Plan for Accelerator Beam Study
Towards J-PARC Muon Project

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for KEK Muon Working Group
at NuFACT08 July 2nd, 2008
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Introduction

- Muon projects at J-PARC
  - There are two beam lines for 50 GeV proton synchrotron.
  - No muon project for particle physics was not built in both beam line.
  - Now three project is being proposed at J-PARC.

- Muon trio
  - muon g-2
  - muon EDM
  - mu-e conversion
g-2

- Plan to Improve BNL E821 experiment by factor of 5~10
- Experimental site may move from BNL to
  - FNAL, J-PARC
- Beam requirement
  - More frequent injection
  - high repetition rate to reduce pile up
COMET/PRISM

**COMET**

- Plan Capture Section
  - A section to capture protons with a large solid angle under a high-solenoid magnetic field by superconducting magnet.

- Plan-Beam and Muon-Transport Section
  - A section to collect muons from decay of protons under a superconducting magnetic field.

- PRIME
  - A detector to search for muon-electron conversion processes.

- **B(μ⁻ + Al → e⁻ + Al) < 10⁻¹⁶**
  - No Phase rotator
  - With slow-extracted pulsed beam
  - J-PARC NP hall
  - First phase
  - Early realization

**PRISM**

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- **B(μ⁻ + Al → e⁻ + Al) < 10⁻¹⁸**
  - Phase rotator
  - With fast-extracted pulsed beam
  - New beam line and hall
  - 2nd phase
  - Ultimate search
LOI, Proposal, CDR ...

- Letter of Intent
  - Three LOIs were submitted.
  - g-2: L17, edm:L22, PRISM/PRIME:L24,L25

- Proposal
  - COMET group has submitted the proposal.
    - It was already reviewed by committee and ten questions came up.
  - g-2 group are preparing for next year submission

- Conceptual design report
  - is prepared in next year.

**Q10 from J-PARC PAC**
- The beam requirements for COMET running are non-standard. The collaboration need to work with the Laboratory to assess the feasibility and impact of running the J-PARC facility for the COMET experiment.
J-PARC standard bunch structure
Requirement for beam

- for g-2/PRISM
  - fast extracted beam with 50~90 bunch
  - extracted every 1 ms

- for comet
  - slow extracted beam with $E=\sim 8$ GeV
  - bunch spacing $\sim 1.1$ us $\Rightarrow$ 4 out of 9 buckets are filled.
  - Extinction (unwanted remained beam between main pulses)
    - $< 10^{-9}$
How to increase # of bunches for g-2/PRISM

- **Longitudinal only**
  - Harmonics number $h=9 \rightarrow h=50\sim90$
  - debunch $\rightarrow$ capture $\rightarrow$ rebunch
  - *fast kicker necessary to kick*

- **Longitudinal & Transverse**
  - Harmonics number $h=9 \rightarrow h=18$
  - Split beam into beamlet transversely by using resonance crossing & nonlinear optics
  - Total $16\times5 = 80$ bunch
CERN Study

M. Giovannozzi and PS multi turn extraction (MTE) project group

- Multi turn extraction (MTE)
  - Splitting by tranverse phase space
  - No loss by mechanical septum.

- Experimental test was successfully carried out at CERN
  - two sextupole and one octupole
Study for J-PARC
Tawada, Sakumi, Saito et al.

Budget is being requested for the test experiment at J-PARC
Why Extinction is necessary for COMET?

- Main Proton Pulse 10 p/pulse
- Prompt Background
- Stopped Muon Decay
- Timing Window
- Signal

100 ns
1.1 μs

1.1 μs
Goal for Extinction study?

- Extinction Goal $\sim 10^{-9}$
  - How to measure by overcoming huge dynamic range?
    - Integrated by time to reduce detector rate
      - good S/N in measurement is essential
    - Avoid prompt pulse
      - Fast switching device (gated PMT, light shutter, kicker magnet)
  - How to improve?
    - While circulating in the ring
      - Clean up all remaining particle except for main pulses.
      - Coherent betatron motion (BNL study)
    - After extraction (One pass)
      - Kick out unwanted particles between pulse
Measurement using slow-extracted beam

- Realistic measurement similar to real exp.
  - including effect of extraction, beam manipulation
  - No clue to source of extinction
- K1.8 BR beamline (2ndary beam)
  - Max momentum 1.2 GeV/c
  - DC separator is available
  - Using TOF setup for E14 exp.
- Measurement
  - PID to reject late arriving particles
  - 50 K pion/pulse
  - One day data taking
Measurement using fast extracted beam

By changing order of injecting pulse, i.e. (B) Empty bucket before main pulse or (B’) empty bucket after main pulse, we can measure the particle number contained in empty RCS bucket.
Experimental setup

- Kicker
- MR beam
- Abort Dump
- scintillator hodoscope
- read thru fiber waveguide
## Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Accelerator status</th>
<th>Test Experiment</th>
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</thead>
<tbody>
<tr>
<td>Jul 2008 ~Nov 2008</td>
<td>Shutdown for installation</td>
<td>Installation detector into abort area</td>
</tr>
<tr>
<td>Dec 2008 ~Jan 2009</td>
<td>Acceleration test</td>
<td>Measurement at Abort dump</td>
</tr>
<tr>
<td>Feb 2009 ~Mar 2009</td>
<td>Slow extraction</td>
<td>Measurement at NH hall</td>
</tr>
</tbody>
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R&D for improvement of Extinction

- **BNL study for MECO**
  Internal extinction w/ AC dipole and kicker

  - AGS Internal Extinction
    - Stripline AC dipole at 80 kHz excites coherent vertical betatron resonance
    - Fast (100 ns) kickers cancel AC dipole at the bunches
    - Kicker duty factor is low 100 ns / 2.7µs = 4%

  - Concept tested in FY98 using existing AC dipole and kickers

- **FNAL design study for US-JAPAN**
  Gap cleaning after extraction
  Conceptual design of AC dipole was done.
Summary

- We have started R&D work on accelerator beam for the future muon projects.
- Test experiment will be performed in the end of this year.
- Collaboration work for accelerator R&D has started.
  - BNL: Multi turn extraction, Extinction study
  - FNAL: Extinction study
  - CERN: Multi turn extraction