Search for Randall-Sundrum Gravitons at the LHC: Recent Results from ATLAS

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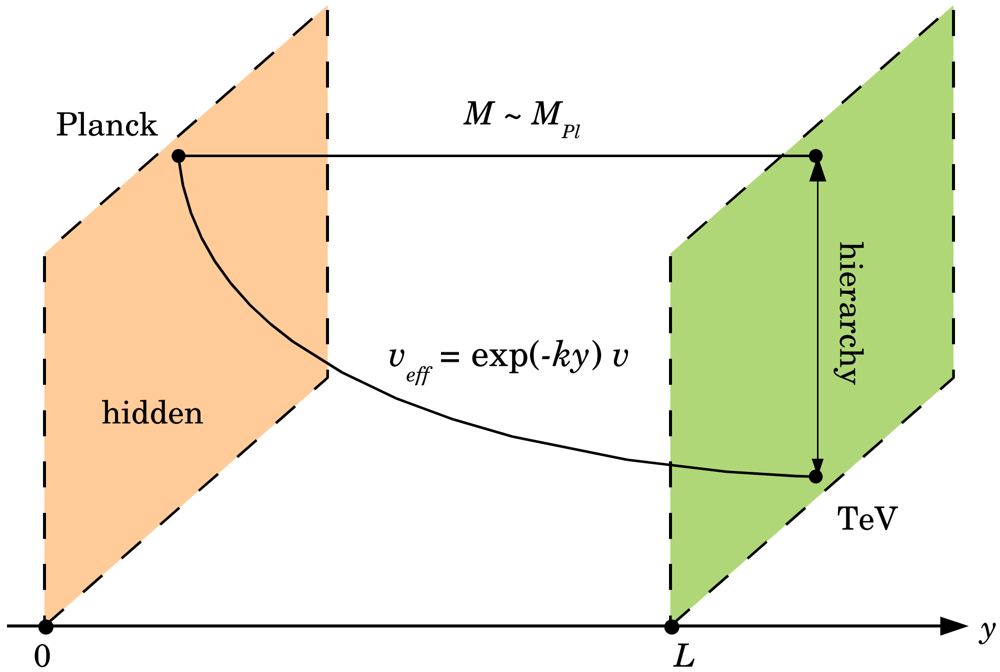
Randall-Sundrum Model

- In the Randall-Sundrum model gravity propagates in a warped extra dimension with two fixed points
- The Standard Model fields are constrained to one brane
- The gravity wave function is concentrated near the other brane, falling off exponentially across the extra dimension

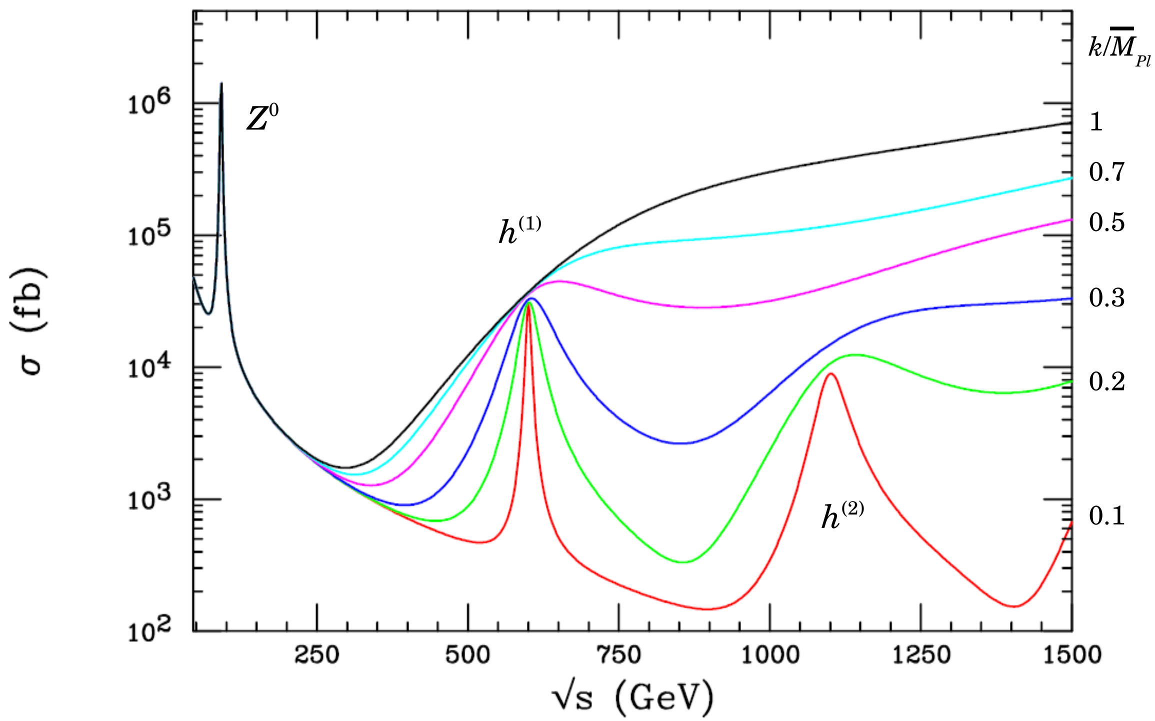


$$ds^2 = e^{-2k|y|}\eta_{\mu\nu}dx^\mu dx^\nu + dy^2$$

Randall-Sundrum Gravitons

arXiv:hep-ph/9909255v1

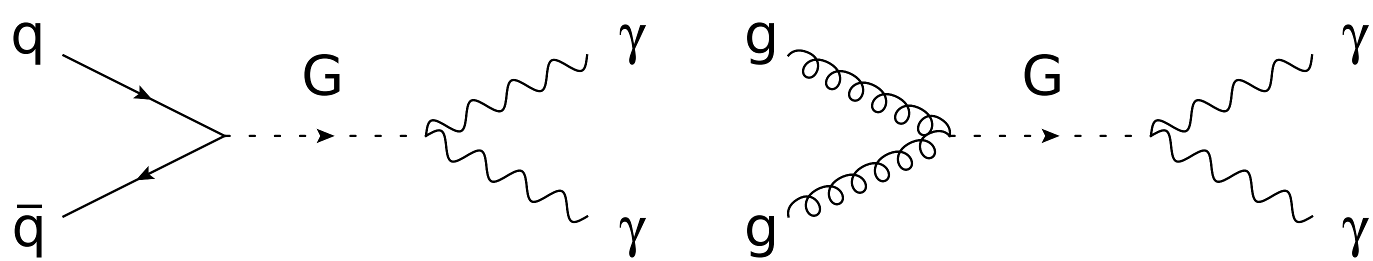
- The model predicts a tower of Kaluza-Klein graviton states with TeV scale masses
- A range of couplings between these gravitons and SM particles are possible:



  - values of $k/\overline{M}_{pl}$ between 0.01 and 0.1 are favored

- The values of the mass of the lowest KK excitation and the coupling fully specify the model

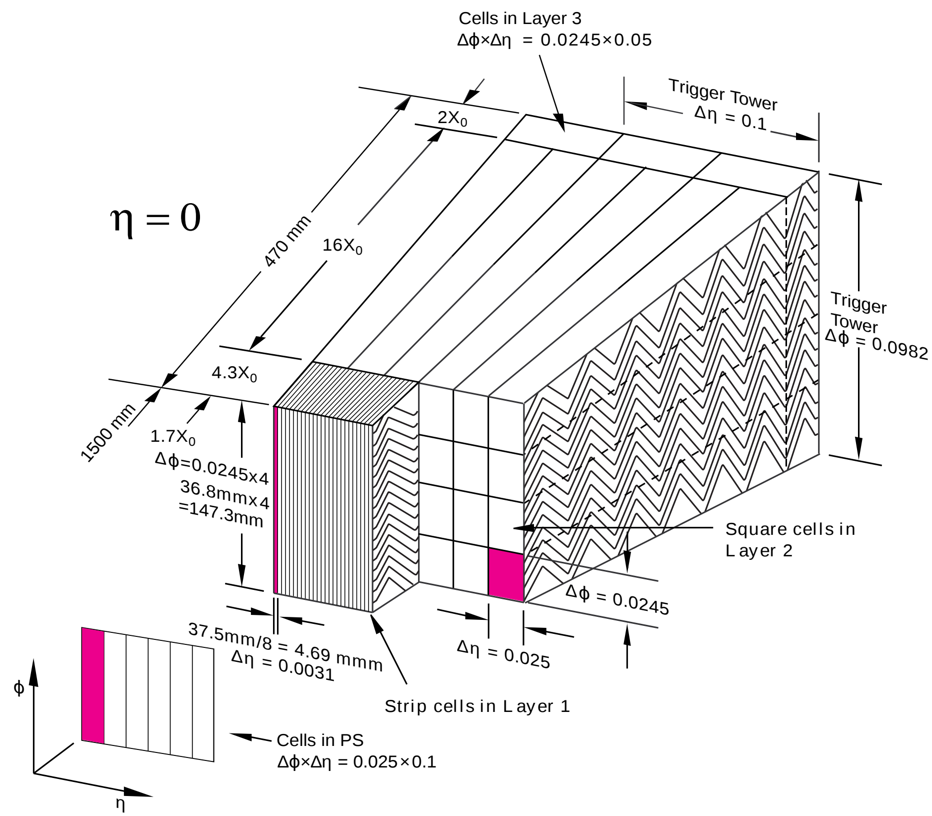
$G \rightarrow \gamma\gamma$



- EM objects offer a clean experimental signature with excellent mass resolution
- RS gravitons have twice the branching ratio to decay to photons as to electrons
- In the diphoton channel, there is less background because the Drell-Yan process ($Z/\gamma^* \rightarrow ll$), which dominates in the dilepton channel, is not present

Identifying Photons

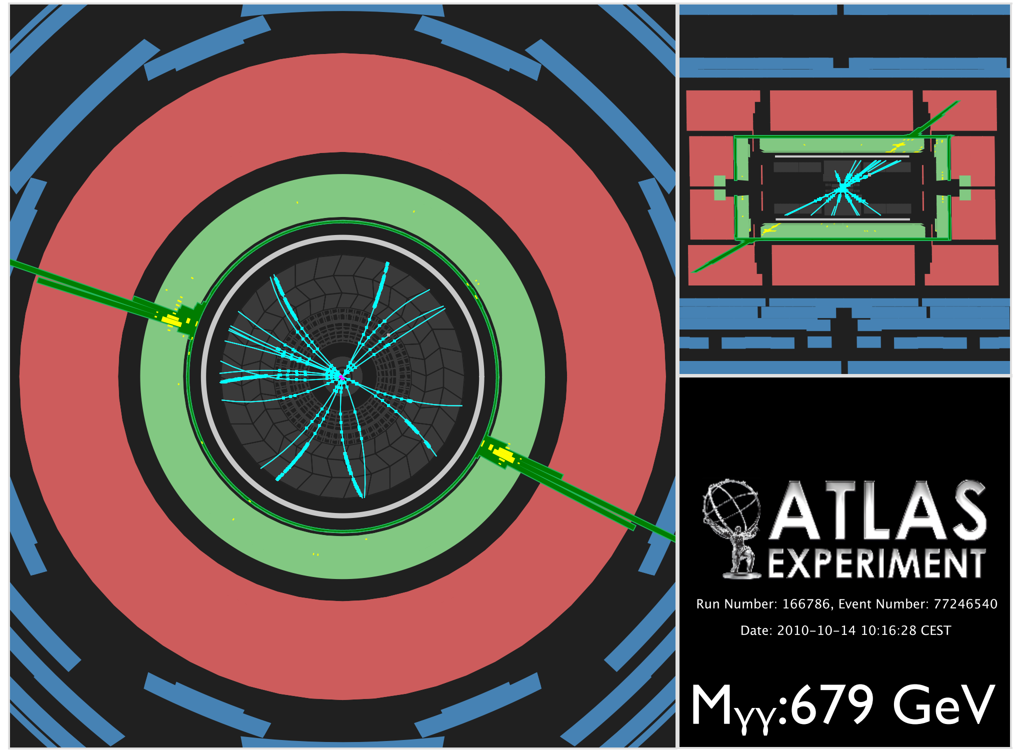
- The ATLAS detector has a finely segmented electromagnetic calorimeter which allows for good separation between real photons and hadrons, such as π^0s
- For eta < 2.5, the EM calorimeter is segmented into three layers:



- The middle layer provides the bulk of the energy resolution and provides loose discrimination based on shower width
- The front layer is more finely segmented, providing tighter rejection of hadrons

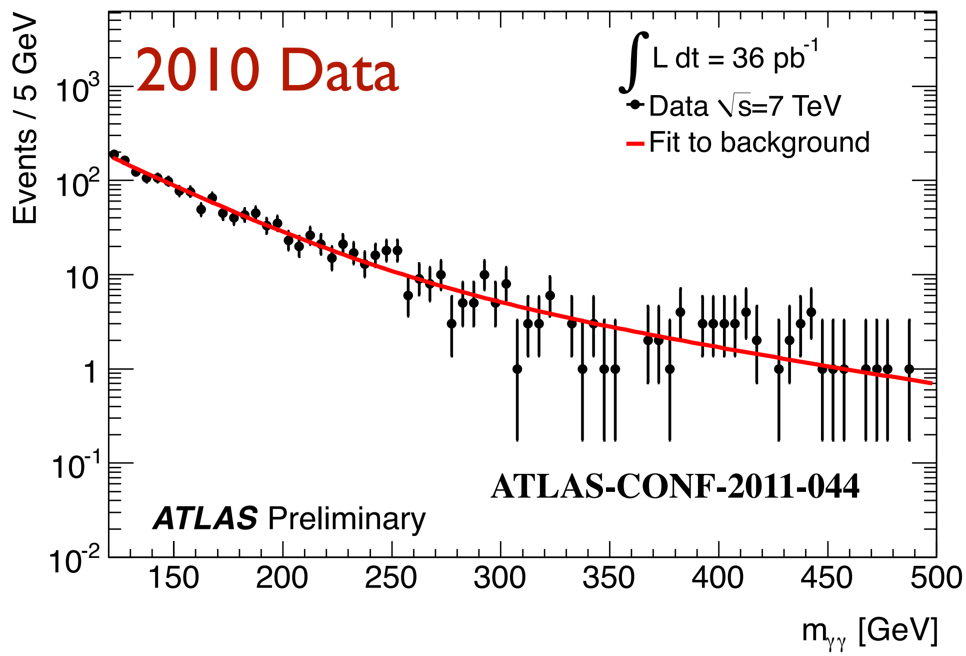
2010 G → γγ Search

- 36 /pb of data were examined
- Photons with more than 20 GeV of transverse energy were selected



- They were additionally required to pass loose selection of cuts to reduce the background from hadronic fakes, including narrowness in the middle layer of the calorimeter and low hadronic leakage

Background Estimation

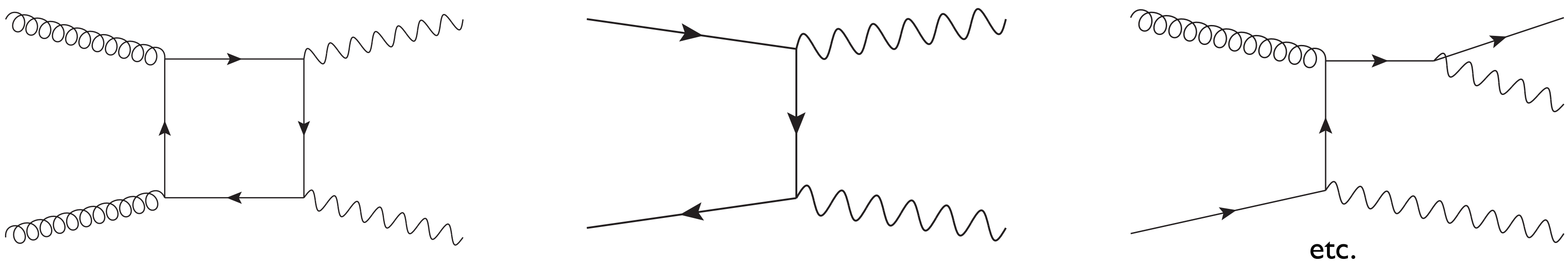


- In the 2010 analysis, the background was simply modeled using two exponentials fit to a control region with $M_{\gamma\gamma}$ between 120 and 500 GeV

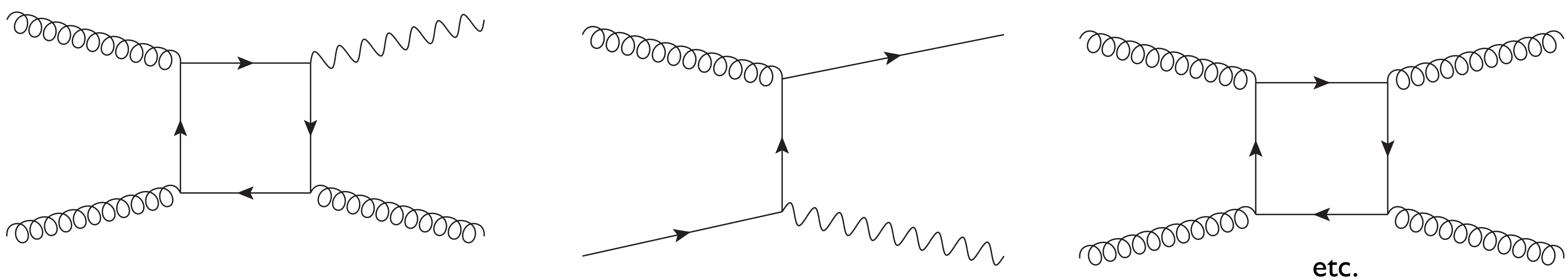
- As our understanding of the background improves we can build a more descriptive background model

Background Decomposition

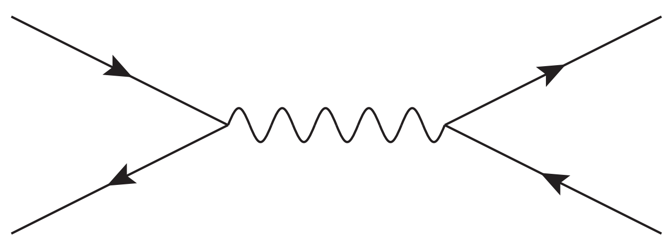
- Standard Model Diphoton:



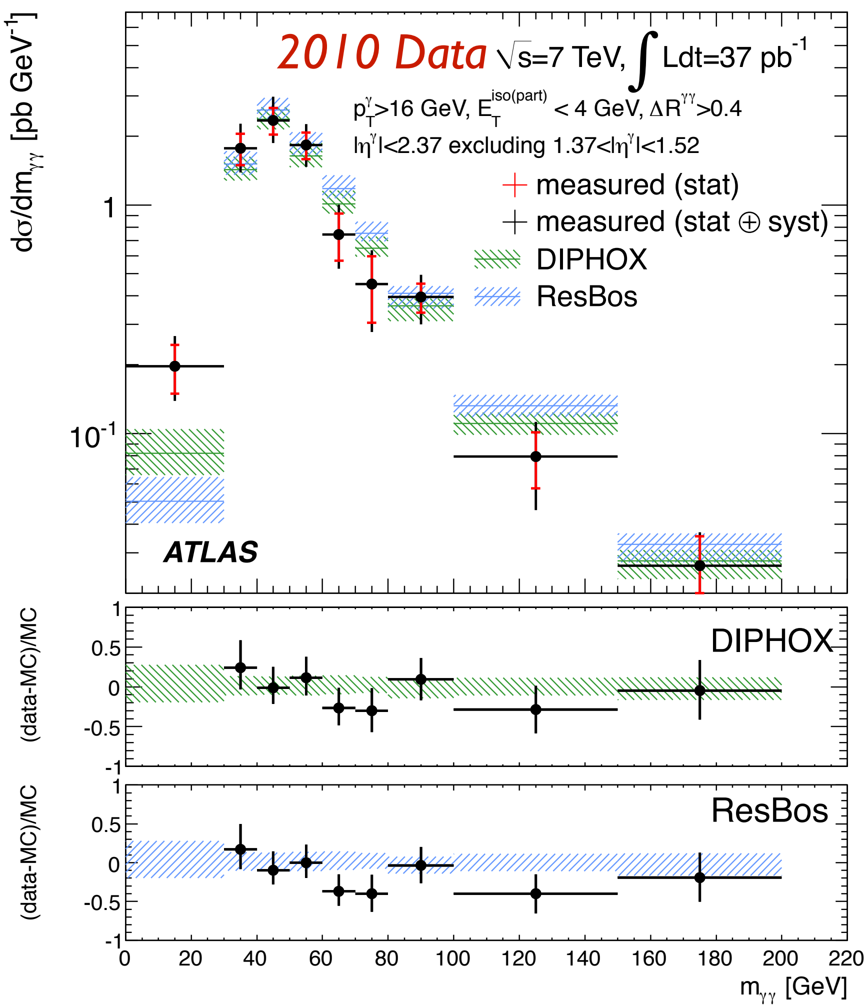
- Gamma-Jet and Dijet: (with hadrons faking photons)



- Drell-Yan: (with electrons faking photons)



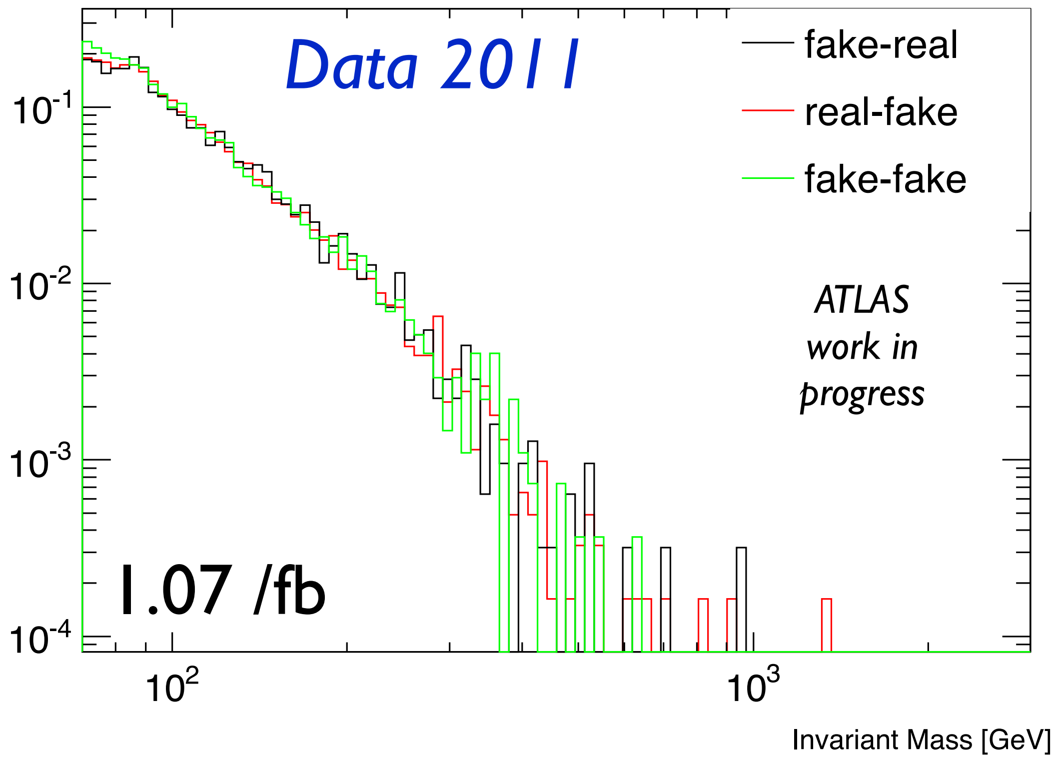
Standard Model Diphoton Production



arXiv:1107.0581v1

The NLO program DIPHOX shows excellent agreement with a measurement of the (unfolded) diphoton mass spectrum

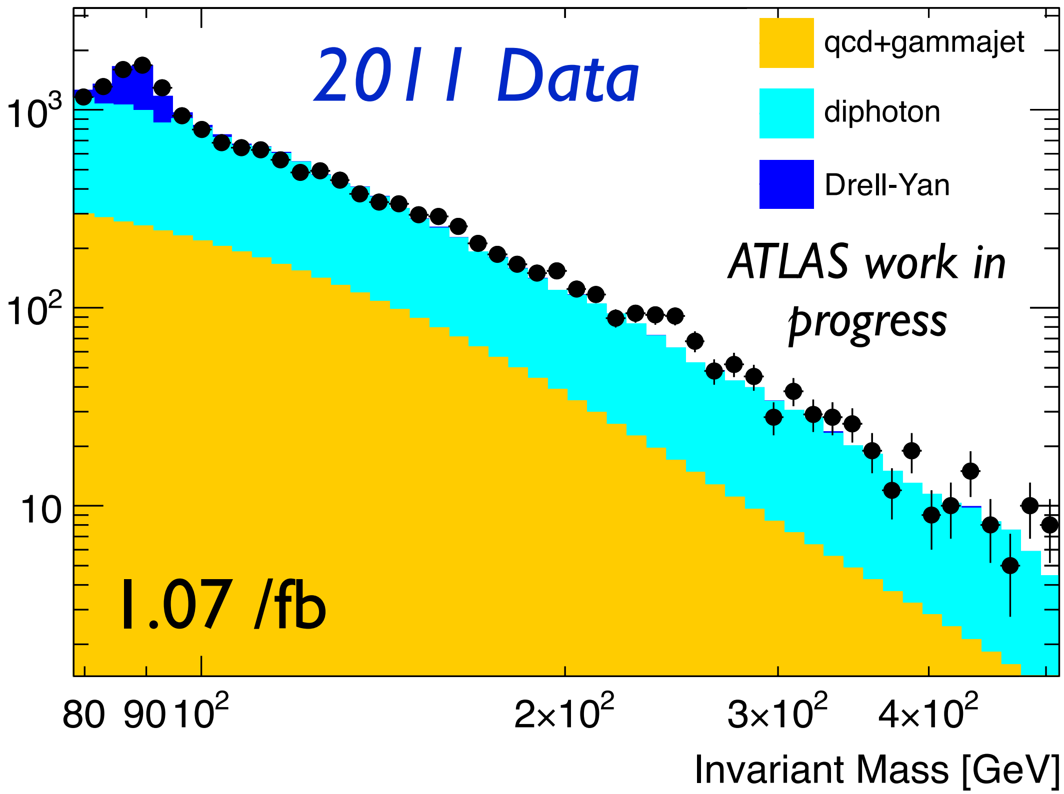
Gamma-Jet / Jet-Jet



Various control samples in data show us that the mass shapes of gamma-jet and jet-jet are quite similar

2011 Data: Control Region

Fitting the Drell-Yan and gamma-jet contributions



Tighter shower shape cuts and calo isolation < 5 GeV

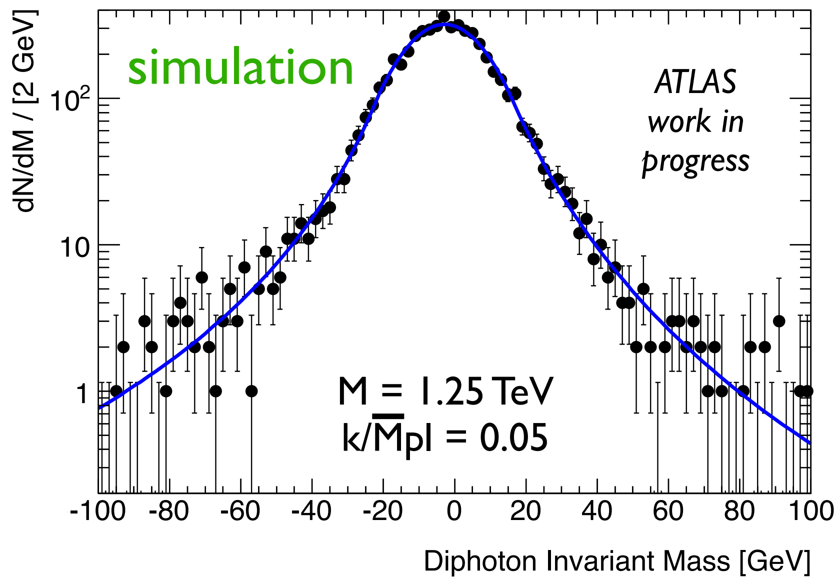
- SM Diphoton: DIPHOX
- qcd+gammajet: data driven
- Drell-Yan: MC

- The SM Diphoton contribution is fixed
- The normalizations of the QCD and DY are allowed to float

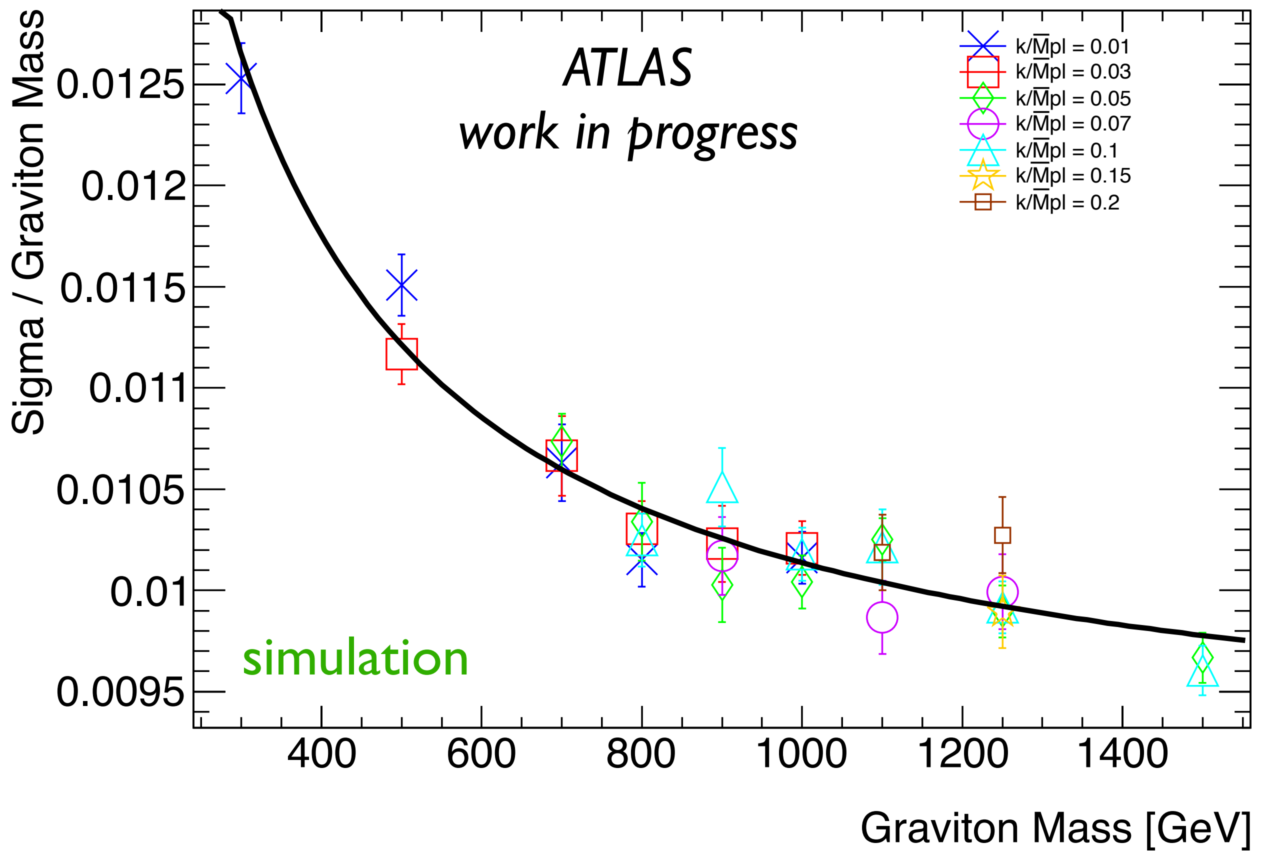
Signal Parameterization

- To cover a wider range of potential signal points, we fit the MC to parameterize our signal
  - To separate the effect of the intrinsic width (which is a function of the coupling) from the detector response, we fit the reconstructed minus truth mass

Double Sided Crystal Ball Function

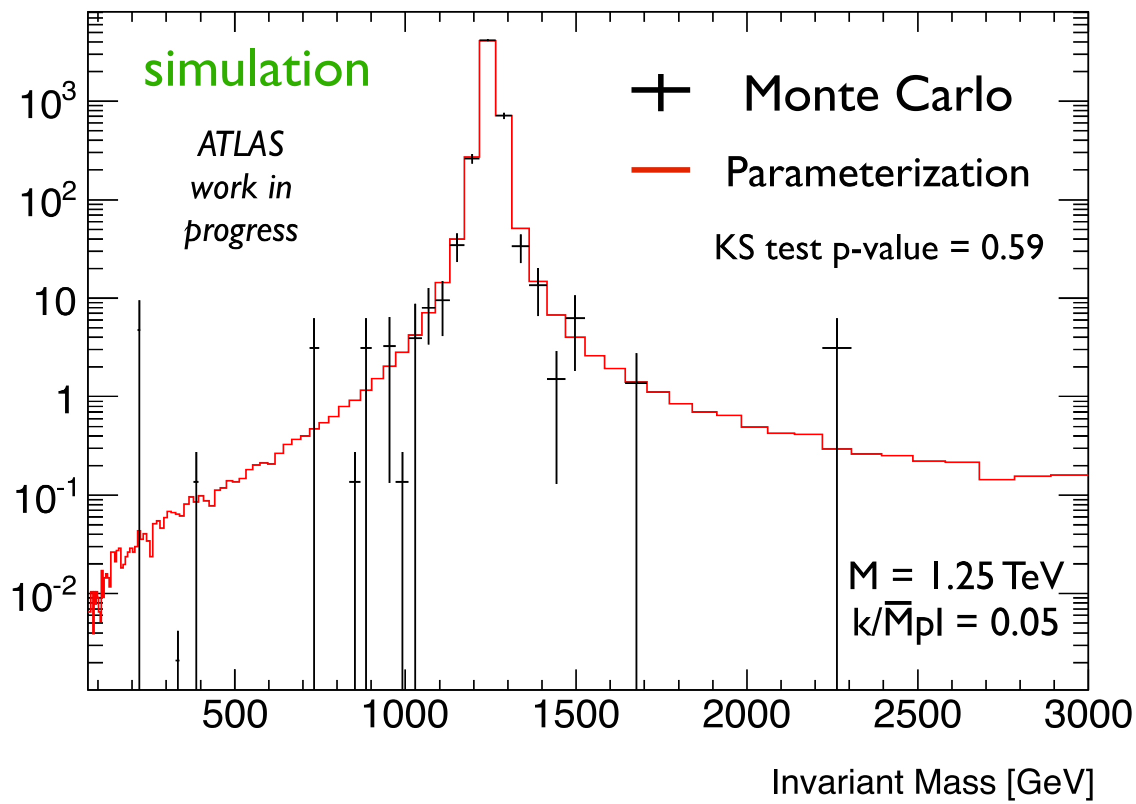


Signal Mass Resolution



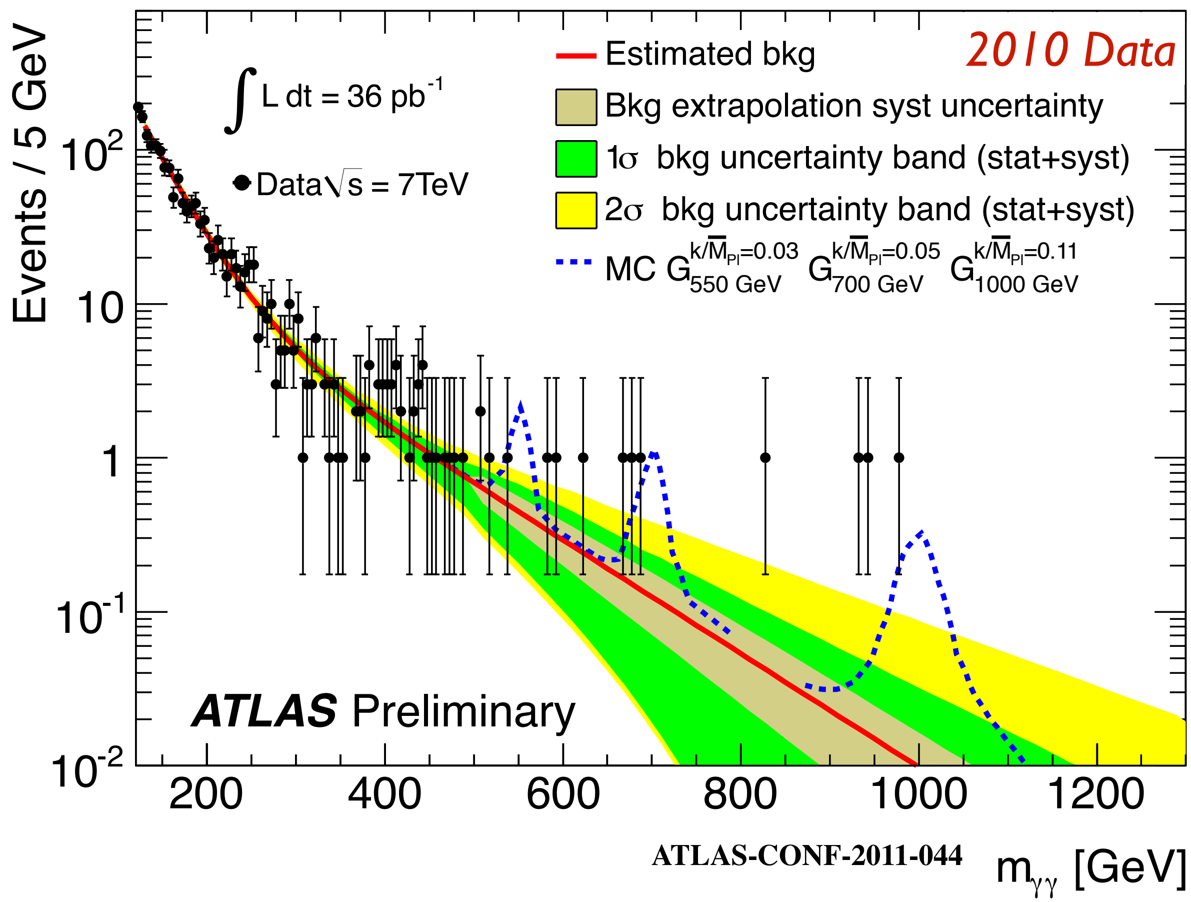
- Mass resolution is approximately 1% for high masses

Final Signal Template



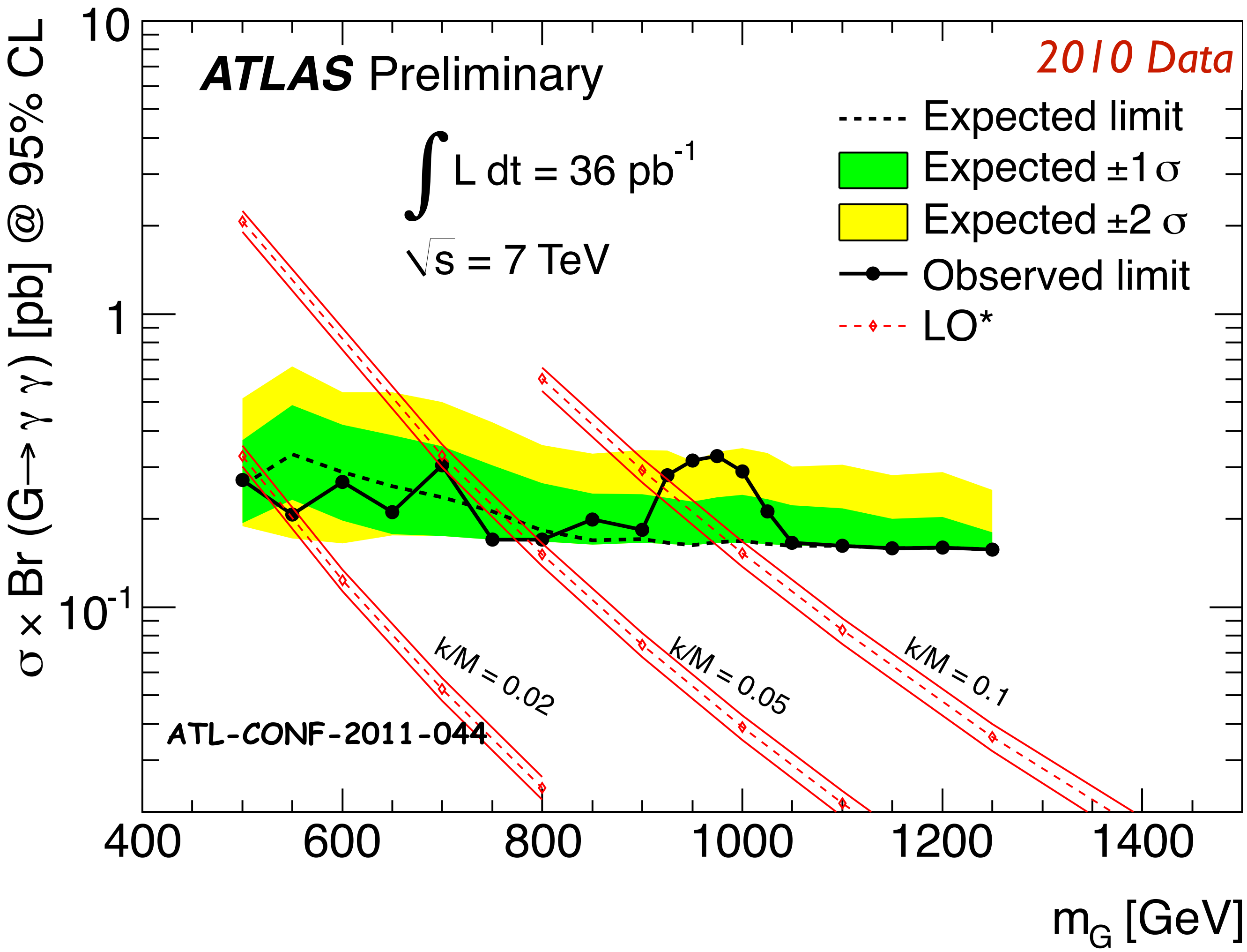
After convoluting our parameterization of the detector response with the appropriate Breit-Wigner, we get templates which are consistent with our original MC

2010 Analysis Results



ATLAS-CONF-2011-044

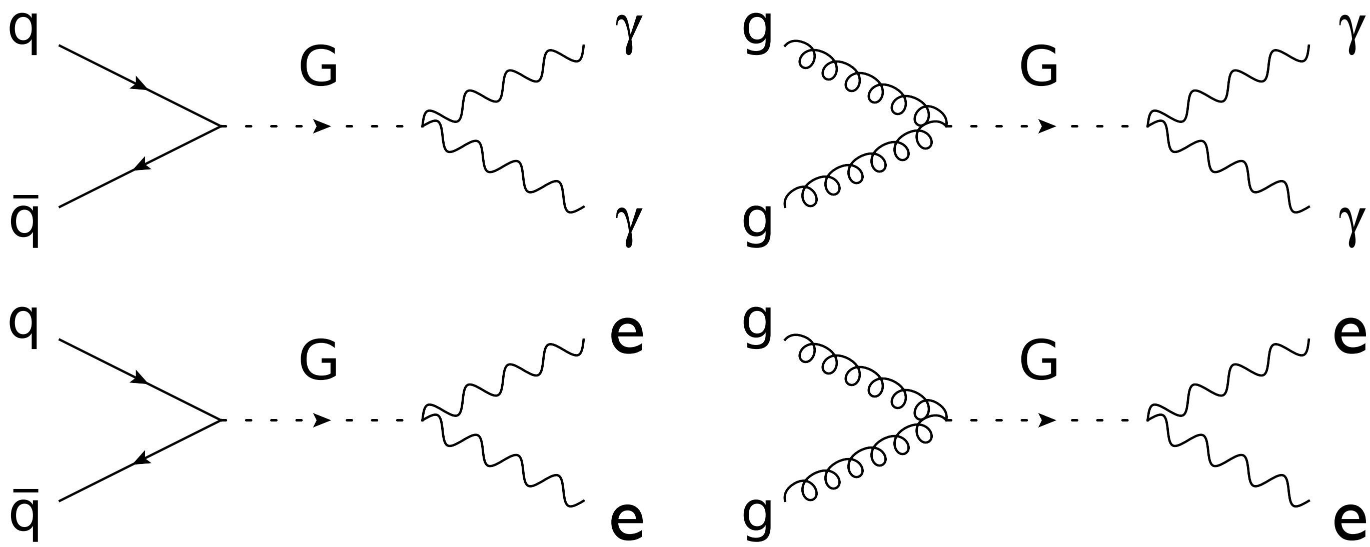
2010 Analysis Results



920 GeV graviton excluded at 95% CL for k/Mpl = 0.1

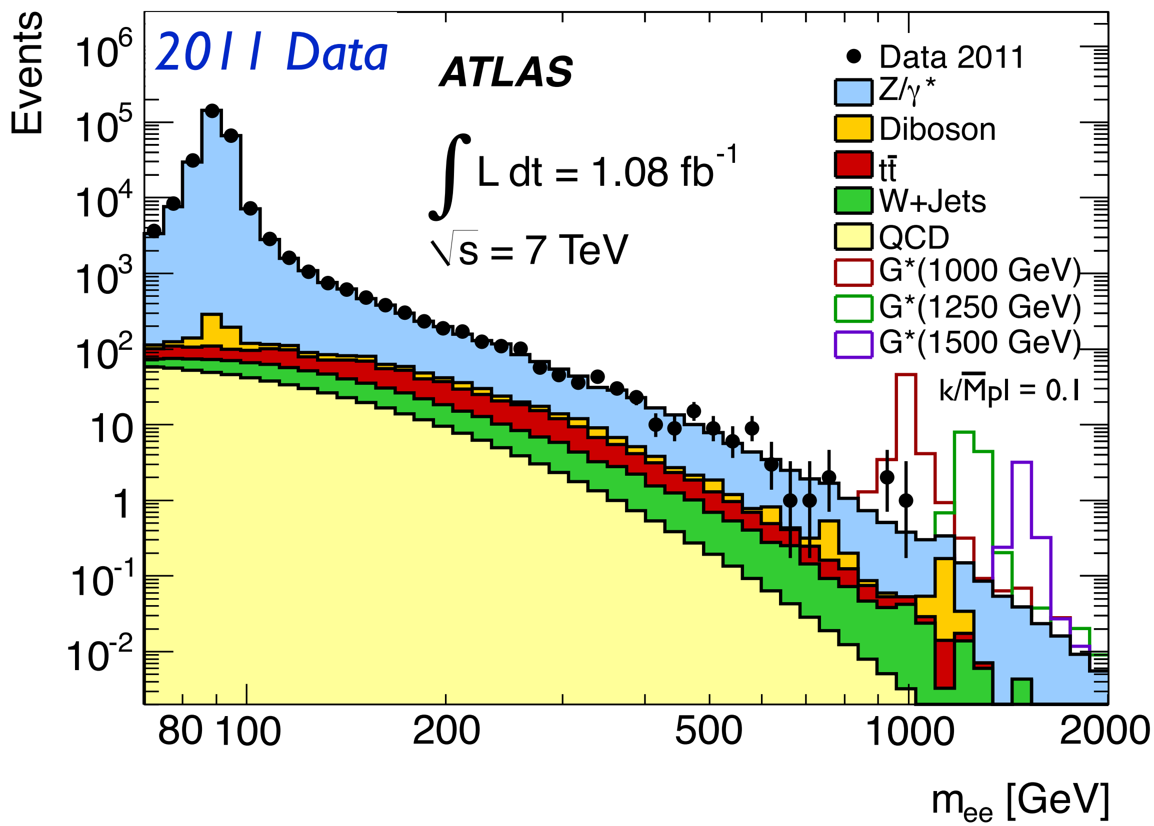
Limits from a modified frequentist approach, where CLs is defined as CLs = CLs+b/CLb with CLs+b = P(LLR ≥ LLRobs|s + b) and CLb = P(LLR ≥ LLRobs|b)

$G \rightarrow \gamma\gamma$, $G \rightarrow ee$



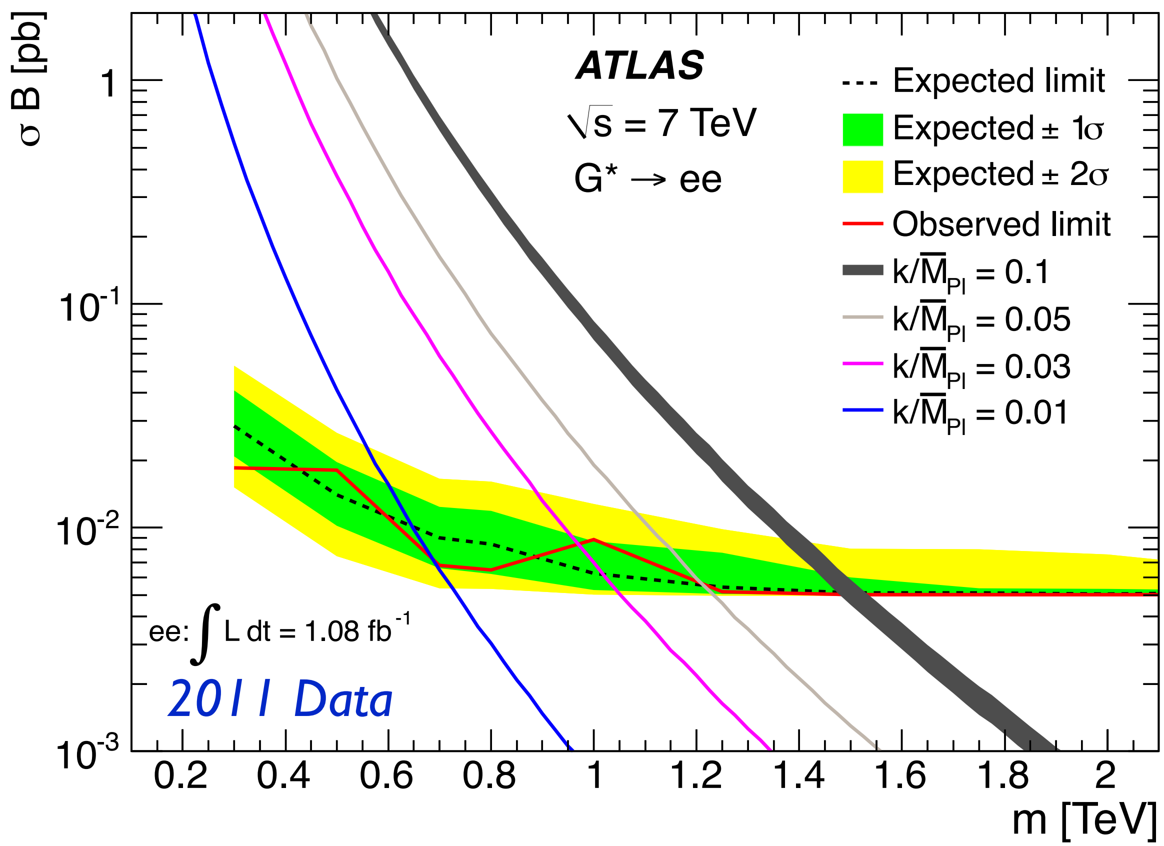
- The $G \rightarrow \gamma\gamma$ and $G \rightarrow ee$ channels are quite similar, in terms of both physics and detector response
- No 2011 photon result is ready to be shown, but the 2011 electron result is quite relevant

2011 G→ee result



- 1/fb Graviton search
- Full analysis presented by D. Olivito in the previous talk

The Power of 1.08 /fb



1.51 TeV graviton excluded at 95% CL for $k/\overline{M}pl = 0.1$

1.63 TeV graviton excluded with ee/μμ combination

We should be able to do significantly better once we add the diphoton channel

Summary

- Using the 2011 dataset, we have an improved understanding of the background in the gamma gamma final state
- We have a consistent signal parameterization which allows us to set limits on a wide range of masses and couplings
- Looking forward to seeing more data!