Status of Search for a Resonance decaying to $W\gamma$ in CMS experiment

Kak Wong, 10/24/2018
Theory

→ Final state described by various models
  ◆ charged Higgs arXiv:1809.09127
  ◆ F quark arXiv:1411.3310, Phys.Rev.D91.055007
  ◆ Technicolor arXiv:1608.01675

→ Model-independent search
→ Set cross-section limit vs resonance mass
→ Lepton channel expected to provide better background suppression for mass < 1TeV
Signal selection

Electron channel
- MET>25
- 1 electron and 1 photon only
- Medium photon in ECAL barrel
- Photon pT>50GeV, pass electron veto
- Tight electron with $|\eta|<2.1$
- Muon veto: veto event with muon with pT>10GeV
- Inverse Z mass: $|m(e,\gamma)-91.2\text{GeV}|>15\text{GeV}$

Muon channel
- MET>25
- 1 muon and 1 photon only
- Medium photon in ECAL barrel
- Photon pT>50GeV, pass Pixel Veto
- Tight muon with $|\eta|<2.4$
- Electron veto: veto event with electron with pT>10GeV

This talk focuses on e channel
**Backgrounds**

**Electron channel**

- Electron -> photon
  - Z+jets
- Jet -> photon
  - W+jets
- Photon -> electron
  - Diphoton
- SM Wγ: irreducible
Backgrounds

Irreducible SM $W\gamma$ background dominates

Sensitive to electron faking photon

- Strict veto of electrons
- Rejects photon with matching tracker seed in Pixel detector
- Barrel photon only

Table 2: MC background passing signal selection in electron channel (statistical uncertainties only)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Event pass (Pixel)</th>
<th>Event pass (CSEV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W\gamma$</td>
<td>$(2.12 \pm 0.06) \times 10^4$</td>
<td>$(2.25 \pm 0.06) \times 10^4$</td>
</tr>
<tr>
<td>Z+Jets</td>
<td>$(2.17 \pm 0.10) \times 10^3$</td>
<td>$(5.68 \pm 0.16) \times 10^3$</td>
</tr>
<tr>
<td>$\gamma\gamma$</td>
<td>$(2.15 \pm 0.03) \times 10^3$</td>
<td>$(2.32 \pm 0.03) \times 10^3$</td>
</tr>
<tr>
<td>Z$\gamma$</td>
<td>$(1.64 \pm 0.04) \times 10^3$</td>
<td>$(1.78 \pm 0.04) \times 10^3$</td>
</tr>
<tr>
<td>$\gamma$+Jets</td>
<td>$(1.06 \pm 0.25) \times 10^3$</td>
<td>$(1.17 \pm 0.26) \times 10^3$</td>
</tr>
<tr>
<td>tt$\gamma$</td>
<td>$990 \pm 17$</td>
<td>$(1.05 \pm 0.2) \times 10^3$</td>
</tr>
<tr>
<td>tt</td>
<td>$879 \pm 25$</td>
<td>$(2.06 \pm 0.03) \times 10^3$</td>
</tr>
<tr>
<td>W+Jets</td>
<td>$662 \pm 53$</td>
<td>$823 \pm 59$</td>
</tr>
<tr>
<td>Total</td>
<td>$(3.08 \pm 0.06) \times 10^4$</td>
<td>$(3.74 \pm 0.07) \times 10^4$</td>
</tr>
</tbody>
</table>

e-$\gamma$ Invariant Mass (n-1)

Missing Transverse Momentum (n-1)

Resonance Mass (limit setting)
Signal Fitting

- Signal MC is fitted to double-sided Crystal Ball function
  - Gaussian with 2 power law tails
- Masses in range from 300 to 1400 GeV
  - narrow 0.01% and wide 5% mass scenarios
- Standard Model $W\gamma$ distribution is fitted to Dijet function to 3rd order
Electron fakes

- Data-driven method to estimate electron fake background
- Define control regions by inverting two selection cuts
  - electron veto; MET
- Fake rate can be measured by fitting $Z$ resonance peaks in regions A, B
  - As function of photon $\eta$ and $p_T$
- Apply measured fake rate to D to obtain a background estimate in signal region

\[ f_e^\gamma = \frac{N_{ee}^{e\gamma}}{2N_{ee}^{ee} + N_{ee}^{e\gamma}} \]
Closure

- Z mass resonance peak $m(e,\gamma)$ in MC is also modeled with a double-sided Crystal Ball
- Largely mis-reconstructed events contribute to a long tail
- estimating and applying fake rate using only Z MC events leads to closure
  - 3.64k estimated vs 3.85k events with stat. unc. 0.06k

Closure test with MC (in photon pT)

Fitting on Z+jets, Zγ background
Summary

➔ Important signature to various BSM theories
➔ Lepton channel analysis
➔ Model electron faking photons in electron channel
➔ Data-driven method to measure leading reducible background
Questions?