K^0_S reconstruction study at $\sqrt{S}$=10 GeV

Natalia Rogacheva

LHEP, JINR, Dubna

SPD meeting
23 July 2024

Event and track selection for the K_S^0 analysis

Event sample

Generation: Pythia 8, (p+p) at $\sqrt{S}$=10 GeV, SoftQCD(MB).
10 000 000 events

PV and V0 selection:

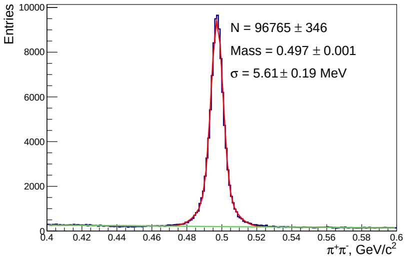
1. The primary vertex coordinates has a gaussian smearing with $\sigma_z = 30$ cm, $\sigma_x = \sigma_y = 0.1$ cm,
2. Daughters = K^0(-211, 211),Λ(2212,-211),$\bar{\Lambda}$(-2212, 211);
   Bg = (321,-321), (-321,211), (321,-211).
3. For track selection: minimum Its hits = 0;
   total minimum hits = 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:

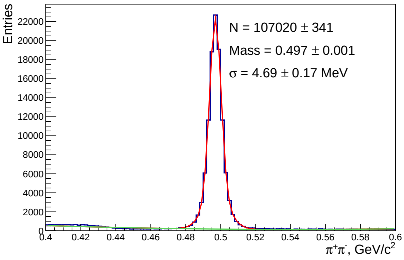
1. $\theta_{coll} < 0.03$ rad for K^0. This cut selects V^0 events the momentum looking at the PV.
2. $Dist = \sqrt{(x_{SV} - x_{PV})^2 + (y_{SV} - y_{PV})^2 + (z_{SV} - z_{PV})^2}$.
   This cut selects V^0 which decay close to PV. $Dist > 0.7$ cm for K_S^0.
3. Helicity angle ($|cos\theta^*| \leqslant 0.8$) for K_S^0. This cut to remove Λ and $\bar{\Lambda}$ hyperons.

Invariant mass of K_S^0 after all cuts

$\sqrt{S}$=27 GeV
$4{\cdot}10^6$ events



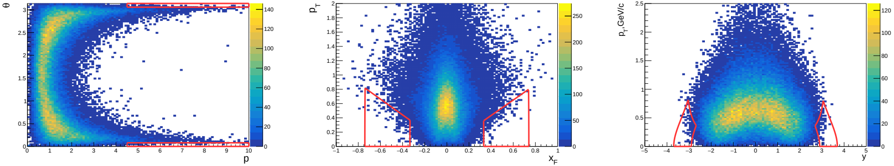
$\sqrt{S}$=10 GeV
$10{\cdot}10^6$ events



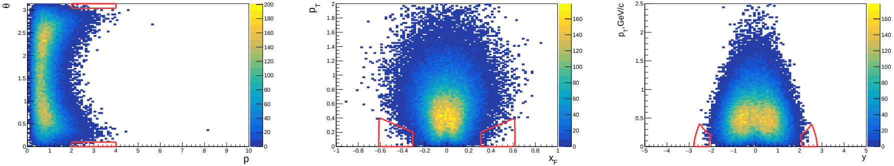
The shape of the K_S^0 signal was parametrized by double Gaussian and background was parametrized by the second order polynomial.

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

Reconstruction data at $\sqrt{S}$=27 GeV:



Reconstruction data at $\sqrt{S}$=10 GeV:



θ - polar angle
p - total momentum

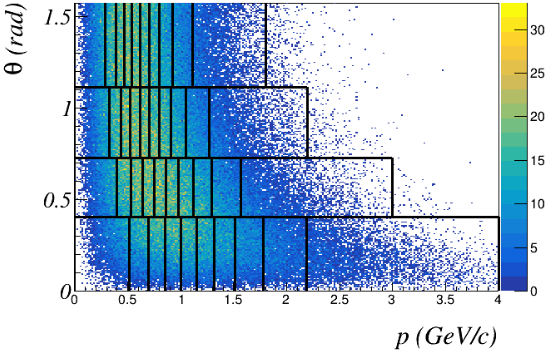
p_T - transverse momentum
x_F - Feynman variable

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

p_T - transverse momentum
y - rapidity

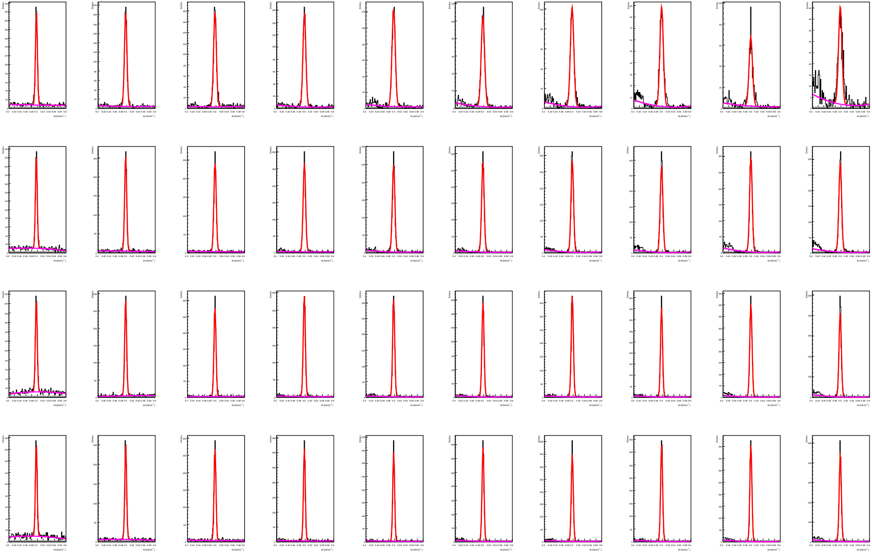
$$y = \frac{1}{2} \ln \frac{\sqrt{p^2+m^2}+p\cos\theta}{\sqrt{p^2+m^2}-p\cos\theta}$$

Binning



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

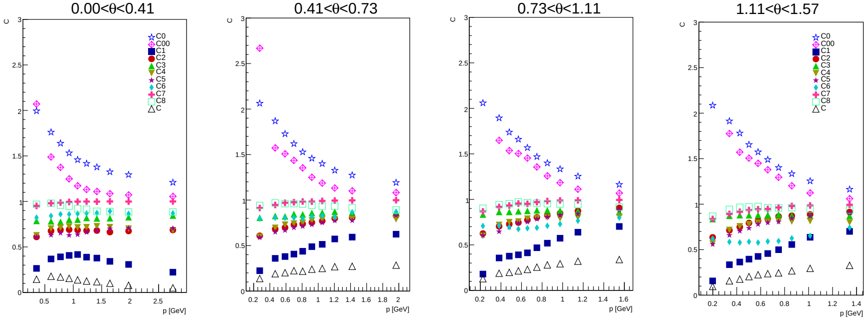
Distributions of the K_S^0 candidates with all cuts



Factorization of the MC correction at $\sqrt{S}$=10 GeV

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

$C0 = \frac{N(K^0_{true}\, inPV)}{N(K^0_{true,direct}\, inPV)}$ – feed down in PV $\quad$ $C00 = \frac{N(K^0_{true}(all))}{N(K^0_{true}\, inPV)}$ – feed down correction outside PV

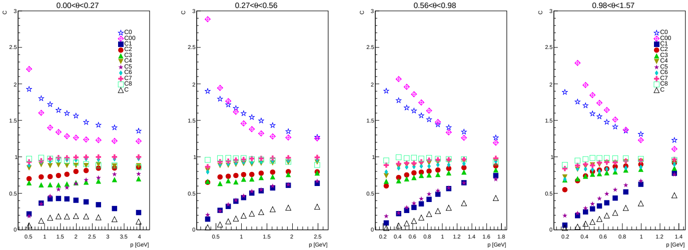


$C1 = \frac{N(3hits)}{N(K^0_{true}(all))}$ $\quad$ $C2 = \frac{N(\chi^2/NDF_{tr1,2} < 6)}{N(3hits)}$ $\quad$ $C3 = \frac{N(\chi^2_{V0} < 2.0)}{N(\chi^2/NDF_{tr1,2} < 6)}$ $\quad$ $C4 = \frac{N(\chi^2_{tr1,2}\, toPV > 10)}{N(\chi^2_{V0} < 2.0)}$

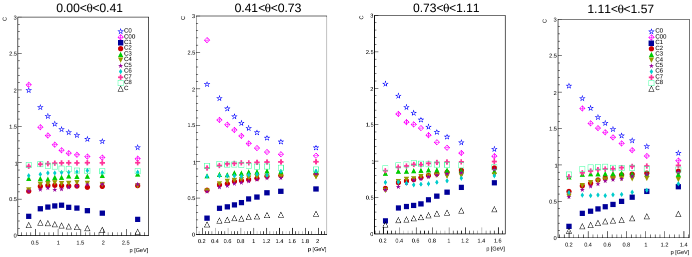
$C5 = \frac{N(convergency == 1)}{N(\chi^2_{tr1,2}\, toPV > 10)}$ $\quad$ $C6 = \frac{N(\theta_{coll} < 0.03)}{N(convergency == 1)}$ $\quad$ $C7 = \frac{N(Dist > 0.7)}{N(\theta_{coll} < 0.03)}$ $\quad$ $C8 = \frac{N(|cos\theta^*| \leqslant 0.7)}{N(Dist > 0.7)}$

Factorization of the MC correction

$\sqrt{S}$=27 GeV



$\sqrt{S}$=10 GeV



Extraction of A_N for selections K_S^0

$$p^{\uparrow} + p \rightarrow K_S^0 + X$$

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

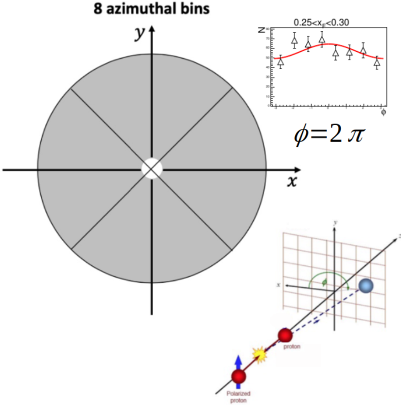
$$\frac{d\sigma}{d\phi} = \frac{d\sigma}{d\phi}\left(1 + \underbrace{P \cdot A_N \cos\phi}\right)$$

Azimuthal cosine modulation

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

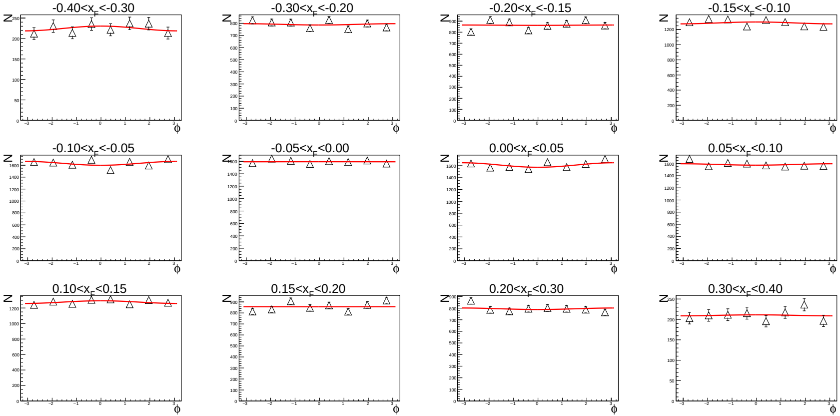
$$A_N = \frac{B}{P}$$

$N_{K_S^0}(\phi)$: Yield of K_S^0
P: Beam polarization,
$P \sim 0.7$ was assumed



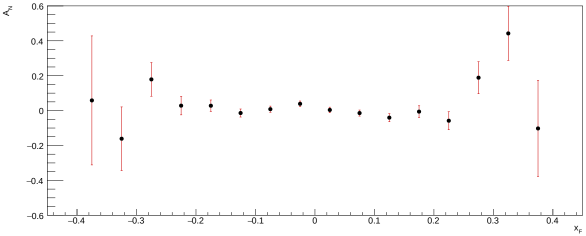
- The spin dependent K_S^0 yields for each bin are extracted from the invariant mass spectra in different x_F sub-ranges for each ϕ bin.
- The invariant mass was fitted with a second order polynomial function for the background and a normalized Gaussian distribution representing the signal peak.

Azimuthal cosine modulation of K_S^0 yields in x_F intervals at 10 GeV

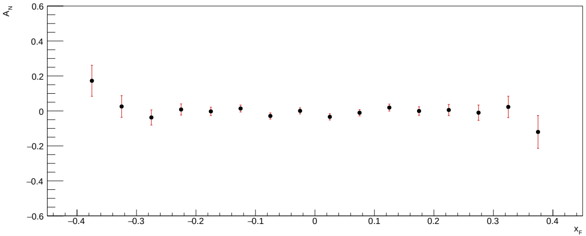


Extraction of A_N for selections K_S^0 at 27 GeV and 10 GeV

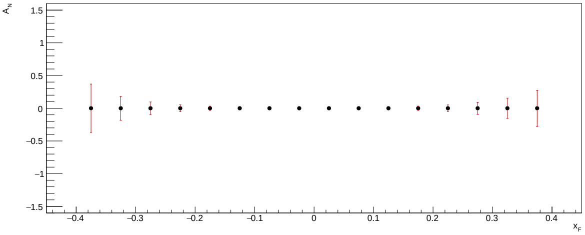
27 GeV, $4 * 10^6$ events



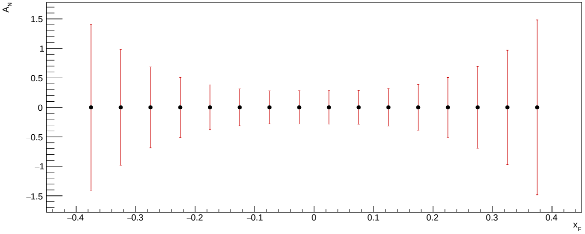
10 GeV, $10 * 10^6$ events



Relative A_N error in x_F intervals at 27 GeV and 10 GeV for 1 sec



27 GeV

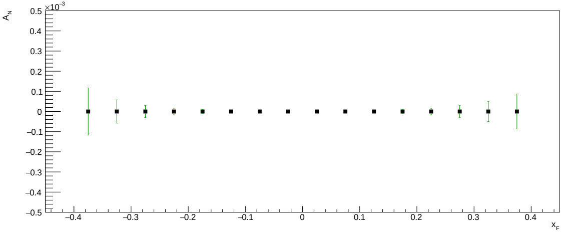


10 GeV

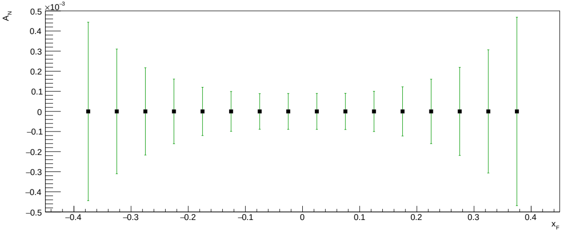
Relative A_N error in x_F intervals for 1 year (10^7 sec)

$4 * 10^6$	1 sec	27 GeV	10^{32}	39.52
$10 * 10^6$	2.5 sec	10 GeV	10^{30}	38.32

$$k(1year) = \frac{1}{\sqrt{10^7 sec/(2.5sec*10^{32}/10^{30})}}$$



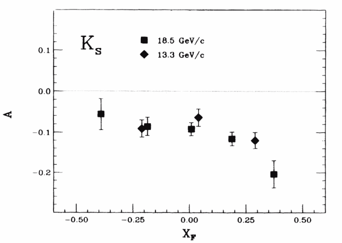
27 GeV



10 GeV

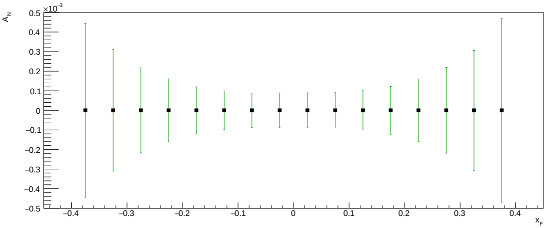
E817 and SPD

$102^* \ 10^3$ of K^0_S for 2 years



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

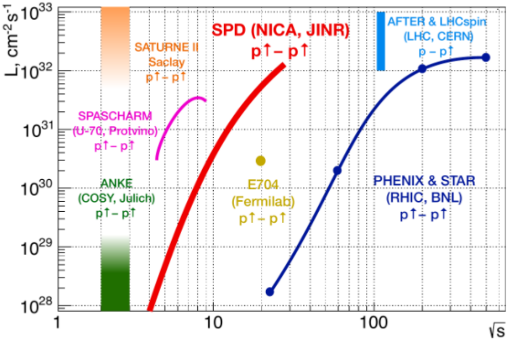
$42^* \ 10^{10}$ for 1 years



Conclusion

1. Analysis of the K_S^0 reconstruction efficiency at $\sqrt{S}$=10 GeV was performed.
2. MC correction was factorized (include feed down correction in PV and outside PV).
3. Relative A_N error in x_F intervals for 1 second and 1 year was obtained.
4. The next step optimisation of kinematical cuts for $\sqrt{S}$=10 GeV will be investigated.

Thank you for your attention.



$p^{\uparrow}p^{\uparrow}$ collision mode