

Λ_c^+ observation possibility at SPD NICA experiment

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An open charm production in proton-proton collisions at medium and low energy provides:

- The opportunity to study in detail heavy quark hadronization processes;
- The better understanding of the proton structure.

Events simulation

Signal

- ~ 12000 events have been generated within the Pythia8 framework using the hard subprocesses $gg \rightarrow c\bar{c}$ and $q\bar{q} \rightarrow c\bar{c}$
- The events with Λ_c^+ has been selected
- All Λ_c^+ baryons have been enforced to decay to $p^+K^-\pi^+$ combination
- $\Lambda_c^+ \rightarrow (\Delta^{++} \rightarrow p^+\pi^+)K^-$ has been temporary used instead of complete decay model due to the technical reasons

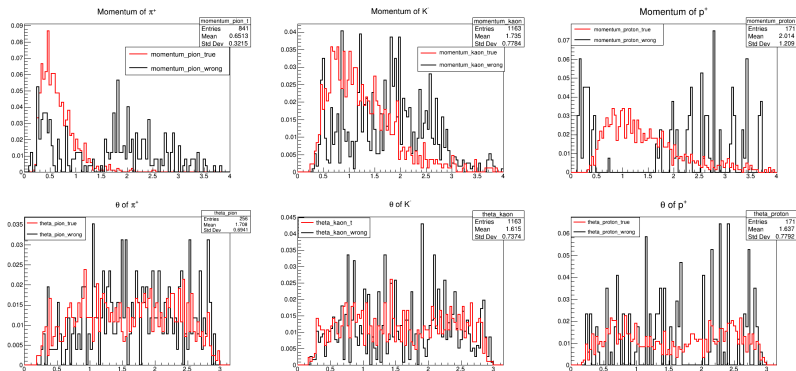
Background

~ 25000 softQCD(MB) events have been simulated within Pythia8 as a background.

Detector simulation

SPDROOT

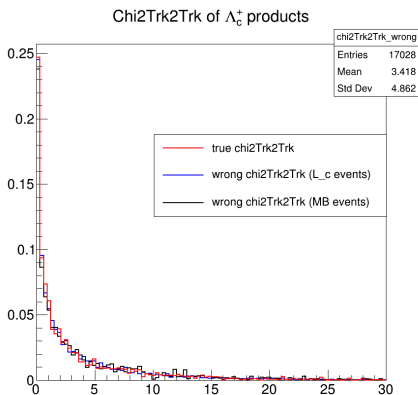
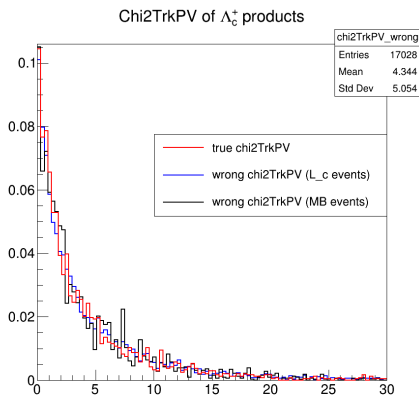
Kinematical distributions: correct v.s. mistake TOF system output in Λ_c^+ events



Cuts suggested to reduce combinatorial background due to wrong PID (TOF):

- $0.1 < P_{pion} < 1.5$ GeV;
- $P_{kaon} < 2$ GeV;
- $0.3 < P_{proton} < 2$ GeV;

(more statistics are needed for a more accurate analysis)



χ^2 of SV p^+ , K^- , π^+ tracks deviation from PV as well as χ^2 deviation between tracks of SV candidate does not give an effective cut on TOF mistake

Secondary vertex selection

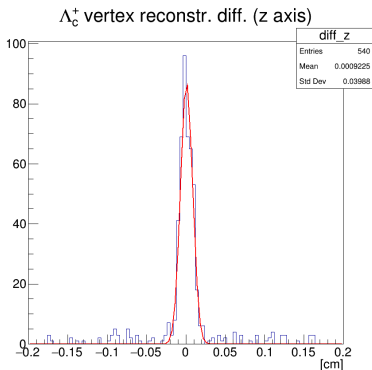
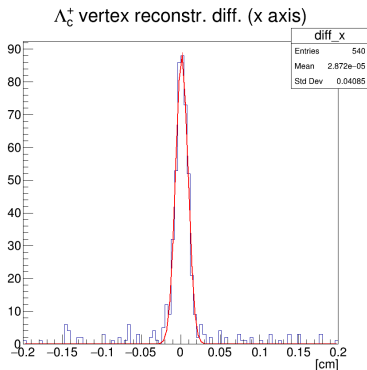
Tracks selection:

- GetNHitsIts > 3;
- GetIsFitted -> ok;
- GetIsGood -> ok;
- track identification implements by TOF system (divide all particles into pions, kaons and protons);
- pion, kaon and proton are at the same combination;
- $\chi_{tr2tr}^2 < 10$;
- $\chi_{PV}^2 > 1$ (temporarily).

Also the minimum Λ_c^+ candidate decay length cut has been added:

- $L > 0.008$ cm.

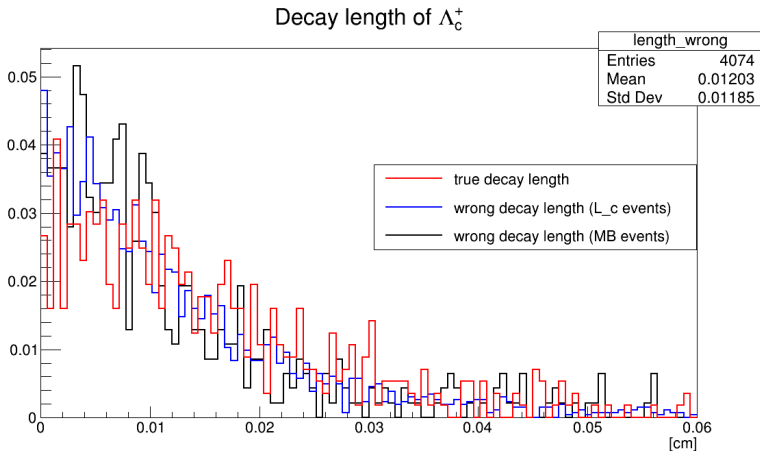
Decay length cut motivation (I)



Gauss fit to the deviation of reconstructed SV position and the true one:

- $\sigma_x = (7.8076 \pm 0.3172)^{-3} \text{cm}$;
- $\sigma_z = (7.6264 \pm 0.2849)^{-3} \text{cm}$.

Decay length cut motivation (II)



With decay length cut $L > 0.008$ cm the ratio of reduced background exceeds the same for signal.

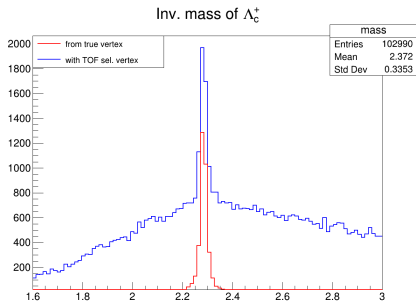
Parameters for the total inv. mass spectrum calculation:

- $\sigma_{\Lambda_c^+} \sim 3.44 \mu b$ (experimental open charm cross section ($20 \mu b$) times ratio of Λ_c^+ Pythia production ~ 0.172);
- $\sigma_{MB} \sim 40 mb$;
- $L \sim 10^{32} cm^{-2} c^{-1}$;
- $\tau \sim 10^7 c$;
- decay branching ~ 0.0626 ;

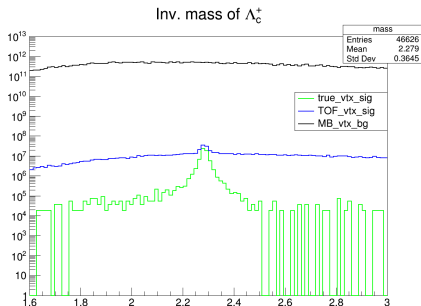
Total numbers

- Events with Λ_c^+ (fixed decay) expects $\sim 22 \cdot 10^7$;
- Events of minimum bias expects $\sim 40 \cdot 10^{12}$.

Cut on PIDs (TOF)

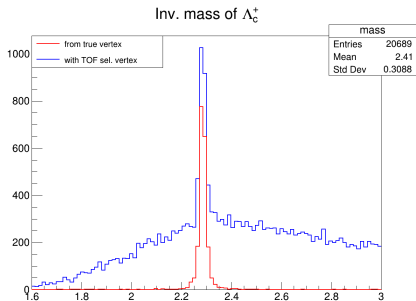


GetsFitted & TOF \rightarrow ok cuts

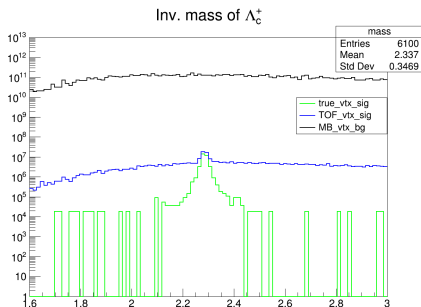


Scaled invariant mass spectrum

Cut on GetNHitsIts

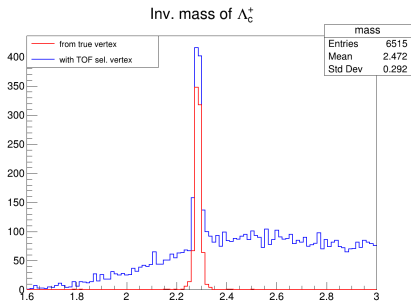


Add GetNHitsIts > 3 cut

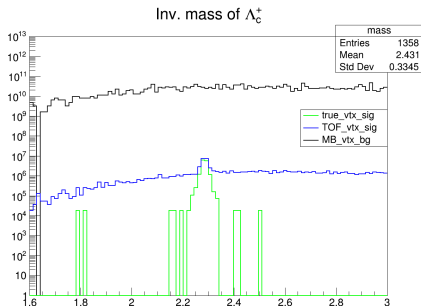


Scaled invariant mass spectrum

Cut on GetsGood

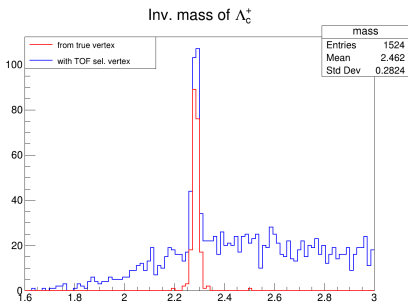


Add GetsGood -> ok cut

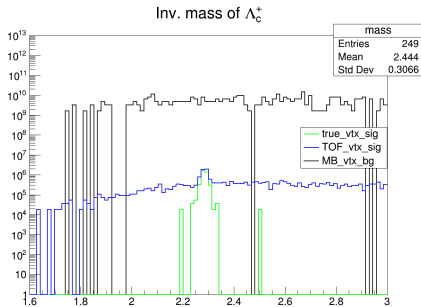


Scaled invariant mass spectrum

Cuts on χ_{PV}^2 & χ_{tr2tr}^2

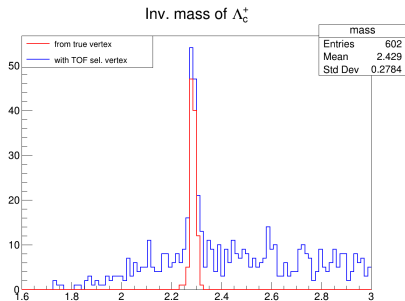


Add $\chi_{PV}^2 > 1$ & $\chi_{tr2tr}^2 < 10$ cuts

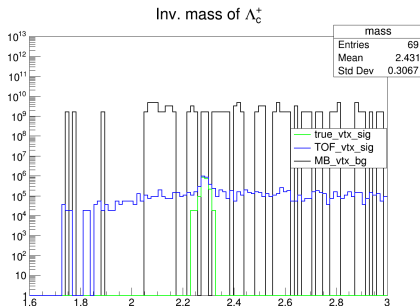


Scaled invariant mass spectrum

Cut on Λ_c decay length

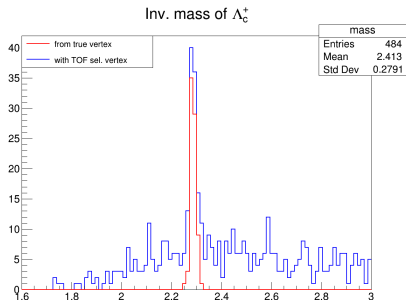


Add length > 0.008 cm cut

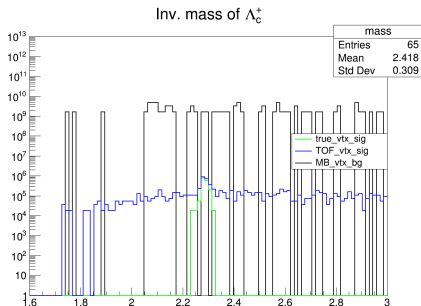


Scaled invariant mass spectrum

Cuts on particle momenta



Add momentum cuts

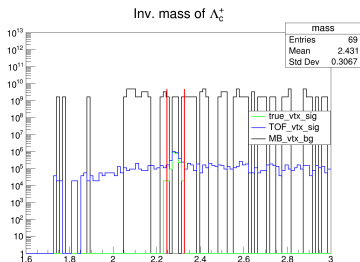
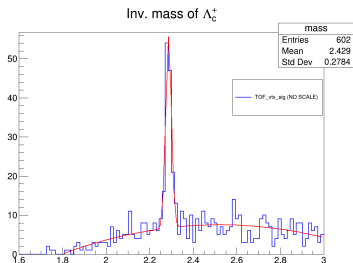


Scaled invariant mass spectrum

All applied cuts

Cut name	$\frac{\Lambda_c^+ \text{ vertices}}{\text{Sel. vertices } (\Lambda_c^+ \text{ events})}$	$\frac{\Lambda_c^+ \text{ vertices}}{\text{Sel. vertices (MB events)}}, 10^{-5}$
GetIsFitted & TOF	0.0369	0.0936
Mass window	0.0681	0.1735
GetNHitsIts	0.0982	0.3817
GetIsGood	0.1288	0.7079
χ_{PV}^2 & χ_{tr2tr}^2	0.1378	0.9664
L_{min}	0.1777	1.7769
$P_{products}$	0.1669	1.6218

Decay products momentum cuts is not effective because previous cuts reduced essential part of background in the cut area. As the result the last cut just reduce signal ratio.



Fit function:

- Gauss + Pol2;

Fit result:

- $m_{\Lambda_c} = 2.2867 \pm 0.0016$ GeV;
- $\sigma = 0.0133 \pm 0.0016$ GeV;

Number of events in 3σ from mean
Gauss value:

- $N_{sig} = 2.87067 \cdot 10^6$;
- $N_{bg} = 6.36848 \cdot 10^9$;

Signal significance:

- $\frac{N_{sig}}{\sqrt{N_{bg}}} \sim 40$;

$$\frac{N_{sig}^{cuts}}{N_{sig}} \sim 0.03 \quad \frac{N_{bg}^{cuts}}{N_{bg}} \sim 0.0015$$

Conclusions

Current result with signal significance ~ 40 provides the opportunity to observe $\Lambda_c^+ \rightarrow p^+ K^- \pi^+$ decay at SPD experiment on $\sqrt{S} = 27$ GeV collision energy.

To do

- to implement the more adequate model of $\Lambda_c^+ \rightarrow p^+ K^- \pi^+$ decay
- to improve signal selection
- to study peaking background $D^+ \rightarrow K^- \pi^+ \pi^+$
- to simulate more statistics

This study was carried out within the project "Production of open charm and tau leptons at the NICA SPD: phenomenology and simulation" supported by JINR.

Thank you for your attention!