Paris, 19 June '04

Neutrino 2004: concluding talk

G. Altarelli
CERN

- Top Highlights at Neutrino '04
- Main lessons from neutrinos in recent years
- Impact on particle physics & cosmology

Solid evidence for solar and atmosph. ν oscillations (+LSND unclear)

Δm^2 values fixed:

$\Delta m^2_{atm} \sim 2.5\ 10^{-3}\ eV^2$,

$\Delta m^2_{sol} \sim 8\ 10^{-5}\ eV^2$

($\Delta m^2_{LSND} \sim 1\ eV^2$)

mixing angles:

θ_{12} (solar) large

θ_{23} (atm) large, ~maximal

θ_{13} (CHOOZ) small

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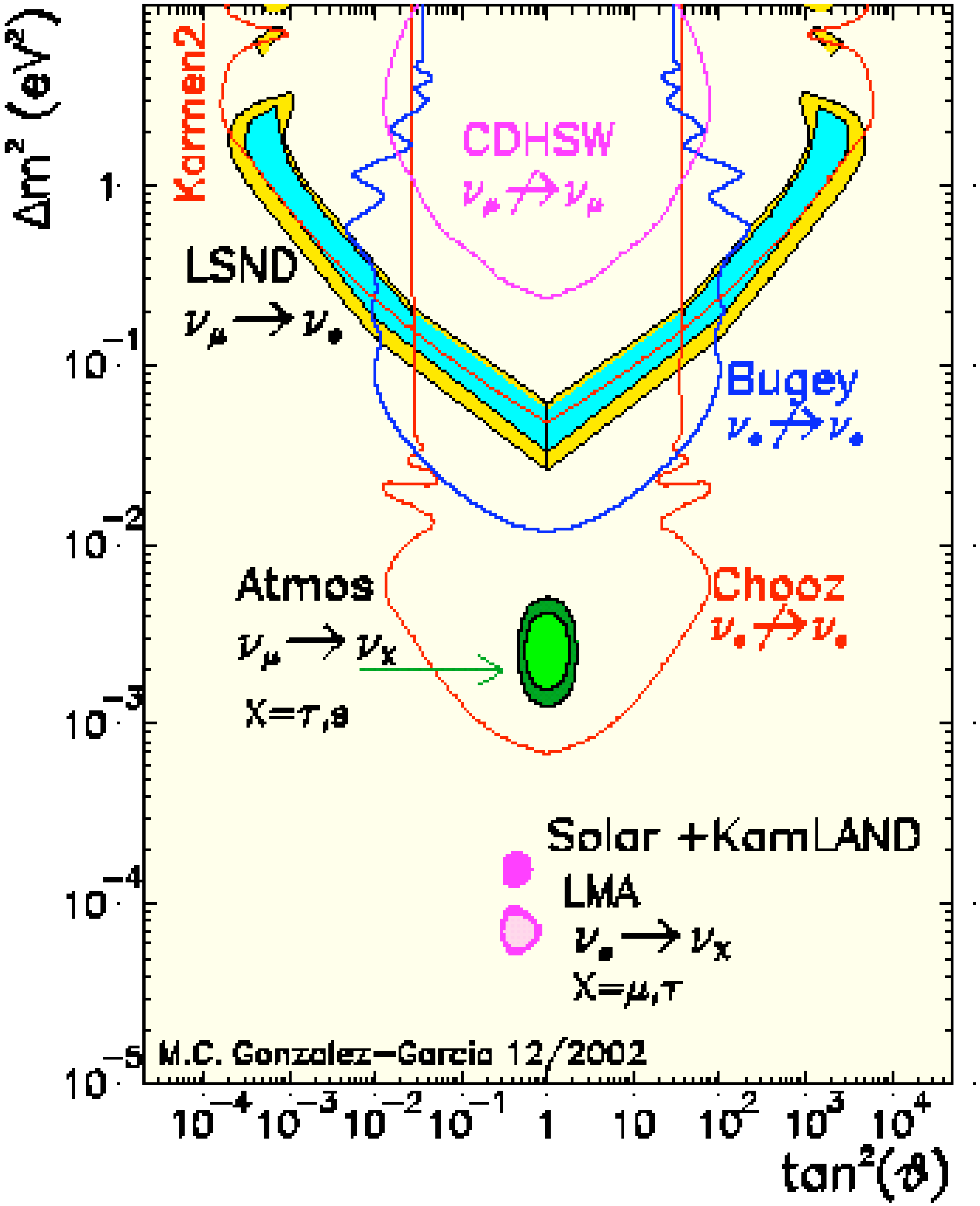
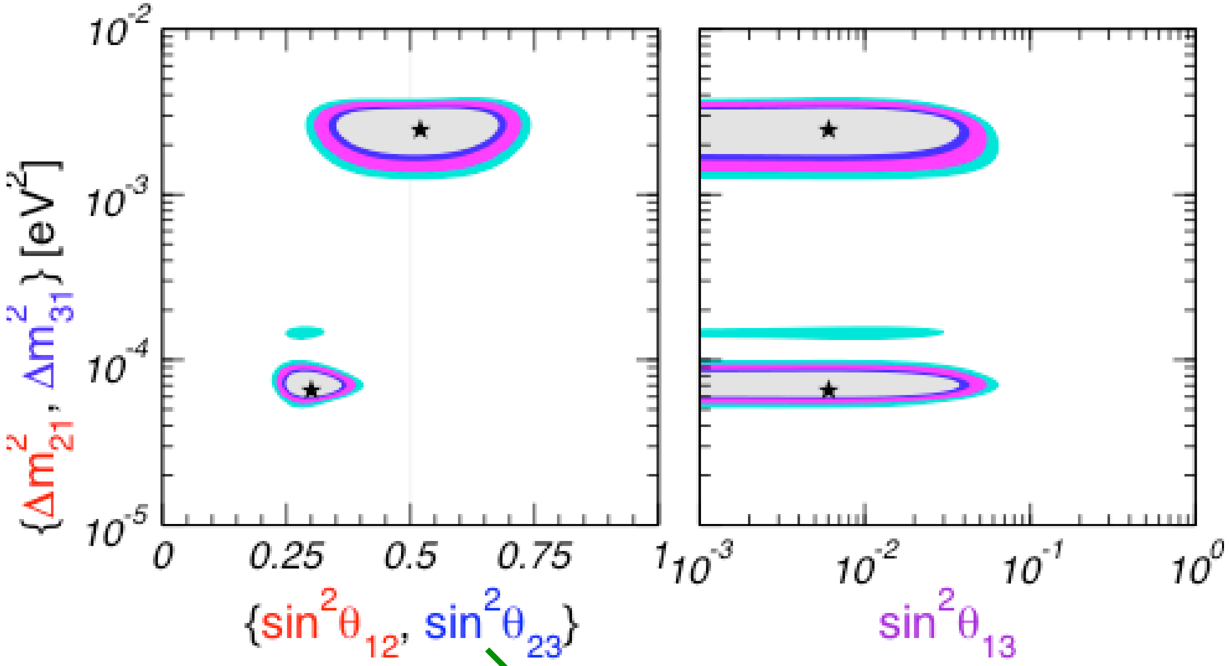


Before Nu'04

Maltoni et al '04

Large ν mixings: different from quarks! At first a surprise

parameter	best fit	2σ	3σ	5σ
Δm^2_{21} $[10^{-5}\text{eV}^2]$	6.9	6.0–8.4	5.4–9.5	2.1–28
Δm^2_{31} $[10^{-3}\text{eV}^2]$	2.6	1.8–3.3	1.4–3.7	0.77–4.8
$\sin^2\theta_{12}$	0.30	0.25–0.36	0.23–0.39	0.17–0.48
$\sin^2\theta_{23}$	0.52	0.36–0.67	0.31–0.72	0.22–0.81
$\sin^2\theta_{13}$	0.006	≤ 0.035	≤ 0.054	≤ 0.11



compatible with maximal but not necessarily or likely so

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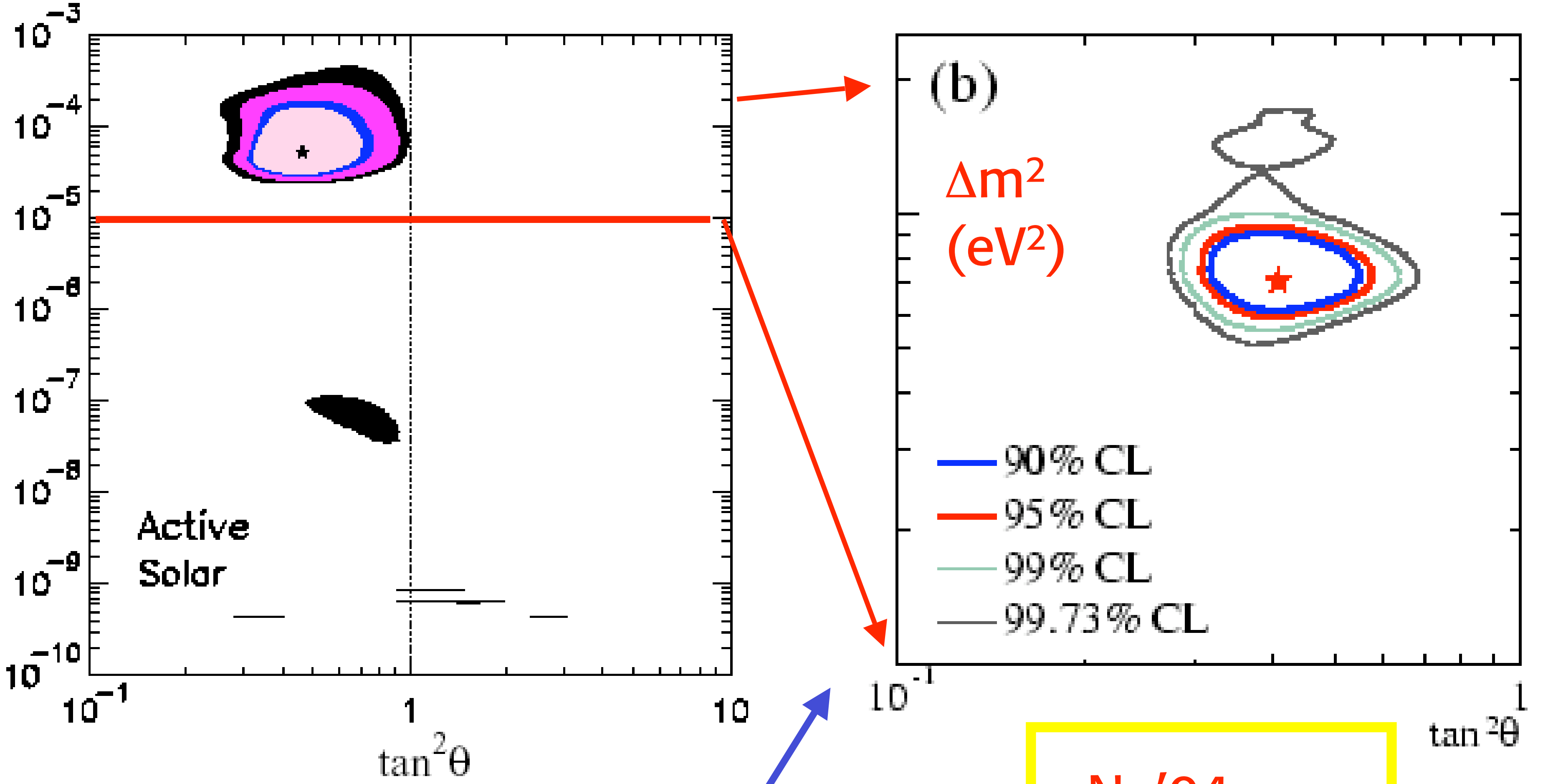
Recently great progress on Δm^2_{12}!

Before KamLAND

After KamLAND I & SNO(salt)



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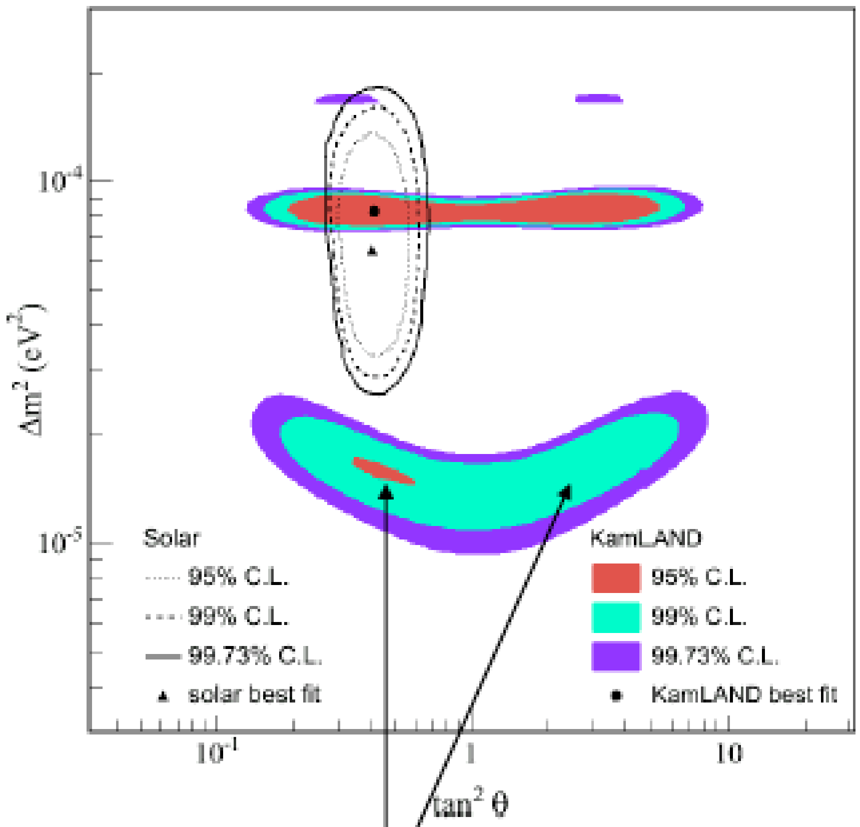
Note the change of scale

Nu'04:
KamLAND II

KamLAND brings $\Delta\nu_{solar}$ down to earth!

Gratta

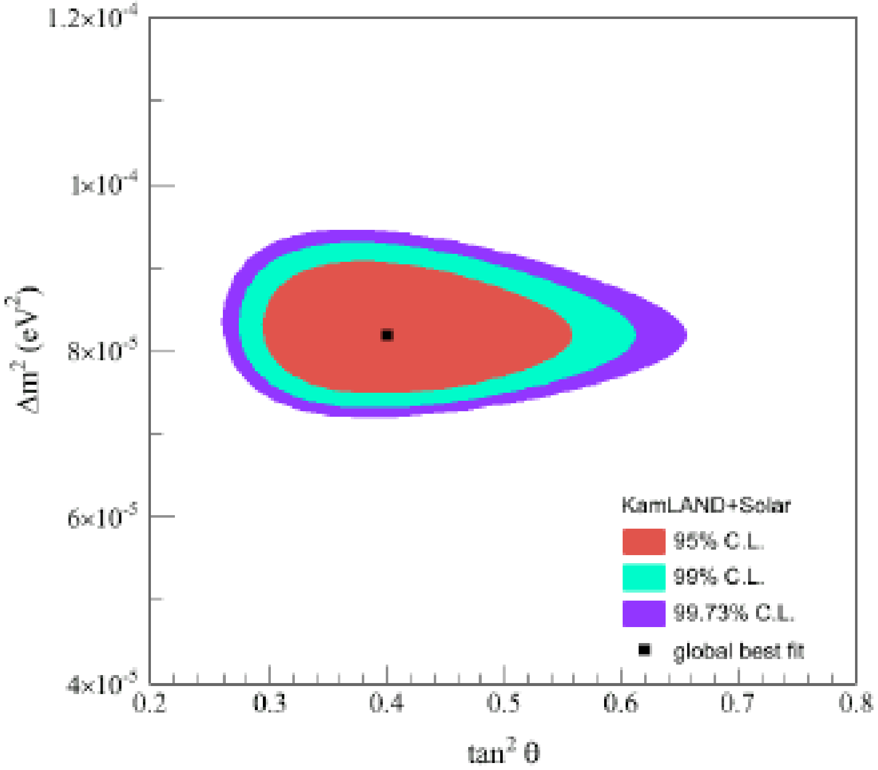
Combined solar ν - KamLAND 2-flavor analysis



Includes (small) matter effects

$$\Delta m^2_{12} = 8.2^{+0.6}_{-0.5} \times 10^{-5}\, eV^2$$

$$\tan^2\theta_{12} = 0.40^{+0.09}_{-0.07}$$



Goswami

- KamLAND has tremendous sensitivity to Δm^2_{21}
- Does not constrain θ_{12} much better than the current set of solar experiments

Data set used	Range* of $\Delta m^2_{21} \times 10^{-5}$ eV^2	spread in Δm^2_{21}
only sol	3.2 - 14.9	65%
sol+162 Ty KL	5.2 - 9.8	31%
sol+ 766.3 Ty KL	7.3 - 9.4	13%
future sol+1.3 kTy KL	6.7 - 7.8	8%

* 99% C.L.

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KamLAND "L"/E distribution: direct look at oscillations

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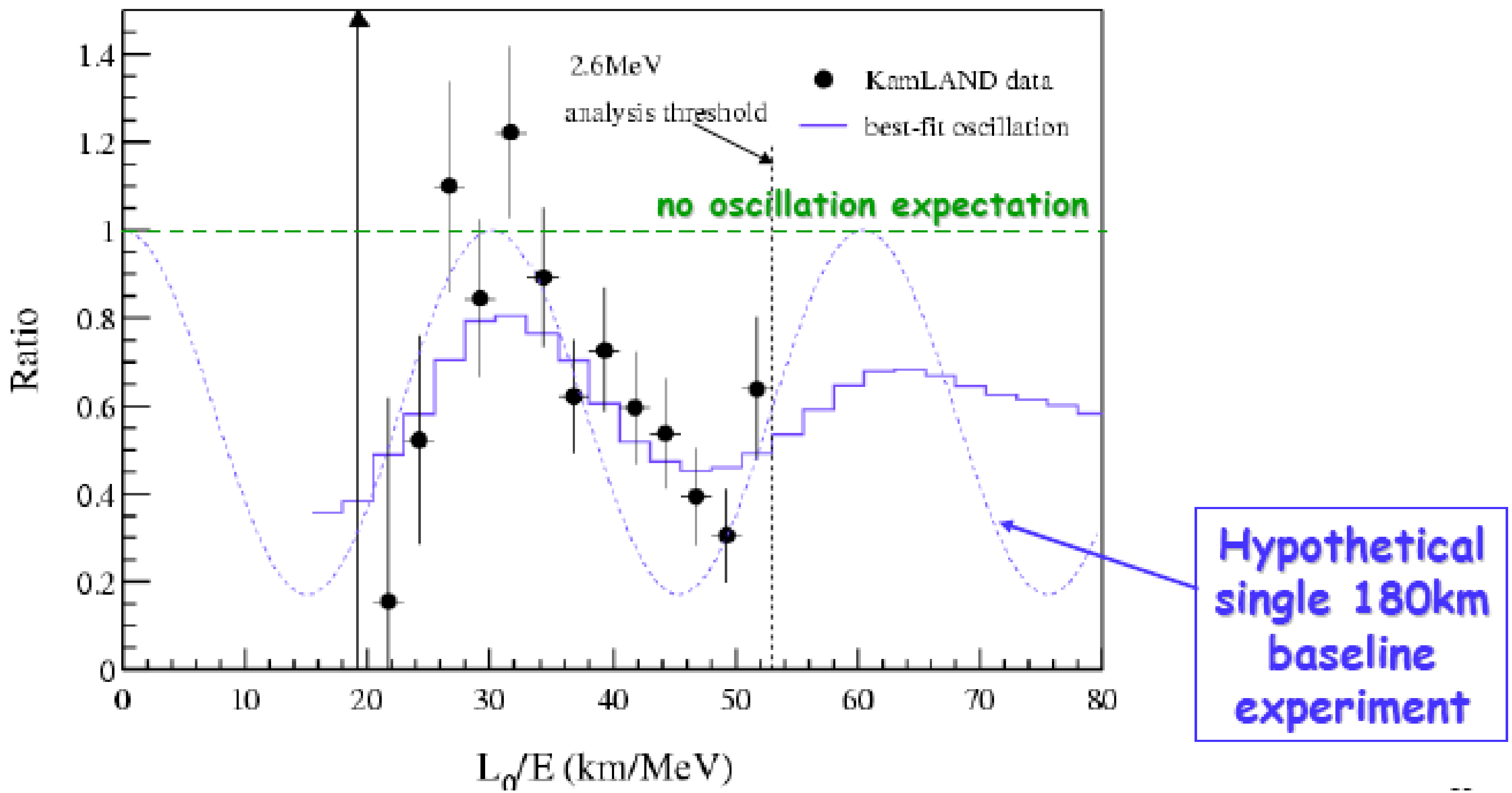

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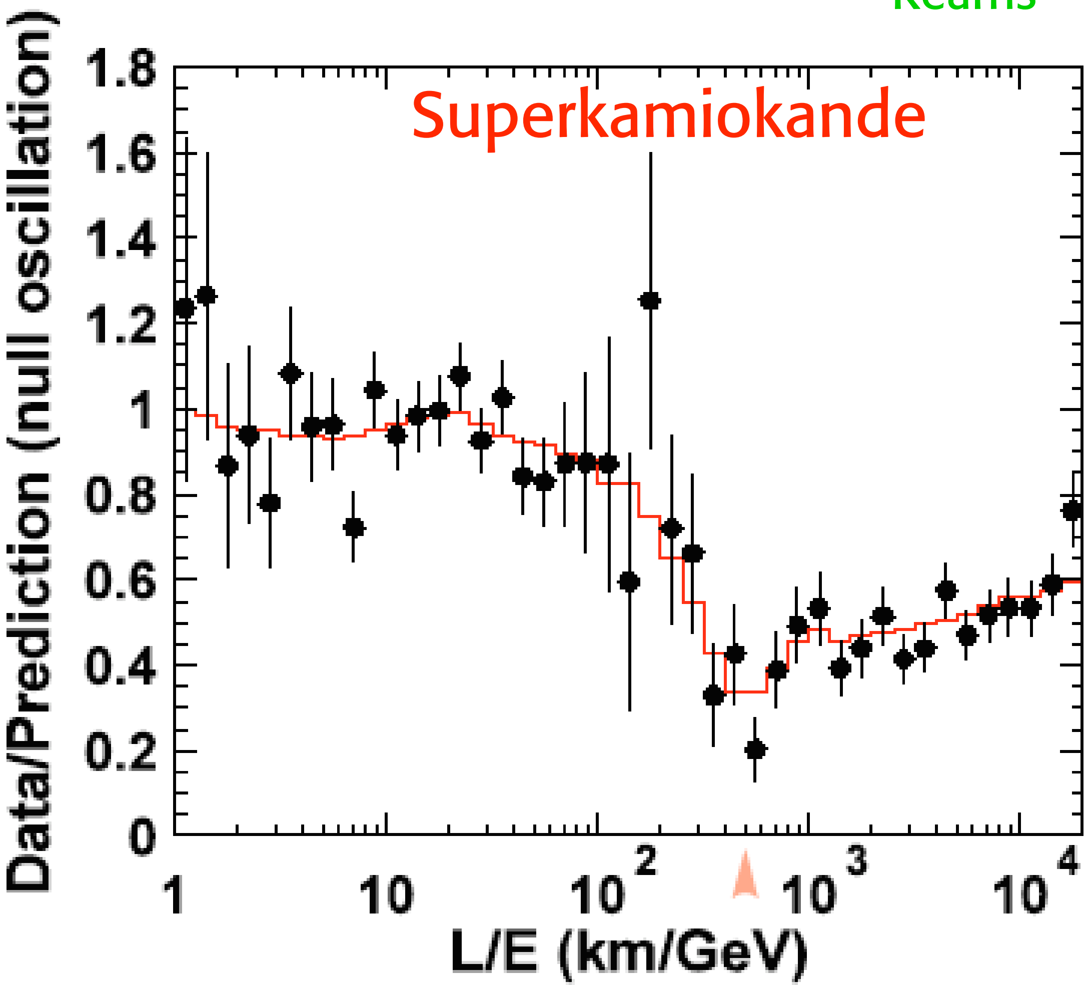
Atmospheric neutrinos: SuperKamiokande L/E analysis

Kearns



oscillation dip seen at ~500 km/GeV

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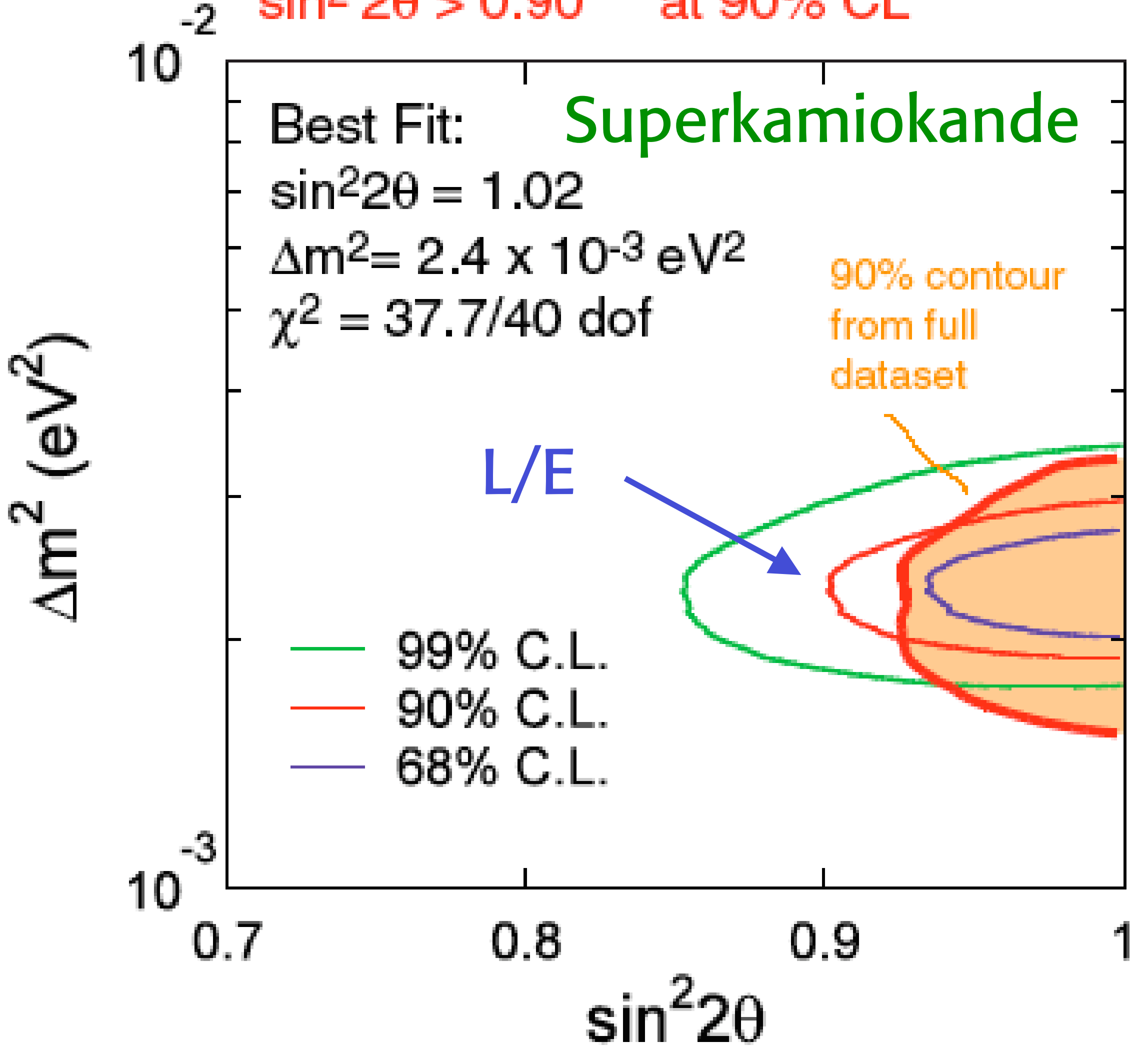
L/E: stronger lower bound on Δm^2

L/E

$1.9 \times 10^{-3}\ eV^2 < \Delta m^2 < 3.0 \times 10^{-3}\ eV^2$
$\sin^2 2\theta > 0.90$ at 90% CL



Kearns

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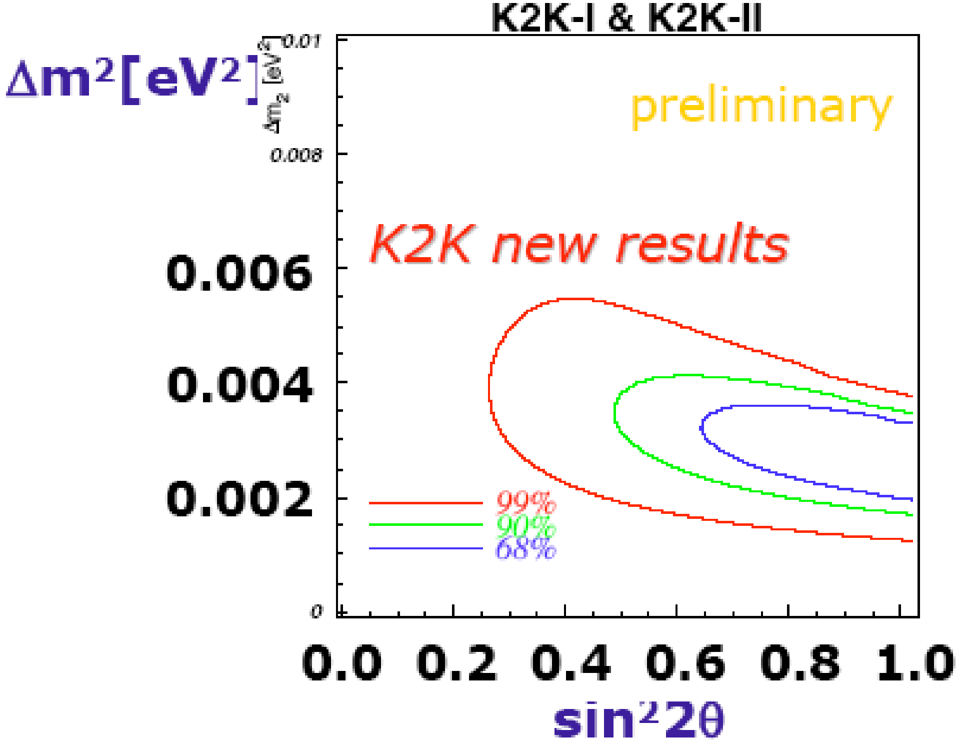
Important progress by K2K (bringing $\Delta\nu_{atm}$ down to earth)

Nakaya

- With 8.9×10^{19} POT, K2K *has confirmed* neutrino oscillations at **3.9σ**.
  - Disappearance of ν_μ **2.9σ**
  - Distortion of E_ν spectrum **2.5σ**



$N_{SK}^{exp} = 150.9^{+11.6}_{-10.0}$

$N_{SK}^{obs} = 108$

- $\sin^2 2\theta$ = **1.00**
- Δm^2 [eV²] = **2.73×10^{-3}**

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Bounds on $\sin^2\theta_{13}$

Goswami

3σ Bounds ($\Delta\chi^2 = 9$)

- Assuming the Δm^2_{32} range from SK+K2K analysis

$\sin^2\theta_{13} < 0.096$ (CHOOZ+ ATM+K2K)
$\sin^2\theta_{13} < 0.077$ (Sol+CHOOZ+ ATM+K2K)
$\sin^2\theta_{13} < 0.074$ (all data)

Bandyopadhyay et al., 2003

- Assuming the SK zenith analysis

$\sin^2\theta_{13} < 0.067$ (all data)

Fogli et al., 2003

- Assuming SK L/E analysis

$\sin^2\theta_{13} < 0.05$ (all data)

Fogli, Lisi, Marrone, Palazo, 2004

- SK zenith+K2K+solar+reactor analysis

$\sin^2\theta_{13} < 0.061$ (all data)

Maltoni et al,2004

Recently Δm^2_{atm} went down. As a consequence the upper bound on $\sin^2\theta_{13}$ is weaker

SK L/E results tend to improve the bound

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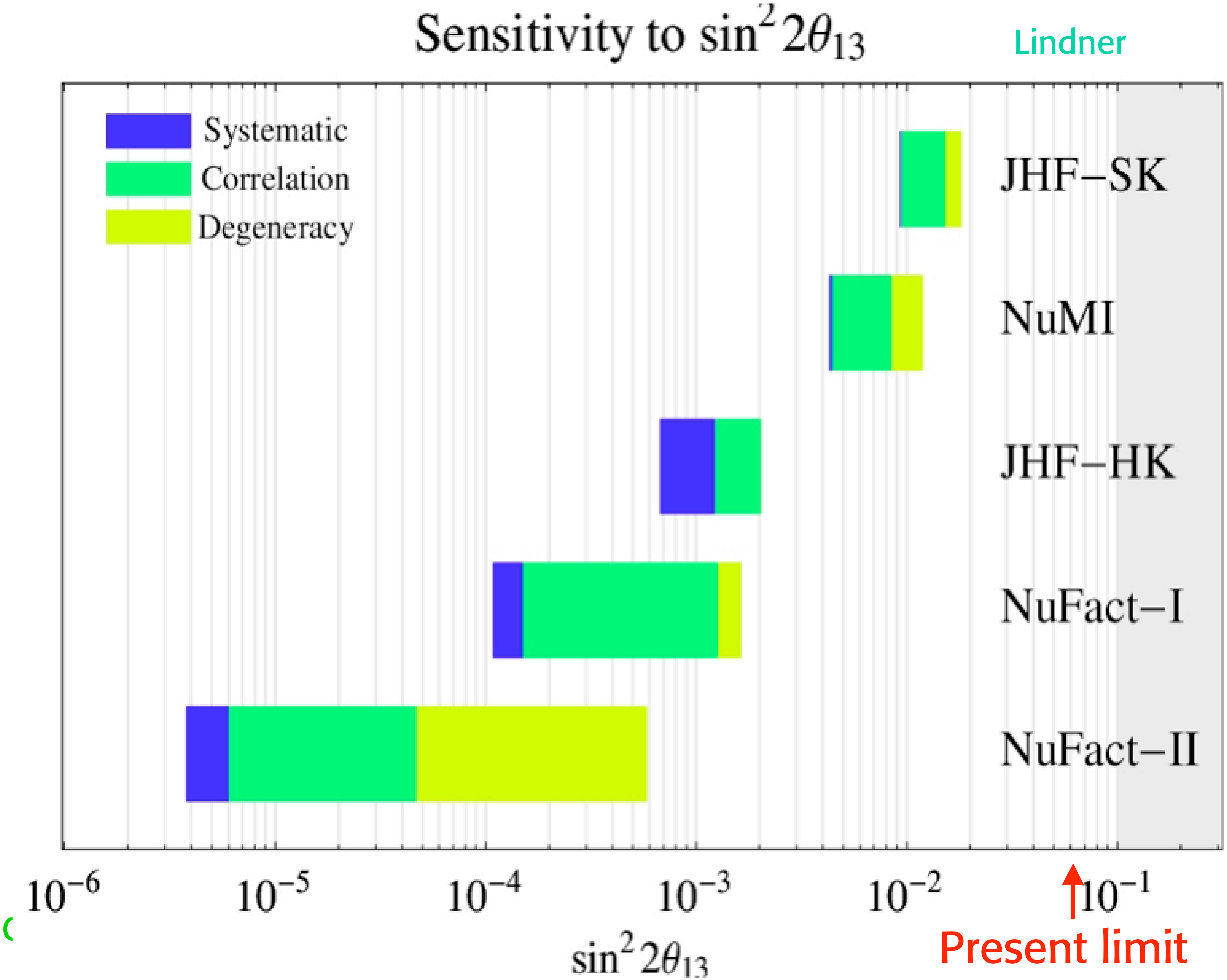


Sensitivity to $\sin^2 2\theta_{13}$
Lindner
Systematic
Correlation
Degeneracy
JHF–SK
NuMI
JHF–HK
NuFact–I
NuFact–II
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
$\sin^2 2\theta_{13}$
Present limit

ν oscillations measure Δm^2. What is m^2?

$\Delta m^2_{atm} \sim 2.5\ 10^{-3}\ eV^2$; $\Delta m^2_{sun} \sim 8\ 10^{-5}\ eV^2$

- Direct limits

$m_{"\nu e"} < 2.2$ eV

$m_{"\nu\mu"} < 170$ KeV

$m_{"\nu\tau"} < 18.2$ MeV

End-point tritium β decay (Mainz, Troitsk)

Future: Katrin (sub-eV)

Eitel

$m_{ee} = |\Sigma\, U_{ei}^2\, m_i|$

- $0\nu\beta\beta$ $m_{ee} < 0.2 - 0.5 - ?$ eV (nucl. matrix elmnts)

Evidence of signal? Klapdor-Kleingrothaus

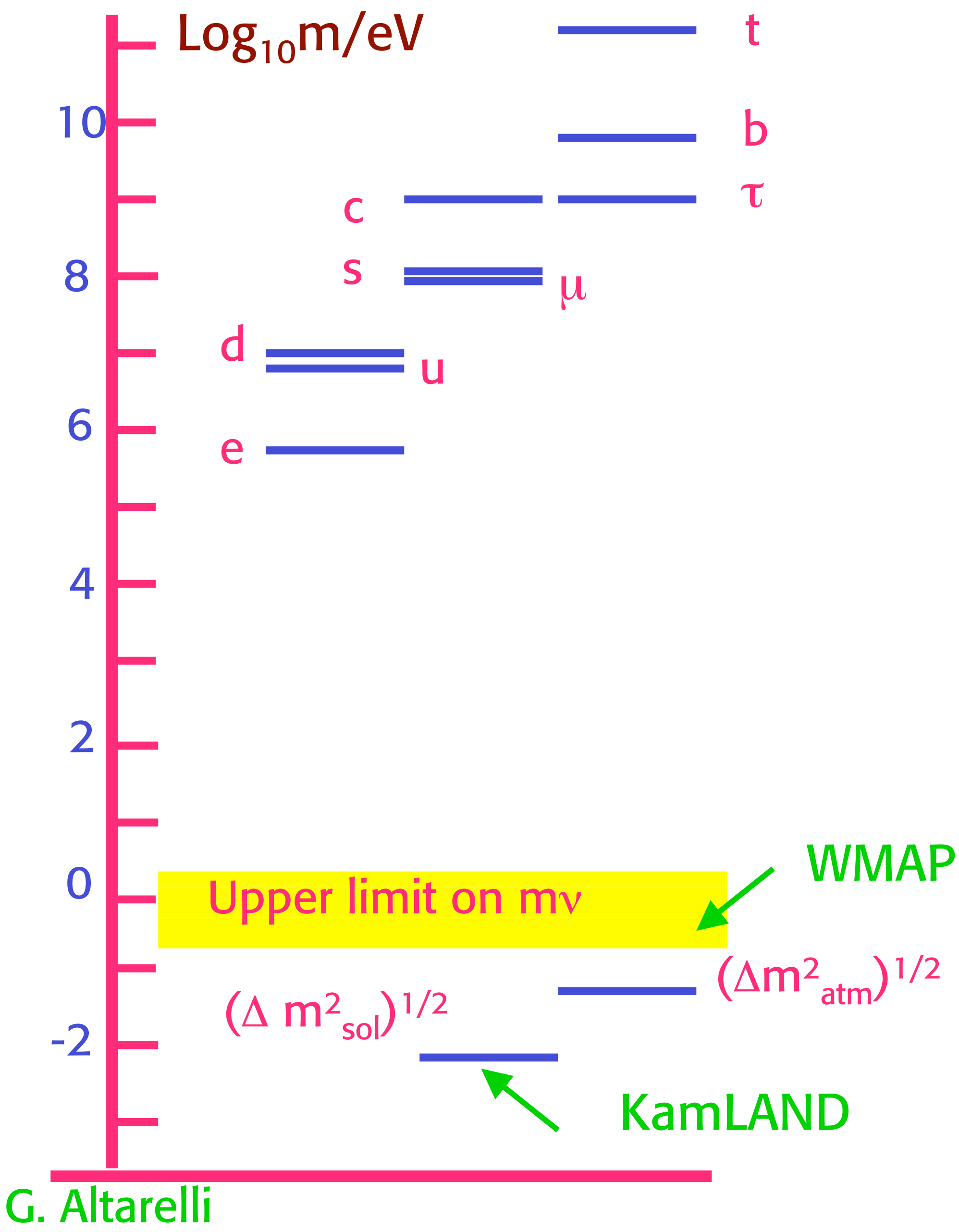
- Cosmology $\Omega_\nu\, h^2 \sim \Sigma_i m_i\ /94\text{eV}$ $(h^2 \sim 1/2)$

$\Sigma_i m_i \sim 0.7\text{-}1.8\text{-}?$ eV (dep. on priors)

WMAP, 2dFGRS...

→ Any ν mass $< 0.23\text{-}0.7$ eV

Why ν's so much lighter than quarks and leptons?



Neutrino masses are really special!

$m_t/(\Delta m^2_{atm})^{1/2} \sim 10^{12}$

Massless ν's?

- no ν_R
- L conserved

Small ν masses?

- ν_R very heavy
- L not conserved

A very natural and appealing explanation:

ν's are nearly massless because they are Majorana particles and get masses through L non conserving interactions suppressed by a large scale $M \sim M_{GUT}$

$$m_\nu \sim \frac{m^2}{M}$$

$m \sim m_t \sim v \sim 200$ GeV

M: scale of L non cons.

Note:

$m_\nu \sim (\Delta m^2_{atm})^{1/2} \sim 0.05$ eV

$m \sim v \sim 200$ GeV

$M \sim 10^{15}$ GeV

Neutrino masses are a probe of physics at M_{GUT} !

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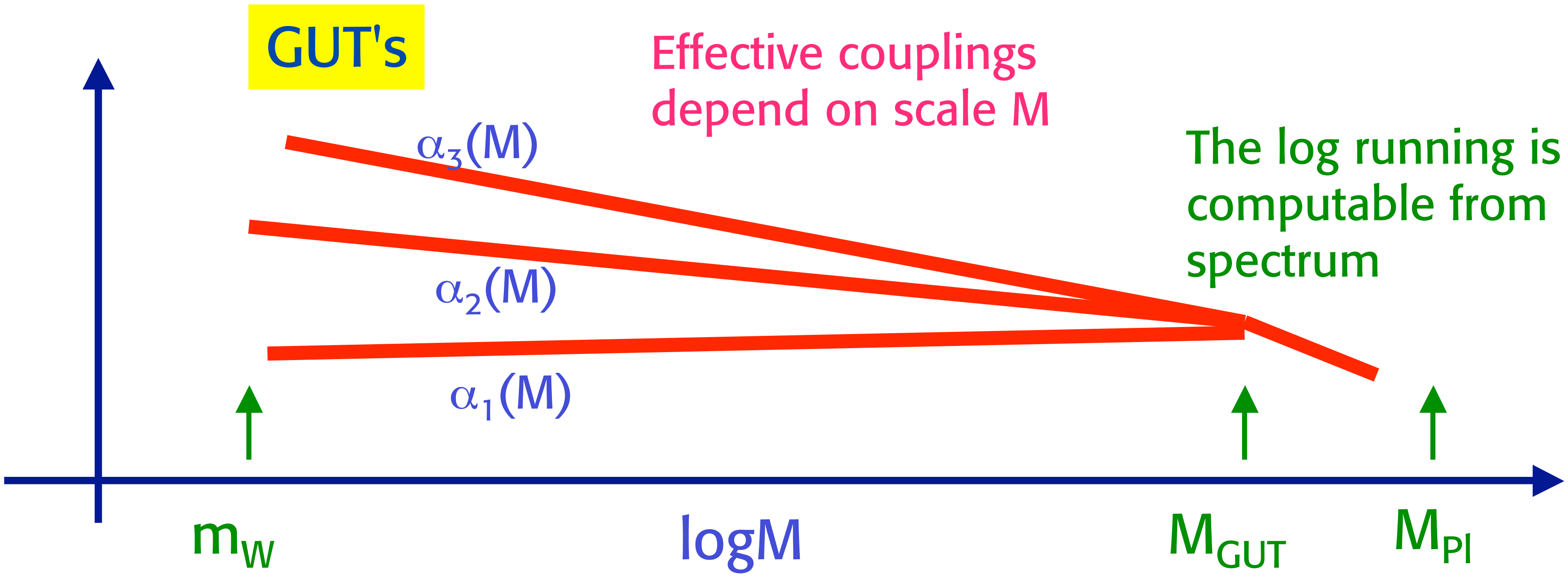

The large scale structure of particle physics:

- SU(3) ⊗ SU(2) ⊗ U(1) unify at M_{GUT}
- at M_{Pl}: quantum gravity

$$G_{Newton} = \frac{\hbar c}{M_{Pl}^2}$$

$r \sim 10^{-33}$ cm

Superstring theory:
a 10-dimensional non-local, unified theory of all interact's

The really fundamental level

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By now GUT's are part of our culture in particle physics

- Unity of forces: $G \supset SU(3) \otimes SU(2) \otimes U(1)$

  unification of couplings
- Unity of quarks and leptons

  different "directions" in G
- Family Q-numbers

  e.g. in SO(10) a whole family in 16
- Charge quantisation: $Q_d = -1/3 \to -1/N_{colour}$
- B and L non conservation

  ->p-decay, baryogenesis, ν masses

• • • • •

Most of us believe that Grand Unification must be a feature of the final theory!

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Conceptual problems of the SM

Most clearly:

- No quantum gravity (M_{Pl} ~ 10^{19} GeV)
- But a direct extrapolation of the SM leads directly to GUT's (M_{GUT} ~ 10^{16} GeV)

M_{GUT} close to M_{Pl}

- suggests unification with gravity as in superstring theories
- poses the problem of the relation m_W vs M_{GUT}- M_{Pl}

Can the SM be valid up to M_{GUT}- M_{Pl}?? ← The hierarchy problem

Not only it looks very unlikely, but the new physics must be near the weak scale!

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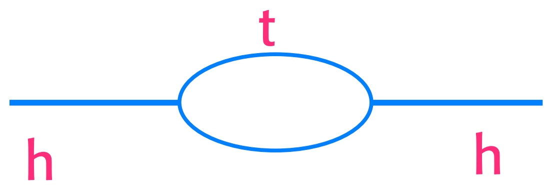
For the low energy theory: the "little hierarchy" problem:

e.g. the top loop (the most pressing):

$m_h^2 = m^2_{bare} + \delta m_h^2$



$$\delta m^2_{h|top} = \frac{3G_F}{\sqrt{2}\pi^2} m_t^2 \Lambda^2 \sim (0.3\Lambda)^2$$

$\Lambda \sim$ o(1TeV)

This hierarchy problem demands new physics near the weak scale

Λ: scale of new physics beyond the SM

- $\Lambda >> m_Z$: the SM is so good at LEP
- $\Lambda \sim$ few times $G_F^{-1/2} \sim$ o(1TeV) for a natural explanation of m_h or m_W

Barbieri, Strumia

The LEP Paradox: m_h light, new physics must be so close but its effects are not directly visible

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Examples:

SUSY

- Supersymmetry: boson-fermion symm.
  exact (unrealistic): cancellation of $\delta\mu^2$
  approximate (possible): $\Lambda \sim m_{SUSY}-m_{ord}$ → top loop $\Lambda \sim m_{stop}$

The most widely accepted

- The Higgs is a $\bar{\psi}\psi$ condensate. No fund. scalars. But needs new very strong binding force: $\Lambda_{new} \sim 10^3 \Lambda_{QCD}$ (technicolor).

Strongly disfavoured by LEP

- Large extra spacetime dimensions that bring M_{Pl} down to o(1TeV)

Elegant and exciting. Rich potentiality. Does it work?

- Models where extra symmetries allow m_h only at 2 loops and non pert. regime starts at $\Lambda \sim 10$ TeV

"Little Higgs" models. Tension with EW precision tests

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SUSY fits with GUT's

From $\alpha_{QED}(m_Z)$, $\sin^2\theta_W$ measured at LEP predict $\alpha_s(m_Z)$ for unification (assuming desert)

EXP: $\alpha_s(m_Z)=0.119\pm0.003$
Present world average

- Coupling unification: Precise matching of gauge couplings at M_{GUT} fails in SM and is well compatible in SUSY

Non SUSY GUT's
$\alpha_s(m_Z)=0.073\pm0.002$

SUSY GUT's
$\alpha_s(m_Z)=0.130\pm0.010$

Langacker, Polonski

Dominant error:
thresholds near M_{GUT}

- Proton decay: Far too fast without SUSY
- $M_{GUT} \sim 10^{15}$GeV non SUSY ->10^{16}GeV SUSY
- Dominant decay: Higgsino exchange

While GUT's and SUSY very well match,
(best phenomenological hint for SUSY!)
in technicolor , large extra dimensions,
little higgs etc., there is no ground for GUT's

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Turner/Lahav

Dark Matter

WMAP

Most of the Universe is not made up of atoms: $\Omega_{tot} \sim 1$, $\Omega_b \sim 0.044$, $\Omega_m \sim 0.27$
Most is Dark Matter and Dark Energy

Most Dark Matter is Cold (non relativistic at freeze out)
Significant Hot Dark matter is disfavoured
Neutrinos are not much cosmo-relevant: $\Omega_\nu < 0.015$ (WMAP)

SUSY has excellent DM candidates: Neutralinos (--> LHC)
Also Axions are still viable (in a small mass window $m \sim 10^{-5}$ eV)
Van Bibber

Identification of Dark Matter is of a task of enormous importance for particle physics and cosmology

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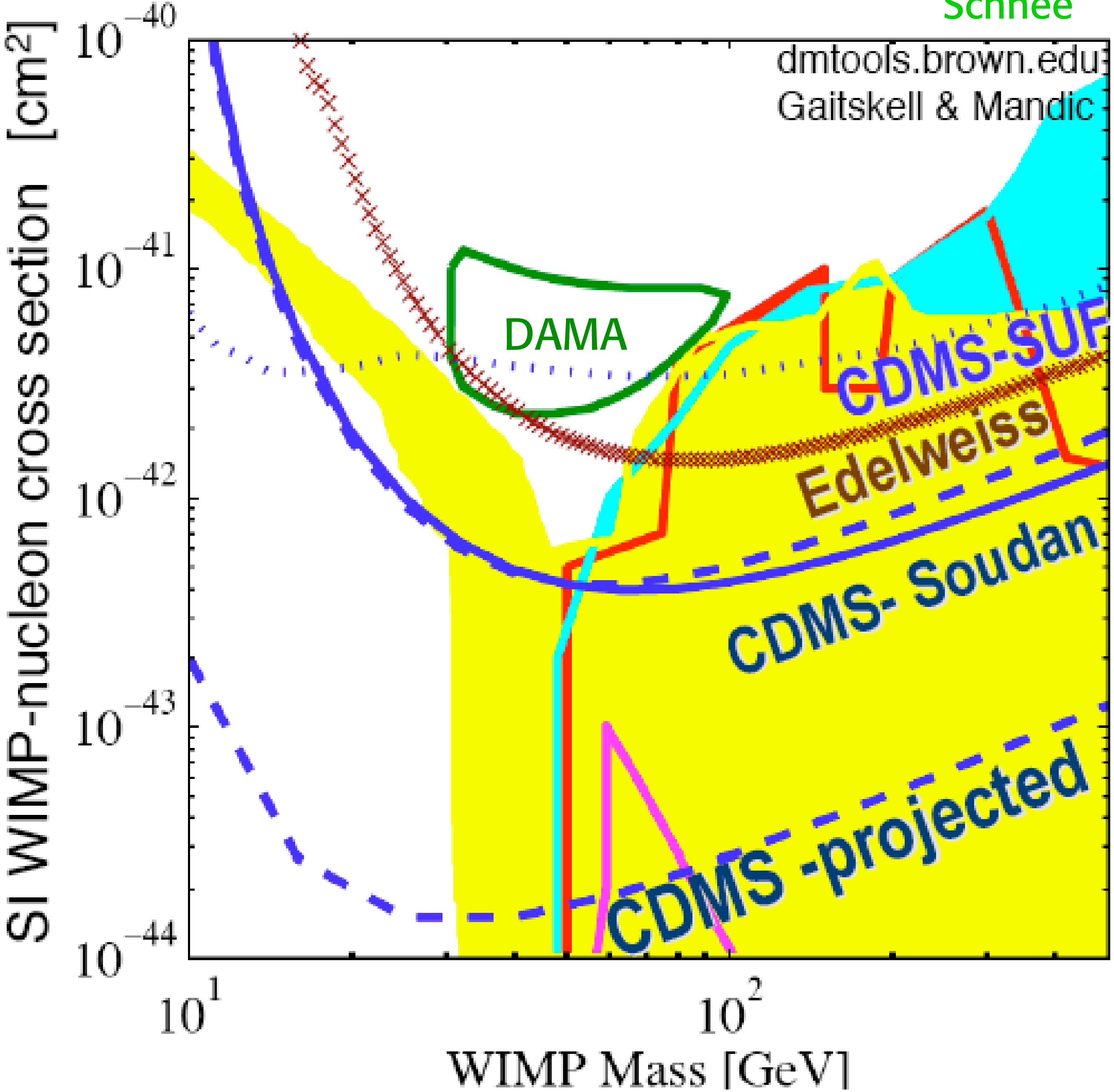
Search for neutralinos

Gascon
Schnee

Edsjo



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Neutrino masses point to M_{GUT}, well fit into the SUSY-GUT's picture:

indeed add considerable support to this idea.

Technicolor, Little Higgs, Extra dim….: nearby cut-off. Problem of suppressing

$$O_5 = \nu_L^T \frac{\lambda}{M} \nu_L HH$$

Another big plus of neutrinos is the elegant picture of baryogenesis thru leptogenesis

(after LEP has disfavoured BG at the weak scale)

Buchmuller

Baryogenesis   A most attractive possibility:

BG via Leptogenesis near the GUT scale

$T \sim 10^{12\pm3}$ GeV (after inflation)

Buchmuller,Yanagida, Plumacher, Ellis, Lola, Giudice et al, Fujii et al

Only survives if Δ(B-L) is not 0
(otherwise is washed out at T_{ew} by instantons)

Main candidate: decay of lightest ν_R ($M \sim 10^{12}$ GeV)

L non conserv. in ν_R out-of-equilibrium decay:
B-L excess survives at T_{ew} and gives the obs. B asymm.

Quantitative studies confirm that the range of m_i from ν oscill's is perfectly compatible with BG via (thermal) LG

In particular the bound was derived
Can be somewhat relaxed for degenerate ν's.

$m_i < 10^{-1}$ eV   Close to WMAP

Buchmuller, Di Bari, Plumacher
Giudice et al

The scale of the cosmological constant is a big mystery.

$\Omega_\Lambda \sim 0.65$ → $\rho_\Lambda \sim (2\ 10^{-3}\ \mathrm{eV})^4 \sim (0.1\mathrm{mm})^{-4}$ → Similar to m_ν!?

In Quantum Field Theory: $\rho_\Lambda \sim (\Lambda_{cutoff})^4$

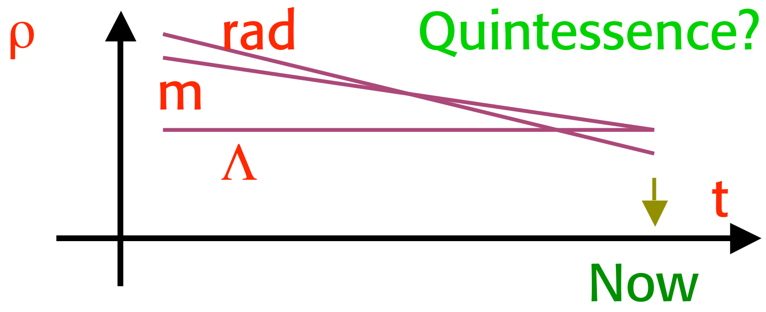
If $\Lambda_{cutoff} \sim M_{Pl}$ → $\rho_\Lambda \sim 10^{123}\ \rho_{obs}$

Exact SUSY would solve the problem: $\rho_\Lambda = 0$

But SUSY is broken: $\rho_\Lambda \sim (\Lambda_{SUSY})^4 \sim 10^{59}\ \rho_{obs}$

It is interesting that the correct order is $(\rho_\Lambda)^{1/4} \sim (\Lambda_{EW})^2/M_{Pl}$

Other problem:
Why now?



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The scale of vacuum energy poses a large naturalness problem!

So far no clear way out:

- A modification of gravity at 0.1mm? (large extra dim.)
- Leak of vac. energy to other universes (wormholes)?

- Anthropic principle: just right for galaxy formation

(Weinberg)

Perhaps naturality irrelevant also for Higgs: Arkani-Hamed, Dimopoulos; Giudice, Romanino '04

Split SUSY: a fine tuned light Higgs + light gauginos and higgsinos. all other s-partners heavy preserves coupling unification and dark matter

Or simply a two-scale non-SUSY GUT with axions as DM

For ν masses all that would remain fine

The current experimental situation is still unclear

- LSND: true or false?
- what is the absolute scale of ν masses?
- $0\nu\beta\beta$? •••

Different classes of models are possible:

If LSND true

Strumia

sterile ν(s)??

CPT violat'n??

• "3-1"

If LSND false → 3 light ν's are OK

We assume this case here

- Degenerate ($m^2 >> \Delta m^2$)

- Inverse hierarchy

- Normal hierarchy

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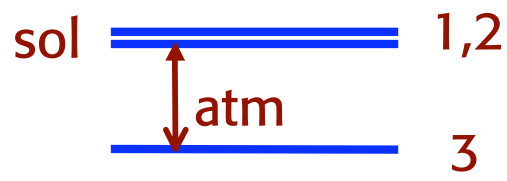
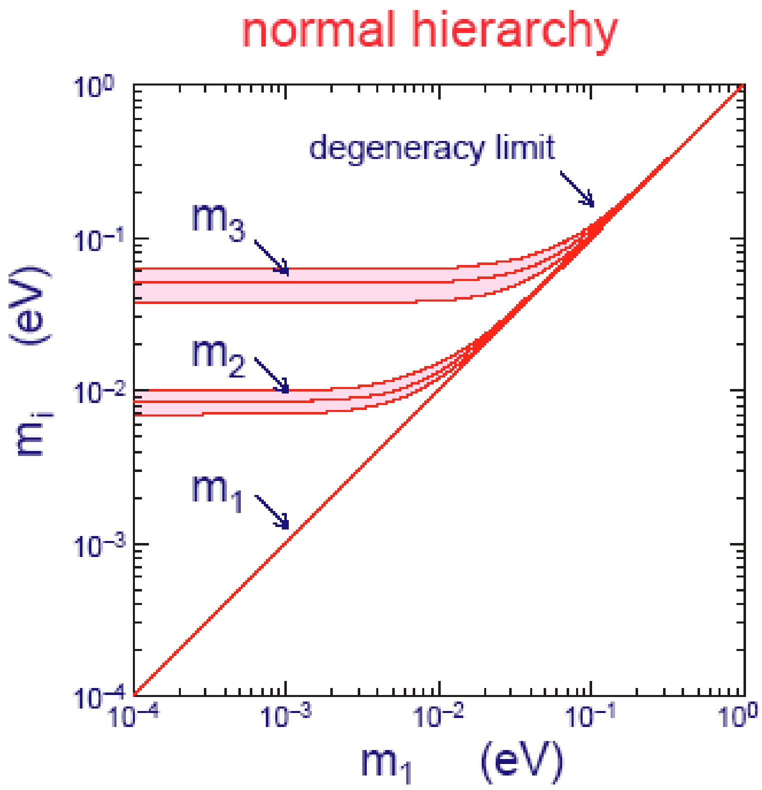
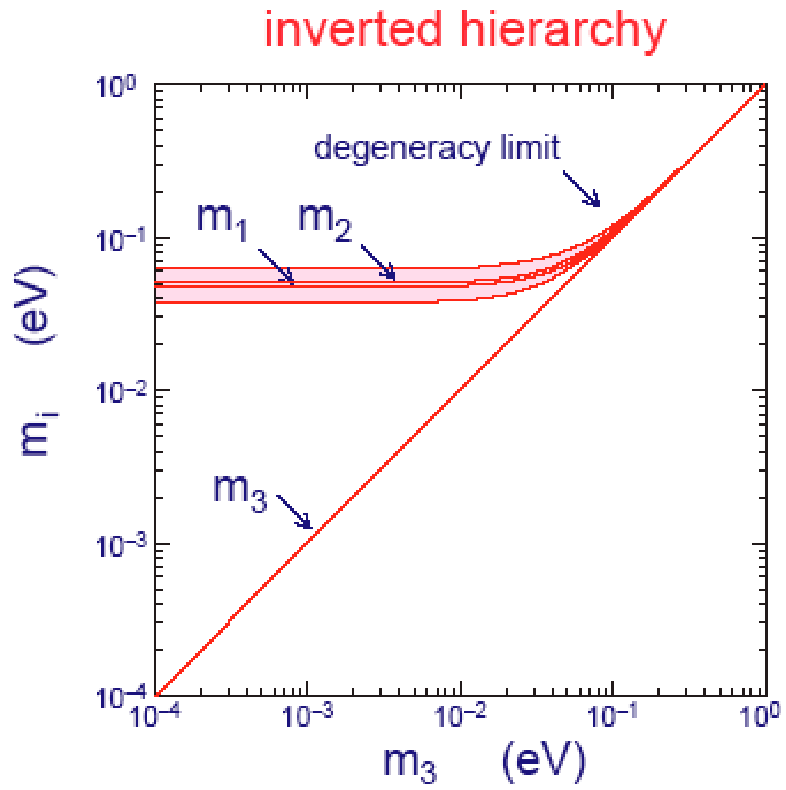
3
atm
sol
1,2


sol
1,2
atm
3


normal hierarchy
degeneracy limit
m3
m2
m1
mi (eV)
m1 (eV)


inverted hierarchy
degeneracy limit
m1
m2
m3
mi (eV)
m3 (eV)

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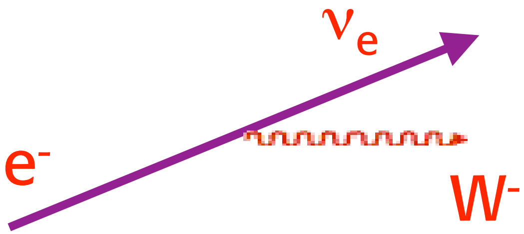
3-ν Models

Petcov
Feruglio

$$\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix} = U \begin{pmatrix}\nu_1\\ \nu_2\\ \nu_3\end{pmatrix}$$

flavour mass



$U = U_{P\text{-}MNS}$

Pontecorvo
Maki, Nakagawa, Sakata

In basis where e^-, μ^-, τ^- are diagonal:

$$U = \begin{bmatrix}1 & 0 & 0\\ 0 & c_{23} & s_{23}\\ 0 & -s_{23} & c_{23}\end{bmatrix}\begin{bmatrix}c_{13} & 0 & s_{13}e^{-i\delta}\\ 0 & 1 & 0\\ -s_{13}e^{i\delta} & 0 & c_{13}\end{bmatrix}\begin{bmatrix}c_{12} & s_{12} & 0\\ -s_{12} & c_{12} & 0\\ 0 & 0 & 1\end{bmatrix} \sim$$

s = solar: large

CHOOZ: $|s_{13}| <\sim 0.25$

$$\sim \begin{bmatrix}c_{13}c_{12} & c_{13}s_{12} & s_{13}e^{-i\delta}\\ \dots & \dots & c_{13}s_{23}\\ \dots & \dots & c_{13}c_{23}\end{bmatrix}$$

atm.: ~ max

$$U = \begin{bmatrix}c & -s & 0\\ \frac{s}{\sqrt{2}} & \frac{c}{\sqrt{2}} & \frac{-1}{\sqrt{2}}\\ \frac{s}{\sqrt{2}} & \frac{c}{\sqrt{2}} & \frac{1}{\sqrt{2}}\end{bmatrix} \longrightarrow U = \begin{pmatrix}0.84 & 0.54 & 0.1\\ -0.44 & 0.56 & 0.71\\ 0.32 & -0.63 & 0.71\end{pmatrix}$$

G. Altare

$$m_\nu \sim U \begin{bmatrix} e^{i\phi_1} m_1 & 0 & 0 \\ 0 & e^{i\phi_2} m_2 & 0 \\ 0 & 0 & m_3 \end{bmatrix} U^T$$

In general 9 parameters:
3 masses, 3 angles,
3 phases

$L^T m_\nu L$

For $s_{13} \sim 0$:

$0\nu\beta\beta$

$$m_\nu \sim \begin{bmatrix} m_1 c^2 + m_2 s^2 & (m_1 - m_2) cs/\sqrt{2} & (m_1 - m_2) cs/\sqrt{2} \\ \dots & (m_1 s^2 + m_2 c^2 + m_3)/2 & (m_1 s^2 + m_2 c^2 - m_3)/2 \\ \dots & \dots & (m_1 s^2 + m_2 c^2 + m_3)/2 \end{bmatrix}$$

Note:

- m_ν is symmetric
- phases included in m_i

Relation between masses and frequencies:

$P(\nu_e <-> \nu_\mu) = P(\nu_e <-> \nu_\tau) = 1/2 \sin^2 2\theta_{12} \cdot \sin^2 \Delta_{sun}$

$P(\nu_\mu <-> \nu_\tau) = \sin^2 \Delta_{atm} - 1/4 \sin^2 2\theta_{12} \cdot \sin^2 \Delta_{sun}$

$$\Delta_{sun} = \frac{m_2^2 - m_1^2}{4E} L \quad ; \quad \Delta_{atm} = \frac{m_3^2 - m_{1,2}^2}{4E} L$$

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In our def.: $\Delta_{sun} > 0$, $\Delta_{atm} >$ or < 0

0νββ can establish L non conservation, Majorana n's and also tell degenerate, inverted or normal hierarchy

$|m_{ee}|=c_{13}^2\ [m_1 c_{12}^2+e^{i\alpha} m_2 s_{12}^2]+m_3 e^{i\beta} s_{13}^2$

LA:~0.3-1

Degenerate: $\sim|m|\ |c_{12}^2+e^{i\alpha} s_{12}^2|$

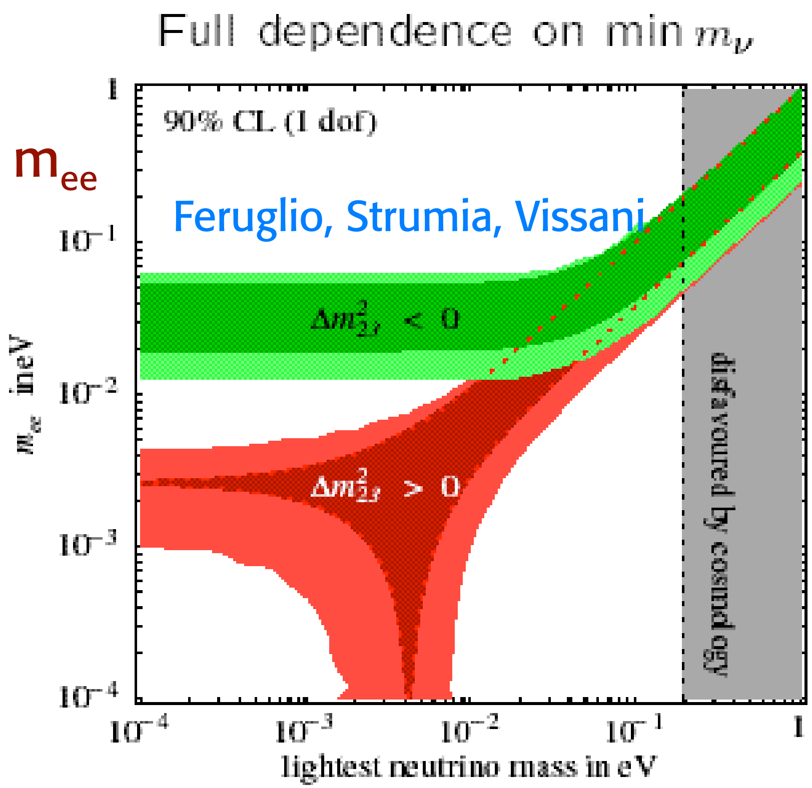
$|m_{ee}|\sim\ |m|\ (0.3\ -1) < \ 0.23\text{-}1\ \text{eV}$

IH: $\sim(\Delta m^2_{atm})^{1/2}|c_{12}^2+e^{i\alpha} s_{12}^2|$

$|m_{ee}|\sim\ (1.6\text{-}5)\ 10^{-2}\ \text{eV}$

NH: $\sim(\Delta m^2_{sol})^{1/2} s_{12}^2+(\Delta m^2_{atm})^{1/2} e^{i\beta}$

$|m_{ee}|\sim\ (\text{few})\ 10^{-3}\ \text{eV}$



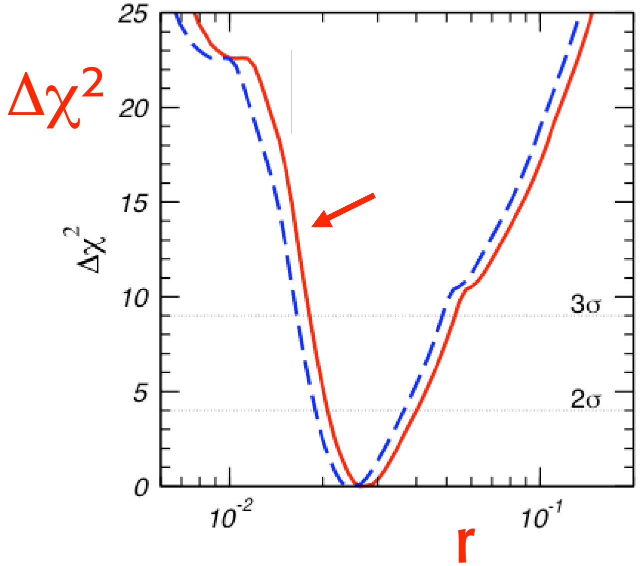
lightest m_ν (eV)

Sarazin
Fiorini
Avignone

Present exp. limit: $m_{ee} < 0.3\text{-}0.5$ eV
(and a hint of signal?) K-K
Future: NEMO3, CUORE, GENIUS, EXO...

After KamLAND, SNO and WMAP not too much hierarchy is needed for ν masses:

$r \sim \Delta m^2_{sol}/\Delta m^2_{atm} \sim 1/35$



Precisely at 3σ: $0.018 < r < 0.053$

or

$m_{heaviest} < 1 - 0.23$ eV
$m_{next} > \sim 8\ 10^{-3}$ eV

For a hierarchical spectrum: $\frac{m_2}{m_3} \approx \sqrt{r} \approx 0.2$

Comparable to: $\lambda_C \approx 0.22$ or $\sqrt{\frac{m_\mu}{m_\tau}} \approx 0.24$

Suggests the same "hierarchy" parameters for q, l, ν

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→ e.g. θ_{13} not too small!

We stress again:

- Still large space for non maximal 23 mixing

  3-σ interval $0.31 < \sin^2\theta_{23} < 0.72$

  Maximal θ_{23} theoretically hard

- θ_{13} not necessarily too small
  probably accessible to exp.

  $\sin\theta_{13} \sim 1/2 \sin\theta_{13}$
  not excluded!

- $r \sim \Delta m^2_{sol}/\Delta m^2_{atm} \sim 1/35$
  $m_{heaviest} < 1 - 0.23$ eV

  Moderate mass hierarchy
  of order λ_C

- absolute spectrum
  though an open experimental question, theoretically welcome
  (but not experimentally unavoidable) properties like GUTs, see-saw and
  relationship with other fermion masses favour a hierarchical spectrum,
  with normal hierarchy less constrained than the inverse one
  by current knowledge of $\tan^2\vartheta_{12}$ and U_{e3}

- Ue3 not un-measurably small in most of models.

Feruglio

Goals of future experiments

- Confirm or reject LSND (In progress: MiniBoone) Brice
- Measure θ_{13} (MINOS, reactors) Thompson/Oberauer/Messier
- Detect ν_τ in $\nu_\mu \leftrightarrow \nu_\tau$ (In preparation: Opera, Icarus) Autiero Bueno
- How close to maximal is θ_{23}?
- Determine signΔm_{23}^2 (LBL, ν factories)
- Go after CP violation (LBL, ν factories) Blondel/Tonazzo/Mezzetto
- Improve sensitivity to $0\nu\beta\beta$ (CUORE, GENIUS, EXO....)
- Cosmic neutrinos (Baikal, Amanda, Antares, Nestor, Nemo, Auger..)
- Lepton flavour violation ($\mu \to e\gamma$...), mag. mom. Aoki/Savoy/Wong DeGouvea
- p decay Jung/ Sulak

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Plenty of work/ projects for many years!

Long baseline osc. experiments

Kobayashi

Classification by
G.Feldman @SB WS@BNL

- 1^{st} phase experiments (Now)
  - Confirmation of atm. ν results
    - K2K(1999~)/MINOS(2005~)/ICARUS/OPERA(2006~)
- 2^{nd} phase experiments (Now~10yrs)
  - **Discovery of ν_e appearance**
  - Designed & Optimized aft. SK atm ν
  - ~MW beam w/ ~50kton detector
    - T2K-I (approved. 2009~)/NOνA (2009?~) / (C2GT)

"Super Beam" Experiments

- 3^{rd} phase experiments(10~20yrs?)
  - **CP violation and mass hierarchy** thru $\overset{(-)}{\nu}_\mu \rightarrow \overset{(-)}{\nu}_e$ app.
  - Typically Multi-MW beam & Mton detector
  - 2^{nd} phase is critical step to go

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Summary of (“super-beam”) LBL experiments

	E_p (GeV)	Power (MW)	Beam	<*E*> (GeV)	*L* (km)	M_{det} (kt)	ν_μCC (/yr)	ν_e @peak	
K2K	12	0.005	WB	1.3	250	22.5	~50	~1%	
MINOS(LE)	120	0.4	WB	3.5	730	5.4	~2,500	1.2%	I
CNGS	400	0.3	WB	18	732	~2	~5,000	0.8%	
T2K-I	50	0.75	OA	0.7	295	22.5	~3,000	0.2%	
NOνA	120	0.4	OA	~2	810?	50	~4,600	0.3%	II
C2GT	400	0.3	OA	0.8	~1200	1,000?	~5,000	0.2%	
T2K-II	50	4	OA	0.7	295	~500	~360,000	0.2%	
NOνA+PD	120	2	OA	~2	810?	50?	~23,000	0.3%	
BNL-Hs	28	1	WB/OA	~1	2540	~500	~13,000		III
SPL-Frejus	2.2	4	WB	0.32	130	~500	~18,000	0.4%	
FeHo	8/120	“4”	WB/OA	1~3	1290	~500	~50,000		

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Running, constructing or approved experiments

Beyond the immediate future:

Japan has a well defined roadmap, J-PARC on its way, funding etc for ν physics in '09

In Europe and the US many ambitious ideas, schemes, sites,.... but no convergence and, most important, no much funding so far.

I really hope this situation will soon improve

Last, not least:

As a last speaker, in behalf of all the partecipants,
I would like to thank the Organisers for this perfect
Conference.

College de France is a great, confortable,
centrally located facility and Paris is one of the
most attractive cities in the world!

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