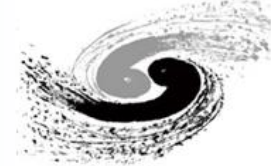


# $B_c \rightarrow J/\psi \mu \mu$ analysis

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Junquan Tao, Jianguo Bian, Zheng Wang, Jian Wang

Institute of High Energy Physics, CAS, Beijing  
Institute of theoretical physics, CQU, CQ

# Experimental status



| Collab.              | $\mathcal{L}_{\text{int}}$ [pb $^{-1}$ ] | Mode                | Signal event         | Mass [MeV/ $c^2$ ]           | Lifetime [ps]                       |
|----------------------|------------------------------------------|---------------------|----------------------|------------------------------|-------------------------------------|
| CDF[24][25]          | 110                                      | $J/\psi \ell^+ \nu$ | $20.4^{+6.2}_{-5.5}$ | $6400 \pm 390 \pm 130$       | $0.46^{+0.18}_{-0.16} \pm 0.03$     |
| D0[26] <sup>†</sup>  | 210                                      | $J/\psi \mu^+ X$    | $95 \pm 12 \pm 11$   | $5950^{+140}_{-130} \pm 340$ | $0.45^{+0.12}_{-0.10} \pm 0.12$     |
| CDF[27]              | 360                                      | $J/\psi \pi^+$      | $14.6 \pm 4.6$       | $6285.7 \pm 5.3 \pm 1.2$     | —                                   |
| CDF[30]              | 360                                      | $J/\psi e^+ \nu_e$  | 238                  | —                            | $0.463^{+0.073}_{-0.065} \pm 0.036$ |
| CDF[28] <sup>‡</sup> | 2400                                     | $J/\psi \pi^+$      | $108 \pm 15$         | $6275.6 \pm 2.9 \pm 2.5$     | —                                   |
| D0[29] <sup>†</sup>  | 1300                                     | $J/\psi \pi^+$      | $54 \pm 12$          | $6300 \pm 14 \pm 5$          | —                                   |
| D0[31] <sup>†</sup>  | 1300                                     | $J/\psi \mu^+ X$    | $881 \pm 80$         | —                            | $0.448^{+0.038}_{-0.036} \pm 0.032$ |

<sup>†</sup>: D0 preliminary

<sup>‡</sup>: CDF preliminary

LHC: p-p collisions at ECM = 14.0 TeV,

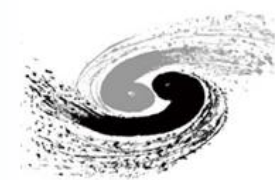
Initial L  $\sim 2 \times 10^{32}$  cm $^{-2}$  s $^{-1}$ , nominal L  $\sim 1 \times 10^{34}$  cm $^{-2}$  s $^{-1}$

CMS: Competition with ALICE, LHCb, (ATLAS)...

but...CMS has excellent muon system, tracker, large acceptance!

Most analyses here based on medium and high PT muons

# Event generation



- Signal:  $B_c \rightarrow J/\psi \mu$ ,  $J/\psi \rightarrow \mu\mu$  generated with BCVEGPY 2.1 generator

[Chang&Wu, EPJC38:267,2004]

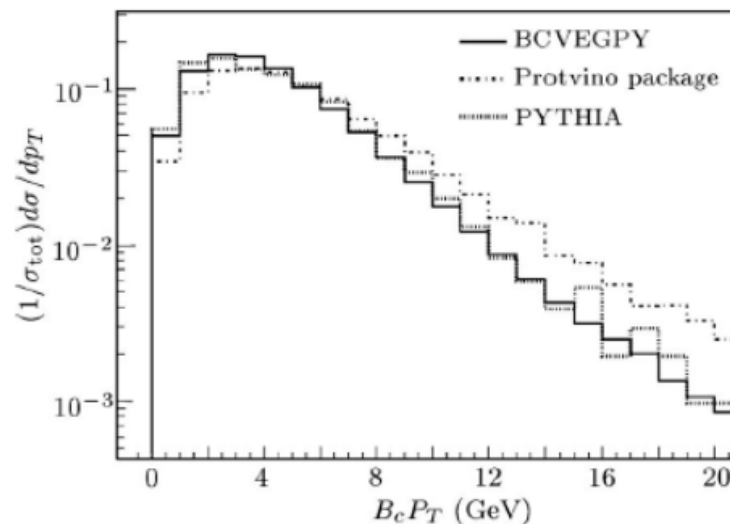
GeneratorInterface/GenExtension(BCVEGPY 2.1) in CMSSW\_3\_1\_x

<https://twiki.cern.ch/twiki/bin/view/CMS/BcGenerator>

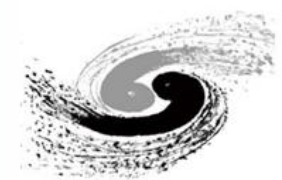
<http://indico.cern.ch/getFile.py/access?contribId=8&resId=0&materialId=slides&confId=52322>

I generate and analyze the signal  
in CMSSW\_2\_2\_3

- Generator cuts (simulate L1 and HLT trigger):
  - $\mu$  pair (from JPsi)  $p_T \geq 2.5 \text{ GeV}$   $|\eta| \leq 2.5$   
InvMass(3.096GeV, 3.098GeV)
  - Third  $\mu$  ( $\mu$  from  $B_c$ )  $p_T \geq 2.5 \text{ GeV}$   $|\eta| \leq 2.5$

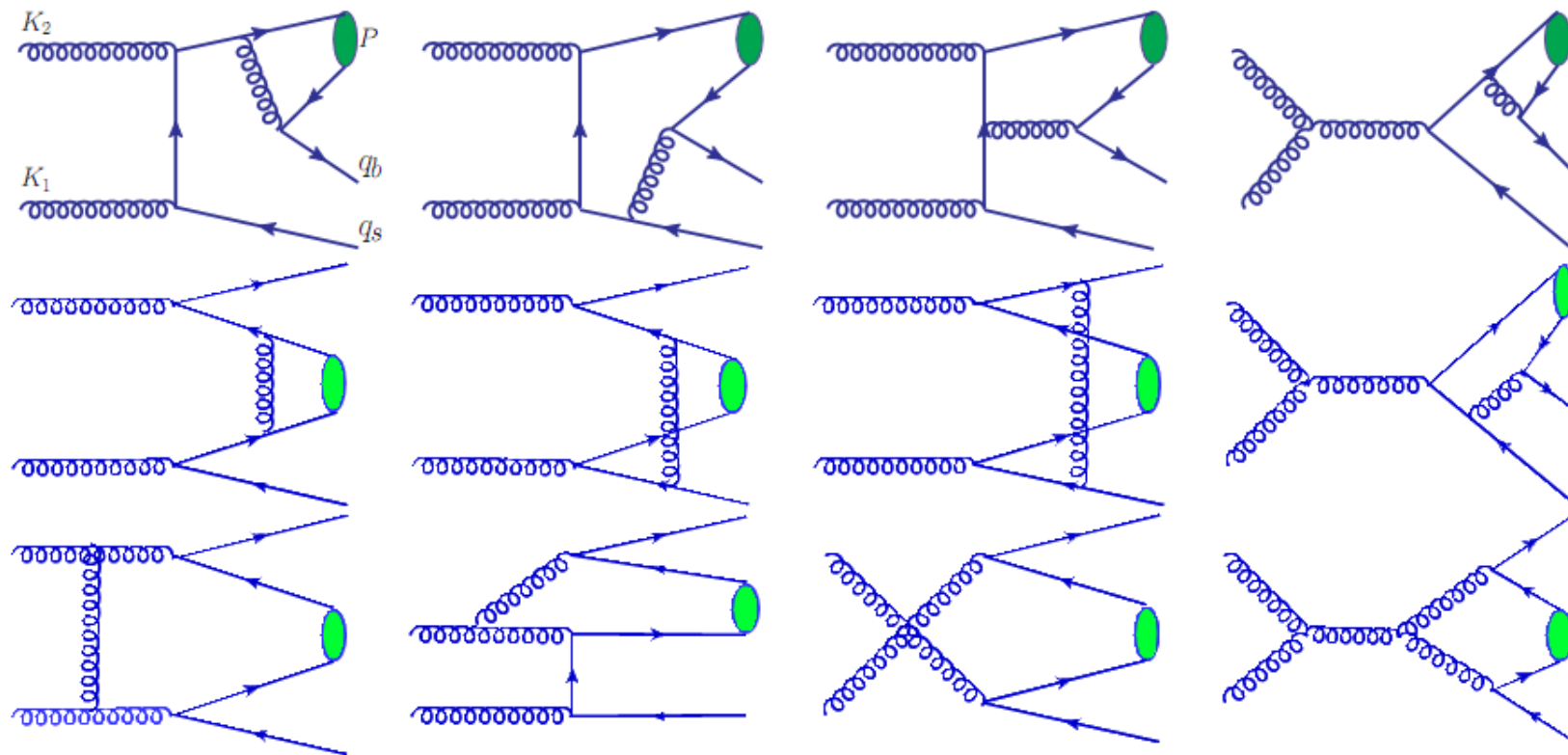
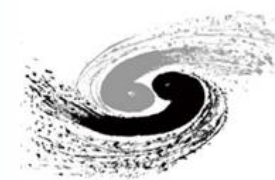


# Event selection

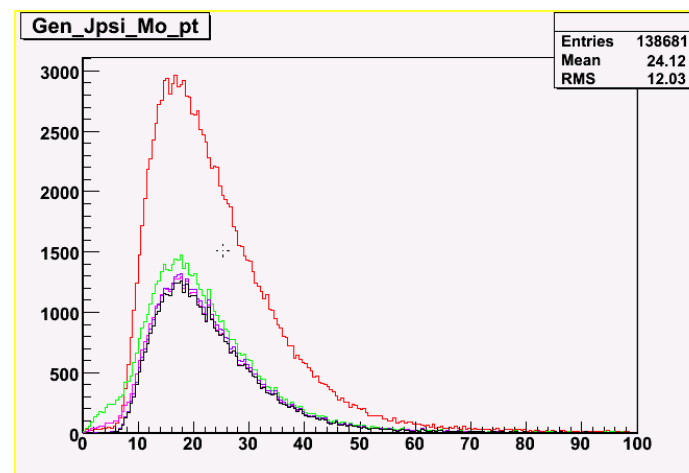
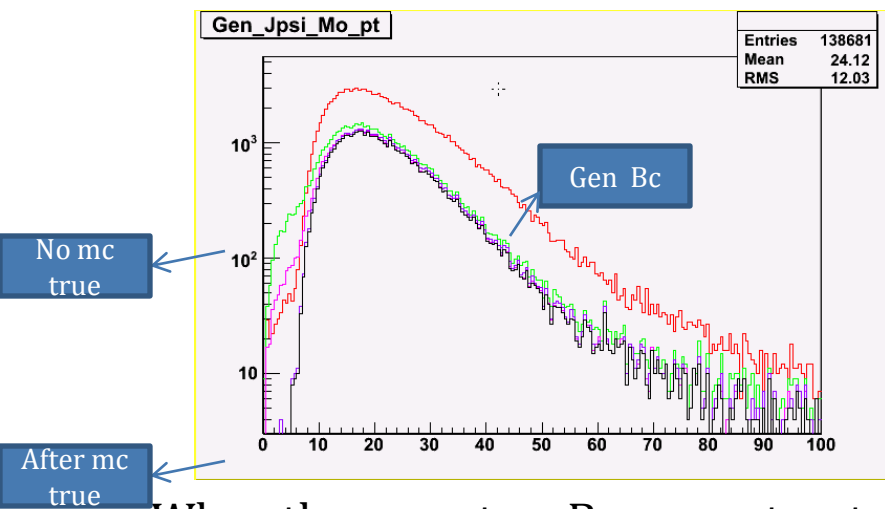
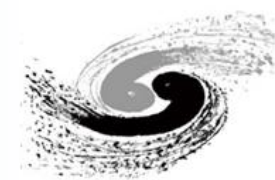


| Candidate selection                      | Selection Criteria                     |
|------------------------------------------|----------------------------------------|
| Jpsi selection                           |                                        |
| Trigger                                  | HLT_DoubleMu3                          |
| Reco Object                              | Global muon                            |
| $p_T(\mu)$ (Gev/c)                       | $>2.5$                                 |
| $ \eta(\mu) $                            | $<2.4$                                 |
| Best dimuon candidate selection          | Colsest mass                           |
| Same vertex dimuon mass window           | (2.8,3.4)                              |
| Final selection                          |                                        |
| Three muon Kerman vertex fit             | yes                                    |
| Bc Nomalized $\chi^2$                    | $<5$                                   |
| Fit strategy                             |                                        |
| Discriminating variables                 | Mass, $c\tau$                          |
| $p_T(Bc)$ (Gev/c)                        | 6-13,13-17,17-21,<br>21-27,27-35,Pt>35 |
| Fit range: Bc Mass (Gev/c <sup>2</sup> ) | (3,8)                                  |
| Fit range: $c\tau$ (cm)                  | (-0.04,0.1)                            |

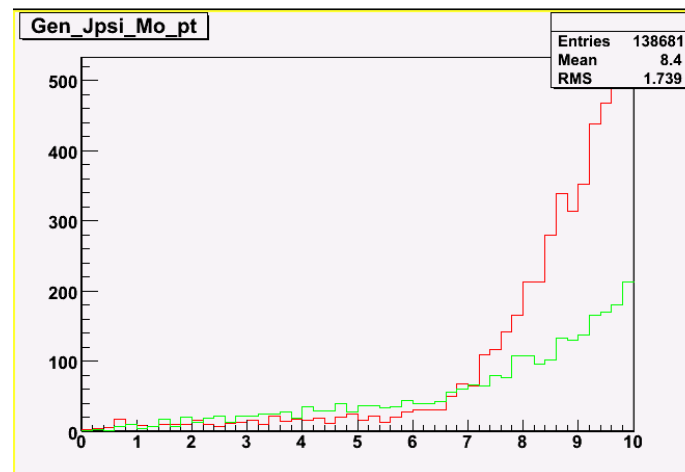
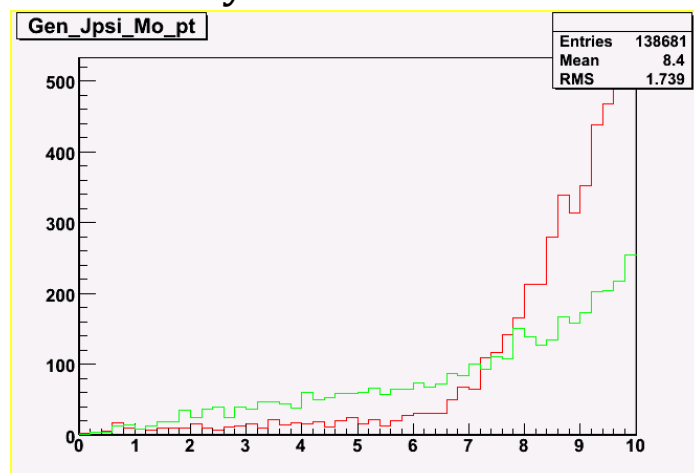
# Typical Feynman diagrams



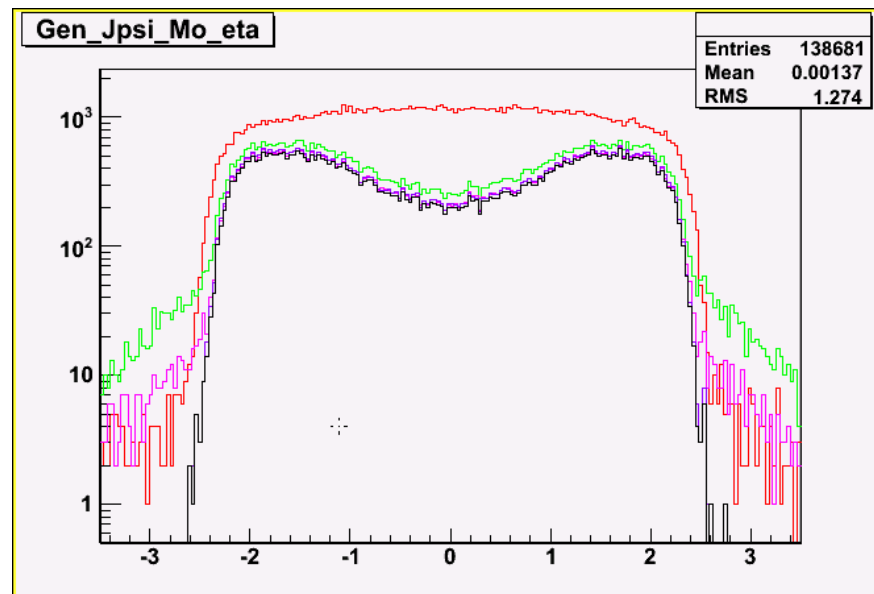
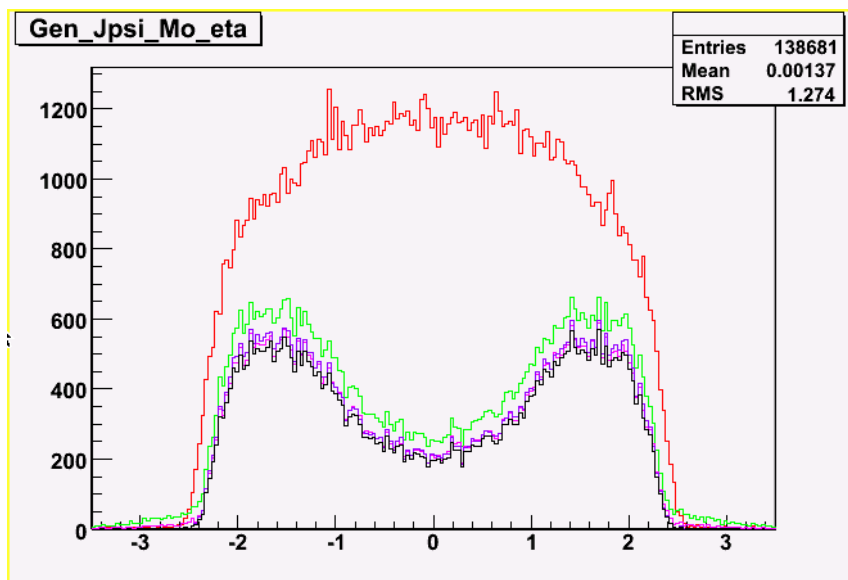
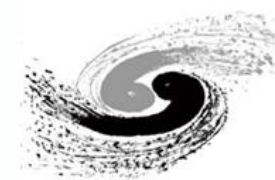
# MC True Match

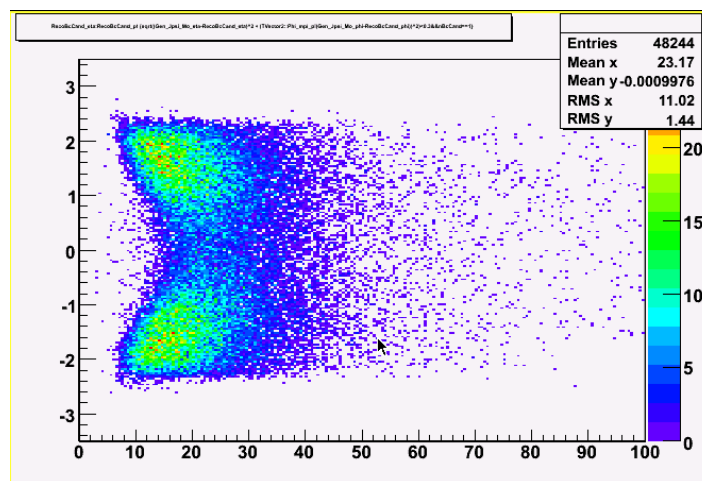
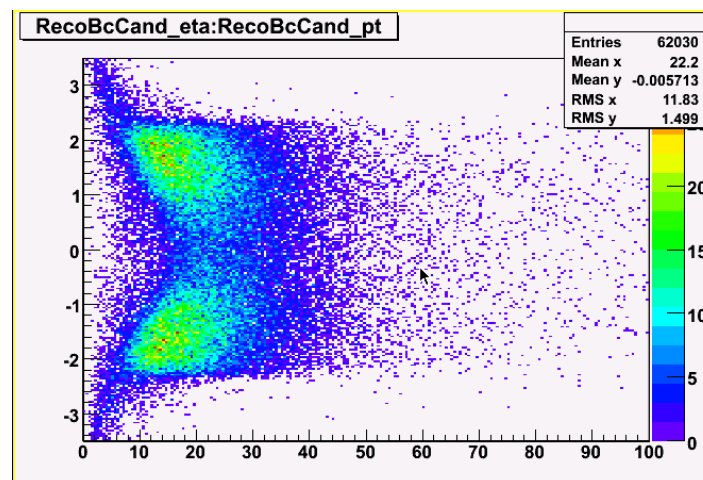
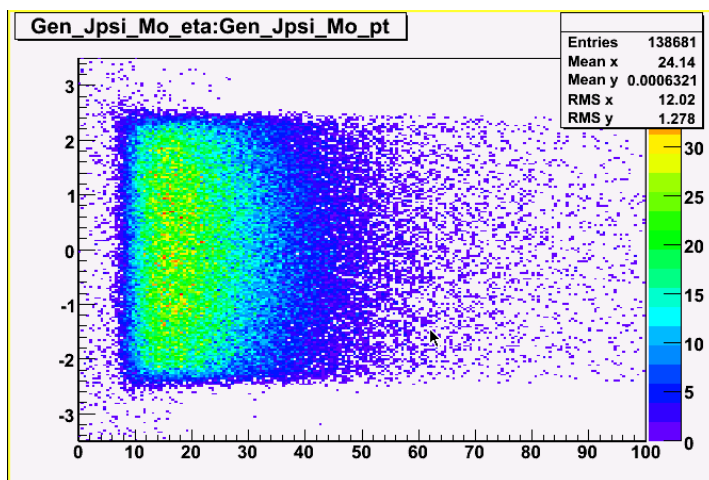
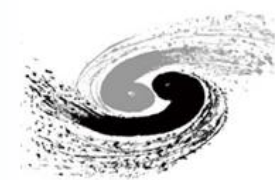


When there are two Bc reconstructed,  
Just select only one Bc reconstructed.



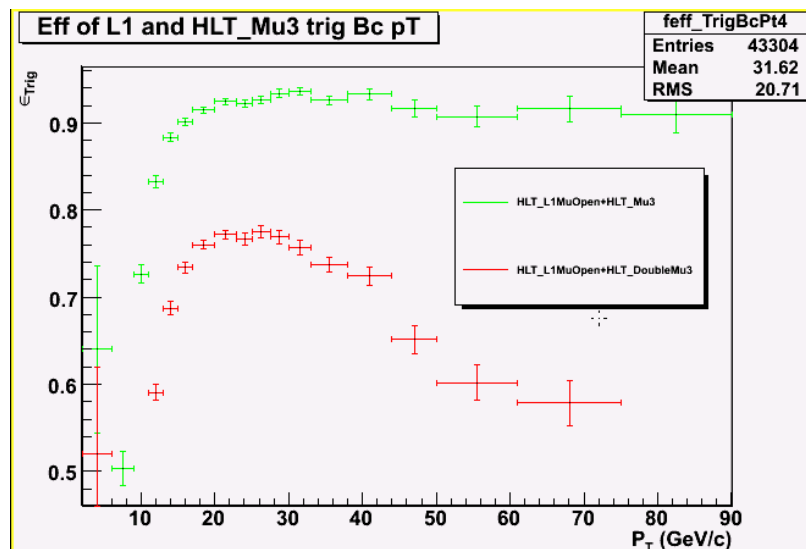
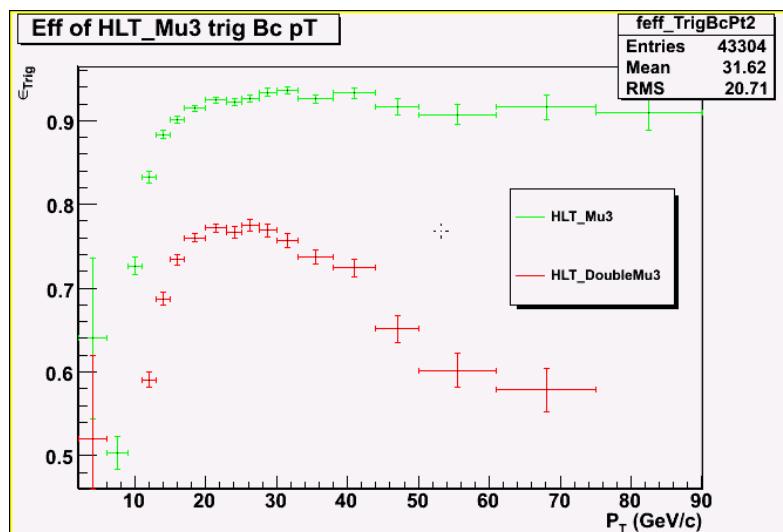
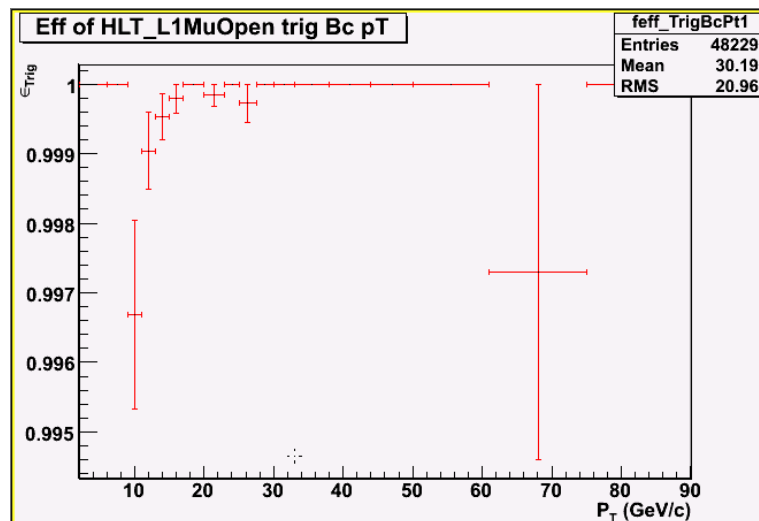
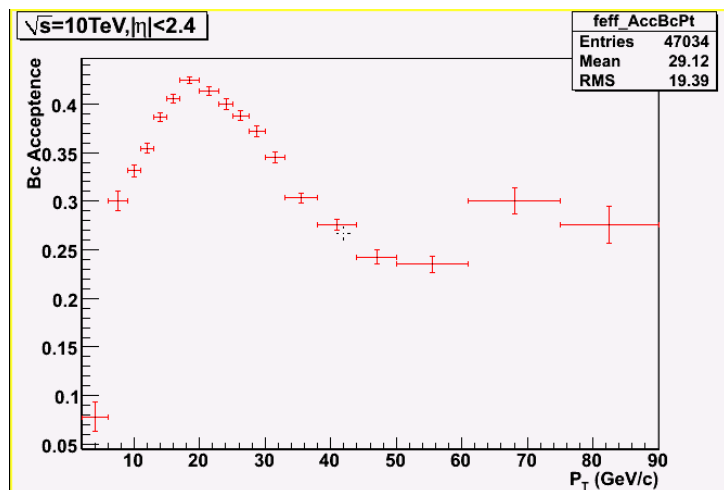
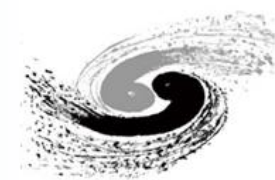
# Eta distribution



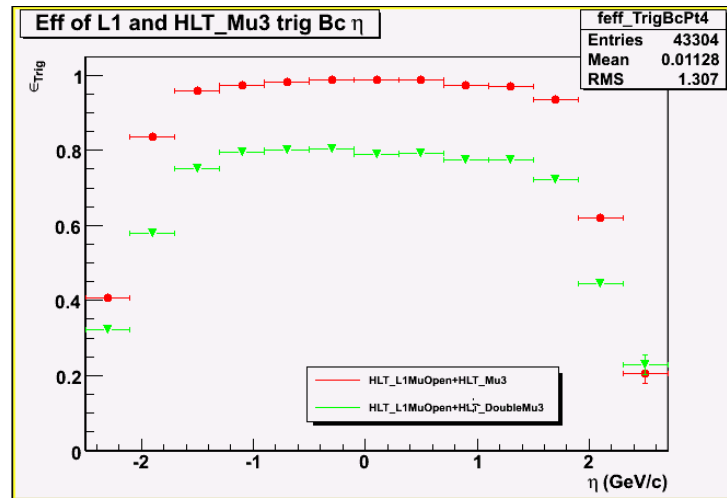
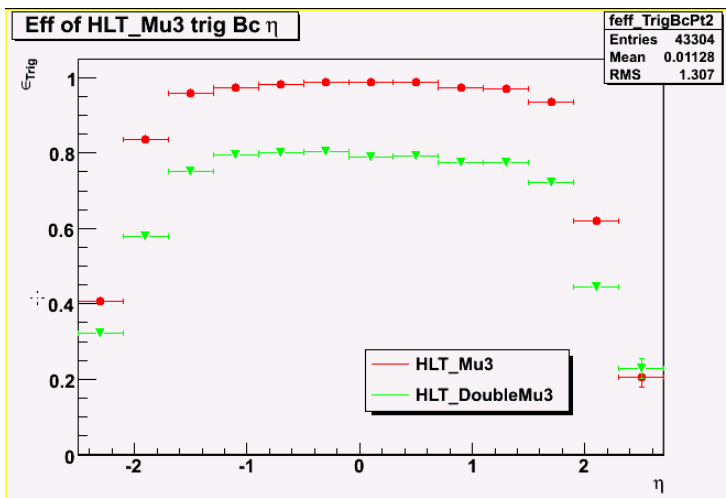
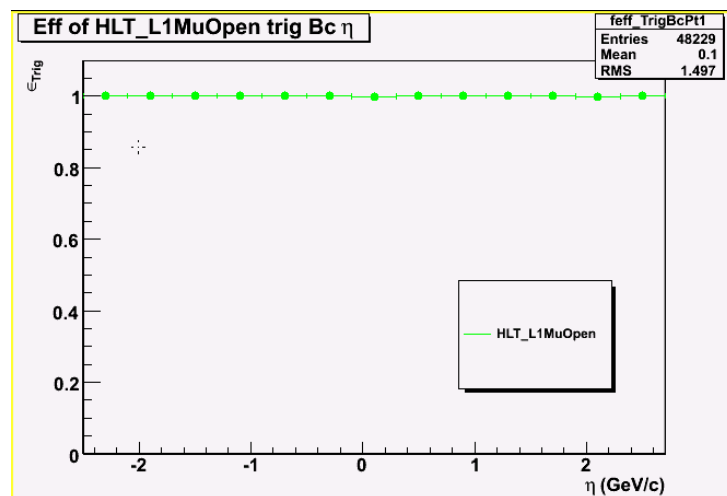
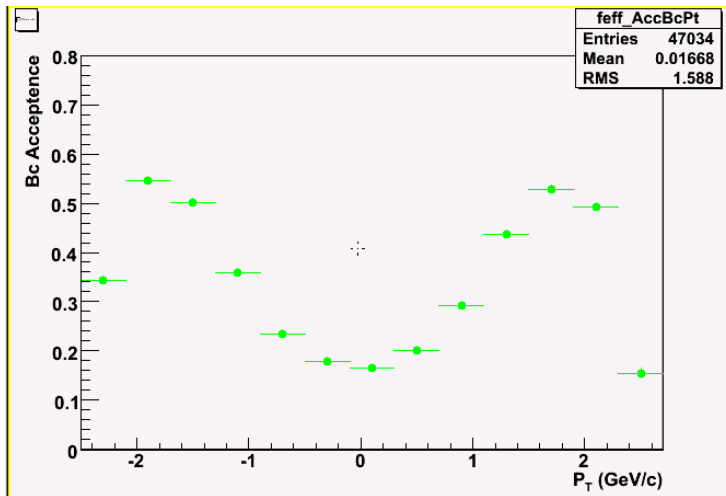
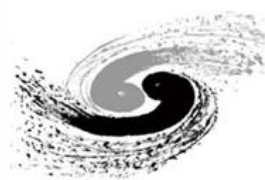




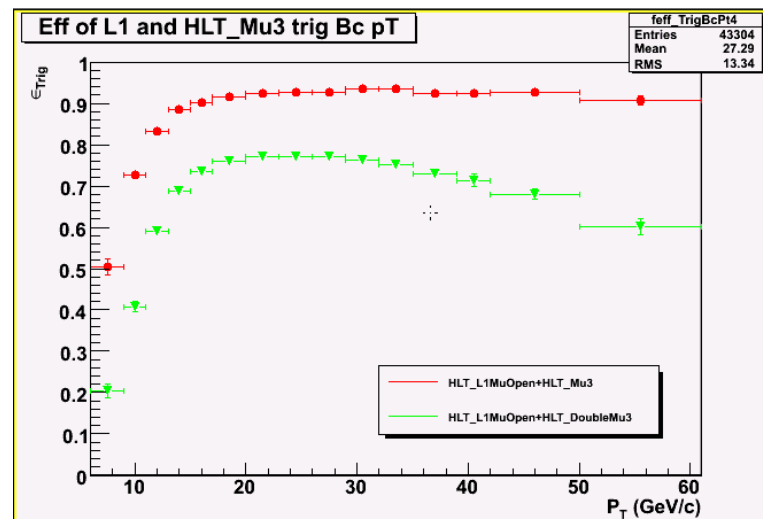
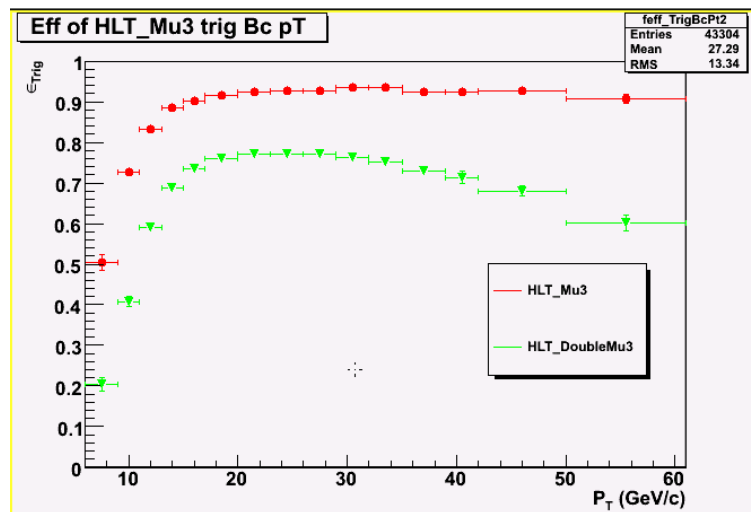
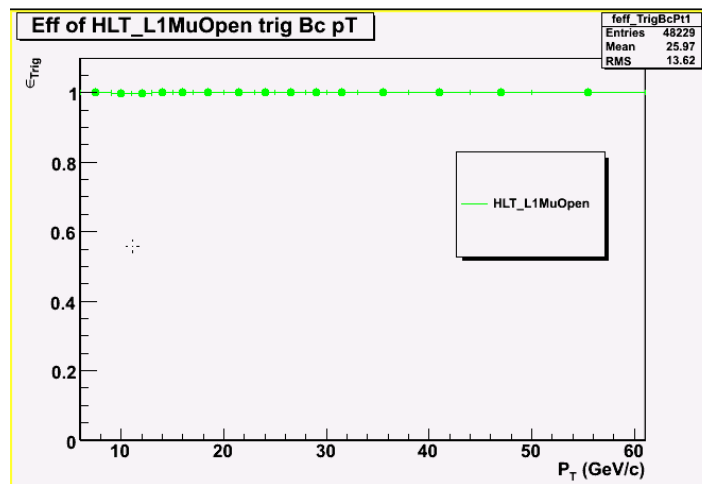
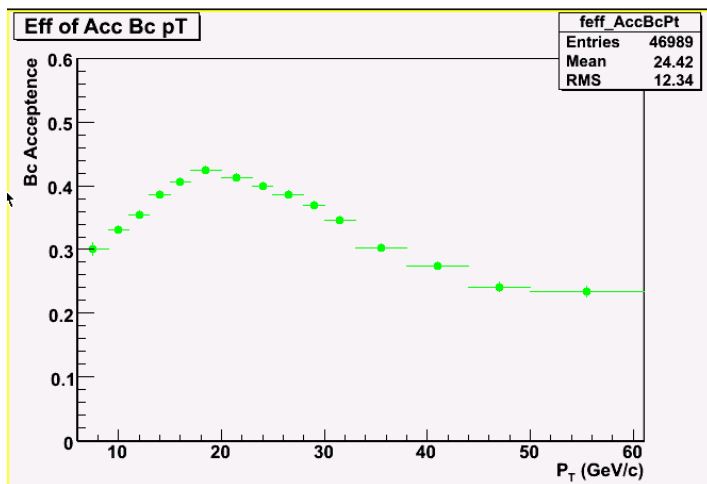
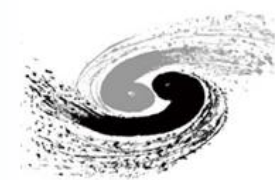
# Trigger efficiency

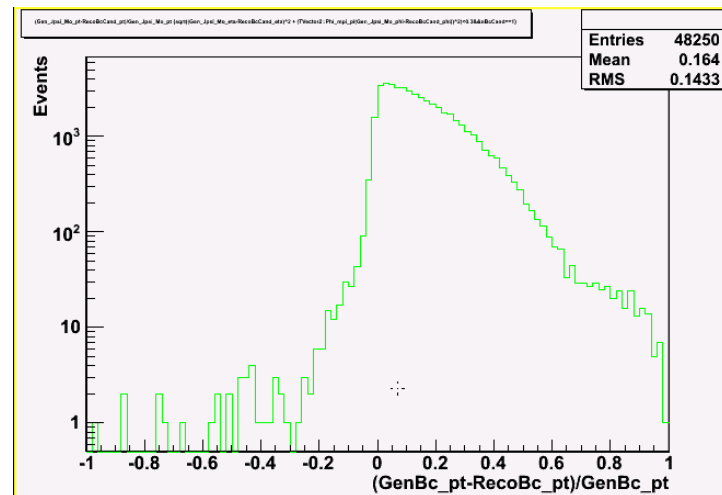
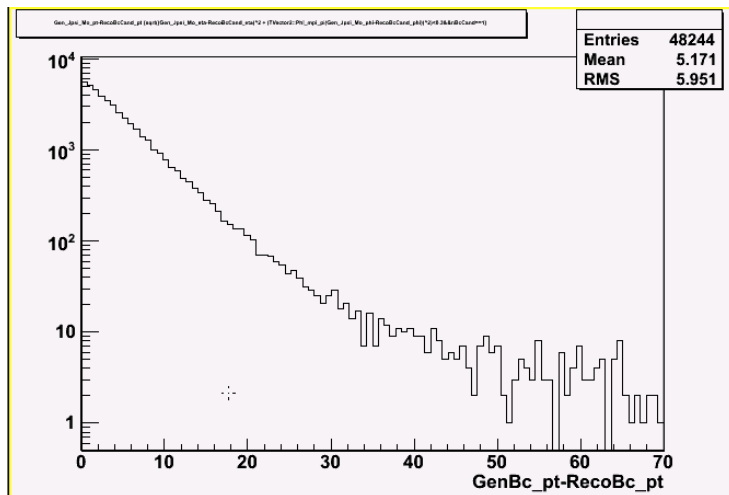
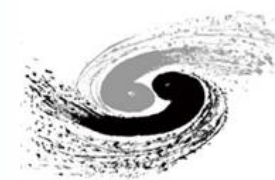


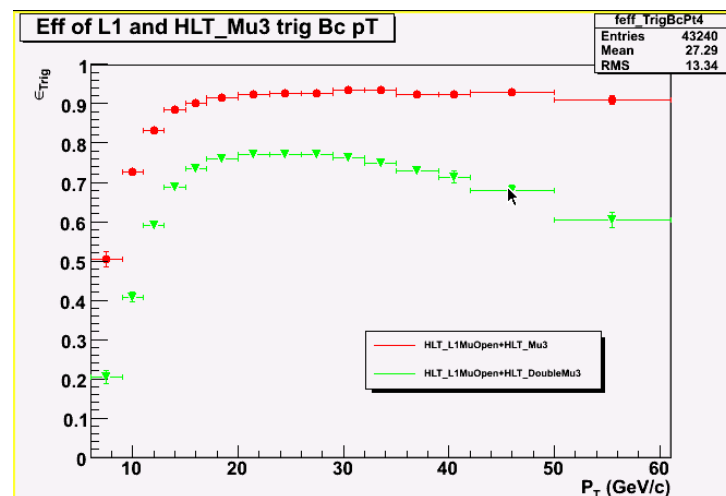
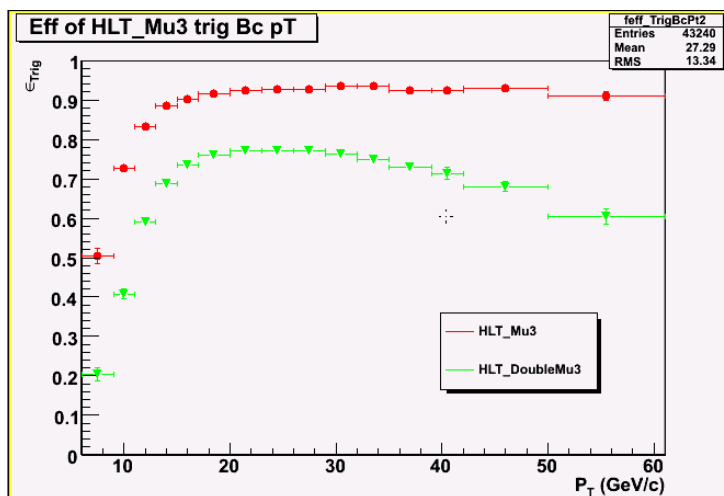
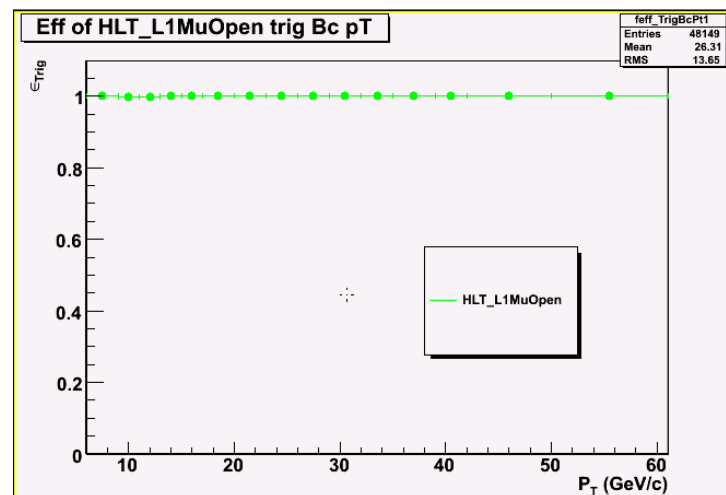
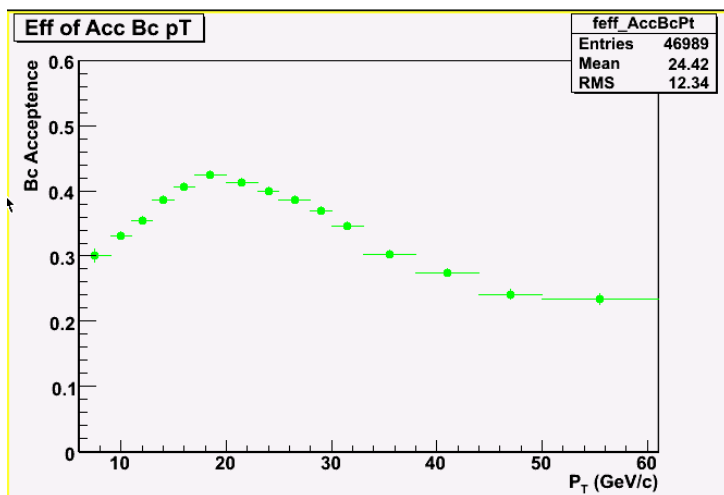
# Eta trigger efficiency



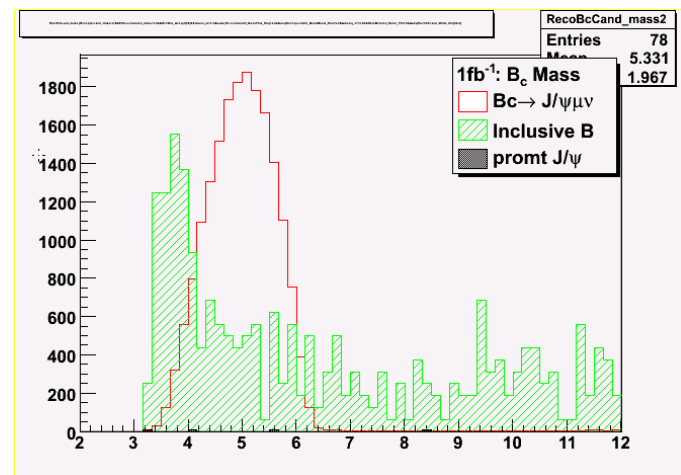
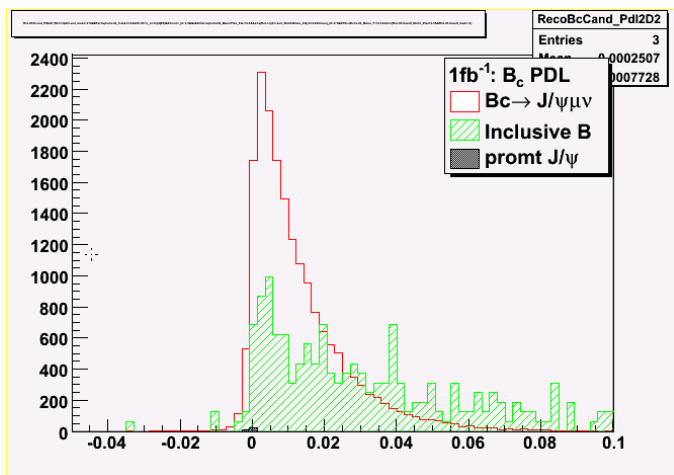
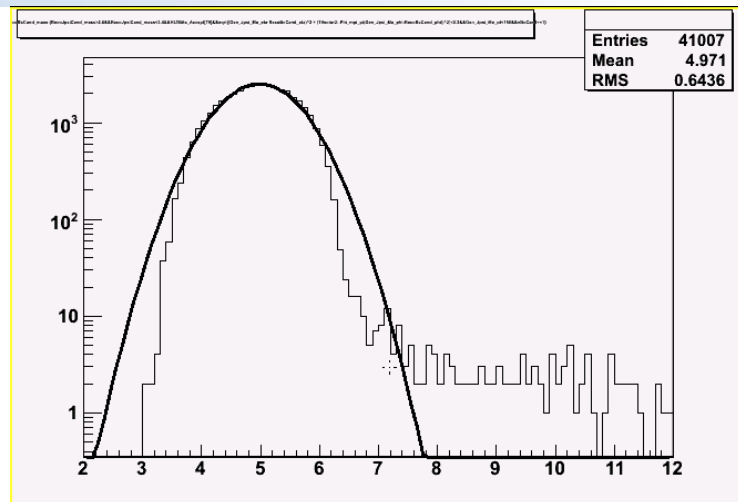
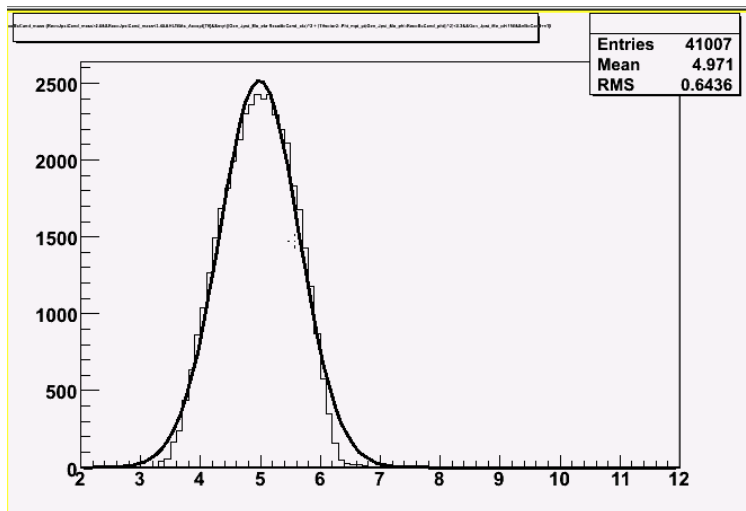
# The last trigger efficiency



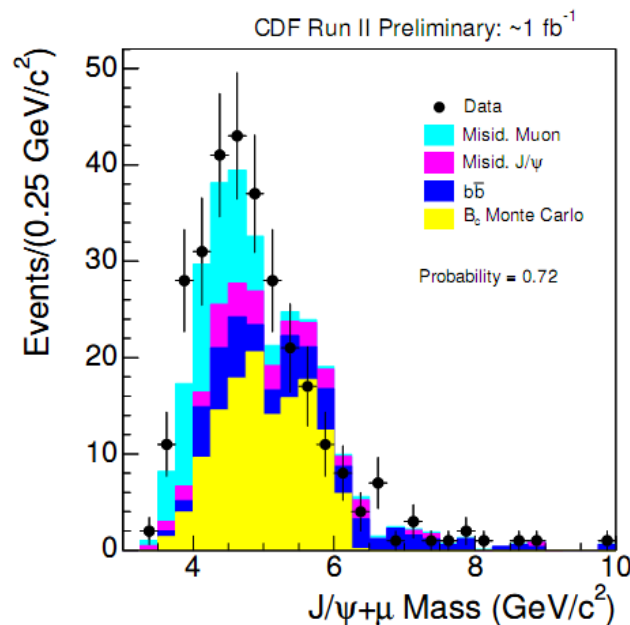
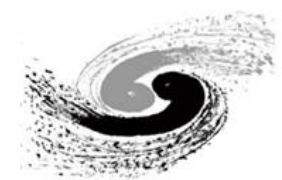




# Fit strategy

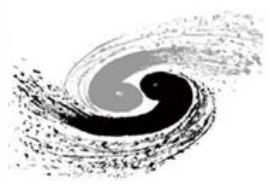


# CDF latest result



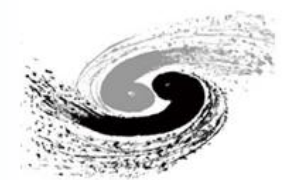
| $B_c^+$ excess                                         | $p_T(J/\psi + \mu^+) > 4 \text{ GeV}/c$ | $p_T(J/\psi + \mu^+) > 6 \text{ GeV}/c$ |
|--------------------------------------------------------|-----------------------------------------|-----------------------------------------|
| $N(B_c^+ \rightarrow J/\psi + \mu^+ + X)$ , observed   | $229 \pm 15.1$                          | $214 \pm 14.6$                          |
| Total background                                       | $106.2 \pm 8.2$                         | $102.1 \pm 8.0$                         |
| $N(B_c^+ \rightarrow J/\psi + \mu^+ + X)$ , bg. sub.   | $122.8 \pm 17.2$                        | $111.9 \pm 16.6$                        |
| Other decay modes                                      | $5.2 \pm 0.5$                           | $4.8 \pm 0.4$                           |
| $N(B_c^+ \rightarrow J/\psi + \mu^+ + \nu)$ , bg. sub. | $117.6 \pm 17.2$                        | $107.1 \pm 16.7$                        |

# Next step



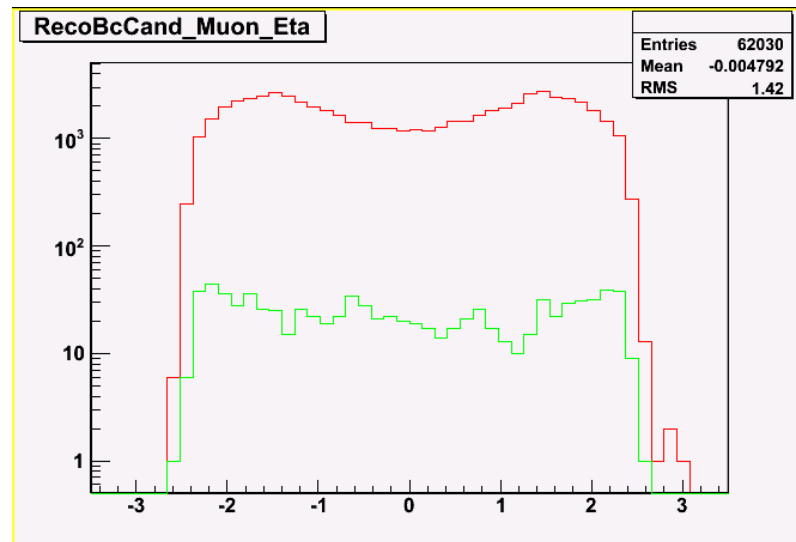
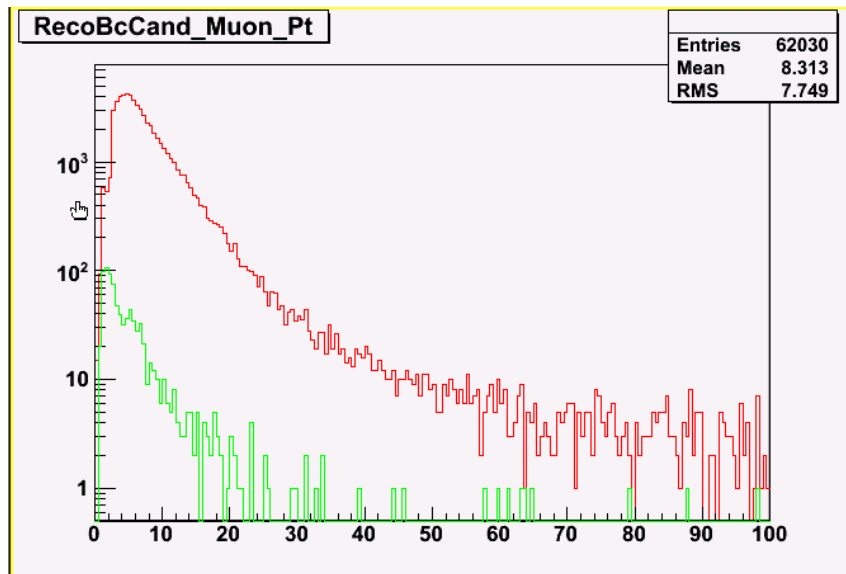
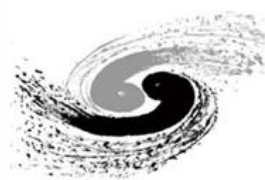
- The mass and proper decay length Fit.
- Use Track muon to reconstruct  $B_c$ .
- $B_c \rightarrow J/\psi \text{ Pi}$  analysis.
- $B_c$  low pt signal production in CMSSW\_3\_1\_x.

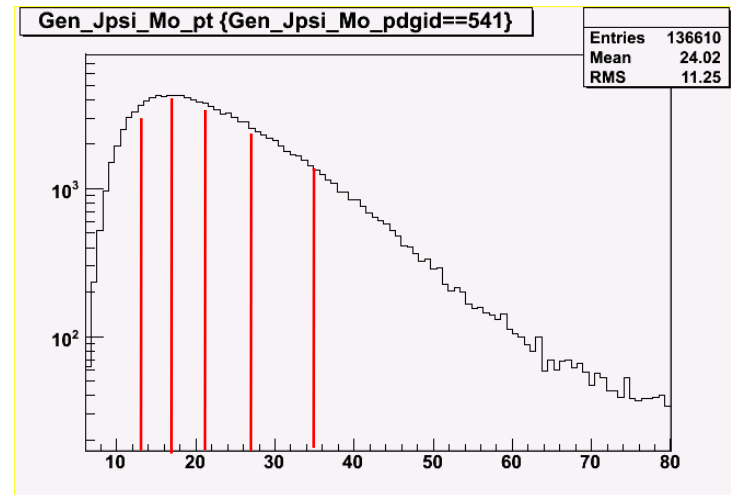
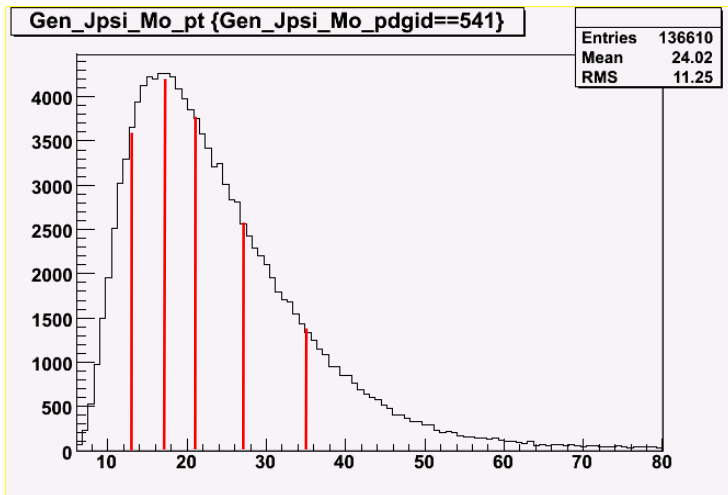
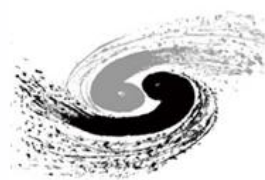




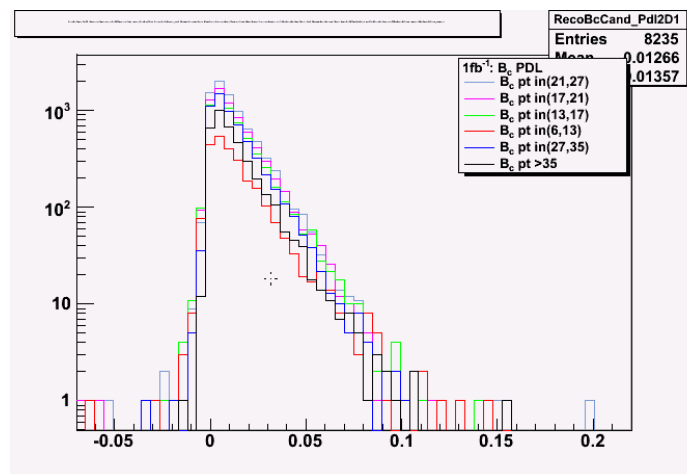
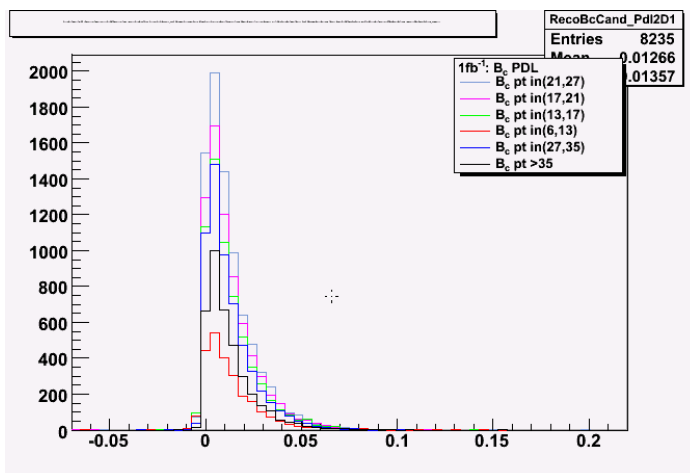
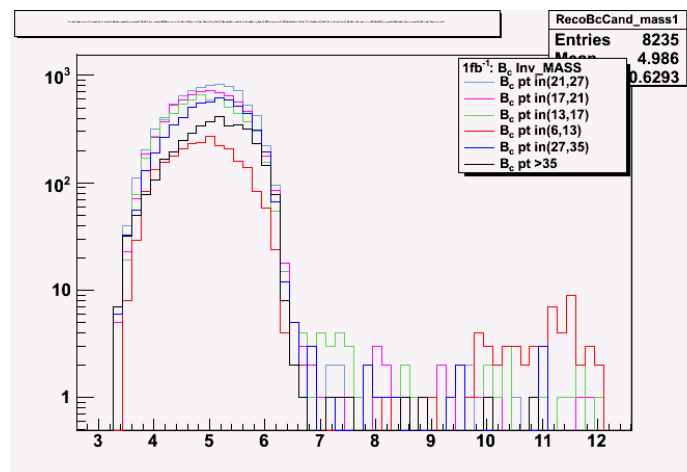
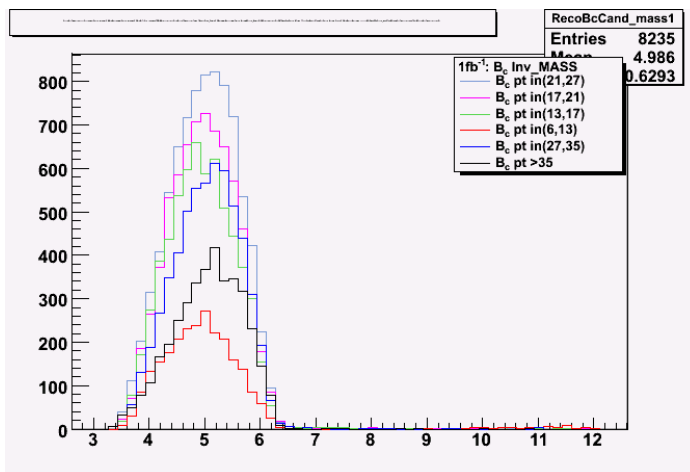
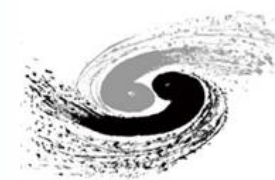
# Thank you!

# Backup

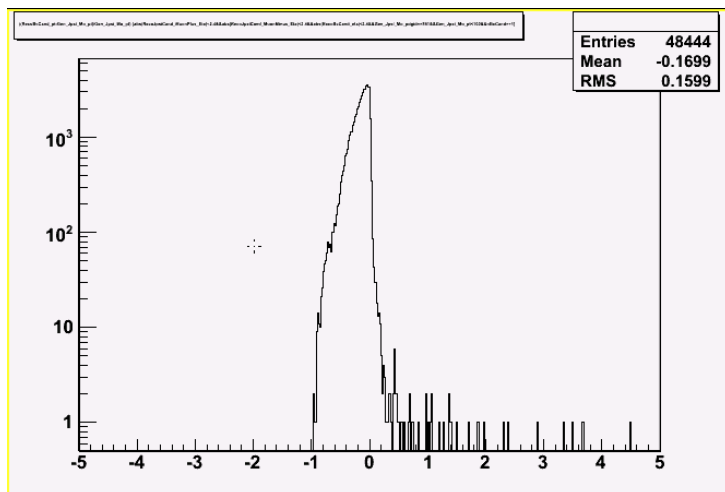
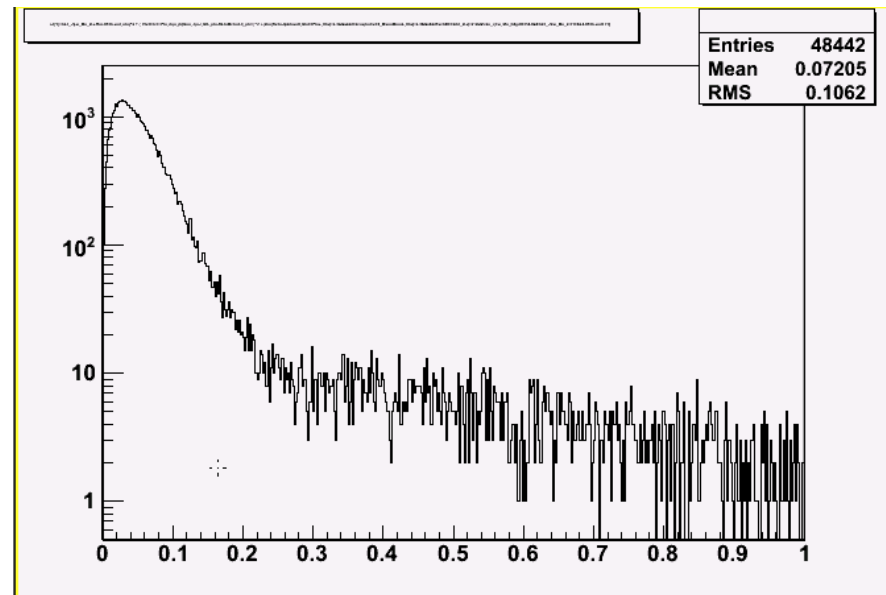
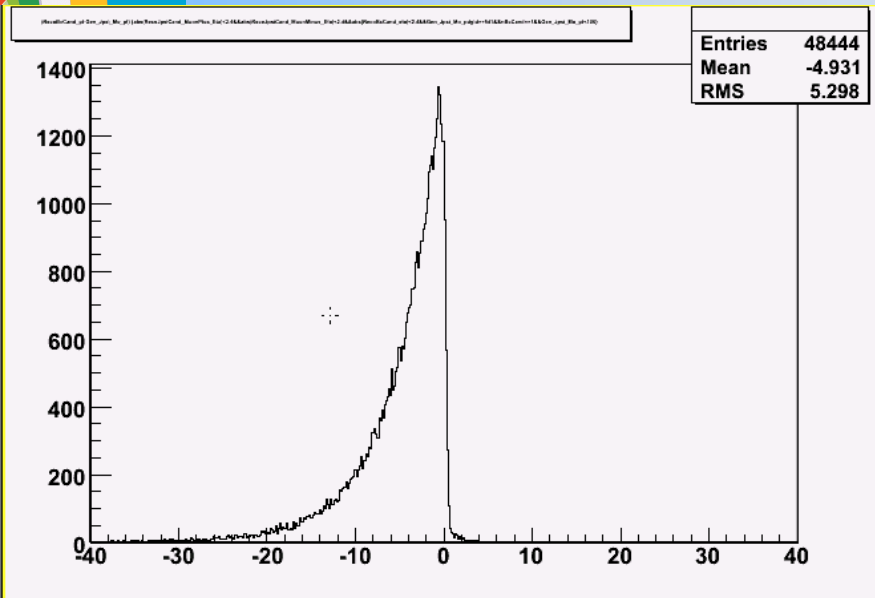




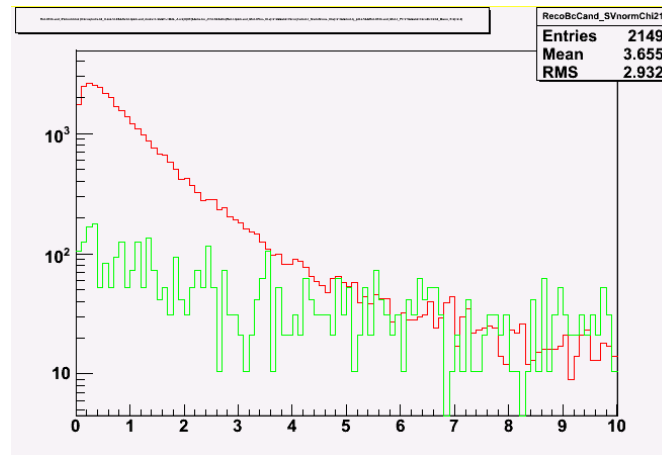
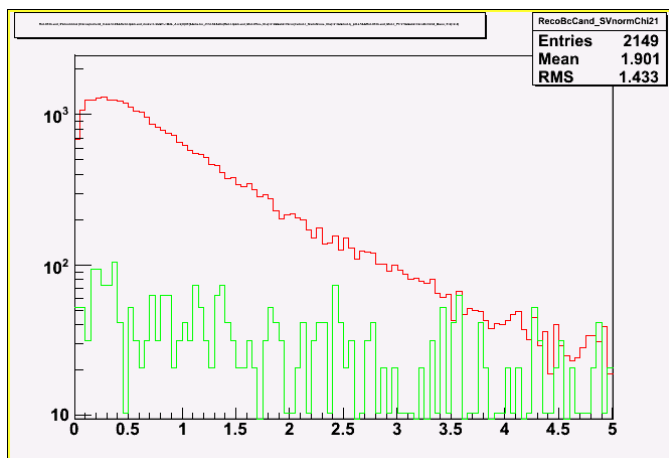
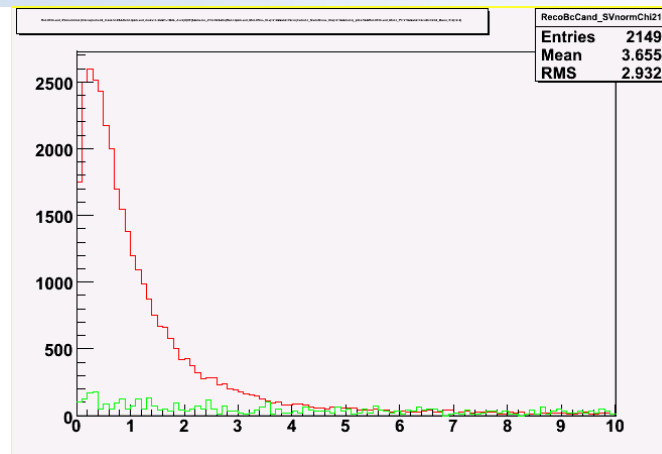
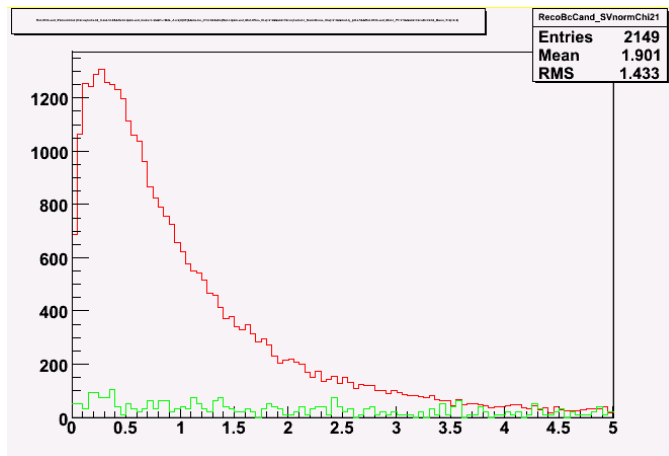
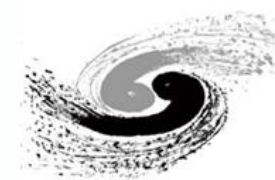
$6 < Pt < 13$ ,  $13 < Pt < 17$ ,  $17 < Pt < 21$   
 $21 < Pt < 27$ ,  $27 < Pt < 35$ ,  $Pt > 35$



| Path Name          | L1 Trigger                         | L1 requirements                               | L2 requirements                           | L2Iso requirements | L3 requirements                        | L3Iso requirements |
|--------------------|------------------------------------|-----------------------------------------------|-------------------------------------------|--------------------|----------------------------------------|--------------------|
| HLT_L1MuOpen       | L1_SingleMuOpen OR<br>L1_SingleMu0 | 1 or more, pT > 0.0GeV                        | none                                      | none               | none                                   | none               |
| HLT_L1Mu           | L1_SingleMu7 OR<br>L1_DoubleMu3    | 1 or more, pT > 0.0GeV                        | none                                      | none               | none                                   | none               |
| HLT_L1Mu20HQ       | L1_SingleMu20                      | 1 or more, pT > 20.0GeV,<br>qualities = { 7 } | none                                      | none               | none                                   | none               |
| HLT_L1Mu30         | L1_SingleMu20                      | 1 or more, pT > 30.0GeV                       | none                                      | none               | none                                   | none               |
| HLT_L2Mu11         | L1_SingleMu7                       | 1 or more, pT > 0.0GeV                        | 1 or more, pT > 11.0GeV,<br>dxy< 9999.0cm | none               | none                                   | none               |
| HLT_IsoMu9         | L1_SingleMu7                       | 1 or more, pT > 0.0GeV                        | 1 or more, pT > 7.0GeV,<br>dxy< 9999.0cm  | 1 or more          | 1 or more, pT > 9.0GeV,<br>dxy< 2.0cm  | 1 or more          |
| HLT_Mu5            | L1_SingleMu3                       | 1 or more, pT > 0.0GeV                        | 1 or more, pT > 4.0GeV,<br>dxy< 9999.0cm  | none               | 1 or more, pT > 5.0GeV,<br>dxy< 2.0cm  | none               |
| HLT_Mu9            | L1_SingleMu7                       | 1 or more, pT > 0.0GeV                        | 1 or more, pT > 7.0GeV,<br>dxy< 9999.0cm  | none               | 1 or more, pT > 9.0GeV,<br>dxy< 2.0cm  | none               |
| HLT_Mu11           | L1_SingleMu7                       | 1 or more, pT > 0.0GeV                        | 1 or more, pT > 9.0GeV,<br>dxy< 9999.0cm  | none               | 1 or more, pT > 11.0GeV,<br>dxy< 2.0cm | none               |
| HLT_Mu15           | L1_SingleMu10                      | 1 or more, pT > 0.0GeV                        | 1 or more, pT > 12.0GeV,<br>dxy< 9999.0cm | none               | 1 or more, pT > 15.0GeV,<br>dxy< 2.0cm | none               |
| HLT_L1DoubleMuOpen | L1_DoubleMuOpen                    | 2 or more, pT > 0.0GeV                        | none                                      | none               | none                                   | none               |
| HLT_DoubleMu0      | L1_DoubleMuOpen                    | 2 or more, pT > 0.0GeV                        | 2 or more, pT > 0.0GeV,<br>dxy< 9999.0cm  | none               | 2 or more, pT > 0.0GeV,<br>dxy< 2.0cm  | none               |
| HLT_DoubleMu3      | L1_DoubleMu3                       | 2 or more, pT > 0.0GeV                        | 2 or more, pT > 3.0GeV,<br>dxy< 9999.0cm  | none               | 2 or more, pT > 3.0GeV,<br>dxy< 2.0cm  | none               |



# Bc normalized $\chi^2$



- Select Criteria :
- 9)Jpsi normalized  $\chi^2 < 5(\chi^2/\text{ndof})$



