MC Correction 2016

Search for Four top in Tau Final States

Anshul Kapoor Huiling Hua[1] Hongbo Liao[1]

[1]IHEP

April 5, 2023

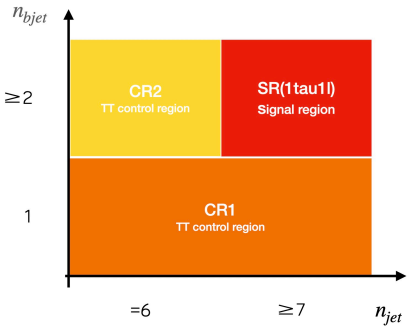
Outline

1. B tag shape SF
2. Validation of b tag shape correction
3. Signal region

Update

- Object removal switched to tight leptons and taus
- HLT SF added
- B tag R remeasured for 2016

1tau1l control region definition



SF and corrections

- Corrections we have considered
  - Prefiring
  - Pileup
  - HLT SF : measured for 2016
  - Tau: both TES and ID SF
  - Jet: JES
  - Lepton efficiency SF
  - B jet: b tag shape correction (2016)
- Have not considered
  - JER

Section 1

B tag shape SF

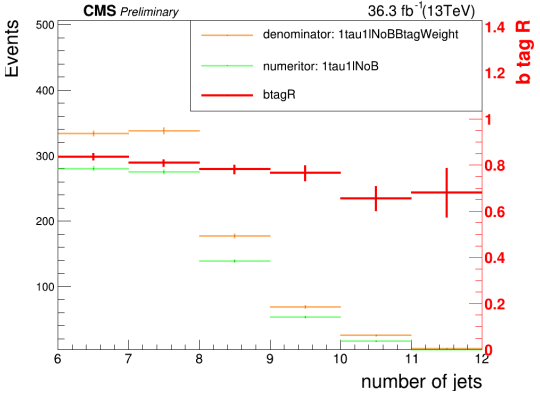
B tag uncertainty(shape)

- Need to correct for both shape and yield
  - For both 1tau1l and 1tau0l, we are using the shape of the b tag score
  - >= 2 b jets(medium working points) for SR (both 1tau0l and 1tau1l)
- BTV 1d) Event reweighting using discriminator-dependent scale factors from BTV
  - https://twiki.cern.ch/twiki/bin/viewauth/CMS/BTagShapeCalibration
  - $w_{event} = \prod_{i}^{N_{jets}} SF(D_i, pt_i, \eta_i, flavor_i)$
    - D_i: b tag discriminant
    - The difference between working points weight is that SF here is more bins with regard to D_i
  - Effect on event yields
    - the number of events (i.e. the sum of event weights) before and after applying b-tag weights should be identical
    - Measure the sum of event weights before and after applying b-tag event weights, without requiring any b-tag selection in both cases
    - $r = \sum w_{before} / \sum w_{after}$ represents a phase space extrapolation and should be multiplied to the b-tag event weight
    - this extrapolation could in general depend on further variables, most notably the jet multiplicity. Especially in analyses with a large number of jets (e.g. $t\bar{t}$ or $t\bar{t}H$) one should consider to measure and apply the ratio r per jet multiplicity bin
    - Measure R in region without b jet requirement

B tag R

- Measurement region
  - tau number=1; lepton =1; jet >=6;(and baseline without b jet requirement: jet >=6; HT>500; 6jet_pt>=40)
- Should we use all background for R calculation or just tt?
  - Just tt
  - MC correction: EVENT_prefireWeight* * (*PUweight_) * (*HLT_weight) * (*tauT_IDSF_weight_new) * (*elesTopMVAT_weight) * (*musTopMVAT_weight)(TES no JER)
- Include b tag shape correction when measuring HLT SF in b jet multiplicity, this means the normalization factor R is taken into account in function of b jet multiplicity

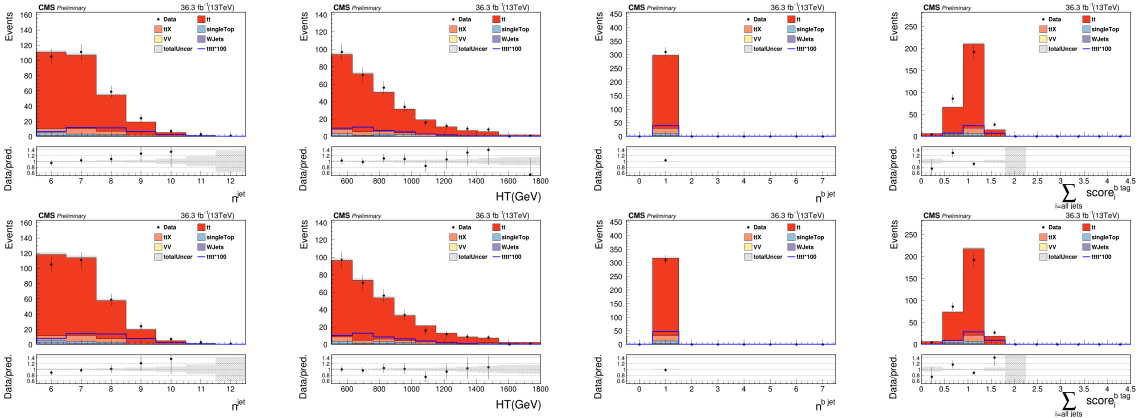
B tag R vs jet multiplicity



Section 2

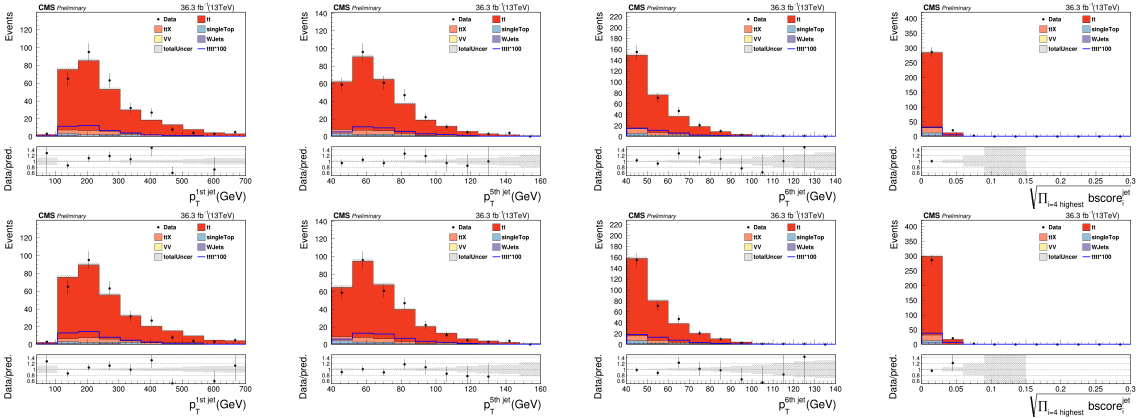
Validation of b tag shape correction

B tag efficiency correction before and after(CR1)



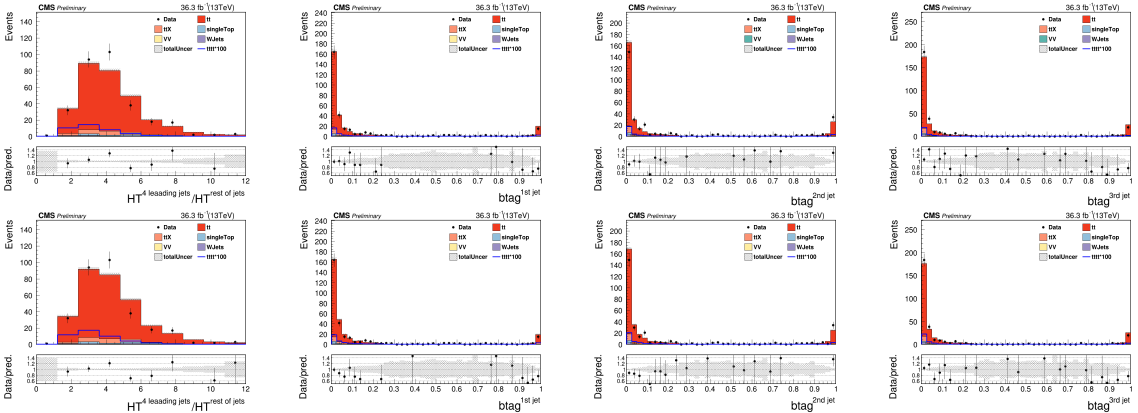
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

B tag efficiency correction before and after(CR1)



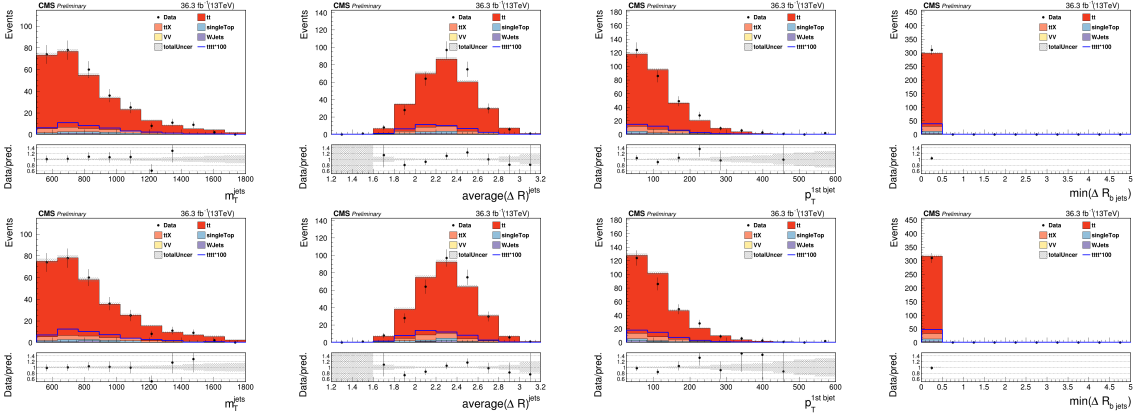
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

B tag efficiency correction before and after(CR1)



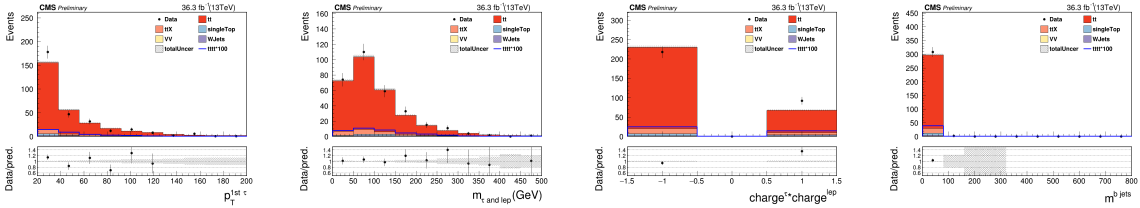
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

B tag efficiency correction before and after(CR1)



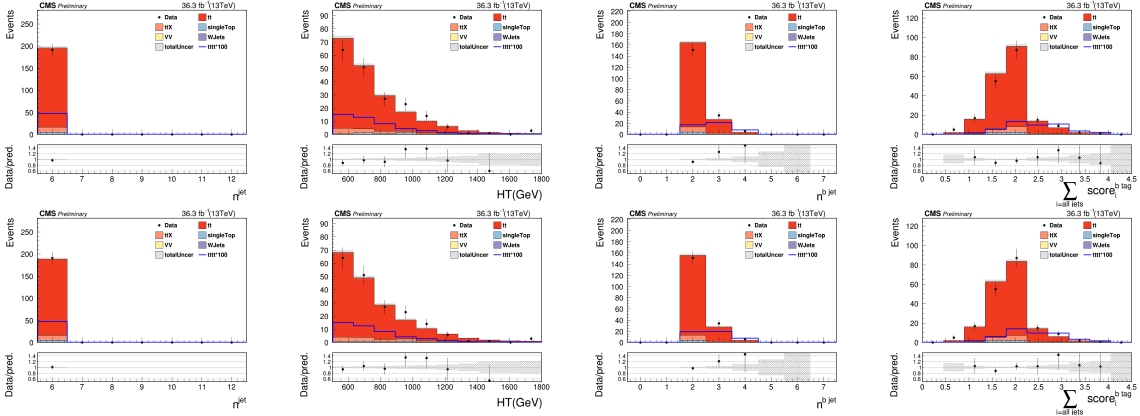
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

B tag efficiency correction before and after(CR1)



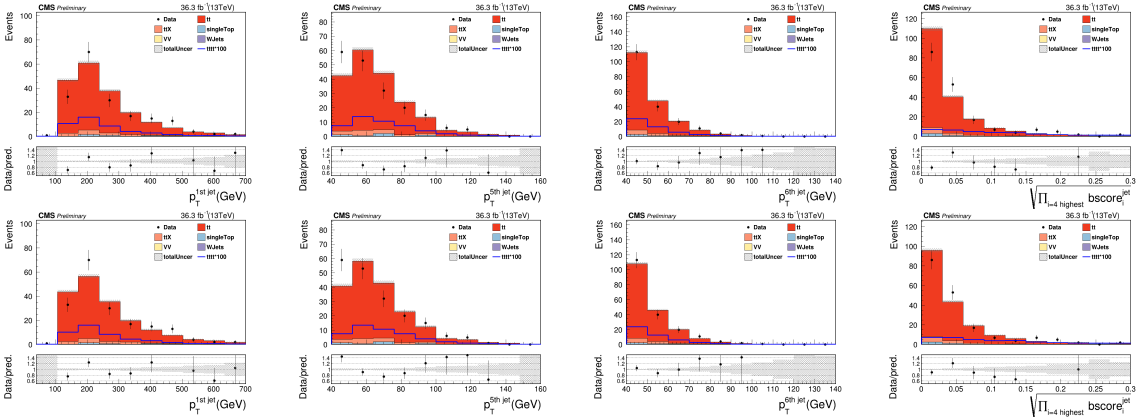
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

B tag efficiency correction before and after(CR2)



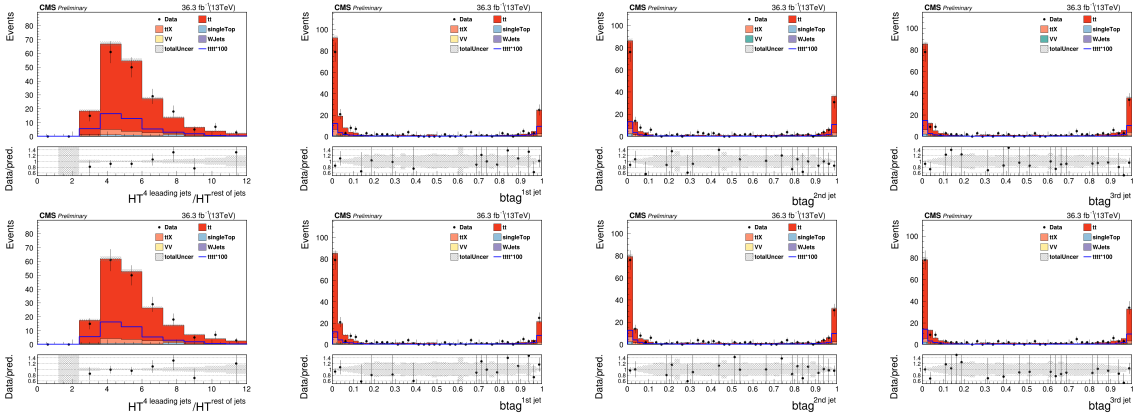
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

B tag efficiency correction before and after(CR2)



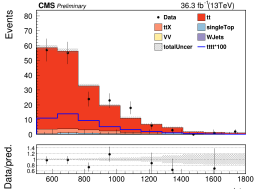
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

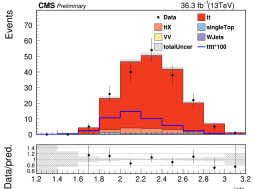
B tag efficiency correction before and after(CR2)

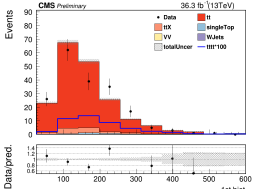


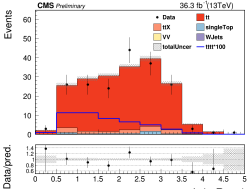
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

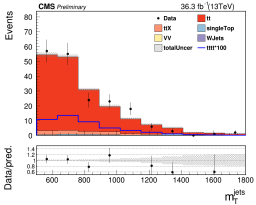
B tag efficiency correction before and after(CR2)

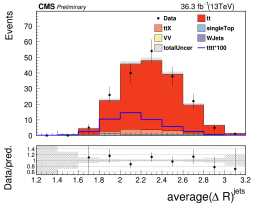


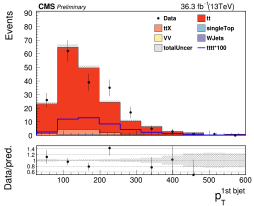


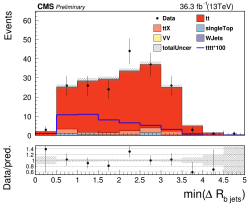






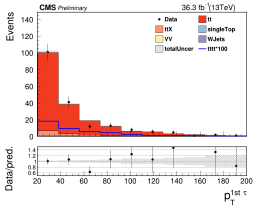


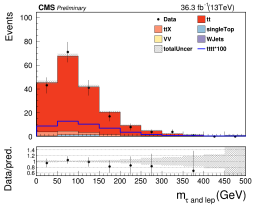


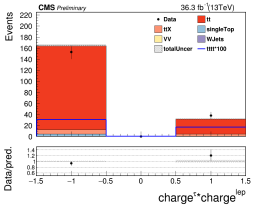


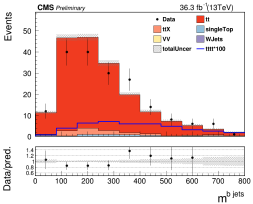
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

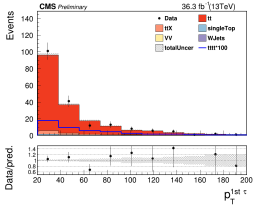
B tag efficiency correction before and after(CR2)

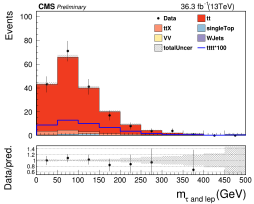


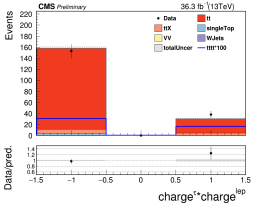


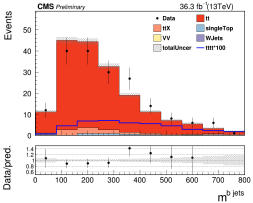










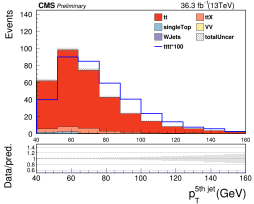


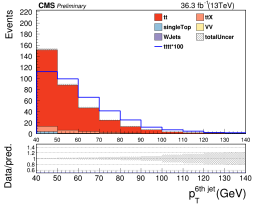
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * JES(no JER)
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

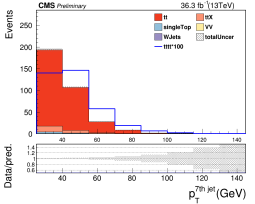
Section 3

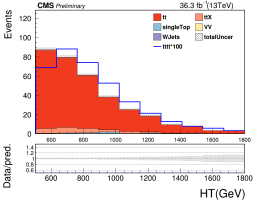
Signal region

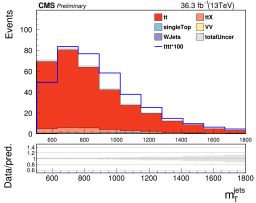
1tau1l SR

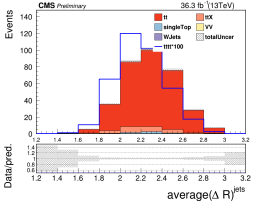


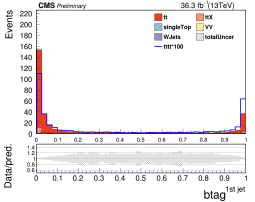


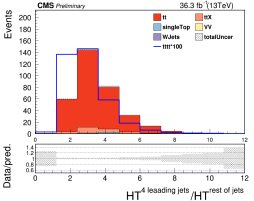






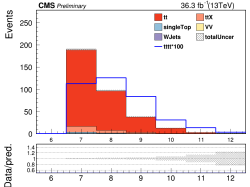


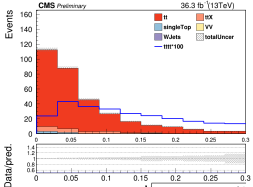


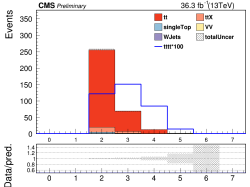


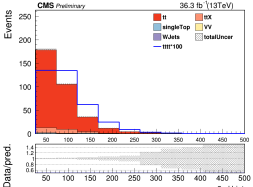
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * b tag shape correction * JES(no JER)

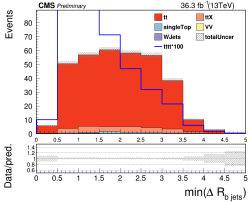
1tau1l SR

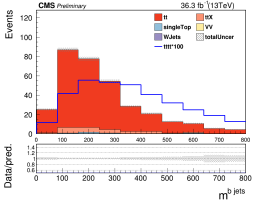


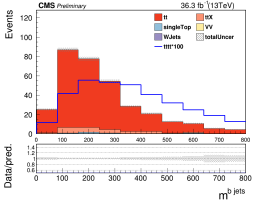


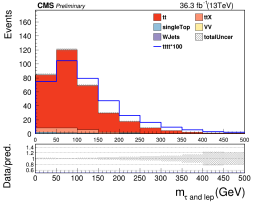






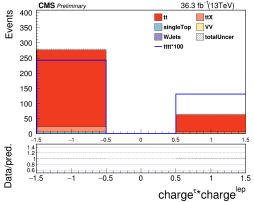


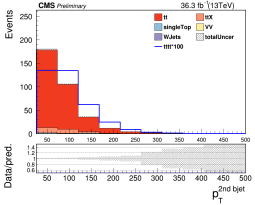


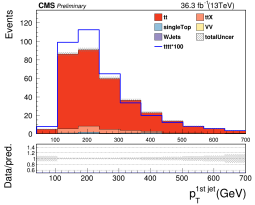


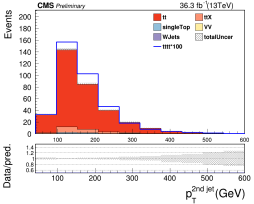
- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * * b tag shape correction * JES(no JER)

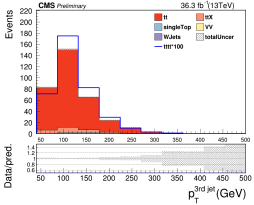
1tau1l SR

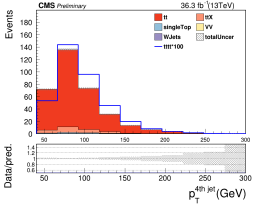


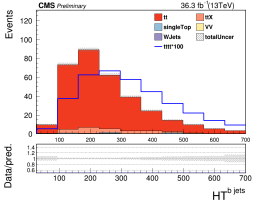


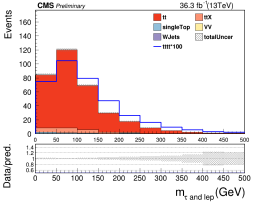












- MC correction: prefireWeight * pileup reweighting * HLT SF * tau efficiency SF and energy scale * lepton efficiency SF * * b tag shape correction * JES(no JER)

Section 4

Back up

Backgournd composition in baseline no b region

regions	tttt	uncert	tt	uncert	qcd	uncert	ttX	uncert	VV	uncert	singleTop	uncert	WJets	uncert	total bg	sensitivity
baselineNoB1Tau	16.895	0.067	17594.889	31.648	22121.704	1360.459	560.346	10.071	0.842	0.099	521.598	11.612	358.248	7945	41157.628	0.083
1tau1lNoB	4.797	0.036	770.216	5.733	4.706	4.706	51.146	2.202	0.008	0.006	17.763	2.084	7.103	1.337	850.942	0.164

- 1tau1lNoB: b tag R measurement region

B tag efficiency SF(yield)

- $SF = \frac{\varepsilon_{data}}{\varepsilon_{MC}}$
- Only using working points
  - $P(MC) = \prod_{i=tagged} \epsilon_i \prod_{j=nottagged} \epsilon_j$?
  - $P(Data) = \prod_{i=tagged} SF_i\epsilon_i \prod_{j=nottagged} SF_j\epsilon_j$?
  - $w = \frac{P_{data}}{P_{MC}}$
- If we ask 2 b tagged jets
  - the probability for jets to have such configuration is as above
- https://twiki.cern.ch/twiki/bin/viewauth/CMS/BTagSFMethods
- $\varepsilon = \frac{N_{btagged}}{N_{total}}$

Questions

- How is our btag sf different than object SF?
  - object efficiency SF
    - electron efficiency means the probability of true electron? passing selection criteria
    - the efficiency means passing or not efficiency. Correct for event yield, after the electron selection
    - Does the event weight impact the shape of other variables?
    - efficiency means the probality of true lepton passing selection, how about non-true object passing selection criteria?
  - For electron and muon, the efficiency is high and close to 1, the 1-efficiency is close to 0 so we don't need to consider the arrangement of true leptons not passing but non-true passing
- How to consider the uncertainty of measured R?

Event yiled in all regions

regions	tttt	uncert	tt	uncert	qcd	uncert	ttX	uncert	VV	uncert	singleTop	uncert	WJets	uncert	total bg	sensitivity	data	data/MC
baseline	275.505	0.320	1079958.066	283.219	11719856.895	307116.491	23567.056	85.740	94.418	1.127	37408.105	112.425	11921.972	58.970	12872806.513	0.077	0.000	0.000
1tau1ISR	3.748	0.035	311.132	3.918	2.811	2.811	22.728	1.521	0.000	0.000	5.971	1.257	1.181	0.519	343.822	0.201	-1.000	-0.003
1tau0ISR	8.162	0.052	3938.591	16.537	3563.692	1019.183	148.817	5.425	0.096	0.040	84.134	4.916	41.621	7.153	7776.951	0.093	-1.000	-0.000