Diphoton Analysis: RS Graviton Search Status and Future Plans

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Overview

- Dataset and Signal Sample Selection
- Signal Data Sample
- SM NLO diphoton spectrum
- Background Sample
  - photon + fake photon
  - Sideband method
- Trigger Efficiency (and plans)
- Efficiencies - used for now
- Limit - temporary
- Future plans

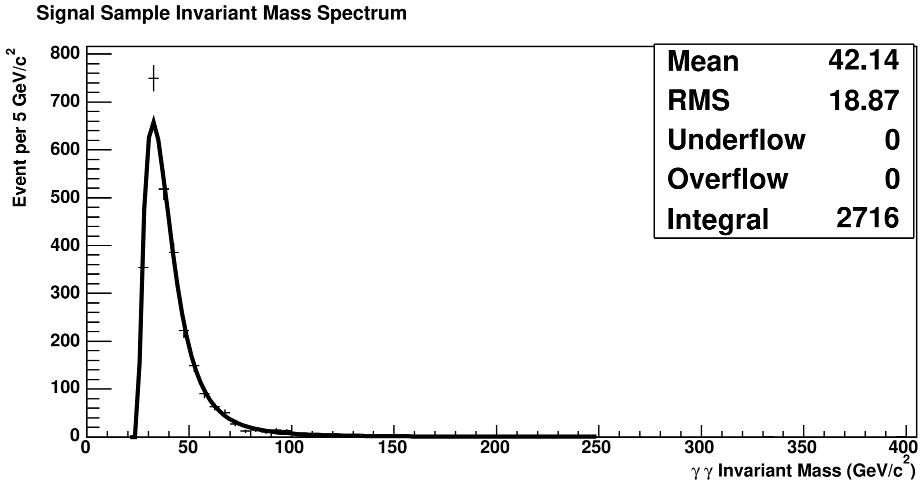
Dataset and Signal Sample Selection Criteria

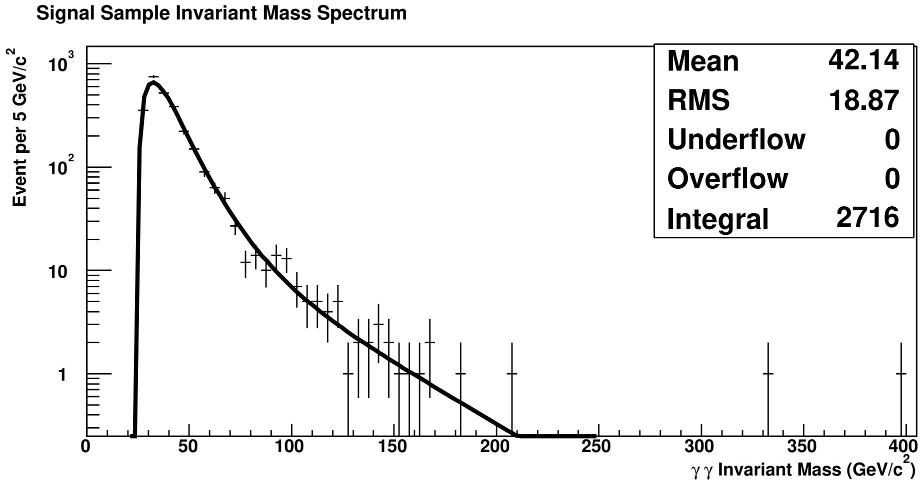
- Data used has 5.1.1 processing
- Stntuplised in version 5.2.0 dev 241
- Stripped 12 and 18 GeV diphoton triggers from the cph20c datasets
- Entered in stntuple catalog: "stntuple/dev_241:cph20c_diphoton"
- Good runs were required: Same as for gg+met, based on DQM v4
  http://www-cdf.fnal.gov/internal/dqm/goodrun/v4/goodv4.html
  Good runs from 138819 to 168889
  Luminosity: 198 pb^{-1}
- Standard Photon cuts V2.1 applied to both photons

Event Cuts
trigger path: DIPHOTON 12 or DIPHOTON 18 ZVertex exists, $\|z\| < 60$ cm GOODRUN
Photon Cuts for both photons
Central CES strip and wire clusters present CES $\|x\| < 21.0$ cm CES $9.0 < \|z\| < 230.0$ cm
Had/EM$< 0.055 + 0.00045 * E$ CalIso(cone 0.4) $< 2.0 + 0.02 * (Et - 20$ GeV) or $< 0.1Et$ if $Et < 20.0$ avg, scaled CES $\chi^2 < 20$ N3D$= 0$ || N3D$= 1$ and Pt$< 1.0 + 0.005 * Et$ SumPt (cone 0.4) $< 2.0 + 0.005Et$ Second CES cluster $E < 2.4 + 0.01 * Et$ or $E < 0.14 * Et$ if $Et < 18.0$

Signal Data Sample

After application of selection cuts: 2716 diphoton events





Three events above 200 GeV/c^2

run: event: 165271 : 2045232 Mass :397 GeV/c^2

Cosmic? some out of time Energy, but event is well-balanced

run: event: 165435 : 446579 Mass : 332 GeV/c^2

run: event: 166007 : 2285035 Mass : 208 GeV/c^2

We plan to study the individual events in more detail

Requirements to obtain the 95 % cross-section limit

Need to know number of expected background events in the search region
Background = SM diphoton production + QCD background

- SM : use Diphox NLO MC
- QCD background :
  1. fit the sideband spectrum
  2. fit the photon + fake photon spectrum

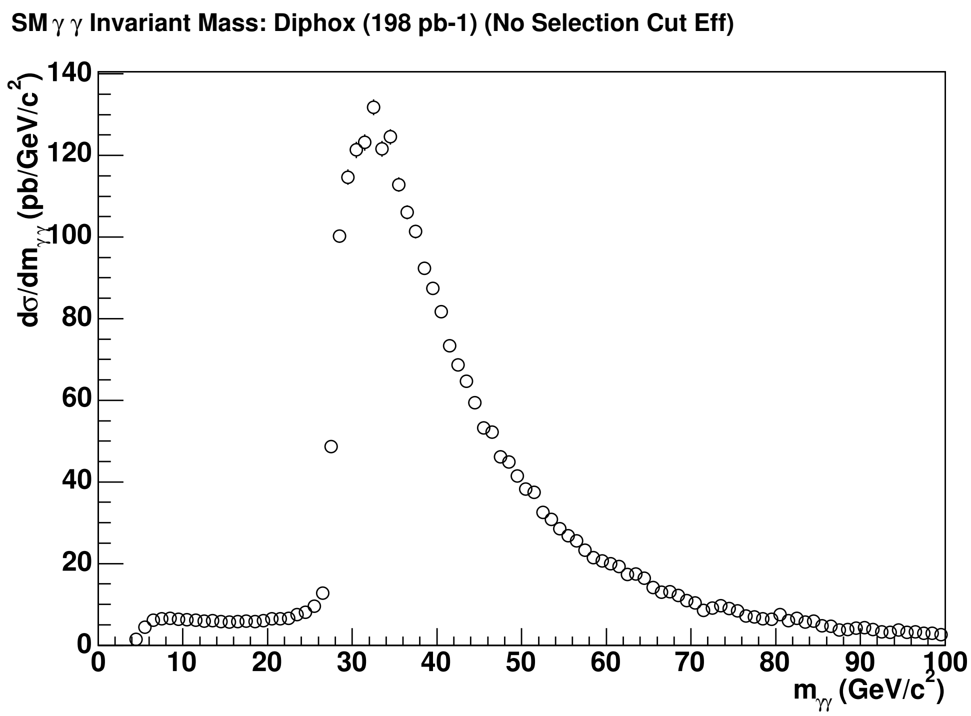
SM contribution for diphoton invariant mass spectrum

Pythia gives a LO estimate of diphoton cross-section
This would underestimate the expected number of events
Diphox gives a NLO estimate of cross-section

Obtain efficiency of MC from Pythia:
by comparing $N_{Generated}$ to the $N_{Pass-Selection-Cuts}$
then apply this efficiency to Diphox NLO generator level cross-section

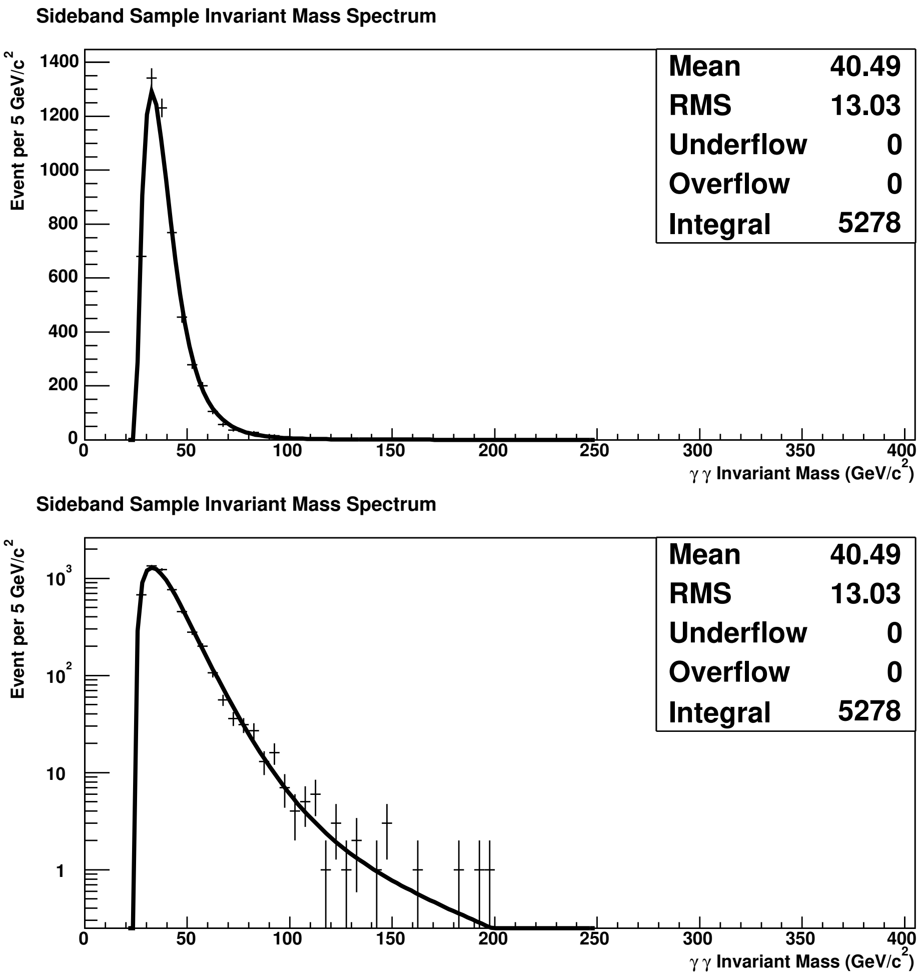
Absolutely normalised diphox cross-section to 198 pb^{-1}, Et $>$ 13, Et $>$ 14 GeV

To be up-dated:
with MC selection cut efficiency and new Et cuts on diphox



Sideband Data Sample

The events are required to be in good runs, have a good vertex and pass the diphoton 12 or 18 trigger
Both photons must pass the loose photon cuts and have Et>13 GeV
but the events which contain 2 or more gold photons are excluded
So this sample does not contain any of our signal events



Fit applied has the form of a double exponential

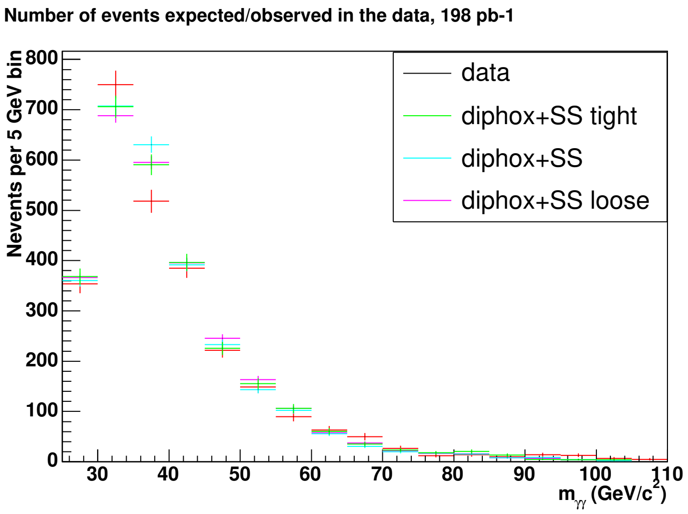
Comparison of Expected/Observed Number of Events

Sideband shapes are normalised such that in the range from 25 to 100 GeV

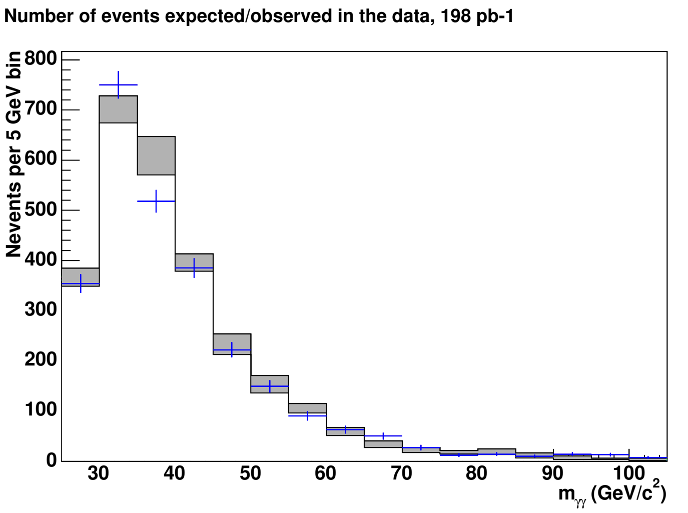
$\int_{25}^{100} N_{data} = \int_{25}^{100} N_{diphox-198pb-1} + \int_{25}^{100} N_{sideband}$

Errors are the statistical errors from the sidebands, scaled due to scale factor (different looser cuts applied)

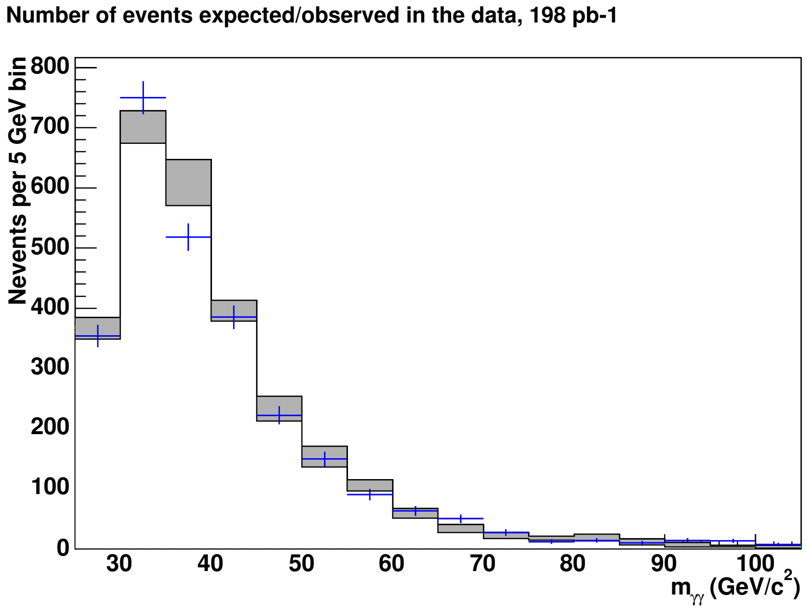
Preliminary MC selection efficiency applied to diphox (to be updated)

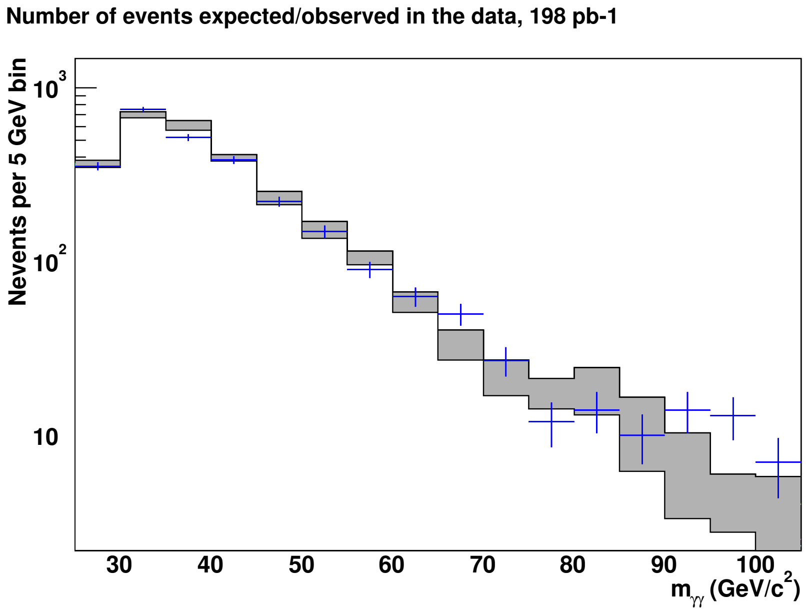


Band shows range from different sideband cuts, statistical errors are included



Comparison of Expected/Observed Number of Events





Plan to make a fit for the sideband shape including systematic and statistical errors.

Alternative method to estimate the background

Using photon fake-rate

Investigate using 10iso triggered
sample (in catalogue "dev_241/cph20c_10iso"), 198 pb^{-1}
same good run list as for signal sample

+ have at least 1 good photon with Et>13 GeV
+ have a good vertex in the event

(1) The loop over jets (with $|eta|< 1.04$)

(2) Weight each jet by appropriate weighting:
Use Fake rate: $(e^{(a*Et+b)} + c) \times 10^{-3}$ (CDF 6838)

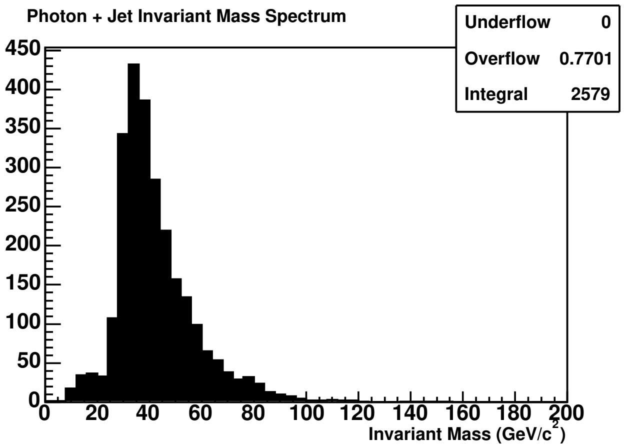
(i) Fake photons from jets have a different energy than the orginal jet
So smear the jet E by a gaussian (mean of 0.934, width of 0.0428)

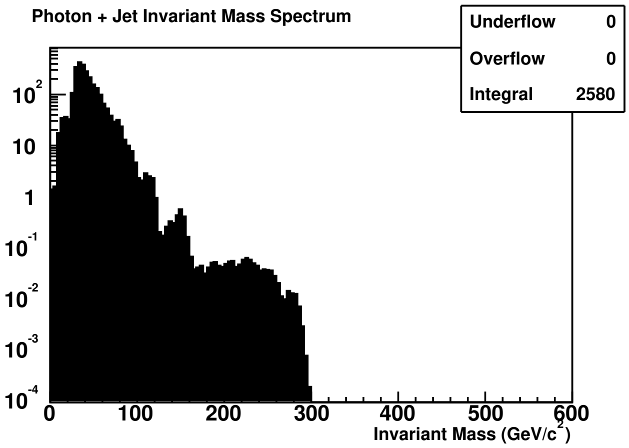
(ii) Integrate over the gaussian: loop over -3 σ to +3.01 σ in bins of 0.1.
$\rightarrow$ 61 entries per jet (assuming all have Et>13), which are weighted according to the gaussian

(3) Apply Jet Et $>$ 13 GeV Et cut
Calculate invariant mass spectrum of photon+jet

(4) Scale up by Trigger prescale of 1600

Photon + Jet Background



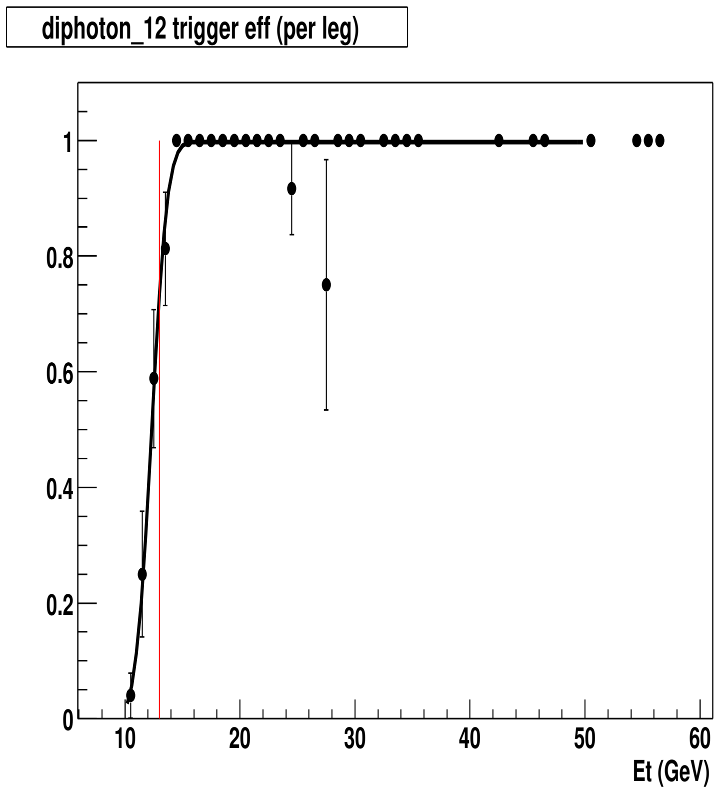


Almost negligible for very high invariant mass.
The probability of a jet faking a photon is 4×10^{-5} above E_t>100 GeV/c^2
Fake rate for 10iso above 200 GeV/c^2 : 0.3
Fake rate for 10iso above 300 GeV/c^2 : 0

So much less than this in a signal window (max width $<$ 100 GeV/c^2 - see later)

Trigger efficiencies for Diphoton 12 and 18

Diphoton 12 Trigger Efficiency is $\approx$ 100 % for Et>15 GeV, $M_{\gamma\gamma}$>30 GeV. Details in CDF note 6312.



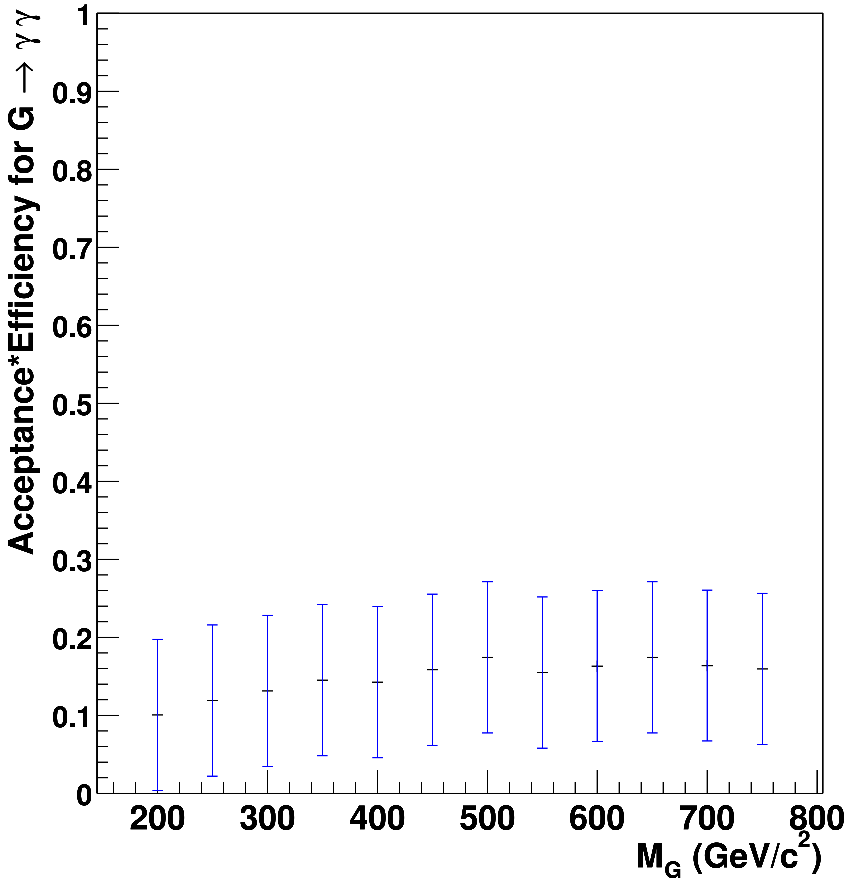
The combination of the diphoton 12 and diphoton 18 triggers are assumed to be 100 % efficient for Et>15 GeV $M_{\gamma\gamma} > 30$ GeV

- Plan to change photon Et cuts to Et $>$ 15 GeV
- Also plan to investigate adding PHOTON 50 and 70 triggers to ensure trigger is 100 % efficient at high invariant mass

Efficiencies and Acceptance

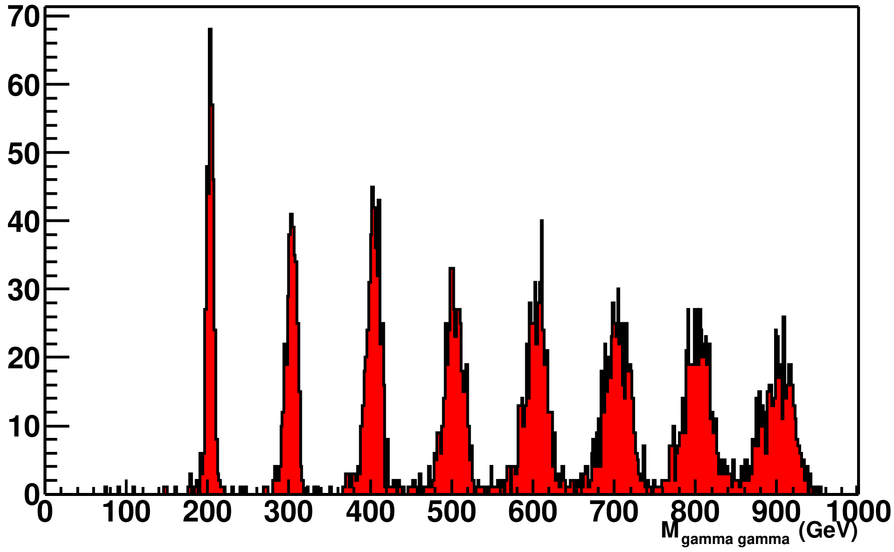
Preliminary results using efficiencies and acceptances calculated with MC version 4.9.1 (CDF Note 6560)
Errors shown are statistical and systematic

Plan to calculate using MC v5.3.1 when released and use reprocessed data



Signal Regions

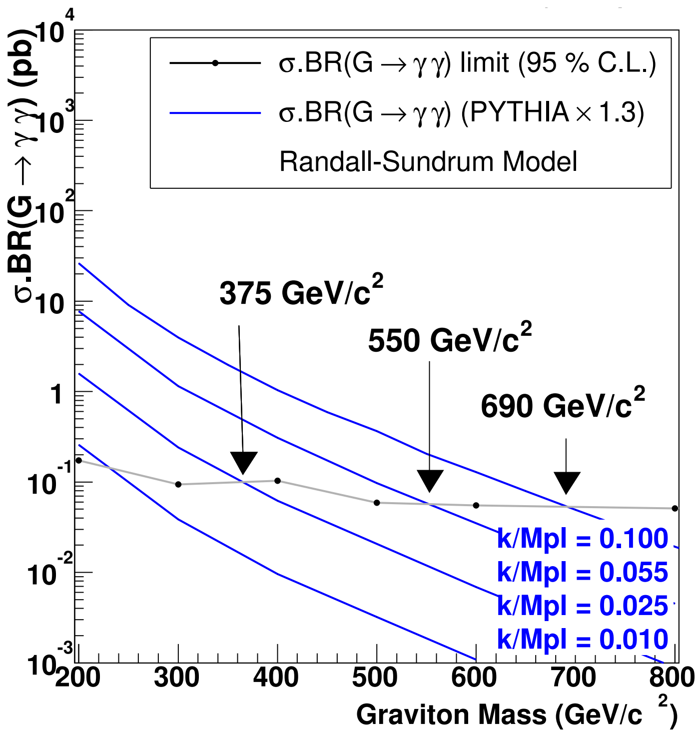
Taking 3 σ around the reconstructed invariant mass for each M_G (CDF Note 6560)

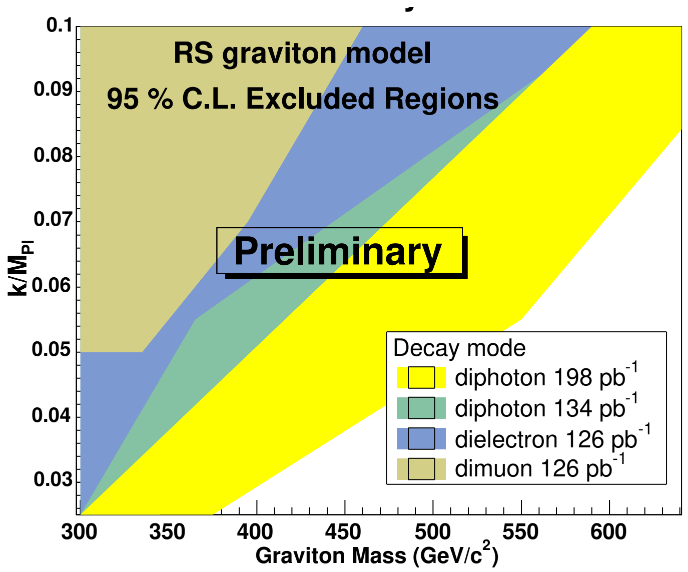


M_G	Mean	Sigma (σ_M)	$3\times\sigma_M$
200	202	5.4	16
250	252	7	21
300	301	11	32
350	352	11	32
400	400	12	36
450	454	13	38
500	499	17	52
550	551	18	55
600	600	19	57
650	645	20	59
700	697	21	64
750	751	22	66
800	797	25	76
850	843	27	80

95 % cross-section limit and Exlcusion Plane

Assuming no background at present,
and using acceptance and efficiencies previously calculated
(CDF Note 6560)





Future Plans

- Include expected background in future limits:
  extrapolate fits of sidebands and photon+fake photon to higher invariant mass
- Update MC when released: conversions better accounted for, so systematic error for these will be reduced
- Calculate efficiencies and acceptance with the new code version
- Look at more generic searches in the diphoton channel