INSS 2011 – group 4, problem 17

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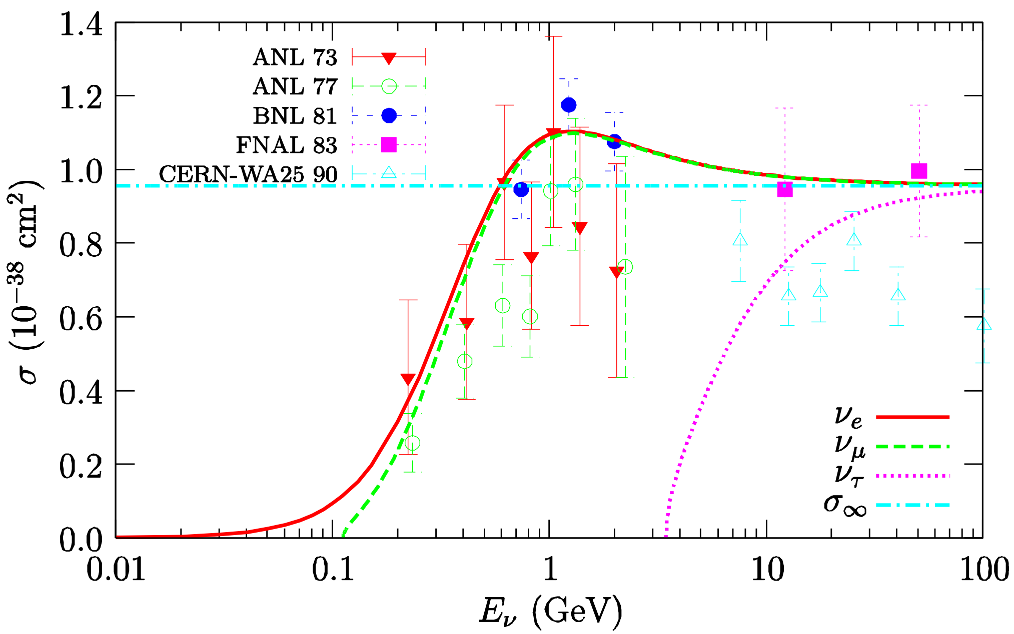
the problem

Produce a ν beam containing a large fraction (>10%) of ν_τ to study charged-current ν_τ interactions. Propose a detector capable of the measurement.

Kinematic constraints require a 4 GeV ν_τ beam.



ν_τ beam 1 – D_S factory

Collide a target with protons and hope to produce D_s.

$$D_s \rightarrow \tau + \nu_\tau \quad (6.6\%)$$

If you can tag D_S with efficiency >10% and trigger the detector, you've effectively created a ν_τ beam.

D_S lifetime = 500 fs, ct = 150 μm

This requires a target with integrated sub-mm tracking.

ν_τ beam 2 – "asymmetric giga-Z factory"

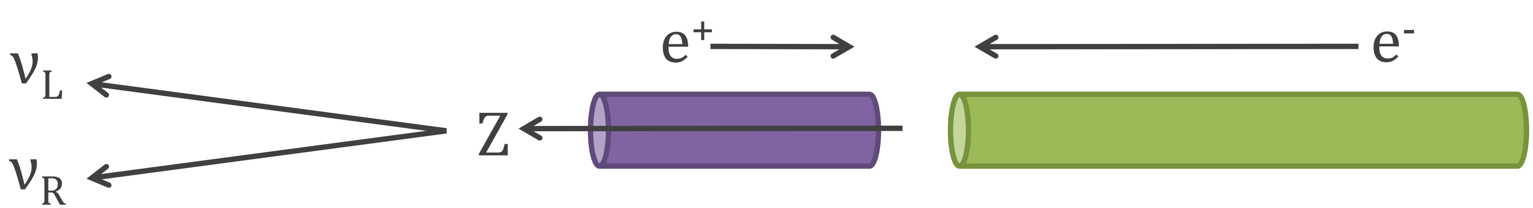
Two linear colliders of unequal energy tuned to the Z resonance. Center of mass is boosted in one direction, producing a ν beam as the Z decays.

LEP luminosity = 24×10^{30} cm^{-2} s^{-1}

$\sigma_Z = 4\times10^{-32}$ cm^2

rate = 0.96 s^{-1}

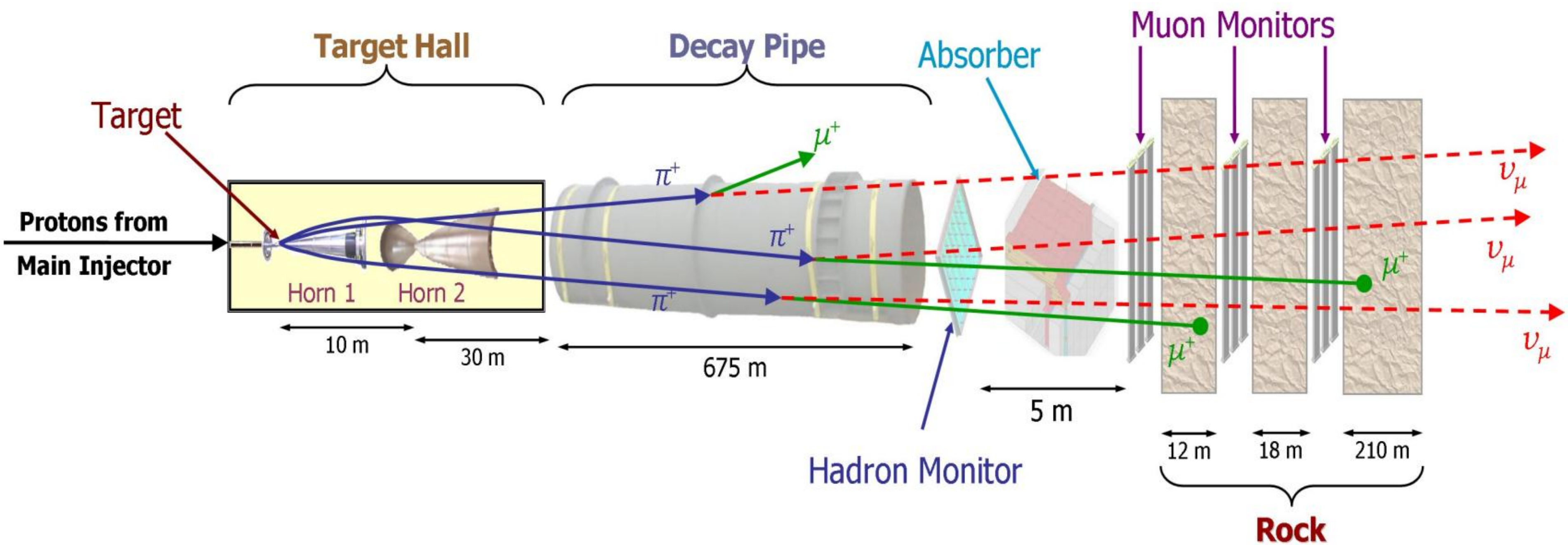
Of which, 1/3 are ν_τ.



ν_τ beam 3 – oscillated ν_μ beam

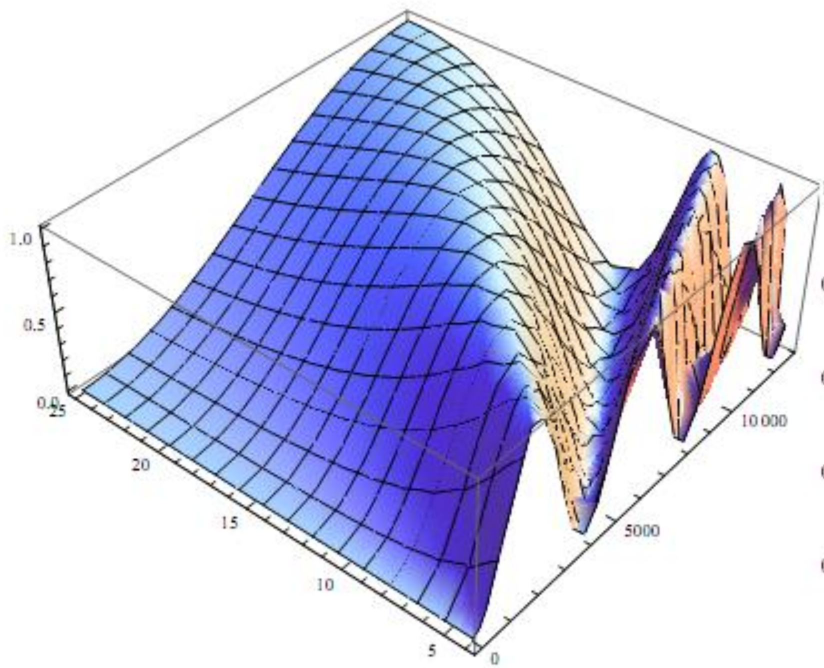
A typical $\pi \rightarrow \mu + \nu_\mu$ beam will oscillate to ν_τ.

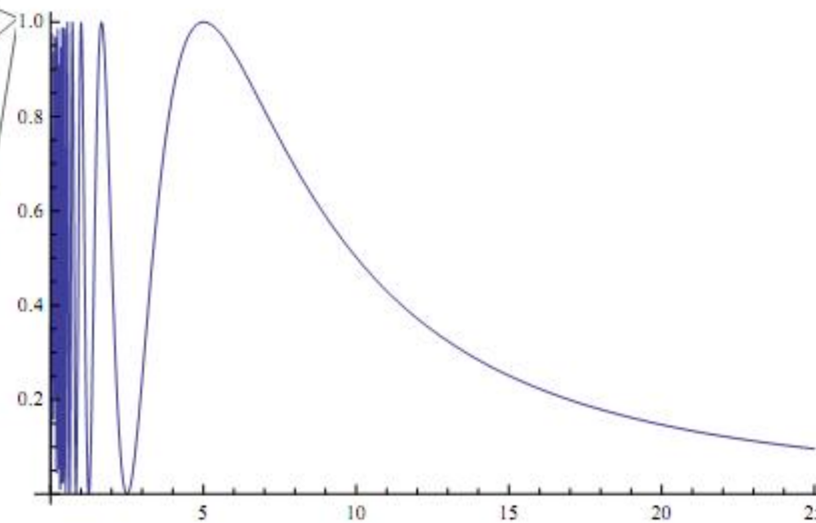
Experimentally measured oscillation parameters determine the ν_τ flux at all points for all energies.



Superbeam at 1st oscillation maximum

- Assume $\sin^2 2\theta_{\mathrm{atm}} = 1$ (maximal mixing)
- Assume $\Delta m^2_{\mathrm{atm}} = (2.43 \pm 0.13) \times 10^{-3}\ \mathrm{eV}^2$ (PDG)
- Choose L for 1st osc. max. at $E_0 = 5$ GeV so at interesting low $\sigma_\tau^{\mathrm{CC}}$ region
- 1st osc. max. at 2550 km ($R_{\mathrm{earth}} = 6378$ km)

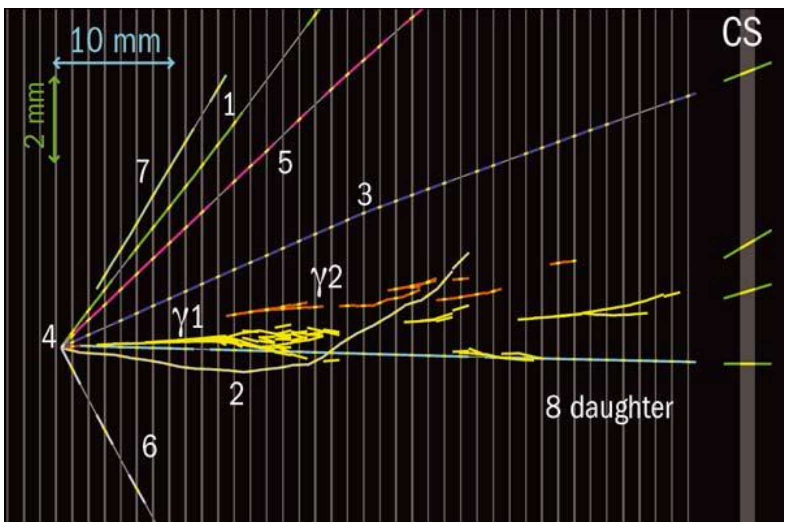


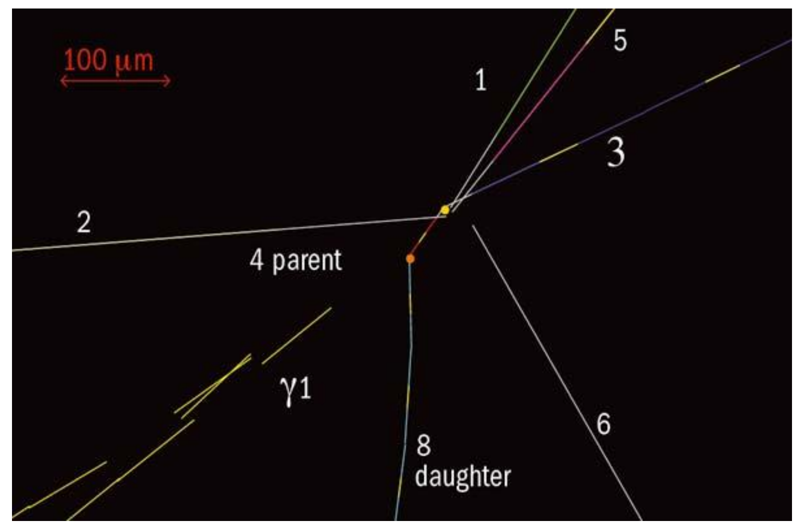


τ detection

Identify a short (150 μm) τ track:

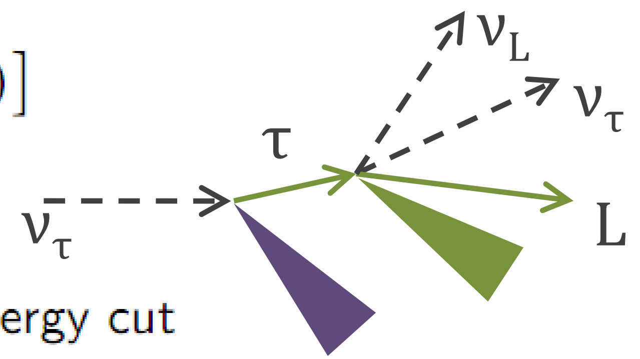
- bubble chamber
- absorber/emulsion stack – DONUT, OPERA





Sketch of the principle for measuring σ_τ^{CC}

- Seek to identify rate in F.D. of creating a τ
- $R_{FD}^{TOTAL} = \Phi N \left[f_\tau(\sigma_\tau^{CC} + \sigma_\tau^{NC}) + f_\mu(\sigma_\mu^{CC} + \sigma_\mu^{NC}) \right]$
- $\tau^- \to \mu^- \nu_\tau \bar{\nu}_\mu$ with B.R. 17.4%
- $\tau^- \to e^- \nu_\tau \bar{\nu}_e$ with B.R. 17.4%
- Identify this 37% with a missing transverse energy cut
- Use a Monte Carlo to study the efficiency ϵ



$$\sigma_\tau^{CC} = \frac{N_{cuts}^{2\nu}}{\Phi N t_{exposure}} \frac{1}{\epsilon} \frac{1}{0.37}$$

- ϵ - and resolution - will be best when intrinsic ν_μ contamination is ~ 0 at E_0
- Near detector for Φ and $\sigma_\mu^{NC} = \sigma_\tau^{NC}$ for M.C.??