Randall-Sundrum Model Search in High Mass Diphotons

Blessing

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Exotics meeting

Overview

- Updates since pre-blessing
- RS model
- Dataset and Signal Sample Selection
- Signal Data Sample
- Acceptance and Efficiency Studies
- Background Studies
  - SM NLO Diphoton Spectrum
  - Sideband Method
- RS model Limit with background
- Future plans

This work is described in cdf note 7024
Blessing Questions and Answers webpage:
http://home.fnal.gov/~pratt/Bless2004/BlessQA2004.html
Blessed plot webpage:
http://home.fnal.gov/~pratt/Bless2004/Bless2004.html

Updates since the preblessing

- added systematic uncertainty due to final/initial state radiation
- changed version 4.9.1 to 5.3.1 comparison to data to data comparison (rather than MC to MC)
- included zVertexing efficiency
- changed Diphox cuts to Et 15 and 15.1 GeV/c^2 to avoid symmetric cut problem in Diphox
- extended SM background estimate up to 1000 GeV/c^2
- updated table with total efficiency table
- updated final limits
- added uncertainties to data and background plots
- added an insert into the plot of data binned with the mass resolution of each bin and added a 2% constant term to account for the EM resolution.
- added event displays of highest two events
- not had a chance to make cos theta plots - could add and bless later?
- updated cdf note 7024
- Made new CDF note

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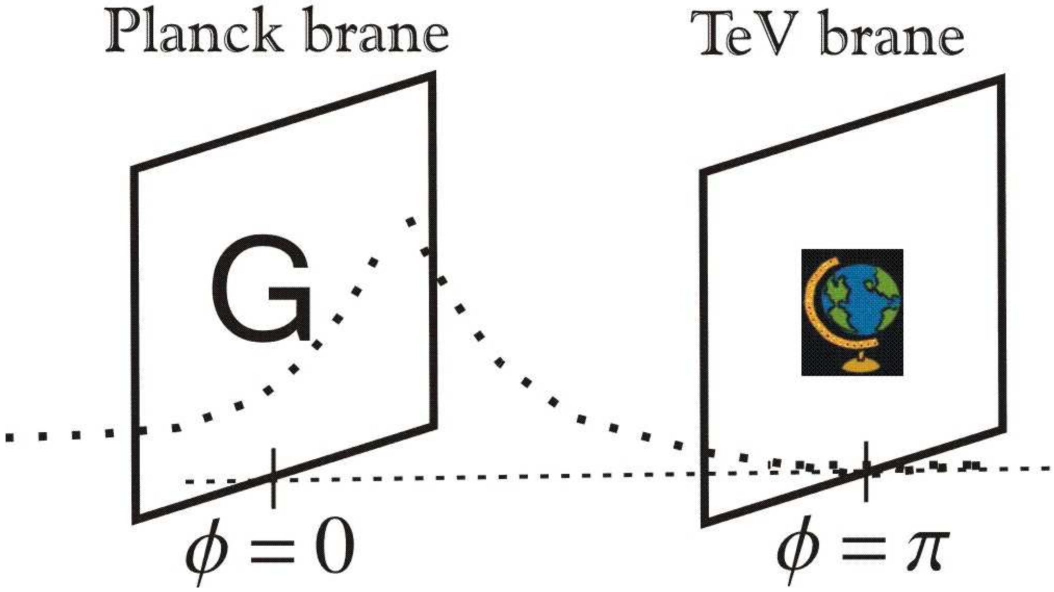
Randall-Sundrum Model

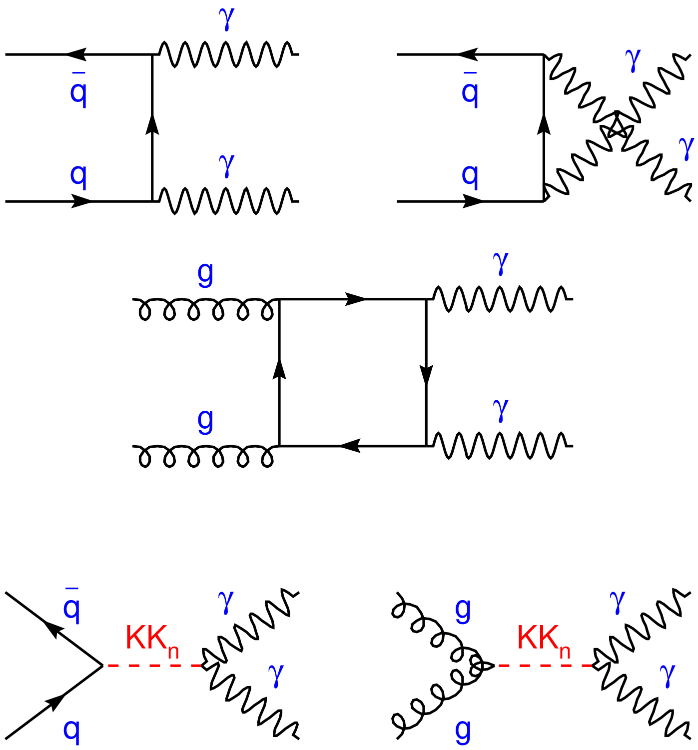
An Extra Dimensional model
with 1 Extra Dimension of finite size, in which gravity propagates
SM particles are confined to a brane (TeV) in the ED



Randall-Sundrum Model

Detect the ED via deviations to the SM diphoton production

Standard Model diphoton production and Graviton (KK) exchange



Search for peaks in the high mass diphoton spectrum

Dataset and Signal Sample Selection Criteria

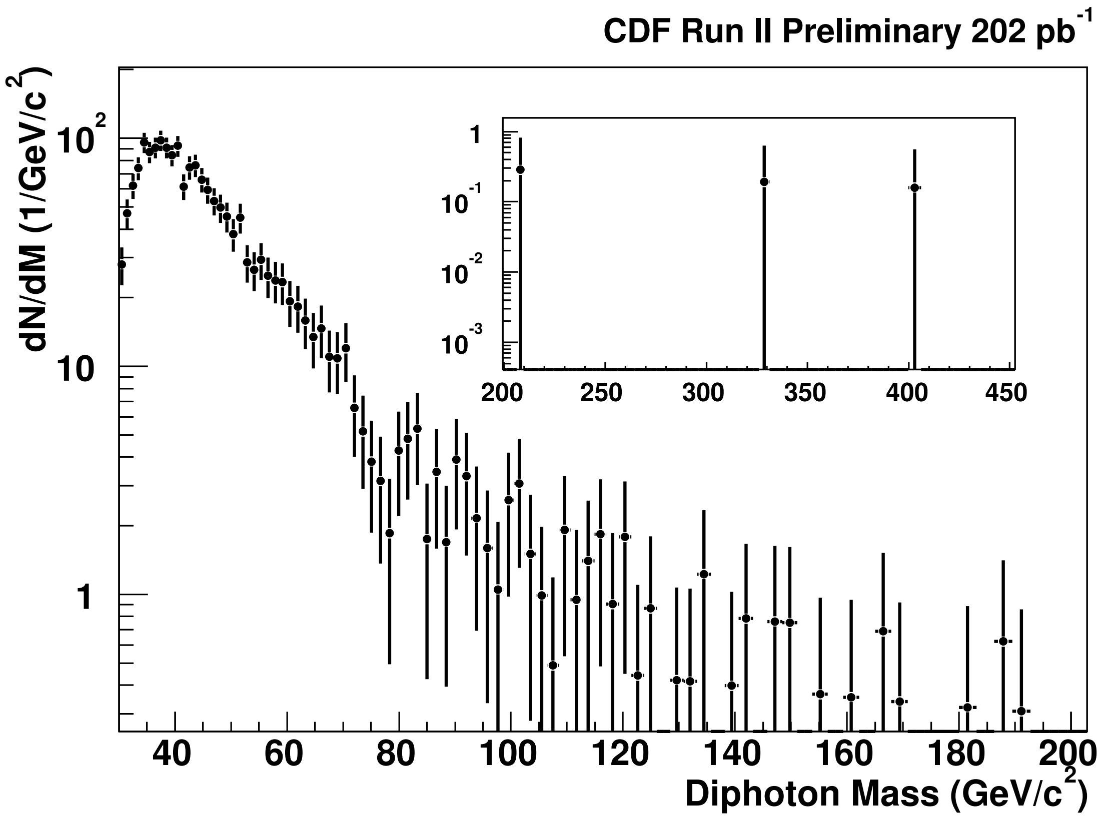
- Data used has 5.3.1 processing
- Stntuplised in version 5.3.1 dev 242
- Stripped 12 and 18GeV diphoton triggers from the cdip0d datasets
- in stntuple catalog: "stntuple/dev_242:cdip0d";
- Good runs were required: Same as for gg+met, based on DQM v4
  http://www-cdf.fnal.gov/internal/dqm/goodrun/v4/goodv4.html
  Good runs from 138819 to 168889
  Luminosity: 202 pb^{-1}
- Standard Photon cuts V2.1 applied to both photons

Event Cuts
trigger path: DIPHOTON 12 or DIPHOTON 18
ZVertex exists, $\lvert z\rvert < 60$ cm
GOODRUN
Photon Cuts for both photons
Central
CES strip and wire clusters present
CES $\lvert x\rvert < 21.0$ cm
CES $9.0 < \lvert z\rvert < 230.0$ cm
Had/EM$< 0.055 + 0.00045 * E$
CalIso(cone 0.4) $< 2.0 + 0.02 * (Et - 20\text{ GeV})$ 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 and
Et $>$ 15 GeV and $M_{\gamma\gamma} > 30$ GeV : 2001 diphoton events

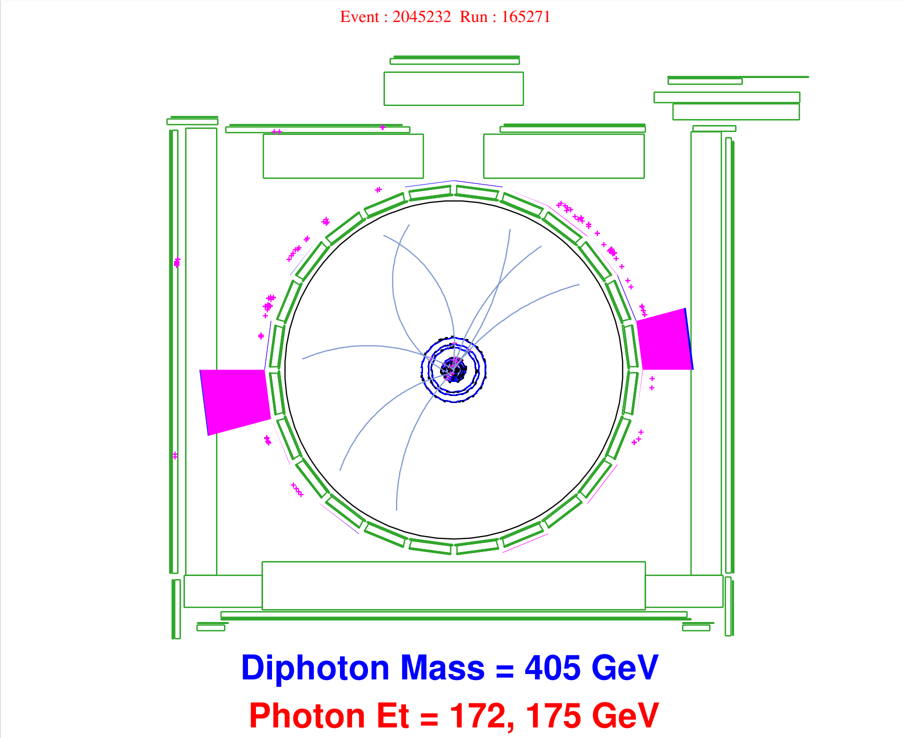
Diphoton spectrum in bins of 1 sigma mass resolution (minimum of 1GeV) with a 2% constant term to account for the EM resolution.

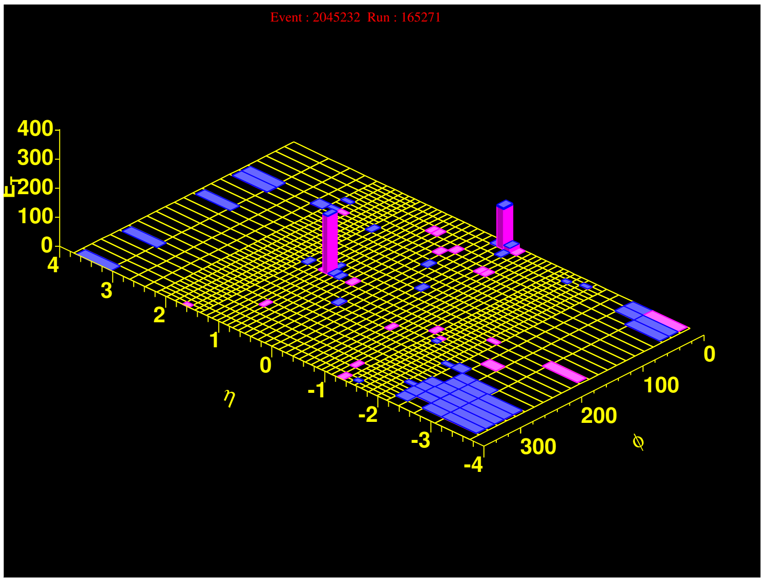


Three events above 200 GeV/c^2

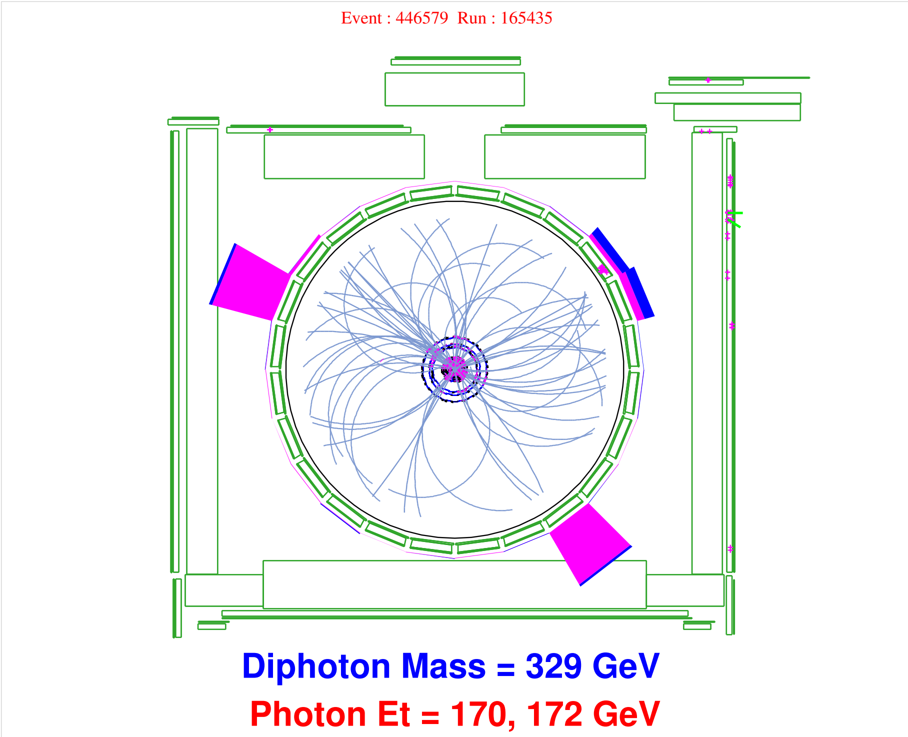
run: event: 165271 : 2045232 Mass : 405 GeV/c^2 : Etc0 : 175 Etc1 : 172
run: event: 165435 : 446579 Mass : 329 GeV/c^2 : Etc0 : 170 Etc1 : 172
run: event: 166007 : 2285035 Mass : 207 GeV/c^2 : Etc0 : 110 Etc1 : 79

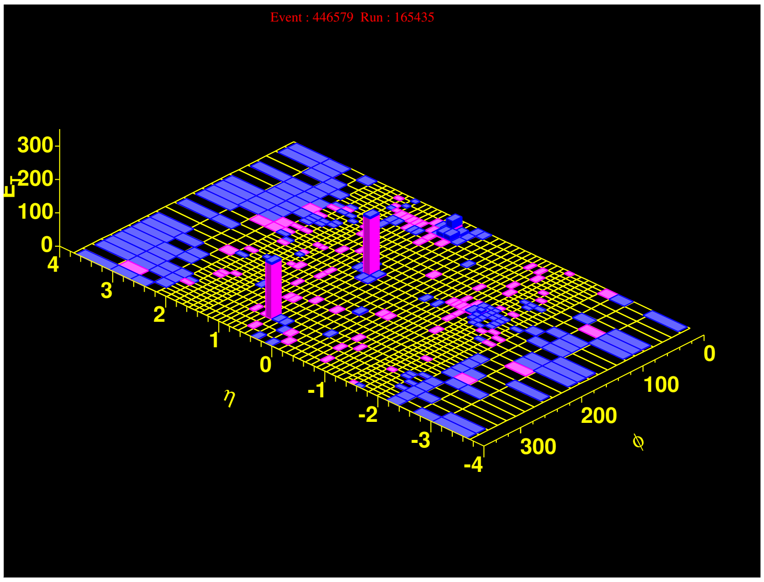
Event display of highest mass event



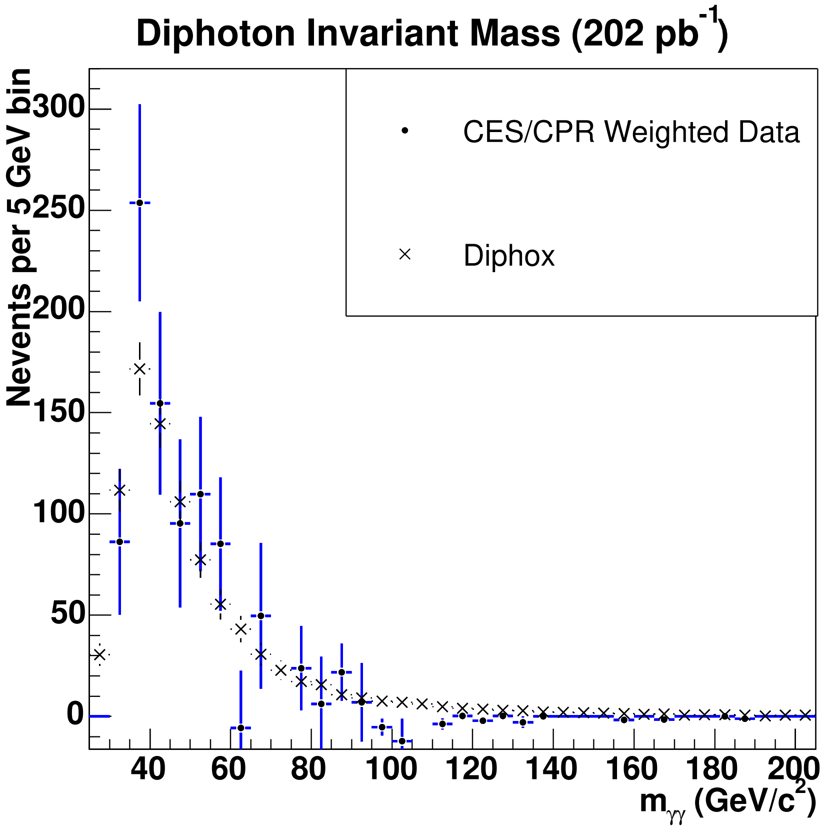


Event display of 2nd highest mass event





Comparison with SM diphoton expectation



Acceptance and Efficiency

Acceptance and Efficiency calculated using 4.9.1 MC
Corrected for 4.9.1 MC $\rightarrow$ 4.9.1 data
Corrected for 4.9.1 data $\rightarrow$ 5.3.1 data

Acceptance and Efficiency from RS MC

RS Signal MC generated using Pythia 6.223 in version 4.9.1
Events weighted to correct for diphoton angular distribution (CDF 6560)
12000 events generated at M_G from 250 GeV to 1000 GeV in 50 GeV steps
PDF = CTEQ5L
Signal regions are 3σ around the reconstructed invariant mass for each M_G
Acceptance and Efficiency determined for the signal regions

Mass Gev/c^2	Signal Region Range in	S. Width Gev/c^2	Acceptance Gev/c^2	Efficiency*Acceptance
200	184 - 218	34	0.246 ± 0.003	0.125 ± 0.002
250	232 - 272	40	0.279 ± 0.003	0.144 ± 0.002
300	278 - 328	50	0.313 ± 0.003	0.162 ± 0.003
350	324 - 382	58	0.345 ± 0.004	0.179 ± 0.003
400	370 - 434	64	0.384 ± 0.005	0.201 ± 0.004
450	416 - 490	74	0.421 ± 0.004	0.225 ± 0.004
500	460 - 544	84	0.440 ± 0.004	0.239 ± 0.004
550	506 - 598	92	0.486 ± 0.005	0.270 ± 0.004
600	552 - 652	100	0.495 ± 0.005	0.269 ± 0.004
650	596 - 704	108	0.522 ± 0.005	0.290 ± 0.005
700	642 - 758	116	0.545 ± 0.005	0.297 ± 0.005
750	684 - 812	128	0.553 ± 0.005	0.295 ± 0.005
800	732 - 864	132	0.555 ± 0.005	0.292 ± 0.005
850	776 - 916	140	0.565 ± 0.006	0.302 ± 0.005
900	820 - 968	148	0.562 ± 0.005	0.300 ± 0.005

Corrections of 4.9.1 MC to 4.9.1 Data

Study details in cdf note 6560

Variable	Correction to MC	Rel.Syst.Unc.	Study
	(%)	(%)	
Had/Em	+2	1.0	UE and Z
Cal iso	-2	5.0	data/MC in UE & Z
Chi2 (Strips+Wires)/2.0	-3	2.0	Z study
N track (N3D)	-1	0.5	UE study
Track Pt	-1	1.0	UE study
Cone 0.4 Track Iso	-2	1.0	UE and Zee
2nd CES cluster	-	-	-
Fiducial	-	3.0	
Conversions	-3.7	1.2	E/p material
Trigger Efficiency	-	-	
Total per photon	-10.7	6.5	
Total per diphoton event	-21.4	13.0	

Correction to efficiency due to version 4.9.1(data) $\rightarrow$ 5.3.1(data)

Estimated by comparing efficiency of e selection criteria in Zee studies
http://www-cdf.fnal.gov/internal/people/links/AidanRobson/Val531pre2/

Cut	n-1 efficiency	
	5.3.1pre2	4.11.2
HadEm $<$ 0.055 + 0.00045*E	0.991 $\pm$ 0.005	0.992 $\pm$ 0.005
CalIso (cone 0.4) $<$ 0.1	0.974 $\pm$ 0.005	0.975 $\pm$ 0.005
CES Chi2 Strips $<$ 10	0.962 $\pm$ 0.004	0.961 $\pm$ 0.004

Differences negligible compared to their statistical uncertainties.
Therefore no correction is made to the efficiency due to the different data processing versions.
A systematic uncertainty of 2 % is included, to account for the change in tracking selection cuts: track isolation and the N3d

Efficiency of $|zVertex| < 60$ cm cut:

$|zVertex|$ efficiency has 2 components:

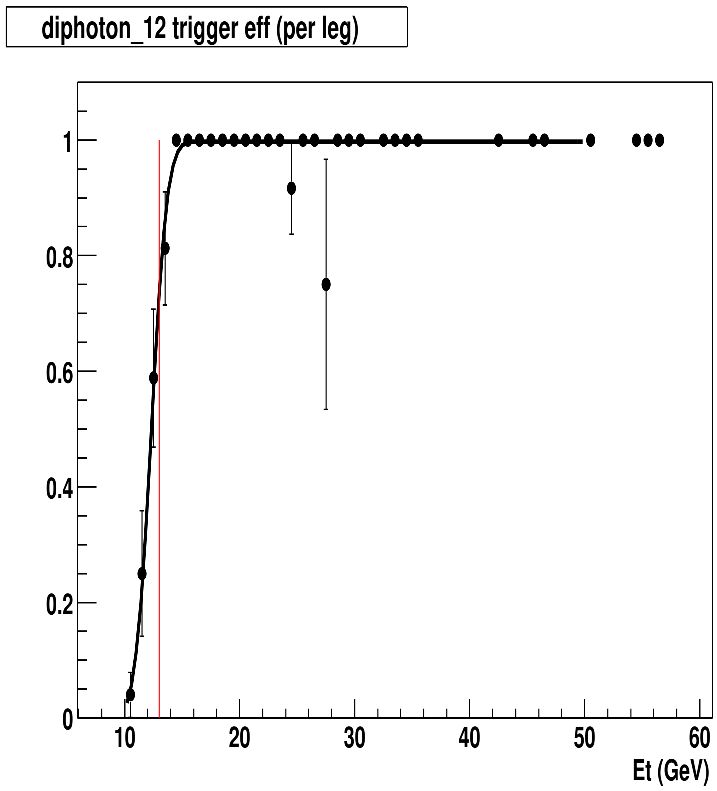
1. interaction to be within 60 cm of the center of the detector $= 0.951 \pm 0.005$ cdf note 6331
2. z Vertex must be reconstructed, expected to be ∼100 % with version 5.3.1 vertexing algorithm

Efficiency of z Vertex cut from signal datasample found by removing z Vertex criteria:
2095 events remain in the sample
2092 have a vertex (99.9 $\pm$ 0.1 %)
2001 of these have a z vertex within $\pm$ 60 cm (95.7 $\pm$ 0.4 %)

Conclusion is that the vertexing is 100 % efficient and the z Vertex efficiency is 95.1 $\pm$ 0.5 %.

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.



Checked using photon 50 and 70 triggers

Conclude: triggers are 100 % efficient

Uncertainties in Acceptance

Sources of uncertainties in Acceptance considered:

- Parton Distribution Function (PDF)
- Final/intial state radiation (FSR/ISR)
- Et scale

Uncertainty in acceptance due to changing the PDF

M_G	Acceptance (%)					
(GeV/c^2)	CTEQ5L	MRST leading order Fit				
		Central	High Gluon	Low Gluon	High Alpha$_s$	Low Alpha$_s$
250	27.9 ± 0.3	27.5 ± 0.4	27 ± 0.5	26.7 ± 0.5	27.3 ± 0.4	26.3 ± 0.4
350	34.5 ± 0.4	33.6 ± 0.6	33.2 ± 0.5	34 ± 0.6	35 ± 0.6	35.2 ± 0.6
450	42.1 ± 0.4	40.7 ± 0.6	38.8 ± 0.7	40.5 ± 0.9	40.7 ± 0.6	41.2 ± 0.6
550	48.6 ± 0.5	46.3 ± 0.7	44.6 ± 0.7	47.4 ± 0.7	46.6 ± 0.9	47.3 ± 0.7
650	52.2 ± 0.5	50.8 ± 0.8	50.3 ± 0.8	51.4 ± 0.9	50.6 ± 0.8	50.9 ± 0.8
750	55.3 ± 0.5	54 ± 0.8	52.6 ± 0.8	54.4 ± 0.9	53.4 ± 0.8	54 ± 0.8
850	56.5 ± 0.6	54.4 ± 0.9	54.2 ± 0.8	55.7 ± 0.8	54.3 ± 1	55.5 ± 0.8
950	76.3 ± 0.4	76.7 ± 0.7	78 ± 0.7	79.7 ± 0.7	75.8 ± 0.9	75.1 ± 0.9

M_G	Average Deviation (%)	$\Delta A/A$
250	1	0.04
350	0.8	0.02
450	2	0.05
550	2	0.05
650	1	0.03
750	2	0.03
850	2	0.03
950	2	0.02

The relative change in acceptance due to a change pdf is taken as 4 %, independent of graviton mass.

Uncertainty in acceptance due to changing the FSR/ISR

Uncertainty taken as half the difference in acceptance with FSR/ISR turned on and off

M_G GeV/c^2	Acceptance FISR on	FISR off	1/2*Δ A/A
200	0.246 ± 0.003	0.2 ± 0.004	-0.09
250	0.279 ± 0.003	0.234 ± 0.005	-0.08
300	0.313 ± 0.003	0.275 ± 0.005	-0.06
350	0.345 ± 0.004	0.316 ± 0.006	-0.04
400	0.384 ± 0.005	0.347 ± 0.006	-0.05
450	0.421 ± 0.004	0.402 ± 0.007	-0.02
500	0.44 ± 0.004	0.439 ± 0.007	-0.001
550	0.486 ± 0.005	0.478 ± 0.008	-0.008
600	0.495 ± 0.005	0.493 ± 0.007	-0.002
650	0.522 ± 0.005	0.527 ± 0.008	0.005
700	0.545 ± 0.005	0.534 ± 0.007	-0.01
750	0.553 ± 0.005	0.56 ± 0.009	0.006
800	0.555 ± 0.005	0.561 ± 0.008	0.006
850	0.565 ± 0.006	0.549 ± 0.008	-0.01
900	0.562 ± 0.005	0.572 ± 0.008	0.01

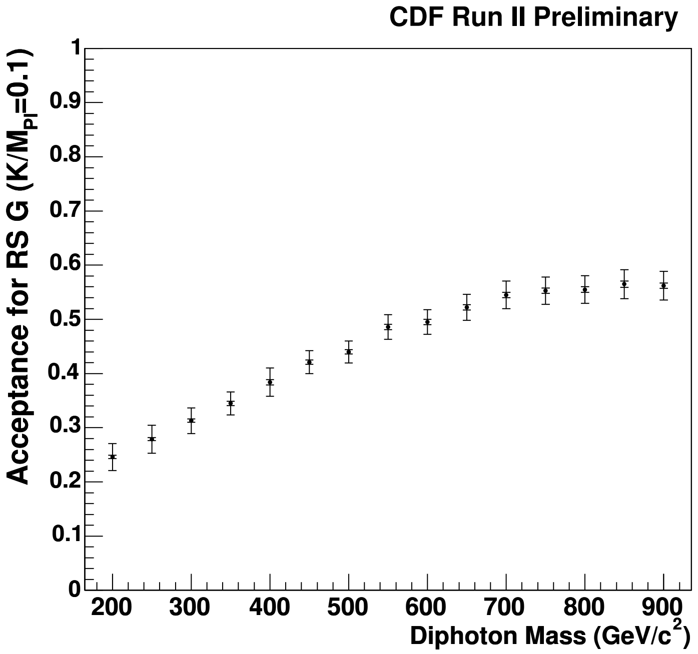
Uncertainty in Acceptance if signal region is shifted by 1%

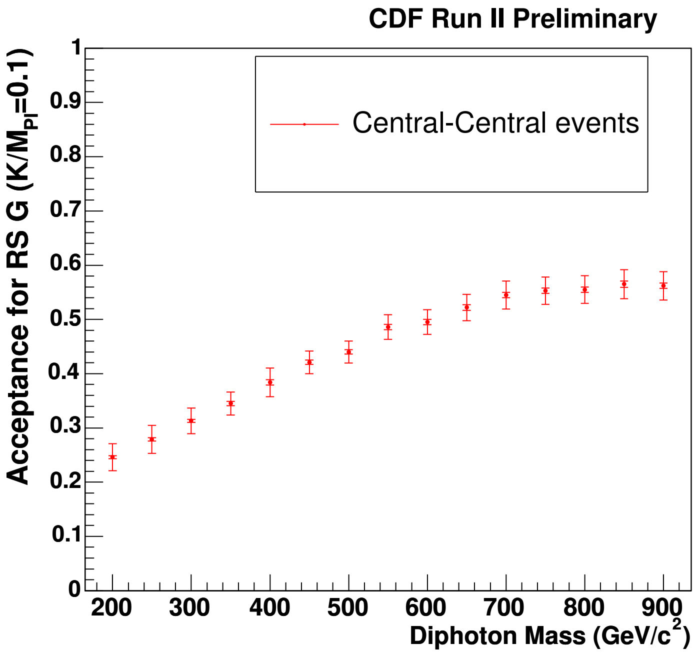
M_G	$\Delta A/A$
200	0.009
250	0.004
300	0.004
350	0.003
400	0.004
450	0.004
500	0.003
550	0.003
600	0.004
650	0.003
700	0.003
750	0.002
800	0.003
850	0.003
900	0.003

Summary of the Acceptance*Efficiency uncertainties.

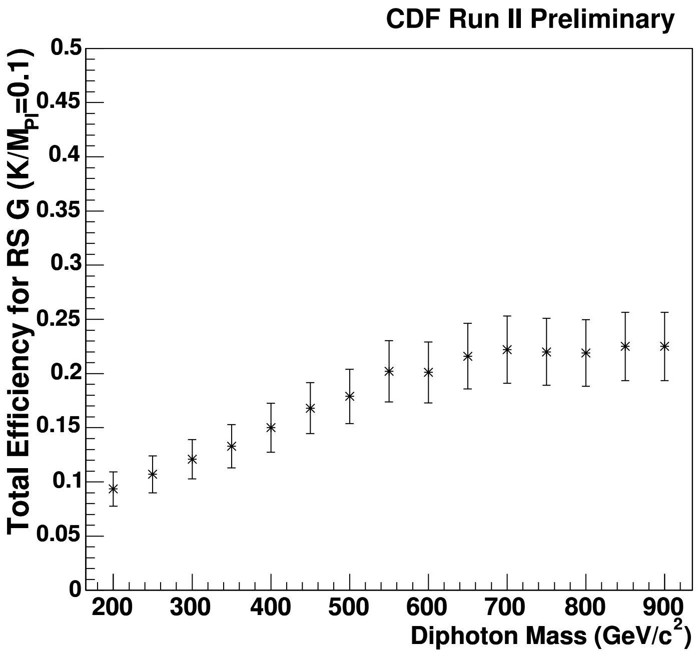
M_G GeV/c^2	Statistical	Systematic		Total
		Acceptance	Efficiency	
200	0.02	0.10	0.13	0.17
250	0.02	0.09	0.13	0.16
300	0.02	0.07	0.13	0.15
350	0.02	0.06	0.13	0.14
400	0.02	0.07	0.13	0.15
450	0.02	0.05	0.13	0.14
500	0.02	0.04	0.13	0.14
550	0.02	0.05	0.13	0.14
600	0.02	0.04	0.13	0.14
650	0.02	0.05	0.13	0.14
700	0.02	0.05	0.13	0.14
750	0.02	0.05	0.13	0.14
800	0.02	0.05	0.13	0.14
850	0.02	0.05	0.13	0.14
900	0.02	0.05	0.13	0.14

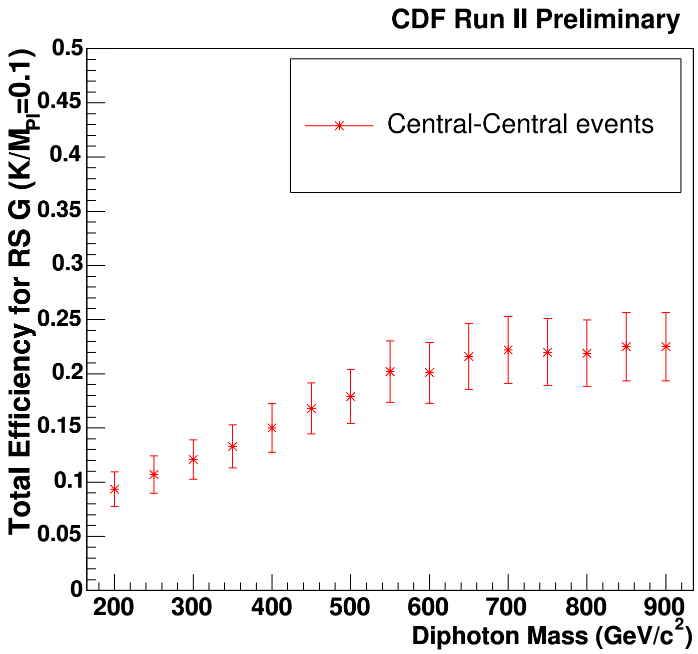
RS MC Acceptance





Total Efficiency





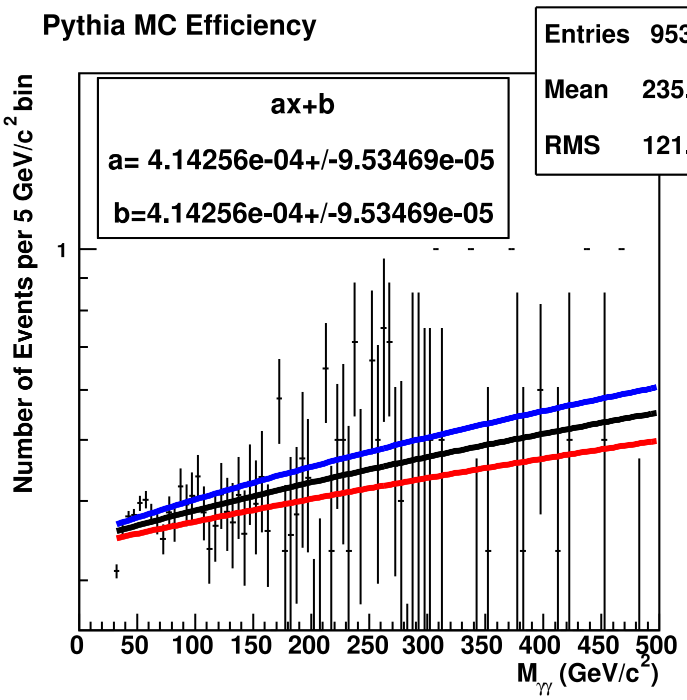
Diphoton Backgrounds

- SM
  Estimate SM background from Diphox
  Diphox is corrected for efficiency using Pythia MC and
  absolutely normalised to 202 pb^{-1}
  scale up to account for Diphox having $|\eta_\gamma|$<0.9 and data $|\eta_\gamma|$<1.04
  - scale factor from Pythia:
  33161.0/456898 $|\eta_\gamma| <$ 1.04 and 25617/456898 $|\eta_\gamma| <$ 0.9

- QCD background using Sideband spectrum

SM Diphoton Spectrum and Uncertainties

Diphox is corrected for efficiency using Pythia MC,
so uncertainty from the efficiency fit



M_G	Signal window	Diphox Background			Δ(Bkdg)/Bkdg
GeV/c^2	GeV/c^2	Eff	Eff L	Eff U	
200	184 - 218	3.8 ± 0.3	3.6 ± 0.3	4.1 ± 0.3	0.06
250	232 - 272	2 ± 0.2	1.9 ± 0.4	2.1 ± 0.4	0.07
300	278 - 328	1.6 ± 0.2	1.5 ± 0.4	1.7 ± 0.5	0.07
350	324 - 382	0.57 ± 0.2	0.52 ± 0.5	0.62 ± 0.5	0.08
400	370 - 434	0.35 ± 0.1	0.32 ± 0.5	0.38 ± 0.5	0.09
450	416 - 490	0.32 ± 0.1	0.29 ± 0.5	0.35 ± 0.5	0.09
500	460 - 544	0.2 ± 0.09	0.18 ± 0.5	0.22 ± 0.5	0.10
550	506 - 598	0.16 ± 0.08	0.14 ± 0.5	0.18 ± 0.5	0.10
600	552 - 652	0.14 ± 0.06	0.13 ± 0.5	0.16 ± 0.5	0.11
650	596 - 704	0.074 ± 0.05	0.066 ± 0.5	0.082 ± 0.5	0.11
700	642 - 758	0.0071 ± 0.04	0.0063 ± 0.5	0.008 ± 0.5	0.11
750	684 - 812	0.019 ± 0.03	0.017 ± 0.5	0.021 ± 0.5	0.12
800	732 - 864	0.015 ± 0.03	0.013 ± 0.5	0.017 ± 0.5	0.12
850	776 - 916	0.023 ± 0.02	0.02 ± 0.5	0.026 ± 0.5	0.12
900	820 - 968	0.02 ± 0.02	0.018 ± 0.5	0.023 ± 0.5	0.13

SM Diphoton Spectrum and Uncertainties

Uncertainty from choice of renormalisation scale in Diphox

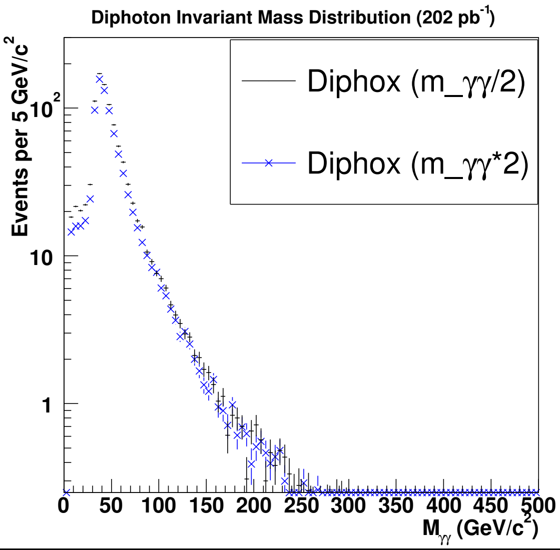
Different scale choices used to calculate uncertainty

$\mu_F = \mu_R = m_{\gamma\gamma}/2$

$\mu_F = \mu_R = m_{\gamma\gamma}*2$

The former is the optimal choice by diphox.

Take average of half the difference a the systematic uncertainty: 20 %



M_G	Signal window	Diphox Background		0.5*Δ(Bkdg)/Bkdg
GeV/c^2	GeV/c^2	$m_{\gamma\gamma}/2$	$m_{\gamma\gamma}*2$	
200	184 - 218	3.8 ± 0.3	3.7 ± 0.3	-0.02
250	232 - 272	2.0 ± 0.2	1.4 ± 0.2	-0.16
300	278 - 328	1.6 ± 0.2	0.92 ± 0.2	-0.21
350	324 - 382	0.57 ± 0.2	0.35 ± 0.1	-0.19
400	370 - 434	0.35 ± 0.1	0.26 ± 0.1	-0.13
450	416 - 490	0.32 ± 0.1	0.18 ± 0.09	-0.22
500	460 - 544	0.20 ± 0.09	0.27 ± 0.08	0.16
550	506 - 598	0.16 ± 0.08	0.25 ± 0.07	0.28
600	552 - 652	0.14 ± 0.06	0.10 ± 0.06	-0.14
650	596 - 704	0.074 ± 0.05	0.03 ± 0.04	-0.30
700	642 - 758	0.007 ± 0.04	0.036 ± 0.03	2.00
750	684 - 812	0.019 ± 0.03	0.022 ± 0.03	0.07
800	732 - 864	0.015 ± 0.03	0.037 ± 0.02	0.74
850	776 - 916	0.023 ± 0.02	0.0036 ± 0.02	-0.42
900	820 - 968	0.02 ± 0.02	0.0029 ± 0.02	-0.43

SM Diphoton Spectrum and Uncertainties

- Uncertainty in scaling factor for eta correction of 0.008 (33161.0/456898 $|\eta_\gamma| < 1.04$ and 25617/456898 $|\eta_\gamma| < 0.9$)

- Systematic uncertainty on the luminosity of 0.06

Total error on Standard Model Backgrounds

M_G	Signal window	Diphox Background	
GeV/c^2	GeV/c^2	Diphotons	
200	184 - 218	$3.8 \pm 0.32 \pm 0.84$	3.8 ± 0.9
250	232 - 272	$2.0 \pm 0.24 \pm 0.44$	2.0 ± 0.5
300	278 - 328	$1.6 \pm 0.20 \pm 0.35$	1.6 ± 0.4
350	324 - 382	$0.57 \pm 0.16 \pm 0.13$	0.6 ± 0.2
400	370 - 434	$0.35 \pm 0.13 \pm 0.08$	0.35 ± 0.15
450	416 - 490	$0.32 \pm 0.11 \pm 0.07$	0.32 ± 0.13
500	460 - 544	$0.20 \pm 0.09 \pm 0.05$	0.20 ± 0.10
550	506 - 598	$0.16 \pm 0.08 \pm 0.04$	0.16 ± 0.09
600	552 - 652	$0.14 \pm 0.06 \pm 0.03$	0.14 ± 0.07
650	596 - 704	$0.07 \pm 0.05 \pm 0.02$	0.07 ± 0.06
700	642 - 758	$0.007 \pm 0.041 \pm 0.002$	0.01 ± 0.04
750	684 - 812	$0.019 \pm 0.032 \pm 0.005$	0.02 ± 0.03
800	732 - 864	$0.015 \pm 0.036 \pm 0.004$	0.02 ± 0.01
850	776 - 916	$0.023 \pm 0.022 \pm 0.01$	0.02 ± 0.02
900	820 - 968	$0.020 \pm 0.017 \pm 0.01$	0.02 ± 0.02

Non-SM Background: 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:

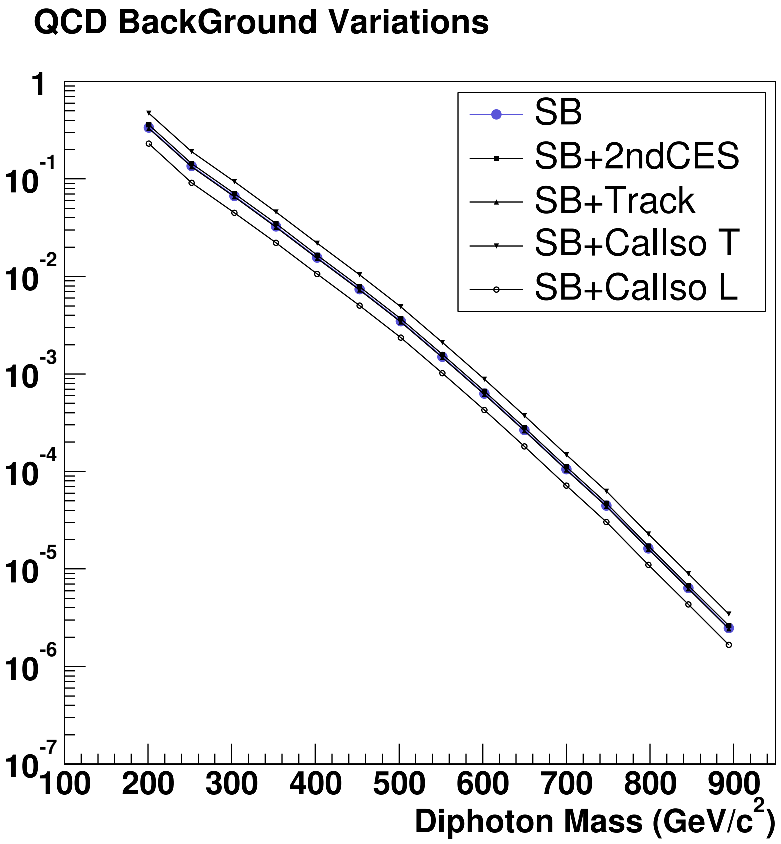
- central detector
- looser iso cut of:
  float iso3 = IsoCorr(photon); // V2.1 cuts
  (etc<20.0 ? iso3<0.15*etc : iso3<3.0 + 0.02*(etc-20.0));
  rather than
  (etc<20.0 ? iso3<0.1*etc : iso3<2.0 + 0.02*(etc-20.0));
- Pt()<0.25*etc
- SumPt4()<5.0
- HadEm()<0.125

and have Et>15 GeV, and Mgg > 30 GeV
but the events which contain 2 or more gold photons are excluded
So this sample does not contain any of our signal events

Signal : 2001 events
Sideband: 3996 (none above 200 GeV)
Sideband + iso (tighten cut, as applied to signal): 2693
Sideband + looser iso (et0<20.0 ? iso0<0.2*et0 : iso0<3.5): 4535
Sideband + N3d (applied to signal) : 2418
Sideband + Sumpt4 (applied to signal) : 1384
Sideband + 2nd CES (applied to signal) : 1927

Fits to Sidebands

- The shape of the sidebands have been fitted with a threshold function times an exponential plus a fit to the shape of the Diphox spectrum at high mass
- Normalise the sideband shapes are normalised such that $\int_{30}^{100} N_{data} = \int_{30}^{100} N_{diphox-202pb-1} + \int_{30}^{100} N_{sideband}$
- Find number of non-SM background in each signal region predicted by the sideband fit and take variation for the other sideband fits as the upper and lower uncertainty.



Total Diphoton Background

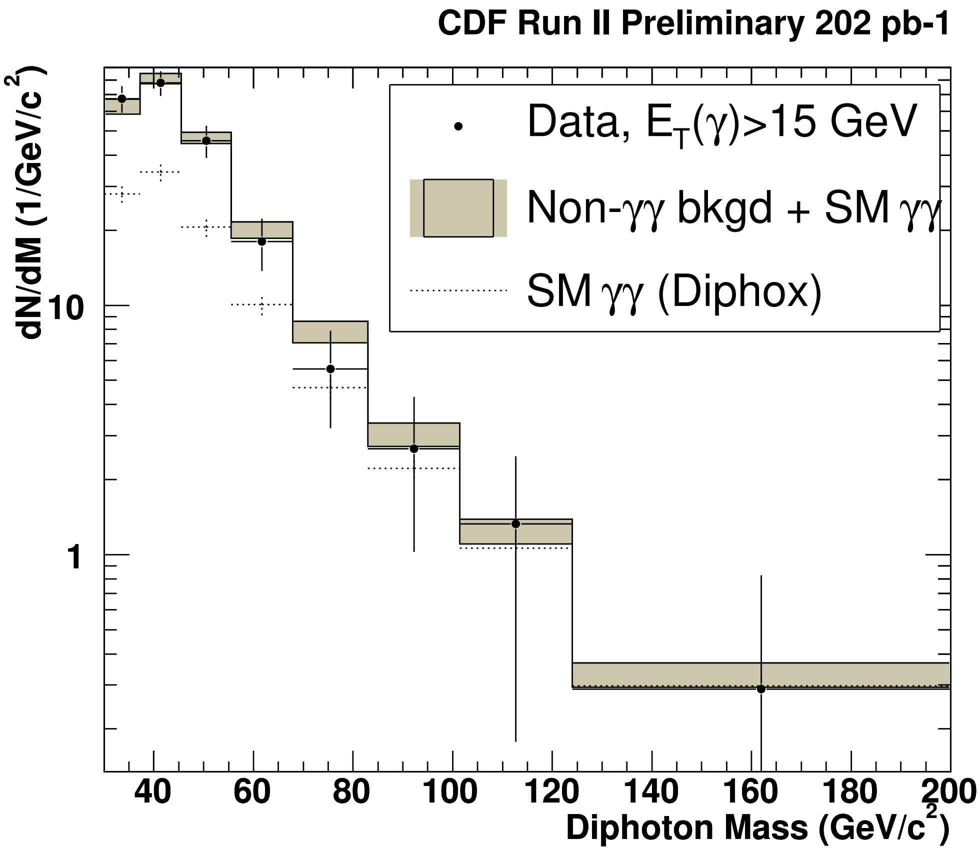
Total Background = non-$\gamma\gamma$ bkgd (from sideband) + SM $\gamma\gamma$ (from diphox)

M_G	Signal Region	Bkgd
200	184-218	4.1 ± 0.9
250	232-272	2.1 ± 0.5
300	278-328	1.7 ± 0.4
350	324-382	0.6 ± 0.2
400	370-434	0.37 ± 0.15
450	416-490	0.33 ± 0.13
500	460-544	0.20 ± 0.10
550	506-598	0.16 ± 0.09
600	552-652	0.14 ± 0.07
650	596-704	0.08 ± 0.06
700	642-758	0.01 ± 0.04
750	684-812	0.02 ± 0.03
800	732-864	0.02 ± 0.03
850	776-916	0.02 ± 0.02
900	820-968	0.02 ± 0.02

Comparison of Expected/Observed Number of Events

Sideband shapes are normalised such that in the range from 30 to 100 GeV $\int_{30}^{100} N_{data} = \int_{30}^{100} N_{diphox-202pb-1} + \int_{30}^{100} N_{sideband}$

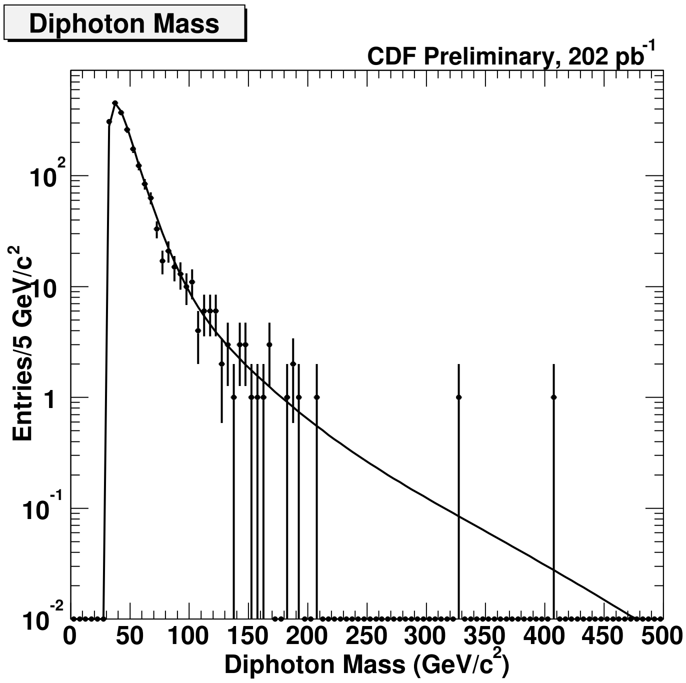
Non-$\gamma\gamma$ bkdg from sidebands (average from sideband cuts and variation from variation of the sidebands per bin)



Comparison of Expected/Observed Number of Events

The Diphox data is absolutely normalised and the number of non-SM events predicted by the sideband method is normalised to the low mass region.

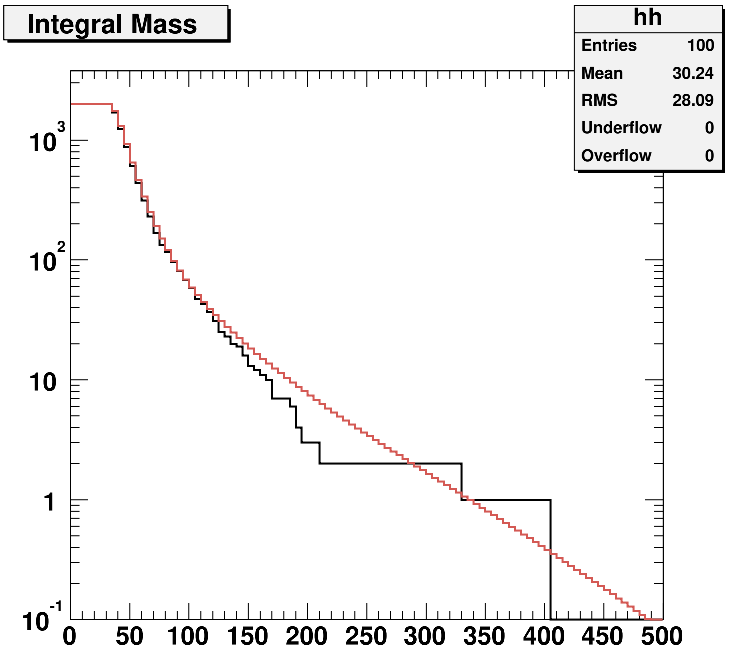
curve = expectation, points = data observed



Comparison of Expected/Observed Number of Events

The Diphox data is absolutely normalised and the number of non-SM events predicted by the sideband method is normalised to the low mass region.

red = expectation, black = data observed



Randal-Sundrum Model Cross-Section Limits

use Bayes program to calculate the 95 % C.L. limits

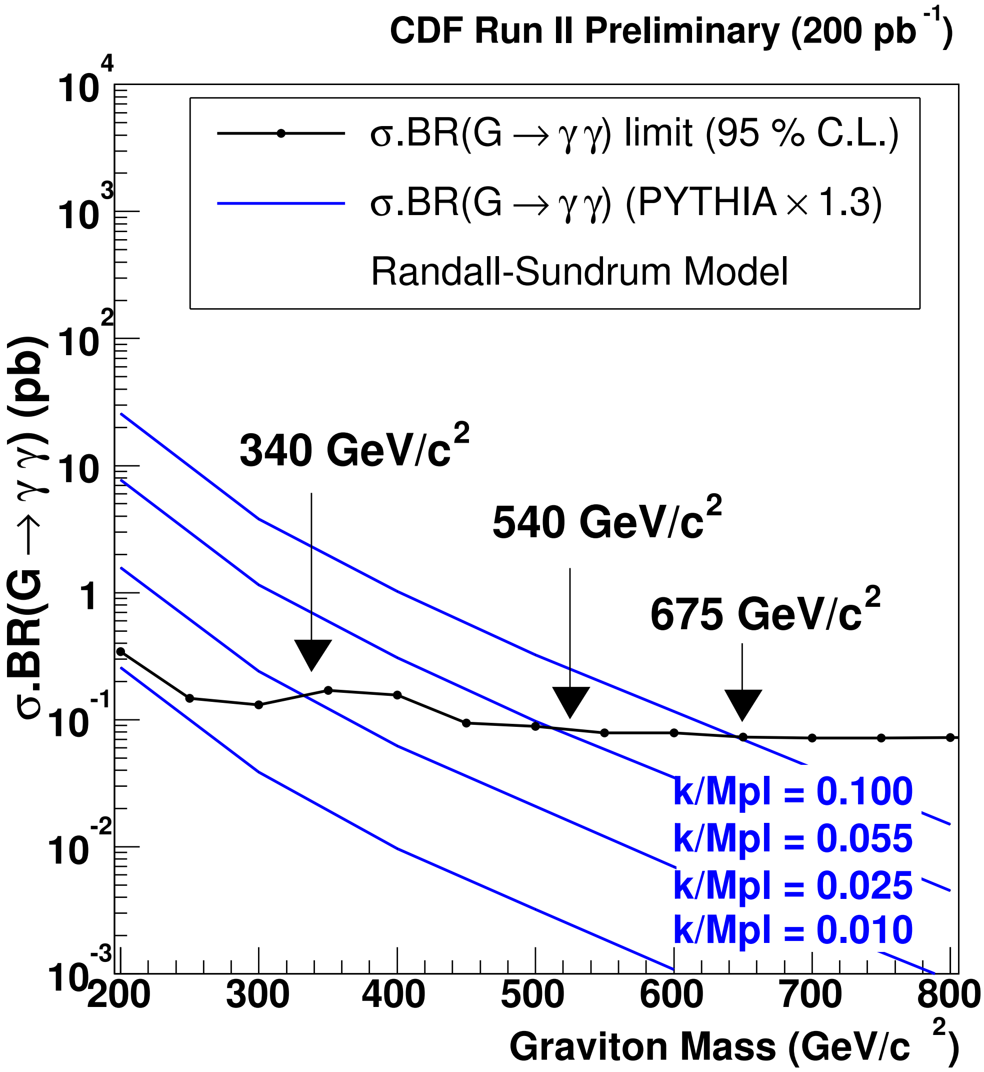
$$\sigma_{95\%} \cdot B(G \to \gamma\gamma) = \frac{N_{95\%}}{\mathcal{L} \times \epsilon \times A(M)} \tag{1}$$

(brackets) show limit using zero background estimate

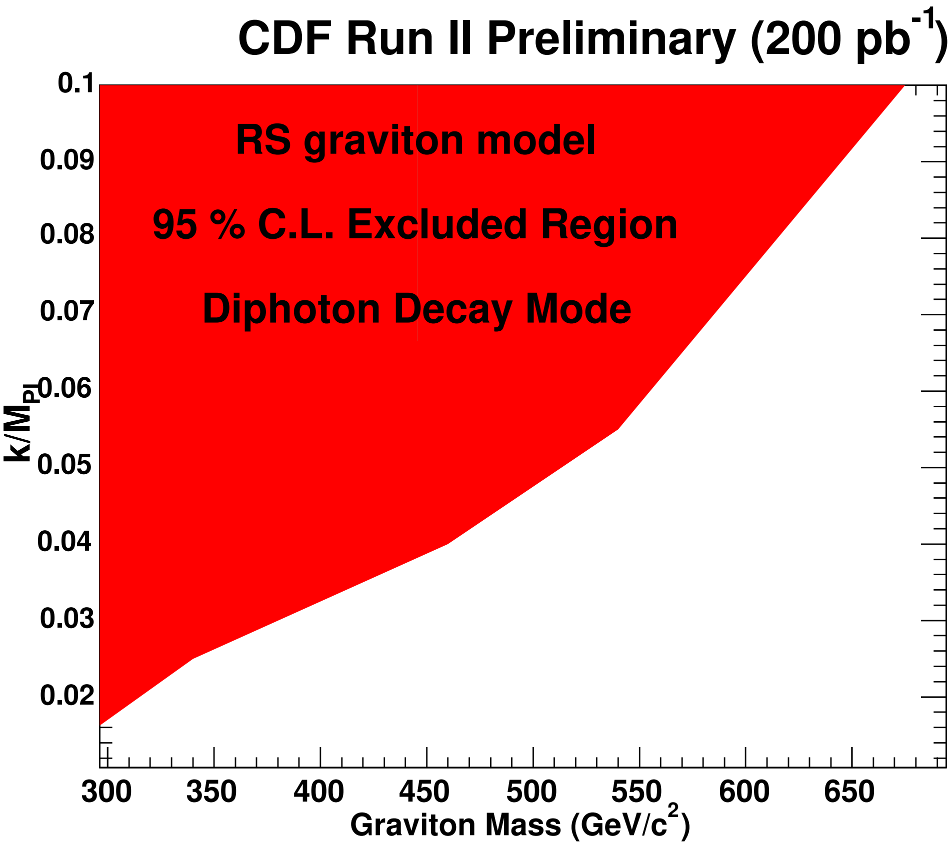
CDF Run II Preliminary (202 pb^{-1})

M_G	$3\times\sigma_{M_G}$	N_{bkdg}	N_{data}	$N_{95\%}$	A*ϵ	$\sigma_{95\%}$
GeV/c^2		Diphotons				pb
200	218-184	4.1 $\pm$ 0.5	4	6.9 (10.3)	0.09 $\pm$ 0.02	0.36 (0.55)
250	272-232	2.1 $\pm$ 0.4	0	3.2	0.11 $\pm$ 0.02	0.15
300	328-278	1.7 $\pm$ 0.4	0	3.2	0.12 $\pm$ 0.02	0.13
350	382-324	0.6 $\pm$ 0.2	1	4.6 (5.0)	0.13 $\pm$ 0.02	0.17 (0.19)
400	434-370	0.4 $\pm$ 0.1	1	4.7 (5.1)	0.15 $\pm$ 0.02	0.16 (0.17)
450	490-416	0.3 $\pm$ 0.1	0	3.2	0.17 $\pm$ 0.02	0.09
500	544-460	0.2 $\pm$ 0.1	0	3.2	0.18 $\pm$ 0.03	0.09
550	598-506	0.16 $\pm$ 0.09	0	3.2	0.20 $\pm$ 0.03	0.08
600	652-552	0.14 $\pm$ 0.07	0	3.2	0.20 $\pm$ 0.03	0.08
650	704-596	0.07 $\pm$ 0.06	0	3.2	0.22 $\pm$ 0.03	0.07
700	758-642	0.01 $\pm$ 0.04	0	3.2	0.22 $\pm$ 0.03	0.07
750	812-684	0.02 $\pm$ 0.03	0	3.2	0.22 $\pm$ 0.03	0.07
800	864-732	0.02 $\pm$ 0.03	0	3.2	0.22 $\pm$ 0.03	0.07
850	916-776	0.02 $\pm$ 0.02	0	3.2	0.23 $\pm$ 0.03	0.07
900	968-820	0.02 $\pm$ 0.02	0	3.2	0.23 $\pm$ 0.03	0.07

Limits including Background



Exclusion Plane including Background



CDF Run II Preliminary (202 pb^{-1})

0 k/M_{Pl}	0 95 % C.L.M$_{95\%}$ 0GeV/c^2
0.1	675
0.055	540
0.025	340

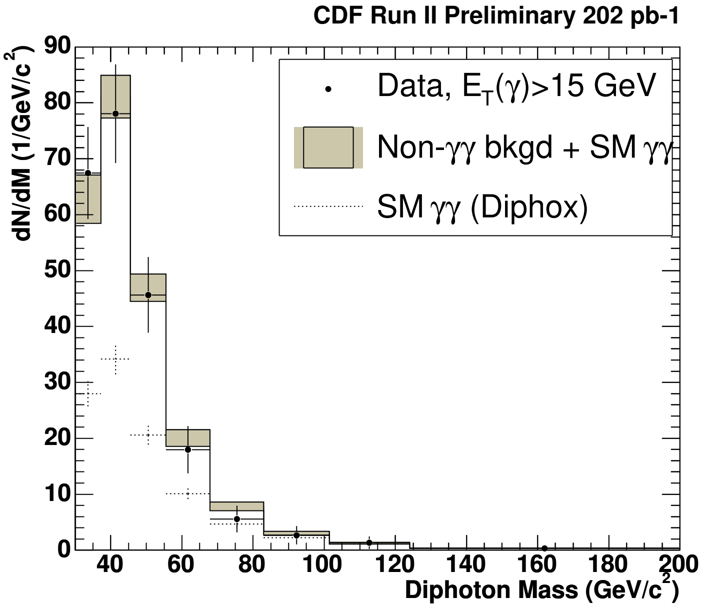
Future Plans

- Hope to present the results next week at SUSY 04!
- and then continue developing the analysis for the future...

Comparison of Expected/Observed Number of Events

Sideband shapes are normalised such that in the range from 30 to 100 GeV
$\int_{30}^{100} N_{data} = \int_{30}^{100} N_{diphox-202pb-1} + \int_{30}^{100} N_{sideband}$

Non-$\gamma\gamma$ bkdg from sidebands (average from sideband cuts and variation from variation of the sidebands per bin)



Non-SM Diphoton Background

M_G	Signal Region	SB	+2ndCES	+Track	+Caliso Tight	+Caliso Loose	Background Estimate
200	184-218	0.34	0.36	0.33	0.47	0.23	$0.34\ ^{+0.14}_{-0.11}$
250	232-272	0.14	0.14	0.13	0.19	0.092	$0.14\ ^{+0.055}_{-0.044}$
300	278-328	0.067	0.071	0.066	0.094	0.045	$0.067\ ^{+0.027}_{-0.022}$
350	324-382	0.033	0.035	0.032	0.046	0.022	$0.033\ ^{+0.013}_{-0.011}$
400	370-434	0.016	0.017	0.015	0.022	0.011	$0.016\ ^{+0.0063}_{-0.0051}$
450	416-490	0.0074	0.0079	0.0073	0.01	0.005	$0.0074\ ^{+0.003}_{-0.0024}$
500	460-544	0.0035	0.0037	0.0034	0.0049	0.0024	$0.0035\ ^{+0.0014}_{-0.0011}$
550	506-598	0.0015	0.0016	0.0015	0.0021	0.001	$0.0015\ ^{+0.00061}_{-0.00049}$
600	552-652	0.00063	0.00067	0.00062	0.00089	0.00043	$0.00063\ ^{+0.00025}_{-0.0002}$
650	596-704	0.00027	0.00028	0.00026	0.00037	0.00018	$0.00027\ ^{+0.00011}_{-8.6e-05}$
700	642-758	0.00011	0.00011	0.0001	0.00015	7.2e-05	$0.00011\ ^{+4.3e-05}_{-3.4e-05}$
750	684-812	4.5e-05	4.8e-05	4.4e-05	6.3e-05	3.1e-05	$4.5e{-}05\ ^{+1.8e-05}_{-1.5e-05}$
800	732-864	1.6e-05	1.7e-05	1.6e-05	2.3e-05	1.1e-05	$1.6e{-}05\ ^{+6.6e-06}_{-5.3e-06}$
850	776-916	6.4e-06	6.8e-06	6.3e-06	9e-06	4.3e-06	$6.4e{-}06\ ^{+2.6e-06}_{-2.1e-06}$
900	820-968	2.5e-06	2.6e-06	2.4e-06	3.5e-06	1.7e-06	$2.5e{-}06\ ^{+1e-06}_{-8e-07}$

Other Backgrounds

Diphoton backgrounds from other Standard Model processes are expected to be small.
Drell-Yan $\rightarrow ee$ can give $\gamma\gamma$ from radiation.

Generated 87000 events with $M_{\gamma\gamma}$>120 GeV/c^2,
using Pythia 6.203 and version 4.9.1 of the offline code.
2 events were observed with $M_{\gamma\gamma}$<50.
$\sigma(DY \rightarrow ee)$ ($M_{\gamma\gamma}$>120 GeV/c^2) = 2.2 pb
corresponds to a luminosity of 39545 pb^{-1}
So expect in datasample of 202 pb^{-1} : (202/39545)*2 = 0.010 events.
And these had $M_{\gamma\gamma}$<50 GeV/c^2

Also generated 59831 DY $\rightarrow ee$ events with $M_{\gamma\gamma}$>300 GeV/c^2
$\sigma(DY \rightarrow ee)$ ($M_{\gamma\gamma}$>300 GeV/c^2) = 0.59 pb
corresponds to a luminosity of 101408 pb^{-1}
Observed 7: 2 with $M_{\gamma\gamma}$>200 GeV/c^2: at 270 GeV/c^2 and 300 GeV/c^2
So expect in datasample of 202 pb^{-1} : (202/101408)*2 = 0.004 events with $M_{\gamma\gamma}$>200 GeV/c^2

Conclude that these backgrounds are negligible compared to the SM background and the non-SM diphoton background

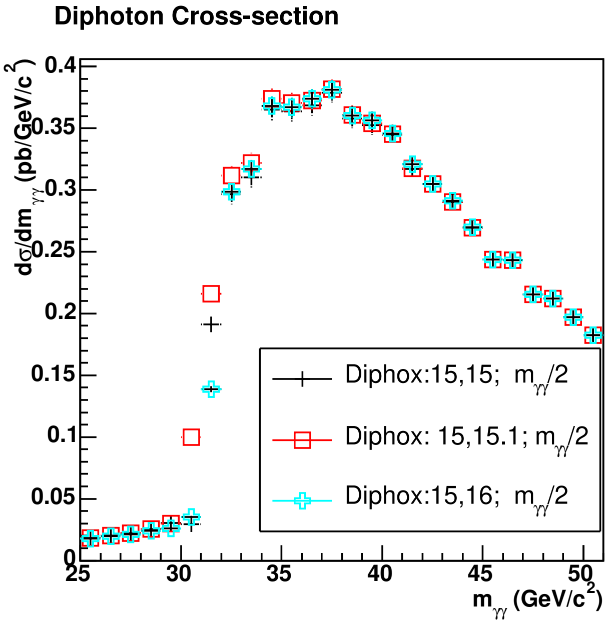


Figure 1: Normalised Standard Model diphoton cross-section as a function of diphoton invariant mass from Diphox (NLO) for different E_t cuts on the photons. The cross-sections have cuts $|\eta_\gamma|<0.9$ applied to both photons.

Diphox Et cuts

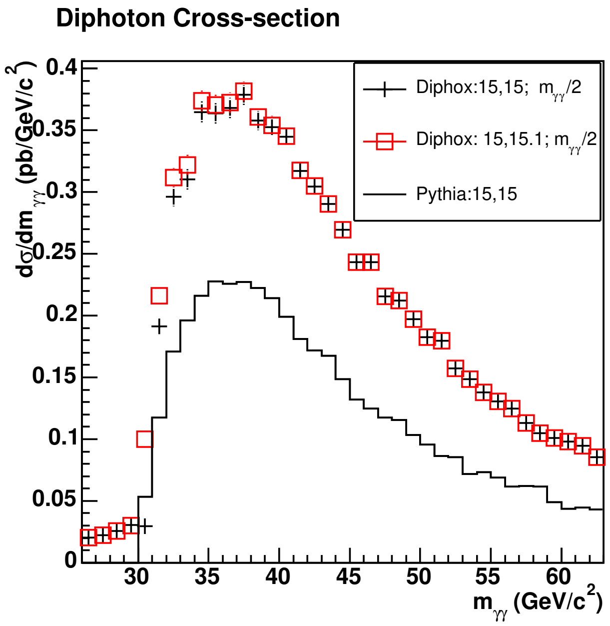


Figure 2: Comparison of Normalised Standard Model diphoton cross-section as a function of diphoton invariant mass from Diphox (NLO) for different E_t cuts on the photons with Pythia (with E_t > 15 GeC/c^2 for both photons). The cross-sections have cuts $|\eta_\gamma|$<0.9 applied to both photons.

Diphox Et cuts

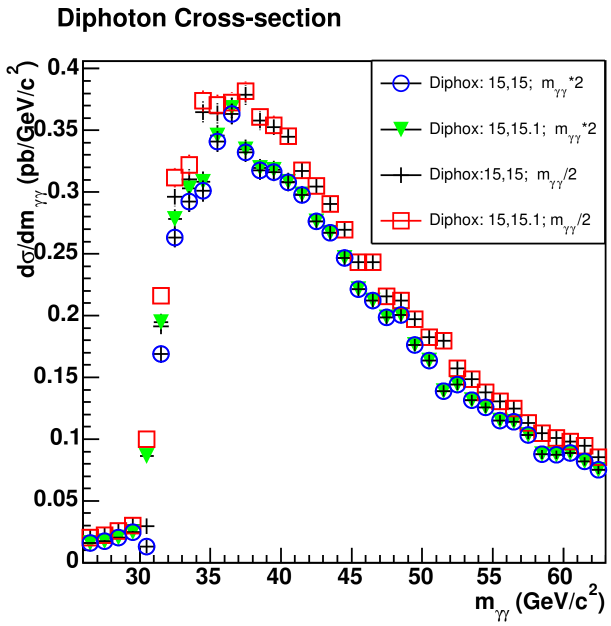
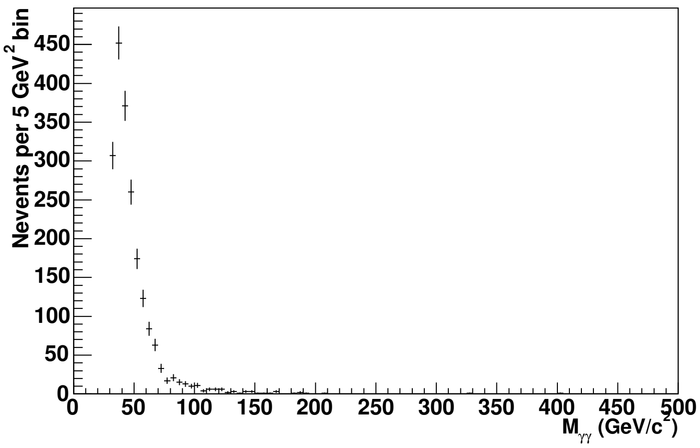
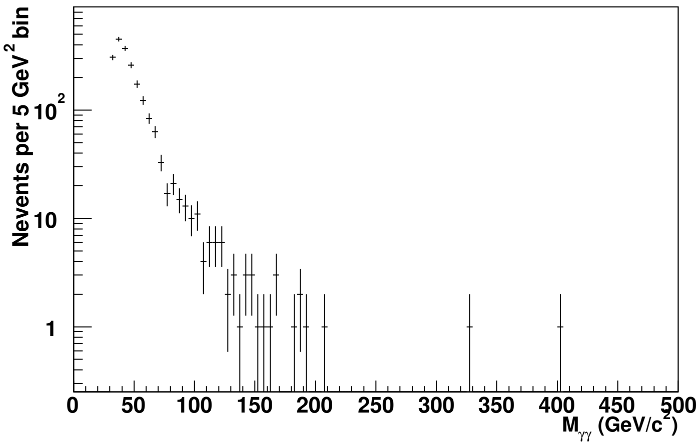


Figure 3: Normalised Standard Model diphoton cross-section as a function of diphoton invariant mass from Diphox (NLO) for different E_t cuts and renormalisation scale. The cross-sections have cuts $|\eta_\gamma|<0.9$ applied to both photons.

Signal Data Sample

After application of selection cuts and
Et > 15 GeV and $M_{\gamma\gamma}$ > 30 GeV : 2001 diphoton events





Three events above 200 GeV/c^2
run: event: 165271 : 2045232 Mass : 405 GeV/c^2 : Etc0 : 175 Etc1 : 172
run: event: 165435 : 446579 Mass : 329 GeV/c^2 : Etc0 : 170 Etc1 : 172
run: event: 166007 : 2285035 Mass : 207 GeV/c^2 : Etc0 : 110 Etc1 : 79