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Very Long Baseline with neutrino Narrow Band Beams.

Outline :

- Introduction.
- An exercise : FNAL to Antares.
- Summary and comments.

INTRODUCTION.

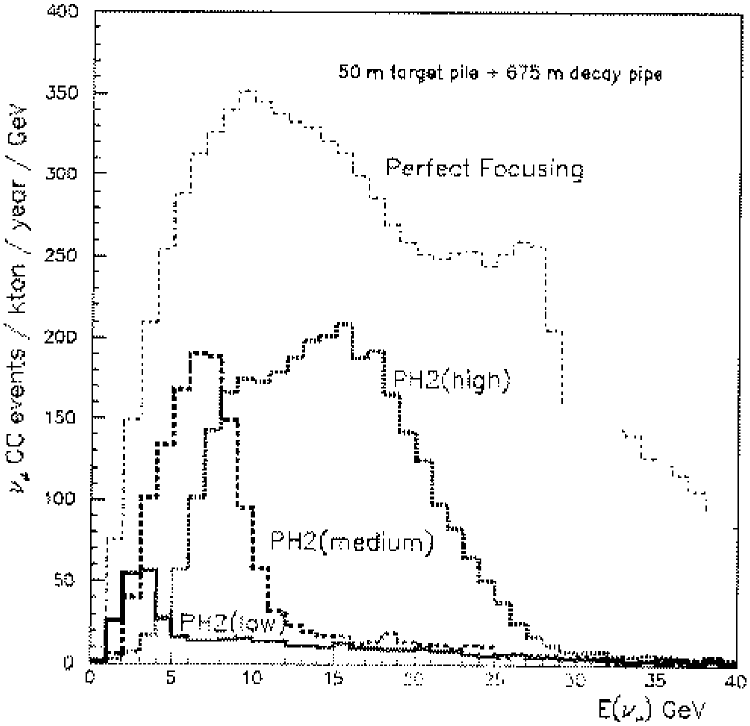
- The most recent Δm^2 values for atmospheric neutrinos are lower than previously anticipated. The true value may be below $2.10^{-3} eV^2$
- The dip of the oscillation may be difficult to establish.
- B.Richter has suggested the use of NBB in order to do appearance of ν_e in LBL.

Here, we consider the use of NBB to achieve reappeareance of ν_μ in Very Long Baseline experiments.

WHY NBB ?

- The band need not to be very narrow, it has to match the oscillation pattern.
- The energy need not to be measured in the detector : it is known from the beam(a **scan** is made, by changing the setting of the beam).
- Therefore, the only task of the detector is to tell that there is an event in coincidence with the arrival of the beam⇒ reject backgrounds from atmospheric neutrino events, cosmic muons and local sources.

NuMI: Flexible Neutrino Beam



- CC Events Rates in Minos 5kt detector:
  - High 16,000/yr
  - Medium 7,000/yr
  - Low 2,500/yr

A. Para.Fermilab
Sorting out neutrino oscillations with MINOS 32

MINOS beams

extrapolation from MINOS beams to NBB

NuMI WBB NuMI WBB	CC event/year/kt at 730 km	NBB band	CC event/kt/year at 7300 km
PH2(high)	950	10-15 GeV	9.5
PH2(high)	340	8-10 GeV	3.4
PH2(medium)	1400	6-8 GeV	3.8
PH2(medium)	1400	4-6 GeV	3.0
PH2(low)	500	3-4 GeV	.55

Table 1:

Extrapolation from NuMI WBB to various possibilities of NBB. The last column is an estimate of the ν_μ flux at 7300 km, in units of event per kiloton of detector per year for charge current interaction without oscillation

0.1 km2 detector

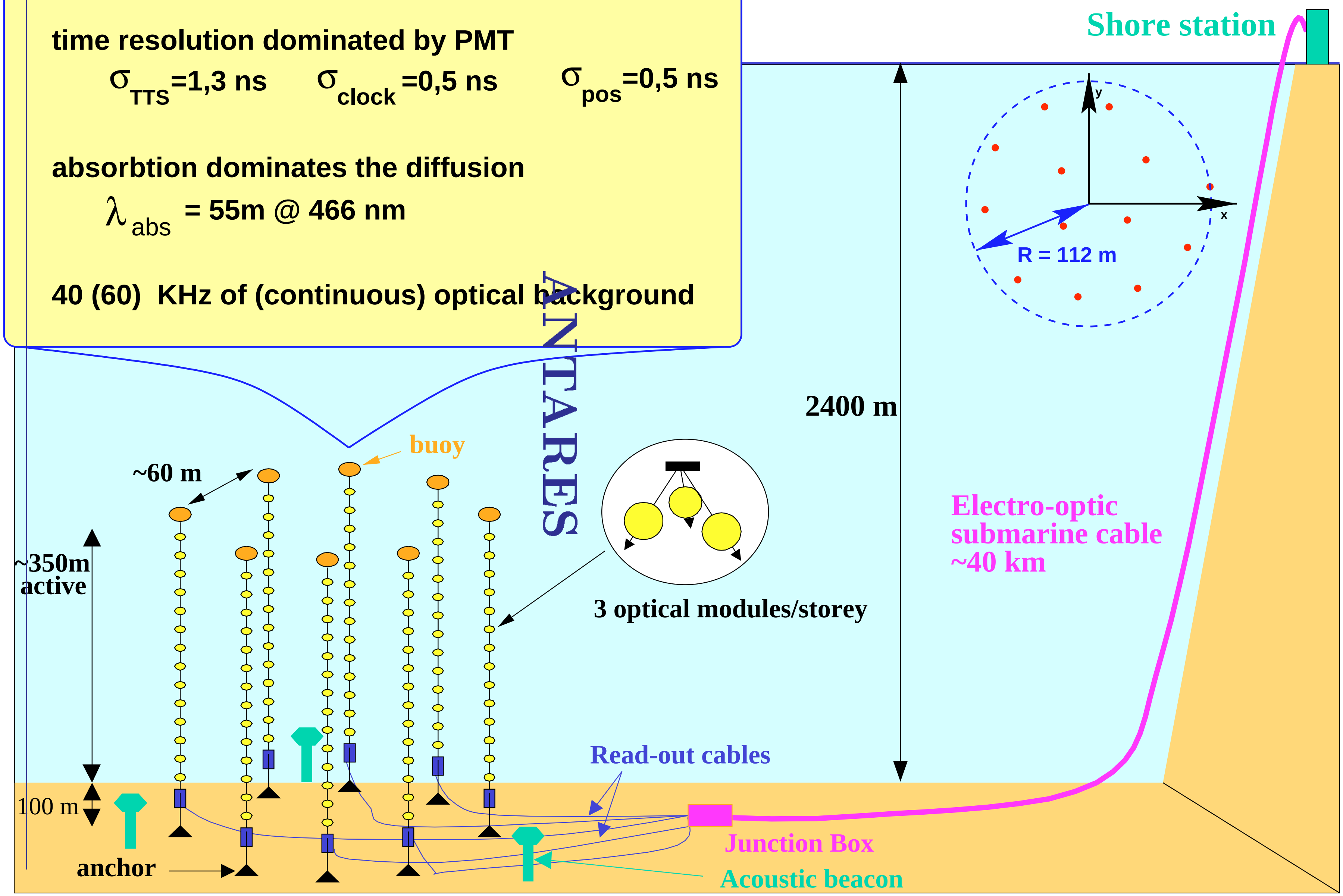
time resolution dominated by PMT

σ_{TTS}=1,3 ns σ_{clock}=0,5 ns σ_{pos}=0,5 ns

absorbtion dominates the diffusion

λ_{abs} = 55m @ 466 nm

40 (60) KHz of (continuous) optical background



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effective downward beams

Account for efficiency of beamline.
For long baseline, large angle from horizontal:

7300 km ↔ 35°
9300 km ↔ 47°

At FNAL, beamline needs to fit in 200m rock layer.
Need room to: (room to optimize?)

bend protons downward
target and focussing
decay channel
shielding and (optional) near detector

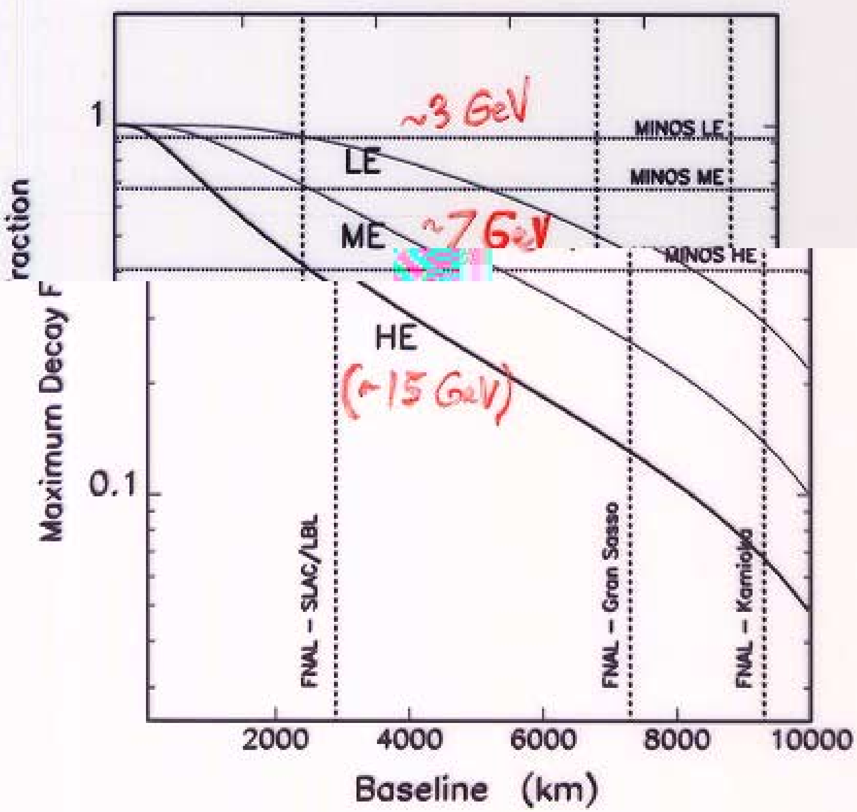

Figure 1: From US study

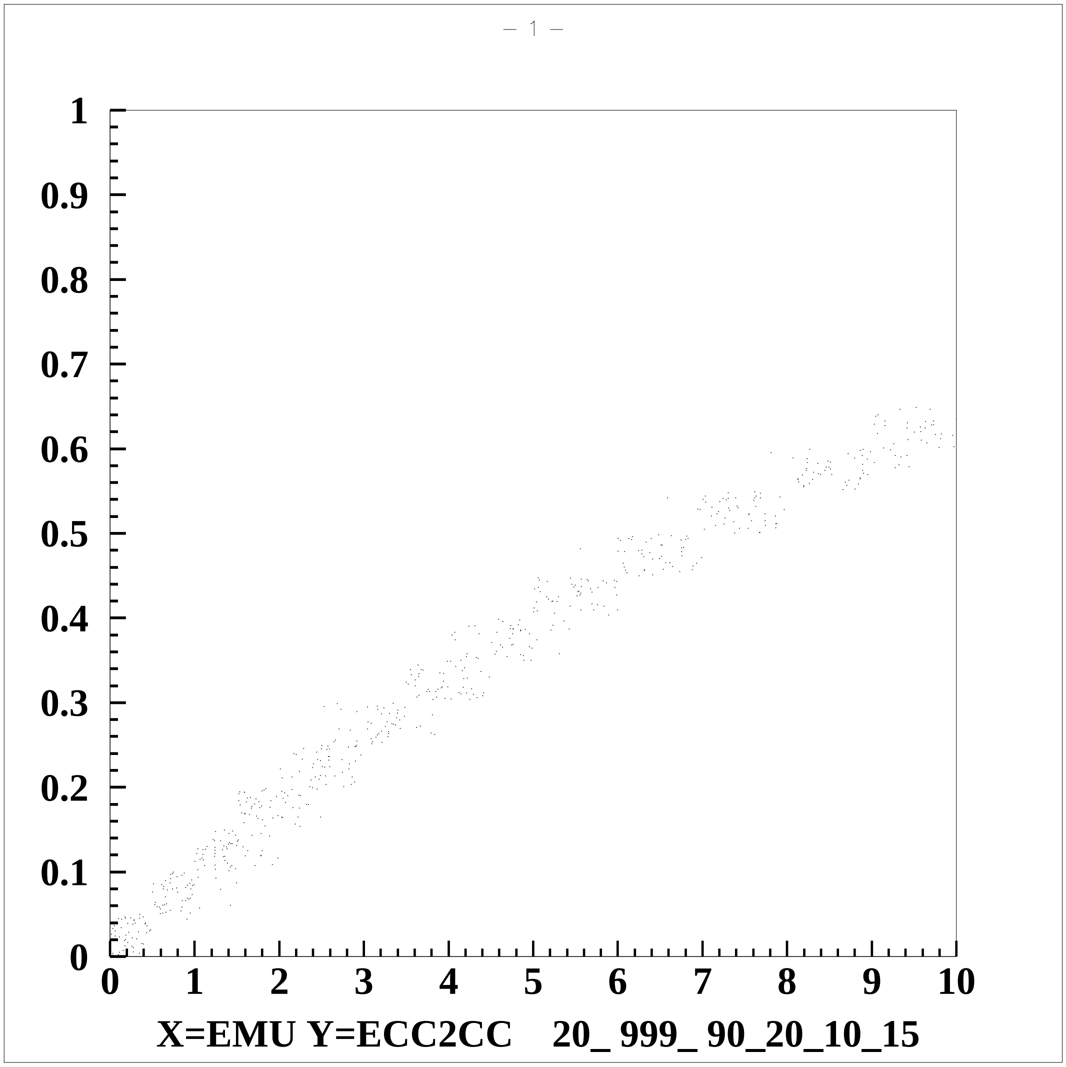

Figure 2: abcissa : nominal energy of ν_μ beam, in GeV

Effective efficiency for event trigger

EXTREMELY PRELIMINARY !

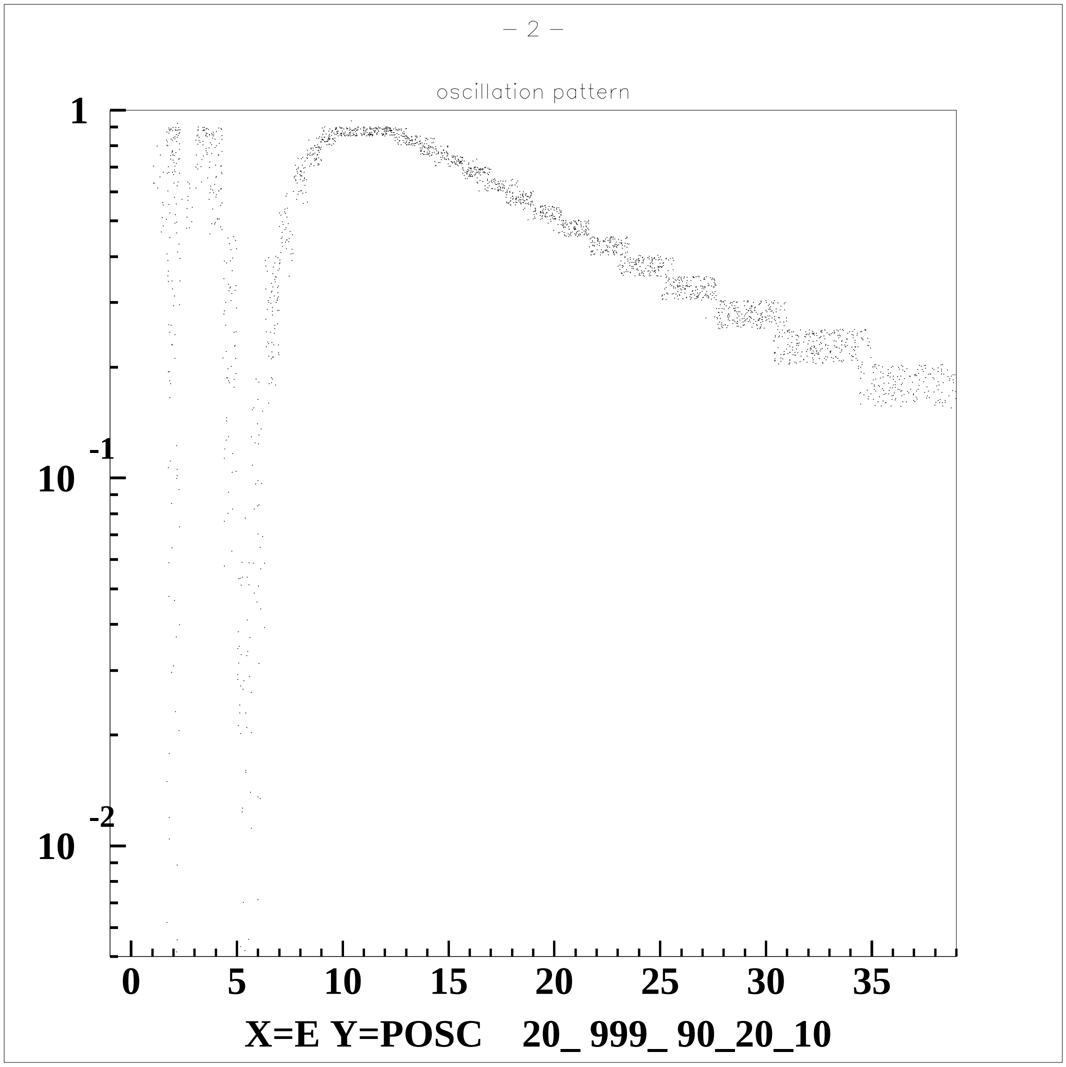

Figure 3: abcissa : nominal energy of ν_μ beam, in GeV

Oscillation pattern

$$\delta m^2 = .002eV^2,\ sin^2(2*\theta) = 0.9$$

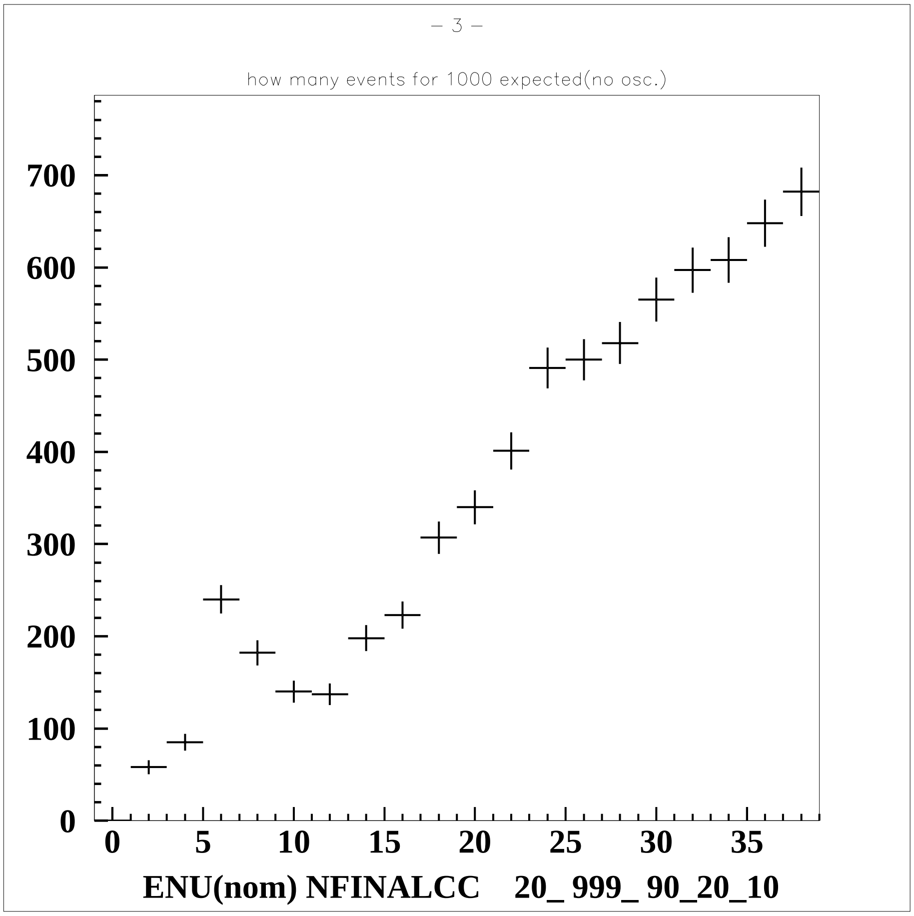

Figure 4: abcissa : nominal energy of ν_μ beam, in GeV. $\delta m^2 = .002eV^2$, $sin^2(2*\theta) = 0.9$

Simulation : observed nb. of events for each energy, for 1000 expected(no osc.)

At 5-10 Gev, the running time is a few months per point, depending on decay tunnel and trigger efficiency.

Summary and comments :

- Narrow band beams towards existing Megaton(s) detectors give many events to study oscillation pattern$\Rightarrow$ reappeareance of ν_μ.
- Building such a beam below 30° is a major operation.
- Understanding such a beam with a near detector is not an easy task.
- Understanding the trigger efficiency in the Megaton(s) detector is not an easy task.
- A useful first step toward neutrino factories?