Looking for Charm-Strange (D_s) Mesons in STAR's Deuteron+Gold Collisions

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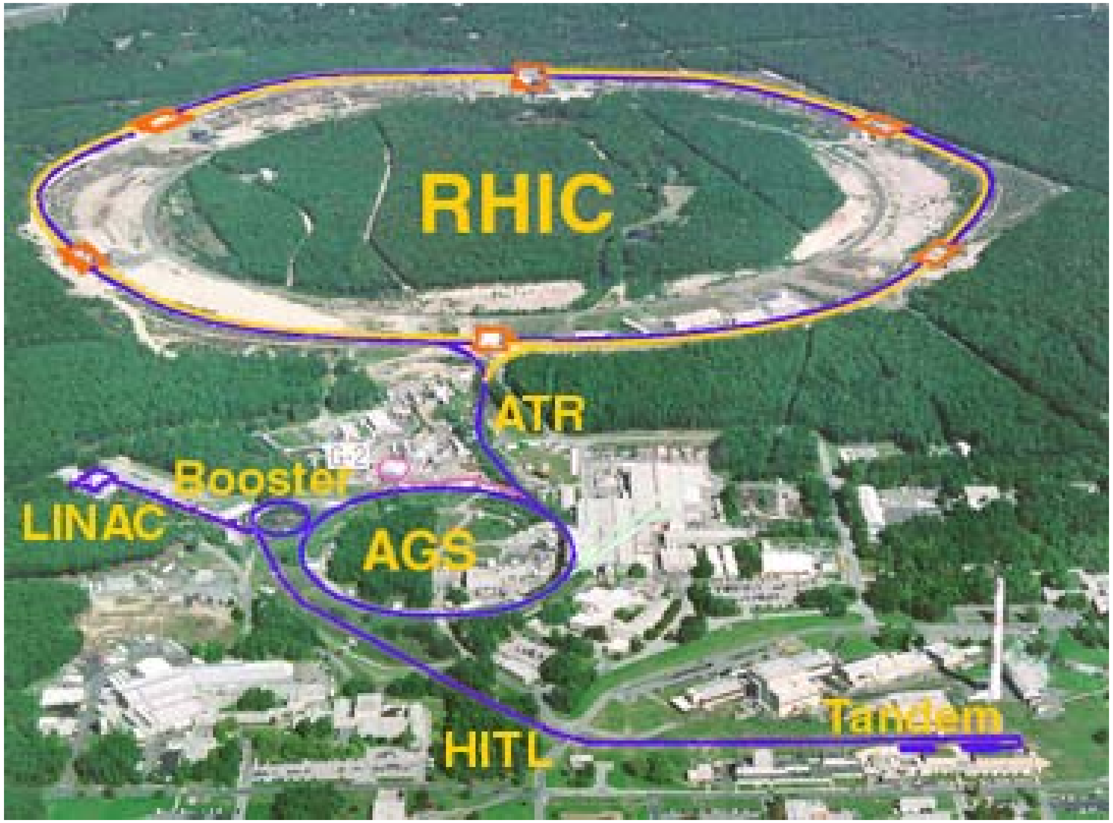
The Relativistic Heavy Ion Collider



- The Relativistic Heavy Ion Collider (RHIC) was build to discover and study a new state of matter, the Quark Gluon Plasma (QGP), in which quarks would no longer be confined within mesons and baryons. In other words, a soup of free quarks would be created.

- Most of RHIC's data is from Au+Au collisions at 200 GeV. d+Au, p+p, and Cu+Cu collisions were also run, again mostly at 200 GeV.

Charmed Motivation

•Charm quarks are produced in relativistic collisions via hard processes. Therefore, one can study the nature of QCD within the collision fireball by measuring the charm yield.

•Charmed mesons are good probes of the early stages of a collision fireball.

•The production of charm-strange (D_s) mesons will be enhanced in a Quark Gluon Plasma (quarks deconfined) relative to a hadronic system (quarks confined) because their production is more kinematically favored.

Therefore, A d+Au study can provide a baseline measurement for a future Au+Au measurement of D_s mesons!

Reconstruction Method

Observable by STAR detector

$\pi^+(u\bar{d})$

$K^-(\bar{u}s)$

$K^+(u\bar{s})$

Intermediate State

$\pi^+(u\bar{d})$

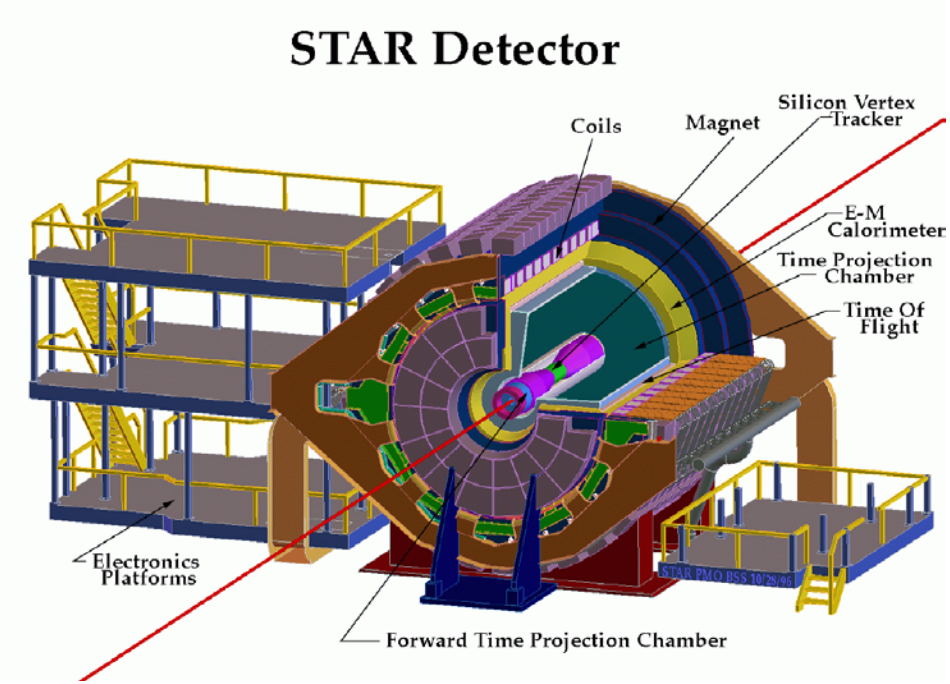
$\phi(s\bar{s})$

Cutting on the ϕ mass will remove a large amount of background.

GOAL!

$D_s^+(c\bar{s})$

The STAR Time Projection Chamber

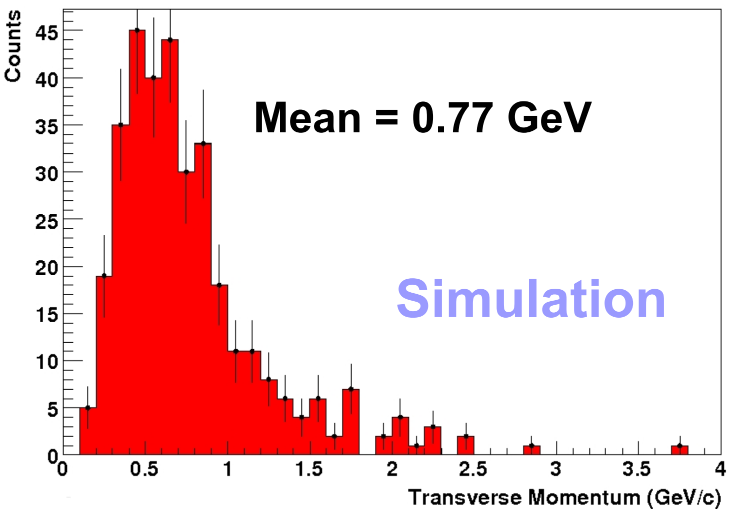


- In this analysis, only data from the STAR Time Projection Chamber (TPC) was used. The TPC measures particles through their ionization of the gas inside the TPC while the particles are under the influence of a magnetic field.
- Minimum bias d+Au collisions at a collision energy of 200 GeV per nucleon were used in this analysis.

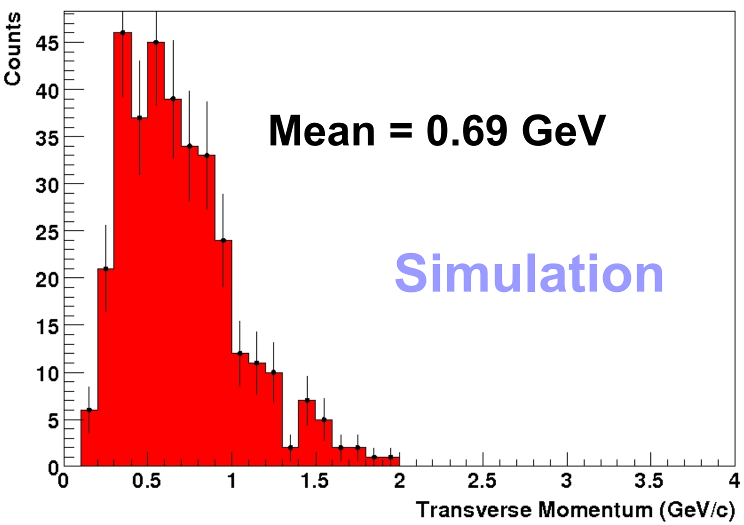
Simulation Study

Simulations show that the $D_s \rightarrow \Phi \pi \rightarrow K^+ K^- \pi$ channel is very promising kinematically. This is because the average p_t of the kaons is relatively low, meaning that they can be cleanly identified in the STAR TPC.

P_t of Accepted π+

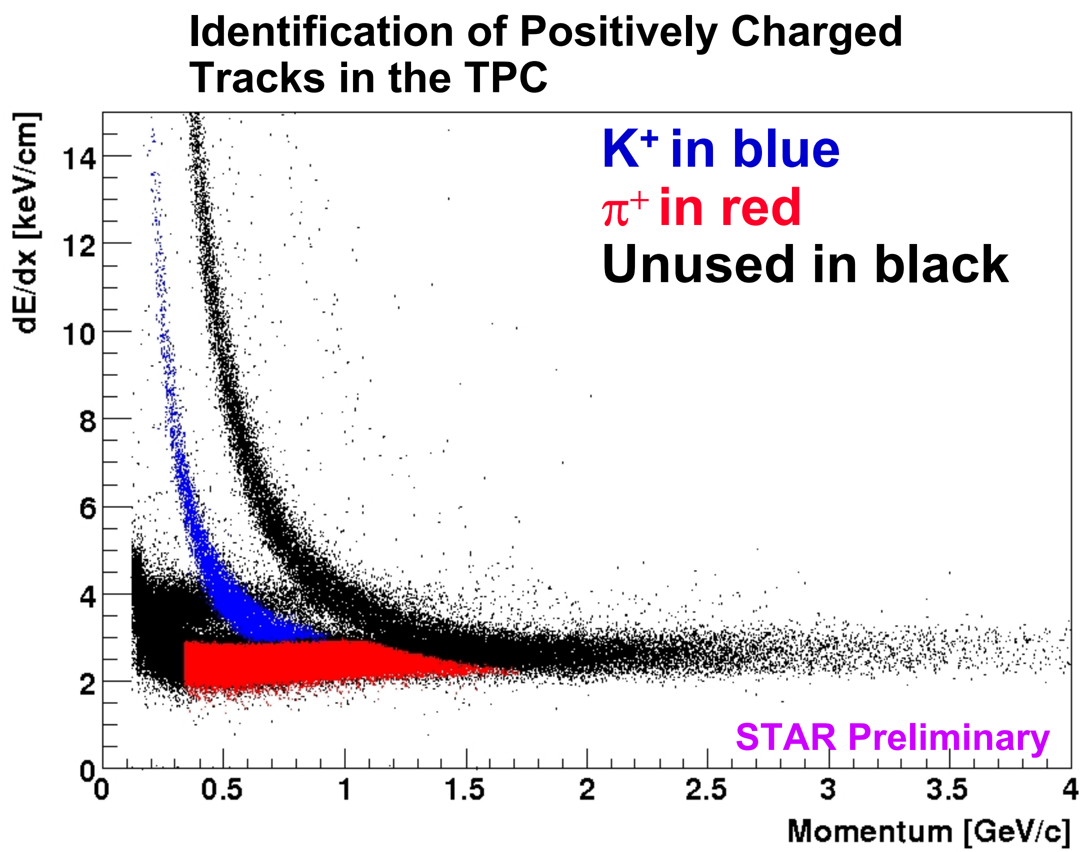


P_t of Accepted K+



Accepted means that there are > 10 hits in the TPC

Particle Identification

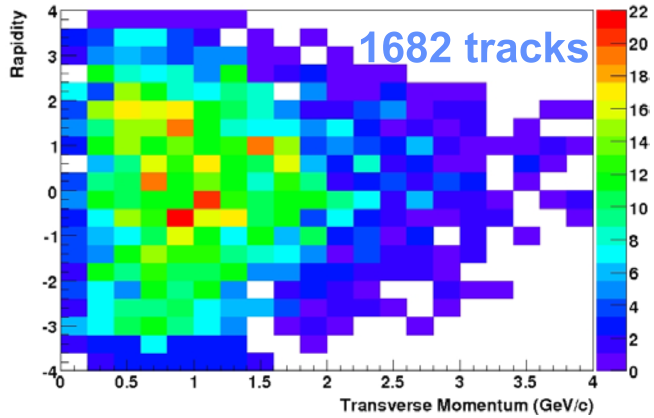


- By using the fact that the three daughters of D_s decay have relatively low momenta, clean tracks can be obtained.
- The kaon band is contaminated by the electrons but it is hoped that the narrow phi mass cut eliminates much of the background added by the electrons.

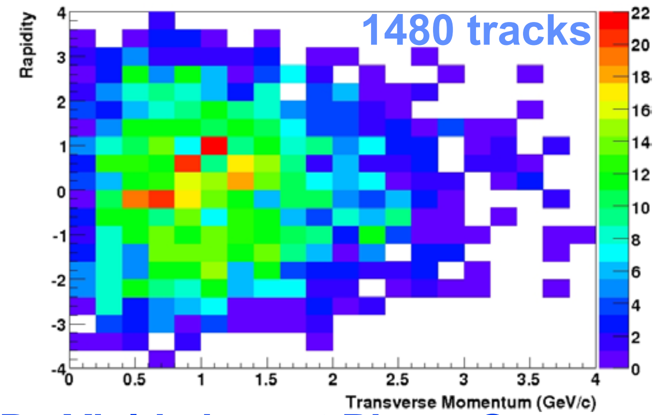
The dE/dx vs. the momenta of the positive tracks used in reconstructing the D_s. The tracks shown here are only a fraction of the total number of tracks for illustrative purposes. The negative track version of this plot looks similar.

Acceptances

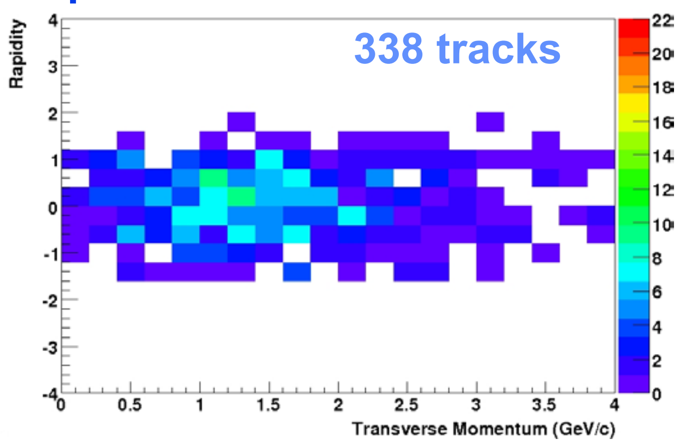
Simulations were done of 100 million pp events. This is equivalent to 13.3 million dAu events if the scaling is by the number of binary collisions.



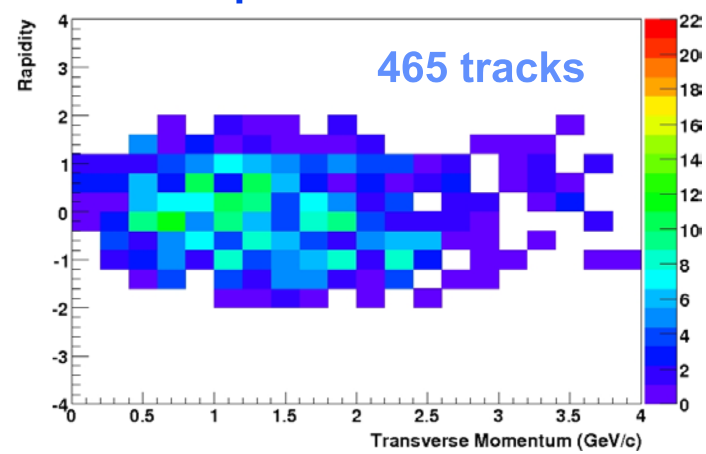
D_s^+ Yields in y-p_t Phase Space before acceptance cuts.



D_s^- Yields in y-pt Phase Space before acceptance cuts

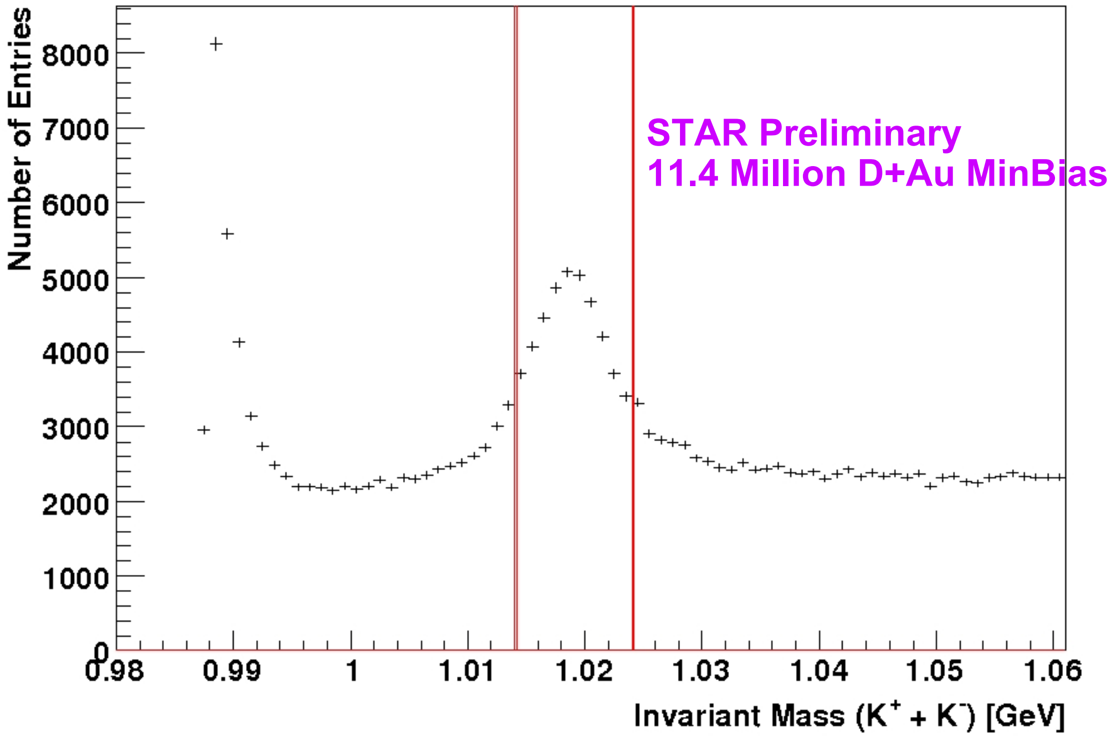


D_s^+ Yields in y-p_t Phase Space before acceptance cuts.



D_s^- Yields in y-pt Phase Space before acceptance cuts.

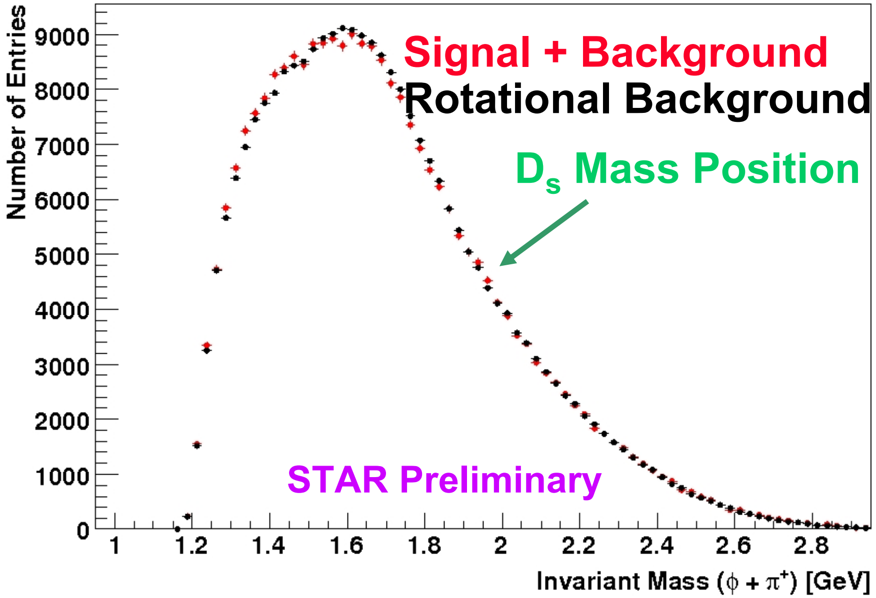
Φ Cuts



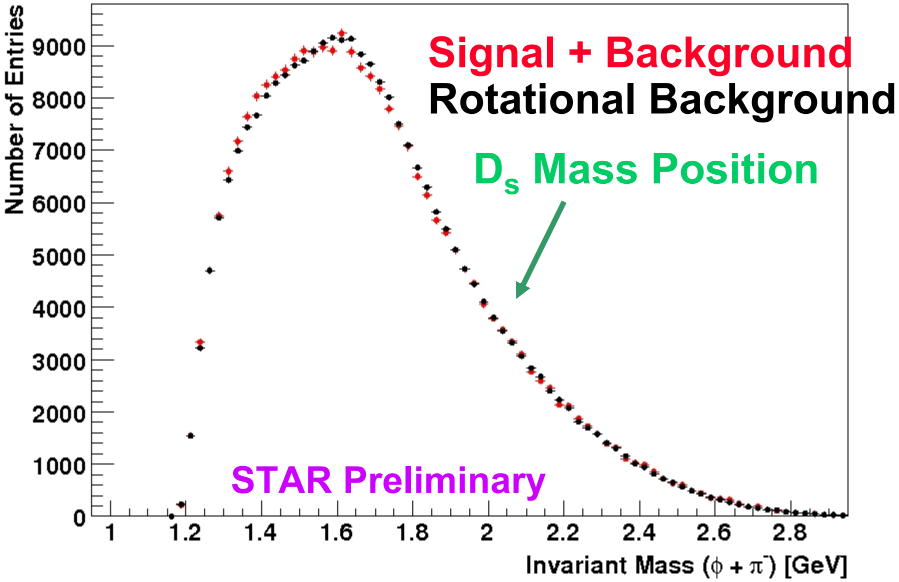
By reconstructing from K^+s and K^-s, a clean ϕ meson peak was obtained. Cuts were done around the phi peak in order to dramatically reduce background. The two red lines in the plot indicate the positions of the invariant mass cuts.

$\Phi + \pi$ Meson Spectra

Reconstructed $\phi\pi+$



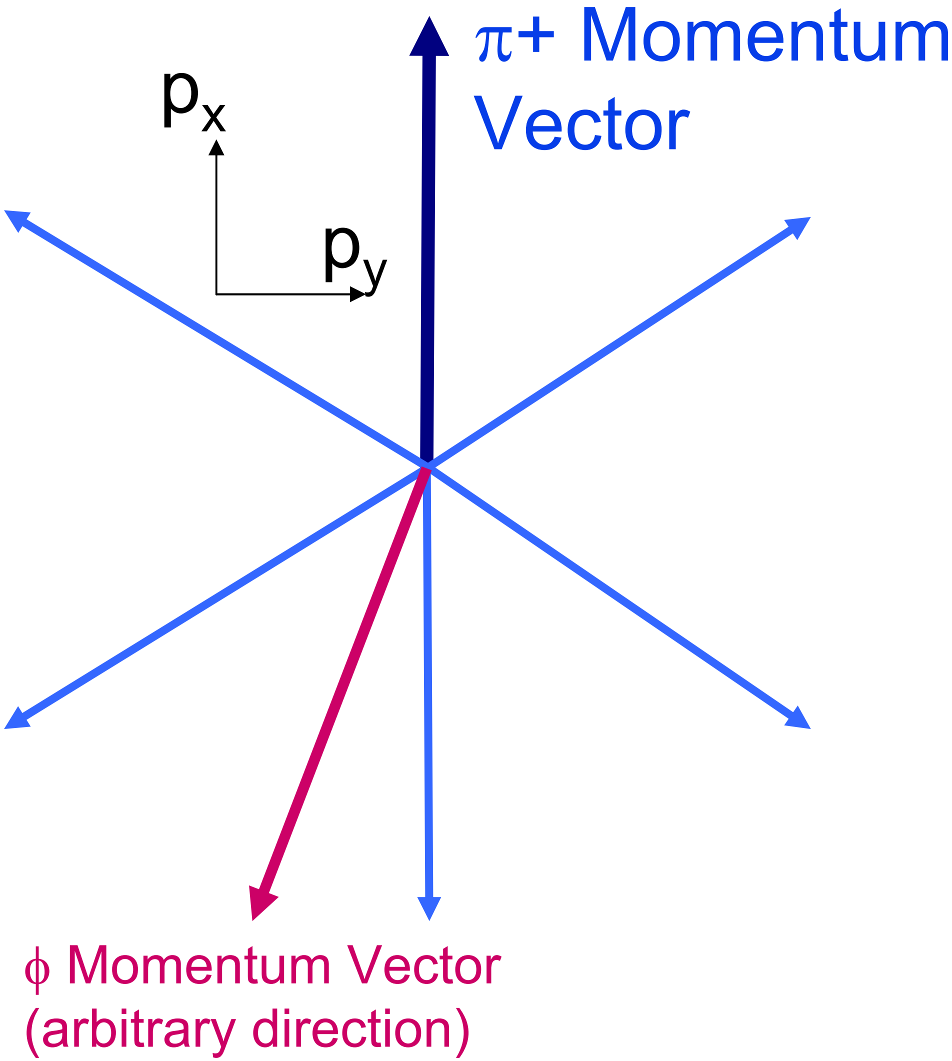
Reconstructed $\phi\pi$-



The rotational background method (explained in the next slide!) seems to do a decent job of reconstructing the background except near the kinematic limit and around the turnover point.

No peaks are evident before background subtraction.

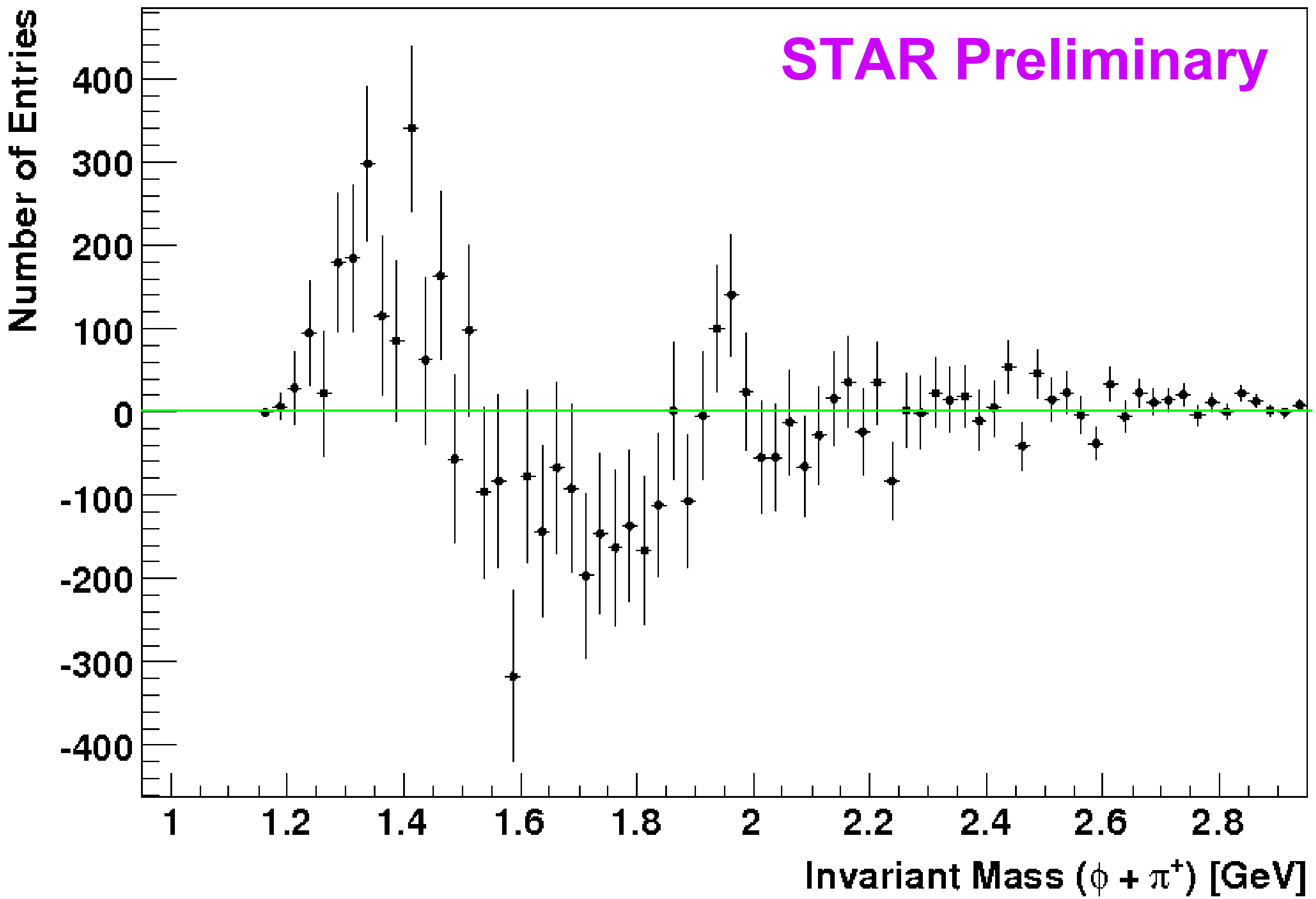
Rotational Background



The background is calculating by rotating the pions's momentum to destroy correlations. The rotated pion's momenta are combined with the phi momentum to create a invariant mass spectrum for the background.

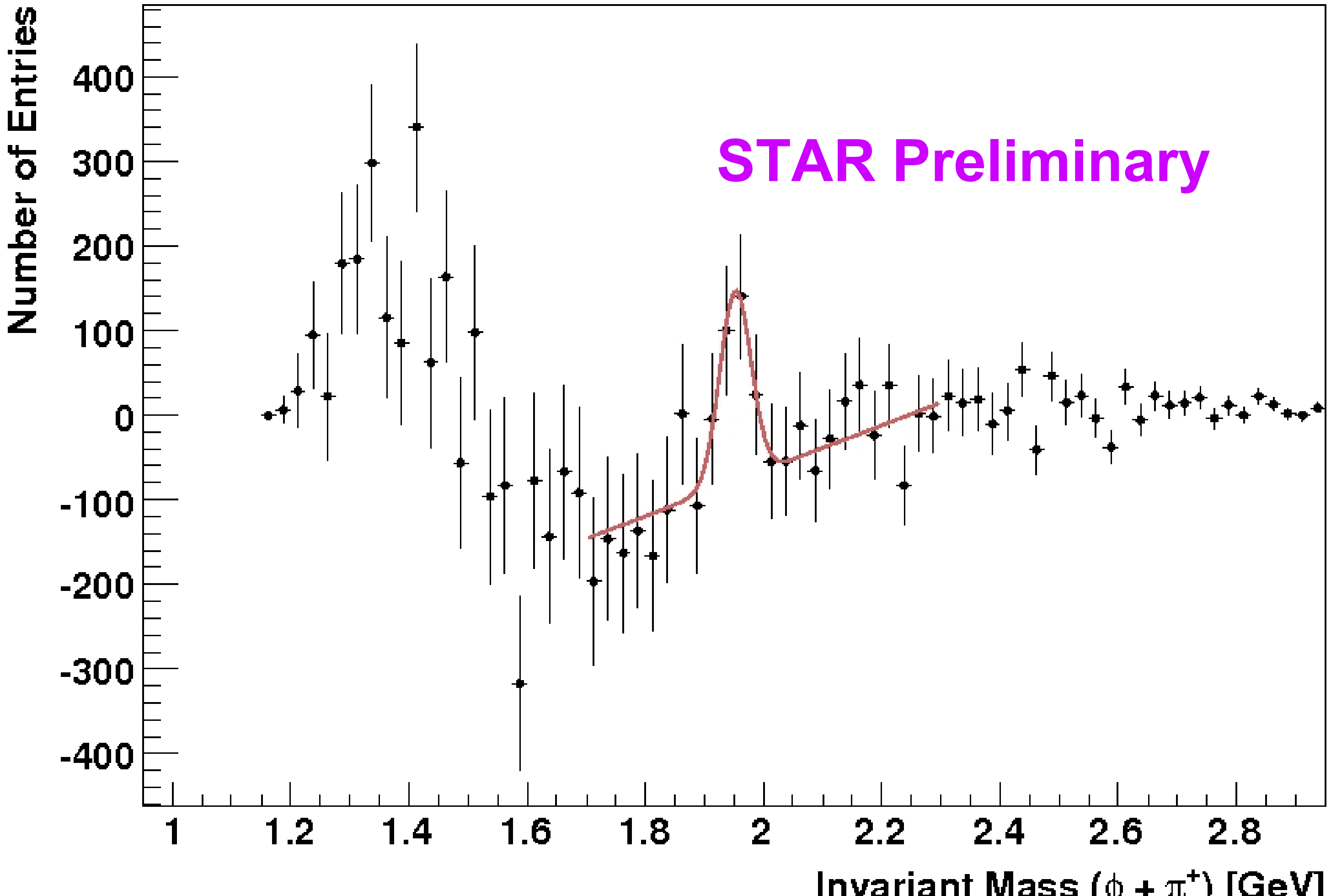
Rotations are done to every 60 degrees starting at 60 degrees from the direction of the original pion momentum vector and ending at 300 degrees. Therefore, a total of 5 background rotations are done.

After Background Subtraction



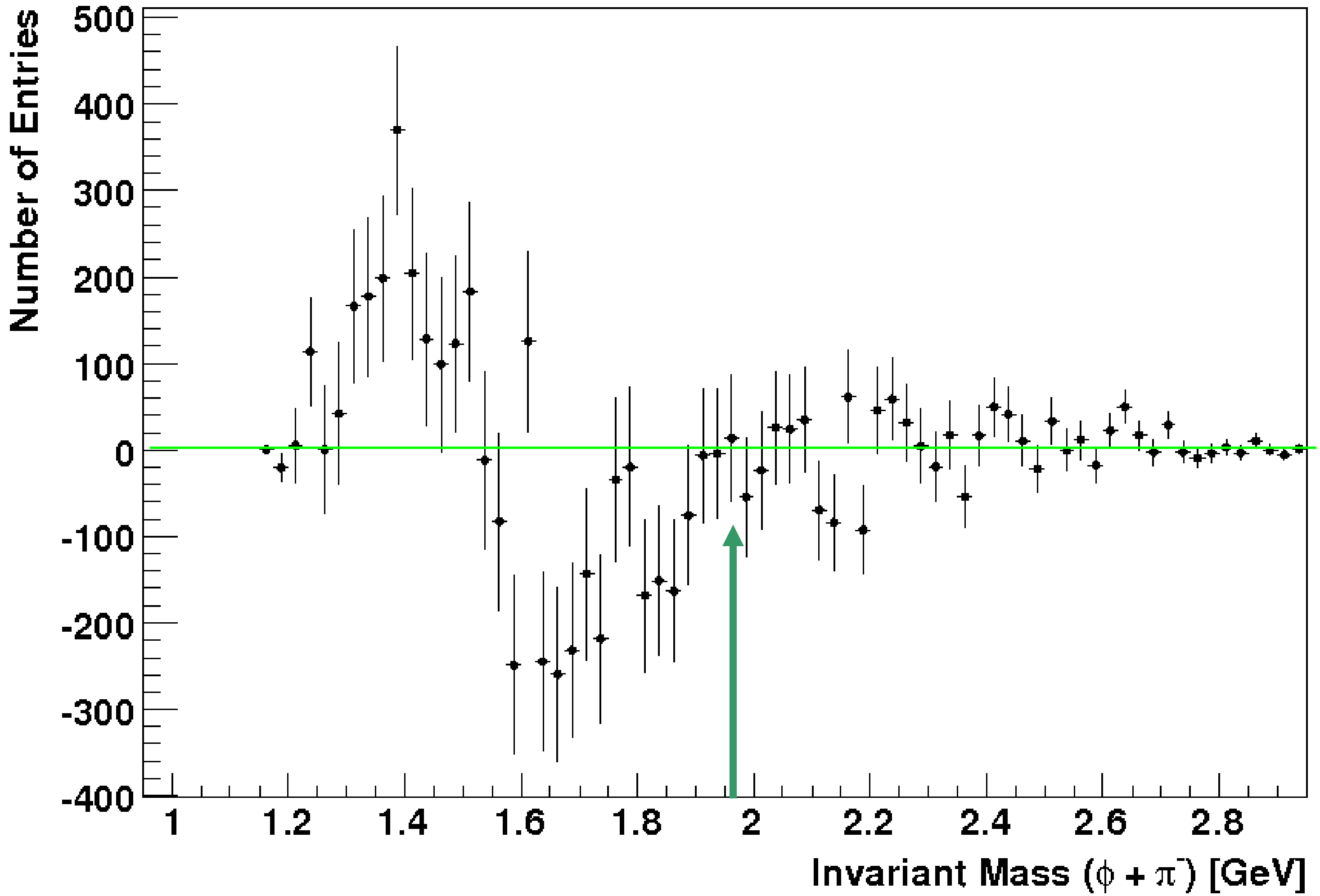
It looks like there might be a possible signal around the D_s mass of 1.9683 GeV. It also looks like there is some structure in the background…

A Gaussian Fit?



This fitted gaussian has a statistical significance of 3.15 with 590 +/- 185 counts within three sigma of the centroid. The centroid is shifted 16 +/- 9 MeV lower than the D_s mass, an effect also observed in the D^0 peak.

Negative Species



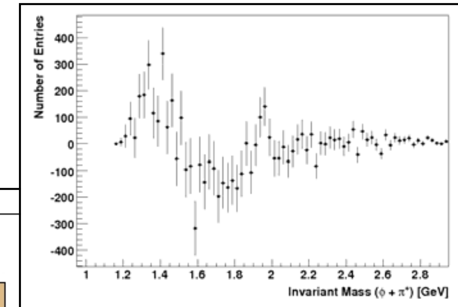
The background structure can still be seen but there does not seem to be anything which can be a candidate for a signal. It is still unknown why the negative particle spectrum is different from the positive one.

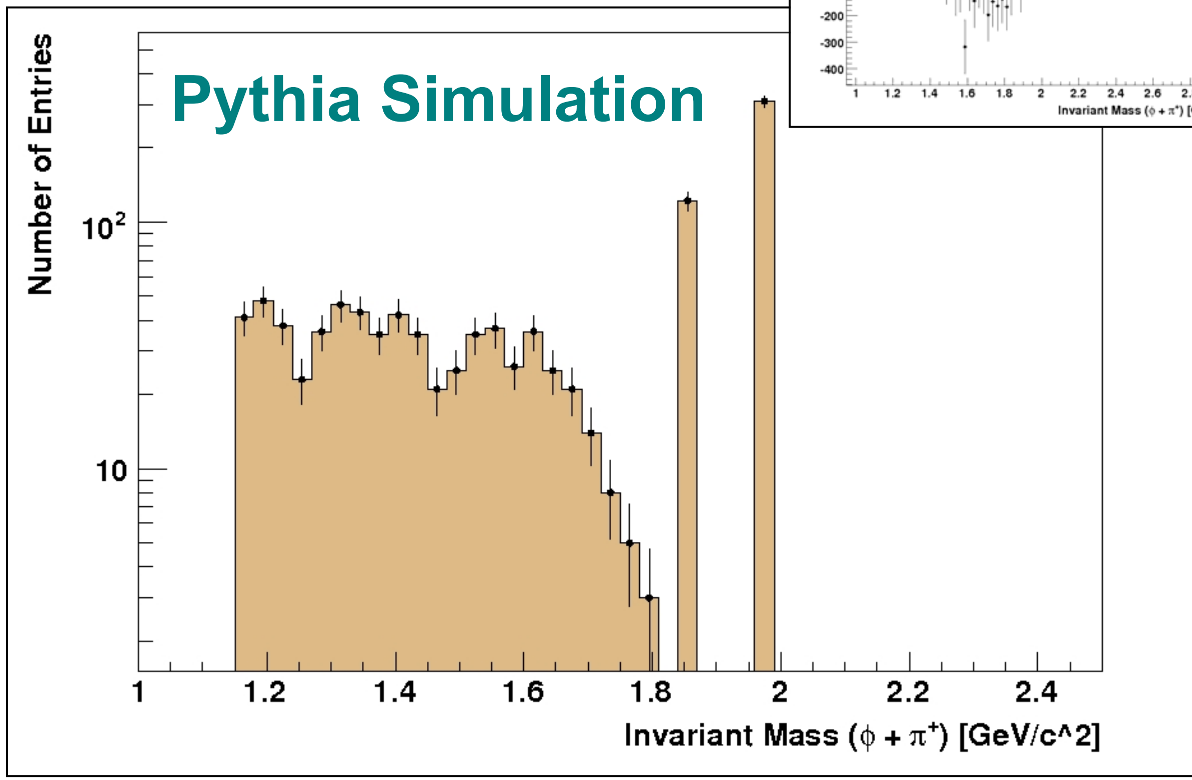
Invariant Mass Prediction

Investigations are being done into why the background subtracted spectra is not flat and seems to have structure. Possible explanations are:

1) This structure is an intrinsic artifact of the way the background is calculated.

2)There are correlations from other decay channels such as $D_s^+ \rightarrow \Phi\pi^+\pi^0$ (Branching Ratio = 9 +/- 5%).

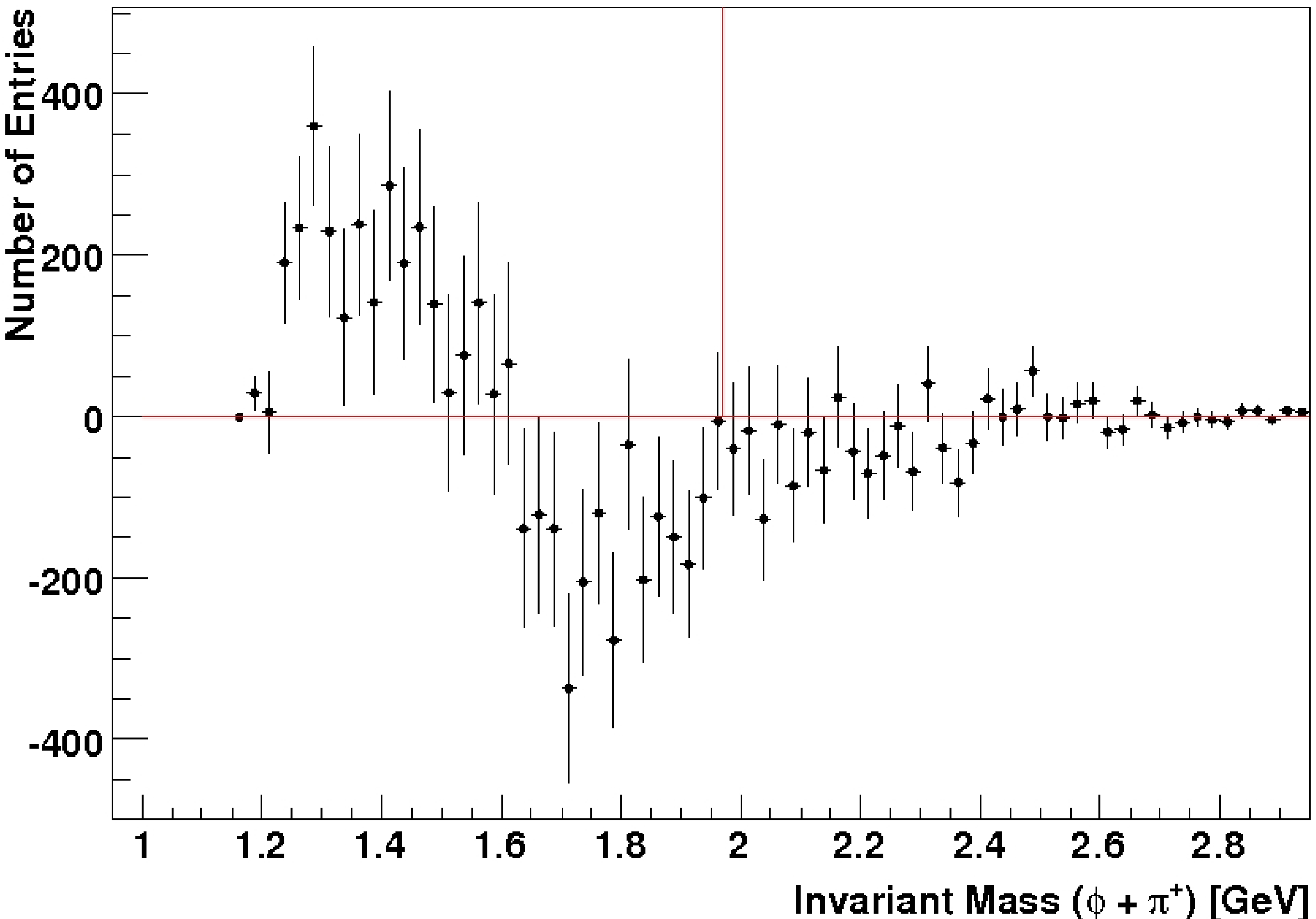




Decays of the D_s^+ and D^+ into ϕ π+ other particles. This may be an explanation of the shape of the background.

Au+Au Work

Au+Au MinBias Centrality > 60%



Nothing Yet! Still Working.

Outlook for the Future

- The residual background must be understood. This will be done through simulation.

- p+p and AuAu datasets must be carefully studied to see if there are any hints of the D_s. This analysis is in progress.

- More d+Au statistics can be used to confirm or reject the evidence for a D_s peak.

- Other charmed particles, such as the Λ_c can be looked at.