Trigger for SUSY trileptons in the mSUGRA Grid

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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 $\tan(\beta) = 10$, $A_0 = 0$ 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 $\tan(\beta)$, $A_0$ planes.
• 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.
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;

\[
\frac{\text{#[Events containing 1+ Leptons with } E_T > \text{ Threshold]} }{\#[\text{Total Events}]} \]

- Study how acceptance varies as threshold \( E_T \) requirements change.

- Based on a logical OR of electron and muon thresholds.

Instantaneous Luminosity \( \sim 10^{31} \rightarrow 10^{32} \)

Isolated signatures for \( 10^{32} \)

Unisolated signatures for \( \sim 10^{32} \)

\( e^\pm \text{ OR } \mu^\pm E_T > 15 \text{ GeV} \)

\( e^\pm > 25 \text{ OR } \mu^\pm E_T > 20 \text{ GeV} \)

\( e^\pm \text{ OR } \mu^\pm E_T > 40 \text{ GeV} \)
Study parameterised trigger efficiencies as there is no trigger simulation in rel 14 ATLFast II.

- Take $Z \rightarrow ee$ 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 $Z \rightarrow ee$ kinematic range ($10 \rightarrow 100$ GeV).
- Shown for $ttbar$ due to SUSY-like kinematics and high statistics samples.

Plateau Efficiencies (40 < $E_T$ < 100 GeV).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Efficiency (%)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monte Carlo</td>
<td>94.2</td>
<td>0.1</td>
</tr>
<tr>
<td>2-D param</td>
<td>97.0</td>
<td>0.4</td>
</tr>
<tr>
<td>3-D param</td>
<td>94.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

- 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.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Efficiency (%)</th>
<th>error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Sim MC</td>
<td>94.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Full Sim Param</td>
<td>93.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Fast Sim Param</td>
<td>92.9</td>
<td>0.9</td>
</tr>
</tbody>
</table>

- 3D parameterisation reproduces MC result to within errors.
- ATLFast II reproduces full simulation results to within errors.

![Efficiency vs $E_T$](chart1.png)

![Efficiency vs $|\eta|$](chart2.png)

![Efficiency vs $\text{etcone}40$](chart3.png)
Parameterised Electron Trigger Efficiencies

- Parameterised electron trigger efficiencies seen to be high across parameter space $\sim 92 \rightarrow 96\%$.
  - Some variation observed between points.

- Trilepton events suffer from small statistics, but generally show high efficiencies $\sim 85 \rightarrow 96\%$. 
Parameterised Muon Trigger Efficiencies

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

All leptons

Leptons in trilepton events

Parameterised Efficiency

Parameterised Efficiency
Preliminary event level efficiency can be calculated based on an OR of parameterised efficiencies:

\[ P(\text{event pass} | \text{leptons}(i,j,k)) = 1 - P(\text{event fail} | \text{leptons}(i,j,k)) = 1 - (P(i, \text{fail}) \times P(j, \text{fail}) \times P(k, \text{fail})) \]

Assumes \( P(i, \text{fail}) \) is independent of \( P(j, \text{fail}) \) is independent \( P(k, \text{fail}) \)

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

- 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 \( E_T \).
• 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:

\[
P(\text{event pass} | \text{leptons}(i,j,k)) = P(\text{only 2-leptons, pass}) + P(\text{3-leptons, pass})
\]

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

• Efficiency ~75% for all points
• Combine both single and dilepton triggers.

• Event efficiency given by:

\[ P(\text{event pass} | \text{leptons}(i,j,k)) = 1 - (P(\text{single lepton triggers, fail}) \times P(\text{double lepton trigger, fail})) \]

• Improved efficiency vs single or double object triggers alone.

• Efficiency 85 → 100% for all points.
Trilepton Acceptance for Jet and $E_T$ Miss Triggers

- Look at acceptance for other trigger thresholds.
- Significant trilepton event acceptance seen for $E_T$ Miss 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.
**Parameterised Efficiency**

- 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.
Overall Acceptance in Other Planes

- Combined acceptance for lepton, Jet and $E_{\text{Miss}}$ 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.