Kaon Decay Experiments at J-PARC

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What Nobel Prizes in Physics in 2008 and 2013 tell us ?



- 2008 : Nambu, Kobayashi, and Maskawa
 - CP-violation was established.



- The size is not enough to explain matter dominant universe.
- New CP-violating particle is expected in higher energy scale.



- 2013 : Englert and Higgs
 - Higgs was discovered but it is far from closing the book.
 - New physics in high energy scale is expected to stabilize Higgs mass.
 - SUSY, little Higgs, Compositeness, Extra Dimension, ...?
 - Dark matter?

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Particle Physics

- How do we search for new physics in high energy scale?
- Two approaches
 - High energy frontier \rightarrow direct production of heavy particle
 - High intensity frontier \rightarrow indirect access

with momentous high-energy phenomena $\ \Delta E imes \Delta t \sim \hbar$

 \rightarrow Rare process.

- Further suppression in SM (GIM,Helicity, CKM, some conservation...)
- Theoretically accurate process
- CP- or T-violation is another guide.

explanation of matter dominant universe

High intensity frontier

• Accelerator plays a critical role

- LHC,SPS,super KEKB, J-PARC,...

- High power ↔ Statistics of rare process
- Slow extraction \Leftrightarrow Event pile-up due to high rate





Fixed Target Experiment

- High intensity proton beam+ Primary target
 - High intensity secondary products
- Beam line \rightarrow key component for each experiment
 - Transport particles of interest
 - Reduce unwanted particles
 - Long life time is required.





Uniqueness of Kaon

- Light mass (0.5 GeV)
- Long life time (15m)
- Strangeness
 - → Flavor Changing Neutral Current in the decay
- $s \rightarrow d$ transition
 - Flavor changing neutral current (GIM)
 - Strong CKM suppression
- $s \rightarrow u$ transition
 - Lepton flavor universality can be checked.
 - Helicity suppression
- CP-violation / T-violation



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$s \rightarrow d$ transition

- Flavor Changing Neutral Current
 - GIM suppression of u and c quarks
 - Hierarchical structure of CKM for t quarks





- K sector is most sensitive to New Physics with different flavor structure
- Large NP effect is possible event with SM-like Bs mixing and Bs $\rightarrow \mu\mu$ 2014/7/13

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(λ=0.23)

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Hadron Experimental Hall

- Two beam lines and three experiment programs
 - KL : neutral beam line
 - charged particle sweeping out + collimators
 - K1.1BR: K+ beam line
 - Enrich K^+ (rejecting pi⁺) tuned for 0.8GeV/c for stopped K^+ experiment



E14 KOTO

E36 and E06 TREK

Will be presented by G.Y. Lim 7/15

E14 KOTO : CP-violating Rare FCNC

 Z^0

 $W(\widetilde{\chi})$

 $t(\widetilde{\mathbf{u}})$

- $K_L \rightarrow \pi^0 \nu \nu$ search
 - $Br(SM) \sim 2.4 \times 10^{-11}$
 - CP-violating process
 - Small theoretical uncertainty(2%)
 - Sensitive to CP-violating new physics.
- 1st physics run in 2013 (~100 hours)
 - Analysis is on going \rightarrow will announce the result soon.



"Two γ from π^0 and nothing else" \longrightarrow CsI calorimeter and Hermetic veto FB NCC MB CV C04 CC05 CC06 BHCV BHPV







Will be presented by S. Shimizu 7/15

E36: Lepton Flavor Universality

• Stage-2 approval and requesting beam in 2015

$$R_K^{SM} = \frac{\Gamma(K^+ \to e^+ \nu_e)}{\Gamma(K^+ \to \mu^+ \nu_\mu)} = 2.477(1) \times 10^{-5}$$
0.04% uncertainty

Suppressed and precise SM value → New Physics contribution



Stopped K+ in the active target Charged particle tracking with radiative process veto Separation of e/µ with TOF, Aerogel Cerenkov, Lead glass.





Other motivations Heavy sterile neutrino search Dark light search

E06 TREK : T-violation

- Transverse μ polarization
 - T-odd product
 - \rightarrow sensitive to CP-violating new physics
 - SM contribution is less than 10-7.
 - Effect of final state interaction is less than 10-5.
 - New physics can contribute.
- Goal : 10-4 (270kW beam x 1.4 107 sec)
- Plan to do E36 (LFU) at first with the same spectrometer when accelerator power is not enough. (Stage-1 approval)



 $K^+ \to \pi^0 \mu^+ \nu$



Summary

• Kaon is a good tool to explore

new physics beyond the SM.

- Three programs in the hadron hall
 - E14 KOTO
 - E36(Lepton Flavor Universality $) \rightarrow E06 TREK$
- Expect rich physics outputs in near future with kaon decay experiments at J-PARC.

More will be presented in the presentations tomorrow and posters.