inclusive b->J/ψ(μ μ)X analysis: Unfolding & HLT in CMSSW_2_1

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Mar. 13 , 2009

Outline

- Unfolding in “inclusive b”
- Cross section
- L1T & HLT

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 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:

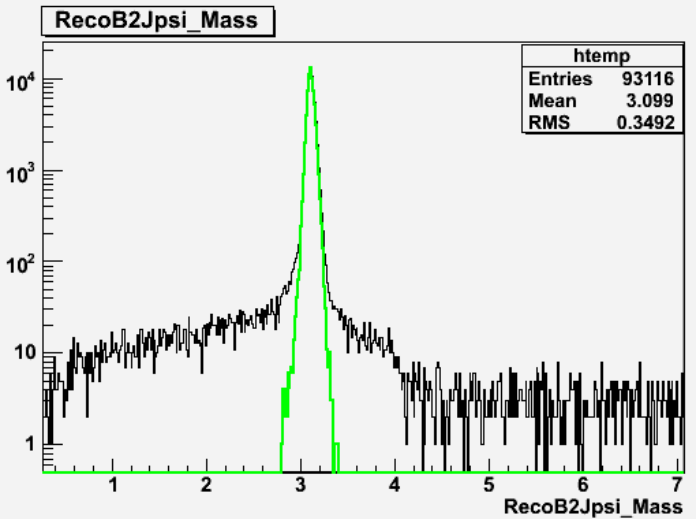
1) choose the initial distribution of $P_0(C)$ from the best knowledge of the process under study, and hence the initial expected number of events $n_0(C_i) = P_0(C_i)N_{obs}$; in case of complete ignorance, $P_0(C)$ will be just a uniform distribution: $P_0(C_i) = 1/n_C$;

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

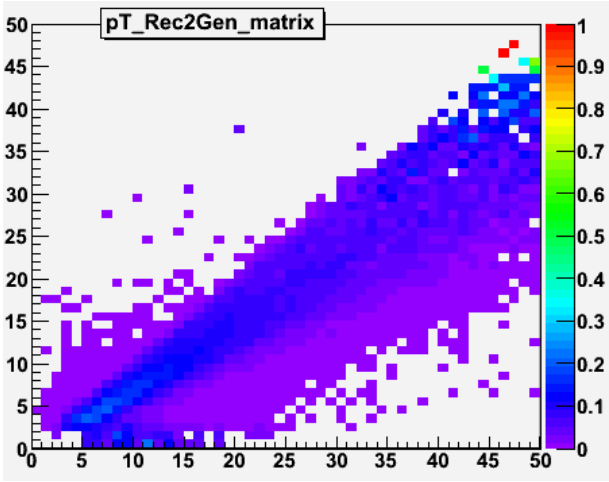
3) make a χ^2 comparison between $\hat{n}(C)$ and $n_0(C)$;

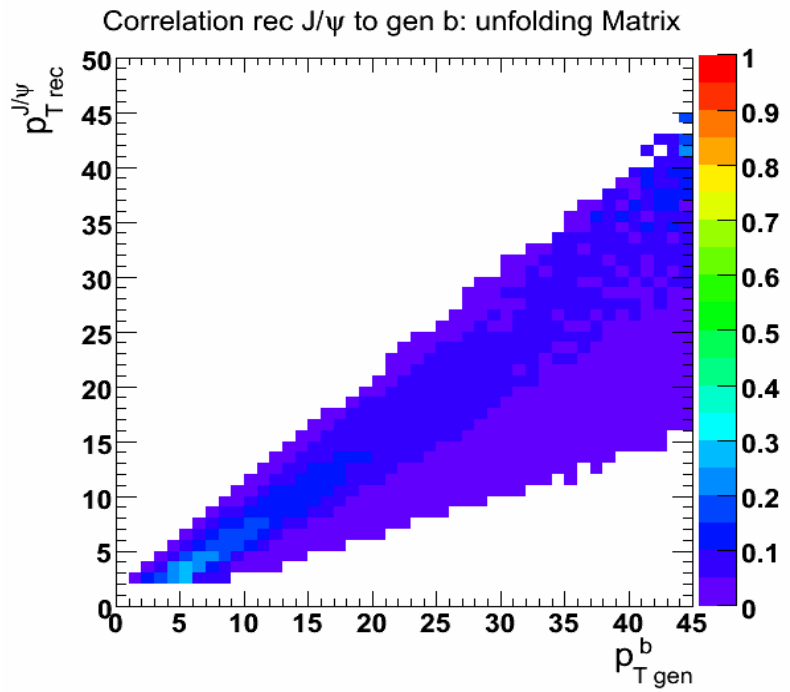
4) replace $P_0(C)$ by $\hat{P}(C)$, and $n_0(C)$ by $\hat{n}(C)$, and start again; if, after the second iteration the value of χ^2 is "small enough", stop the iteration; otherwise go to step 2. Some criteria about the optimum number of iterations will be discussed later.

Correlation Matrix

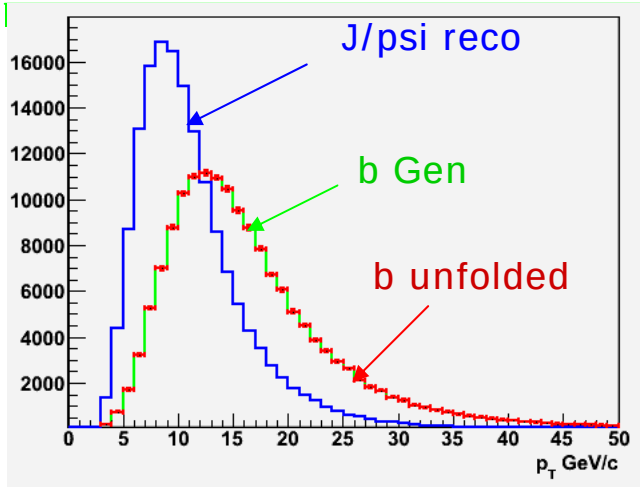


$\Delta R^{J/\Psi} < 0.01$

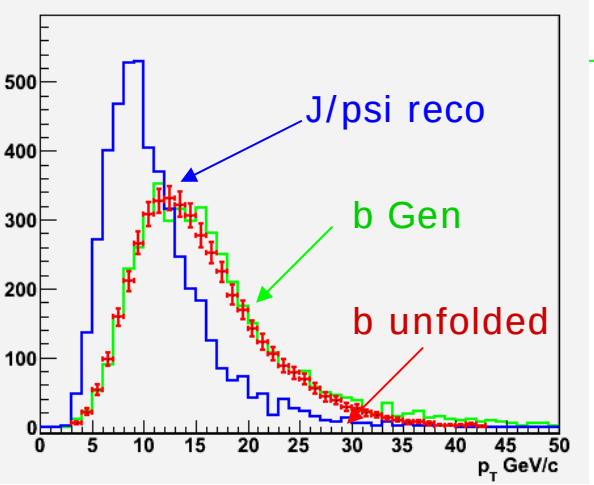




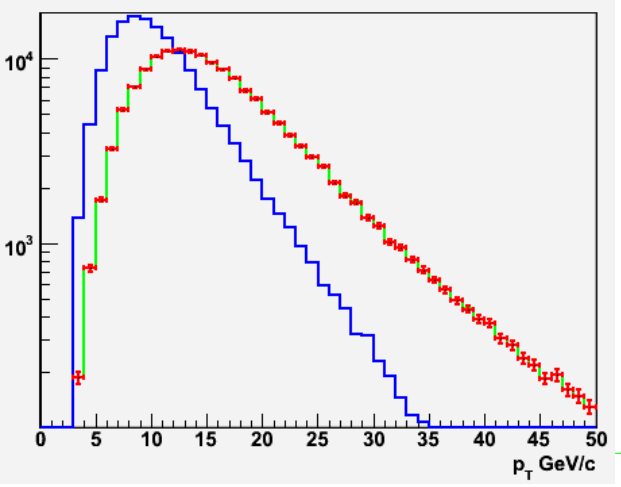
Unfolding on M.C. data

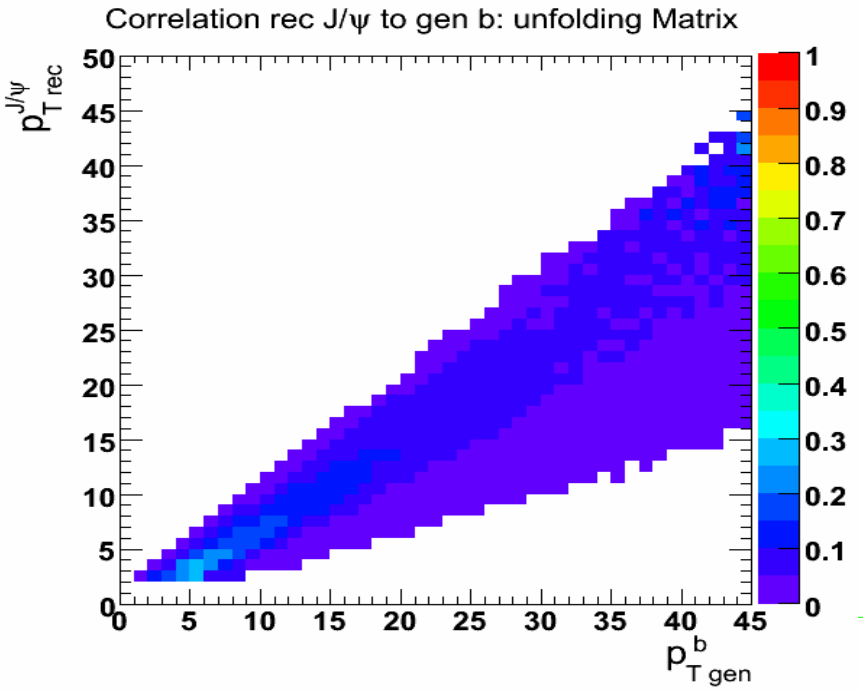


M.C. "real data"
Nevt: 4760

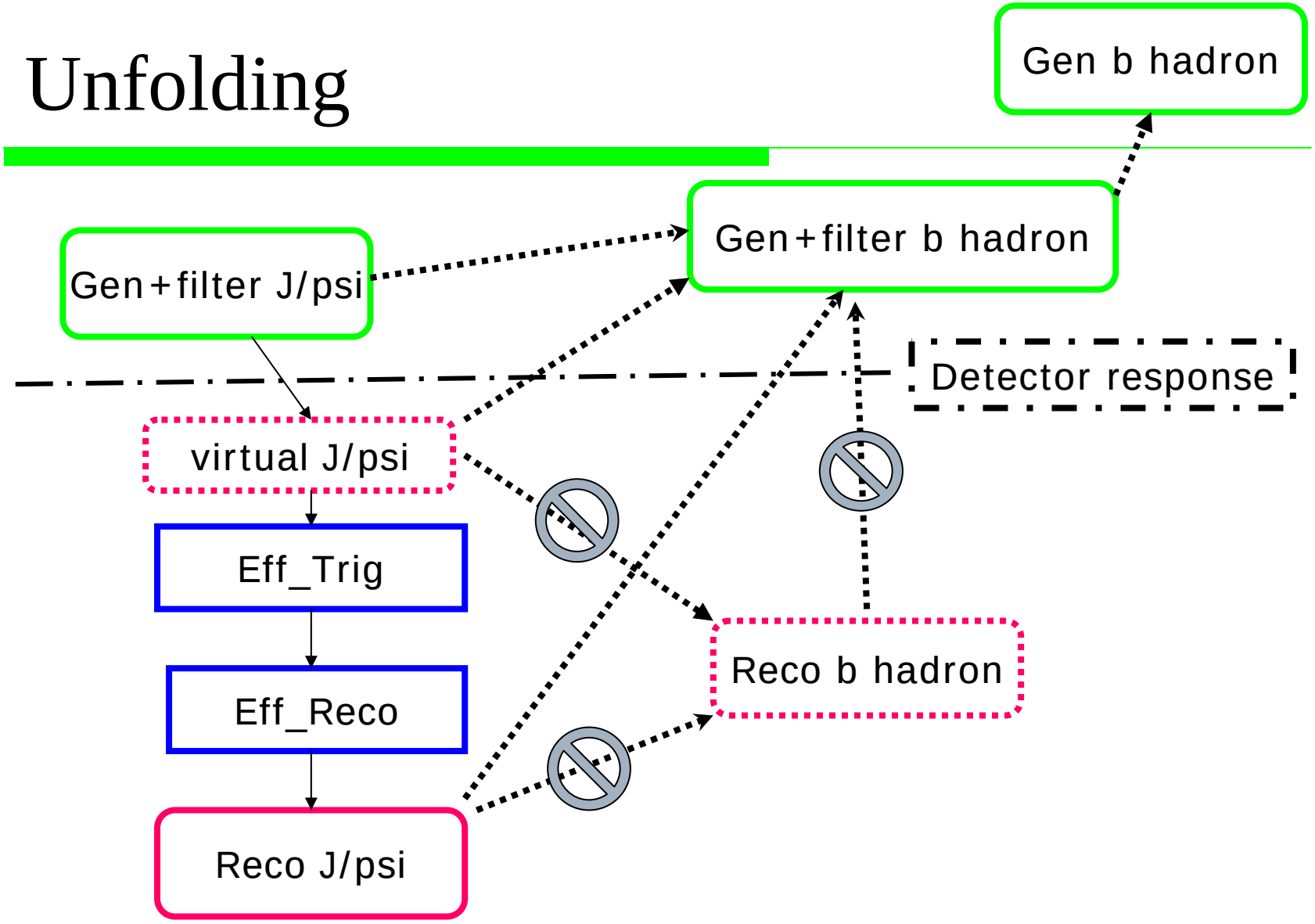


M.C. big sample
Nevt: 160,000



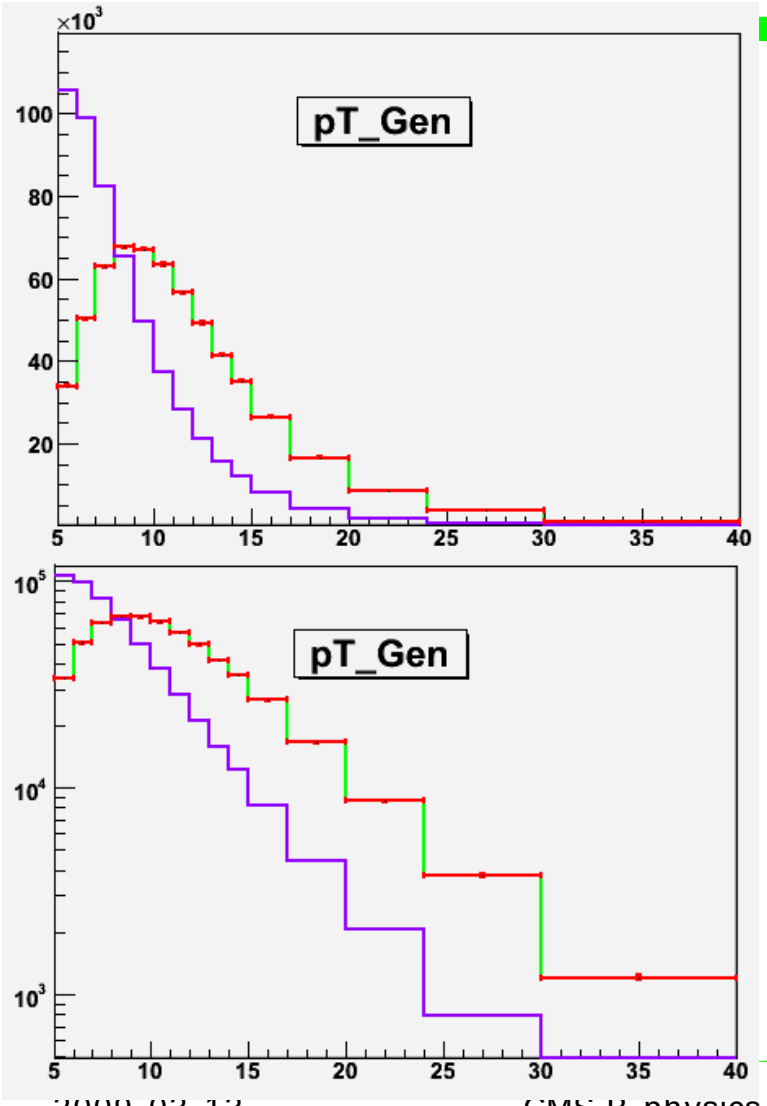


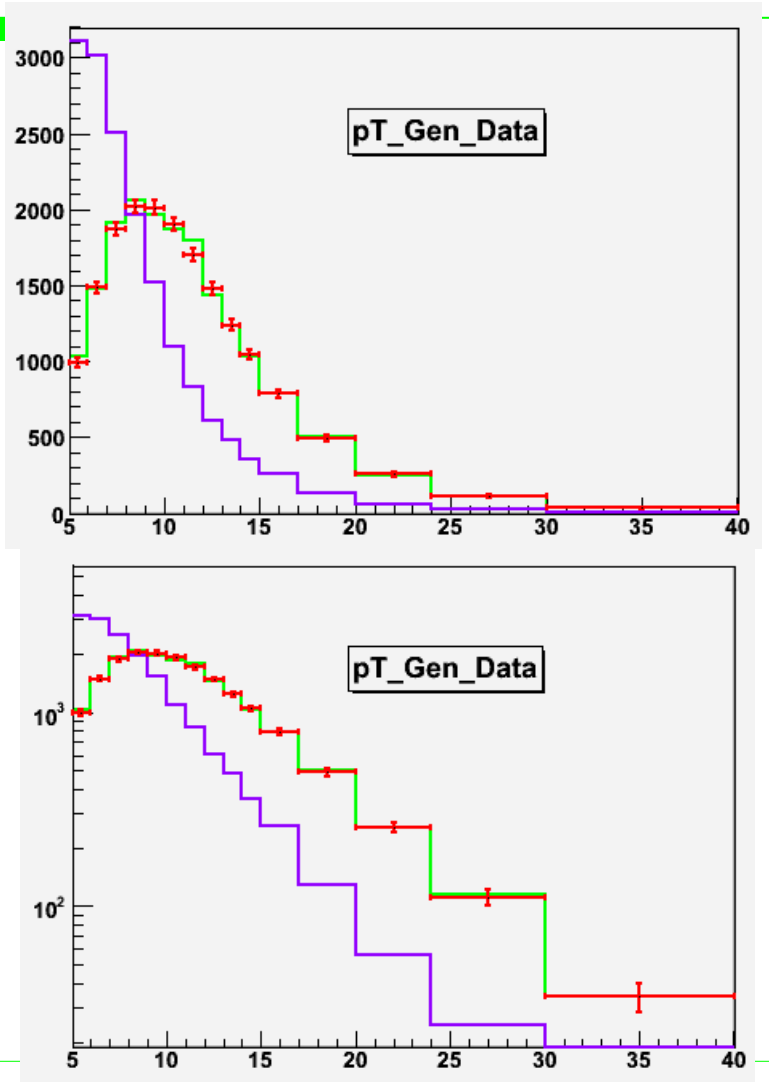
Unfolding


Gen b hadron
Gen+filter b hadron
Gen+filter J/psi
Detector response
virtual J/psi
Eff_Trig
Eff_Reco
Reco b hadron
Reco J/psi

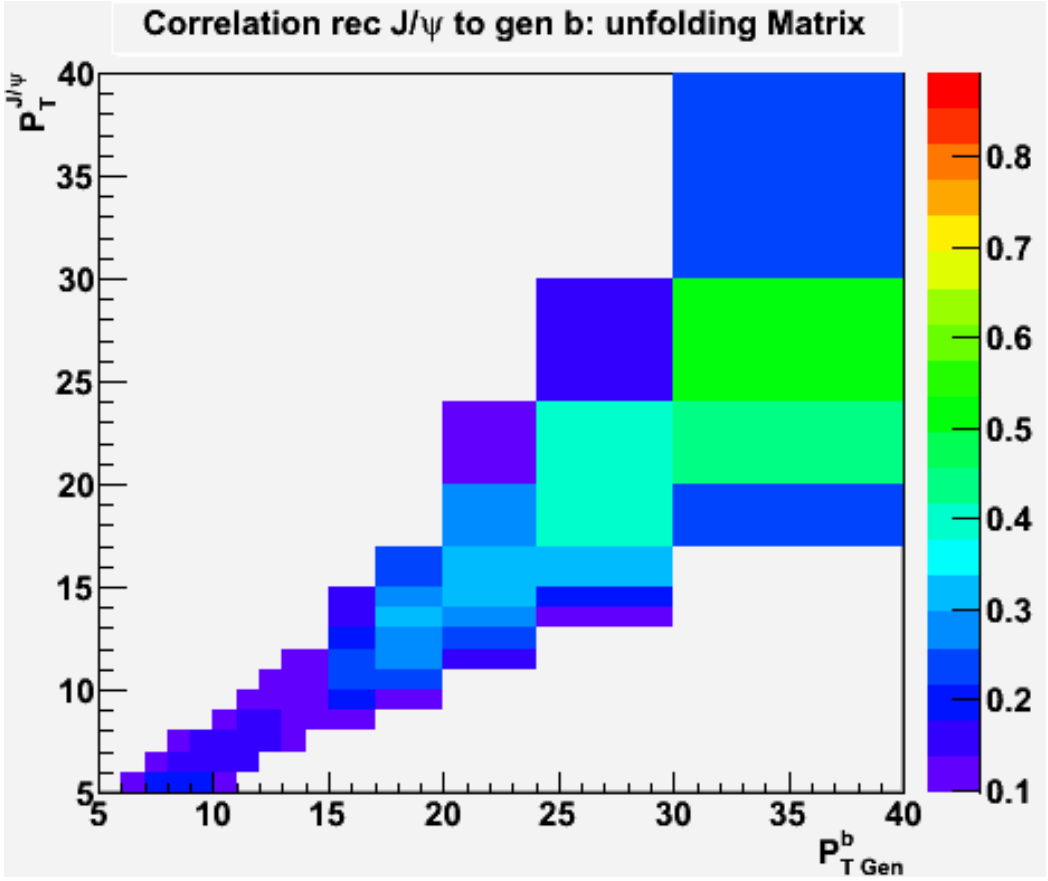
M.C. big sample
Nevt: 700,000

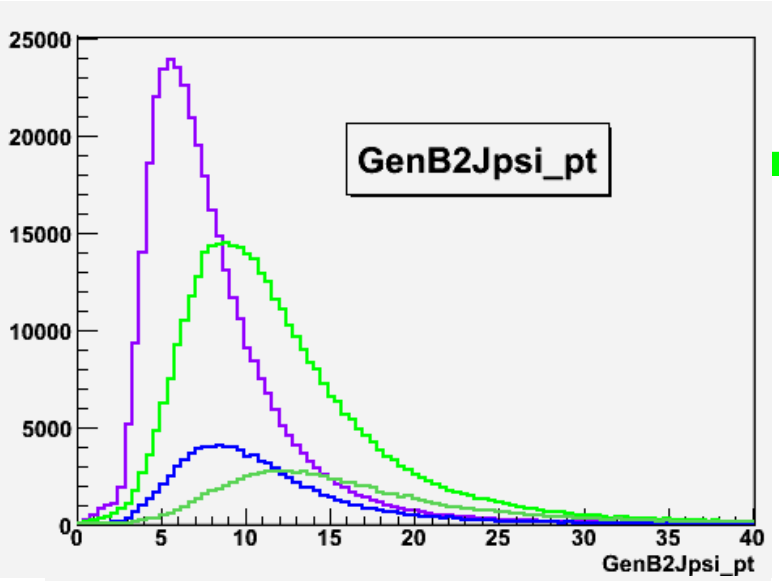
M.C. “real data”
Nevt: 20946

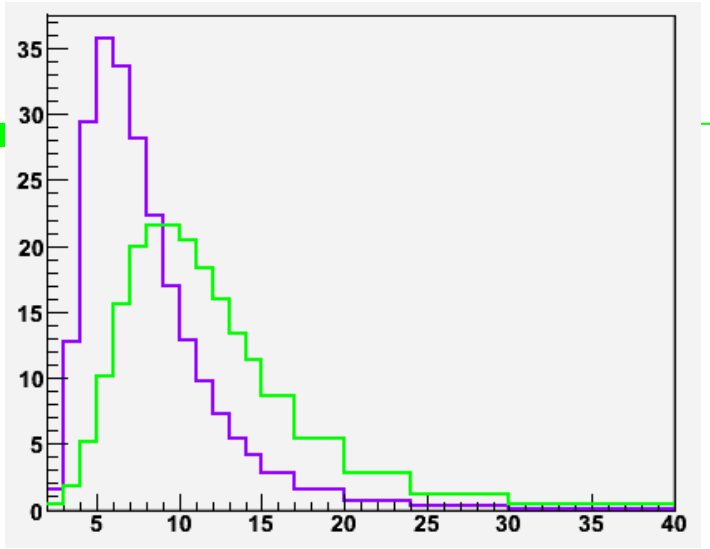


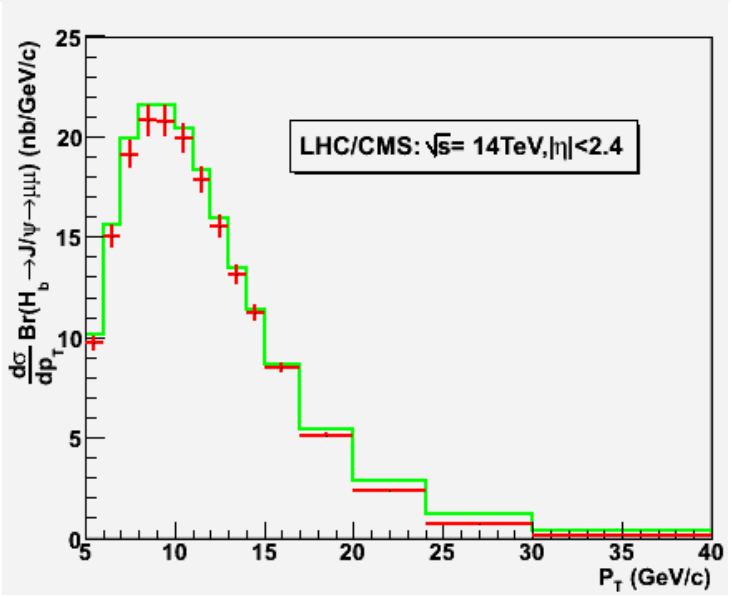


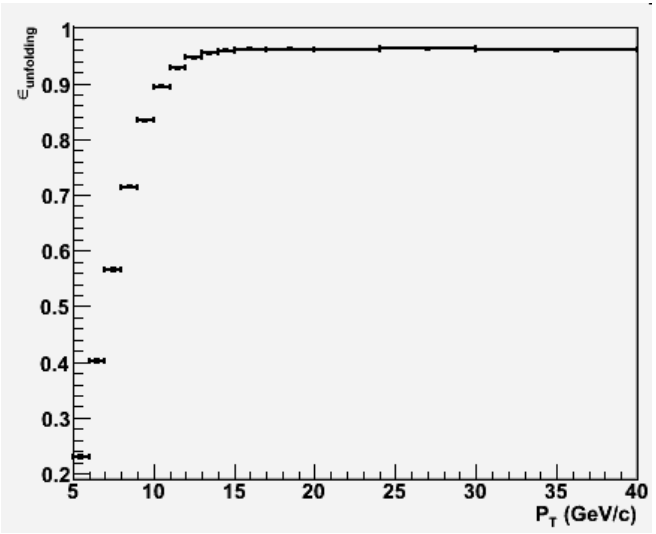
Unfolding Matrix




GenB2Jpsi_pt
GenB2Jpsi_pt




LHC/CMS: √s= 14TeV,|η|<2.4
$\frac{d\sigma}{dp_T}$ Br($H_b \to J/\psi \to \mu\mu$) (nb/GeV/c)
P_T (GeV/c)


$\epsilon_{unfolding}$
P_T (GeV/c)

Inclusive b EvtGen Production

•EvtGen Generator:
10M will for
Gen & Gen+Filter
•Cross-section
σ (tot) * BR(b->J/psi) * BR(J/psi->mumu)
=51.56 mb * 0.0116 * 0.06
=35.886 mub

? 1

filterEfficiency = cms.untracked.double(0.000644)
crossSection = cms.untracked.double(38280000)

```
> Evts generated: 10,000,000
> Evts after filter:        7139
> b and jpsi gened @same point /total
> B0                250/  1357
> anti-B0           282/  1480
> B+                  0/  1464
> B-                  0/  1450
> B_s0              192/   383
> anti-B_s0         203/   415
> Lambda_b0           0/   306
> anti-Lambda_b0      0/   304
> ----------------------------
>     > jpsi/evt, total    7159
      > 0,    3
      > 1,7113
      > 2,   23
```

? 2

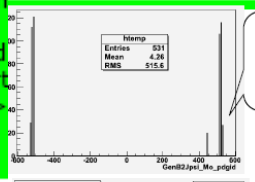
actually it is a problem I asked myself a lot of times,
I don't have a good solution for this. What we do in LHCb is that we generate B+ and Lambda_b0 separatly and then we reweight each sample. But it is not perfect since in Lambda_b0 sample, you have B+ -> Jpsi X coming from the other b quark of the event, then the proportion of B+ -> Jpsi X in the sample is not the one you would like to have

Patrick Robbe LHCb EvtGenLHC
Roberto Covarelli CMS EvtGen
Sarah Dambach CMS EvtGen

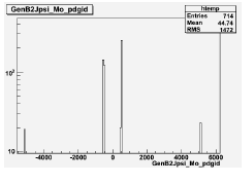
This might be due to a convention of EvtGen for mixing. Wh
EvtGen does is a time-dependent calculation of the mixing probability, but when it has decided if the meson has mixed not (say yes), the flavor is changed just at the ENDING vert
E.g. B0 -> (flies for ~1.5 ps) -> B0bar -> (immediately) ->
J/psi X. Since the only experimental observable is the final flavor this does no affect at all the physics.

2008-10-31 CMS B-physics Group Meeting 10,31,2008

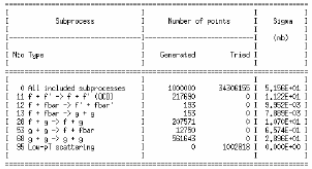
/BtoJpsiMuMu/Summer08_IDEAL_V9_v1/
Gen OK! So go Re-production!



1M Gen's:
B0 511
B+ 521
Bs 531
Λb 5122



•EvtGen Generator:
10M will for
Gen & Gen+Filter
•Cross-section
σ (tot) * BR(b->J/psi) * BR(J/psi->mumu)
=55 mb * 0.0116 * 0.06
=38.28 mub



Cross section

CMS values for the major SM cross sections

These numbers have been obtained by using *PYTHIA* 6.323 (compatible with 6.227) with *CTEQ5L* (default PDF for PTDR) and with *CTEQ6M* structure functions .
Note, that *alpha_s* at *1st (2nd)* order is used with *STEQ5L (CTEQ6M)*.
P0 stands for PThat_min
X-section values evaluated with CTEQ6M include the errors (+/- in %) due to PDFs

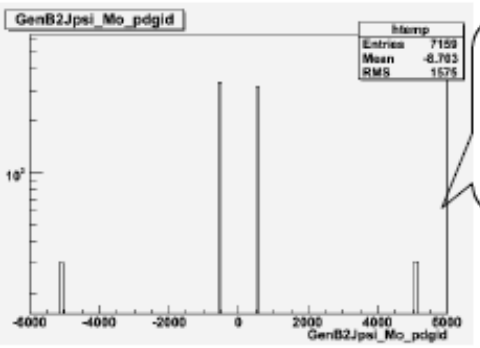
Process	Cross section value	Comment
σ_{tot}	110 +/- 10 mb	different models
σ_{tot}	111.5 +/- 1.2 +4.1 -2.1 mb	COMPETE coll.

Heavy quarks			
b b~, Mb = 4.8 GeV Details	479 mub	187 mub (+9.67 -13.2)%	
t t~, *Mt = 175 GeV*	830 +/- 90 pb		NLO
t t~, *Details*	488 pb	492.9 pb (+3.24 -3.31)%	PYTHIA (LO)
single top, *Details*			
g g + q q~ -> t t~ b b~	10 pb		AcerMC 1.2
Inclusive Higgs (mH = 150 GeV)	23.8 pb		
Inclusive Higgs (mH = 500 GeV)	3.8 pb		

Gen vertex: GenParticles

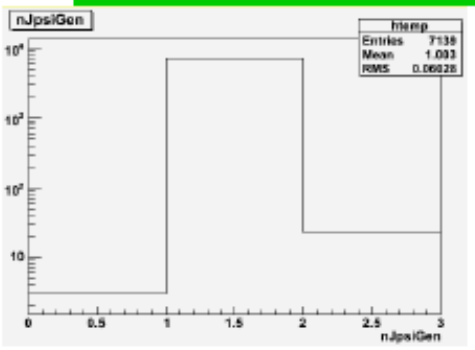
Gen pdg_id & Lxy, Pdl_B & Pdl_jpsi

•Jpsi ->(....)->b hadrons

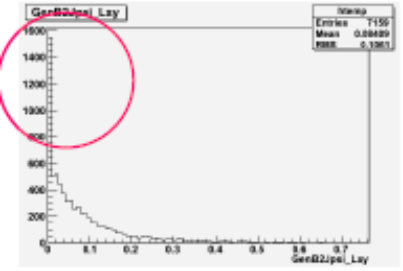


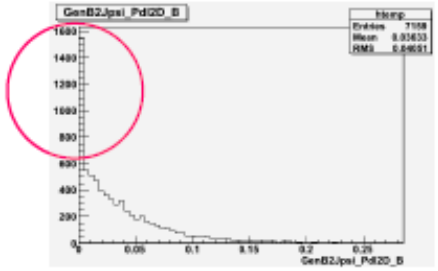
10M Gen's:

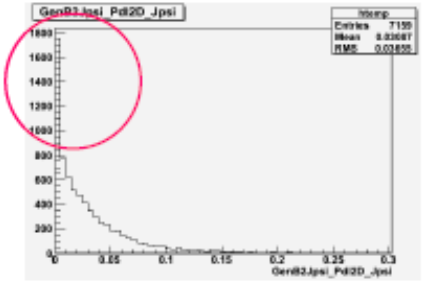
B0	511
B+	521
Bs	531
Λb	5122



HepMC:
- GenEvent
  - GenVertex
    - particles_in_const_iterator
    - particles_out_const_iterator







L1 & HLT

- TWiki > CMS Web > WorkBook > WorkBookHLTTutorial
  https://twiki.cern.ch/twiki/bin/view/CMS/WorkBookHLTTutorial
  HLTrigger/HLTanalyzers : HLTanalyzers

- Use the ConfDB web browser to browse the content of the configuration database and inspect available HLT menus.
  http://cms-project-confdb-hltdev.web.cern.ch/cms-project-confdb-hltdev/browser/

  - HLT paths: HLT_2E30_cff.py
  - L1 Global Trigger: Available Trigger Menus
  - Trigger Tables

L1T-Report CMSSW_2_1_12

L1T-Report ---------- Event Summary ----------

DAQ partition	Total	Passed	Rejected	Errors
0	6339	6339	0	0
1	6339	6339	0	0

L1T-Report ---------- L1 Trigger Global Summary - DAQ Partition ----------

Trigger Menu Key	Algorithm Key	Prescale	Mask	Passed	Rejected	Error
L1Menu2008_2E30	L1_DoubleEG1	1	0	5601	738	0
L1Menu2008_2E30	L1_DoubleEG10	1	0	11	6328	0
L1Menu2008_2E30	L1_DoubleEG15	1	0	2	6337	0
L1Menu2008_2E30	L1_DoubleEG5	1	0	85	6254	0
L1Menu2008_2E30	L1_DoubleIsoEG10	1	0	5	6334	0
L1Menu2008_2E30	L1_DoubleIsoEG8	1	0	11	6328	0
L1Menu2008_2E30	L1_DoubleMu3	1	0	2921	3418	0
L1Menu2008_2E30	L1_SingleMu0	1	0	5141	1198	0
L1Menu2008_2E30	L1_SingleMu10	1	0	1455	4884	0
L1Menu2008_2E30	L1_SingleMu14	1	0	610	5729	0
L1Menu2008_2E30	L1_SingleMu20	1	0	282	6057	0
L1Menu2008_2E30	L1_SingleMu25	1	0	191	6148	0
L1Menu2008_2E30	L1_SingleMu3	1	0	4899	1440	0
L1Menu2008_2E30	L1_SingleMu5	1	0	3808	2531	0
L1Menu2008_2E30	L1_SingleMu7	1	0	2614	3725	0
L1Menu2008_2E30	L1_SingleMuBeamHalo	1	0	191	6148	0
L1Menu2008_2E30	L1_SingleMuOpen	1	0	5719	620	0

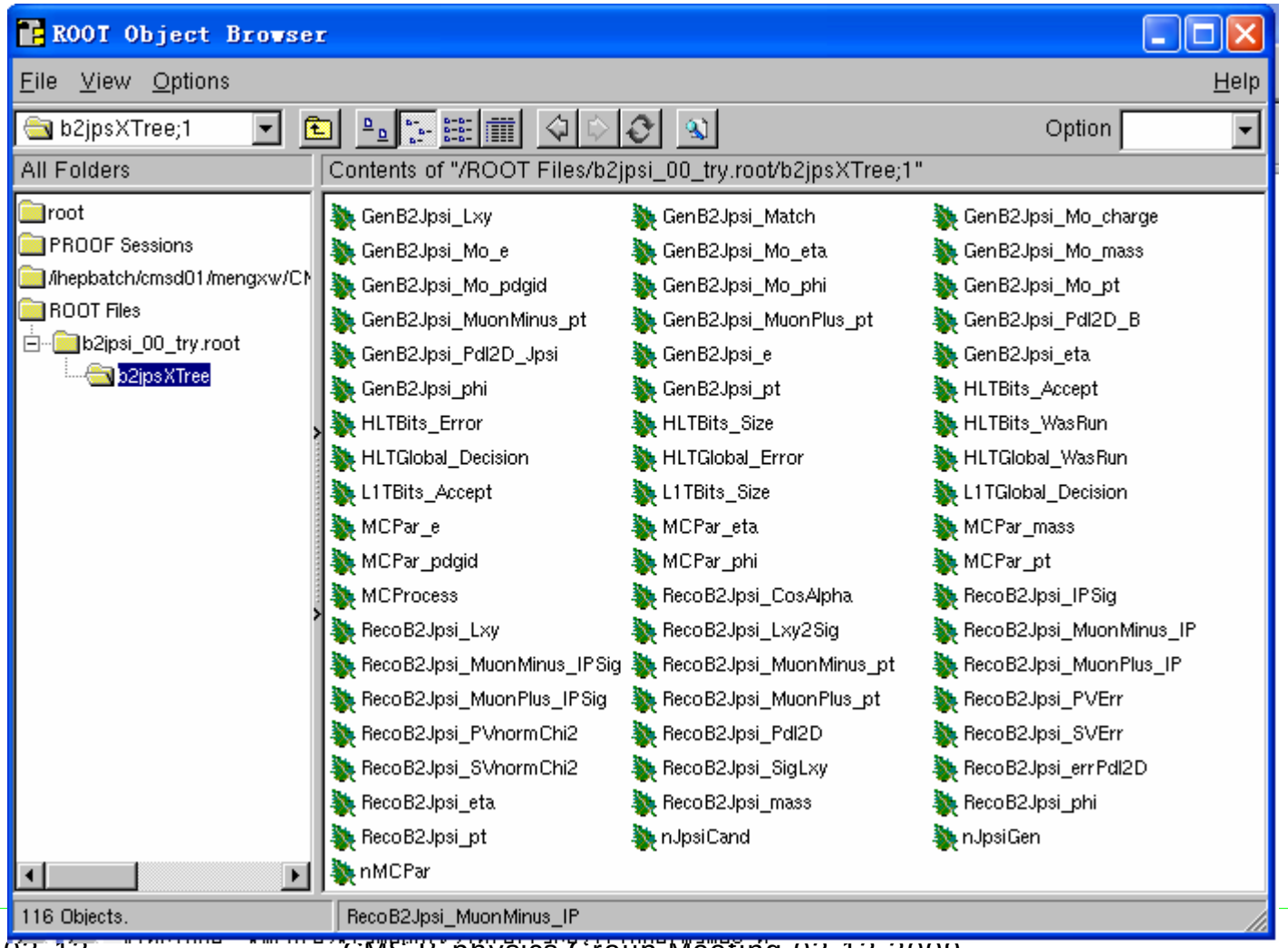
HLT-Report CMSSW_2_1_12

```
HLT-Report ---------- Event  Summary ------------
HLT-Report Events total = 6339 wasrun = 6339 passed = 6339 errors = 0

HLT-Report ---------- HLTrig Summary ------------
HLT-Report  HLT  Bit#    WasRun    Passed    Errors Name
HLT-Report        0      6339      6339         0 generation_step
HLT-Report        1      6339      6339         0 simulation_step
HLT-Report        2      6339      6339         0 digitisation_step
HLT-Report        3      6339      6339         0 L1simulation_step
HLT-Report        4      6339      6339         0 digi2raw_step
HLT-Report        5      6339         0         0 HLTriggerFirstPath
HLT-Report        6      6339      1579         0 HLT_L1Jet15
HLT-Report        7      6339       966         0 HLT_Jet30

HLT-Report       72      6339      3834         0 HLT_L1Mu
HLT-Report       73      6339      5719         0 HLT_L1MuOpen
HLT-Report       74      6339       763         0 HLT_L2Mu9
HLT-Report       75      6339       311         0 HLT_IsoMu9
HLT-Report       76      6339       124         0 HLT_IsoMu11
HLT-Report       77      6339        66         0 HLT_IsoMu13
HLT-Report       78      6339        35         0 HLT_IsoMu15
HLT-Report       79      6339      3966         0 HLT_Mu3
HLT-Report       80      6339      2470         0 HLT_Mu5
HLT-Report       81      6339      1210         0 HLT_Mu7
HLT-Report       82      6339       612         0 HLT_Mu9
HLT-Report       83      6339       314         0 HLT_Mu11
HLT-Report       84      6339       178         0 HLT_Mu13
HLT-Report       85      6339       113         0 HLT_Mu15
```

HLT-Report CNT.

```
HLT-Report      86     6339      117        0 HLT_Mu15_L1Mu7
HLT-Report      87     6339      117        0 HLT_Mu15_Vtx2cm
HLT-Report      88     6339      117        0 HLT_Mu15_Vtx2mm
HLT-Report      89     6339      769        0 HLT_DoubleIsoMu3
HLT-Report      90     6339     1389        0 HLT_DoubleMu3
HLT-Report      91     6339     1389        0 HLT_DoubleMu3_Vtx2cm
HLT-Report      92     6339     1380        0 HLT_DoubleMu3_Vtx2mm
HLT-Report      93     6339     1150        0 HLT_DoubleMu3_JPsi
HLT-Report      94     6339       53        0 HLT_DoubleMu3_Upsilon
HLT-Report      95     6339        1        0 HLT_DoubleMu7_Z
HLT-Report      96     6339      143        0 HLT_DoubleMu3_SameSign
HLT-Report      97     6339        8        0 HLT_DoubleMu3_Psi2S

HLT-Report     116     6339     1138        0 HLT_DoubleMu3_BJPsi
HLT-Report     117     6339      760        0 HLT_DoubleMu4_BJPsi
HLT-Report     142     6339     6339        0 HLT_ZeroBias
HLT-Report     143     6339     2287        0 HLT_MinBias
HLT-Report     144     6339     1213        0 HLT_MinBiasHcal
HLT-Report     145     6339     5682        0 HLT_MinBiasEcal
HLT-Report     146     6339     6337        0 HLT_MinBiasPixel
HLT-Report     147     6339     1463        0 HLT_MinBiasPixel_Trk5
HLT-Report     148     6339        0        0 HLT_BackwardBSC
HLT-Report     149     6339        0        0 HLT_ForwardBSC
HLT-Report     150     6339      191        0 HLT_CSCBeamHalo
HLT-Report     151     6339        0        0 HLT_CSCBeamHaloOverlapRing1
HLT-Report     152     6339        0        0 HLT_CSCBeamHaloOverlapRing2
HLT-Report     153     6339       74        0 HLT_CSCBeamHaloRing2or3
HLT-Report     154     6339        0        0 HLT_TrackerCosmics
HLT-Report     155     6339        2        0 AlCa_IsoTrack
HLT-Report     156     6339     6339        0 AlCa_EcalPhiSym
HLT-Report     157     6339      128        0 AlCa_EcalPi0
HLT-Report     158     6339        0        0 HLTriggerFinalPath
```

final EDAnalyzer rootuple via CMSSW_2_1_12



backups