Y(nS) Analysis Report

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HIN Di-lepton Meeting

30-Mar-16

(1) UC Davis, (2) Chonnam Univ., (3) Korea Univ.

Overall status

- Physics observables determined
  - Double ratio vs centrality
  - Double ratio vs pT in 5 bins
  - Double ratio vs rapidity in 6 bins

  } 3 major plots
  - Upper limit of Y(3S), perhaps in integrated bin
- AN-16-063 grows rapidly. (47 page as of today)

Final result based on private MC exercise

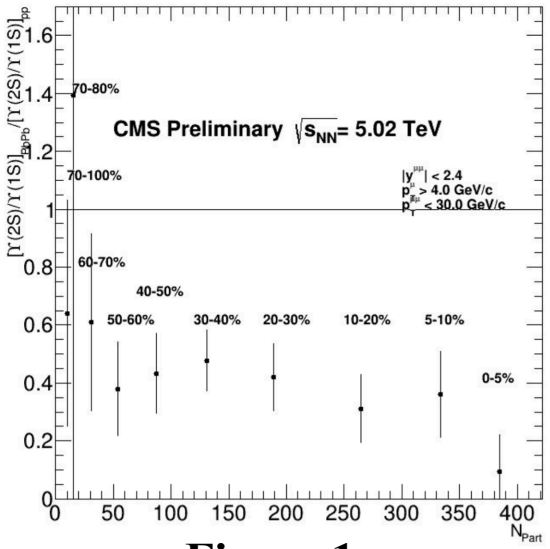


Figure 1

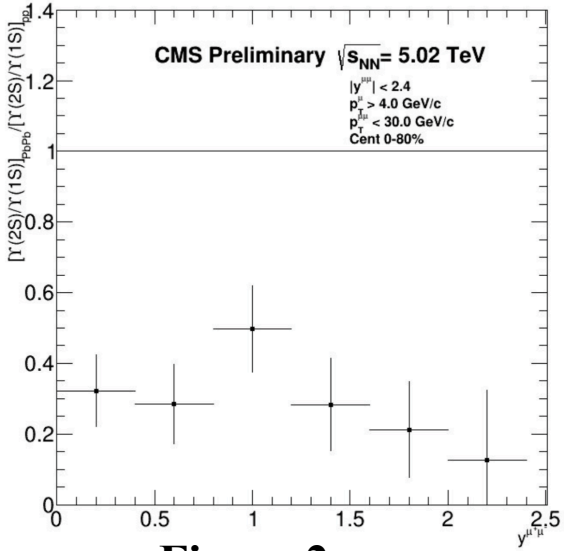


Figure 2

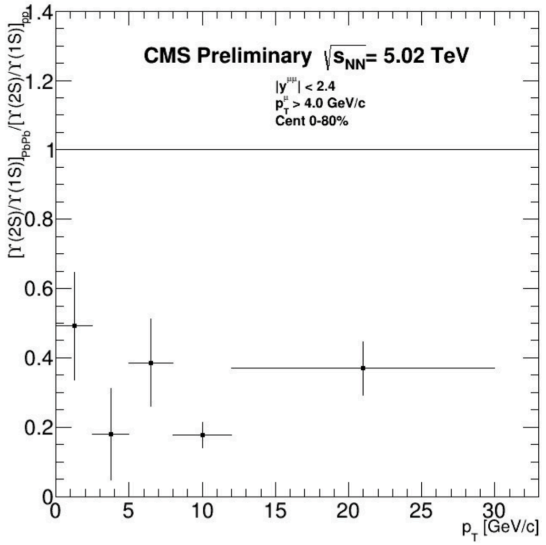


Figure 3

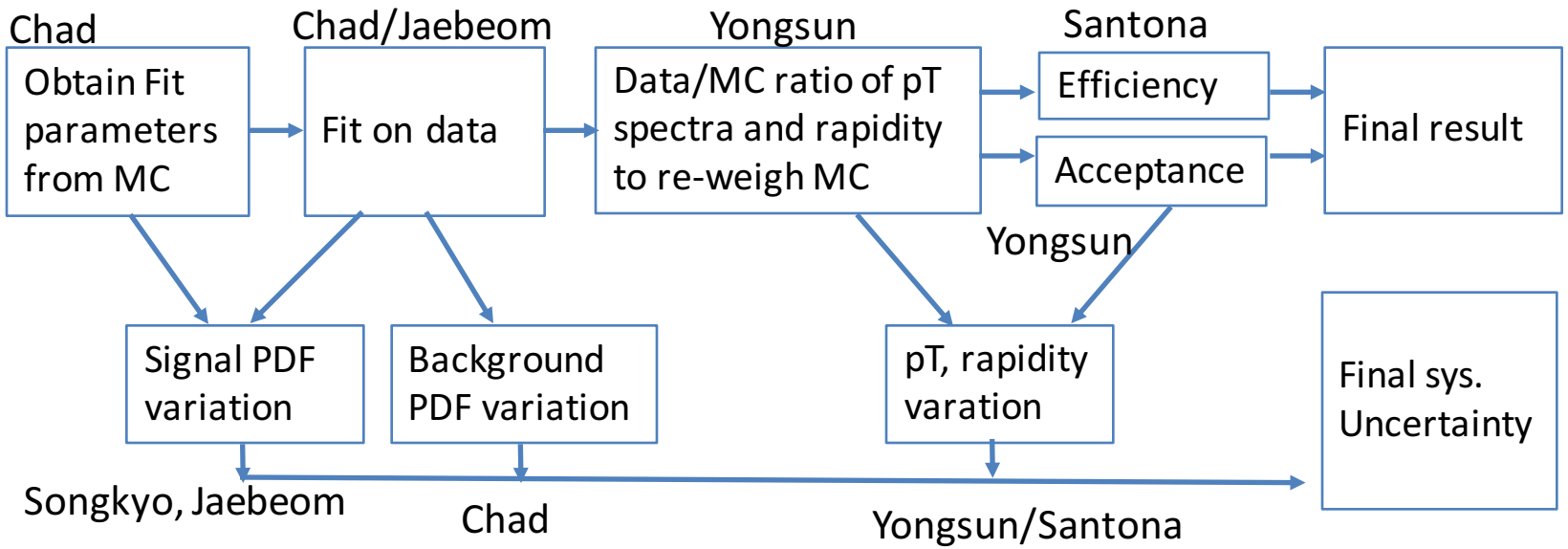
Overall status

- Physics observables determined
  - Double ratio vs centrality
  - Double ratio vs pT in 5 bins
  - Double ratio vs rapidity in 6 bins

  } 3 major plots

  - Upper limit of Y(3S), perhaps in integrated bin (Geonhee, Chad)

- Y(2S)/Y(1S) double ratio workflow

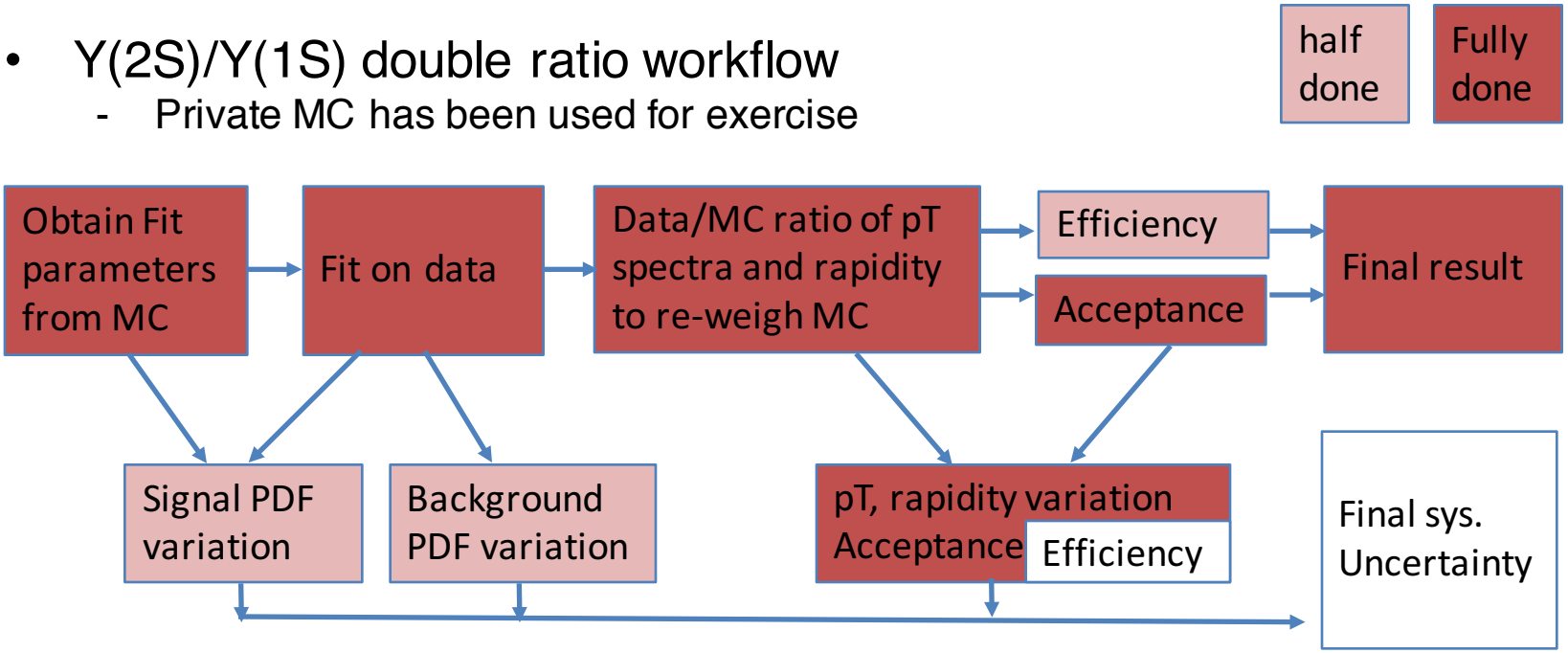


Overall status

- Physics observables determined
  - Double ratio vs centrality
  - Double ratio vs pT in 5 bins
  - Double ratio vs rapidity in 6 bins

  } 3 major plots
  - Upper limit of Y(3S), perhaps in integrated bin

- Y(2S)/Y(1S) double ratio workflow
  - Private MC has been used for exercise



  - Official MC status : Embedded samples's tree are ready. PYTHIA is being skimmed

Scope of approval schedule

- Analysis review by di-leptoners
  - Will send AN draft CM and di-leptons ~Apr 8th
  - Double ratio study can be done
  - Upsilon(3S) might not be in the final state yet
- Summary presentation in di-lepton meeting
  - Apr 13th
- First AN freeze, request CADI, write PAS
  - April 15th (Fri) – April 22th (Fri)
- Pre-approval
  - April 29th
- Approval
  - TBD…

Acceptance correction

- Acceptance based on the GEN-only sample.

Bin	PYTHIA (1S)	pp (1S)	PbPb (1S)	PYTHIA (2S)	pp Rwgt (2S)	PbPb Rwgt (2S)	final crrection
p_T, y integrated	0.225	0.218	0.221	0.272	0.275	0.276	0.992
$p_T < 2.5$GeV/c	0.258	0.258	0.258	0.375	0.372	0.371	0.998
$2.5 < p_T < 5$GeV/c	0.155	0.155	0.155	0.216	0.215	0.215	0.999
$5 < p_T < 8$GeV/c	0.185	0.184	0.184	0.215	0.216	0.216	1.000
$8 < p_T < 12$GeV/c	0.29	0.289	0.289	0.304	0.306	0.306	0.999
$12 < p_T < 30$GeV/c	0.475	0.466	0.47	0.473	0.483	0.484	0.994
$\|y\| < 0.4$	0.253	0.244	0.247	0.304	0.309	0.311	0.992
$0.4 < \|y\| < 0.8$	0.251	0.243	0.246	0.303	0.308	0.309	0.992
$0.8 < \|y\| < 1.2$	0.251	0.242	0.245	0.302	0.307	0.308	0.992
$1.2 < \|y\| < 1.6$	0.249	0.241	0.244	0.302	0.306	0.307	0.992
$1.6 < \|y\| < 2.0$	0.221	0.216	0.218	0.27	0.27	0.27	0.991
$2.0 < \|y\| < 2.4$	0.098	0.096	0.097	0.119	0.117	0.117	0.991

Table 2: Acceptance corrections after reweighting PYTHIA simulation by PbPb and pp p_T spectra

Correciton <1%

- Uncertainty : varied +/-20% on pt and rapidity shapes
  - HIN-15-001 method. Detailed procedure in BACKUP.

Bin	nominal acceptance		p_T re-weigh Y(1S)		p_T re-weigh Y(2S)		y re-weigh Y(1S)		y re-weigh Y(2S)		Systematic uncertainty
	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	
p_T, y integrated	0.279	0.281	1.3%	1.4%	0.7%	0.9%	0.7%	0.7%	0.7%	0.7%	2.7%
$p_T < 2.5$GeV/c	0.337	0.337	0.2%	0.2%	0.1%	0.1%	1.6%	1.6%	1.3%	1.3%	3%
$2.5 < p_T < 5$GeV/c	0.204	0.204	0%	0%	0%	0%	1.2%	1.2%	1.2%	1.2%	2.4%
$5 < p_T < 8$GeV/c	0.234	0.234	0.1%	0.1%	0%	0%	0.6%	0.6%	0.6%	0.6%	1.3%
$8 < p_T < 12$GeV/c	0.355	0.355	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.4%
$12 < p_T < 30$GeV/c	0.546	0.550	0.6%	0.6%	0.7%	0.7%	0.4%	0.4%	0.4%	0.4%	1.6%
$\|y\| < 0.4$	0.256	0.259	1.7%	1.8%	1.1%	1.2%	0%	0%	0%	0%	3%
$0.4 < \|y\| < 0.8$	0.262	0.265	1.6%	1.7%	1%	1.1%	0%	0%	0%	0%	2.8%
$0.8 < \|y\| < 1.2$	0.270	0.273	1.5%	1.7%	0.9%	1%	0%	0%	0%	0%	2.7%
$1.2 < \|y\| < 1.6$	0.295	0.298	1.3%	1.5%	0.7%	0.9%	0%	0%	0%	0%	2.3%
$1.6 < \|y\| < 2.0$	0.330	0.332	0.7%	0.8%	0.1%	0.2%	0%	0%	0%	0%	1.1%
$2.0 < \|y\| < 2.4$	0.290	0.290	0.1%	0%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	1%

Table 5: Systematic deviations of double ratio by acceptance cut

Uncertainty <3%

- Tables will be updated when official MC trees are released
  - Need dN/dpT comparsions of data and MC

Acceptance correction

- Acceptance based on the GEN-only sample

Bin	PYTHIA (1S)	pp (1S)	PbPb (1S)	PYTHIA (2S)	pp Rwgt (2S)	PbPb Rwgt (2S)	final crrection
p_T, y integrated	0.225	0.218	0.221	0.272	0.275	0.276	0.992
$p_T < 2.5$GeV/c	0.258	0.258	0.258	0.375	0.372	0.371	0.998
$2.5 < p_T < 5$GeV/c	0.155	0.155	0.155	0.216	0.215	0.215	0.999
$5 < p_T < 8$GeV/c	0.185	0.184	0.184	0.215	0.216	0.216	1.000
$8 < p_T < 12$GeV/c	0.29	0.289	0.289	0.304	0.306	0.306	0.999
$12 < p_T < 30$GeV/c	0.475	0.466	0.47	0.473	0.483	0.484	0.994
$\|y\| < 0.4$	0.253	0.244	0.247	0.304	0.309	0.311	0.992
$0.4 < \|y\| < 0.8$	0.251	0.243	0.246	0.303	0.308	0.309	0.992
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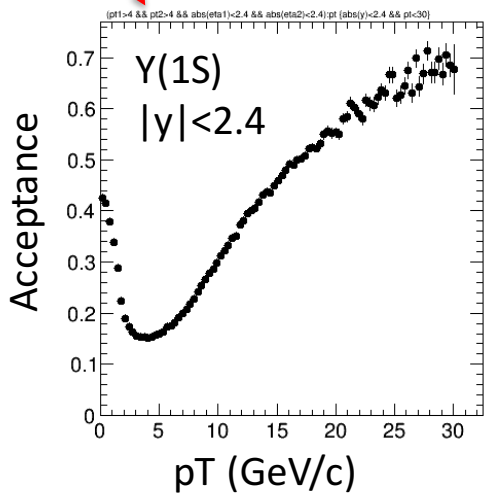
$1.2 < \|y\| < 1.6$	0.249	0.241	0.244	0.302	0.306	0.307	0.992
$1.6 < \|y\| < 2.0$	0.221	0.216	0.218	0.27	0.27	0.27	0.991
$2.0 < \|y\| < 2.4$	0.098	0.096	0.097	0.119	0.117	0.117	0.991

Table 2: Acceptance corrections after reweighting PYTHIA simulation by PbPb and pp p_T spectra



Acceptance cut

$p_T^{mu} > 4$GeV/c

$|eta^{mu}| < 2.4$

Is this non-monotonic shape normal?

Sanity checks for PDF assumption

- We required 3 peaks have the identical parameter sets (sigma/m, alpha, n, f, x)
- Validated this assumption by MC study
- Parameters obtained from Y(1S), and tested on Y(2S) peak
- The result looked sane for every kinematic bin.
- Details are in AN

Jaebeom

Lowest pT

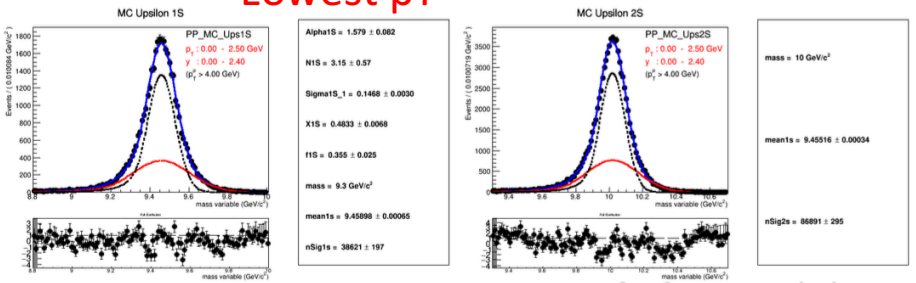


Figure 34: Fit to Y(1S) (left) and Y(2S) (right) in pp private MC for p_T[GeV/c] ∈ [0-2.5]

Highest pT

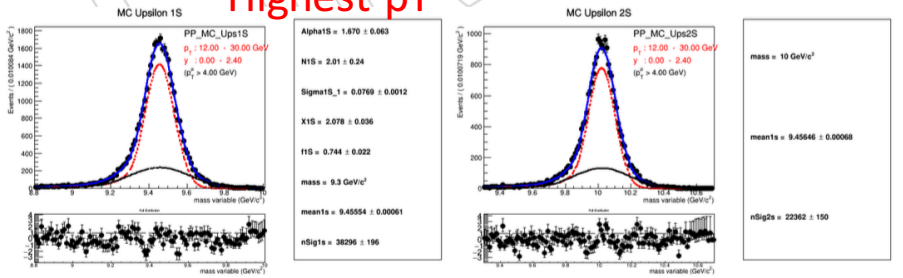


Figure 38: Fit to Y(1S) (left) and Y(2S) (right) in pp private MC for p_T[GeV/c] ∈ [12.0-30.0]

Most forward rapidity

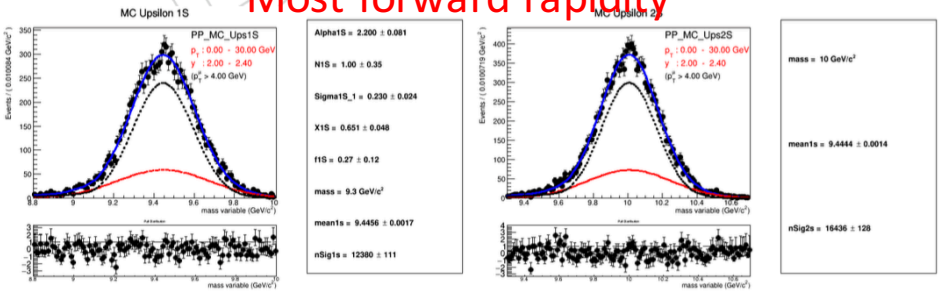
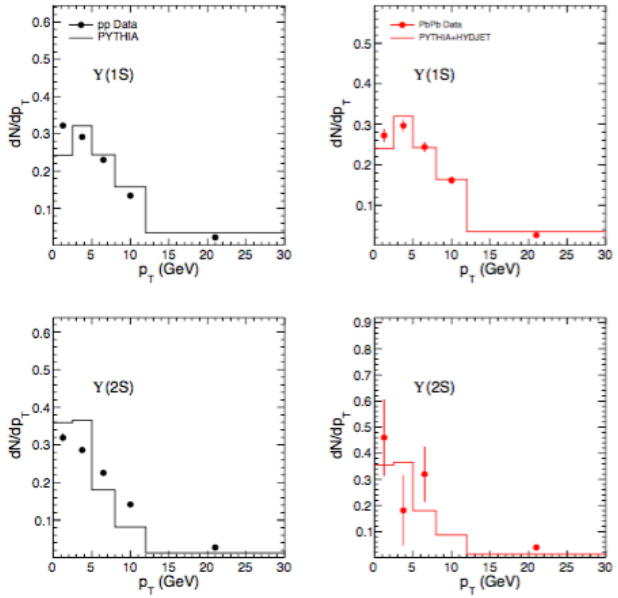


Figure 44: Fit to Y(1S) (left) and Y(2S) (right) in pp private MC for $|y^{\mu\mu}|$ ∈ [2.0-2.4]

BACKUP



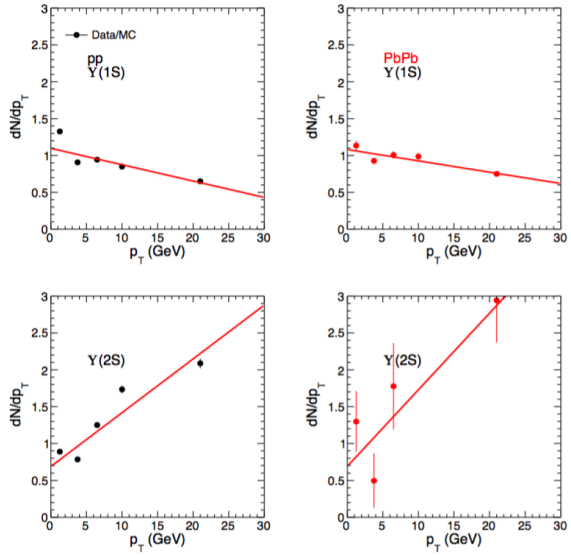


Figure 19: Data/MC ratios of p_T spectra and their fit functions in linear polinomials.

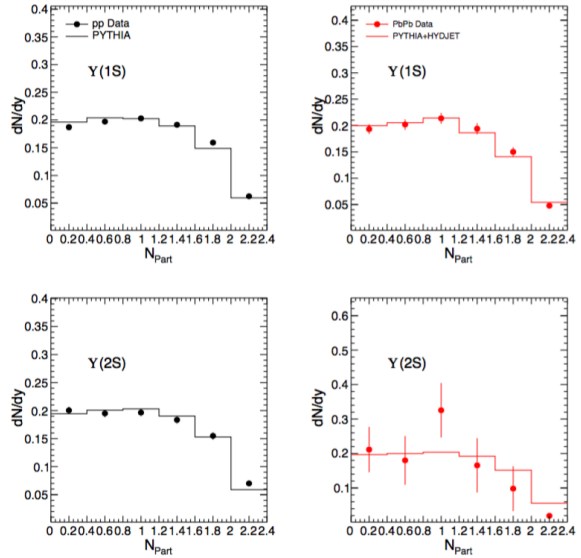


Figure 20: The measured data vs Pythia distributions of rapidity.

Exercise using private MC

Bin	nominal acceptance		p_T re-weigh Y(1S)		p_T re-weigh Y(2S)		y re-weigh Y(1S)		y re-weigh Y(2S)		Systematic
	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	uncertainty
p_T, y integrated	0.279	0.281	1.3%	1.4%	0.7%	0.9%	0.7%	0.7%	0.7%	0.7%	2.7%
$p_T < 2.5$GeV/c	0.337	0.337	0.2%	0.2%	0.1%	0.1%	1.6%	1.6%	1.3%	1.3%	3%
$2.5 < p_T < 5$GeV/c	0.204	0.204	0%	0%	0%	0%	1.2%	1.2%	1.2%	1.2%	2.4%
$5 < p_T < 8$GeV/c	0.234	0.234	0.1%	0.1%	0%	0%	0.6%	0.6%	0.6%	0.6%	1.3%
$8 < p_T < 12$GeV/c	0.355	0.355	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.4%
$12 < p_T < 30$GeV/c	0.546	0.550	0.6%	0.6%	0.7%	0.7%	0.4%	0.4%	0.4%	0.4%	1.6%
$\|y\| < 0.4$GeV/c	0.256	0.259	1.7%	1.8%	1.1%	1.2%	0%	0%	0%	0%	3%
$0.4 < \|y\| < 0.8$GeV/c	0.262	0.265	1.6%	1.7%	1%	1.1%	0%	0%	0%	0%	2.8%
$0.8 < \|y\| < 1.2$GeV/c	0.270	0.273	1.5%	1.7%	0.9%	1%	0%	0%	0%	0%	2.7%
$1.2 < \|y\| < 1.6$GeV/c	0.295	0.298	1.3%	1.5%	0.7%	0.9%	0%	0%	0%	0%	2.3%
$1.6 < \|y\| < 2.0$GeV/c	0.330	0.332	0.7%	0.8%	0.1%	0.2%	0%	0%	0%	0%	1.1%
$2.0 < \|y\| < 2.4$GeV/c	0.290	0.290	0.1%	0%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	1%

Table 5: Systematic deviations of double ratio by acceptance cut

Exercise using private MC

Further variance on pT weight

pp Y(1S) : 1.09 - 0.022*pt
pp Y(2S) : 0.69 + 0.073*pt
AA Y(1S) : 1.08 - 0.015*pt
AA Y(2S) : 0.68 + 0.1*pt

Bin	nominal acceptance		p_T re-weigh Y(1S)		p_T re-weigh Y(2S)		y re-weigh Y(1S)		y re-weigh Y(2S)		Systematic
	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	uncertainty
p_T, y integrated	0.279	0.281	1.3%	1.4%	0.7%	0.9%	0.7%	0.7%	0.7%	0.7%	2.7%
$p_T < 2.5$GeV/c	0.337	0.337	0.2%	0.2%	0.1%	0.1%	1.6%	1.6%	1.3%	1.3%	3%
$2.5 < p_T < 5$GeV/c	0.204	0.204	0%	0%	0%	0%	1.2%	1.2%	1.2%	1.2%	2.4%
$5 < p_T < 8$GeV/c	0.234	0.234	0.1%	0.1%	0%	0%	0.6%	0.6%	0.6%	0.6%	1.3%
$8 < p_T < 12$GeV/c	0.355	0.355	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.4%
$12 < p_T < 30$GeV/c	0.546	0.550	0.6%	0.6%	0.7%	0.7%	0.4%	0.4%	0.4%	0.4%	1.6%
$\|y\| < 0.4$GeV/c	0.256	0.259	1.7%	1.8%	1.1%	1.2%	0%	0%	0%	0%	3%
$0.4 < \|y\| < 0.8$GeV/c	0.262	0.265	1.6%	1.7%	1%	1.1%	0%	0%	0%	0%	2.8%
$0.8 < \|y\| < 1.2$GeV/c	0.270	0.273	1.5%	1.7%	0.9%	1%	0%	0%	0%	0%	2.7%
$1.2 < \|y\| < 1.6$GeV/c	0.295	0.298	1.3%	1.5%	0.7%	0.9%	0%	0%	0%	0%	2.3%
$1.6 < \|y\| < 2.0$GeV/c	0.330	0.332	0.7%	0.8%	0.1%	0.2%	0%	0%	0%	0%	1.1%
$2.0 < \|y\| < 2.4$GeV/c	0.290	0.290	0.1%	0%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	1%

Table 5: Systematic deviations of double ratio by acceptance cut

Exercise using private MC

Acceptance after the pT re-weight slope varied by 20%

pp Y(1S) +20% : (1.09 - 0.022*pt) * (0.8 + 0.0133*pt)
pp Y(1S) - 20% : (1.09 - 0.022*pt) * (1.2 - 0.0133*pt)

Varied acceptances are divided by the normal value, and bigger deviation recorded

Relative deviation (%)
From the first column values

Bin	nominal acceptance		p_T re-weigh Y(1S)		p_T re-weigh Y(2S)		y re-weigh Y(1S)		y re-weigh Y(2S)		Systematic uncertainty
	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	
p_T, y integrated	0.279	0.281	1.3%	1.4%	0.7%	0.9%	0.7%	0.7%	0.7%	0.7%	2.7%
$p_T < 2.5$GeV/c	0.337	0.337	0.2%	0.2%	0.1%	0.1%	1.6%	1.6%	1.3%	1.3%	3%
$2.5 < p_T < 5$GeV/c	0.204	0.204	0%	0%	0%	0%	1.2%	1.2%	1.2%	1.2%	2.4%
$5 < p_T < 8$GeV/c	0.234	0.234	0.1%	0.1%	0%	0%	0.6%	0.6%	0.6%	0.6%	1.3%
$8 < p_T < 12$GeV/c	0.355	0.355	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.4%
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$1.6 < \|y\| < 2.0$GeV/c	0.330	0.332	0.7%	0.8%	0.1%	0.2%	0%	0%	0%	0%	1.1%
$2.0 < \|y\| < 2.4$GeV/c	0.290	0.290	0.1%	0%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	1%

Table 5: Systematic deviations of double ratio by acceptance cut

Exercise using private MC

Acceptance after the pT re-weight slope varied by 20%

pp Y(1S) +20% : (1.09 - 0.022*pt) * (0.8 + 0.0133*pt)
pp Y(1S) - 20% : (1.09 - 0.022*pt) * (1.2 - 0.0133*pt)

Varied acceptances are divided by the normal value, and bigger deviation recorded

Same procedure done for AA Y(1S), pp Y(2S), and AA Y(2S)…

Bin	nominal acceptance		p_T re-weigh Y(1S)		p_T re-weigh Y(2S)		y re-weigh Y(1S)		y re-weigh Y(2S)		Systematic uncertainty
	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	
p_T, y integrated	0.279	0.281	1.3%	1.4%	0.7%	0.9%	0.7%	0.7%	0.7%	0.7%	2.7%
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$2.5 < p_T < 5$GeV/c	0.204	0.204	0%	0%	0%	0%	1.2%	1.2%	1.2%	1.2%	2.4%
$5 < p_T < 8$GeV/c	0.234	0.234	0.1%	0.1%	0%	0%	0.6%	0.6%	0.6%	0.6%	1.3%
$8 < p_T < 12$GeV/c	0.355	0.355	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.4%
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$0.4 < \|y\| < 0.8$GeV/c	0.262	0.265	1.6%	1.7%	1%	1.1%	0%	0%	0%	0%	2.8%
$0.8 < \|y\| < 1.2$GeV/c	0.270	0.273	1.5%	1.7%	0.9%	1%	0%	0%	0%	0%	2.7%
$1.2 < \|y\| < 1.6$GeV/c	0.295	0.298	1.3%	1.5%	0.7%	0.9%	0%	0%	0%	0%	2.3%
$1.6 < \|y\| < 2.0$GeV/c	0.330	0.332	0.7%	0.8%	0.1%	0.2%	0%	0%	0%	0%	1.1%
$2.0 < \|y\| < 2.4$GeV/c	0.290	0.290	0.1%	0%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	1%

Table 5: Systematic deviations of double ratio by acceptance cut

Exercise using private MC

Acceptance after the Rapidity re-weight slope varied by 20%

pp Y(1S) +20% : (1.09 - 0.022*pt) * (0.8 + 0.167*abs(y)

pp Y(1S) - 20% : (1.09 - 0.022*pt) * (1.2 - 0.167*abs(y)

Varied acceptances are divided by the normal value, and bigger deviation recorded

And so on for other 3 columns.

Bin	nominal acceptance		p_T re-weigh Y(1S)		p_T re-weigh Y(2S)		y re-weigh Y(1S)		y re-weigh Y(2S)		Systematic uncertainty
	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	
p_T, y integrated	0.279	0.281	1.3%	1.4%	0.7%	0.9%	0.7%	0.7%	0.7%	0.7%	2.7%
$p_T < 2.5$GeV/c	0.337	0.337	0.2%	0.2%	0.1%	0.1%	1.6%	1.6%	1.3%	1.3%	3%
$2.5 < p_T < 5$GeV/c	0.204	0.204	0%	0%	0%	0%	1.2%	1.2%	1.2%	1.2%	2.4%
$5 < p_T < 8$GeV/c	0.234	0.234	0.1%	0.1%	0%	0%	0.6%	0.6%	0.6%	0.6%	1.3%
$8 < p_T < 12$GeV/c	0.355	0.355	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.4%
$12 < p_T < 30$GeV/c	0.546	0.550	0.6%	0.6%	0.7%	0.7%	0.4%	0.4%	0.4%	0.4%	1.6%
$\|y\| < 0.4$GeV/c	0.256	0.259	1.7%	1.8%	1.1%	1.2%	0%	0%	0%	0%	3%
$0.4 < \|y\| < 0.8$GeV/c	0.262	0.265	1.6%	1.7%	1%	1.1%	0%	0%	0%	0%	2.8%
$0.8 < \|y\| < 1.2$GeV/c	0.270	0.273	1.5%	1.7%	0.9%	1%	0%	0%	0%	0%	2.7%
$1.2 < \|y\| < 1.6$GeV/c	0.295	0.298	1.3%	1.5%	0.7%	0.9%	0%	0%	0%	0%	2.3%
$1.6 < \|y\| < 2.0$GeV/c	0.330	0.332	0.7%	0.8%	0.1%	0.2%	0%	0%	0%	0%	1.1%
$2.0 < \|y\| < 2.4$GeV/c	0.290	0.290	0.1%	0%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	1%

Table 5: Systematic deviations of double ratio by acceptance cut

Exercise using private MC

Final uncertainty obtained by

sqrt (Sum of deviation^{i}^2)

i = index for 3rd - 10th values

Bin	nominal acceptance		p_T re-weigh Y(1S)		p_T re-weigh Y(2S)		y re-weigh Y(1S)		y re-weigh Y(2S)		Systematic uncertainty
	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	pp	PbPb	
p_T, y integrated	0.279	0.281	1.3%	1.4%	0.7%	0.9%	0.7%	0.7%	0.7%	0.7%	2.7%
$p_T < 2.5$GeV/c	0.337	0.337	0.2%	0.2%	0.1%	0.1%	1.6%	1.6%	1.3%	1.3%	3%
$2.5 < p_T < 5$GeV/c	0.204	0.204	0%	0%	0%	0%	1.2%	1.2%	1.2%	1.2%	2.4%
$5 < p_T < 8$GeV/c	0.234	0.234	0.1%	0.1%	0%	0%	0.6%	0.6%	0.6%	0.6%	1.3%
$8 < p_T < 12$GeV/c	0.355	0.355	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.4%
$12 < p_T < 30$GeV/c	0.546	0.550	0.6%	0.6%	0.7%	0.7%	0.4%	0.4%	0.4%	0.4%	1.6%
$\|y\| < 0.4$GeV/c	0.256	0.259	1.7%	1.8%	1.1%	1.2%	0%	0%	0%	0%	3%
$0.4 < \|y\| < 0.8$GeV/c	0.262	0.265	1.6%	1.7%	1%	1.1%	0%	0%	0%	0%	2.8%
$0.8 < \|y\| < 1.2$GeV/c	0.270	0.273	1.5%	1.7%	0.9%	1%	0%	0%	0%	0%	2.7%
$1.2 < \|y\| < 1.6$GeV/c	0.295	0.298	1.3%	1.5%	0.7%	0.9%	0%	0%	0%	0%	2.3%
$1.6 < \|y\| < 2.0$GeV/c	0.330	0.332	0.7%	0.8%	0.1%	0.2%	0%	0%	0%	0%	1.1%
$2.0 < \|y\| < 2.4$GeV/c	0.290	0.290	0.1%	0%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	1%

Table 5: Systematic deviations of double ratio by acceptance cut

We need Santona to do the same exercise for efficiency