Three Diphoton Results from CDF

Cross Section • Peaks Search • MEt Search

Ray Culbertson, FNAL      August 28, 2004
## Diphoton Triggers and Selections

### Triggers
- $2 \times E_t > 12$, w/cal iso
- $2 \times E_t > 18$, wo/cal iso

- high-mass search includes high-Et very loose trigger

### Main Cuts
<table>
<thead>
<tr>
<th></th>
<th>Searches</th>
<th>Cross Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central ($</td>
<td>\eta</td>
<td>&lt;1.0$) only</td>
</tr>
<tr>
<td>Had/EM</td>
<td>$&lt;0.055$+sliding</td>
<td>$&lt;0.055$+sliding</td>
</tr>
<tr>
<td>Cal Iso, cone 0.4</td>
<td>$&lt; 2$ GeV</td>
<td>$&lt; 1$ GeV</td>
</tr>
<tr>
<td>shower in CES, $\chi^2$</td>
<td>$&lt; 20$</td>
<td>$&lt; 20$</td>
</tr>
<tr>
<td>leading track Pt</td>
<td>$&lt; 1$ GeV</td>
<td>$&lt; 0$ GeV</td>
</tr>
<tr>
<td>track isolation, cone 0.4</td>
<td>$&lt; 2$ GeV</td>
<td>-</td>
</tr>
<tr>
<td>second CES cluster Et</td>
<td>$&lt; 2$ to $3$ GeV</td>
<td>$&lt; 1$ GeV</td>
</tr>
</tbody>
</table>

MEt search adds anti-cosmic cuts on Hadron TDC times, topology, unattached muon stubs

All analyses use $Z\rightarrow ee$ and minbias to study/correct ID efficiencies
Cross Section - BG subtraction

Primary background
- $\pi^0 \eta$, and other multi-photon clusters
- can only be subtracted on a statistical basis

Et<35 GeV, CES
- shower-max can detect larger clusters

Et>35 GeV, CPR
- preradiator detects more conversions for bg

Validated
- Control samples, $\rho$, $\eta$, and isolation
Diphoton Cross Section

Sample
- 207 pb\(^{-1}\)
- \(E_T > 13, 14\) GeV, \(|\eta| < 0.9\)
- Tight photon ID cuts
- 426±59 \(\gamma\gamma\) in 889 events
- bg subtr. dominates uncertainty

Compare Pythia
- All LO + ISR model
- scaled \(\times 2\) for plots

Compare RESBOS
- LO + qq →\(\gamma\gamma\) at NLO
- soft g ISR resummed

Compare Diphox
- All NLO but gg→\(\gamma\gamma\) box
- gg→\(\gamma\gamma\) NLO added by us


Diphoton Cross Section

$qt = \text{diphoton system } Pt$

- Diphox breaks down at low $qt$ due to singularities in NLO
- RESBOS does better at low $qt$ due to continuous ISR resumming
- Diphox shows additional source at low $m(\gamma\gamma)$, small $\Delta\phi$, and $qt > 30$ GeV
  these are ($qg \rightarrow gq\gamma \rightarrow g\gamma\gamma$) where the $q$ fragmented to a photon
Search for Diphoton Peaks

Model
- Randall-Sundrum Gravitons
- Extra dimension is "warped", warp factor $k$
- S-channel Graviton yields $ee, \mu\mu, \gamma\gamma$ peaks at high-mass

Analysis
- 2 Central $\gamma$ ($|\eta|<1$, $E_t>15$ GeV
- Mass $>30$ GeV

High-Mass Events
Mass: 207 248 305 329 405
cos $\theta^*$: 0.47 0.09 0.33 0.08 0.52
- no sign of cosmics

$\gamma\gamma$ Mass in bins of $1\sigma$ mass resolution
Search for Diphoton Peaks

SM Diphoton background
- NLO Diphox calculation
- normalized to $\mathcal{L}$

Jets Faking Photons
- Mass shape from a sample of loose diphotons
- normalized to low Mass

Diphoton RS Graviton Search

CDF Run II Preliminary, 345 pb$^{-1}$

- Data, $E_{\gamma}>15$ GeV, $|\eta|<1.04$
- Total Background $\pm 1\sigma$
- SM $\gamma\gamma$ (Diphox NLO)

Diphoton RS Graviton Search: Mass Distribution

CDF Run II Preliminary, 345 pb$^{-1}$

- Data, $E_{\gamma}>15$ GeV, $|\eta|<1.04$
- Total Background
Diphoton Peaks Search - A•ε

Acceptance times efficiency
- Pythia 6.223, reweighted for spin-2 particle
- losing 6% per leg to conversions!

Spin Effects
- cos θ* can be sensitive to some models
- not included in limits

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**Diphoton RS Graviton Search, Total Efficiency**

**CDF Run II Preliminary**

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**Diphoton RS Graviton Search, Collins-Soper Frame cos θ***

**CDF Run II Preliminary (345 pb⁻¹)**

- $M_{γγ} > 200$ GeV/c²
- Data
- Total Background
- Randall-Sundrum MC
- $M_{γγ}=500$ GeV/c², K/Mₚ=0.1
Randall-Sundrum Graviton Limits

Limits
- $k/M_{pl}=0.1$, $M(G)>690$ GeV
- $ee$, $\mu\mu \sim 200$ pb,
  $\gamma\gamma \sim 350$ pb
- $\gamma\gamma$ has larger BR
- $\gamma\gamma$ spin factors improve acceptance

Acceptance Potential
- $\gamma\gamma$ combined with $ee$
- accept conversions
- add plug ($x2$ at high-$\eta$)
Search in Diphoton and Met

Model
- Gauge-Mediated
  SUSY Breaking
  Snowmass model
- Lambda parameter
  scales masses
- Largest cross section
  C1-N2 and C1C1
- all production leads
to events with
diphotons and MEt
- X not used in analysis

High-Et
- Median MEt 70GeV
- \( \gamma \) Et : 60/30 GeV
Diphoton and Met - Backgrounds

- Optimized MEt > 45 GeV

**Standard Model**

- Diphoton production
- Jets: $\pi^0$ faking a photon, shape from loose diphotons normed to low MEt

  $0.01 \pm 0.01 \pm 0.01$

$e\gamma$, with $e$ faking a photon

observed $e\gamma$ fake rate

  $0.14 \pm 0.06 \pm 0.05$

**Cosmics**

derived from control samples

  $0.12 \pm 0.03 \pm 0.09$

**Total:** $0.27 \pm 0.07 \pm 0.10$

**Observed:** 0
**Diphoton and Met - Efficiencies**

**Acceptances**
- ISAJET 7.51
- for $M(C1)=175$, $A = 32\%$
  (Et, and central Cal fiducial)

**Efficiency**
- GEANT simulation
- inefficiency due to X spoiling isolation is significant
- for $M(C1)=175$, and $MEt > 45\text{ GeV}$, $\varepsilon = 23\%$
Diphoton and Met - limits

Limits
- NLO (+ ~20%) from Prospino
- background subtraction
  0 events observed
- Bayesian methods

Snowmass GMSB model
- $M(C1) > 167$ GeV
- $M(N1) > 93$ GeV
- $\Lambda > 69$ TeV
Last Slide

**DiPhoton Cross Section**
- Consistent with NLO Diphox
- Interesting comparison with generators

**DiPhoton Peaks Search**
- Data well-modeled by background estimates
- Set limits on R.S. Gravitons

**DiPhoton and MEt Search**
- Central, $E_t>13$, $M(E_t)>45$, 0 events observed
- $M(C1) > 167$ GeV in Snowmass GMSB Model