# Latest Results from NA50 Experiment on Charmonium Production in Pb-Pb Collisions

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The NA50 Collaboration
Alessandria, Annecy, Bucharest, Cagliari, CERN, Clermont-Ferrand, Lisbon, Lyon, Moscow, Orsay, Palaiseau, Strasbourg, Torino and Yerevan

## The NA50 Collaboration

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# OUTLINE

$J/\psi$ suppression versus centrality in PB-Pb

$J/\psi/DY$

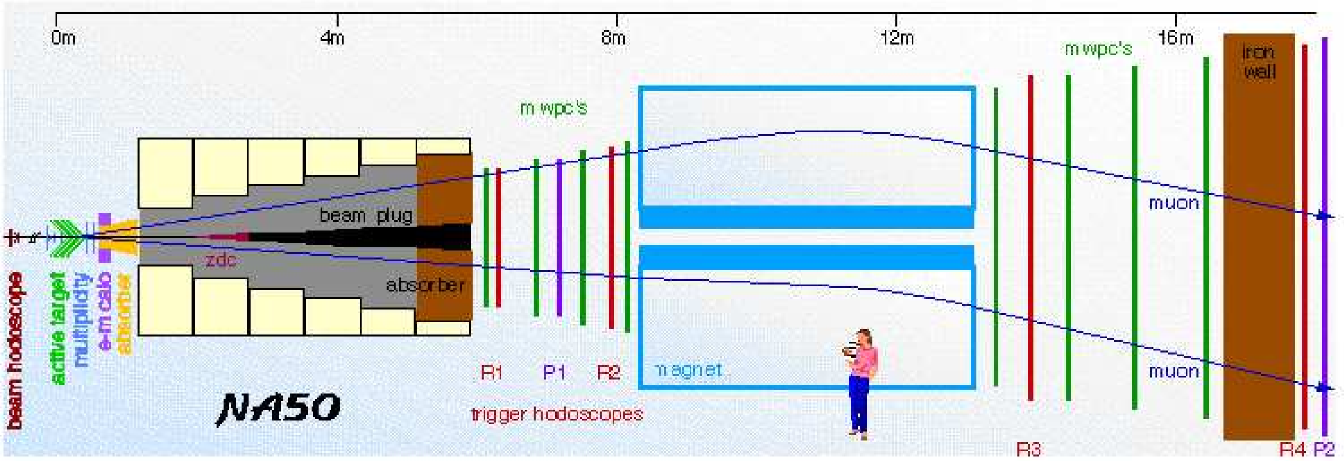
- 1996 DATA: Final Results
  (*Physics Letters B 450(1999) 456*)
- 1998 DATA: Preliminary Results

$J/\psi$/MB - Estimation of DY events from a Minimum Bias trigger sample

- 1996 DATA: Final
- 1998 DATA: Preliminary

CONCLUSIONS

# EXPERIMENTAL SETUP




**The $J/\psi$ is detected via its decay into muon pairs**

- Dimuon spectrometer

$0 < y_{CM} < 1 \quad (2.92 < y_{LAB} < 3.92) \quad |\cos\theta_{CS}| < 0.5$

| | | |
|---|---|---|
| **Acceptance** | $J/\psi$ | 13.5% |
| | **DY**$(2.9 - 4.5)$ | 15.1% |
| | **DY** $(2.9 - 8.0)$ | 15.4% |

- Active target (Cherenkov counters)

- Centrality detectors

- E.m. calorimeter $(1.1 < \eta_{lab} < 2.3)$
- Multiplicity detector $(1.5 < \eta_{lab} < 3.5)$
- Zero Degree Calorimeter $(\eta_{lab} > 6.3)$

# 1996 Pb-Pb data taking

**1995,1996 and 1998 very similar setup except for the target**

**Main task: high statistics → increase the number of high mass muon pairs**
**→ peripheral collisions**

Active target: $30\%\lambda_I$ in 7 subtargets ($17\%\lambda_I$ in 1995)

Better beam optics, collimation. Higher intensity

Beam tuning → less off-target events

| | |
|---|---|
| Beam Intensity (ions per burst) | $5.4 \star 10^7$ |
| Number of collected triggers | $170 \star 10^6$ |
| Total $J/\psi$ events | 190000 |
| Total Drell-Yan events ($M_{\mu\mu} > 4.2\ \ GeV/c^2$) | 2100 |

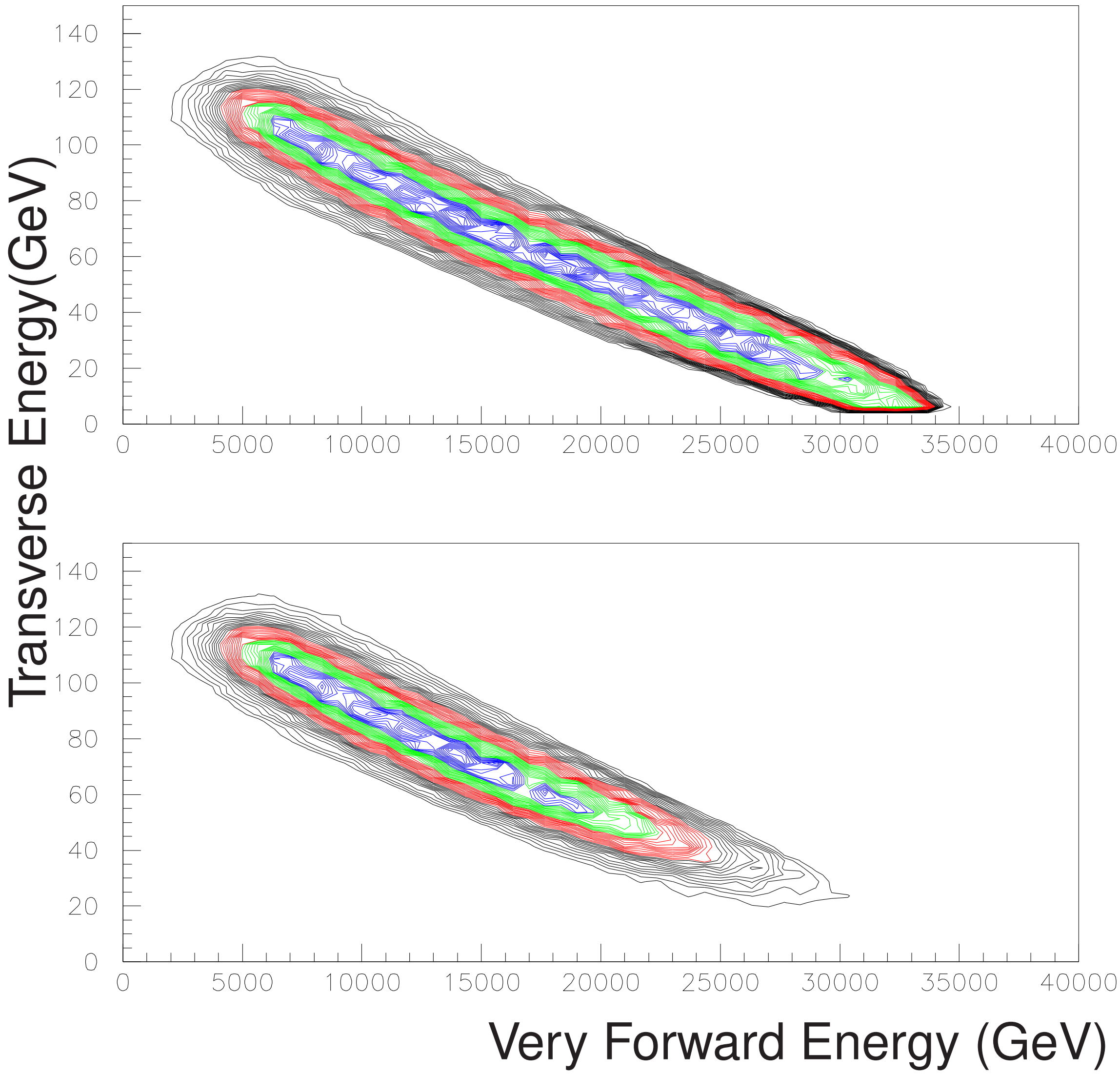
# Event selection

→ Obtain a clean sample of dimuon events originating in the target

1. Dimuon trigger
2. Pile-up rejection from the Beam hodoscope
3. Beam halo rejection
4. Rejection of interactions in the beam hodoscope
5. Target identification (Cherenkov counters) and correlation $E_T - E_{ZDC}$
6. Severe cuts on the muon track quality
7. “Image” cut (to have the same acceptance for $\mu^+\mu^+, \mu^-\mu^-, \mu^+\mu^-$)

# Identification of Pb-Pb interactions

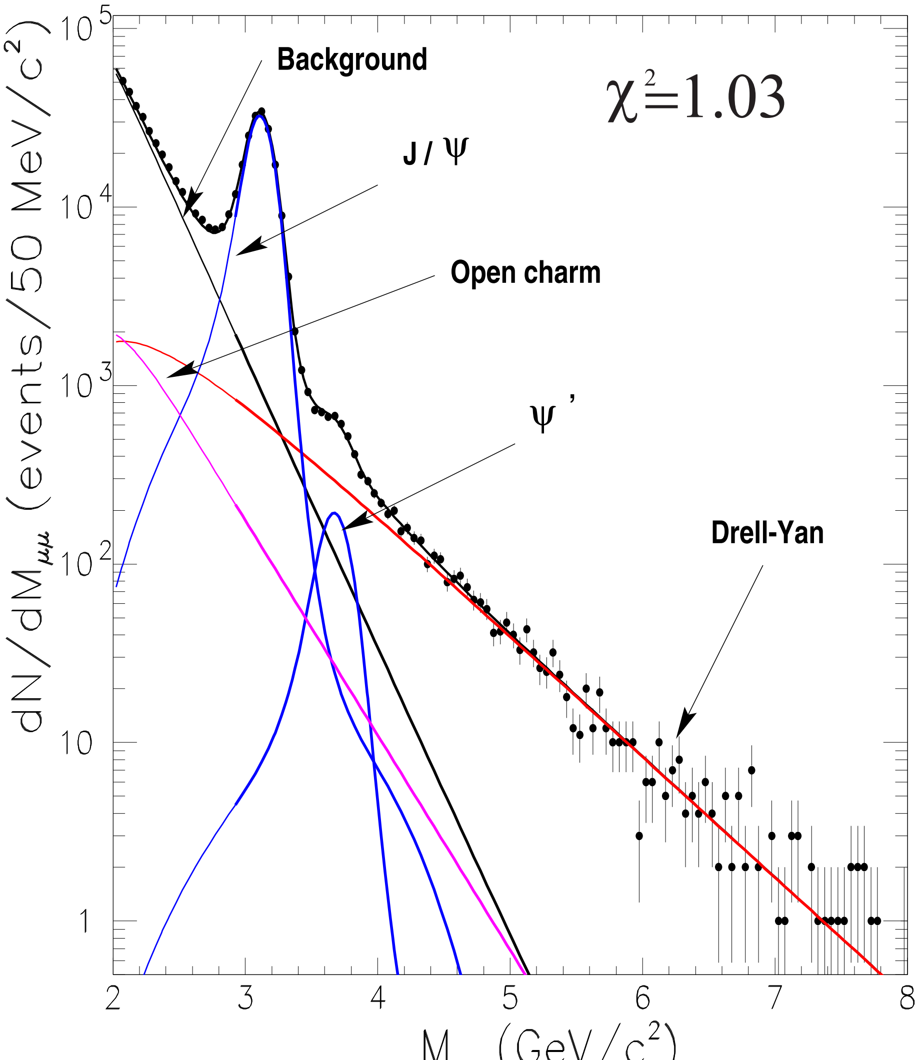
## Target Algorithm based on Quartz Cherenkov counters




Contour cut on the $E_T$ - $E_{ZDC}$ correlation: increase the statistics for peripheral events.

## Fit to the mass spectrum

$$\frac{dN}{dM} = A_{J/\psi}\frac{dN_{J/\psi}}{dM} + A_{\psi'}\frac{dN_{\psi'}}{dM} + A_{DY}\frac{dN_{DY}}{dM} + \frac{dN_{D\bar{D}}}{dM} + \frac{dN_{BG}}{dM}$$



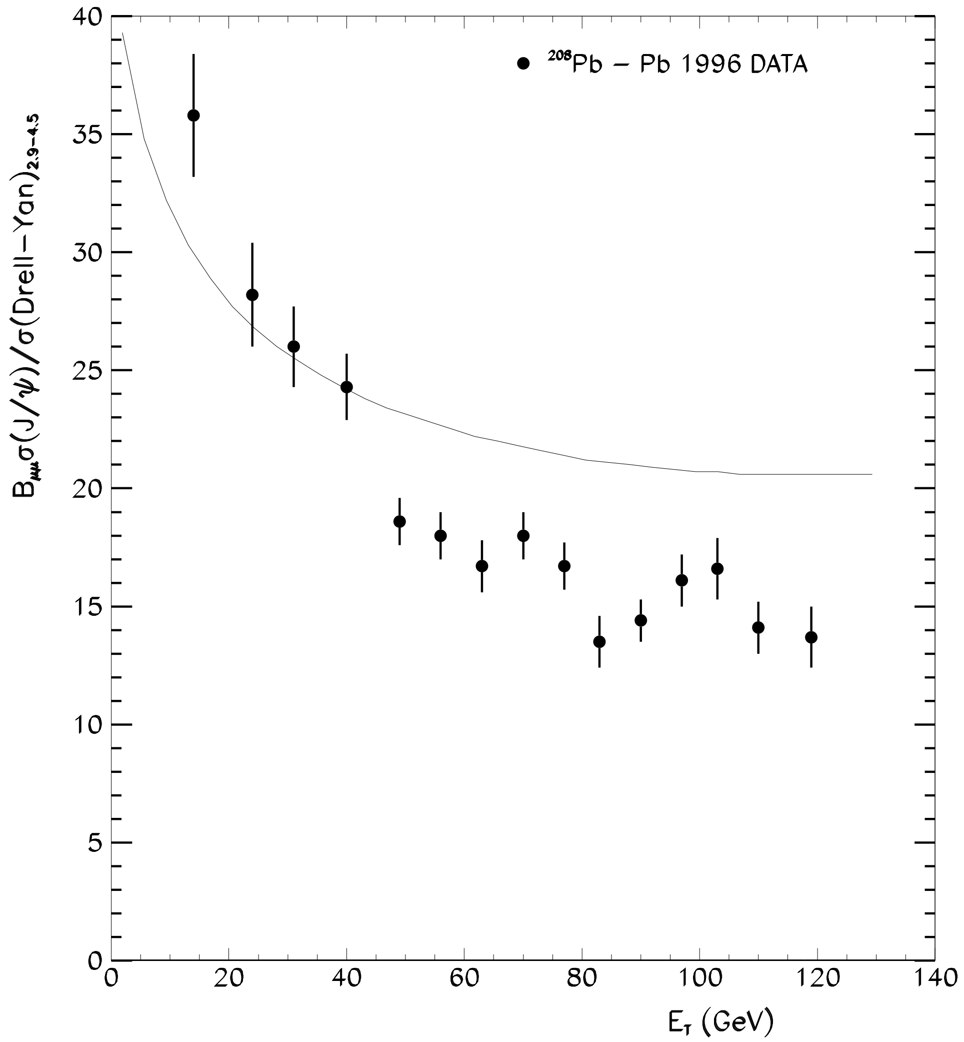

Combinatorial background: due to $\pi$ and $K$ decays.
Estimated from like-sign pairs: $N_{BG} = 2\sqrt{N^{++}N^{--}}$

$J/\psi$,$\psi'$, open charm and Drell-Yan shapes: Monte Carlo.

Charm component $\rightarrow$ two-step fit $(2.2 \leq M \leq 2.9)$

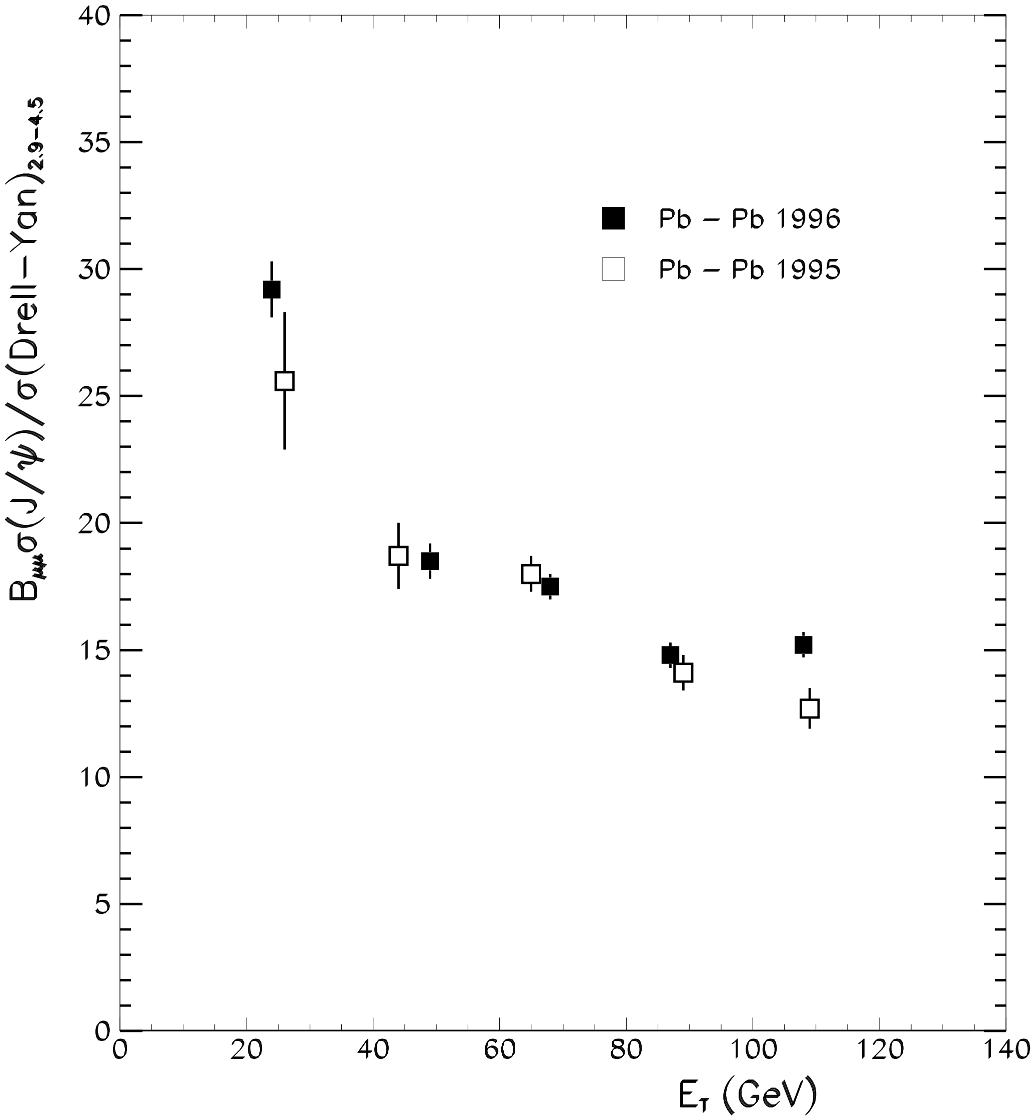
Final fit $(M \geq 2.9)$ with 3 free parameters: $A_{J/\psi}, A_{\psi'}, A_{DY}$

# $J/\psi$/DY vs $E_T$ 96 data




The curve accounts for an ordinary nuclear absorption with $\sigma_{abs} = 6.4$ mb, as obtained from p-A and S-U data.

# Compare 95 and 96 Data




Difference at high $E_T$ probably due to reinteraction events in 96 data

# 98 data taking

A single active target 3 mm thick ($7\%\lambda_I$)

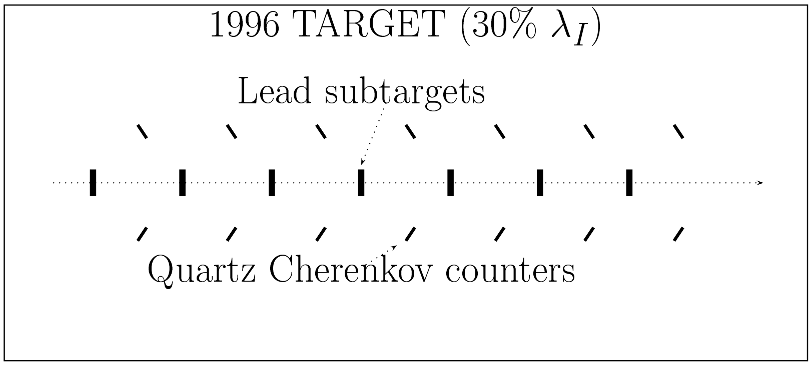
Less reinteraction events

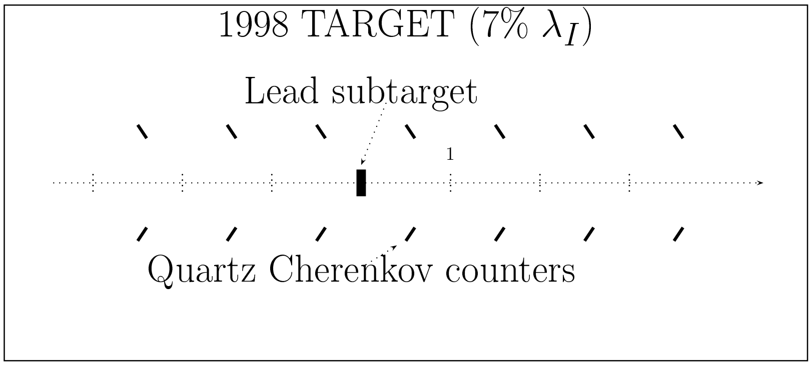
Better mass and $E_T$ resolution

Statistics:

$80 \star 10^6$ dimuon triggers

$\approx$ 40000 reconstructed $J/\psi$ events



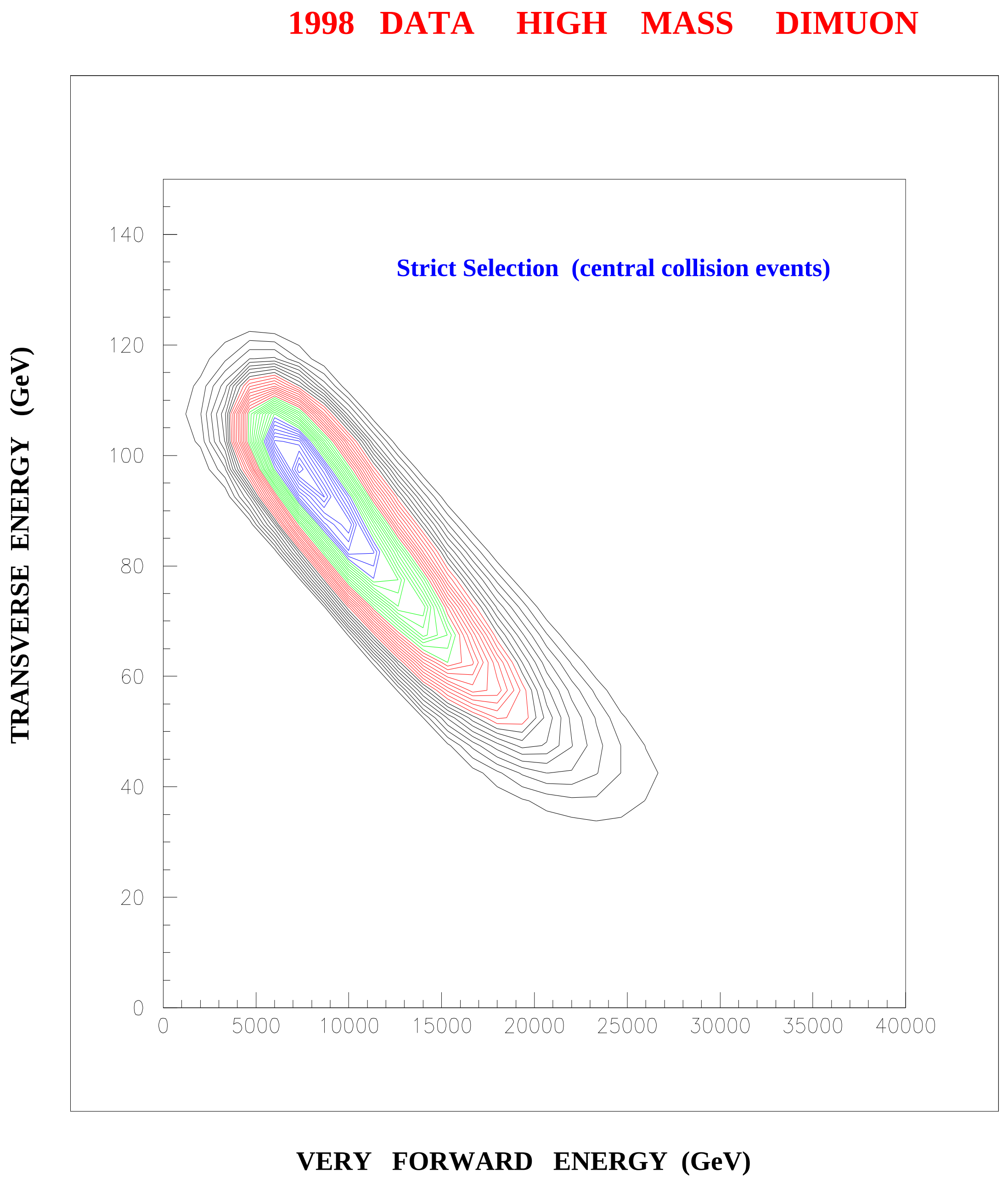



# Event selection for 98

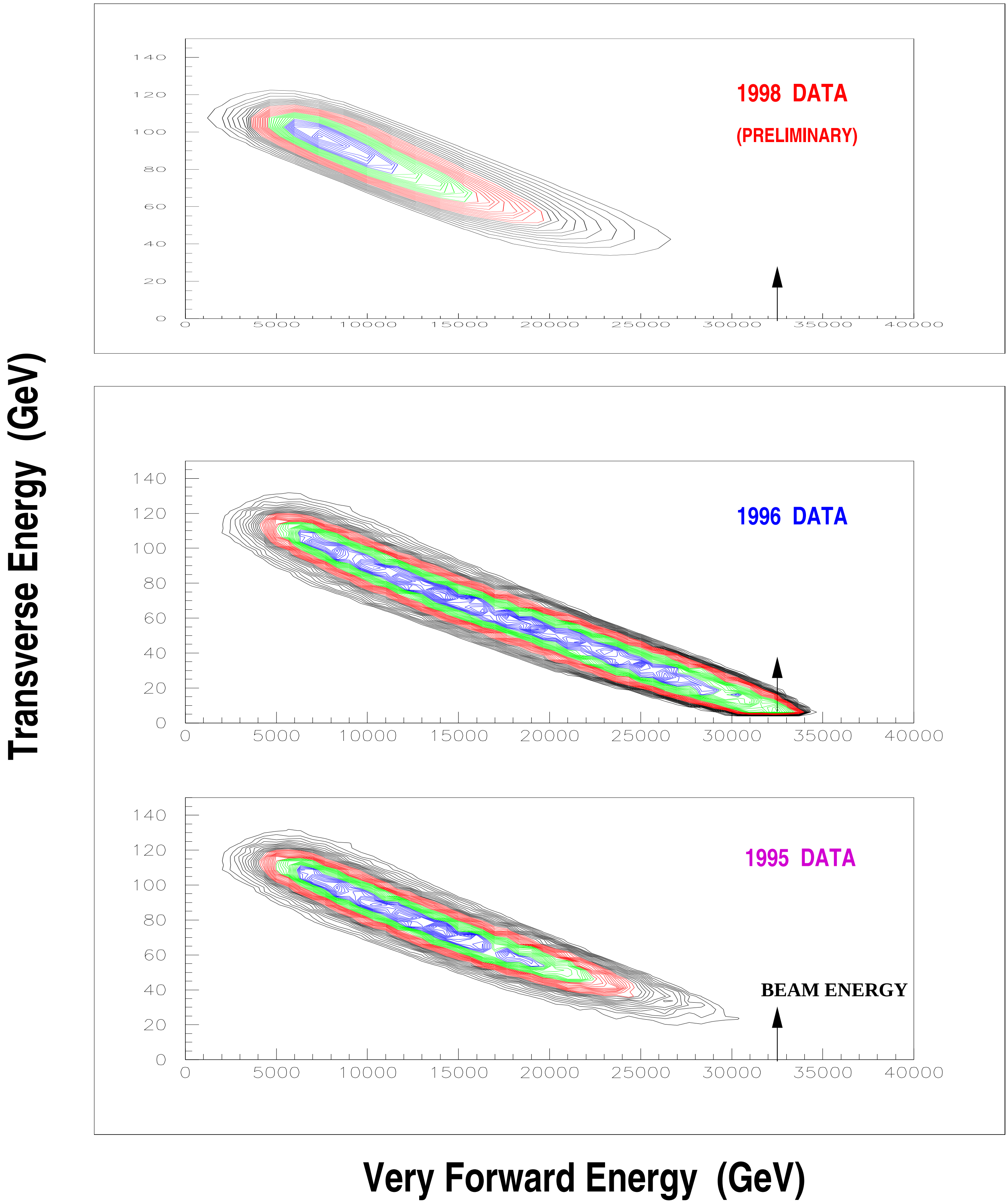
The analysis is very similar to 1996 sample

Severe cuts on the Cherenkov counters of the active target to avoid interactions in air

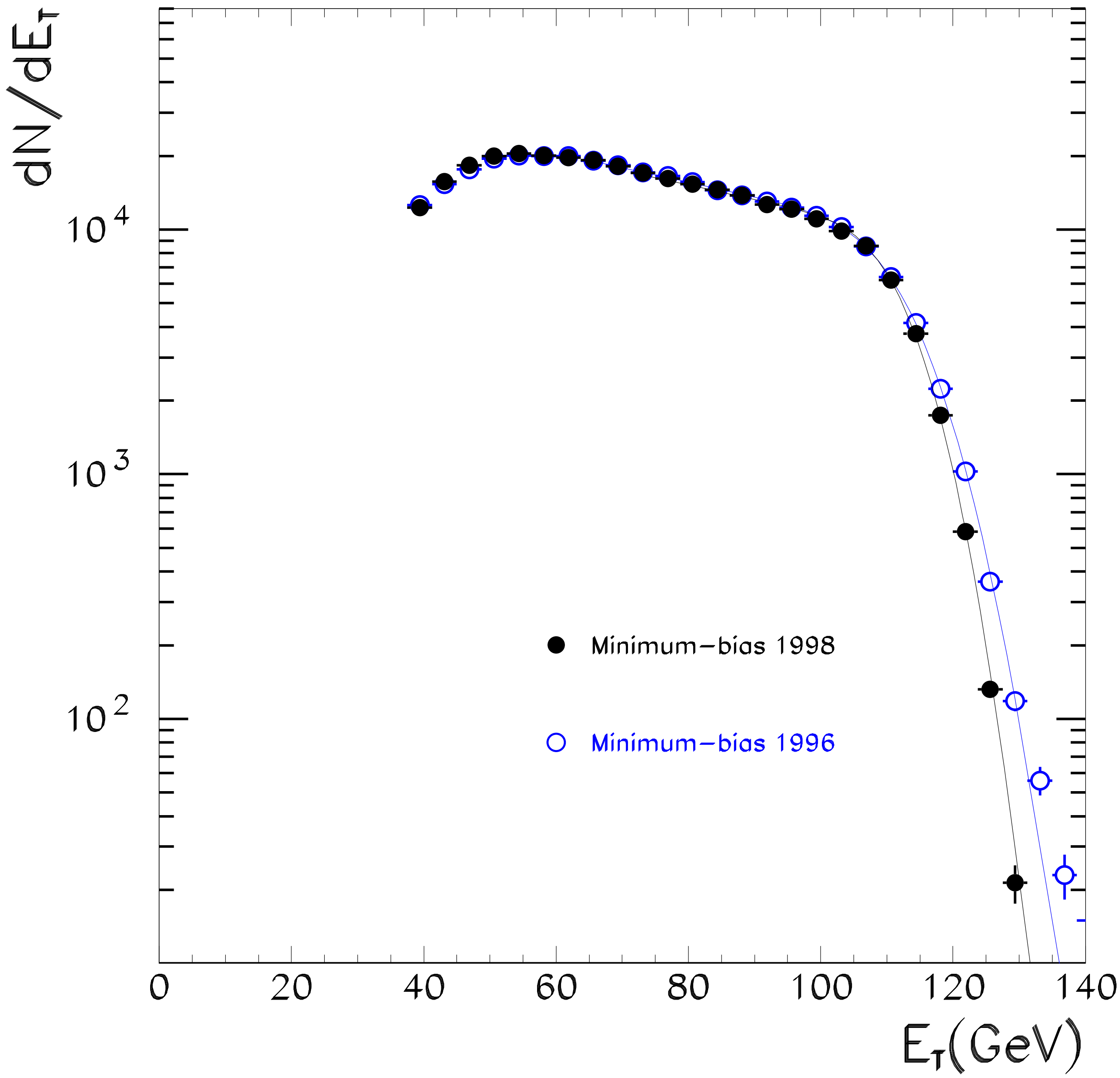
Transverse energy range limited to $E_T > 40$ GeV



# 95 96 98 contour cut

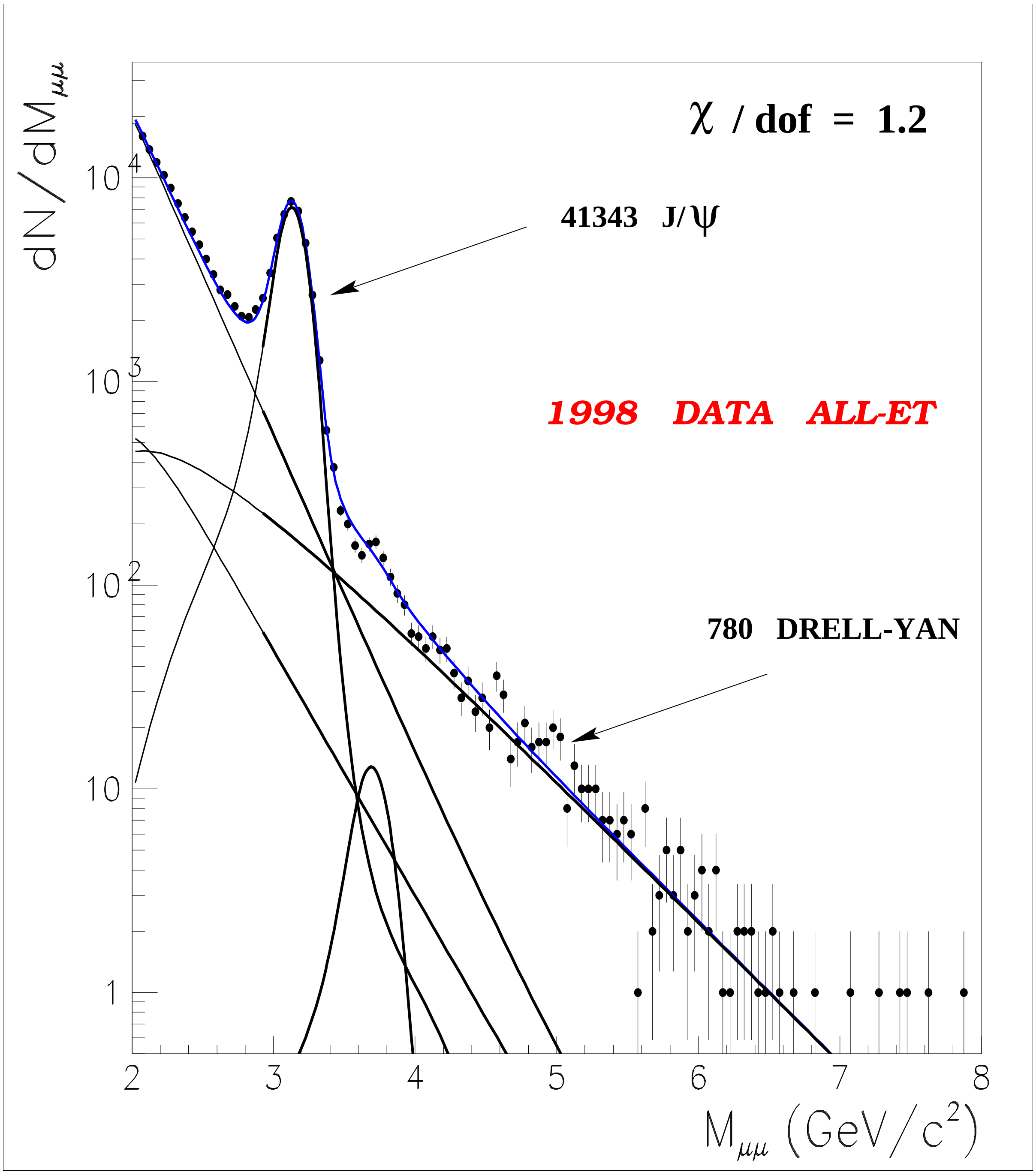


## $E_T$ distribution for Minimum Bias events



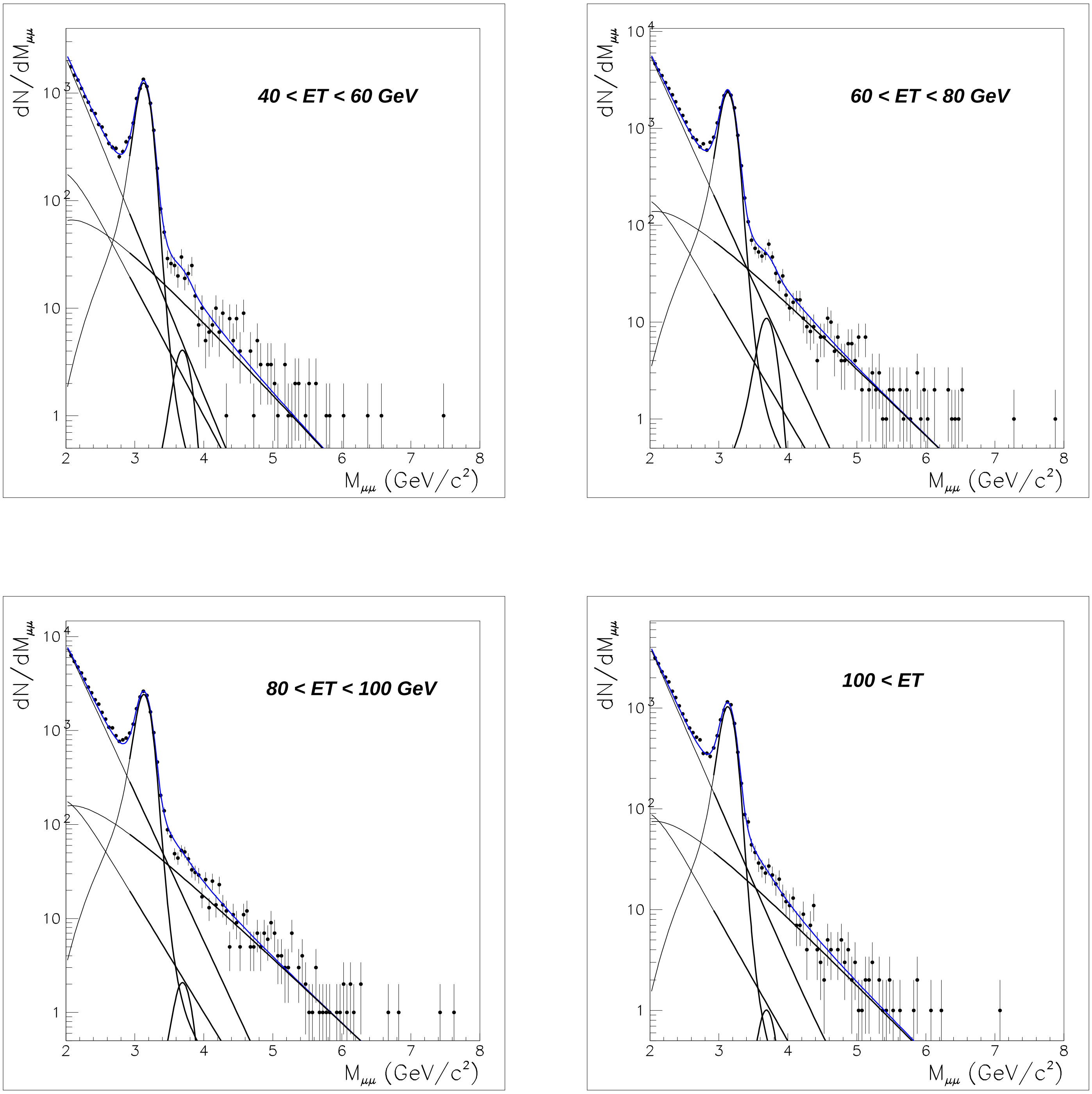

- 1996: 7 subtargets, $30\%\lambda_I$
- 1998: 1 target, $7\%\lambda_I$

# Mass spectrum 1998 sample



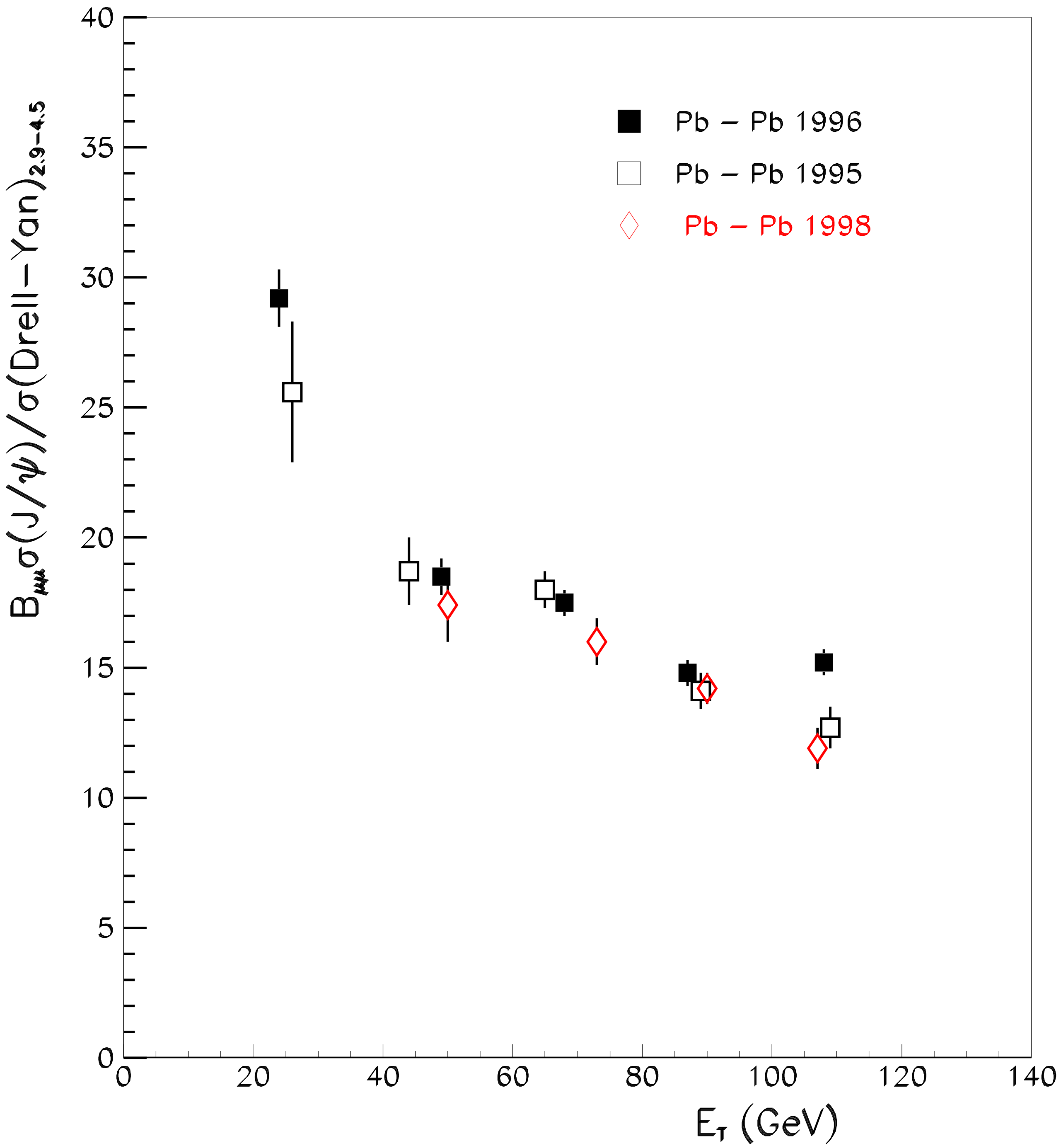
# Mass for different $E_T$ bins

**1998 DATA versus CENTRALITY**



# $J/\psi$/DY

## Comparison between 95, 96 and 98 data



# "Minimum bias" analysis

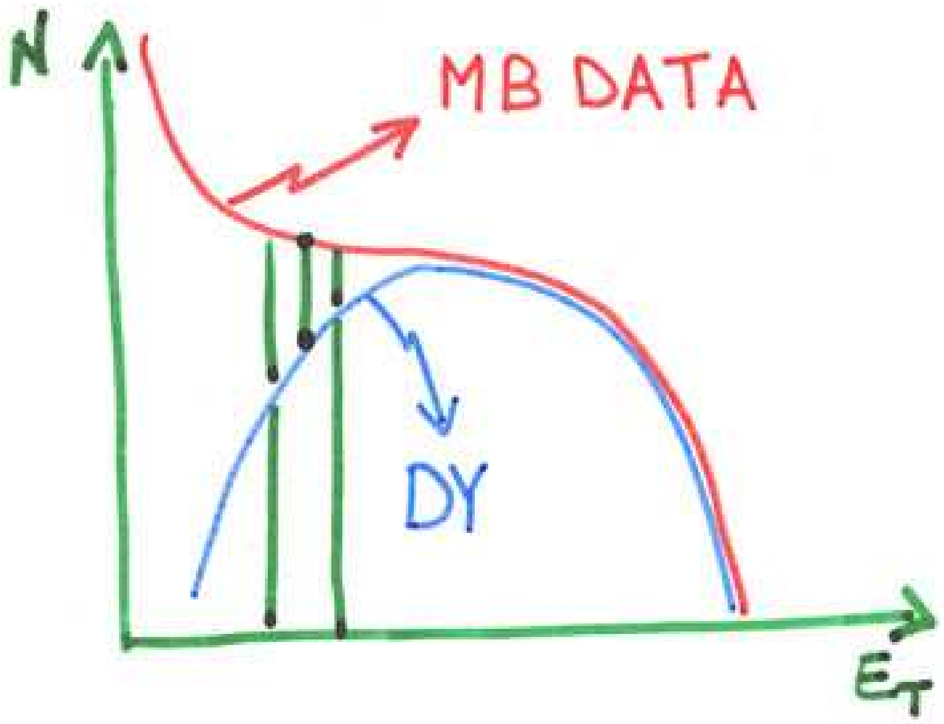
Using the sample of events collected with a "minimum bias" (ZDC) trigger as an estimator for the Drell-Yan in the ratio $J/\psi/DY$.

- Reduce statistical error
- Independent sample
- Target algorithm selection for all the events
- Counting technique: no fits to the mass spectra

Different systematic effects:

- Minimum bias trigger based on ZDC
- No selection on the muon tracks
- Empty target contamination at low $E_T$

# Minimum bias: the method



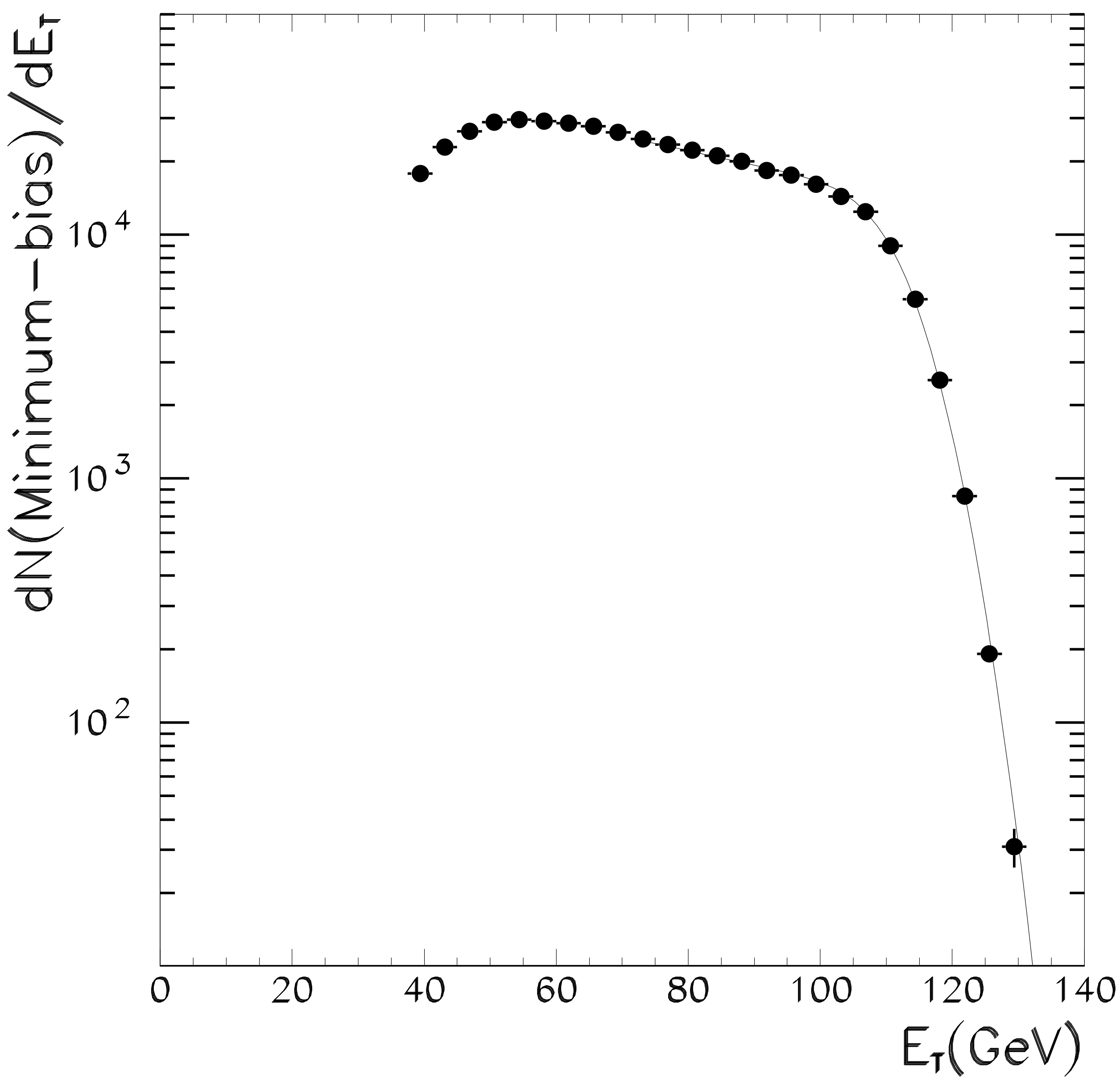

$N_{AB}(b)$: number of collisions for a given b (Glauber model)

$$\frac{N_{DY}(E_T)}{N_{MB}(E_T)} \sim N_{AB}(E_T)$$

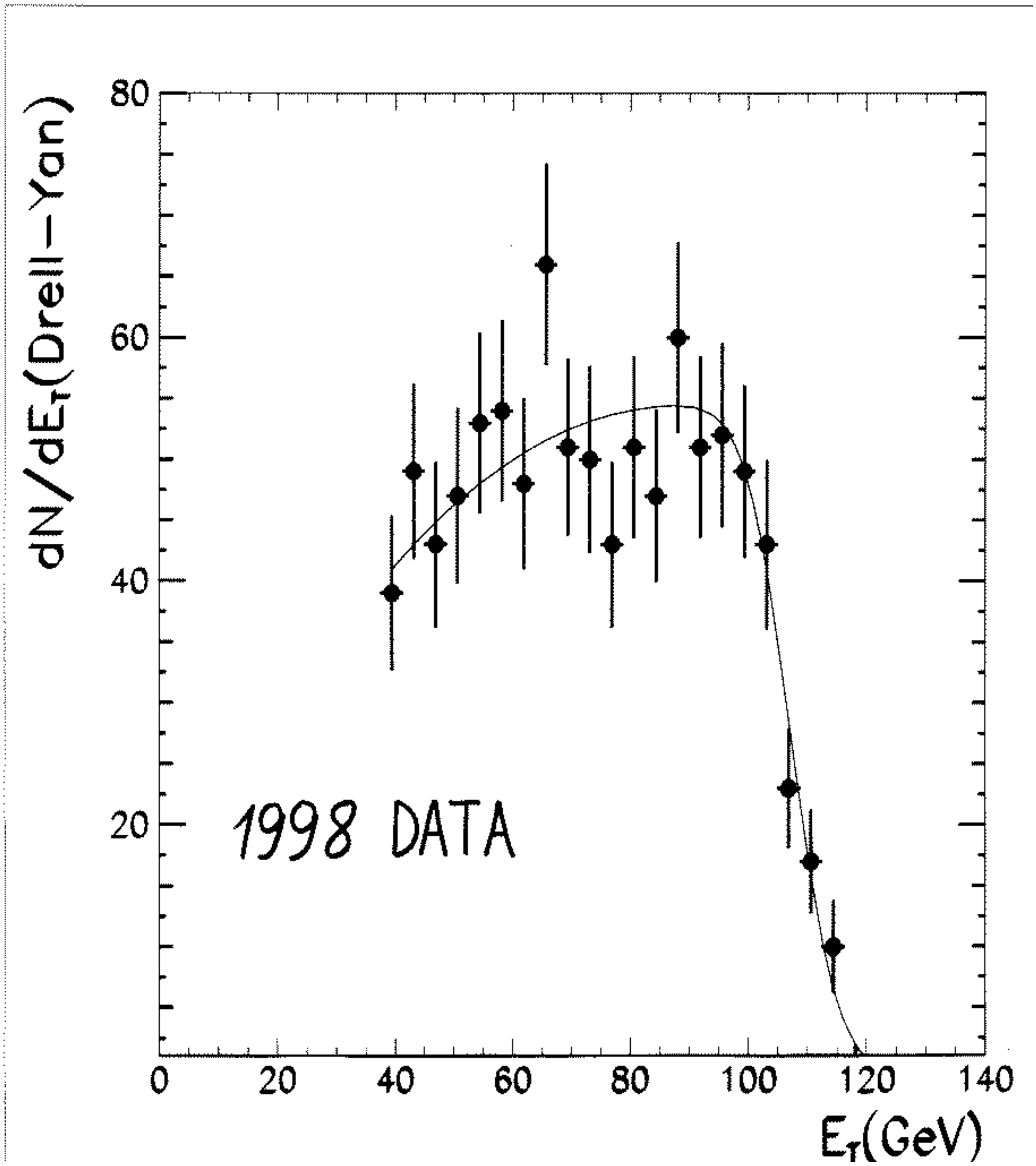
$$N_{DY^\star}(E_T) = N_{MB}^{exp}(E_T) \times N_{AB}(E_T)$$

$$\frac{N_\psi(E_T)}{N_{MB}(E_T)} \rightarrow \frac{N_\psi(E_T)}{N_{DY}(E_T)}$$

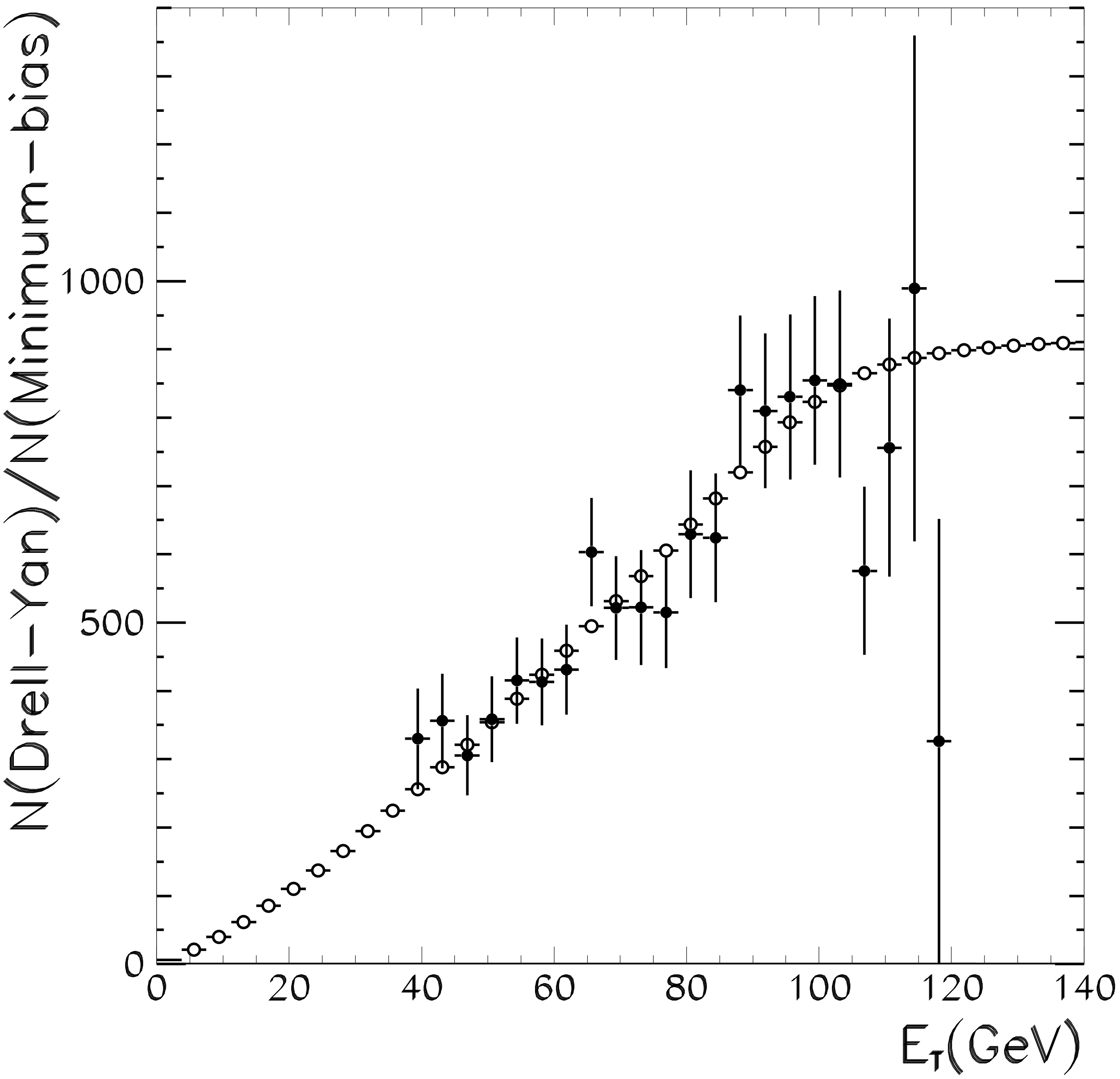
## $E_T$ distribution for Minimum Bias events



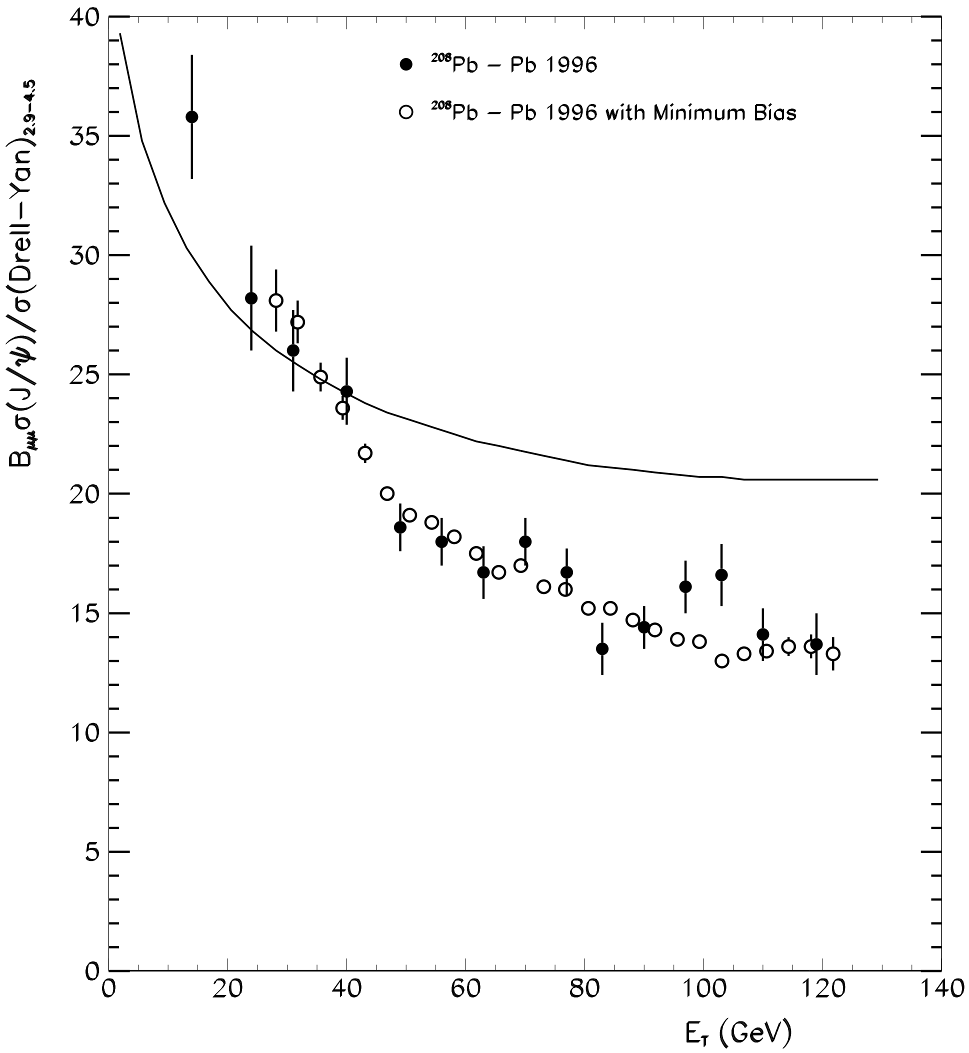
## $E_T$ distribution for Drell-Yan events



## $N_{AB}$ vs $E_T$ 98 sample



# $J/\psi$/DY vs $E_T$ 1996



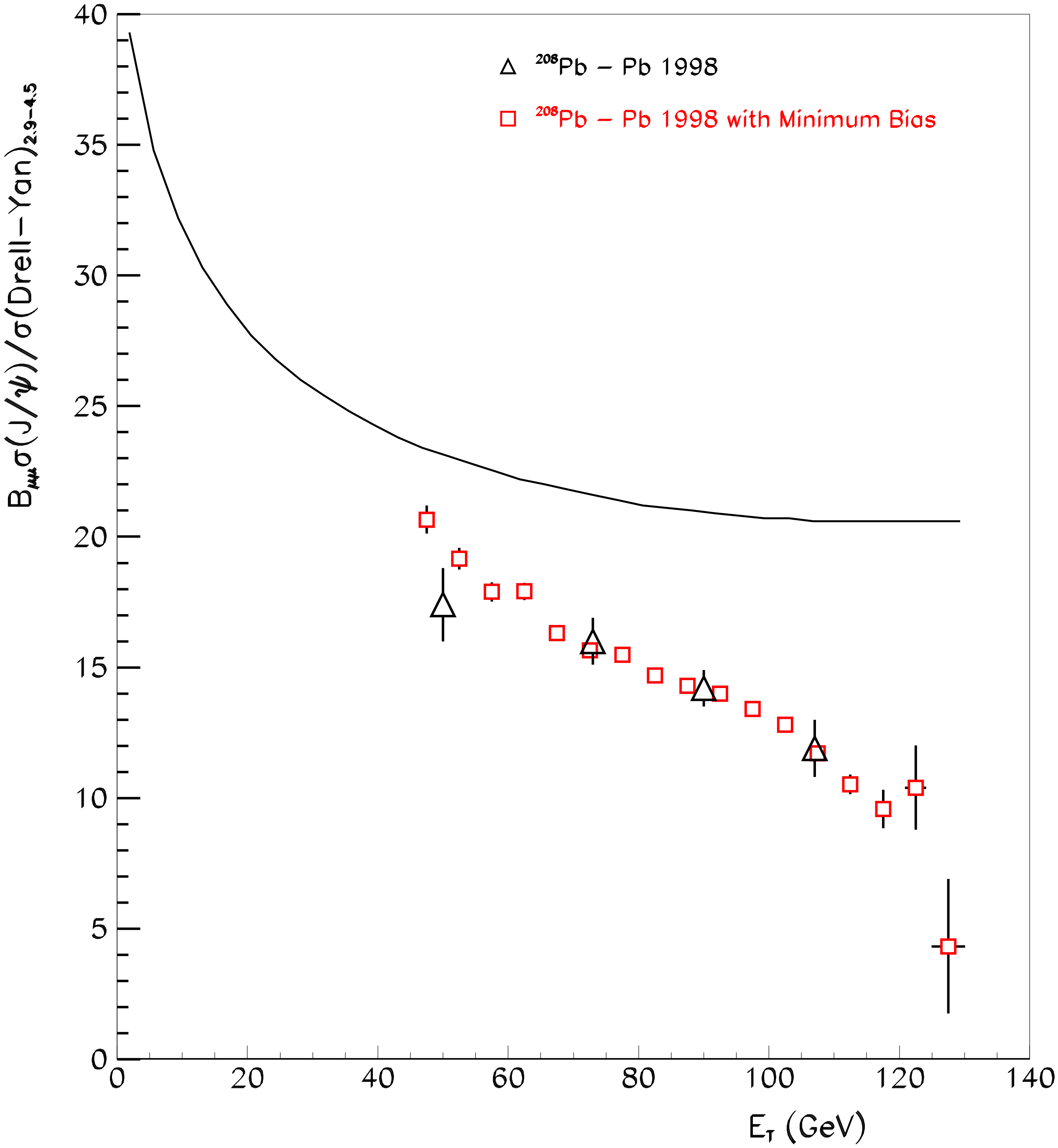

Normalization for MB: $55 < E_T < 75$

Cut at $E_T < 26$ GeV (contamination from off-target events, evaluated with target out runs)

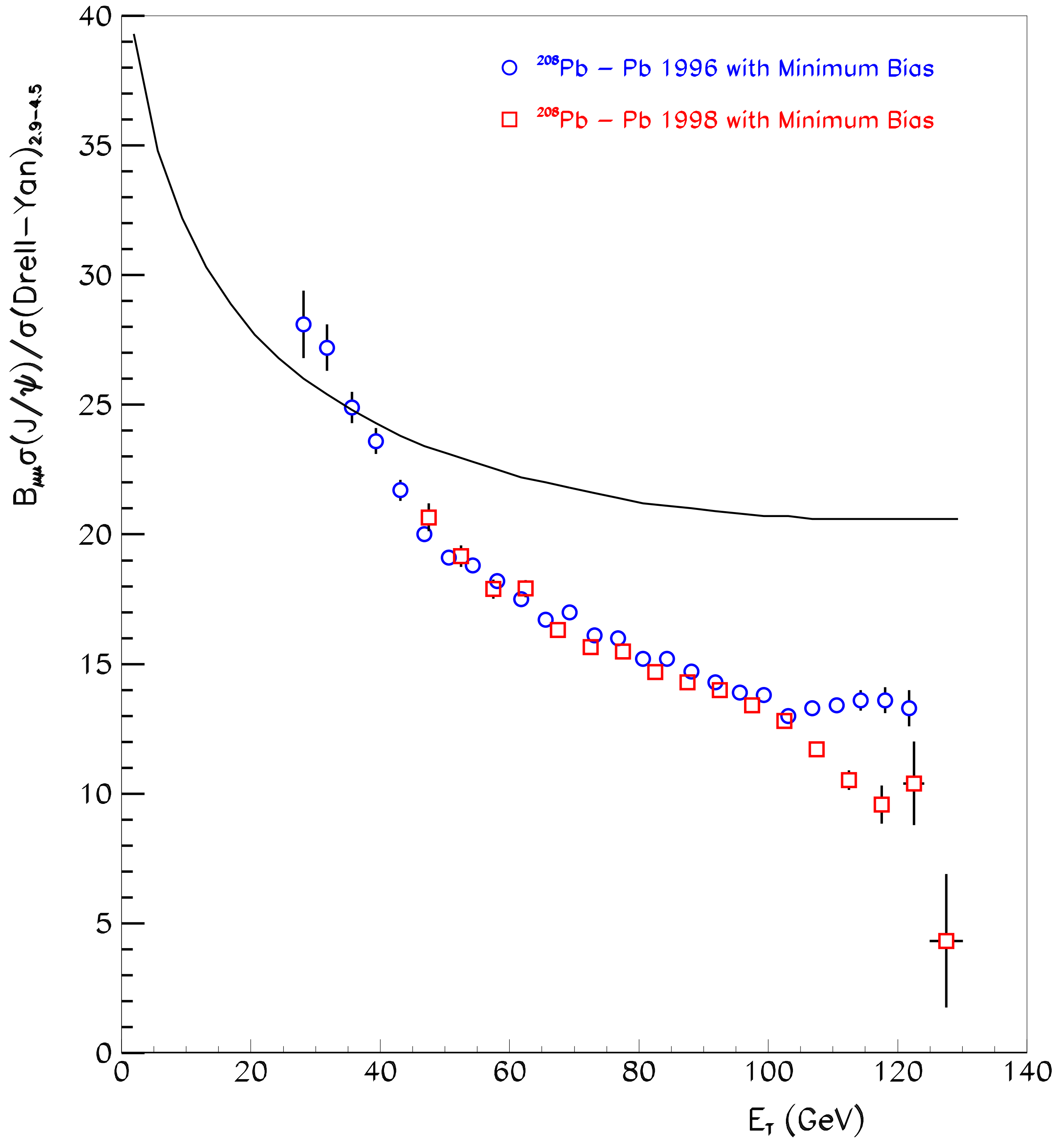
Shapes compatible

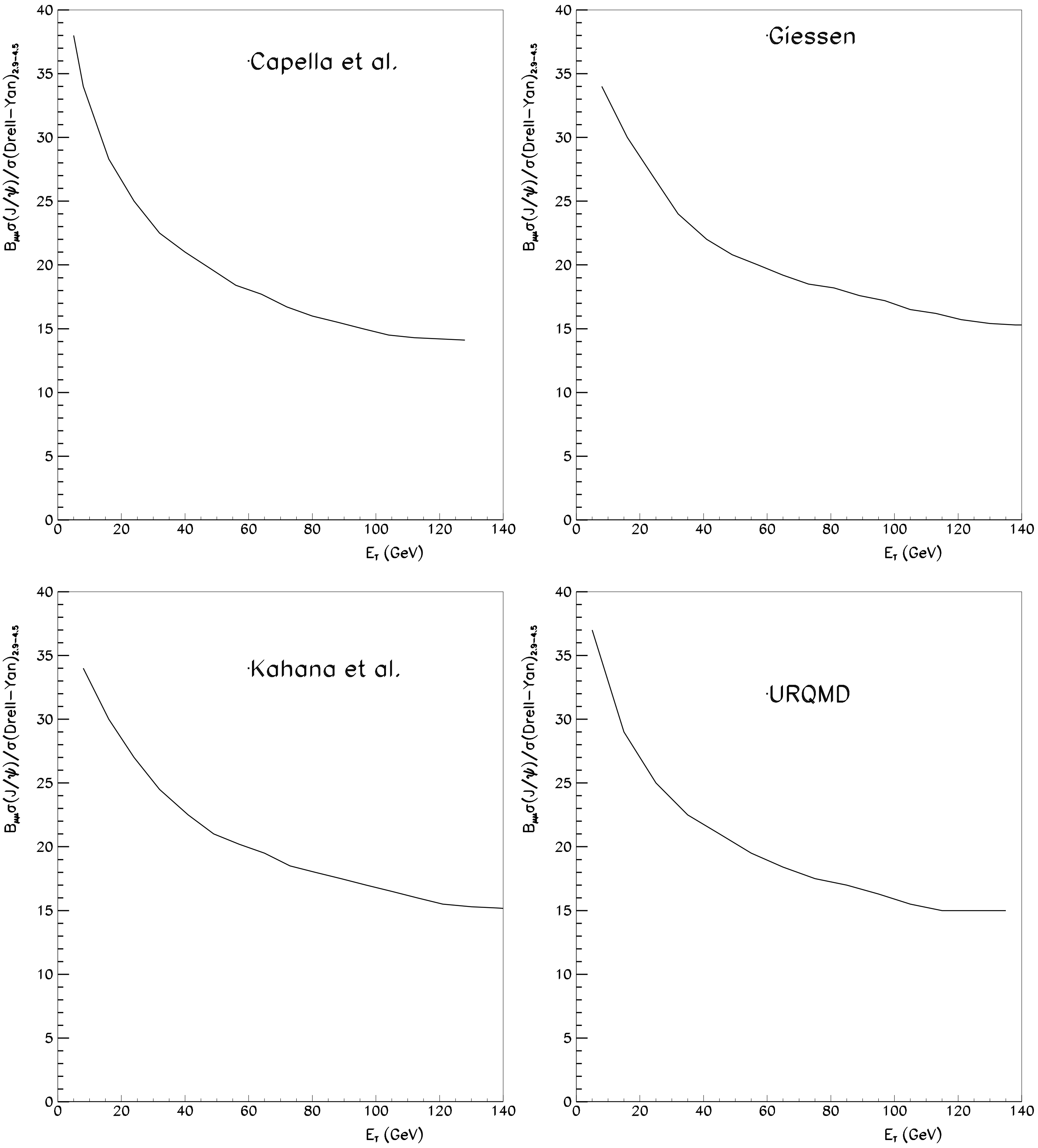
Agreement at low $E_T$

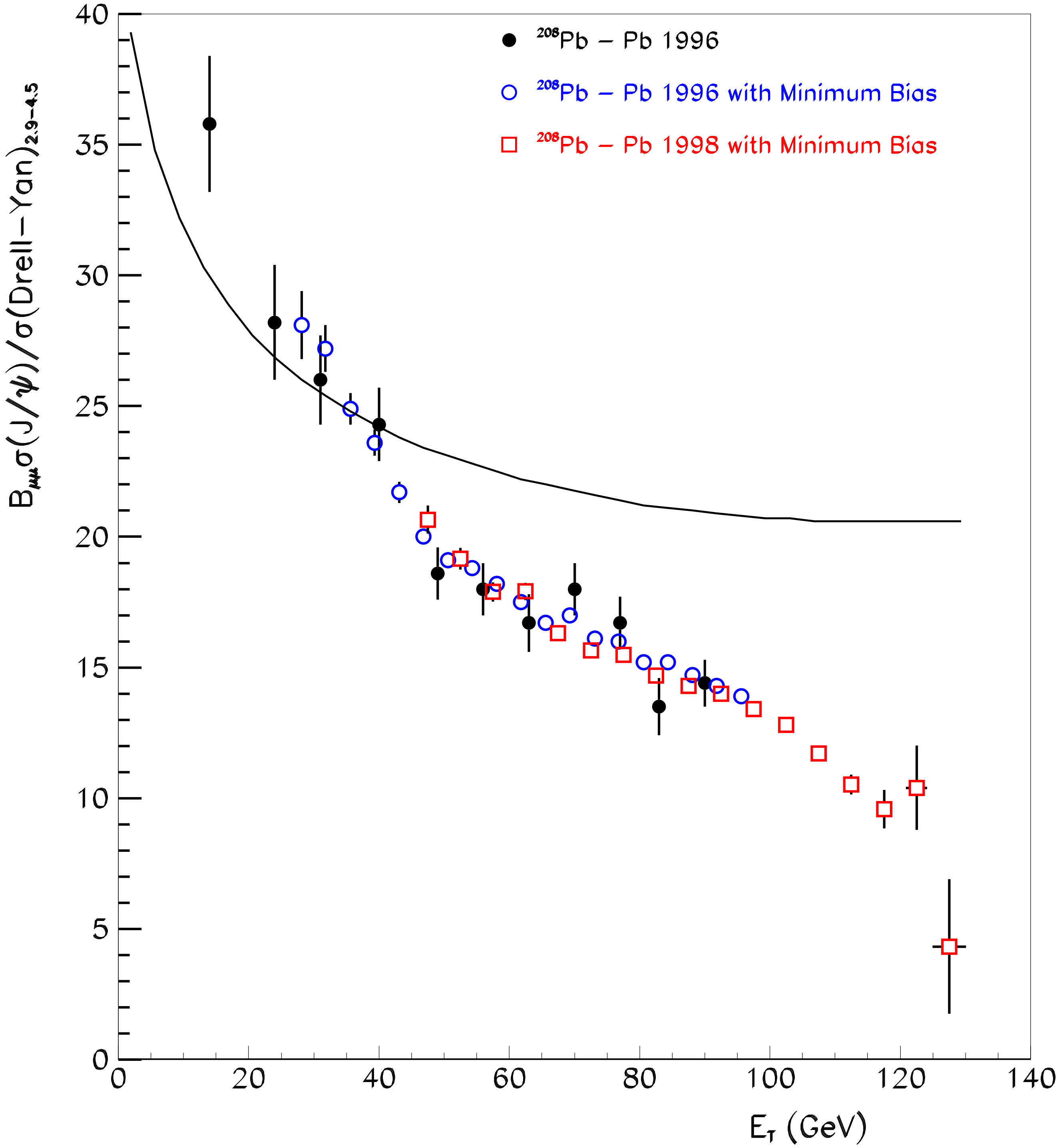
## $J/\psi/$DY vs $E_T$ 1998



## $J/\psi/\mathbf{DY}$ vs $E_T$

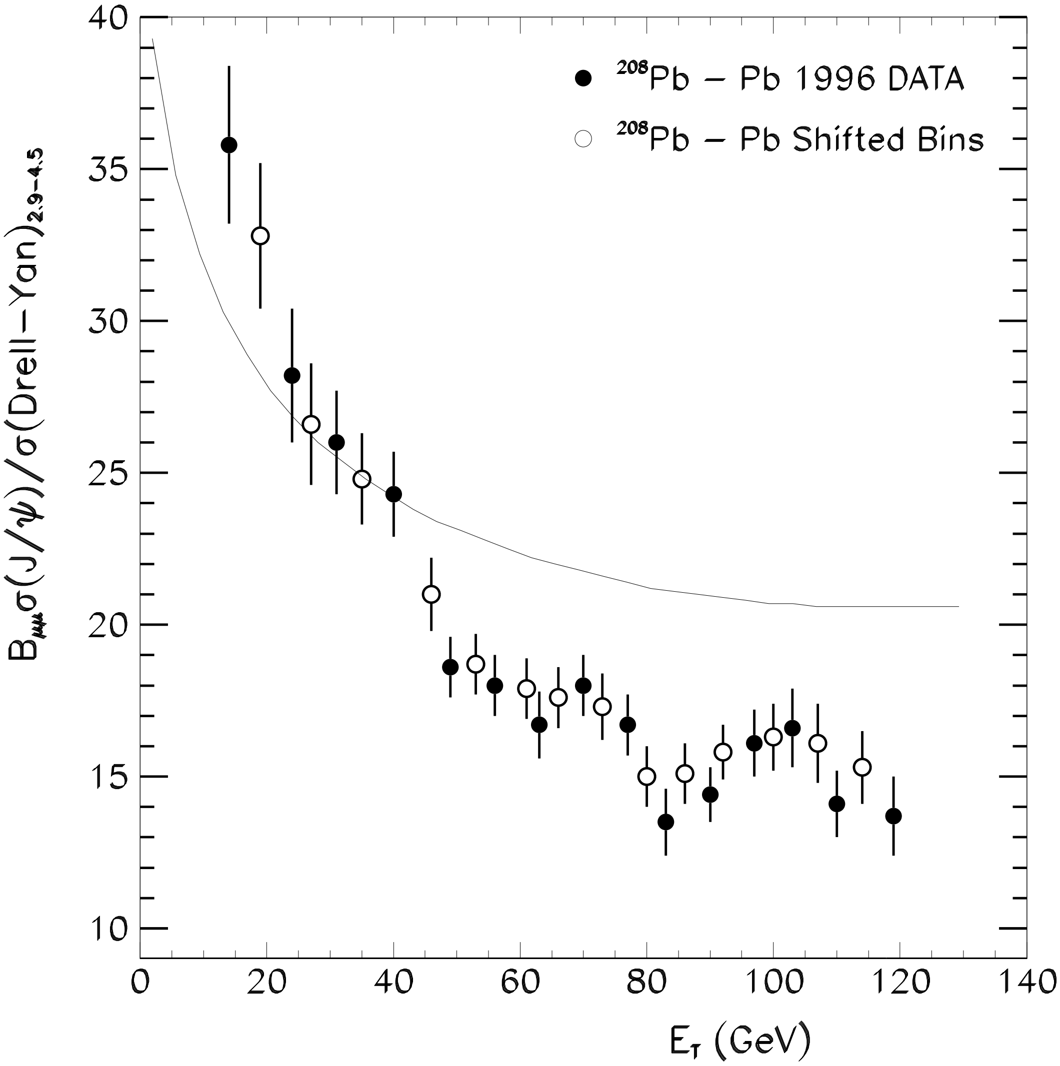



Capella et al.
Giessen
Kahana et al.
URQMD
$B_{\mu\mu}\sigma(J/\psi)/\sigma(\text{Drell-Yan})_{2.9-4.5}$
$E_T$ (GeV)



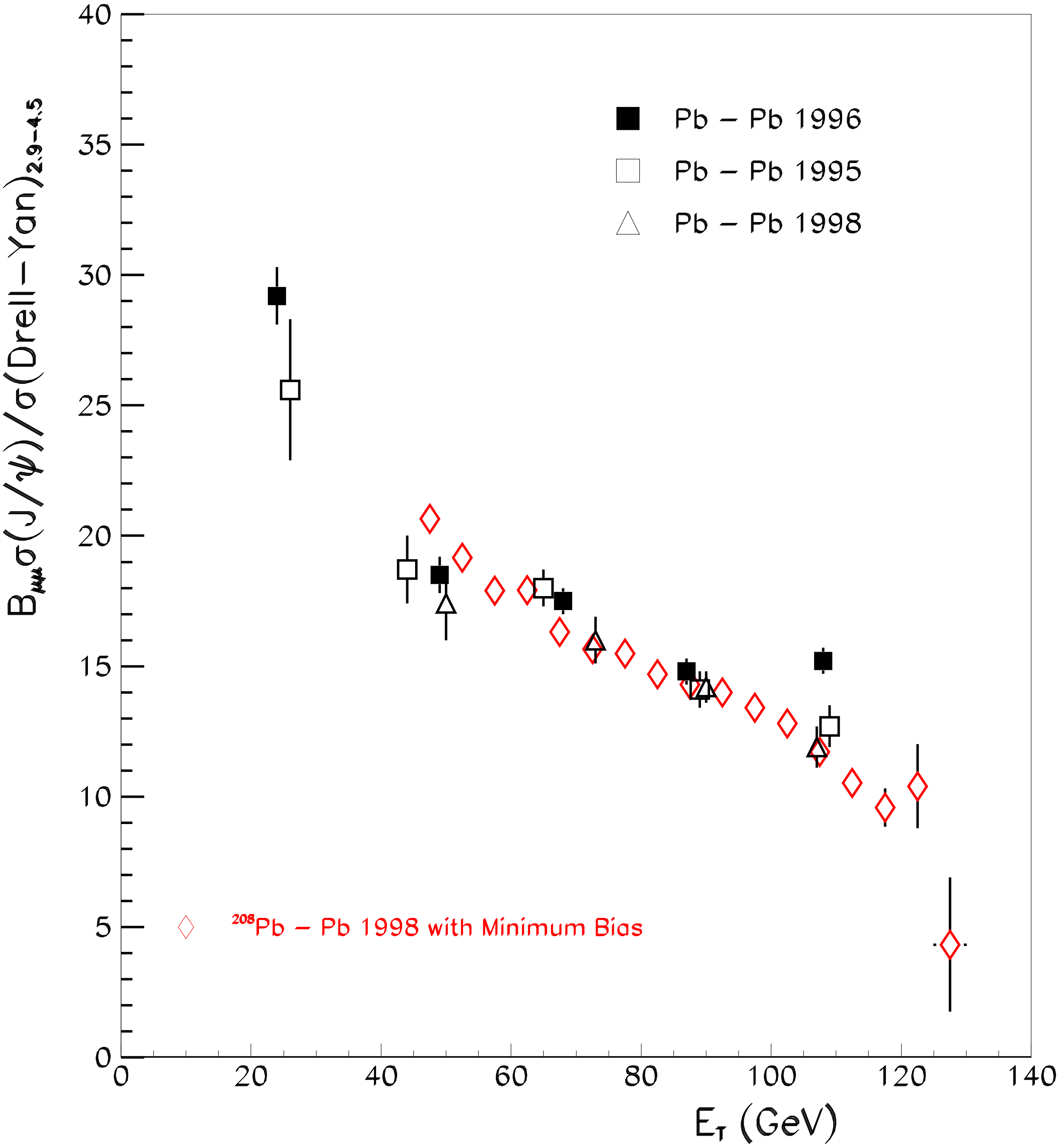
$^{208}$Pb – Pb 1996
$^{208}$Pb – Pb 1996 with Minimum Bias
$^{208}$Pb – Pb 1998 with Minimum Bias
$B_{\mu\mu}\sigma(J/\psi)/\sigma(\text{Drell-Yan})_{2.9-4.5}$
$E_T$ (GeV)
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
120
140

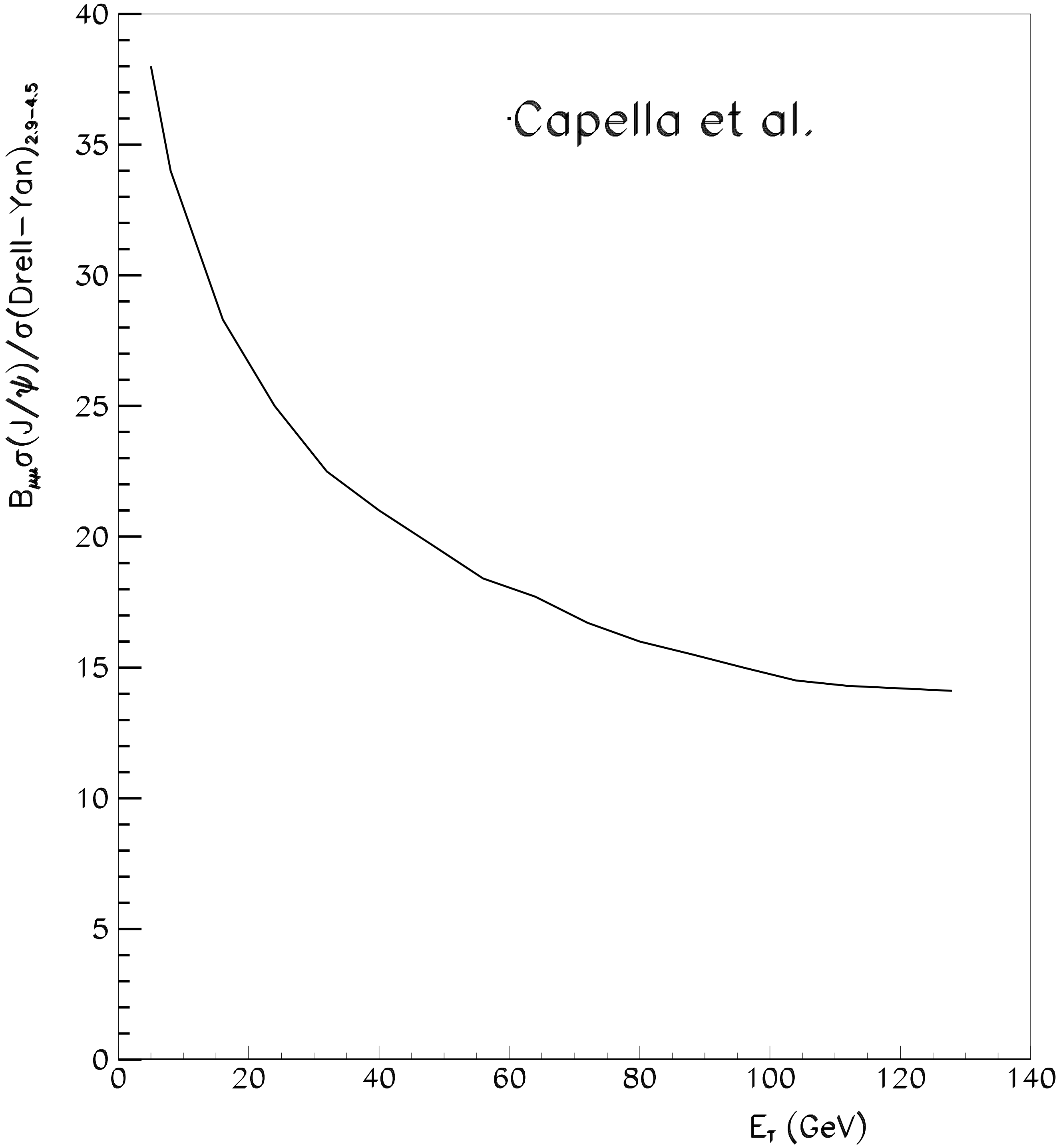
# $J/\psi$/DY vs $E_T$ 96 data




Stability check: different binning in $E_T$

## $J/\psi/\mathbf{DY}$ vs $E_T$




Capella et al.
B_μμσ(J/ψ)/σ(Drell−Yan)_2.9−4.5
E_T (GeV)
0
5
10
15
20
25
30
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Giessen
$B_{\mu\mu}\sigma(J/\psi)/\sigma(\text{Drell}-\text{Yan})_{2.9-4.5}$
40
35
30
25
20
15
10
5
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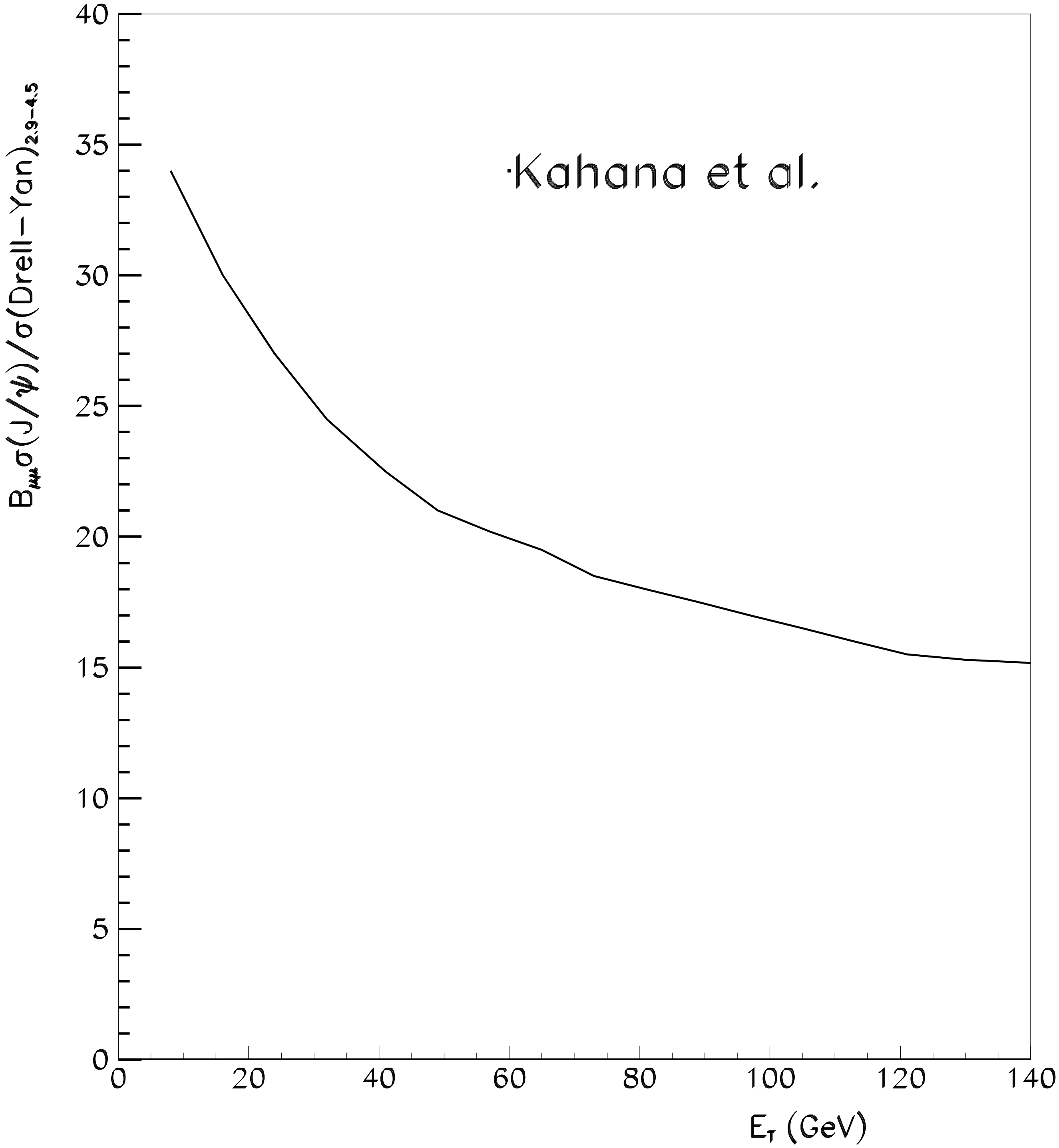
140
$E_T$ (GeV)

QM99



Kahana et al.
$B_{\mu\mu}\sigma(J/\psi)/\sigma(\text{Drell-Yan})_{2.9-4.5}$
$E_T$ (GeV)
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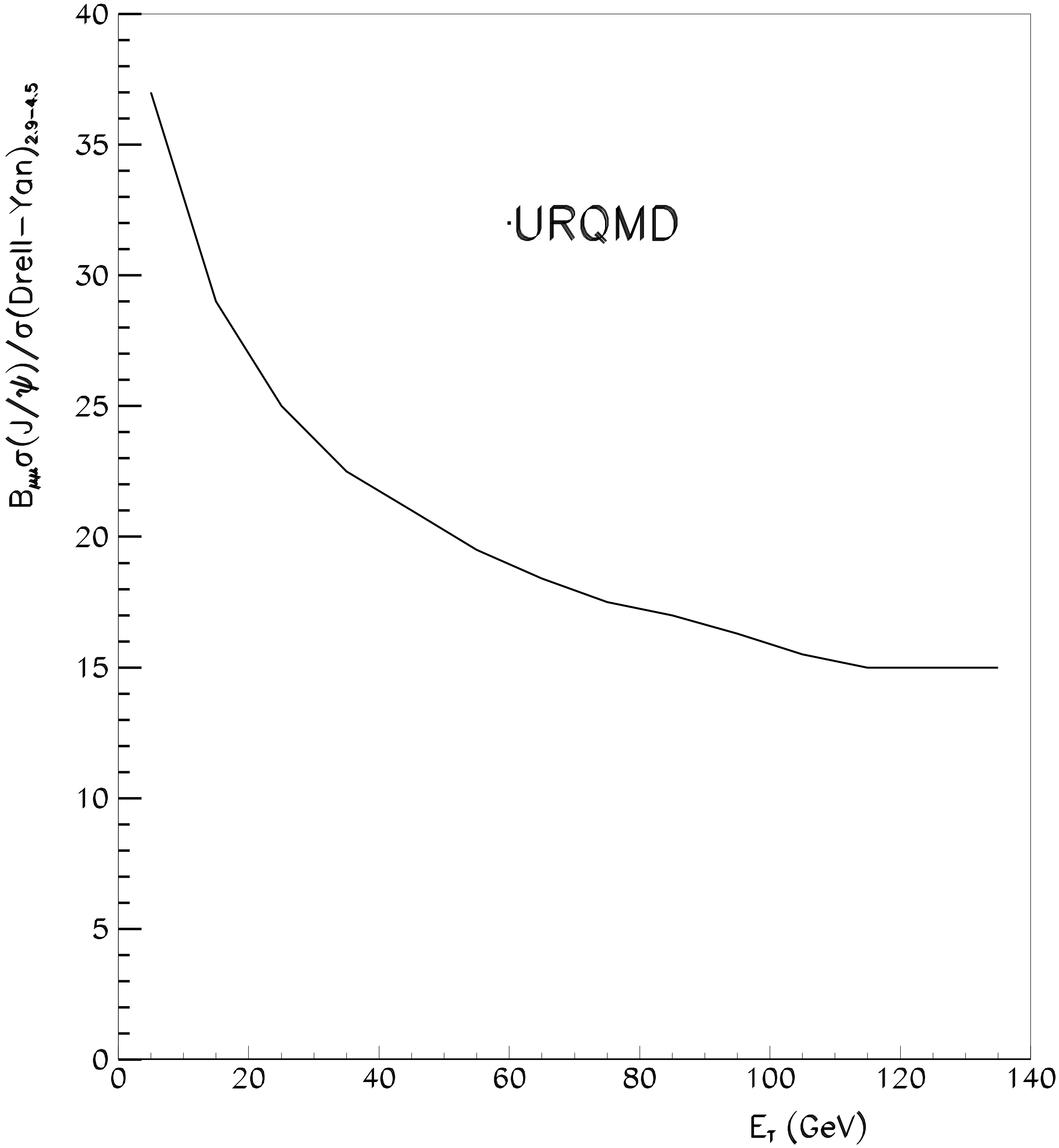
140



URQMD
$B_{\mu\mu}\sigma(J/\psi)/\sigma(\text{Drell-Yan})_{2.9-4.5}$
$E_T$ (GeV)
0
5
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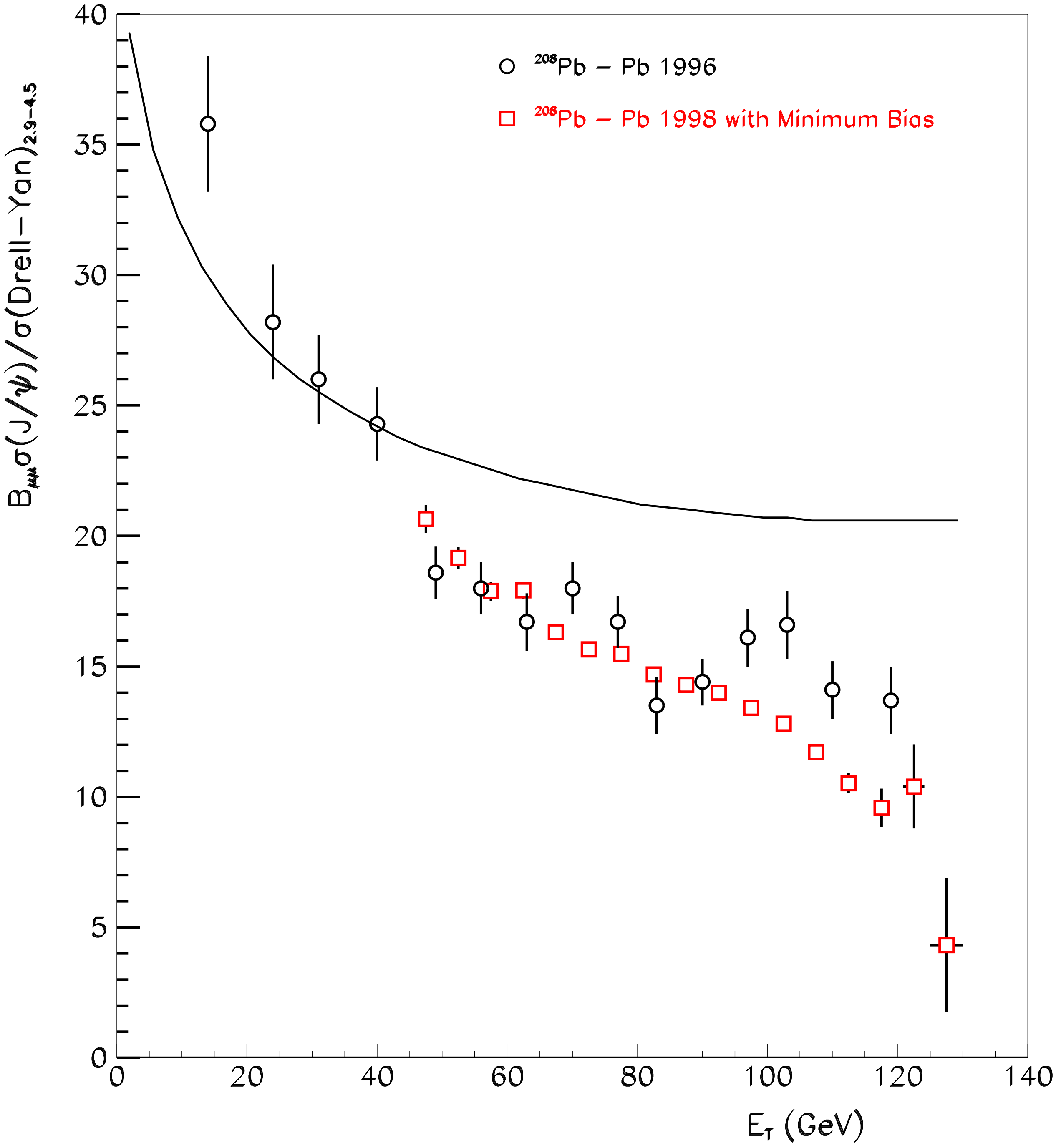
140

# $J/\psi$/DY vs $E_T$



$^{208}$Pb – Pb 1996
$^{208}$Pb – Pb 1998 with Minimum Bias
$B_{\mu\mu}\sigma(J/\psi)/\sigma(\text{Drell-Yan})_{2.9-4.5}$
$E_T$ (GeV)
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