Search for μ-e Conversion With DeeMe Experiment at J-PARC MLF

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μ-e Conversion?

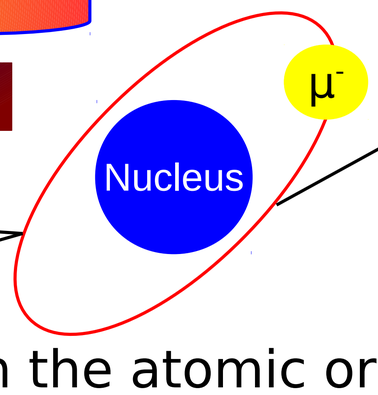
In Standard Model of particle physics

Muon capture:

$\mu^- + (A, Z) \rightarrow \nu_\mu + (A, Z\text{-}1)$

Muon Decay in Orbit (DIO)

$\mu^- \rightarrow e^- \nu\bar{\nu}$



μ trapped in the atomic orbit
→ Muonic Atom (1s)

Beyond the Standard Model

μ-e Conversion

$\mu^- + (A, Z) \rightarrow e^- + (A, Z)$

- One of charged-Lepton Flavor Violation
- SUSY-GUT, SUSY-seesaw: BR($\mu \rightarrow e$) ≤ 10^{-14}
- Powerful probe to search for new physics
- Mono energy, not mix with background as $\mu^\pm \rightarrow e^\pm \gamma$ & $\mu^\pm \rightarrow e^\pm e^+ e^-$

μ-e conversion has not been discovered yet

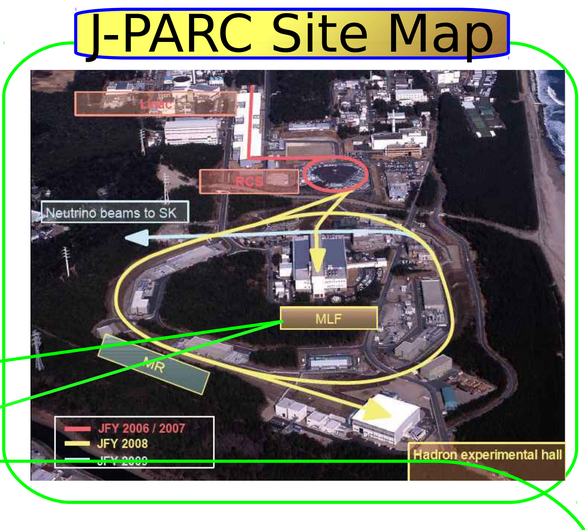
Current upper limits

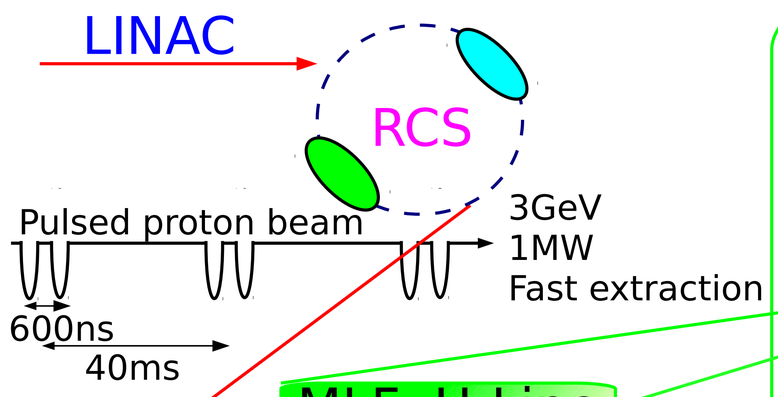
$BR(\mu^- + Au \rightarrow e^- + Au) < 7 \times 10^{-13}$ at SINDRUM II

$BR(\mu^- + Ti \rightarrow e^- + Ti) < 4.3 \times 10^{-12}$ at TRIUMF

=> Need new experiments

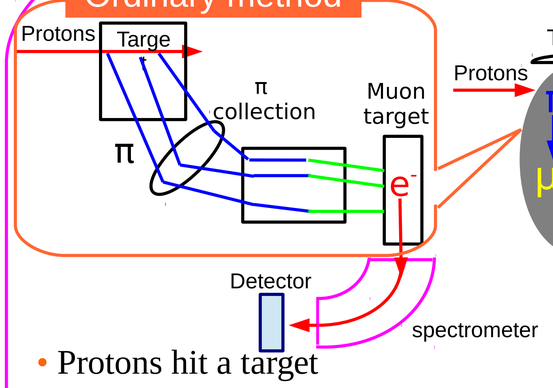
J-PARC Site Map





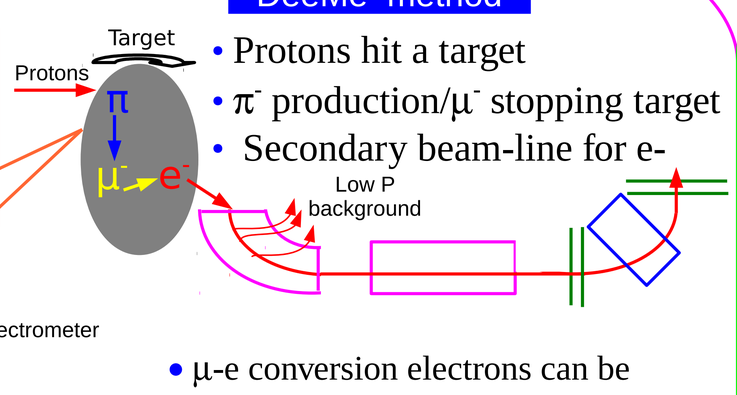
DeeMe – A new-method experiment

Ordinary method



- Protons hit a target
- Pions are produced
- Beam-line for π - μ transport
- Muons stop in muon target
- Muons are trapped in the atomic orbit and forms muonic atoms
- Muon to electron conversion may occur in a muonic atom
- Beam-line for electrons transfer

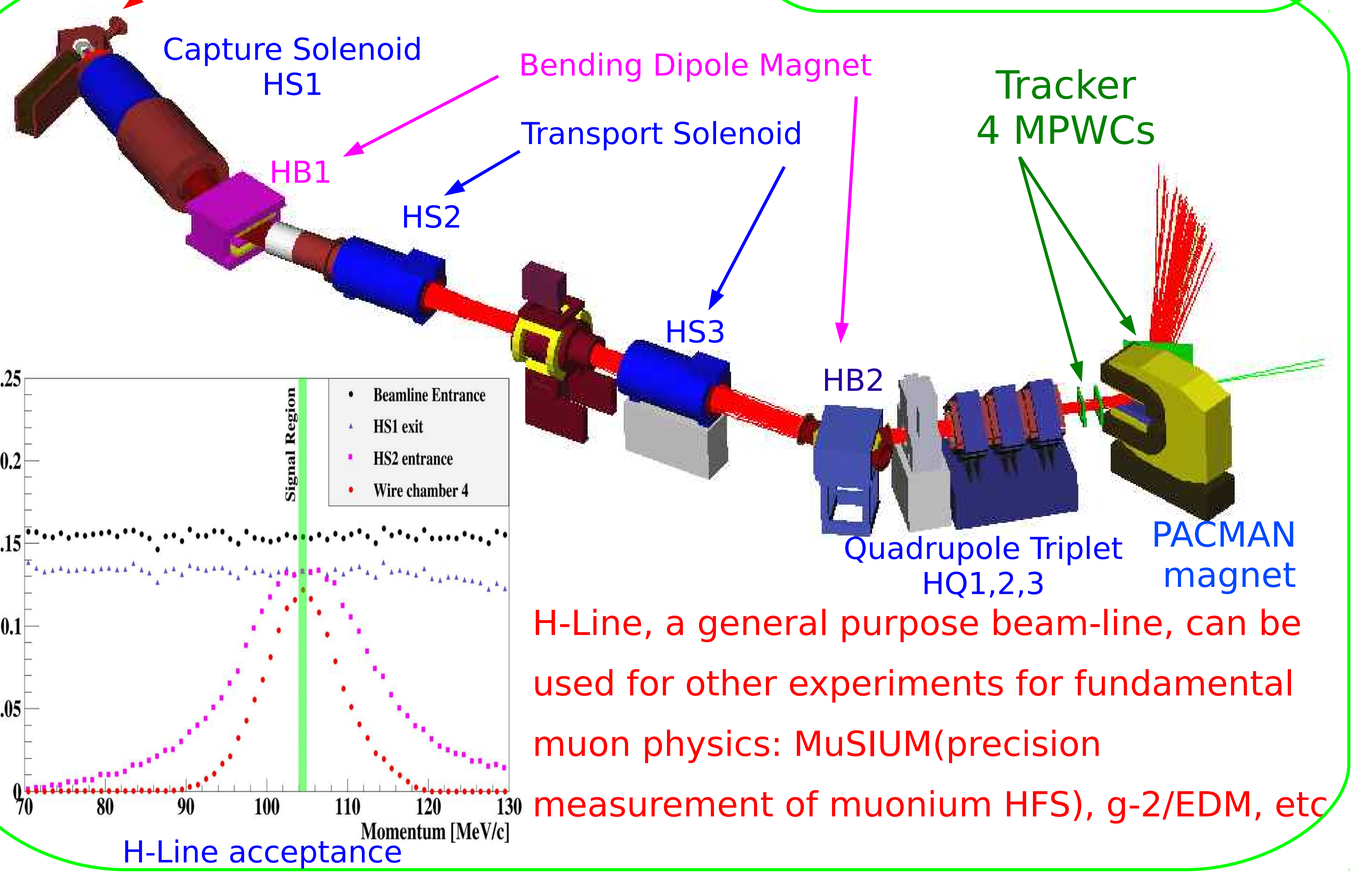
DeeMe method



- Protons hit a target
- π⁻ production/μ⁻ stopping target
- Secondary beam-line for e-

- μ-e conversion electrons can be obtained directly from a muon production target => reduce a lot of cost and time for experiment
- Low momentum background are reduced by momentum selection in the secondary beam line → Neither Michel electrons nor protons hit detectors: very small detector rate

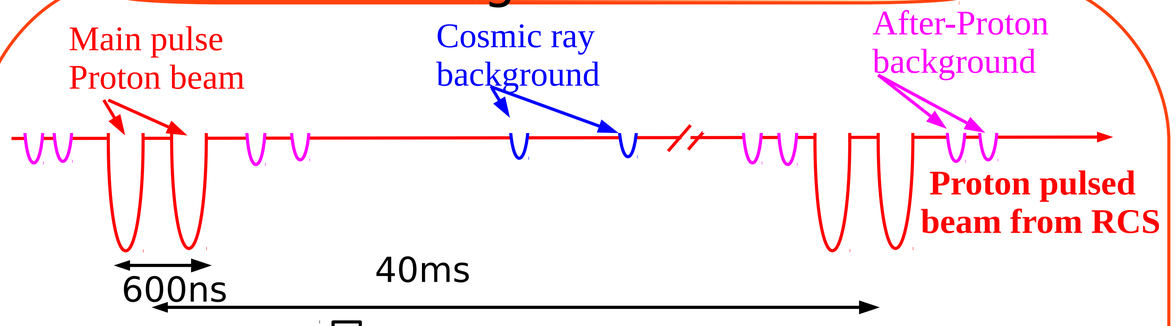
MLF, H-Line



H-Line acceptance

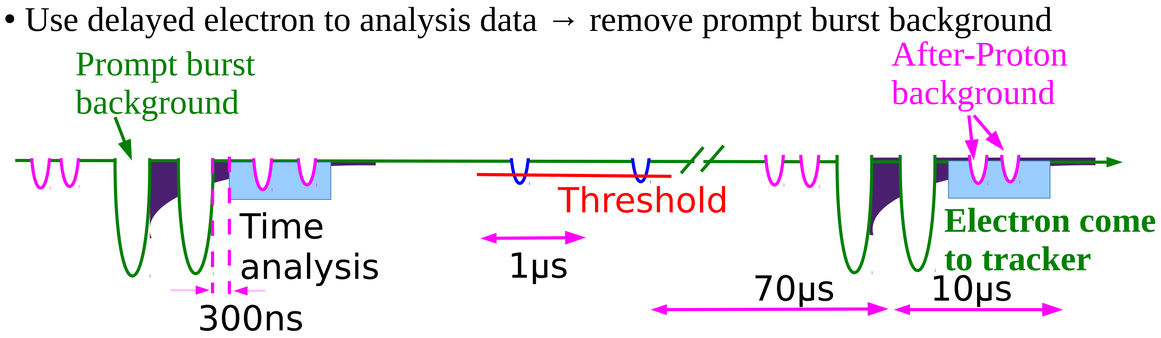
H-Line, a general purpose beam-line, can be used for other experiments for fundamental muon physics: MuSIUM(precision measurement of muonium HFS), g-2/EDM, etc

Control background in DeeMe



After muon is captured by nucleus τ(μ-,Si) = 0.76μs, electron is emitted and transfer through H-Line

- Use delayed electron to analysis data → remove prompt burst background

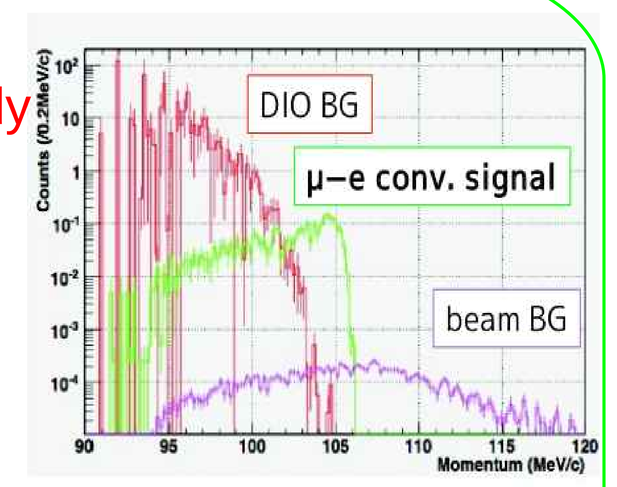


- Use real data to estimate after-proton background
  - Record detector signal before main pulse 70μs and 10μs after proton hit target
  - Signal before beam extraction and after-proton background have same mechanism – they come from beam halo
  - Measure signal before beam extraction and compare with beam lost monitor data in RCS → estimate after-proton background more exactly
- Small duty factor of detector live time ~1/20000
  - reduce effect come from cosmic rays background
  - longer time region to experimentally-monitor the cosmic rays background by using self trigger

Sensitivity and Background

Single Event Sensitivity estimated by Monte Carlo study

2×10^{-14} for SiC target
1×10^{-13} for C target
(Running time 2×10^7s)



Background estimation

- DIO: 0.09
  - Ee < 102 MeV, Prob(Ec>102.5MeV) < 10^{-14}
  - Tracker's momentum resolution: ΔP < 1MeV/c (FWHM) → DIO distinguish with μ - e coversion signal
- After-proton rate $R_{AP} < 10^{-18}$ → After-proton background < 0.027 (0.05 90% C.L.) (see Nagao's poster)
- Cosmic rays induced e < 0.018, μ < 0.001, → will be suppressed by duty factor

Summary

- μ - e conversion is a powerful tool to search for new physics
- DeeMe experiment will search for μ - e conversion at sensitivity 10^{-14}
- Development of tracker system has completed (see Teshima's poster)
- The graphite target has already installed
- Upstream-half of H-Line has constructed. The construction of downstream half will come in a year.
- Data taking in 2016