\( \Sigma N \) Cusp Effect and Angular Distributions in the CMS Frame in the \( pp \rightarrow pK^+\Lambda \) Reaction

Sedigheh Jowzaee(1), (2)

for the COSY-TOF collaboration

**Physics of the Reaction**

- An elementary reaction to examine the \( \Lambda \) hyperon and its production mechanism.
- Understanding the dynamics of the associated strangeness production in the reaction.
- Analysis of the \( pp \rightarrow pK^+\Lambda \) reaction to determine properties of
  - \( p\Sigma \) cusp effect
  - \( N^* \)-resonances
  - \( \Sigma N \) interaction
- Exploring the mechanism of the \( pp \rightarrow pK^+\Lambda \) reaction with different differential observables
  - Dalitz plot
  - Spin independent observables
  - Angular distribution
  - \( p\Lambda \) invariant mass
  - Spin dependent observables
  - \( \Lambda \) polarization
  - Kaon and \( \Lambda \) analyzing power

**Dalitz Plot Analysis**

- The COSY-TOF experiment covers the full phase-space
- The Dalitz plot distribution of the \( pp \rightarrow pK^+\Lambda \) has strong deviations from homogenous phase space
- Enhancements seen on the left and center
- Interference effects
  - \( p\Lambda \) final-state interaction
  - \( N^* \)-resonances
  - \( p\Sigma \) cusp

**Cusp Effect**

- Selection \( \cos\theta_{K^+} < 0 \) or \( > 0 \) divides the Dalitz plot into two equal phase space volume halves
- Studying of different physical effects in the \( p\Lambda \) channel without crossed channels effects
- \( p\Sigma \) cusp shape may change due to resonances interference
- \( p\Sigma \) cusp angular distribution is symmetric with dominant S-wave part

**Angular Distributions**

- All the distributions are corrected for detector acceptance and reconstruction efficiency
- Angular distribution of particles in center of mass frame
- The angular distributions in the overall CMS are expected to be symmetric around \( \cos\theta = 0 \) due to the identical particles in the entrance channel
- Some asymmetries are seen in the forward and backward regions
  - Background mixed with data
  - Incomplete Monte Carlo description of the detector at small angles
- Angular distributions described by Legendre polynomials

\[
\frac{d\sigma}{d\Omega} = \sum_{l=0}^{\infty} \left(2l+1\right)a_{l}\cos^{l}\theta = 
C_{0} + C_{2}\cos^{2}\theta + C_{4}\cos^{4}\theta \ldots
\]

**Current Status**

- High statistics measurement of \( pK^+\Lambda \) events with the COSY-TOF spectrometer
  - \( p_{\text{beam}} = 2.95 \text{ GeV/c} \)
  - Polarized proton beam \( P = \left( 87.5 \pm 2.0 \right)\% \)
  - 132000 reconstructed \( pK^+\Lambda \) events
- Reconstruction of \( pp \rightarrow pK^+\Lambda \rightarrow pK^+\pi^0 \) events with the straw-tube-tracker provides
  - Precise reconstruction of secondary vertex
  - Reduced background
  - High resolution
- Current COSY-TOF results show
  - 28% reconstruction efficiency
  - 139 \( \mu \)m spatial resolution
  - Invariant mass resolution 1.4 MeV/c²
  - Delayed vertex identification above 2.5 cm from primary vertex

Contact: s.jowzaee@fz-juelich.de

(1) Jagiellonian University, Poland
(2) Forschungszentrum Jülich, Germany