Kinematics Calculation of the Feasibility of Λ-P Scattering Experiment Using Tagged Photon Beam at ELPH

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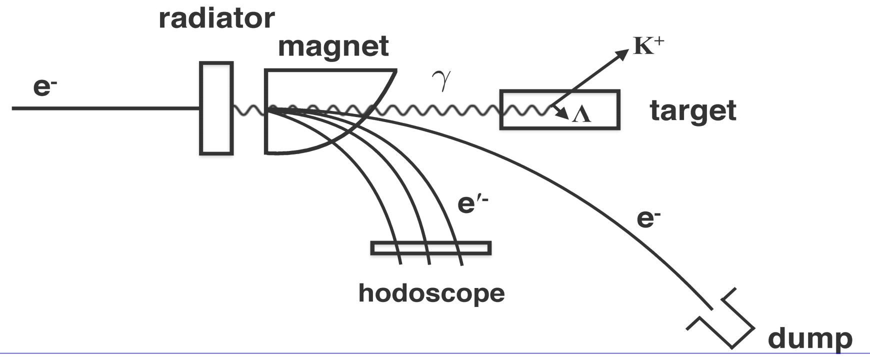
Introduction

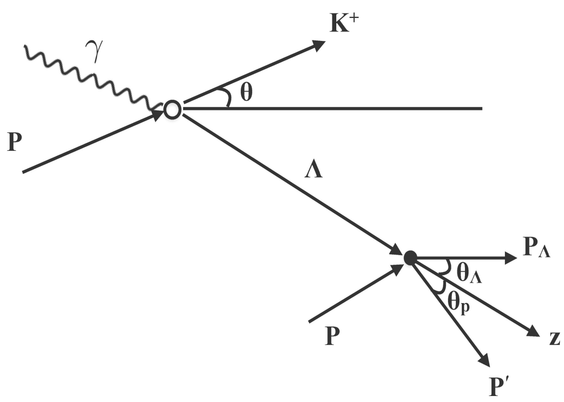
- The Λ particle was discovered in early 1950s but we don't have sufficient data to explain the Λ-N interaction.
- Bubble chamber data taken between 1959 to 1975, is so limited for confirming the correctness of the nuclear Λ models.

Goal

To obtain direct Λ-p scattering data with better quality and higher statistics. The kinematics calculation is to study the feasibility of such an experiment at ELPH.

Schematics





$$\gamma + p \longrightarrow K^+ + \Lambda$$

- 1.3 GeV electrons are incident on a radiator to produce photons.
- Outgoing photons interact with protons in the LH target, producing positively charged Kaon and Λ particles in pairs.
- These Λ particles will play in a role as Λ beam.

Kinematics with assumed conditions

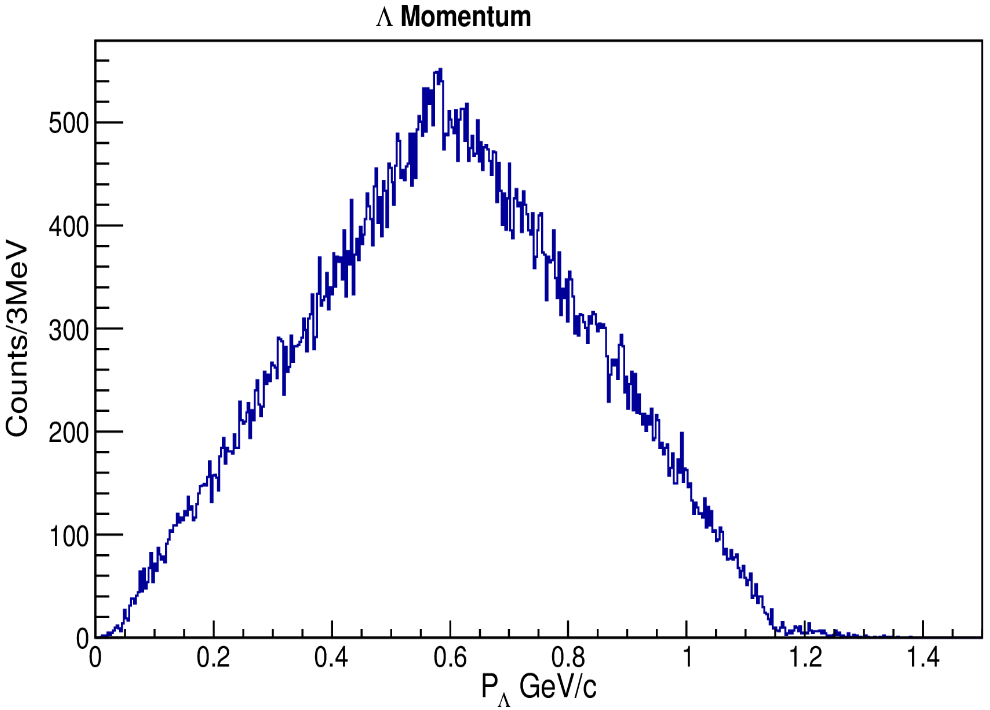
$$E_\gamma = 0.68 - 1.25 GeV$$

$$K_p^+ = 0.1 - 0.68 GeV/c$$

Production of Λ particle

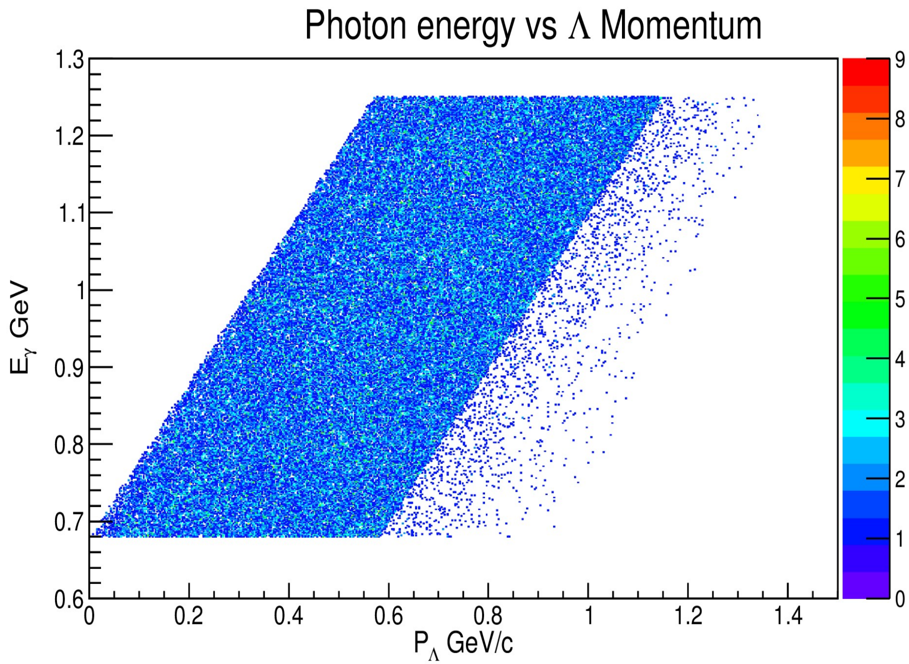
$$\vec{P_\gamma} = \vec{P_{K^+}} + \vec{P_\Lambda}$$

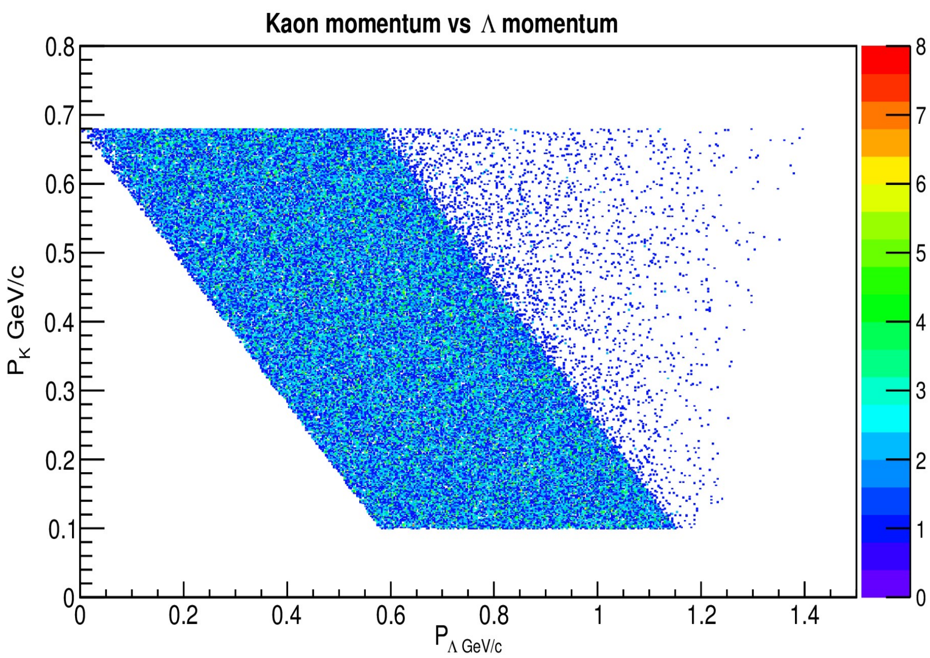
$$\vec{P_\Lambda} = \vec{P_\gamma} - \vec{P_{K^+}}$$



Production of Λ particle – *Cont.*

The Λ production kinematics calculation gives the correlations between Λ momentum and energy of the tagged photons as well as momentum of tagged kaons. Selection of ΔE_γ and ΔP_K can then be used to optimize the desired P_Λ range.

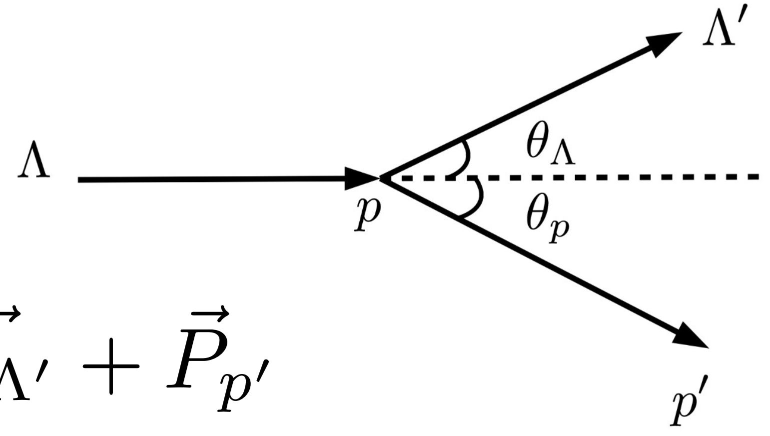




For E_γ = 0.68 to 1.25 GeV, Λ particles are produced in the momentum range of 0 to 1.2 GeV/c

Λ-p elastic scattering

$$\Lambda + p \rightarrow \Lambda' + p'$$



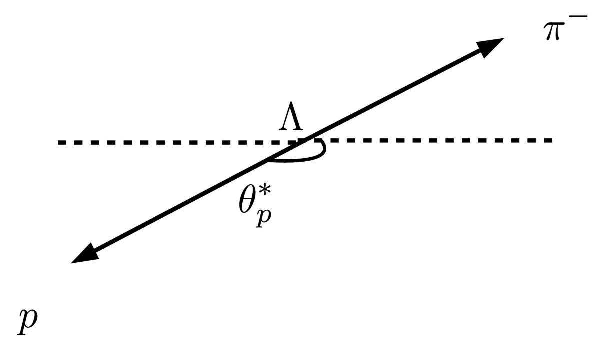
$$\vec{P}_\Lambda + \vec{P}_p = \vec{P}_{\Lambda'} + \vec{P}_{p'}$$
$$E_\Lambda + E_p = E_{\Lambda'} + E_{P'}$$

In the first step momentum and angle of scattered Λ' are calculated. Then, by using the cosine law, momentum and angle of scattered proton are calculated.

$$P_{p'}^2 = P_\Lambda^2 + P_{\Lambda'}^2 - 2P_\Lambda P_{\Lambda'} cos\theta_\Lambda$$
$$cos\theta_p = \frac{P_\Lambda^2 + P_{p'}^2 - P_{\Lambda'}^2}{2P_\Lambda P_{p'}}$$

Decay of Λ particle

$$\Lambda \to p + \pi^-$$



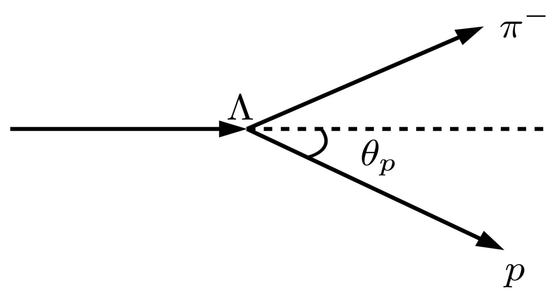
Center of mass frame

$$E_p^* = \frac{m_\Lambda^2 + m_p^2 - m_\pi^2}{2m_\Lambda}$$

$$P_p^* = \sqrt{E_p^{*2} - m_p^2}$$

By using the Lorentz transformation, the center of mass momentum is changed into lab momentum.

Lab frame

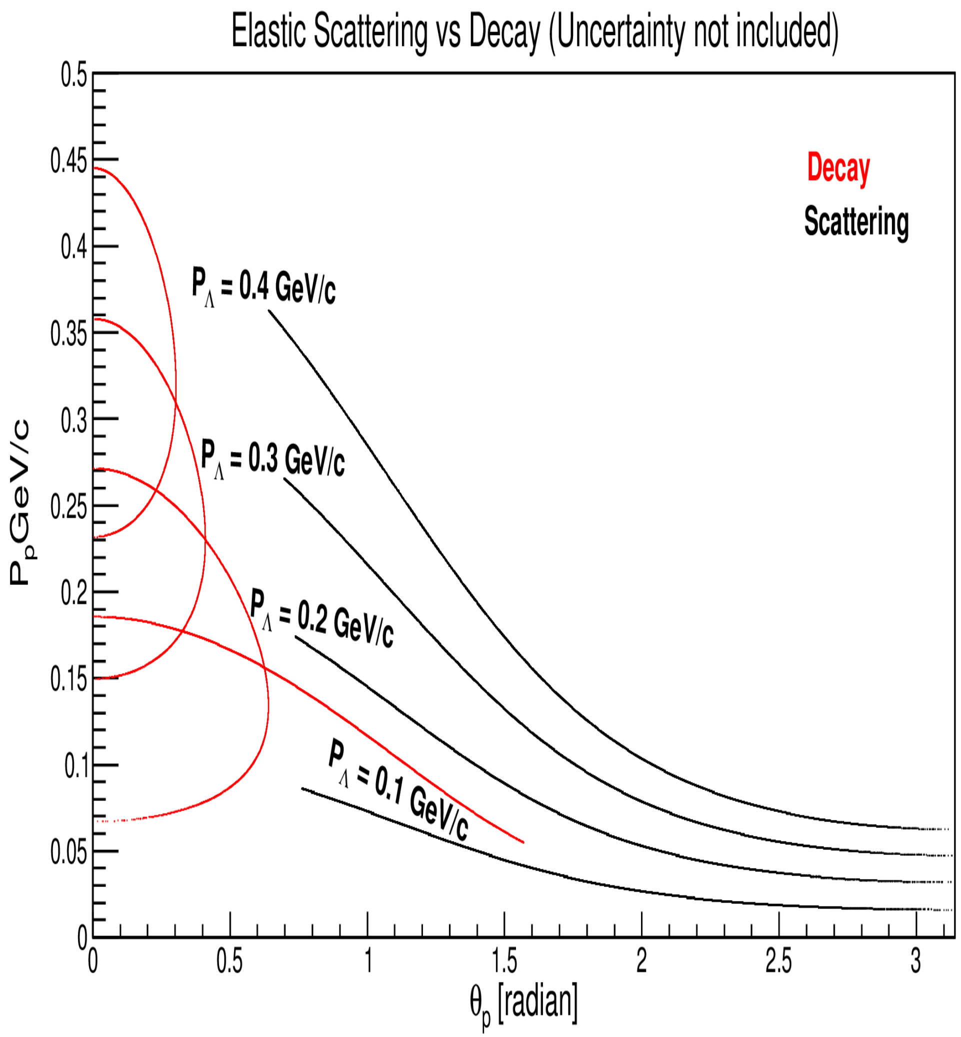


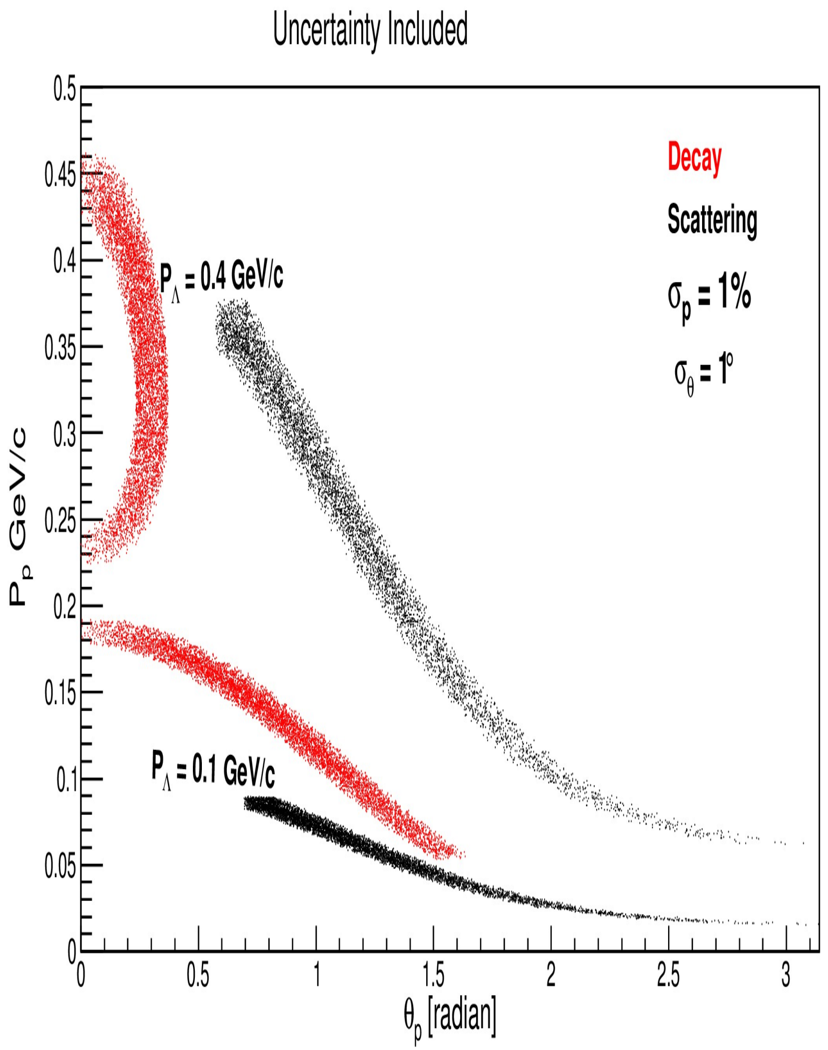
$$P_p = \sqrt{P_L^2 + P_T^2}$$

$$tan\theta_p = \frac{\beta_p^* \sin\theta_p^*}{\gamma_\Lambda(\beta_p^* \cos\theta_p^* + \beta_\Lambda)}$$

Where, $-1 \leq \cos\theta_p^* \leq 1$

Result


Elastic Scattering vs Decay (Uncertainty not included)
Decay
Scattering
P_Λ = 0.4 GeV/c
P_Λ = 0.3 GeV/c
P_Λ = 0.2 GeV/c
P_Λ = 0.1 GeV/c
P_p GeV/c
θ_p [radian]


Uncertainty Included
Decay
Scattering
σ_p = 1%
σ_θ = 1°
P_Λ = 0.4 GeV/c
P_Λ = 0.1 GeV/c
P_p GeV/c
θ_p [radian]

Conclusion

- The kinematics simulation studied dependence of P_Λ to E_γ and P_K with assumed kaon solid angle acceptance ($\Delta\Omega_K \approx 11msr$), so that the experiment can be optimized by the desired P_Λ range.
- Studied capability of the separating Λ-p scattering events from Λ decay events when only the protons are detected.

Thank you