HLT Study Part2

Search for Four top in Tau Final States

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

[1]IHEP

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Outline

Section 1

Introduction

Trigger study strategy

- For trigger choice the primary goal is to have very high signal efficiency
- Define baseline selection so that trigger efficiency rest on turn on curve

Trigger choice

year	MC	data
2016	HLT_PFJet450	same as MC
	HLT_PFHT450_SixJet40_BTagCSV_p056	same
	HLT_PFHT400_SixJet30_DoubleBTagCSV_p056	same
2017	HLT_PFJet500	HLT_PFJet500
	HLT_PFHT380_SixPFJet32_DoublePFBTagCSV_2p2	HLT_PFHT430_SixJet40_BTagCSV_p080 or HLT_PFHT380_SixJet32_DoubleBTagCSV_p075 [297050, 299329)
	HLT_PFHT430_SixPFJet40_PFBTagCSV_1p5	HLT_PFHT430_SixPFJet40_PFBTagCSV_1p5 or HLT_PFHT380_SixPFJet32_DoublePFBTagCSV_2p2 [299329, 306460]
2018	HLT_PFJet500	HLT_PFJet500
	HLT_PFHT450_SixPFJet36_PFBTagDeepCSV_1p59	HLT_PFHT430_SixPFJet40_PFBTagCSV_1p5 or HLT_PFHT380_SixPFJet32_DoublePFBTagDeepCSV_2p2 ([315257, 315974)
	HLT_PFHT400_SixPFJet32_DoublePFBTagDeepCSV_2p94	HLT_PFHT430_SixPFJet40_PFBTagDeepCSV_1p5 or *HLT_PFHT380_SixPFJet32_DoublePFBTagDeepCSV_2p2 [315974, 317509)
		HLT_PFHT450_SixPFJet36_PFBTagDeepCSV_1p59 or HLT_PFHT400_SixPFJet32_DoublePFBTagDeepCSV_2p94 [317509, 325173]

Section 2

Trigger efficiency

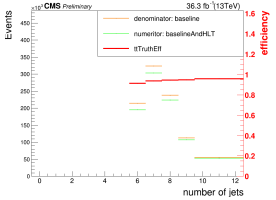
Trigger efficiency

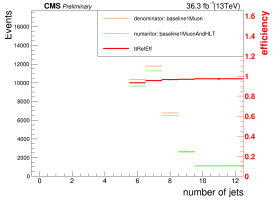
- Reference trigger efficiency method
  - $P(trigger) = \frac{P(trigger)P(preselection)}{P(preselection)} = \frac{P(trigger \bigcap preselection)}{P(preselection)}$(preselection and trigger independent)
  - single Muon triggers HLT_IsoMu24 (2016) or HLT IsoMu27 (2017, 2018)
  - A unbiased reference trigger, to be able to measure efficiency in data
- Pre-selection for trigger measurement
  - baseline: HT>500GeV; jet multiplicity >= 6; leading 6 jet pt > 40GeV; b jet multiplicity>=1
  - muon selection: muon number == 1 and muons pt >= 30
  - pre-selection = (HLT_IsoMu24(2016)(HLT_IsoMu27(2017 and 2018)))+ baseline + muon selection
  - Corrections for MC: pileup reweighting, pre-firing reweighting
- efficiency = $\frac{events_{HLT\ \&\ preselection}}{events_{preselection}}$

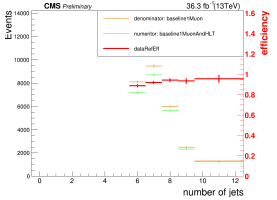
Selection for efficiency measurement

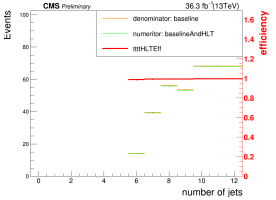
- Baseline: HT>500GeV; jet multiplicity >= 6; leading 6 jet pt > 40GeV: b jet number>=1
- muon selection: muon number == 1 and muons pt >= 30
- pre-selection = HLT_IsoMu24(2016) + muon selection + baseline
- HLT : HLT_PFHT450_SixJet40_BTagCSV_p056 or HLT_PFHT400_SixJet30_DoubleBTagCSV_p056 or HLT_PFJet450(2016)
- efficiency = $\frac{events_{HLT\ \&\ preselection}}{events_{preselection}}$

Trigger efficiency

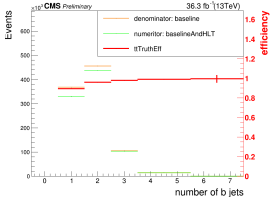


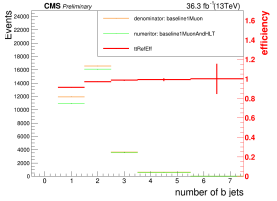


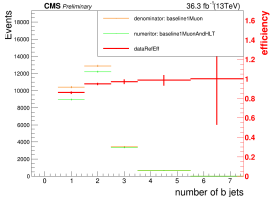


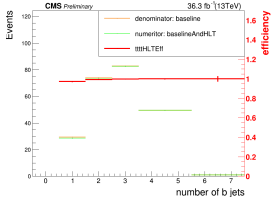


Trigger efficiency

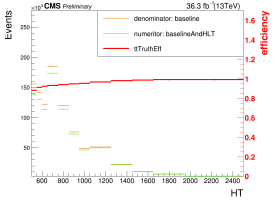


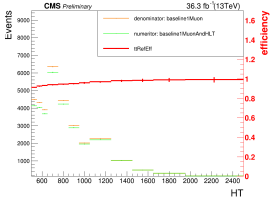


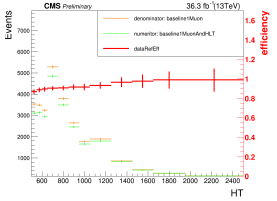


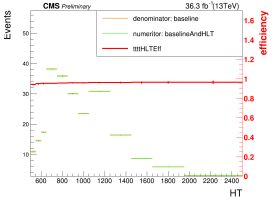


Trigger efficiency

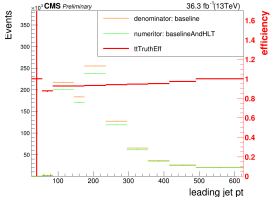


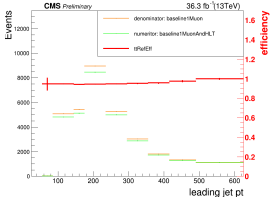


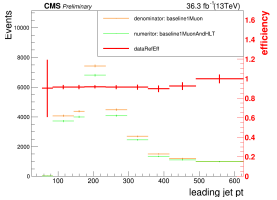


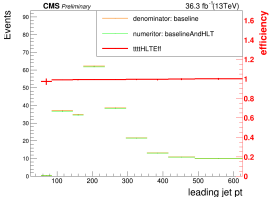


Trigger efficiency

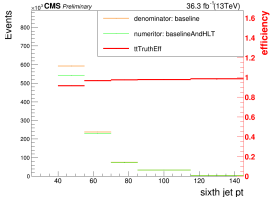


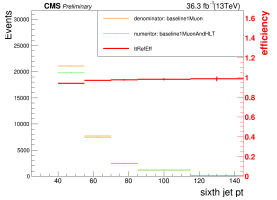


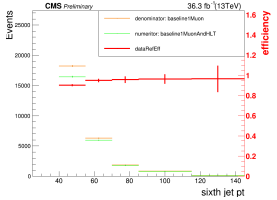


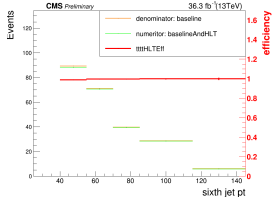


Trigger efficiency

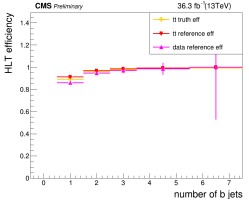


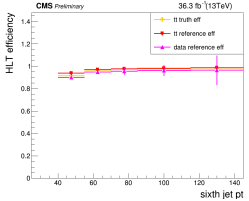


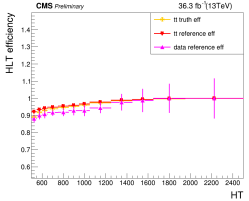


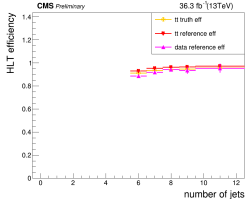


Overlay of efficiencies









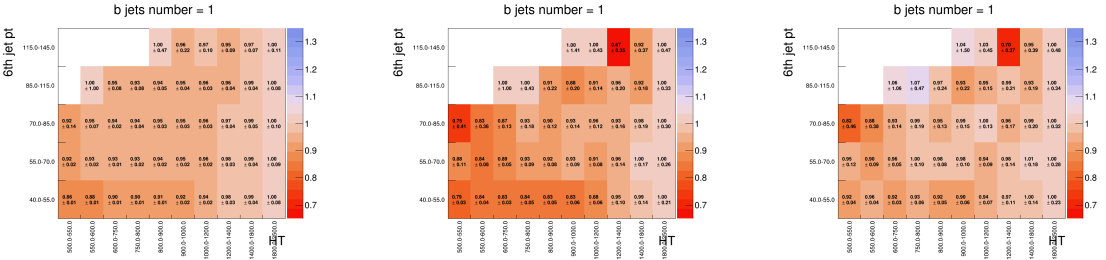
Section 3

Trigger SF

Trigger SF

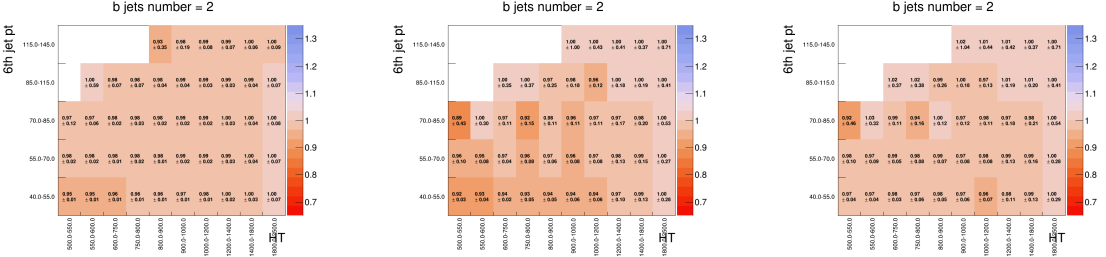
- $SF = \frac{efficiency_{data}}{efficiency_{MC}}$
- MC: tt; data: singleMu
- Binning: number of b jets binning: 1, 2, 3-7; HT and 6th jet pt
- uncertainty of SF
  - Statistic: calculated by root histogram division
  - Systematic: not considered yet

SF 2D plots



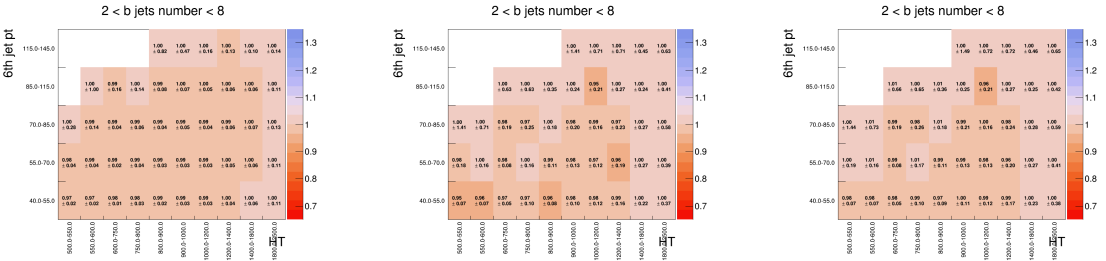
- left: tt trigger efficiency; middle: data efficiency; right: SF = data/tt

SF 2D plots



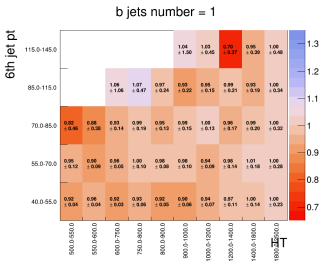
- left: tt trigger efficiency; middle: data efficiency; right: SF = data/tt

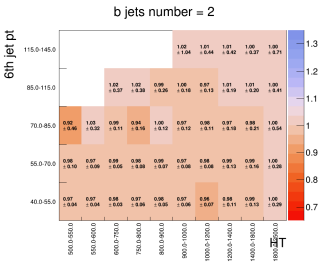
SF 2D plots

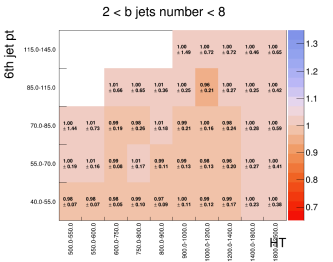


- left: tt trigger efficiency; middle: data efficiency; right: SF = data/tt

SF 2D plots







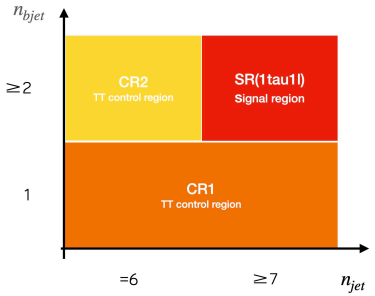
- Trigger efficiency SF
- Binning needs to be optimized

Section 4

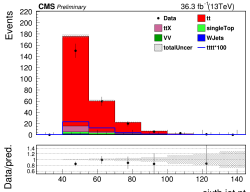
SF validation

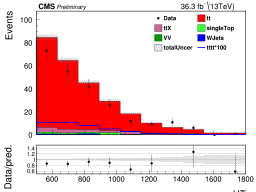
Analysis stratedy in 1tau1l

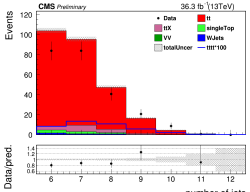
- Train BDT to extract signal
- Apply correlation removal method for input variable optimization
- Designed 2 tt control region to validate BDT input and score
- TT major background, from MC

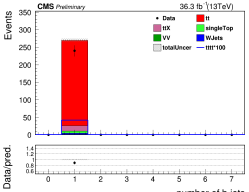


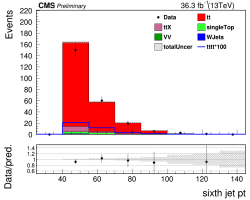
Variable validation before and after HLT SF(CR1)

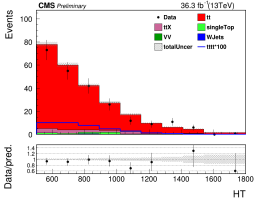


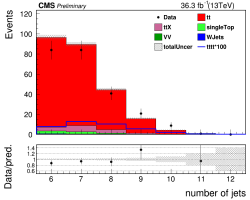


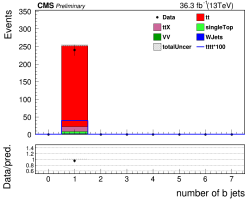






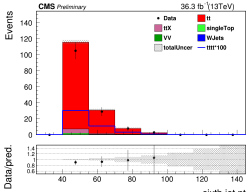


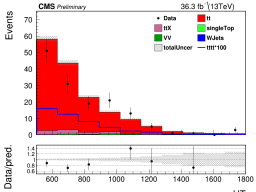


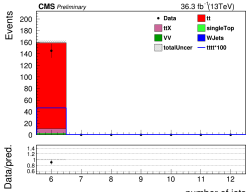


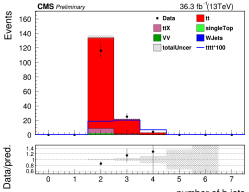
- Up: pre-firing and pileup reweighting
- Down: pre-firing and pileup and HLT efficiency SF correction

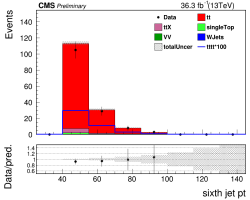
Variable validation before and after HLT SF(CR2)

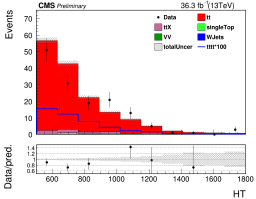


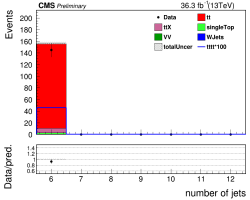


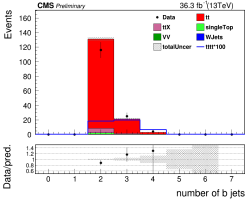












- Up: pre-firing and pileup reweighting
- Down: pre-firing and pileup and HLT efficiency SF correction

Background composition 1tau1l

regions	tttt	uncert	tt	uncert	qcd	uncert	ttX	uncert	VV	uncert	singleTop	uncert	WJets	uncert	total bg	sensitivity	data	data/MC
1tau1lCR0	0.424	0.012	243.750	3.389	0.000	0.000	15.366	1.225	0.042	0.034	6.056	1.305	4.534	1.058	269.747	0.026	240.000	0.890
1tau1lCR2	0.468	0.011	148.138	2.621	0.000	0.000	7.870	1.048	0.000	0.000	2.701	0.864	0.333	0.105	159.042	0.037	145.000	0.912
1tau1lSR	3.074	0.031	256.995	3.473	0.000	0.000	16.319	1.289	0.000	0.000	5.992	1.331	1.341	0.884	280.647	0.182	-1.000	-0.004

regions	tttt	uncert	tt	uncert	qcd	uncert	ttX	uncert	VV	uncert	singleTop	uncert	WJets	uncert	total bg	sensitivity	data	data/MC
1tau1lCR0	0.401	0.011	229.474	3.193	0.000	0.000	14.456	1.159	0.041	0.033	5.751	1.244	2.449	0.371	252.171	0.025	240.000	0.952
1tau1lCR2	0.460	0.011	145.062	2.567	0.000	0.000	7.707	1.031	0.000	0.000	2.641	0.844	0.328	0.103	155.737	0.037	145.000	0.931
1tau1lSR	3.028	0.031	252.100	3.407	0.000	0.000	16.010	1.267	0.000	0.000	5.884	1.307	0.461	0.135	274.455	0.182	-1.000	-0.004

- CR0=CR1
- Up: no HLT SF correction
- Down: HLT SF correction

Section 5

Back up

Questions

- Why do we require 1 muon to ensure reference trigger fires?
  - We need to ensure the pre-selection efficiency the same for data and MC, to not introduce bias for our SF measurement
  - Let's say we add 1 muon requirement to be on the plataea of turn on curve, how can we say the efficiency of this cut is the same for data and MC?
    - I think the purpose of adding the additional muon selection is the ensure the P(muonTrigger) data and P(muonTrigger) MC is the same and don't bias our trigger SF measurement
  - additional muon selection for efficiency measurement, should we correct MC with muon selection efficiency then?
    - I think yes, because the muon selection ensures the muon trigger doesn't bias our SF but nothing is ensure it's own bias
- Why do we have to require just one bg not all of then?
  - Some minor bg with not enough statistics could introduce more uncertainty
  - The efficiency should be uniform among all bg processes?

Possible challenges for HT+6jet+btag trigger

- Trigger re- tuned in 2017 and 2018 data
- HLT offline b tag and online b tag algorism
  - DeepJet is used offline while CSVv2 (2016, 2017) or DeepCSV (2018) are used online
  - differences in online and offline b-tagging can lead to shifts in turn-ons
  - o validate the performance of the trigger strategy, the efficiencies are additionally measured using the same b-tagging algorithm on analysis level (offline) and trigger level (online)
- Drop in data efficiency in high HT
  - last run period of the LHC in 2016 (Run H) which had very high instantaneous luminosity.
  - L1 HT triggers suffered a problem in which saturated (high pT) jets were excluded from the HT calculation
  - A partial mitigation strategy of including an OR of a single jet trigger HLT PFJet450 v* has been implemented, which recovers most of the lost efficiency at high HT.
- 2017
  - HLT_PFHT300PT30_QuadPFJet_75_60_45_40_TriplePFBTagCSV_3p0: BTagCSV