Determining the Unknown ΛN Interaction by Investigating the ΛNN Resonance

Update on E12-17-003 Experiment

(Data Taken: October 30 to Nov. 26, 2018)

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8th Workshop of the APS Topical Group on Hadronic Physics
Denver, CO
04/10/2019

Jefferson Lab

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Physics Motivation

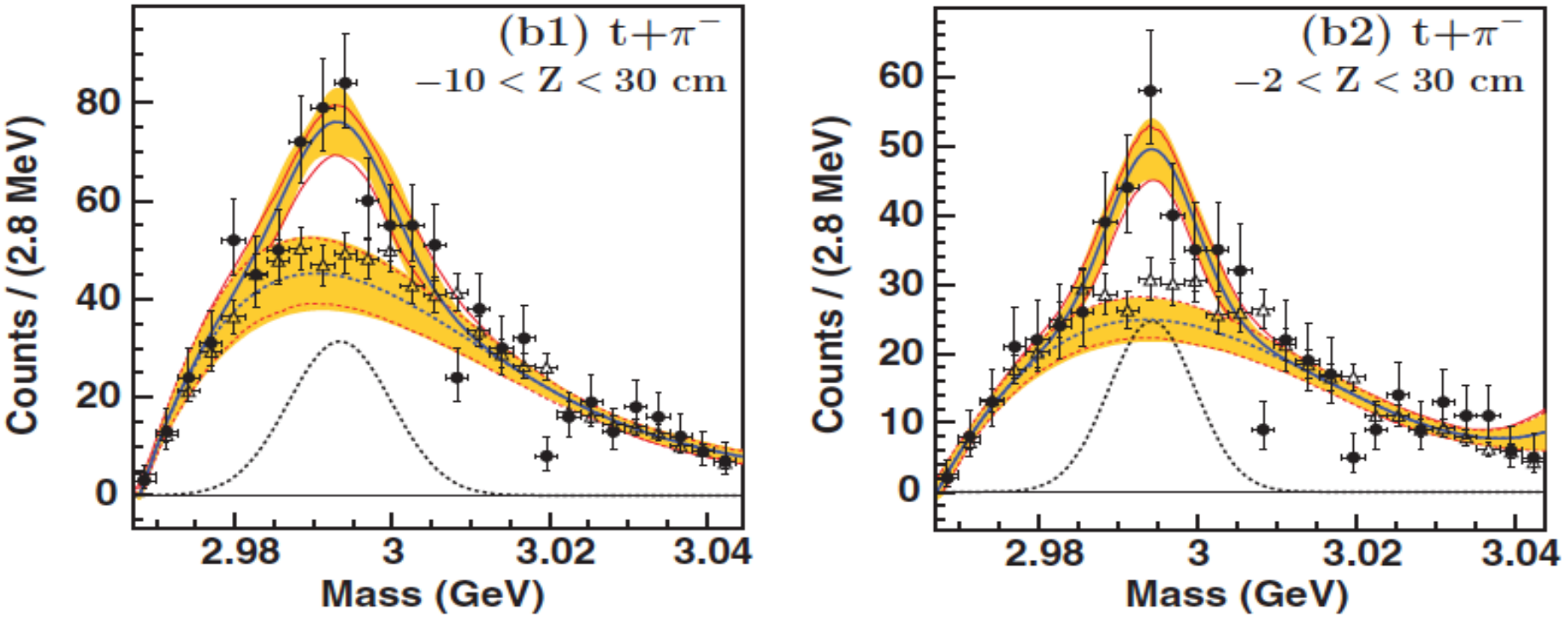
- Plenty of scattering data on the **NN** interaction exist, however, for **YN** and **YY** interactions the data are limited or do not exist. **Λ-n** has no data.

- Recent precise experimental results show that charge symmetry breaking (**CSB**) is much more significant in **Λ-N** interaction. Thus determining the unknown **Λ-n** interaction is critically important to understand the **CSB**.

- The **Λ-n** interaction is treated to have the same properties as the **Λ-p** interaction.

Physics Motivation Continue

^{6}Li (2A GeV) on ^{12}C target and study the invariant mass of final state particles

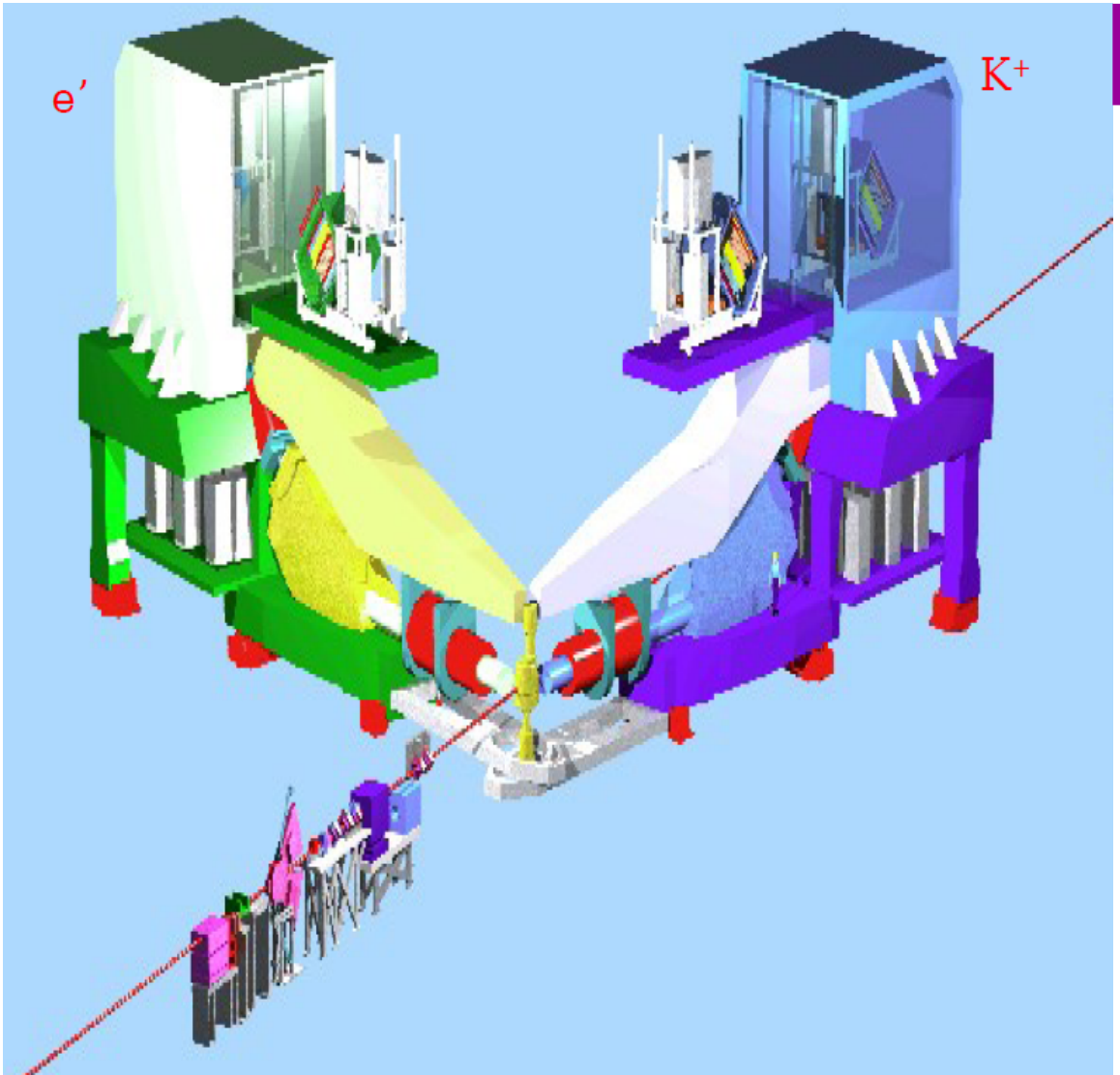


*C. Rappold et al., Phys. Rev. C **88**, 041001(R) (2013)*

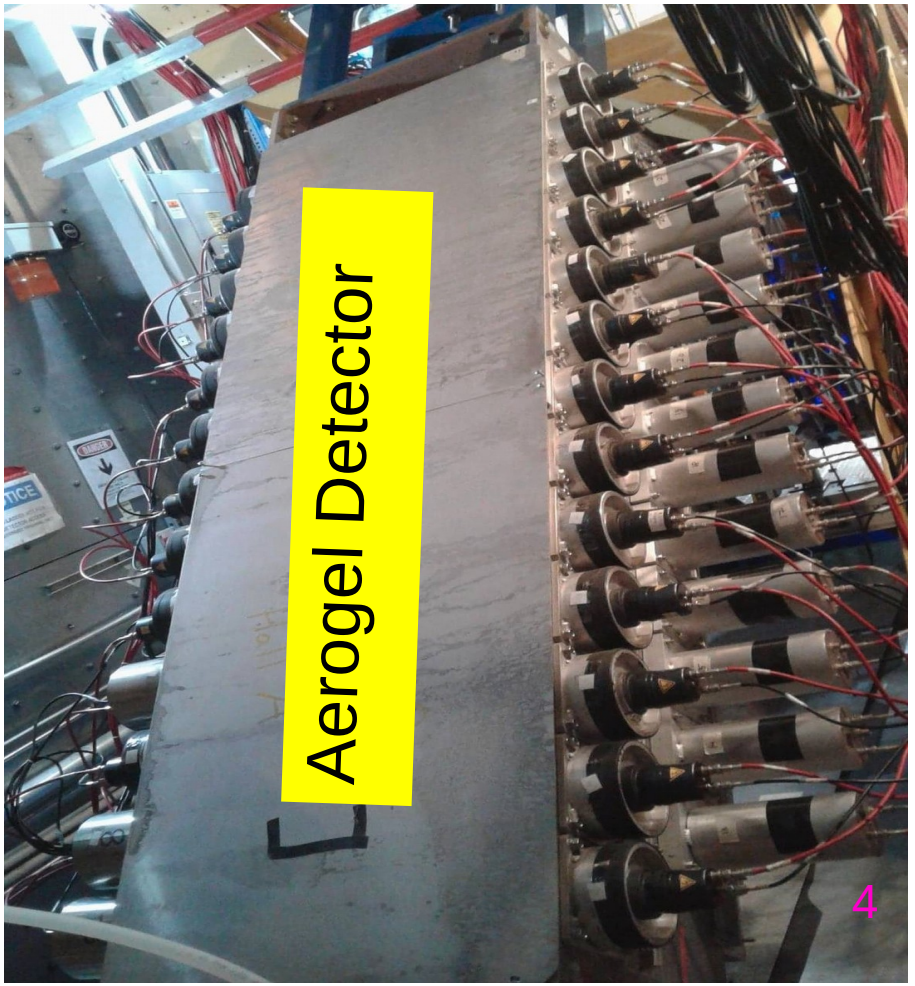
- It was claimed to be a bound state.
- All the theoretical studies ruled out bound **Λnn** system.
- However, some theoretical studies indicated that **Λnn** resonance may likely exist and by measuring the binding energy and the natural width of such state, it is possible to extract the **Λ-n** interaction.

Experimental Status and Experimental Setup

- The experiment, E12-17-003 was carried out from October 30 to November 25, 2018
- The ideal case for such experiment is to have a short spectrometer with large solid angle acceptance and a tritium target



K^+ identification required

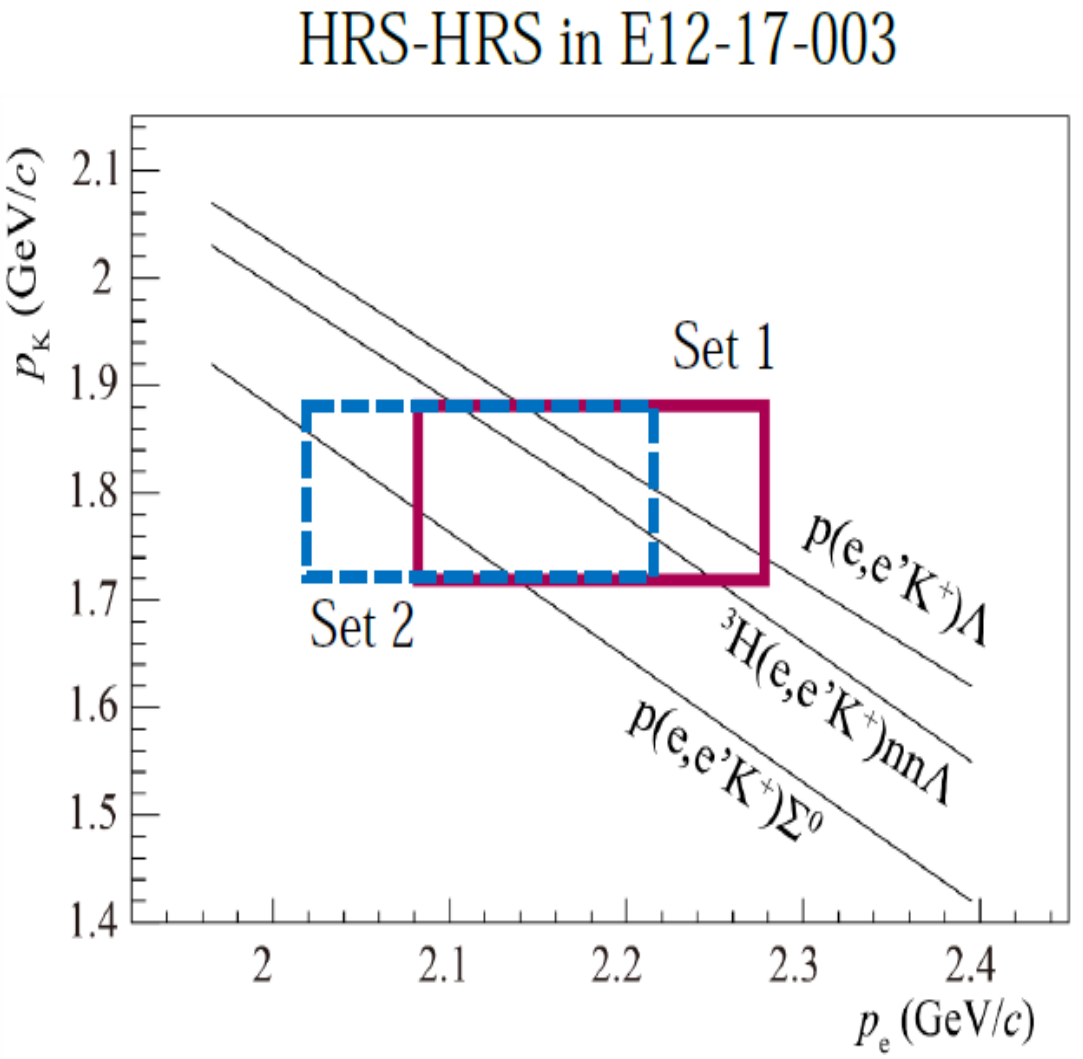


Kinematics for E-12-17-003

The data were taken with two different kinematics with fixed beam energy of 4.319 GeV and fixed HRS angles, 13.2° for each arm

1. H kinematics:
Target: H
PK = 1.8231 GeV/c
Pe' = 2.1000 GeV/c

2. T kinematics:
Target: T, H and He
PK = 1.8231 GeV/c
Pe' = 2.2180 GeV/c



Took All Types of Data for the Analysis

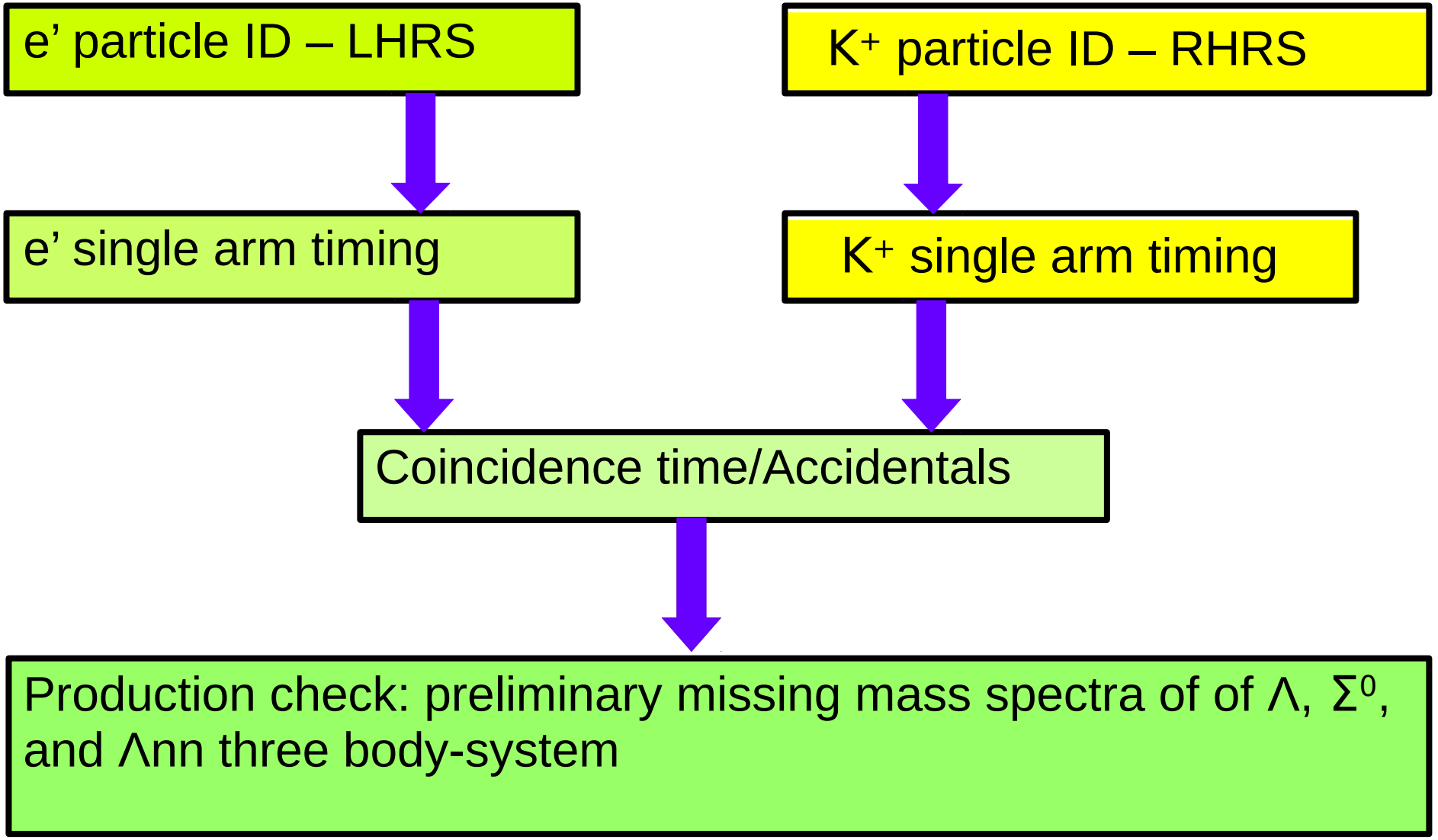
1. Optics data
   Target: Multi-Carbon-foil w/ and w/o raster and with seive slits in
   Target: Thick-Al and dummy targets w/ and w/o raster
   Purpose: To optimize the various reconstructions(z-vertex, raster and angles in both of the arms)

2. Calibration data :
   Target: H (with H kinematics)
   Purpose: Kinematics calibration with known Λ and Σ^0 masses and for the determination of the absolute beam energy and spectrometer central momentum.

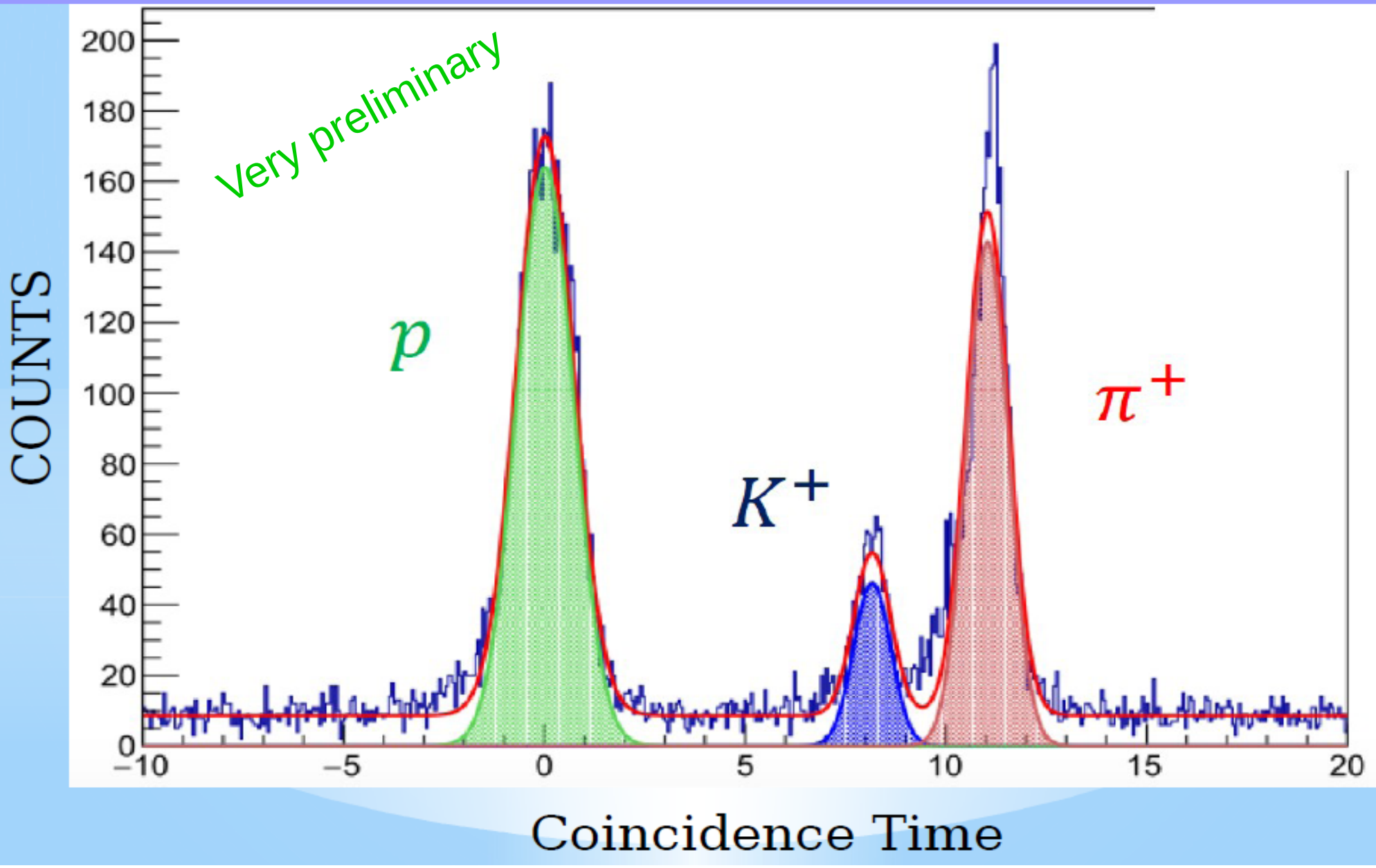
3. Production data:
   Targets: H,He and T (with T kinematics)
   Purpose: To check the effect of H and He contamination and for the physics purpose

Completed Stage I Analysis

- Optimize the detectors and check on productions

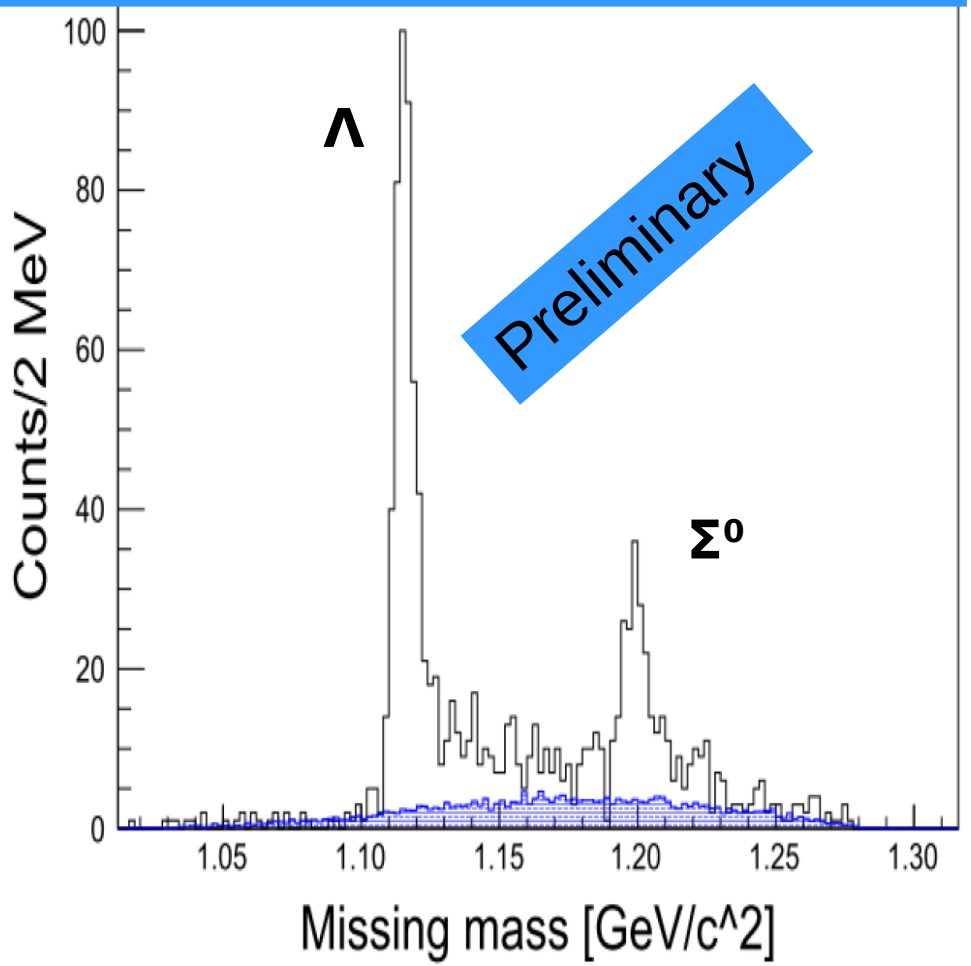


Quick Online Analysis

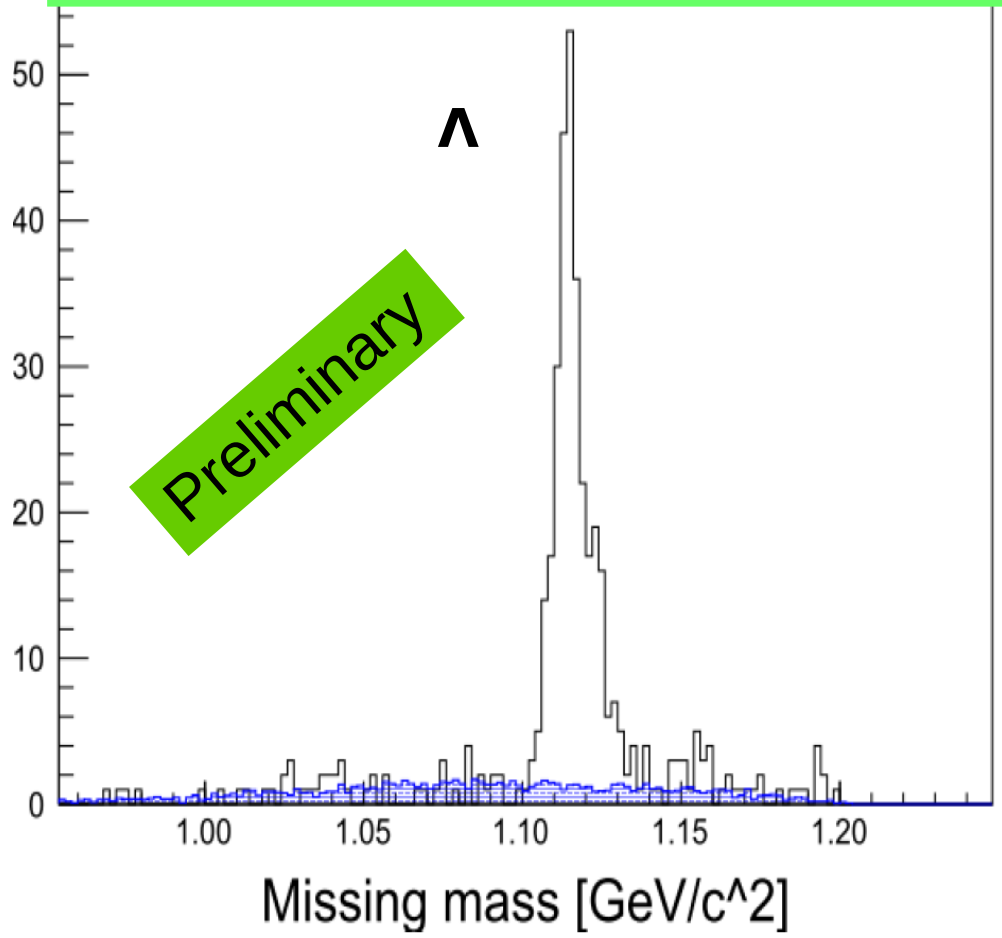


Quick Online Analysis Continue

Target: H
Kinematics: H

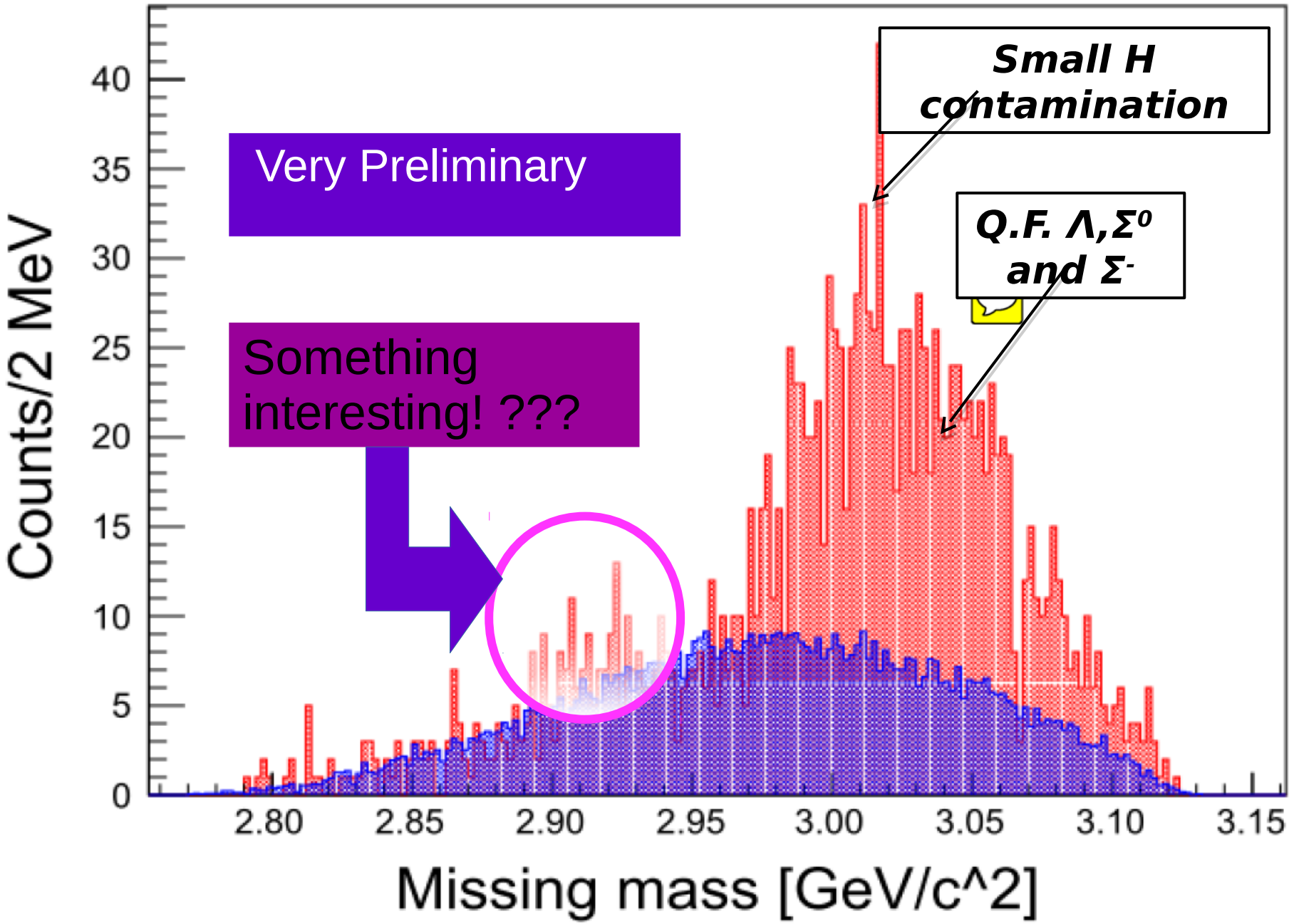


Target: H
Kinematics: T

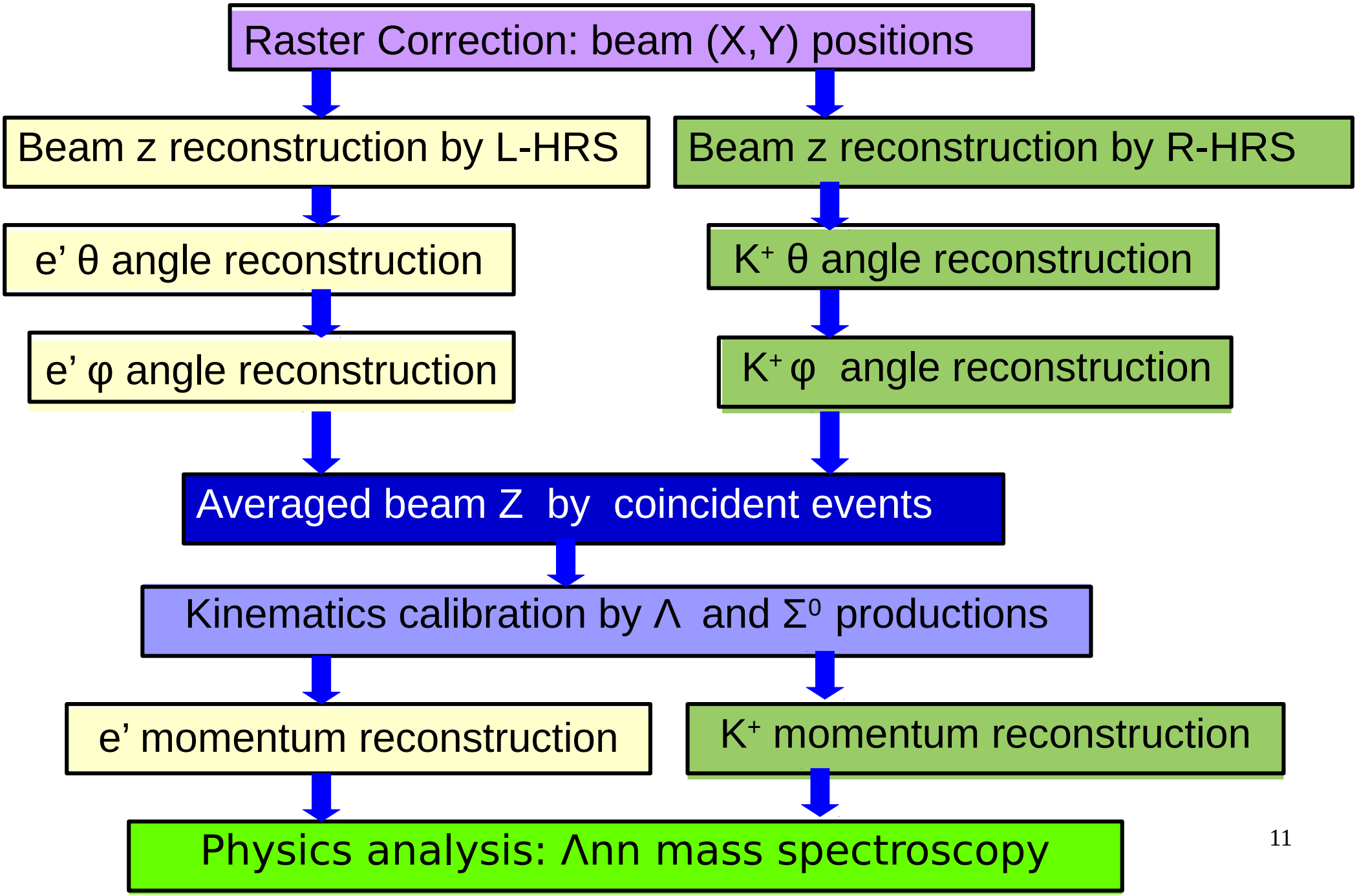


Since the optics and the kinematics are not calibrated yet, so the online spectroscopy has a significant mass shift and energy resolution is poor.

Quick Online Analysis Continue



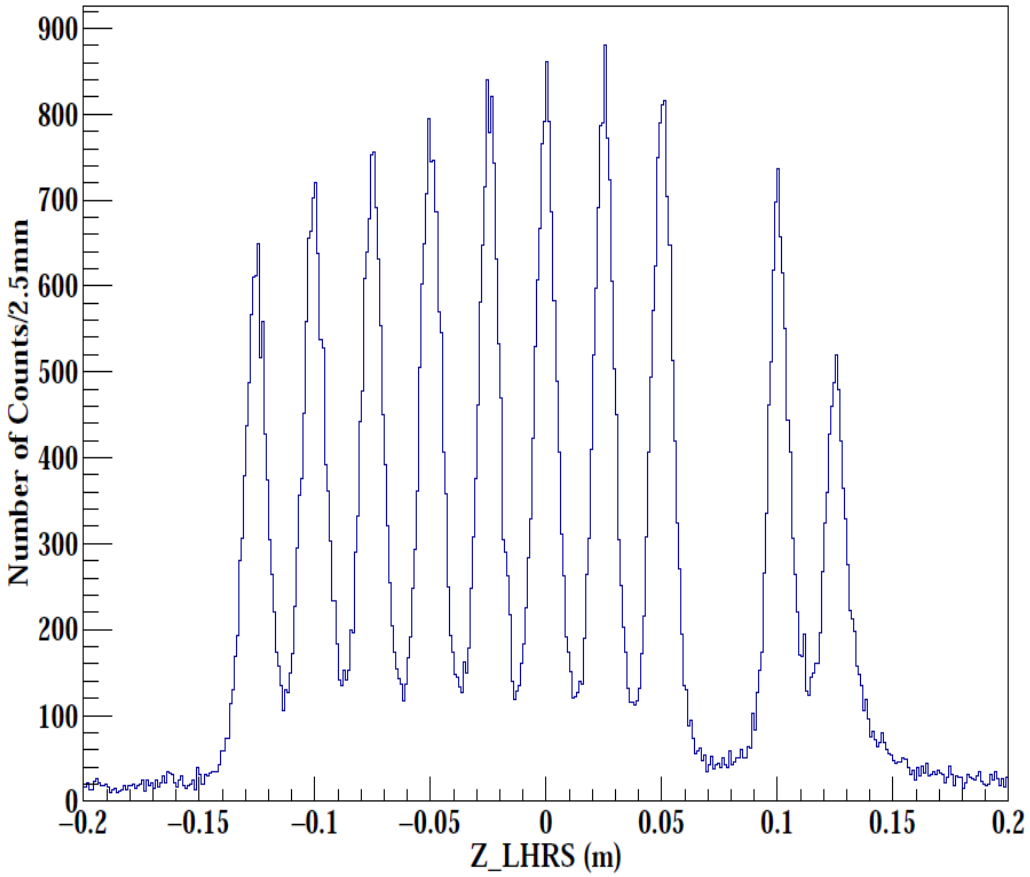
Stage II Analysis: Detailed Optimizations



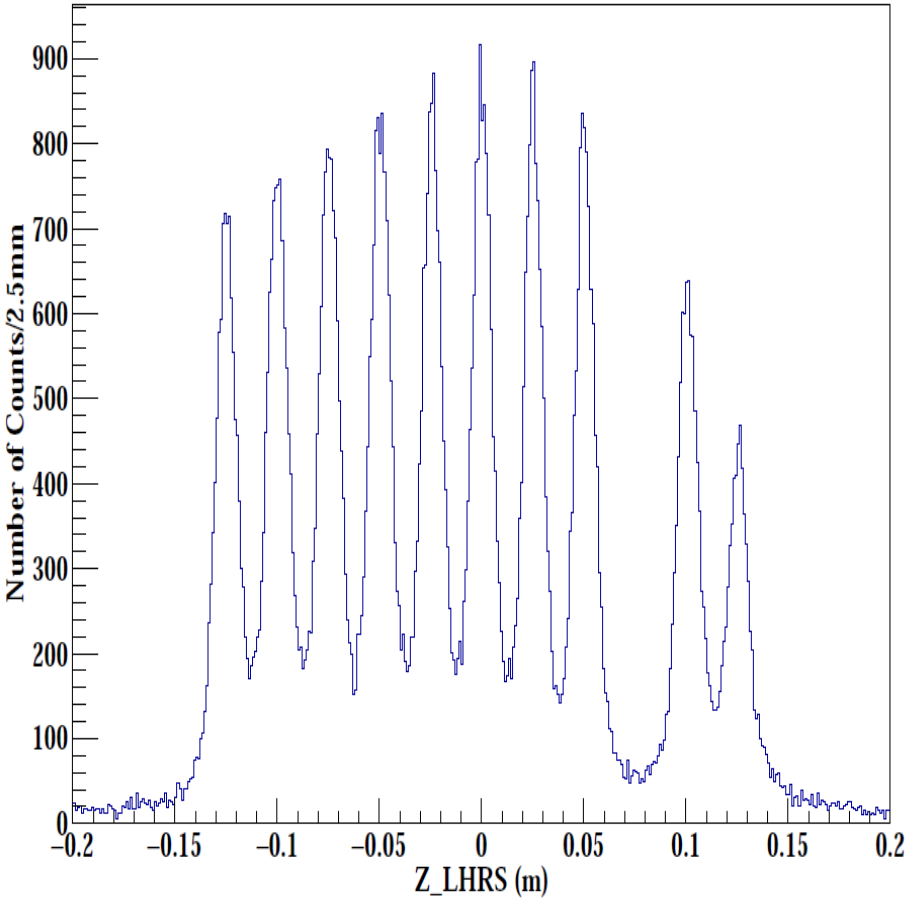
Current Analysis

1. a. LHRS Z-Vertex Reconstruction

Multi-C-foil target with raster off



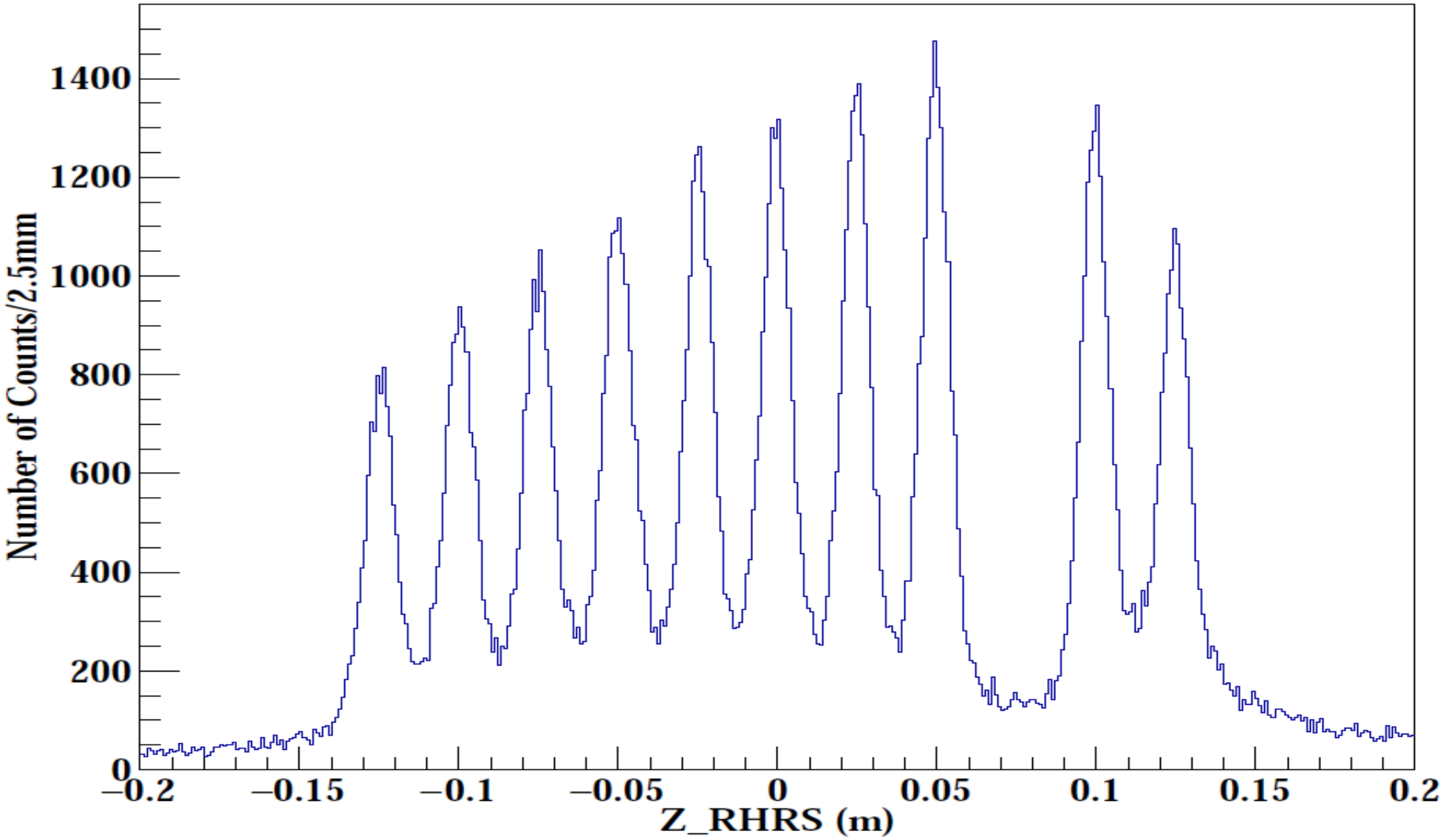
Multi-C-foil target with raster on



- Achieved good Z-vertex resolution for both about σ ≈ 5.2 mm
- Conformed good raster correction

1. b. RHRS Z-Vertex Reconstruction

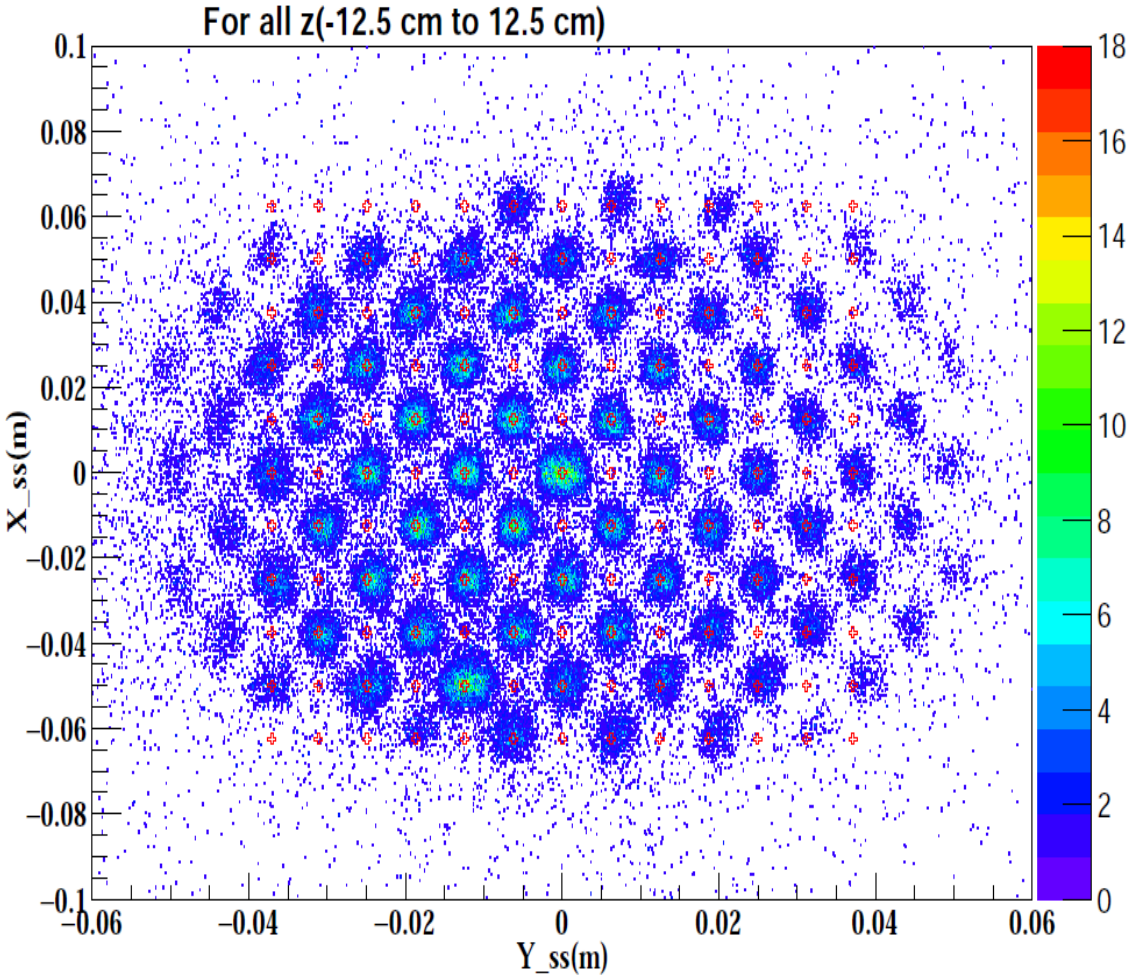
Multi-C-foil target with raster off



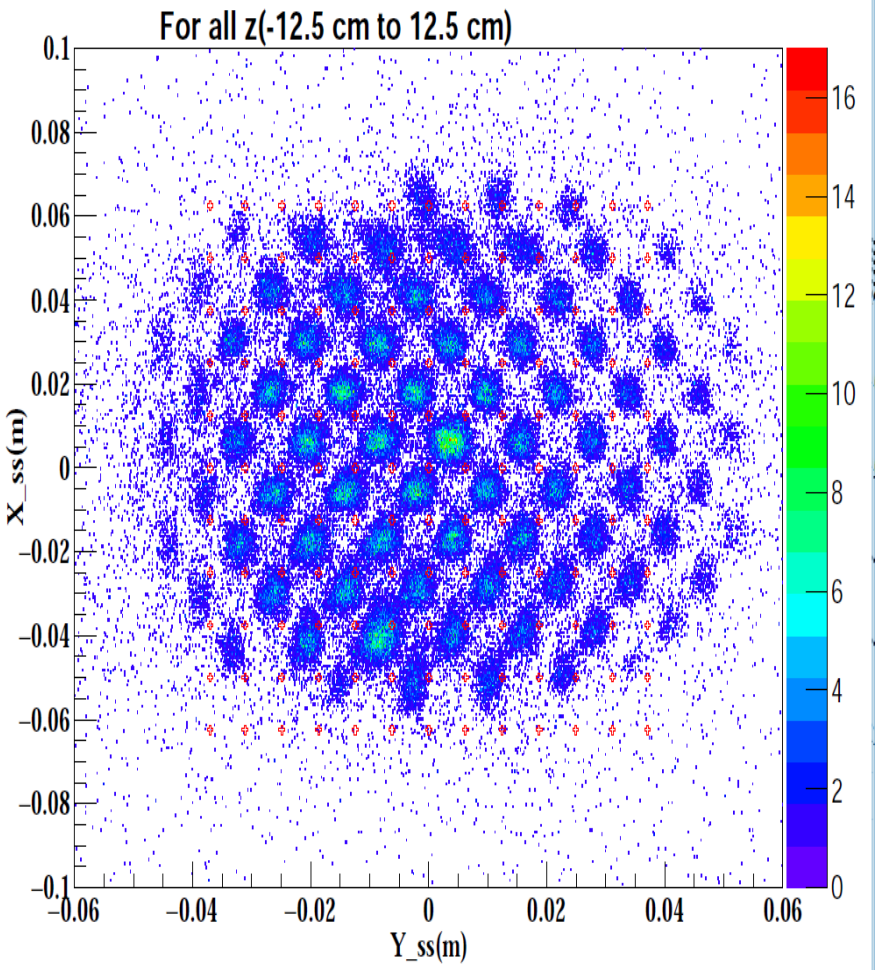
- RHRS Z-vertex has the same resolution as LHRS that is σ ≈ 5.2 mm

2. LHRS Angle Reconstruction

Using our optimized matrix



Using Hall A matrix



Achieved good angular resolution.

1. In the dispersive plane σ ≈ 3 mrad
2. In the non dispersive plane σ ≈ 2 mrad
3. The right histogram has some offsets as the holes are not landed at their nominal

Snap Shots:Target Cell

Target cell of tritium gas

Cell material:

Al alloy (ASTM B209 AL 7075-T651)

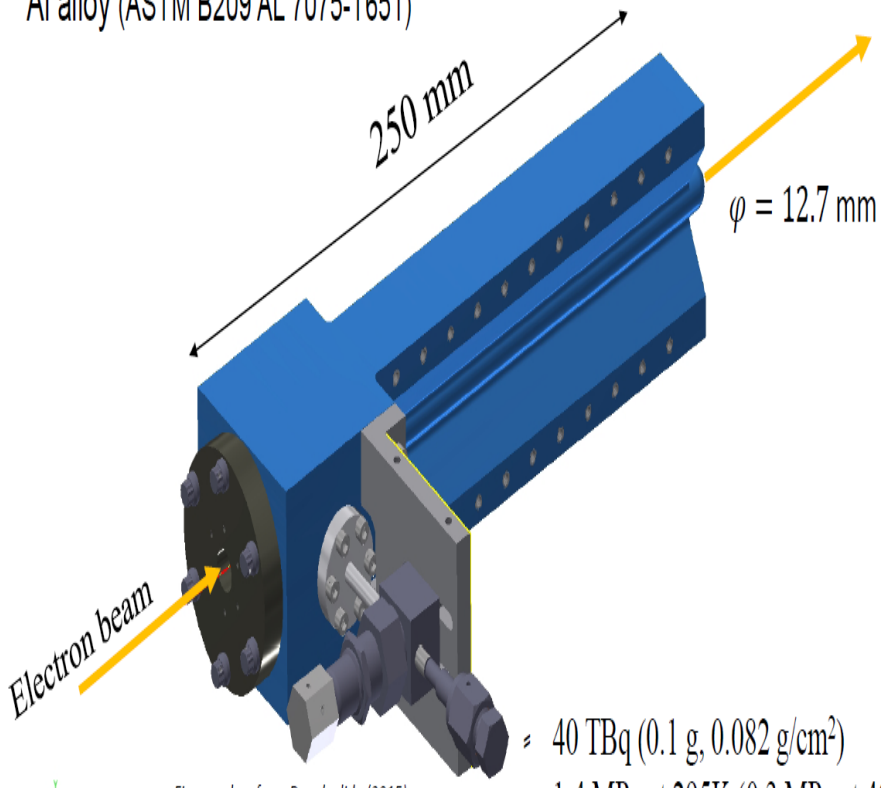
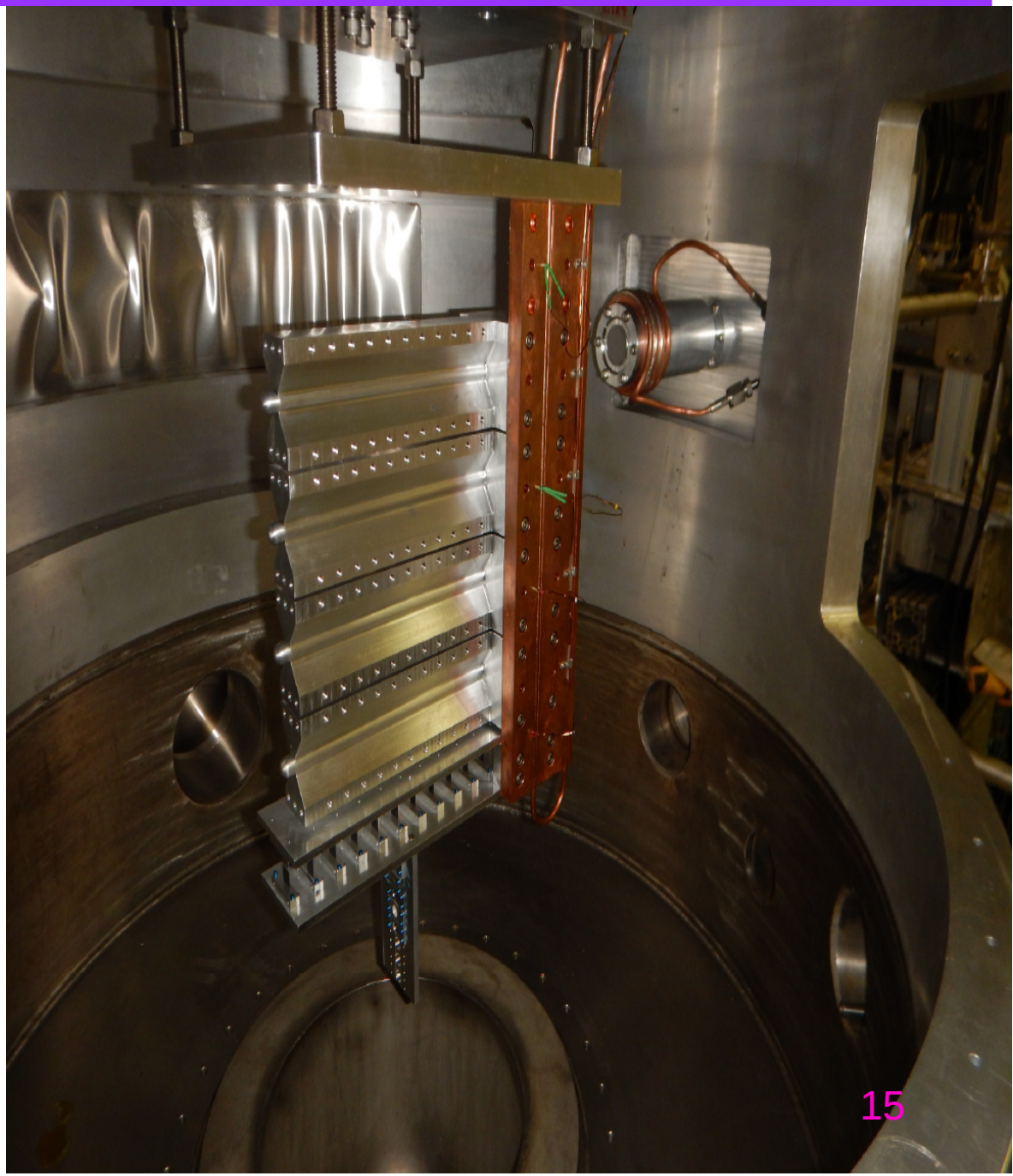
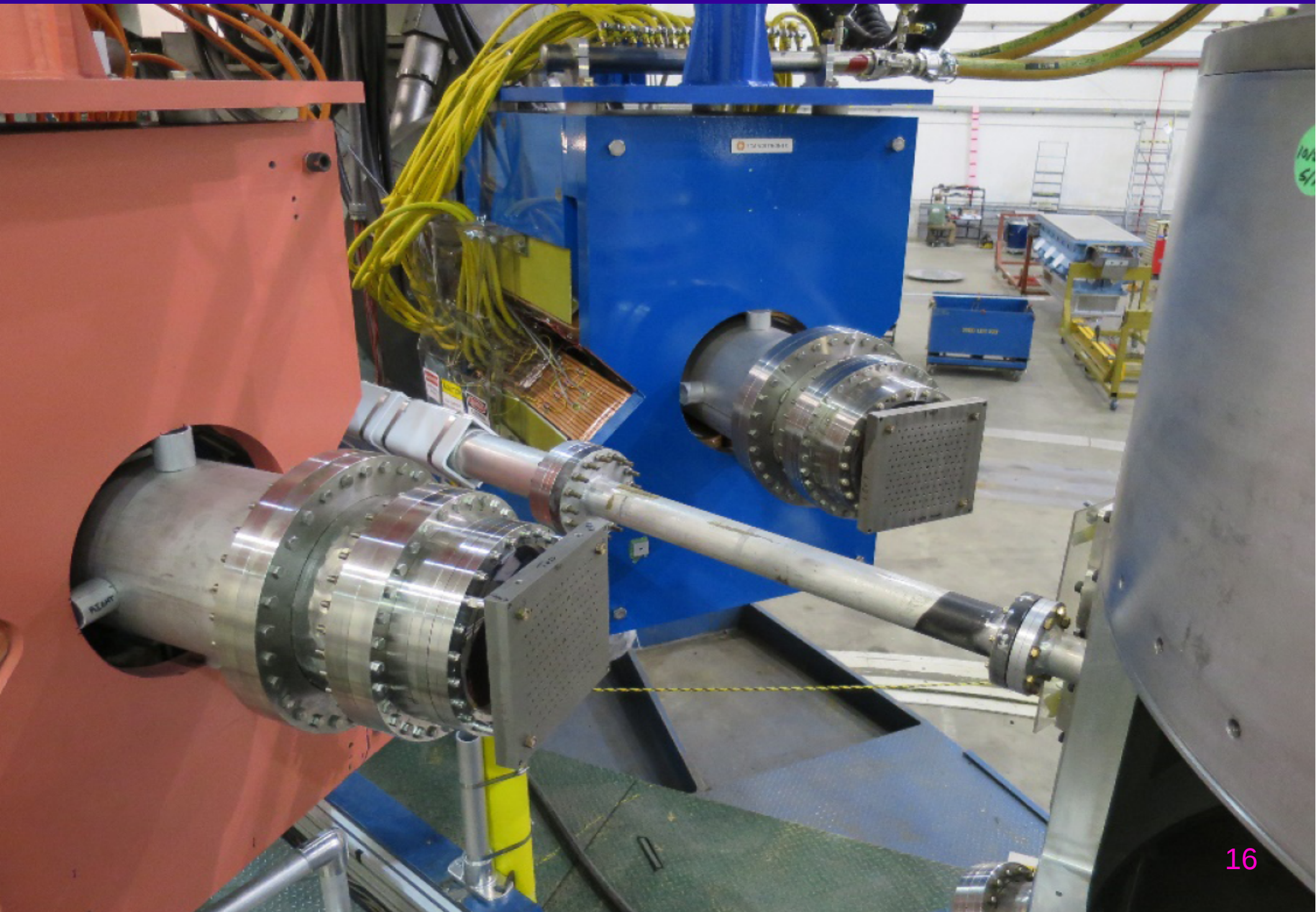


Figure taken from Dave's slide (2015).

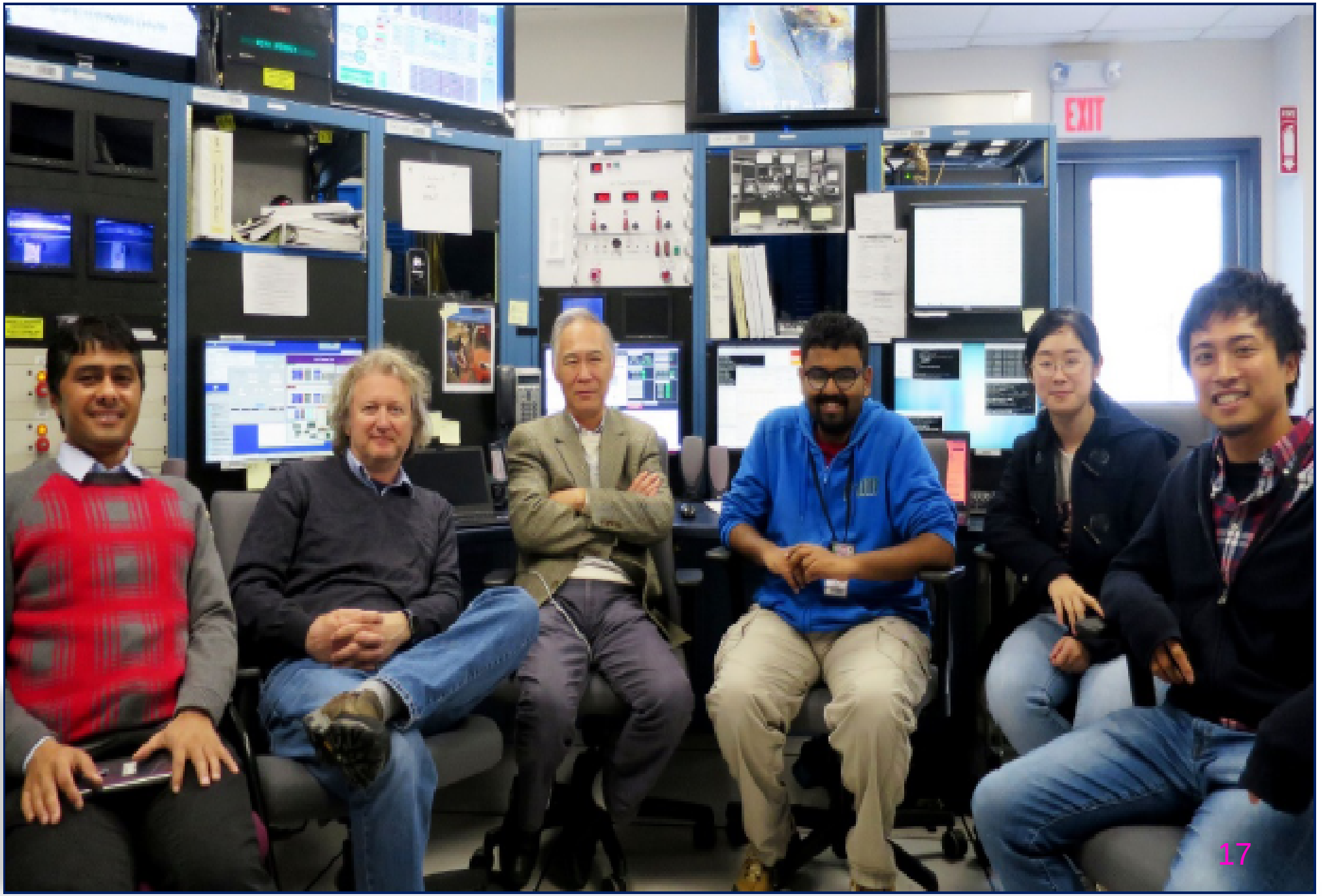
- 40 TBq (0.1 g, 0.082 g/cm^2)
- 1.4 MPa at 295K (0.3 MPa at 40K)
- 34 cc



Seive Slit



Hall A Counting House



Counting House

Acknowledgements

- I would like to acknowledge my advisor and spokesperson of this experiment Dr. Liguang Tang and all of the collaborator of the HKS group for their continuous support and encouragement.

- This project is supported by DE-FG02-97ER41047

Conclusions

- The experiment E12-17-003 (e,e',K^+) was carried out successfully at Jefferson lab, hall A in November 2018.
- The experiment collected about 85 % production data of proposed data.
- The preliminary results shows that the experiment is going in to the right direction.
- The detailed and the careful calibrations are in progress.
- The experiment will dig out the unknown Λn interaction by searching the possible Λnn resonance.

Thank You