

Spectroscopic Study of Hyperon Resonances below $K^{\text{bar}}N$ Threshold via the (K^-,n) Reaction on Deuteron

H. Noumi, Osaka Univ. RCNP, for the E31 collaboration

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1. Introduction:

1. Research Center for Nuclear Physics, Osaka University, Japan

2. University of Victoria, Canada, 3. Seoul National University, South Korea

4. Stefan Meyer Institut für subatomare Physik, Austria,

5. INFN Sezione di Torino, Italy, 6. Università di Torino, Italy

7. Osaka University, Japan, 8. Laboratori Nazionali di Frascati dell'INFN, Italy

9. RIKEN, Japan, 10. Tokyo Institute of Technology, Japan

11. Osaka Electro-Communication University, Japan, 12. University of Tokyo, Japan

13. Kyoto University, Japan, 14. High Energy Accelerator Research Organization (KEK), Japan

15. Technische Universität München, Germany, 16. Tohoku University, Japan

$K^{\text{bar}}N$ int. and $\Lambda(1405)$

2. Preparation Status

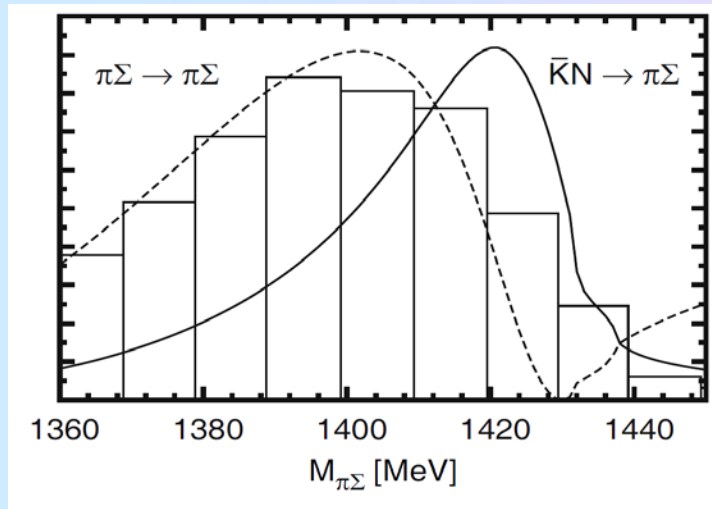
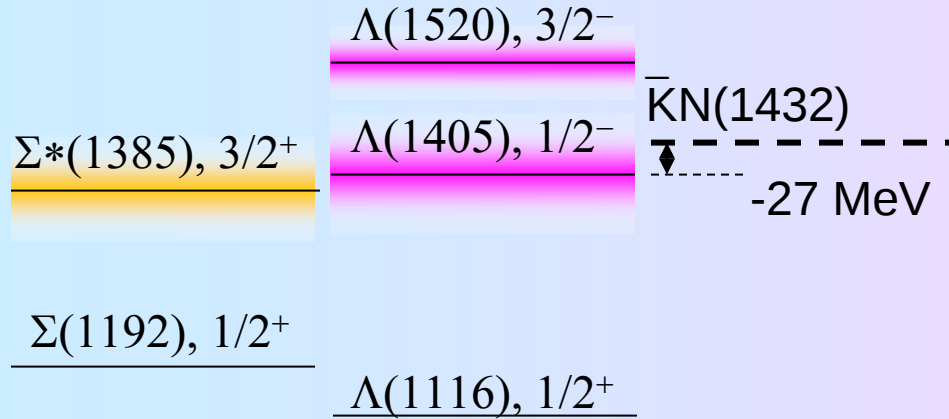
Target System

Detectors for $\Lambda^*(1405) \rightarrow \pi^0 \Sigma^0$

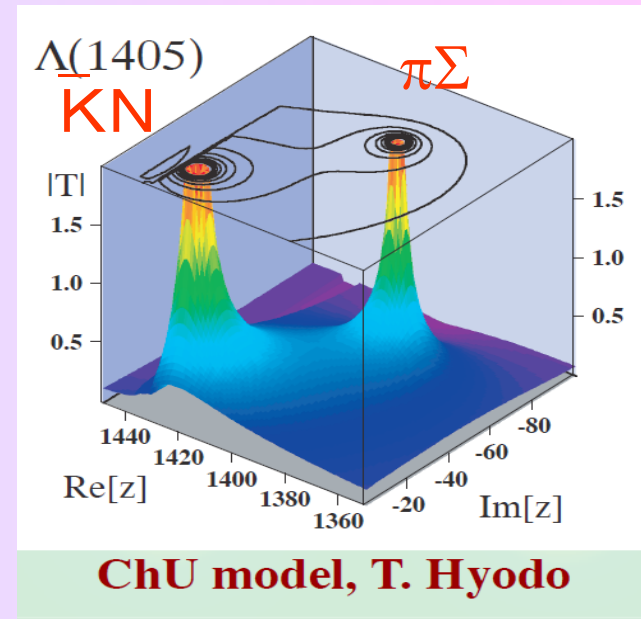
3. Summary

$\Lambda(1405)$: meson-baryon molecular state?

$\mathcal{J}^P = \frac{1}{2}^-$, $I = 0$, $M_{\Lambda(1405)} < M_{\bar{K}N}$, lightest in neg. parity baryons



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ChU model, T. Hyodo

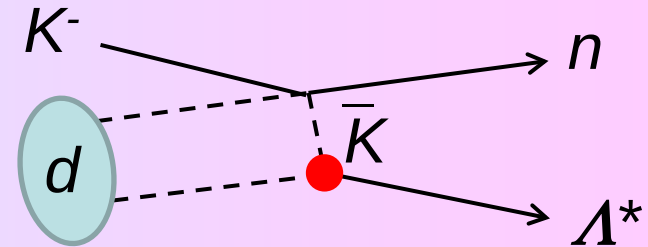
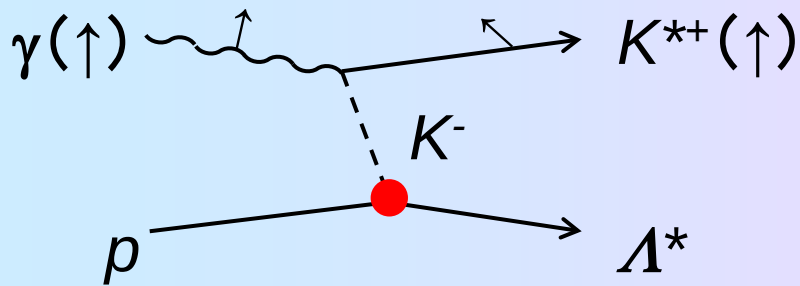
E31 aims:

1. to conclude if $\Lambda(1405)$ as a $K\bar{b}N$ state appears at 1420 MeV or not .
 - This gives basic information on a longstanding argument on a deeply bound kaonic nuclei.
2. to provide new aspect on a structure of baryon resonances beyond naïve constituent quark model.

$\Lambda(1405)$: meson-baryon molecular state?

$K^{\text{bar}}N \rightarrow \pi\Sigma$ scattering below $K^{\text{bar}}N$ threshold

Reactions to realize $KN\Lambda^*$ coupling ($\bar{K}N \rightarrow \pi\Sigma$ scattering)

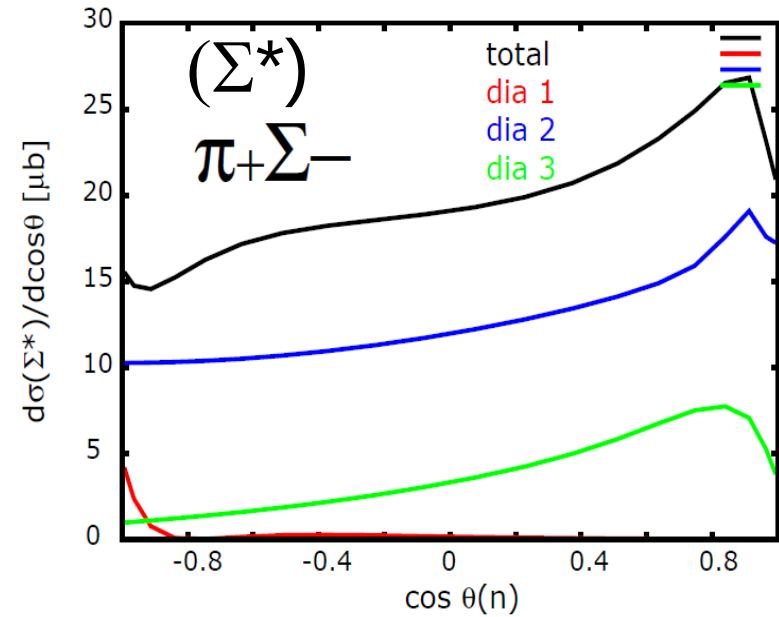
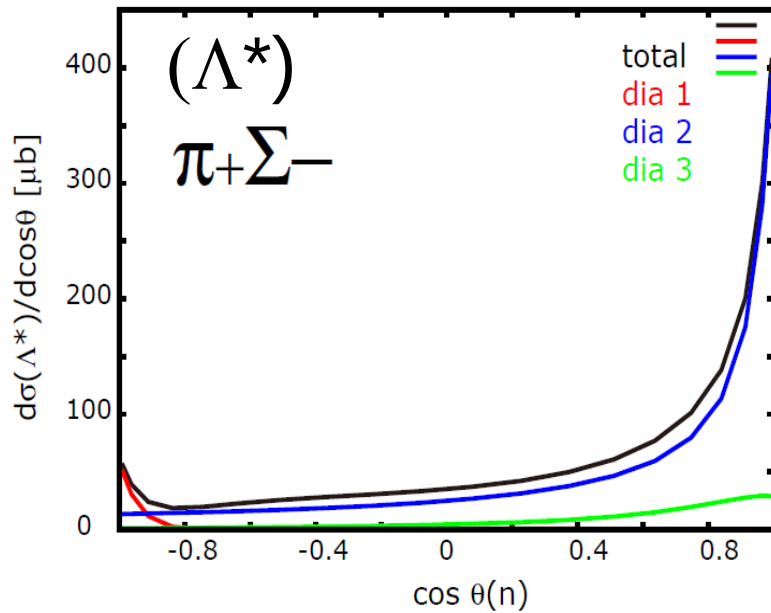


Spin-Isospin Amplitude be decomposed in the final state.

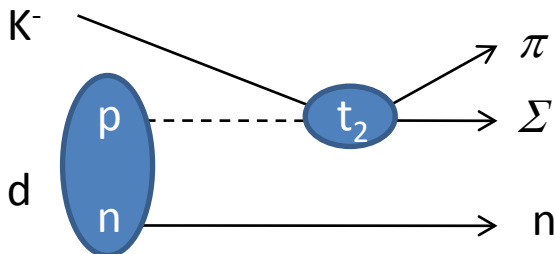
$\Lambda(1405)$	S-wave, $l=0$	$\pi^0\Sigma^0$, $\pi^{+/-}\Sigma^{-/+}$
$\Sigma^*(1385)$	P-wave, $l=1$	$\pi^0\Lambda$, $\pi^{+/-}\Sigma^{-/+}$
Non-resonant	S,P,..., $l=0,1$	$\pi\Lambda$, $\pi\Sigma$

S-wave $K^{\text{bar}}N$ scattering is enhanced at $\theta_n = 0$ degree.

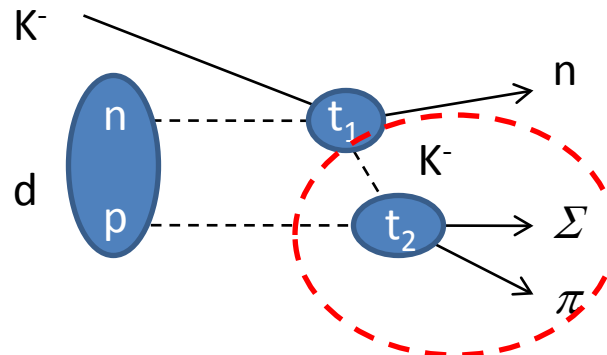
$d(K^-,n)\pi^+\Sigma^-$ at $p_K=800$ MeV/c J. Yamagata-Sekihara, T. Sekihara, and D. Jido



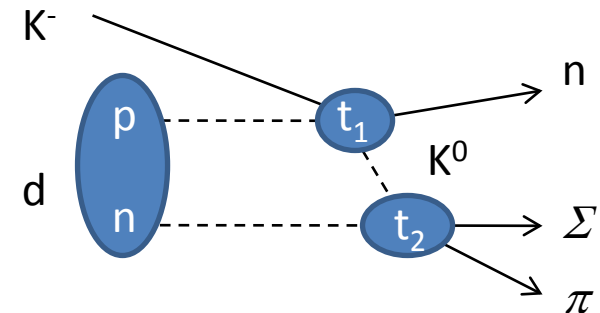
dia.1:small



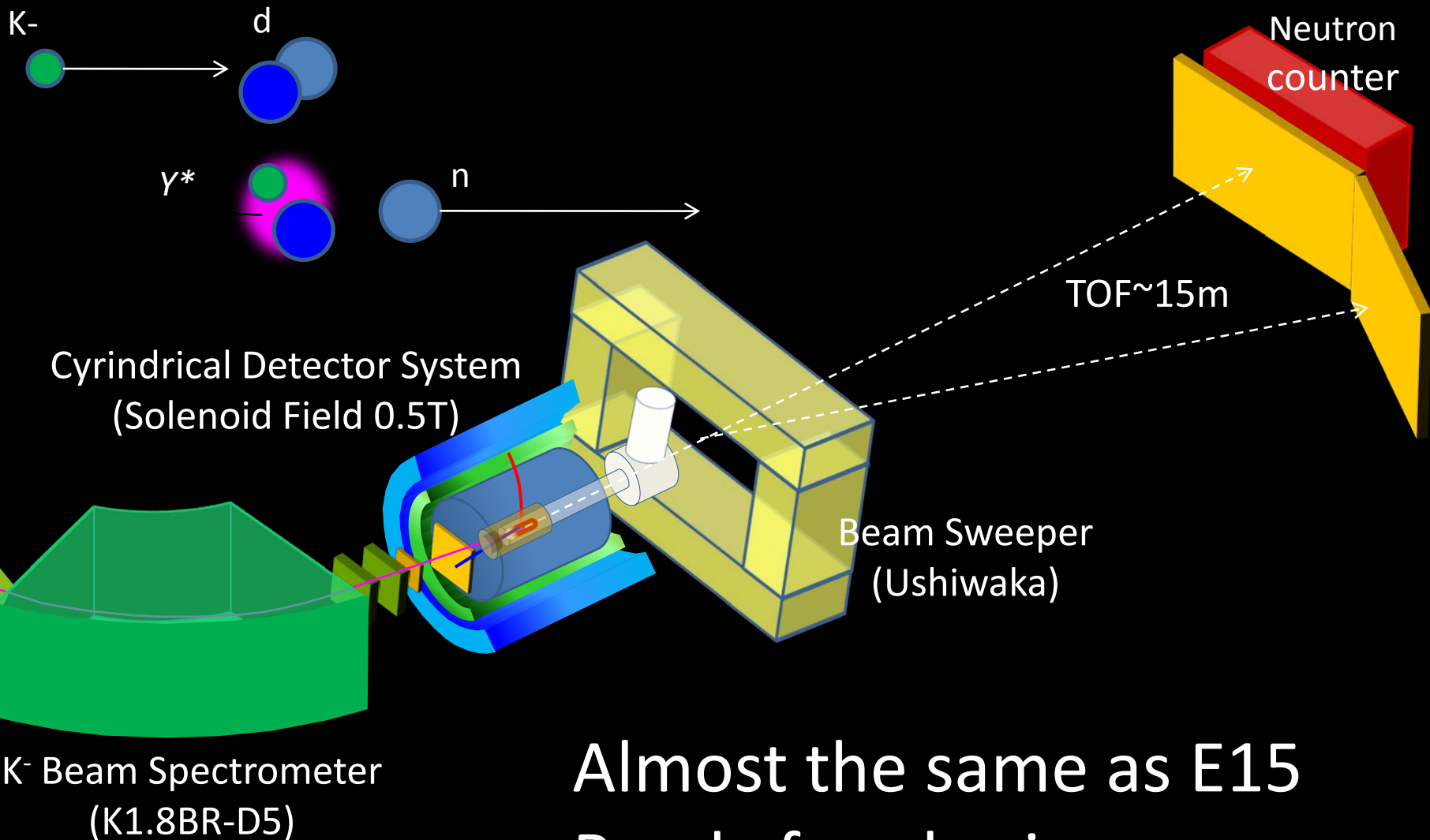
dia.2:dominant



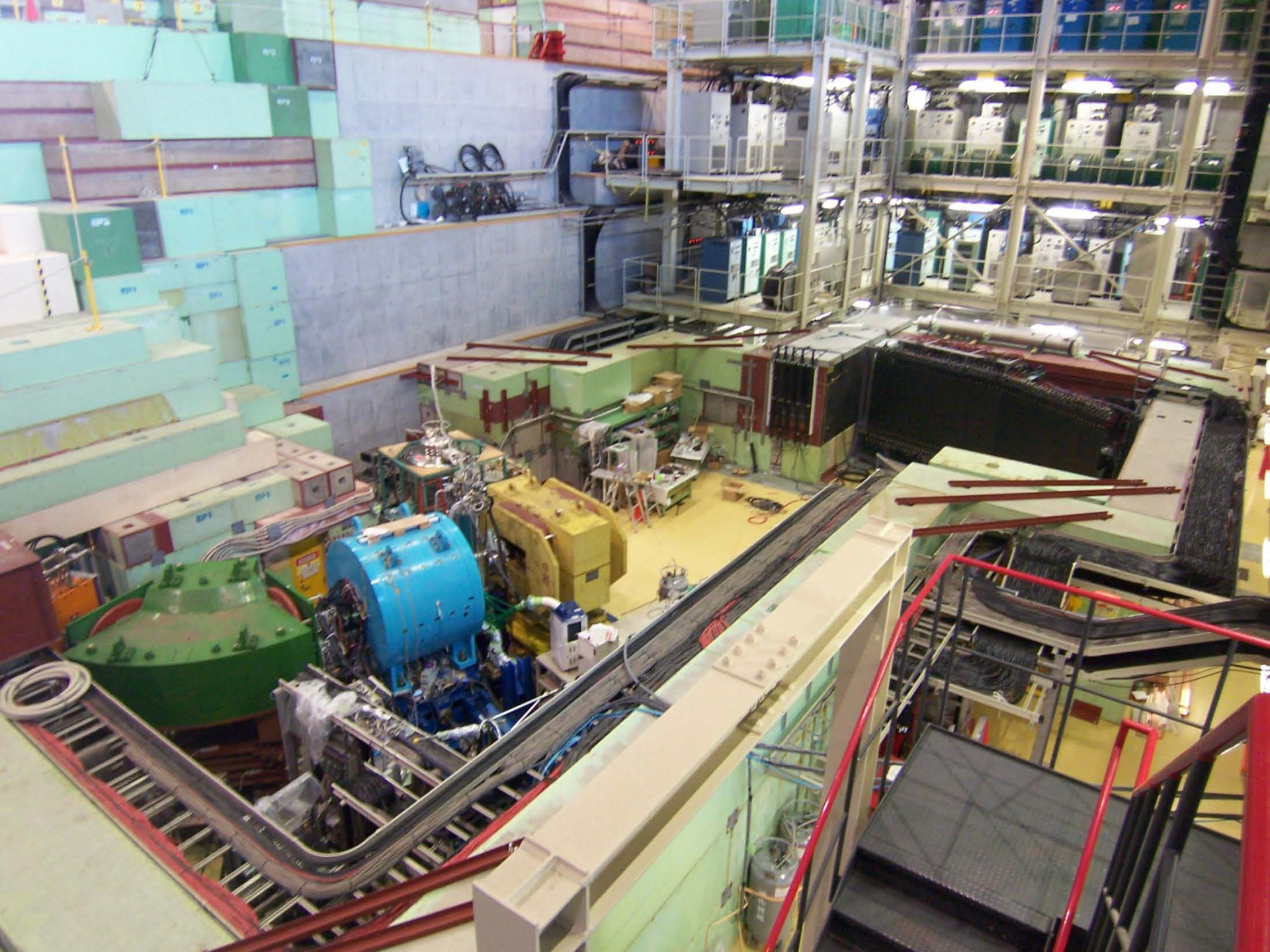
dia.3:Interference



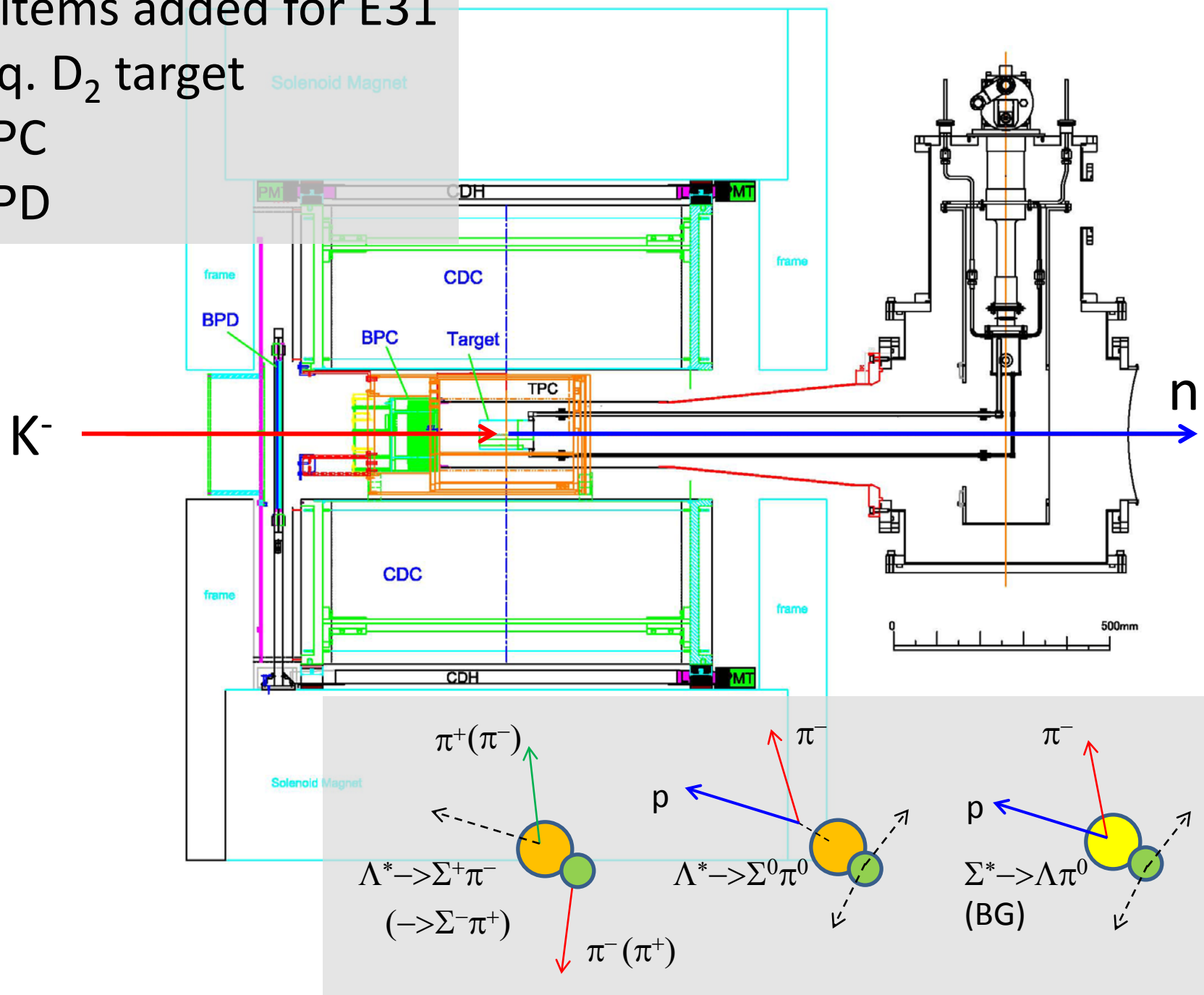
Experimental Setup for E31



Almost the same as E15
Ready for physics run.



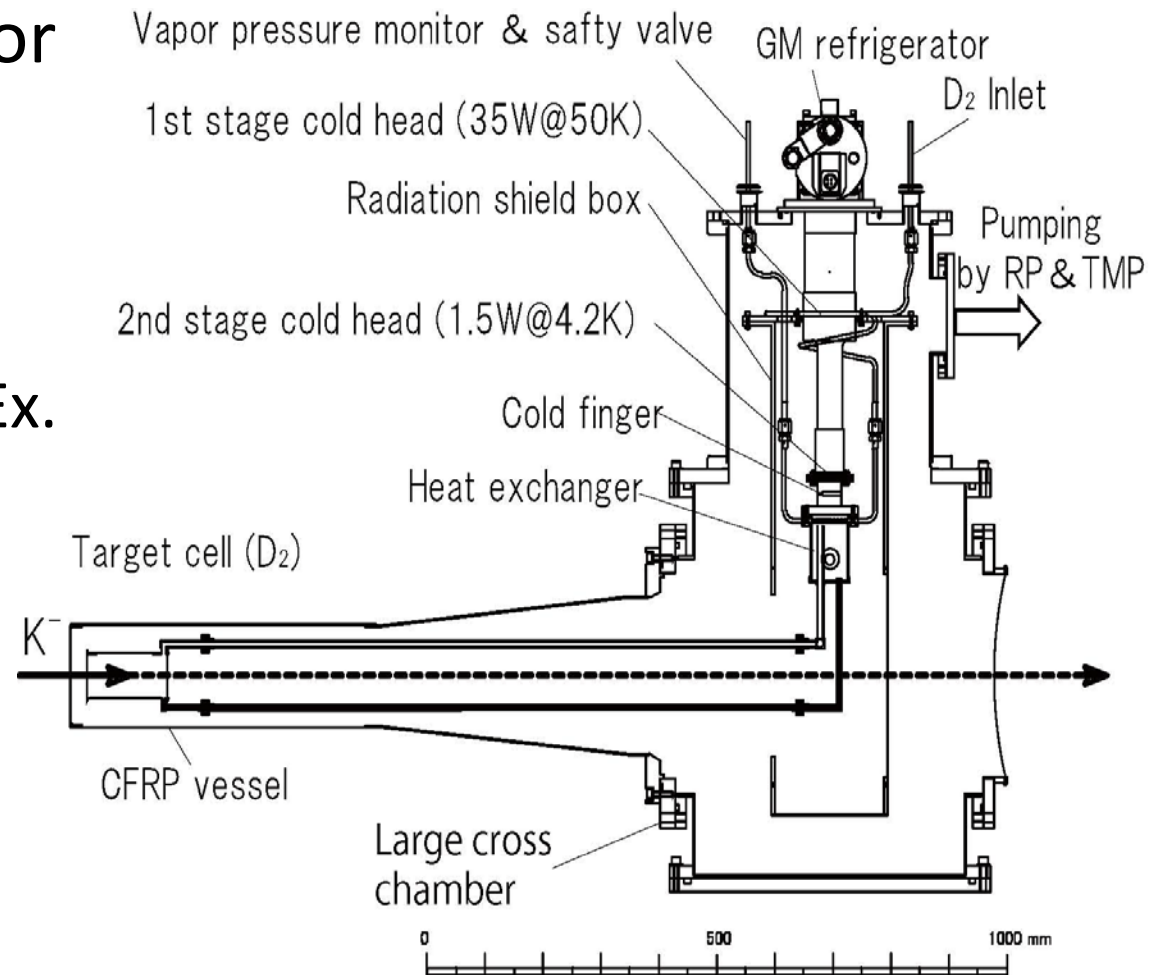
- Liq. D₂ target
- BPC
- BPD



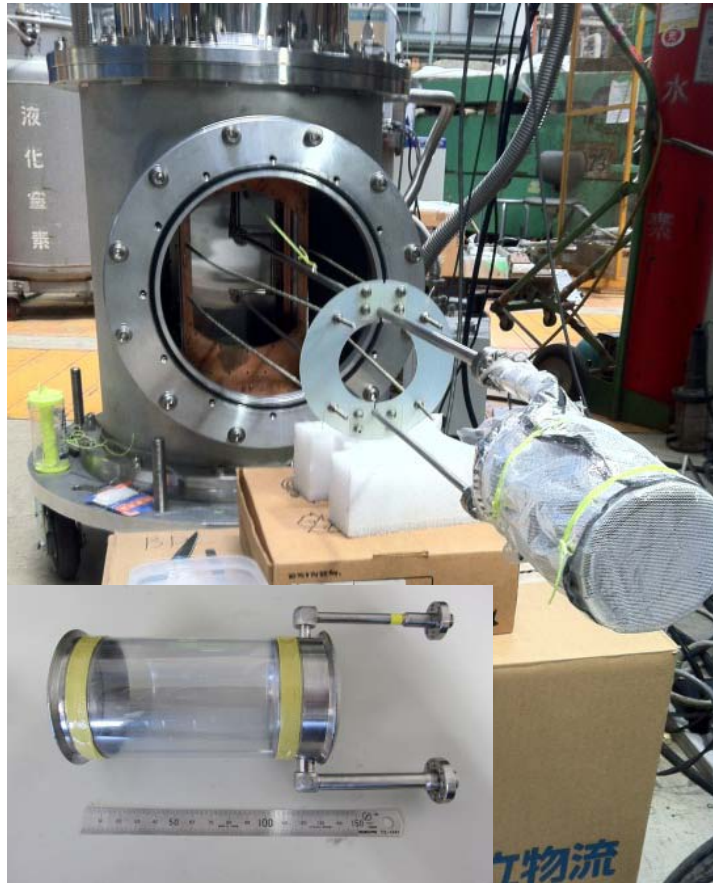
Liq. D₂ Target

S. Kawasaki, S. Ishimoto, S. Suzuki, M. Iio, T. Ohta

- 4K G-M refrigerator to liquify
 - Easy to control temperature w/ a heater at a Heat Ex.

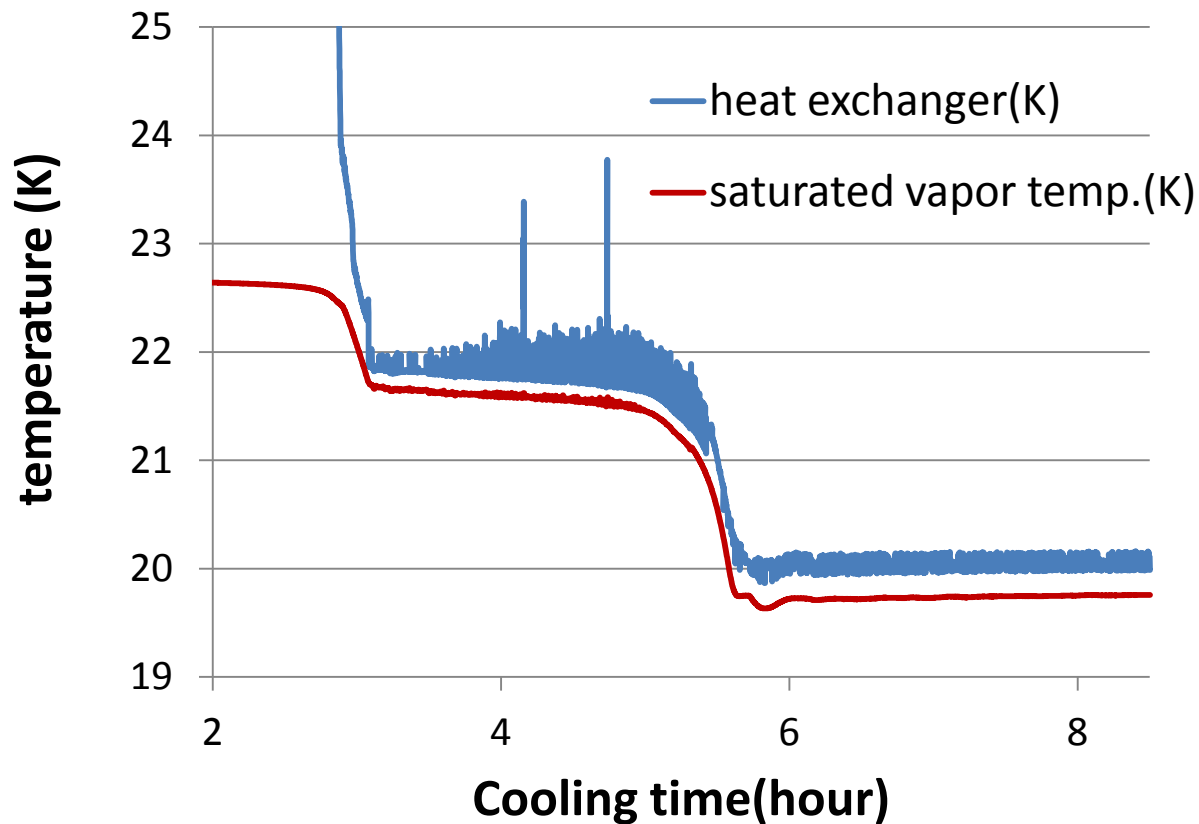


Liq. D₂ Target



Liq. D₂ Target

- Demonstration to liquify Hydrogen



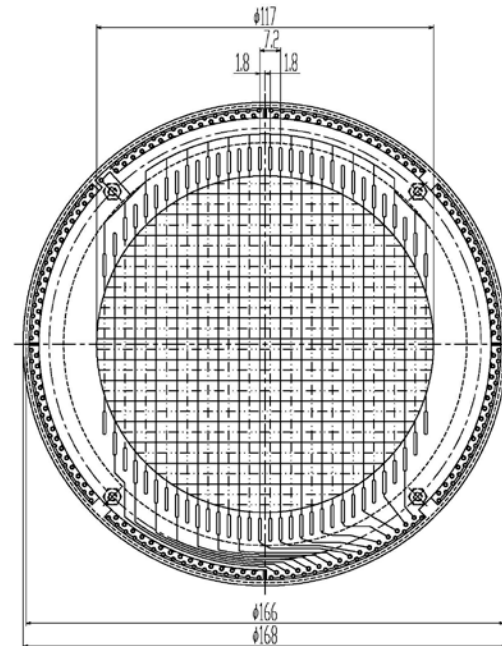
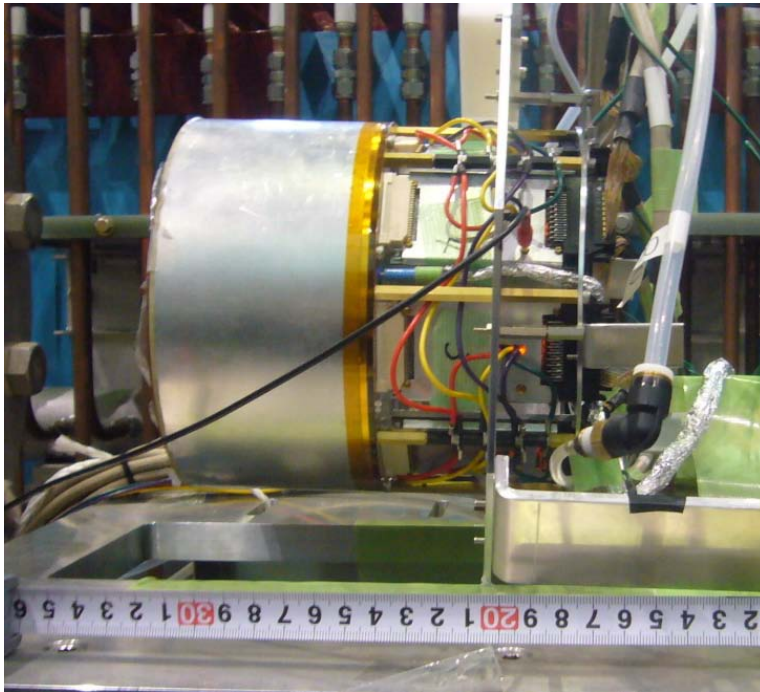
BPC and BPD

S. Enomoto and K. Inoue

- Two detectors to identify backward emitted proton in $\Lambda(1405) \rightarrow \Sigma^0 \pi^0$
 - BPC: MWDC placed close to TGT
 - Track a proton trajectory
 - determine a decay vertex of $\Lambda(1116)$
 - BPD: Plastic scintillator hodoscopes
 - Measure a TOF of the emitted proton
 - determine Momentum

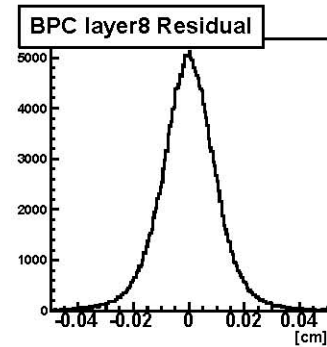
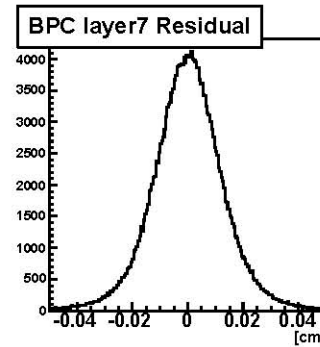
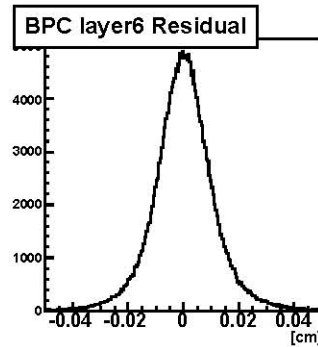
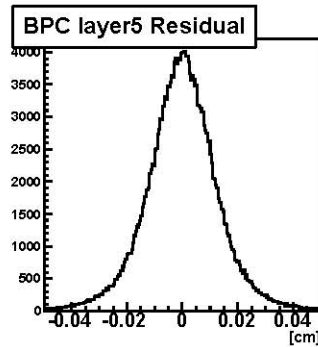
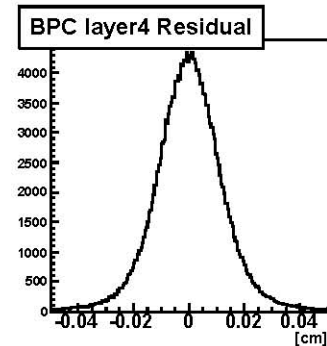
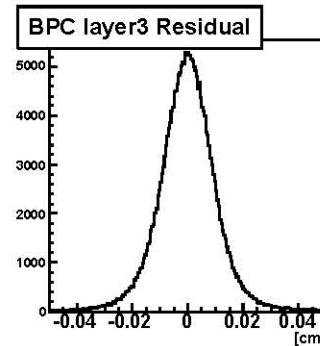
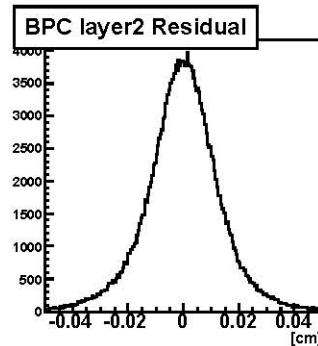
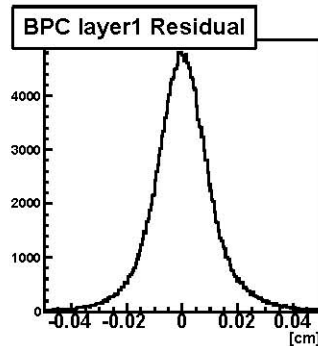
BPC

- planar type, 8 planes (XX'YY'XX'YY')
 ± 3.6 mm drift space, $\phi 112.6$ mm sensitive area
- 8 Compact Pre-amps, 4 ASD chips in a amp.
- Operation Gas: Ar-Isobutan (80:20)

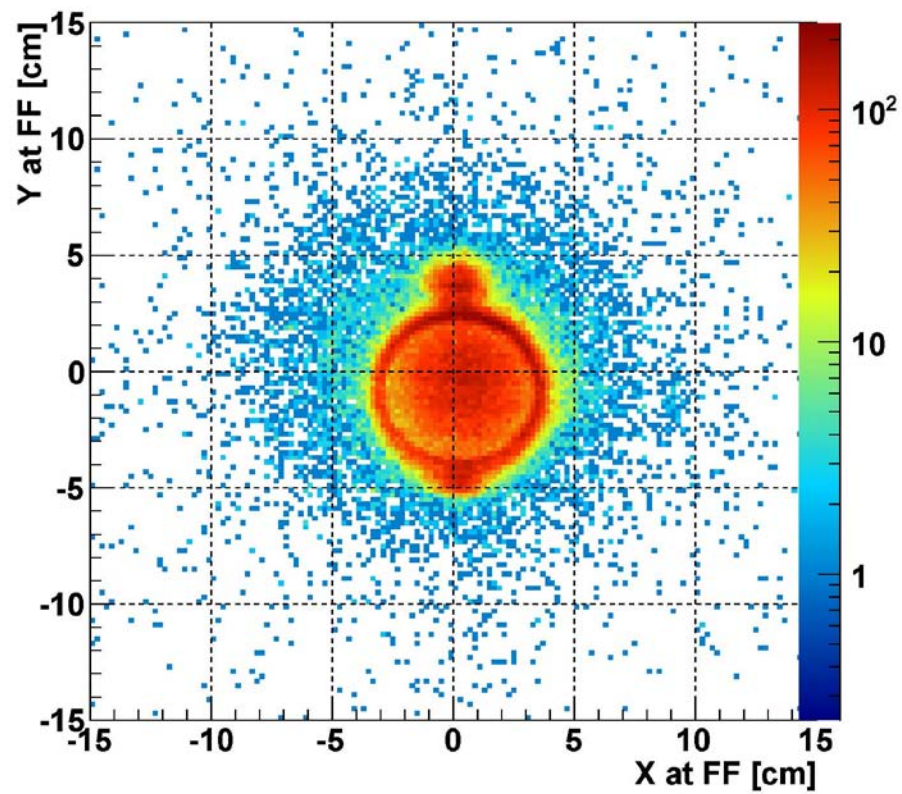


BPC

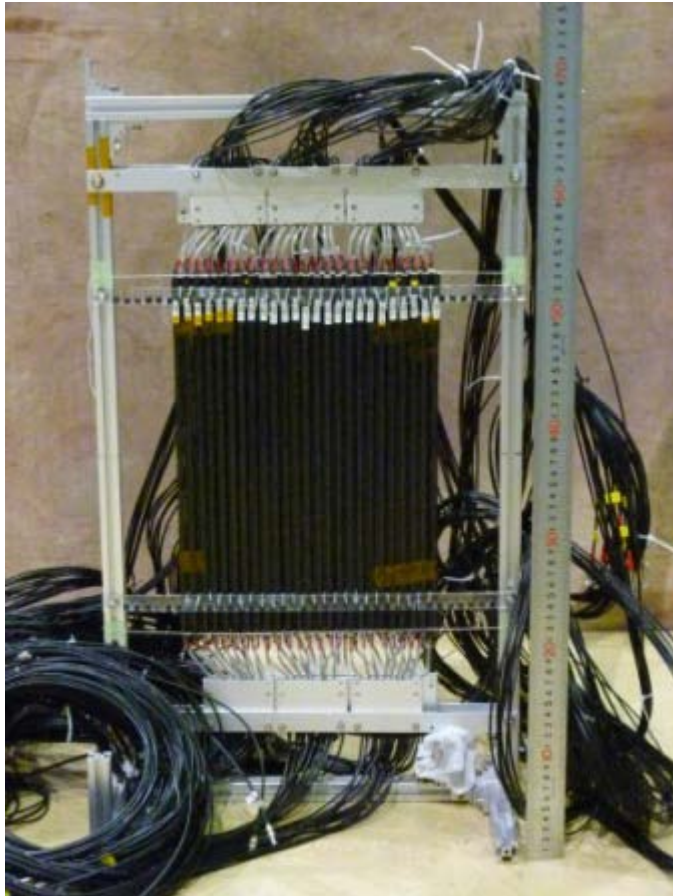
- Typical residual distribution:
90 ~ 100 μm in 1 sigma



BPC



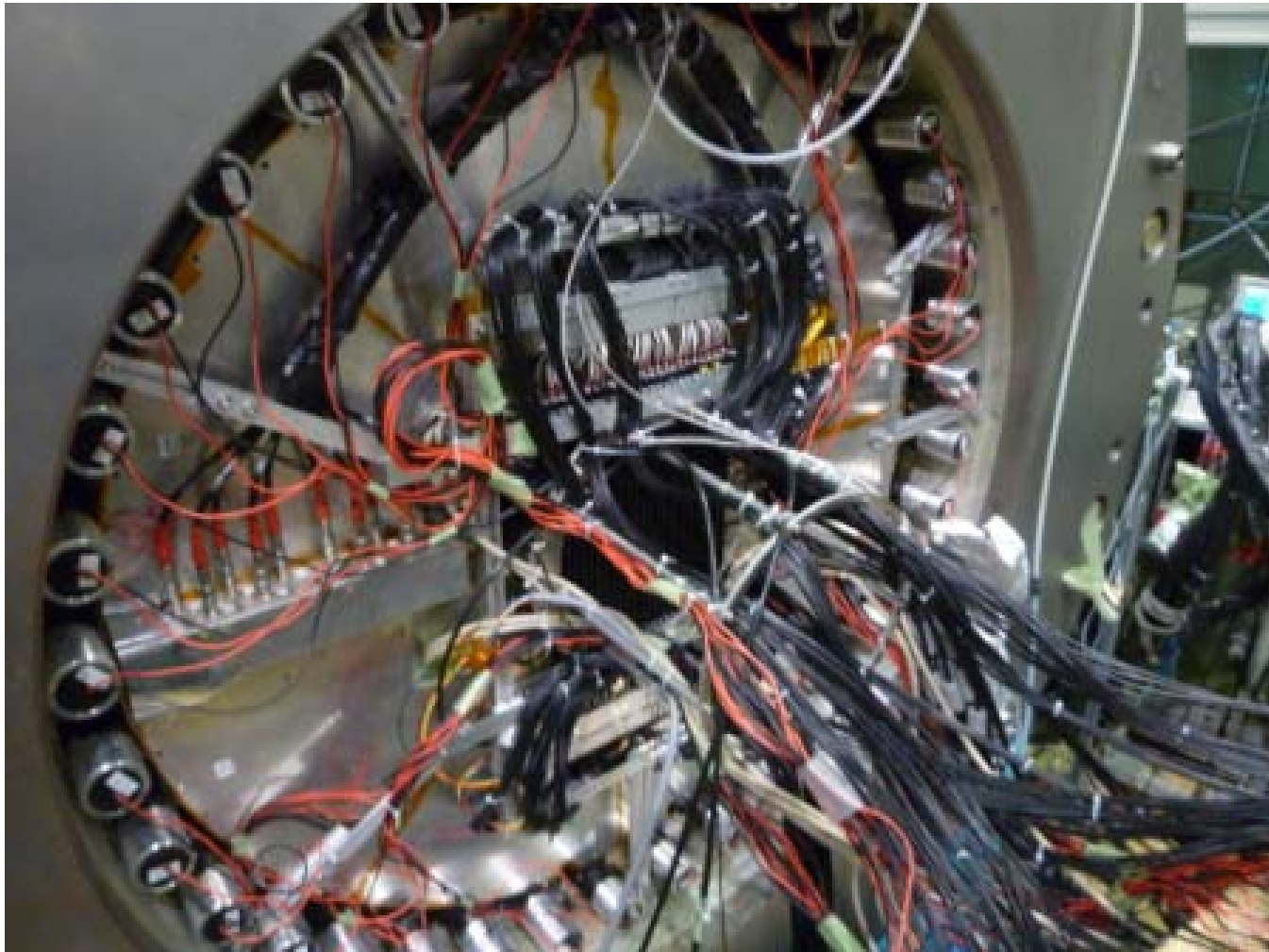
BPD



- 70 slabs of plastic scint.
 - $340 \times 5 \times 5 \text{ mm}^3$
- MPPC photo sensor
 - $3 \times 3 \text{ mm}^2$
 - No matter in a Magnetic Field
 - Fast time response, $< 200 \text{ ps}$

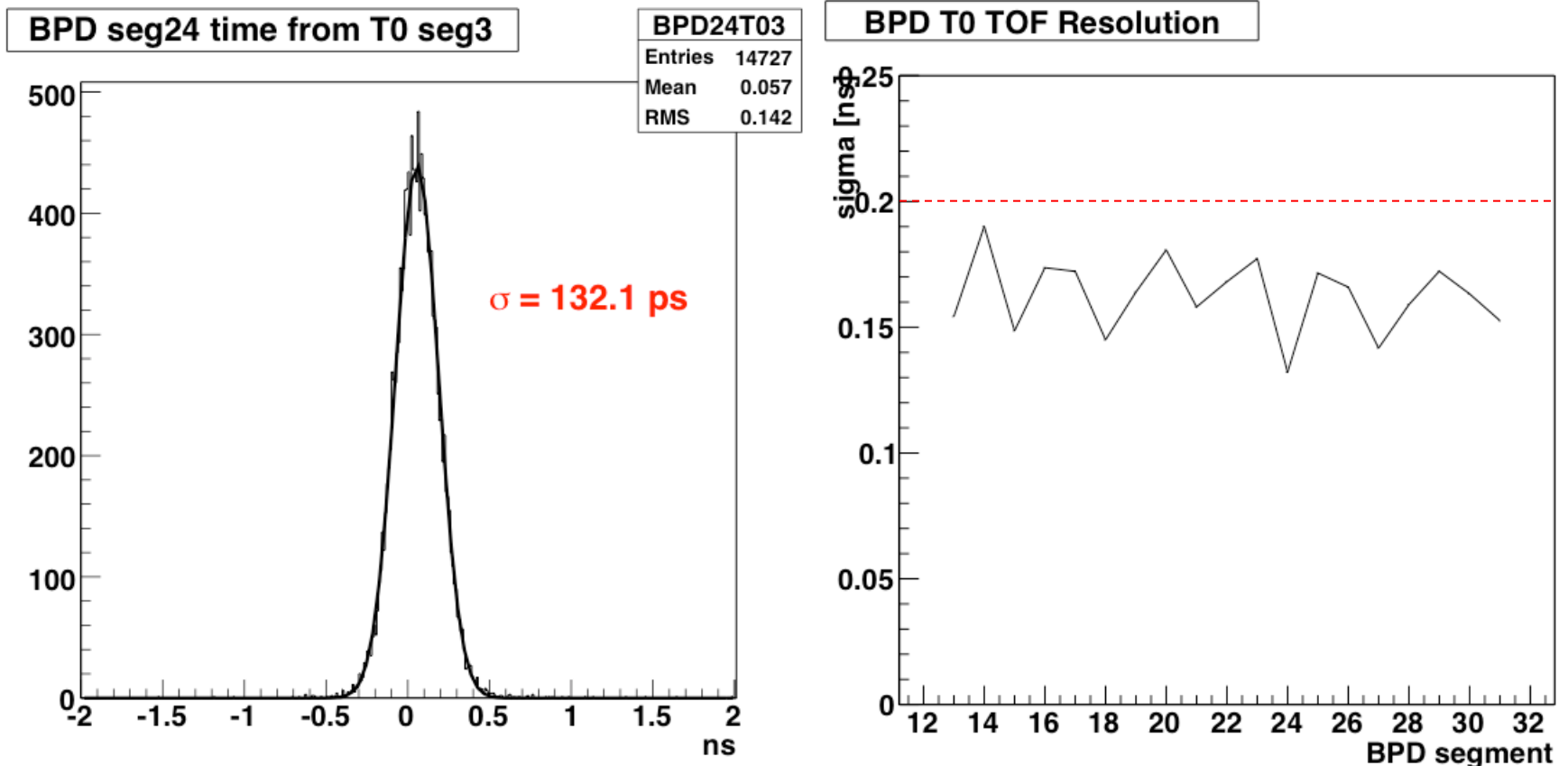
BPD

- Installed in CDS



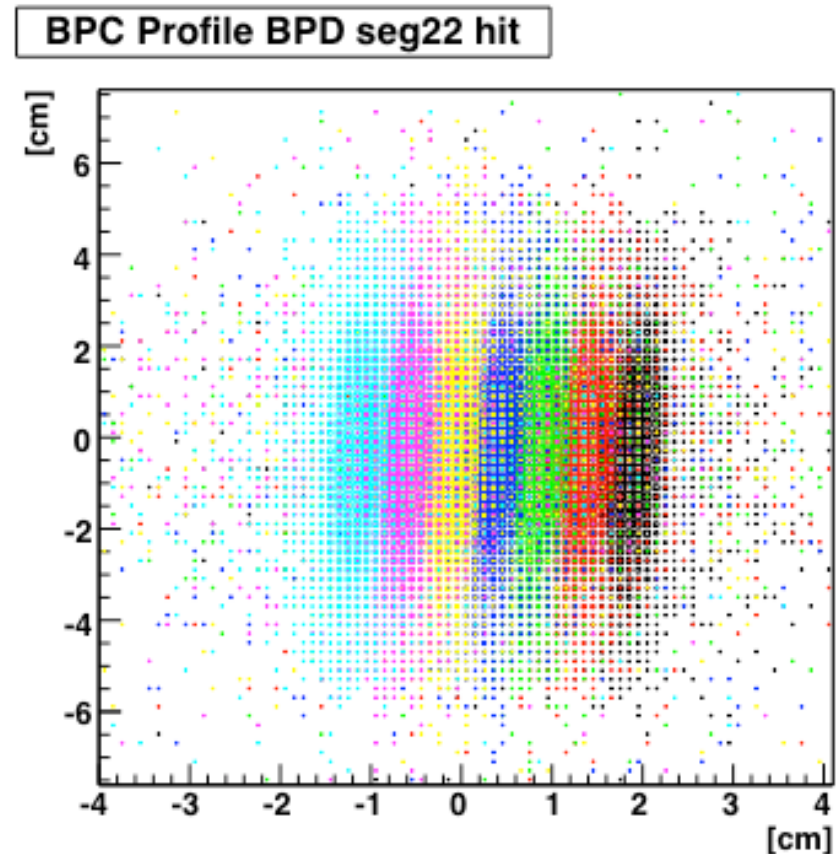
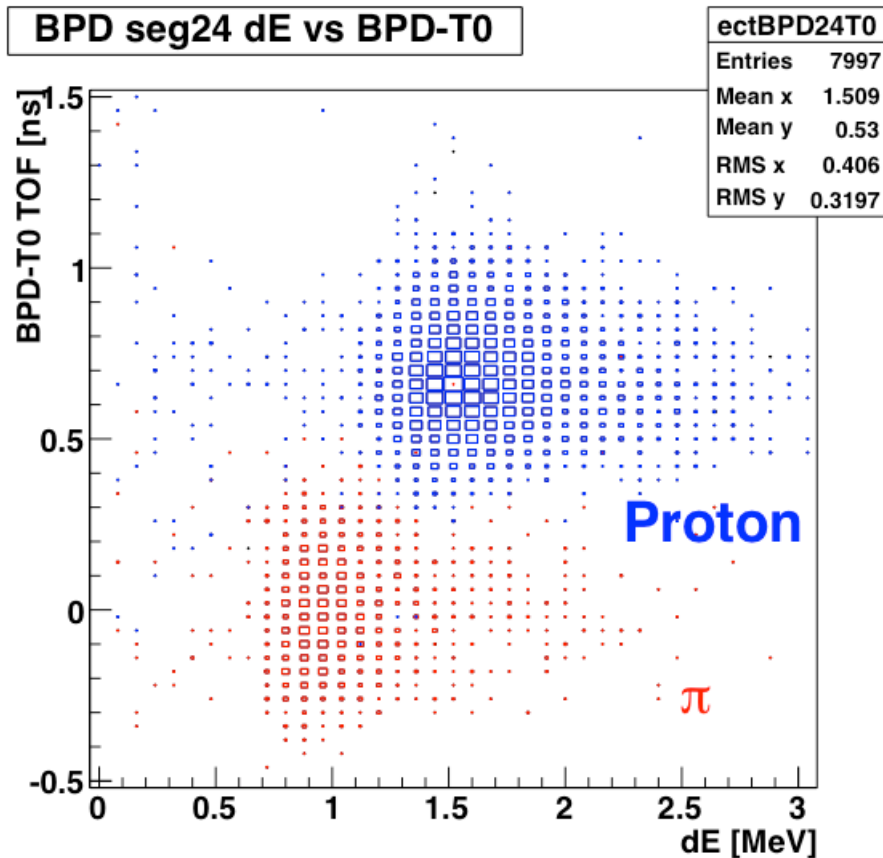
BPD

- TOF resolution demonstrated for a pion beam



BPC and BPD

- Response for pion and proton beams at 1 GeV/c
- BPD image reconstructed by BPC (no rotation corrected)



E31 Request Summary

1. E31 is ready to take data.

A several days may be enough to switch the target system.

2. Milestones for E31

Proposed Beam Time Request:

120 shifts (40 days) with 27 kW primary proton

$\sim 19200[\Lambda(1405) \rightarrow \Sigma^- \pi^+]$, $\sim 4800[\Lambda(1405) \rightarrow \Sigma^+ \pi^-]$, $\sim 350[\Lambda(1405) \rightarrow \Sigma^0 \pi^0]$

— wish to have a short term run first, even for 10kW*week

- Confirm that the $d(K^-, n)$ reaction really enhances an S-wave $\bar{K}N$ scattering to form $\Lambda(1405)$.
- Collect $>250 \Sigma^+ \pi^-$ (new), $>1000 \Sigma^- \pi^+$ (x2 of old DBC exp.)
- Demonstrate performance to identify the $\Sigma^0 \pi^0$ mode
- Compare w/ Σ^* production by $d(K^-, p)$

We request a stage-2 approval.