Study of the Λ/Σ^0 electroproduction at JLab Hall A

Kazuki Okuyama

Graduate School of Science, Tohoku University, Japan

Graduate Program on Physics for the Universe (GP-PU), Tohoku University, Japan

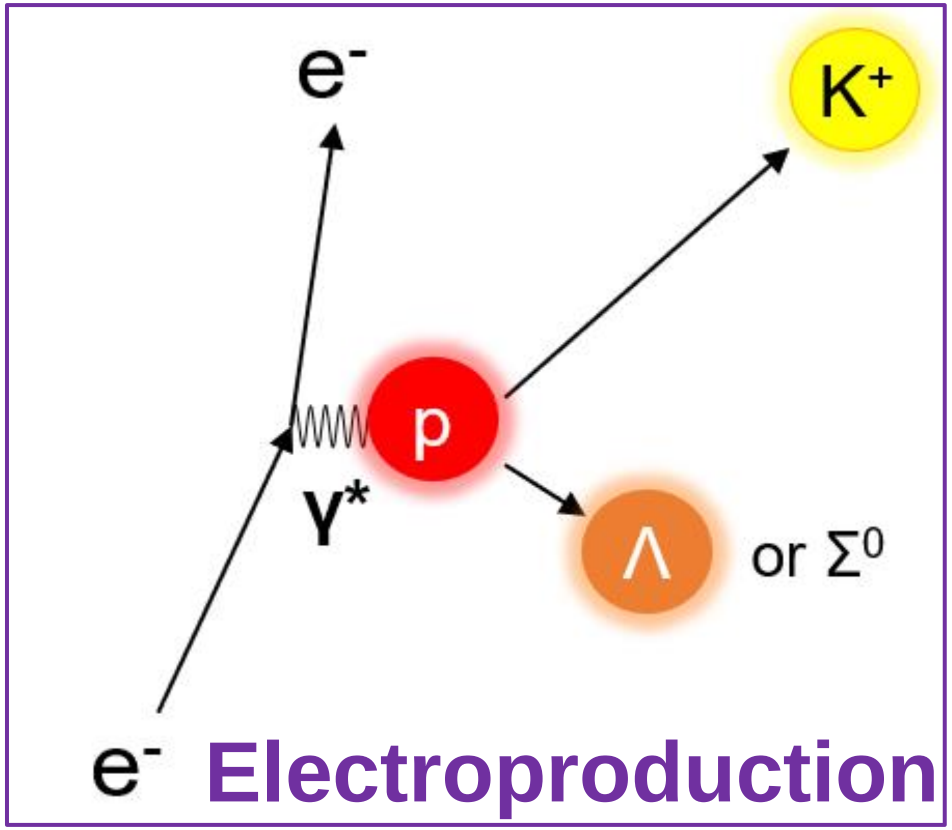
Contents

Searching for nnΛ state
(I won't talk about this.)

gas hydrogen target:
also available
as a calibration

JLab E12-17-003 (2018); I'm focusing on the $p(e,e'K^+)\Lambda/\Sigma^0$ reaction

- Introduction
- Experimental Setup
- Data Analysis: $p(e,e'K^+)\Lambda/\Sigma^0$ reaction
- Results & Summary



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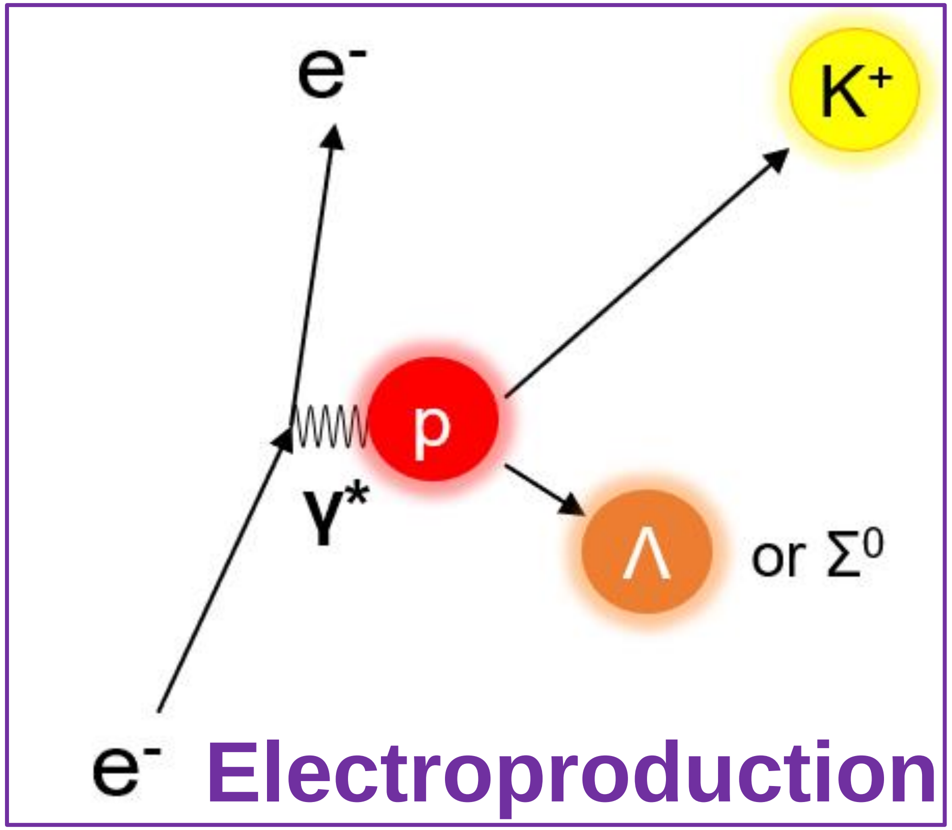
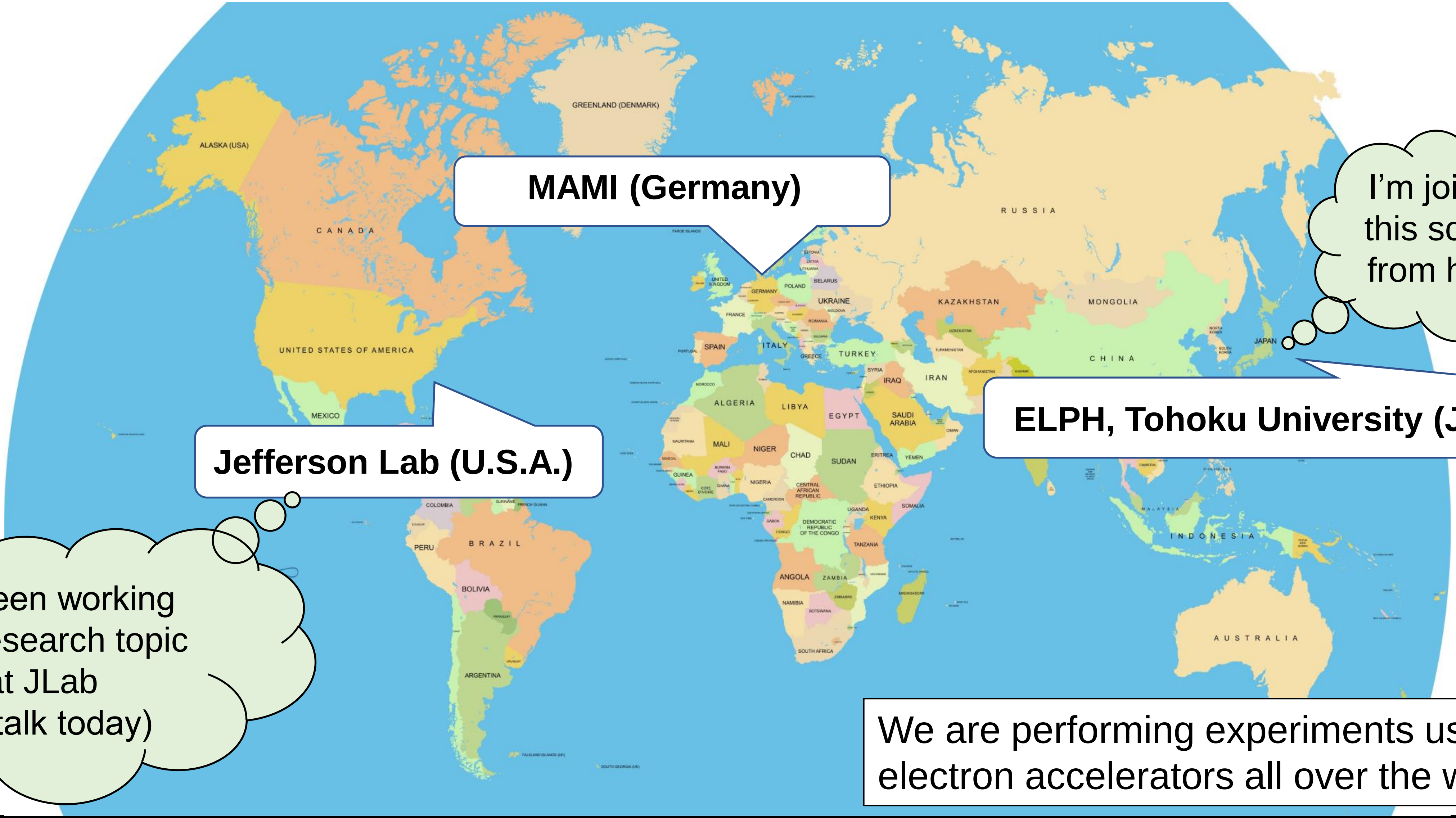


Our group have been researching globally



MAMI (Germany)

Jefferson Lab (U.S.A.)

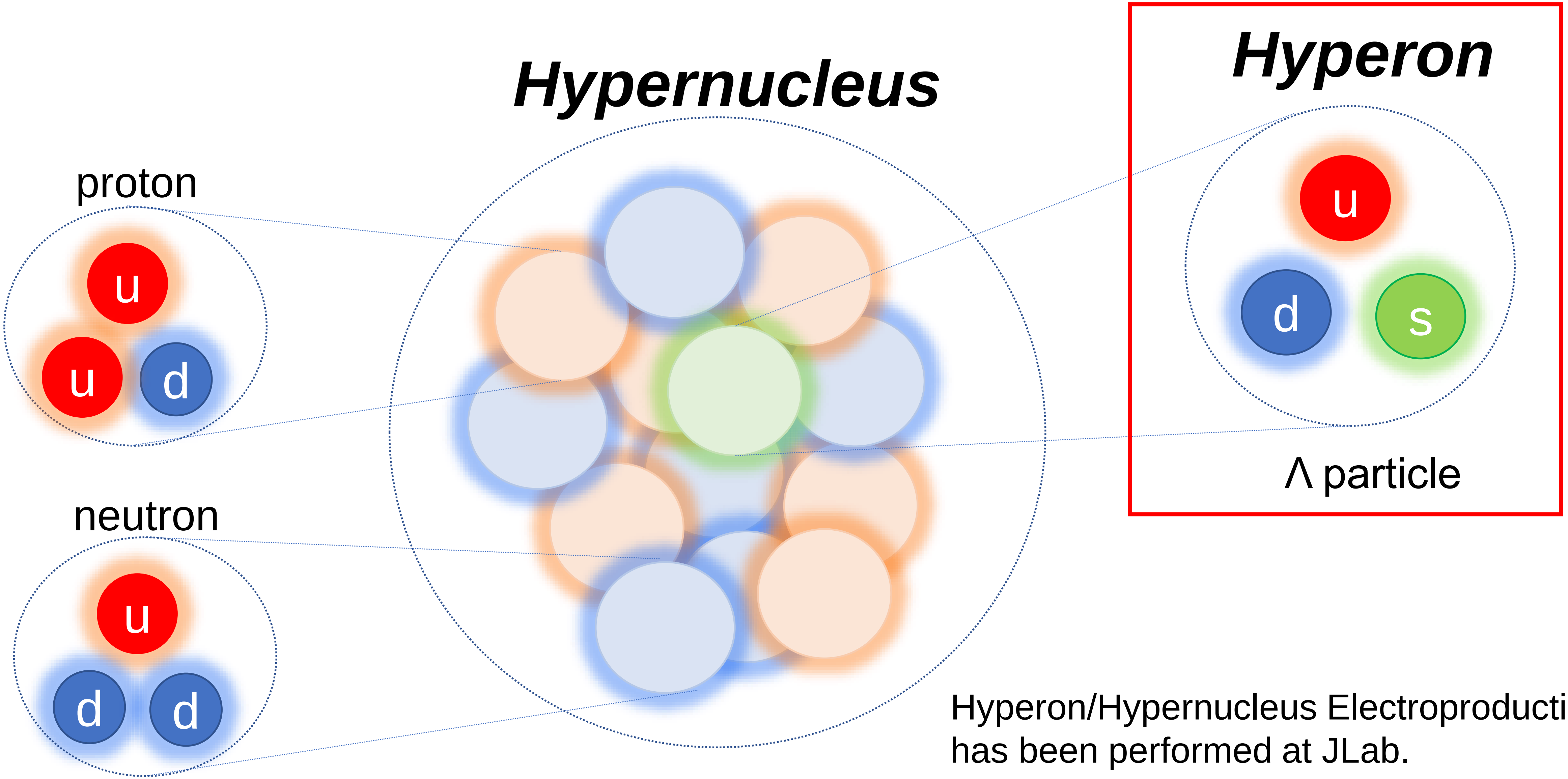
ELPH, Tohoku University (Japan)

I've been working on a research topic at JLab (I'll talk today)

I'm joining this school from here!

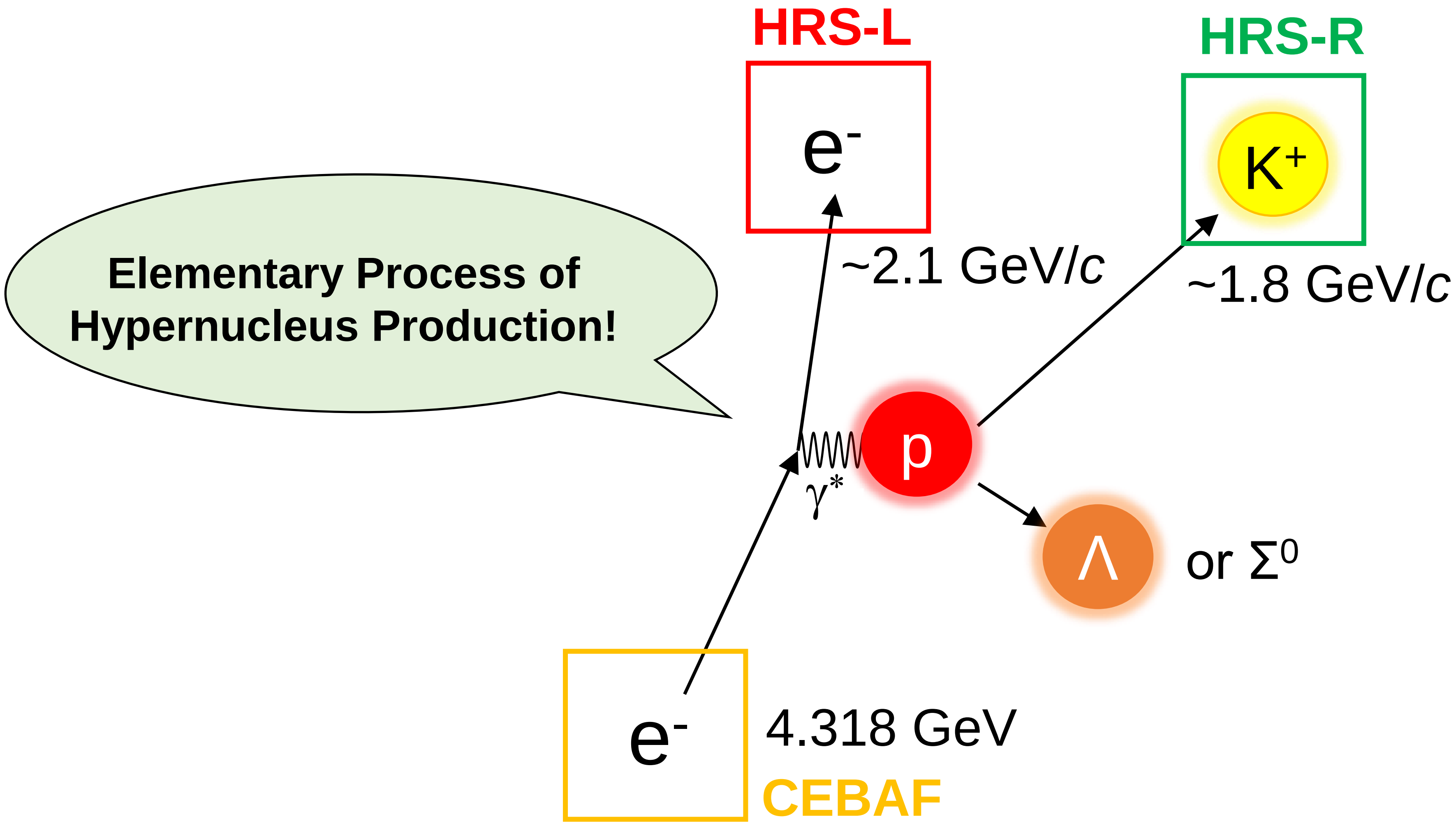
We are performing experiments using electron accelerators all over the world.

Strangeness Nuclear Physics



Hyperon/Hypernucleus Electroproduction has been performed at JLab.

Hyperon **Electroproduction** at JLab



E12-17-003

$\theta_{\gamma K}^{CM}$=8°,

Q^2=0.5 (GeV/*c*)^2

$$\text{Missing Mass} = \sqrt{\{(E_e - E_{e'}) + M_p - E_K\}^2 - \{(\boldsymbol{P}_e - \boldsymbol{P}_{e'}) - \boldsymbol{P}_K\}^2}$$

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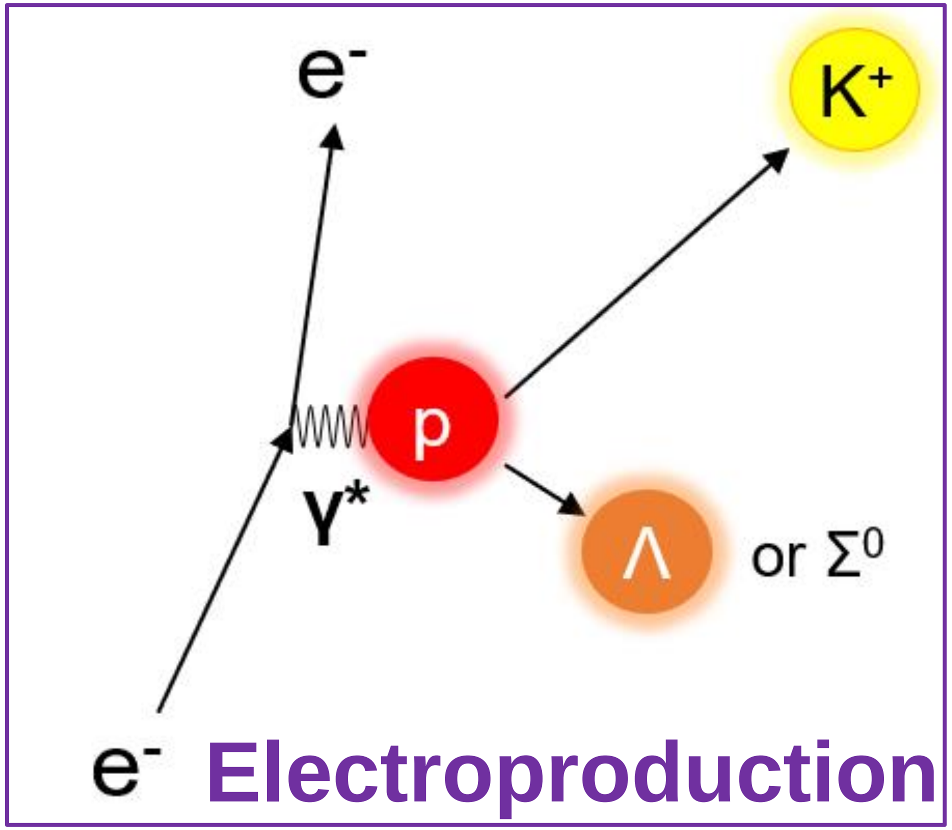
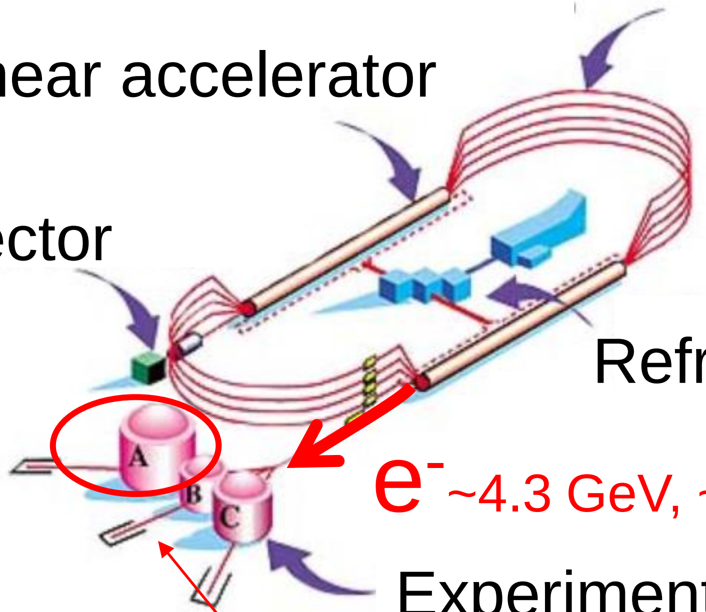


E12-17-003: at JLab Hall A in 2018

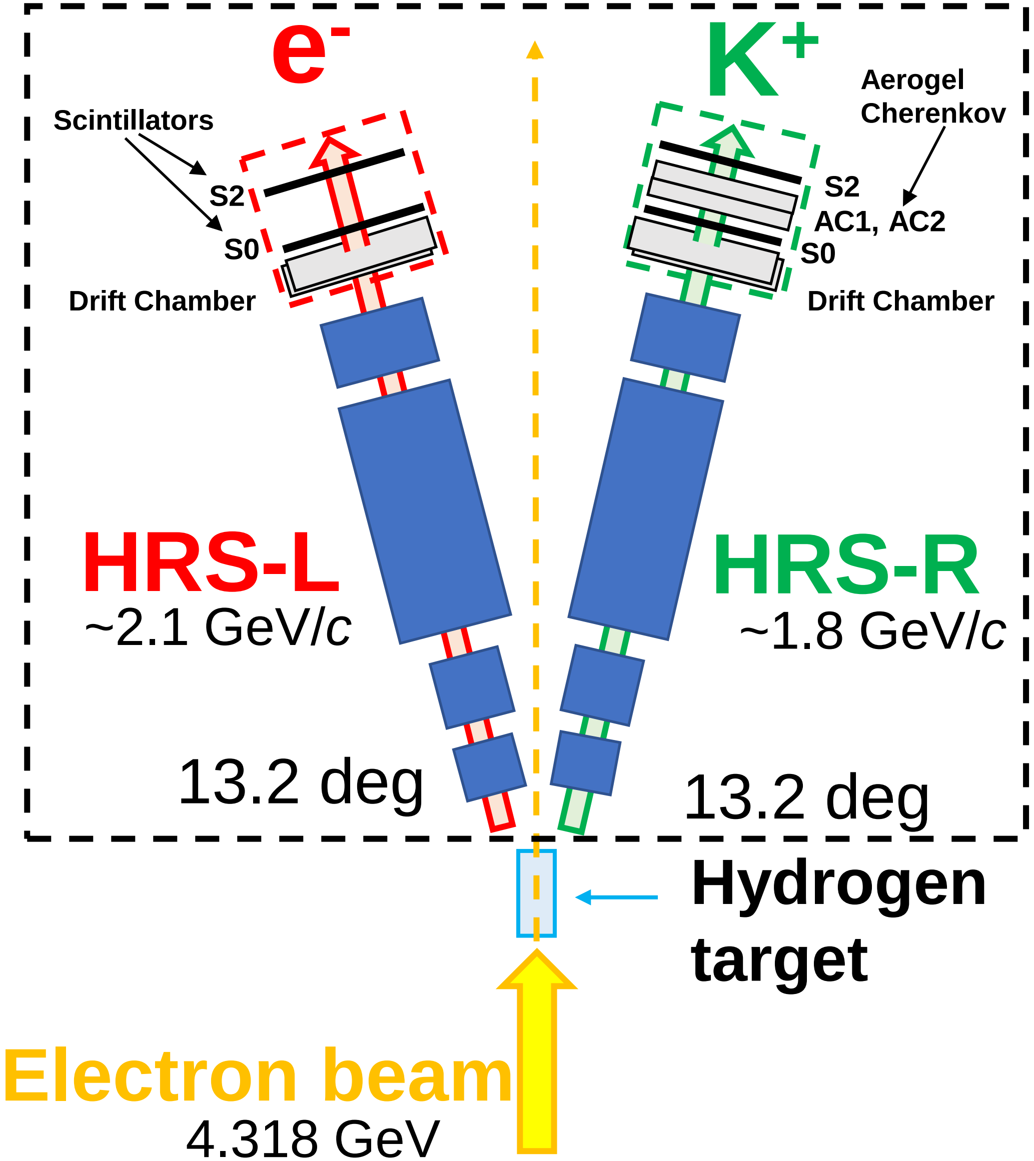
Continuous Electron Beam Accelerator Facility (CEBAF)



e^- ~4.3 GeV, ~20 μA (this exp.)

Hall A

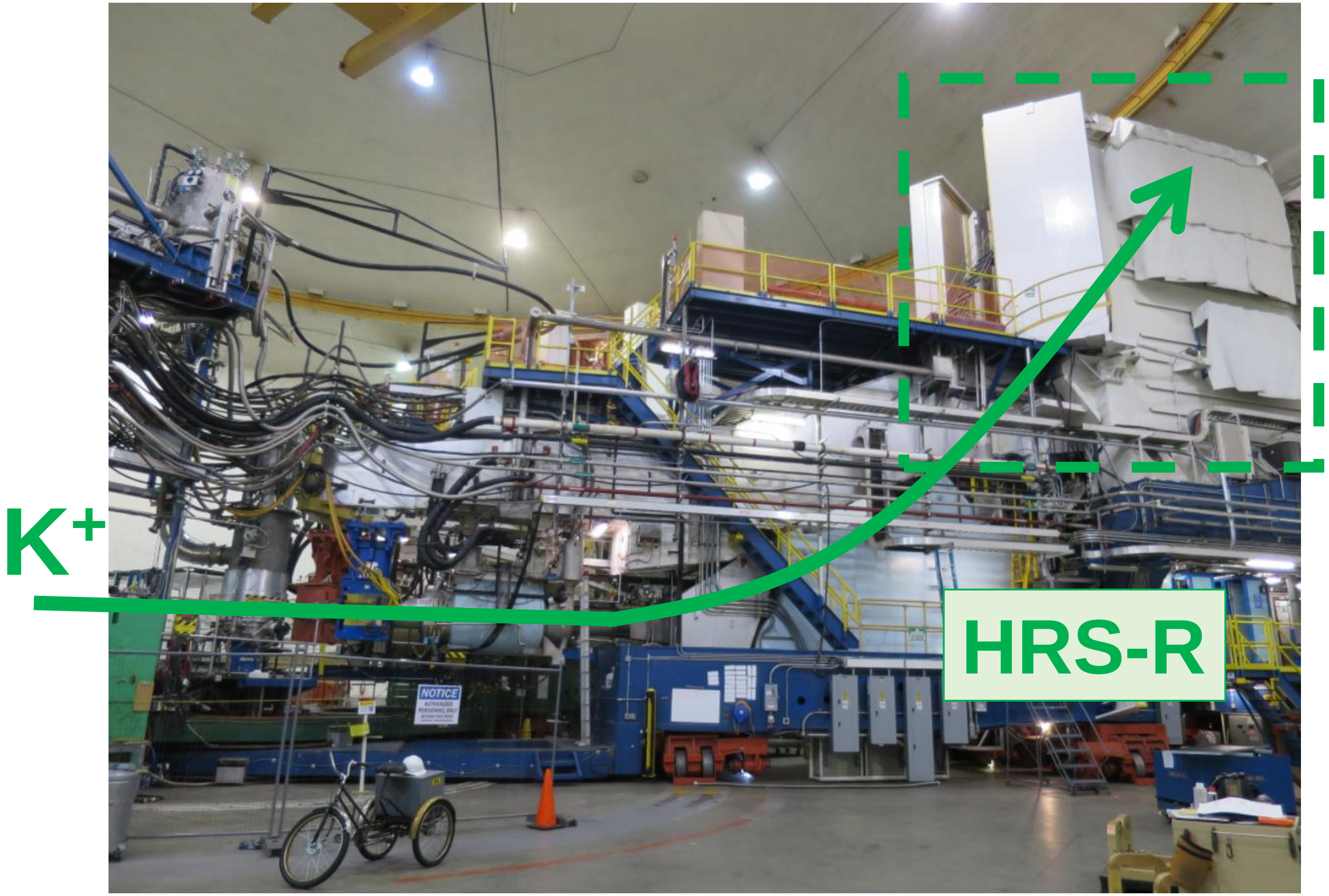
Experimental Setup



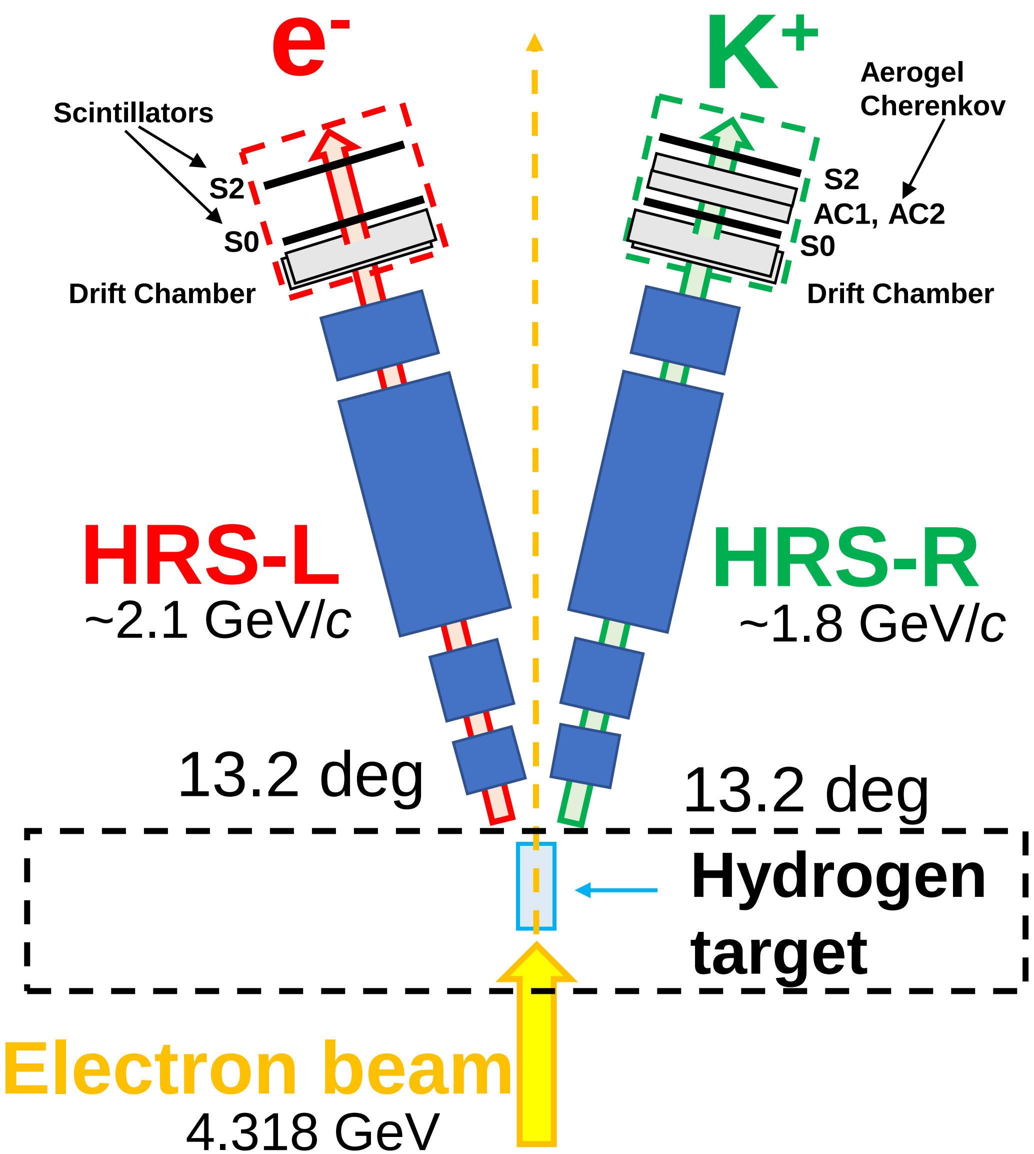
Detectors in HRS-R

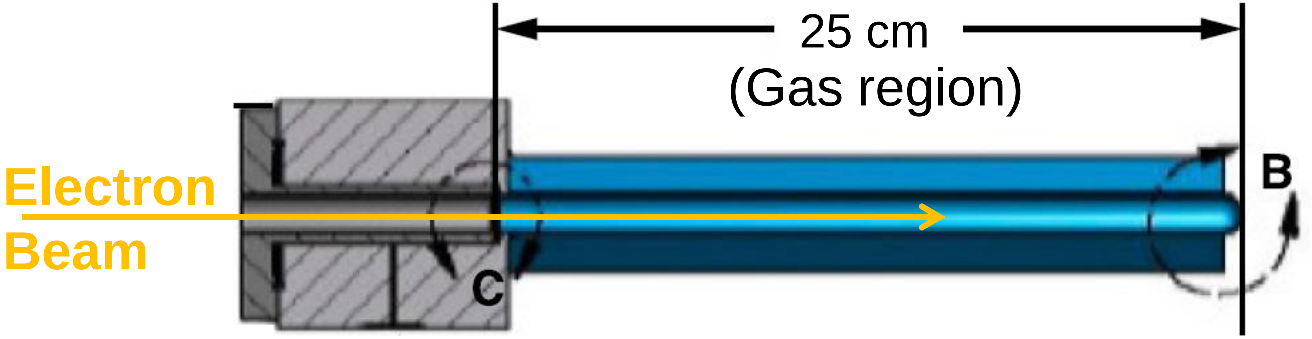
same as HRS-L:
- Drift Chamber (Tracking)
- Scintillators (Timing)

- Aerogel Cherenkov (K^+ identification)

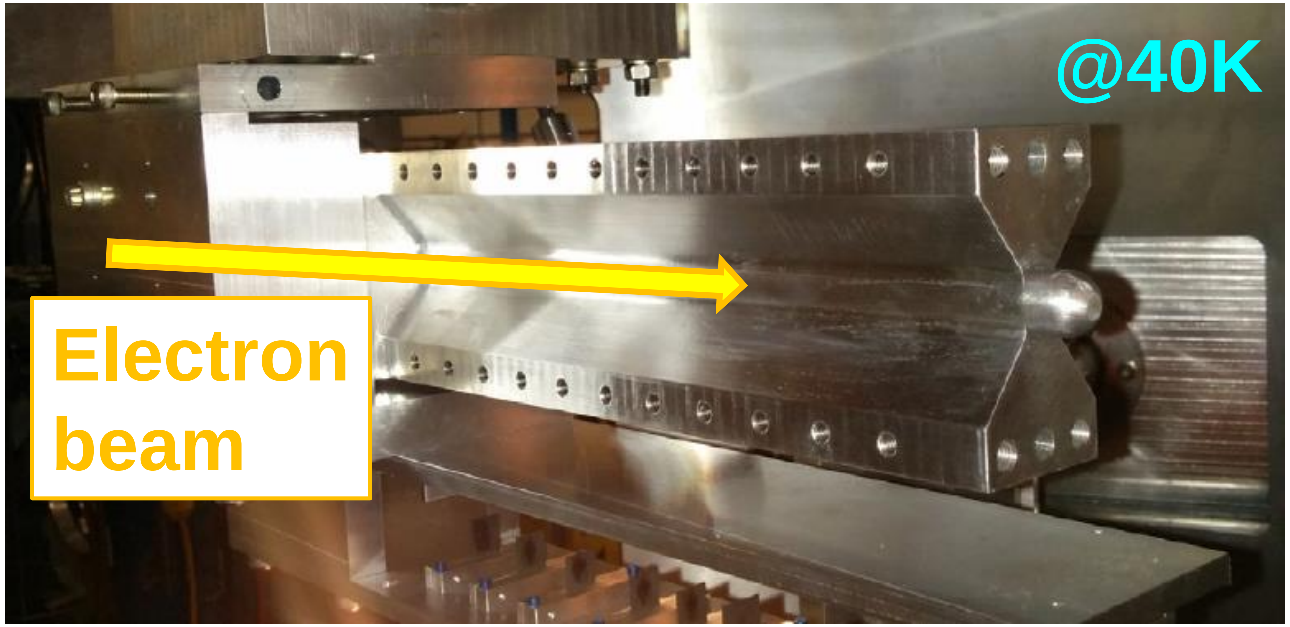


Target Cell





Aluminum Cell thickness: 400 μm



S.N. Santiesteban *et al.*, Nucl. Inst. and Meth. A **940**, 351 (2019).

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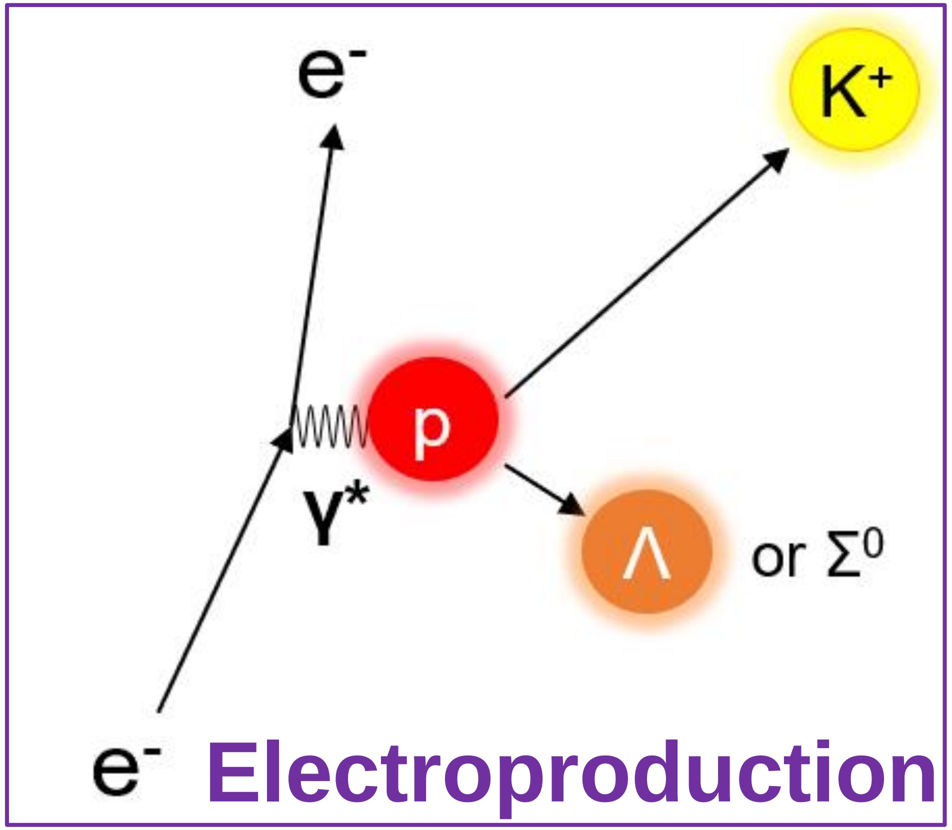


Analysis flow

Hydrogen Data

↓

- Target ID (Vertex Position)
- Kaon ID 1 (Aerogel Cherenkov)
- Kaon ID 2 (Coincidence Time)

Λ/Σ^0 Missing Mass Spectrum

Event selection: $p(e,e'K^+)\Lambda/\Sigma^0$ reaction

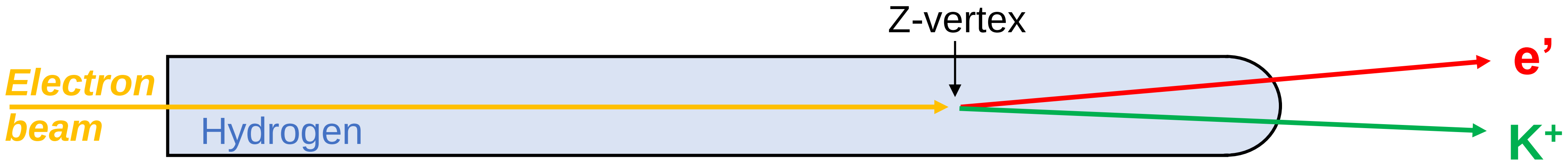
↓

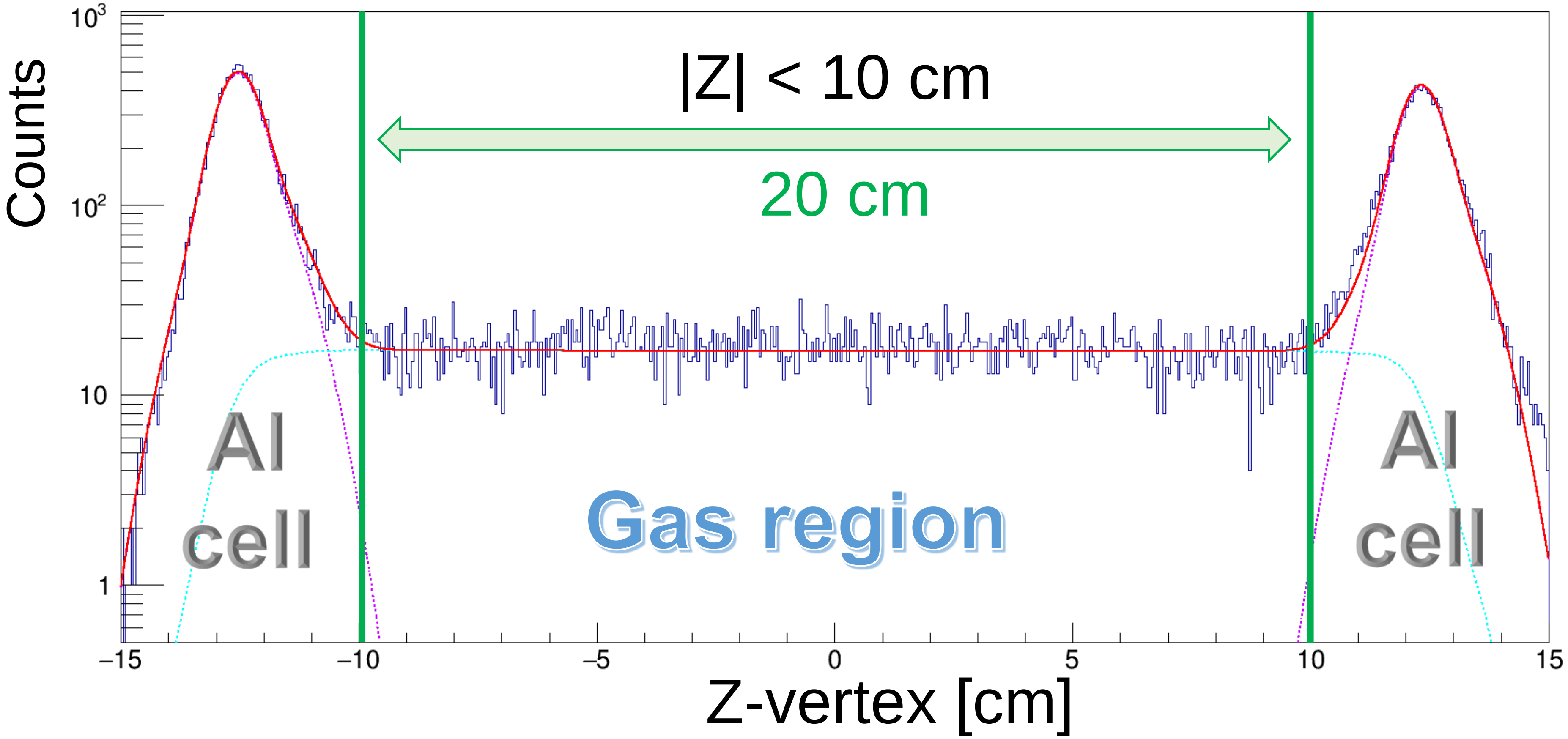
- Efficiency
- Acceptance

The Differential Cross Sections (D.C.S.)

D.C.S. derivation of the hyperon electroproduction

Z-vertex (Target selection)





Z-vertex is derived from the tracking information.

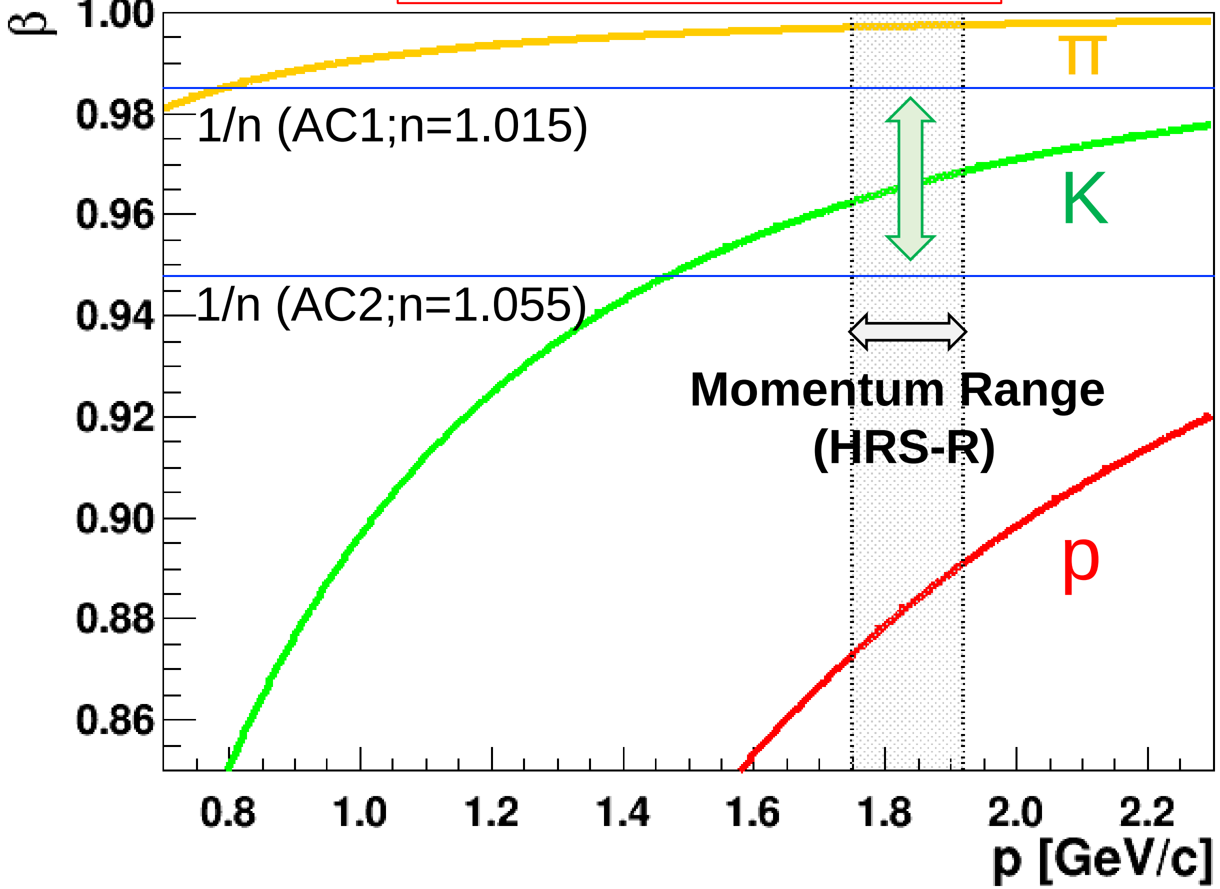
- Gas region: 25 cm
- Used only 20 cm (80% of total)

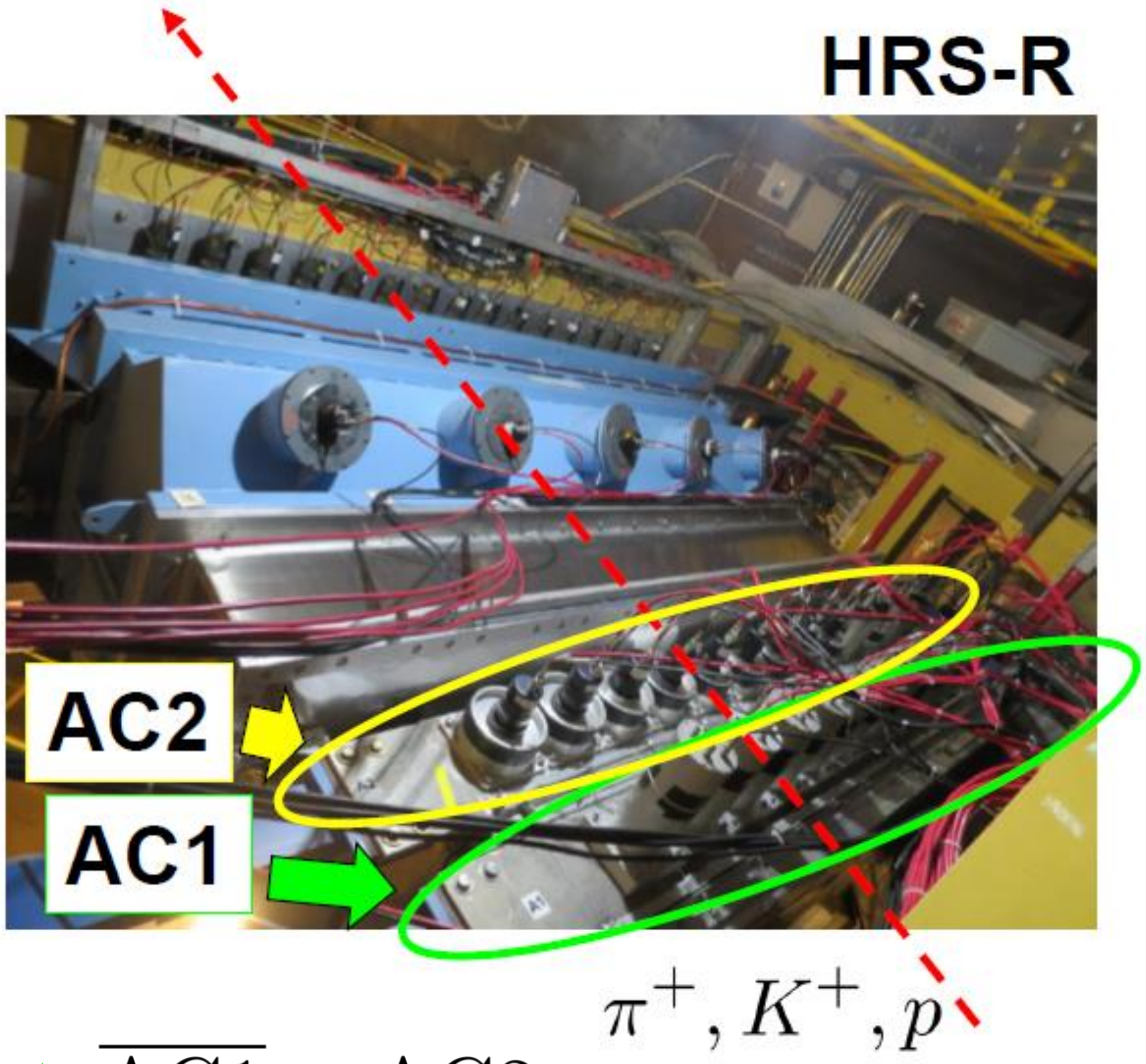
Aerogel Cherenkov (Kaon identification)

AC1 (n=1.015): π^+, K^+, p

AC2 (n=1.055): π^+, K^+, p

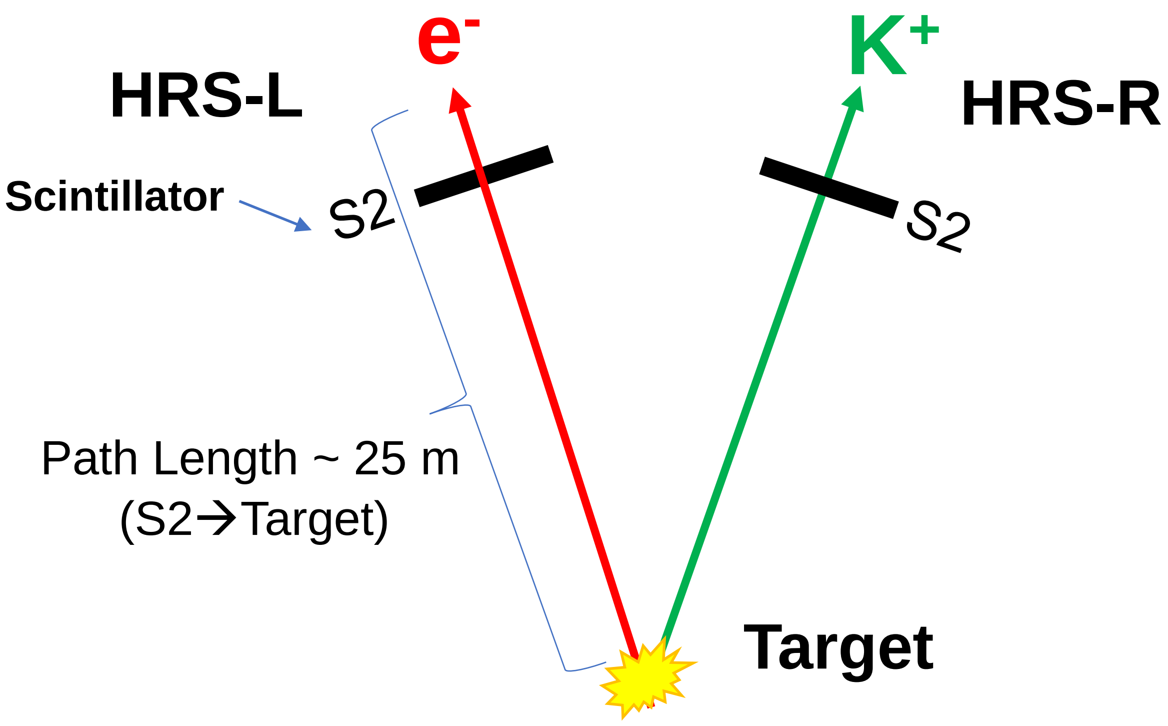
β>1/n (Cherenkov light)





$\Rightarrow \overline{AC1} \otimes AC2$

Coincidence Time (Kaon identification)

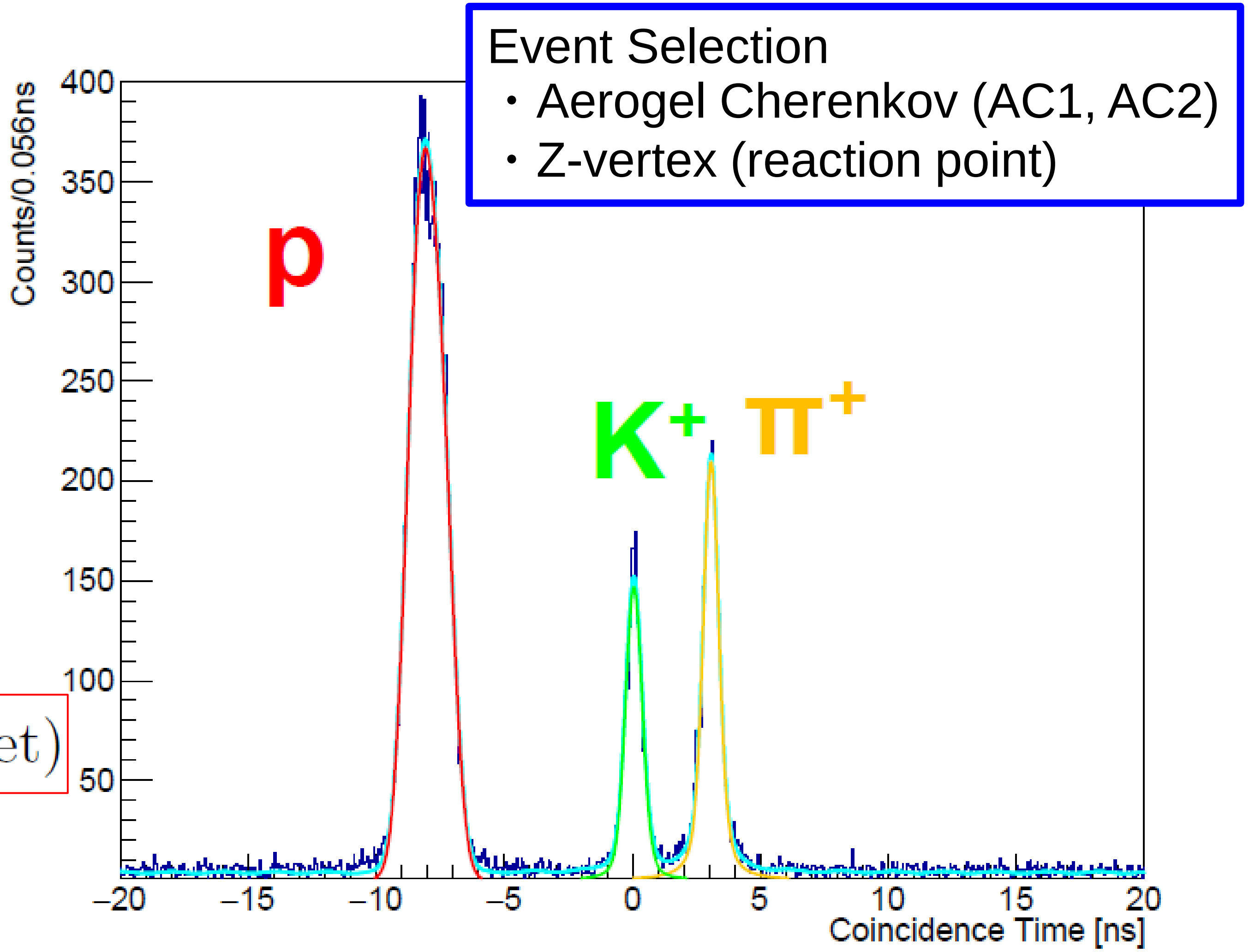


Coincidence Time = Time difference at Target

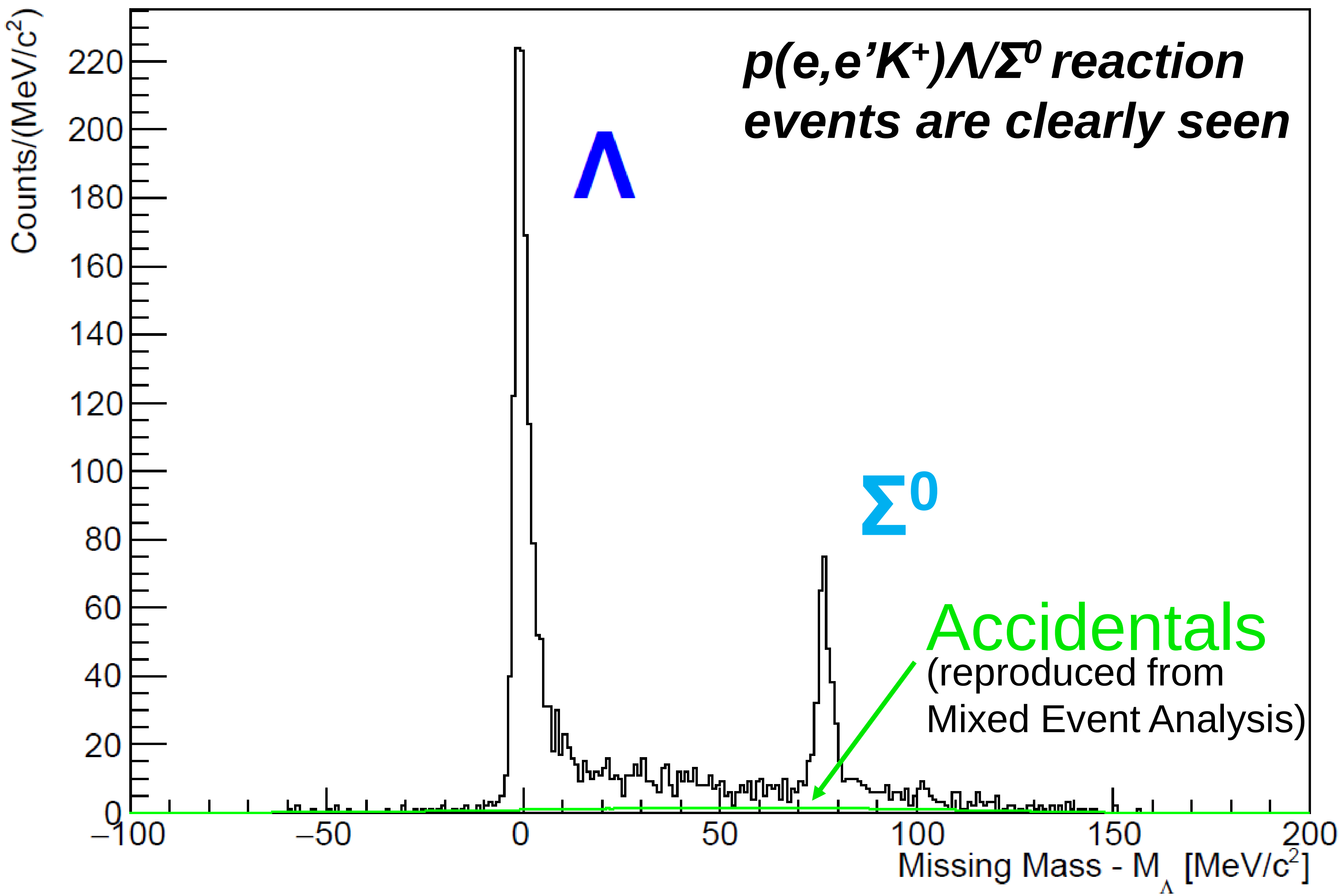
$$t_{\text{Coin.}} := t_{\text{HRS-L}}(\text{Target}) - t_{\text{HRS-R}}(\text{Target})$$

Reaction timing at Target:

$$t(\text{Target}) := t(\text{S2}) - \frac{\text{Path Length}}{\beta c}$$



Missing Mass Spectrum



Analysis flow

Hydrogen Data

- Target ID (Vertex Position)
- Kaon ID 1 (Aerogel Cherenkov)
- Kaon ID 2 (Coincidence Time)

Λ/Σ^0 Missing Mass Spectrum

Event selection: $p(e,e'K^+)\Lambda/\Sigma^0$ reaction

I will briefly explain this part.

- Efficiency
- Acceptance

The Differential Cross Sections (D.C.S.)

D.C.S. derivation of the hyperon electroproduction

Derivation of the differential cross section

$$\overline{\left(\frac{d\sigma_{\gamma^* p\to K^+\Lambda(\Sigma^0)}}{d\Omega_{K^+}}\right)}_{\text{HRS-R}} \simeq \frac{1}{N_{\text{Target}}}\cdot\frac{1}{N_{\gamma^*}}\cdot\frac{1}{\bar{\varepsilon}}\cdot\sum_{i=1}^{N_{\Lambda(\Sigma^0)}}\frac{1}{\varepsilon_i^{\text{DAQ}}\cdot\Delta\Omega_{\text{HRS-R}}(p_{\text{K}}, z)}$$

~1270 (Λ), ~350 (Σ^0)
Num. of Hyperons

Num. of Target
0.0375 b^{-1}

Num. of Virtual Photon
3.49×10^{13} (Λ)
5.23×10^{13} (Σ^0)

Survival Ratios
0.0680 (Λ)
0.0664 (Σ^0)

DAQ efficiency
~0.96

Solid Angle
~5.5 msr (Lab)

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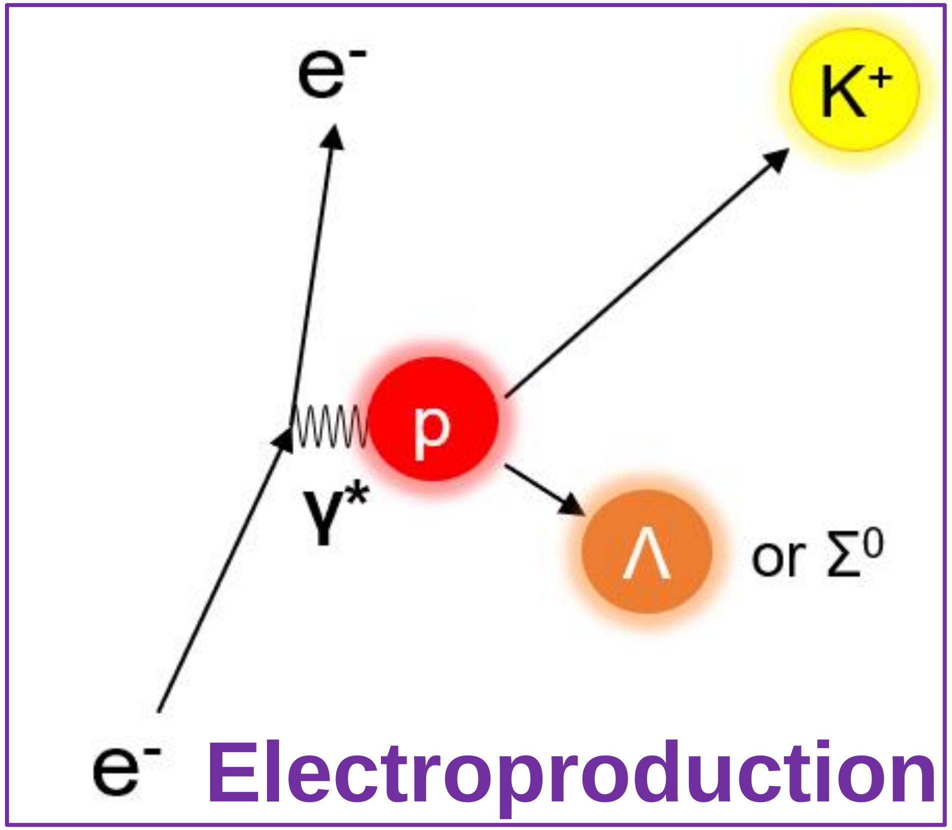
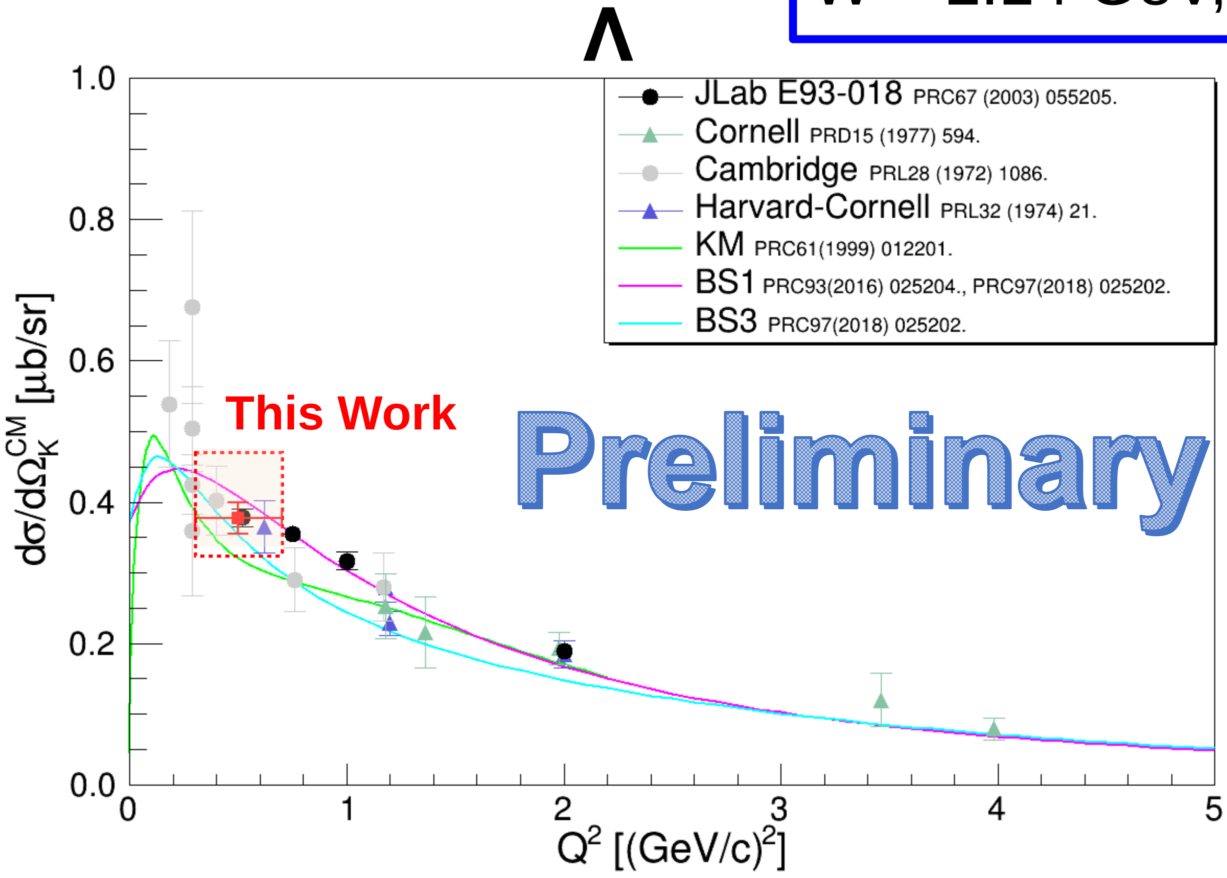
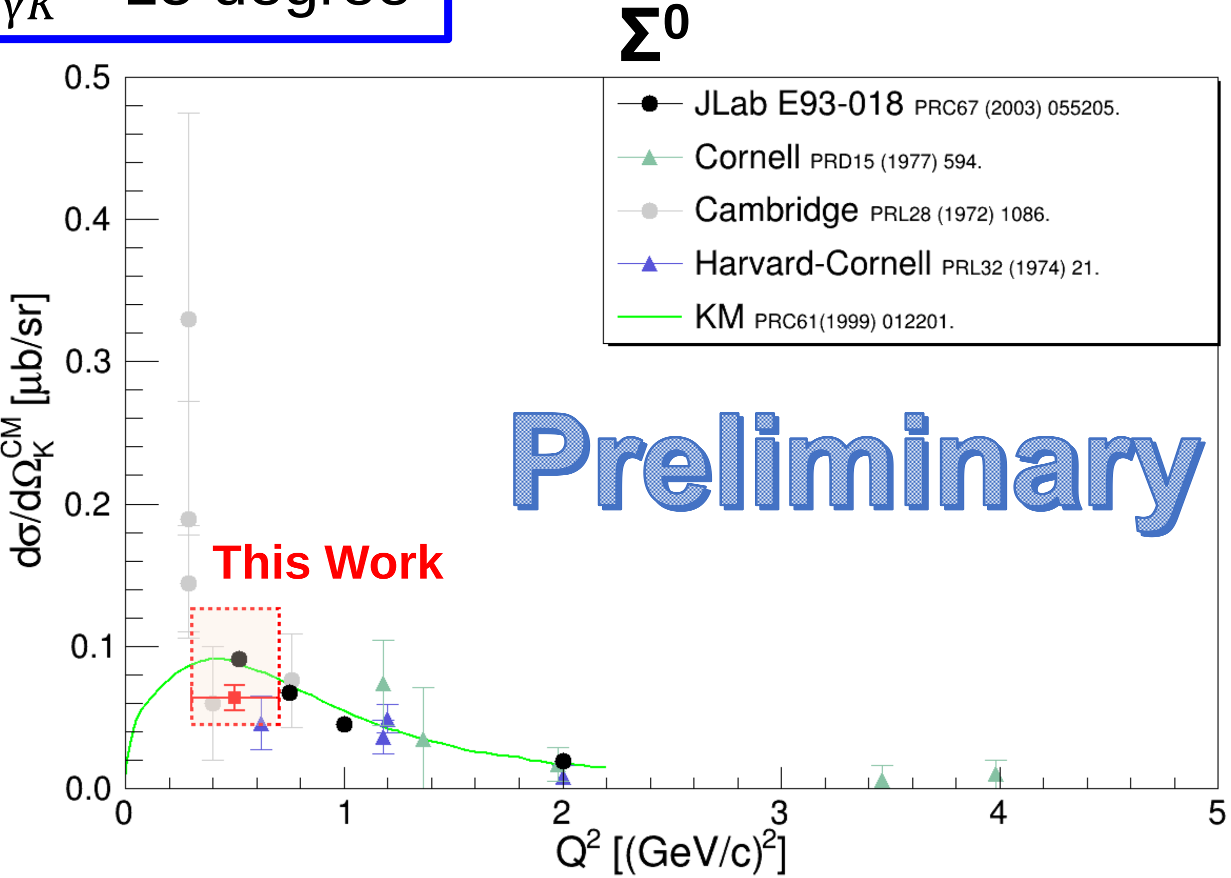


Results

- I deduced the differential cross sections at Q^2~0.5 (GeV/*c*)^2

W = 2.14 GeV, $\theta_{\gamma K}^{CM}$ <15 degree

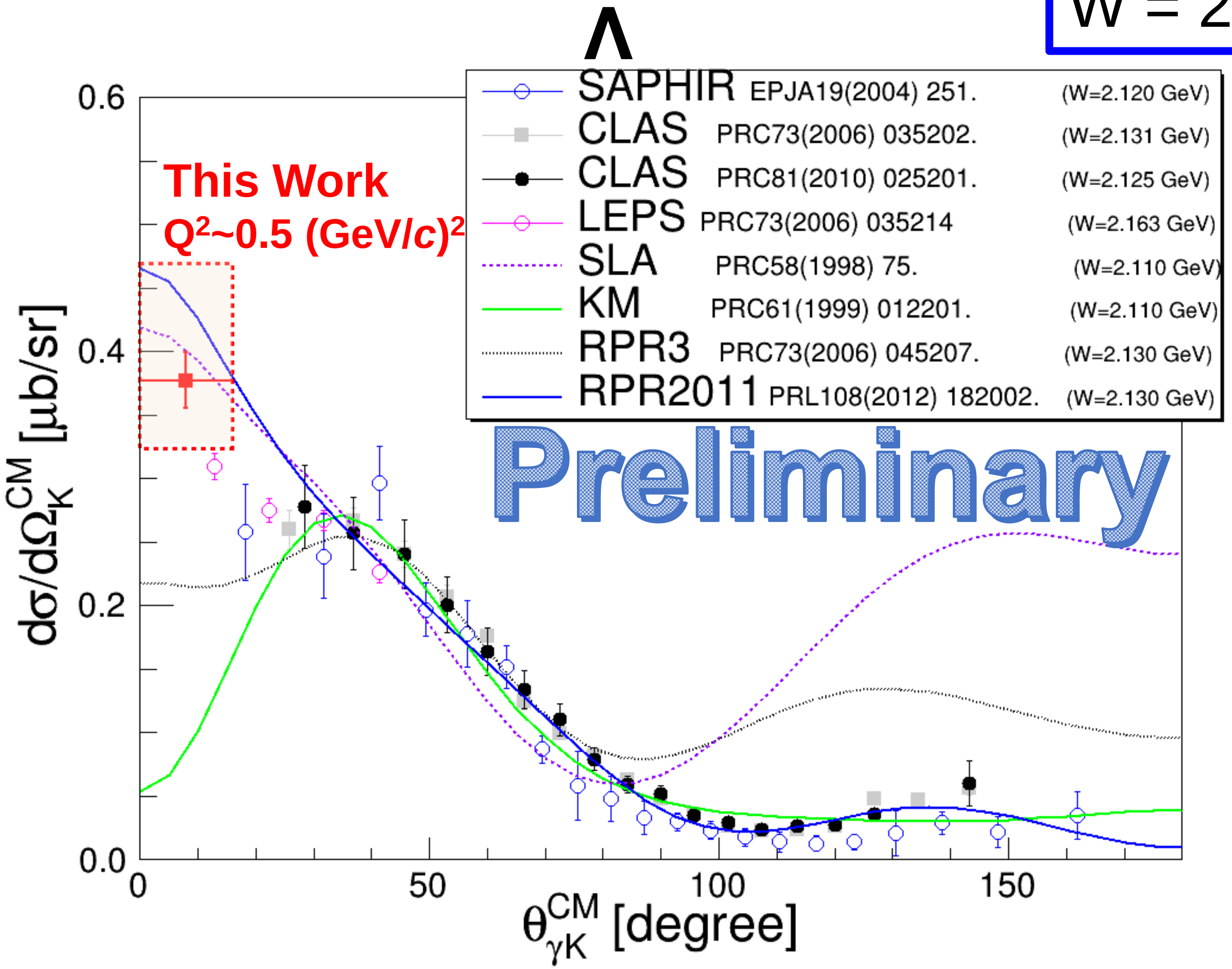


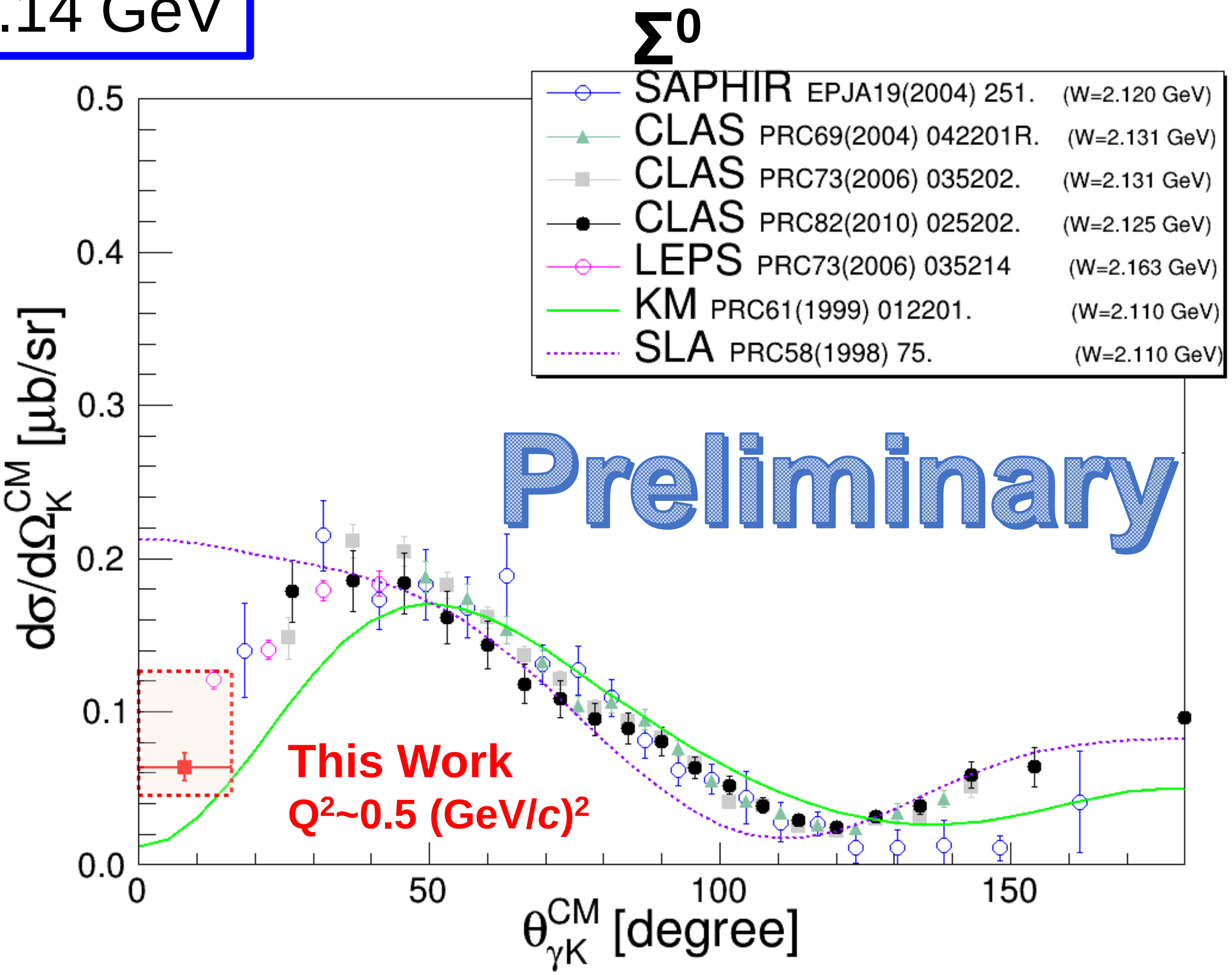


Results: Comparison with Photoproduction

➢ **I deduced the differential cross sections in forward angles**

W = 2.14 GeV





Summary

- We have been performing hypernuclear experiments around the world
- Our latest experiment: JLab E12-17-003 was perfomed in 2018
- $p(e,e'K^+)\Lambda/\Sigma^0$ reaction is an elementary process of a hypernucleus production
- I deduced the differential cross section of the Λ/Σ^0 electroproduction
- I hope my work helps understanding about hyperon/hypernucleus production

Thank you for your attention!
Thank you for organizing such a wonderful school!
I'm having fun!!