MTV-S1183
Beam Time Report

Test of Time Reversal Symmetry Using Polarized Unstable Nuclei

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Final Test Run for Physics production in 2014
Schedule: Beam Time 11/15-11/16

TRIUMF-ISAC Science Forum (20. Nov. 2013)
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  ✓ DAQ for MTV experiment

• RESULTS
  ✓ Rate Stability
  ✓ Systematic Study

• MTV-G experiment
INTRODUCTION
MTV : Mott Polarimetry for T-Violation experiment

R correlation 3 components
1. Pol. Nuclei. produced @ ISAC
2. Electron momentum

the sign changed under T transform

Evidence for New Physics beyond the Standard Model
Previous MTV Experiment

2008. 4 : Unpol. Test Exp.
2008. 9 : Physics Run : 10% precision

Main detector: planer MWDC
@KEK-TRIAC JAPAN

178keV/u @ 10^5 pps
8% polarization

R = -0.020 ± 0.41_{sta} ± 0.024_{sys}

2009. 11 : Run-I Test Exp. : 1% precision

2010.11 : Run-II Physics Run : 0.1% precision Exp.

Main detector: planer MWDC
@TRIUMF CANADA

28keV @ 10^4-10^7 pps
80% polarization

Asym. ~ (0.2 ± 2.1) × 10^{-4} (preliminary)

2011. 11 : Run-III Unpol. CDC Commissioning

Goal : checking V-track event using a part of CDC.

2012. 11 : Run-IV Trigger Detector & DAQ full setup Test

Goal : Installing trigger detector and DAQ for CDC & obtaining V-track rate using full setup.

2013. 11: Run-V Final Demonstration Exp.

Main detector : Cylindrical Drift Chamber

High beam intensity & polarization required.
2013 Beam Time Run-V

Schedule: 11/15-11/16 (original) → 11/16 – 11/17 (actual)

- Beam time actually started from 11/16(12:00) to 11/17(12:00). → 2 shifts.
- It’s because tuning of $^7$Li for MTV/βNMR/βNQR took long time due to Faraday Cup trouble.

Motivation

- Studying systematic effect for Physics Run using CDC scheduled in 2014.

Beam Menu

- Rate Stability using beam $10^7$pps
- Systematic Study
  ✓ taking unpolarized beam data as UP-DOWN-UNPOL sequence
  ✓ comparison high and low rate beam intensity.
- Relaxation time measurement
  ✓ Beam Stopper Upgrade

Beam : Pol. / Unpol. $^8$Li
Energy : 28keV
Intensity : $10^4$pps ~ $10^7$pps
DETECTOR SETUP & DAQ
Detector Setup

- Readout: 400ch
- gap: 4 mm
- Ar:CF4=160:80

Diagram:
- Beam Stopper
- Stopping Counter
- Scattered Electron
- Polarized Nucleus
- Trigger Counter
- Analyzer Foil

Cylindrical Drift Chamber
Detector Setup

- **Beam Stopper**
  - Thickness: 1 mm
  - Wrapped with aluminum-vaporized tape

- **Stopping Counter**
  - Thickness: 7 cm
  - Wrapped with aluminum tape
  - Stopping Beta ray

- **Cylindrical Drift Chamber**
  - Readout: 400ch
  - Gap: 4 mm
  - Ar:CF4=160:80

- **Trigger Counter**
  - Thickness: 1 mm
  - Wrapped with aluminum-vaporized tape
  - Triggering Event
New FPGA-based system is developed with General Purpose VME board.

**Trigger part**
- Lv.1 trigger (Plastic Scintillation Counter) OR logic circuit of 12 Trigger Counters.
- Lv.2 trigger (CDC + Counters) Counter circuit for hit wires for setting lower limit to the count number of hit wires.

**DAQ part**
- Hit pattern is recorded.  
  $\Rightarrow$ No TDC information
- Fixed data size in each event

**Coincidence Register**
- Speeding Up!

**Run-V Logic diagram**

**Master-Slave System using 3 FPGA Board**
Lv.1 (Scintillation Counter)

- Small hit number events dominate

Histogram of CDC's Hit Wire Number

Entries 1875841
Mean 2.365

Lv.2 (Counter + CDC)
**Result — Rate Stability —**

**Lv.1 (Scintillation Counter)**

- **CDC’s Hit Wire Number**
  - Count
  - Hit Wire Number Distribution
  - **Hist_sum**
    - Entries: 1875841
    - Mean: 2.365

Small hit number events dominate

**Lv.2 (Counter + CDC)**

- **CDC’s Hit Wire Number**
  - Count
  - Hit Wire Number Distribution
  - **Hist_sum**
    - Entries: 42671
    - Mean: 18.83

Suppressed small hit number event.
Result — Rate Stability —

4.4 M pps @ purity ≤16 %

Beam Intensity [pps]

V-track rate [Hz]

eye scan

Tracking
Result — Rate Stability —

4.4 M pps
@purity $\leq 16\%$

Beam Intensity [pps]

V-track rate [Hz]

- eye scan
- Tracking

$V_{track rate}$ [Hz] vs. $Beam Intensity$ [pps]
Result — Rate Stability —

1 shift was used for tuning setup. Another 1 shift was used for Physics run.

<table>
<thead>
<tr>
<th>Run</th>
<th>Obtained event #</th>
</tr>
</thead>
<tbody>
<tr>
<td>High intensity</td>
<td>70 M events</td>
</tr>
<tr>
<td>Low intensity</td>
<td>6.3 M events</td>
</tr>
<tr>
<td>Unpol. run</td>
<td>3.9 M events</td>
</tr>
</tbody>
</table>

V-track event rate: Max. 100Hz (purity:16%)  

We achieved to collect enough number of events for systematic study.
**Result — Systematic Study —**

**UP-DOWN-UNPOL sequence**

Unpol. data is required from Run-II analysis. It’s found that the left-right efficiency of the detector doesn’t conserve during spin-flip and that we can correct the systematic effect using Unpol. data.
whether the fluctuation become systematic effect should be checked.
Beam Time Result — Relaxation time —

- previous beam stopper was designed for planer MWDC.
- There are Al frame and magnet at the emission angle of electron.

new beam stopper

- Plastic
- magnet
- Al target

- planer MWDC

CDC

Stopper

e^-

CDC
Beam Time Result — Relaxation time —

- Previous beam stopper: ~ 2.0 sec.
- New beam stopper: ~ 4.0 sec.

Improved
MTV-G EXP.
MTV-G exp. is the test of Inverse square law by Newton at Nuclear scale and search for Large-extra dimension model (called ADD model).

We will search short-range gravitational field around atomic nucleus using MTV detector, and test the tilting from Longitudinal polarization of electron spin by analyzing power of Mott scattering.

By using the electron which have Transverse polarization, it could be checked the principle and the set up of MTV exp.

If a strong gravitational field around Nuclei exist, an electron spin is getting more changed the direct by Geodetic precession than without the effect (only Thomas precession and Coulomb scattering).
With change the incidence angle of Sr source to the scattering lead ball, we take the spin change angle by angle.

almost of the device material are Plastic to reduce brems.
w/ scatt. Rate : 100~200Hz
w/o scatt. Rate : 40~50Hz

Final data taking is going on now @ OSAKA beamline!!!!
Summary

✓ The MTV experiment is aiming to search non-zero T-violation in nuclear beta decay by measuring electron transverse polarization.
✓ The electron transverse polarization is measured as left-right scattering asymmetry in Mott scattering.
✓ Final test experiment for physic run was performed on 11/16 – 11/17
✓ We check the rate stability of CDC setup using $10^7$ pps
✓ We developed new beam stopper and measured relaxation time.

Future Plan

✓ Offline tracking analysis
✓ Systematic Study
✓ First physics run using CDC will performed in 2014.
THAT’S ALL
THANK YOU FOR LISTENING