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Investigation of K/π Discrimination with a New Aerogel Čerenkov Detector Using MPPC Readout

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for the J-PARC E80 collaboration

Outline

1. Search for "K^-ppn" – J-PARC E80 Experiment –
2. Particle Detection in E80
    - *I. Cylindrical Detector System*
    - *II. Aerogel Čerenkov Detector*
3. AC Performance Evaluation for E80
    - *I. Setup*
    - *II. Result*
    - *III. Outlook*
4. Summary

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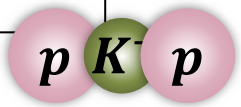
Search for "K^-ppn" – J-PARC E80 Experiment –

Kaonic Nuclei

- Strongly attractive $\bar{K}N$ interaction in $I = 0$ channel
  - Deeply bound states between antikaons & nuclei
- Systematic investigation @J-PARC K1.8BR beamline
  - Insight into low-energy QCD

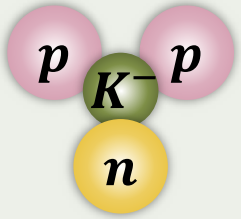
- **J-PARC E15 Experiment**
  revealed the existence of the "K^-pp" bound state

Phys. Rev. C **102** (2020), Article 044002
Phys. Lett. B, **789** (2019), p. 620



Next Step!

- **J-PARC E80 Experiment**
  will explore the existence of the "K^-ppn" bound state



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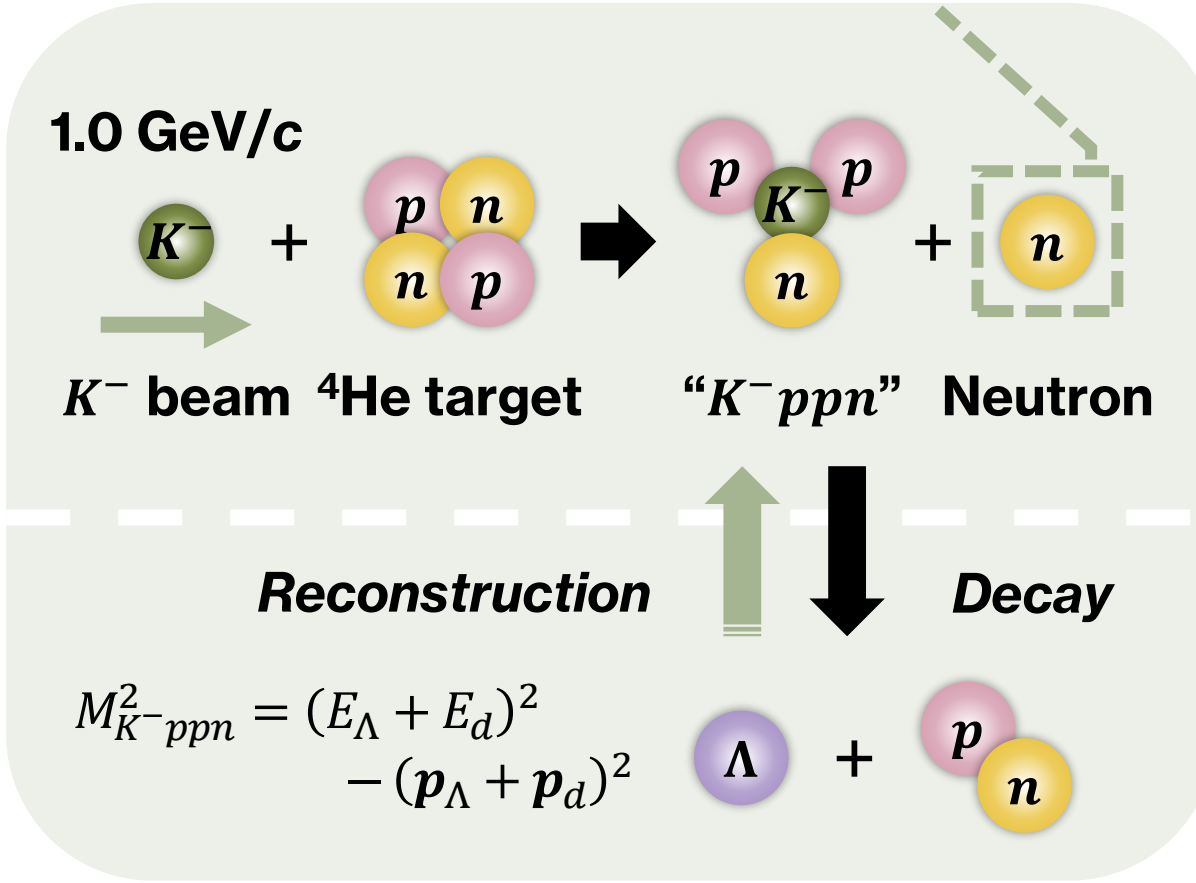
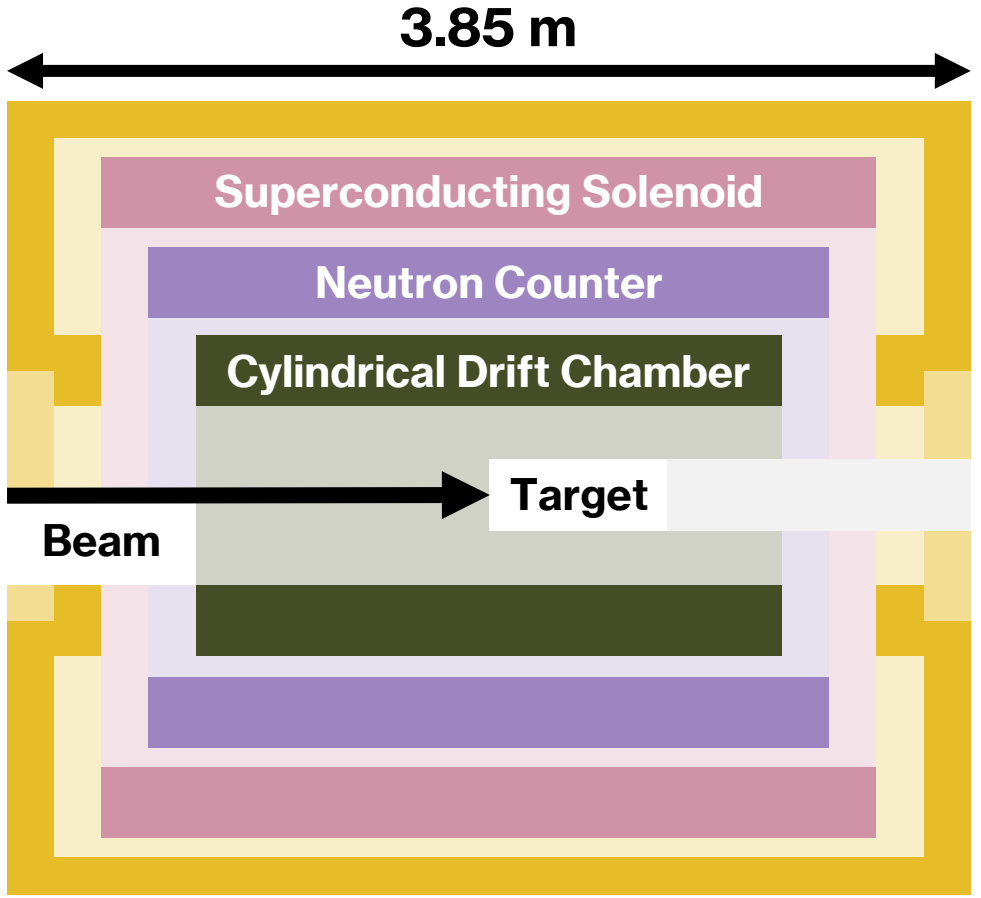
Particle Detection in E80 ➤ *Cylindrical Detector System*

Exclusive Measurement via n detection



Invariant Mass Spectroscopy



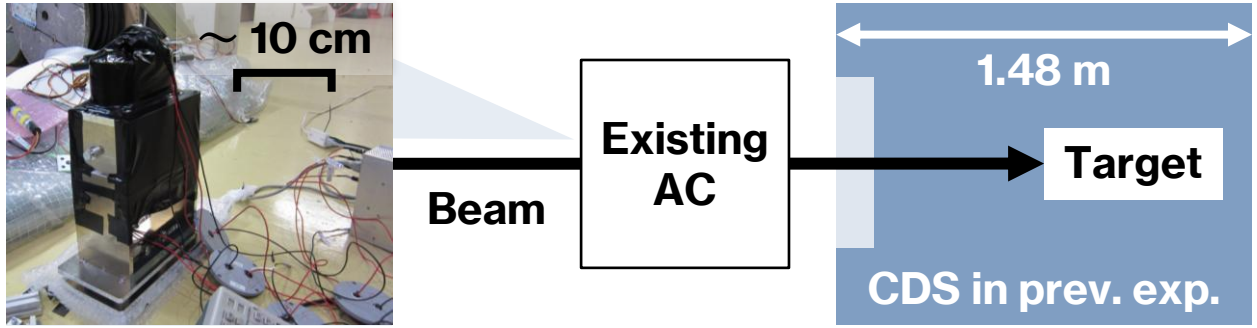
Cylindrical Detector System

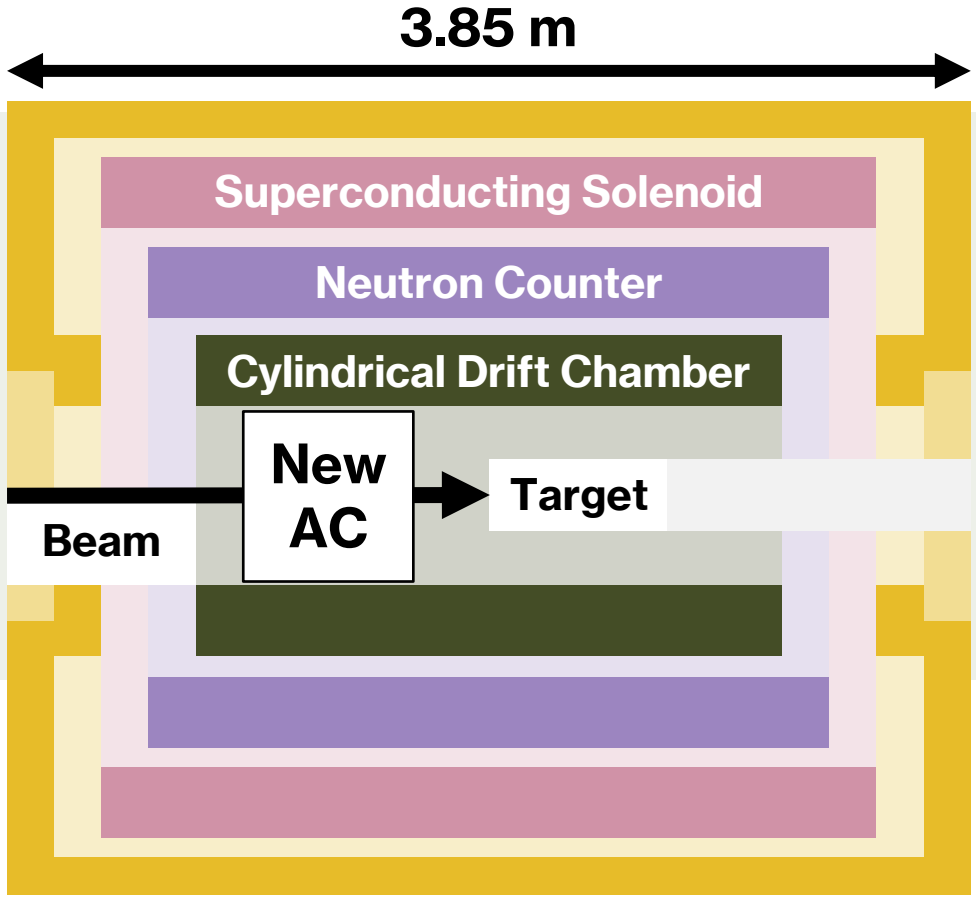
provides ~ 4π acceptance

Particle Detection in E80 ➤ *Aerogel Čerenkov Detector*

Aerogel Čerenkov Detector (AC)

- » Identifying K/π in the beam
  - › With Čerenkov radiation from π
  - › Using aerogel radiator ($n = 1.05$)
- » Operating inside the magnet
  - › To be placed near the target
  - › To suppress kaon decay events





Cylindrical Detector System

provides ~ 4π acceptance

Particle Detection in E80 ➤ *Aerogel Čerenkov Detector*

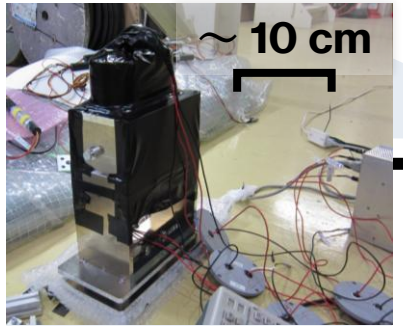
Aerogel Čerenkov Detector (AC)

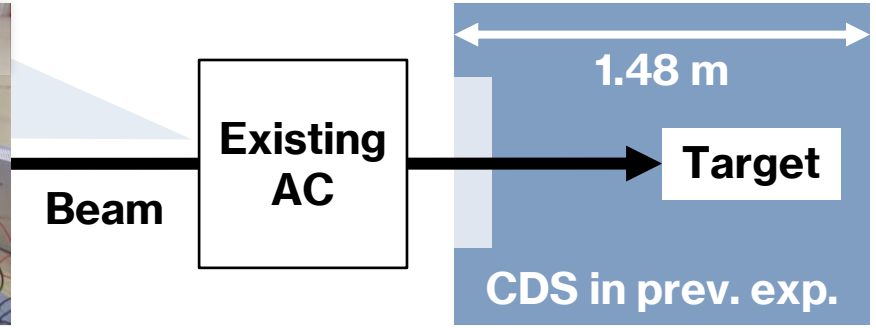
» Detecting photons by MPPCs
  › For magnetic-field tolerance
  › Instead of fine-mesh PMTs

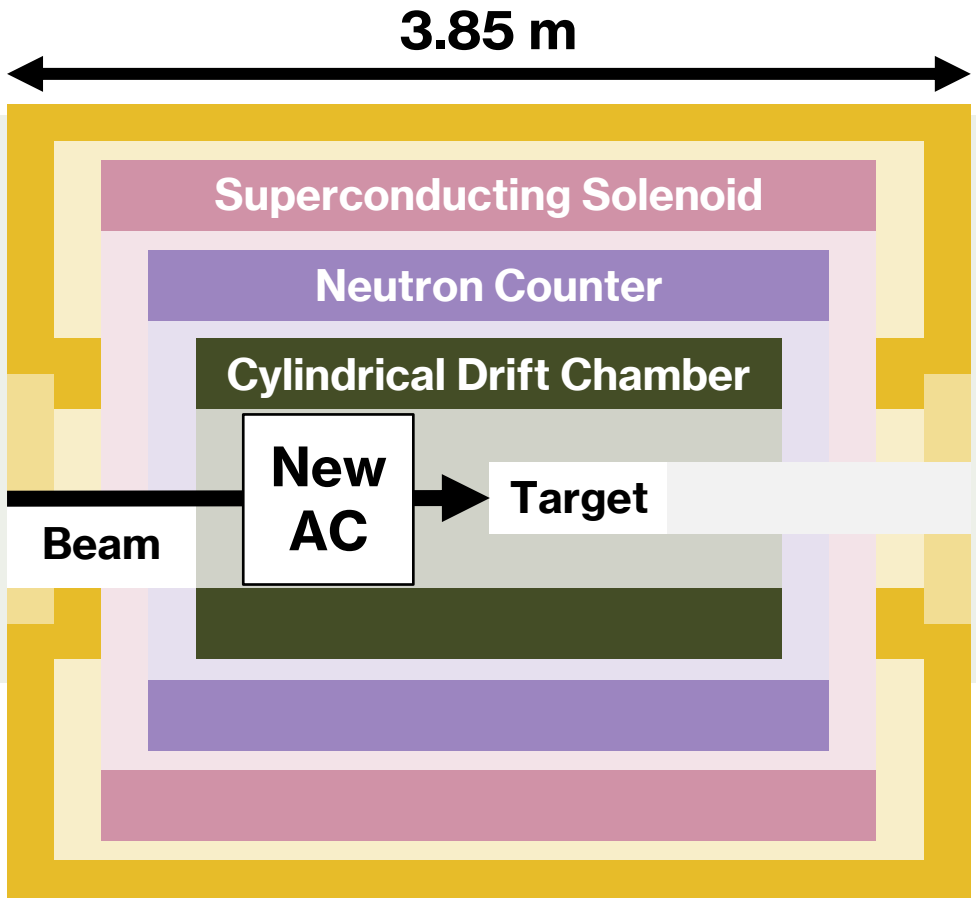
Required Performance

- π efficiency ∼ 99%
- K loss prob. ∼ 1%

Compatible to Existing AC







Cylindrical Detector System
provides ∼ 4π acceptance

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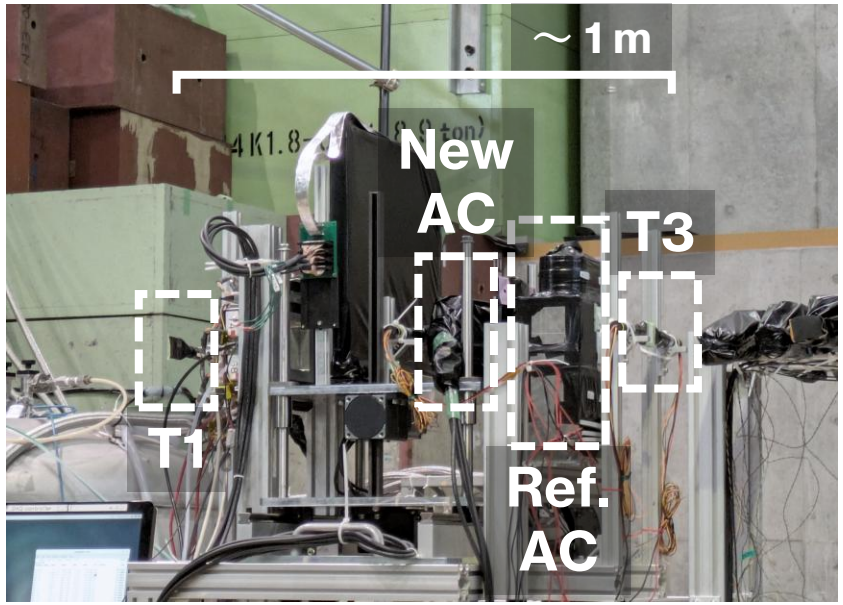
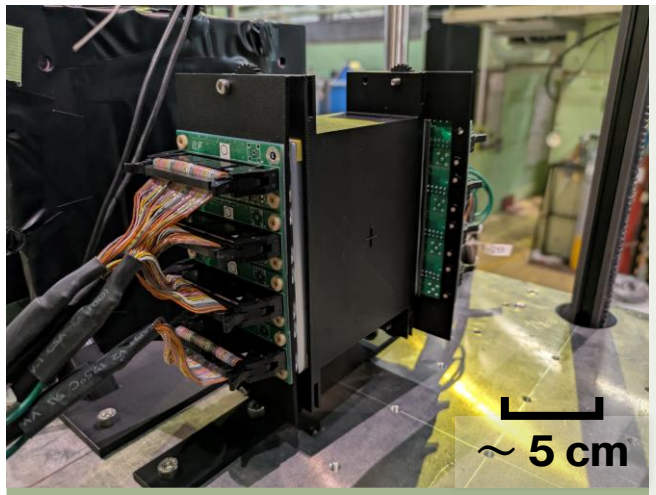
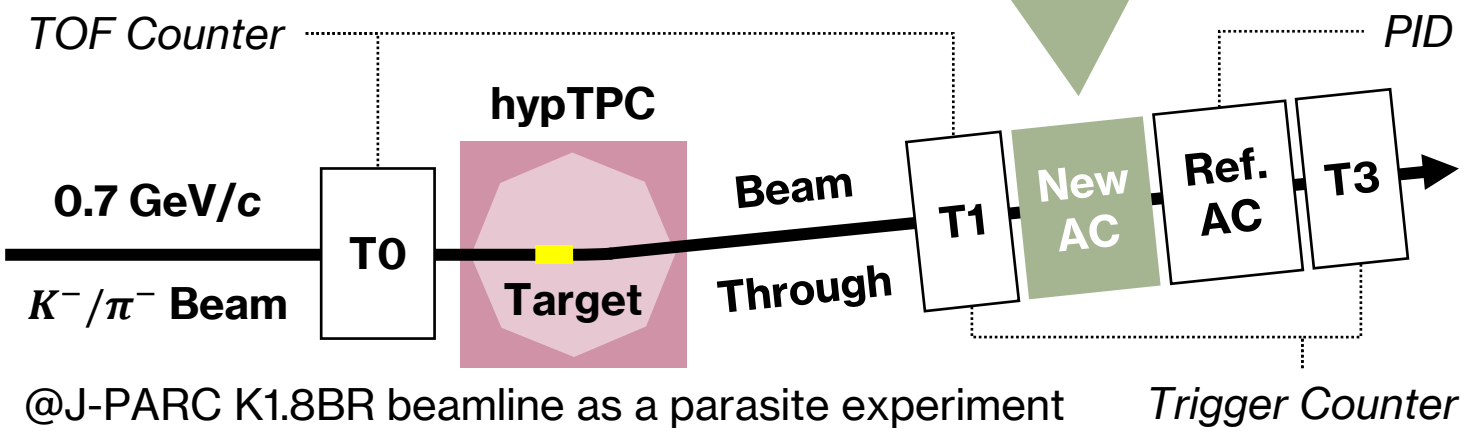
AC Performance Evaluation for E80 ➤ *Setup*





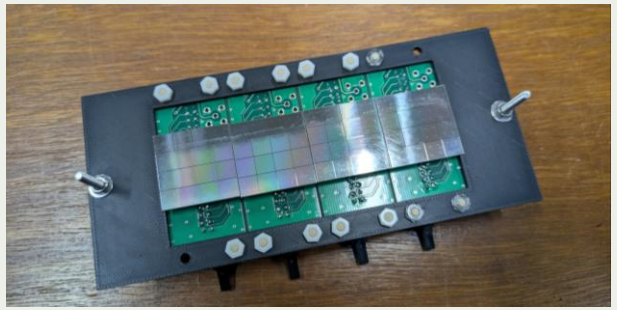
New AC Prototype



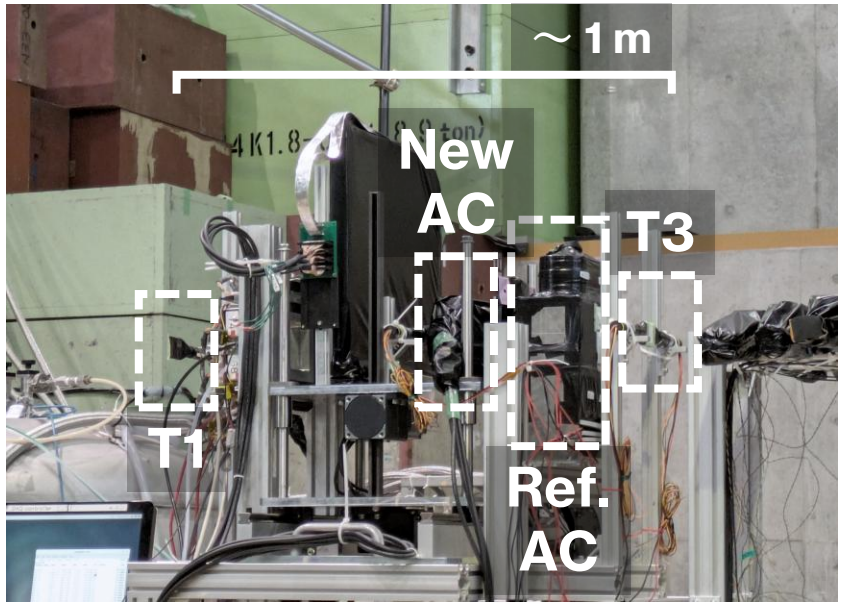
@J-PARC K1.8BR beamline as a parasite experiment

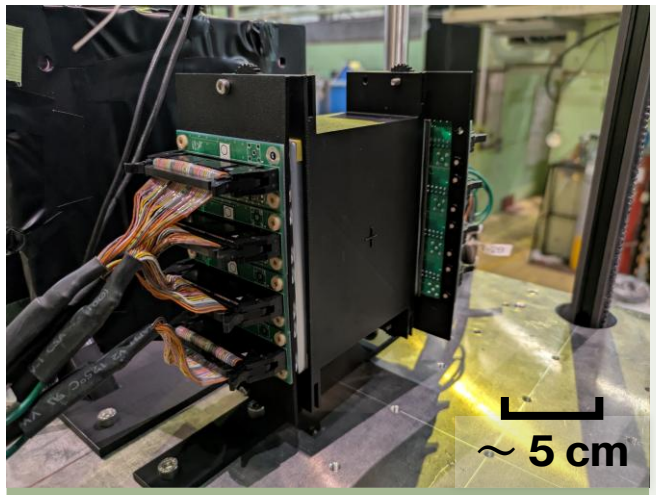
- **Aerogel** (Aerogel Factory)
  10 × 10 cm², 4 cm-thick
  With ESR reflector

- **MPPC** (HAMAMATSU)
  S13361-6050AS-04
  16 sensors × 8 arrays

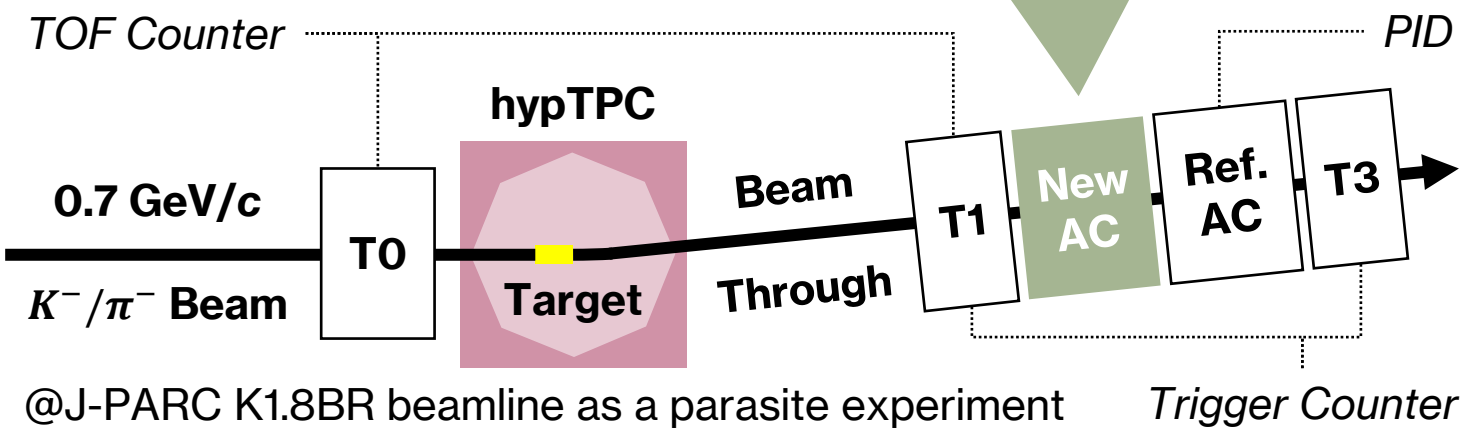


AC Performance Evaluation for E80 ➤ *Setup*



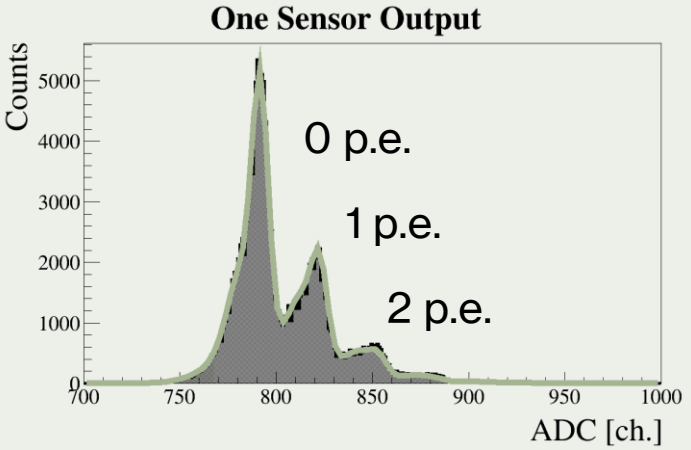


New AC Prototype



- **NIM-EASIROC** (OMEGA)

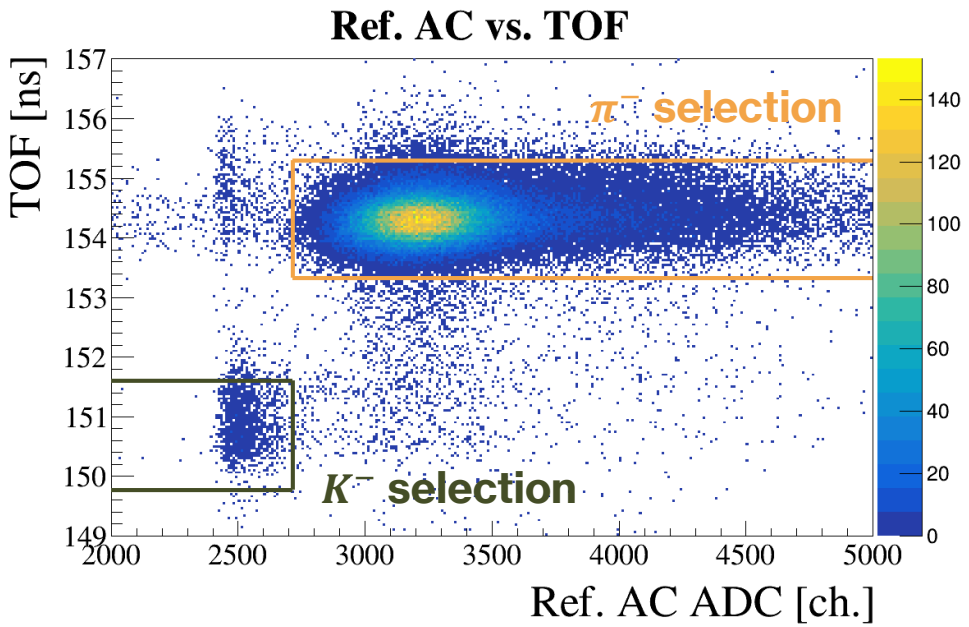
  Sensor-by-sensor readout
  128 ch. ADC data taking



ADC-to-NPE Conversion by peak fitting

Sum across All Channels

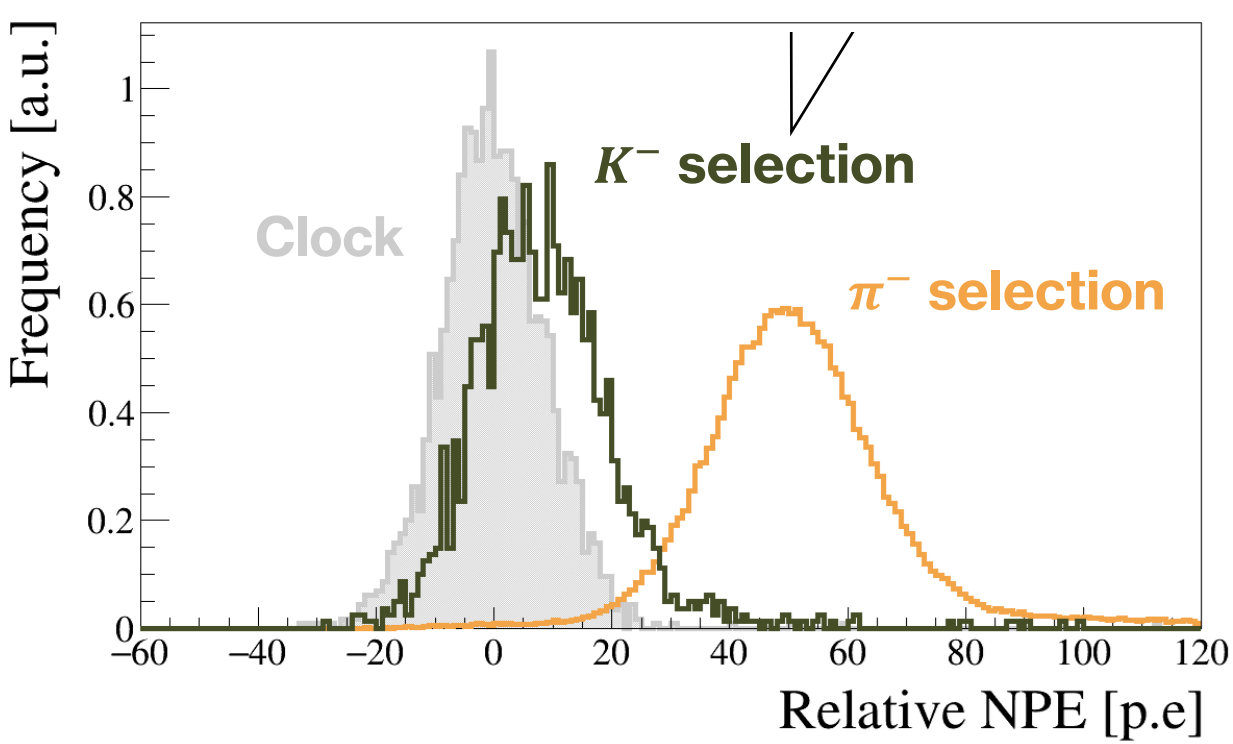
AC Performance Evaluation for E80 ➤ *Result*



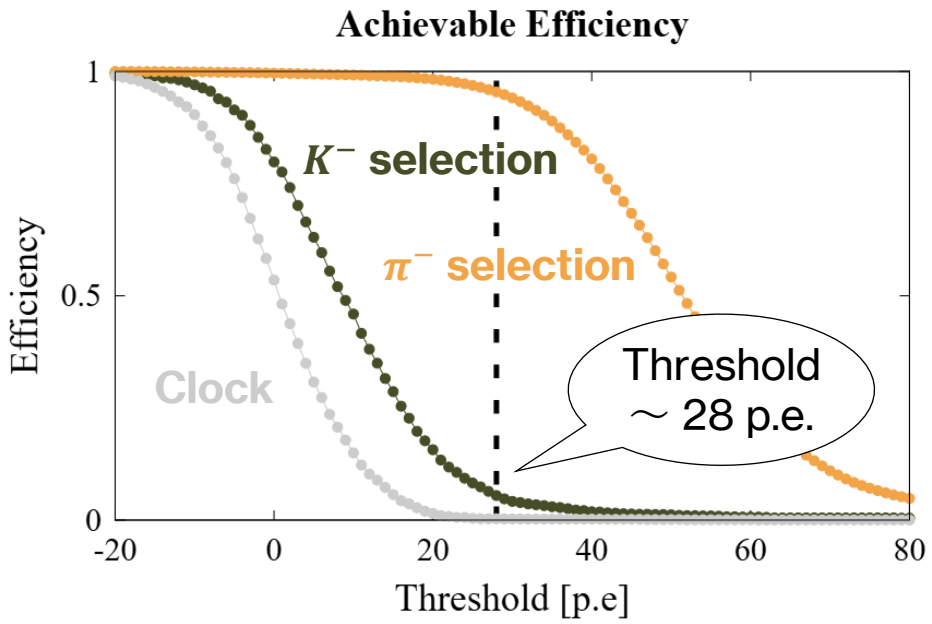
π^- selection	K^- selection
~ 50 p.e. *Existing AC* *~ 15 p.e.*	**~ 8 p.e.** *Existing AC* *~ 0 p.e.*

Event Selection

Scintillation light in ESR reflector



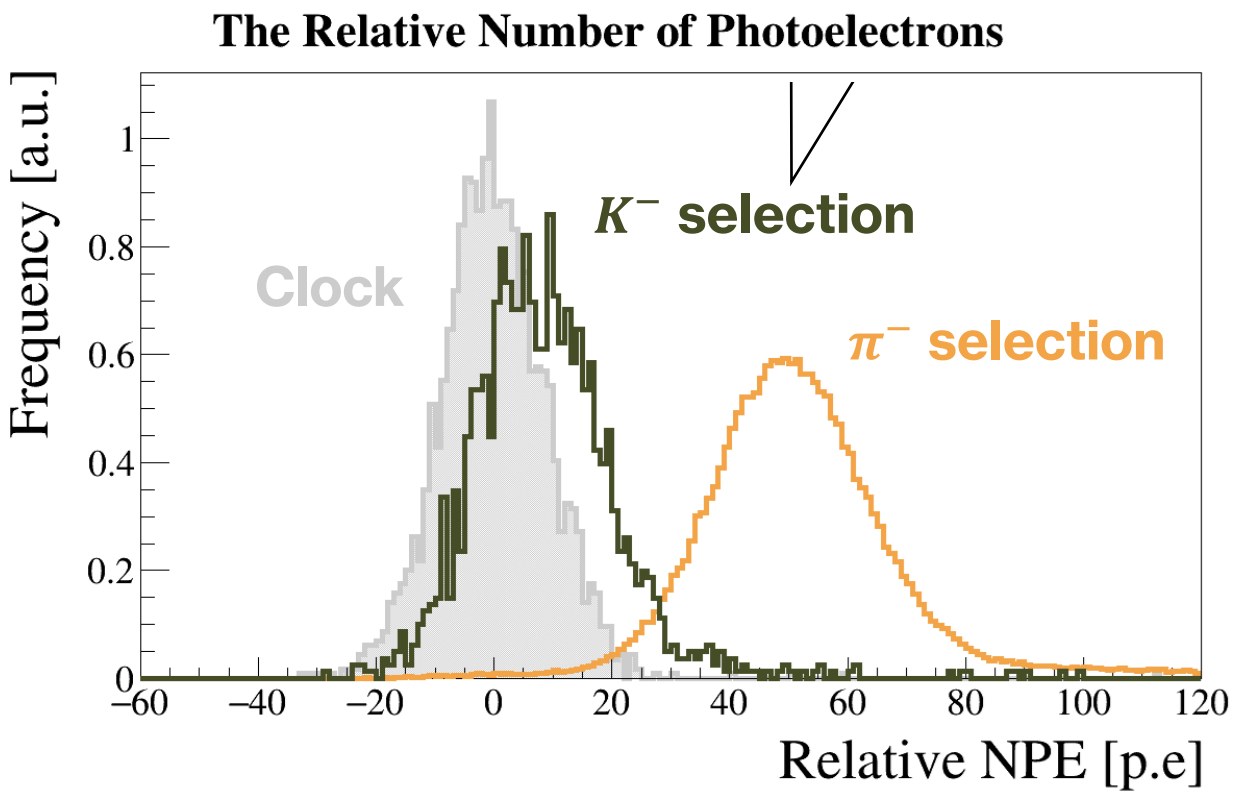
AC Performance Evaluation for E80 ➤ *Result*



π^- efficiency	K^- loss prob.
~ 95%	**~ 5%**
Existing AC ~ 99%	*Existing AC ~ 1%*

Performance Estimation

Scintillation light in ESR reflector



AC Performance Evaluation for E80 ➤ *Outlook*

There is the possibility of improvement

- » Can the light yield of π events be increased?
  - › **Additional MPPC arrays** ➡ Improvement in coverage
- » Can the light yield of K events be decreased?
  - › **Different types of reflectors** ➡ Suppression of scintillation light
- » Can the peak width of clock events be narrowed?
  - › **Modification of readout method** ➡ Reduction in dark counts

Next Beam Time

K/π beam test in Apr. 2026 @J-PARC K1.8BR beamline

Further investigation!

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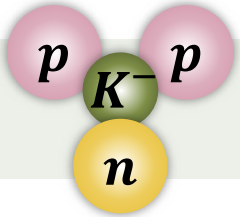
Summary

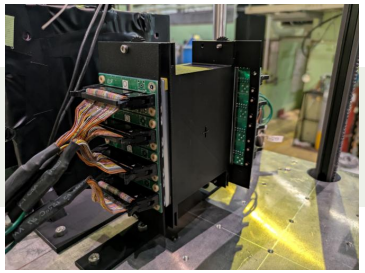
J-PARC E80 Experiment

» Aimed at searching for the existence of the "K^-ppn"



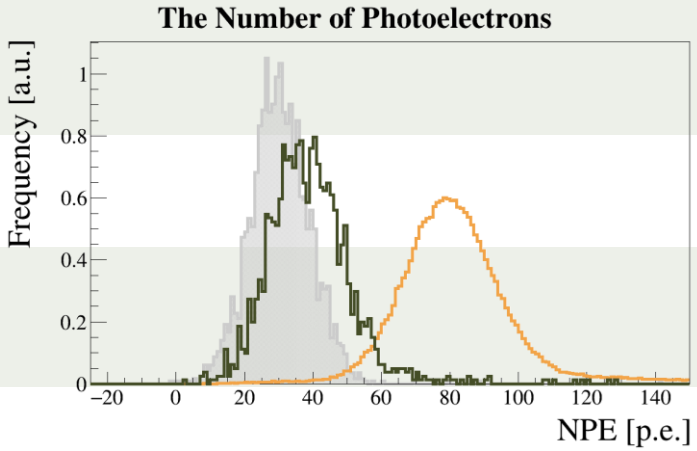
Aerogel Čerenkov Detector

» Used for K/π identification with **MPPC** readout



AC Performance Evaluation

» Suggesting room for **improvement**

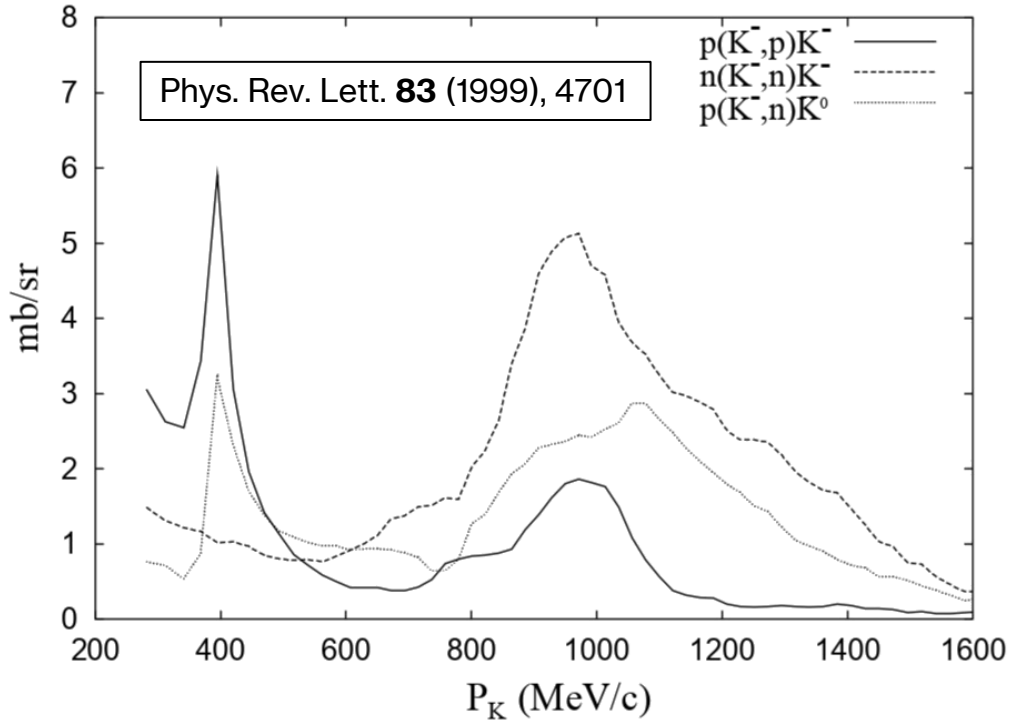


Further Investigation

» During the next beam time in **Apr. 2026**

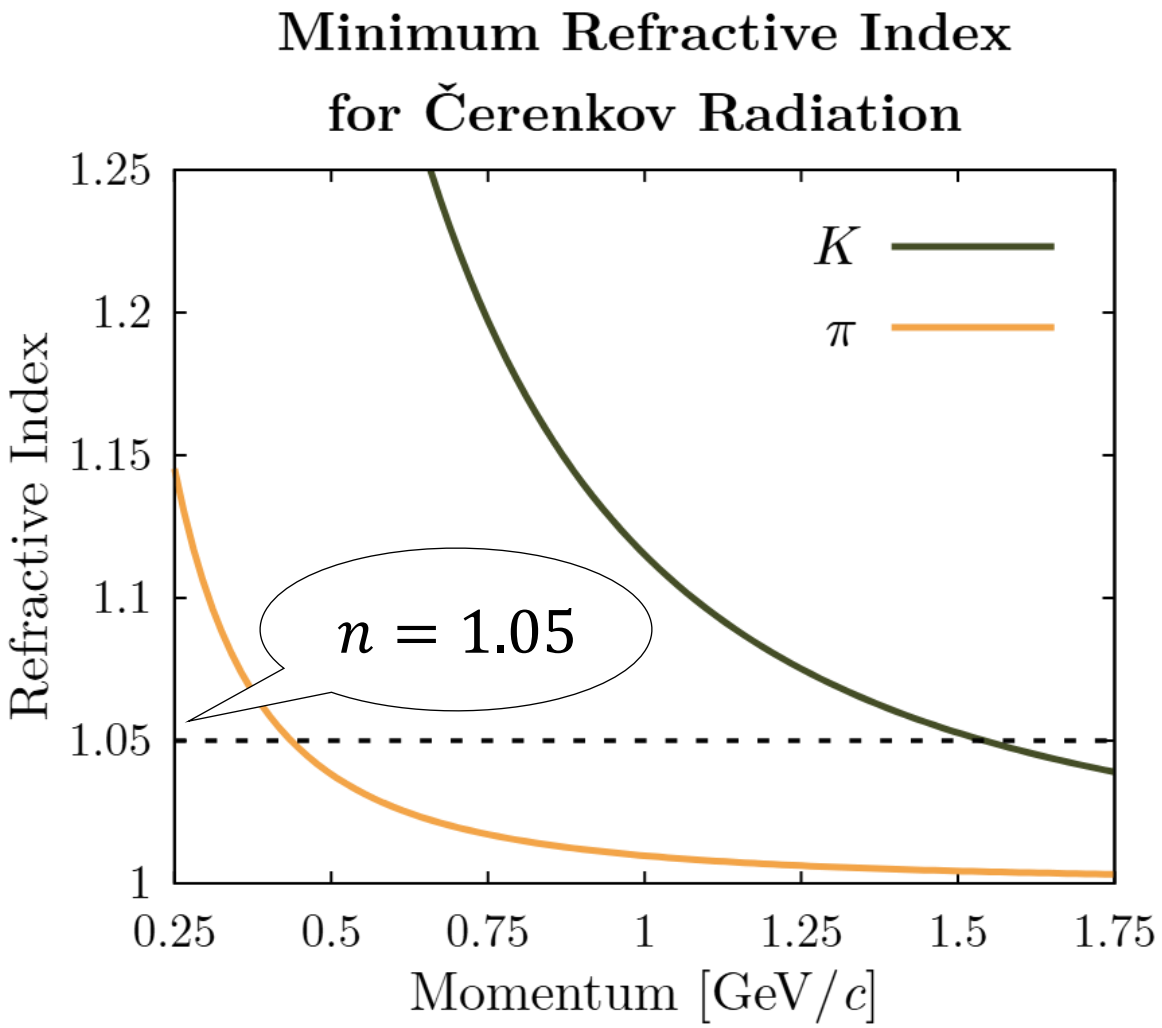
Backup

Backup ➤ *Design of Beam Momentum & Refractive Index*

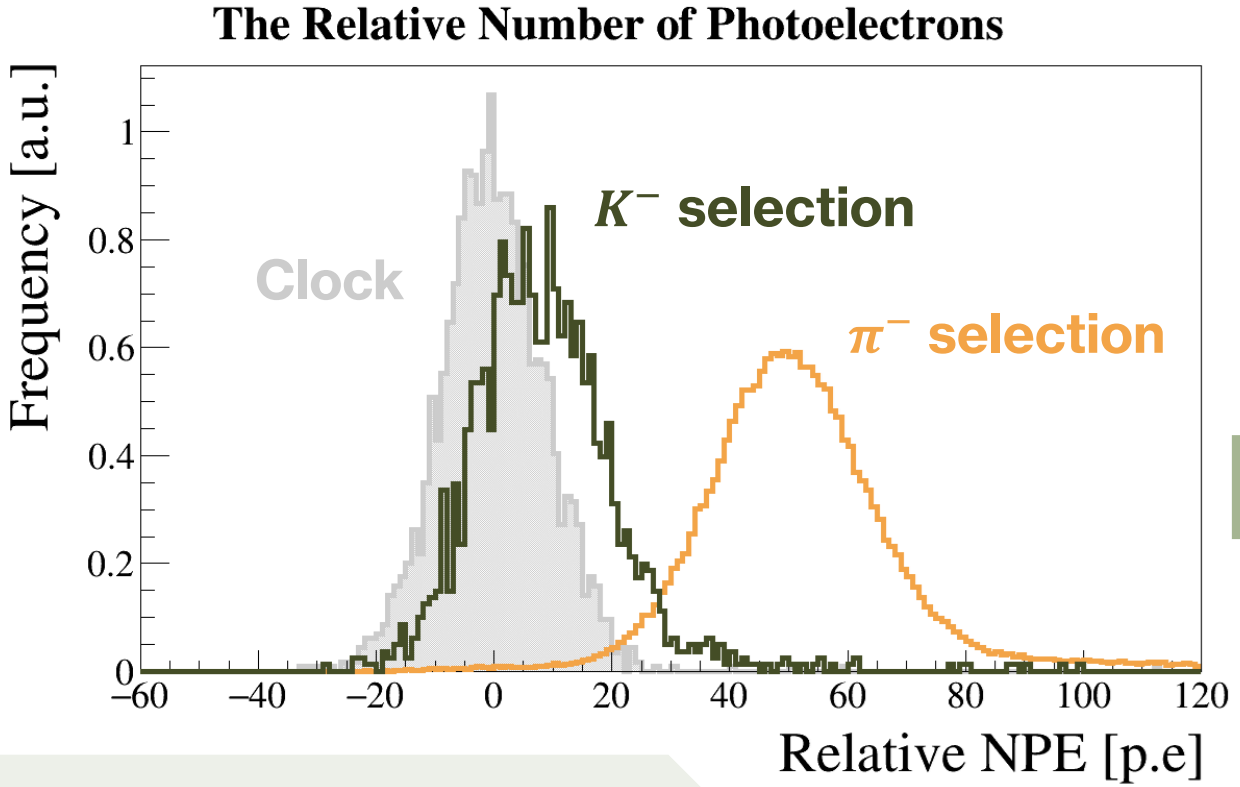


Maximum $\bar{K}N$ reaction rate
@zero degree

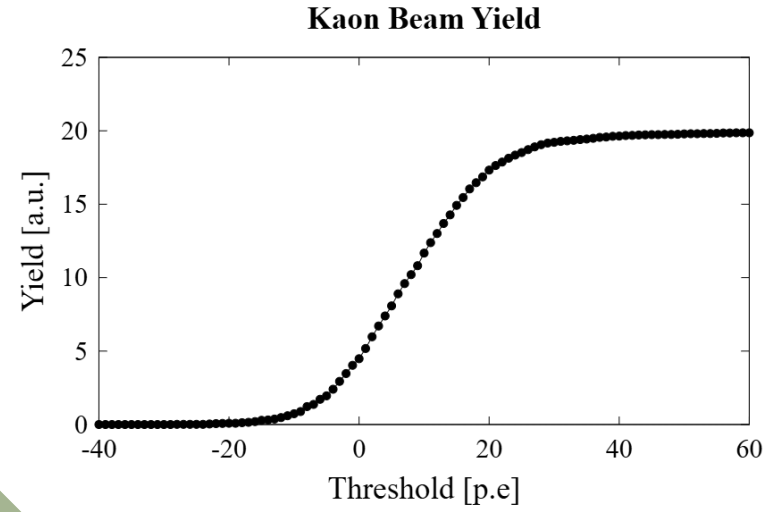
➥ 1.0 GeV/c Incident Kaon

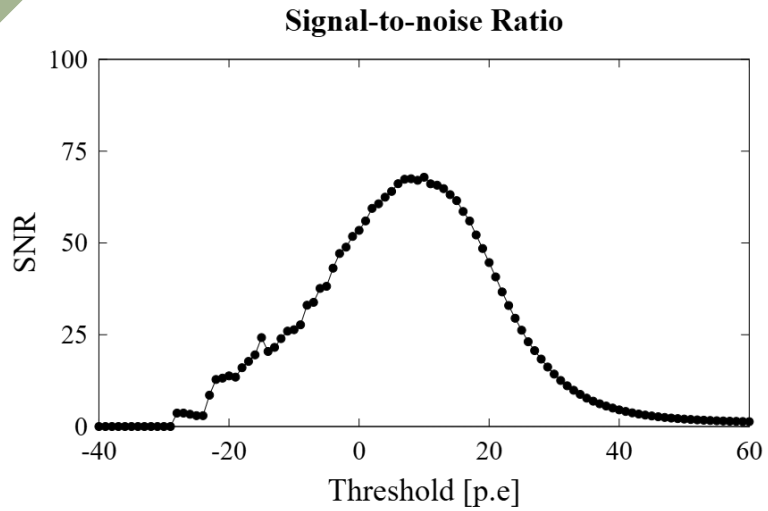


Backup ➤ *Kaon Beam Yield & Signal-to-noise Ratio*

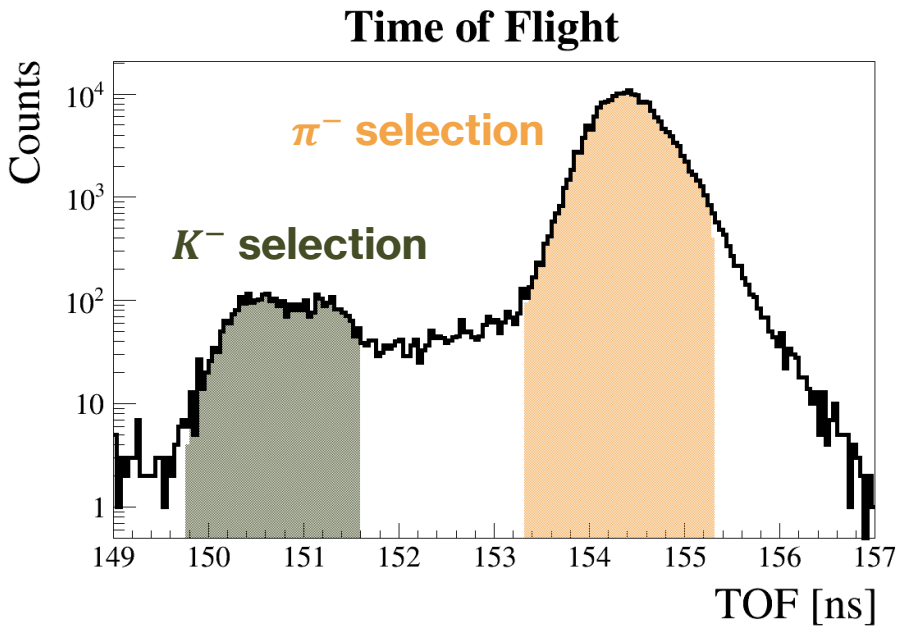


Signal: # of K events
Noise: # of π events





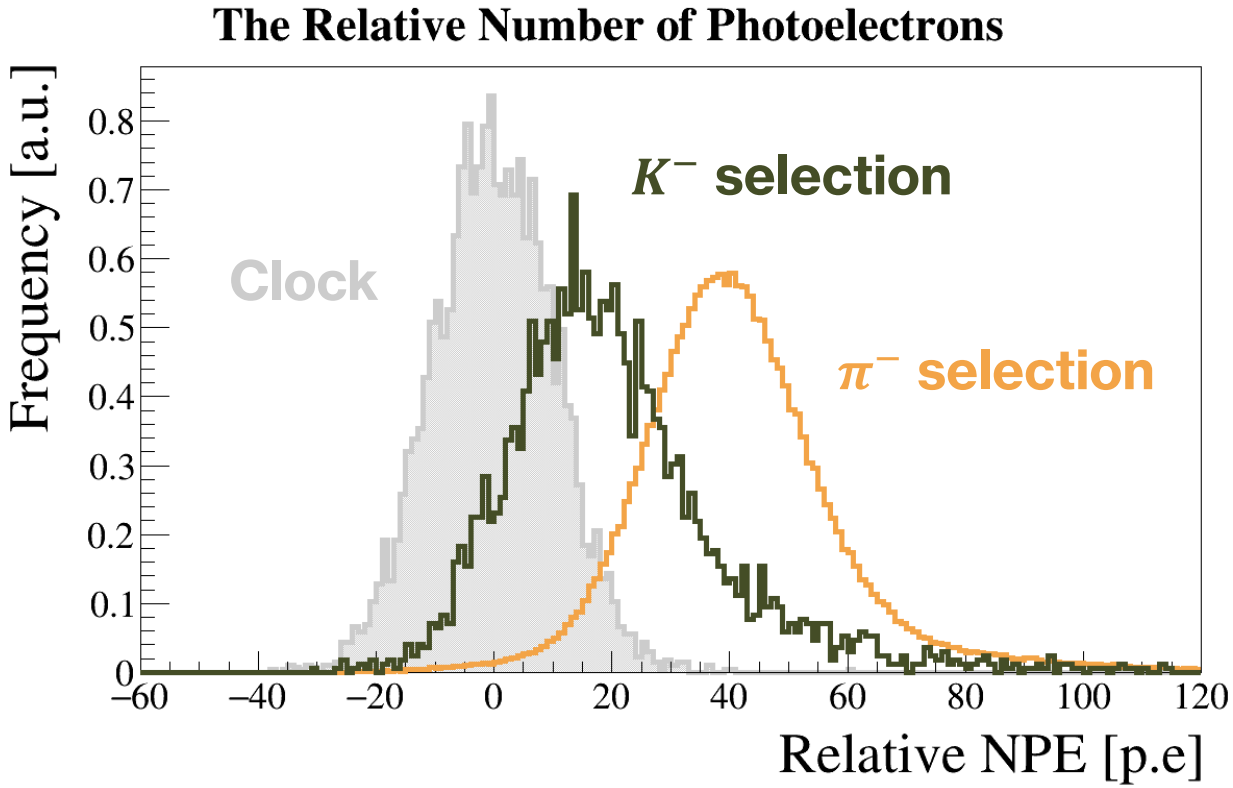
Backup ➤ *Result with 2 cm-thick Aerogel Radiator*



π^- selection	K^- selection
~ 40 p.e.	**~ 18 p.e.**
Existing AC ~ 15 p.e.	*Existing AC ~ 0 p.e.*

Event Selection

※ No data available from Ref. AC



Backup ➤ *Scintillation Light in ESR Reflector*