Fully Hadronic Triggers

Efficiency Studies

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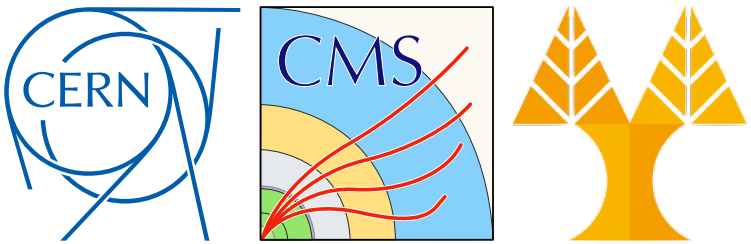
Wednesday 6th September, 2017



- The fully hadronic TOP triggers are a combination of multijet and online b-tagging requirements.
- All the unprescaled `L1_HTT` and `L1_HTTX_QuadJetY` (2017) seeds are feeding these paths.

2016 paths:

HLT Path	Calo-Jets				PF-Jets			
	H_T	p_T	b-tags	CSV	H_T	p_T	b-tags	CSV
HLT_PFHT400_SixJet30_DoubleBTagCSV_p056	300	25	1	0.44	400	30	2	0.63
HLT_PFHT450_SixJet40_BTagCSV_p056	300	35	-	-	450	40	1	0.63
HLT_PFHT400_SixJet30	300	25	-	-	400	30	-	-
HLT_PFHT450_SixJet40	300	35	-	-	450	40	-	-

2017 paths have lower thresholds but tighter CSV working points:

HLT Path	Calo-Jets				PF-Jets			
	H_T	p_T	b-tags	CSV	H_T	p_T	b-tags	CSV
HLT_PFHT380_SixPFJet32_DoublePFBTagCSV_2p2	300	25	1	0.44	380	32	2	0.75
HLT_PFHT430_SixJet40_PFBTagCSV_1p5	300	35	-	-	430	40	1	0.80
HLT_PFHT380_SixJet32	300	25	-	-	380	32	-	-
HLT_PFHT430_SixJet40	300	35	-	-	430	40	-	-

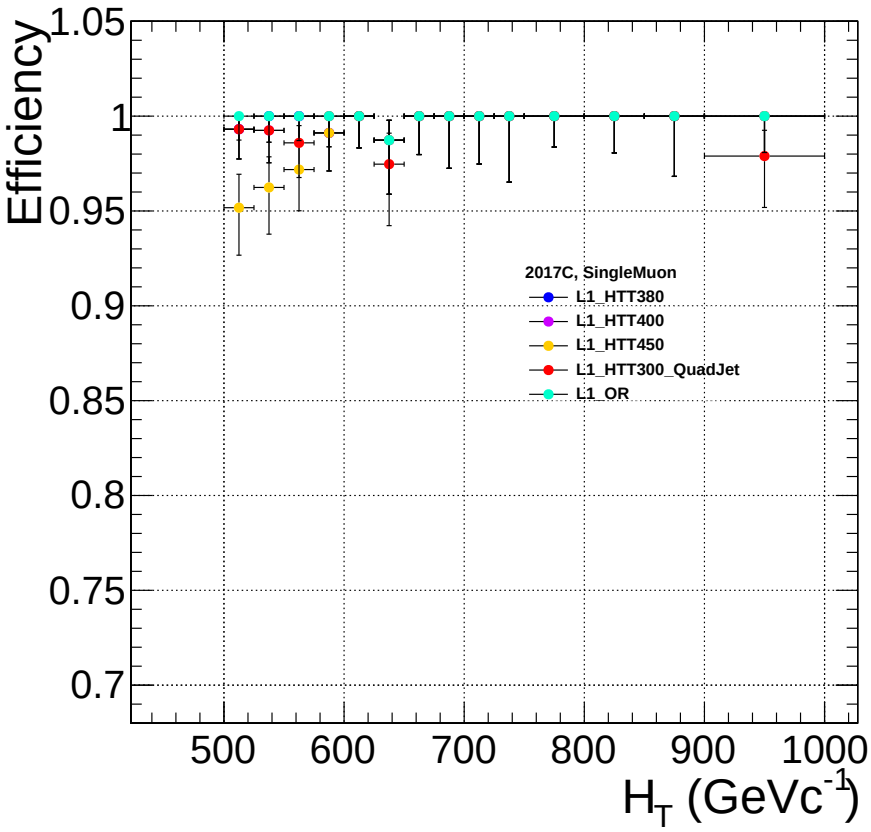
The L1 efficiency is defined as:

$$\varepsilon_{HLT} = \frac{Offline\ Selection\ \&\&\ Reference\ Trg\ \&\&\ L1\ Seed}{Offline\ Selection\ \&\&\ Reference\ Trg}$$

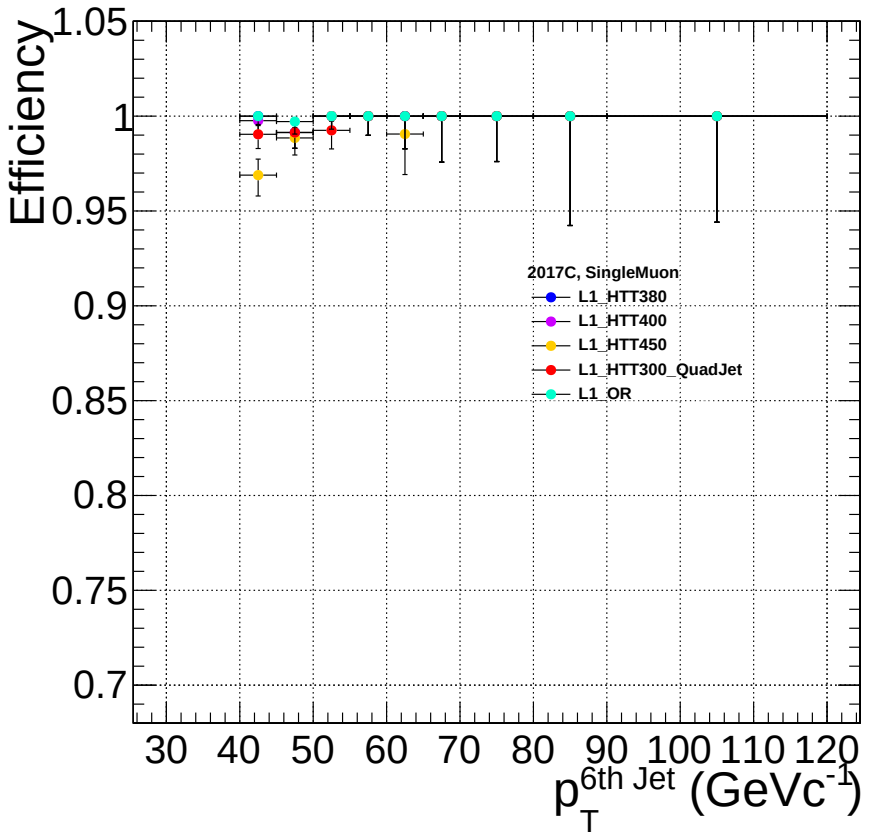
where:

- L1 seed is:
  - `L1_HTTX` (X=320, 340, ..., 500)
  - `L1_HTTX_QuadJet_70_55_40_35` (X=280, 280, 300)
- Reference Trg is: `HLT_IsoMu27`
- Offline Selection is:
  - $\geq$ 1 muon with $p_T \geq 28$ GeV, $|\eta| \leq 2.4$, $rellso_{EA} \leq 0.15$
  - $\geq$ 6 PF Jets with $p_T > 40$ GeV and $|\eta| < 2.4$.
    - ($p_T^{1st} > 70$ GeV, $p_T^{2nd} > 55$ GeV)
  - $H_T > 500$ GeV
  - $N_{b-jets} \geq 2$ with $p_T > 40$ GeV, $|\eta| \leq 2.4$, Medium WP (0.8484)
  - (No matching is applied between online and offline b-tagged jets.)
- L1 efficiencies are calculated using the SingleMuon dataset from 2017C data taking period.

H_T

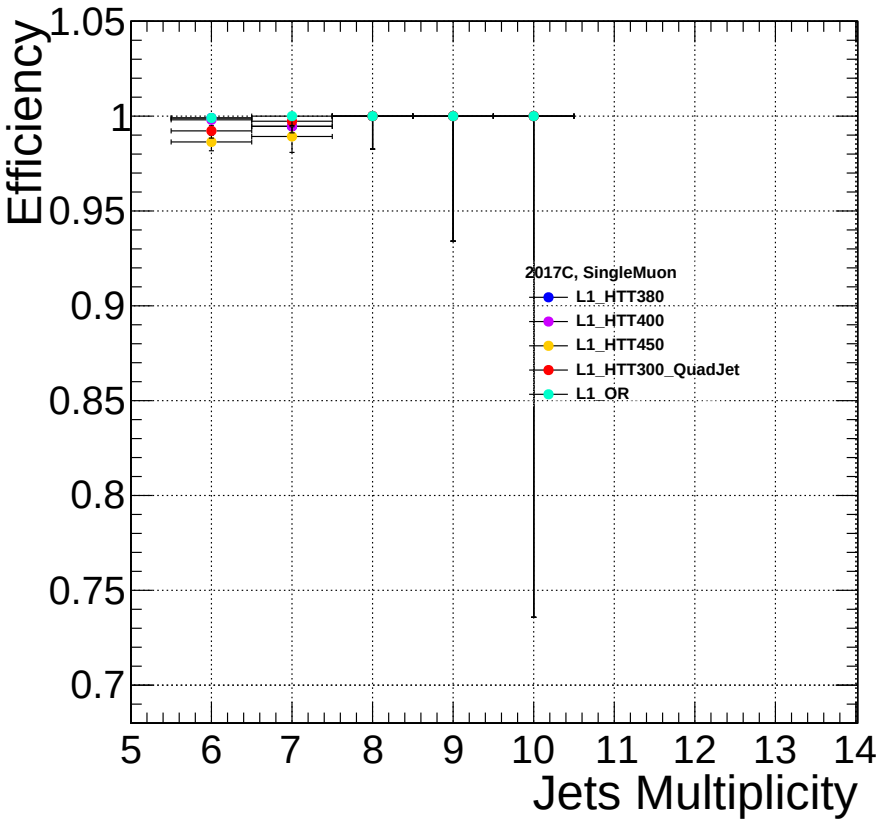


p_T of the 6th Jet

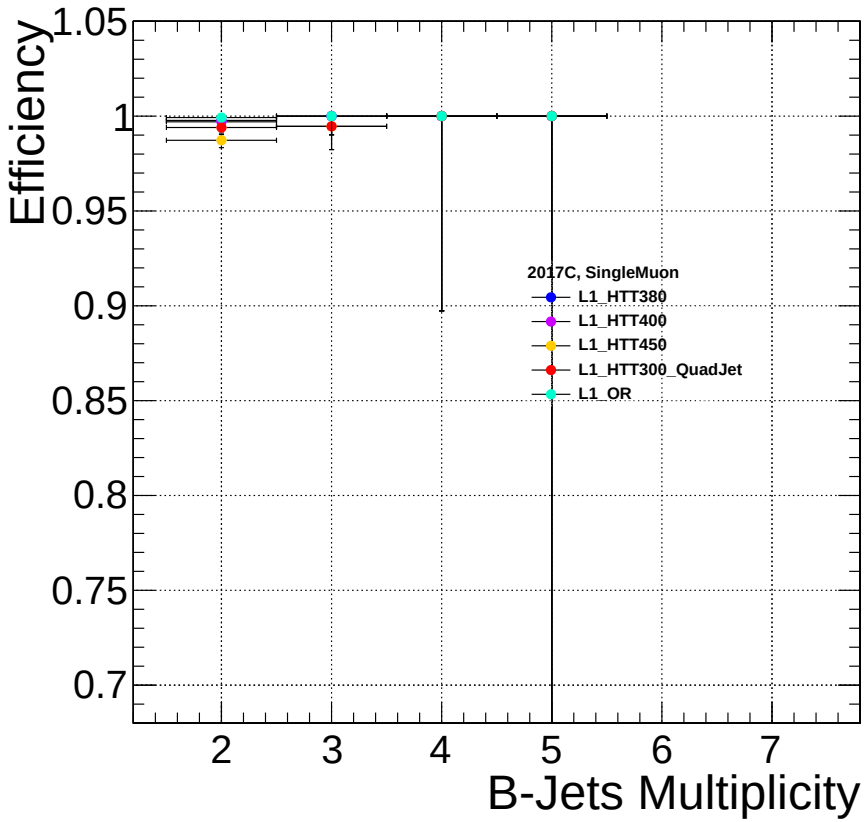


- The OR of the L1 Seeds is fully efficient with respect to the offline selection.

Jets Multiplicity



B-Jets Multiplicity



- The OR of the L1 Seeds is fully efficient with respect to the offline selection.

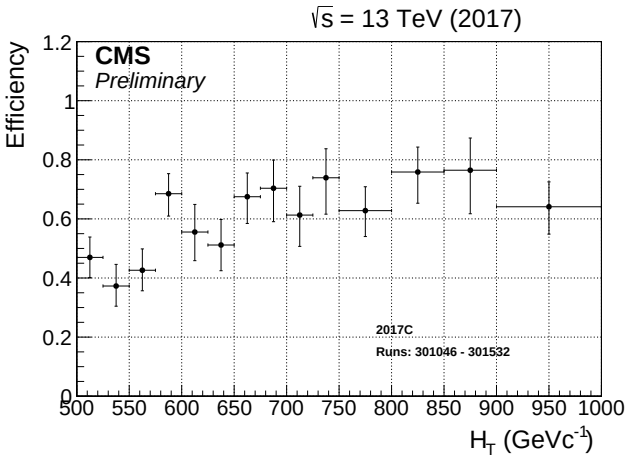
- CMSSW release: `CMSSW_9_2_10`
- Global Tag: `92X_dataRun2_HLT_v7`
- JSON: `Cert_294927-301567_13TeV_PromptReco_Collisions17_JSON.txt`
- Running on 2017C (runs 301046 - 301532)

The trigger efficiency is defined as:

$$\varepsilon_{HLT} = \frac{\textit{Offline Selection \&\& Reference Trg \&\& Signal Trg}}{\textit{Offline Selection \&\& Reference Trg}}$$

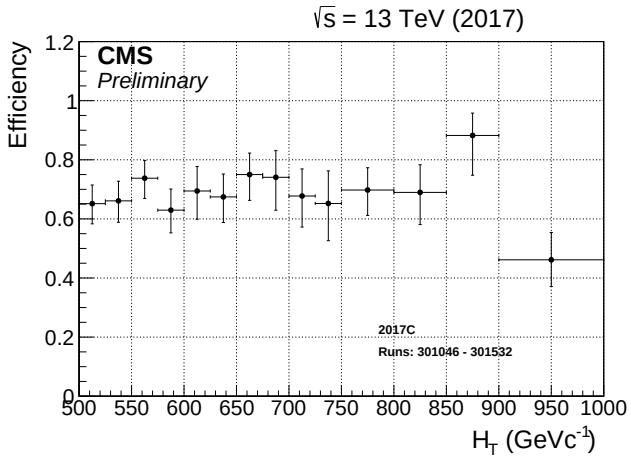
- Signal Trg is:
  - `HLT_PFHT430_SixPFJet40_PFBTagCSV_1p5`
  - `HLT_PFHT380_SixPFJet32_DoublePFBTagCSV_2p2`
- Reference Trg is: `HLT_IsoMu27`
- Offline Selection is:
  - No electrons with $p_T \geq 15$ GeV, $|\eta| \leq 2.5$, $\textit{rellso}_{EA} \leq 0.15$
  - ≥ 1 muon with $p_T \geq 28$ GeV, $|\eta| \leq 2.4$, $\textit{rellso}_{EA} \leq 0.15$
  - ≥ 5 PF Jets with $p_T > 40$ GeV, 6^{th} jet with $p_T > 30$ GeV
    - ($p_T^{1st} > 70$ GeV, $p_T^{2nd} > 55$ GeV)
  - $H_T > 500$ GeV
  - $N_{b-jets} \geq 2$ with $p_T > 40$ GeV, $|\eta| \leq 2.4$, Medium WP (0.8484)
  - (No matching is applied between online and offline b-tagged jets.)
- Global efficiencies are calculated using the SingleMuon dataset.

Single B-Tagging



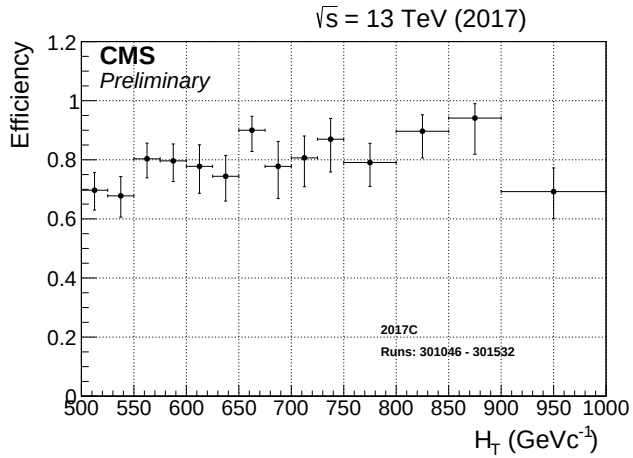
- Plateau around 650-700 GeV
- Efficiency at the plateau: 75%

Double B-Tagging



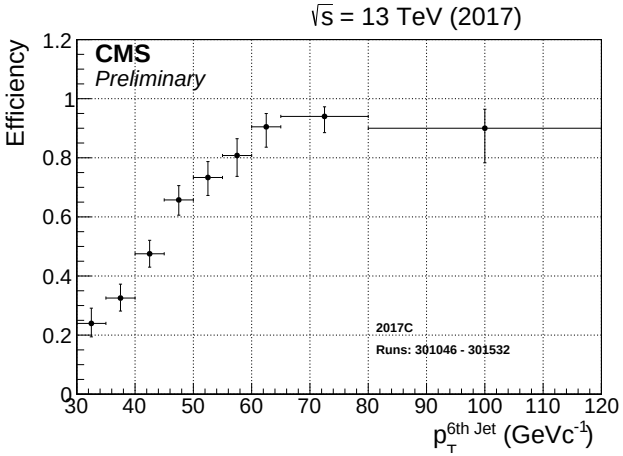
- Efficiency at the plateau: 70%

OR



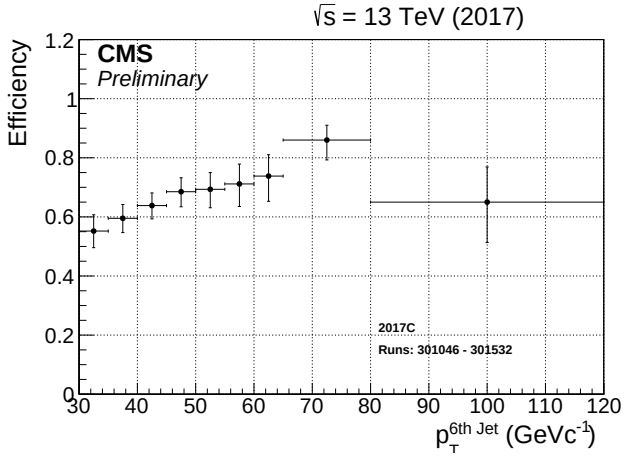
- Efficiency gain

Single B-Tagging



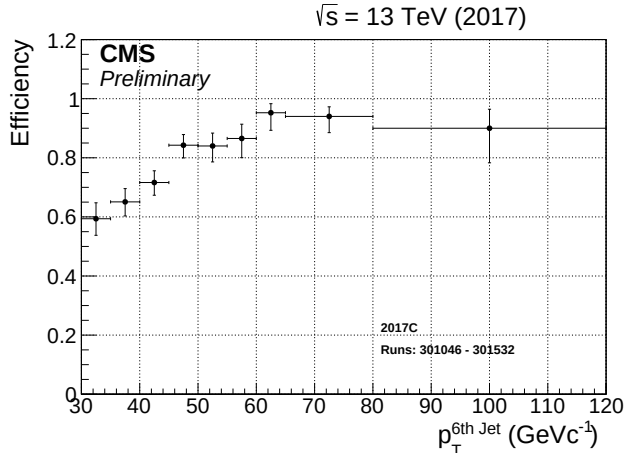
- Plateau around 65 GeV
- Efficiency at the plateau: 90%

Double B-Tagging



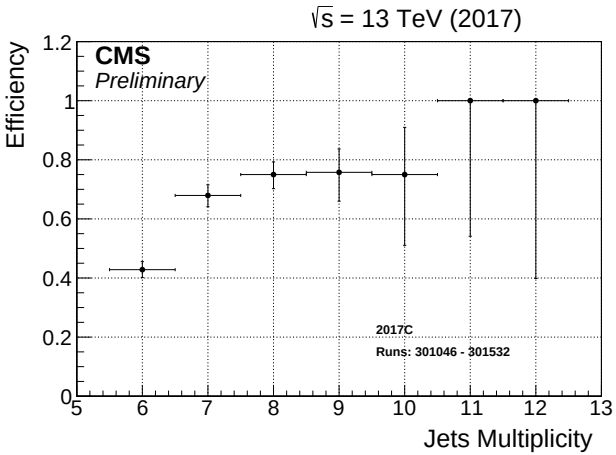
- Efficiency at the plateau: 70%

OR

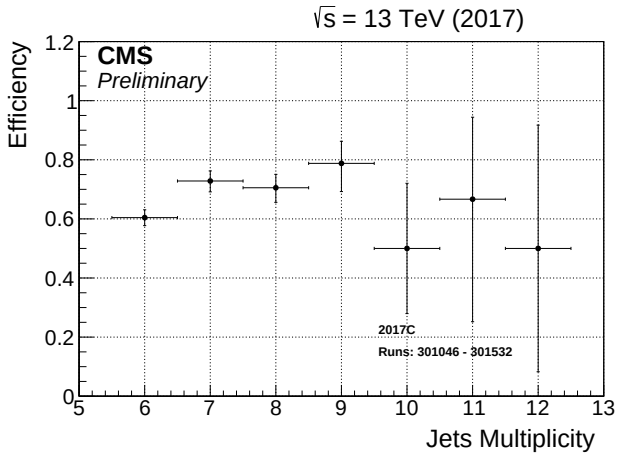


- Efficiency gain

Single B-Tagging



Double B-Tagging



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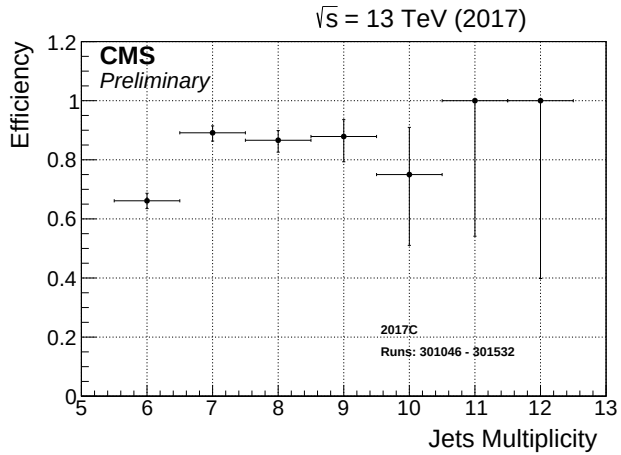
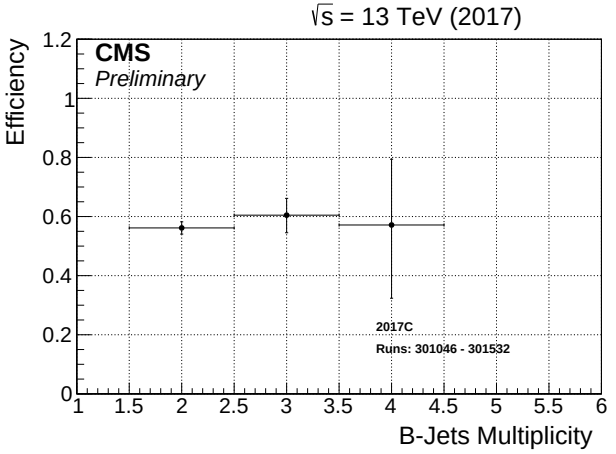
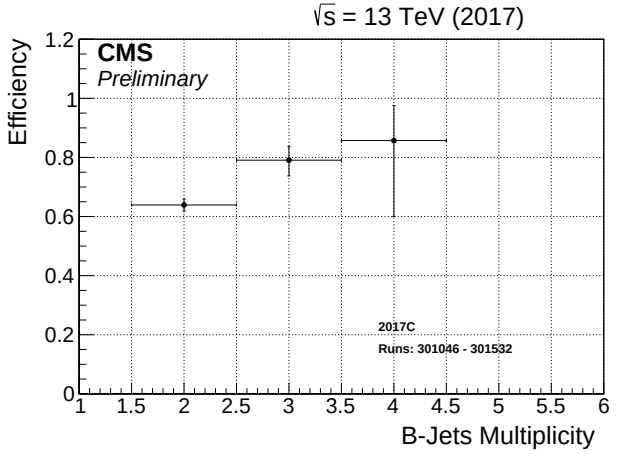


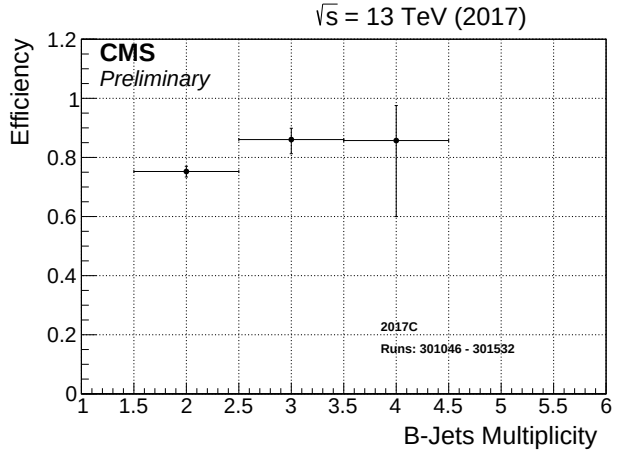
Single B-Tagging



Double B-Tagging



OR



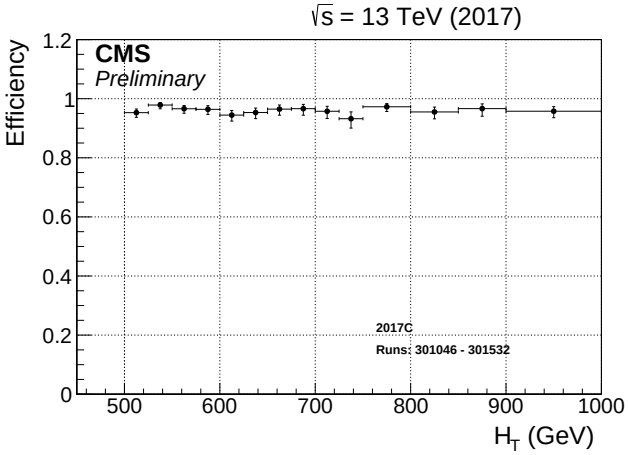
The b-tagging leg efficiency is defined as:

$$\varepsilon_{HLT} = \frac{Offline\ Selection\ \&\&\ Control\ Trg\ \&\&\ Signal\ Trg}{Offline\ Selection\ \&\&\ Control\ Trg}$$

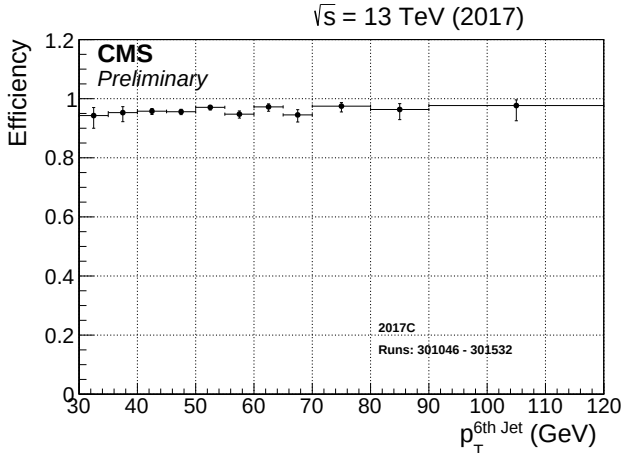
where:

- Signal Trg is:
  - `HLT_PFHT430_SixPFJet40_PFBTagCSV_1p5`
  - `HLT_PFHT380_SixPFJet32_DoublePFBTagCSV_2p2`
- Control Trg is:
  - `HLT_PFHT430_SixPFJet40`
  - `HLT_PFHT380_SixPFJet32`
- Offline Selection is:
  - Lepton veto
  - ≥ 5 PF Jets with $p_T > 40$ GeV, 6^{th} jet with $p_T > 30$ GeV
    - ($p_T^{1st} > 70$ GeV, $p_T^{2nd} > 55$ GeV)
  - $H_T > 500$ GeV
  - $N_{b-jets} \geq 2$ with $p_T > 40$ GeV, $|\eta| \leq 2.4$, Medium WP (0.8484)
  - (No matching is applied between online and offline b-tagged jets.)
- Efficiencies are calculated using the JetHT dataset and for the 2017C period (runs 301046 - 301532)

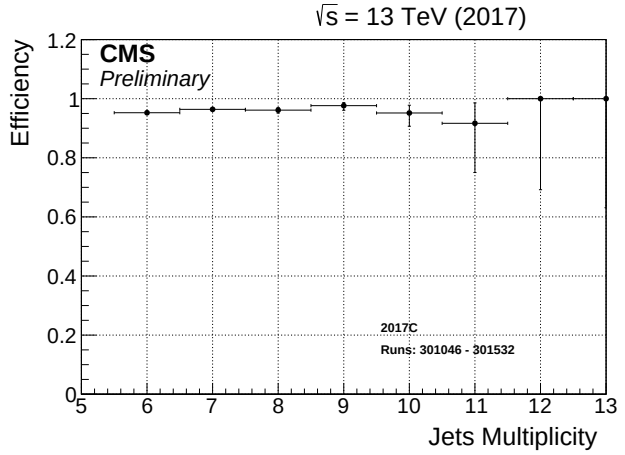
H_T



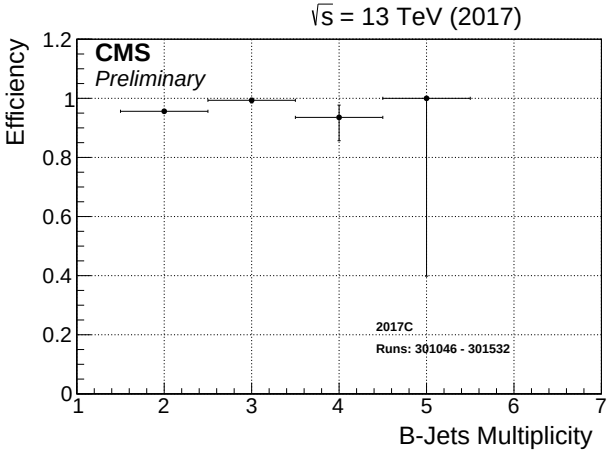
6th Jet p_T



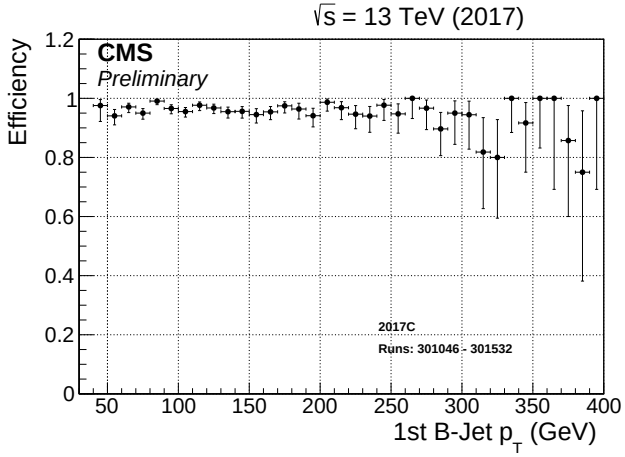
Jets Multiplicity



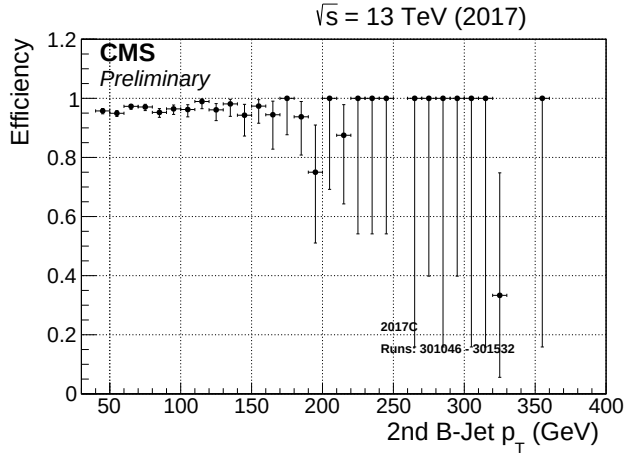
B-Jet Multiplicity



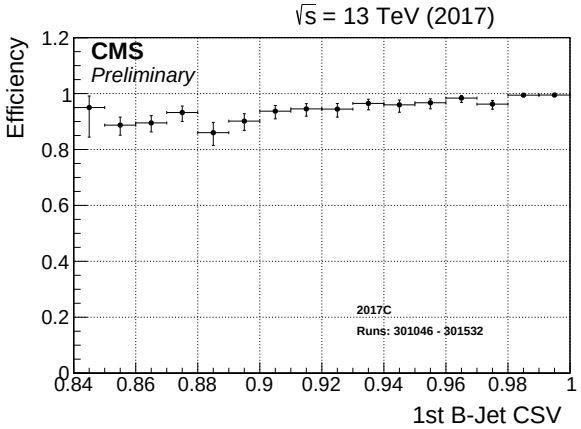
1st B-Jet p_T



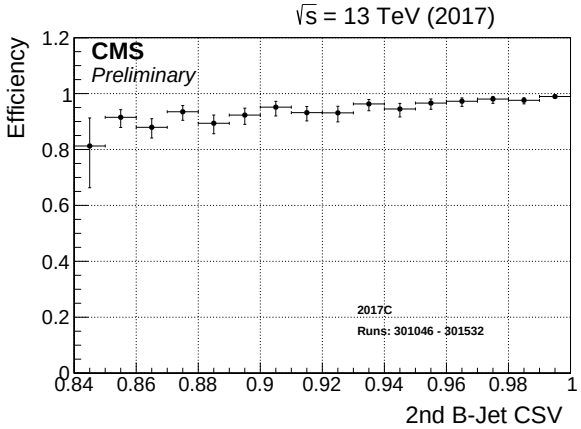
2nd B-Jet p_T



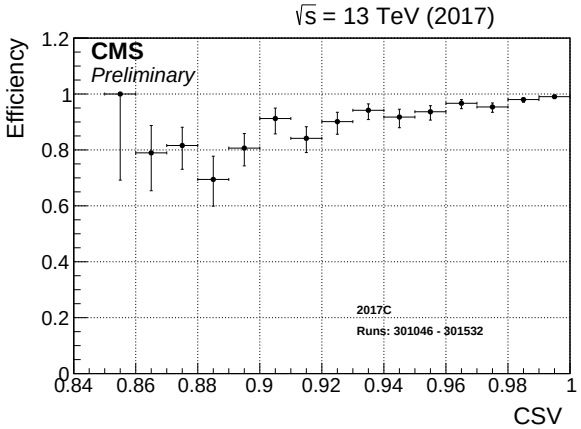
1st B-Jet CSV



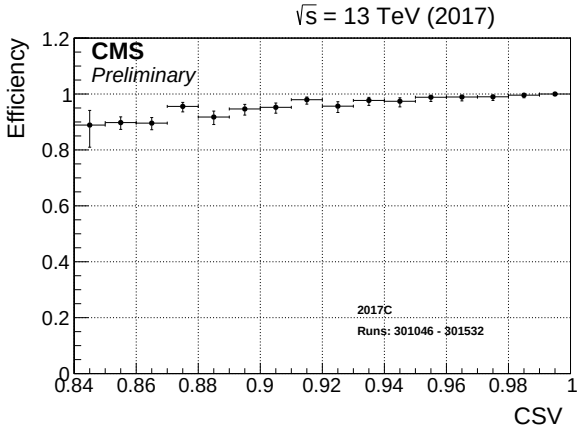
2nd B-Jet CSV



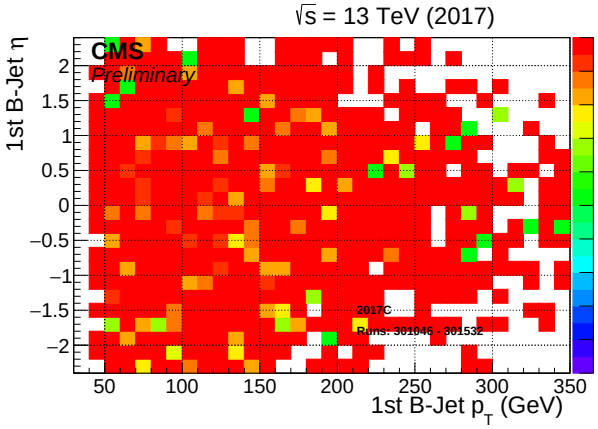
Max CSV



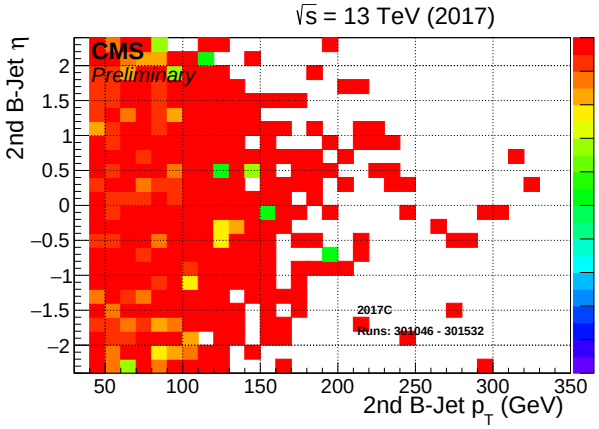
Second max CSV



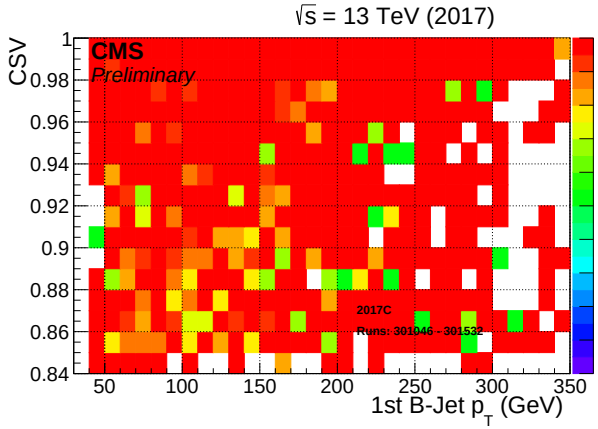
1st B-Jet p_T Vs. η



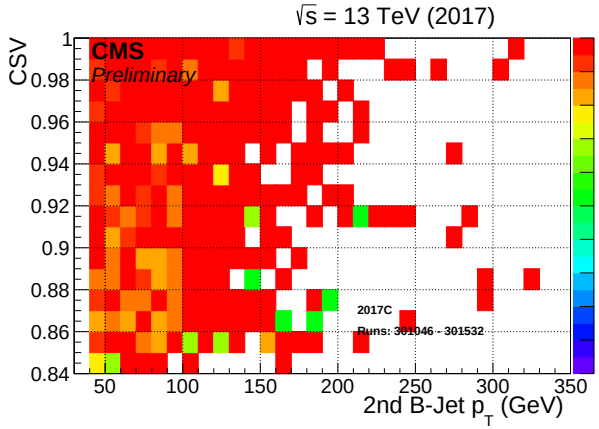
2nd B-jet p_T Vs. η



1st B-Jet CSV Vs p_T

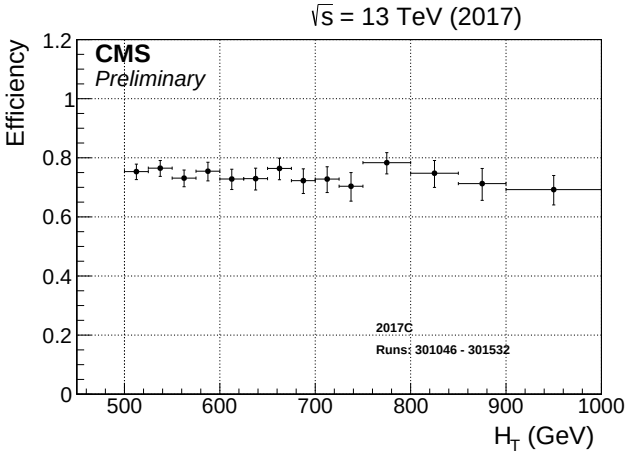


2nd B-Jet CSV Vs p_T

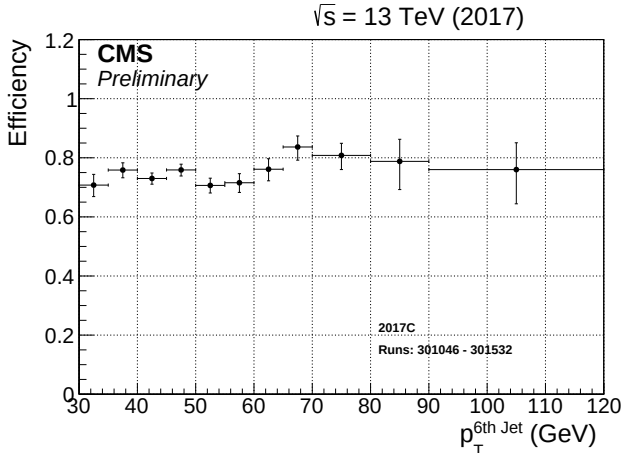


Double B-Tagging Path

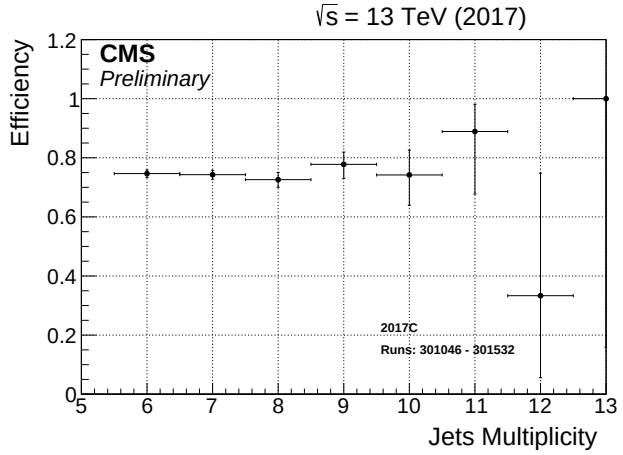
H_T



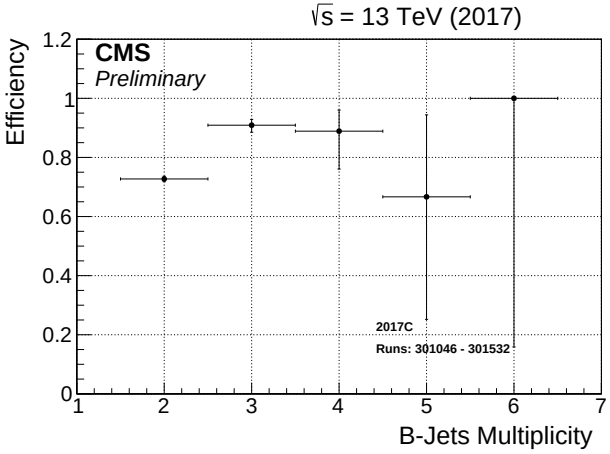
6th Jet p_T



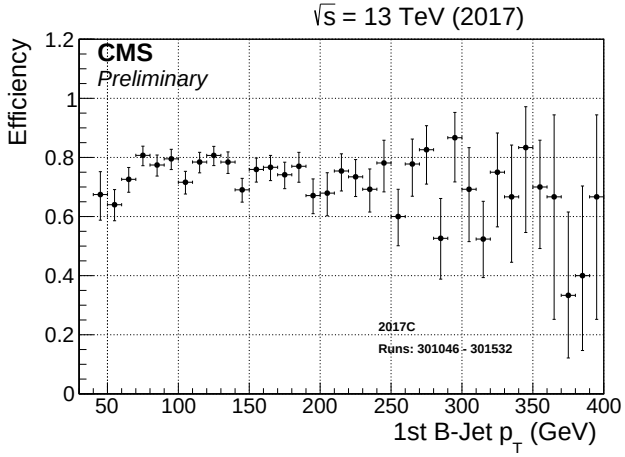
Jets Multiplicity



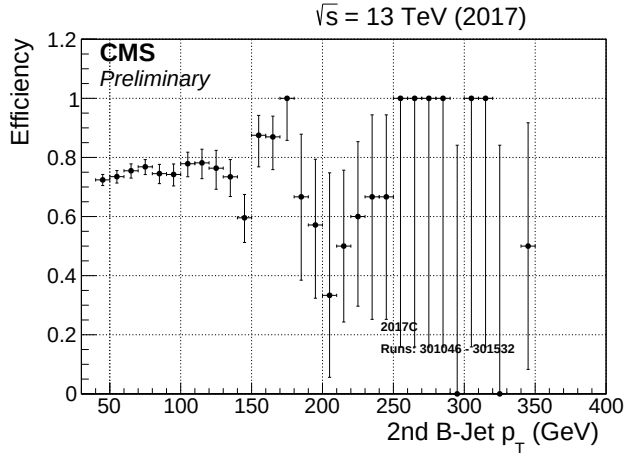
B-Jets Multiplicity



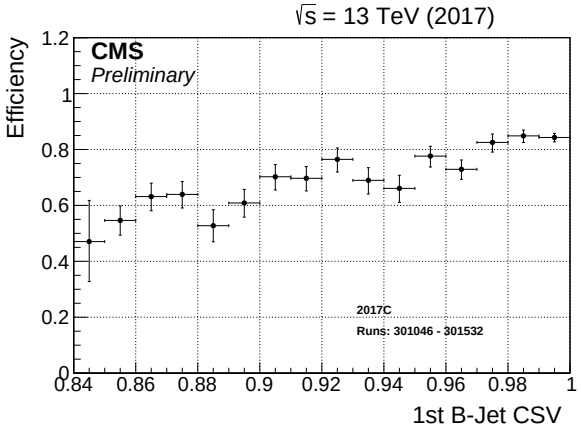
1st B-Jet p_T



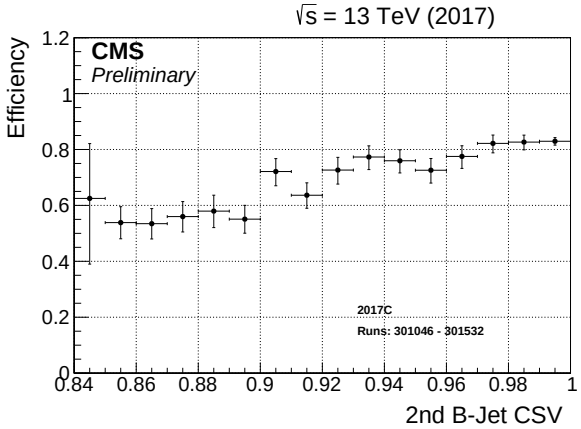
2nd B-Jet p_T



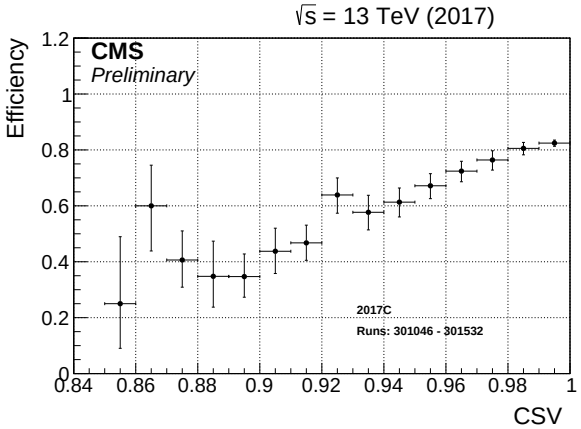
1st B-Jet CSV



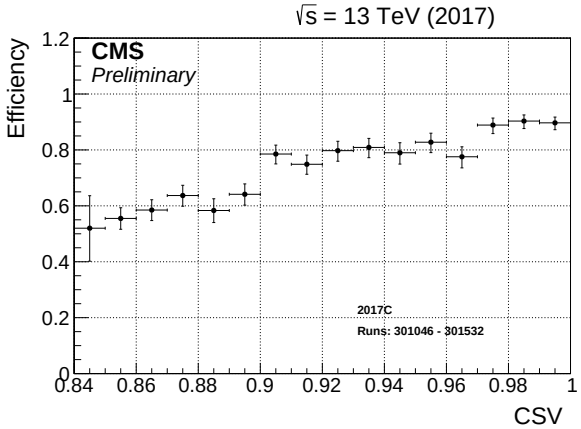
2nd B-Jet CSV



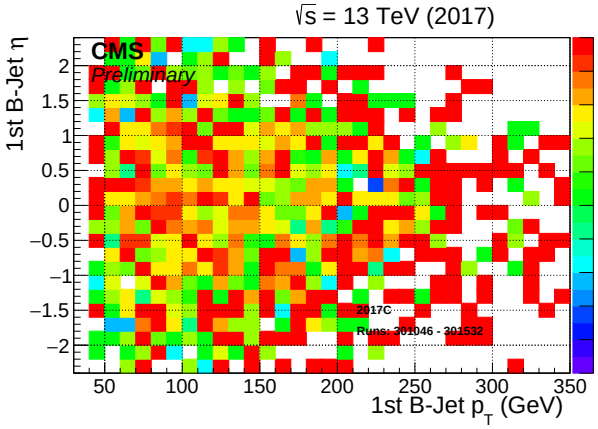
Max CSV



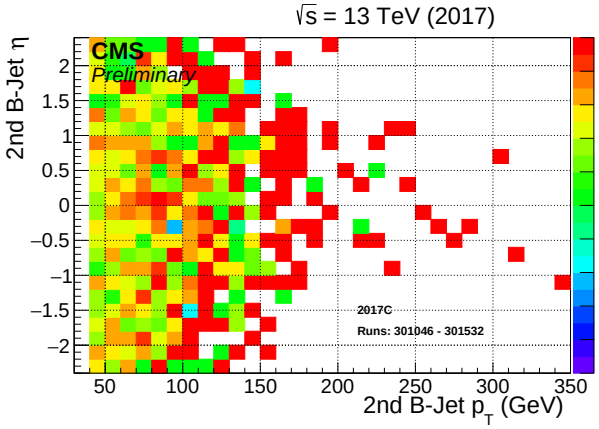
Second max CSV



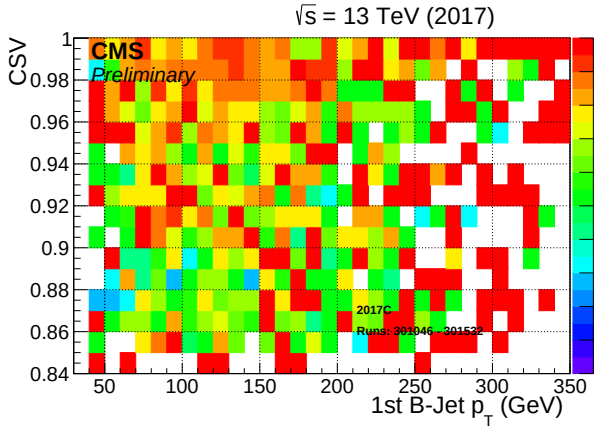
1st B-Jet p_T Vs η



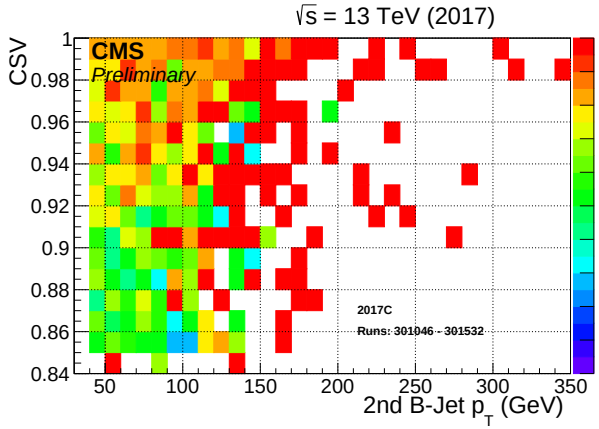
2nd B-Jet p_T Vs η



1st B-Jet CSV Vs p_T



2nd B-Jet CSV Vs p_T



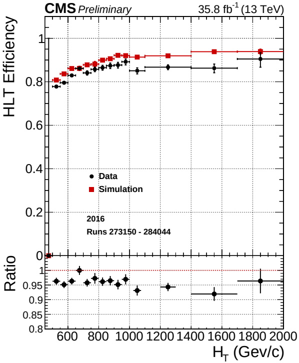
The trigger efficiency is defined as:

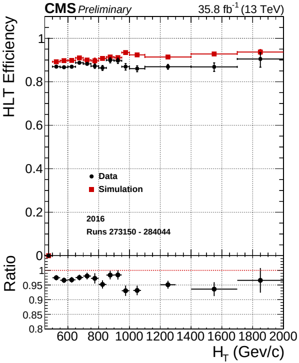
$$\varepsilon_{HLT} = \frac{Offline\ Selection\ \&\&\ Reference\ Trg\ \&\&\ Signal\ Trg}{Offline\ Selection\ \&\&\ Reference\ Trg}$$

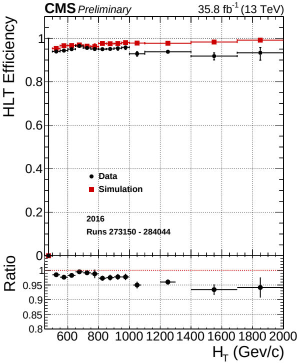
where:

- Signal Trg is:
  - `HLT_PFHT450_SixJet40_BTagCSV_p056`
  - `HLT_PFHT400_SixJet30_DoubleBTagCSV_p056`
- Reference Trg is: `HLT_IsoMu24`
- Offline Selection is:
  - No electrons with $p_T \geq 15$ GeV, $|\eta| \leq 2.5$, $rellso_{EA} \leq 0.15$
  - ≥ 1 muon with $p_T \geq 26$ GeV, $|\eta| \leq 2.4$, $rellso_{EA} \leq 0.15$
  - $N_{jets} \geq 6$ with $p_T > 40$ GeV, $|\eta| \leq 2.4$
    - $p_T^{1st} > 70$ GeV, $p_T^{2nd} > 55$ GeV
  - $H_T > 500$ GeV
  - $N_{b-jets} \geq 2$ with $p_T > 40$ GeV, $|\eta| \leq 2.4$, Medium WP (0.8484)

Tight Selection







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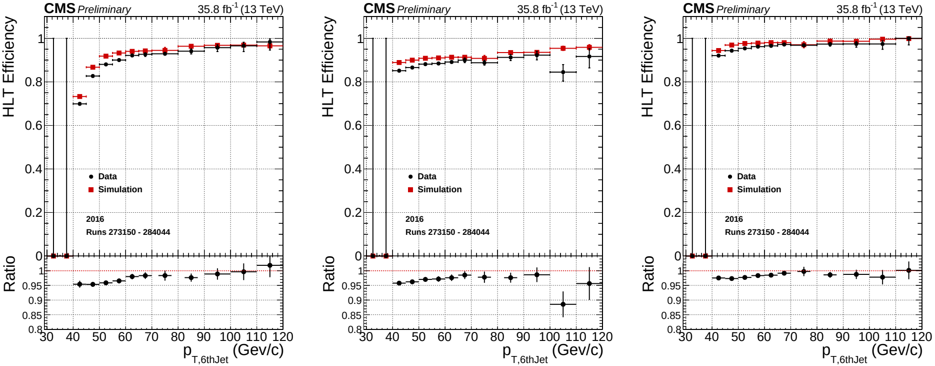

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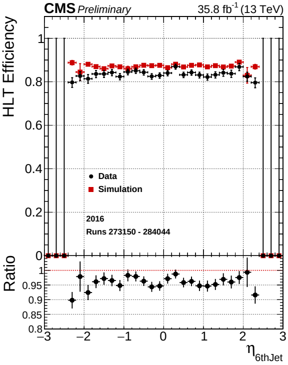

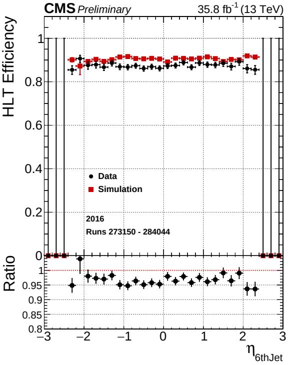

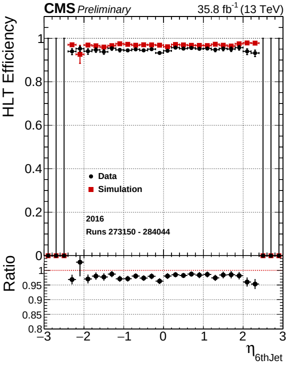

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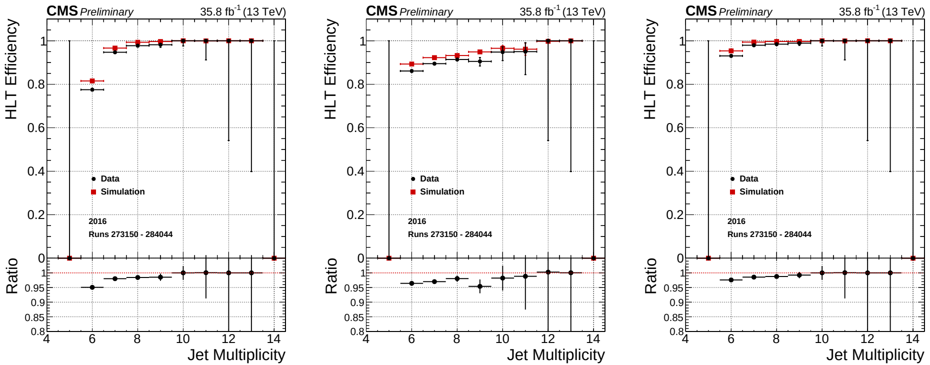
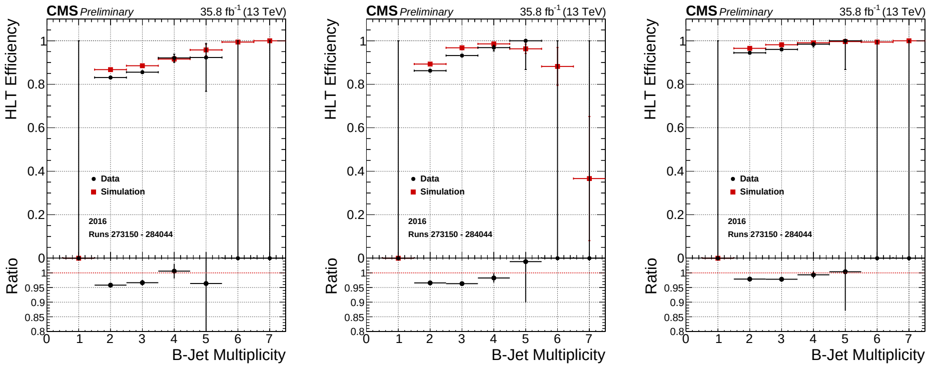


Tight Selection



- Checked the efficiencies from 2017C data taking period.
- Used runs 301046 - 301532 including the unprescaled Single B-Tagging path.
- Trigger efficiencies found to be similar to those observed during 2017B.
- 2017 triggers have lower efficiencies than in 2016.
- The tighter online CSV working points might be responsible for this efficiency loss.
- Further studies are needed to check (in)efficiency on the several legs.

Next:

- Calculate efficiencies from 2017D
- Compare the performace of DoublePFBTag CSV and DeepCSV triggers.

Table: Prescales as in HLT v3

HLT Path	Prescales					
	2.0e34	1.8e34	1.6e34	1.4e34	1.2e34	1.0e34
HLT_PFHT350	415	374	332	291	249	208
HLT_PFHT370	1	2	2	7	7	7
HLT_PFHT430	1	2	2	3	6	6
HLT_PFHT380_SixPFJet32	36	32	29	25	21	18
HLT_PFHT430_SixPFJet40	19	17	15	13	11	10
HLT_PFHT380_SixPFJet32_DoublePFBTagCSV_2p2	1	1	1	1	1	1
HLT_PFHT430_SixPFJet40_PFBTagCSV_1p5*	1	1	1	1	1	1
*prescales during HLT v2.0 and v2.1:	7	6	6	5	4	4