

Qualification Task AFT 455:

Optimization of Inputs for High Level Discriminants (DL1 and MV2) to
Improve Performance of B-Tagging in Heavy Ion Collisions

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- B-Tagging Optimization
 - Running data on changing min pT Cuts (for both “high quality first selection” and “low quality second selection”)
 - Implementing number of tracks from B/D/Fragmentation plots.
- Overlay Geometry
 - Made histograms of x, y, z shifts from different parts of inner detector.
 - Plot for other parts? Plot angles?

Tracking Geometry Ascii

```
Trk::TrackingVolume 'InDet::Detectors::Pixel::Barrel'  
  - transform      : Translation : (0.000000, 0.000000, 0.000000)  
                      Rotation   : (1.00000000, 0.00000000, 0.00000000)  
                                (0.00000000, 1.00000000, 0.00000000)  
                                (0.00000000, 0.00000000, 1.00000000)
```

```
  - listing Trk::BoundarySurface objects :
```

```
Trk::Surface object of type 2
```

```
  - transform      : Translation : (0.000000, 0.000000, -447.774440)  
                      Rotation   : (1.00000000, 0.00000000, 0.00000000)  
                                (0.00000000, 1.00000000, 0.00000000)  
                                (0.00000000, 0.00000000, 1.00000000)
```

TrackingVolume: Which detector::which part. E.g.: Pixel::Barrel

Tracking::Surface: type (shape), location and rotation of modules. E.g.: a module of IBL

```
Trk::Layer with LayerIndex 16
```

```
  - writing surface representation :
```

```
    Trk::Surface object of type 1
```

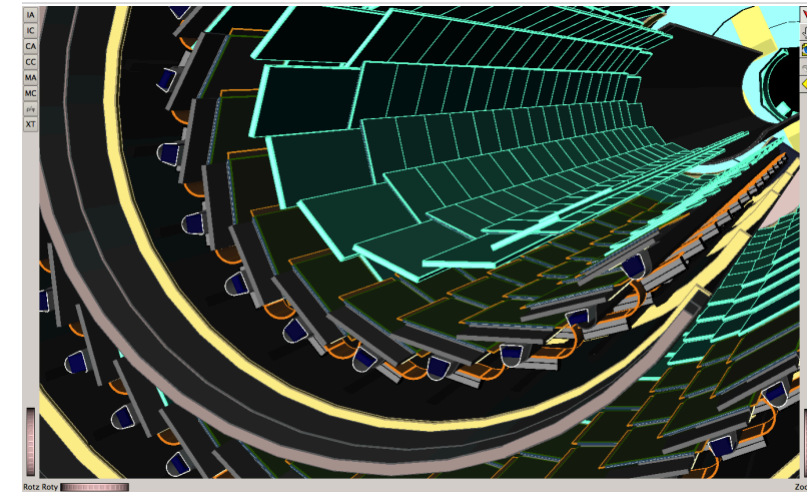
```
      - transform      : Translation : (0.000000, 0.000000, 0.000000)  
                          Rotation   : (1.00000000, 0.00000000, 0.00000000)  
                                    (0.00000000, 1.00000000, 0.00000000)  
                                    (0.00000000, 0.00000000, 1.00000000)
```

```
  - contains 280 confined Trk::Surface objects.
```

```
  - listing Trk::Surface objects :
```

```
    Trk::Surface object of type 4
```

```
      - transform      : Translation : (-31.151655, -13.418575, -323.939896)  
                          Rotation   : (0.11046642, -0.00076359, -0.99387956)  
                                    (-0.99387647, 0.00252575, -0.11046801)  
                                    (0.00259464, 0.99999652, -0.00047990)
```



Issues: difference in simulation and reconstruction

Geometry dumps - Last time

Example for InDet::Detectors::Pixel::Barrel Trk::Layer with LayerIndex 16 (IBL) first module in the list

Overlay with **2018 PbPb data** - simulation step:

```
Trk::Surface object of type 4
transform      : Translation : (-31.151995, -13.417471, -323.944905)
                  Rotation   : (0.11046642, -0.00076189, -0.99387956)
                              (-0.99387646, 0.00252785, -0.11046802)
                              (0.00259655, 0.99999651, -0.00047798)
```

Overlay with **2018 PbPb data** - reconstruction step:

```
Trk::Surface object of type 4
transform      : Translation : (-31.151655, -13.418575, -323.939896)
                  Rotation   : (0.11046642, -0.00076359, -0.99387956)
                              (-0.99387647, 0.00252575, -0.11046801)
                              (0.00259464, 0.99999652, -0.00047990)
```

<https://indico.cern.ch/event/908155/>

Diff:

```
transform      : Translation : (-0.00034 , 0.001104, -0.005009)
                  Rotation   : (0.0 , -0.0000017, 0.0 )
                              (0.00000001, 0.0000021, -0.00000001)
                              (0.00000191, -0.00000001, -0.00000192)
```

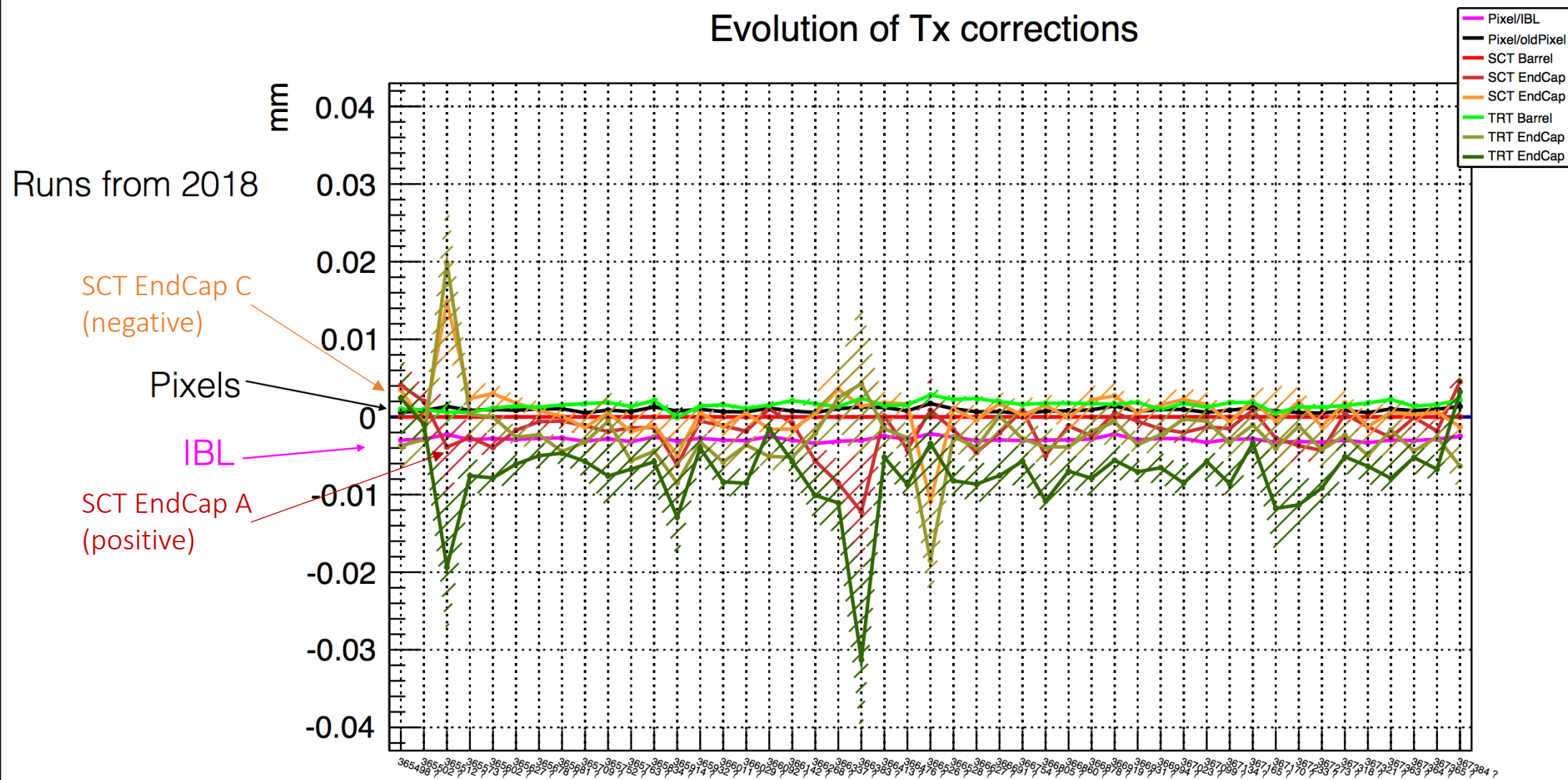
Sizable difference in x,y,z
coordinates and in small
difference in the angle!

Wrong alignment constants?

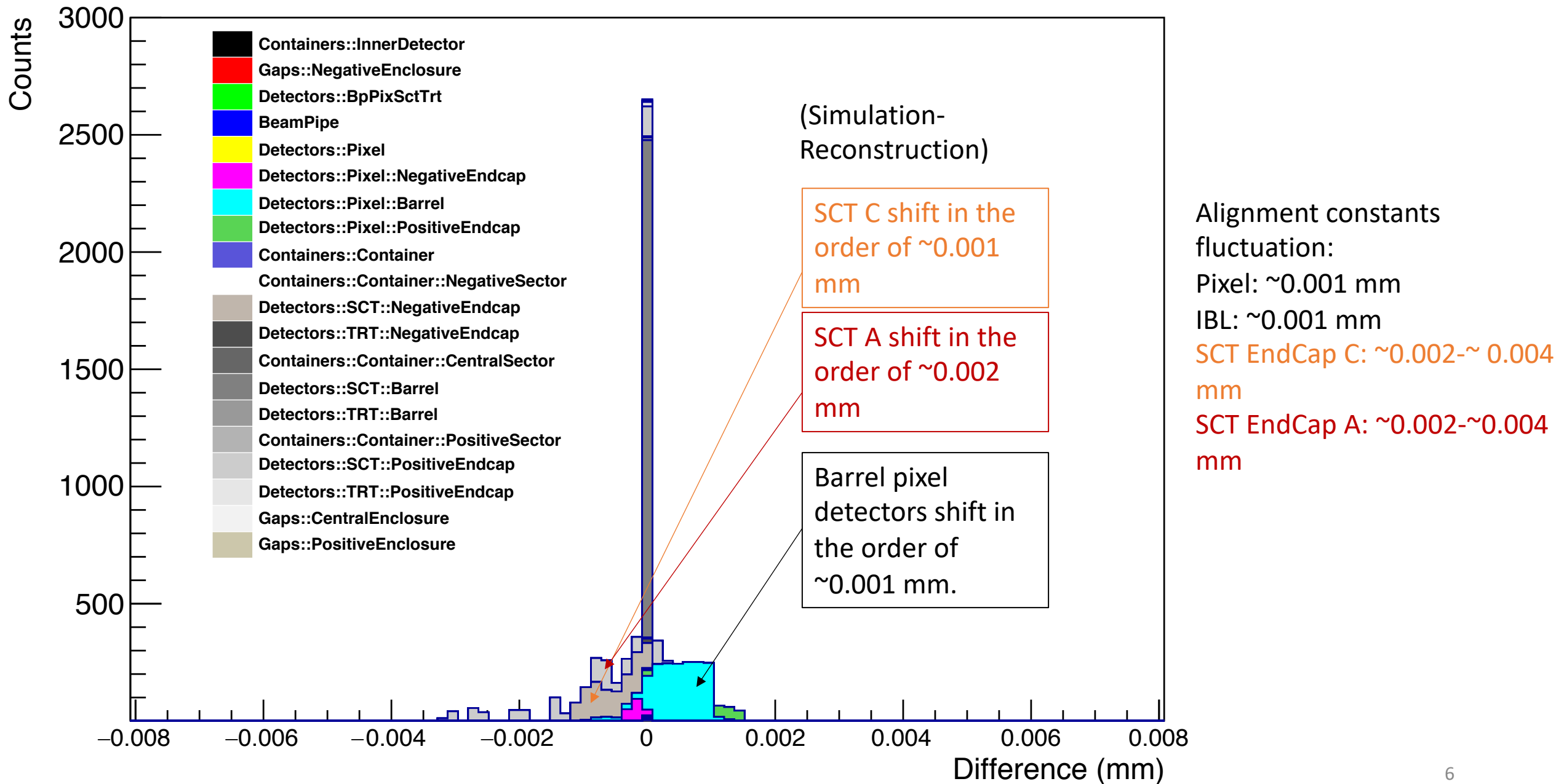
<https://indico.cern.ch/event/908155/>

Changes of the alignment constants during the run and running period

Evolution of Tx corrections

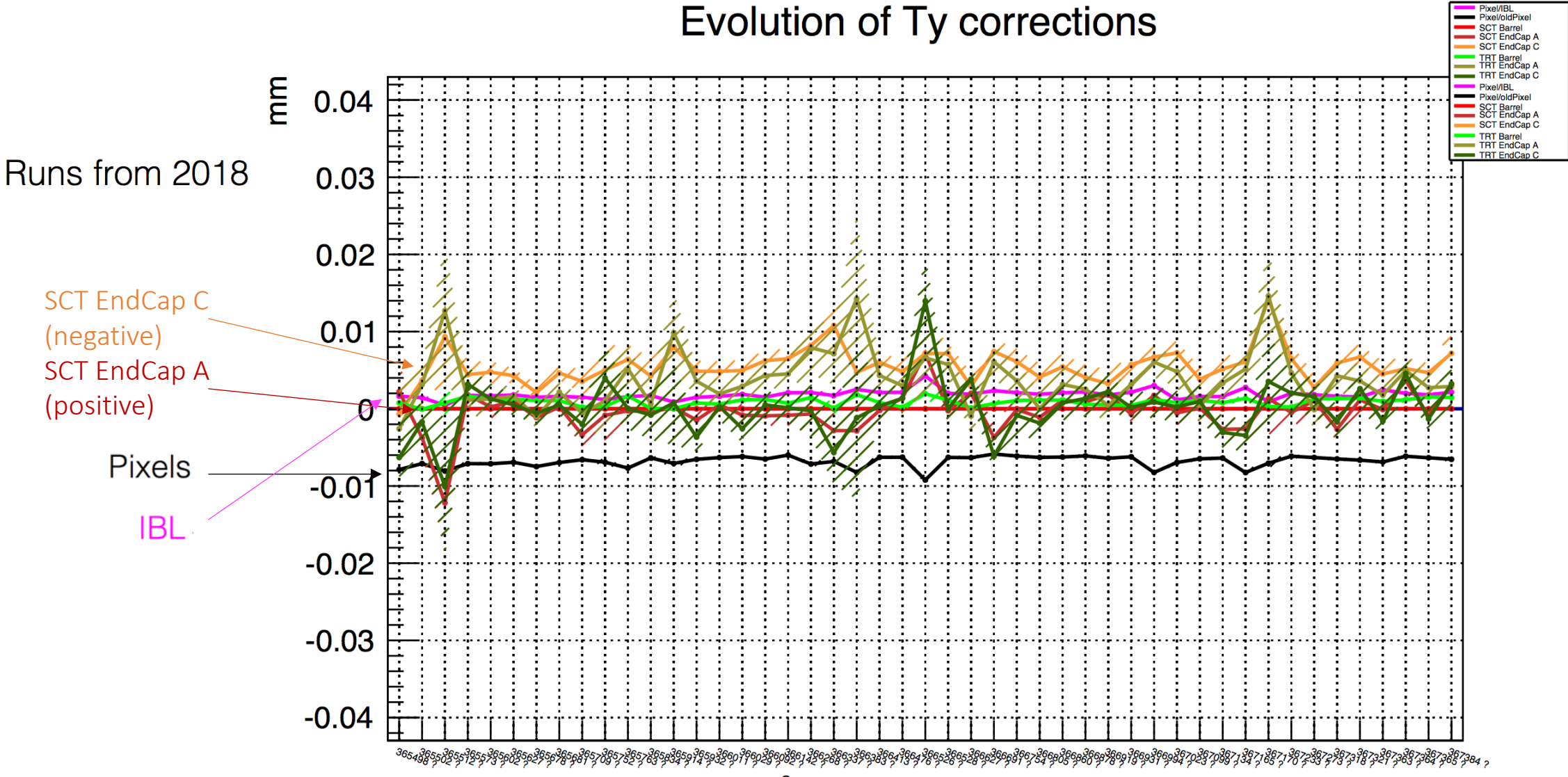


x diff for compare2018

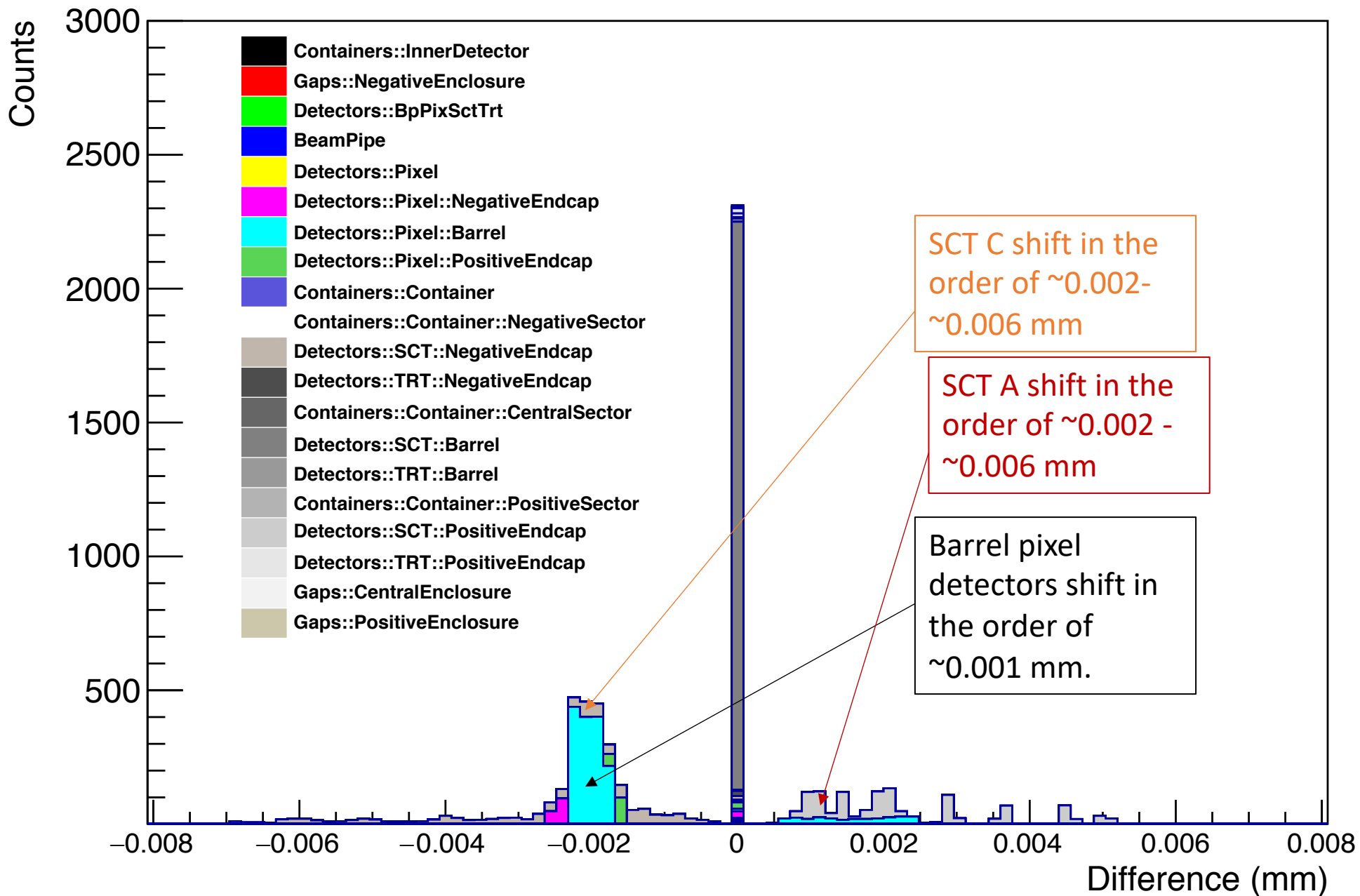


Changes of the alignment constants during the run and running period

Evolution of Ty corrections

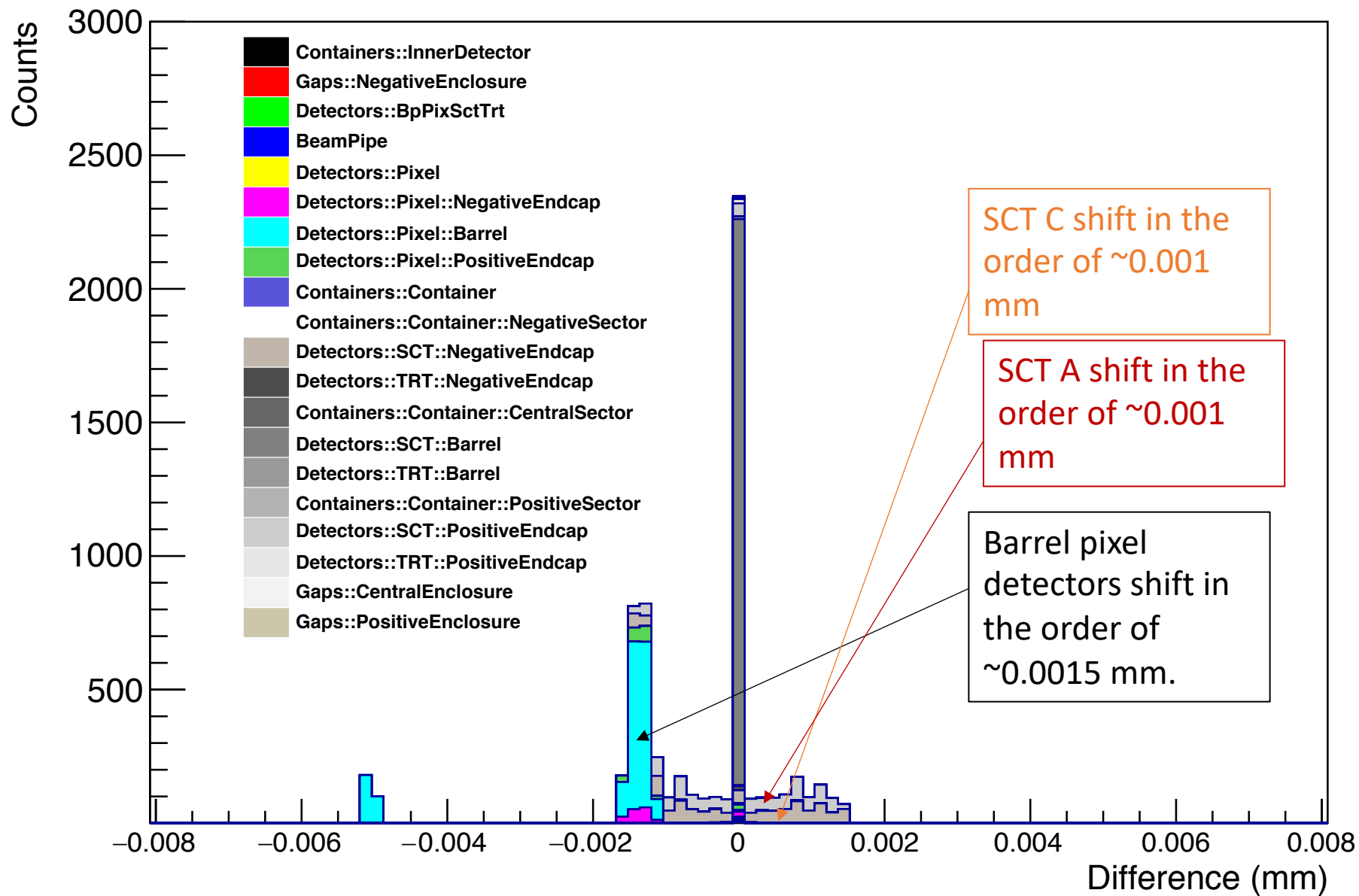


y diff for compare2018



Alignment constants fluctuation:
 Pixel: ~ 0.001 - ~ 0.002 mm
 IBL: ~ 0.001 mm
 SCT EndCap C: 0.004 mm
 SCT EndCap A: 0.002 mm

z diff for compare2018



No comparison plots yet, looking into making the alignment plots.

Summary

- X,Y shifts are approximately on the same scale with alignment constants' fluctuation
 - It might come from using wrong alignment constant
- Suspicious systematic shifts to negative in y, z and to positive to x in pixel detectors
 - Systematic rotation? How?
 - Idea: try to convert rotation matrix into (r,phi,theta) and look at angular shifts

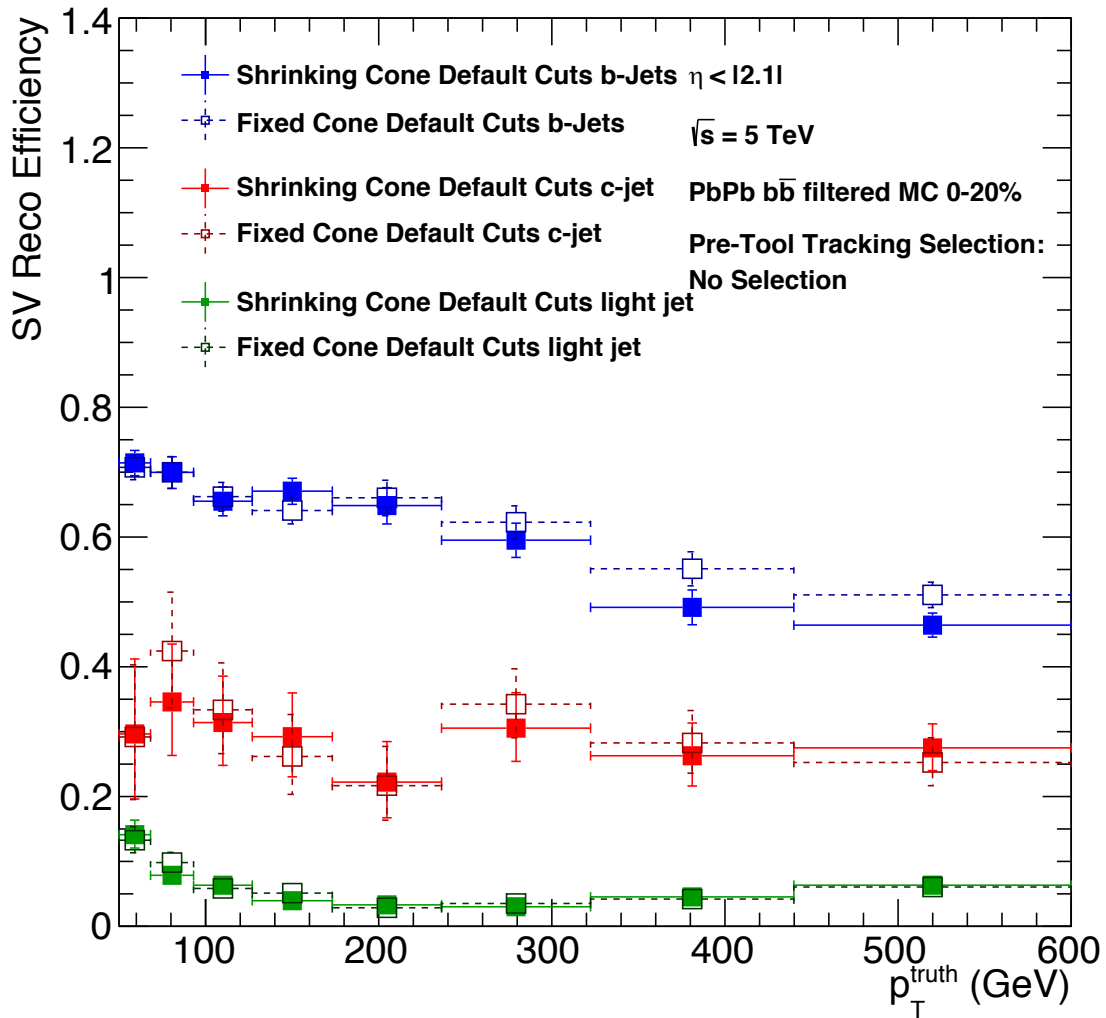
Effects of Cuts on Overlay

- Cuts those are effective in improving efficiency at pp MC were used in overlay.
- Fixed Cone: Using Fixed cone at 0.4 for tracks to jet association in contrast to shrinking cone algorithm optimized for pp.
- Minimum pT fraction: (wrong understanding previously)
 - 2-trk vertices candidates are created.
 - For tracks those are not in the candidates' tracks, if they pass $\text{minfraction} \times \text{jet_Pt}$, then the common fitting algorithm will also use them.
 - **Correction:** minimum fraction of Pt used to select tracks used to form 2-trk vertices; misunderstood one of the selections last time (see back-up).
- Anti Pile Up tool:
 - Remove tracks with small xy impact parameter and big z impact parameter those are presumably from pileup.
- IP Selection:
 - Maximum xy-plane and z-plane impact parameter selections.
- This week:
 - looked at comparison with pp with SVF
 - A first look at JetFitter efficiency
- Things to look at :
 - Min number of shared hits. (the algorithm seems to not be using it? But there is an effect...)

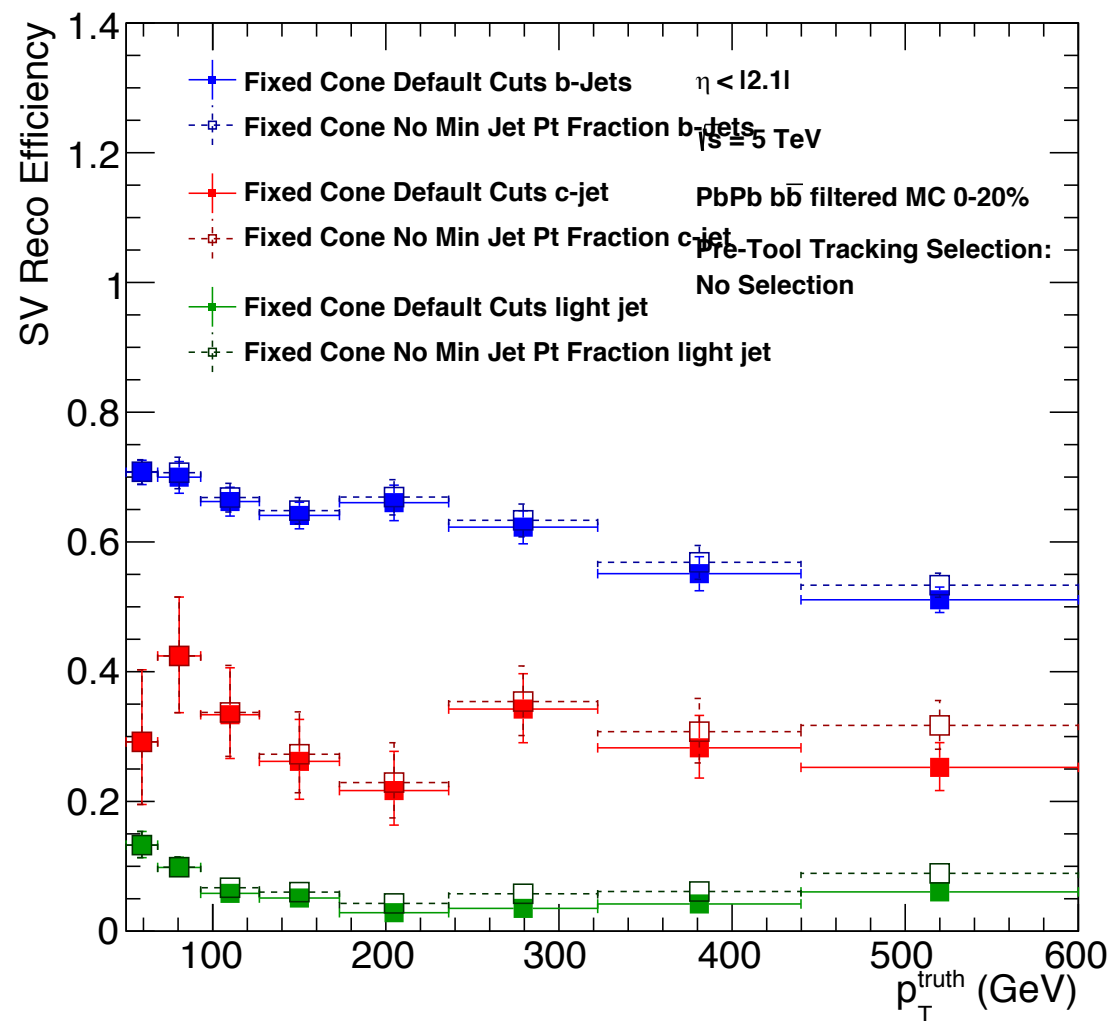
Summary of Effects of Cuts on Overlay (0-20%)

Cuts (original) (New)	Efficiency	Purity	Comment	Action
Fixed Cone (0.4)	+(~5%) at high pT	No change	Safer to use for HI jets	Keep using
Min pT Fraction(0.01) (0.00)	+(~2%) at high pT b +(~3%) at high pT c	+(~3%) fake ☹️		Do not change
Anti Pile Up tool (On) (Off)	+(~2%) at high pT c	No change	Does it make sense to use in HI?	Keep using
IP Selection(On) (Off)	No significant Effect	No change		Do not change

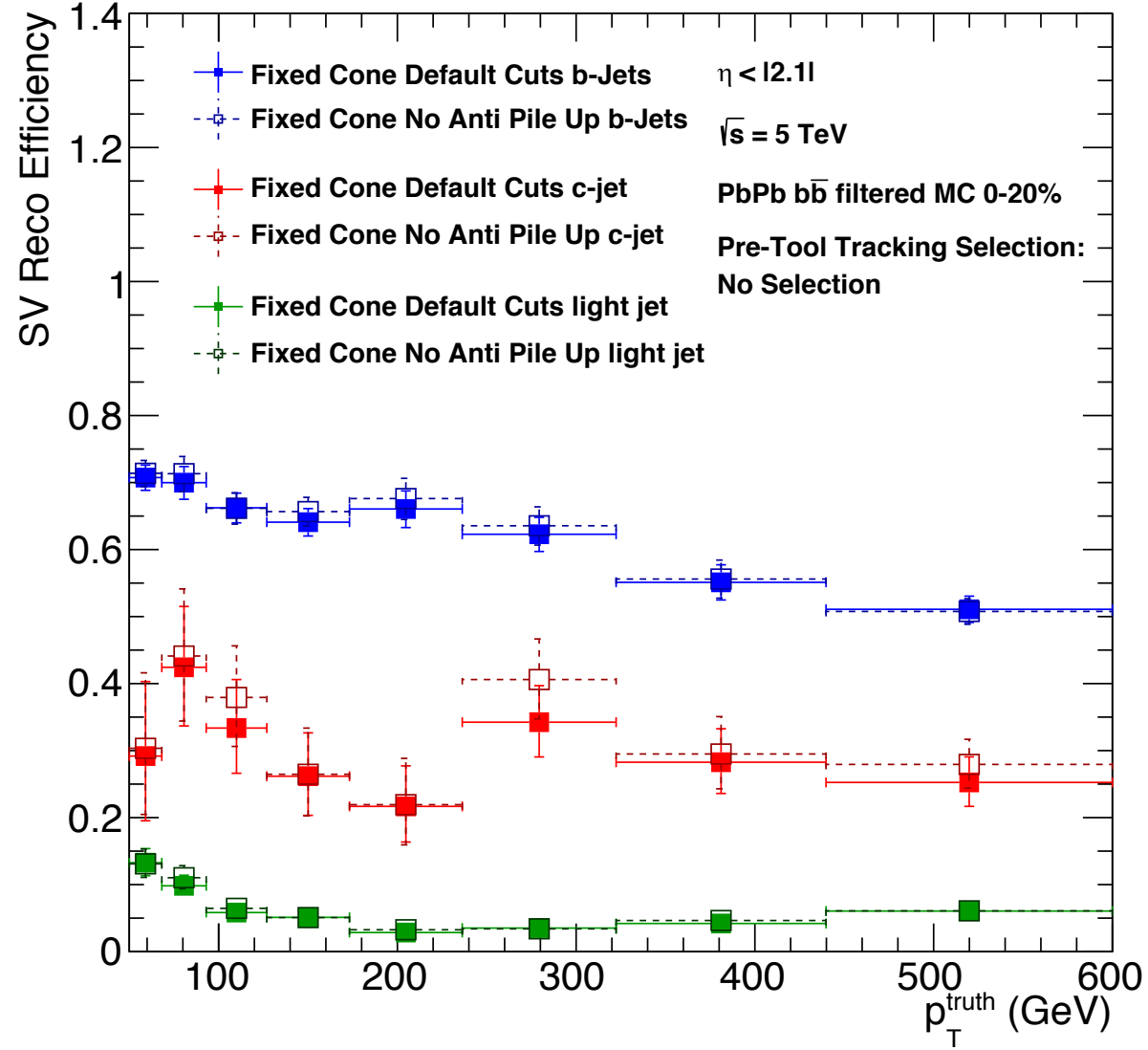
SV Reco Efficiency for Different Flavors of Jets in PbPb 0-20%



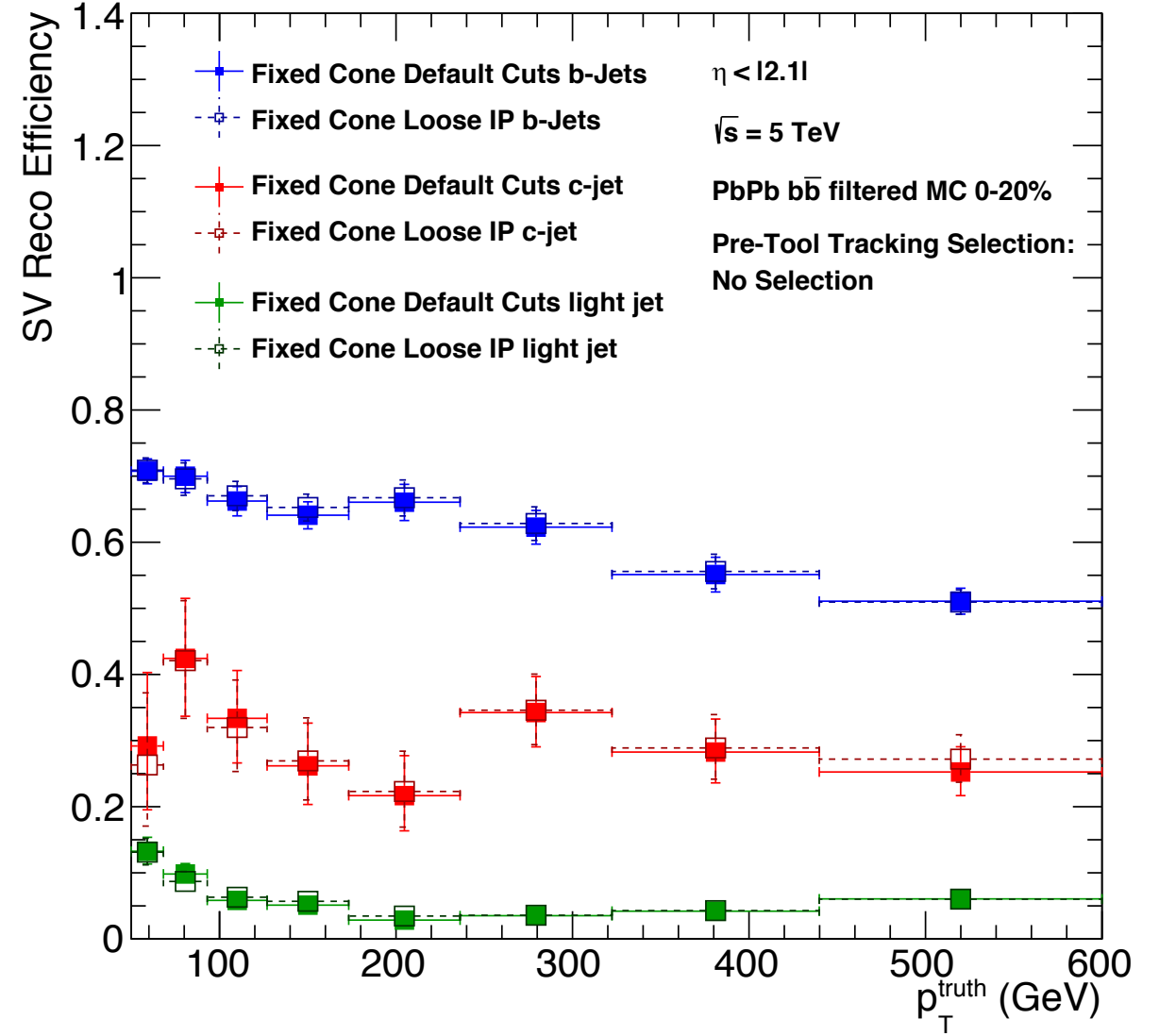
SV Reco Efficiency for Different Flavors of Jets in PbPb 0-20%



SV Reco Efficiency for Different Flavors of Jets in PbPb 0-20%



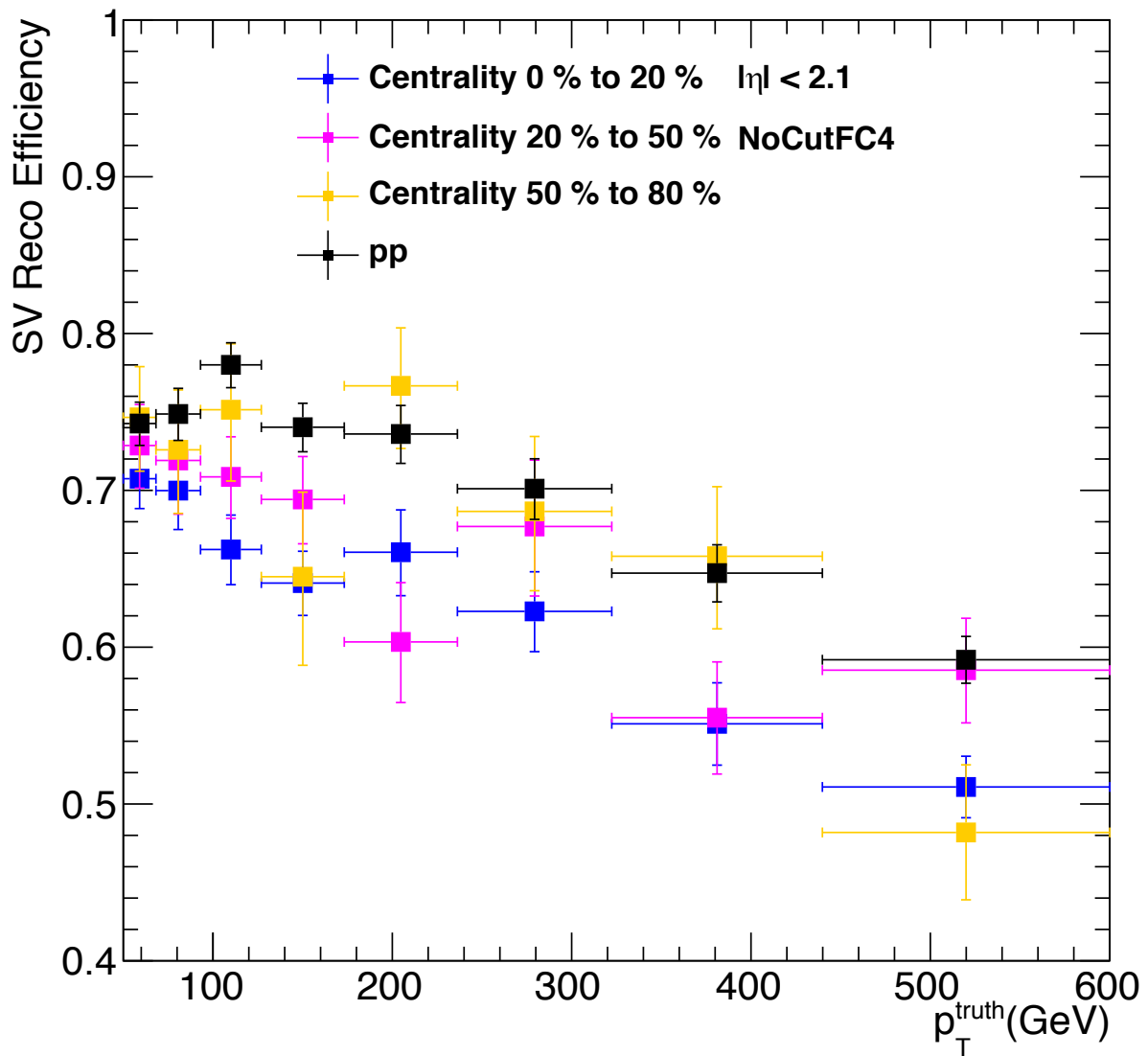
SV Reco Efficiency for Different Flavors of Jets in PbPb 0-20%



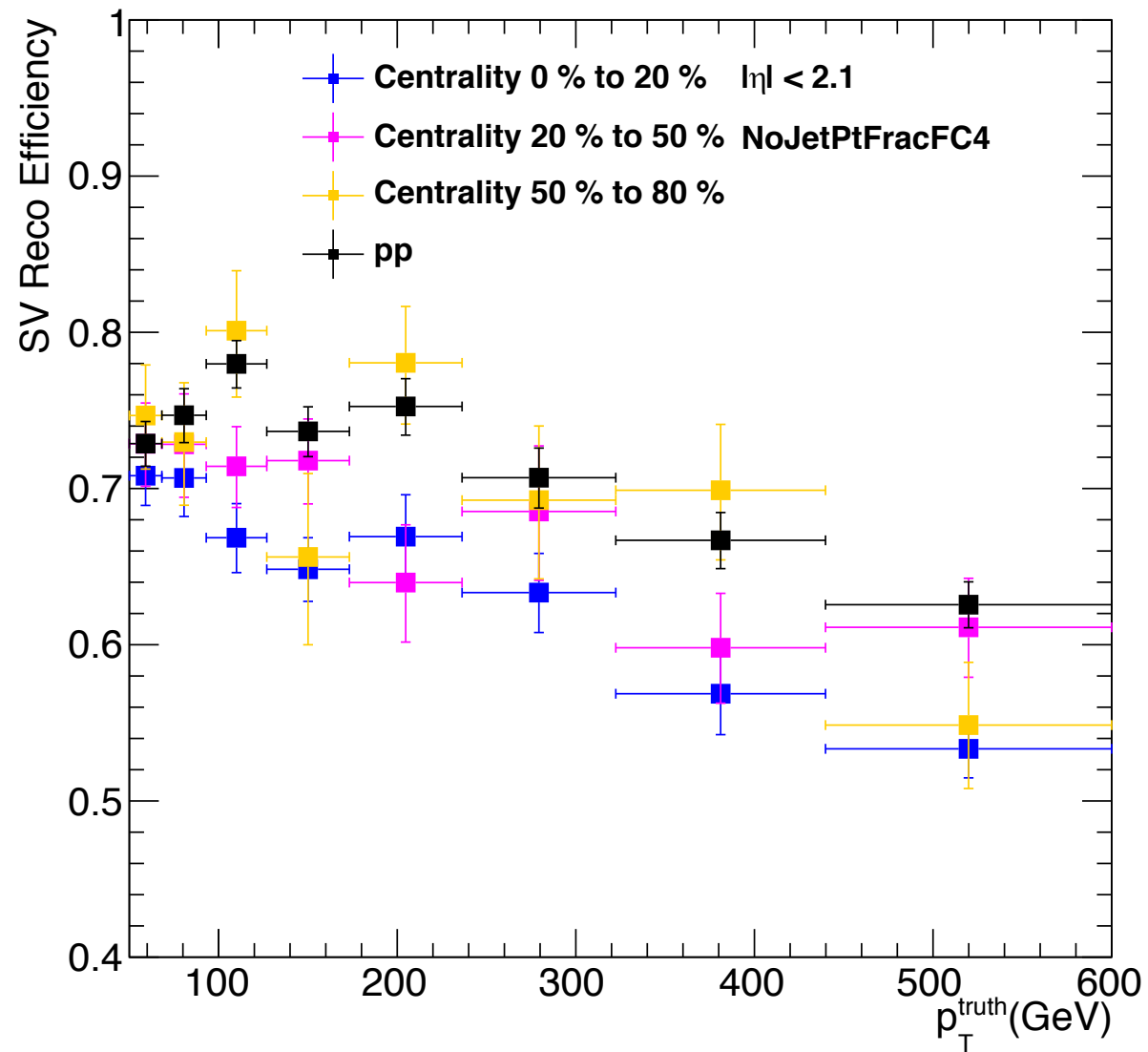
Comparison to pp

- Most of the points follow the trend (worse in central, similar to pp in peripheral)
- Due to limit in statistics, not clear.
- Will try change binning so lower pT range is clear.

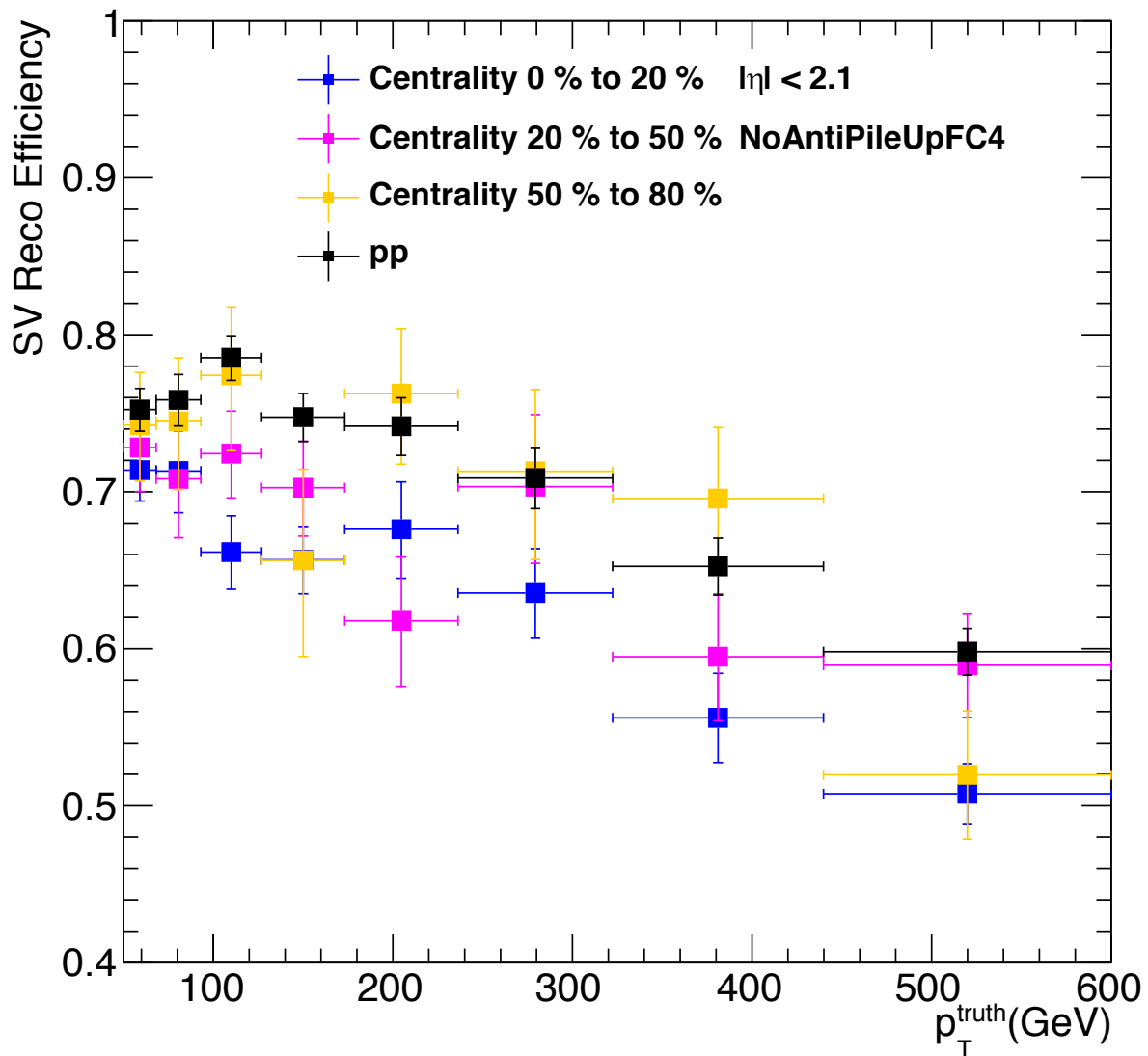
SV Reconstruction Efficiency in b-jet with SV1 Tagger in MC



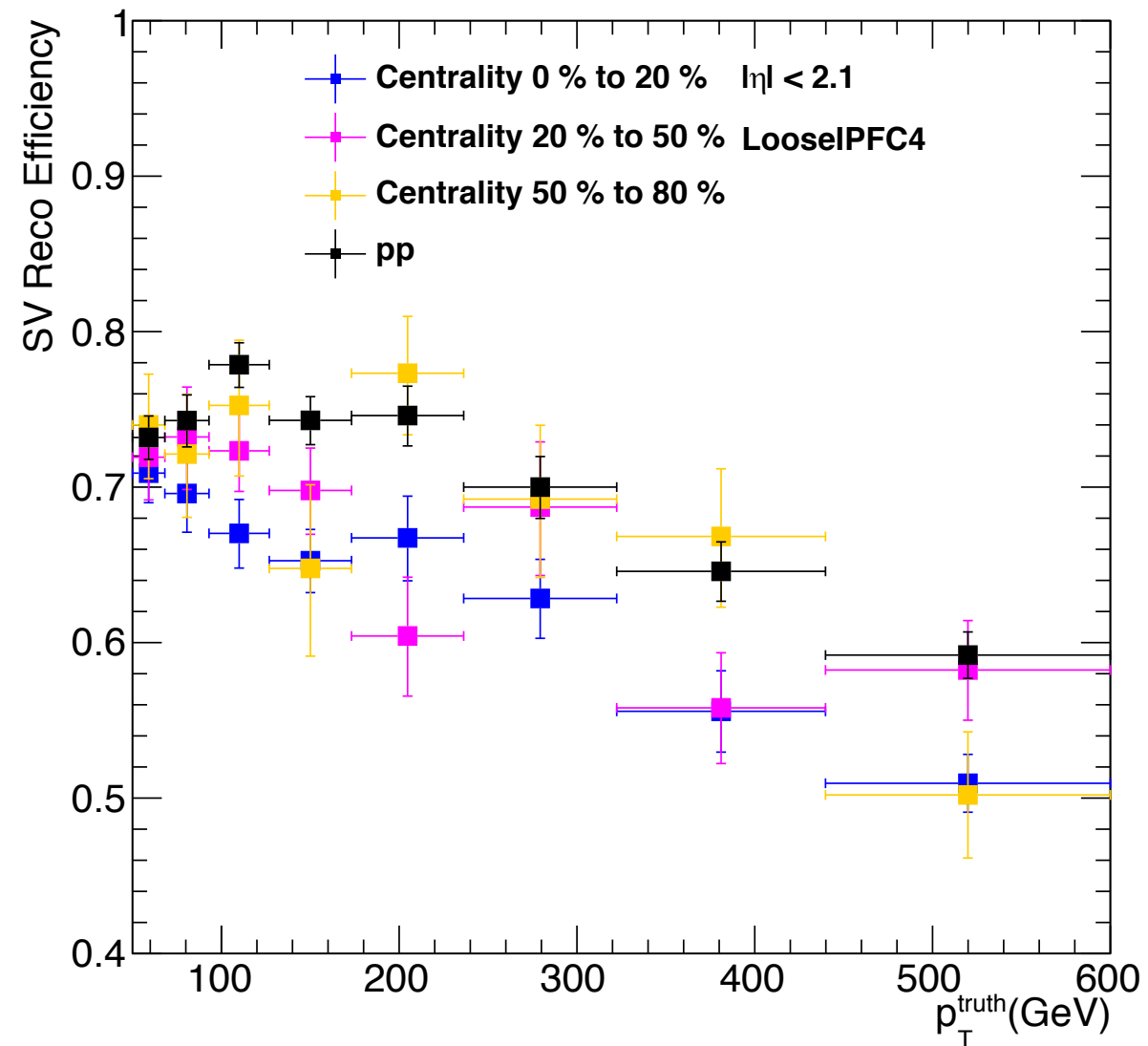
SV Reconstruction Efficiency in b-jet with SV1 Tagger in MC



SV Reconstruction Efficiency in b-jet with SV1 Tagger in MC



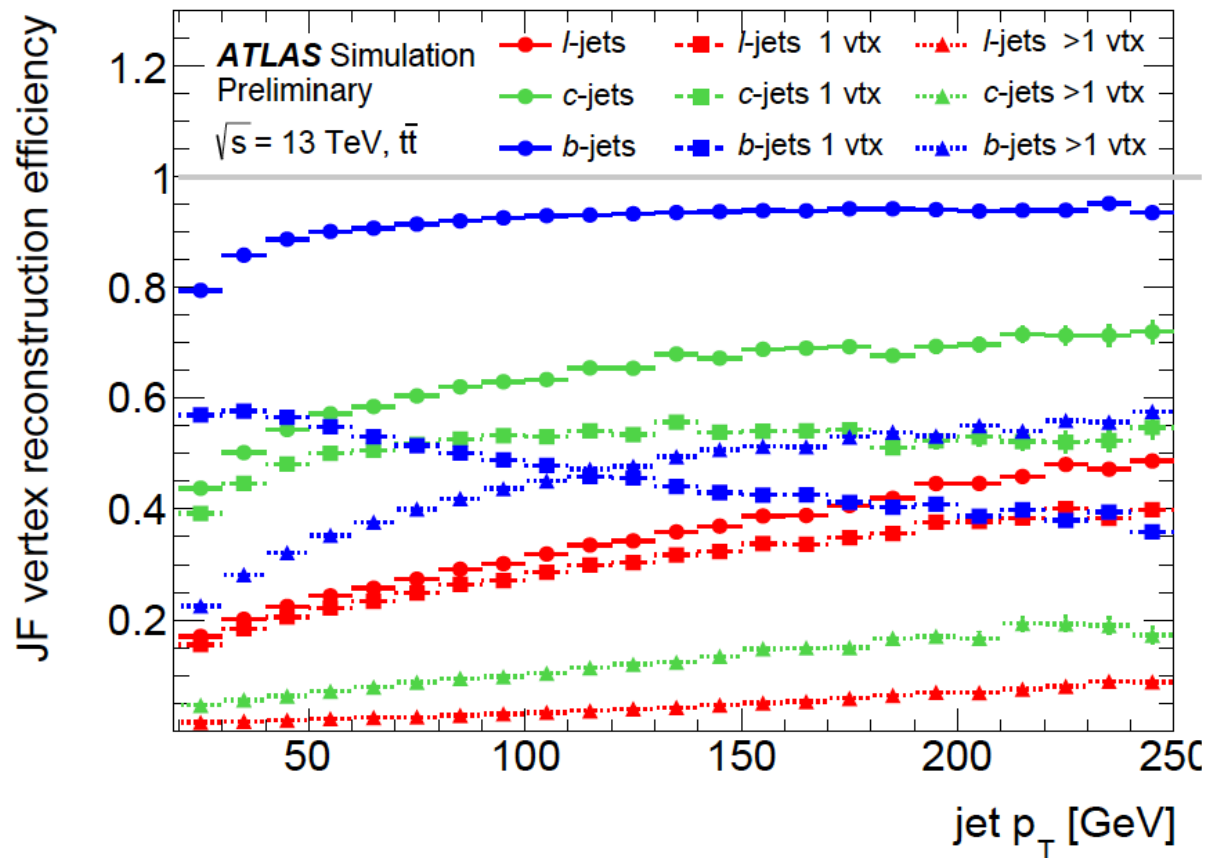
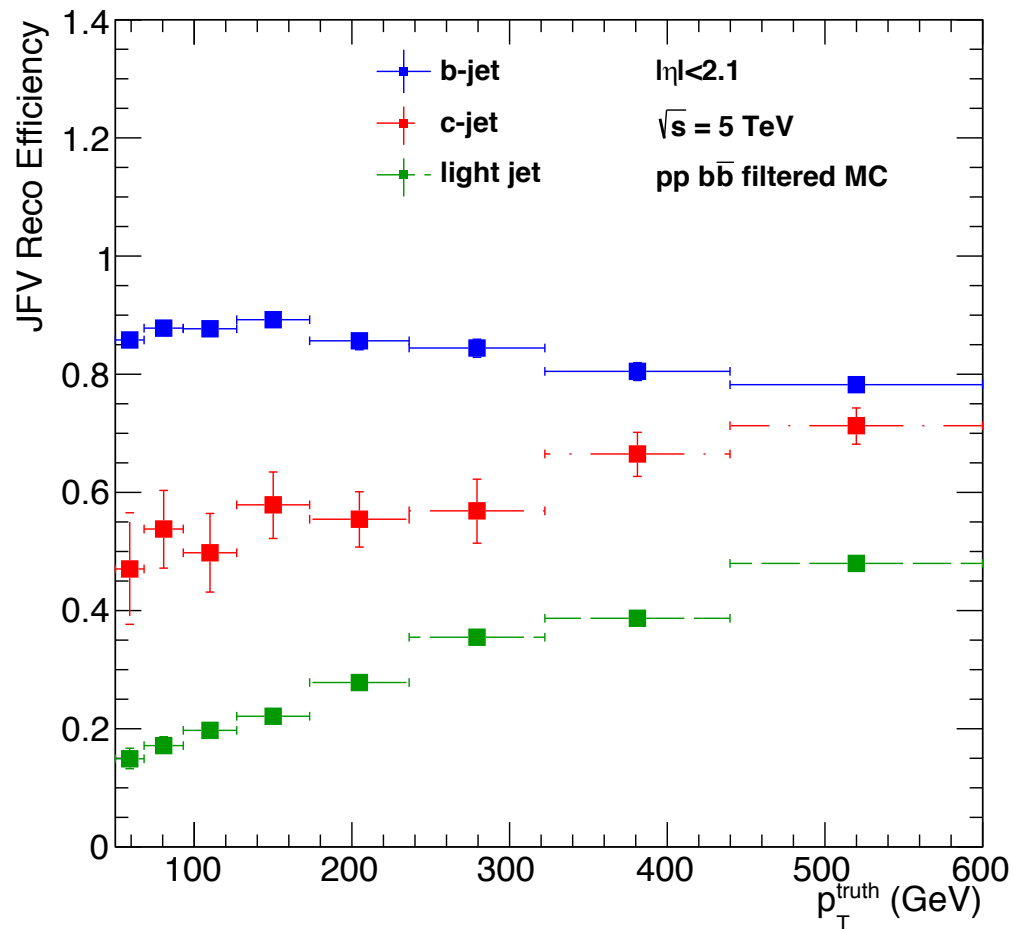
SV Reconstruction Efficiency in b-jet with SV1 Tagger in MC



JetFitter Algorithm—i.e., not only one vertex but also decay chain

- 1. Select Tracks
 - Form all possible 2-track vertices, and exclude tracks compatible with primary vertex, and hadronic material interactions.
- 2. Fitting and Merging
 - Initialize B-hadron flight direction as jet direction.
 - Initialize vertices candidates as closest approach position of each of the selected tracks to this direction.
 - Iteratively merge vertices and reject tracks with χ^2 cut.
 - Meanwhile iteratively align vertices with a common B-hadron flight direction and reject vertices with χ^2 cut.
 - Output a list of vertices aligned at common B-hadron flight axis
- Performance Paper: <https://cds.cern.ch/record/2645405/files/ATL-PHYS-PUB-2018-025.pdf>

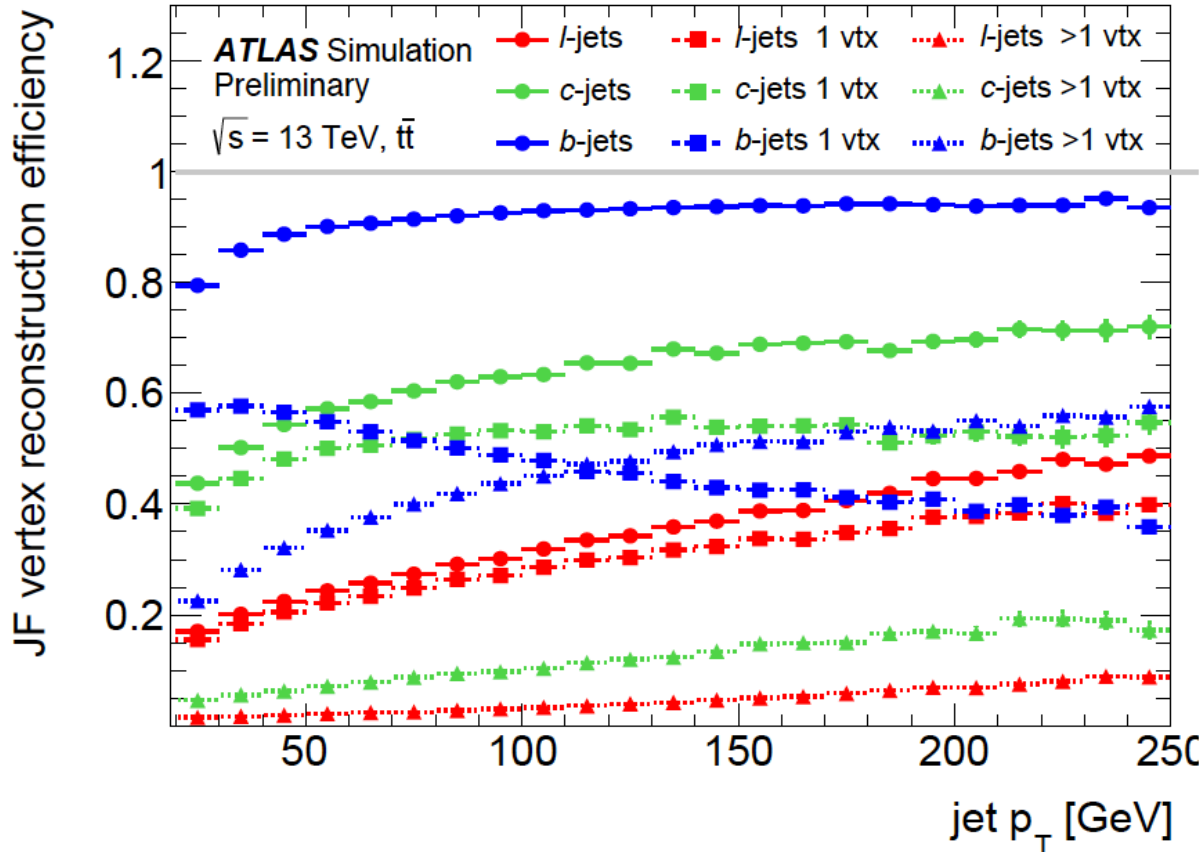
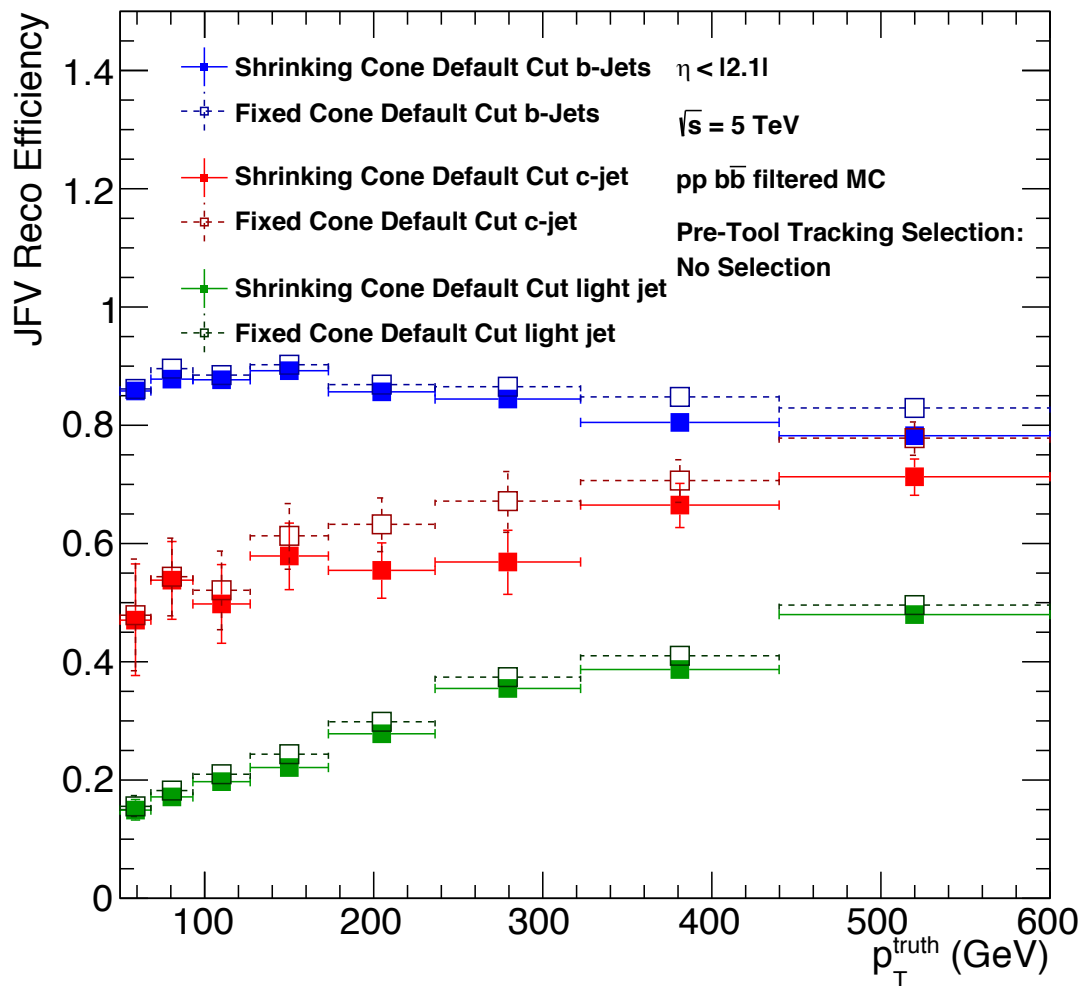
Efficiency Comparison to pp at 13 TeV



- Observed a minor decrease in efficiency at higher p_T
- Higher than 250 GeV results are not shown in the performance paper
- 50-250 range is relatively flat.

Does Fixed Cone still work wit JetFitter?

JFV Reco Efficiency for Different Flavors of Jets in pp MC



Default JetFitter Results and Fixed Cone Results

Default Cuts

Integrated Efficiency (pT >20 GeV)	0-20%	20-50%	50-80%	pp
B-jet	0.939	0.901	0.844	0.865
C-jet	0.708	0.553	0.519	0.496
Light-jet (fake)	0.645	0.409	0.152	0.165

Fixed Cone at 0.4

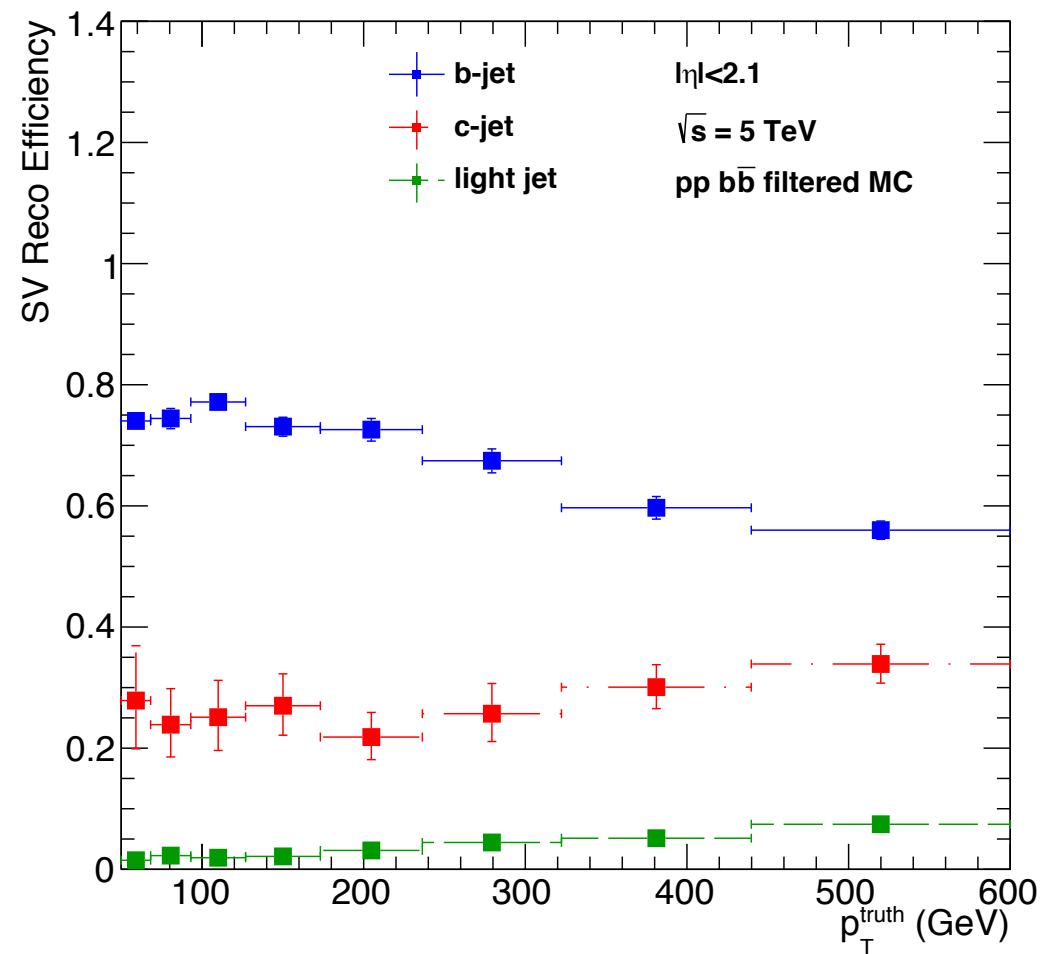
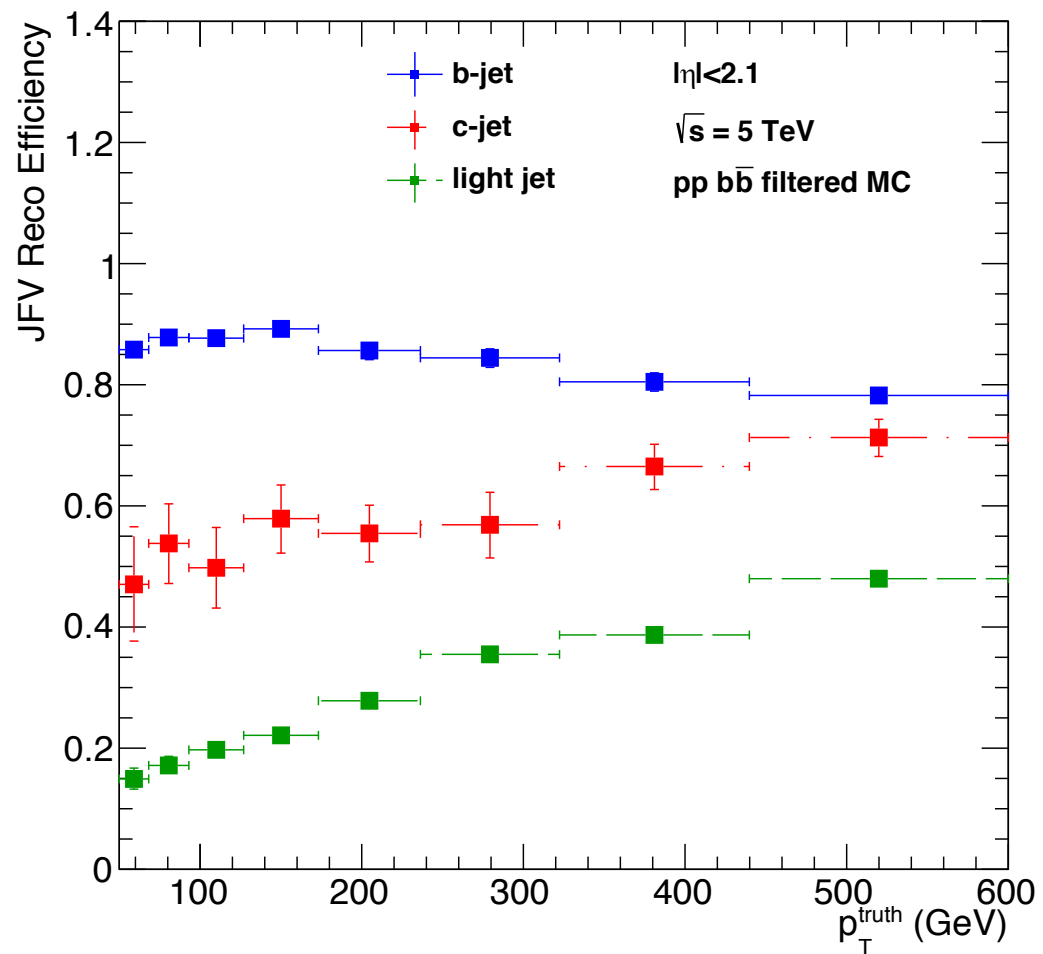
Integrated Efficiency (pT >20 GeV)	0-20%	20-50%	50-80%	pp
B-jet	0.954	0.907	0.860	0.872
C-jet	0.716	0.579	0.507	0.507
Light-jet (fake)	0.723	0.468	0.160	0.174

Performance Paper results:

	JF Vertices All
<i>b</i> -jets	0.893
<i>c</i> -jets	0.556
light jets	0.234

Back-up

Back-up: compare to SV



Minimum Jet Pt Fraction

- Algorithm overview:
 - 1. Select list of good particles
 - A0 Z0 track error cuts (Perigee quality)
 - For tracks with $p > 10$ GeV, $\text{stdev} < 50\%$
 - Min Pixel hits, SCT hits and IBL hits requirement should be met
 - within 0.4 of JetDir
 - 2. Select list of two track vertices using selected good particles
 - Vertices are not in material layer and invariant mass is not a V^0 decay
 - Both track passes Jet Pt Fraction and vertex fitting quality

Other to-do

- Reproduce plots from JetFitter performance with our MC.
- Plan on summary of progress for flavour tagging group.