K^0_S reconstruction study in SPD

Natalia Rogacheva

LHEP, JINR, Dubna

XXX Anniversary International Seminar
Nonlinear Phenomena in Complex Systems

19-23 June 2023

Nuclotron-based Ion Collider fAcility (NICA)

Polarized beams

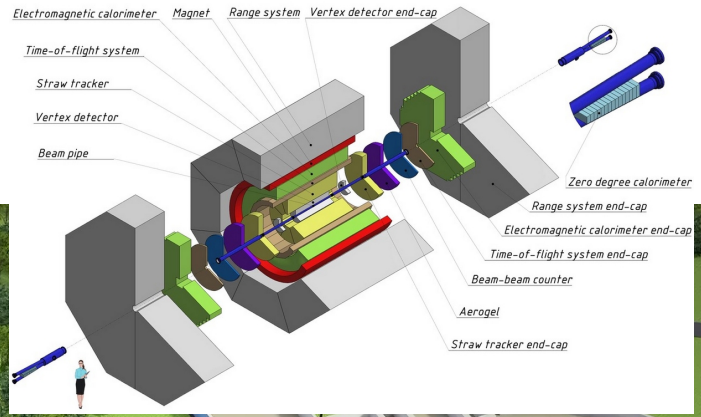
$p\uparrow p\uparrow$ at $\sqrt{s_{pp}} \leq 27$ GeV, $L_{av} \approx 10^{32}$ cm^{-2}s^{-1}

$d\uparrow d\uparrow$ at $\sqrt{s_{NN}} \leq 13.5$ GeV

$p\uparrow d\uparrow$ at $\sqrt{s_{NN}} \leq 19$ GeV

Operation: after **2028**

Spin Physics Detector (SPD)

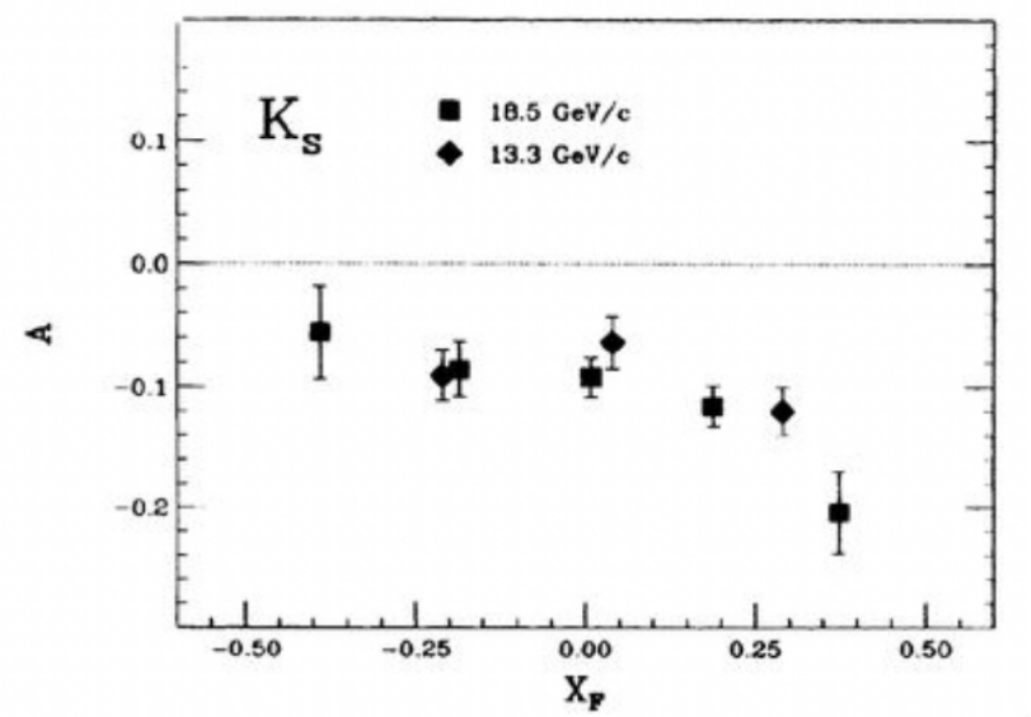


Motivation of study

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

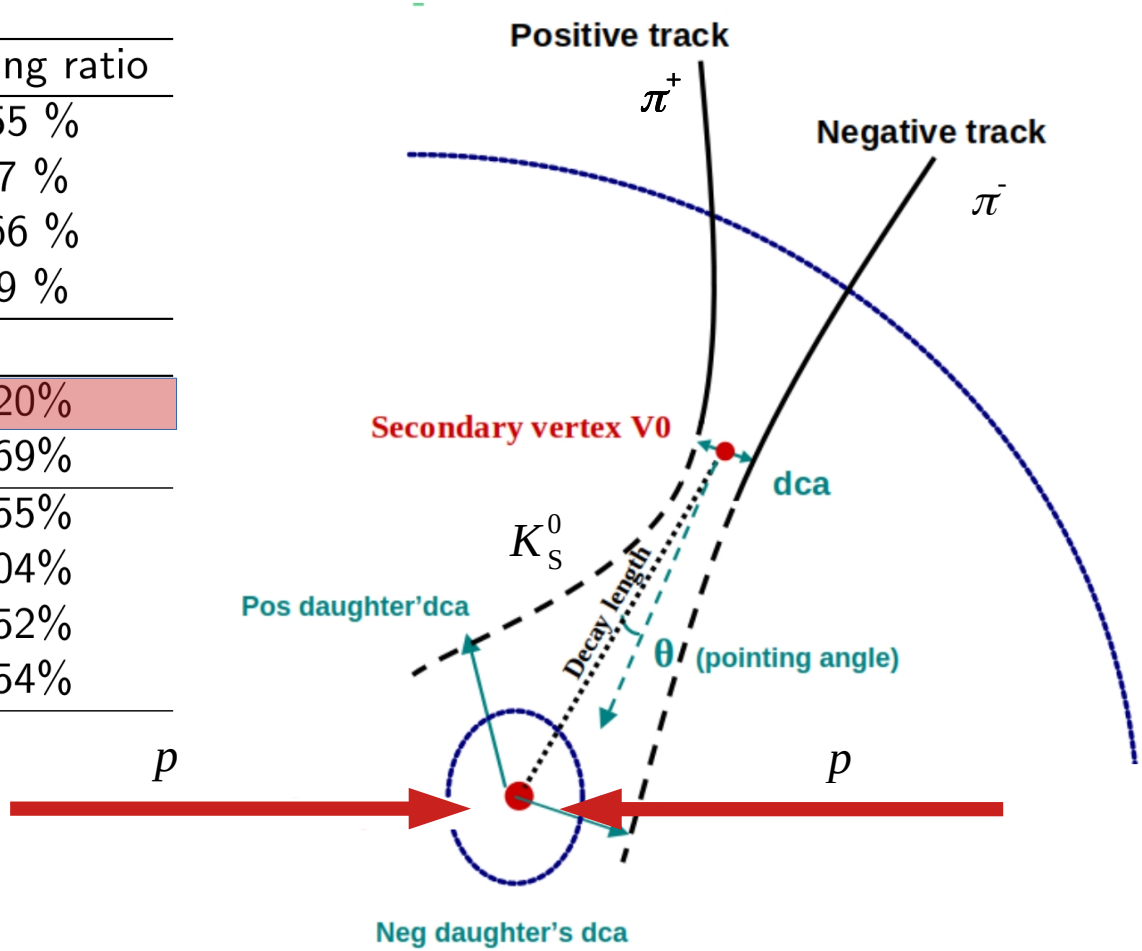
Measurement of A_N for K_S^0 could help us to study the orbital motion of strange quark inside proton.



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

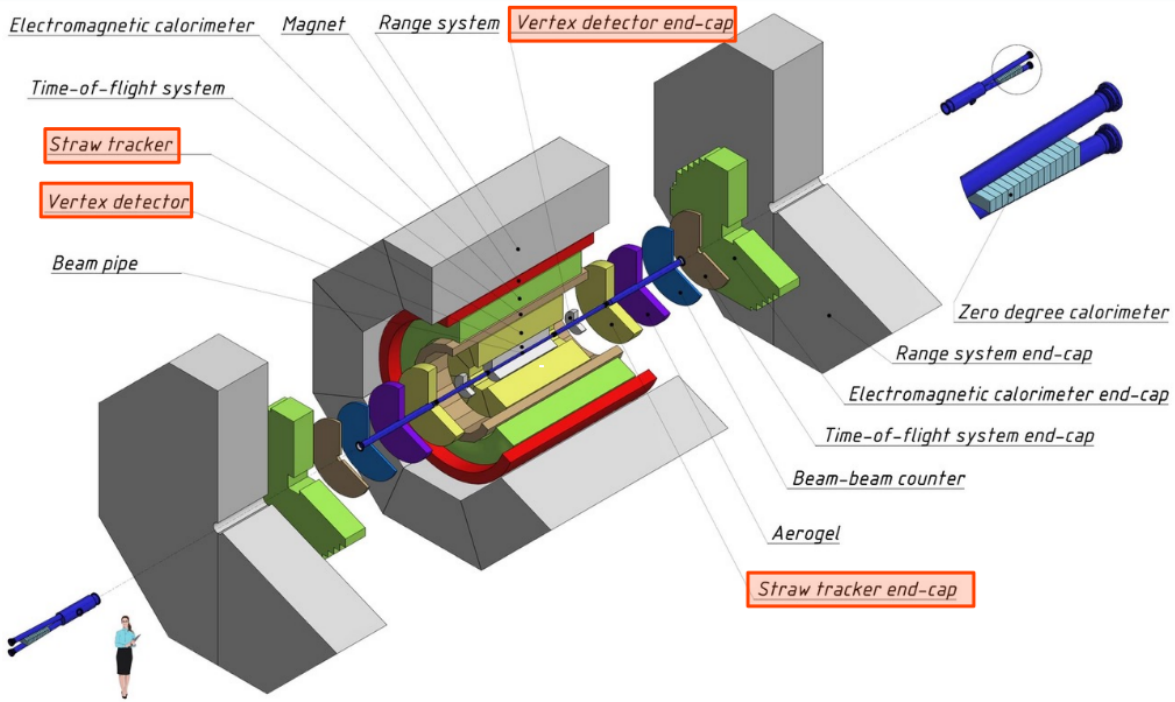
K meson

	Decay products	Branching ratio
K^+	$\mu^+ \nu_\mu$	63.55 %
	$\pi^0 e^+ \nu_e$	5.07 %
	$\pi^+\pi^0$	20.66 %
	$\pi^+\pi^+\pi^-$	5.59 %
K^0	50% K^0_S, 50% K^0_L	
K^0_S	$\pi^+\pi^-$	69.20%
	$\pi^0\pi^0$	30.69%
K^0_L	$\pi^\pm e^\mp \nu_e$	40.55%
	$\pi^\pm \mu^\mp \nu_\mu$	27.04%
	$3\pi^0$	19.52%
	$\pi^+\pi^-\pi^0$	12.54%



Spin Physics Detector and event sample for the K^0_S analysis

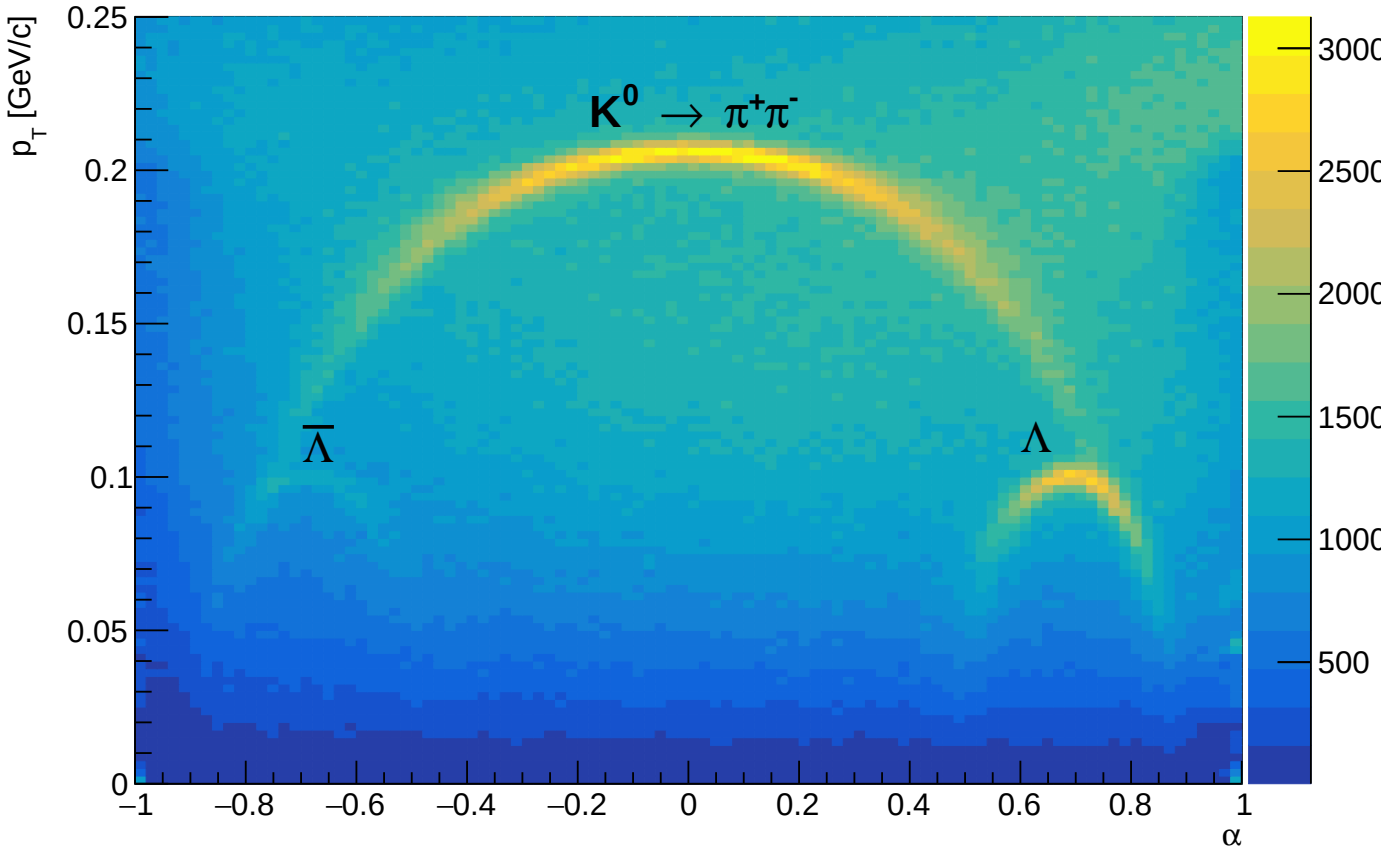
Secondary vertex (V^0) are reconstructed in the detectors: Vertex detector and Straw tracker.

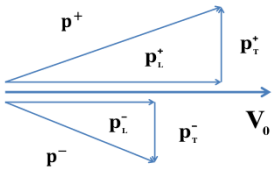


Event sample

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

Distributions of the V^0 candidates in the Podolanski-Armenteros



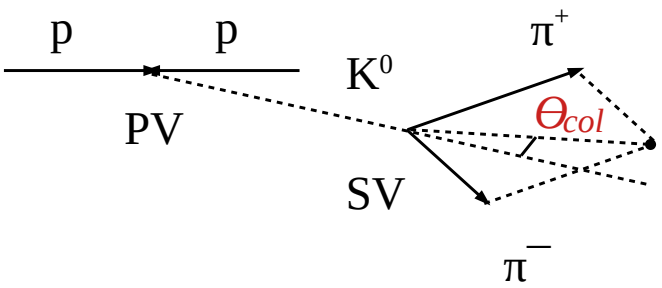


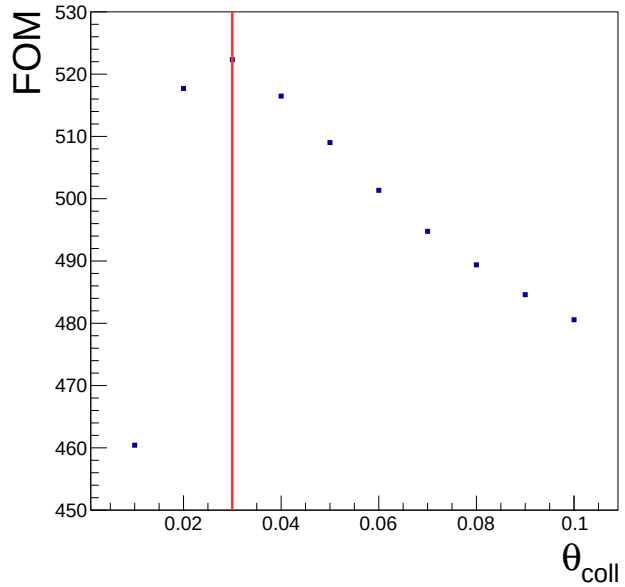
$$\alpha = \frac{p_L^+ - p_L^-}{p_L^+ + p_L^-}$$

p_L^+ and p_L^- are the longitudinal momenta of the positive and negative decay particle respectively

Selection criteria

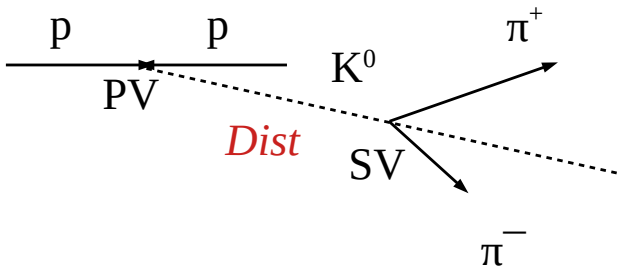
1. The cuts on the quality of the tracks

2. 

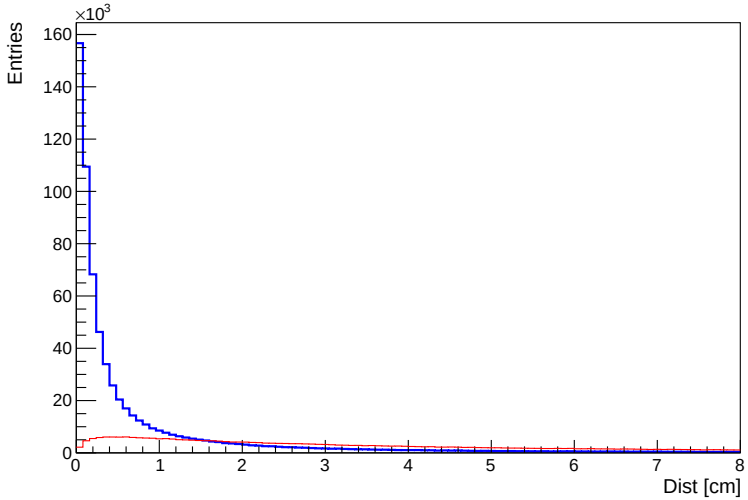


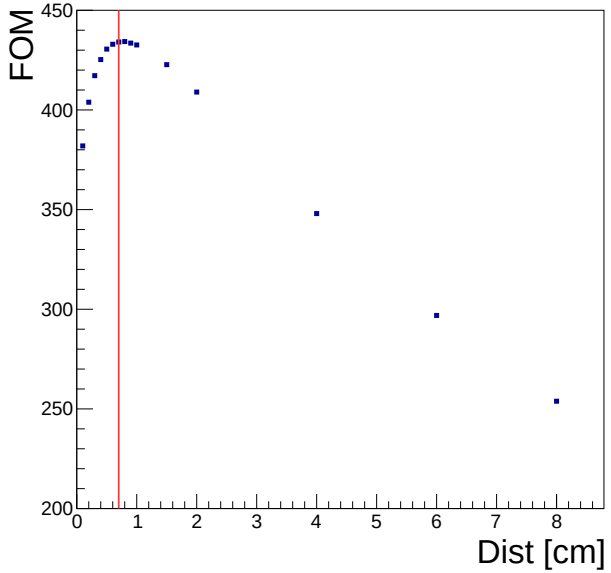
- $FOM = \frac{N_{sig}}{\sqrt{N_{sig}+N_{bg}}}$;
- This cut selects V^0 events the momentum looking at the PV. $\theta_{coll} < 0.03$ rad. for K^0_S.

Distance between PV and SV (V0 vertex)

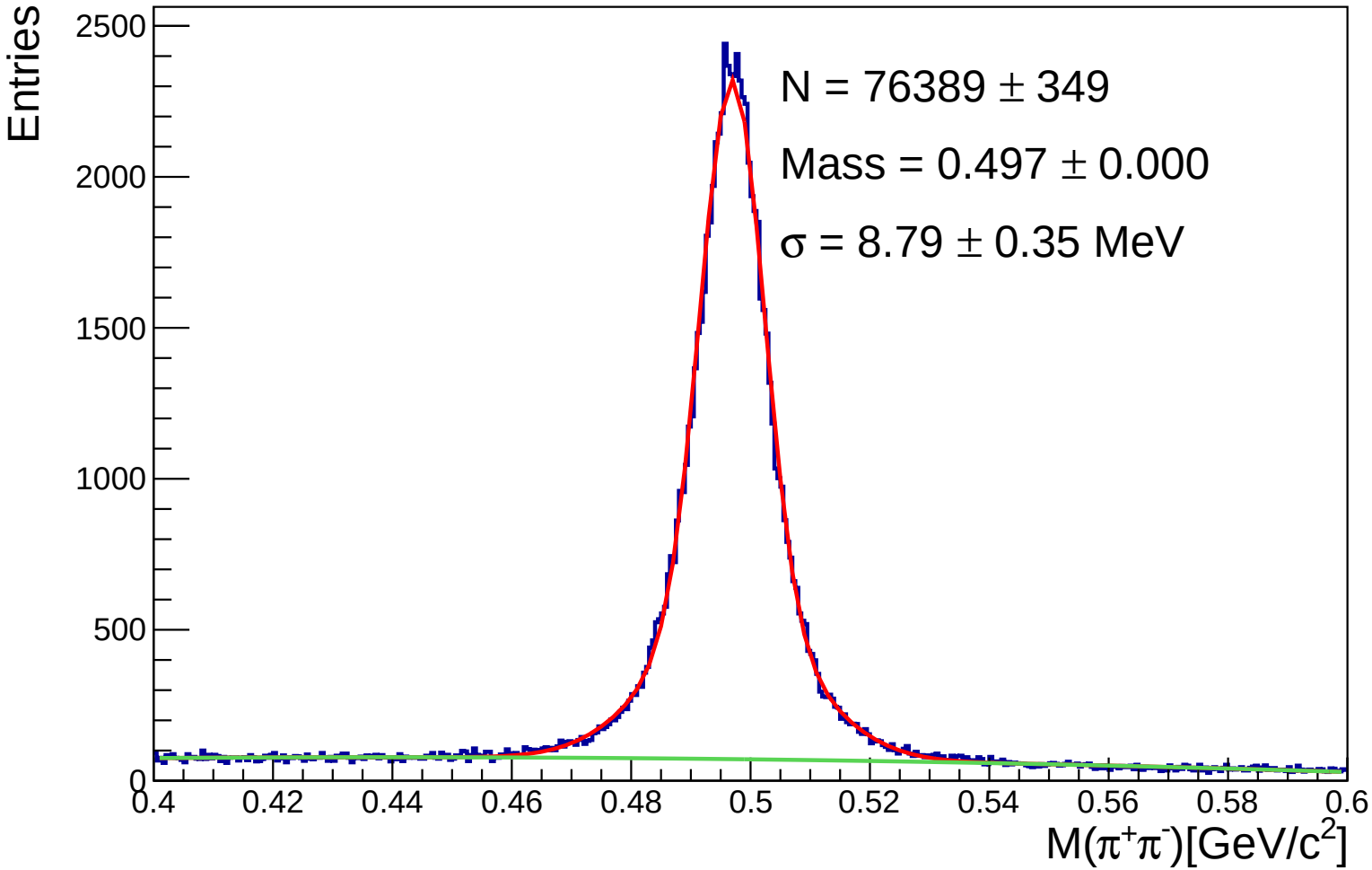


- $Dist = \sqrt{(x_{SV} - x_{PV})^2 + (y_{SV} - y_{PV})^2 + (z_{SV} - z_{PV})^2}$;
- This cut selects V^0 which decay close to PV.
  $Dist > 0.7$ cm for K^0_S.





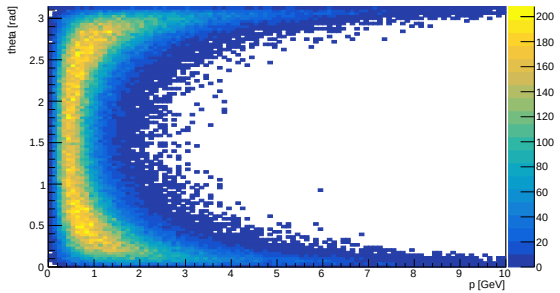
Invariant mass of K_S^0 after all cuts

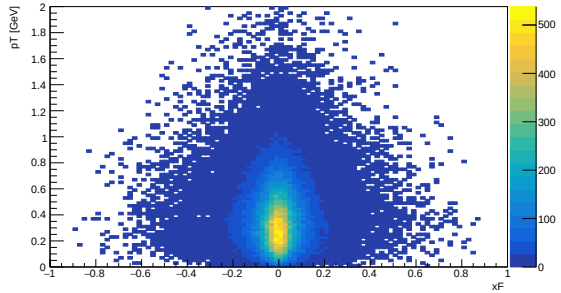


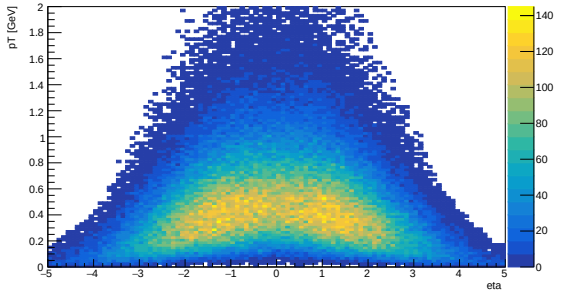
The shape of the K_S^0 signal was parametrized by double Gaussian and background was parametrized by the second order polynomial.

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

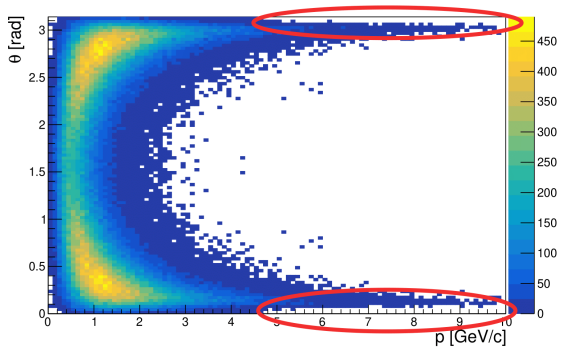
Pure Pythia 8, K^0_S:



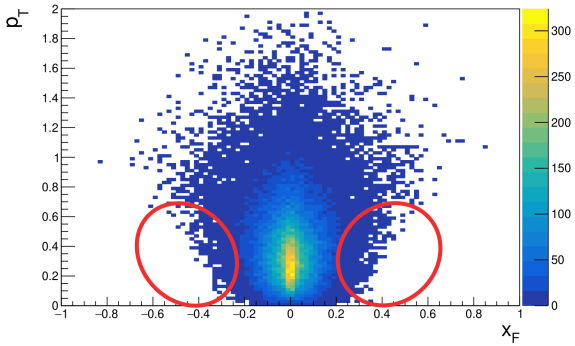




Reconstruction data:

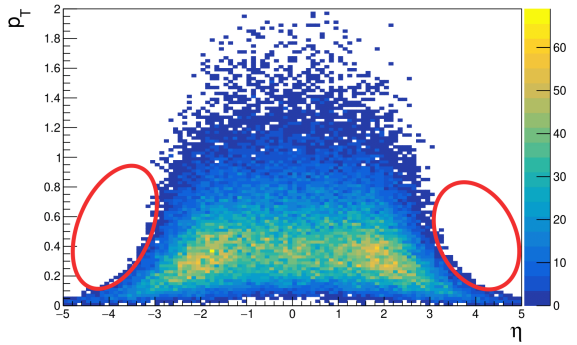


θ - polar angle
p - total momentum



p_T - transverse momentum
x_F - Feynman variable

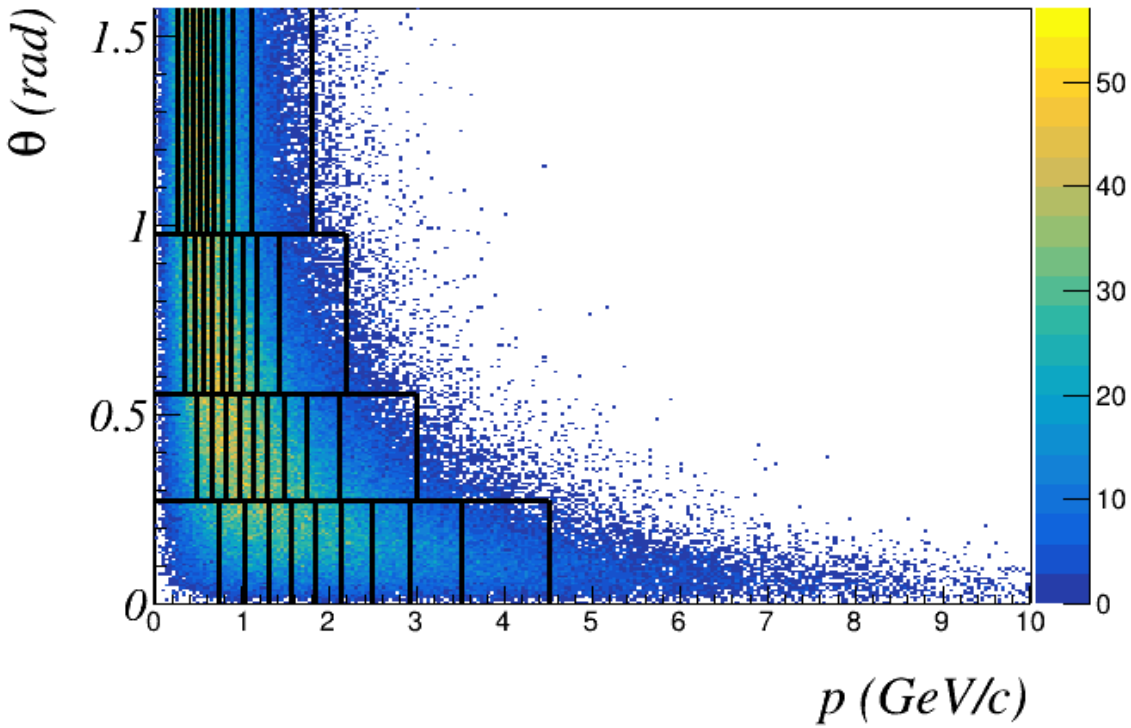
$$x_F = \frac{2p_T}{\sqrt{S}}$$



p_T - transverse momentum
η - pseudorapidity

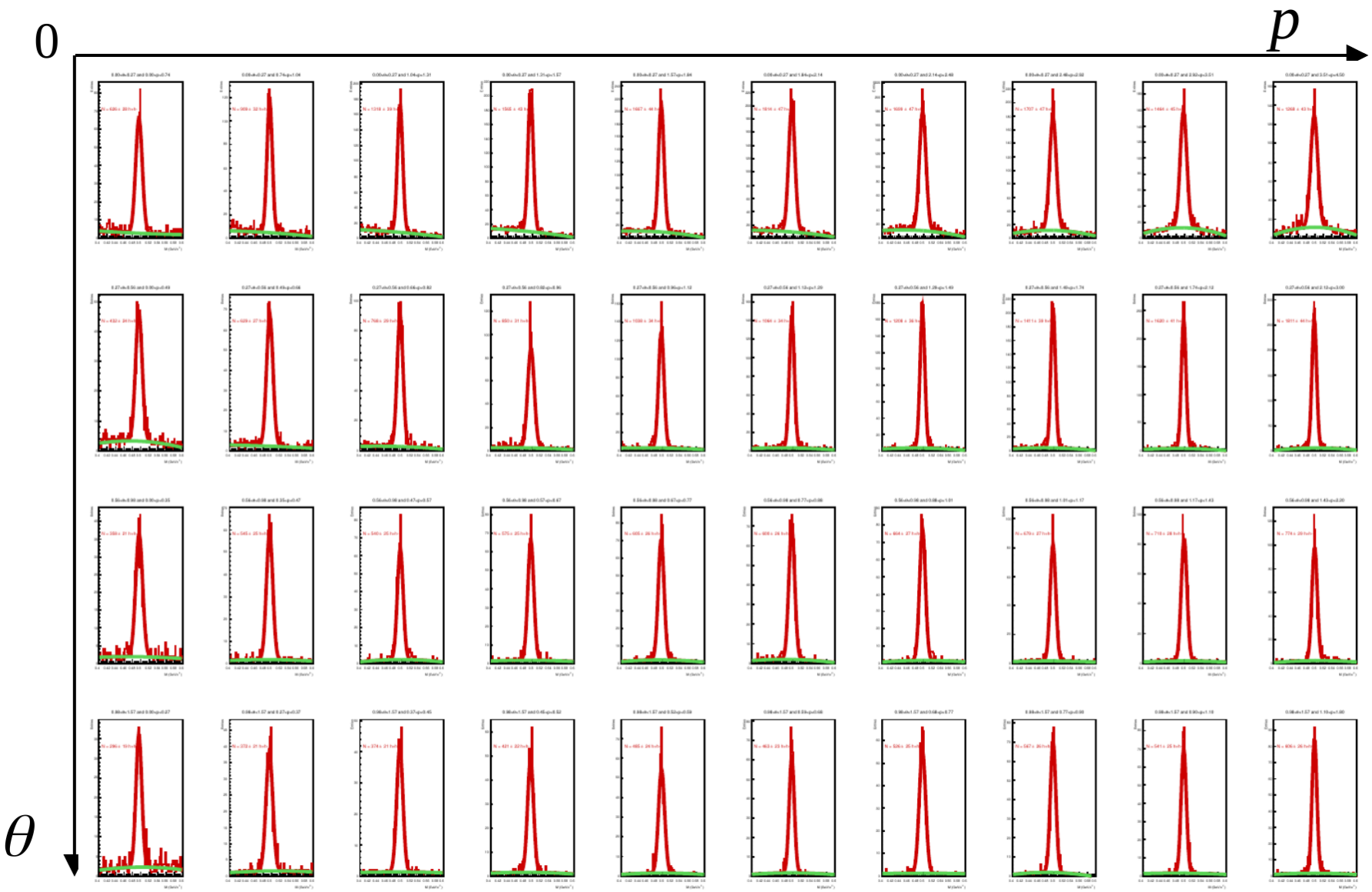
$$\eta = -\ln\left[\tan\left(\frac{\theta}{2}\right)\right]$$

Binning

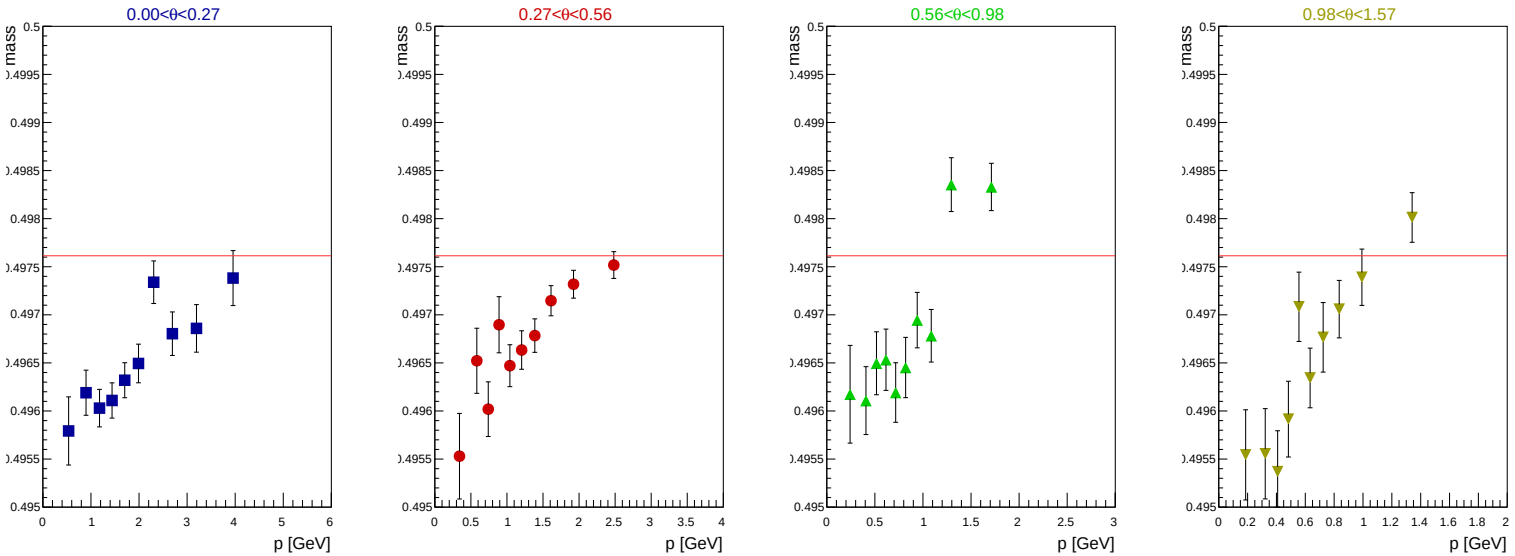


The choice of the binning scheme is obtained from distribution of K_S^0 simulated in Pythia 8. It was done to have the similar number of K_S^0 in bins ($n_{bin}^{\theta} = 4, n_{bin}^{p} = 10$).

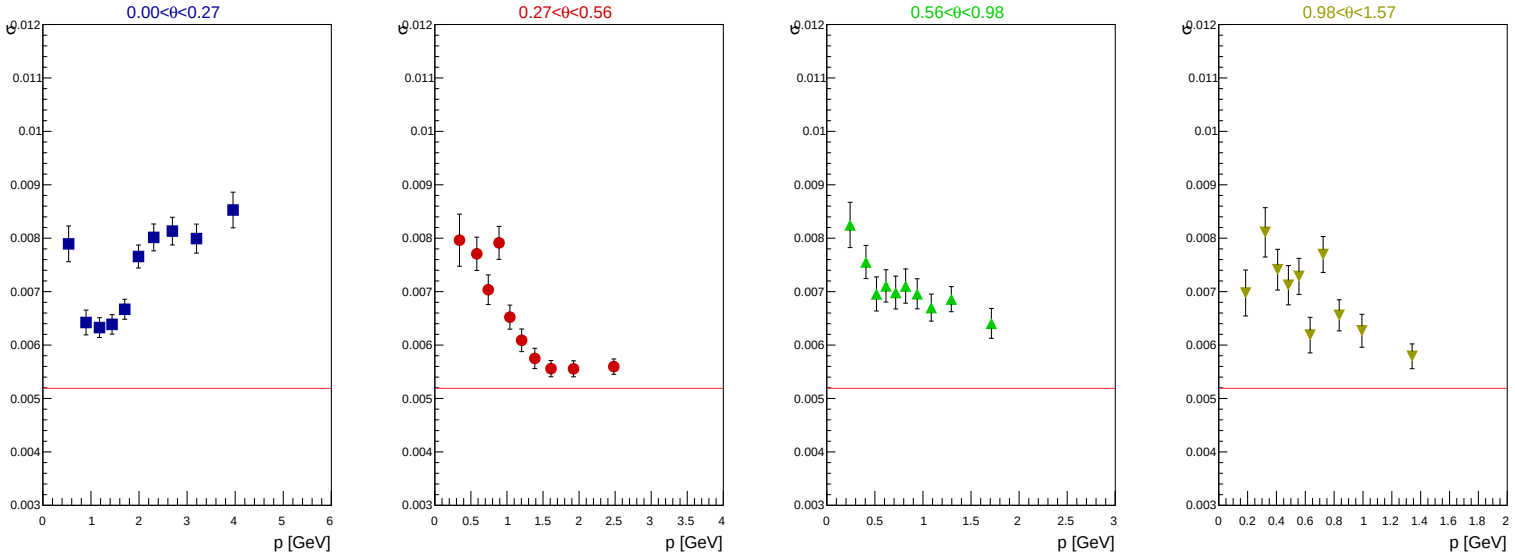
Distributions of the K^0_S candidates with all cuts



Mass and sigma of K^0_S (in p for fixed θ interval)

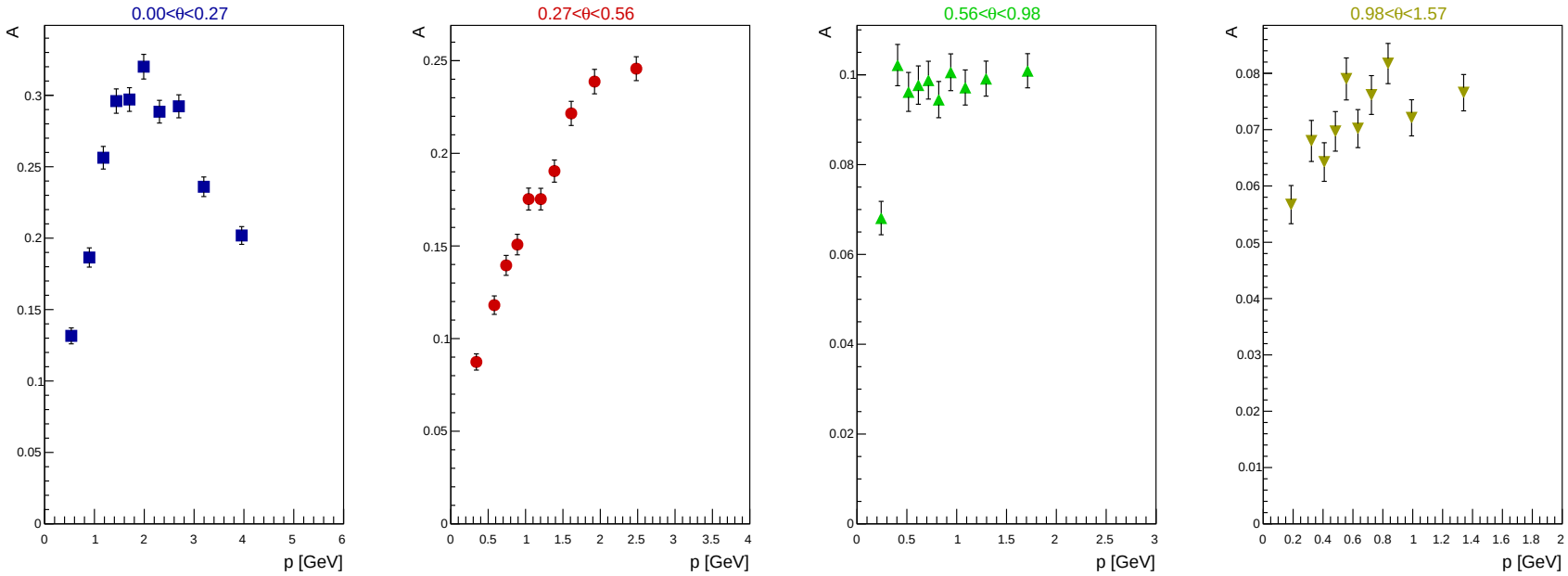


red line shows m(PDG) = 0.497 GeV



red line shows the sigma of the K^0_S fit using full data sample

K^0_S reconstruction efficiency with all corrections included (A=$N^{MC}_{Rec}/N^{MC}_{pythia}$)



Total correction factor includes: geometrical acceptance, track and vertex reconstructed efficiency and feed down contribution.

Conclusion

- Analysis the K_S^0 reconstruction efficiency was performed. This procedure will be further applied for analysis $\Lambda(\bar{\Lambda})$.
- K_S^0 reconstruction efficiency depends on p and θ and in general is about 20%.
- Once the data are collected in a real experiment, they will be used to test and tune the existing MC generators (K_S^0/Λ, $\Lambda/\bar{\Lambda}$ etc).