Update on D^0 analysis progress in Isobar collisions

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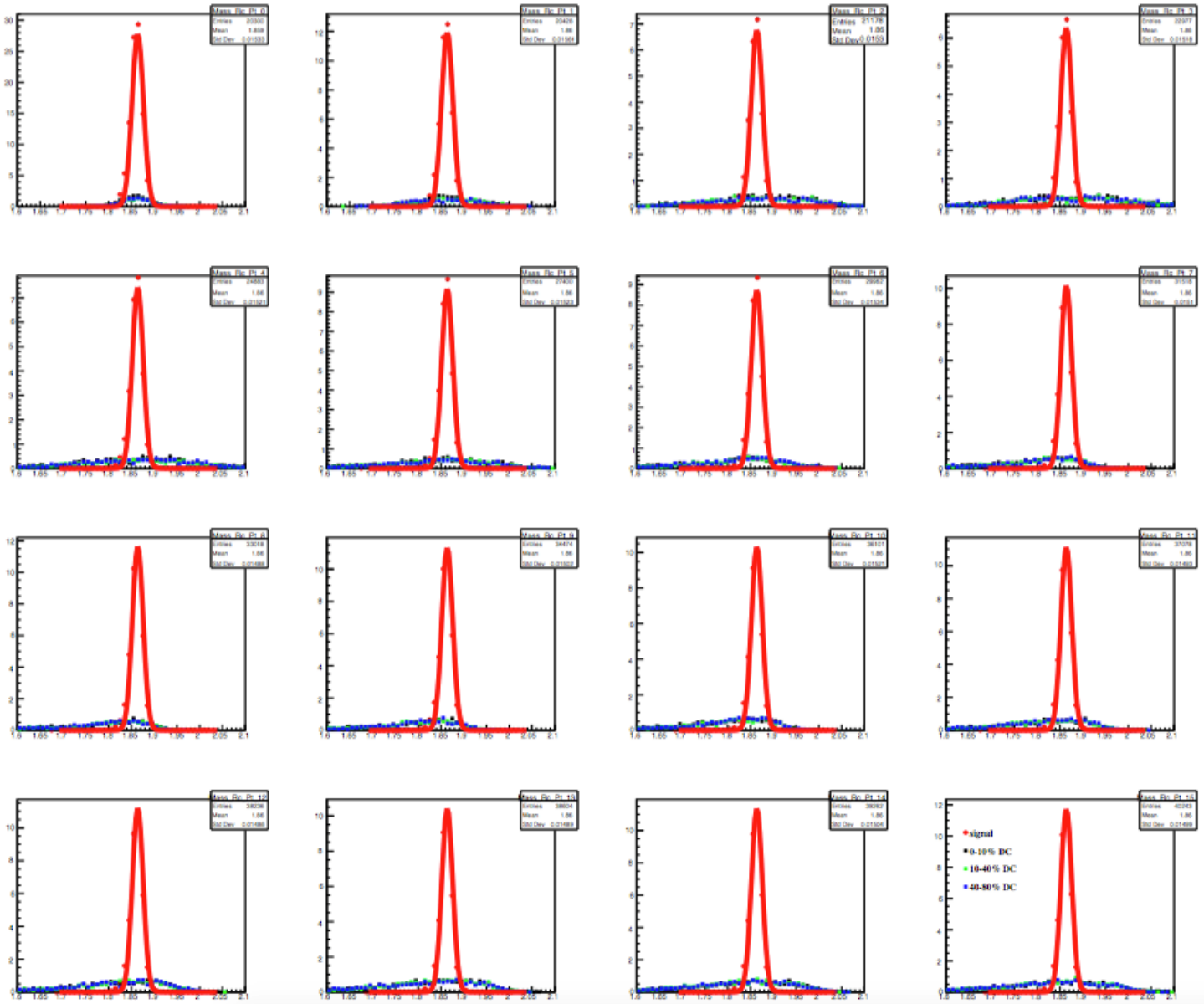
D^0 Double-counting Estimation



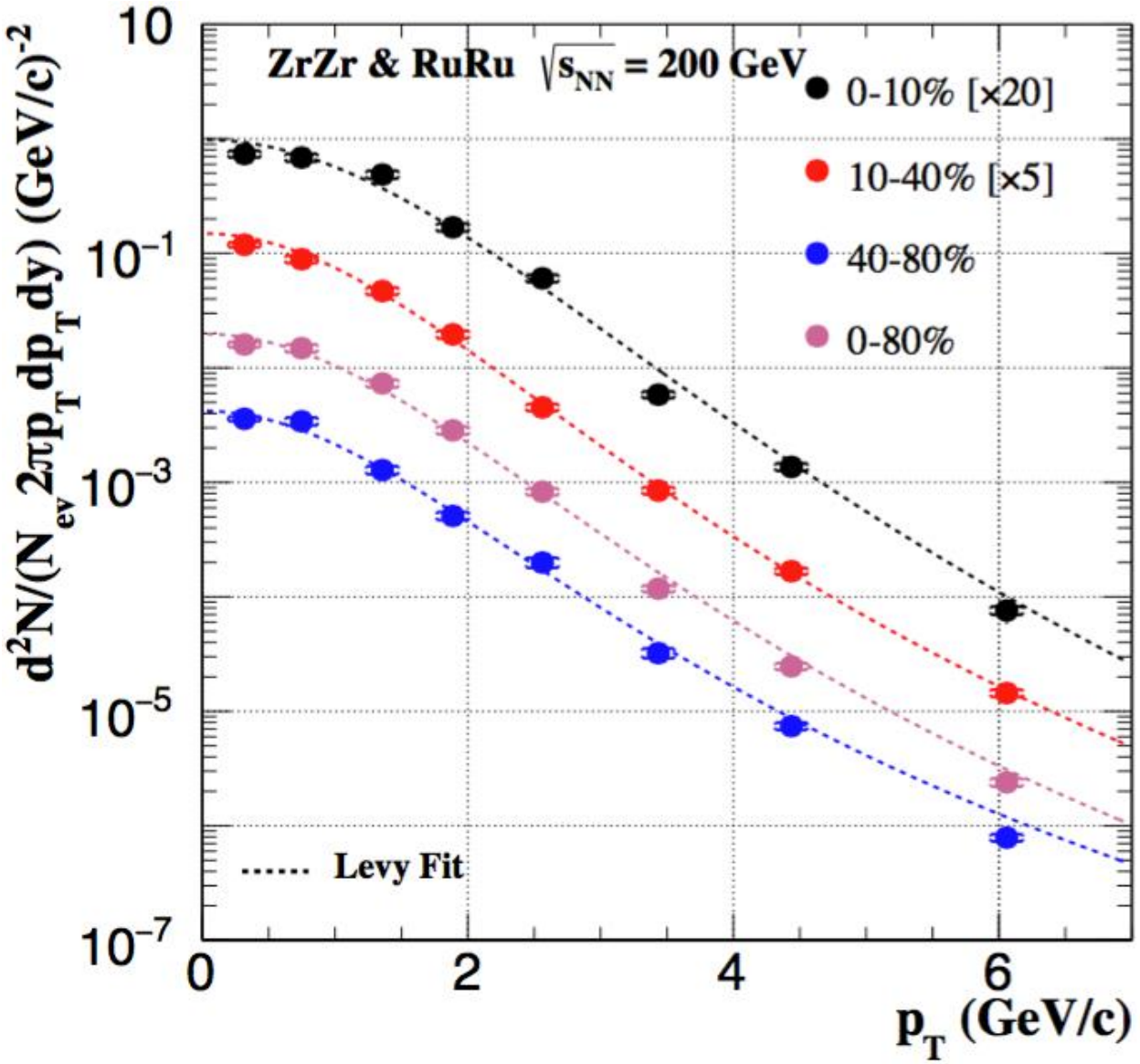
- Momentum resolution smearing obtained from embedding;
- Fold in the mis-PID probability into the D^0 decay kinematics by PYTHIA;
- Signals and double-counting entries were counted within 3σ mass window as done in real data analysis.

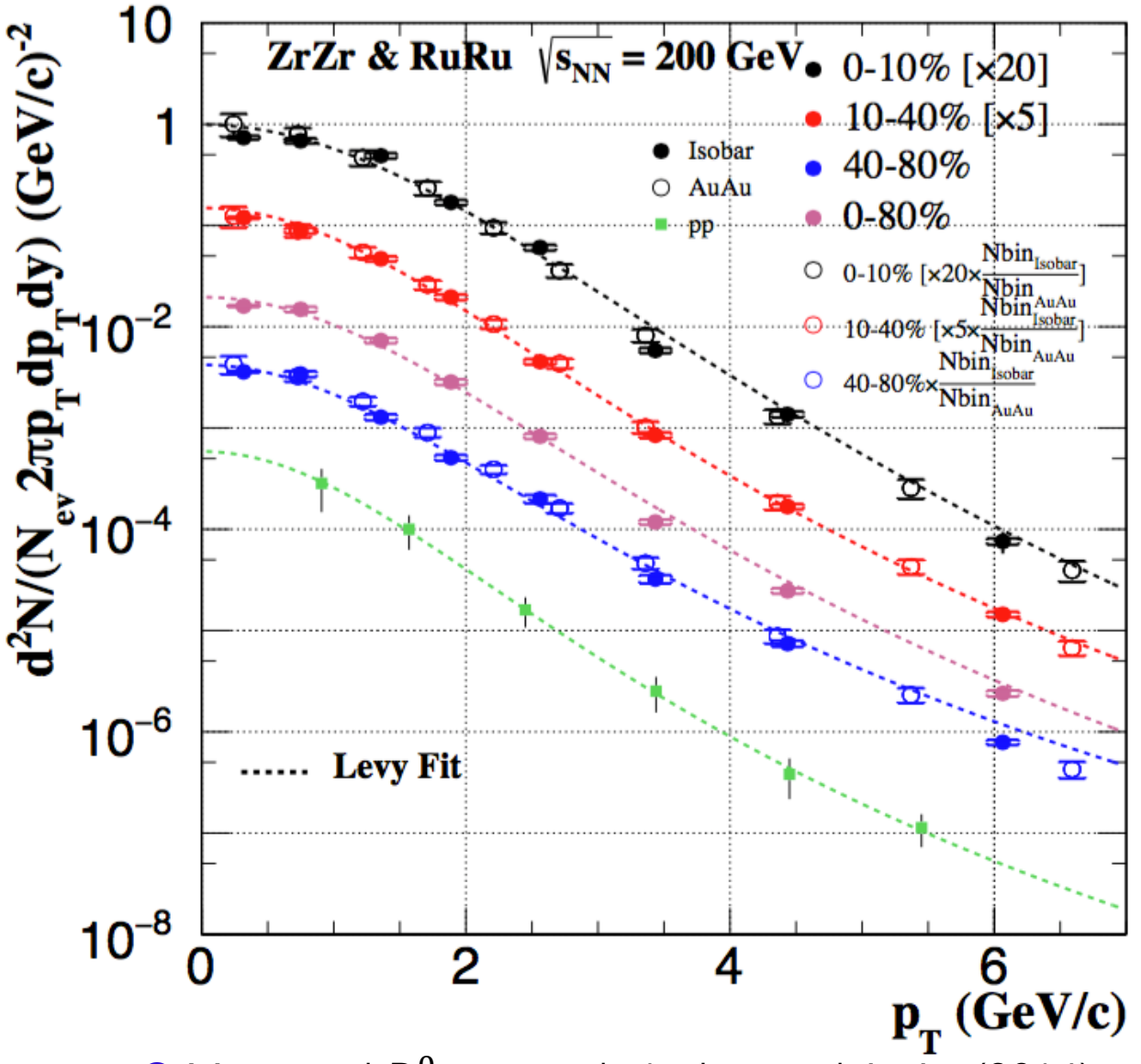
- Reconstructed $K\pi$ invariant mass distributions from clean PID and doubly misidentification.
- The relative magnitude is fixed according to the realistic mis-identification probability.
  hDC -> Scale(0.01)
  hsig -> Scale(0.01*(Max_DC/Max_Sig)/0.06)
- Double-counting Rate 0.06

Systematic uncertainties

		0-10%	10-40%	40-80%	Correlation in p_T
spectra	Raw yield	1-4%	1-3%	1-8%	uncorrelated
	Double counting	0.7%	0.8%	0.9%	uncorrelated
	Efficiency correction	2-6%	2-6%	2-6%	Largely correlated
	B.R.	0.5%	0.5%	0.5%	global
R_{AA}	$<N_{bin}>$	1.6%	0.6 %	0.4 %	global
	pp_{base}	7.6-68.6%	12.3-100.4%	8.9-79.4%	partially correlated
	pp_{base}	20.6-71.8%	20.6-71.8%	20.6-71.8%	partially correlated
R_{cp} (/40-80%)		0-10%		10-40%	
	Double counting	negligible		negligible	uncorrelated
	B.R.	0		0	global
	Efficiency correction	0		0	
	Total	8.3-12.7% (3.7-8.4%)		6.9-12.4% (1.6-8.0%)	
Integrated cross section		$p_T > 0$		$p_T > 4\ GeV/c$	
	Total	7.0-7.6% (5.4-6.2%)		7.0-7.6% (6.2-7.2%)	

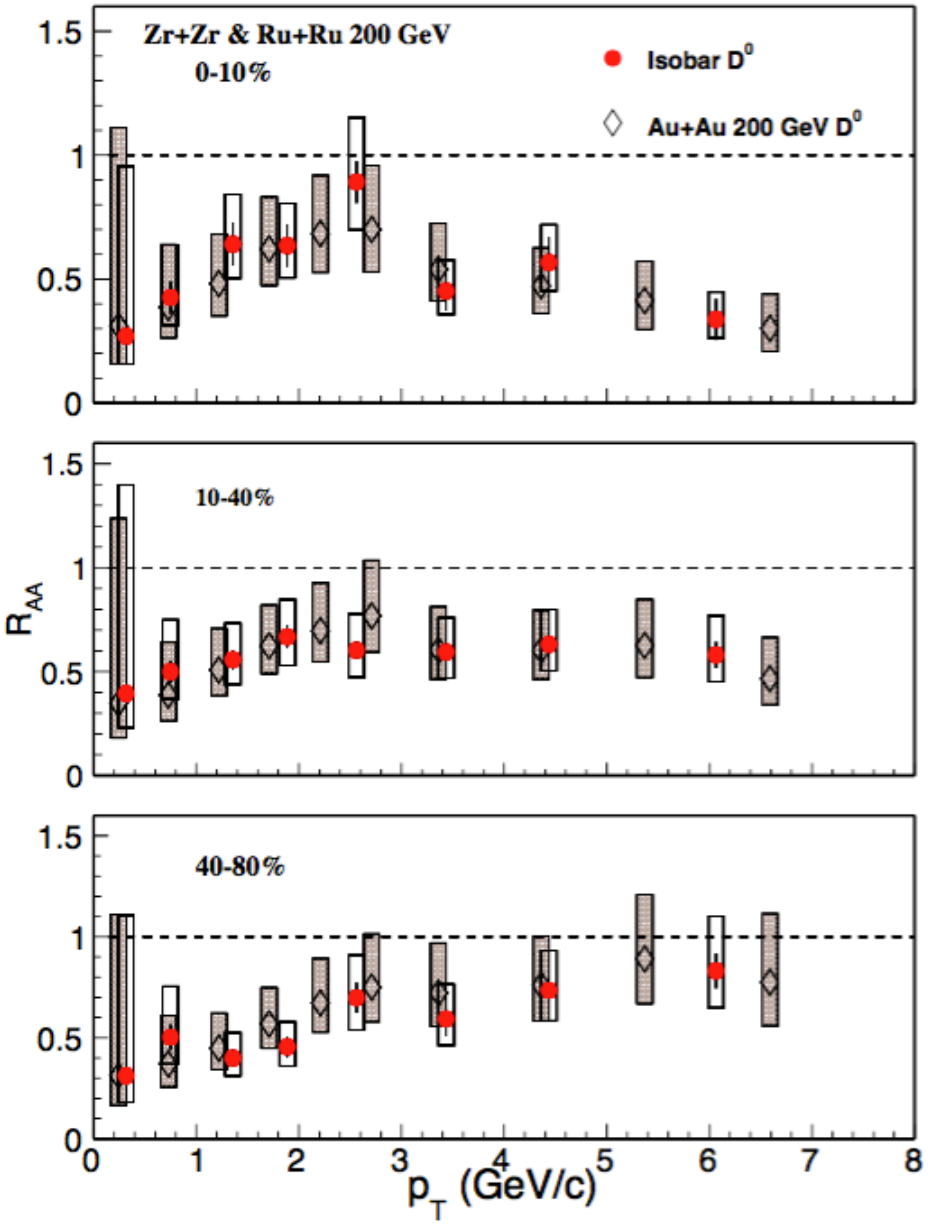
D^0 spectra in Isobar

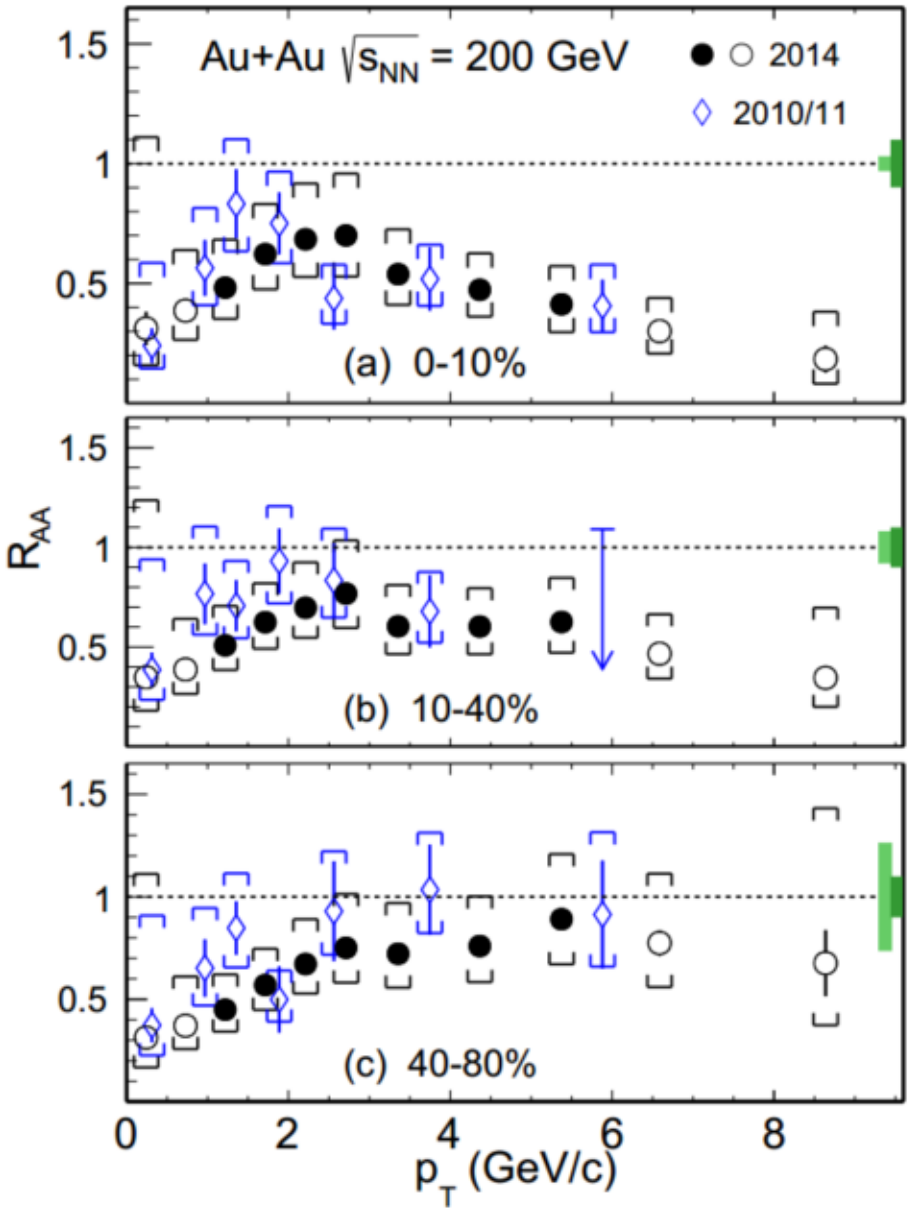




◉ Measured D^0 spectra in Isobar and AuAu (2014)

D^0 R_{AA} in Isobar





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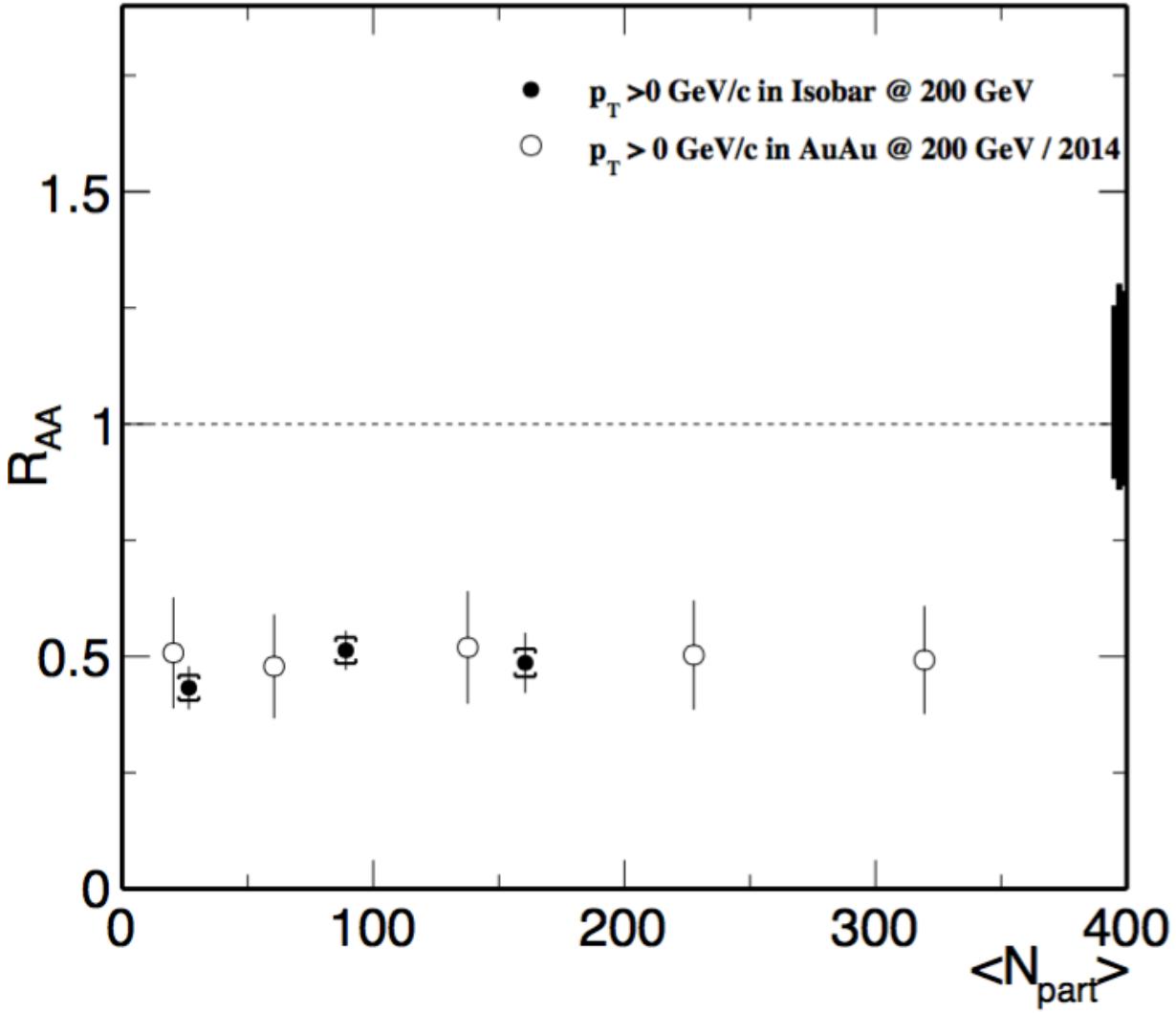
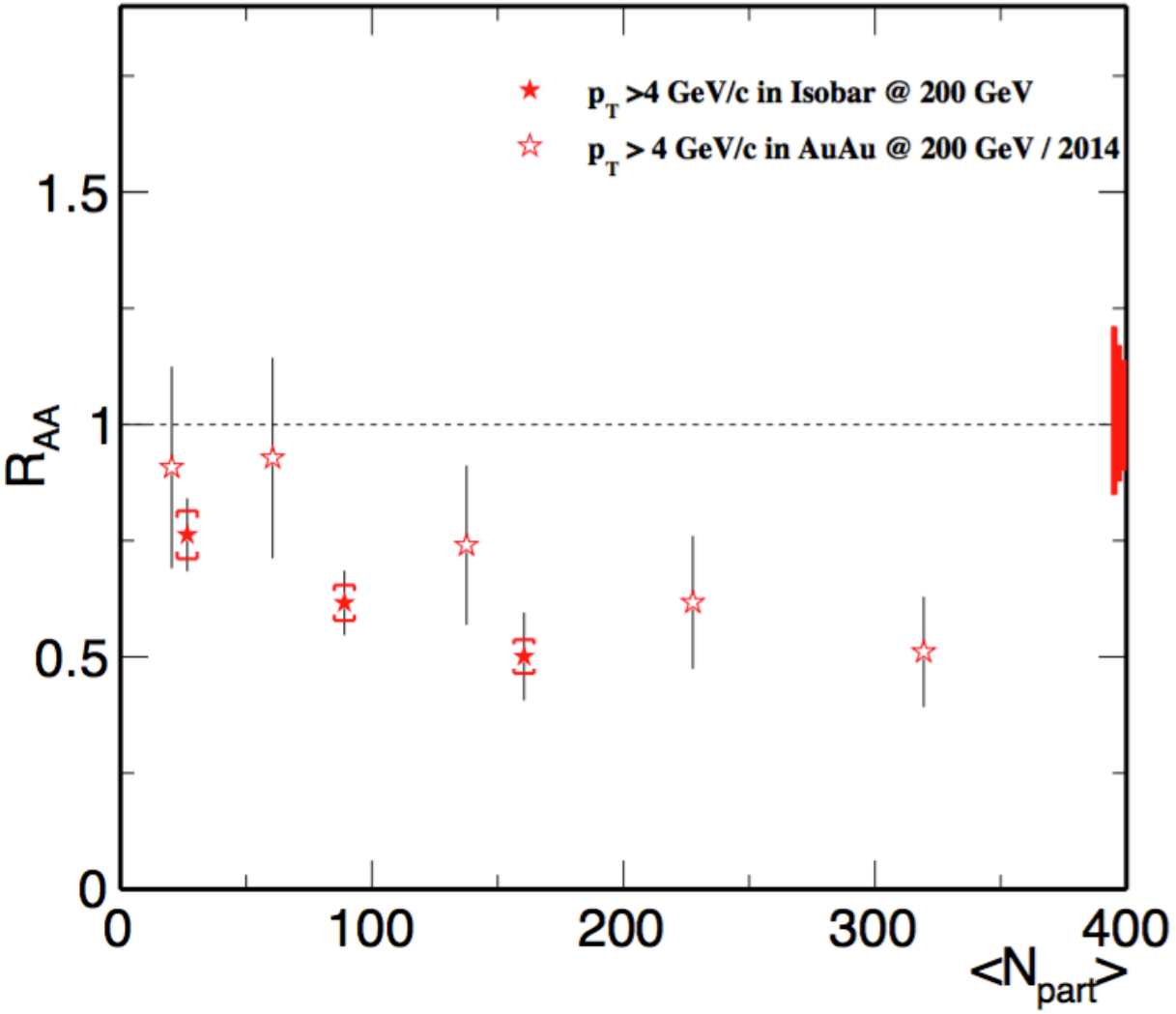
- The light and dark green boxes on the right depict the normalization uncertainties in determining the N_{bin} in Au+Au collisions and the total inelastic cross section in p+p collisions, respectively.

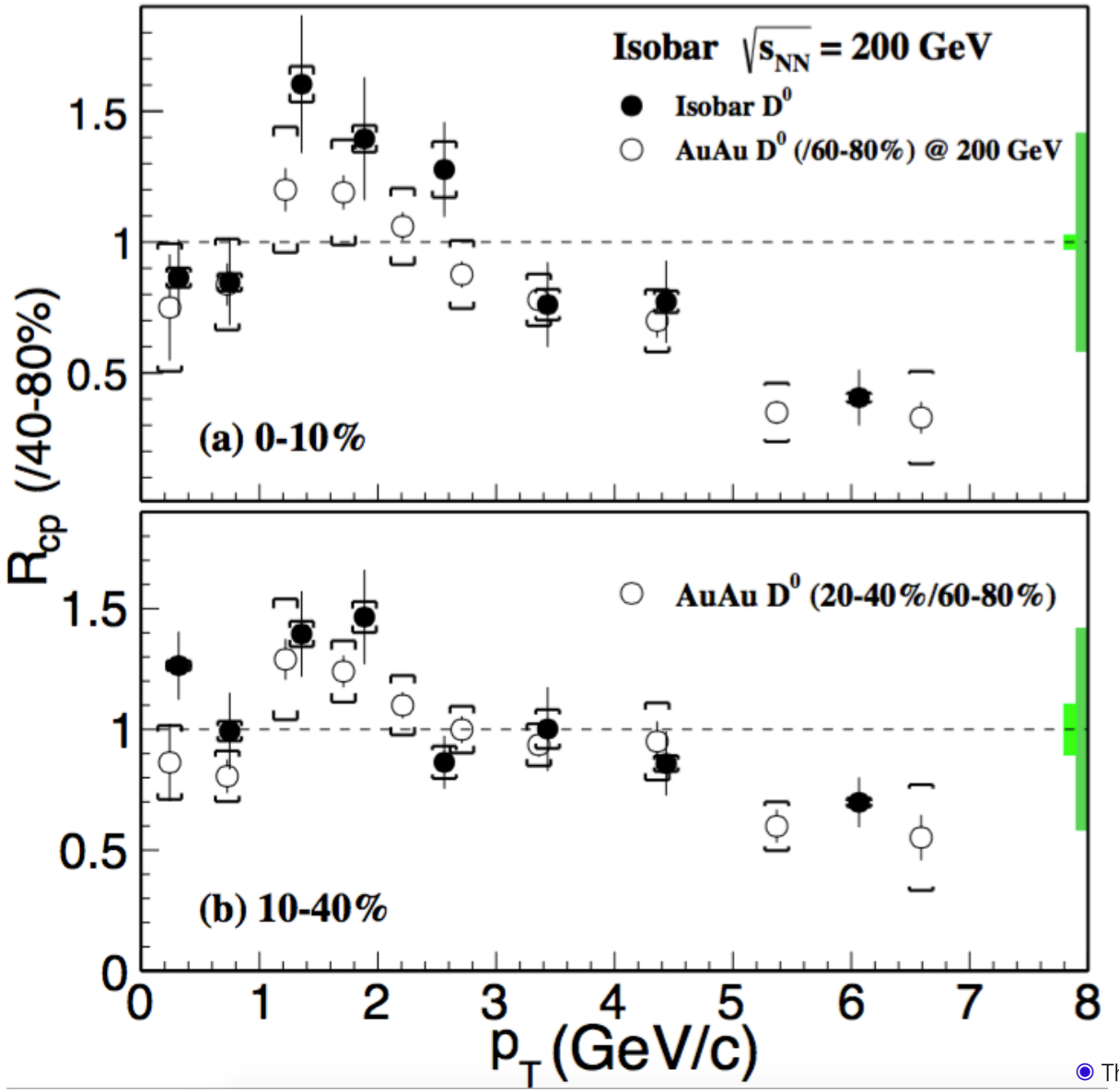
R_{AA} as a function of N_{part}

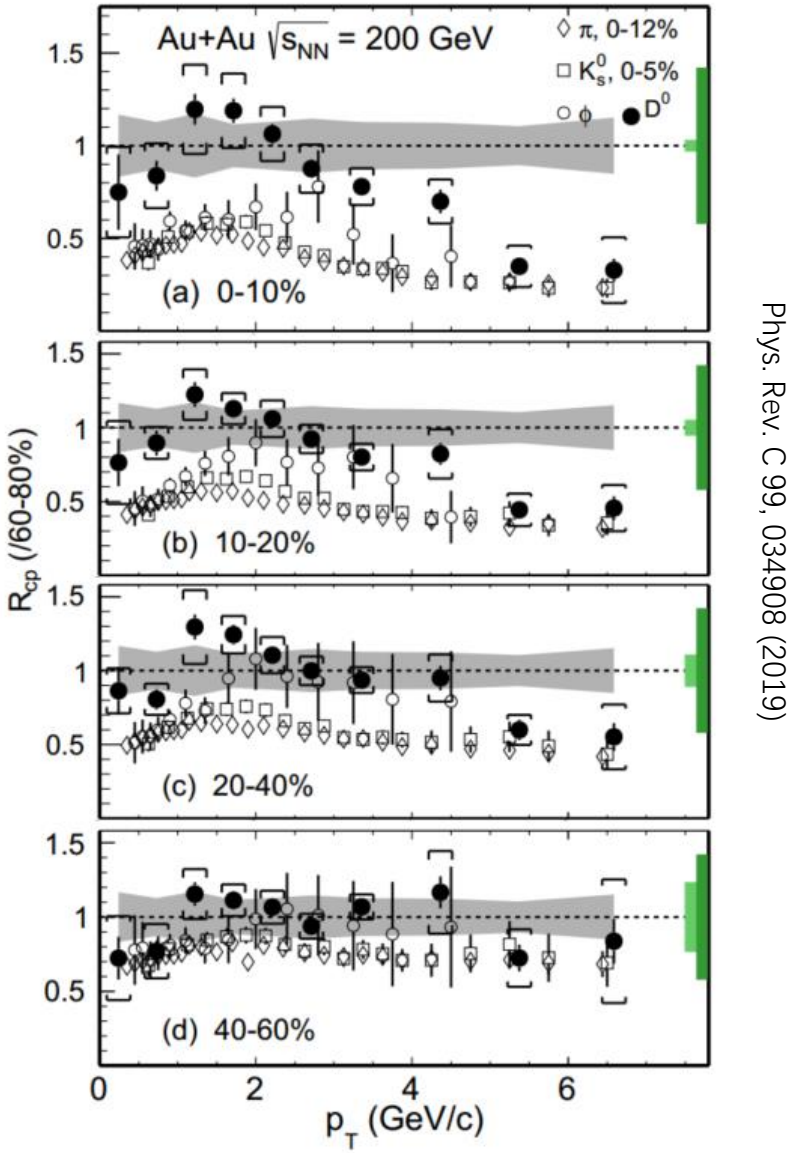




- Integrated D^0 R_{AA} as a function of N_{part} in p_T > 0 GeV/c.
- Integrated D^0 R_{AA} as a function of N_{part} in p_T > 4 GeV/c.

D^0 R_{cp} in Isobar





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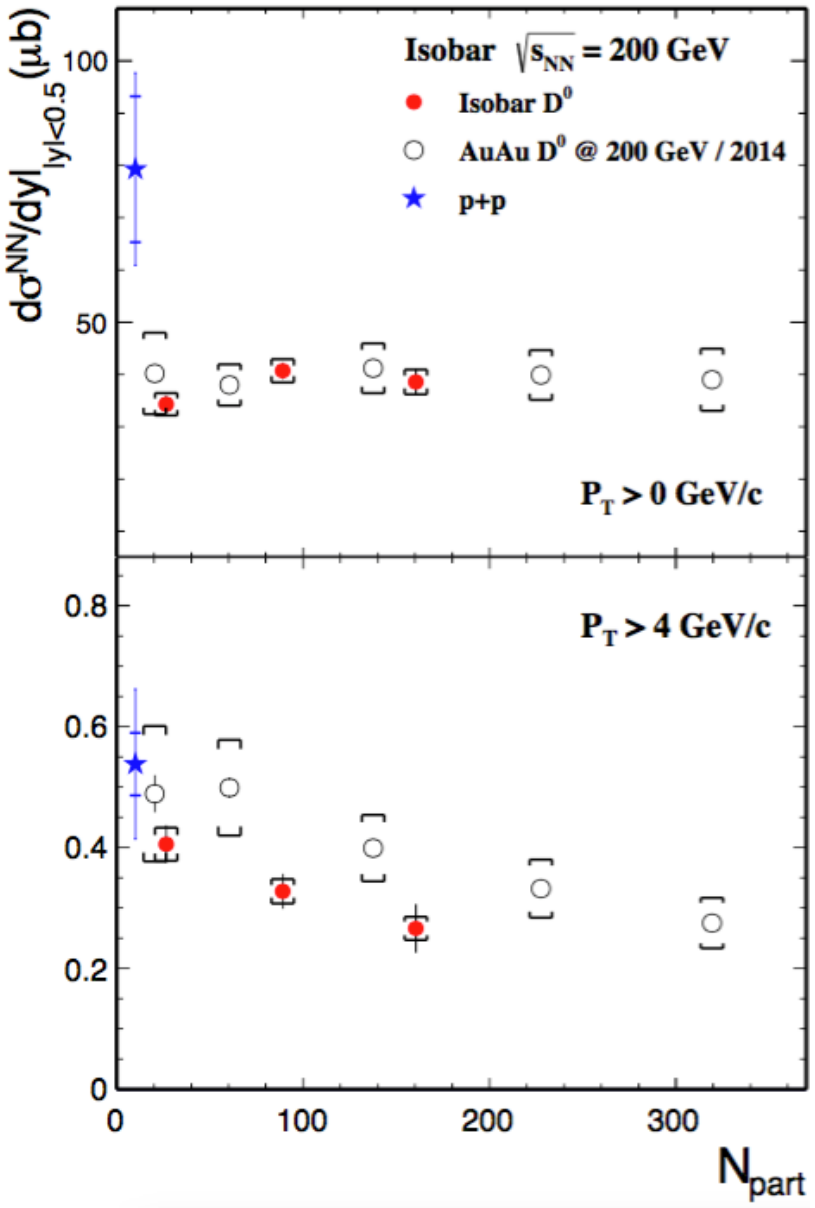
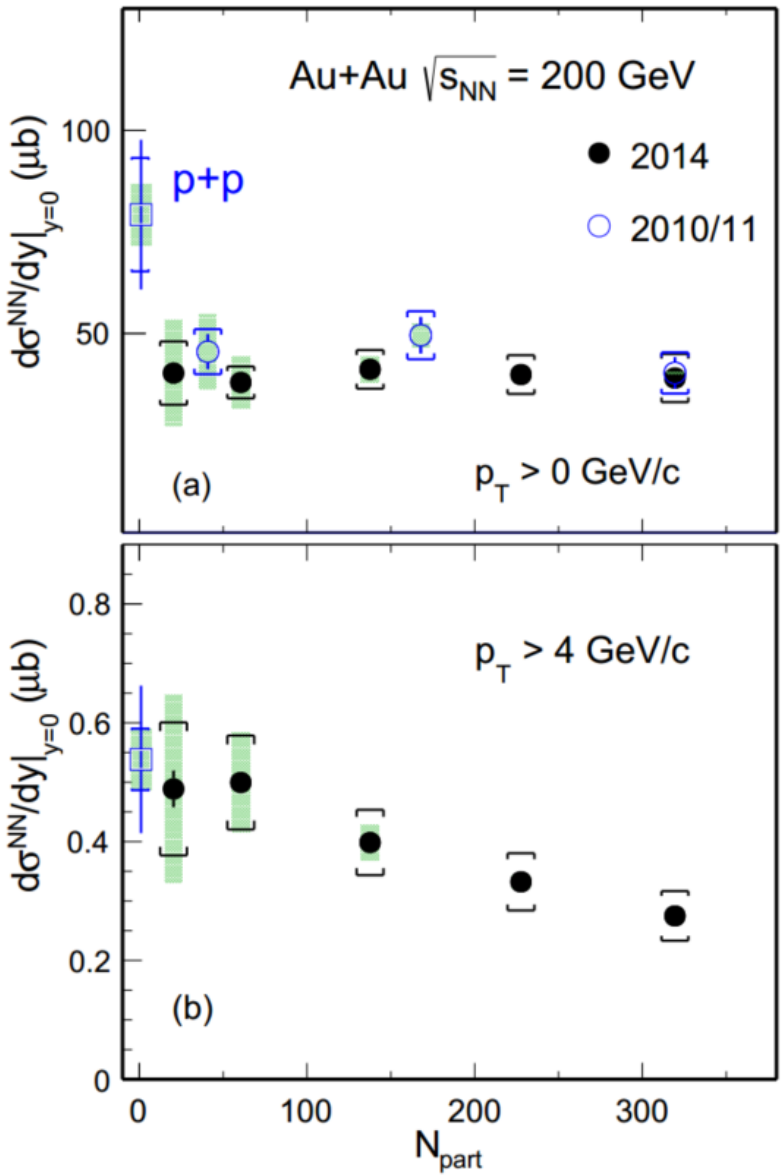
- The grey bands around unity depict the systematic uncertainty due to vertex resolution correction
- The normalization uncertainties in determining the N_{bin} for each centrality (light green) and the 60-80% (dark green).

Integrated D^0 cross section in Isobar





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$$\frac{d\sigma_{D^0}^{NN}}{dy}|_{y=0} = \frac{dN_{D^0}^{AA}}{dy}|_{y=0} \times \frac{\sigma_{inel}^{pp}}{< N_{bin} >}$$

$$\frac{dN_{D^0}^{AA}}{dy}|_{y=0} = \frac{\Delta N^{raw}/\epsilon_{D^0}^{tot}/2}{\Delta y \times N_{events} \times B.R.}$$

- σ_{inel}^{pp} error

$$\frac{0.4054}{0.538 * 31.75} = \frac{0.754}{31.75} = 0.024$$

- The green boxes on the data points depict the overall normalization uncertainties in p+p and Au+Au data respectively.

Summary and Future plan

- D^0 p_T spectra, R_{AA}, R_{cp} and integrated cross sections are measured in Isobar, and the result is compared to Au+Au collisions at 200 GeV;

- Isobar D^0 production paper proposal.

Back up

Levy func (charm differential cross section):

$$\frac{A(n-1)(n-2)}{nT(nT+m_0(n-2))} \times (1+\frac{m_T-m_0}{nT})^{-n}$$

par[4]={A, n, T, m_0} ; $m_T = \sqrt{{p_T}^2 + {m_0}^2}$

- $\frac{d^2N}{2\pi dp_T dy}|_{pp}$ = Levy func * p_T* F.R / σ_{inel}^{pp} (D^0 differential production * p_T),

  Y(pp)=$\int_{p_T1}^{p_T2} \frac{d^2N}{2\pi dp_T dy}|_{pp}\, d_{p_T} * 2\pi$

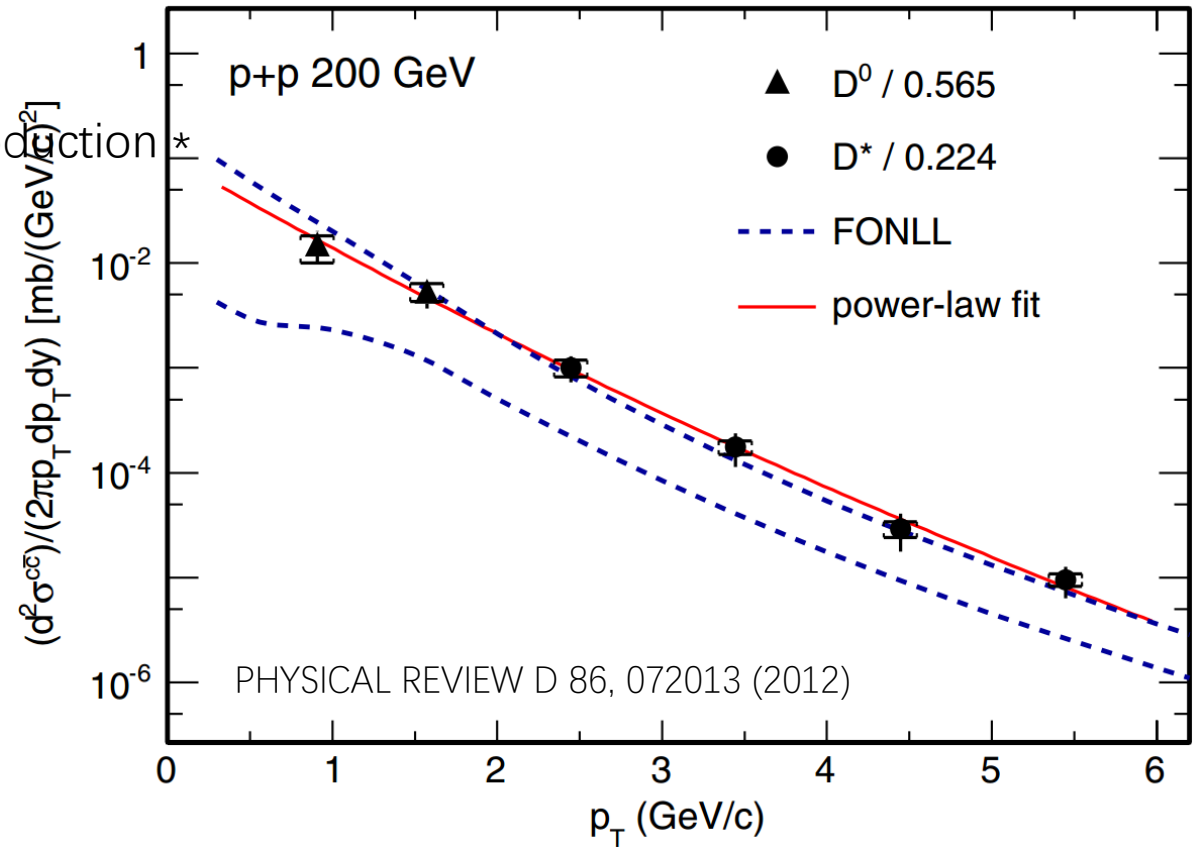
- Y(Isobar) = $\frac{d^2N}{2\pi p_T dp_T dy}|_{Isobar} * 2\pi * p_{T\,center} * \Delta p_T$

$$R_{AA} = \frac{Y(Isobar)}{< N_{coll} > Y(pp)}$$

$D^0(c\bar{u}) \rightarrow K^- + \pi^+$ $\bar{D}^0 \rightarrow K^+ + \pi^-$ 0.6~2.0 GeV/c

$D^{*+}(c\bar{d}) \rightarrow D^0\pi^+ \rightarrow K^- + \pi^+ + \pi^+$ 2.0~6.0 GeV/c

Charm quark fragmentation ratios
0.565 (c -> D^0) and 0.224 (c->D^*)



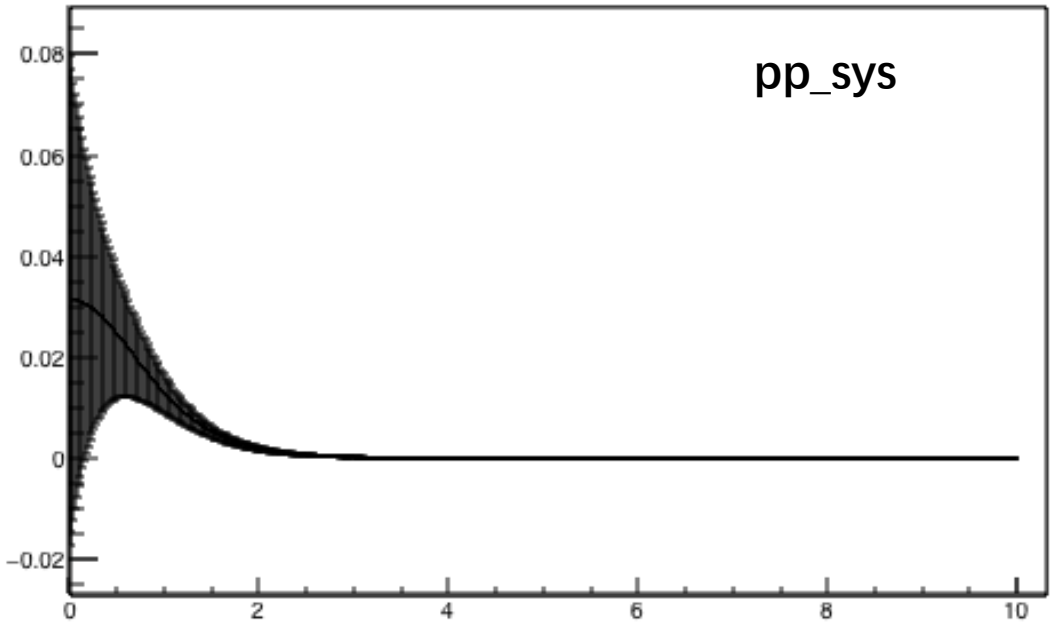
Back up

- Y(pp) = $\int_{p_T1}^{p_T2} \frac{d^2\sigma^{c\bar{c}}}{2\pi p_T dp_T dy} dp_T$* F.R / σ_{inel}^{pp}

$$Y_{pp_{low}} = \sum_{p_T1}^{p_T2}\{ (pp\_base[i] - EY[i])* p_T[i] \} * \text{F.R} / \sigma_{inel}^{pp} * 2\pi * \frac{10}{500}$$

$$Y_{pp_{up}} = \sum_{p_T1}^{p_T2}\{ (pp\_base[i] + EY[i])* p_T[i] \} * \text{F.R} / \sigma_{inel}^{pp} * 2\pi * \frac{10}{500}$$

$$R_{AA_{low}} = \frac{Y(Isobar)}{< N_{coll} > Y_{pp_{up}}} \qquad R_{AA_{up}} = \frac{Y(Isobar)}{< N_{coll} > Y_{pp_{low}}}$$



$$R_{AA_{sys\_low}} = \sqrt{(R_{AA} - R_{AA_{low}})^2 + {R_{AA\_sys}}^2}$$

$$R_{AA_{sys\_up}} = \sqrt{(R_{AA_{up}} - R_{AA})^2 + {R_{AA\_sys}}^2}$$

- List results for HP PWG on 7/14/2022

$R_{AA} - R_{AA_{low}}$ are different for different centrality bin;

$(R_{AA} - R_{AA_{low}})/R_{AA_{low}}$ are universal.

- Systematic uncertainties for pp_{base} :

$$Sys_{low} = \frac{\text{Y(pp)} - Y_{pp_{low}}}{Y(pp)} \qquad Sys_{up} = \frac{Y_{pp_{up}} - \text{Y(pp)}}{Y(pp)}$$

Back up

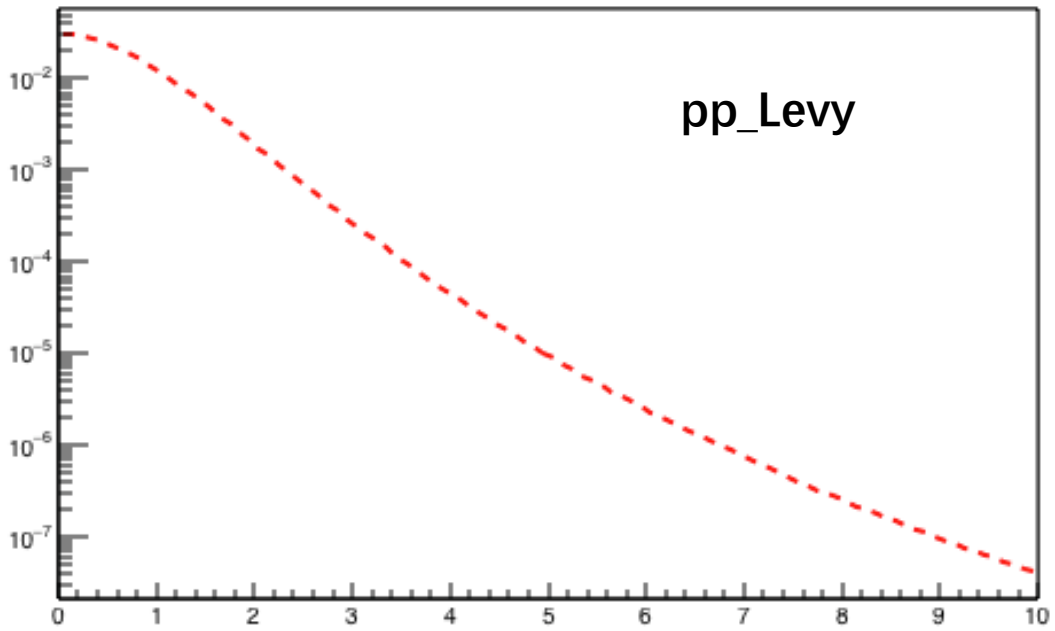
Sys_{low}[0.718, 0.331, 0.236, 0.207, 0.222, 0.214, 0.206, 0.242] = $\frac{R_{AA_{up}} - R_{AA}}{R_{AA_{up}}}$

Sys_{up}[0.718, 0.340, 0.262, 0.243, 0.260, 0.250, 0.237, 0.268] = $\frac{R_{AA} - R_{AA_{low}}}{R_{AA_{low}}}$

- Y(pp) = $\sum_{p_T1}^{p_T2}$ ($pp\_base[i] * p_T[i]$) * F.R / σ_{inel}^{pp} $* 2\pi * \frac{10}{500}$

$$Sys_{low} = \frac{\mathrm{Y(pp)} - Y_{\mathrm{pp}_{low}}}{Y(pp)} = Sys_{up} = \frac{Y_{\mathrm{pp}_{up}} - \mathrm{Y(pp)}}{Y(pp)}$$

$Sys_{low/up}$[0.718, 0.334, 0.246, 0.221, 0.236, 0.228, 0.218, 0.252]



Back up

- Systematic uncertainties for R_{cp} :

$$R_{cp} = \frac{Y(0\text{-}10\%)/< N_{coll\_0\text{-}10} >}{Y(40\text{-}80\%)/< N_{coll\_40-80} >}$$

$$Y(0\text{-}10\%) = \frac{(\Delta N^{raw} - D.C)/\epsilon_{D^0}^{tot}/2}{2\pi p_T \Delta p_T \Delta y \times N_{events} \times B.R.} = \frac{(\Delta N^{raw} - D.C)}{\epsilon_{D^0}^{tot} * B.R.} * \text{Const.}$$

$$\text{Const.} = \frac{1}{2*2\pi p_T \Delta p_T \Delta y \times N_{events}}$$

$$\text{Const.\_Rcp} = \frac{1}{\epsilon_{D^0}^{tot} * 2*2\pi p_T \Delta p_T \Delta y \times N_{events}}$$

- Systematic uncertainties for spectra
- Systematic uncertainties of $\epsilon_{D^0}^{tot}$ for R_{cp} cancel (same embedding)

Function	Standard Deviation
f=aA	$\sigma_f = \lvert a \rvert \sigma_A$
f=aA±bB	$\sigma_f = \sqrt{a^2\sigma_A^2 + b^2\sigma_B^2 \pm 2ab\sigma_{AB}}$
f=AB	$\approx \lvert f \rvert \sqrt{(\frac{\sigma_A}{A})^2 + (\frac{\sigma_B}{B})^2 + 2\frac{\sigma_{AB}}{AB}}$
f=A/B	$\approx \lvert f \rvert \sqrt{(\frac{\sigma_A}{A})^2 + (\frac{\sigma_B}{B})^2 - 2\frac{\sigma_{AB}}{AB}}$

Back up

- Systematic uncertainties for integrated D^0 cross section:

$$\frac{d\sigma_{D^0}^{NN}}{dy}|_{y=0} = \frac{dN_{D^0}^{AA}}{dy}|_{y=0} \times \frac{\sigma_{inel}^{pp}}{< N_{bin} >}$$

3

$$\frac{dN_{D^0}^{AA}}{dy}|_{y=0} = \frac{1}{\Delta y \times N_{events} \times B.R.} \boxed{(\Delta N^{raw} - D.C)} / \epsilon_{D^0}^{tot} / 2$$

2 (two methods, directly sys. Uncertainty propagator or transfer absoluty error)

- Note for counting method: the statistical uncertainties in different p_T bins are considered uncorrelated while the systematic uncertainties are considered fully correlated as a conservative estimate. (R_{AA}-N_{part})

Au-Au

Centrality	$\langle N_{\rm bin} \rangle$	$\langle N_{\rm part} \rangle$	$\varepsilon_{\rm trg}$
0–10 %	938.8 ± 26.3	319.4 ± 3.4	1.0
10–20 %	579.9 ± 28.8	227.6 ± 7.9	1.0
20–40 %	288.3 ± 30.4	137.6 ± 10.4	1.0
40–60 %	91.3 ± 21.0	60.5 ± 10.1	0.92
60–80 %	21.3 ± 8.9	20.4 ± 6.6	0.65