

NEUTRINO 2010
ATHENS



Snap Shot From Neutrino 2010

Alan Bross
MICE VC
June 24, 2010

more and more accelerator ν physics at the Neutrino conference

..... dominated by ν transitions

Neutrino 2010 PROGRAMME SCHEDULE

5/18/2010

	Session I	Session II	Session III	Session IV	Eve
Mo 6/14	OPENING SESSION (90) Welcome (10) ν helicity L. Grodzins (MIT) (40) ν phys today S. Parke (FNAL) (40)	TOPIC 1 (90) Neutrino Mixing and Oscillations ν mixing Theory (J. Valle) (30) MINOS (D. Vobis) (40) OPERA (Osamu Sato) (20)	TOPIC 1(90) Neutrino Mixing and Oscillations MiniBooNE (R. Van deWater) (20) MiniBooNE (G. Karagiorgi) (20) T2K (T. Kobayashi) (25) NOVA (K. Heller) (25)	TOPIC 4 (90) Neutrino Beams and Sources Reactor neutrino flux (Jun Cao, IHEP) (20) Hadron spectra mess (A. Bondel) (30) Had Spec to neutrino flux (Bishai) (20) Alternative methods (S. Kopp) (20)	Poster Talks (3 min)
Tu 6/15	TOPIC 4 (90) Neutrino Beams and Sources Future Acc ν phys (V. Palladino) (20) S-Beams (Review) (K. Sakashita) (20) Beta Beams (E. Wildner, CERN) (20) Neutrino Factory (K. Long) (30)	TOPIC 5 (90) Future Detectors and Experiments Plan Underground Facilities (N. Smith) (30) ICARUS (A. Guglielmi) (20) LAR Det at Fermilab (Soderberg) (20) LAR Det in Japan (Hasegawa) (20)	TOPIC 1 (90) Neutrino Mixing and Oscillations Theory – Models (M-C Chen) (20) SNO (Josh Klein) (20) BOREXINO (F. Cappucci) (20) SUPER-K (Yasuo Takeuchi) (30)	TOPIC 1 / TOPIC 7 (90) Neutrino Mixing and Oscillations Double CHOOZ (A. Cabrera) (20) Daya Bay (Meng Wang) (20) RENO (KyungKwang Joo) (20) Reactor monitoring (Adam Bernstein) (30)	Poster Talks (3 min)
Wed 6/16	TOPIC 2 (90) Neutrino Mixing and Masses OvBB decay theory (Rodejohann) (20) Intro to Expts + CUORE (M. Pavan) (25) EXO-200 + Ba Tagging (M. Dolinski) (25) Scint (kamLand++) (K. Nakamura) (20)	TOPIC 2 (100) Neutrino Mixing and Masses Tracking (NEMO, ++) (Saskyan) (25) GERDA + other (Barnabe-Heider) (25) KATRIN (T. Thümmel) (25) LFV Expts (Review) (D. Nicolò) (25)	TOPIC 6 (90) Astro/Cosmo Neutrinos Astrophysical Sources (Berezinsky) (30) AUGER Neutrinos (D. Gors) (30) TEV γ -Astronomy (Vandenbrouke) (30)	TOPIC 6 (90) Astro/Cosmo Neutrinos Intro + IceCube (E. Resconi) (30) ANTARES (G. Anton) (20) KM3NeT (Petros Rapidis) (20) ARIANNA/ANITA + other (S. Klein) (20)	Banquet
Thu(6/17)	Free Day				
Fri 6/18	TOPIC 3 (90) Neutrino Interactions Theory (L. Alvarez-Ruso) (30) Nuclear effects (S. Singh) (20) QE Scattering (M. Wascko) (20) Resonant Pion Production (Tzanov) (20)	TOPIC 3/ TOPIC 2 (90) Neutrino Interactions / Neutrino Mixing and Masses Coh. Pion Production (L. Camilleri) (20) Future (MINERVA++) (D. Harris) (30) MARE (A. Nucciotti) (20) Matrix Elements (F. Simkovic) (20)	TOPIC 6 (90) Astro/Cosmo Neutrinos Nuclear Astrophysics (C. Broggini) (30) Precision Cosmology (Y. Wong) (30) Leptogenesis (P. Di Bari) (30)	TOPIC 5 (90) Future Detectors and Experiments Physics at undgrnd Fac (Mauger) (30) Water Cherenkov Det (Shiozawa) (20) Liquid Scintillator Det (Obersauer) (20) Solid Scintillator Det (A. Bross) (20)	Poster Session Public Talk
Sat 6/19	TOPIC 6 (90) Astro/Cosmo Neutrinos Supernova Modeling (C. Cardall) (30) Flavor Oscil of SN ν 's (A. Mirizzi) (30) Detectors for SN ν 's (M. Vagins) (30)	TOPIC 5 (100) Future Detectors and Experiments Project 8 (J. Formaggio) (20) DUSEL (R. Svoboda) (20) Neutrino Oscillometry (Vergados) (20) DAEDALUS (Janet Conrad) (20) LENS Experiment (R. Raghavan) (20)	MISC SESSION (90) Neutrinos and LHC (R. Mohapatra) (30) Dark Matter (Review) (G. Bertone) (30) Geo-Neutrinos (Review) (N. Tolich) (30)	CLOSING SESSION (100) Theory Summary (Eligio Usi) (40) Exp Summary (Art McDonald) (40) INC Report (10) Concluding Remarks (10) Adjourn at 18:10	ancillary studies



Neutrino 2010

- **Excellent Conference**
- **I can't do it justice in a few minutes. All the talks are now on the Indico site:**
<http://indico.cern.ch/conferenceDisplay.py?ovw=True&confId=73981>
- **This was the first "Neutrino" conference in many years where there was a detailed presentation of the "Future" of neutrino physics**
 - This included talks on strategies for accelerator-based experiments (Vittorio), the Neutrino Factory (IDS-NF, Ken) and β -beams (Elena Wildner).
- **Overall, it was a very comprehensive exposition of what we are working towards**
- **HOWEVER:**



Neutrino 2010 (2)

- The experimental neutrino physics community represented at this conference still is not “on-board” (my impression).
 - θ_{13} will be accessible at the next round (super-beamish) experiments (LBNE, etc)
 - Although the most recent global fits that include the most recent MINOS ν_e appearance data pull the value lower, it is still felt θ_{13} will be accessible
 - NF (and/or β -beam) TOO expensive
 - Need a detector of “Everything” (oscillation physics, nucleon decay, supernova ν
 - Harder if NF included due to the need for magnetization
- Stephen Parke's opening session talk did stress the need to be prepared for
 - Surprises, Surprises, Surprises

Confirmations, too

MICE at Neutrino 2010

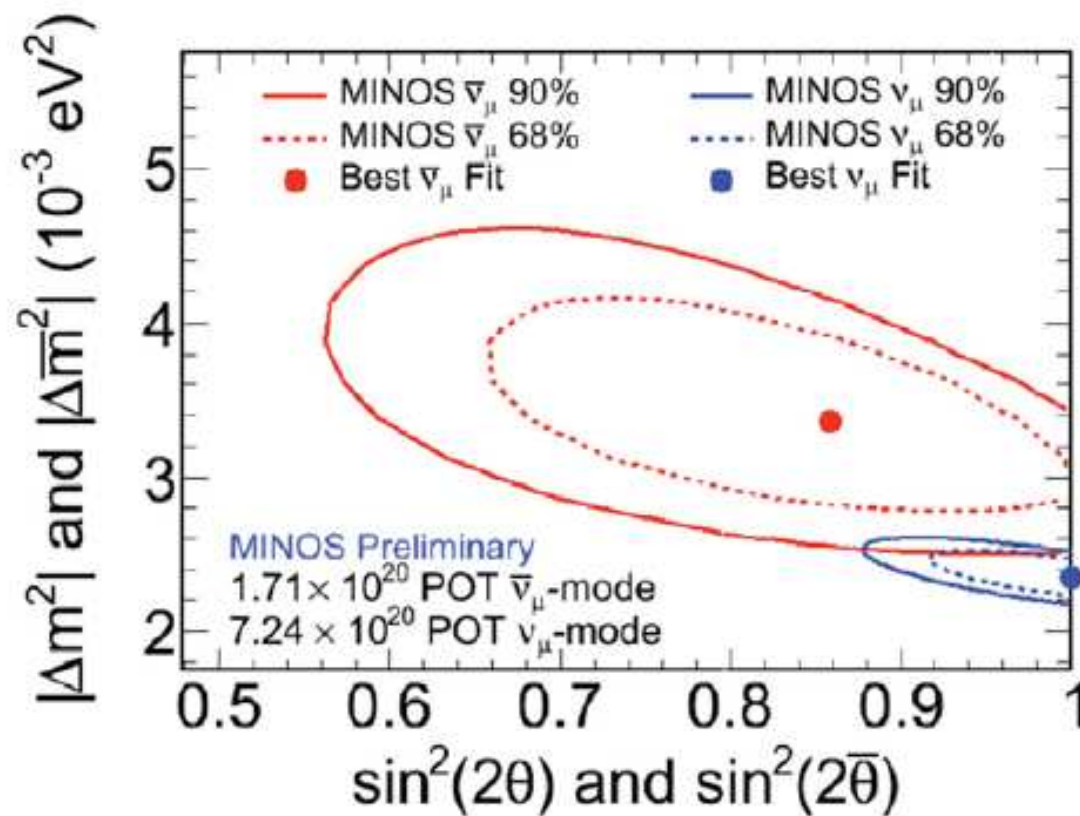
- Poster Bross “Status”
- Poster Coney “Step I”
- Poster Snopok “Beyond Step I”



MINOS $\nu_\mu \rightarrow \nu_x$

Comparisons to Neutrinos

47



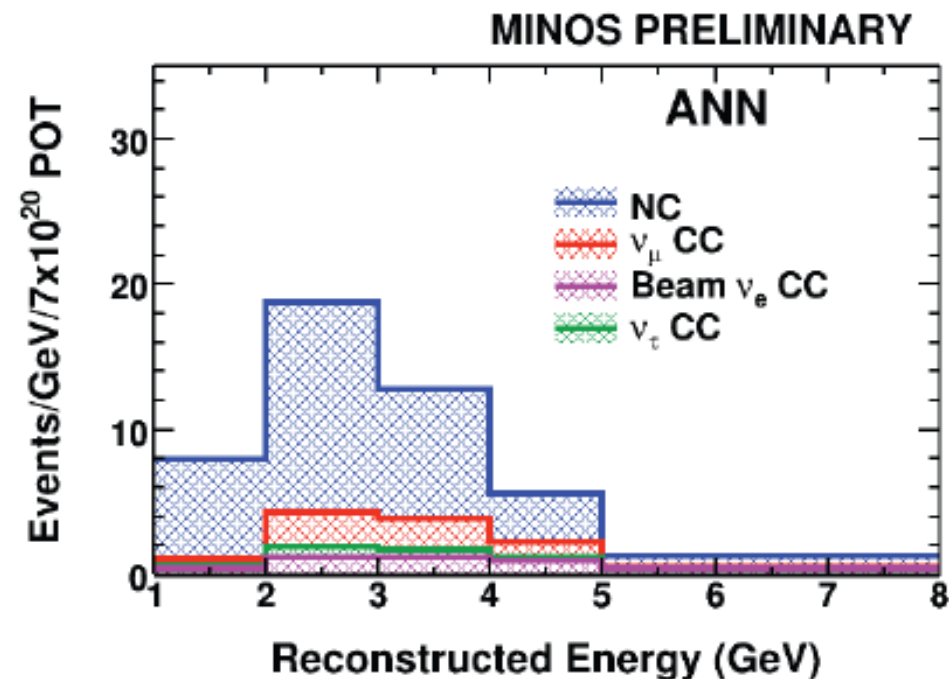
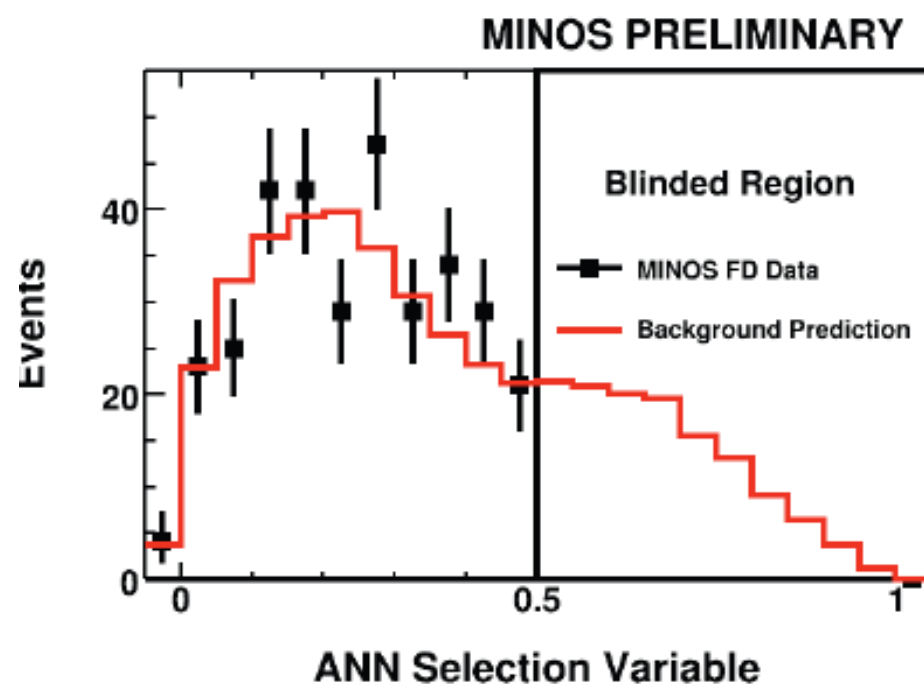
P. Vahle, Neutrino 2010

ν_e Appearance Results

MINOS $\nu_\mu \rightarrow \nu_e$

36

- Based on ND data, expect: $49.1 \pm 7.0(\text{stat.}) \pm 2.7(\text{syst.})$



Summary

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- With 7×10^{20} POT of neutrino beam, MINOS finds

- muon-neutrinos disappear

$$|\Delta m^2| = 2.35_{-0.08}^{+0.11} \times 10^{-3} \text{eV}^2, \\ \sin^2(2\theta) > 0.91 \text{ (90\% C.L.)}$$

- NC event rate is not diminished

$$f_s < 0.22(0.40) \text{ at 90\% C.L.}$$

- electron-neutrino appearance is limited

$$\sin^2(2\theta_{13}) < 0.12(0.20) \text{ at 90\% C.L.}$$

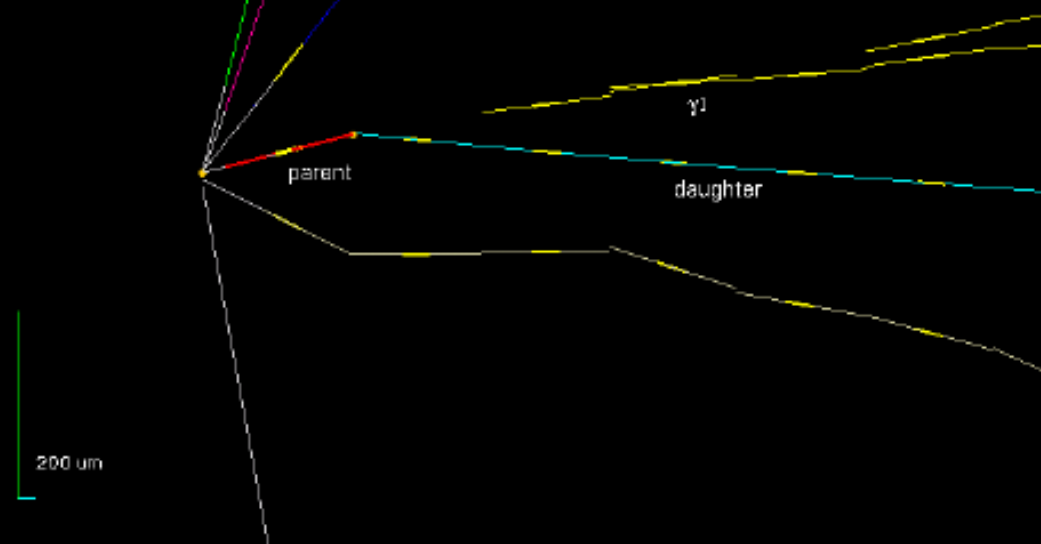
- With 1.71×10^{20} POT of anti-neutrino beam

- muon anti-neutrinos also disappear with

$$|\overline{\Delta m^2}| = 3.36_{-0.40}^{+0.45} \times 10^{-3} \text{eV}^2, \\ \sin^2(2\bar{\theta}) = 0.86 \pm 0.11$$

- we look forward to more anti-neutrino beam!

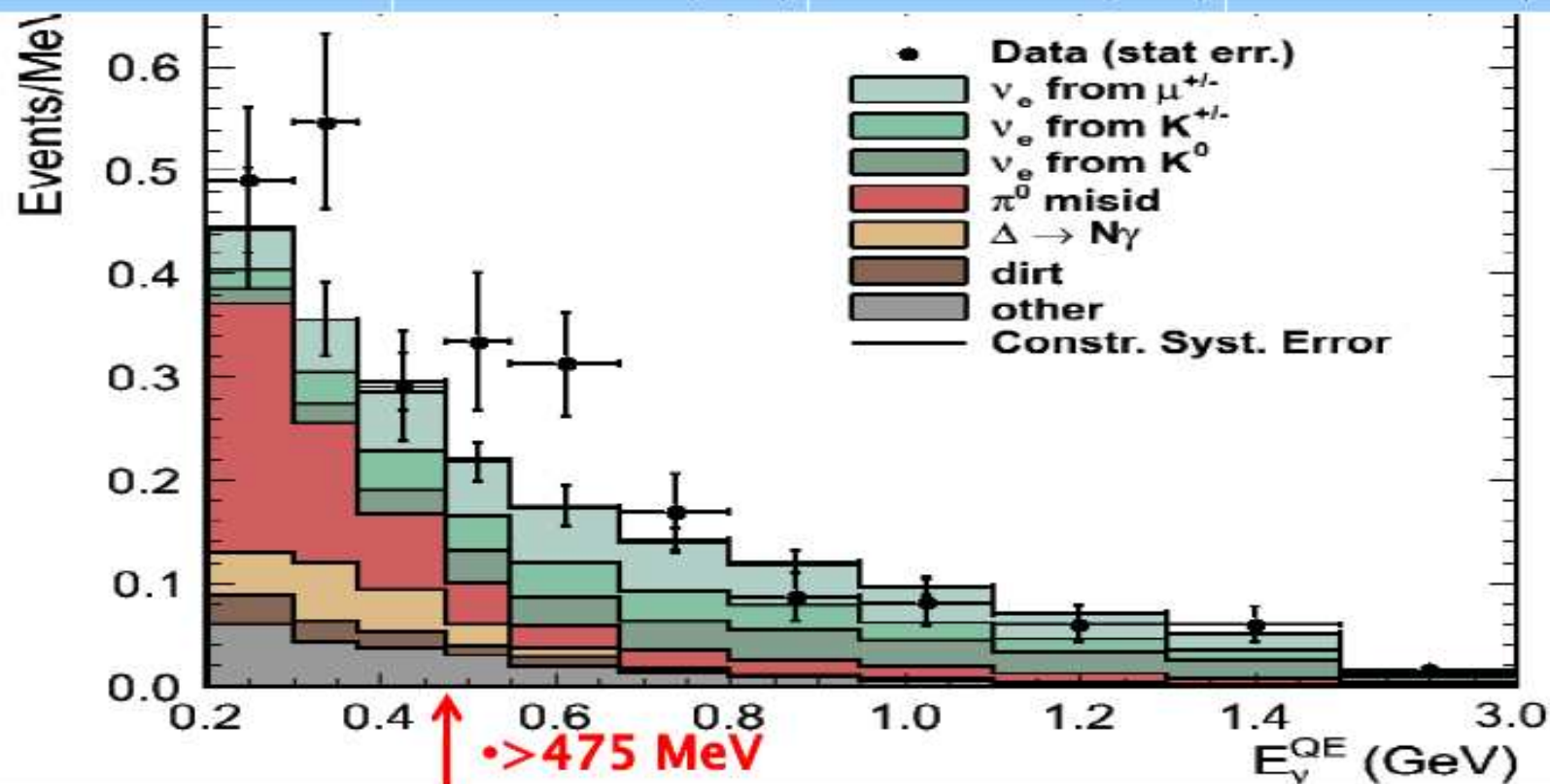
OPERA $\nu_{\mu} \rightarrow \nu_{\tau}$



...and thank you for your attention!

New Antineutrino Result with 5.66E20 POT

	200-475 MeV	475-1250 MeV	200-3000 MeV
Data	119	120	277
MC (stat+sys)	100.5 \pm 14.3	99.1 \pm 13.9	233.8 \pm 22.5
Excess (stat)	18.5 \pm 10.0 (1.9 σ)	20.9 \pm 10.0 (2.1 σ)	43.2 \pm 15.3 (2.8 σ)
Excess (stat+sys)	18.5 \pm 14.3 (1.3 σ)	20.9 \pm 13.9 (1.5 σ)	43.2 \pm 22.5 (1.9 σ)

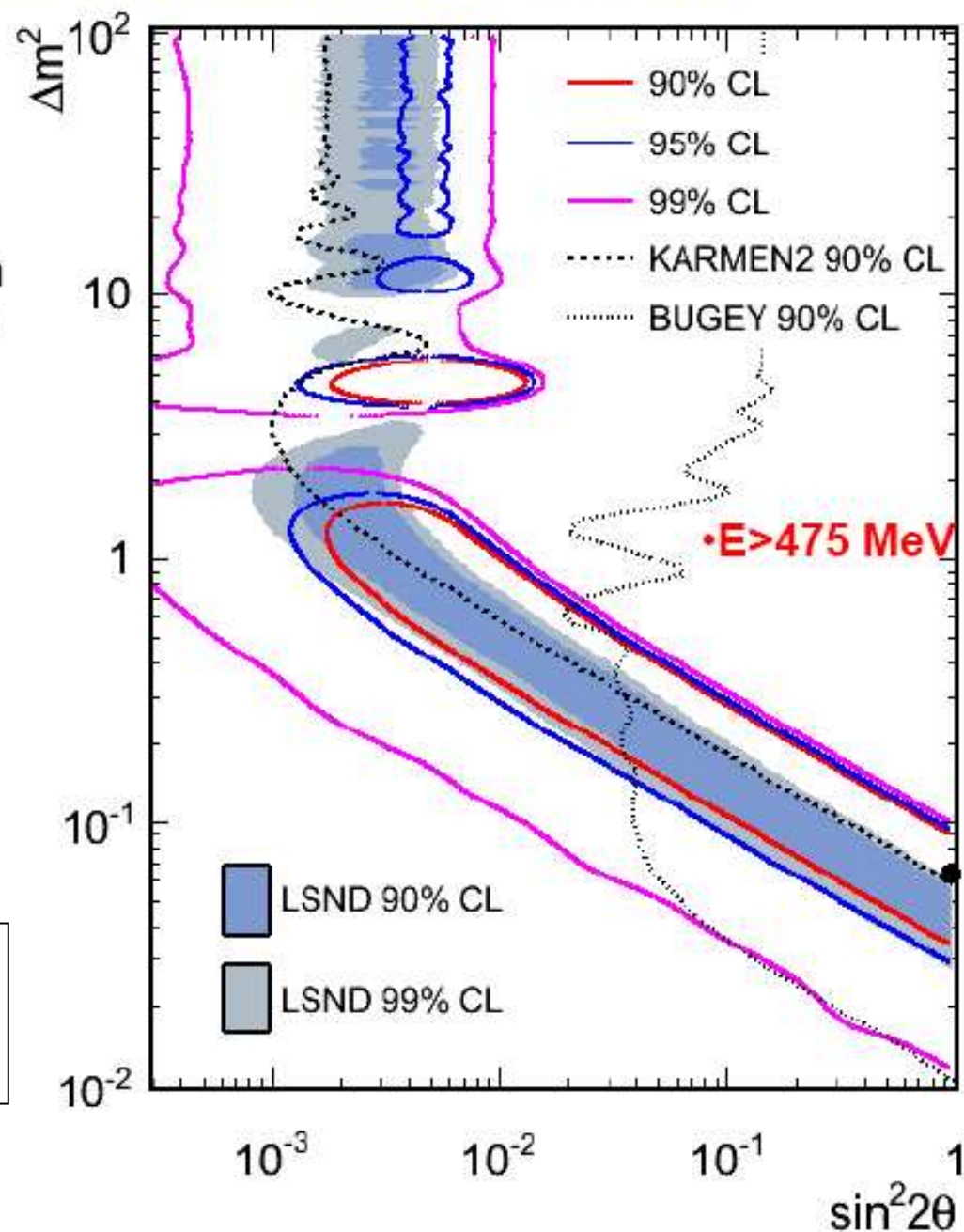


Updated Antineutrino mode MB results for $E > 475$ MeV (official oscillation region)

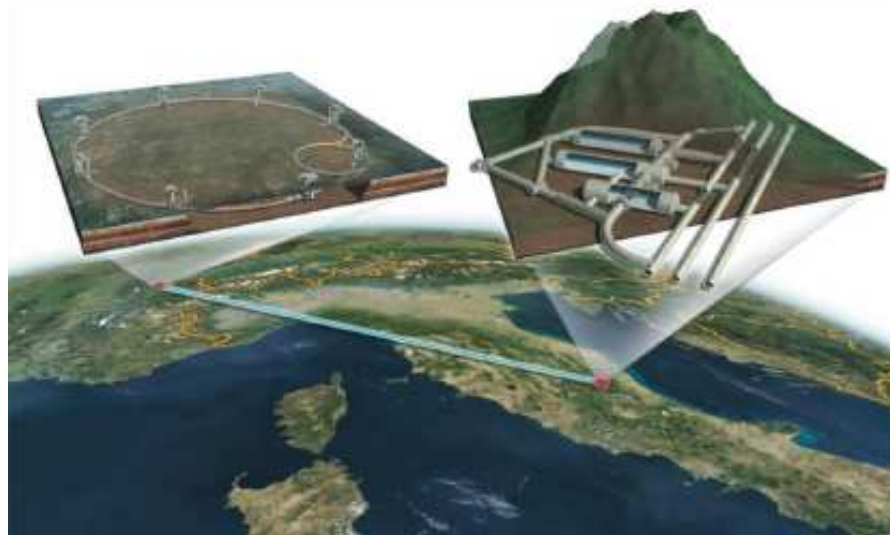
- Results for **5.66E20 POT**
- Maximum likelihood fit.
- Null excluded at 99.4% with respect to the two neutrino oscillation fit.
- Best Fit Point
 $(\Delta m^2, \sin^2 2\theta) =$
 $(0.064 \text{ eV}^2, 0.96)$
 $\chi^2/\text{NDF} = 16.4/12.6$
 $P(\chi^2) = 20.5\%$
- Results to be published.

LSND
Its Baaackkk!

????



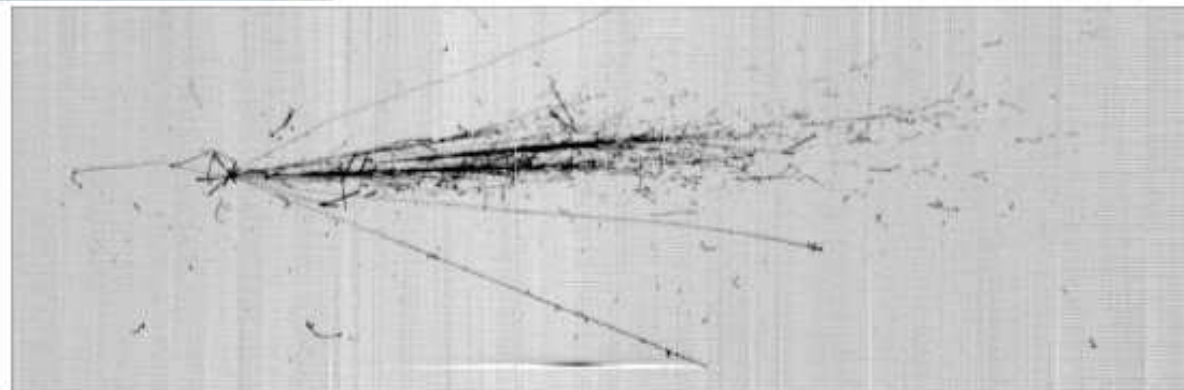
Status and early events from ICARUS T600



A. Guglielmi*

INFN - Padova

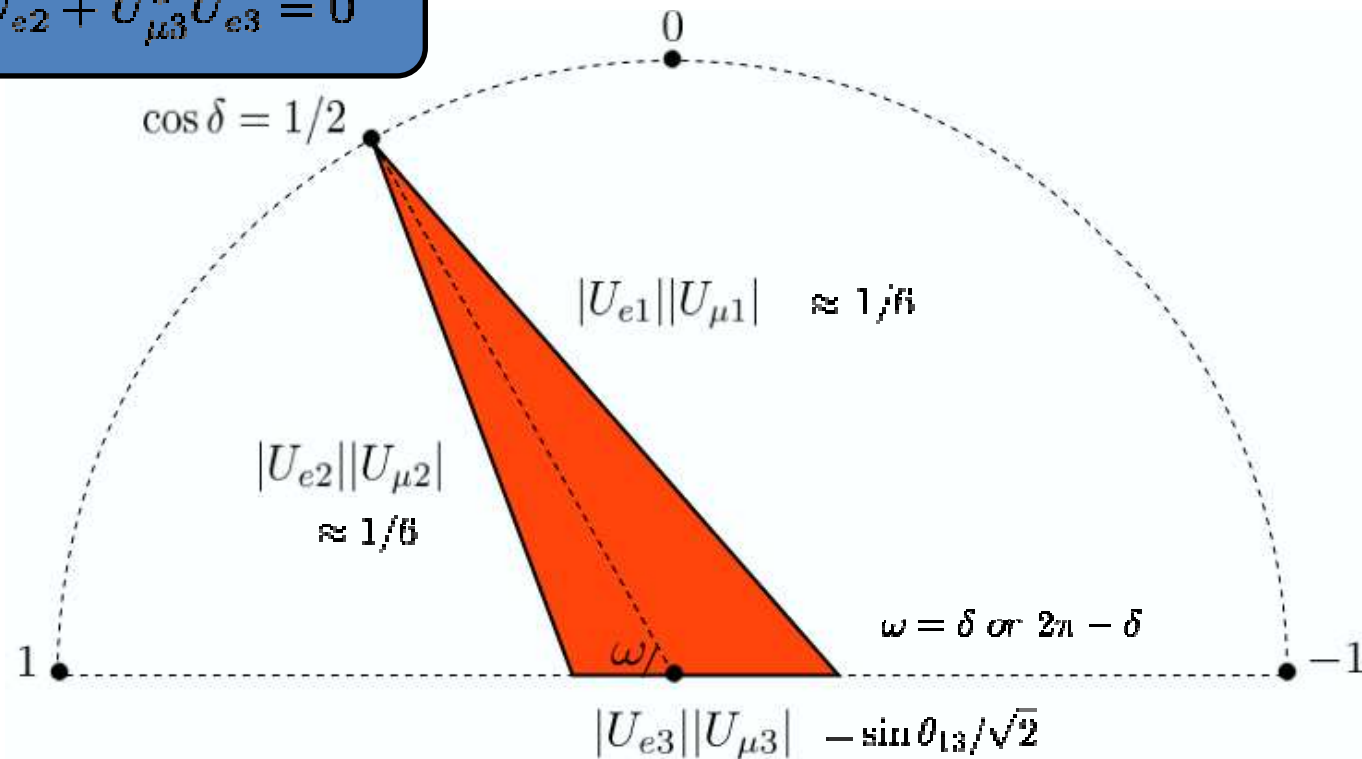
- ICARUS T600 LAr-TPC @ LNGS
- Detector commissioning
- First CNGS/cosmic-rays events



* On behalf of the ICARUS Collaboration

Unitarity Triangle:

$$U_{\mu 1}^* U_{e 1} + U_{\mu 2}^* U_{e 2} + U_{\mu 3}^* U_{e 3} = 0$$



$$|J| = 2 \times \text{Area}$$

$$J = s_{12} c_{12} s_{23} c_{23} s_{13} c_{13}^2 \sin \delta$$

Eu possible Strategies for Future Accelerator ν Physics

NEu2012 Network

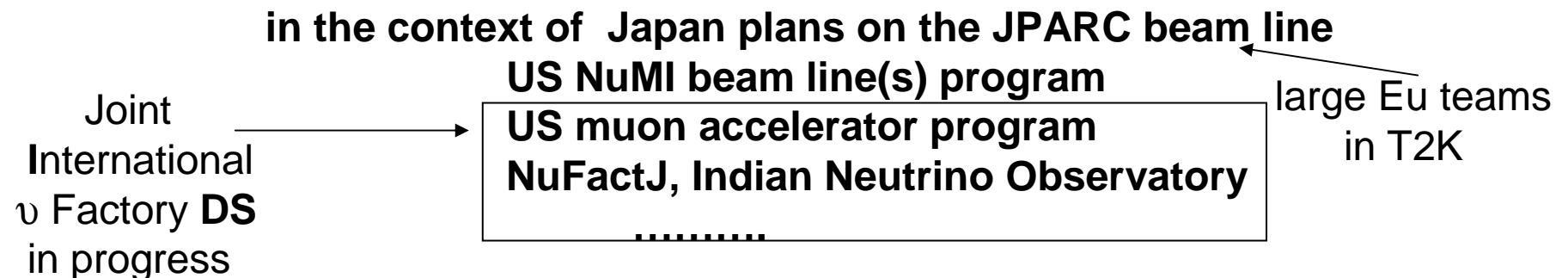
Neutrinos for Europe in2012

EUROnu Design Study (beams)

LAGUNA Design Study (sites)

CERN Council Strategy Document
dixit, July 2006

..... *be in position to define the optimal neutrino program*
..... *in around 2012*



Mar 31, 2013

Conclusions

Strategies for Future Accelerator ν Physics

- The Quark mixing matrix (CKM) is nearly 60 years old (strangeness 1953)
and we are still building strangeness, charm and beauty factories
- The Neutrino mixing (PMNS) has a long way to go, we have to
 - 1) establish its 3*3 nature detect θ_{13}
 - 2) measure its δ_{CPV} and the mixings precisely
 - 3) check its unitarity & invariance properties ... CP, T, CPTNB Many answers will come only from accelerator neutrinos

We have a **double task** to **coherently**
progress with **conventional beams** (π decay tunnel) **and detectors**

- 1) T2K, NO ν A, CNGS+
- 2) T2K+, LBNE, CERN

while we design, prototype and build **novel beams and detectors**
neutrino factory (μ decay ring)
betabeam (β decay ring)

do the experiments
we can do

prototype for the
ultimate experiments

Sustainable only if we build in steady solid progress in
in MWatts AND ν / Watt
as well as in detector Mtons

R&D !!!!!!!!

THE INTERNATIONAL DESIGN STUDY
FOR THE NEUTRINO FACTORY



K. Long, 14 June, 2010



Steps towards the
Neutrino Factory



Imperial College
London

Conclusions:

- The Neutrino Factory, the ‘facility of choice’:
 - Best discovery reach
 - Best precision:
 - But need to define agreed figure of merit
 - Best sensitivity to non-standard interactions
- The IDS-NF baseline established and, so far, robust
 - Alternatives to the baseline, addressing particular issues (e.g., Low Energy Neutrino Factory), are under discussion
- The IDS-NF collaboration:
 - Energetic and ambitious, working towards IDR 2010/11 and RDR 2012/13:
 - EUROnu: encompasses and coordinates European contributions
- Scientific imperative:
 - Make the Neutrino Factory an option for the field!

Neutrino 2010, Athens, 18 June, 2010

Developments in Leptogenesis

Pasquale Di Bari

UNIVERSITY OF
Southampton



The double side of Leptogenesis

Cosmology (early Universe)

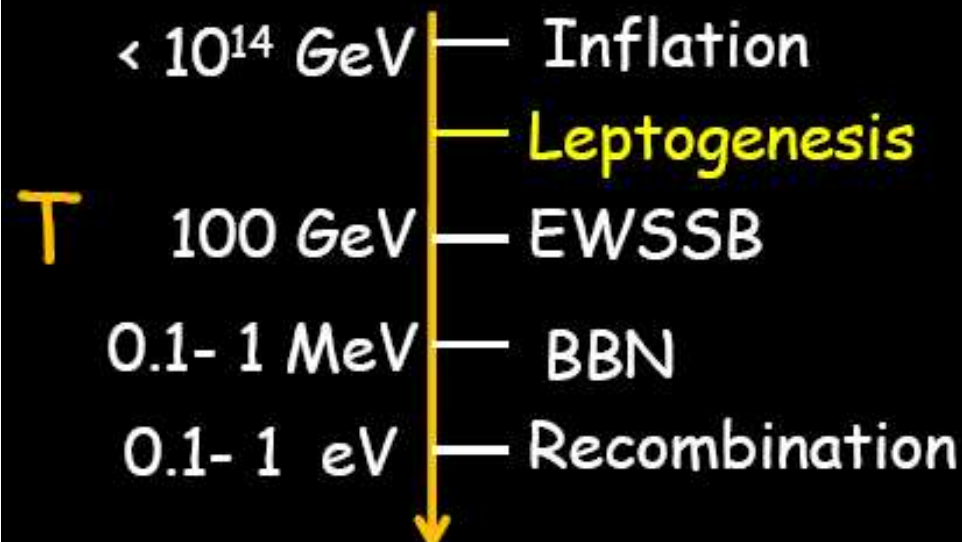


Neutrino Physics, New Physics

• Cosmological Puzzles:

1. Dark matter
2. Matter - antimatter asymmetry
3. Inflation
4. Accelerating Universe

• New stage in early Universe history:



Leptogenesis complements
low energy neutrino experiments
testing the
high energy parameters
of the seesaw mechanism

⇒ It provides a
precious information
to understand what
kind of new physics is
responsible for the neutrino
masses and mixing:
a model builders compass

Conclusions

Leptogenesis complements low energy neutrino experiments to test the see-saw mechanism since the high energy parameters are involved as well.

However, just leptogenesis+low energy neutrino experiments are still not sufficient to over-constrain the see-saw parameter space and one has
i) either to look for additional phenomenologies (LFV processes ? EDM's ? collider physics ?) or ii) Add some reasonably justified assumption.
E.g., $SO(10)$ -inspired models are ruled out in a traditional N_1 -dom scenario

The N_2 dominated leptogenesis is becoming more and more interesting: it rescues the " $SO(10)$ -inspired scenario" and seems to yield predictions on the low energy parameters...though many subtle effects have to be taken into account.

It is quite remarkable that in the minimal $SO(10)$ -inspired scenario realizes the only possible situation where the predictions do not depend of the initial conditions !

Leptogenesis is an important guidance for the identification of the Theory responsible for neutrino masses and mixing

Conclusions

- **Solid Scintillator (plastic) has many potential applications**
 - **Large-Scale (many kT) applications are looking more affordable**
 - Producing massive quantities of plastic scintillator straightforward.
But, the ultimate Cost is the CONCERN
 - **R&D needed to address cost issues is relatively modest**
 - SiPM development and packaging
 - High-rate extrusion capability (X5)
 - WLS Fiber (??) Need industry involvement/interest
 - **Clear Opportunities in certain applications**
 - Near detectors for conventional ν beams
 - Doping for neutron detection
- **Proposals to develop new Inorganic Scintillators for HEP may have application in DMS as complementary experiment to noble liquid experiments**
 - **This work is just starting**

Future Conferences

In addition to the proposal for London we had an excellent proposal from Heidelberg presented by Matthew Lindner. We give this proposal a very high priority for 2018, and we ask that it be resubmitted in 2012.

Given that new experiments in neutrino physics now have time scales of the order 20 years we can take a look what things may look like over that period for the Neutrino conferences.

2012 Kyoto

2014 Boston

2016 London

2018 Heidelberg (provisional)

2020 North America or Asia-Pacific

2022 Asia-Pacific or North America

2024 Europe

2026 North America or Asia-Pacific

2028 Asia-Pacific or North America

2030 100th Anniversary of Pauli's prediction



Neutrino 2010 (2)

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 - NF (and/or β -beam) TOO expensive
 - Need a detector of “Everything” (oscillation physics, nucleon decay, supernova ν
 - Harder if NF included due to the need for magnetization

Decisive is what rate of progress we manage to implement

in the halls of

MICE and other R&D projects



Thank you