Inclusive b→J/ψ ($J/\psi \to \mu\ \mu$) X analysis VII

Xiangwei Meng, Guoming Chen

Institute of High Energy Physics, CAS, Beijing

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Outline

- CSA07 Data Samples
- Muon efficiency: M.C. Truth
  Tag&Probe
- Acceptance
- Unfolding
- Ongoing work

CMS CSA07 M.C. data samples

b2J/psi

- /BtoJpsi/CMSSW_1_6_0-PreCSA07-HLT-A4/GEN-SIM-DIGI-RECO
  556324 events, 154 files, 18 block(s), 858.3GB
- /BtoJpsi/CMSSW_1_6_0-PreCSA07-A1/GEN-SIM-DIGI-RAW
  563463 events, 156 files, 16 block(s), 719.8GB
- /BbartoJpsi/CMSSW_1_6_0-PreCSA07-HLT-A4/GEN-SIM-DIGI-RECO
  509527 events, 141 files, 16 block(s), 786.6GB
- /BbartoJpsi/CMSSW_1_6_0-PreCSA07-A1/GEN-SIM-DIGI-RAW
  520373 events, 144 files, 14 block(s), 665.0GB

Incl b: 13.5 pb-1

CSA08 Incl b: 10 pb-1

p-J/psi

- /Charmonium_Pt_0_20/CMSSW_1_6_0-PreCSA07-HLT-A4/GEN-SIM-DIGI-RECO
  1021134 events, 160 files, 21 block(s), 1.0TB
- /Charmonium_Pt_0_20/CMSSW_1_6_0-PreCSA07-A1/GEN-SIM-DIGI-RAW
  1039884 events, 163 files, 19 block(s), 895.3GB
- /Charmonium_Pt_20_inf/CMSSW_1_6_0-PreCSA07-HLT-A4/GEN-SIM-DIGI-RECO
  1012650 events, 362 files, 37 block(s), 1.8TB
- /Charmonium_Pt_20_inf/CMSSW_1_6_0-PreCSA07-A1/GEN-SIM-DIGI-RAW
  1040964 events, 372 files, 32 block(s), 1.5TB

3pb-1

400pb-1

CSA08 p-J/Psi: ~10 pb-1

QCD

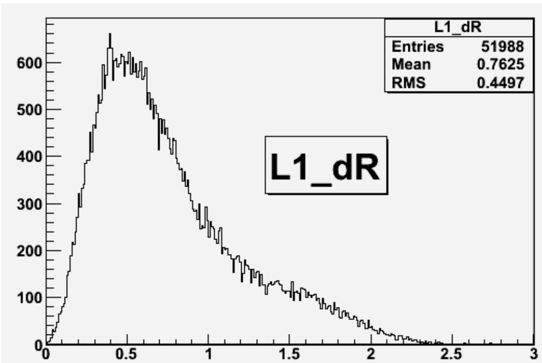
- /Muon_ppMuX/CMSSW_1_6_0-PreCSA07-HLT-B3/GEN-SIM-DIGI-RAW
  20697806 events, 5502 files, 29.3TB
- /Muon_ppMuX/CMSSW_1_6_0-PreCSA07-B2/GEN-SIM-DIGI-RAW
  21365589 events, 5679 files, 25.9TB
- /Muon_ppMuX/CMSSW_1_6_7-CSA07-1197906039/GEN-SIM-DIGI-RAW
  5555458 events, 5487 files, 9.6TB

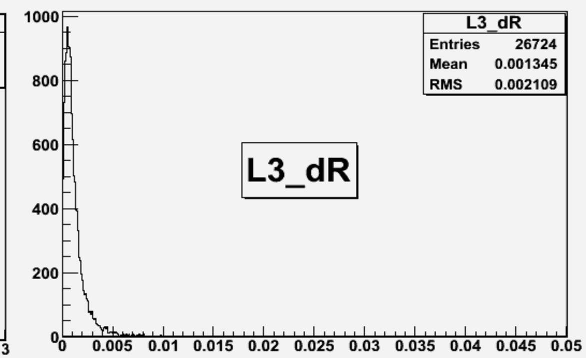
QCD: 0.45 pb-1

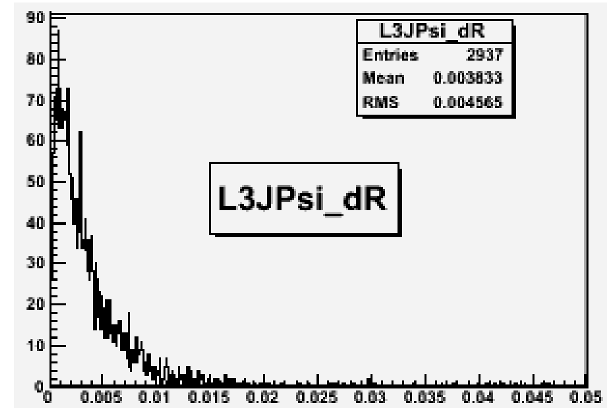
CSA08 QCD: 0.45 pb-1

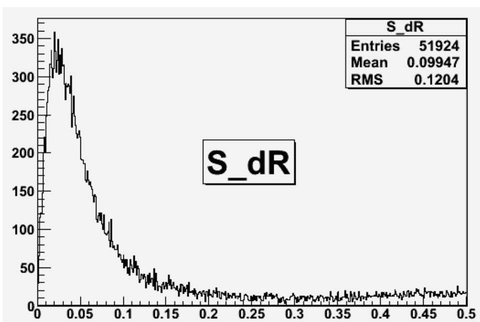
from p-JPsi sample

dR: trig & reco vs. gen



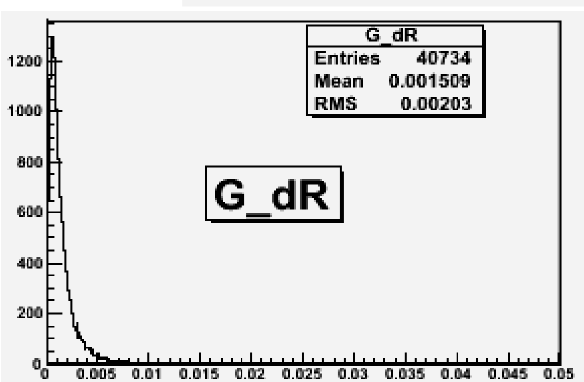


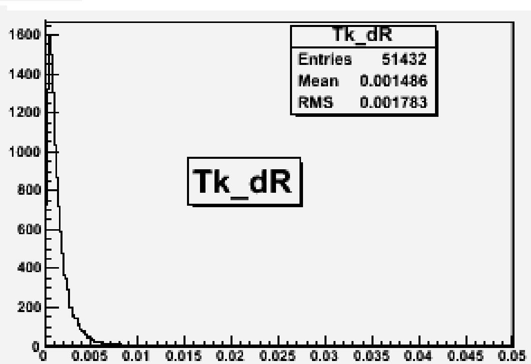


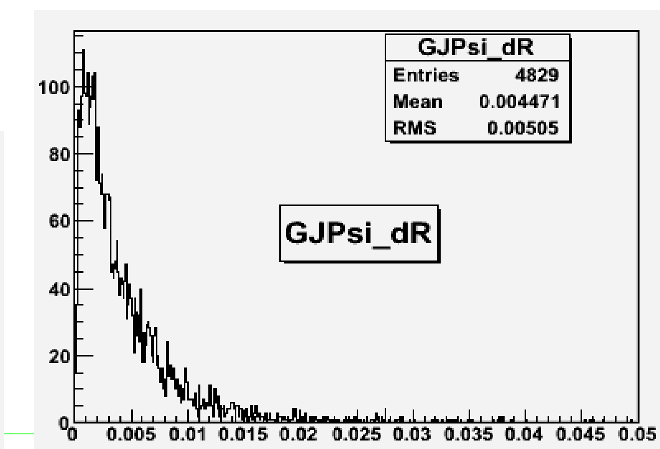


μ

J / Ψ

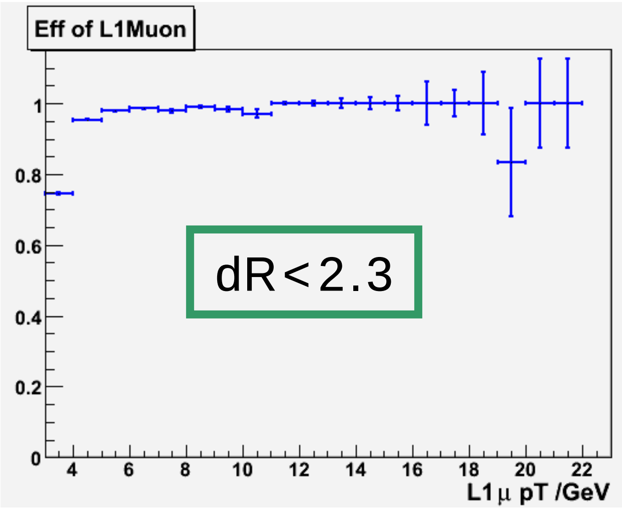


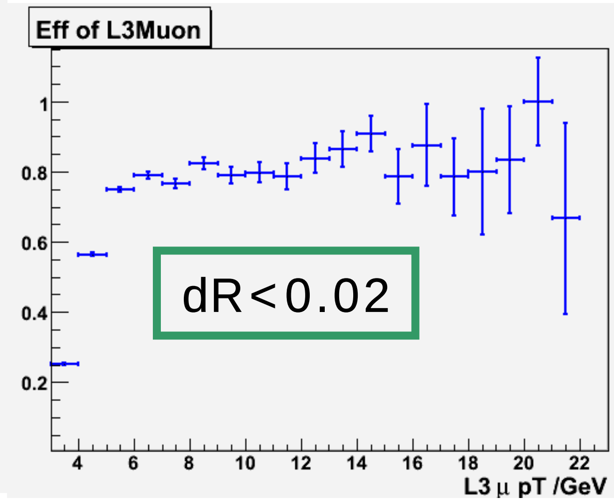


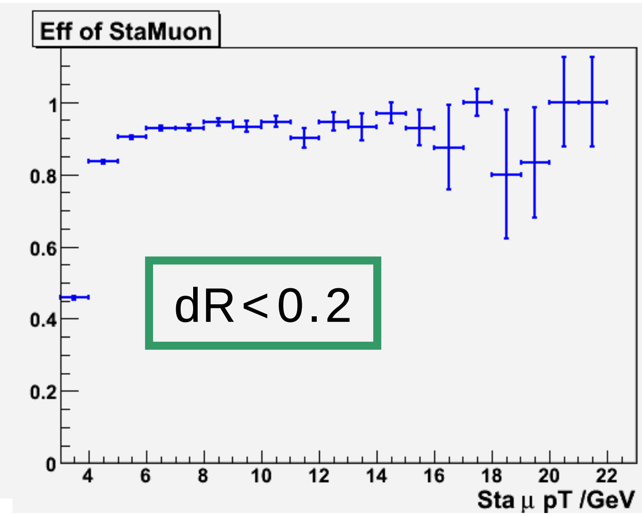


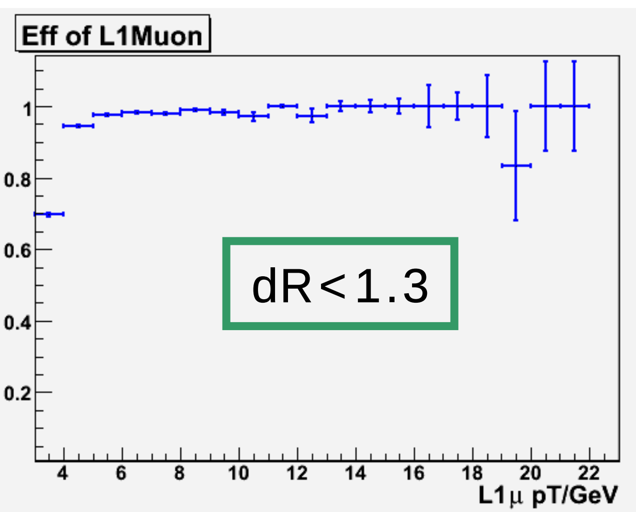
M.C. Truth

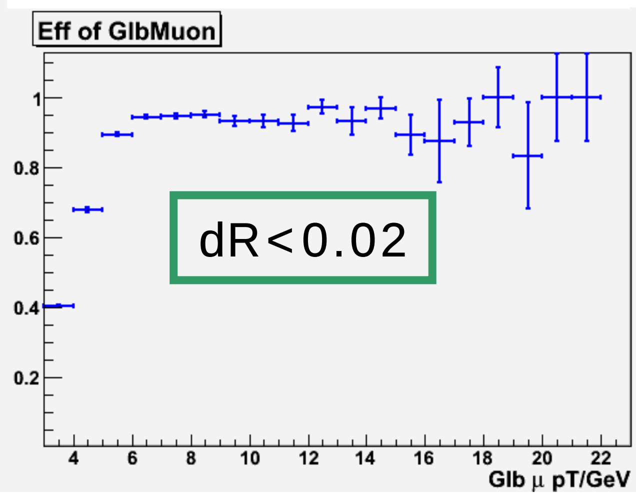
L1 , L1*L3, Sta,Glb & Tk: muon Eff. vs. pT

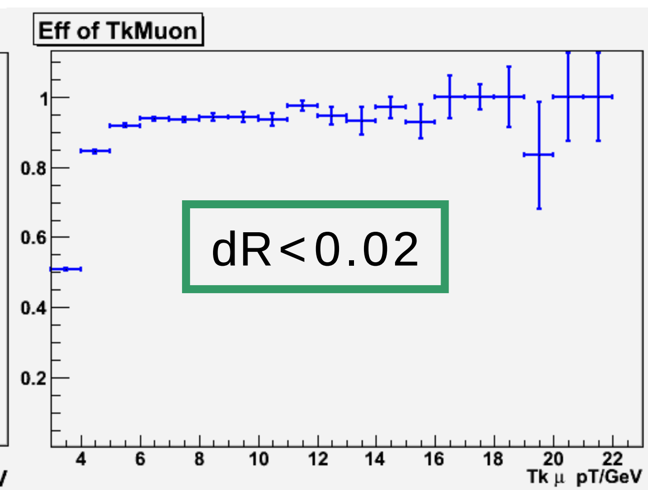






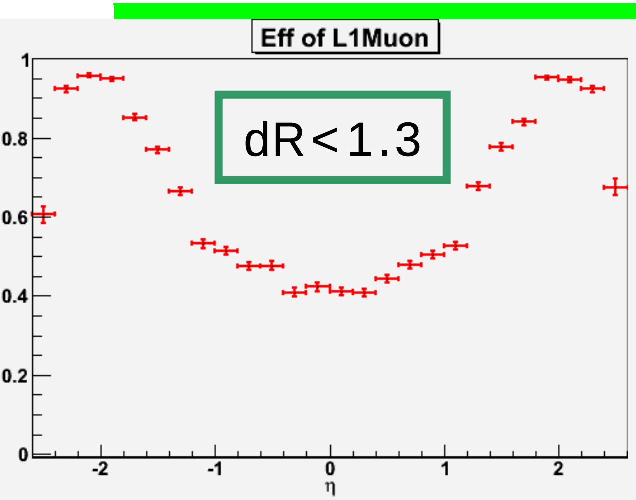


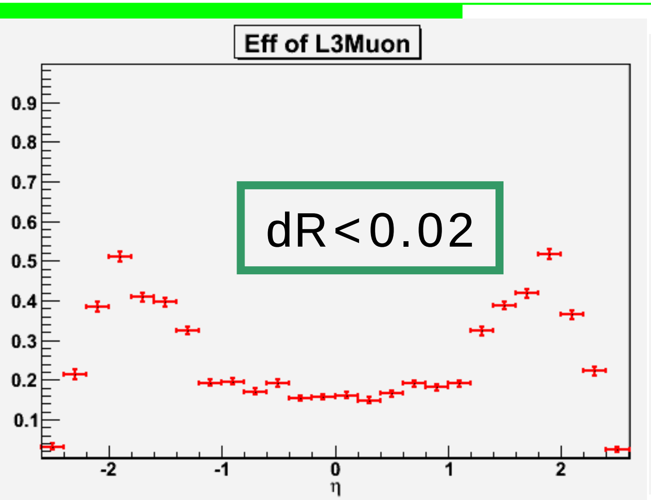


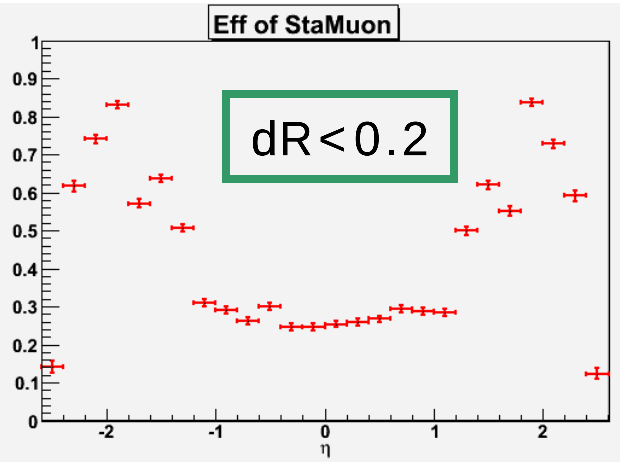


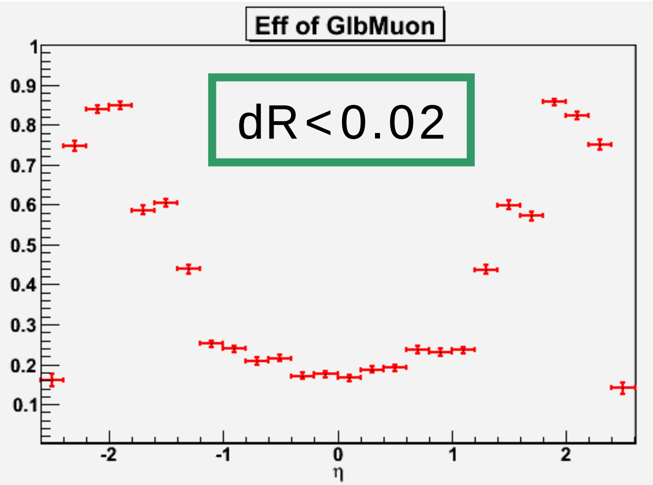
M.C. Truth

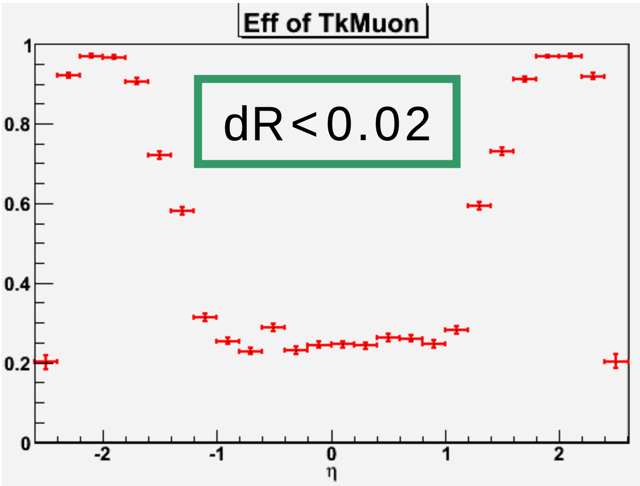
L1 , L1*L3, Sta,Glb & Tk: muon Eff. vs. η











Efficiencies from data: Tag&Probe

- Tag-and-Probe
  - Successfully used in experiments: CDF and D∅
- Current availability of code
  - Egamma: EgammaAnalysis/EgammaEfficiencyAlgos
  - Muon: MuonAnalysis/TagAndProbe

<u>adapt code to use under CMSSW_16X with PAT</u>

Efficiency Measurements: Tag&Probe

- **The overall dimuon efficiencies of the measurement are assumed to be the product of several parts**

$$\varepsilon = \varepsilon_{\mathrm{acceptance}} \times \varepsilon_{\mathrm{trigger}} \times \varepsilon_{\mathrm{offline}}^{2}$$

$$\varepsilon_{\mathrm{trigger}} = \varepsilon_{\mathrm{L1}} \times \varepsilon_{\mathrm{HLT}}$$

$$\varepsilon_{\mathrm{offline}} = \varepsilon_{\mathrm{global}} \times \varepsilon_{\mathrm{isolation}} \times \varepsilon_{\mathrm{id}}$$

$$\varepsilon_{\mathrm{global}} = \varepsilon_{\mathrm{standalone}} \times \varepsilon_{\mathrm{tracker}} \times \varepsilon_{\mathrm{matching}}$$

- Choose a *tag* muon
  - A “high quality” reconstructed muon
- Choose a *probe* track
  - A probable muon in tracker or muon system
- Requiring $M_{\mu\mu}$ consistent with $M_{J/\Psi}$ yileds a high-purity and almost unbiased sample of *probe* muons

Description of Tag and Probe

TAG	**Global muon with p_T > 5GeV** **Associated to a L3 muon**

Probe Type	Description
<u>G</u>olden	Global muon that is also a TAG
<u>M</u>atched	Global muon that is not a TAG
<u>U</u>nmatched	Tracker track AND Standalone muon found, but they are not associated with a Global Muon
<u>T</u>racker Only	Only a tracker track
<u>S</u>tand Alone Muon	Only a standalone muon

With the five types of probes, we get five combinations of tag-and-probe: GG, GM, GU, GS, GT

Tracking and Matching Efficiencies I

- Standalone, Tracking, and Matching efficiencies calculated with simple event counting

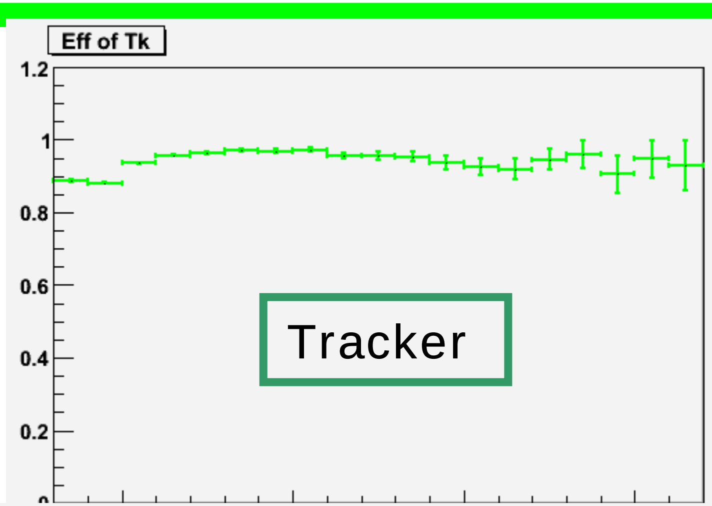
$$\varepsilon_{\text{standalone}} = \frac{2N_{GG} + N_{GM} + N_{GU}}{2N_{GG} + N_{GM} + N_{GU} + N_{GT}}$$

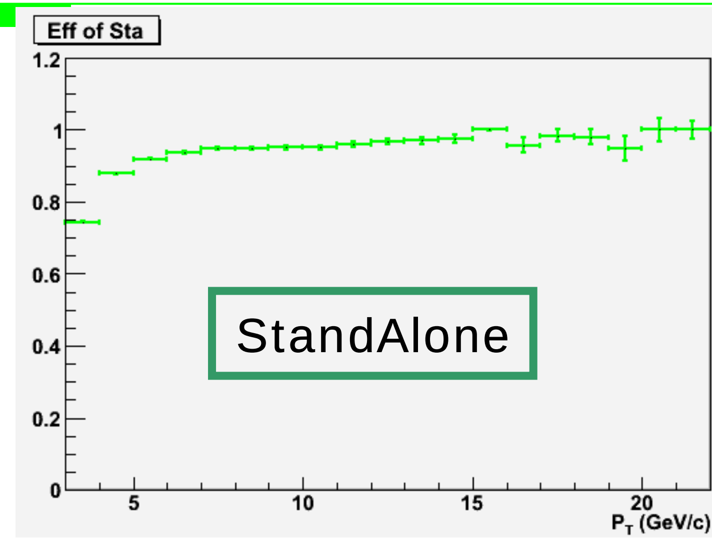
$$\varepsilon_{\text{tracker}} = \frac{2N_{GG} + N_{GM} + N_{GU}}{2N_{GG} + N_{GM} + N_{GU} + N_{GS}}$$

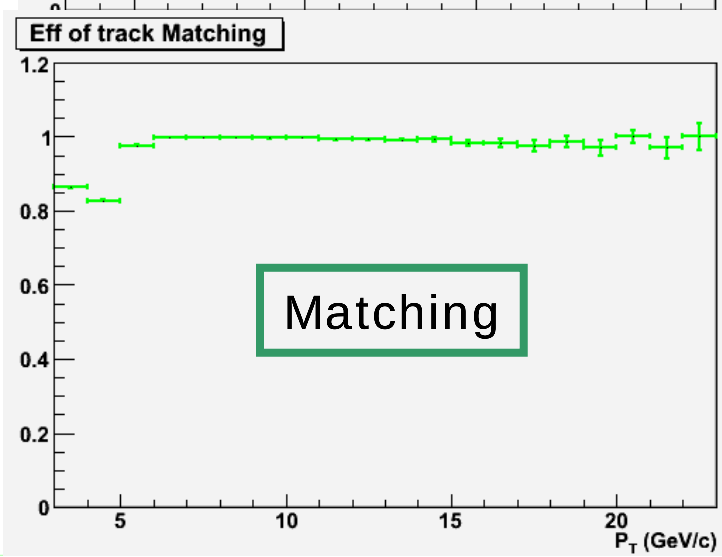
$$\varepsilon_{\text{matching}} = \frac{2N_{GG} + N_{GM}}{2N_{GG} + N_{GM} + N_{GU}}$$

$$\varepsilon_{\text{global}} = \varepsilon_{\text{standalone}} \times \varepsilon_{\text{tracker}} \times \varepsilon_{\text{matching}}$$

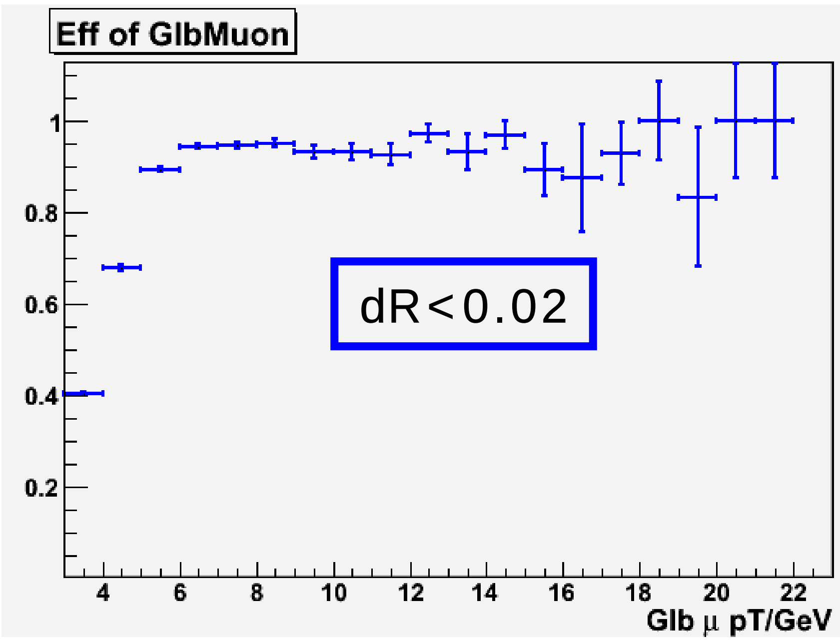
Tracking and Matching Efficiencies II

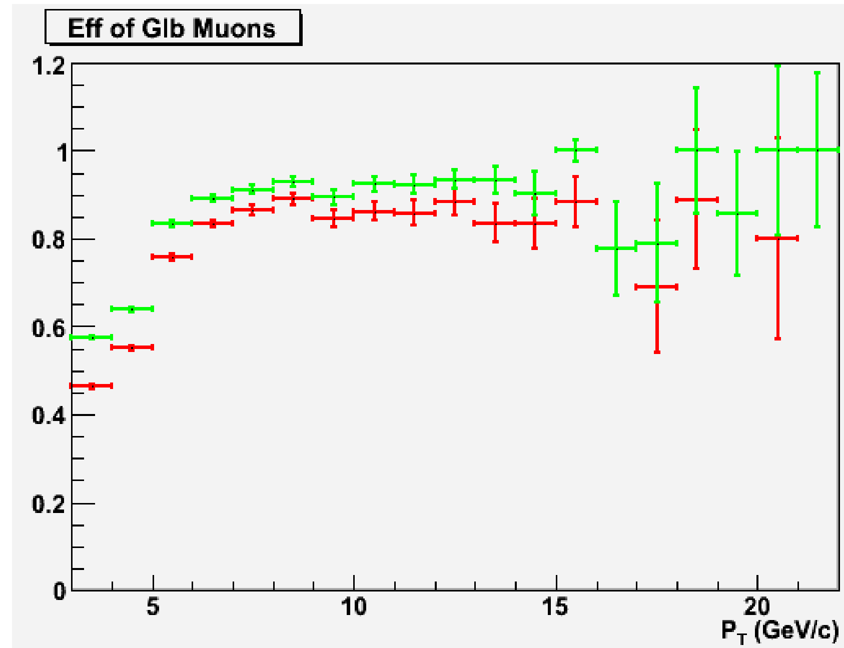






Glb Muon efficiency I



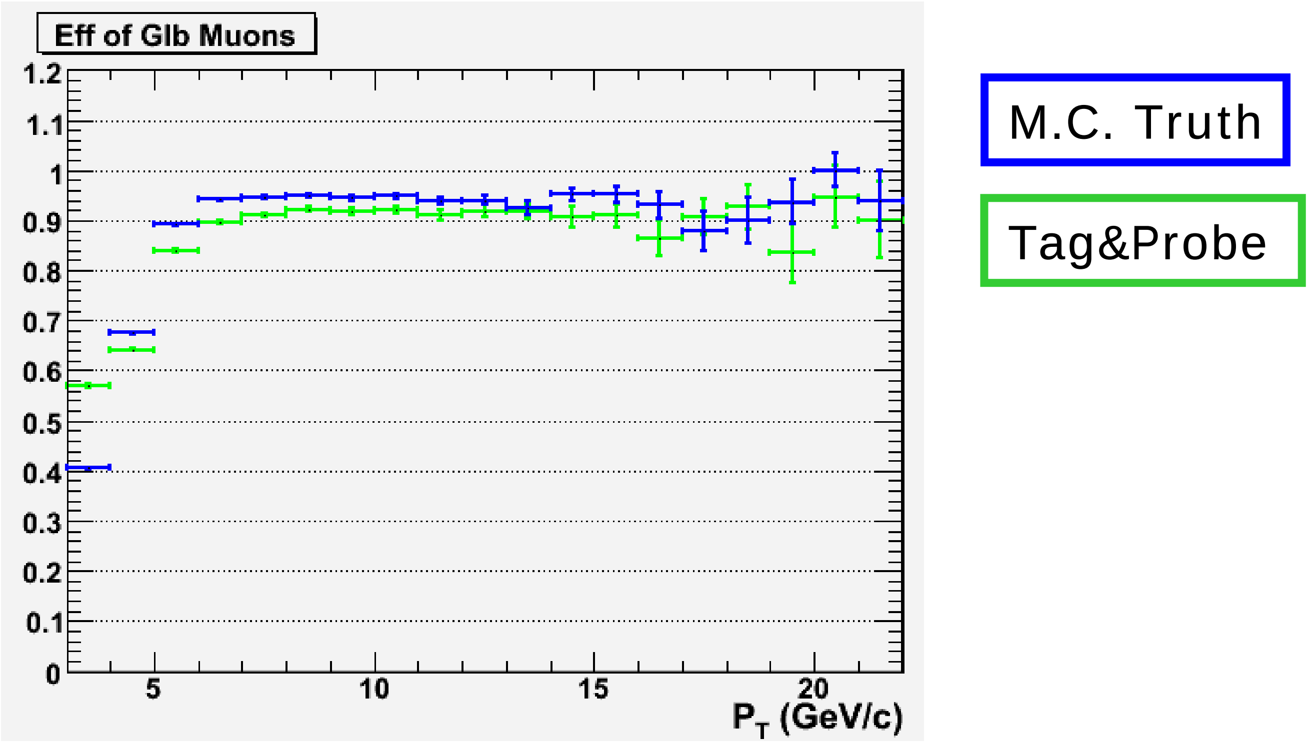


M.C. Truth

Tag&Probe

TrackTrackMap dR<0.3
dR<0.1

Glb Muon efficiency II



Measurement of Cross-secton

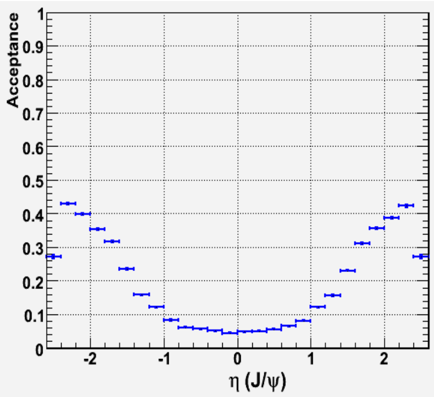
- The inclusive b-> J/ψ cross-section is calculated by

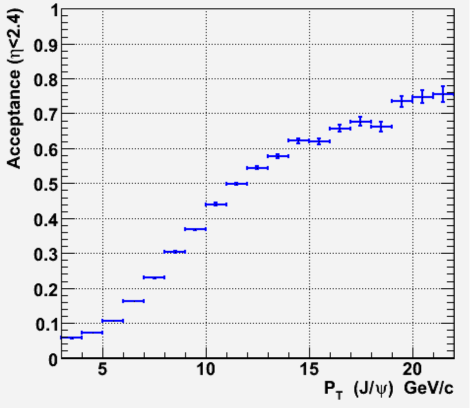
$$\frac{d\sigma}{dp_T}\cdot \mathrm{Br}(J/\psi \rightarrow \mu^+\mu^-) = f_b(p_T)\cdot \frac{N_{reco}(p_T)\cdot(1-A')}{\int Ldt\cdot A\cdot \varepsilon_{trig}\cdot \varepsilon_{offline}\cdot \Delta p_T}$$

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**

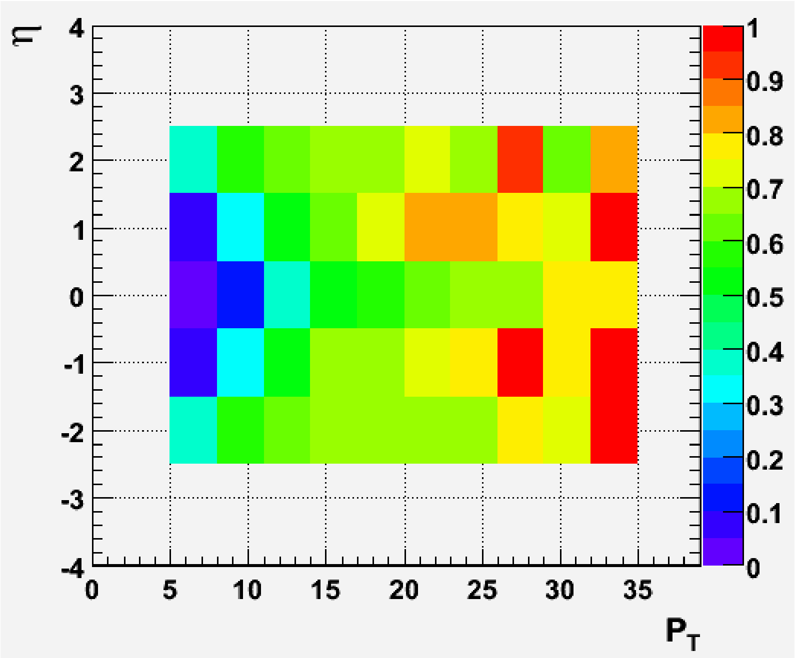
Acceptances I

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





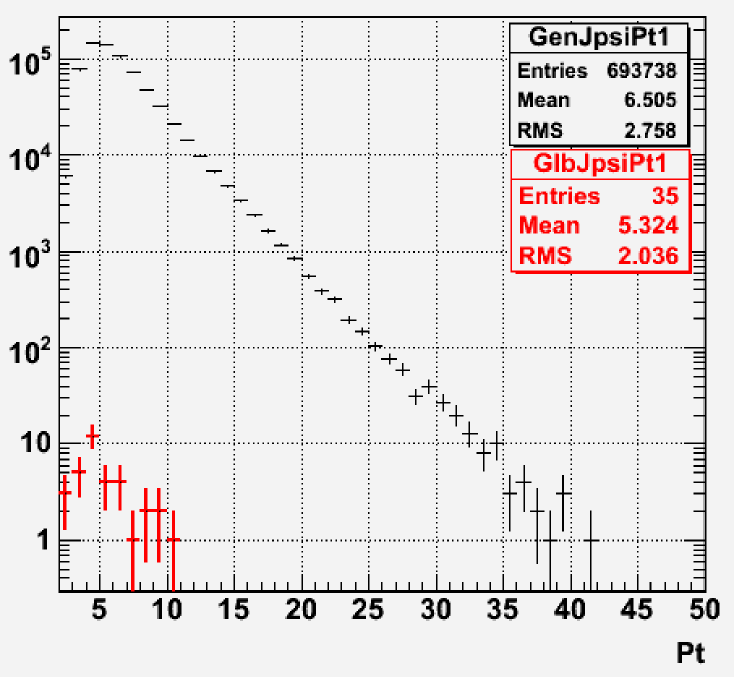
$$A(p_T,\eta\,|\,J/\psi)=\frac{N^{rec}(p_T(J/\psi),|\eta(J/\psi)|<2.4)}{N^{gen}(p_T(J/\psi),|\eta(J/\psi)|<2.4)}$$



* Kinematic acceptance is related with J/ψ's polarization considered, not included.

Acceptances II

- Due to the detector resolution and the size of the interaction region, some J/ψ with $|\eta^{gen}|>2.4$ can also be reconstructed as $|\eta^{rec}|<2.4$. This effect, should be very small due to the nice η resolution.



- The relative acceptance is defined as:

$$A'(P_T)=\frac{N^{rec}(P_T,|\eta^{rec}|<2.4,|\eta^{gen}|>2.4)}{N^{gen}(P_T,|\eta^{gen}|<2.4)}$$

CMS:99.995%

CDF: 99.93%(η<0.6)

$N^{rec}(P_T,|\eta^{rec}|<2.4,|\eta^{gen}|>2.4)$ number of J/ψ events in M.C. sample, generated with $|\eta^{gen}|>2.4$ and reconstructed in $|\eta^{rec}|<2.4$.

$N^{gen}(P_T,|\eta^{gen}|<2.4)$ total number of J/ψ events generated within $|\eta^{gen}|<2.4$.

Why Unfolding

- **The differential *b*-hadron cross section vs. pT(H_b) is extracted from the measured differential ones of $H_b \rightarrow J/\Psi X$**

- **Distortions between *b*-hadron pT distribution and J/Ψ pT's from b-hadrons**

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

$$P(\mathrm{C}_i|\mathrm{E}_j) = \frac{P(\mathrm{E}_j|\mathrm{C}_i)P_0(\mathrm{C}_i)}{\sum_{l=1}^{n_\mathrm{C}} P(\mathrm{E}_j|\mathrm{C}_l)P_0(\mathrm{C}_l)}.$$

$$\hat{n}(\mathrm{C}_i)|_{\mathrm{obs}} = \sum_{j=1}^{n_\mathrm{E}} n(\mathrm{E}_j)P(\mathrm{C}_i|\mathrm{E}_j)$$

$$\hat{n}(\mathrm{C}_i) = \frac{1}{\epsilon_i}\sum_{j=1}^{n_\mathrm{E}} n(\mathrm{E}_j)P(\mathrm{C}_i|\mathrm{E}_j) \quad \epsilon_i \neq 0$$

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

$$\hat{N}_{\mathrm{true}} = \sum_{i=1}^{n_\mathrm{C}} \hat{n}(\mathrm{C}_i),$$

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

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

the unfolding can be performed through the following steps:

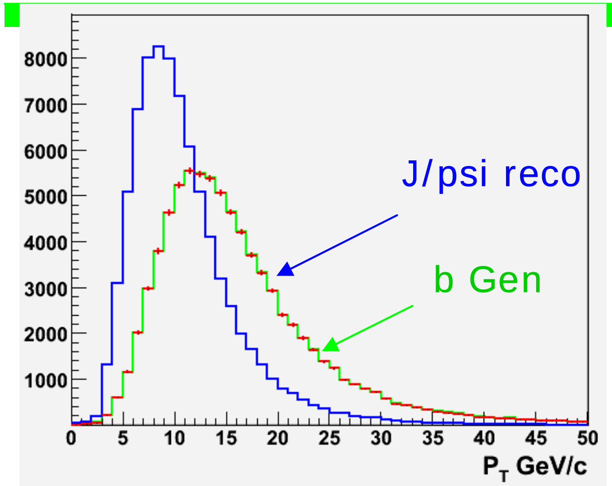
1) choose the initial distribution of $P_0(\mathrm{C})$ from the best knowledge of the process under study, and hence the initial expected number of events $n_0(\mathrm{C}_i) = P_0(\mathrm{C}_i)N_{\mathrm{obs}}$; in case of complete ignorance, $P_0(C)$ will be just a uniform distribution: $P_0(\mathrm{C}_i)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

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

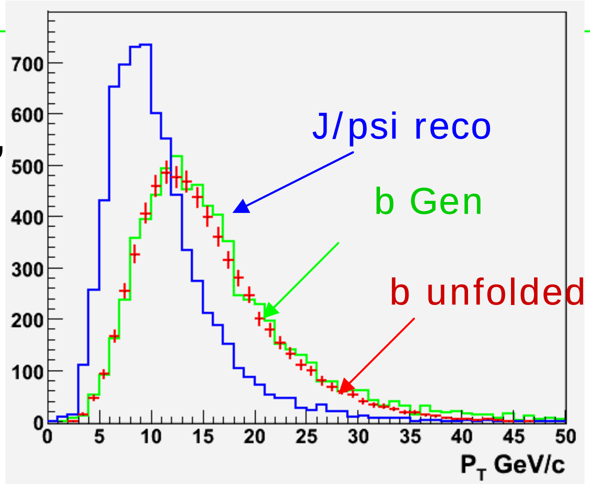
3) make a χ^2 comparison between $\hat{n}(\mathrm{C})$ and $n_0(\mathrm{C})$;

4) replace $P_0(\mathrm{C})$ by $\hat{P}(\mathrm{C})$, and $n_0(\mathrm{C})$ by $\hat{n}(\mathrm{C})$, 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.

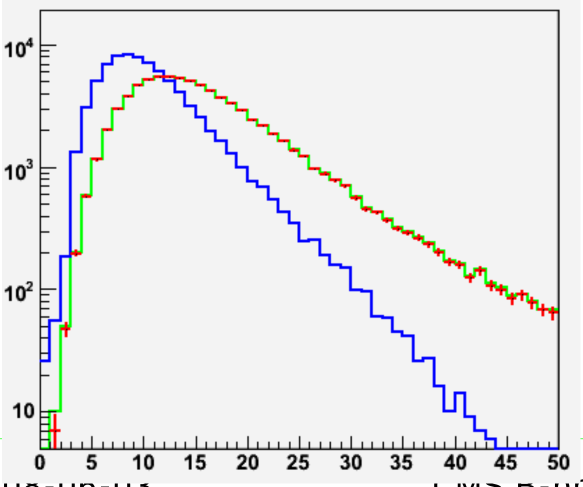
Unfolding on M.C. data

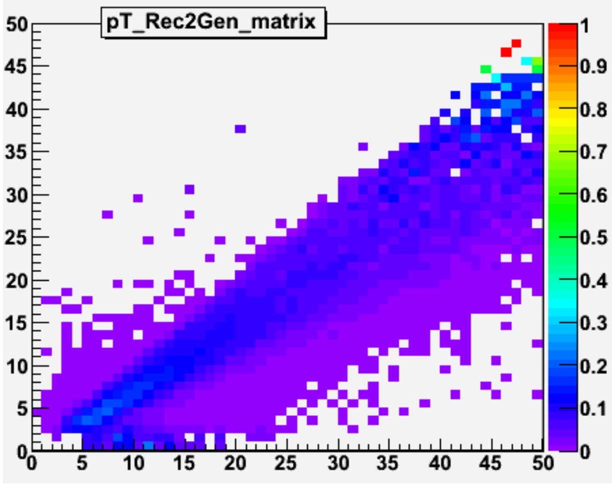


M.C. "real data"
Nevt: 7011



M.C. big sample
Nevt: 80,000





Done & to do list

- □ Unbinned combined MLH fit & analysis method: Toy M.C.
- □ Unfolding method (test cnt.) improved!!!
- □ Acceptance and efficiency

1. Geometric & kinematic Acceptance: A(pT, η)
2. Reco. Efficiency: local reco., matching & selection cuts, Glb muon,etc. **Tag & Probe**

to use CSA07 data in process

3. Trig. Efficiency: L1 moun., HLT muon, etc. **Tag & Probe**

- □ Unbinned combined MLH fit & analysis method: M.C. data.
- □ Systematic uncertainties: sources & estimation

with CMSSW_1_6_11