Anomalous Production of Photon+Jets (+MET)

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Outline

- Intro
- Triggers and Datasets
- Event, Photon, Jet and Signal Selection
- Backgrounds
- Results
SUSY GMSB processes for Photon+Jet production (source 8378)

SM- Tree level diagrams for Photon+Jet production
Triggers and Datasets

- **Triggers**
  - PHOTON_25ISO, 50 and 70

- **Datasets**
  - cph10d,0h,0i,0j (up to p.13) Lum = 2.4 fb$^{-1}$

- **Photon MC**
  - QCD group, PYTHIA, Pt min 22 GeV, jqcdfh

- **W/Z MC**
  - EWK group, PYTHIA, $W\to e+\nu$ (wewkfe, wewkge)
    & $Z/\gamma^*\to e+e$ (zewk6d, zewkad)
Event Selection

- Require at least one of the three triggers
  - PHOTON_25ISO, 50 and 70
- must be in good run list (v19_ph0)
- >=1 Class 12 vertices
- z < 60 cm
- Photon+>=1 Jet or Photon+>=2 Jets
# Photon selection

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cut value</th>
</tr>
</thead>
<tbody>
<tr>
<td>detector</td>
<td>central</td>
</tr>
<tr>
<td>$E_T^{corr}$</td>
<td>$&gt; 30$ GeV</td>
</tr>
<tr>
<td>CES X and Z fiducial</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td>$9$ cm $\leq</td>
</tr>
<tr>
<td>Had/Em</td>
<td>$\leq 0.125 \</td>
</tr>
<tr>
<td>$E_T^{iso(corr)}$ in cone 0.4</td>
<td>$\leq 0.1 \times E_T^{corr}$ if $E_T^{corr} &lt; 20$ GeV</td>
</tr>
<tr>
<td></td>
<td>$\leq 2.0 + 0.02 \times (E_T^{corr} - 20)$ if $E_T^{corr} &gt; 20$ GeV</td>
</tr>
<tr>
<td>average CES $\chi^2$ (Strips+Wires)/2</td>
<td>$\leq 20$</td>
</tr>
<tr>
<td>N tracks in cluster (N3D)</td>
<td>$\leq 1$</td>
</tr>
<tr>
<td>Track $p_T$</td>
<td>$&lt; 1 + 0.005 \times E_T^{corr}$</td>
</tr>
<tr>
<td>Track Iso(0.4)</td>
<td>$&lt; 2.0 + 0.005 \times E_T^{corr}$</td>
</tr>
<tr>
<td>2nd CES cluster $E \times \sin(\theta)$ (both wire and strip E individually)</td>
<td>$\leq 0.14 \times E_T^{corr}$ if $E_T^{corr} &lt; 18$ GeV</td>
</tr>
<tr>
<td></td>
<td>$\leq 2.4 + 0.01 \times E_T^{corr}$ if $E_T^{corr} \geq 18$ GeV</td>
</tr>
</tbody>
</table>
Jet Selection

- Cone size =0.4, JetClu
- Remove identified EM objects
- Corrected up to level 6 (UE), particle jet.
- Require one or more jets with Et >15 GeV
- Can be in Central or plug (DetEta<3.0)
Selecting the Photon + Jets Signal

- a photon passing tight photon ID cuts
- in-time (> -4.8ns & <4.8ns)
- reject events with a trackless muon stubs in first 400 pb-1.
- reject photon and electron events
- reject di-photon events
- reject if beam halo
- 1 or more Jets
Backgrounds

- Non-collision
  - PMT spikes
  - Beam halo
  - Cosmics
- SM processes with MET, where e->gamma
  - largely from Ws.
  - smaller contributions from Zs, di-boson, tau ...
- QCD fake MET

All predictions are data based!
Backgrounds: Non-collision: PMT spikes

- Can reject 100% using PMT asymmetry.
**Backgrounds: Non-collision: Beam halo**

- Use topological cuts (cdfnote:8409)

<table>
<thead>
<tr>
<th>Halo Type</th>
<th>Selection Cut</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>seedWedge &gt; 8</td>
</tr>
<tr>
<td>1</td>
<td>seedWedge &gt; 4 &amp; Nhad &gt; 1</td>
</tr>
<tr>
<td>2</td>
<td>seedWedge &gt; 4 &amp; Nhad &gt; 2</td>
</tr>
<tr>
<td>3</td>
<td>seedWedge &gt; 7 &amp; Nhad &gt; 2</td>
</tr>
<tr>
<td>4</td>
<td>seedWedge &gt; 8 &amp; Nhad &gt; 2</td>
</tr>
<tr>
<td>5</td>
<td>seedWedge &gt; 8 &amp; Nhad &gt; 3</td>
</tr>
</tbody>
</table>

seedWedge = number of EM towers (Et>0.1 GeV) in same wedge as photon
Nhad = number of plug HAD towers (Et>0.1 GeV) in same wedge as photon
Backgrounds: Non-collision: **Beam halo**

**SAMPLE PLOTS**

- **wedge number of halo candidate**
  - HaloPhiWedge
    - Entries: 355
    - Mean: 11.41
    - RMS: 8.4

- **BH Photons: Em towers in Seed Wedge and Had towers (east+west)**
  - Entries: 2529

**Halos from no vertex events.**
Backgrounds: Non-collision: **Beam halo**

- use electrons to measure **mis-id** rates and to estimate the remainder.
  - use photon-like electron ID cuts and e + Jet events

<table>
<thead>
<tr>
<th>Halo Type</th>
<th>Mis-ID rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>68%</td>
</tr>
<tr>
<td>1</td>
<td>55%</td>
</tr>
<tr>
<td>2</td>
<td>16%</td>
</tr>
<tr>
<td>3</td>
<td>6.5%</td>
</tr>
<tr>
<td>4</td>
<td>4.1%</td>
</tr>
<tr>
<td>5</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

Expect 3065 events!
Backgrounds: Non-collision: **Beam halo**

- start with a tight photon
- in-time (> - 4.8ns & < 4.8ns)
- select beam halo using halo cuts (type 5)
- 1 or more Jets
Backgrounds: Non-collision: Beam halo

[Graphs representing particle distributions related to beam halo]
Backgrounds: Non-collision: Cosmic

- **Use EM timing**
  - require photon to be in-time (>-4.8ns & <4.8ns) for events after $1^{st}$ 400 pb$^{-1}$.
  - Veto all event with trackless muon stubs in first 400 pb$^{-1}$. 
Backgrounds: Non-collision: Cosmic
Backgrounds: Non-collision: **Cosmic**

Tight Photon EM timing before corrections.

- Entries: 1664099
- Mean: 2.072
- RMS: 4.275
- $\chi^2 / \text{ndf}$: 572.7 / 25
- Prob: 0
- Constant: $7.292 \times 10^4 \pm 114$
- Mean: $1.893 \pm 0.002$
- Sigma: $1.73 \pm 0.00$
Backgrounds: Non-collision: Cosmic

Mean Em Times of Photons (+2Jets > 15GeV) Vs Run Number

Entries: 289213
Mean: 2.249e+05
Mean y: 0.006479
RMS: 1.533e+04
RMS y: 1.855

→ Got corrections to EM timing thanx to Max.

02-12-2008
Backgrounds: Non-collision: **Cosmic**

Photon EM timing after corrections.

![Graph showing photon EM timing after corrections with sample plots and a cosmic window highlighted.](image)

- **Entries**: 2179889
- **Mean**: 0.5121
- **RMS**: 6.416
Backgrounds: Non-collision: Cosmic

- Pick time window >30ns and < 90ns
- Count how many has trackless muon stubs.
Backgrounds: Non-collision: Cosmic

- Expect 5 events for the period with timing.
- 23 events in first 400 pb$^{-1}$. 
Backgrounds: Non-collision: Cosmic

- Tight photon
- Time between >30ns and < 90ns
- Exclude first 400pb$^{-1}$
- 1 or more Jets
Backgrounds: Non-collision: Cosmic

Template

02-12-2008

VEP
Use Phoenix rejection (~60% eff. Et>35GeV)
### Backgrounds: SM Processes: Electron

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<td>$\leq 0.055 + 0.00045 \times E$</td>
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<td>N3D tracks in cluster</td>
<td>$= 1, 2$</td>
</tr>
<tr>
<td>$E/p$ of $1^{\text{st}}$ track</td>
<td>$0.8 \leq E/p \leq 1.2$ if $p_T &lt; 50$ GeV</td>
</tr>
<tr>
<td></td>
<td>no cut if $p_T \geq 50$ GeV</td>
</tr>
<tr>
<td>$2^{\text{nd}}$ track $p_T$ if N3D = 2</td>
<td>$\leq 1.0 + 0.005 \times E_T$</td>
</tr>
<tr>
<td>$\text{TrkIso}(0.4) - p_T^{1^{\text{st}}\text{trk}}$</td>
<td>$\leq 2.0 + 0.005 \times E_T$</td>
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<td>$E_T$ of $2^{\text{nd}}$ CES cluster (wire and strip)</td>
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<td>\Delta z</td>
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**Photon-like electron ID cuts**
Electron

- Using photon-like electron ID cuts to identify electrons and use fake rate function (cdfnote 8220 -Sasha Pronko et.al.)
- Expect 1281+/-147+/-4
Backgrounds: SM Processes: **Electron**

- electron passing photon-like electron ID cuts
- in-time
- not a conversion electron
- use fake rate
- 1 or more Jets
Backgrounds: SM Processes: Electron
Backgrounds: SM Processes: Electron

- $W$ cross section = 3052 pb$^{-1}$ (2782 pb$^{-1}$ - cdfnote-6939)
- $Z$ cross section = 279.3 pb$^{-1}$ (255.2 pb$^{-1}$ - cdfnote-6939)
Backgrounds: SM Processes: Electron

Cross checks

Z cross section over run periods 0-11

\[ \chi^2 / \text{ndf} \rightarrow 206.6 / 11 \]

\[ p_0 \rightarrow 279.3 \pm 0.888 \]

W cross section over run periods 0-11

\[ \chi^2 / \text{ndf} \rightarrow 298 / 11 \]

\[ p_0 \rightarrow 3052 \pm 5.38 \]
### Summary of Backgrounds

<table>
<thead>
<tr>
<th>Type</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>for &gt;=1 Jets</td>
<td></td>
</tr>
<tr>
<td>Cosmic</td>
<td>23</td>
</tr>
<tr>
<td>Beam halo</td>
<td>3065</td>
</tr>
<tr>
<td>Electron</td>
<td>1281+/-147 +/- 4</td>
</tr>
</tbody>
</table>
RESULTS
RESULTS

- $\gamma + >=1$Jet (scaled)
- $\gamma^{\text{halo}} + >=1$Jet (not normalized)
- e + >=1Jet
- $\gamma^{\text{cosmic}} + >=1$Jet

[Graph showing invariant mass distribution with different categories and their respective histograms and distributions.]
Thank you.

- Special thanks to Karen (Baylor) for writing down the correction during my practice talk.