Trigger for SUSY trileptons in the mSUGRA Grid

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Introduction

Follows on from Tina Potters previous talk.

Same data samples, and object definitions used:

- $\sqrt{s}$ = 10 TeV, 14.2.25, ATLFast II, mSUGRA parameter space grid.
- CSC note object definitions and overlap removal.
- Results presented for tan(β)=10, A0 =0 plane.

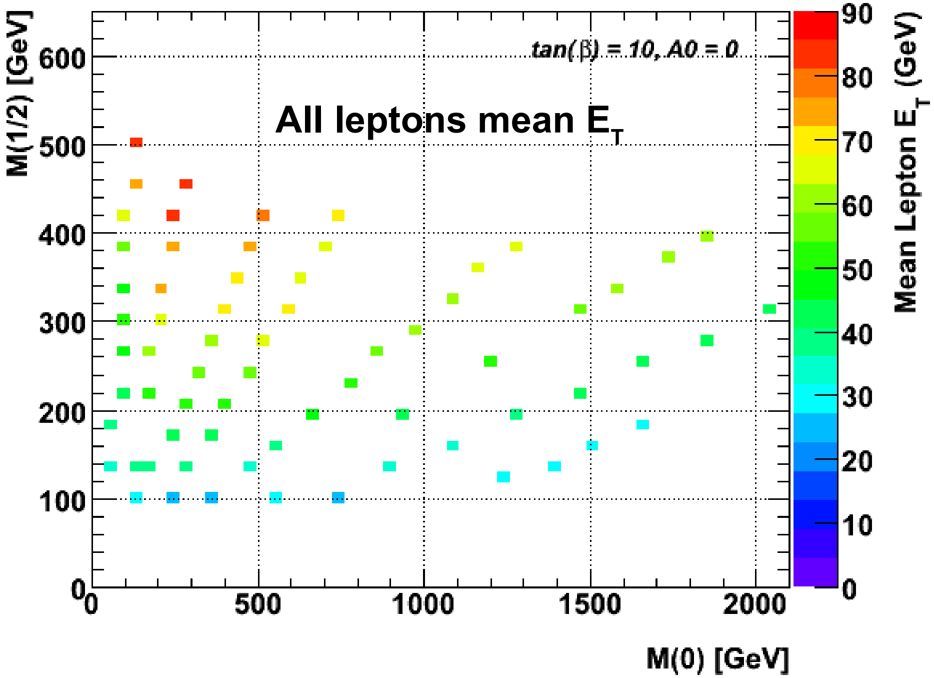
This talk will deal with **lepton kinematics, acceptance and trigger efficiency** measurement from data in a mSUGRA **SUSY 3-lepton** context.

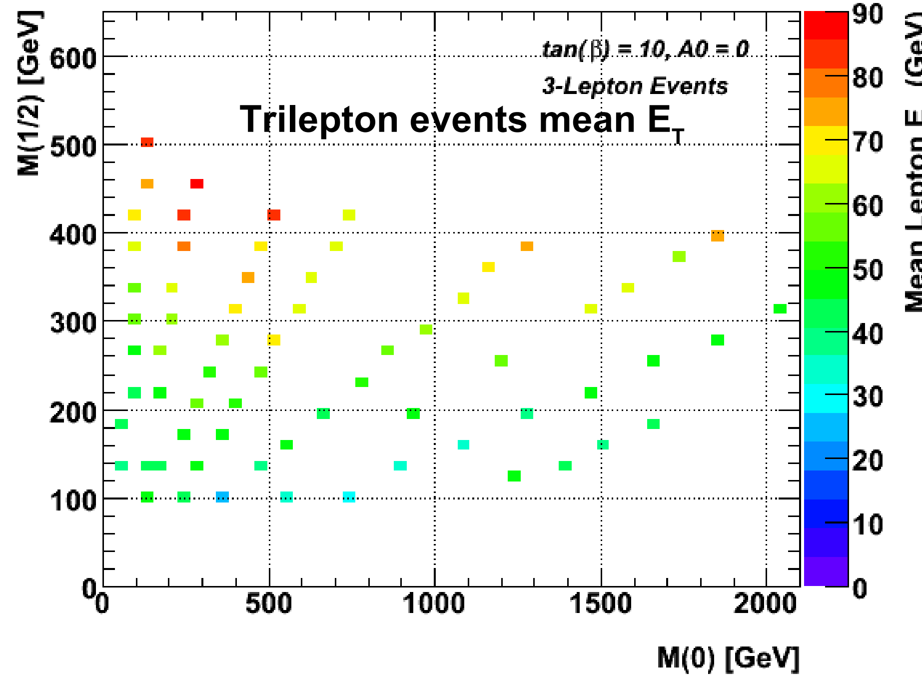
Only points for which there are > 10 Trilepton events are included (so as to minimize errors).

Contents

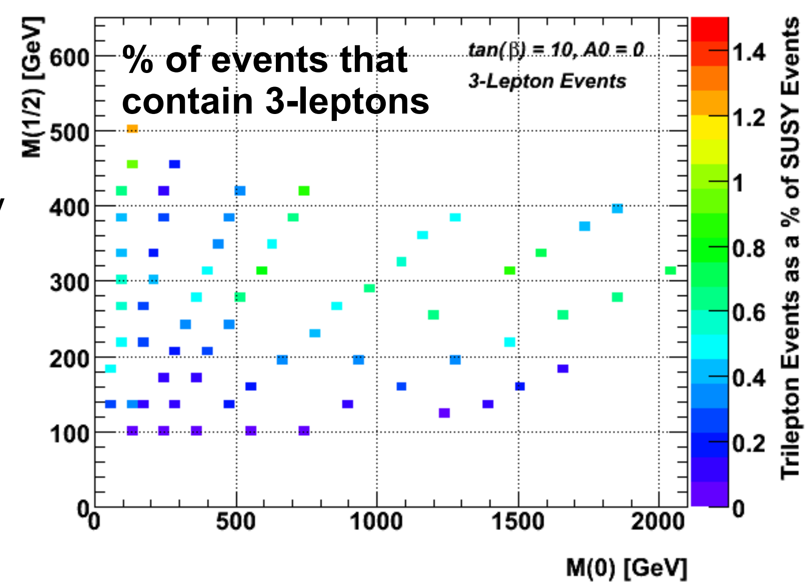
- Brief leptonic and trileptonic phenomenology.
- Lepton Acceptance.
- Parameterisation of Trigger Efficiencies for all leptons:
  - Electron trigger efficiency (EF_e25i_medium1): object level.
  - Muon trigger efficiency (EF_mu20): object level.
  - Preliminary efficiencies for trilepton events
    - Single lepton triggers (EF_e25i_medium1 OR EF_mu20): event level.
    - Double lepton triggers (EF_2e15i_medium, EF_2mu10): event level.
- Acceptance from other triggers
- Results summary for other tan(β), A0 planes.

Lepton Phenomenology I

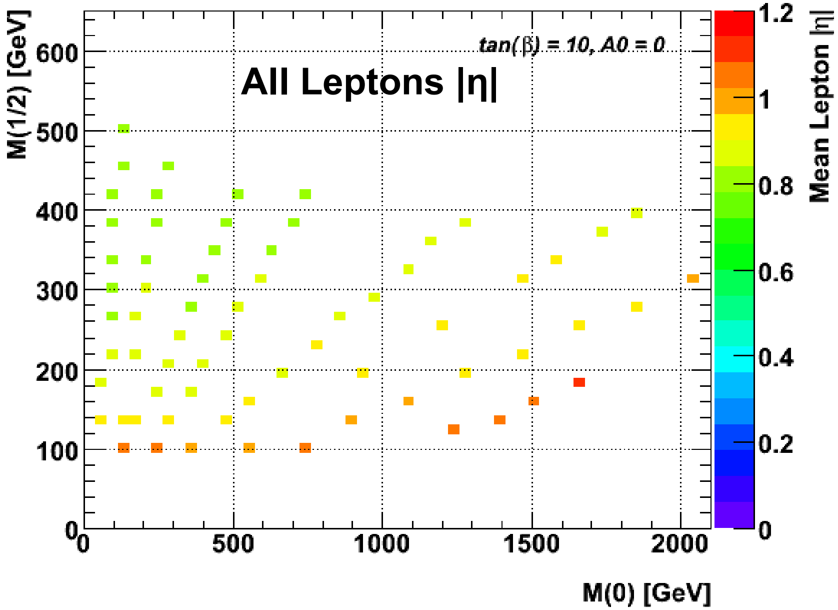


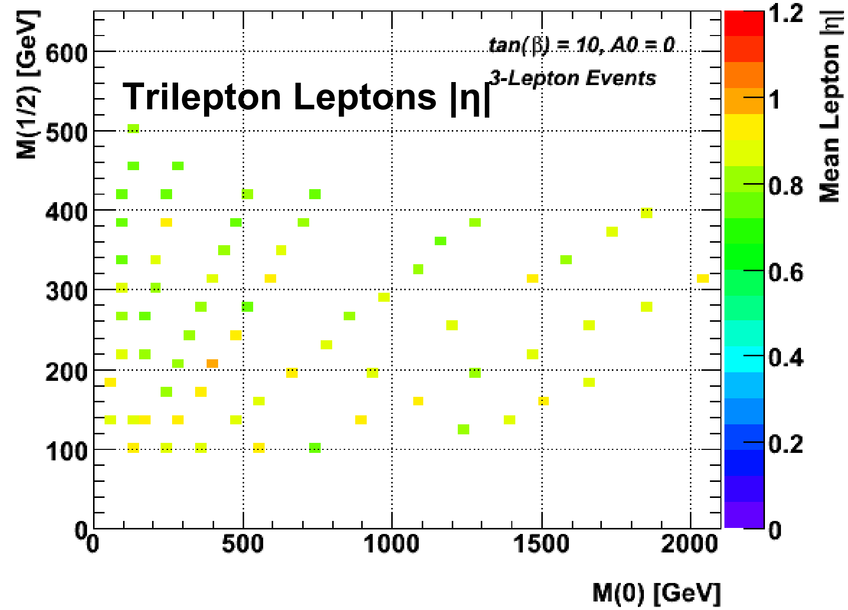


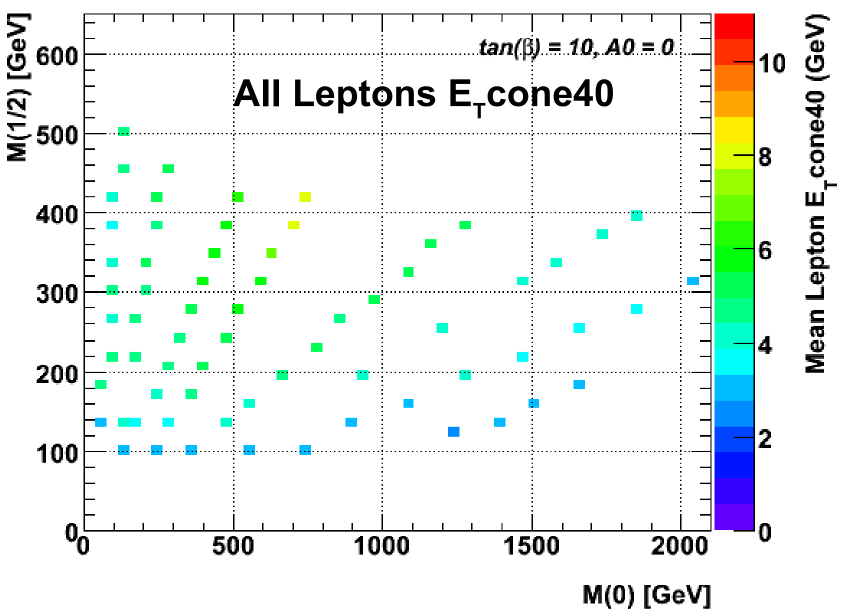
- As SUSY mass scale increases so does mean Lepton E_T and the relative importance of Trilepton events.
- Leptons are an important handle that can be used to identify rare SUSY decays.
- It is important that we understand such events and how our trigger is behaving towards them.

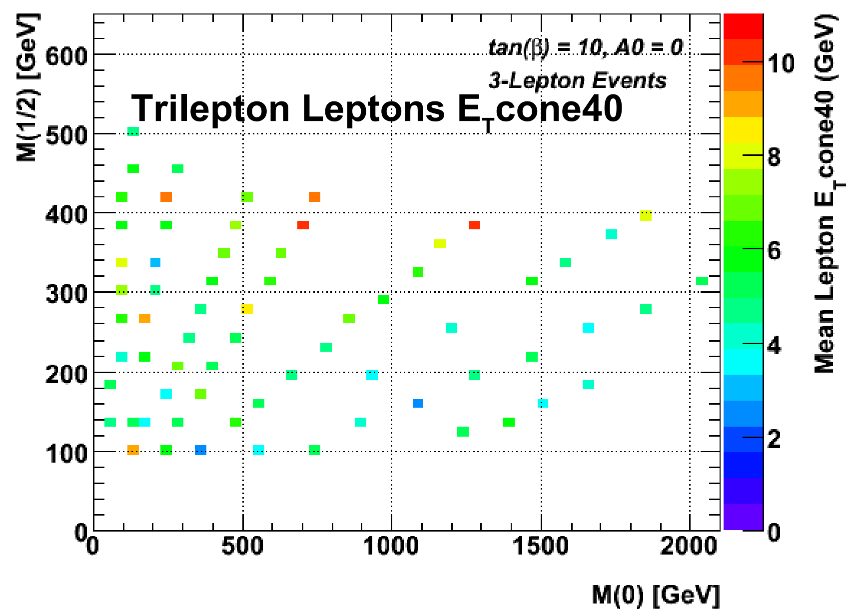


Lepton Phenomenology II









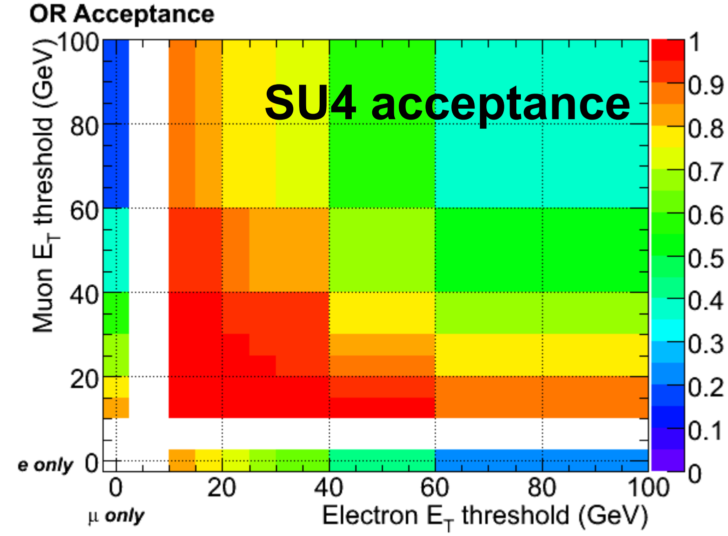
Trilepton Event Acceptance

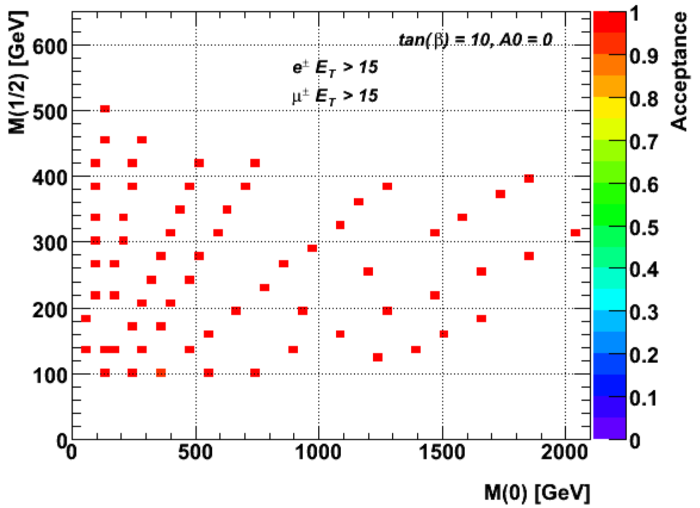
Acceptance threshold can be viewed as “ideal” triggers, giving us a feel for how such trigger thresholds will behave towards our samples.

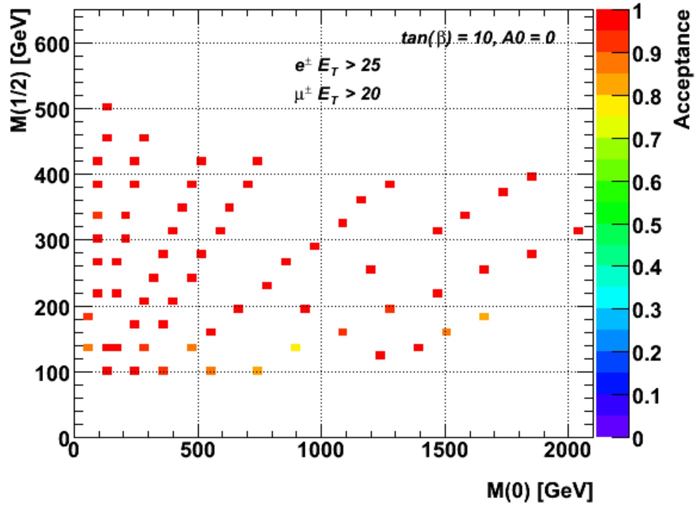
- Acceptance (for trilepton events) defined as;

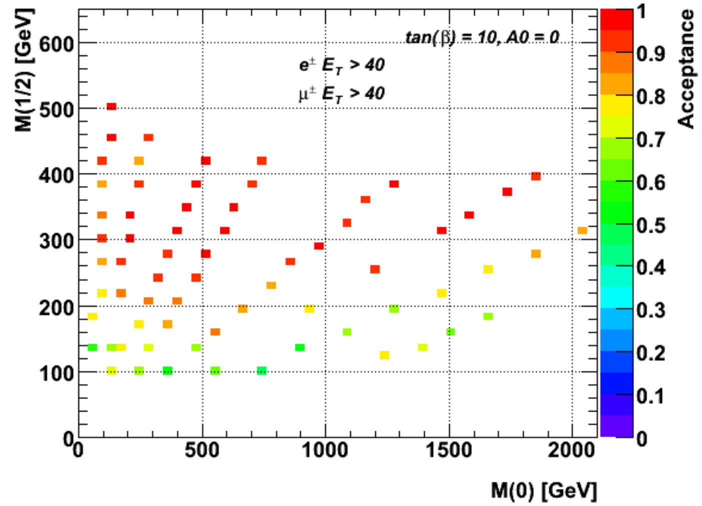
#[Events containing 1+ Leptons with E_T > Threshold] / #[Total Events]

- Study how acceptance varies as threshold E_T requirements change.
- Based on a logical OR of electron and muon thresholds.







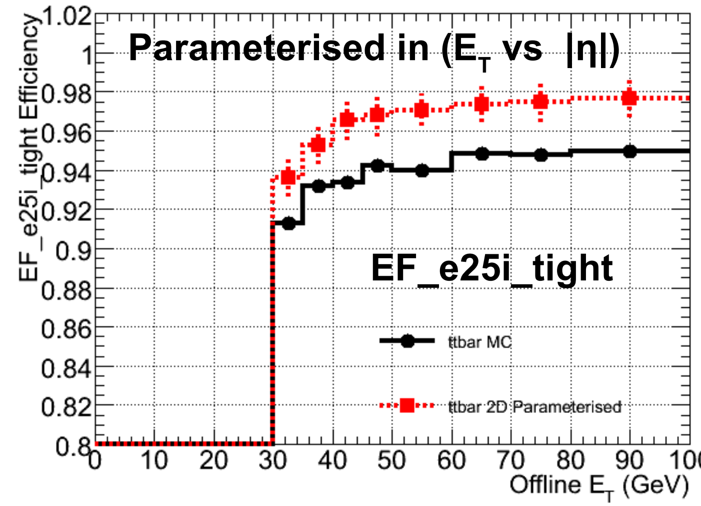


e± OR μ± E_T > 15 GeV	e± > 25 OR μ± E_T > 20 GeV	e± OR μ± E_T > 40 GeV
Instantaneous Luminosity ~ $10^{31} \rightarrow 10^{32}$	Isolated signatures for 10^{32}+	Unisolated signatures for ~ 10^{32}+

- Acceptance decreases for low SUSY mass scale as threshold E_T increases.

Parameterisation of Electron Trigger Efficiency (ttbar v13)

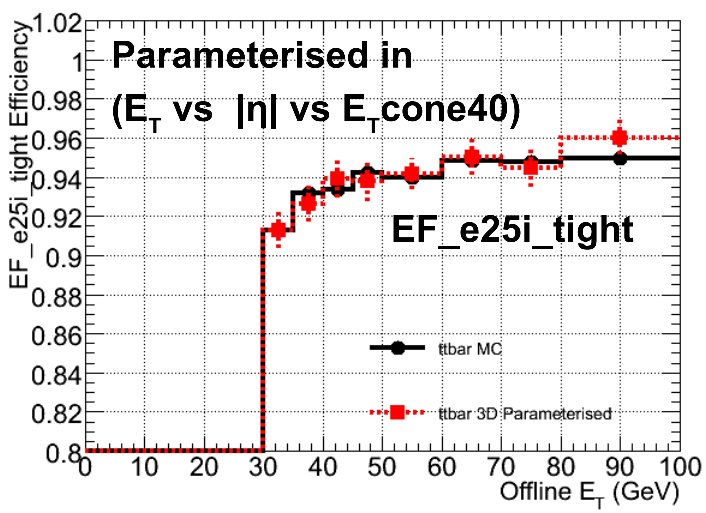
Study parameterised trigger efficiencies as there is no trigger simulation in rel 14 ATLFast II.



- **Take Z→ee MC trigger efficiency and apply to ttbar sample, then compare to MC.**
    - Can be measured with Tag & Probe from real data.

Current limitations:

- Fake effects excluded (using truth matching).
- Limited to Z→ee kinematic range (10→100 GeV).
- Shown for **ttbar** due to SUSY-like kinematics and high statistics samples.



Plateau Efficiencies (40 < E_T < 100 GeV).

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

- 2D parameterisation does not account for isolation effects.
    - Important in busy events such as SUSY.
- 3D parameterisation well reproduces the MC result to within errors.

- Works well for all studied samples. For more details see;

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

  Note: ATL-COM-PHYS-2009-407

SU4 Fast Simulation and Efficiency Parameterisation

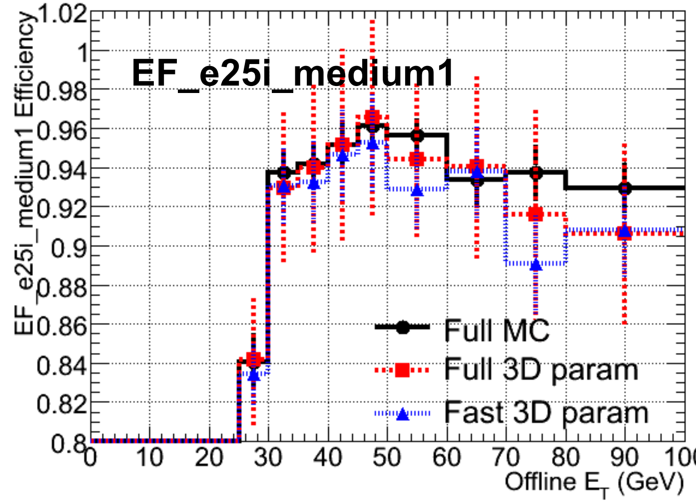
- **Compare full simulation of SU4 to ATLFast II simulation.**
  - In particular compare behaviour of parameterisations.

Sample	Efficiency (%)	error
Full Sim MC	94.5	0.4
Full Sim Param	93.9	1.8
Fast Sim Param	92.9	0.9

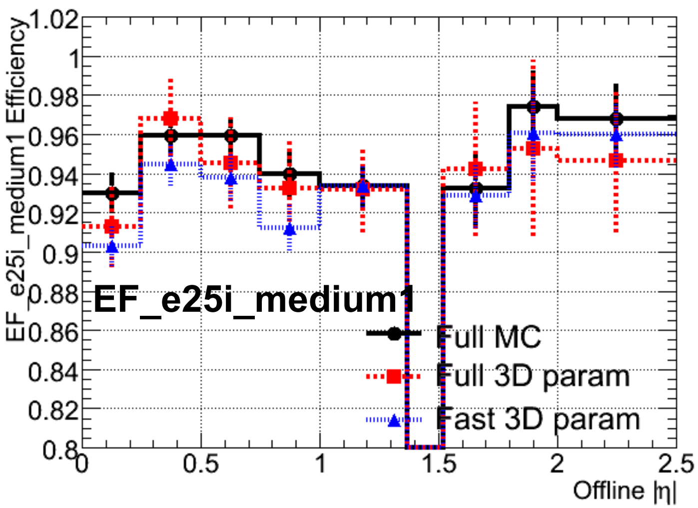
- 3D parameterisation reproduces MC result to within errors.

- ATLFast II reproduces full simulation results to within errors.

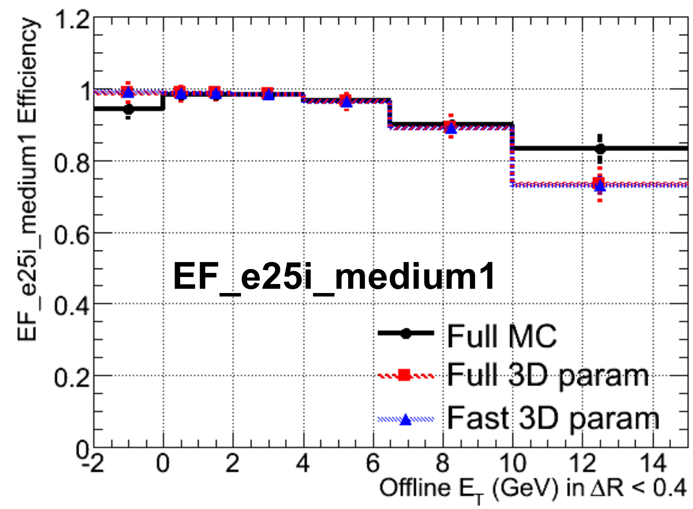
Efficiency vs E_T



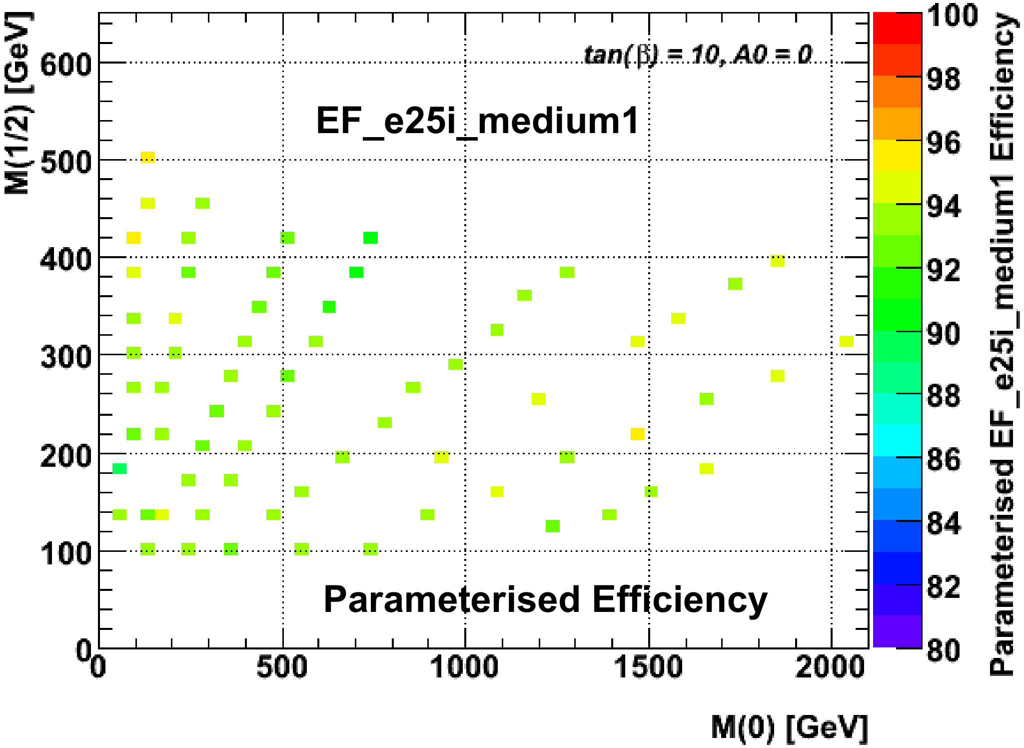
Efficiency vs |η|



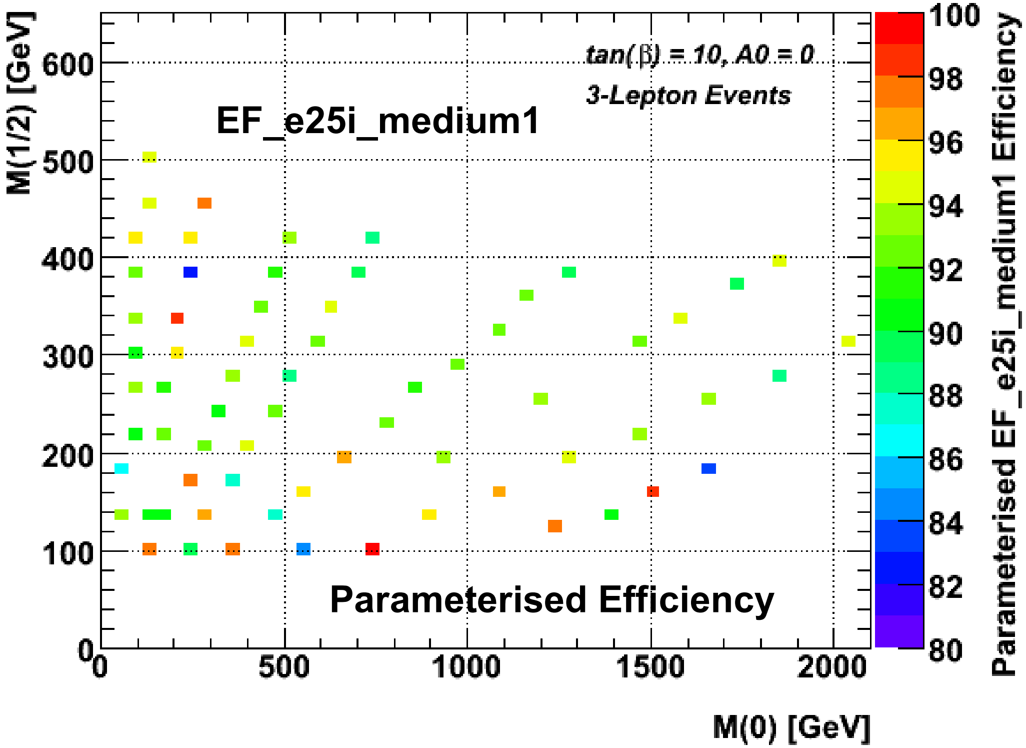
Efficiency vs etcone40



Parameterised Electron Trigger Efficiencies



All leptons



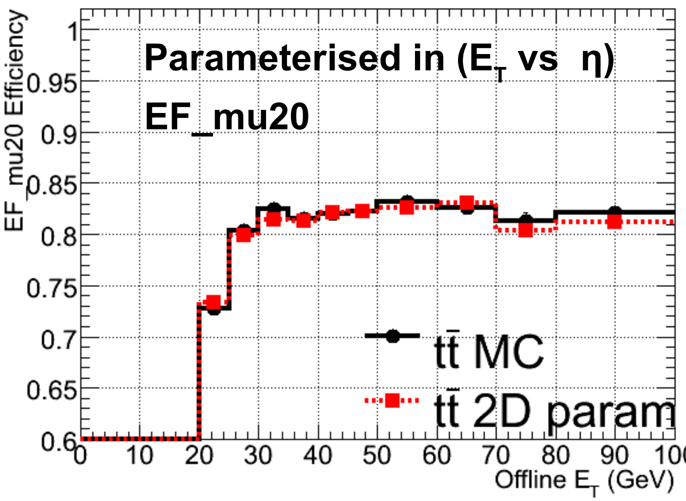
Leptons in trilepton events

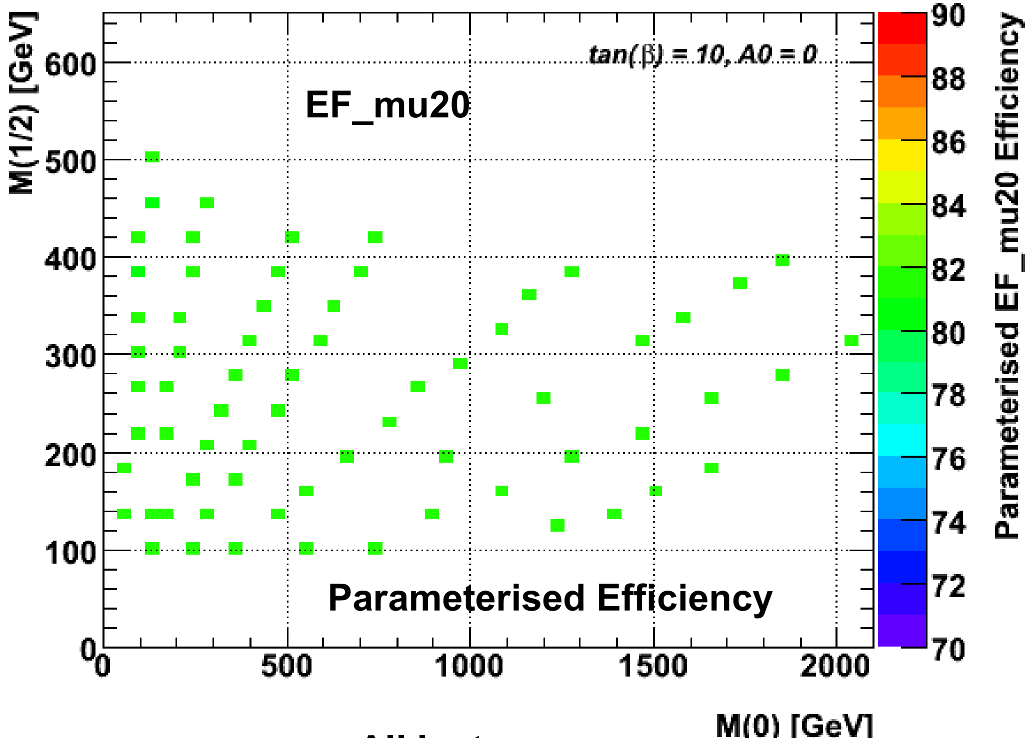
- Parameterised electron trigger efficiencies seen to be high across parameter space **~92 → 96%**.
  - Some variation observed between points.

- Trilepton events suffer from small statistics, but generally show high efficiencies **~85 → 96%**.

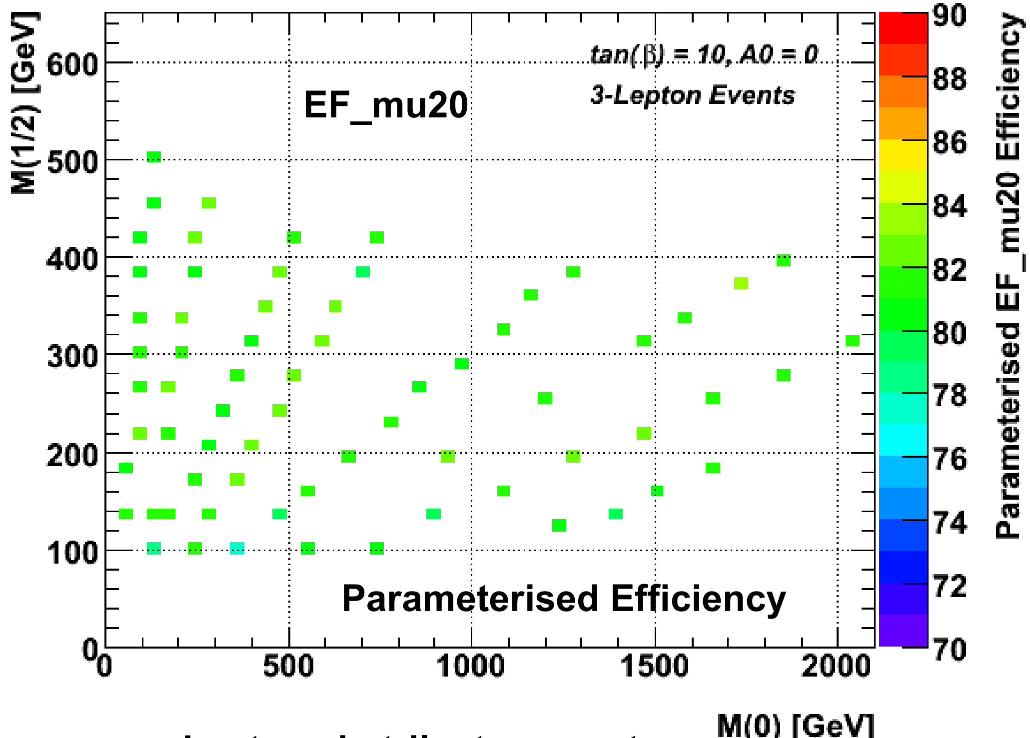
Parameterised Muon Trigger Efficiencies

- Muon trigger **efficiencies estimated using efficiency parameterisations** obtained from Tag and Probe on $Z \rightarrow \mu\mu$.
- Sufficient to parameterised in **2D** E_T vs η.
- Efficiencies seen to be high and consistent across parameter space **~80%**.





All leptons



Leptons in trilepton events

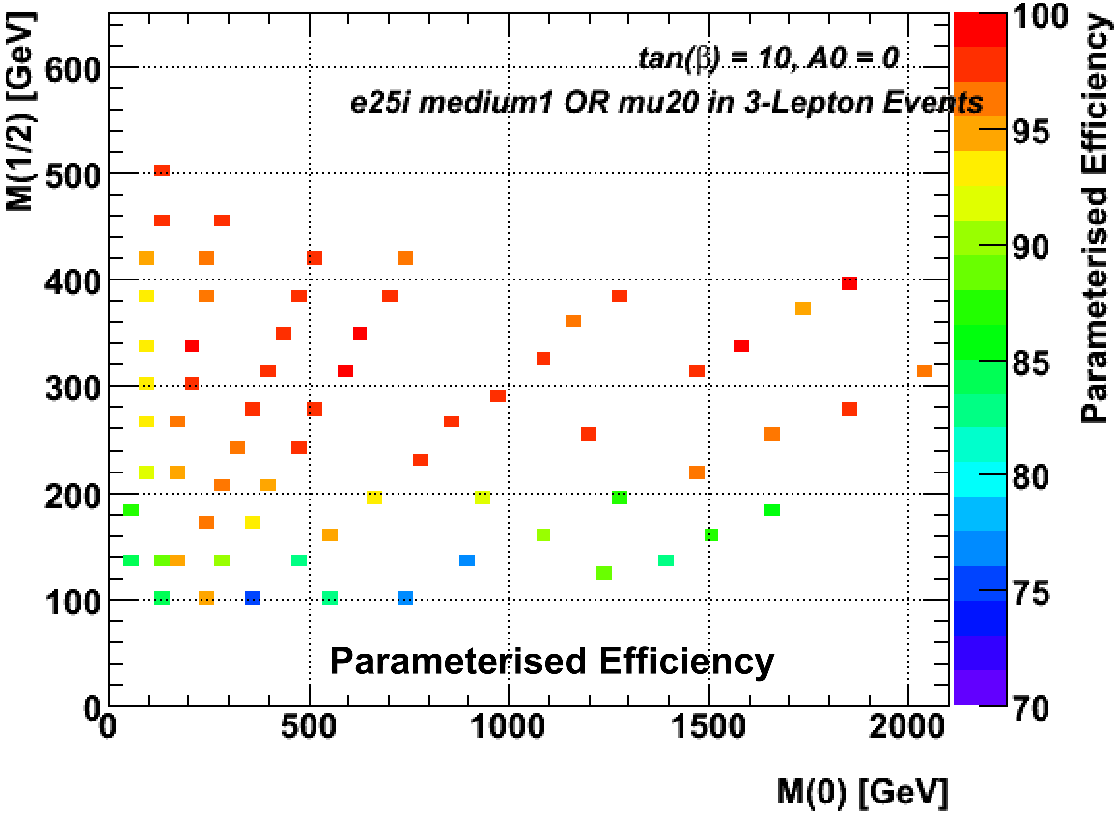
Trilepton Event Efficiency for Single Lepton Triggers

- **Prelimenary event level efficiency** can be calculated based on an OR of parameterised 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))

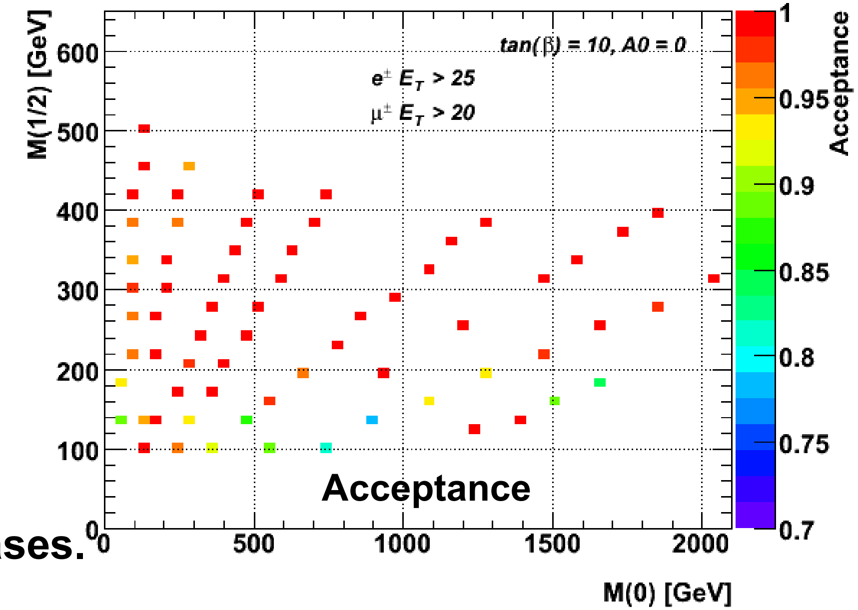
Assumes P(i, fail) is independent of P(j, fail) is independent P (k, fail)

Efficiency =[$\sum_{events}$ P(Event passes | leptons(i,j,k)] / # Events



- **Not a full description of event level efficiency** due to caveats in parameterisation methods described previously.

- **Efficiency 75 → 100 %**



Efficiency is seen to increase as the SUSY mass scale increases.

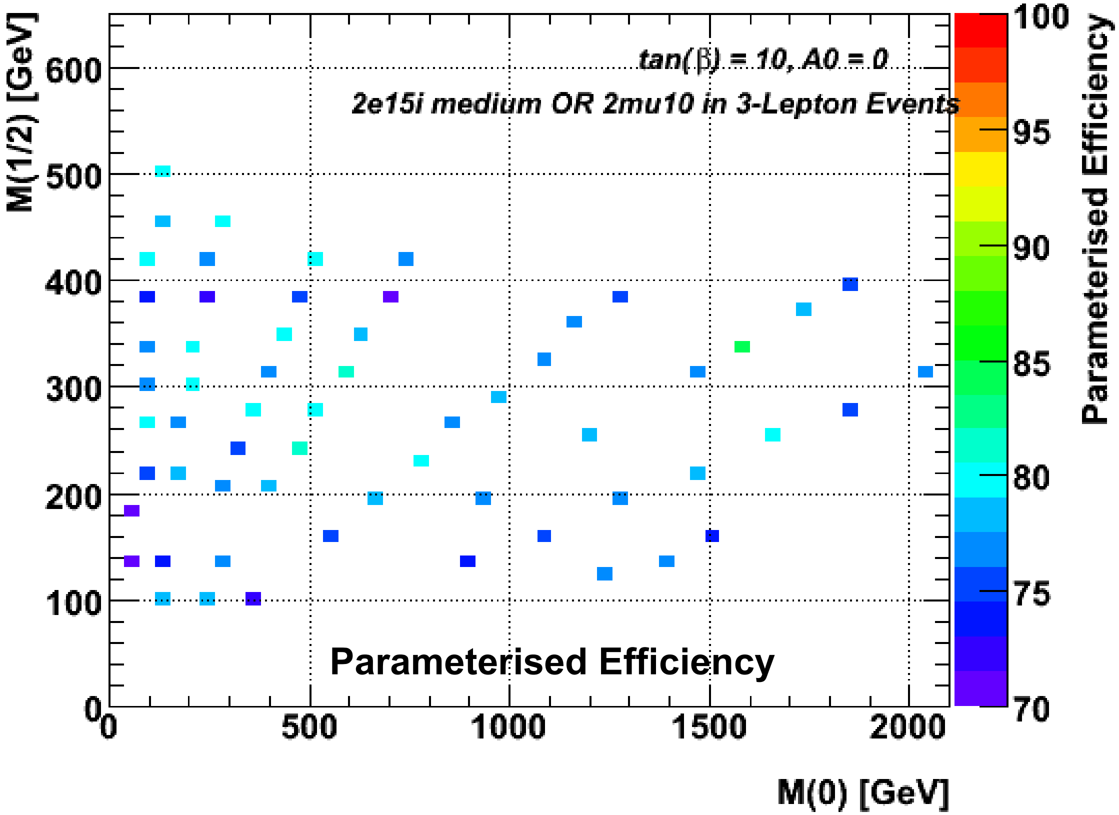
- As did Lepton E_T.

Trilepton Event Efficiency for Dilepton Triggers

- Extend previous method to dilepton triggers.

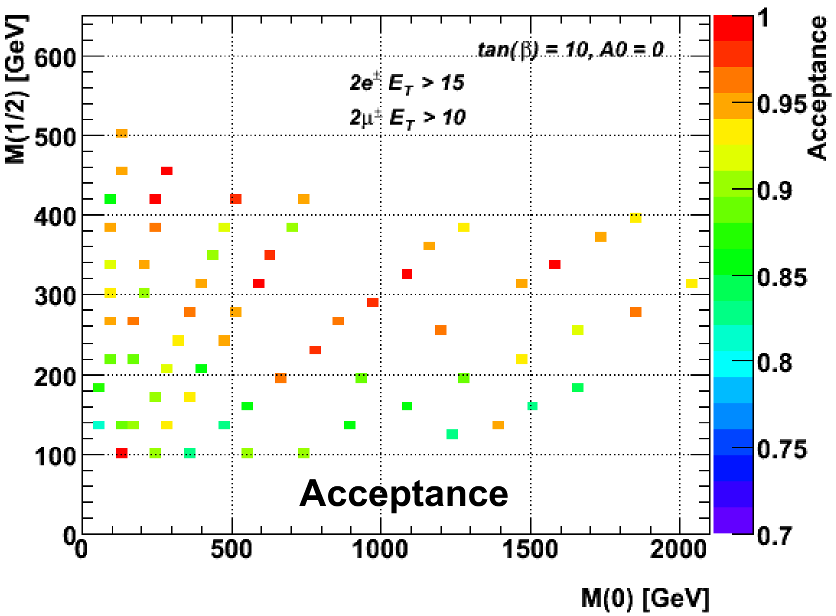
- Efficiency measured using single lepton triggers then parameterisations are applied to all leptons in the event.

- Event efficiency then given by: P(event pass| leptons(i,j,k)) = P(only 2-leptons, pass) + P(3-leptons, pass)



- Efficiencies generally lower than single lepton efficiencies across the grid.

- **Efficiency ~75% for all points**

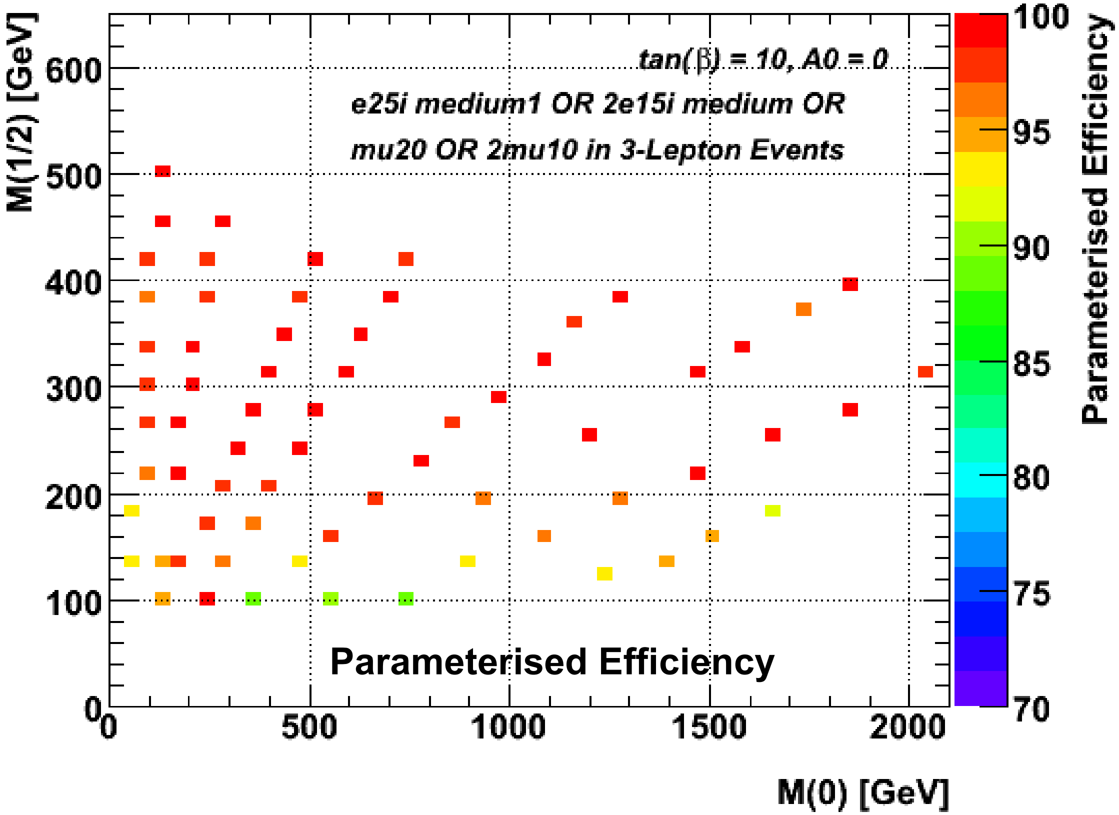


Trilepton Event Efficiency for Single and Dilepton Triggers

- Combine both single and dilepton triggers.

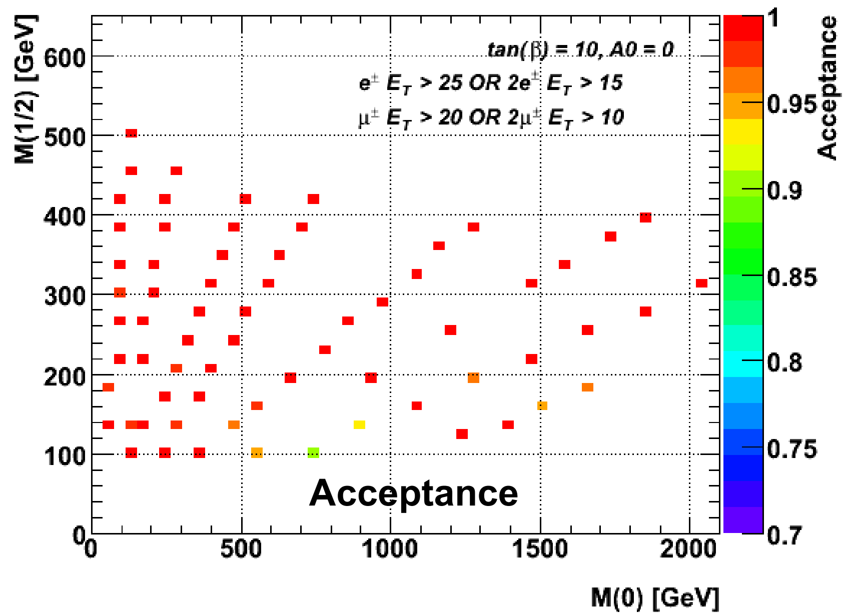
- Event efficiency given by:

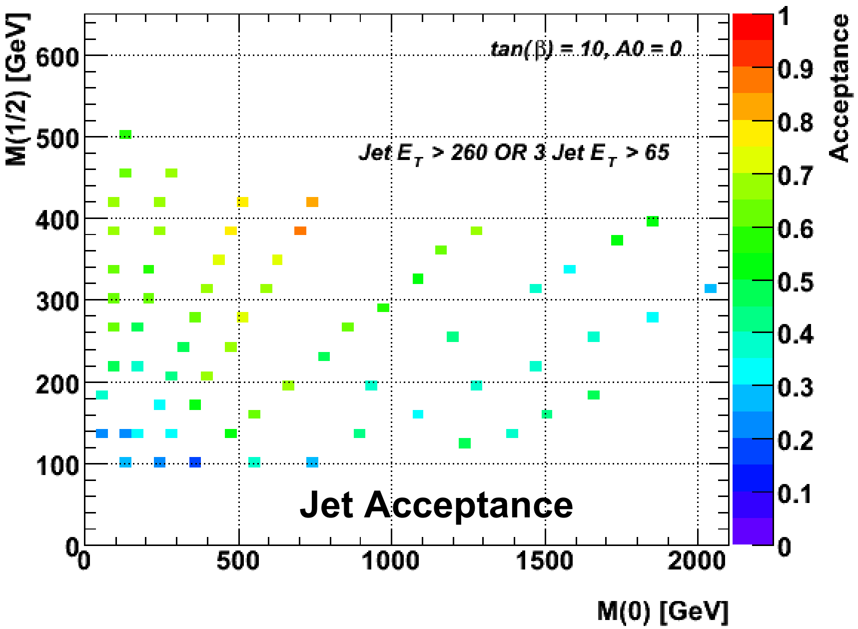
P(event pass| leptons(i,j,k)) = 1 -(P(single lepton triggers, fail)*P(double lepton trigger, fail))

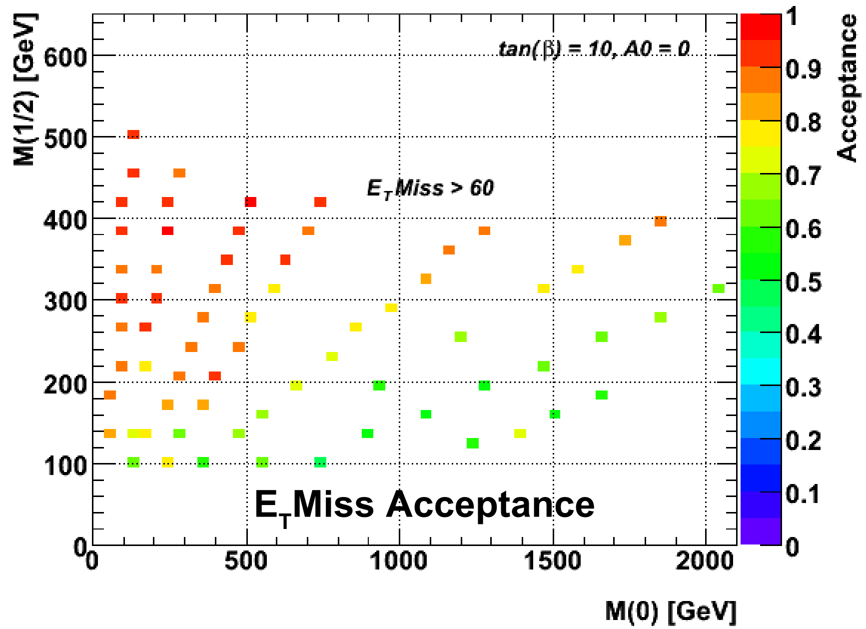


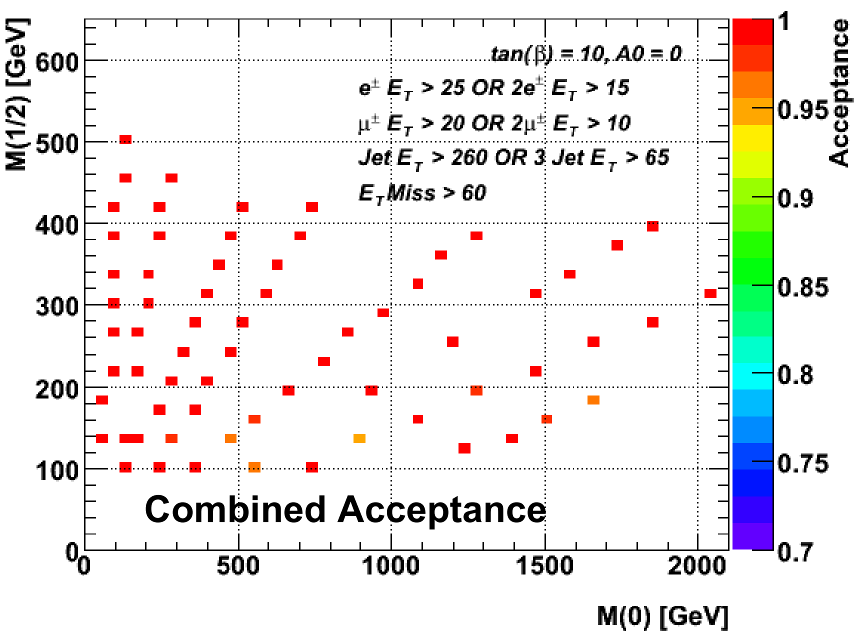
- Improved efficiency vs single or double object triggers alone.

- **Efficiency 85 → 100% for all points.**



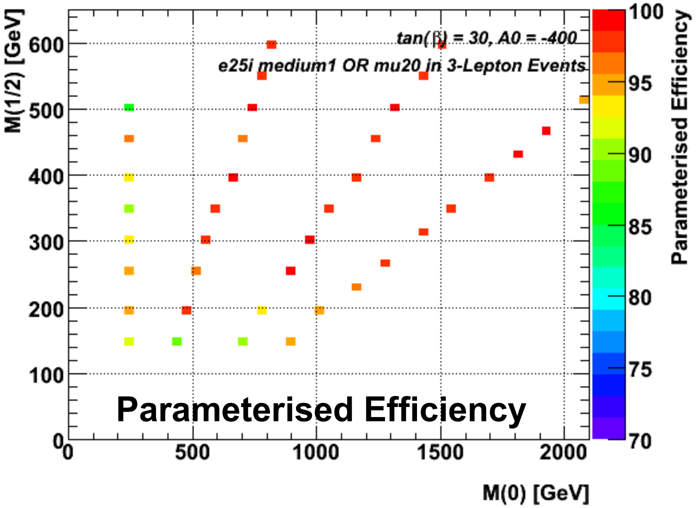


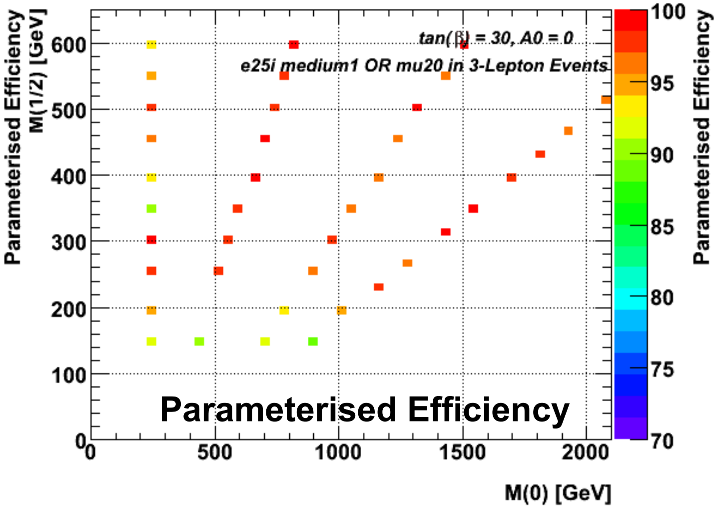


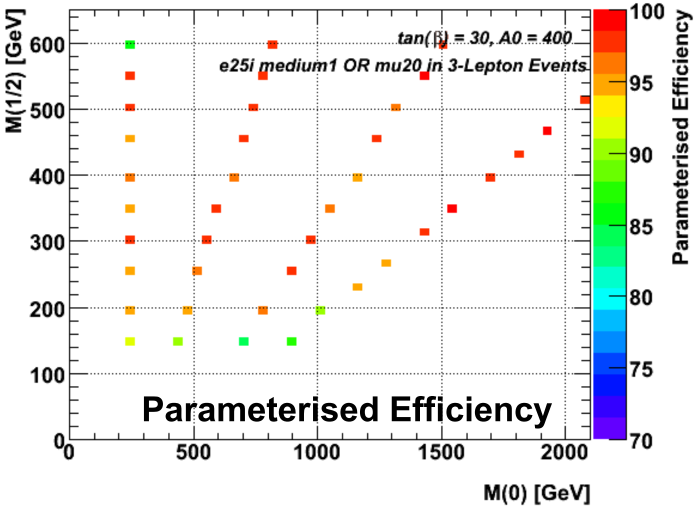


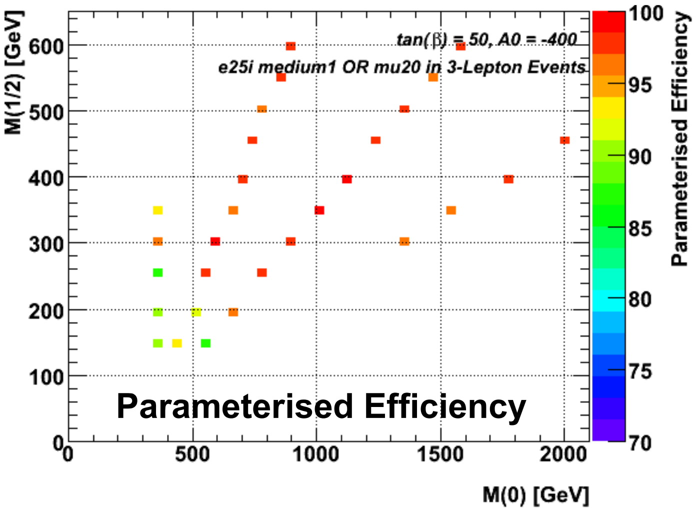
- Look at acceptance for other trigger thresholds.
- Significant trilepton event acceptance seen for E_TMiss and Jet trigger thresholds alone.
- These can be combined with lepton thresholds to get a feel for maximum possible acceptance.
- Some gains seen for low mass points where lepton acceptance was not 100%
- **Combined acceptance > 95% for all points.**

Single Lepton Triggers in Other Planes

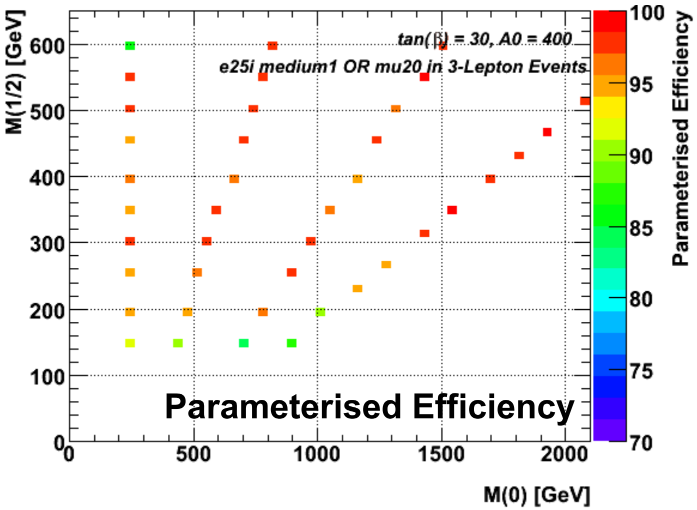




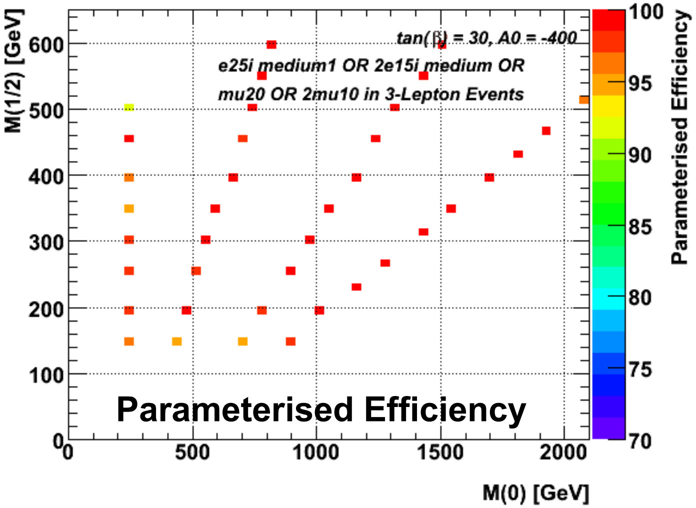


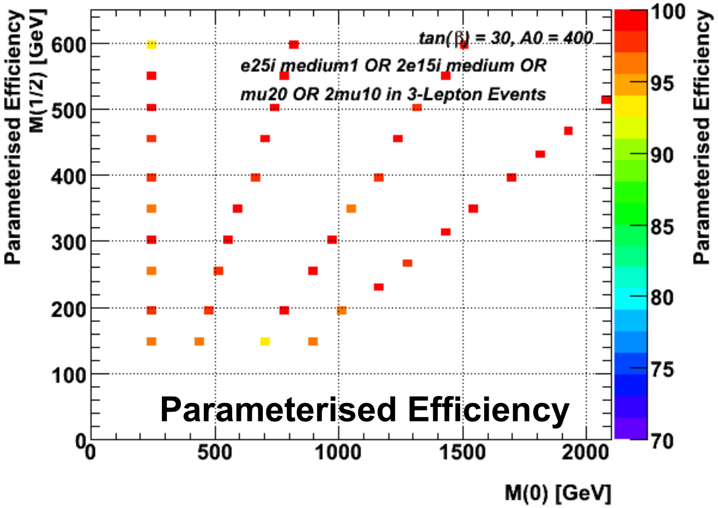


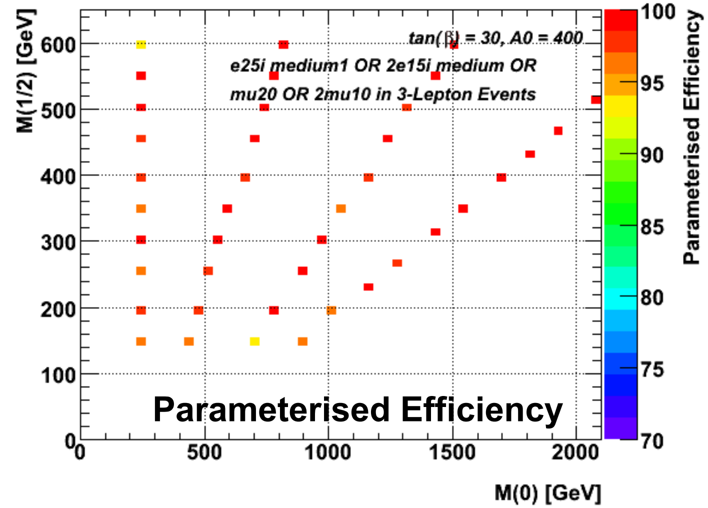
- Parameterised single lepton trigger efficiencies for other mSUGRA planes.
- Efficiency > 85% for all points/ planes.

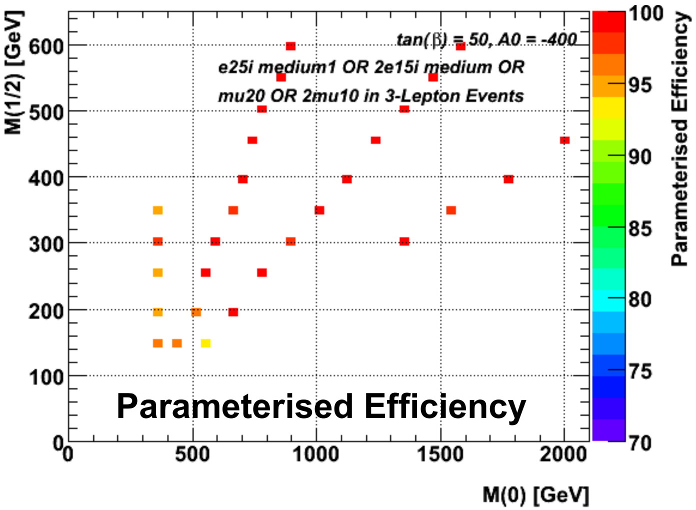


Single or Double Lepton Triggers in Other Planes

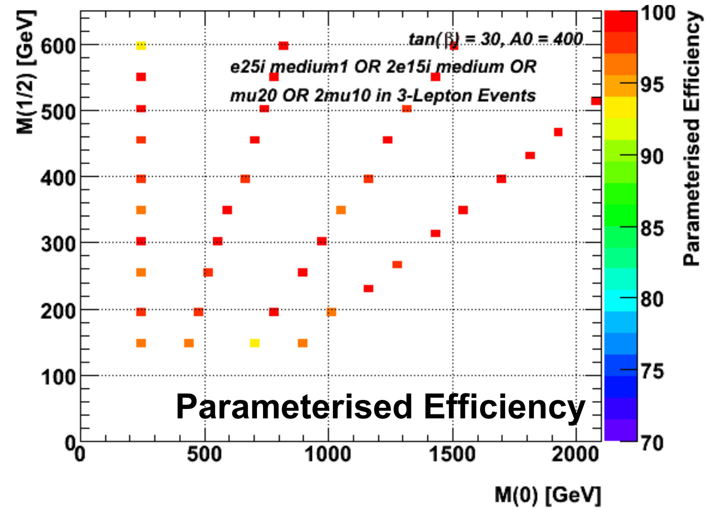


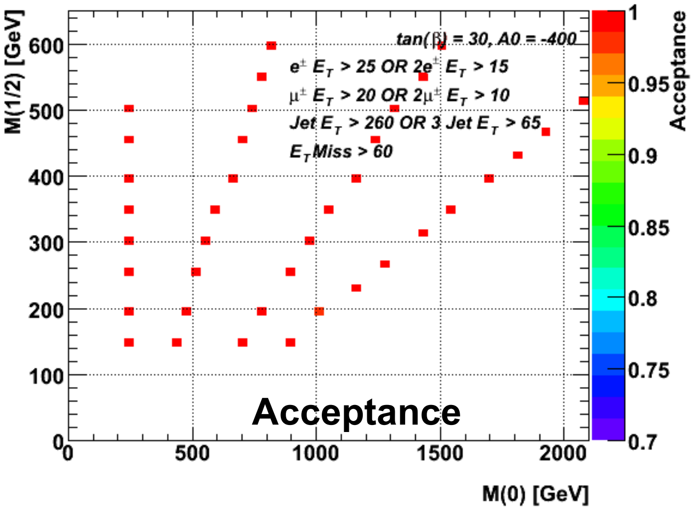


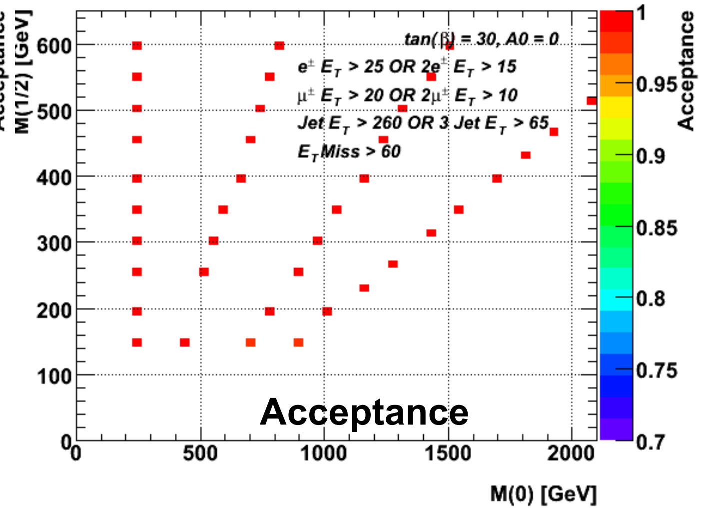


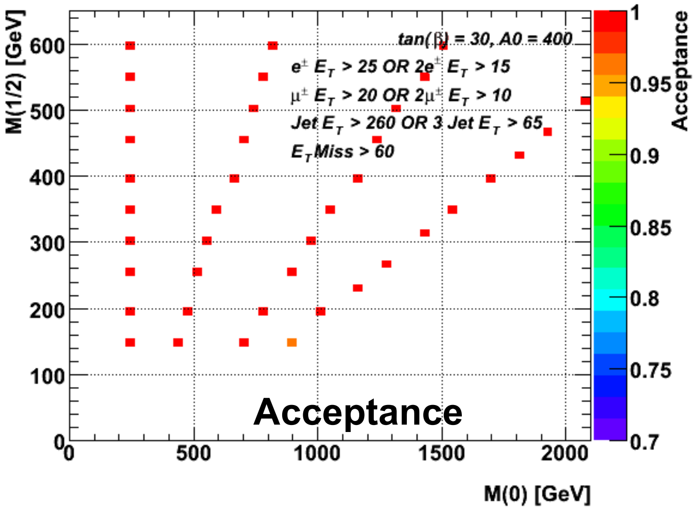


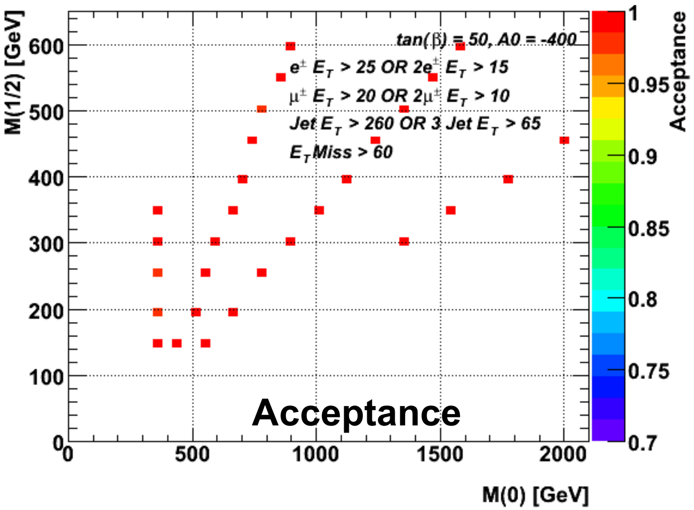
- Parameterised single OR double lepton trigger efficiencies for other mSUGRA planes.
- Efficiency > 90% for all points/ planes.



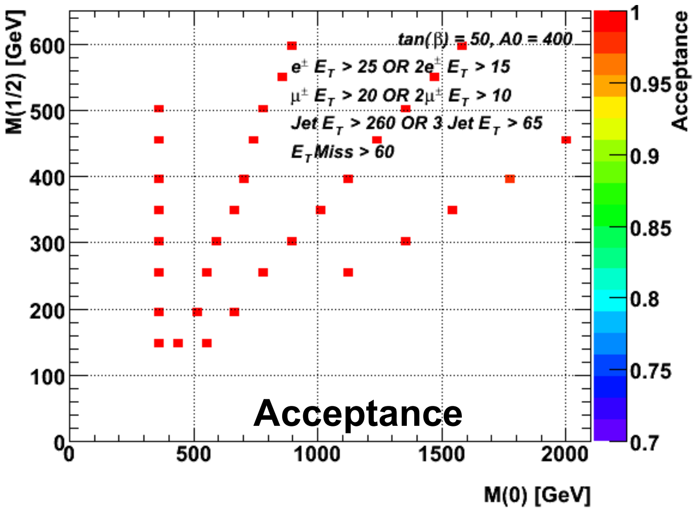








- Combined acceptance for lepton, Jet and E_TMiss thresholds for other mSUGRA planes.
- Acceptance ~100% for all points/planes.



Conclusions & Outlook

Conclusions

- Lepton acceptance and trigger efficiency parameterisations have been studied across the available mSUGRA parameter space.

- Acceptance of trilepton events for leptonic thresholds is high across the plane for low threshold cuts, but decreases with decreasing SUSY mass scale and increasing threshold cuts.

- Parameterised electron and muon efficiencies are high and consistent across the studied mSUGRA planes.

- Preliminary studies of Trilepton event level single lepton trigger efficiencies show decreasing efficiency with decreasing mass scale.
    - By combining with dilepton triggers high consistent efficiency is achieved

- Further gains can be made using non-leptonic triggers. This also provides orthogonal trigger streams for analysis/efficiency checks.

Outlook

- Understand and measuring the effects of fakes on trigger efficiencies.
- More “realistic” event level efficiency calculation.