Investigation of the Light Kaonic Nuclei

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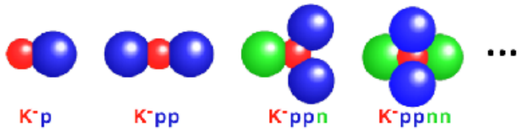
Big Fundamental Question



Can meson be a constituent particle forming nuclei ?

- Matter in the world is made up of fermions (Mesons aren't fermions).
- In nuclei,
  mesoms are virtual particles and form a nuclear potential.
  (In a vacuum, mesons are real particle with their intrinsic mass.)

So basically, meson isn't a constituent of nuclei.

Focus on Strong Attractive $\bar{K}N$ Interaction

- Existence of $\Lambda(1405) \overset{?}{\simeq}$ Bound state of $\bar{K}N$ —> B.E.= 37 MeV
  (Normal nuclear B.E./A ~ 10 MeV)
- Supported by Kaonic Hydrogen X-ray data (SIDDHARTA etc)

One can embed $\bar{K}$ into nucleus!

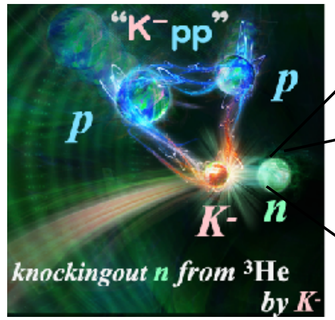
Strong Bound System!

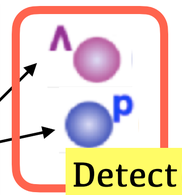
Whole New State of Matter, breaking the mold!

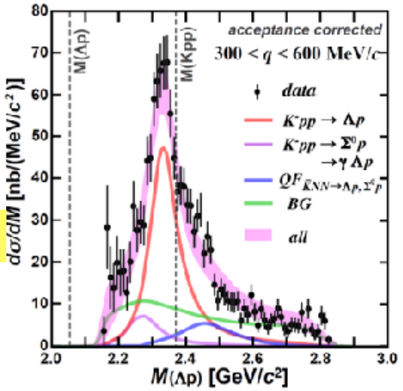
Confirmation of K^-pp

Our group's past exp. J-PARC E15

The binding energy
~ 40 MeV
The decay width
~ 100 MeV





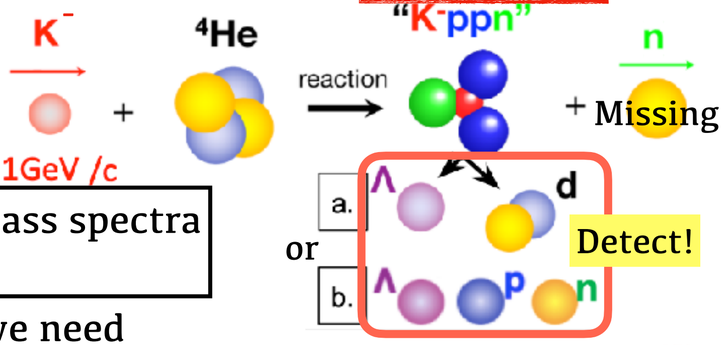


Our Next Step

"Systematic study from the $\bar{K}N$ to $\bar{K}NNNN$ systems to robustly confirm the existence of $\bar{K}$-nuclei and clarify the internal structure"

- As a next step, investigate the $\bar{K}NNN$ system.
  - Increase decay particle
  - Emitted two neutrons
- Detect **all decay particles**

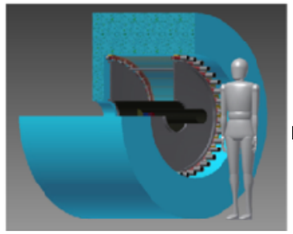
J-PARC E80

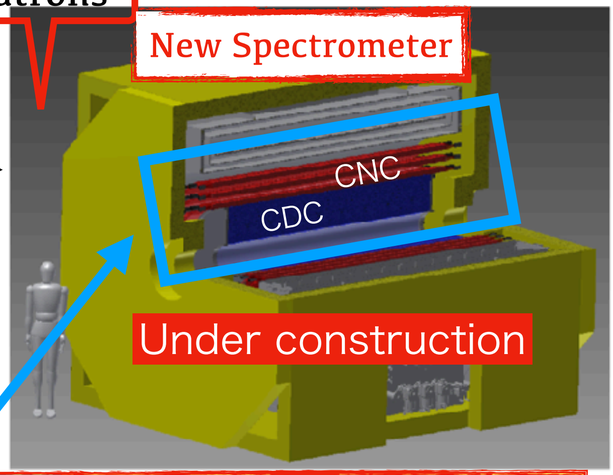


- Reconstruct the invariant mass spectra
  Search for Isospin partner
- To realize the experiment, we need
  - a larger acceptance
  - a higher efficiency of detecting neutrons

Exclusive expriment

Current Spectrometer





According to our simulation,
- Acceptance (59% —> 93%)
- Efficiency of detecting neutron
  (~3% —> ~15%)

I'm responsible for two detectors in the new spectrometer.

- Cylindrical Neutron Counter (CNC)
- Cylindrical Drift Chamber (CDC)

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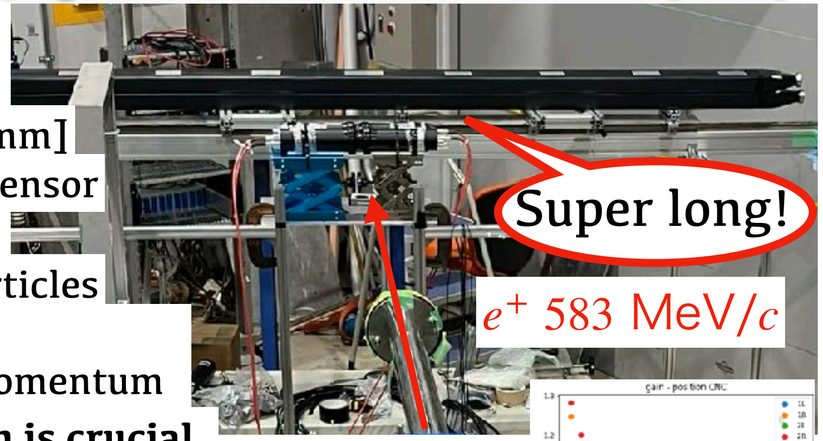
My work this year, Cylindrical Neutron Counter (CNC)

☞ **Prototype of CNC**
- Plastic scintilater
- 2600*120*50t [mm]
- PMT as a photon sensor

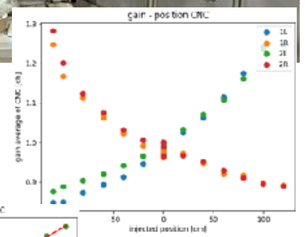


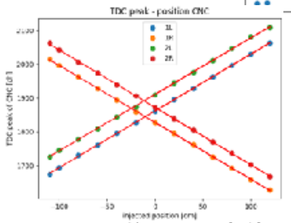
☞ **Roles of CNC**
- To identify the particles
- To detect neutron & determine its momentum

☞ **The time resolution is crucial.**
- Required performance $\sigma \sim 150$ ps

☞ **Test experiment @ELPH in Oct2023.**

- **I did design & make the frame & zig!**
- **I made a plan of all.**

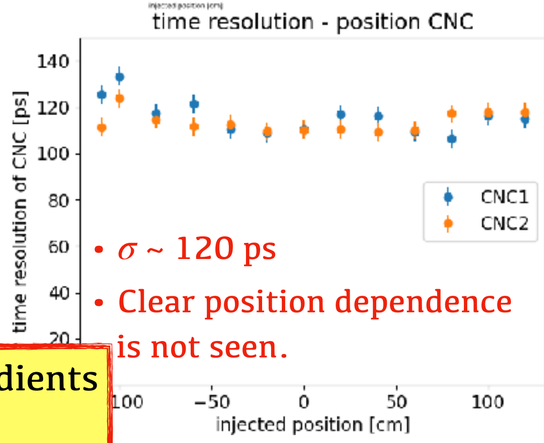




Check the QDC & TDC values

Main purpose of this experiment
- To determine the intrinsic time resolution
- To check the position dependence

Extra test for a higher resolution
- MPPC instead of PMT
- Length of light guide



- $\sigma \sim 120$ ps
- Clear position dependence is not seen.

☞ **I got a lot of data** that would be ingredients for final decision about the design.

☞ Working for a publication

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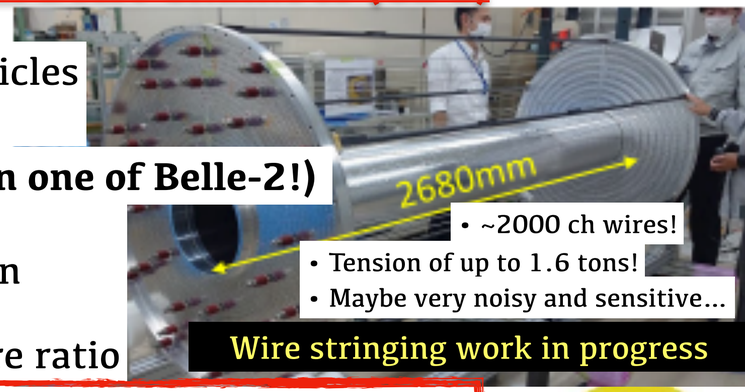
My next work, Cylindrical Drift Chamber (CDC)

☞ **Roles of CDC**
- Tracking charged decay particles
- Analyzing their momentum



☞ **Very large size (bigger than one of Belle-2!)**

☞ **My Work**
- Establish operation condition
- Develop analysis routine
- Select the proper gas mixture ratio

☞ **It requires great patience.**
I have the power of perseverance. Only I can do it!

My Research Plan

Ph.D project @ **J-PARC**

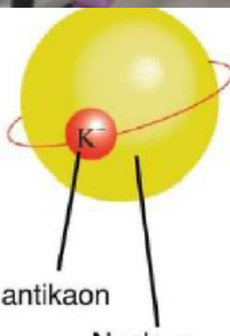
M2 (2024)
- (2024.3~) Launch CDC
- Make it available

D1 (2025)
- Prepare the J-PARC E80

D2 D3 (2026 ~2027)
- Take data in the **J-PARC E80**
- Complete the Ph.D

Oversea project @ **LNF-INFN**

I have to be a specialist about $\bar{K}N$ interaction!



- **SIDDHARTA-2** (~2024.6) **kaonic deuterium** X-ray spectroscopy to get the fundamental information about $\bar{K}N$ interaction
- **EXKALIBUR** (2025.6~) Investigation of **heavier kaonic atom** for further constraints about $\bar{K}N$ interaction

Motivations I applied for GP-PU

In the future, I'd like to lead large-scale international experiments to enlarge the human knowledge. So, through the international experiment in the GPPU, I'll obtain cutting-edge techniques and improve my international communication skills!