



# UCL Update

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23 Oct 2015

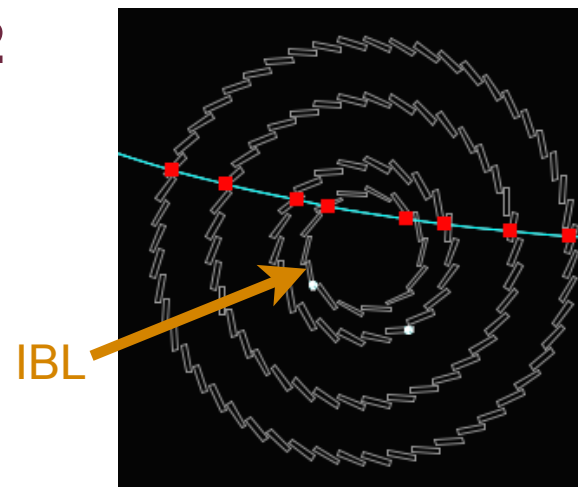


# 1) Data Commissioning of Flavour Tagging



## Improvements to Flavour Tagging for Run-2

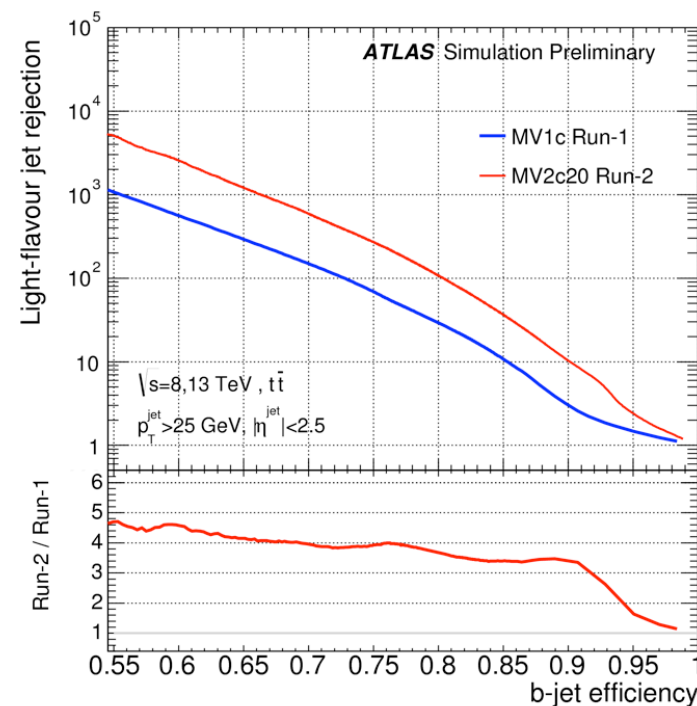
- 1) Insertable B-layer (IBL).
  - New innermost tracking layer located 33mm from the beam line
- 2) Upgraded the multi-variate tagger to MV2
- 3) Improvements to the base tagging algorithms.



These changes have been tested and optimised using Monte Carlo (MC) Simulation

## Data Commissioning

- However, we need to show that the flavour tagging performance found in MC is also seen in data.
- This can be done by comparing Monte-Carlo Simulation to Data for key flavour tagging variables.





### Samples

- Data - 56 pb<sup>-1</sup> of early Run-2 data taken May-July 2015
  - Only use data if stable beam and calorimeters and inner detector working.
  - 13 TeV collision energy with a 50ns bunch spacing.
- Simulation - Monte Carlo simulation of QCD multi-dijet events
  - 50ns bunch spacing and 13 TeV collision energy.
  - Pythia 8 used to simulate the events, EVTGEN used to decay heavy hadrons.
  - Reweight average number of interactions per beam crossing,  $\langle \mu \rangle$ , to match data.

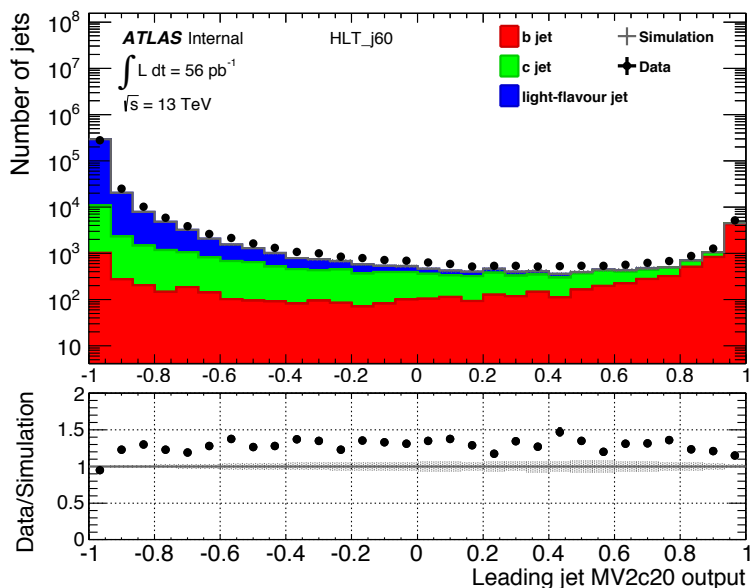
### Object and Event Selection

- Jet - anti-k<sub>T</sub> algorithm with  $R = 0.4$ 
  - $P_T > 35$  GeV,  $|\eta| < 2.4$
  - JVT  $> 0.641$ , if jet  $p_T < 50$  GeV
- Trigger: HLT\_j60
- General Cuts
  - 2 jets in event (dijet event)
  - Leading jet- $P_T > 70$  GeV
- Monte-Carlo Cuts
  - Average  $P_T$  of two highest  $P_T$  jets  
 $< 1.4 * \text{Truth Leading Jet } P_T$

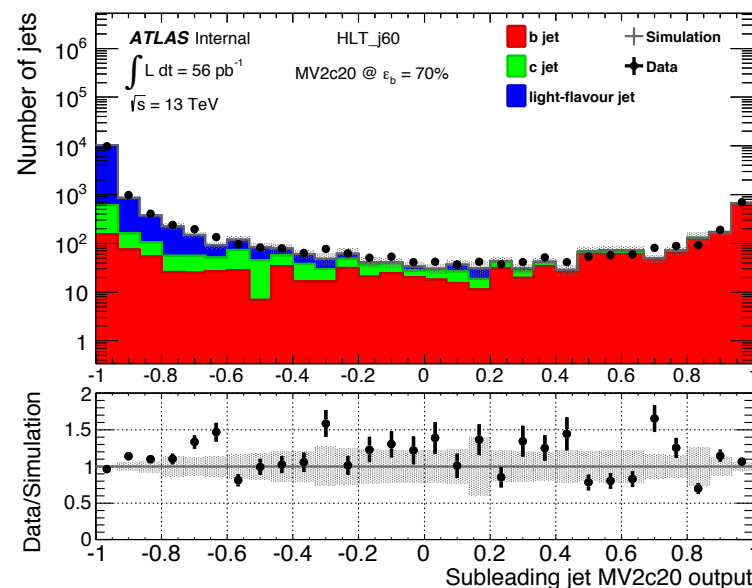


- We first examine the mv2c20 distribution of the leading jet
- Then compare to an unbiased b-enhanced sample
  - This is created by tagging the leading jet @ 70% eff using MV2c20
  - Then we study the subleading jet.
  - (Fraction of b's ~3% to ~13%)

Leading jet sample:



b-enhanced sample.

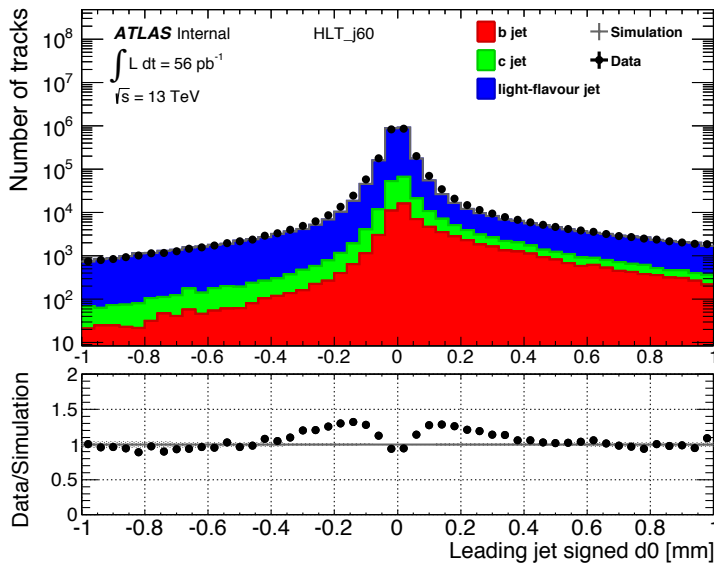


- Clear discrepancy in lowest bin in leading jet sample.
  - We want to understand this discrepancy.

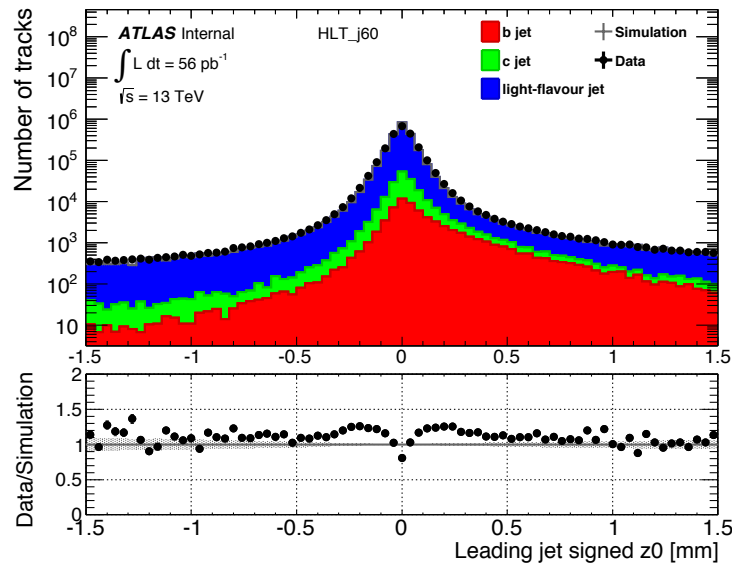


Impact  
Parameter

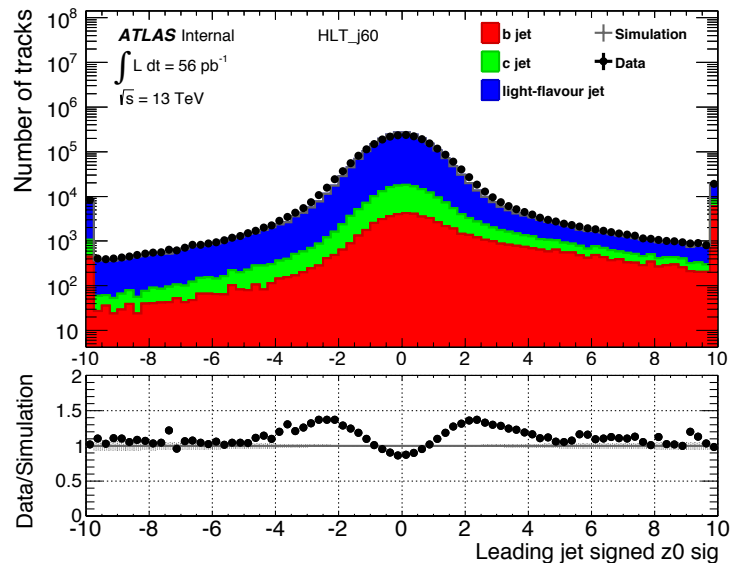
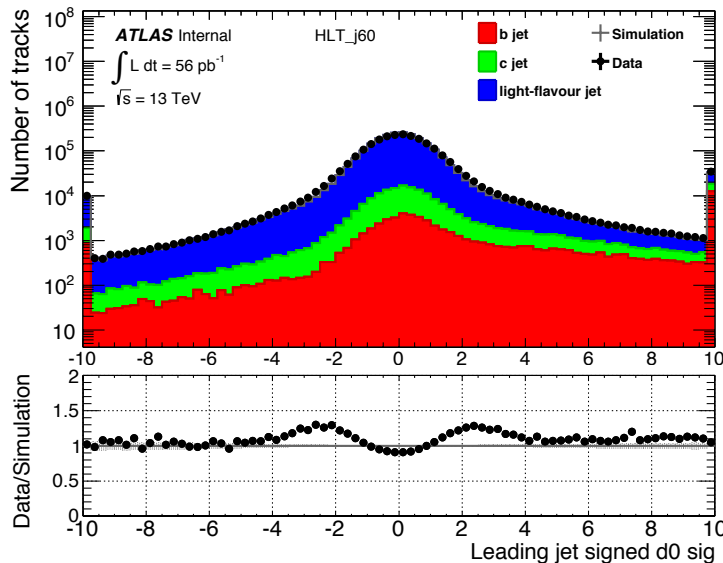
Transverse (d0)



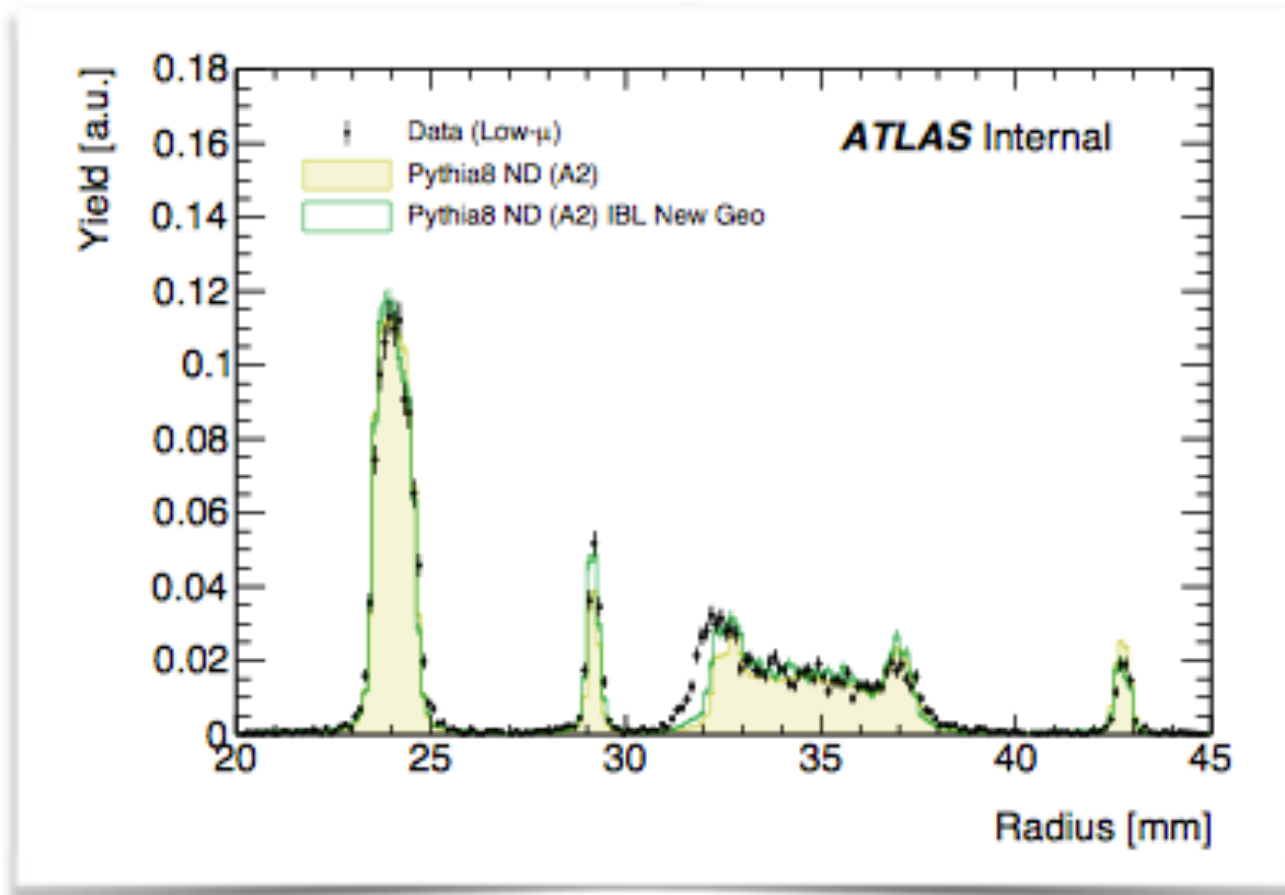
Longitudinal (z0)



Impact  
Parameter  
Significance



- Problems likely due to material mismodelling in simulation.  
- Believed that IBL material is underestimated.
- Working with tracking experts to solve this problem.  
- New geometry model undergoing validation. (Hopefully will be ready soon)





Investigation: Is the discrepancy in bottom bin due to the fact if no SV or JF is found then IPxD is more dominant in deciding MV2c20 value, and hence discrepancies become large.

### 1. Normal

- Leading Jet
- No MV2c20 Requirements
- The usual sample

### 2. Bottom Bin Only

- Leading Jet
- **Only** data from troublesome bottom bin ( $MV2c20 < -0.933334$ )

### 3. Bottom Bin Excluded

- Leading Jet
- **Exclude** the problematic bottom bin ( $MV2c20 > -0.933333$ )

### 4. B-Enhance

- Unbiased b-enhanced sample
- **Sub-Leading Jet**
- Leading Jet Tagged @ 70% Efficiency

### 5. SV reco

- Leading Jet
- Only if a secondary vertex is reconstructed ( $SV\_m > 0$ )

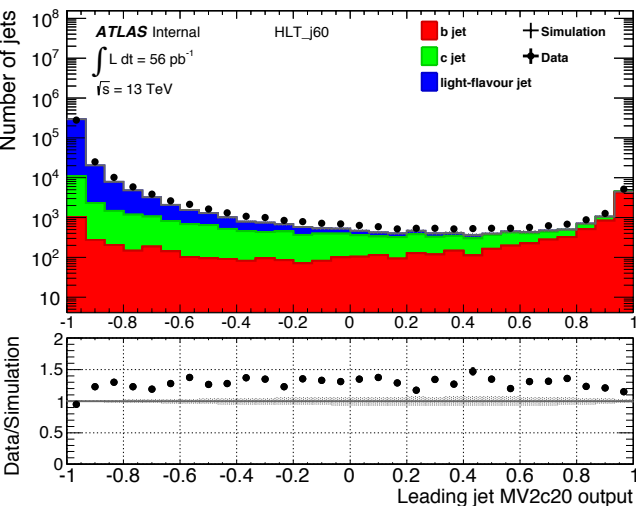
### 6. No JF or SV reco

- Leading Jet
- SV and JF **don't** reconstruct a vertex - ( $SV\_m \ \&\& \ JF\_m == 0$ )

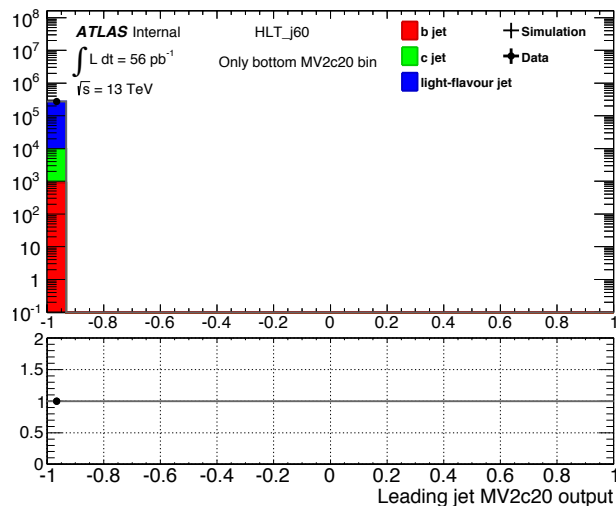




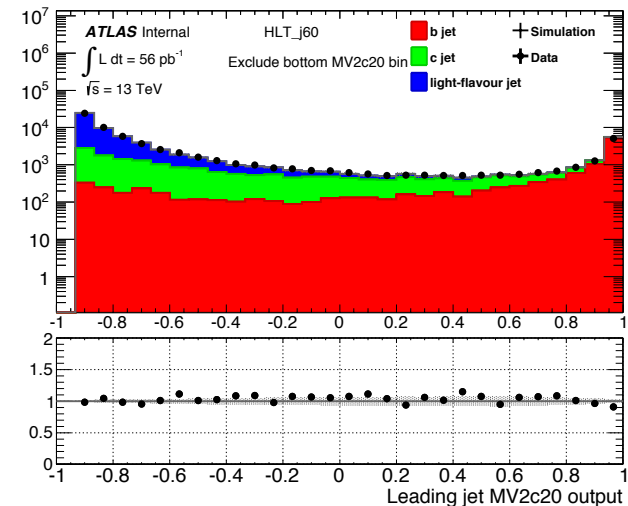
## Normal:



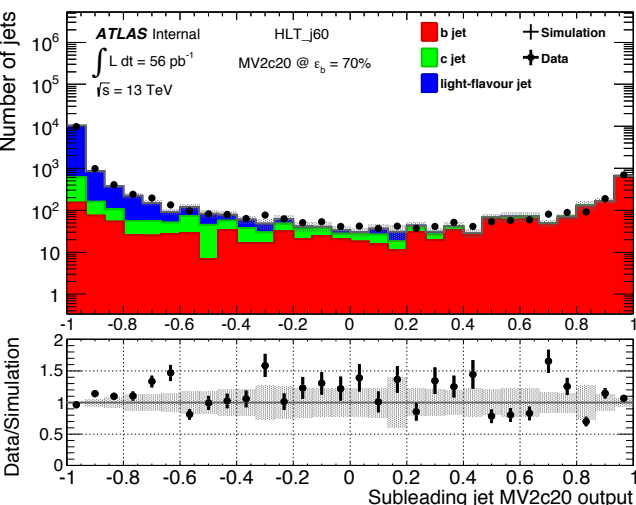
## Bottom Bin Only:



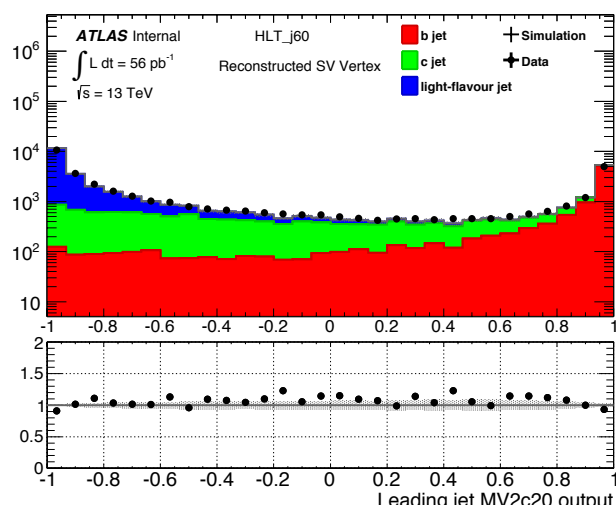
## No Bottom Bin:



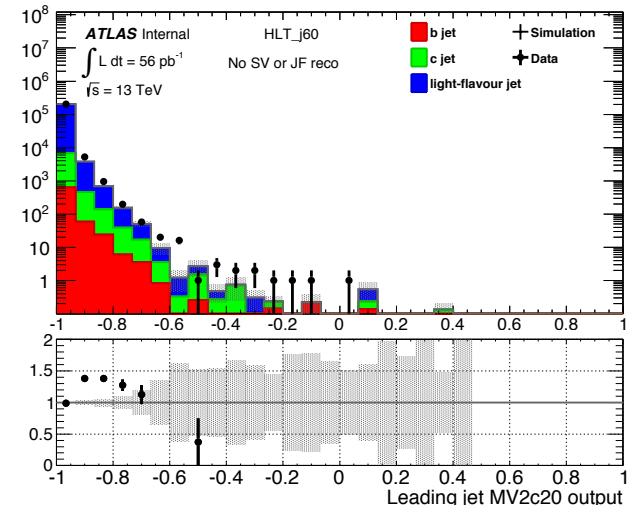
## b-enhanced (SL):



## SV reconstructed:

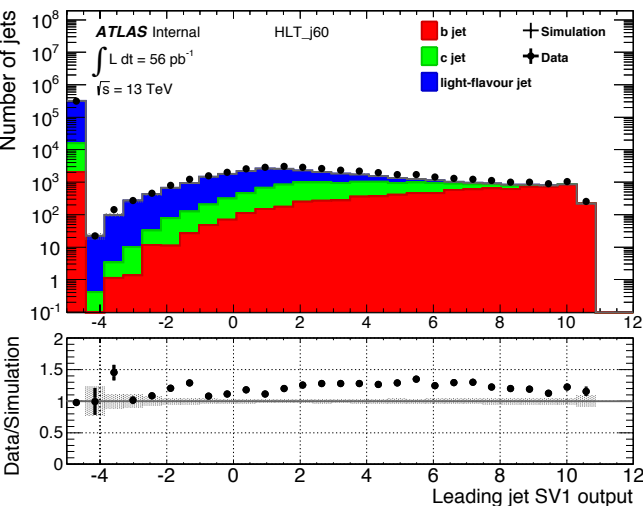


## No JF or SV reconstructed:

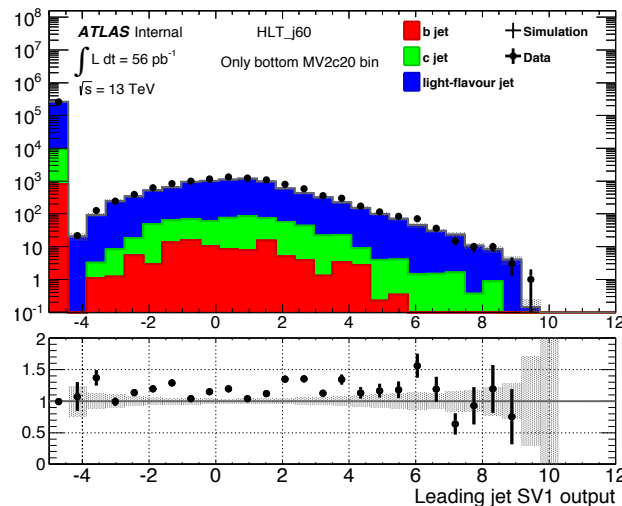




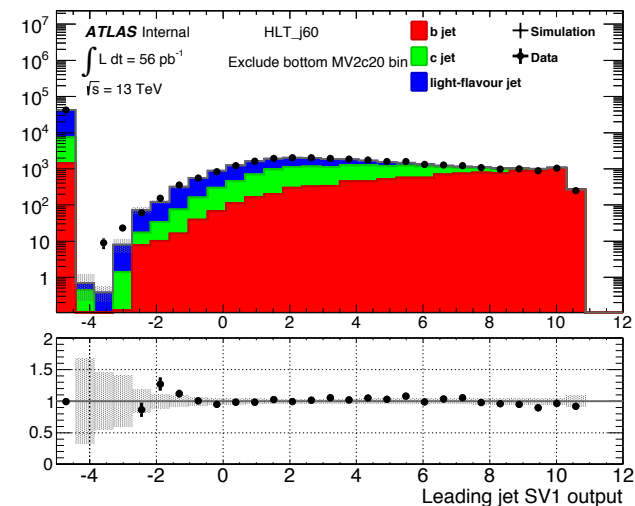
## Normal:



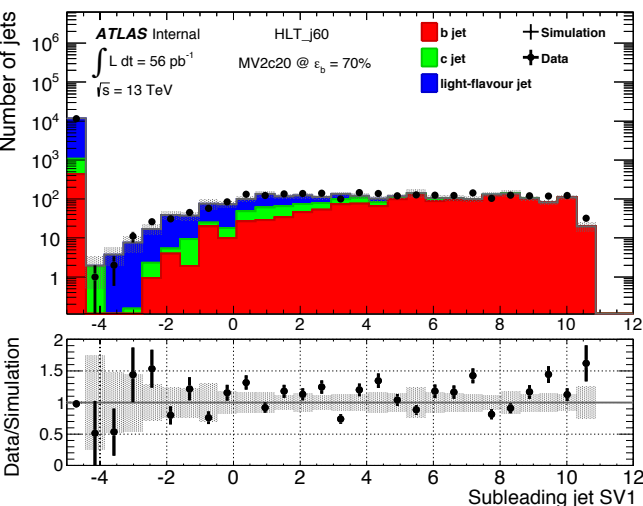
## Bottom Bin Only:



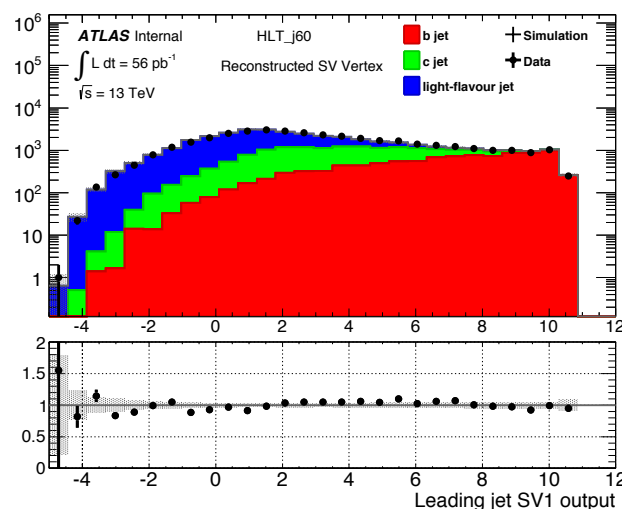
## No Bottom Bin:



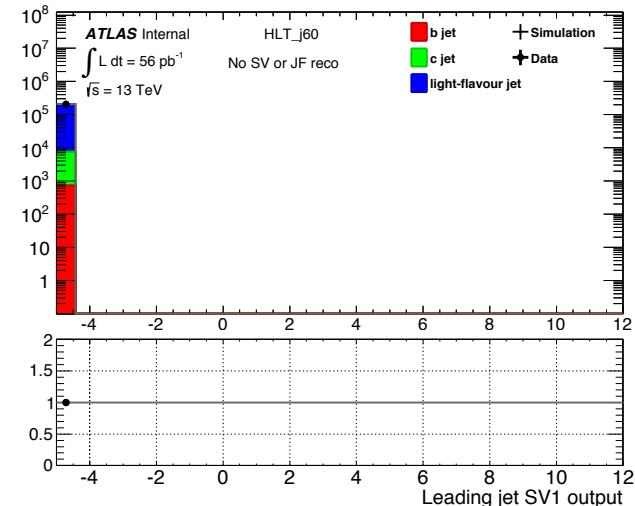
## b-enhanced (SL):



## SV reconstructed:

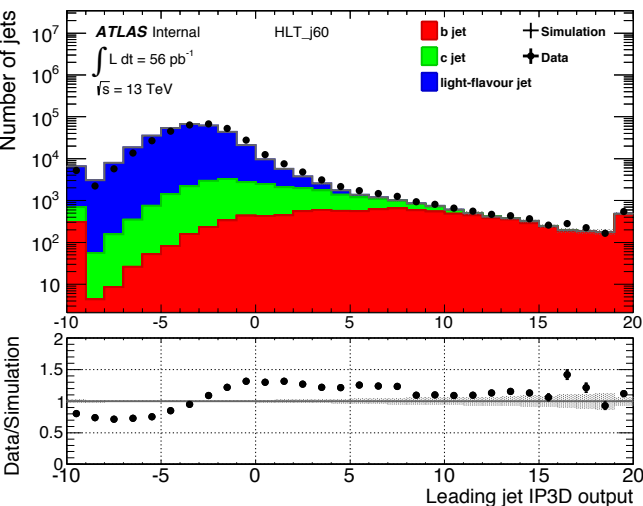


## No JF or SV reconstructed:

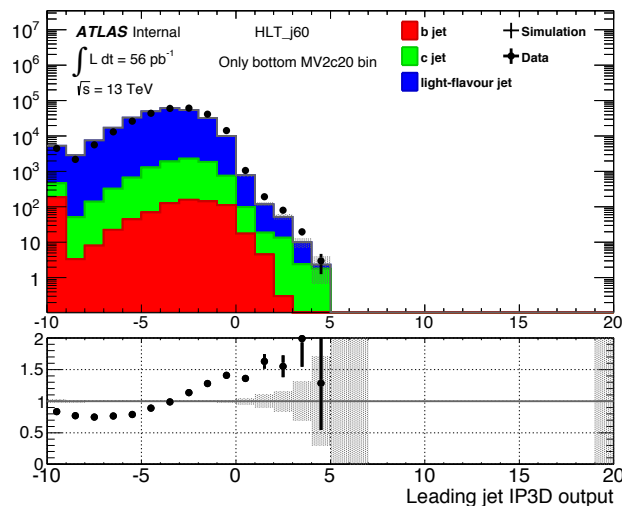




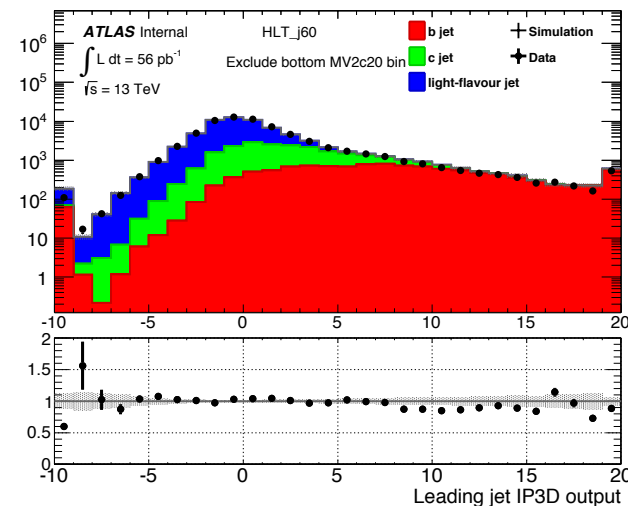
Normal:



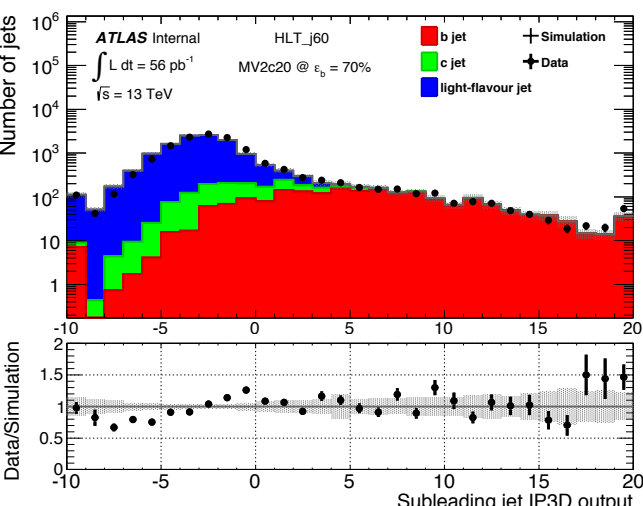
Bottom Bin Only:



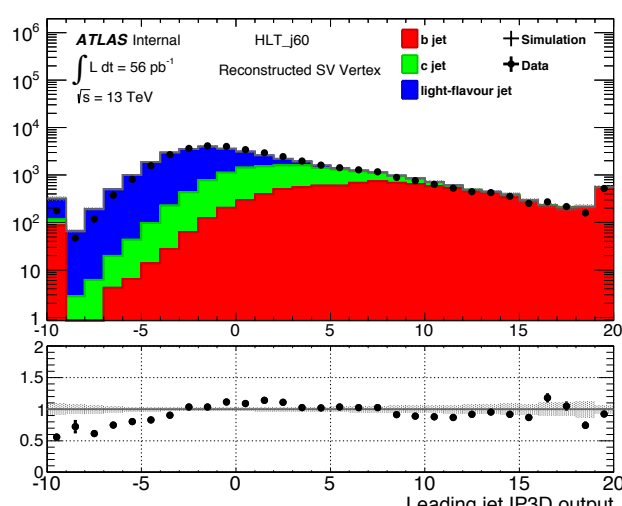
No Bottom Bin:



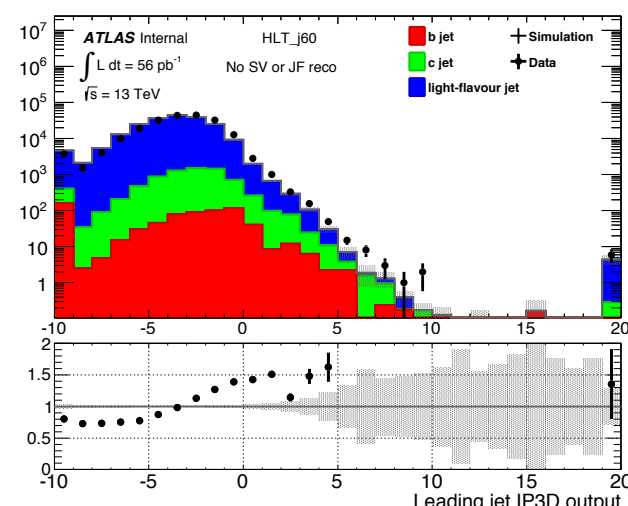
b-enhanced (SL):



SV reconstructed:



No JF or SV reconstructed:





- Some events have no SV or JF:

These events are:

- Likely to be in the at the low end of mv2c20
  - Dominated by IPxD tagger
- 
- We know IPxD puts thing as more “b-like” in data than in MC.
    - This might lead to a deficit in data in the bottom bin of the MV2c20 distribution

## **Future Plans**

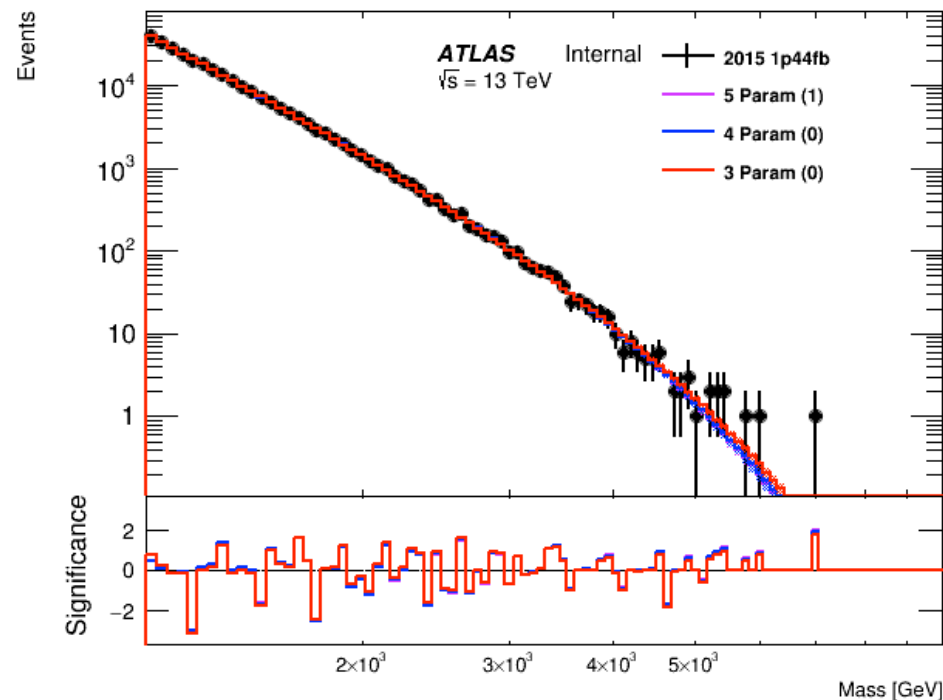
- A ttbar sample has been produced with a new geometry tag
  - This will need validation
  - Then we can launch a di-jet sample with new geometry tag.



## 2) Data Commissioning of Flavour Tagging



- Di-jets is one of the most sensitive probes of new physics at high masses.
- Many BSM models predict resonances that can decay to  $b\bar{b}$ 
  - Use of  $b$ -tagging increases sensitivity to these models.
  - ATLAS has never done a di- $b$ -jet analysis before (CMS has)
- Di- $b$ -jet search will use a similar strategy as the exotic di-jet analysis
  - Fit the QCD background using a smoothly falling function.
  - Look for excesses from this fitted background



Latest Inclusive Dijet Spectrum  
(Jeff Dandoy)

## Fit Function

$$f(x) = p_1(1-x)^{p_2}x^{p_3+p_4\ln x+p_5(\ln x)^2}$$

- 3 Parameter ( $p_4, p_5 = 0$ )
- 4 Parameter ( $p_5 = 0$ )
- 5 Parameter



- For di-b-jet analysis we want to understand how varying the flavour composition will affect the fitting function.
- Are the fitting functions robust to flavour composition.
  - Below I have fitted to a di-b-jet spectrum and show the different flavour compositions.
  - Next step is to weight all b's or c's to increase their contribution.
- We want to see if we can break the fit...

## Details

Pythia8EvtGen MC Di-Jet Sample

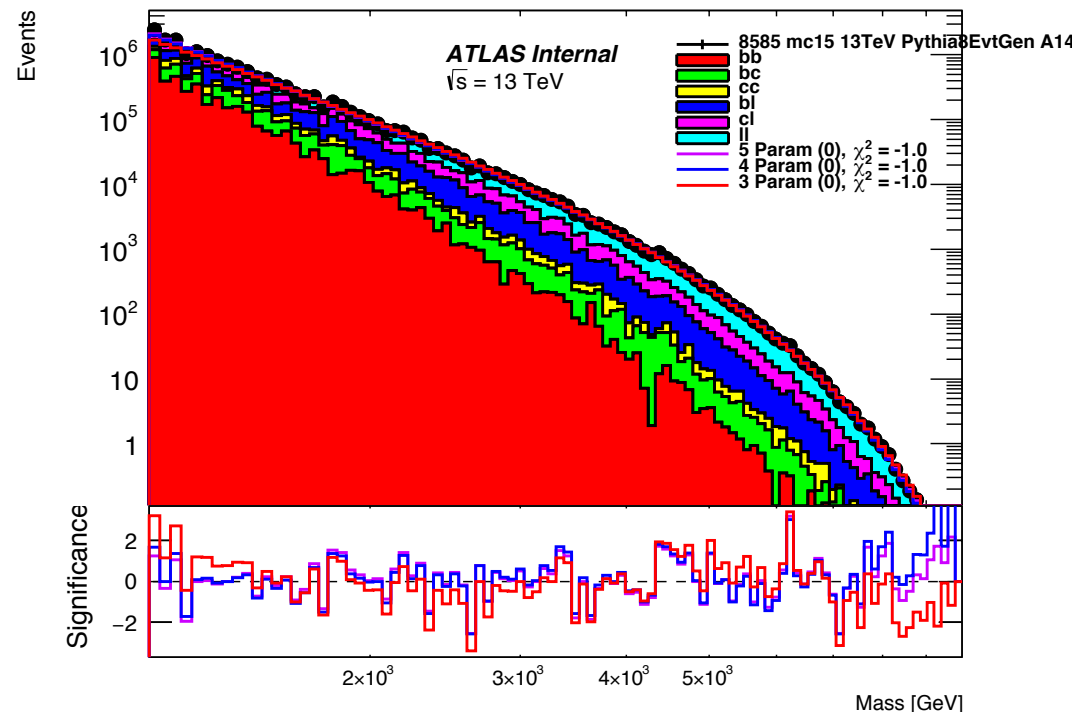
Standard Dijet Resonance Cuts

- Leading Jet  $p_T > 410$  GeV
- Sublead Jet  $p_T > 50$  GeV
- $|y^*| < 0.6$
- $m_{jj} > 1100$  GeV

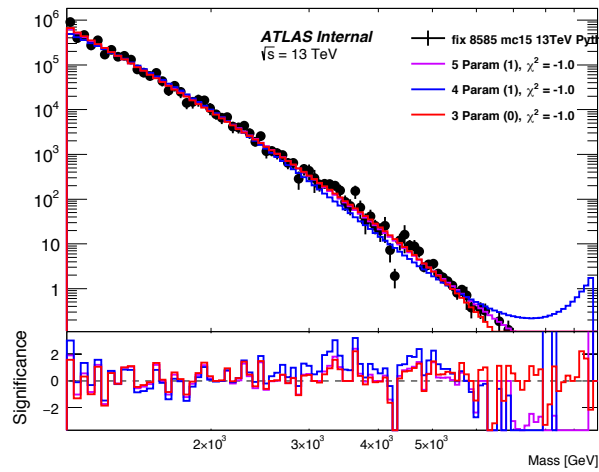
b-tag required for both jets at 85% WP

- Fixed cut on MV2c20

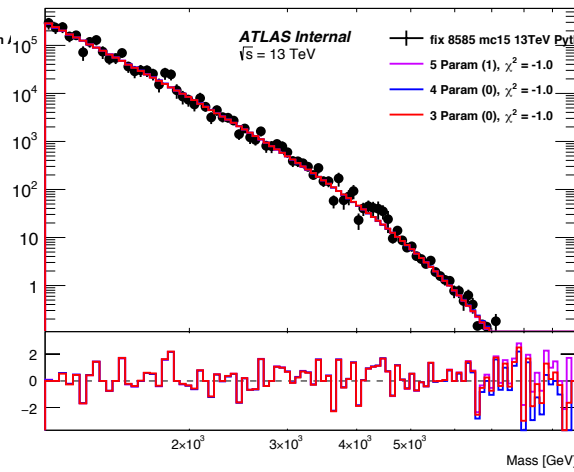
Use cone matching to identify flavour



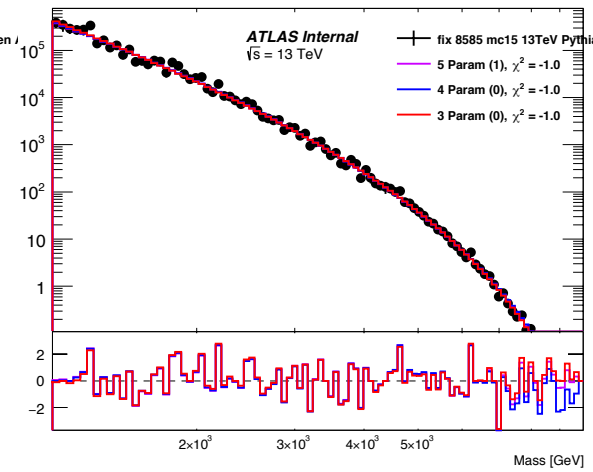
bb:



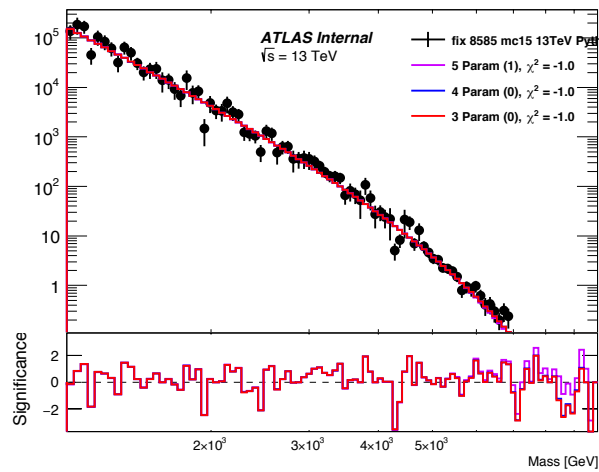
bc:



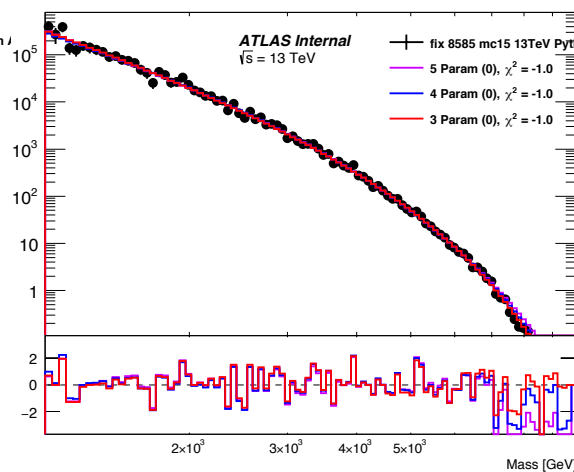
bl:



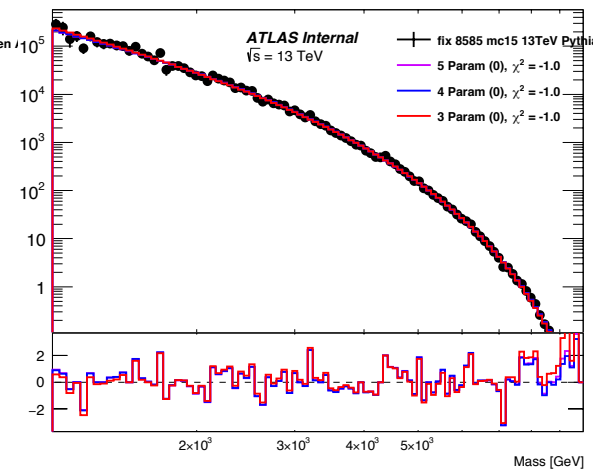
cc:



cl:



ll:



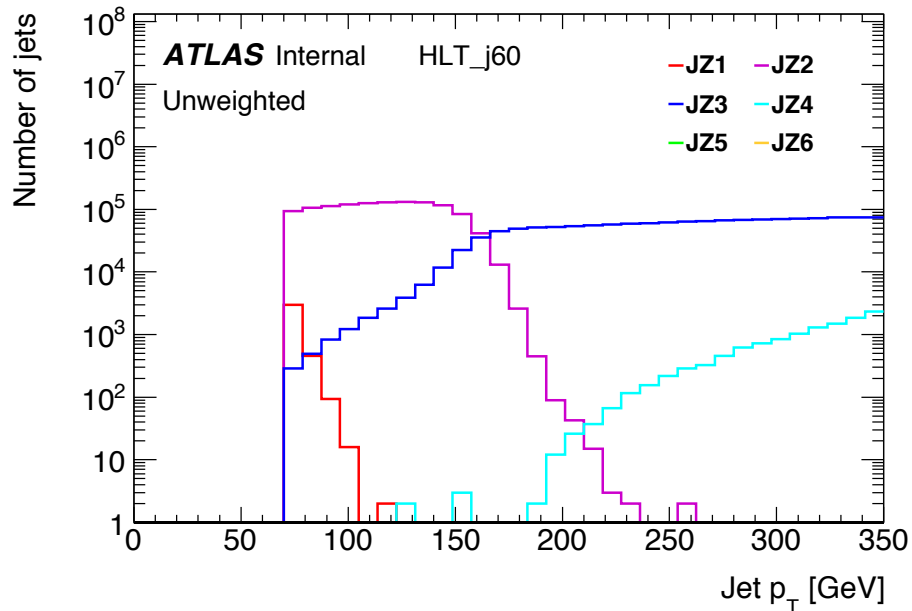
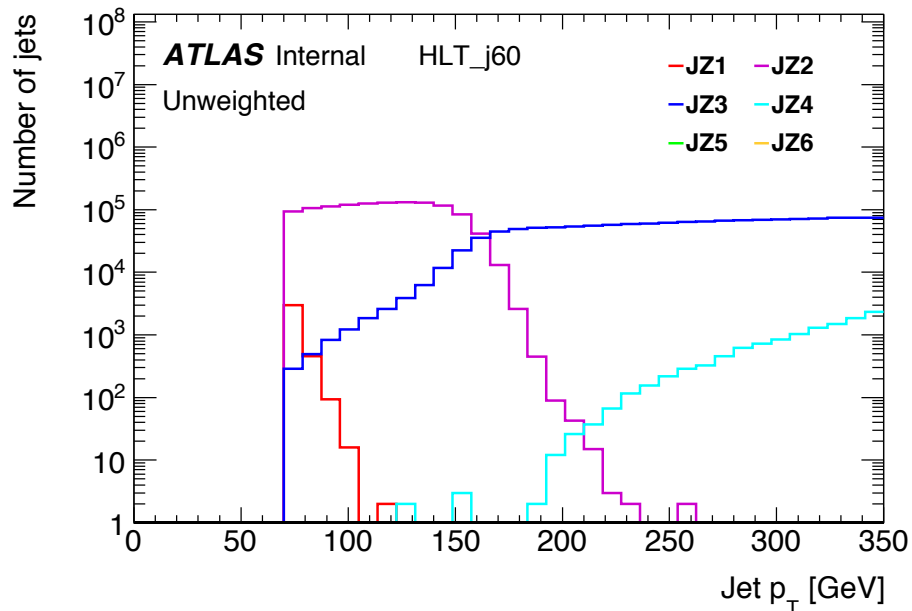




Backup

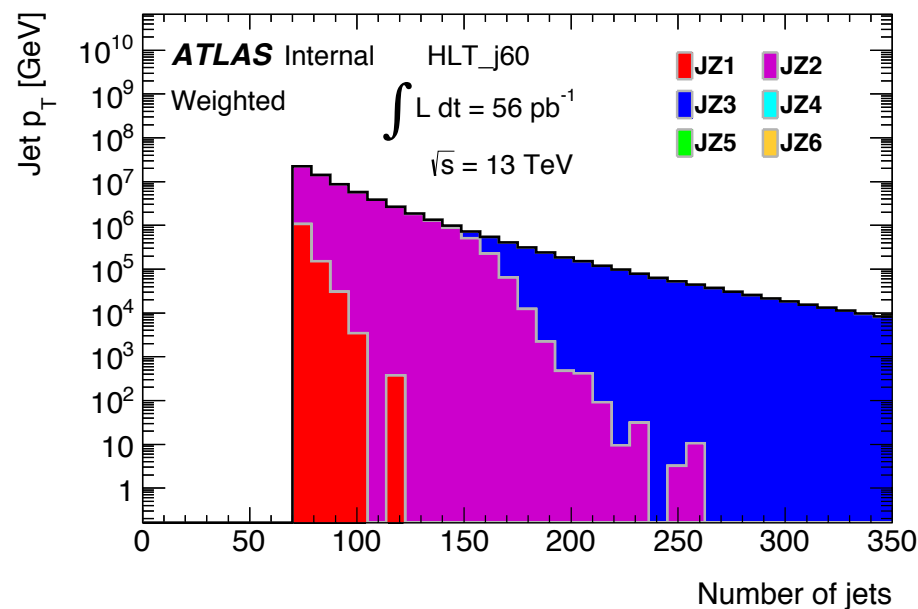


# 18 Di-jet sample re-weighting



$$\text{Total Weight} = \frac{mcwg * (\text{Filter Eff.}) * (CS[fb]) * (Lumi[fb^{-1}])}{(\# \text{ Events})}$$

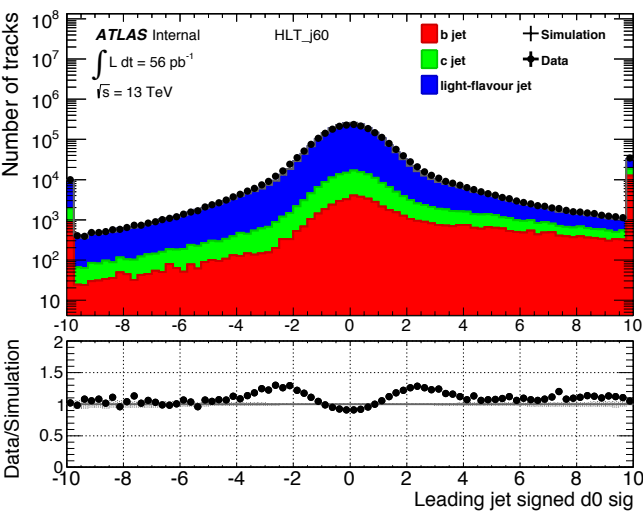
<u>Xs(fb)</u>	<u>Eff.</u>	<u>Slice and Energy</u>
7.8420E+13	6.7198E-04	#JZ1W 20-60 GeV
2.4334E+12	3.3264E-04	#JZ2W 60-160 GeV
2.6454E+10	3.1953E-04	#JZ3W 160-400 GeV
2.5464E+08	5.3009E-04	#JZ4W 400-800 GeV



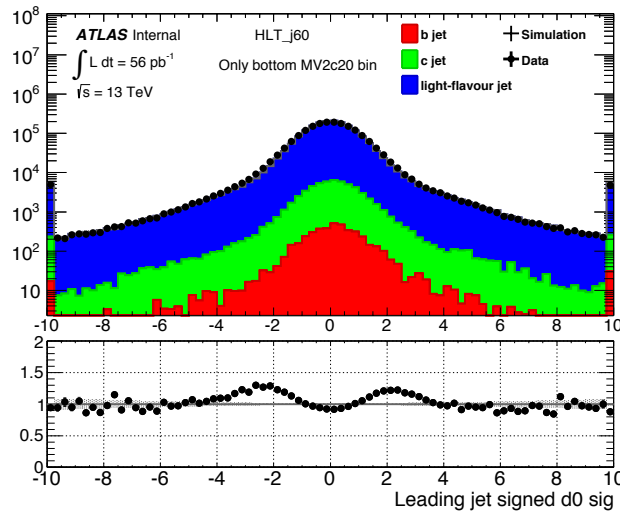
Average  $P_T$  of two highest  $P_T$  jets  
 $< 1.4 * \text{Truth Leading Jet } P_T$



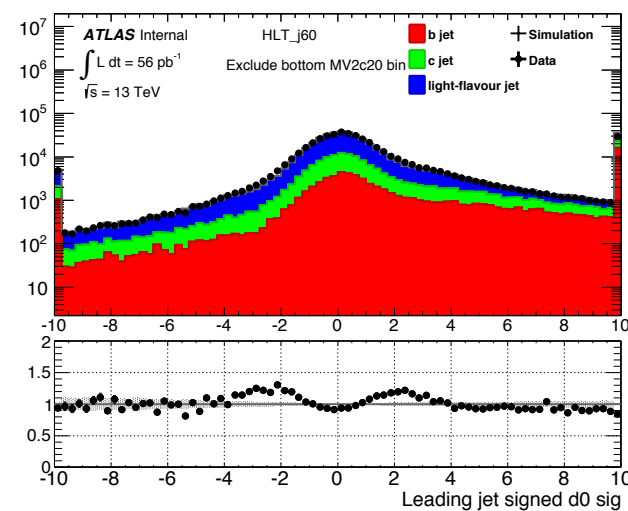
Normal:



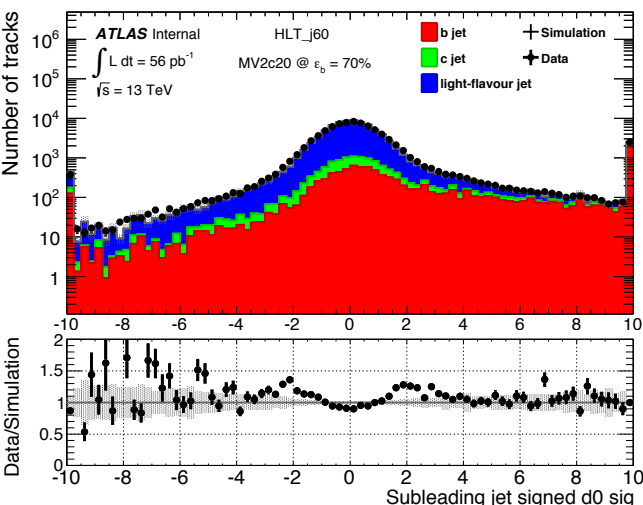
Bottom Bin Only:



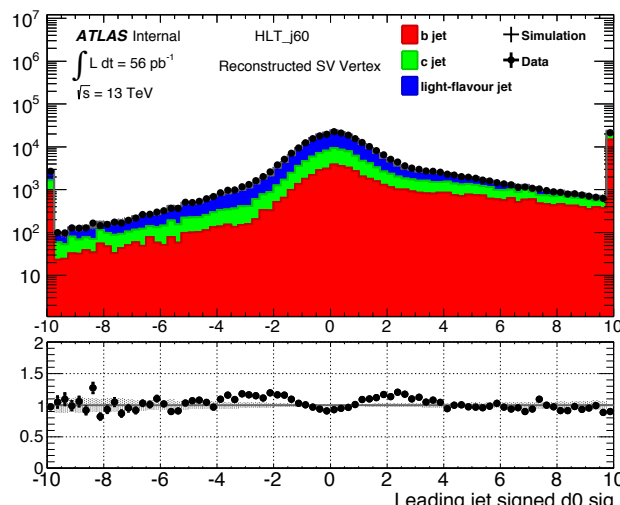
No Bottom Bin:



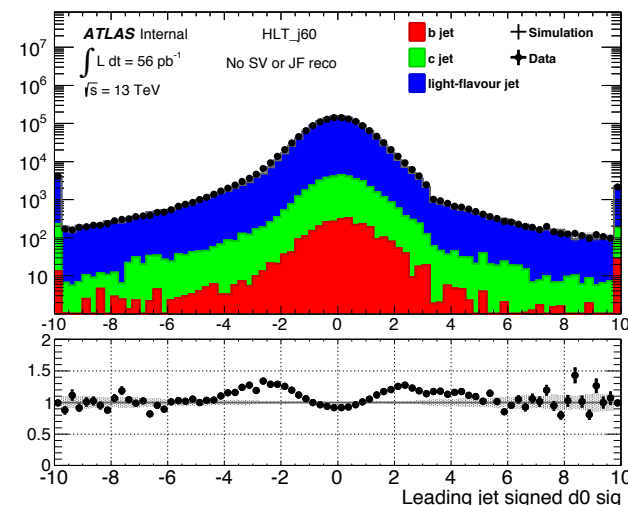
b-enhanced (SL):



SV reconstructed:

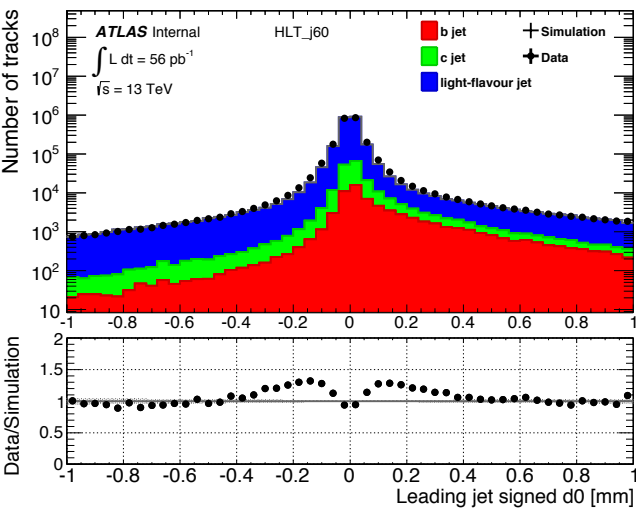


No JF or SV reconstructed:

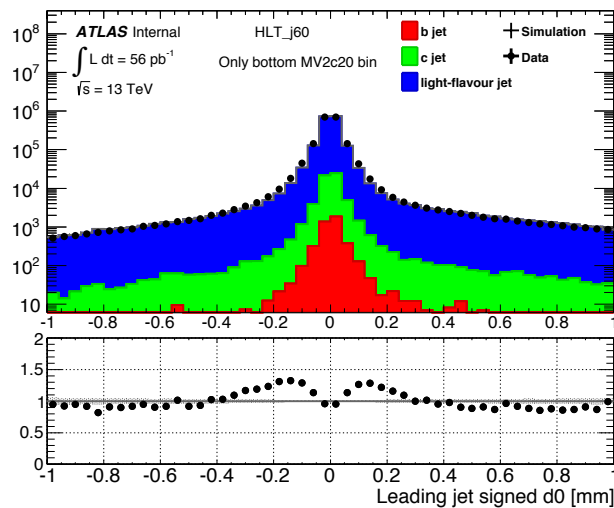




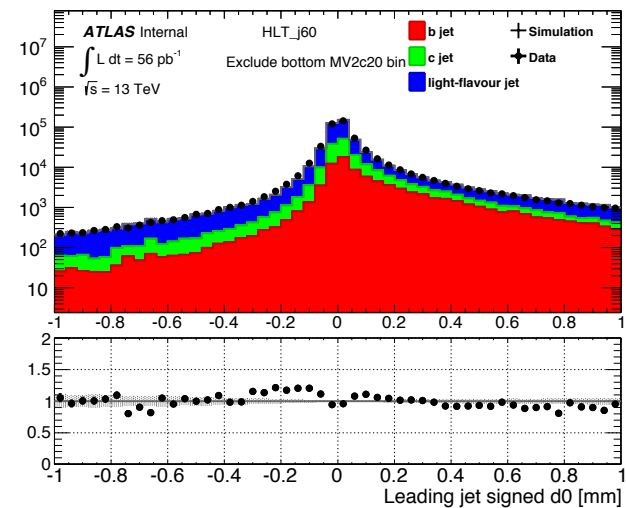
## Normal:



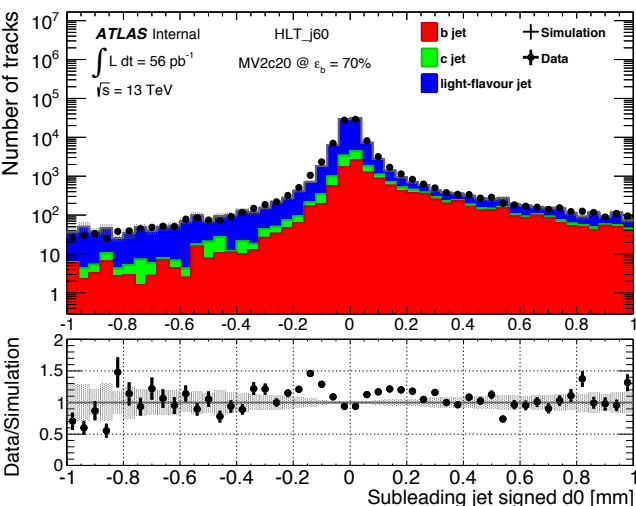
## Bottom Bin Only:



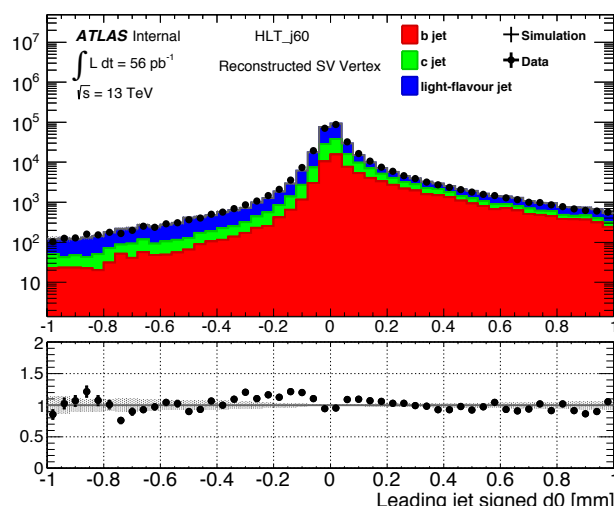
## No Bottom Bin:



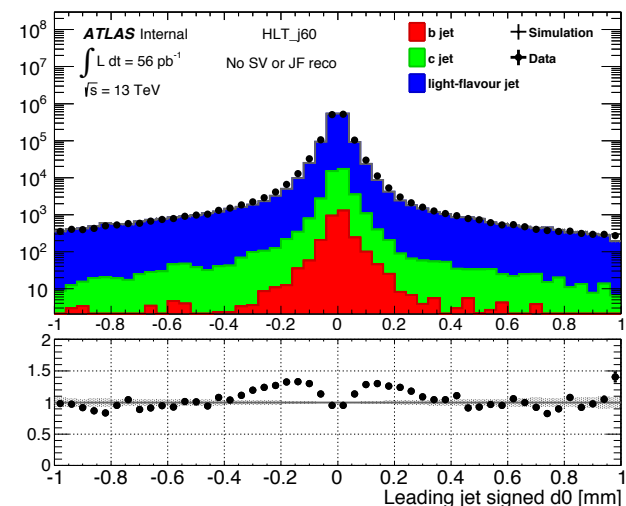
## b-enhanced (SL):



## SV reconstructed:

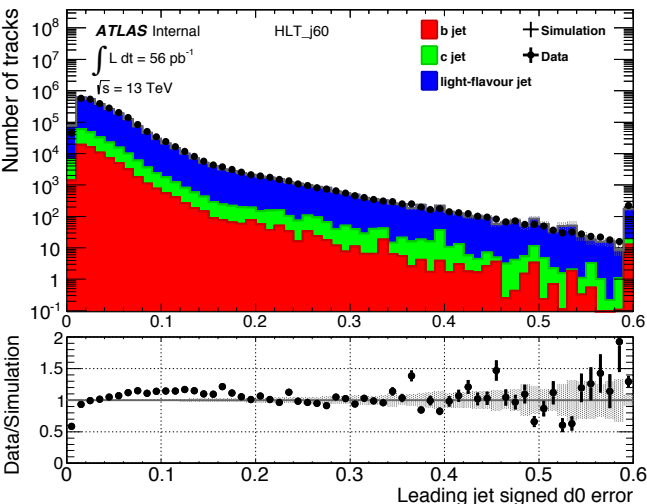


## No JF or SV reconstructed:

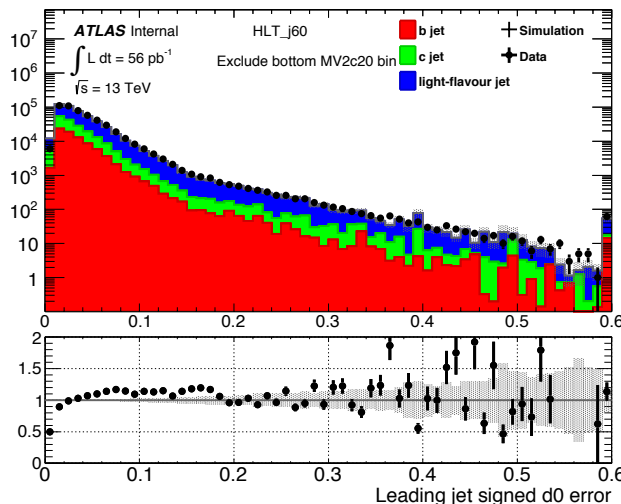




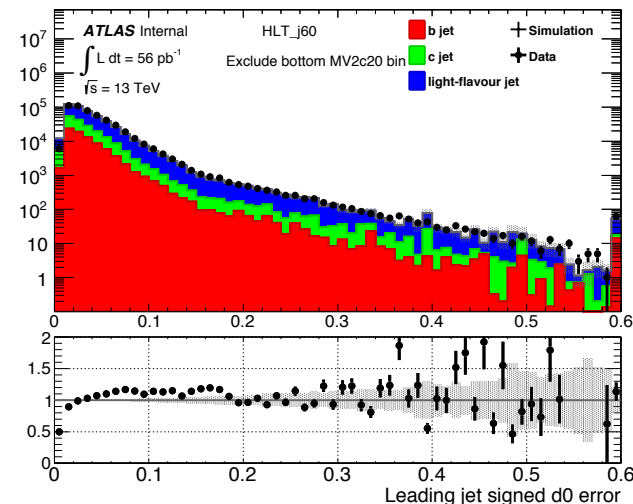
Normal:



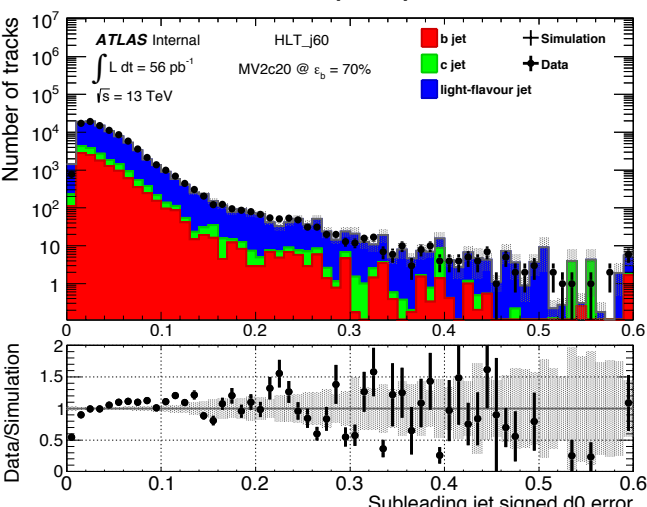
Bottom Bin Only:



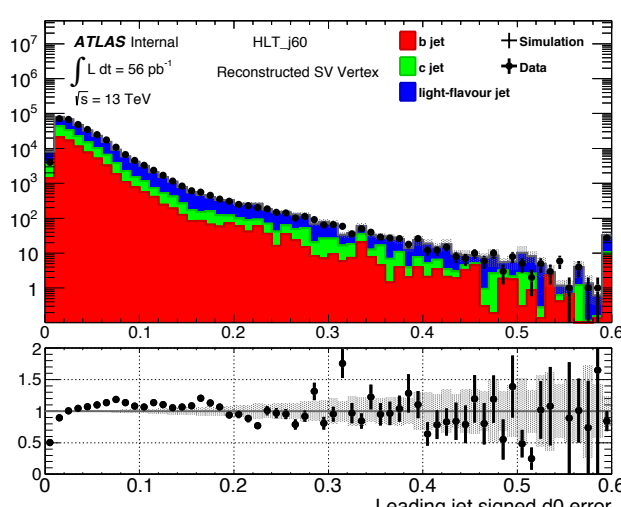
No Bottom Bin:



b-enhanced (SL):



SV reconstructed:



No JF or SV reconstructed:

