

HEP NTUA Weekly Report

15/4/2021

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Summary Z' Analysis

- Switch to $m_{JJ} > 1000$ GeV cut:
 - No sensitivity for higher Z' masses (> 2.5 TeV)
 - Calculate significance and Asymptotic for different m_{JJ} cuts
 - m_{JJ} Cuts: [1000, 1200, 1400, 1600, 1800, 2000] GeV
 - $Significance = \frac{Signal}{\sqrt{Signal+Bkg}}$ where signal is the Z' distribution and $Bkg := ttbar + QCD + Subdominant$
- I was using $ttbar$ as the extracted signal from data: Instead, I use the $ttbar$ MC distribution (scaled to the signal strength)
- For QCD I use the QCD MC distribution which is scaled to data (using k-factor)
- Sliding m_{JJ} Cut
 - Asymptotic limits using Limit value as guide and not significance
 - Use Systematic variations within my datacard (talked with Lisa and Anna about this)
 - **shapeN (not lnN or shape)**
 - Not yet JES (production)



Datacard Summary (example for mJJ > 1600 GeV)

```
imax * number of bins
jmax * number of processes minus 1
kmax * number of nuisance parameters

-----
shapes *      SR_C      ProcessesFile_1600.root h_chi_$PROCESS h_chi_$PROCESS_$SYSTEMATIC
shapes Zprime  SR_C      ZprimeFile_2000_20_massCut1600.root h_chi_$PROCESS
shapes data_obs SR_C      DataFile_1600.root h_Data

-----
bin          SR_C
observation -1.0

-----
bin          SR_C      SR_C      SR_C      SR_C
process      Zprime    qcd      Subdominant ttbar
process      0         1         2         3
rate         -1.0      -1.0      -1.0      -1.0

-----
yield_ttbar  lnN      -         -         -         1.5
yield_qcd    lnN      -         1.5      -         -
yield_Subdominant lnN  -         -         1.5      -
lumi_13TeV   lnN      -         1.025    1.025    1.025
scale        shapeN   -         -         -         1.0
pdf          shapeN   -         -         -         1.0
fsr          shapeN   -         -         -         1.0
isr          shapeN   -         -         -         1.0
btag         shapeN   -         -         -         1.0
* autoMCStats 10 1
```

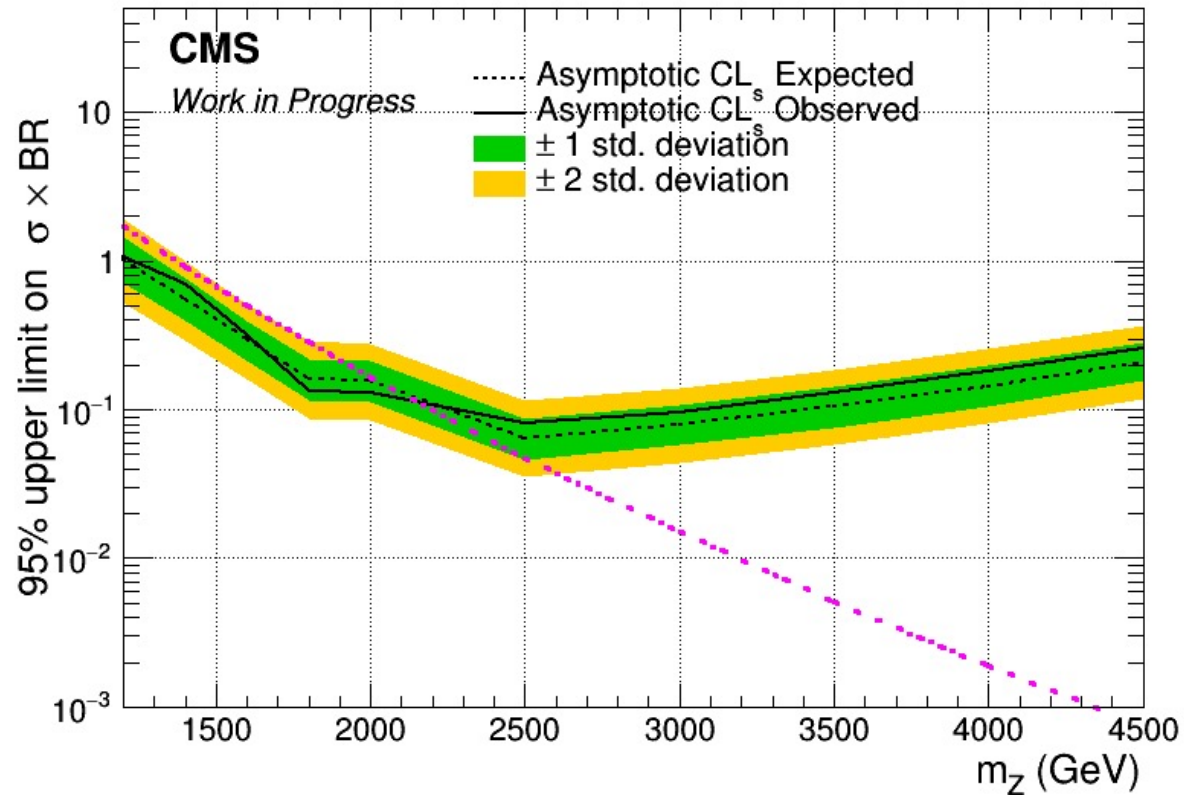


Brazilian Plots (2017 and 2018) with sliding mJJ Cut

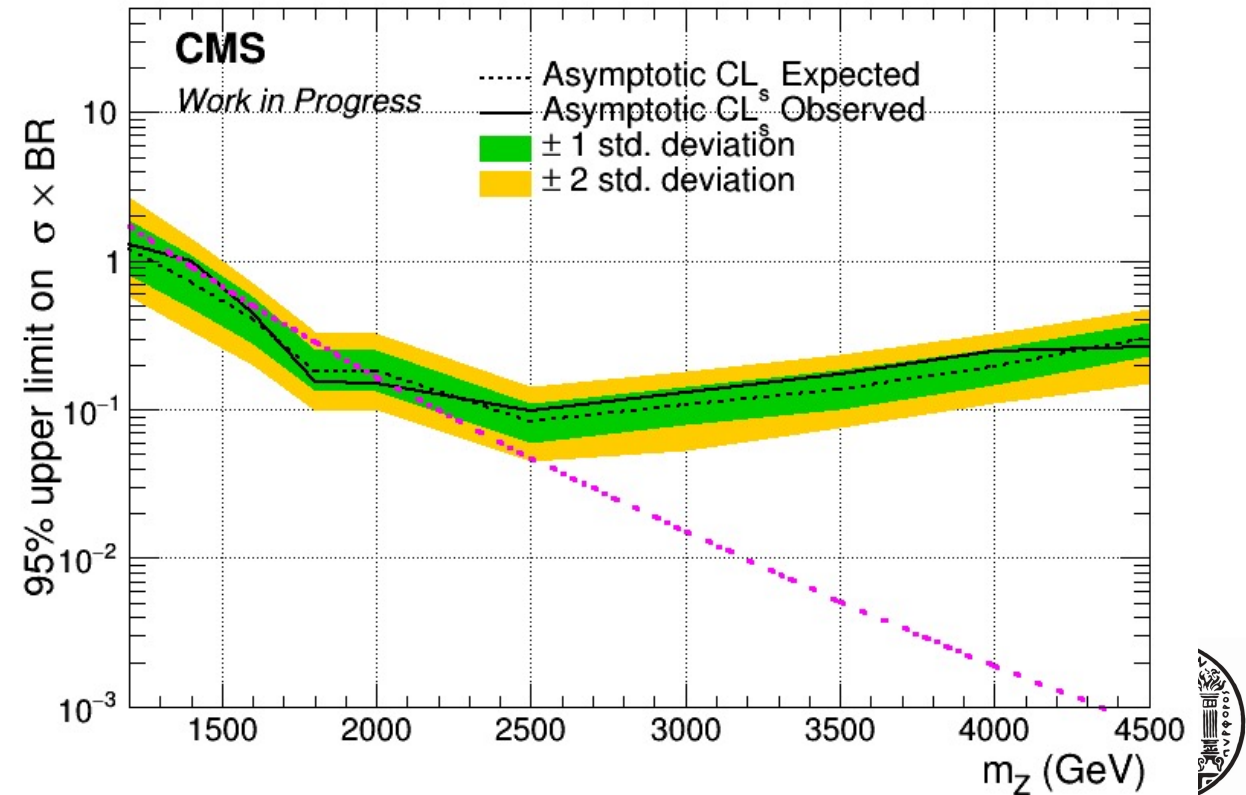
Mass Cut Mapping

{"mZ_1200_12":1000, "mZ_1400_14":1200, "mZ_1600_16":1400, "mZ_1800_18":1600, "mZ_2000_20":1600,
"mZ_2500_25":2000, "mZ_3000_30":2000, "mZ_3500_35":2000, "mZ_4000_40":2000, "mZ_4500_45":2000}

2017



2017 with systematics

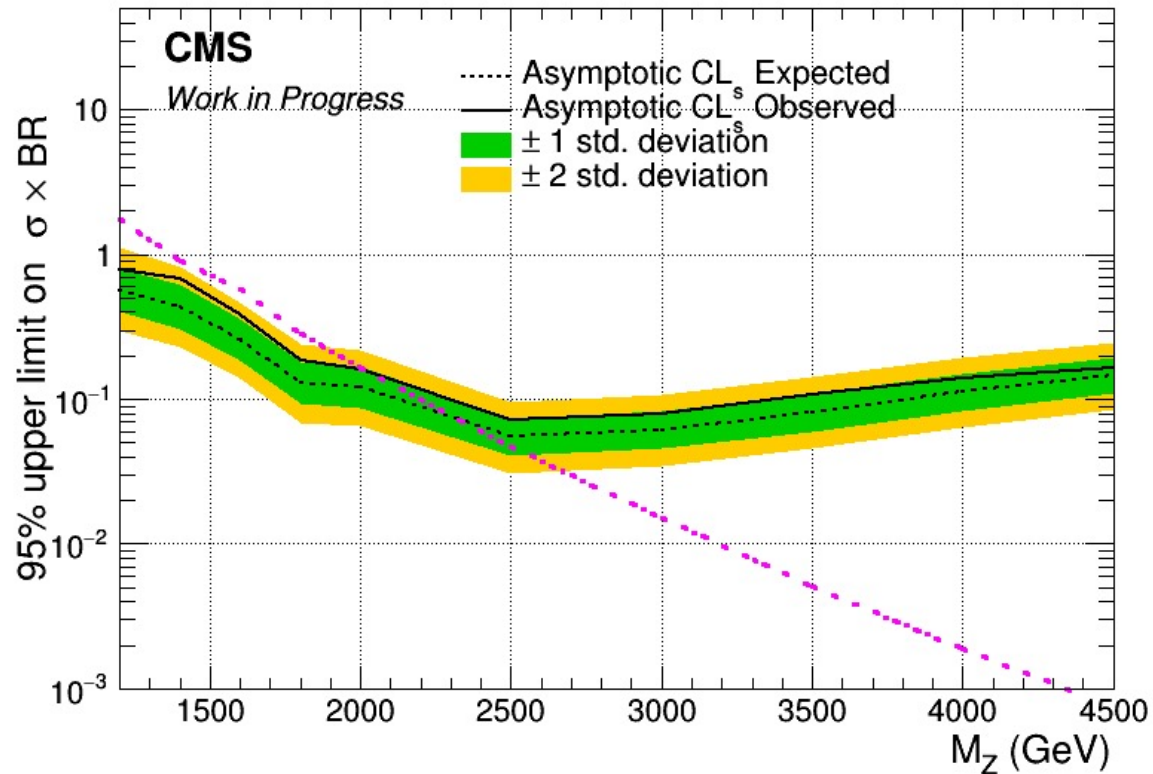


Brazilian Plots (2017 and 2018) with sliding mJJ Cut

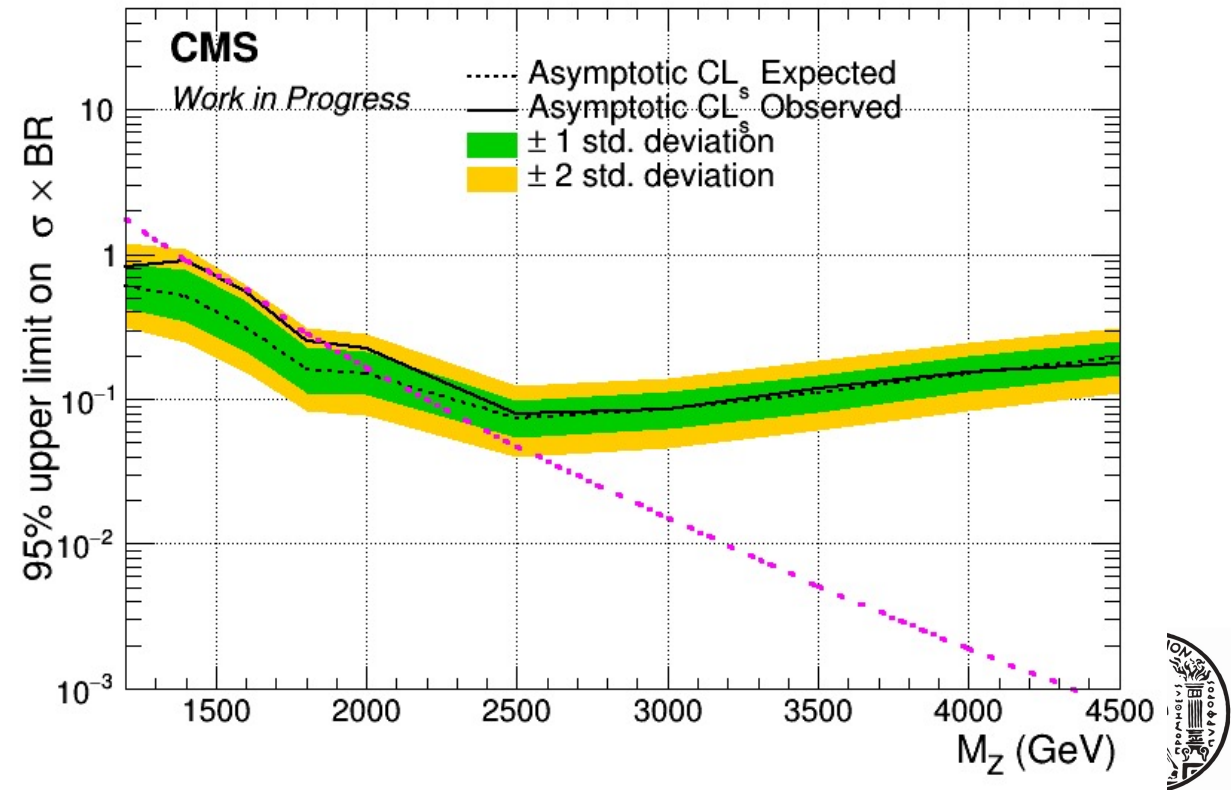
Mass Cut Mapping

{"mZ_1200_12":1000, "mZ_1400_14":1200, "mZ_1600_16":1400, "mZ_1800_18":1600, "mZ_2000_20":1600, "mZ_2500_25":2000, "mZ_3000_30":2000, "mZ_3500_35":2000, "mZ_4000_40":2000, "mZ_4500_45":2000}

2018



2018 with systematics



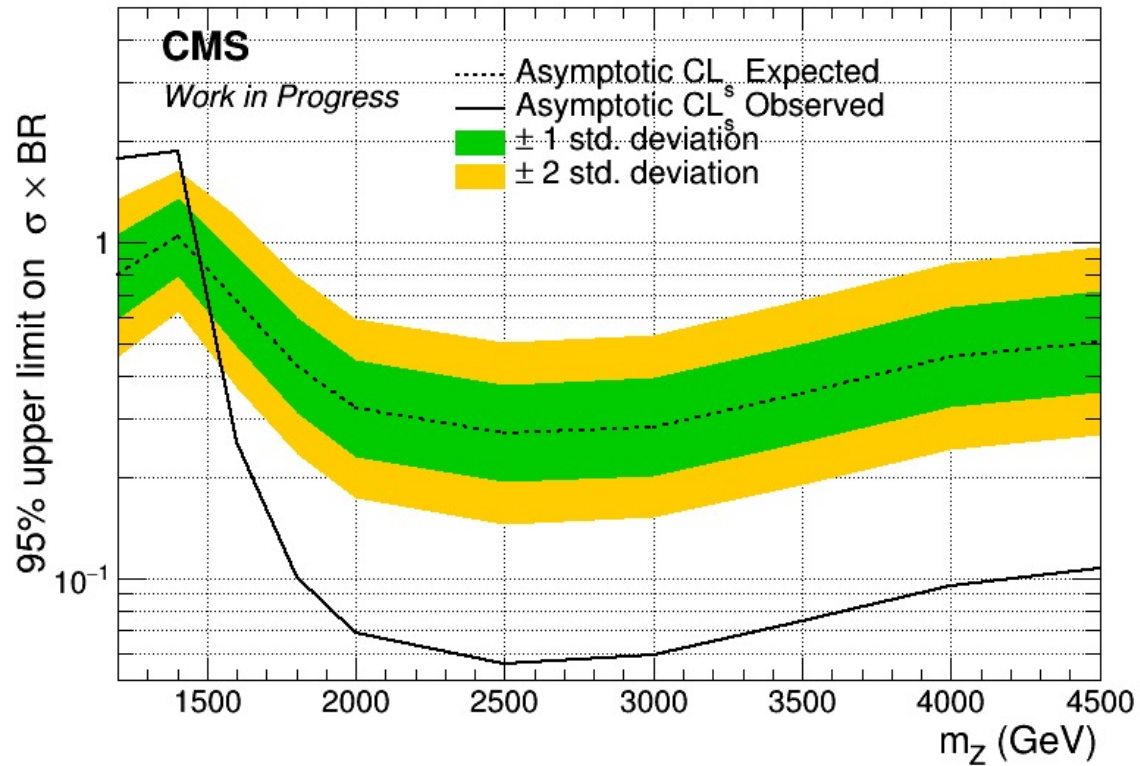
BACKUP



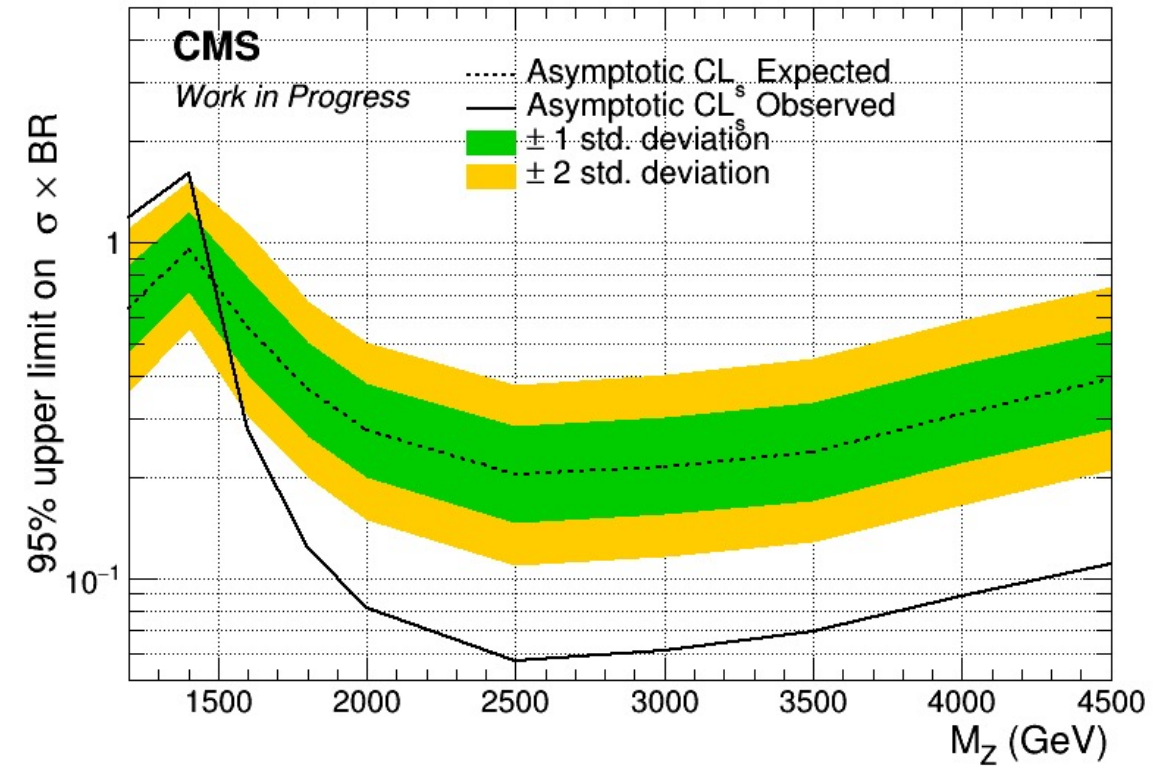
Angular Distributions (Brazilian Plot using data!!!!)

Asymptotic limits for $M_{Z'}$: 1.2, 1.4, 1.6, 1.8, 2, 2.5, 3, 3.5, 4, 4.5 TeV
Width 1%

2017



2018

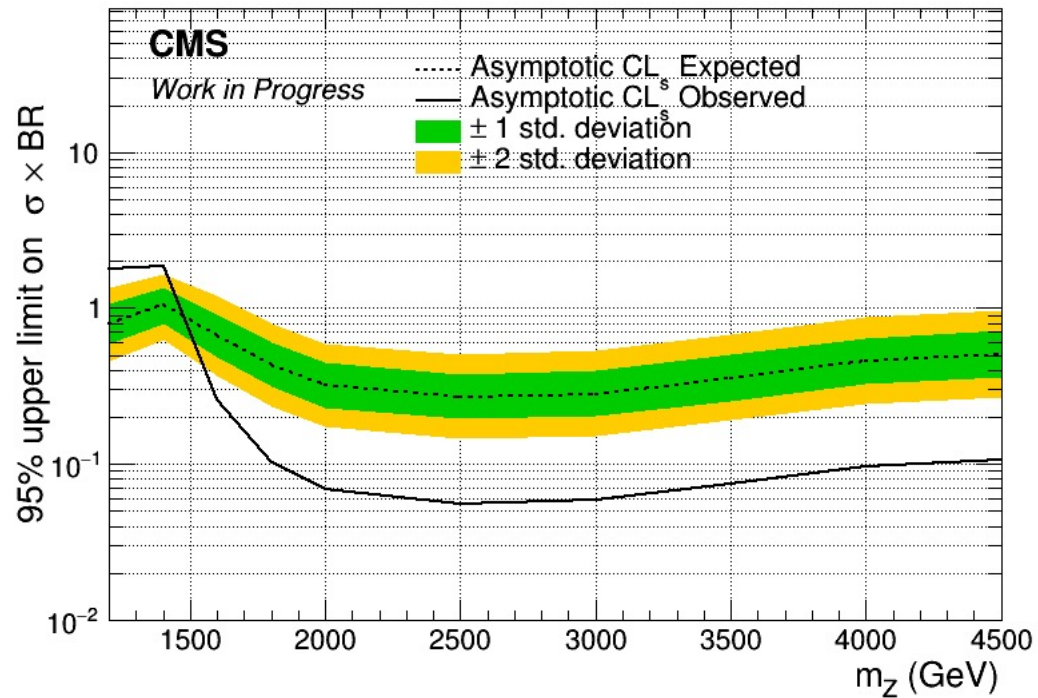


Angular Distributions (Brazilian Plot using extracted signal!!) vs B2G-16-015

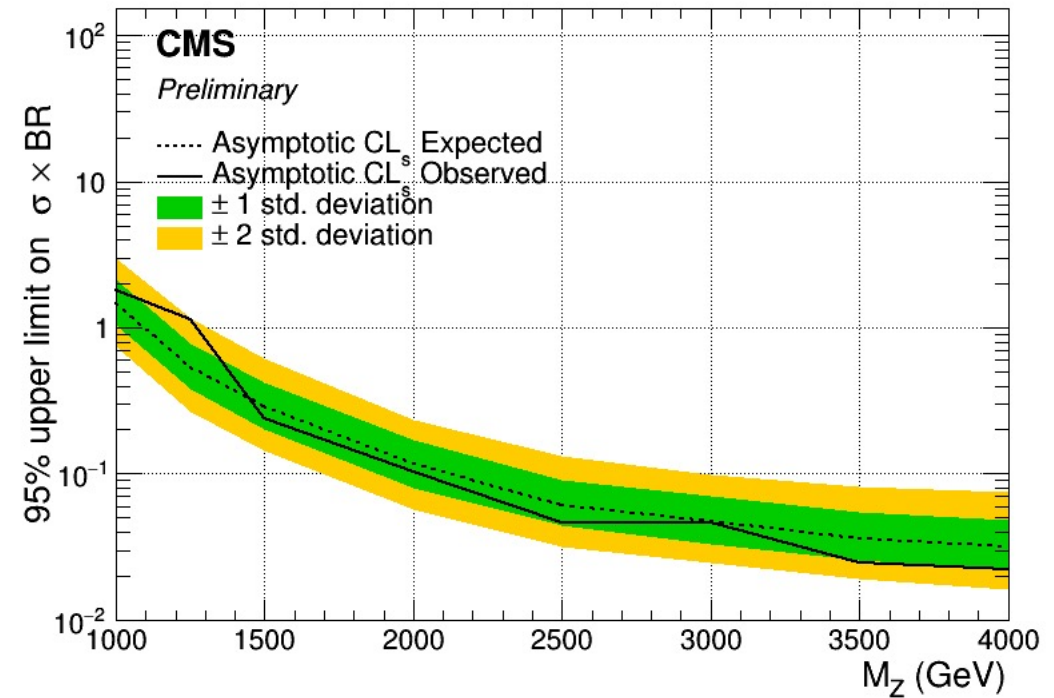
Asymptotic limits for $M_{Z'}$: 1.2, 1.4, 1.6, 1.8, 2, 2.5, 3, 3.5, 4, 4.5 TeV

Width 1%

2017



B2G-16-015

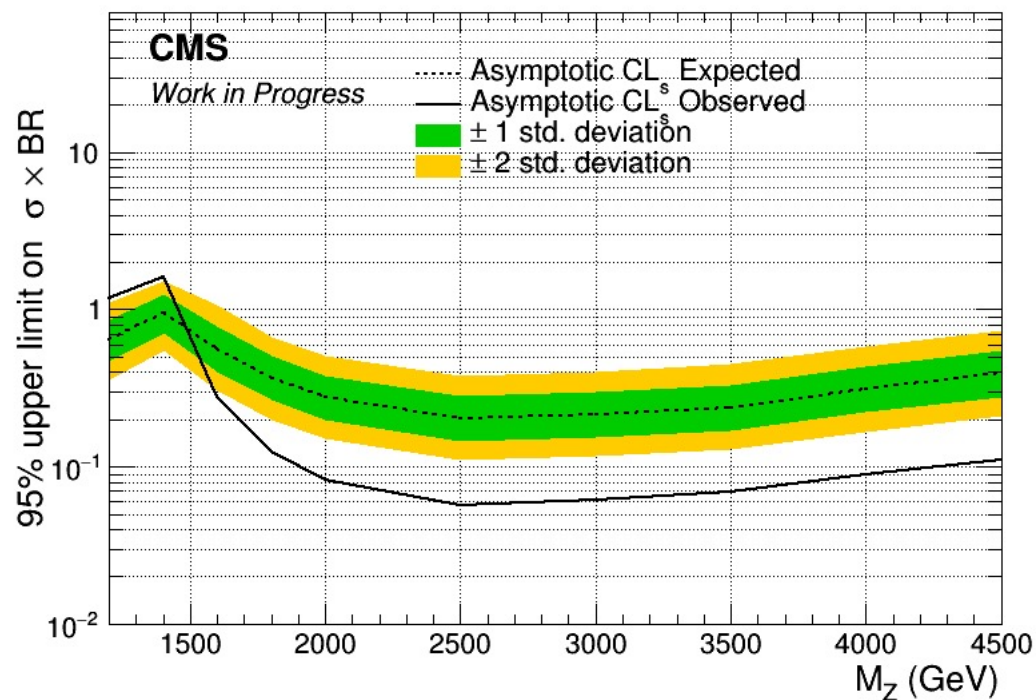


Angular Distributions (Brazilian Plot using extracted signal!!) vs B2G-16-015

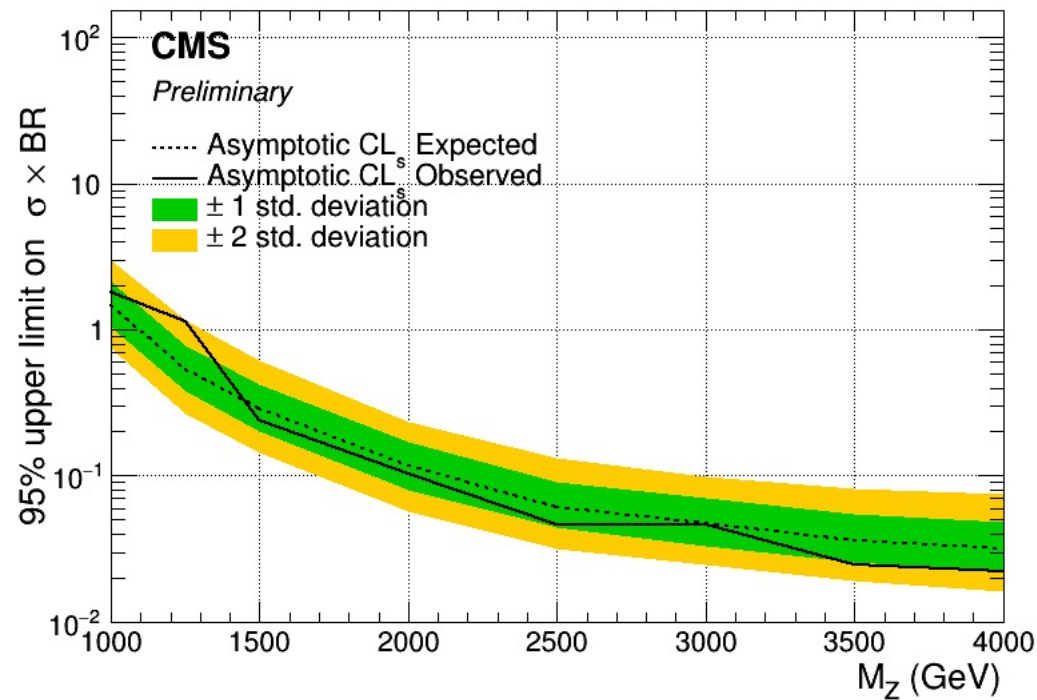
Asymptotic limits for $M_{Z'}$: 1.2, 1.4, 1.6, 1.8, 2, 2.5, 3, 3.5, 4, 4.5 TeV

Width 1%

2018



B2G-16-015

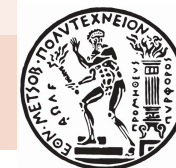


Signal Selection

Variables	Selected Cut
pT (both leading jets)	> 400 GeV
Njets	> 1
N leptons	= 0
eta (both leading jets)	< 2.4
mJJ	> 1000 GeV
jetMassSoftDrop (only for fit)	(50,300) GeV
Top Tagger	> 0.2, 0, 0.1
B tagging (2 btagged jets)	> Medium WP
Signal Trigger	

Control Region Selection

Variables	Selected Cut
pT (both leading jets)	> 400 GeV
Njets	> 1
N leptons	= 0
eta (both leading jets)	< 2.4
mJJ	> 1000 GeV
jetMassSoftDrop (only for fit)	(50,300) GeV
Top Tagger	> 0.2, 0, 0.1
B tagging (0 btagged jets)	< Medium WP
Control Trigger	



Top Angular Distributions

- We employ the dijet angular variable χ from the rapidities of the two leading jets
- Why χ ?
 - The distributions associated with the final states produced via QCD interactions are relatively flat in comparison with the distributions of the BSM models or new particles, which typically peak at low values of χ
- We can measure the variable χ in two ways

1. By measuring the difference of the rapidities of the two leading jets such as the corresponding rapidity in the ZMF is:

$$y^* = \frac{1}{2}(y_1 - y_2)$$

χ is defined as $\chi = e^{|y^*|} = e^{|y_1 - y_2|}$ (1) and can be measured by creating the TLorentzVector, boost it to the ZMF and find the rapidity difference of the two leading jets

2. By measuring the scattering angle θ^* (angle between top quark and z-axis in the Zero Momentum Frame)

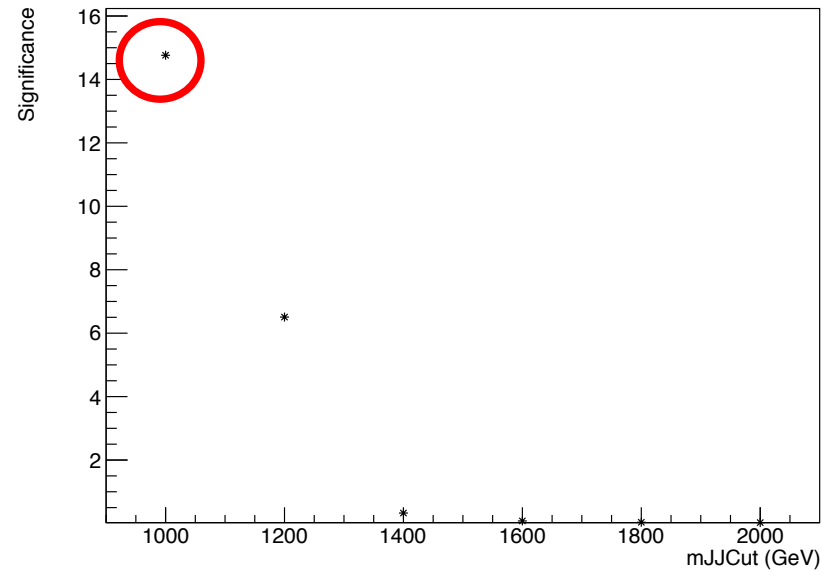
We define as $y^* = \frac{1}{2} \ln\left(\frac{1+|\cos\theta^*|}{1-|\cos\theta^*|}\right)$ and from (1) we can find that:

$$\chi = \frac{1 + |\cos\theta^*|}{1 - |\cos\theta^*|}$$



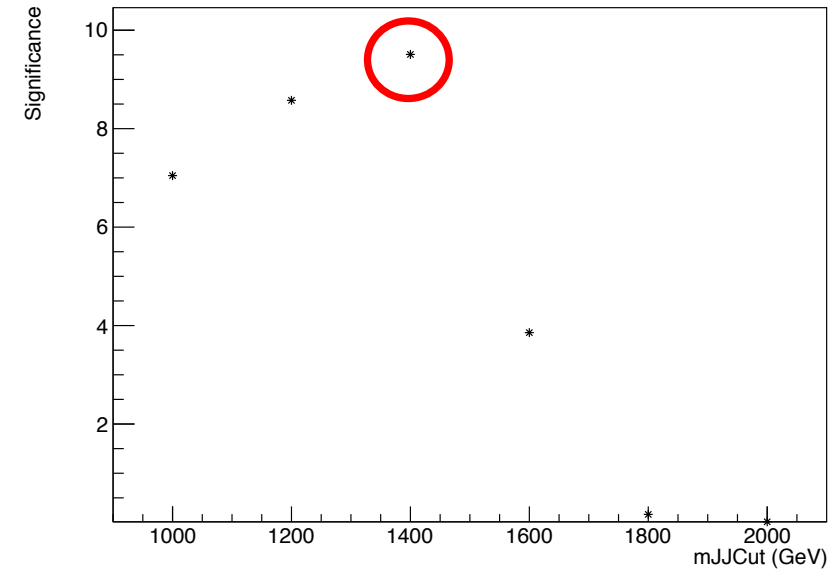
Significance Graphs (2017)

Significance_M1200_W12



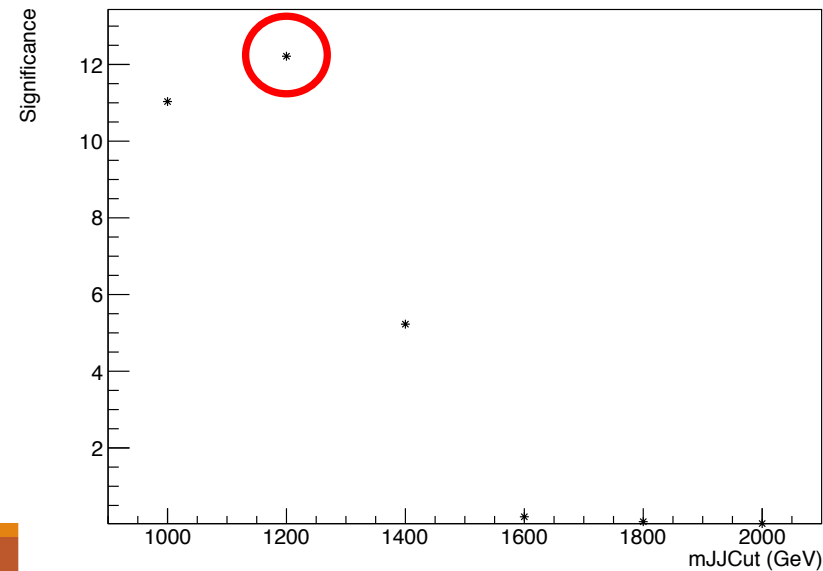
$M_{Z'} = 1200, w = 1\%$

Significance_M1600_W16



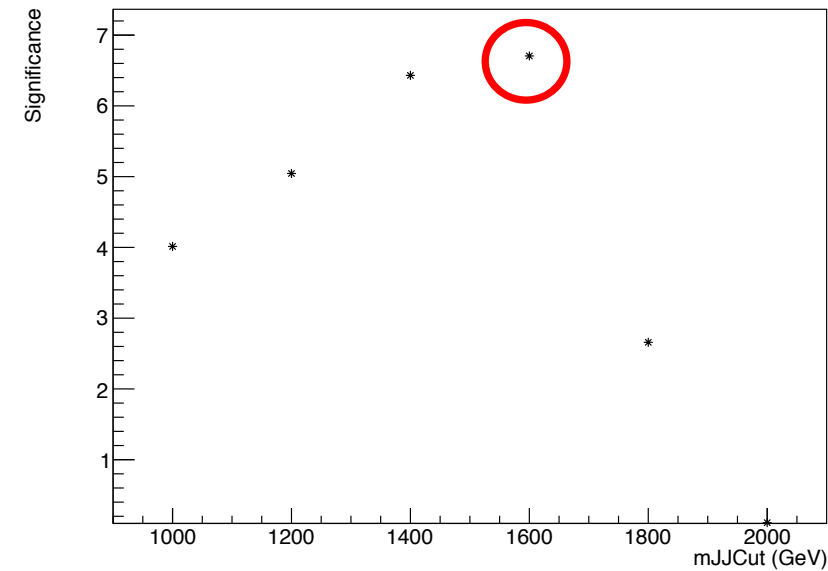
$M_{Z'} = 1600, w = 1\%$

Significance_M1400_W14



$M_{Z'} = 1400, w = 1\%$

Significance_M1800_W18

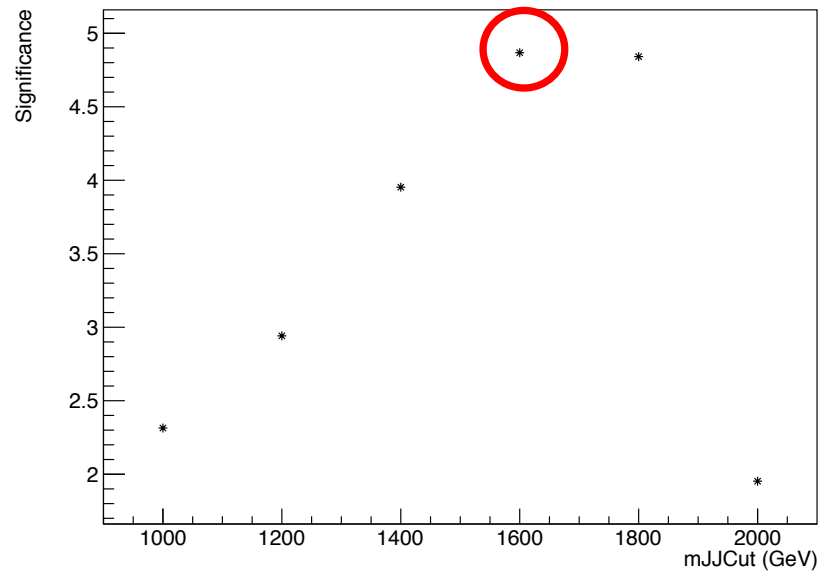


$M_{Z'} = 1800, w = 1\%$



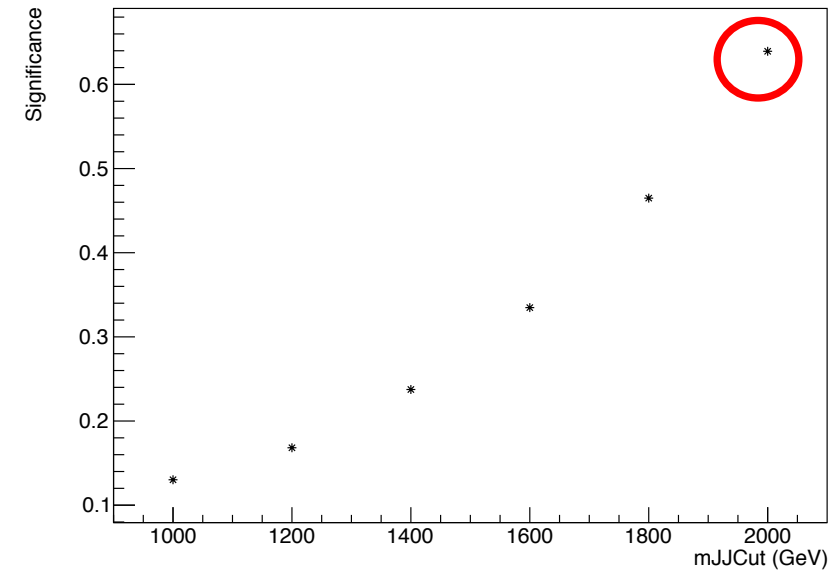
Significance Graphs (2017)

Significance_M2000_W20



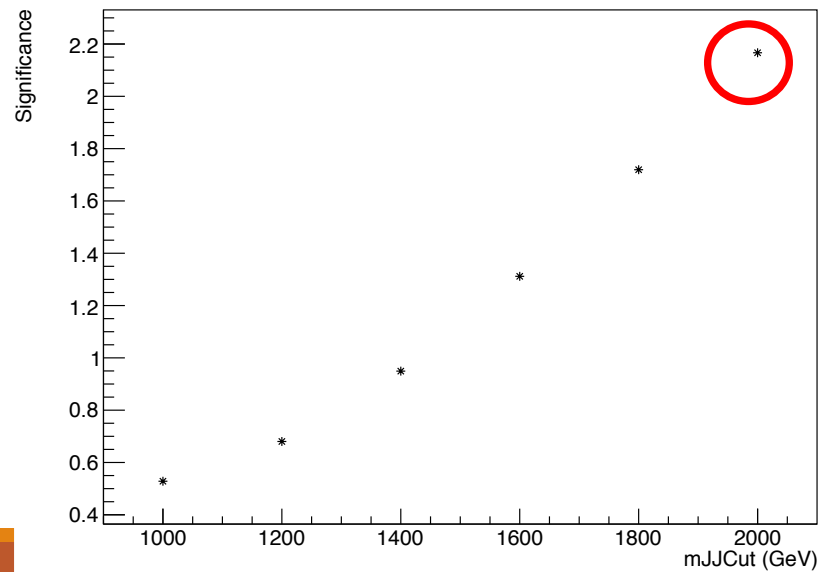
$M_{Z'} = 2000, w = 1\%$

Significance_M3000_W30



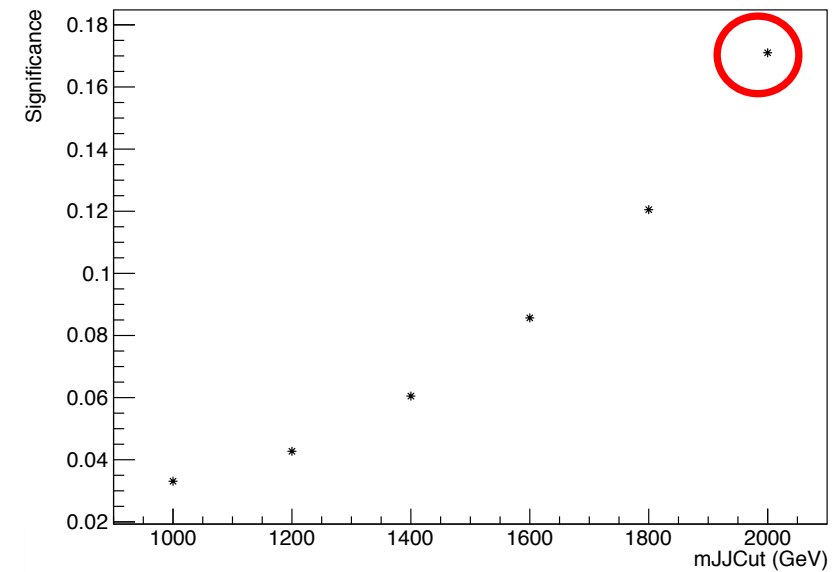
$\Lambda_{Z'} = 3000, w = 1\%$

Significance_M2500_W25



$M_{Z'} = 2500, w = 1\%$

Significance_M3500_W35

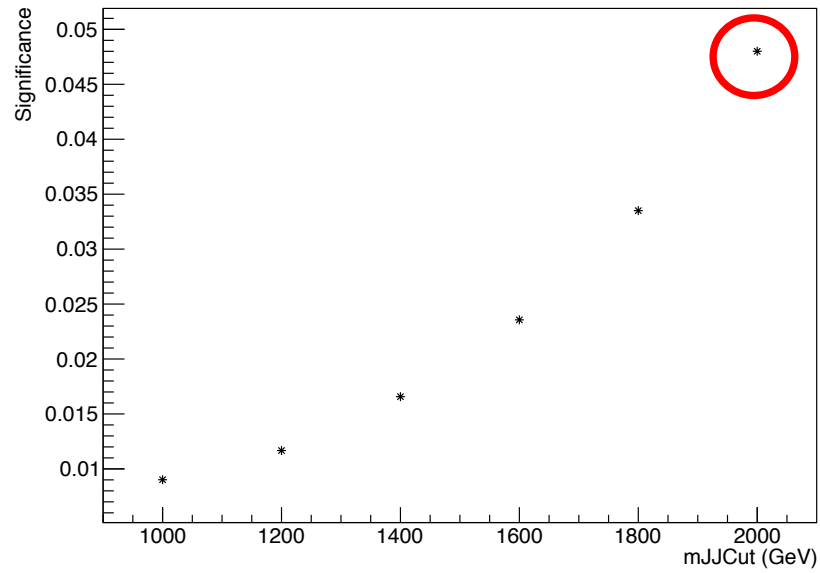


$\Lambda_{Z'} = 3500, w = 1\%$



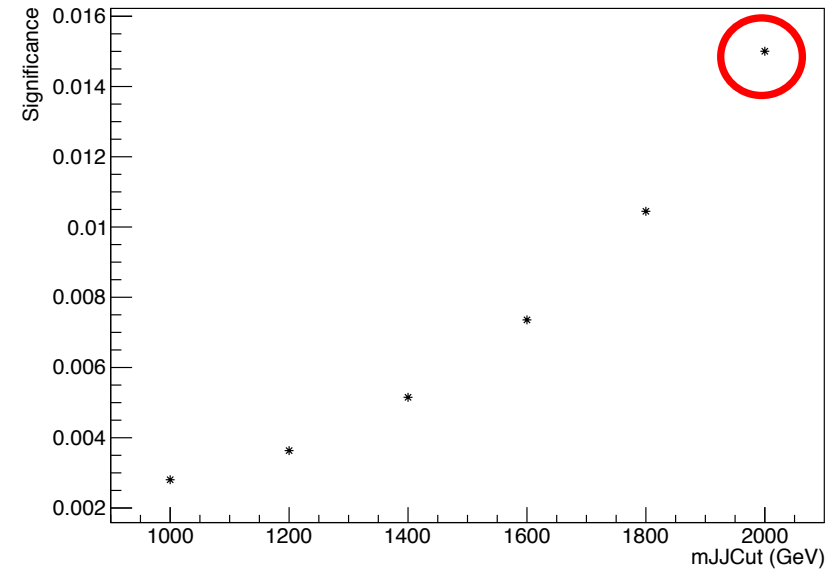
Significance Graphs (2017)

Significance_M4000_W40



$M_{Z'} = 4000$, $w = 1\%$

Significance_M4500_W45

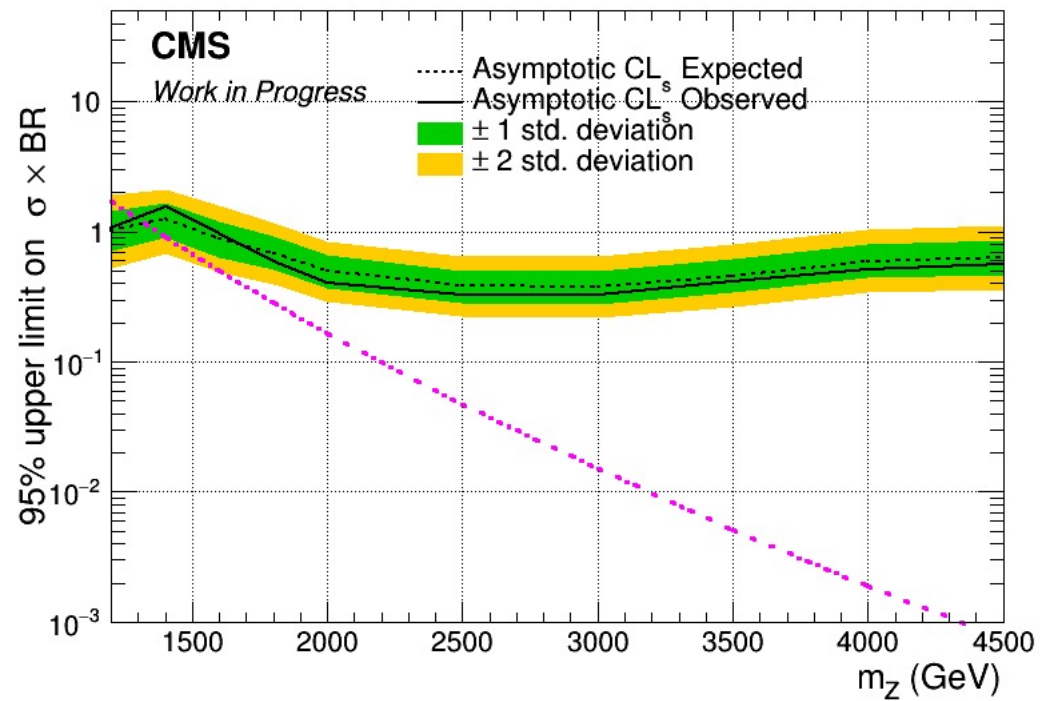


$M_{Z'} = 4500$, $w = 1\%$

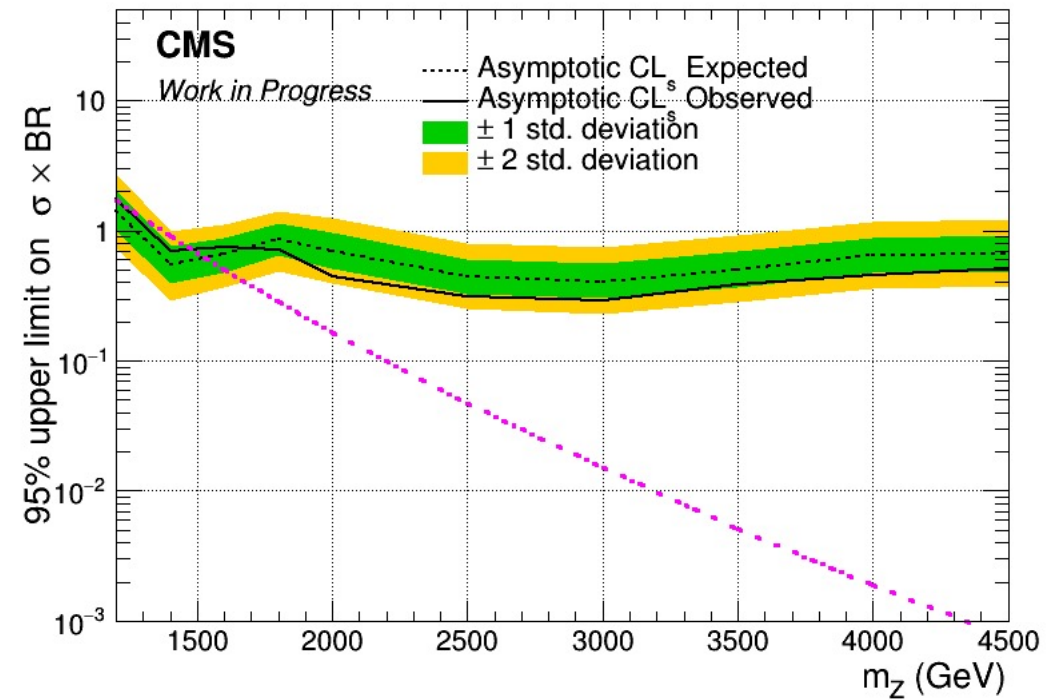


Brazilian Plots (2017)

$m_{JJ} > 1000$ GeV

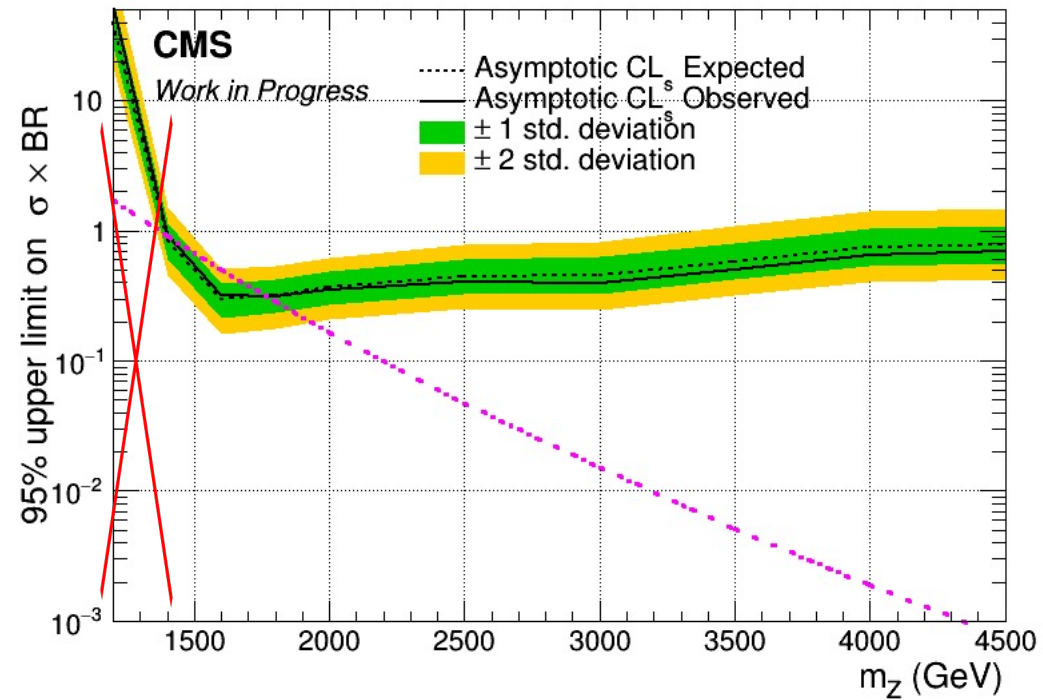


$m_{JJ} > 1200$ GeV

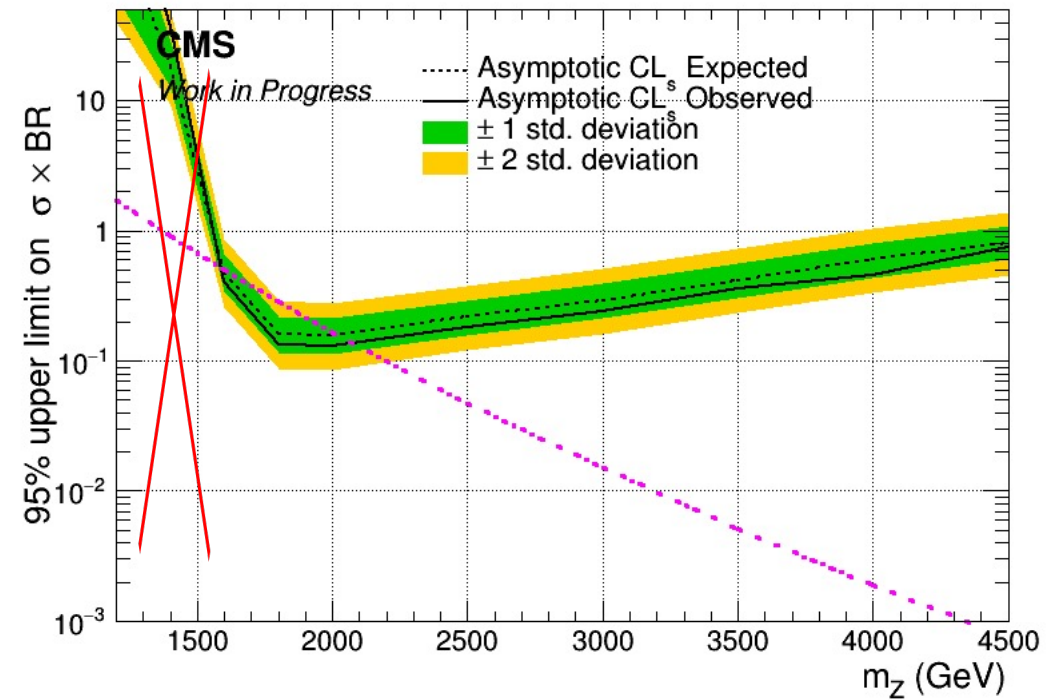


Asymptotic Limits - Brazilian Plots (2017)

$m_{JJ} > 1400$ GeV

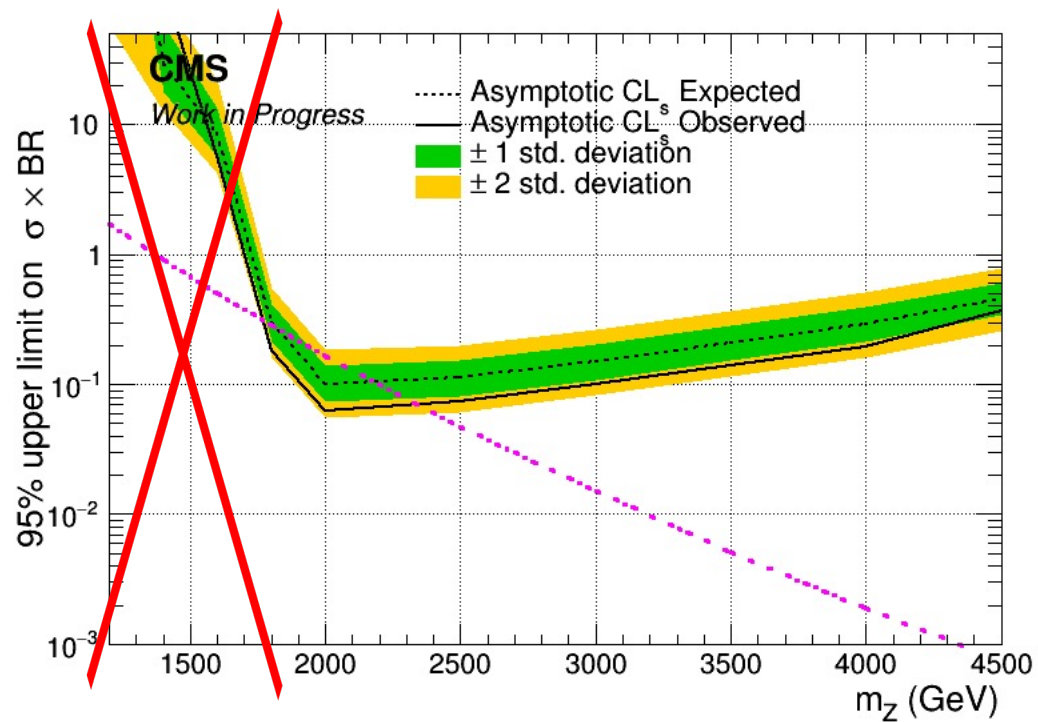


$m_{JJ} > 1600$ GeV



Brazilian Plots (2017)

$m_{JJ} > 1800$ GeV



$m_{JJ} > 2000$ GeV

