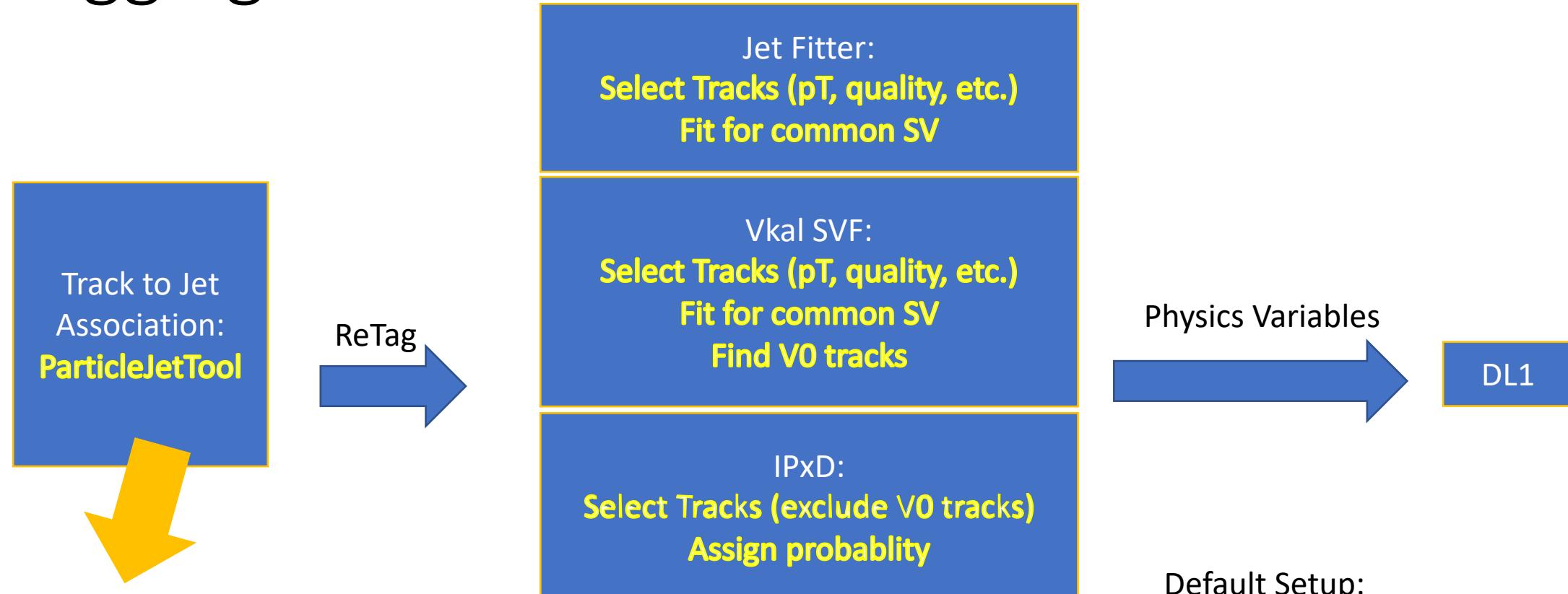


# Plans

- Taggers: IPxD, SVF, JetFitter
  - IPxD: re-tune with inclusive dijet samples:
    - Weights added.
    - Centrality dependence added.
    - Setup LOCALGROUPDISK space for inclusive n-tuples.
    - templates and evaluation using Shrinking Cone No Cut and 1.5 GeV Cut, making ROC curves
      - Made curves for pp samples, making PbPb samples.
  - SVF & JetFitter Performance: physics variables:
    - Added comparison with light jet
    - Simplified cuts being compared
    - ROC curve for vertexing efficiency of different tagger & centrality

# B-Tagging Workflow



-track pass **TrkSelectionTool**

-associate each track to closest jet

-if  $dR <$  threshold, track is associated

**Shrinking Cone:** higher jet pT, smaller the threshold  $dR$

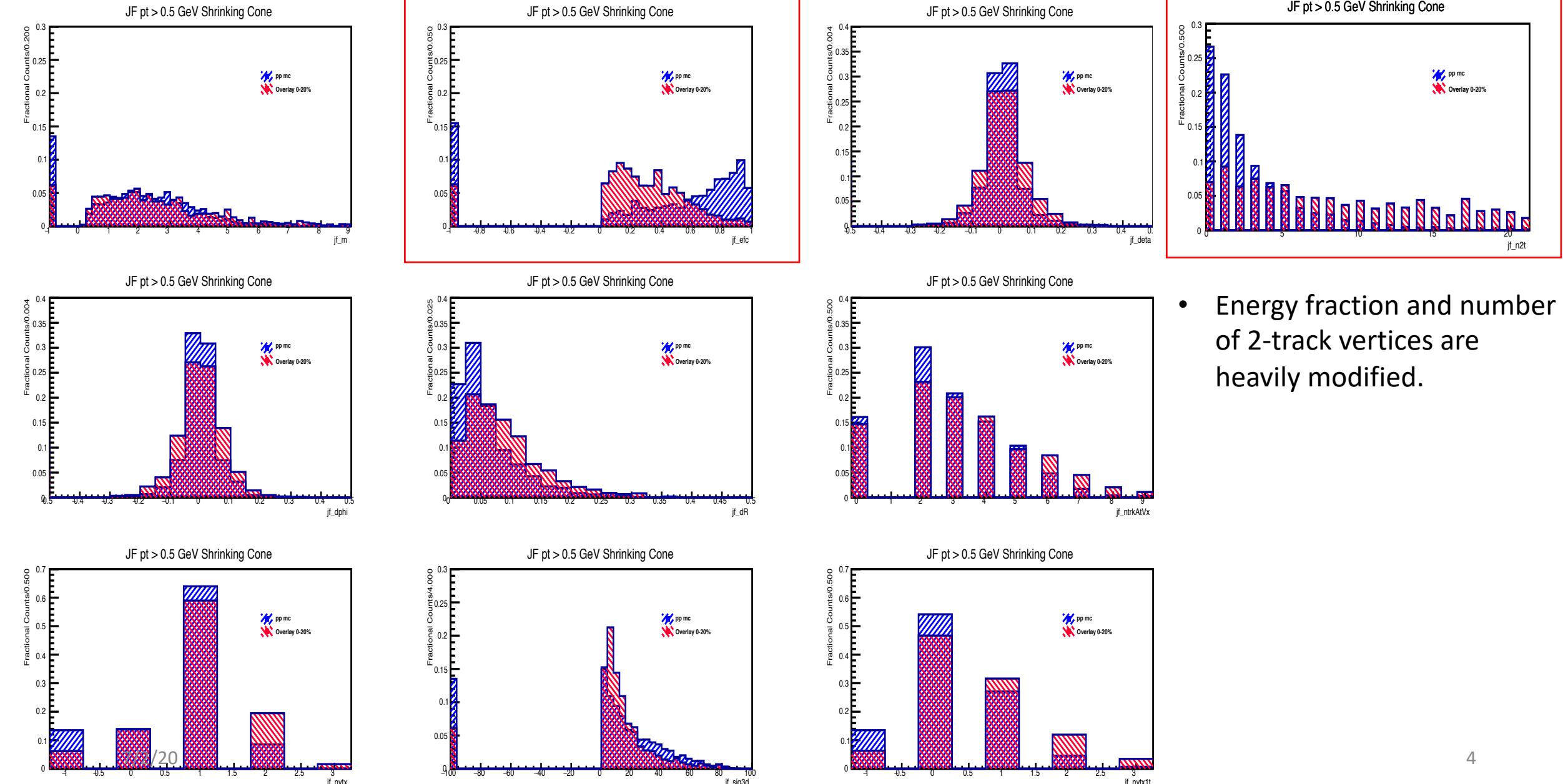
**Fixed Cone:** threshold  $dR = 0.4$  for all jet pR

Pre-Tagging  
Selection

# MC Samples

- pp MC and MC overlay (**JetFitter and SV1 plots**):
  - pp MC: 50k events (12.5k each for JZ1-JZ4) of pythia dijets events at 5.02 TeV, applied with bbar filter Selection on Jets.
  - Configuration file: [https://gitlab.cern.ch/atlas-physics/pmg/infrastructure/mc15joboptions/blob/master/share/DSID420xxx/MC15.420271.Pythia8EvtGen\\_A14NN\\_PDF23LO\\_jetjet\\_JZ1\\_bbfilter.py](https://gitlab.cern.ch/atlas-physics/pmg/infrastructure/mc15joboptions/blob/master/share/DSID420xxx/MC15.420271.Pythia8EvtGen_A14NN_PDF23LO_jetjet_JZ1_bbfilter.py)
  - Overlay: pp MC + 2018 minBias data to simulate underlying events.
- pp Inclusive dijets samples (**IP3D**):
  - [https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/HIJetMCSamples#Pythia8\\_dijets\\_8M\\_per\\_sample\\_in](https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/HIJetMCSamples#Pythia8_dijets_8M_per_sample_in)
  - Pythia8 dijets - 8M per sample in 21.0.93
- Selection on Jets:
  - Reco jets with  $\Delta R(\text{truth-reco}) < 0.3$
  - $p_T^{\text{truth jet}} > 50 \text{ GeV or } 100 \text{ GeV}$  (see back up plots)
- B-Jets: jets with a truth B hadron associated with it. Similarly for C-jets
  - $p_T^B > 5 \text{ GeV}$
  - $\Delta R(\text{jet-BHadron}) < 0.3$
- Tool: [https://gitlab.cern.ch/stapiaar/tagging\\_framework\\_hi/tree/master/](https://gitlab.cern.ch/stapiaar/tagging_framework_hi/tree/master/)
  - The most updated modified version is at [https://gitlab.cern.ch/xiaoning/hiretagging\\_framework](https://gitlab.cern.ch/xiaoning/hiretagging_framework)

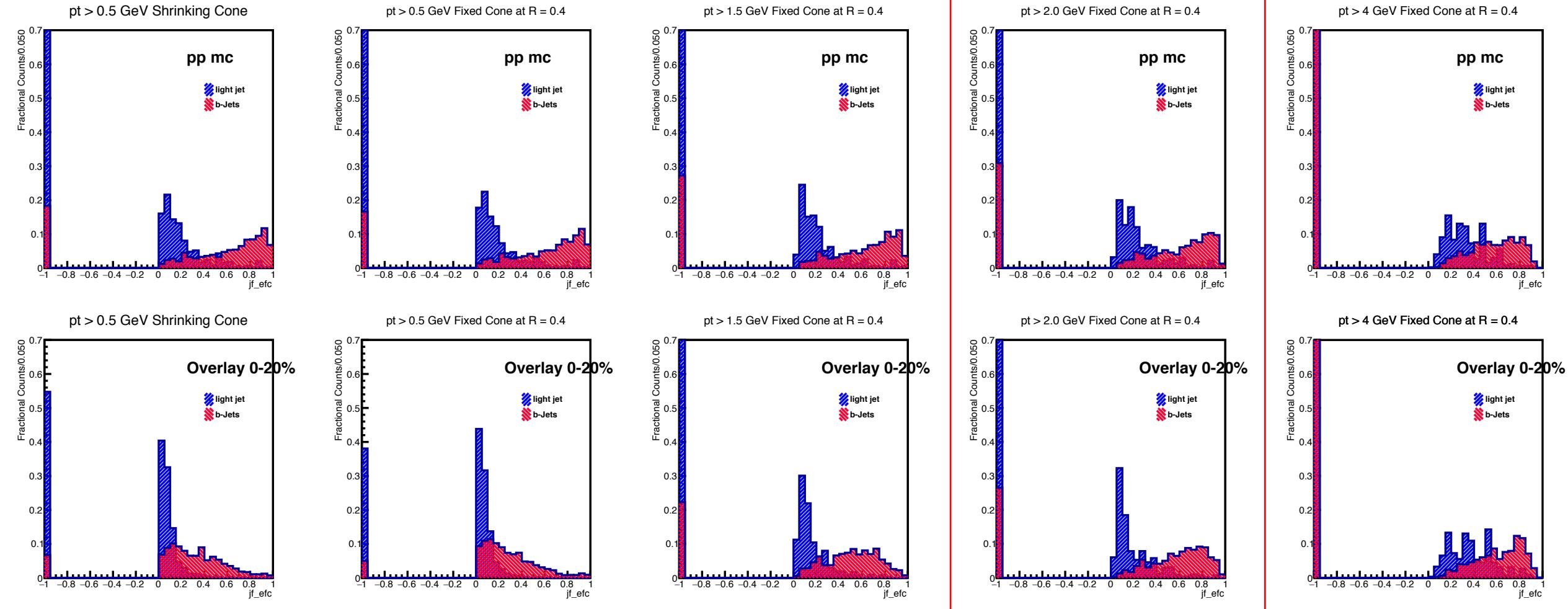
# JF Variables at Default Setup



# JF Energy Fraction

↓ Visually the two distributions are the most distinct at 2 GeV

↓ over cutting causes light jet to right-shift as well



Top Row: pp mc

Bottom Row: Overlay 0-20%

From left to right:

1. No pT Shrinking Cone
2. No pT Fixed Cone
3. Min pt = 1.5 GeV Fixed Cone

4. Min pt = 2.0 GeV Fixed Cone

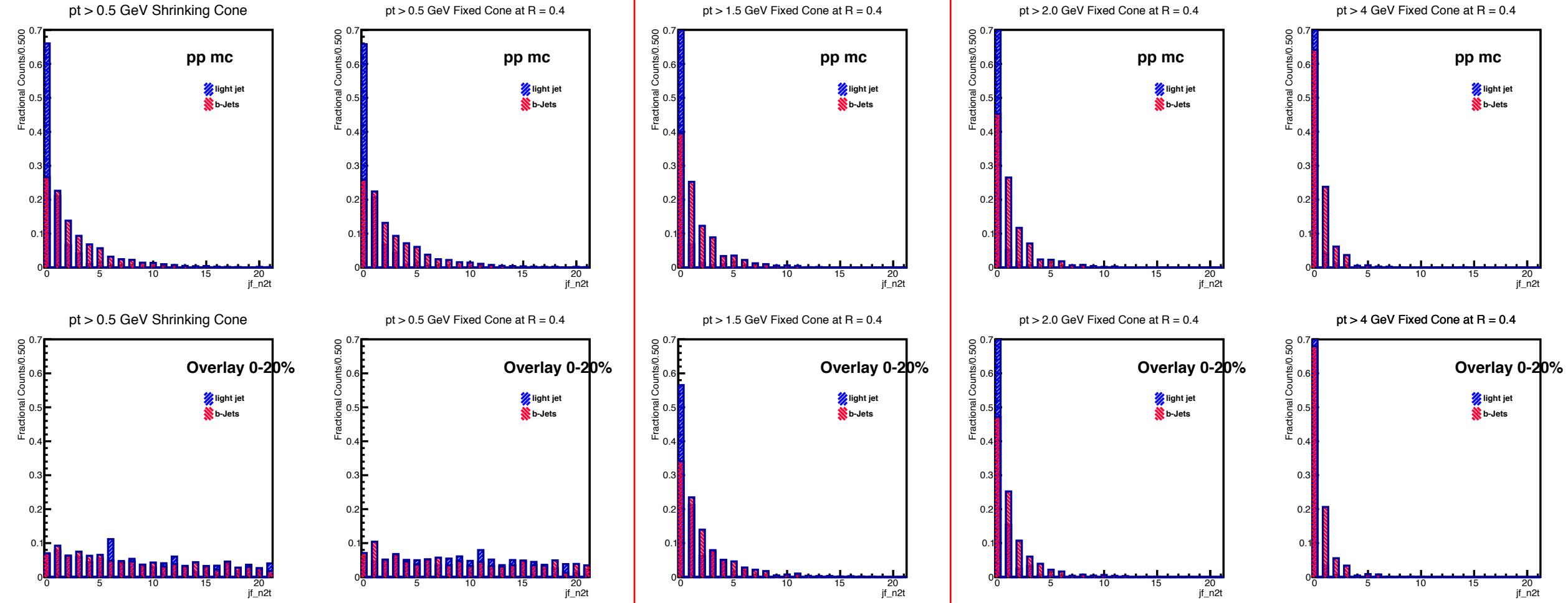
5. Min pt = 4.0 GeV Fixed Cone

Red: b-jet

Blue: light jet

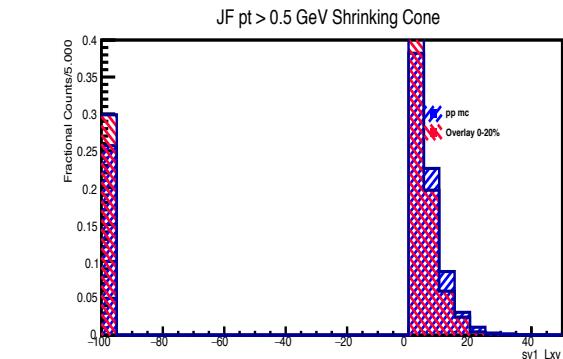
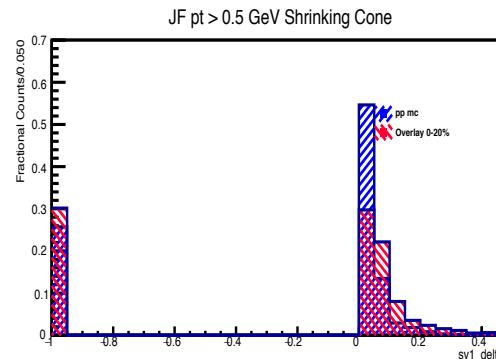
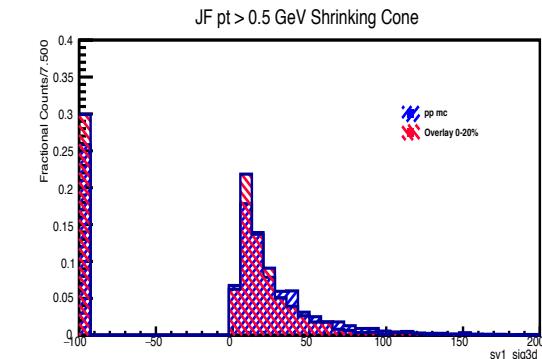
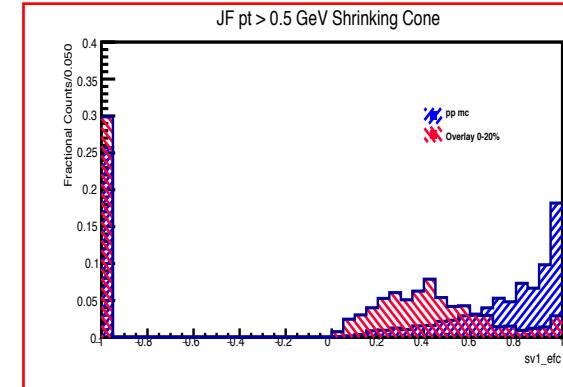
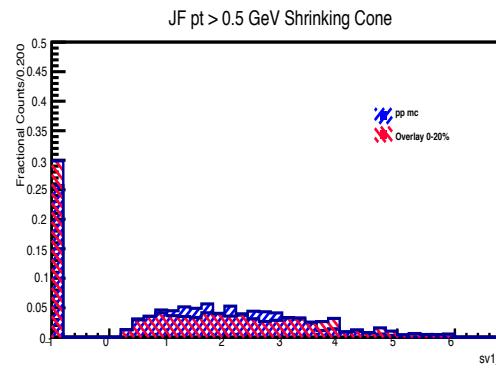
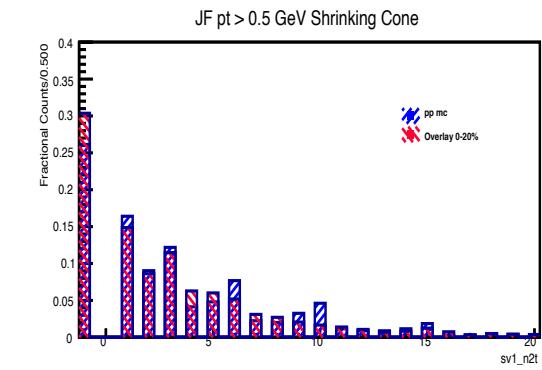
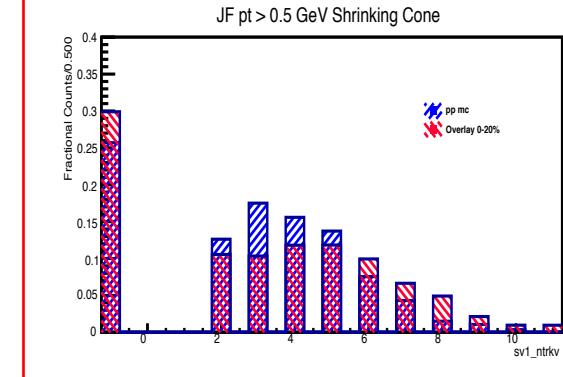
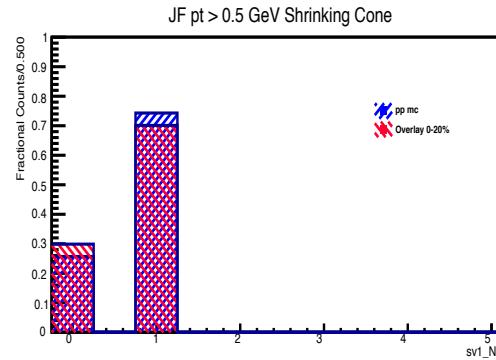
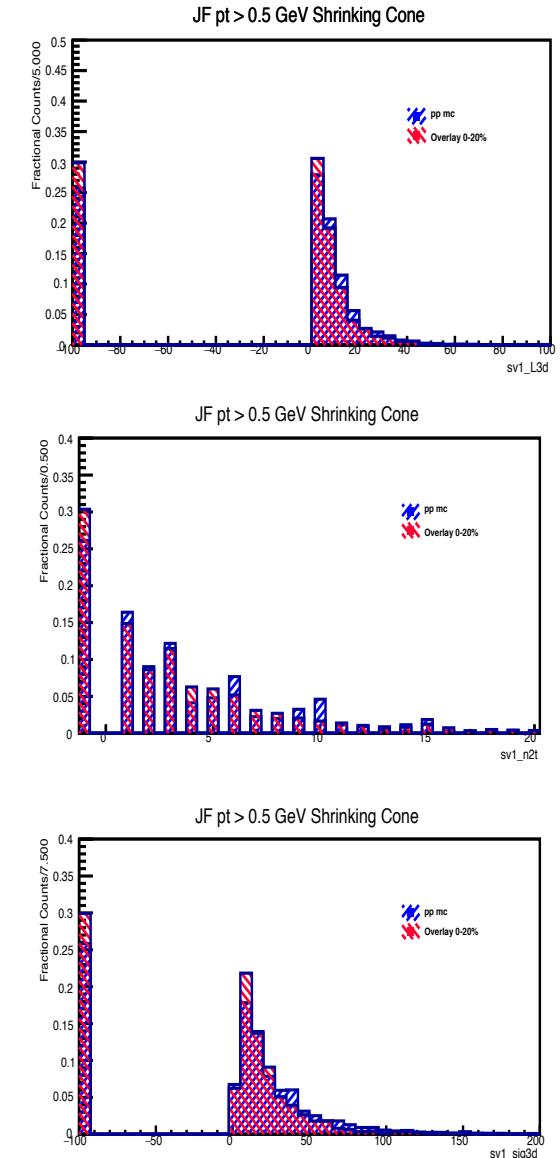
# JF n2t (2-trk vertices candidates)

↓ over cutting leaves too few bins



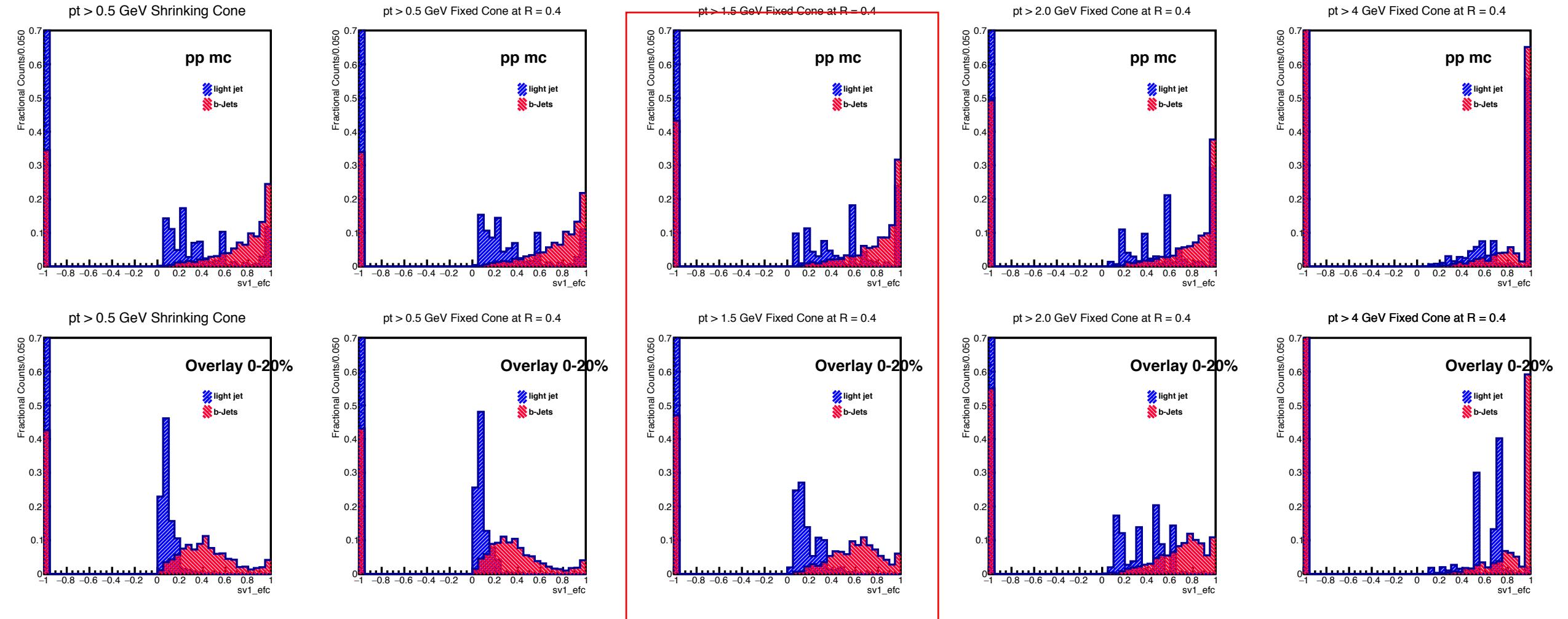
- Before applying cuts in  $p_T$ , distribution is even, possibly for combinatorics of UE tracks.
- Starting at 1.5 GeV or above, overlay have a similar distribution as pp.

# SV Variables at Default Setup



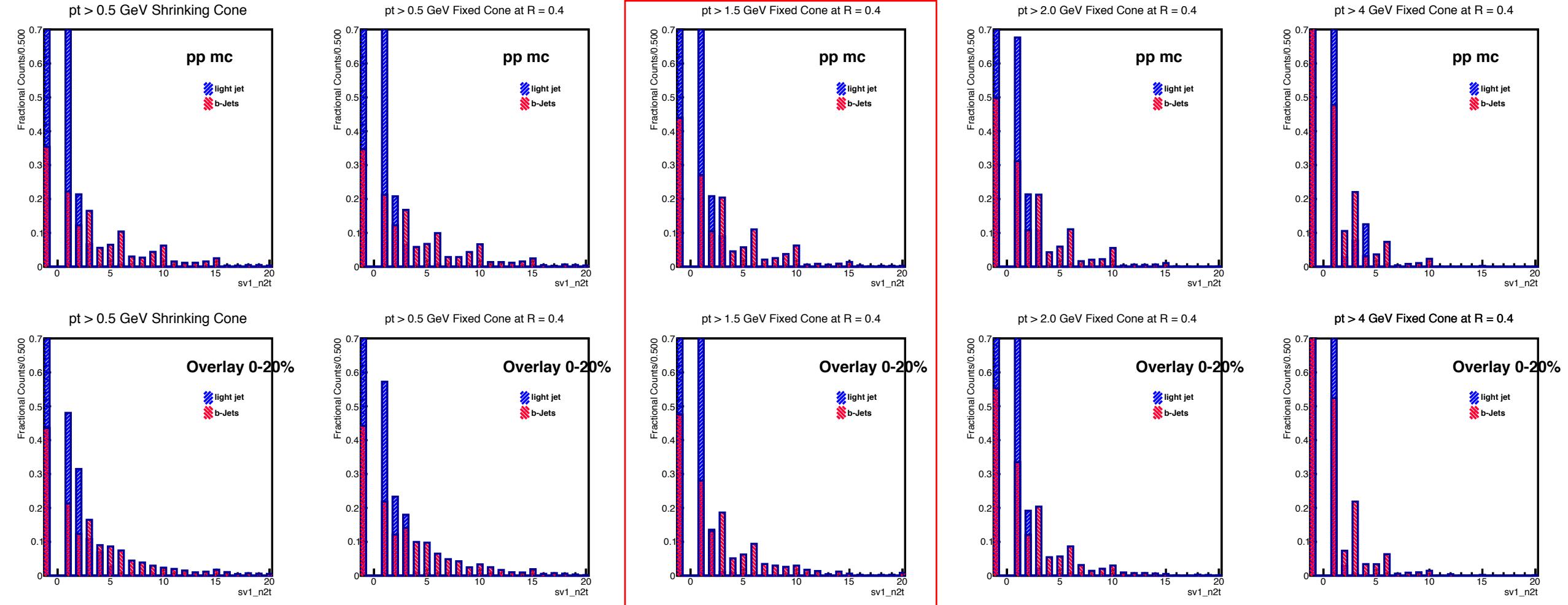
- Energy fraction and number of 2-track vertices are heavily modified.
- Peak at 1 is due to missing tracks. See back up slide 18.

# SV Energy Fraction



- Visually speaking, light and b-jets distributions are the most different/separated when cutting at 1.5 GeV
- Over cutting or under cutting right-shift/left-shift both distributions.

# SV n2t (2-trk vertices candidates)



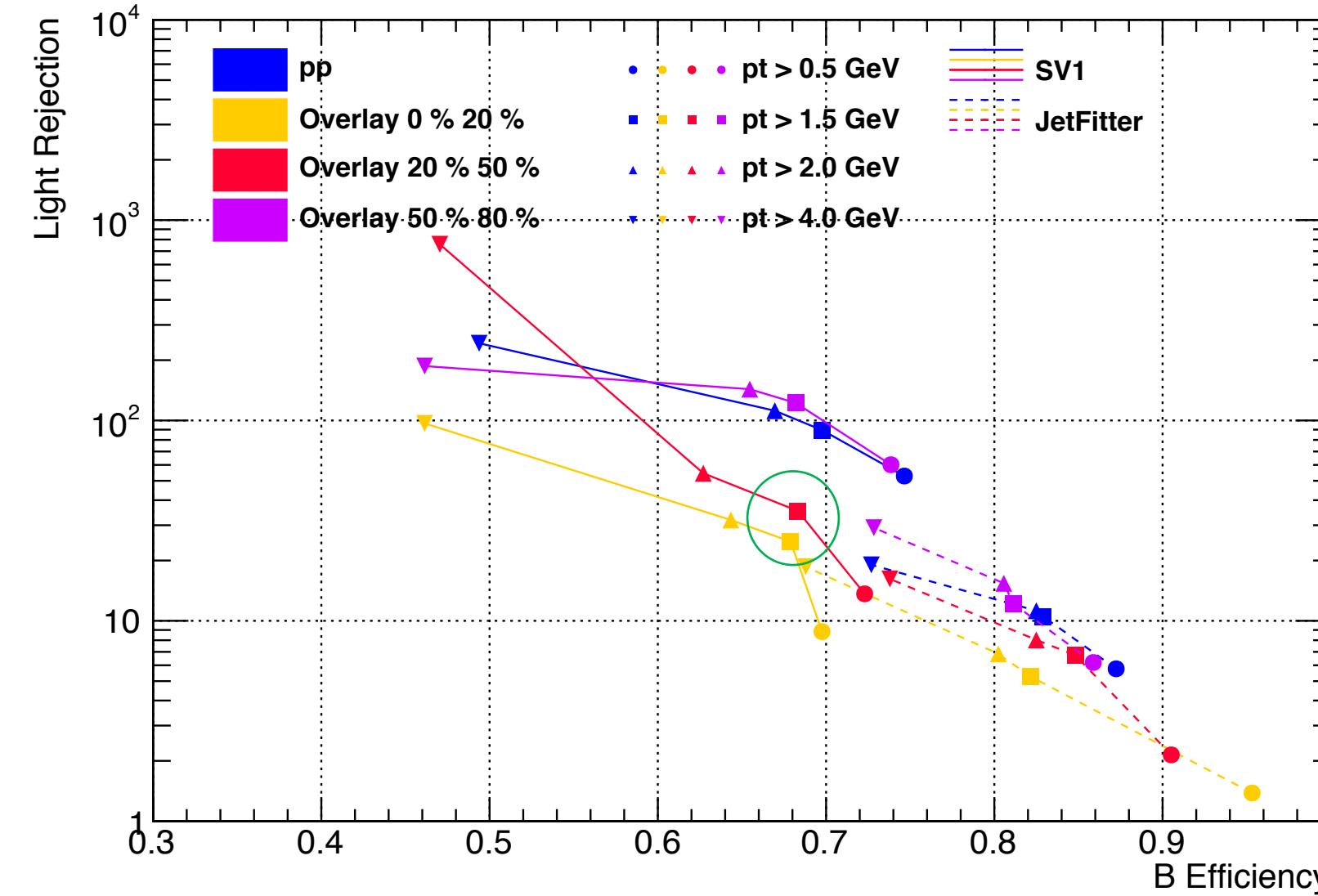
- 1.5 GeV or above cuts reduces light jet candidates in overlay to 1 or 0

↑ overcutting  
removes too many b-jets candidates as well

# Secondary Vertexing Performance for JetFitter and SVF

# ROC curve for JF and SV1 Vertexing Efficiency

ROC Curve of Vertexing Efficiency with min Jet pt 50 GeV



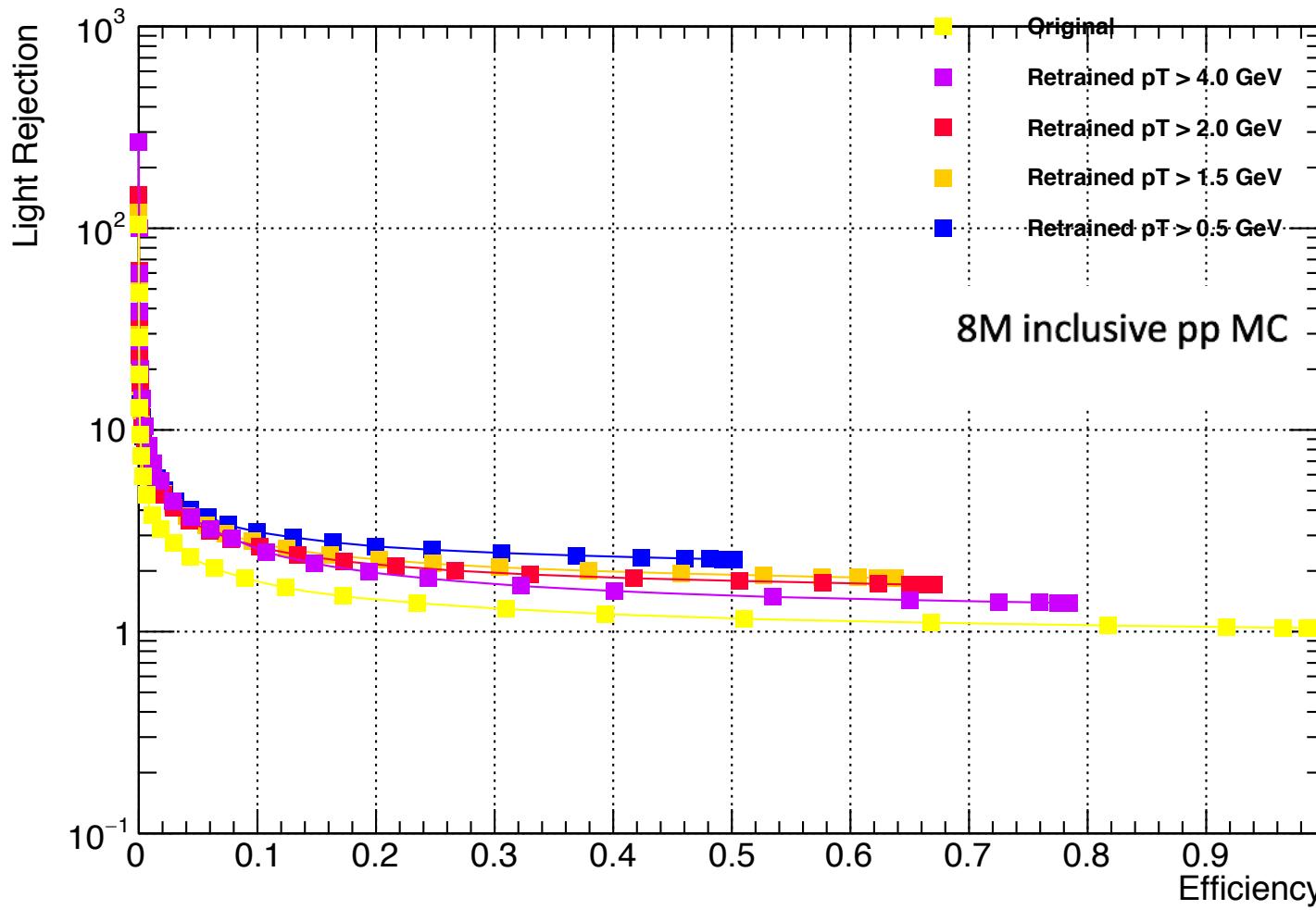
- For JetFitter, cutting at  $pT = 1.5$  GeV or  $pT = 2.0$  GeV gives the most similar performance of different centrality.
- In most central events in SV1, cutting at 1.5 GeV have a uprise in performance
- What else can we tell from the plot?
  - JetFitter is better in efficiency and worse in rejection than SV
  - Ideas on how to choose the best cut?

# IP3D Templates Remaking

- Made templates with 8M inclusive dijet samples
- Jets selection:
  - $pT > 50 \text{ GeV}$
  - Truth matched
  - Rapidity  $< 2.1$
  - Default JVT (Jet Vertex Tagger)\* score related requirements
    - JVT is used to suppress pile-up interactions, will shut this down in future templates making
  - Flavour Labelling in templates:
    - `jet_LabDr_HadF` branch in the ntuple, as originally used by Ftag people
    - Is based on  $dR < 0.3$ , with some minor changes (waiting for replies from Francesco in FTAG on Skype xD)
- Retraining: make new templates with 8M sample and use these templates for evaluating the same MC.

\*:ATLAS Collaboration, Tagging and suppression of pileup jets with the ATLAS detector, ATLAS-CONF-2014-018, url: <https://cds.cern.ch/record/1700870>.

# IP3D Templates Shrinking Cone with pp



- Performance is not good :/
- With efficiency at 0.5, only have purity on the order of 1...
- Plan:
  - Double check the plots
  - Try fixed cone at 0.4 and PbPb
- Good news:
  - Retraining improves performance, and for pp, 0.5 GeV cuts seem the most reasonable.

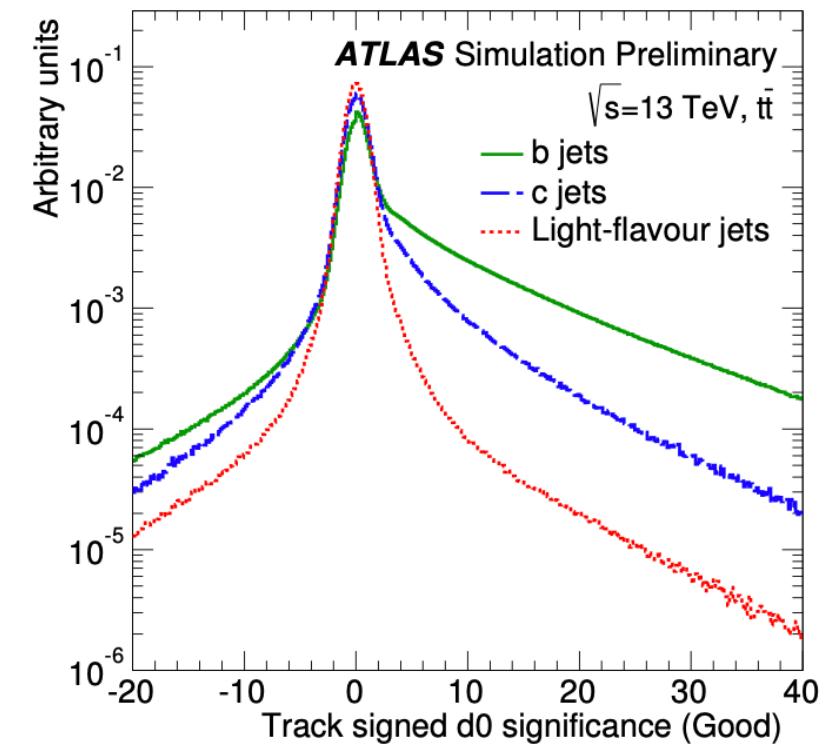
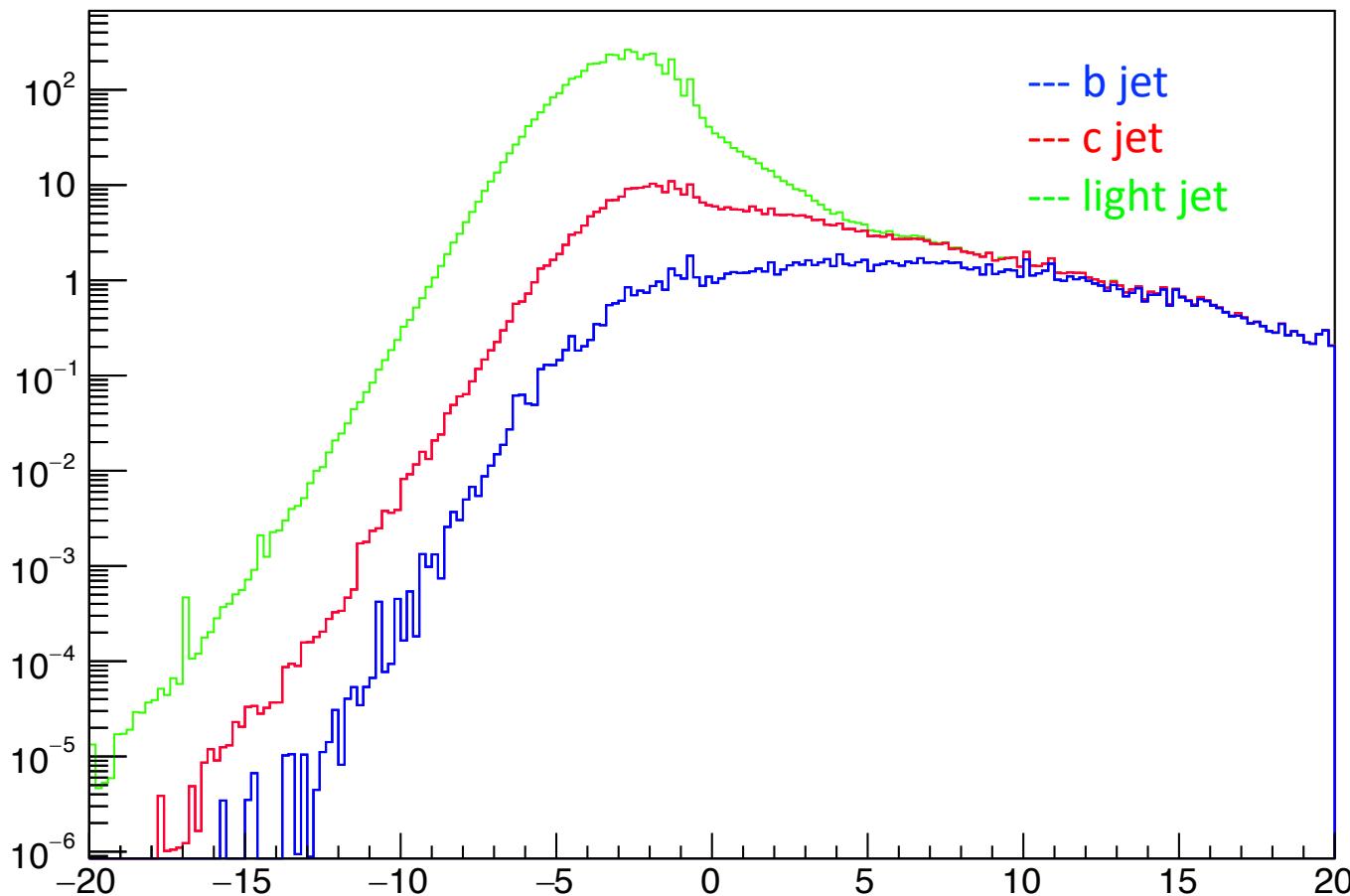
# Summary

- Comparing some typical physics variables, cutting pT at 1.5 GeV optimized most modified variables.
  - some variables are better optimized at 2.0 GeV cut, should combine results of IPxD for choosing the best cut.
  - To better evaluate everything together, consider writing a simple probabilistic classification for each tagger.
- IP3D for pp shows improvements with retraining.
  - Although for pp seems cutting at 0.5 GeV with shrinking cone is the most reasonable.
  - Will now plot for PbPb.

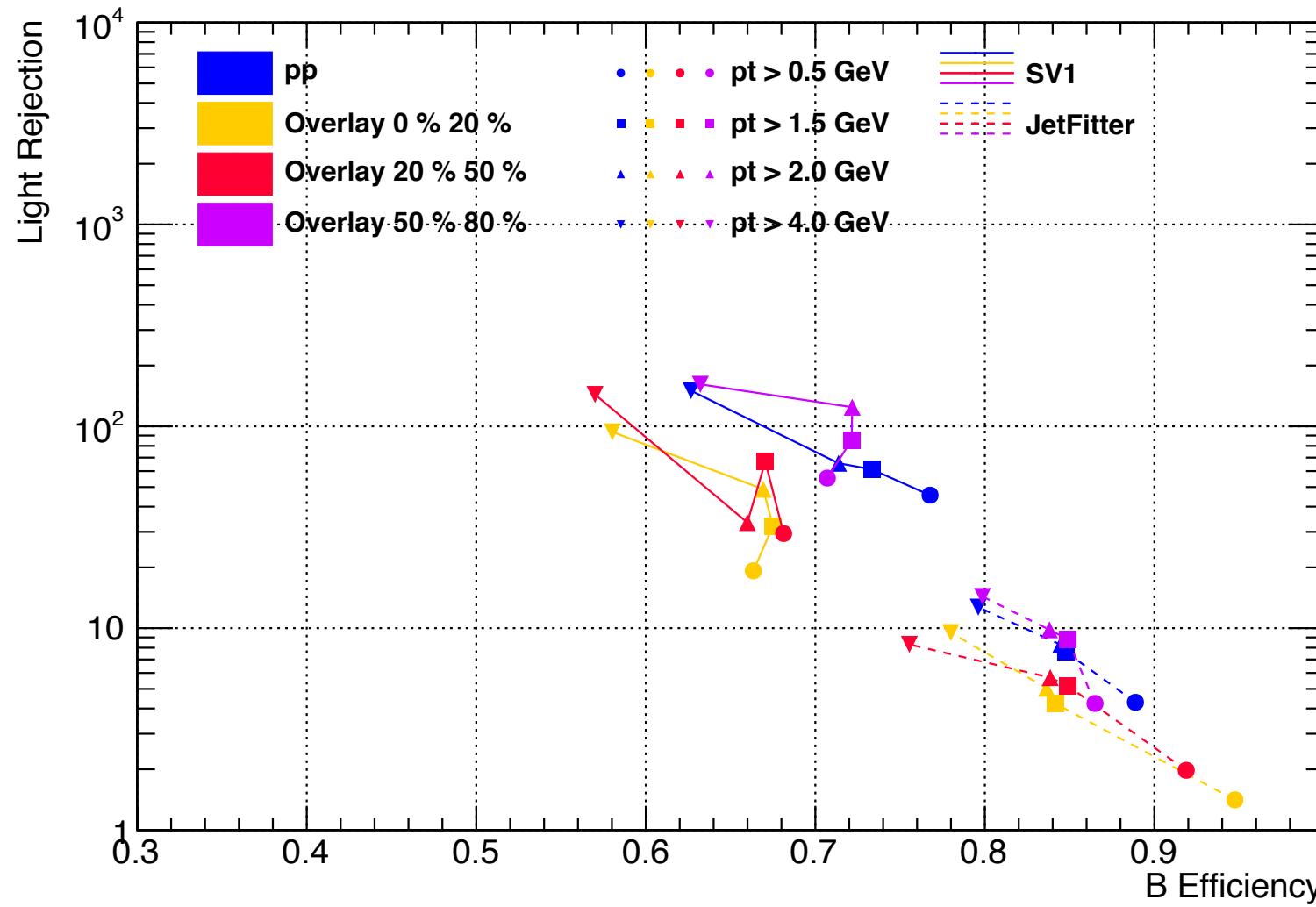
# Back up

# IP3D New Templates

IP3D\_Stack

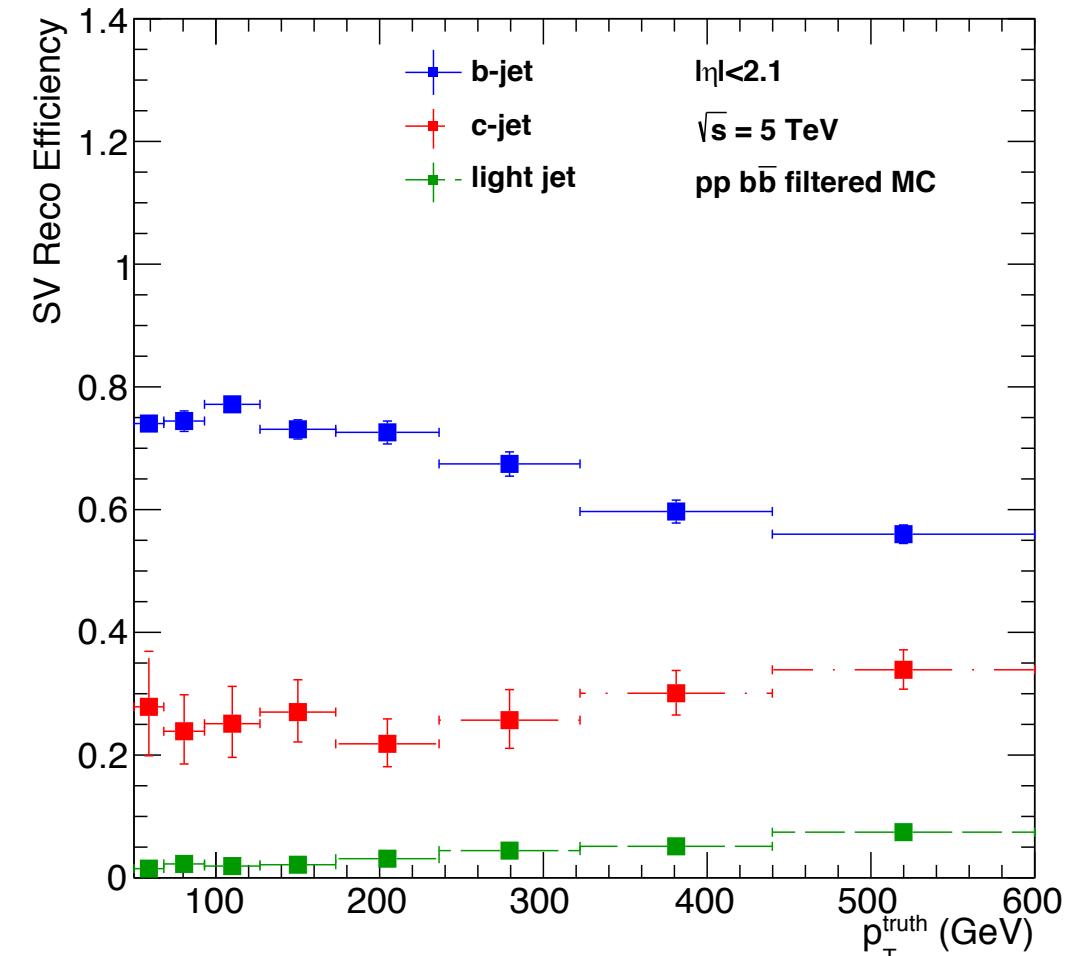
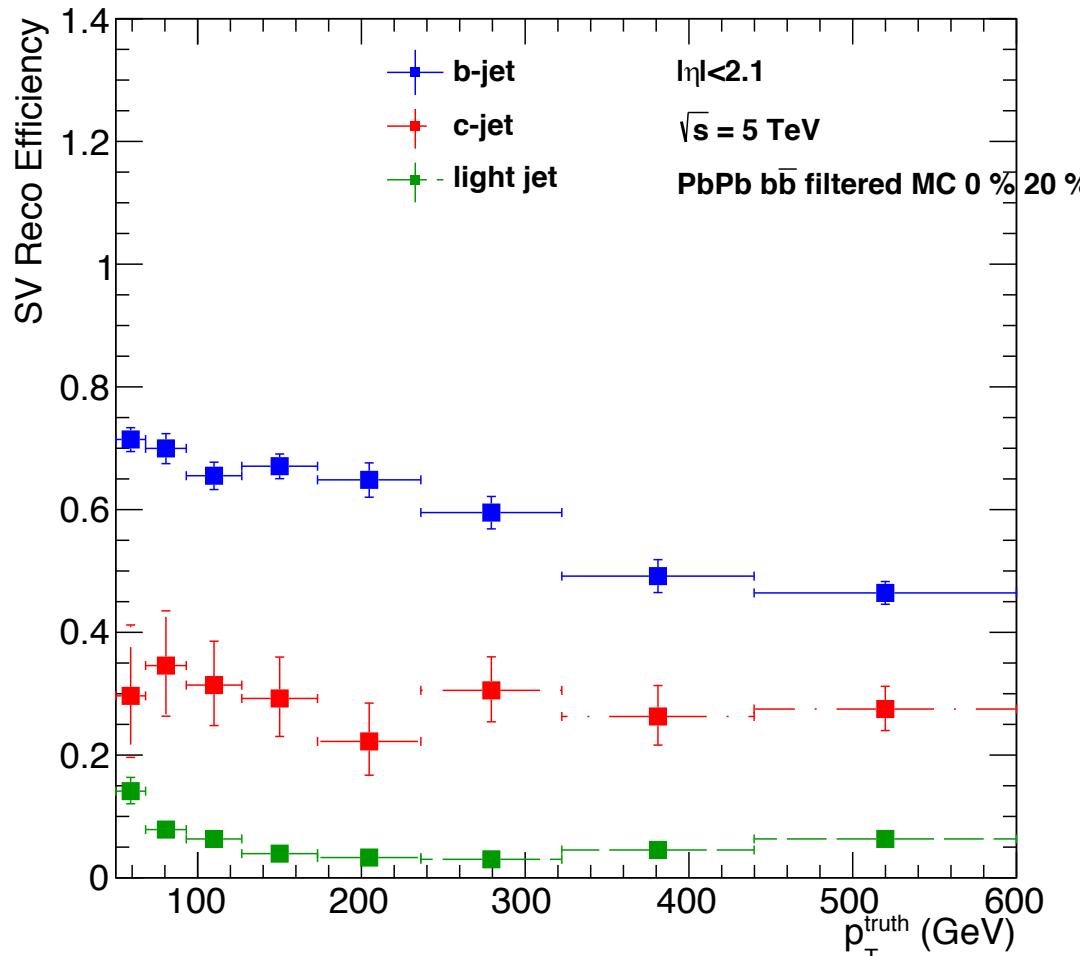


## ROC Curve of Vertexing Efficiency with min Jet pt 100 GeV



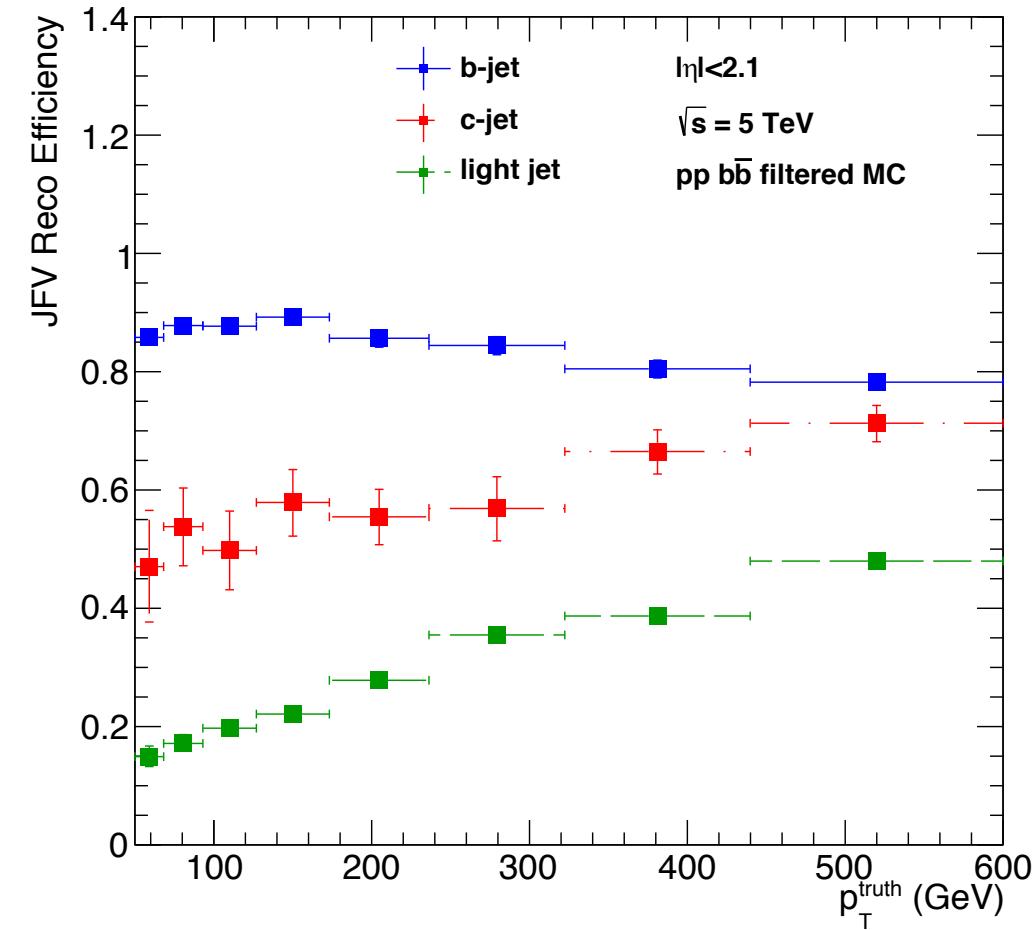
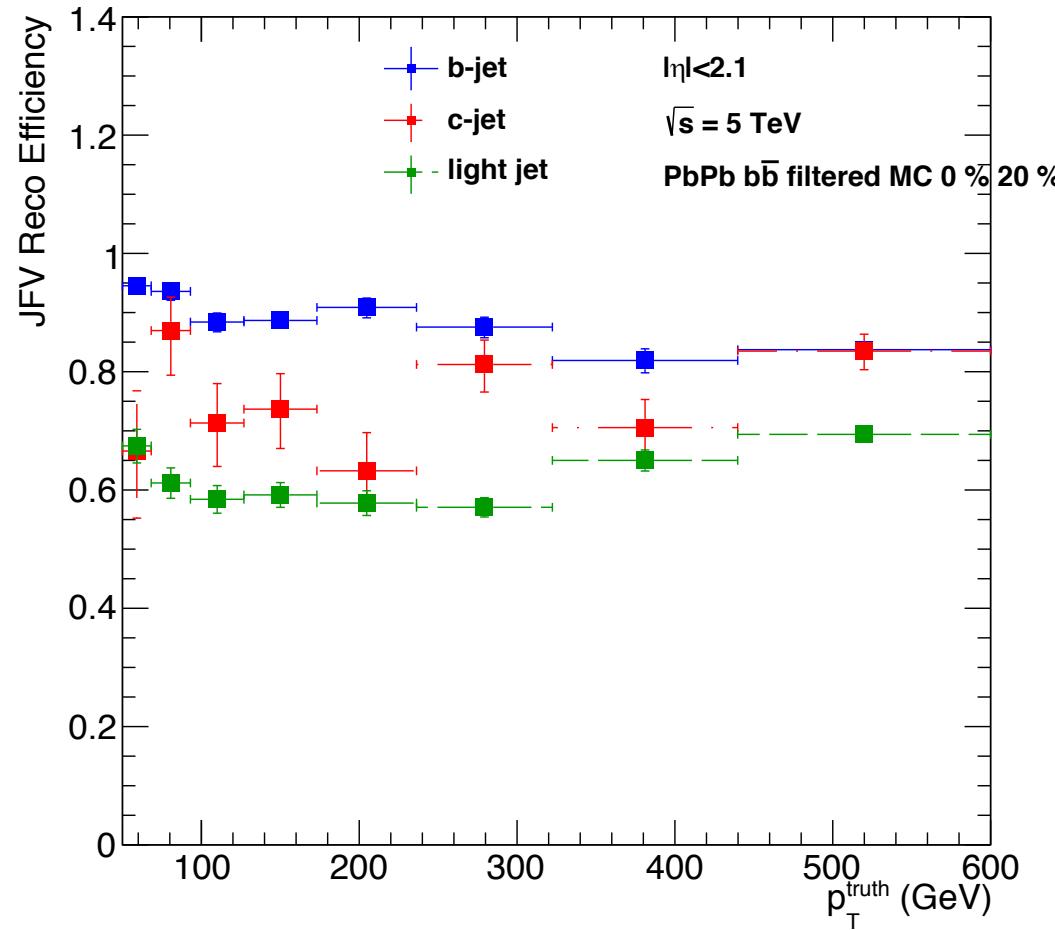
Small statistics at high pT is causing many problems.  
Better plot with inclusive dijets for pT > 100 GeV.

# Secondary Vertexing at Default Setup for SVF (VKal)



In comparison to pp, central PbPb MC has lower tagging efficiency, especially in high jet  $p_T$  region, the efficiency drops to below 50%.

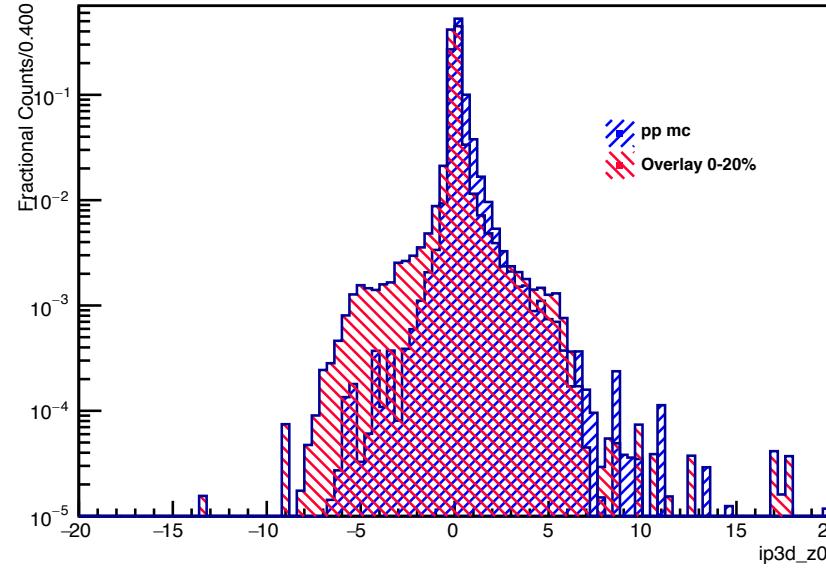
# Secondary Vertexing at Default Setup for JetFitter



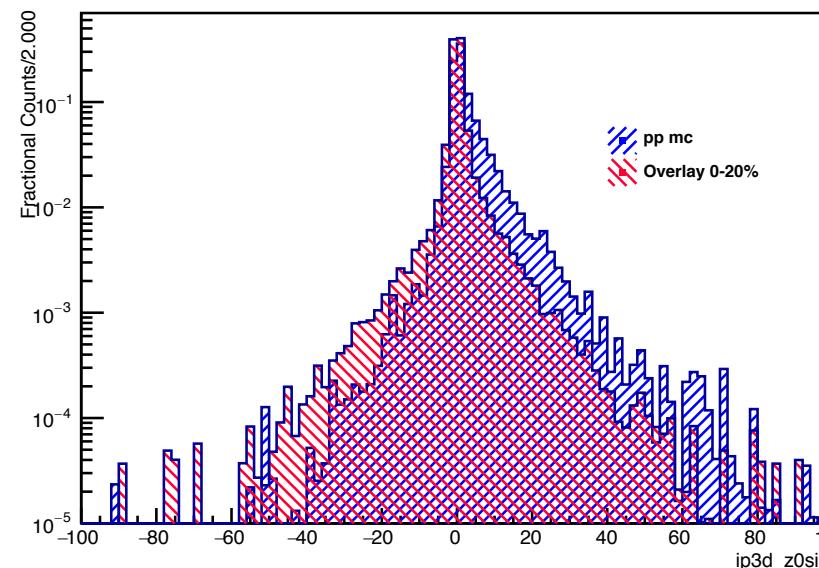
In comparing to pp, central PbPb MC has similar b-tagging efficiency but very high fake rate from both c-jet and light jet.

# IPxD Variables

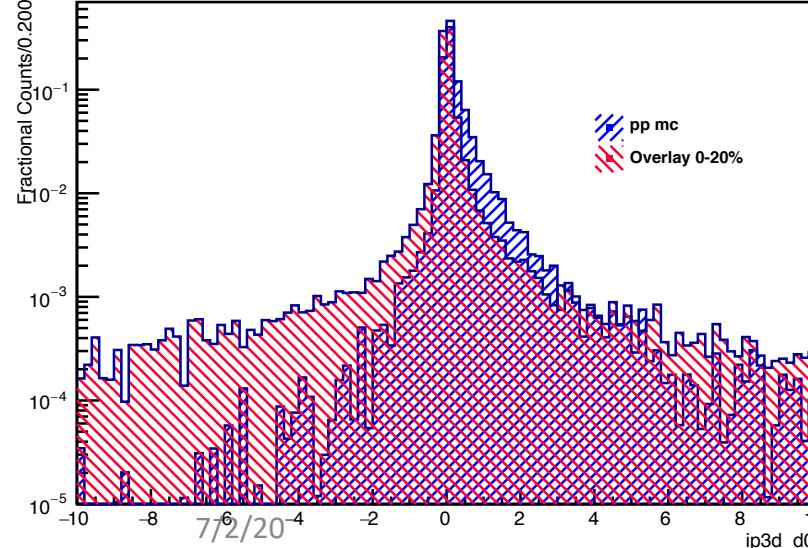
Default Cuts Shrinking Cone



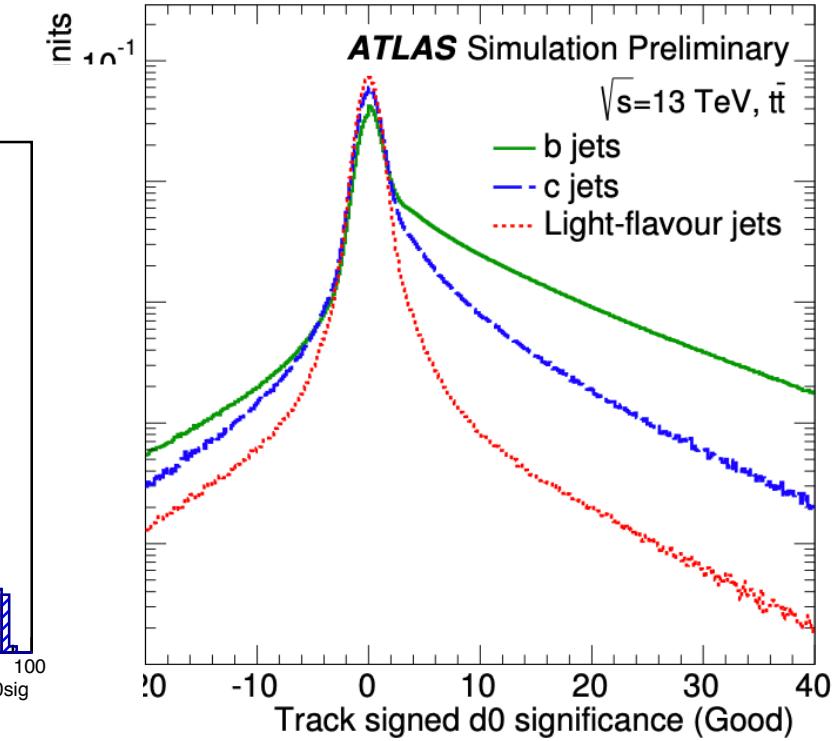
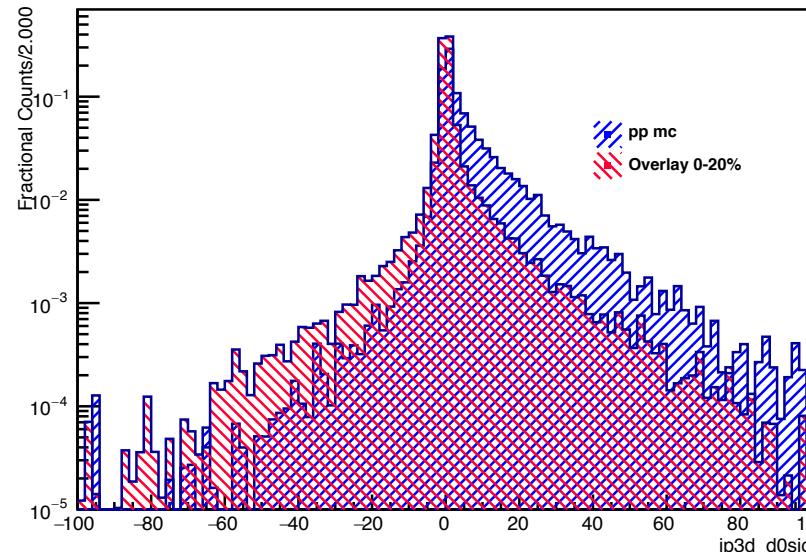
Default Cuts Shrinking Cone



Default Cuts Shrinking Cone



Default Cuts Shrinking Cone



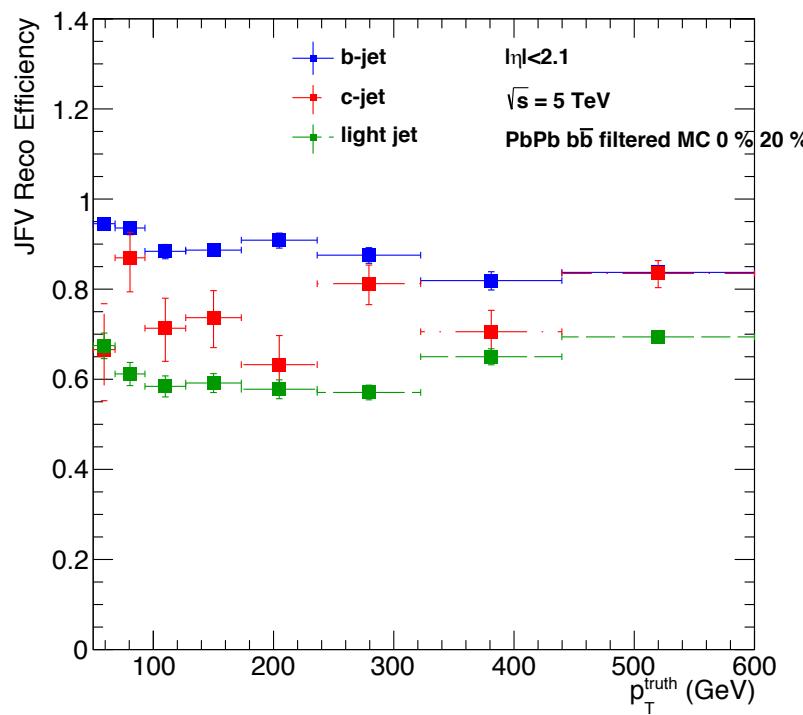
- Overlay samples have almost symmetric distribution of d0 and z0. (left two plots)
- IPxD uses IP significance (right two plots)

# Motivation for Cuts made

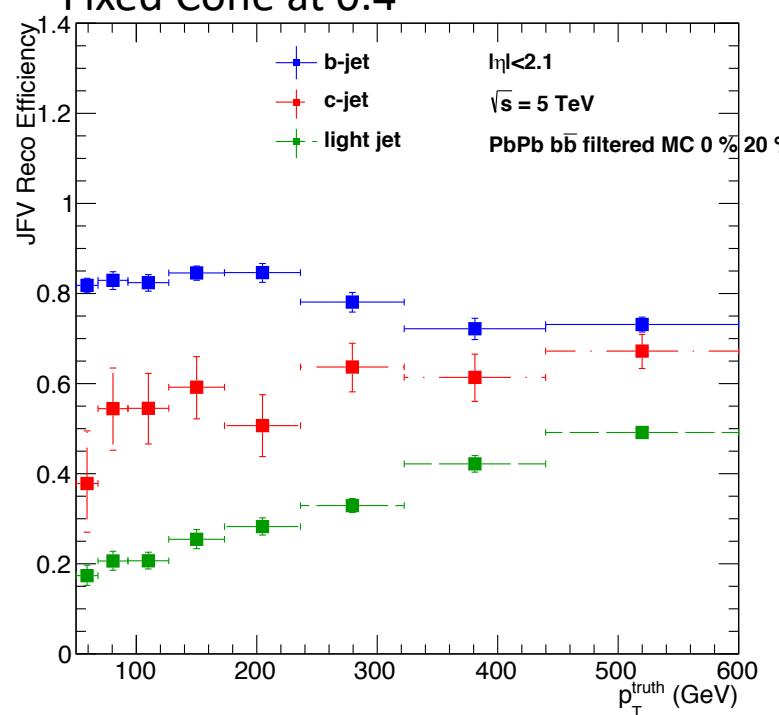
| Item              | Default        | Change        | Which Tool       | Reason  |
|-------------------|----------------|---------------|------------------|---|
| Track Association | Shrinking Cone | Fixed R = 0.4 | ParticleJetTools | Unknown PbPb track distribution vs jet pT<br>SVF has efficiency drop in high pT due to track loss |
| Min pT Cut        | 0.5 GeV        | 1.5 GeV       | JetFitter        | Central Events have high fake rate possibly due to<br>UE tracks contribution                      |
| Min pT Cut        | 0.7 GeV        | 1.5 GeV       | VKal             | Same as above   |
| Min pT Cut        | No Cut         | 1.5 GeV       | ParticleJetTools | Physics variables like efc are still affected by UE<br>tracks if only modifies in tagger algo     |
| Anti Pile Up Tool | On             | Off           | Vkal + JetFitter | Irrelevant in single PV events  |

# Secondary Vertexing Efficiency with JetFitter

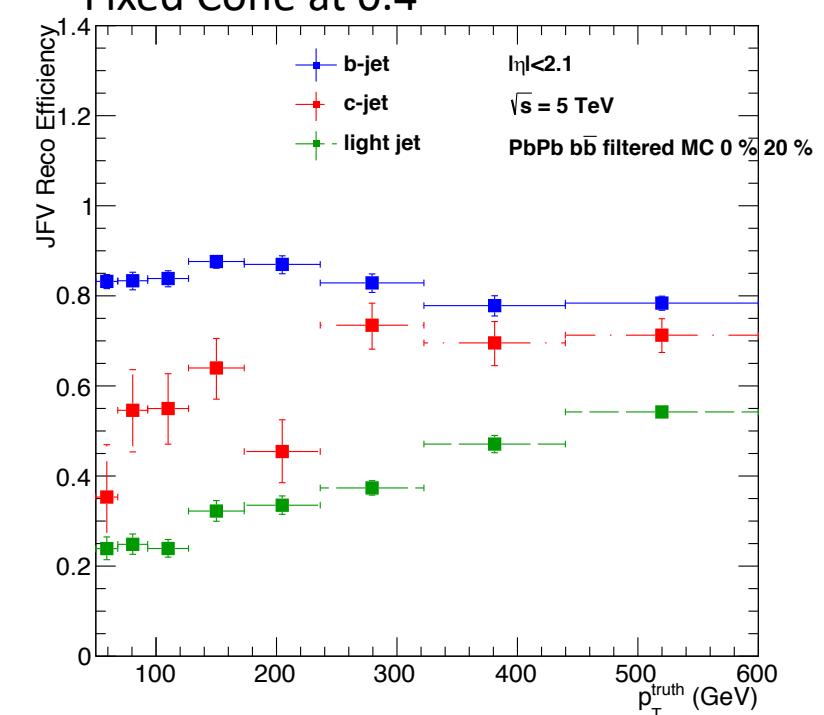
Default JF Setup  
No Selection on Input Tracks  
Shrinking Cone



Default JF Setup  
Selection on TrackAssociation:  
-- Min  $p_T = 1.5 \text{ GeV}$   
-- "HILoose" without IP cuts  
Fixed Cone at 0.4



Modified JF Setup:  
Requirement for SV candidate tracks:  
-- Min  $p_T = 1.0 \text{ GeV}$  for first fitting  
-- Min  $p_T = 1.75 \text{ GeV}$  for second fitting  
No Selection on Input Tracks  
Fixed Cone at 0.4

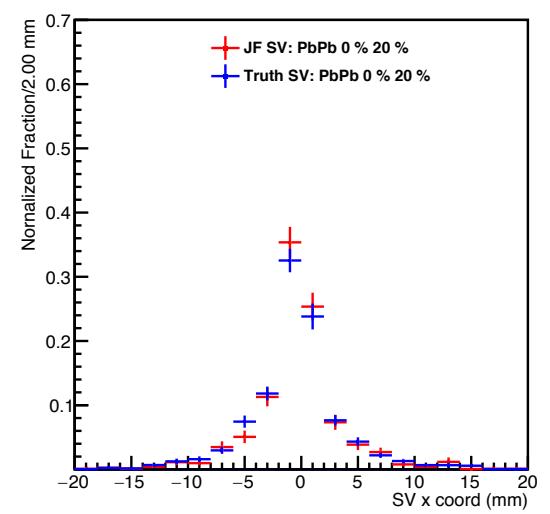


The vertexing efficiency for secondary vertex is similar when using the same value of minimum  $p_T$ , either by selecting tracks before vertexing or changing  $p_T$  selection in JF algorithm.

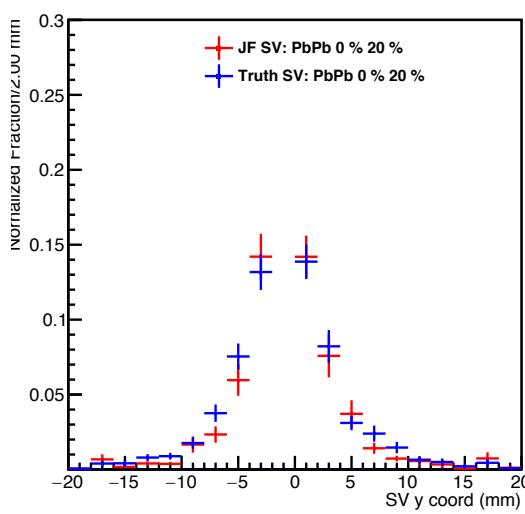
# Secondary Vertexing Resolution with JetFitter

Default JF Setup; No Selection on Input Tracks; Shrinking Cone

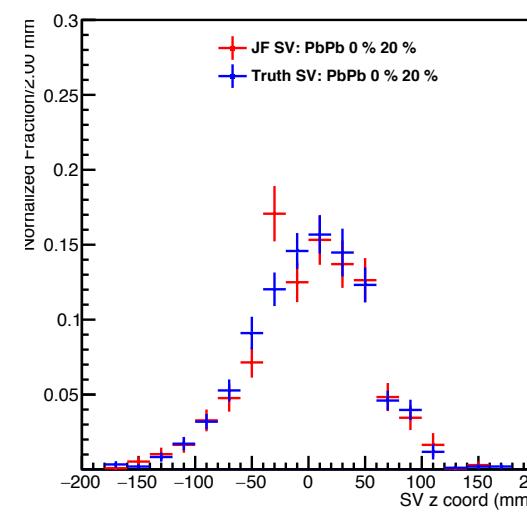
x Coordinate of JF Secondary Vertex



y Coordinate of JF Secondary Vertex



z Coordinate of JF Secondary Vertex

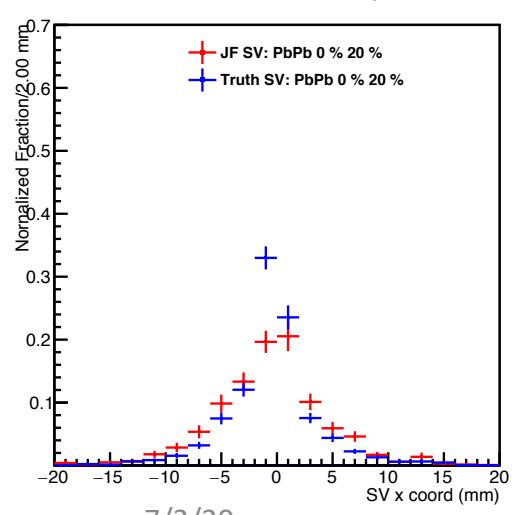


No big change in secondary vertex resolution, reconstructed SV coordinates have similar distribution with truth SV.

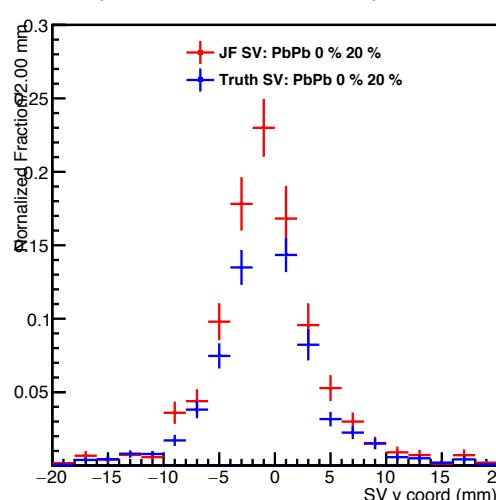
*Plan: plot coordinate difference and fit for quantitative comparison.*

Default JF Setup (anti PU off); Loose Selection on TrackAssociation; Min pT = 1.5 GeV; Fixed Cone at 0.4

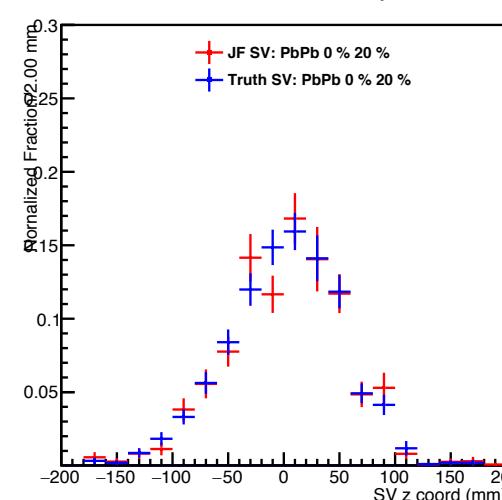
x Coordinate of JF Secondary Vertex



y Coordinate of JF Secondary Vertex



z Coordinate of JF Secondary Vertex

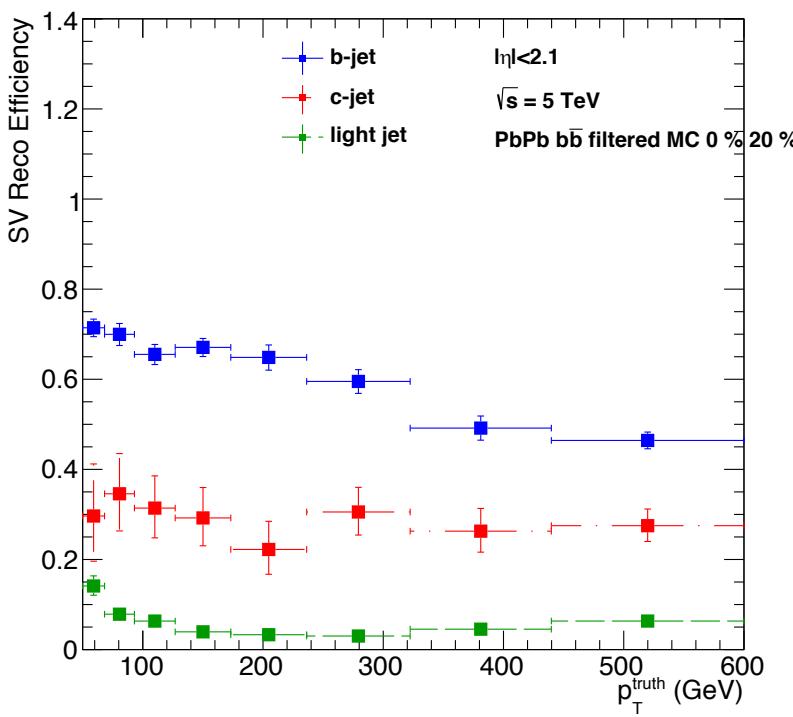


# Secondary Vertexing Efficiency with SV1

Default JF Setup

No Selection on Input Tracks

Shrinking Cone



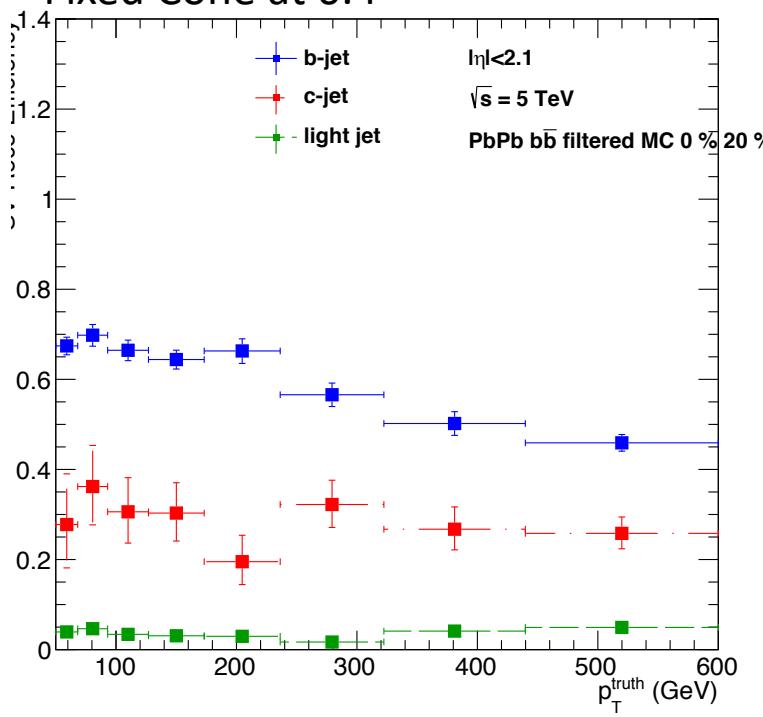
Default SVF Setup

Selection on TrackAssociation:

-- Min  $p_T = 1.5 \text{ GeV}$

-- "HILoose" without IP cuts

Fixed Cone at 0.4



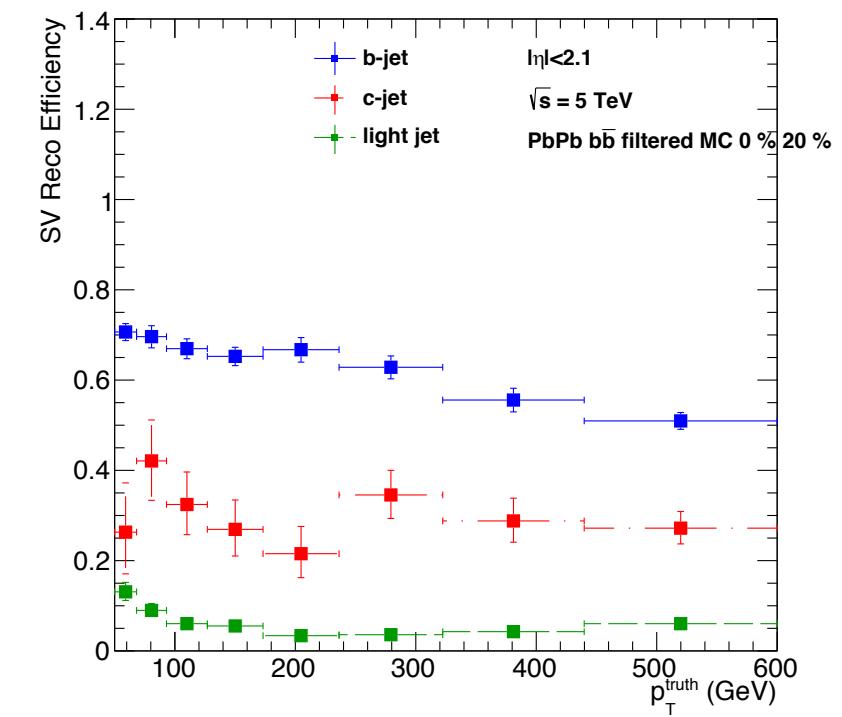
Modified SVF Setup:

SVF requirement for SV candidate tracks:

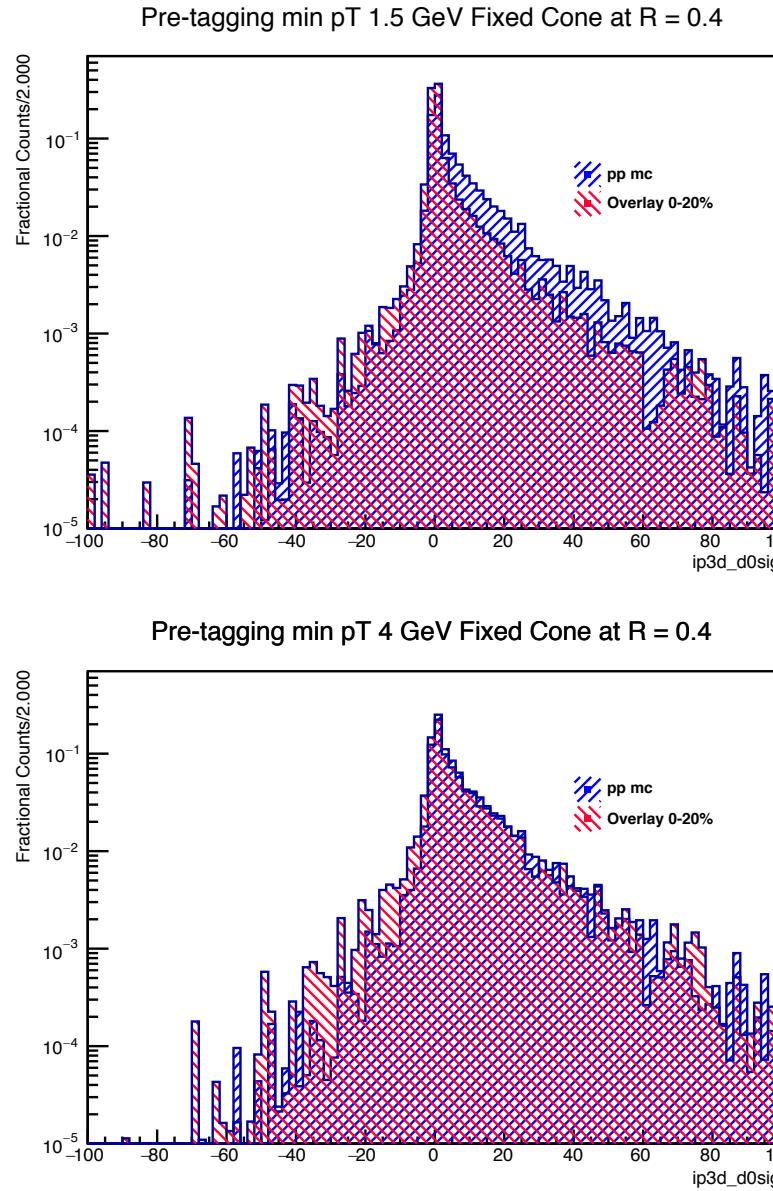
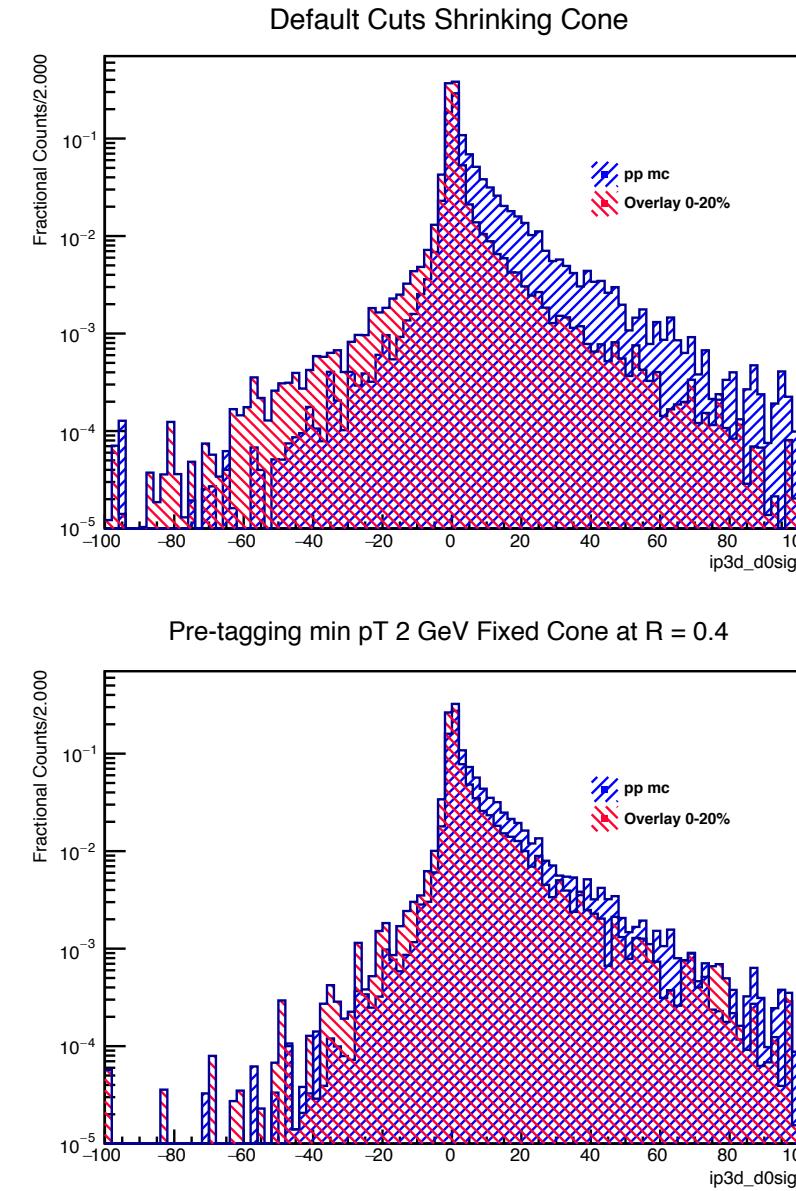
-- Min  $p_T = 1.0 \text{ GeV}$  (**will compare for 1.5 GeV**)

No Selection on Input Tracks

Fixed Cone at 0.4



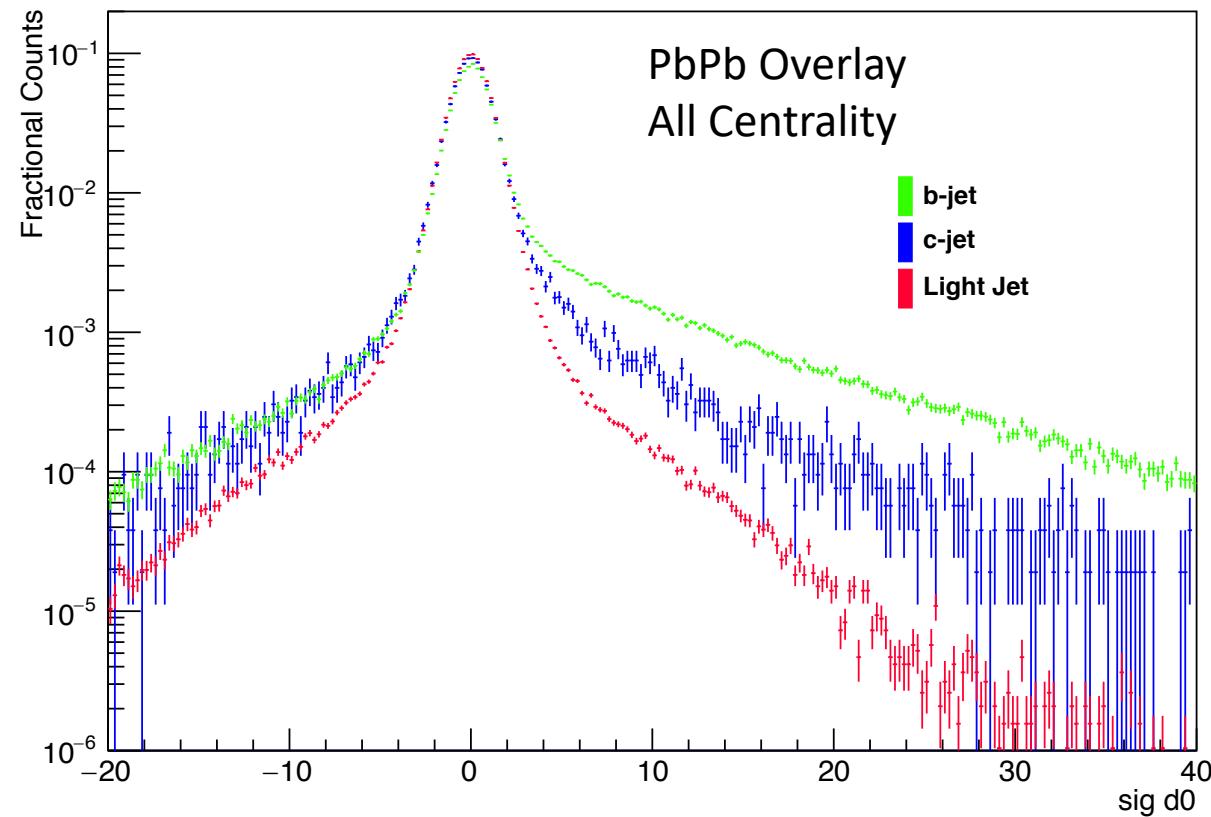
# IPxD Variables improvements over pT cuts



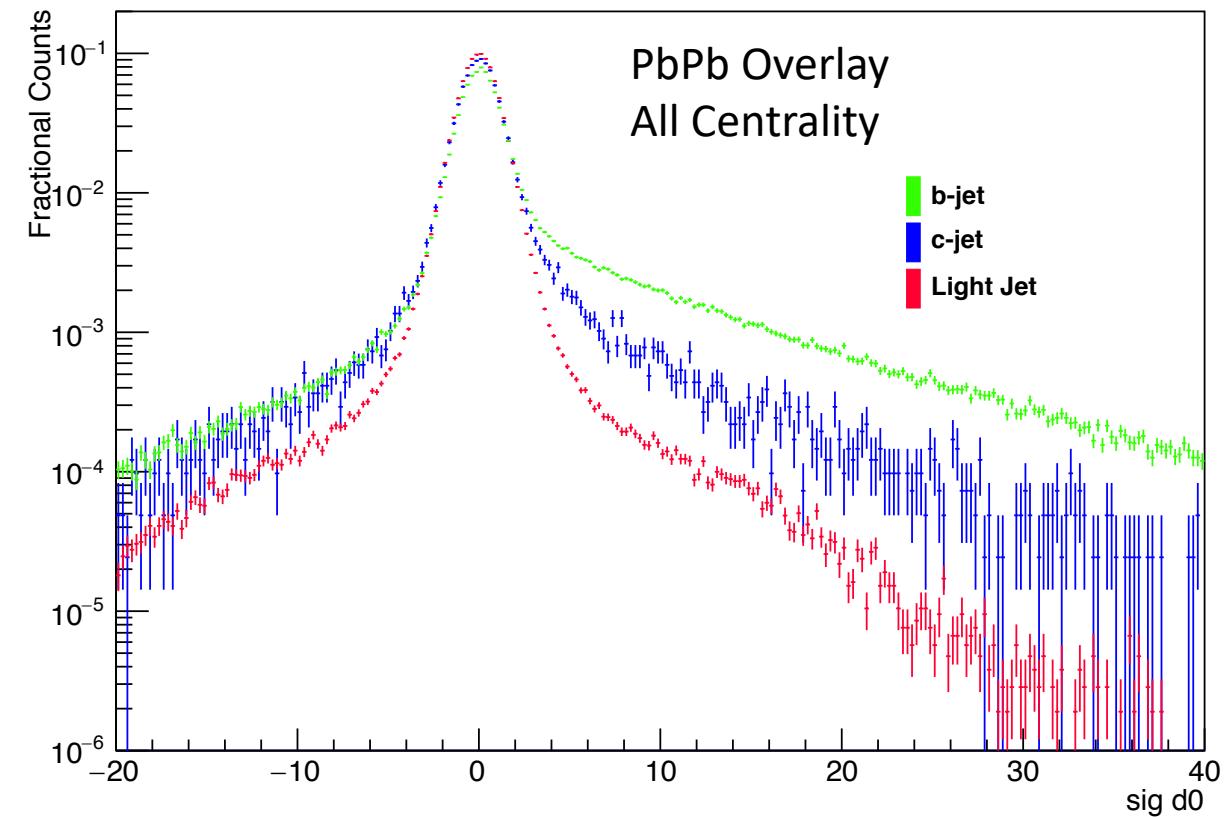
- d0 significance distributions assimilate at pT cut  $\approx 2$  GeV.
- Similarly for z0 and z0sig.

# Templates Making with Overlay Sample for Quality Good

Default Setup Shrinking Cone



Fixed Cone +  $pT \geq 1.5 \text{ GeV}$

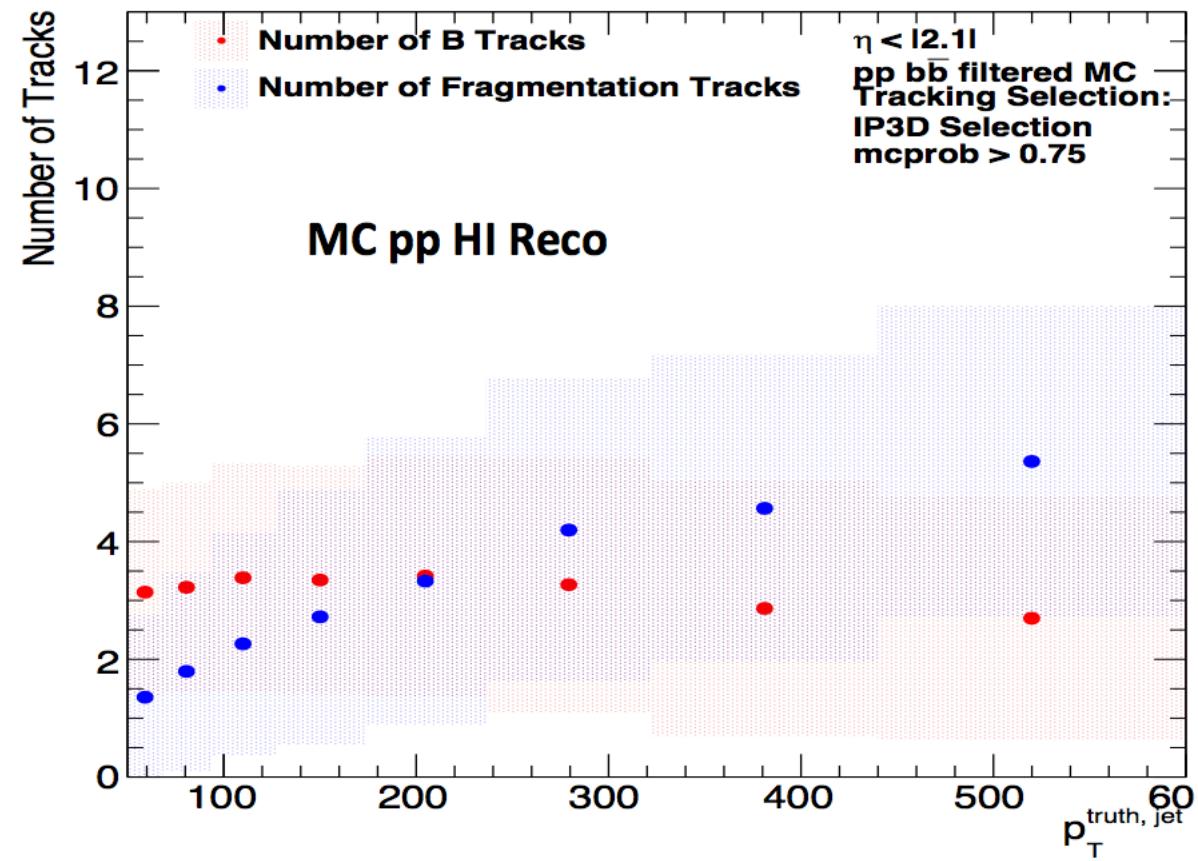


With  $pT$  cut combined with changing to fixed cone, the difference between jets are wider spreadout, which should help classification.

# Conclusion and next steps

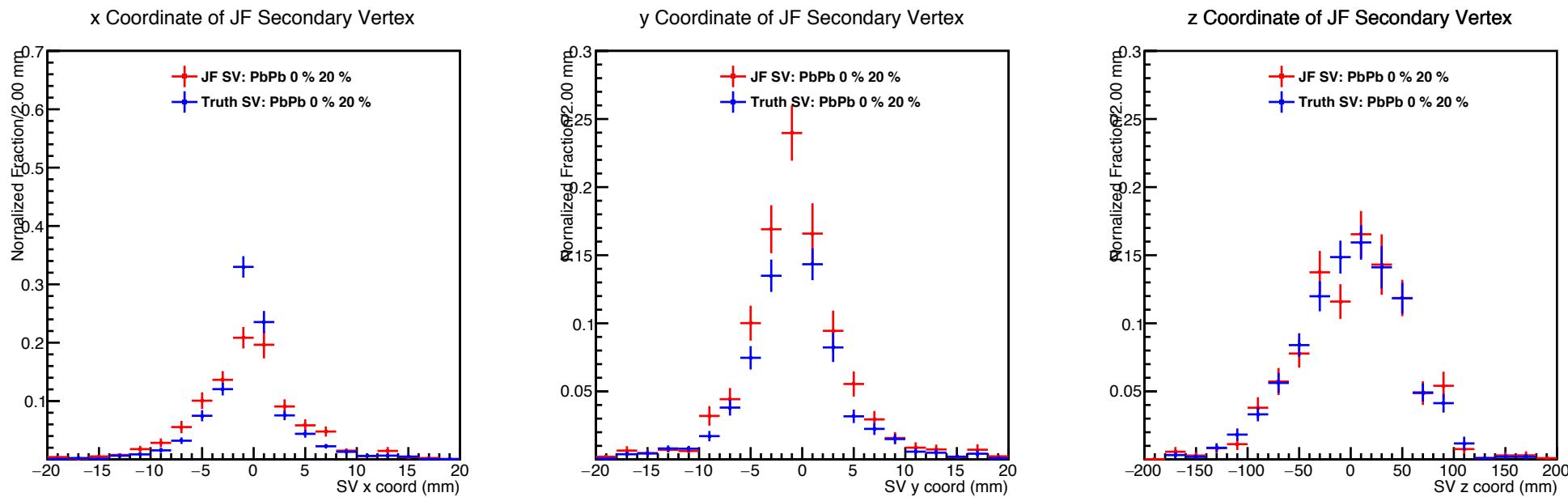
- Experimented cuts, especially with min pT requirement helps reduce fake and improve physics variables.
- Cuts applied at TrackAssociation stage to improve physics variables like energy fraction.
- Applying these cuts do not affect SV resolution qualitatively in JetFitter.
  - Plan: compare for VKal tool.
  - Plan: make fitting and quantitative comparison.
- In SVF tool, lower cuts (1 GeV instead of 1.5 GeV) are giving better SV efficiency.
  - Plan: modify tagger algo further to reproduce improvements by changing TrackAssociation s.t. cuts can be tagger specific.

# Back-up





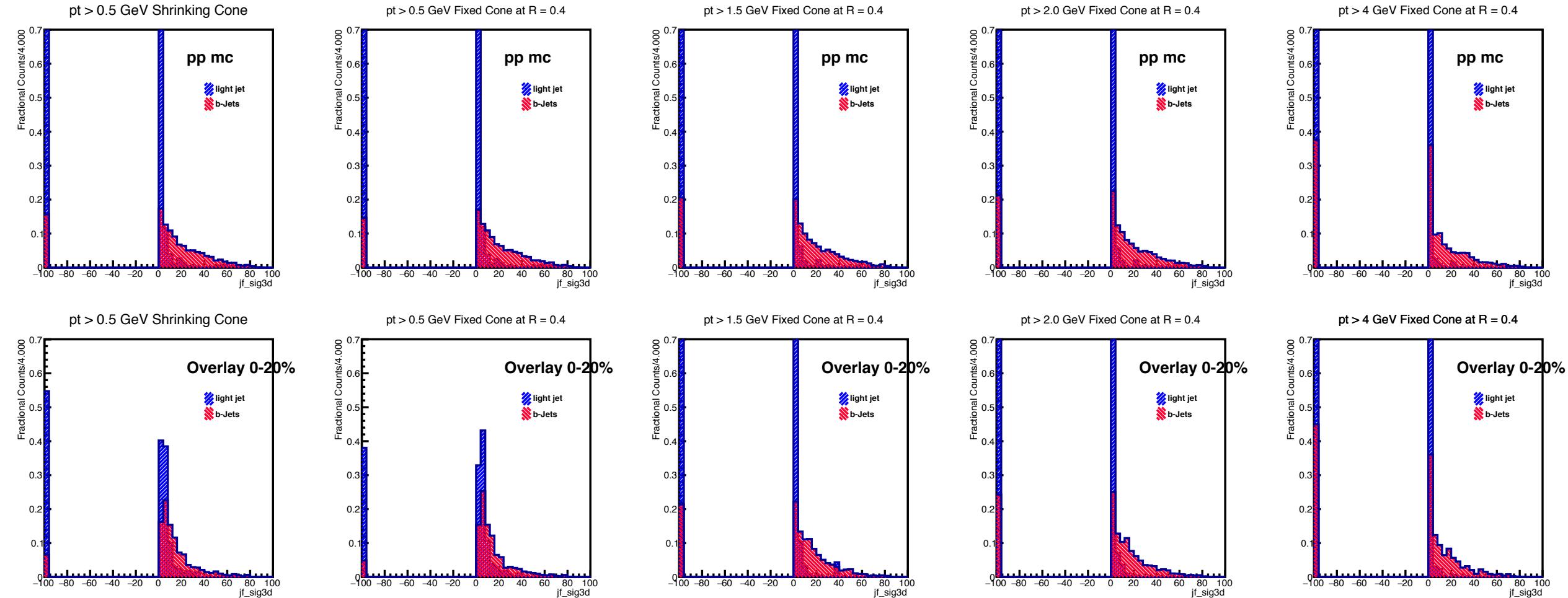
# JF pre-tagging selection, $pT \geq 1.5$ GeV



Modified JF Setup (anti PU off)  
First Fitting min Track  $pT$ : 1.5 GeV  
Second Fitting min Track  $pT$ : 1.75 GeV  
No Selection on Input Tracks  
Fixed Cone at 0.4

SV1

# JF sig3d (decay length significance)



Top Row: pp mc

Bottom Row: Overlay 0-20%

From left to right:

1. No pT Shrinking Cone
2. No pT Fixed Cone
3. Min pt = 1.5 GeV Fixed Cone

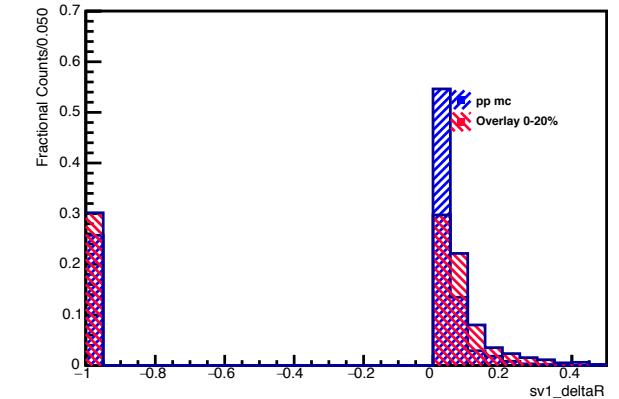
4. Min pt = 2.0 GeV Fixed Cone

5. Min pt = 4.0 GeV Fixed Cone

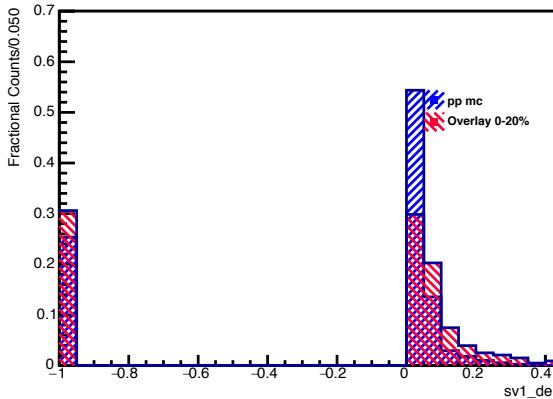
Red: b-jet

Blue: light jet

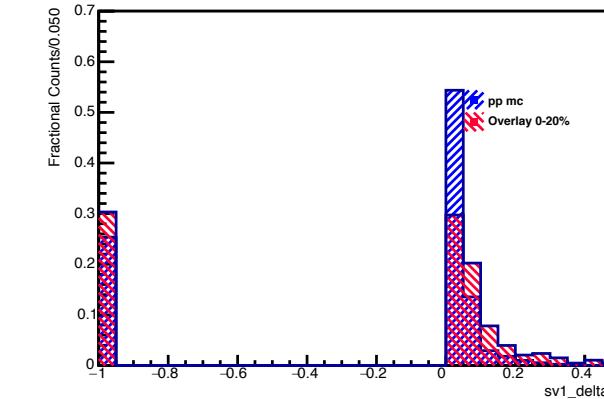
JF pt &gt; 0.5 GeV Shrinking Cone



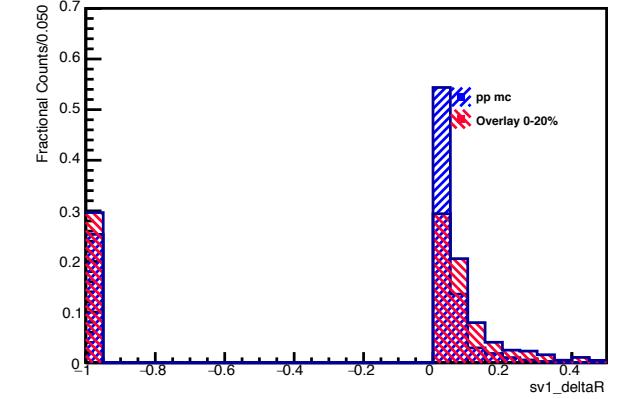
JF pt &gt; 0.5 GeV Fixed Cone at R = 0.4



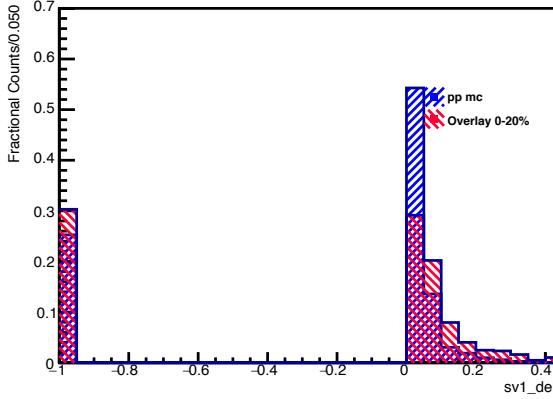
JF pt &gt; 1.0 GeV Fixed Cone at R = 0.4



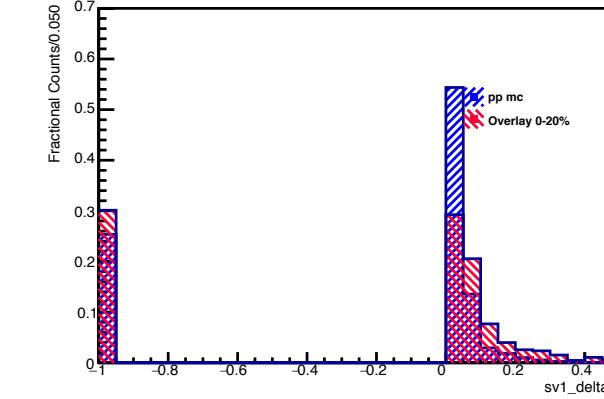
JF pt &gt; 1.5 GeV Fixed Cone at R = 0.4



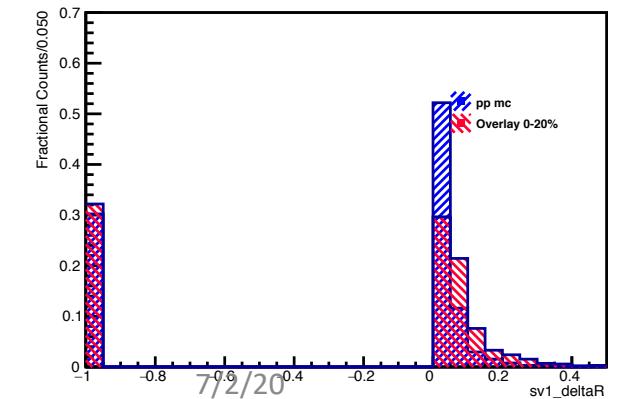
JF pt &gt; 2.0 GeV Fixed Cone at R = 0.4



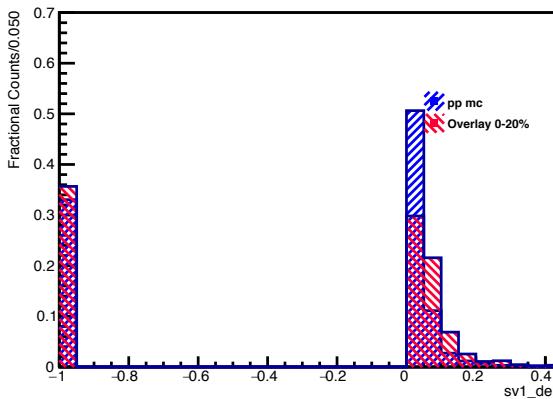
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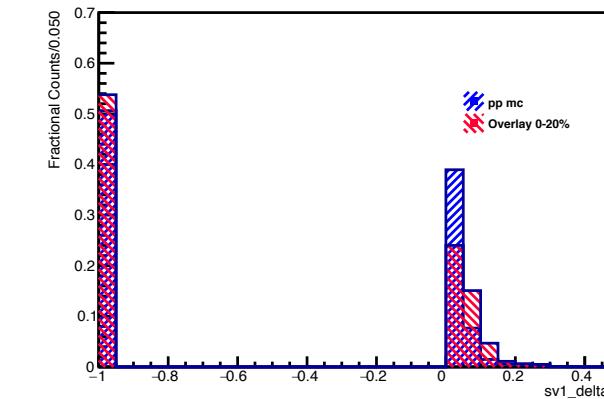
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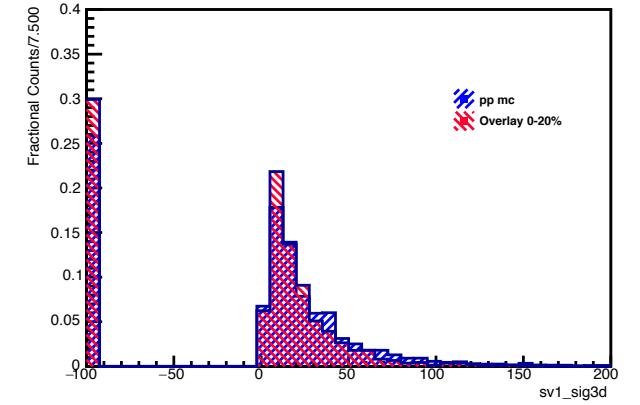
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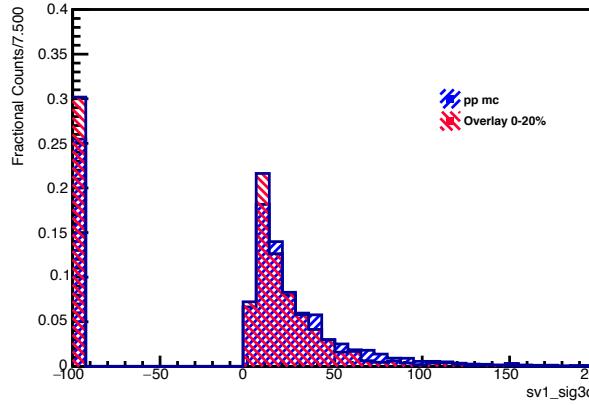
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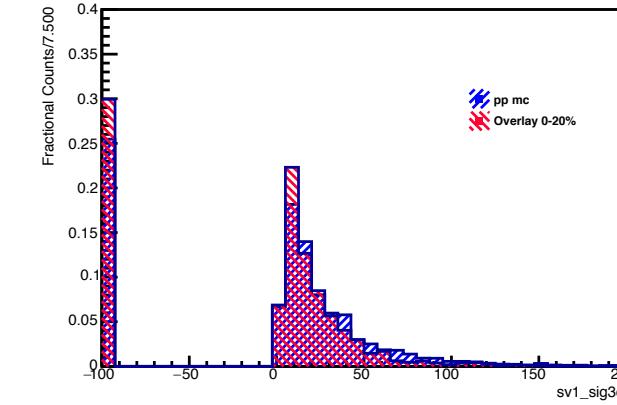
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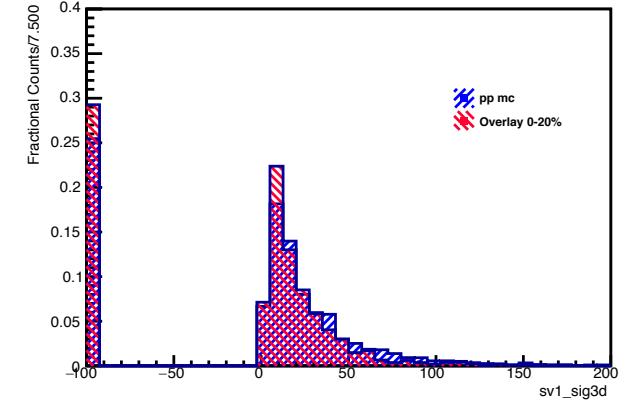
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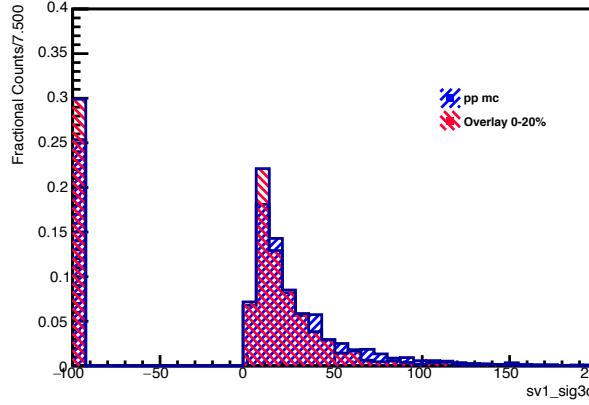
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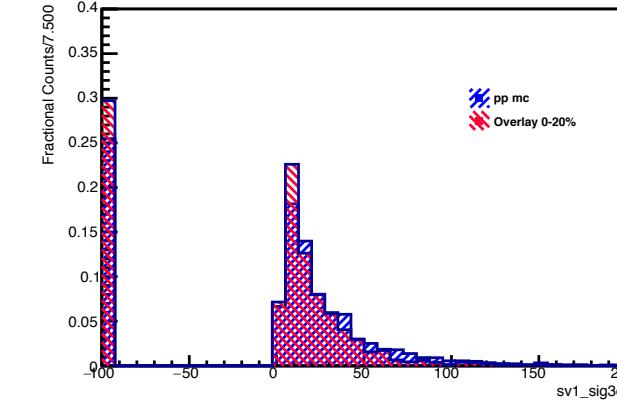
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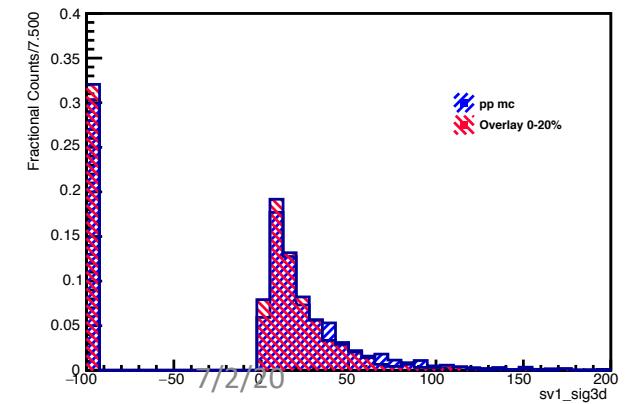
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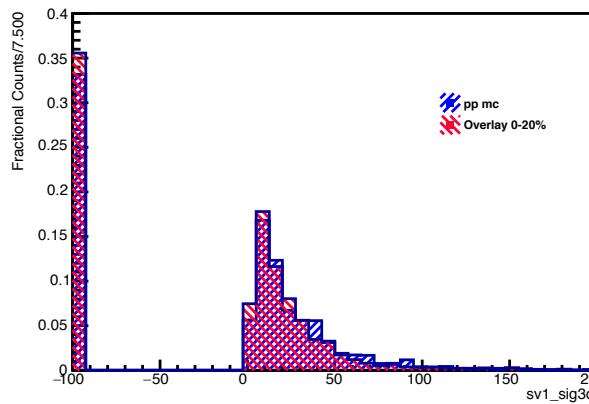
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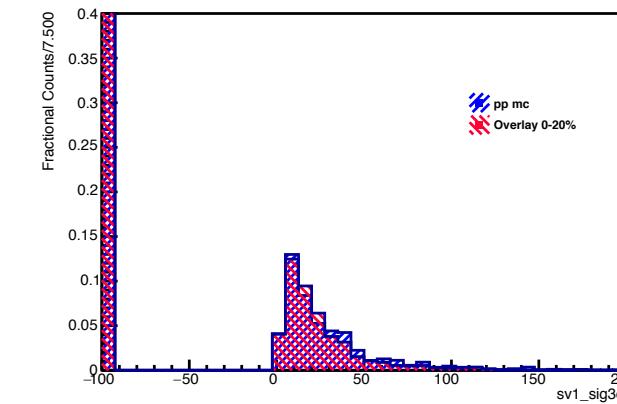
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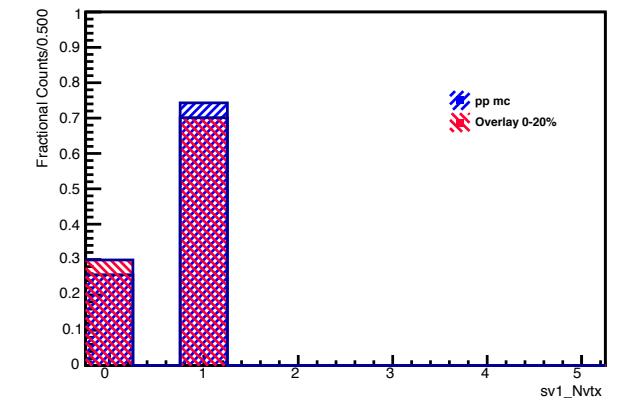
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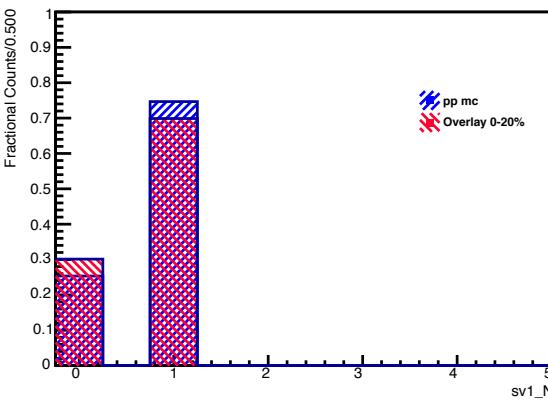
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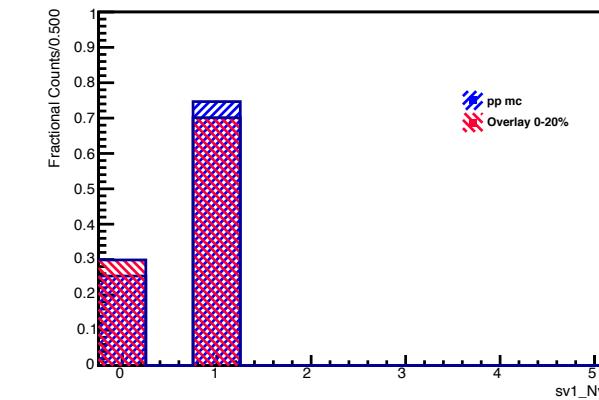
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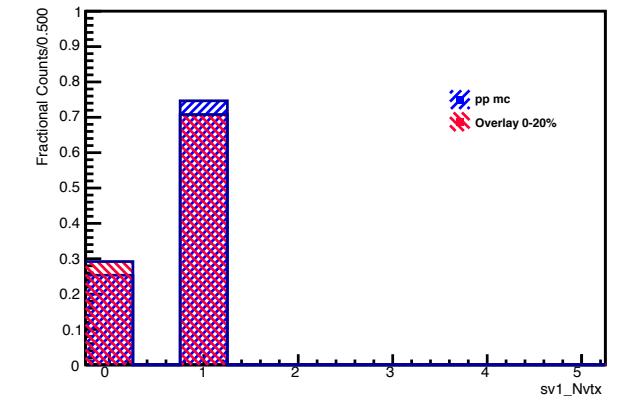
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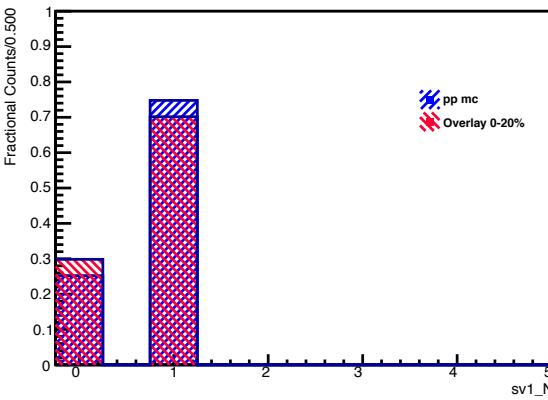
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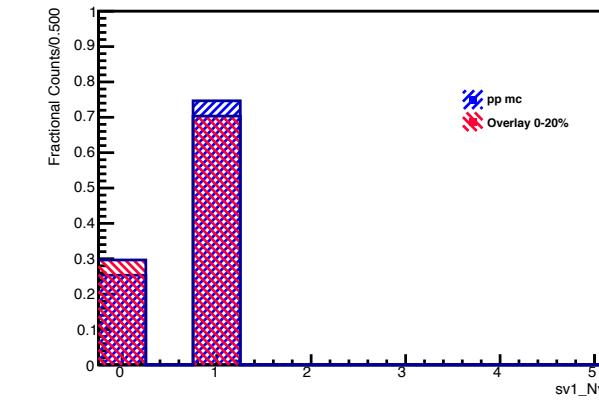
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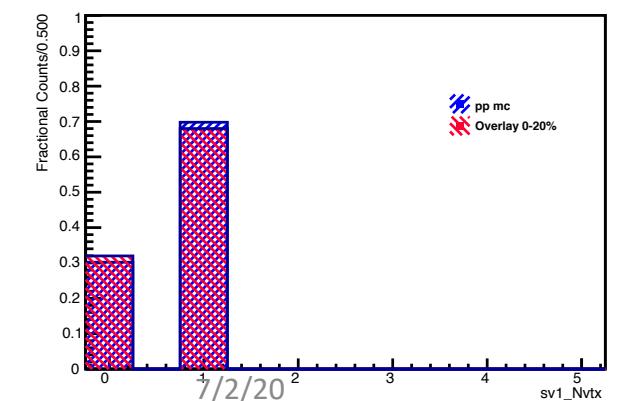
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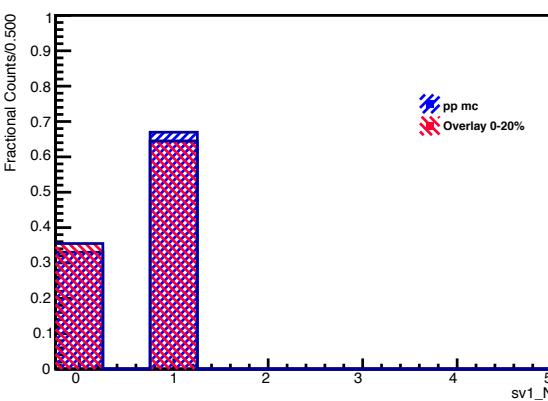
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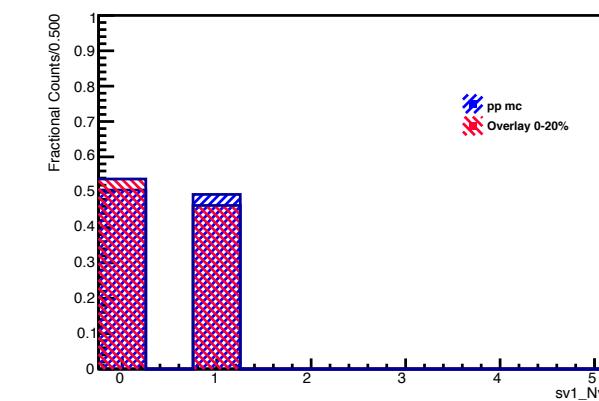
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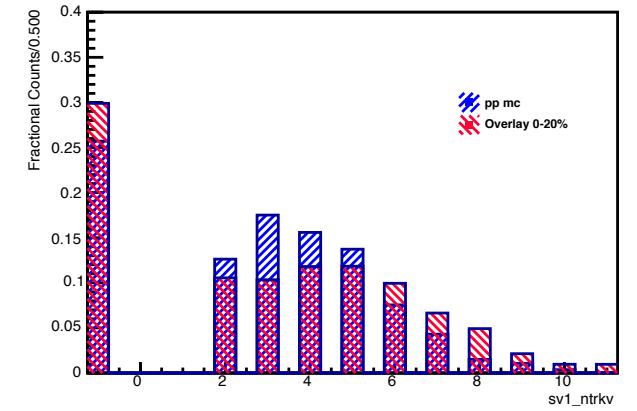
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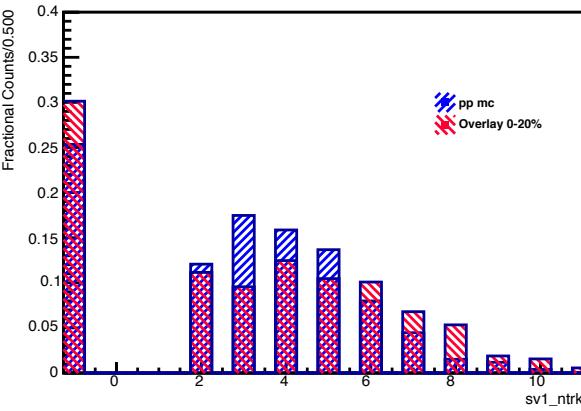
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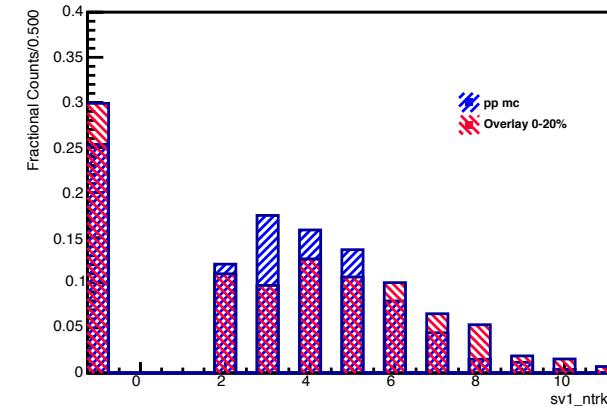
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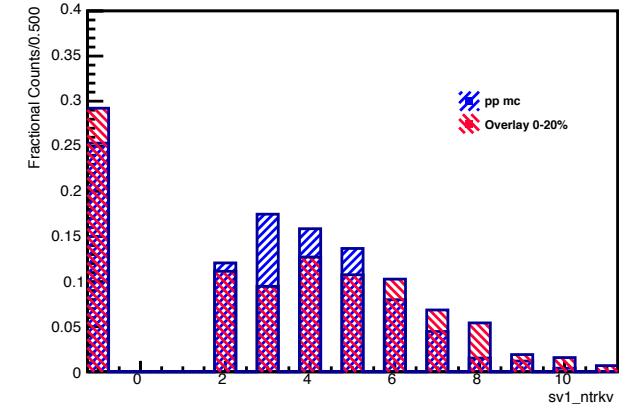
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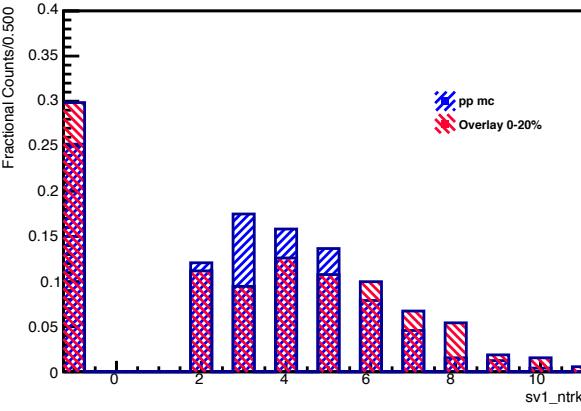
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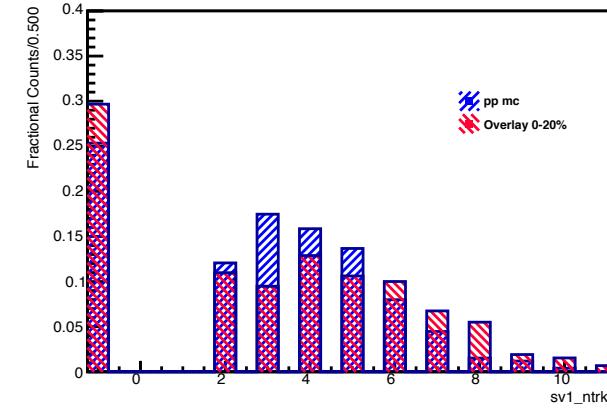
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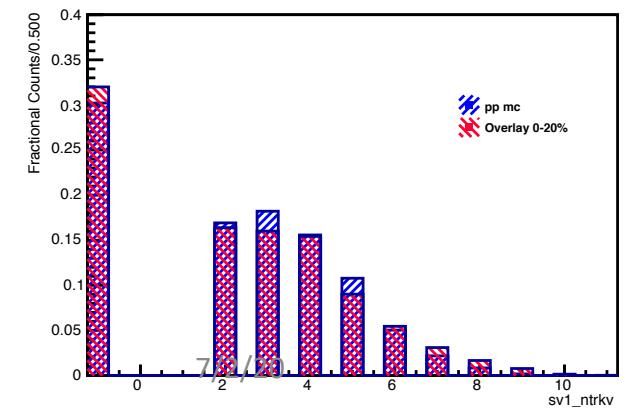
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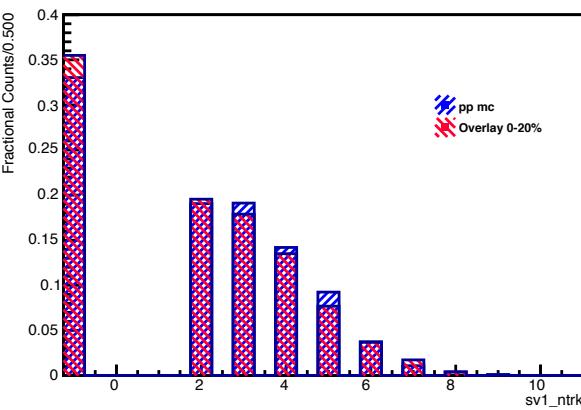
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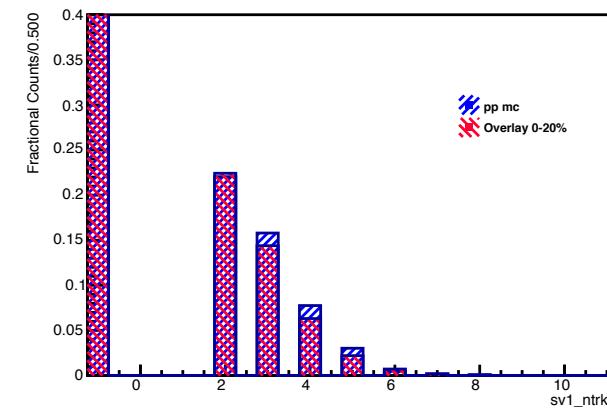
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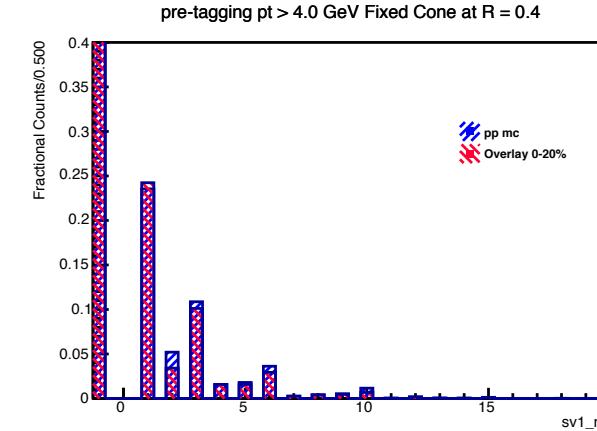
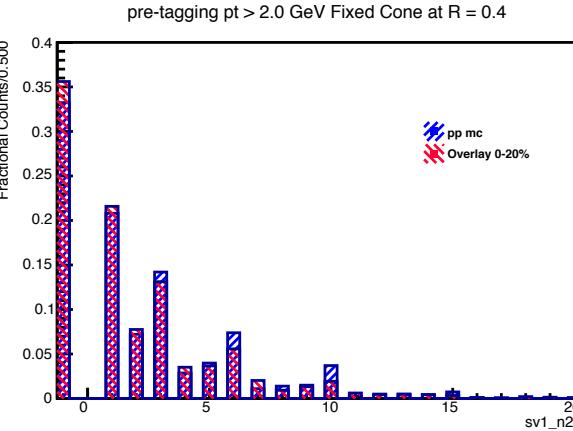
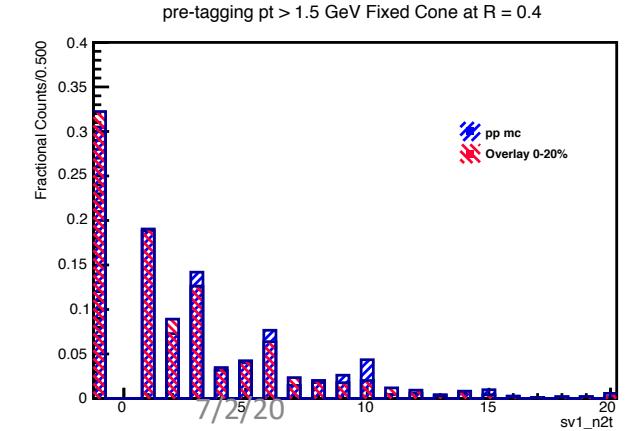
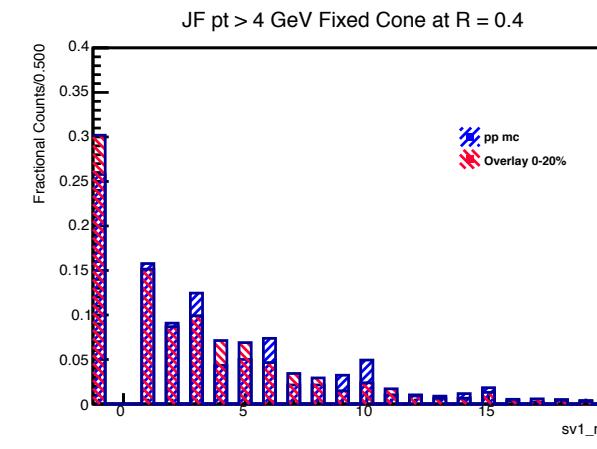
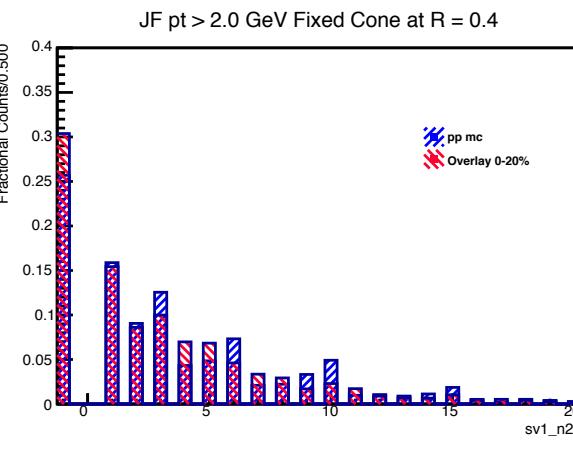
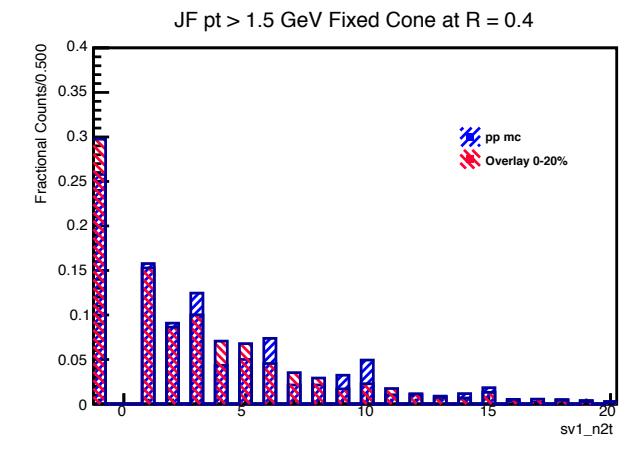
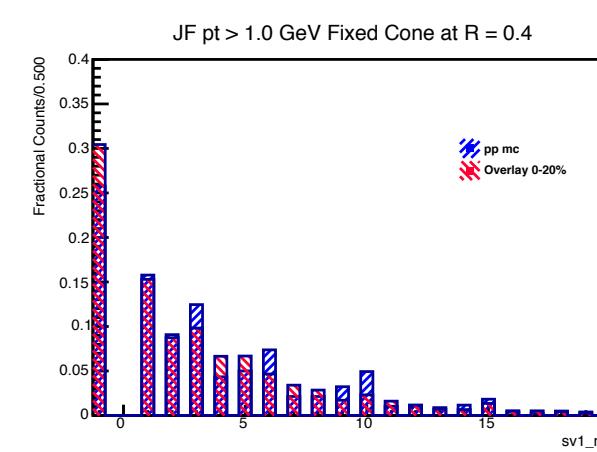
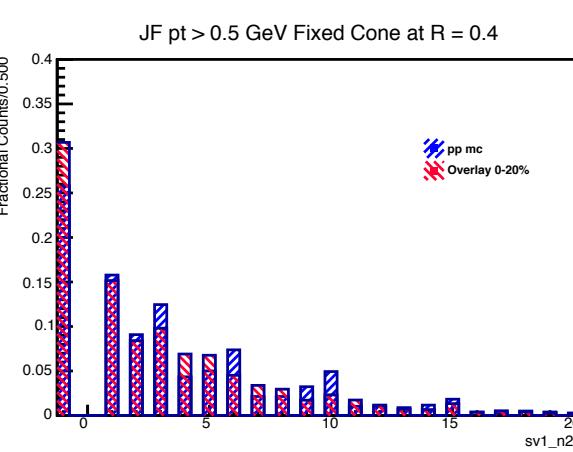
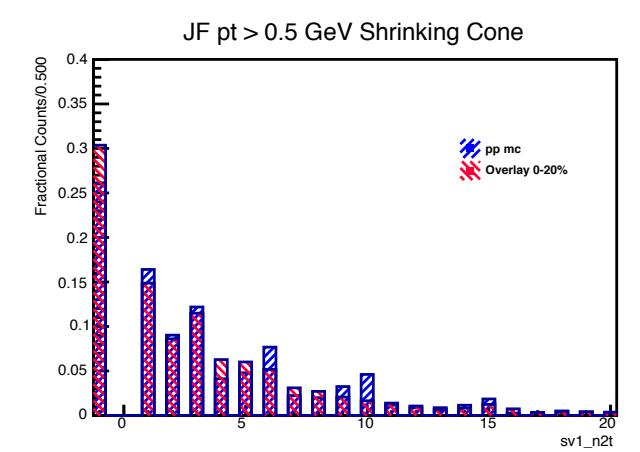


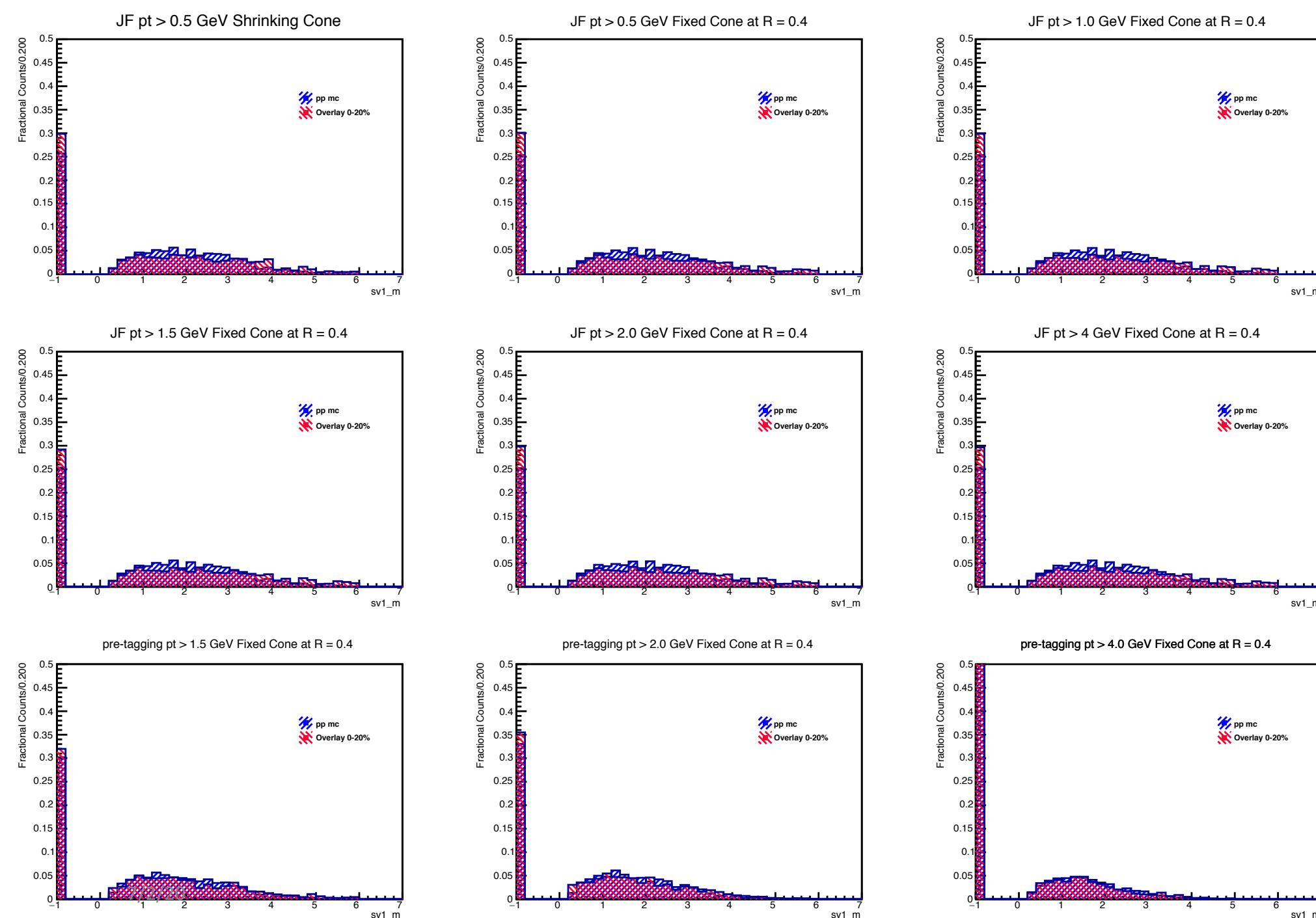
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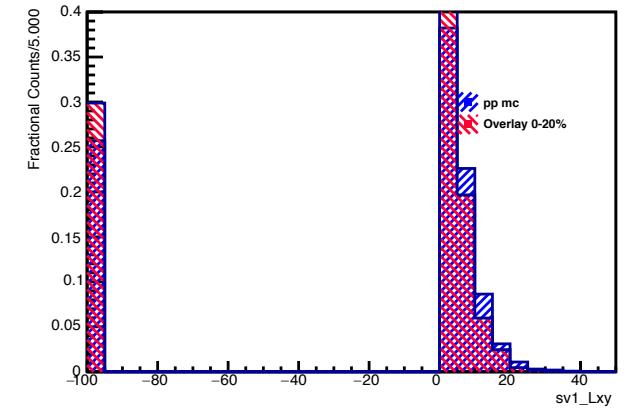
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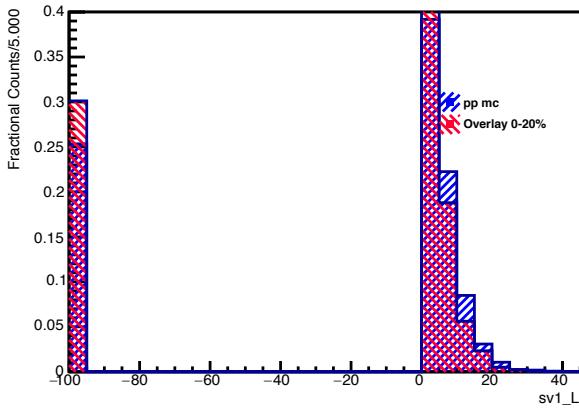




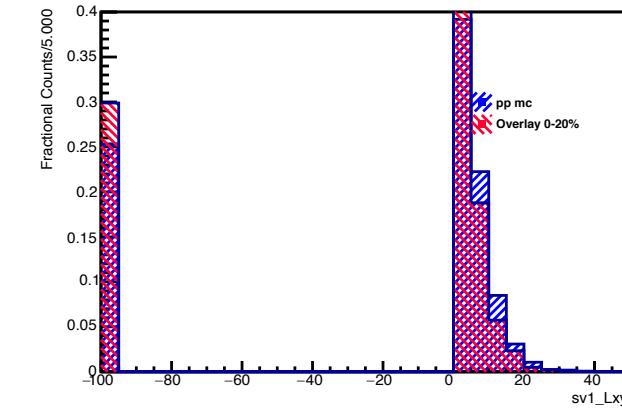
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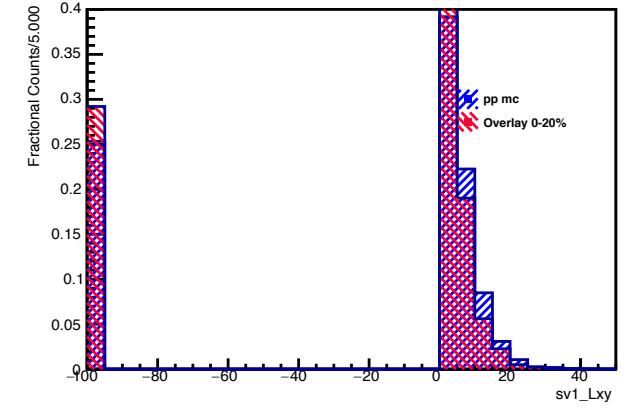
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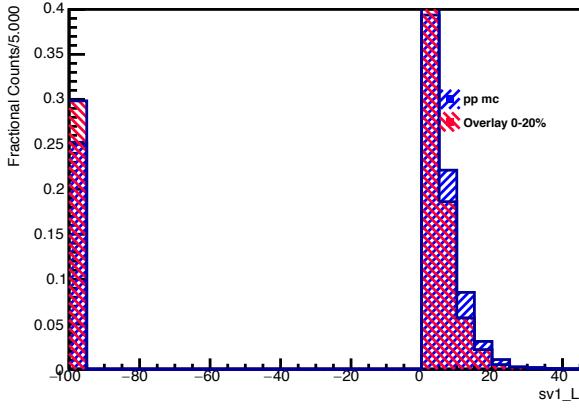
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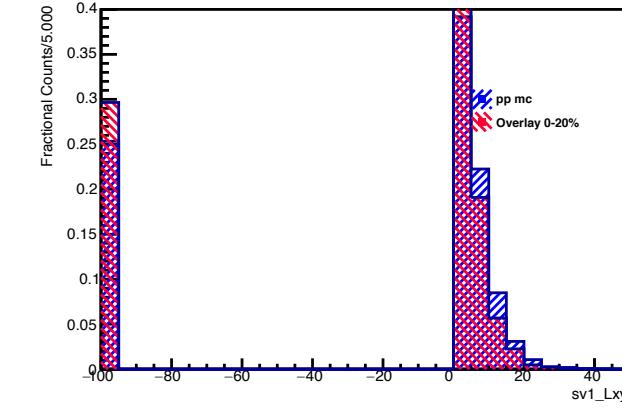
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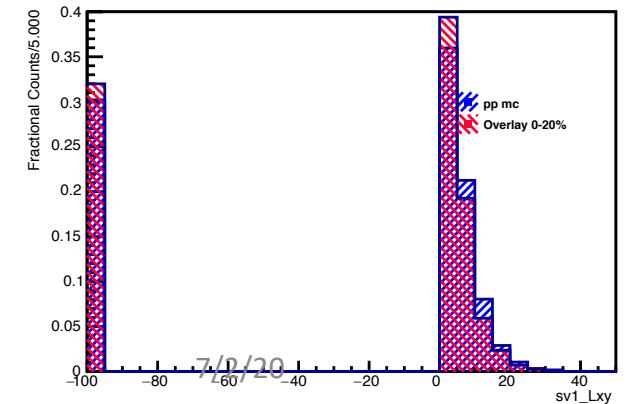
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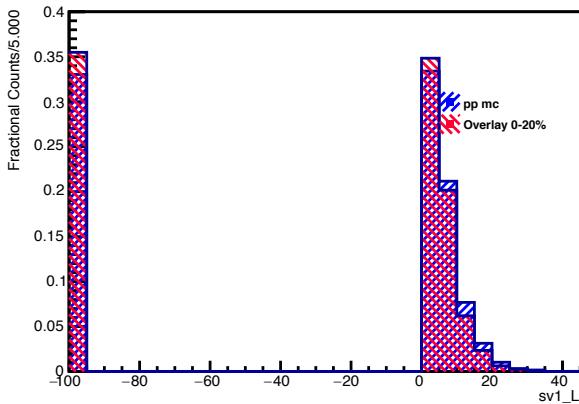
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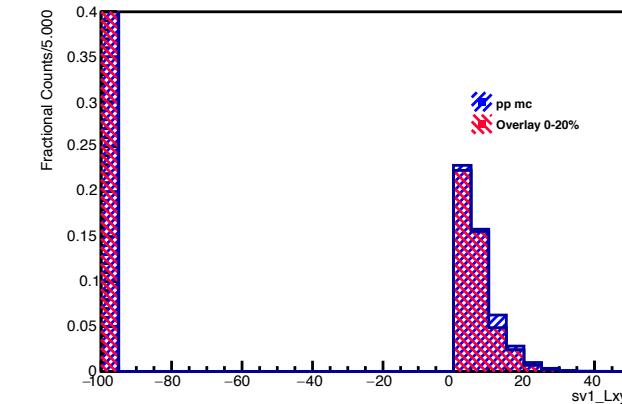
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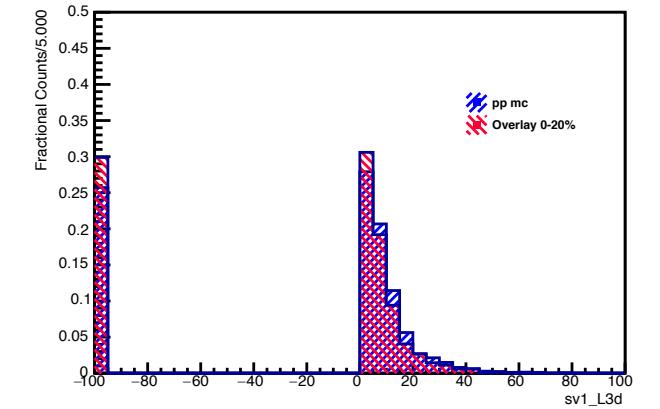
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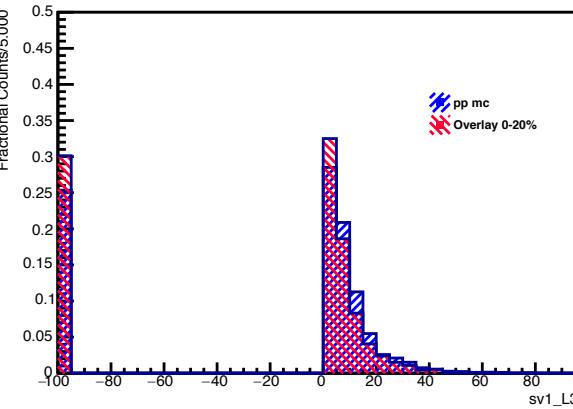
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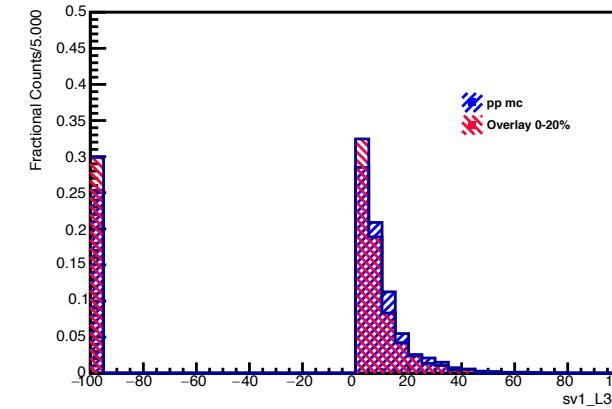
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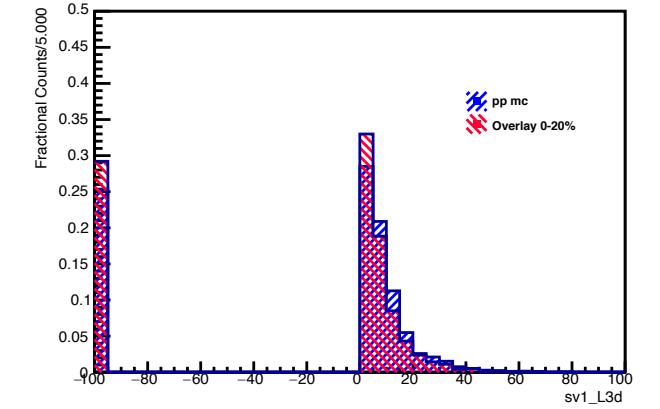
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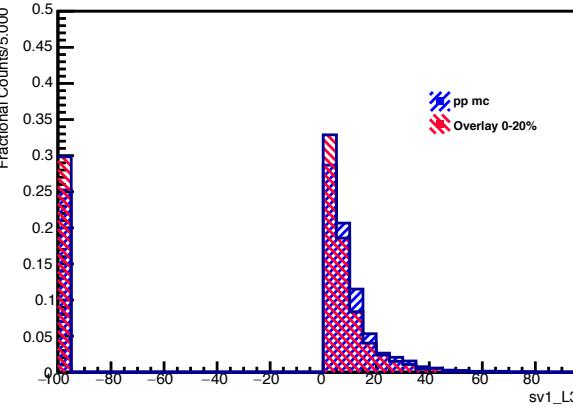
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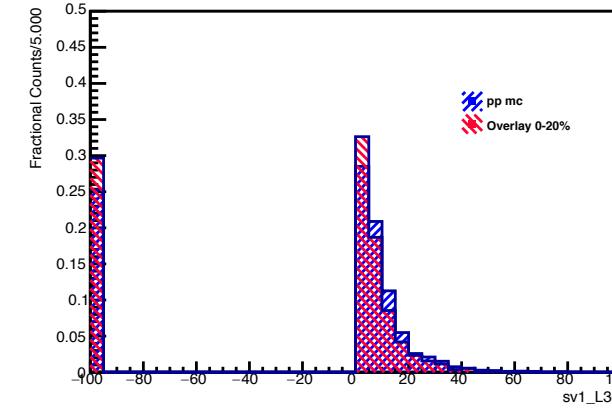
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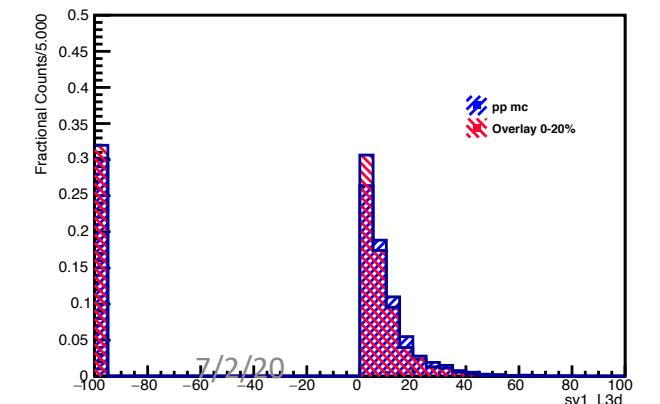
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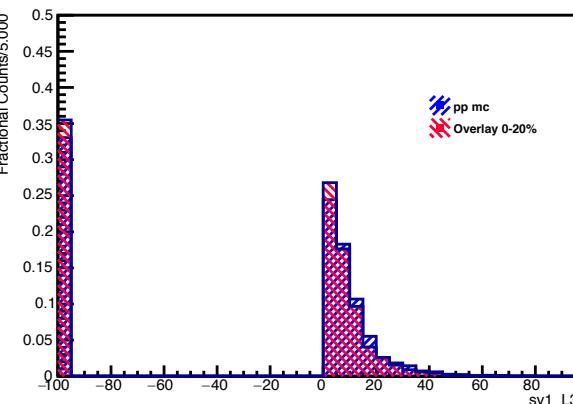
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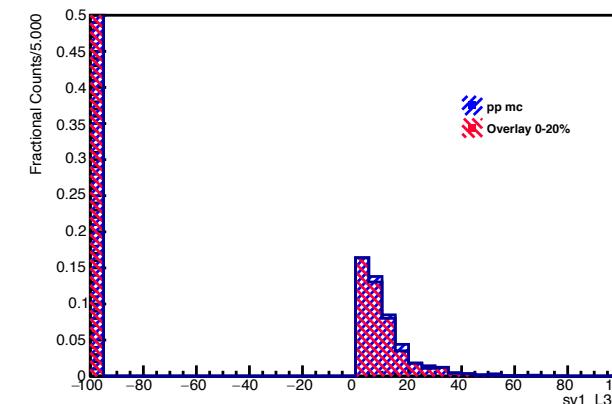
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pre-tagging pt &gt; 2.0 GeV Fixed Cone at R = 0.4

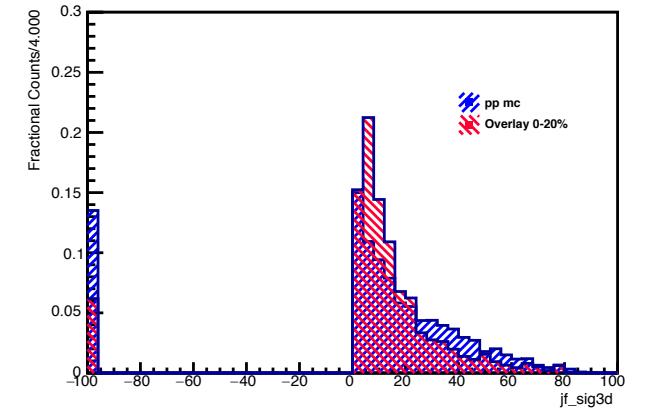


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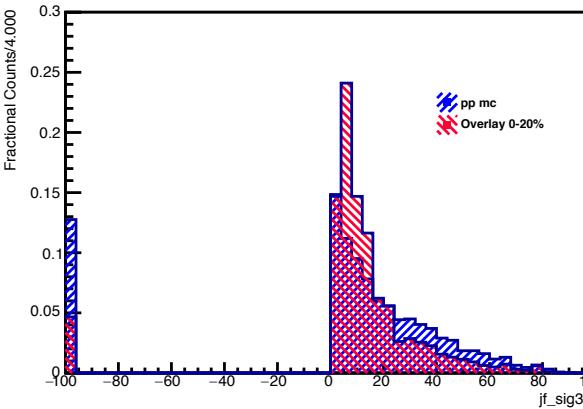


# JetFitter

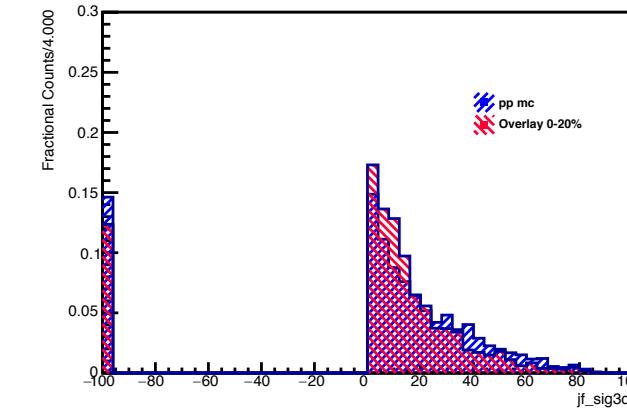
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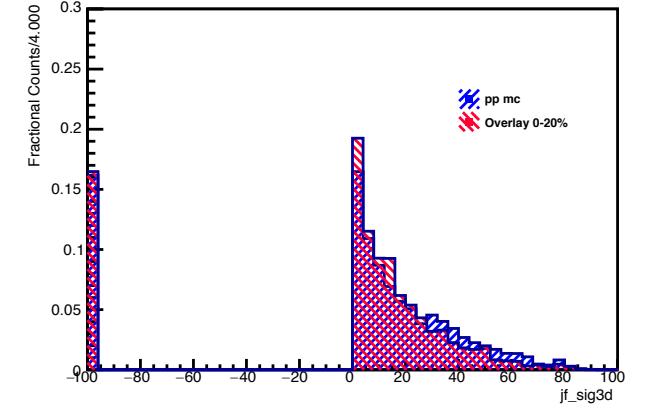
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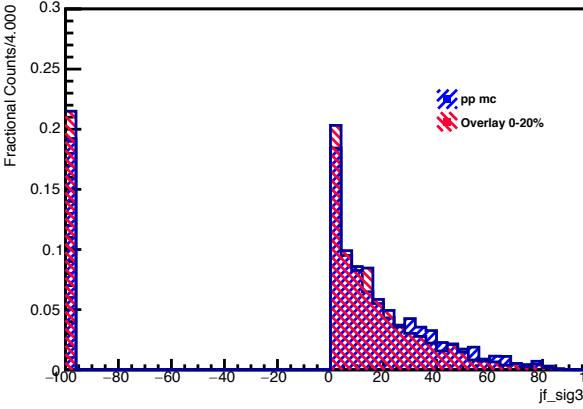
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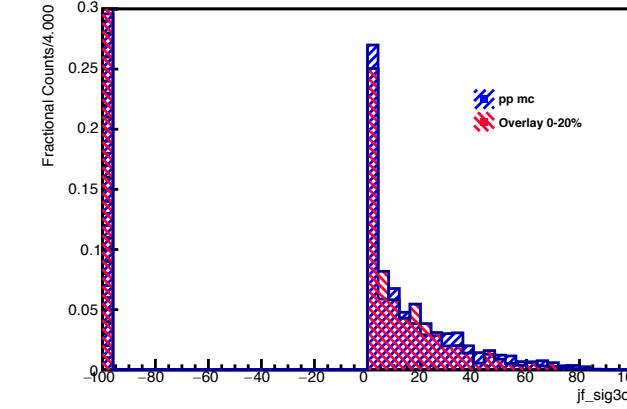
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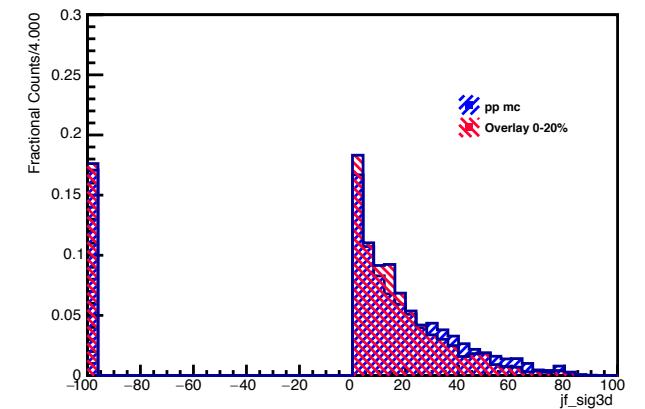
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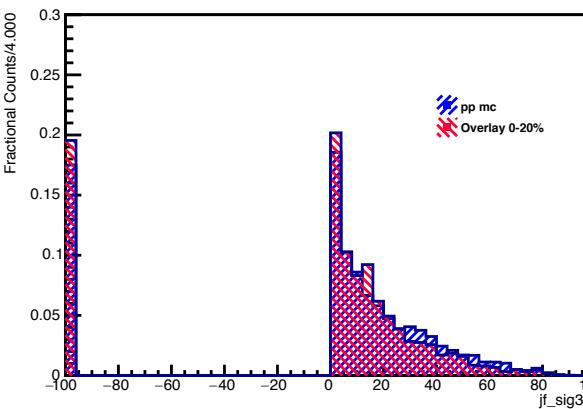
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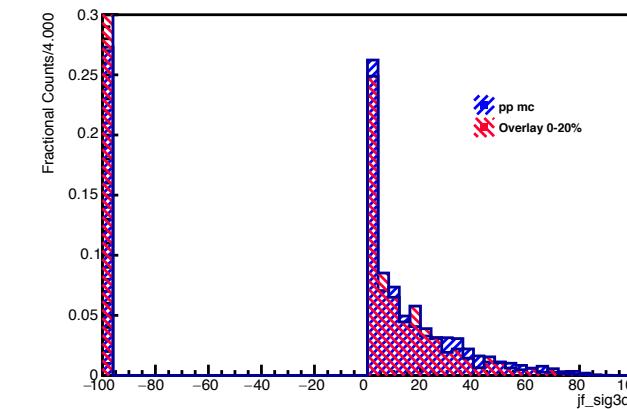
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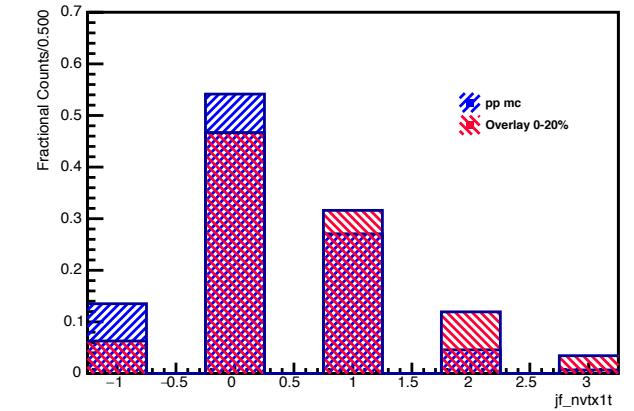
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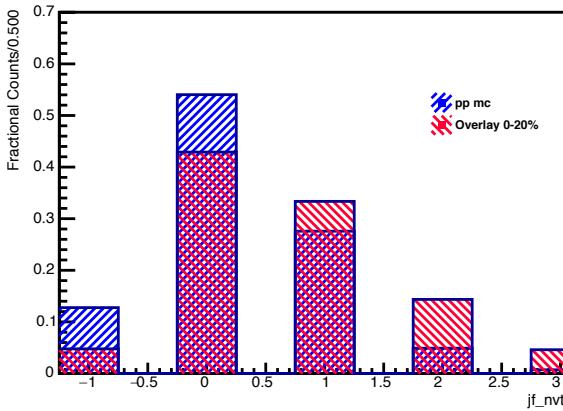
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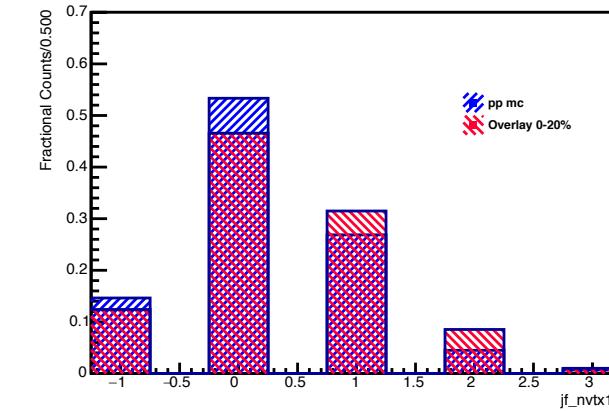
JF pt &gt; 0.5 GeV Shrinking Cone



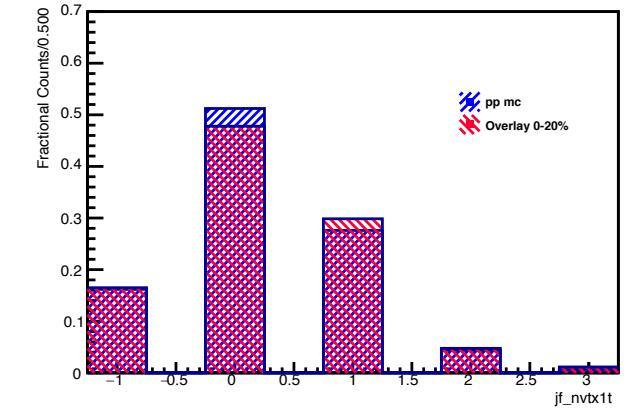
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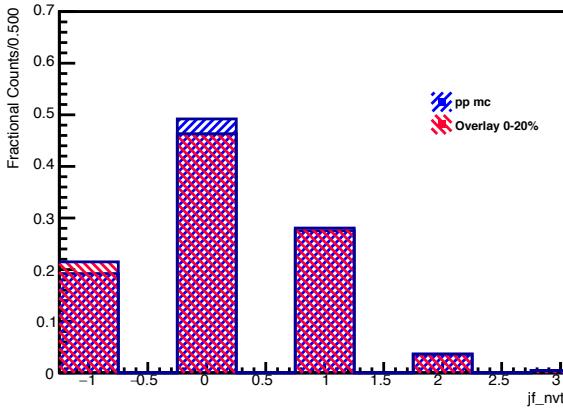
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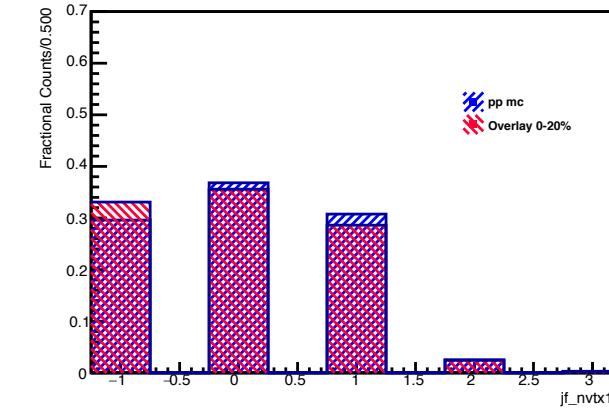
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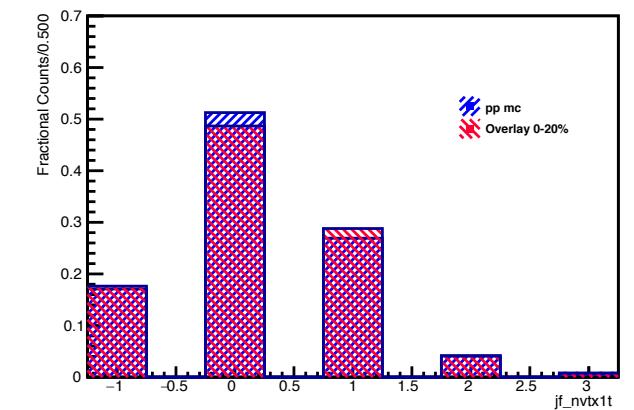
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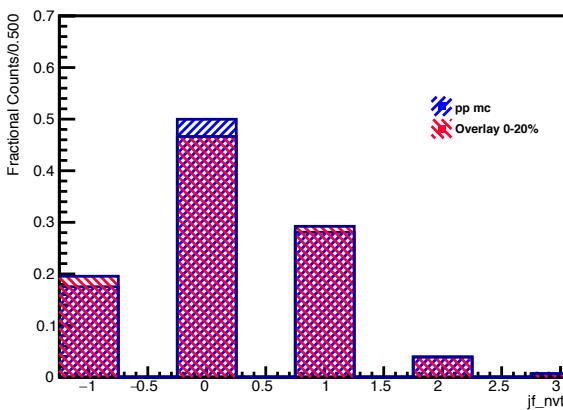
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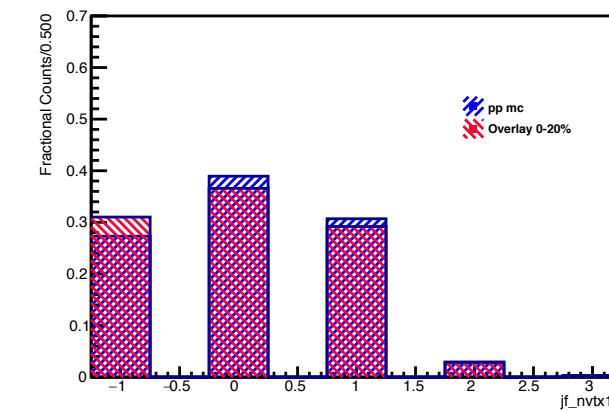
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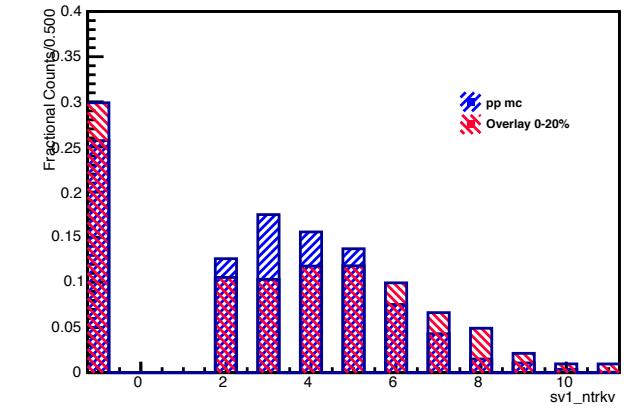
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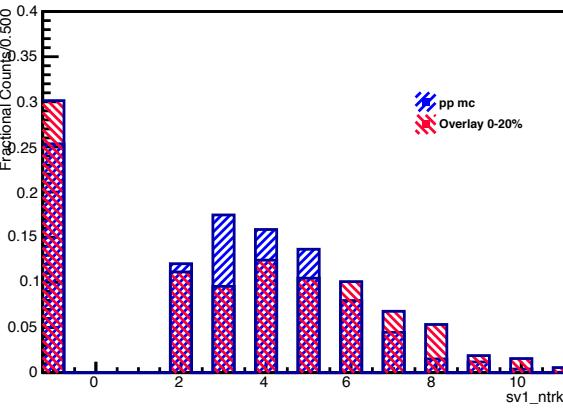
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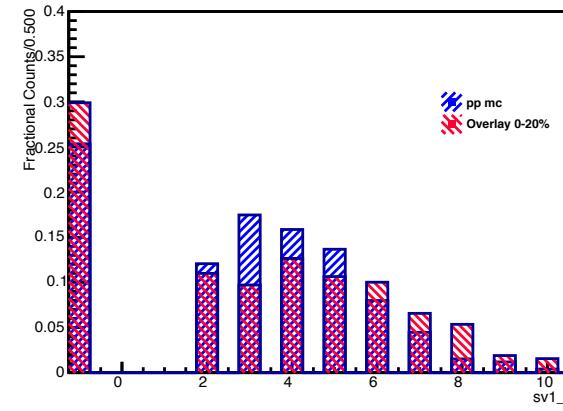
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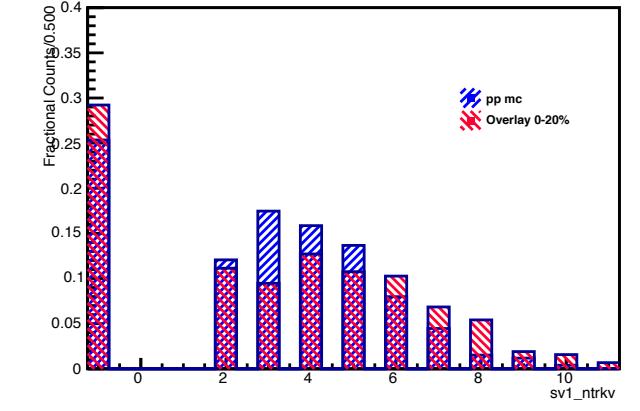
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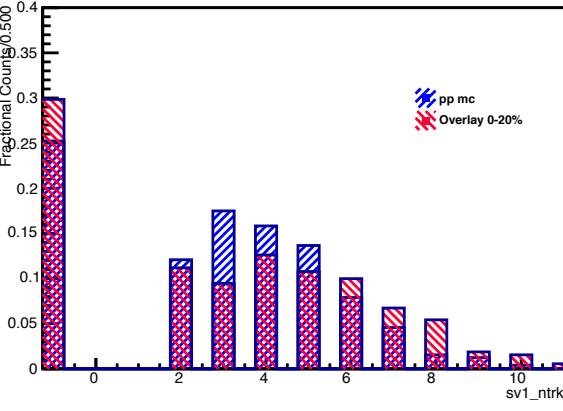
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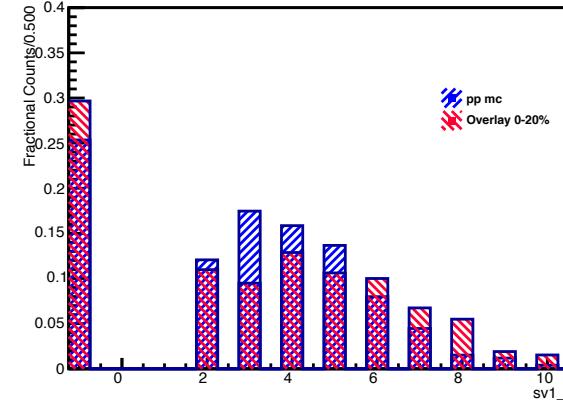
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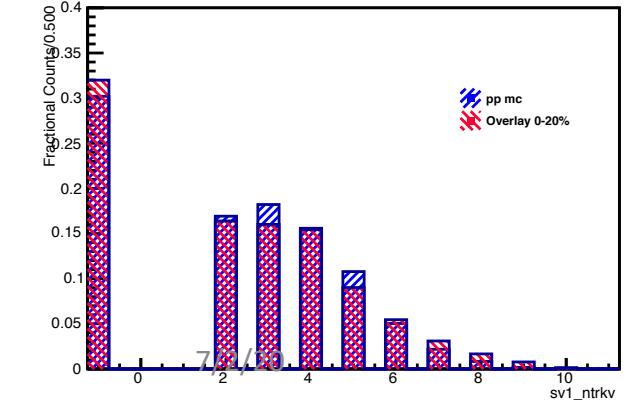
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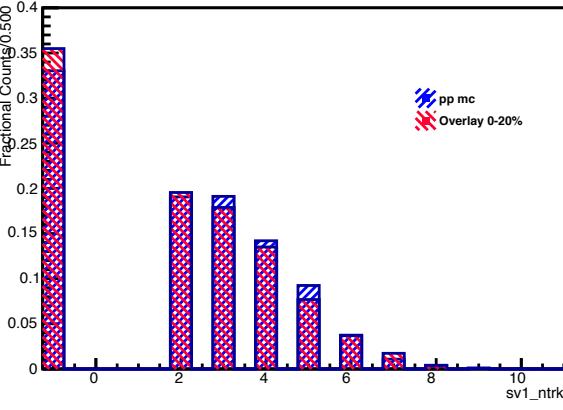
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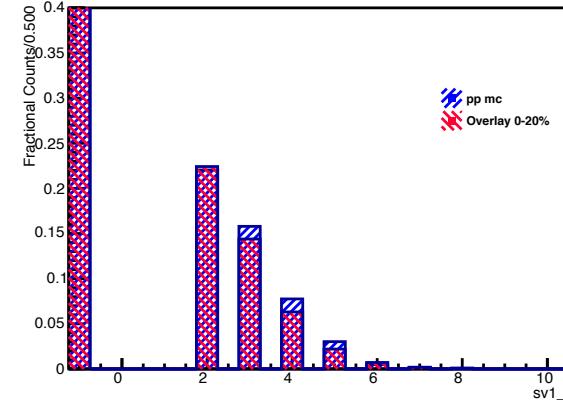
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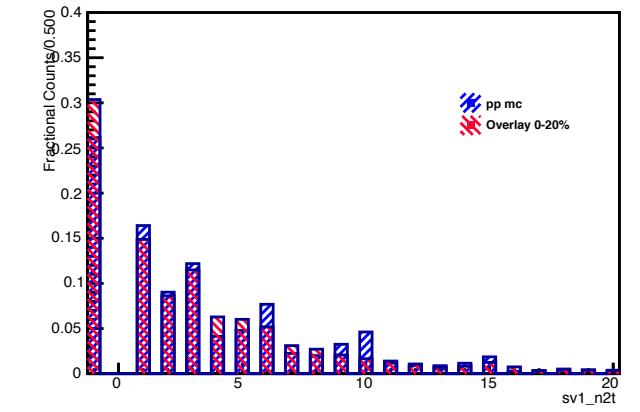
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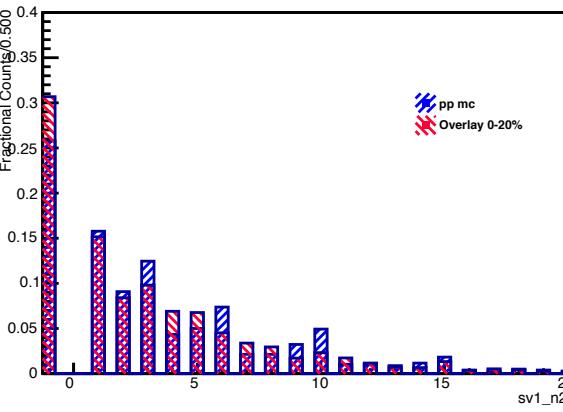
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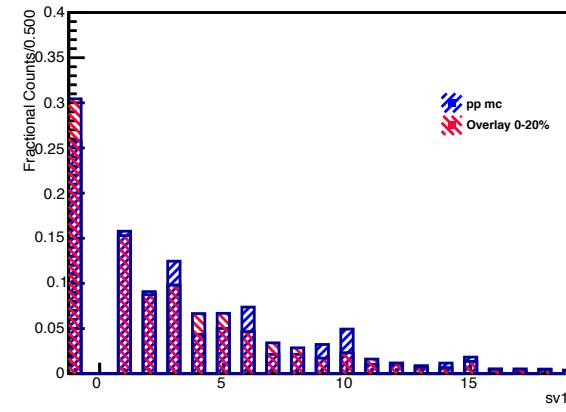
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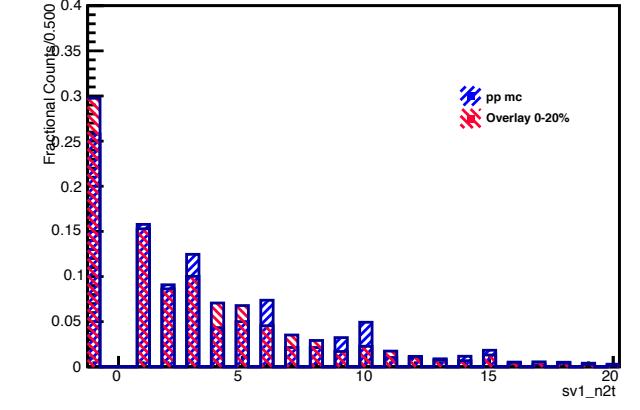
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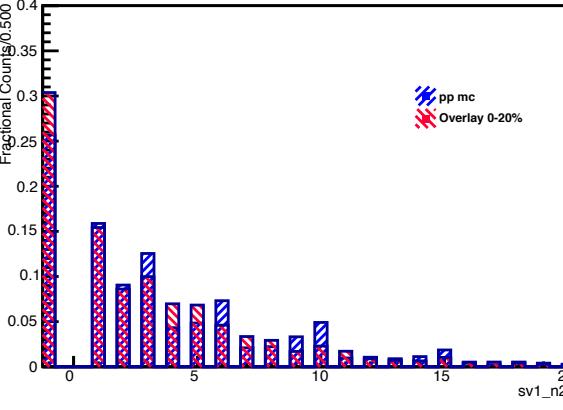
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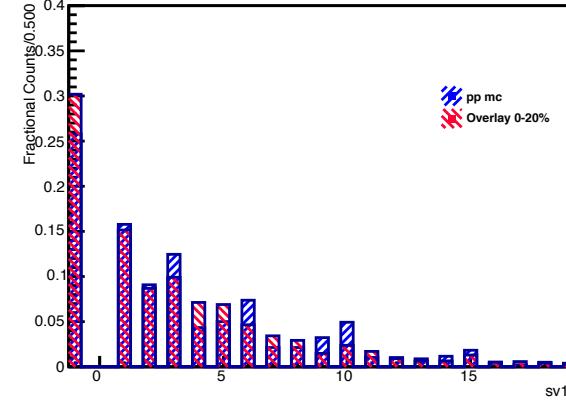
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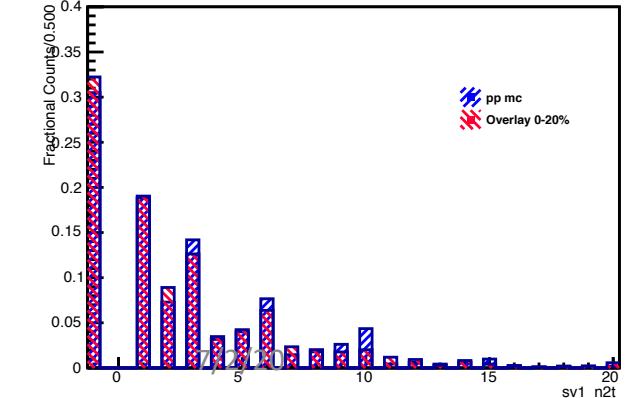
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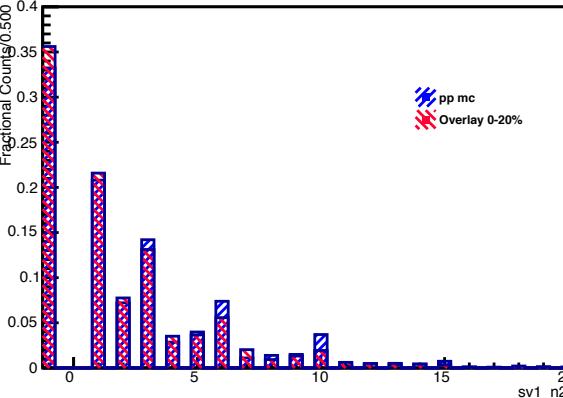
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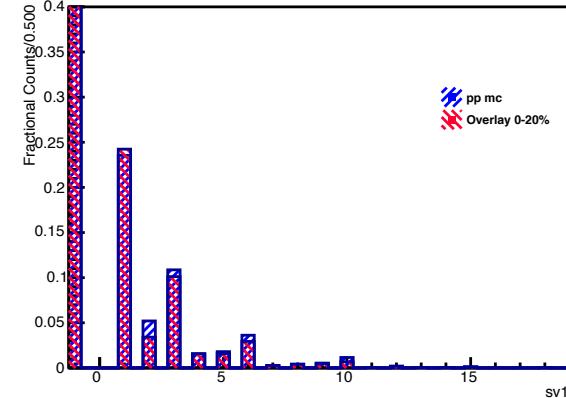
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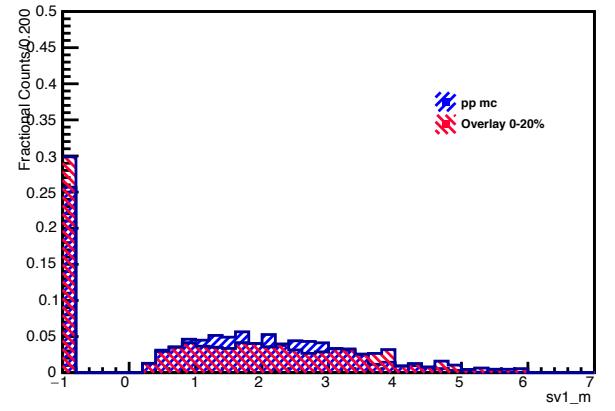
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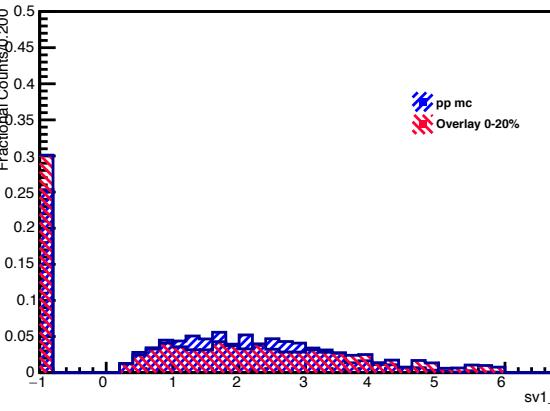
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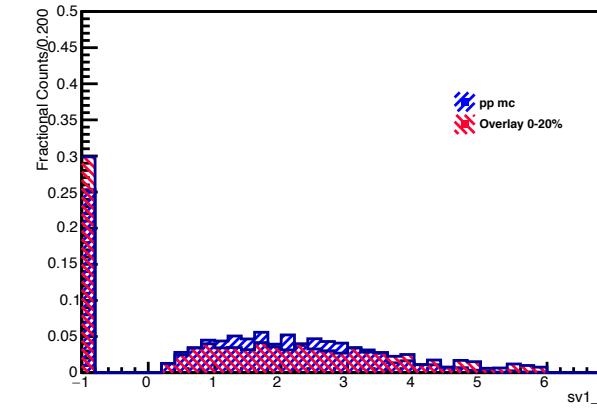
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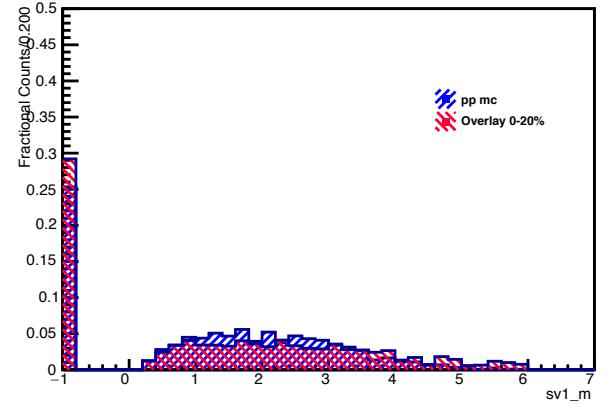
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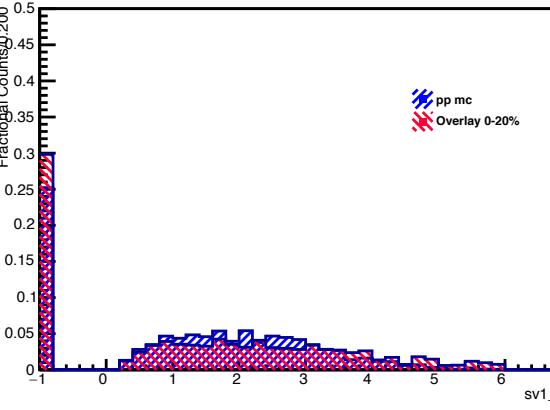
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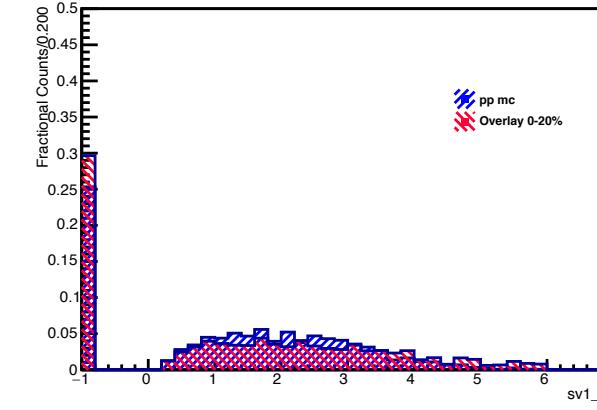
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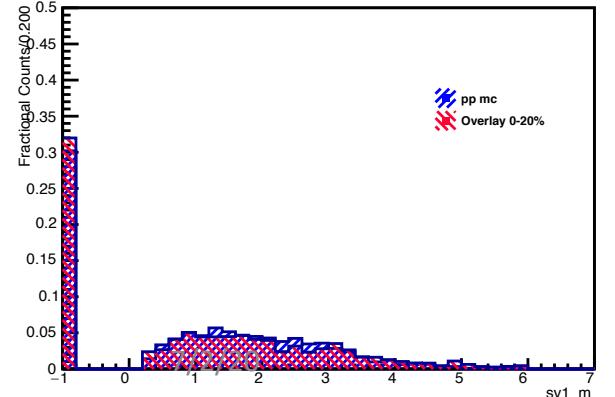
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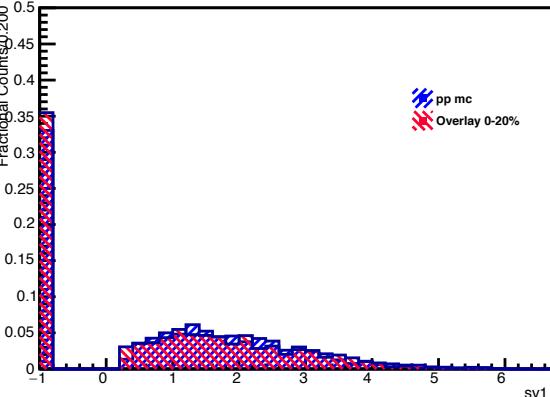
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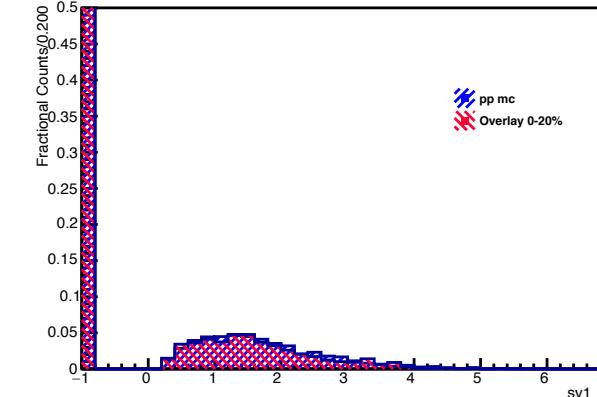
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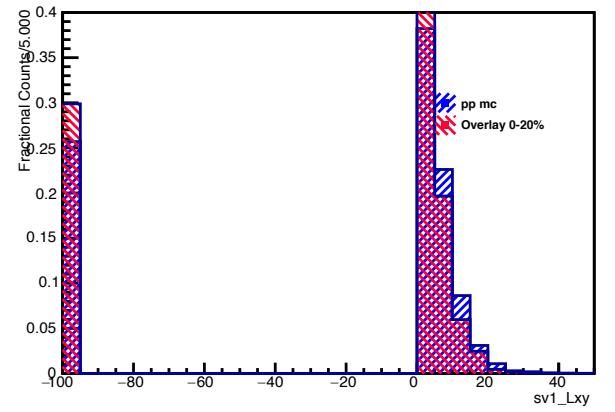
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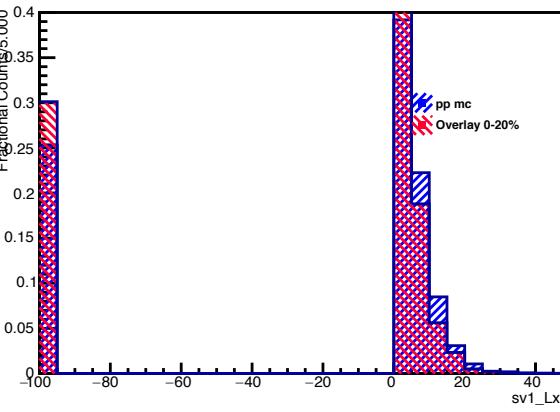
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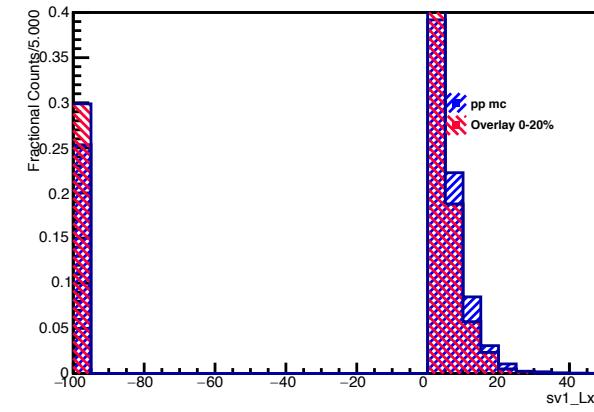
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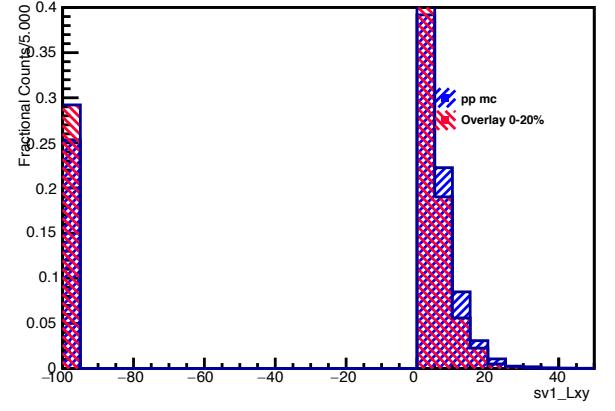
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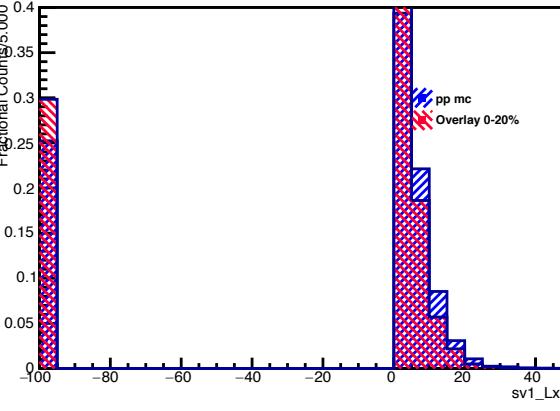
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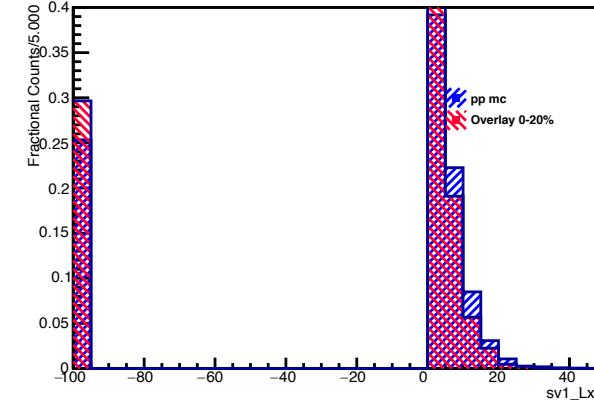
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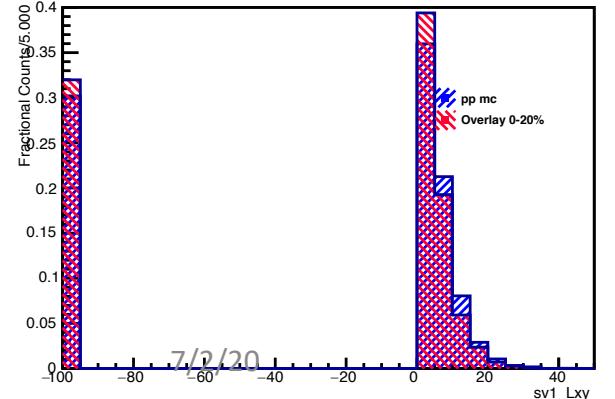
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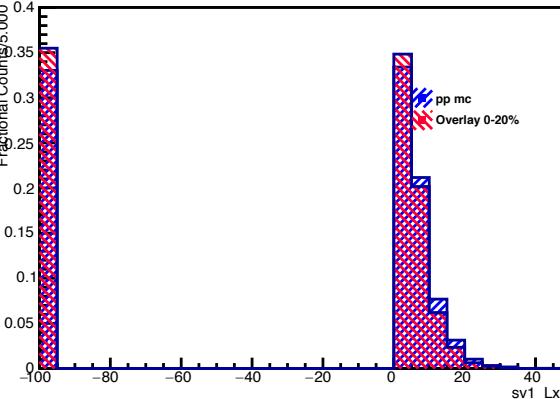
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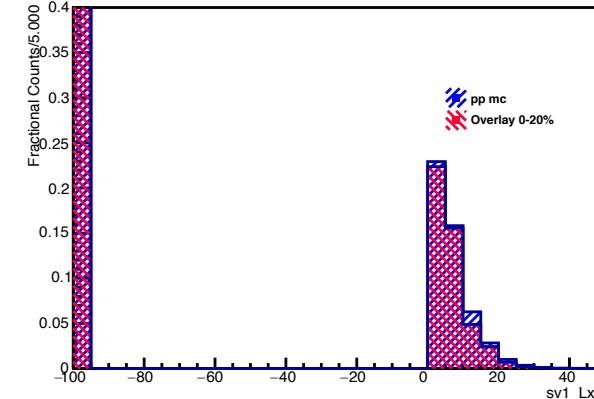
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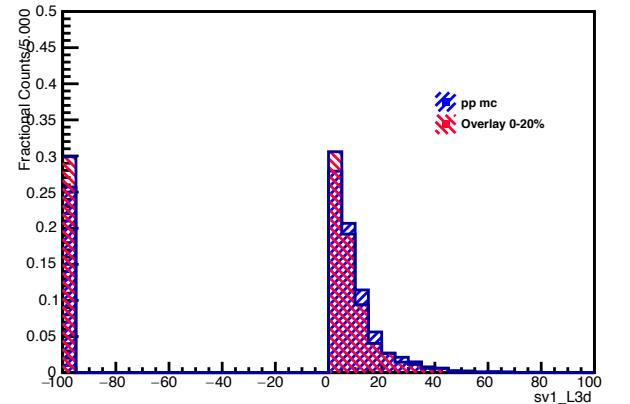
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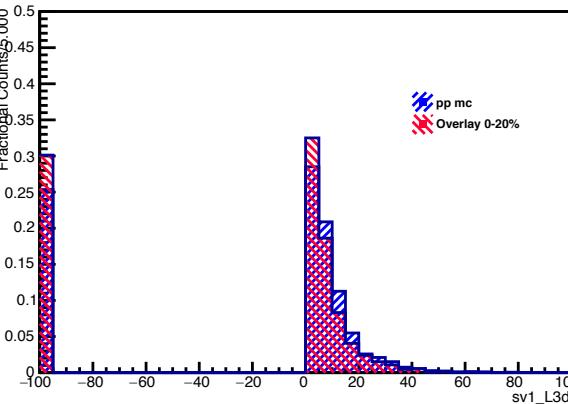
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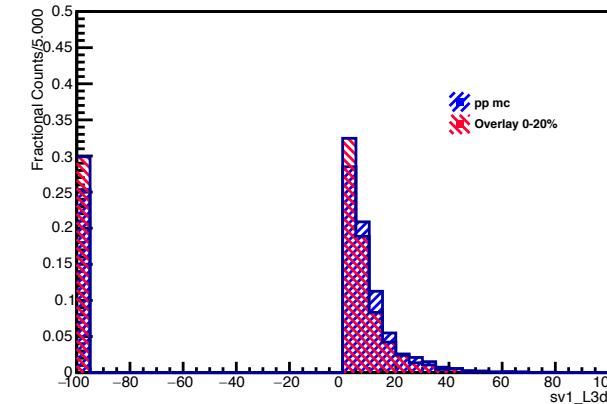
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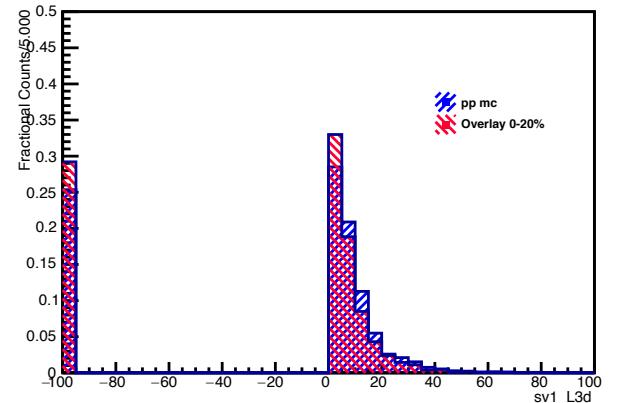
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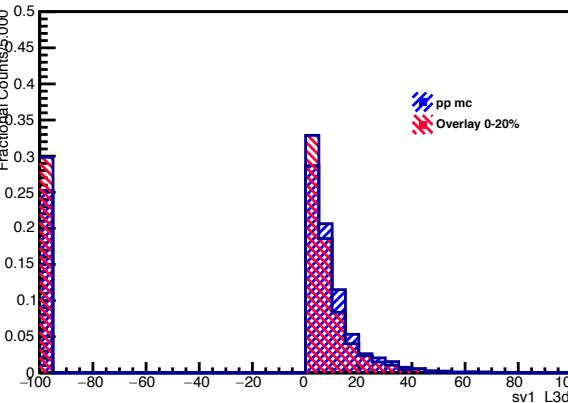
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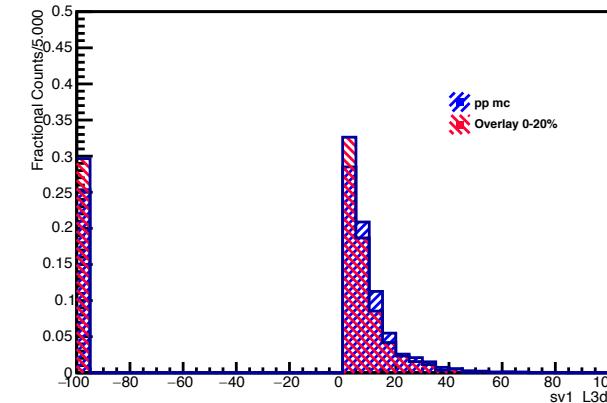
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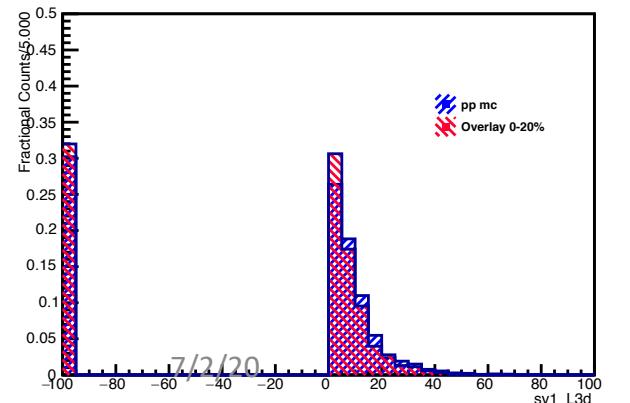
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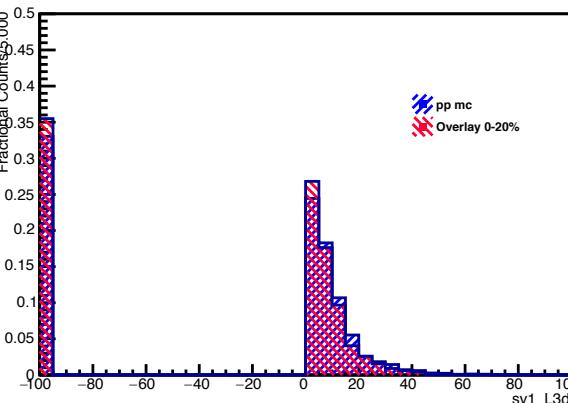
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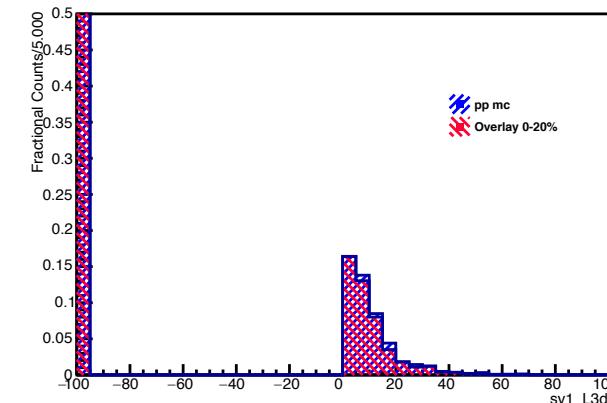
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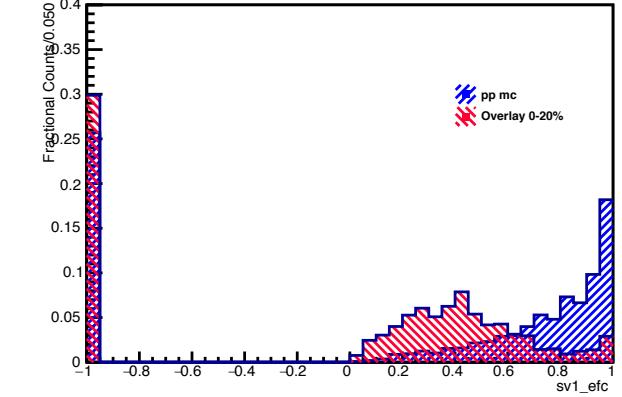
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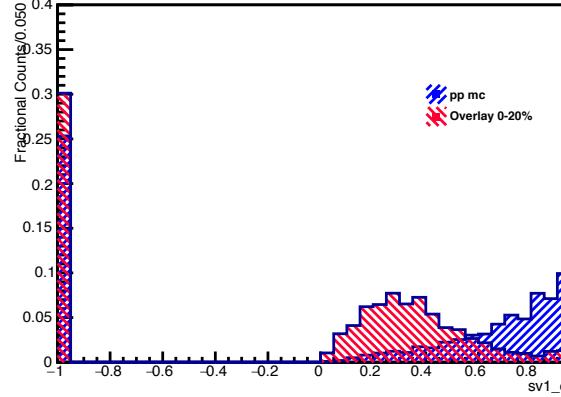
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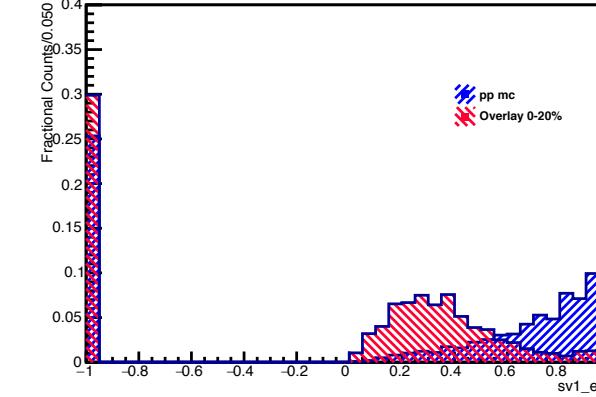
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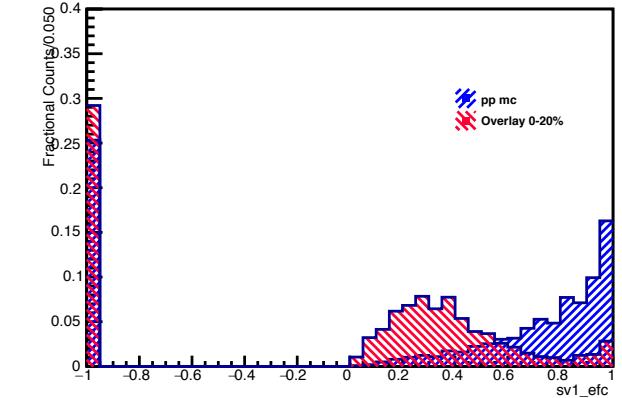
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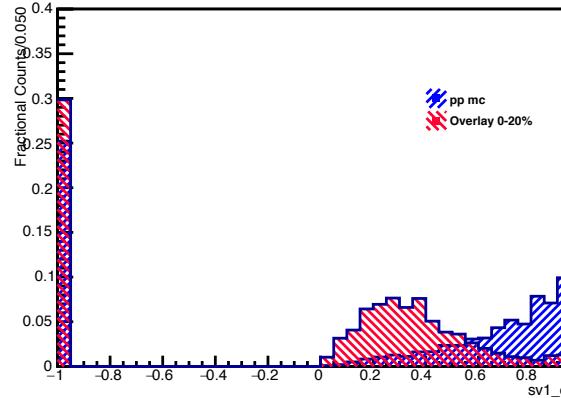
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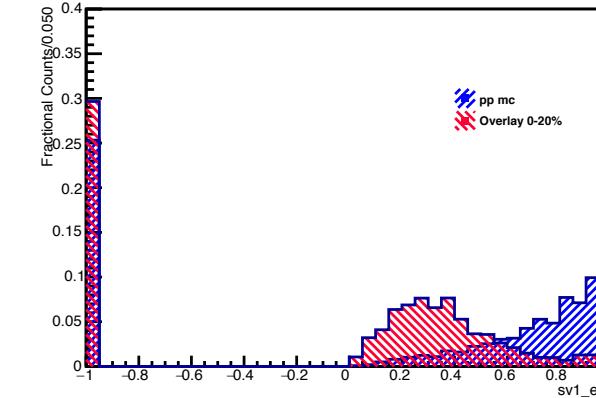
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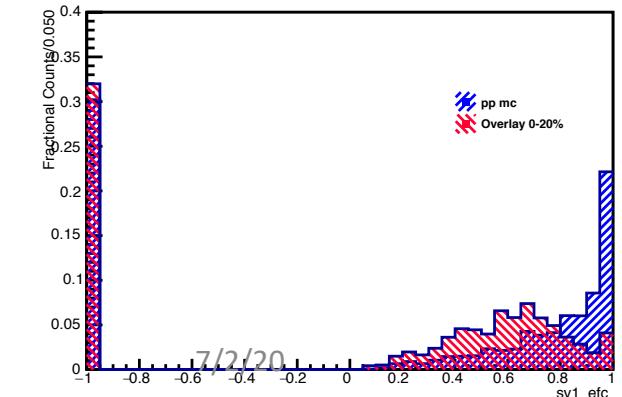
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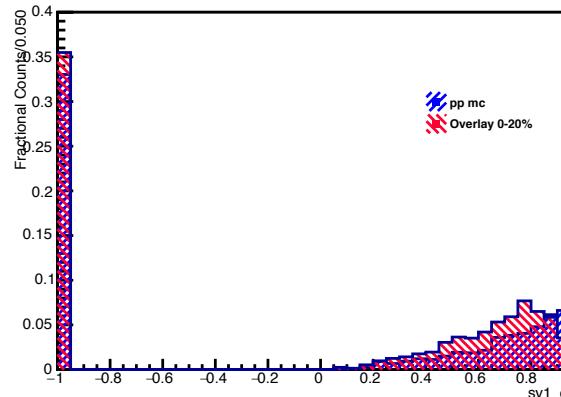
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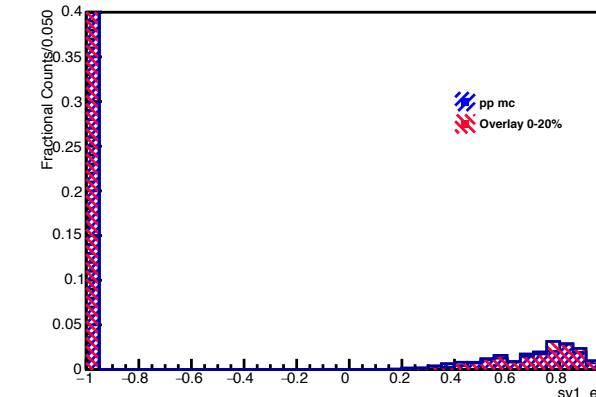
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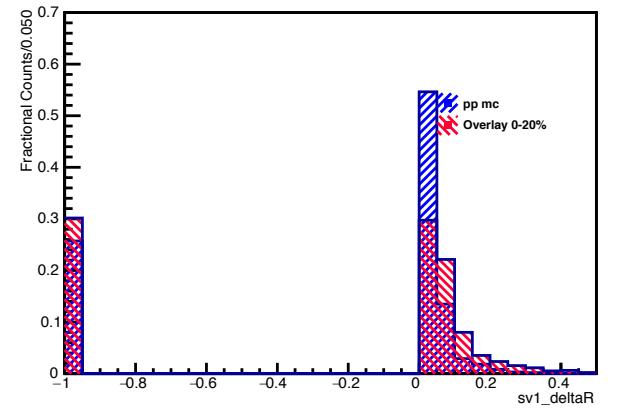
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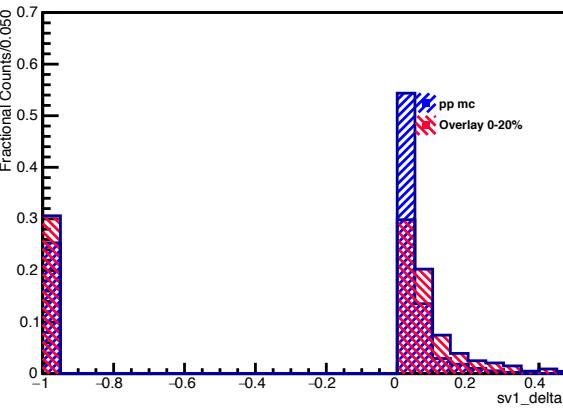
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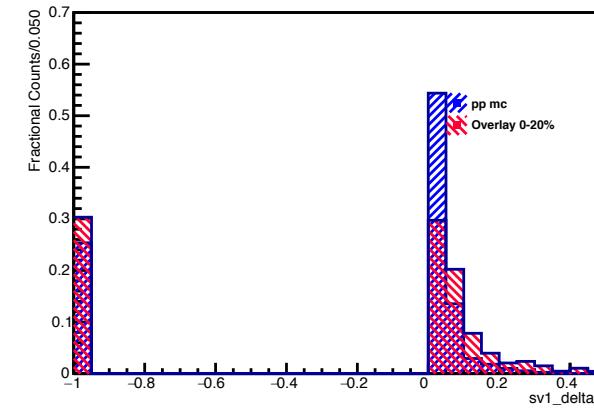
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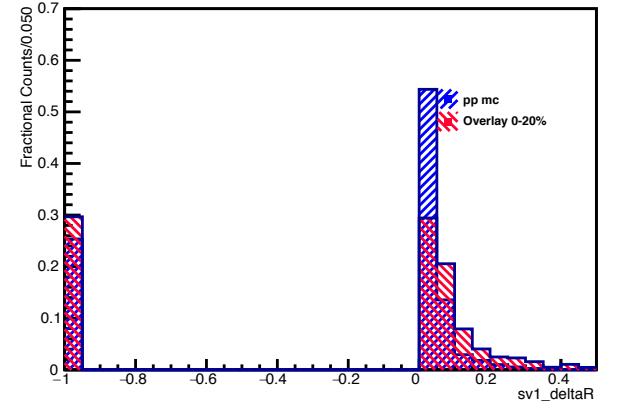
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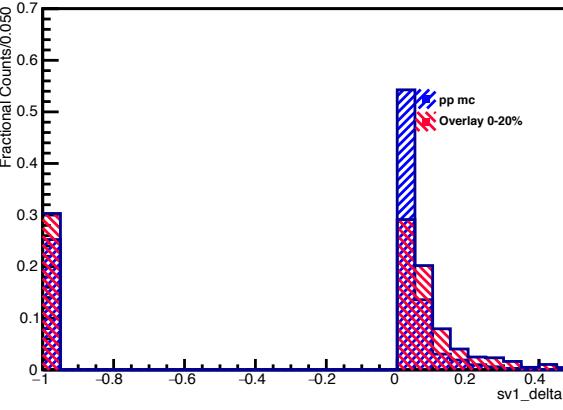
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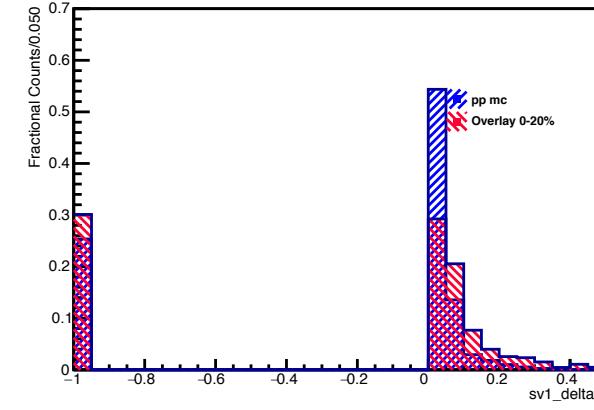
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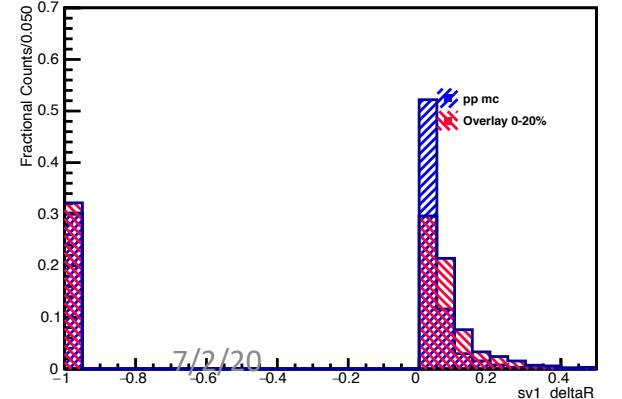
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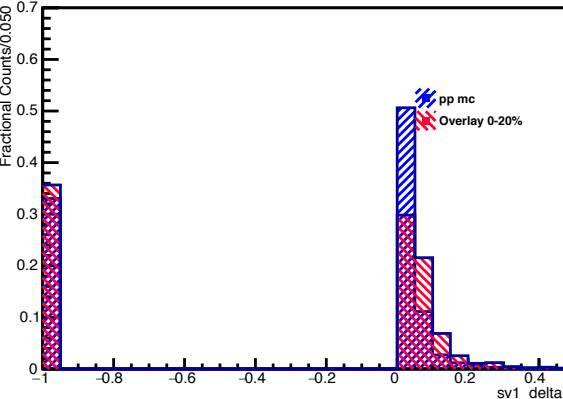
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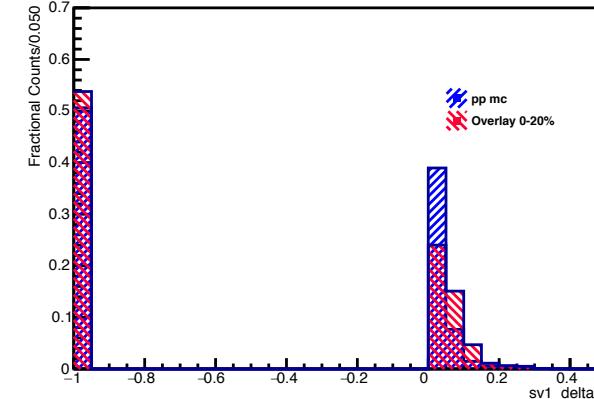
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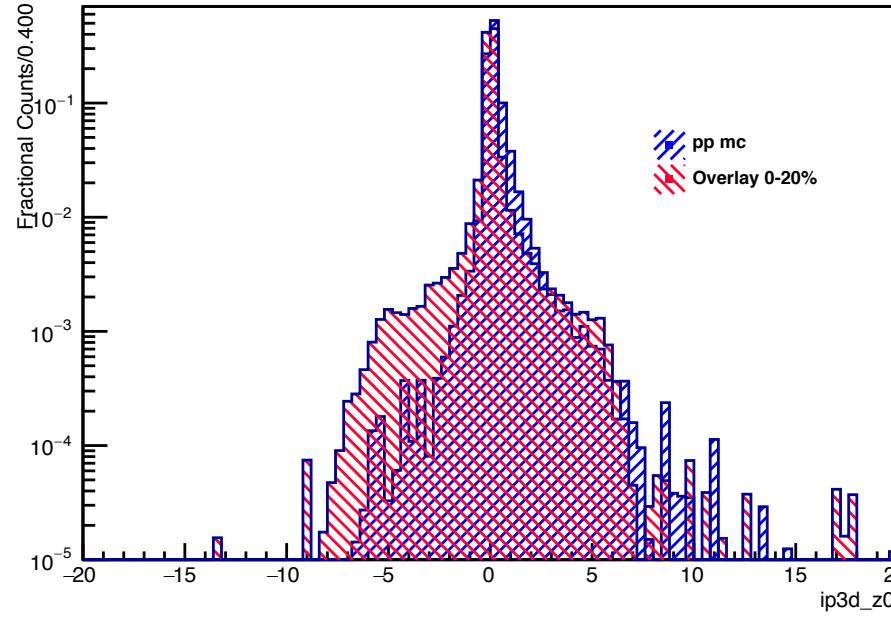


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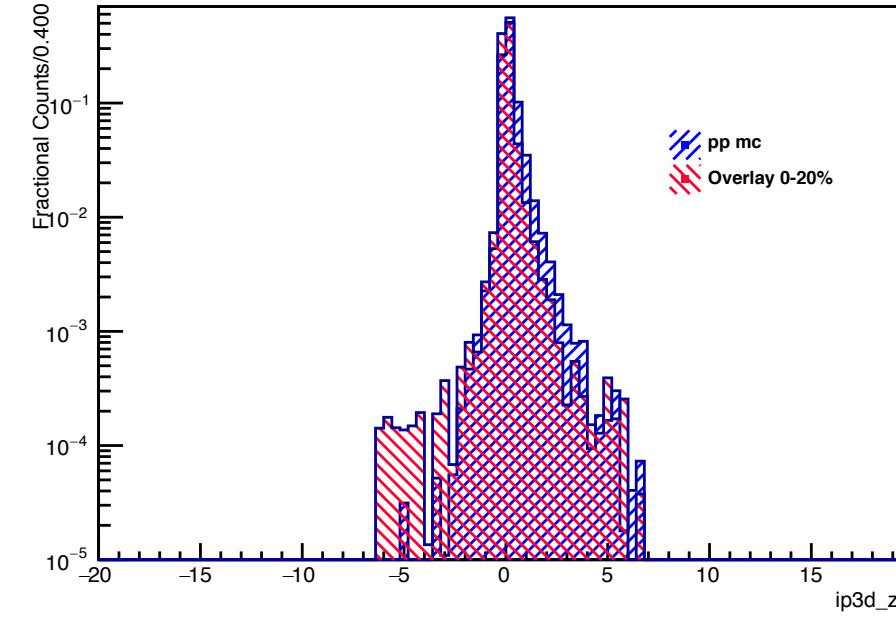


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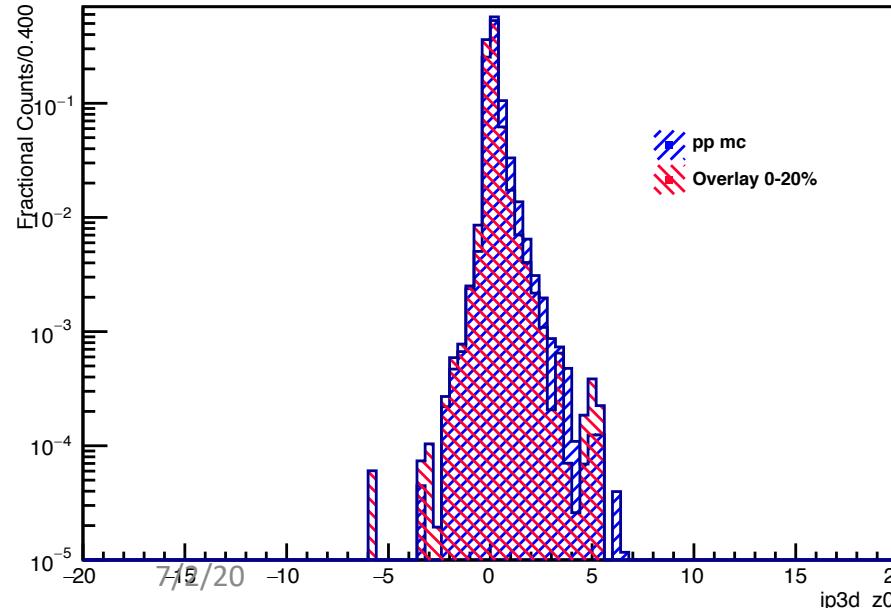
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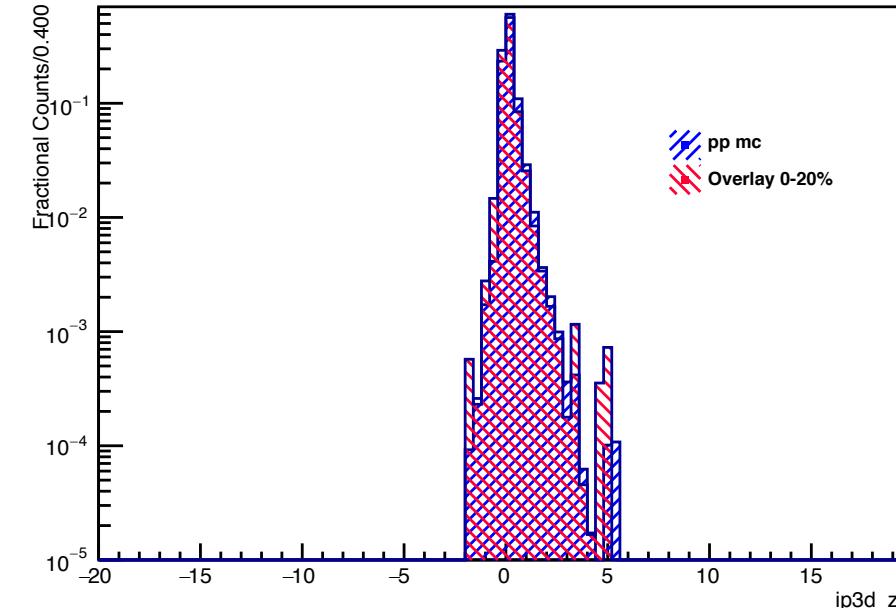
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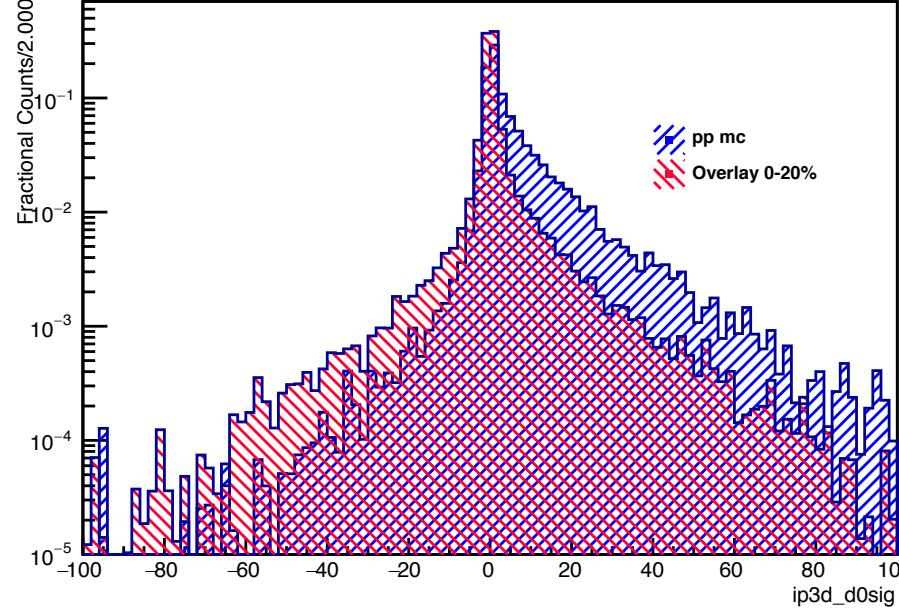
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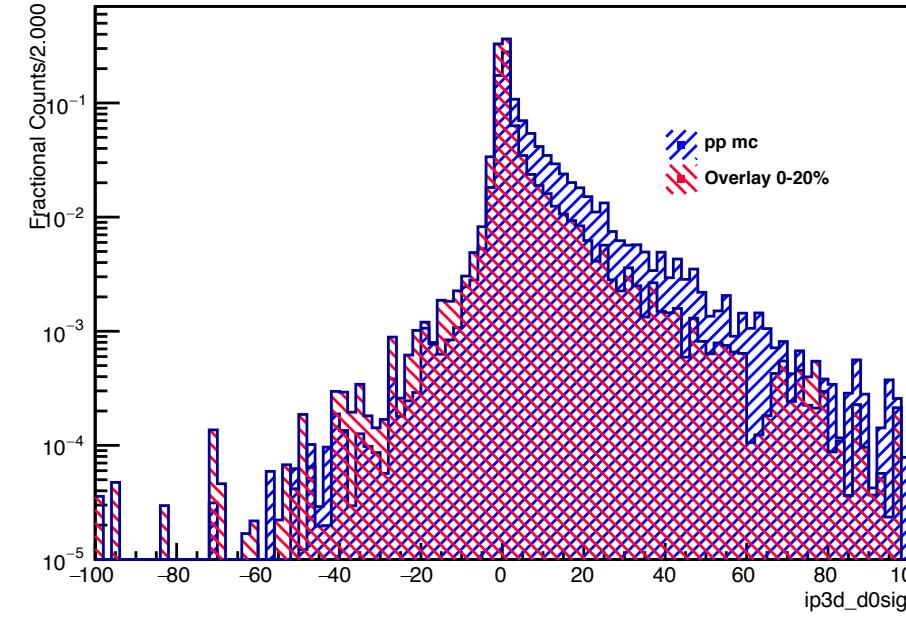
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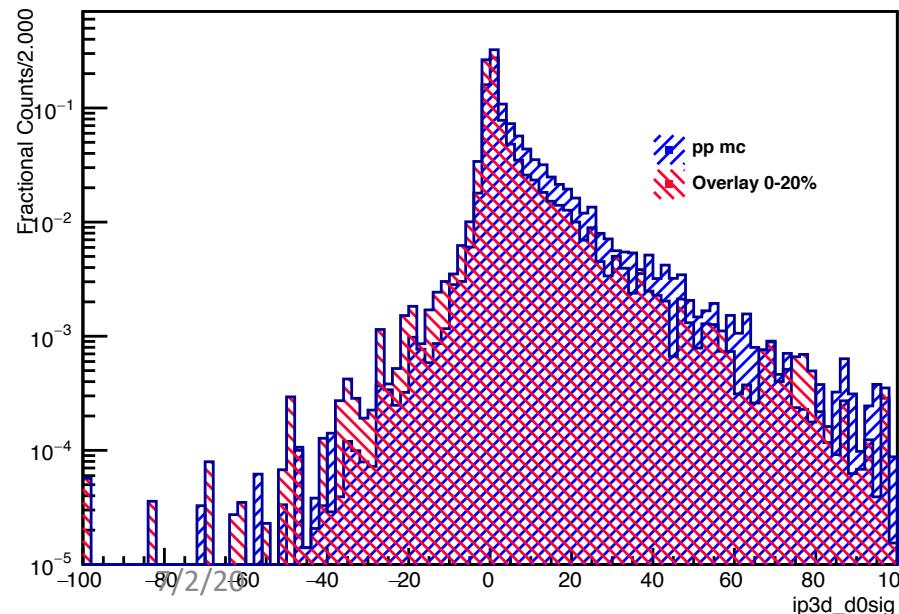
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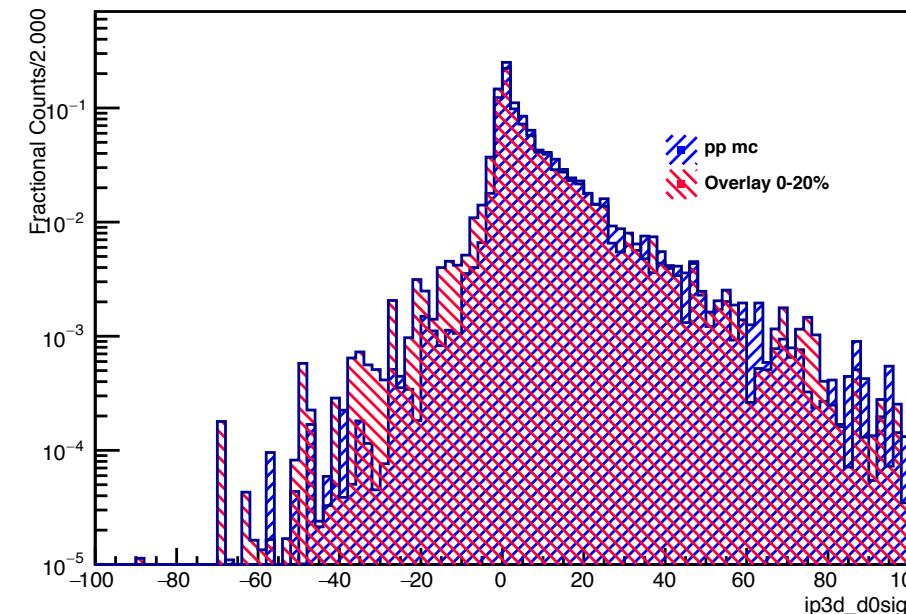
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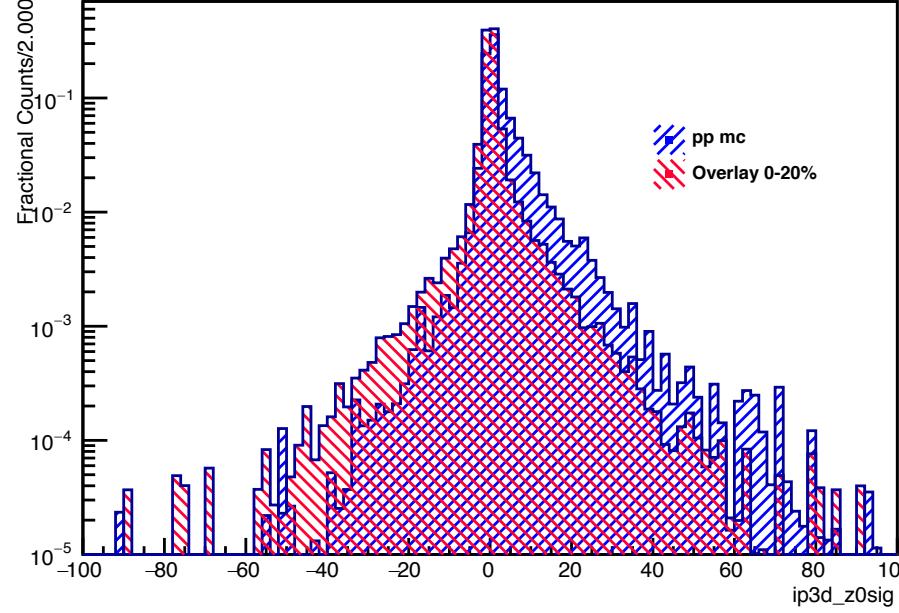
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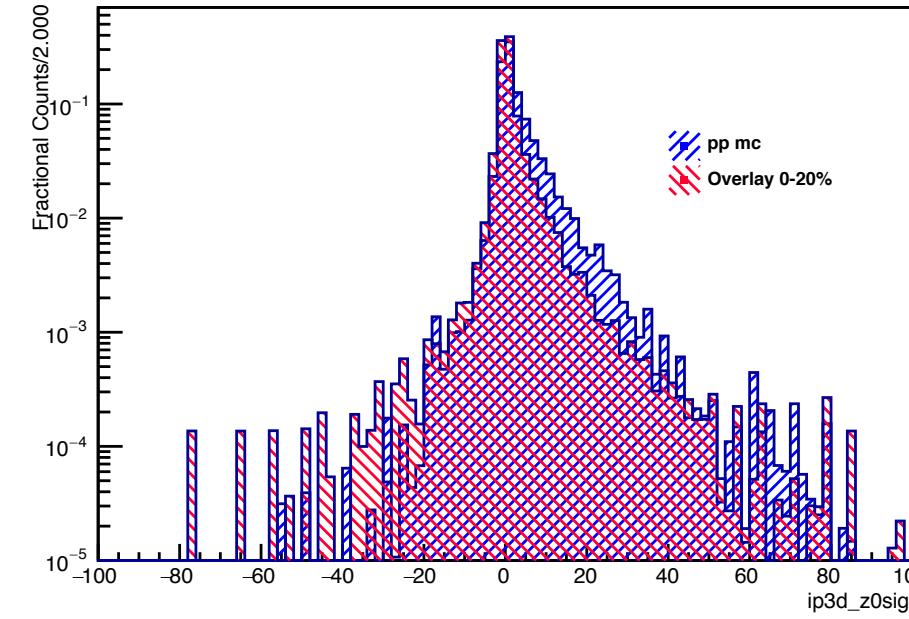
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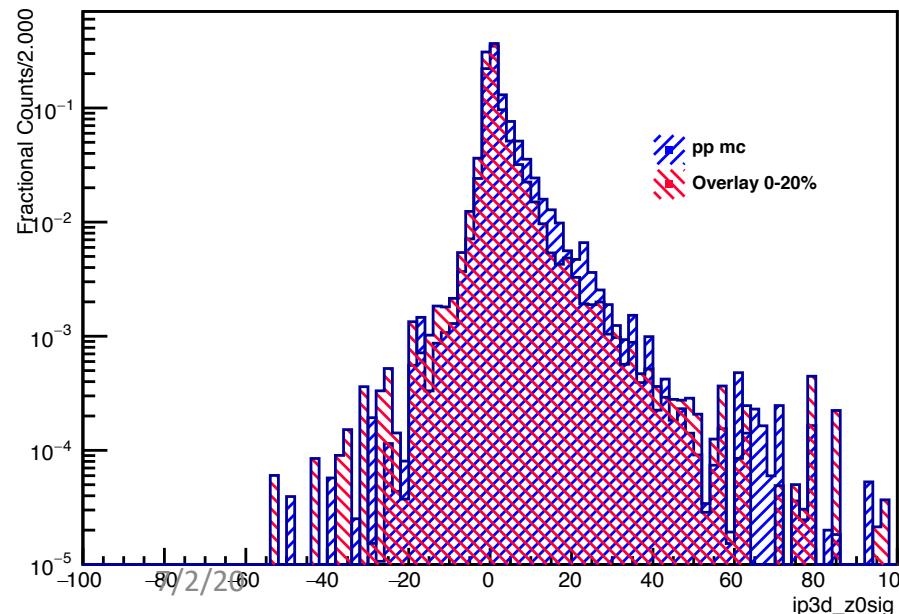
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Pre-tagging min pT 1.5 GeV FC4



Pre-tagging min pT 2 GeV FC4



Pre-tagging min pT 4 GeV FC4

