European Muon Concertation Oversight Group

-- back to the neutrino road map
-- EMCOG and EU funding activities

Warning: situation in rapid movement,
some changes should be expected

Alain Blondel

Road Map

Experiments to find θ_{13} :

1. search for $\nu_\mu \to \nu_e$ in conventional ν_μ beam (ICARUS, MINOS)
limitations: NC π^0 background, intrinsic ν_e component in beam
2. Off-axis beam (JHF-SK, off axis NUMI, off axis CNGS) or
3. Low Energy Superbeam

Experiments to find CP violation or to search further if θ_{13} is too small

1. Neutrino factory with muon storage ring

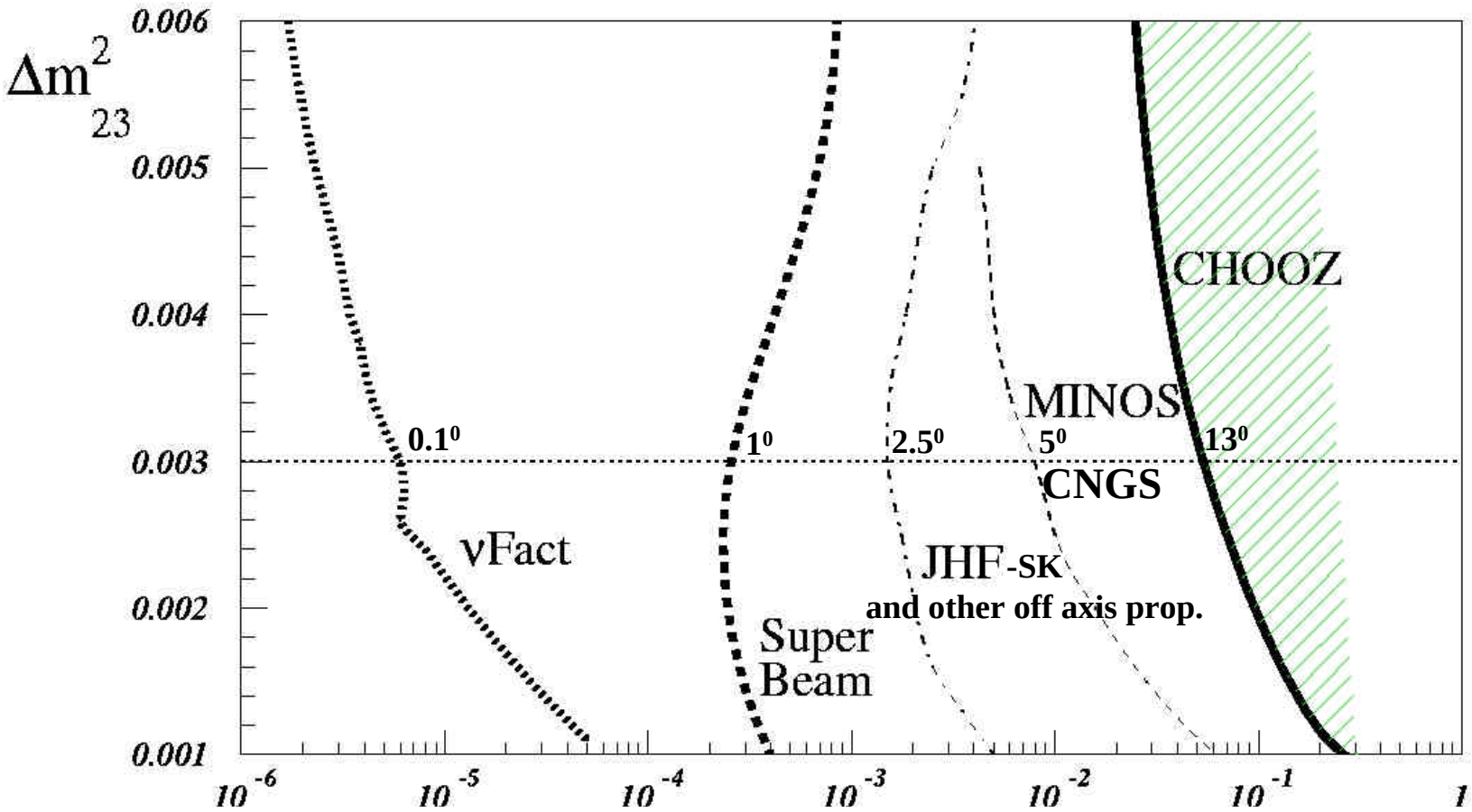
$\mu^+ \to e^+ \nu_e \bar{\nu}_\mu$ **and** $\mu^- \to e^- \bar{\nu}_e \nu_\mu$

2. beta-beam $^6He^{++} \to {}^6Li^{+++} \bar{\nu}_e e^-$ $\quad {}^{18}_{10}Ne \to {}^{18}_{9}F \nu_e e^+$

fraction thereof will exist.

Open discussion at NUFACT02:

=> Neutrino Factory really IS the ultimate.



comparison of reach in the oscillations; right to left:
present limit from the CHOOZ experiment,
expected sensitivity from the MINOS and ICARUS experiments,
0.75 MW JHF to super Kamiokande with an off-axis narrow-band beam,
Superbeam: 4 MW CERN-SPL to a 400 kton water Cerenkov in Fréjus or J-Parc->HyperK
from a 10^{21} muons Neutrino Factory with 40 kton large magnetic detector, including systematics

Neutrino fluxes $\mu^+ \rightarrow e^+ \nu_e \nu_\mu$

ν_μ/ν_e ratio reversed by switching μ^+/μ^-

ν_e ν_μ spectra are different

No high energy tail.

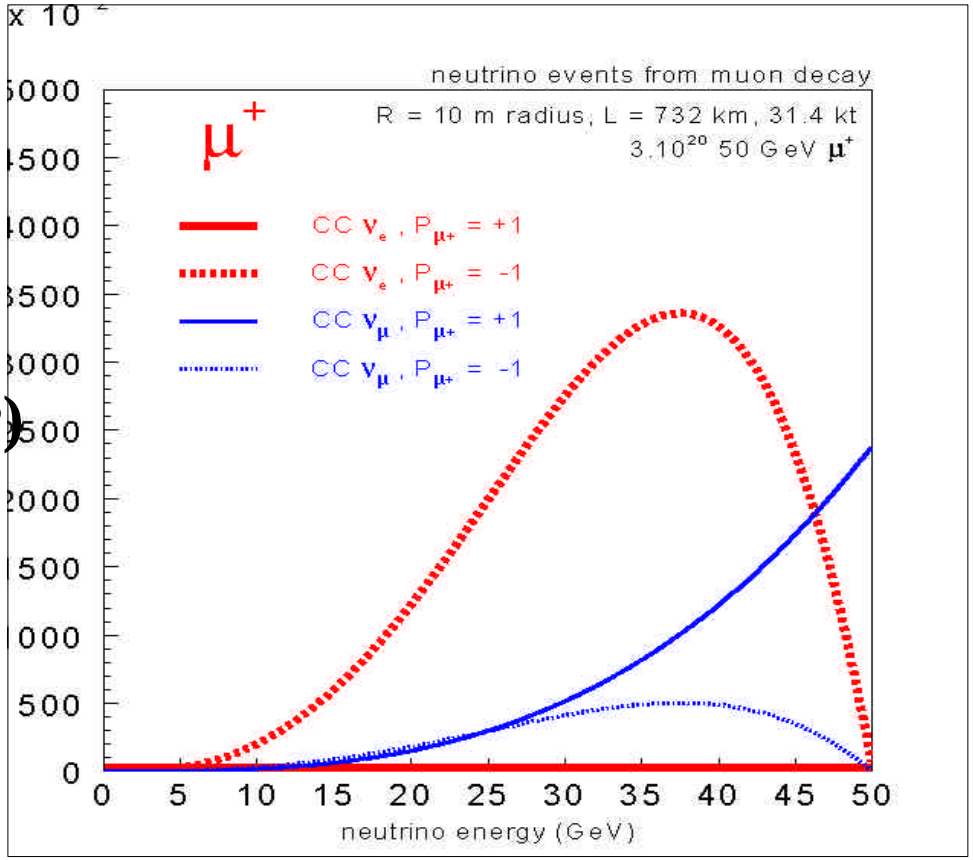
Very well known flux (aim is 10^{-3})

-- E& s_E calibration from muon spin precession

-- angular divergence:
small measurable effect if $\theta \leq 0.2/\gamma$

-- absolute flux measured from muon current
or by $\nu_\mu e^- \rightarrow \mu^- \nu_e$ in near expt.

-- in race track or triangle ring
muon polarization precesses and averages out.



μ polarization controls ν_e flux:

μ^+ -X> ν_e **in forward direction**

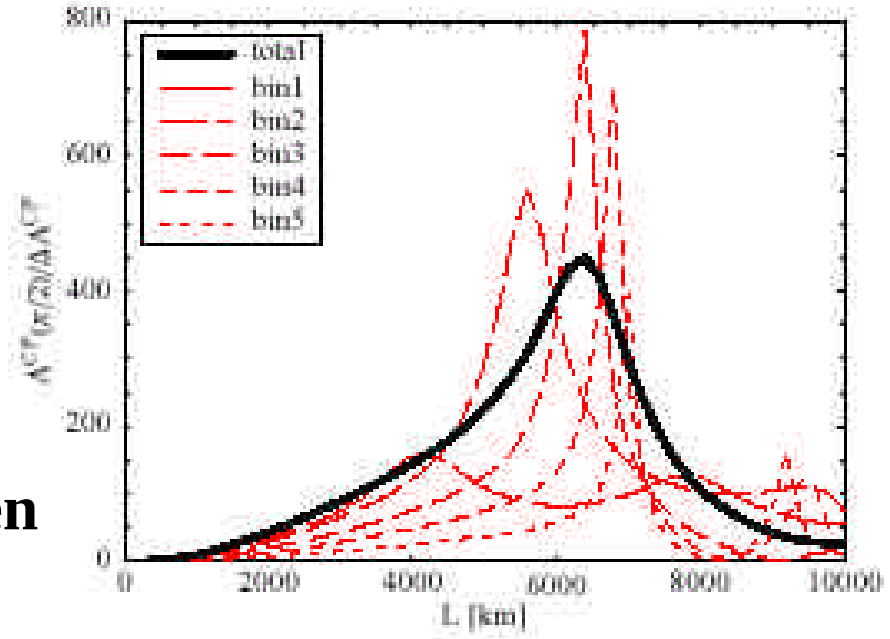
CP asymmetries
compare $\nu_e \to \nu_\mu$ to $\bar{\nu}_e \to \bar{\nu}_\mu$ probabilities

$$P_{\nu_e\nu_\mu(\bar{\nu}_e\bar{\nu}_\mu)} = \sin^2\theta_{23}\sin^2 2\,\theta_{13}\left(\frac{\Delta m^2_{23}}{B_\pm}\right)^2 \sin^2 B_\pm L$$

with $$B_\pm \equiv \sqrt{(\Delta m^2_{23}\cos 2\,\theta_{13} \pm \mu)^2 + (\Delta m^2_{23}\sin 2\,\theta_{13})^2}$$

μ **is prop matter density, positive for neutrinos, negative for antineutrinos**

$$\mathbf{A} = \frac{\mu^- / n_e - \mu^+ / \bar{n}_e}{\mu^- / n_e + \mu^+ / \bar{n}_e}$$



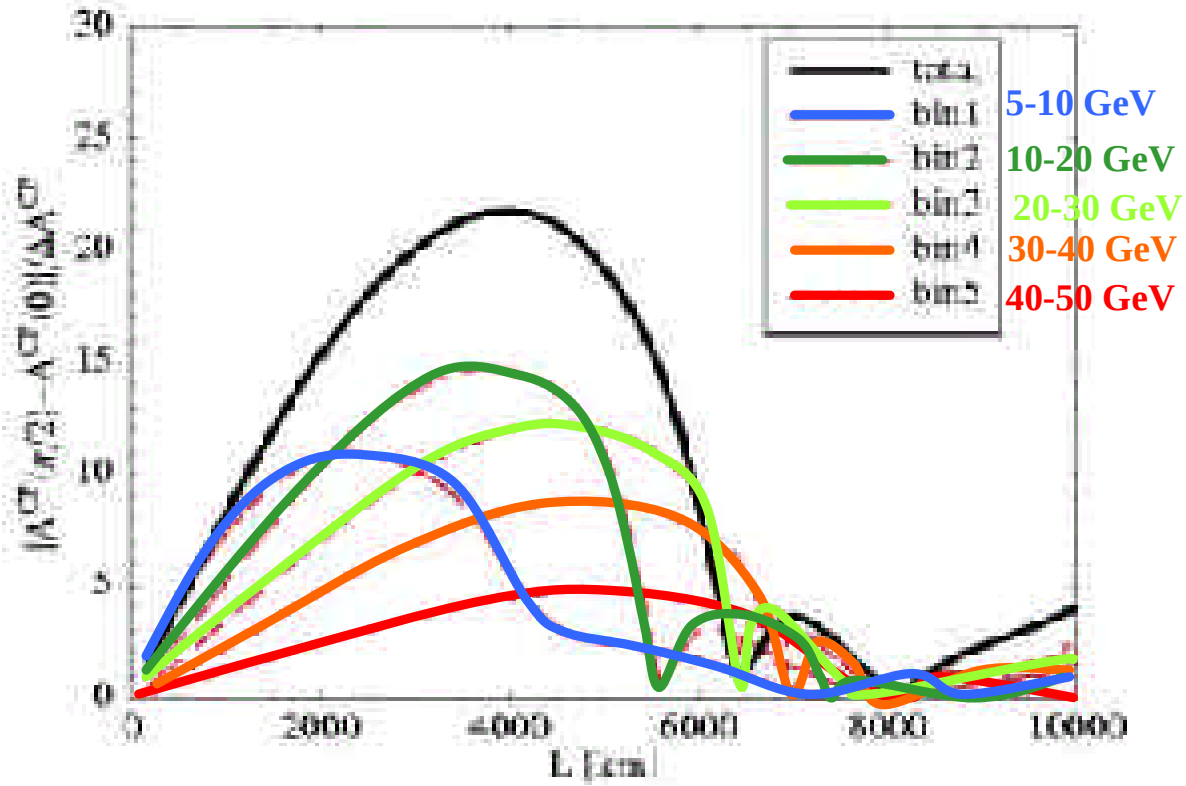
HUGE effect for distance around 6000 km!!

Resonance around 12 GeV when

$$\Delta m^2_{13}\cos 2\,\theta_{13} \pm \mu = 0$$

CP violation (ctd)

Matter effect must be subtracted. One believes this can be done with uncertainty Of order 2%. Also spectrum of matter effect and CP violation is different
⇒It is important to subtract in bins of measured energy.
⇒knowledge of spectrum is essential here!



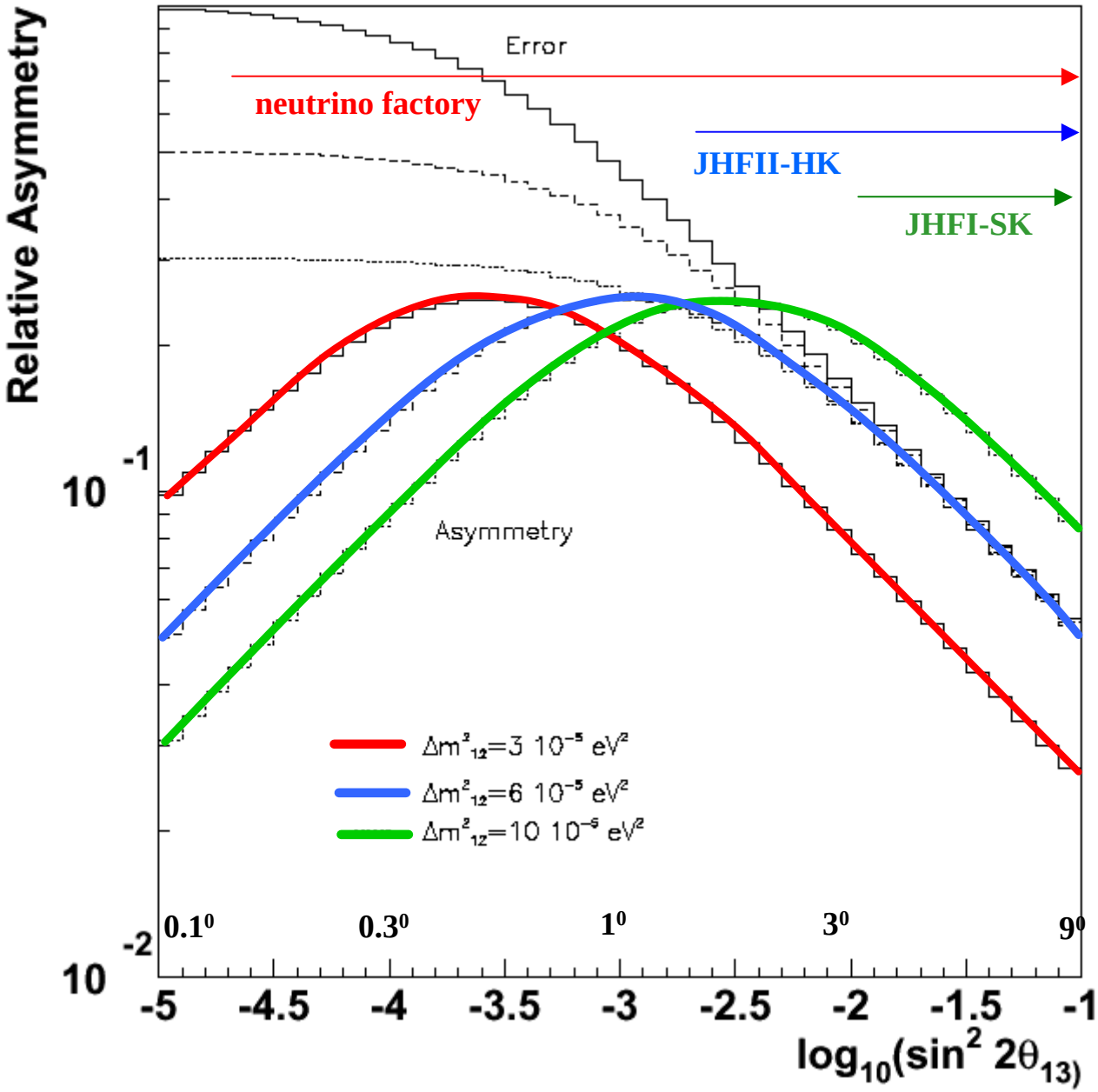
40 kton L M D
50 GeV nufact
5 yrs 10^{21}m /yr

In fact, 20-30 GeV Is enough!

Best distance is 2000-4000 km

e.g. FNAL/BNL-> west coast
or CERN ->Las Palmas

T asymmetry for sin d = 1

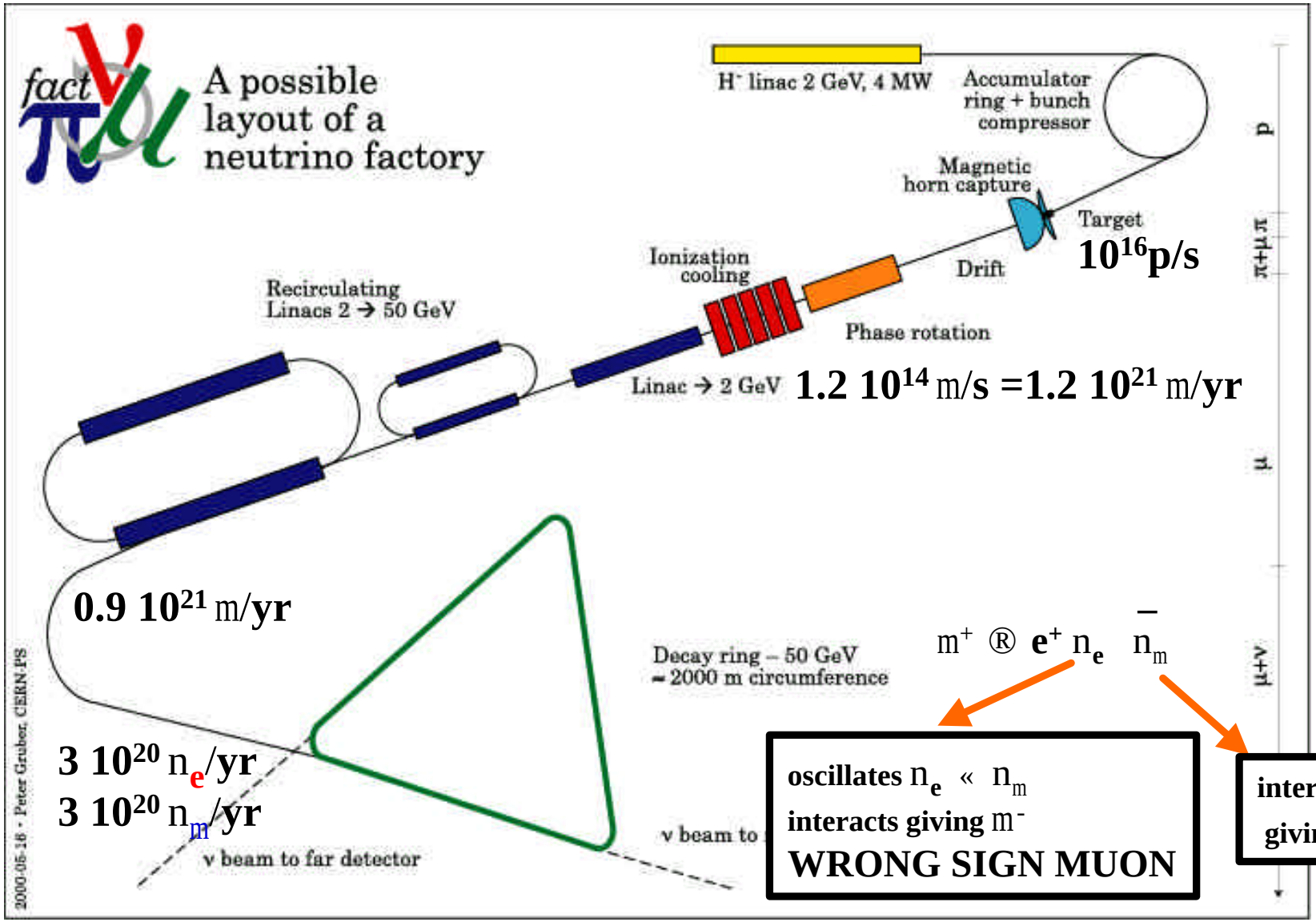


!

asymmetry is a few % and requires excellent flux normalization (neutrino fact. or off axis beam with not-too-near near detector)

!

Nufact CERN layout



Possible step 0: Neutrino SUPERBEAM

Fréjus underground lab.

300 MeV ν_μ Neutrinos

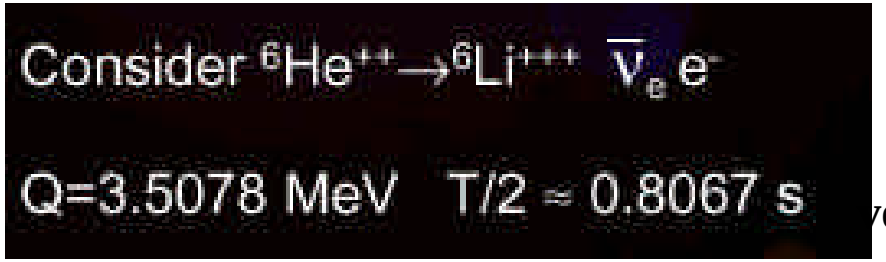
small contamination from ν_e (no K at 2 GeV!)

A large underground water Cerenkov (400 kton)
UNO/HyperK is best choice
also : proton decay search, supernovae events solar and atmospheric neutrinos.

BETA Beam

new idea by P. Zucchelli

produce ^{6}He++, store, accelerate (100 GeV/u), store



very pure anti-n_e beam at » 600 MeV

or:

$$^{18}_{10}Ne \rightarrow {}^{18}_{9}F\ n_e\ e^+$$

very pure n_e beam at » 600 MeV

oscillation signal: appearance of low energy muons
water Cerenkov excellent for this too! Same as for Superbeam
seems feasible; but cost unknown so far.
Critical: duty cycle. A nice *** idea to be followed up!

Combination of beta beam with low energy super beam

Unique to CERN:

need few 100 GeV accelerator
experience in radioactive beams at ISOLDE

many unknowns: what is the duty factor that can be achieved? (needs < 10^{-3})

combines CP and T violation tests

$$\nu_e \to \nu_\mu \quad (b^+) \quad \mathbf{(T)} \quad \nu_\mu \to \nu_e \quad (p^+)$$

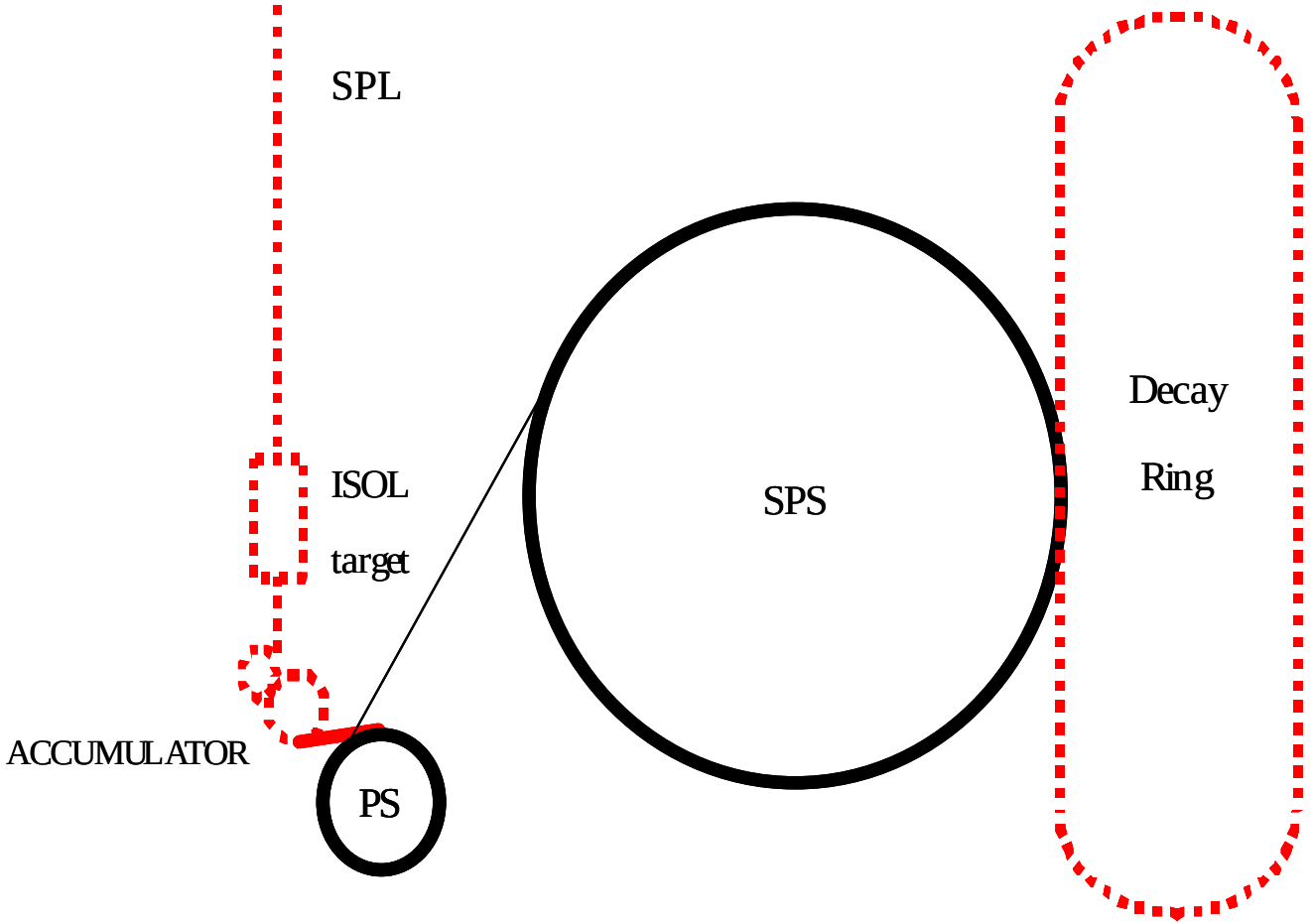
$$\mathbf{(CP)}$$

$$\bar{\nu}_e \to \bar{\nu}_\mu \quad (b^-) \quad \mathbf{(T)} \quad \bar{\nu}_\mu \to \nu_e \quad (\bar{p}^-)$$

Can this work????

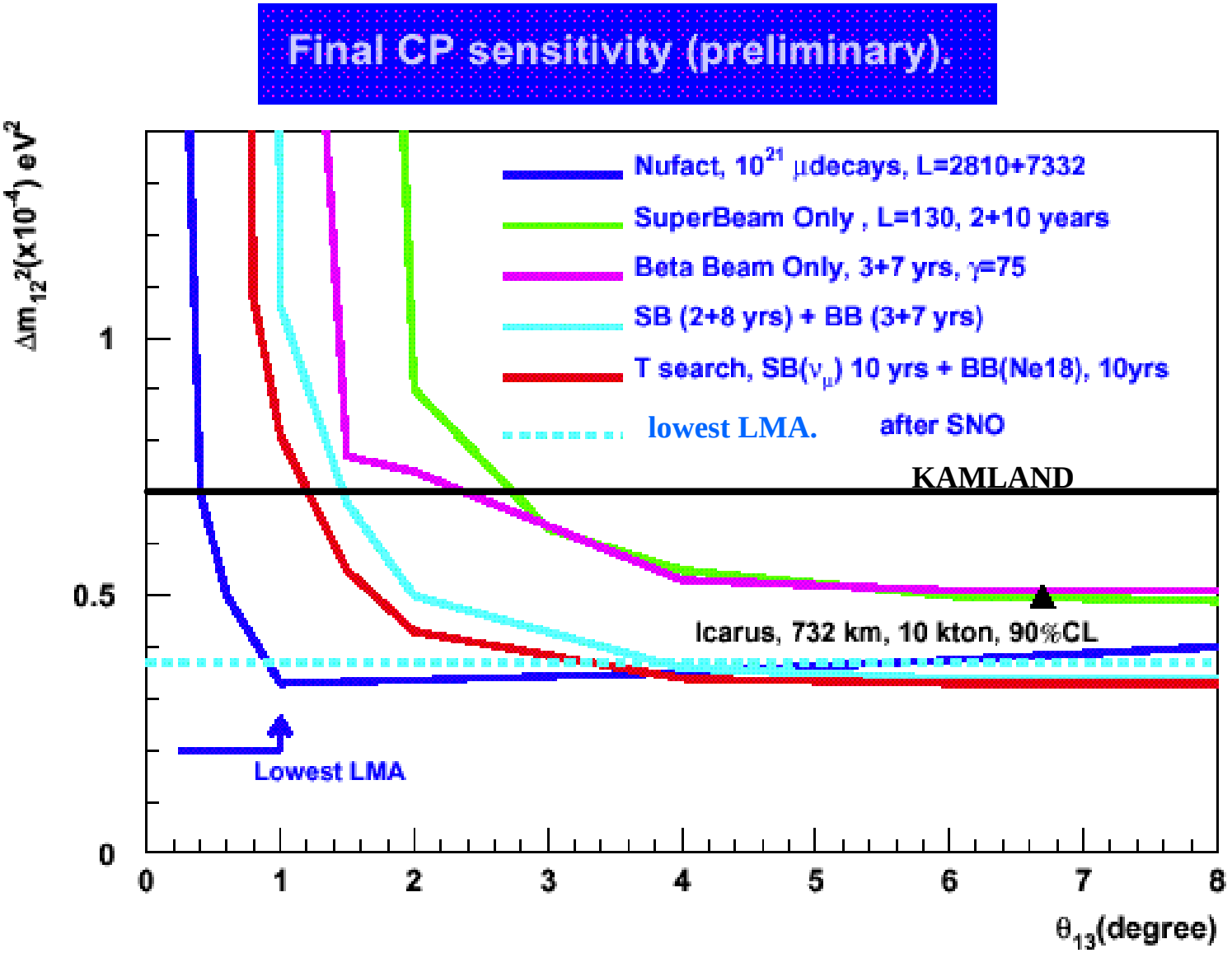
Beta Beam

(P. Zucchelli)



M. Lindroos et al.

Combination of Beta beam and superbeam is in the same ballpark of performance as neutrino factory …
(bewrare of systematics for low Energy neutrino events, though)



M.Mezzetto, CERN workshop NNN02, january 2002

European Muon Concertation and Oversight Group (EMCOG)

CERN:	**Carlo Wyss (chair), Helmut Haseroth, John Ellis**
CEA-DAPNIA:	**Pascal Debu, François Pierre**
IN2P3:	**Stavros Katsanevas, Marcel Lieuvin**
INFN:	**Marco Napolitano (Napoli), Andrea Pisent (Legnaro)**
GSI:	**Oliver Boine-Frankenheim, Ingo Hofmann**
PSI:	**Ralph Eichler, Albin Wrülich**
Geneva:	**Alain Blondel (secretary)**
RAL:	**Ken Peach, Rob Edgecock**
PPARC:	**Ken Long**

Meetings

18-19 April 2002
15 Octobre 2002
10 December 2002
6 February 2003
25 March 2003

First meeting of the European Muon Concertation and Oversight Group (EMCOG) April 18-19 2002

1. Mandate

A neutrino factory based on a muon storage ring is the ultimate tool for studies of neutrino oscillations, including possibly leptonic CP violation. It is also the first step towards $\mu^+\mu^-$ colliders. This interesting type of new accelerators has already been the object of conceptual studies, starting in the US and more recently in Europe and Japan. A European Neutrino Factory Complex may be one of the future possibilities for CERN.

A first round of studies has shown that a neutrino factory could probably be built with accessible technologies, and with performances matching the requirements of an exciting physics programme. The cost evaluations are however quite high and the techniques envisaged have often never been applied in practice. Many appealing and partially explored options exist for several of the subsystems. It thus appears that a sizeable programme of R&D will be necessary.

It is felt desirable that accelerator R & D effort be kept at a level allowing CERN an active but affordable role in a framework of enhanced collaboration among Laboratories.

It is proposed to develop a European Collaborative effort to undertake a programme of studies at the theoretical, engineering and experimental levels. The first step, as already discussed since 2000, is to assemble a Muon Concertation and Oversight Committee.

The first task of this committee will be to review the status of R&D studies and plans and of the more or less formal collaborations that have already taken place, and to establish a fist set of basic goals. Two persons (one representative and one surrogate) of the major participating laboratories and funding agencies had been nominated. An organisational structure should be discussed and proposed to the relevant authorities.

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Task of EMCOG:

- Undertakes actions in order to promote and coordinate activities making optimal use of resources across the laboratories and ensure convergence on a unique conceptual design.

- Provides a forum where major European laboratories and funding agencies exchange information and ideas and monitor progress of R&D activities.

- Advises laboratories and funding agencies on the above matters and make proposals for implementing them.

EMCOG : FIRST SET OF BASIC GOALS

The long-term goal is to have a Conceptual Design Report for a European Neutrino Factory Complex by the time of LHC start-up, so that, by that date, this would be a valid option for the future of CERN.

An earlier construction for the proton driver (SPL + accumulator & compressor rings) is conceivable and, of course, highly desirable.
The SPL, targetry and horn R&D have therefore to be given the highest priority.

Cooling is on the critical path for the neutrino factory itself; there is a consensus that a cooling experiment is a necessity.

The emphasis should be the definition of practical experimental projects with a duration of 2-5 years. Such projects can be seen in the following four areas:

NDLR 'Neutrino Factory' does not *a priori* imply a muon storage ring here

1. High intensity proton driver. Activities on the front end are ongoing in many laboratories in Europe, in particular at CERN, CEA, IN2P3, INFN and GSI. Progressive installation of a high intensity injector and of a linear accelerator up to 120 MeV at CERN (R. Garoby et al) would have immediate rewards in the increase of intensity for the CERN fixed target program and for LHC operation. GSI…. EMCOG will invite a specific report on the status of the studies and a proposal for the implementation process.

2. Target studies

. This experimental program is already well underway with liquid metal jet studies. Goal: explore synergies among the following parties involved: CERN, Lausanne, Megapie at PSI, EURISOL, etc…

3. Horn studies.

A first horn prototype has been built and is being equipped for pulsing at low intensity.
5 year program to reach high intensity, high rep rate pulsing, and study the radiation resistance of horns. Optimisation of horn shape. Explore synergies between CERN, IN2P3 Orsay, PSI (for material research and fatigue under high stress in radiation environment)

4. MICE. A collaboration towards and International cooling experiment has been established with the muon collaboration in United States and Japanese groups. There is a large interest from European groups in this experiment. Following the submission of a letter of Intent to PSI and RAL, the collaboration has been encouraged to prepare a full proposal at RAL, with technical help fro RAL. PSI offers a solenoid muon beam line and CERN, which as already made large initial contributions in the concept of the experiment, could earmark some very precious hardware that could be recuperated. A summary of the requests should be presented by the collaboration.

It is noted that the first three items are also essential for a possible initial neutrino program with a high intensity low energy conventional neutrino beam (superbeam).

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Theoretical studies.
Many open questions exist on the design of Neutrino Factory. For instance:
-- Choice of proton driver: energy, intensity, time structure and repetition rate.
-- Muon beam preparation technique: FFAG vs phase rotation and cooling, possibility to combine the two.
-- Muon acceleration: FFAG vs recirculating linacs

It is believed that if a sufficient program of experimental activities exists, it should be naturally accompanied by theoretical studies.
Mandate is given to Helmut Haseroth to propose a Europe-wide Neutrino Factory Working Group.

European Neutrino Group (ENG)
has been created based on the activities of the former CERN-based Neutrino Factory Working Group

Conveners:	**CERN**	**EU**
proton driver SPL	**Roland Garoby**	**Pascal Debu (Saclay)**
proton driver (RCS)	**Horst Schonauer**	**Chris Prior (RAL)**
target and collection	**Helge Ravn**	**Roger Bennett(RAL)/R. Bauer (Julich)**
cooling	**Alessandra Lambardi**	**Rob Edgecock (RAL)**
acceleration	**André Verdier**	**?**

In general the task of transfering the activities from CERN to laboratories around Europe is difficult, despite goodwill generally expressed. The pool of accelerator physicists available for new projects is not very large.

Nevertheless some encouraging collaborations have been identified:

on Horns: IN2P3 accepts to lead the studies in colaboration with CERN.

on cooling: RAL enthusiastic about MICE

on proton driver: Saclay quite keen to proceed with installation of HIPHI at CERN, to raise intensity of CNGS and perhaps LHC

on beta-beams: synergy with nuclear physicists -> workshop, Les Arcs March 15-22

on targets: many institutes interested (PSI, Julich, GSI, RAL) who will lead the effort?

……

ENG will be launched during muon week 25-27 March

EU Funding

at initiative of ECFA and EPS (M. Spiro) a concerted request will be made by laboratories collaborating in accelerator R&D in Europe
ESGARD (European Steering Group for Accelerator R&D) (chair: Roy Aleksan) coordinates the proposals

two possible frames:

I-- Integrated Infrastructure Initiatives (deadline April 2003)
This should support Networking Activities, transnational access and Joint Projects
These Proposals are required to focus on the enhancement of existing European infrastructures

Our NA on neutrinos should consist of a number of subnetworks (or work programs).
1) CNGS and its upgrades
2) proton drivers of superior intensity (SPL & alternatives)
3) hi power targets
4) hi power collection systems (horns, solenoids, etc)
5) muon phase rotation & ionization cooling
6) betabeams (ion sources, acceleration, storage)
7) physics requirements: neutrino oscillations & slow muons

II- Feasibility studies (deadline: october 2003)
suggest two such studies
1. Neutrino Factory (will be launched in muon week) (This is where MICE fits!)
2. Beta-beams (will be launched in workshop at Les Arcs)

Summary

The cuts at CERN were definitely a blow to the NFWG: key people {such as K. Hanke, A. Lombardi} are redispatched to LHC or SPL. We fight on.

The – difficult -- on-going process is very interesting since it seeks at decentralizing accelerator R&D in Europe back to national labs and universities. If it works this will be a very positive development.

MICE is an example of such decentralization. Again, if it works it shows the value of specific, concrete projects, susceptible to lead to PhD thesis and results in a reasonable number of years.

Large activity on-going for EU funding and re-organisation of Study groups. Clearer picture in a few months.

ECFA/01/213
13 September 2001

ECFA **EUROPEAN COMMITTEE FOR FUTURE ACCELERATORS**

REPORT OF THE WORKING GROUP ON THE FUTURE OF ACCELERATOR-BASED PARTICLE PHYSICS IN EUROPE[1]

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4) an improved educational programme in the field of accelerator physics and increased support for accelerator R&D activity in European universities, national facilities and CERN.

For the long-term:

5) a co-ordinated collaborative R&D effort to determine the feasibility and practical design of a neutrino factory based on a high-intensity muon storage ring**;**

In the immediate future:

1) the allocation of all necessary resources to fully exploit the unique and pioneering LHC facility;

2) continued support for ongoing experiments, since they promise significant scientific results, provide an optimal physics return on previous investment, and are vital for the education of young physicists;

3) the realisation, in as timely a fashion as possible, of a world-wide collaboration to construct a high-luminosity e^+e^- linear collider with an energy range up to at least 400 GeV as the next accelerator project in particle physics; decisions concerning the chosen technology and the construction site for such a machine should be made soon;

4) an improved educational programme in the field of accelerator physics and increased support for accelerator R&D activity in European universities, national facilities and CERN.

For the long-term:

5) a co-ordinated collaborative R&D effort to determine the feasibility and practical design of a neutrino factory based on a high-intensity muon storage ring**;**

6) a co-ordinated world-wide R&D effort to assess the feasibility and estimate the cost of a 3-5 TeV e^+e^- linear collider (CLIC), a very large hadron collider (VLHC) and a muon collider; in particular, R&D for CLIC is well advanced and should be vigorously pursued.

The central role of CERN in Europe must continue and will be essential as the fulcrum of the long-term future of particle physics. The Working Group considers it essential that, through CERN, Europe should be able to play a key role in the exploration of the multi-TeV horizon that will open in the post-LHC era.