Evaluate performance of the prototype detector for Polarimeter Tracker

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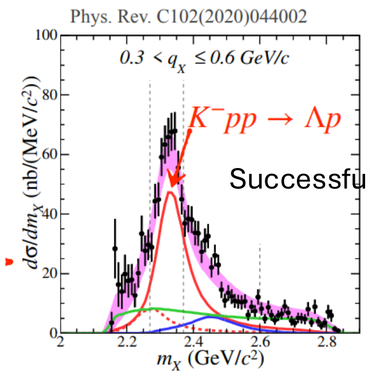
Abstract

The I_Z = +1/2 $\overline{K}NN$ state, the "K^-pp" bound state has been exhibited by the J-PARC E15 experiment. As a next step, fundamental properties of the $\overline{K}NN$ system should be examined more comprehensive manner, especially focusing on the spin and parity of the state. Therefore, we will prepare Polarimeter Tracker to measure this properties. For the R&D of this detector, I conducted a test experiment with a prototype detector at the J-PARC 1.8BR beamline.
In this poster, I present the results of the evaluation of the position resolution and efficiency of this detector.

Previous experiment
J-PARC E15 experiment



Successfully observed

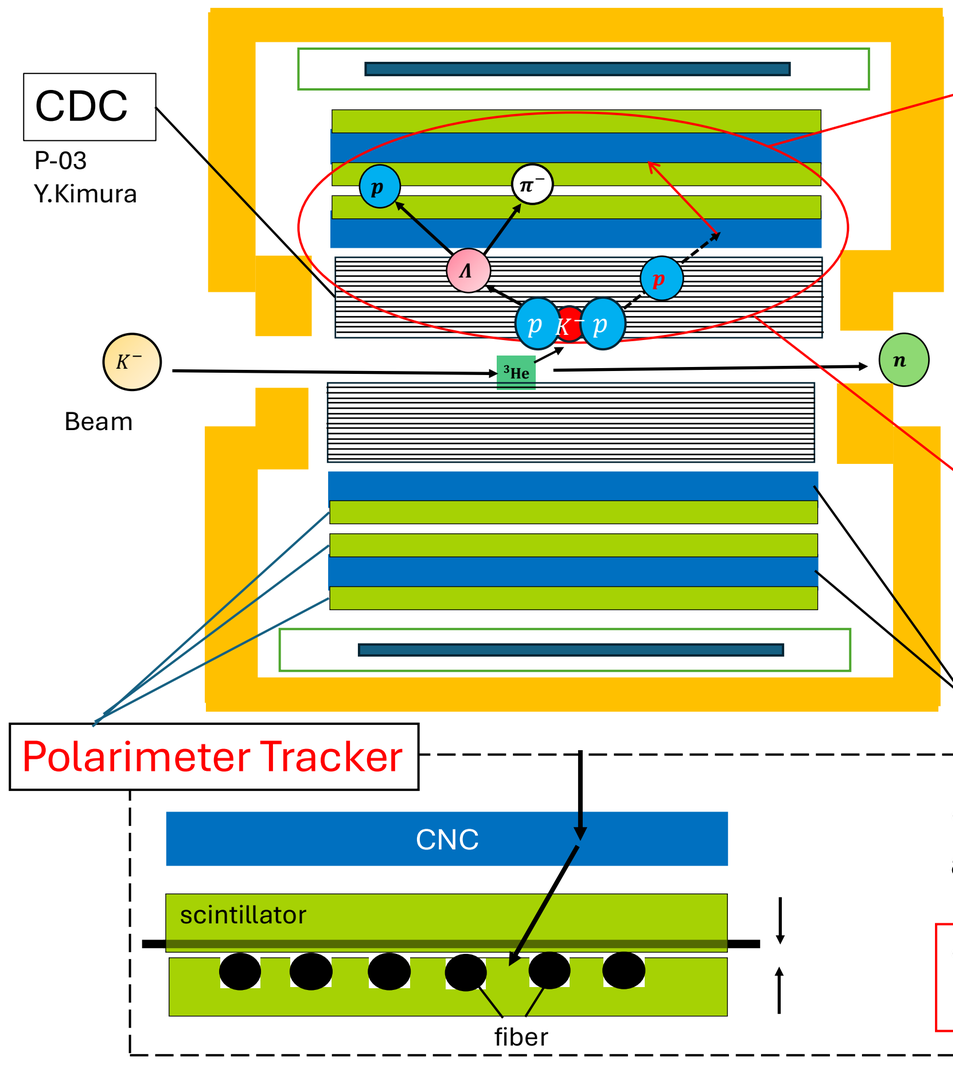
① J-PARC E89 experiment

Objective : Researching fundamental properties of the $\overline{K}NN$ system

Next step

We can determine J^p from observed decay particles

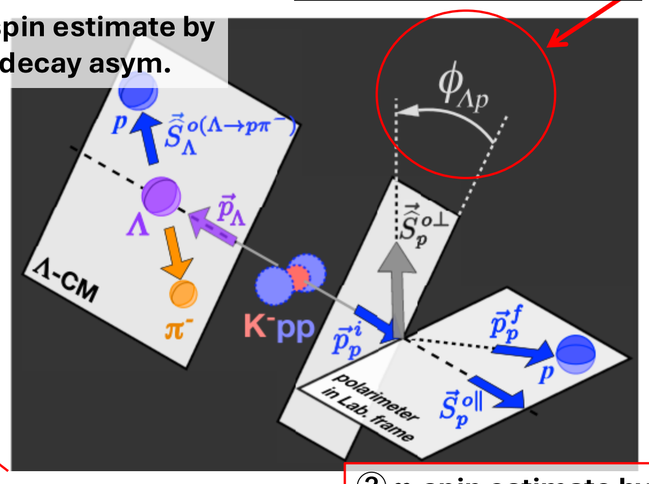
New Cylindrical Detector System



- Observe the proton scattered after Neutron Counter
- Requirement
  Position resolution σ = 1 mm

Decay figure

$\phi_{\Lambda p}$ = ①Plane−②Plane⊥

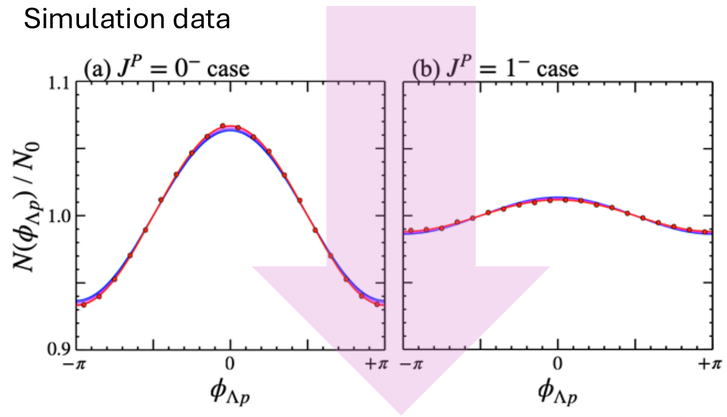


$\phi_{\Lambda p}$ -distribution

$$N(\phi_{\Lambda p}) = N_o(1 + r\alpha_{\Lambda p}\cos\phi_{\Lambda p})$$

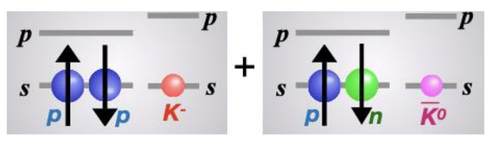
r: asymmetry reduction factor defined by ;
α_-: Λ asym. Parameter
B: magnetic field
A_{PC} : analyzing power
$B_{\overline{K}}$: Binding energy
$f_{\vec{S}_\Lambda}$: spin distribution
q : momentum transfer

Simulation data



There are two possible of J^p of the $\overline{K}NN$ grand state

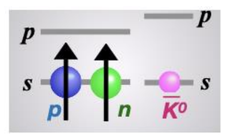
$J^p = 0^-$



$$\frac{|I_{\overline{K}N}=0|^2}{|I_{\overline{K}N}=1|^2} = \frac{3}{1}$$

Deeper bound expected

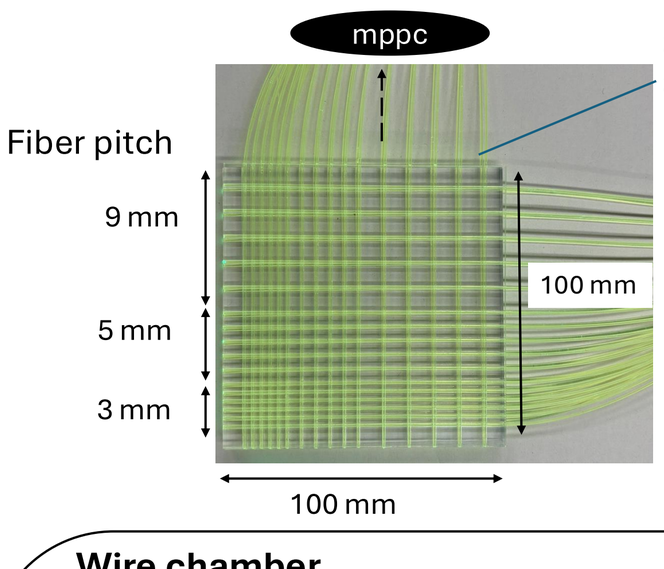
$J^p = 1^-$



$$\frac{|I_{\overline{K}N}=0|^2}{|I_{\overline{K}N}=1|^2} = \frac{1}{3}$$

Shallower bound expected

② R&D prototype detector

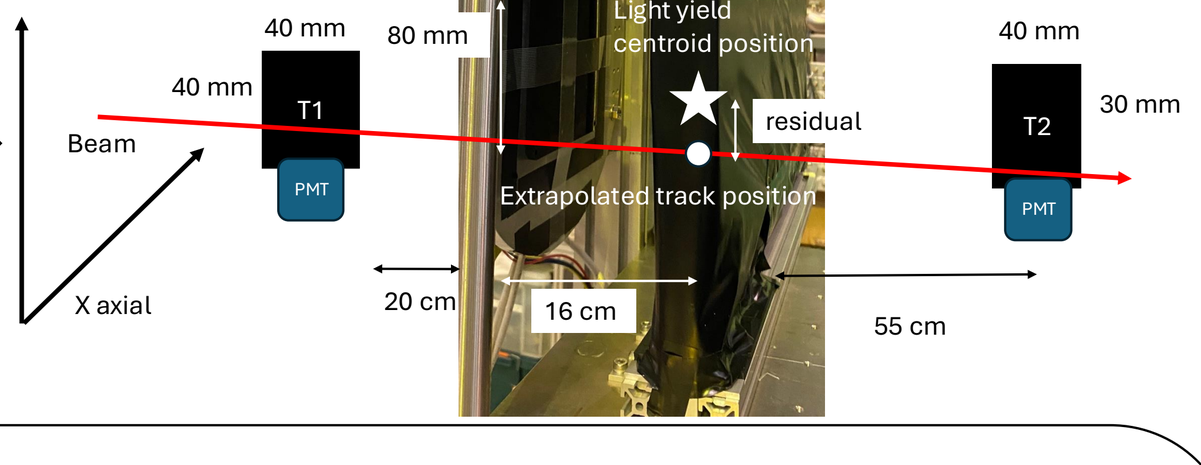


Scintillator thickness
3 mm, 5mm

I studied ...
- optimal fiber pitch (9mm,5mm,3mm...?)
- necessary scintillator thickness (3mmt,5mmt...?)

Beam test

Set up
- J-PARC K1.8BR (Nov.,2025)
- Trigger: T1 ⊗ T2
- Beam: charge particle (K^-,π^- ,e^-)



calculation residual by comparing with wire chamber & prototype detector

Wire chamber

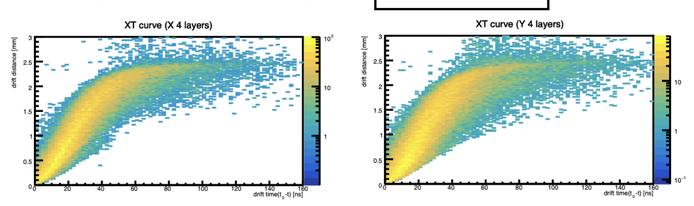
- 8 layer (XX'-YY'-XX'-YY')
- 16 sense wire & 17 potential wire, 5mm spacing for each wire (1 layer)

Efficiency :

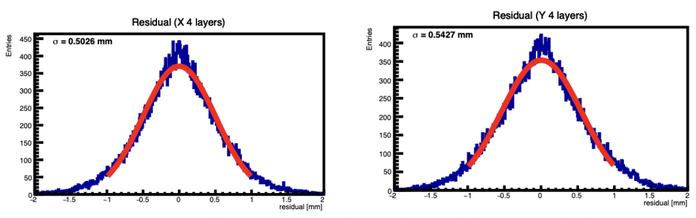
$$E_{wire} = N_{wire\geq 3hit}/(N_{T1} \otimes N_{T2})$$

X : 98.70 %
Y : 95.90 %

XT curve



Residual distribution



→ σ ≃0.5 mm

The extrapolated tracking result is treated as the true position.

Prototype detector

Light yield centroid :

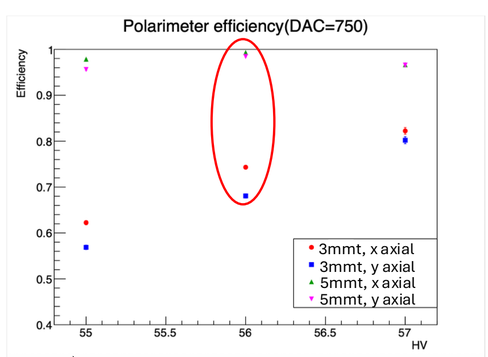
$$\mu = \frac{\sum_i A_i x_i}{\sum_i A_i}$$

A_i: light yield of fiber index i
x_i: position of fiber index i

→ We require at least two consecutive hits.

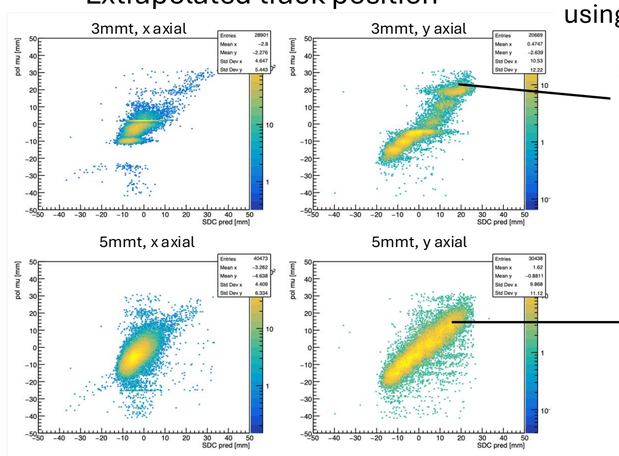
Efficiency :

$$E_{proto} = N_{fiber\geq 2hit}/(N_{T1} \otimes N_{T2})$$

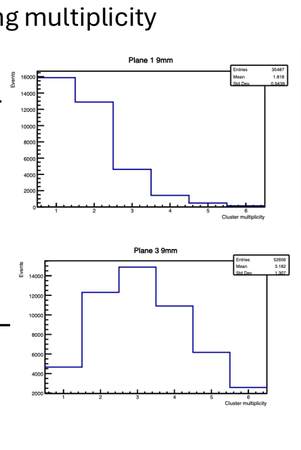


→ High efficiency at 5 mm thickness was confirmed.

Light yield centroid position vs Extrapolated track position



Comparison of scintillator thicknesses using multiplicity



- The 5 mm scintillator was found to perform better.
- Residual evaluation for each fiber is currently in progress.

Summary

We are going to conduct J-PARC E89 experiment to determine J^p of $\overline{K}NN$. We need to install Polarimeter Tracker in New CDS to fill this objective. The requirement of this detector is position resolution σ = 1 mm, and I'm researching it by using of prototype detector. As a result, we found that the 5 mm scintillator performs better. The optimal fiber pitch is currently under evaluation.