200 GeV $Cu + Cu : J/\psi \rightarrow \mu^+\mu^-$
status update : Aug 24, 2006

Evolving Analysis Note available at:
https://www.phenix.bnl.gov/phenix/WWW/p/draft/silvermy/run5/CuCu/note2/note2.pdf

Today :
Overall status, North vs South comparisons,
R_{AA} results vs centrality, pT and rapidity with new Run5pp reference.
Note: not all acc.*eff. systematic errors are yet quite final.

Coming soon, from dimuon $Cu + Cu$ team:
More detailed info regarding acc*eff for $Cu + Cu$ (run-by-run dep. etc.),
and revised cross-section plots;
Finalized numbers/results, systematic errors.

A brief re-cap of some previous out-standing issues..:

1. We are following in the footsteps of Au+Au trail-blazers (Hugo et al.); using the same framework (CabanaBoy) and tools for both acc*eff and yield estimates, error treatment etc.
2. We found the cause for the North MUID LL1 low efficiency values during Run5: two swapped fibers.. We have modified the code, and generated another run5 LL1 map to account for this in our acc*eff. calculation.
3. We found that using event-mixing on the Lvl2-filtered data (with MUTR and mass-cut included for Lvl2-algorithm in Run5) seems to strongly distort the mass distribution. Thus, we have to revert to like-sign subtraction for now.
4. After the $Cu + Cu$ production had started, we evaluated (in late May) what the gain would be if we used the full LL1 sample instead of (LL1 + Lvl2-filter) which had been used so far. We found the gain to be likely not too significant; possible less mass shape distorsions (below J/ψregion), and also somewhat more statistics, but not really improved Signal/Background. So, we decided to go ahead and try to finish up the analysis with what we have.

Reminder: The Signal/Background ranges from ∼0.3 for 0–5% most central to ∼5–10 for the most peripheral in $Cu + Cu$.

We estimate the yield by comparing/averaging the results from different fits to the data. The used fits and methods are the same as for $Au + Au$:

1. Single Gaussian + exp.
2. Double Gaussian + exp.
3. Exponential: fit outside mass window, subtract inside

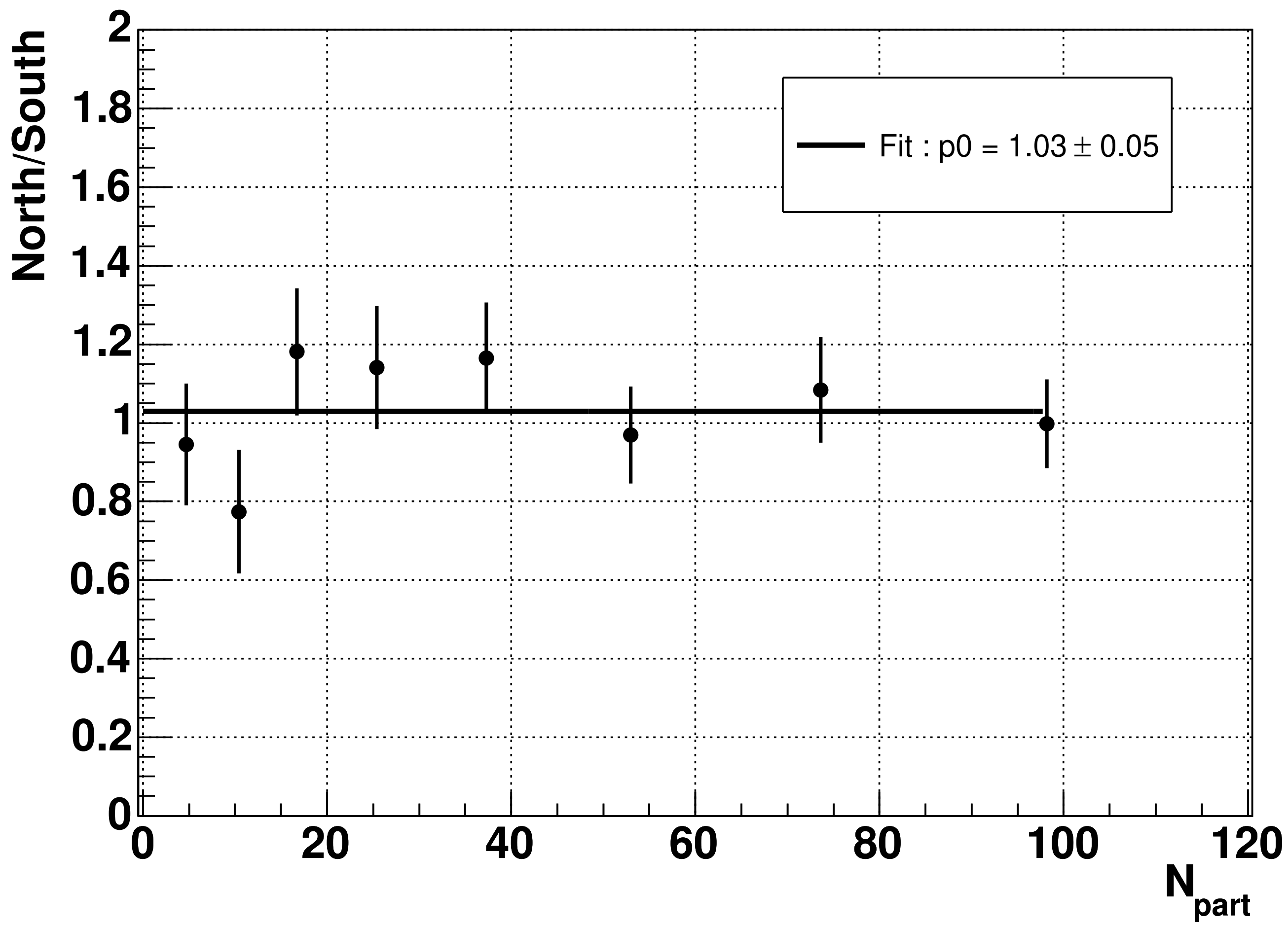
Systematics are evaluated by varying the background normalization by 0,± 2%, and taking the RMS of the 9 obtained values. [3 fits * 3 normalizations]

10%-wide centrality bins (0-10, .., 60-70, 70-94).

Table 1: $1/N_{coll} BdN/dy$ for different centrality bins.

Arm	Centrality	N_{coll}	N_{part}	$yield \pm stat \pm syst(10^{-7})$	Common	+Syst	All
South	$[0, 10]$	182.7 ± 20.7	98.2 ± 2.4	$3.33 \pm 0.20 \pm 0.18$	0.53	0.27	0.46
South	$[10, 20]$	121.1 ± 13.6	73.6 ± 2.5	$3.28 \pm 0.22 \pm 0.13$	0.52	0.26	0.45
South	$[20, 30]$	76.1 ± 8.5	53.0 ± 1.9	$3.90 \pm 0.24 \pm 0.24$	0.61	0.34	0.55
South	$[30, 40]$	47.1 ± 5.3	37.3 ± 1.6	$4.19 \pm 0.29 \pm 0.27$	0.66	0.39	0.61
South	$[40, 50]$	28.1 ± 3.4	25.4 ± 1.3	$4.00 \pm 0.35 \pm 0.20$	0.66	0.40	0.60
South	$[50, 60]$	16.2 ± 1.9	16.7 ± 0.9	$5.06 \pm 0.42 \pm 0.22$	0.82	0.48	0.74
South	$[60, 70]$	9.0 ± 1.0	10.4 ± 0.6	$5.87 \pm 0.58 \pm 0.21$	0.92	0.62	0.90
South	$[70, 94]$	3.4 ± 0.4	4.7 ± 0.3	$5.69 \pm 0.57 \pm 0.30$	0.92	0.64	0.90
North	$[0, 10]$	182.7 ± 20.7	98.2 ± 2.4	$3.33 \pm 0.23 \pm 0.13$	0.53	0.26	0.59
North	$[10, 20]$	121.1 ± 13.6	73.6 ± 2.5	$3.55 \pm 0.24 \pm 0.25$	0.56	0.34	0.66
North	$[20, 30]$	76.1 ± 8.5	53.0 ± 1.9	$3.78 \pm 0.26 \pm 0.24$	0.59	0.35	0.69
North	$[30, 40]$	47.1 ± 5.3	37.3 ± 1.6	$4.88 \pm 0.34 \pm 0.17$	0.77	0.38	0.86
North	$[40, 50]$	28.1 ± 3.4	25.4 ± 1.3	$4.56 \pm 0.37 \pm 0.21$	0.75	0.42	0.86
North	$[50, 60]$	16.2 ± 1.9	16.7 ± 0.9	$5.98 \pm 0.51 \pm 0.31$	0.97	0.60	1.14
North	$[60, 70]$	9.0 ± 1.0	10.4 ± 0.6	$4.54 \pm 0.55 \pm 0.57$	0.71	0.79	1.06
North	$[70, 94]$	3.4 ± 0.4	4.7 ± 0.3	$5.38 \pm 0.60 \pm 0.24$	0.87	0.64	1.08

10%-wide centrality bins (0-10, .., 60-70, 70-94). South and North yields agree within errors.



The table summarizes the estimated 1-RMS systematic errors. The info on how 4,7,8 are estimated will be in the new $Cu + Cu$ note. Items 1,2 were in the first (QM) $Cu + Cu$ note, and items 3,5 and 6, are based on the Run4 soon-to-be-submitted final AN.

Table 2: Summary of global/common systematic error contributions.

Systematic Error Source	Error	Reference
1. # Live BBCLL1 triggers	1.0%	AN 406
2. z_{vtx} and BunchCross cuts	3.0%	AN 406
3. $A\varepsilon_{J/\psi}$ (Cuts & Input Dist)	4.0%	AN Run4
4. $A\varepsilon_{J/\psi}$ (Run to Run)	8.0% (P)	Note2
5. RD vs MC acceptance: octant eff.	5.0%	AN Run4
6. RD vs MC embedding	∼0%	ANRun4
7. MUTR Chamber Efficiency and Hot Packets	2.0% (P)	Note2
8. MUID Tube Efficiency	2.0% (P)	Note2
Quadrature Sum	11%	

The rows marked (P) are Preliminary,and are being evaluated currently.

Note: We normally also divide with N_{coll} numbers from Glauber, which have $\sim$ 15% sys. error, and compare with $p+p$ values, which have ∼10% level associated errors. We add the Glauber errors when needed, in quadrature, to obtain the total systematics. The $p+p$ errors are also included as either common, or point-to-point errors.

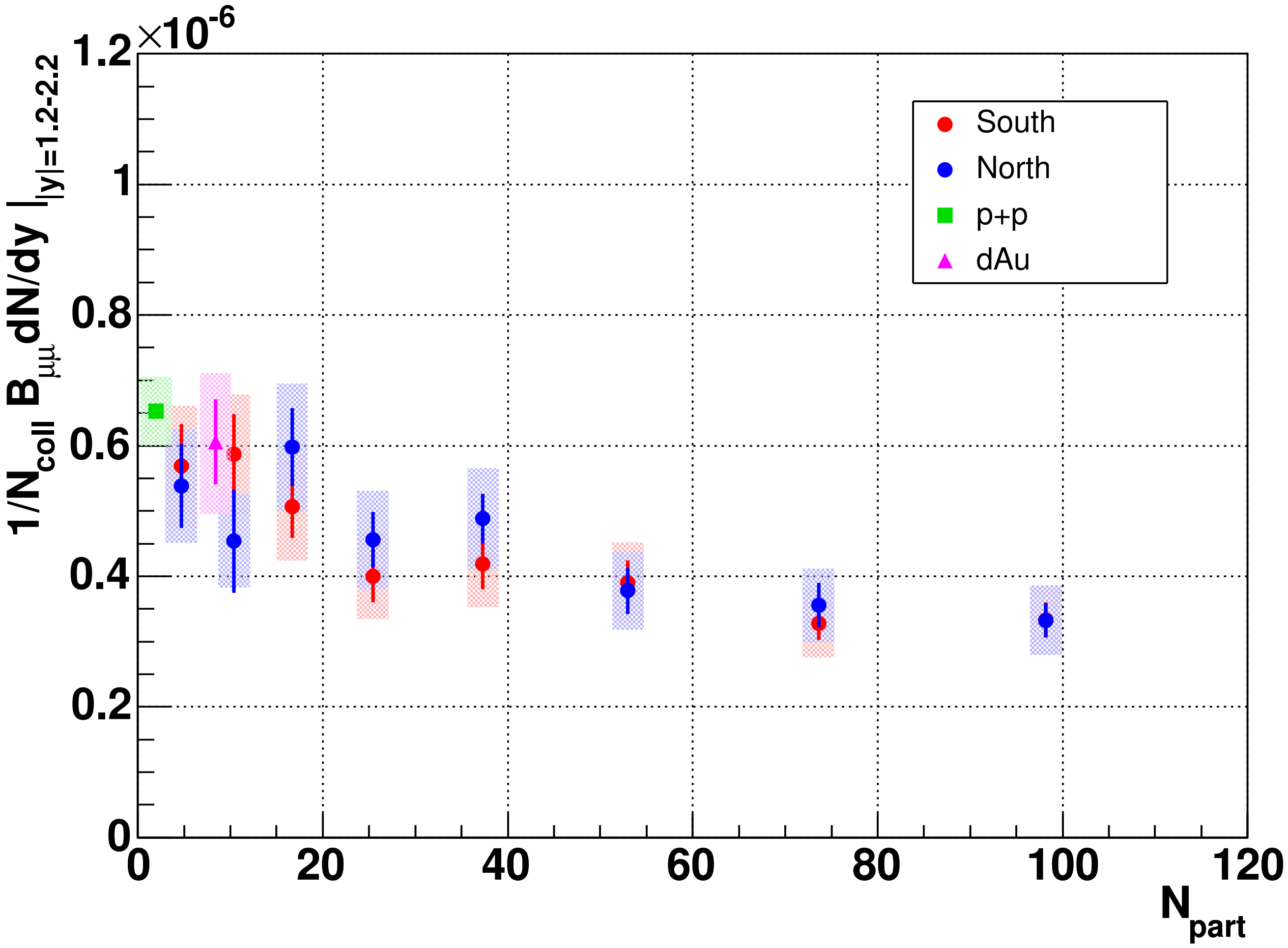
These topics related to J/ψ production are covered on the following pages

- Centrality dependence
- p_T dependence
- rapidity dependence

Like for Run4 $Au+Au$ analysis: point-to-point un-correlated errors (shown as bars) and common/global errors (shown as boxes) are now separated. I.e. just two type of errors. No extra brackets, or pp-reference band uncertainties etc. anymore, as those tended to be confusing.

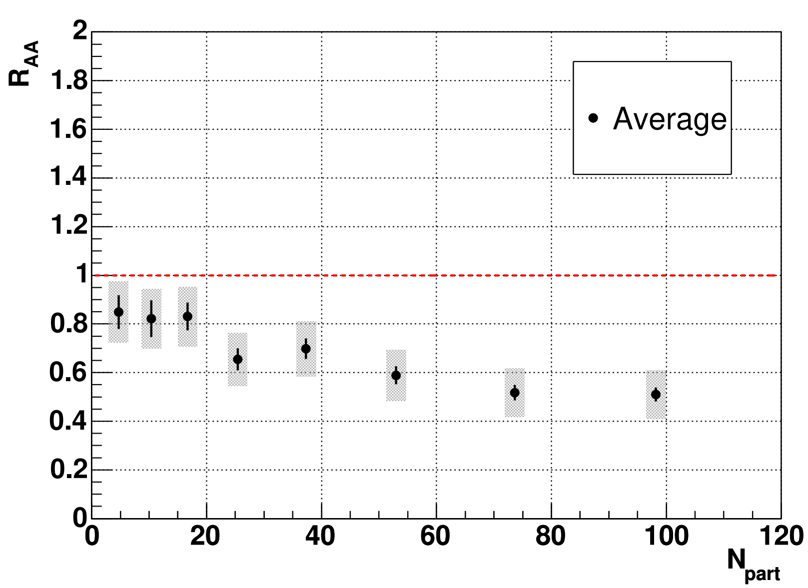
[We can have the usual discussion here about how one best plots R_{AA} errors if you want. We will follow whatever gets chosen for the Run4 $Au+Au$ J/ψ publication.]

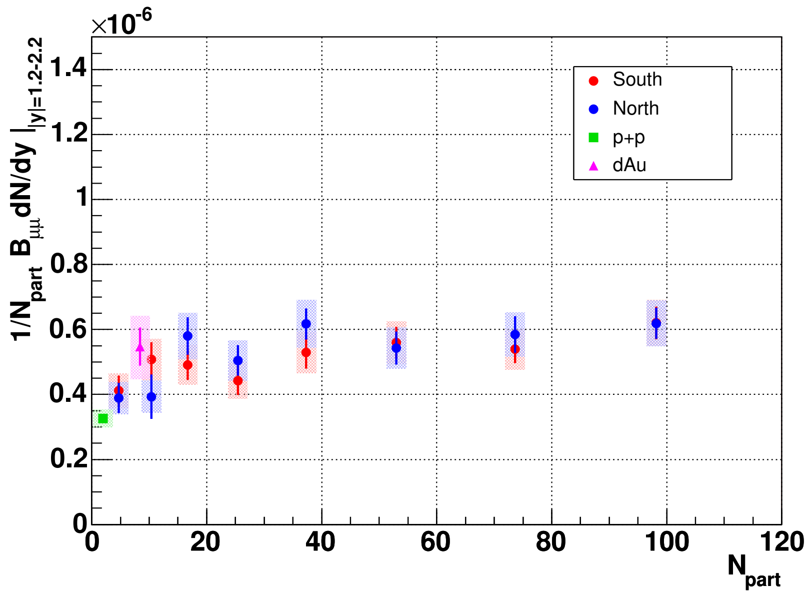
10%-wide centrality bins (0-10, .. 60-70, 70-94):



R_{AA}, and vs N_{part}; medium-size bins

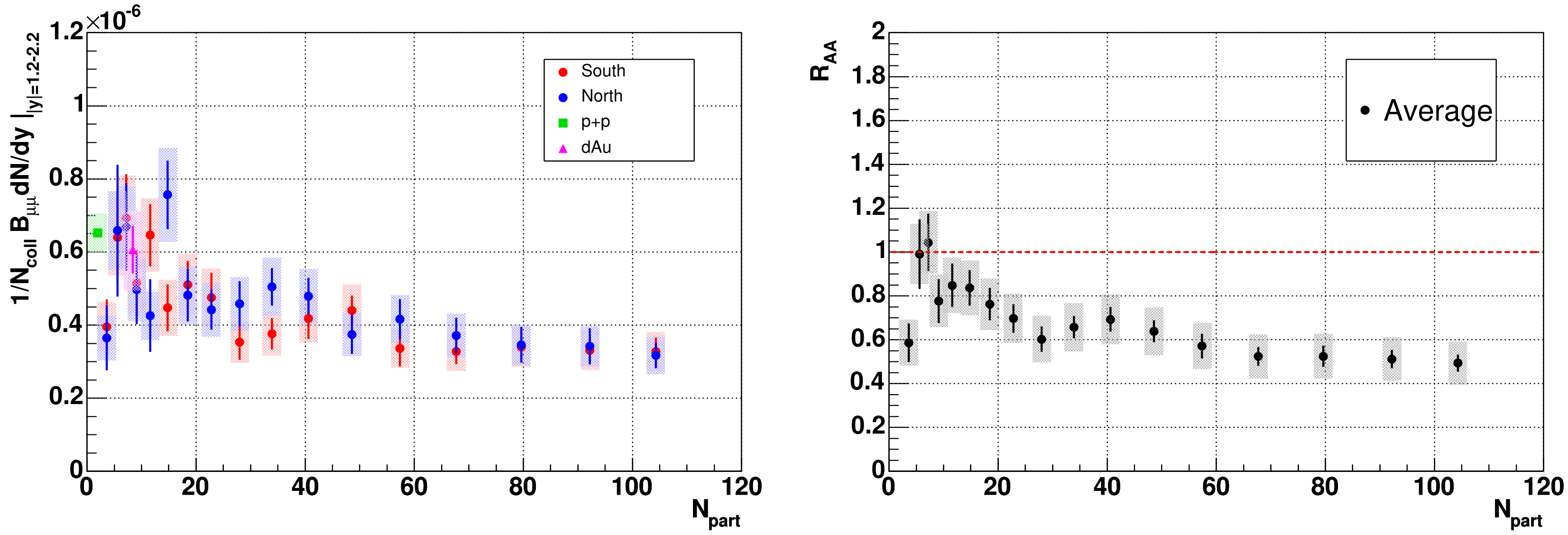
10%-wide centrality bins (0-10, .. 60-70, 70-94):





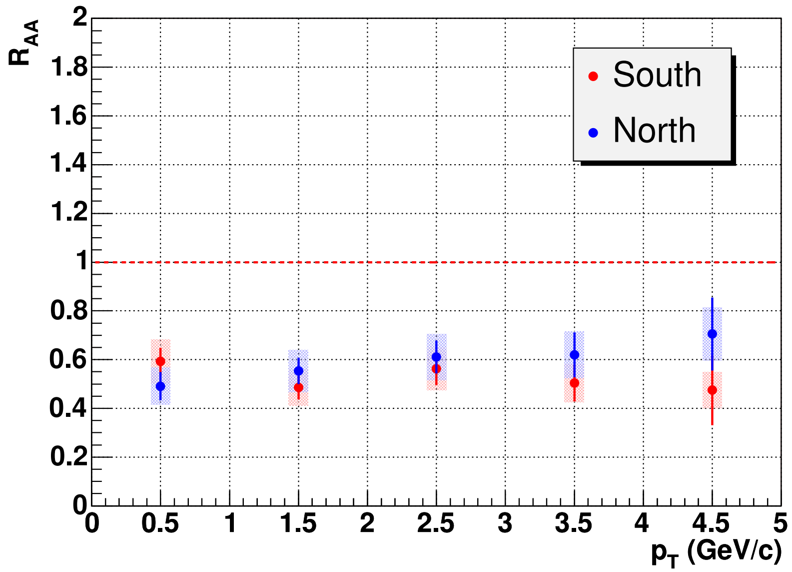
As shown earlier, data for the two arms overlap, so it's OK to take the average. Rather smooth scaling for yield vs centrality. Reasonable agreement (within errors) for the two arms. Approximately a factor of two suppression relative to $p + p$ for most central $Cu + Cu$.

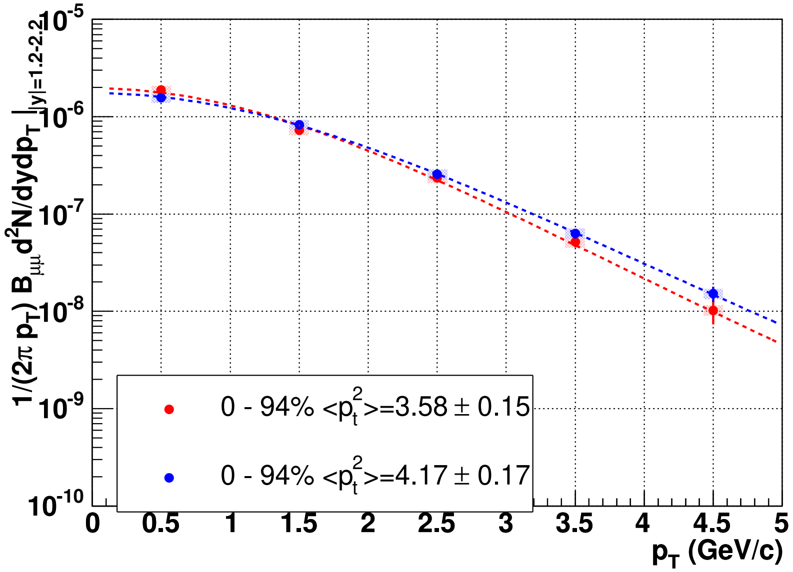
Invariant yield, and R_{AA}: 5%-wide centrality bins (0-5, .., 75-80, 80-94):



The acceptance * efficiency corrections are somewhat preliminary (not yet vetted by the expert - Andry).

Suppression was mainly see at lower p_T values, with the previous Run3 $p+p$ reference. With Run5 $p+p$ it now looks quite flat.. We should add comparisons with theory later.

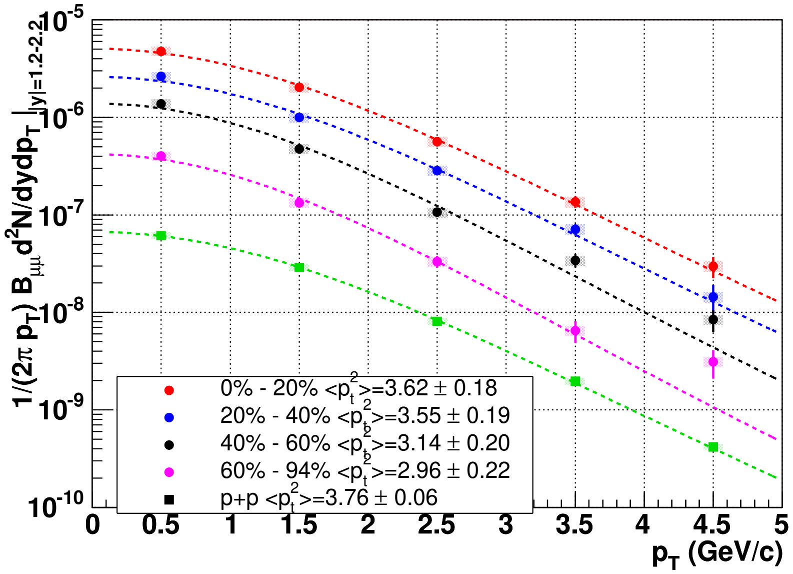


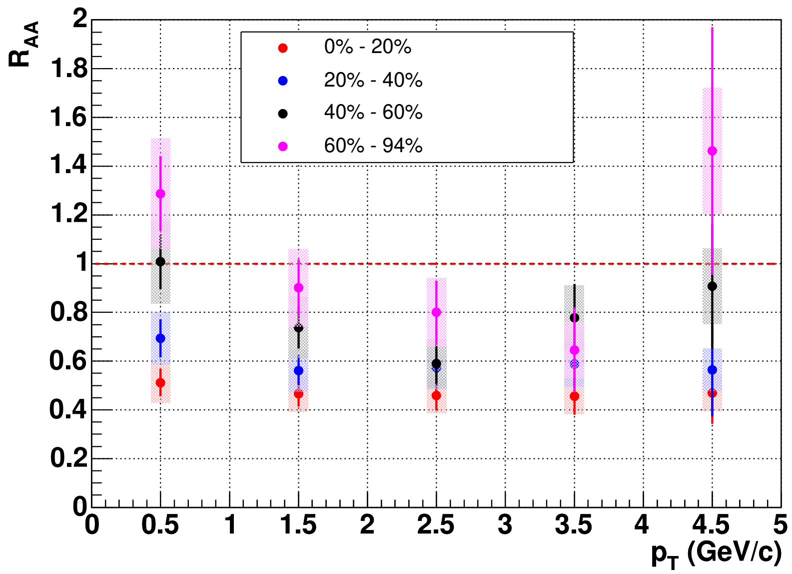


Mean p_T^2 : $\sim$ 3-4 (GeV/c)^2.

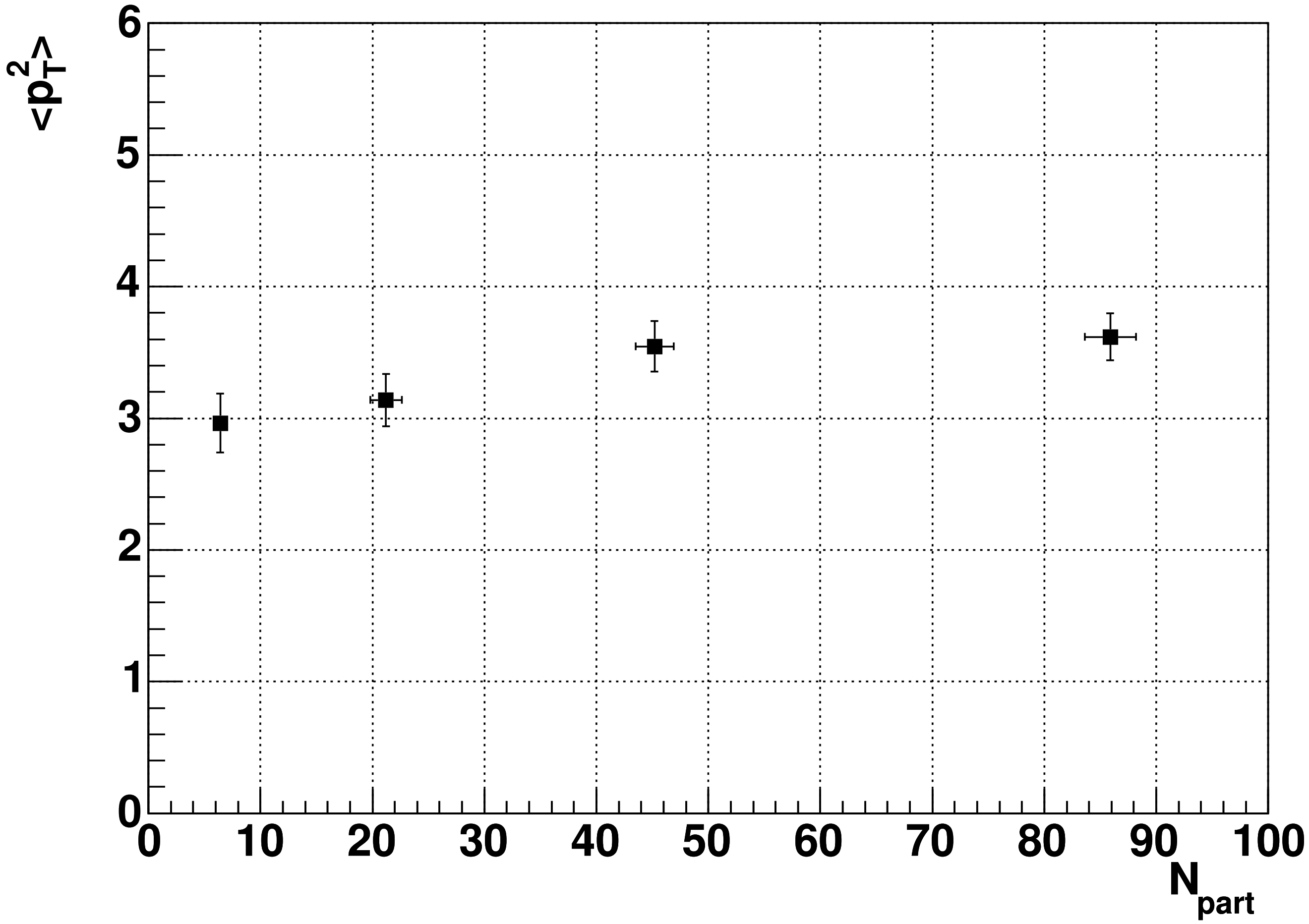
The yield curve's up/down (bin-center) corrections are close to identical to what was obtained for $p+p$.

Suppression mainly for more central: 0–20, 20–40% bins..

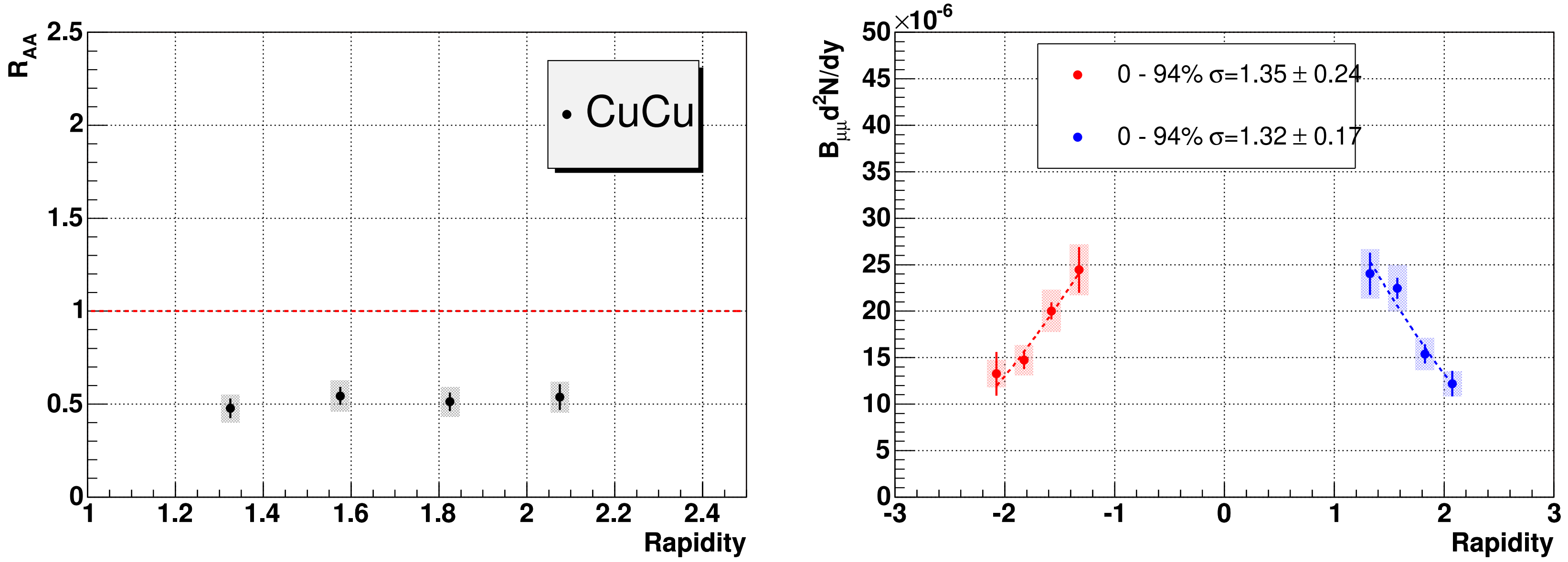




Rather flat, within errors, vs centrality. Possible increasing trend...



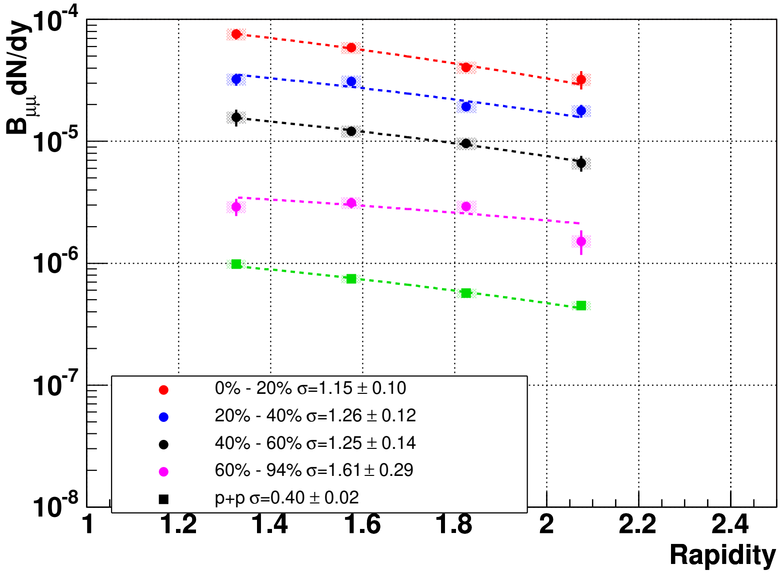
This is for all centralities. Gaussian fit, with mean fixed at 0, to the rapidity distribution for the right plot.

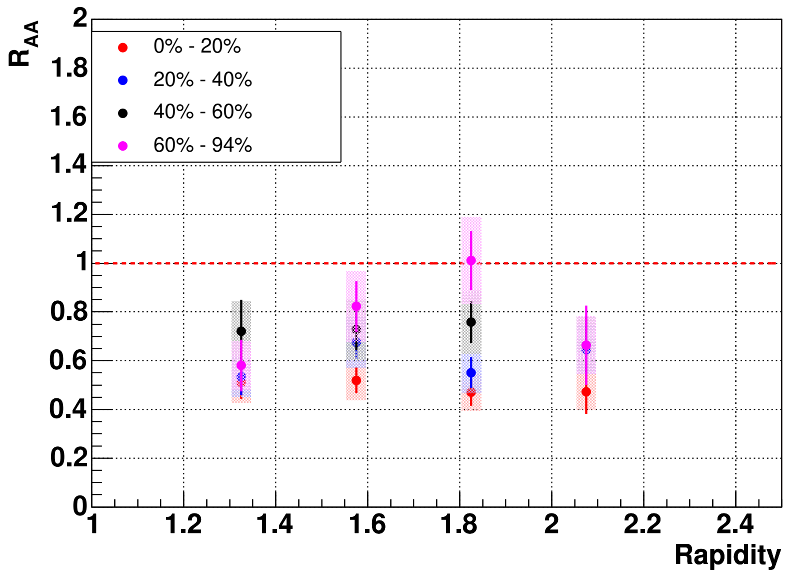


Do not claim that fit form is realistic or optimal choice but wanted to have some handle on whether we see a narrowing width with increasing centrality or not.

R_{AA} vs y, coarse centrality bins

Suppression fairly flat with y (?): 0–20, 20–40% bins..

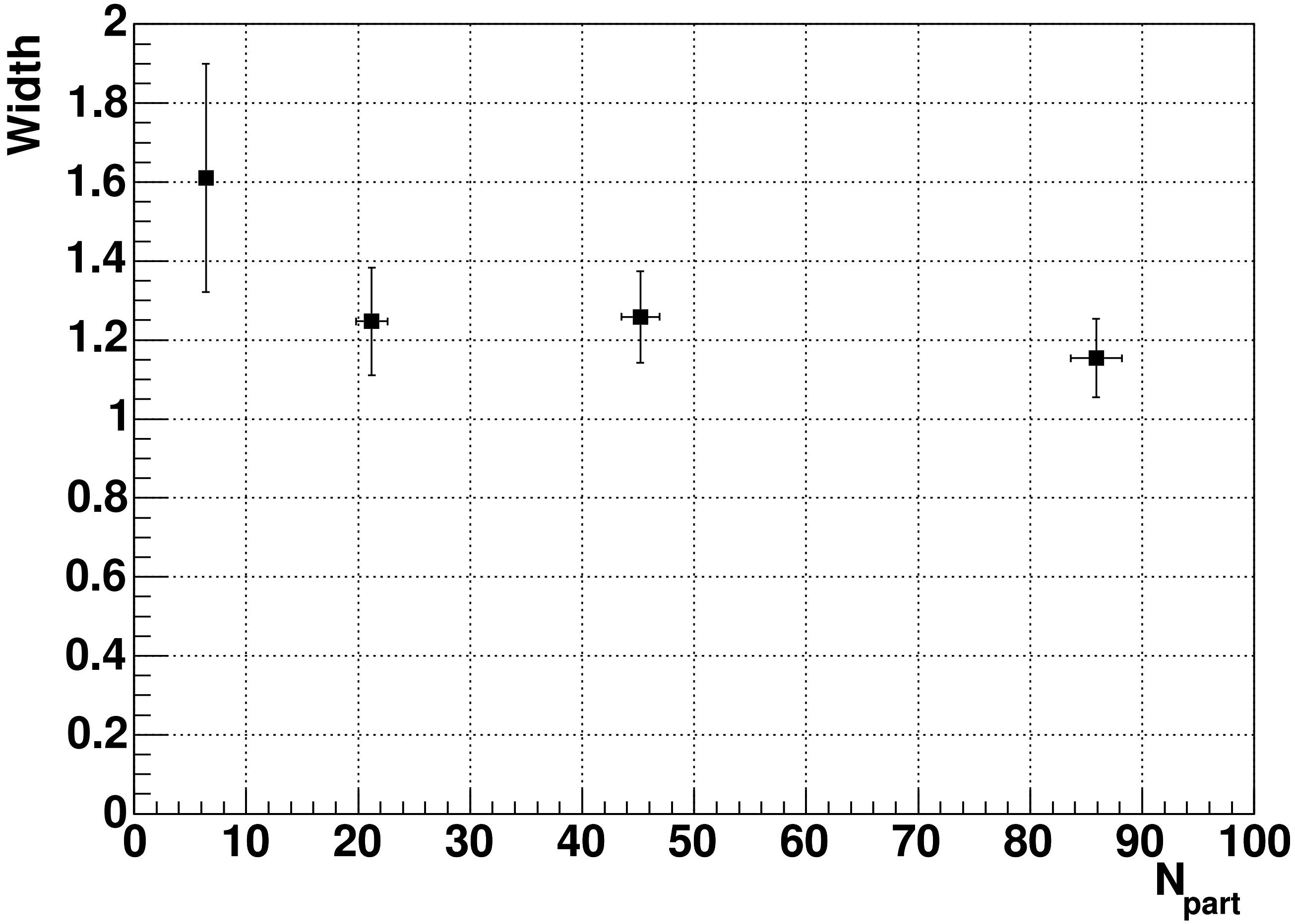




[not sure yet what happened with $p + p$ fit..]

Like for R_{AA} vs p_T, y behaviour does not appear to me (DS) to be a shape change but rather just an overall scale change with centrality.

Width rather flat vs centrality. Possible decreasing trend...



The R_{AA} accuracy is much improved with the run5 $p+p$ data reference.

We found the following in 200 GeV $Cu+Cu$ dimuon J/ψ:

- Centrality dependence: suppression relative to N_{coll} scaling by a factor of about 2 for the most central collisions.
- p_T dependence/R_{AA}: suppression seems rather flat with p_T;
  Mean p_T^2 appears to be approx. flat vs centrality.
- rapidity dependence/R_{AA}: suppression seems rather flat with y too;
  rapidity width perhaps also appears to be approx. flat with centrality.

Since we have a $p+p$ reference with much smaller errors now, we have only looked at R_{AA}, and not R_{CP}, as we did for QM. [We think that should no longer be needed]

Our plan is to finalize the few not-yet-updated systematic errors over the next week or two, and finalize the analysis note, particularly acc*eff section (or a whole separate note), in the process.

Will report back to H/L PWG after that and suggest to move on to form the PPG (with di-electrons, I assume).