Analysis Review: Update

15 February 2023

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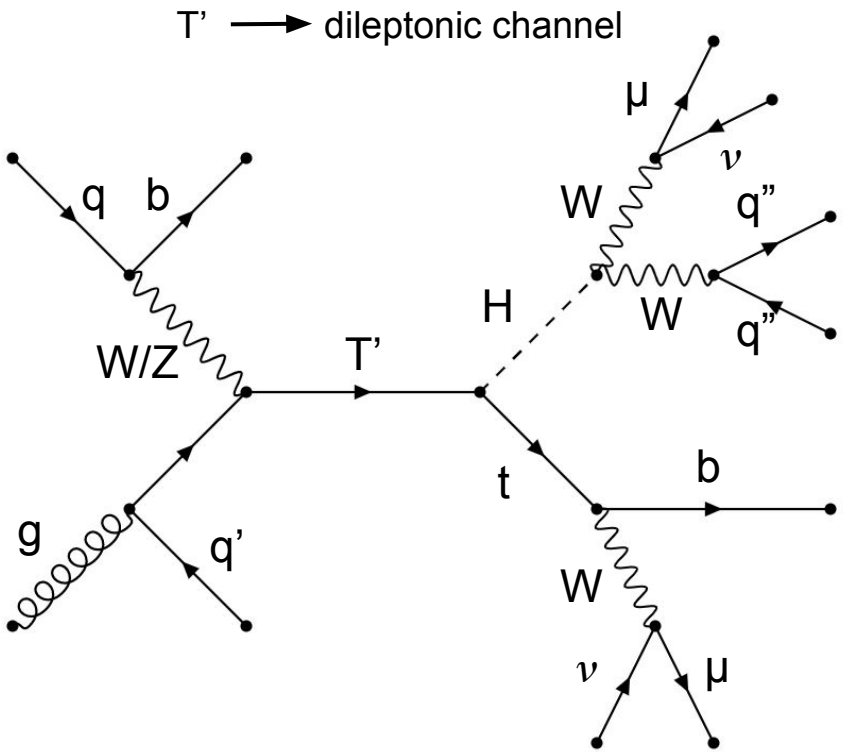


Current analysis:

Identification of the muons: tight ID, Pt > 20 GeV, |eta| < 2.4, Muon_sip3d < 3 and Muon_miniPFRelIso_all < 0.05.

Identification of the electrons: tight ID, Pt > 25 GeV, |eta| < 2.5, Electron_sip3d < 3 and Electron_miniPFRelIso_all < 0.05.

Cut 0: 2 Leptons SS with Sum of Pt of the two leptons > 160 GeV.

Cut 1: at least 3 jets with at least one b-jet (b-tag medium) of Pt > 50 GeV.

Cut 2: minimum of the invariant mass of the three jets with a least one b-jet > 34 GeV (Mass of the top +/- 2σ).

Cut 3: DeltaR between the two leptons > 1.8.

Adding all the mass point values:

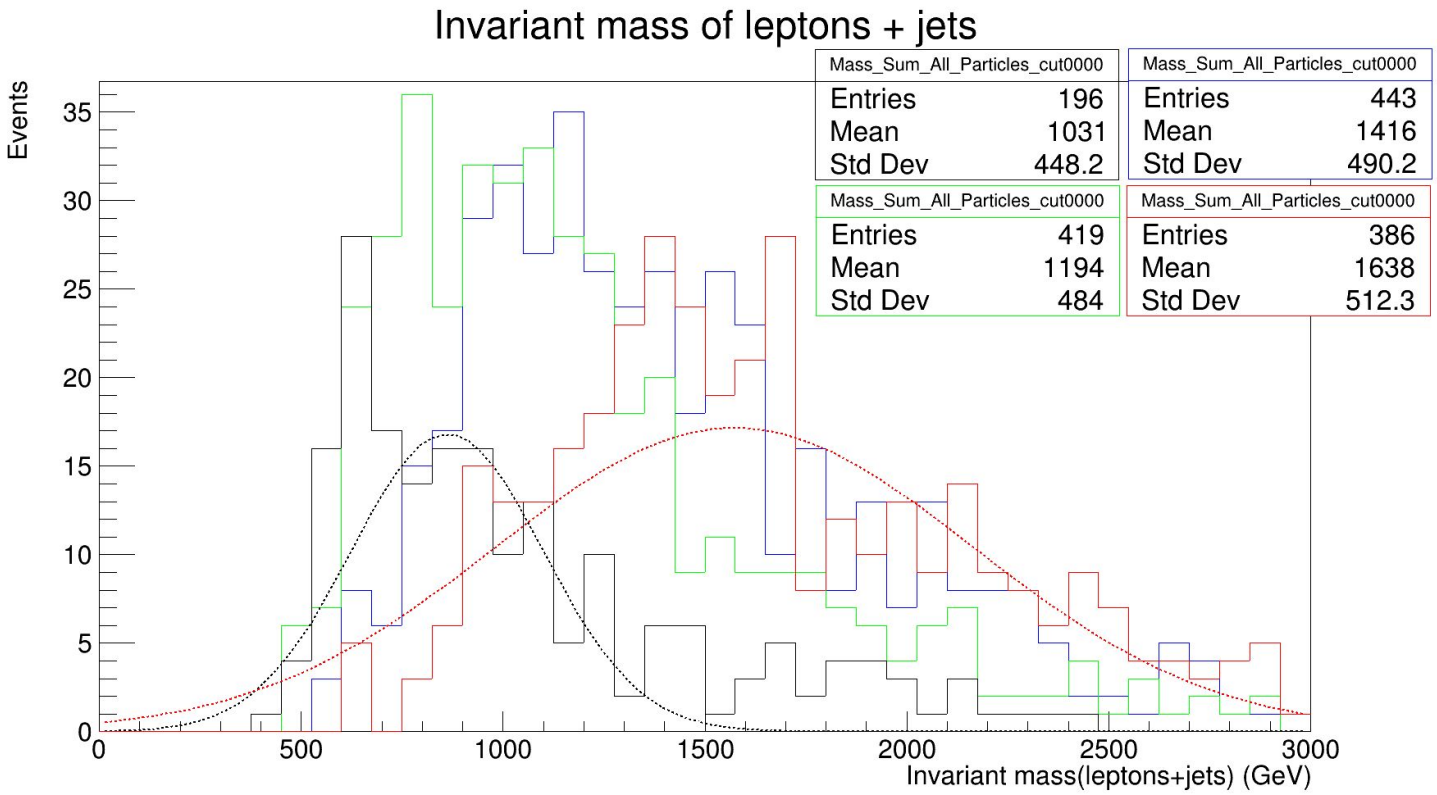
T' Mass (GeV)	Cross-section (fb)
600	176.4
625	148.9
650	121.3
675	105.0
700	88.6
800	45.9
900	25.1
1000	14.5

T' Mass (GeV)	Cross-section (fb)
1100	8.67
1200*	5.36
1300	3.39
1400	2.19
1500	1.45
1600	0.974
1700	0.663
1800	0.458

*: no dataset for UL18

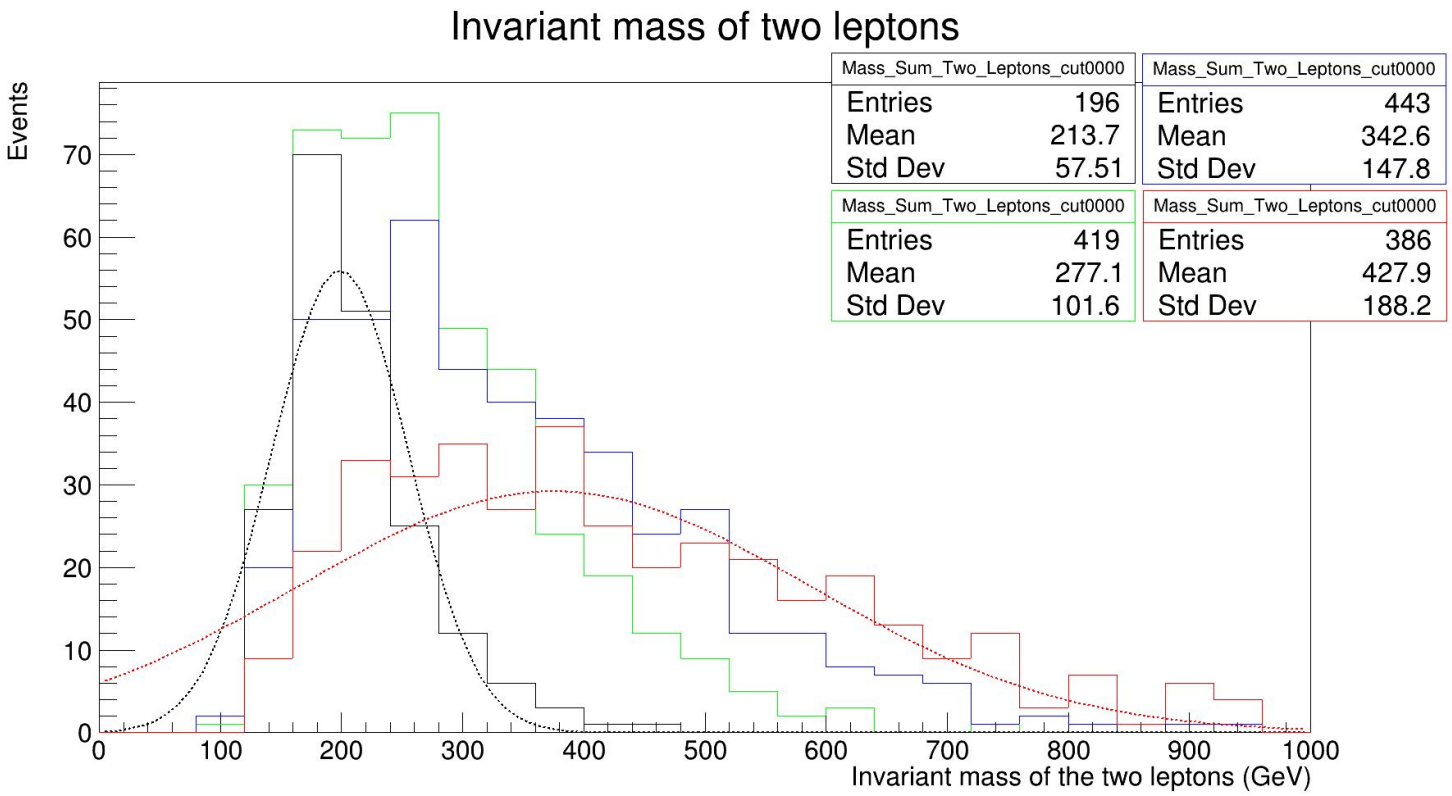
Checking new variables of interest:

- Invariant (leptons + jets) mass.
- Invariant dilepton mass.



600 GeV: black
900 GeV: green
1300 GeV: blue
1800 GeV: red

The invariant (leptons + jets) mass is dependant of the T' mass.
The signal shape is roughly gaussian.



600 GeV: black
900 GeV: green
1300 GeV: blue
1800 GeV: red

Same conclusion for the invariant dilepton mass with a better resolution for the gaussian fit.

After selection:

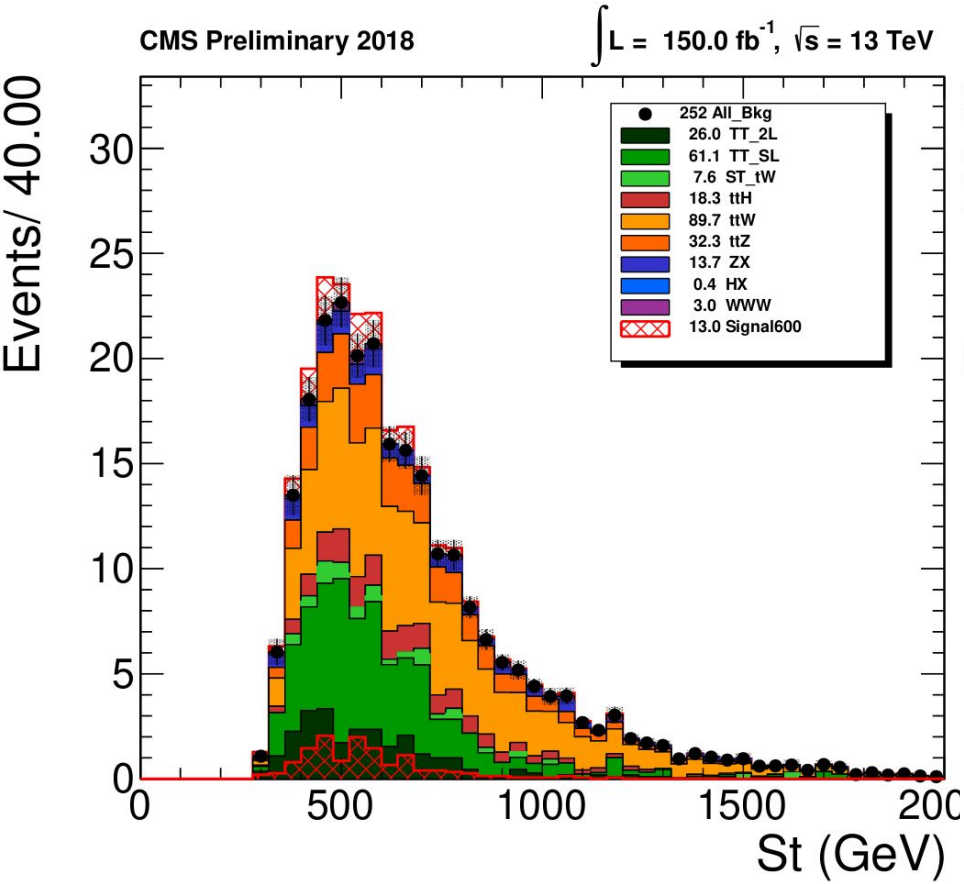
T' Mass (GeV)	Cross-section (fb)	Signal events	Background events	S/B
600	176.4	13.0	253.5	5.13%
625	148.9	11.6	253.5	4.58%
650	121.3	8.9*	253.5	3.51%
675	105.0	10.5	253.5	4.14%
700	88.6	8.6	253.5	3.39%
800	45.9	5.8	253.5	2.29%
900	25.1	3.9	253.5	1.54%
1000	14.5	2.3	253.5	0.91%

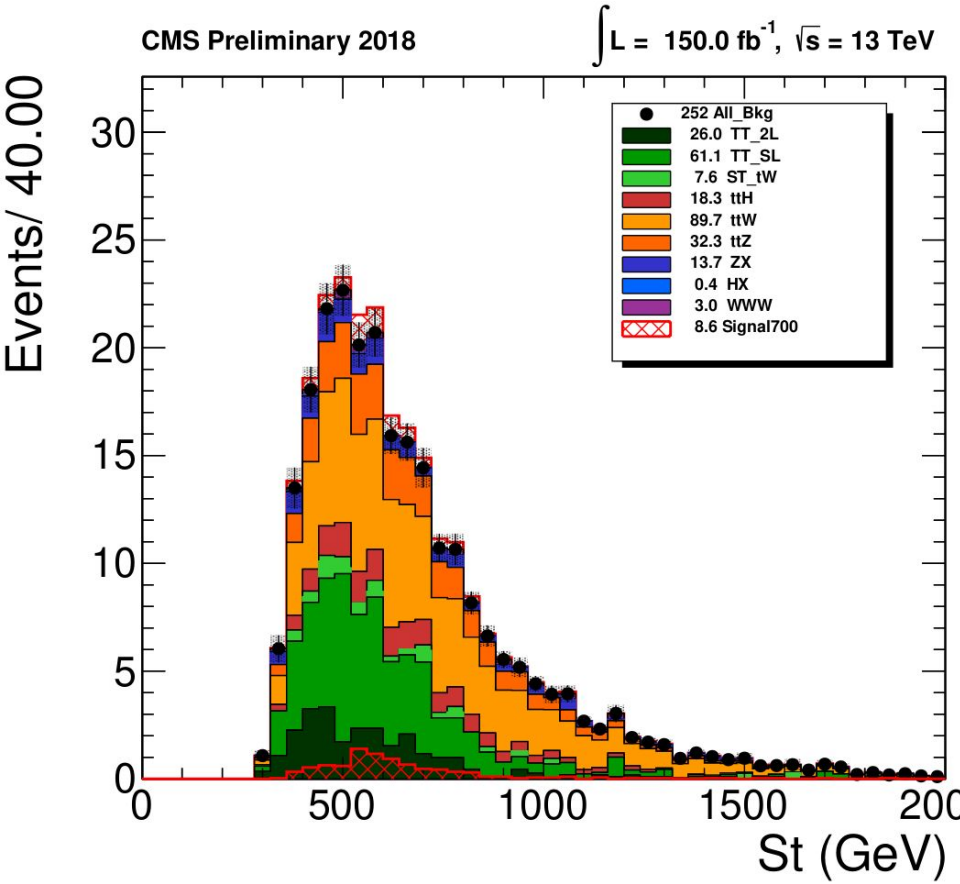
T' Mass (GeV)	Cross-section (fb)	Signal events	Background events	S/B
1100	8.67	1.5	253.5	0.59%
1300	3.39	0.57	253.5	0.22%
1400	2.19	0.38	253.5	0.15%
1500	1.45	0.24	253.5	0.09%
1600	0.974	0.15	253.5	0.06%
1700	0.663	0.09	253.5	0.03%
1800	0.458	0.07	253.5	0.03%

*: drop of statistics for 650 GeV

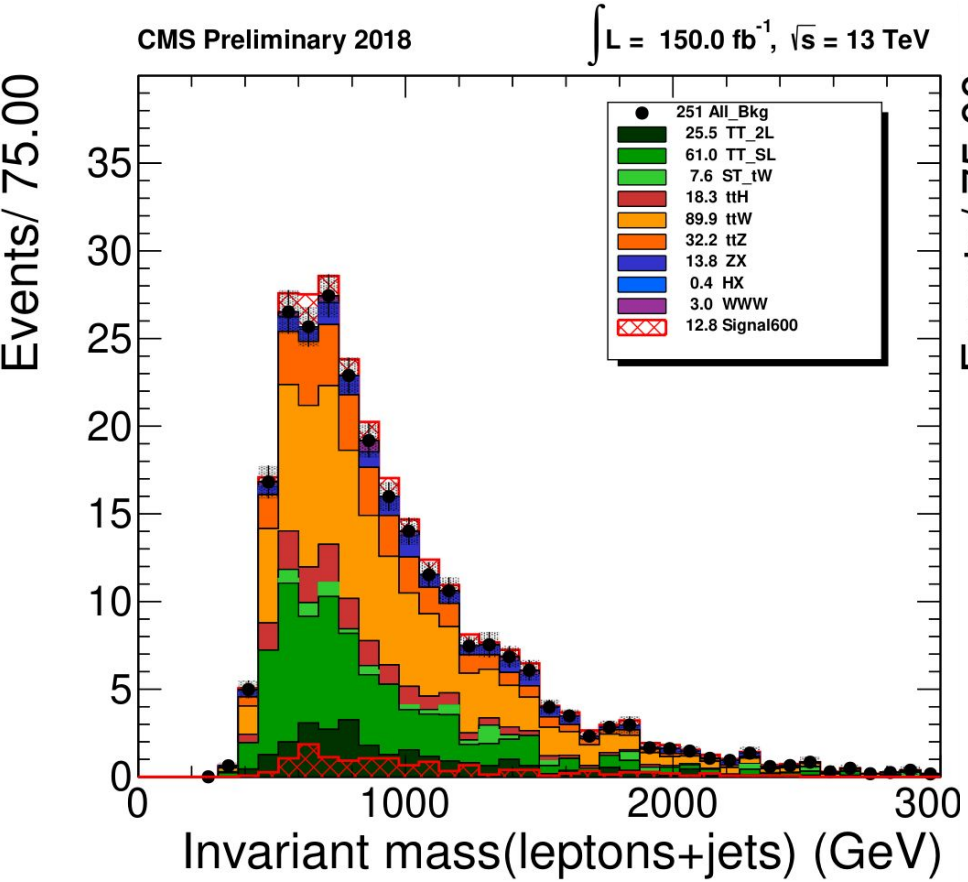
The number of events is very low above 800 GeV (the whole Run 2 statistics need to be added).

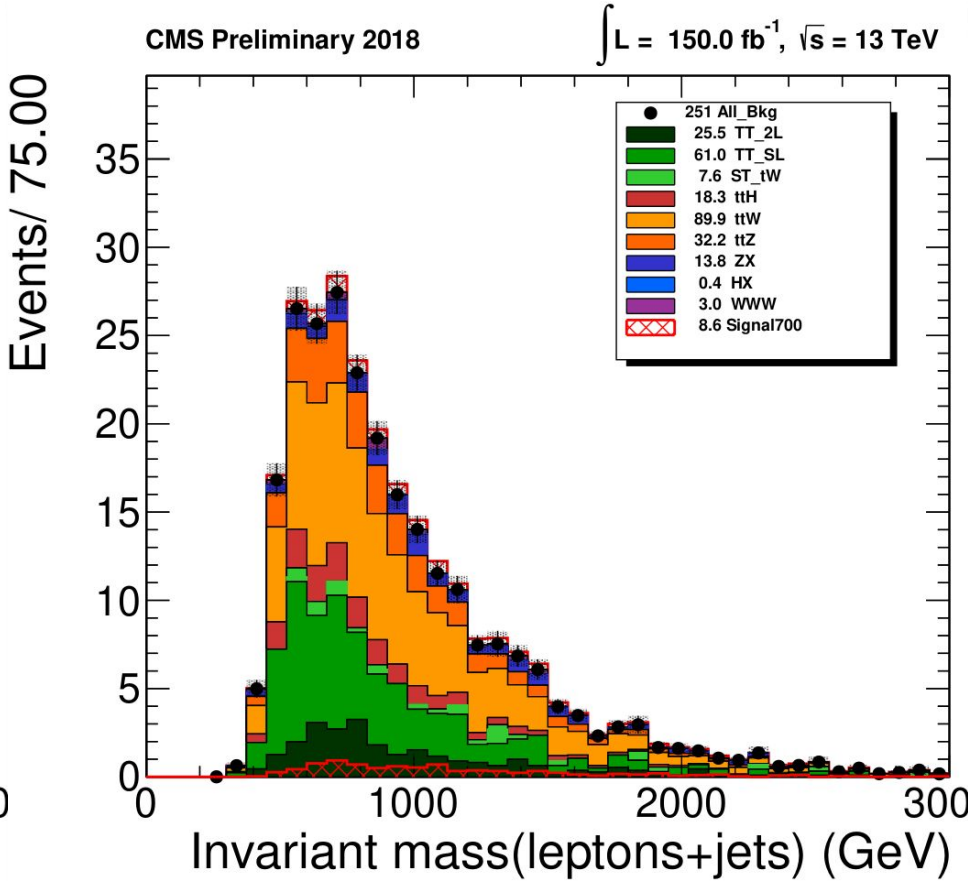
St after the full selection (600 GeV vs 700 GeV)



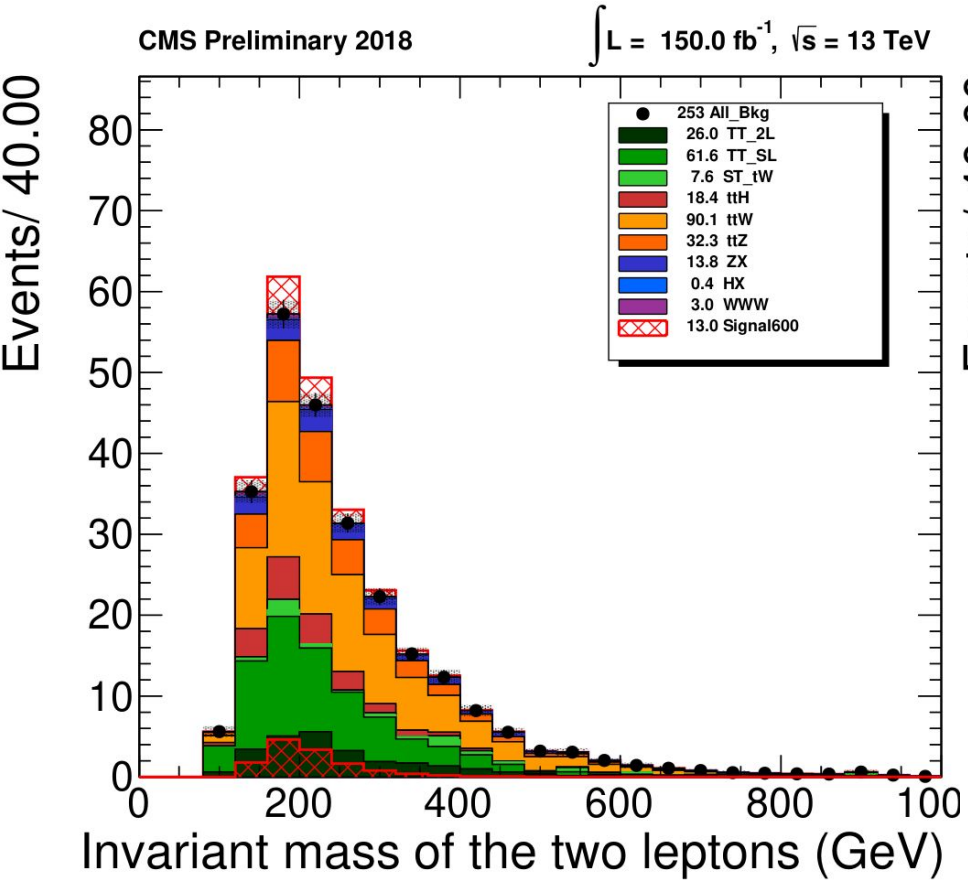


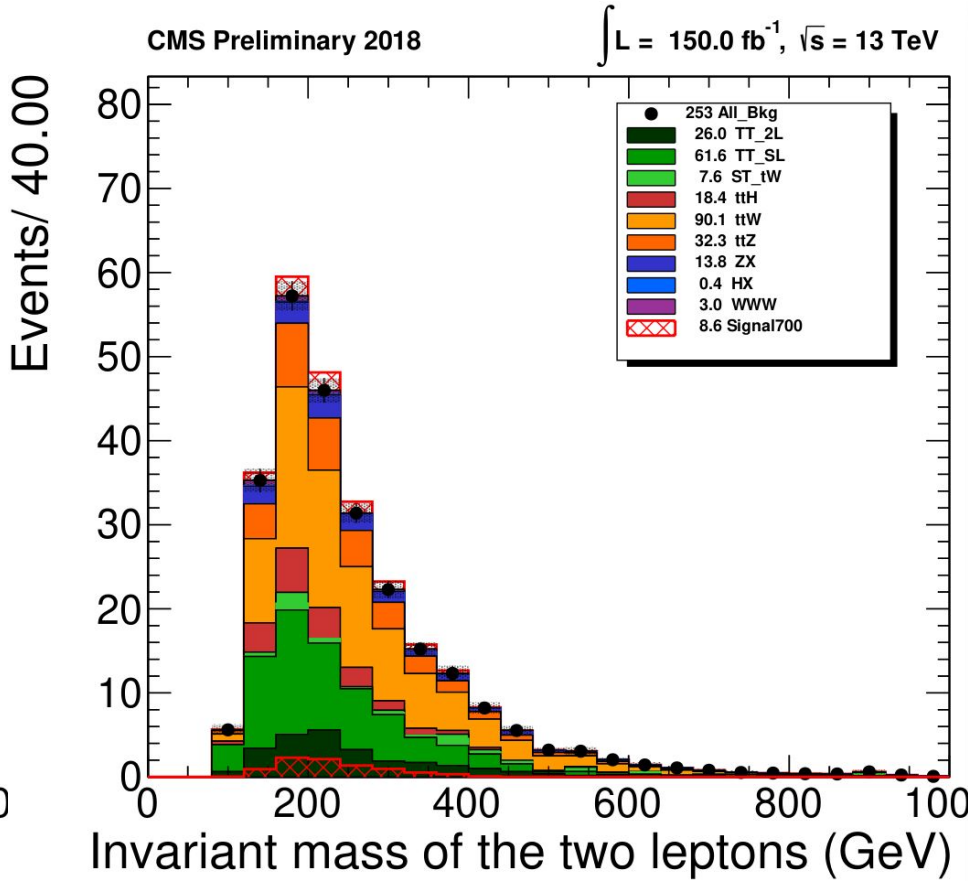
Invariant (leptons + jets) mass after the full selection (600 GeV vs 700 GeV)





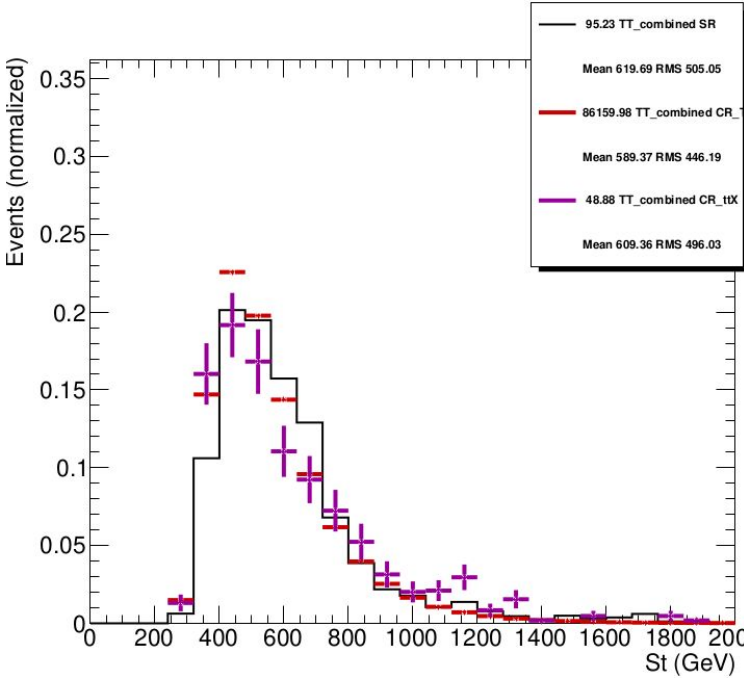
Invariant dilepton mass after the full selection (600 GeV vs 700 GeV)

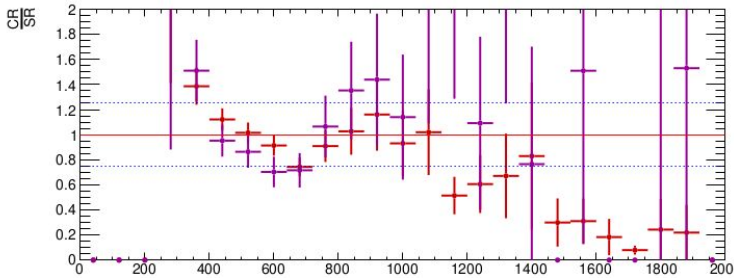




Shapes in the different regions for combined ttbar dileptonic, semileptonic and single top (St)

The distribution is pretty different…?

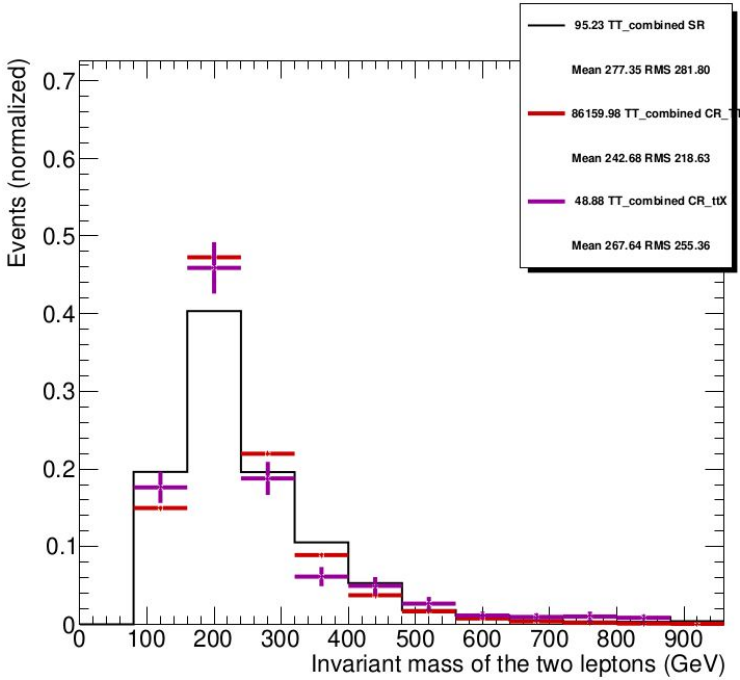


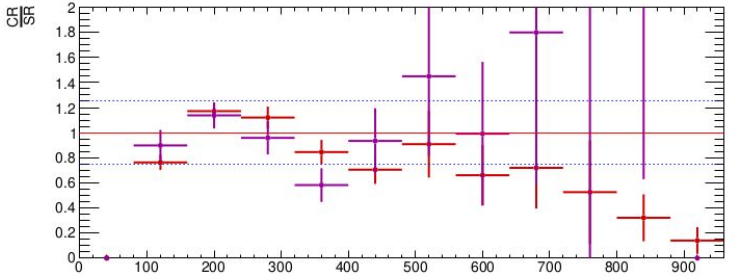


Shapes in the different regions for combined ttbar dileptonic, semileptonic and single top (Invariant dilepton mass)

The distribution is roughly the same.

⟶ OK for a combined CR systematics included?





Combine

```
Combination of SR=datacard_SR.txt  CR_TT_2L=datacard_CR_TT_2L.txt  CR_ttX=datacard_CR_ttX.txt
imax 3 number of bins
jmax 2 number of processes minus 1
kmax 0 number of nuisance parameters
----------------------------------------------------------------------------------------------------------------
shapes TT_2L     CR_TT_2L  workspace_data_Signal700.root w:TT_2L_CR_TT_2L_histo
shapes data_obs  CR_TT_2L  workspace_data_Signal700.root w:Data_CR_TT_2L_histo
shapes signal    CR_TT_2L  workspace_data_Signal700.root w:Signal_CR_TT_2L_histo
shapes ttX       CR_TT_2L  workspace_data_Signal700.root w:ttX_CR_TT_2L_histo
shapes TT_2L     CR_ttX    workspace_data_Signal700.root w:TT_2L_CR_ttX_histo
shapes data_obs  CR_ttX    workspace_data_Signal700.root w:Data_CR_ttX_histo
shapes signal    CR_ttX    workspace_data_Signal700.root w:Signal_CR_ttX_histo
shapes ttX       CR_ttX    workspace_data_Signal700.root w:ttX_CR_ttX_histo
shapes TT_2L     SR        workspace_data_Signal700.root w:TT_2L_histo
shapes data_obs  SR        workspace_data_Signal700.root w:Data_histo
shapes signal    SR        workspace_data_Signal700.root w:Signal_histo
shapes ttX       SR        workspace_data_Signal700.root w:ttX_histo
----------------------------------------------------------------------------------------------------------------
bin          SR        CR_TT_2L  CR_ttX
observation  -1        -1        -1
----------------------------------------------------------------------------------------------------------------
bin          SR        SR        SR        CR_TT_2L  CR_TT_2L  CR_TT_2L  CR_ttX    CR_ttX    CR_ttX
process      signal    TT_2L     ttX       signal    TT_2L     ttX       signal    TT_2L     ttX
process      0         1         2         0         1         2         0         1         2
rate         -1        -1        -1        -1        -1        -1        -1        -1        -1
----------------------------------------------------------------------------------------------------------------

scale_TT_2L rateParam CR_TT_2L TT_2L 1 [0,2]
scale_TT_2L rateParam CR_ttX TT_2L 1 [0,2]
scale_ttX rateParam CR_ttX ttX 1 [0,2]
scale_TT_2L rateParam SR TT_2L 1 [0,2]
scale_ttX rateParam SR ttX 1 [0,2]
```

imax = 3 regions (SR, CR_TT_2L and CR ttX)
jmax = 2 main backgrounds (TT_2L and ttX)
kmax = 0 nuisance parameters for the moment

SR = X% TT_2L + (1-X)% ttX + Y% signal
CR_TT_2L = 100% TT_2L
CR_ttX = A% TT_2L + (1-A)% ttX

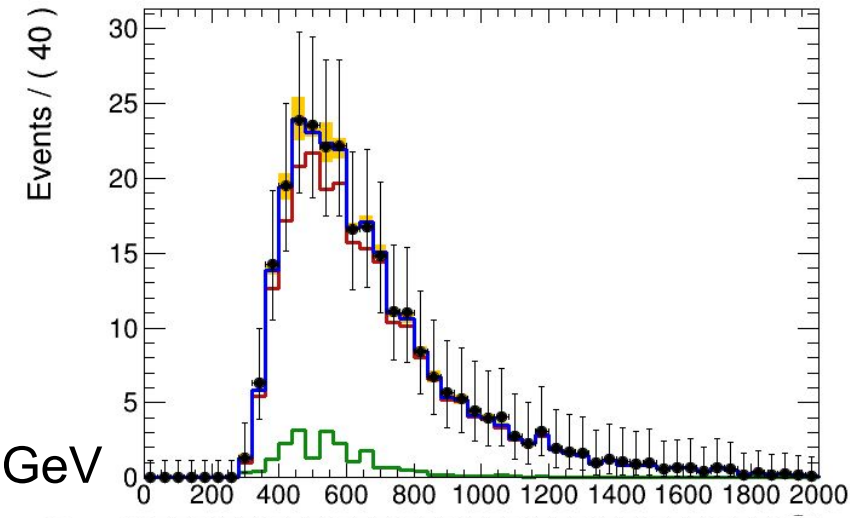
The parameters scale_TT_2L and scale_ttX force the two backgrounds to have the same shape in all the regions.

Parameter of interest r and Significance σ with Combine (St)

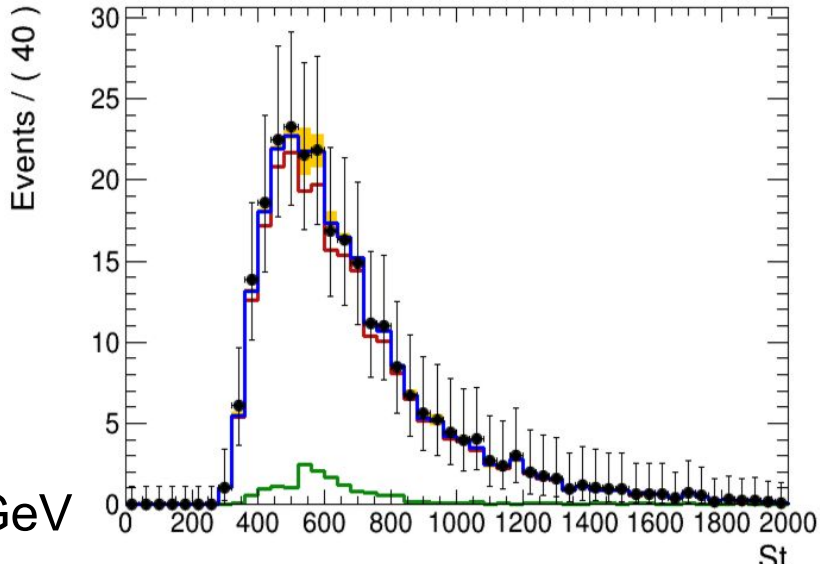
T' Mass (GeV)	POI r	Significance σ
600	1.5577	1.1524
625	2.0349	0.7520
650	1.8713	0.8175
675	1.7439	0.8825
700	1.7578	0.7682
800	2.0489	0.6330

$r = \sigma_{exp}/\sigma_{th}$ (~1 with signal, >> 1 is strange)

600 GeV



700 GeV

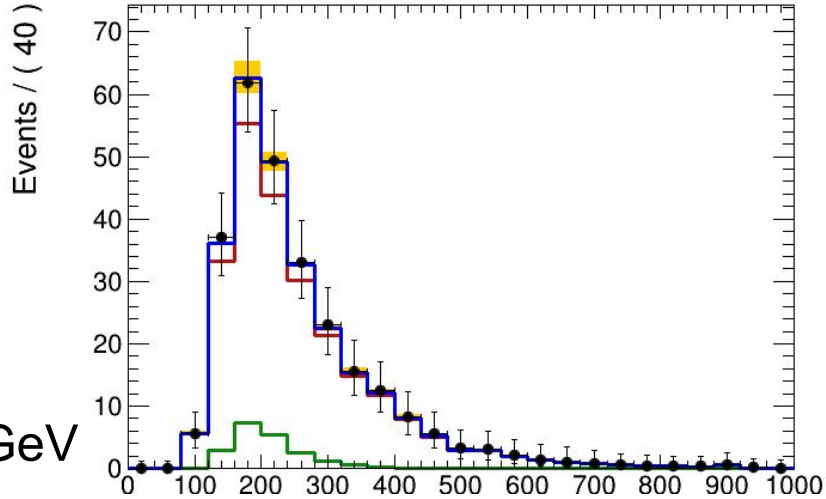


Parameter of interest r and Significance σ with Combine (Invariant dilepton mass)

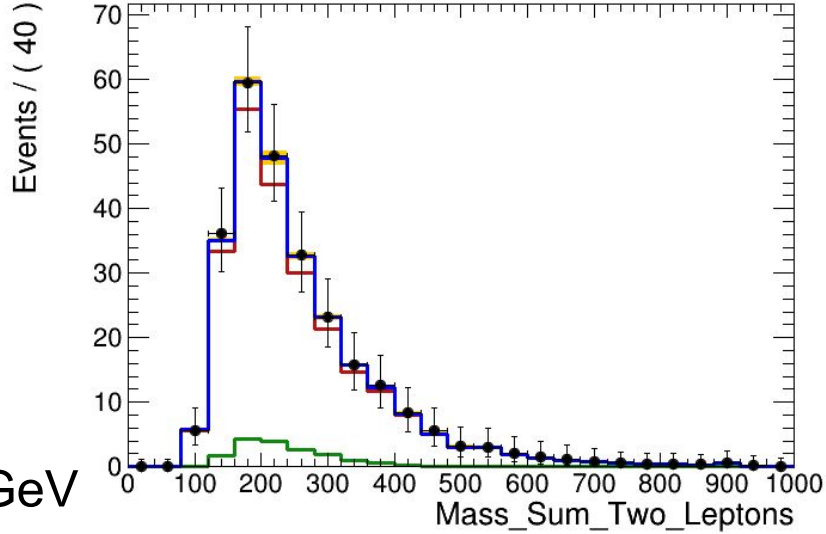
T' Mass (GeV)	POI r	Significance σ
600	1.5761	0.9597
625	2.2125	0.7447
650	2.0210	0.8041
675	1.7374	0.8597
700	1.8684	0.6961
800	2.3830	0.6339

$r = \sigma_{exp}/\sigma_{th}$ (~1 with signal, >> 1 is strange)

600 GeV



700 GeV



Next steps (order?):

- Add the uncertainties in Combine.
- Add the SFs.
- Add 2016 and 2017.