Royal Holloway
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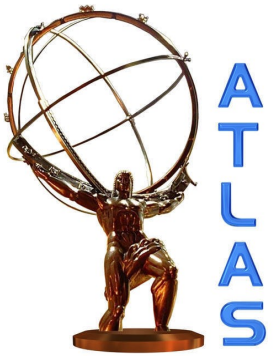


Leptonic triggers for Trilepton Analyses

Matthew Tamsett, RHUL

Antonella De Santo, Univ. of Sussex

Introduction

- This talk will deal with lepton **trigger efficiency** measurement from data in a **SUSY 3-lepton** context.

- **ATLAS goals for 2009-10 running, 200pb^{-1} at 10 TeV** – Instantaneous luminosity **~10^{32}**

Talk outline

Lepton (electron and muon) trigger efficiencies for SU4 and the major trilepton backgrounds

Recap on Tag and Probe and efficiency measurement from data

Electron trigger efficiency measurement from data

Muon trigger efficiency measurement from data

Efficiency for Multi-lepton triggers

Acceptance

Definitions

Efficiency = N1 / N2

N1 = Number of good offline **truth matched** leptons associated to objects passing trigger, (using dR matching).
N2 = Number of good offline **truth matched** leptons.

Error – Statistical error only, no systematics (for now)
Binomial errors relative to offline. No account of errors in offline definition

SUSY CSC note electron definition.

- egamma electrons
- IsEM medium
- Pt > 10 GeV
- Eta < 2.5
- No crack (exclude 1.37 < |eta| < 1.52)
- Isolation; require etcone20 < 10 GeV
- Jet Veto in cone 0.4; electron is discarded if within a jet.

SUSY CSC note muon definition.

- Staco muons
- HighPt Author
- Combined muons
- Best Match
- Pt > 10 GeV
- Eta < 2.5
- Isolation; require etcone20 < 10 GeV
- Chi^2 < 100
- Jet overlap, disguarded if within dR < 0.4 of a Jet

Trilepton Analysis cuts.

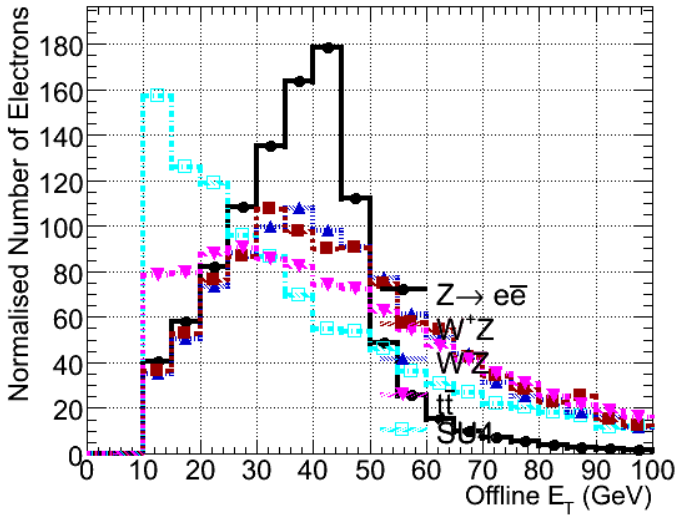
- 3 leptons

Samples, all rel 14 10TeV samples

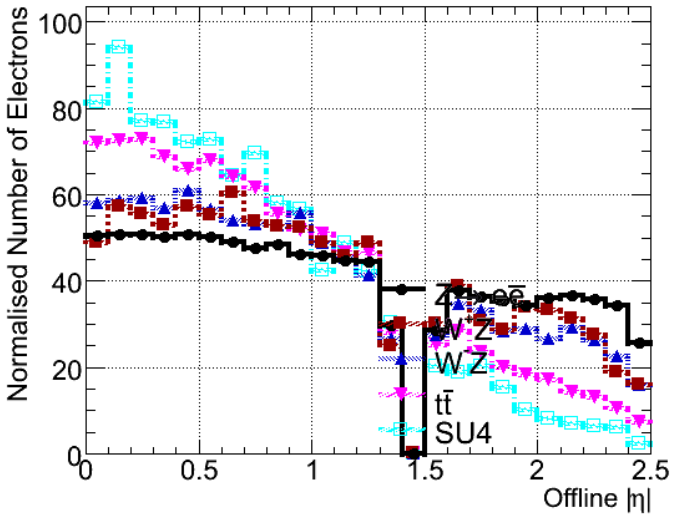
Zee	*mc08.106050.PythiaZee_1Lepton.recon.AOD.e347_s462_r604/*	*494k*
Zmumu	*mc08.106061.McAtNloZmumu_1Lepton.recon.AOD.e349_s462_r635/*	*179k*
Ttbar	*mc08.105200.T1_McAtNlo_Jimmy.recon.AOD.e357_s462_r635/*	*170k*
W+Z	*mc08.105941.McAtNlo0331_JIMMY_WpZ_lnull.recon.AOD.e367_s462_r635/*	*5k*
W-Z	*mc08.105971.McAtNlo0331_JIMMY_WmZ_lnull.recon.AOD.e367_s462_r635/*	*15k*
SU4	*mc08.106400.SU4_jimmy_susy.recon.AOD.e352_s462_r635/*	*50k*

EF e25i medium1 Efficiency

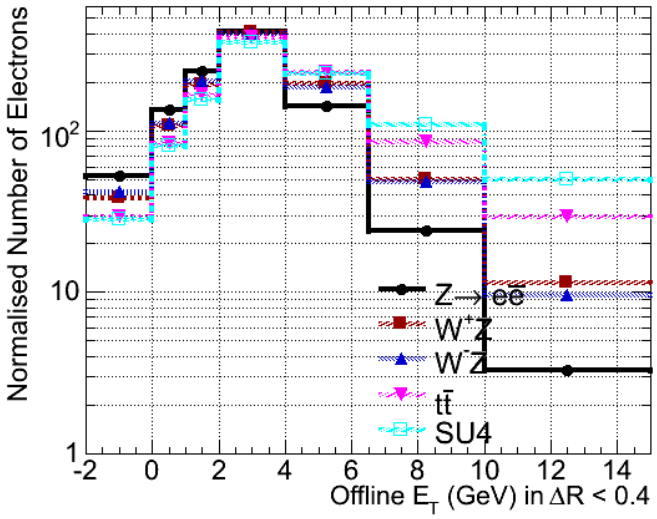
Electron Kinematics



E_T

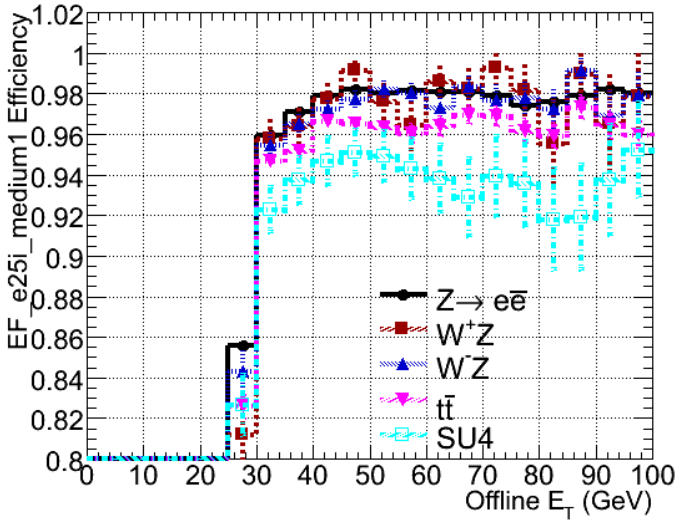


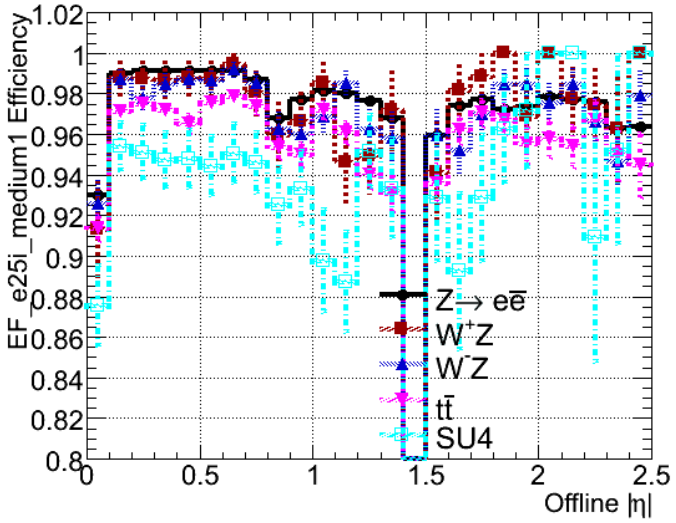
$|\eta|$

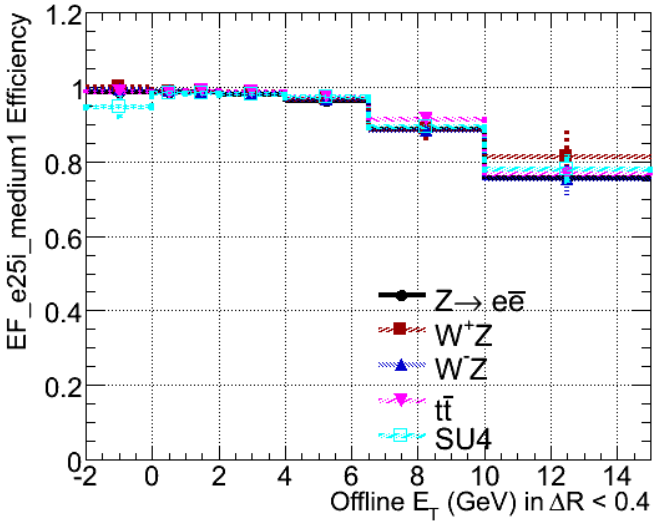


etcone40

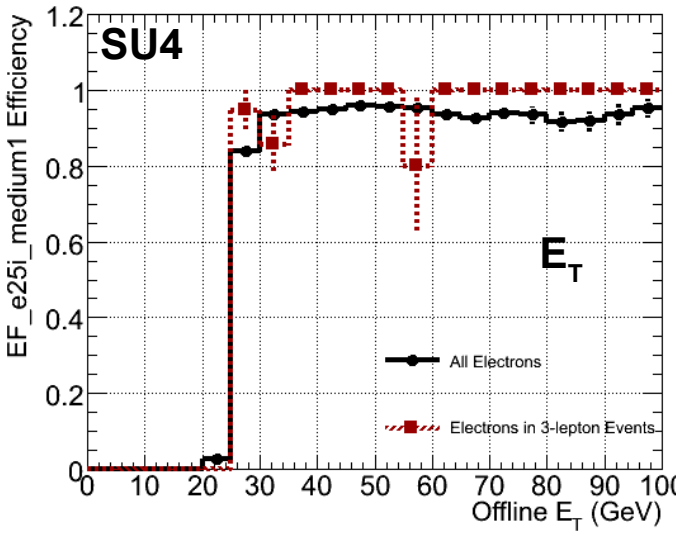
EF e25i medium1 efficiency

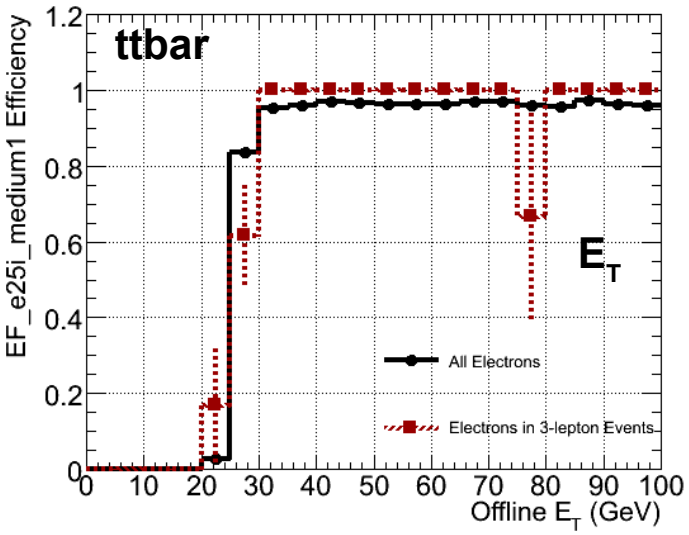






Trilepton EF e25i medium1 Efficiency



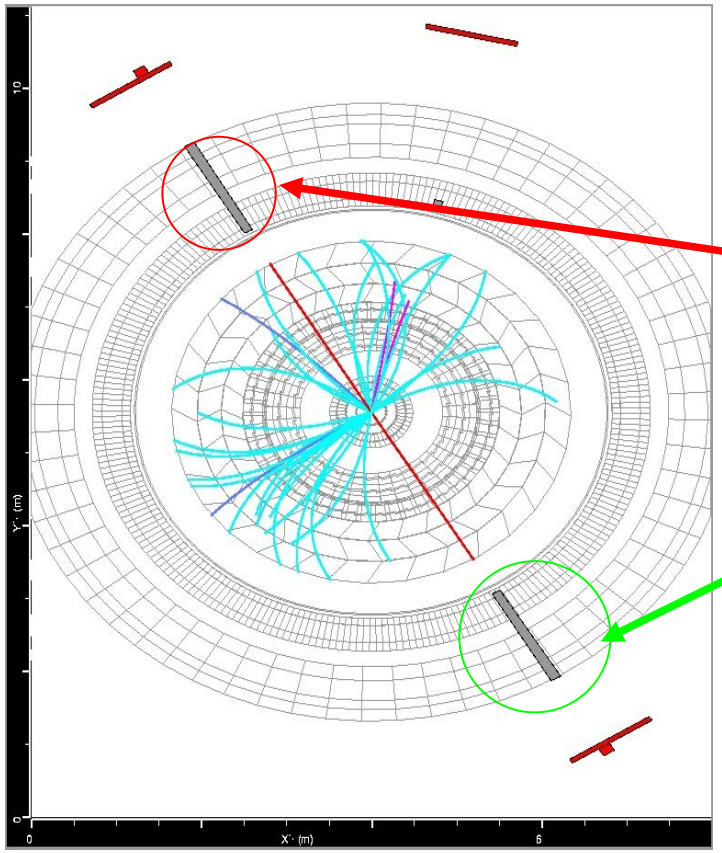


Sample	Efficiency (%)	error
Z→ee	97.7	0.0
ttbar	96.2	0.1
ttbar 3-lep	98.7	1.3
W+Z	97.5	0.3
W+Z 3-lep	97.3	0.5
W-Z	97.3	0.2
W-Z 3-lep	97.7	0.2
SU4	93.8	0.4
SU4 3-lep	97.1	1.6

Black curve; efficiency for all electrons in sample
Red curve; efficiency for electrons in trilepton events

- **Electron efficiency in Trilepton events** similar within errors to **efficiency for all electrons** in samples.
- Therefore if we can determine efficiency for all electrons then we will also know the efficiency for electrons in trilepton events.
- Binomial errors tend to 0 when efficiency tends to 1.

Recap; Measuring Efficiencies from data; Tag and Probe (v13)



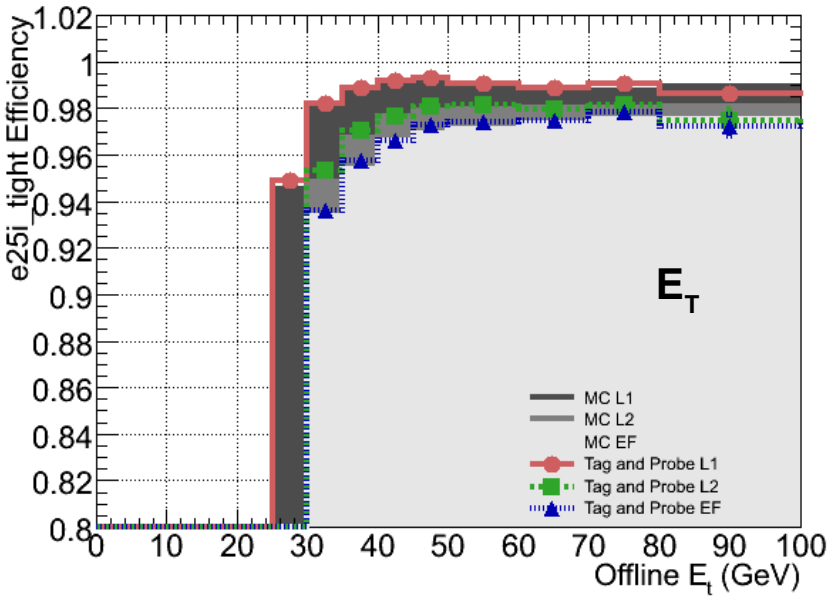
- **Control sample** defined by:

"Good" Z→ee reconstructed (from 2 offline e^+e^- with loose selection cuts) + 1 e trigger signature satisfied

- **Trigger efficiency determined from** control sample counting in how many cases the second $e^{\pm}$ satisfies the trigger requirements

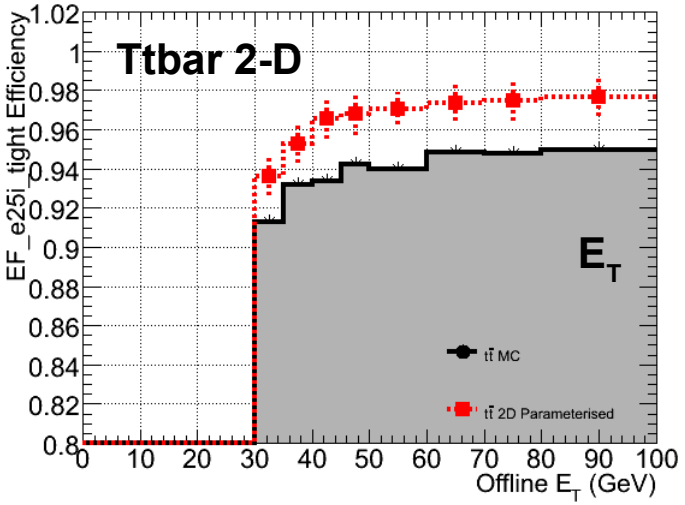
- Key of the T&P method is that it provides a "clean good sample of electrons"

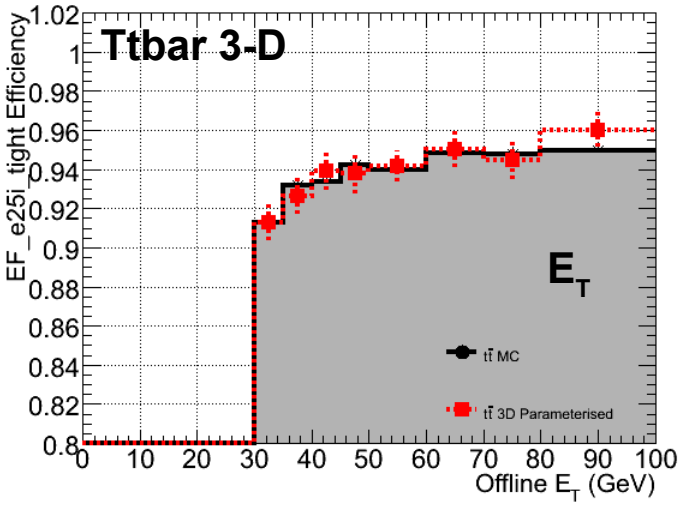
- To determine "electron trigger efficiency" you need to identify first "a good electron" and with this you can measure the efficiency of your trigger



Recap; Electron Efficiency measurement from data (v13)

- **Take Z→ee MC, work out 2D (E_T vs $|\eta|$) efficiency then apply to ttbar sample and compare to MC.**
  - Parameterisation made from all Z→ee MC data. (Will be done with T&P with real data.)
  - Plateau Efficiencies (40 < E_t < 100 GeV)





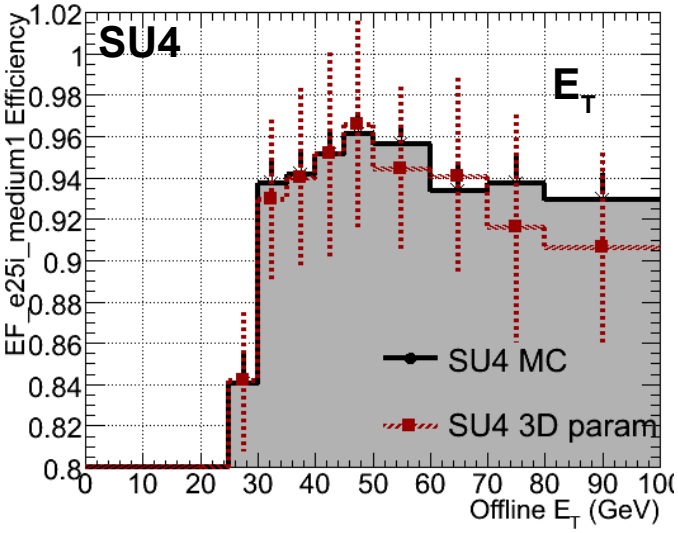
- Repeat but in 3D **(E_T vs $|\eta|$ vs etcone40).**

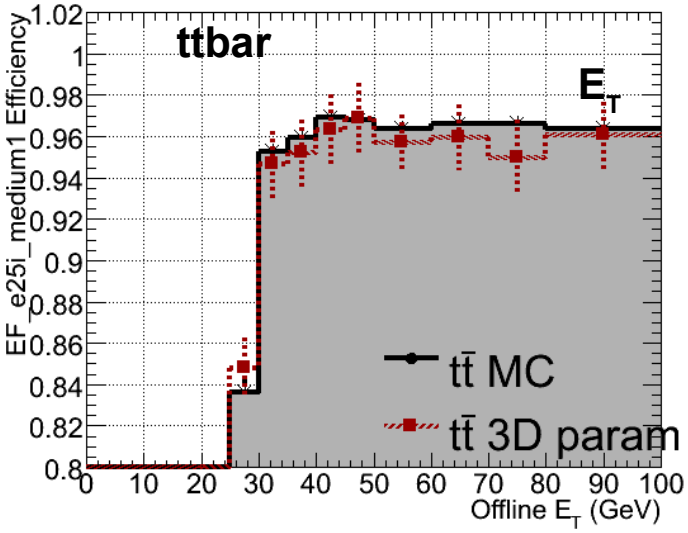
Sample	Efficiency (%)	error
Monte Carlo	94.2	0.1
2-D param	97.0	0.4
3-D param	94.4	0.4

- For more details see;

http://indico.cern.ch/conferenceDisplay.py?confId=44626

Electron Efficiency measurement from data for all Electrons





Monte Carlo

Sample	Efficiency (%)	error
ttbar	96.5	0.1
W+Z	97.8	0.3
W-Z	97.5	0.2
SU4	94.5	0.4

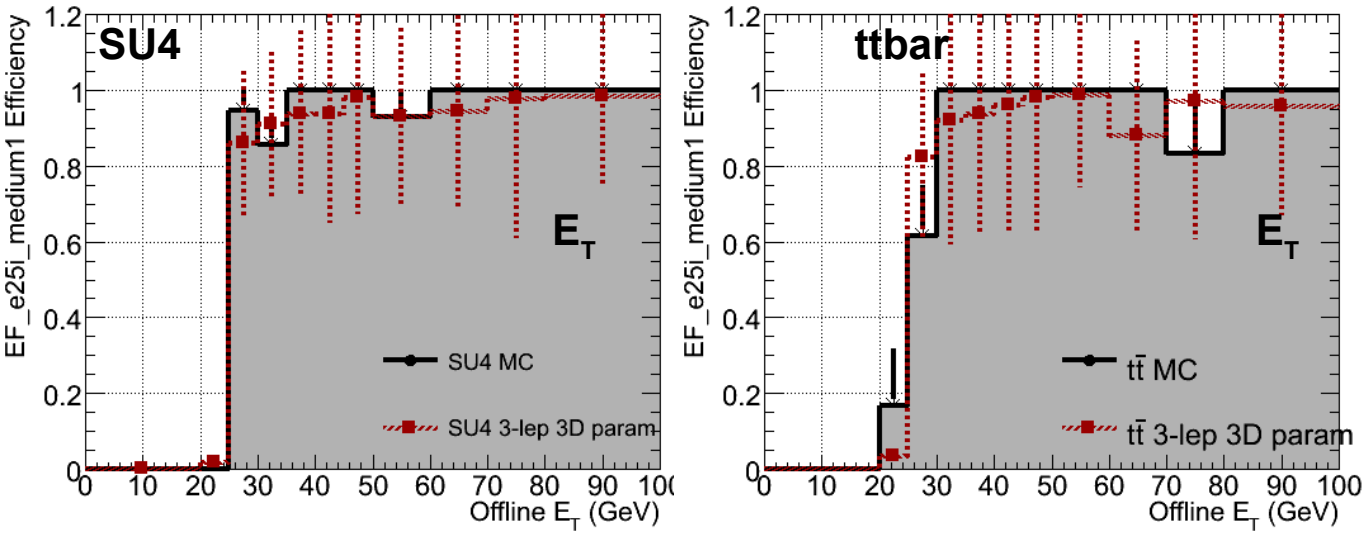
Tag and Probe parameterisations

Sample	Efficiency (%)	error
ttbar	95.9	0.6
W+Z	97.5	1.9
W-Z	97.4	1.1
SU4	93.8	1.8

- **Parameterised efficiencies** agree well with **MC efficiencies.**

- Electron efficiencies **estimated using efficiency parameterisations** obtained from Tag and Probe on Z→ee.
- For all electrons in samples.
- **Additional cut; E_T < 100 GeV;** limits the parameter space we must parameterise.
- Efficiency parameterised in 3D; **E_T vs $|\eta|$ vs etcone40**
- Statistical errors on both sample distributions and T&P efficiency considered.

Electron Efficiency measurement from data for trilepton events



- Trilepton electron efficiencies **estimated using efficiency parameterisations** obtained from Tag and Probe on Z→ee.
- Efficiency parameterised in 3D; **E_T vs $|\eta|$ vs etcone40.**

Monte Carlo

Sample	Efficiency (%)	error
ttbar	98.4	1.6
W+Z	97.5	0.5
W-Z	97.9	0.2
SU4	98.8	1.2

Tag and Probe parameterisations

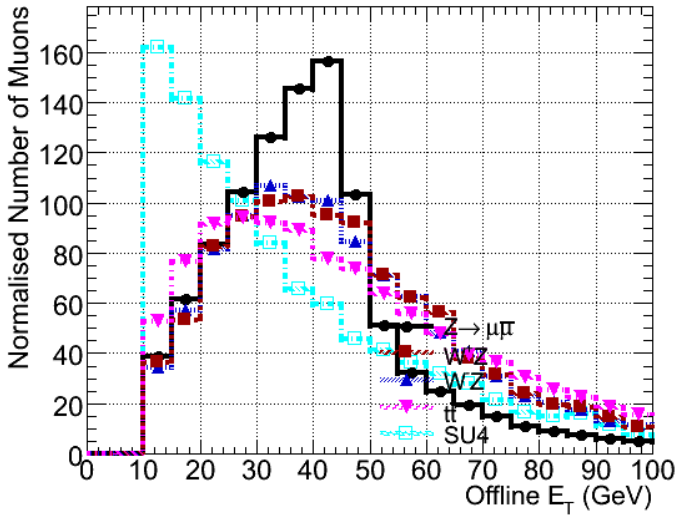
Sample	Efficiency (%)	error
ttbar	95.1	11.9
W+Z	97.2	3.0
W-Z	97.6	1.6
SU4	95.3	10.4

- **Parameterised efficiencies** agree well with **MC efficiencies.**
- Large errors on parameterisations due to low statistics

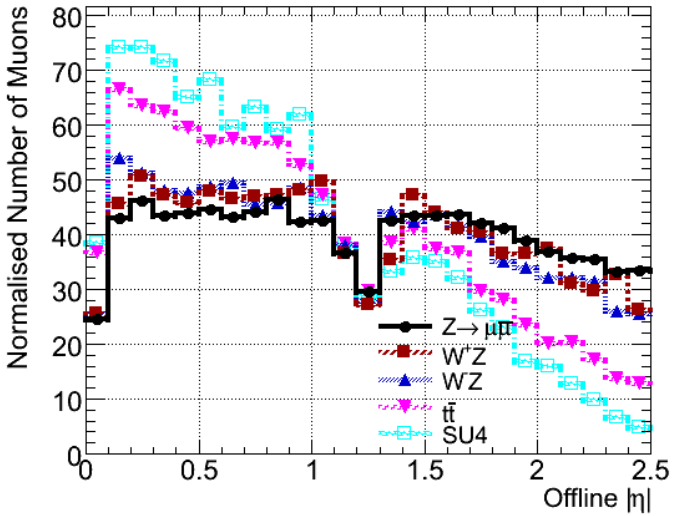
SU4: 84
Ttbar: 64
W+Z: 1050
W-Z: 3528

Muons: EF mu20 Efficiency

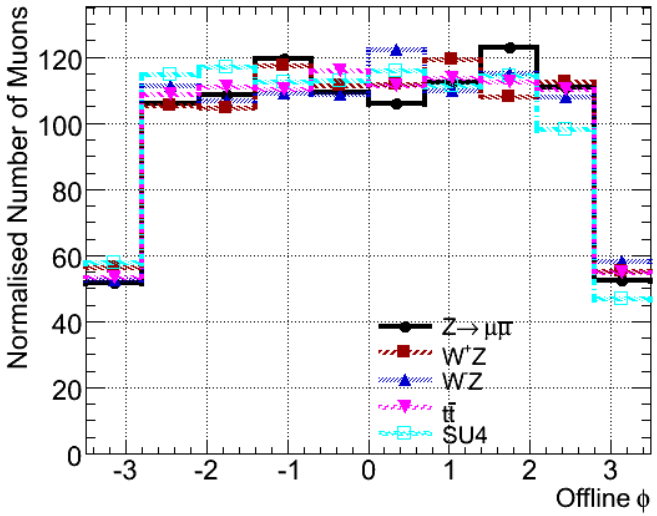
Muon Kinematics



E_T



$|\eta|$



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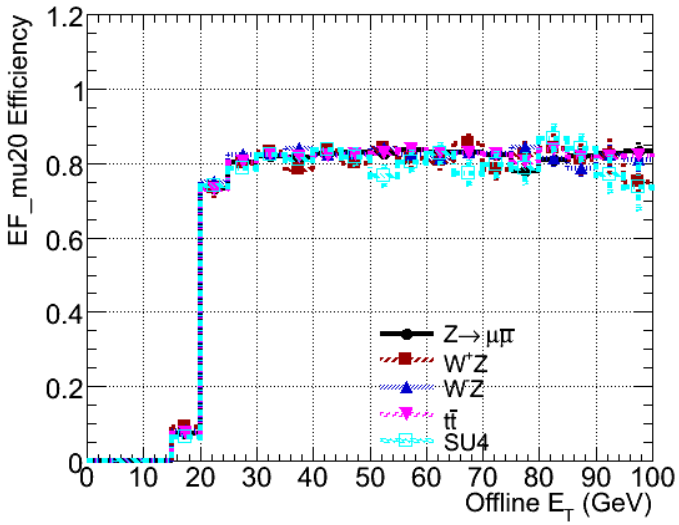
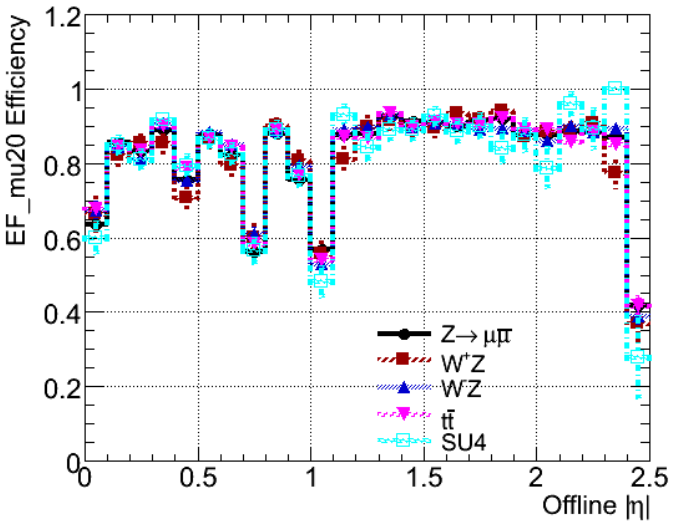
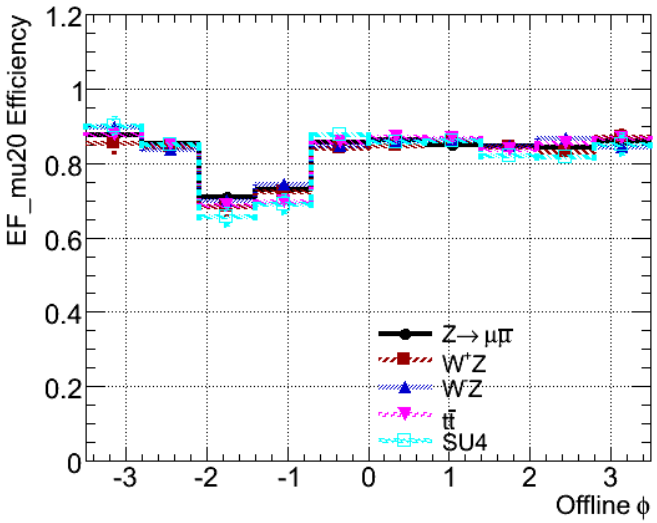
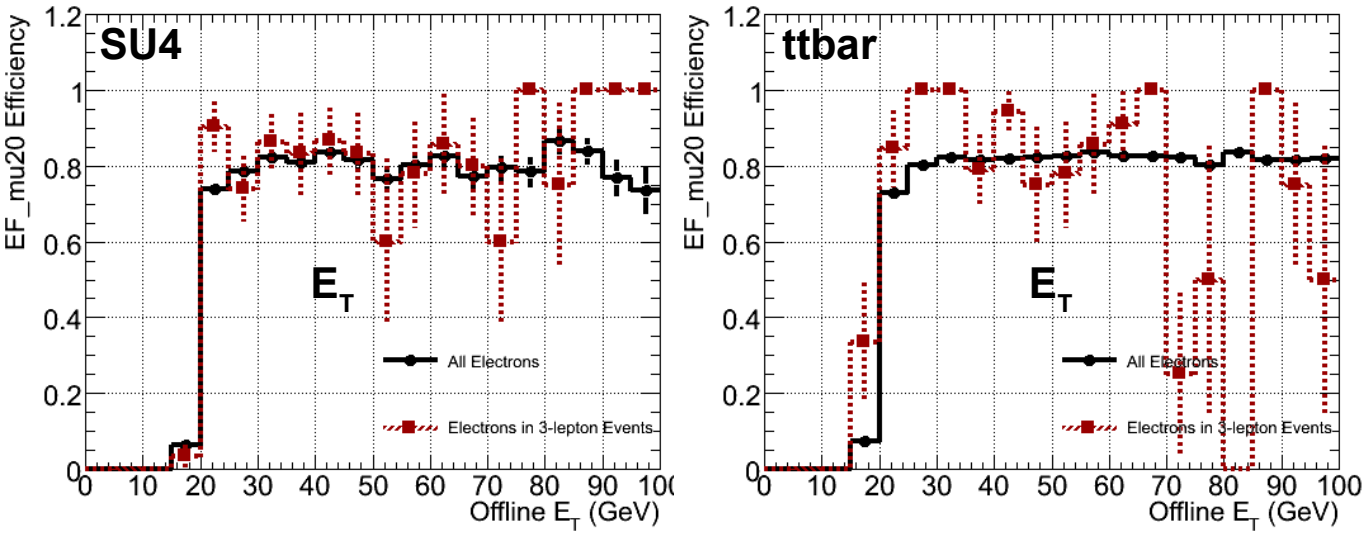
EF mu20 efficiency







Trilepton EF mu20 Efficiency



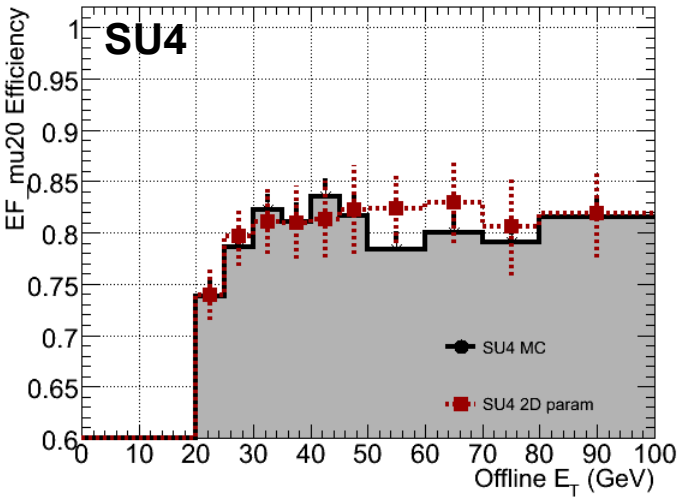
Sample	Efficiency (%)	error
Z→μμ	82.3	0.2
ttbar	82.1	0.2
ttbar 3-lep	82.2	3.7
W+Z	81.4	0.7
W+Z 3-lep	81.0	1.0
W-Z	82.6	0.4
W-Z 3-lep	82.1	0.2
SU4	81.0	0.6
SU4 3-lep	81.3	3.5

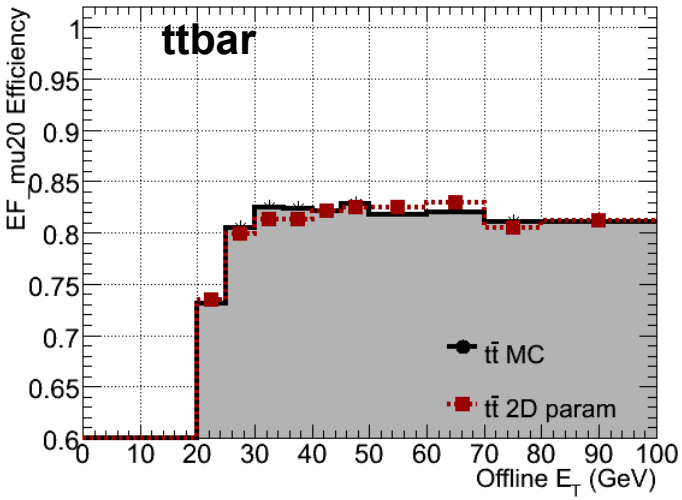
Black curve; efficiency for all muons in sample
Red curve; efficiency for muons in trilepton events

- **Muon efficiency in Trilepton events** similar within errors to **efficiency for all muons** in samples.

- Similarly for electrons if we can determine efficiency for all muons then we will also know the efficiency for electrons in trilepton events.

Muon Efficiency measurement from data





- Muon **efficiencies estimated using efficiency parameterisations** obtained from Tag and Probe on $Z \rightarrow \mu\mu$.
- For all muons in sample.
- Sufficient to parameterised in **2D**; **E_T vs $|\eta|$**
- Non-isolated trigger shows flat efficiency in etcone40.

Monte Carlo

Sample	Efficiency (%)	error
ttbar	82.0	0.2
W+Z	81.6	0.7
W-Z	82.6	0.4
SU4	80.9	0.7

Tag and Probe parameterisations

Sample	Efficiency (%)	error
ttbar	81.8	0.5
W+Z	82.3	1.5
W-Z	82.2	0.8
SU4	81.7	1.4

- **Parameterised efficiencies** agree well with **MC efficiencies.**
- Similarly for electrons this efficiency will be representative of muons in trilepton samples

Event Level Trigger Efficiency measurement from data

Trilepton events

- **Event level efficiency;**

  Efficiency = N1 / N2

  N1 = Number of **Events** that pass the trigger with at least one good offline **truth matched** lepton.
  N2 = Number of **Events** with at least one good offline **truth matched** lepton.

- Parameterising this from single lepton efficiencies;

  P(event pass| leptons(i,j,k)) = 1- P(event fail| leptons(i,j,k)) = 1 – (P(i, fail) * P (j, fail) * P(k, fail))

  Assuming P(i, fail) is independent of P(j, fail) is independent P (k, fail)

  Efficiency = N2*P(N2 pass | leptons(i,j,k)) / N2

Monte Carlo

Sample	Efficiency (%)	error
ttbar	80.1	3.3
W+Z	94.9	0.6
W-Z	95.4	0.3
SU4	83.3	2.9

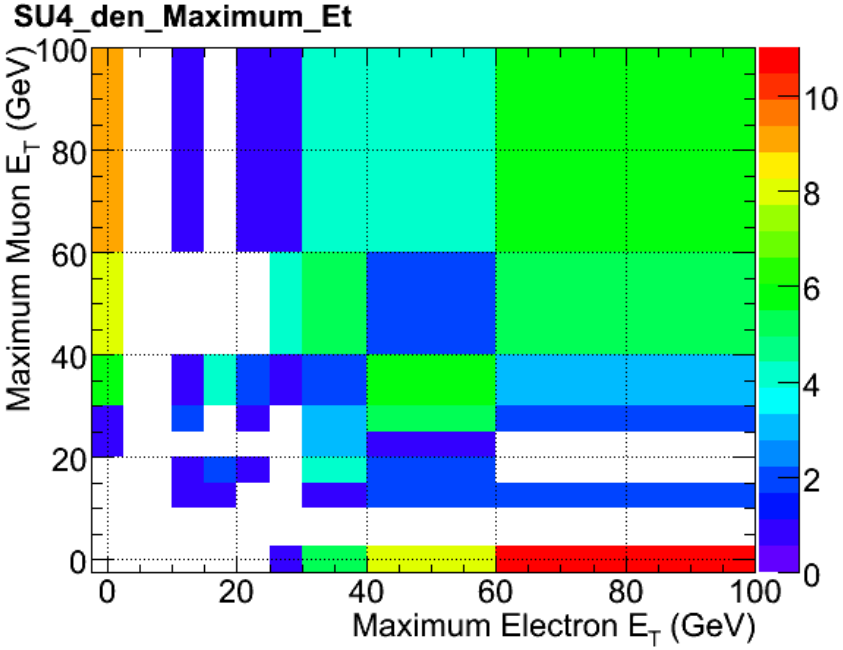
Tag and Probe parameterisations

Sample	Efficiency (%)	error
ttbar	80.7	3.2
W+Z	96.3	0.5
W-Z	95.9	0.3
SU4	85.5	2.7

- Agreement seen within errors.

- Parameterised errors do not yet take into account errors on Tag and Probe efficiencies.

Signal Acceptance



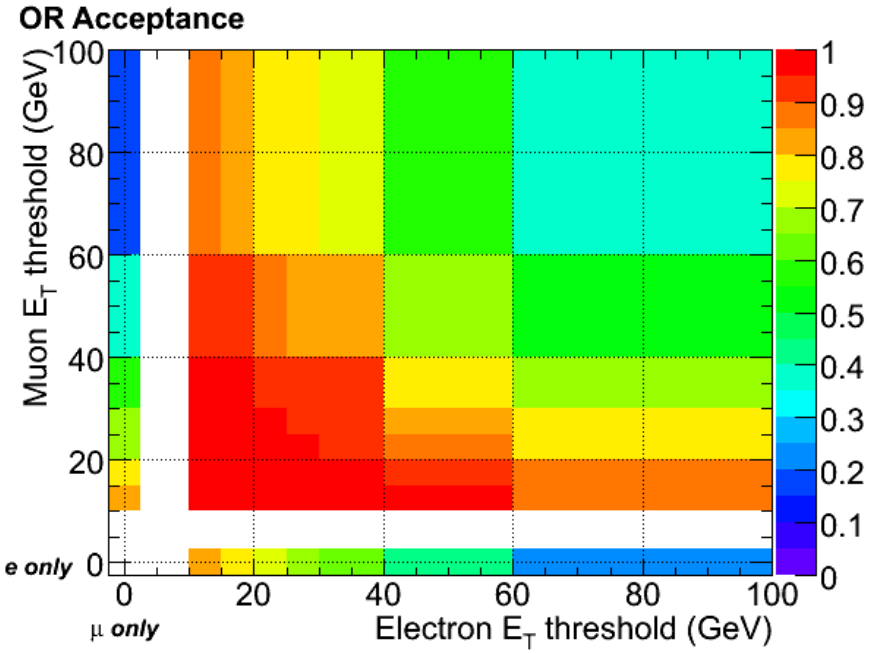
- Left: Distribution of Maximum **offline** E_T of Leptons in SU4 **Trilepton events.**

- Right: Event acceptance vs **offline** lepton E_T threshold.

Acceptance = N(Trilepton events with lepton E_T > threshold) \ N(Trilepton Events)

- 1st and 2nd leptons are generally energetic → good acceptance with an OR of single lepton triggers.

- **Offline** acceptance ~ 90% with e25 OR mu25



Conclusions

- Leptons in trilepton events show trigger efficiencies that agree with efficiency for any lepton seen in all studied samples.
- Lepton efficiencies can be obtained from Tag and Probe using the Z-resonance.
- These efficiencies are representative of those seen in MC for all leptons and for leptons in trilepton events.

Outlook

- Study effect of triggers on backgrounds and background estimates.