Heavy Ion DiMuon Trigger

1. DiMuon Trigger Improvement
2. Oct. 5th Trigger Review Preparation
3. HydJet Validation related to DiLepton Group (Backup Slide 23-29)

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2009/09/26 CMS KR Meeting

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Part 3. Hydjet Validation related to Quarkonia (Backup Slide 23-29)

1) Quarkonia Production in Hydjet Sample
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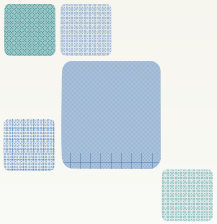


PART 1

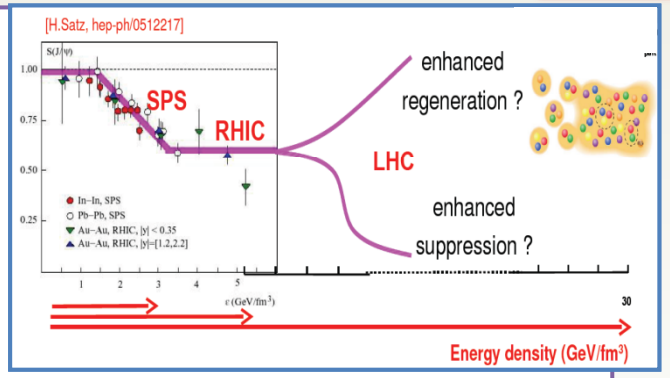
Heavy Ion DiMuon Trigger Improvement

CMS-KR Meeting 2009 0926

Heavy Ion DiMuon Trigger

1. Study Motivation

1) Heavy quarkonia (J/ψ, Υ) suppression is generally used for understanding the formation of the QGP, which will be created in HI collision at LHC.
2) Almost low-p_T quarkonia will also decay into low-p_T muons, which are hardly measured at Muon system due to CMS dedicated to search high-p_T particles. (default muon trigger was set with 3 GeV/c p_T cut in pp measurement, but now DoubleMu0 is included at Dec. 15th 2008)
3) Full p_T spectrum of quarkonia covering low-p_T region is necessary not only in HI but also in p+p (as reference measurements) collisions using CMS dimuon trigger in order to compare RHIC measurement limited at low-p_T region.
4) CMS detector can measure muons' momentum down to ~1 GeV/c in the forward region.



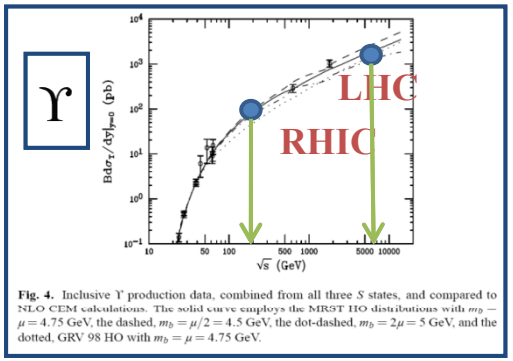


Fig. 4. Inclusive Υ production data, combined from all three S states, and compared to NLO CEM calculations. The solid curve employs the MRST HO distributions with $m_b = \mu = 4.75$ GeV, the dashed, $m_b = \mu/2 = 4.5$ GeV, the dot-dashed, $m_b = 2\mu = 5$ GeV, and the dotted, GRV 98 HO with $m_b = \mu = 4.75$ GeV.

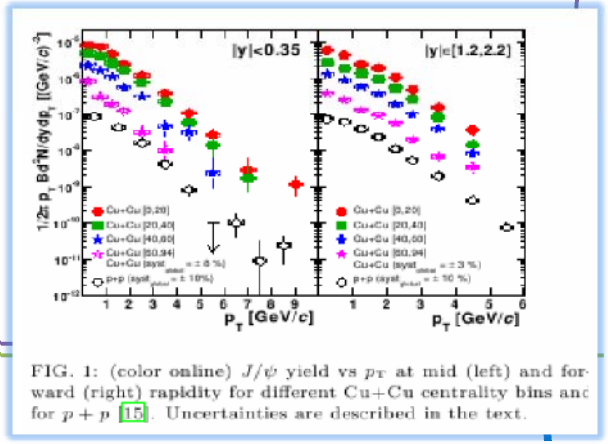
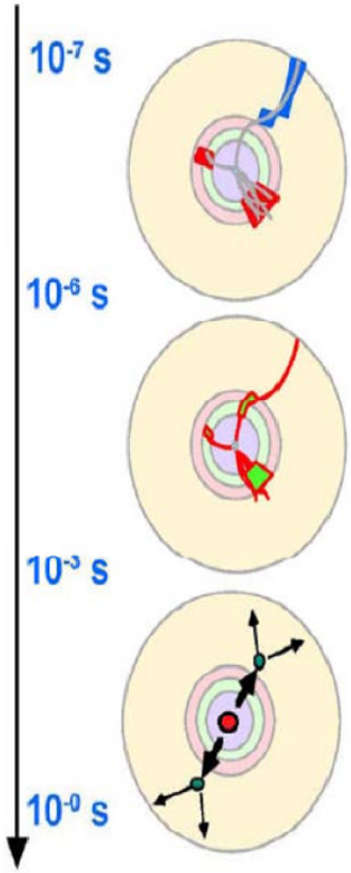


FIG. 1: (color online) J/ψ yield vs p_T at mid (left) and forward (right) rapidity for different Cu+Cu centrality bins and for $p+p$ [15]. Uncertainties are described in the text.

Heavy Ion DiMuon Trigger

2. CMS Muon Trigger

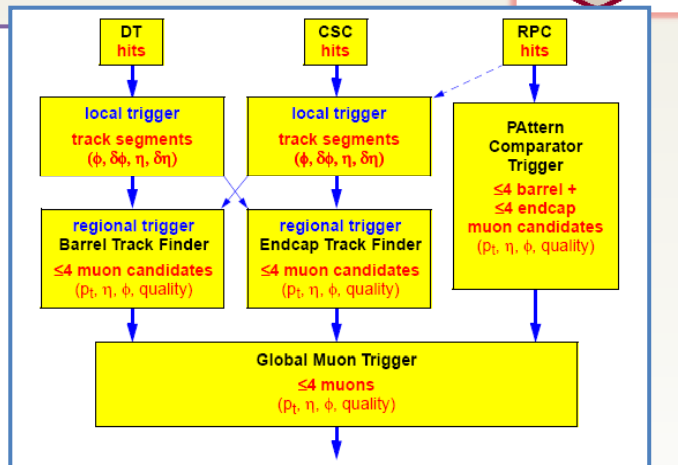


Collision rate 10^9 Hz
Channel data sampling at 40 MHz

Level-1 selected events 10^5 Hz
Particle identification (High p_T e, μ, jets, missing E_T)
- Local pattern recognition
- Energy evaluation on prompt macro-granular information

Level-2 selected events 10^3 Hz
Clean particle signature (Z, W, ..)
- Finer granularity precise measurement
- Kinematics. effective mass cuts and event topo
- Track reconstruction and detector matching

Level-3 events to tape 10..100 Hz
Physics process identification
- Event reconstruction and analysis



Algorithm of L1 Trigger

L2 Muon Reconstruction
- Seeded by L1 muons
- STA muon reco

L3 Muon Reconstruction
- Seeded by L2 muons
- Tracker muon & vtx reco
- Globla muon reco : matcing with STAMuon

Algorithm of High Trigger

Heavy Ion DiMuon Trigger

3. CMS Heavy Ion DiMuon Trigger

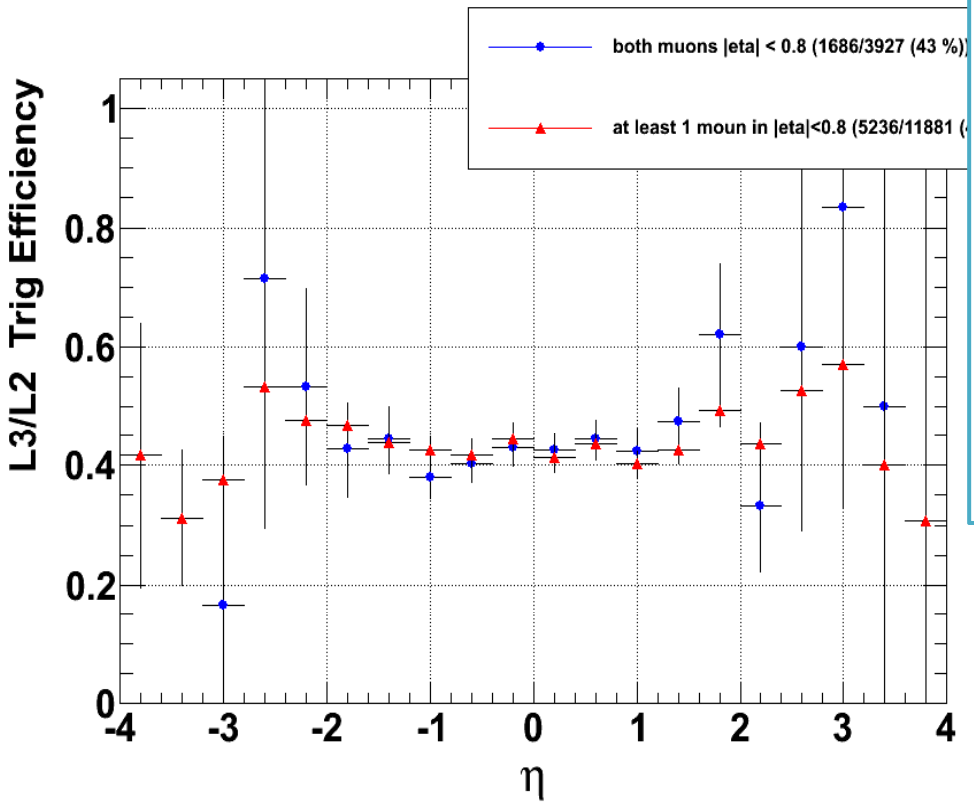
> Path Name : HLT_HIDoubleMu
> L1 condition : L1_DoubleMuOpen (Low quality and 2 muons)
> L1 – L2 : using p-p L1-L2 trigger algorithm

> L3 HI DiMuon trigger algorithm
  > Investigation on Primary Vertex existence (≥ 1)
  > L2 accepted : number of L2 muon ≥ 2 on L2 Muon Collection
  > Fast Muon Propagation : from Muon station to tracker
  > DiMuon Seeding
  > Trajectory Building (from outside to inside)
  > DiMuon's Vertex finding (if the vertex is found, L3 accepted)

Heavy Ion DiMuon Trigger

4. Starting Poing & Previous L3/L2 efficiency

> Data : 100k Upsilon produced (Ramona's distribution)



> Reported at Physics Review

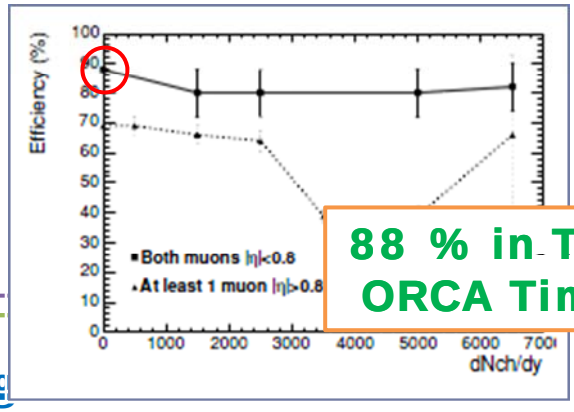
> Trigger report

TrigReport ---------- Module Summary ----------

Visited	Passed	Failed	Name
100000	25428	74572	hltHIL1sDoubleMu
25428	5392	20036	hltHIMML3Filter

> L3/L2 trigger efficiency : 43 % in the barrel

> The conclusion : the HLT is 20 times faster but efficiency ½



88 % in TDR, ORCA Times

Heavy Ion DiMuon Trigger

5. Why is ½ lower than ORCA times ?

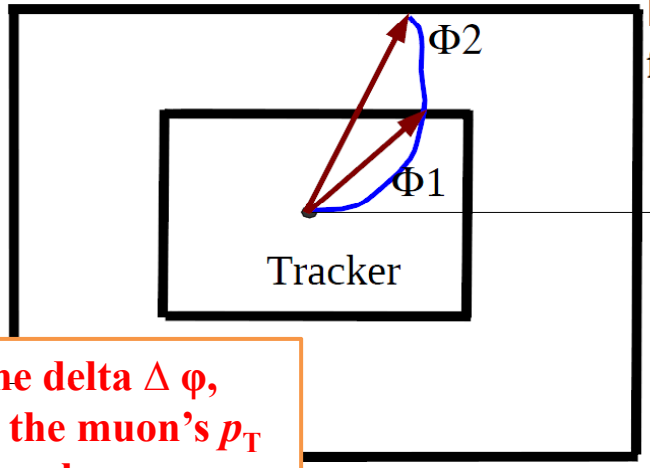
1) Fast Muon propagation Seeding Parameter was calculated at 4 T

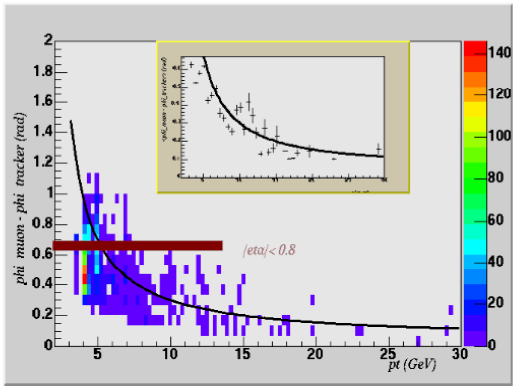
Fast Muon propagation

Using L1 or L2 muon candidate from prompt muon sample (isolated muons sample):

Tables $|\phi_{L2/L1}^{\mu} - \phi_{RecHit}^{\mu}|$ vs $P_T^{L1/L2}$ for barrel

$|\phi_{L2/L1}^{\mu} - \phi_{RecHit}^{\mu}|$ vs $P_z^{L1/L2}$ for endcap are generated.





If we have the delta Δ φ, we can predict the muon's p_T in the tracker

Parametrization of Z-prediction with line: between Zvertex and R,Z

Previous calculation was done in 4 T. So it is needed to be calculated again in 3.8 T

Presented at 7th of May in the Dilepton Meeting by Olga

or low P m

Heavy Ion DiMuon Trigger

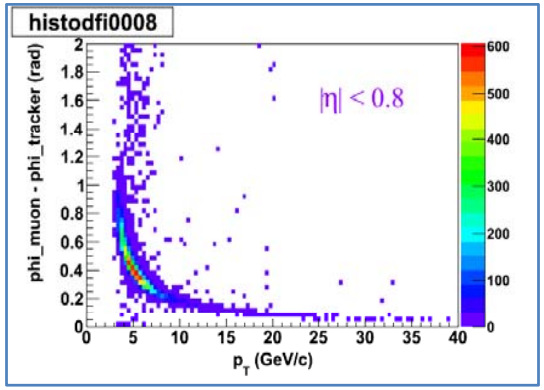
5. Why is ½ lower than ORCA times ?

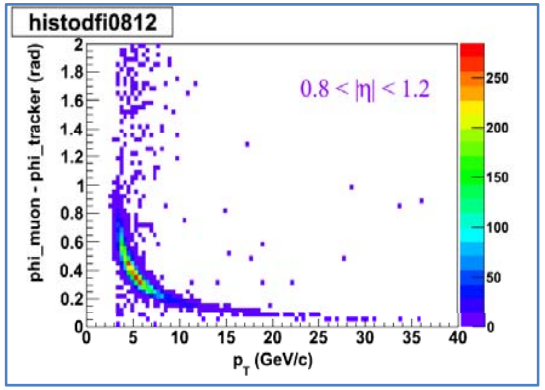
1) Fast Muon propagation Seeding Parameter was calculated at 4 T

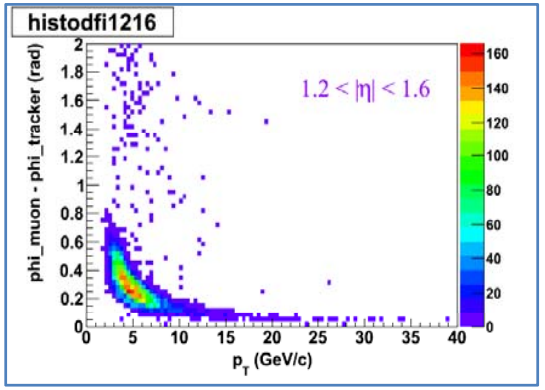
> $phi_{L2Muon} - phi_{RecHit\ in\ the\ Tracker}$ vs $MuonP_T$

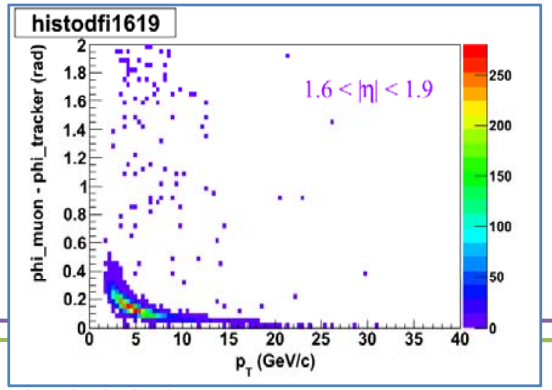
> depending on 5 η region

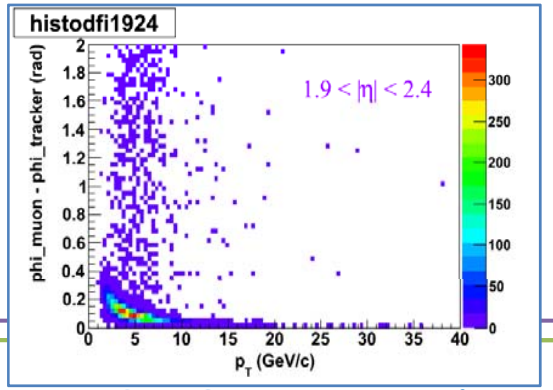
(|η| : < 0.8, 0.8 ~ 1.2, 1.2 ~ 1.6, 1.6 ~ 1.9, 1.9 ~ 2.4)











Heavy Ion DiMuon Trigger

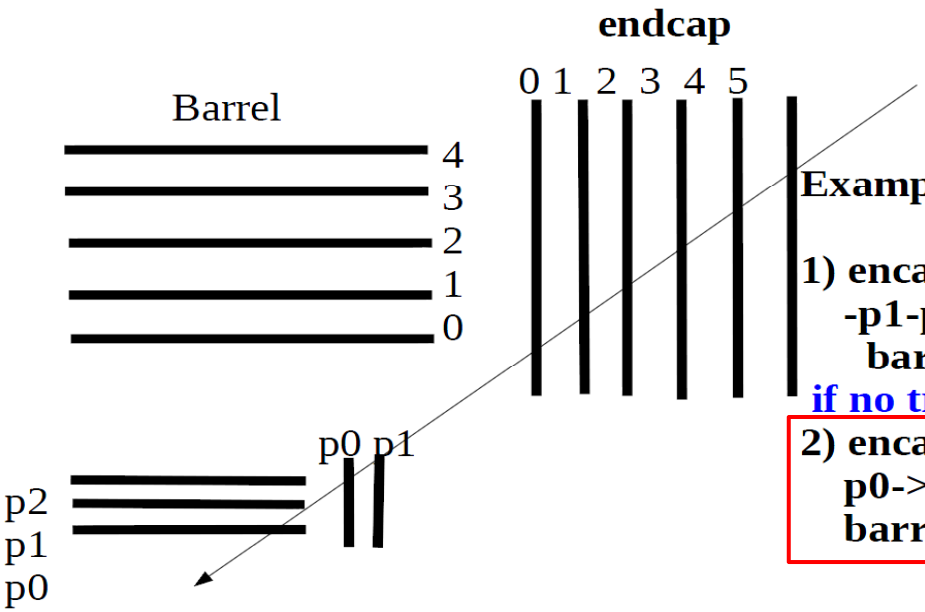
5. Why is ½ lower than ORCA times ?

2) Lost cluster treatment is added in the navigation set for endcap

Navigation set for HI

No empty layers during propagation are allowed!
At least 1 pixel hit is required
Primary vertex position is known.

A set of layers navigations is created and passed to the HICCombinatorialTrajectoryFinder



Presented at 7th of May in the Dilepton Meeting by Olga

Examples of navigation:

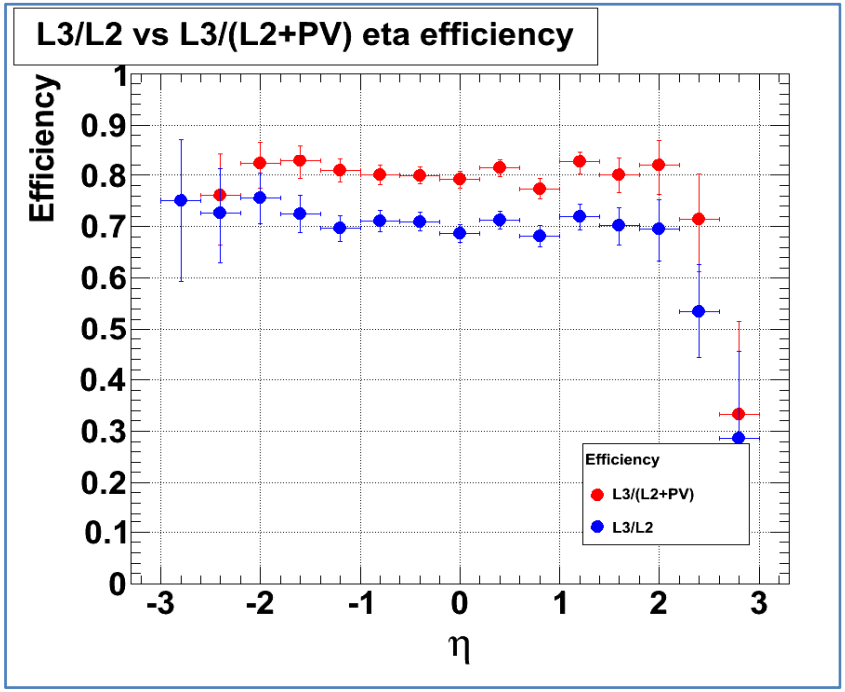
1) encap 5-4-3-2-1-0-
-p1-p0->
barrel p1-p0
if no trajectories are found

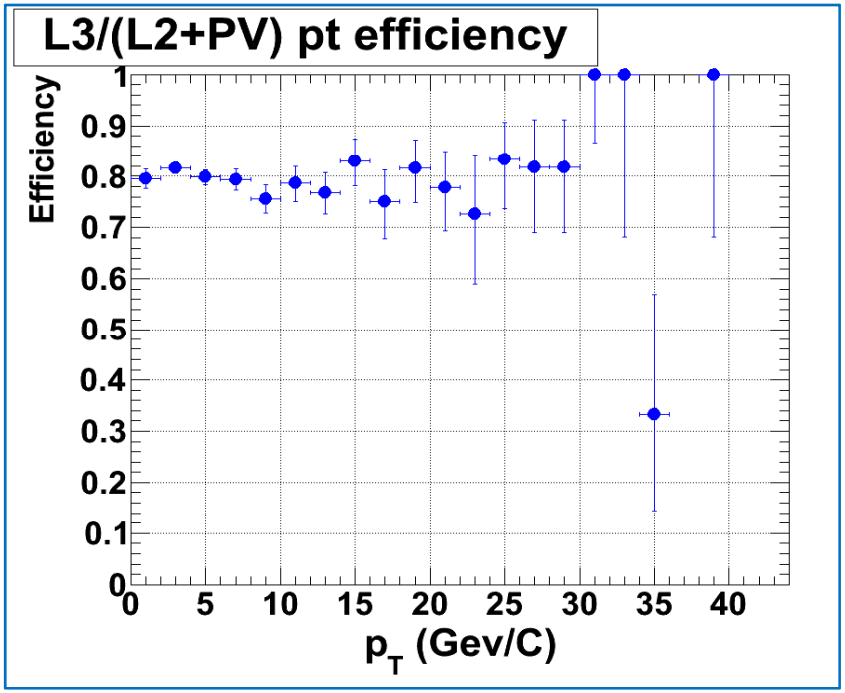
2) encap 5-3-2-1-0-p1-
p0->
barrel p1-p0

Heavy Ion DiMuon Trigger

6. Current Performance in Barrel (|eta| < 0.8)

RecoHIMuon/HiMuSeed V00-03-01
RecoHIMuon/HiMuTracking V00-03-01
RecoHIMuon/HiMuPropagator V00-02-00





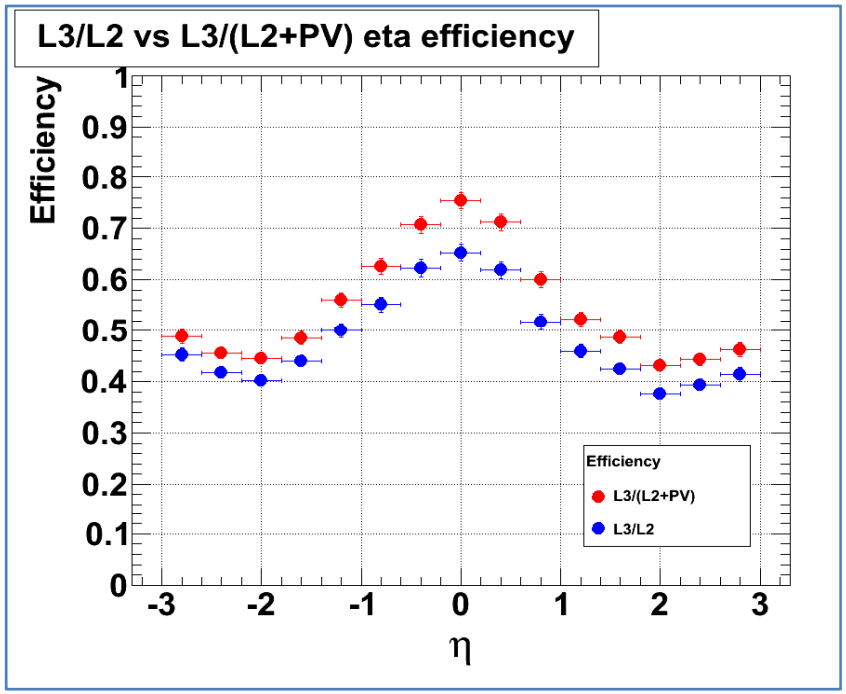
1) L3/L2 Accepted efficiency : 2982/4253 = 70 %
2) L3/(L2 Acc + P.V) efficiency : 2982/3726 = 80 %
(TDR ~ 88 %) closer to ORCA Times

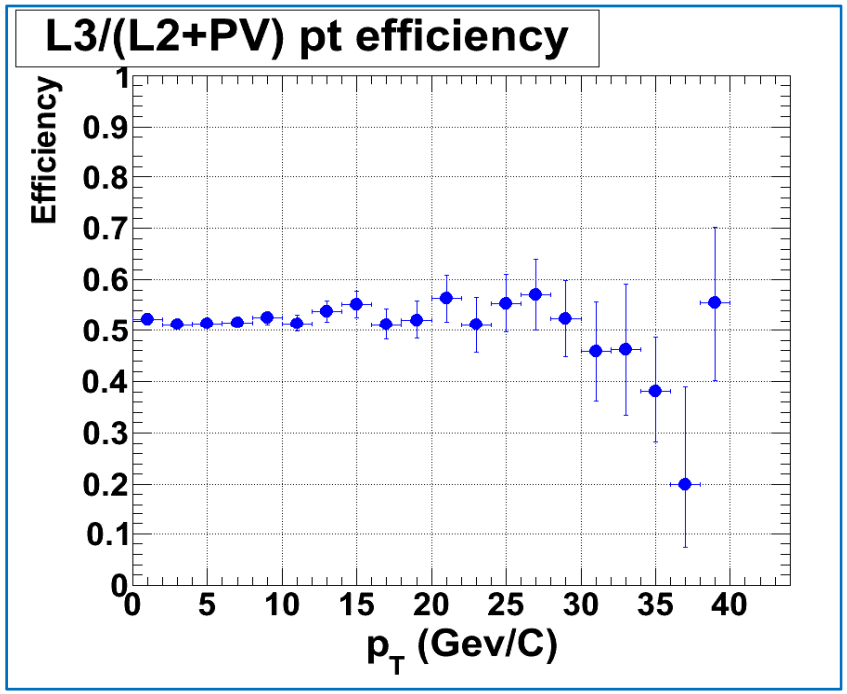
http://www.cms-kr.org/twiki/bin/view/HeavyIon/DongHosLogHITestMuL3FilterStudy

Heavy Ion DiMuon Trigger

6. Current Performance in Barrel + Endcap

RecoHIMuon/HiMuSeed V00-03-01
RecoHIMuon/HiMuTracking V00-03-01
RecoHIMuon/HiMuPropagator V00-02-00





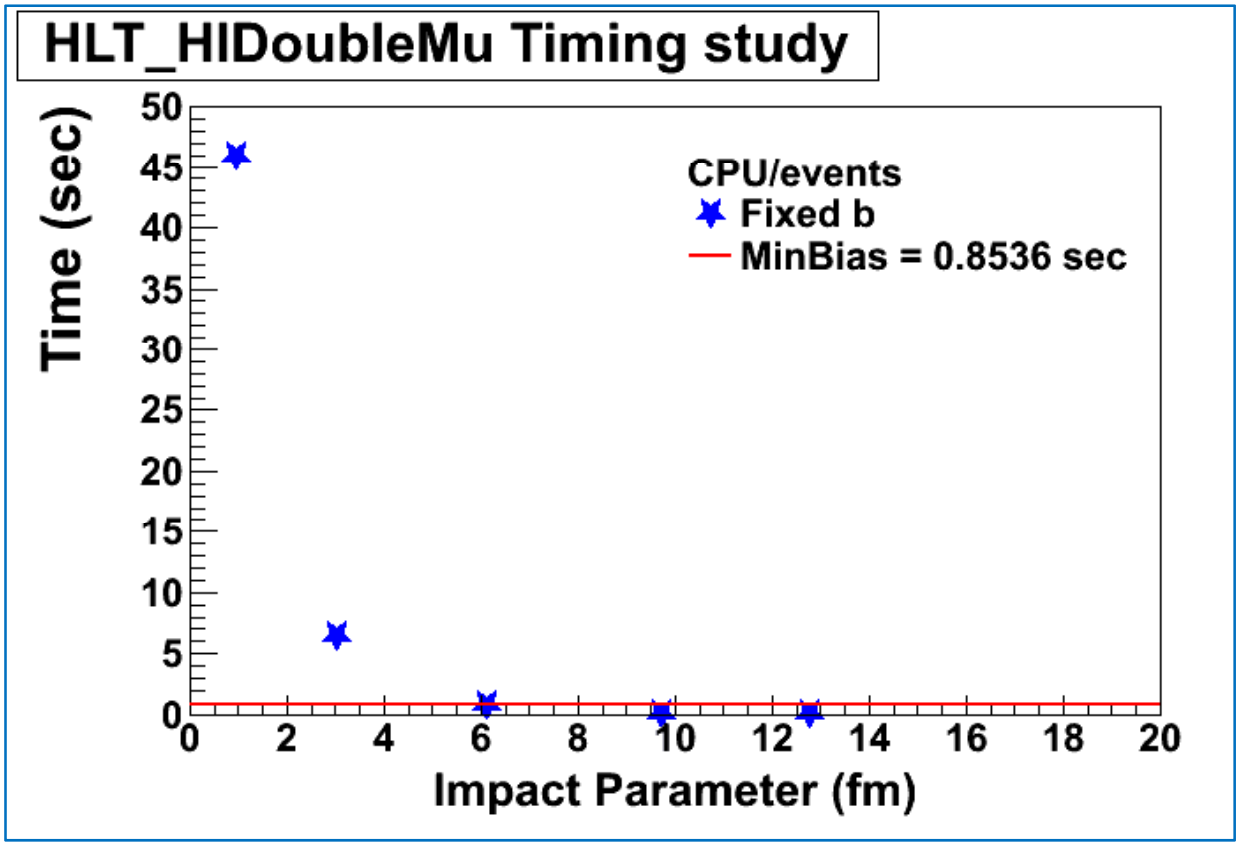
1) L3/L2 Accepted efficiency : 2982/4253 = 46 %
2) L3/(L2 Acc + P.V) efficiency : 2982/3726 = 51 %

http://www.cms-kr.org/twiki/bin/view/HeavyIon/DongHosLogHITestMuL3FilterStudy

Heavy Ion DiMuon Trigger

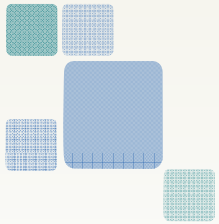
7. Timing Study with hltTiming Summary tool

RecoHIMuon/HiMuSeed V00-03-01
RecoHIMuon/HiMuTracking V00-03-01
RecoHIMuon/HiMuPropagator V00-02-00



0.8536 sec in
the case of MinBias
is enough !!

http://www.cms-kr.org/twiki/bin/view/HeavyIon/DongHosLogHITestMuL3FilterStudy



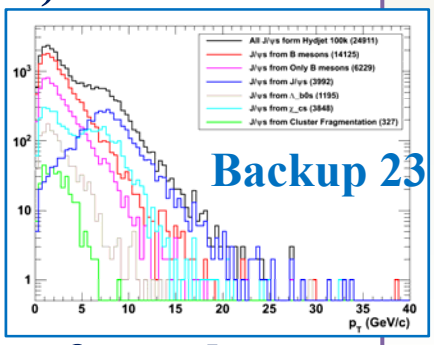
PART 2

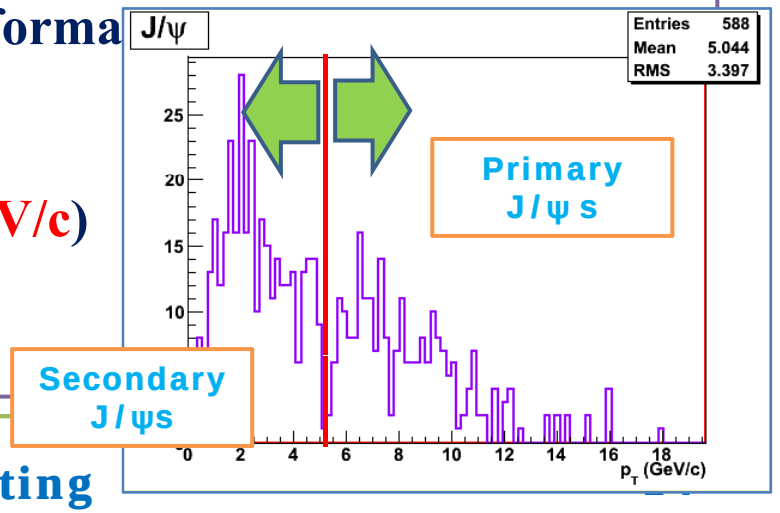
Oct. 5th Trigger Review Preparation

CMS-KR Meeting 2009 0926

Trigger Review Preparation

1. Overview of Trigger Study
   1) Date Oct. 5th , 3 PInG HLT representatives should present for each group (3 PinG : High p_T Jet, Photon, Dilepton)
   2) Requirement from TSG (Trigger Study Group)
      >> Trigger Efficiency
      >> Trigger Rate and Fake Rate
      >> Timing Study of Trigger
2. Study Tools
   1) Open HLT tools : Official Tools which TSG require perform the Estimation of Efficiency and Rate
   2) hltTimingSummaryTools : Timing informa
3. Generation Sample
   1) 40 k Hydjet samples are ready
      >> Quarkonia turn on (pthat = 7 GeV/c)
      >> Photon channels switched on



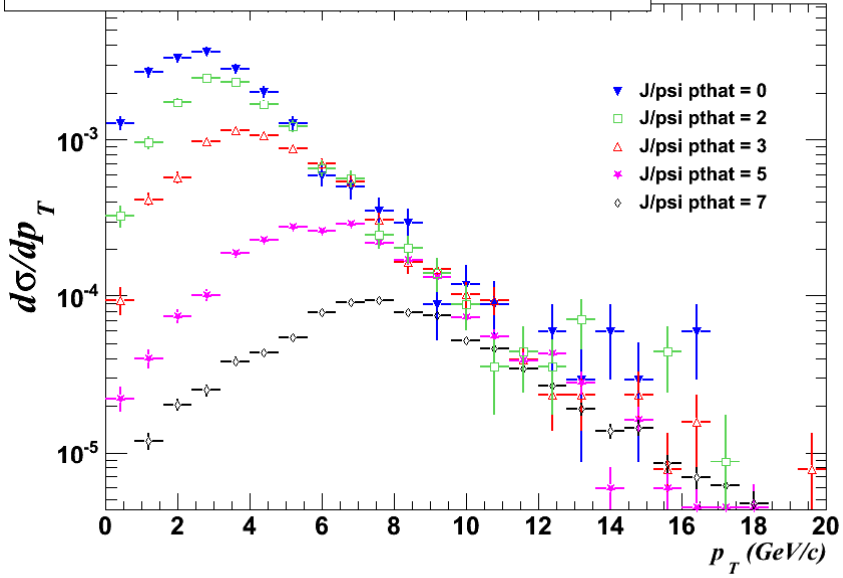


Trigger Review Preparation

4. Data sample discussion

1) PInG Dilepton group proposed MinBias Hydjet + Embedding

2) J/ψ production information as p_T hat 0, 2, 3, 5, 7 GeV/c with pythia6 generator. >> conclusion : it should go down to 2 ~ 3 GeV/c



3) In order to investigate the effect of trigger rate when going down to 2 ~ 3 GeV/c pT hat, required special request samples to turn off hydro part at b = 0 (central collision)

Trigger Review Preparation

5. Open HLT running

1) twiki page : https://twiki.cern.ch/twiki/bin/view/CMS/HIHLTReview2009

2) Everyday 2 pm meeting in the MIT office until Trigger Review day

3) Structure of Open HLT

a) HLTAnalyzer : Making the Ntuple of each MC and Trigger info

>> HLTMuon.cc filling up the L2 & L3 muon info
(HI DiMuon doesn't record L3 muon information due to save time for running HLT. It should be modified for HI.

>> Instead of L3MuonCands, gen muons are used for L3 info when "HLT_HIDoubleMu" is fired,

>> Current Tag : OpenHLT_2_0

>> Modified code in CVS here
http://cmssw.cvs.cern.ch/cgi-bin/cmssw.cgi/UserCode/HIHLTStudy/HLTrigger/HLTanalyzers/src/

Trigger Review Preparation

5. Open HLT running

b) RateEff module : Efficiency and rate estimation

>> running example

./OHltRateEff hltmenu_HIon_2009Sep.cfg

>> Waiting for Rate and Efficiency results will show !!

Summary

6. Summary & Study plan

1) HI DiMuon Trigger Performance is pretty improved 46 % >> 80 % in Barrel. (51 % at Barrel + Endcap)
2) Timing study is confirmed by HLT team (0.83 sec is enough in MinBias)
3) Trigger Review preparation : Open HLT code development for HI.
   >> implementation is finished and rate estimation remains
4) Timing info with hltTimingSummary
5) 10/2 PInG analysis presentation in Heavy Ion regular meeting.
   >> HLT part, adding embedding upsilon 20k sample.

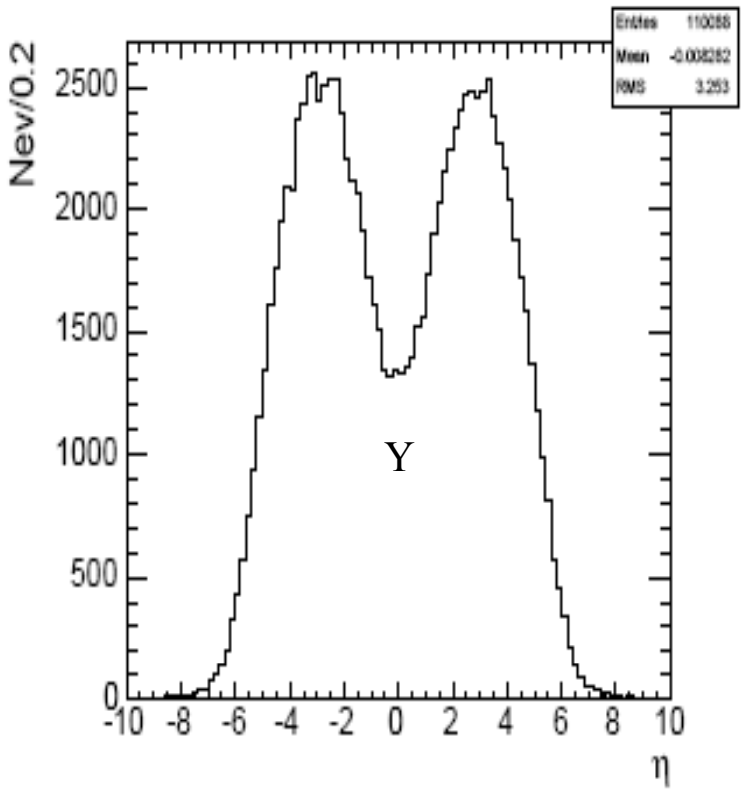
6) Twiki page update :
   http://www.cms-kr.org/twiki/bin/view/HeavyIon/DongHoNewLog

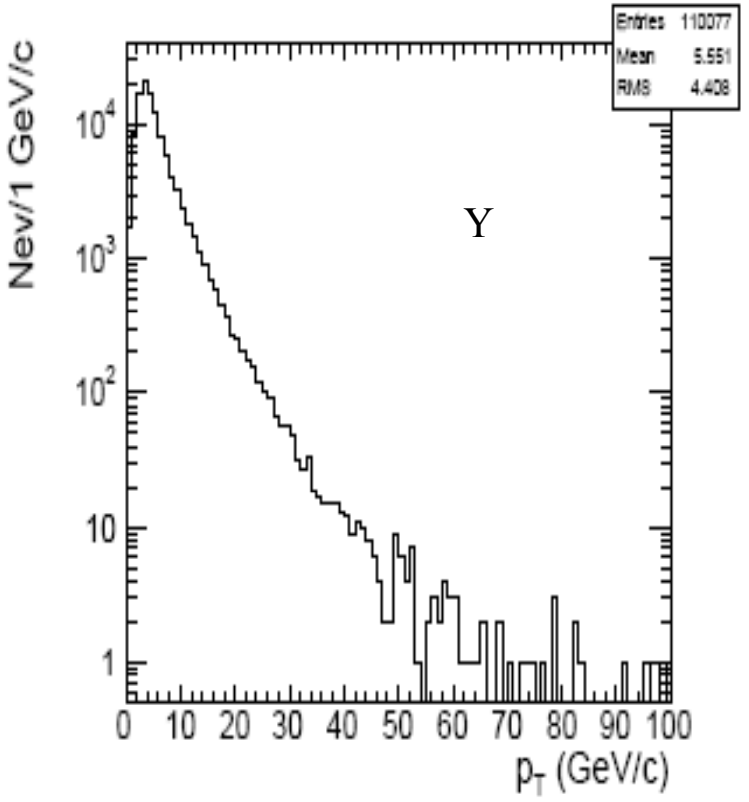
Backup Slides

Backup

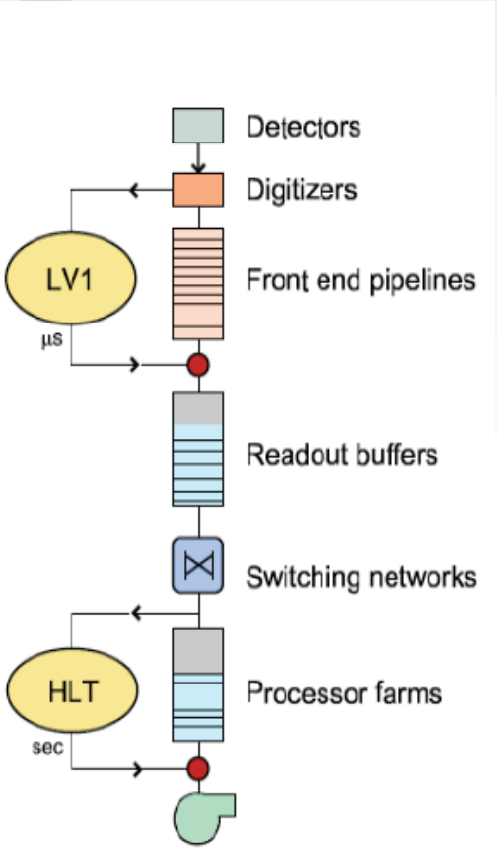
Data Sample for Study

1. Upsilon produced in HI collisions following Ramona's distribution





Pb+Pb and p+p Trigger Rate



Level 1 Trigger

- **Uses custom hardware**
- **Muon chamber + calorimeter information**

Level-1	Pb+Pb	p+p
Collision rate	3kHz(8kHz peak)	1GHz
Event rate	3kHz(8kHz peak)	40MHz
Output bandwidth	100 GByte/sec	100 GByte/sec
Rejection	none	99.7%

High Level Trigger

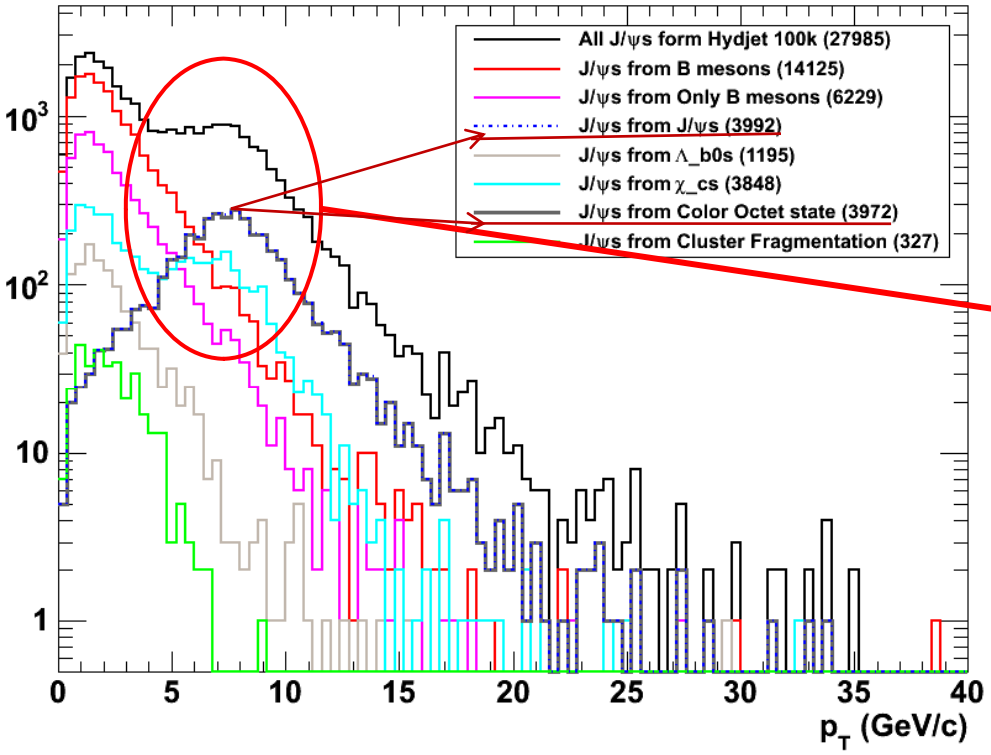
- **Full event information available**
- **Run "offline" algorithms**

High Level Trigger	Pb+Pb	p+p
Input event rate	3kHz(8kHz peak)	100kHz
Output bandwidth	225 MByte/sec	225 MByte/sec
Output rate	10-100Hz	150Hz
Rejection	97-99.7%	99.85%

Status of Hydjet generation

1. J/ψ results

-



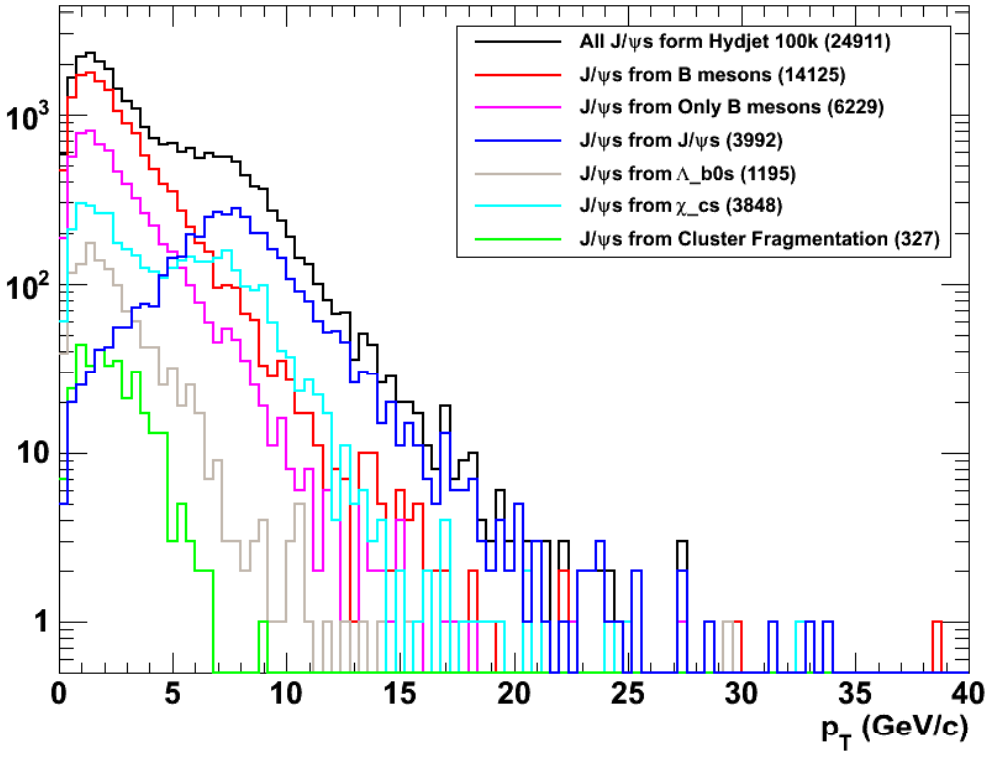
- Total found J/ψ : 28036
- no mother : 24
- B mesons (B_0, $B^{\pm}$, B_s, etc)
- Only B mesons (B_0)
- Own J/ψ : 3992

- Flat region around 5 – 10 GeV/c : initial state effect (Igor saying : pT min is setup to 7 GeV/c ??)

- COS (color octet state) >> J/ψ >> J/ψ + X : it must be double counted at the total number (almost overlaped two cases)

Status of Hydjet generation

1. J/ψ results
- removed J/ψ from Color Octet State.



- Total found J/ψ : 24911
- no mother : 24
- B mesons (B_0, $B^{\pm}$, B_s, etc)
- Only B mesons (B_0)
- Own J/ψ : 3992

- Flat region around 5 – 10 GeV/c somehow goes down

Status of Hydjet generation

1. J/ψ results

Mothers of J/psi

Mother (id)	Number of production	Status of Mother	Status of J/psi	Comment
None	20	21	21	
J/psi (443)	3992	21	11	
B0(+-511)	3133(3096)	11 or 12	11	
B+(+-521)	3152(2927)	11	11	
Bs0(+-531)	885(884)	11	11	
B_c(+-541)	27(21)	11	11	
chi_1c(20443)	3848	11	11	
chi_2c(445)	407	11	11	
chi_0c(10441)	17	11	11	
Lambda_b0(+-5122)	618(577)	11	11	
Xi_b-(+-5132)	23(19)	11	11	
Xi_b0-(+-5132)	24(15)	11	11	
Omega_b-(5332)	1	11	11	
Cluster(91)	327	11	11	cluster fragmention (p
cc~(9900443)	3375	11	11	Color Octet system
cc~(9910441)	336	11	11	Color Octet system
cc~(9900441)	261	11	11	Color Octet system
Total J/psi	27985			

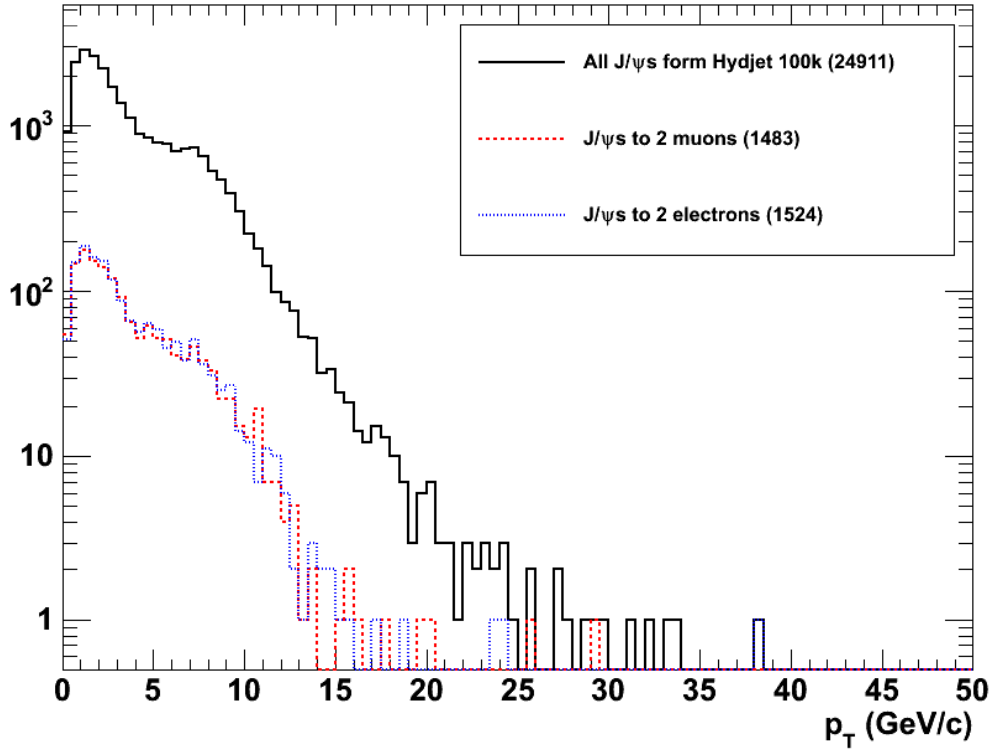
- Unusual status ('11, 12, 21' used)
  >> there were several discussion with Yetkin and then he fixed it (it was caused by HiRoot of previous software, but no new production, yet)
- So, it's not easy to trace mother status.

- Which one is primary J/ψ ?
: in the case of
  - no mother ??
  - mother is itself ??
  - cluster fragmentation ??

Status of Hydjet generation

1. J/ψ results

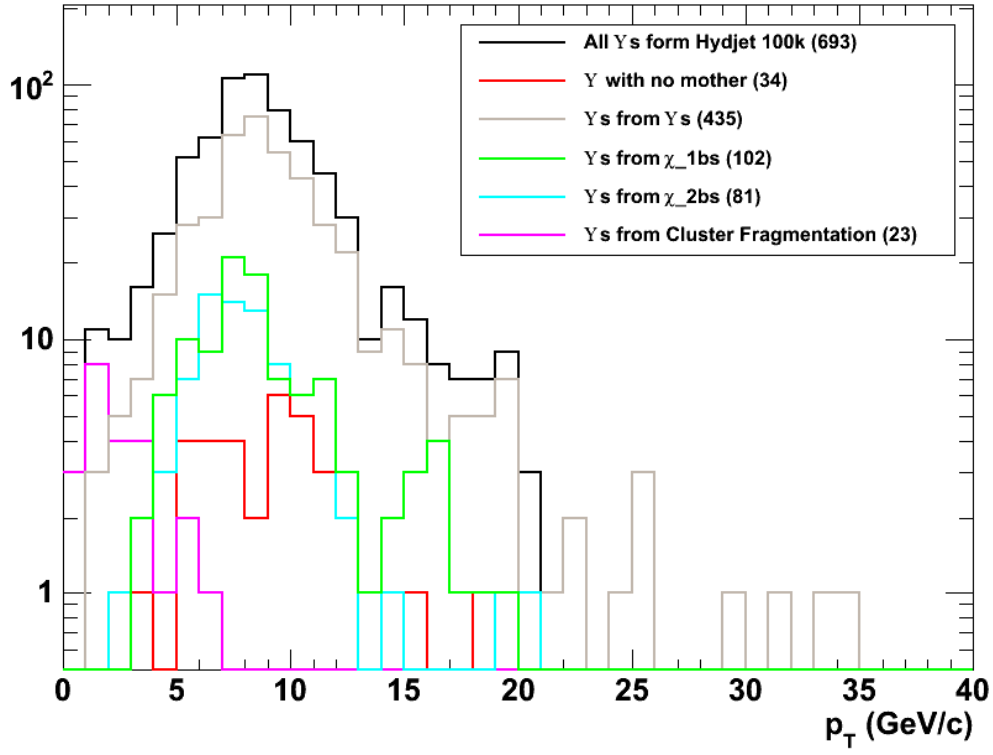
- J/ψ to 2 muons & 2 electrons



- Branching ratio J/ψ to
  - 2 muons
    >> 1483/24911 = 0.059
  - 2 electrons
    >> 1524/24911 = 0.061

Status of Hydjet generation

2. Υ results



- Total found Υ : 693
- no mother : 34
- χ_1b and χ_2b : 183
- Own Υ : 435

- Color Octet State are removed as the same reason with J/ψs

Status of Hydjet generation

2. Υ results

- Unusual status information ('11, 12, 21' used) same with J/ψ So, it's not easy to trace mother study.

- Which one is primary Υ ?

: in the case of
  - no mother ??
  - mother is itself ??
  - cluster fragmentation ??

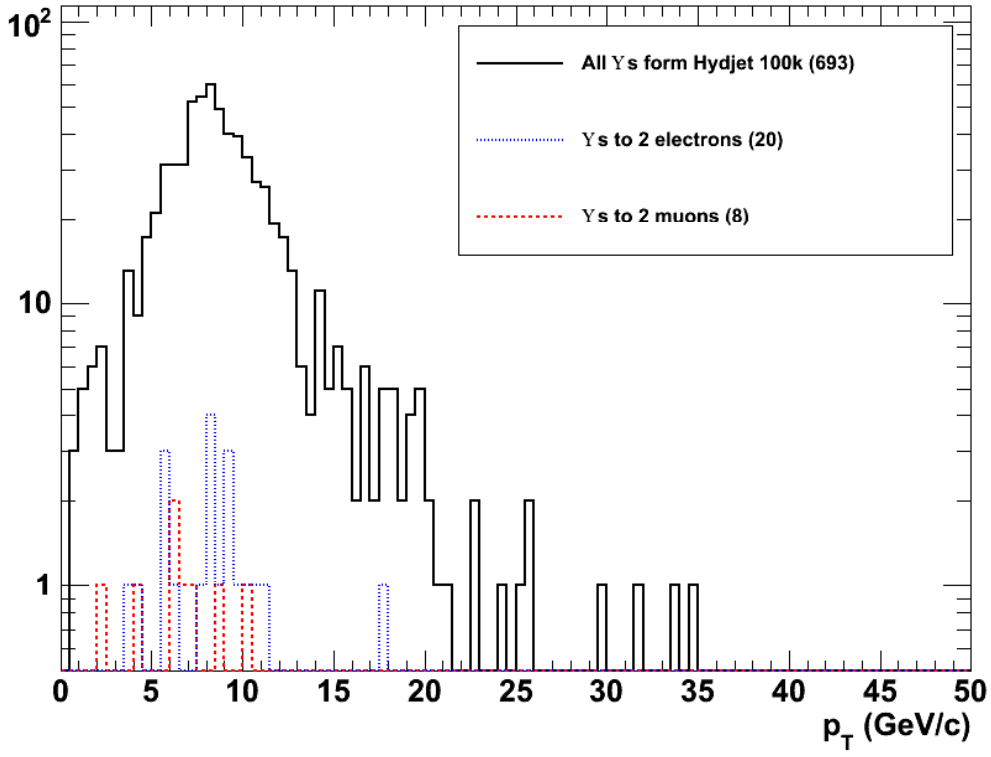
Mothers of Upsilon

Mother (id)	Number of production	Status of Mother	Status of J/psi	
None	34	21	21	
Upsilon (553)	435	21	11	
Chi_0b (10551)	8	11	11	
Chi_1b (20553)	102	11	11	
Chi_2b (555)	81	11	11	
bb bar 1s (9900551)	32	11	11	Color Octet system
bb bar 3s (9900553)	364	11	11	Color Octet system
bb bar 3p (9910551)	5	11	11	Color Octet system
Cluster (91)	328	11	11	cluster fragmention (pQCD)

Status of Hydjet generation

2. Υ results

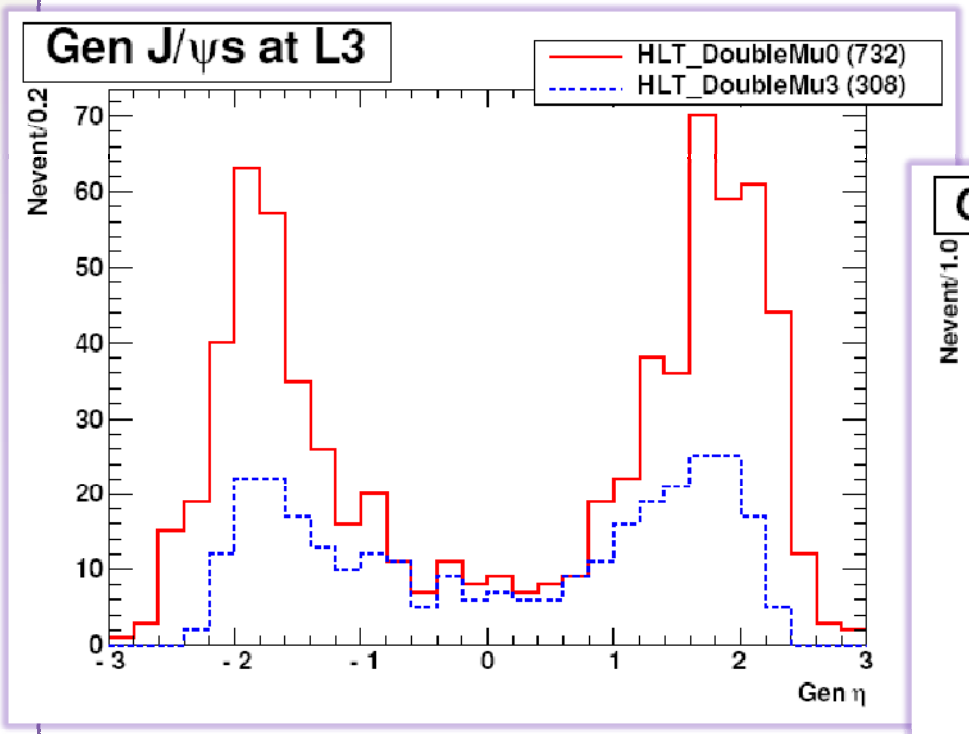
- Υ to 2 muons & 2 electrons

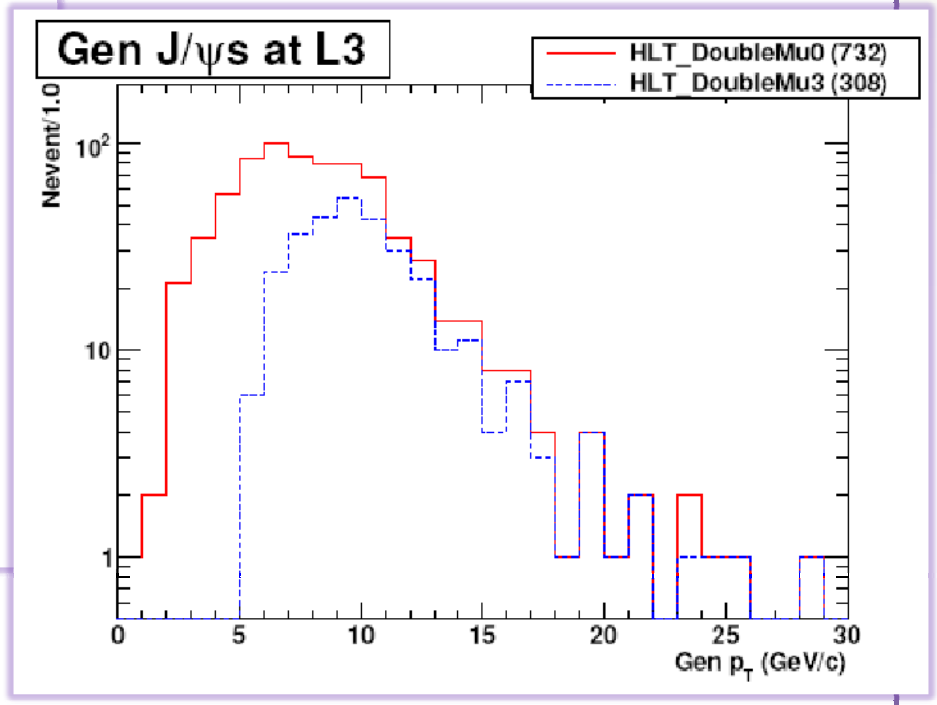


- Branching ratio J/ψ to
  - 2 muons
    >> 8/693 = 0.012
  - 2 electrons
    >> 20/693 = 0.029

Gen. J/ψ in Successful Events

J/ψs of generator level in the triggered events by L3





We expect low-p_T J/ψs (< 7 GeV/c) will be triggered by using HLT_DoubleMu0.

Trigger Efficiency : J/ψ

J/ψs of generator level in the triggered events by L3

$$\varepsilon_{J/\psi}^{Trig} = \frac{N_{J/\psi}^{Trig}}{N_{J/\psi}^{Gen} \cdot Geometrical\ Acceptance}$$