

New Perspectives on exotic and heavy hadrons

Investigating the $\Lambda\eta$ Threshold Region with the J-PARC E72 Experiment

Search for a Narrow Λ^* Resonance using the $p(K^-, \Lambda)\eta$ Reaction with the HypTPC Detector

2026. 08. 28

Haein Lee

Department of Physics, Korea University
for the J-PARC E72 Collaboration

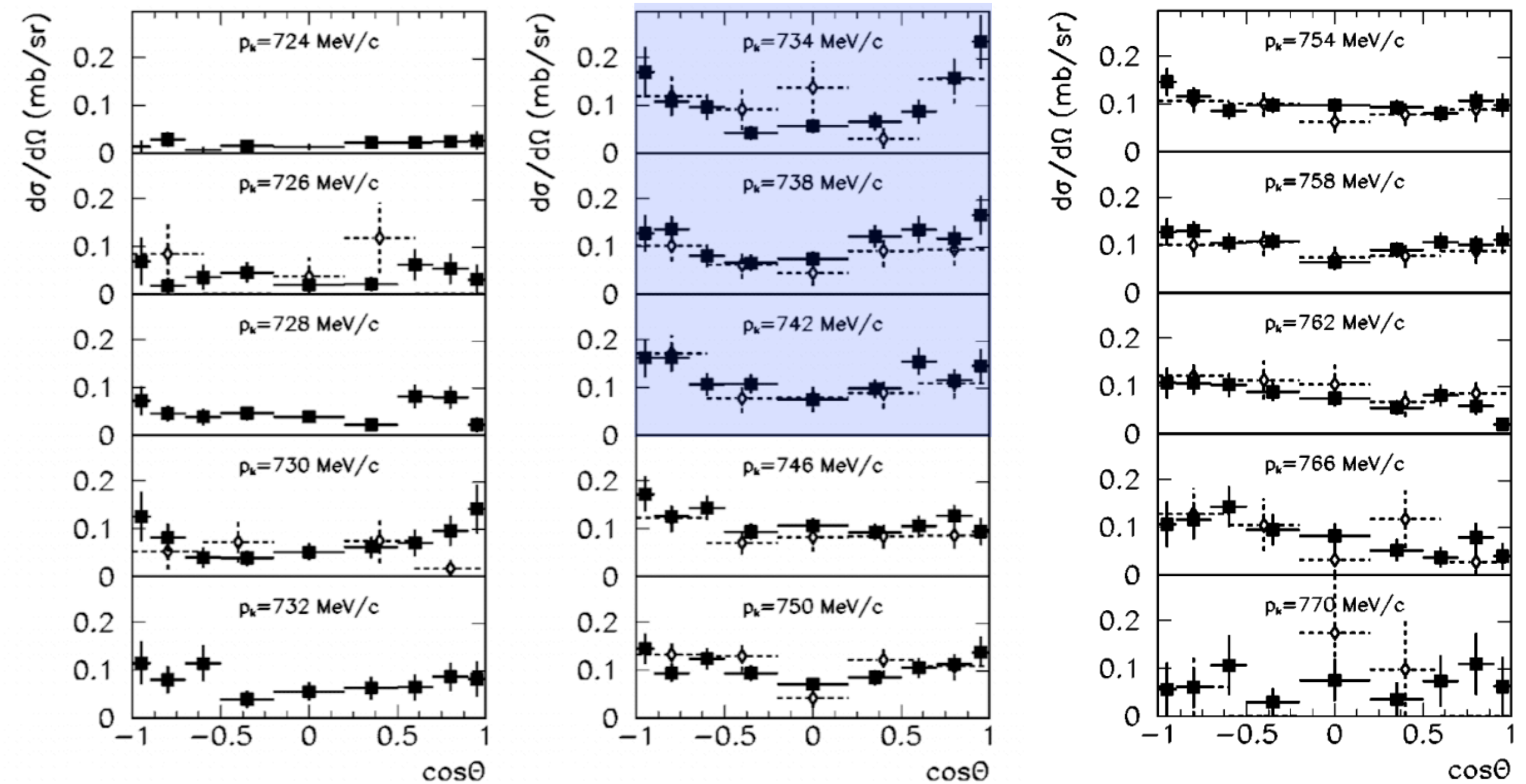
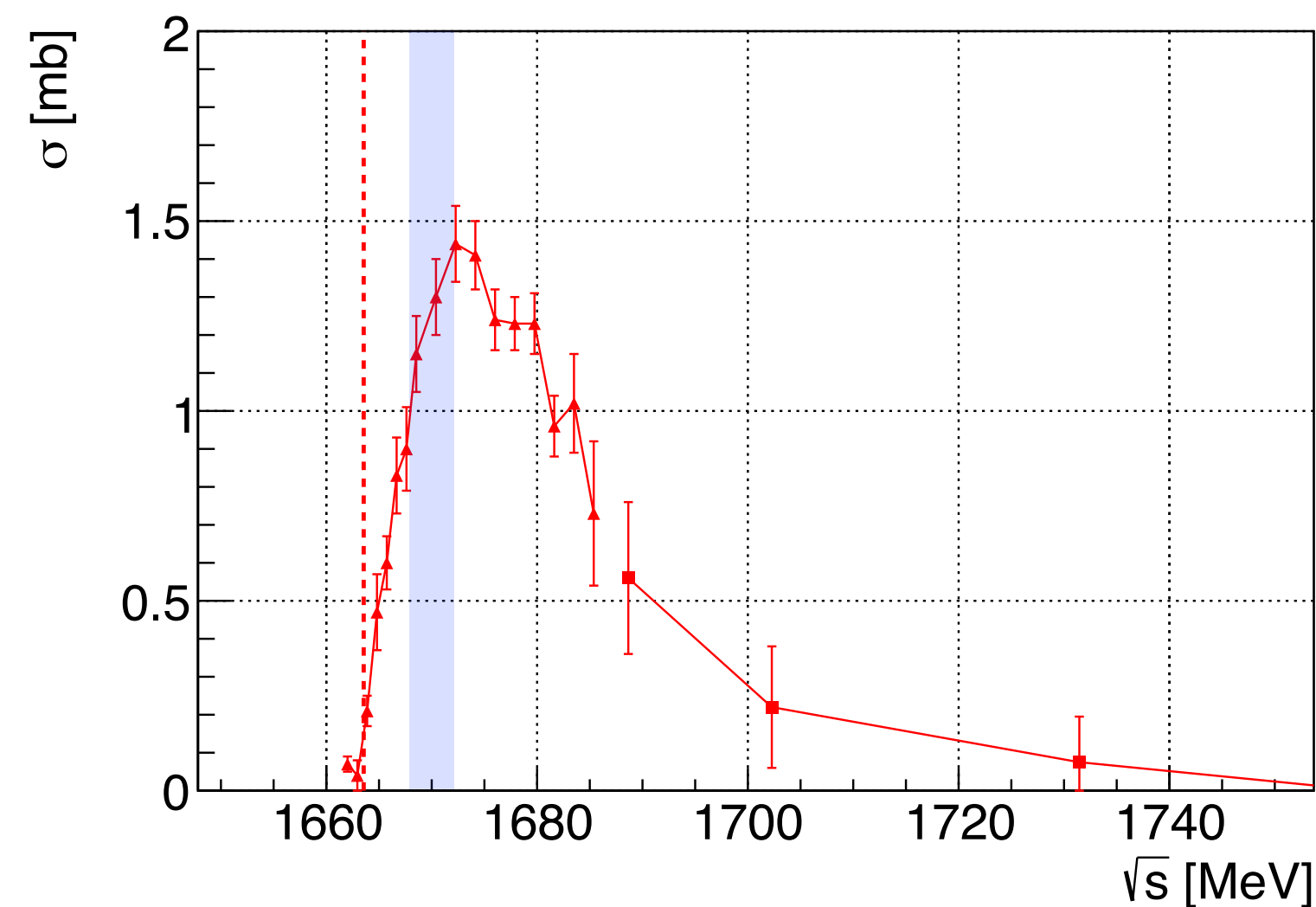
■ Λ Resonance near the $\Lambda\eta$ threshold

2000 $K^-p \rightarrow \Lambda\eta$ (Crystal Ball)

A. Starostin et al., Phys. Rev. C. 64, 055205 (2001)

Crystal Ball ●→

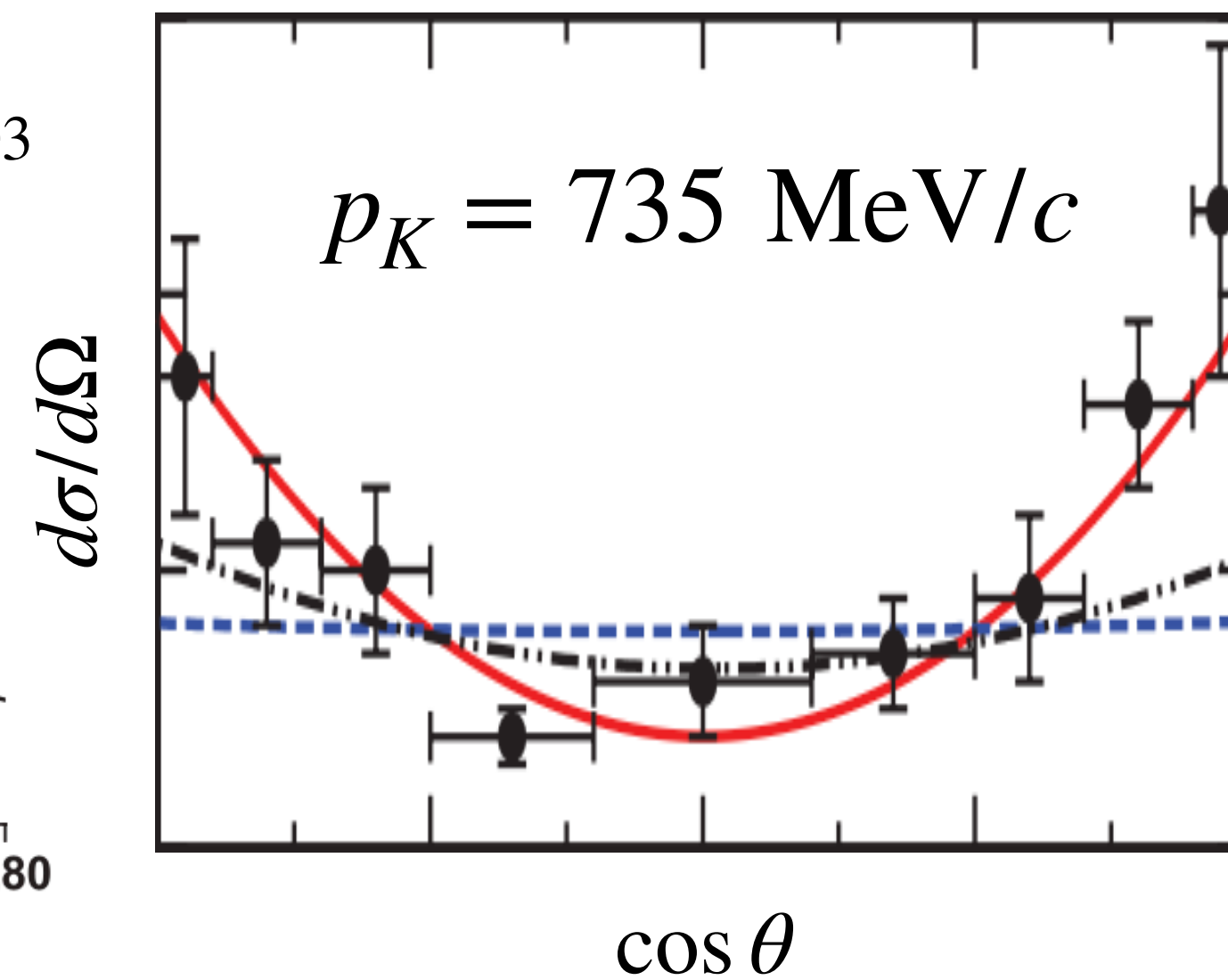
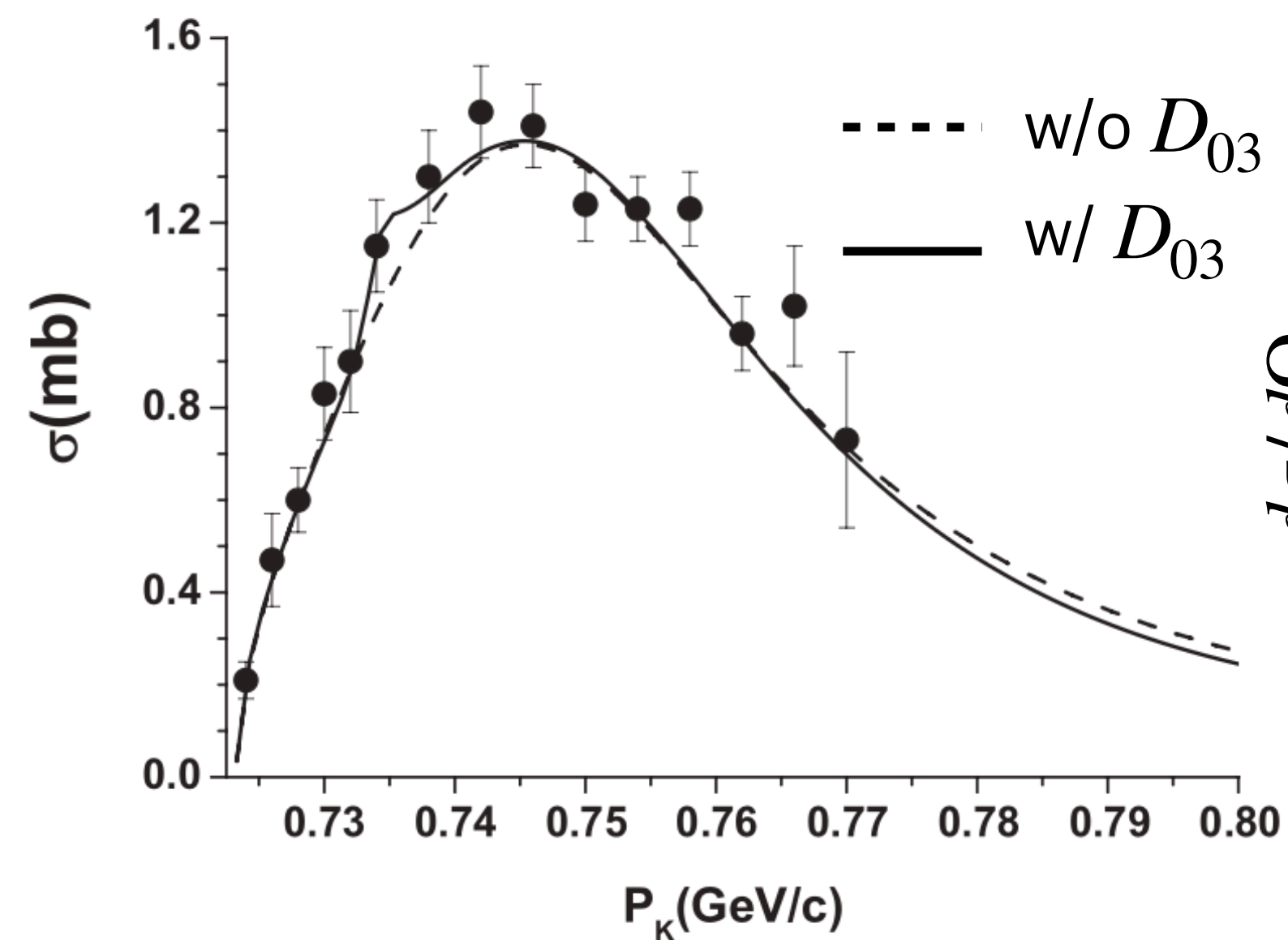
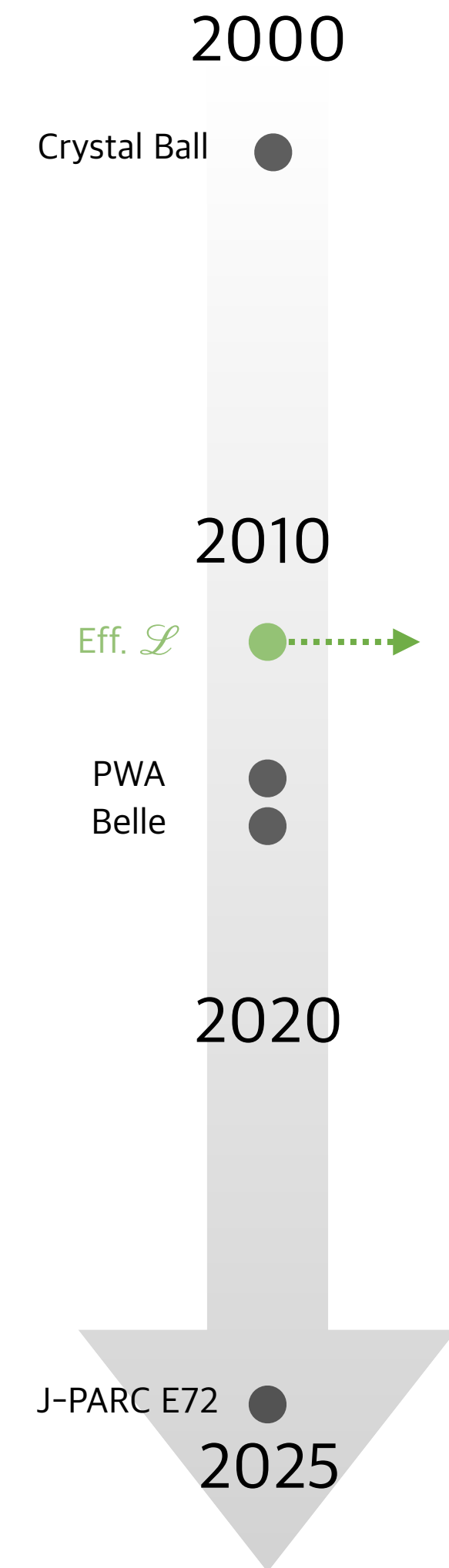
$\Lambda\eta$ Threshold



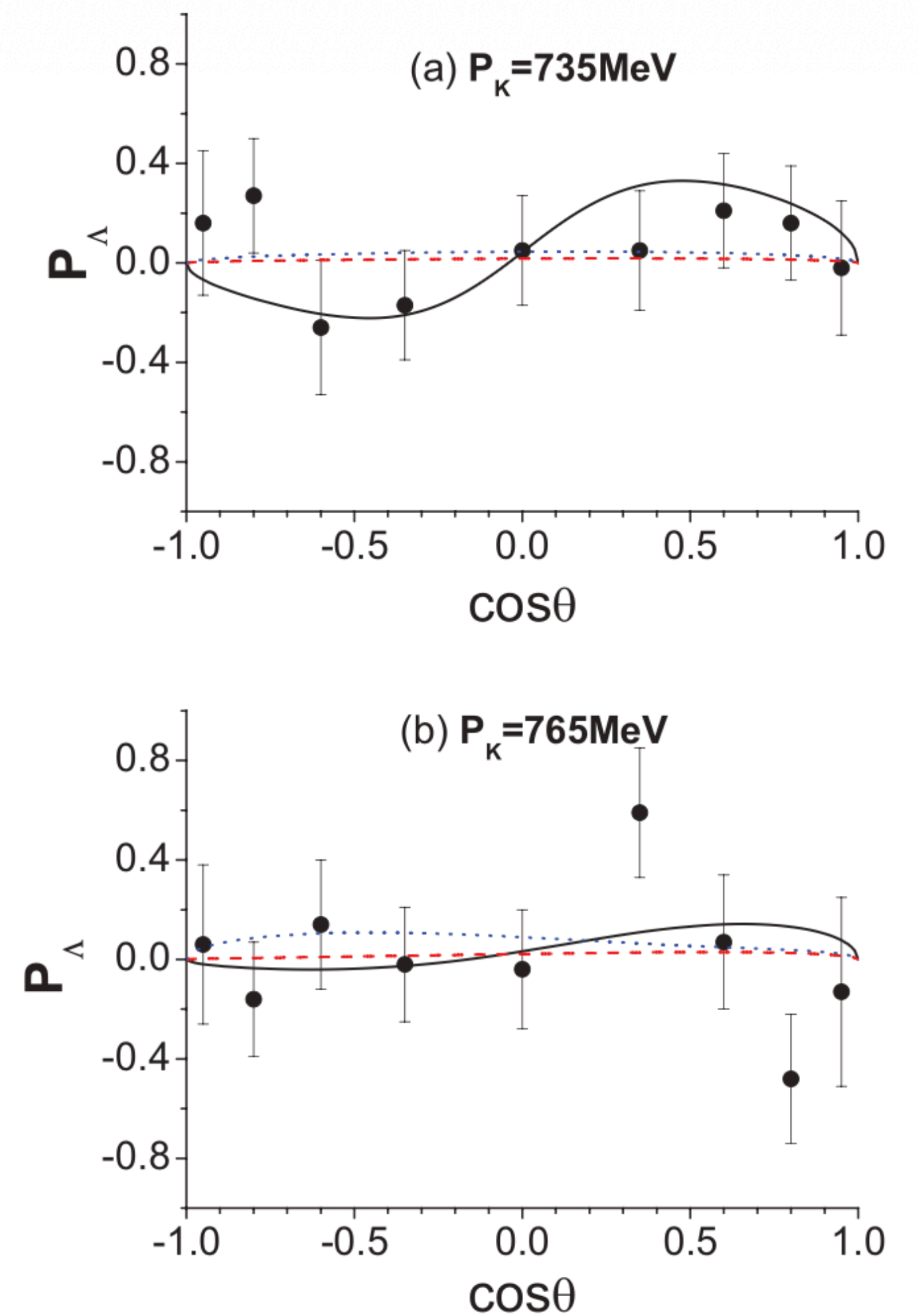
Total cross section
Differential cross section
 Λ Polarization

Clean probe of Λ^* resonances due to the isospin constraint

■ Λ Resonance near the $\Lambda\eta$ threshold

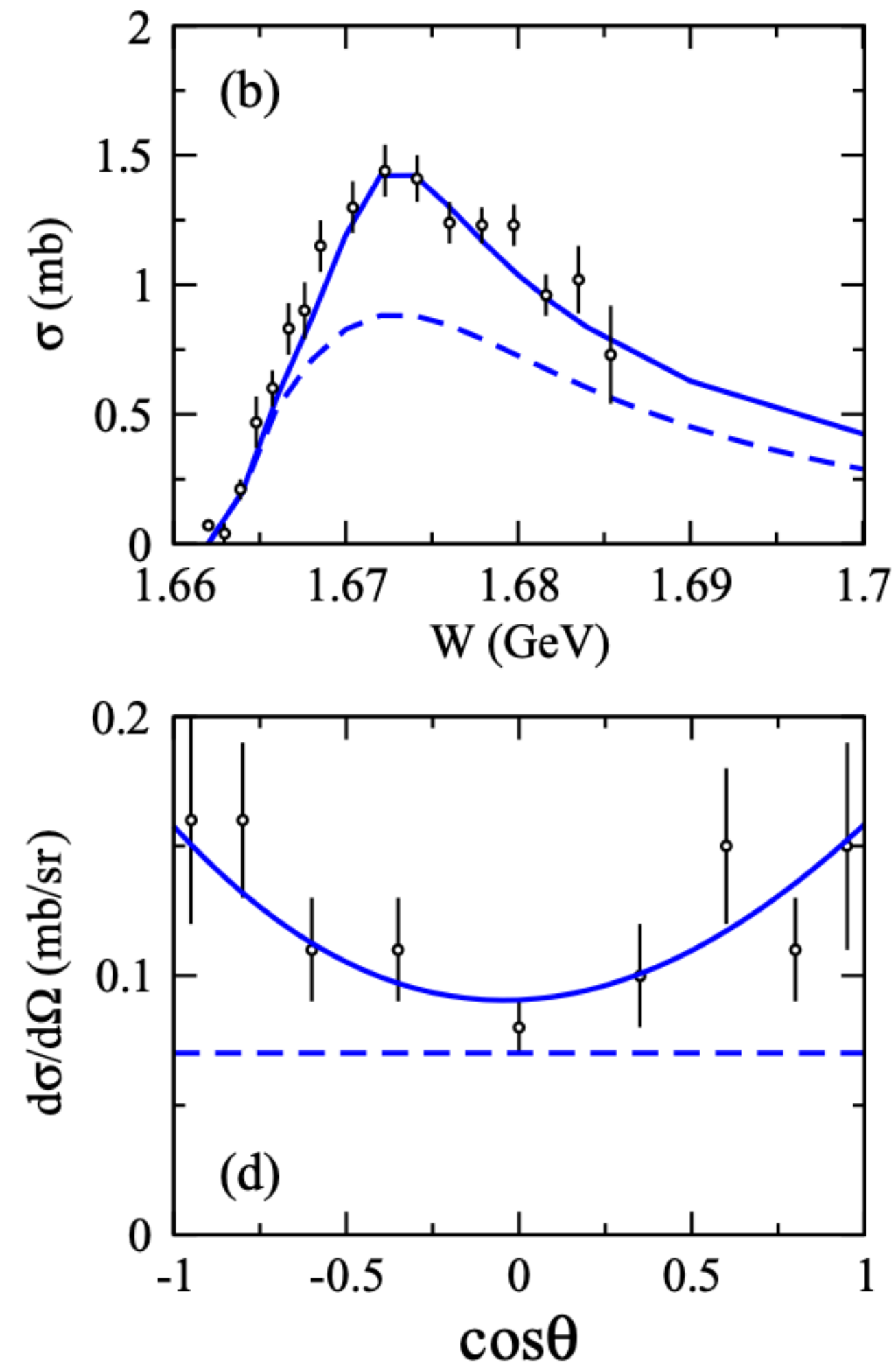
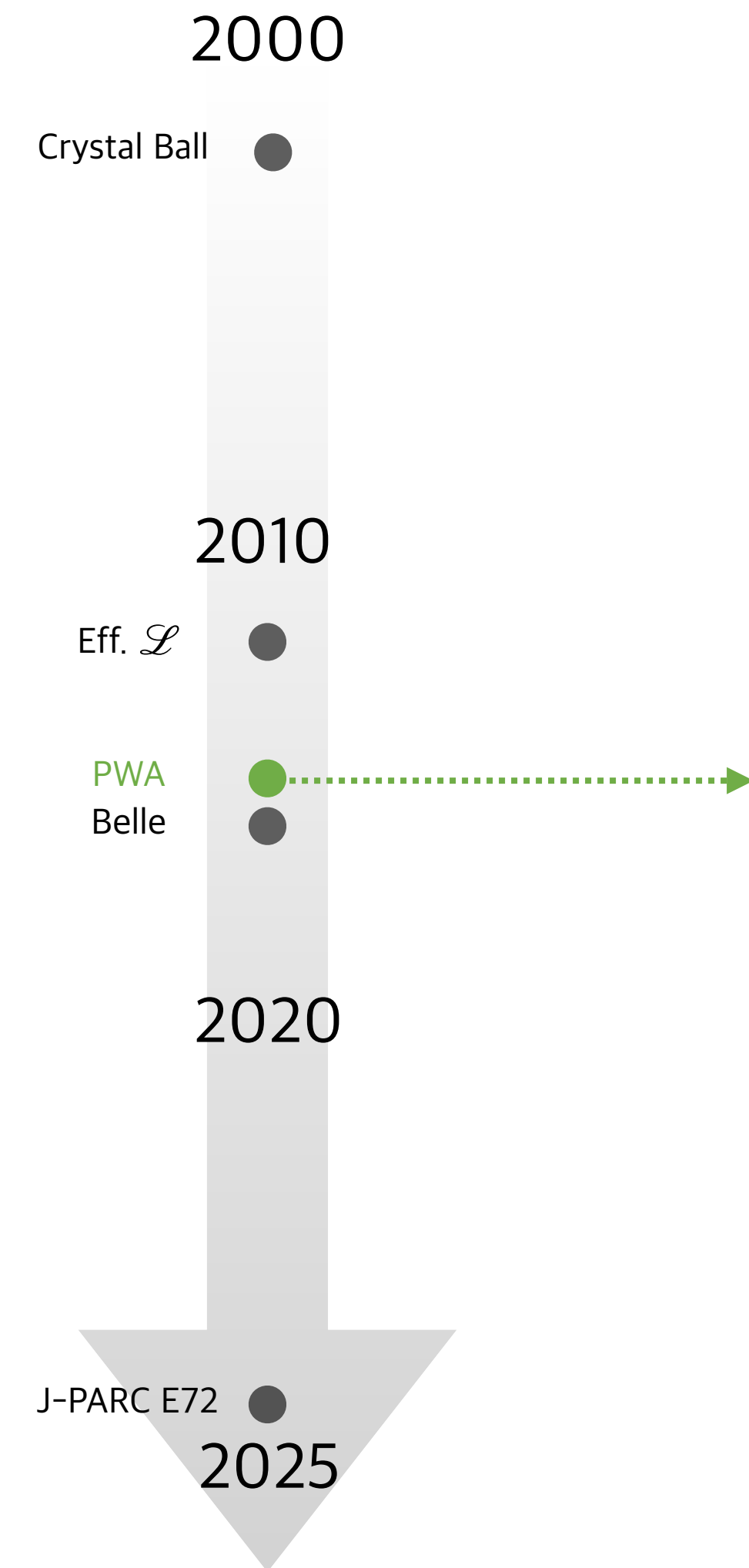


Theoretical cal. w/ Effective Lagrangian
 $\rightarrow$ Prediction of D_{03} Resonance ($3/2^-$)

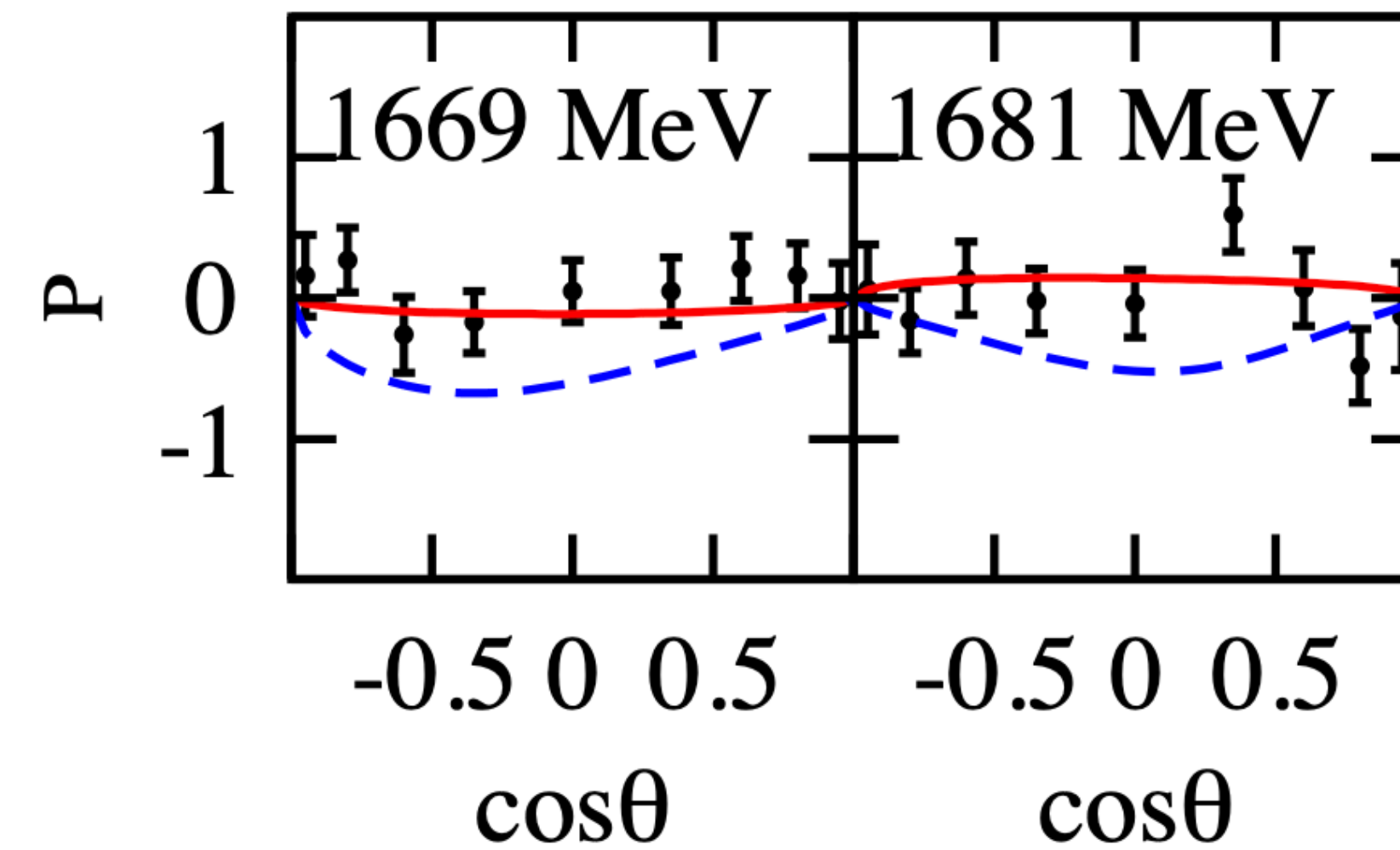


Bo-Chao Liu et al., Phys. Rev. C. 86, 055202 (2012)

■ Λ Resonance near the $\Lambda\eta$ threshold



H. Kamano et al., Phys. Rev. C. 92, 025205 (2015)



PWA w/ dynamic coupled-channels model
 → Prediction of P_{03} Resonance ($3/2^+$)

■ Λ Resonance near the $\Lambda\eta$ threshold

S.B. Yang et al., Phys. Rev. D. 108, L031104 (2023)

2000

Crystal Ball

2010

Eff. $\mathcal{L}$

PWA

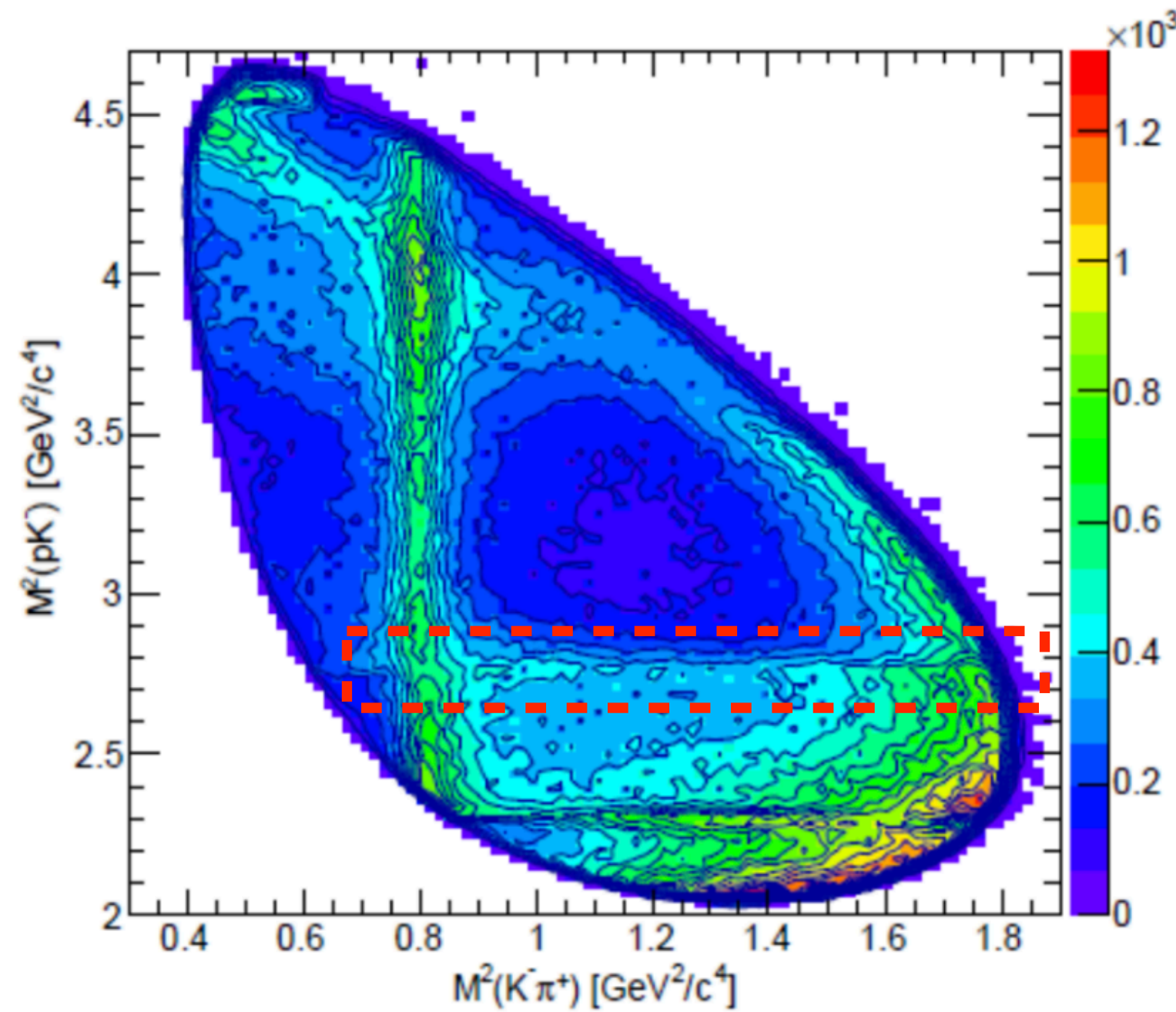
Belle

2020

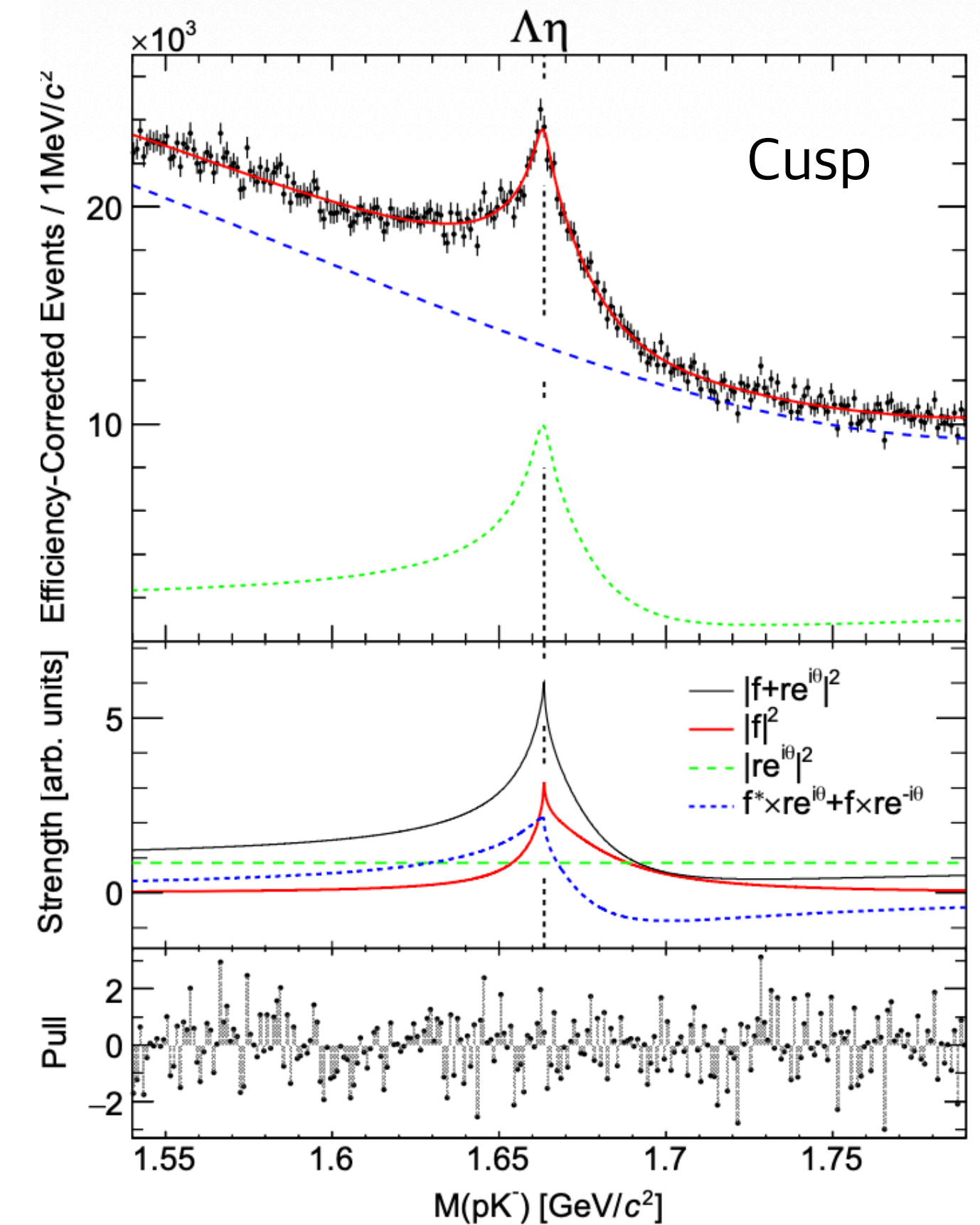
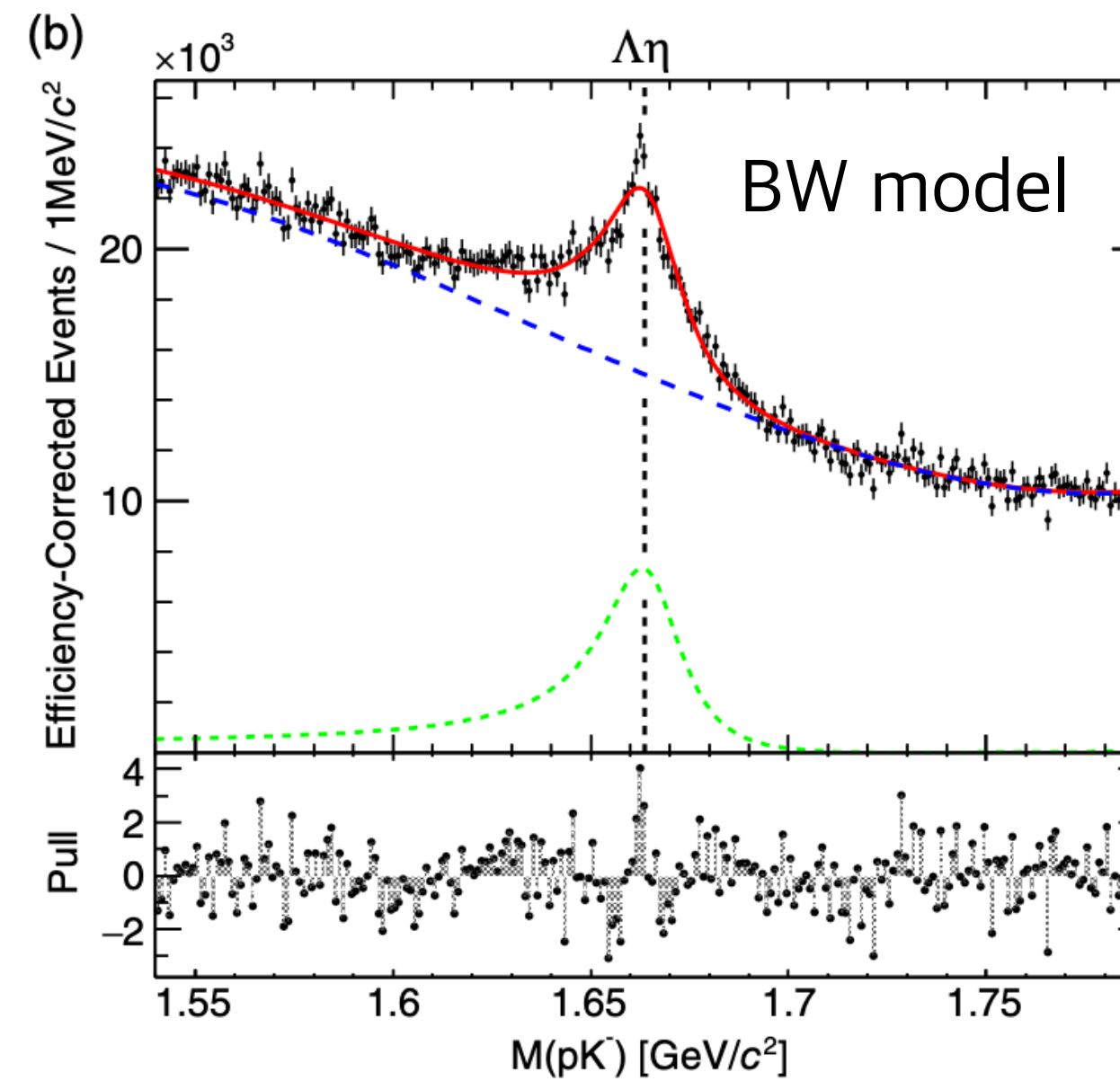
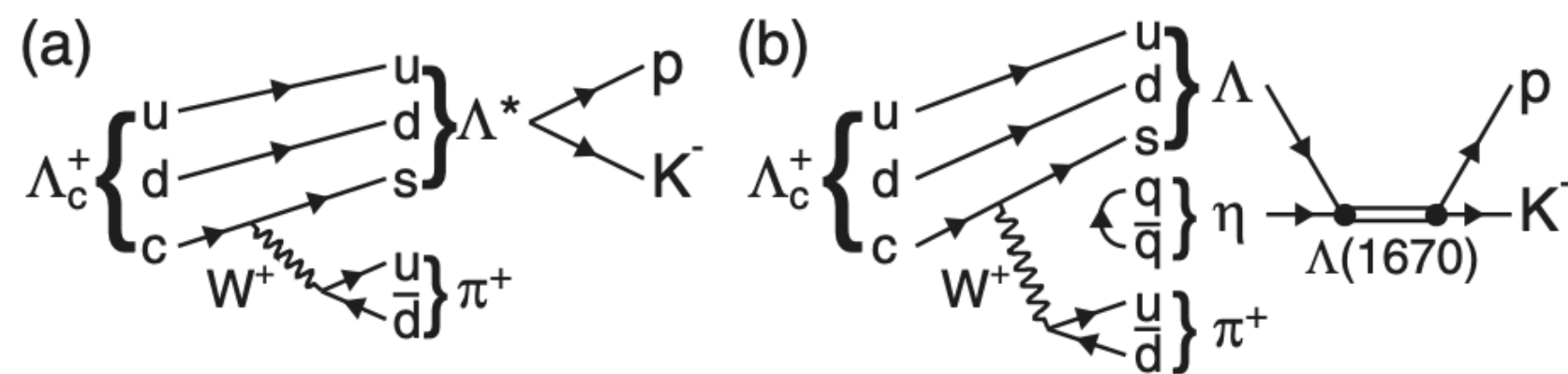
J-PARC E72

2025

$$\Lambda_c^+ \rightarrow p K^- \pi^+ \text{ (Belle)}$$



S.B. Yang et al., Phys. Rev. Lett. 117, 011801 (2016)



$$\frac{dN}{dm} \propto |f(m)|^2 = \left| \frac{1}{m - m_f + \frac{i}{2}(\Gamma' + \bar{g}_{\Lambda\eta}k)} \right|^2$$

■ Λ Resonance near the $\Lambda\eta$ threshold

D. $K^- p \rightarrow \eta\Lambda$

Currently, the data of differential cross sections (Fig. 19) for $K^- p \rightarrow \eta\Lambda$ are limited in the near-threshold region. We observe visible differences between Models A and B in the differential cross sections. Although the Model B shows a better χ^2/data value for this observable, it is not easy to judge the models within the current limited data. There is an inconsistency in the data at $W = 1664$ MeV. The lower set of the data comes from the recent BNL data [81], while the higher set comes from an old bubble chamber experiment at CERN [63]. Our model curves seem to follow the BNL data. Also, we observe that the differential cross section data show a concave-up angular dependence at most W , which suggests a possibility of the sizable contribution from higher partial waves even in the very threshold region. In fact, Model B captures

this angular dependence better than Model A and this is due to the large contribution from P_{03} wave near the threshold, as shown later in Sec. IV A. As for the polarization P (Fig. 20), the data are available only at two W points near the threshold. Model B is found to be a bit off the data.

As for the $\eta\Lambda$ channel, the model dependence in the threshold parameters is significant. As for the $K\Xi$ channel, however, the scattering lengths agree reasonably well between Models A and B, while significant model dependences are seen for the effective ranges. The model dependence in the $\eta\Lambda$ and $K\Xi$ threshold parameters are understandable, because they are constrained indirectly by the data of $K^- p$ reactions, in particular by those of $K^- p \rightarrow \eta\Lambda$ and $K^- p \rightarrow K\Xi$, respectively, through coupled-channels effects. Because the quality of the data for $K^- p \rightarrow \eta\Lambda$ and $K^- p \rightarrow K\Xi$ is still poor, it is difficult to strongly constrain the threshold parameters for $\eta\Lambda$ and $K\Xi$.

H. Kamano et al., Phys. Rev. C. 90, 065204 (2014)

2000

Search for a Narrow Λ^* Resonance using the $p(K^-, \Lambda)\eta$ Reaction with the HypTPC Detector

2025.03 - 2025.10

Crystal Ball ●----->

2010

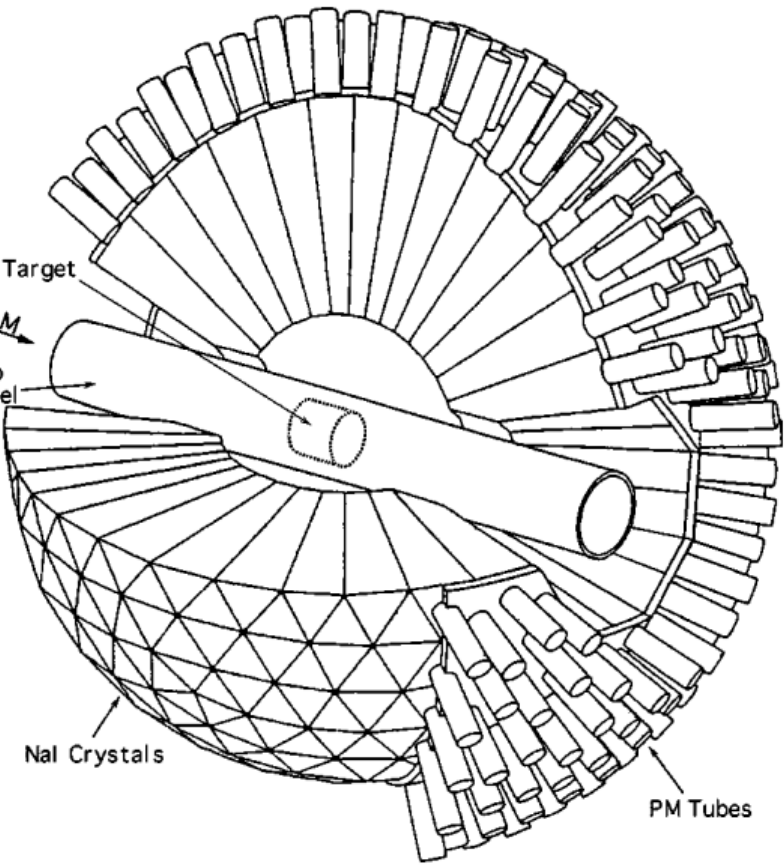
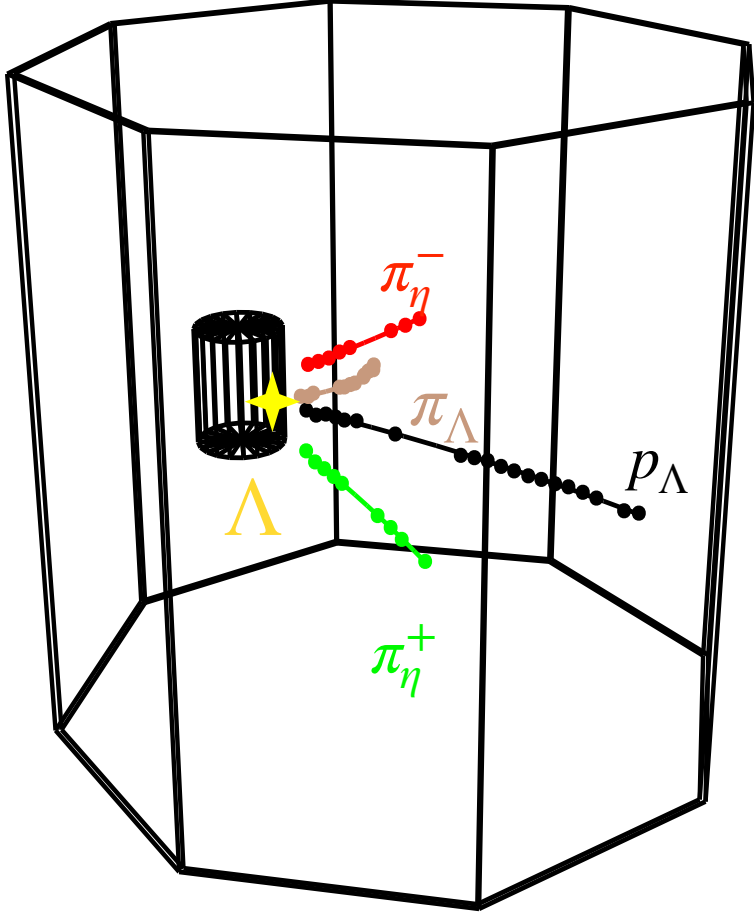
Eff. $\mathcal{L}$ ●

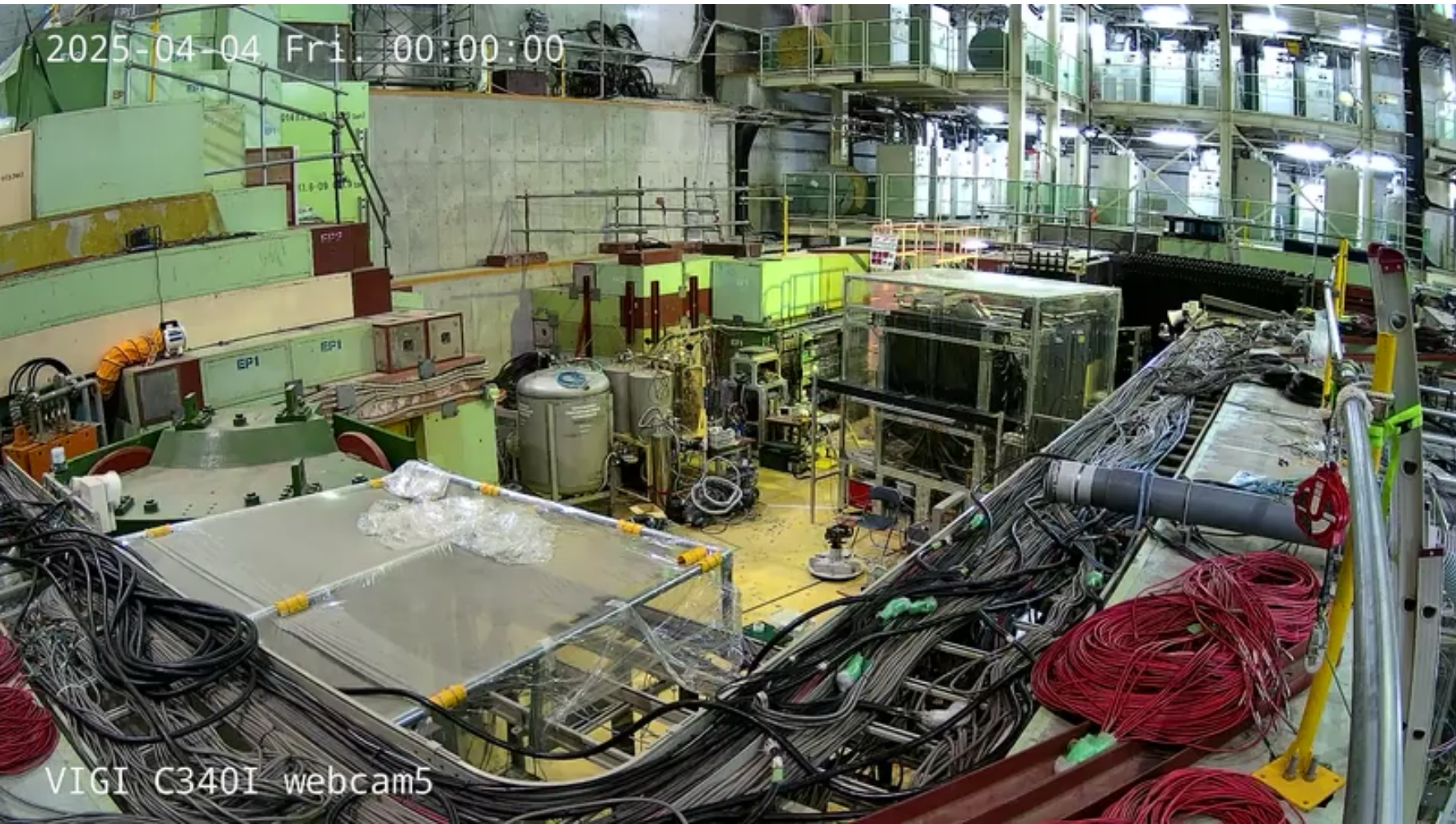
PWA
Belle ●
●

2020

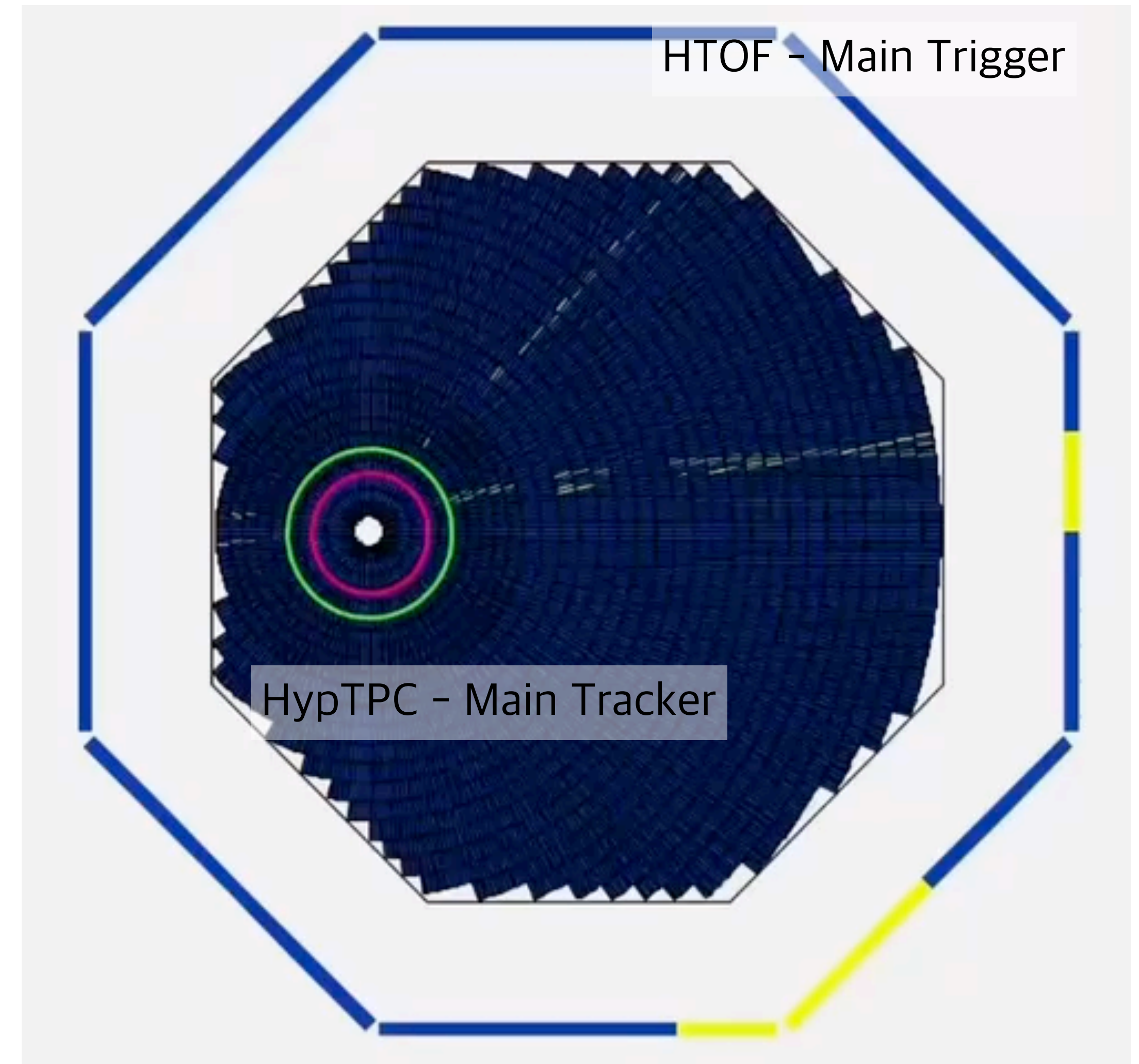
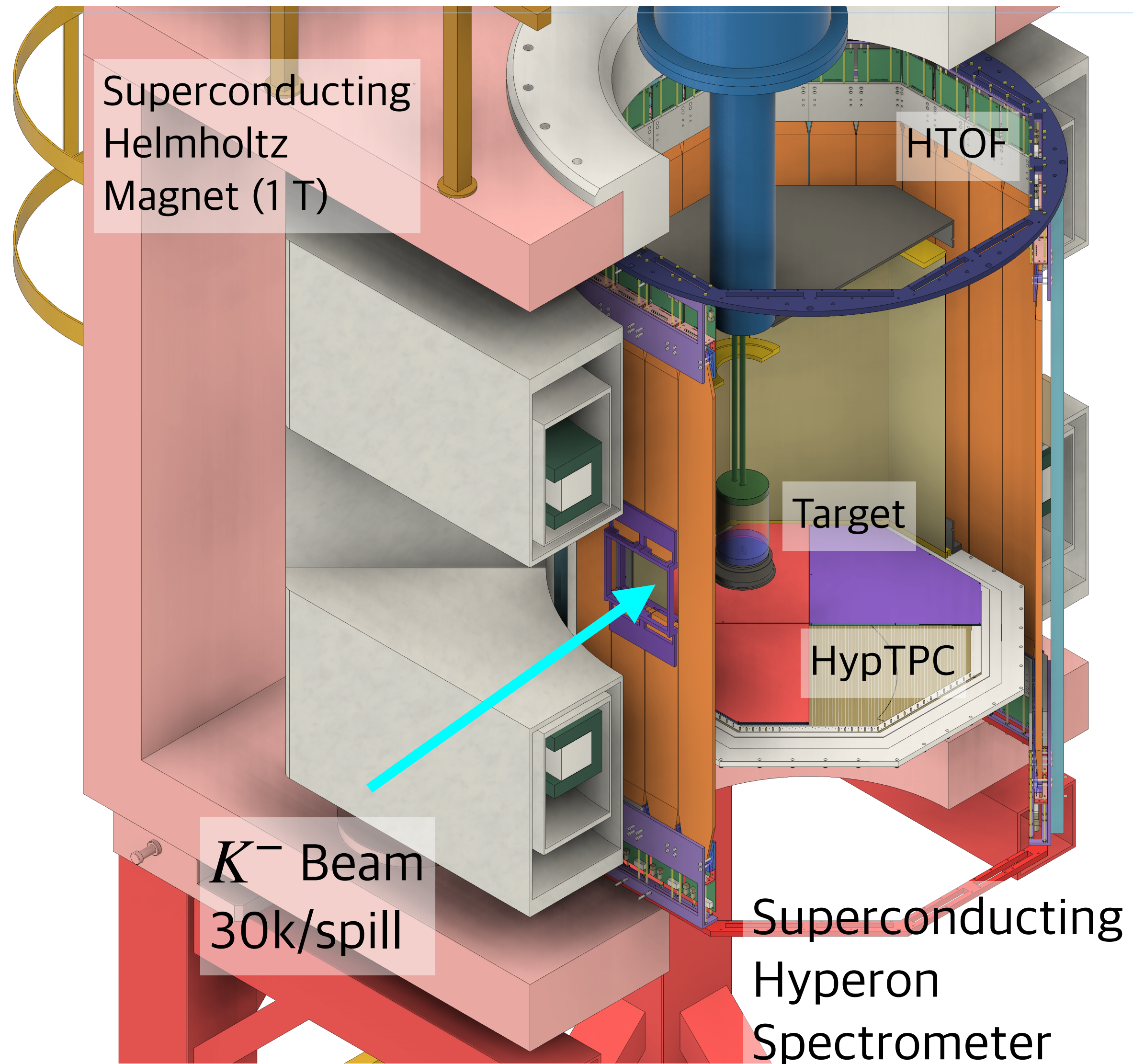
J-PARC E72 ●----->

2025

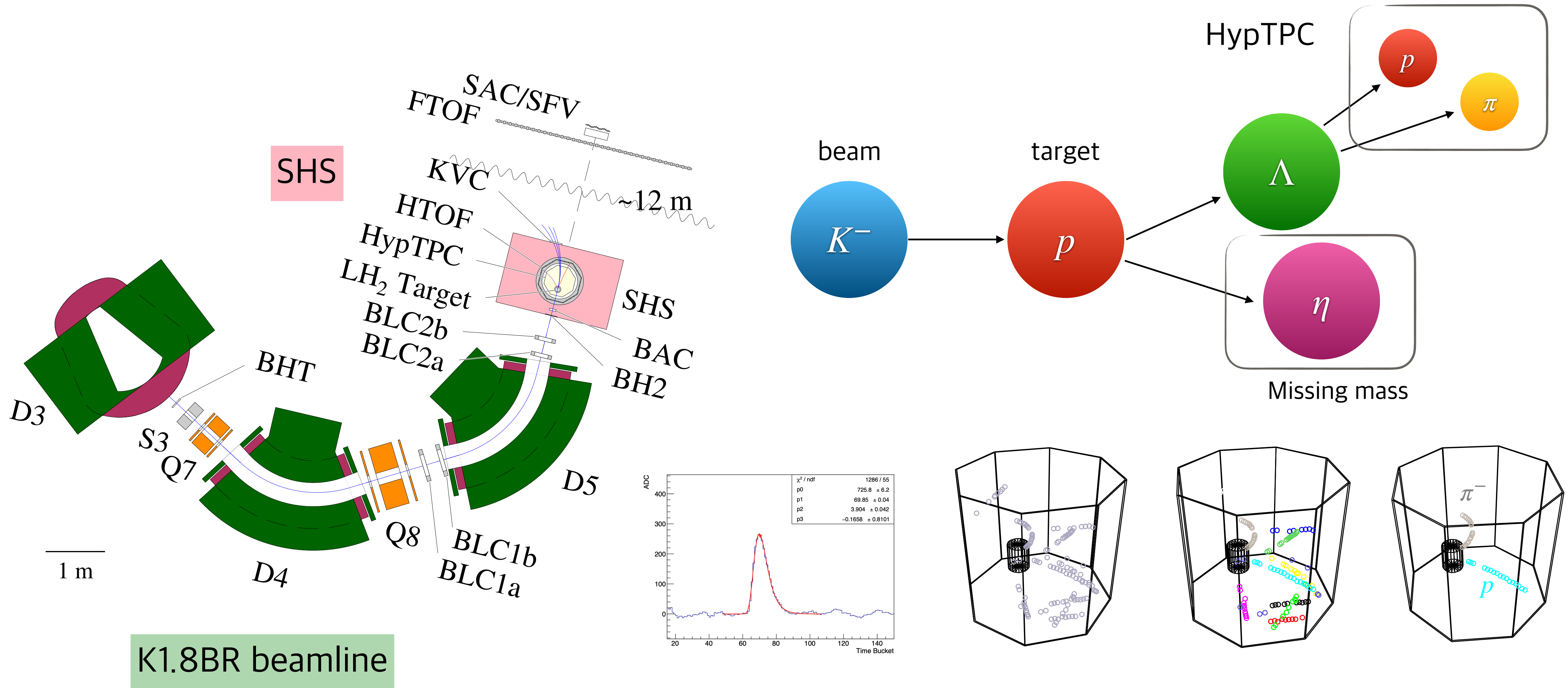
	Crystal Ball	J-PARC E72
Beam	$K^- (p_{K^-} \approx 735 \text{ MeV}/c)$	
Target	Liquid Hydrogen	
Setup		
Measured decay mode	$\eta \rightarrow \gamma\gamma$ or $3\pi^0$, $\Lambda \rightarrow \pi^0 n$ Neutral decay modes	$\Lambda \rightarrow p\pi$ Charged decay mode
Statistics	2k	0.2M



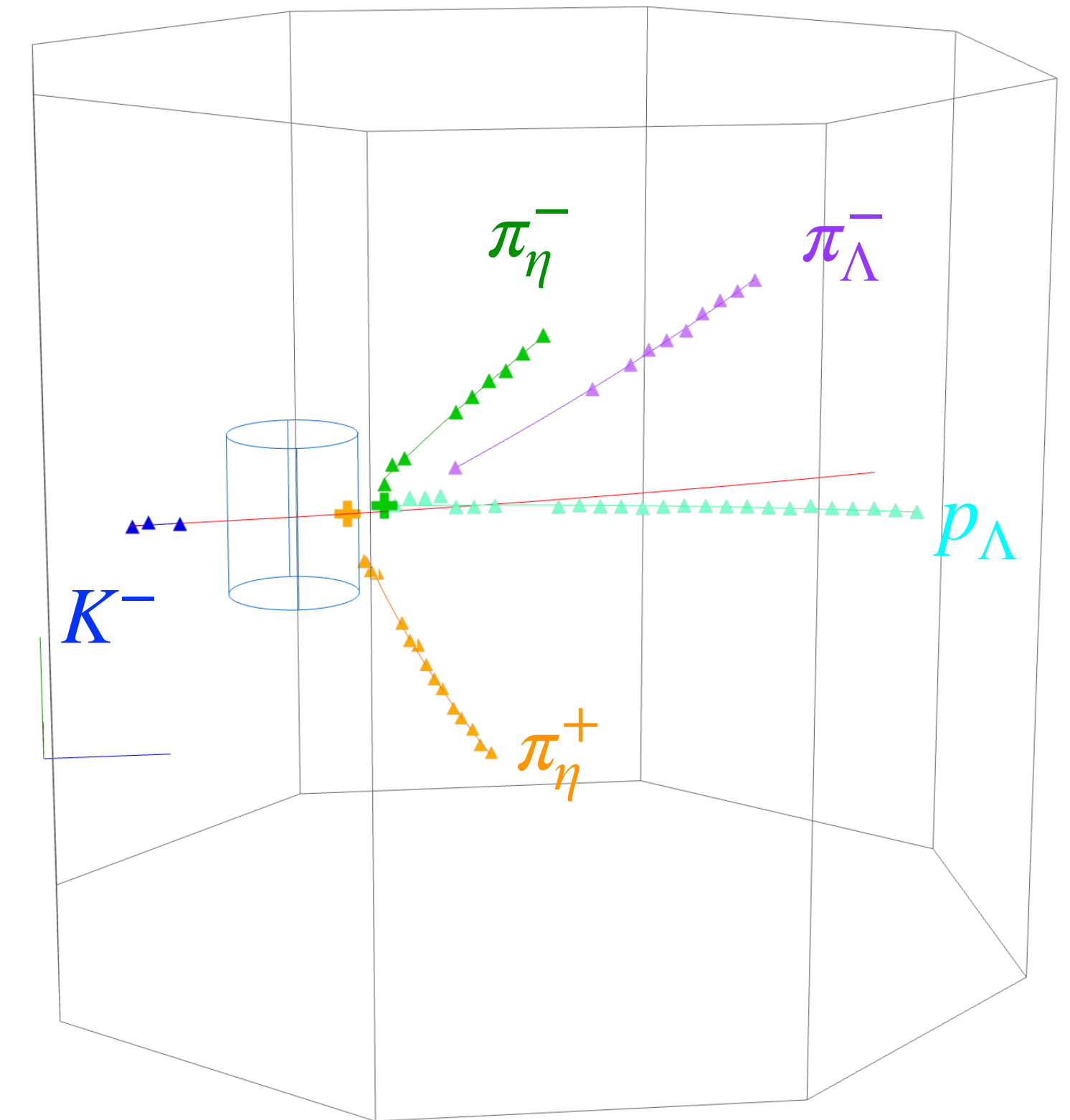
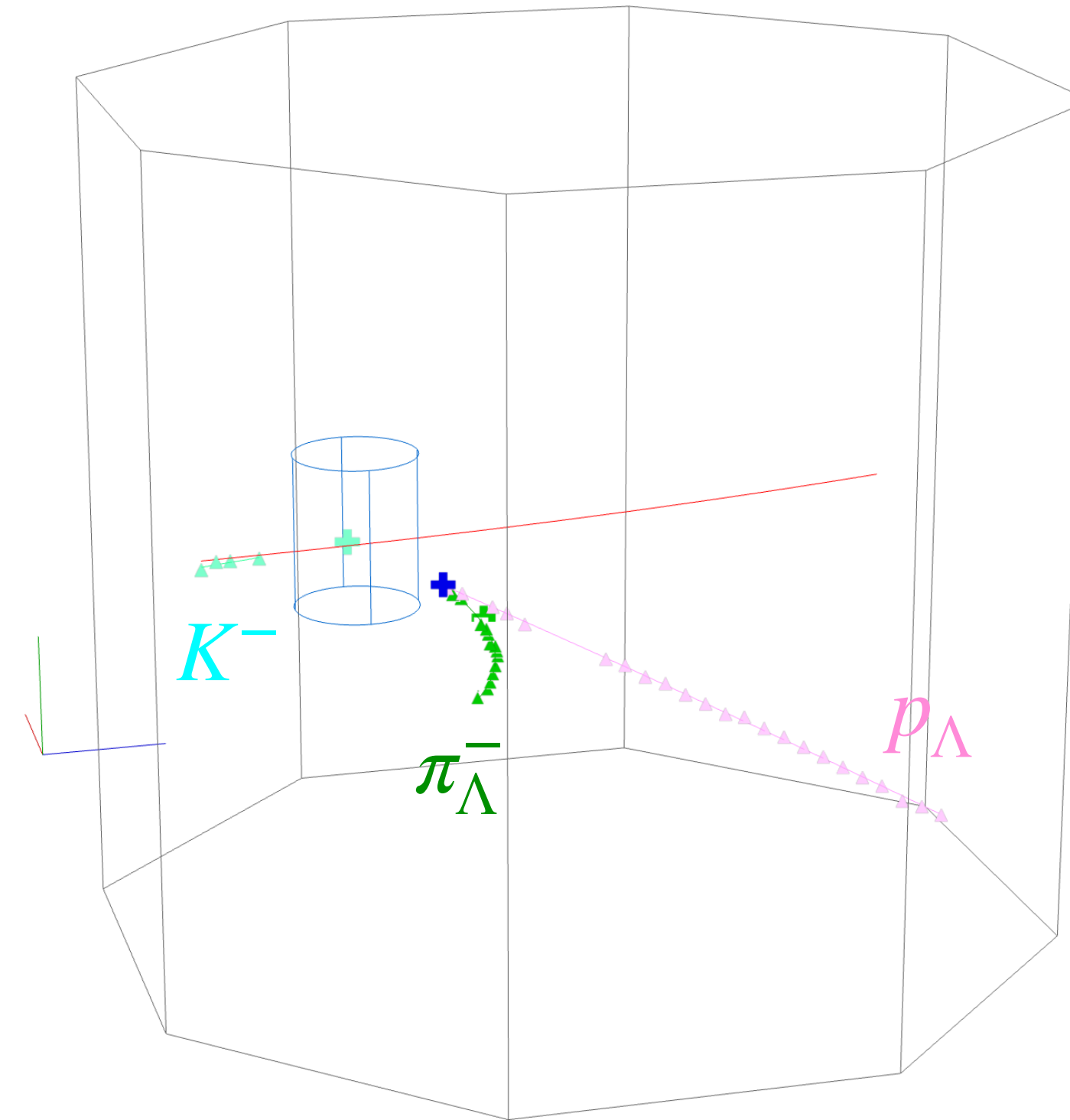
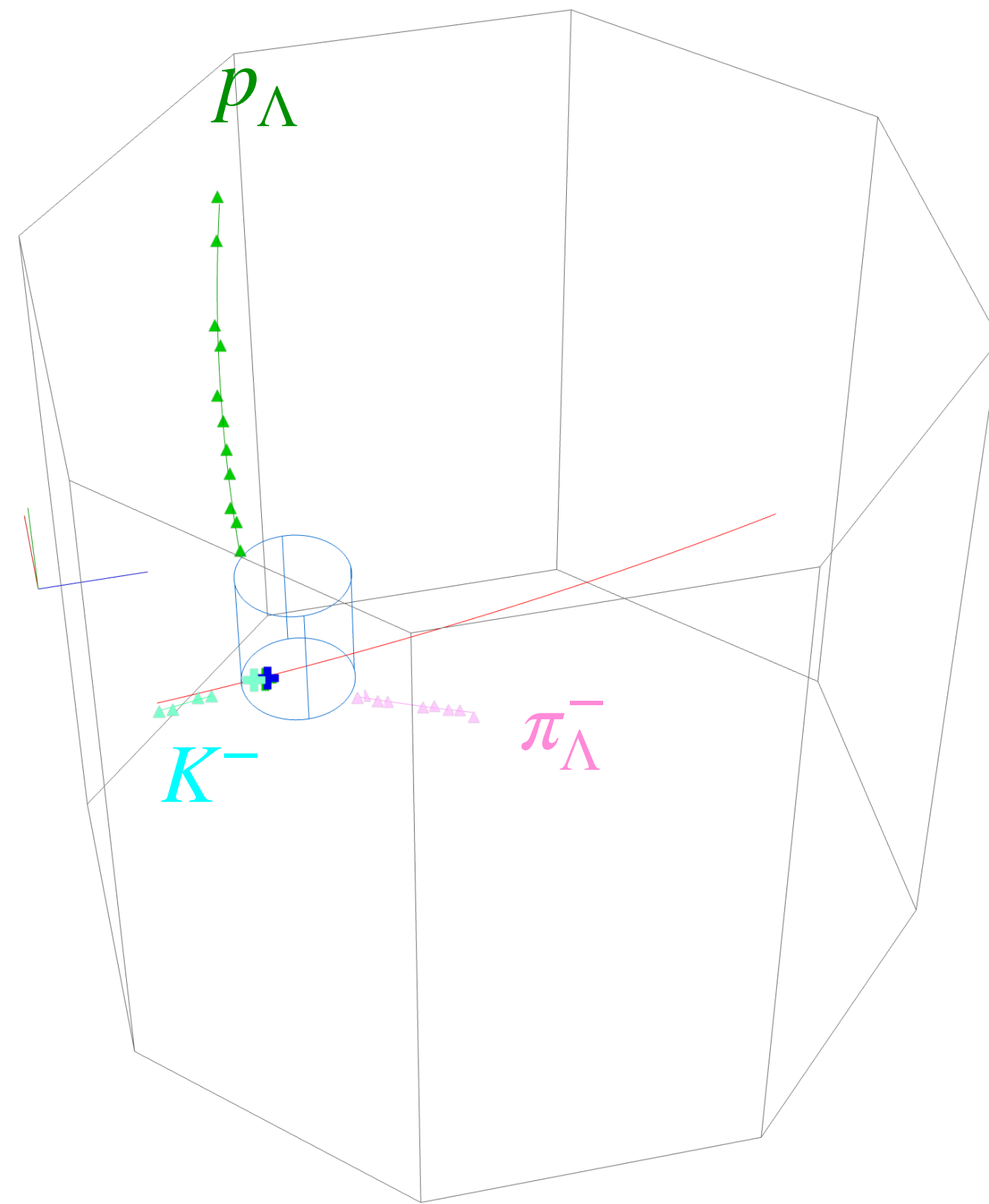
■ SHS in K1.8BR beamline



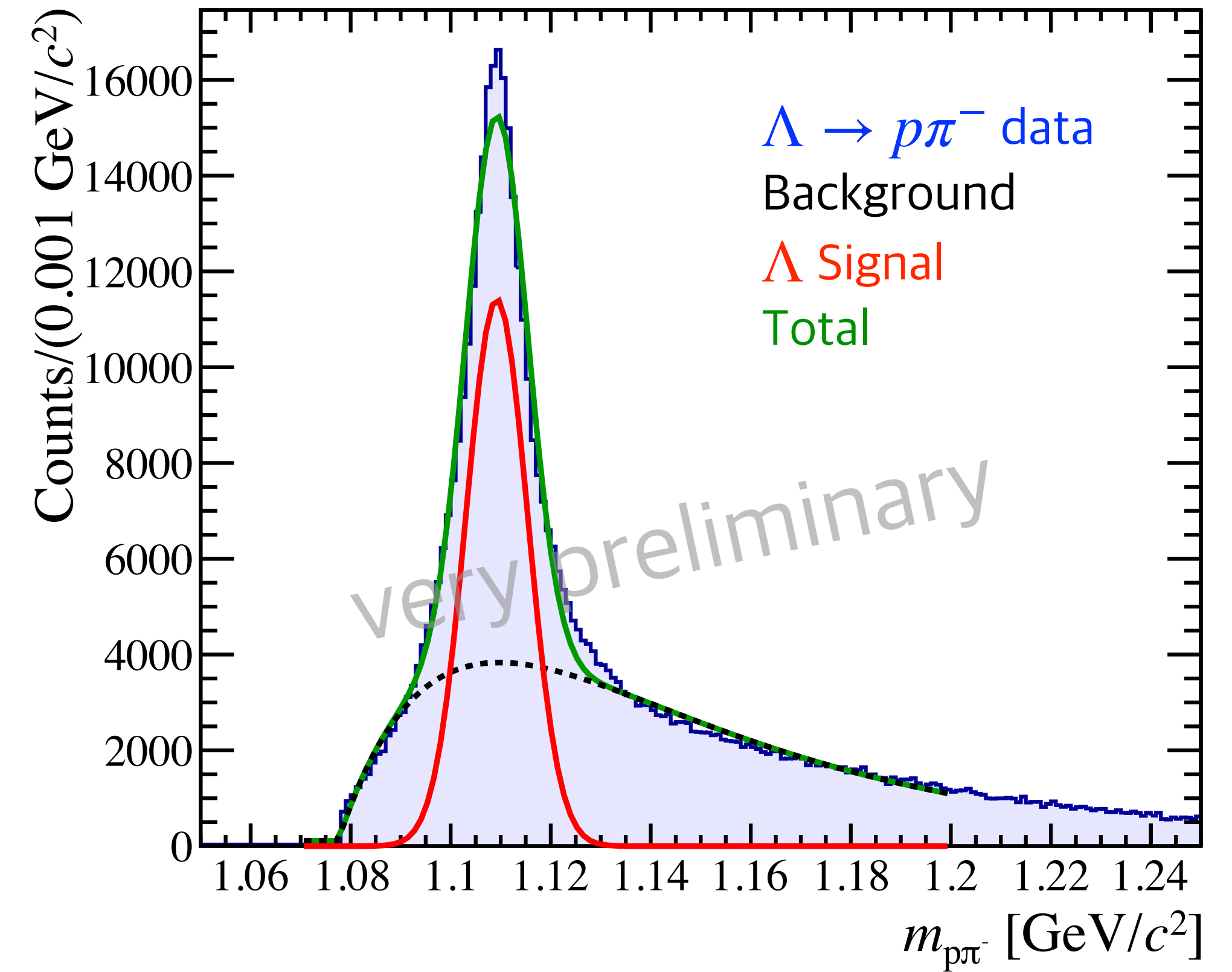
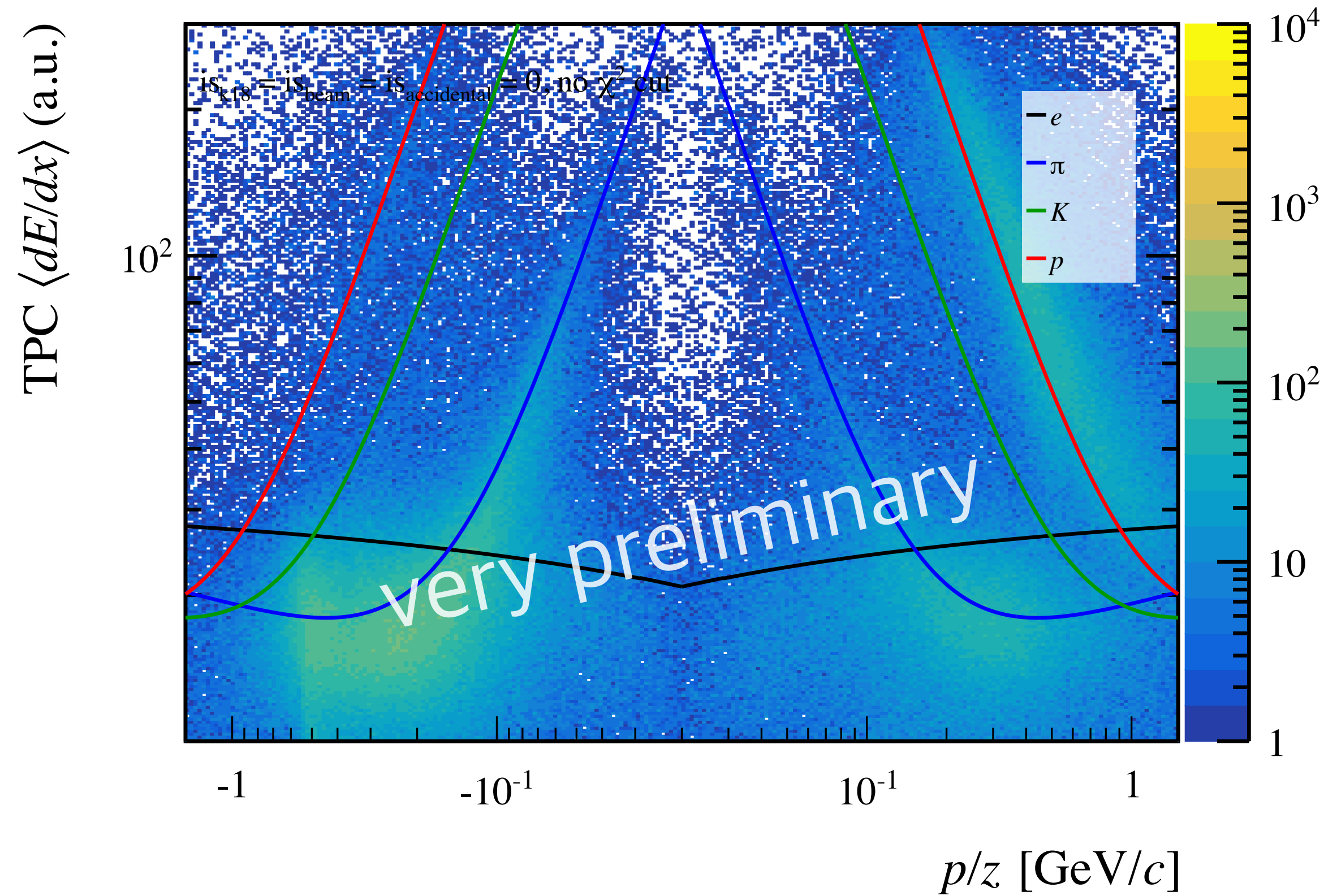
■ Analysis Flow



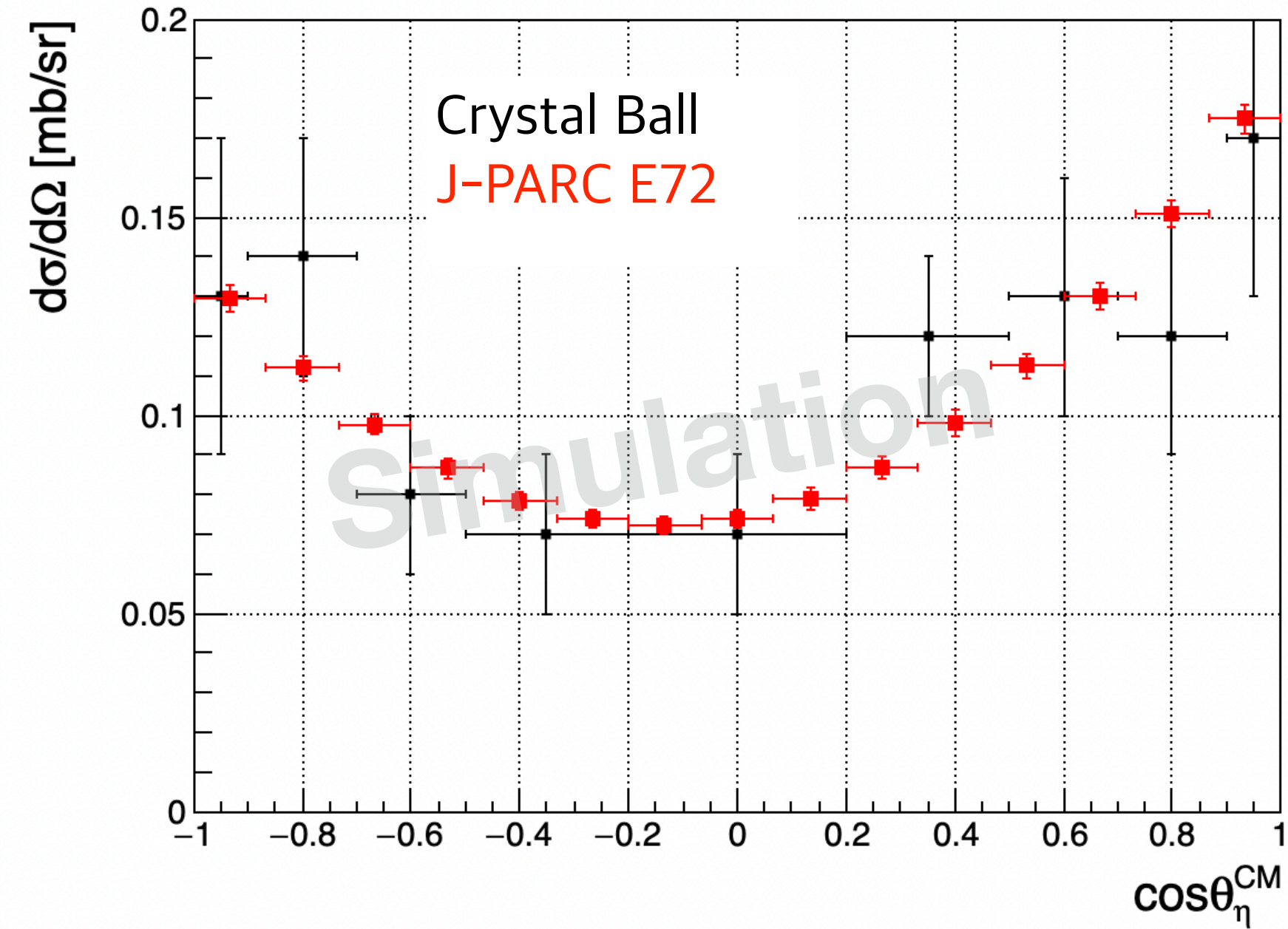
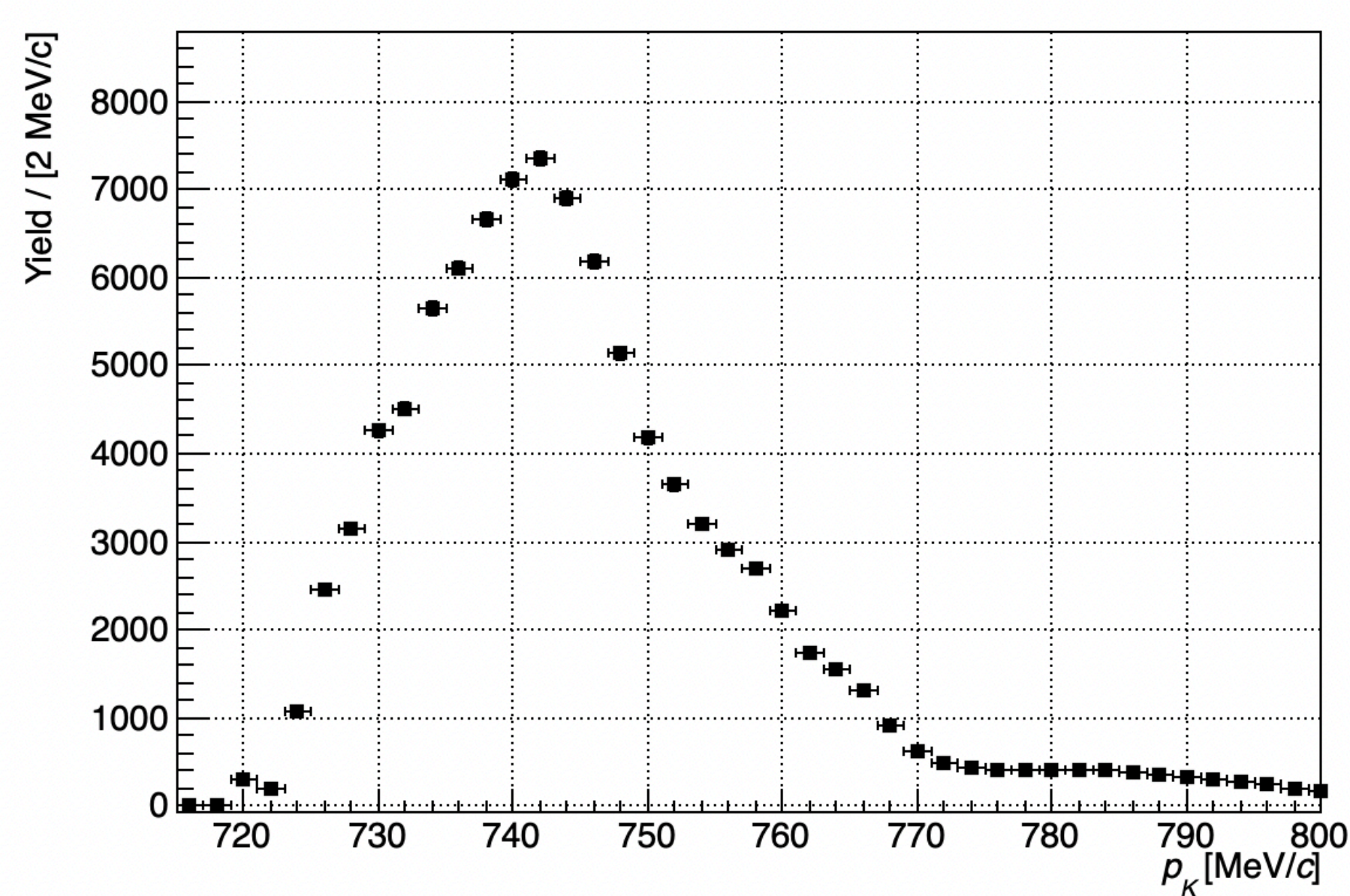
■ Event Display



■ Analysis Status



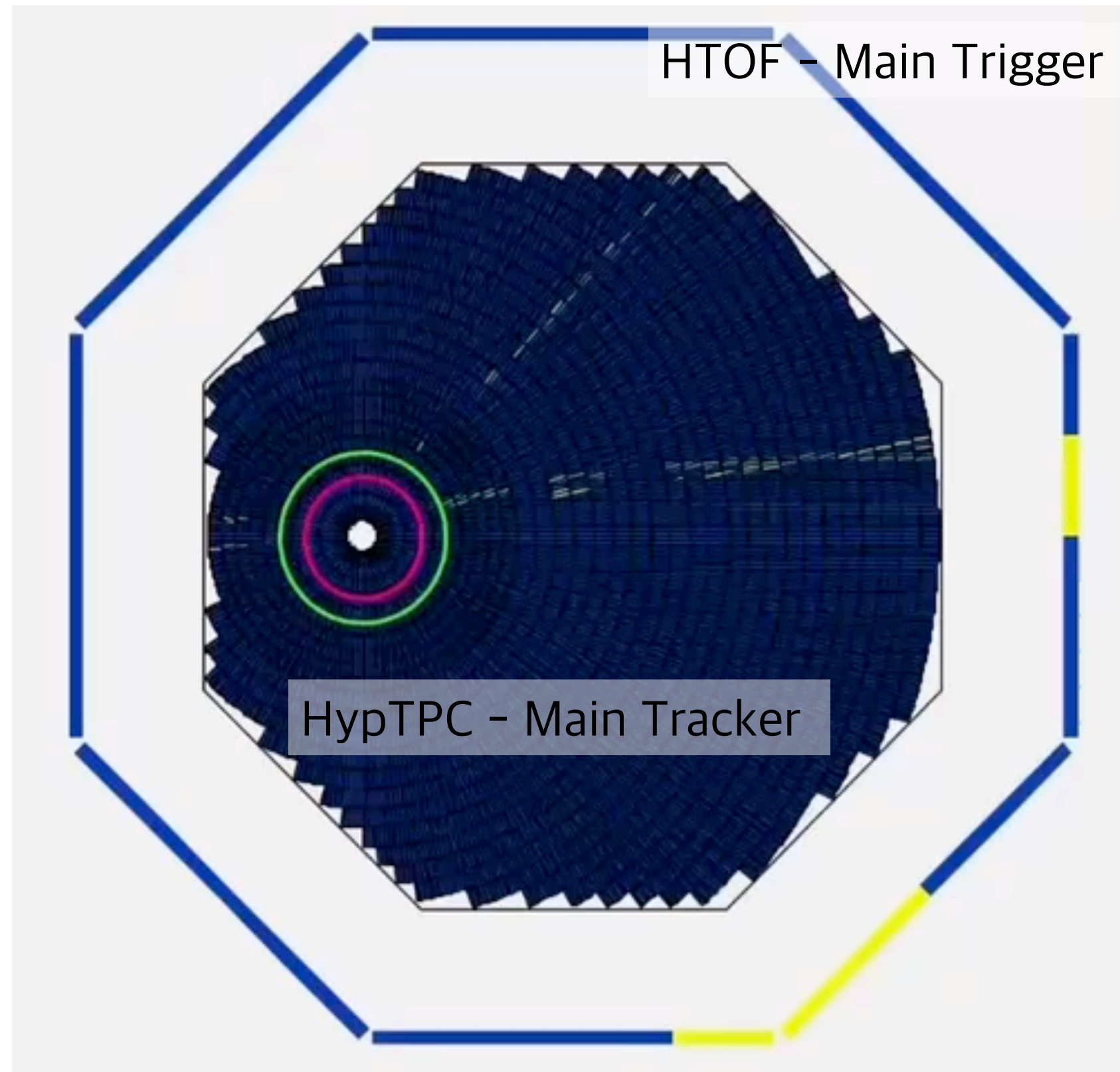
Expected statistics and sensitivity of J-PARC E72



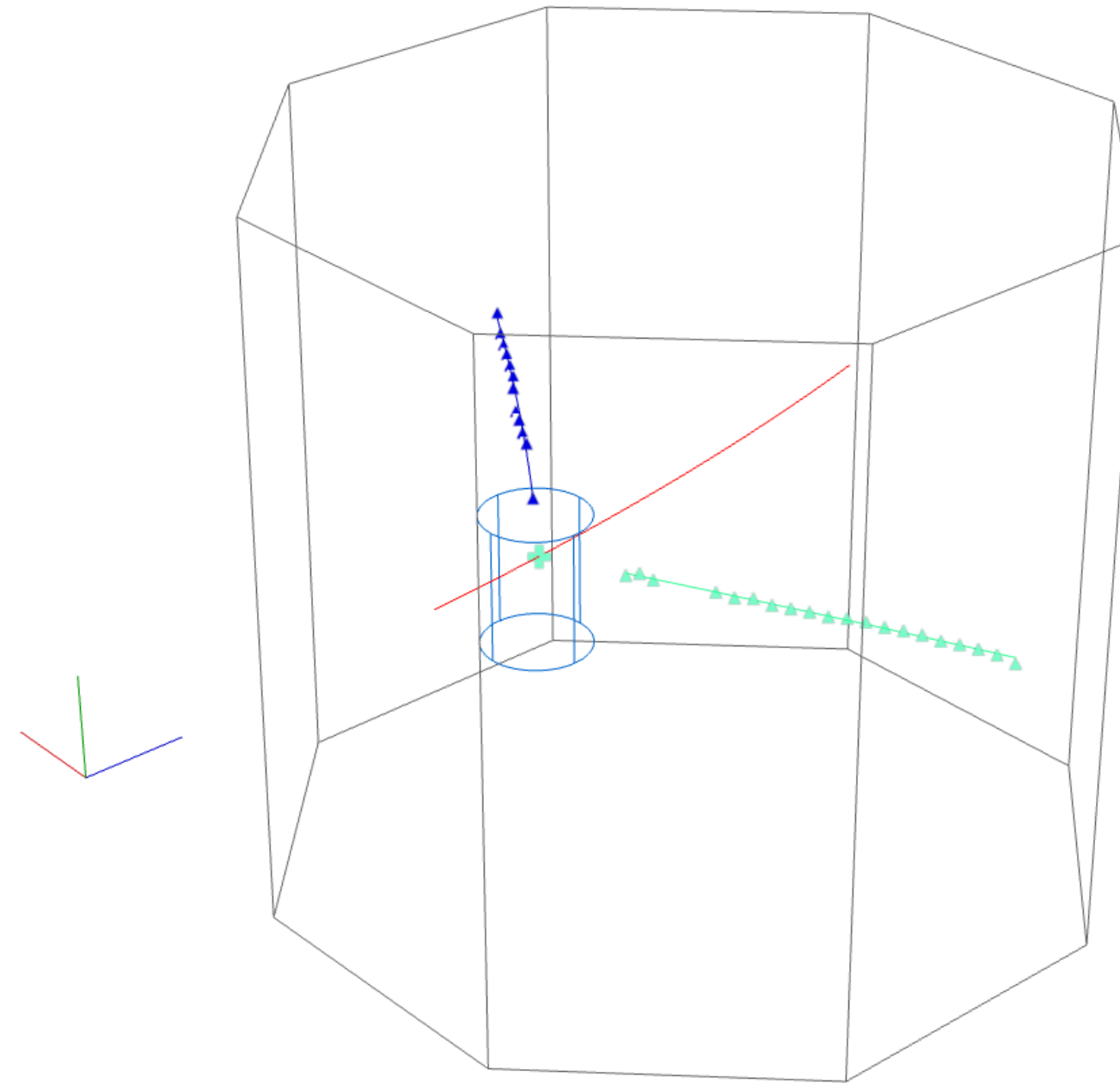
Parameters	J-PARC E72
Physics run (day)	4.4
Number of K^- per spill (F_K)	3.3×10^4
Spill length	4.24 s
Fraction of K^- reaching the target	80%
Number of total K^- (N_{beam})	1.5×10^9
Target effective thickness (L_{target})	7.14 cm
Target density (ρ)	0.07085 g/cm ³
Number of nuclei (N_{target})	3.02×10^{23} /cm ²
$\text{Br}(\Lambda \rightarrow p\pi^-)$	0.64
$\epsilon_{\text{trigger}} \cdot \epsilon_{\text{offline}}$	50%
$\Lambda\eta$ Yield	0.2M

Approximately two orders of magnitude more data than the previous measurement

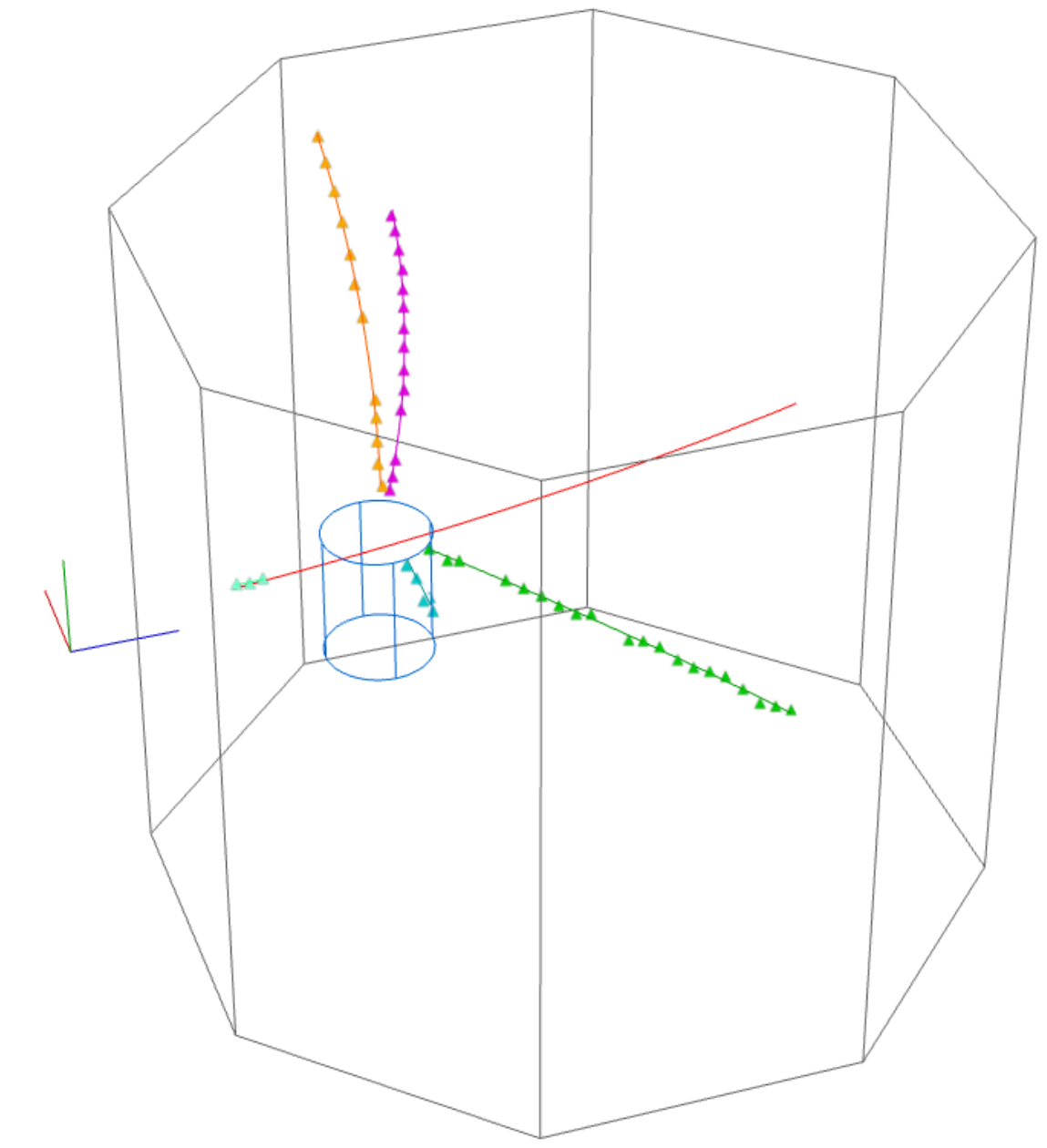
■ Byproducts



K^-p



$\Lambda\pi\pi$

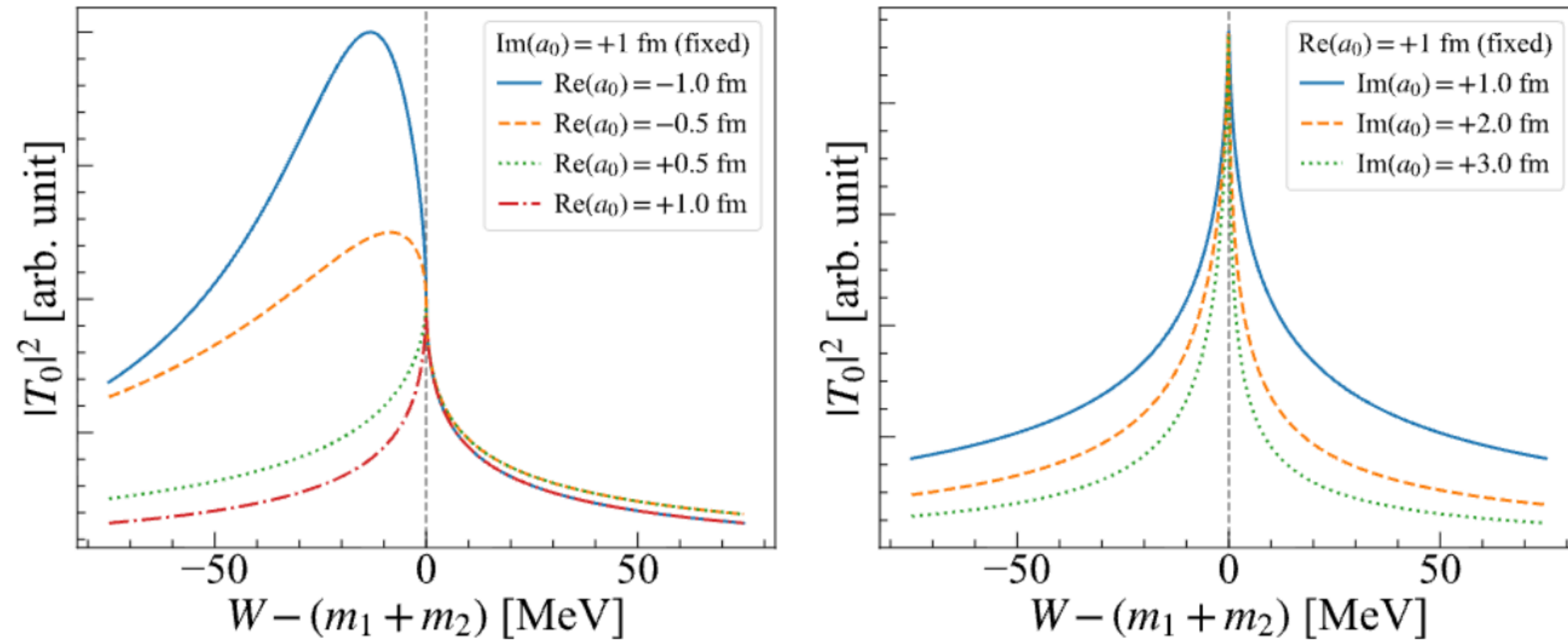


Inclusive trigger condition

- ≥ 2 charged particles in HTOF, or
- a forward-going proton

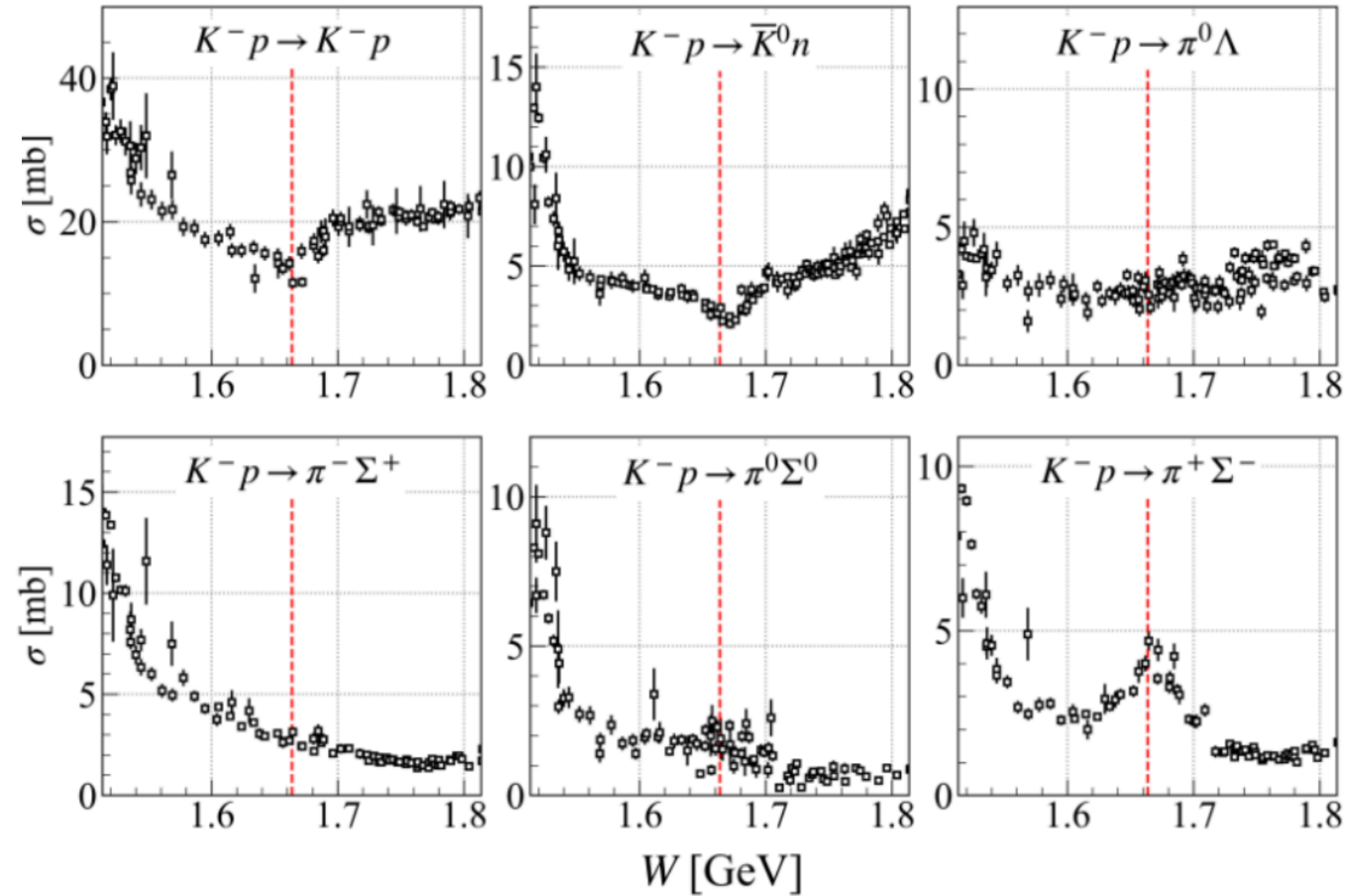
→ Various decay channels satisfying the trigger condition were recorded simultaneously.

■ Byproducts : Cusp Spectroscopy



$$T_0(E) \propto \frac{1}{1/a_0 - i\sqrt{2\mu E}}$$

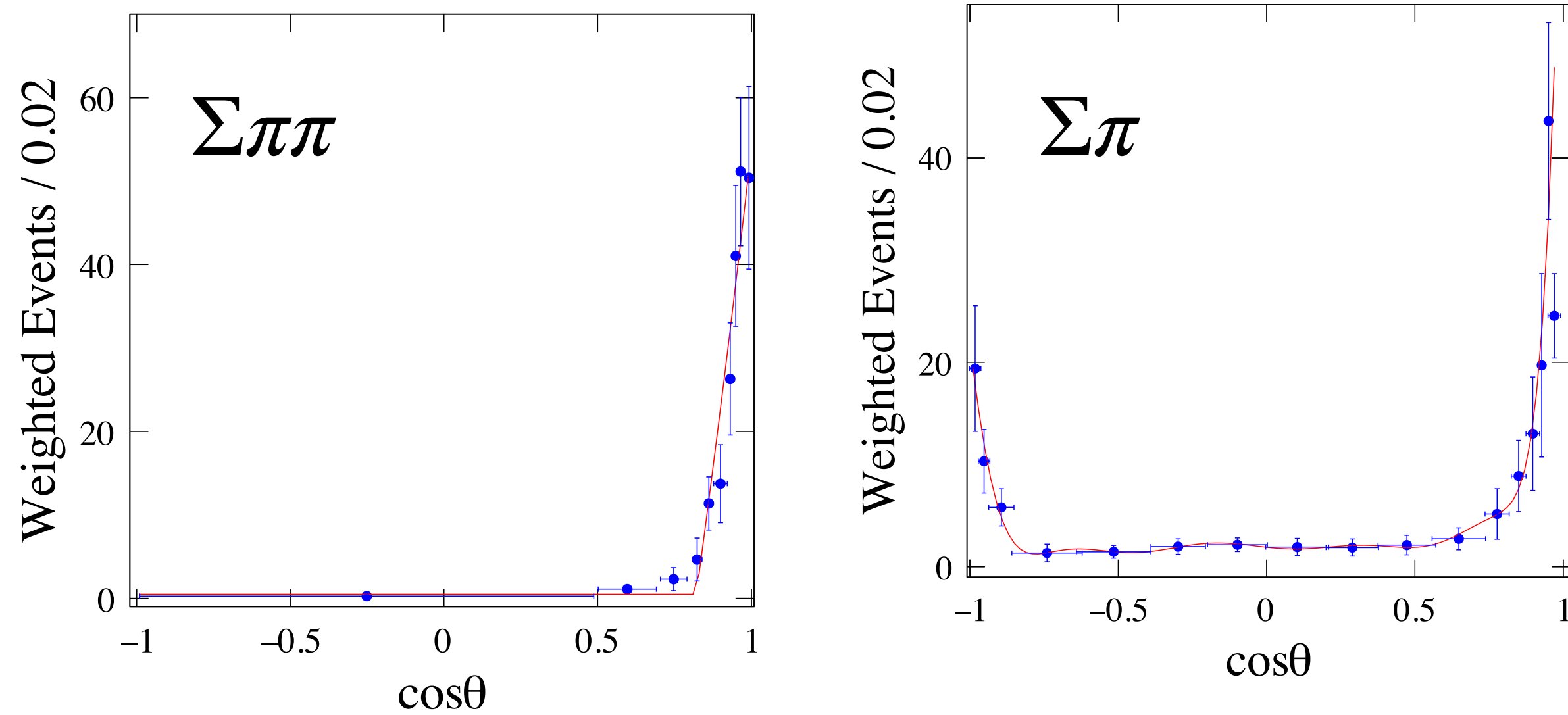
a_0 : S-wave scattering length



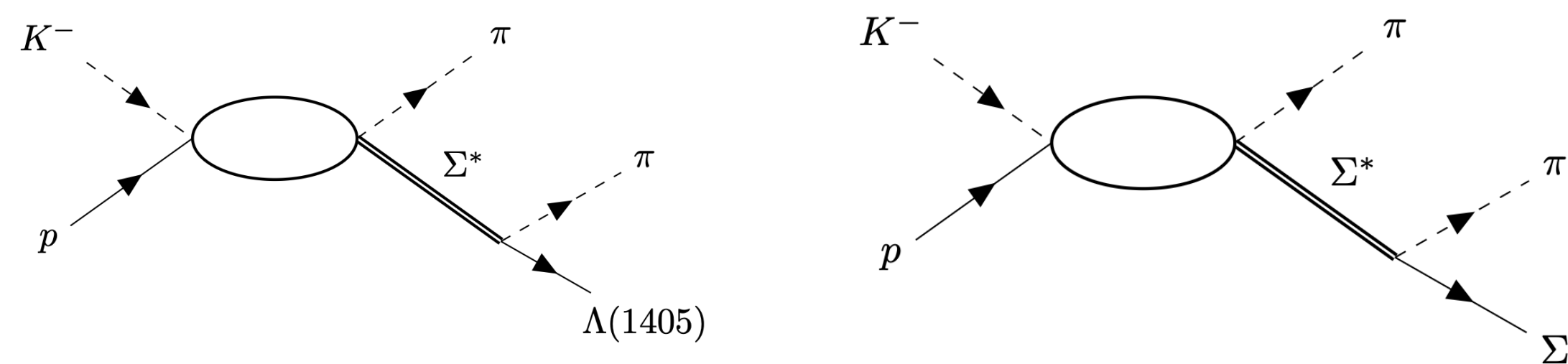
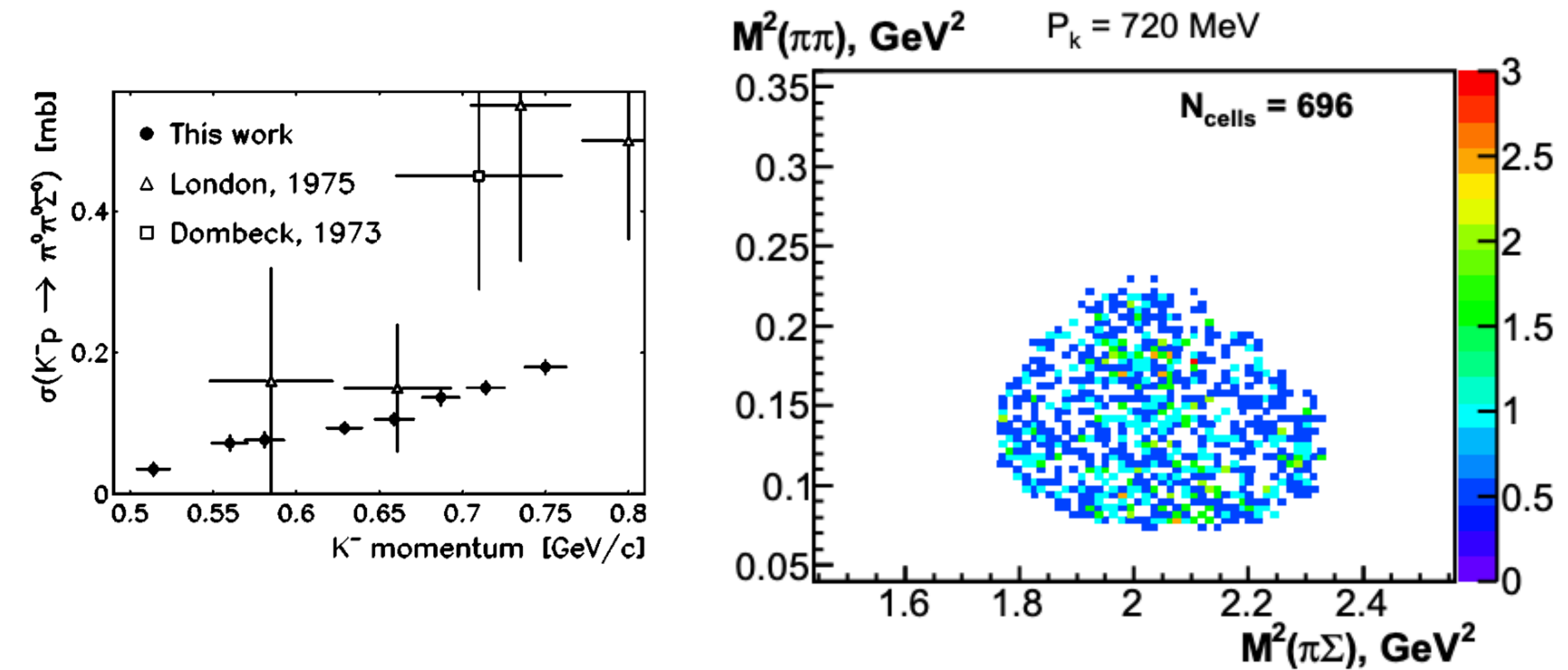
R.J. Saito et al., JPS Conf. Proc. 45, 011097 (2026).

■ Byproducts : Revisiting the $\Sigma(1670)$ Puzzle

J.J.M. Timmermans et al., Nucl. Phys. B112, 77 (1976)



A. V. Sarantsev et al., Eur. Phys. J. A 55, 180 (2019)



Decay-mode dependent angular distribution
→ Two nearly mass-degenerate Σ states?

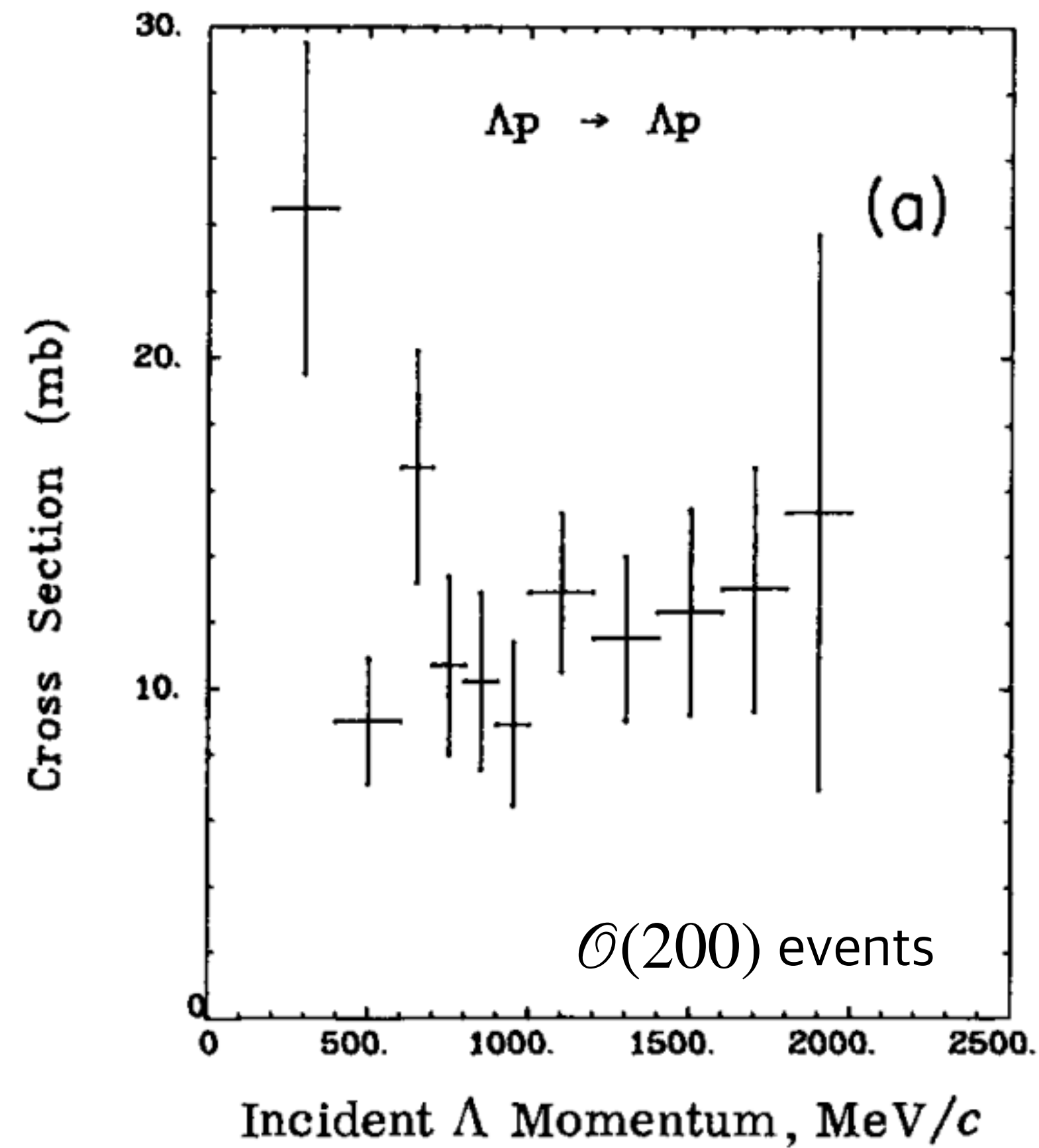
Crystal Ball, $K^- p \rightarrow \Sigma^0 \pi^0 \pi^0$: $\Lambda(1405)\pi$ allowed

J-PARC E72, $K^- p \rightarrow \Sigma \pi$, $K^- p \rightarrow \Sigma^0 \pi^+ \pi^-$

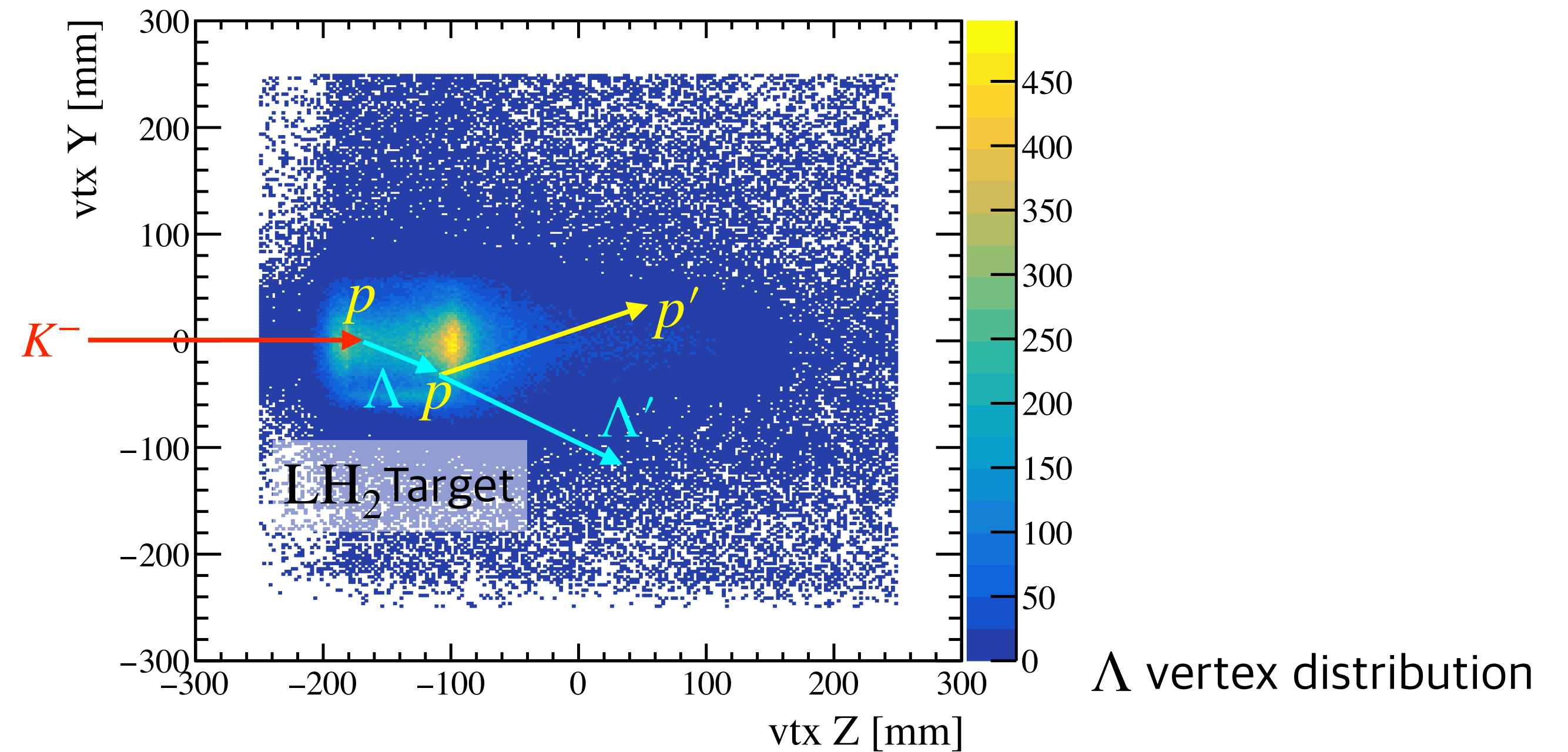
→ Direct test of the $\Lambda(1405)\pi$ contribution
in the $\Sigma(1670)$ region

■ Byproducts : Λp Elastic Scattering

Improved YN constraints are relevant to hypernuclear structure and the hyperon puzzle in neutron stars.



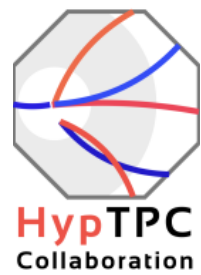
J.A. Kadyk et al., Nucl. Phys. B 27, 13-22 (1971)



Potential $\mathcal{O}(10^3)$ Λp sample with the E72 dataset

■ Summary

- J-PARC E72 aims to investigate the $\Lambda\eta$ threshold region through the $K^-p \rightarrow \Lambda\eta$ reaction with the Superconducting Hyperon Spectrometer.
- High-statistics data were successfully collected in November 2025, providing approximately two orders of magnitude more data than the previous measurement.
- Analysis of the 2025 dataset is ongoing, with $\Lambda \rightarrow p\pi^-$ reconstruction established and the $\Lambda\eta$ analysis currently in progress.
- Additional data taking is planned for November 2026, further improving the sensitivity to the $\Lambda\eta$ threshold structure.
- The large and inclusive E72 dataset also provides opportunities for broader hyperon physics.



Thank you