Using Track based missing Et tools to reject fake MET background

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TWiki page for Track Based MET project:
https://twiki.cern.ch/twiki/bin/view/AtlasProtected/TrackMET

Why measuring MET with track?

- Provide an alternative measurement
- --Different detector has different un-related systematic effect
- Can associate tracks to primary vertex, can calculate MET and SumPt based on primary vertex of the event ,thus more correlated to true MET of the main physics process – important in pileup case
- Will deteriorate less than calorimeter based variables as instantaneous luminosity increase
- Has less effect due to cosmic muon and beam background
- Disadvantages :
- --See only charged particles
- --Smaller geometrical coverage
- --Momentum resolution get worse in higher Pt
- Trackmet tool could be used in rejecting these background in W/Z analysis :

❑ QCD jet background

❑ Cosmic background

❑ Pileup background

❑ Beam halo background

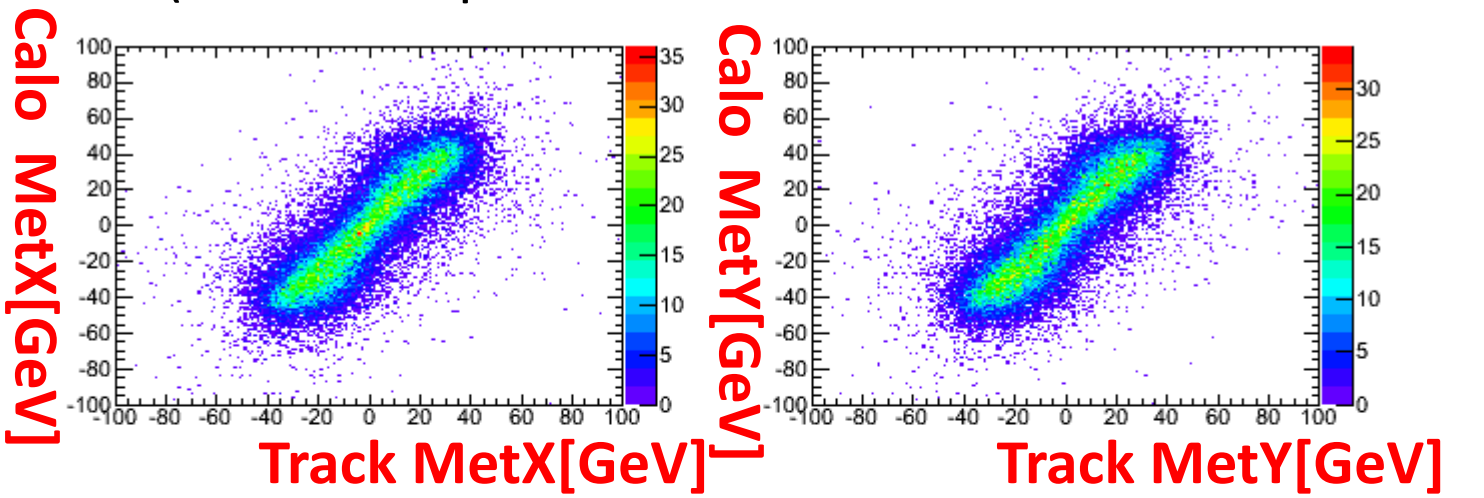
How to calculate Track based MET?
Loose track selection or tight selection ?

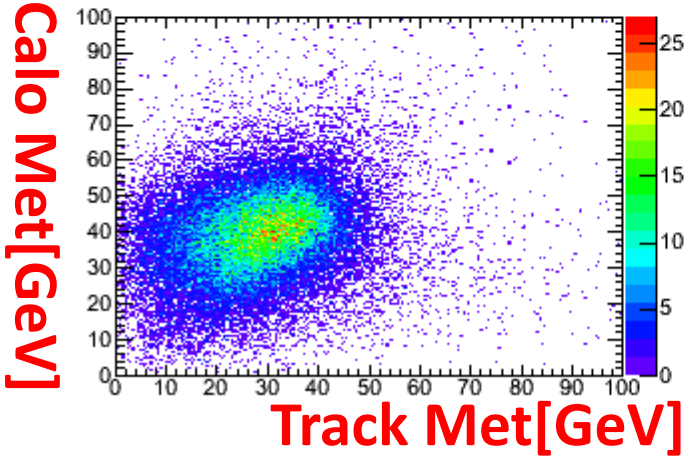
- Select good tracks for this measurement
- ❑ Select tracks from primary interaction
- ❑ Remove tracks from conversion
- Too loose or too tight could worsen Track MET resolution
- This track selection criteria need more time to do careful study
- Current track selection cut for reconstructing track MET :
- ❑ |Track _z0 respect to primary vertex |<20 mm
- ❑ |Track _d0 respect to primary vertex |<2 mm
- ❑ Track_Pt>0.5GeV , Track_Pt<300GeV
- ❑ Number of pixel hits >=2
- ❑ Number of SCT hits >=6
- ❑ Track MET = -1 *(Vector sum of the selected track momentum)
- ❑ The work of Implementation of Track based MET algorithm in official MissingET reconstuction package is on going

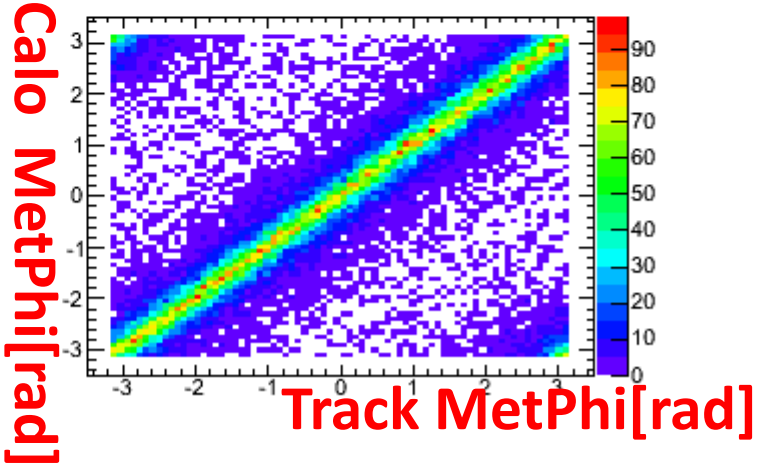
Example 1:Reject QCD background in Wenu analysis

Track_MET VS Calo_MET

(Wenu sample :events with at least one medium isem electron)

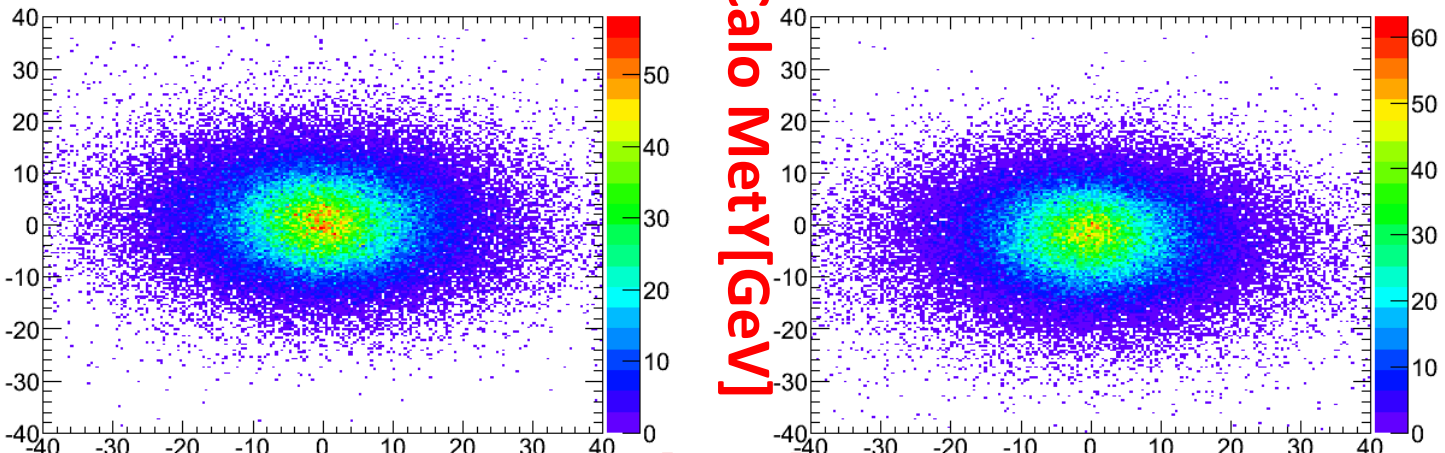


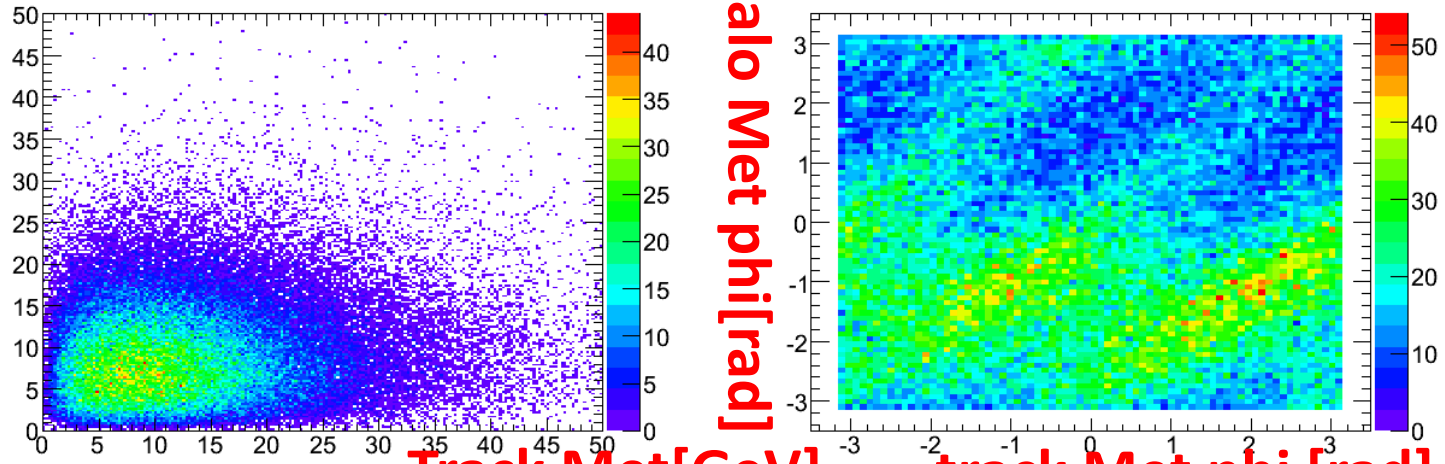




- Observe strong correlation between Calo_MET and Track_MET

Example 1:Reject QCD background in Wenu analysis
Track_MET VS Calo_MET
(QCD Dijet JF17 sample)





- Observe no correlation between Calo_MET and Track_MET

Track Met in W analysis: cut flow

Cut A: Medium IsEM electron
Pt>20GeV
0<|Eta|<1.37 or 1.52<|Eta|<2.37
EtCone/Et<0.2

Cut B:Calo MET >20GeV (CutB)
Cut C:track MET & Calo MET correlation
|CaloMET_Phi- TrackMET_Phi| <0.9

	W(enu)	JF17	S/B
Cross section (pb)	17440	1.461E9	
Generator Filter efficiency	0.625	0.0706	
Expected events numbers in 100 pb-1	1090k	103076k	
Expected event in 100 pb-1 (after cut A : electron ID cut)	(556+-3)k	(1784+-52)k	
Expected event in 100 pb-1 (after cut B: Calo MET cut)	(522+-3)k	(149+-15)k	3.57+-0.03
Expected event in 100 pb-1 (after cut C: track met cut) |CaloMET_Phi- TrackMET_Phi| <0.9	(465+-3)k	(48+-9)k	9.68+-0.07

Make use of CaloMET and TrackMET correlation to define a cut .
Track met cut can help to improve signal to background ratio.
S/B ratio can almost reach 10 after using track met cut

Summary

- TrackMet could help in rejecting processes which are source of fake MET, such as QCD Di-jets, cosmics, pile-up effects...
  It can be a powerful tool in W/Z analysis, and any other processes with real MET.
- On Going work:

- The Academia Sinica group working toward the implementation and the use in physics
  analysis.
- Implementation of TrackMET alogorithm in the global MET package.
- TrackMET information will be calculated at reconstruction level from ESD/DPD data, with the option of re-running it at AOD level.
- Internal Note in preparation summarizing the implementation and the performances of TrackMET.
- Feasibility study for H->WW analysis (rejection of fake MET from Z-ee/mumu)
- Study of improvement on QCD jet rejection in W->tau+nu and Z->tautau
  Results will be shown a the next physics group meetings

Discussion

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  Loose track selection or tight selection ?

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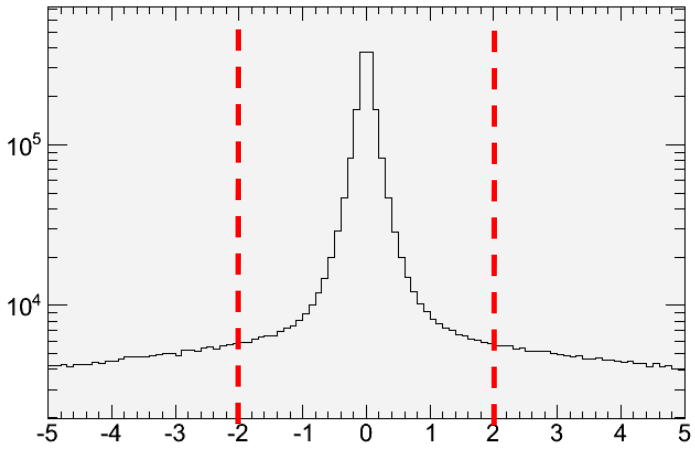
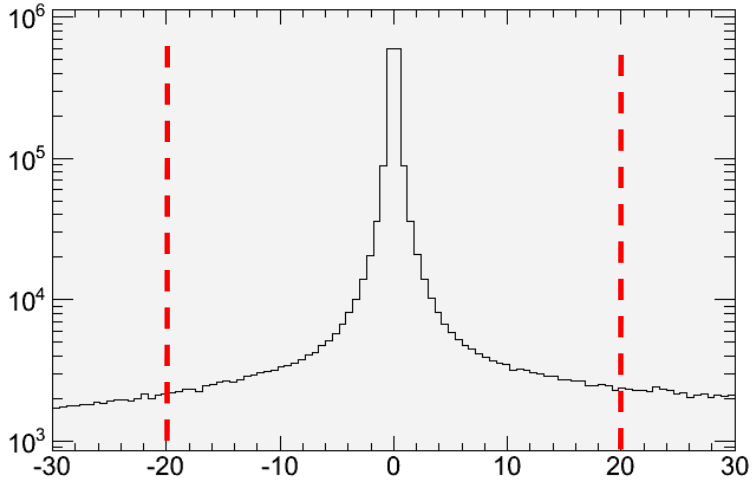
Track distribution before track quality cut (QCD Dijet JF17 sample)



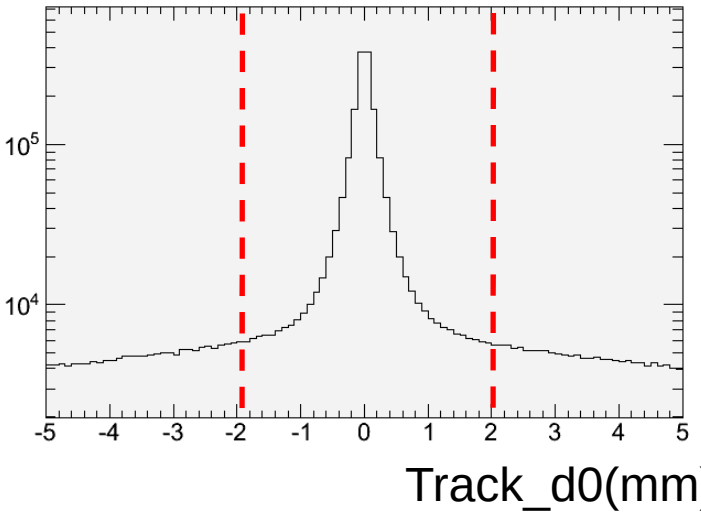
Track_d0(mm)

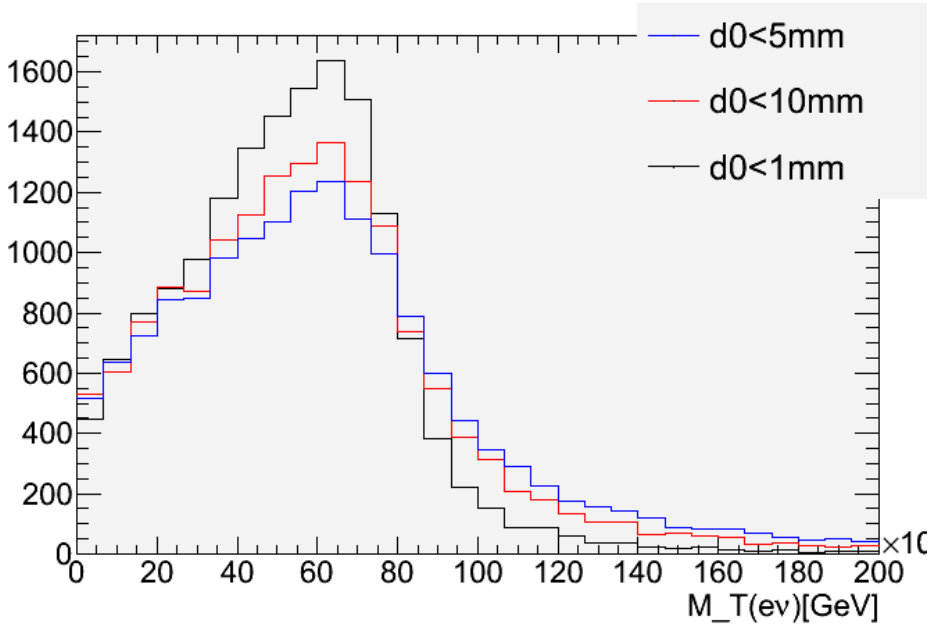


Track_z0(mm)

Could we Use W(enu) data to optimize track selection criteria?

- Use Track based MET to reconstruct transverse mass of W , and see how track selection cut would change M_T distribution
- Use track impact parameter d0 as a example .
- In the figure , if the d0 cut too loose , there would be a unphysical tail in track based M_T distribution .

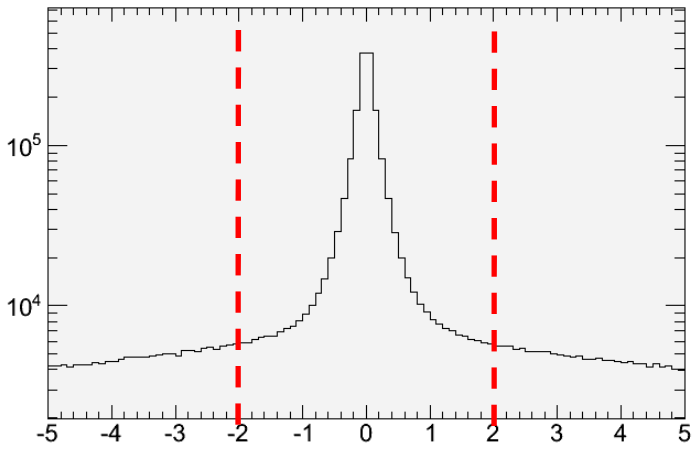




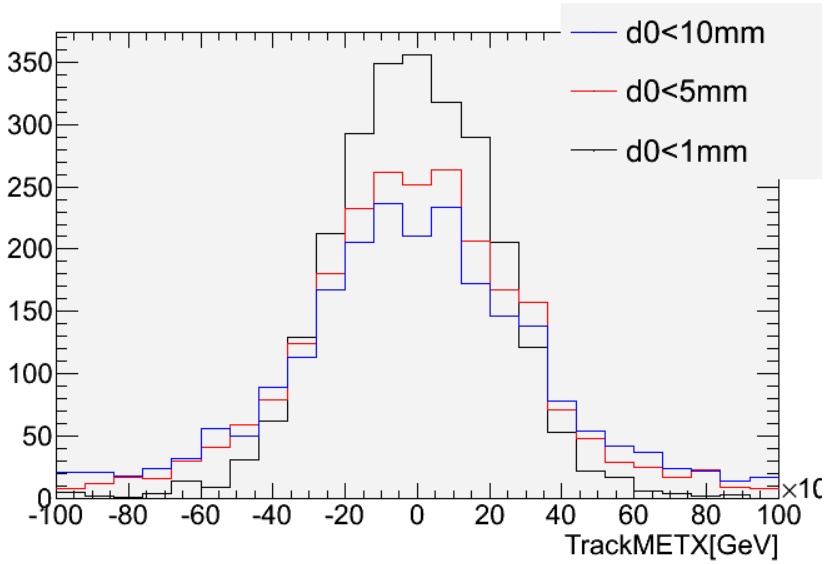
W Track based transverse mass[GeV]

Could we use Dijet data to optimize track selection criteria ?

- Dijet samples do not have real MET .
- X or Y component of Track MET should have Gaussian shape , the width of TrackMET X Y component reflect TrackMET resolution .
- Try to optimize impact parameter cut to get better resolution of TrackMET.

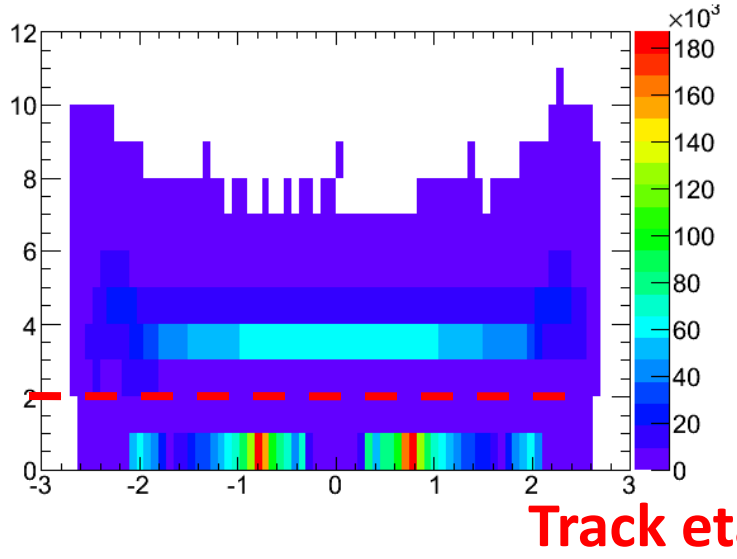


Track_d0(mm)

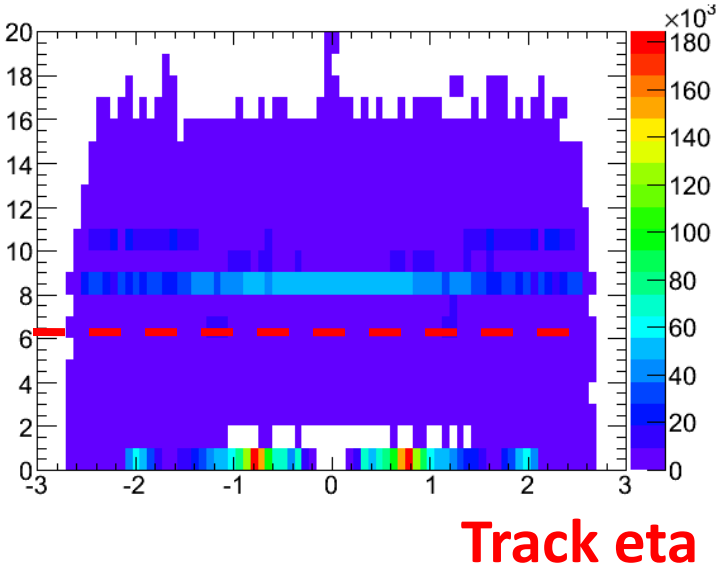


Track distribution before track quality cut (QCD Dijet JF17 sample)

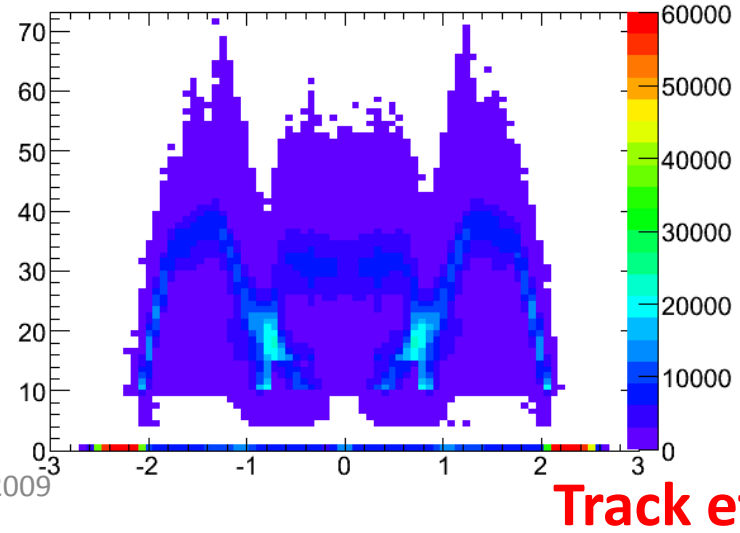
#pixel hit



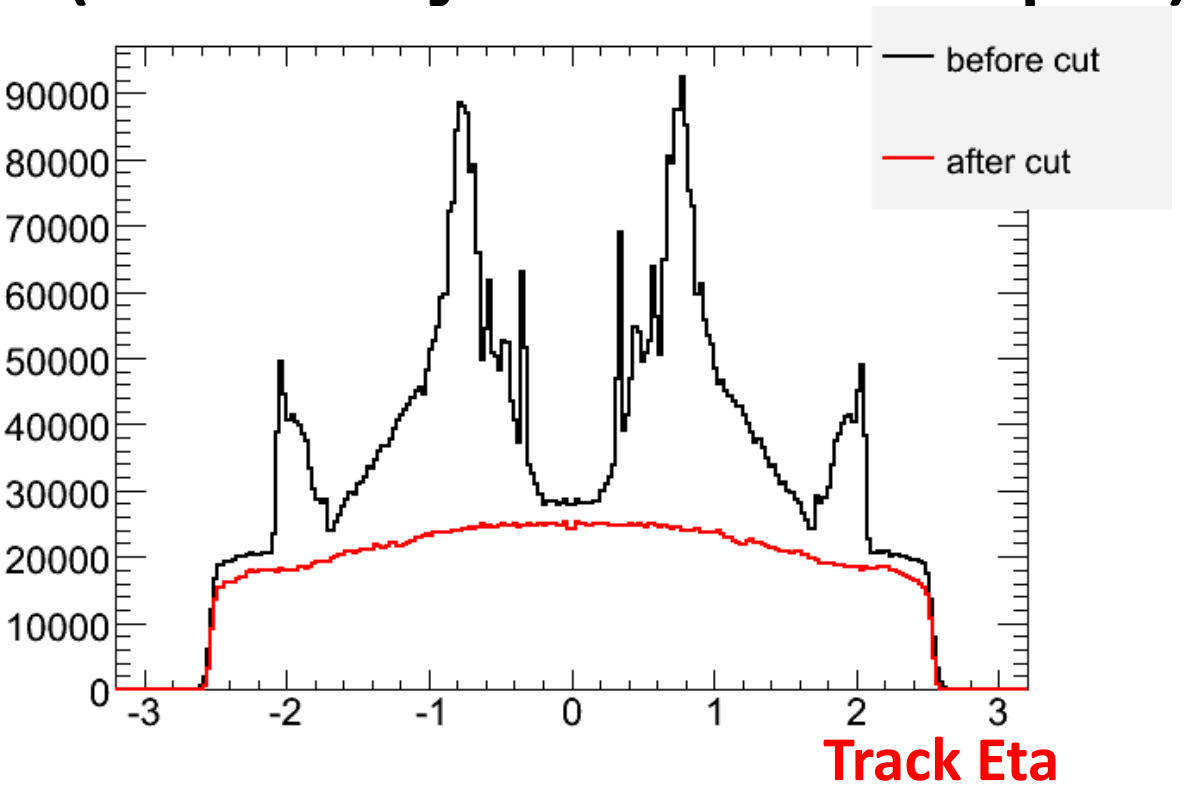
#SCT hit



#TRT hit



Track distribution before track quality cut (QCD Dijet JF17 sample)



After track quality cut , Track eta distribution looks much better .

Discussion

- Could we use TrackMET tool to reject pileup background ?

Could we use TrackMET tool to reject pileup background ?

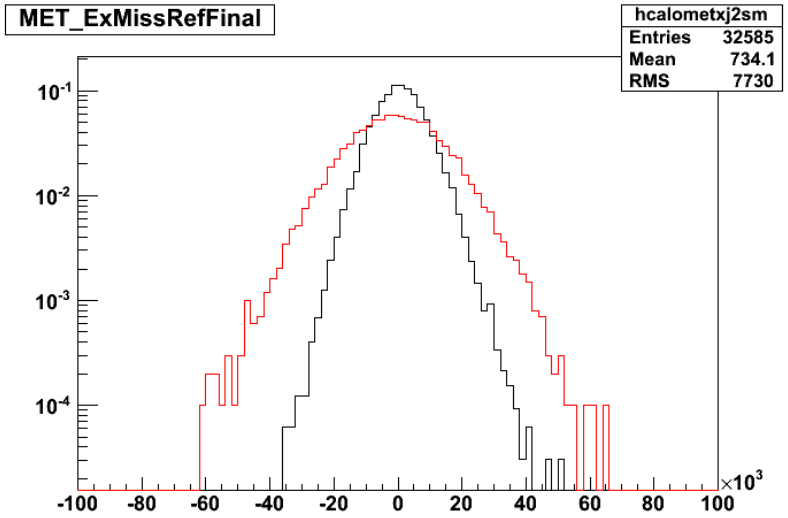
- MET resolution become worse in pileup case ,rejection power of MET cut in W analysis become weak .
- In order to continue W analysis or get control sample of W in pileup situation , we need better way to reject events with fake MET .
- Ideas is that calorimeter does not know where this deposited energy comes from ,while tracker know which track comes from which vertex .
- Track Met could build up MET for each collision vertex ,without mixing up primary interaction and others min-bias events.

Example 2: TrackMET performance in Pileup samples

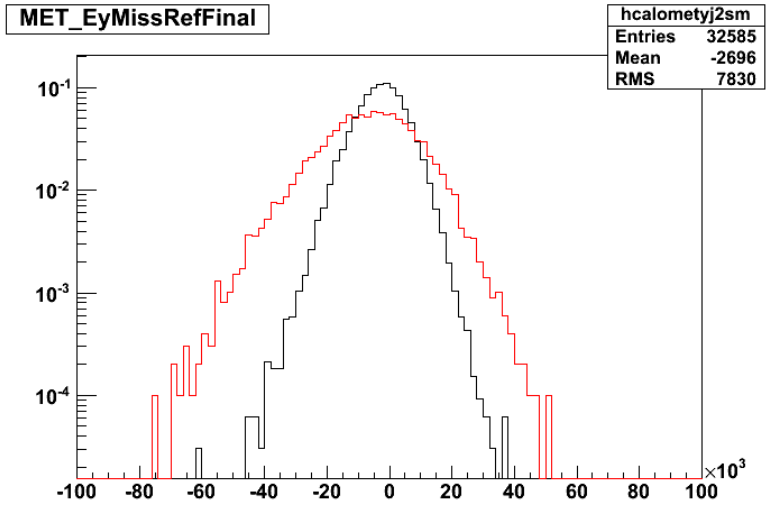
Calo based MET: Dijet J2

Red: pile up

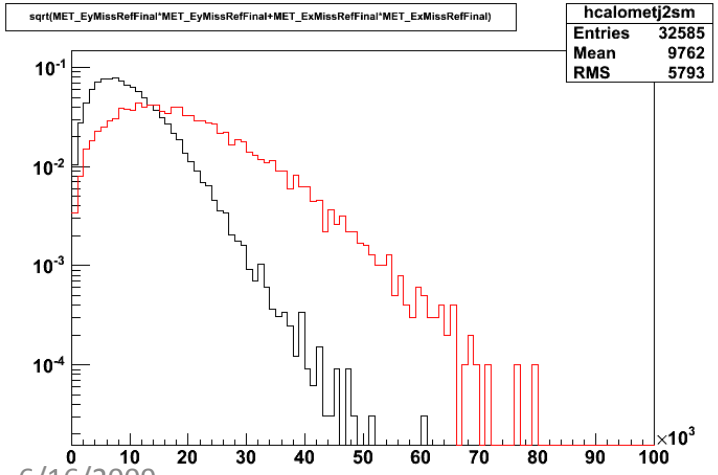
Black : Non pile up



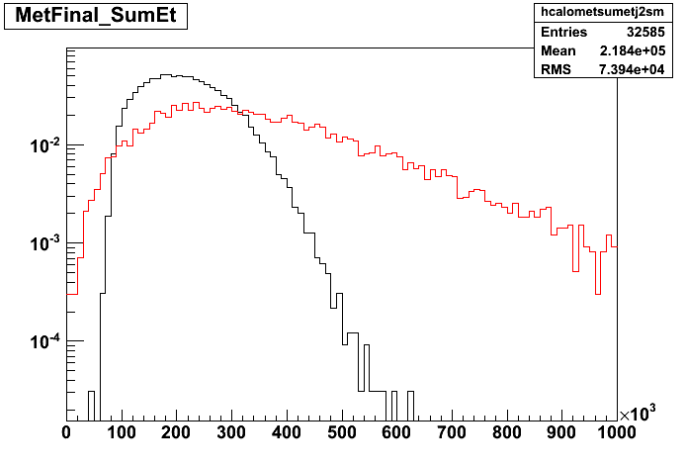
Calo METX(MeV)



Calo METY(MeV)



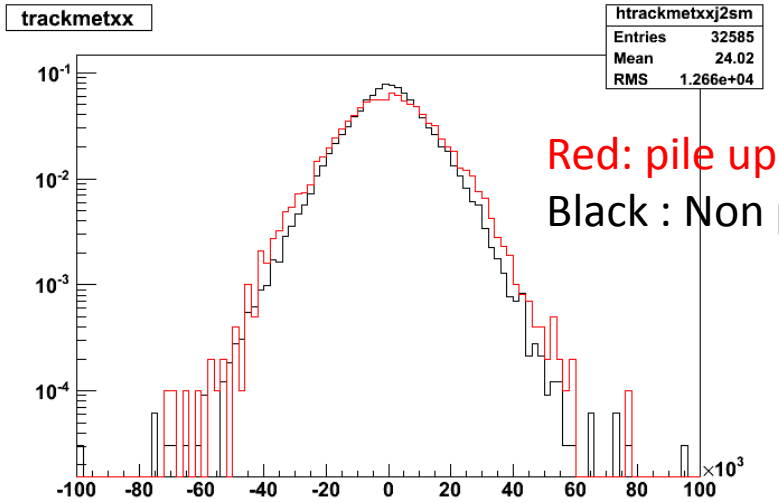
Calo MET(MeV)

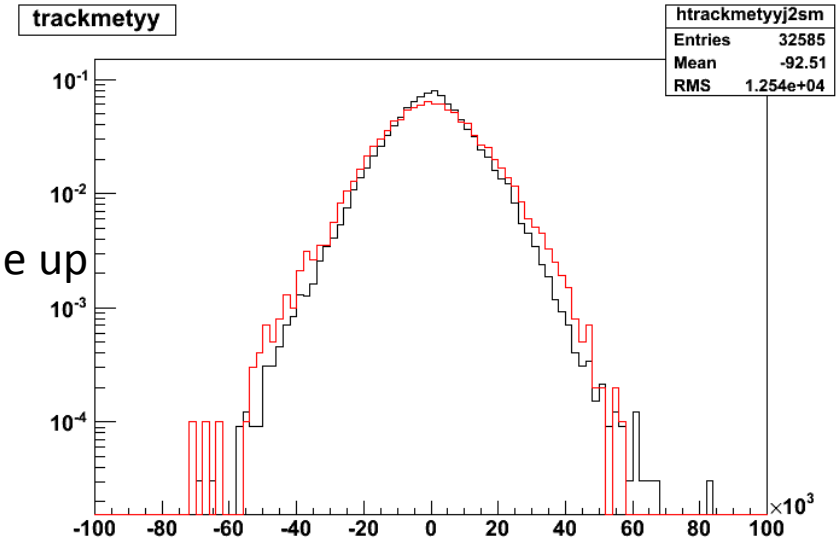


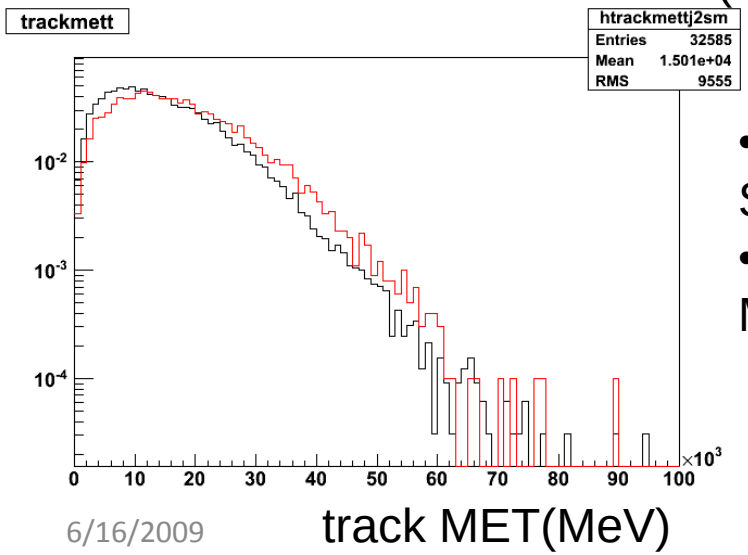
Sum Calo ET (MeV)

Example 2: TrackMET performance in Pileup samples

Track based MET: Dijet J2







- Calo Met resolution become worsen in Pileup Sample ,Calo METX is much broaden in Pileup case.
- While track MET resolution doesn't change too Much between these two sample ,just a little effect

Could we use TrackMET tool to reject pileup background ?

- CaloMET is very sensitive to pileup effect , its performance worsen a lot in case of pileup.
- Track based Missing Et is less affected by pileup background
- Since resolution of TrackMET and CaloMET is close to each other in pileup case .
- Correlation between TrackMET and CaloMET become more important to reject fakeMET in pileup situation

Discussion

- How to optimized TrackMET cut in W(enu) analysis to get the best S/B ?

Review of W analysis in CSC note

- Using Track met as a tool to reject QCD background :
- In CSC note , we see QCD di-jet is main background in W cross section analysis ,
- Here is Table quoted from csc note :
- Table : Num of signal and background events (x10^4) in 50 pb $^{-1}$

Selection	$W \to e\nu$	jets	$W \to \tau\nu$	$Z \to ee$
Trigger	37.01 ± 0.09	835 ± 18	1.73 ± 0.02	6.07 ± 0.01
$p_T > 25$ GeV, $\|\eta\| < 2.4$	30.84 ± 0.09	383 ± 12	1.03 ± 0.01	2.95 ± 0.01
Electron ID	26.77 ± 0.09	110 ± 6	0.91 ± 0.01	3.23 ± 0.01
$\not\!\!E_T > 25$ GeV	22.06 ± 0.09	4.6 ± 0.7	0.55 ± 0.01	0.06 ± 0.01

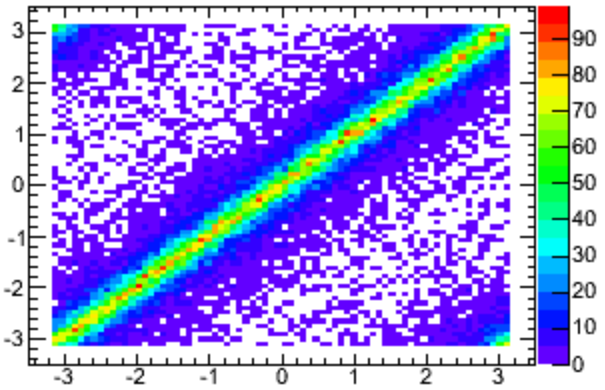
- How to improve S/B using track met ?
- No real missing ET in Di-jet sample , so if we do two kind of missing ET measurement :track Met and Calo Met , they should be not correlated .
- While in W sample , track Met and Calo Met are highly correlated since there is real missing ET , and there is not too much neutral particles inside these two samples.
- Track met provide us a independent measurement ,so we can double check whether there is real missing ET in the event .

Track_MET VS Calo_MET (QCD Dijet JF17 sample)

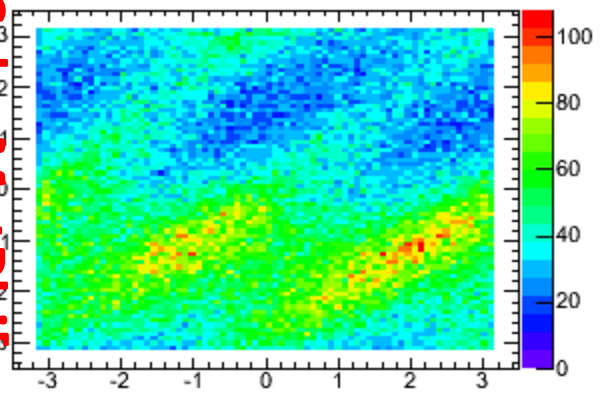
- Observe no correlation between Calo_MET and Track_MET
- That is because there is no real missing ET in dijet sample , What MET measuring is just the fluctuation .
- The fluctuation can be very different and uncorrelated in tracker and Calo
- In the following page , we will see how Track_MET and Calo_MET are correlated in sample with real missing ET (Wenu) sample

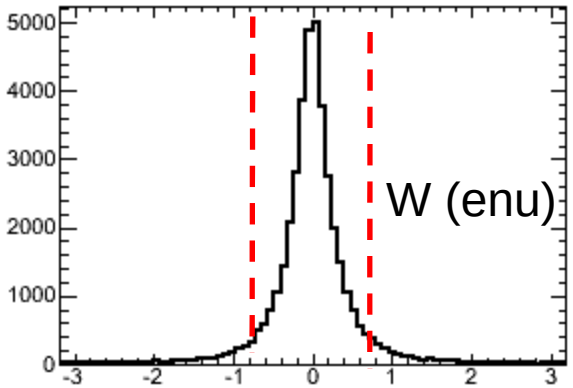
MET_Phi : W (enu) vs JF17

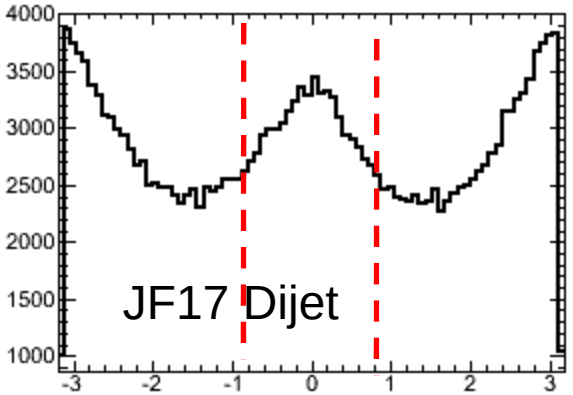
W (enu)



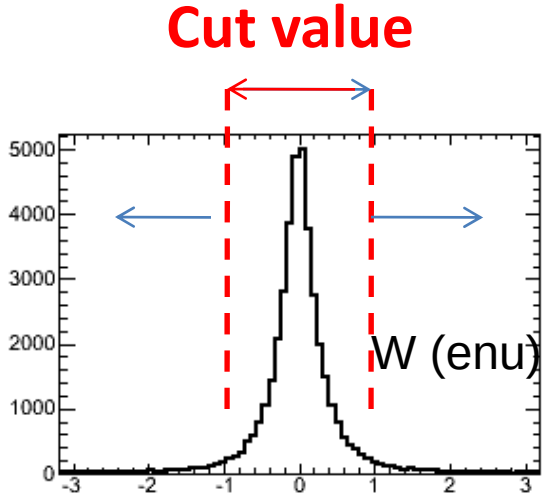
JF17 Dijet



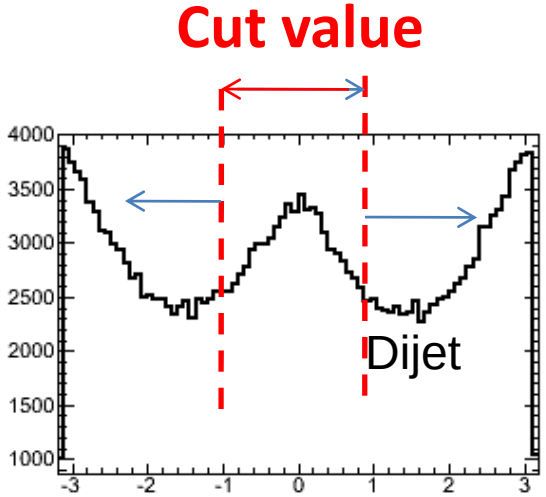




Tuning the trackmet cut



Calo MetPhi-Track MetPhi[rad]



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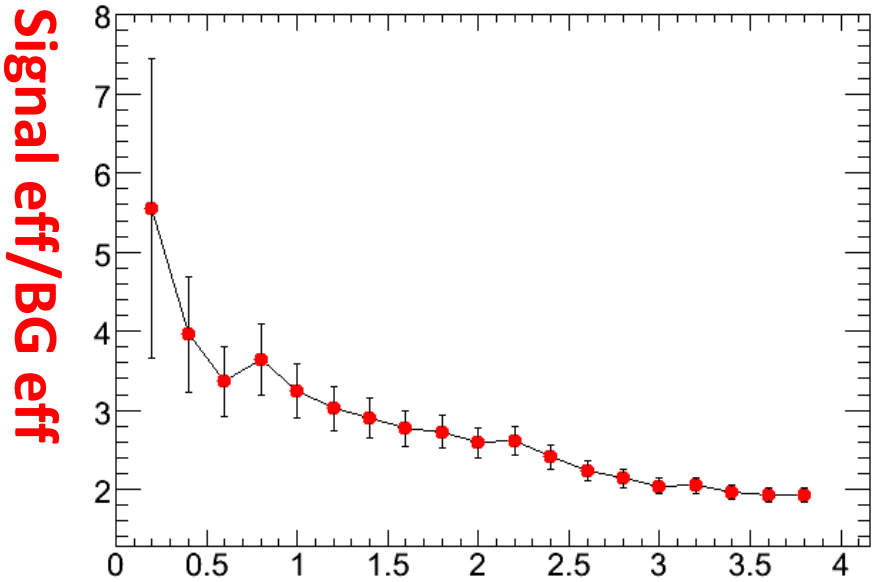
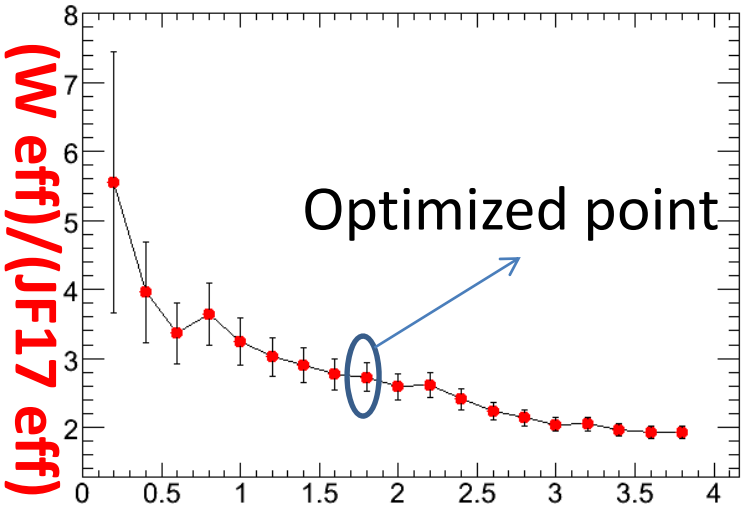
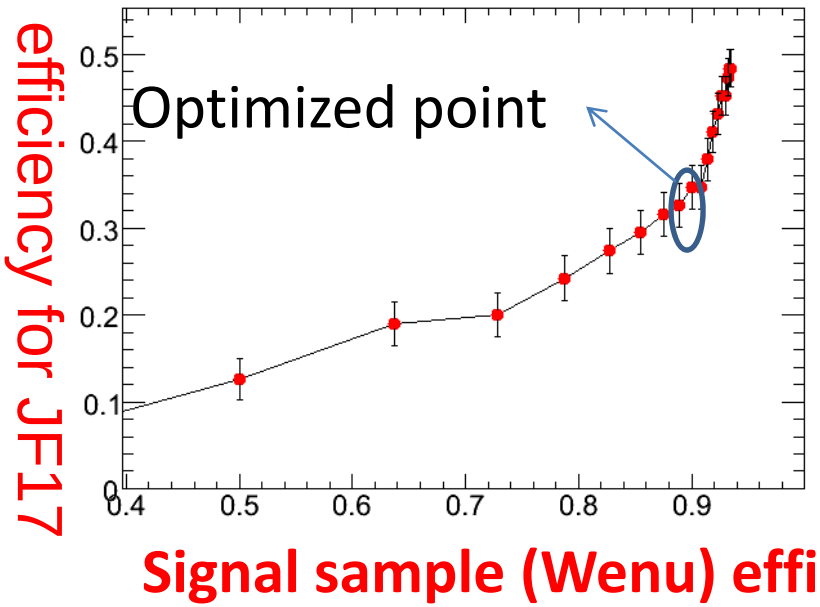


Tightening the cut in delta phi Between Two kind of MET , We can improve S/B ratio up to a factor of 5

Define a Track_met cut (signal efficiency vs S/B)





optimized point could be found in right plot . The tuning point of the curve , is the best choice .

1.Define Track_Met cut : |CaloMET_Phi- TrackMET_Phi| <0.9

2.So using this track_MET VS Calo_MET correlation cut ,

we can gained a factor of 3 in Signal to background ratio(S/B)

While only losing 10% of signal events

Track Met in W analysis: cut flow

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Make use of CaloMET and TrackMET correlation to define a cut .
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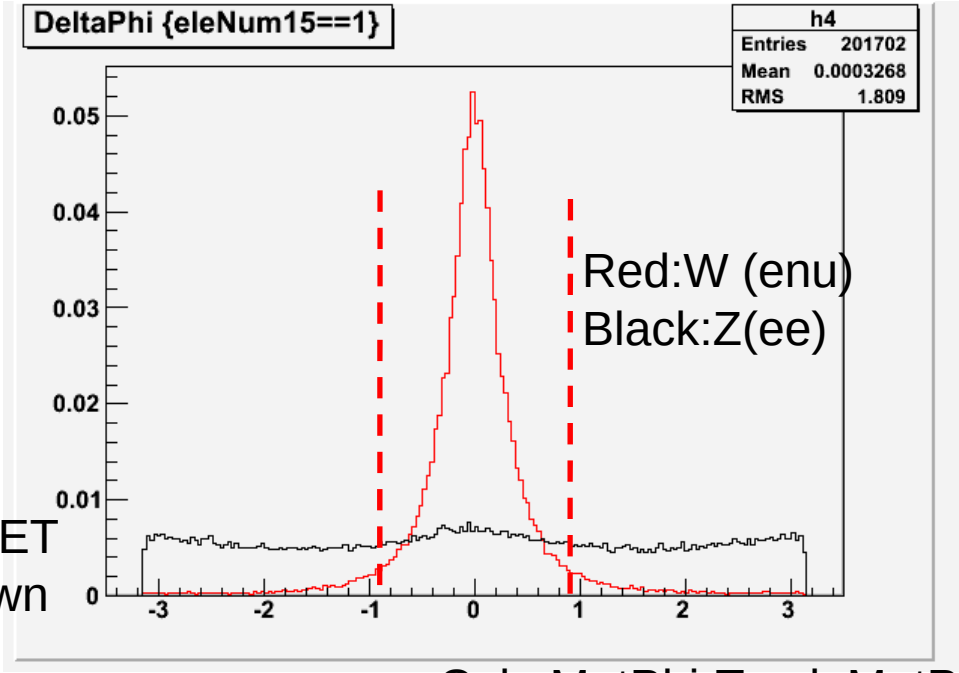
S/B ratio can almost reach 10 after using track met cut

Discussion

- Could TrackMET tool be use in other fake MET background ?

Example : Using trackMET to reject Z(ee) background in W(enu)

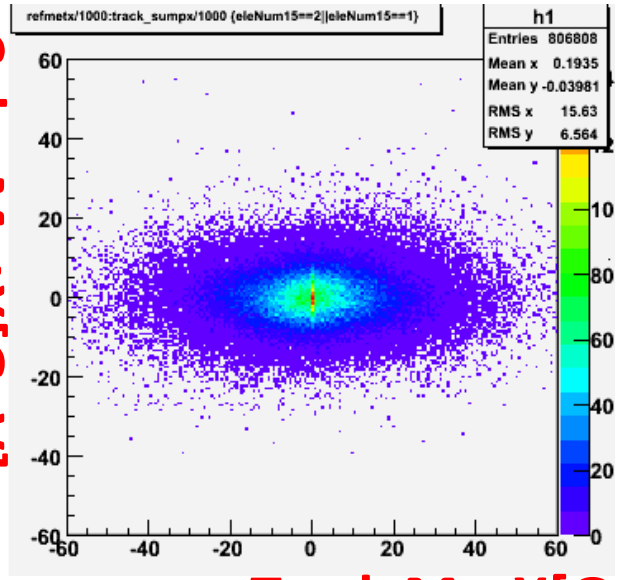
- TrackMET VS CaloMET correlation would also help in rejecting Z(ee) ,which is secondary background of W(enu) Analysis .
- Select events with at least one electrons are reconstructed , make Dphi plot as below
- We can play the same trick as in Dijet case , further rejecting Z(ee) events by making cut on | Calo MetPhi-Track MetPhi|<0.9



More information
About Z(ee) TrackMET
Distribution are shown
In backup slide

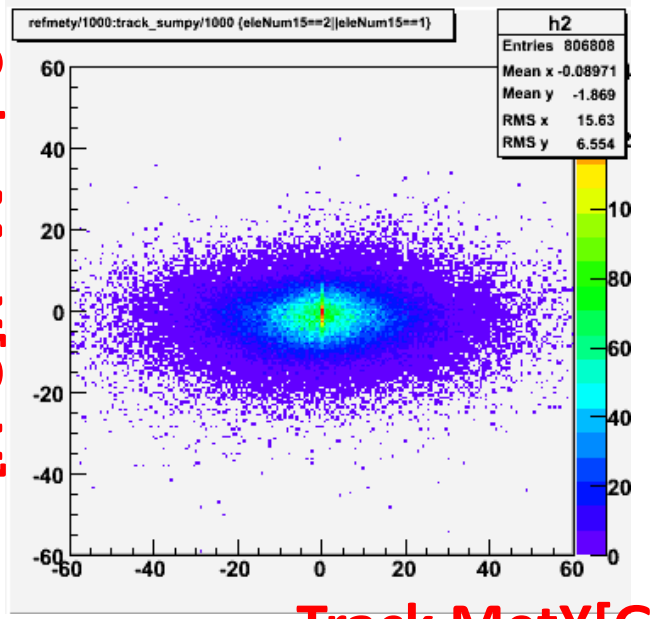
Example : Using trackMET to reject Z(ee) background in W(enu)

TrackMET VS CaloMET in Z(ee) with at least one electron



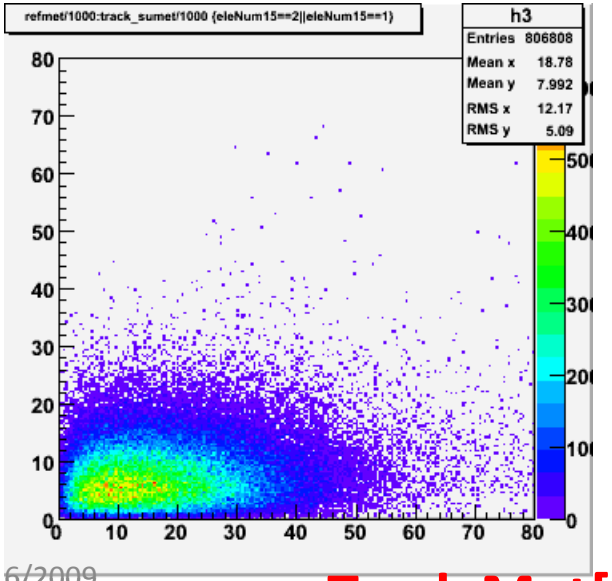
Calo MetX[GeV]

Track MetX[GeV]



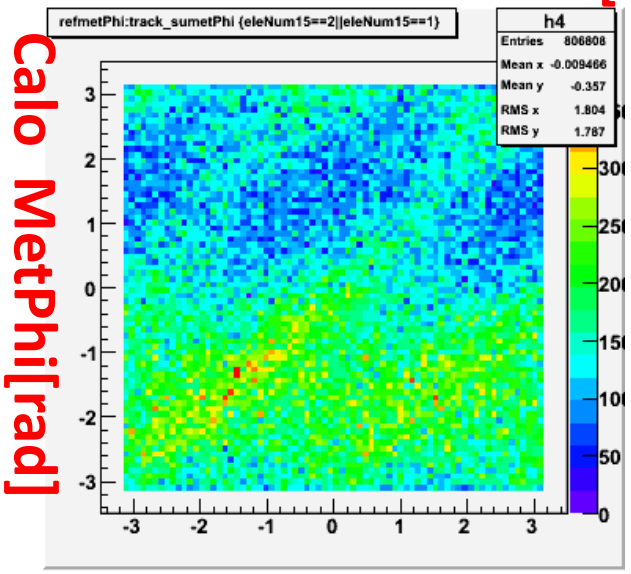
Calo MetY[GeV]

Track MetY[GeV]



Calo Met[GeV]

Track Met[GeV]



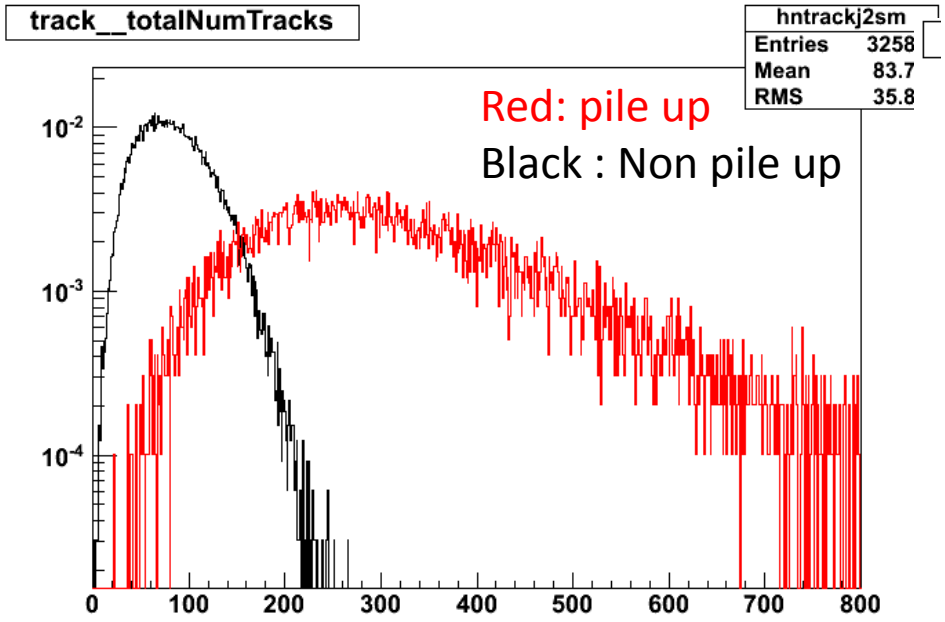
Calo MetPhi[rad]

Track MetPhi[rad]

Backup: Pileup and nonpileup Dijet J2 Data sample

- MC08 Official Pythia Dijet events as non pileup reference sample :
- ❑ No Pileup ,ATLAS-GEO-02-01-00,OFLCOND-SIM-00-00-03
- ❑ mc08.105011.J2_pythia_jetjet.recon.AOD.e344_s479_r541_tid026916
- ❑ Simu: 14.2.0.1 Digi : 14.2.10.1 , Reco :14.2.20.3
- Dijet sample in Luminosity 10^{33} cm^{-2} s^{-1} , bunch space 75ns
- ❑ valid1.105011.J2_pythia_jetjet.recon.AOD.e344_s479_d145_r588
- ❑ Pileup Sample , +6.9 Minimum-bias events per bunch crossing
- ❑ ATLAS-GEO-02-01-00,OFLCOND-SIM-00-00-03
- ❑ Simu :14.2.10.1 Digi :14.2.24.1 Reco: 14.2.24.1

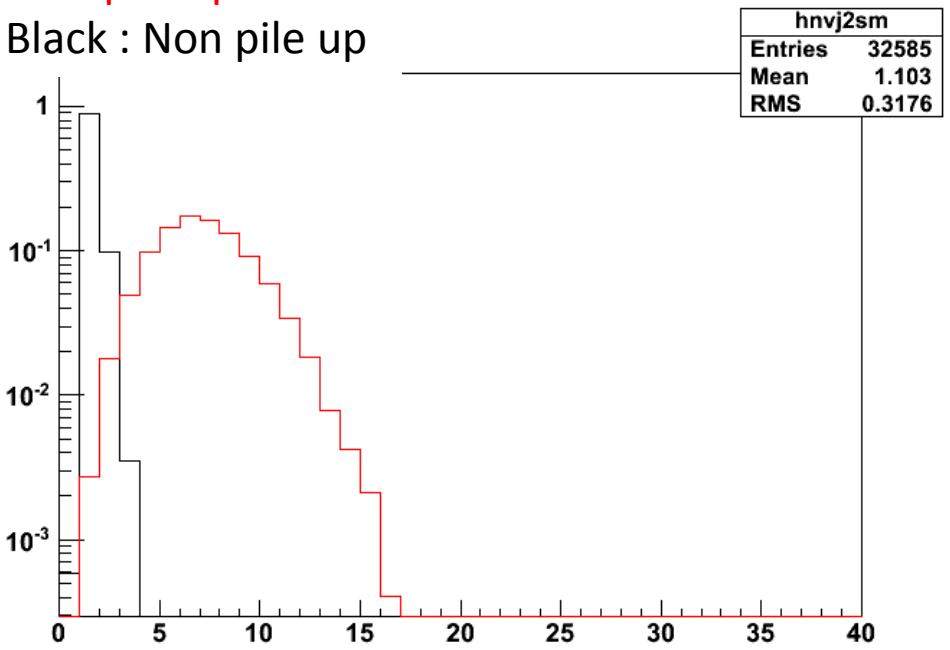
Backup :
Total number of tracks and vertex per events



number of tracks/per event

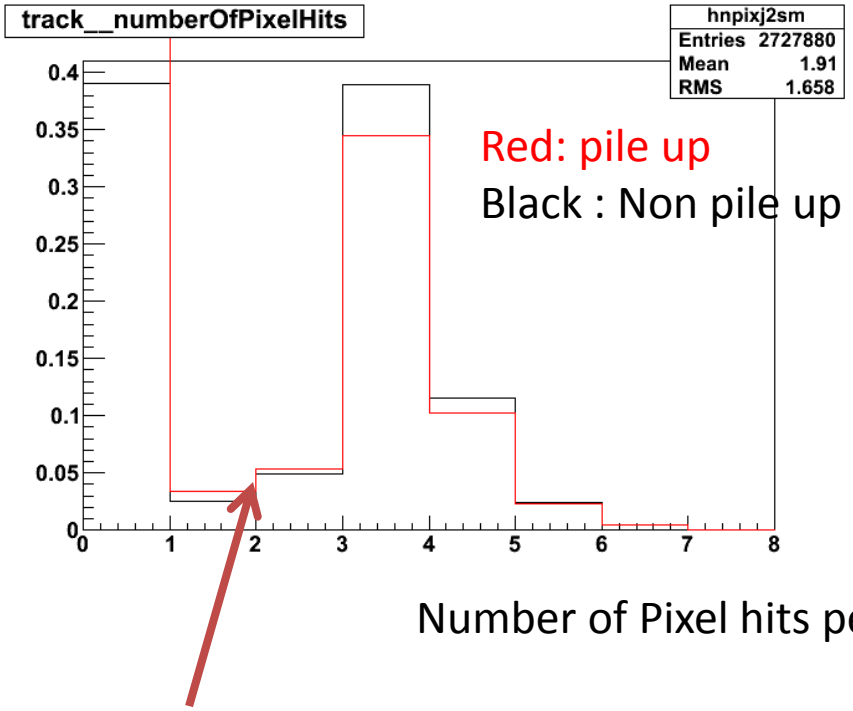
Red: pile up

Black : Non pile up

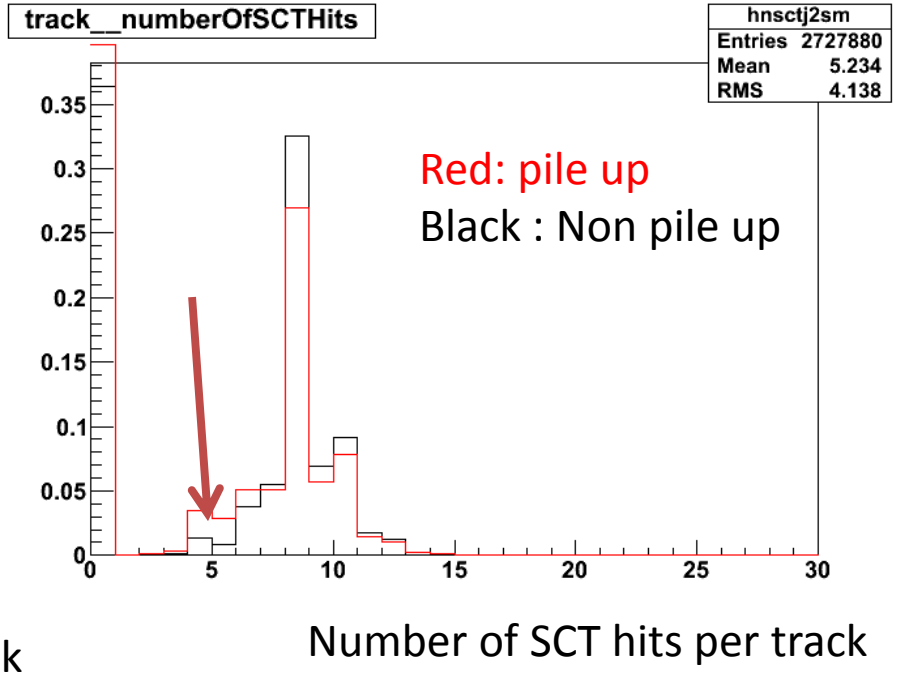


number of primary vertex per events

Backup : Number of pixel hits and SCT hits per track



Number of Pixel hits per track

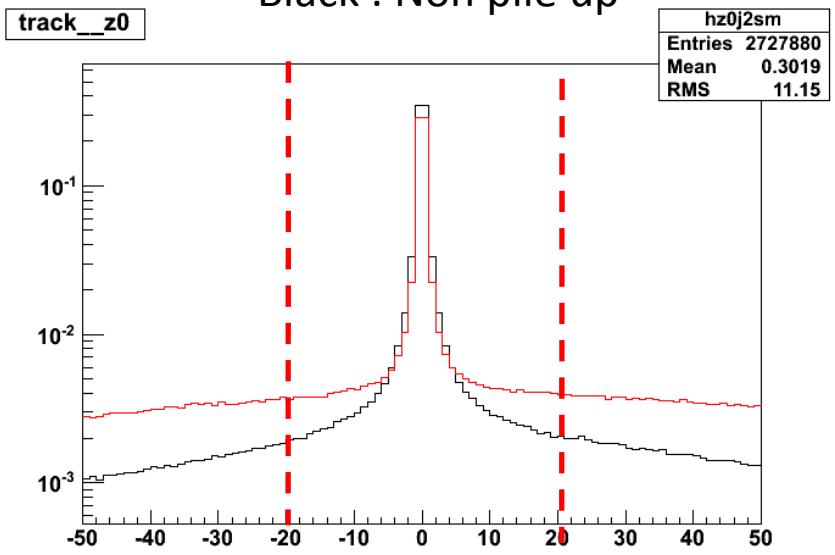


Number of SCT hits per track

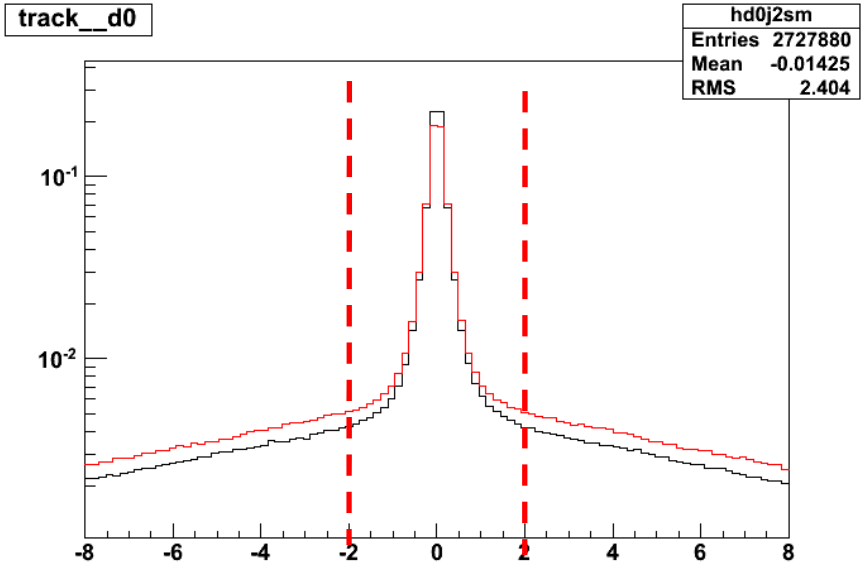
Backup :
Track Z0 respect to Primary vertex

Red: pile up

Black : Non pile up



Track Z0(mm)



Track d0(mm)

Broaden distribution in pileup sample

Track_Z0 significant

Sample list

- W (enu) sample (100k events):

  mc08.005104.PythiaWenu.recon.AOD.e323_s400_d99_r474

- Dijet (6000k events) :

  mc08.105802.JF17_pythia_jet_filter.recon.AOD.e347_s462_r563