

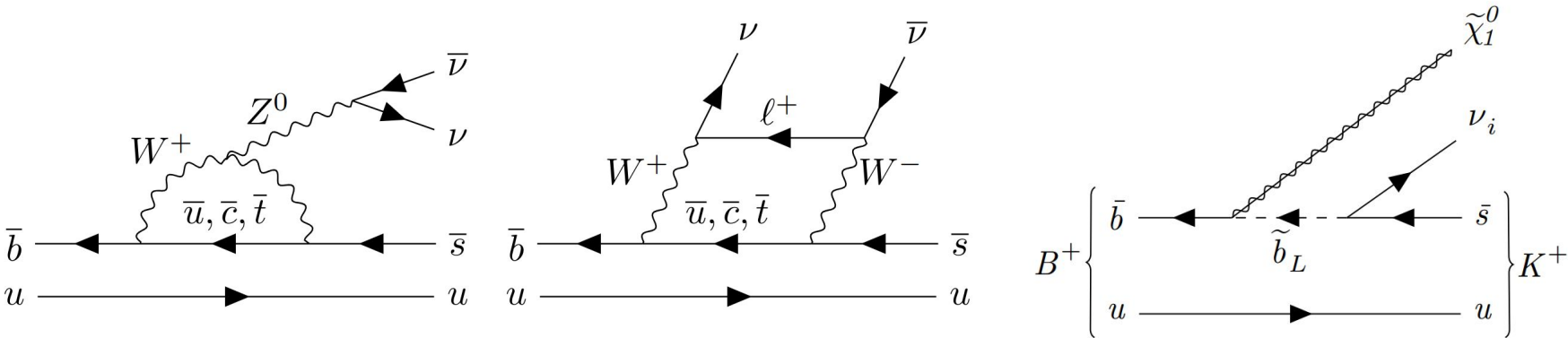
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# $s \rightarrow d \nu \nu$ transitions and KOTO II

19 June 2026, Sasha Glazov

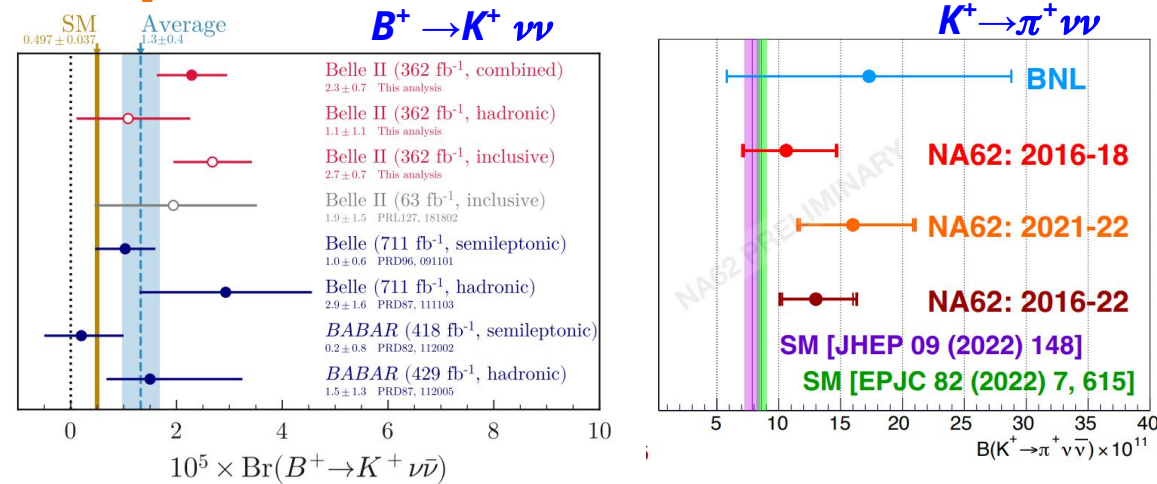
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# Flavour changing neutral currents and new physics

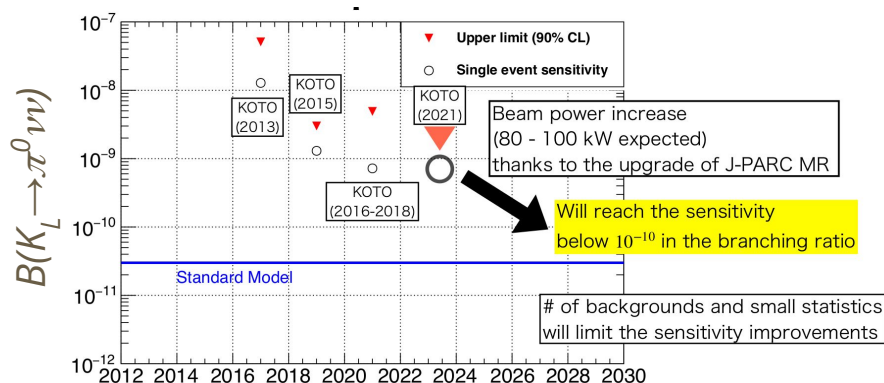


- Flavor-changing neutral currents  $q \rightarrow q' \nu \nu$  transitions in SM occur at loop level only
- Rare, theoretically clean processes, sensitive to **3rd generation** couplings
- $K_L \rightarrow \pi^0 \nu \nu$  is a rare clean **direct CP** violation probe of the height of the unitarity triangle.
- Many new physics extensions, including **dark matter**

# Experimental status

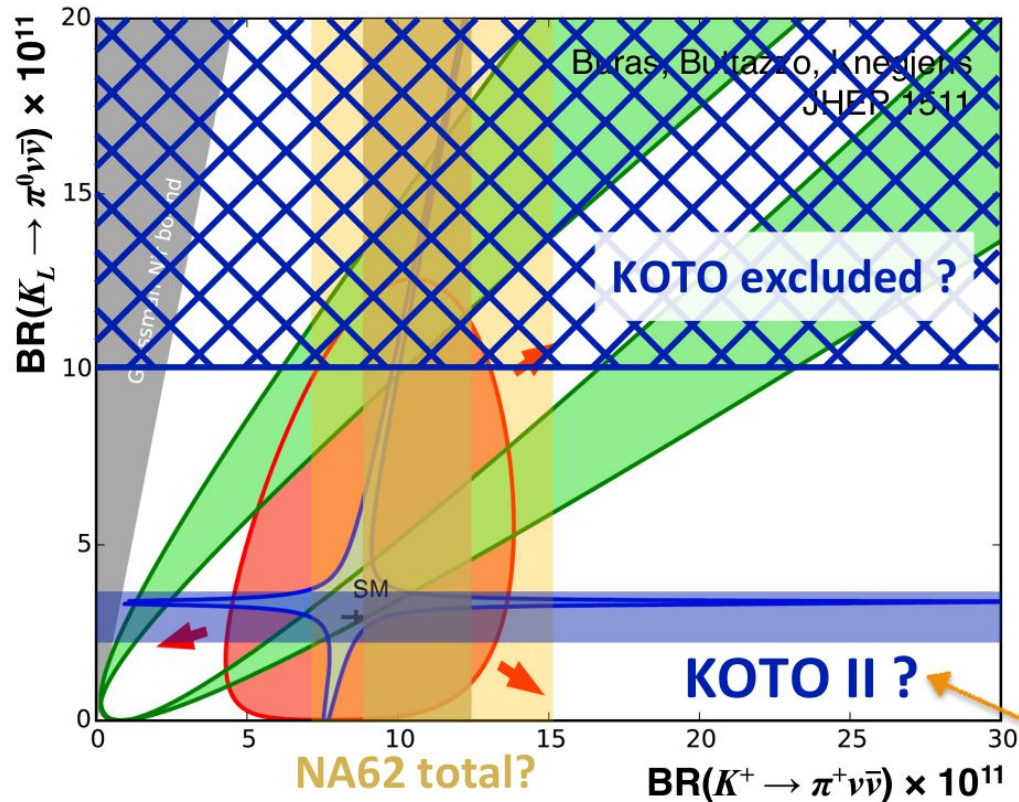


- Evidence for  $B^+ \rightarrow K^+ \nu \bar{\nu}$  by Belle II and observation of  $K^+ \rightarrow \pi^+ \nu \bar{\nu}$  by NA62
- Both measurements are somewhat above SM.
- KOTO will reach below  $10^{-10}$  sensitivity for  $K_L \rightarrow \pi^0 \nu \bar{\nu}$ , compared to SM expectation of  $3 \times 10^{-11}$



→ KOTO II proposal is to reach SM sensitivity.

# Status and plans for $K^+ \rightarrow \pi^+ \nu \nu$ and $K_L \rightarrow \pi^0 \nu \nu$



## Run 1: 2016-2018



- 20 events (7 estimated bkg events)
- $\mathcal{B}(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = (10.6^{+4.0}_{-3.4} \pm 0.9) \times 10^{-11}$

## All NA62: 2016-2025 (up to LS 3)

- Total error of  $\pm 1.8 \times 10^{-11}$

## 2021 Data



- No signal candidates
- $\mathcal{B}(K_L \rightarrow \pi^0 \nu \bar{\nu}) < 2 \times 10^{-9}$

## All KOTO: up to ~2028

- Br sensitivity  $\sim 1 \times 10^{-10}$

## Next successor

- Aiming  $\sim 35$  SM decays  $\rightarrow$  Observation

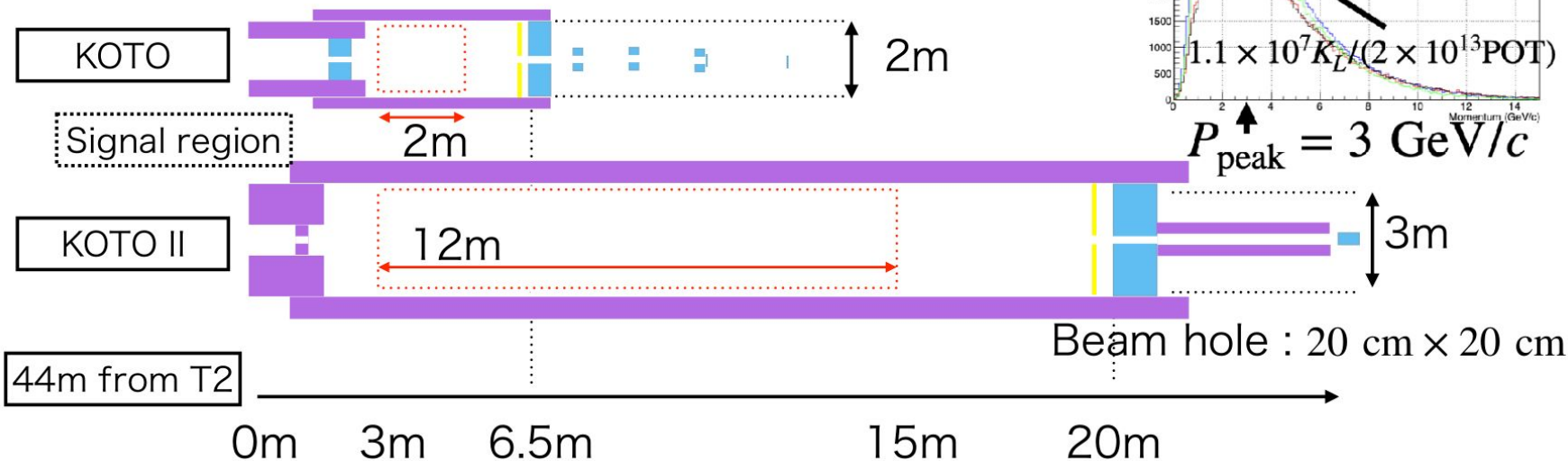
# KOTO-II detector

LOI: arXiv:2501.14827

Peak  $K_L$  momentum : 1.4 GeV/c (KOTO)  $\rightarrow$  3 GeV/c (KOTO II)

Longer decay volume (2 m  $\rightarrow$  12 m)

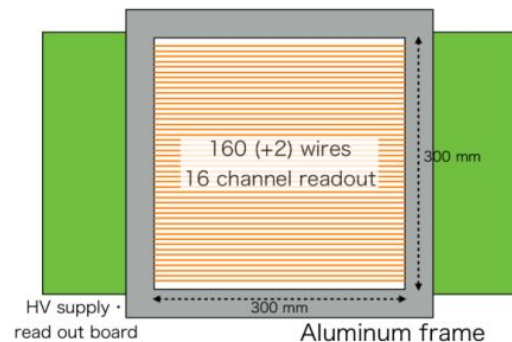
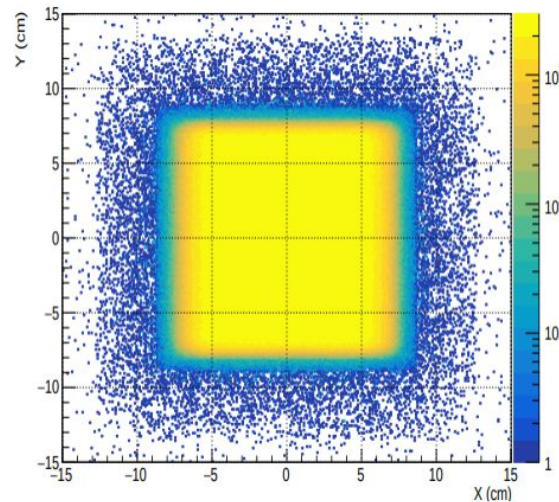
Larger diameter calorimeter (2 m  $\rightarrow$  3 m)



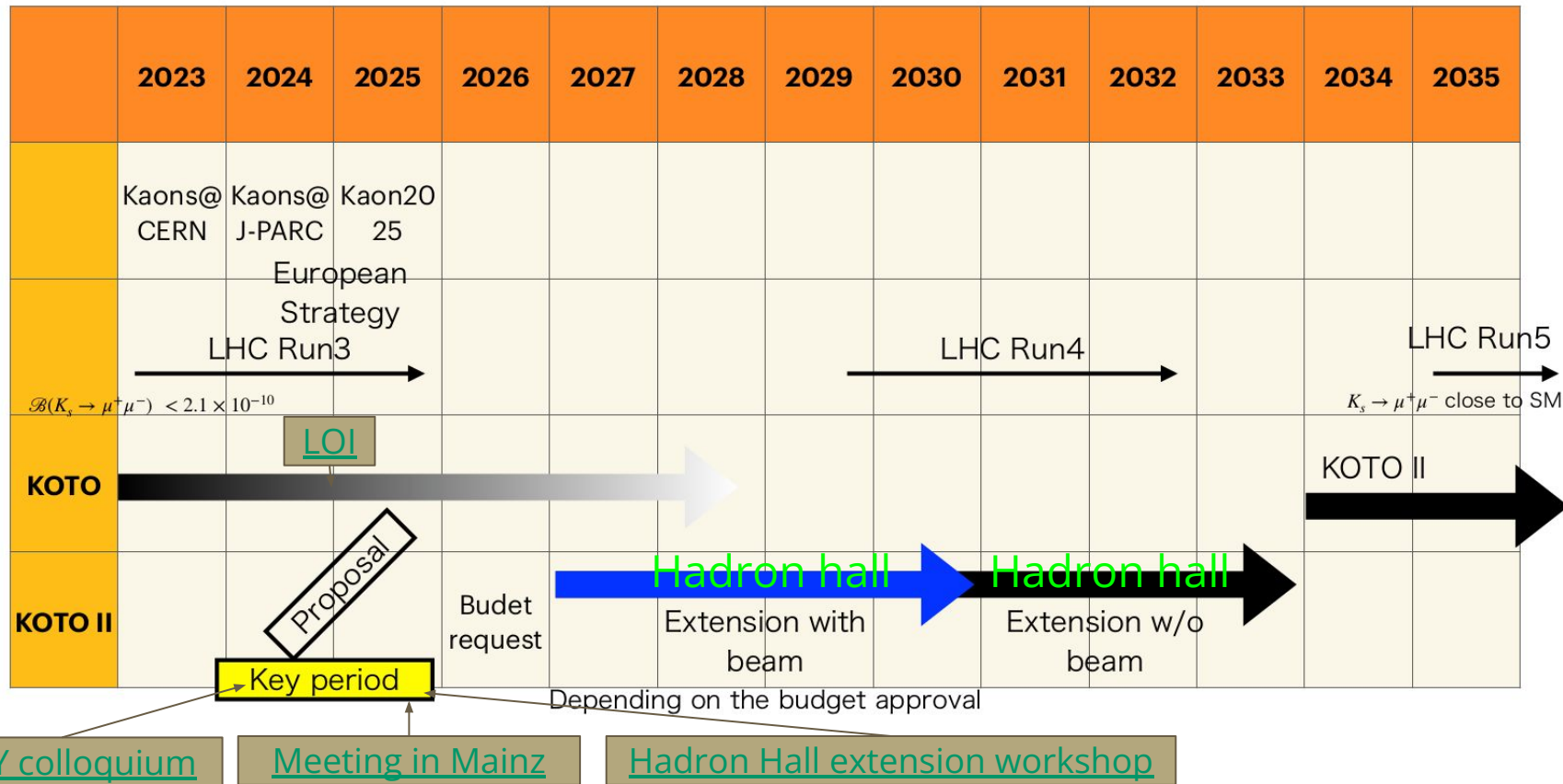
# Some detector opportunities

- New detector: many ways to contribute
  - Vacuum tank
  - Tracking:
    - In-beam silicon veto counter
    - Forward tracker inspired by LHCb “mighty tracker” design
  - Calorimeter:
    - Extending existing CsI calorimeter, several options discussed
  - Barrel veto counters

## Silicon detector projects

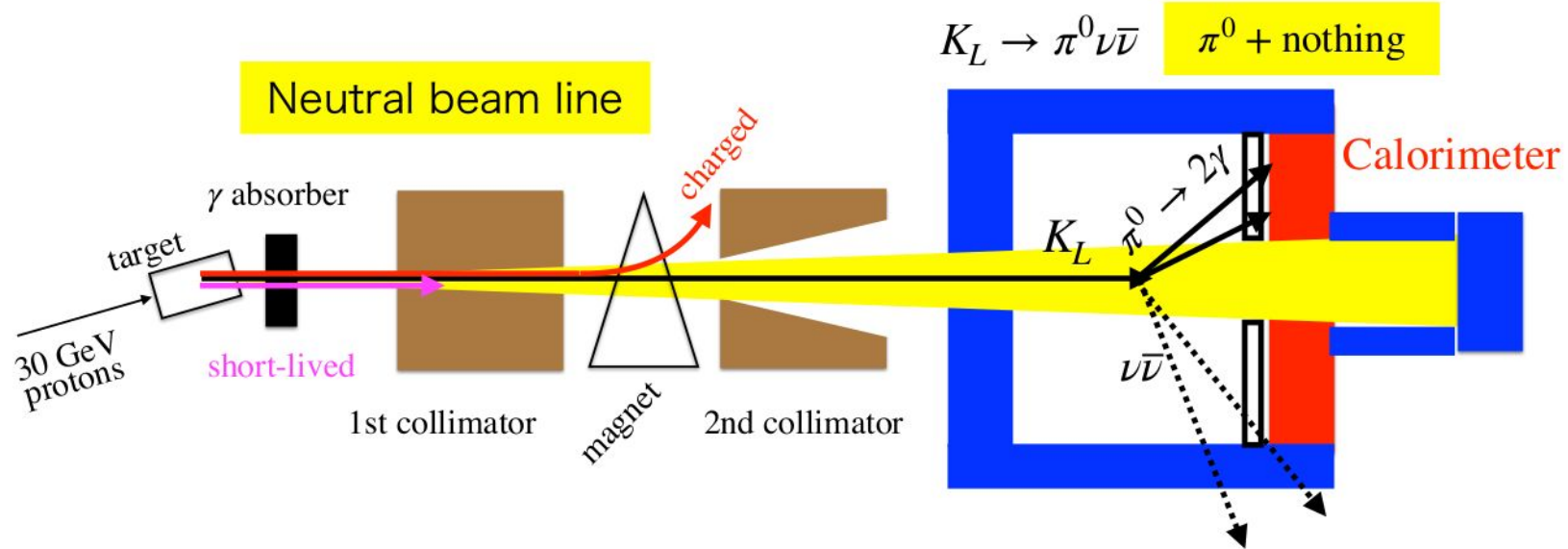


# KOTO II - Time line



# Backup

# KOTO experiment at J-PARC

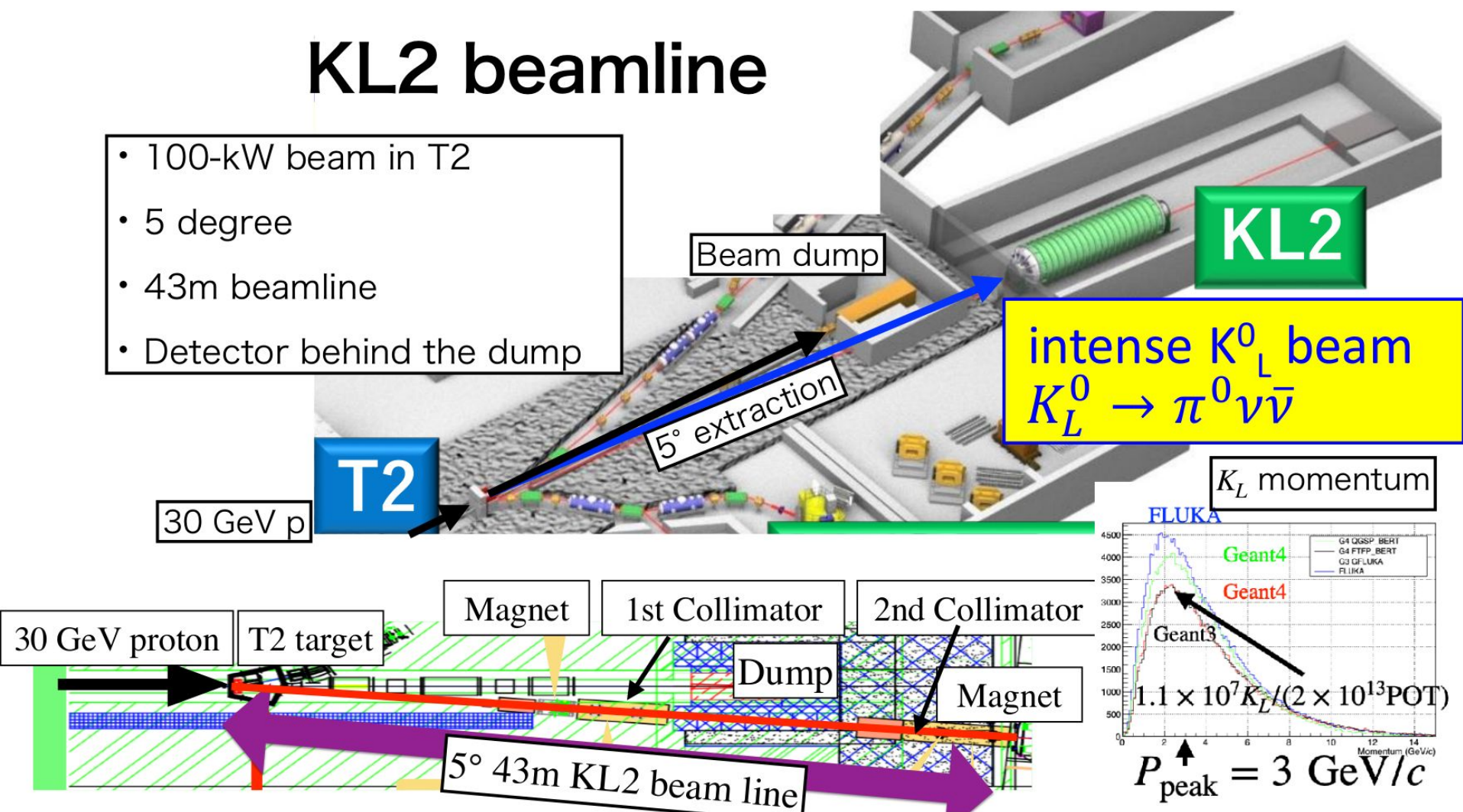


- Narrow neutral (neutron,  $K_L$ , photon) beam, reconstruct  $K_L$  decays in the vacuum decay volume
- Calorimeter for photons, veto counters.
- Kinematic cuts to define signal region remove leading backgrounds.



# KL2 beamline

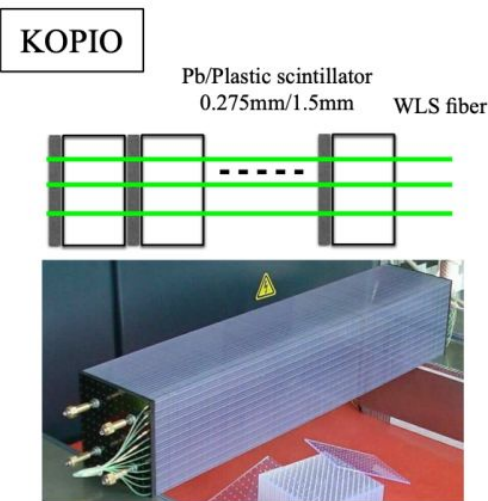
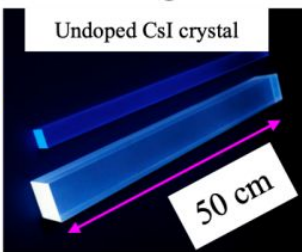
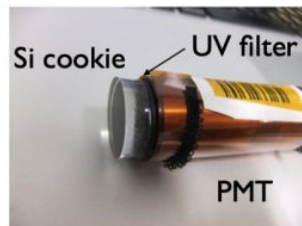
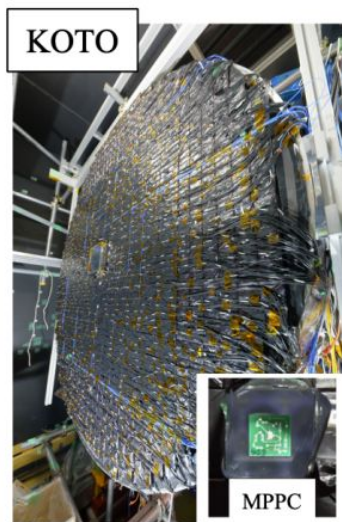
- 100-kW beam in T2
- 5 degree
- 43m beamline
- Detector behind the dump



# Recent developments

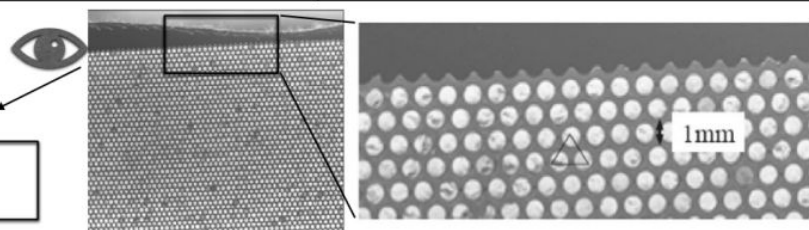
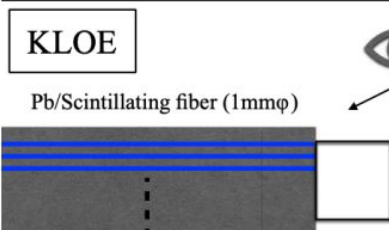
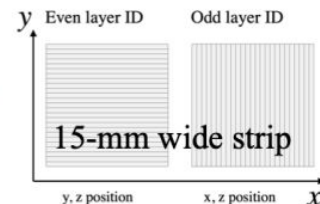
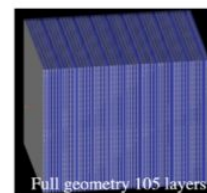
- KLEVER / HIKE proposals are not supported at CERN: end of  $K^+$  physics program with NA62 termination ( $K_S \rightarrow \text{LHCb}$ )
- Discussion of several european groups joining KOTO II, extending experimental program to include charge modes such as  $K_L \rightarrow \pi^0 e^+ e^-$ 
  - Requires dedicated tracking chambers (spectrometer)
  - Currently planned to run after the main  $K_L \rightarrow \pi^0 \nu \nu$  program
- J-PARC asked for re-evaluation of extension hall upgrade, to reduce costs
- Immediate plans remain:
  - Open to expand the collaboration
  - Lol: arXiv:2501.14827
  - Proposal sent by end of Japanese fiscal year (March 2025)
  - European Strategy document <https://cds.cern.ch/record/2931440>
  - KOTO II meeting in Mainz (Sept 2025)
  - J-PARC Hardon hall extension meeting (Sept 2025)

# KOTO II Detector: Calorimeter Options being studied



## Angle measurement capability

1-mm lead / 5-mm plastic scinti.  
for upstream part of the calorimeter



MC Study to obtain incident angle  
from shower development.  
a few degree resolution so far  
for 0.2-2 GeV photons