



# Introduction

## Aims of the Workshop

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CERN & Neutrino Physics

Recent History – the political picture

Potential Future Accelerator Neutrino  
Activities ?2015

Future Non-Accelerator Activities

Workshop Goals

# Why do Neutrino Physics?

- **Least understood particle**
  - Yet after photon most common
- **Beyond the Standard Model**
  - A trivial Addition?
  - The Window on the Fundamental Theory?
- **Understanding the Flavour Problem**
  - Understanding lepton flavour as fundamental as quark flavour (and no QCD complications)
- **New Source(s) of CP Violation**
  - Contributor (solution) to the anti-matter asymmetry
- **Ultimate theory must relate quarks & leptons**
  - Cannot do this without a full understanding of the neutrino sector
  - Cannot do this with LHC or ILC

# This Neutrino Workshop



- Not a Neutrino Conference
- Brief Review of what can be expected over the next 5 years
  - Oscillation and non-oscillation neutrino physics
- Review theoretical ideas of the importance of lepton physics

## ■ Main Aim

- To position the European Particle Physics Community to be major players in the period 2015 – 2030
- The emphasis will be on accelerator-based neutrino oscillation experiments - this requires substantial design, R&D and planning. Here CERN has much expertise.
- Non-accelerator experiments and neutrino astrophysics will be reviewed only briefly. CERN has not traditionally been involved - but this could change.

# Some Logistics

## ■ Posters

- 44 Posters - this afternoon & tomorrow morning

## ■ Discussions

- Tried to leave substantial time for discussions
- Full Programme
- Tomorrow we start at 8.30

## ■ Proceedings

- Yellow Report, Talks, Posters & Discussions

## ■ Dinner

- Friday evening for registered participants

# CERN & Neutrino Physics

- Over the years CERN has played a major role in the development of Neutrino Physics

# Yesterday's Sensation - Neutral Currents

From David Wark  
EPS 2009



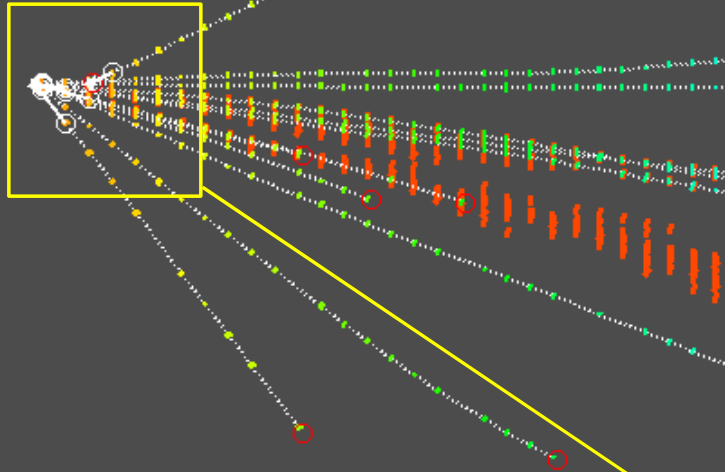
Congratulations to the Gargamelle Collaboration for  
winning this year's EPS Prize

# Today OPERA – CNGS

## The charm decay kink

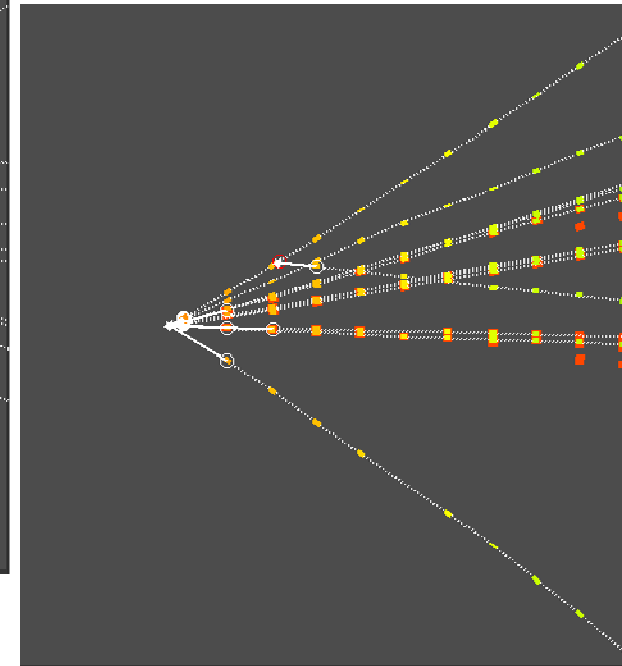
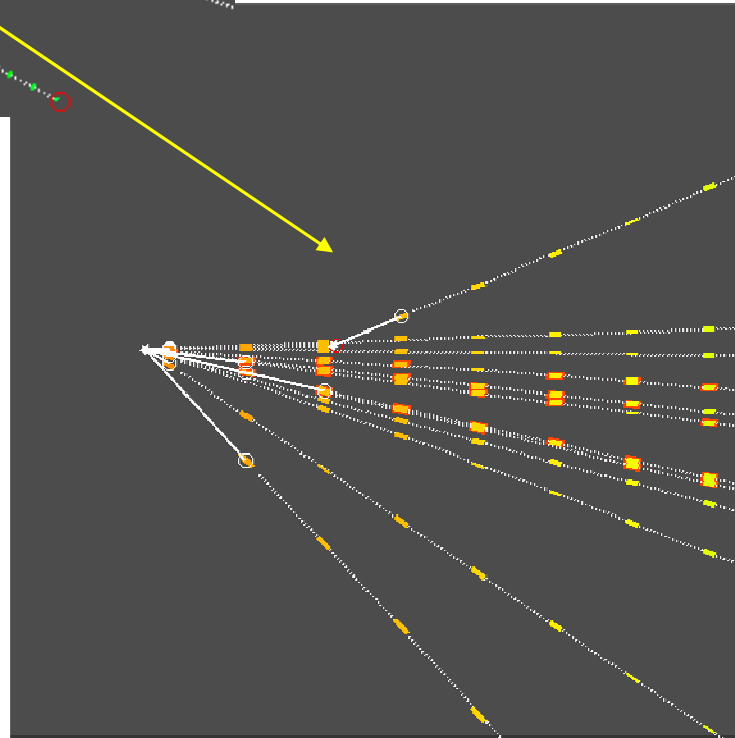


and soon the first tau signal  
- we hope



Secondary Vertex  
(1 prong decay)

kink angle = 0.204 rad  
Decay length = 3247  $\mu\text{m}$   
 $p(\text{daughter}) =$   
 $3.9^{+1.7}_{-0.9} \text{ GeV}$   
 $p_t = 796 \text{ MeV}$   
 $p_t^{\text{MIN}} = 606 \text{ MeV (90\% CL)}$   
(probability  $\sim 4 \cdot 10^{-4}$  for an  
hadron re-interaction)



# CERN & Neutrino Physics

- CERN has played a major role in the development of Neutrino Physics
- Neutrino Physics has played a major role in CERN's development
- **But now no physicist activity**

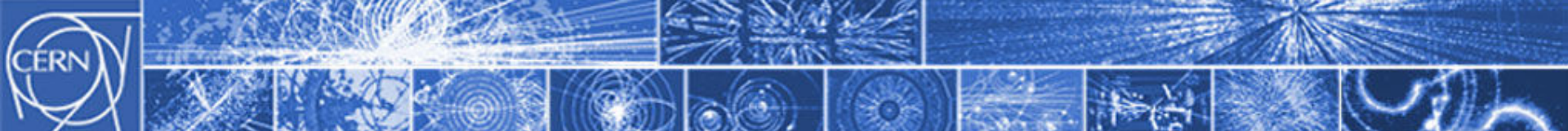
# CERN & Neutrino Physics

## Accelerator activity

- CNGS Beam
  - But probably impracticable to boost this
- Small activity on beta-beams and a little on neutrino factory within the FP programmes
- For the future, the critical item is

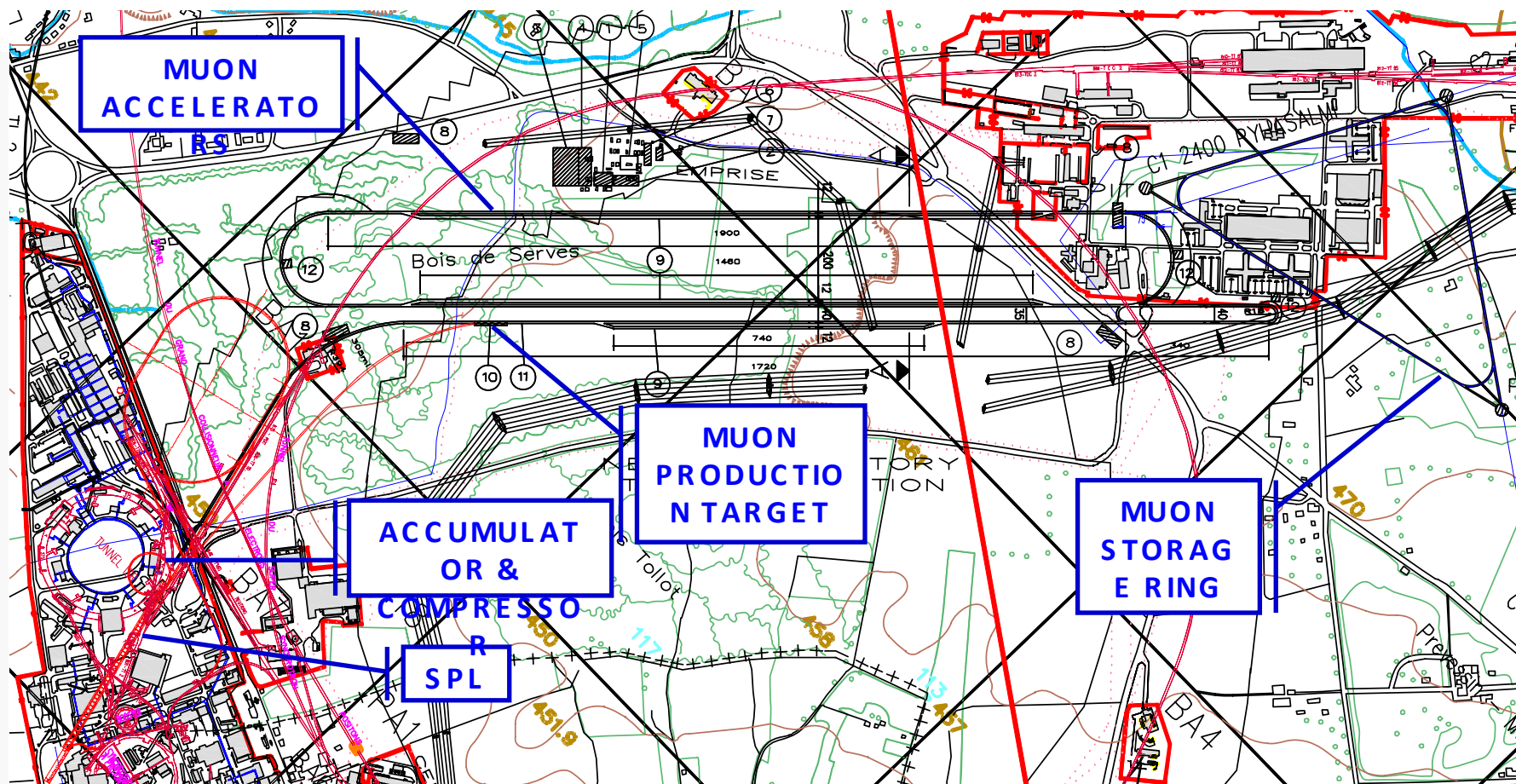
## ■ Future - The (4MW) SPL

- This gives CERN the potential for a long term Superbeam, Betabeam or Neutrino Factory programme
- **can be competitive with plans forming in the USA and Japan**



# $\nu$ FACTORY

- ✓ The layout of the future injectors is compatible with a  $\nu$  Factory at CERN.



From Roland Garoby

# Recent History

## The Political Picture

## *The European strategy for particle physics*

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### June 2006 Lisbon

Studies of the scientific case for future neutrino facilities and the R&D into associated technologies are required to be in a position to define the optimal neutrino programme based on the information available in around 2012;  
*Council will play an active role in promoting a coordinated European participation in a global neutrino programme*

And

*[...] it is vital to strengthen the advanced accelerator R&D programme; a coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.*

# Dec 2008 – Council Question to the SPC

- What is the view fo the SPC on the importance of the neutrino oscillation parameters, in particular the CP violating phase and mass hierarchy?
  - One of the most promising techniques for such measurements is the neutrino factory and there is currently an international design Study (IDS) to produce a conceptual design report for a neutrino factory by 2012. This is not site specific. What is the view of the SPC on the overall value of the IDS for the future of the subject? Should CERN take a more active role in enabling the study to reach its goals, irrespective of where such a facility would be sited?
  - What is the view of the SPC on the merit of a European strategy in this phase of neutrino experimentation and whether it should have a place on the future CERN road map?
- **An SPC panel is set up. The panel is Agnieszka Zalewska (Chair), Roy Aleksan, Alain Blondel, Peter Dornan, Karlheinz Meier (Tatsuya Nakada), Fabio Zwirner.**
  - The panel was asked to produce a report for the Dec 2009 SPC

# 2009 – CERN Review non-LHC Programme

- With the LHC construction coming to an end the new CERN management start examining what non-LHC accelerator activities they should be supporting.
- This led in May 2009 to the Workshop '**New Opportunities in the Physics Landscape at CERN**'.
- And now to this on '**European Strategy for Future Neutrino Physics**' to be held in conjunction with the SPC panel although with a wider scope.

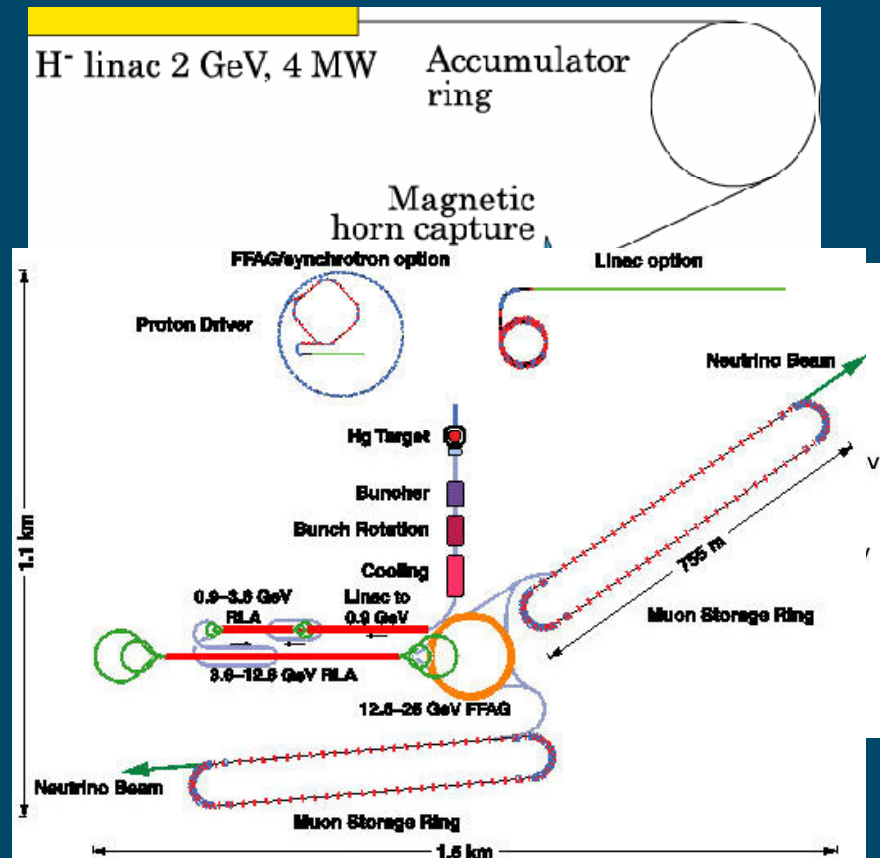
# Possibilities

## The Precision Era

### 2015 - 2030

# Neutrino source – options:

- Second generation super-beam
  - CERN, FNAL, BNL, J-PARC II
- Beta-beam
- Neutrino Factory



**But all Require R&D before a Realistic Choice can be made**

# R & D for Accelerator Expts >2015

- Workshop emphasis is on accelerator based oscillation experiments for >2015
  - Here a substantial, reasonably well-defined programme for accelerator and detector R&D with strong CERN participation can be envisaged
- Super beams
  - ?Target, Horn....Detectors, Cost
- Beta Beam
  - ?Ion production, Beam bunching ..... Detectors, Cost
- Neutrino Factory
  - ?Target, Cooling, Magnetised Detector..... Detectors, Cost

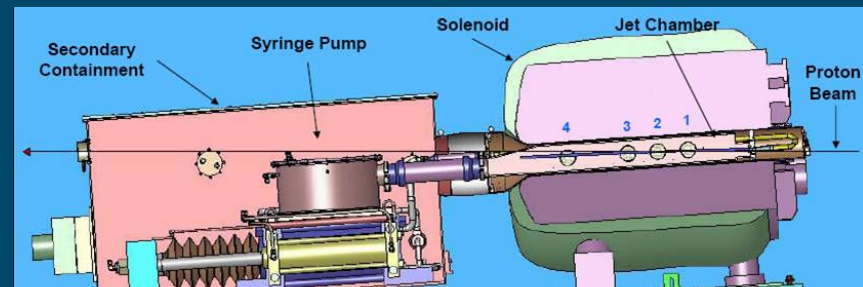
# Current Activity - Design

- European Programmes
- FP6
  - Bene (part of CARE), EURISOL ( $\beta$ -beam)
- FP7
  - EUROnu - Superbeam, Betabeam, Neutrino Factory Design Components
  - EUCARD –Neutrino2012 (Network) , MICE (Transnational Activity)
  - LAGUNA - Water Cerenkov, Liquid Argon & Scintillator Detectors
- International Programmes (with European Participation)
  - ISS
    - Mainly neutrino factory, but some on superbeams and comparisons with beta beam
  - IDS – International Design Study for a Neutrino Factory
  - NFMCC – in US but with some European participation
  - (T2K Upgrade)
- **Additional Support from CERN would definitely increase the chance of success**

# Current Activity - Prototyping

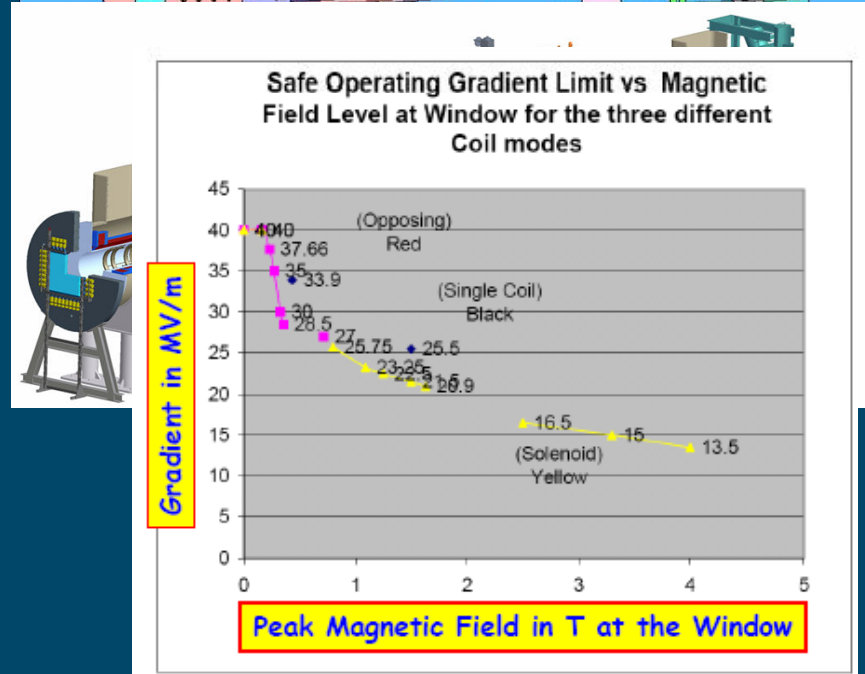
## ■ MERIT

- At CERN – Very successful US – Europe collaboration to successfully demonstrate the feasibility of a Hg jet target for a high power beam.



## ■ MICE

- At RAL Will be the first demonstration of muon ionisation cooling, critical for neutrino factory and muon collider. First data taking next year and final results ~2013



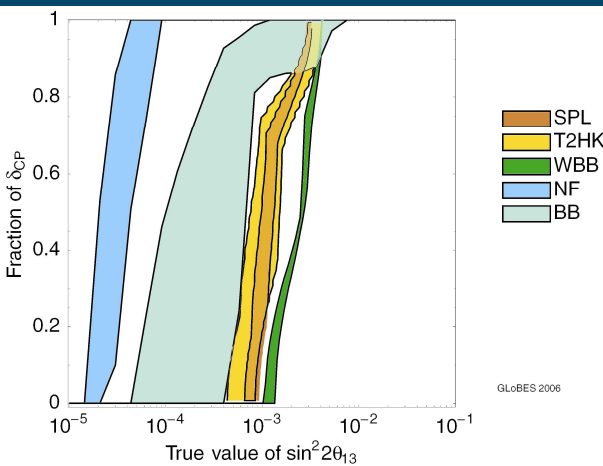
## ■ MUCOOL

- At FNAL – testing various components of cooling channel, a most important one being the behaviour of rf cavities in a magnetic field

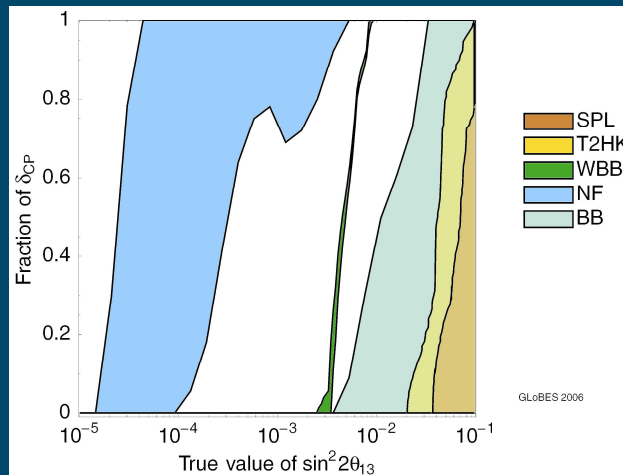
# The Potential Discovery Domains

From the ISS Report

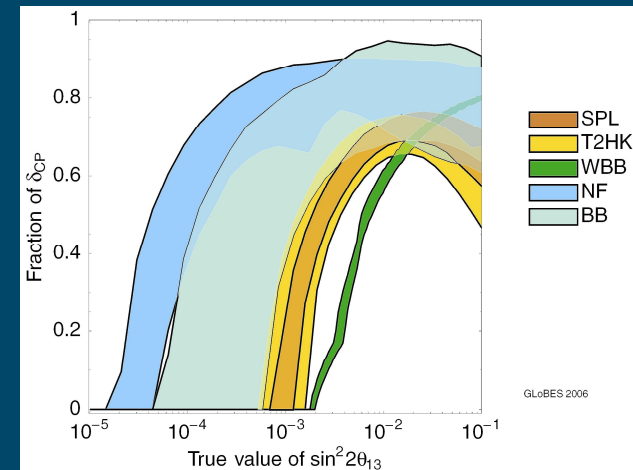
$\sin^2 2\theta_{13}$



Mass Hierarchy



CP Violation



Plots are Fraction of  $\delta$  v.  $\sin^2 2\theta_{13}$   
for the region of  $\theta_{13}$  below the Chooz limit

# Non-Accelerator Experiments >2015

Situation here is much less clear

- What role could/should CERN play
  - These experiments now fall within the European Strategy which is approved by CERN Council

## Oscillation Expts

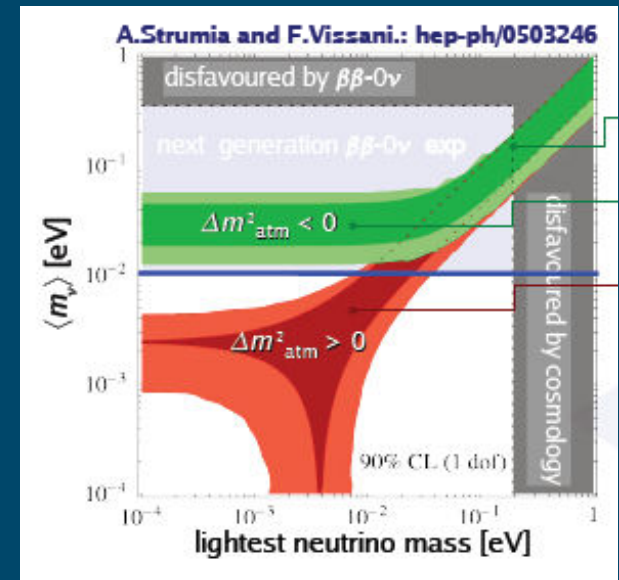
- Solar, Reactor

## Non-Oscillation Expts

What if

- KATRIN does not measure the mass
- No convincing evidence for  $0\nu\beta\beta$

**Future, larger experiments will require R & D soon**



# Goals for the Workshop

## ***To begin the process of establishing a roadmap for a coherent European participation in future Neutrino Physics***

The European Strategy Document for particle Physics states

*‘Studies of the scientific case for future neutrino facilities and the R&D into associated technologies are required to be in a position to define the optimal neutrino programme based on the information available in around 2012; Council will play an active role in promoting a coordinated European participation in a global neutrino programme.’*

but whilst a substantial number of European physicists are involved with neutrino related activities a coherent approach for the longer term has yet to be achieved.

## ***To examine those techniques which potentially can substantially improve precision over that expected from current and future experiments in construction.***

The experiments which will dominate neutrino physics until circa 2015 are either under construction or about to start taking data. However a number of techniques for both accelerator and non-accelerator experiments have been proposed which will enable greatly improved accuracy for the measurable parameters. These experiments could start in the latter half of the next decade or early in the 2020's.

# Goals for the Workshop

## ***To stress the substantial technical problems associated with each technique***

The viability of some aspects of these future procedures is not fully established and so it will be a major task of the workshop to highlight those areas where major challenges remain. Many of these are substantial and will require the development of technologies of a size and complexity not previously encountered in the neutrino area. For the accelerator experiments this includes both the accelerator and detector developments necessary to achieve the goals.

## ***To devise plans for the European contribution to the R&D necessary to enable decisions to be taken around 2012 – 2013.***

For precision neutrino experiments to commence data taking around 2020 decisions need to be made by ~2013 in keeping with the aims of the European Strategy. An energetic programme incorporating design, R&D and costings is therefore necessary. Neutrino experiments at this level will necessarily be international but it is vital that the European neutrino community has a major impact on the debate for future facilities both within Europe and outside. An important aspect of the workshop is to highlight the areas where R&D is required and evaluate to what extent these are covered by current programmes either within the present European frameworks or on a broader international level.

# Goals for the Workshop

## ***To consider the role of CERN in future international neutrino activities***

Neutrino physics at CERN has a long and positive history yet today, apart from producing the CNGS beam for the OPERA experiment, there is little activity in the experimental or phenomenological physics areas, the accelerator developments required for the next phase of experiments or the detector technologies needed to fully exploit them.

CERN has unique expertise and if Europe is to be a major player in this area in the future it would seem essential that CERN re-establishes a viable neutrino activity to participate in a wider European programme. This should be independent of whether future facilities are at CERN, elsewhere in Europe or the rest of the world. Speakers at the workshop will be asked to draw attention to those areas where they consider CERN participation would be most effective.

## ***To bring to light synergies between the neutrino area and other areas of physics***

As experiments become larger and more costly there are obvious merits if the experiments and the technical developments they require have wider application. Obvious examples are the needs of cosmology, theories relating neutrino properties to charged lepton flavour violation, the simultaneous use of large detectors for nucleon decay and the production of intense muon beams which may also be used for lepton flavour violation and a future muon collider. Such synergies will need to be taken into consideration when decisions over future directions are taken.

# Goals for the Workshop

***To suggest a procedure for future coordination and development of European activities in the Neutrino area***

As an integrated part of the implementation of the European strategy for Particle Physics it will be necessary to establish an organisation and follow-up structures for the key R&D areas. This requires coordination with the Strategy Secretariat of the European Session of Council and appropriate means to achieve this will be discussed.

# Ultimately



If Europe wishes to have a long term accelerator neutrino programme a decision on the direction is necessary by ~2013

Between npw and 2013 we must decide which is the best option - on scientific (and cost) grounds

Do we go for a Superbeam, Betabeam, Neutrino Factory – or nothing

A consensus is necessary and must be widely supported  
- support from CERN is vital

- **The aim of this workshop is to make this happen**