Same Sign Dilepton Search: A Model Independent Interpretation

Gaurab Sarangi

University of Florida

collaborators

Konstantin Matchev and Myeonghun Park

How does a theorist rule out a model?

1. Ask experimentalist friends to redo their analysis for the model and tell the answer.

   No work! Easy, more accurate, full simulation.

   Issue: Have to depend on someone else who is really busy.

2. Run a detector simulation, like PGS

   -Get the cuts the experimentalists use

   -Apply the cuts to model

   -Compare expectations to observed number of events (get number of background events from paper)

   Don't have to rely on someone else.

   Issue: PGS has not been validated by ATLAS or CMS

Thanks to Jay Wacker and his group
for sharing their samples with us.

How does a theorist rule out a model?

3. Emulation: Prescribed by the CMS collaboration.

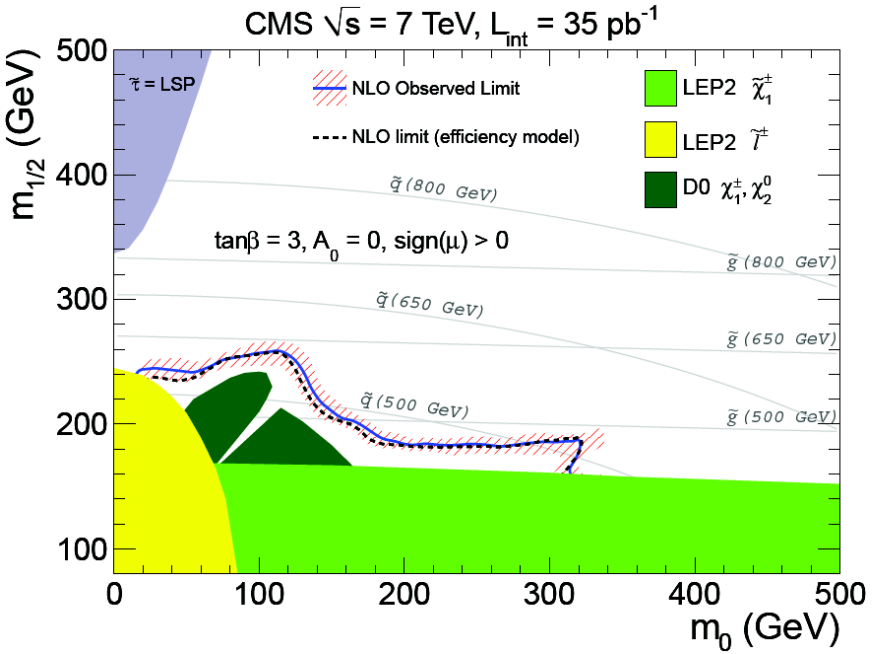
-Theorist only needs to compute σ.BR

-Impose cuts at parton level

-Don't have to worry about Hadronization, Fragmentation or Underlying Event

Issue: Only given for same sign dilepton channel.

Must be supplied for each signature → must depend on someone else



Method 2: Using Detector simulation

We divide this in 2 steps.

1. Step 1 (Model Independent part)

- Choose the search channel (the signal we are looking for).

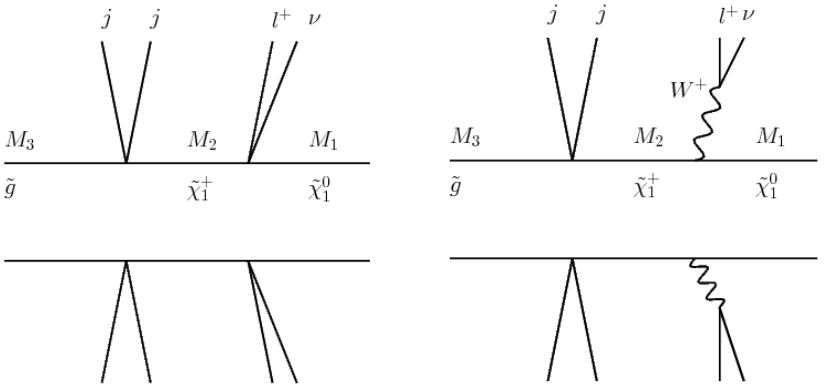
  In our case: same sign dilepton search.

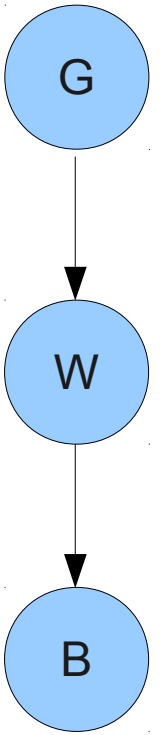
- Identify the relevant production channel to produce the signature

  In our case:

$$pp \to \tilde{g}\tilde{g}$$
$$\tilde{g} \to \tilde{\chi}_1^+ 2j$$
$$\tilde{\chi}_1^+ \to \tilde{\chi}_1^0 l\nu$$

Parameters (M_1, M_2 and M_3)





- Conservative bound, there usually are
  - extra production subprocesses and
  - extra decay channels for gluino decays,

  both of which increase the signal.

Cuts

- Get cuts and the number of background events passing the cuts for the search channel from the experimental paper (CMS PAPER SUS-10-004).

  In our case:

  Minimum number of jets: 2

  P_T cut for electrons: 10 GeV, muons: 5 GeV, jets: 30 GeV

  H_T (=sum of all jet P_T) cut: 300 GeV

  MET cut: 30 GeV

  N_{bkg} (for 34.7 pb^{-1} luminosity)= 0.4096 (scale to luminosity)

  * Cuts change → pile up, reoptimization

Parameter Space

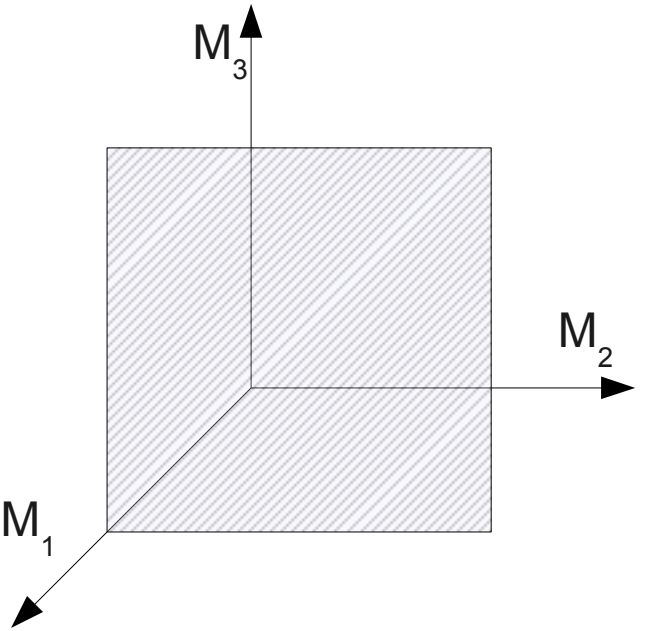
- Run detector simulation in the chosen parameter space.

  In our case:

  we fix M_1 = 10 GeV

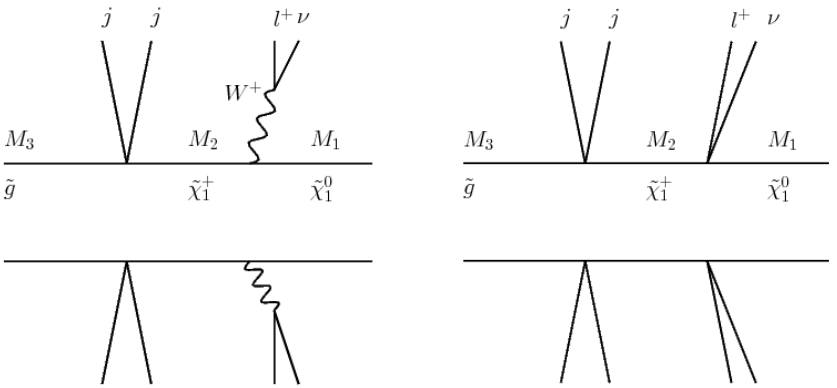
  and vary M_2 and M_3

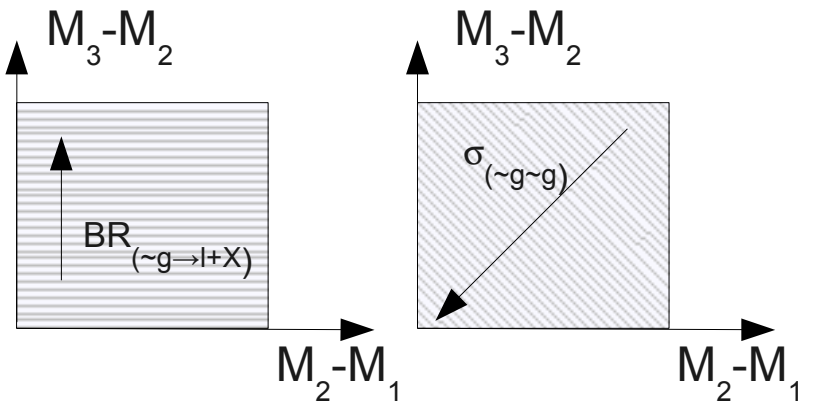
- Calculate efficiency (ε)=N_{cut} /N_{tot}
- Plot the limit on the cross-section using the formula:



$$(\sigma.BR)_{max}(M_i) = \frac{S\sqrt{N_{bkg}}}{L.\epsilon(M_i)}$$

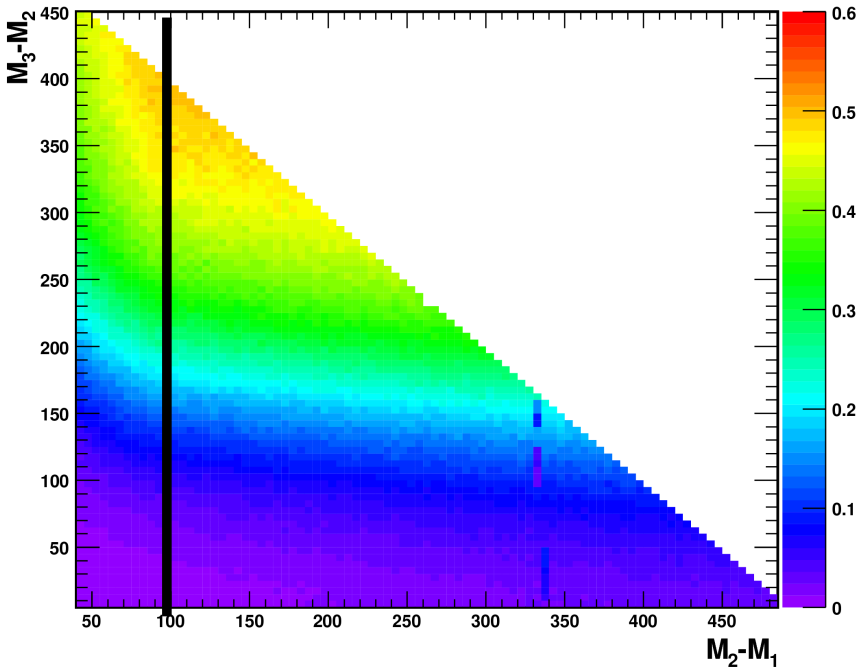
Where, 'S' is the significance and L is the luminosity





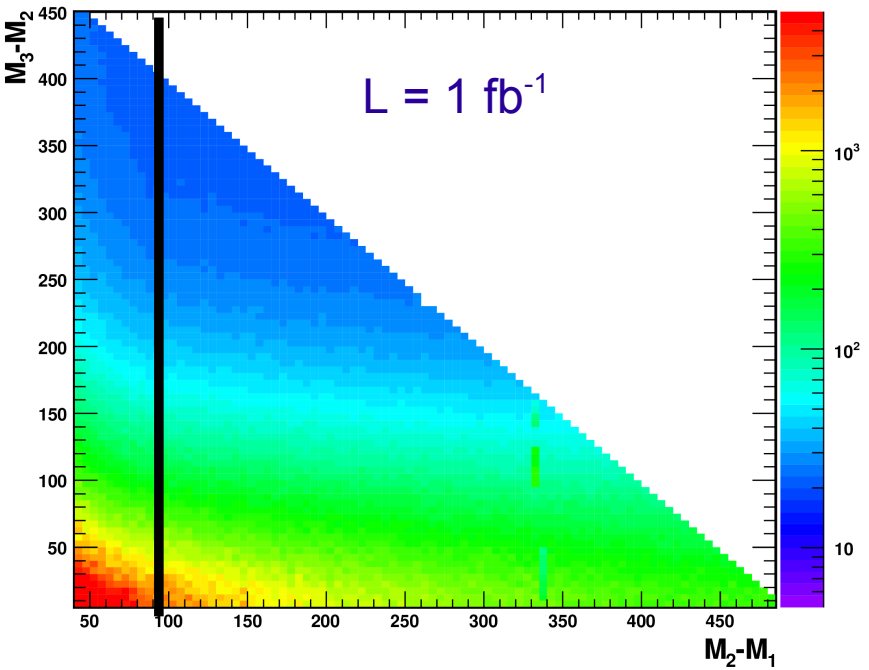
Model independent limit

Efficiency



3 σ model independent limit on σ x BR

fb



$$(\sigma.BR)_{max}(M_i) = \frac{S\sqrt{N_{bkg}}}{L.\epsilon(M_i)}$$

Here,

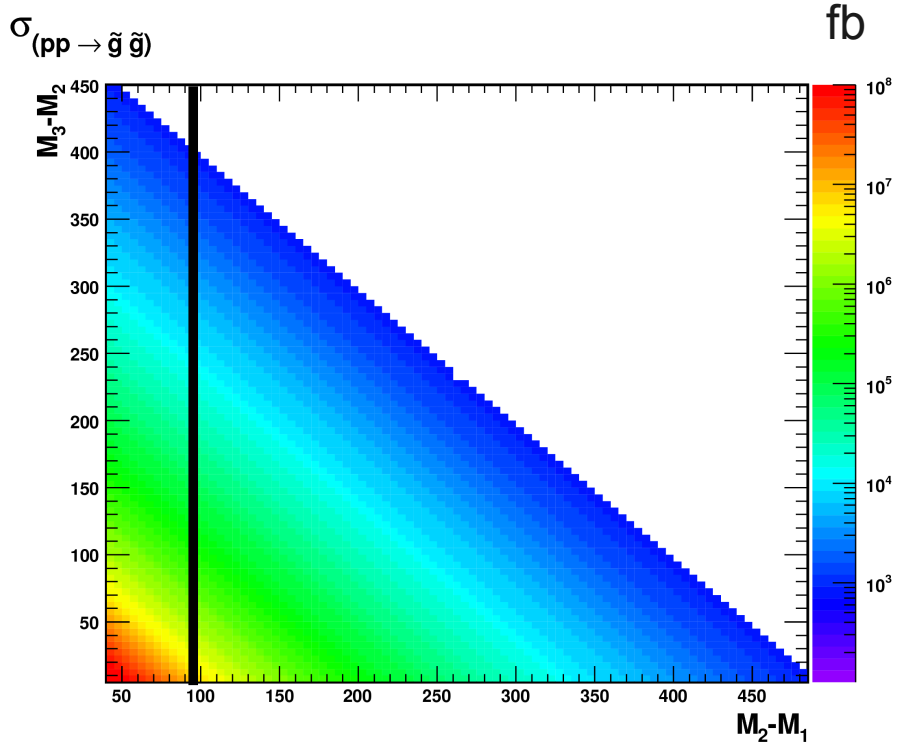
S = 3 (for 3 σ)

N_{bkg} = 11.8 (rescaling the N_{bkg} = 0.4096 given for 34.7 pb^{-1})

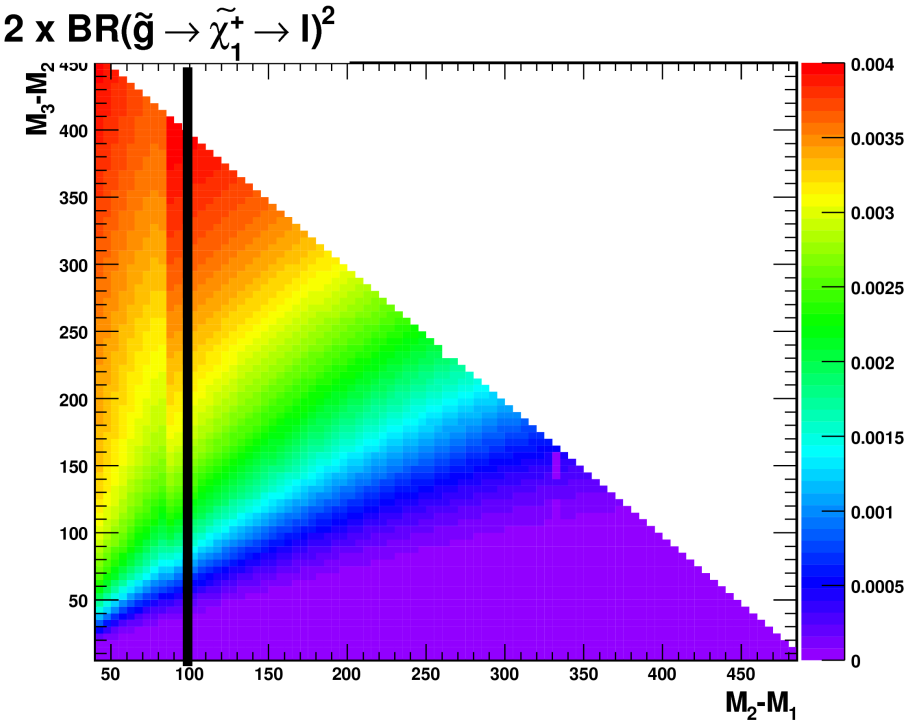
L = 1 fb^{-1}

Step 2: Model Dependent part

- For each of the points in the parameter space for the specific production channel for the model calculate the cross-section (σ) and the branching ratios (BR)



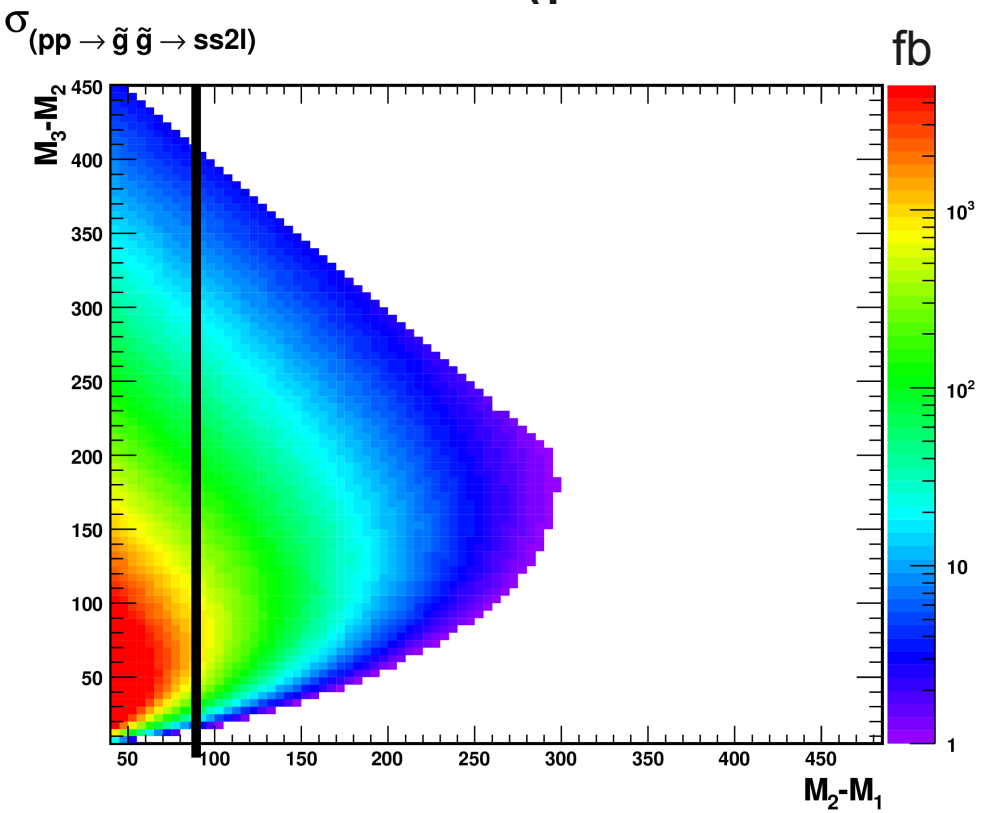
σ = gluino production cross-section

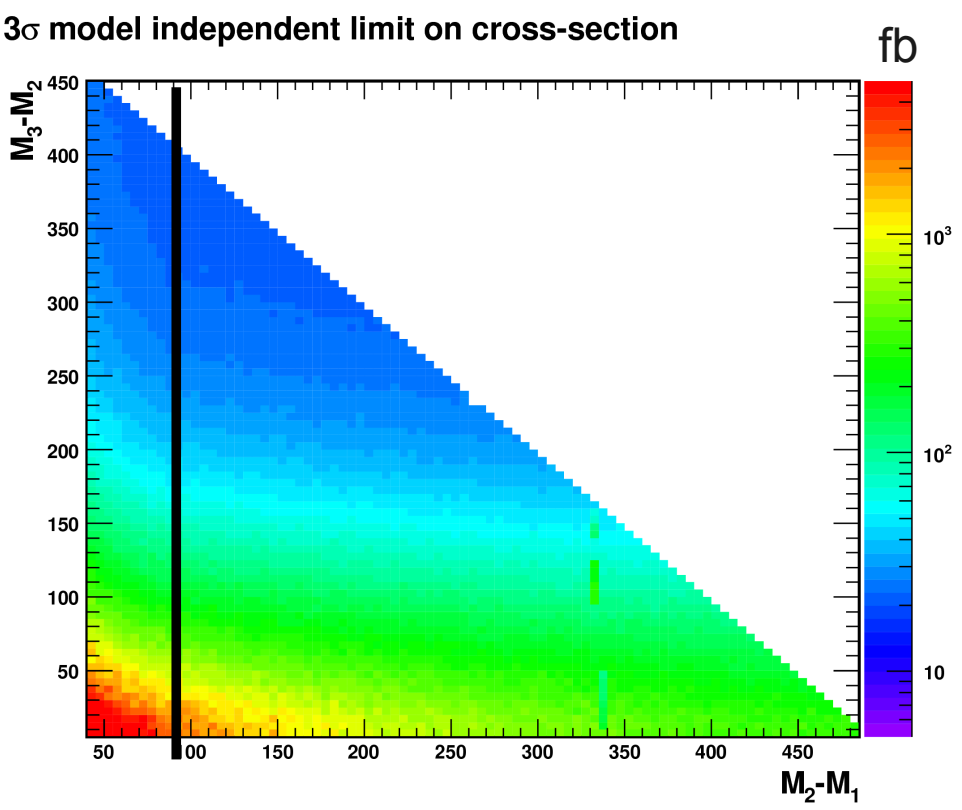


BR =2 x [br(~g→~χ^+_1(+2j)→~χ^0_1+l)]^2

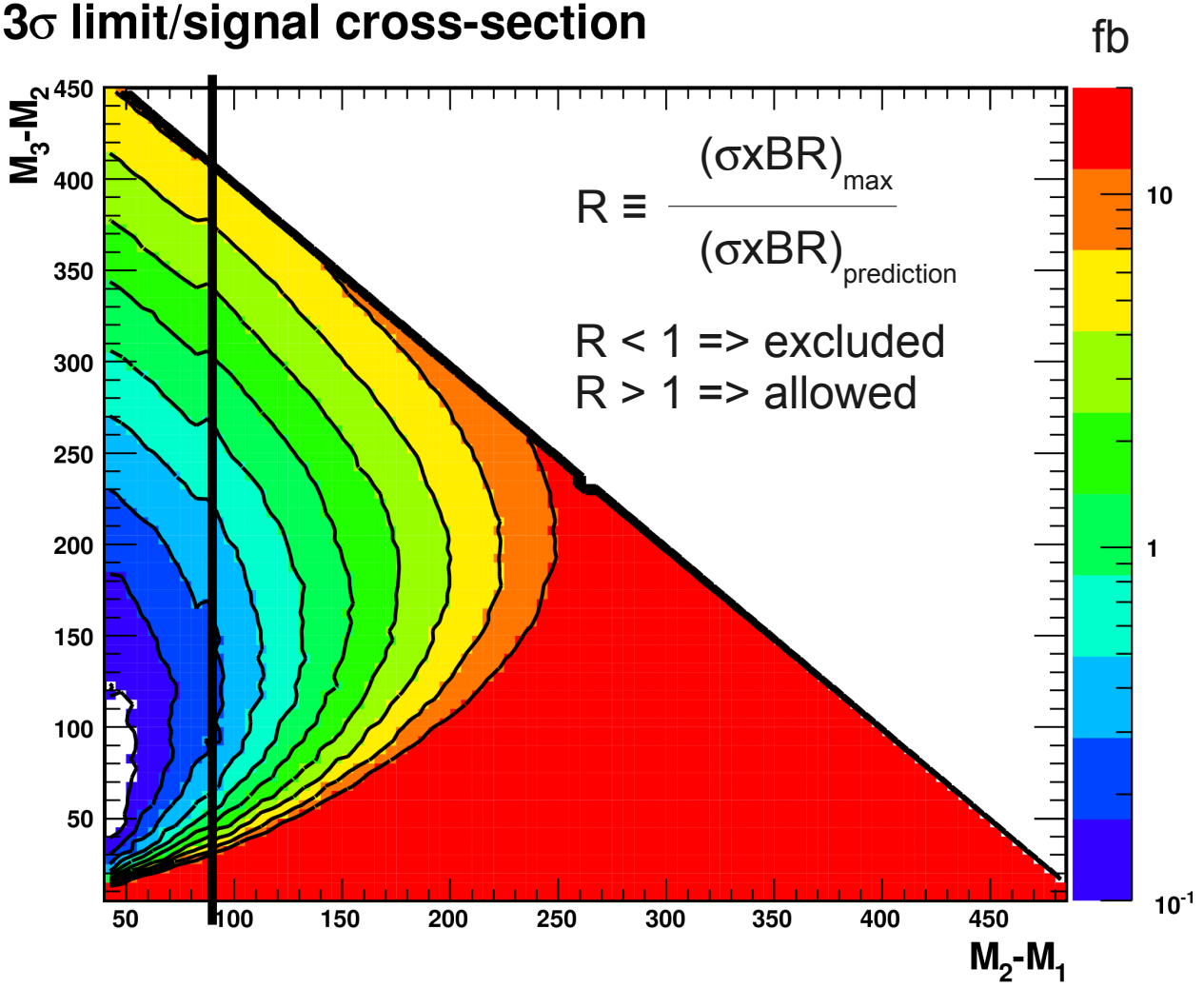
Model dependent cross-section

- Compute σ x BR for any point in the parameter space
- and compare it to the plot for limit on the cross-section (plot on the last slide).





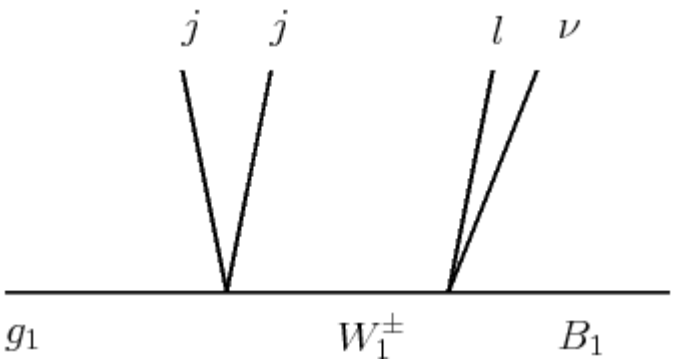
Final cross-section contours



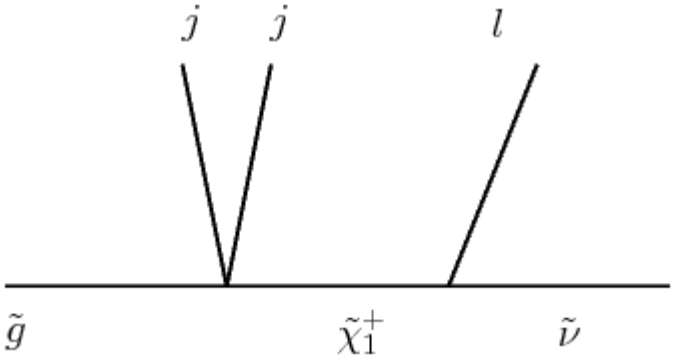
- More data ~ 1/Sqrt(L)
- By scaling up the gluino-gluino production cross-section ~ 1/σ
- By taking into account other decay channels

Conclusion and Outlook

- Results:
  - Step I: Model independent limit on σxBR on any model from the ss2l analysis in the M_1, M_2 and M_3 parameter space
  - Step II: Pick a model and calculate σxBR, then compare with limit on parameter space.
- Will do the same analysis with emulation.
- For other topologies, they need to be kinematically compatible for us to be able to use the same model independent limit.



Kinematically compatible topology (UED)



Kinematically incompatible topology