

KTeV: E799 Status Report

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Outline

- Goals of experiment
- Highlights from results
- Publications to date
- PhD theses defended
- Plans for remaining work
- Resources needed to complete



Goals of E799

- Search for rare decay $K_L \rightarrow \pi^0 e^+ e^-$ with single-event sensitivity of 10^{-11}
- Search for the related rare decays $K_L \rightarrow \pi^0 \mu^+ \mu^-$ and $K_L \rightarrow \pi^0 \nu \bar{\nu}$
- Search for and measure a variety of other kaon decays to determine branching ratios, form factors, angular distributions and asymmetries, etc.



Highlights from E799

- Limit on $K_L \rightarrow \pi^0 e^+ e^-$ has been reported from 1997 data (about half the total dataset):

$$B(K_L \rightarrow \pi^0 e^+ e^-) < 5.1 \times 10^{-10} \text{ (90\% CL)}$$

This is an factor of 10 improvement over the E799-I result from 1993.

- Limit on $K_L \rightarrow \pi^0 \mu^+ \mu^-$ has also been reported from 1997 data:

$$B(K_L \rightarrow \pi^0 \mu^+ \mu^-) < 3.8 \times 10^{-10} \text{ (90\% CL)}$$

This is a factor of 15 improvement over the E799-I result from 1993



Highlights from E799

- Limits on $K_L \rightarrow \pi^0 \nu \nu$ have been determined from two different analyses. From a special one-day run with a pencil beam, using $\pi^0 \rightarrow \gamma \gamma$ we found

$$B(K_L \rightarrow \pi^0 \nu \nu) < 1.6 \times 10^{-6} \text{ (90\% CL)}$$

- From the full 1997 dataset, using the dalitz decay $\pi^0 \rightarrow e^+ e^- \gamma$:

$$B(K_L \rightarrow \pi^0 \nu \nu) < 5.9 \times 10^{-7} \text{ (90\% CL)}$$

This is still a factor 20,000 bigger than the Standard Model prediction of $\sim 3 \times 10^{-11}$



Highlights from E799

- E799 has observed over 5000 examples of the never-before-seen decay $K_L \rightarrow \pi^+ \pi^- e^+ e^-$
- This decay exhibits a large asymmetry in the final-state angular distributions, which is CP-violating and T-odd.
- The $\sim 14\%$ asymmetry results from interference between a CP-conserving amplitude for direct emission $K_L \rightarrow \pi^+ \pi^- \gamma$ and a CP-violating amplitude for $K_L \rightarrow \pi^+ \pi^-$ with inner bremsstrahlung.



E799 Published Results

- “Measurement of the Branching Fraction of the Decay $K_L \rightarrow \pi^+ \pi^- e^+ e^-$ ”
Phys Rev Letters 80, 4123 (1998)
(21 citations in Spires)
- “Search for the Decay $K_L \rightarrow \pi^0 \nu \nu$ ”
Phys Letters B447, 240 (1999)
(26 citations in Spires)
- “Observation of $\Xi^0 \rightarrow \Sigma^+ e^- \nu$ ”
Phys Rev Letters 82, 3751 (1999)
(9 citations in Spires)



E799 Published Results

- “Measurement of the Branching Ratio of $\pi^0 \rightarrow e^+e^-$ Using $K_L \rightarrow \pi^0\pi^0\pi^0$ Decays in Flight”
Phys Rev Letters 83, 922 (1999)
(17 citations in Spires)
- “Observation of CP Violation in $K_L \rightarrow \pi^+\pi^-e^+e^-$ Decays”
Phys Rev Letters 83, 22 (1999)
(48 citations in Spires)
- “Search for the Decay $K_L \rightarrow \pi^0\nu\nu$ Using $\pi^0 \rightarrow e^+e^-\gamma$ ”
Phys Rev D61, 072006 (2000)
(46 citations in Spires)

E799 Published Results

- “Search for the Decay $K_L \rightarrow \pi^0 \mu^+ \mu^-$ ”
Phys Rev Letters 84, 5279 (2000)
(17 citations in Spires)
- “Observation of the Decay $K_L \rightarrow \mu^+ \mu^- \gamma$ ”
Phys Rev D62, 112001 (2000)
(6 citations in Spires)
- “Search for the Decay $K_L \rightarrow \pi^0 e^+ e^-$ ”
Phys Rev Letters 86, 397 (2001)
(19 citations in Spires)

E799 Published Results

- “Measurement of the Branching Ratio and Asymmetry of the Decay $\Xi^0 \rightarrow \Sigma^0 \gamma$ ”
Phys Rev Letters 86, 3239 (2001)
(4 citations in Spires)
- “First Observation of the Decay $K_L \rightarrow \pi^0 e^+ e^- \gamma$ ”
Phys Rev Letters 87, 021801 (2001)
(1 citation in Spires)
- “Measurement of the Branching Ratio of $K_L \rightarrow e^+ e^- \gamma \gamma$ ”
Phys Rev D64, 012003 (2001)
(5 citations in Spires)



E799 Published Results

- “Measurements of the Rare Decay

$$K_L \rightarrow e^+e^-e^+e^-$$

Phys Rev Letters 86, 5425 (2001)

(9 citations in Spires)

- “Measurement of the Branching Ratio and

$$\text{Form Factor of } K_L \rightarrow \mu^+\mu^-\gamma$$

Phys Rev Letters 87, 071801 (2001)

(8 citations in Spires)



E799 Published Results

- “Branching Ratio Measurement of the Decay $K_L \rightarrow e^+e^- \mu^+\mu^-$ ”
Phys Rev Letters 87, 111802 (2001)
(7 citations in Spires)
- “First Measurement of Form Factors of the Decay $\Xi^0 \rightarrow \Sigma^+ e^- \nu$ ”
Phys Rev Letters 87, 132001 (2001)
(2 citations in Spires)

E799 Published Results

- “Search for the $K_L \rightarrow \pi^0 \pi^0 e^+ e^-$ Decay in the KTeV Experiment”

Phys Rev Letters 89, 211801 (2002)

(1 citation in Spires)

- “Measurements of the Decay $K_L \rightarrow e^+ e^- \mu^+ \mu^-$ ” accepted by Phys Rev Letters for 2003 (first paper using 1999/2000 KTeV data)

18 papers published so far; 14 in PRL

E799 has many results dominating averages in the 2002 PDG tables.

E799 Doctoral Dissertations

- Kazunori Hangaki, Univ. of Osaka
 $K_L \rightarrow \pi^0 \nu \nu$, August 1998
- Masayoshi Sadamoto, Univ. of Osaka
 $K_L \rightarrow \pi^0 \mu^+ \mu^-$, February 1999
- Eric Zimmerman, Univ. of Chicago
 $\pi^0 \rightarrow e^+ e^-$, March 1999
- Ashkan Alavi-Harati, Univ. of Wisconsin
 $\Xi^0 \rightarrow \Sigma^+ e^- \nu$, April 1999



E799 Doctoral Dissertations

- Greg Graham, Univ. of Chicago
 $K_L \rightarrow \pi^0 e^+ e^- \gamma$, August 1999
- Katsumi Senyo, Univ. of Osaka
 $K_L \rightarrow \pi^+ \pi^- e^+ e^-$, December 1999
- Peter Mikelsons, Univ. of Colorado
 $K_L \rightarrow \pi^0 e^+ e^-$, December 1999
- Steve Bright, Univ. of Chicago
 $\Xi^0 \rightarrow \Sigma^+ e^- \nu$, March 2000



E799 Doctoral Dissertations

- Breese Quinn, Univ. of Chicago
 $K_L \rightarrow \mu^+ \mu^- \gamma$, June 2000
- Eva Halkiadakis, Rutgers Univ.
 $K_L \rightarrow e^+ e^- e^+ e^-$, May 2001
- Jason Hamm, Univ. of Arizona
 $K_L \rightarrow e^+ e^- \mu^+ \mu^-$, August 2002
- Angela Bellavance, Rice Univ.
 $K_L \rightarrow \pi^0 \mu e$, November 2002



E799 Doctoral Dissertations

- Nancy Lai, Univ. of Chicago
 $K_L \rightarrow \pi^0 e^+ e^-$, February 2003
- Jason LaDue, Univ. of Colorado
 $K_L \rightarrow e^+ e^- \gamma$, May 2003

14 PhD's produced
through Spring 2003



Plans for Remaining Work

- The number of people involved in E799 analysis is dwindling (especially since the demise of KAMI)
- However, a number of analyses of the data collected in 1999/2000 are making good progress.
- The first paper using 1999/2000 data has been accepted for publication.
- Four PhD theses using 1999/2000 data will have been defended by the end of May '03



Plans for Remaining Work

■ $K_L \rightarrow \pi^0 e^+ e^-$ Limit

- Thesis of Nancy Lai; paper to be submitted soon

■ $K_L \rightarrow \pi^0 \mu^+ \mu^-$ Limit

- Analysis in progress by Julie Whitmore at Fermilab; results for summer '03

■ $K_L \rightarrow e^+ e^- \gamma$ and $K_L \rightarrow e^+ e^- e^+ e^-$ Measurements

- Thesis of Jason LaDue; papers to be submitted by end of 2003



Plans for Remaining Work

■ $K_L \rightarrow \pi^+ \pi^- e^+ e^-$ BR and Form Factors

- Thesis of Sasha Golossanov, to be submitted for publication by end of '03

■ $\pi^0 \rightarrow e^+ e^- e^+ e^-$ Measurements

- Thesis of Patrick Toale, to be submitted for publication by summer '04

■ $\pi^0 \rightarrow e^+ e^- \gamma$ Form Factor

- Also the work of Patrick Toale; to be submitted for publication by the end of '04



Plans for Remaining Work

■ $K_L \rightarrow \pi^0 \mu e$ Limit

- Thesis of Angela Bellavance; to be submitted for publication by end of '03

■ $\pi^0 \rightarrow \mu e$ Limit

- Work by Marj Corcoran at Rice; to be submitted for publication by summer '04

■ $K_L \rightarrow eee\mu$ Limit

- Thesis of Katsushige Kotera at Osaka; to be completed by end of '04



Plans for Remaining Work

■ Search for $\Xi^0 \rightarrow \Lambda \pi^0 \gamma$

- Analysis underway at Univ. of Wisconsin

■ Measurement of $\Xi^0 \rightarrow \Lambda \gamma$

- Analysis underway at Univ. of Wisconsin

■ Search for $\Xi^0 \rightarrow \Sigma^+ \mu^- \nu$

- Analysis underway at Sao Paulo

These hyperon analyses to be completed
by the end of '04



Possible future analyses

- Additional analysis topics are available for students working on projects like CKM and BTeV whose time scales are long. For example:
 - $\pi^0 \rightarrow e^+e^- \gamma\gamma$
 - $\pi^0 \rightarrow e^+e^-$ with 1999/2000 data
 - $\pi^0 \rightarrow e^+e^- \gamma$ branching ratio



Resources Needed

- Access to tape archive at FNAL is required for ongoing analyses
- Code archives, databases, and records from the KTeV runs are maintained on DEC/Compaq/HP machines kpassa, ksera, klik, and klak.
- All FNAL and some non-FNAL collaborators use these (obsolescent) True64 unix machines for analysis work.



Availability of Data

- E799 data on tape can be made available to the public; but the code might be challenging to learn.
- Students working on other experiments (e.g. CKM, BTeV) might wish to write theses based on analysis of E799 data for some years to come.

