

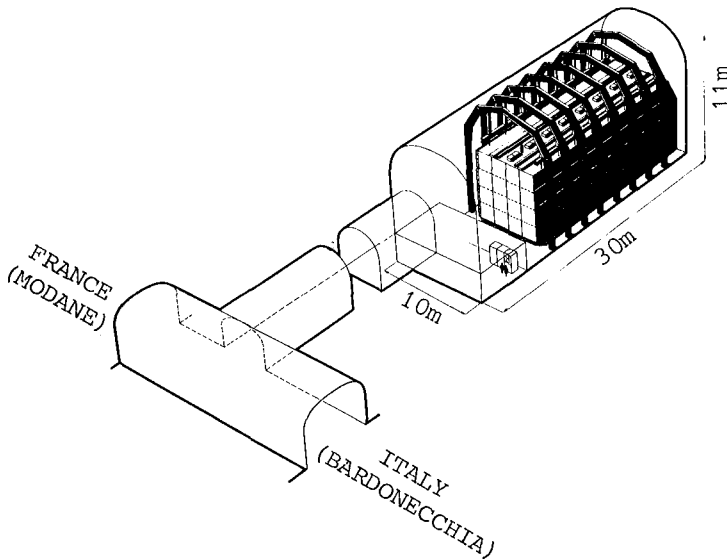
SEARCH FOR PROTON DECAY IN
THE FREJUS EXPERIMENT

AACHEN¹, ORSAY², PALAISEAU³, SACLAY⁴, WUPPERTAL⁵, Collaboration

ABSTRACT

We will report, in this paper, the present status of the Frejus experiment and the preliminary results obtained in the search for nucleon decay.

1. Frejus laboratory and detector. A modular, fine grain tracking calorimeter has been installed in the Frejus laboratory in the period extending from October 1983 to May 1985. The 3300 m³ underground laboratory, located in the center of the Frejus tunnel in the Alps is covered in the vertical direction by 1600 m of rocks (4400 m w.e). The average number of atmospheric muons in the lab. is 4.2/m². day. Fig. 1 shows a sketch of the Frejus laboratory with the detector.



The 912 ton detector is made of 114 modules, each one including eight flash chamber and one Geiger vertical planes of (6 × 6) m² dimensions. The flash chamber (and Geiger) planes are alternatively crossed to provide a 90° stereo reconstruction.

Figure 1 : General picture of the Frejus laboratory

-
- ¹ Ch. Berger, A. Hoffmann, F. Raupach, J. Tutas, G. Schmitz
I. Phys. Inst. der Techn. Hochschule, Aachen (Germany)
- ² B. Dudelzak, P. Eschstruth, G. Deuzet, S. Jullian, D. Lalanne,
F. Laplanche, C. Longuemare, C. Paulot, Ph. Roy, G. Szklarz
Laboratoire de l'Accélérateur Linéaire, Orsay (France)
- ³ L. Behr, R. Bland, B. Degrange, U. Nguyen-Khac, P. Serri, S. Tisserant
Laboratoire PNHE, Ecole Polytechnique, Palaiseau (France)
- ⁴ P. Bareyre, R. Barloutaud, G. Chardin, L. Di Ciaccio, J. Ernwein,
G. Berbier, M.A. Jabiol, W. Kolton, L. Mosca, L. Moscoso
DPHPE, CEN Saclay (France)
- ⁵ K.H. Becker, H.J. Daum, S. Demski, R. Hinnners, W. Kohrs, B. Kuznik,
R. Mayer, H. Meyer, D. Ortmann, J. Peters, M. Schubnell, J. Thierjung
Universitaet - Gesamthochschule Wuppertal (Germany)

They are separated by 3 mm iron plates as illustrated in Fig. 2.

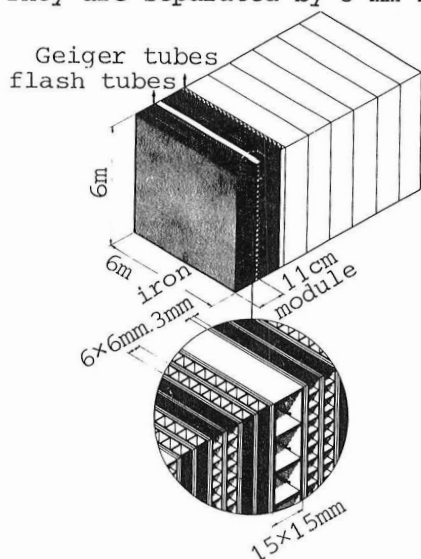


Figure 2 : Structure of the Frejus detector

The 934.000 (5×5) mm² section polypropylene flash tubes are filled with a neon-helium gas mixture in which a plasma is produced when an electrical field of 8 KV/cm is applied. The plasma detected at the end of each tube by a capacitive read-out method allows the localization of a charged particle in the detector with an accuracy of the order of 2 mm.

The 40.000 (15×15) mm² section, aluminium Geiger tubes filled with an argon-ethanol gas mixture provide the trigger of the flash chambers when a charged particle is produced inside or crosses the detector. They also give a spatial and time information on the event.

2. Status of the experiment. The detector performances are summarized in Table 1. The space resolution, the amount of background and the separation

- efficiency per cell : flash 80 %, Geiger 85 %
- background per cell per trigger : flash $8 \cdot 10^{-5}$, Geiger $5 \cdot 10^{-4}$
- space resolution : 2 mm
- energy resolution : electron $\sigma(E)/E = 12 \% \sqrt{E}$ muon $\sigma(p) \approx 10 \text{ MeV}/c$ at 500 MeV/c
- particle identification e - μ (π) separation : less than 10 % above 200 MeV/c
- $\mu^+ \rightarrow e^+$ decays : $\sim 60 \%$ efficiency

Table 1

between showering and non showering particles may be illustrated in Fig. 3

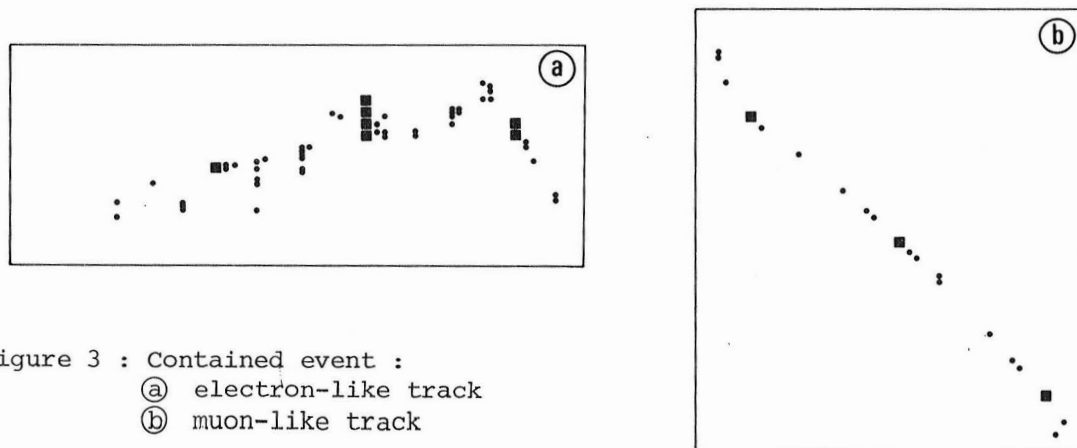


Figure 3 : Contained event :
 (a) electron-like track
 (b) muon-like track

when two contained events with electron (a) and muon (b) are displayed. The trigger logic consists on the coincidence (within 300 ns resolution time) between five Geiger tubes belonging to five adjacent planes with a maximum contribution of three tubes per plane. In these conditions the trigger rate amount to about 40 per hour, half of them being random coincidences due to radioactivity while the other half is essentially due to atmospheric muons.

Although the complete detector (912 tons) is in operation since June 1985, data have been taken during the installation since March 1984 when its total mass amounted to 240 tons.

3. Data analysis and preliminary results on contained events. The on-line scanning of the events and the monitoring of the detector is assured by a physicist controlling the experiments outside the underground laboratory. Off-line analysis consisting of a systematic check of the on-line scanning and the measurement of the important events, has recently started.

Only events originating at more than 50 cm of the external faces of the detector are considered as produced in the detector. Strict containment conditions are equally defined to assure that the charged particles stop in the detector. The preliminary results presented thereafter are based on a sensitivity of 194 TON(FID).YEARS. Table 2 summarizes the raw data obtained

Raw data : on line scanning

- single muons	71 400
- stopping muons	520
- muon bundle	2 010
- exotic	470
- events inside the detector	30

Data reduction of events inside the detector
from the 30 scanned events

13	have their vertex outside fiducial volume
1	is a vertical crossing muon
2	are vertical downward stopping muons
1	is an upward stopping muon
13	are contained vertex events
9	with tracks fully contained
4	with tracks partly contained

Table 2

after the on-line scanning and the final number of events produced in the detector fully or partly contained. The nature of the (eventual) charged lepton found in each event is defined and its zenithal angle determined ; this is presented in Fig. 4a. Assuming first that all these events are atmospheric neutrino interactions, one deduces after trigger efficiency correction a number of 90 ± 30 and neutrino interactions for kiloton-year,

and a ratio $\frac{(\bar{\nu})_e \text{ interactions}}{(\bar{\nu})_\mu \text{ interactions}} = 0.7 \pm 0.4$. These numbers agree within the

statistical error with the previous results found in other large underground detectors and with the Monte Carlo predictions.

For each event the visible energy has been evaluated. The distribution of this quantity as a function of the number of prong of the events is shown in Fig. 4b, for the fully and partly contained events. From this figure we consider that the only candidates for nucleon decay into charged lepton are the fully contained events with at least 2 prongs and a visible energy less than 2 GeV. For the two events fullfilling these conditions the asymmetry parameter $|\Sigma \vec{p}|/E$ has been determined and is shown in Fig. 4c. These events are clearly incompatible with a nucleon decay for which the asymmetry parameter should be close to zero.

Therefore no candidate for the nucleon decay into charged lepton is found in this first sample of events. This leads after correction for trigger efficiency to a lower limit for the partial lifetime $\tau_{N \rightarrow \ell^\pm + X} > 4.10^{31}$ years with 90 % C.L.

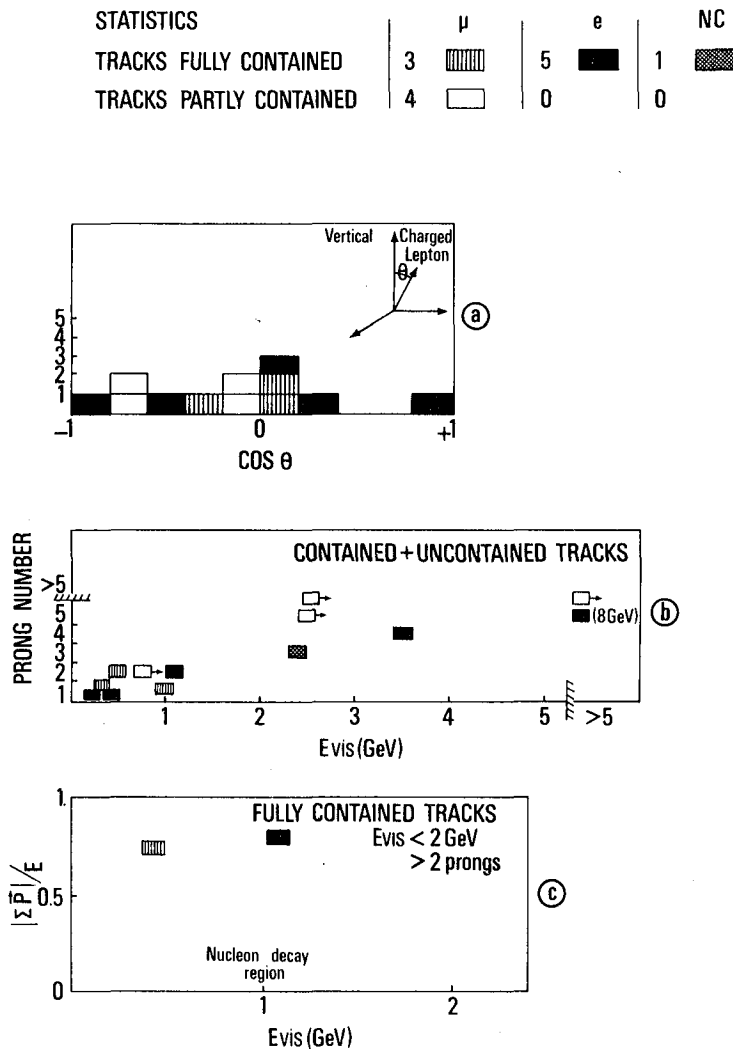


Figure 4 : (a) angular distribution
 (b) topology versus visible energy
 (c) asymmetry versus visible energy