



Paper Proposal



Target Journal : European Physical Journal C (EPJC)

Measurements of inclusive D^0 -meson production in Isobar collisions at $\sqrt{s_{NN}} = 200$ GeV

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Abstract

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We report the first measurements of D^0 -meson production at mid-rapidity ($|y| < 1$) in Isobar collisions ($^{96}\text{Ru} + ^{96}\text{Ru}$ and $^{96}\text{Zr} + ^{96}\text{Zr}$) at $\sqrt{s_{NN}} = 200$ GeV with the STAR experiment. D^0 p_T differential invariant yield with transverse momentum $p_T < 8$ GeV/c are reported at 0-10%, 10-40% and 40-80% centrality bins. The N_{bin} -scale effect of the D^0 p_T spectra between Isobar and Au + Au collision system is observed by using $N_{bin}^{Isobar}/N_{bin}^{AuAu}$ to scale D^0 p_T spectra in Au + Au collisions at 200 GeV. The strong suppression D^0 nuclear modification factor R_{AA} is also observed for $p_T > 3$ GeV/c in the central Isobar collisions, demonstrating that charm quarks suffer significant energy loss in the bulk QCD medium. And model calculations reproduce the feature of our measured R_{AA} suppression phenomenon.



D^0 signal Reconstruction

hadronic modes:

$$D^0 \rightarrow K^- + \pi^+; \bar{D}^0 \rightarrow K^+ + \pi^- (\Gamma_i/\Gamma \sim 3.9\%)$$

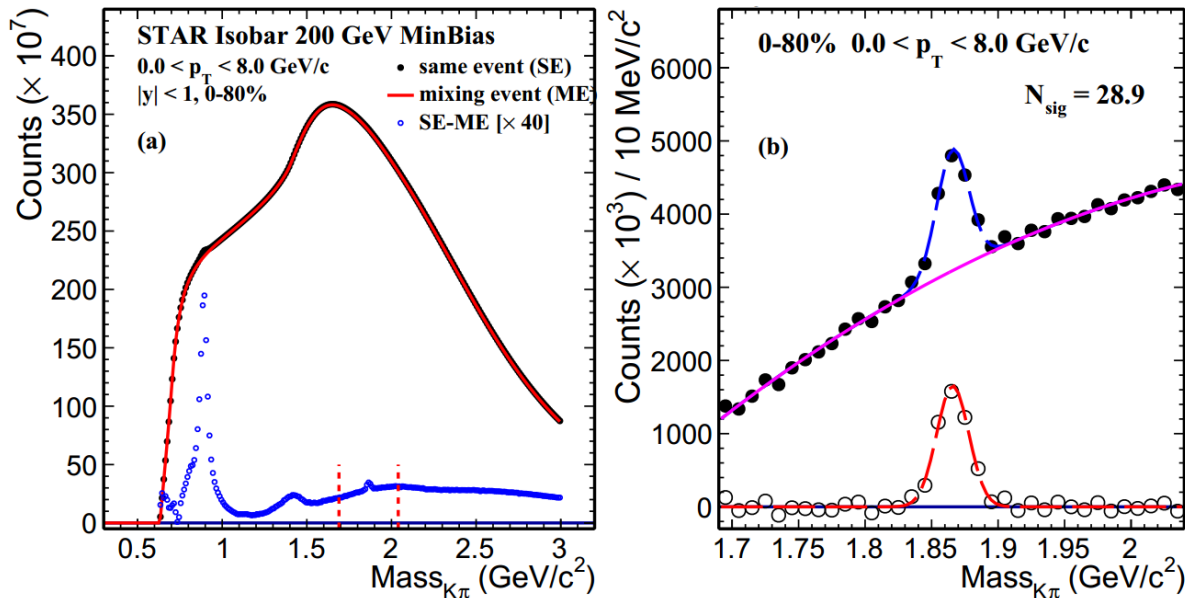


Fig. 3 The K, π invariant mass distribution with centrality 0-80% and p_T range 0-8 GeV/c at midrapidity. On the left panel, the black solid circles depict the unlike-sign distribution under the same event, the red line shows that the mix-event method can well reproduce the combination background and the open blue circles represent the invariant mass distribution after removing the combination background. On the right panel, a Gaussian and quadratic polynomial combination function fitting is applied to extract D^0 raw yield. The signal significance is 28.9 for p_T range 0-8 GeV/c within 0-80% centrality bin.

D^0 signals

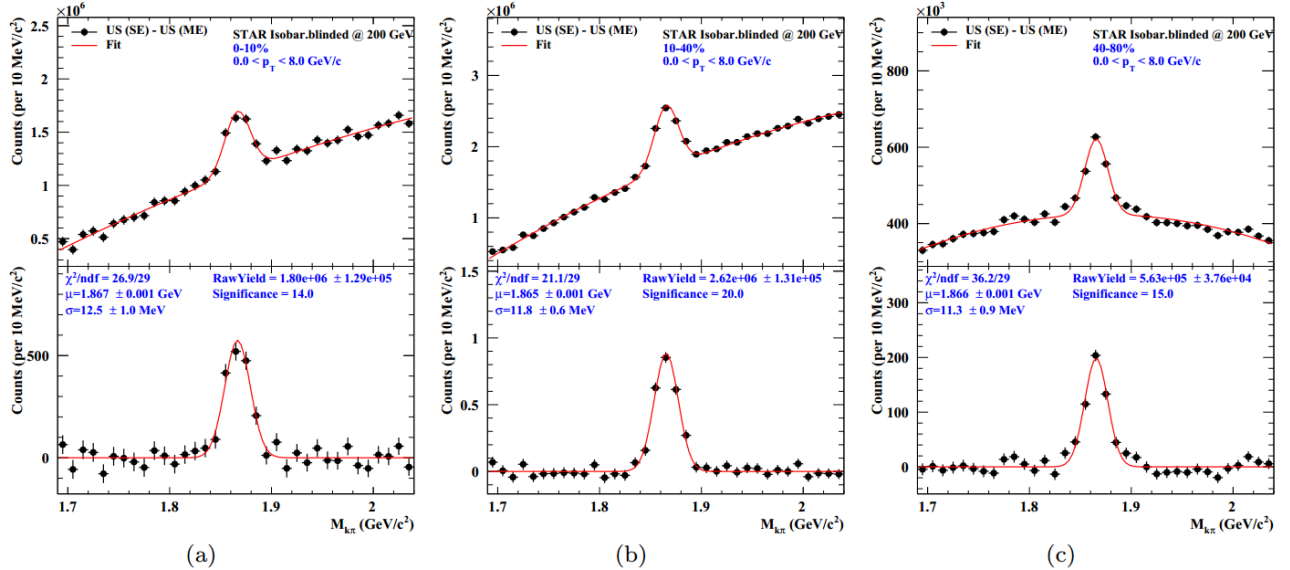


Fig. 4 D^0 signal at 0-10%, 10-40%, 40-80% centrality bins with transverse momentum range 0-8 GeV/c at midrapidity. On the top panel, the solid points show the invariant mass distribution after removing the combination background, and the red line represents a Gaussian and quadratic polynomial combination function fitting. On the bottom panel, the solid points show the D^0 signal after the redundant background is removed, and the red line is a Gaussian function fitting to the signal.



Efficiency correction procedures

$$\frac{d^2 N}{2\pi p_T dp_T dy} = \frac{\Delta N^{raw} / \epsilon_{D^0}^{reco} / 2}{2\pi p_T \Delta p_T \Delta y \times N_{events} \times B.R.}$$

$$\epsilon_{D^0}^{reco} = \epsilon_{Accept} \times \epsilon_{TPC} \times \epsilon_{PID}$$

$$\epsilon_{PID} = \epsilon_{n\sigma_X} \cdot \epsilon_{TOF} \cdot \epsilon_{n\sigma_X}^{TOF} + \epsilon_{n\sigma_X} \cdot (1 - \epsilon_{TOF})$$

- ΔN^{raw} : the raw yield measured in the bin $\Delta p_T \Delta y$;
- $\epsilon_{Accept} \times \epsilon_{TPC}$: TPC acceptance and tracking efficiency (embedding);
- ϵ_{PID} : particle identification efficiency (data).



D^0 Efficiency

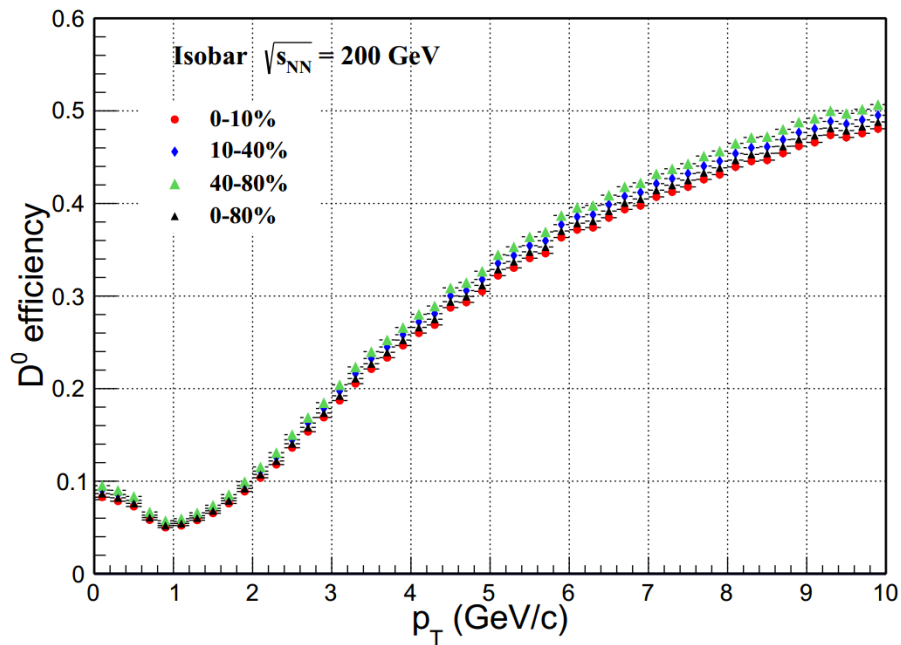


Fig.5. D^0 efficiency as a function of D^0 transverse momentum at 0-10%, 10-40%, 40-80% and 0-80% centrality bins.



Systematic uncertainties

● Signal extraction

- The difference between the fitting and counting methods;
- The order of polynomial function to depict the residual background;
- Signal fit range;
- p_T cut variation for daughter particles;
- Mix-event like-sign normalization factor;

● TPC tracking

- DCA: 2cm (default);
- nHitsFit: 20 (default)

$$R(nHitsFit) = \frac{N_{data}(nHitsFit > 15)/N_{data}(nHitsFit \geq 20)}{N_{emb}^{MC}(nHitsFit > 15)/N_{emb}^{MC}(nHitsFit \geq 20)}$$

● PID cuts 3%

● B.R. 0.5%

● p + p inelastic scattering cross section 8%



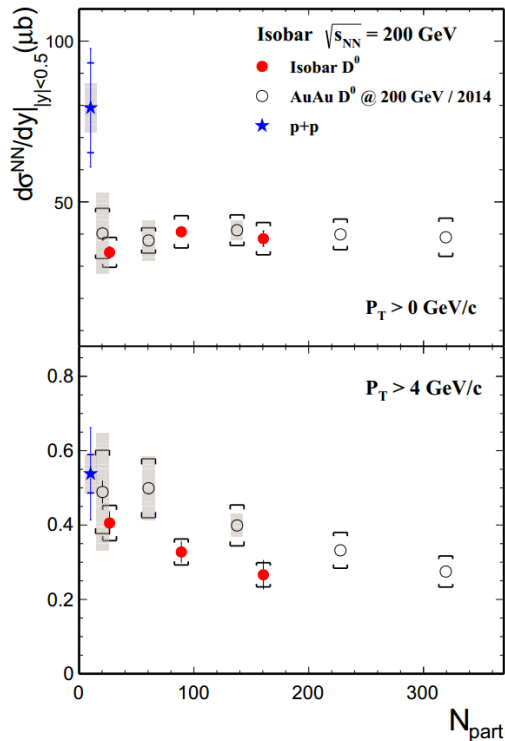
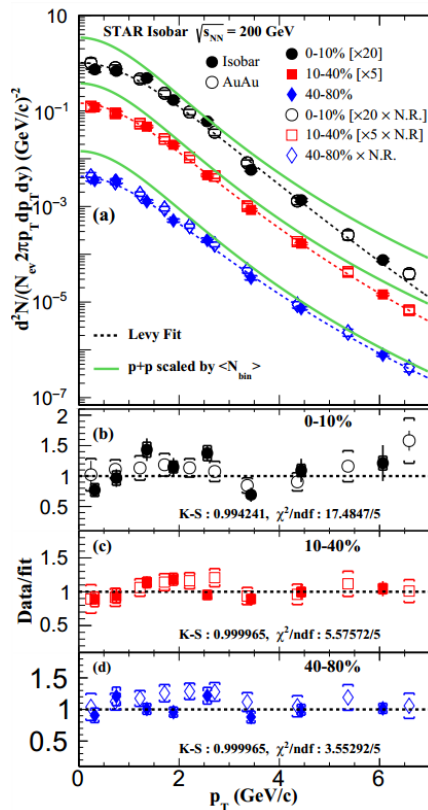
Systematic uncertainties

Table 2 Systematic uncertainties in D^0 analysis

		0-10%	10-40%	40-80%	Correlation in pT
spectra	Raw yield	8.6-14.1%	6.9-12.3%	7.9-12.7%	uncorrelated
	Double counting	0.7%	0.8%	0.9%	uncorrelated
	PID	3%	3%	3%	Largely correlated
	TPC	2-6%	2-6%	2-6%	Largely correlated
	B.R.	0.5%	0.5%	0.5%	global
RAA	<Nbin>	1.6%	0.6%	0.4%	global
	ppbase	20.6-71.8%	20.6-71.8%	20.6-71.8%	partially correlated
		0-10%		10-40%	
Rcp (/40-80%)	Raw yield	11.1-18.2%		9.8-17.1%	uncorrelated
	B.R.	0		0	global
	TPC	0		0	Largely correlated
Integrated cross section		pt>0		pt >4 GeV/c	
	Total	12.3-13.6%		10.7-12.2%	



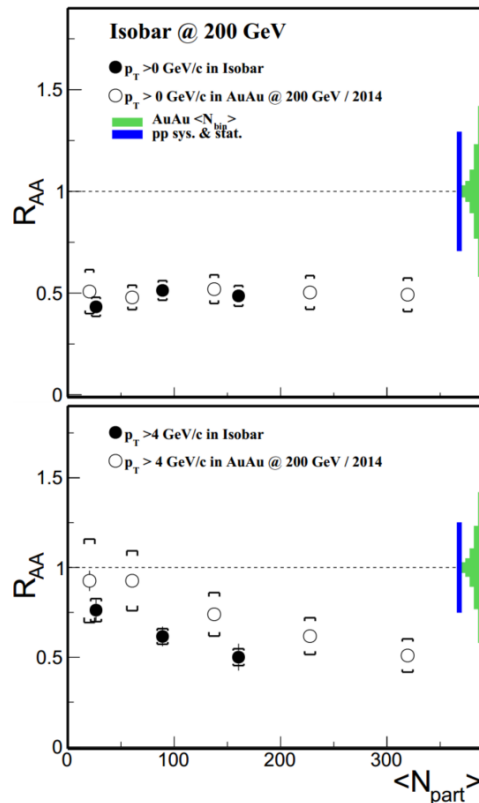
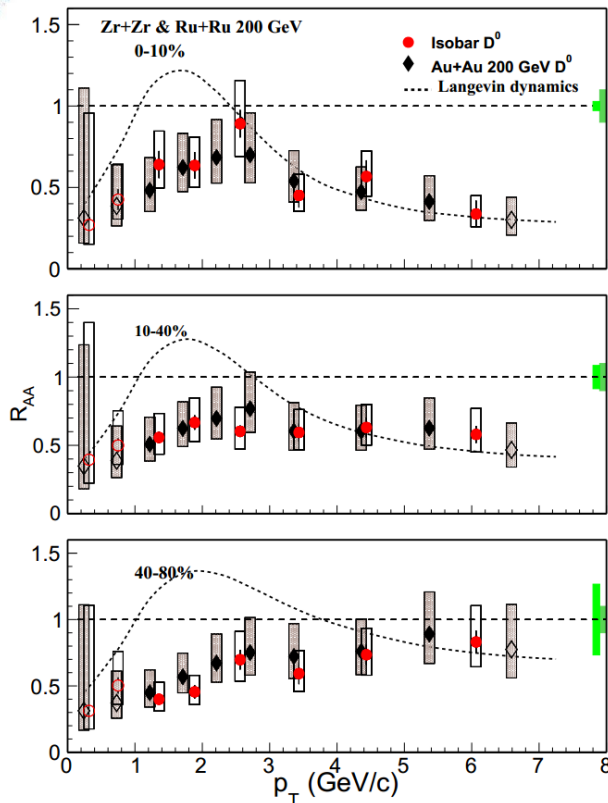
p_T Spectra and Integrated Yields



- Fig.6. D^0 invariant yields at mid-rapidity ($|y|<1$) vs. transverse momentum for different centrality classes in Isobar (solid) and Au + Au (open) collisions at $\sqrt{s_{NN}} = 200$ GeV.
- Fig.7. D^0 integrated cross sections per nucleon-nucleon collision in Isobar.



R_{AA} and R_{AA} vs. N_{part}



- Fig.8. $D^0 R_{AA}$ for different centrality classes in Isobar collisions compared to that of Au + Au results,
- quenching of hard probes.
- Fig.9. D^0 integrated R_{AA} vs. $\langle N_{part} \rangle$ for $p_T > 0$ and $p_T > 4$ GeV/c in Isobar and Au + Au collisions.

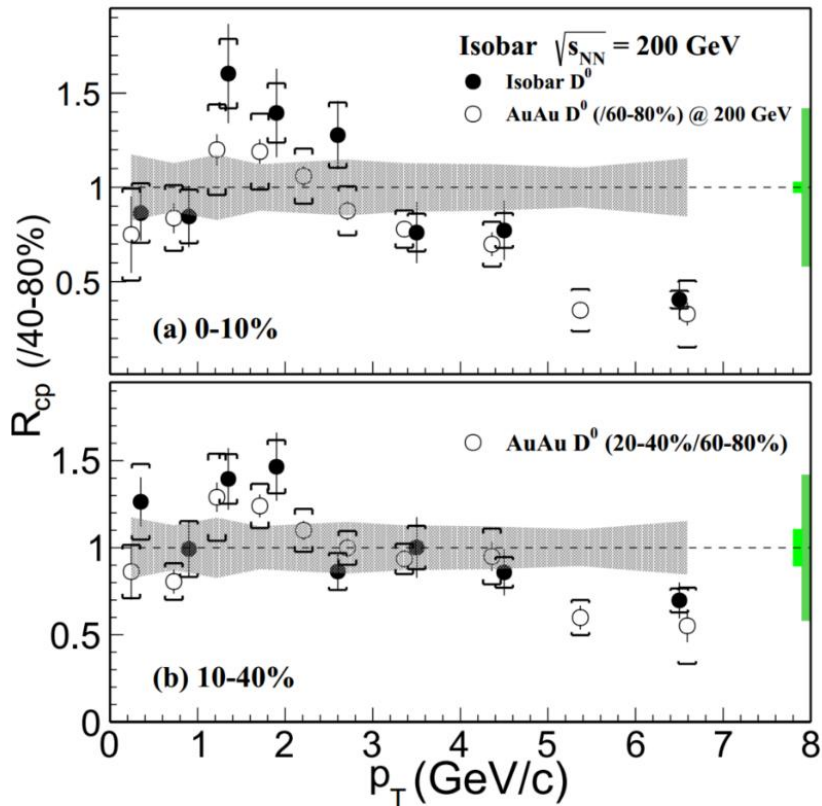
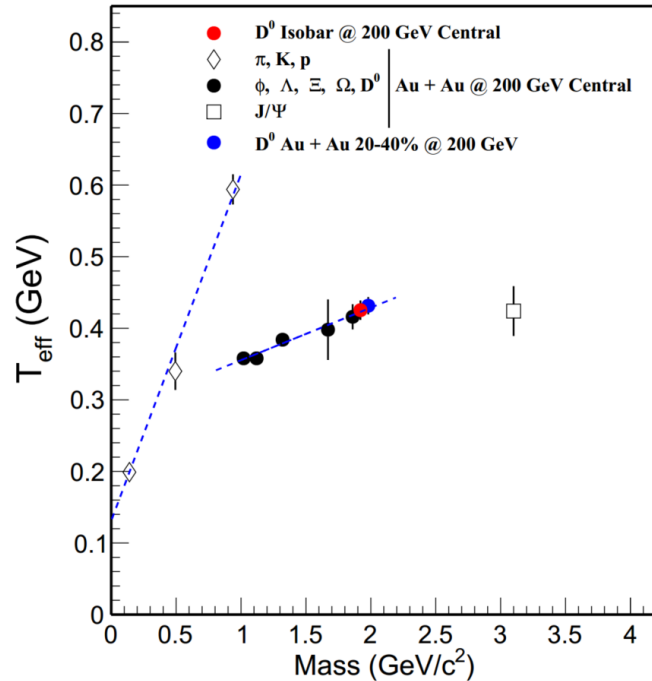
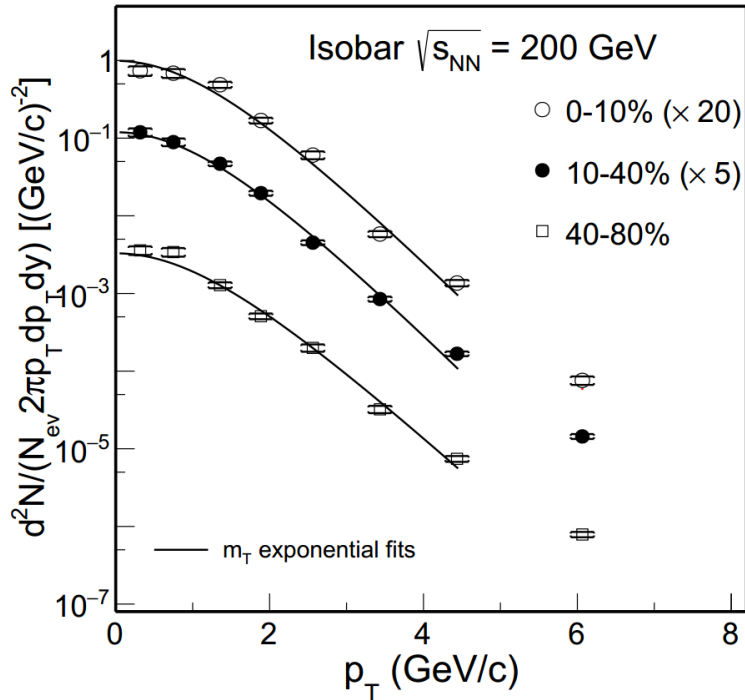


Fig.10. $D^0 R_{CP}$ with the 40-80% spectrum as the reference for 0-10% and 10-40% centrality in Isobar collisions compared to that of Au + Au results.



m_T Spectra and Collectivity

$$\frac{d^2N}{2\pi p_T dp_T dy} = \frac{d^2N}{2\pi m_T dm_T dy} = \frac{dN/dy}{2\pi T_{\text{eff}} (m_0 + T_{\text{eff}})} e^{-(m_T - m_0)/T_{\text{eff}}}$$

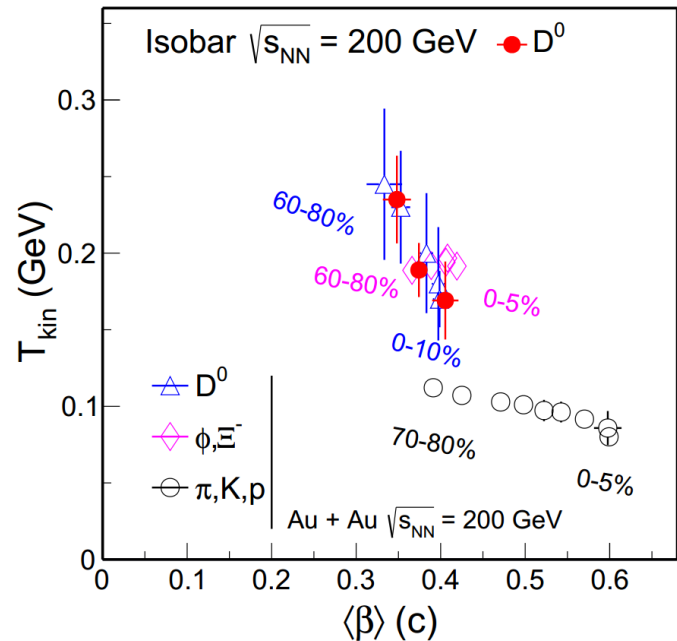
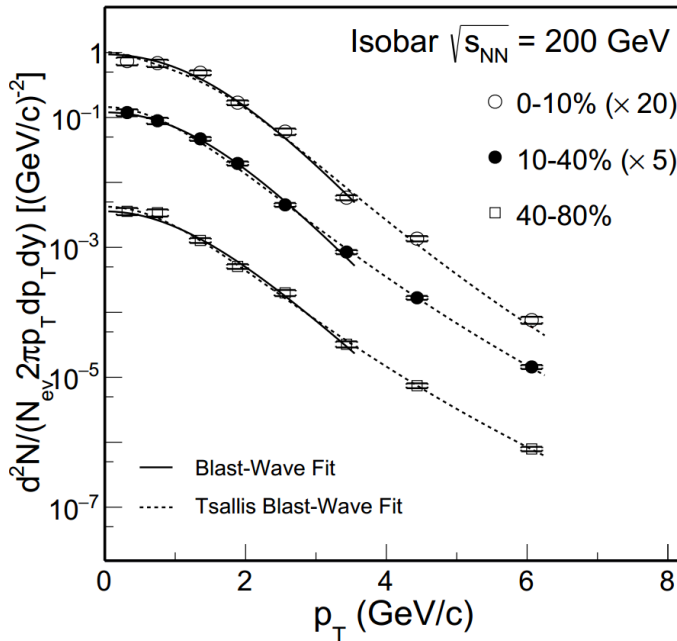


- Fig.11. D^0 invariant yield at mid – rapidity ($|\eta| < 1$) vs. p_T for different centrality bins fitted with m_T distribution.
- Fig.12. T_{eff} for D^0 in central Isobar collisions is consistent with that of Au + Au results.



Blast – Wave Fits

$$\frac{dN}{p_T dp_T} = \frac{dN}{m_T dm_T} \propto \int_0^R r dr m_T I_0 \left(\frac{p_T \sinh \rho}{T_{\text{kin}}} \right) K_1 \left(\frac{m_T \cosh \rho}{T_{\text{kin}}} \right)$$



- Fig.13. D^0 invariant yield at mid – rapidity ($|y| < 1$) vs. p_T for different centrality bins fitted with blast-wave function
- Fig.14. D^0 freeze out temperature in Isobar collisions are consistent with that of in Au + Au collisions for the same centrality.