SEARCH FOR STERILE NEUTRINOS

- *'Sterile' neutrinos arise in many models trying to accommodate massive neutrinos. If their mass is not excessively high, they can be searched by their decay signature in an intense neutrino beam. This is done more efficiently at low energy. Previous limits come from the PS191 experiment (1984).*
- A new accelerator can deliver a much higher luminosity, thus improving the limits in mixing parameters, or finding new states.
- *The detector is simple, it uses an empty decay volume followed by a fine-grain calorimeter.*

Recent motivation: the νMSM model

T. Asaka and M. Shaposhnikov Phys.Lett.B620(2005)17 , M.Shaposhnikov, Nucl.Phys.B763(2007)49

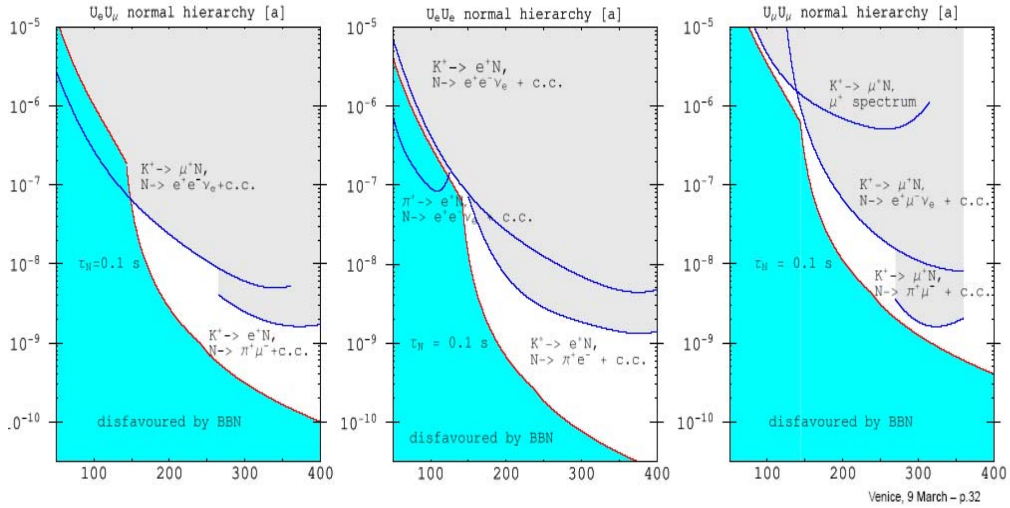
- *See-saw* formula for active neutrinos $m_\nu = -M^D (1/M_M)(M^D)^T$
  - –Majorana mass M_M
  - –Dirac mass $M_D = fv$ v=174 GeV vac exp val of Higgs field

  - Usual choice: f as in quark sector, $M_M = 10^{10}$-10^{15} GeV
  - Alternative choice: small f

- Three singlet RH neutrinos N_1 N_2 N_3
  - ⇒ N_1 with very large lifetime,
    - *Best choice : $m(N_1)$ ~10 keV*
  - ⇒ N_2, N_3 almost degenerate (leptogenesis)
    - *With masses 100 MeV-few GeV*

Present limits

m
i
x
i
n
g



Mass of heavy neutrino (MeV)

They come from cosmology (blue area) and PS191 (grey area)

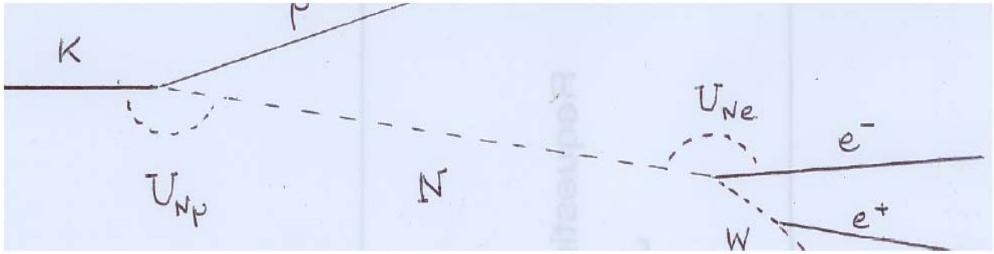
Production and decay of N

•N's are mixed with active neutrinos, in all production processes they appear at the level U_{Nl}^2

Their mass is limited by the decaying parent particles

Example: $K \Rightarrow e\ N$ $m(N) < 450$ MeV

N weak decay

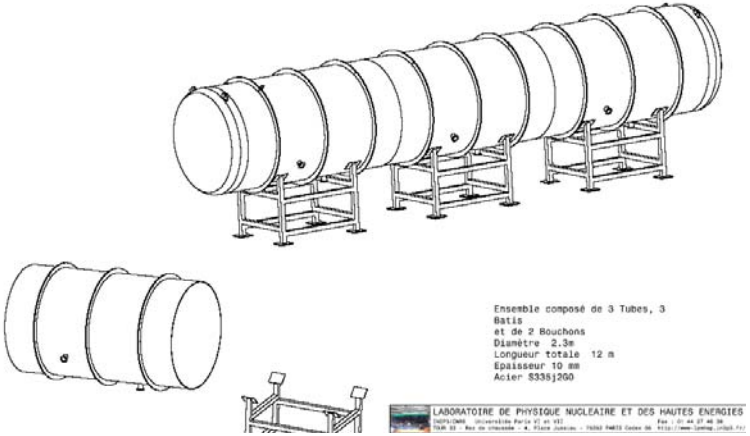


Lifetime for $e^+e^-\nu$ $\tau = 2.8\ 10^4\ (1/m(\mathrm{MeV})^5)(1/U^2)$ (s)

Detector

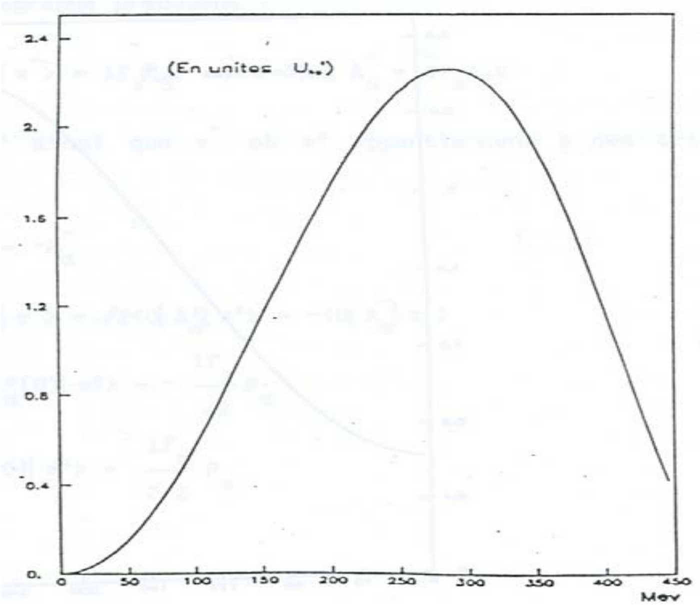
Signature: 2-prong vertex in a decay volume

Background: neutrino interactions. Need of a vacuum tank (10^{-3} atm)

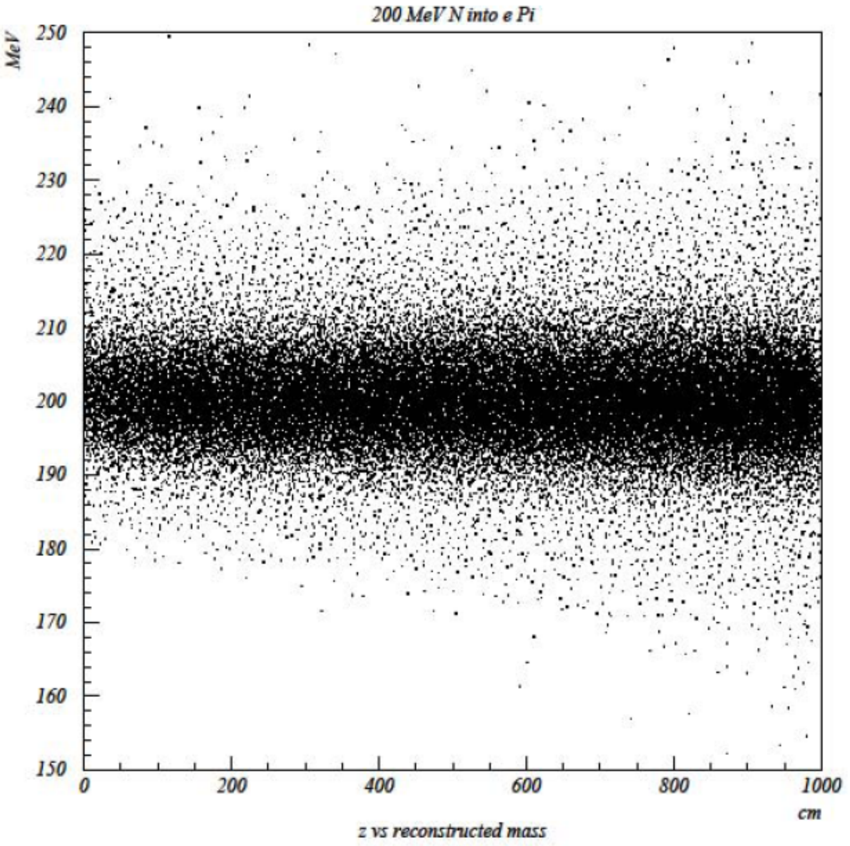


Followed by a fine-grain EM calorimeter

Some calculations



K → eN



Helicity conservation revisited

Expectations

PS191 (1984!) accumulated 5 10^{18} protons of 19 GeV on target

Much higher luminosity possible: *10^{21} easily accessible*

At low energies, neutrinos come from π and K decays

Favorable conditions to improve limits on $U_{Ne}{}^2$ and $U_{N\mu}{}^2$ up to the K mass

$\Rightarrow$ *Improvement by factor ~ 20*

At higher energies (1 TeV SPS+)

Neutrino beams from D and B decays are possible

One can envisage a beam-dump experiment

Mass range of N extended up to the B mass

First tests of mixings of N with τ

Limits on $U_{\tau\tau}^2$ *down to* 10^{-8} *for masses up to ~ 3 GeV*