IMPROVING TRIGGER EFFICIENCY FOR THE ATLAS DI-HIGGS SEARCH

SUMMER STUDENT PROJECT 2019

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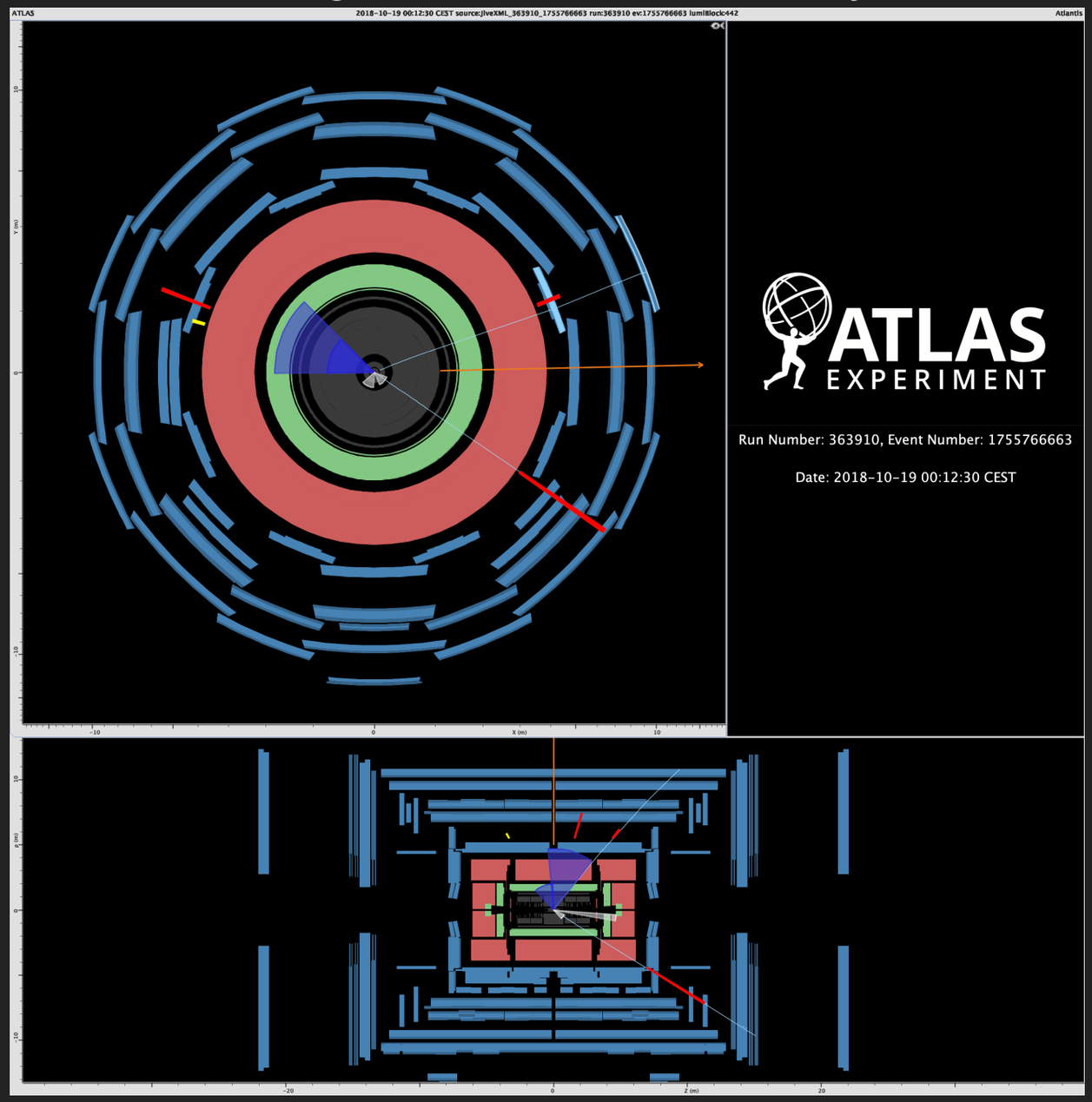
THE ATLAS EXPERIMENT

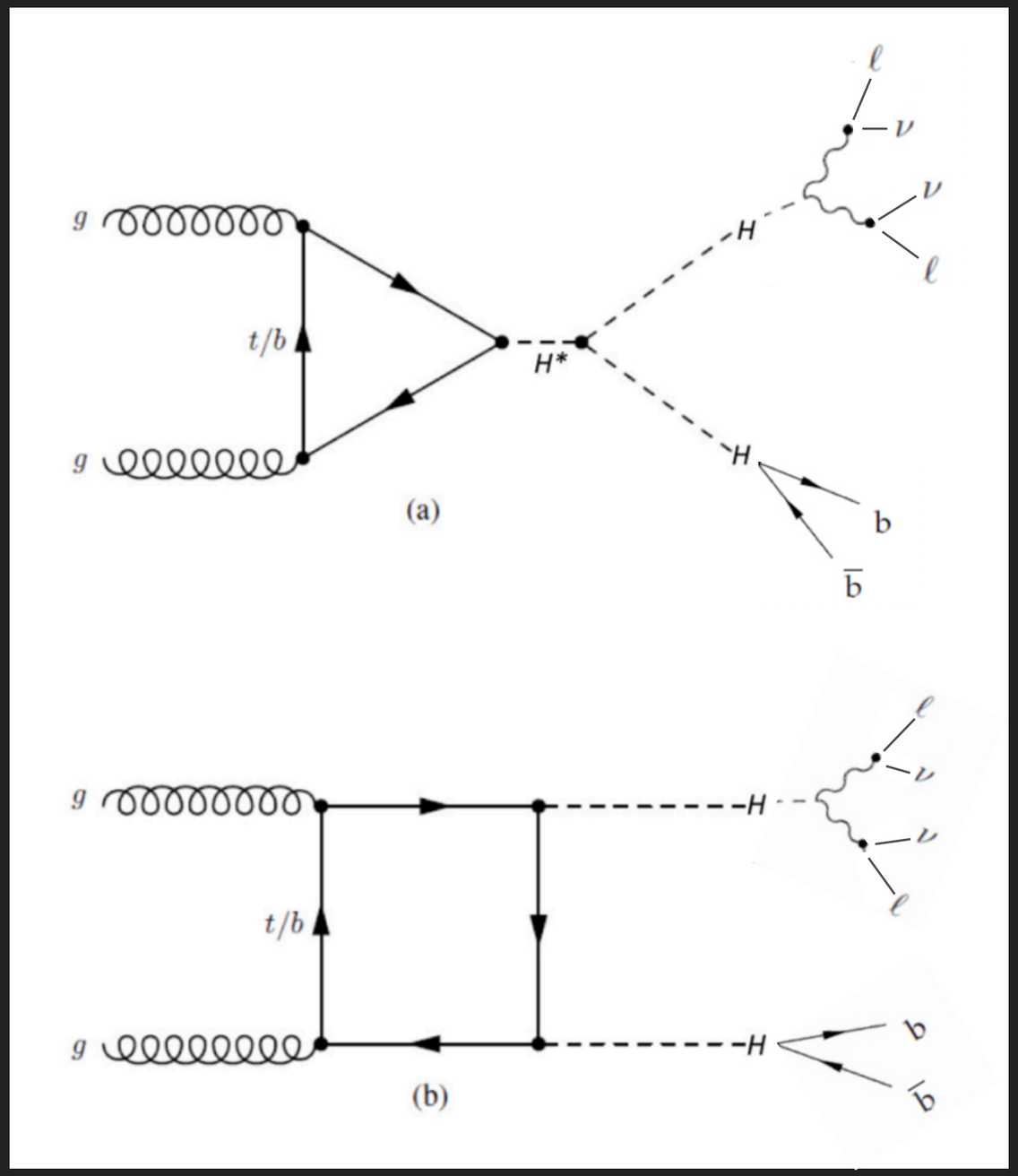
- General-purpose particle physics experiment observing proton-proton collisions
- Uses silicon trackers, electromagnetic and hadronic calorimeters, and muon spectrometers to detect both charged and neutral particles
- Records events of interest using a combination of hardware triggers (L1) and software triggers (HLT)

bbll+MET signal-like event detected by ATLAS



Shows two muons with $p_T > 9$ GeV (periwinkle), two b-jets with $p_T > 20$ GeV (blue), and MET (orange)

PROJECT GOAL



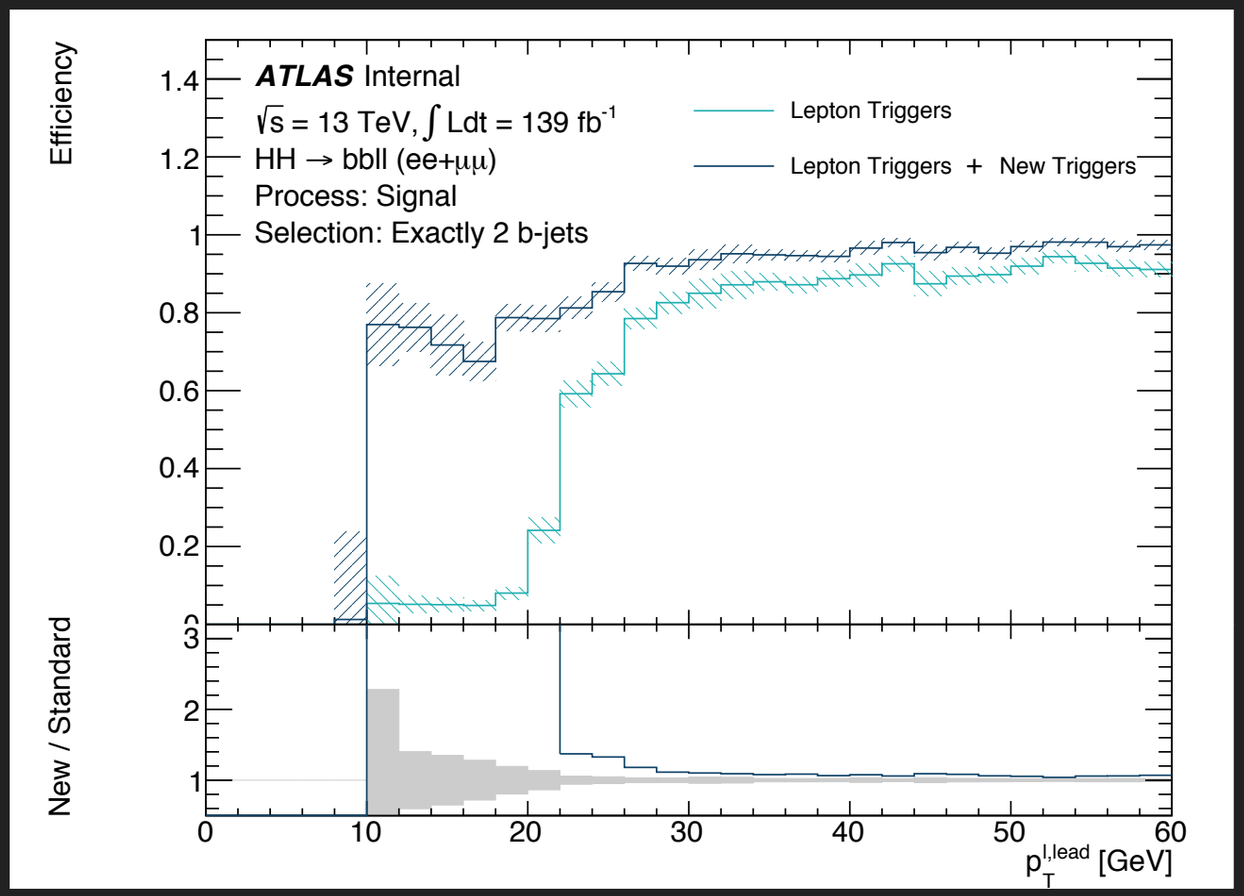
Leading-order diagrams for non-resonant di-Higgs production from gluon-gluon fusion resulting in a $bbll$+MET final state (bbWW channel)

- Recover $HH \rightarrow bbll$+MET events that the standard High Level Triggers miss
- Standard triggers are lepton only
- Adding b-jet and MET triggers can recover events involving leptons with transverse momentum (p_T) lower than the trigger thresholds

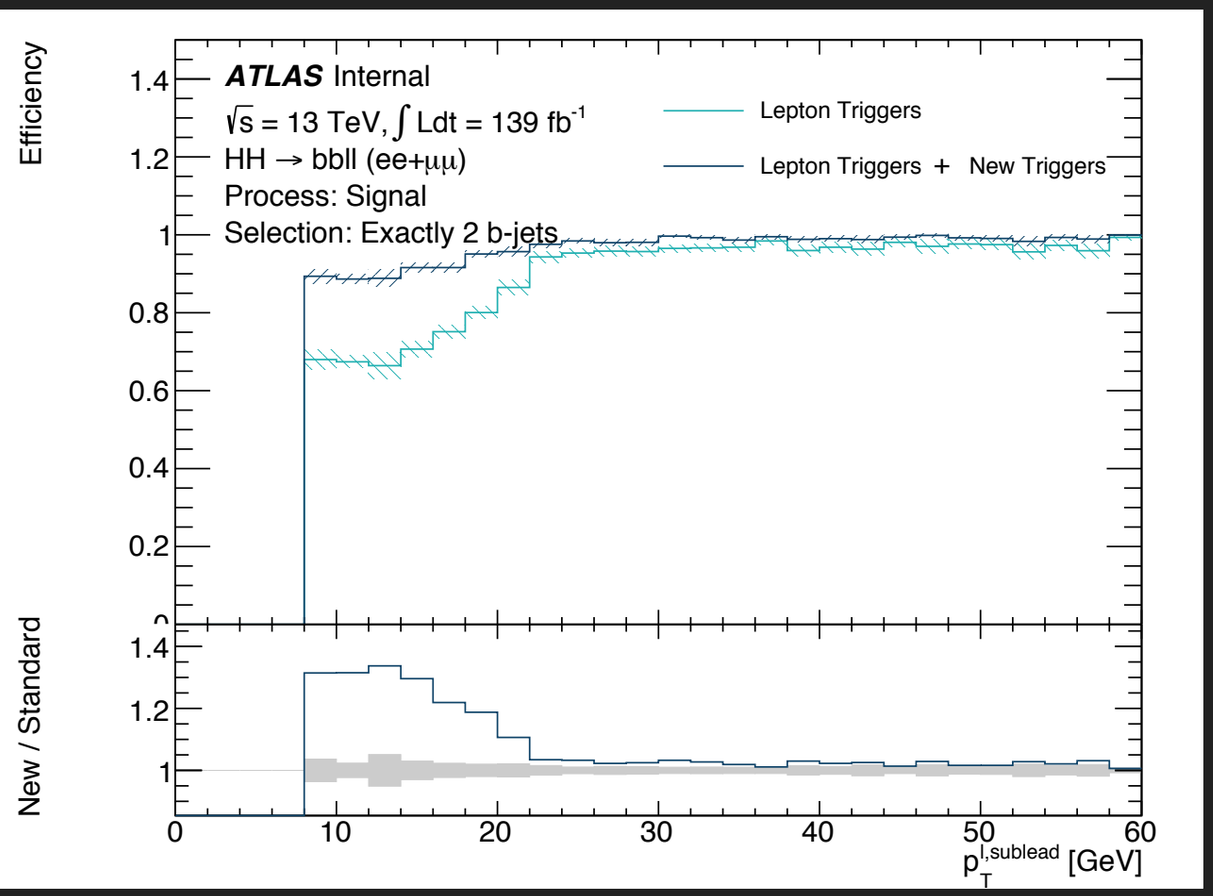
INITIAL EVENT SELECTION

- Analyze MC simulation data of $HH \rightarrow bbWW$, $HH \rightarrow bbZZ$, and $HH \rightarrow bb\tau\tau$ signal events, all of which can decay into the $HH \rightarrow bbll$+MET final state
- Data undergoes initial event selection cuts before reaching the High Level Triggers
  - Must have a primary vertex
  - Must have two signal leptons with $p_T > 9$ GeV
  - Must have at least one signal jet with $p_T > 20$ GeV
    - Performed the analysis with the stricter selections “at least one signal b-jet” and “exactly two signal b-jets” as well

RESULTS



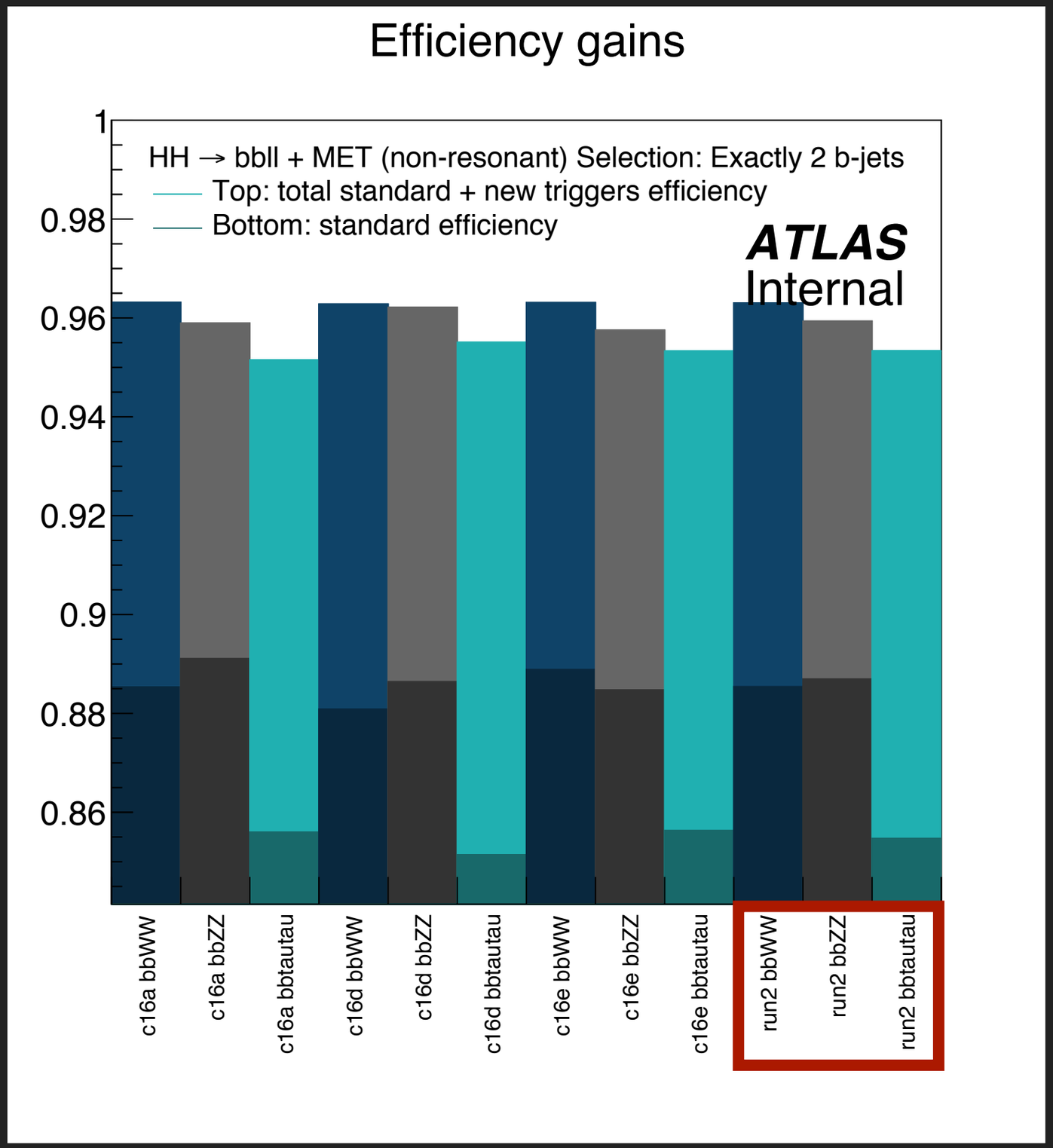
Higher p_T lepton



Lower p_T lepton

As expected, see efficiency gain with additional triggers in low lepton-p_T region for both signal leptons

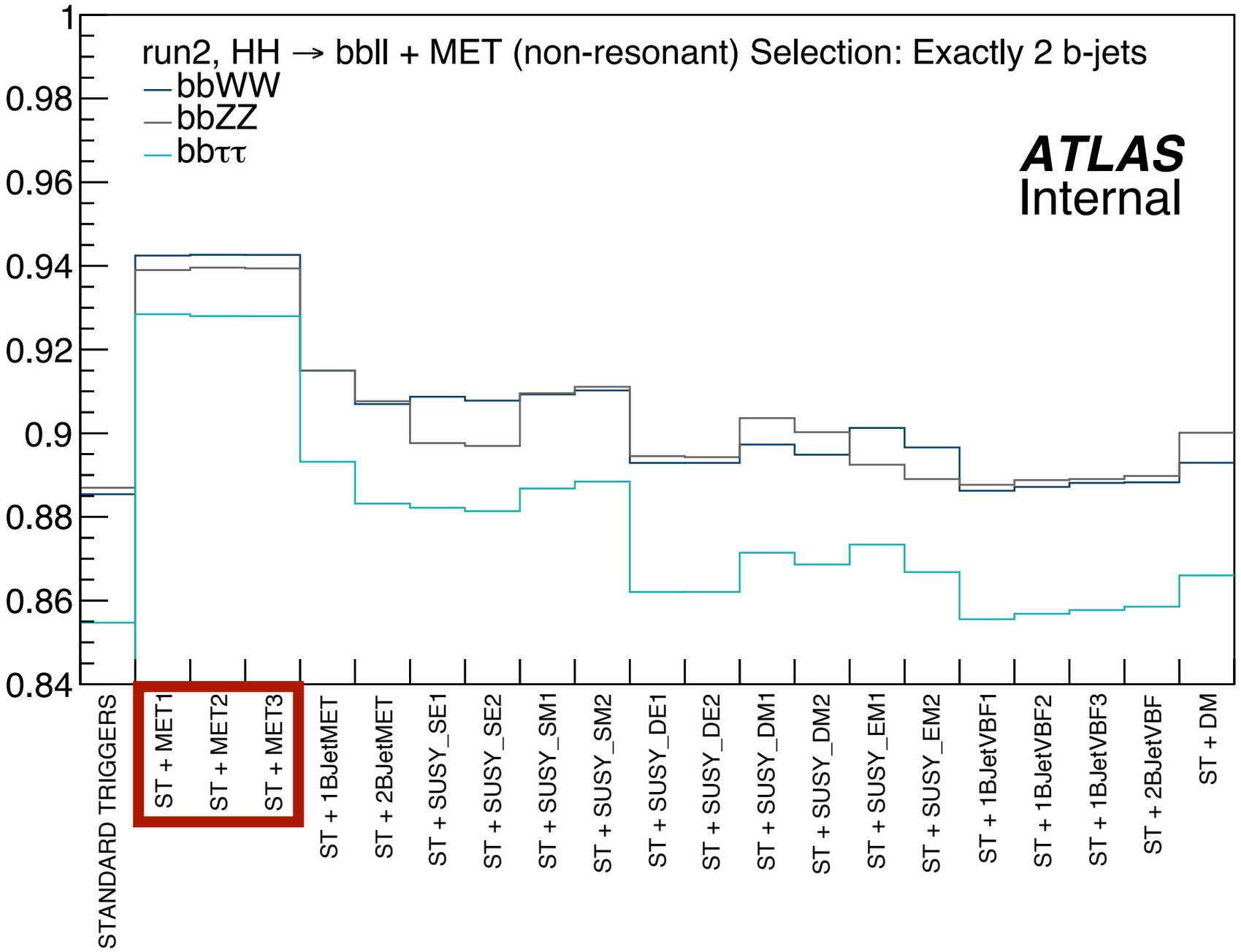
RESULTS



- Total efficiency gain of around 7-11% for the three signal samples
- Highest gain for $bb\tau\tau$ sample (aqua) because the τ particle produces leptons with lower p_T than the signals with W and Z bosons
- Calculated the gains for all three jet selection criteria
  - The final jet selection used will be determined in the future

RESULTS

Efficiency gains from individual triggers



See highest gain from MET triggers

NEXT STEPS

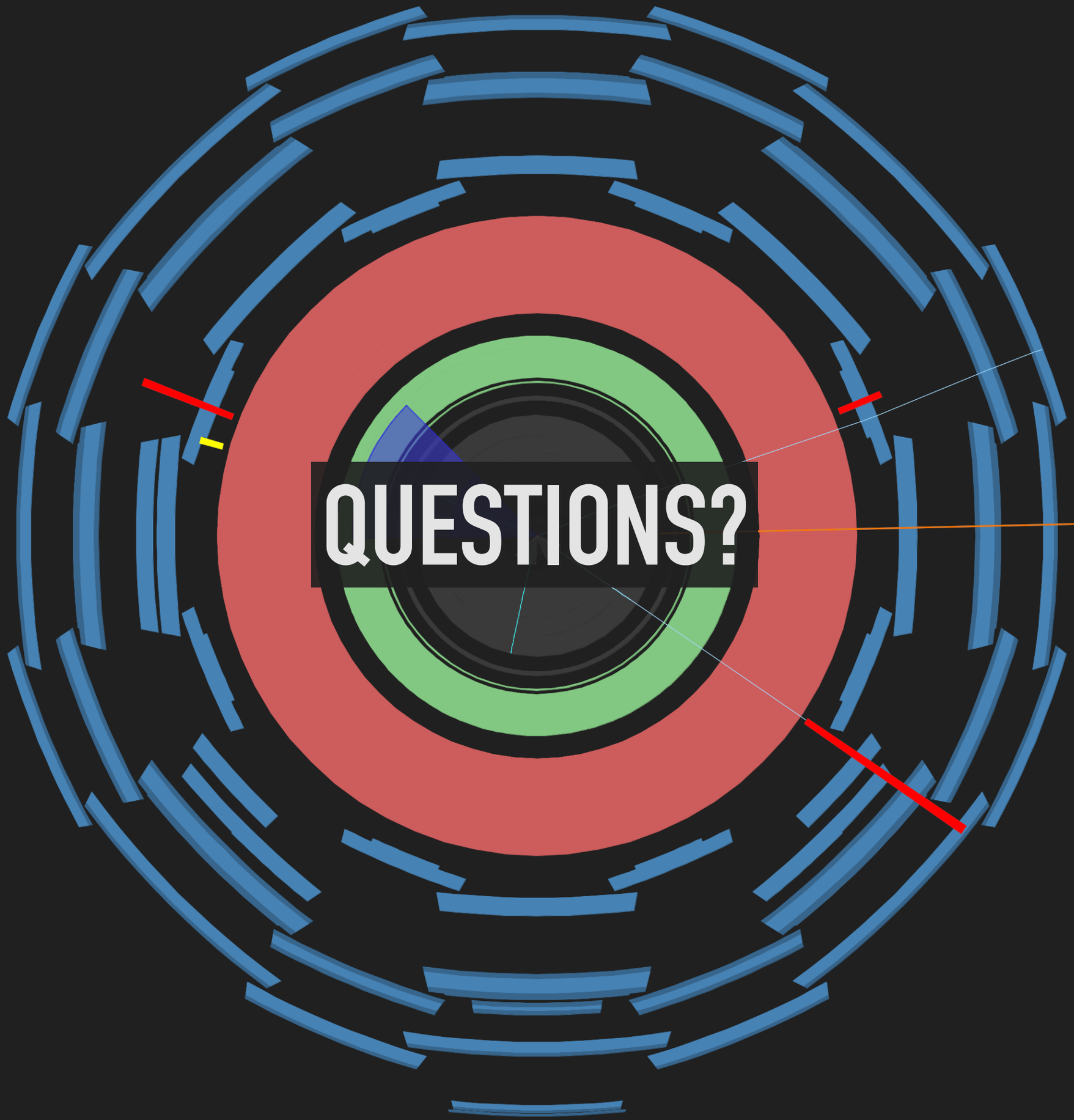
- Confirm that the leptons that pass the event selection (offline) match the leptons that triggered the event (online)
- Remove highly correlated triggers to minimize redundancy
  - Triggers come in groups with slight differences (such as MET1, MET2, MET3) – we will choose one from each group
  - To choose which ones to keep, need to determine which triggers have calibration support already – prioritize triggers that are simpler to implement
- Integrate the final list of new triggers into the standard analysis

EXPERIENCES ABROAD

ACKNOWLEDGEMENTS

I would like to thank my supervisors for supporting me this summer. A special thanks to Suyog Shrestha, Benjamin Rottler, and the rest of the ATLAS $bbll$ di-Higgs search group for working with me and providing feedback all along the way. They helped me hone my Python skills, better understand the physics of di-Higgs production, and experience what working in a scientific collaboration is like.

I would also like to thank the University of Michigan CERN-REU program and the National Science Foundation for this opportunity.


QUESTIONS?

BACKUP

TRIGGERS INCLUDED UNDER EACH ALIAS

Group name	Year [period]	Trigger
MET1	2015	HLT_xe70
	2016	HLT_xe90_mht_L1XE50
	2017	HLT_xe110_pufit_L1XE55
	2018	HLT_xe110_pufit_xe70_L1XE50
MET2	2015	HLT_xe70_mht
	2016	HLT_xe90_mht_L1XE50
	2017	HLT_xe110_pufit_L1XE55
	2018	HLT_xe110_pufit_xe70_L1XE50
MET3	2015	HLT_xe70_tc_lcw
	2016	HLT_xe90_mht_L1XE50
	2017	HLT_xe110_pufit_L1XE55
	2018	HLT_xe110_pufit_xe70_L1XE50
1BJetMET	2016	HLT_j80_bmv2c2060_split_xe60_L12J50_XE40
	2017	HLT_j60_gsc100_bmv2c1050_split_xe80_mht_L1XE60
	2018	HLT_j85_gsc100_bmv2c1050_split_xe85_pufit_xe50_L1XE55
2BJetMET	2017	HLT_2j25_gsc45_bmv2c1070_split_xe80_mht_L12J15_XE55
	2018	HLT_2j35_gsc45_bmv2c1070_split_xe85_pufit_xe50_L12J15_XE55
SUSY_SE1	2017 [B1-B4]	HLT_e5_lhloose_nod0_j40_xe70_pufit_2dphi10_L1XE60
	2017 [B5-]	HLT_e5_lhloose_nod0_j50_xe70_pufit_2dphi10_L1J40_XE50_DPHI-J20s2XE50
	2018	HLT_e5_lhloose_nod0_j50_xe70_pufit_2dphi10_L1J40_XE50_DPHI-J20s2XE50

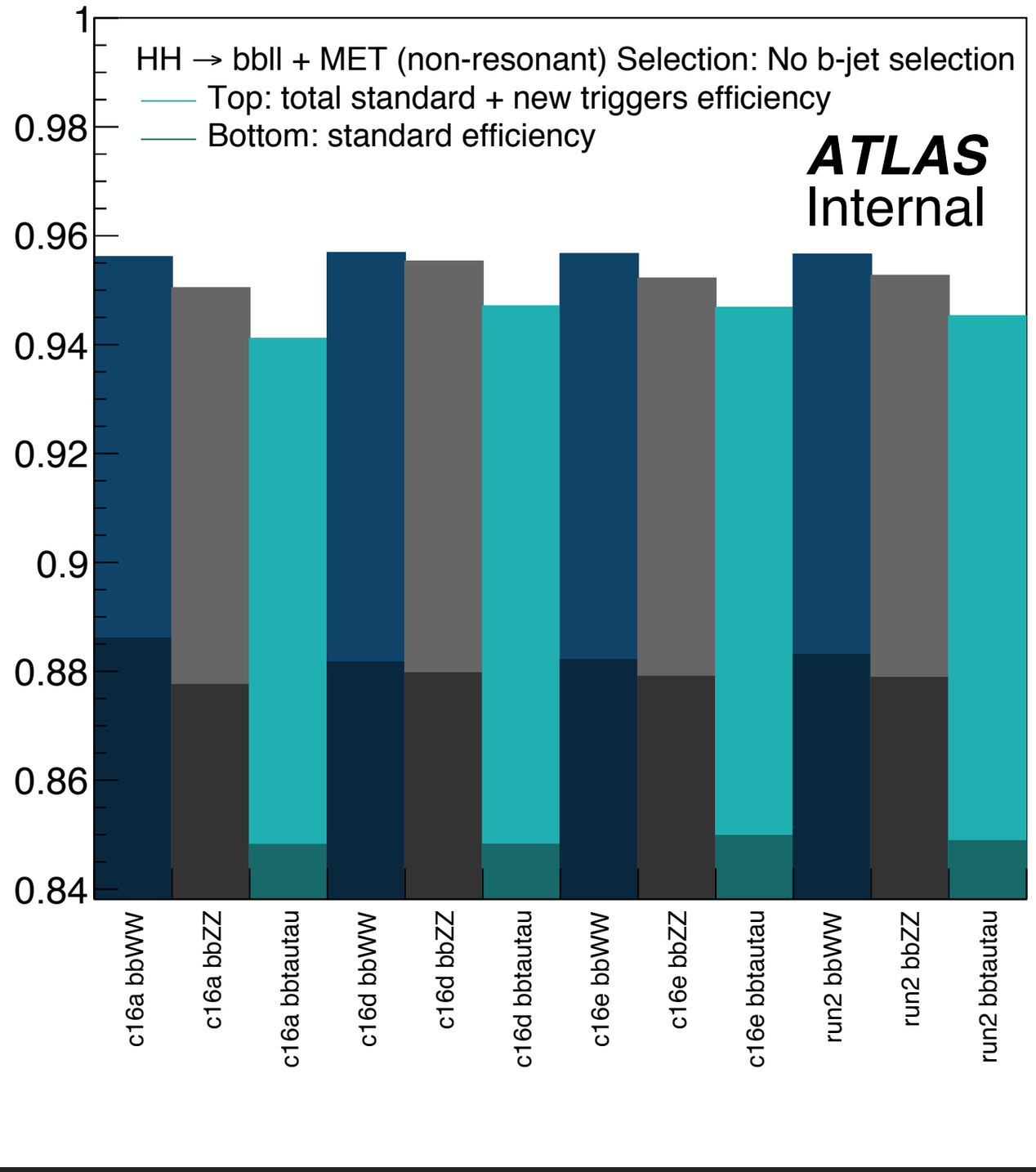
CONTINUED

SUSY_SE2	2017	HLT_e5_lhloose_nod0_j40_xe70_pufit_2dphi10_L1XE60	non-L1Topo backup
	2018	HLT_e5_lhloose_nod0_j40_xe70_pufit_2dphi10_L1XE60	non-L1Topo backup
SUSY_SM1	2017 [B1-B4]	HLT_mu4_j90_xe90_pufit_2dphi10_L1MU4_XE60	
	2017 [B5-]	HLT_mu4_j90_xe90_pufit_2dphi10_L1MU4_J50_XE50_DPHI-J20s2XE30	
	2018	HLT_mu4_j90_xe90_pufit_2dphi10_L1MU4_J50_XE50_DPHI-J20s2XE30	
SUSY_SM2	2017	HLT_mu4_j90_xe90_pufit_2dphi10_L1MU4_XE60	non-L1Topo backup
	2018	HLT_mu4_j90_xe90_pufit_2dphi10_L1MU4_XE60	non-L1Topo backup
SUSY_DE1	2017 [B1-B4]	HLT_2e5_lhvloose_nod0_j40_xe70_pufit_2dphi10_L1XE60	
	2017 [B5-]	HLT_2e5_lhvloose_nod0_j40_xe70_pufit_2dphi10_L1J40_XE50_DPHI-J20s2XE50	
	2018	HLT_2e5_lhvloose_nod0_j40_xe70_pufit_2dphi10_L1J40_XE50_DPHI-J20s2XE50	
SUSY_DE2	2017 [B1-B4]	HLT_2e5_lhvloose_nod0_j40_xe70_pufit_2dphi10_L1XE60	non-L1Topo backup
	2017 [B5]	HLT_2e5_lhvloose_nod0_j40_xe70_pufit_2dphi10_L1XE60	non-L1Topo backup
SUSY_DM1	2017 [B1-B4]	HLT_2mu4_invm1_j20_xe60_pufit_2dphi10_L12MU4_J40_XE50	
	2017 [B5]	HLT_2mu4_invm1_j20_xe40_pufit_2dphi10_L12MU4_J20_XE30_DPHI-J20s2XE30	
	2018	HLT_2mu4_invm1_j20_xe40_pufit_2dphi10_L12MU4_J20_XE30_DPHI-J20s2XE30	
SUSY_DM2	2017 [B1-B4]	HLT_2mu4_invm1_j20_xe60_pufit_2dphi10_L12MU4_J40_XE50	non-L1Topo backup
	2017 [B5]	HLT_2mu4_invm1_j20_xe60_pufit_2dphi10_L12MU4_J40_XE50	non-L1Topo backup

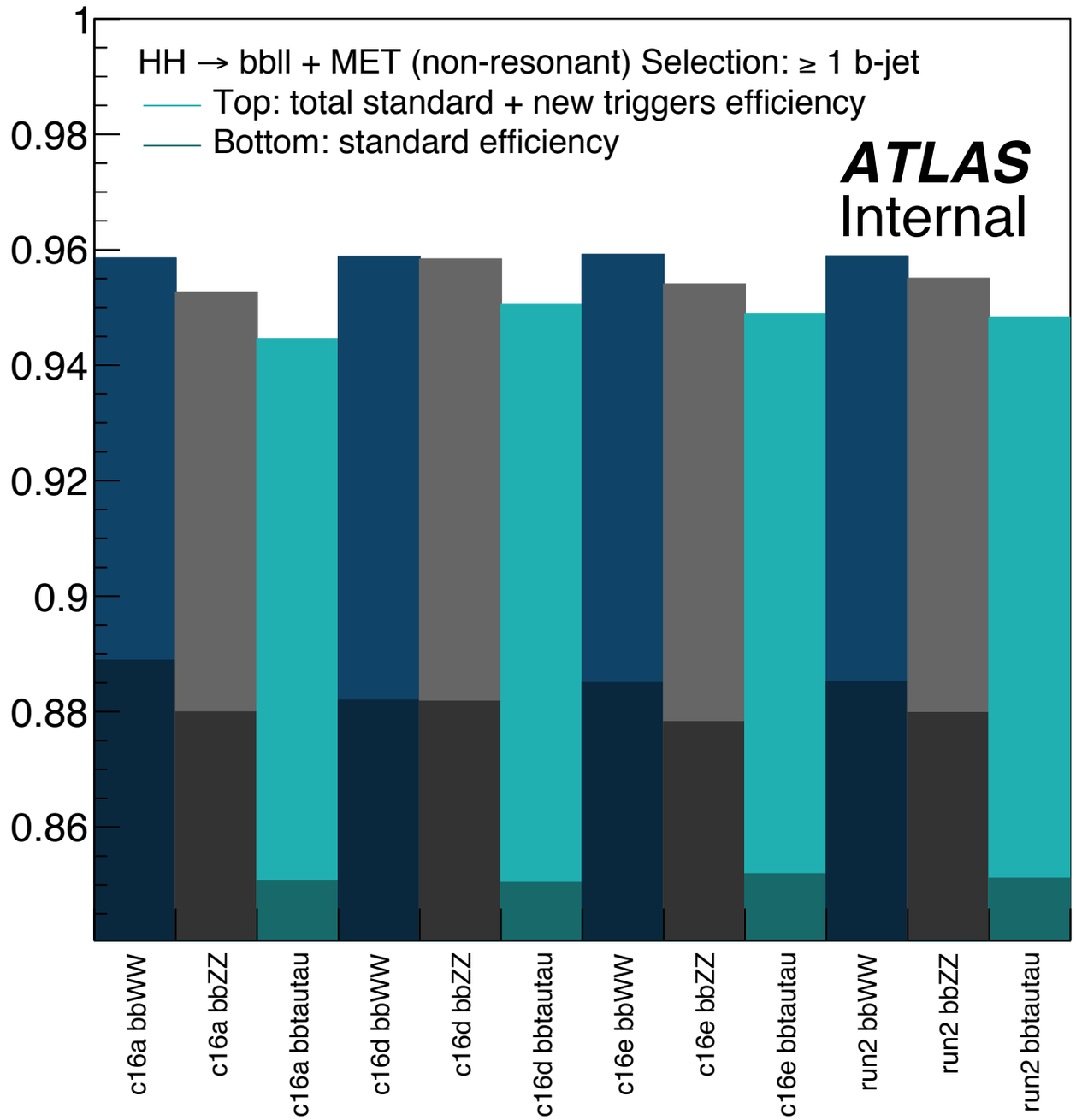
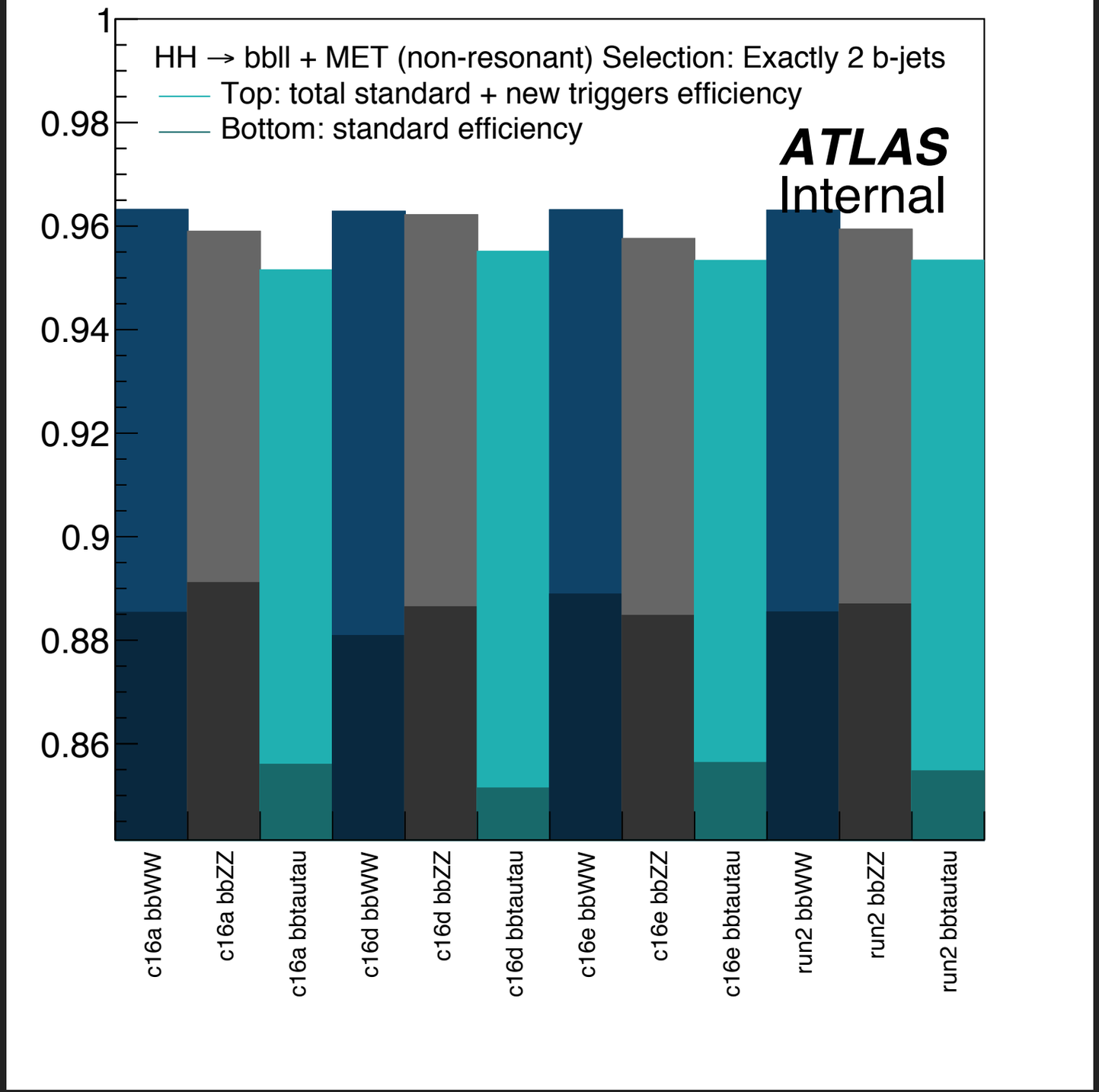
CONTINUED

SUSY_EM1	2017 [B1-B4]	HLT_e5_lhmedium_nod0_mu4_j30_xe65_pufit_2dphi10_L1MU4_XE60
	2017 [B5-]	HLT_e5_lhvloose_nod0_mu4_j30_xe40_pufit_2dphi10_L1MU4_J30_XE40_DPHI-J20s2XE30
	2018	HLT_e5_lhvloose_nod0_mu4_j30_xe40_pufit_2dphi10_L1MU4_J30_XE40_DPHI-J20s2XE30
SUSY_EM2	2017	HLT_e5_lhmedium_nod0_mu4_j30_xe65_pufit_2dphi10_L1MU4_XE60
	2018	HLT_e5_lhmedium_nod0_mu4_j30_xe65_pufit_2dphi10_L1MU4_XE60
1BJetVBF1	2016	HLT_g25_medium_L1EM22VHI_j35_0eta490_bmv2c2077_split_3j35_0eta490_invm700
	2017 [B1-B4]	HLT_j35_gsc55_bmv2c1070_split_2j45_320eta490_L1J25.0ETA23_2J15.31ETA49
	2018 [B]	HLT_j45_gsc55_bmv2c1070_split_2j45_320eta490_L1J25.0ETA23_2J15.31ETA49
1BJetVBF2	2016	HLT_g25_medium_L1EM22VHI_j35_0eta490_bmv2c2077_split_3j35_0eta490_invm700
	2017 [B1-B4]	HLT_j35_gsc55_bmv2c1070_split_2j45_320eta490_L1J25.0ETA23_2J15.31ETA49
	2018 [B]	HLT_j80_0eta240_j60_j45_320eta490_AND_2j35_gsc45_bmv2c1070_split
1BJetVBF3	2016	HLT_g25_medium_L1EM22VHI_j35_0eta490_bmv2c2077_split_3j35_0eta490_invm700
	2017 [B1-B4]	HLT_j55_gsc80_bmv2c1070_split_j45_gsc60_bmv2c1085_split_j45_320eta490
	2018 [B]	HLT_j55_gsc80_bmv2c1070_split_j45_gsc60_bmv2c1085_split_j45_320eta490
2BJetVBF	2015 [C2-C4, D3-D6]	HLT_2j55_bloose_L14J20.0ETA49
	2016	HLT_g25_medium_L1EM22VHI_2j35_0eta490_bmv2c2077_split_2j35_0eta490
	2017 [B5-B8]	HLT_ht300_2j40_0eta490_invm700_L1HT150-J20s5.ETA31_MJJ-400-CF_AND_2j25_gsc45_bmv2c1070_split
	2018	HLT_ht300_2j40_0eta490_invm700_L1HT150-J20s5.ETA31_MJJ-400-CF_AND_2j35_gsc45_bmv2c1070_split
DM	2015	HLT_2mu10
	2016	HLT_2mu14
	2017	HLT_2mu14
	2018	HLT_2mu14

Efficiency gains



Efficiency gains



Efficiency gains