

Concluding Remarks

H. Nanjo

Kaons@J-PARC 2024 July 29, 2024

Conclusion

- Strategy
 - Message from CERN DG
 - Fabiola Gianotti (CERN DG): “The kaon physics case remains excellent and I do hope that the experimental study of kaons remains a worldwide goal”
- Physics
 - Kaon plays Important / indispensable roles
 - New physics contributions and correlation to other flavors
 - Evaluation of LD effect with lattice ↔ Extraction of NP contribution
- Experiments
 - On-going experiments : NA62, LHCb, and KOTO
 - KOTO II
 - $K_L \rightarrow \pi^0 \nu \bar{\nu}$: Understanding of basic strategies and points to be improved
 - $K_L \rightarrow \pi^0 l l$: First quantitative evaluation with KOTO-II setup
 - Detector options
 - Preparation to the proposal

Andreas's conclusion

The kaon physics case is just too strong not to be pursued by at least one experiment which will be in the spotlight, therefore I think it's important that

- KOTO-II must be realised
- Kaon physics must feature in the upcoming European-Strategy update

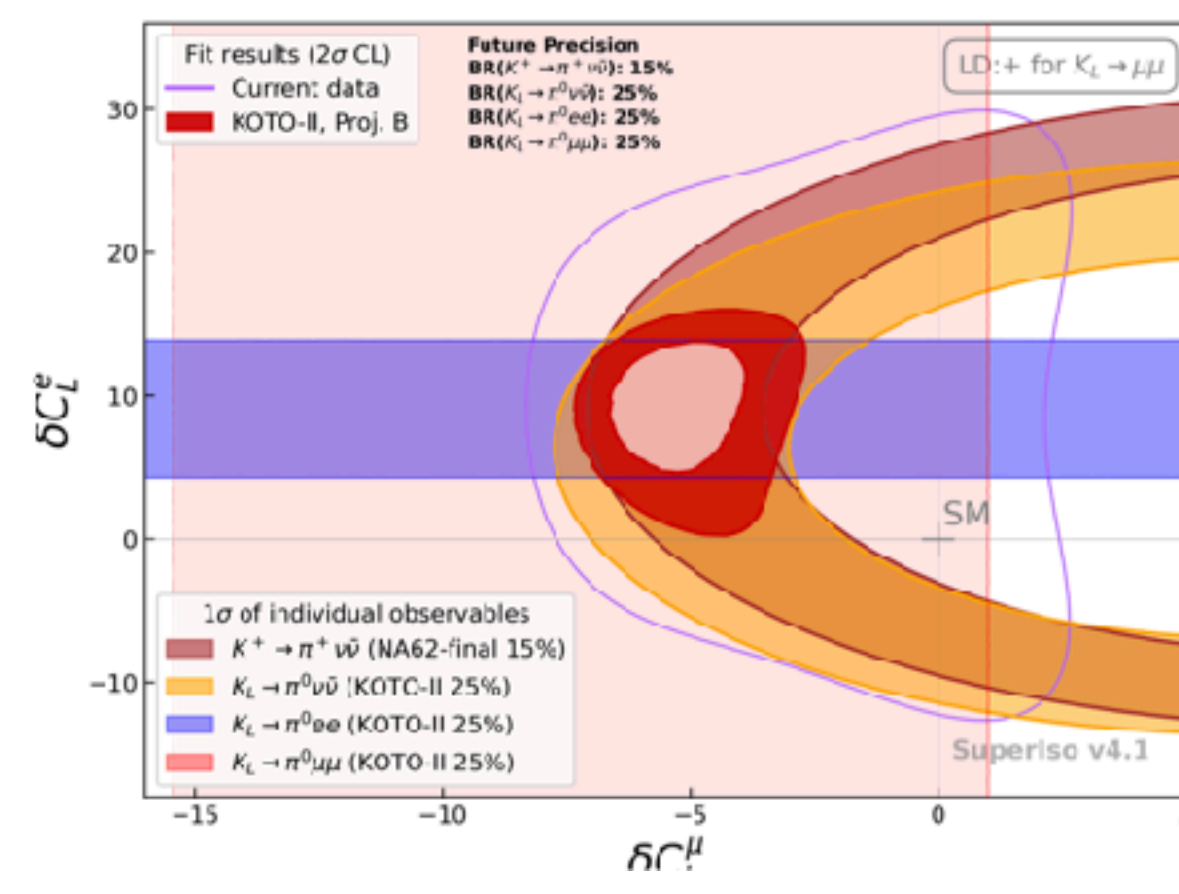
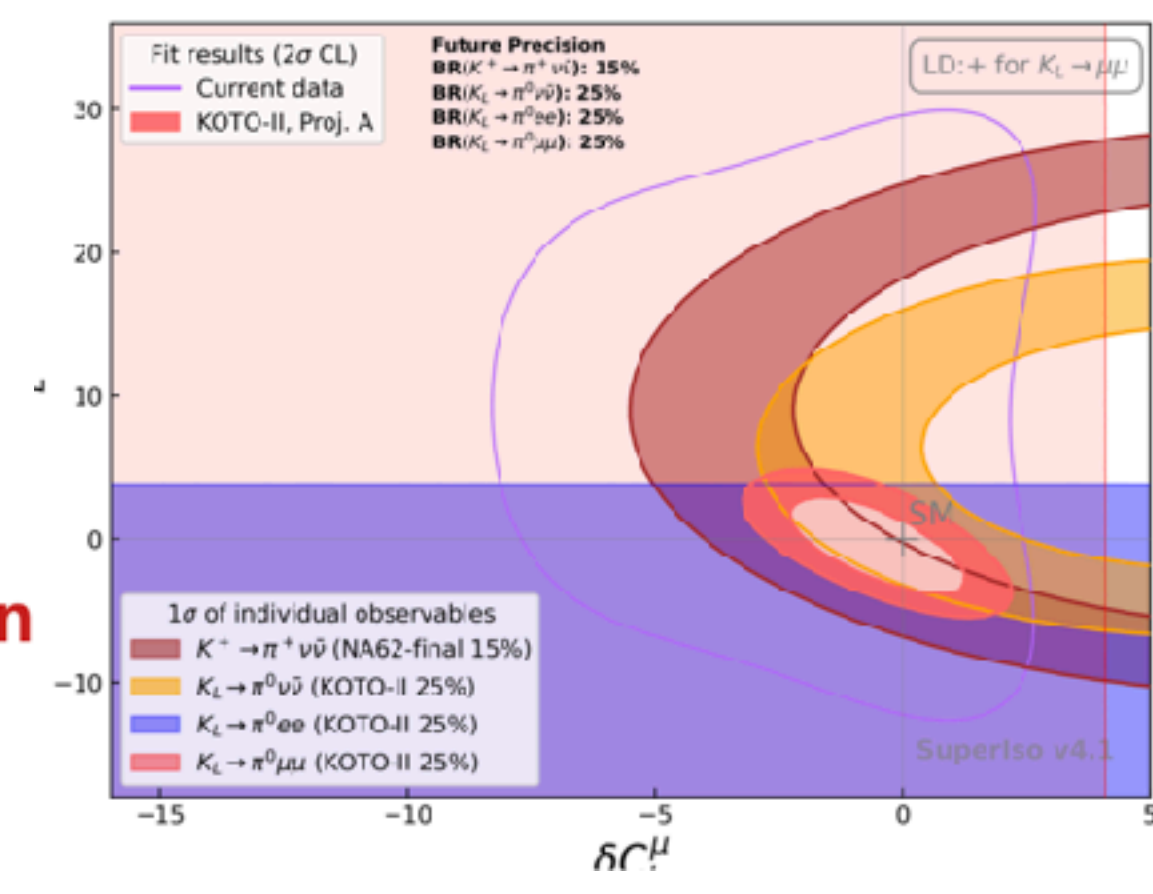
- Rare kaon decays offer valuable insights into short-distance physics
 - ⇒ providing indirect portal to new physics

- $K \rightarrow \pi \nu \nu$ decays are predicted in the SM with very high precision
 - ⇒ An experimental measurement of $K_L \rightarrow \pi \nu \nu$ will be of utmost important
 - ⇒ Together with $K_L \rightarrow \pi^0 ee$ and $K_L \rightarrow \pi^0 \mu \mu$ provides a great potential for probing and distinguishing new physics scenarios
 - ⇒ will be further enhanced via advancements in theoretical precision using continuum, data-driven approaches and lattice calculations

Improvement in the theoretical and experimental determination of rare kaon decays offers promising avenue for uncovering signs of new physics

Conclusions

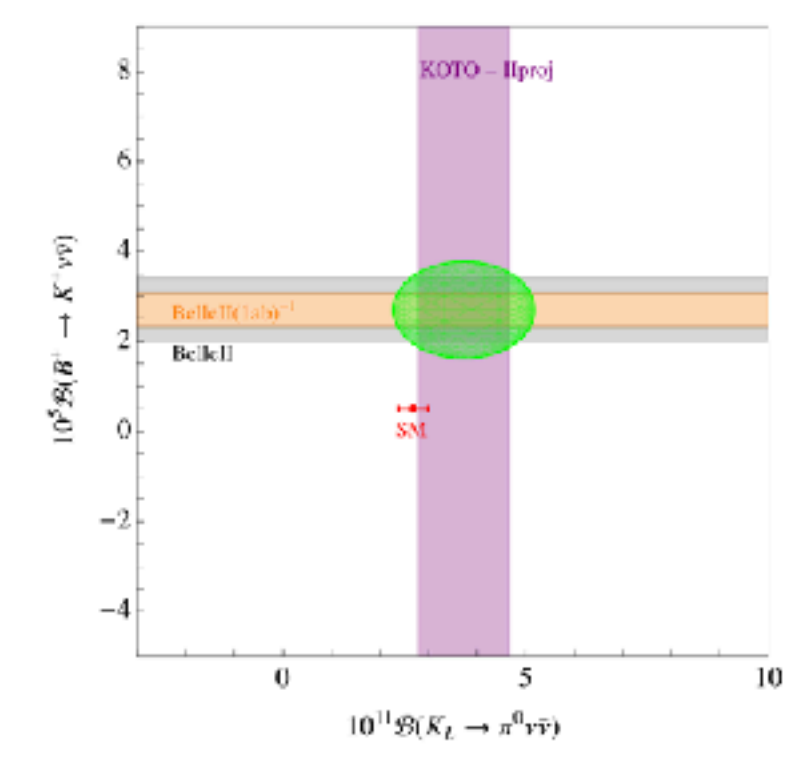
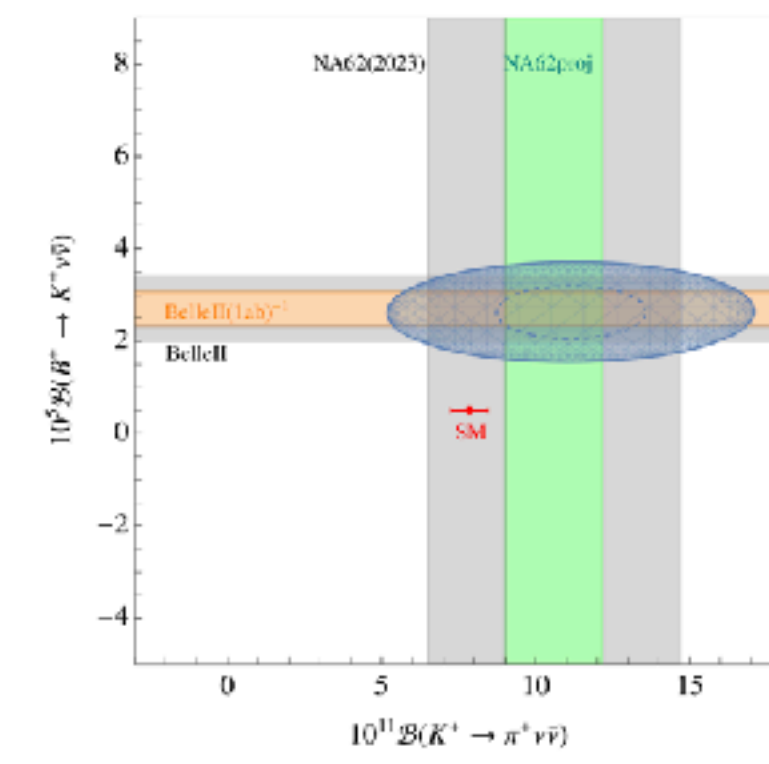
Nazila MAHMOUDI



Martzia Bordone

B vs. K decays – correlations

- Flavour physics has exciting prospects in the search for New Physics
- Understanding the origin of the Flavour Puzzle might hint at what structure new physics couplings have
- Correlations among different observables are crucial to studying the viability of classes of models
 - ⇒ Di-neutrino modes are one of the golden modes where to look for new physics signals
 - ⇒ The complementarity between measurements $B^+ \rightarrow K^+ \nu \bar{\nu}$, $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ and $K_L \rightarrow \pi^0 \nu \bar{\nu}$ are essential to ping down specific scenarios



plots by M. Bordone

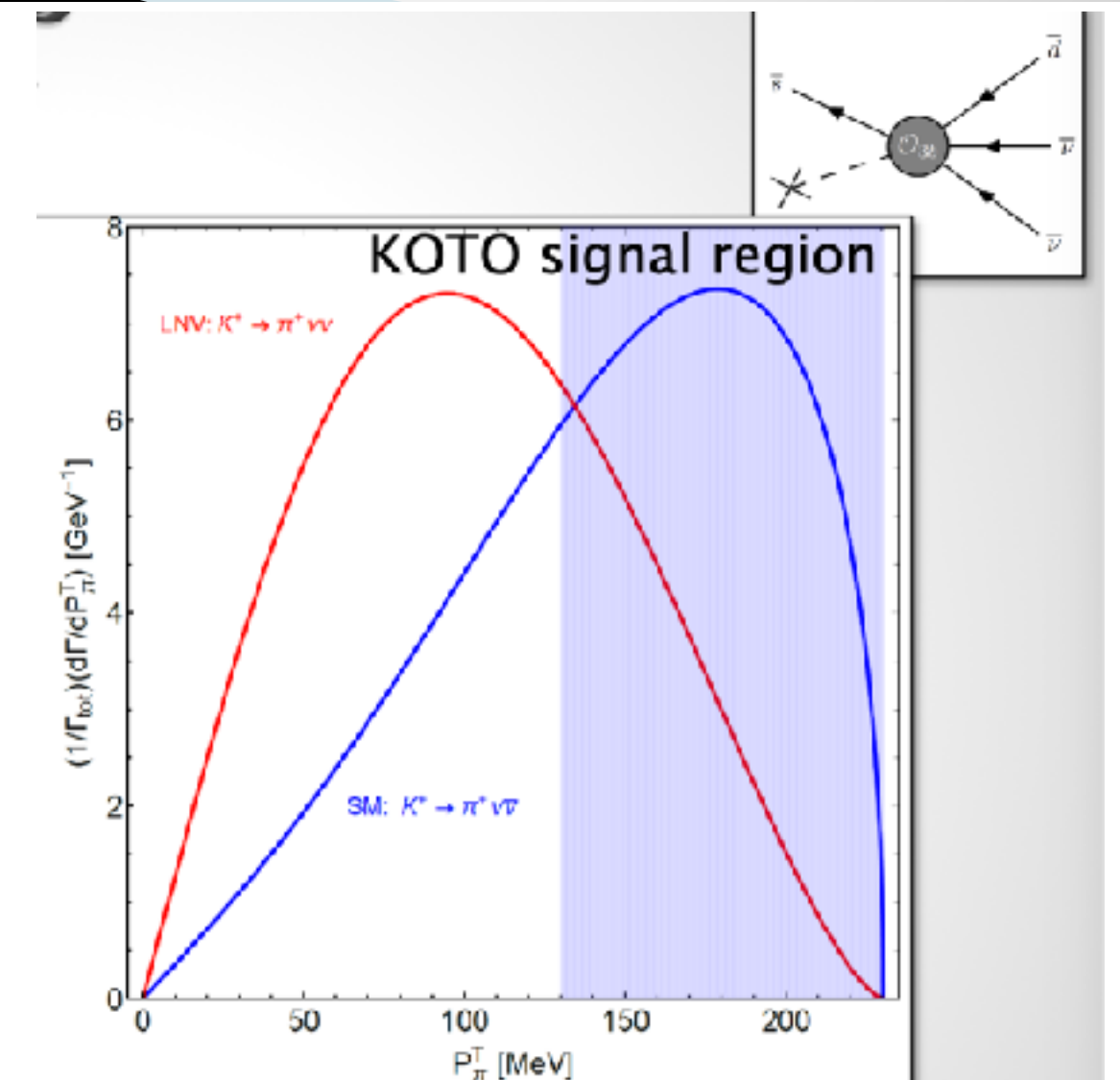
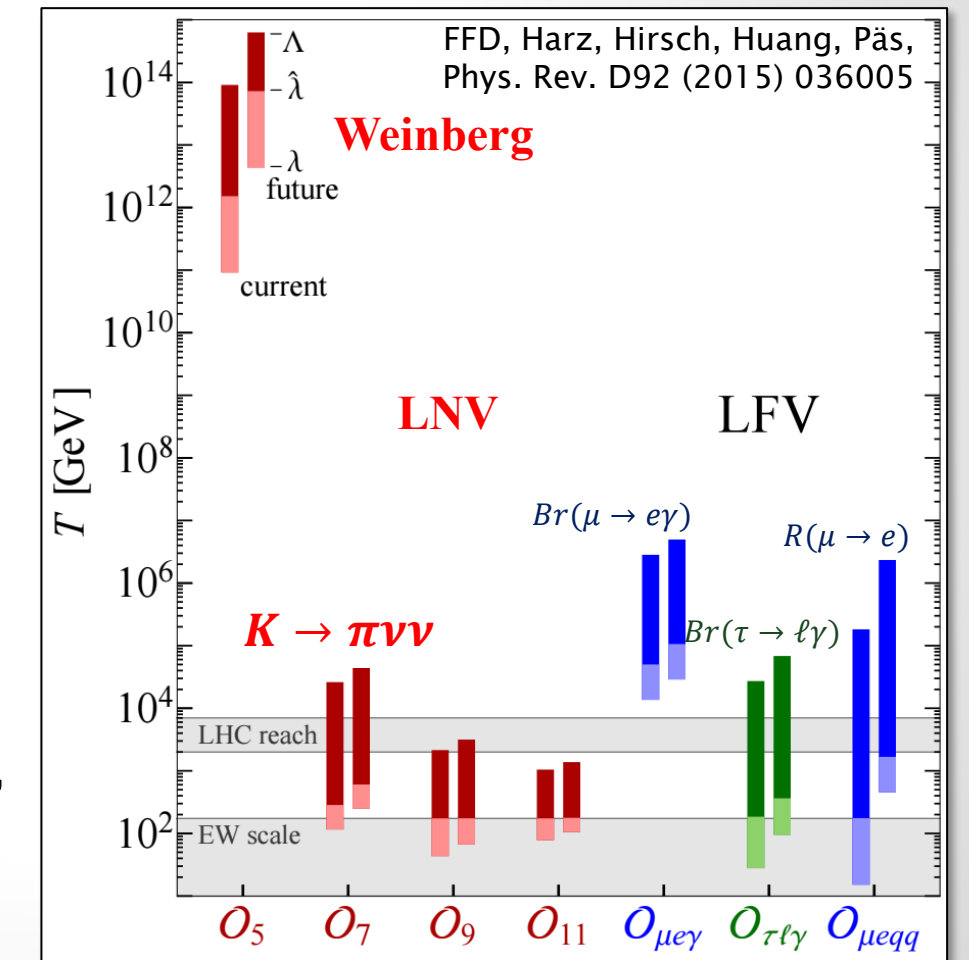
Conclusion

- ▶ **New Physics at short and long distances**
- ▶ **Lightness of neutrinos as motivation**
 - Breaking of lepton number at a high scale
 - Light, super-weakly-coupling HNLs
- ▶ **Kaons can probe both**
 - $K_L \rightarrow \pi\nu\nu$ theoretically clean
 - Probing lepton number violation at high scales
 - Impact on baryogenesis mechanism
 - $K^+ \rightarrow l^+N$ best sensitivity to tiny active-sterile mixing
 - Probing seesaw floor of neutrino mass generation
 - Agnostic to HNL nature and decay length

LVN Kaon Decays

FFD, Fridell, Harz, JHEP 12 (2020) 186

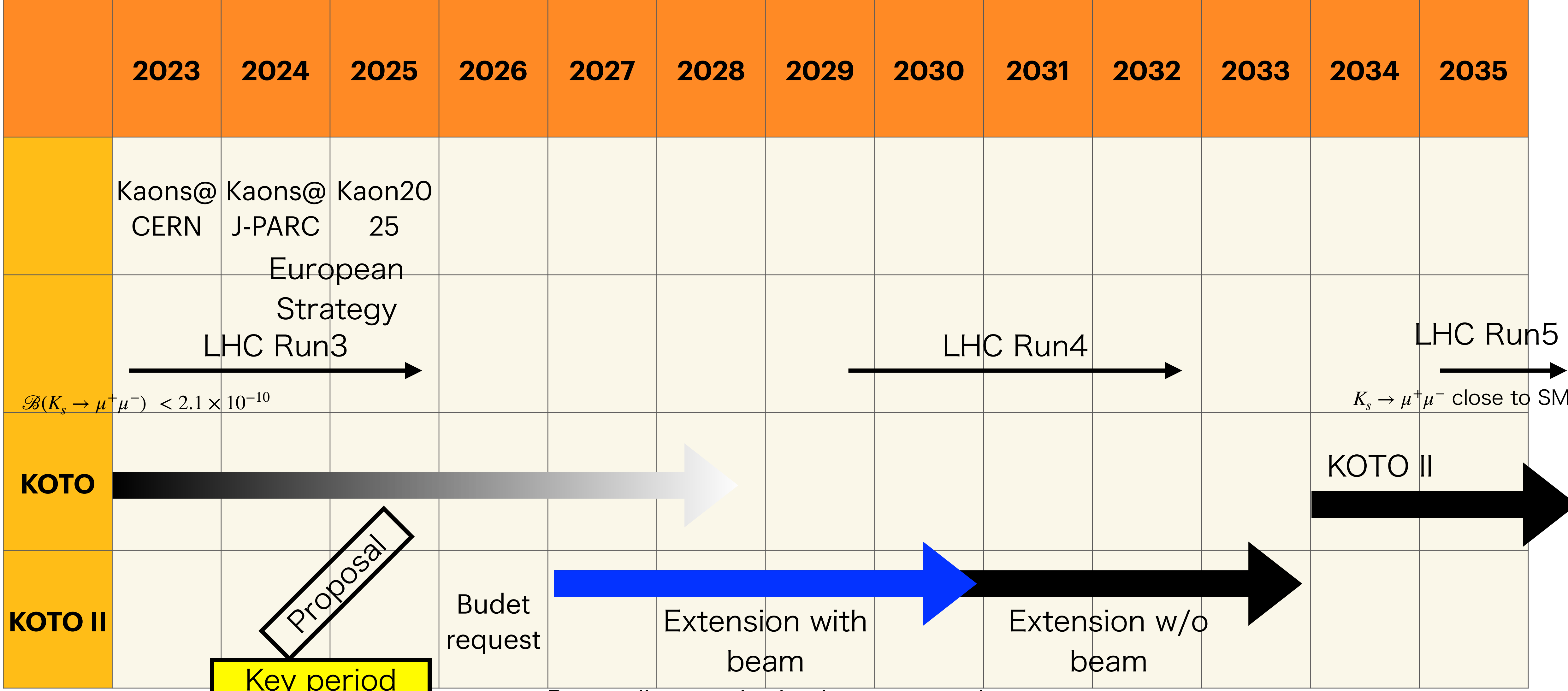
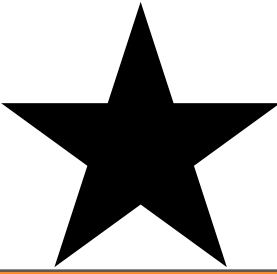
- ▶ **Impact on Baryogenesis Mechanisms**
- ▶ **Temperature ranges of strong equilibration**
 - Assumes observation of corresponding process!
- ▶ **Observation of LVN**
 - gives information at what temperatures operators are in equilibrium
 - **can falsify high-scale baryogenesis scenarios**
FFD, Harz, Hirsch, Phys.Rev.Lett. 112 (2014) 221601,
FFD, Harz, Hirsch, Huang, Päs, Phys.Rev.D 92 (2015) 3, 036005



Lattice comments

- $K_S \rightarrow \mu^+ \mu^-$
 - close to the SM prediction at LHCb.
 - At what point can one decide whether the current $\sim 30\%$ accuracy is enough?
- $K_L \rightarrow \pi^0 e^+ e^-$
 - to be realized at KOTO II.
 - The input for $K_{\{e 3\}}$ branching fractions, lifetimes, Wilson coefficients etc. should be updated, but all of this only makes sense once new information on the $K_S \rightarrow \pi^0 \gamma^*$ form factor becomes available (LHCb).
- $K_L \rightarrow \pi^0 \mu^+ \mu^-$
 - to be realized at KOTO II.
 - the two-photon contribution would need to be improved, a rather challenging project.
- $K_L \rightarrow l^+ l^-$, $K_L \rightarrow l^+ l^- \gamma$, $K_L \rightarrow \pi^+ \pi^- \gamma$, $K_L \rightarrow \pi^0 \gamma \gamma$, time-dependent $K \rightarrow \mu^+ \mu^-$ may be considered with phasing

Time line



Key period

Depending on the budget approval

Writeup

- Purpose
 - Focus to KL
 - For our understanding
 - Inputs to broad communities and Management
 - 1st step toward European Strategy and its reference
- Format
 - 1 page text summary per talk and discussion session
 - Impressive messages and plots
 - Overleaf will be prepared
- Deadline
 - 1st 12 August : Text/Memo for fresh memory
 - 2nd 31 August : Plots
 - A few weeks for editing

Try to cook up the strategy
toward further study

Special Thanks

- Participants: A lot of inputs including hot discussions
- Support by KEK IPNS
- Co-host : KEK Theory Center, J-PARC center, Hadron Hall User's Association
- J-PARC Users office and KEK PR division
- Pre-discussions among organizers and sharing the direction to speakers
- Discussion chairs for the preparation / leading discussions
- Preparation
 - Tadashi Nomura : Budget and KEK procedure
 - Koji Shiomi : Venue and Reception
 - Hiroaki Watanabe and Lim GeiYoub
 - Katsushige Kotera, Daiki Ogawa, Mei Homma
 - Mayumi Suehiro (Secretary of KEK J-PARC Hadron group)
 - Junko Maeda (Osaka Secretary)

**Continue Discussions and
Collaboration!
See you again at meetings and
Kaon2025**

R&D meetings
Proposal preparation
Input of European Strategy