New Results from the DONUT Collaboration

Direct Observation of NU Tau

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A Progress Report – We are still working on it

Old Results


• A new upper limit for the tau-neutrino magnetic moment ($\mu_{\nu_\tau} < 3.9 \times 10^{-7}\mu B$) Phys. Lett. B 513(2001) 23-29
DONUT Collaboration

**Minnesota**

**Fermilab**
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New Results - Preliminary

Using “Old” Found Events to Improve Analysis

- Event Selection in Spectrometer Using Neural Network Analysis
- Iterative Vertex Prediction by Spectrometer Data
- Faster Emulsion Scanning Hardware
- Improved Vertex Location Strategies in Emulsion
- Single Event Statistical Analysis

Goal – More Statistics, Understand Acceptance to get Cross-section

Currently 7 $\nu_e$ interactions and 7 $\nu$ interactions giving charm

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Experimental Technique

directly observe cc interactions of the $\nu_\tau$

$\nu_\tau + N \rightarrow \tau + X$

800GeV

BEAM DUMP

SHIELDING

EMULSION TARGET

SPECTROMETER

$p$ $D_s$ $\tau$

$\nu_\tau$ $\bar{\nu_\tau}$

$\sim 10^{17}$ protons for 400 $\nu$ interactions

$\sim 5\%$ $\nu_\tau$

c$\tau = 0.09$mm
• trigger
• muon ID
• electron ID
• momentum
• vertex location
\( \nu_\tau \) interaction selection

- No e, \( \mu \) from primary vertex
- At least one segment on parent
  - 76\% of \( \tau \)'s have visible track
- Decay with only at least one charged product
  - 86\% of decays are single charge
- Minimum transverse momentum
  \( p_t > 250 \text{ MeV/c} \)

- Short decay length
  - length < 5 mm (mean 2.3 mm)
- Small production angle
  - angle < 200 mr (mean 40 mr)

\( \nu_\tau \) acceptance = 0.5
$p = 4.6^{\pm 0.5} \text{ GeV}$

EXP.: DONUT
3039/01910
MOD.: ECC-1

Beam-view

$\theta_{\text{kin}} = 0.090 \text{ rad}$

length $280 \mu m$
All Segments in Event Vicinity

Event tracks
Through going tracks
Unmatched segments

Event 3039-01910
Located Event
Typical Event – Not Located
Probability Event is a Tau Neutrino, Charm Background, or Scatter Background

Parameters
- Track production angle
- Event angular symmetry
- Track decay length
- Daughter decay angle
- Daughter momentum

\[ \nu_\tau \text{ cc} \]
\[ .69 \quad .98 \quad .16 \quad .99 \]

\[ \nu + \text{charm} \]
\[ .31 \quad .02 \quad .14 \quad .01 \]

\[ \nu + \text{hadron scatter} \]
\[ 0 \quad 3 \times 10^{-4} \quad .70 \quad 0 \]

Probability all events are background
\[ = 4 \times 10^{-4} \text{ old} \]
\[ = 7.5 \times 10^{-5} \text{ new} \]
New $\nu_\tau$ Candidates

Event analysis not complete
predicted vertices from spectrometer
within fiducial volume
digitized emulsion data exists
emulsion vertex location attempted
vertex found
systematic decay search
ντ candidates

Data Set

6.6×10^6 triggers

1011 898

815 699

744 511

704

Improves vertex prediction

370

346

203

7

Improves vertex location
Conclusion

• Sampling emulsion tracker + spectrometer works even better than expected
  – Still learning to use all of its power
    • Near 100% reconstruction efficiency possible
      – (<50% was previously “excellent” ie CHORUS)
    • Single event probabilities

• Increasing event sample continues
  – From 203 to 364 since publication
  – Expect a similar increase
    • Problems are getting harder

• Better understanding of efficiencies and twice as many tau and charm events
  – Improved understanding of backgrounds and systematics
  – Cross section measurements

• Technology for future detectors to study short lived particles.