BENE meeting at CERN

(22-25 November 2005)

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The MEMPHYS project

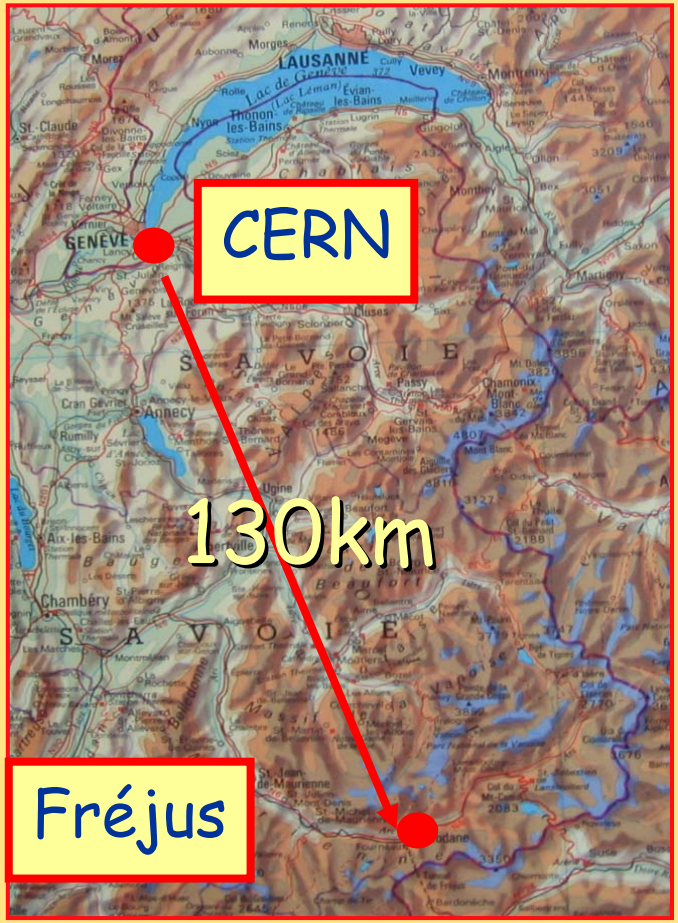
MEgaton Mass PHYSics
in a Large
International Underground Laboratory
in the Fréjus tunnel

- proton decay
- supernovae explosion
- solar and atmosphéric neutrinos
- neutrino super-beam and beta-beam from CERN

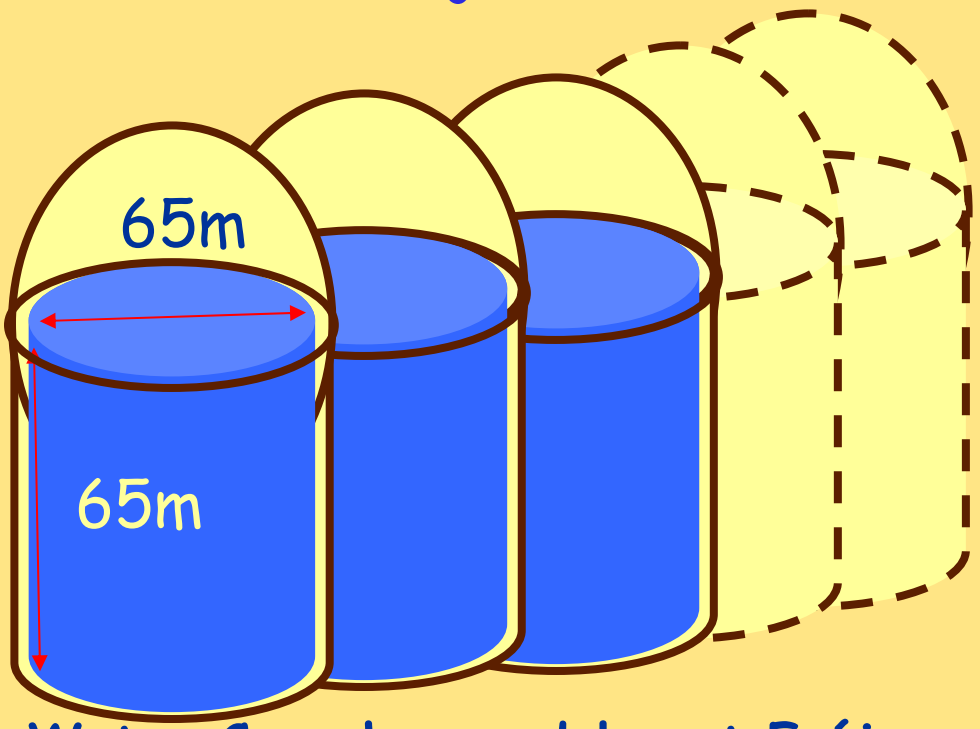
The MEMPHYS project

- Physics Motivations
- The Installation
  - **a Very Large Laboratory**
  - a MegaTon scale Detector
  - the Neutrino Beams
- Expected physics potential
- Tentative schedule

The MEMPHYS Project



4800mwe



Water Cerenkov modules at Fréjus

CERN to Fréjus
Neutrino Super-beam and Beta-beam

Excavation engineering pre-study has been done for 5 shafts

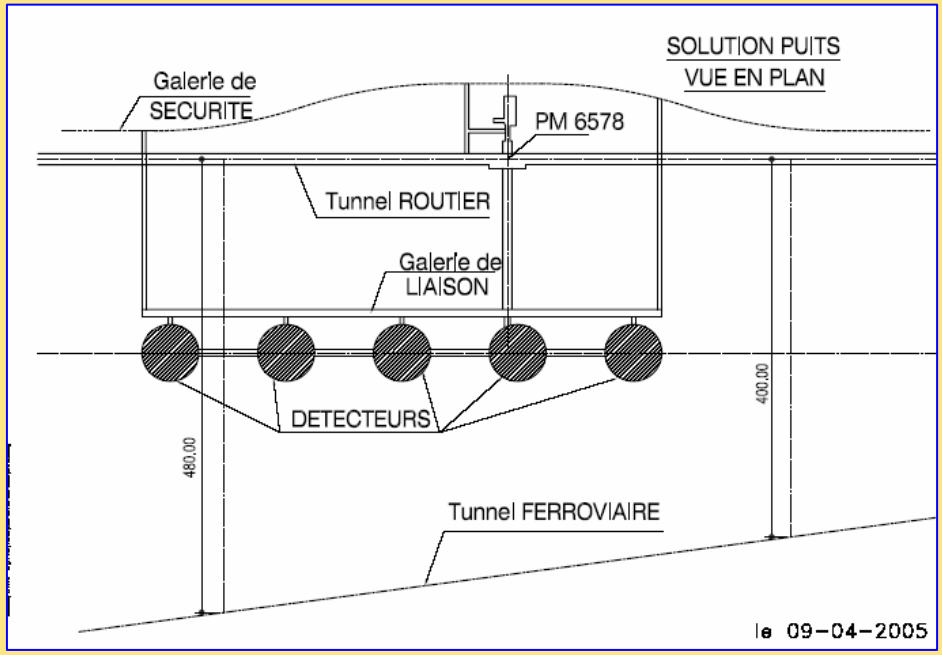
Physics Motivations

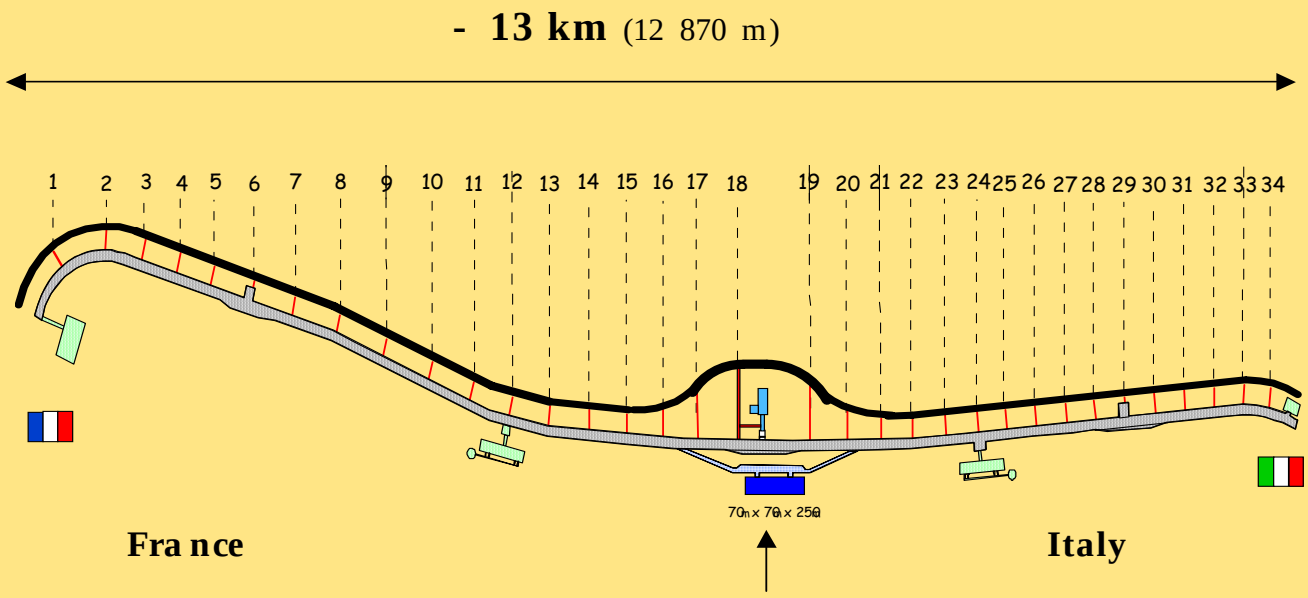
- Nucleon Decay
- Super Novae Neutrinos:
  - burst & relic
- Solar & Atmospheric Neutrinos
- Neutrinos from Accelerators
  - Super Beam, Beta Beam
- And also:
  - Dark Matter (WIMP) indirect detection, High energy neutrinos,…

A Very Large Laboratory

In the middle of the Fréjus tunnel at a depth of4800 m.w.e

a preliminary investigation shows the feasibility to excavate up to five shafts of about 250,000 m^3 each





Present road Tunnel at Fréjus (grey)
and
future Tunnel (black) for safety with 34 bypasses (shelters)
connecting the two Tunnels

Main results of the Preliminary Study

1) the best site (rock quality) is found in the middle of the mountain,
at a depth of 4800 mwe : a really good chance !

2) of the two considered shapes : “tunnel” and “shaft”,
the “shaft (= well) shape” is strongly preferred

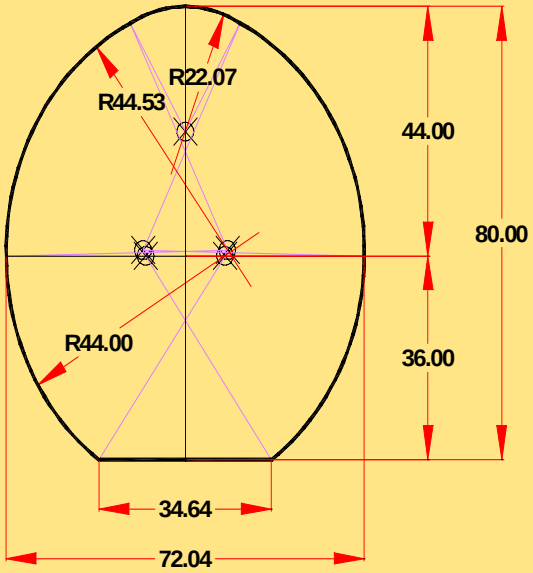
3) Cylindrical shafts are feasible up to :
a diameter Φ = 65 m and a full height h = 80 m (≈ 250 000 m^3)

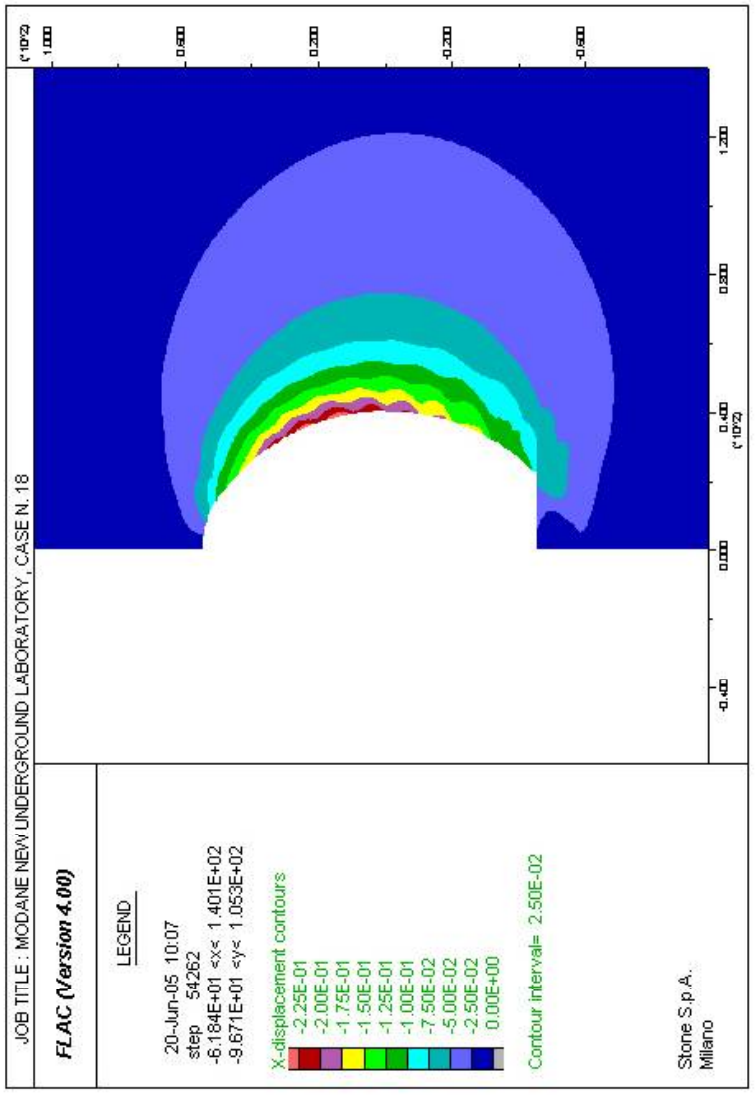
4) with “egg shape” or “intermediate shape” the volume
of the shafts could be still increased

5) The estimated cost is ≈ 80 M€ X Nb of shafts

Exemple of “egg shape” simulation, constrained by the rock parameter measurements made during the present tunnel and laboratory excavation.

The main feasibility criterium is that the significantly perturbated region around the cavity should not exceed a thickness of about 10 m





Two examples of scenario for Water Cerenkov detectors

a) 3 shafts of 250 000 m^3 each, with a fiducial mass of 450 Ktons
("UNO-like" scenario)

b) 4 shafts of 250 000 m^3 each, with a fiducial mass of 600 Ktons

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-> In both scenarios one additional shaft would be necessary for a Liquid Argon detector of about 100 ktons total mass

A MegaTon scale Detector

3 to 4 Water Cerenkov modules (= 20 x Super K ≈ 500kT fiducial mass) equipped with a large number of Photodetectors (eg. 250,000 PMTs 12")

a very well proved and robust technique which provided already remarkable physical results mainly in Nucleon Decay and Neutrino Physics and Astrophysics

Very intense 300÷400 MeV Neutrino Beams from CERN

- Super Beam based on a 4MW Proton Driver (eg. SPL) :
  ν_μ and $\overline{\nu}_\mu$ from pion decay

- Beta Beam (possibly in connection with the EURISOL project) :
  ν_e and $\overline{\nu}_e$ from heavy ions decay

Main Physics potential

A) non accelerator physics

- Nucleon decay
  - up to $\sim 10^{35}$ yrs ($\mathbf{p \rightarrow e^+ \pi^0}$)
  - few 10^{34} yrs ($\mathbf{p \rightarrow \bar{\nu} K^+}$) with a detection threshold below 6MeV

- Neutrino bursts from Super-Novae explosion
  - 150,000 events from SN at 10kpc
  - 50 events from Andromeda

- Relic Neutrinos from past Super-Novae explosions
  - 250 events/10y/0.5Mt (with pure water)
  - 2500 events/10y/0.5Mt (with Gd loaded water)

Main Physics potential (continued)
B) accelerator physics

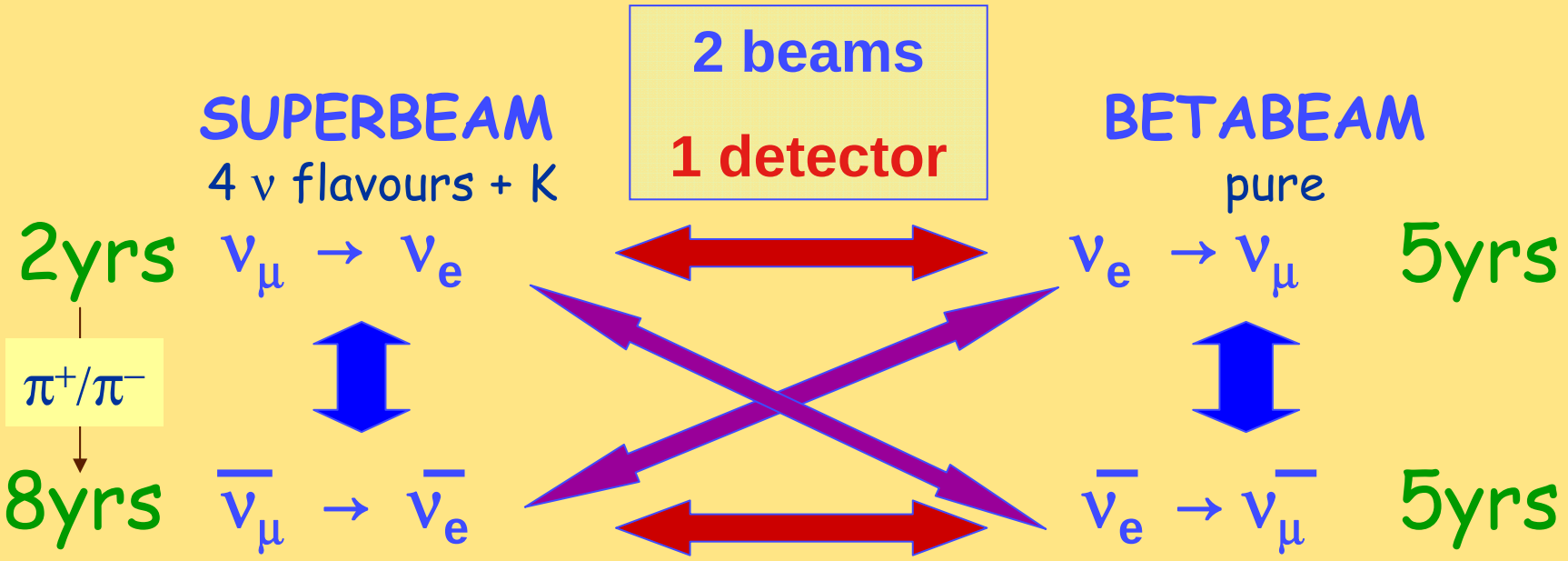
- PMNS matrix parameters measurement :

–> $\theta_{13} < 0.7°$ @90%CL (ν_μ beam 2.5Mt.y)

-> for $40° < |\delta_{CP}| < 140°$: CP violation discovery @ > 3σ

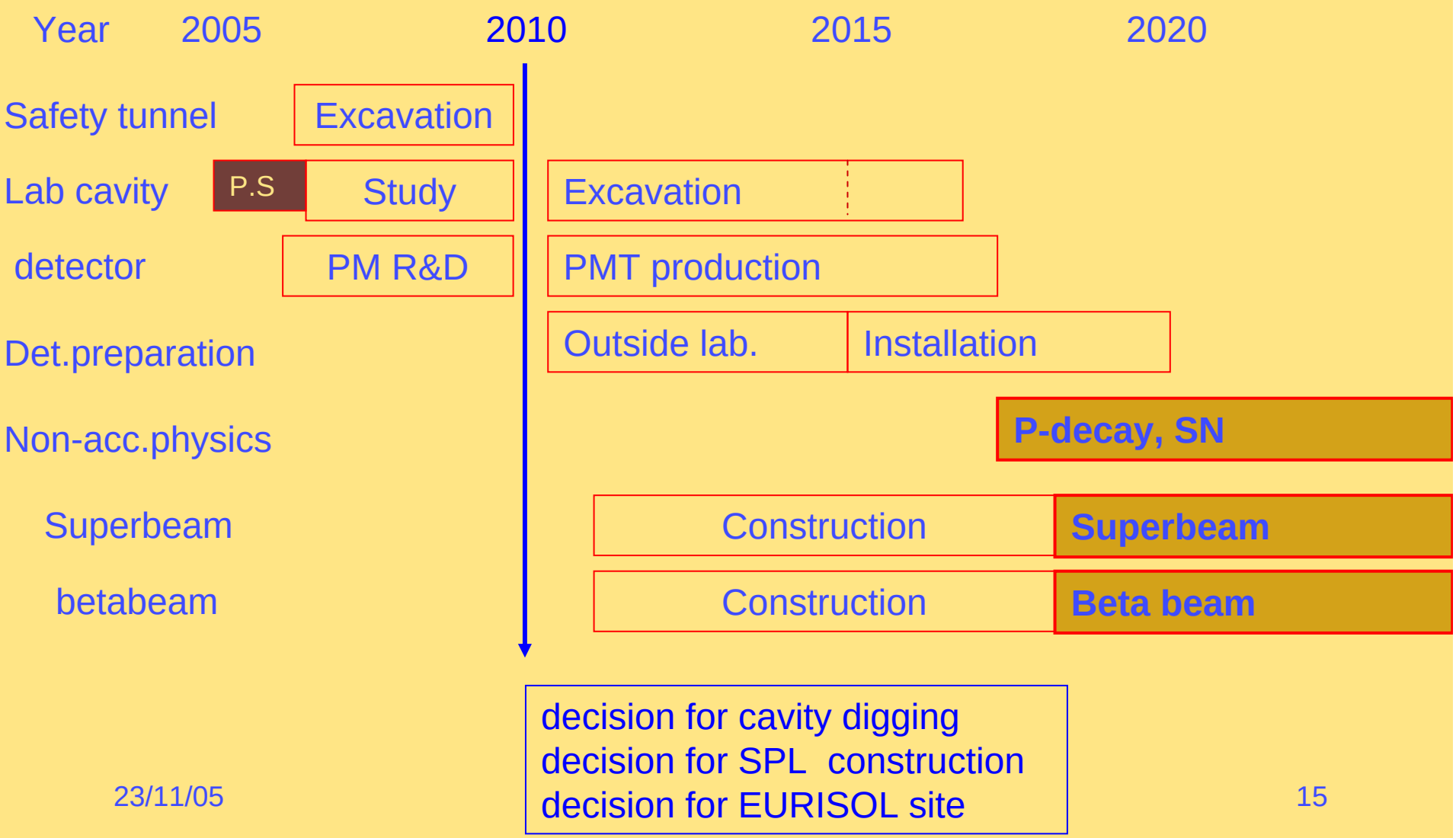
(at $\theta_{13} = 1°$ and 10yrs of Beta Beam and Super Beam)

Superbeam + beta beam together



2 ways of testing CP, T and CPT : redundancy and check of systematics

A possible schedule for a European Lab. at Frejus



Design Study for the **MEMPHYS' Laboratory**

concerning the excavation of **3 to 5 "shafts"** of about **250000 m^3 each** in the central region of the Fréjus Tunnel, the **associated equipments** and the **mechanics of the detector** modules :

a) precise "in situ" investigation of the rock quality parameters

b) optimisation of the shafts shape

c) optimisation (choice) of the type of local access

d) definition of the required equipments : ventilation and air-conditioning, water purification "factory", electric power supply, etc.

e) definition of the best solution for the water containment and for the photo-detectors support