Charmed Meson Reconstruction using Silicon Trackers in STAR Experiment at RHIC

- Motivation
- STAR Detector
- Microvertexing
- Results
- Summary and Future

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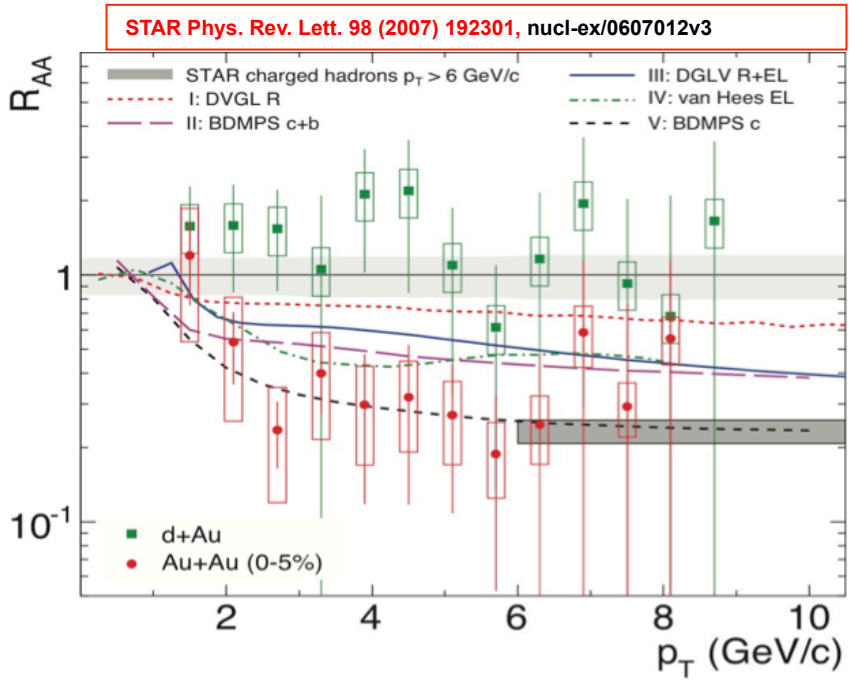
Why Charm Mesons?

❑ **Heavy quarks are produced during the early stages of collision mainly through gluon fusion.**

- ❑ They are unaffected by chiral symmetry restoration
- ❑ Their production cross-section scales with binary collisions

Heavy quarks are ideal to probe the medium created in HI collisions.



❑ Their measurement through semi-leptonic decay channel shows suppression levels comparable to light quarks at $p_T \geq 6$ GeV[1]

$R_{AA}(n.p.e.) \sim R_{AA}(h^{\pm})$!

❑ This contradicts theoretical predictions

- ❑ Dead-cone effect[2]

❑ A measurement of charm elliptic flow, v_2 can tell us if thermalization is reached during early stages of collision.

Need to understand the mechanism of parton energy loss and Thermalization

[1] B. I. Abelev et al (STAR Collaboration), Phys.Rev.Lett.98:192301,2007; Erratum-ibid.106:159902,2011
Adare A et al. (PHENIX Collaboration) 2010 arXiv:1005.1627
*[2] Dokshitzer, Yuri L. and Kharzeev, D. E., Phys. Lett. B**519***

Measurement through Indirect & Direct Methods

Indirect measurement through Semi-leptonic decay channels:

- $D^0 \rightarrow e^+ + X$ (BR : 6.9 %)
- $D^{+/-} \rightarrow e^{+/-} + X$ (BR : 17.2%)

✔ Large p_T range.
✔ Relative contribution of electrons from B and D mesons are unknown.

Direct measurement through Hadronic decay channels

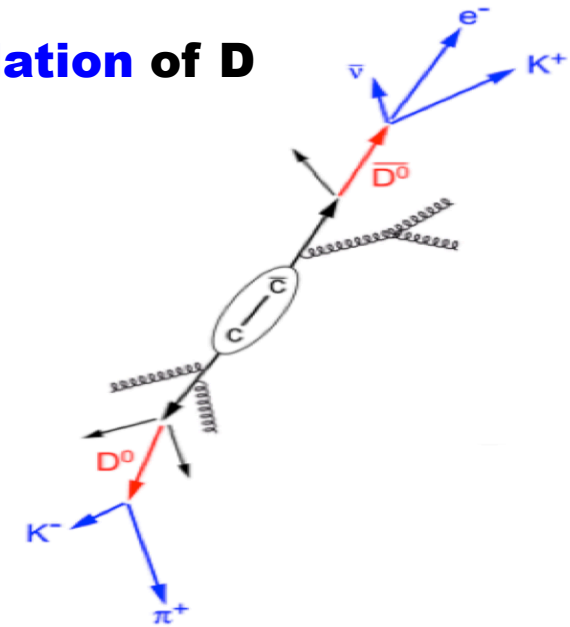
- $D^0(\overline{D^0}) \rightarrow K^-\pi^+(K^+\pi^-)$ (BR : 3.8 %)
- $D^{+/-} \rightarrow K\pi\pi$ (BR : 9.2%)

✔ C and B contributions separated.
✔ Limited to low momentum range.
✔ Challenging for charm mesons due to small decay length

Measurement using azimuthal correlation of D mesons with e^-

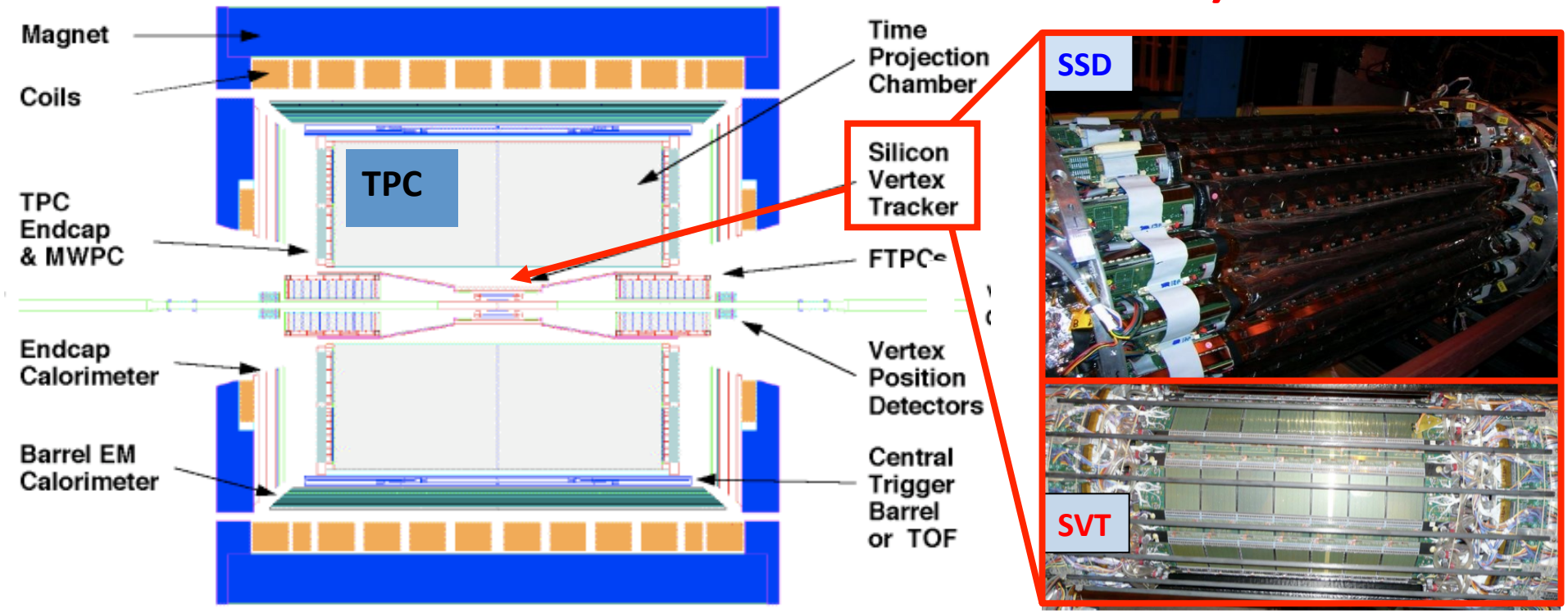
Azimuthal correlation of open charm mesons with non-photonic Electron can be utilized to disentangle the charm and bottom contributions[3]

✔ **Triggers on high p_T electrons**



[3] Phys. Le.. B671(2008) 361, Phys. Rev. Le.. 105 (2010) 202301

STAR detector (in 2007)



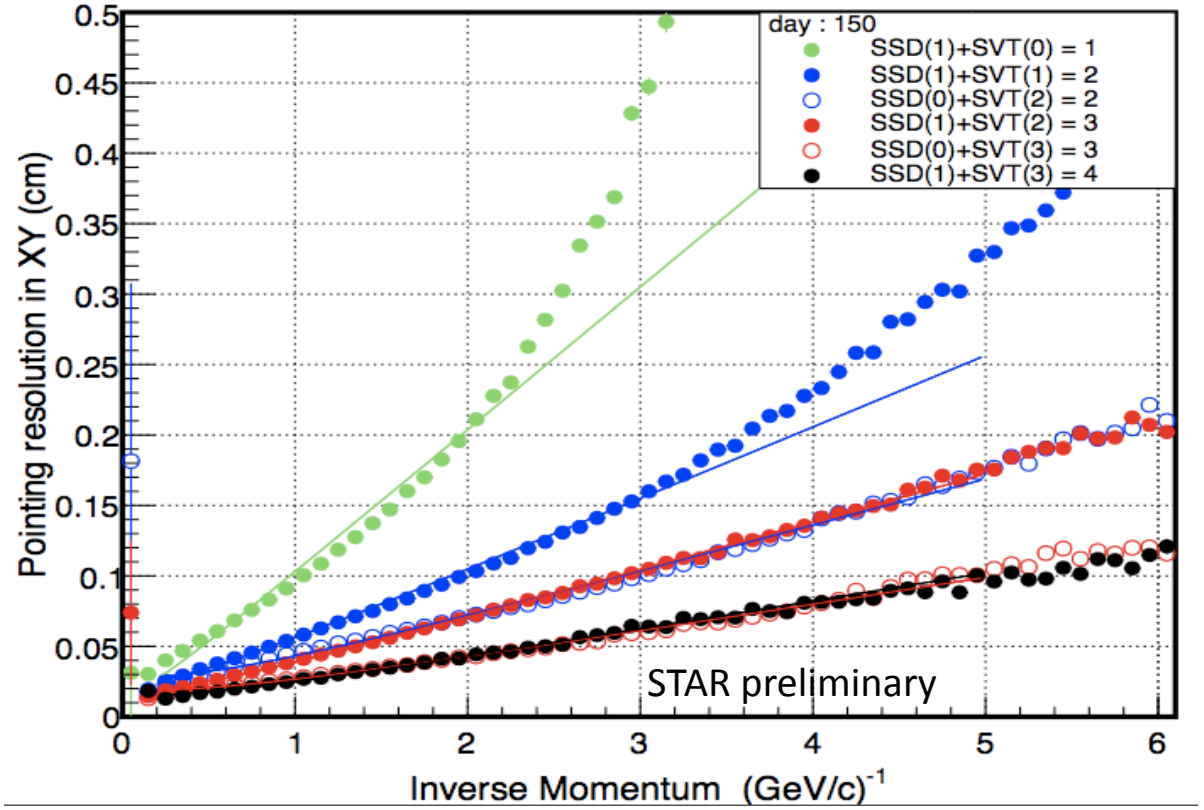
The tracking system consisted of :

- **TPC :** provides momentum, particle identification
- Silicon detectors :
  - 1 layer of silicon **strip** detectors (**SSD**) and 3 layers of silicon **drift** detectors (**SVT**).
  - **high spatial resolution** : pointing resolution of 250μm in transverse direction (at 1GeV) was achieved[*] (next slide).
  - was not designed (thickness, geometry) for charm measurement.

[*] Fisyak Y V et al. 2008 J. Phys. Conf. Ser. 119 032017

Distance of Closest Approach resolution

- run 7 Au+Au@200GeV (MinBias trigger).
- DCA resolution as a function of inverse momentum.
- Reflect the resolution and Multiple Coulomb Scattering.



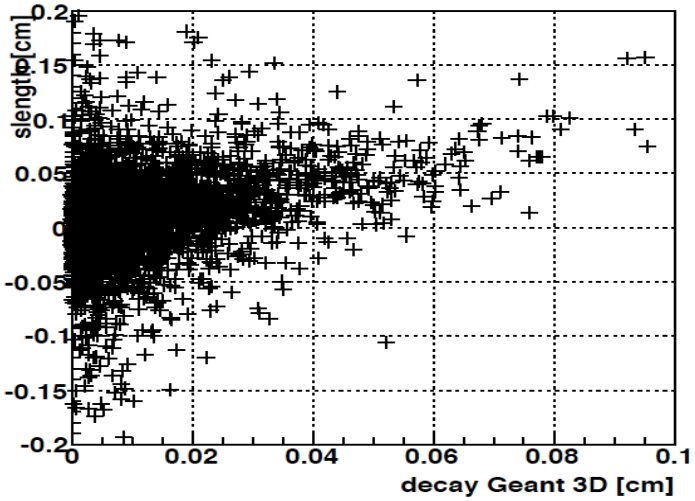
➔Including the silicon detectors in the tracking improves the pointing resolution.

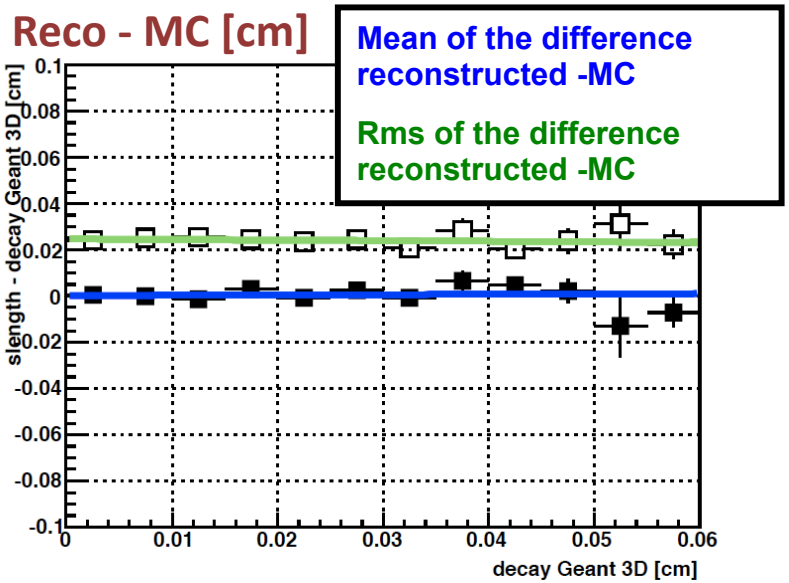
➔with 4 silicon hits, the pointing resolution to the interaction point ~ 250 μm at P = 1GeV/c.

Microvertexing using STAR Silicon Detectors

✧ We tried a **full topological reconstruction** of the charm decay. The method uses a constrained fit for decay vertex reconstruction[*]

✧ The code uses full track/error information.

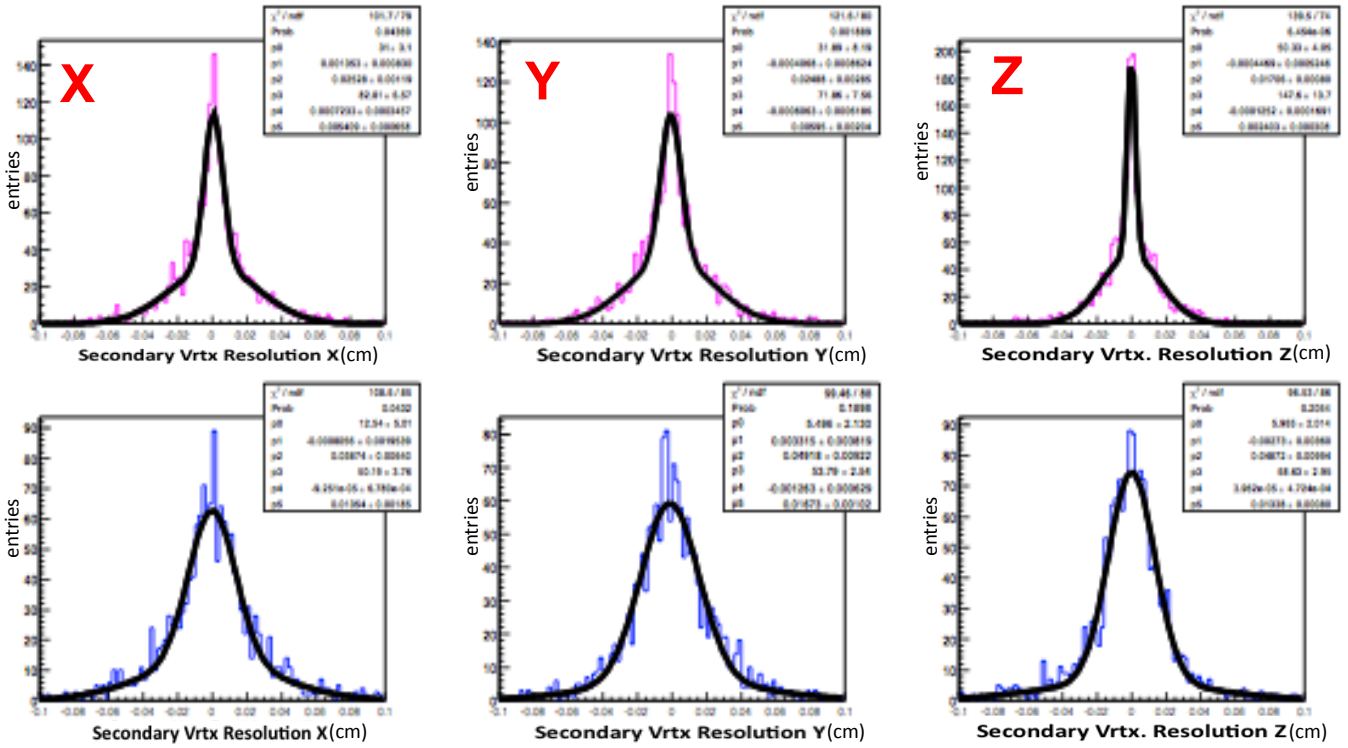




- There is no systematic shift in reconstructed quantities.
- The standard deviation of the distribution is flat at ~ 250 μm , which is of the order of the resolution of (SSD+SVT).

[*] Decay Chain Fitting with a Kalman Filter,W. D. Hulsbergen (arxiv:physics,0503191)

Secondary Vertex Resolution Plots (x,y,z)



Fit Method

(central region)

σ_{XY} ~ 55µm

σ_Z ~ 25µm

Helix Swimming Method

(central region)

σ_{XY} ~ 150µm

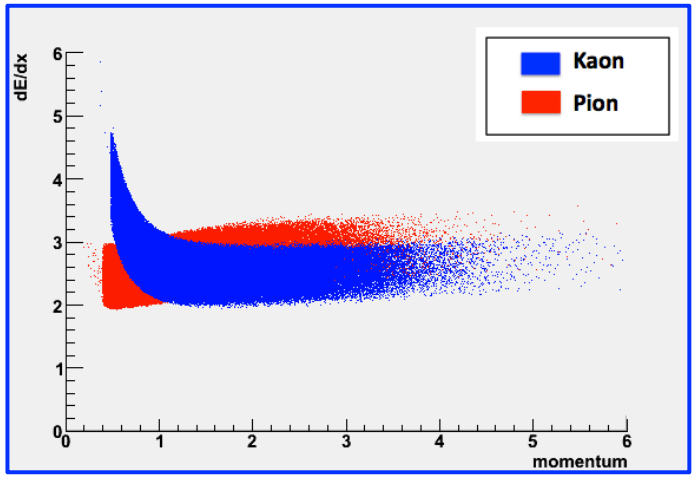
σ_Z ~ 135µm

Simulation results shows that a factor of two was gained in secondary vertex Resolution

D^0/D^0bar Cross-feed

(Monte Carlo using power law p_T D^0)

- The D^0 candidates are built by combining a K^- and π^+ track ($D^0 \longrightarrow K^-pi^+$)
- Because of the overlapping dE/dx bands of Kaon and Pion tracks, at intermediate momenta

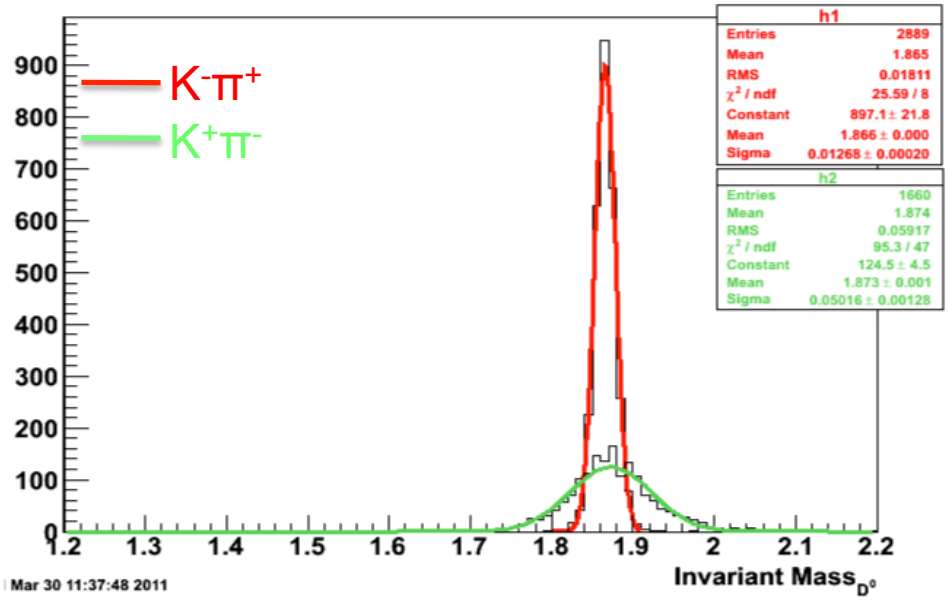


➔ a K^- can be indentified as π^-

➔ a π^+ can be identified as a K^+

➔ Therefore, $K^-\pi^+ \longrightarrow K^+\pi^-$ and can contribute to the the D^0bar mass window and a pseudo-enhancement.

- The X-feed is reduced
  - with a tighter cut on |nσ| (better PID)
  - with increase in p_T
- X-feed has a strong dependence on the Kaon opening angle, Cos(θ*)



The estimated overall X-feed (Ratio of reconstructed pairs with wrong signs to all pairs) ~ 35%

Data Production

Initial analysis of the Au-Au dataset (34 Million Events) is complete. Although the cuts used were not optimized, we got preliminary results from this production (next slides). A new production of run-7 data using the microvertexing code was just completed. Analysis is in progress.

Highlights of this new production/analysis set-up:

- ✓ We calculate the flow parameter, v_2
- ✓ All charge combinations (D^0, D^0bar, ++,--) are included for study of systematics
- ✓ Optimized cuts

New Cuts

Event Level: Primary vertex position along the beam axis : **|zvertex| < 10 cm**
Resolution of the primary vertex position along the beam axis: **$|\sigma_{zvertex}| < 200\mu m$**

Track: **Ratio TPC hits Fitted/Possible > 0.51**
Pseudo-rapidity : **$|\eta| < 1.2$**
dEdxTrackLength>40 cm

Silicon Hits: **SiHit > 1**, radius of 1st Hit < 9cm if SiHit = 2
else, radius of 1st Hit < 13cm
DCA to Primary vertex (transverse), **$DCA_{xy} < .2$ cm**

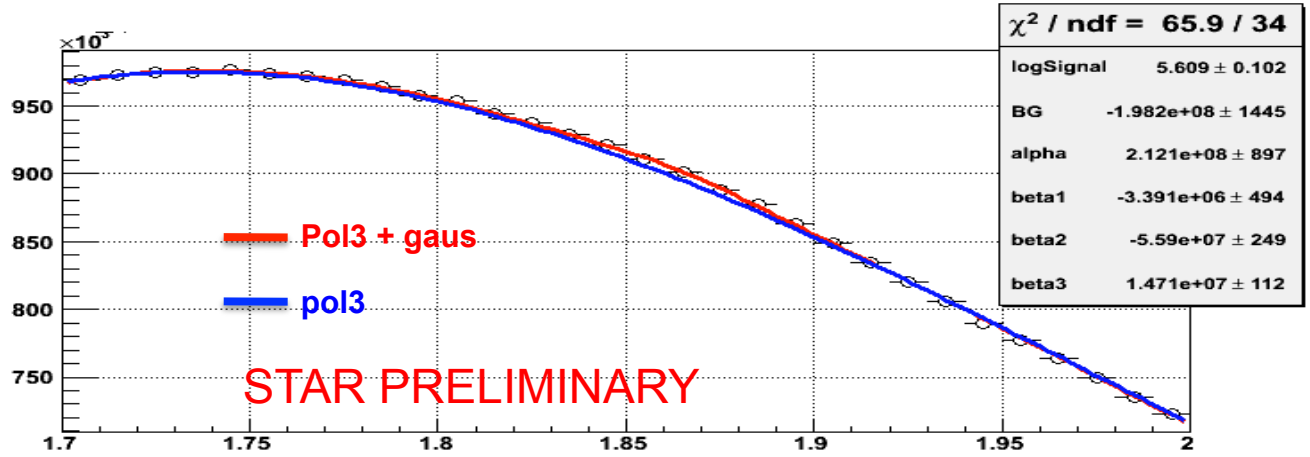
Track momenta: **$p_K + p_\pi > 1.5$GeV**

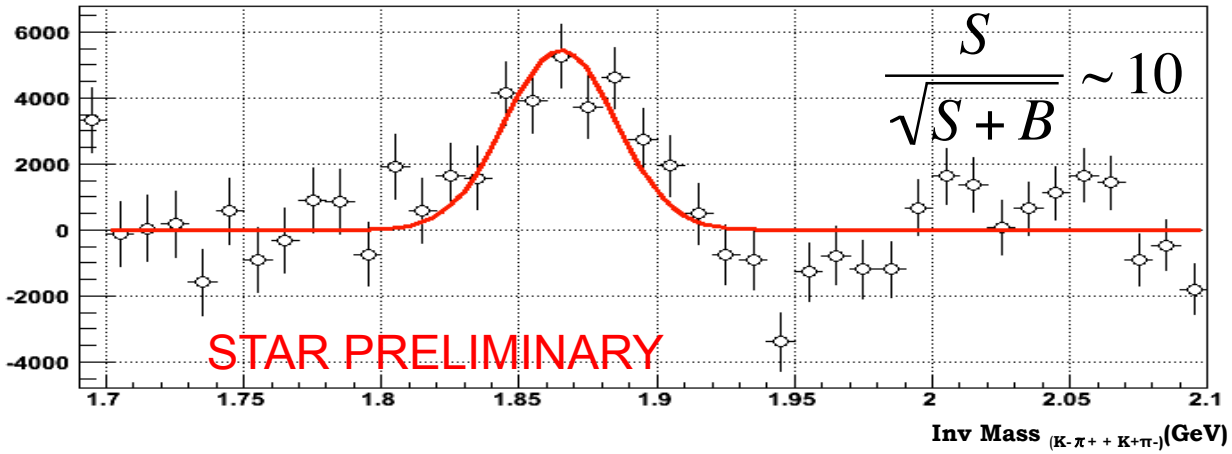
Particle ID: **$|n\sigma_K| < 2.5$, $|n\sigma_\pi| < 2.5$**

D^0 candidate: **$|y(D^0)| < 1$**

DECAY FIT level: **Probability of fit >0.05 && |sLength|<.2cm**

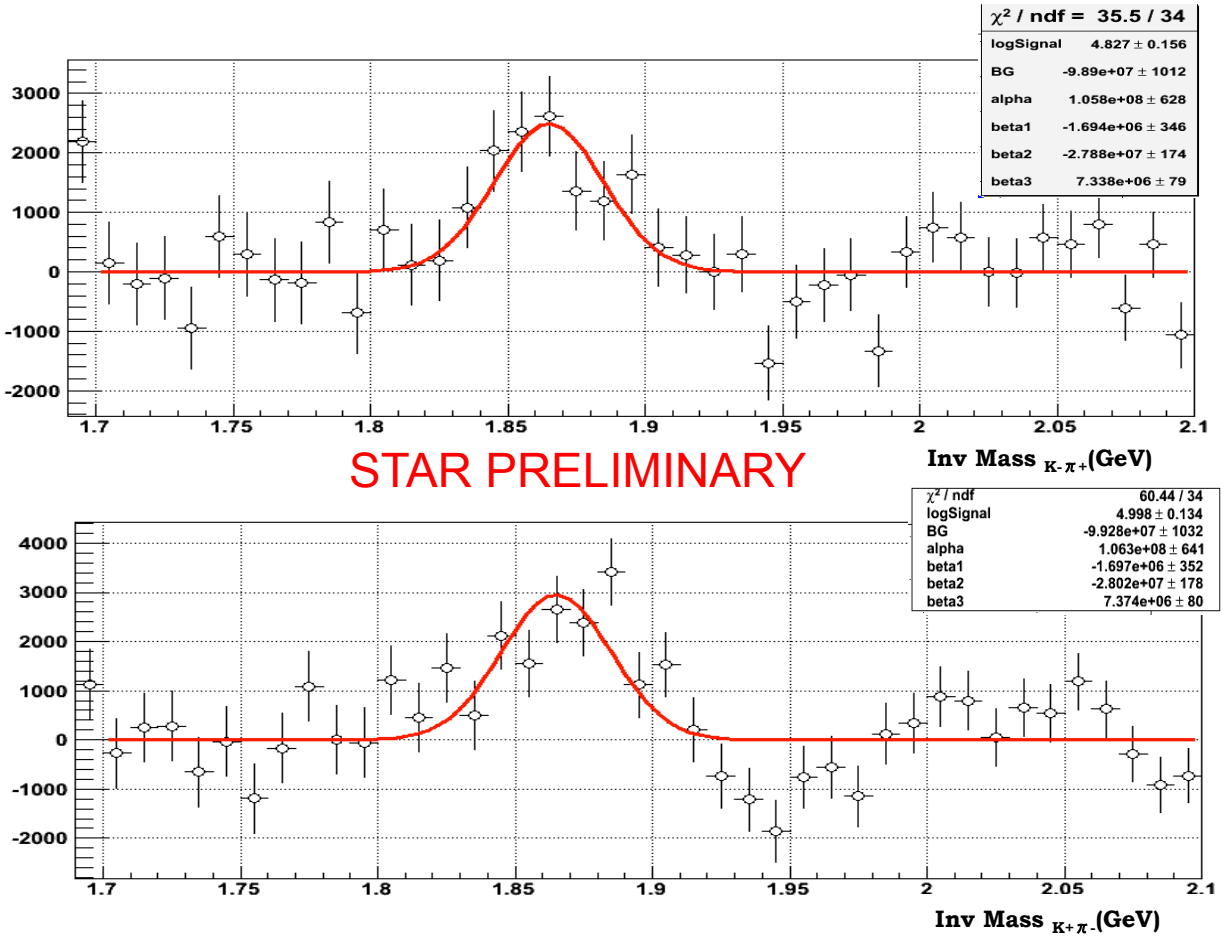
D^0+D^0bar signal in 2007 Data (MinBias Files)





- 34 Million Events used for this analysis.
- Kinematic fit yields an improved significance of 10σ for combined D^0+D^0bar.
- The signal is somewhat sensitive to the degree of the pol. Fit.
- Need a robust backgr. estimation method (new production)

D^0 and D^0bar separately



Preliminary D0bar/D0 ratio ~ 1.05±0.19(stat.)

Summary

- We present progress on a method for full Topological reconstruction of open charm mesons.
- Ongoing efforts to measure cross-section (with smaller errors) and some D^0 flow(v_2)
- Method developed is baseline for analyses involving the future upgrade of STAR – Heavy Flavor Tracker (HFT), which will provide unambiguous measurement of charm.

Thank you

Back-Up

2007 Production MinBias

- cut changed
- new cut

Cuts from Previous Production

EVENT level

triggerId : 200001, 200003, 200013
Primary vertex position along the beam axis :
|zvertex| < 10 cm
Resolution of the primary vertex position along the beam axis:
$|\sigma_{zvertex}| < 200\mu m$

TRACKS level

Number of hits in the vertex detectors :
SiliconHits>2 (tracks with sufficient DCA resolution)
Transverse Momentum of tracks:
p_T >.5GeV/c
Momentum of tracks:
p >.5GeV/c
Number of fitted:
TPC hits > 20
Pseudo-rapidity : **$|\eta|<1$** (SSD acceptance)
dEdxTrackLength>40 cm
DCA to Primary vertex (transverse),
DCA_{xy}< .1 cm

Cuts in New Production

EVENT level

triggerId : 200001, 200003, 200013
Primary vertex position along the beam axis :
|zvertex| < 10 cm
Resolution of the primary vertex position along the beam axis:
$|\sigma_{zvertex}| < 200\mu m$
selects the best vertex only (highest Rank)

TRACKS level

Number of hits in the vertex detectors:
SiliconHits >1
Radius of first hit on track :
< 9 cm if number of silicon hits =2
< 13 cm else
SvtHits < 4, SsdHits < 2
Momentum of tracks
pK+pPi >1.5GeV/c
Ratio TPC hits Fitted/Possible > 0.51
TpcHits fitted > 25
Pseudo-rapidity : **$|\eta|<1.2$**
dEdxTrackLength>40 cm
DCA to Primary vertex (transverse),
DCA_{xy}< .2 cm

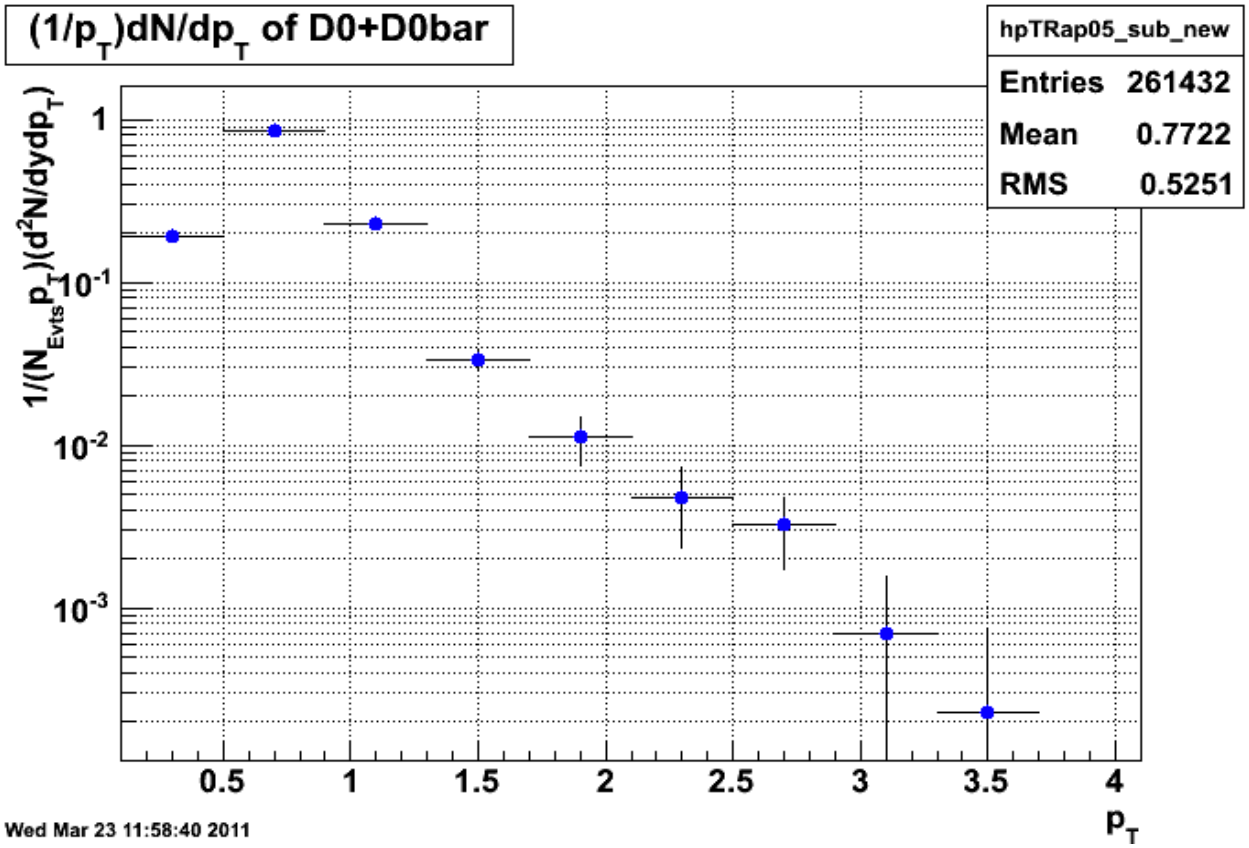
Continued..

Cuts from Previous production	Cuts in New Production
	D^0 candidate $\|y(D^0)\|<1$ $\|\cos(\theta^*)\|<0.8$ $1.2 < Mass_{D0} < 2.2$
DECAY FIT level	**DECAY FIT level**
Probability of fit >0.1 && |sLength|<.1cm	**Probability of fit >0.05 && |sLength|<.2cm** error of decay length: **dslength < 0.1cm**
Particle ID : ndEdx : $\|n\sigma_K\|<2$, $\|n\sigma_\pi\|<2$	Particle ID : ndEdx : $\|n\sigma_K\|<2.5$, $\|n\sigma_\pi\|<2.5$

In both productions we made a pico file for further analysis.

D^0 –p_T distribution

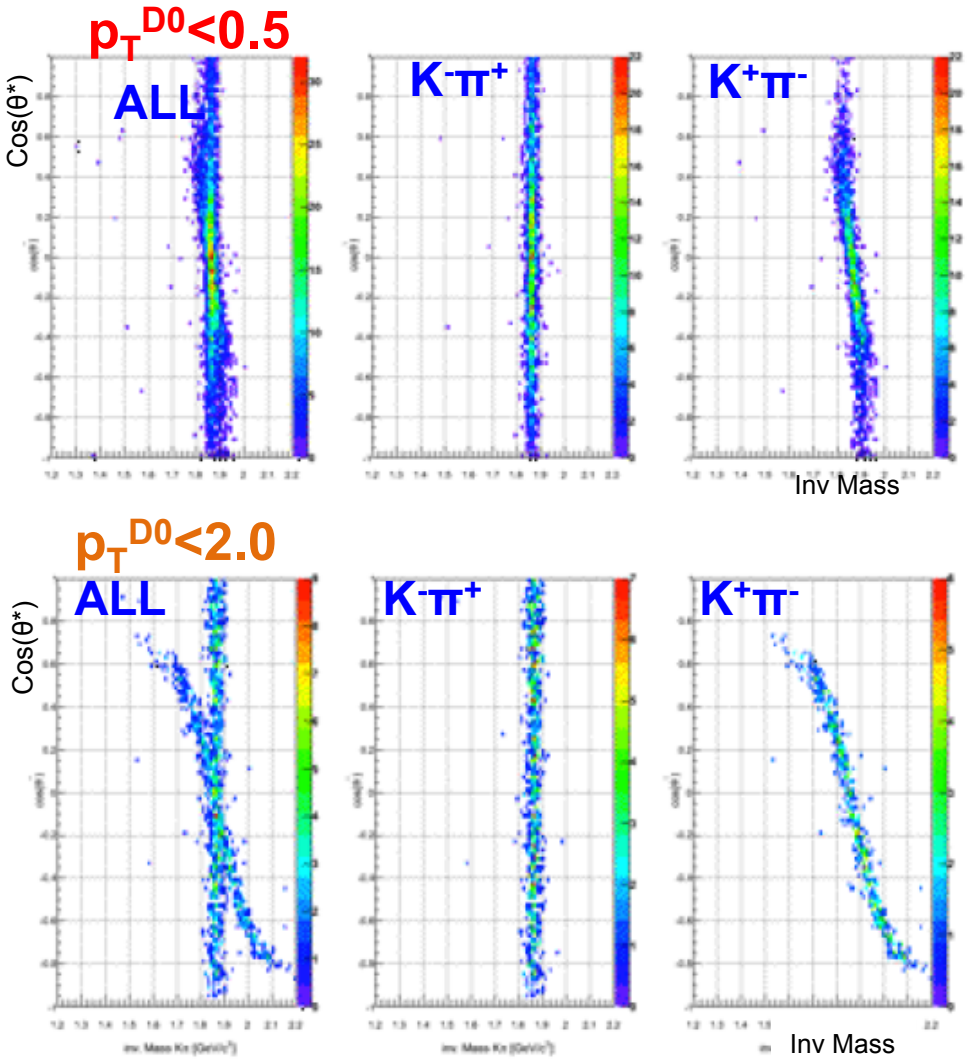
$$\frac{1}{N_{Events} p_T} \frac{d^2 N}{dy dp_T}$$



Uncorrected p_T spectra for D^0+D^0bar

D^0 p_T is done by subtracting from the central mass peak the normalized sum of the side bands.

Cross-feed Vs Kaon Opening Angle in the CM frame



* *The cut |Cos(θ*)|<0.6 removes the poorly reconstructed soft tracks*.

For Low p_T^{D0}:

Both true pairs and misidentified pairs have the distribution going from -1 to 1

For High p_T^{D0}:

The true pairs have the same distribution(-1,1)
Misidentified pairs have shortened tails (-0.8,0.8)

The Cut* |Cos(θ*)|<0.6, can be limited to the low p_T D^0s.