Rare Processes & Precision measurements. Group RF2 : Weak decays of strange & light quarks – Rare kaon decays

20220121 2nd BNL Snowmass Retreat

D. Jaffe

Letter of Intent	Title
SNOWMASS21-RF2_RF0-010.pdf	Rare decays at the CERN high-intensity kaon beam facility
SNOWMASS21-RF2_RF0-012.pdf	Rare Kaon Decays
SNOWMASS21-RF2_RF0-EF5_EF0-TF5_TF0-CompF2_CompF0_El-Khadra-094.pdf	Precise Lattice QCD calculations of kaon and pion
SNOWMASS21-RF2_RF0-TF5_TF0-CompF2_CompF0_Antonin_Portelli-055.pdf	Rare strange-to-down processes from lattice QCD
SNOWMASS21-RF2_RF0_Worcester-092.pdf	US Participation in Current & Future Rare Kaon Decay Experiments
SNOWMASS21-RF2_RF0_Y.W.Wah-065.pdf	Measurement of KL → π0νν at J-PARC KOTO Step-2
SNOWMASS21-RF2_RF1-058.pdf	Novel EFT connections between K and B physics

Rare kaon decays $K \longrightarrow \pi\nu\nu$

- FCNC loop process of s $\longrightarrow$ d coupling, CKM-suppressed
- Theoretically clean with hadronic ME from K_{l3} decays
- Sensitive to mass scales >> LHC
- LFU sensitivity $K \longrightarrow \pi\nu_\tau\nu_\tau$
- SM predictions (Buras *et al.*, JHEP 11(2015)033)

$$BR(K^+ \to \pi^+ \nu\overline{\nu}) = (0.84 \pm 0.03) \times 10^{-10} \left(\frac{|V_{cb}|}{0.0407}\right)^{2.8} \left(\frac{\gamma}{73.2^\circ}\right)^{0.74} = (0.84 \pm 0.10) \times 10^{-10}$$

$$BR(K_L \to \pi^0 \nu\overline{\nu}) = (0.34 \pm 0.05) \times 10^{-10} \left(\frac{|V_{ub}|}{0.00388}\right)^{2} \left(\frac{|V_{cb}|}{0.0407}\right)^{2} \left(\frac{\sin\gamma}{\sin 73.2^\circ}\right)^{2} = (0.34 \pm 0.06) \times 10^{-10}$$

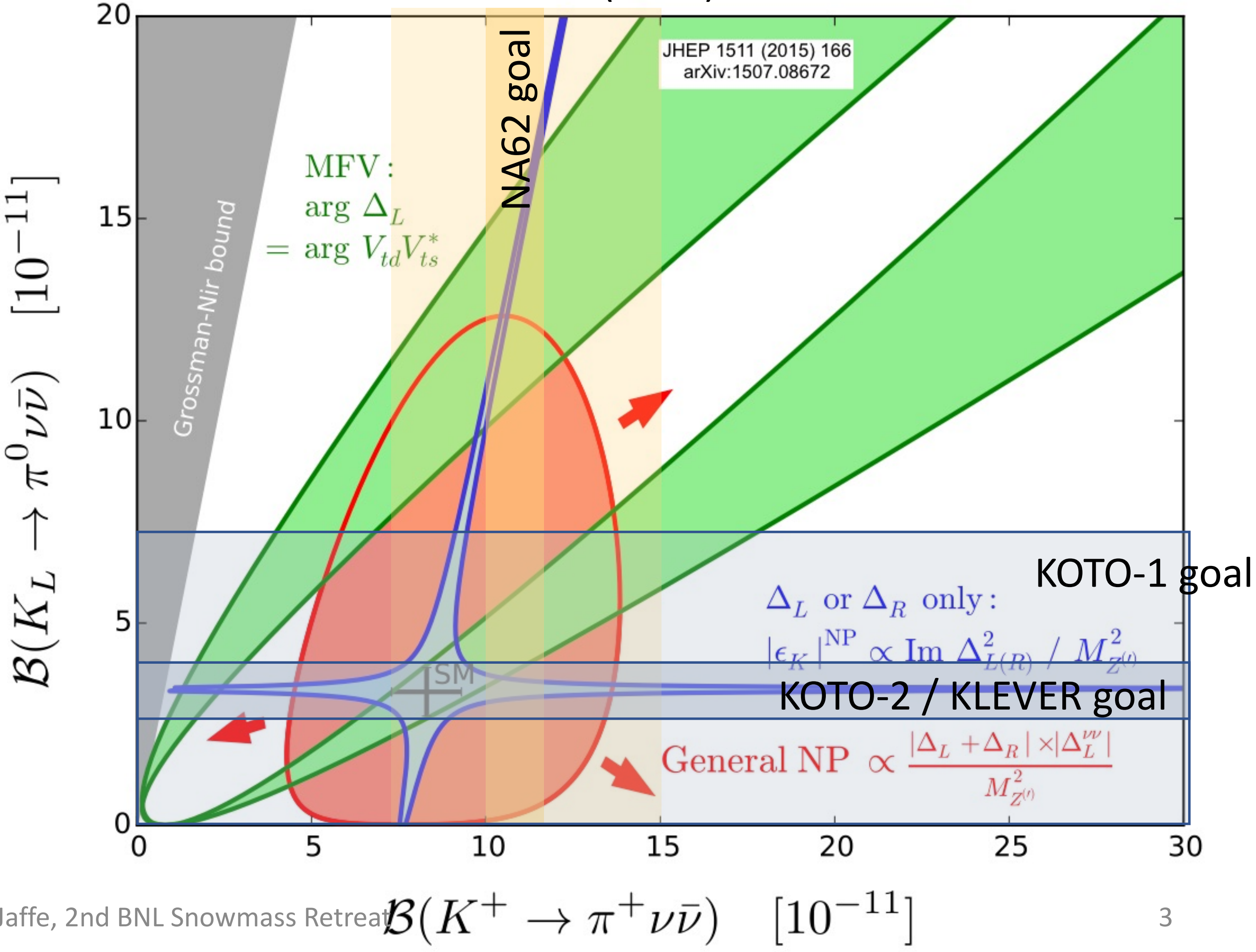
Current status

- CERN NA62 :
  - 2016-8 data with 20 cand/7 bkgd

$$\mathrm{BR}(K^+ \to \pi^+ \nu\bar{\nu}) = (10.6^{+4.0}_{-3.4}|_{\mathrm{stat}} \pm 0.9_{\mathrm{syst}}) \times 10^{-11}$$

  - goal is 10% measurement
- J-PARC KOTO-1 :
  - 2016-8 data with 3 cand/1.2 bkgd
    BR(K_L) < 490 x 10^{-11} at 90%CL
  - goal SM sensitivity with S/B=1
- Both experiments intend to reach goals in approx. 2025

NA62:JHEP06(2021)093



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Future possibilities

- CERN KLEVER :
  - Evolve NA62 to accept higher intensity charged and neutral kaon beams
  - Goal BR(K+) : 5%
  - Goal BR(K_L) : 20%
  - Searches for K_L LFV, exotic decays
  - Measure BR($K_L \rightarrow \pi^0 l^+ l^-$)
- J-PARC KOTO-2 :
  - New beam K_L beam line, longer target, smaller prod. angle, longer decay region, large calorimeter
  - Goal BR(K_L) : 20% with O(35) events

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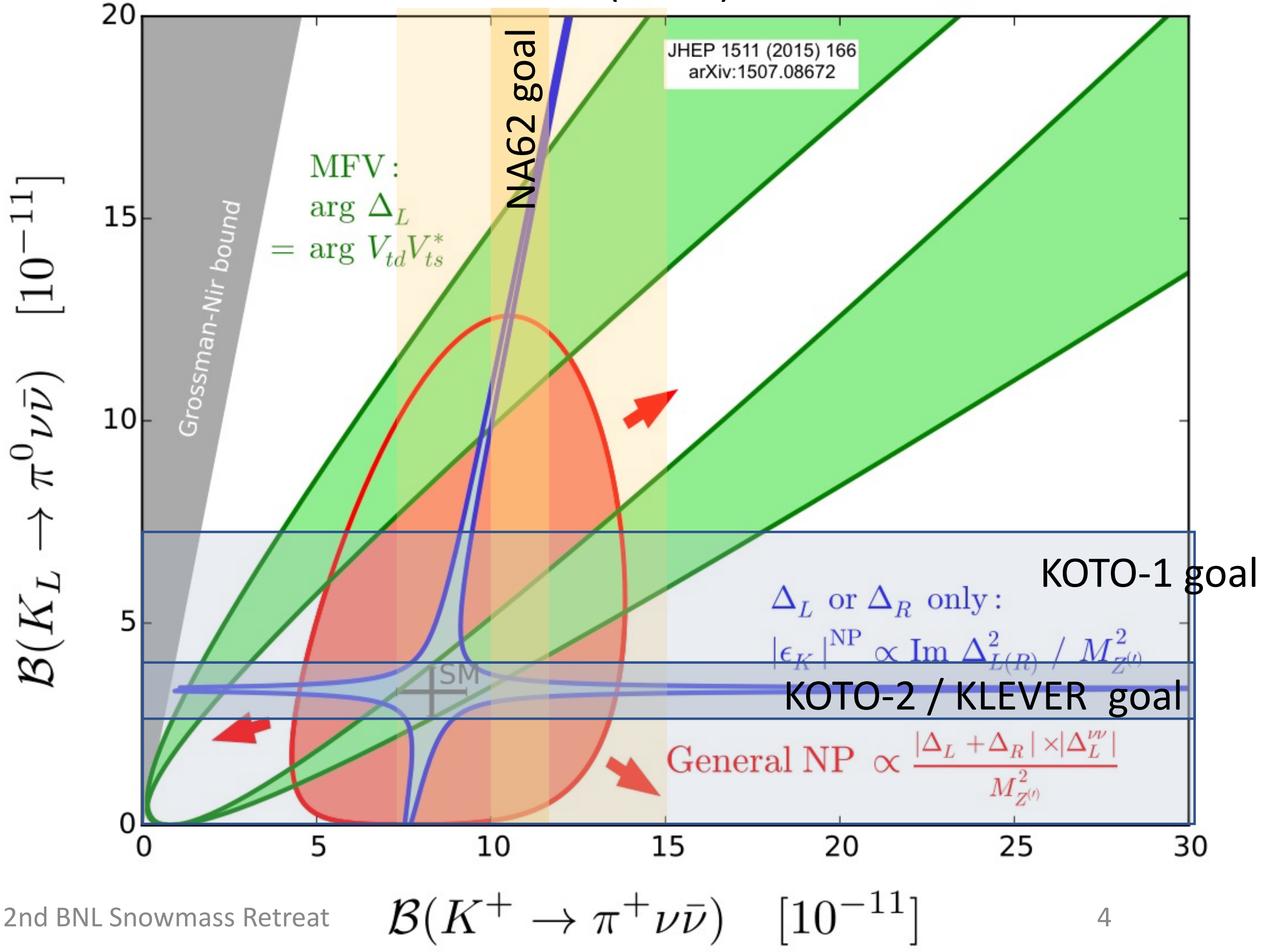

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- US participation
  - US physicists have “contributed to NA62” and “played significant roles in KOTO”.
  - BNL physicists are collaborating with KOTO on potential contributions to computing, simulation, analysis under the US-Japan Cooperation program.
  - A US-based, KOPIO-like, K_L experiment with ~1000 SM event sensitivity could be accommodated by an upgraded FNAL accelerator complex
  - How can the US make contributions to rare kaon physics?