A Search for Randall-Sundrum Gravitons Decaying to Photon Pairs in √s = 7 TeV pp Collisions

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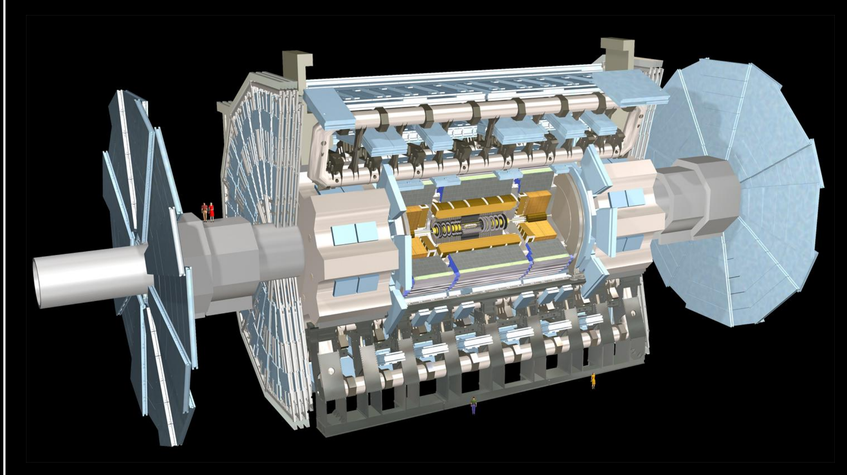
A search has been performed for evidence of a narrow resonance in the diphoton invariant mass spectrum. The analysis uses the ATLAS 2010 data set of proton-proton collisions at a center-of-mass energy of 7 TeV, produced by the CERN Large Hadron Collider, corresponding to an integrated luminosity of 36 pb^{-1}. No evidence of a narrow resonance above the Standard Model background is observed. The results exclude at 95% confidence level (CL) Randall-Sundrum graviton masses below 545 GeV (920 GeV), for values of the dimensionless coupling k/M_{Pl} of 0.02 (0.1).

Introduction

The difference in the Standard Model (SM) between the Planck scale and the electroweak scale is known as the hierarchy problem. Of great interest are models which resolve the hierarchy problem through the existence of extra spatial dimensions., such as the Randall-Sundrum (RS) model, which postulates the existence of a fifth spatial dimension that has a "warped" geometry.
In the RS model, the 5-dimensional spacetime is bounded by two (3+1)-dimensional branes. The particles of the SM are localized on one brane, while gravity is localized on the other. Gravitons are the only particles that can propagate in the bulk. As a result, a series of massive spin-2 graviton excitations (KK tower), is predicted. The degrees of freedom of the RS model can be expressed in terms of universal dimensionless coupling k/M_{Pl} to the SM fields and the mass M_G of the lightest KK graviton excitation.
A striking signature of the RS model at hadron colliders would be graviton production , followed by their decay to pairs of SM fermions or bosons. The diphoton channel is of particular interest due to higher cross section with respect to dilepton channels (factor of two) and relative low expected experimental background.
Described here is the analysis of the $G \rightarrow \gamma\gamma$ final state using 36 pb^{-1} of data recorded by ATLAS in 2010.

ATLAS Detector



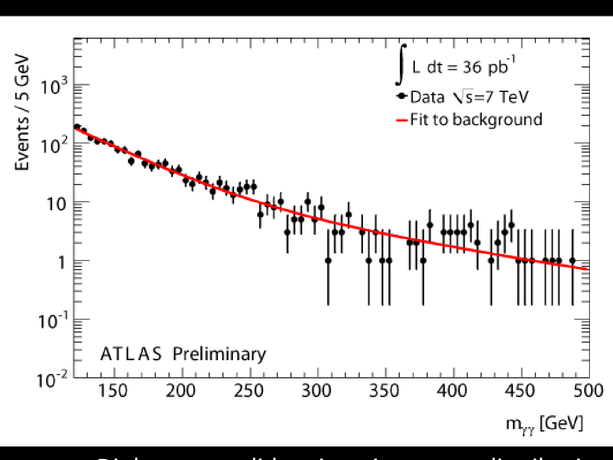
Size 44 x 22 m
Weight 7000 t.
~10^8 electronic channels
2T solenoid field
3 level trigger system

2010 data taking efficiency > 92%

Data Sample & Event Selection

The analysis uses the dataset collected in 2010 with the ATLAS detector at the LHC during stable beam periods of pp collisions at a center-of-mass energy of $\sqrt{s}$ = 7 TeV.

Selection cuts	
Trigger	2 clusters, E_T >15 GeV
Primary Vertex	One vertex with at least three tracks
Kinematical	2 γ , E_T >25 GeV $\|\eta\|$<2.37 (removing the region 1.37 <$\|\eta\|$<1.52)
Photon Quality	Shower shape on the 2nd sampling of the EM calo + hadronic leakage
# Events after all selection cuts	8090 (1650 m > 120 GeV)

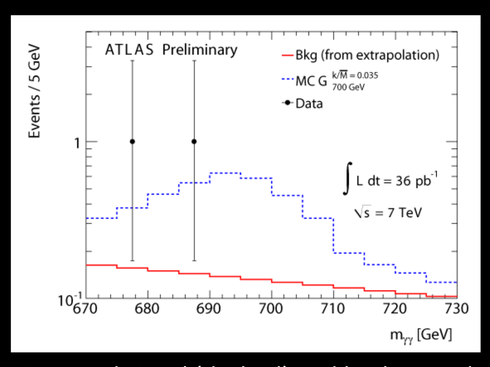


Diphoton candidate invariant mass distribution measured in the control region of 120 - 500 GeV. Superimposed is the result of a fit to the data of the background parameterization of the sum of two exponential functions.

Background Description

The main backgrounds include the irreducible background from SM diphoton production, and reducible backgrounds from QCD + jet and multijet events with at least one fake photon.
The inclusive shape of the diphoton invariant mass distribution of the background is determined from a fit to a control region of masses 120-500 GeV (sum of two exponentials).
P-value of the fit from χ^2-test = 94%

Analysis Method



Expected signal (dashed) and background (solid), and observed (points) distributions in a mass window +/- 30 GeV around the resonance mass. The uncertainty on the signal and background is not shown in this illustration. The MC signal represents a 700 GeV graviton with k/MPl = 0.035 and is normalized to the number of expected signal events for these parameter values.

To search for evidence of a resonance signal for a given graviton mass and coupling k/M_{Pl}, the observed invariant mass distribution within a window around the test mass was compared with histograms of the expected signal and background templates. The background prediction was determined by extrapolating the background fit function, with the parameters fixed to the values determined in the fit to the control region, into the search region of higher diphoton masses. The signal templates were determined from the signal MC samples.

Systematics

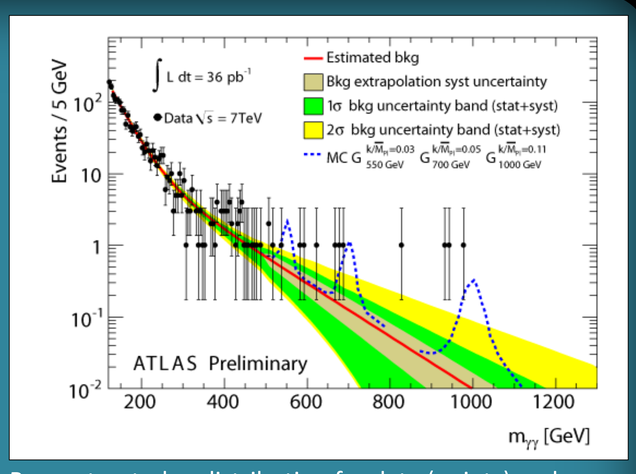
Source	Uncertainty (%)
Luminosity	3.4
Photon efficiency and ID	3.8
Pile-up	3.6
Photon energy resolution	Shape
Photon energy scale	Shape

List of main systematic uncertainties attributed to signal.

In addition, the signal cross section is affected by the choice of the PDF used in Pythia which varies from 5.2 to 9.2% for masses between 500 to 1250 GeV. Factorization and renormalization scales systematic uncertainties were estimated to be at most 6%.

Results (i)

Data was found to be consistent with background description over the whole mass range of study , and there is no evidence of a narrow resonance.
Therefore limits on graviton production were set following the the CLs method (CLs+b/CLb) . A log-likelihood ratio was used as the test statistic to extract the p-values.

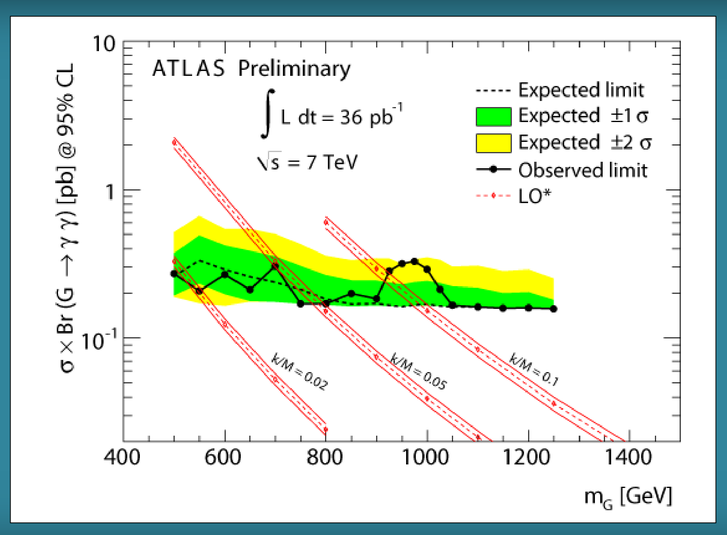


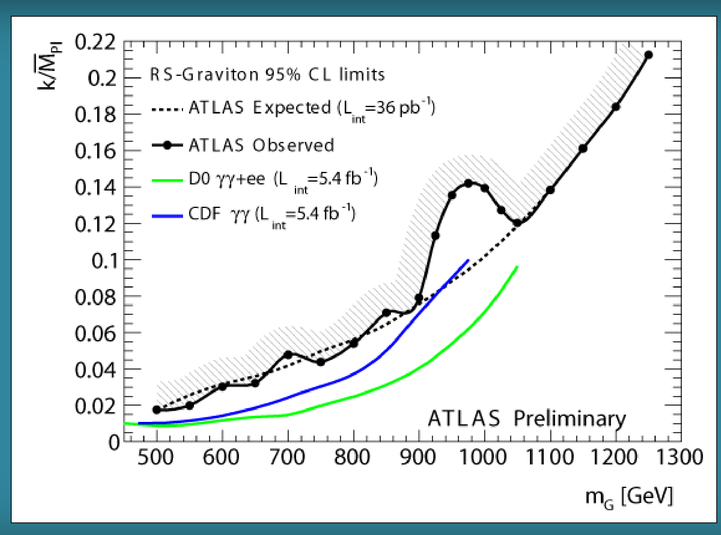
Reconstructed m distribution for data (points) and expected background (red line). Also shown are graviton signals of masses 550, 700 and 1000 GeV and couplings k/M_{Pl}= 0.03, 0.05 and 0.11, respectively. The signal is normalized to the number of expected events in an integrated luminosity of 36 pb^{-1}.

Results(ii)

(left)The 95% CL on the production cross section times branching ratio of an RS model graviton decaying into two photons (σ× Br(G→γγ) as a function of the graviton mass. Superimposed are the theoretical cross section prediction bands for a variety of k/M_{Pl} values.

(right) 95% CL excluded region in the plane of k/MPl versus graviton mass. Also shown are the expected limit and published limits from the Tevatron experiments





Summary

No evidence of a narrow resonance decaying into a pair of photons above the continuum background is observed. The results are used to set limits on the production of Randall-Sundrum gravitons decaying into diphoton final states. The results exclude at 95% CL RS graviton masses below 545 (920) GeV for the dimensionless RS coupling *k/MPl = 0.02 (0.1).*