Simulation of the $K\pi$ spectroscopy

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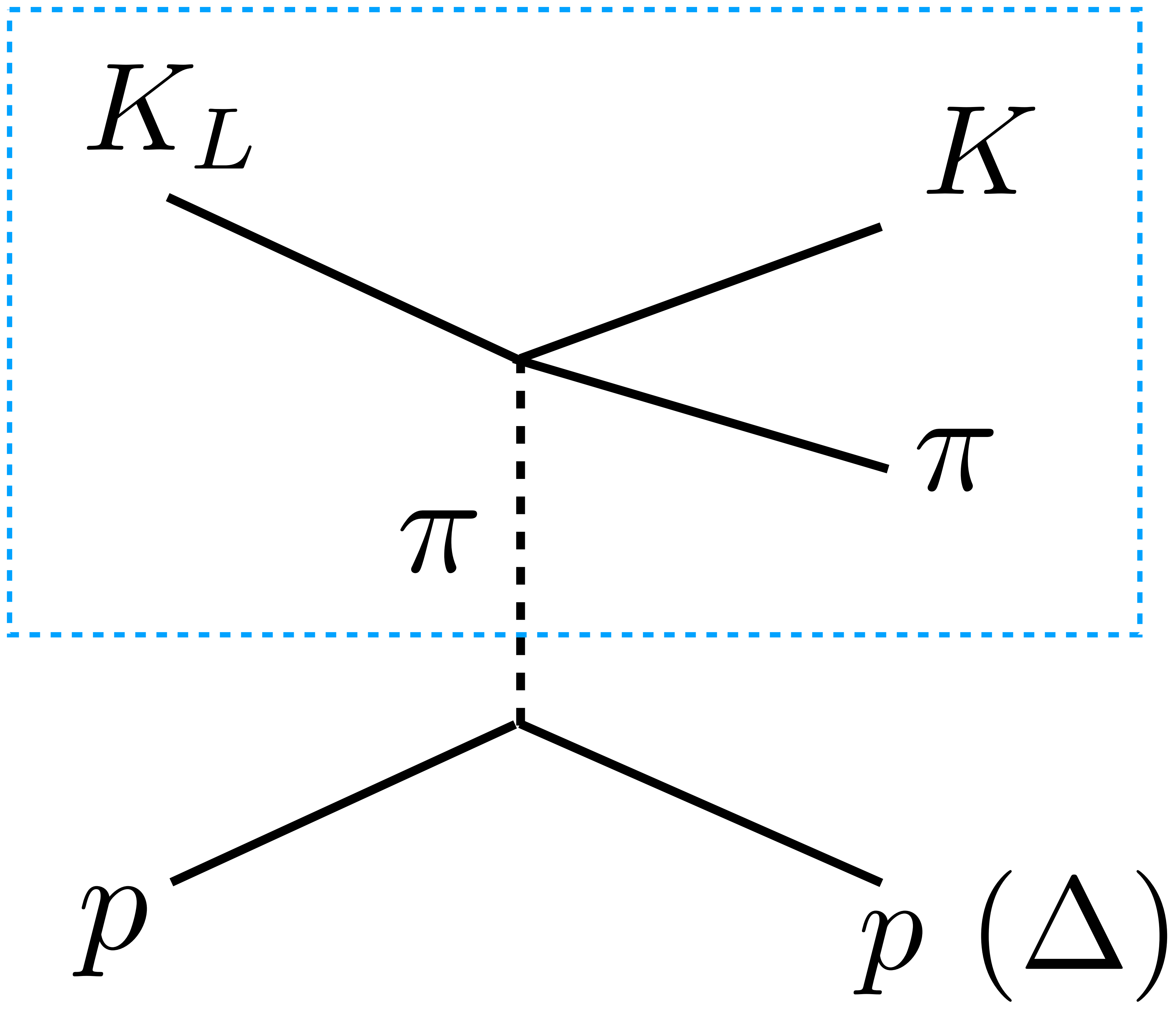
Motivation of the $K\pi$ spectroscopy

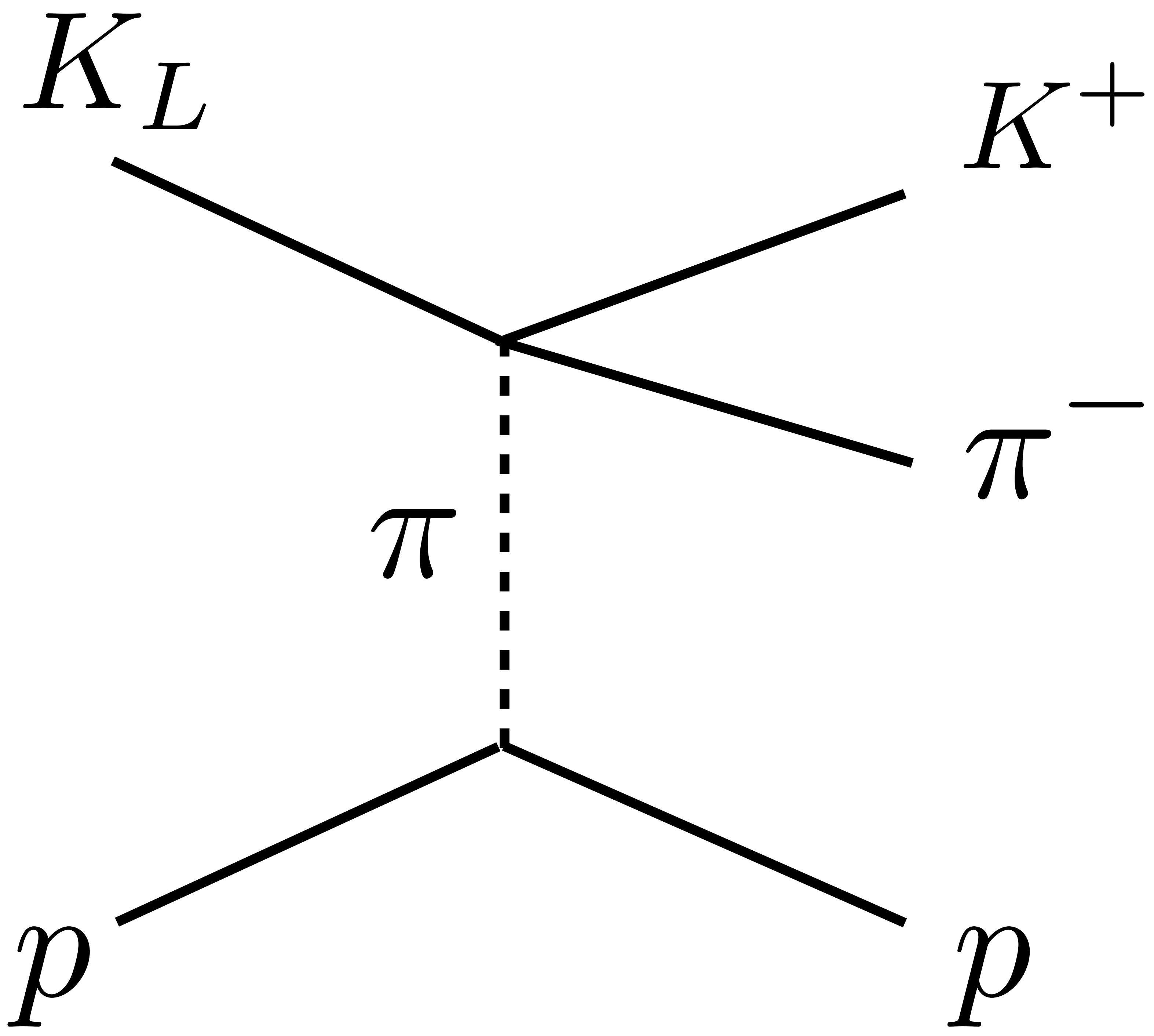
- The simplest hadronic reaction that involves s quark
  - crucial for understanding non-pQCD
- $K\pi$ scattering amplitude can be calculated based on Chiral Perturbation Theory, but the low energy parameters such as the scattering length show discrepancy between existing measurements. The new KLF input will settle this issue.
- Existence of the exotic κ meson ($I = 1/2$ S-save) is unclear. The partial wave analysis at the low t Mandelstam variable in the reaction $KN \to K\pi N$ and $KN \to K\pi\Delta$ is important to unravel this state and determine its pole position.

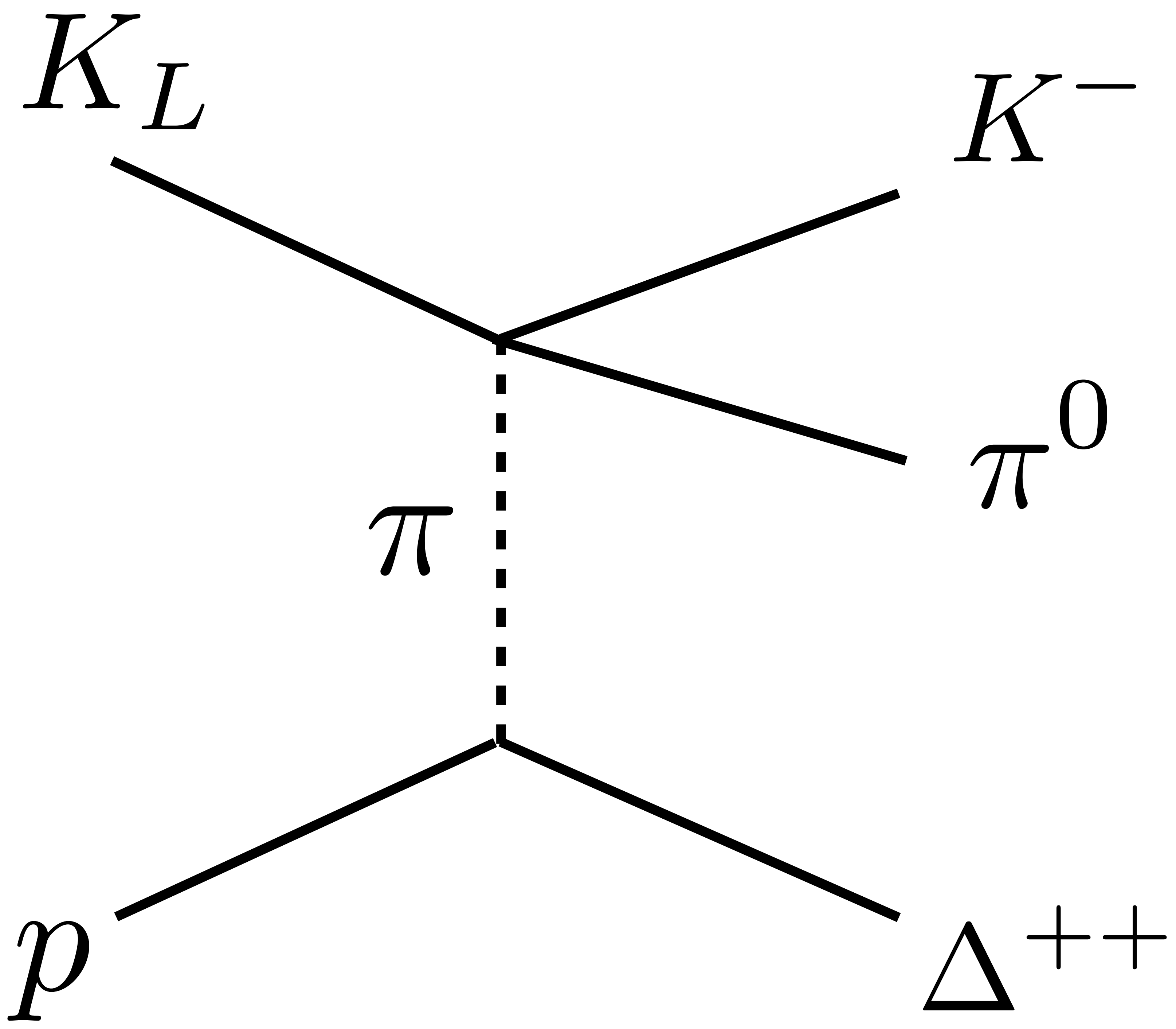


Dominant diagram at low t

$K\pi$ channels we focus

$K_L p \to K^+ \pi^- p$ $\qquad$ $K_L p \to K^- \pi^0 \Delta^{++}$



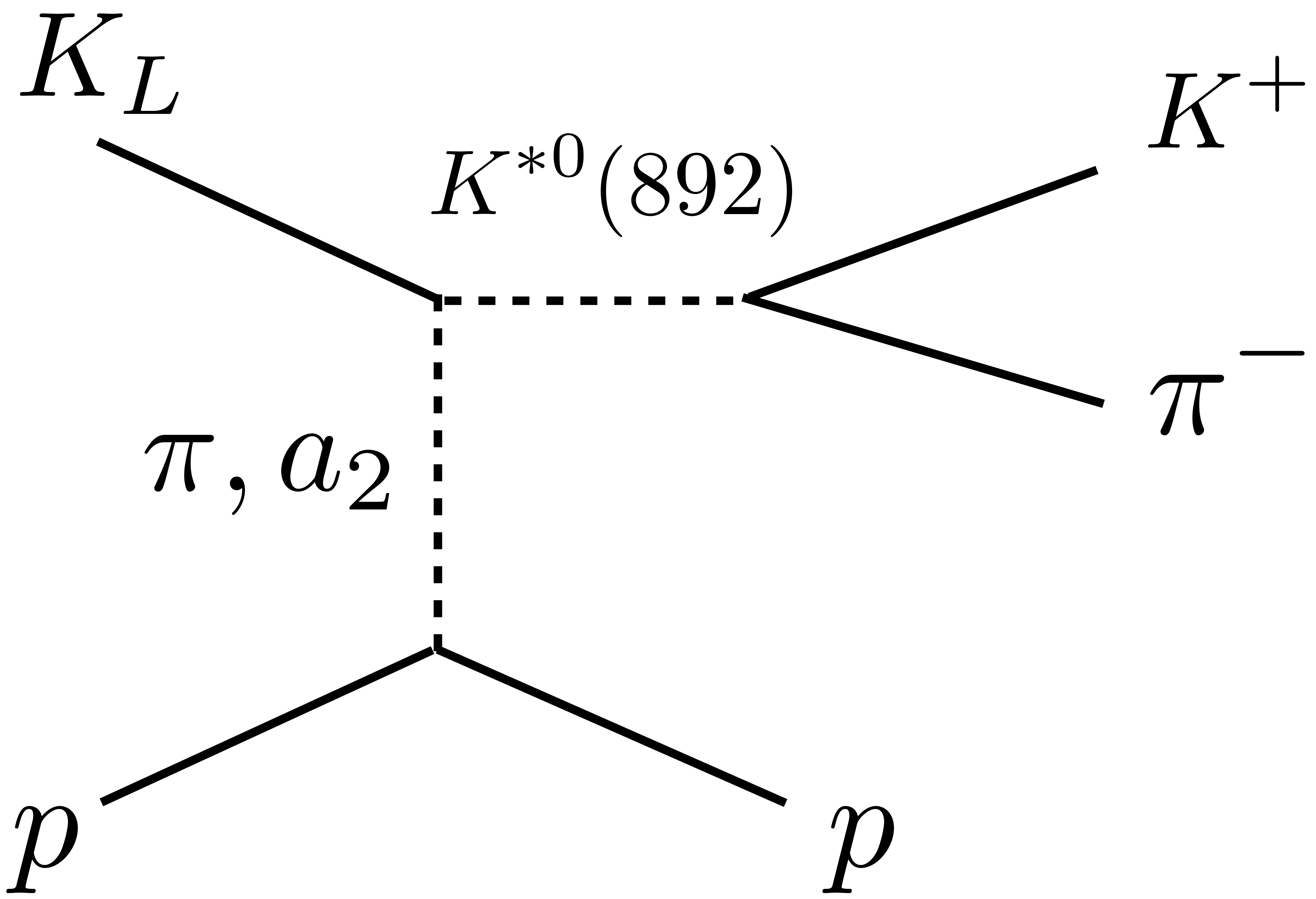


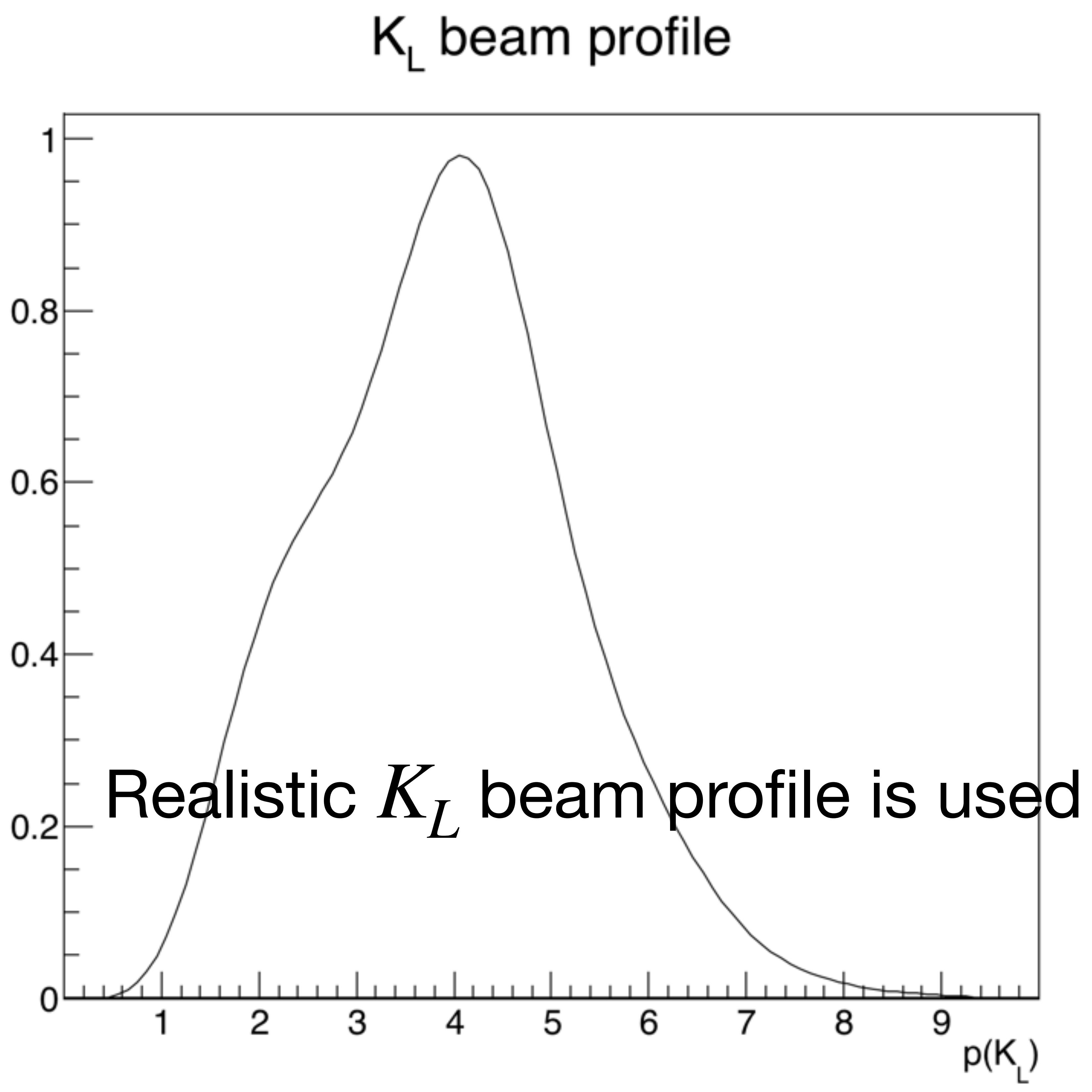
One pion exchange diagram is dominant at small momentum transfer t.

Simulation for $K_L p \to K^{*0}(892) p \to K^+ \pi^- p$

The Regge Model (NPB**151**, 10 (1969)) is used for the simulation.

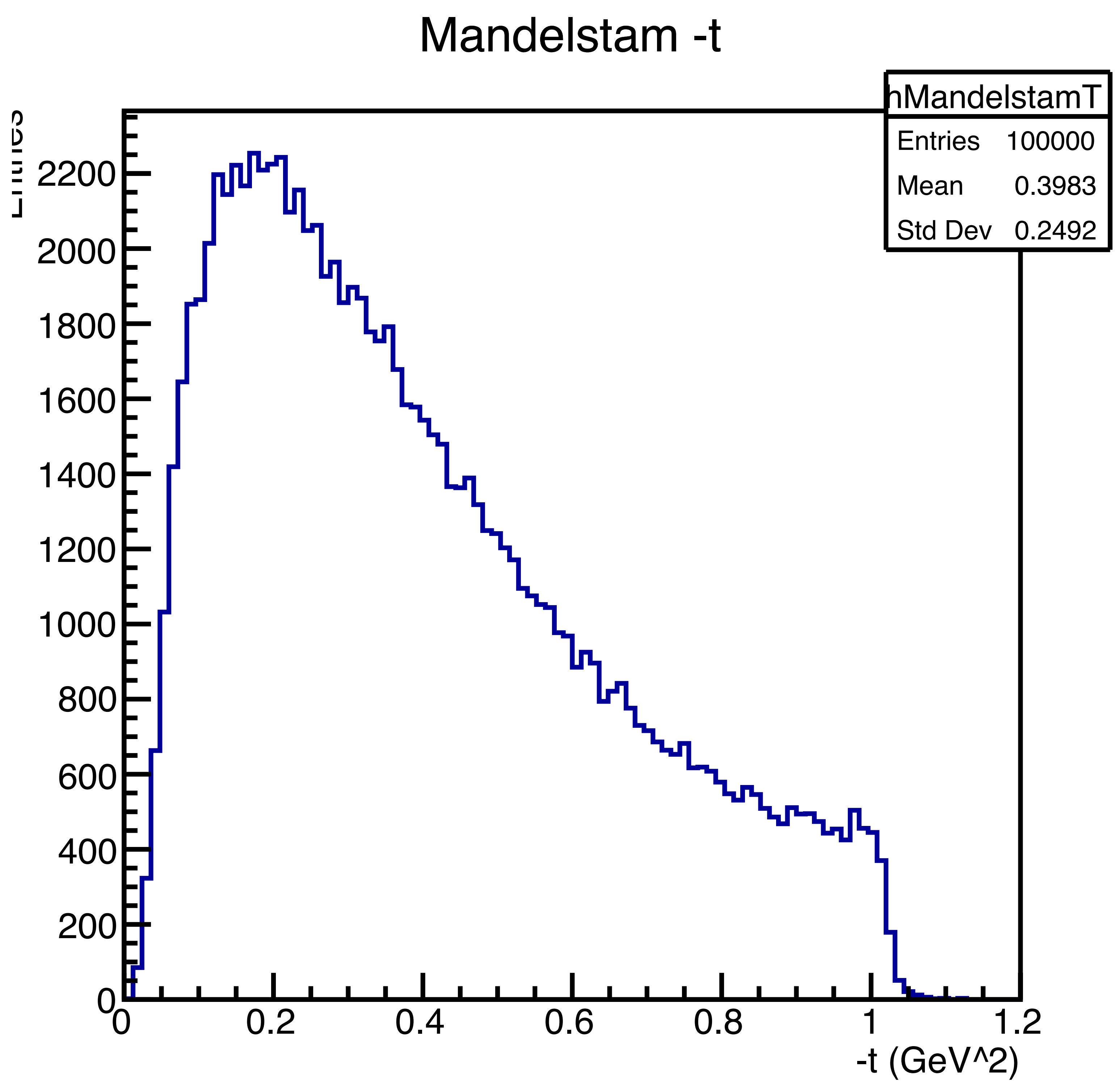
* describes the neutral exchange production that involves $K\pi$ P-wave
* π and a_2 Regge trajectories are exchanged in the t-channel (π Regge-pole is dominant)
* the original paper calculates the reaction with charged kaon beam
  * we assume that the neutral exchange amplitude with charged kaon beam is similar to neutral kaon beam

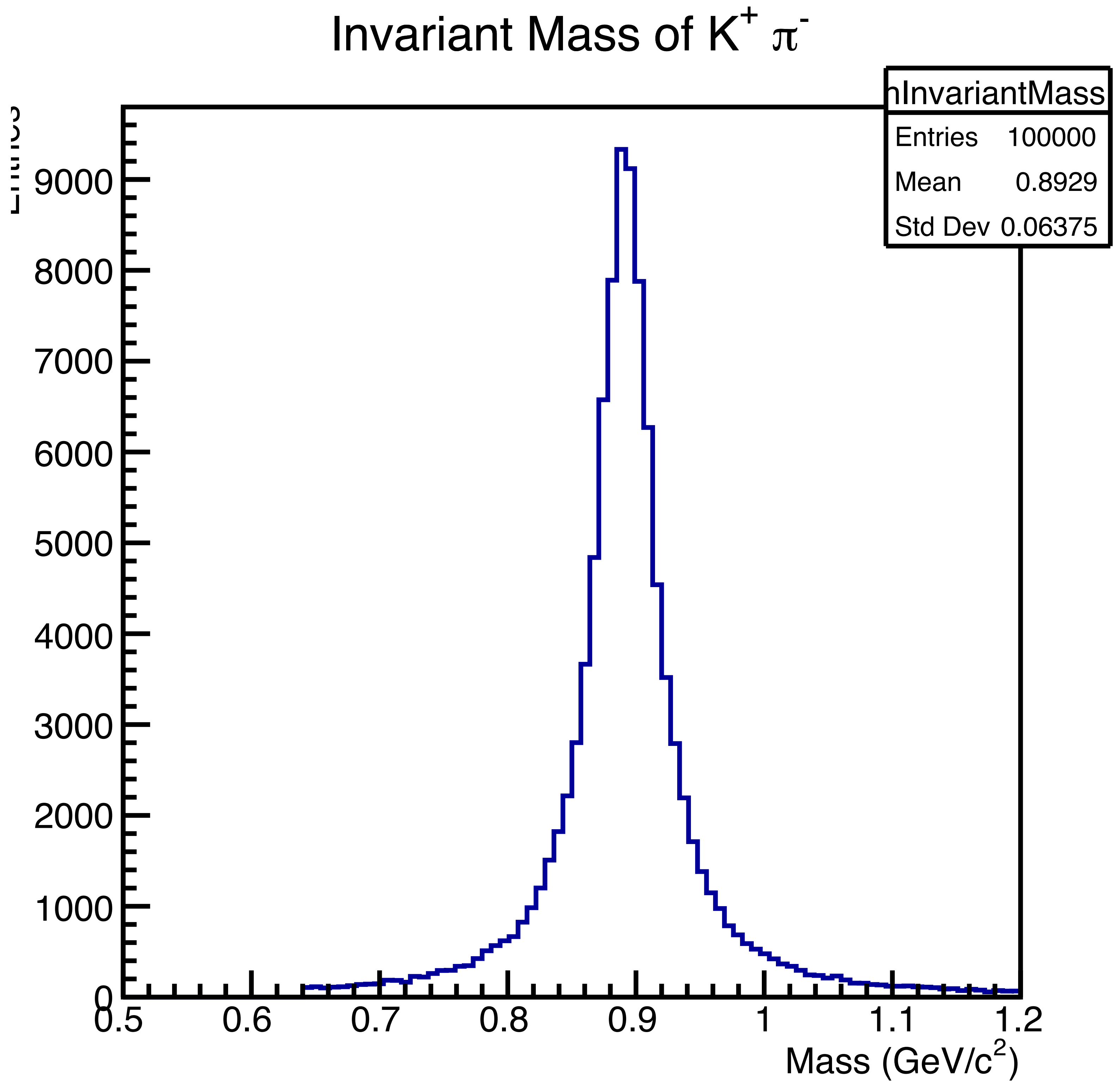




Simulation for $K_L p \to K^{*0}(892)p \to K^+\pi^- p$

* The relativistic Breit-Wigner is used to simulate $K^{*0}(892)$.
* $K^{*0}(892)$ decays to K^+ and π^- uniformly in the phase space.

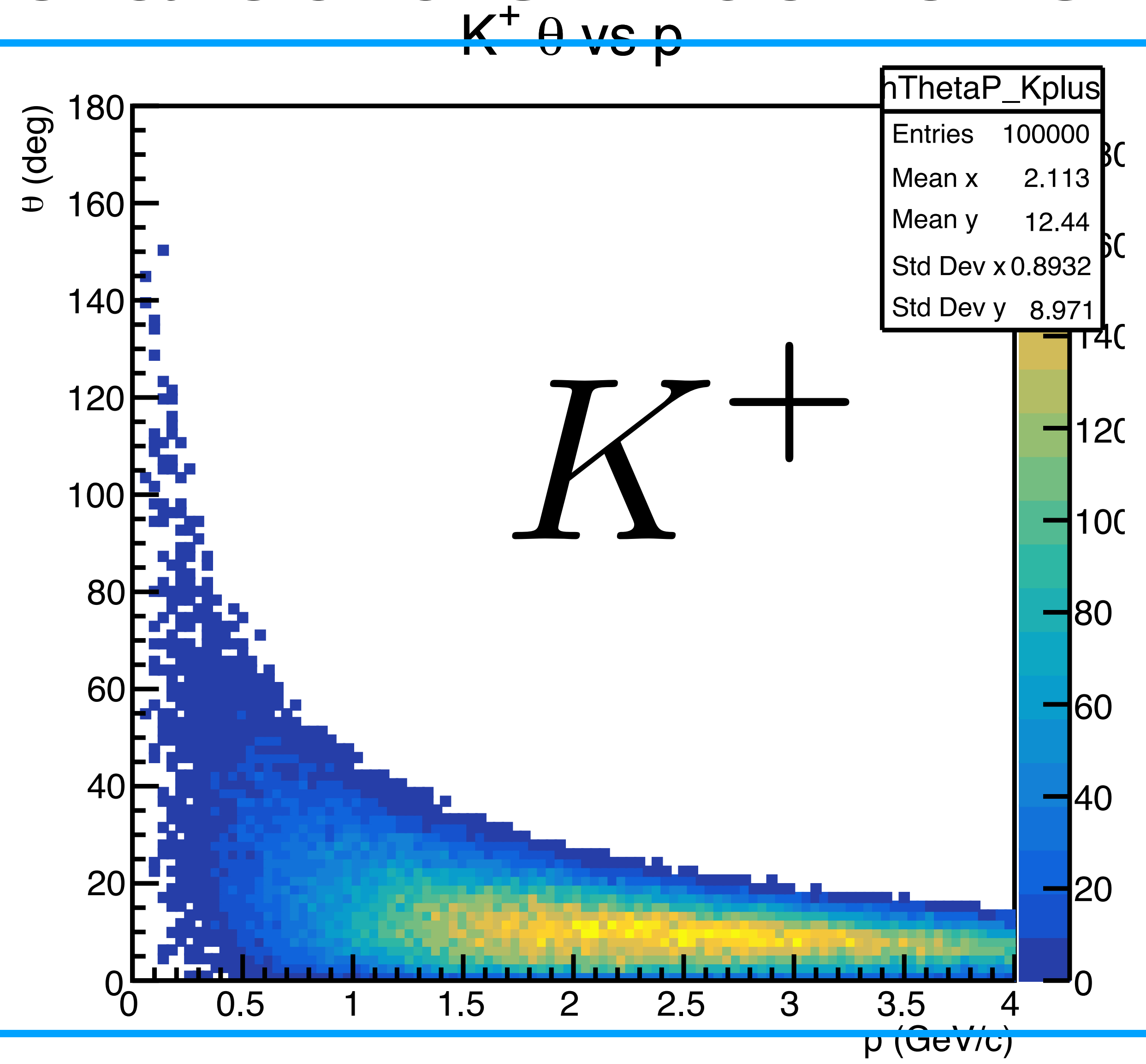


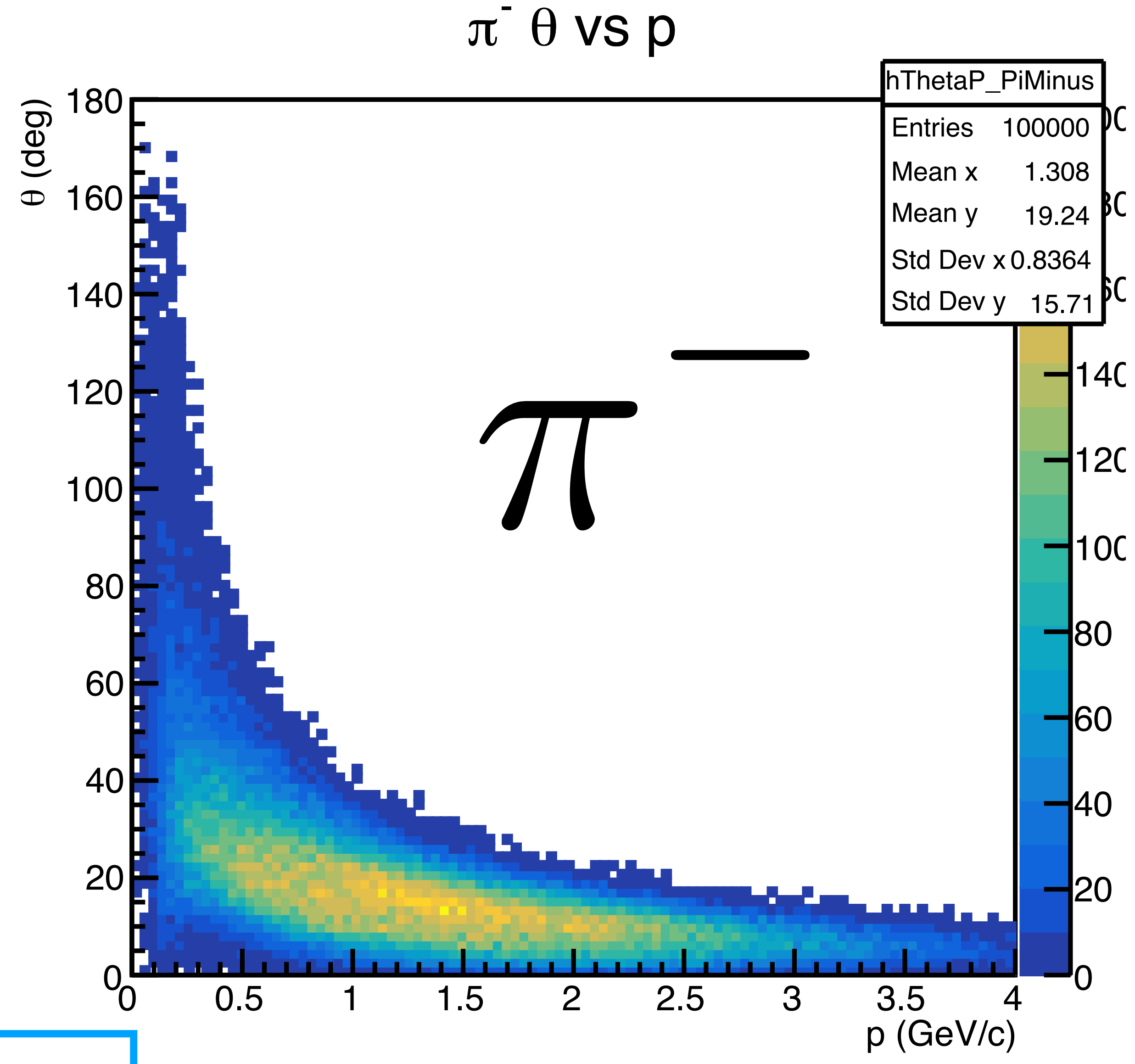


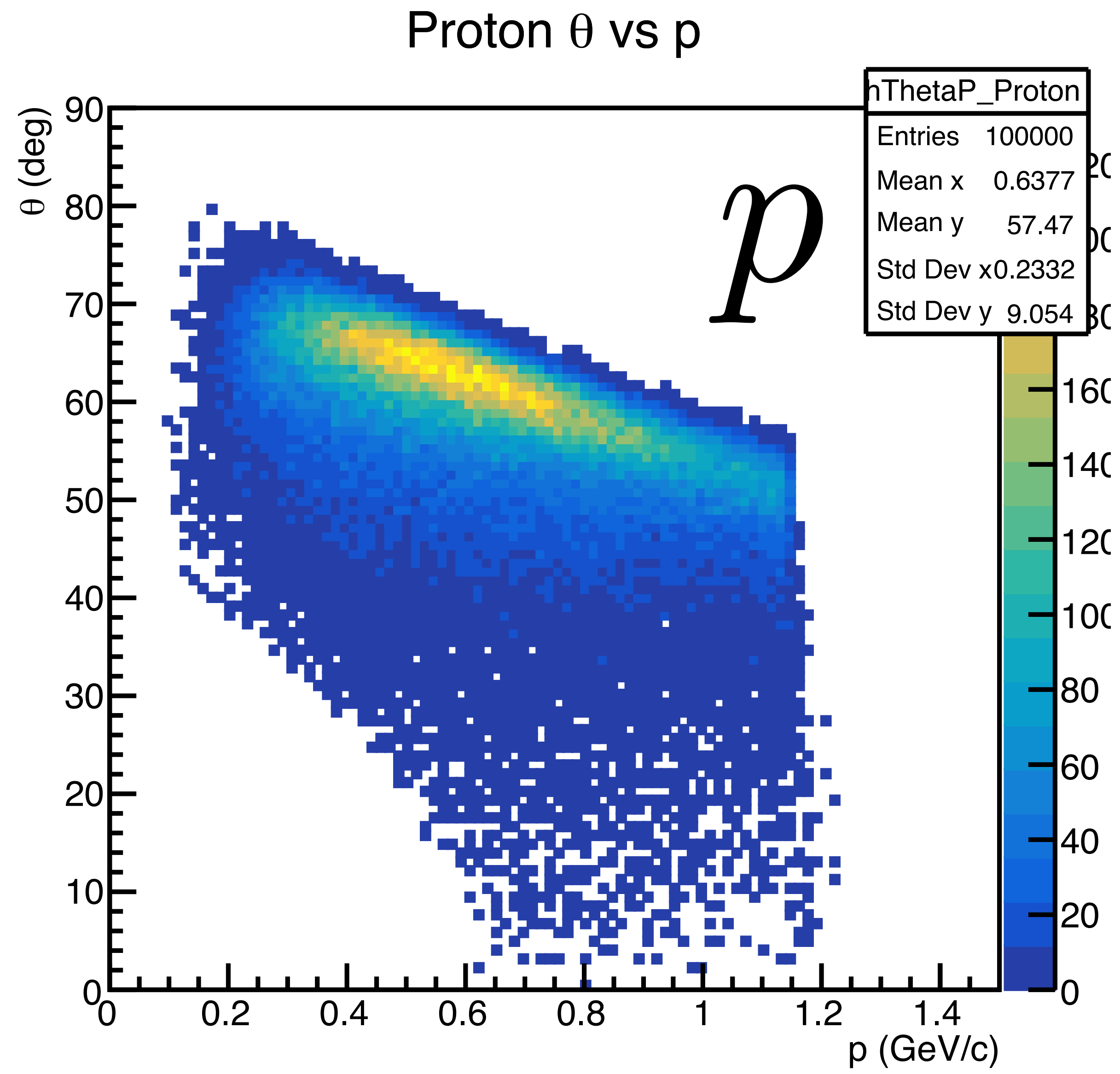
The generated event sample is simulated through GlueX detector using Geant4-based GlueX software to simulate the detector response, and the reconstruction of simulation is made by the JLab Reconstruction Framework JANA.

Kinematics of $K_L p \to K^{*0}(892)p \to K^+\pi^-p$

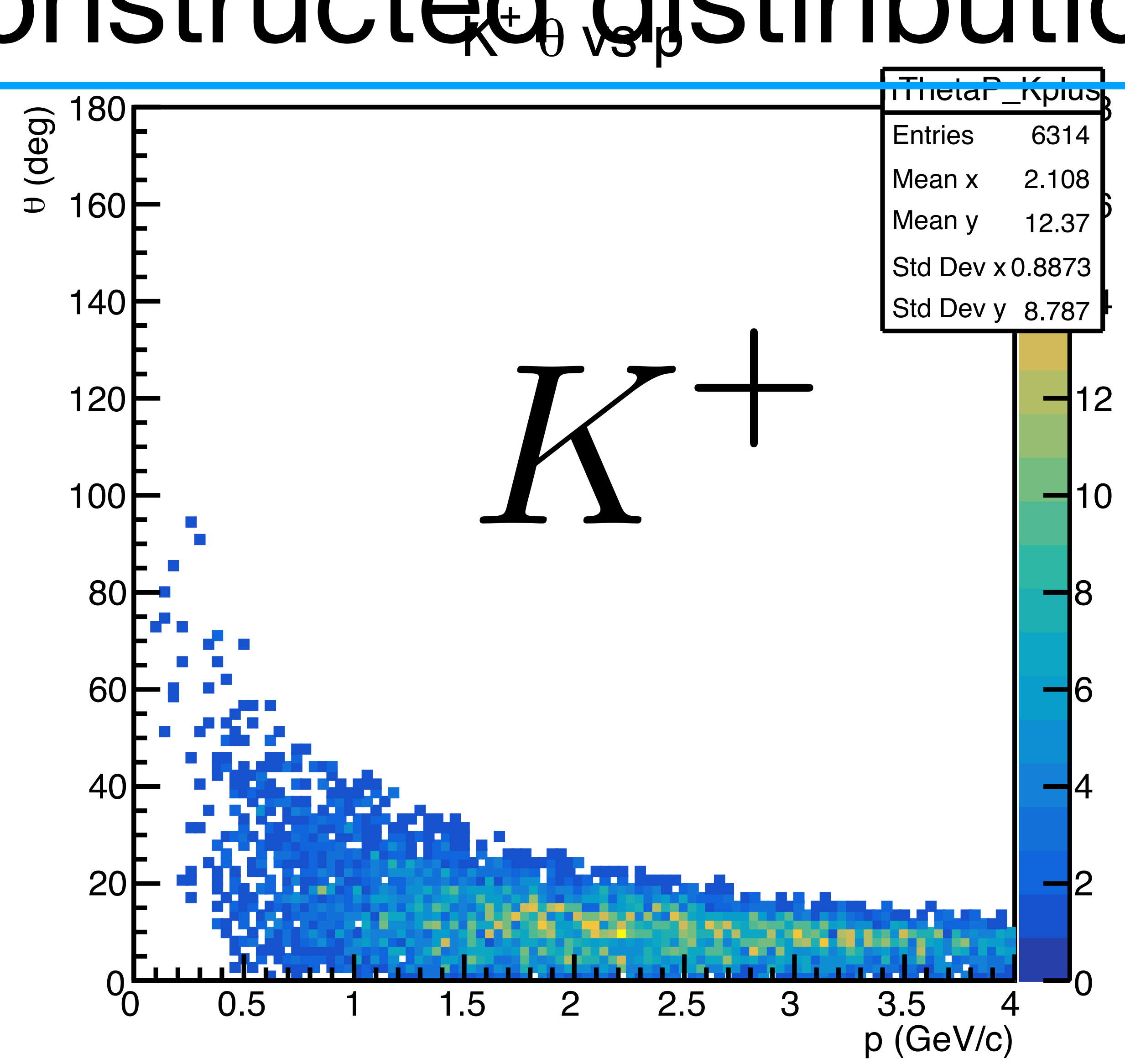
Generated distiributions

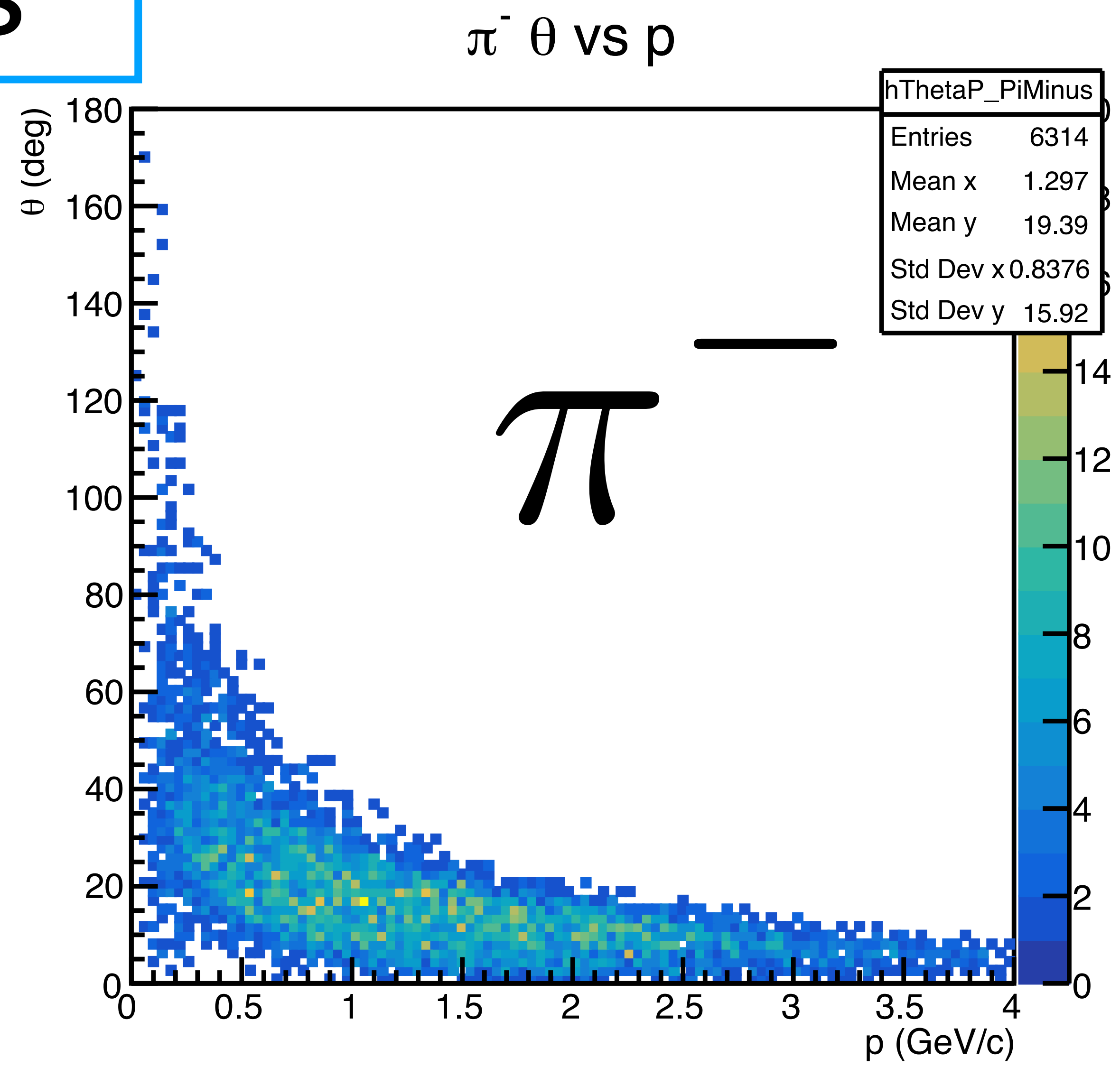


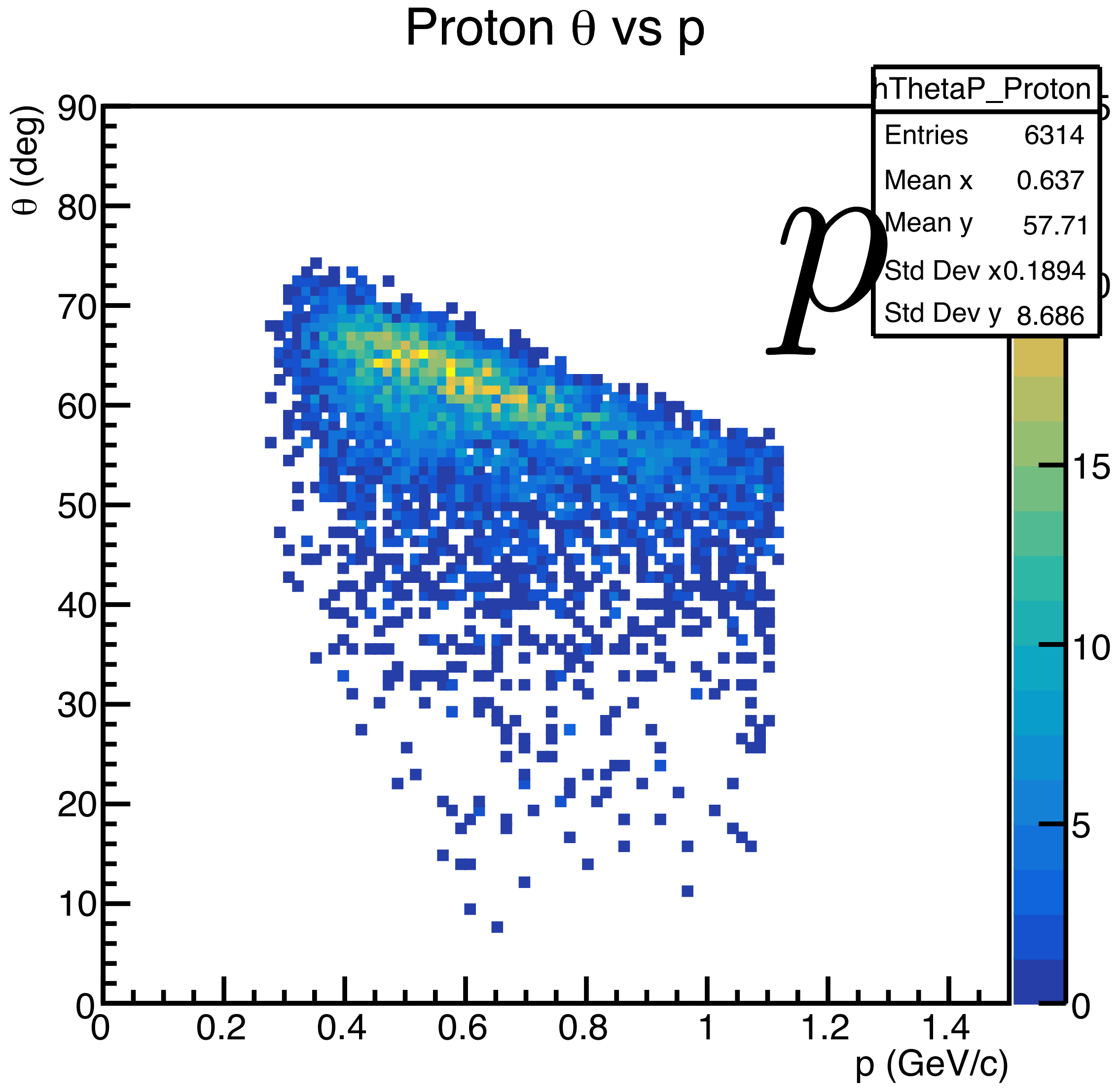




Reconstructed distiributions

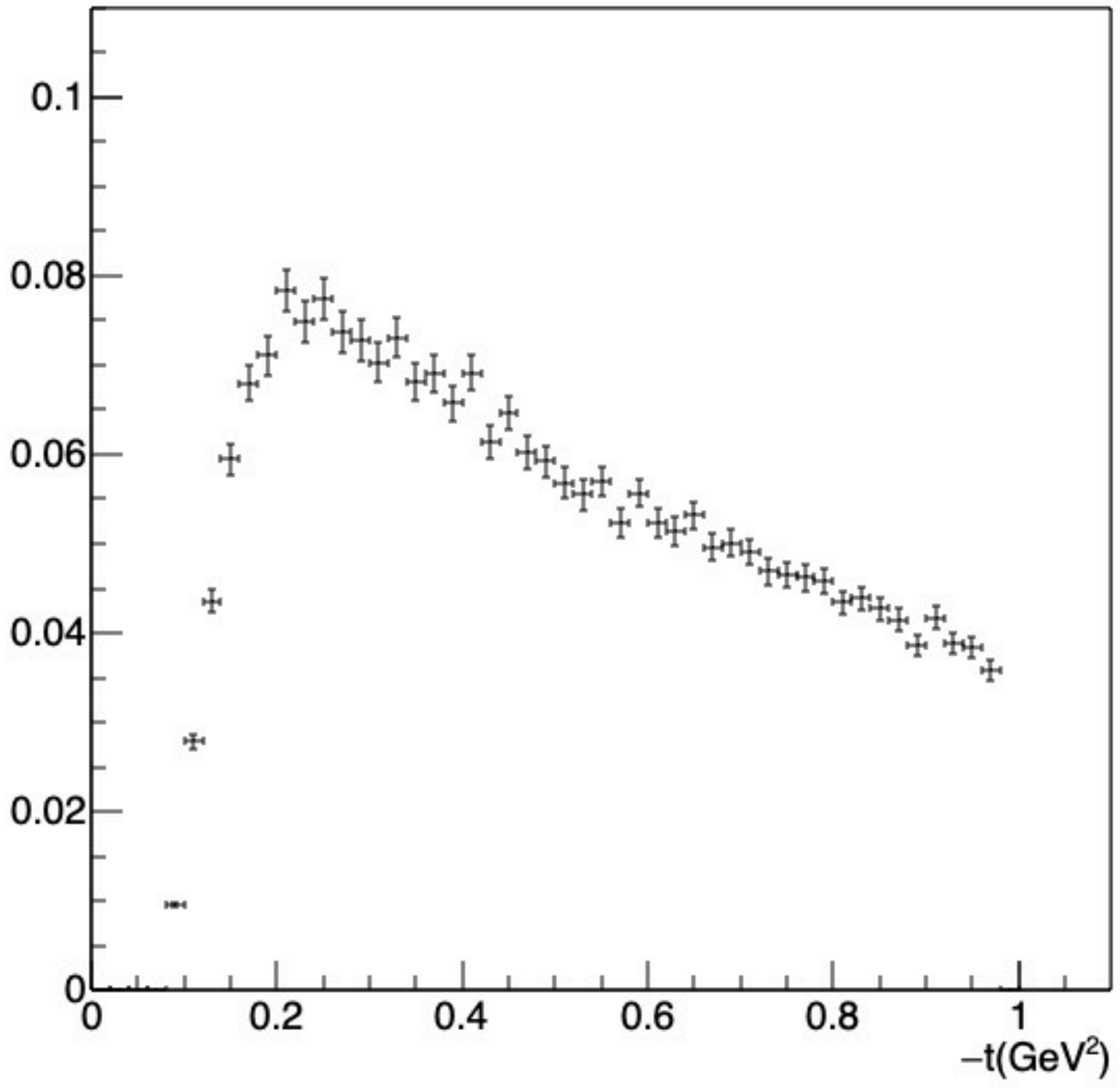




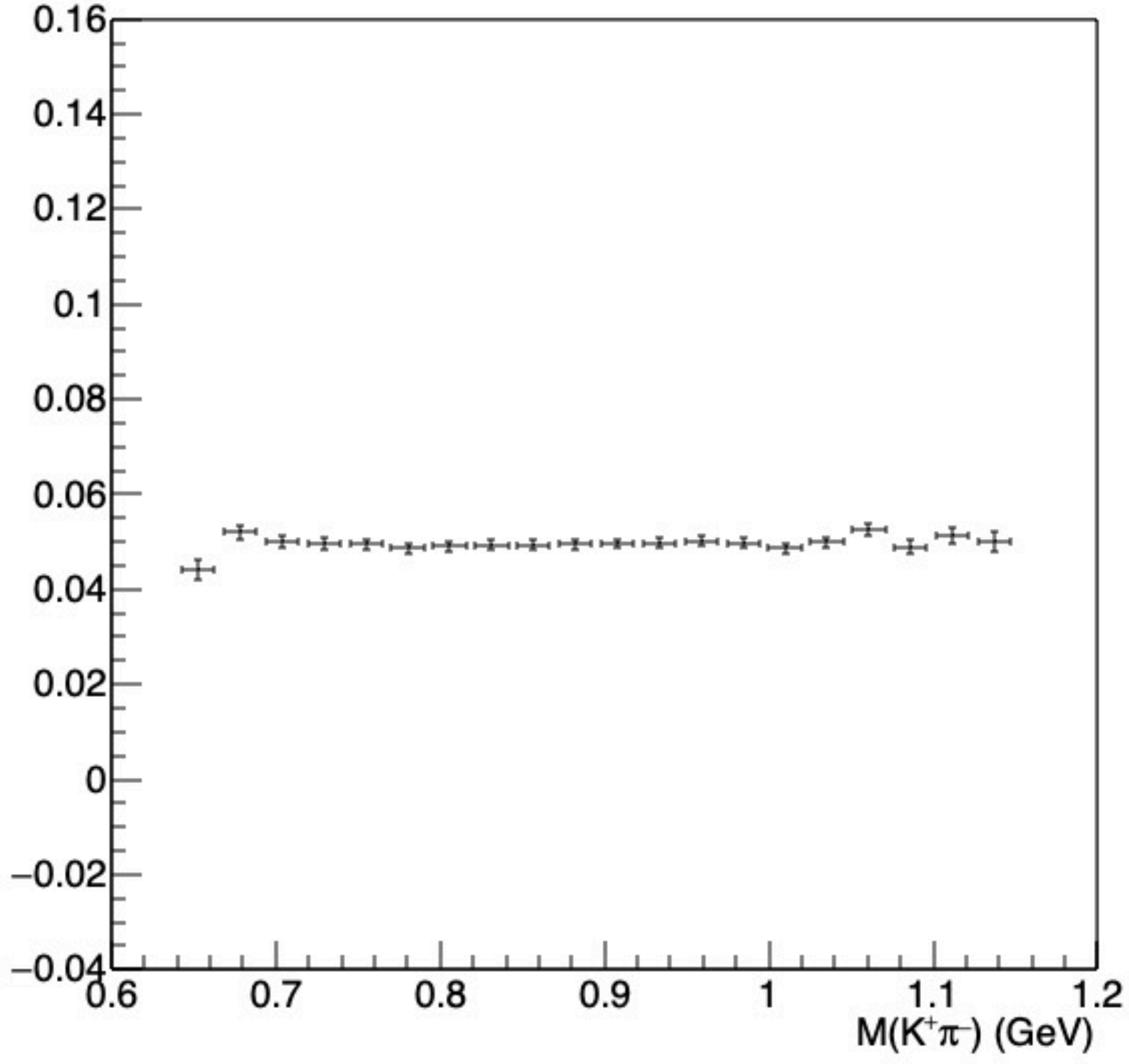


Effieciency $K_L p \to K^{*0}(892)p \to K^+\pi^-p$

Transfer 4-mom Efficiency



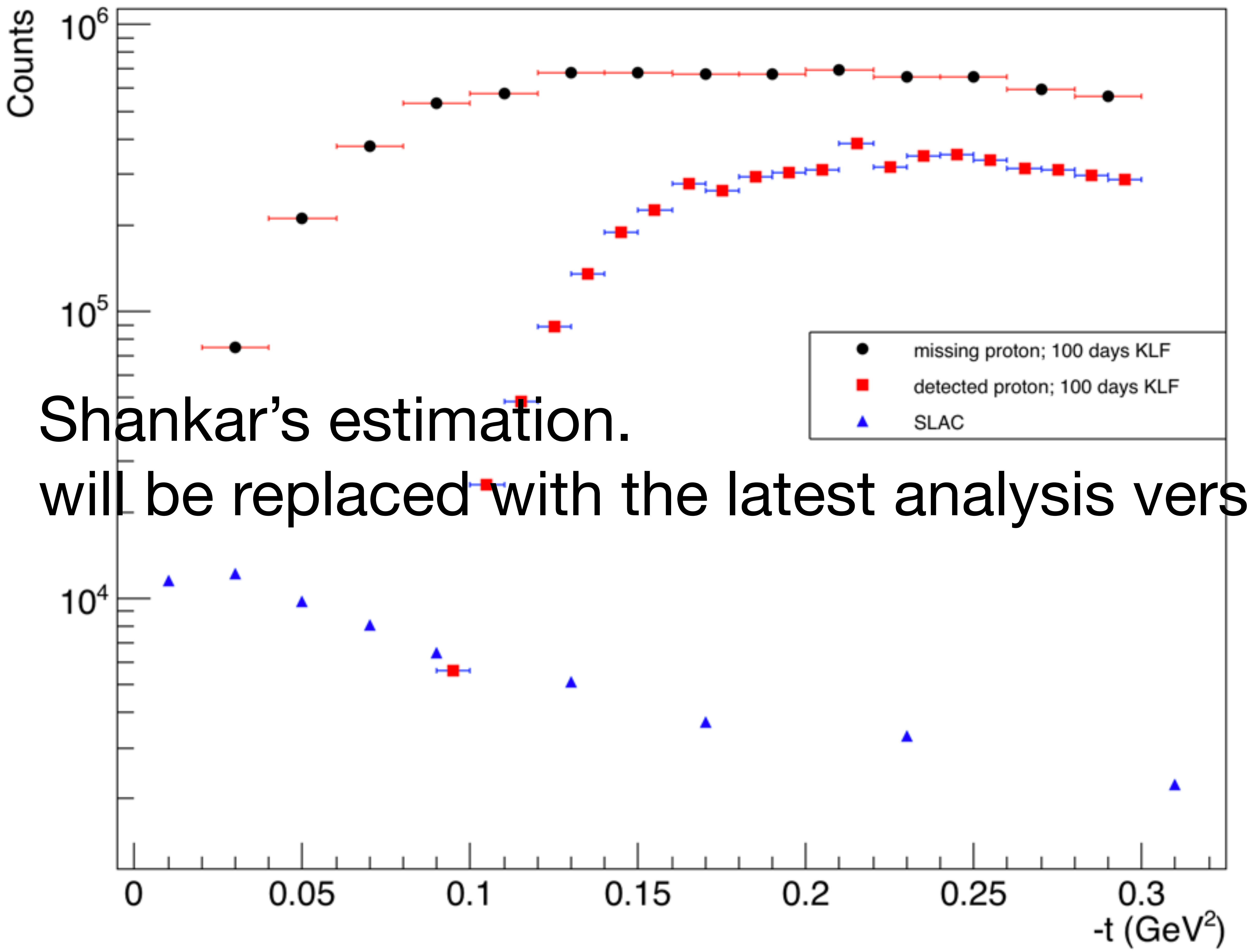
M(K+π-) Efficiency



The K+π-p events can be reconstructed with ~5% efficiency on average.

Yield estimation for $K_L p \to K^{*0}(892)p \to K^+\pi^- p$

Taking into account the luminosity and detector acceptance effect and 100 days KLF running, we expect one to two order of more statistics compared to the past experiment.

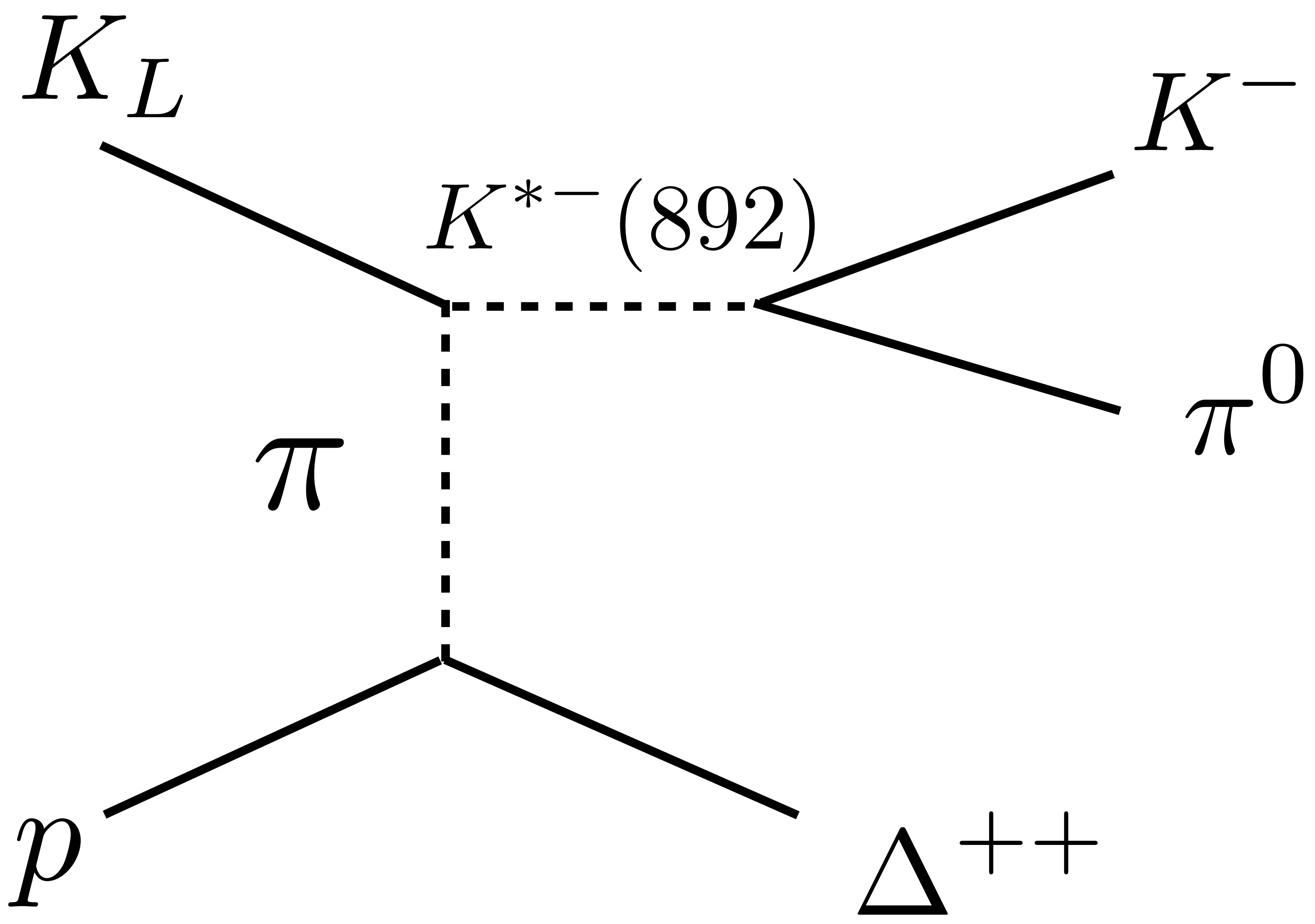


Shankar's estimation.
will be replaced with the latest analysis version.

Simulation for $K_L p \to K^{*-}(892)\Delta^{++} \to K^- \pi^0 p \pi^+$

$K\pi$ scattering amplitude by A. Rhodas (PRD**93**, 074025 (2016)) is used.

* the parametrization of the amplitude is tuned to describe the existing $K\pi$ scattering.



$K_L p \to K^{*-}(892)\Delta^{++} \to K^- \pi^0 p \pi^+$

* The relativistic Breit-Wigner is used to simulate $K^{*0}(892)$.
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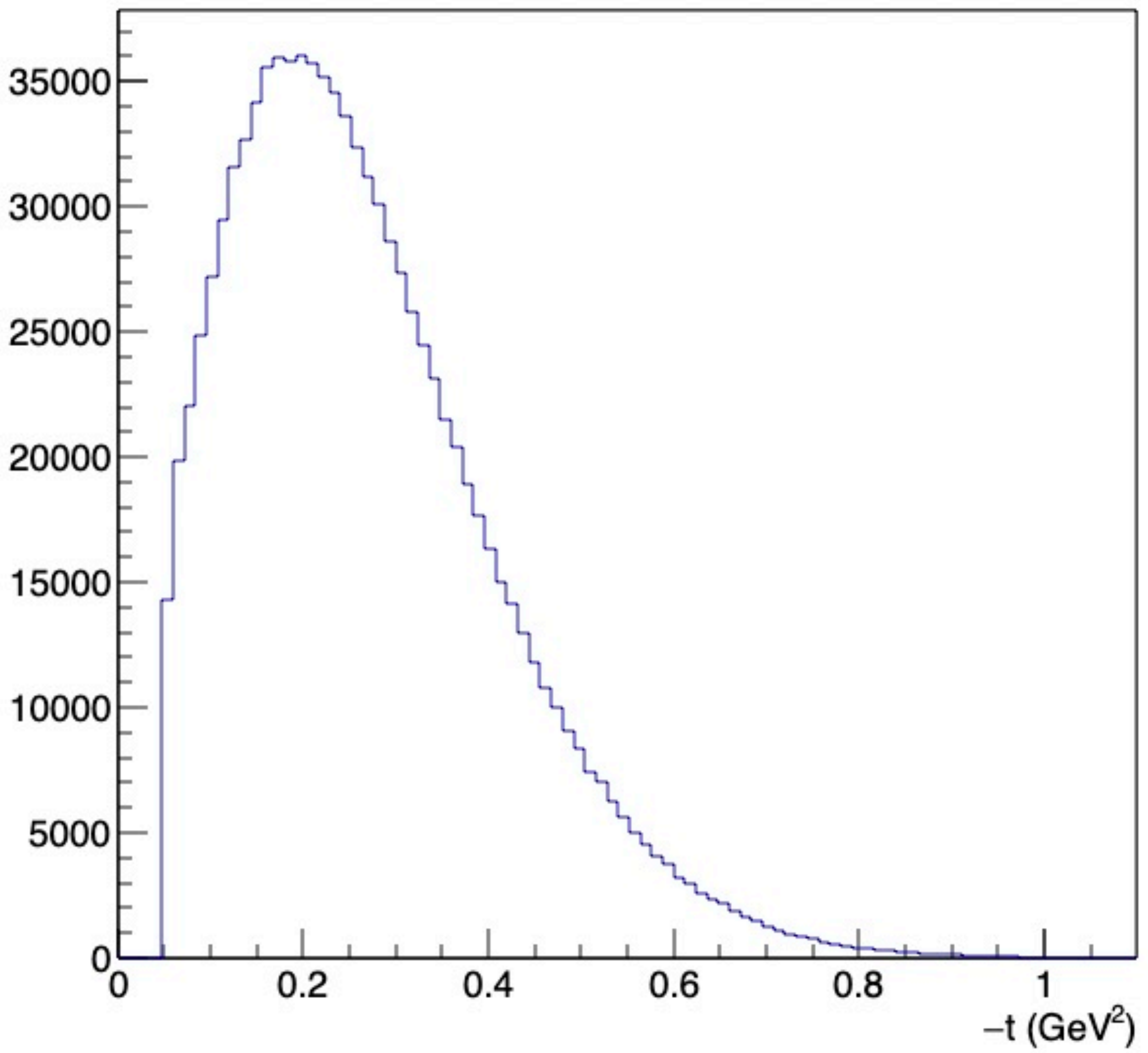

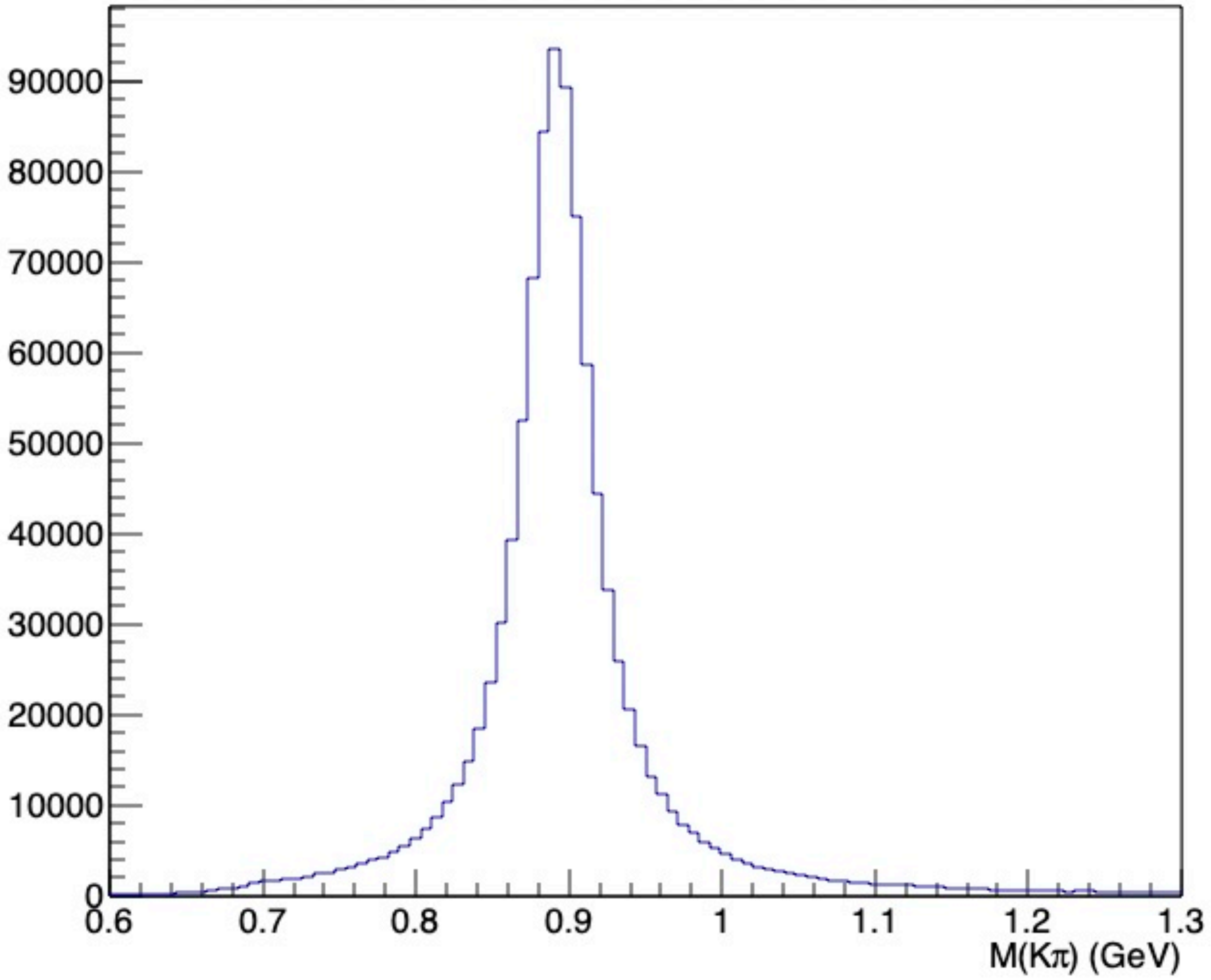

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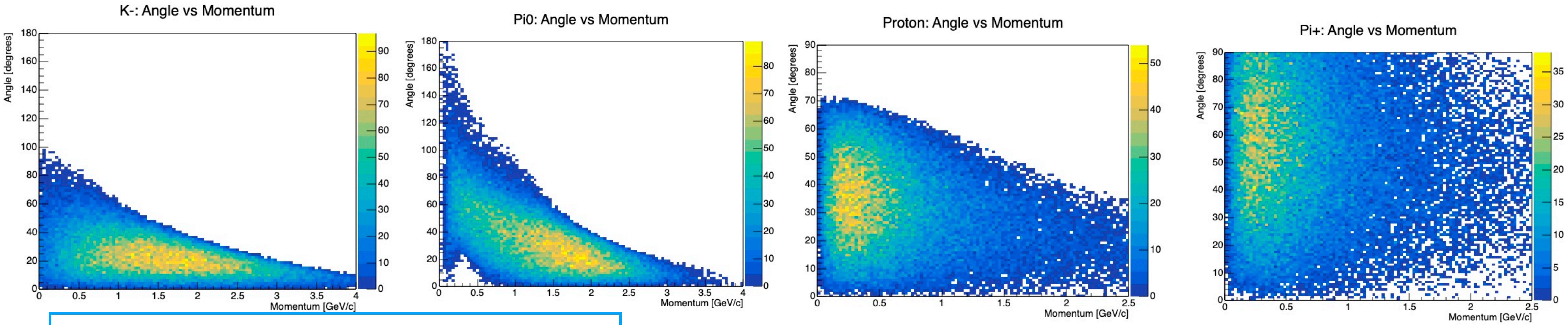
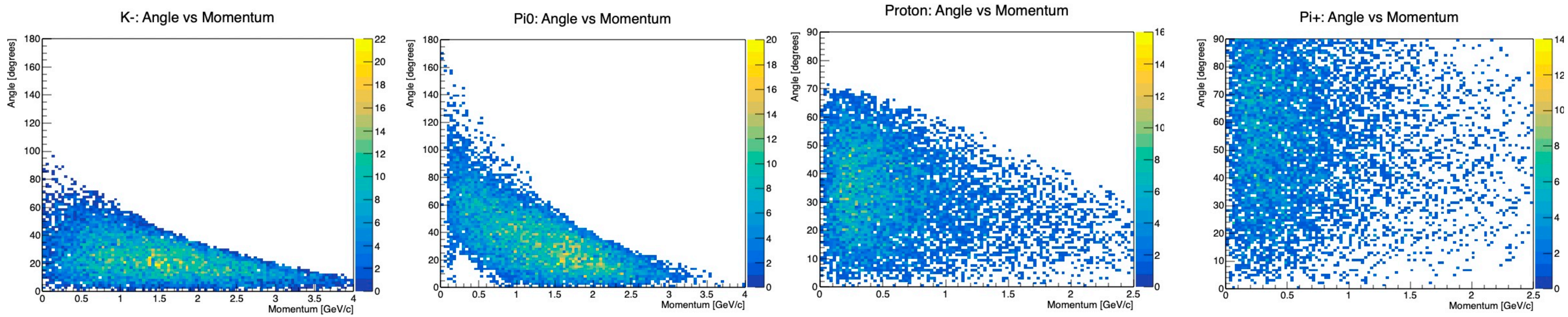
Kinematics of $K_L p \rightarrow K^{*-}(892)\Delta^{++} \rightarrow K^- \pi^0 p \pi^+$

Generated distiributions



Reconstructed distiributions



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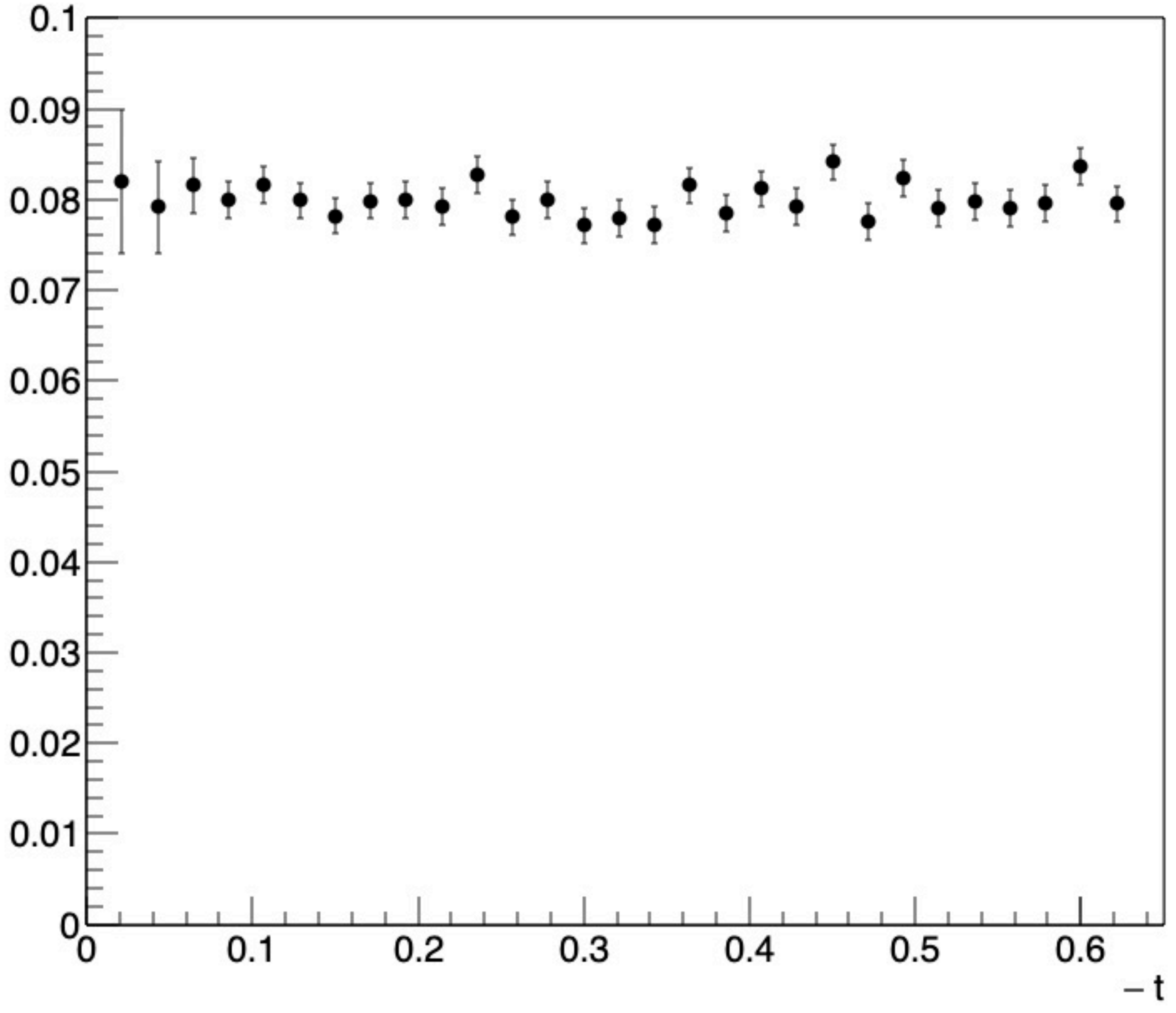
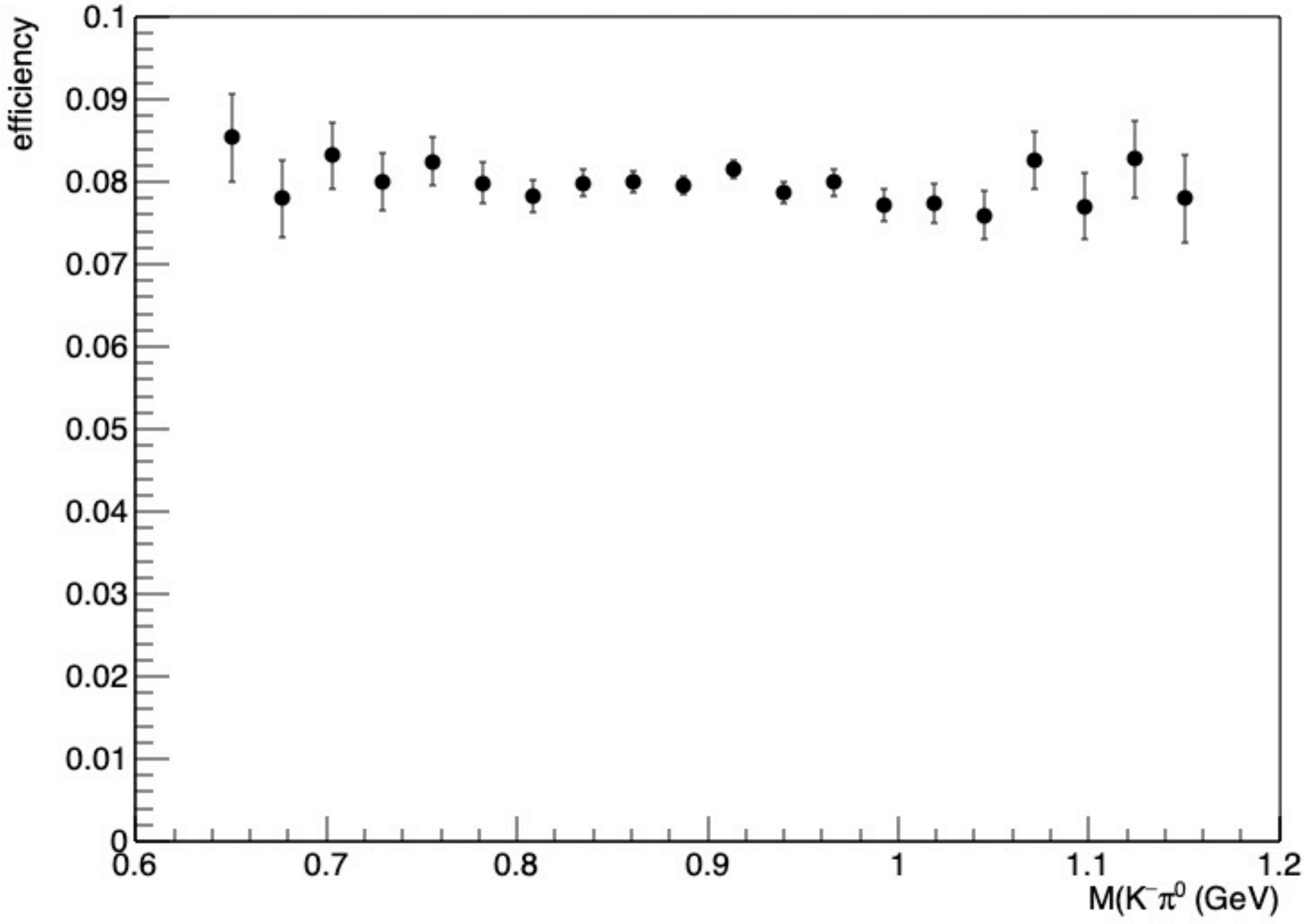


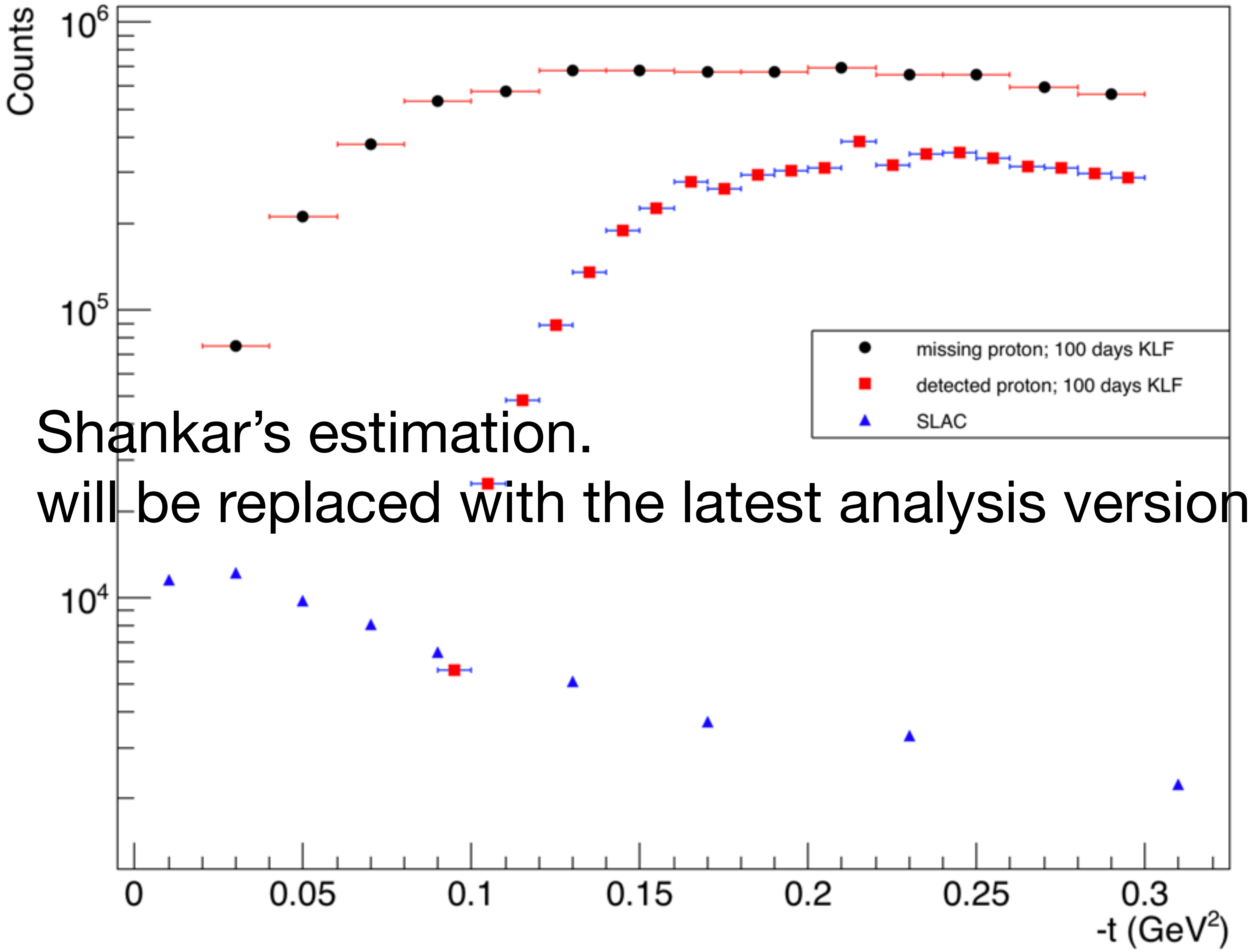
M(K⁻π⁰) Efficiency



The events can be reconstructed with ~8% efficiency, and the t dependence of the event reconstruction efficiency is very small.

Yield estimation for $K_L p \to K^{*-}(892)\Delta^{++} \to K^- \pi^0 p \pi^+$

Taking into account the luminosity and detector acceptance effect and 100 days KLF running, we expect one to two order of more statistics compared to the past experiment.



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Summary

- The simplest hadronic reaction with s quark, $K\pi$ scattering, is crucial for understanding of the non-perturbative QCD. Also, it is the quest to establish existence or non-existence of scaler kappa mesons. The new KLF data can access these fundamental questions.

- The realistic event generators for $K_L p \to K^{*0}(892)p \to K^+\pi^- p$ and $K_L p \to K^{*-}(892)\Delta^{++} \to K^-\pi^0 p\pi^+$ have been prepared.

- The simulations with these generators show that 100-day KLF running will accumulate more than 10 times statistics for these reactions, and can be used to extract the low energy parameters such as scattering length.

$K\pi$ channels we focus

$K_L p \to K^+ \pi^- p$ $\quad$ $K_L p \to K^- \pi^0 \Delta^{++}$ $\quad$ $K_L p \to K^0 \pi^- \Delta^{++}$

One pion exchange diagram is dominant at small momentum transfer t.