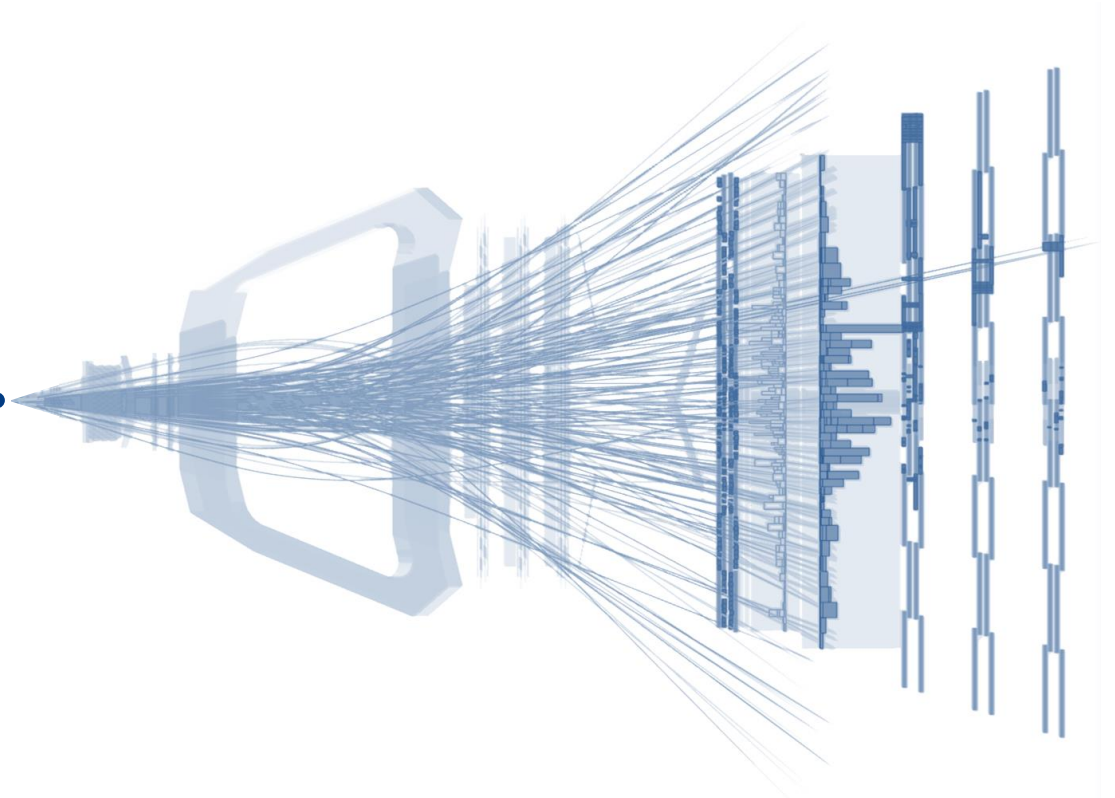


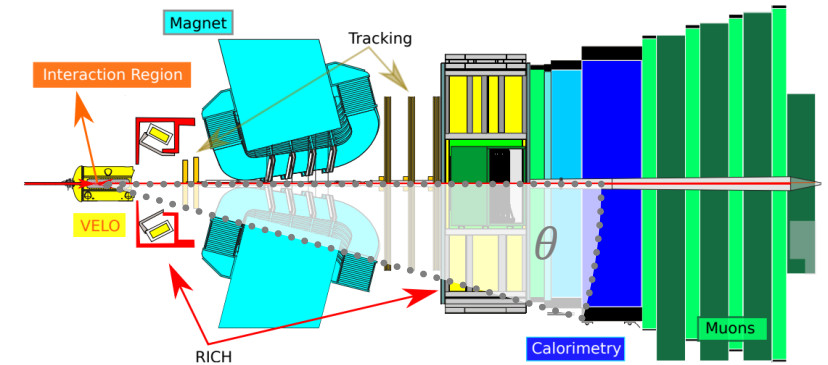
Charge asymmetry

Forward top physics

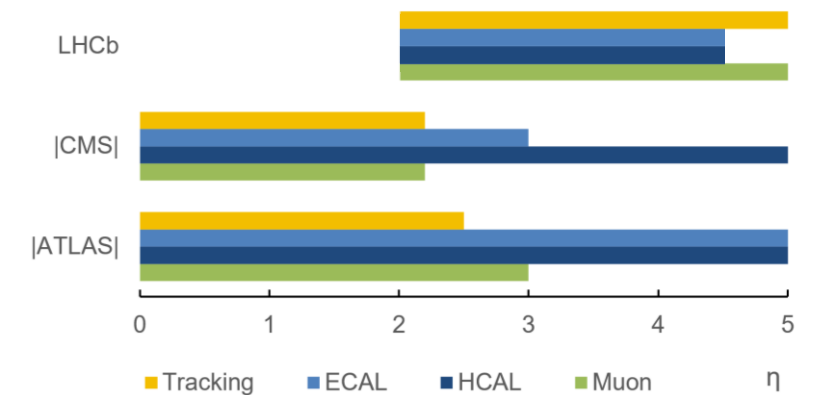


- ***Cornerstone of the Standard Model***
 - The top quark is the heaviest known fundamental particle
- Expected to play a special role in beyond Standard Model scenarios
 - ***Drive for precision measurement***
 - Test of well predicted perturbative QCD in an unexplored region
 - Complementary constraints on effective field theory operators
 - ***Probing the contents of the proton***
 - To constrain parton distribution functions in extremes of phase space
 - Gluon initiated high mass states benefit from improved gluon-PDF

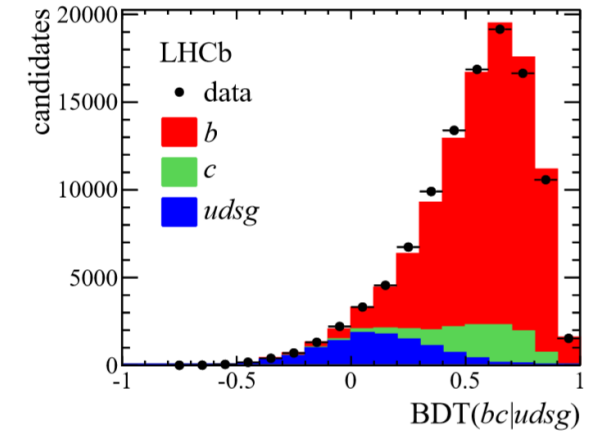
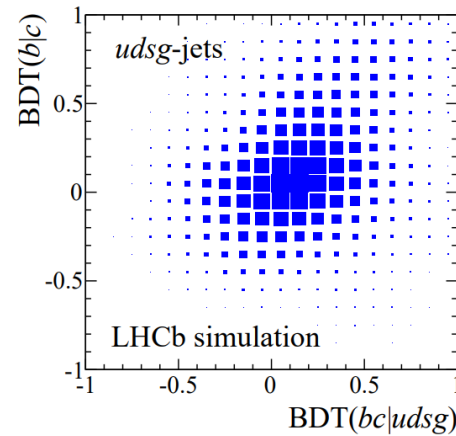
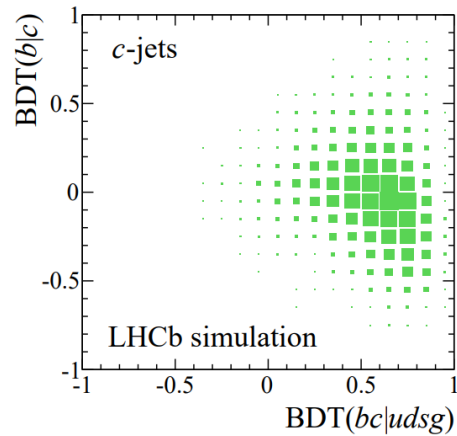
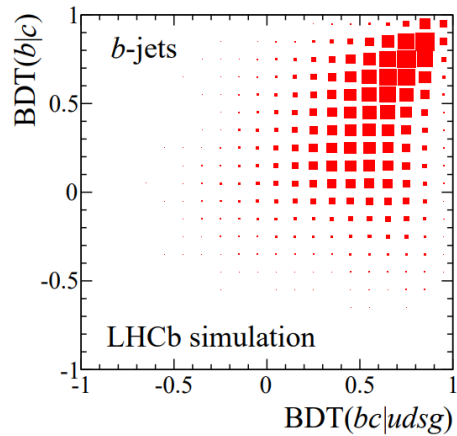
- **LHCb detector**
 - Uniquely instrumented in the forward region
 - Excellent vertex resolution & particle identification
 - Low pile-up, 1-2 interactions per bunch crossing
 - Lower luminosity with lower data rate
- **Forward physics**
 - Access to new kinematic regions
 - Complementary phase space to ATLAS/CMS
 - Constrain PDFs at high & low momentum fraction
 - Small solid angle acceptance



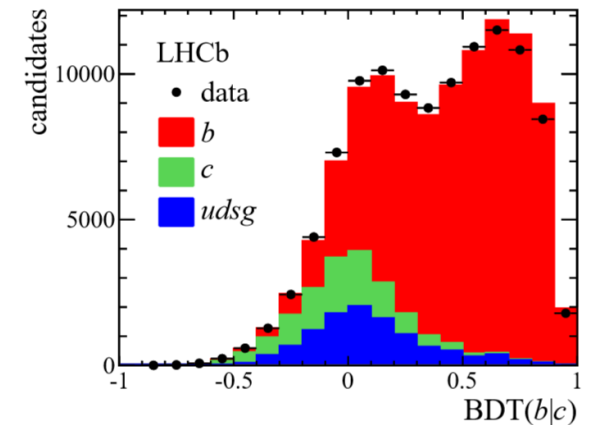
$$\eta \equiv -\ln(\tan \theta/2)$$



- **Jet reconstruction**
 - Collimated QCD radiation undergoing hadronisation
 - Tracks, calorimeters & vertices are clustered into cones
 - Energy resolution $\sim 15\%$, fake rate $< 1\%$, b -mistag $< 0.5\%$
 - Binary classifiers using SV information to distinguish c & b



[JINST(2015)P06013]



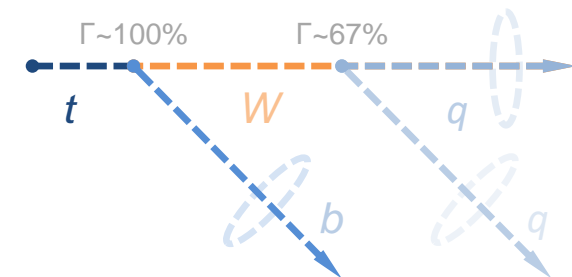
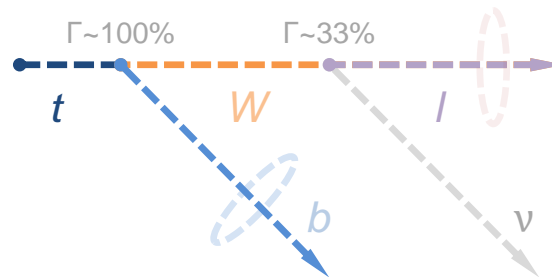
- **Top production**

- $t\bar{t}$ pairs ~ 80%
- single- t ~ 20%

- **Partial reconstruction**

- $t\bar{t} \rightarrow lb$ [arXiv:1506.00903]
 - Signature decay
 - Irreducible single- t

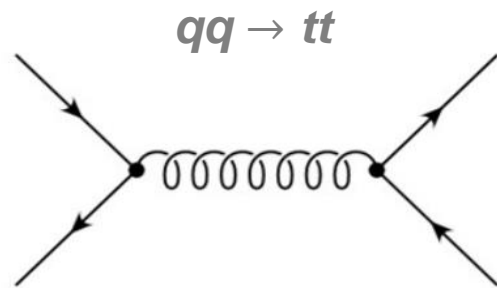
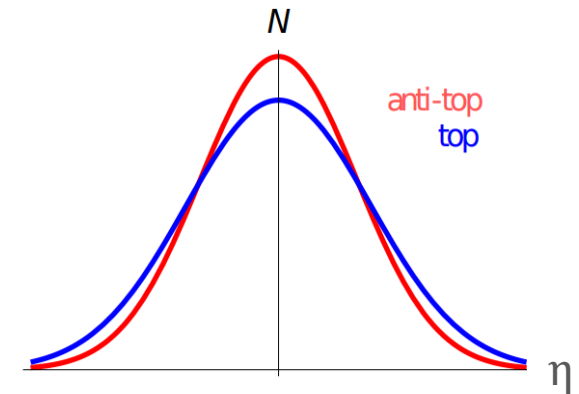
- **Top quark decay**



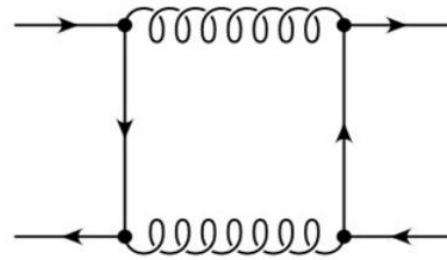
- $t\bar{t} \rightarrow lbb$ [arXiv:1610.08142v2]
 - Highest statistics
 - Background dominated

- $t\bar{t} \rightarrow l^+l^-b$ [arXiv:1803.05188v2]
 - Very high purity
 - Statistically limited

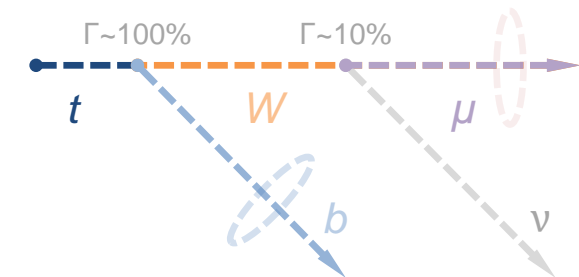
- **Exclusive to quark initiated pair production**
 - Asymmetry from next-to leading order interference
 - Positive asymmetry boosts t forward relative to \bar{t}
 - Suppressed gluon fusion contribution in forward region
 - Differential measurement viable with Run II data set



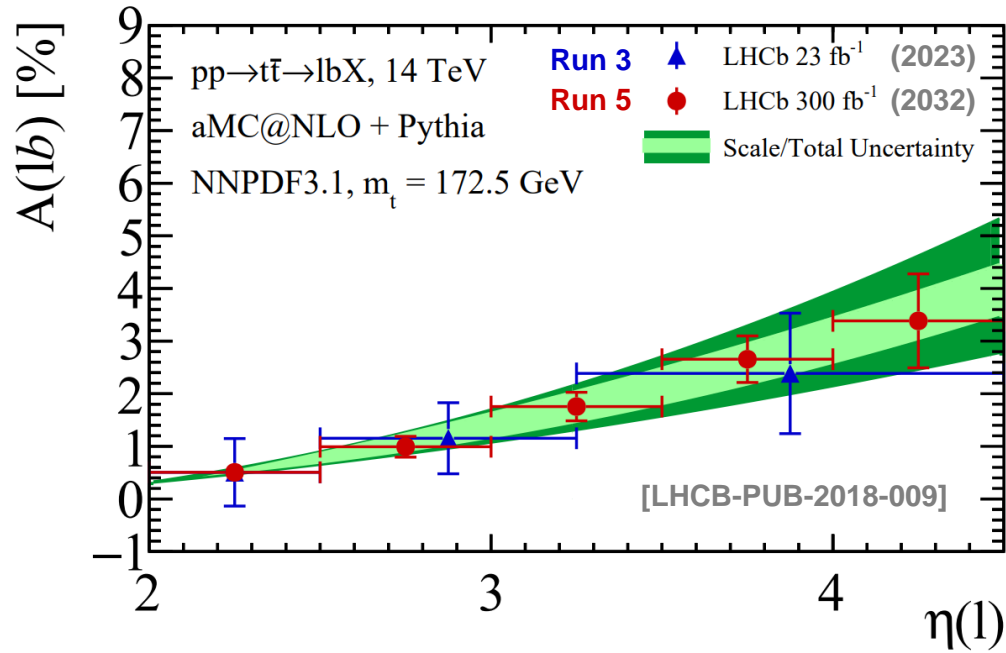
LO



NLO

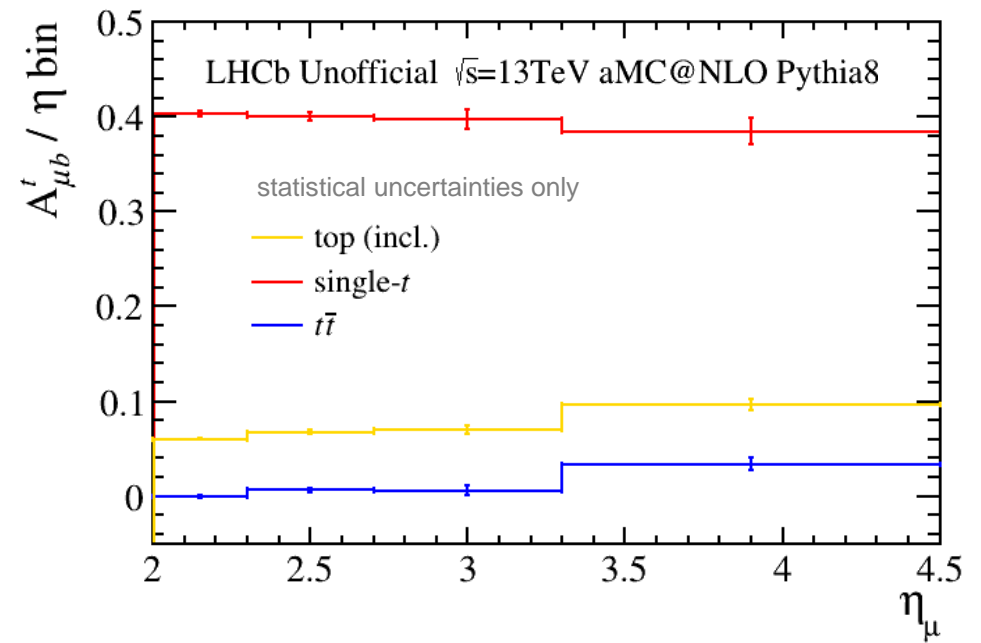


High statistics runs



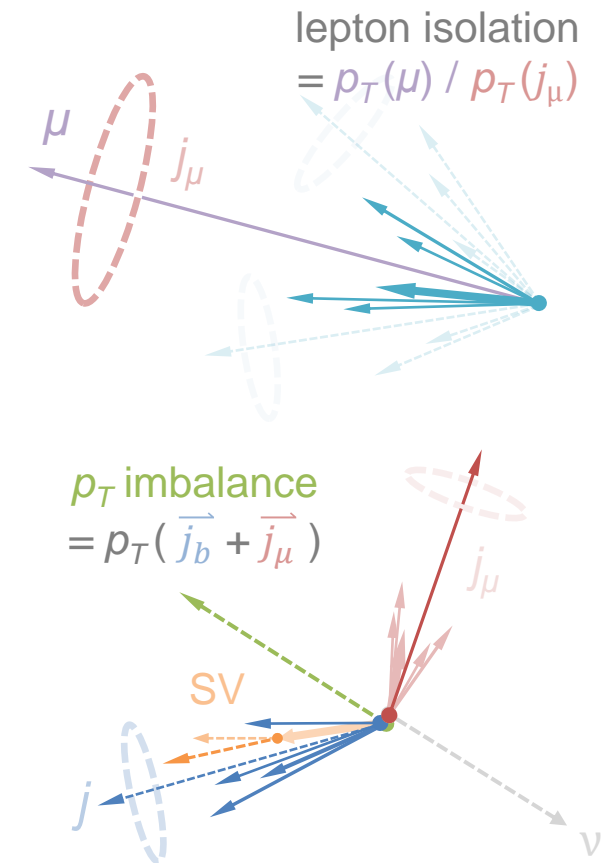
- Projected precision holds promise

Inclusive top asymmetry

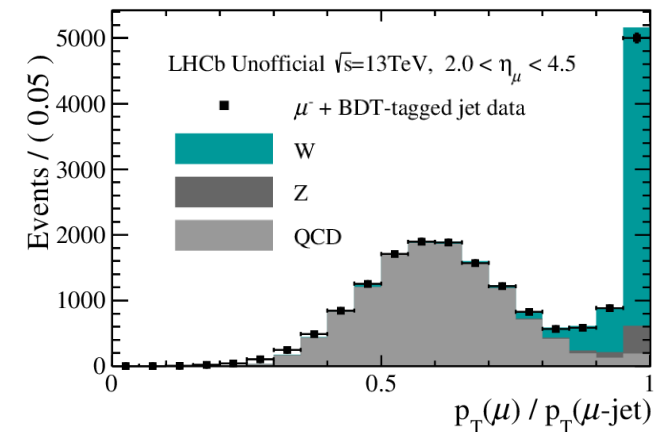
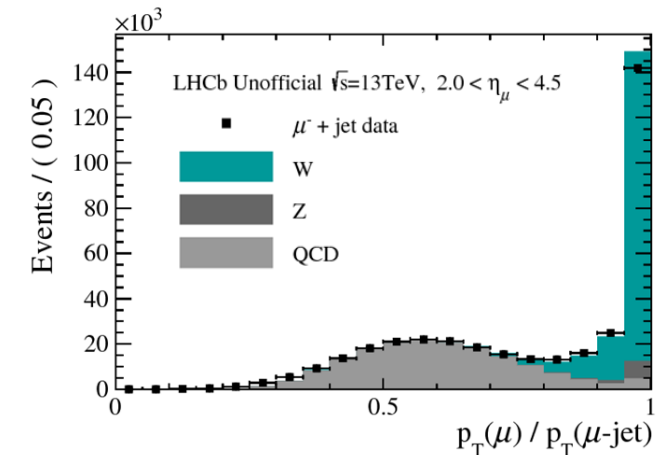


- $t\bar{t}$ differential asymmetry dominates

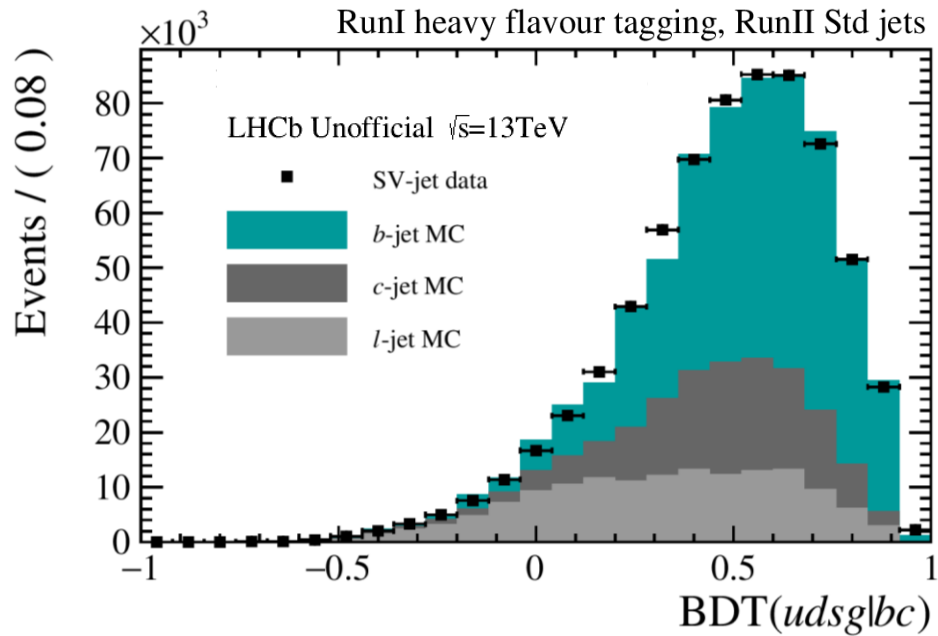
- ***lb event selection***
 - Single muon: isolated high- p_T track traversing detector
 - b -jet: secondary decay vertex (SV) in a high- p_T cone
- ***Run I measurement*** [arXiv:1506.00903]
 - Partially reconstructed decays in $\mu + b$ final state
 - 3 fb^{-1} combined from 7 and 8 TeV data
- ***First observation***
 - Forward production confirmed to 5.4σ significance
 - Consistent with NLO Standard Model predictions



- **Advantages at 13 TeV**
 - 10 fold top fiducial cross-section increase from Run I
 - Improved signal to dominant Wb background ratio
- **Fit to muon isolation distributions**
 - W +jet, $d\sigma/d\eta$ & Wb background normalisation
 - $W+c$, negligible t contribution, valuable cross-check
 - $W+b$, high- p_T threshold preferentially selects tops
- **Improvements to jets**
 - Higher efficiency jet reconstruction new configuration
 - Flavour tagging methods undergoing retrain for Run II

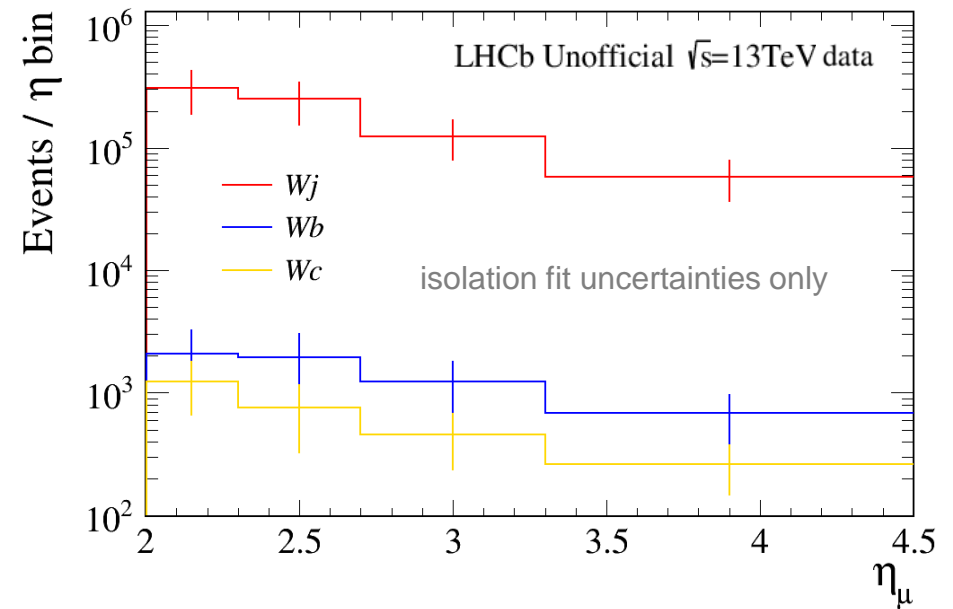


Scaling data by flavour



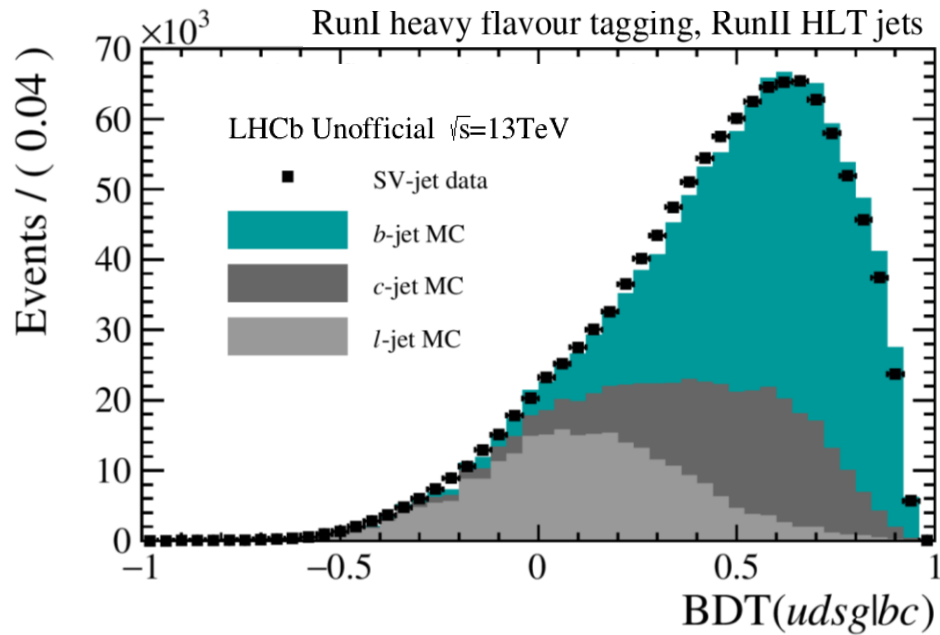
- BDT output for Std jets in Run II

Differential $W+jet$ yields



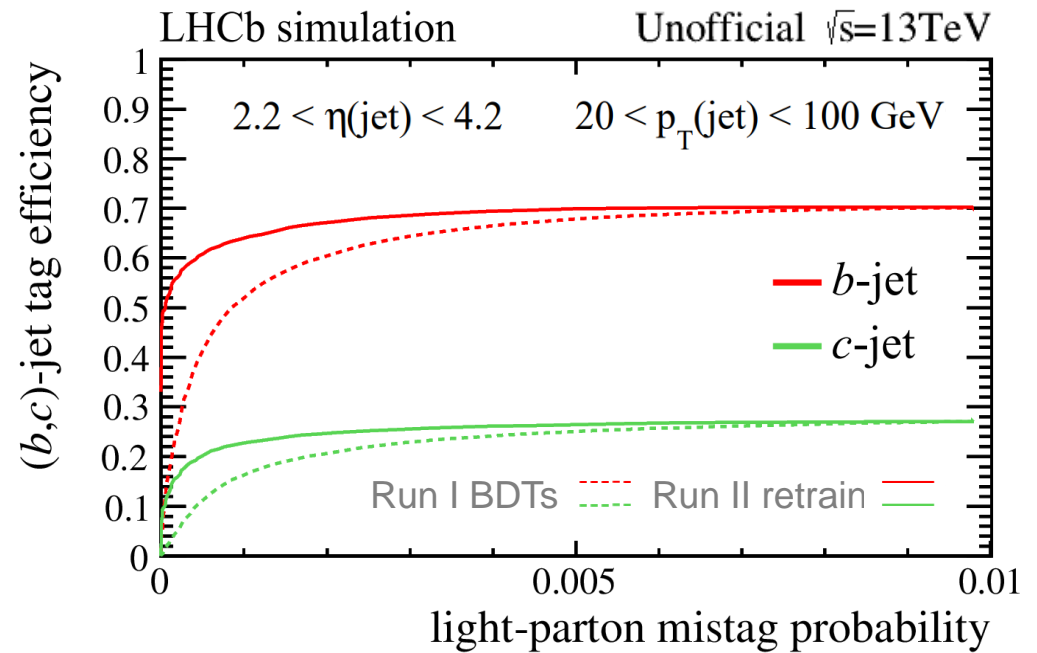
- Run I jet performance in 2016 data

New jet configuration



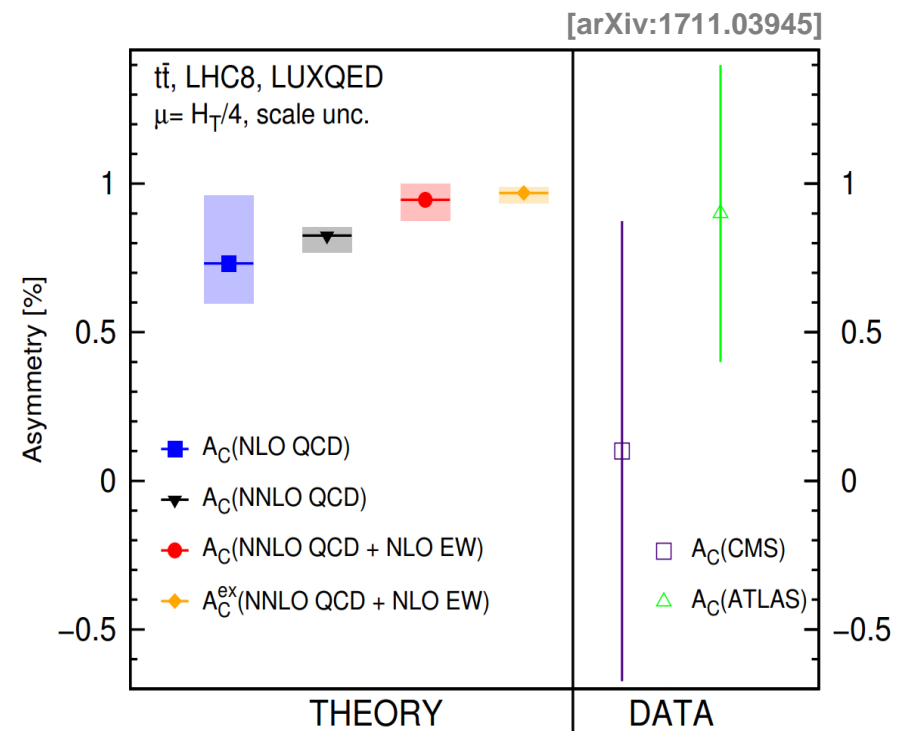
- Update required for jets in Run II

Renewing classifier training



- Revision of ML approach ongoing

- **LHC top asymmetry**
 - Currently consistent with SM and zero
 - Run II LHCb measurement work ongoing
- **LHCb upgrades**
 - Precision top studies with Run III data
 - Sub-percent asymmetry precision in Run IV
- **Constraints on theory**
 - W +jet differential cross-sections on their way
 - Pair production in highly pure $\mu e b$ final state



- ***Top physics***
 - Extreme mass & precisely predicted behaviour
 - Differential measurements aid EFT and PDF constraints
- ***LHCb measurement***
 - 13 TeV analysis in 6 fb^{-1} data with forward sensitivity in progress
 - Developments in jet reconstruction and flavour tagging methods
- ***Prospects***
 - Standalone differential cross-sections on the road to the top
- Expecting to contribute to LHC's precision top program from Run III

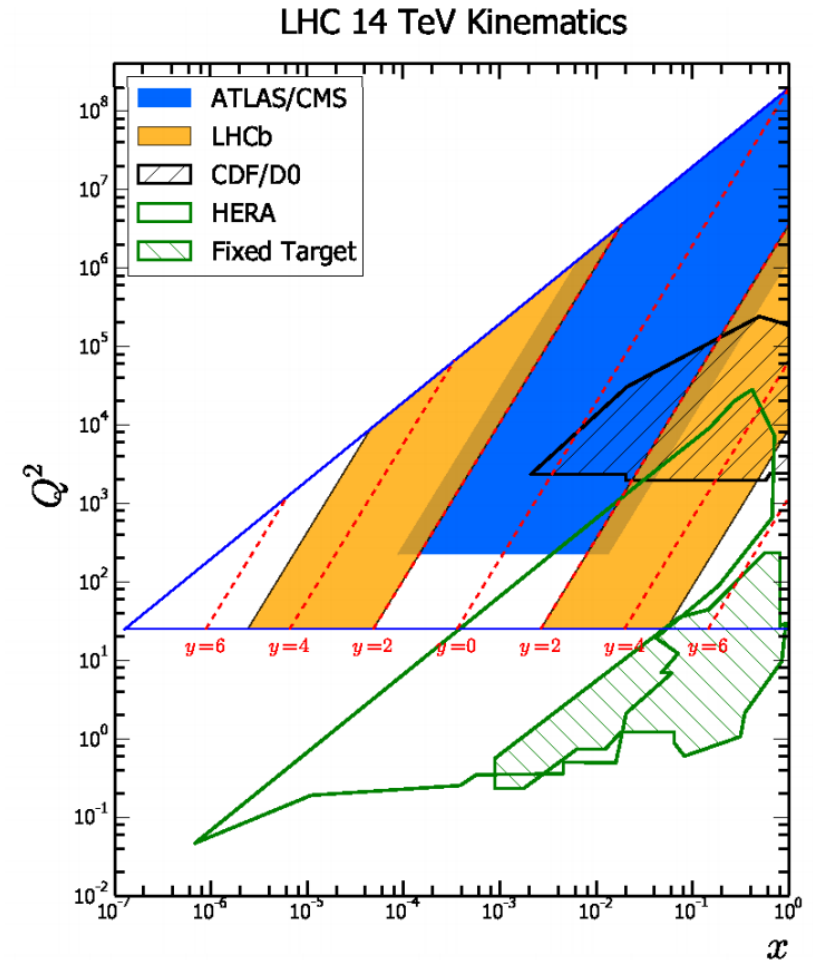
IOP 2019

LHCT
THCA

The logo consists of the text 'LHCT' in a blue, italicized serif font above the text 'THCA' in a white, serif font. A red diagonal slash cuts through the 'THCA' text from the bottom-left to the top-right.

thank you

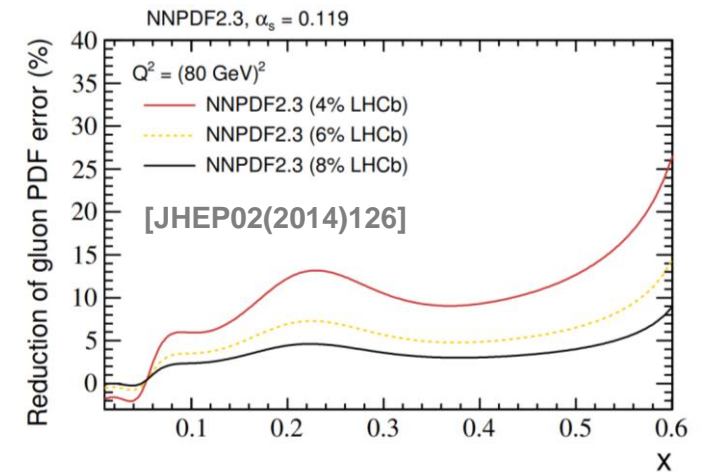
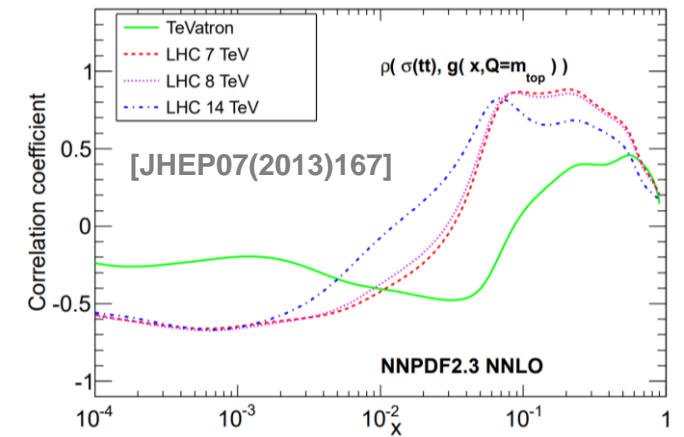
- **The LHCb detector**
 - Unique coverage at high pseudorapidity, η
 - Excellent vertex resolution & particle identification
 - Relatively clean collision environment
- **The forward region**
 - Access new kinematic regions
 - Complementary phase space to ATLAS/CMS
 - Constrain parton distribution function (PDF) uncertainties at high & low momentum fraction, x



- **Constraints from forward tops**
 - Gluon PDF correlated with top pair cross-section
 - Correlation with g -PDF is maximised at high- x
 - Tops naturally access high- x ; forward tops, even higher

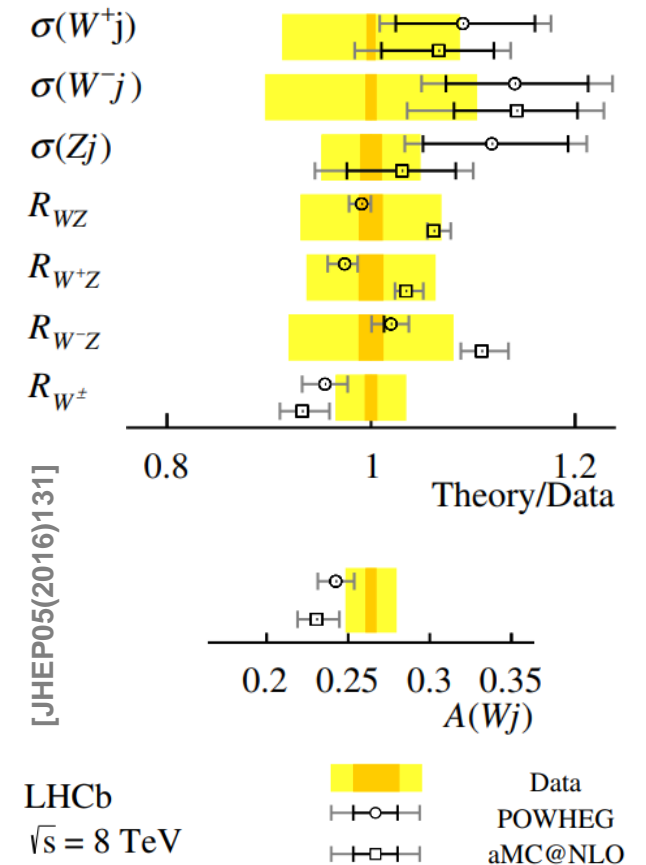
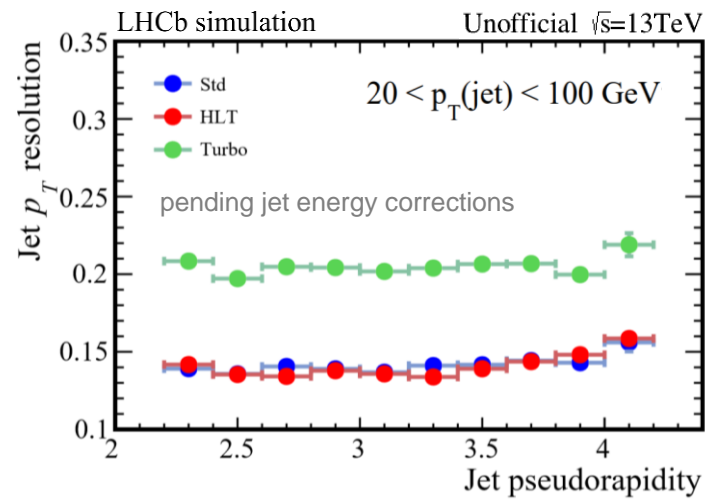
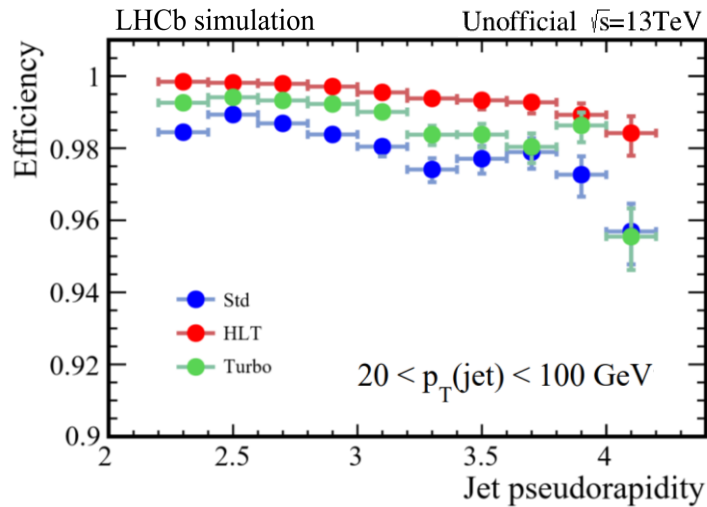
$d\sigma(\text{fb})$	7 TeV		8 TeV		14 TeV	
lb	285	± 52	504	± 94	4366	± 663
lbj	97	± 21	198	± 35	2335	± 323
lbb	32	± 6	65	± 12	870	± 116
$lbbj$	10	± 2	26	± 4	487	± 76
l^+l^-	44	± 9	79	± 15	635	± 109
l^+l^-b	19	± 4	39	± 8	417	± 79

[LHCb-PUB-2013-009]

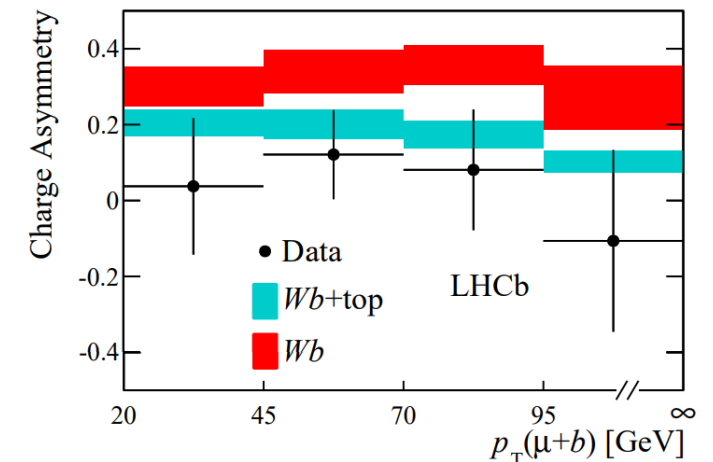
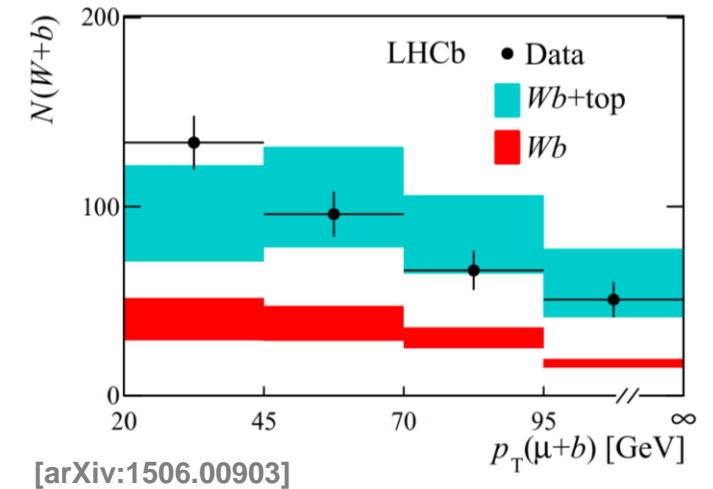


- **Run II jet configurations**

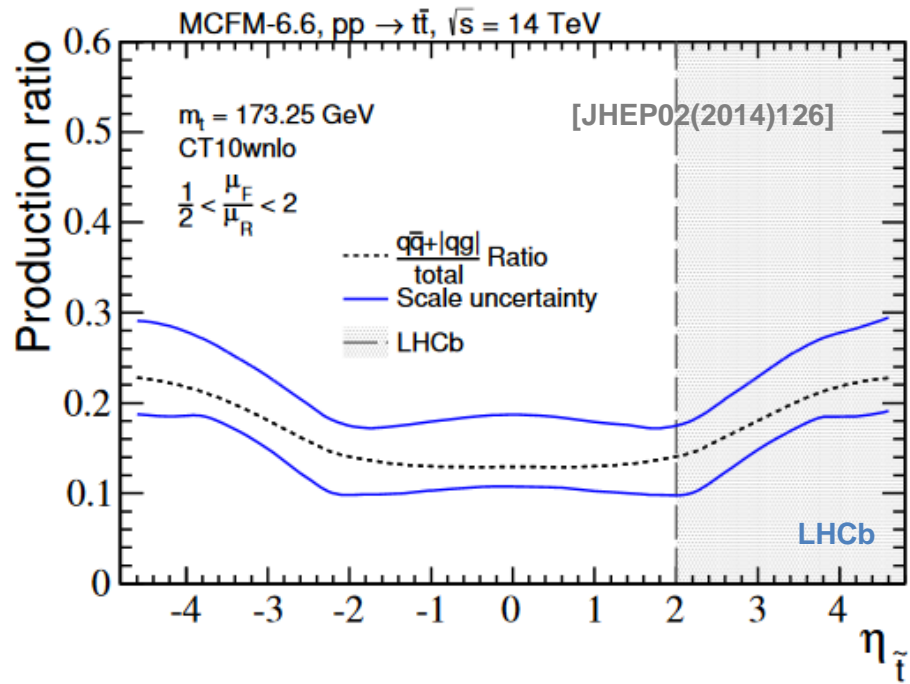
- Higher efficiency reconstruction with new input selection
- Faster particle flow algorithm designed for online trigger
- Energy resolution $\sim 15\%$, fake rate $< 1\%$, b -mistag $< 0.5\%$



- **Run I measurement**
 - Top decays in $\mu + b$ final state
 - 3 fb^{-1} combined from 7 and 8 TeV data
- **Event selection**
 - Single muon: high- p_T track dominates surroundings
 - b -tagged jet: secondary decay vertex in a high- p_T cone
 - Min. angular separation & combined final state p_T
- **First observation**
 - Modelled against background only hypothesis
 - Forward production confirmed to 5.4σ significance

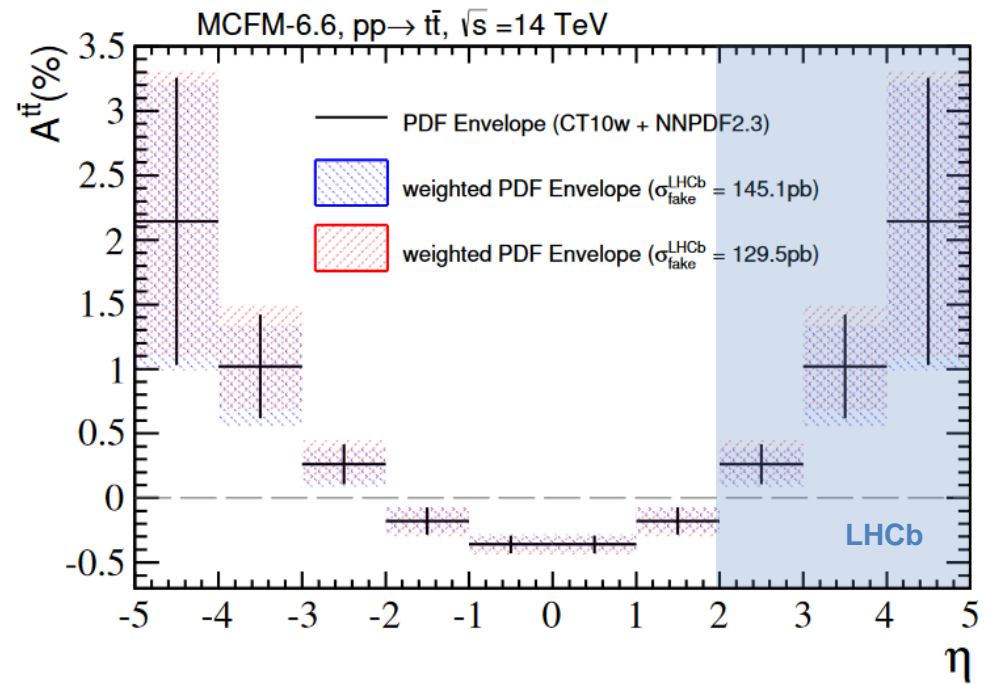


Relative symmetric contribution



- Projected precision holds promise

Pseudorapidity dependence



- Sensitive to differential asymmetry