Trigger studies with UL2018

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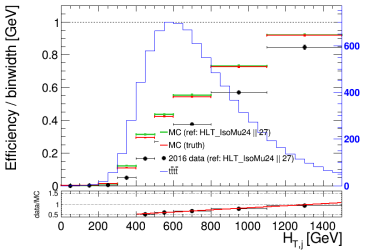
Trigger studies in 2018

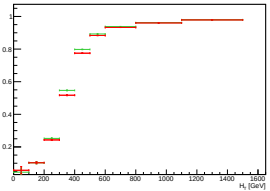
- 2018 simulation has the following multijet triggers available:
  - `HLT_PFHT400_SixPFJet32_DoublePFBTagDeepCSV_2p94`
  - `HLT_PFHT450_SixPFJet36_PFBTagDeepCSV_1p59`
- In 2018 data, two different sets of triggers run, depending on era:
  - 2018 A:
    - `HLT_PFHT380_SixPFJet32_DoublePFBTagDeepCSV_2p2`
    - `HLT_PFHT430_SixPFJet40_PFBTagDeepCSV_1p5`
  - 2018 B, C and D:
    - `HLT_PFHT400_SixPFJet32_DoublePFBTagDeepCSV_2p94`
    - `HLT_PFHT450_SixPFJet36_PFBTagDeepCSV_1p59`
- **Problem: trigger that run in 2018 A are not emulated in MC**

Trigger studies in 2018

- Not 100% about how to proceed
- An idea (maybe?):
  - When running on MC, ask for the triggers available
  - When running on data, ask for triggers available in different eras
  - When adding together TEfficiency objects for data, **reweight each era for it's integrated luminosity**
  - Extract trigger SF
  - This should take into account the differences in trigger in 2018 A
- **For now run on 2018 B,C and D**

1D trigger efficiency plots





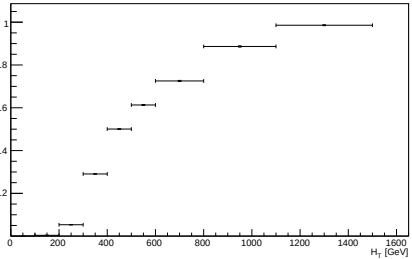
- Trigger choice
  - `HLT_PFHT400_SixPFJet32_DoublePFBTagDeepCSV_2p94`
  - `HLT_PFHT450_SixPFJet36_PFBTagDeepCSV_1p59`
  - `HLT_PFJet500`
- Reference triggers: OR of
  - `HLT_IsoMu24`
  - `HLT_IsoMu27`
- Selection:
  - Preselection: 1 tau, 2 jets, 2 loose bjets
  - $== 1\ \ell$, $== 1\ \mu$
  - Designed to have reference firing
- **Bad, smeared turn on, low MC eff, very low data eff**

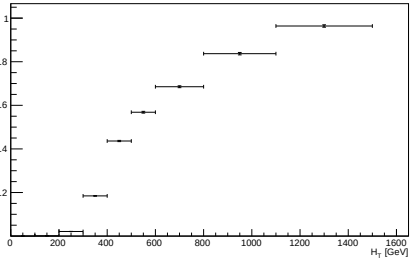
Why spoiled efficiency?

- I suspect the bad plots come from the **b tagging leg of the trigger**
- In **2018** they used **DeepCSV instead of CSV**
- I checked some ttbar SL events in 2016 and 2018
- Single btag trigger has eff of $\frac{4811}{80640} \simeq 6\%$ in 2018 and $\frac{5823}{83152} \simeq 7\%$ in 2016
- Double btag trigger has eff of $\frac{5346}{80640} \simeq 6\%$ in 2018 and $\frac{10315}{83152} \simeq 12\%$ in 2016

Remove btag legs

- In NanoAOD there are the **same triggers but with no b tag legs**
- Tried to see what happens when running on them
- Quickly checked the result on ttbar semileptonic



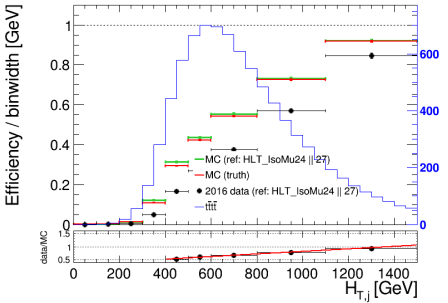


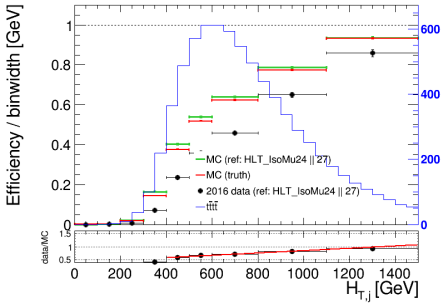
- Left: 2016 preVFP; right 2018 with no btag legs
- 2018 is slightly more inefficient, but look similar

What could the problem be with b tag?

- In **preselection** we ask for **at least 2 loose b jets tagged with DeepJet**
- I thought that **maybe DeepCSV** (used in 2018 trigger) **has better background rejection** than CSV (used in 2016) trigger
- Maybe our loose b jets in presel are not enough b-like to make the trigger fire
- Tried some different preselection scenarios

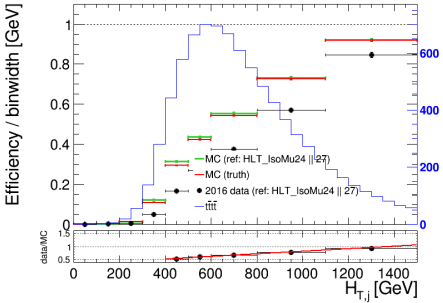
At least 3 loose b jets in presel

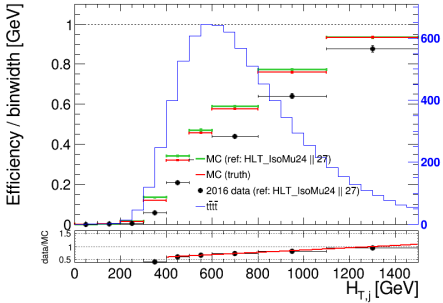




- Left: ≥ 2 loose b jets presel; right: ≥ 3 loose b jets presel
- Slight improvement in MC efficiency
- Still, way lower efficiency in data

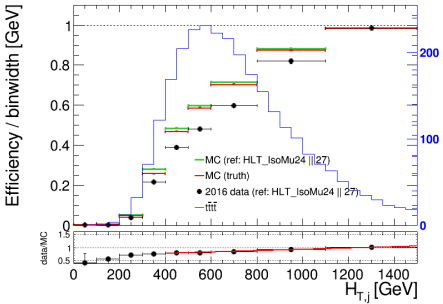
At least 2 medium b jets in presel

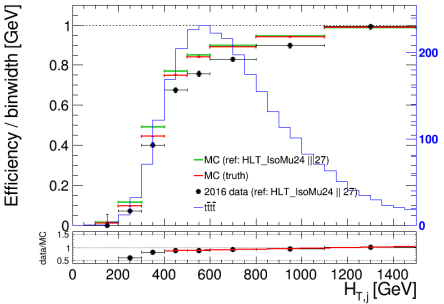




- Left: ≥ 2 loose b jets presel; right: ≥ 3 loose b jets presel
- Slight improvement in MC efficiency
- Worse than previous scenario
- Still, way lower efficiency in data

Some general comments





- Our turn ons are not very good in general, including in 2016.
- Asking for 6 jets makes them already way better (compare left with right)
- I am thinking about possible questions coming about this
- I think it would be better to have a steeper turn on and place ourselves more on the turn on

Some general comments

Category	Njets online[1]	Njets offline	Our cut
1tau0L	11	10	≥ 8
1tau1L	9	8	≥ 6
1tau2L	7	6	≥ 4
1tau3L	5	4	≥ 2
2tau0L	10	8	≥ 6
2tau1L	8	6	≥ 4
2tau2L	6	4	≥ 2

- Njets we request is 2 less than the expected offline number
- What happens if we increase it? We could increase number of jets in presel
- Dropping 1tau3L and 2tau2L we could even ask for 6 jets in preselection

[1] I include hadronic taus in this calculation, not sure if they are counted as jets in the trigger

Summary

- Results look bad in 2018
- I do not fully understand the reason (especially for the low efficiency in data)
- Also I reported some general comments about preselection and event categorization