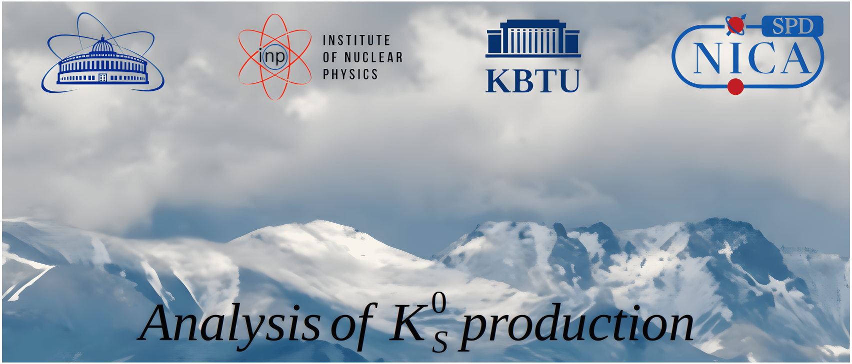


Analysis of K_S^0 production

Natalia Rogacheva

LHEP, JINR, Dubna

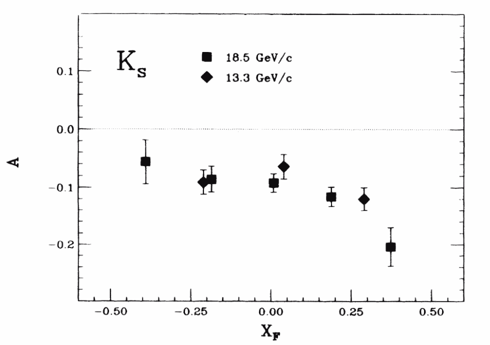
SPD collaboration meeting
20-24 May 2024

Motivation of study

The ultimate goal is to measure the transverse single-spin asymmetries (SSA) A_N for K_S^0 which are related to

- transversity PDF
- Sivers PDF
- Collins fragmentation function

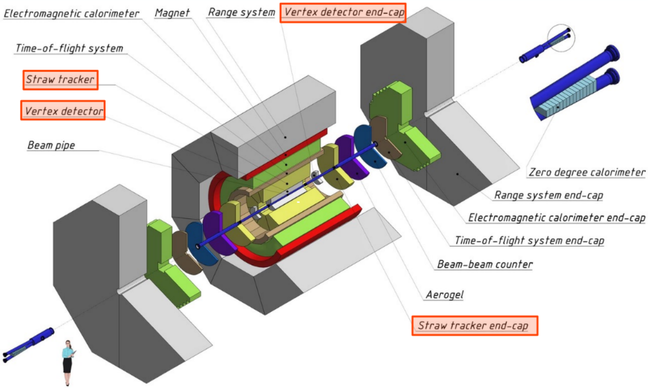
Measurement of A_N for K_S^0 could help us to study the orbital motion of strange quark inside proton.



BNL-AGS-E817
Phys.Rev.D41(1990)13-16.

Spin Physics Detector and event sample for the K_S^0 analysis

Secondary vertex (V^0) are reconstructed in the detectors: Vertex detector and Straw tracker.



Event sample

Generation: Pythia 8, (p+p) at $\sqrt{S}$=27 GeV, SoftQCD(MB).
4 000 000 events (1 sec of data taking).

Selection criteria

PV and V0 selection:

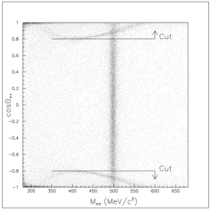
1. The primary vertex coordinates has a gaussian smearing with $\sigma_z = 30$ cm, $\sigma_x = \sigma_y = 0.1$ cm,
2. Daughters = K^0(-211, 211),Λ(2212,-211),$\bar{\Lambda}$(-2212, 211); Bg = (321,-321), (-321,211), (321,-211).
3. For track selection: minimum Its hits = 0;
   total minimum hits = 3.
4. The track candidates were required to be well-fitted and to have a track fit χ^2 over the number of degrees of freedom less than 6 ($\chi^2/NDF < 6$).
5. Minimum χ^2_{V0} track to PV is less than 2.
6. Track extrapolation χ^2 is more than 10.
7. Track fit is converged.

Kinematical cuts:

1. $\theta_{coll} < 0.03$ rad for K^0. This cut selects V^0 events the momentum looking at the PV.
2. $Dist = \sqrt{(x_{SV} - x_{PV})^2 + (y_{SV} - y_{PV})^2 + (z_{SV} - z_{PV})^2}$. This cut selects V^0 which decay close to PV. $Dist > 0.7$ cm for K^0_S.

New cuts is helicity angle for selestions K_S^0

Thanks to Mihai Dima.

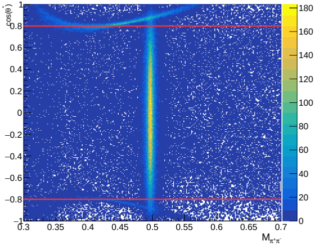


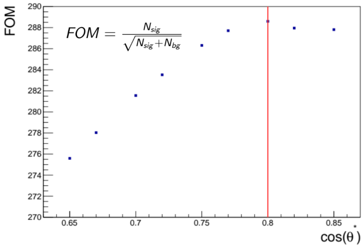
Strange Particle Production in Hadronic Z^0 Decays

by Kenneth George Baird III

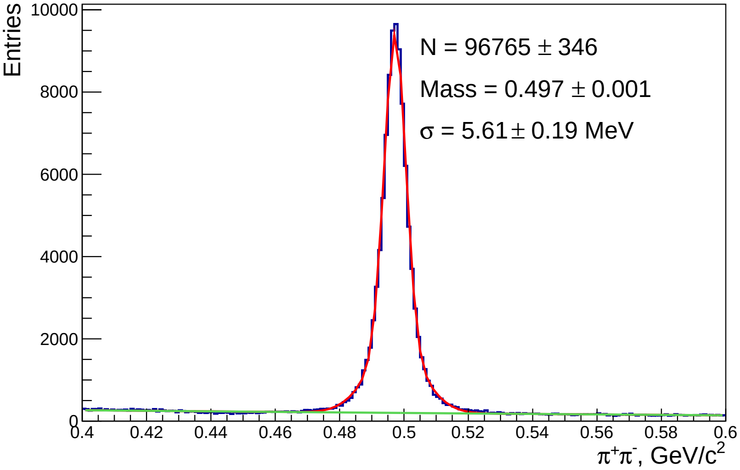
For the K_s^0 analysis, the $\Lambda^0/\bar{\Lambda}^0$ background causes an asymmetric "bump" in the $\pi\pi$-invariant mass distribution, as seen in Figure 6.2, which complicated the fitting procedure. A cut on the "helicity angle" θ^*, defined as the angle between the π^+ momentum vector in the K_s^0 rest frame and the K_s^0 flight direction, was used to remove the Λ^0 and $\bar{\Lambda}^0$ contamination (Fig. 6.3). K_s^0 candidates were required to have $|cos\theta^*| \leq 0.8$, which removed 20% of the K_s^0 signal. This cut also removes the γ-conversion background.

Helicity angle ($|cos\theta^*| \leqslant 0.8$) for K_S^0 at SPD.





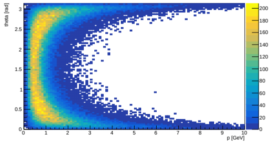
Invariant mass of K_S^0 after all cuts

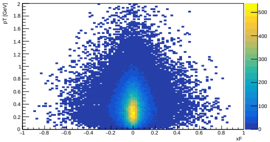


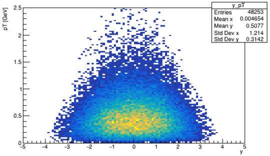
The shape of the K_S^0 signal was parametrized by double Gaussian and background was parametrized by the second order polynomial.

The selected V^0 candidates are plated in (p,θ), (x_F, p_T) and (η, p_T) phase space

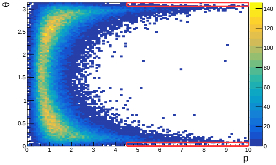
Pure Pythia 8 (true), K^0_S:

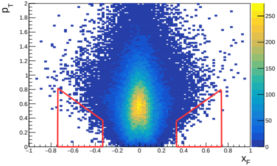


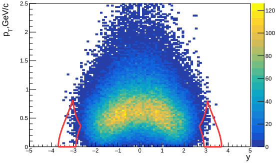




Reconstruction data (RD):







θ - polar angle
p - total momentum

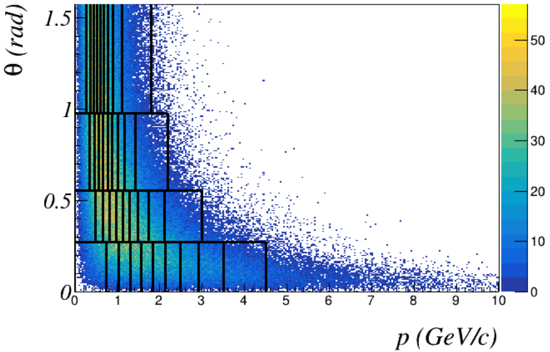
p_T - transverse momentum
x_F - Feynman variable

$$x_F = \frac{2p_T}{\sqrt{S}}$$

p_T - transverse momentum
y - rapidity

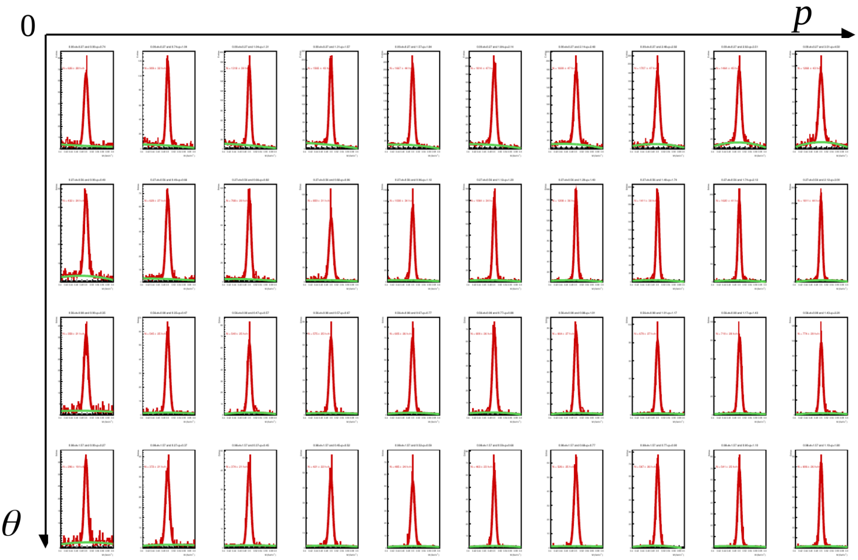
$$y = \frac{1}{2}\ln\frac{\sqrt{p^2+m^2}+p\cos\theta}{\sqrt{p^2+m^2}-p\cos\theta}$$

Binning



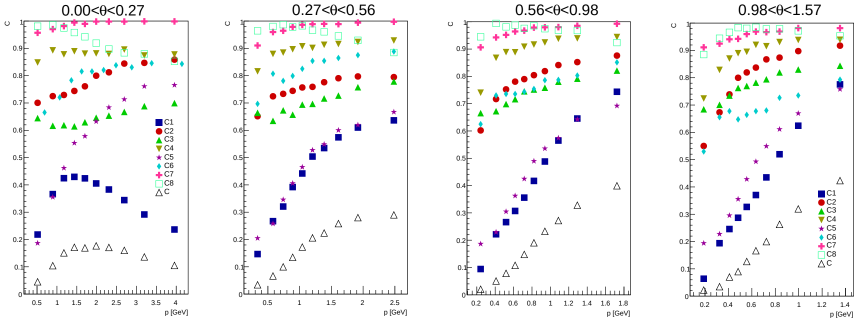
The choice of the binning scheme is obtained from distribution of K^0 simulated in Pythia 8. It was done to have the similar number of K_S^0 in bins ($n_{bin}^{\theta} = 4, n_{bin}^{p} = 10$).

Distributions of the K_S^0 candidates with all cuts



Factorization of the MC correction (1st step)

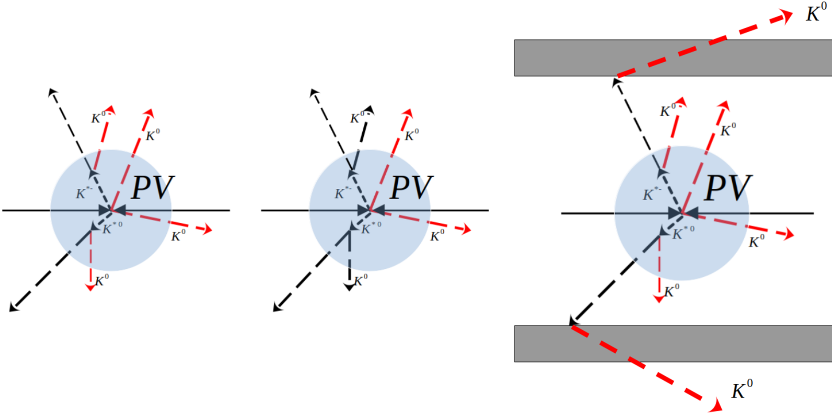
$$C = \frac{N(RD)}{N(K^0_{true}(all))} = C1 * C2 * C3 * C4 * C5 * C6 * C7 * C8$$



$C1 = \frac{N(3hits)}{N(K^0_{true}(all))}$ $C2 = \frac{N(\chi^2/NDF_{tr1,2}<6)}{N(3hits)}$ $C3 = \frac{N(\chi^2_{V0}<2.0)}{N(\chi^2/NDF_{tr1,2}<6)}$ $C4 = \frac{N(\chi^2_{tr1,2}toPV>10)}{N(\chi^2_{V0}<2.0)}$

$C5 = \frac{N(convergency==1)}{N(\chi^2_{tr1,2}toPV>10)}$ $C6 = \frac{N(\theta_{coll}<0.03)}{N(convergency==1)}$ $C7 = \frac{N(Dist>0.7)}{N(\theta_{coll}<0.03)}$ $C8 = \frac{N(|cos\theta^*|\leqslant 0.7)}{N(Dist>0.7)}$

Feed down correction in PV and outside PV (2nd step)



$N(K^0_{true} inPV)$ $N(K^0_{true,direct} inPV)$ $N(K^0_{true}(all))$

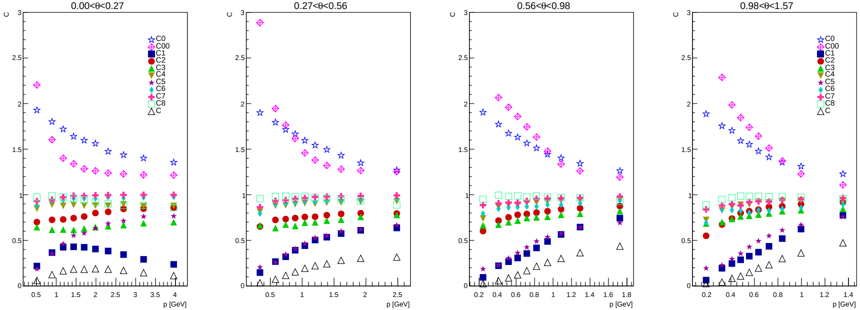
$$C0 = \frac{N(K^0_{true} inPV)}{N(K^0_{true,direct} inPV)} \qquad C00 = \frac{N(K^0_{true}(all))}{N(K^0_{true} inPV)}$$

Factorization of the MC correction

$$C = \frac{N(RD)}{N(K^0_{true,direct}\, inPV)} = C0 * C00 * C1 * C2 * C3 * C4 * C5 * C6 * C7 * C8$$

$C0 = \frac{N(K^0_{true}\, inPV)}{N(K^0_{true,direct}\, inPV)}$ – feed down in PV

$C00 = \frac{N(K^0_{true}(all))}{N(K^0_{true}\, inPV)}$ – feed down correction outside PV



$C1 = \frac{N(3hits)}{N(K^0_{true}(all))}$ ... $C8 = \frac{N(|cos\theta^*| \leqslant 0.7)}{N(Dist > 0.7)}$

Extraction of A_N for selestions K_S^0

Thanks to Katherin Shtejer.

$p^{\uparrow} + p \rightarrow \boldsymbol{\pi^0} + X \qquad \phi = 2\pi$

The cross section of hadron production in polarized $p^{\uparrow} + p$ collisions, is modified in azimuth.

$$\frac{d\sigma}{d\phi} = \frac{d\sigma}{d\phi_0}(1 + \underbrace{P \cdot A_{\mathrm{N}} \cdot \cos\phi}_{\text{Azimuthal cosine modulation}})$$

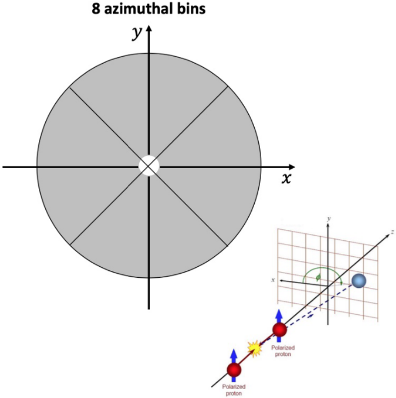
$$N_{\pi^0}(\phi) = A(1 + B\cos\phi)$$

$$A_N = \frac{B}{P}$$

$N_{\pi^0}(\phi)$: Yield of π^0

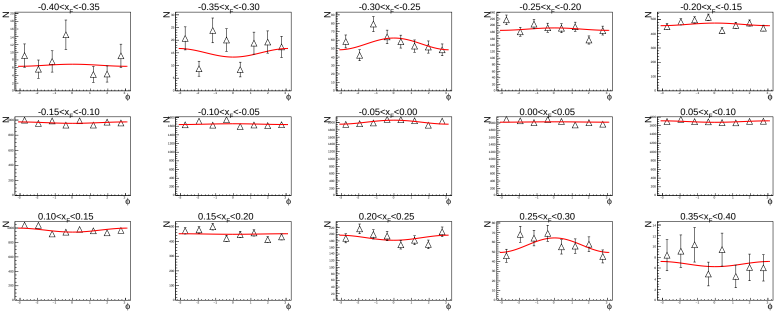
P: Beam polarization

- $P \sim 0.7$ was assumed

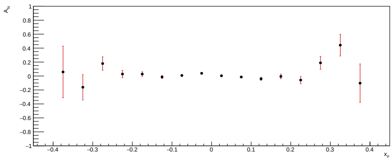


- The spin dependent K_S^0 yields for each bin are extracted from the invariant mass spectra in different x_F sub-ranges for each ϕ bin.
- The invariant mass was fitted with a second order polynomial function for the background and a normalized Gaussian distribution representing the signal peak.

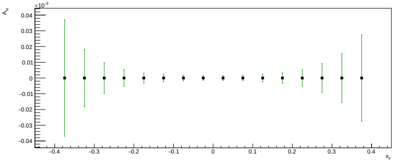
Extraction of A_N for selestions K_S^0



A_N in x_F intervals



Relative A_N error in x_F intervals for 1 year



Conclusion

1. Analysis of the K_S^0 reconstruction efficiency was performed.
2. MC correction was factorized (include feed down correction in PV and outside PV).
3. A_N for K_S^0 can be one of the first results of polarised measurements at SPD.

Thank you for your attention.