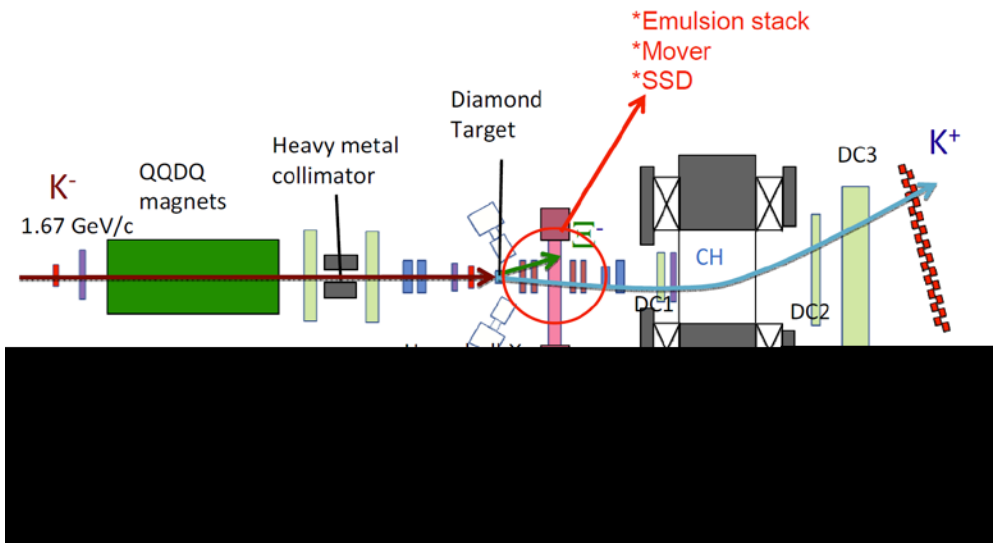
J-PARC E07 Experiment: Development of Overall Scan

○Masahiro Yoshimoto, Kazuma Nakazawa (Gifu Univ.),
Junya Yoshida (ASRC, JAEA), and other J-PARC E07 collaboration

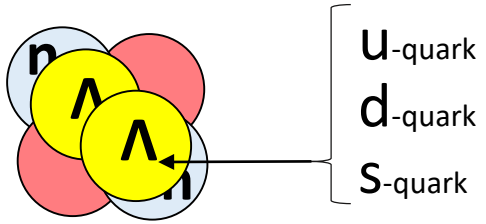
Aims of J-PARC E07 experiment

- Detection of double hypernuclei (S=-2)
  - Obtain double Λ hypernuclei with 10 times statistics
  - Nuclear dependence of Λ-Λ binding energy
  - ΞN interaction via twin-Λ hypernuclei.
- Ξ^- atom X-ray spectroscopy

K1.8 Beam Line @J-PARC



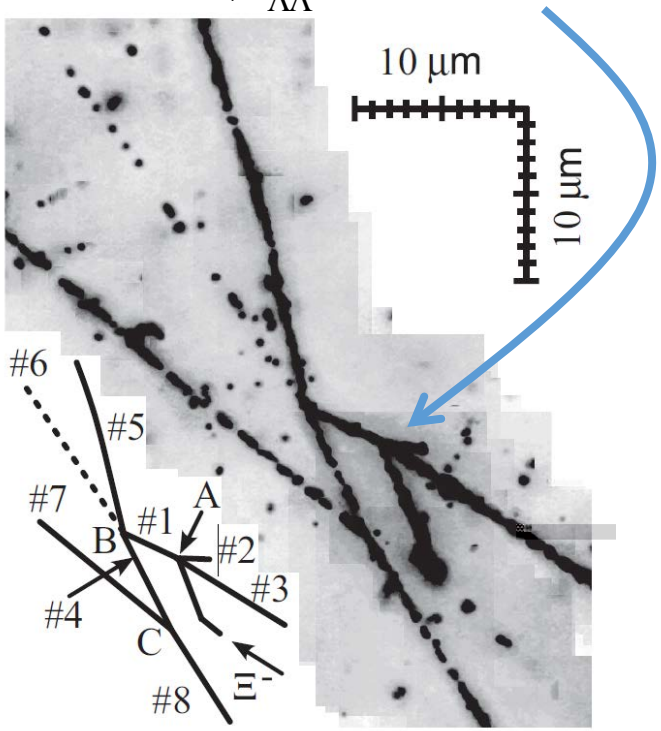
Double Λ hypernucleus



$^{6}_{\Lambda\Lambda}$He (^{4}He + 2Λ)

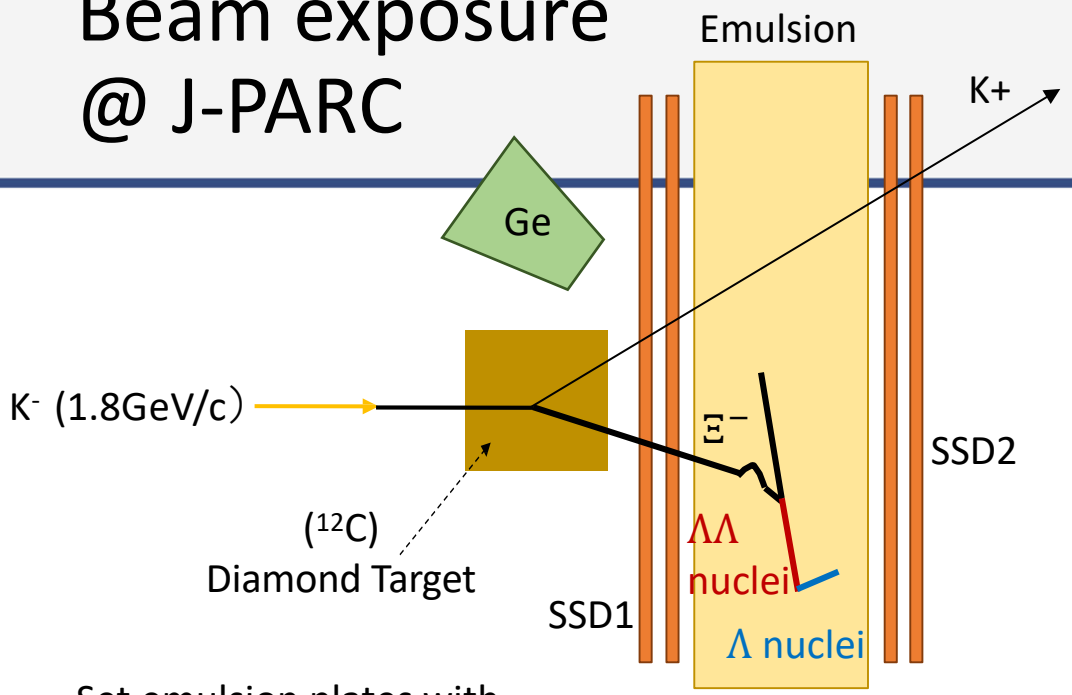
Nagara event (KEK PS E373)

$\Xi^- + {}^{12}C \rightarrow {}^{6}_{\Lambda\Lambda}He + {}^{4}He + t$

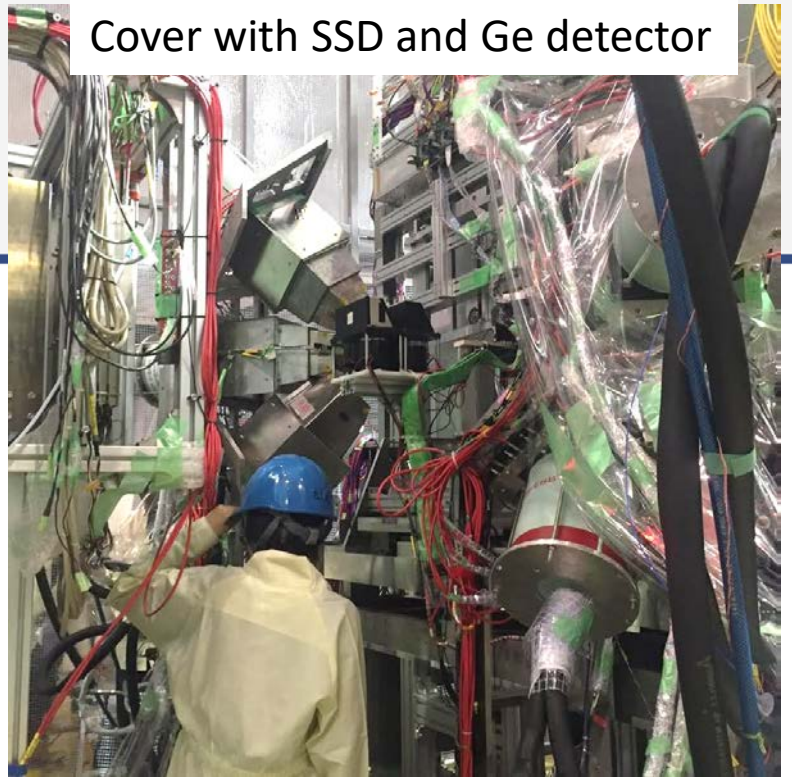


PRL 87 (2001) 212502.
PRC 88 (2013) 014003.

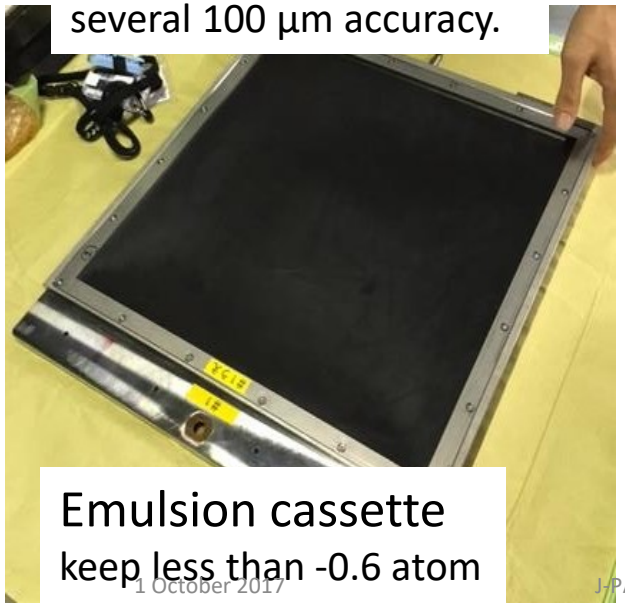
Beam exposure @ J-PARC



Cover with SSD and Ge detector

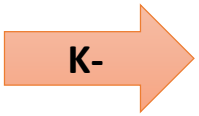


Set emulsion plates with several 100 μm accuracy.



Emulsion cassette
keep less than -0.6 atom

Emulsion mover

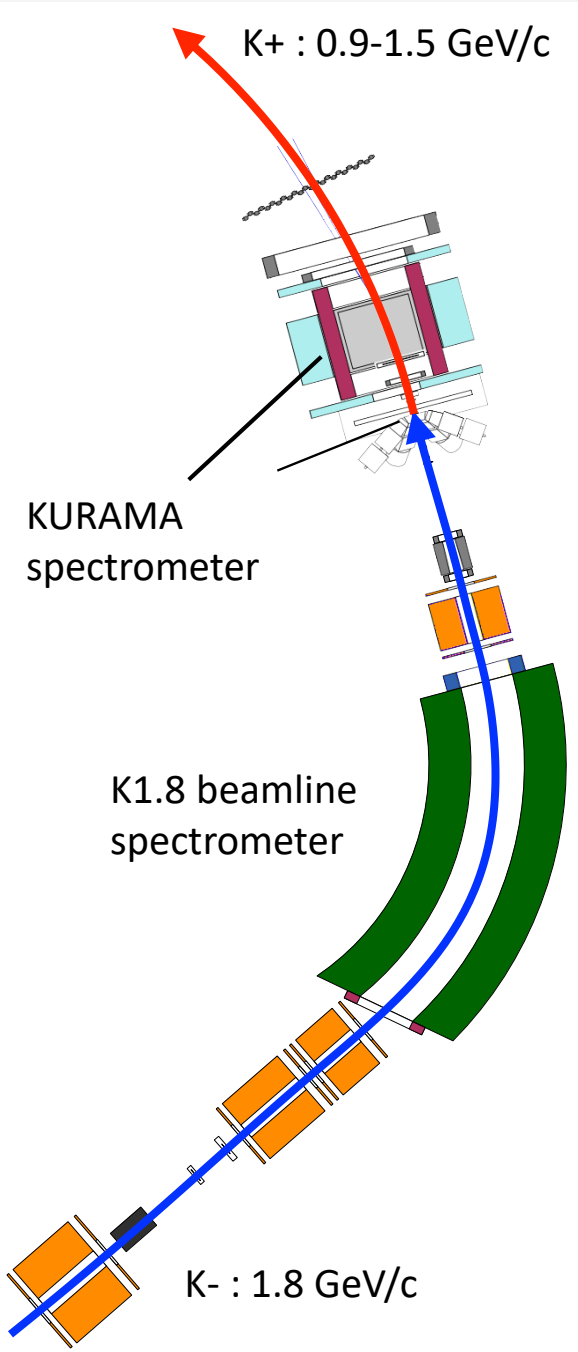


Beam exposure @ J-PARC

- Produce Ξ^- with quasi-free p(K-,K+)Ξ^- reaction
  - Target: diamond (^{12}C)
  - Spectrometer for incident and scattered particles

80%

S. Hayakawa slide in JPS 2017 autumn

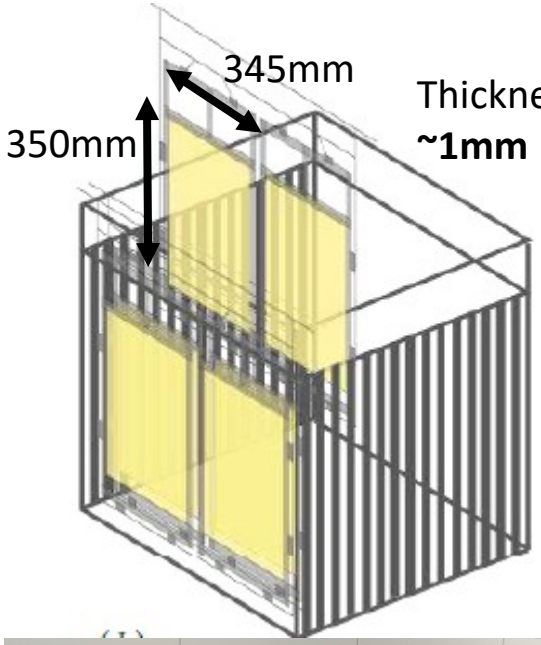


- Purity of K- meson is x3.5 higher than KEK-PS
- Mass of emulsion is x3 larger than KEK E373

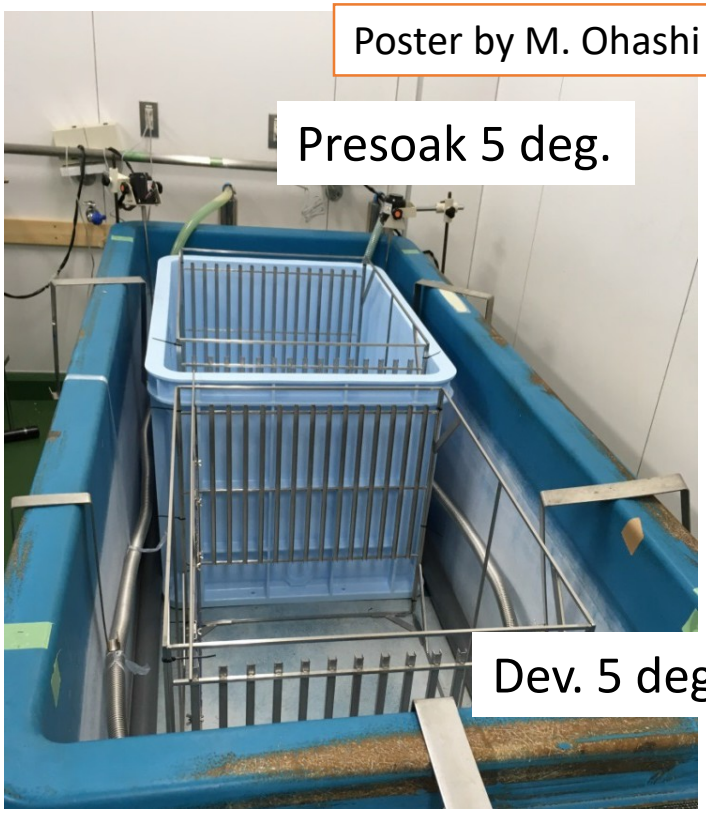
10 times higher statistics than KEK-PS E373

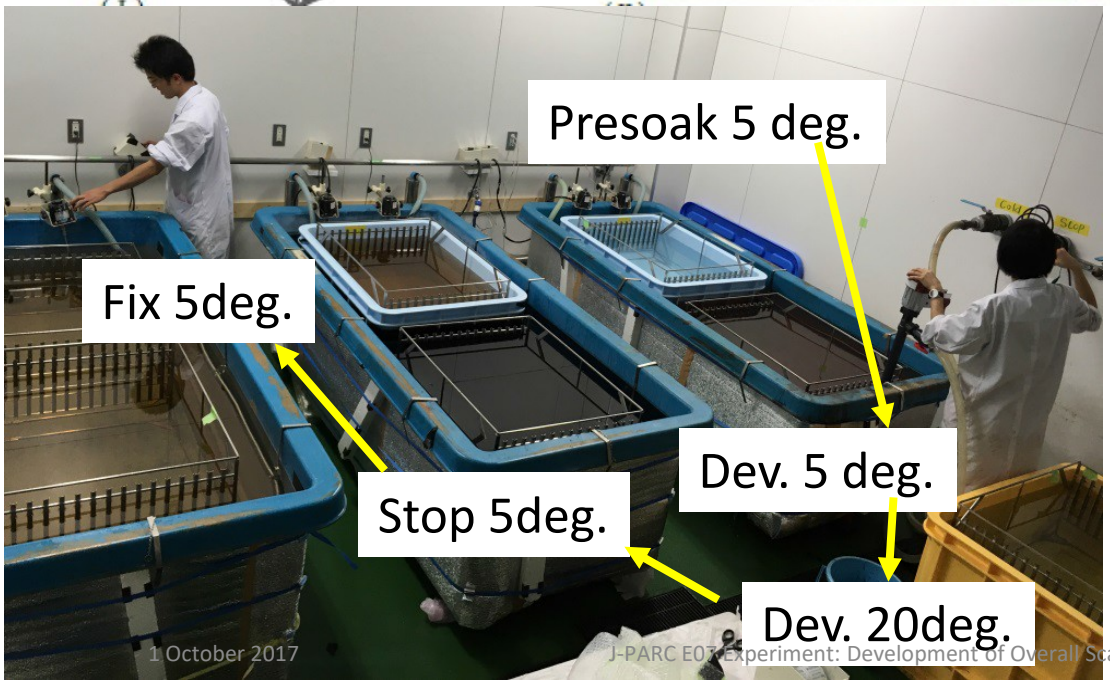
Chemical development for E07

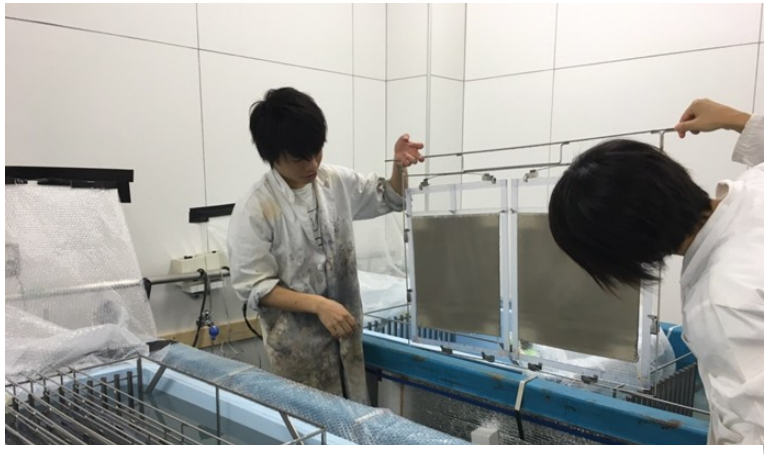
Poster by M. Ohashi



Thickness
~1mm



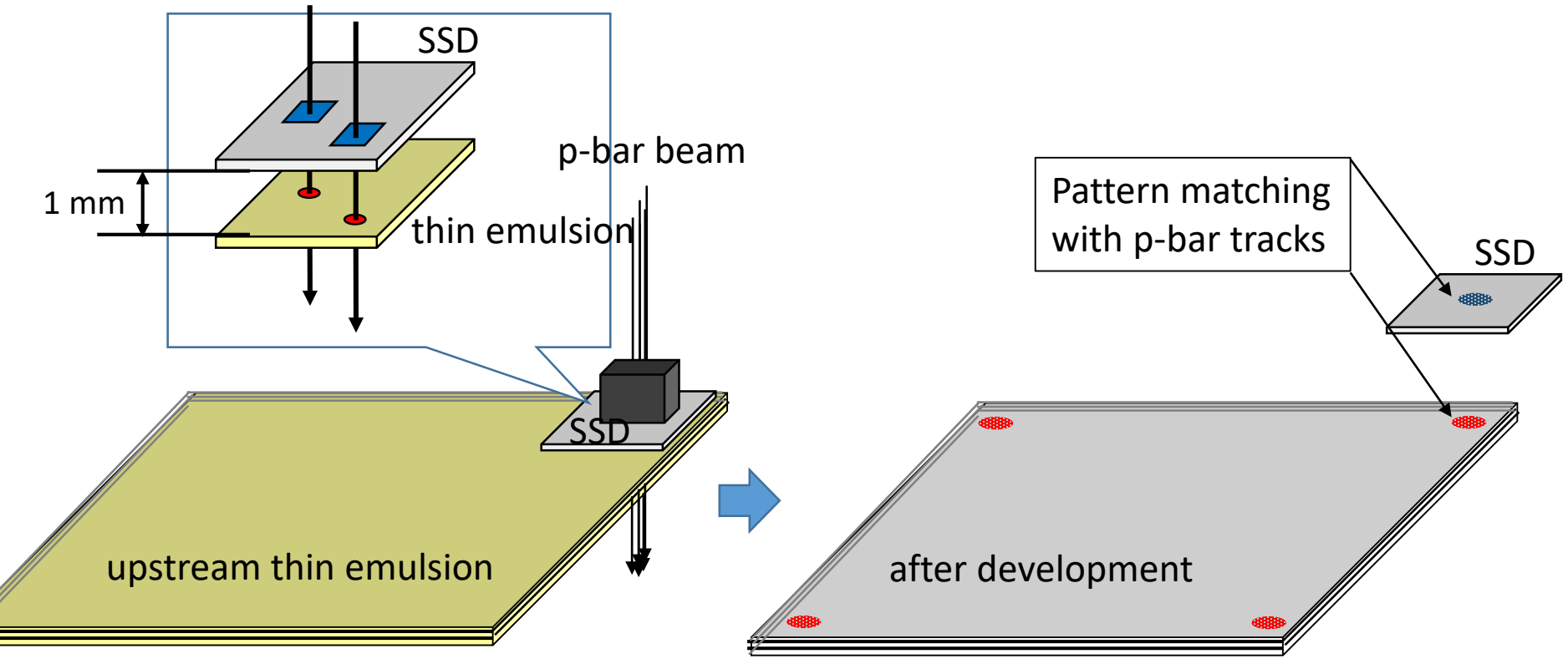




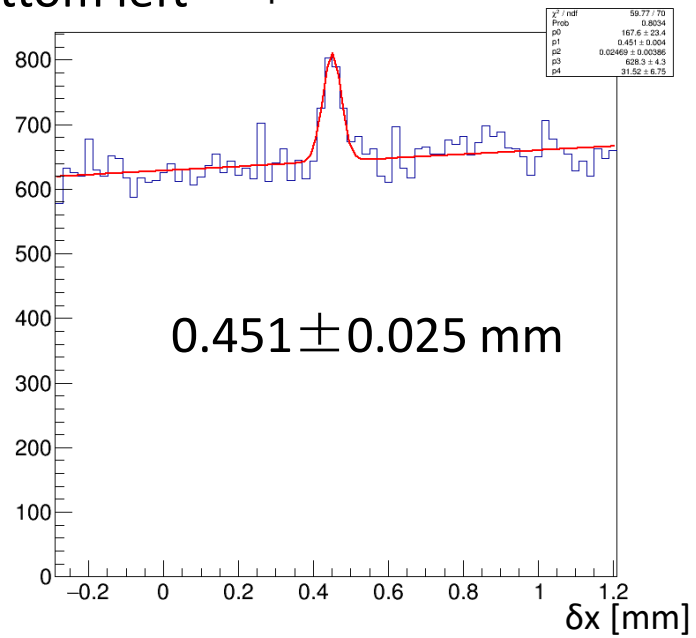
60 plates/cycle (total 1298 plates)
~5 days/cycle from presoak to fix

Positional alignment from SSD to emulsion

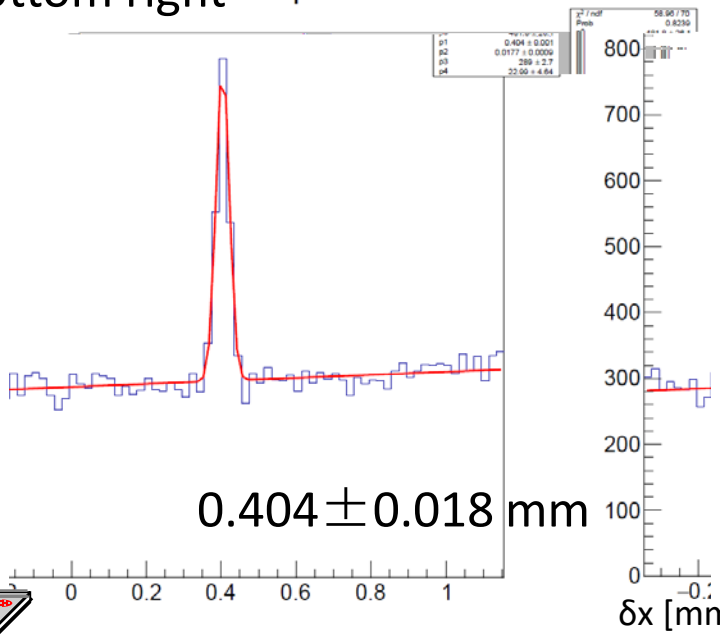
- To know the positional alignment from SSD to emulsion, we irradiated antiproton (p-bar) beam with the flux of ~10^4/cm^2 to emulsion at four corners.
  - Considering the pitch of SSD is 50 μm ↔ the resolution of emulsion is 1 μm



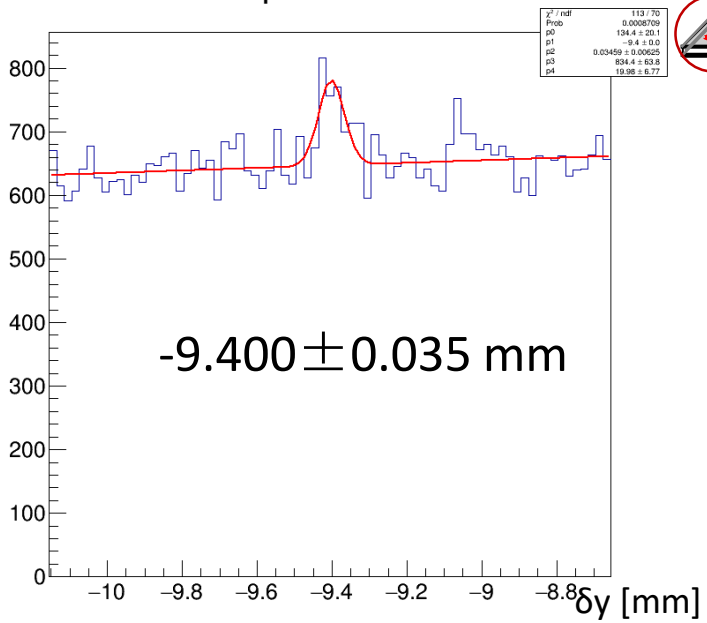
Bottom left Displacement X

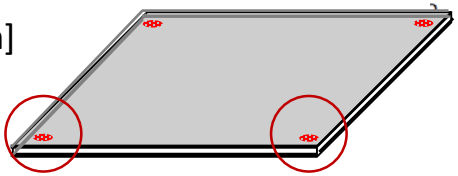


Bottom right Displacement X

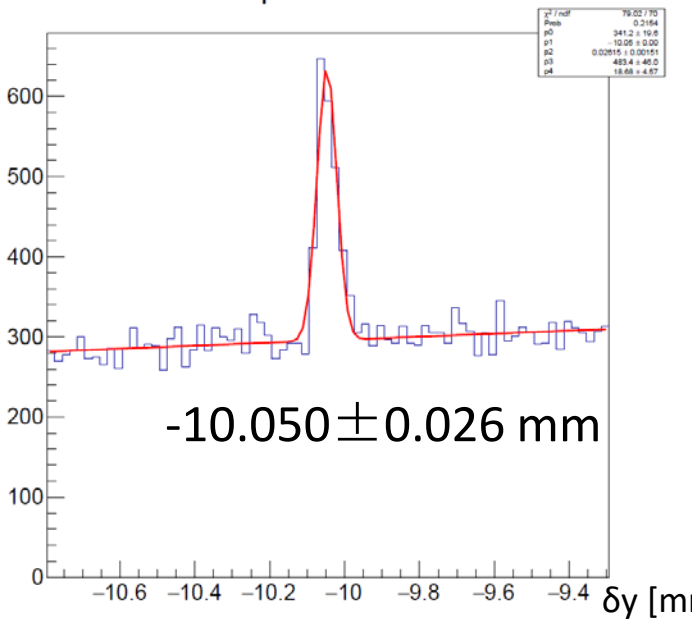


Displacement Y





Displacement Y



Ξ^- detection by hybrid method

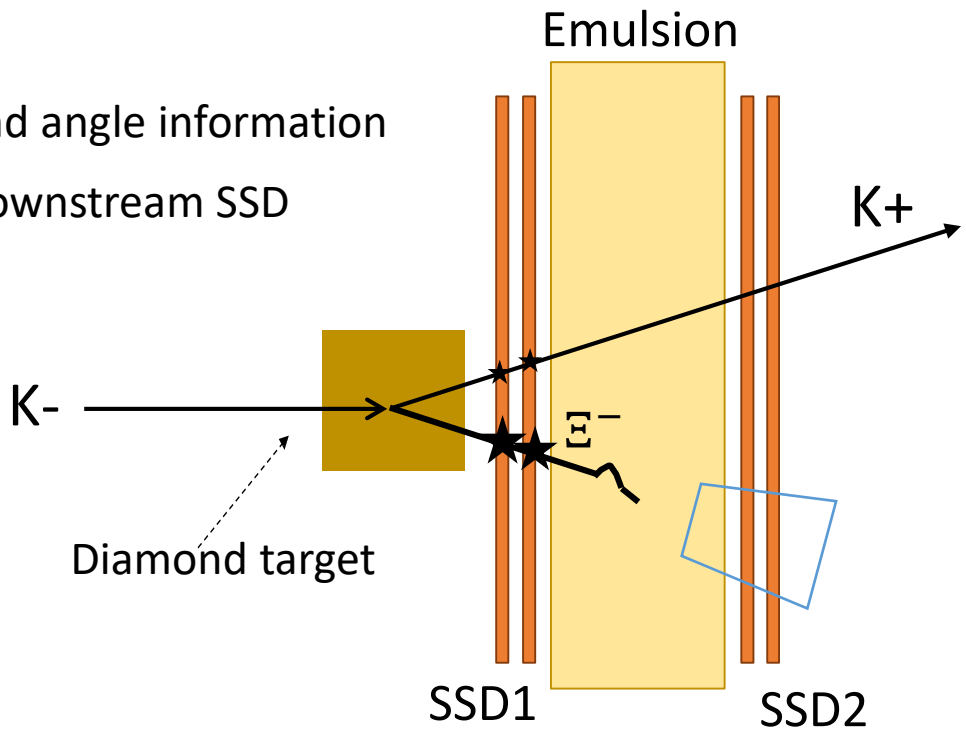
- Detect Ξ^- stopped in the emulsion from p(K-, K+) Ξ^- interactions
- Method
  - Detect (K-, K+) with spectrometers
  - Select high dE tracks with upstream SSD to reject MIP* and choose Ξ^-
  - Ξ^- was identified using vertex and angle information
  - Check penetrated tracks with downstream SSD

* Minimum ionizing particle

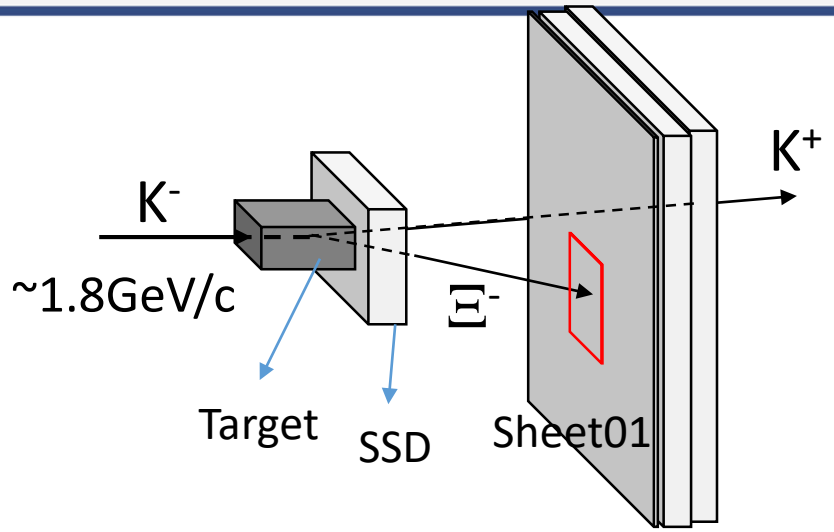
of Ξ^- candidates is 52,259.
of Ξ^- stop (MC) is 9,180.

H. Ekawa slide in JPS 2017 autumn

~10^2 double hypernuclei,
~10 identification of nuclide.



Connect Ξ^- from SSD to emulsion



Positional discrepancy between **predicted** tracks from SSD and **found** tracks in the emulsion

Preliminary

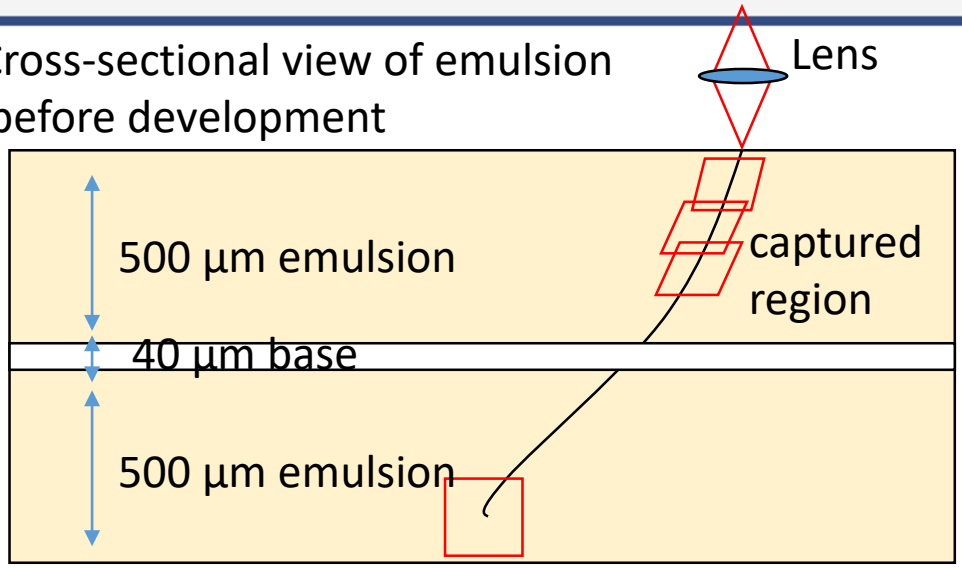
δy [mm]

δx [mm]

Follow Ξ^- in thick emulsion

M.K.Soe et al., NIM-A 848 (2017) 66–72
Poster by R. Goto

Cross-sectional view of emulsion
before development



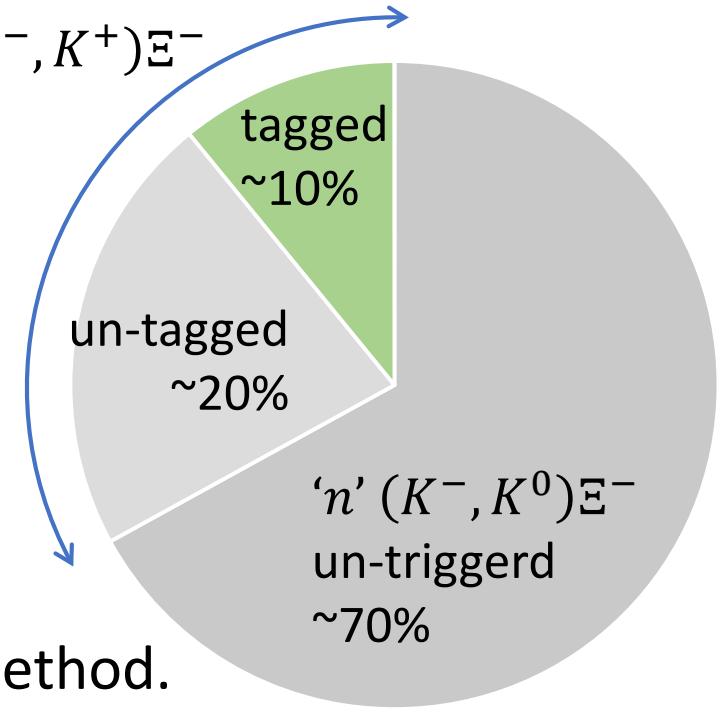
Follow the Ξ^- candidate tracks.
When the track stops,
save the surrounding images

Superposition image
around stopping point
with depth of 290 µm

Overall detection method

- Yield of the hybrid method is limited.
  - Ξ^- hyperons from ~30% of 'p' $(K^-, K^+)\Xi^-$ and ~70% from 'n' $(K^-, K^0)\Xi^-$.
  - K^+ Tagging yield is ~30% due to detector acceptance and tracking efficiency.

10 times higher statistics than hybrid method

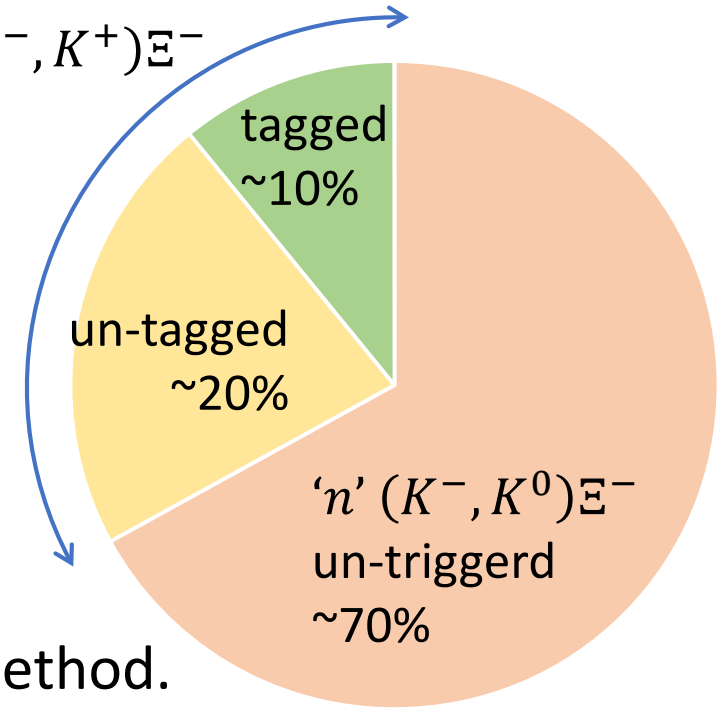


- However, it is necessary to readout ~1000 times larger area than hybrid method.

Overall detection method

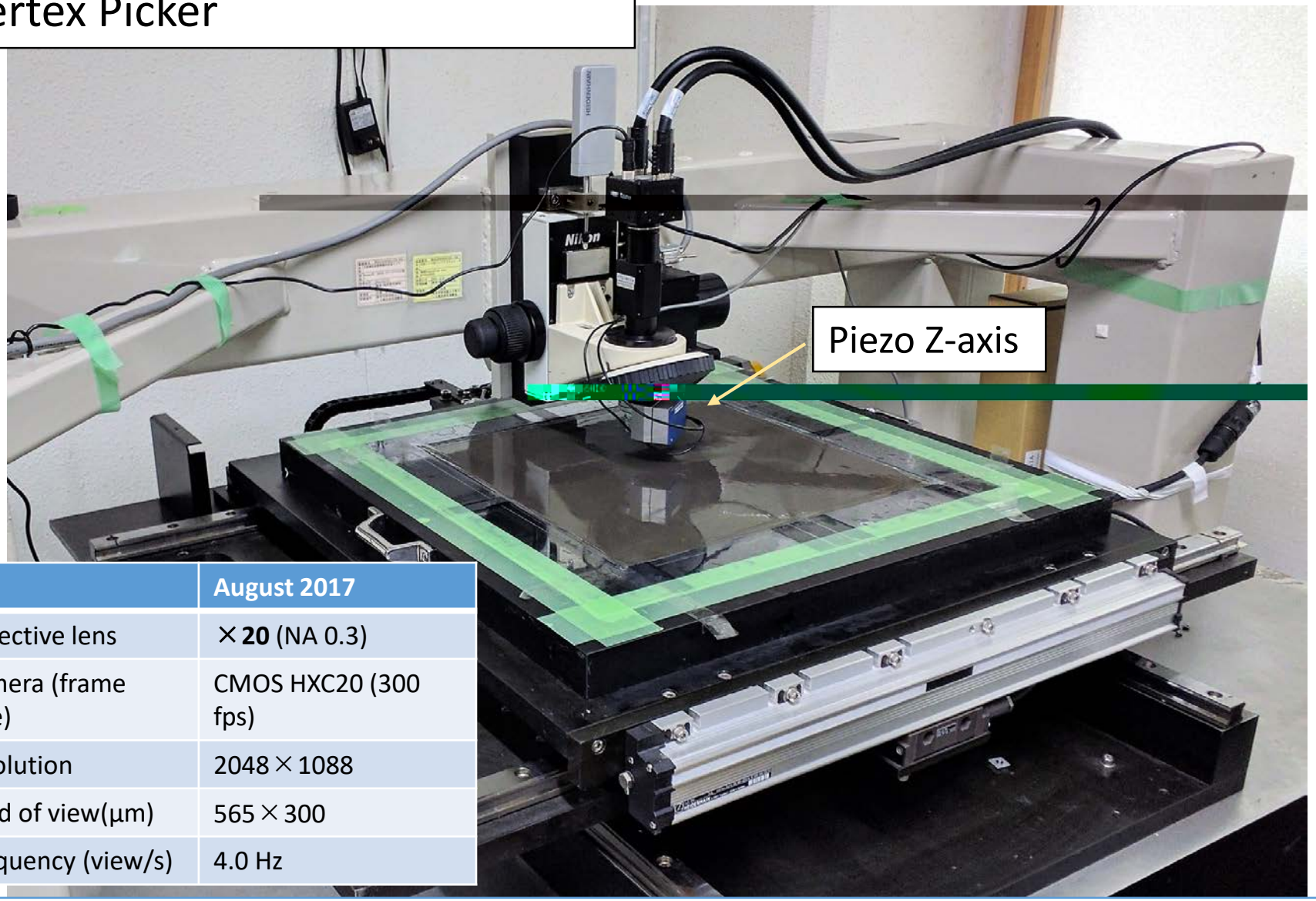
- Yield of the hybrid method is limited.
  - Ξ^- hyperons from ~30% of 'p' $(K^-, K^+)\Xi^-$ and ~70% from 'n' $(K^-, K^0)\Xi^-$.
  - K^+ Tagging yield is ~30% due to detector acceptance and tracking efficiency.

10 times higher statistics than hybrid method



- However, it is necessary to readout ~1000 times larger area than hybrid method.

Fully automated readout system Vertex Picker



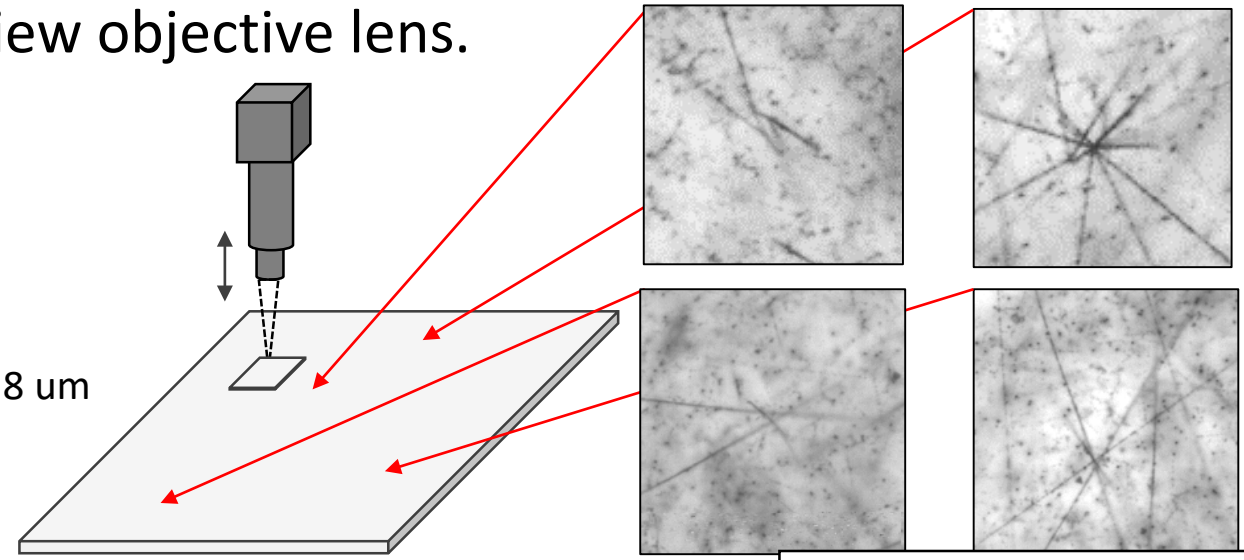
	August 2017
Objective lens	×**20** (NA 0.3)
Camera (frame rate)	CMOS HXC20 (300 fps)
resolution	2048×1088
Field of view(μm)	565×300
Frequency (view/s)	4.0 Hz

All thick emulsion plates of E07 can be readout in 2 years (400 days) with 10 stages

1st scanning by Vertex Picker

developed by J. Yoshida

Select vertex like event by overall scanning with wide-view objective lens.

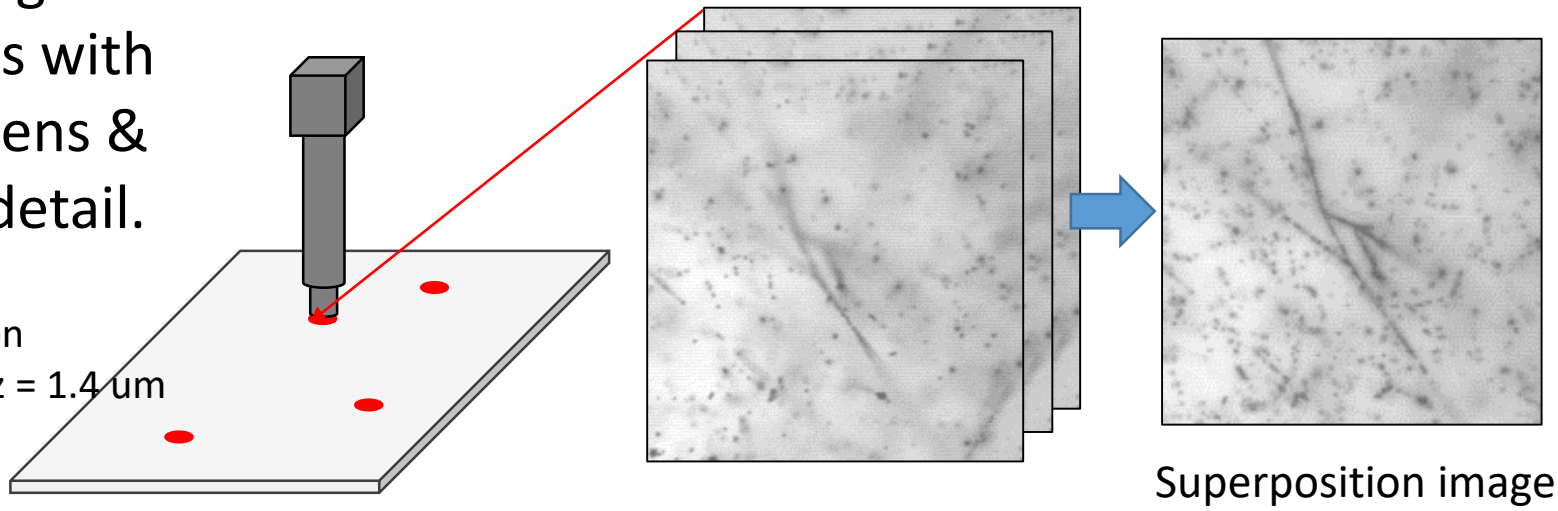


Spatial resolution
δx = 0.9 um, δz = 8 um

High purity vertex selection is needed.

2nd scanning

Take images with higher NA lens & analyze in detail.



Spatial resolution
δx = 0.36 um, δz = 1.4 um

Superposition image

Summary

- J-PARC E07 experiment aimed at double Λ hypernuclei with 10 times statistics.
- Beam exposure was succ1(s)]4.1(f(t)-25(su)ll3(i)-0y4(c)-4)-5 tsusu1(d4(h)-3..4(a(r