Hyperon-Nucleon Scattering Experiment II

- E452 Data Analysis
  - Polarization
  - L-R Asymmetry
- Summary

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Polarization

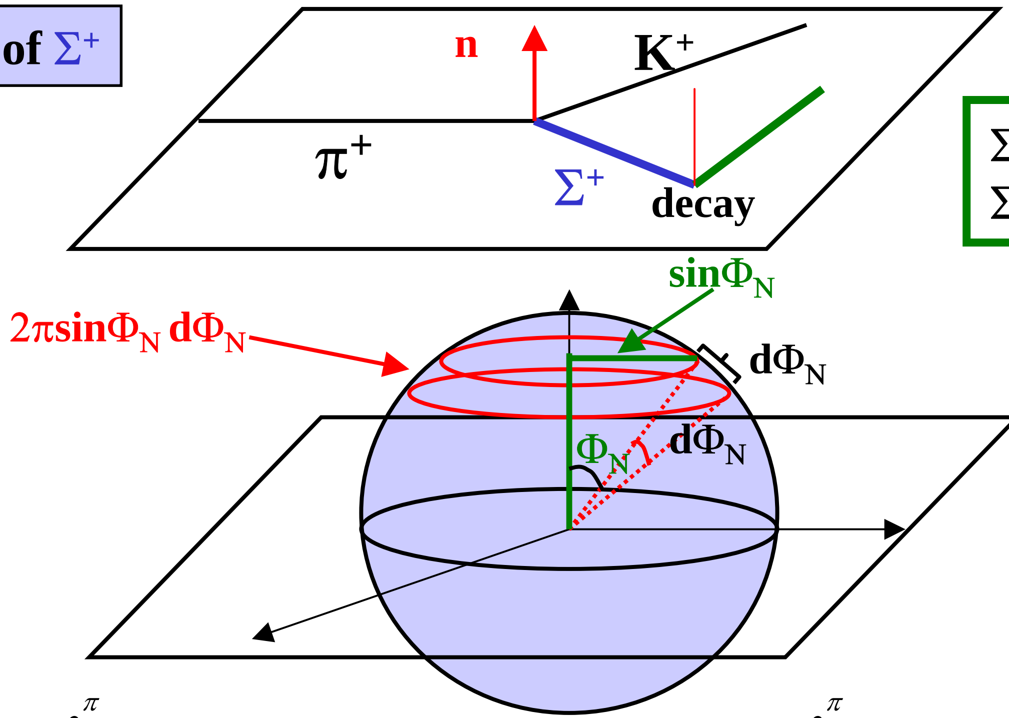
Angular distribution of emitted nucleon in the decay of Y (p (π^+ ,K^+) Y)

$$I(\theta_K, \Phi_N) = I_0(\theta_K)(1 + \alpha P_Y \cos\Phi_N)$$

α : asymmetry parameter

P_Y : polarization of Hyperon

Polarization of Σ^+



$\Sigma^+ \rightarrow p + \pi^0$

$\Sigma^+ \rightarrow n + \pi^+$

$$N_U = 2\pi I_0 \int_0^{\frac{\pi}{2}} \underbrace{\Gamma_0 (1+\alpha_0 P_\Sigma \cos\Phi_p) \sin\Phi_p d\Phi_p}_{p} + \overbrace{2\pi I_0 \int_0^{\frac{\pi}{2}} \Gamma_+ (1+\alpha_+ P_\Sigma \cos\Phi_n) \sin\Phi_n d\Phi_n}^{n}$$

$$\Downarrow$$

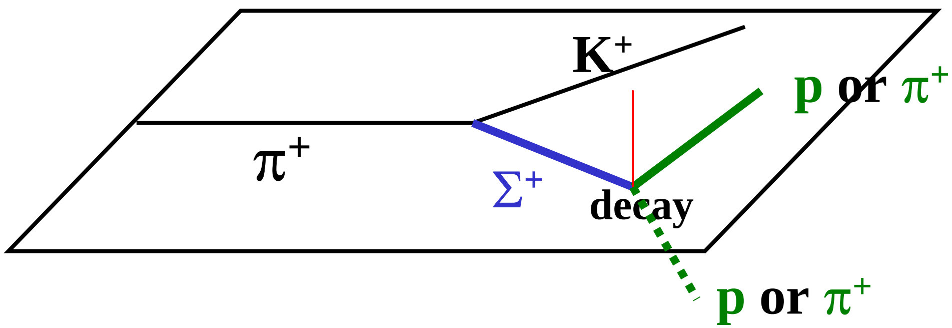
$$2\pi I_0 \int_0^{\frac{\pi}{2}} \Gamma_+ (1-\alpha_+ P_\Sigma \cos\Phi_{\pi^+}) \sin\Phi_{\pi^+} d\Phi_{\pi^+}$$

$$N_U = 2\pi I_0[1+\frac{1}{2}(\Gamma_0\alpha_0 - \Gamma_+\alpha_+)P_\Sigma]$$

$$N_D = 2\pi I_0[1-\frac{1}{2}(\Gamma_0\alpha_0 - \Gamma_+\alpha_+)P_\Sigma]$$

$$\Rightarrow \boxed{P_\Sigma = \frac{2}{\Gamma_0\alpha_0 - \Gamma_+\alpha_+}\frac{N_U - N_D}{N_U + N_D}}$$

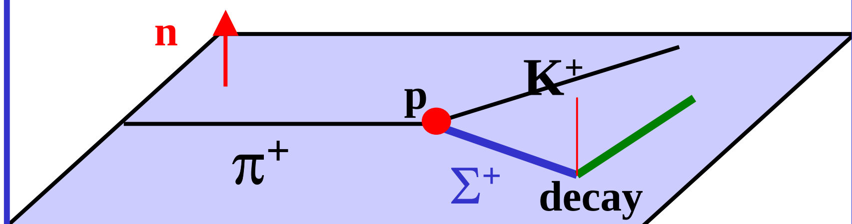
Decay Mode	Branching ratio (Γ)	Asymmetry parameter (α)
$P\pi^0$	Γ_0=(51.57±0.30)%	$\alpha_0 = -0.980_{-0.015}^{+0.017}$
$n\pi^+$	Γ_+=(48.31±0.30)%	$\alpha_+ = 0.068 \pm 0.013$
$p\gamma$	$(1.23 \pm 0.05) \times 10^{-3}$ %	



Polarization of Σ^+ ← direction vector of p or π^+ track

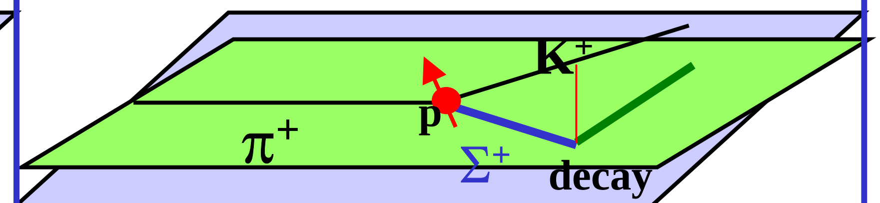
$\pi^+ + p \rightarrow K^+ + \Sigma^+$ **(Production)**

Free Process (Hydrogen)	**Quasi Free Process (Carbon)**



Polarization plane → UNIQUE

Fermi Motion



Polarization plane → NOT UNIQUE

N_U , N_D

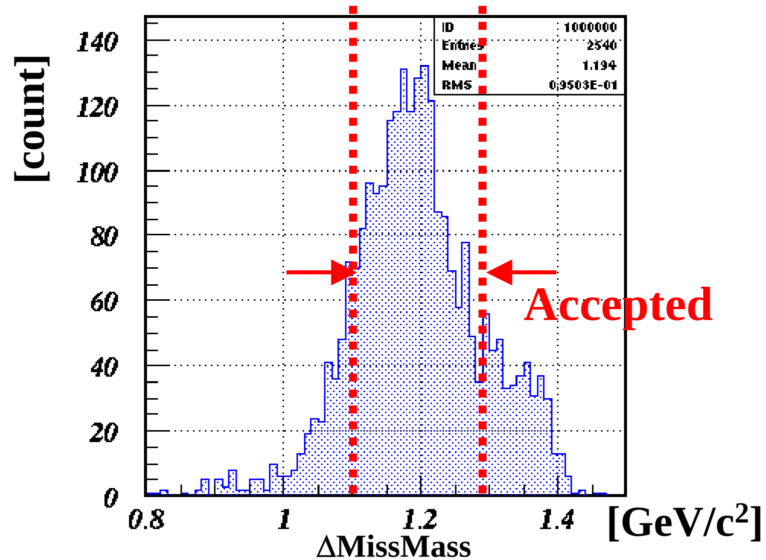
Proton rest frame

N_U , N_D

Later

Different way of analysis

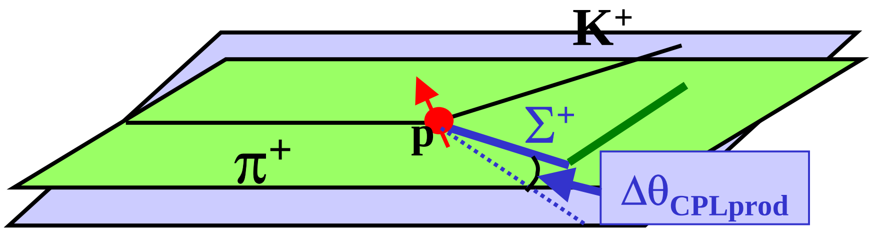
Free Process (Hydrogen)

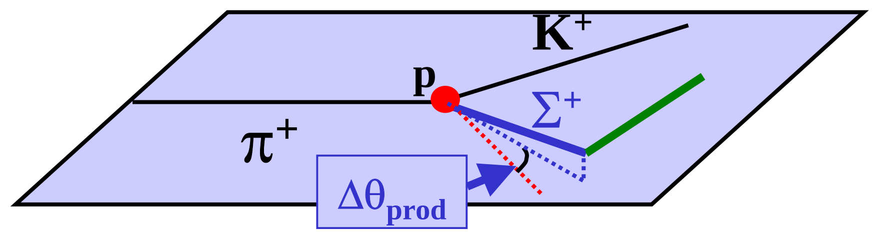


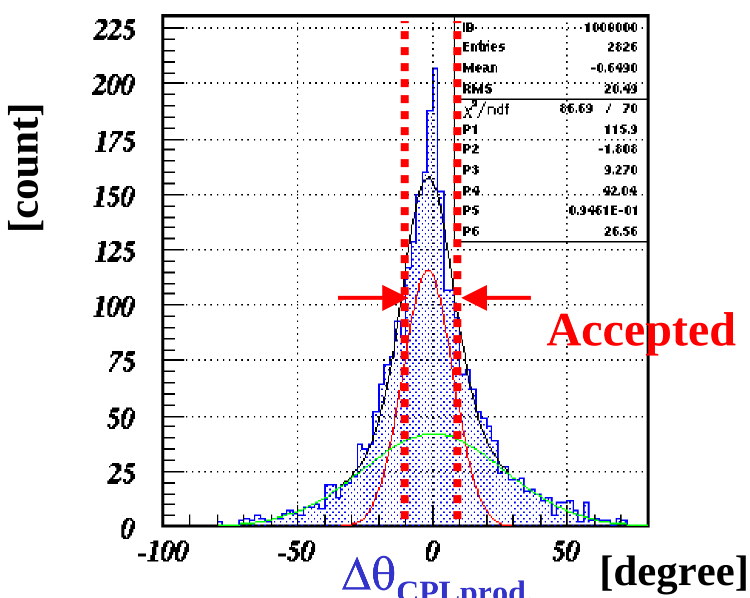
Cut Condition $|\Delta \mathrm{MissMass}| < 100$ [MeV/c^2]

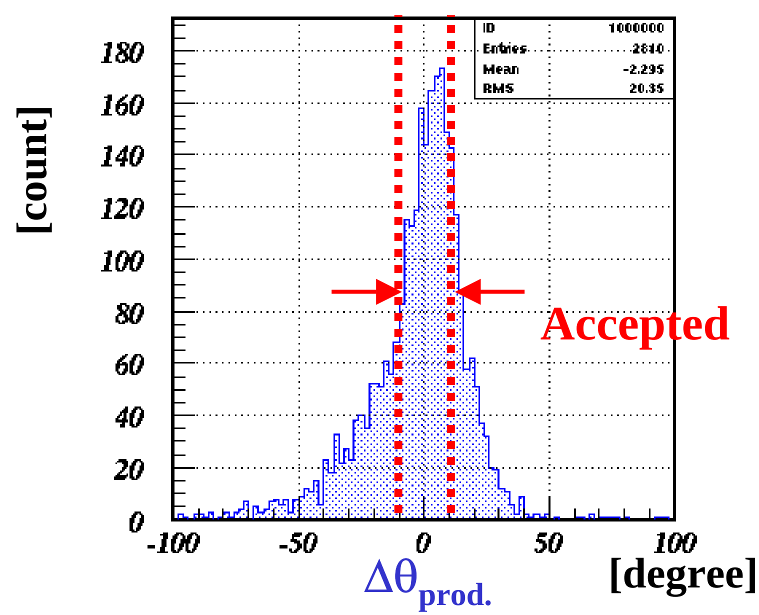
$|\Delta\theta_{\mathrm{CPLprod.}}| < 10°$

$|\Delta\theta_{\mathrm{prod.}}| < 10°$

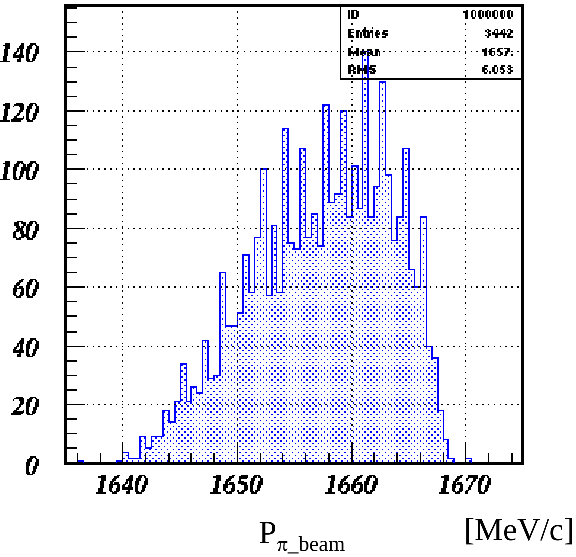


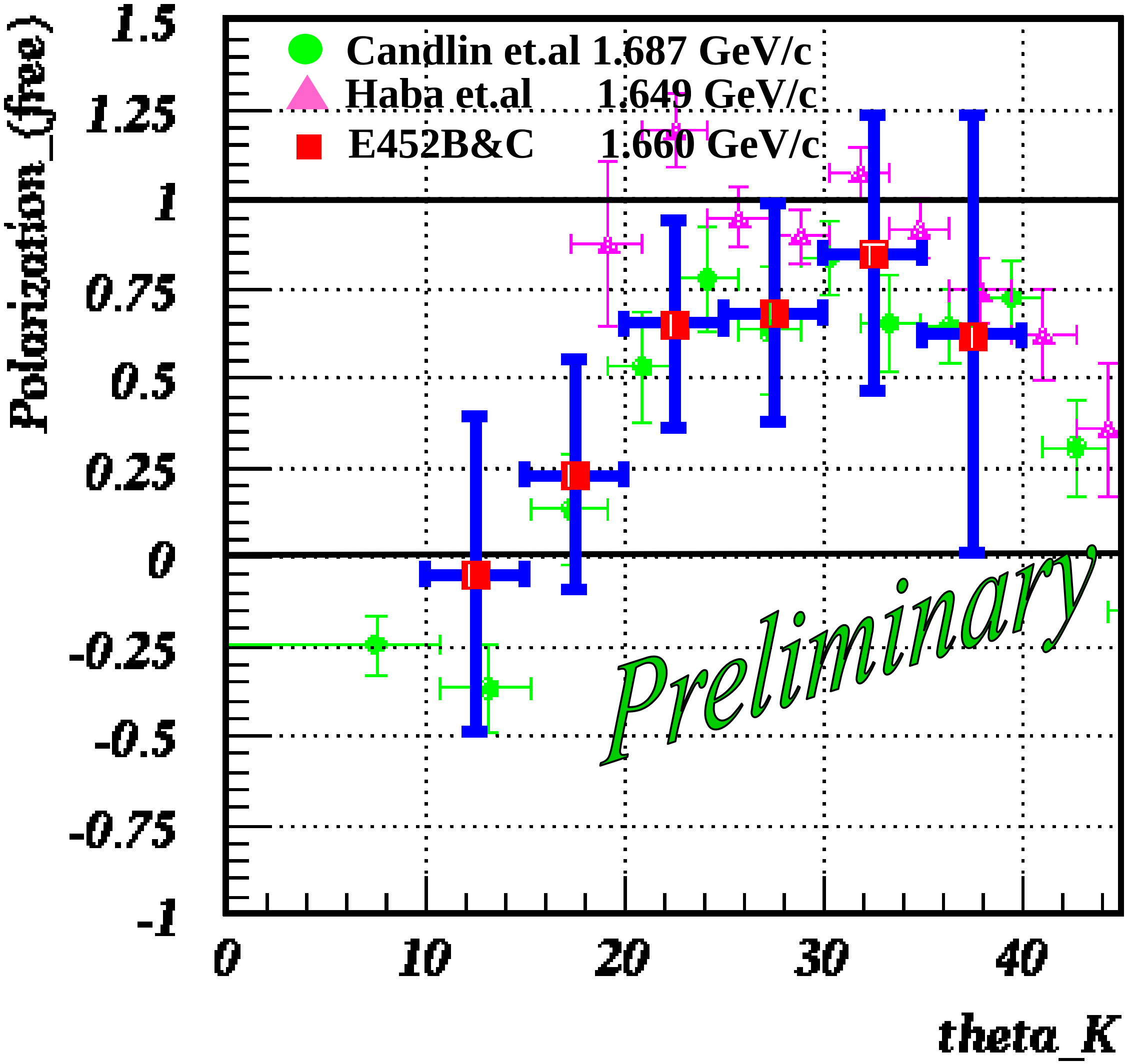






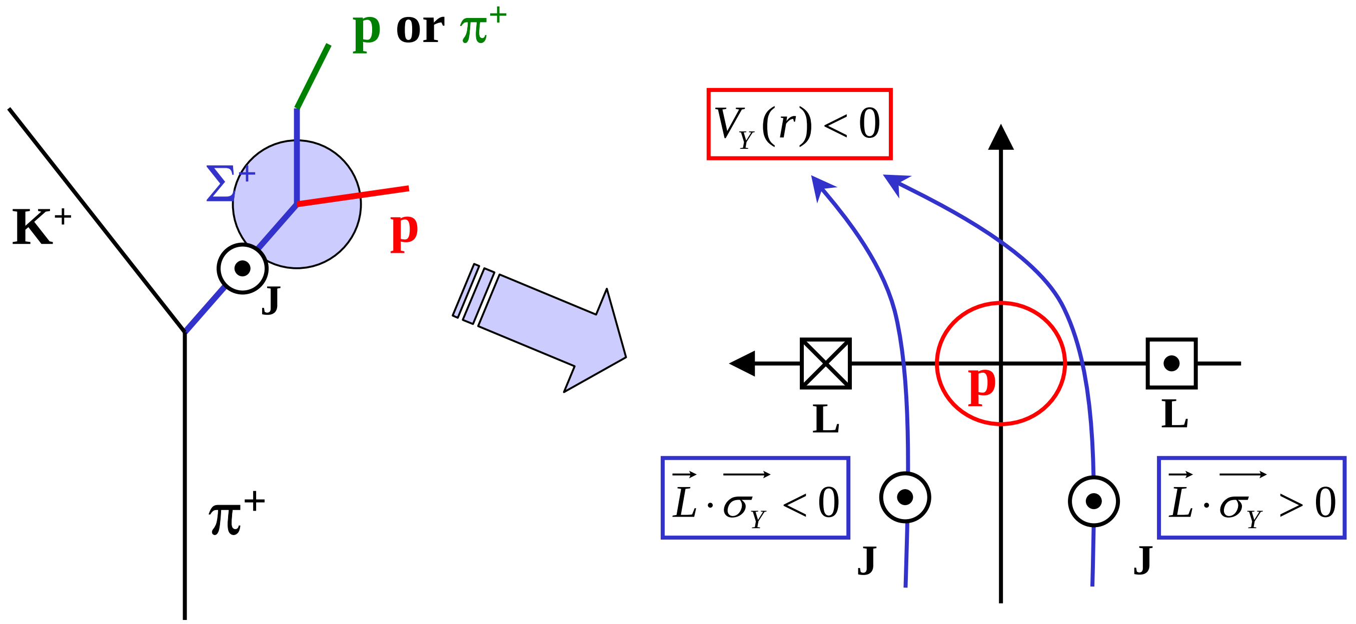
Polarization of Σ^+ (Free Process (Hydrogen))





Left-Right Asymmetry

LS Interaction : $V_Y(r)(\vec{L}\cdot\vec{\sigma_Y})$



$V_Y(r) = 0$: Symmetry

$V_Y(r) \neq 0$: Asymmetry

$$\boxed{A_\Sigma = \frac{N_L - N_R}{N_L + N_R}}$$

Free Process (Hydrogen)

Cut Condition

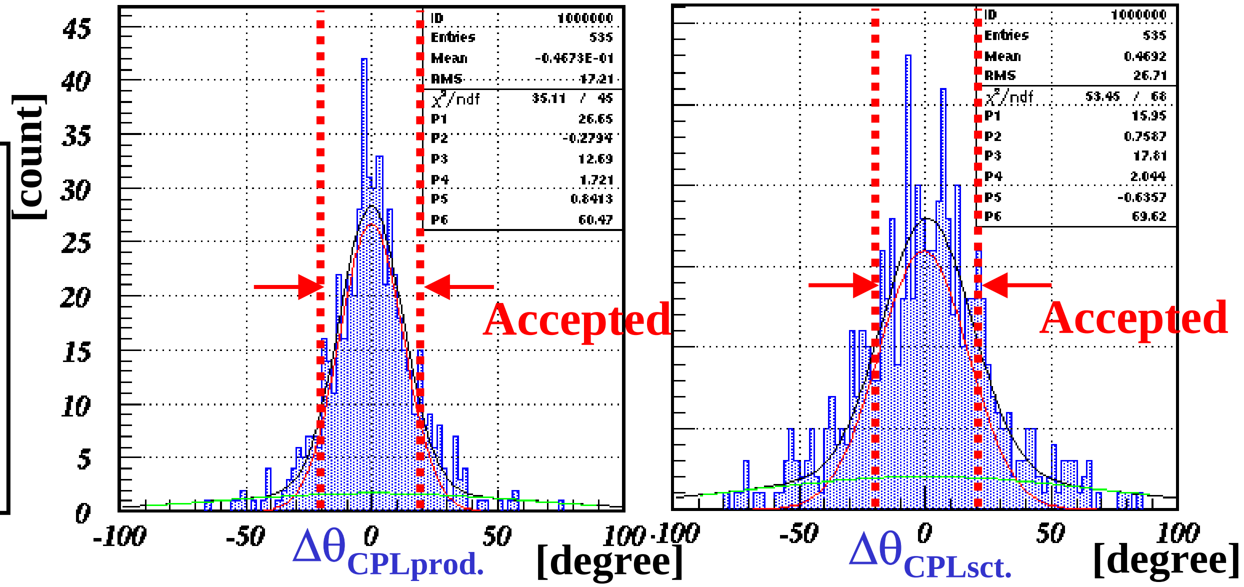
$|\Delta \mathrm{MissMass}| < 100\ [\mathrm{MeV}/c^2]$

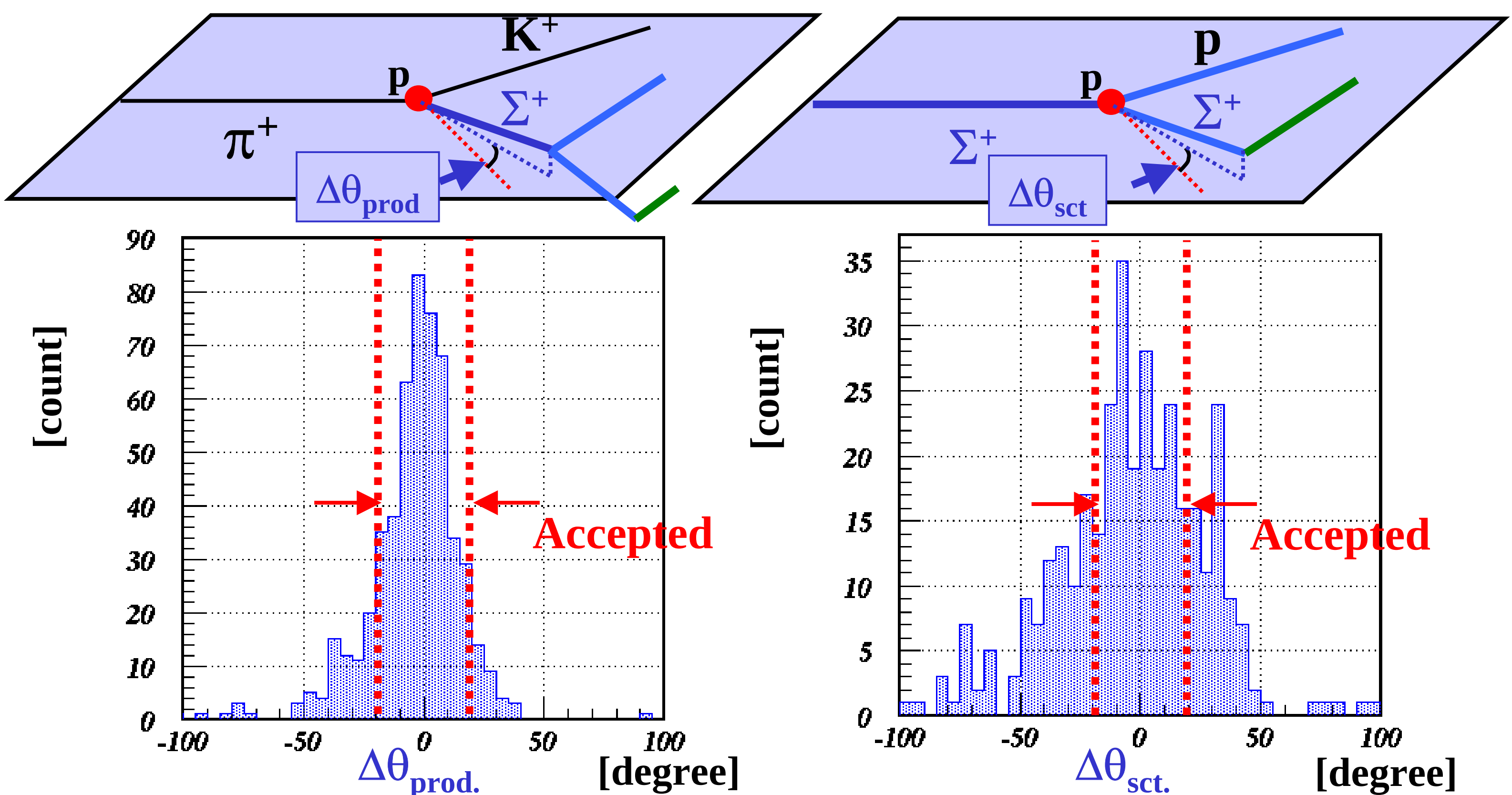
$|\Delta\theta_{\mathrm{CPLprod.}}| < 20^\circ$

$|\Delta\theta_{\mathrm{prod.}}| < 20^\circ$

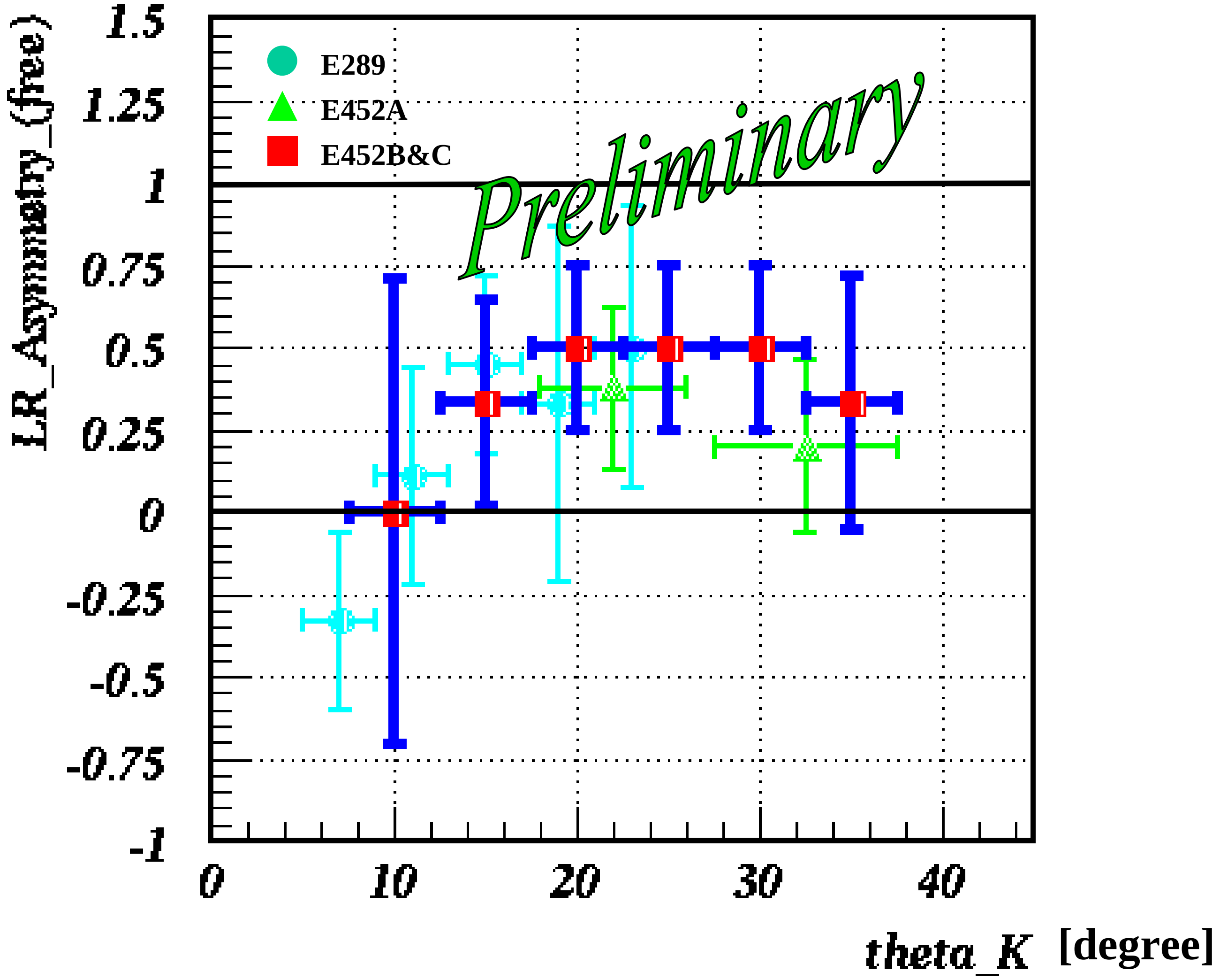
$|\Delta\theta_{\mathrm{CPLsct.}}| < 20^\circ$

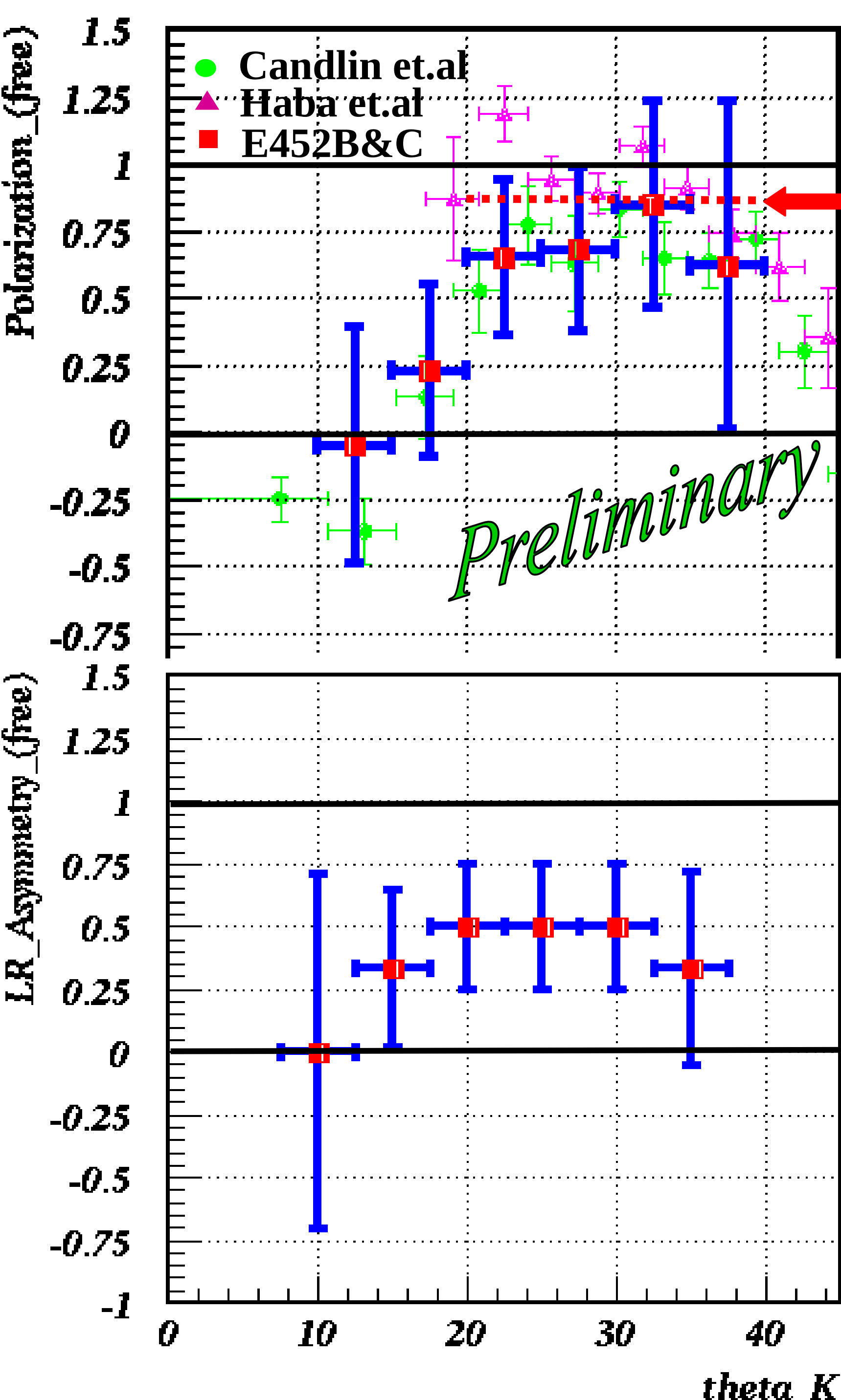
$|\Delta\theta_{\mathrm{sct.}}| < 20^\circ$





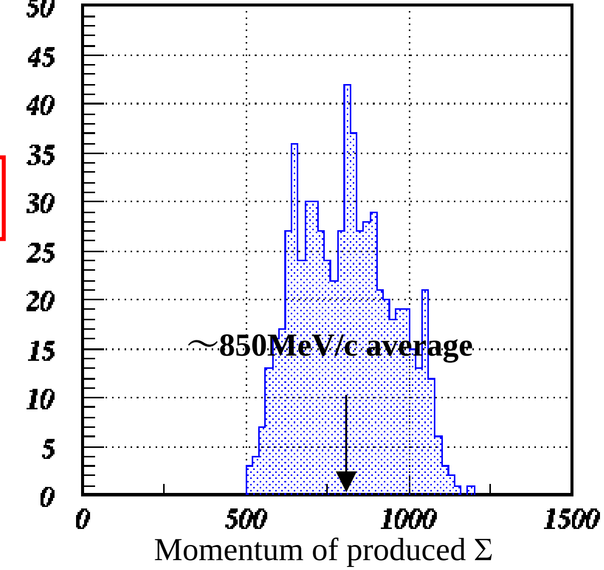
L-R Asymmetry (Free Process (Hydrogen))

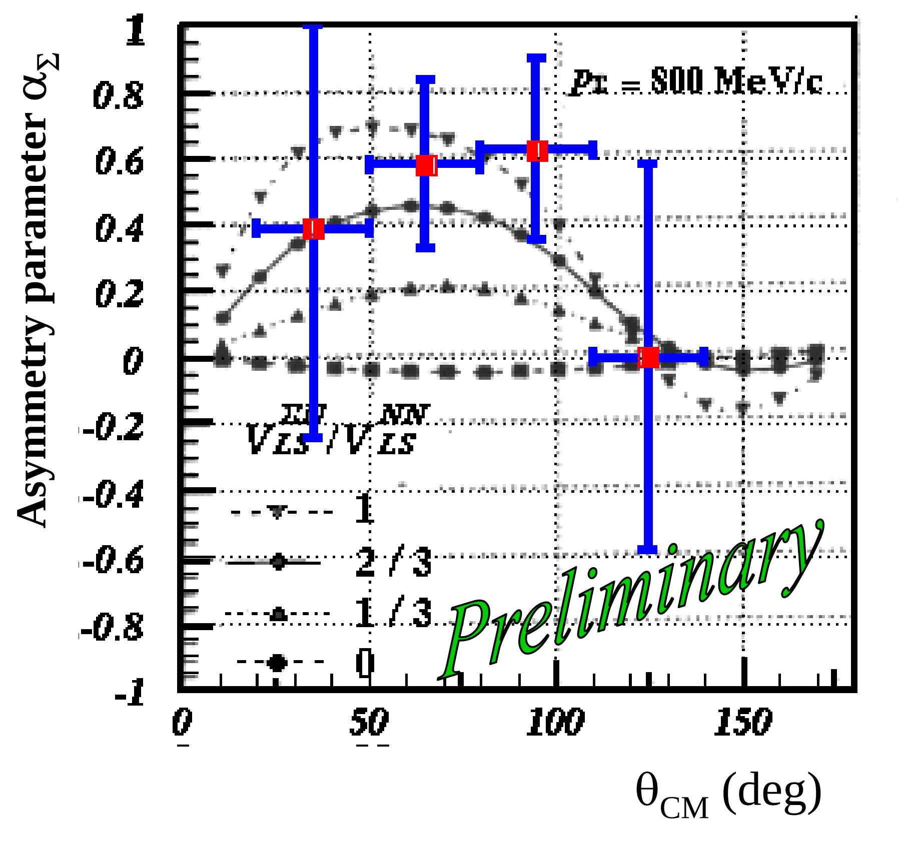




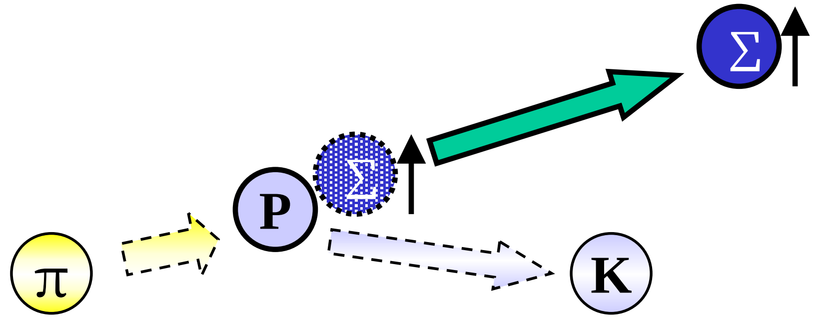
$\overline{P_\Sigma} = 0.86 \pm 0.03$

$$\alpha_\Sigma = \frac{A_\Sigma}{\overline{P_\Sigma}}$$



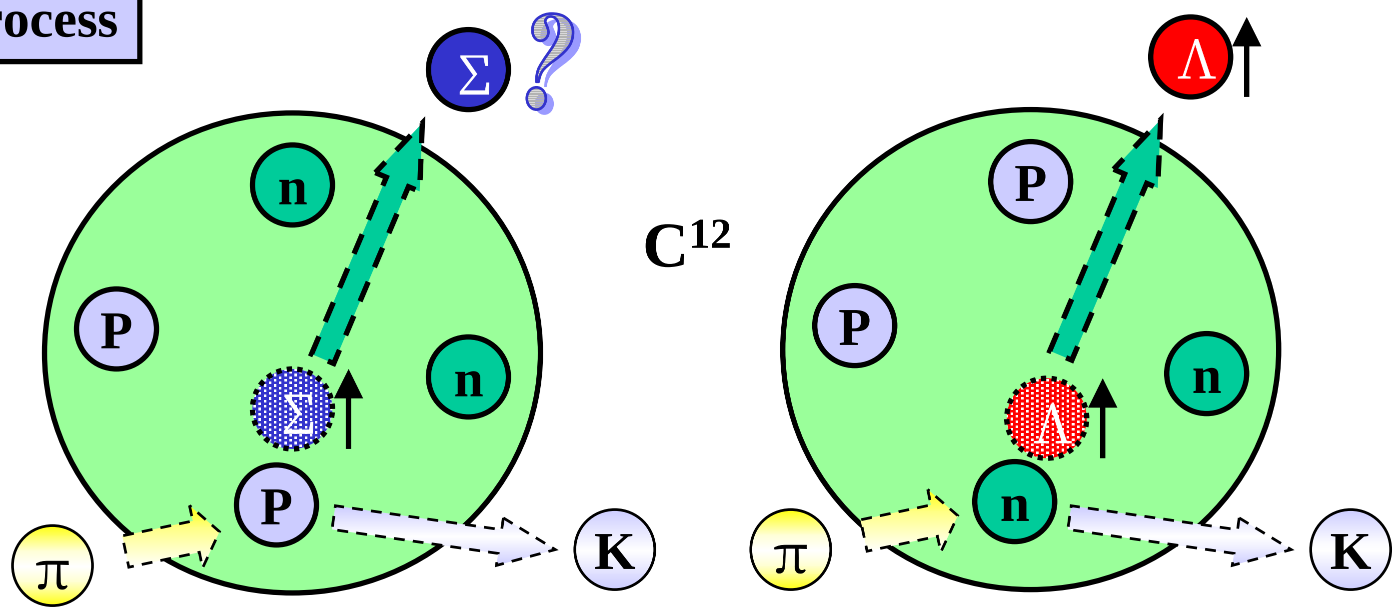


Free process



Direction of spin is kept

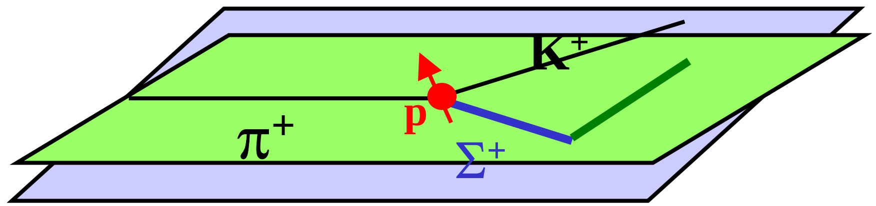
Quasi free process



For Σ, there is possibility of spin exchange

Quasi Free Process (Carbon)

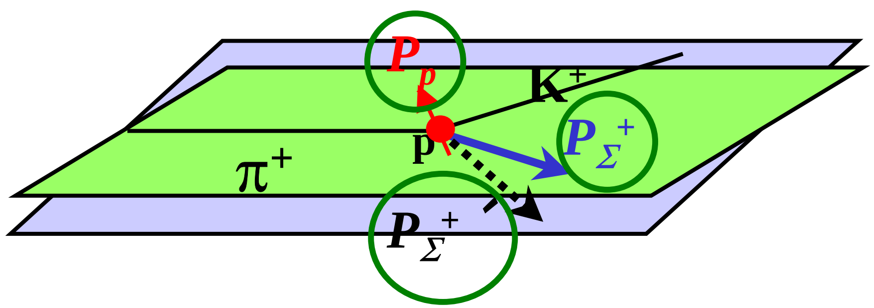
proton inside the carbon → Fermi Motion



Polarization plane → NOT UNIQUE

$\boxed{\text{Proton rest frame}}$

Momentum vector of proton



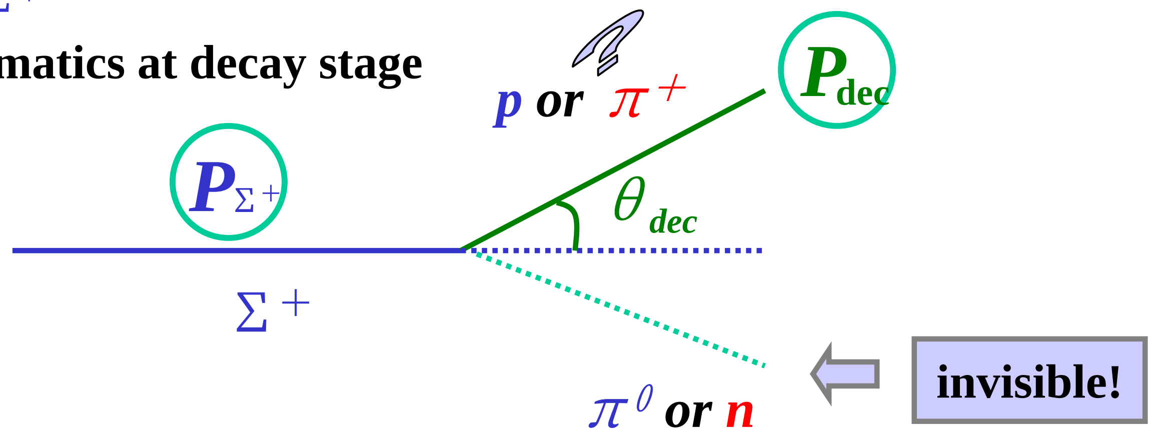
$\vec{P}_{\Sigma^+}$: Momentum of Σ^+

$\vec{P}'_{\Sigma^+}$: From kinematics of reaction stage

$$\boxed{\vec{P}_p = \vec{P}_{\Sigma^+} - \vec{P}'_{\Sigma^+}}$$

Momentum of Σ $\vec{P}_{\Sigma^+}$

By solving kinematics at decay stage



We have 3-dimentional track image

Track length of decay charged particle

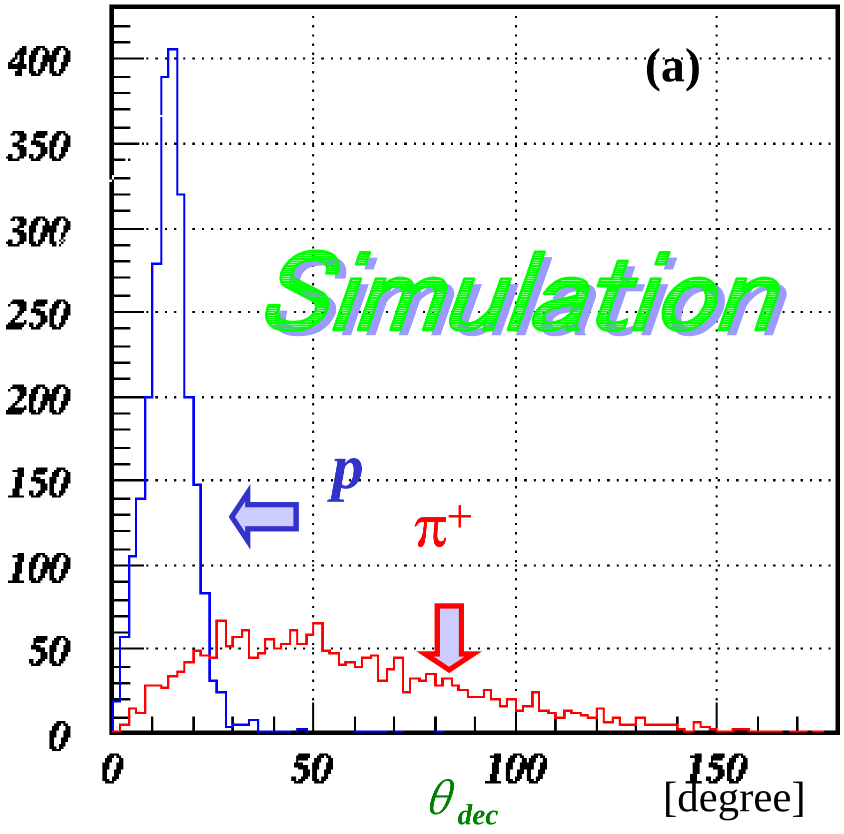
⇓ Energy loss

Momentum of decay particle P_{dec}

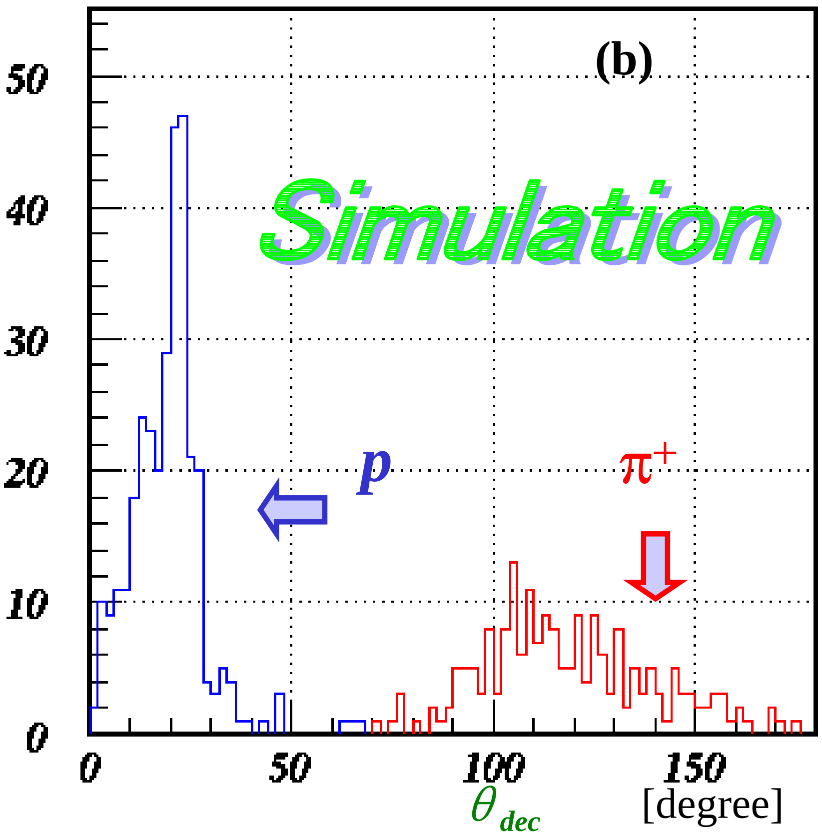
Angle of decay particle with Σ track θ_{dec}

Require p, π identification of decay particles

Particle Identifier

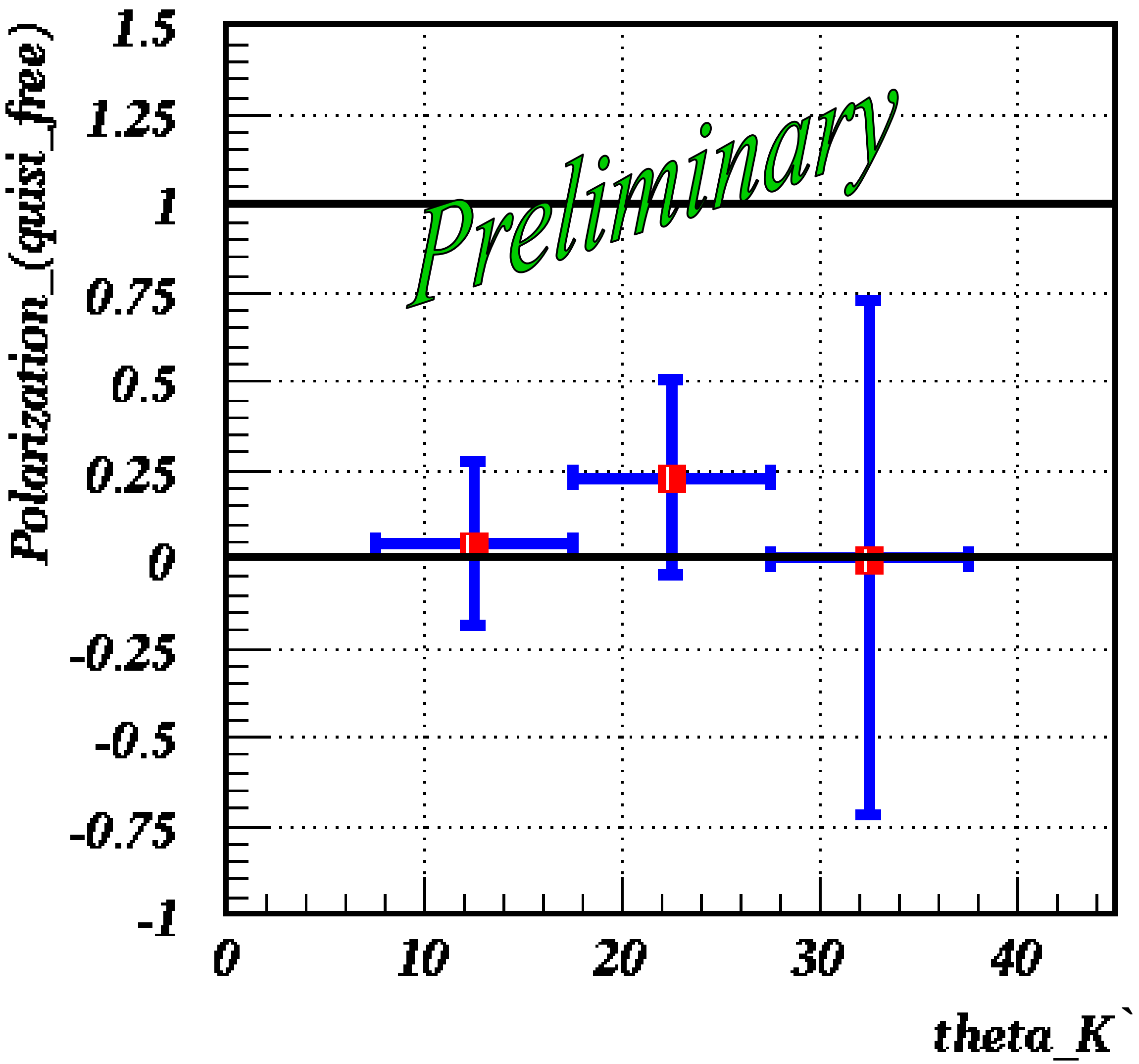


Track stop in the target



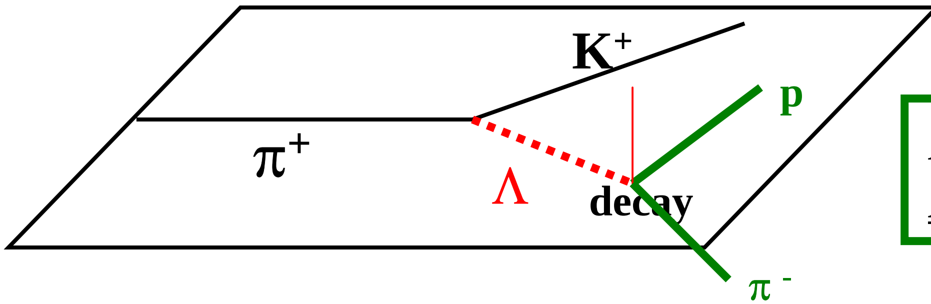
We can identify decay particles

Polarization of Σ^+ (Quasi Free Process (Carbon))



Polarization of Λ

$\pi^+ + n \rightarrow K^+ + \Lambda$ **(Production)**



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

$\Lambda \rightarrow n + \pi^0$

$$N_U = 2\pi I_0 (1 + \frac{1}{2}\alpha\_P_\Sigma)$$

$$N_D = 2\pi I_0 (1 - \frac{1}{2}\alpha\_P_\Sigma)$$

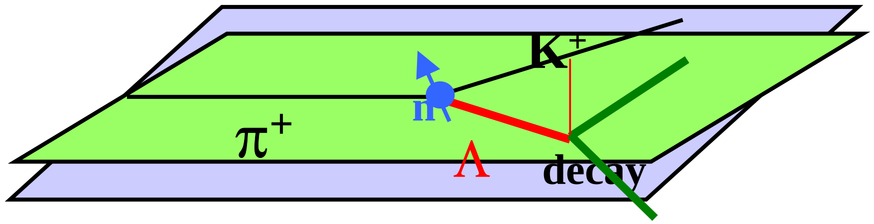
$$\Rightarrow \quad \boxed{P_\Lambda = \frac{2}{\alpha_-} \frac{N_U - N_D}{N_U + N_D}}$$

Decay Mode	Branching ratio (Γ)	Asymmetry parameter (α)
$P\pi^-$	$\Gamma_- = (63.9 \pm 0.5)\%$	$\alpha_- = -0.642 \pm 0.013$
$n\pi^0$	$\Gamma_0 = (35.8 \pm 0.5)\%$	$\alpha_0 = 0.65 \pm 0.05$

Polarization of Λ $\leftarrow$ direction vector of p track

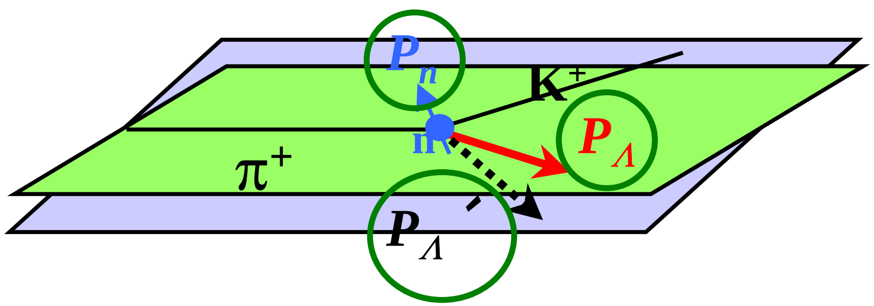
Quasi Free Process (Carbon)

neutron : inside the carbon → Fermi Motion



Polarization plane → NOT UNIQUE
Up and Bottom direction can't be defined

Momentum vector of neutron



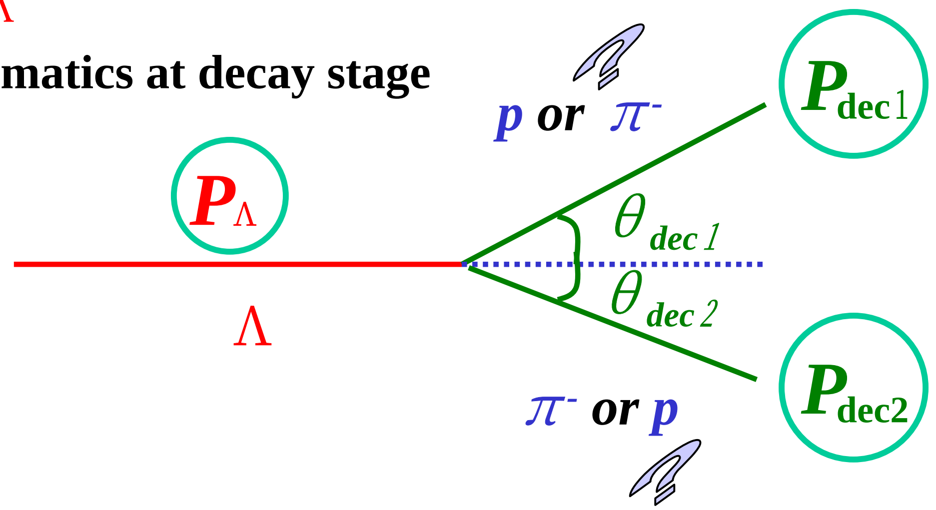
$\vec{P}_\Lambda$ **: Momentum of** Λ

$\vec{P}_\Lambda'$ **: From kinematics of reaction stage**

$$\boxed{\vec{P}_n = \vec{P}_\Lambda - \vec{P}_\Lambda'}$$

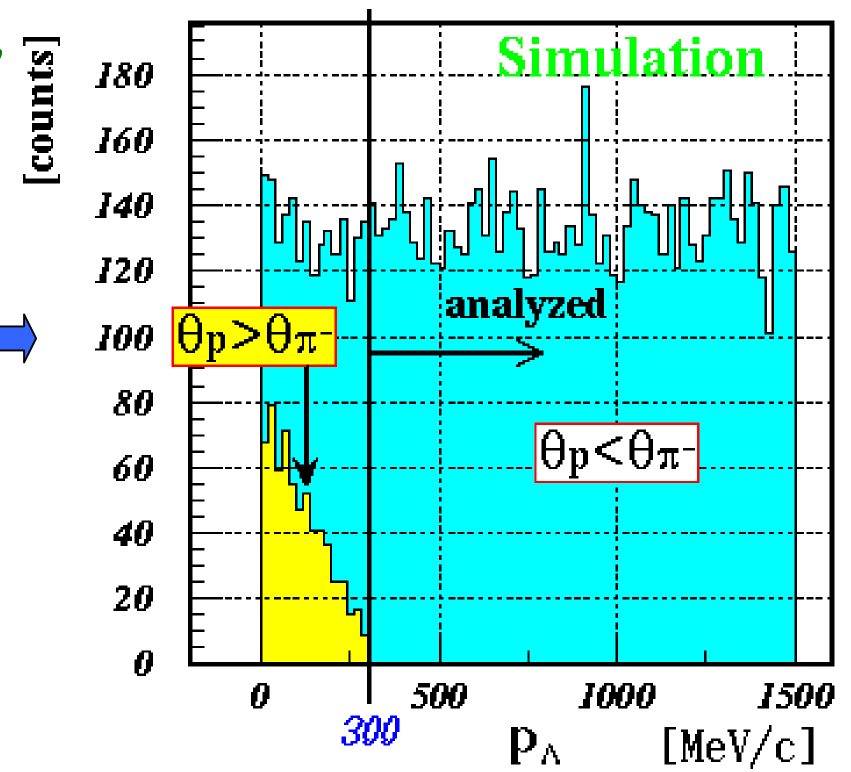
Momentum of Σ $\vec{P}_\Lambda$

By solving kinematics at decay stage

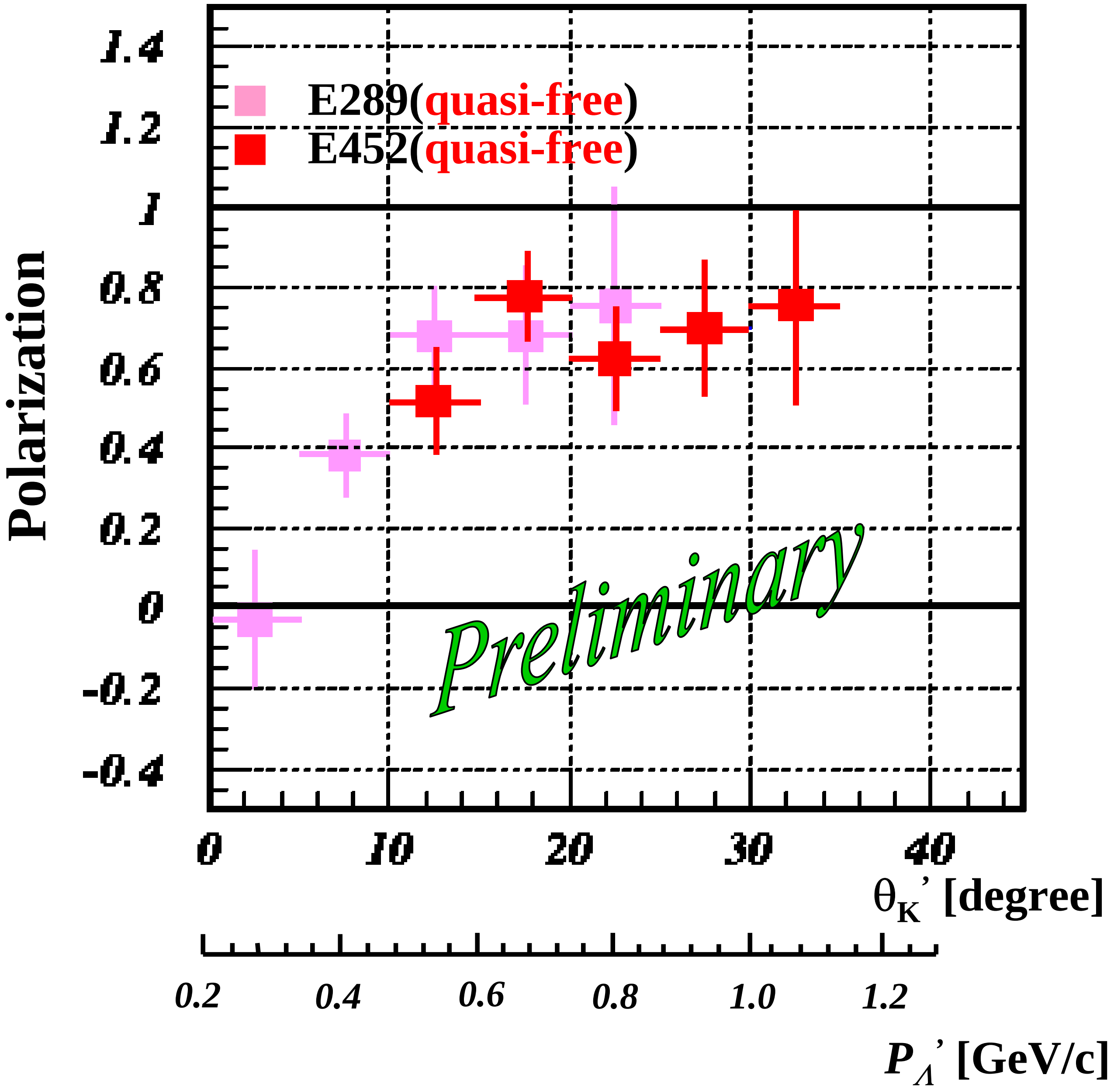


Angle of decay particle with Λ track $\theta_{dec\,1}$ $\theta_{dec\,2}$

Necessity to identify decay particle, p and π -

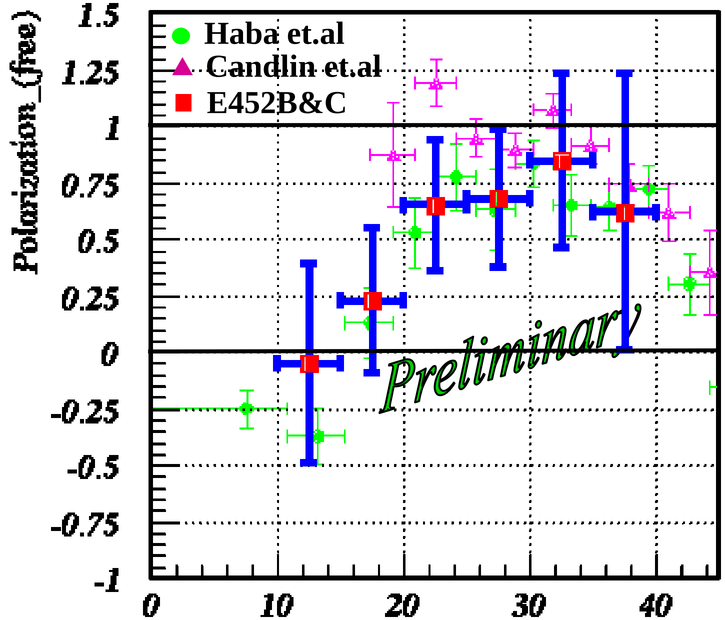


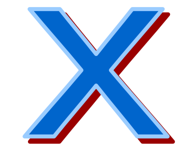
Polarization of Λ (Quasi Free Process (Carbon))



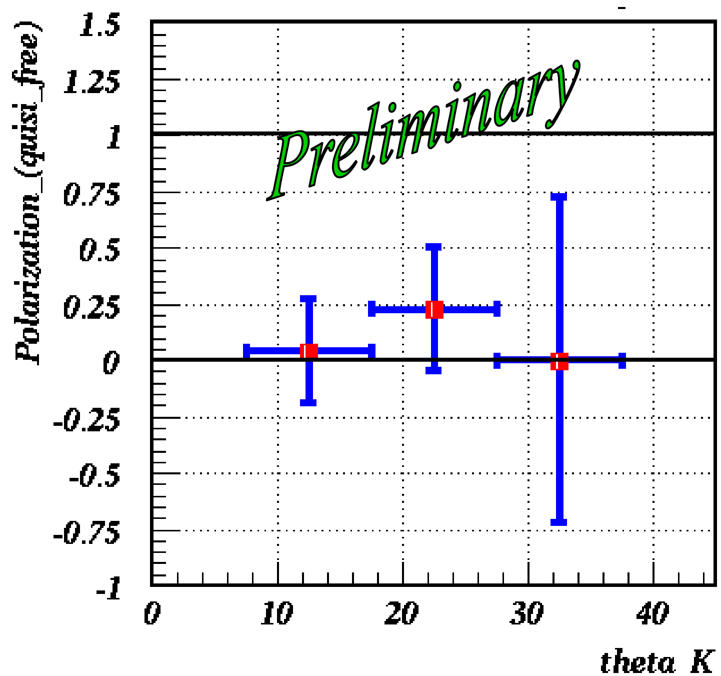
Σ^+ Λ

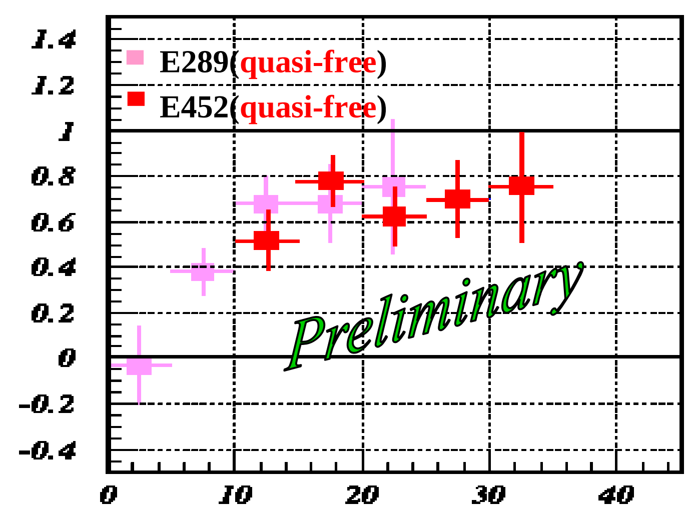
Free process





Quasi-free process





Summary

•We determined polarization and L-R Asymmetry of Σ in free process.

•The polarization of Σ consisted with previous Experiment.

•We found large LS force between Σ and proton despite of small LS splitting for Λ.

•The polarization of Σ was consistent with <u>0</u> in quasi-free process in contrast to <u>large polarization</u> in free process

•The polarization of Λ was <u>large</u> despite of quasi-free process

We will continue the analysis and improve statistic