First Results on Bilepton Production Based on LHC data and Predictions for Run II

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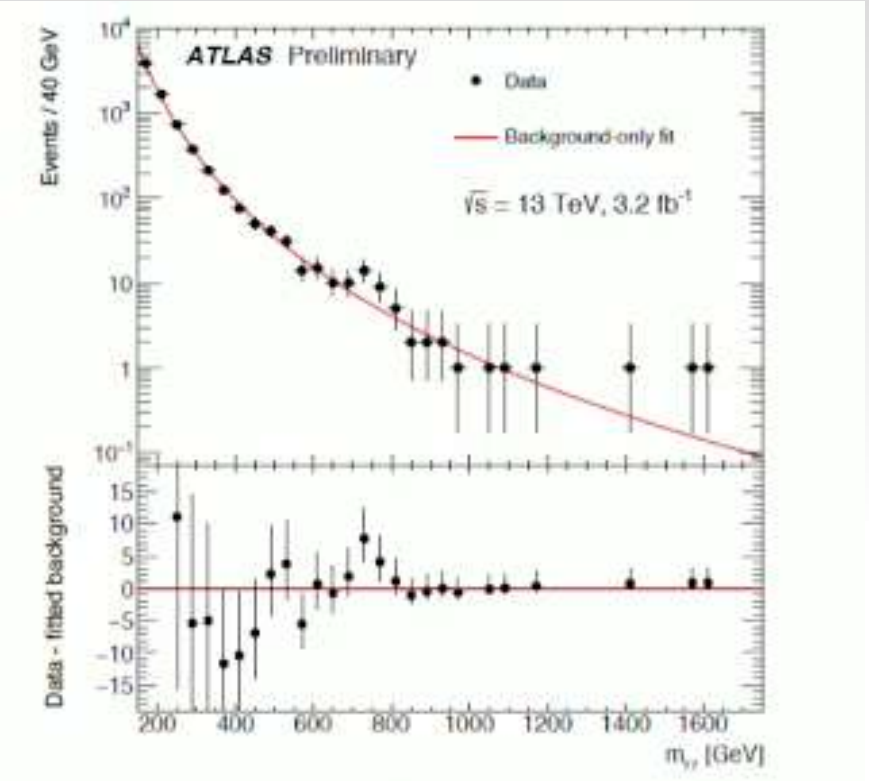
Motivation

- The famous SM puzzles that have motivated the pre-LHC model building era are still unsolved.
- Recent ATLAS and CMS results may have seen hints of new bosons.
- New vector and scalar bosons are present in many models that embeds the SM in larger gauge groups. This talk: **predictions of the 331 Models**



Local significance: 3.6σ (ATLAS) and 2.6σ (CMS)

Motivation – Why 331 Model ?

- Based on the gauge symmetry $SU(3)_C$ X $SU(3)_L$ X $U(1)_X$.
- Provides an elegant solution for the family replication problem of the SM. Nontrivial anomaly cancellation takes place between families.
- Lepton family number is not required to be conserved.
- It foresees a number of new gauge bosons (vectors and scalars).

Predictions: **Vector Bileptons $Y^{\pm\pm}$**
New neutral gauge boson Z'
Three new heavy Leptoquarks (Q_1,Q_2,Q_3)

Bileptons are bosons with two units of leptonic number

Decay Modes:

$$Y^{\pm\pm} \rightarrow \ell^{\pm}\ell^{\pm}$$

$$Y^{\pm\pm} \rightarrow Qq$$

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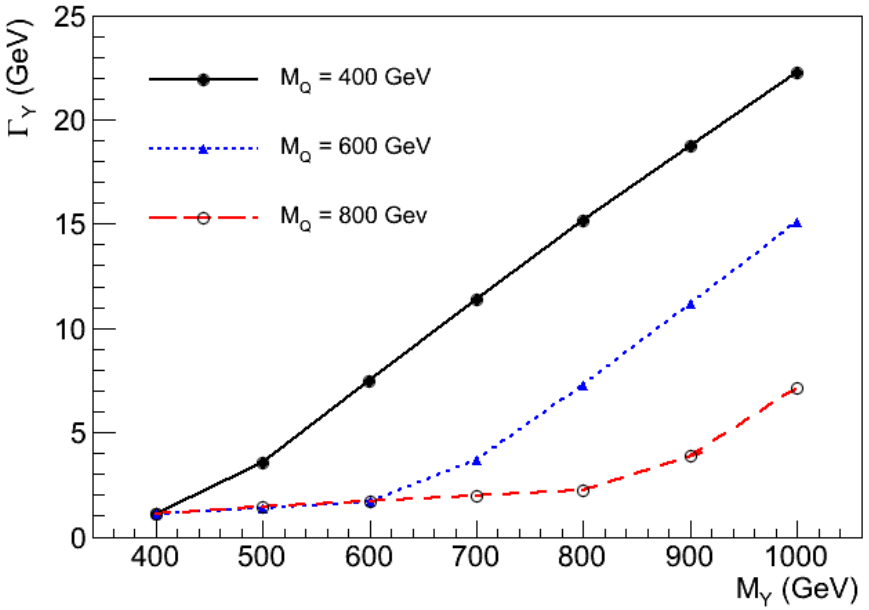
Bilepton Production at LHC

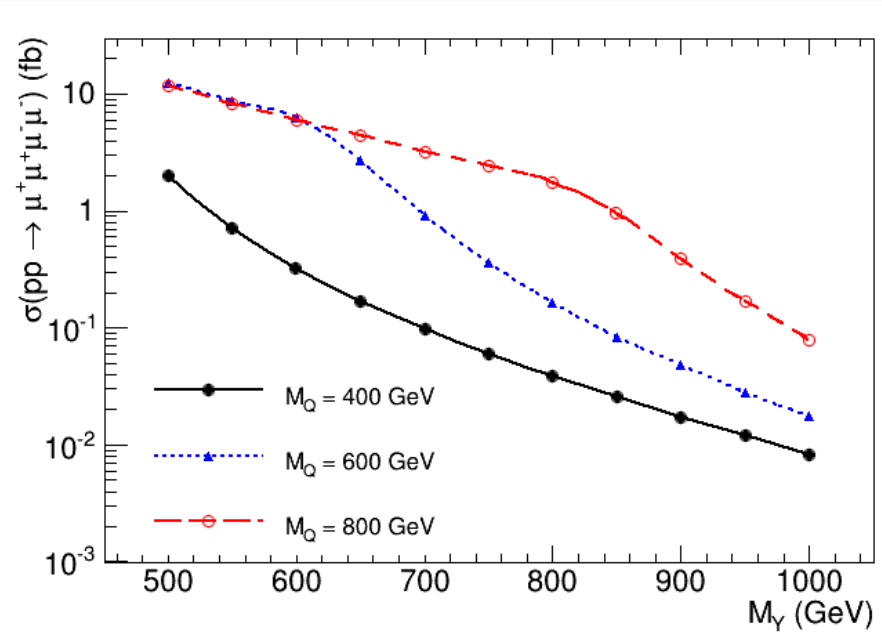
- Previous study of bilepton production at LHC 14 TeV through the process

$$pp \rightarrow Y^{++} Y^{--} \rightarrow e^{\mp} e^{\mp} \mu^{\pm} \mu^{\pm}$$ (BM, AAN, **PRD 84, 2011**)

- Now we investigate the bilepton production at 7 TeV and 13 TeV in the channel

$$pp \rightarrow Y^{++} Y^{--} \rightarrow \mu^{+} \mu^{+} \mu^{-} \mu^{-}$$

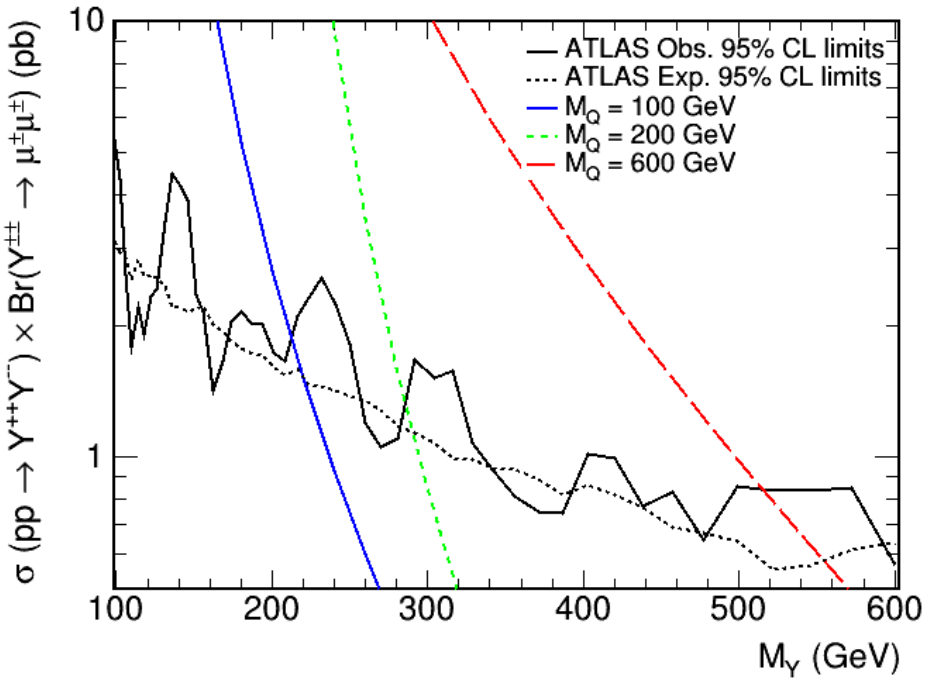


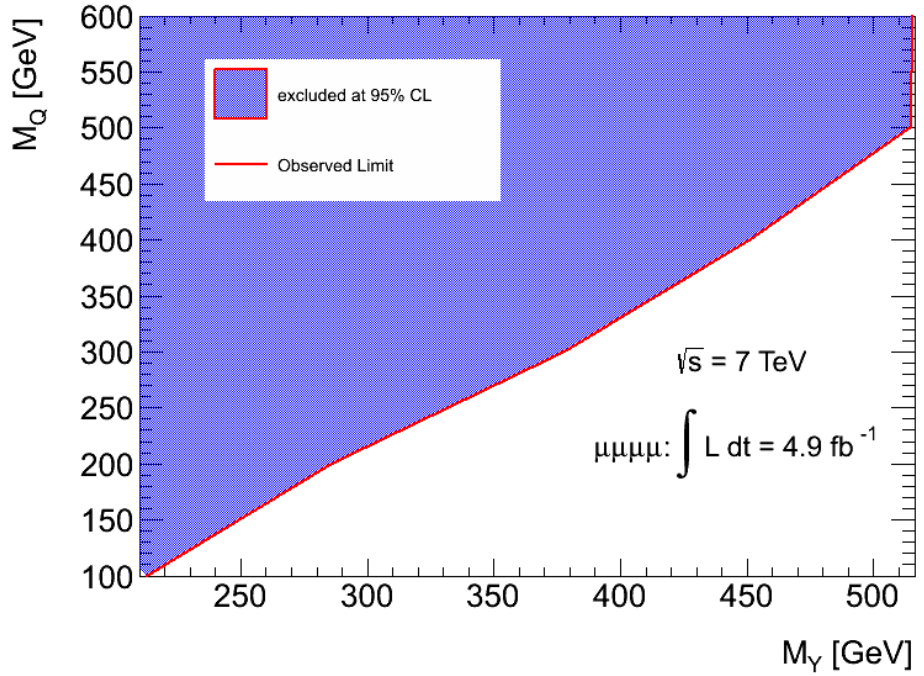


For $M_Y > M_Q$, decays like $Y^{\pm\pm} \rightarrow Qq$ become kinematically allowed.

Exclusion Limits at 7 TeV

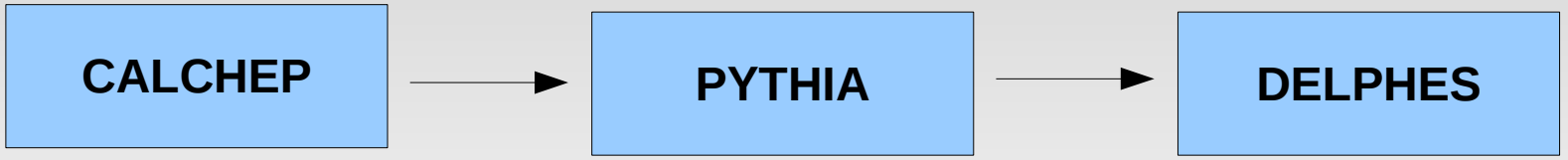
ATLAS collaboration limits on cross-section for doubly-charged higgs production are used to set 95% CL limits on bilepton mass.





Bileptons with masses between 250 GeV and 550 GeV, depending on the exotic quark mass, are excluded.

Bileptons at LHC Run II – 13 TeV

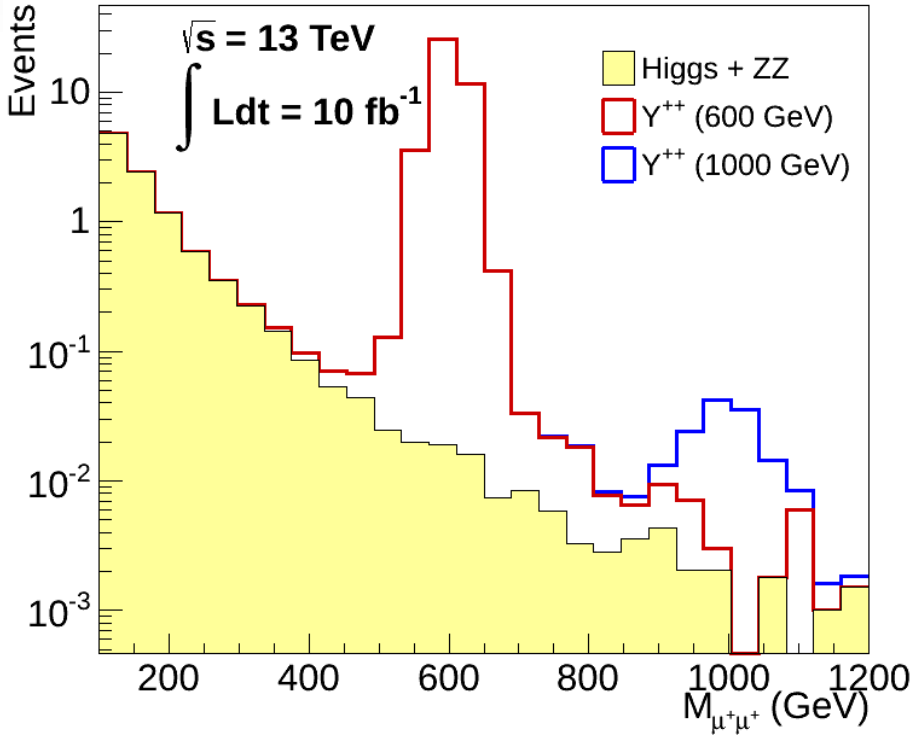


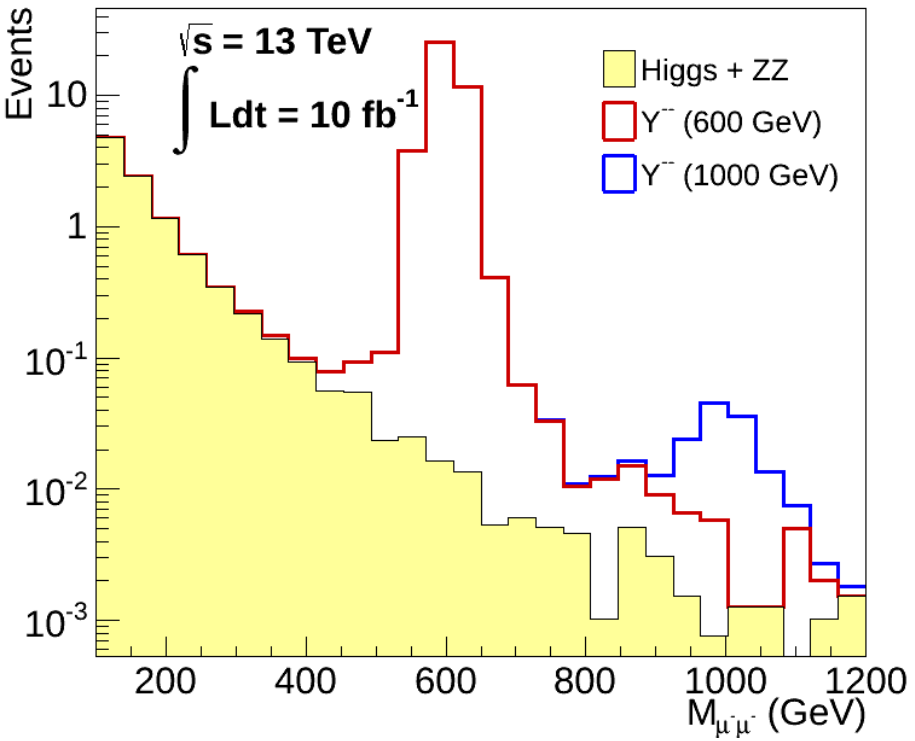
Bileptons at LHC Run II – 13 TeV

Event Selection
- At least four muons
- The two pairs must have opposite signs
- $|\eta| < 2.5$ and $p_T > 20$ GeV
- Trigger Efficiency: 80%
- Signal overall efficiency: ~ 60%

Background
- Higgs production
- ZZ production

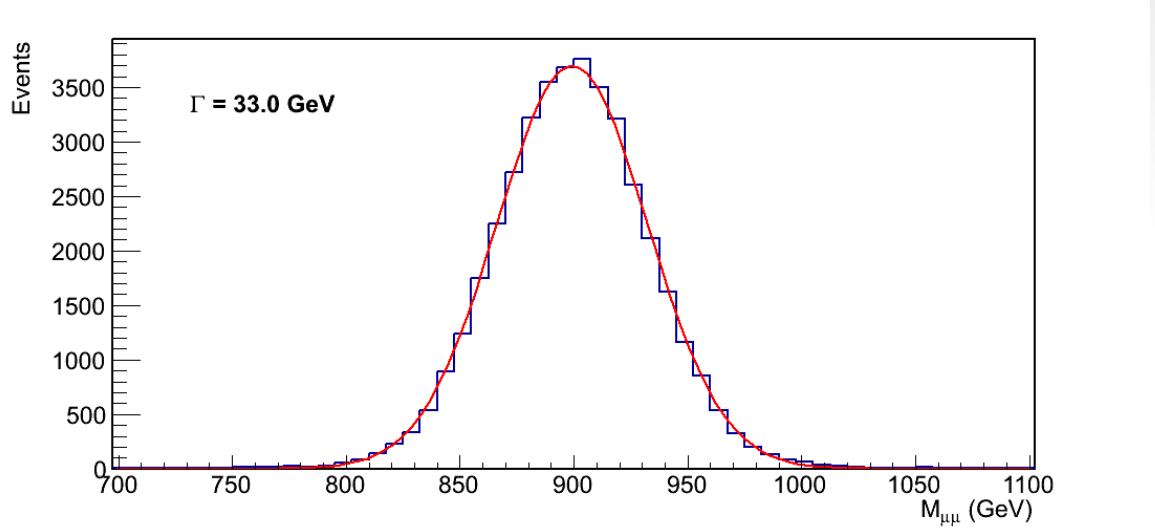
Higgs production only relevant for Mμμ < 500 GeV.





Discovery Potential – Signal Region

- The invariant mass of the same sign muons pair is used as the discriminant variable.
- The signal region is defined as $[5\Gamma - M_Y, M_Y + 5\Gamma]$, where Γ is the width obtained from a Gaussian fit to the signal reconstructed invariant mass distribution.



Discovery Potential – Test Statistic

An optimized χ^2 is used as test statistic (Almeida et.al., NIMA. **449,** 2000):

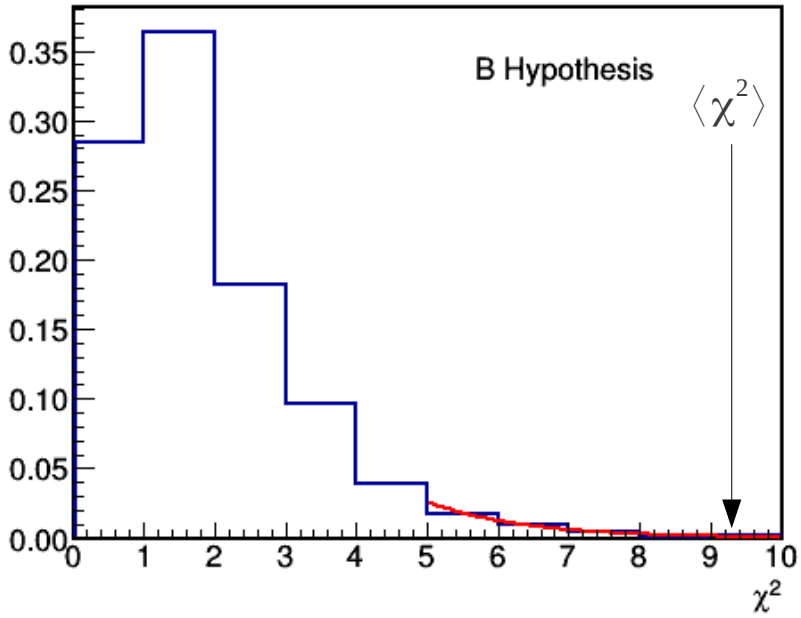
$$\chi^2 = \sum_{i=i}^{N} \left[2(n - n_b) + (2n_b + 1) \log\left(\frac{2n_b + 1}{2n + 1} \right) \right]$$

The χ^2 distribution for background only hypothesis (B) and for signal + background hypothesis (S+B) are determined by performing 5000 pesudo-experiments for each bilepton mass M_Y. The most probable value of the χ^2 for the S+B hypothesis is used to calculate the *p*-value.

P-value

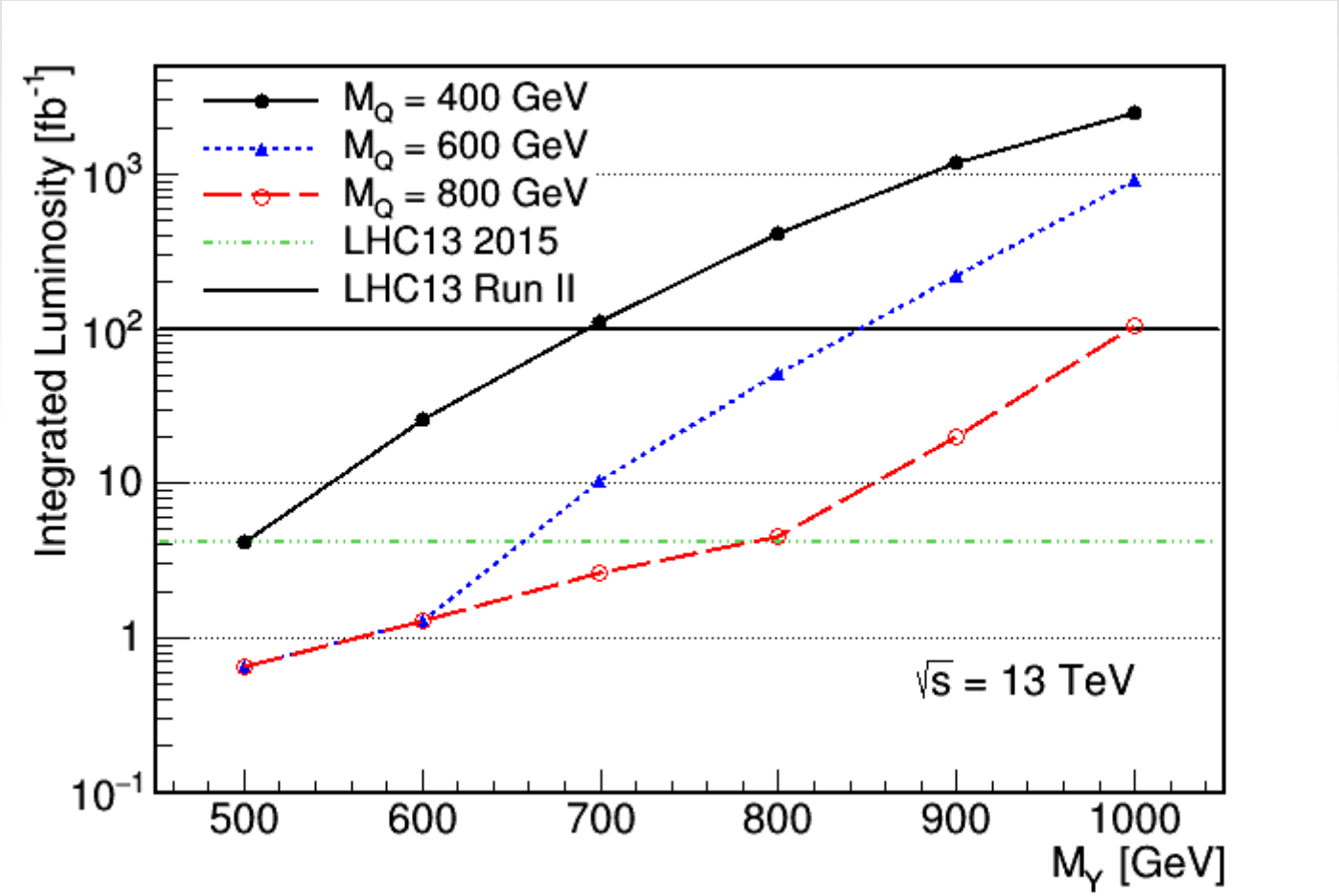
$$P = \int_{\langle \chi^2 \rangle}^{\infty} f_b(z)\, dz$$

Discovery: *P* < 2.3 x 10^{-7}



Discovery Potential

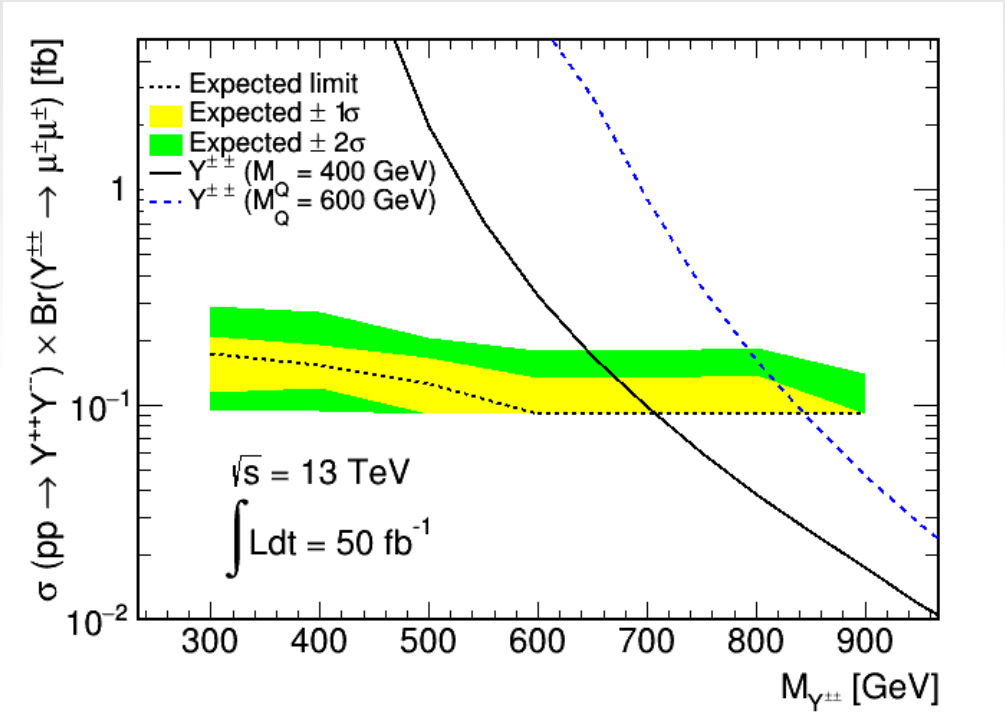
Minimal integrated luminosity needed to claim a discovery (13 TeV)

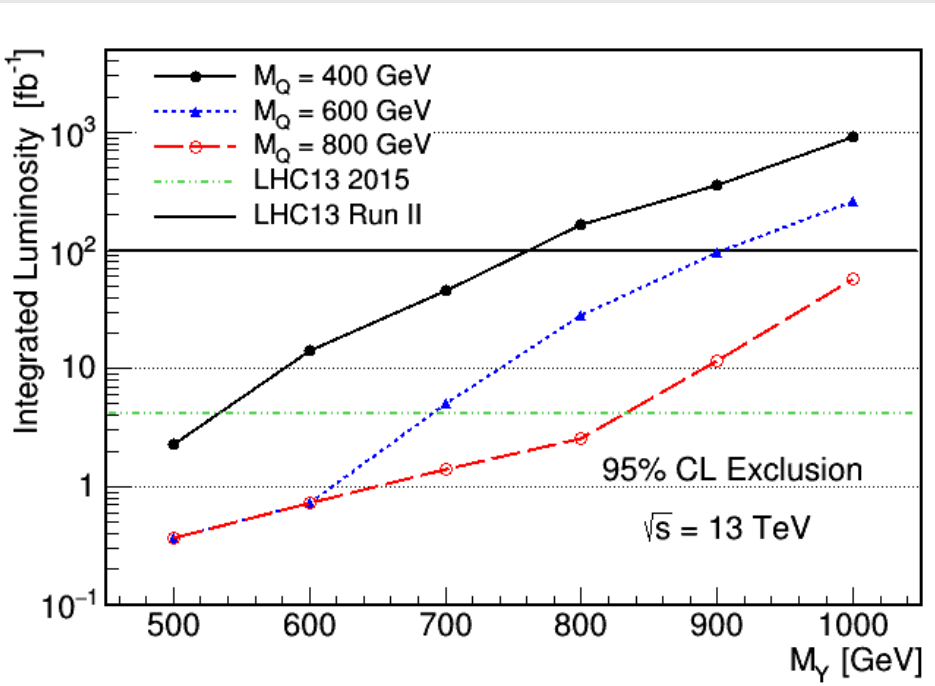


Bileptons masses up to 1 TeV can be probed with ~ 100 fb^{-1}.

Exclusion Limits at 13 TeV

A Bayesina approach is used to set expected limits on the bilepton production cross-section at 13 TeV (implemented in MCLimits)





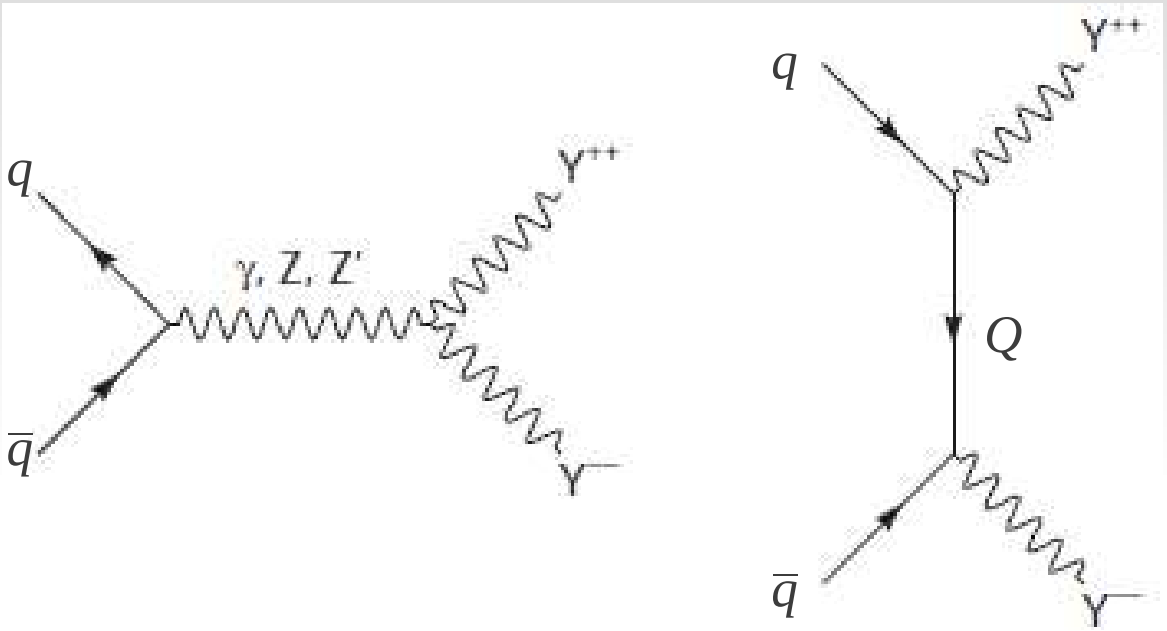
Bileptons with masses between 550 GeV and 850 can be already excluded

Summary

- Lower limits on bilepton mass for different branching rations are derived from ATLAs results at 7 TeV.
- Bileptons with masses between 250 GeV and 550 GeV are excluded.
- Signal of bileptons with 1 TeV mass could be observed in the second phase of LHC13 (~100 fb^{-1}).
- With ~ 4.0 fb^{-1} of data, it is possible to extend the limits to 850 GeV.
- To appear in arXiv soon.

Back-up Slides

Bileptons Production



331 Z'

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