernphysik)
- 09:00 **Sterile Neutrinos and CMB/LSS 30'**  
Speaker: Yvonne Wong (RWTH Aachen)
- 09:30 **Sterile Neutrinos and Supernova Nucleosynthesis 30'**  
Speaker: Rebecca Surman (Union College)
- 10:00 **Phenomenological Alternatives to Sterile Neutrinos 30'**  
Speaker: Gabriela Barenboim (U. of Valencia)
- 11:00 - 12:30 Session 6  
Convener: Georga Karagiorgi (Columbia University)
- 11:00 **Borexino Source Experiment 30'**  
Speaker: Gioacchino Ranucci (INFN Milano)
- 11:30 **51Cr Source Experiments 30'**  
Speaker: Jonathan Link (VirginiaTech)
- 12:00 **LENS Source Experiment 30'**  
Speaker: Ramaswamy Raghavan (Virginia Tech)

- 14:00 - 15:30 Session 7  
Convener: Karsten Heeger (University of Wisconsin-Madison)
- 14:00 **RENO 20'**  
Speaker: Yeongduk Kim (Sejong U.)
- 14:20 **Double Chooz 20'**  
Speaker: Jelena Maricic (Drexel U.)
- 14:40 **Daya Bay 20'**  
Speaker: Liang Zhan (IHEP Beijing)
- 15:00 **New Short Baseline Reactor Experiments 20'**  
Speaker: Nathaniel Bowden (LLNL)
- 16:00 - 17:30 Session 8  
Convener: Hamish Robertson (University of Washington)
- 16:00 **Atmospheric Neutrinos as a Probe of the Sterile Sector 20'**  
Speaker: Raj Gandhi (HCRI)
- 16:20 **IceCube Sterile Sensitivity 20'**  
Speaker: Soebur Razzaque (George Mason U.)
- 16:40 **MINOS 30'**  
Speaker: Alexandre Sousa (Havard)
- 17:10 **Discussion on Prospects of Non-accelerator based Experiments 20'**
- 17:30 - 18:30 Posters Session

## Wednesday 28 September 2011

- 09:00 - 10:30 Session 9  
Convener: Wei Wang (College of William and Mary)
- 09:00 **Future Beam Experiments on Sterile Neutrinos 30'**  
Speaker: Roxanne Guenette (Yale University)
- 09:30 **Stopped Pion Beams 30'**  
Speaker: Gerry Garvey (LANL)
- 10:00 **Evidence from Particle Physics 30'**  
Speakers: William Louis (LANL), Concha Gonzalez-Garcia (U. of Barcelona)
- 11:00 - 12:30 Session 10  
Convener: Osamu Yasuda (Tokyo Metropolitan University)
- 11:00 **Evidence from Astrophysics 30'**  
Speaker: Gail McLaughlin (NCSU)
- 11:30 **Discussion 45'**
- 12:15 **Plans for a White Paper 15'**  
Speakers: Patrick Huber (Virginia Tech), Jonathan Link (VirginiaTech)
- 13:30 - 18:30 KURF Tour  
Convener: Bruce Vogelaar (Virginia Tech)

All talk slides can be viewed at:

<http://www.cpe.vt.edu/snac/>

# Proposals for Source Experiments

## Monday 26 September 2011

- 09:00 - 10:30 **Session 1**  
Convener: Djordje Minic (Virginia Tech)
- 09:00 **Particle Theory Review 45'**  
Speaker: Paul Langacker (IAS, Princeton)
- 09:45 **Astrophysics Theory Review 45'**  
Speaker: Kevork Abazajian (University of California Irvine)
- 11:00 - 12:30 **Session 2**  
Convener: Gabriel Oribi Gann (University of Pennsylvania)
- 11:00 **LSND 35'**  
Speaker: William Louis (LANL)
- 11:35 **MiniBoONE 35'**  
Speaker: Geoff Mills (LANL)
- 12:10 **Bolometric Neutral Current Search 20'**  
Speaker: Joseph Formaggio (MIT)
- 14:00 - 15:30 **Session 3**  
Convener: Adam Bernstein (Livermore National Laboratory)
- 14:00 **Short Baseline Reactor Measurements 30'**  
Speaker: Yves Declais (IN2P3)
- 14:30 **Cumulated Beta Spectrum Measurement from Fission Products at ILL and FRM II 30'**  
Speaker: Klaus Schreckenbach (TU Muenchen)
- 15:00 **Nuclear Theory of Reactor Neutrino Fluxes 30'**  
Speaker: Petr Vogel (Caltech)
- 16:00 - 17:30 **Session 4**  
Convener: Robert McKeown (Jefferson Lab)
- 16:00 **Recent Re-evaluation of Reactor Neutrino Fluxes 45'**  
Speaker: David Lhuillier (CEA)
- 16:45 **Global Oscillation Fits 45'**  
Speaker: Thomas Schwetz-Mangold (MPK Heidelberg)

## Tuesday 27 September 2011

- 09:00 - 10:30 **Session 5**  
Convener: Werner Rodejohann (Max-Planck-Institut für Kernphysik)
- 09:00 **Sterile Neutrinos and CMB/LSS 30'**  
Speaker: Yvonne Wong (RWTH Aachen)
- 09:30 **Sterile Neutrinos and Supernova Nucleosynthesis 30'**  
Speaker: Rebecca Surman (Union College)
- 10:00 **Phenomenological Alternatives to Sterile Neutrinos 30'**  
Speaker: Gabriela Barenboim (U. of Valencia)
- 11:00 - 12:30 **Session 6**  
Convener: Georga Karagiorgi (Columbia University)
- 11:00 **Borexino Source Experiment 30'**  
Speaker: Gioacchino Ranucci (INFN Milano)
- 11:30 **51Cr Source Experiments 30'**  
Speaker: Jonathan Link (VirginiaTech)
- 12:00 **LENS Source Experiment 30'**  
Speaker: Ramaswamy Raghavan (Virginia Tech)

- 14:00 - 15:30 **Session 7**  
Convener: Karsten Heeger (University of Wisconsin-Madison)
- 14:00 **RENO 20'**  
Speaker: Yeongduk Kim (Sejong U.)
- 14:20 **Double Chooz 20'**  
Speaker: Jelena Maricic (Drexel U.)
- 14:40 **Daya Bay 20'**  
Speaker: Liang Zhan (IHEP Beijing)
- 15:00 **New Short Baseline Reactor Experiments 20'**  
Speaker: Nathaniel Bowden (LLNL)
- 16:00 - 17:30 **Session 8**  
Convener: Hamish Robertson (University of Washington)
- 16:00 **Atmospheric Neutrinos as a Probe of the Sterile Sector 20'**  
Speaker: Raj Gandhi (HCRI)
- 16:20 **IceCube Sterile Sensitivity 20'**  
Speaker: Soebur Razzaque (George Mason U.)
- 16:40 **MINOS 30'**  
Speaker: Alexandre Sousa (Harvard)
- 17:10 **Discussion on Prospects of Non-accelerator based Experiments 20'**
- 17:30 - 18:30 **Posters Session**

## Wednesday 28 September 2011

- 09:00 - 10:30 **Session 9**  
Convener: Wei Wang (College of William and Mary)
- 09:00 **Future Beam Experiments on Sterile Neutrinos 30'**  
Speaker: Roxanne Guenette (Yale University)
- 09:30 **Stopped Pion Beams 30'**  
Speaker: Gerry Garvey (LANL)
- 10:00 **Evidence from Particle Physics 30'**  
Speakers: William Louis (LANL), Concha Gonzalez-Garcia (U. of Barcelona)
- 11:00 - 12:30 **Session 10**  
Convener: Osamu Yasuda (Tokyo Metropolitan University)
- 11:00 **Evidence from Astrophysics 30'**  
Speaker: Gail McLaughlin (NCSU)
- 11:30 **Discussion 45'**
- 12:15 **Plans for a White Paper 15'**  
Speakers: Patrick Huber (Virginia Tech), Jonathan Link (VirginiaTech)
- 13:30 - 18:30 **KURF Tour**  
Convener: Bruce Vogelaar (Virginia Tech)

All talk slides can be viewed at:

<http://www.cpe.vt.edu/snac/>

# Proposals for Source Experiments

These experiments involve a new type of measurement known as precision Oscillometry.

- Joe Formaggio – NC detectors and a  $^{51}\text{Cr}$  source.
- Gioacchino Ranucci – inverse  $\beta$ -decay ( $^{90}\text{Sr}$ ,  $^{144}\text{Ce}$ ) or elastic scattering ( $^{51}\text{Cr}$ ) sources with Borexino.
- Raju Raghavan – LENS with on site production of short lived source ( $^6\text{He}$ ).
- Brice Littlejohn (poster) – inverse  $\beta$ -decay source ( $^{144}\text{Ce}$ ) with the Daya Bay far detectors.
- Jon Link –  $^{51}\text{Cr}$  source inside the SNO+ detector.

# Proposals for Accelerator Experiments

## Monday 26 September 2011

- 09:00 - 10:30 **Session 1**  
Convener: Djordje Minic (Virginia Tech)
- 09:00 **Particle Theory Review 45'**  
Speaker: Paul Langacker (IAS, Princeton)
- 09:45 **Astrophysics Theory Review 45'**  
Speaker: Kevork Abazajian (University of California Irvine)
- 11:00 - 12:30 **Session 2**  
Convener: Gabriel Oribi Gann (University of Pennsylvania)
- 11:00 **LSND 35'**  
Speaker: William Louis (LANL)
- 11:35 **MiniBoONE 35'**  
Speaker: Geoff Mills (LANL)
- 12:10 **Bolometric Neutral Current Search 20'**  
Speaker: Joseph Formaggio (MIT)
- 14:00 - 15:30 **Session 3**  
Convener: Adam Bernstein (Livermore National Laboratory)
- 14:00 **Short Baseline Reactor Measurements 30'**  
Speaker: Yves Declais (IN2P3)
- 14:30 **Cumulated Beta Spectrum Measurement from Fission Products at ILL and FRM II 30'**  
Speaker: Klaus Schreckenbach (TU Muenchen)
- 15:00 **Nuclear Theory of Reactor Neutrino Fluxes 30'**  
Speaker: Petr Vogel (Caltech)
- 16:00 - 17:30 **Session 4**  
Convener: Robert McKeown (Jefferson Lab)
- 16:00 **Recent Re-evaluation of Reactor Neutrino Fluxes 45'**  
Speaker: David Lhuillier (CEA)
- 16:45 **Global Oscillation Fits 45'**  
Speaker: Thomas Schwetz-Mangold (MPK Heidelberg)

## Tuesday 27 September 2011

- 09:00 - 10:30 **Session 5**  
Convener: Werner Rodejohann (Max-Planck-Institut für Kernphysik)
- 09:00 **Sterile Neutrinos and CMB/LSS 30'**  
Speaker: Yvonne Wong (RWTH Aachen)
- 09:30 **Sterile Neutrinos and Supernova Nucleosynthesis 30'**  
Speaker: Rebecca Surman (Union College)
- 10:00 **Phenomenological Alternatives to Sterile Neutrinos 30'**  
Speaker: Gabriela Barenboim (U. of Valencia)
- 11:00 - 12:30 **Session 6**  
Convener: Georga Karagiorgi (Columbia University)
- 11:00 **Borexino Source Experiment 30'**  
Speaker: Gioacchino Ranucci (INFN Milano)
- 11:30 **51Cr Source Experiments 30'**  
Speaker: Jonathan Link (VirginiaTech)
- 12:00 **LENS Source Experiment 30'**  
Speaker: Ramaswamy Raghavan (Virginia Tech)

- 14:00 - 15:30 **Session 7**  
Convener: Karsten Heeger (University of Wisconsin-Madison)
- 14:00 **RENO 20'**  
Speaker: Yeongduk Kim (Sejong U.)
- 14:20 **Double Chooz 20'**  
Speaker: Jelena Maricic (Drexel U.)
- 14:40 **Daya Bay 20'**  
Speaker: Liang Zhan (IHEP Beijing)
- 15:00 **New Short Baseline Reactor Experiments 20'**  
Speaker: Nathaniel Bowden (LLNL)
- 16:00 - 17:30 **Session 8**  
Convener: Hamish Robertson (University of Washington)
- 16:00 **Atmospheric Neutrinos as a Probe of the Sterile Sector 20'**  
Speaker: Raj Gandhi (HCRI)
- 16:20 **IceCube Sterile Sensitivity 20'**  
Speaker: Soebur Razzaque (George Mason U.)
- 16:40 **MINOS 30'**  
Speaker: Alexandre Sousa (Harvard)
- 17:10 **Discussion on Prospects of Non-accelerator based Experiments 20'**
- 17:30 - 18:30 **Posters Session**

## Wednesday 28 September 2011

- 09:00 - 10:30 **Session 9**  
Convener: Wei Wang (College of William and Mary)
- 09:00 **Future Beam Experiments on Sterile Neutrinos 30'**  
Speaker: Roxanne Guenette (Yale University)
- 09:30 **Stopped Pion Beams 30'**  
Speaker: Gerry Garvey (LANL)
- 10:00 **Evidence from Particle Physics 30'**  
Speakers: William Louis (LANL), Concha Gonzalez-Garcia (U. of Barcelona)
- 11:00 - 12:30 **Session 10**  
Convener: Osamu Yasuda (Tokyo Metropolitan University)
- 11:00 **Evidence from Astrophysics 30'**  
Speaker: Gail McLaughlin (NCSU)
- 11:30 **Discussion 45'**
- 12:15 **Plans for a White Paper 15'**  
Speakers: Patrick Huber (Virginia Tech), Jonathan Link (VirginiaTech)
- 13:30 - 18:30 **KURF Tour**  
Convener: Bruce Vogelaar (Virginia Tech)

All talk slides can be viewed at:

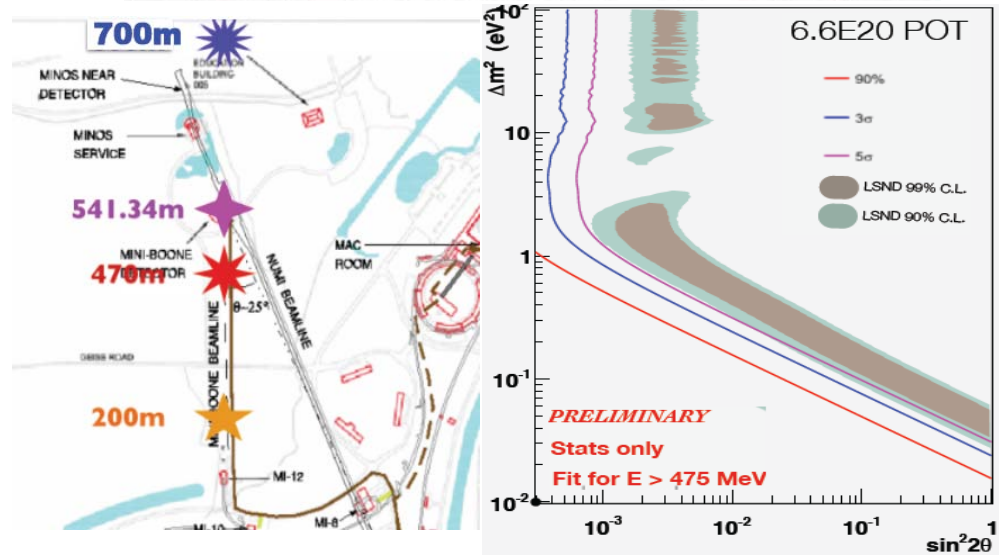
<http://www.cpe.vt.edu/snac/>



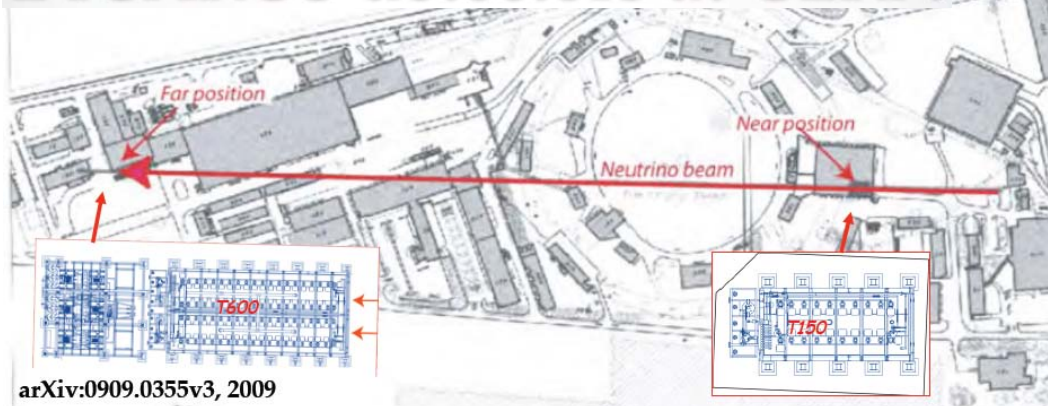
# Proposals for Accelerator Experiments

Roxanne Guenette

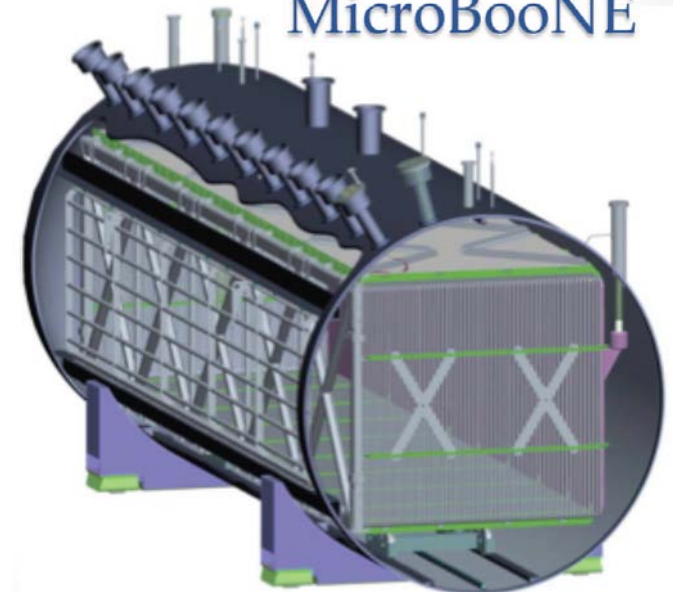
## 2 LAr detectors at FNAL



## 2 ICARUS detectors at CERN



## MicroBooNE





# Proposals for Accelerator Experiments

Gerry Garvey

## OscSNS

### MiniBooNE detector at the SNS Beamstop

Relevant SNS design Parameters

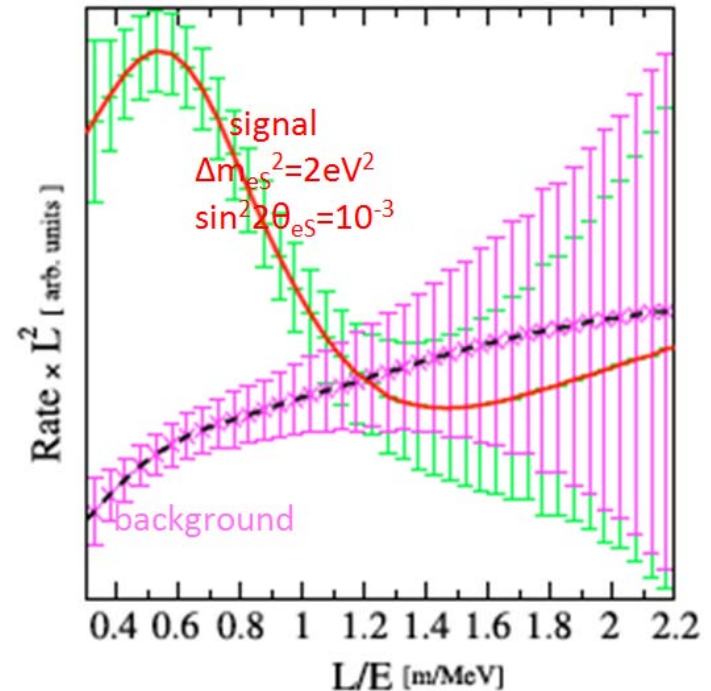
beam power on the target	1.4 MW
beam energy on the target	1.3 GeV
average beam current	1.54 mA
repetition rate	60 Hz
ion type, source-linac	$H^-$
linac-beam duty factor	6.2%
number of injected turns	1225
particles stored in ring	$1.5 \times 10^{14}$
(protons per pulse, ppp)	
extracted pulse length	695 ns
peak current on target	45 A
target	mercury

## Going Underground

Sanjib K. Agarwalla, Patrick Huber: *Physics Letters B* 696 (2011) 359–361

Gd doped Super K to pursue the LSND appearance signal

- 300kW of 1 GeV protons to create the  $\pi^+$  and  $\mu^+$  decay at rest provided via the Conrad and Shaevitz *Daeδalus* cyclotron scheme.



Large scintillating detectors like LENA and Nova can also be paired with cyclotrons

# Sterile Neutrino White Paper

## Monday 26 September 2011

- 09:00 - 10:30 Session 1  
Convener: Djordje Minic (Virginia Tech)
- 09:00 **Particle Theory Review 45'**  
Speaker: Paul Langacker (IAS, Princeton)
- 09:45 **Astrophysics Theory Review 45'**  
Speaker: Kevork Abazajian (University of California Irvine)
- 11:00 - 12:30 Session 2  
Convener: Gabriel Oribi Gann (University of Pennsylvania)
- 11:00 **LSND 35'**  
Speaker: William Louis (LANL)
- 11:35 **MiniBoONE 35'**  
Speaker: Geoff Mills (LANL)
- 12:10 **Bolometric Neutral Current Search 20'**  
Speaker: Joseph Formaggio (MIT)
- 14:00 - 15:30 Session 3  
Convener: Adam Bernstein (Livermore National Laboratory)
- 14:00 **Short Baseline Reactor Measurements 30'**  
Speaker: Yves Declais (IN2P3)
- 14:30 **Cumulated Beta Spectrum Measurement from Fission Products at ILL and FRM II 30'**  
Speaker: Klaus Schreckenbach (TU Muenchen)
- 15:00 **Nuclear Theory of Reactor Neutrino Fluxes 30'**  
Speaker: Petr Vogel (Caltech)
- 16:00 - 17:30 Session 4  
Convener: Robert McKeown (Jefferson Lab)
- 16:00 **Recent Re-evaluation of Reactor Neutrino Fluxes 45'**  
Speaker: David Lhuillier (CEA)
- 16:45 **Global Oscillation Fits 45'**  
Speaker: Thomas Schwetz-Mangold (MPK Heidelberg)

## Tuesday 27 September 2011

- 09:00 - 10:30 Session 5  
Convener: Werner Rodejohann (Max-Planck-Institut für Kernphysik)
- 09:00 **Sterile Neutrinos and CMB/LSS 30'**  
Speaker: Yvonne Wong (RWTH Aachen)
- 09:30 **Sterile Neutrinos and Supernova Nucleosynthesis 30'**  
Speaker: Rebecca Surman (Union College)
- 10:00 **Phenomenological Alternatives to Sterile Neutrinos 30'**  
Speaker: Gabriela Barenboim (U. of Valencia)
- 11:00 - 12:30 Session 6  
Convener: Georga Karagiorgi (Columbia University)
- 11:00 **Borexino Source Experiment 30'**  
Speaker: Gioacchino Ranucci (INFN Milano)
- 11:30 **51Cr Source Experiments 30'**  
Speaker: Jonathan Link (VirginiaTech)
- 12:00 **LENS Source Experiment 30'**  
Speaker: Ramaswamy Raghavan (Virginia Tech)

- 14:00 - 15:30 Session 7  
Convener: Karsten Heeger (University of Wisconsin-Madison)
- 14:00 **RENO 20'**  
Speaker: Yeongduk Kim (Sejong U.)
- 14:20 **Double Chooz 20'**  
Speaker: Jelena Maricic (Drexel U.)
- 14:40 **Daya Bay 20'**  
Speaker: Liang Zhan (IHEP Beijing)
- 15:00 **New Short Baseline Reactor Experiments 20'**  
Speaker: Nathaniel Bowden (LLNL)
- 16:00 - 17:30 Session 8  
Convener: Hamish Robertson (University of Washington)
- 16:00 **Atmospheric Neutrinos as a Probe of the Sterile Sector 20'**  
Speaker: Raj Gandhi (HCRI)
- 16:20 **IceCube Sterile Sensitivity 20'**  
Speaker: Soebur Razzaque (George Mason U.)
- 16:40 **MINOS 30'**  
Speaker: Alexandre Sousa (Harvard)
- 17:10 **Discussion on Prospects of Non-accelerator based Experiments 20'**
- 17:30 - 18:30 Posters Session

## Wednesday 28 September 2011

- 09:00 - 10:30 Session 9  
Convener: Wei Wang (College of William and Mary)
- 09:00 **Future Beam Experiments on Sterile Neutrinos 30'**  
Speaker: Roxanne Guenette (Yale University)
- 09:30 **Stopped Pion Beams 30'**  
Speaker: Gerry Garvey (LANL)
- 10:00 **Evidence from Particle Physics 30'**  
Speakers: William Louis (LANL), Concha Gonzalez-Garcia (U. of Barcelona)
- 11:00 - 12:30 Session 10  
Convener: Osamu Yasuda (Tokyo Metropolitan University)
- 11:00 **Evidence from Astrophysics 30'**  
Speaker: Gail McLaughlin (NCSU)
- 11:30 **Discussion 45'**
- 12:15 **Plans for a White Paper 15'**  
Speakers: Patrick Huber (Virginia Tech), Jonathan Link (VirginiaTech)
- 13:30 - 18:30 KURF Tour  
Convener: Bruce Vogelaar (Virginia Tech)

All talk slides can be viewed at:

<http://www.cpe.vt.edu/snac/>

# Sterile Neutrino White Paper

## Outline and Section Editors

(Editors: Patrick Huber, Virginia Tech and Jon Link, Virginia Tech)

### 1. Theory and Motivation

(Section Editors: Gabriela Barenboim, Valencia and Werner Rodejohann, MPI Heidelberg)

### 2. Astrophysical Evidence

(Section Editors: Kev Abazajian, UC Irvine and Yvonne Wong, Aachen)

### 3. Evidence from Oscillation Experiments

(Section Editors: Joachim Kopp, FNAL and Bill Louis, LANL)

### 4. Global Picture

(Section Editors: Thierry Lasserre, CEA Saclay and Thomas Schwetz, MPI Heidelberg)

### 5. Requirements for Future Measurements

(Section Editors: Bonnie Fleming, Yale and Joe Formaggio, MIT)

### 6. Appendix: Possible Future Experiments

(Section Editors: Patrick Huber, Virginia Tech and Jon Link, Virginia Tech)

Visit [http://cnp.phys.vt.edu/white\\_paper](http://cnp.phys.vt.edu/white_paper) to participate