

Υ Production in $\sqrt{s} = 200$ GeV p + p Collisions at PHENIX in 2005

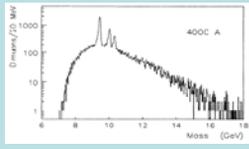
S.A. Butsyk, M.J. Leitch for the PHENIX Collaboration

1st Upsilon's at RHIC !



$\Upsilon(1S, 2S, 3S)$ at FNAL

Υ state	Mass (GeV)	BR	CDF $\sqrt{s} = 1.8$ TeV	FNAL E605 $\sqrt{s} = 39$ GeV
1S	9.46	2.48%	73%	72%
2S	10.02	1.31%	17%	19%
3S	10.36	1.81%	10%	9%



Upsilon mass spectrum from E605 - PR D43, 2815 (1991)

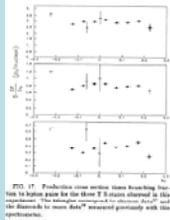
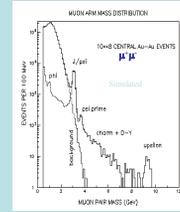
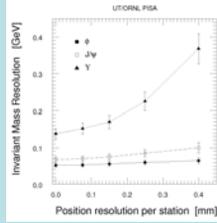


FIG. 17. Production cross section ratios branching ratios for muon pairs for the three Υ states observed at FNAL. The ratios are compared to previous FNAL and E605 results to more clearly represent generally with the uncertainties.

$\Upsilon \rightarrow \mu\mu$ in the PHENIX CDR (simulations)



Expectations for RHIC-II (12-wk run)

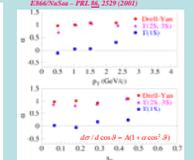
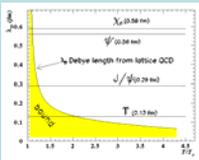
	$\Upsilon - \mu\mu$	$\Upsilon - ee$
pp	530	210
AuAu	1000	400

Upsilon physics

Υ should melt in QGP at higher temperature than J/ψ

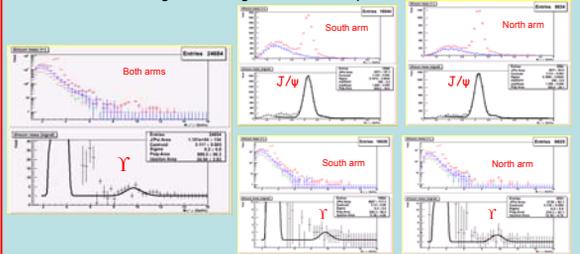
Polarization anomaly from FNAL fixed target:

- 1S unpolarized, 2S+3S maximal transverse ($a = 1$) polarization



Mass spectra and yields - p+p at $\sqrt{s} = 200$ GeV

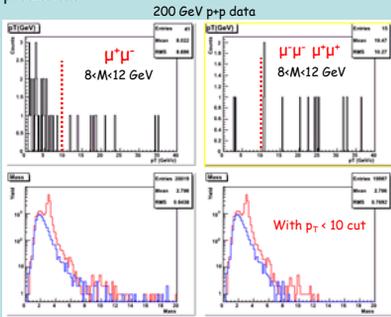
- $J/\psi \sim 160$ MeV; Upsilon's - simulations indicate expected mass resolution of ~ 500 to 700 MeV due to several effects:
 - we see three states, 1S, 2S, 3S, together within our resolution
 - Upsilon resolution is worse than J/ψ because the higher momentum tracks from the Upsilon
 - experience less multiple scattering in the absorbers between the tracking (momentum measuring volume) and the vertex, and so are dominated by tracking resolution (unlike the J/ψ)
 - bend less so again tracking resolution is important



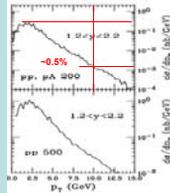
Arm	8.5 - 11.5 GeV			8 - 12 GeV			9 - 11 GeV		
	Unlike-sign	Like-sign	Signal	Unlike-sign	Like-sign	Signal	Unlike-sign	Like-sign	Signal
Both	27	0	27 ± 5	34	3	31 ± 6	22	0	22 ± 5
South	15	0	15 ± 4	20	2	18 ± 5	11	0	11 ± 3
North	12	0	12 ± 4	14	0	14 ± 4	11	0	11 ± 3

Another verification of the Υ signal

- Foreground shows a clear peak in pair mass
- Background is dominated by high p_T pairs
- di-muon p_T cut ($p_T < 10$ GeV/c) makes signal more pronounced
- Should not lose a lot of signal with this cut ($\sim 0.5\%$), according to theoretical predictions



Theoretical p_T distributions from R. Vogt



In p_T distributions of unlike-sign pairs (top left) and like-sign pairs (top right) for $8 < \text{Mass} < 12$ GeV, we see that real pairs peak at small p_T as expected, while randoms are more flat with p_T . With a real cut requiring that $p_T < 10$ GeV/c the Upsilon signal/noise at ~ 9.5 GeV (bottom left) is greatly enhanced (bottom right). Unlike-sign pairs are black & like-sign blue in this plot in bottom plots.

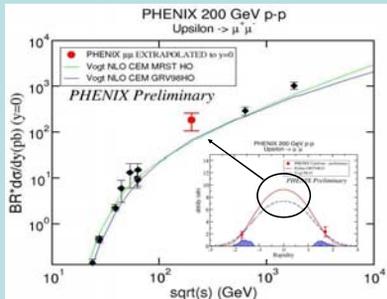
Systematics due to uncertainty in Upsilon mass resolution

- tested by varying size of mass window for counting
- and by applying same counting/mass windows to data & simulation
- with simulation smeared to 500 or 700 MeV resolution

Mass Window (GeV)	Data Count ratio	Simulations	
		$\sigma = 500$ MeV Yield frac. relative	$\sigma = 700$ MeV Yield frac. relative
8 - 12	1.15	0.96	1.02
8.5 - 11.5	1	0.968	1
9 - 12	0.82	0.821	0.85

- narrow mass window causes counts to decrease as expected from simulation
- wider window appears to pick up more (background counts?) than expected from simulation
- take a 10% systematic on this - small compared to statistical errors!

Upsilon cross section and its sqrt(s) dependence



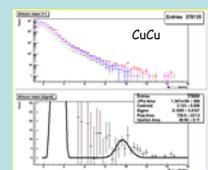
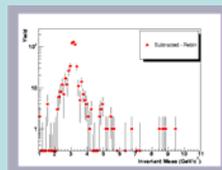
Upsilon cross sections (1S+2S+3S) in muon arms extrapolated to $y = 0$ using various shapes (inset fig):

- PYTHIA shape using GRV94LO structure functions
- other structure functions look almost identical
- NLO shape from Ramona Vogt (NLO CEM model)
- <http://rhic-heavy.bnl.gov/doc/April05Meeting/ramona-nlo.pdf>

Blue histograms at the bottom of the plot are a representation of the shape of the accepted events in the two muon arms

Energy dependence for Upsilon differential cross section at $y=0$ including our 200 GeV preliminary estimate, by extrapolation to $y=0$ from our di-muon measurements at $|y|=1.7$

Consistency with other Run5 data



Di-electron mass spectrum from near-online analysis showing 4-5 events near the Upsilon mass. Consistent with extrapolated cross section from the muon arms.

CuCu mass spectrum also showing a possible Upsilon peak at a level roughly consistent with that seen in pp collisions. But unclear until further analysis is done since peaks appears to be higher in mass than expected.