Measurement of the Run-II Inclusive J/ψ Cross-section

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CDFNOTE 6288

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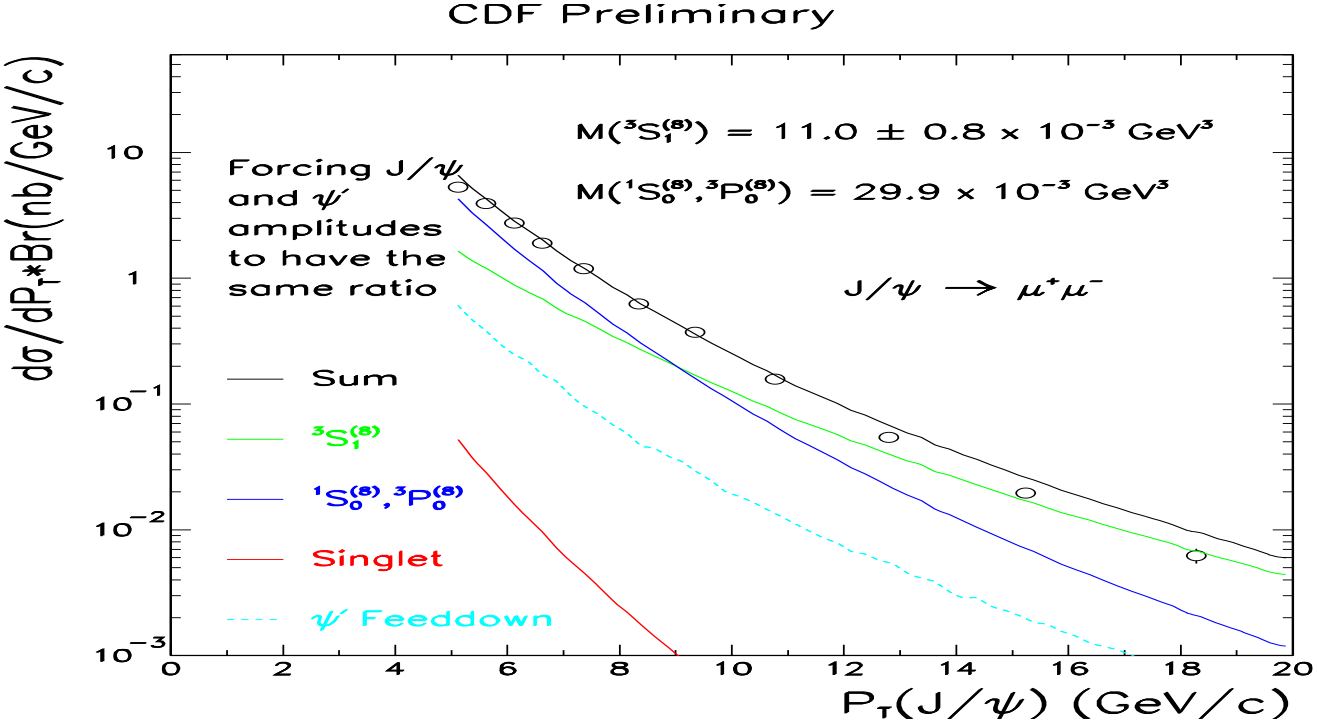
Introduction

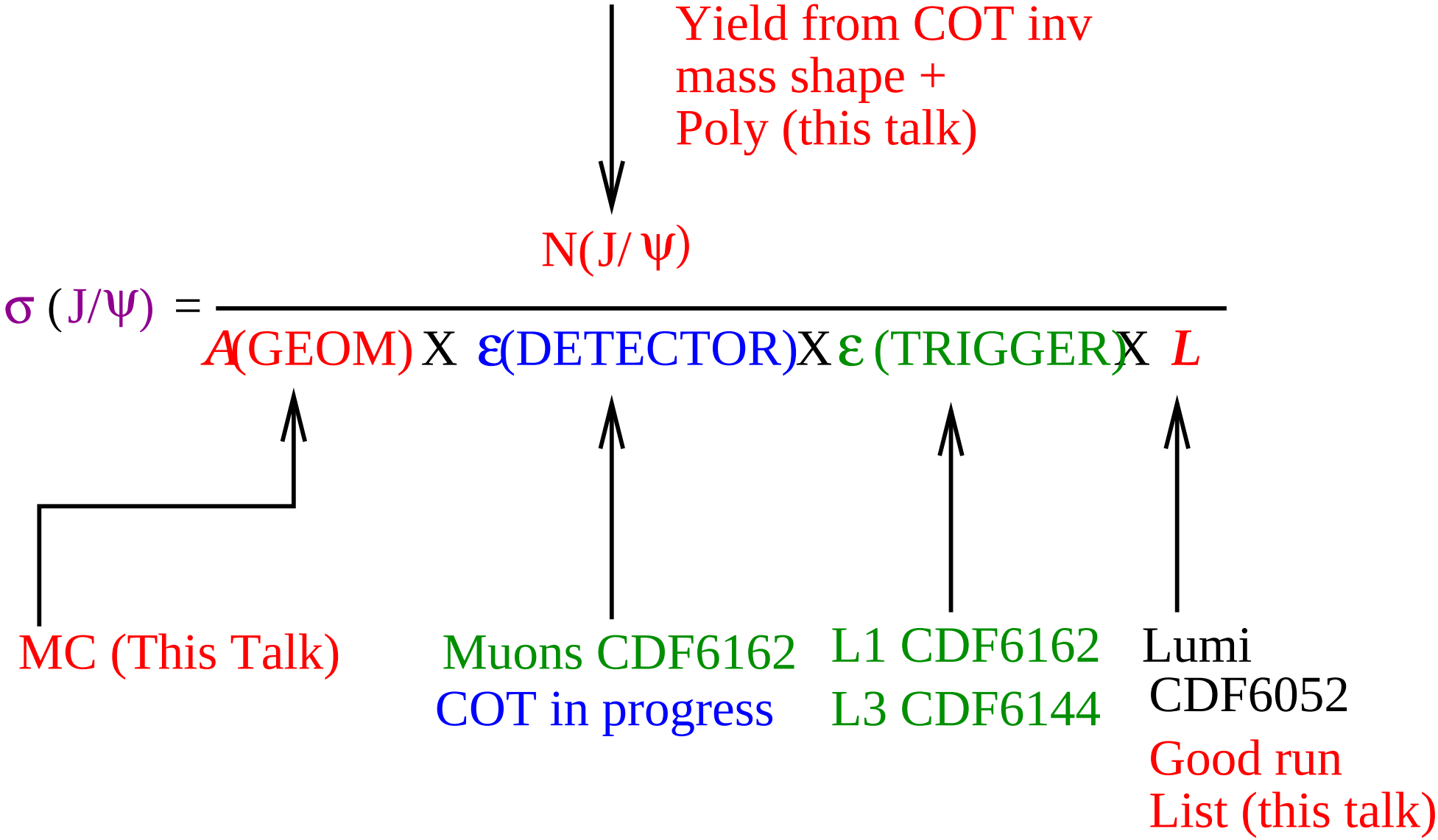
Quarkonia bound states are non-relativistic. NRQCD LO perturbative expansion is $\mathcal{O}(\alpha_s^3 v^0)$ as in the color singlet model (CSM) + higher order $\mathcal{O}(\alpha_s^3 v^4)$. Fragmentation processes $\propto$ color octet matrix element dominate. Predictions agree reasnably well with data at the Tevatron at high p_t.



Run I Direct J/ψ production

Run II : Measure the TOTAL cross-section down to 0 GeV/c

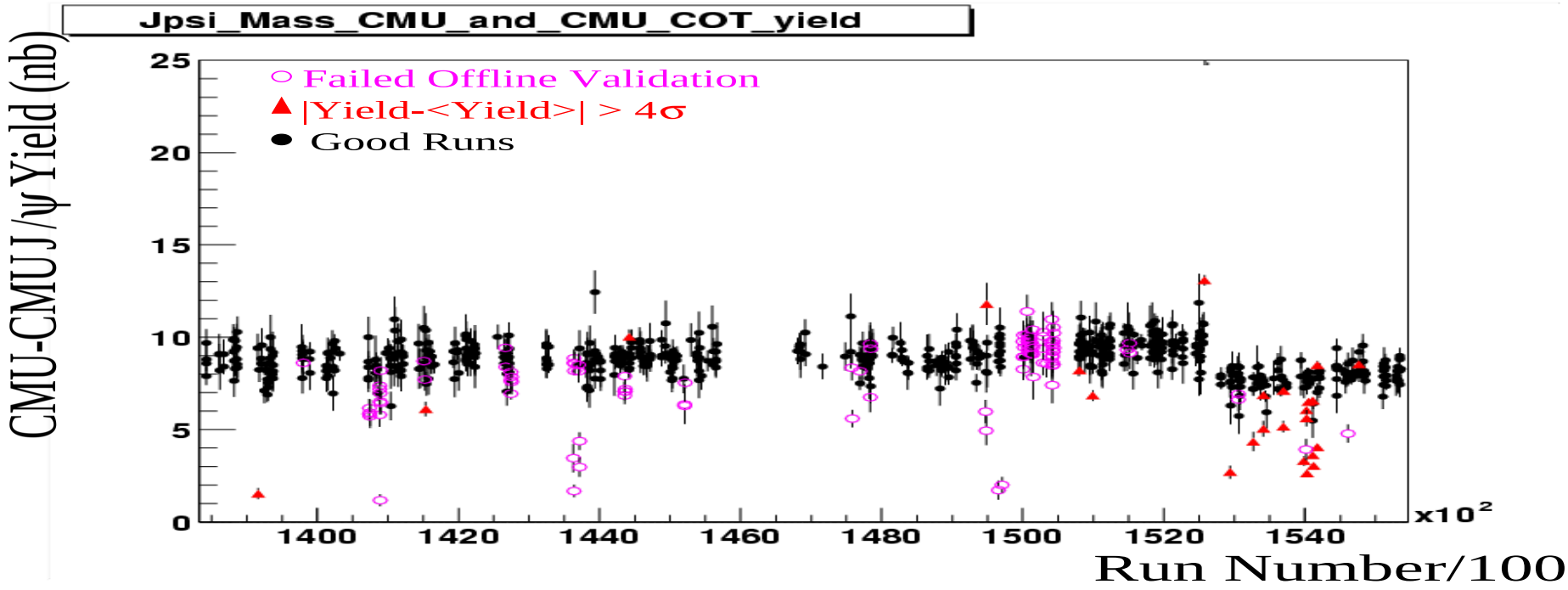
Measuring the cross-section



Good Run List

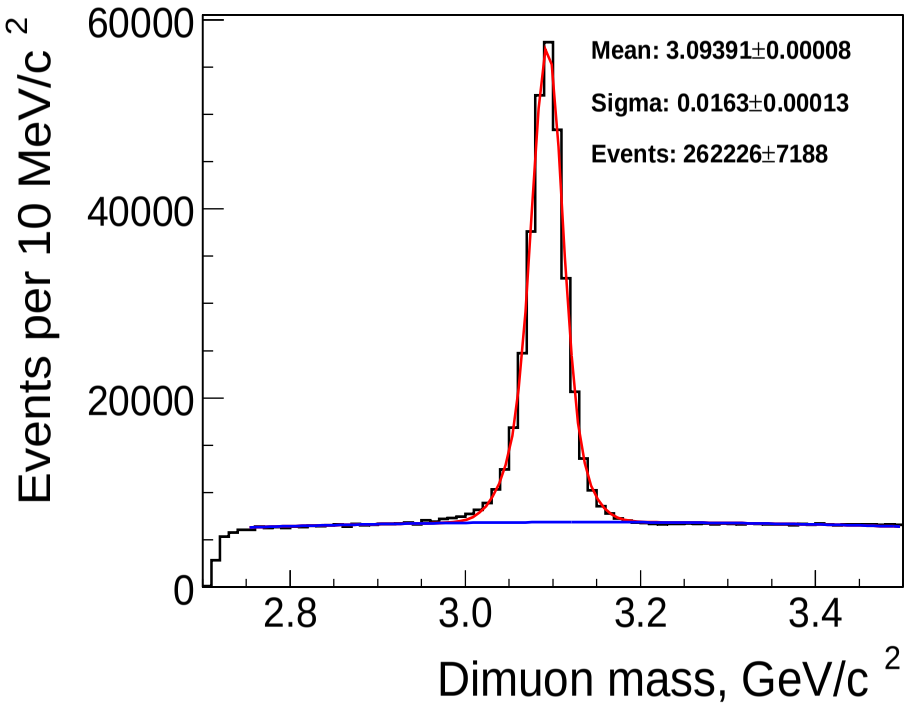
2-Miss only runs 138425-152625

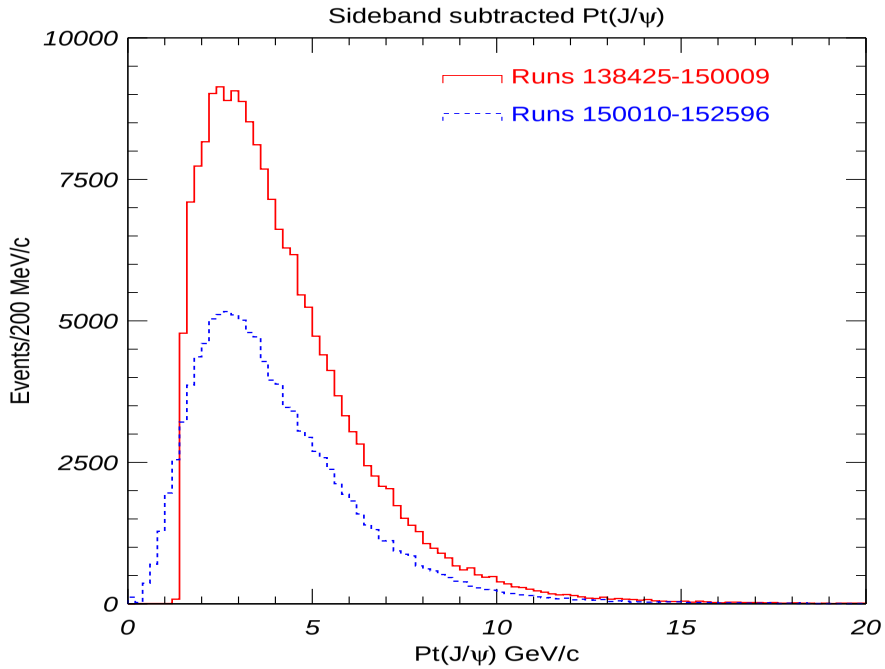
RUNCONTROL_STATUS, SHIFTCREW_STATUS, CLC_STATUS, L1T_STATUS, L3T_STATUSm OFFLINE_STATUS, COT_OFFLINE ,CMU_OFFLINE. *Chauvenets criterion: 0.03 runs expected to have yields* $> 4\sigma$ *from average in 480 runs. 5 found and excluded* $= 1\%$ *of total* $\int \mathcal{L} = 37.9 pb^{-1}$.



L3 Trigger Path

Run range	J/ψ L3 Trigger	$\mathcal{L}$ (pb^{-1})	CMU-CMU J/ψ rate (nb)	Opening angle selection critiria
138425 - 150009	JPSI_CMUCMU1.5	24	9.05 ± 0.05	$\Delta\phi(\mu\mu) < 130^0$
150010 - 152625	JPSI_CMUCMU1.5_ALLPHI	14	9.69 ± 0.11	No $\Delta\phi(\mu\mu)$ cut

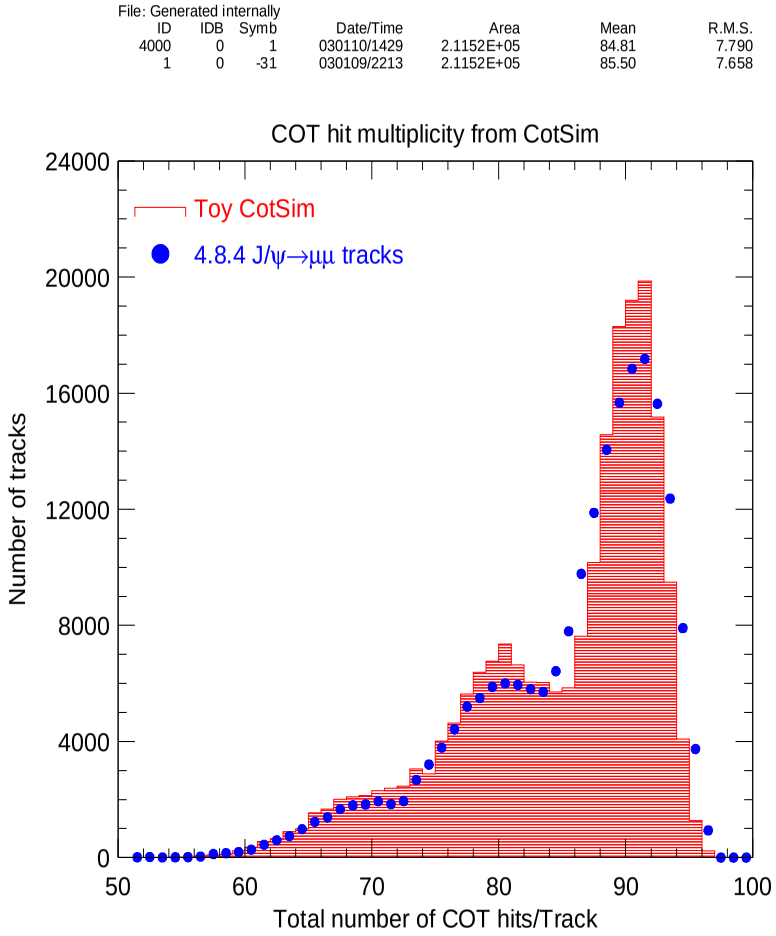




Use ALL data for $p_T > 2$ Gev/c and only ALLPHI data for $p_T < 2$ GeV/c

J/ψ Mass Shape

- Hit level COT simulation and track fitter from Ashutosh Kotwal
- Multiple scattering and ionization energy loss in the COT and SVXII
- Silimap v4.9.1 SVXII material map
- dE/dX corrections from Cosmic Ray studies
- B field corrections
- Radiative ψ decay using QQ



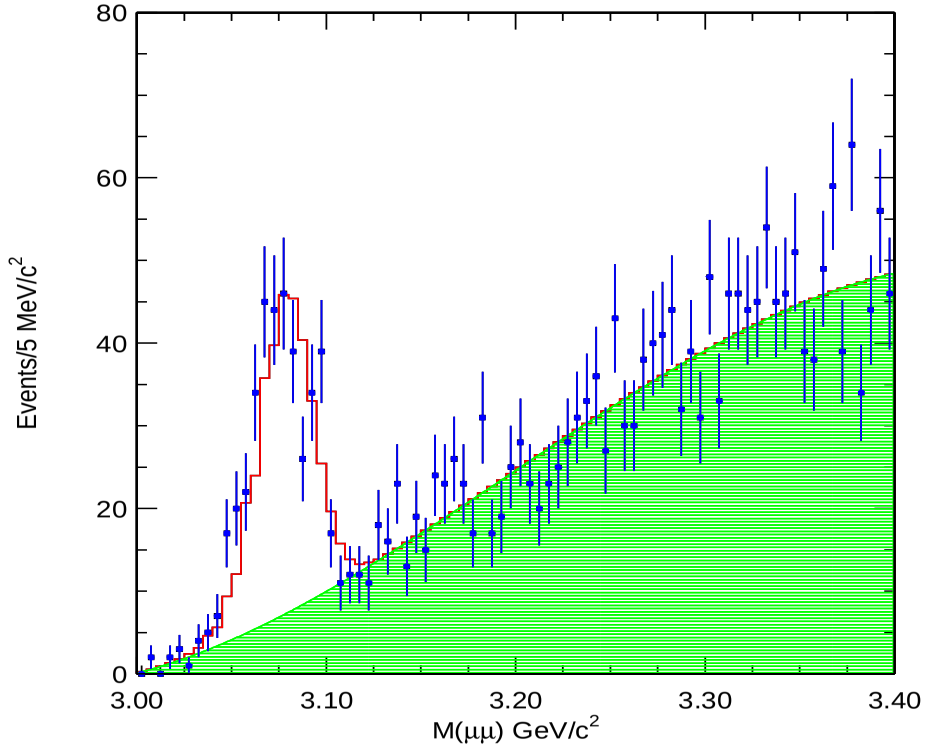
COT hit distributions tuned, 210 μm resolution, SVXII material scaled by 10%

J/ψ Yield

In each momentum bin, use CotSim mass shape + Chebyshev polynomial.

MINUIT χ^2 Fit to Plot 1002&0
0.0<Pt<0.25
File: fit.hst 28-JAN-2003 02:08
Plot Area Total/Fit 3182.0 / 2330.0 Fit Status 3
Func Area Total/Fit 3907.0 / 2240.8 E.D.M. 1.339E-06
χ^2= 90.5 for 80 - 5 d.o.f., C.L.= 10.7%

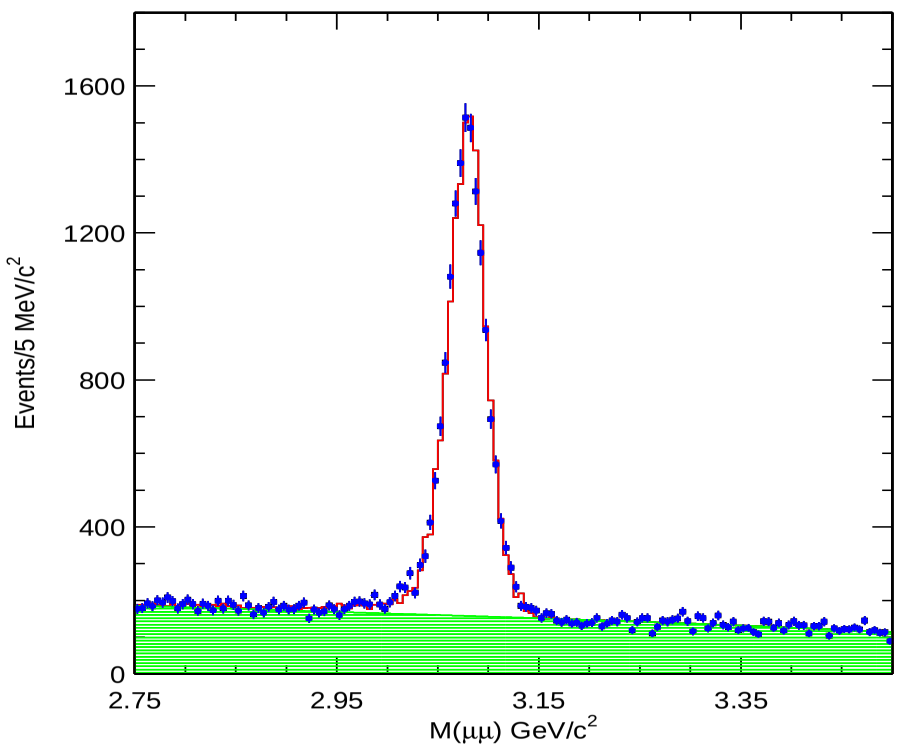
Errors		Parabolic	Minos	
Function 1: Chebyshev Polynomial of Order 3				
NORM	5801.3	± 1616.	- 1566.	+ 1567.
CHEB01	0.44457	± 0.7961	- 0.6115	+ 1.049
CHEB02	0.65664	± 0.1245	- 0.1649	+ 9.5444E-02
CHEB03	-0.45285	± 0.1270	- 0.1034	+ 0.1603
Function 2: Histogram 210 0 Normal errors				
NORM	580.80	± 46.14	- 45.88	+ 45.93



$0 < p_T(J/\psi) < 0.25 GeV/c$

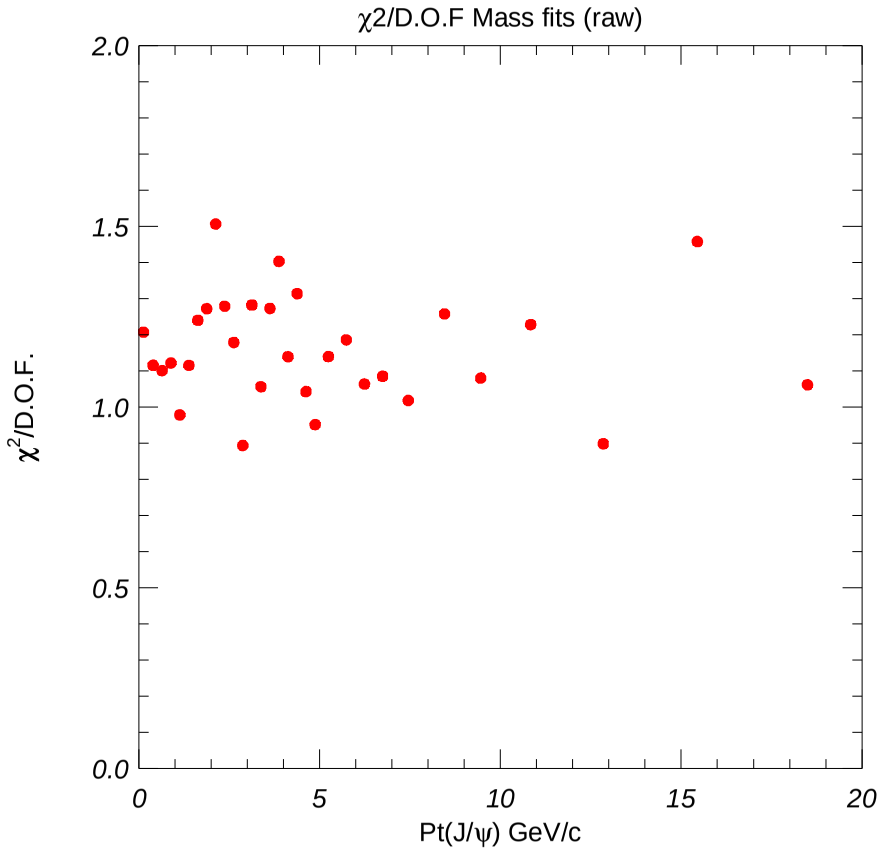
MINUIT χ^2 Fit to Plot 1016&0
3.5<Pt<3.75
File: fit.hst 28-JAN-2003 02:08
Plot Area Total/Fit 38273. / 36479. Fit Status 3
Func Area Total/Fit 38262. / 36350. E.D.M. 2.991E-06
χ^2= 180.8 for 150 - 5 d.o.f., C.L.= 2.3%

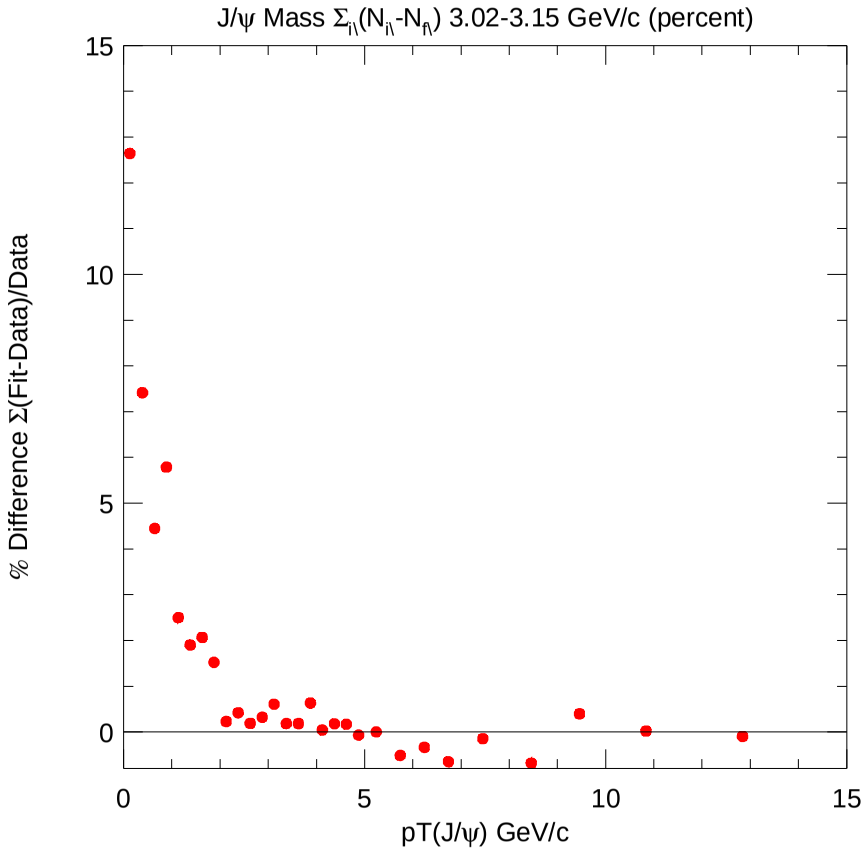
Errors		Parabolic	Minos	
Function 1: Chebyshev Polynomial of Order 3				
NORM	30770.	± 296.5	- 295.0	+ 295.2
CHEB01	-0.24441	± 1.7683E-02	- 1.7449E-02	+ 1.7617E-02
CHEB02	-1.26226E-02	± 1.7366E-02	- 1.6782E-02	+ 1.6572E-02
CHEB03	-5.72063E-03	± 1.4633E-02	- 1.4043E-02	+ 1.4158E-02
Function 2: Histogram 1610 0 Normal errors				
NORM	27372.	± 409.6	- 416.0	+ 421.7



$3.5 < p_T(J/\psi) < 3.75 GeV/c$

Mass fit systematics





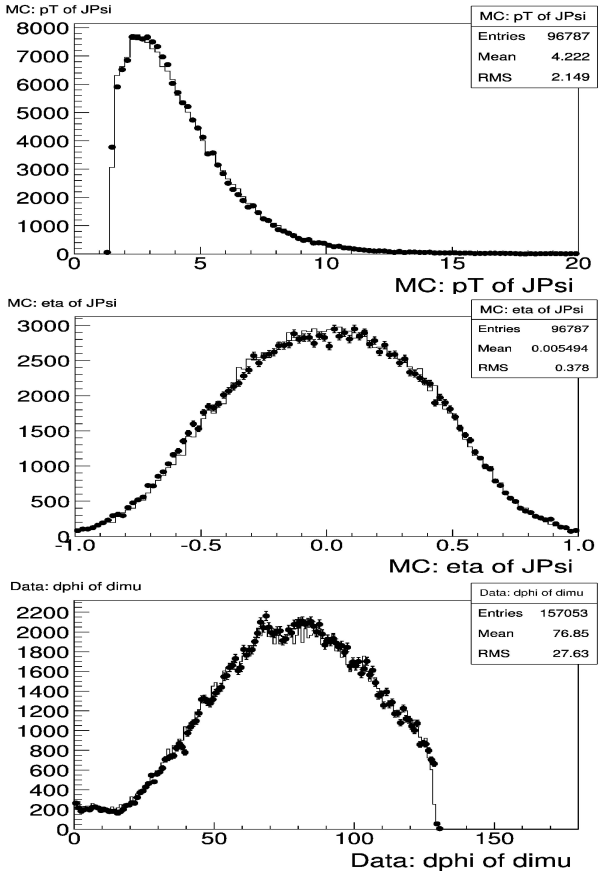
Mass fit $\chi^2/D.O.F$

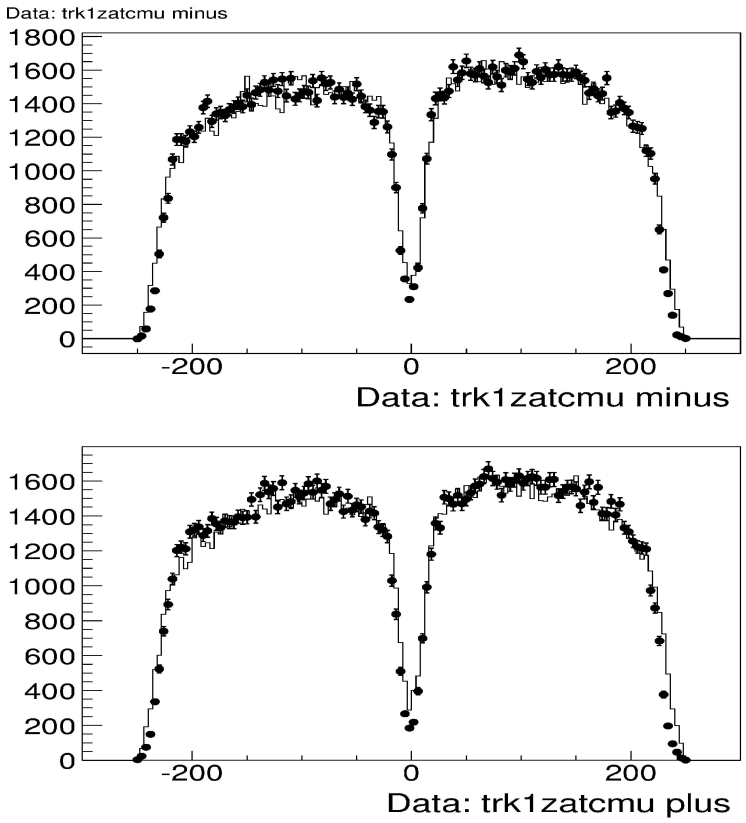
$\sum(DATA - FIT)/Yield$ signal region

Systematic error is bin dependent -0.2% to +13% (0.0-0.25 GeV/c bin)

GEANT Simulation

Generate using Run I $p_T(J/\psi)$ spectrum from 1 - 20 GeV/c. Flat from 0 - 3 GeV/c. *Reweigh p_T spectrum to match data for validation.*

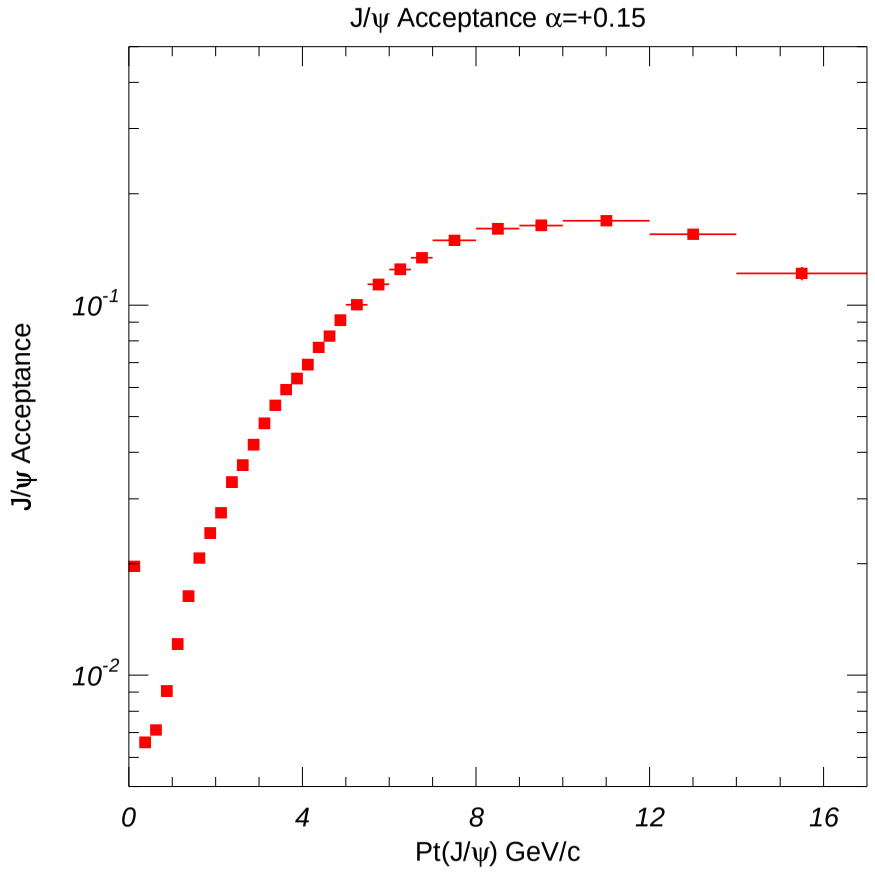


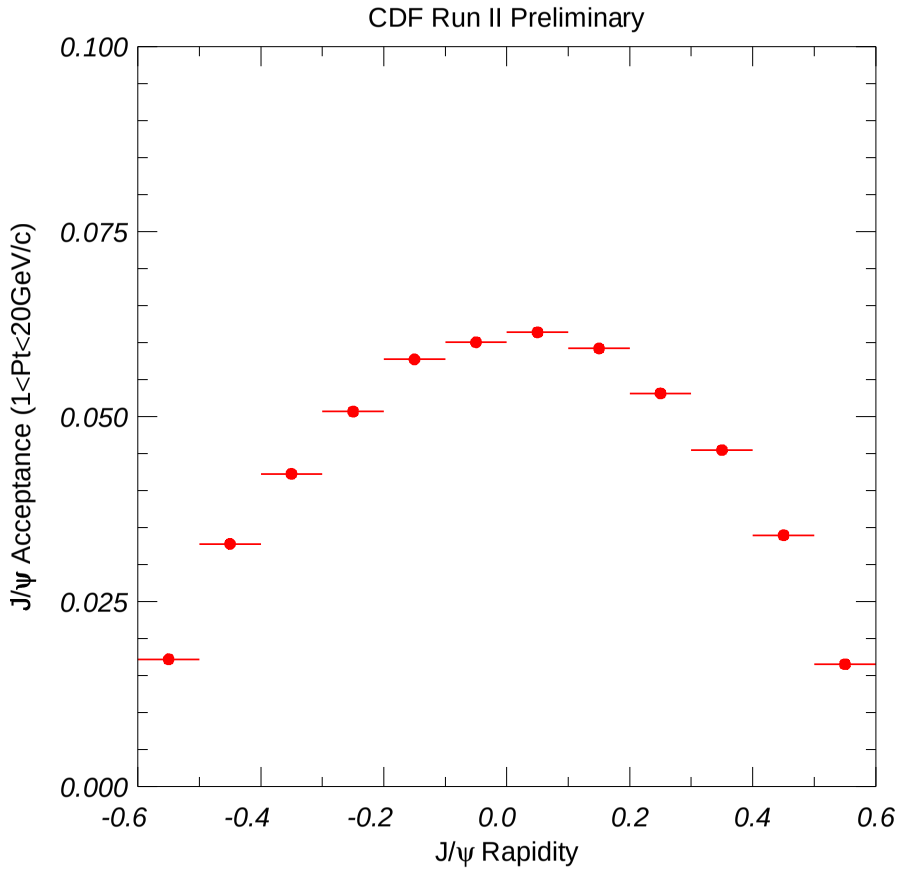


Kinematics match well

Geometry simulation is reasonable

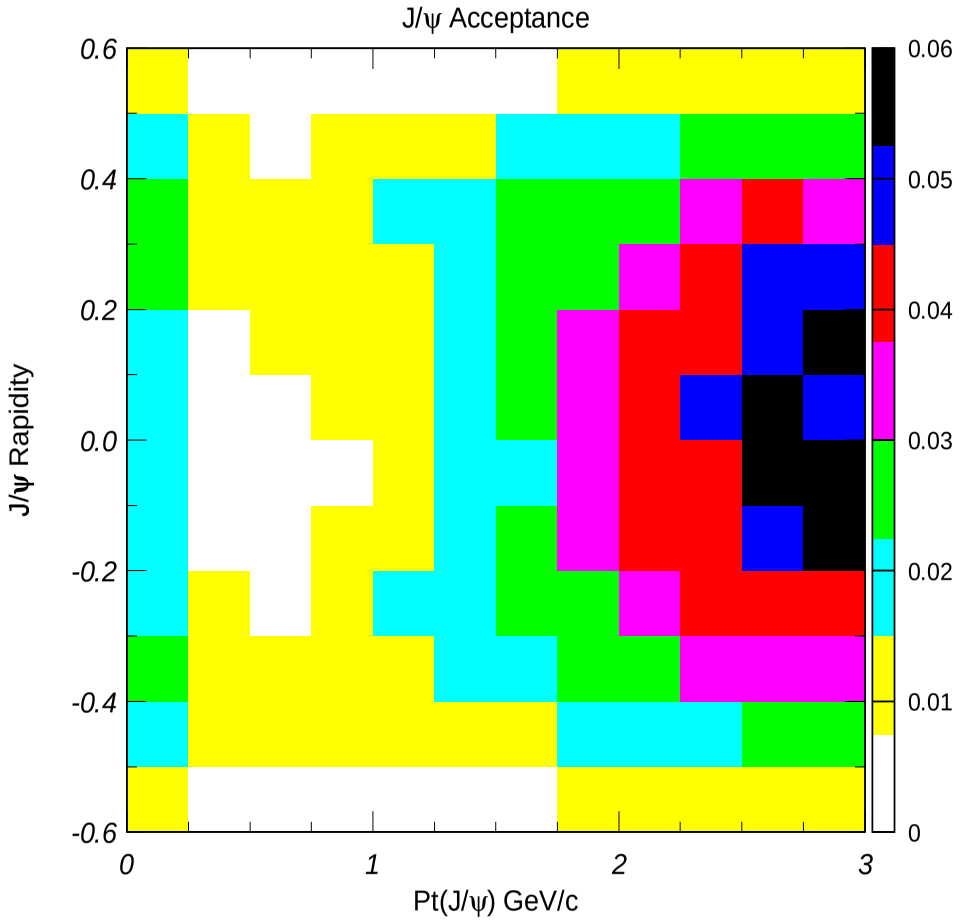
Acceptance: $p_T(J/\psi), |y| < 0.6$

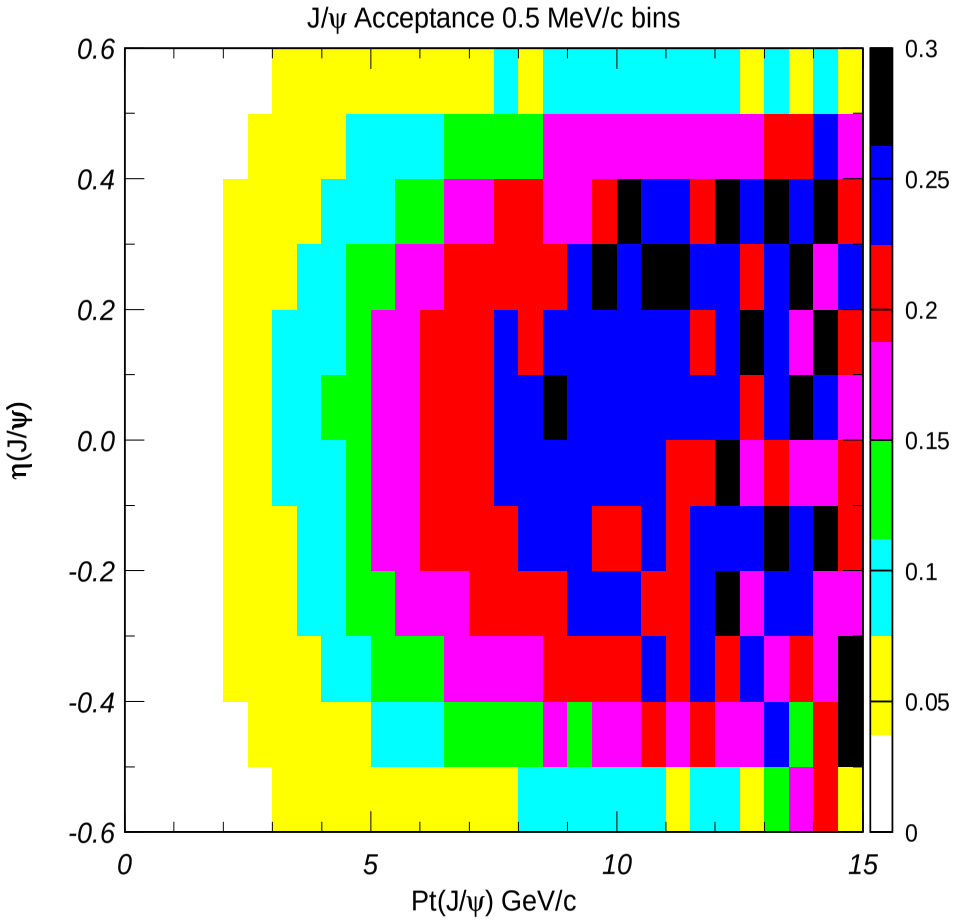




Percentage of events generated with $|y| > 0.6$ *and reconstructed* $|y| < 0.6$,
$\mathcal{A}' = 0.00071 \pm 0.00006(stat)$

2-D Acceptance

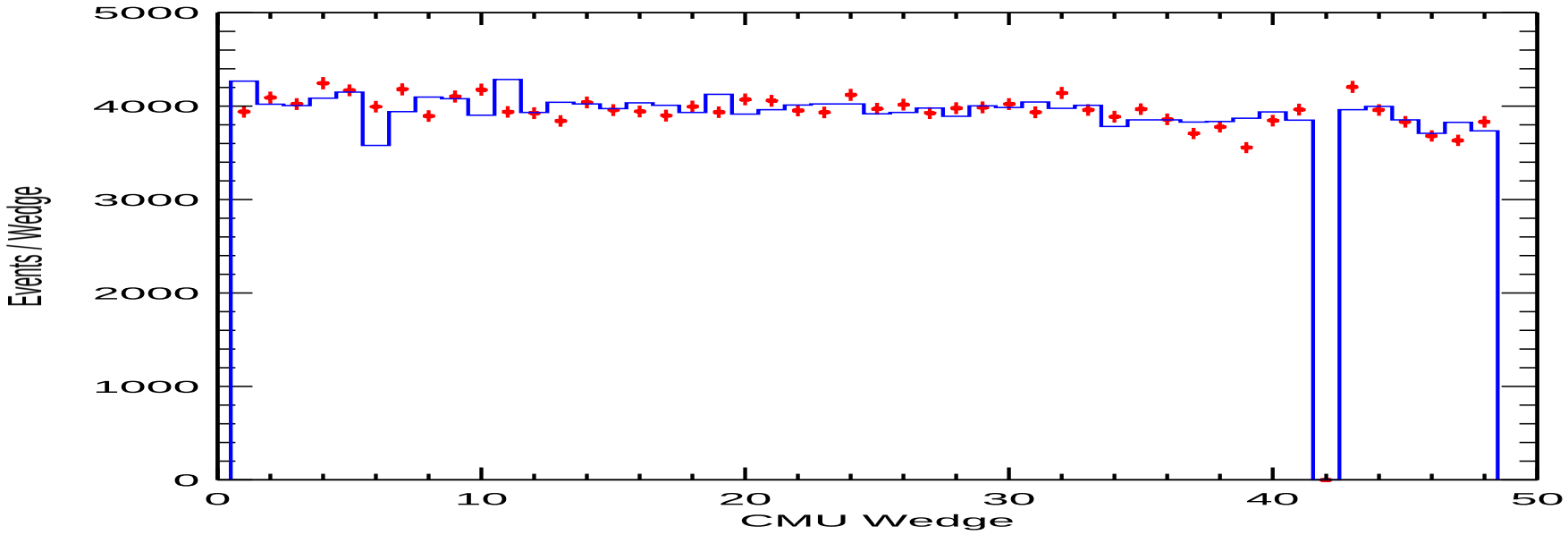




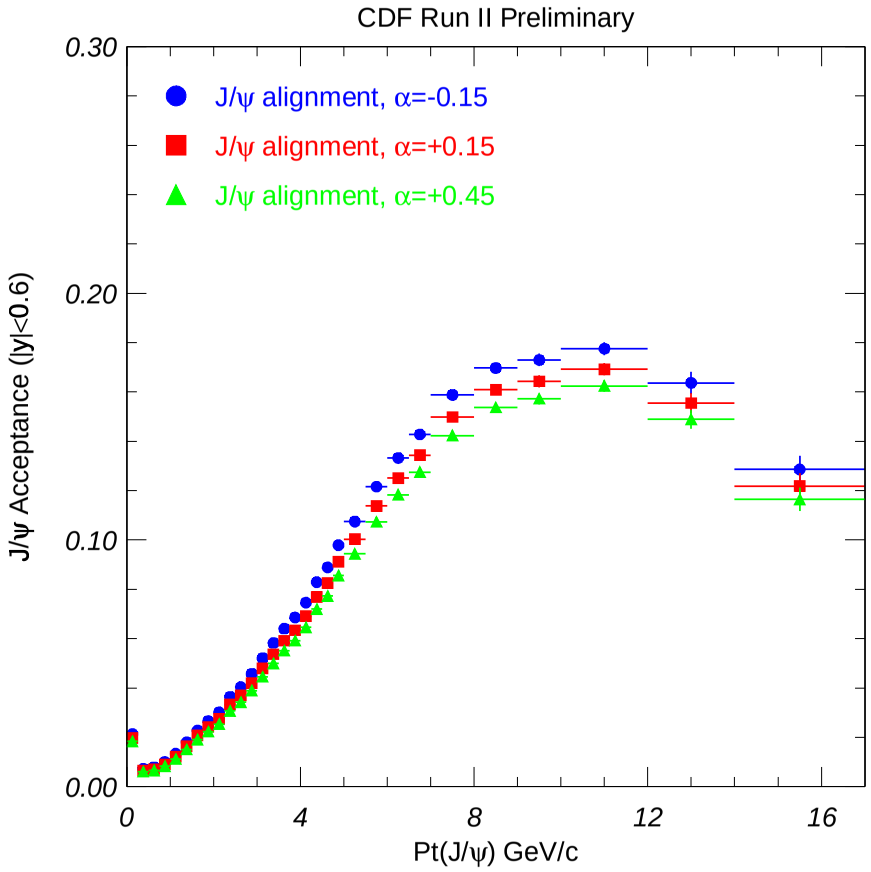
Lots of 2-D structure $\Rightarrow$ acceptance corrections in both y and p_T.

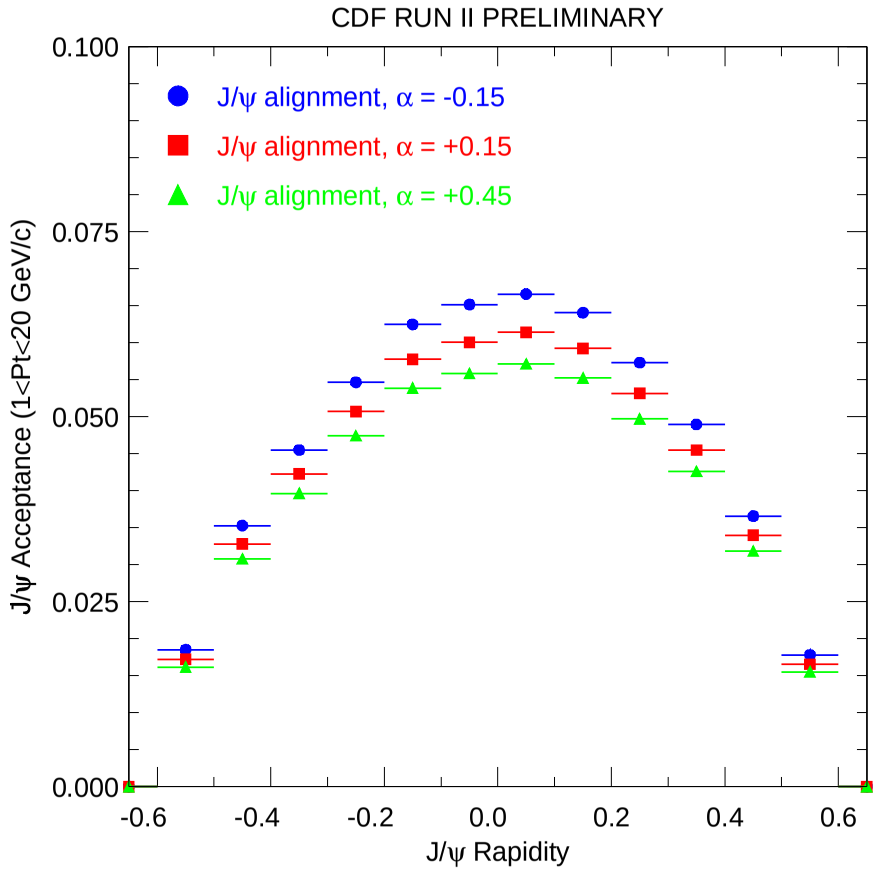
CMU Geometry

Effect	Systematic error
Primary vertex simulation	±0.28%
CMU East-West asymmetry	±0.80%
CMU wedge-wedge variations	±0.55%
Total	±1.0%



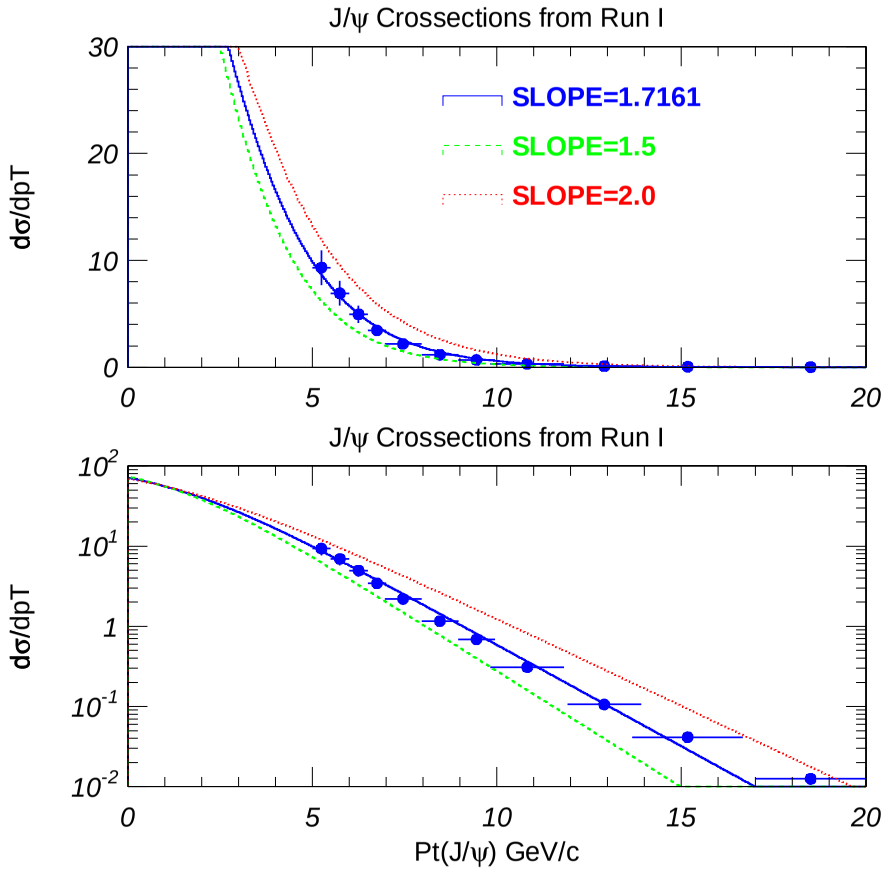
J/ψ polarization

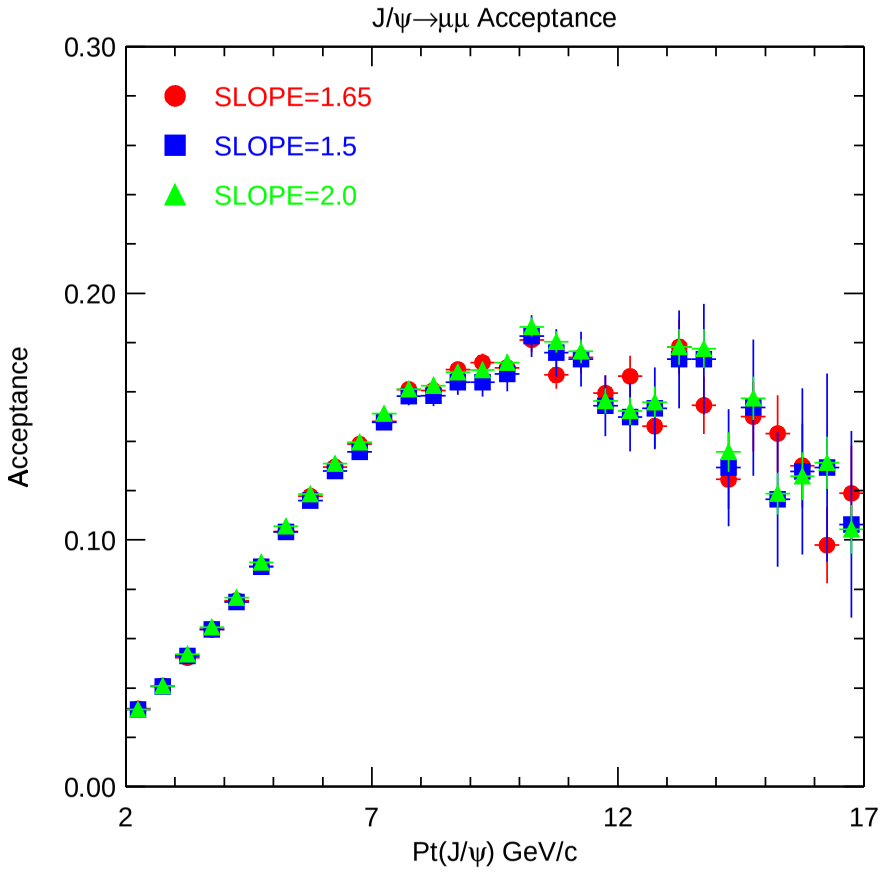




J/ψ acceptance as a function of p_T, and y for different different polarization states. p_T dependant uncertainty $\leq \pm 8\%$

J/ψ production



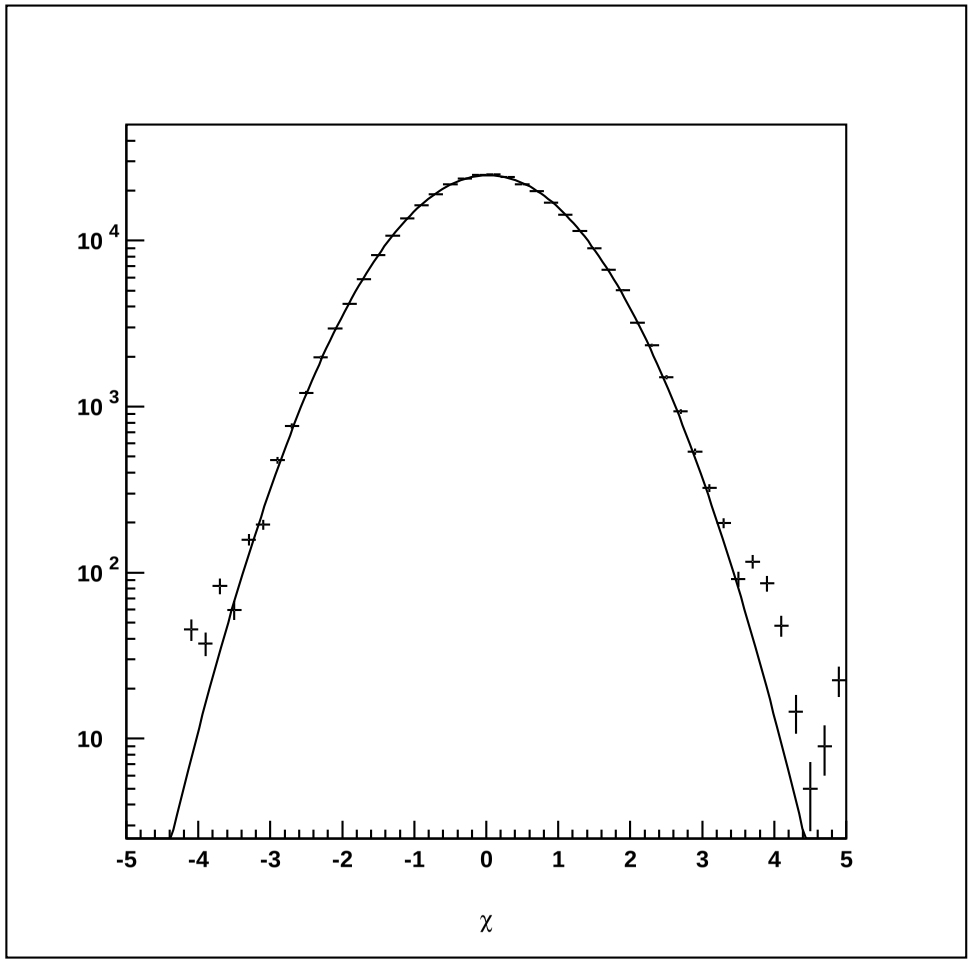


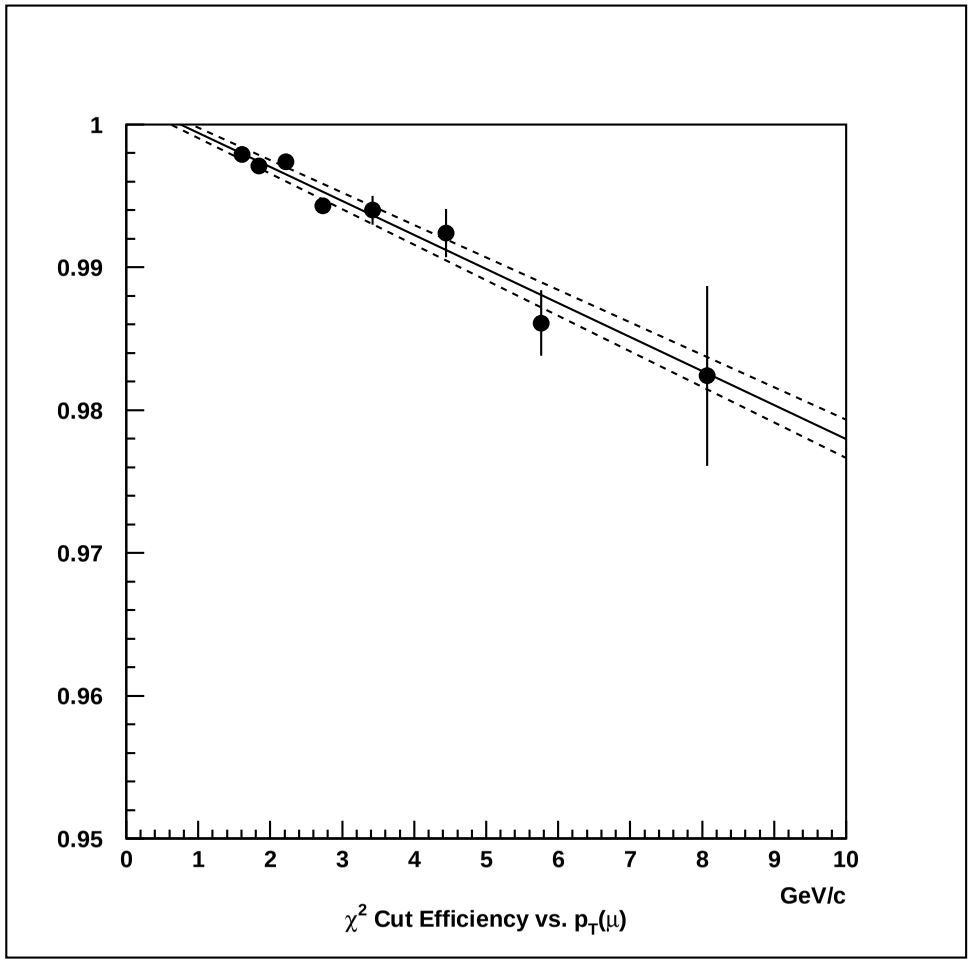
J/ψ acceptance as a function of generated p_T. Vary Run I spectrum.

$\sigma(p_T < 10$ GeV/c$) \leq \pm 3\%$, $\sigma(p_T > 10$GeV/c$) \approx \pm 15\%$

Track stub match - $\chi^2(\Delta r\phi)$

$$\epsilon_{\chi^2} = (1.0018 \pm 0.0003) - (0.0024 \pm 0.0001)p_T$$





BLESS: CDFNOTE 6114

Reconstruction Efficiency

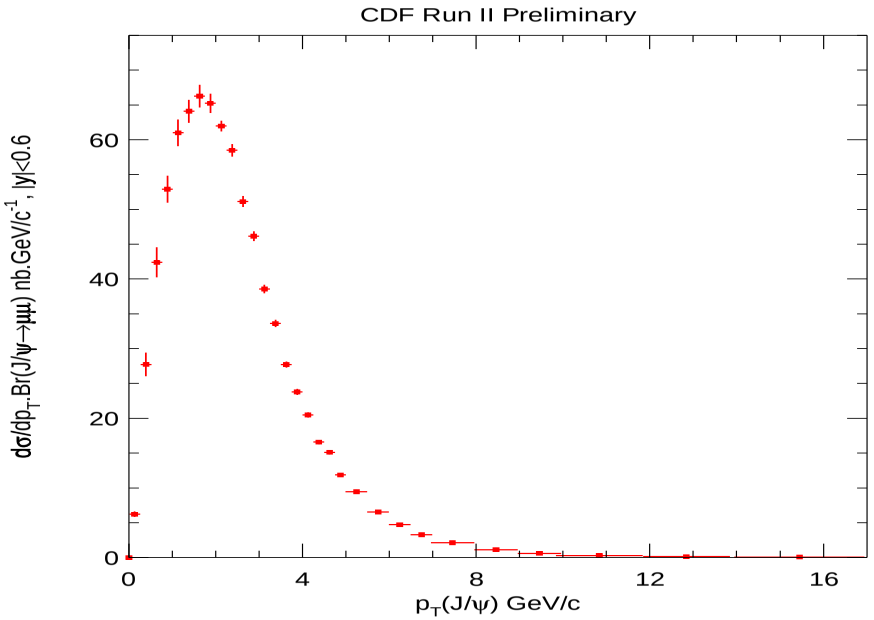
J/ψ Selection	Efficiency	Reference
L1/L3&Offline	$\epsilon^{\mu}_{L1} = (0.9774 \pm 0.0020) freq\left(\frac{(1.10\pm0.11)-1/p_T}{(0.390\pm0.085)}\right)$	CDFNOTE 6162
$\chi^2(\Delta r\phi)_{CMU} < 9$	$\epsilon_{\chi^2} = (1.0018 \pm 0.0003) - (0.0024 \pm 0.0001)p_T$	CDFNOTE 6114
L3&Offline/Offline	$\epsilon^{\mu}_{L3} = 0.997 \pm 0.001(stat) \pm 0.002(syst)$	CDFNOTE 6144
COT Offline	$\epsilon_{COT} = 99.7^{+0.3}_{-5.0}\%$	CDFNOTE 5983
Muon Offline	$\epsilon_{CMU} = 98.4 \pm 0.9 \pm 0.2\%$	CDFNOTE 6029
$z_0(\mu) < 90cm$	$\epsilon_{z0} = 99.43 \pm 0.16\%$	J/ψs muons
$\lvert z_{0\mu_1} - z_{0\mu_2}\rvert < 5$ cm	$\epsilon_{\Delta z} = 1.0013 \pm 0.0011$	D. Litvintsev

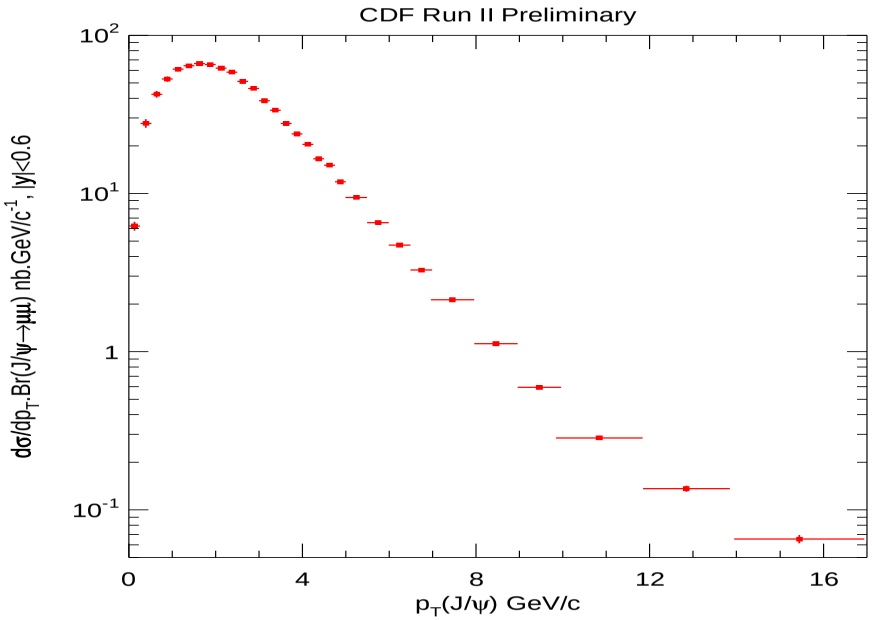
The combined p_T independant COT tracking, muon and L3 reconstruction efficiencies for CMU-CMU J/ψ is $\epsilon_{rec} = \epsilon^2_{COT} \cdot \epsilon^2_{CMU} \cdot \epsilon^2_{L3} \cdot \epsilon^2_{z_0} \cdot \epsilon_{\Delta_z} = 94.7^{+1.5}_{-5.3}\%$.

Differential Cross-section

The J/ψ yield in each p_T bin is corrected for$\mathcal{A}(p_T^{J/\psi}, y^{J/\psi})$, $\epsilon_{L1}(p_T^{\mu})$, and $\epsilon_{\chi^2<9}(p_T^{\mu})$, using an event by event weighing. Mass is then refit to get $N(p_T)_{corrected}$.

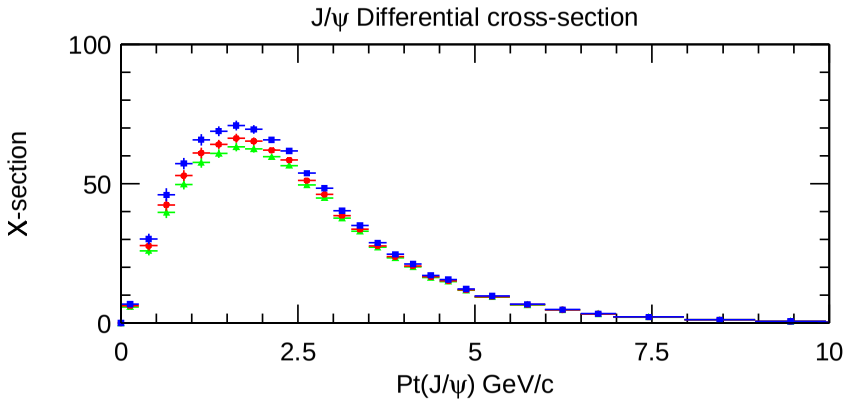
$$\frac{d\sigma(p\bar{p} \to J/\psi X) \cdot Br(J/\psi \to \mu^+\mu^-)}{dp_T} = \frac{N(p_T)_{corrected} \cdot (1 - \mathcal{A}')}{\epsilon_{rec} \cdot \int Ldt \cdot \Delta p_T}$$

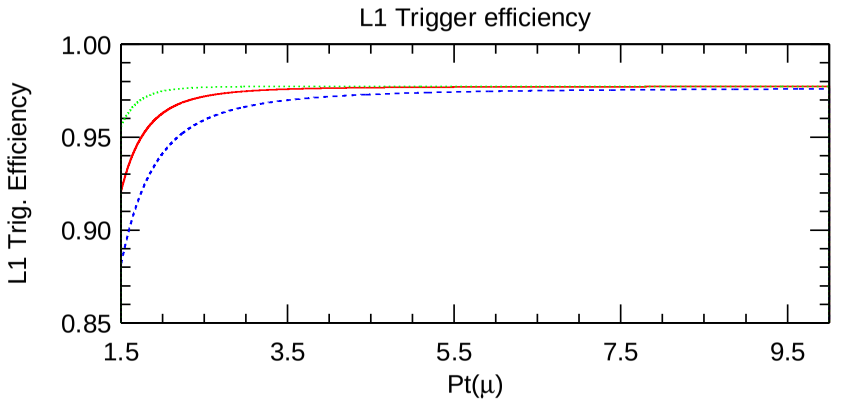




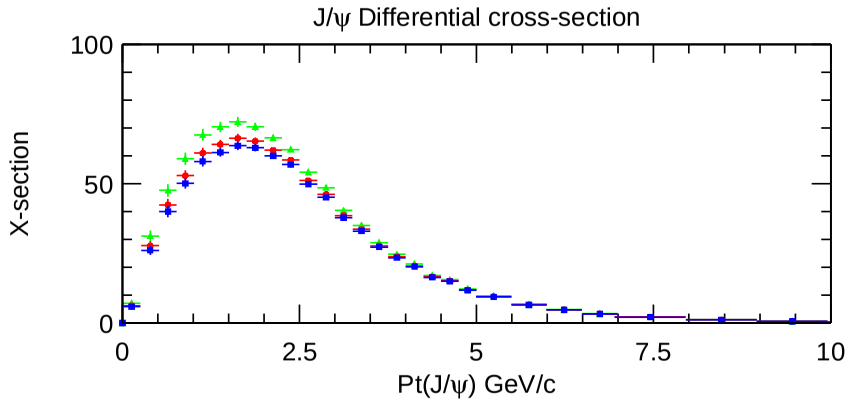
BLESS: differential J/ψ crossection as a function of J/ψ p_T. Table in note.

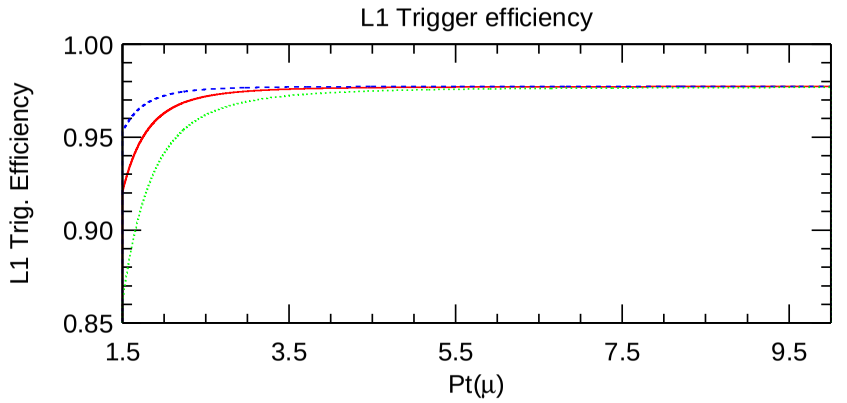
L1 Trigger uncertainty





Vary SLOPE of trig. function





Vary OFFSET of trig. function

Systematic error from -7% to +13%

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Systematic errors

Source	Systematic uncertainty
J/ψ Polarization	$\pm 4 - 10\%$ (p_T dependant)
J/ψ Spectrum	$\pm 3 - 15\%$ (p_T dependant)
L1 trigger efficiency	-0.2% *to* $+13\%$ (p_T dependant)
Mass fits	-0.01% *to* $+13\%$ (p_T dependant)
Luminosity	$\pm 6\%$
Reconstruction eff.	$+1.44\%, -5\% \oplus \epsilon_{\chi^2}(p_T)$
CMU Simulation	$\pm 1\%$
Momentum resolution	$\pm 0.5\%$

BLESS: The TOTAL integrated inclusive J/ψ cross section :

$$\sigma(J/\psi) \equiv \sigma(p\bar{p} \to J/\psi X, p_T(J/\psi), \mid y(J/\psi) \mid < 0.6) = 214.7 \pm 1.3(stat)^{xx}_{-xx}(syst) \text{ nb}$$