Work @ CERN

Analysis Strategy on Acceptance, Trigger & Reconstruction efficiency

Inclusive $b \to J/\psi X$, $J/\psi \to \mu \ \mu$

Xiangwei Meng

Institute of High Energy Physics, CAS, Beijing

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Work @ CERN

- CSC trivial tasks: small gears on cable and installation in Carven P5, etc.(Feb. – May.)
- CSC shift for Beijing IHEP
  - Common commissioning and test:
    CRUZET 2 (Jun.-Jul.)
  - CRUZET 3,4(Aug. –Sep.)
  - CRAFT 1-4 (Oct. – Nov.)
- Inclus b analysis in B physics group

Outline

- Motivation
- Strategy in anal Inclus b & B+ production @ CDF
- Strategy for Jpsi production @ CMS
- Inclus b analysis @ CMS
- To do list

Acceptance, Trigger & Reconstruction efficiency

- Acceptance: the detector geometric and kinematic acceptances. Determinateed from Monte Carlo simulation

- Efficiency: Triggered vs. unTriggered & reconstructed vs. nonreconstructed

Muon: hits , Segments, Stubs, Macthing

***J/ ψ & b*-hadron**

CDF: Acceptance, Trigger & Reconstruction efficiency I

$$\mathcal{A}(p_T, y) = \frac{N^{\text{rec}}(p_T(J/\psi), |y(J/\psi)| < 0.6)}{N^{\text{gen}}(p_T'(J/\psi), |y'(J/\psi)| < 0.6)}$$

$$\mathcal{A}' = \frac{N^{\text{rec}}(|y|_{\text{gen}} > 0.6, |y|_{\text{rec}} < 0.6)}{N^{\text{gen}}(|y|_{\text{gen}} < 0.6)}$$

The GEANT simulation is validated by comparing the resulting distributions of various kinematic quantities such as , *pT*, the track-stub matching distance, and the *z* vertex distribution in reconstructed data and reconstructed Monte Carlo events. Differences in the data and Monte Carlo distributions are used to estimate the systematic uncertainties on the modeling of the CDF detector geometry in the simulation.

For the level 1 di-muon trigger efficiency, used *Jspi* events that were taken with a high-*pT* single-muon trigger. At level 1, this trigger requires a muon with *pT* greater than 4.0 GeV/*c*. In level 3, a *Jpsi* is reconstructed using the triggered high-*pT* muon and a second muon which is not required to pass the level 1 requirements. This second muon is then used to measure the level 1 single-muon efficiency. The denominator of the efficiency measurement is the number of *Jpsi* reconstructed using the level 3 track and muon information.

$$\epsilon^{\mu}_{\text{L1}}(p^{\mu}_T) = E \cdot \text{freq}\left(\frac{A - 1/p_T}{R}\right), \qquad \epsilon^{J/\psi}_{\text{L1}}(p^{J/\psi}_T) = \epsilon^{\mu}_{\text{L1}}(p^{\mu_1}_T) \cdot \epsilon^{\mu}_{L1}(p^{\mu_2}_T)$$

The level 3 reconstruction efficiency is the difference between the on-line and the off-line tracking efficiencies. A fast tracking algorithm is used for pattern recognition in the COT in level 3. In the off-line reconstruction a more accurate tracking algorithm is combined with the result of the level 3 algorithm to give a higher overall COT-tracking efficiency.

$$\epsilon^{\mu}_{\text{L3/Offline}} = 0.997 \pm 0.001(\text{stat}) \pm 0.002(\text{syst}).$$

CDF: Acceptance, Trigger & Reconstruction efficiency II

TABLE II. Summary of J/ψ reconstruction efficiencies.

J/ψ selection	Efficiency
Level 3 muon reconstruction	$\epsilon_{L3} = 0.997 \pm 0.001 \pm 0.002$
COT off-line tracking	$\epsilon_{COT} = 0.9961 \pm 0.0002^{+0.0034}_{-0.0091}$
Muon off-line reconstruction	$\epsilon_{CMU} = 0.986 \pm 0.003 \pm 0.010$
Muon z_0 position less than ± 90 cm	$\epsilon_{z_0} = 0.9943 \pm 0.0016$
Dimuon z_0 separation less than 5 cm	$\epsilon_{\Delta z_0} = 1.0 \pm 0.001$
Total reconstruction	$\epsilon_{rec} = \epsilon_{L3}^2 \cdot \epsilon_{COT}^2 \cdot \epsilon_{CMU}^2 \cdot \epsilon_{z_0} \cdot \epsilon_{\Delta z_0} = 95.5\% \pm 2.7\%$

the track-stub matching

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

An event-by-event weighting to determine the *Jpsi* yield

$$1/w_i = \epsilon_{L1}(p_T^{\mu 1}) \cdot \epsilon_{L1}(p_T^{\mu 2}) \cdot \epsilon_{\chi^2}(p_T^{\mu 1}) \cdot \epsilon_{\chi^2}(p_T^{\mu 2}) \cdot \mathcal{A}(p_T^{J/\psi}, y^{J/\psi}).$$

The *Jpsi* differential cross section calculated as follows

$$\frac{d\sigma}{dp_T} \cdot \mathrm{Br}(J/\psi \to \mu\mu) = \frac{N(p_T)_{\mathrm{corrected}} \cdot (1 - \mathcal{A}')}{\epsilon_{\mathrm{rec}} \cdot \int \mathcal{L} dt \cdot \Delta p_T}$$

$$\sigma_i(H_b) = \frac{\sigma_i(\mathrm{raw})}{f_\sigma^i} = \frac{\sum_{j=1}^{N} w_{ij} \sigma_j(J/\psi)}{f_\sigma^i}$$

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***B*+ production**

CDF: Acceptance, Trigger & Reconstruction efficiency III

TABLE I. Detector acceptance, $\mathcal{A}$, as a function of the $B^{\pm}$ p_T. The acceptance $\mathcal{A}_{corr}$ includes corrections evaluated using the data. The average $\langle p_T \rangle$ is the value at which the theoretical differential cross section [1] equals the integrated cross section in each momentum bin divided by the bin width.

p_T range (GeV/c)	$\langle p_T \rangle$ (GeV/c)	$\mathcal{A}$ (%)	$\mathcal{A}_{corr}$ (%)
6–9	7.37	1.545	1.780 ± 0.045
9–12	10.38	3.824	4.405 ± 0.111
12–15	13.39	5.966	6.872 ± 0.173
15–25	19.10	8.819	10.16 ± 0.25
≥ 25		12.516	14.42 ± 0.36

The bin width *pT* and Acorr, the geometric and kinematic acceptance that includes trigger and tracking efficiencies measured with the data, are listed in Table I.

The *B*+ differential cross section calculated as follows

$$\frac{d\sigma(B^+)}{dp_T} = \frac{N/2}{\Delta p_T \times \mathcal{L} \times \mathcal{A}_{corr} \times BR}$$

TABLE II. Summary of efficiencies for reconstructing $B^{\pm}$ candidates in the data and the simulation. The last column indicates the corrections applied to the simulated acceptance and used to derive $\mathcal{A}_{corr}$ in Table I.

Source	Data	Simulation	Corr.
COT tracking	$(0.996 \pm 0.006)^3$	$(0.998 \pm 0.002)^3$	1.00 ± 0.02
Kaon interaction			1.000 ± 0.003
CMU acc. and eff.	$(0.6251 \pm 0.0047)^2$	$(0.6439 \pm 0.0004)^2$	0.942 ± 0.014
L1 CMU primitives	$(0.9276 \pm 0.0005)^2$	$(0.8369 \pm 0.0004)^2$	1.228 ± 0.002
L1 eff.	0.9879 ± 0.0009	0.9868	1.0011 ± 0.0009
L2 eff.	0.9948 ± 0.0001	0.9939	1.0009 ± 0.0001
L3 eff.	$(0.997 \pm 0.002)^2$	1	0.994 ± 0.004
Total	0.328 ± 0.008	0.283 ± 0.002	1.152 ± 0.029

In the simulation, the efficiencies of the L1 and L2 triggers are 0.9868 and 0.9939, respectively. By studying *Jpsi* candidates acquired with the CMUP*pT*4 trigger, the L1 efficiency is measured to be 0.9879 ± 0.0009, and that of the L2 trigger 0.9948 ± 0.0001. The L3 trigger is not simulated. The L3 trigger efficiency is dominated by differences between the online and offline reconstruction code efficiency.5 The relative L3 efficiency for reconstructing a single muon identified by the offline code has been measured to be 0.997 ± 0.002 [26]. The reconstruction efficiencies in the data and in the simulation are summarized in Table II.

Zongchang' Jpsi production @ CMS

Ngen is the *total* true number of *Jpsi*'s present, i.e. *before applying the generator dimuon filter*

$$A(p_T^{J/\psi}, \eta_{J/\psi}) = \frac{N_{J/\psi}^{rec}(p_T^{J/\psi}, \eta_{J/\psi})}{N_{J/\psi}^{gen}(p_T^{J/\psi}, \eta_{J/\psi})}.$$

$$\epsilon_{J/\psi}^{filt}(p_T^{J/\psi}, \eta_{J/\psi}) = \frac{N_{J/\psi}^{fit}(p_T^{J/\psi}, \eta_{J/\psi})}{N_{J/\psi}^{gen+filt}(p_T^{J/\psi}, \eta_{J/\psi})}$$

$$\epsilon_{offline}^{J/\psi}(p_T^{J/\psi}, \eta_{J/\psi}, \theta_{J/\psi}) = \epsilon_{\mu_1}(p_T^{\mu_1}, \eta_{\mu_1}) \times \epsilon_{\mu_2}(p_T^{\mu_2}, \eta_{\mu_2})$$

$$\epsilon_{trig}(p_T^{J/\psi}, \eta_{J/\psi}) = \frac{N_{trig}(p_T^{J/\psi}, \eta_{J/\psi})}{N_{offlinereco}(p_T^{J/\psi}, \eta_{J/\psi})}$$

$$\lambda_{reco}^{corr}(p_T^{\mu}, \eta^{\mu}) = \frac{\epsilon_{data}^{\mu}(p_T^{\mu}, \eta^{\mu})}{\epsilon_{MC}^{\mu}(p_T^{\mu}, \eta^{\mu})}$$

$$\epsilon_{trigger}^{J/\psi} = \epsilon_{trigger}^{\mu_1}\epsilon_{trigger}^{\mu_2}\zeta(\mu_1, \mu_2)$$

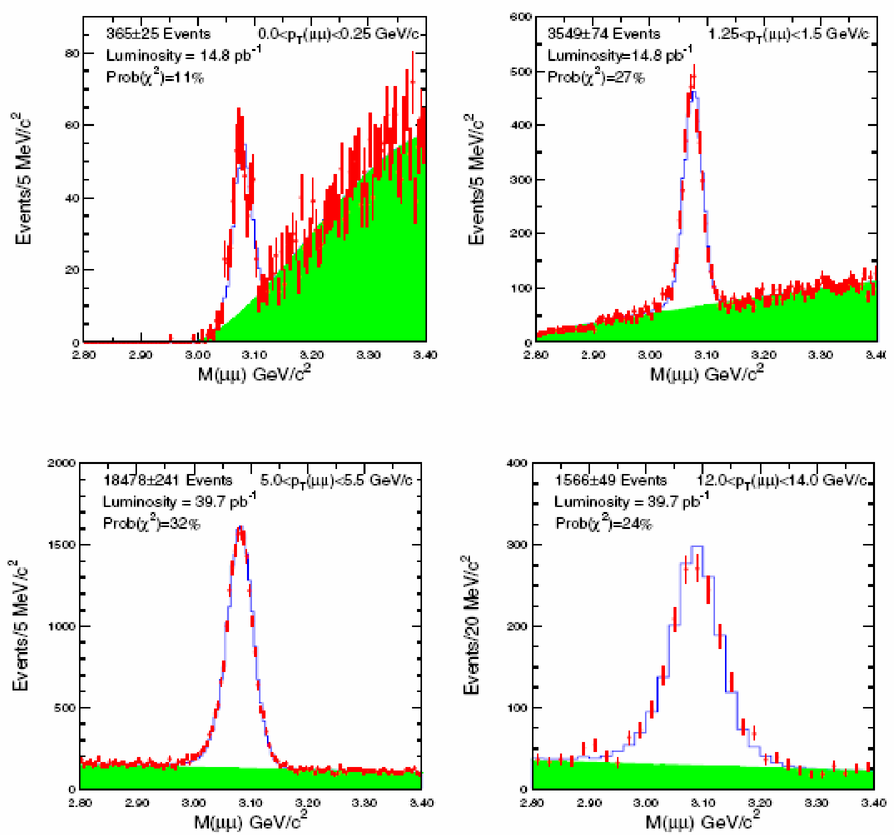
$$\begin{aligned} \epsilon_{trigger}^{\mu} &= \epsilon_{L1}^{\mu} \cdot \epsilon_{L2}^{\mu} \cdot \epsilon_{L3}^{\mu} \\ &= P(L1, offl|offl) \cdot P(L1, L2, offl|L1, offl) \cdot P(L1, L2, L3, offl|L1, L2, offl) \end{aligned}$$

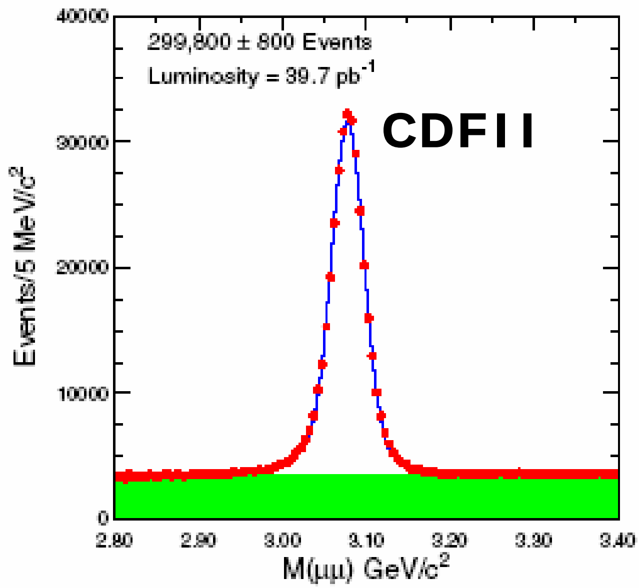
$$\frac{d\sigma}{dp_T}(J/\psi) \cdot Br(J/\psi \to \mu^+\mu^-) = \frac{N_{J/\psi}^{fit}}{\int Ldt \cdot A \cdot \lambda_{trigger}^{corr} \cdot \lambda_{reco}^{corr} \cdot \Delta p_T}$$

$$(p_T^{\mu}, \eta^{\mu}) = \frac{\epsilon_{trigger}^{data}(p_T^{\mu}, \eta^{\mu})}{\epsilon_{trigger}^{MC}(p_T^{\mu}, \eta^{\mu})}$$

- $N_{J/\psi}^{fit}$ is the number of reconstructed J/ψ candidates in a given p_T bin. This is obtained by fitting the J/ψ mass spectrum with a linear background and double gaussian signal hypothesis, as was explained in Sec. 4.2.3.
- A is the the total efficiency for triggering and offline reconstructing the J/ψ events, as extracted from Monte Carlo. It will be explained in Sec. 5.1.
- $\lambda_{trigger}^{corr}$ and λ_{reco}^{corr} are correction factors to the trigger and offline efficiencies, respectively, as measured in data compared to the Monte Carlo simulation , and will be addressed in Sec.5.2.1.
- $\int Ldt$ is the integrated luminosity.
- Δp_T is the size of the p_T bin.

Inv. Mass of J/ψ vs diff. pT bin





$3.093\,91 \pm 0.000\,08\ \mathrm{GeV}/c^2$

CDF II's Results

PHYSICAL REVIEW D 71, 032001 (2005)

- PPbar energy: 1.96 TeV with 39.7 pb^{-1}.

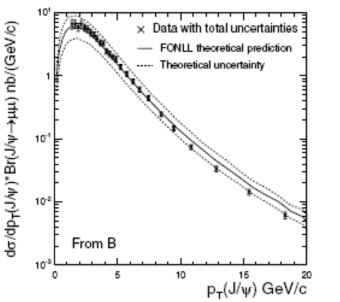


FIG. 9. Differential cross-section distribution of J/ψ events from the decays of b hadrons as a function of J/ψ transverse momentum integrated over the rapidity range $|y| < 0.6$. The crosses with error bars are the data with systematic and statistical uncertainties added including correlated uncertainties. The solid line is the central theoretical values using the FONLL calculations outlined in [41]; the dashed line is the theoretical uncertainty.

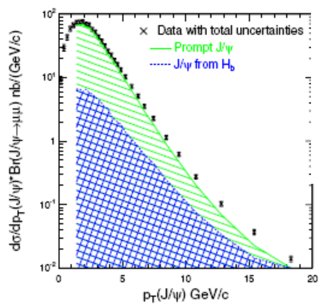


FIG. 10 (color online). The inclusive J/ψ cross section as a function of J/ψ p_T integrated over the rapidity range $|y| < 0.6$ i… plotted as points with error bars where all uncertainties hav… been added. The hatched histogram indicates the contribution t… the cross section from prompt charmonium production. Th… cross-hatched histogram is the contribution from decays of … hadrons.

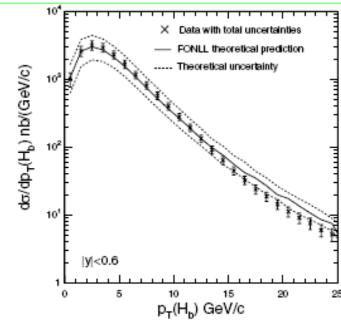
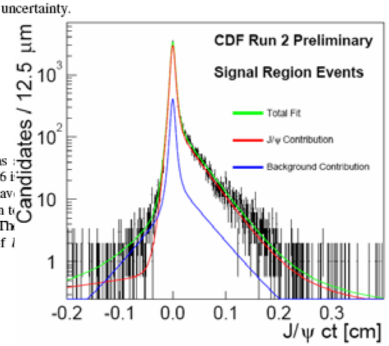


FIG. 11. Differential cross-section distribution of b-hadron production as a function of b-hadron transverse momenta. The crosses with error bars are the data with systematic and statistical uncertainties added, including correlated uncertainties. The solid line is the central theoretical values using the FONLL calculations outlined in [41]; the dashed line is the theoretical uncertainty.



$$\sigma[p\bar{p}\to J/\psi X, |y(J/\psi)| < 0.6] = 4.08 \pm 0.02(\text{stat})^{+0.36}_{-0.33}(\text{syst})\ \mu\text{b}.$$

$$\sigma[p\bar{p}\to H_b, H_b\to J/\psi, p_T(J/\psi) > 1.25\ \text{GeV}/c, |y(J/\psi)| < 0.6] = 0.330 \pm 0.005(\text{stat})^{+0.036}_{-0.033}(\text{syst})\ \mu\text{b}.$$

$$\sigma[p\bar{p}\to J/\psi_p X, p_T(J/\psi) > 1.25\ \text{GeV}/c, |y(J/\psi)| < 0.6\ ] = 2.86 \pm 0.01(\text{stat})^{+0.34}_{-0.45}(\text{syst})\ \mu\text{b},$$

$$\sigma(p\bar{p}\to H_b X, |y| < 0.6) = 17.6 \pm 0.4(\text{stat})^{+2.5}_{-2.3}(\text{syst})\ \mu\text{b}$$

In Figs. 9 and 11, we compare our measurement to a QCD calculation of the b-hadron cross section by Cacciari *et al.* [41]. This calculation uses a fixed-order approach with a next-to-leading-log resummation and a new technique to extract the b-hadron fragmentation function from LEP data [20,41]. The single b-hadron cross section from this FONLL calculation using the CTEQ6M parton distribution functions [43] is $\sigma^{\text{FONLL}}_{(|y|<0.6)} = 16.8^{+7.0}_{-5.0}\ \mu\text{b}$ which is in good agreement with our measurement of $17.6 \pm 0.4(\text{stat})^{+2.5}_{-2.3}(\text{syst})\ \mu\text{b}$.

We also compare this result to the QCD calculation described in Ref. [19]. This calculation employs a factorization scheme where the mass of the quark is considered negligible and a different treatment of the b-hadron fragmentation function is used. The cross-section calculation in [19] is repeated using $\sqrt{s} = 1960\ \text{GeV}/c$ and the MRST2001 parton distribution functions [44]. The central value of the calculated cross section integrated over the rapidity range $|y| < 0.6$ and $p_T(J/\psi) > 5.0\ \text{GeV}/c$ is $\sigma(p\bar{p}\to H_b X, |y| < 0.6)\cdot\text{Br}(H_b\to J/\psi X)\cdot\text{Br}(J/\psi\to\mu\mu) = 3.2$ nb [45] which is in good agreement with our result of $3.06 \pm 0.04(\text{stat}) \pm 0.22(\text{syst})$ nb.

A more complete discussion of the changes in QCD calculations can be found in Refs. [18,20,41]. Updated determinations of proton parton densities and bottom quark fragmentation functions have brought the QCD calculations into better agreement with the CDF measurements of the total b-hadron cross section and the b-hadron p_T distribution.

a fixed-order approach with a next-to-leading-log resummation

CDF note 6023

$$\tau_B = 1.526 \pm 0.034\ (\text{stat}) \pm 0.035\ (\text{syst})\ \text{ps}$$

Inclus b @ CMS

- First measurement of b-production cross section at sqrt(s) = 10 and 14 TeV
- Test of QCD calculations
- Essential measurement of background for many other processes, validation of b-tagging

Inclusive J/ ψ cross section $\sigma[pp \to J/\psi X]$

- **J/ ψ from b;**
- **Prompt J/ ψ: directly produced, prompt decay of heavier charmonium $^1p_0$ χ_{c0}, $^3p_1$ χ_{c1}, $^3p_2$ χ_{c2}, etc.**

to measure: $\sigma[pp \to H_b, H_b \to J/\psi X]$

- Inclusive b production cross section

(another approach based on bJets Andreev, *et al.* (CMS NOTE 2006/120)

from the fraction of inclusive b→J/ψX to deduce the total inclusive b production

$Br(H_b \to J/\psi X) = 1.16\% \pm 0.10\%$
$Br(J/\psi \to \mu\mu) = 5.93\% \pm 0.06\%$

$$\sigma[pp \to H_b X] \cdot Br(H_b \to J/\psi X)$$
$$= \sigma[pp \to H_b, H_b \to J/\psi X]$$

- The further study on inclusive b lifetime
  - **calibrate resolution function**
  - **understand calibration & alignment**

CMSSW_2_1_12
CMSSW_2_2_3

pp@10TeV

CMS Summer08 M.C. data samples

b2J/psi

- **/BtoJpsiMuMu/Summer08_IDEAL_V11_redigi_v1/GEN-SIM-RECO** CMSSW_2_2_1
- **/BtoJpsiMuMu/Summer08_IDEAL_V9_v2/GEN-SIM-RECO** CMSSW_2_1_7

Created 14 Nov 2008, 2434076 events, 381 files, 5 block(s), 643.2GB, located at 5 sites

- **T2_US_Purdue : dcache.rcac.purdue.edu** 2434076 381 643.2GB
- **T2_CH_CSCS : storage01.lcg.cscs.ch**
- **No SiteDB name : cmsdca2.fnal.gov**
- **T1_DE_FZK : gridka-dCache.fzk.de**
- **T2_CN_Beijing : srm.ihep.ac.cn**

p-J/psi

- **/JPsi/Summer08_IDEAL_V9_v1/GEN-SIM-RECO** CMSSW_2_1_8

Created 11 Dec 2008, 1122884 events, 220 files, 5 block(s), 234.4GB, located at 3 sites

- **No SiteDB name : f-dpm001.grid.sinica.edu.tw** 224713 44 46.9GB
- **T1_TW_ASGC : srm.grid.sinica.edu.tw** 449166 88 93.7GB
- **No SiteDB name : lxfs07.jinr.ru**

QCD

- **/InclusivePPmuX/Summer08_IDEAL_V11_redigi_test2/GEN-SIM-RAW** CMSSW_2_2_1

Created 13 Jan 2009, 414945 events, 400 files, 4 block(s), 397.0GB, located at 1 site

- **T1_ES_PIC : srmcms.pic.es** 414945 400 397.0GB

- **/InclusivePPmuX/Summer08_IDEAL_V9_v4/GEN-SIM-RECO** CMSSW_2_1_8

Created 17 Nov 2008, 5232662 events, 1315 files, 33 block(s), 1.5TB, located at 3 sites

- **T1_ES_PIC : srmcms.pic.es** 5232662 1315 1.5TB
- **No SiteDB name : f-dpm001.grid.sinica.edu.tw**
- **T2_EE_Estonia : io.hep.kbfi.ee**

Measurement of Cross-secton

- The inclusive b-> J/ψ cross-section is calculated by

$$\frac{d\sigma}{dp_T}\cdot \mathrm{Br}(J/\psi \rightarrow \mu^+\mu^-) = f_b(p_T)\cdot \frac{N_{Reco}(p_T)\cdot(1-A')}{\int L dt \cdot A \cdot \varepsilon_{Trig}\cdot \varepsilon_{Offline}\cdot \Delta p_T}$$

1. **$\int L$ dt : the integral luminosity**
2. **f_b : fraction for J/ Ψ from b**
3. **ΔP_T : the size of the P_T bin.**
4. **N_{Reco}: the number of reconstructed J/ψ signals**
5. **A, A' : the acceptance and relative acceptance**
6. **ε_{Trig} : trigger efficiency**
7. **$\varepsilon_{Offline}$: off-line reconstruction efficiency**

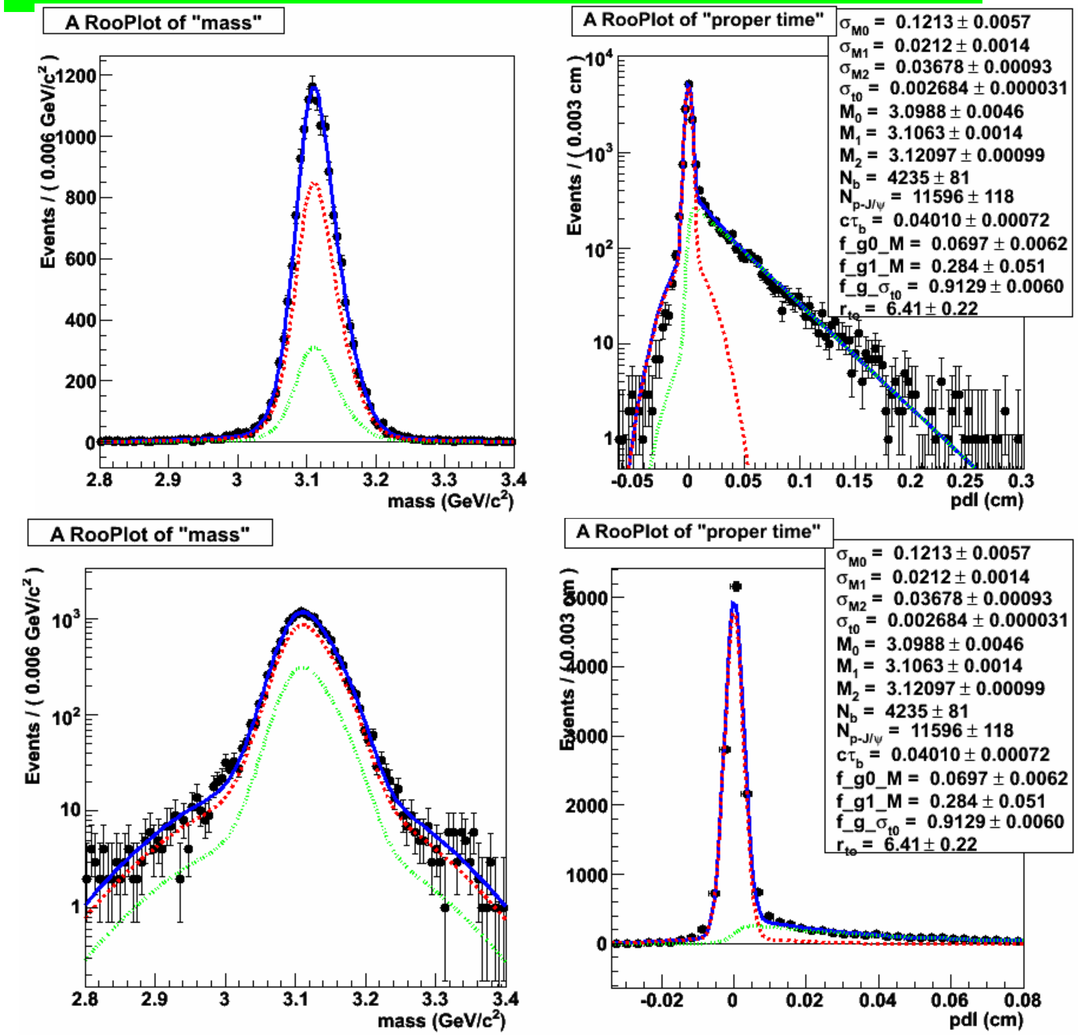
Acceptances I

- Acceptances include the detector geometric and kinematic acceptances, Can be obtained by Monte Carlo simulation. is treated and defined as:

$$A(p_T^{J/\psi}, \eta^{J/\psi}) = \frac{N^{Rec}(p_T^{J/\psi}, |\eta^{J/\psi}| < 2.4)}{N^{Gen}(p_T^{J/\psi}, |\eta^{J/\psi}| < 2.4)}$$

pT: 9-10GeV

Offline p-jpsi: 11545
b: 4288



1. a finite experimental resolution on each measurement

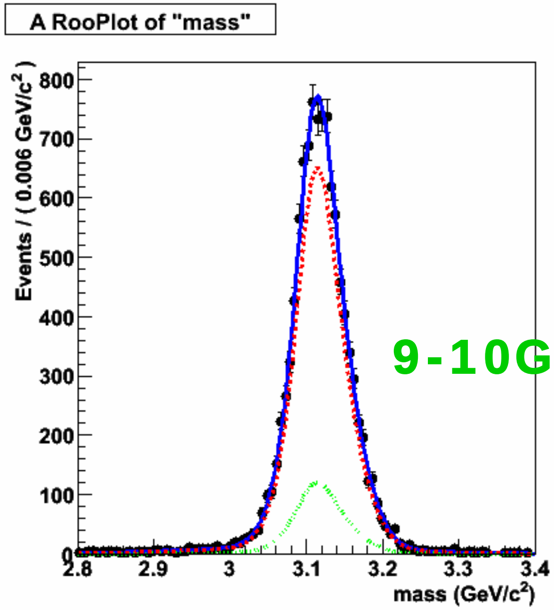
$$F_I(t) = \exp(-t/\tau)$$

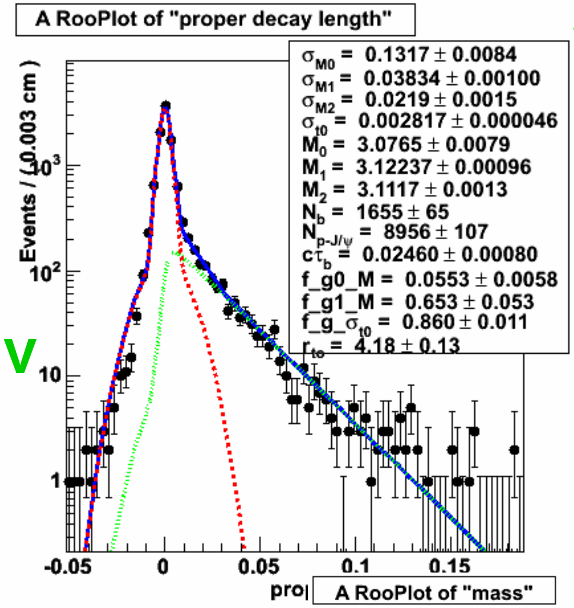
$$F_R(t) = \exp(-t/\tau) \otimes G(t, \mu, \sigma)$$
$$\equiv \int dt' \exp(-t'/\tau)\, G(t-t', \mu, \sigma)$$

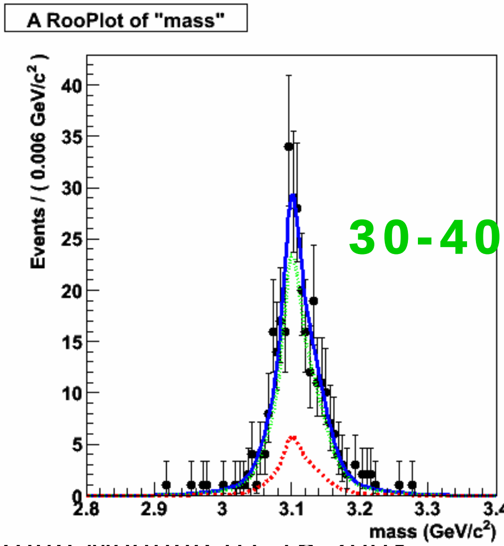
$$F_E(t,dt) = \exp(-t/\tau) \otimes G(t, \mu, \mathbf{dt})$$

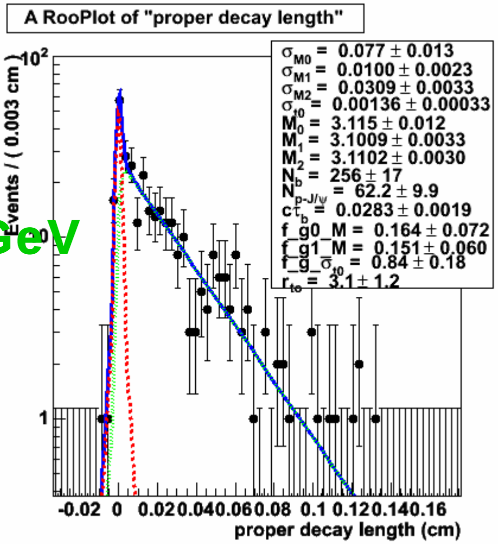
$$F_E(t,dt) = \exp(-t/\tau) \otimes G(t, \mu, \mathbf{s \cdot dt})$$

Unbinned combined MLH fit & analysis method: 3pb-1 “data”

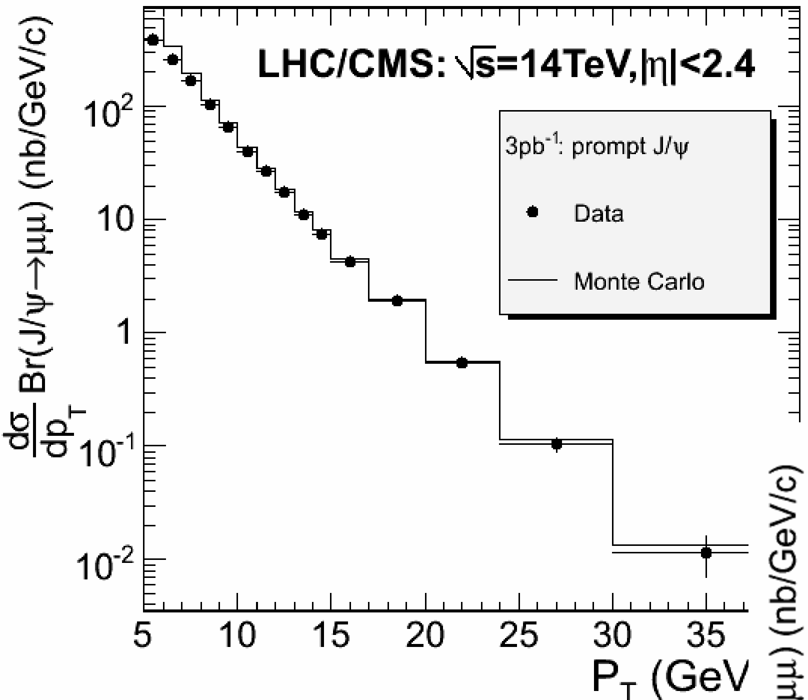


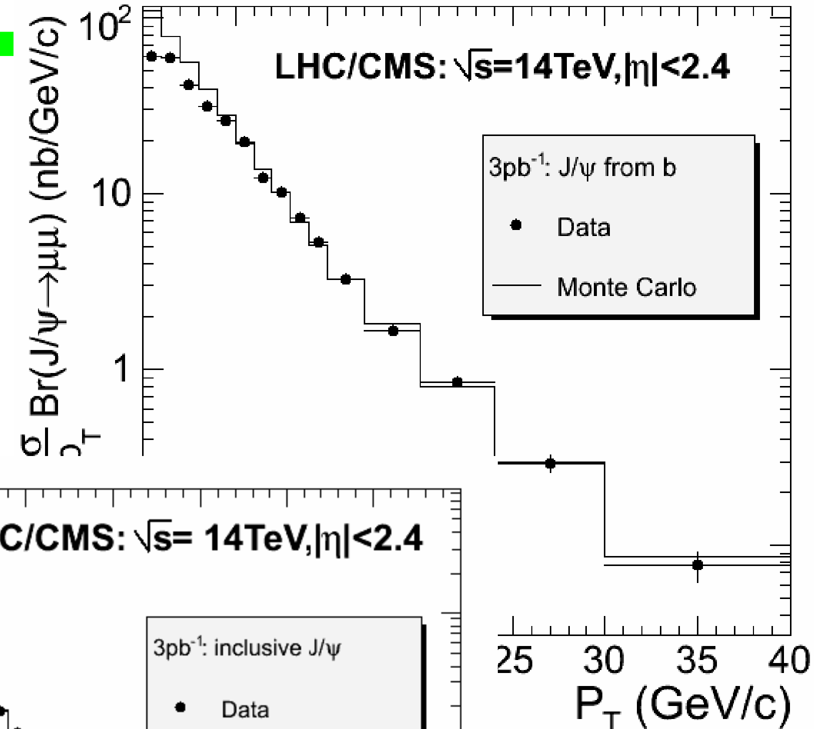


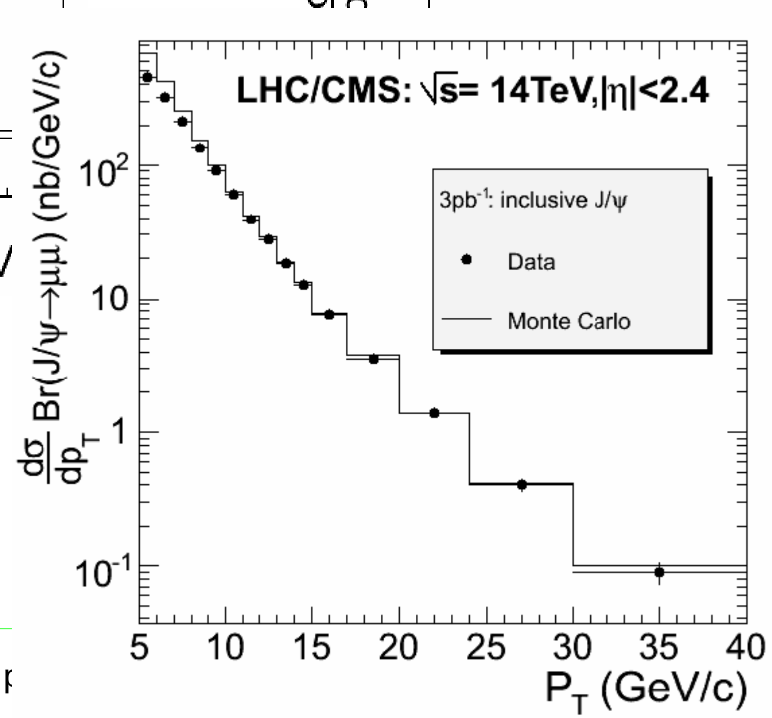




3pb-1: M.C. vs "Data" jpsi differential production Cross section



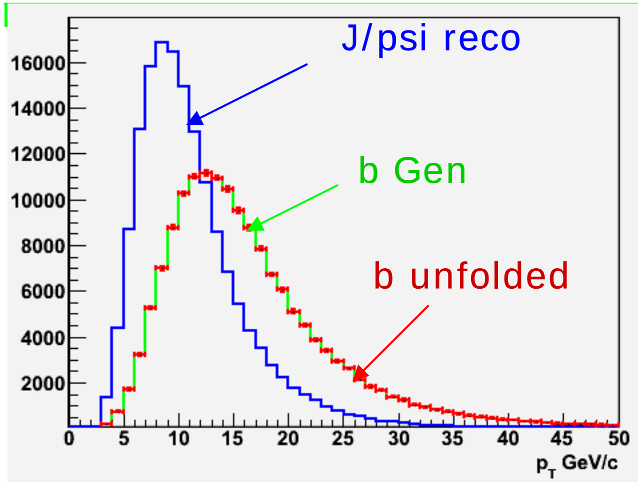




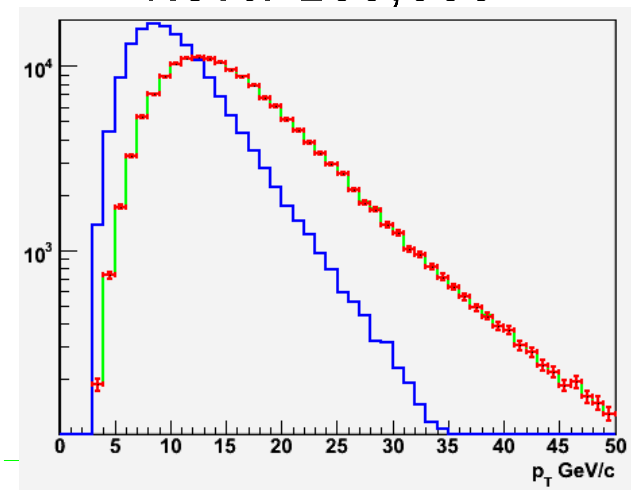
Unfolding

- **The differential *b*-hadron cross section vs. pT(H_b) is extracted from the measured differential ones of H_b ->J/ΨX**
- **Distortions between pT distribution of b hadrons and J/Ψs from them**

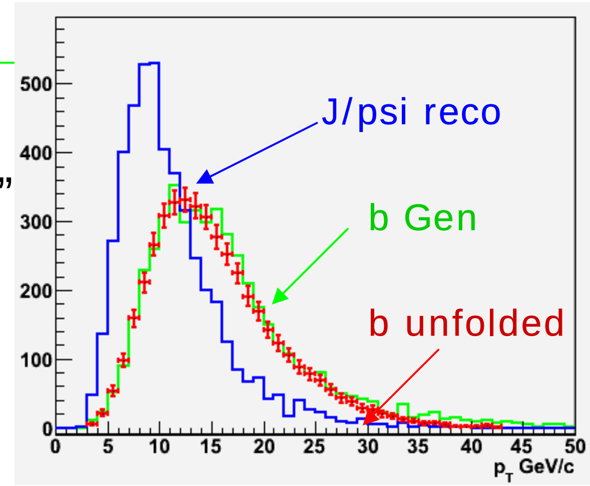
Unfolding on M.C. data

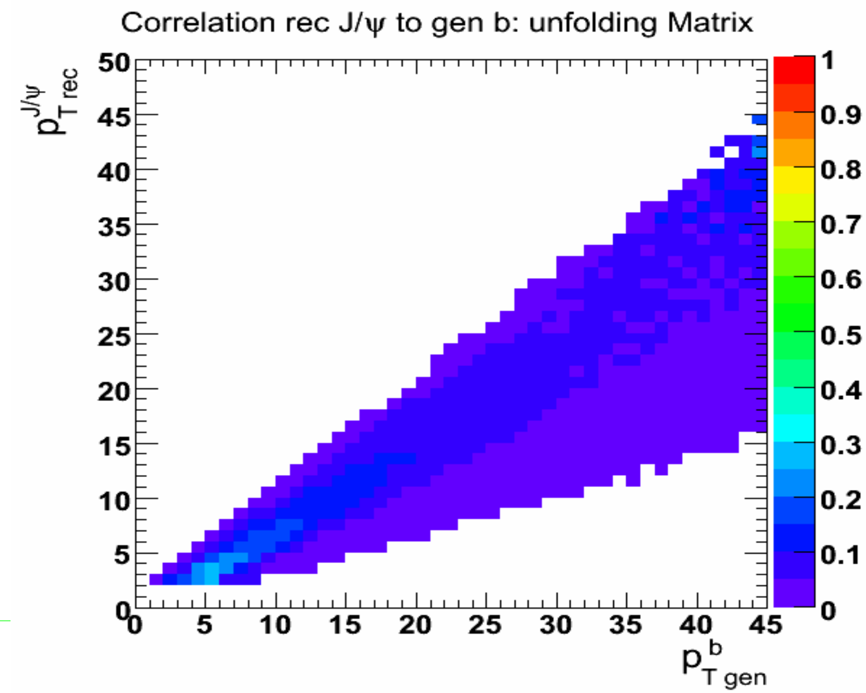


M.C. big sample
Nevt: 160,000



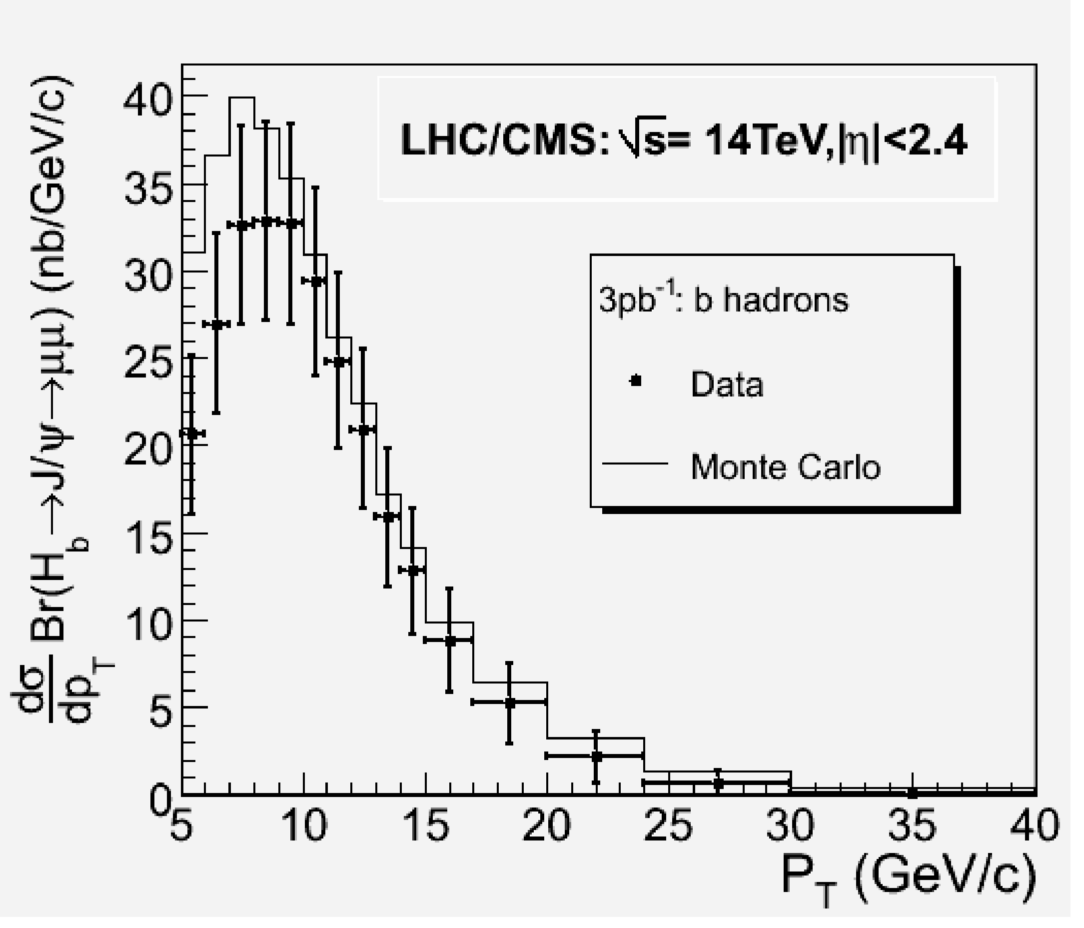
M.C. "real data"
Nevt: 4760





3pb-1: M.C. vs "Data"

inclusive b differential production Cross section



Fast Sim:

ProductionWinter2009

TWiki > CMS Web > GeneratorMain > GeneratorProduction > GeneratorProduction2009 > ProductionWinter2009

The 1G Winter09 pp@10TeV Fast Sim Production for Physics with CMSSW 22x

- Min bias: 100 Mevt with Pythia
- QCD jets: 600 Mevt with Madgraph+Pythia
- tt + Jets: 10 Mevt with Madgraph)
- t+ jets: 3 Mevt with Madgraph
- Photon+jets: 25 Mevt with Madgraph
- Z/W + jets: 50 Mevt with Madgraph
- Enriched electrons/muons (mostly from b-decays) 25Mevt with Pythia+Madgraph
- Enriched photons ? 10 Mevt with Pythia+Madgraph
- bbbar 50 Mevt with Pythia+Madgraph
- Onia 5 Mevt with Pythia
- 120 Mevt of additional requests

Twiki **IHEP CMS Wiki**

To do List

- Solve the discrepancy (data vs. M.C.) of CSA07 data anal(1 or 2 weeks)
- Start CMSSW_2_1_12 anal on Summer08 data
  - Efficiency: Accept., Trig & reco. M.C. & T.P.
  - Comprehensive anal method
    - Ctau efficiency
    - Scale factor
    - Unfolding method
- Fast Sim Production: QCD @Beijing T3?
- Prepare PAS and Note draft.

backups

Pseudo proper decay length

$$\vec{X} = \vec{x}_B - \vec{x}_{prim}$$

$$L_{xy}^B = \frac{\vec{X} \cdot \vec{p}_T^B}{|\vec{p}_T^B|}.$$

$$\lambda^B = \frac{L_{xy}^B}{(\beta\gamma)_T^B} = L_{xy}^B \cdot \frac{M_B}{p_T^B};$$

$$\lambda_\psi = \frac{L_{xy}^\psi}{(\beta\gamma)_T^\psi} = L_{xy}^\psi \cdot \frac{M_\psi}{p_T^\psi}.$$

$$\lambda = \frac{\lambda_\psi}{\langle F(p_T^\psi)\rangle} = L_{xy}^\psi \cdot \frac{M_\psi}{p_T^\psi \langle F(p_T^\psi)\rangle}$$

$$F(p_T^\psi) = \frac{(\beta\gamma)_T^B}{(\beta\gamma)_T^\psi} = \frac{\lambda_\psi}{\lambda_B}$$

- **Measure the 2-dimensional decay length *Lxy* for the *J/* Ψ meson sample**
- **pseudo proper decay length distribution**
- **Measure the l distribution of the background under the *J/* Ψ by studying the μ + μ - mass sidebands of the *J/* Ψ**
- **Fit the distribution to the sum of background, direct (zero-lifetime) and *B* decay (non-zero lifetime) Contributions and extract the lifetime**

Unfolding methods I

- **Bin-to-bin correction: no into account migrations a bin to the others; neglect correlation between adjacent bins.**
- **The matrix method: solve the problem of migrations; singular problem; statistical fluctuations; results unstable.**
- **Regularized unfolding: satisfactory results but technical complications; only with one dimension**

Unfolding Method II: Bayes'

A Multidimensional unfolding method based on Bayes' theorem by G.D'Agostini, Nucl. Instr. Meth. A362 (1995) 487-498. -- Model independent method

$$P(C_i|E_j) = \frac{P(E_j|C_i)P_0(C_i)}{\sum_{l=1}^{n_C} P(E_j|C_l)P_0(C_l)}.$$

$$\hat{n}(C_i)|_{obs} = \sum_{j=1}^{n_E} n(E_j)P(C_i|E_j)$$

$$\hat{n}(C_i) = \frac{1}{\epsilon_i}\sum_{j=1}^{n_E} n(E_j)P(C_i|E_j) \quad \epsilon_i \neq 0$$

Ci: cause in i-th bin
Ej: effect in j-th bin
P(Ci|Ej): corelation matrix for Ej to Ci

$$\hat{N}_{true} = \sum_{i=1}^{n_C} \hat{n}(C_i),$$

$$\hat{P}(C_i) \equiv P(C_i | n(E)) = \frac{\hat{n}(C_i)}{\hat{N}_{true}},$$

$$\hat{\epsilon} = \frac{N_{obs}}{\hat{N}_{true}}.$$

the unfolding can be performed through the following steps:

1) choose the initial distribution of $P_0(C)$ from the best knowledge of the process under study, and hence the initial expected number of events $n_0(C_i) = P_0(C_i)N_{obs}$; in case of complete ignorance, $P_0(C)$ will be just a uniform distribution: $P_0(C_i) = 1/n_C$;

2) calculate $\hat{n}(C)$ and $\hat{P}(C)$;

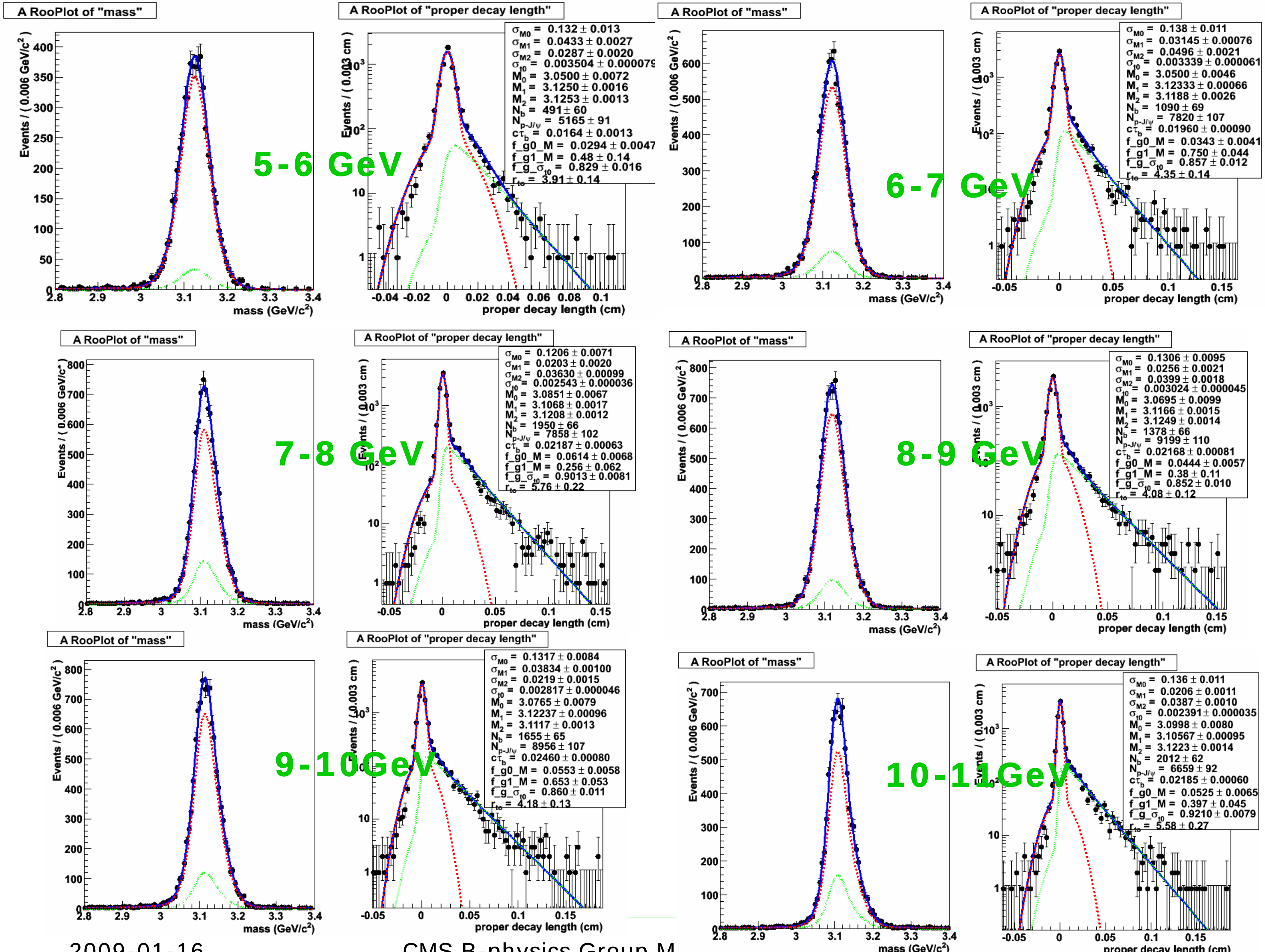
3) make a χ^2 comparison between $\hat{n}(C)$ and $n_0(C)$;

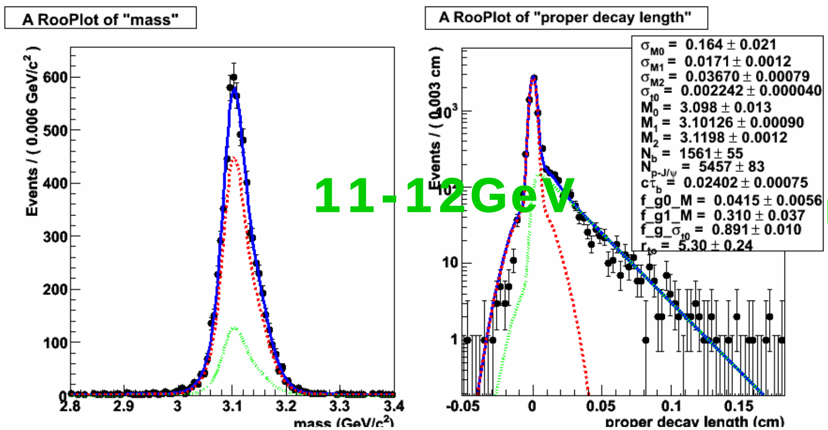
4) replace $P_0(C)$ by $\hat{P}(C)$, and $n_0(C)$ by $\hat{n}(C)$, and start again; if, after the second iteration the value of χ^2 is "small enough", stop the iteration; otherwise go to step 2. Some criteria about the optimum number of iterations will be discussed later.

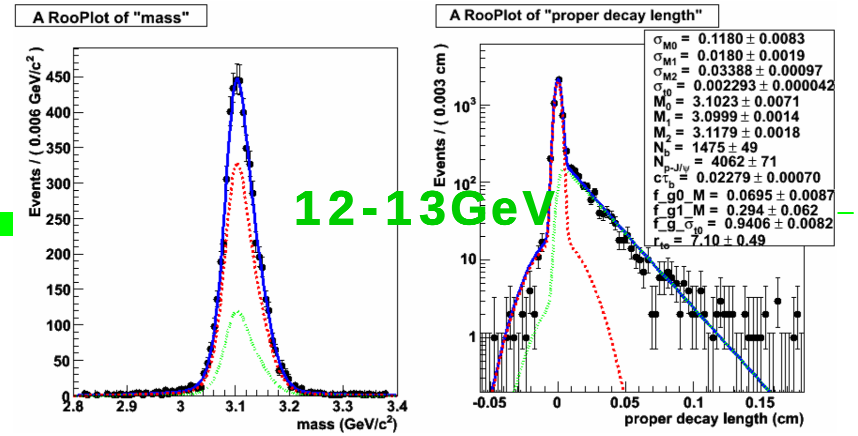
UCMLH fit & analysis

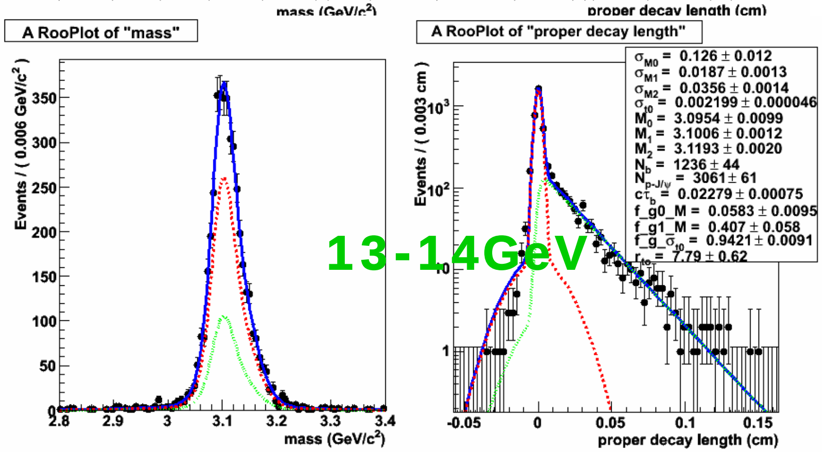
Unbinned combined MLH fit & analysis method: 3pb-1 “data” PT: 5-40 GeV/c

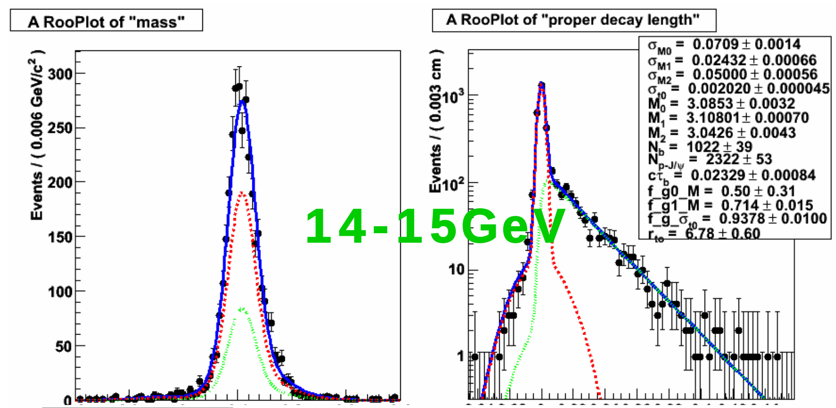
1) Jpsi: prompt, b hadrons, and inclusive production
2) abstraction for b fraction

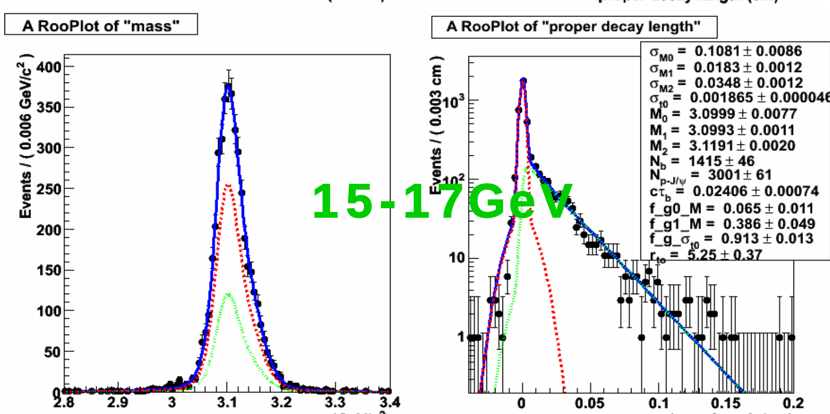

A RooPlot of "mass"
A RooPlot of "proper decay length"
5-6 GeV
σ_{M0} = 0.132 ± 0.013
σ_{M1} = 0.0433 ± 0.0027
σ_{M2} = 0.0287 ± 0.0020
σ_{t0} = 0.003504 ± 0.000079
M_0 = 3.0500 ± 0.0072
M_1 = 3.1250 ± 0.0016
M_2 = 3.1253 ± 0.0013
N_b = 491 ± 60
$N_{p-J/\psi}$ = 5165 ± 91
$c\tau_b$ = 0.0164 ± 0.0013
f_g0_M = 0.0294 ± 0.0047
f_g1_M = 0.48 ± 0.14
f_g_σ_{t0} = 0.829 ± 0.016
r_{to} = 3.91 ± 0.14
6-7 GeV
σ_{M0} = 0.138 ± 0.011
σ_{M1} = 0.03145 ± 0.00076
σ_{M2} = 0.0496 ± 0.0021
σ_{t0} = 0.003339 ± 0.000061
M_0 = 3.0500 ± 0.0046
M_1 = 3.12333 ± 0.00066
M_2 = 3.1188 ± 0.0026
N_b = 1090 ± 69
$N_{p-J/\psi}$ = 7820 ± 107
$c\tau_b$ = 0.01960 ± 0.00090
f_g0_M = 0.0343 ± 0.0041
f_g1_M = 0.750 ± 0.044
f_g_σ_{t0} = 0.857 ± 0.012
r_{to} = 4.35 ± 0.14
7-8 GeV
σ_{M0} = 0.1206 ± 0.0071
σ_{M1} = 0.0203 ± 0.0020
σ_{M2} = 0.03630 ± 0.00099
σ_{t0} = 0.002543 ± 0.000036
M_0 = 3.0851 ± 0.0067
M_1 = 3.1068 ± 0.0017
M_2 = 3.1208 ± 0.0012
N_b = 1950 ± 66
$N_{p-J/\psi}$ = 7858 ± 102
$c\tau_b$ = 0.02187 ± 0.00063
f_g0_M = 0.0614 ± 0.0068
f_g1_M = 0.256 ± 0.062
f_g_σ_{t0} = 0.9013 ± 0.0081
r_{to} = 5.76 ± 0.22
8-9 GeV
σ_{M0} = 0.1306 ± 0.0095
σ_{M1} = 0.0256 ± 0.0021
σ_{M2} = 0.0399 ± 0.0018
σ_{t0} = 0.003024 ± 0.000045
M_0 = 3.0695 ± 0.0099
M_1 = 3.1166 ± 0.0015
M_2 = 3.1249 ± 0.0014
N_b = 1378 ± 66
$N_{p-J/\psi}$ = 9199 ± 110
$c\tau_b$ = 0.02168 ± 0.00081
f_g0_M = 0.0444 ± 0.0057
f_g1_M = 0.38 ± 0.11
f_g_σ_{t0} = 0.852 ± 0.010
r_{to} = 4.08 ± 0.12
9-10GeV
σ_{M0} = 0.1317 ± 0.0084
σ_{M1} = 0.03834 ± 0.00100
σ_{M2} = 0.0219 ± 0.0015
σ_{t0} = 0.002817 ± 0.000046
M_0 = 3.0765 ± 0.0079
M_1 = 3.12237 ± 0.00096
M_2 = 3.1117 ± 0.0013
N_b = 1655 ± 65
$N_{p-J/\psi}$ = 8956 ± 107
$c\tau_b$ = 0.02460 ± 0.00080
f_g0_M = 0.0553 ± 0.0058
f_g1_M = 0.653 ± 0.053
f_g_σ_{t0} = 0.860 ± 0.011
r_{to} = 4.18 ± 0.13
10-11GeV
σ_{M0} = 0.136 ± 0.011
σ_{M1} = 0.0206 ± 0.0011
σ_{M2} = 0.0387 ± 0.0010
σ_{t0} = 0.002391 ± 0.000035
M_0 = 3.0998 ± 0.0080
M_1 = 3.10567 ± 0.00095
M_2 = 3.1223 ± 0.0014
N_b = 2012 ± 62
$N_{p-J/\psi}$ = 6659 ± 92
$c\tau_b$ = 0.02185 ± 0.00060
f_g0_M = 0.0525 ± 0.0065
f_g1_M = 0.397 ± 0.045
f_g_σ_{t0} = 0.9210 ± 0.0079
r_{to} = 5.58 ± 0.27
Events / (0.006 GeV/c^2)
mass (GeV/c^2)
Events / (0.003 cm)
proper decay length (cm)

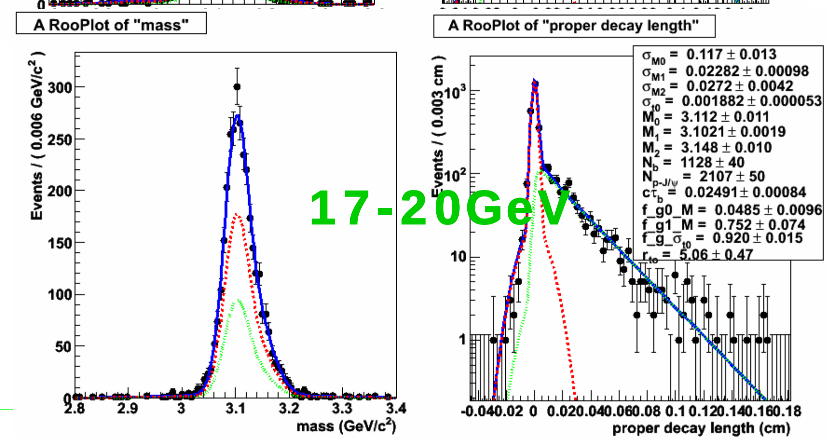

A RooPlot of "mass"
Events / (0.006 GeV/c^2)
mass (GeV/c^2)
A RooPlot of "proper decay length"
Events / (0.003 cm)
proper decay length (cm)
σ_{M0} = 0.164 ± 0.021
σ_{M1} = 0.0171 ± 0.0012
σ_{M2} = 0.03670 ± 0.00079
σ_{t0} = 0.002242 ± 0.000040
M_0 = 3.098 ± 0.013
M_1 = 3.10126 ± 0.00090
M_2 = 3.1198 ± 0.0012
N_b = 1561 ± 55
$N_{p-J/\psi}$ = 5457 ± 83
$c\tau_b$ = 0.02402 ± 0.00075
f_g0_M = 0.0415 ± 0.0056
f_g1_M = 0.310 ± 0.037
f_g_σ_{t0} = 0.891 ± 0.010
r_{to} = 5.30 ± 0.24
11-12GeV

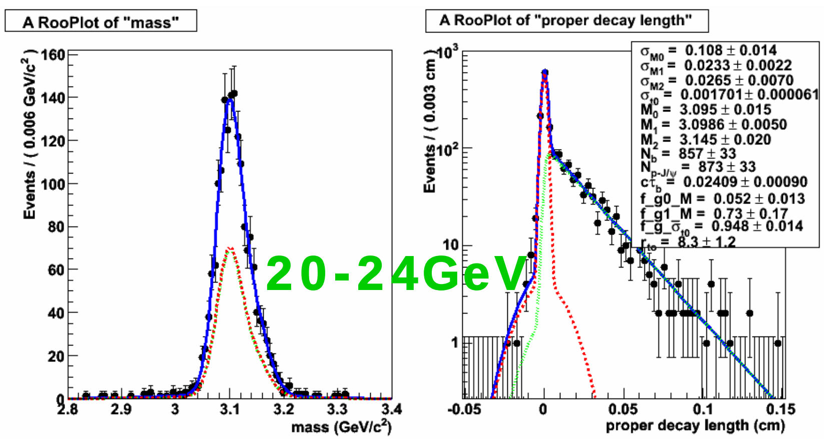

A RooPlot of "mass"
Events / (0.006 GeV/c^2)
mass (GeV/c^2)
A RooPlot of "proper decay length"
Events / (0.003 cm)
proper decay length (cm)
σ_{M0} = 0.1180 ± 0.0083
σ_{M1} = 0.0180 ± 0.0019
σ_{M2} = 0.03388 ± 0.00097
σ_{t0} = 0.002293 ± 0.000042
M_0 = 3.1023 ± 0.0071
M_1 = 3.0999 ± 0.0014
M_2 = 3.1179 ± 0.0018
N_b = 1475 ± 49
$N_{p-J/\psi}$ = 4062 ± 71
$c\tau_b$ = 0.02279 ± 0.00070
f_g0_M = 0.0695 ± 0.0087
f_g1_M = 0.294 ± 0.062
f_g_σ_{t0} = 0.9406 ± 0.0082
r_{to} = 7.10 ± 0.49
12-13GeV

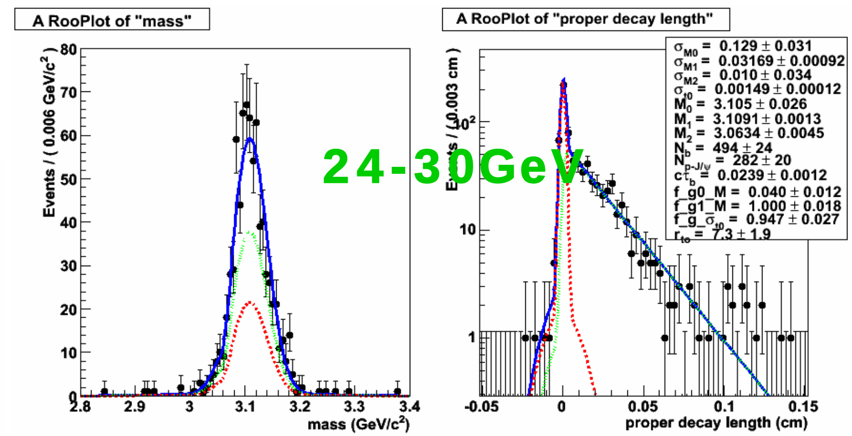

A RooPlot of "mass"
Events / (0.006 GeV/c^2)
mass (GeV/c^2)
A RooPlot of "proper decay length"
Events / (0.003 cm)
proper decay length (cm)
σ_{M0} = 0.126 ± 0.012
σ_{M1} = 0.0187 ± 0.0013
σ_{M2} = 0.0356 ± 0.0014
σ_{t0} = 0.002199 ± 0.000046
M_0 = 3.0954 ± 0.0099
M_1 = 3.1006 ± 0.0012
M_2 = 3.1193 ± 0.0020
N_b = 1236 ± 44
$N_{p-J/\psi}$ = 3061 ± 61
$c\tau_b$ = 0.02279 ± 0.00075
f_g0_M = 0.0583 ± 0.0095
f_g1_M = 0.407 ± 0.058
f_g_σ_{t0} = 0.9421 ± 0.0091
r_{to} = 7.79 ± 0.62
13-14GeV

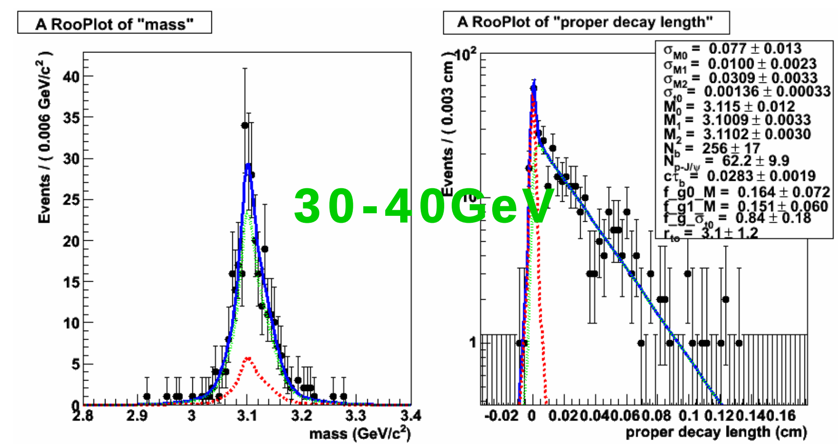

A RooPlot of "mass"
Events / (0.006 GeV/c^2)
A RooPlot of "proper decay length"
Events / (0.003 cm)
σ_{M0} = 0.0709 ± 0.0014
σ_{M1} = 0.02432 ± 0.00066
σ_{M2} = 0.05000 ± 0.00056
σ_{t0} = 0.002020 ± 0.000045
M_0 = 3.0853 ± 0.0032
M_1 = 3.10801 ± 0.00070
M_2 = 3.0426 ± 0.0043
N_b = 1022 ± 39
$N_{p-J/\psi}$ = 2322 ± 53
$c\tau_b$ = 0.02329 ± 0.00084
f_g0_M = 0.50 ± 0.31
f_g1_M = 0.714 ± 0.015
f_g_σ_{t0} = 0.9378 ± 0.0100
r_{to} = 6.78 ± 0.60
14-15GeV


A RooPlot of "mass"
Events / (0.006 GeV/c^2)
mass (GeV/c^2)
A RooPlot of "proper decay length"
Events / (0.003 cm)
proper decay length (cm)
σ_{M0} = 0.1081 ± 0.0086
σ_{M1} = 0.0183 ± 0.0012
σ_{M2} = 0.0348 ± 0.0012
σ_{t0} = 0.001865 ± 0.000046
M_0 = 3.0999 ± 0.0077
M_1 = 3.0993 ± 0.0011
M_2 = 3.1191 ± 0.0020
N_b = 1415 ± 46
$N_{p-J/\psi}$ = 3001 ± 61
$c\tau_b$ = 0.02406 ± 0.00074
f_g0_M = 0.065 ± 0.011
f_g1_M = 0.386 ± 0.049
f_g_σ_{t0} = 0.913 ± 0.013
r_{to} = 5.25 ± 0.37
15-17GeV


A RooPlot of "mass"
Events / (0.006 GeV/c^2)
mass (GeV/c^2)
A RooPlot of "proper decay length"
Events / (0.003 cm)
proper decay length (cm)
σ_{M0} = 0.117 ± 0.013
σ_{M1} = 0.02282 ± 0.00098
σ_{M2} = 0.0272 ± 0.0042
σ_{t0} = 0.001882 ± 0.000053
M_0 = 3.112 ± 0.011
M_1 = 3.1021 ± 0.0019
M_2 = 3.148 ± 0.010
N_b = 1128 ± 40
$N_{p-J/\psi}$ = 2107 ± 50
$c\tau_b$ = 0.02491 ± 0.00084
f_g0_M = 0.0485 ± 0.0096
f_g1_M = 0.752 ± 0.074
f_g_σ_{t0} = 0.920 ± 0.015
r_{to} = 5.06 ± 0.47
17-20GeV


20-24GeV
A RooPlot of "mass"
Events / (0.006 GeV/c^2)
mass (GeV/c^2)
A RooPlot of "proper decay length"
Events / (0.003 cm)
proper decay length (cm)


24-30GeV
A RooPlot of "mass"
Events / (0.006 GeV/c^2)
mass (GeV/c^2)
A RooPlot of "proper decay length"
Events / (0.003 cm)
proper decay length (cm)


30-40GeV
A RooPlot of "mass"
Events / (0.006 GeV/c^2)
mass (GeV/c^2)
A RooPlot of "proper decay length"
Events / (0.003 cm)
proper decay length (cm)