Beam-edge Photon Detector with Low Sensitivity to Neutrons for the KOTO Experiment

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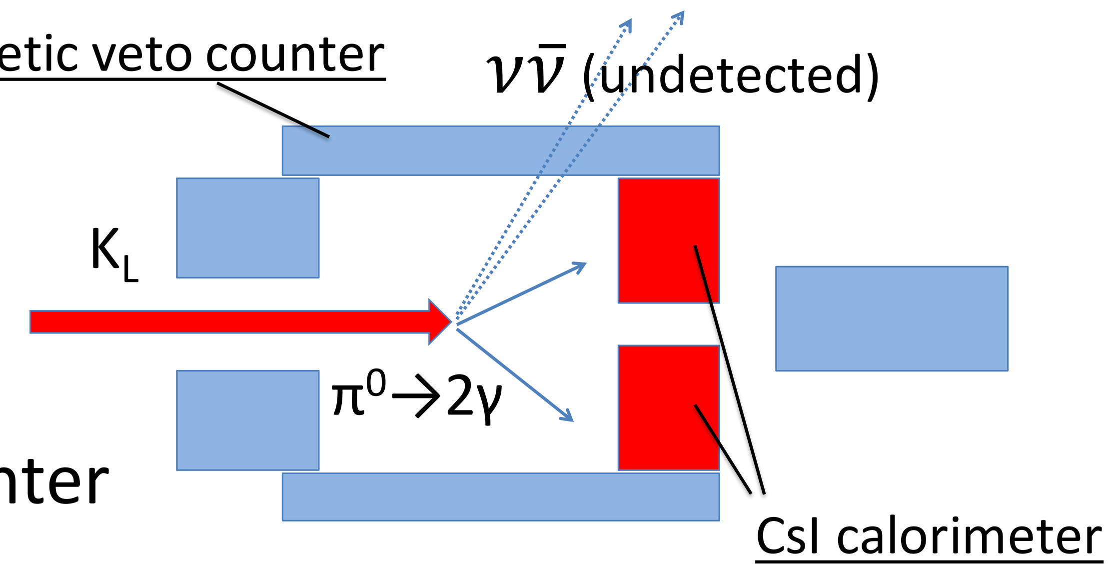
KOTO experiment

Goal of the KOTO experiment

- **Discovery of the $K_L \rightarrow \pi^0 \nu\bar{\nu}$.**
- **Search for New Physics beyond the SM.**

Principle of the KOTO

- 2γ + nothing
  - 2γ → CsI calorimeter
  - Nothing → Hermetic veto counter



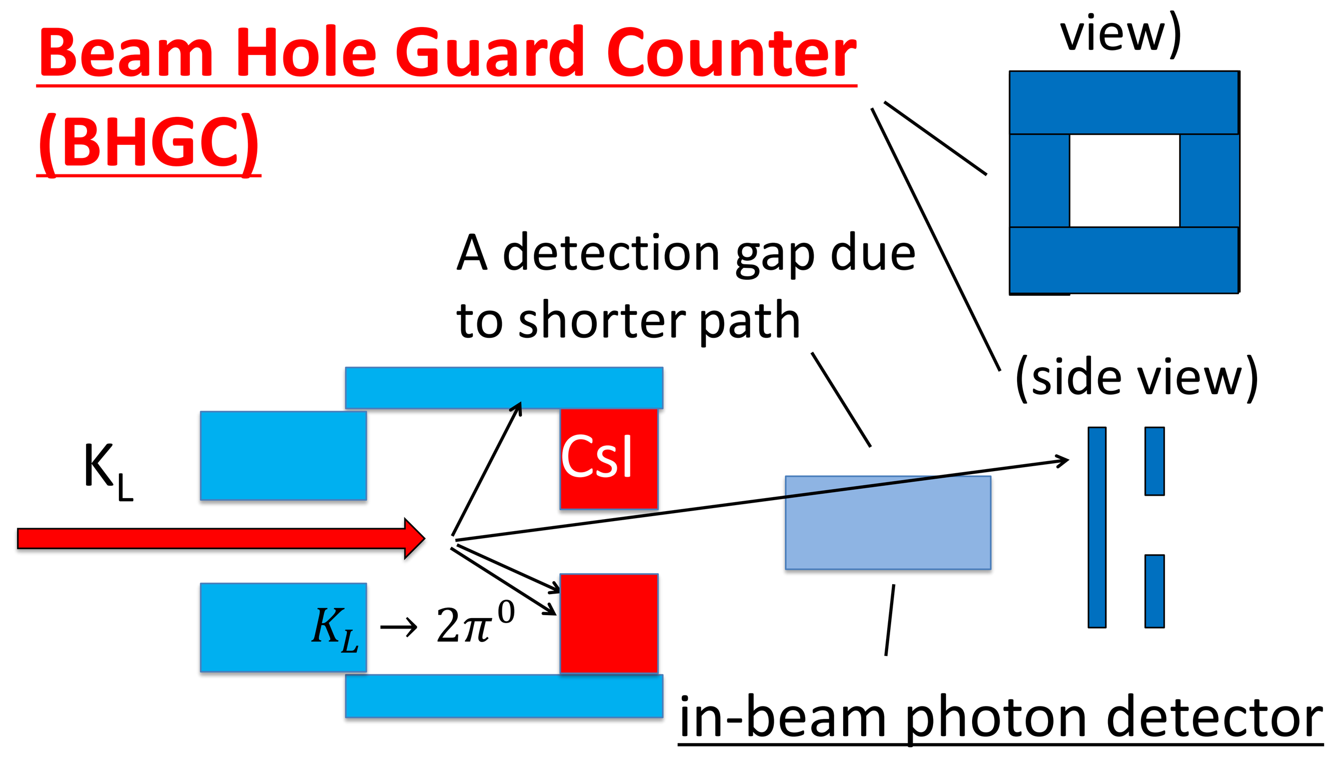
Weak spot in the In-beam photon detector

- A detection gap of the in-beam photon detector
  - Shorter path in radiation length for the outer photon.
  - 1.9 backgrounds from $K_L \rightarrow 2\pi^0$ at the SM level is expected.

  Need **new photon detector** around the beam core.
- **Requirement**
  - A large amount of neutrons around the beam core (~17MHz).

  →Need sensitivity to photons and low sensitivity to neutrons.

new photon detector, **Beam Hole Guard Counter (BHGC)**



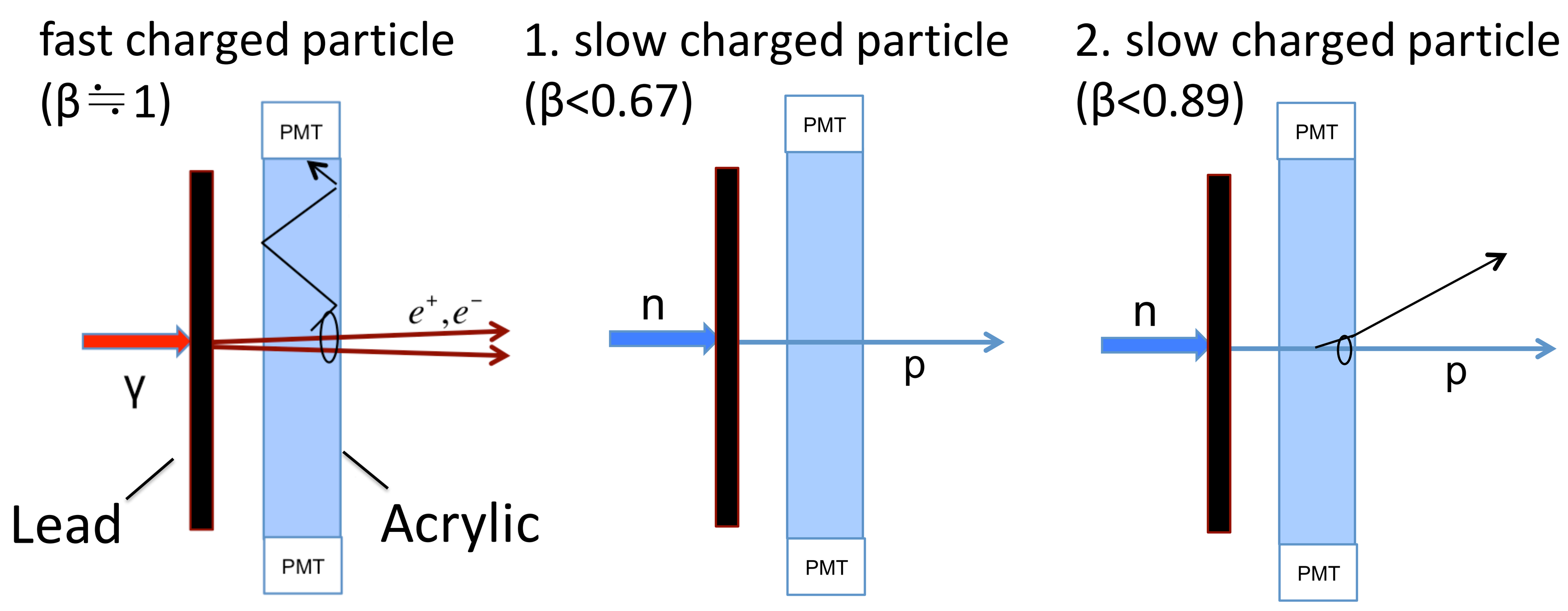
Beam Hole Guard Counter (BHGC)

Principle of Acrylic Cherenkov Counter

- BHGC has lead plate and acrylic.
- Two steps of threshold

  Charged particles generated from neutrons tend to be slow.

  →Low sensitivity to neutrons.



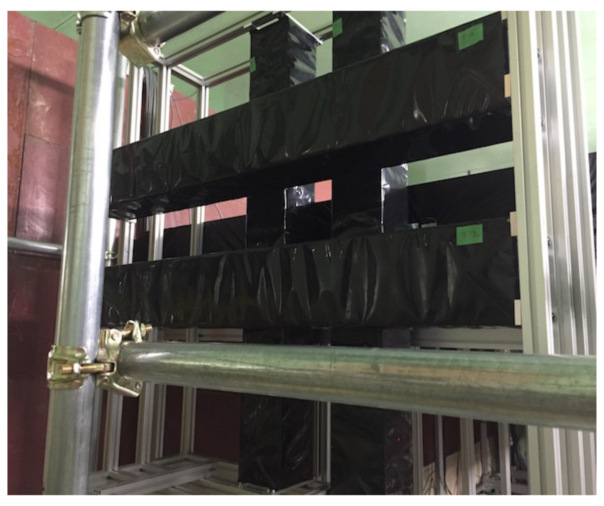
Cherenkov radiation comes to PMTs | No Cherenkov radiation | Cherenkov radiation goes out

Physics run with BHGC in 2015

Design of BHGC

- Optimized to reduce 66% of the gap-induced BG.
- Efficiency for neutron (< 1GeV/c) is less than 2.5 % in MC.

BHGC module
- Lead plate : 9.6 mm
- Acrylic : 50 × 12 × 1 cm^3
- PMT : 5inch (R1250)

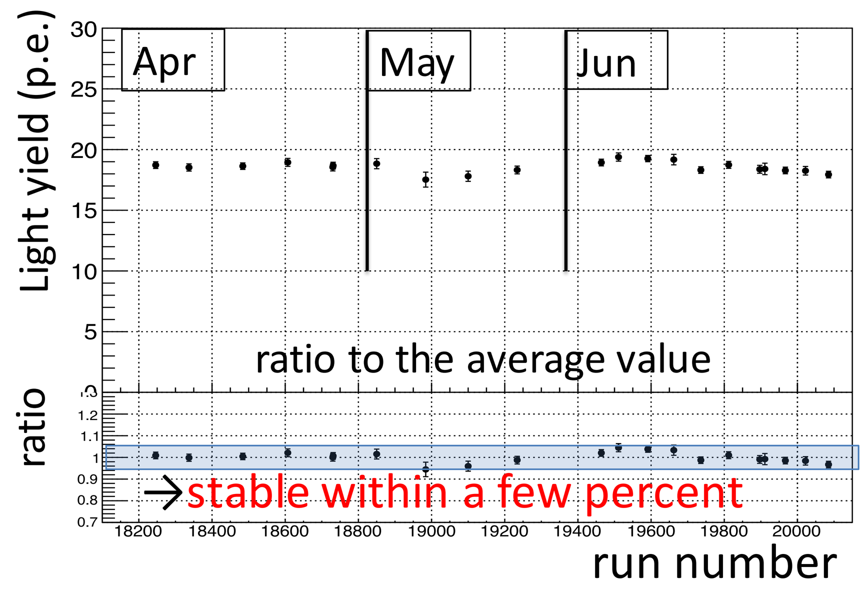


BHGC (View from downstream)

Light Yield stability

- Selected high momentum charged particles.
- Stable within a few percent.

  →No radiation damage.



Single counting rate

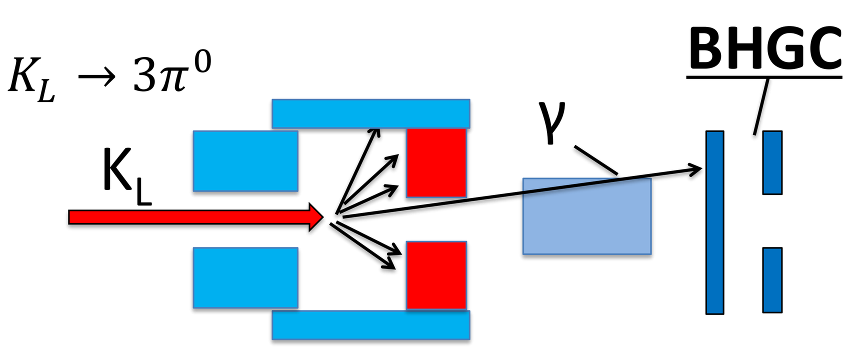
- Expected value (~0.3MHz) with random trigger data.

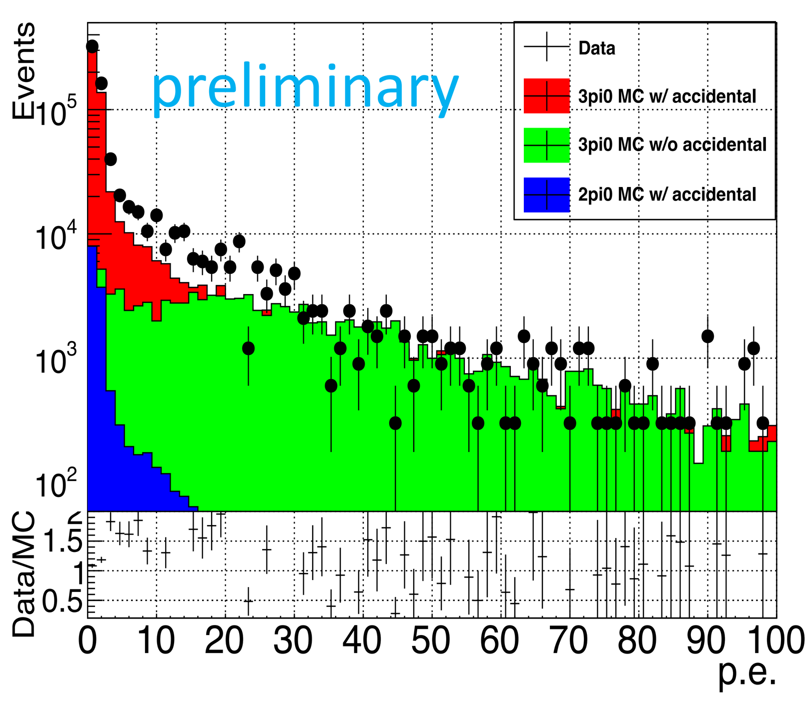
  → Low sensitivity to neutrons.

Detector response in physics data

- Compared with $K_L \rightarrow 3\pi^0$ data and MC.
  - K_L decay : good agreement
  - Accidental : not sufficient

→Need to study more.



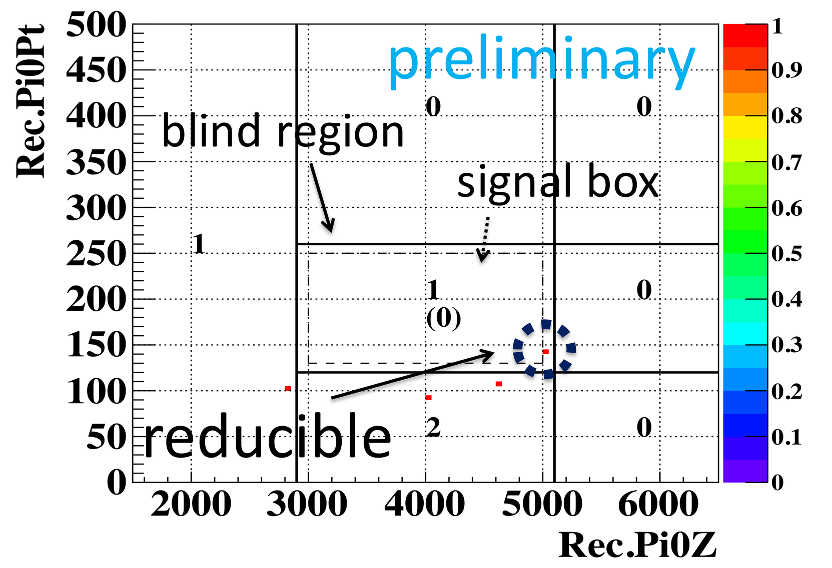


Result of $K_L \rightarrow 2\pi^0$ simulation

- One remaining event inside the blind region is reduced.
- Reduce 2/3 events related to the detection gap.

→ Consistent with design and BHGC reduce $K_L \rightarrow 2\pi^0$ BG.

Reconstructed π^0 Pt and Z distribution (w/ kinematic cut, w/ veto(w/o BHGC)
S.E.S : 1.8 × 10^{-10} equivalent)



Conclusion

- BHGC is new photon veto detector to cover the detection gap.
- Good operation and good reproducibility.
- BHGC reduce $K_L \rightarrow 2\pi^0$ background.
- Further study with the data is on-going on gamma detection efficiency and background reduction with BHGC.