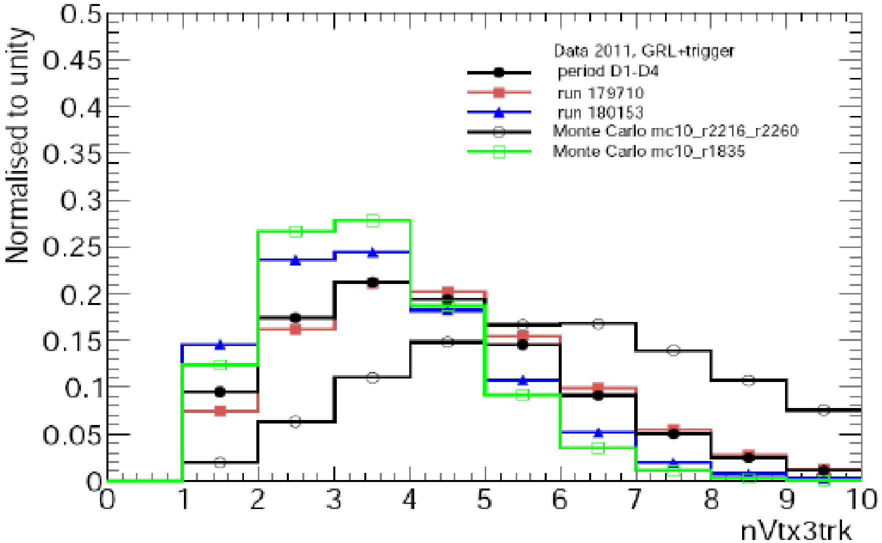
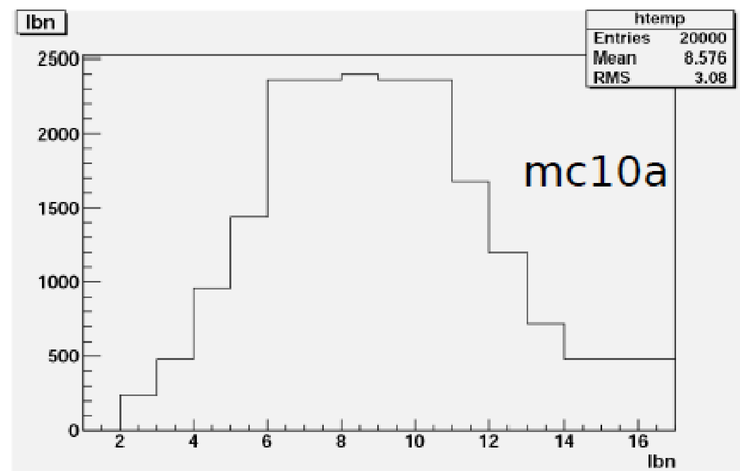
Few analysis details

Pileup in 2011



Number of reconstructed 3-trk vertices	Weight GRL+ trigger
1	$4.66 \cdot 10^{0}$
2	$2.81 \cdot 10^{0}$
3	$1.90 \cdot 10^{0}$
4	$1.29 \cdot 10^{0}$
5	$8.61 \cdot 10^{-1}$
6	$5.61 \cdot 10^{-1}$
7	$3.62 \cdot 10^{-1}$
8	$2.32 \cdot 10^{-1}$
≥ 9	$9.71 \cdot 10^{-2}$

- nVtx_3track distribution used in 2010 data to reweight MC to data
- This method will not be used in 2011, to be replaced by PAT tool
- As temporary for results presented today mc10 reweighted according to nVtx_3trk distribution



Period D-H (EPS dataset)
1.02fb^{-1} , 2.2 10^6 probes

Selection	Nb of events	Relative acceptance (%)
GRL	$1.24 \cdot 10^8$	—-
Vtx	$1.24 \cdot 10^8$	99.4
Trigger	$1.61 \cdot 10^7$	13.0
Cleaning	$1.42 \cdot 10^7$	99.4
Electron ($E_T > 15GeV$)	$1.33 \cdot 10^7$	82.3
veto Zee	$1.33 \cdot 10^7$	99.9
$\rightarrow e^+$	$\rightarrow 7.10 \cdot 10^6$	$\rightarrow$ frac = 53.39 %
$\rightarrow e^-$	$\rightarrow 6.20 \cdot 10^6$	$\rightarrow$ frac = 46.61 %
$MET_{LocHadTopo}$	$1.05 \cdot 10^7$	79.11
m_T	$1.02 \cdot 10^7$	97.10
$\rightarrow e^+$	$\rightarrow 5.49 \cdot 10^6$	$\rightarrow$ frac = 53.7 %
$\rightarrow e^-$	$\rightarrow 4.73 \cdot 10^6$	$\rightarrow$ frac = 46.3 %
loose	$2.71 \cdot 10^6$	ϵ = 26.5 %
medium	$2.10 \cdot 10^6$	ϵ = 20.5 %
tight	$1.66 \cdot 10^5$	ϵ = 16.2 %
E_T^{miss} isol ($\Delta R > 0.7$)	2239434	16.2
$\rightarrow e^+$	$\rightarrow$ 1283007	$\rightarrow$ frac = 57.3 %
$\rightarrow e^-$	$\rightarrow$ 9564270	$\rightarrow$ frac = 42.7 %
loose	1652143	$\epsilon = 73.8 \pm 0.03$ %
medium	1478092	$\epsilon = 66.0 \pm 0.03$ %
tight	1222282	$\epsilon = 54.6 \pm 0.03$ %

Trigger:

- Accumulated statistics should allow to study trigger bias

Period D-H (EPS dataset)

Trigger	Number probes	Fraction
	Before track quality	
OR of triggers vs GRL	$1.62 \cdot 10^7$	13.0 %
EF_xs60_noMu_L1EM10XS45	$6.65 \cdot 10^6$	41.1 %
EF_xs75_noMu_L1EM10XS50	$1.47 \cdot 10^6$	9.1 %
EF_g20_etcut_xe30_noMu	$3.40 \cdot 10^6$	21.0 %
EF_e13_etcut_xs60_noMu	$6.53 \cdot 10^6$	40.4 %

In period G pileup noise suppression introduced

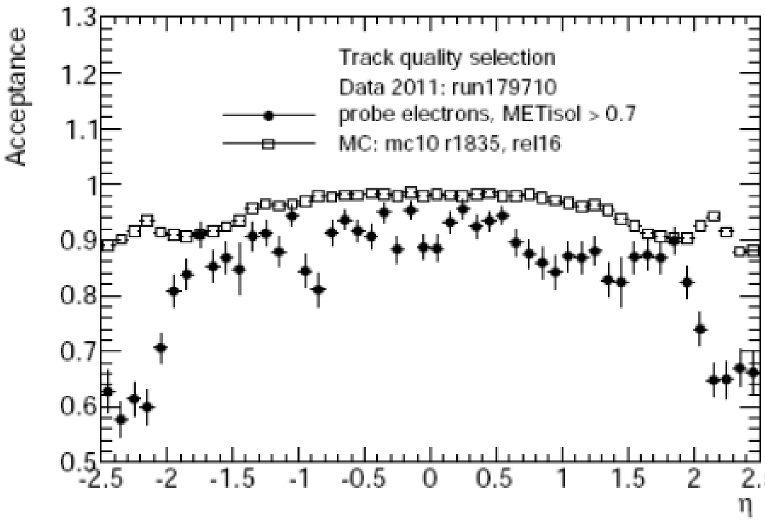
In period G-H, electron reconstructed with track quality

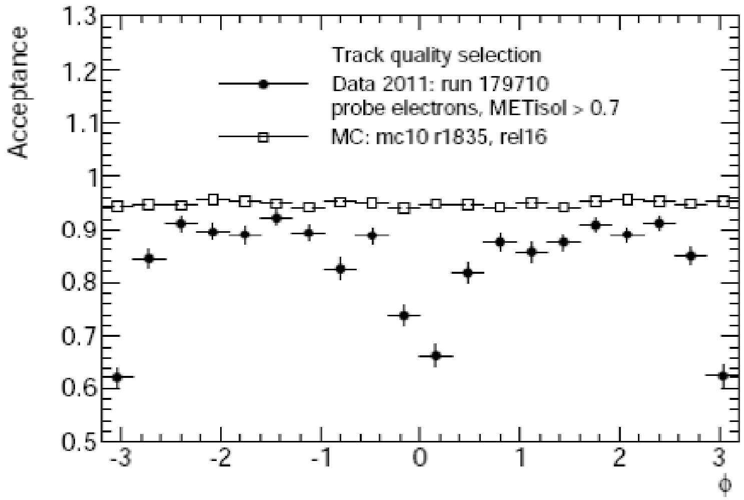
Trigger	Number probes	Fraction
	Before track quality	
EF_xs60_noMu_L1EM10XS45	788647	35.22 %
EF_xs75_noMu_L1EM10XS50	20064	0.90 %
EF_g20_etcut_xe30_noMu	99904	4.46 %
EF_e13_etcut_xs60_noMu	1330819	59.43 %
	After track quality	
EF_xs60_noMu_L1EM10XS45	612591	31.36 %
EF_xs75_noMu_L1EM10XS50	14862	0.76 %
EF_g20_etcut_xe30_noMu	79619	4.08 %
EF_e13_etcut_xs60_noMu	1246476	63.8 %

Track quality selection

- Require
  - **nPixHit >=1 && nSiHits >=7**
- It was shown to suppress beam background (could be rejected also with METisol < 3.0)
- Fraction accepted corresponds to condition of period I in 2010 data

Track quality selection	All Probes	Bad Probes	Accept (%)
$METisol > 0.7$	8616	1489	82.7 %
$METisol > 1.5$	5715	1101	80.7 %
$METisol > 2.5$	4158	929	77.7 %





Kinematics for probes

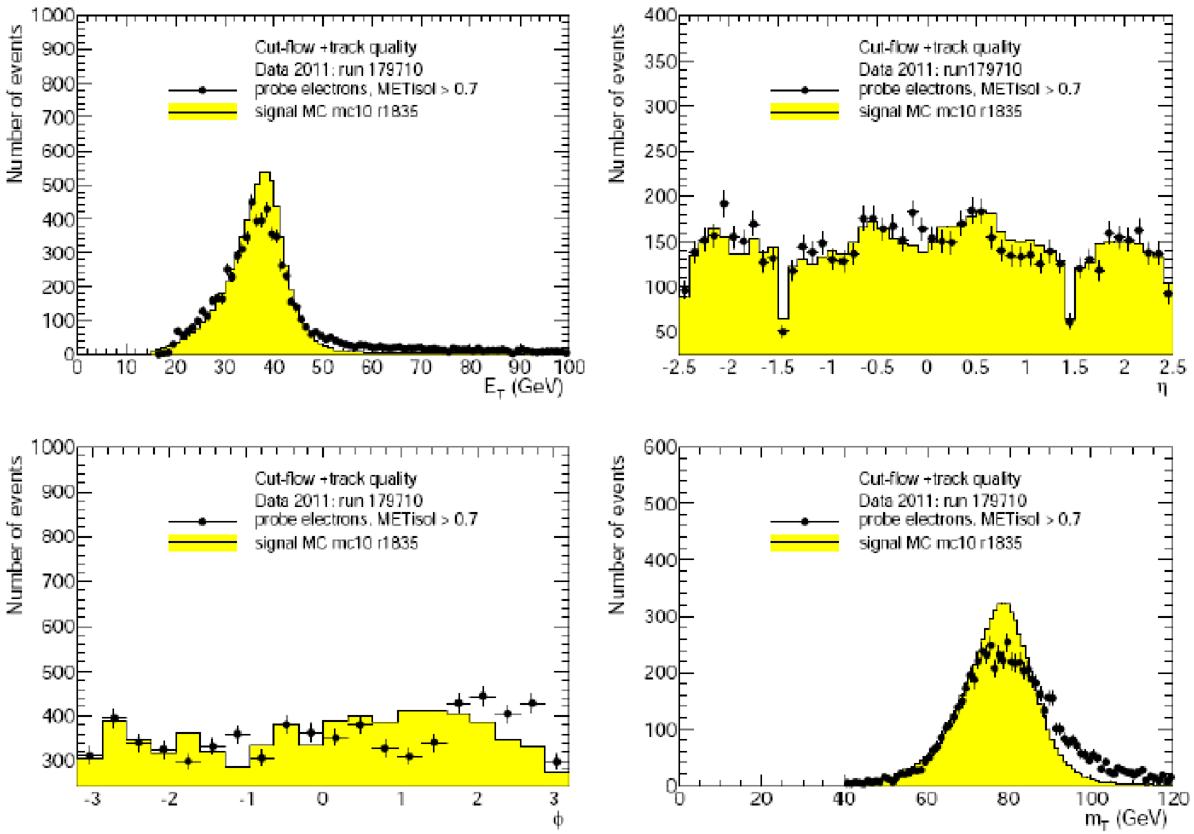


Figure 4: Kinematical distributions of selected probes in the data processed with rel.16 and signal Monte Carlo mc10 r1835, loose matching to the truth. MC normalised to number of events in data.

Kinematics for tight

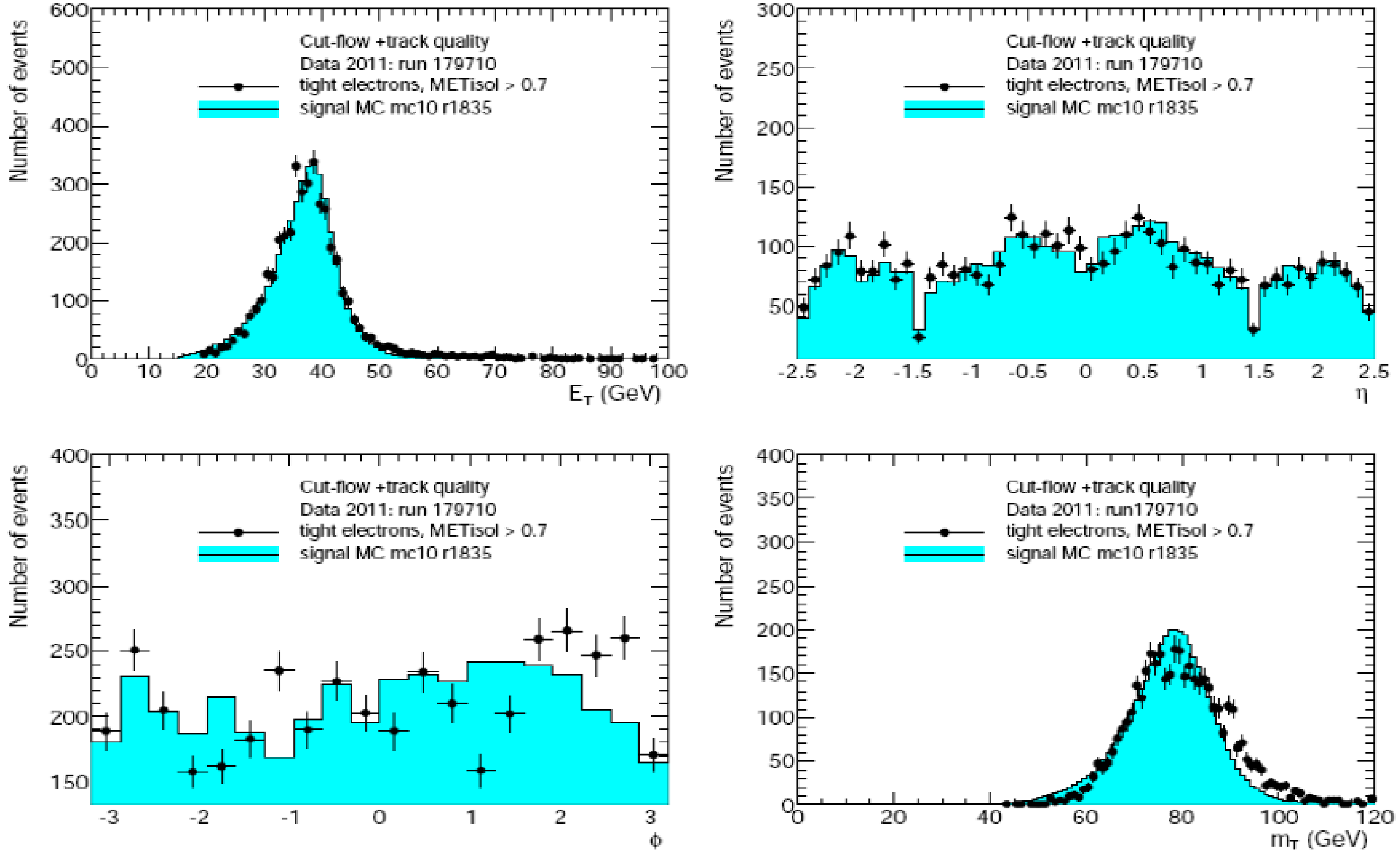


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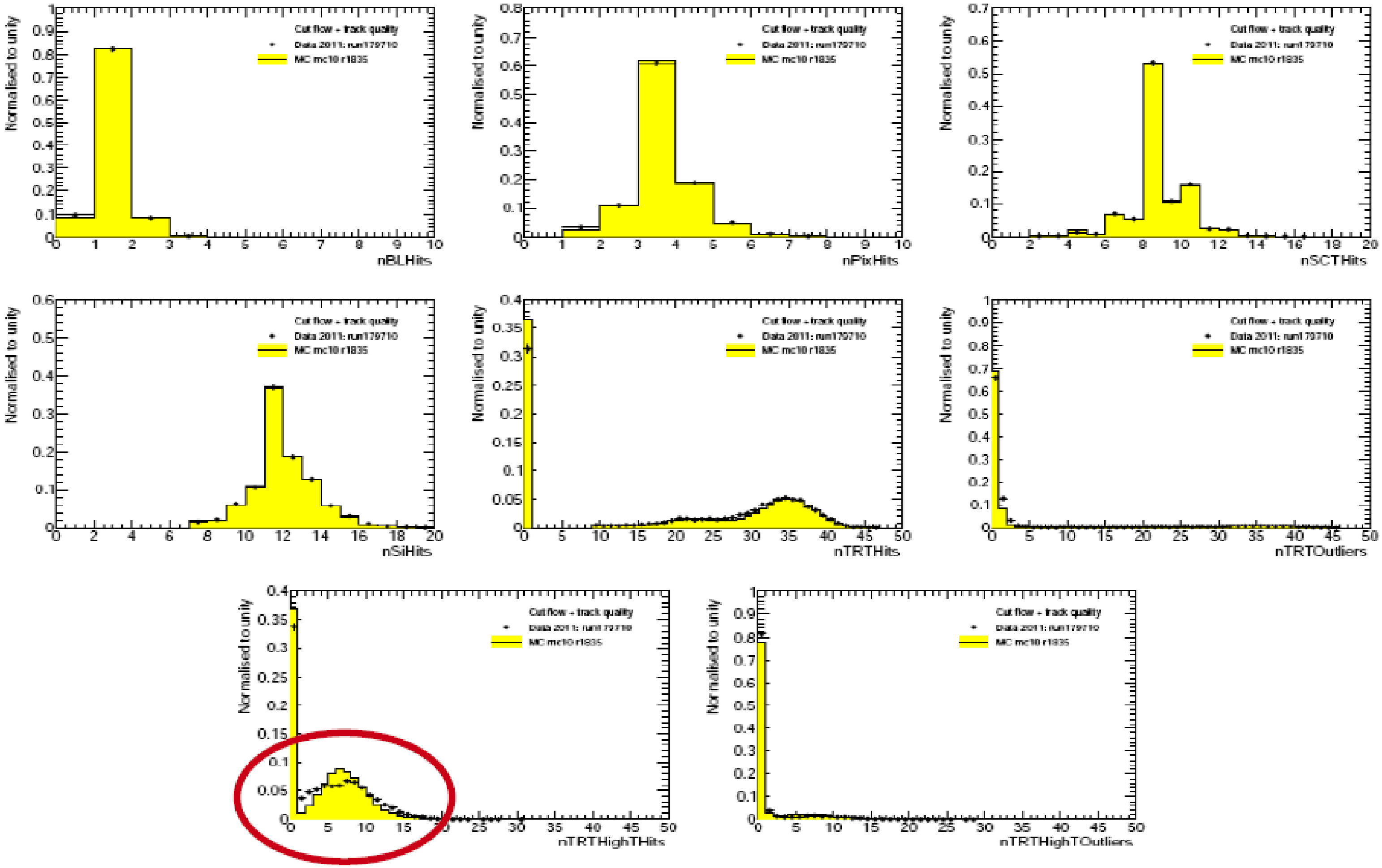
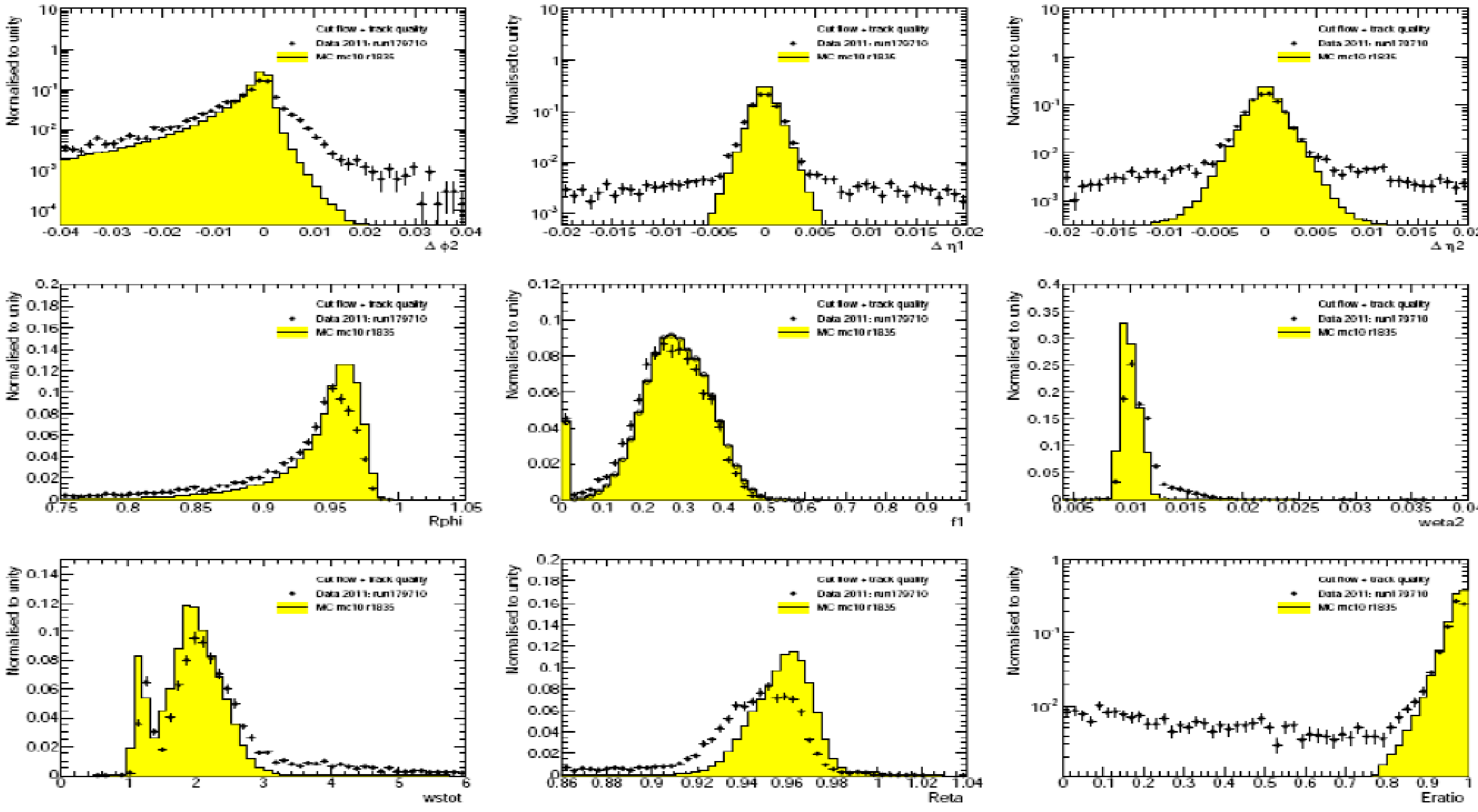
Figure 5: Same as above but for tight electrons.

Egamma variables: tracking

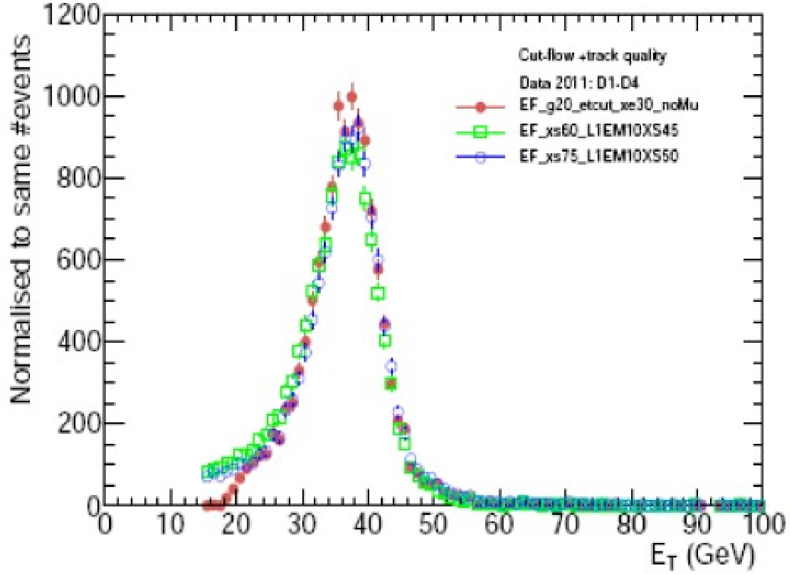


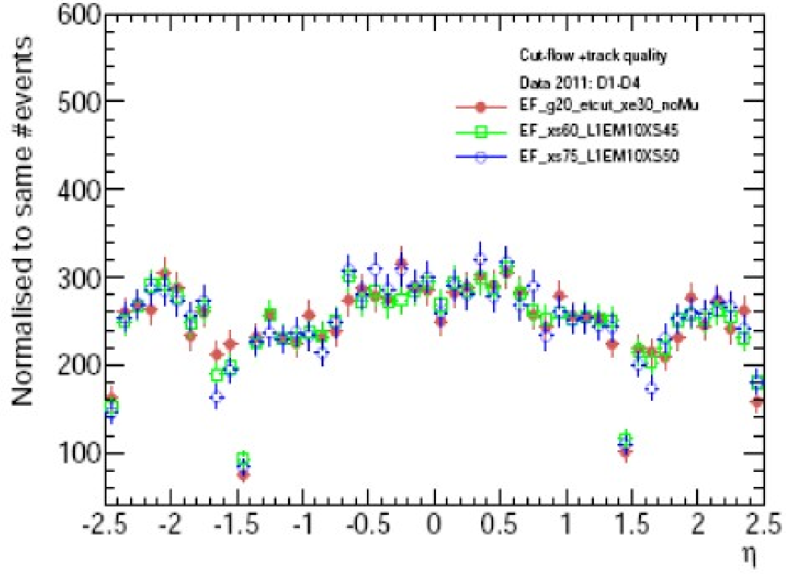
Egamma variables: calo



Trigger in 2011

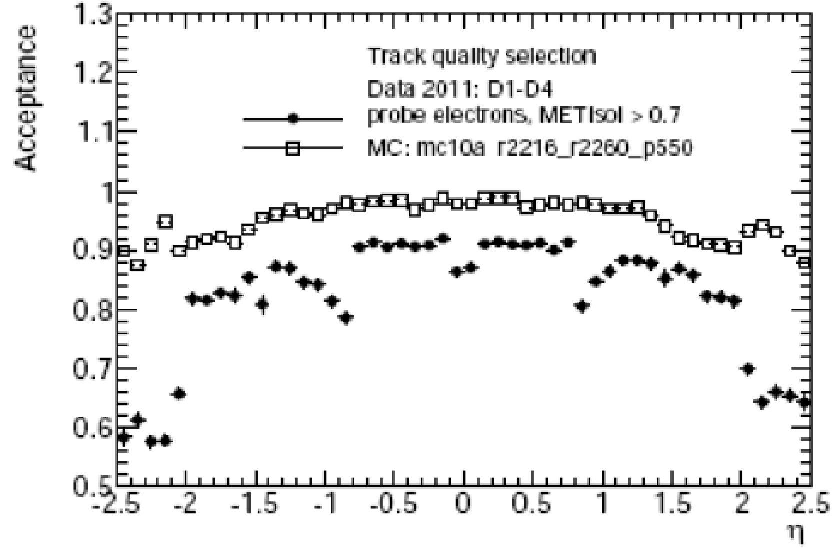
- With g20_etcut_xe30_noMu suppressed probes E_T<25 GeV
- Otherwise stable E_T, η distributions vs different triggers
- D4 composition: xs60(60%); xs75(36%); g20(4%)

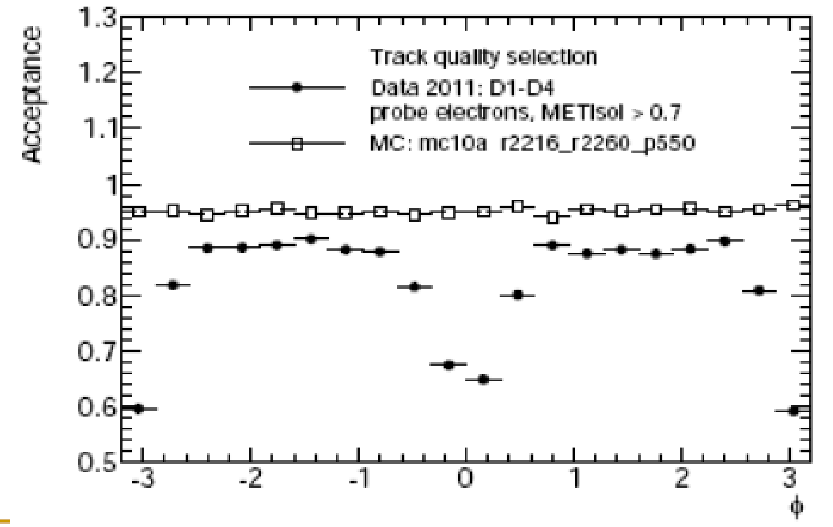




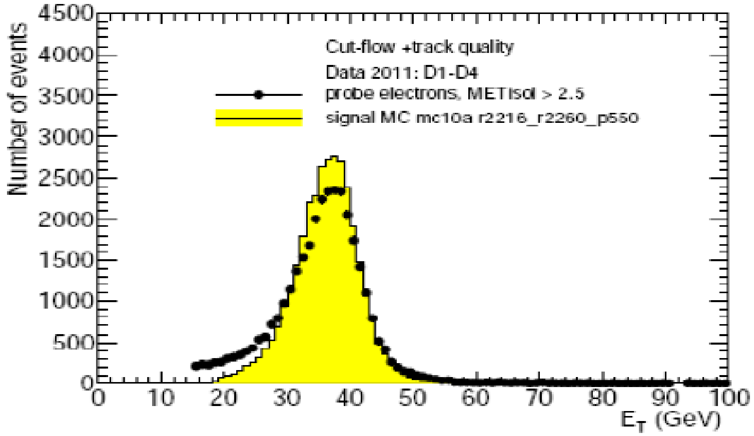
Track quality selection

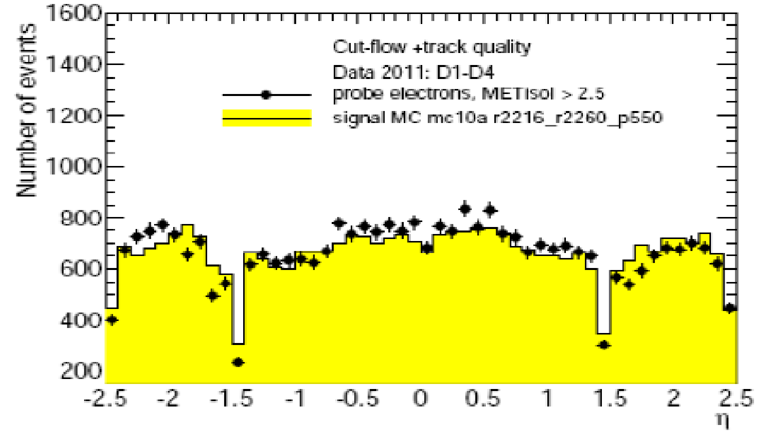
- 117971 probes in data select before track quality
  - Require
    - **nPixHit >=1 && nSiHits >=7**
  - It was shown to suppress beam background (could be rejected also with METisol < 3.0)
  - Fraction of accepted probes (81.3%) corresponds to condition of period H in 2010 data

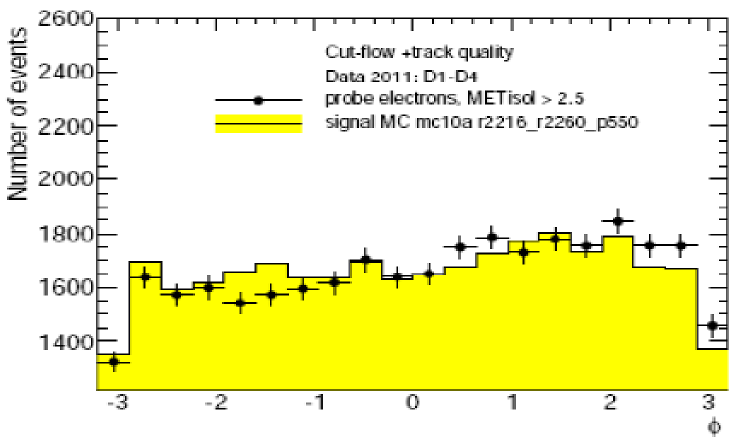


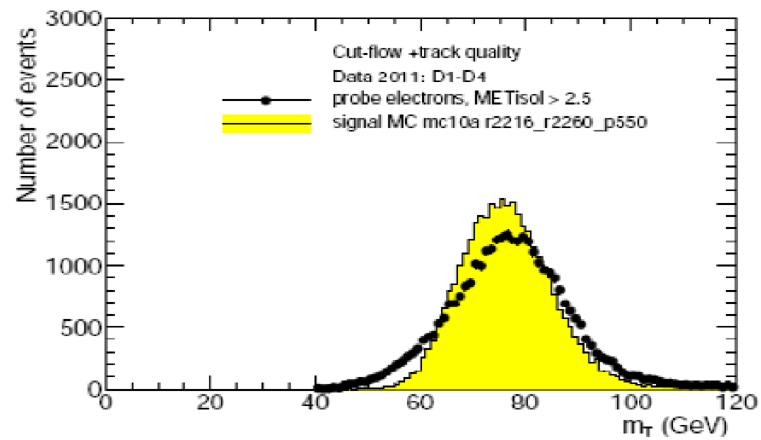


Kinematics for probes

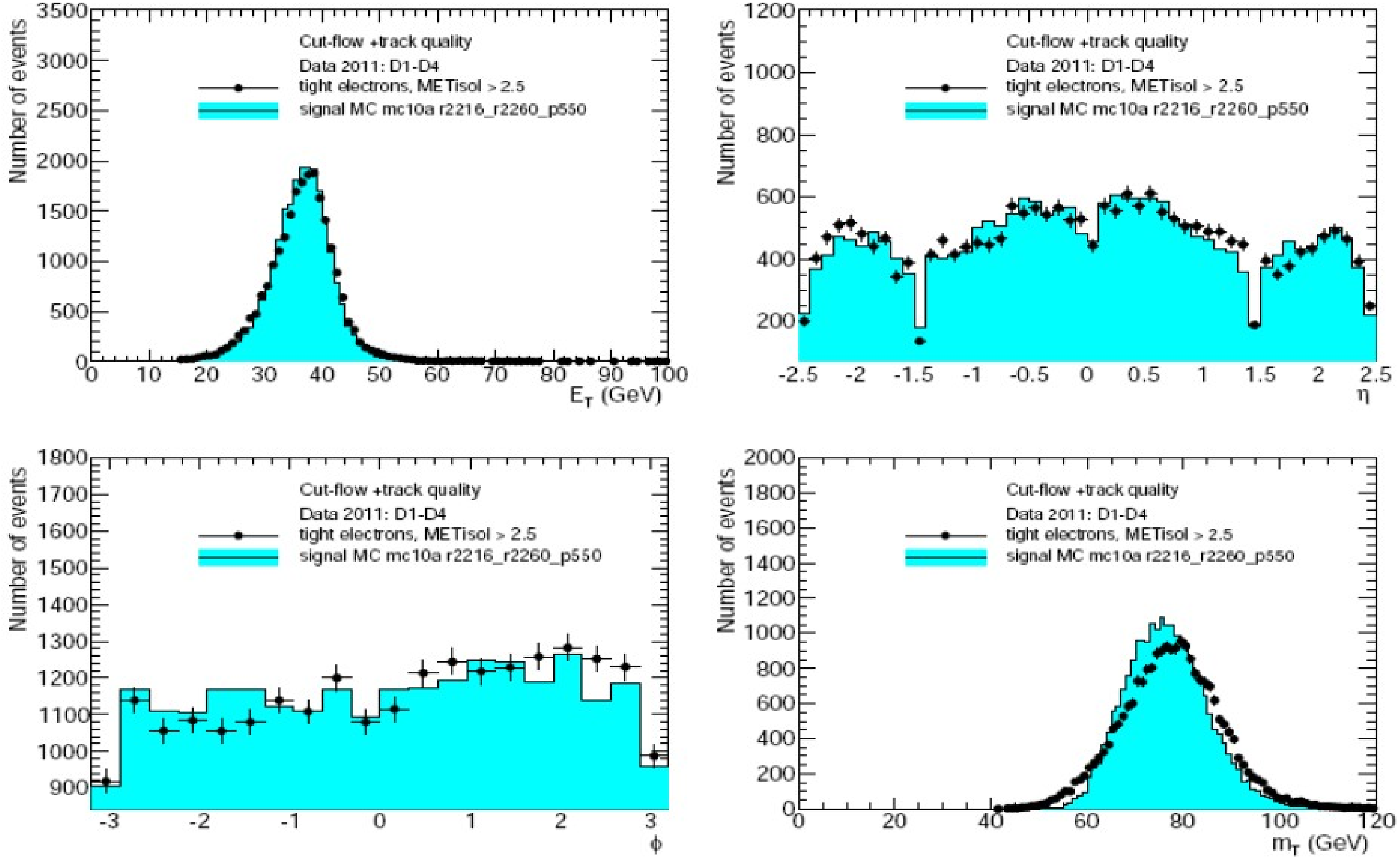






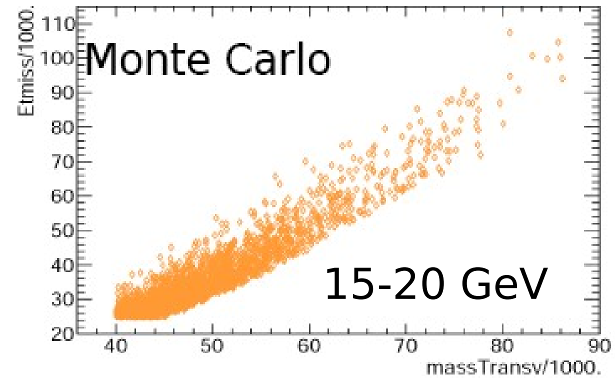


Kinematics for selected tight

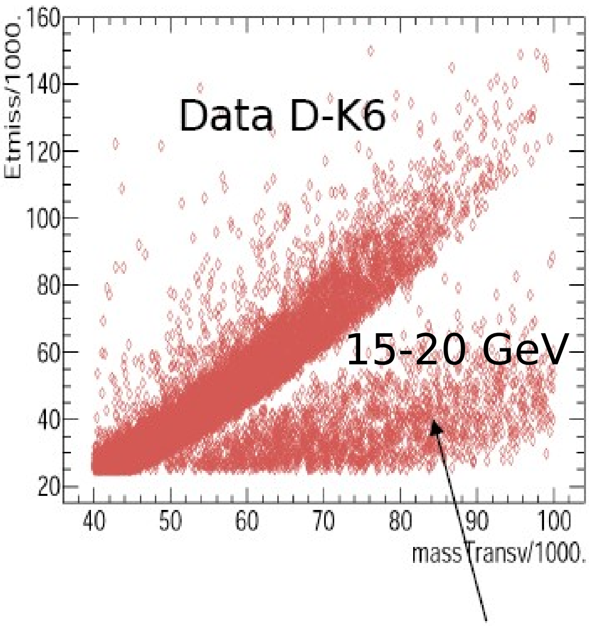


D-K6: final selection

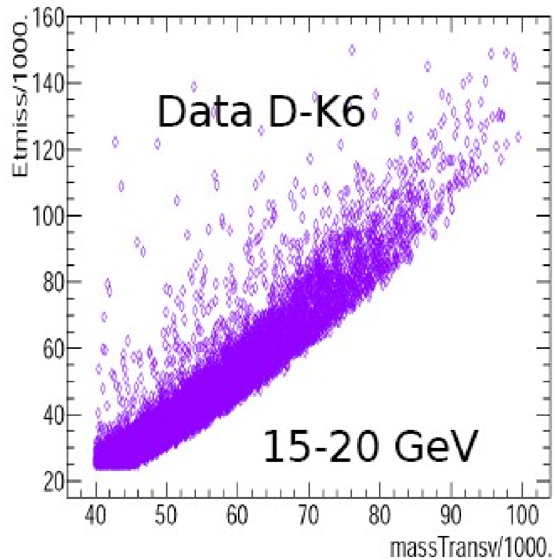
- Kinematical distribution spans esonable wide range, we can play with kinematical cuts



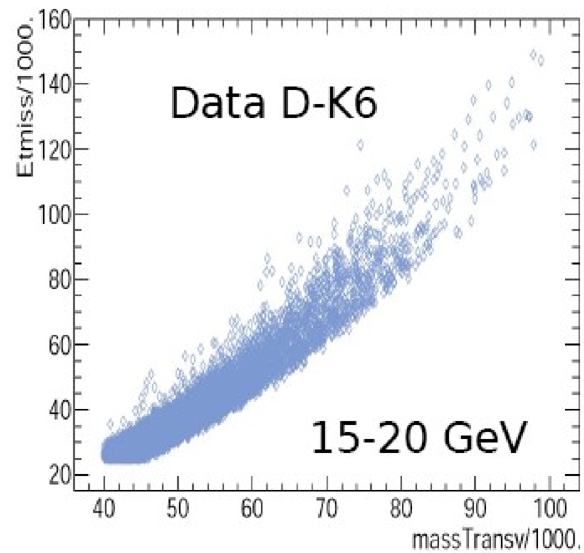
Baseline cut flow



+ track quality

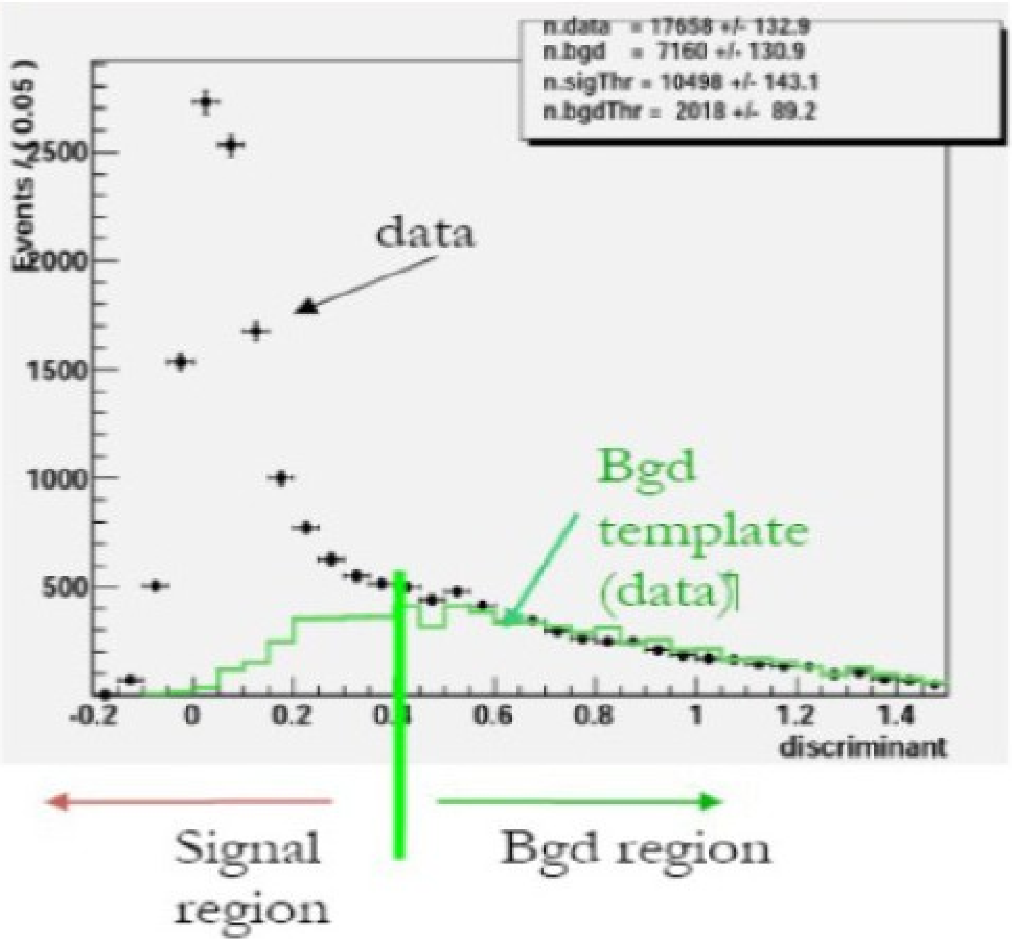


+ METisol > 2.0

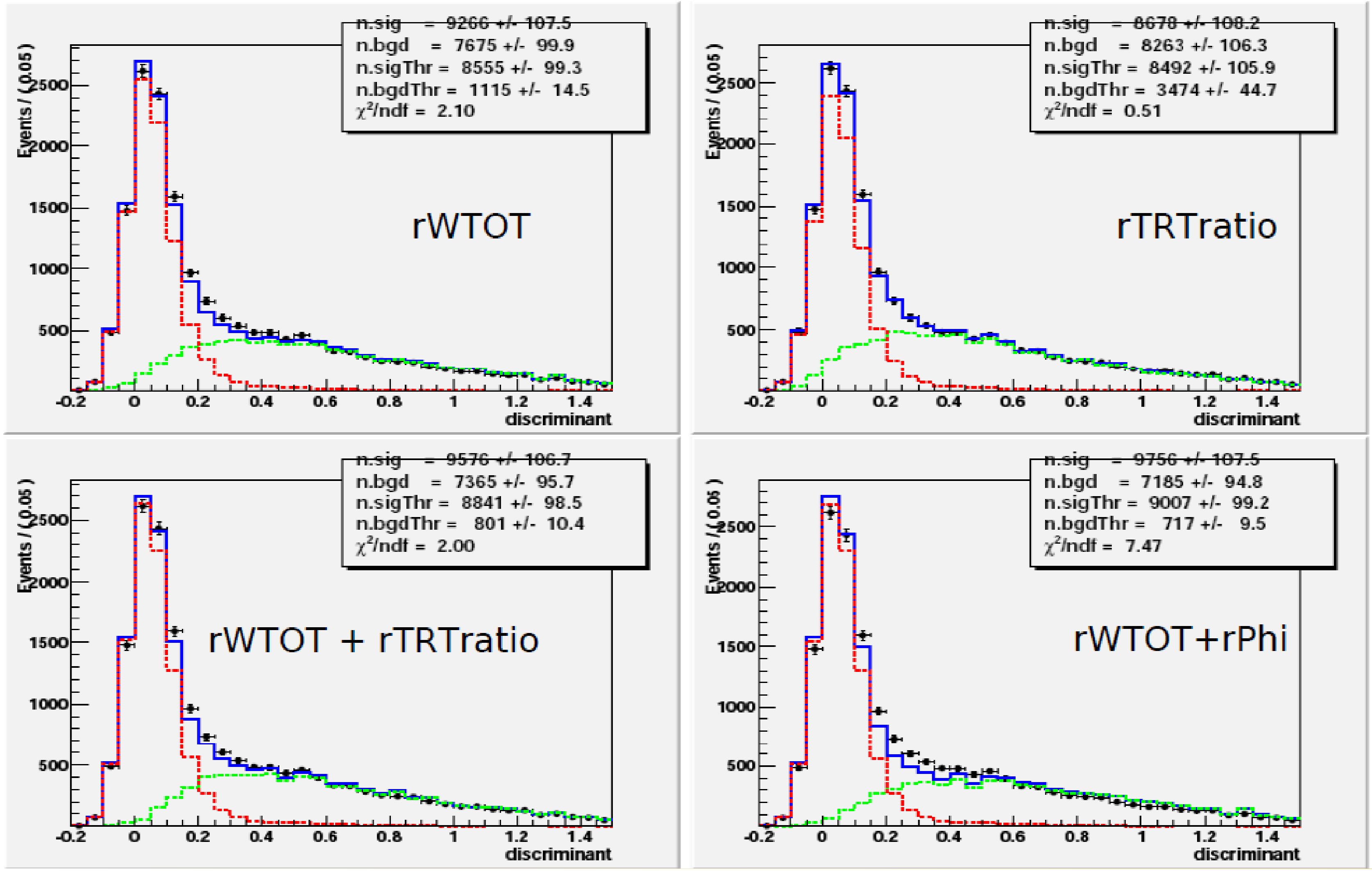


Beam-halo bgd, suppressed by track quality

Simple subtraction method



Barrel: denominator, 20-25 GeV



IsEM bits

Used for tight
Used for medium
Used for loose

Bit number	Bit name
Bit 1	ConversionMatch
Bit 2	HadronicLeakage
Bit 4	ClusterMiddleEratio37
Bit 6	ClusterMiddleWidth
Bit 11	ClusterStripsWtot
Bit 15	ClusterStripsDEmaxs1
Bit 16	TrackBLayer
Bit 19	TrackA0
Bit 20	TrackMatchEta
Bit 21	TrackMatchPhi
Bit 22	TrackMatchEoverP
Bit 24	TrackTRThits
Bit 25	TrackTRTratio
Bit 26	TrackTRTratio90
Bit 27	TrackA0Tight
Bit 28	TrackMatchEtaTight
Bit 29	IsolationElectron
Bit 30	ClusterIsolationElectron
Bit 31	TrackIsolationElectron

LOOSE identification

Hadronic leakage	⋆ Ratio of E_T in the first layer of the hadronic calorimeter to E_T of the EM cluster (used over the range $\|\eta\| < 0.8$ and $\|\eta\| > 1.37$) ⋆ Ratio of E_T in the hadronic calorimeter to E_T of the EM cluster (used over the range $\|\eta\| > 0.8$ and $\|\eta\| < 1.37$)	R_{had1} R_{had}
Second layer of EM calorimeter	⋆ Ratio in η of cell energies in 3×7 versus 7×7 cells. ⋆ Lateral width of the shower.	R_η $w_{\eta 2}$

MEDIUM identification

Medium cuts (includes Loose)		
First layer of EM calorimeter.	⋆ Total shower width. ⋆ Ratio of the energy difference associated with the largest and second largest energy deposit over the sum of these energies	w_{stot} E_{ratio}
Track quality	⋆ Number of hits in the pixel detector (≥ 1). ⋆ Number of hits in the pixels and SCT (≥ 7). ⋆ Transverse impact parameter (<5 mm).	d_0
Track matching	⋆ $\Delta\eta$ between the cluster and the track (< 0.01).	$\Delta\eta_1$

TIGHT identification

Tight cuts (includes Medium)		
b-layer	⋆ Number of hits in the b-layer (≥ 1).	
Track matching	⋆ $\Delta\phi$ between the cluster and the track (< 0.02). ⋆ Ratio of the cluster energy to the track momentum ⋆ Tighter $\Delta\eta$ cut (< 0.005)	$\Delta\phi_2$ E/p $\Delta\eta_1$
Track quality	⋆ Tighter transverse impact parameter cut (<1 mm).	d_0
TRT	⋆ Total number of hits in the TRT. ⋆ Ratio of the number of high-threshold hits to the total number of hits in the TRT.	
Conversions	⋆ Electron candidates matching to reconstructed photon conversions are rejected	

Efficiency: simple counting

The simplest case is just counting the number N_0 of candidate events and the number N_p that pass a cut. The efficiency is then given by

$$\epsilon = \frac{N_p}{N_0}. \tag{1}$$

Since N_p and N_0 are correlated, using equation 1 with propagation of uncorrelated Poisson errors does not give the correct uncertainty on the efficiency. Usually, this is handled by noting that this is equivalent to a binomial problem with total events N_0 and a probability ϵ for each event to pass. The uncertainty on ϵ is then given by

$$(\Delta\epsilon)^2 = \frac{\epsilon(1-\epsilon)}{N_0}. \tag{2}$$

Efficiency: simple counting

An equivalent, alternative method is to consider the number N_p of events that pass and the number N_f that fail (see pages 46-48 of **Statistics for Nuclear and Particle Physicists** by Louis Lyons, Cambridge University Press, 1986). These two are uncorrelated and hence easier to use in error propagation. Note that in this approach, the total number of events $N_0 = N_p + N_f$ is not a fixed number, but is itself Poisson distributed. The efficiency is

$$\epsilon = \frac{N_p}{N_p + N_f}. \tag{3}$$

Standard error propagation then gives

$$\begin{aligned}
(\Delta\epsilon)^2 &= \left(\frac{\partial\epsilon}{\partial N_p}\right)^2 (\Delta N_p)^2 + \left(\frac{\partial\epsilon}{\partial N_f}\right)^2 (\Delta N_f)^2 && (4)\\
&= \left(\frac{N_f}{N_0^2}\right)^2 (\Delta N_p)^2 + \left(\frac{-N_p}{N_0^2}\right)^2 (\Delta N_f)^2 && (5)\\
&= \frac{(1-\epsilon)^2 N_p + \epsilon^2 N_f}{N_0^2} && (6)\\
&= \frac{\epsilon(1-\epsilon)}{N_0}. && (7)
\end{aligned}$$

Note that this is exactly the same result as obtained by considering it as a binomial problem, as it should be since they are equivalnet. The reason for considering the second method is that it is easier to extend to the cases considered below.

Efficiency: fits

Instead, suppose that the fit number that pass the cut is $N_p \pm \Delta N_p$ and the fit number that fail the cut is $N_f \pm \Delta N_f$. The efficiency is

$$\epsilon = \frac{N_p}{N_p + N_f}. \tag{8}$$

Standard error propagation gives

$$\begin{aligned}
(\Delta\epsilon)^2 &= \left(\frac{\partial\epsilon}{\partial N_p}\right)^2 (\Delta N_p)^2 + \left(\frac{\partial\epsilon}{\partial N_f}\right)^2 (\Delta N_f)^2 & (9)\\
&= \frac{(1-\epsilon)^2(\Delta N_p)^2 + \epsilon^2(\Delta N_f)^2}{N_0^2}, & (10)\\
& & (11)
\end{aligned}$$

where we assume $N_0 = N_p + N_f$ (which is not exactly true in each case since each of these numbers comes from a fit, but is a hopefully good approximation).

Efficiency: fits

Instead, suppose that the fit number that pass the cut is $N_p \pm \Delta N_p$ and the fit number that fail the cut is $N_f \pm \Delta N_f$. The efficiency is

$$\epsilon = \frac{N_p}{N_p + N_f}. \tag{8}$$

Standard error propagation gives

$$(\Delta\epsilon)^2 = \left(\frac{\partial\epsilon}{\partial N_p}\right)^2 (\Delta N_p)^2 + \left(\frac{\partial\epsilon}{\partial N_f}\right)^2 (\Delta N_f)^2 \tag{9}$$

$$= \frac{(1-\epsilon)^2(\Delta N_p)^2 + \epsilon^2(\Delta N_f)^2}{N_0^2}, \tag{10}$$

$$\tag{11}$$

where we assume $N_0 = N_p + N_f$ (which is not exactly true in each case since each of these numbers comes from a fit, but is a hopefully good approximation).

Efficiency: fits

If we also assume that $(\Delta N_0)^2 = (\Delta N_p)^2 + (\Delta N_f)^2$, then we can rewrite $(\Delta\epsilon)^2$ completely in terms of results of fits to the total number before the cut and the number that pass the cut, that is,

$$(\Delta\epsilon)^2 = \frac{(1-\epsilon)^2(\Delta N_p)^2 + \epsilon^2(\Delta N_f)^2}{N_0^2} \quad (12)$$

$$= \frac{(1-2\epsilon)(\Delta N_p)^2 + \epsilon^2((\Delta N_p)^2 + (\Delta N_f)^2)}{N_0^2} \quad (13)$$

$$= \frac{(1-2\epsilon)(\Delta N_p)^2 + \epsilon^2(\Delta N_0)^2}{N_0^2}. \quad (14)$$

Note that if we replace $(\Delta N_p)^2$ and $(\Delta N_0)^2$ by their Poisson values of N_p and N_0, respectively, we get back the usual binomial formula.

Efficiency: side-band subtraction

We define a signal region and a side band region. Let N_p and N_f, be the numbers of events in the signal region that pass and fail the cut, respectively. Let $N_{p,SB}$ and $N_{f,SB}$ be the corresponding numbers in the side bands. Define $N_0 = N_p + N_f$ and $N_{0,SB} = N_{p,SB} + N_{f,SB}$. We want to include the fact that the side bands may not have the same number of expected background events as the signal region by defining the ratio of expected events to be α, that is, if there are N_{SB} side band events, we expect αN_{SB} events in the signal region. In this derivation, it is assumed that α is the same before and after the cut. If this is not the case, the reader is left to extend the derivation.

The efficiency is

$$\epsilon = \frac{N_p - \alpha N_{p,SB}}{N_p + N_f - \alpha(N_{p,SB} + N_{f,SB})} \tag{18}$$

Standard propagation of errors gives

$$\begin{aligned}
(\Delta\epsilon)^2 &= \left(\frac{\partial\epsilon}{\partial N_p}\right)^2 (\Delta N_p)^2 + \left(\frac{\partial\epsilon}{\partial N_{p,SB}}\right)^2 (\Delta N_{p,SB})^2 + \\
&\quad \left(\frac{\partial\epsilon}{\partial N_f}\right)^2 (\Delta N_f)^2 + \left(\frac{\partial\epsilon}{\partial N_{f,SB}}\right)^2 (\Delta N_{f,SB})^2 && (19) \\
&= \frac{(1-\epsilon)^2((\Delta N_p)^2 + \alpha^2(\Delta N_{p,SB})^2) + \epsilon^2((\Delta N_f)^2 + \alpha^2(\Delta N_{f,SB})^2)}{(N_0 - \alpha N_{0,SB})^2} && (20) \\
&= \left[(1-2\epsilon)((\Delta N_p)^2 + \alpha^2(\Delta N_{p,SB})^2) + \epsilon^2((\Delta N_p)^2 + (\Delta N_f)^2) + \right. \\
&\quad \left. \epsilon^2\alpha^2((\Delta N_{p,SB})^2 + (\Delta N_{f,SB})^2)\right] / (N_0 - \alpha N_{0,SB})^2 && (21) \\
&= \frac{(1-2\epsilon)(N_p + \alpha^2 N_{p,SB}) + \epsilon^2(N_0 + \alpha^2 N_{0,SB})}{(N_0 - \alpha N_{0,SB})^2}, && (22)
\end{aligned}$$