

Development of a gaseous TPC for the detection of Migdal effect



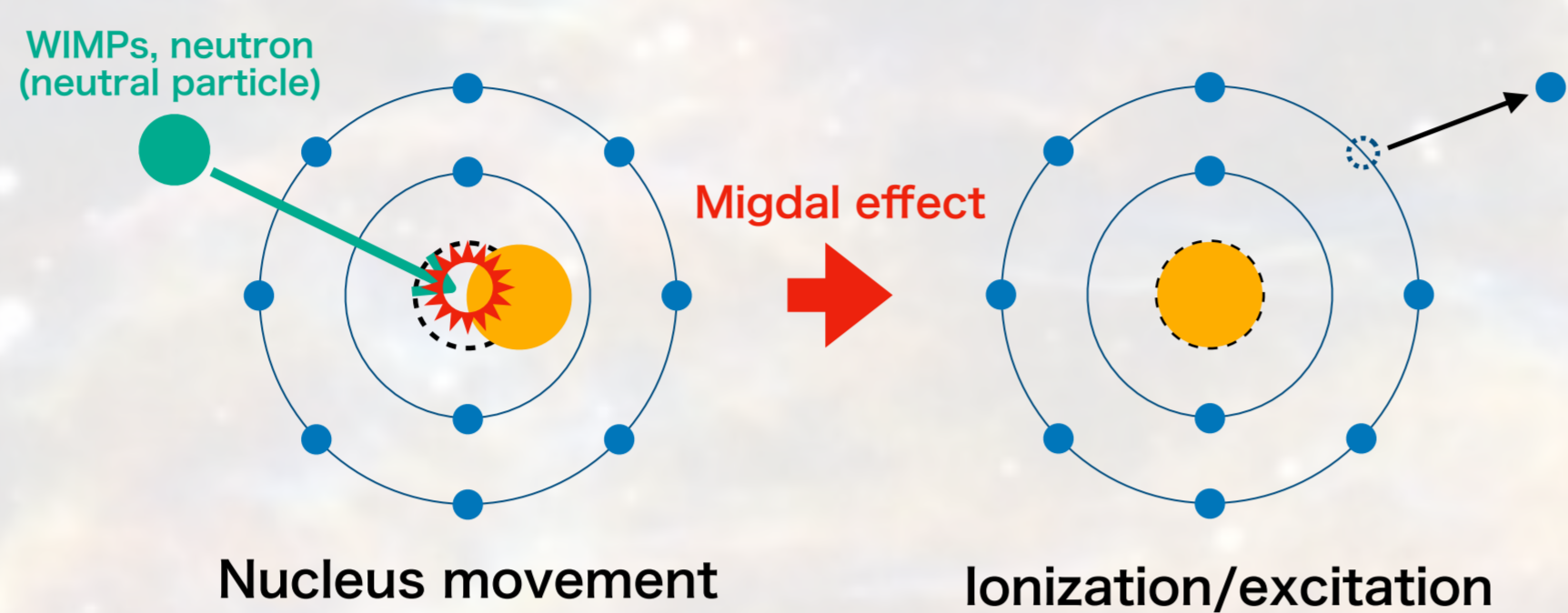
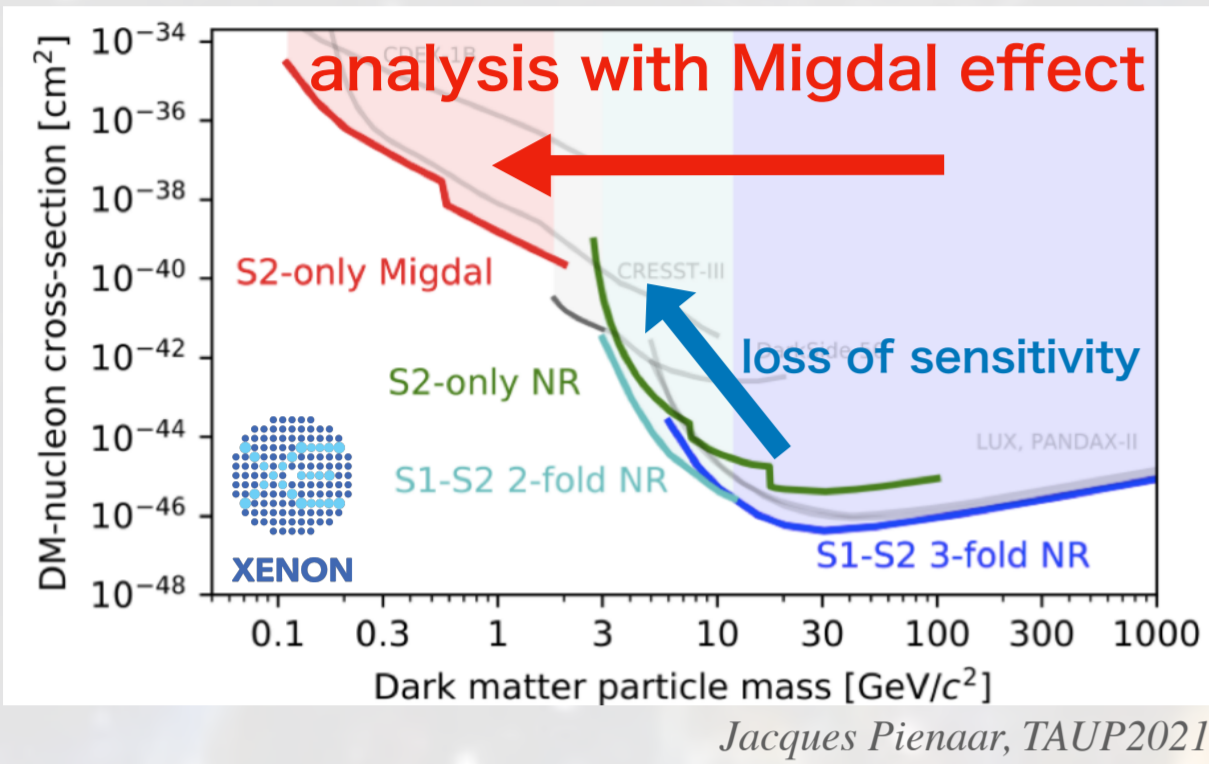
Kei Kanazaki, Kobe University
on behalf of the **MIRACLUE** Collaboration



UGAP 2022 Workshop, 13th-15th, June, Tokyo University of Science

1. Introduction

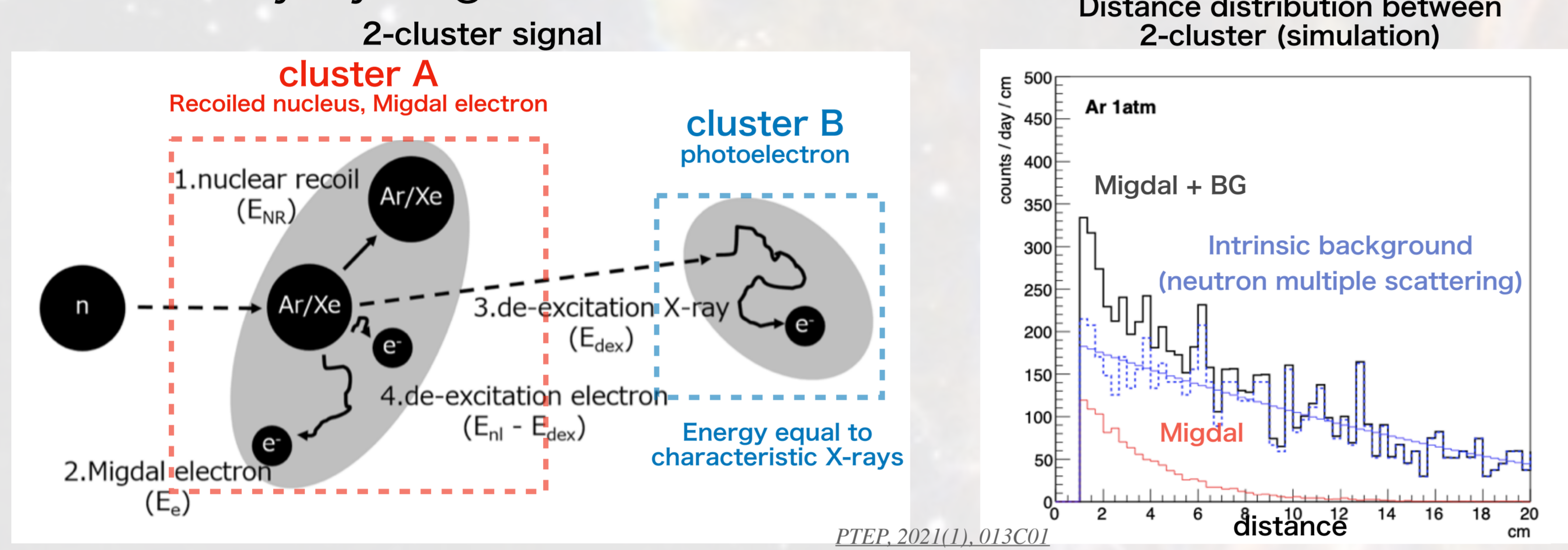
- In recent years, the search for **low-mass WIMPs** as candidates for **dark matter** has been active.
- Especially, the search for low-mass WIMPs using the **Migdal effect** has attracted much attention.



- Migdal effect is a phenomenon in which **ionization or excitation** occurs due to the **rapid nuclear movement**, with **low probability**. (Ionization branching is $10^{-1} \sim 10^{-5}$ in Ar)
→ Additional electric energy are generated by nuclear recoil.
→ low-mass WIMPs with low recoil energy can be searched for.
- However, **Migdal effect with nuclear recoil has not been confirmed !**

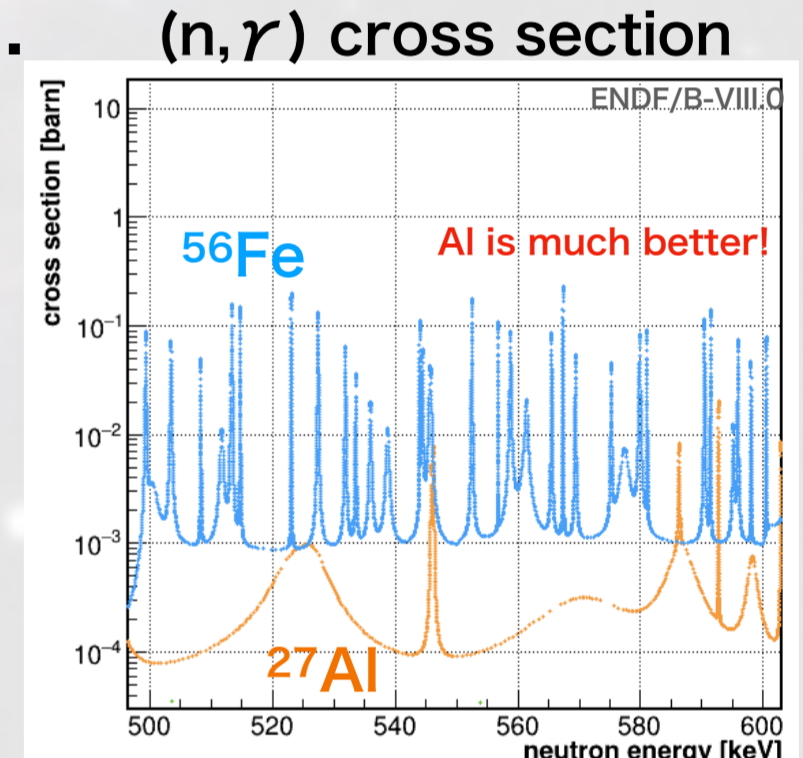
2. MIRACLUE

- We are aiming to confirm Migdal effect via nuclear recoil using **neutron beam and a gaseous TPC** (Time Projection Chamber)
- Argon(Kobe)/Xenon(Tohoku) gas TPCs are developed.
- 3D position reconstruction** of "**2-cluster**" signal with K-shell X-ray by Migdal effect.



3. Background reduction

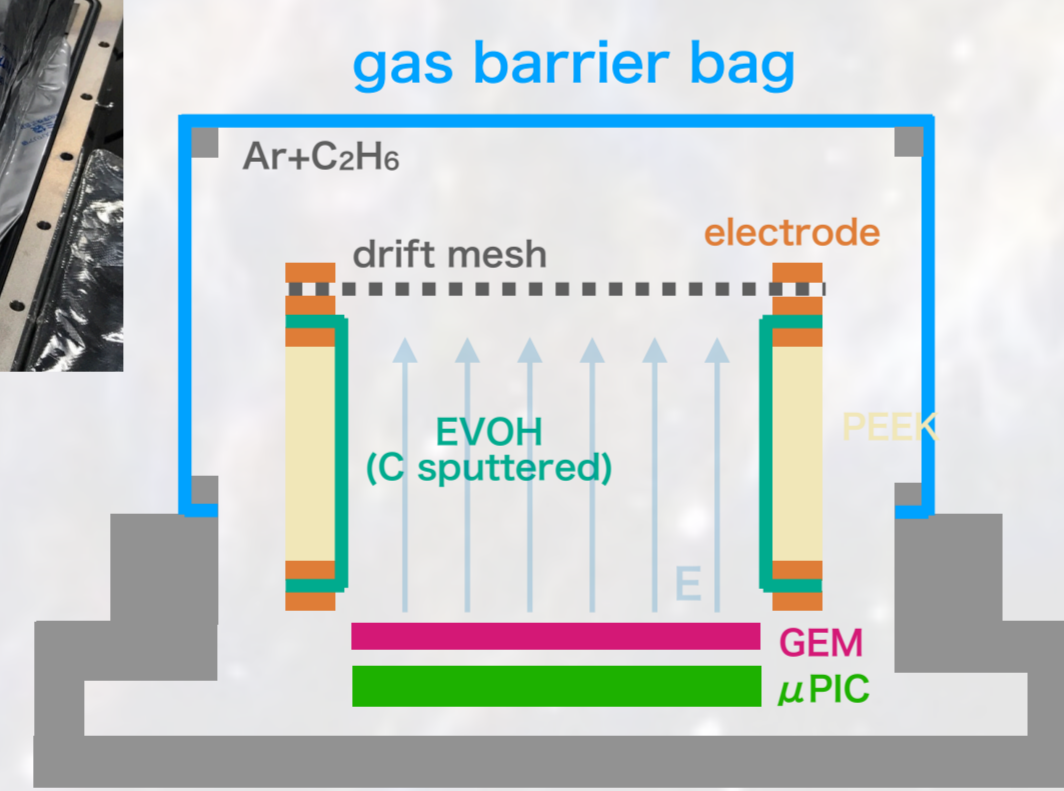
- Main background is γ -ray from (n, γ) reaction**
- γ -ray from laboratory**
The most dominant (estimation by simulation)
→ Constructing collimator made of **polyethylene with 50% LiF***
- γ -ray from detector components**
→ ^{56}Fe in a TPC vessel has a large (n, γ) cross section for fast neutron.
→ More thinner, less reactive vessel is required.
→ **TPC using gas barrier bags** has been developed.



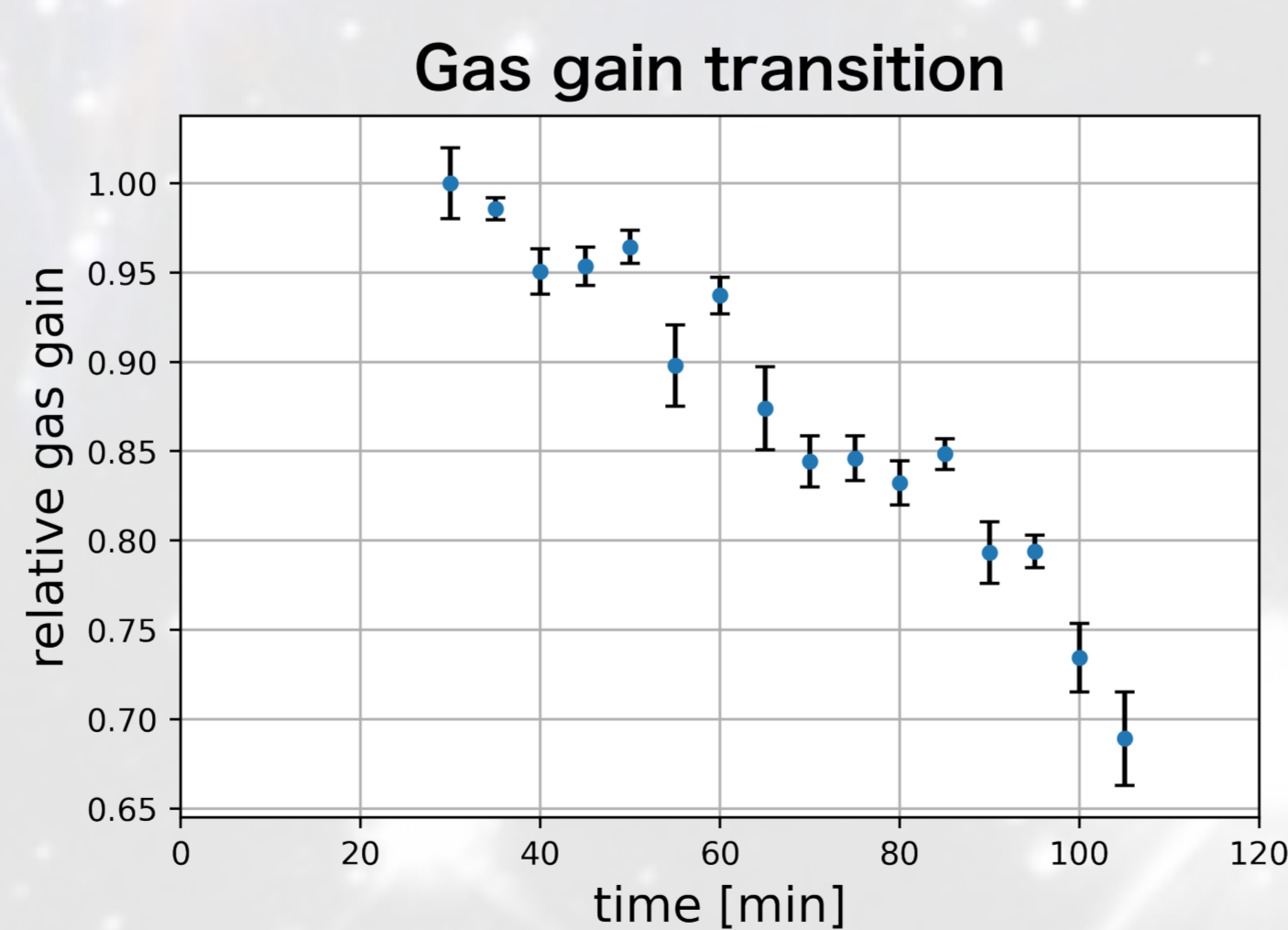
* BG measurement results will be presented in M.Ofuji's poster presentation. (P27)

4. Detector Development

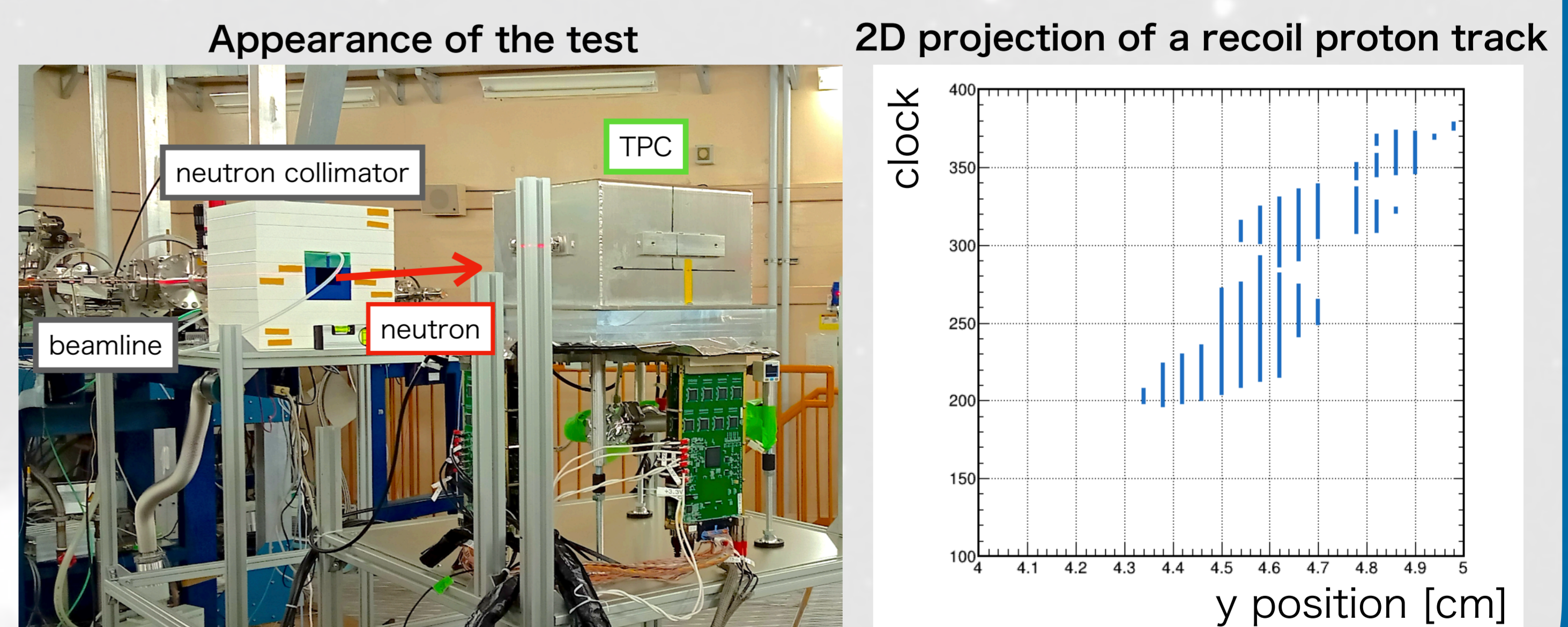
- Detector Overview**
 - Gas (1atm)**
Ar : C₂H₆ (quencher) = 9 : 1
 - Detection Volume**
10×10×8 cm³
 - Gas Amplification & readout**
GEM & μ PIC (10×10 cm²)
 - Gas barrier bag**
Al+plastic bag (MITSUBISHI GAS CHEMICAL)



- Test of gas gain transition for checking hermeticity.
→ **Gas gain is decreasing**
→ **Identification of gas leak**



- We carried out first neutron beam test.
- April 2022, at National Institute of Advanced Industrial Science and Technology (AIST)
- beam information
565keV neutron, $^6\text{Li}(p,n)^7\text{Be}$ reaction, using metal Li target
- Operation was confirmed in a high intensity neutron field. (flux $\sim 10^3/\text{cm}^2/\text{sec}$)
→ **Successfully obtained a tracking.***



* The analysis results will be presented in Y.Hamada's poster presentation. (P20)

5. Prospects

- Gas barrier improvements.
- Larger TPC development using a 30×30 cm² μ PIC for more larger statistics.
→ **World's first observation of the Migdal effect or first limit on its branching !**
- Components selection that are less likely to cause (n, γ) .

6. Summary

- Argon gas TPC with gas barrier bag was developed.
- Neutron beam tests were performed using the TPC
→ Successfully obtained recoil tracks.
- We'll develop a larger detector for world's first Migdal effect detection.