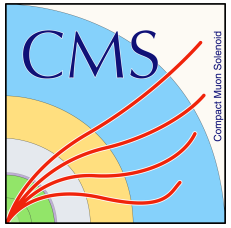
HEP NTUA
Weekly Report

17/5/2021

George Bakas



Summary

- ttX analysis:
  - Variation Handling
    - Validation with Giannis
    - JES, PS, PDF, Scale and bTag variations for 2017 and 2018
    - For each variation:
      - ❖ Histograms (0 and 2 btag), Response Matrices
      - ❖ Fit jetMassSoftDrop in Extended SR
      - ❖ Signal Extraction (Transfer Factors, etc)
      - ❖ Unfolding

- Z' analysis:
  - Sliding mJJ cut
  - Added Variations in Datacard
    - PS, PDF(RMS), Scale (RMS), bTag for 2017 and 2018
    - JES 2018 only
    - For each variation
      - Up, Down variation
      - Added it into datacard as ttbar variation
      - Brazilian Plots for 2017 and 2018

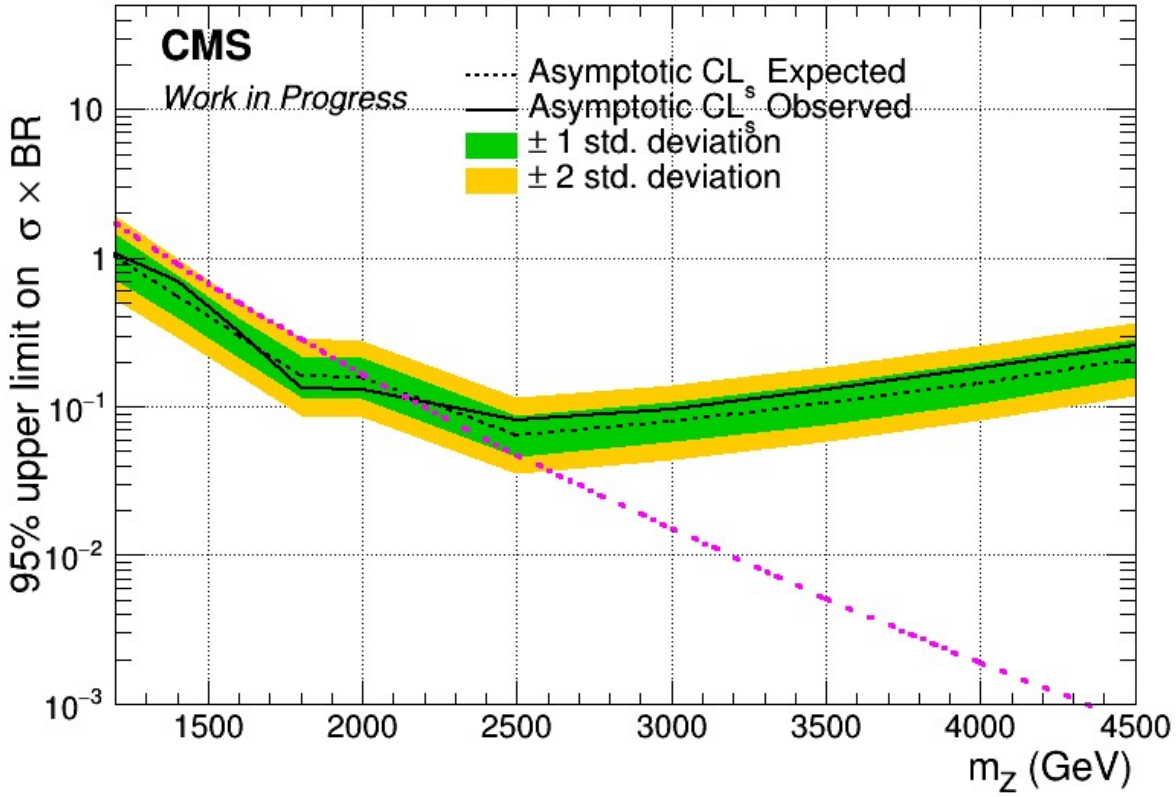
Datacard Summary (example for mJJ > 1600 GeV)

```
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
JES                 shapeN  -       -       -       1.0
btag                shapeN  -       -       -       1.0
*  autoMCStats  10  1
```

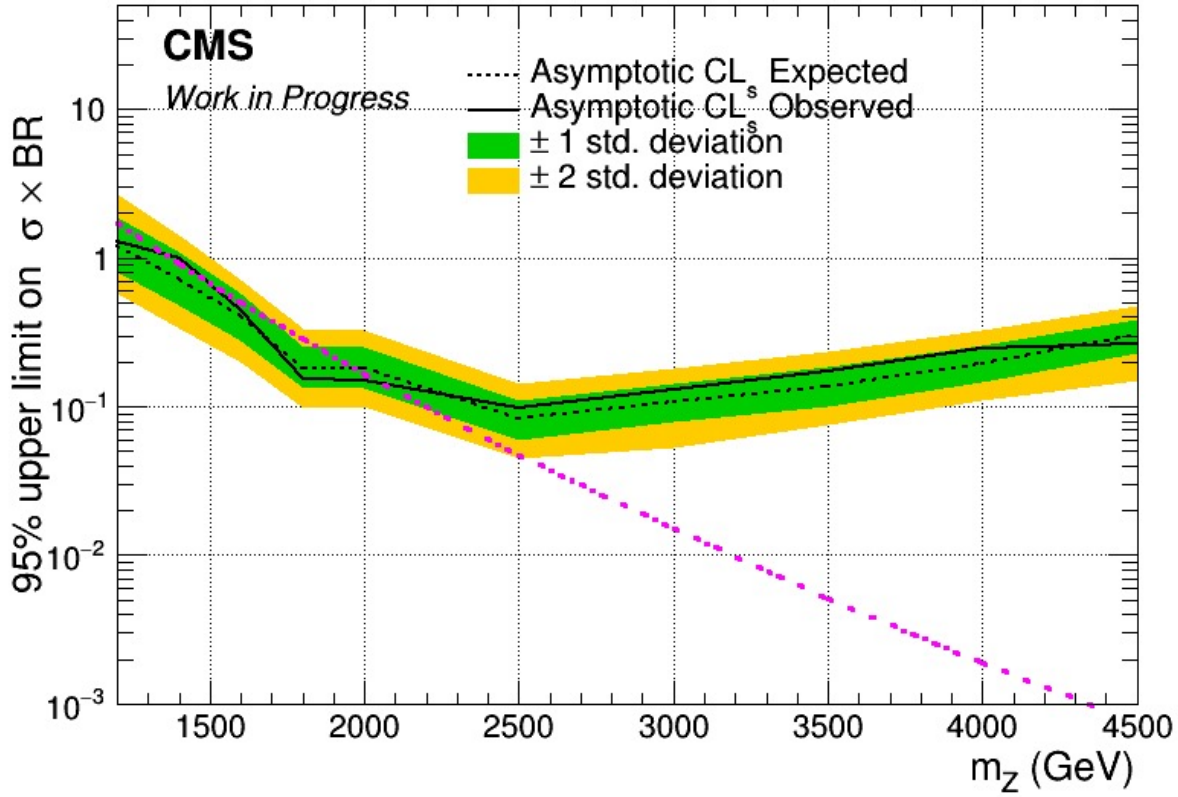
Brazilian Plots (2017 and 2018) with sliding mJJ Cut

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 (no JES)

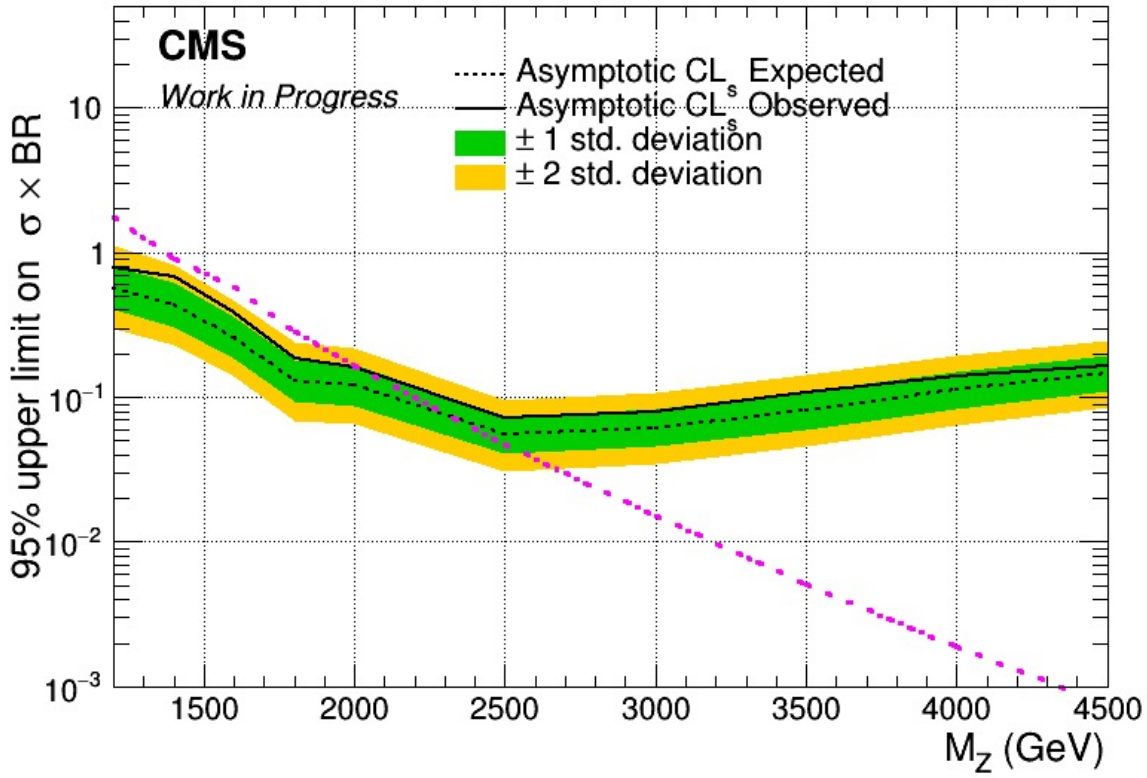


Brazilian Plots (2017 and 2018) with sliding mJJ Cut

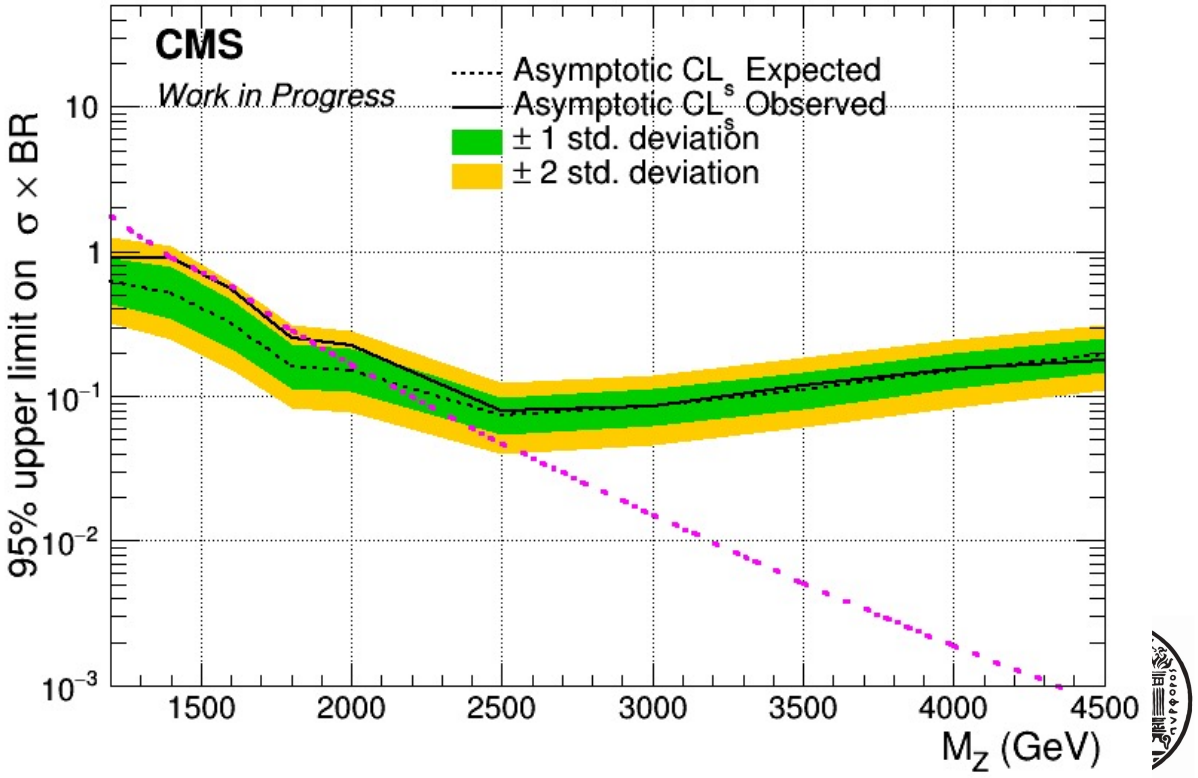
Mass Cut Mapping

{"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



ttX and Z' files UL (19 and 20)

- Two different issues in the Summer19 campaign:
  - A bug in Pythia related to fragmentation
    - Affects all years (2016/2017/2018)
    - Marginal/negligible effects.
  - A bug in the beamspot position that affects only (most of the) 2016 samples (both pre and post VFP)
    - The impact on physics (e.g. JECs, lepton impact parameter, etc...) is large
- Recommendation:
  1. For 2017 and 2018, Summer19 samples are allowed for analyses (and in fact used by many POGs for SF measurement), as long as the corresponding Summer 20 samples are missing
  2. For 2016, only Summer20 samples can be used.

- Z' UL files
  - We only have Z' 1% mass width files for 2016_preVFP (20UL), 2017 (both UL 19 and 20), 2018 (both UL 19 and 20)
  - Status of other files in production:
    - 0% for all Z' files !!

ttX and Z’ files UL (19 and 20)

B2G-RunIISummer20UL16MiniAOD-00473 ZPrimeToTT_M400_W40_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00474 ZPrimeToTT_M4000_W1200_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00475 ZPrimeToTT_M600_W60_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00476 ZPrimeToTT_M1000_W100_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00477 ZPrimeToTT_M4500_W1350_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00478 ZPrimeToTT_M900_W90_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00479 ZPrimeToTT_M3000_W900_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00480 ZPrimeToTT_M500_W50_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00481 ZPrimeToTT_M3500_W1050_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00482 ZPrimeToTT_M1200_W120_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00483 ZPrimeToTT_M1400_W140_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00484 ZPrimeToTT_M2500_W750_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00485 ZPrimeToTT_M800_W80_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL16MiniAOD-00486 ZPrimeToTT_M2000_W600_TuneCP2_13TeV-madgraph-pythia8	Expected: **230k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats

ttX and Z’ files UL (19 and 20)

B2G-RunIISummer20UL17MiniAOD-00467 ZPrimeToTT_M1800_W180_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00468 ZPrimeToTT_M700_W70_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00469 ZPrimeToTT_M500_W50_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00470 ZPrimeToTT_M1600_W160_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00471 ZPrimeToTT_M800_W80_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00472 ZPrimeToTT_M600_W60_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00473 ZPrimeToTT_M1200_W120_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00474 ZPrimeToTT_M1000_W100_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00475 ZPrimeToTT_M900_W90_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00476 ZPrimeToTT_M4000_W1200_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00477 ZPrimeToTT_M2000_W200_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00478 ZPrimeToTT_M4500_W1350_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00479 ZPrimeToTT_M2500_W250_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL17MiniAOD-00480 ZPrimeToTT_M1400_W140_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats

ttX and Z’ files UL (19 and 20)

B2G-RunIISummer20UL18MiniAOD-00466 ZPrimeToTT_M4500_W1350_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00467 ZPrimeToTT_M600_W60_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00468 ZPrimeToTT_M1000_W100_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00469 ZPrimeToTT_M400_W40_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00470 ZPrimeToTT_M4000_W1200_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00471 ZPrimeToTT_M1400_W140_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00472 ZPrimeToTT_M1200_W120_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00473 ZPrimeToTT_M500_W50_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00474 ZPrimeToTT_M1800_W540_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00475 ZPrimeToTT_M3500_W1050_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00476 ZPrimeToTT_M800_W80_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00477 ZPrimeToTT_M2500_W750_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00478 ZPrimeToTT_M900_W90_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats
B2G-RunIISummer20UL18MiniAOD-00479 ZPrimeToTT_M1800_W180_TuneCP2_13TeV-madgraph-pythia8	Expected: **500k**	Produced: **0**	0%	Priority: **85011**	Show in DAS Show in Stats

BACKUP

Summary Z' Analysis

- Switch to mJJ > 1000 GeV cut:
  - No sensitivity for higher Z' masses (> 2.5 TeV)
  - Calculate significanceD and Asymptotic for different mJJ cuts
    - mJJ Cuts: [1000, 1200, 1400, 1600, 1800, 2000] GeV
    - $Significance = \frac{Signal}{\sqrt{Signal+Bkg}}$ where signal is the Z' distribution and $Bkg := ttbar + QCD + Subdominant$

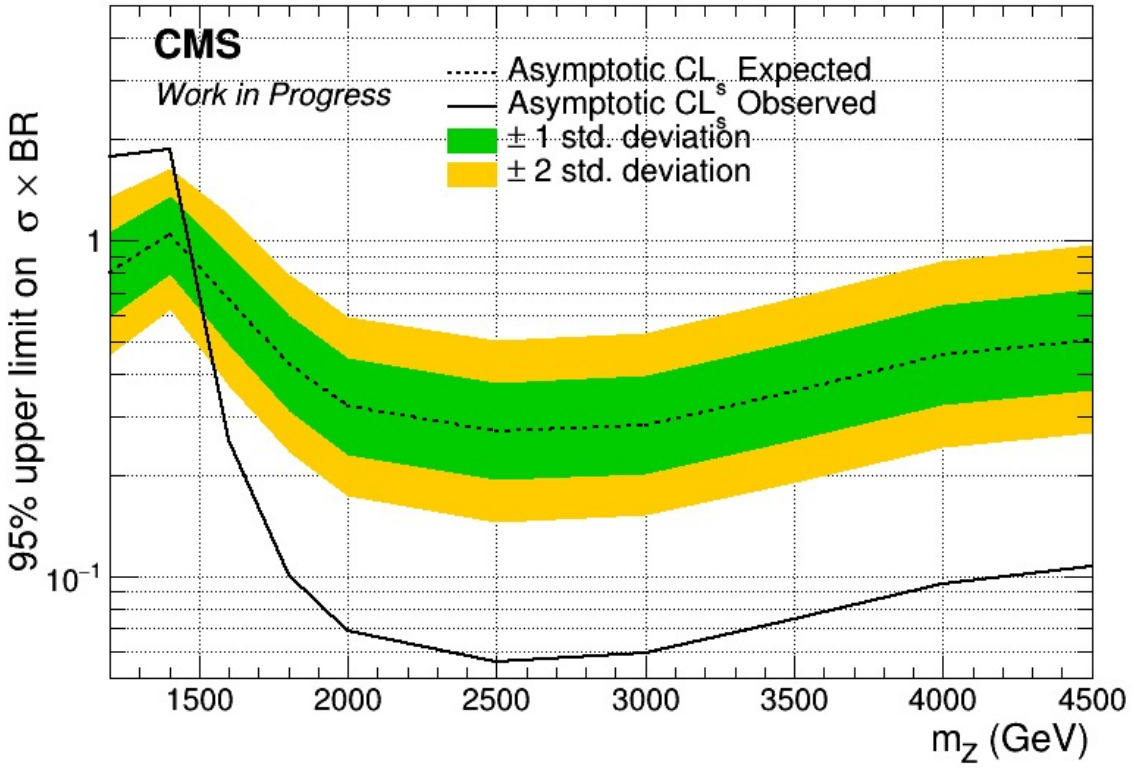
  - I was using ttbar as the extracted signal from data: Instead, I use the ttbar MC distribution (scaled to the signal strength)
  - For QCD I use the QCD MC distribution which is scaled to data (using k-factor)

  - Sliding mJJ 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)

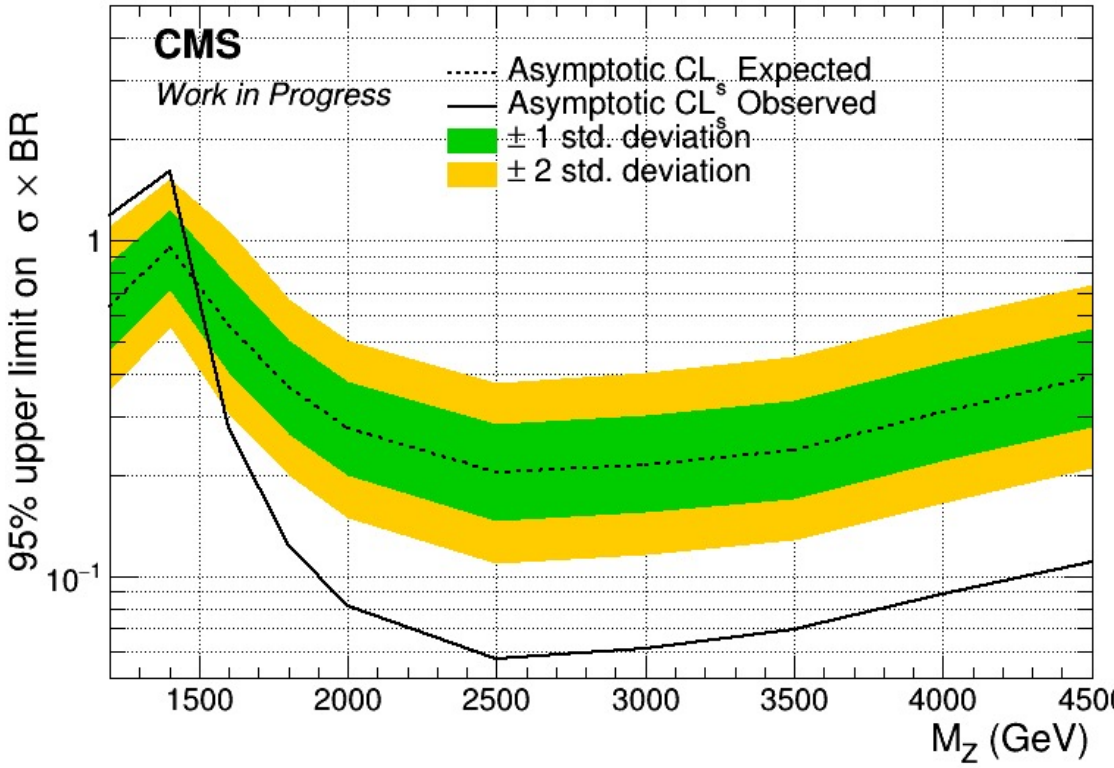
Angular Distributions (Brazilian Plot using data!!!!)

Assymptotic 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



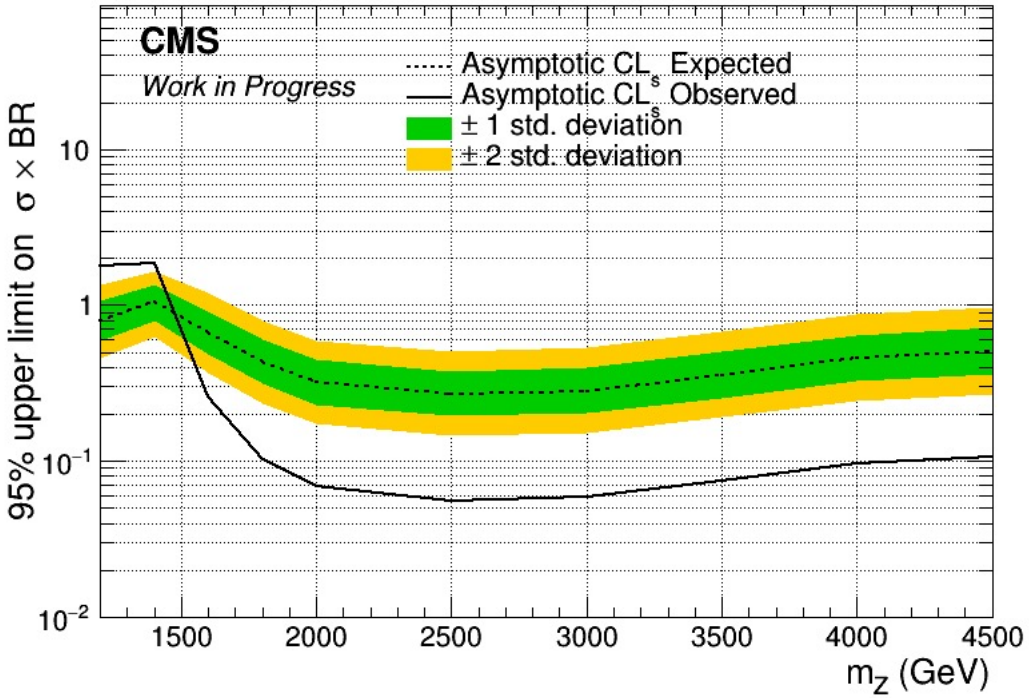
2018



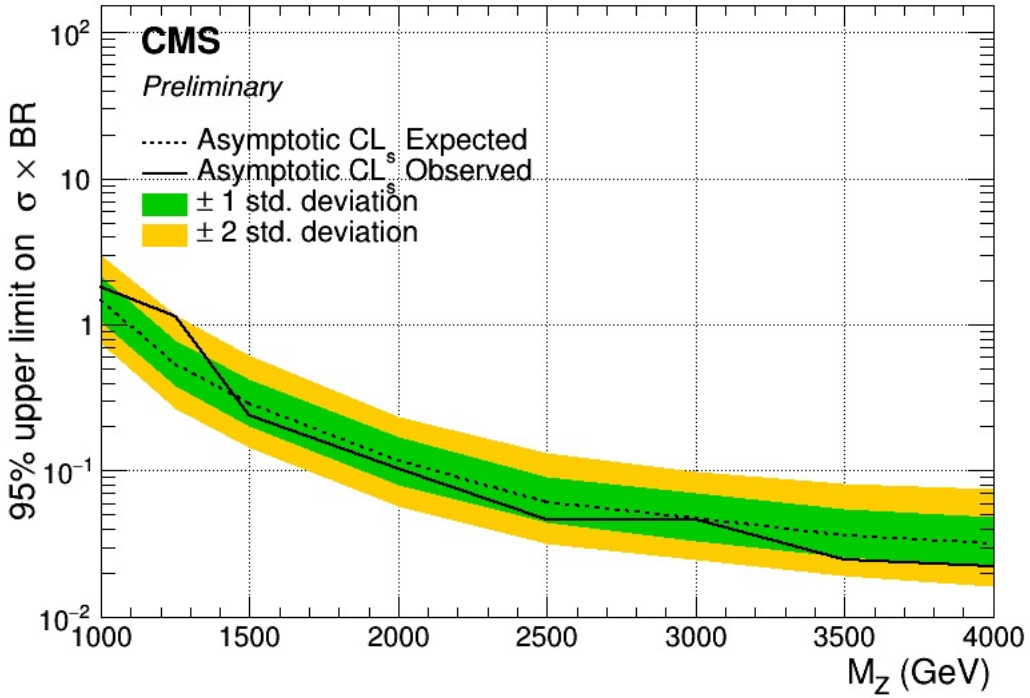
Angular Distributions (Brazilian Plot using extracted signal!!) vs B2G-16-015

Assymptotic 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



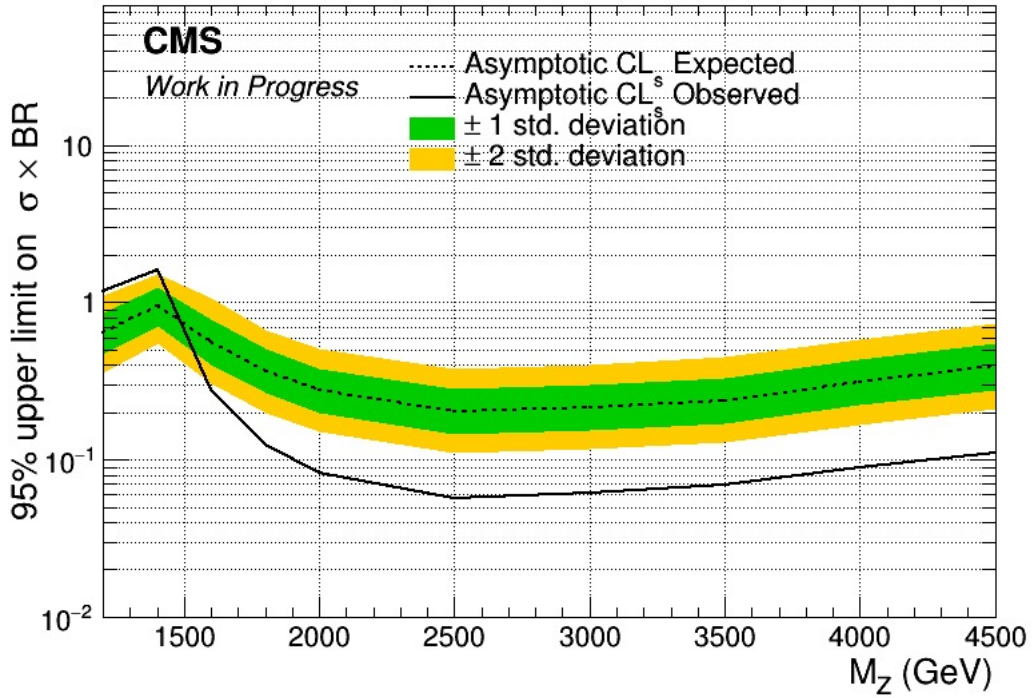
B2G-16-015



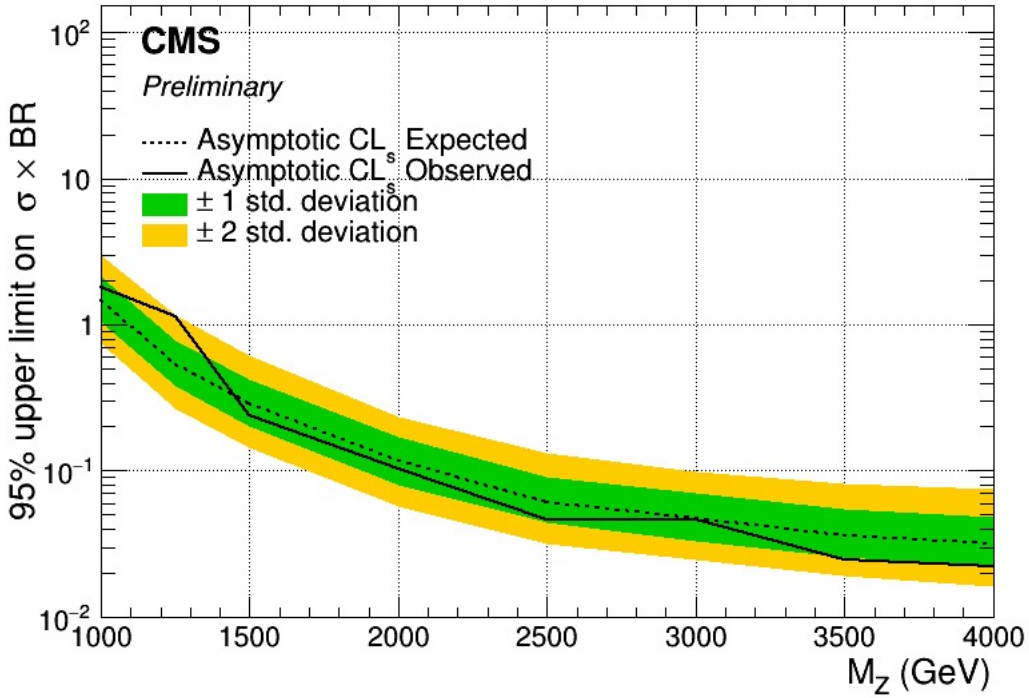
Angular Distributions (Brazilian Plot using extracted signal!!) vs B2G-16-015

Assymptotic 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 x

- 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:

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

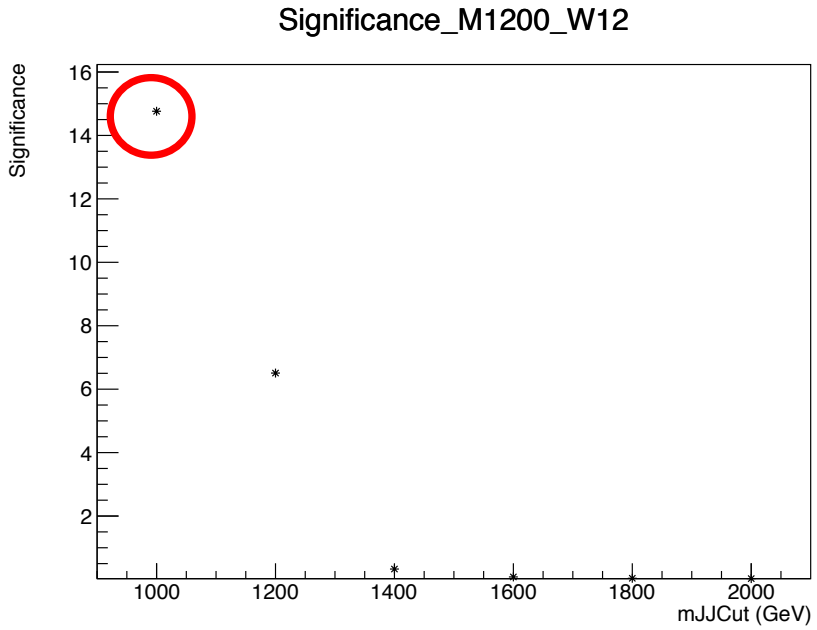
X is defined as $\chi = e^{|y^*|} = e^{|y_1 - y_2|}$ (1) and can be measured by creating the TLorentzVector, boost it to the ZMF and find the rapidity difference of the two leading jets

2. By measuring the scattering angle θ* (angle between top quark and z-axis in the Zero Momentum Frame)
We define as $y^* = \frac{1}{2}\ln(\frac{1+|cos\theta^*|}{1-|cos\theta^*|})$ and from (1) we can find that:

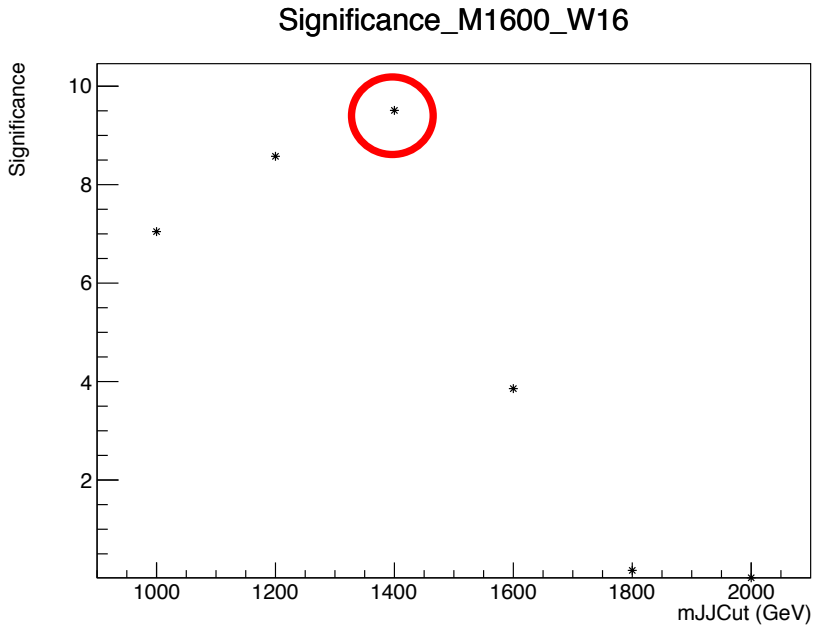
$$\chi = \frac{1 + |cos\theta^*|}{1 - |cos\theta^*|}$$

Significance Graphs (2017)

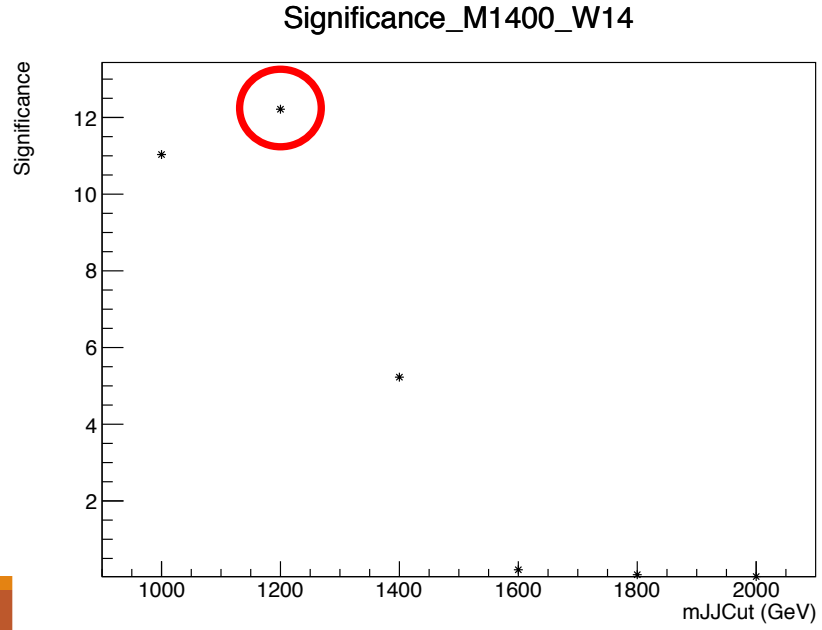
$M_{z'}$ =1200, w = 1%



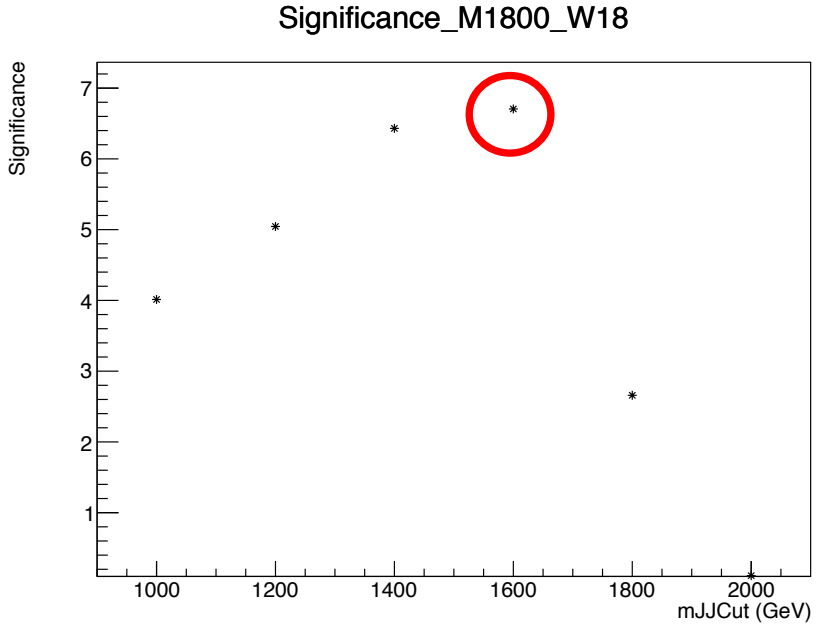
$M_{z'}$ =1600, w = 1%



$M_{z'}$ =1400, w = 1%

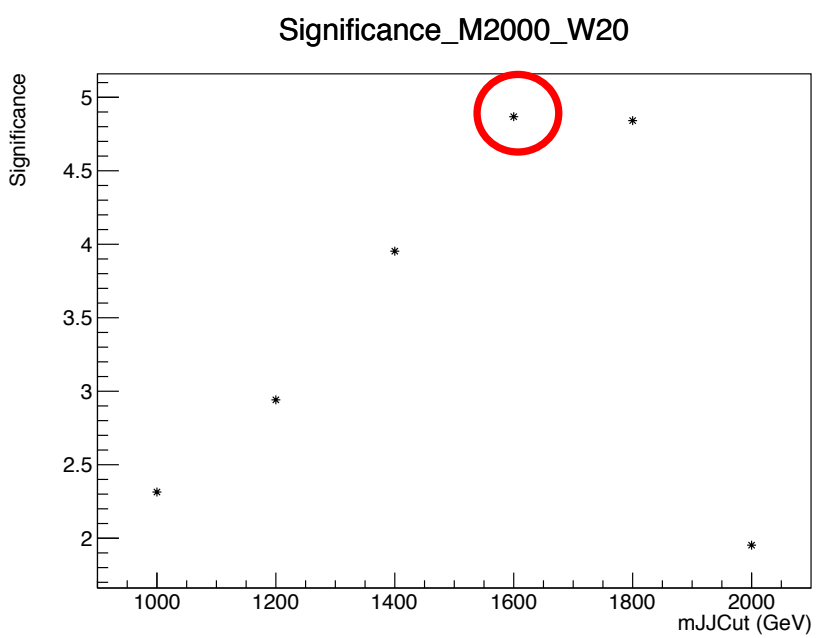


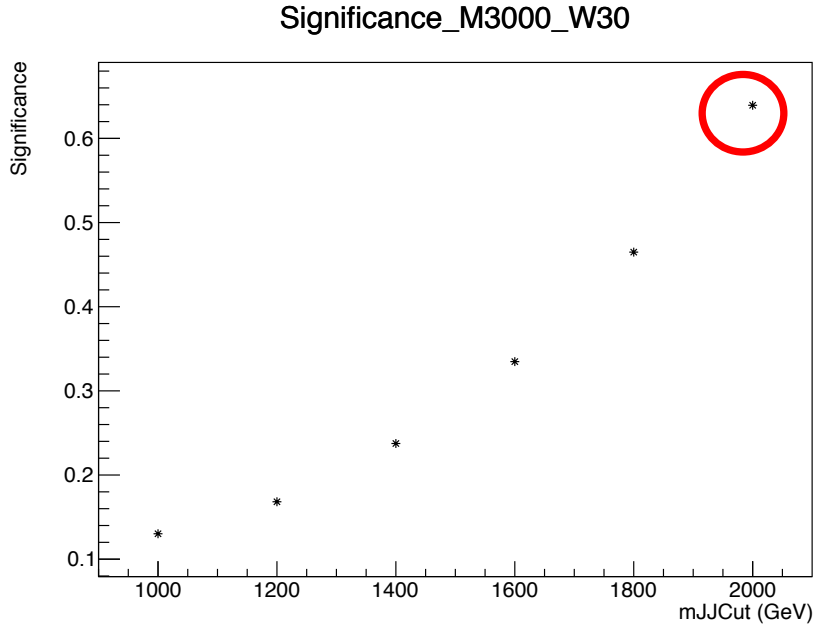
$M_{z'}$ =1800, w = 1%



Significance Graphs (2017)

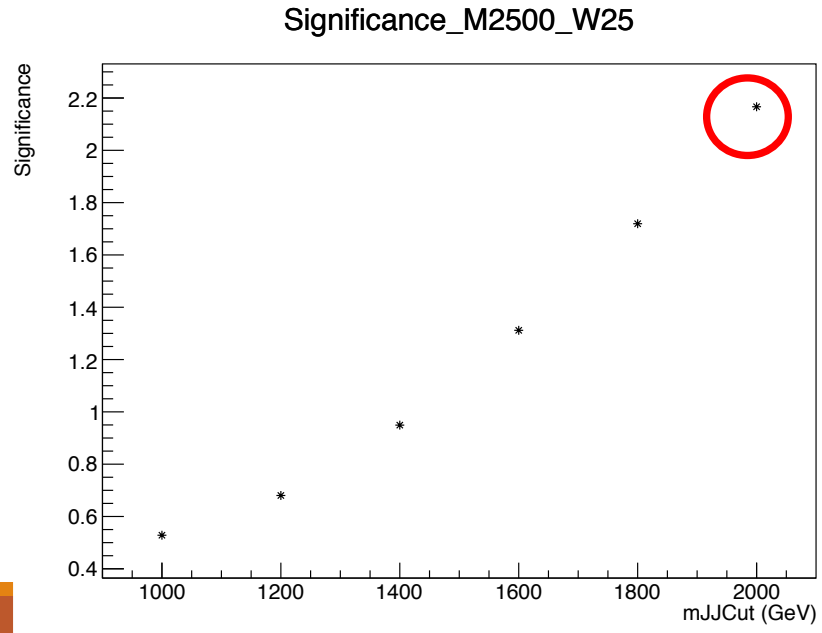
$M_{z'}$ =2000, w = 1%

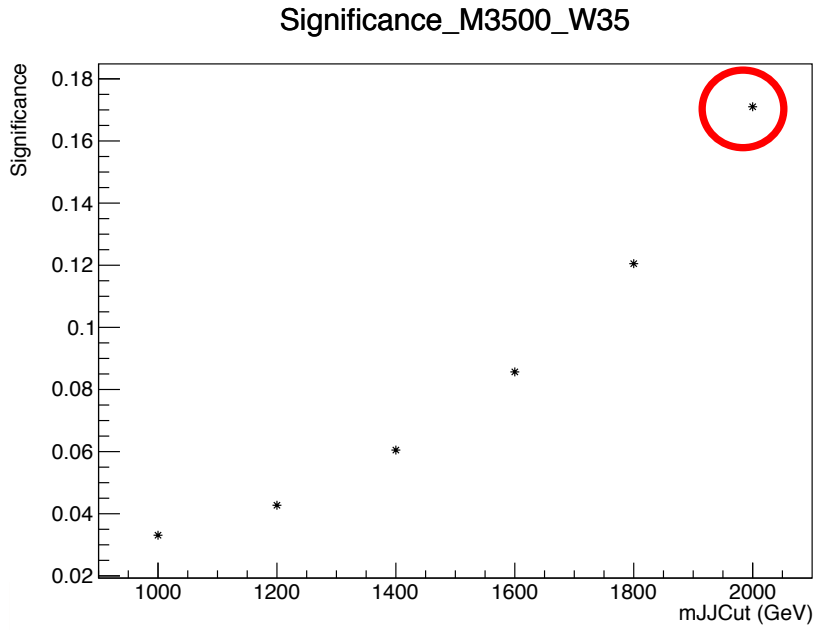




$M_{z'}$ =3000, w = 1%

$M_{z'}$ =2500, w = 1%

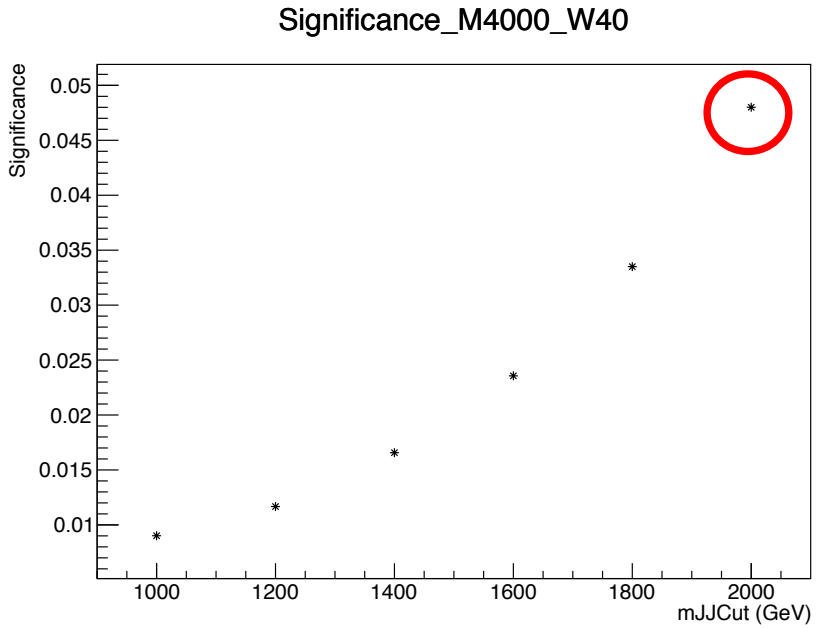


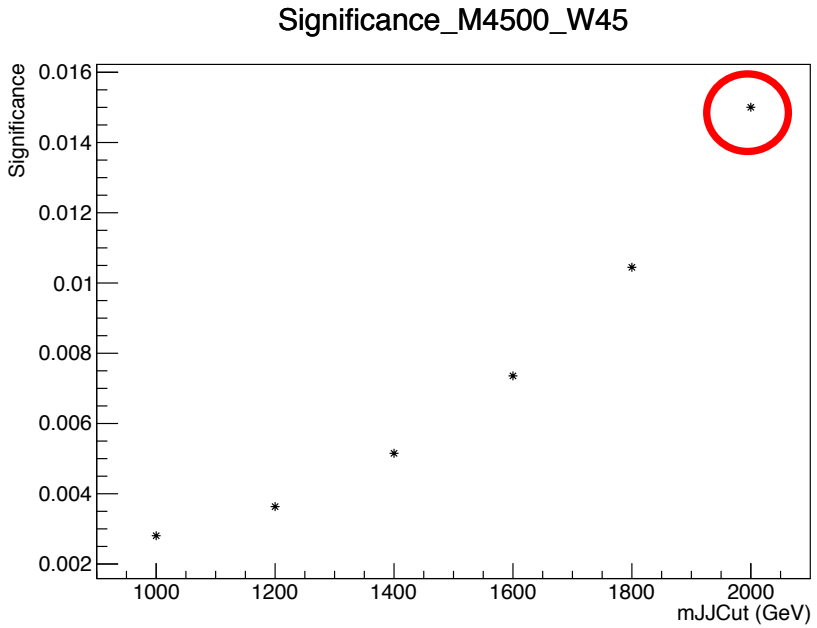


$M_{z'}$ =3500, w = 1%

Significance Graphs (2017)

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

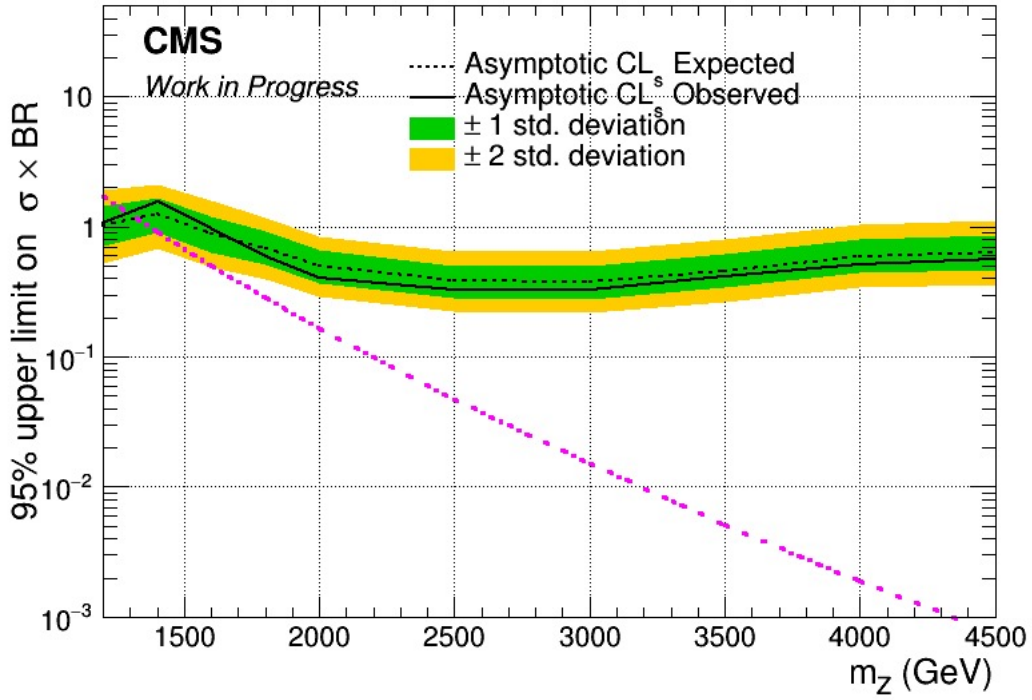




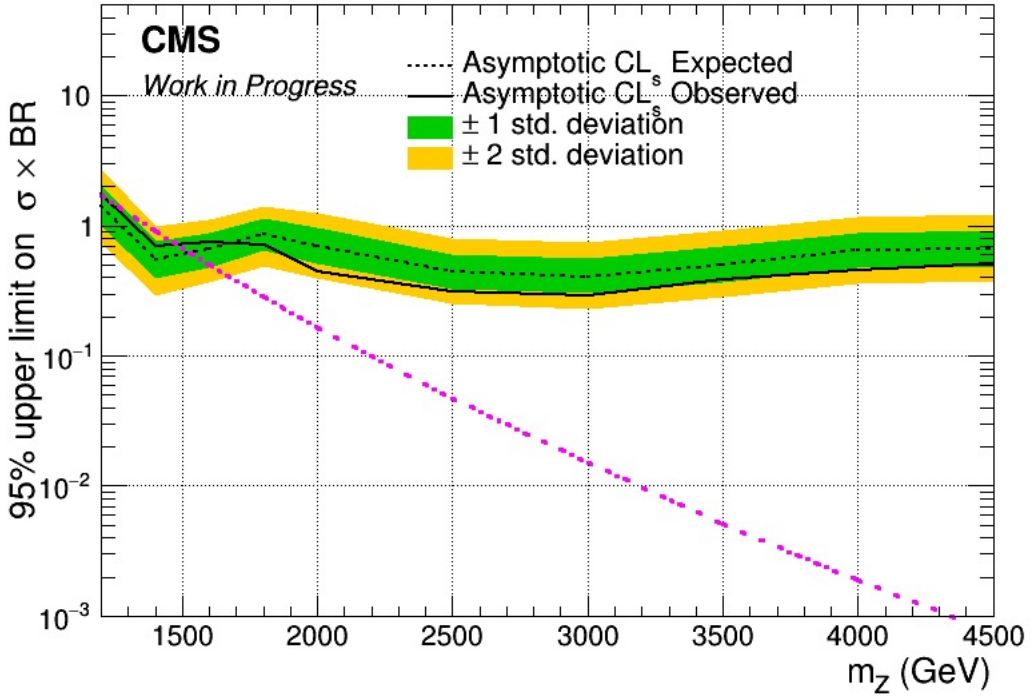
$M_{Z'}$ =4500, w = 1%

Brazilian Plots (2017)

mJJ > 1000 GeV

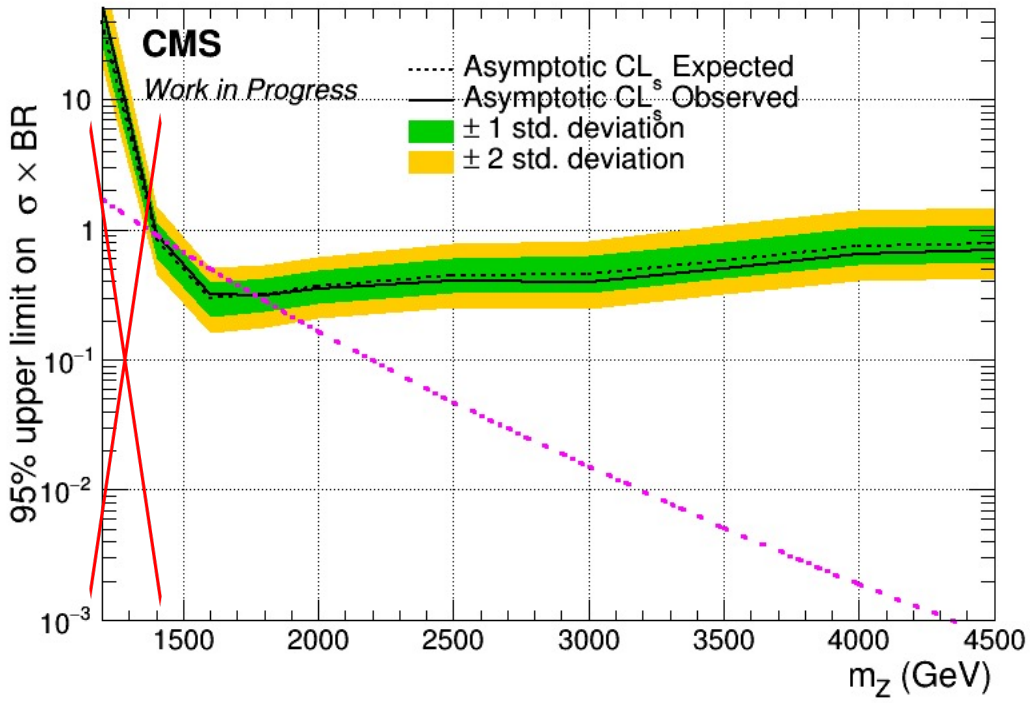


mJJ > 1200 GeV

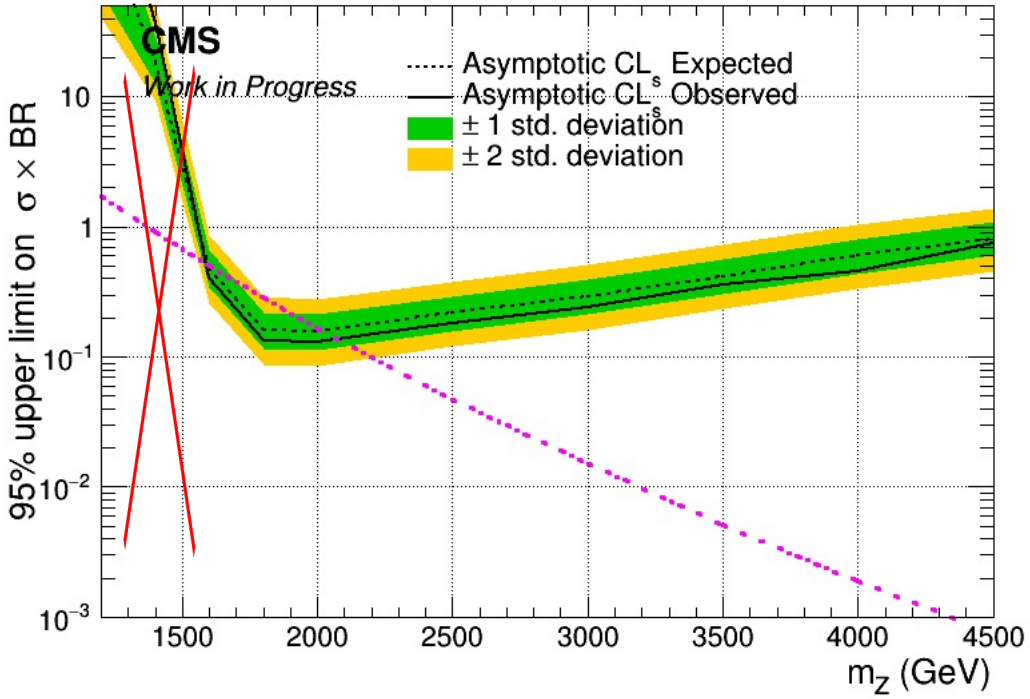


Asymptotic Limits - Brazilian Plots (2017)

mJJ > 1400 GeV

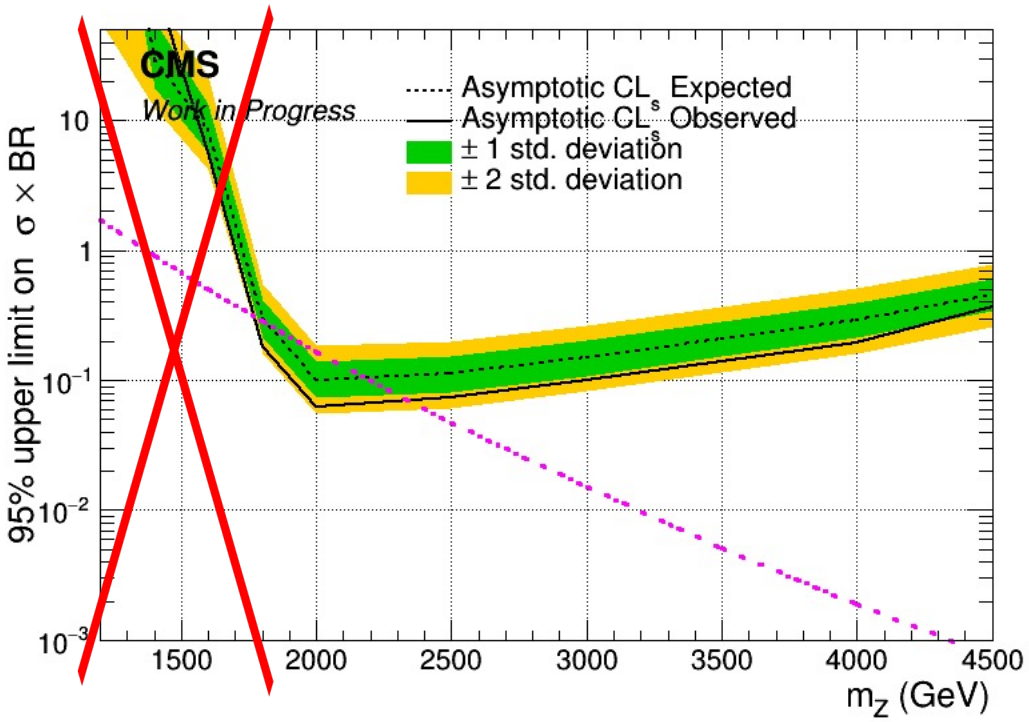


mJJ > 1600 GeV



Brazilian Plots (2017)

mJJ > 1800 GeV



mJJ > 2000 GeV