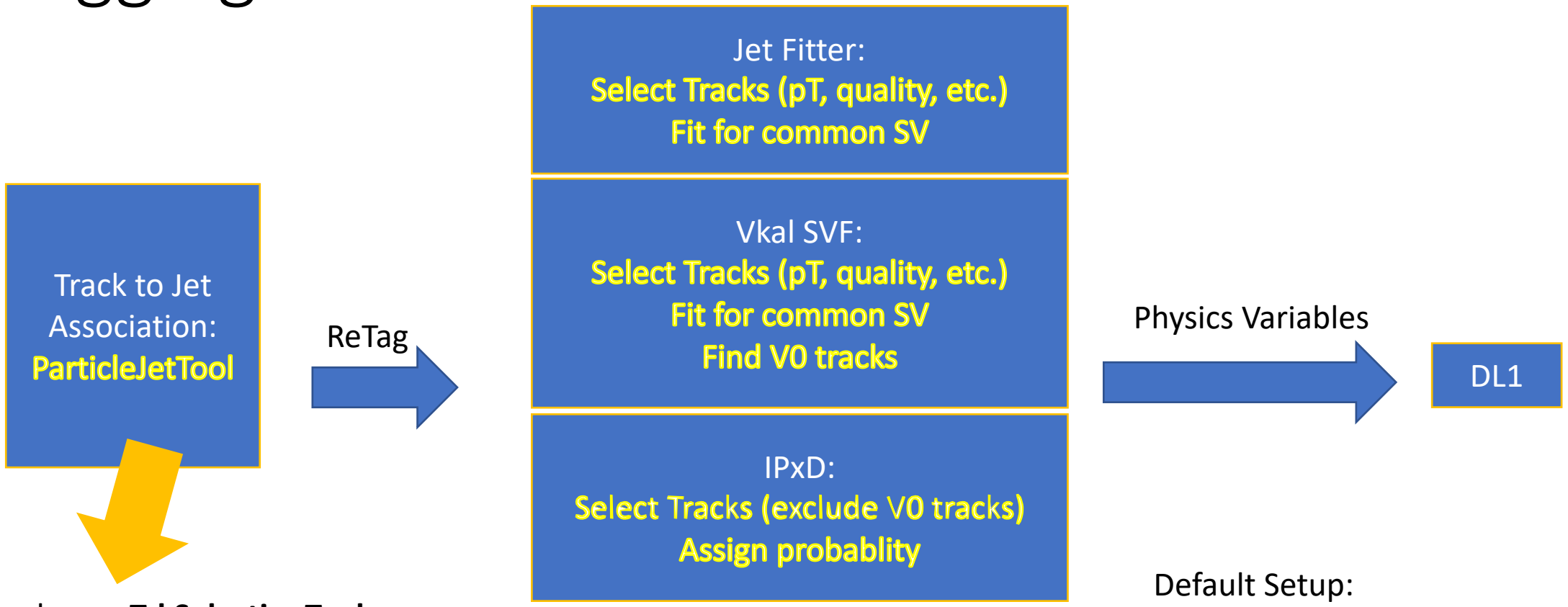
Plans

- 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

Default Setup:
Shrinking Cone, min track pT > 0.5 GeV

MC Samples

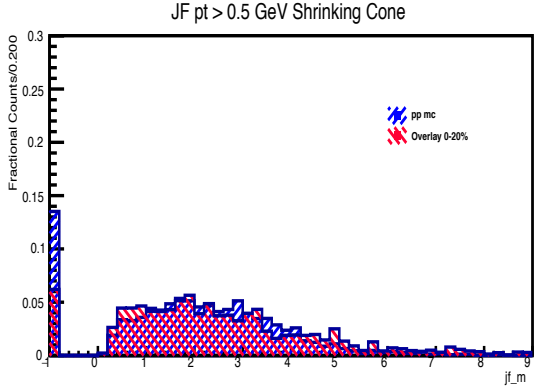
- pp MC and MC overlay (JetFitter and SV1 plots):
  - pp MC: 50k events (12.5k each for JZ1-JZ4) of pythia dijets events at 5.02 TeV, applied with bbar filter Selection on Jets.
  - Configuration file: https://gitlab.cern.ch/atlas-physics/pmg/infrastructure/mc15joboptions/blob/master/share/DSID420xxx/MC15.420271.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ1_bbfilter.py
  - 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
  - Pythia8 dijets - 8M per sample in 21.0.93

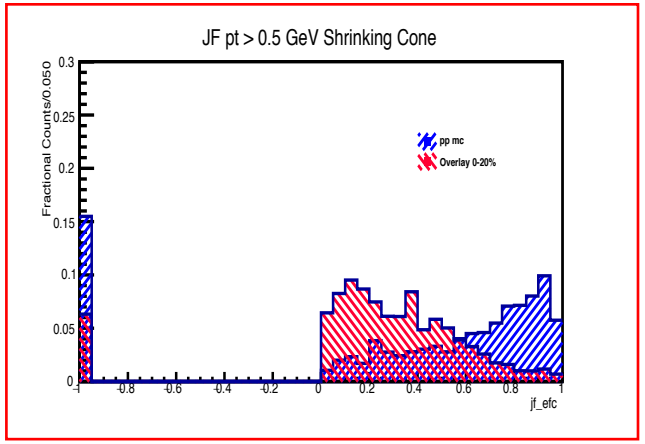
- Selection on Jets:
  - Reco jets with ΔR(truth-reco) < 0.3
  - $p_T^{truth\ jet} > 50$ GeV or 100 GeV (see back up plots)

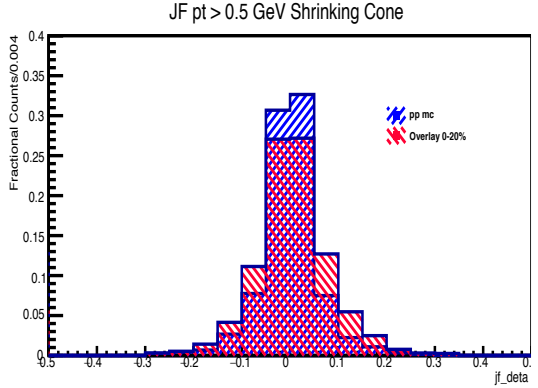
- B-Jets: jets with a truth B hadron associated with it. Similarly for C-jets
  - $p_T^B > 5$ GeV
  - ΔR(jet-BHadron) < 0.3

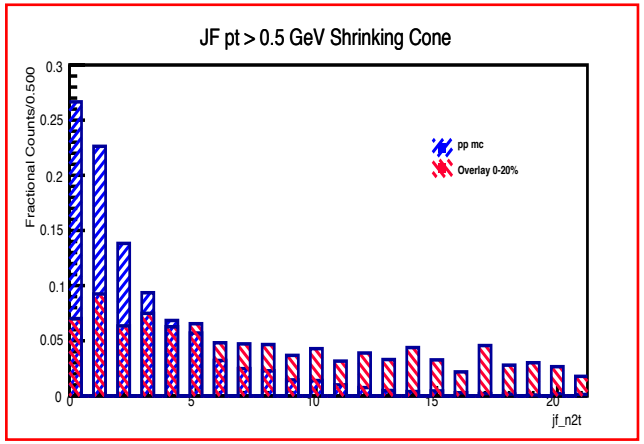
- Tool: https://gitlab.cern.ch/stapiaar/tagging_framework_hi/tree/master/
  - The most updated modified version is at https://gitlab.cern.ch/xiaoning/hiretagging_framework

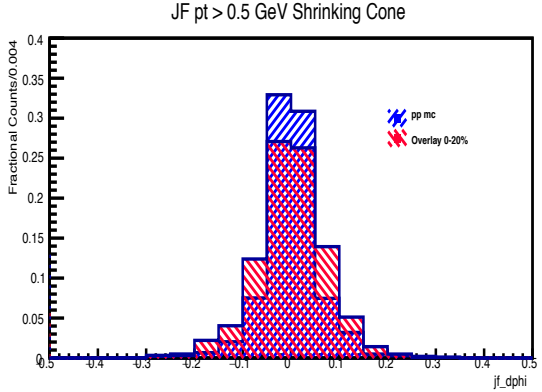
JF Variables at Default Setup

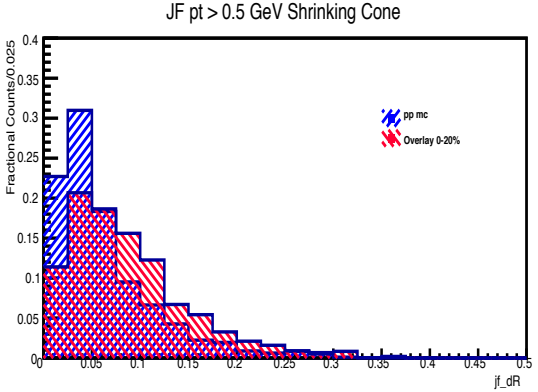


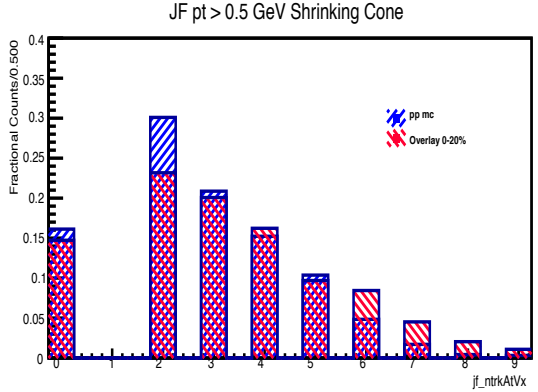




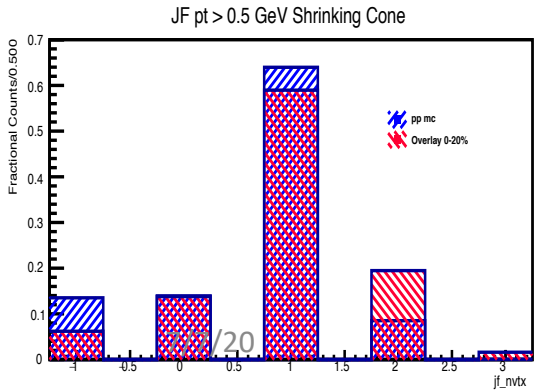


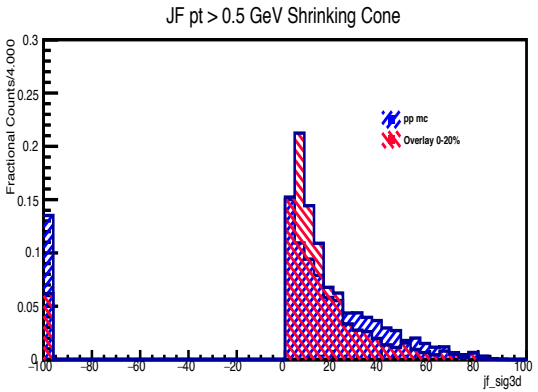


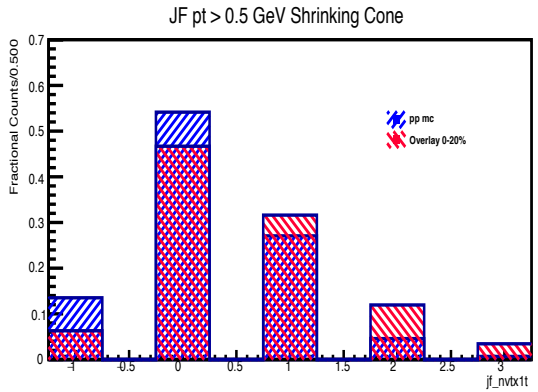




- Energy fraction and number of 2-track vertices are heavily modified.



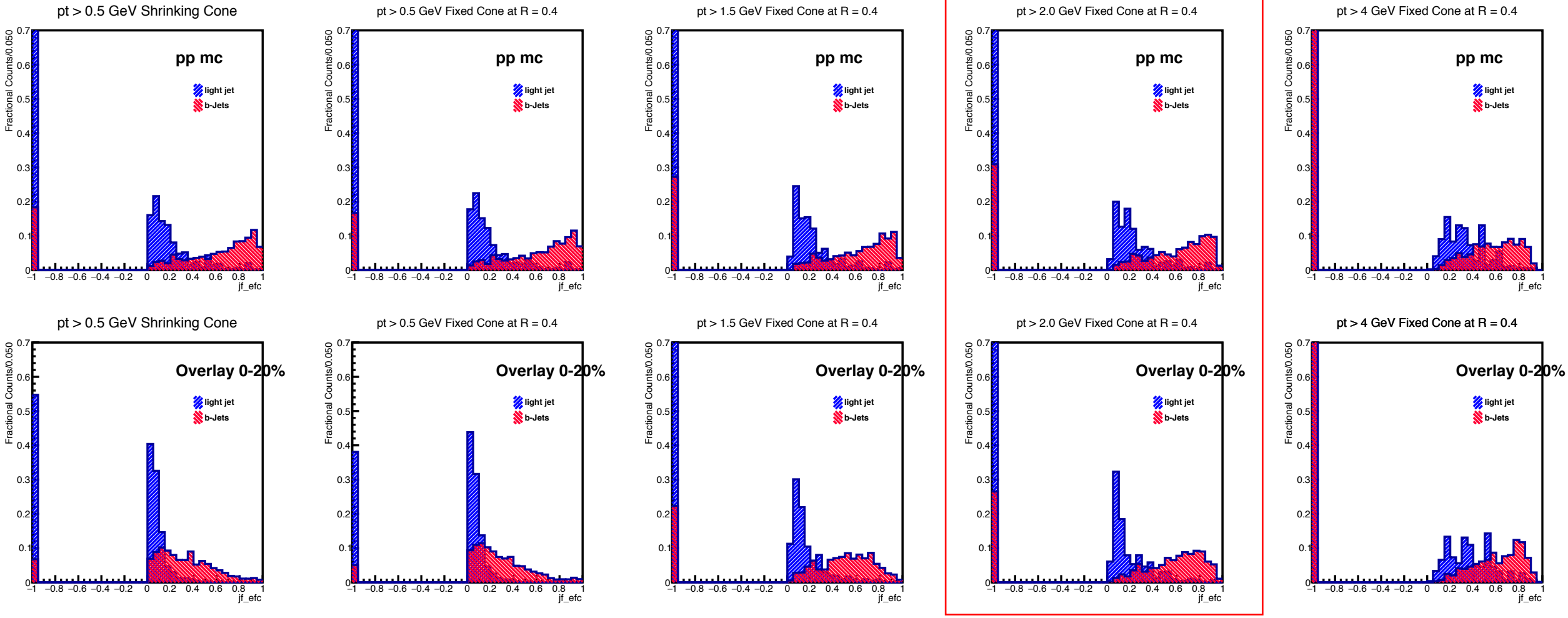




JF Energy Fraction

↓ 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:

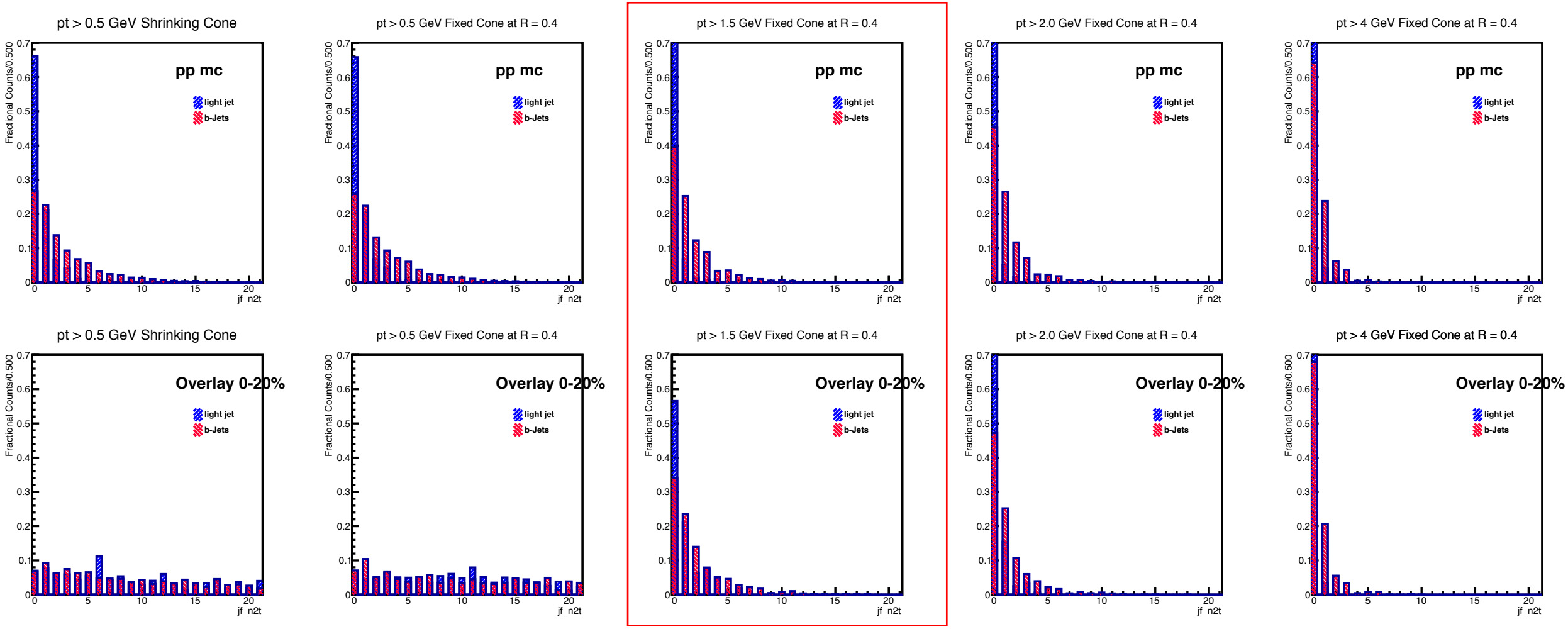
1. No pT Shrinking Cone
2. No pT Fixed Cone
3. Min pt = 1.5 GeV Fixed Cone
4. Min pt = 2.0 GeV Fixed Cone
5. Min pT = 4.0 GeV Fixed Cone

Red: b-jet

Blue: light jet

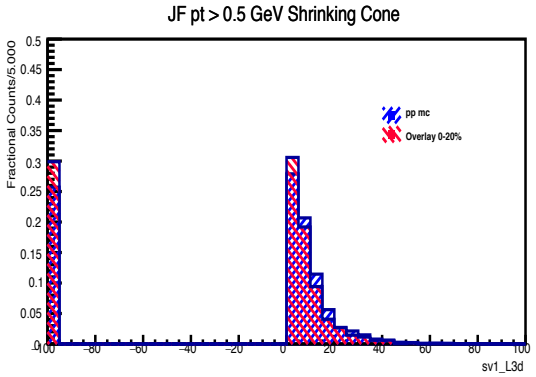
JF n2t (2-trk vertices candidates)

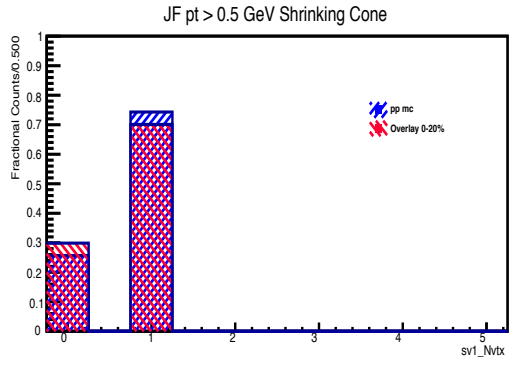
↓ over cutting leaves too few bins

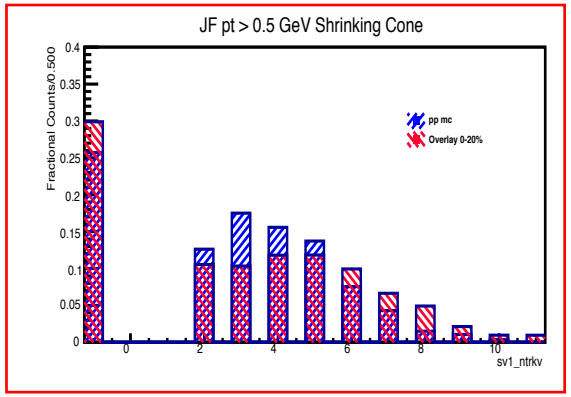


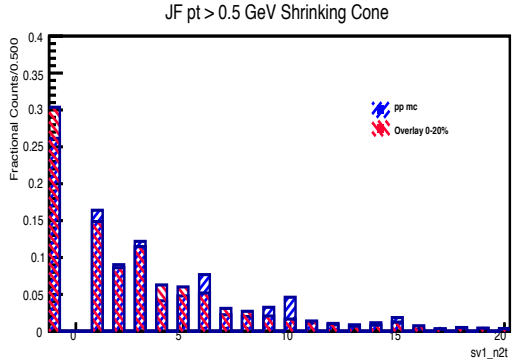
- Before applying cuts in pt, distribution is even, possibly for combinatorics of UE tracks.
- Starting at 1.5 GeV or above, overlay have a similar distribution as pp.

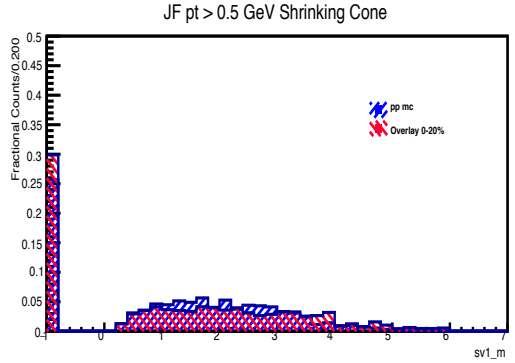
SV Variables at Default Setup

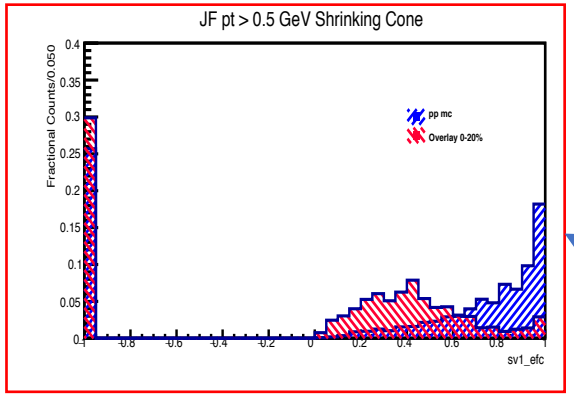


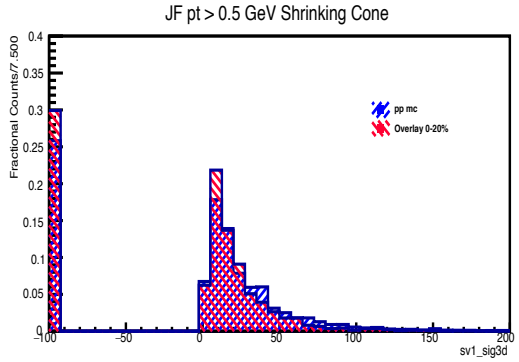


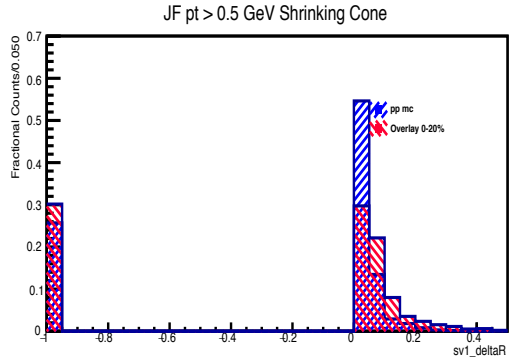


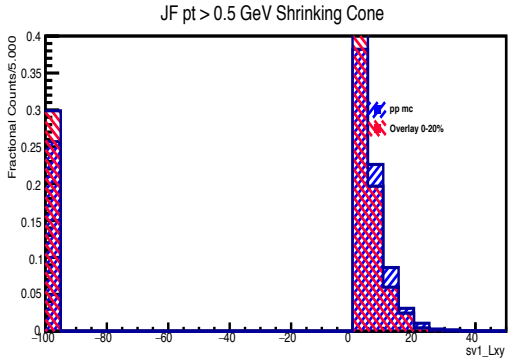






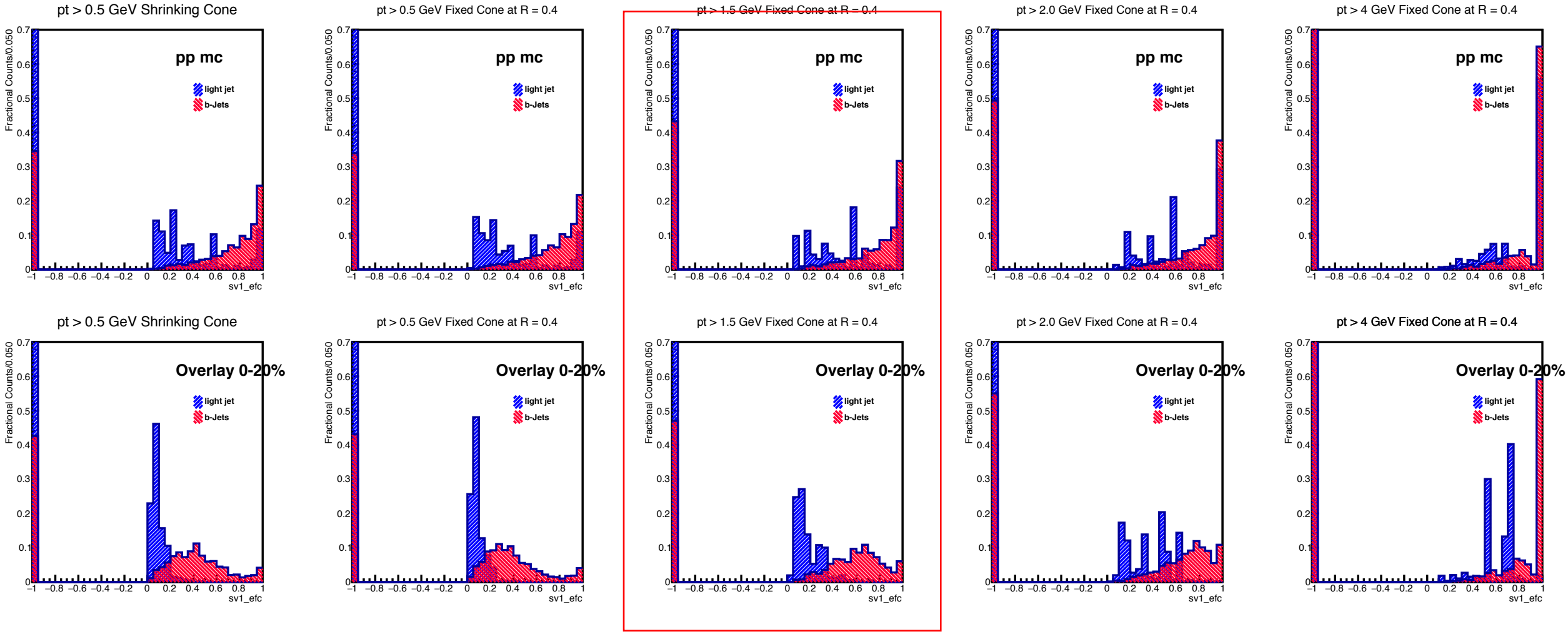






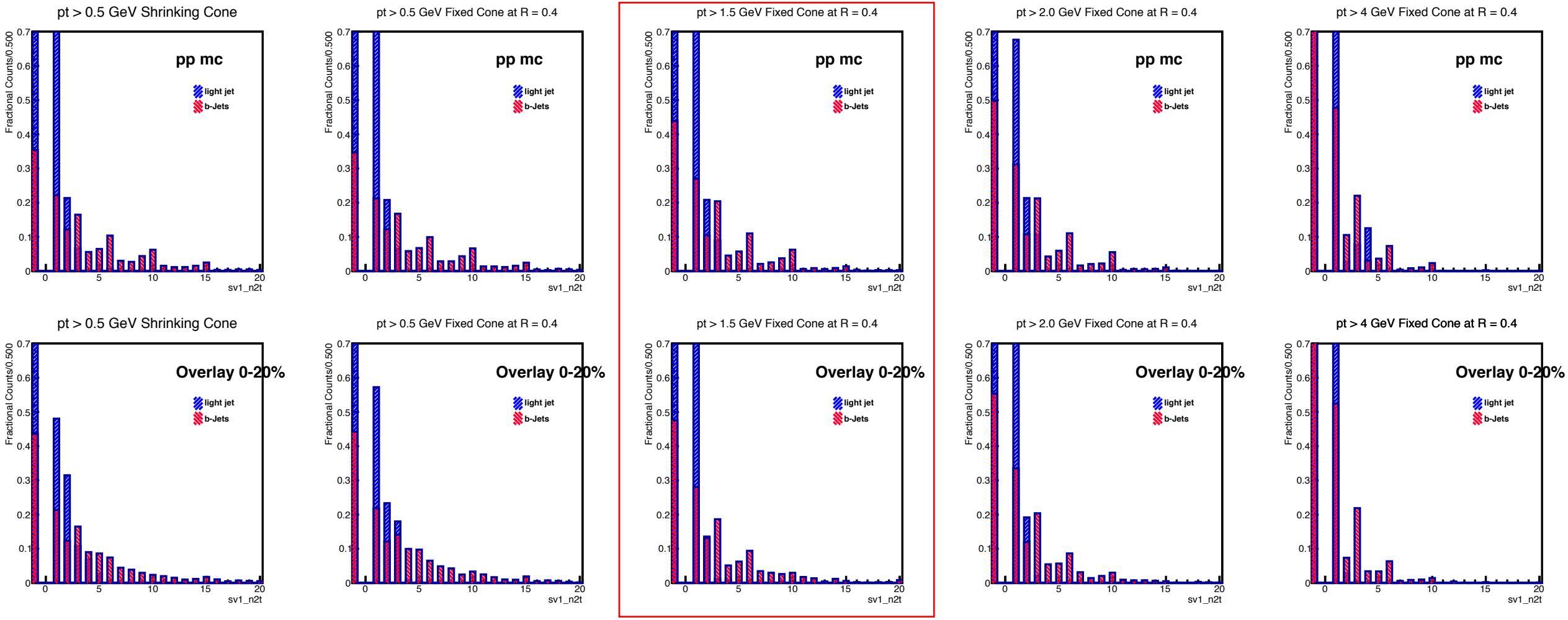
- Energy fraction and number of 2-track vertices are heavily modified.
- Peak at 1 is due to missing tracks. See back up slide 18.

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)

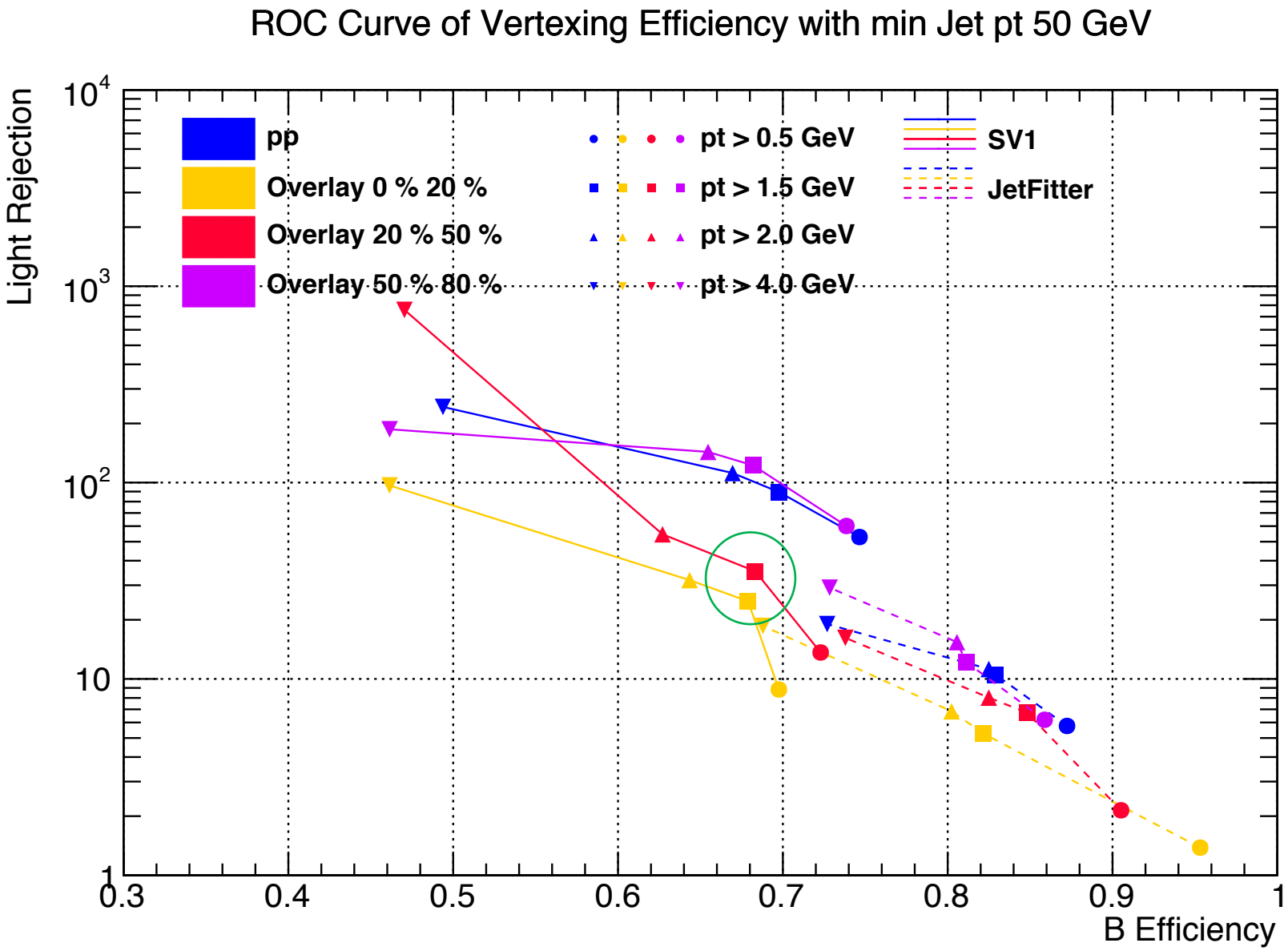


- 1.5 GeV or above cuts reduces light jet candidates in overlay to 1 or 0

↑ overcutting removes too many b-jets candidates as well

Secondary Vertexing Performance for JetFitter and SVF

ROC curve for JF and SV1 Vertexing Efficiency



- 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

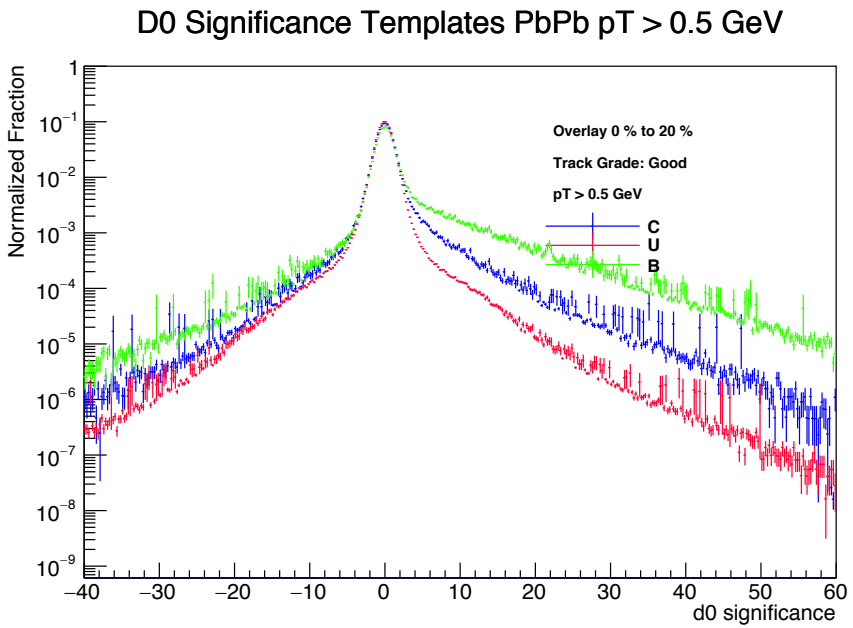
- What else can we tell from the plot?
  - JetFitter is better in efficiency and worse in rejection than SV
  - Ideas on how to choose the best cut?

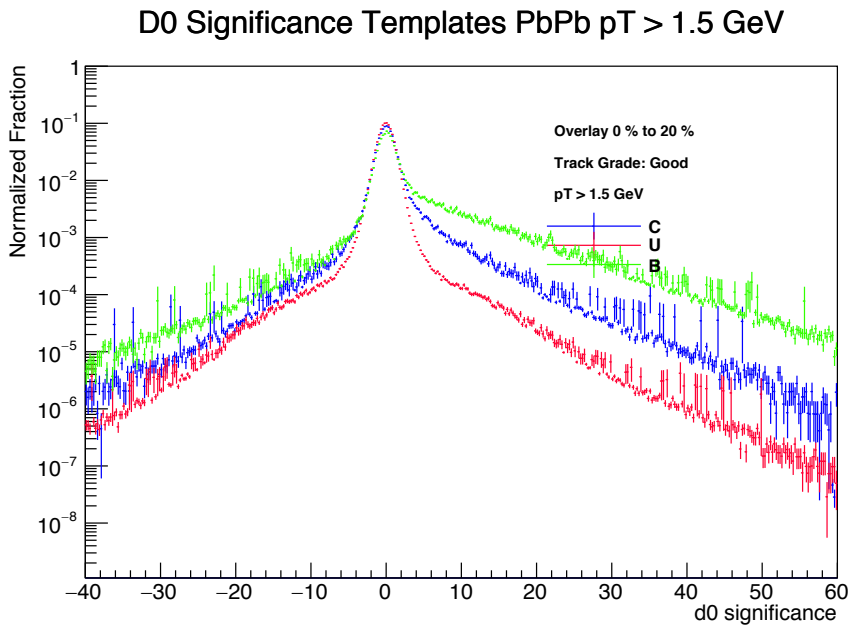
IP3D Templates Remaking

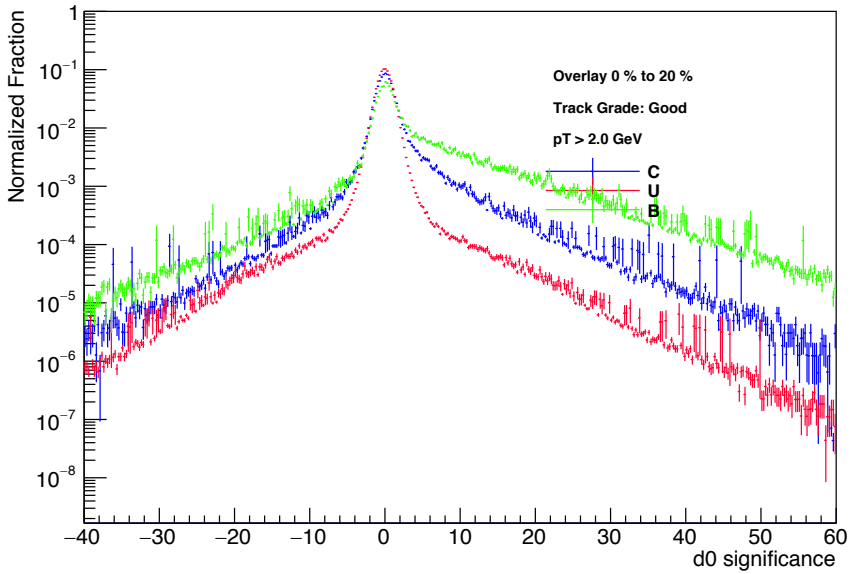
- Made templates with 8M inclusive dijet samples
- Jets selection:
  - pT > 50 GeV; 100 GeV
  - Truth matched
  - Rapidity < 2.1
  - Default JVT (Jet Vertex Tagger)* score related requirements
    - JVT is used to suppress pile-up interactions, will shut this down in future templates making
  - Flavour Labelling in templates:
    - jet_LabDr_HadF branch in the ntuple
    - based on dR < 0.3, requiring min hadron pT > 5 GeV, implemented in ParticleJetTools.
  - Retraining: make new templates with 8M sample and use these templates for evaluating the same MC.

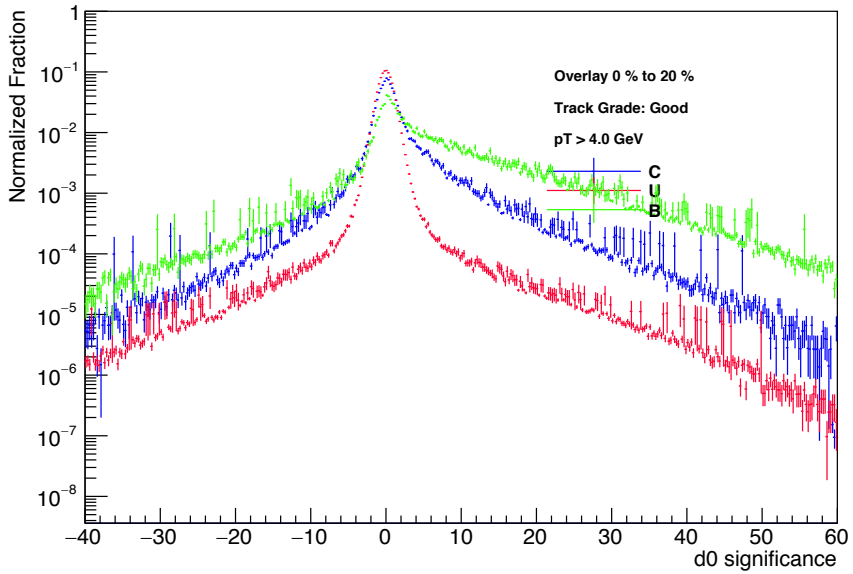
*:ATLAS Collaboration, Tagging and suppression of pileup jets with the ATLAS detector, ATLAS-CONF-2014-018, url: https://cds.cern.ch/record/1700870.

New Templates Making

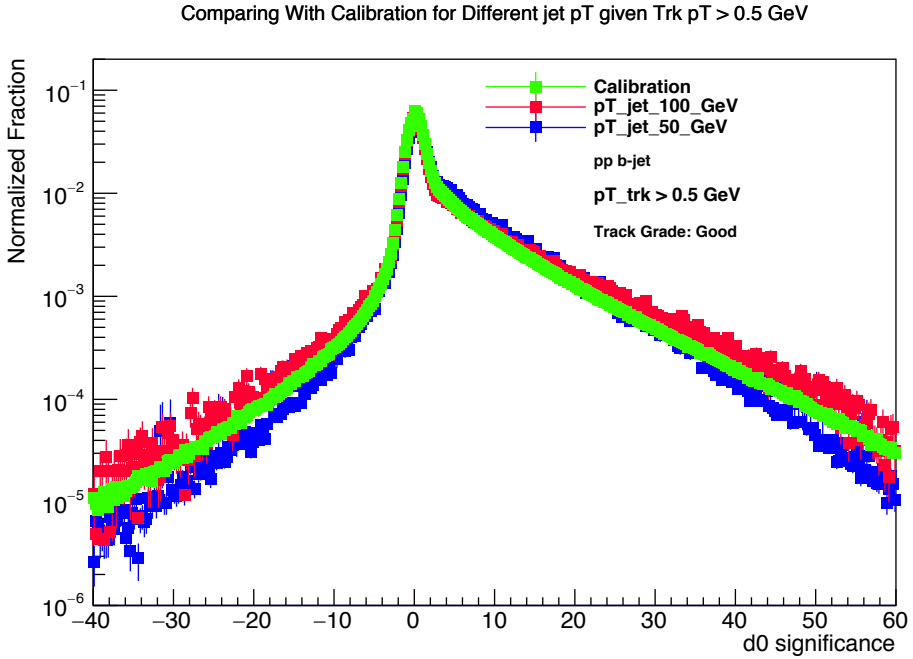


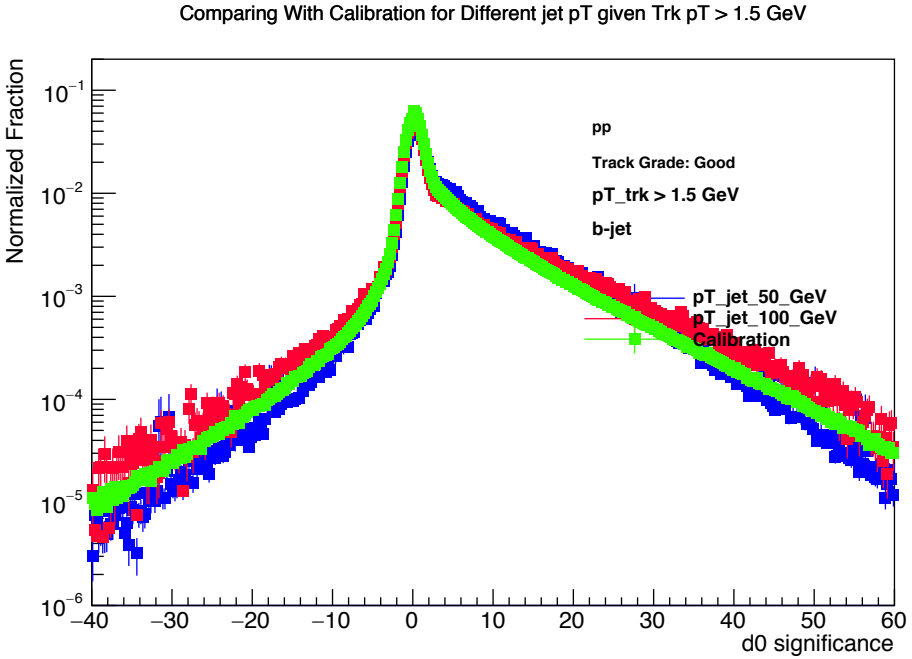


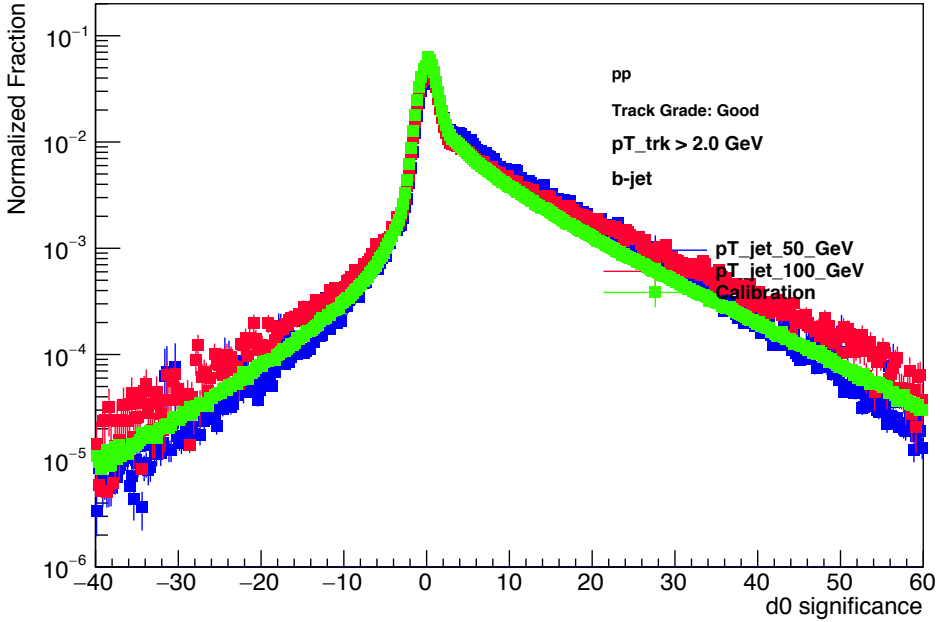


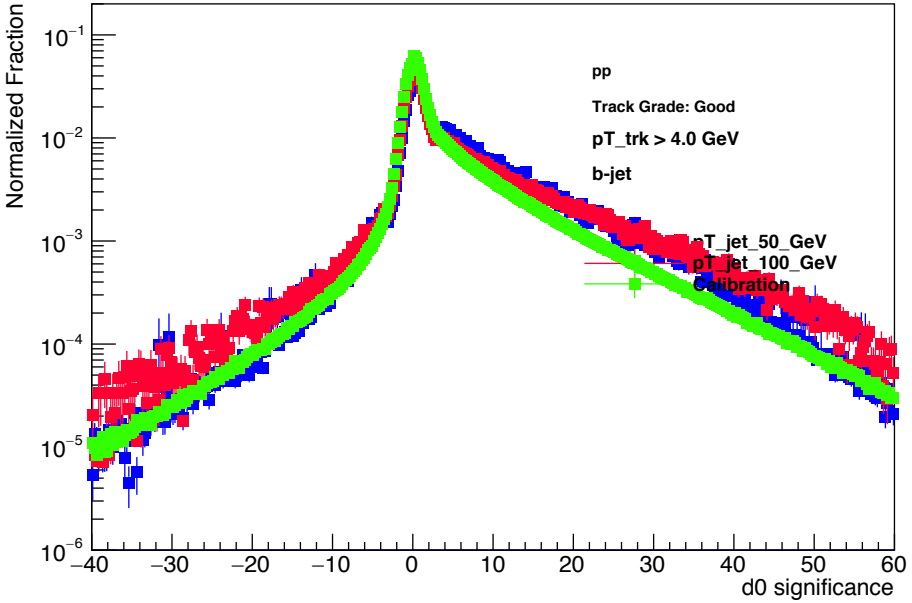


Comparison to calibration templates

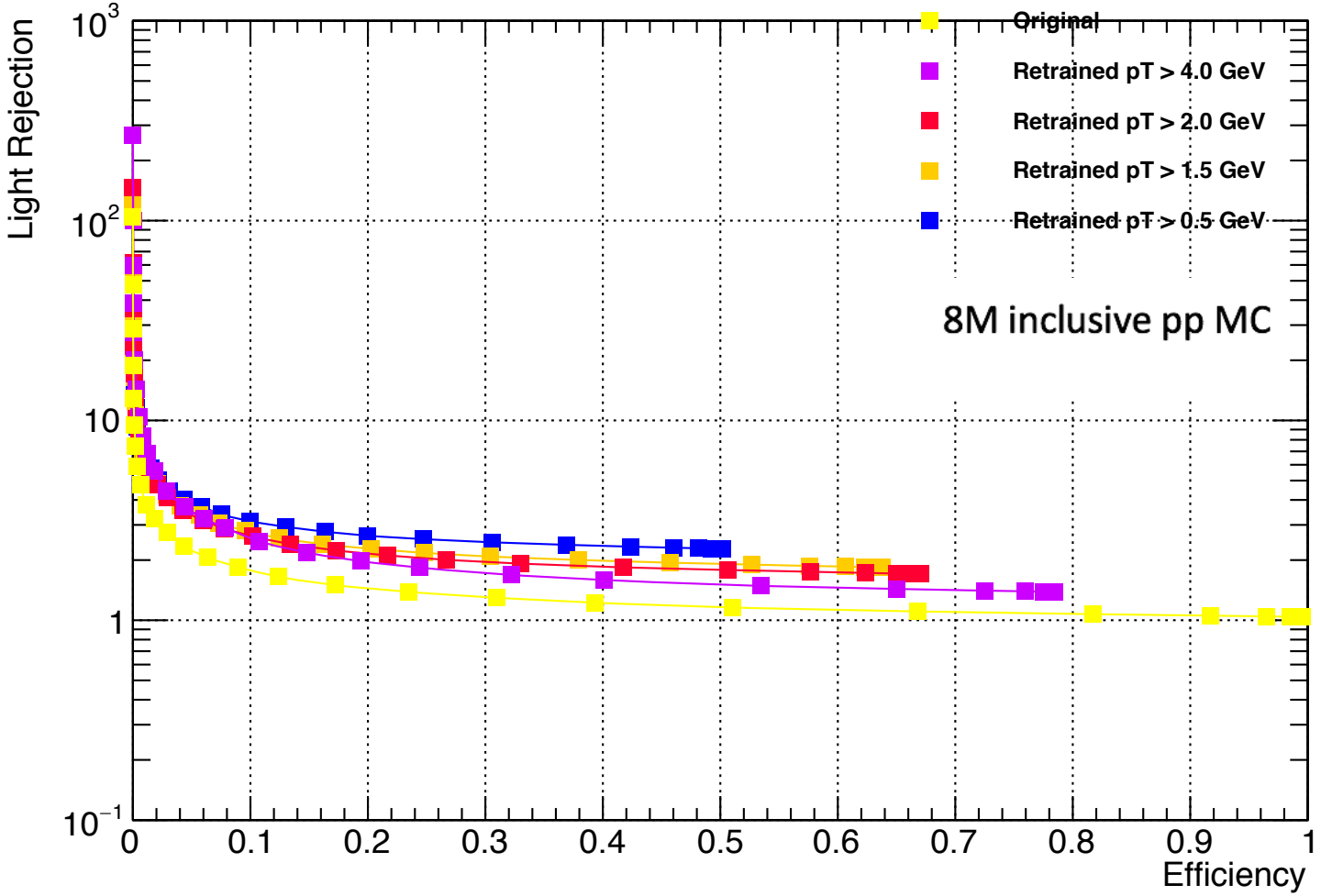








IP3D ROC curve with pp

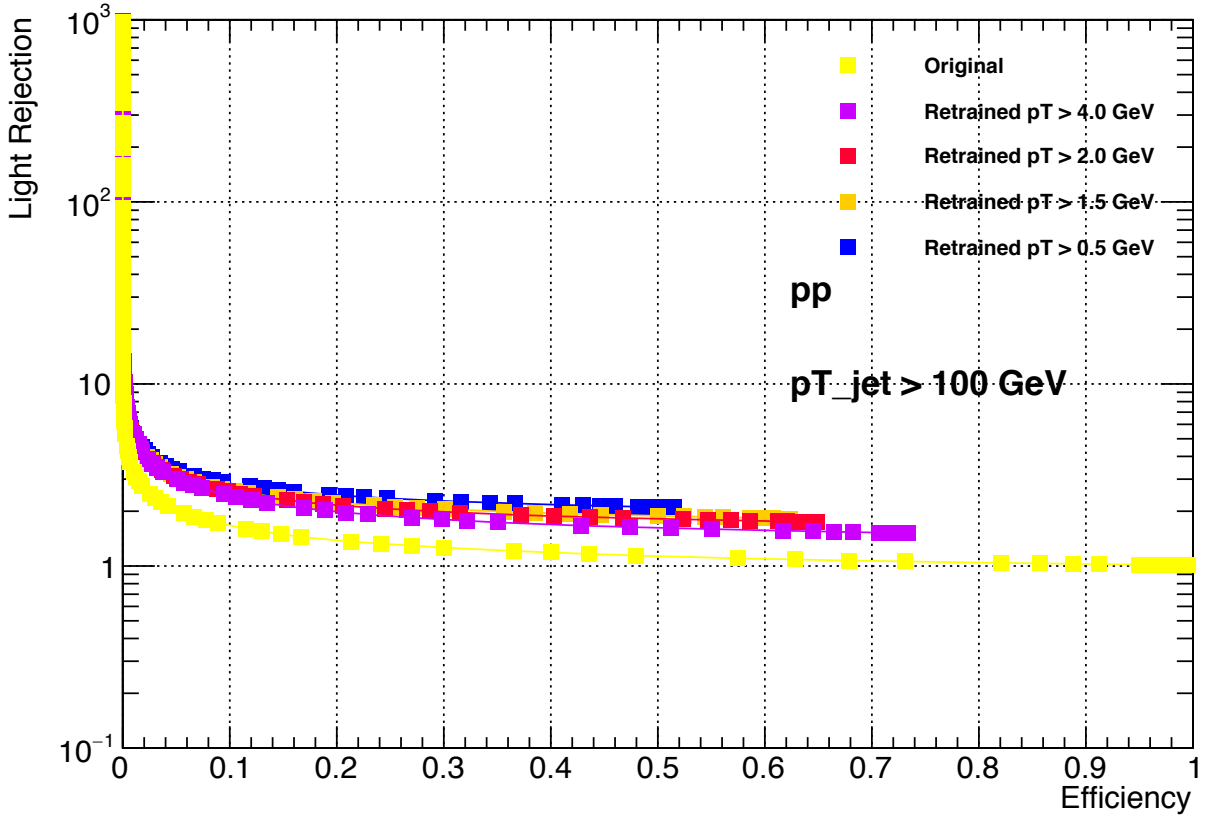


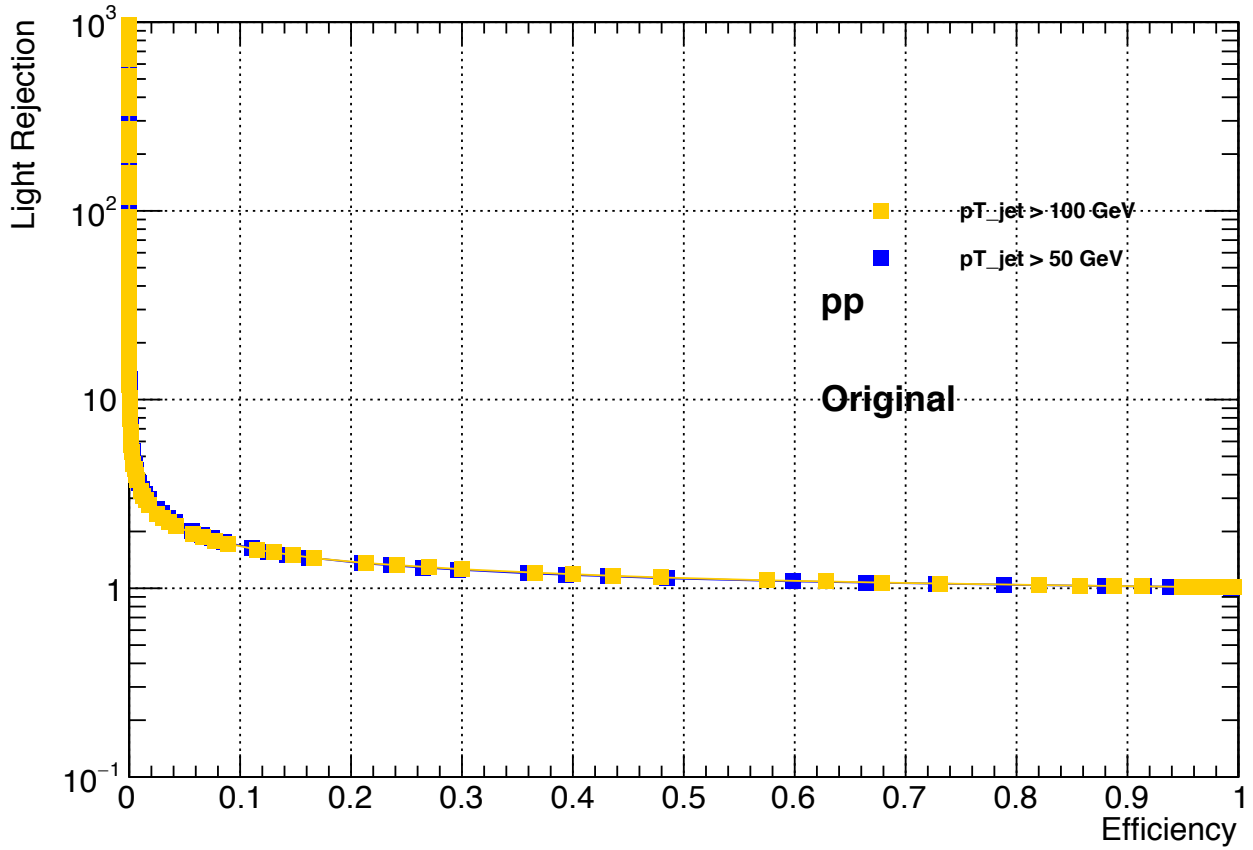
- Performance is not good :/
- With efficiency at 0.5, only have purity on the order of 1…
- Plan:
  - Double check the plots
  - Try fixed cone at 0.4 and PbPb
- Good new:
  - Retraining improves performance, and for pp, 0.5 GeV cuts seem the most reasonable.

Checklist

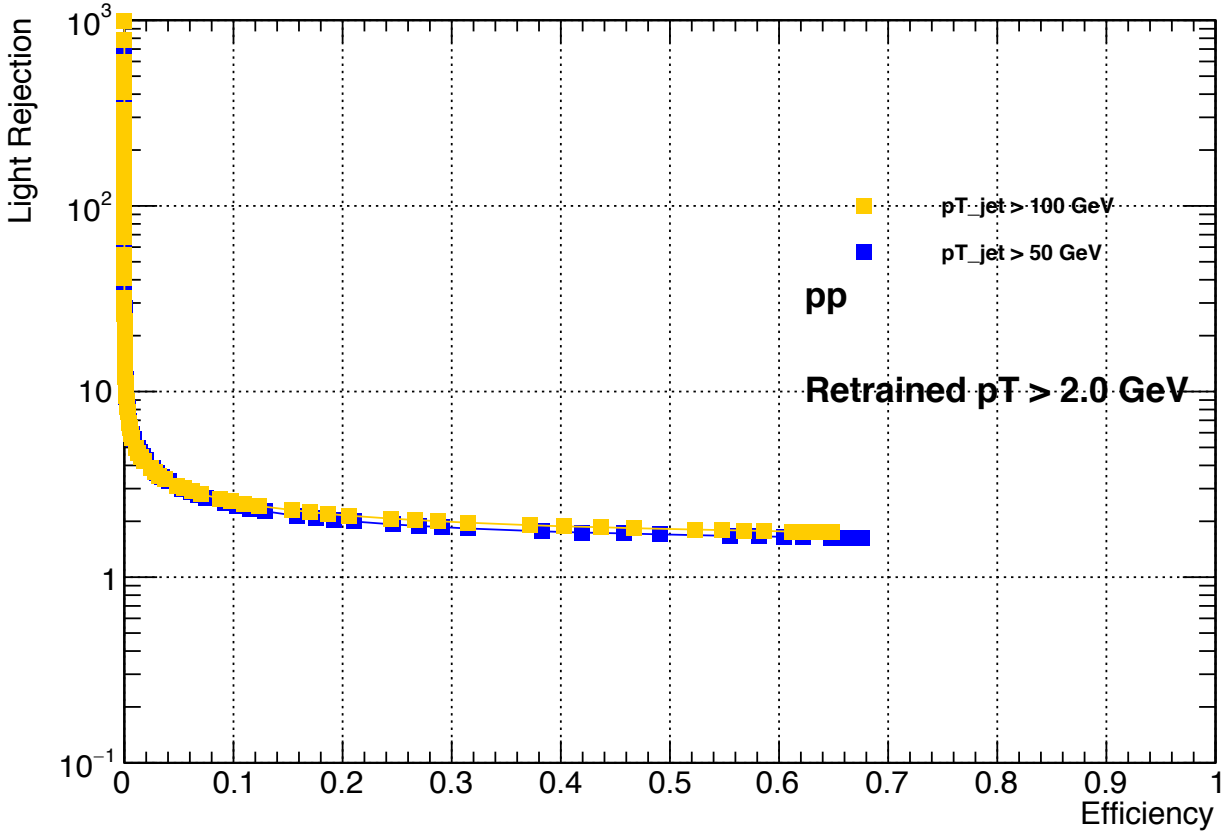
- Jet pT? (Slide 16 -17)
  - Jet pT > 50 GeV
  - Jet pT > 100 GeV
- Centrality? (Slide 18)
  - Is it just the pp samples? Compared most central at jet pT > 100 GeV with pp
- Samples? (Slide 18)
  - Compared small 50k samples to 8M inclusive samples
- Track quality? Other ideas?
- Look for single IPxD performance plots. (There’re none in the btagging performance papers, have it always been this bad??)

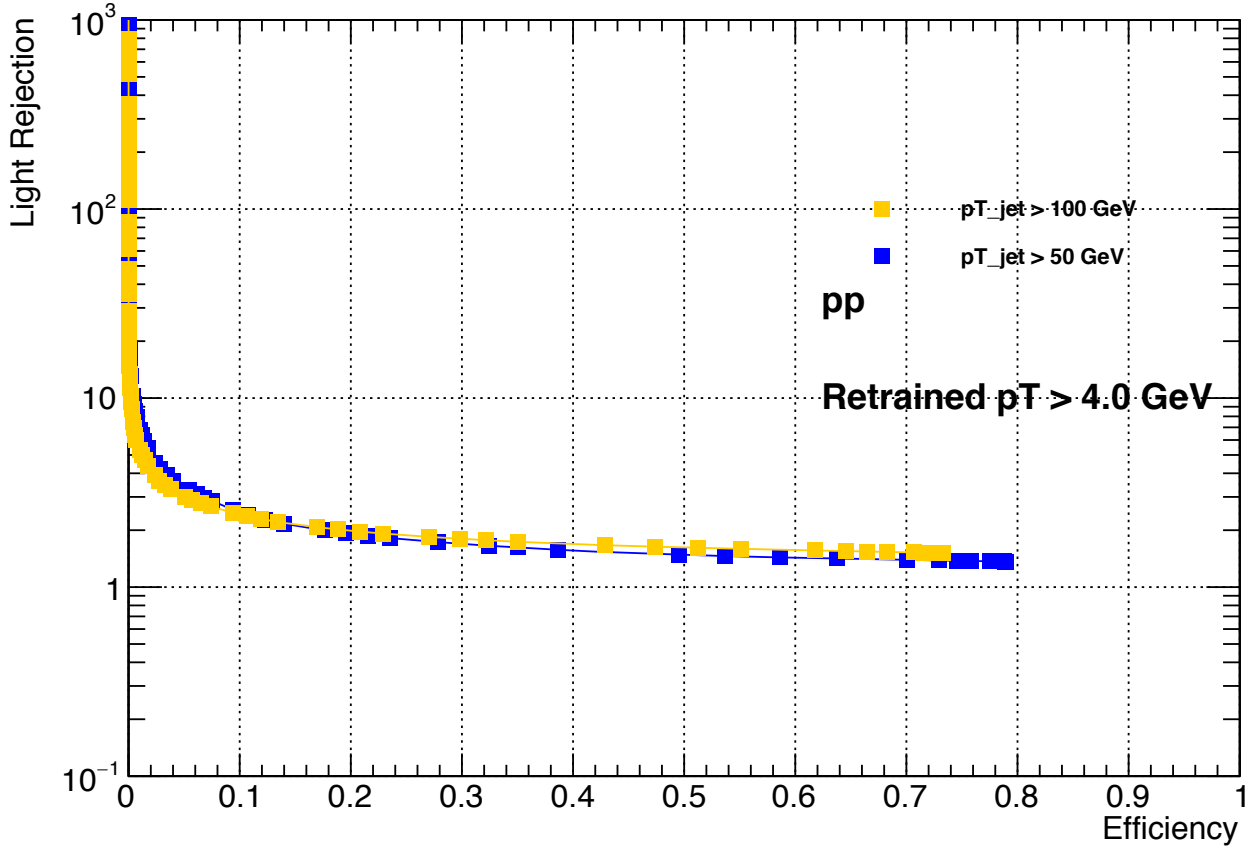
Different Jet pT comparisons





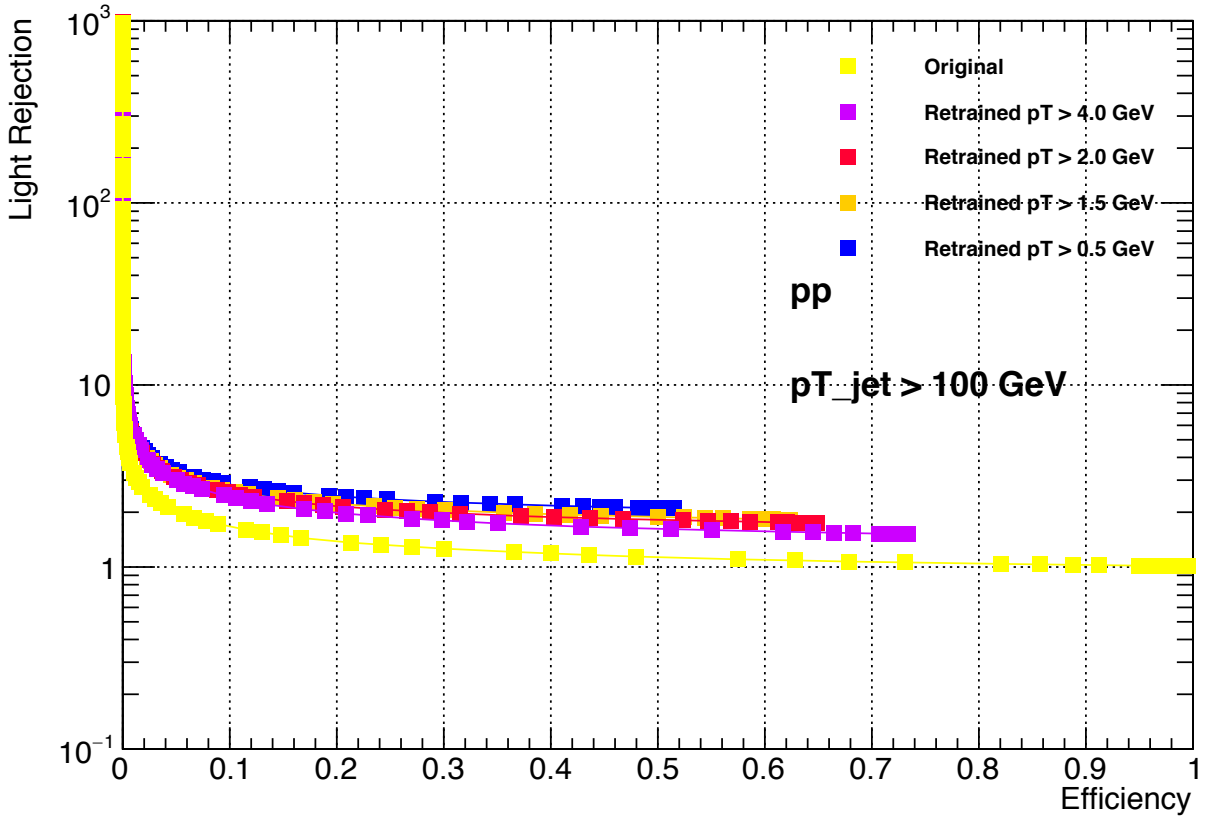
Original: evaluations from using the default calibration templates. (BTagCalibRUN2Onl-08-40.root, 2017 pp templates)
Retrained pT > xx GeV: evaluations from using inclusive samples' templates with the cut track pT > xx GeV and jet pT > xx GeV

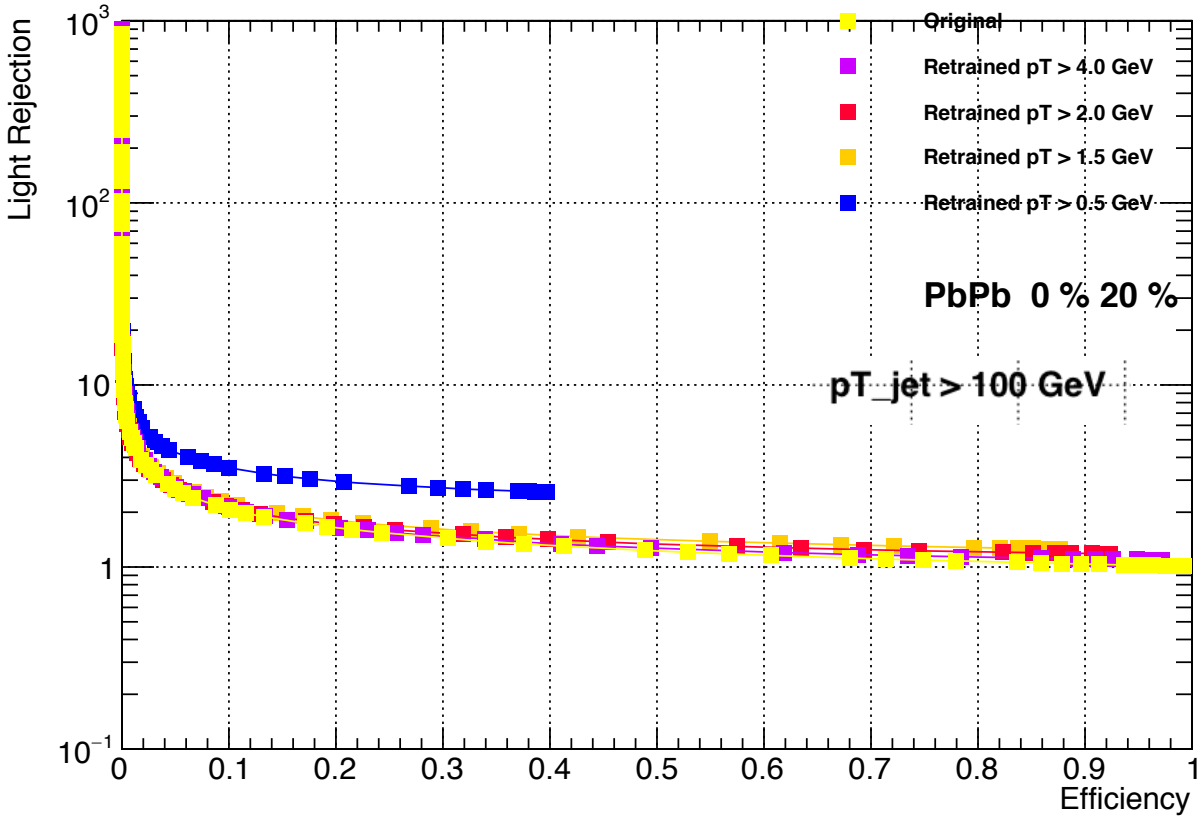




pT_jet > 100 GeV with the same llr cut threshold is better in purity but worse in efficiency, as expected
In general the performance is similarly bad.

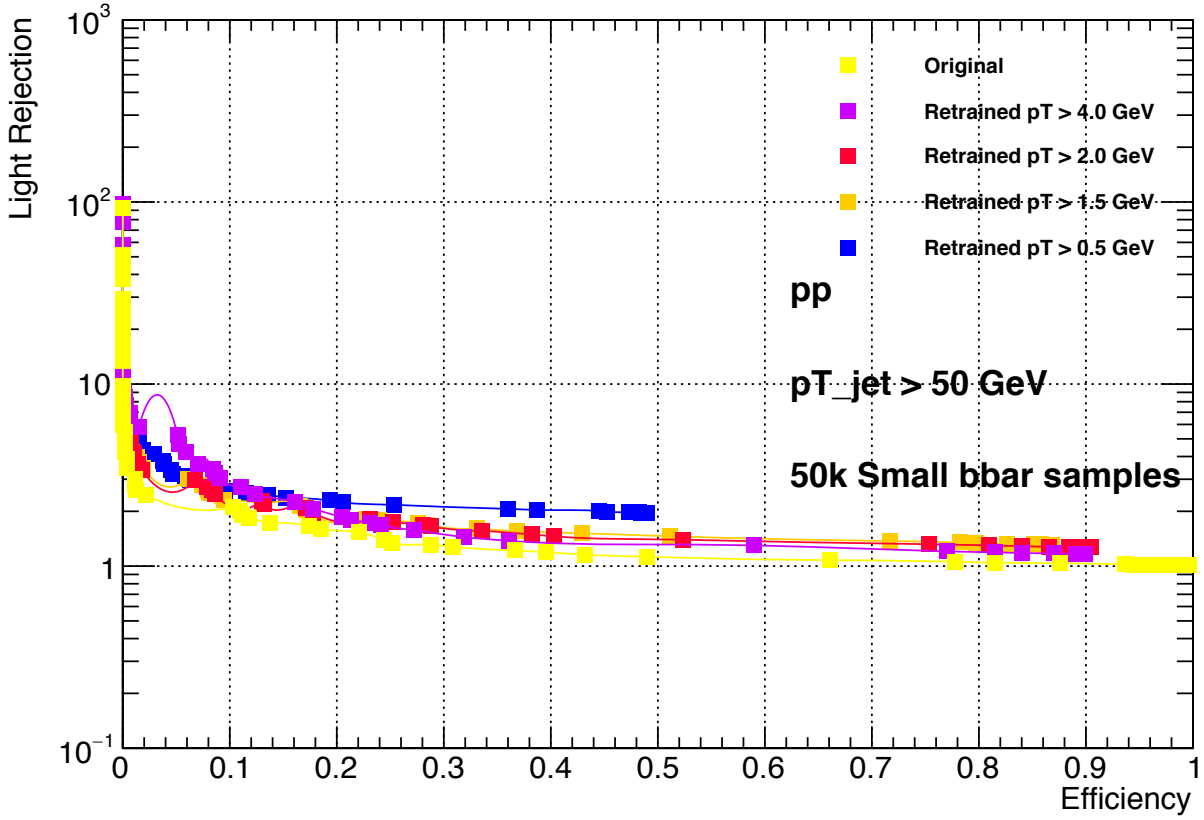
Comparison with PbPb (?)

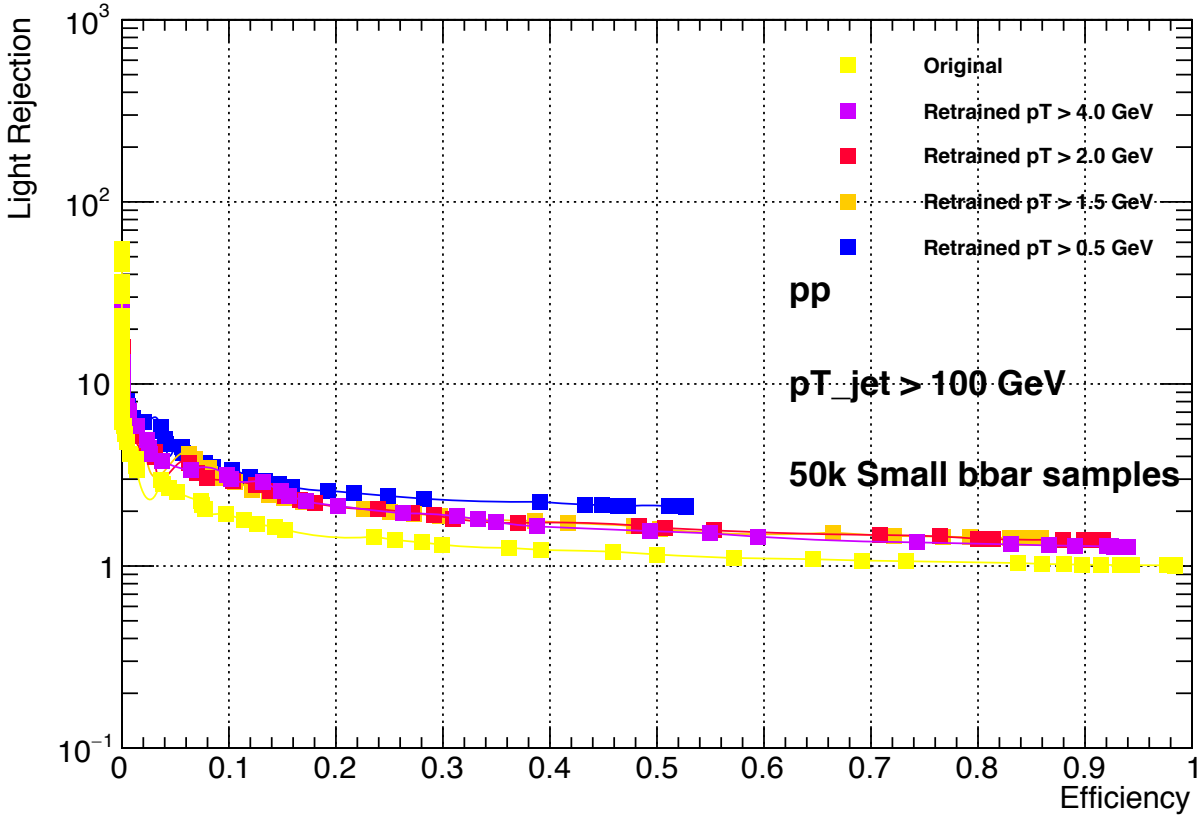




Most central events are better in light rejection but worse in efficiency if we don't cut on track pT. (??)
Others better in efficiency but worse in light rejection.

Comparison with Small samples





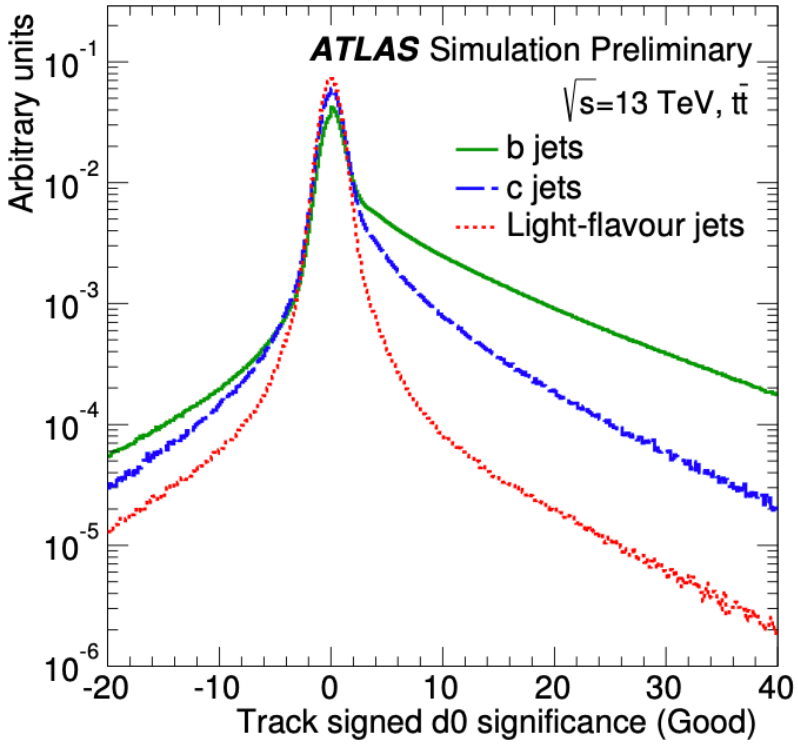
Small bbar samples: https://its.cern.ch/jira/browse/ATLHI-240
Performance is qualitatively similar to inclusive dijet samples.

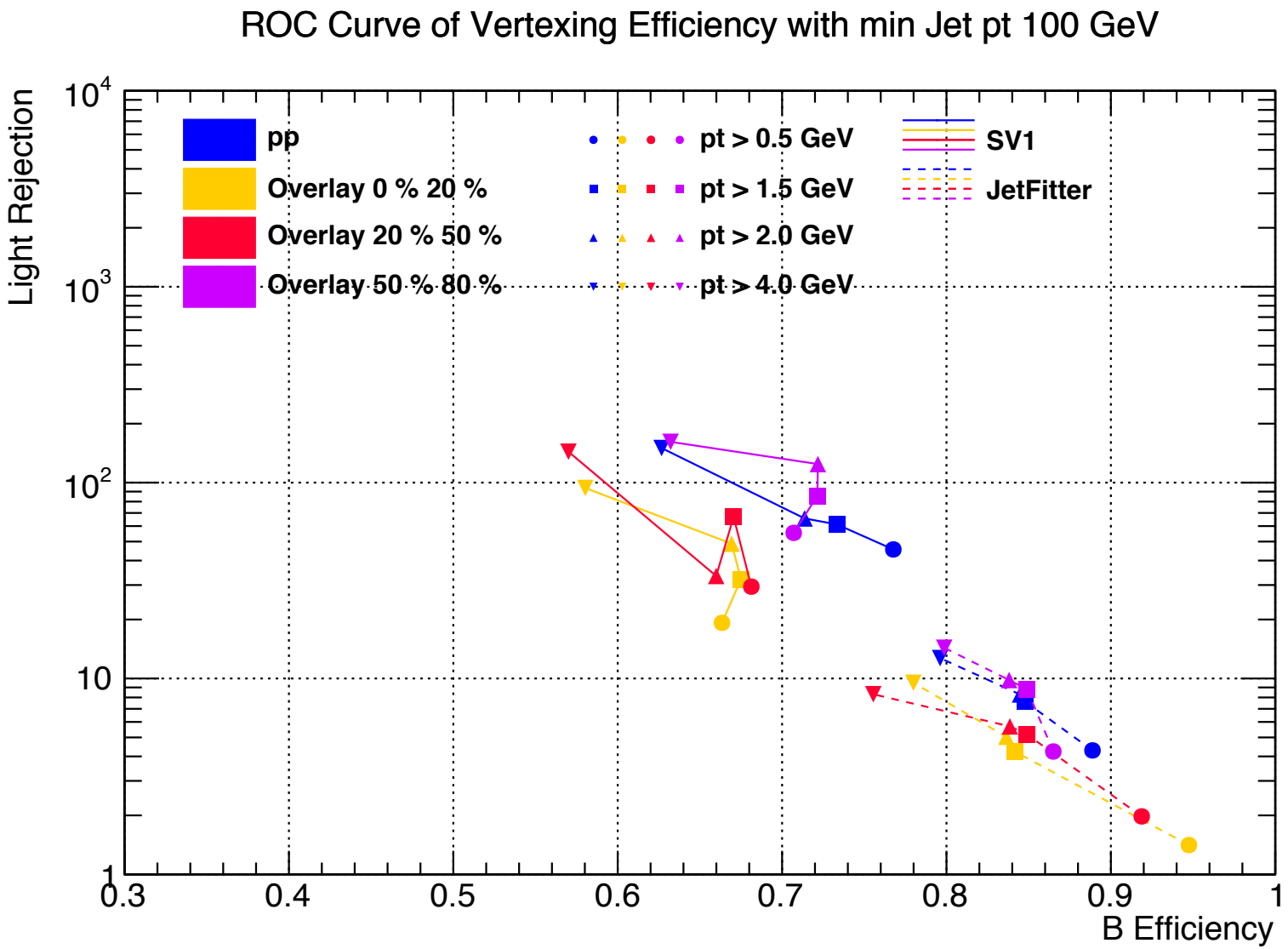
Summary

- 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

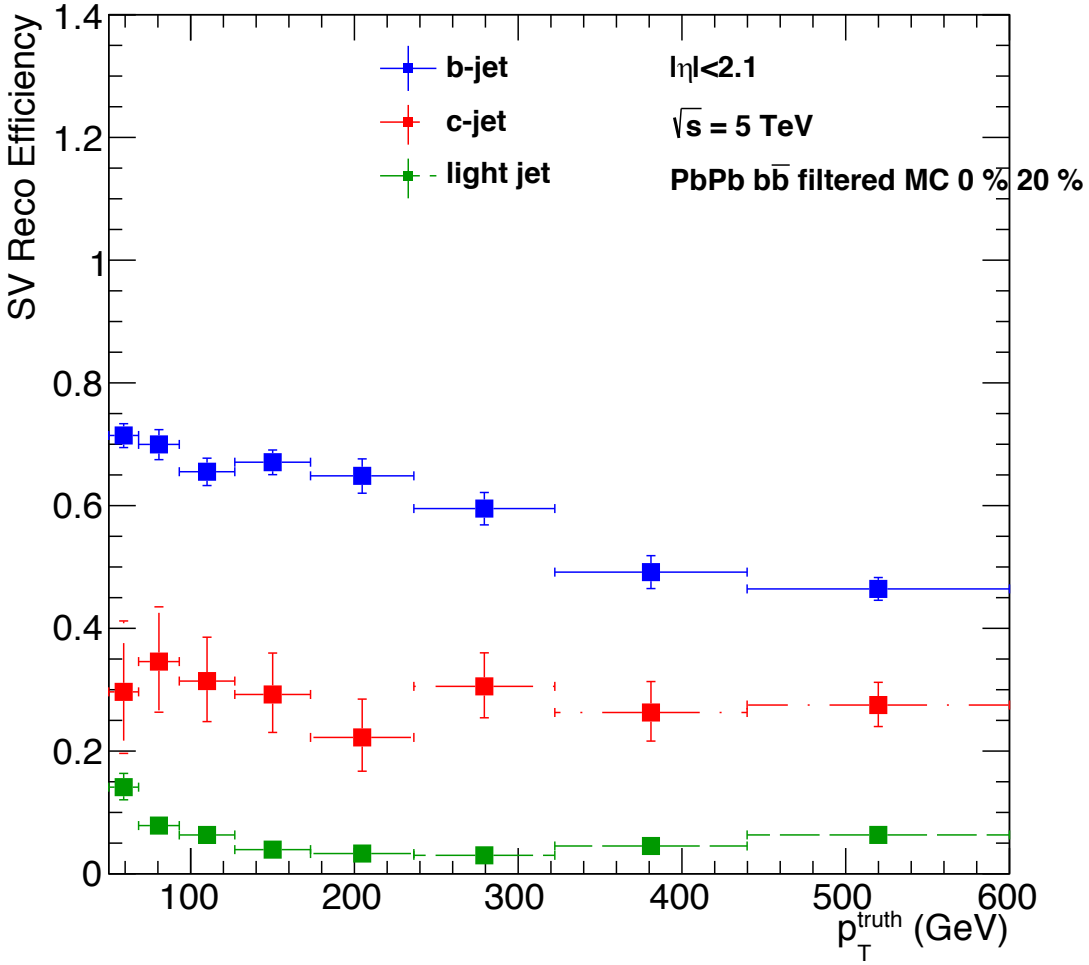
IP3D New Templates

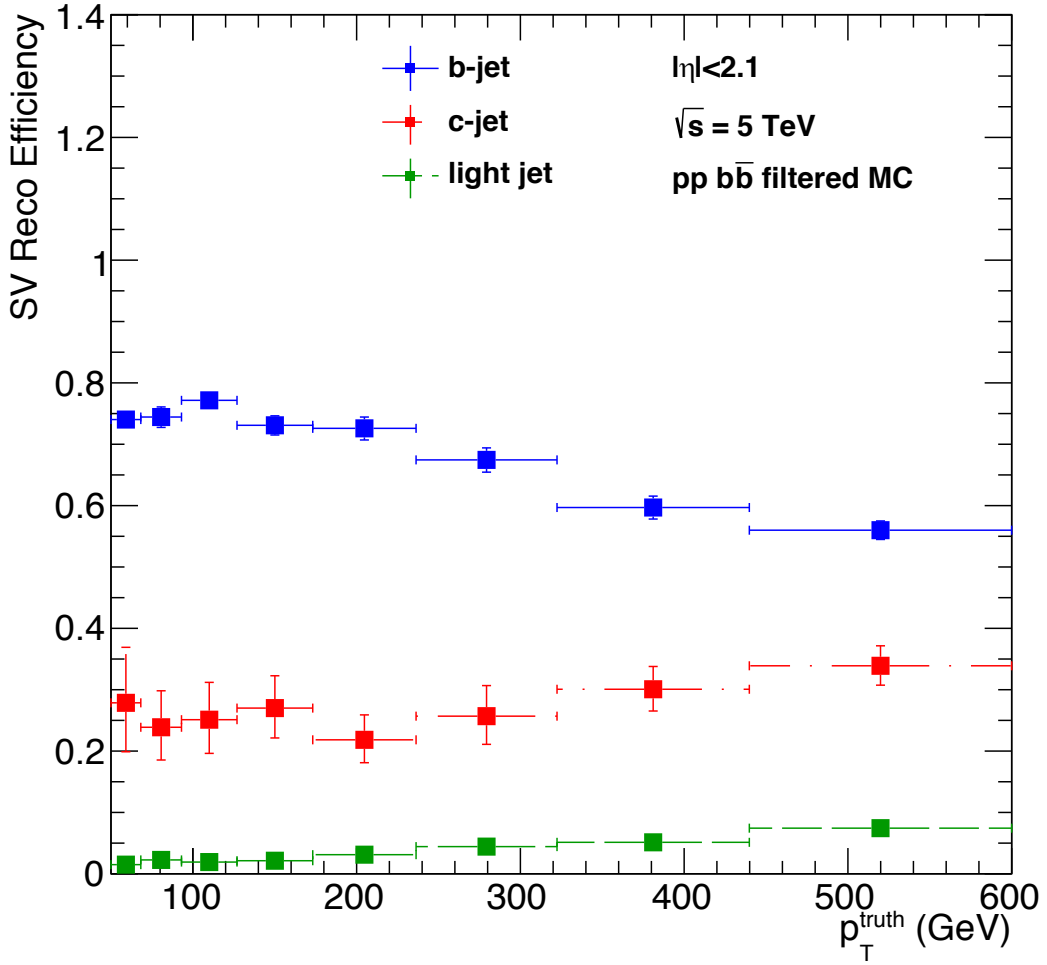




Small statistics at high pT is causing many problems.
Better plot with inclusive dijets for pT > 100 GeV.

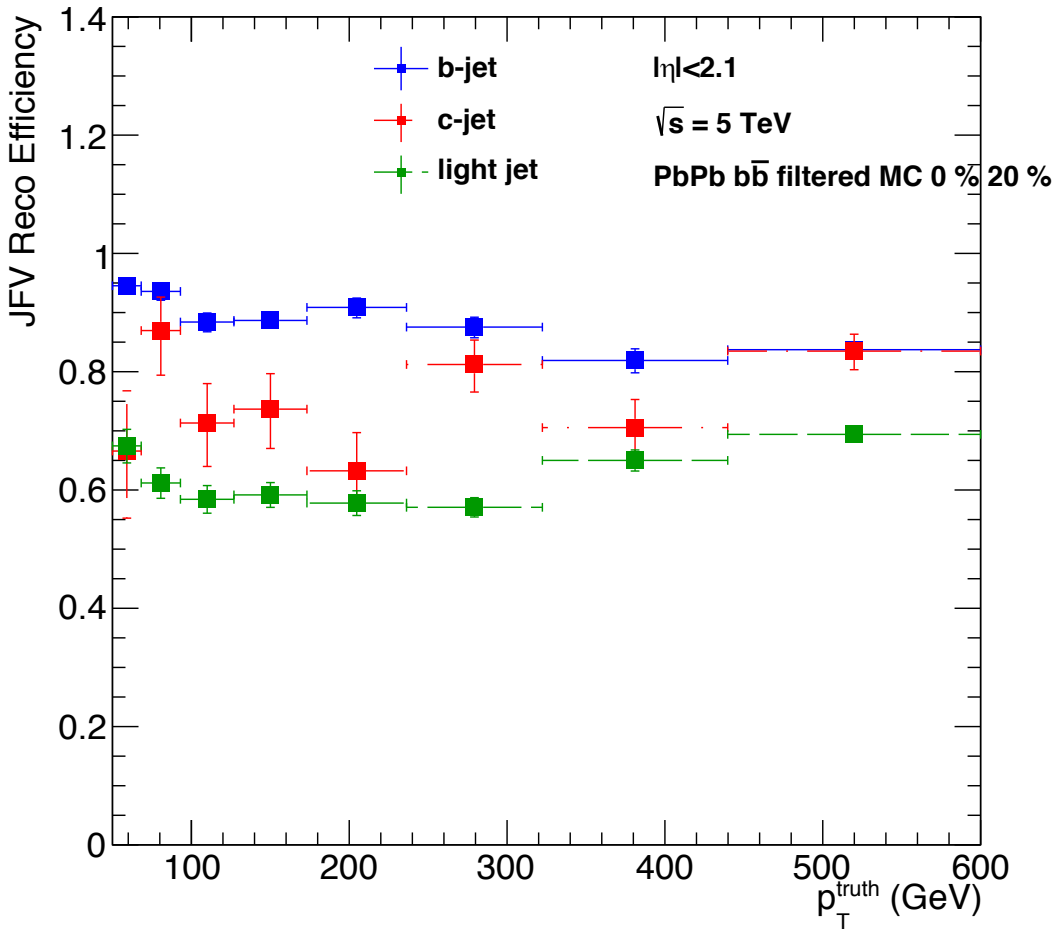
Secondary Vertexing at Default Setup for SVF (VKal)

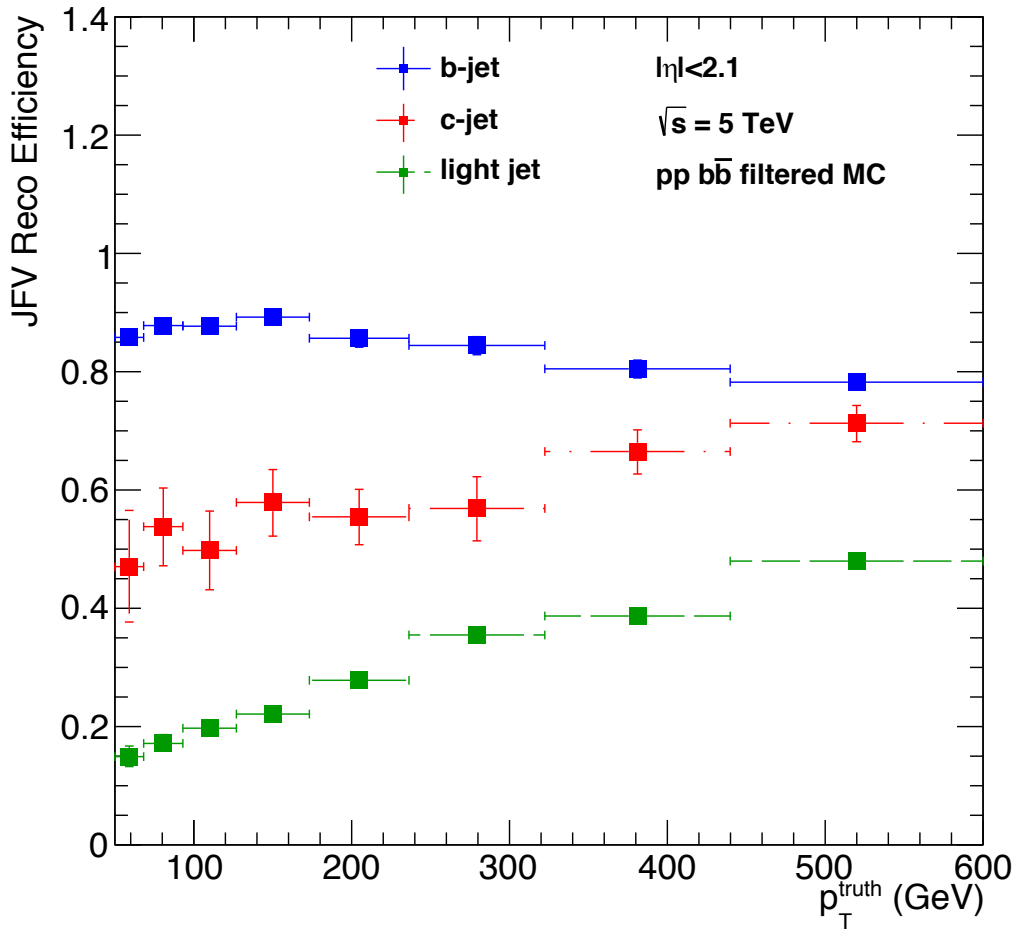




In comparison to pp, central PbPb MC has lower tagging efficiency, especially in high jet pT region, the efficiency drops to below 50%.

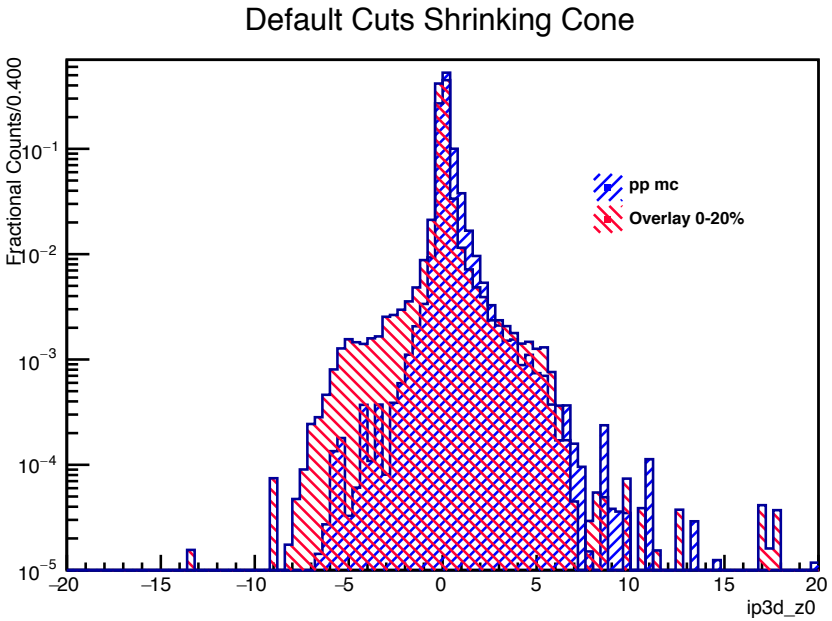
Secondary Vertexing at Default Setup for JetFitter

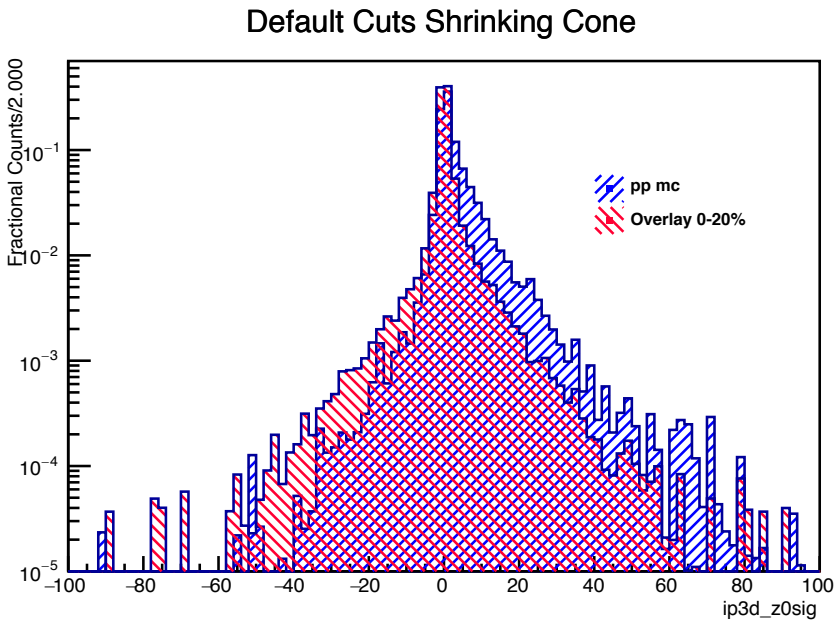


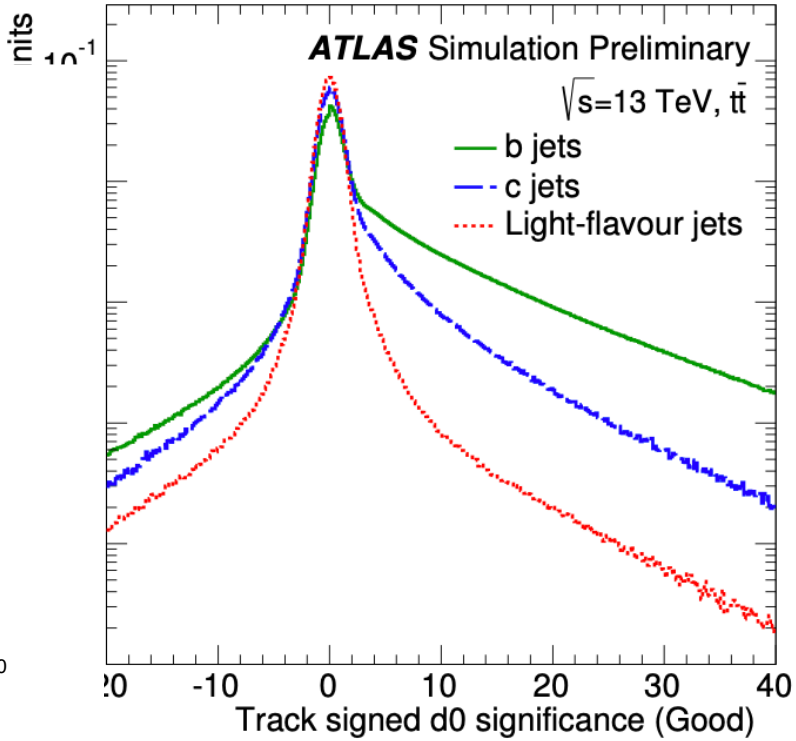


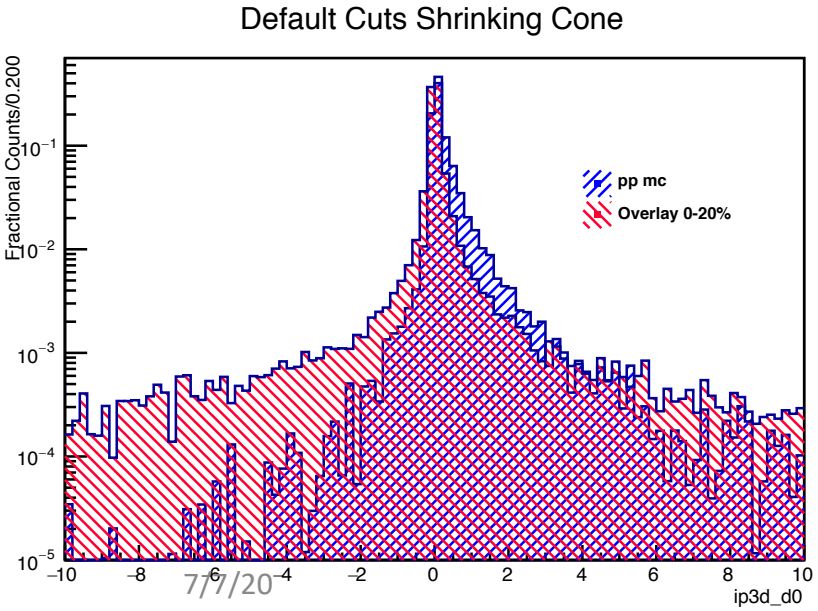
In comparing to pp, central PbPb MC has similar b-tagging efficiency but very high fake rate from both c-jet and light jet.

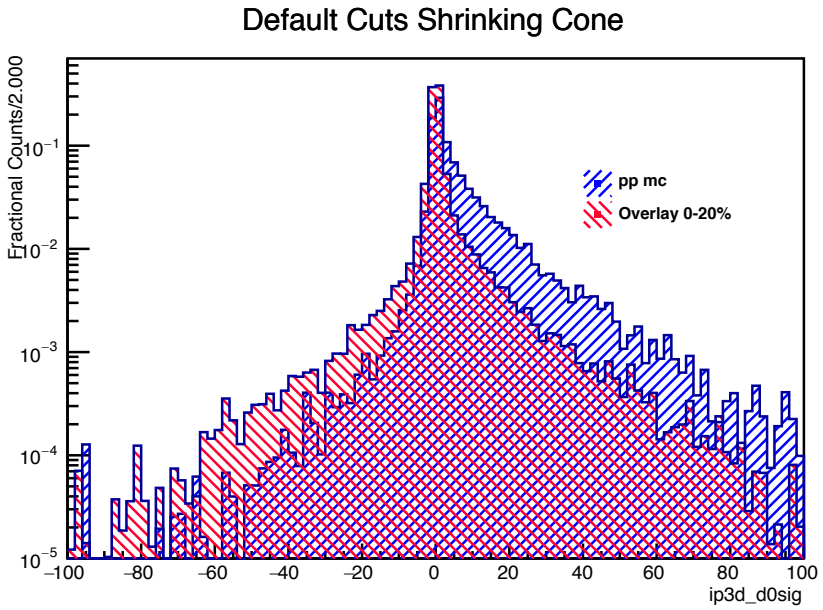
IPxD Variables











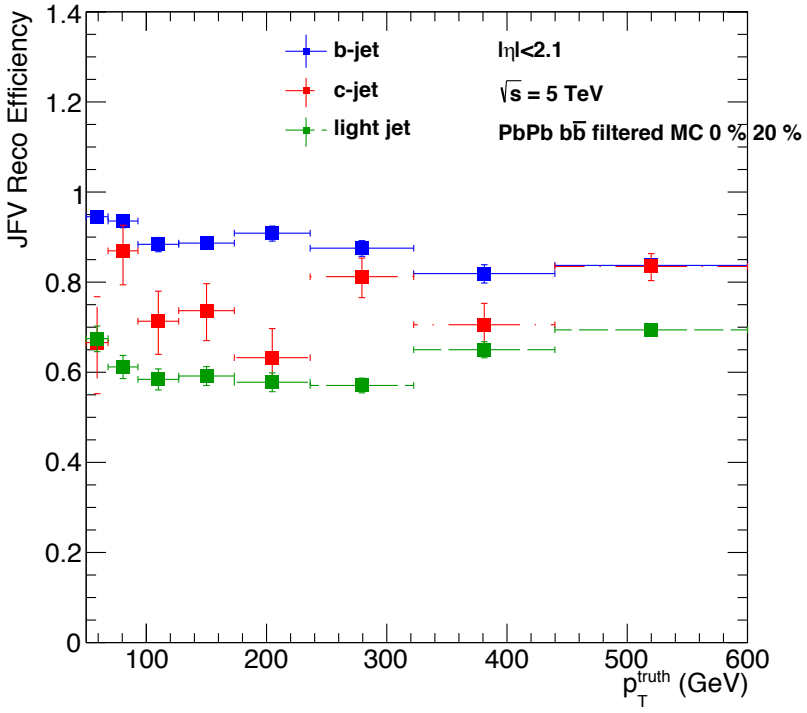
- Overlay samples have almost symmetric distribution of d0 and z0. (left two plots)
- IPxD uses IP significance (right two plots)

Motivation for Cuts made

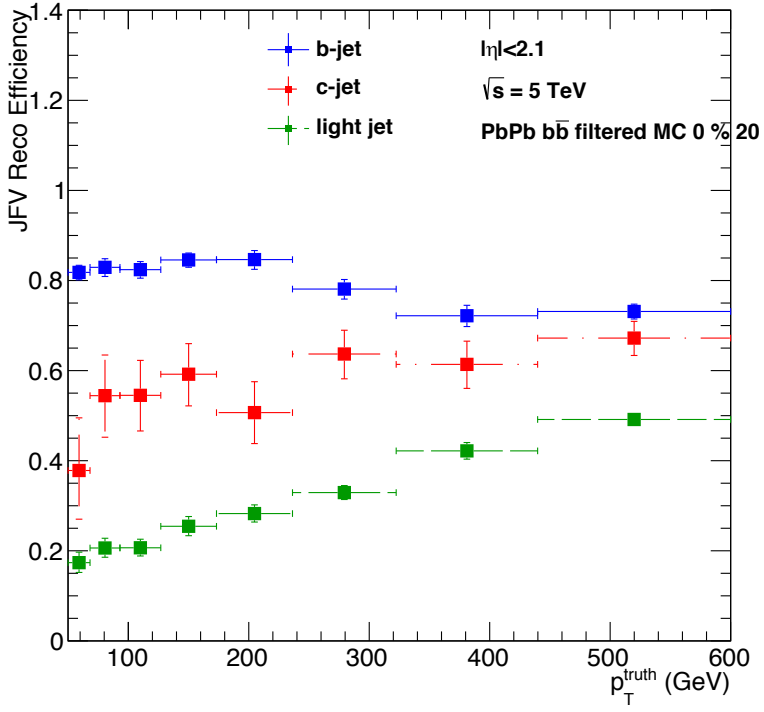
Item	Default	Change	Which Tool	Reason
Track Association	Shrinking Cone	Fixed R = 0.4	ParticleJetTools	Unknown PbPb track distribution vs jet pT SVF has efficiency drop in high pT due to track loss
Min pT Cut	0.5 GeV	1.5 GeV	JetFitter	Central Events have high fake rate possibly due to UE tracks contribution
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 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

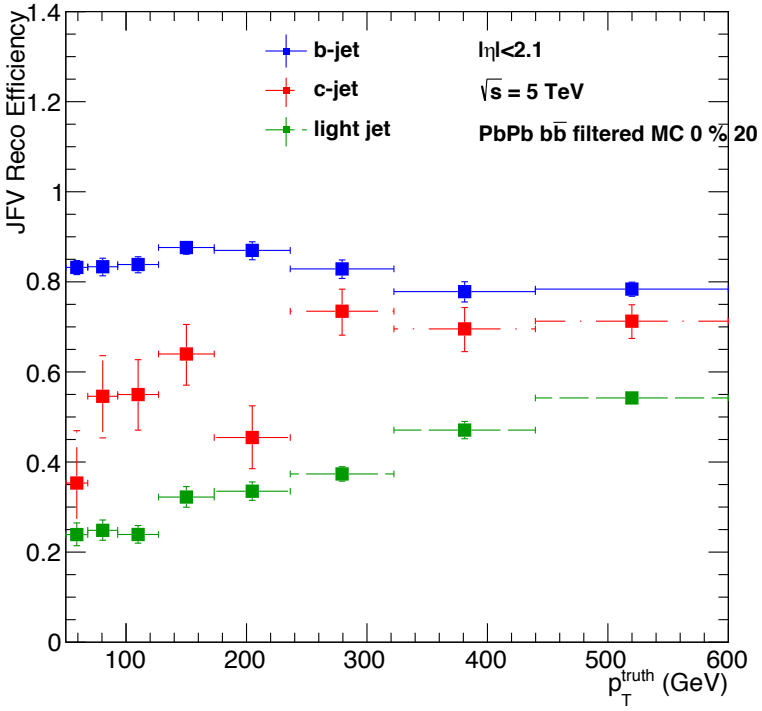
Default JF Setup
No Selection on Input Tracks
Shrinking Cone



Default JF Setup
Selection on TrackAssociation:
-- Min pT = 1.5 GeV
-- "HILoose" without IP cuts
Fixed Cone at 0.4



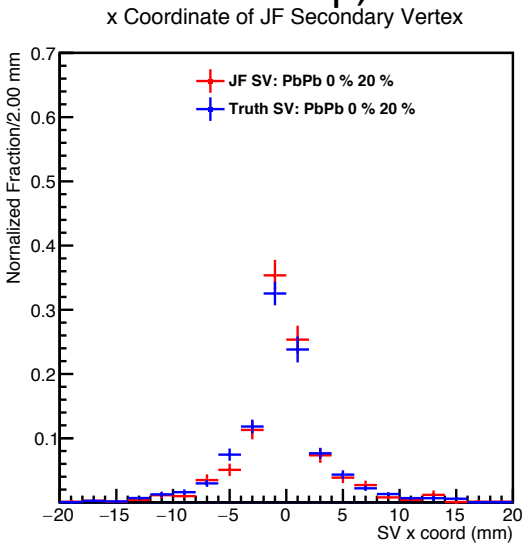
Modified JF Setup:
Requirement for SV candidate tracks:
-- Min pT = 1.0 GeV for first fitting
-- Min pT = 1.75 GeV for second fitting
No Selection on Input Tracks
Fixed Cone at 0.4

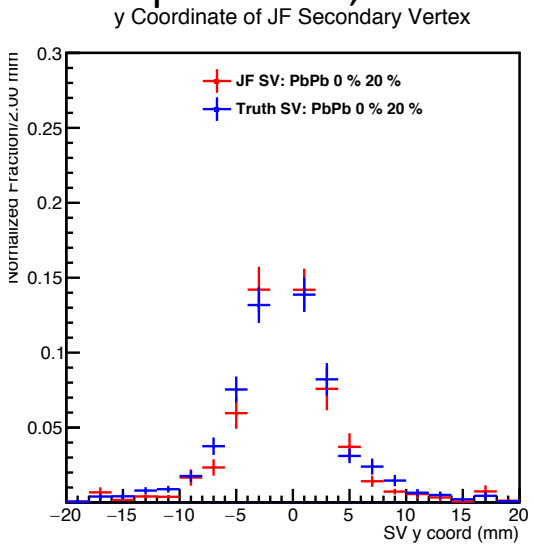


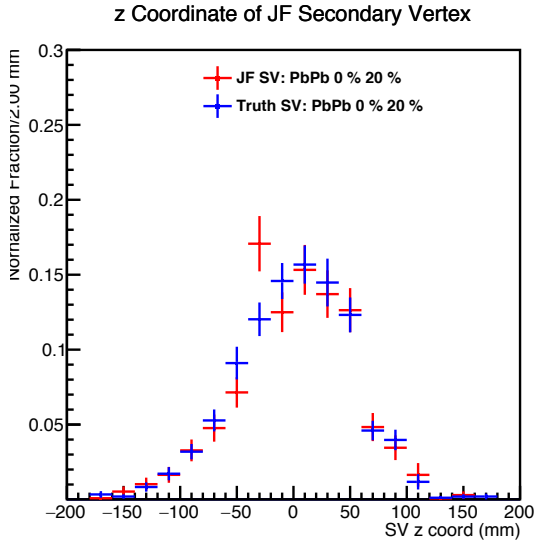
The vertexing efficiency for secondary vertex is similar when using the same value of minimum pT, either by selecting tracks before vertexing or changing pT selection in JF algorithm.

Secondary Vertexing Resolution with JetFitter

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



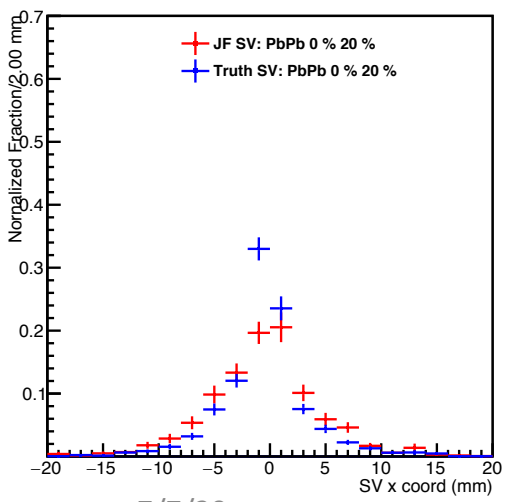


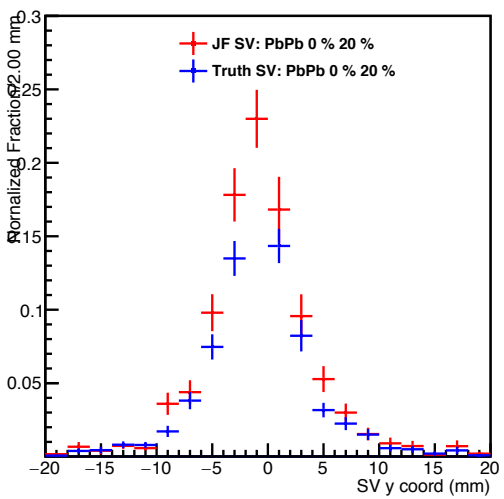


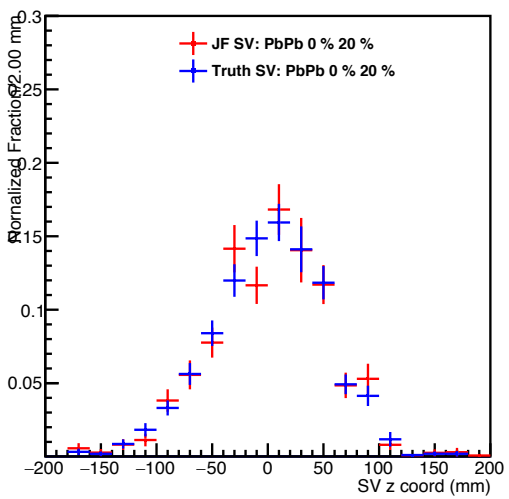
No big change in secondary vertex resolution, reconstructed SV coordinates have similar distribution with truth SV.

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

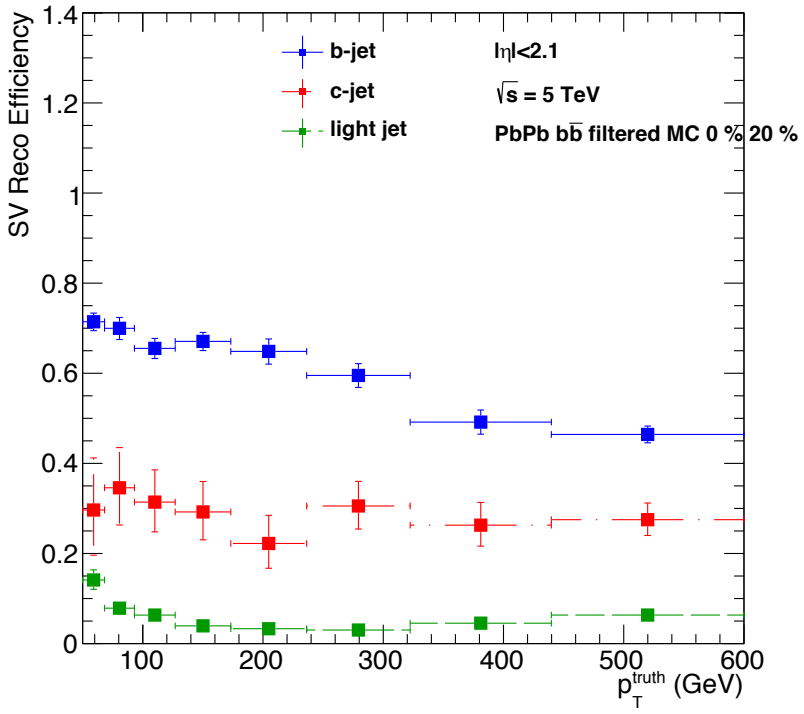




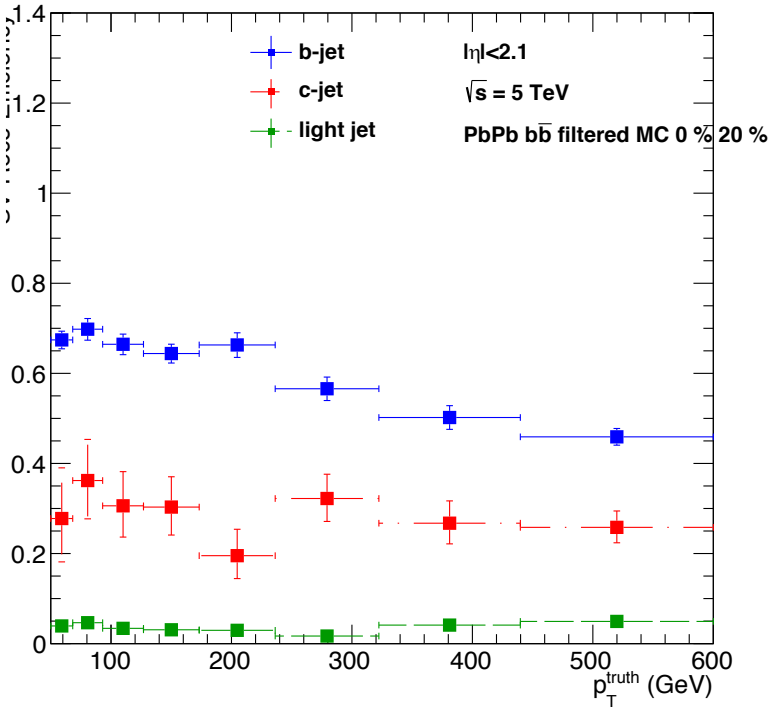


Secondary Vertexing Efficiency with SV1

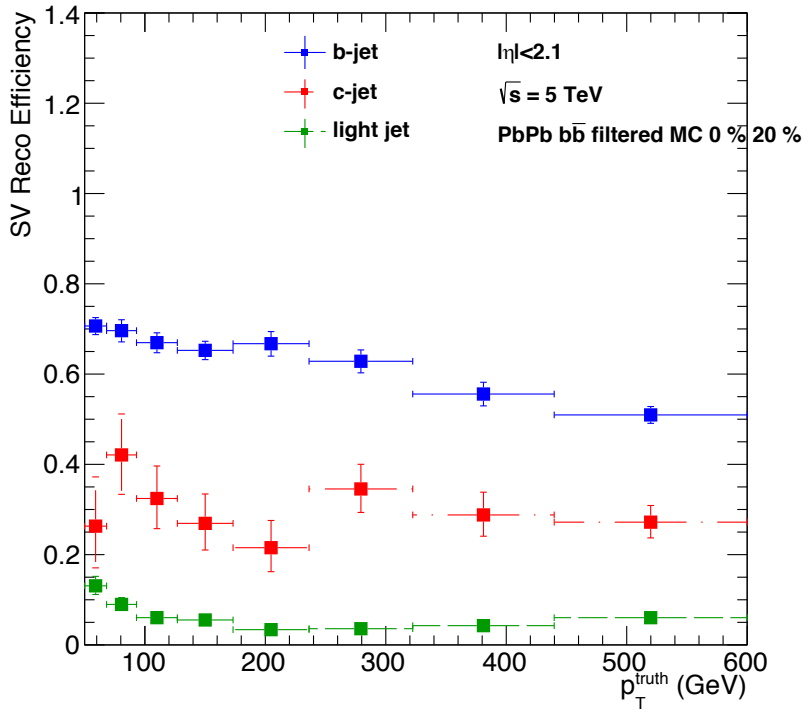
Default JF Setup
No Selection on Input Tracks
Shrinking Cone



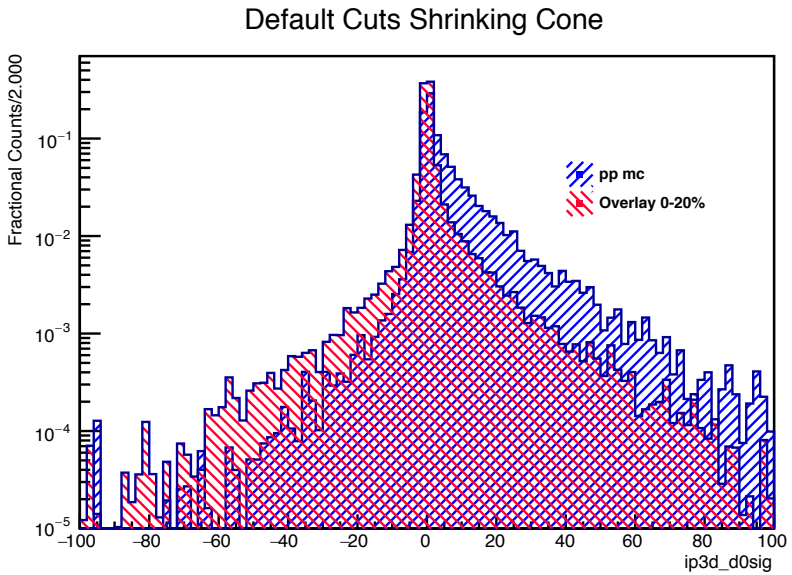
Default SVF Setup
Selection on TrackAssociation:
-- Min pT = 1.5 GeV
-- “HILoose” without IP cuts
Fixed Cone at 0.4

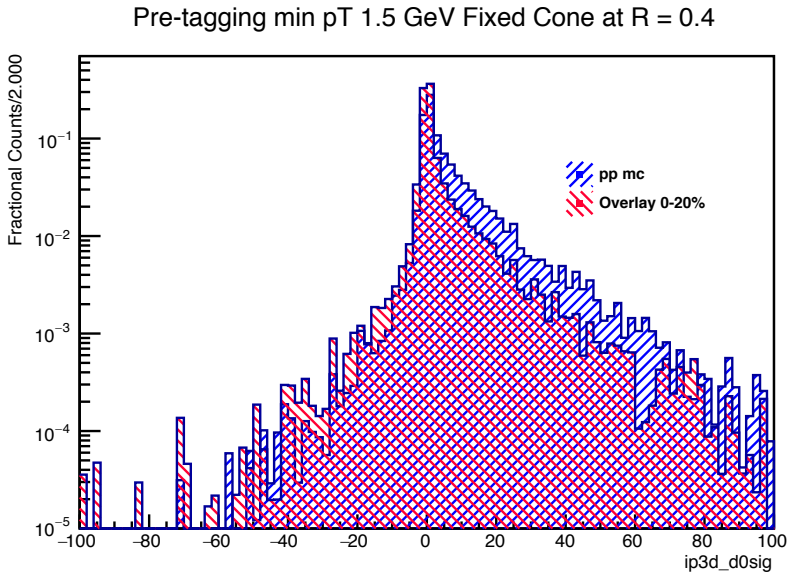


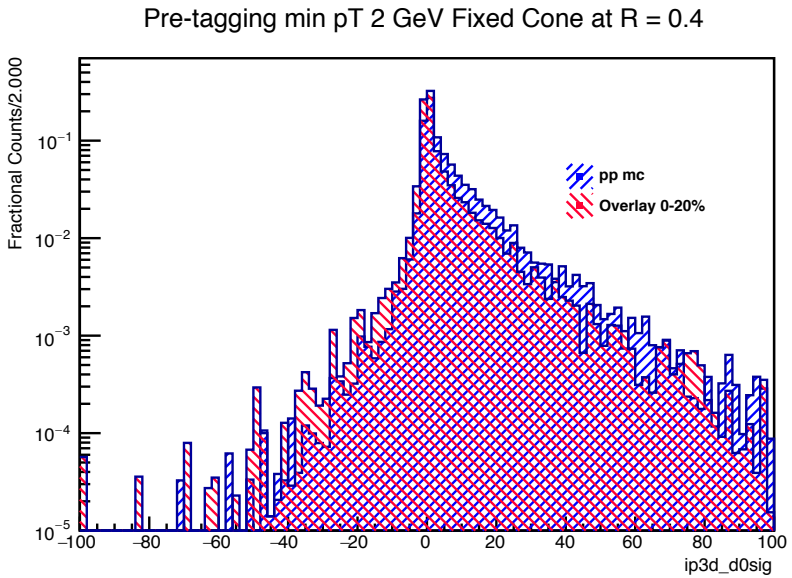
Modified SVF Setup:
SVF requirement for SV candidate tracks:
-- Min pT = 1.0 GeV (will compare for 1.5 GeV)
No Selection on Input Tracks
Fixed Cone at 0.4

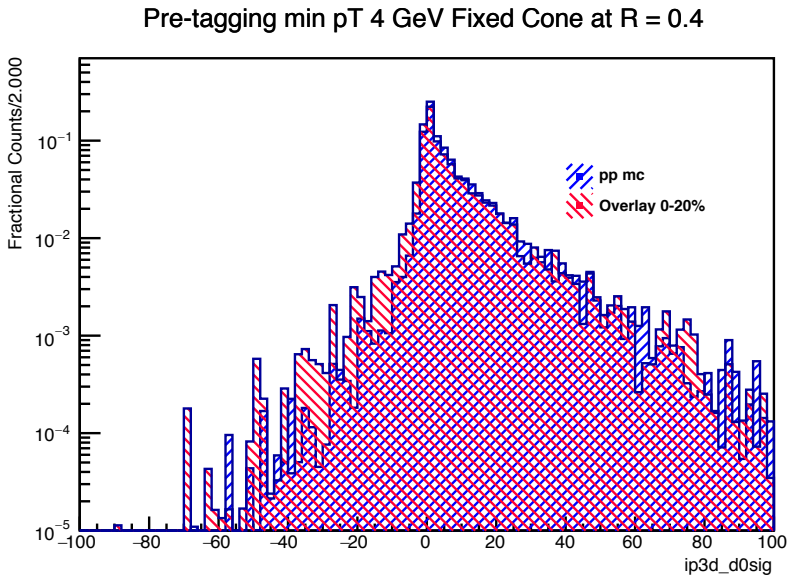


IPxD Variables improvements over pT cuts





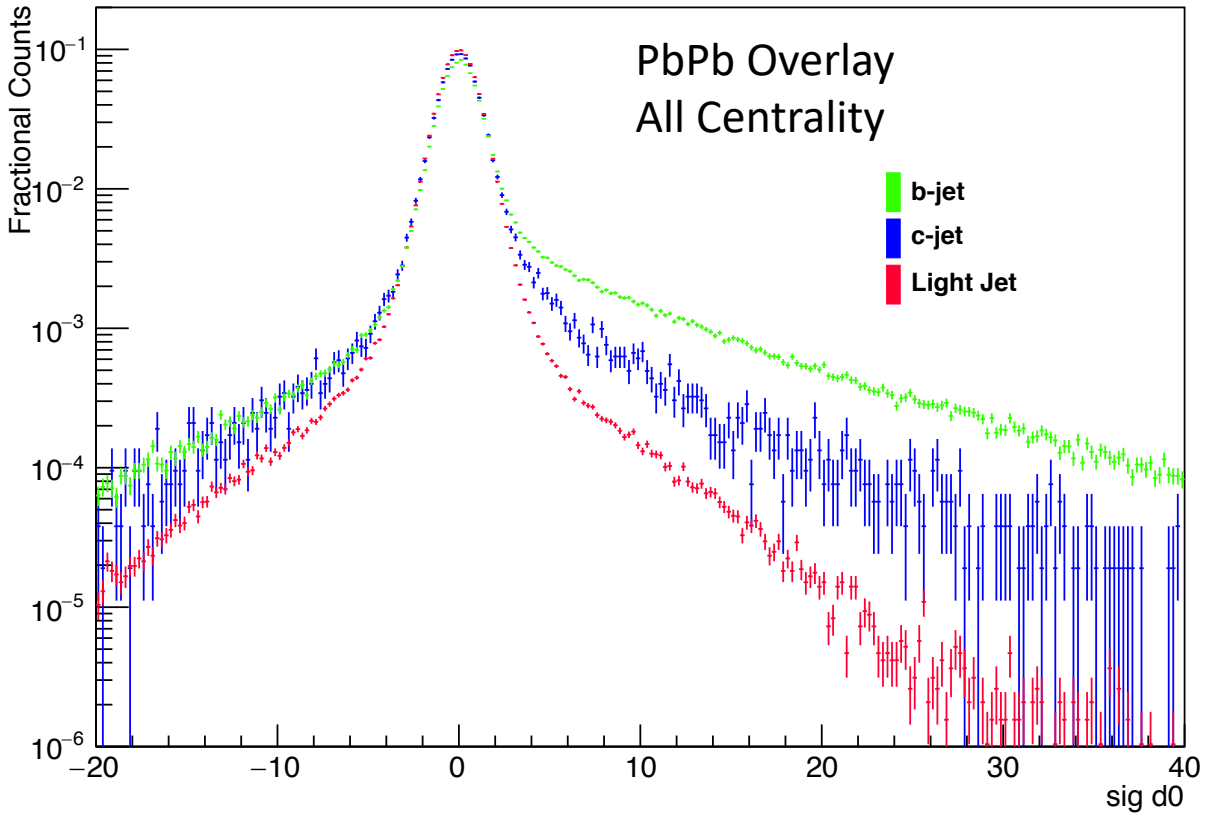




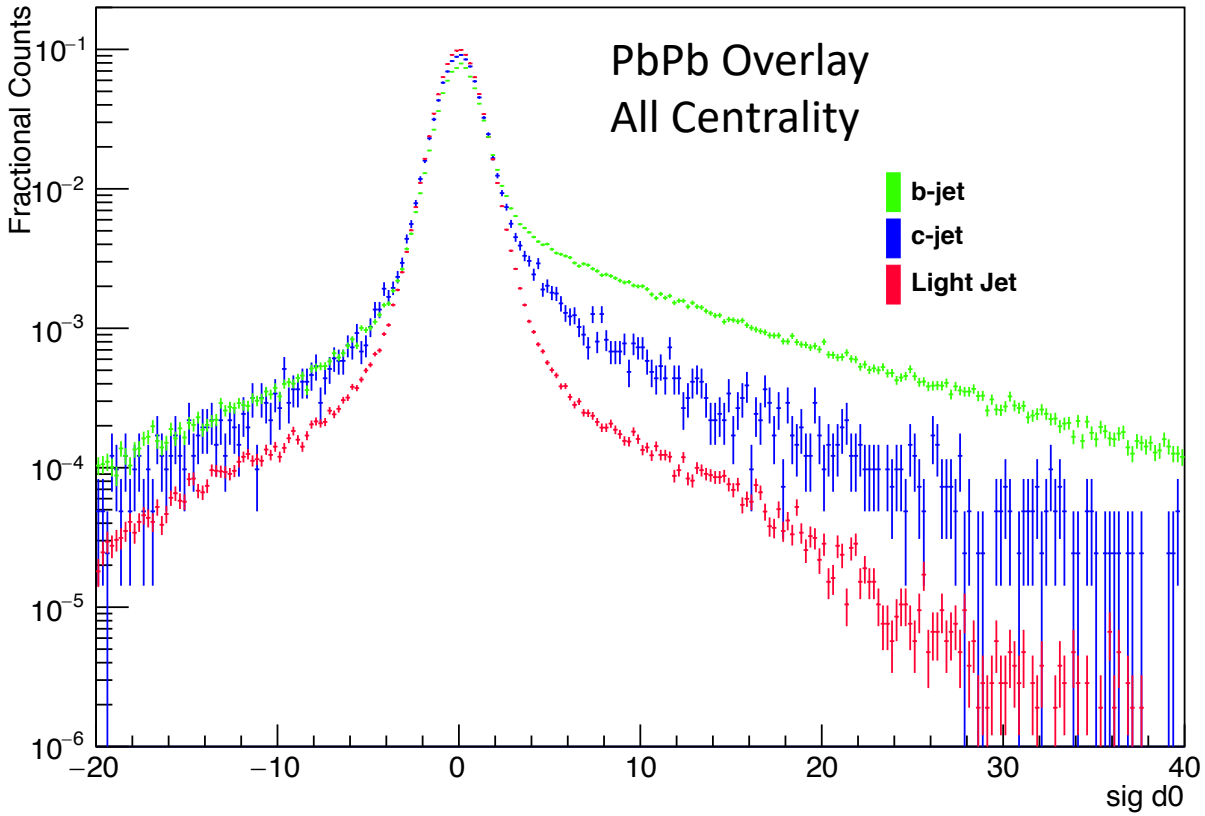
- d0 significance distributions assimilate at pT cut ~= 2 GeV.
- Similarly for z0 and z0sig.

Templates Making with Overlay Sample for Quality Good

Default Setup Shrinking Cone



Fixed Cone + pT >= 1.5 GeV

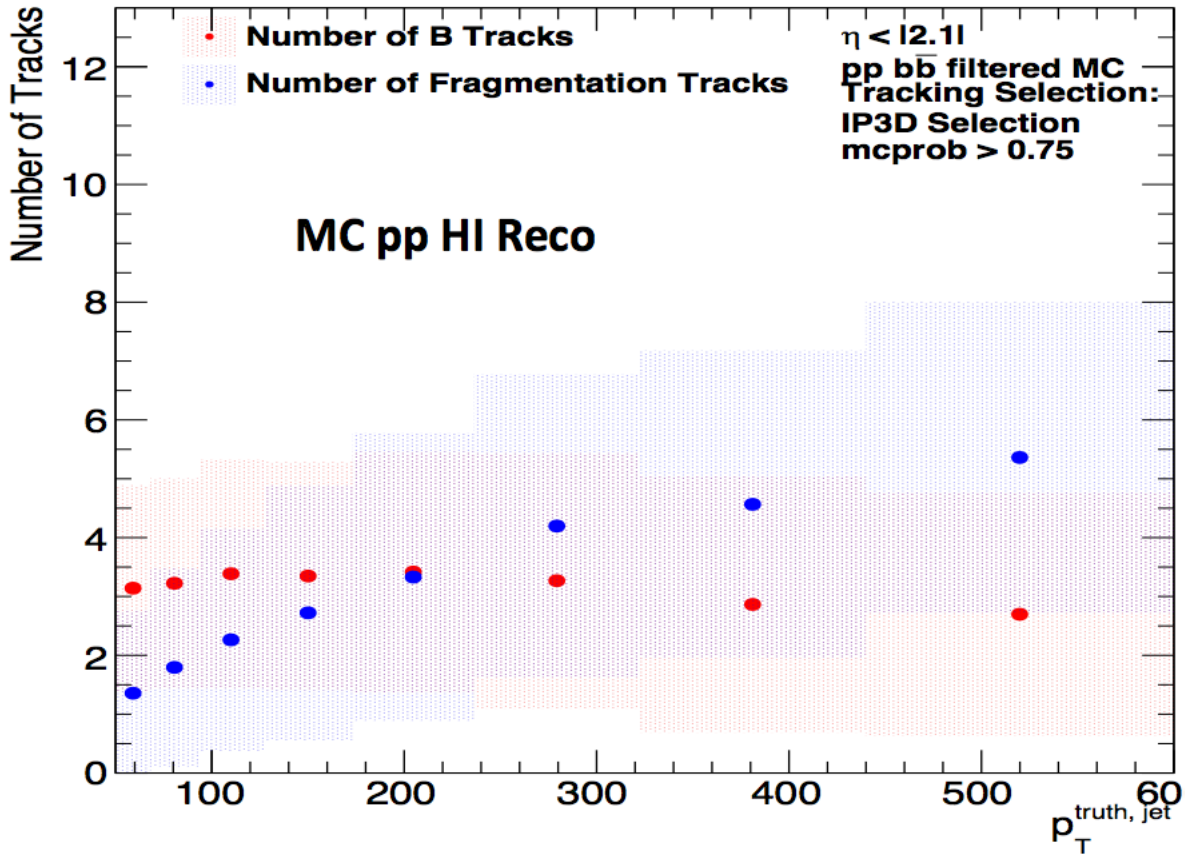


With pT cut combined with changing to fixed cone, the difference between jets are wider spreadout, which should help classification.

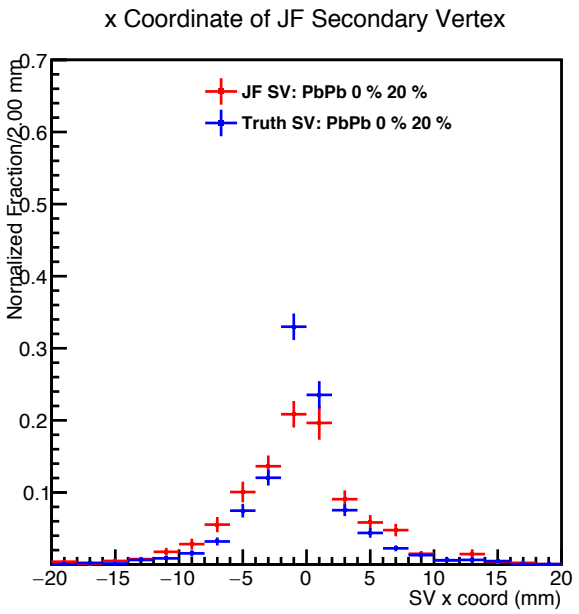
Conclusion and next steps

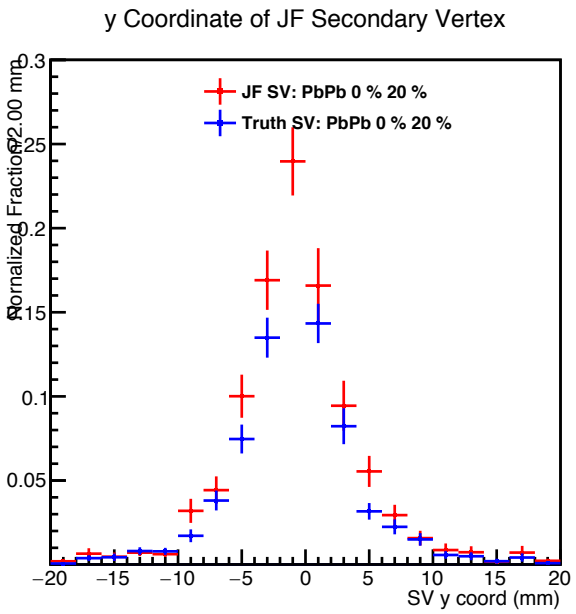
- Experimented cuts, especially with min pT requirement helps reduce fake and improve physics variables.
- Cuts applied at TrackAssociation stage to improve physics variables like energy fraction.
- Applying these cuts do not affect SV resolution qualitatively in JetFitter.
  - Plan: compare for VKal 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.

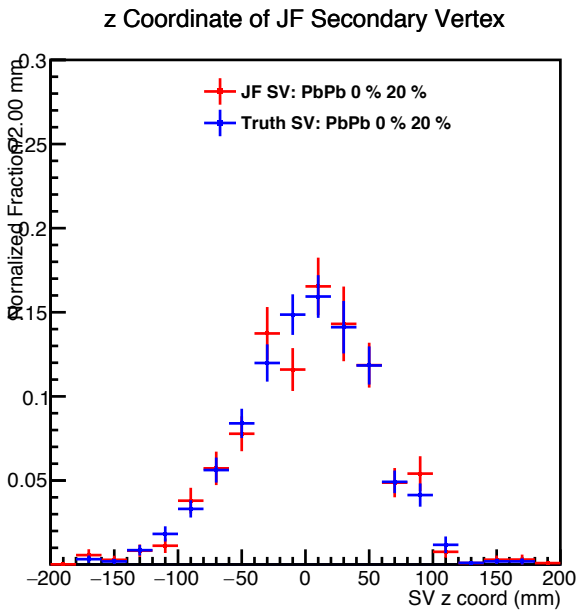
Back-up


Number of B Tracks
Number of Fragmentation Tracks
η < |2.1|
pp b$\bar{b}$ filtered MC
Tracking Selection:
IP3D Selection
mcprob > 0.75
MC pp HI Reco
Number of Tracks
0
2
4
6
8
10
12
100
200
300
400
500
60
$p_T^{truth, jet}$

JF pre-tagging selection, pT >= 1.5 GeV



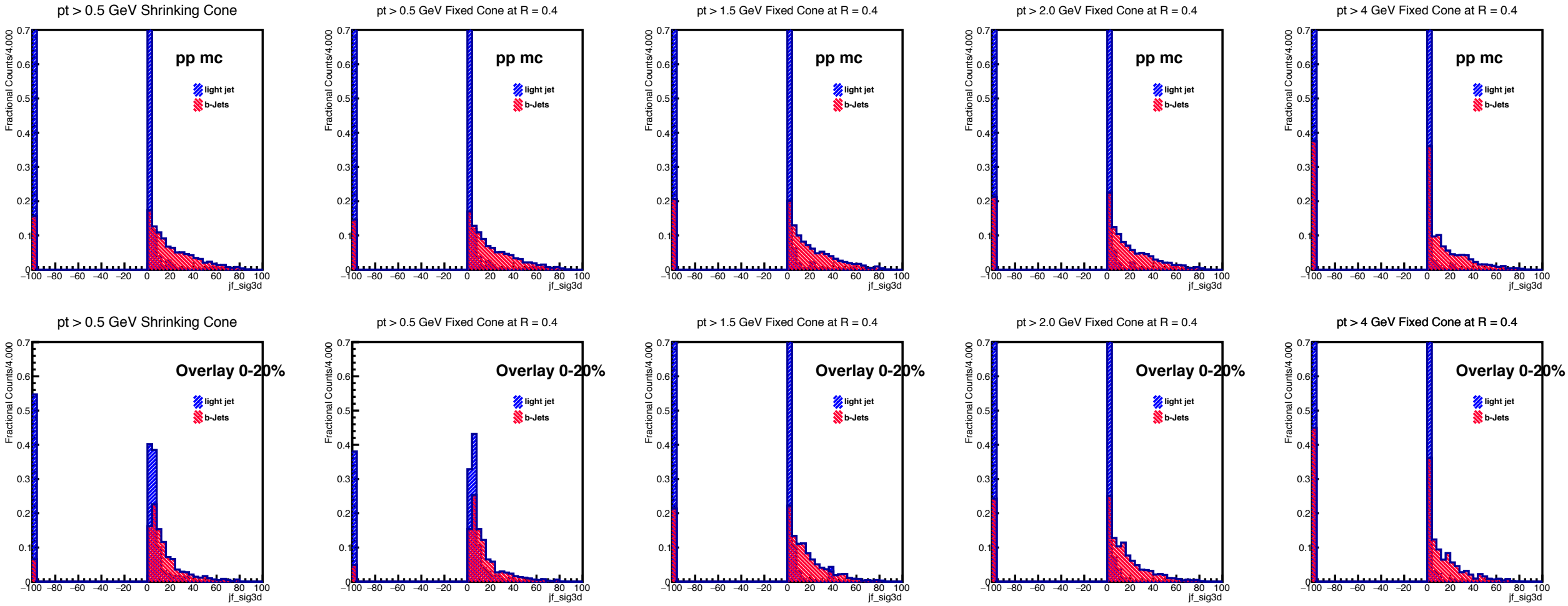




Modified JF Setup (anti PU off)
First Fitting min Track pT: 1.5 GeV
Second Fitting min Track pT: 1.75 GeV
No Selection on Input Tracks
Fixed Cone at 0.4

SV1

JF sig3d (decay length significance)

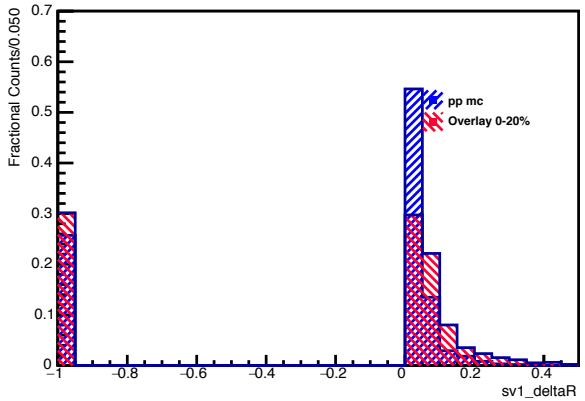


Top Row: pp mc
Bottom Row: Overlay 0-20%

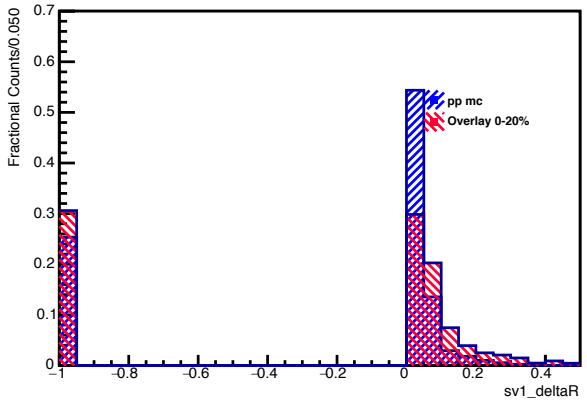
From left to right:
1. No pT Shrinking Cone
2. No pT Fixed Cone
3. Min pt = 1.5 GeV Fixed Cone
4. Min pt = 2.0 GeV Fixed Cone
5. Min pT = 4.0 GeV Fixed Cone

Red: b-jet
Blue: light jet

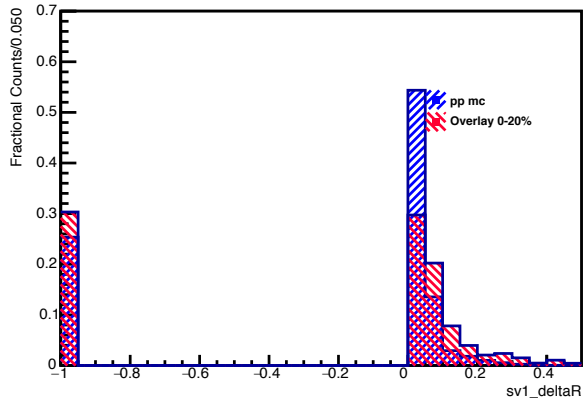
JF pt > 0.5 GeV Shrinking Cone



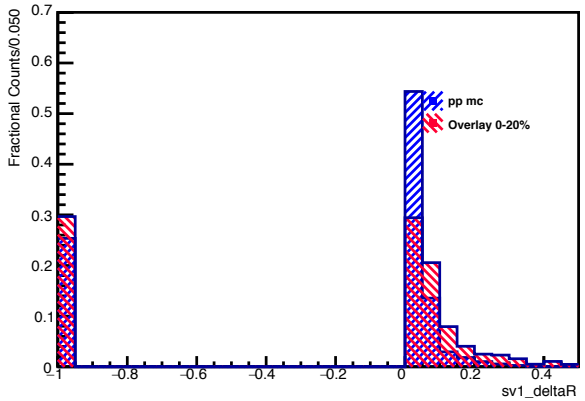
JF pt > 0.5 GeV Fixed Cone at R = 0.4



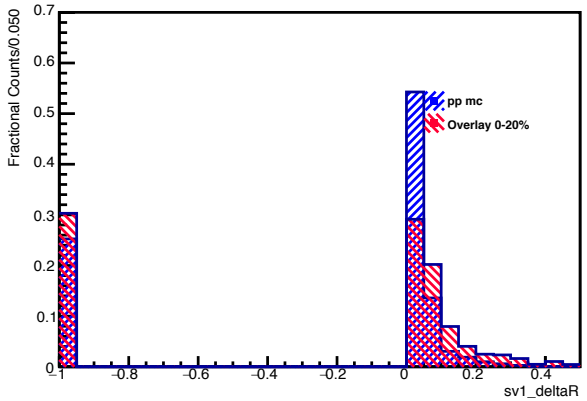
JF pt > 1.0 GeV Fixed Cone at R = 0.4



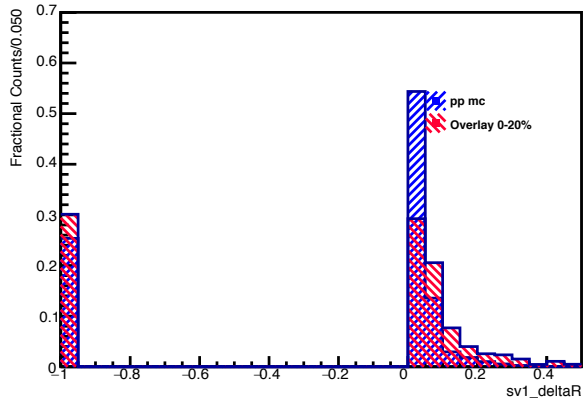
JF pt > 1.5 GeV Fixed Cone at R = 0.4



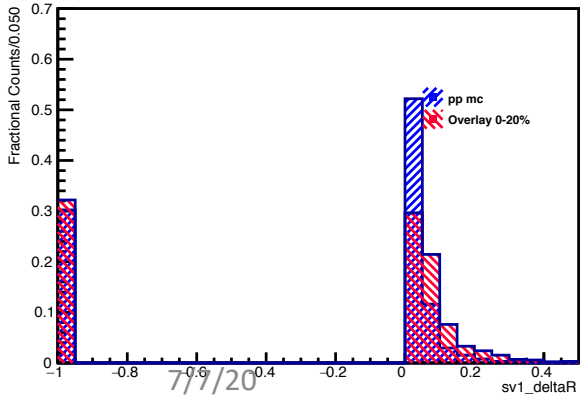
JF pt > 2.0 GeV Fixed Cone at R = 0.4



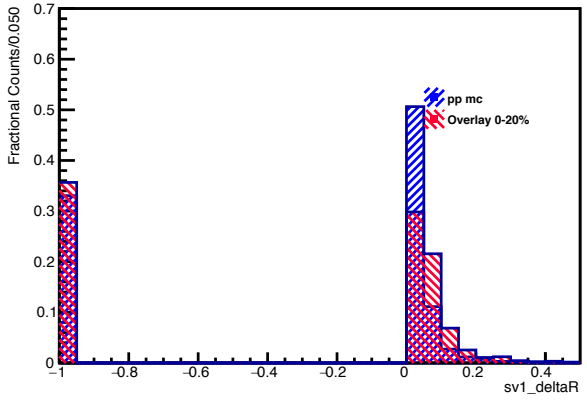
JF pt > 4 GeV Fixed Cone at R = 0.4



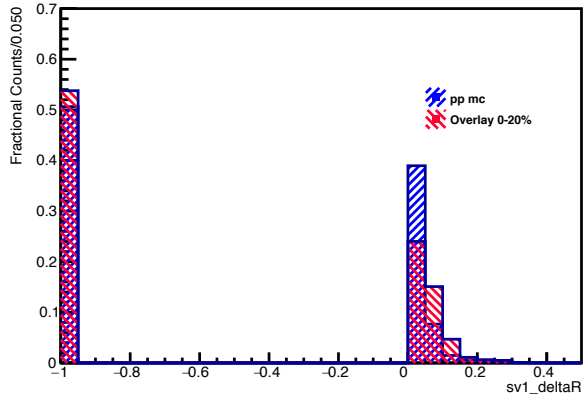
pre-tagging pt > 1.5 GeV Fixed Cone at R = 0.4



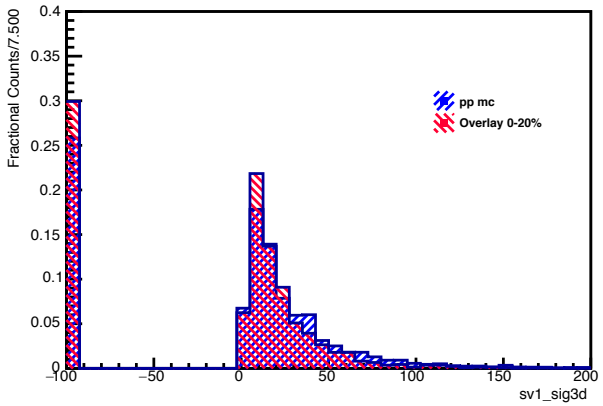
pre-tagging pt > 2.0 GeV Fixed Cone at R = 0.4



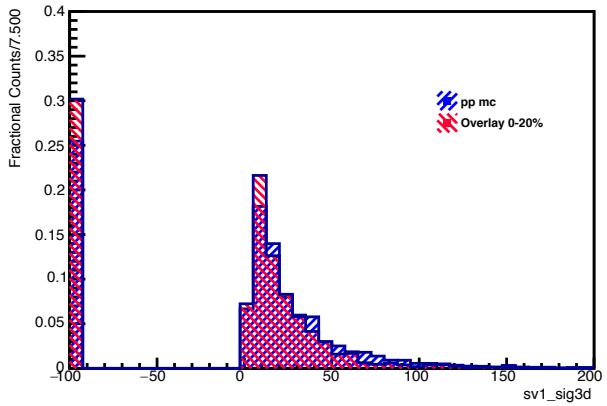
pre-tagging pt > 4.0 GeV Fixed Cone at R = 0.4



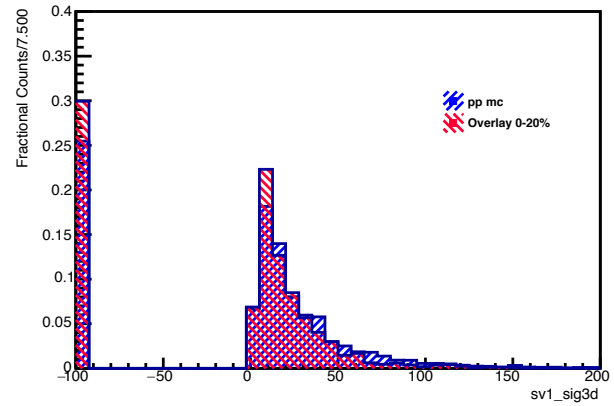
JF pt > 0.5 GeV Shrinking Cone



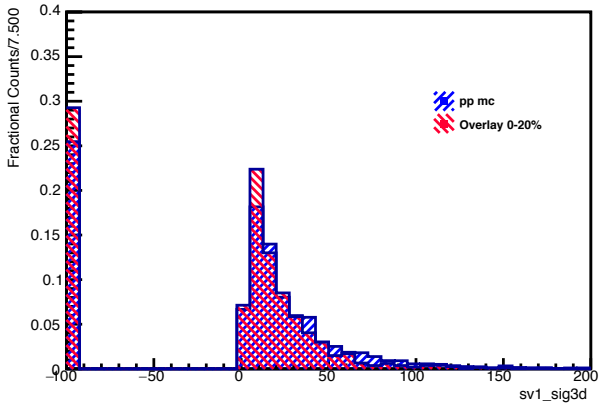
JF pt > 0.5 GeV Fixed Cone at R = 0.4



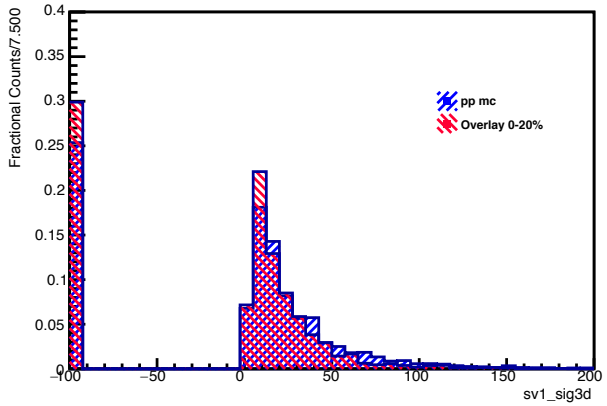
JF pt > 1.0 GeV Fixed Cone at R = 0.4



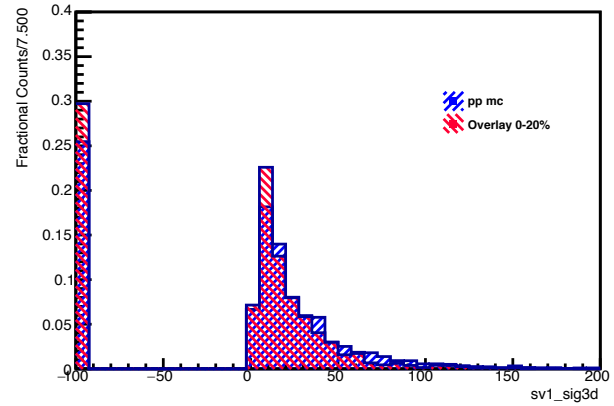
JF pt > 1.5 GeV Fixed Cone at R = 0.4



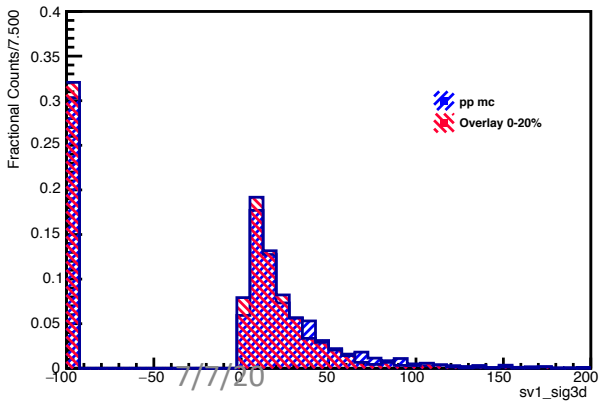
JF pt > 2.0 GeV Fixed Cone at R = 0.4



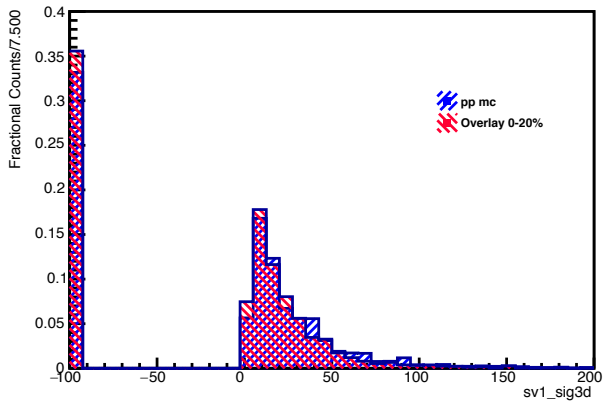
JF pt > 4 GeV Fixed Cone at R = 0.4



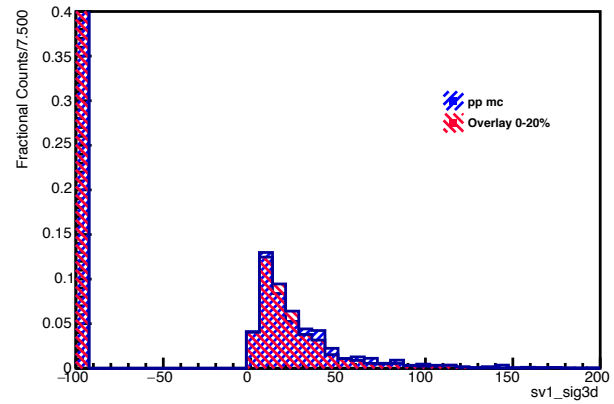
pre-tagging pt > 1.5 GeV Fixed Cone at R = 0.4



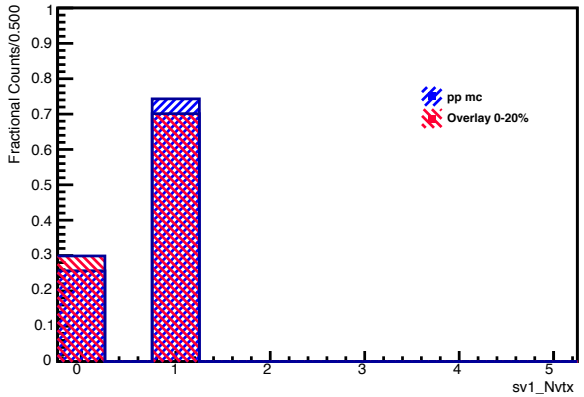
pre-tagging pt > 2.0 GeV Fixed Cone at R = 0.4



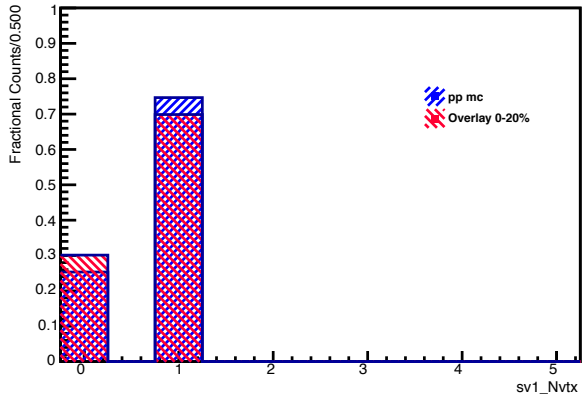
pre-tagging pt > 4.0 GeV Fixed Cone at R = 0.4



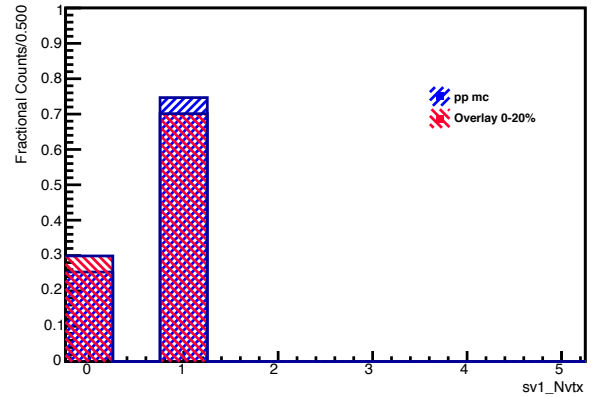
JF pt > 0.5 GeV Shrinking Cone



JF pt > 0.5 GeV Fixed Cone at R = 0.4



JF pt > 1.0 GeV Fixed Cone at R = 0.4



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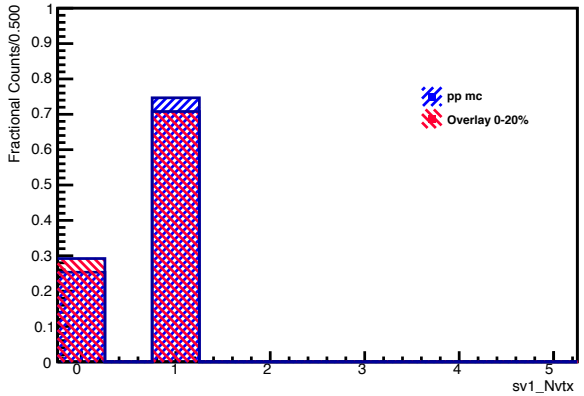

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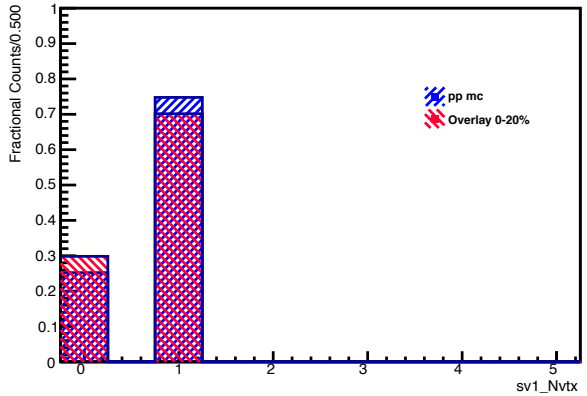

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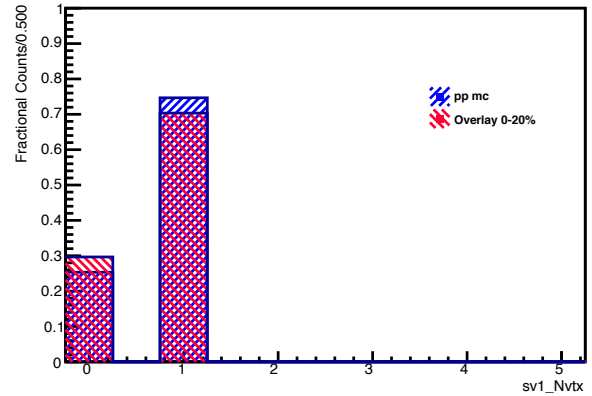

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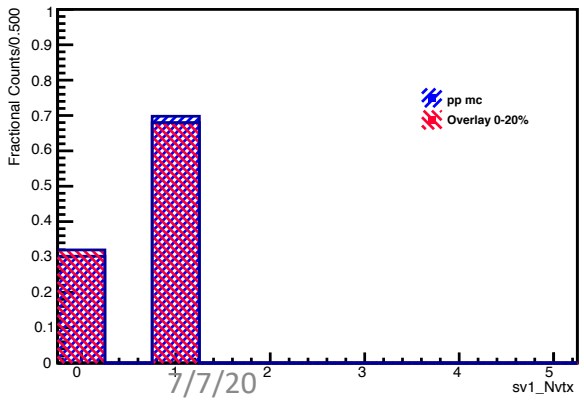

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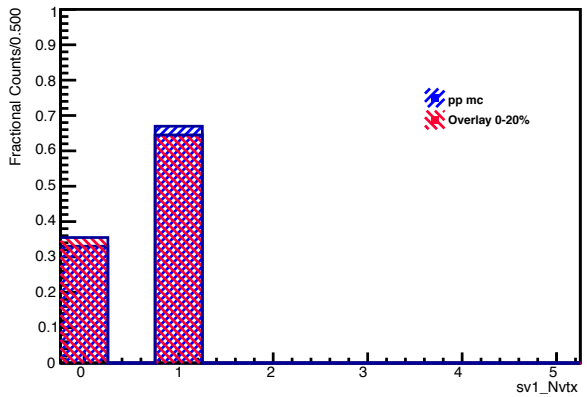

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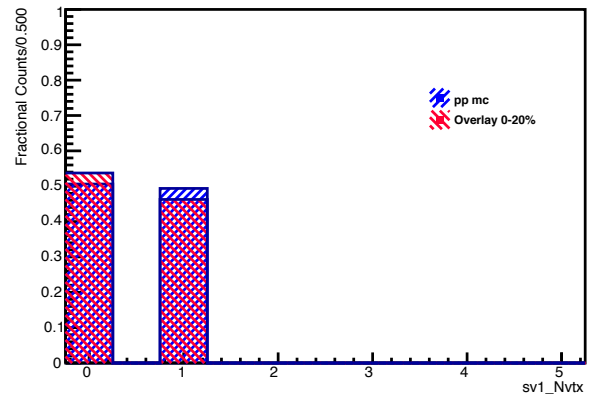

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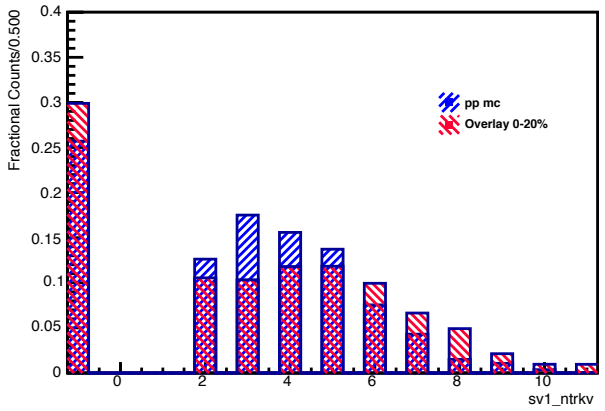

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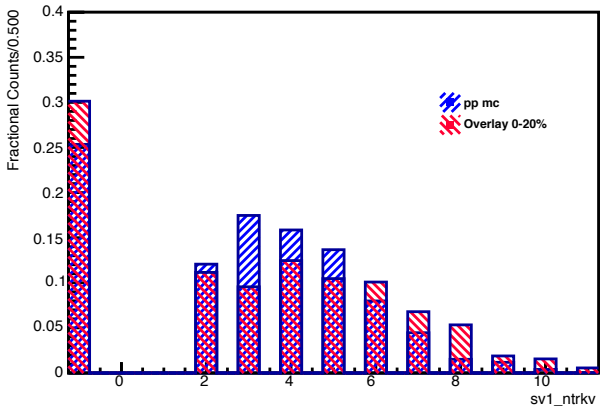

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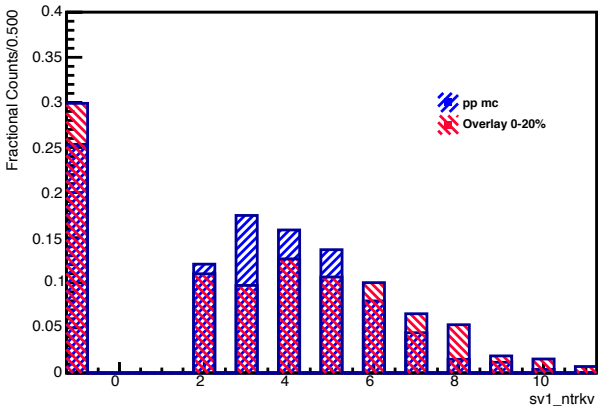

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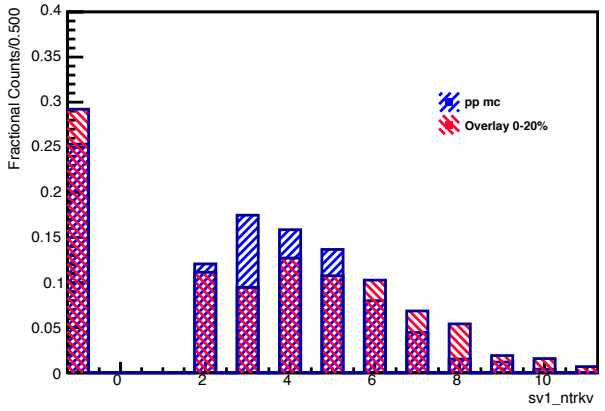

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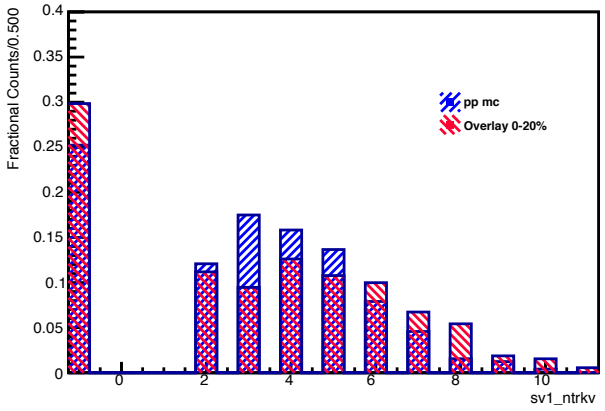

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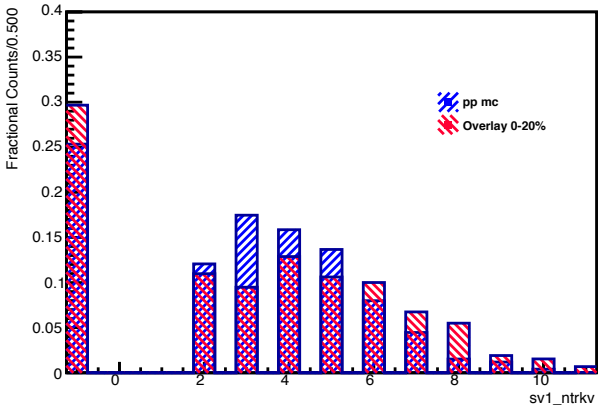

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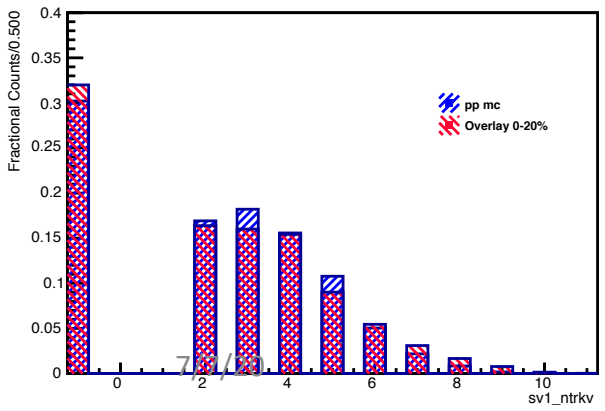

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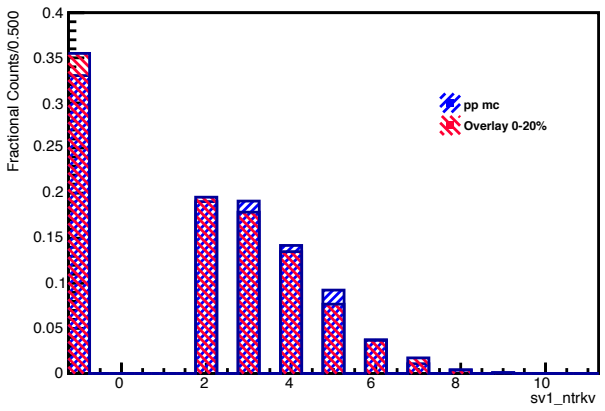

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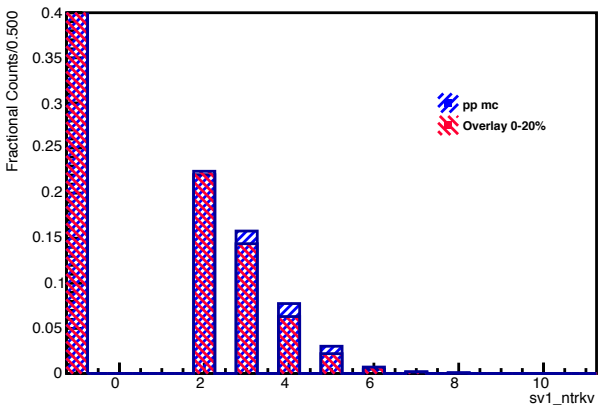

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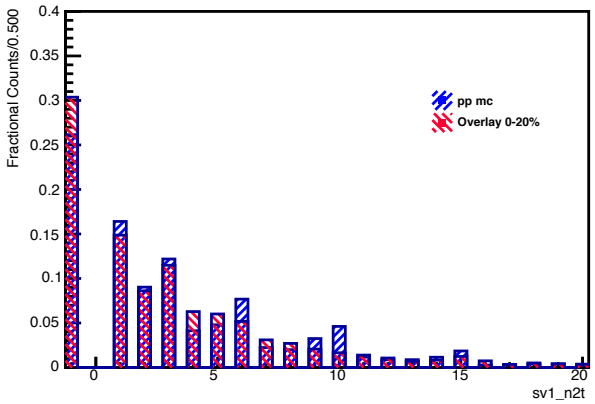

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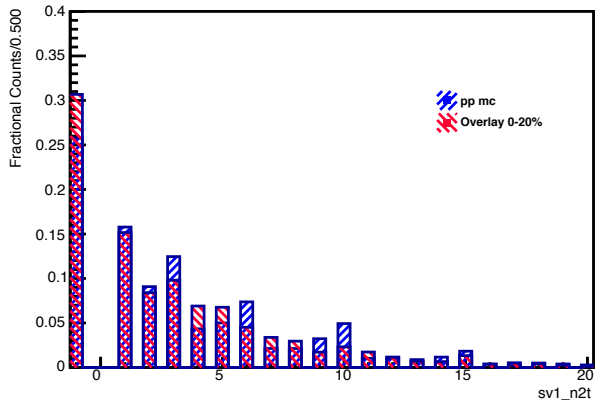

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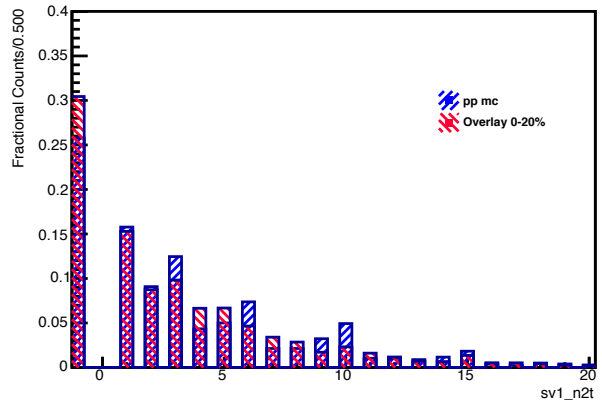

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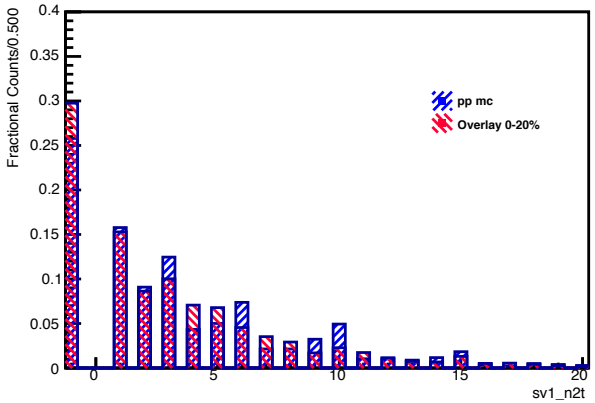

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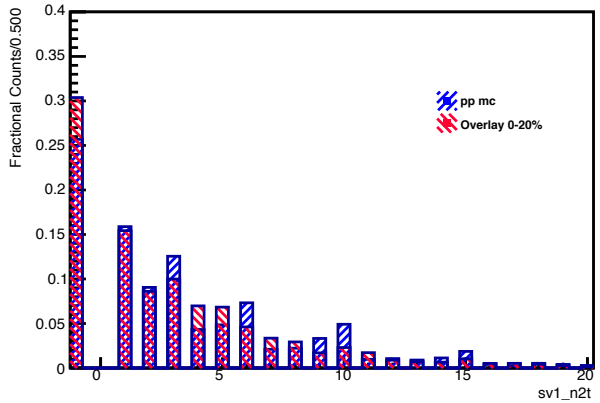

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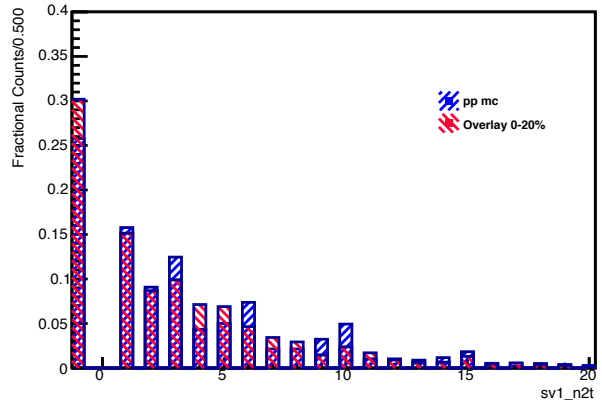

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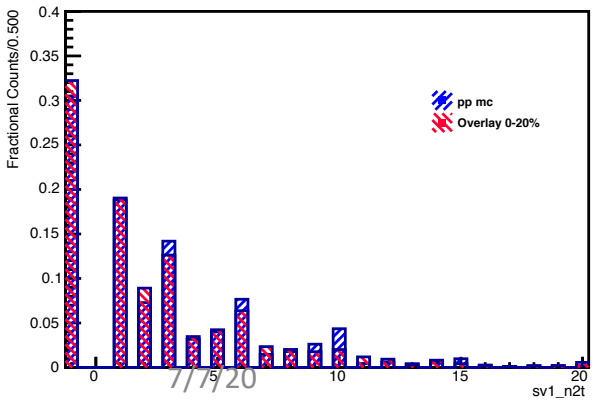

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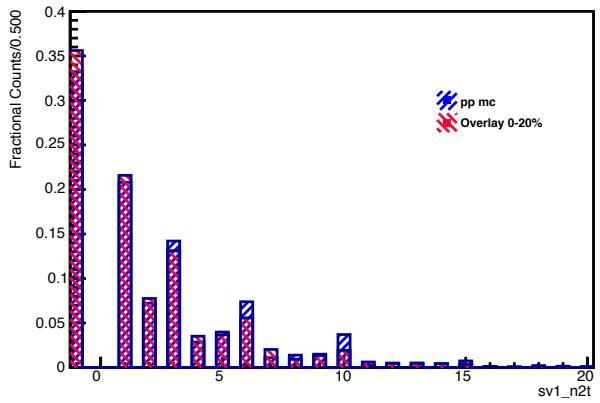

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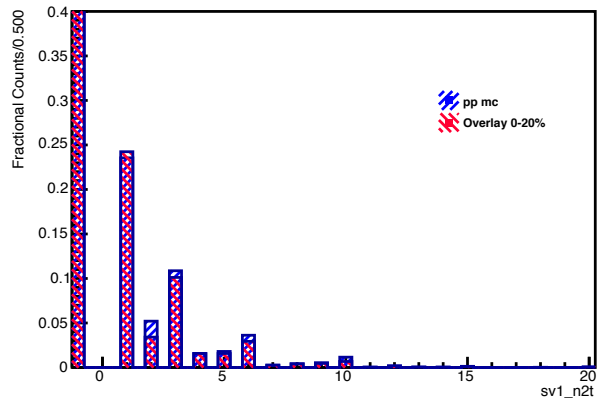

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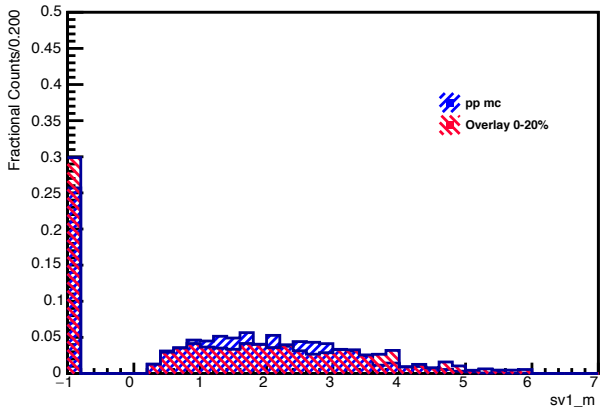

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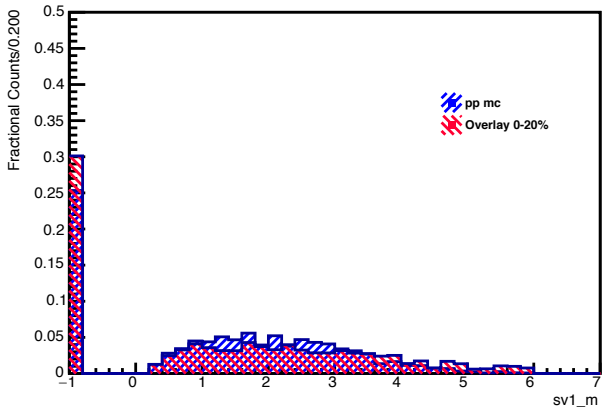

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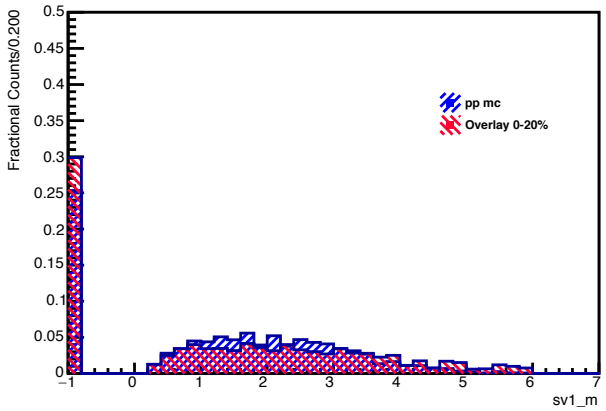

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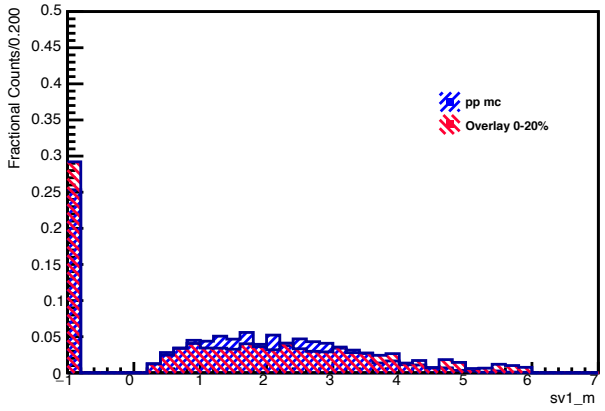

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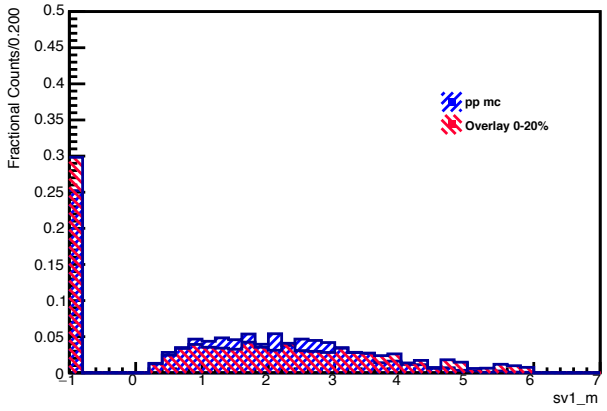

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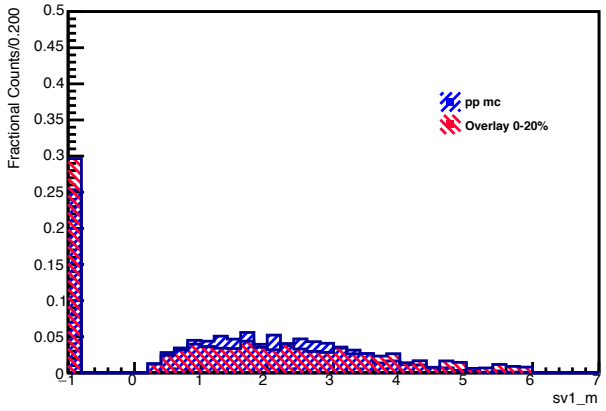

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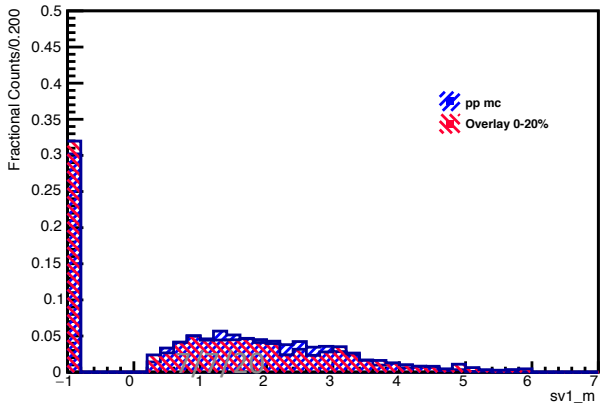

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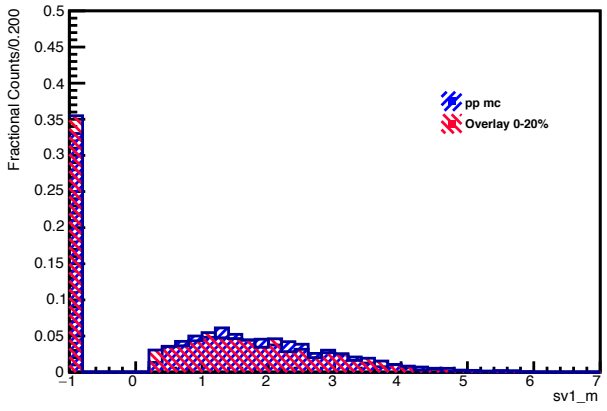

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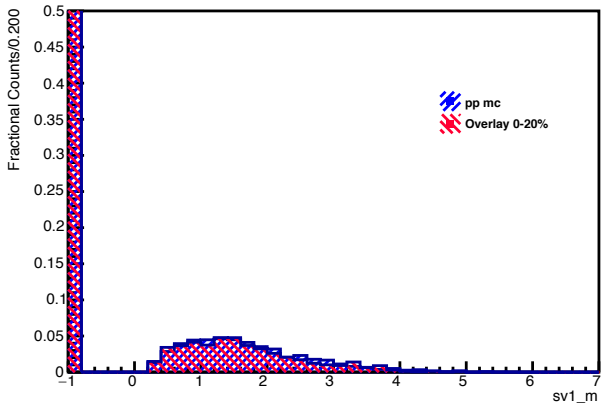

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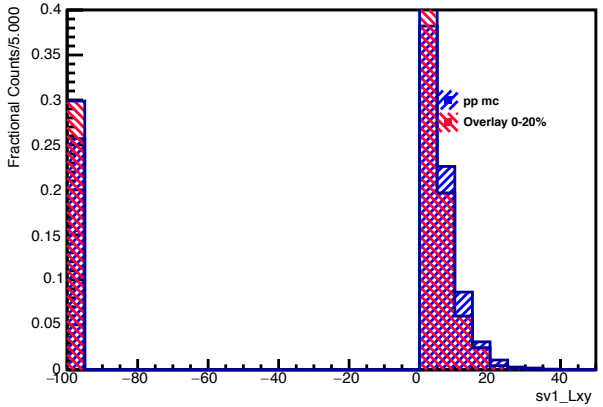

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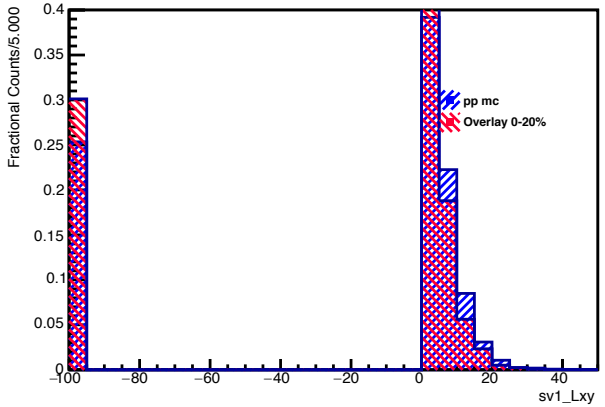

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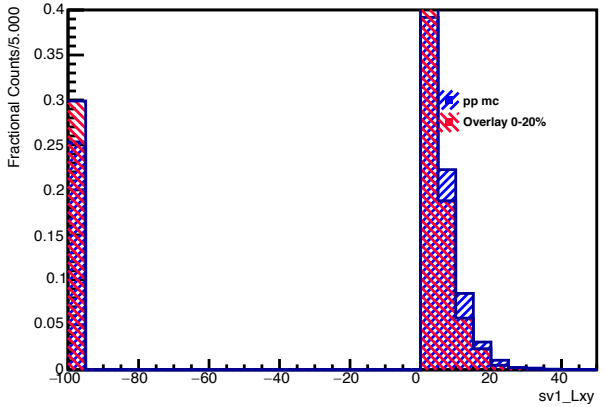

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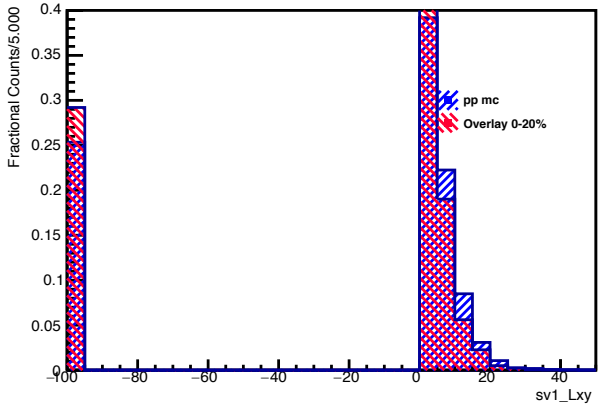

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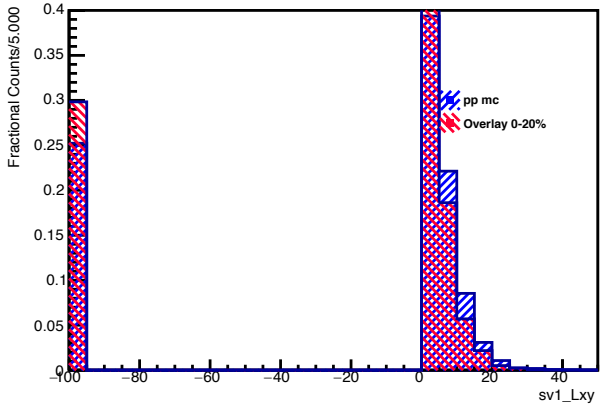

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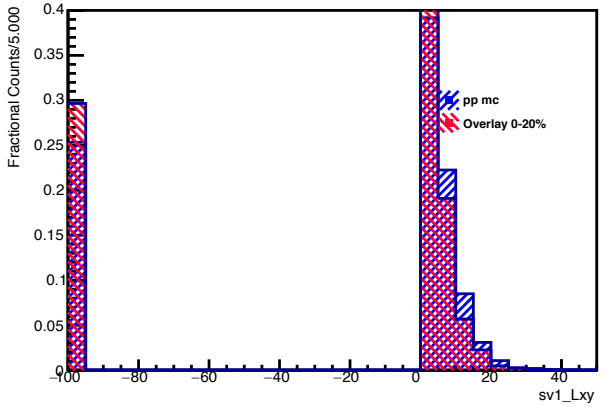

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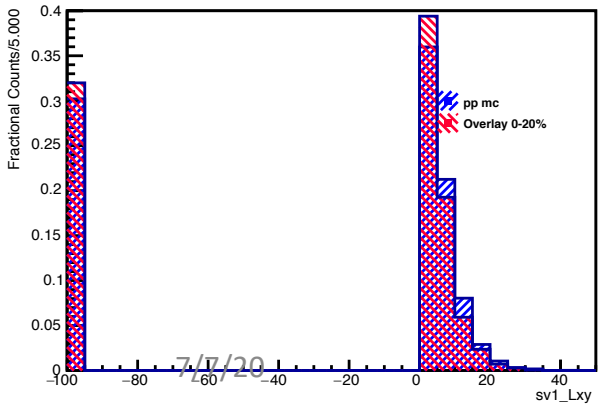

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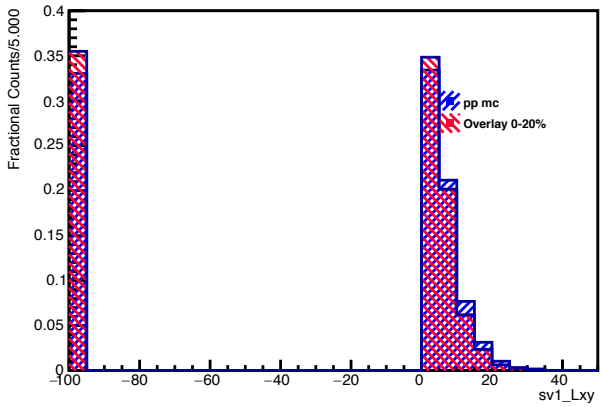

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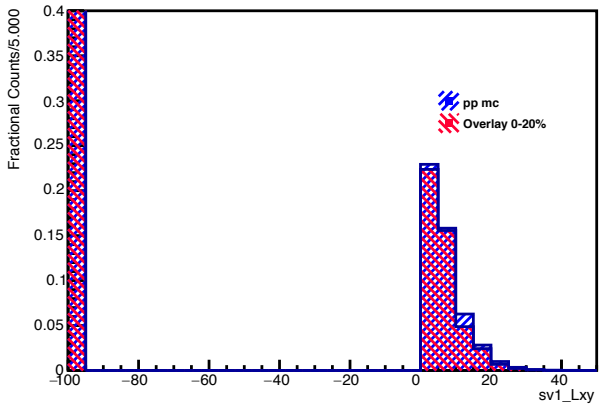

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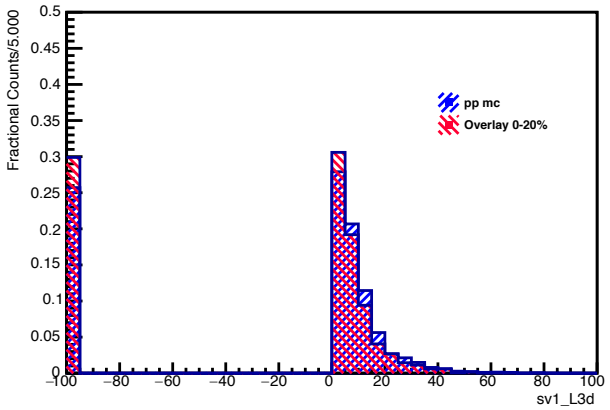

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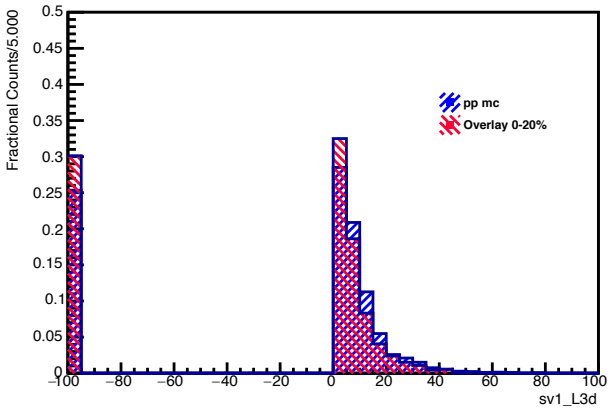

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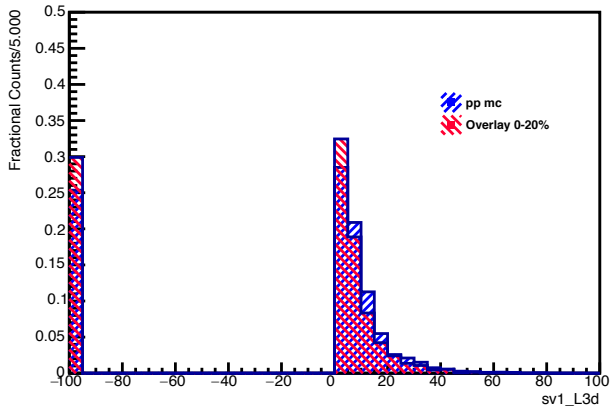

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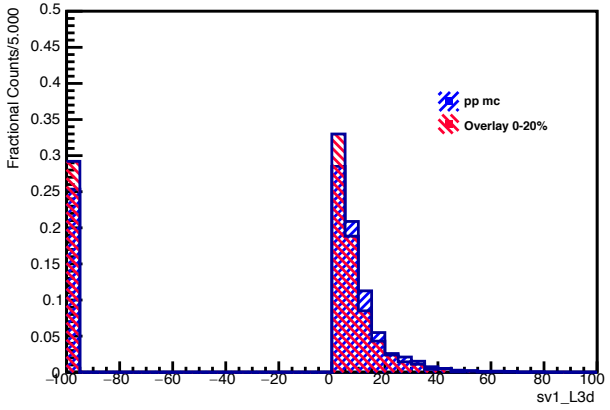

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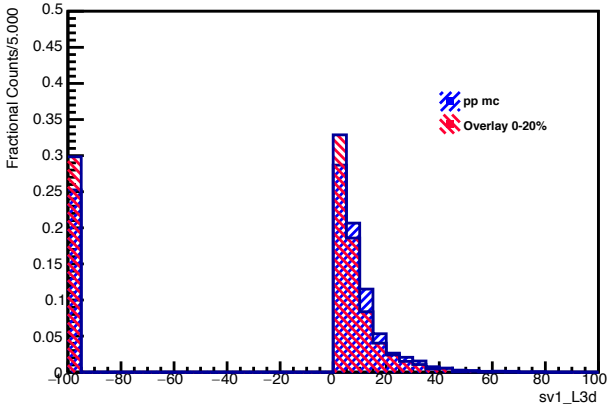

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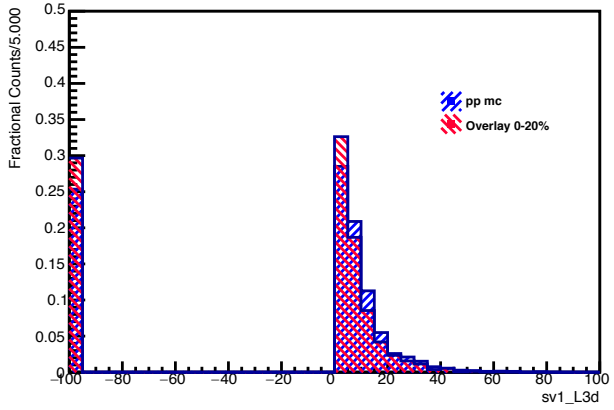

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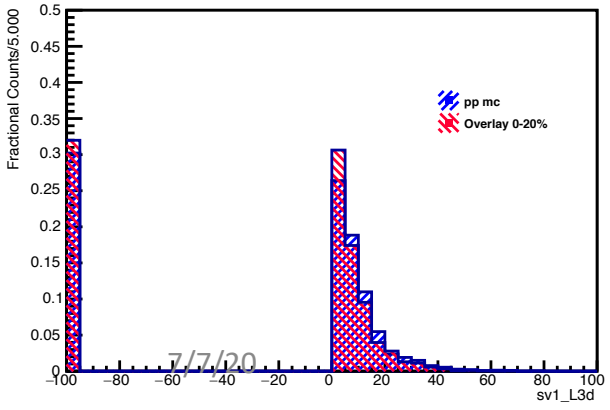

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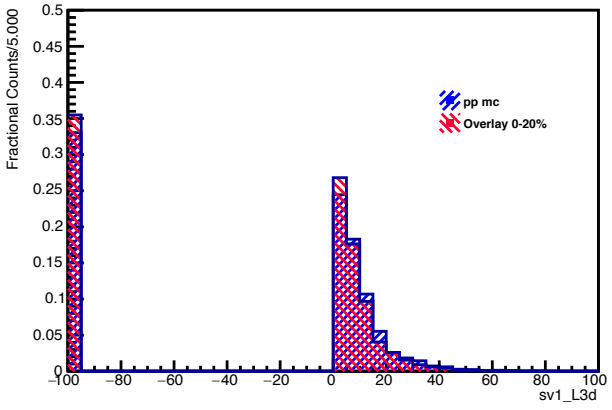

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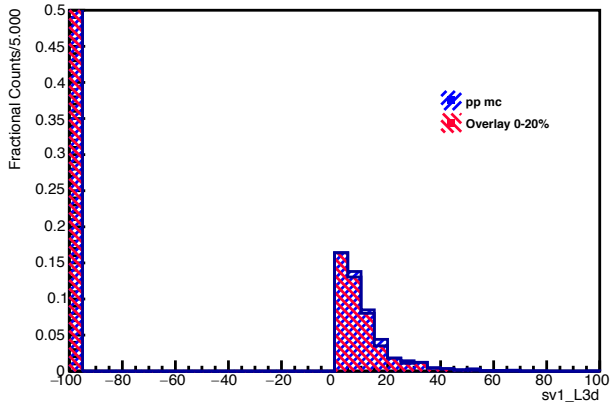

JetFitter

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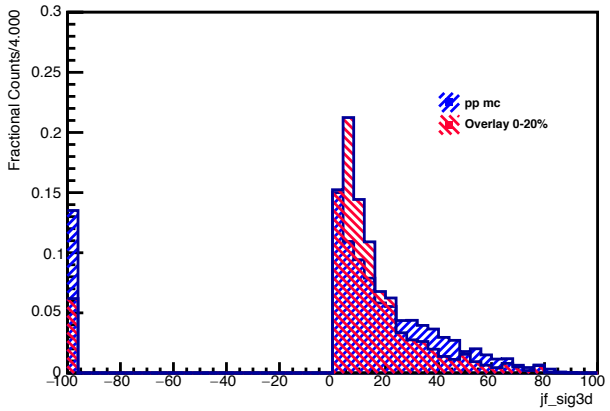

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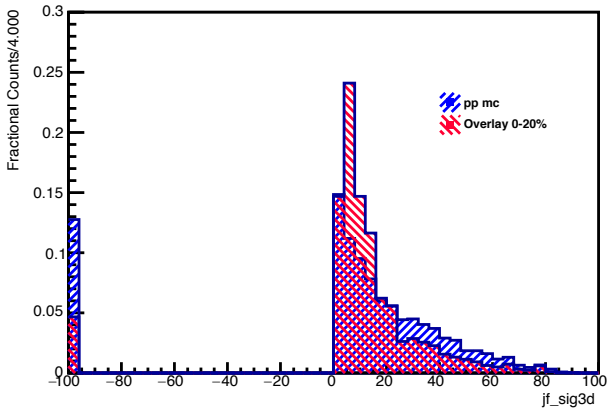

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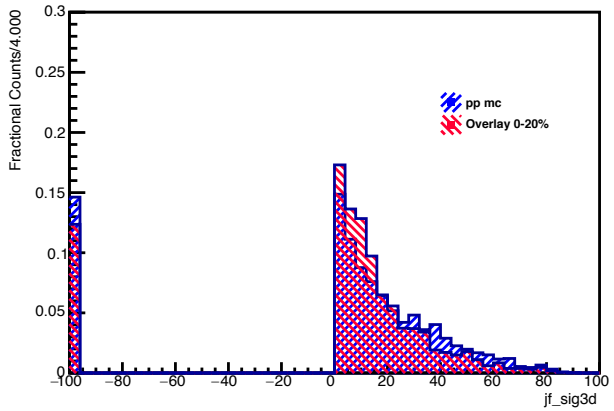

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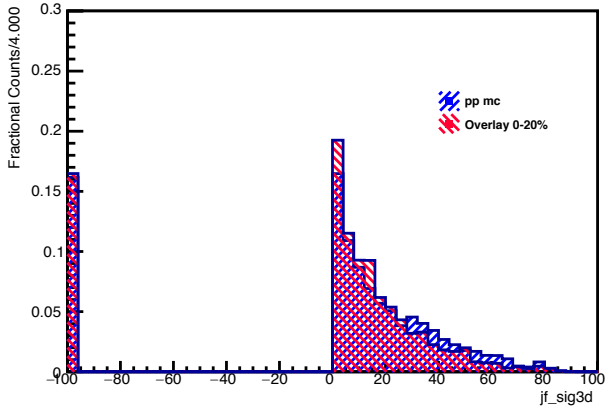

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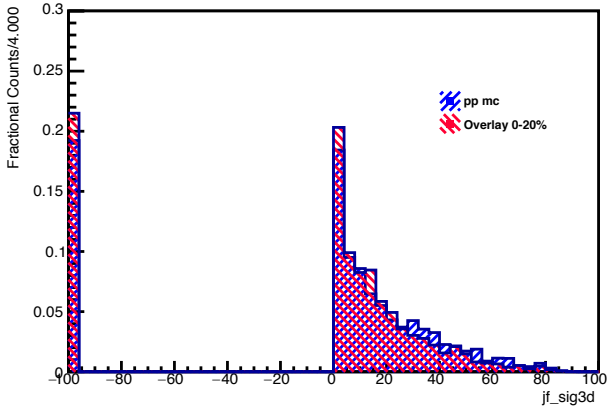

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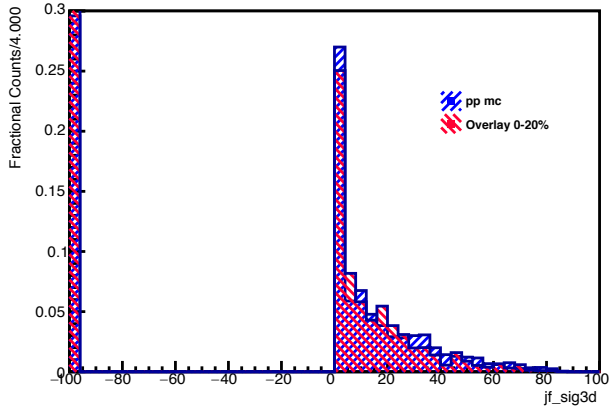

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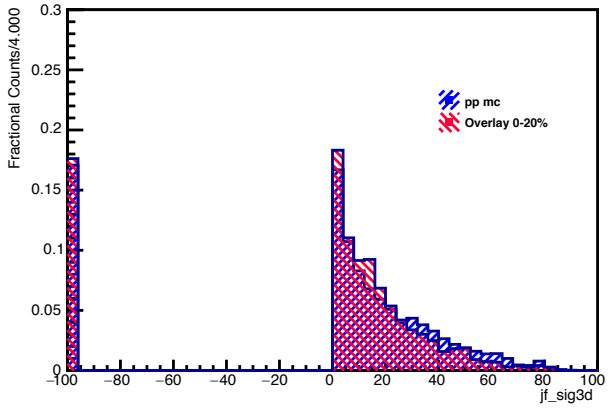

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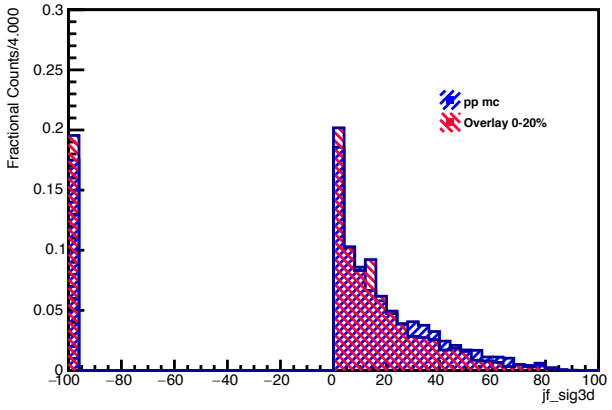

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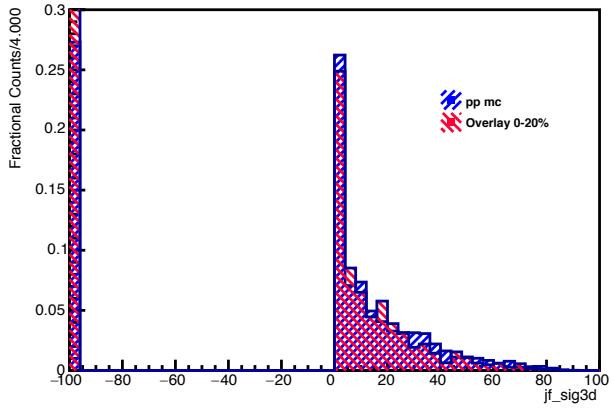

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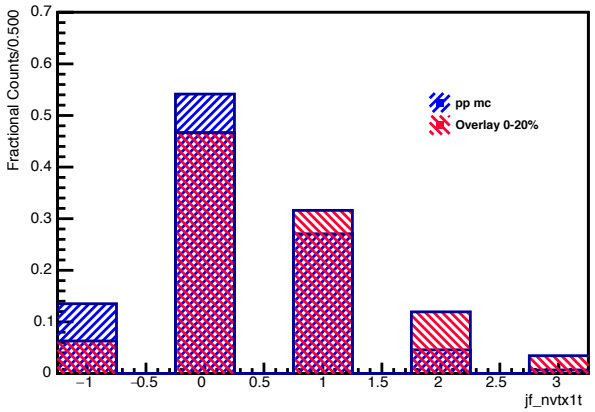

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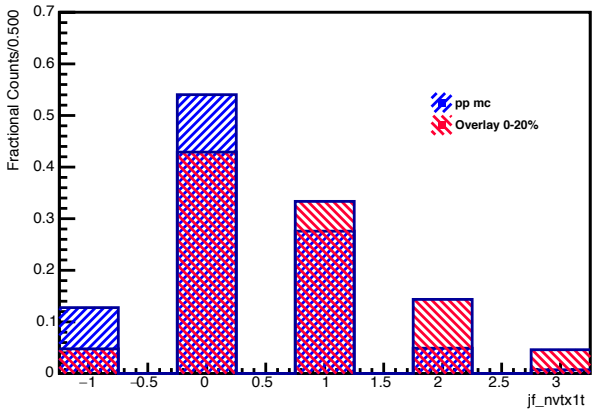

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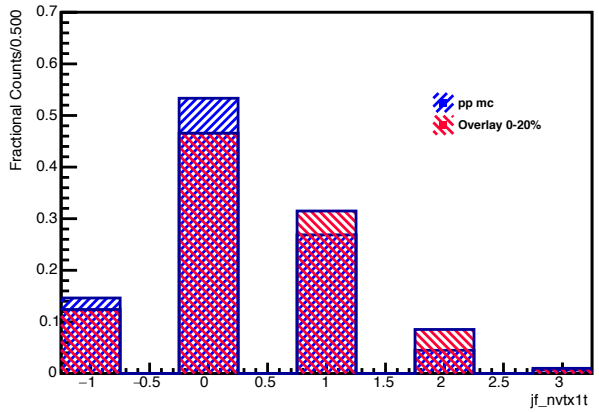

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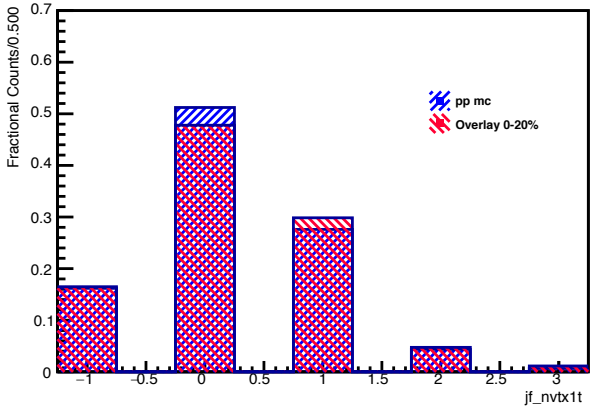

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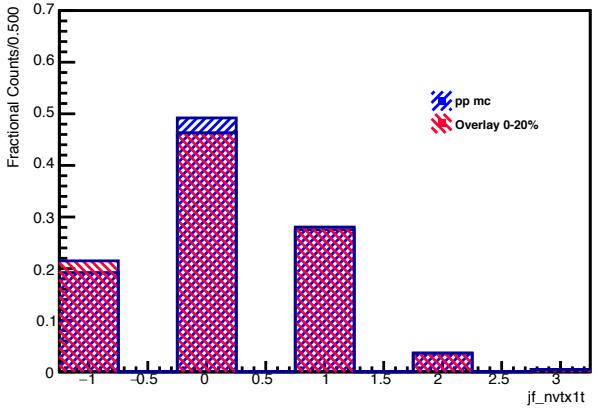

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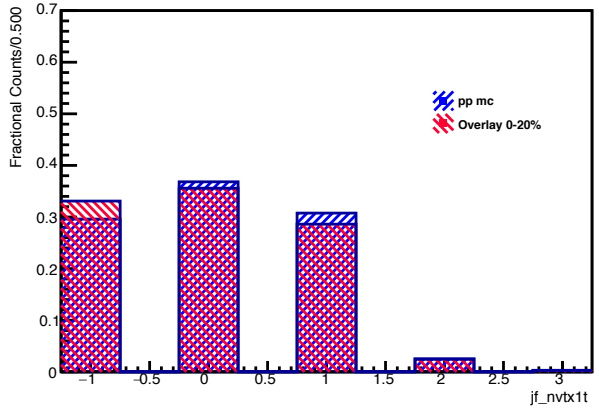

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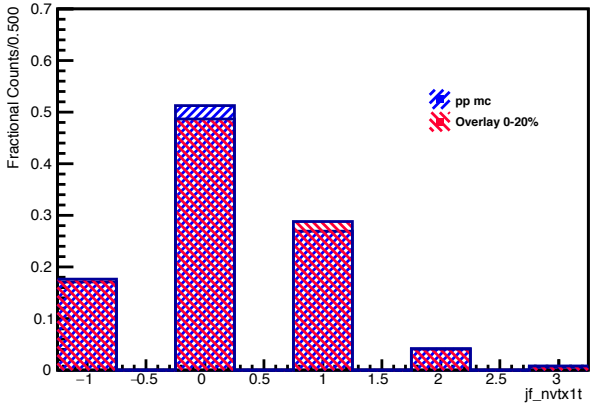

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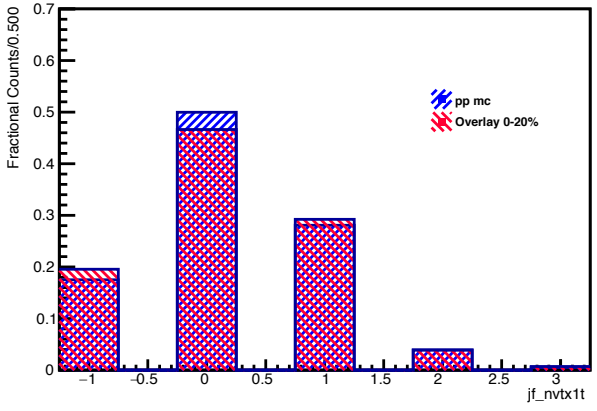

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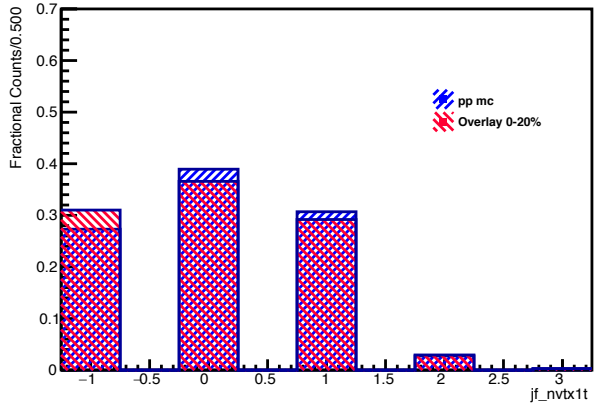

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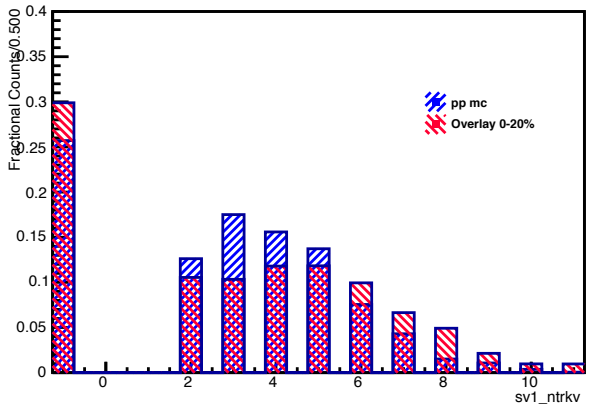

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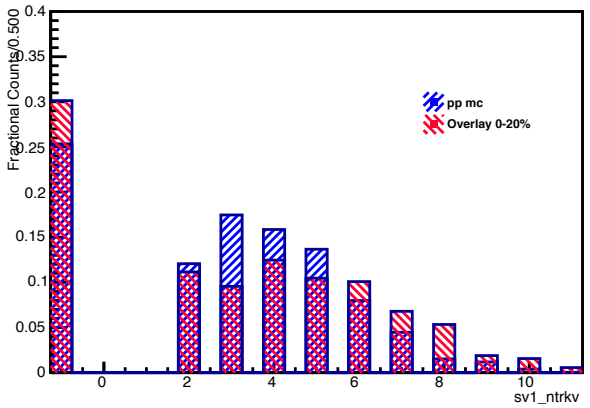

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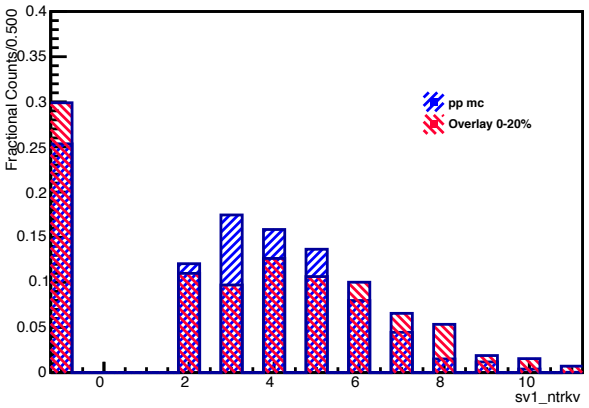

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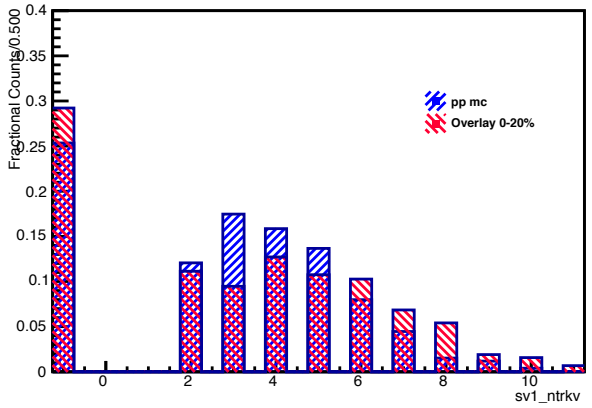

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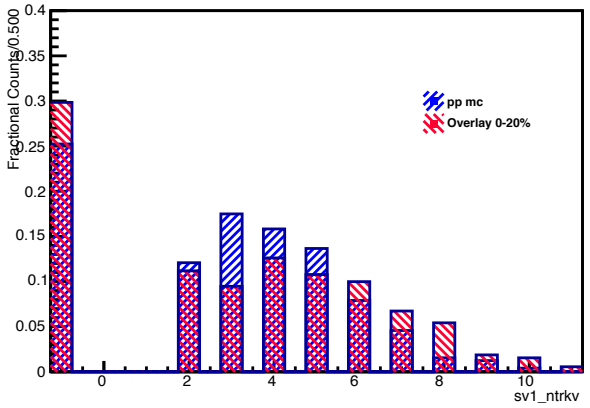

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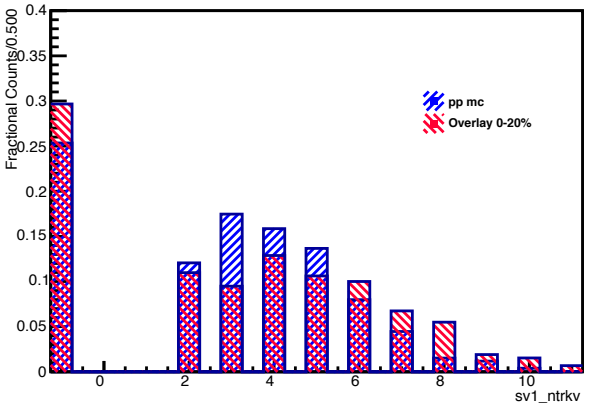

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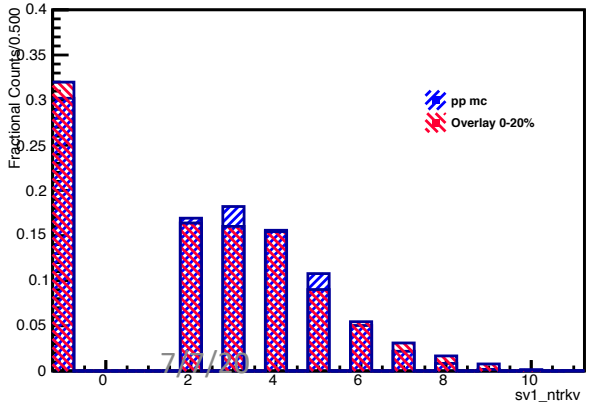

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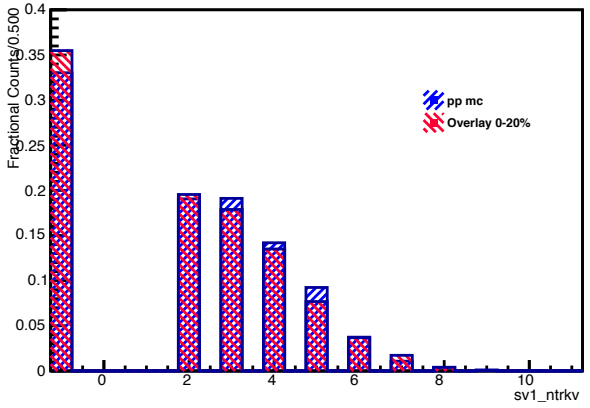

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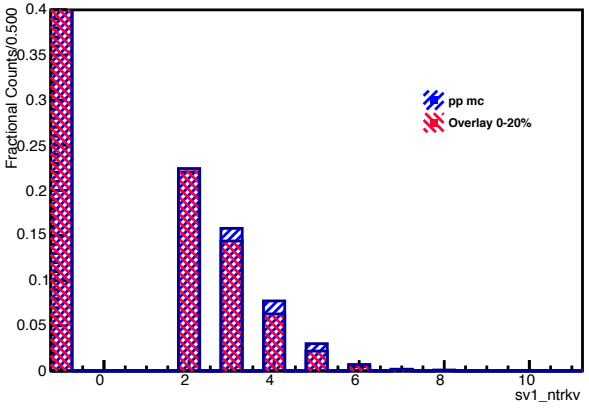

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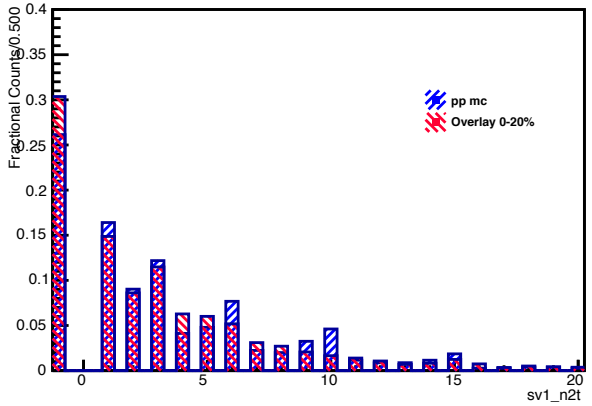

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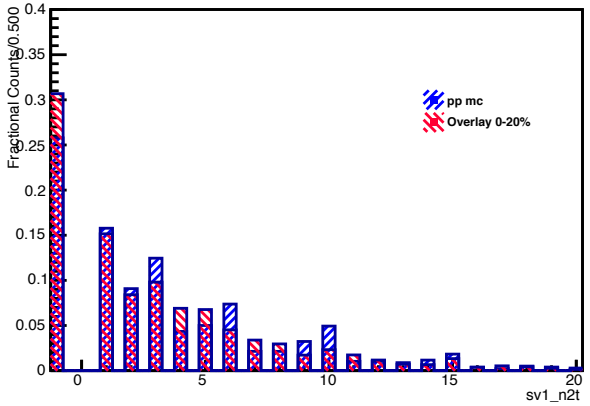

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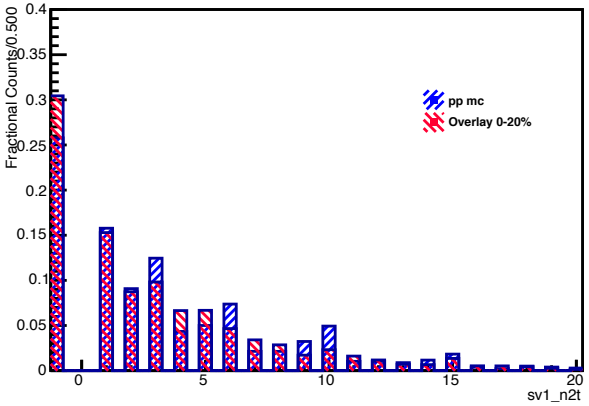

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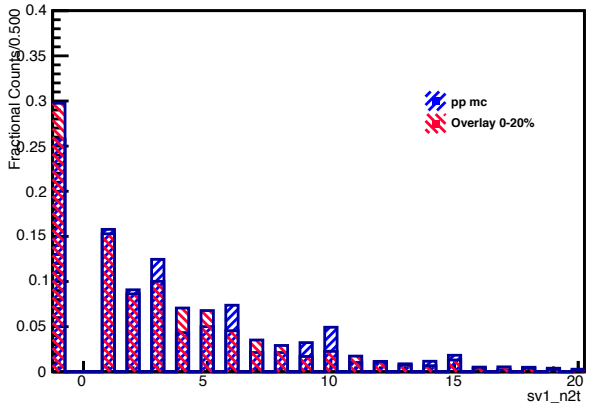

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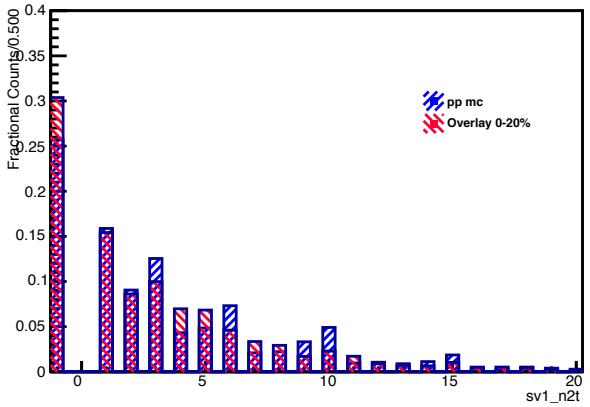

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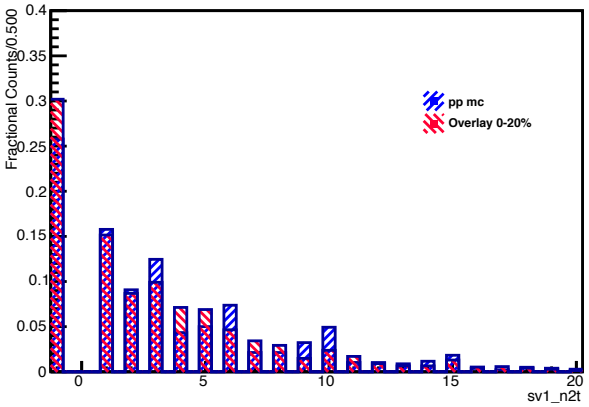

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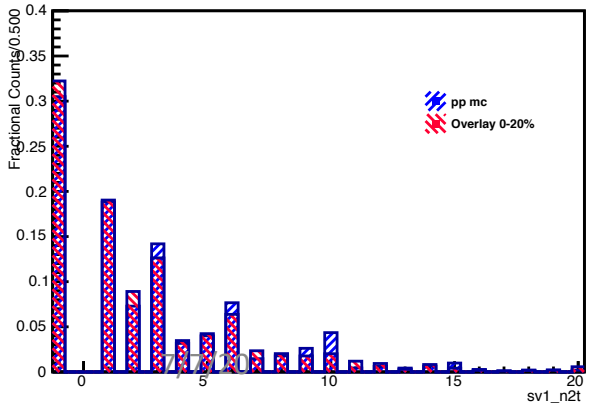

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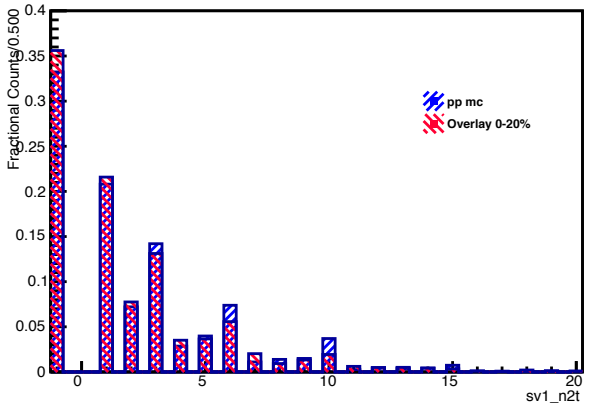

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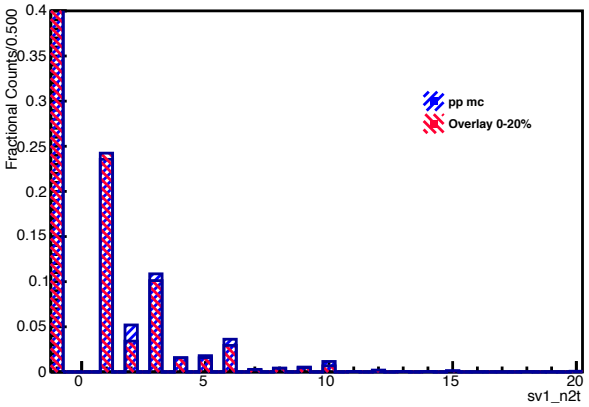

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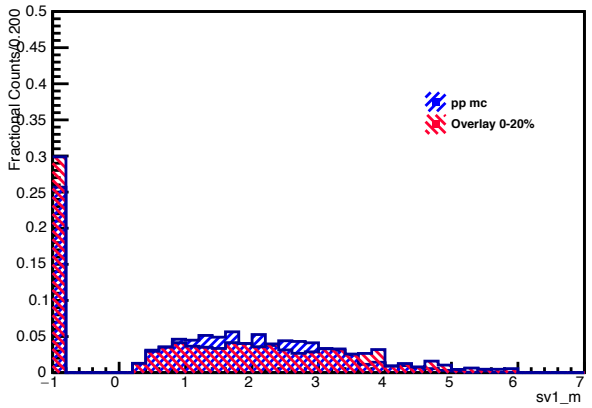

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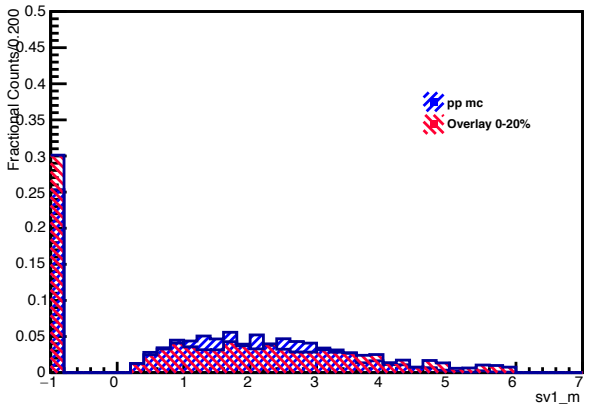

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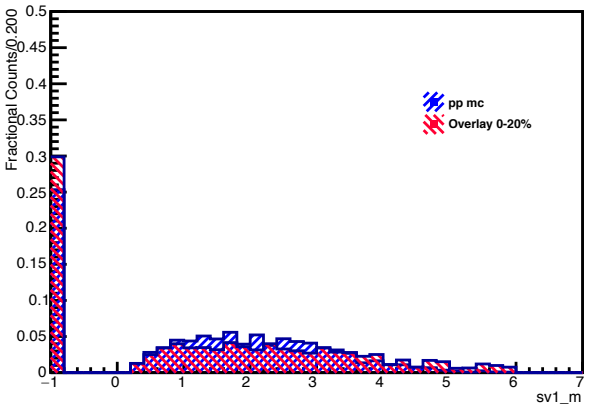

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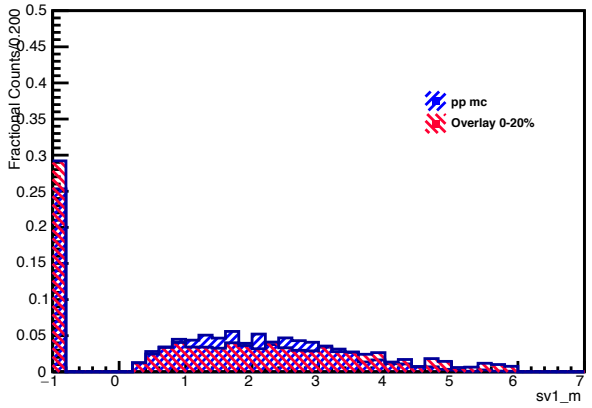

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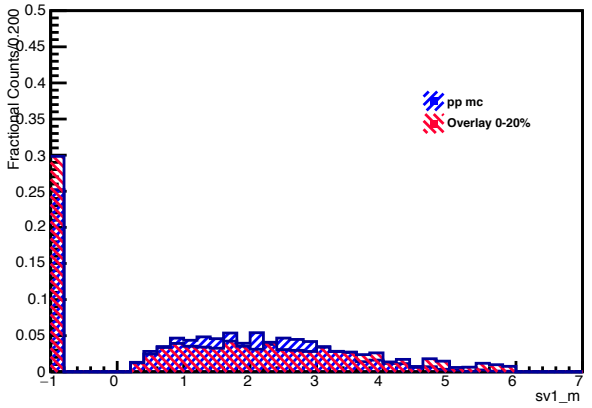

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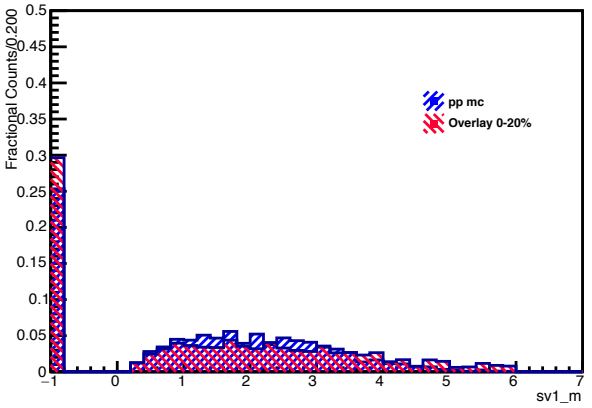

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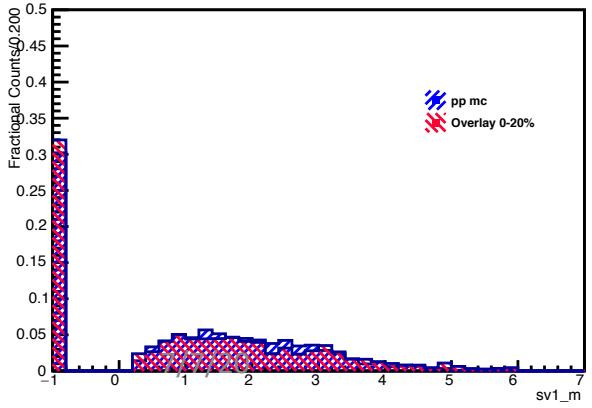

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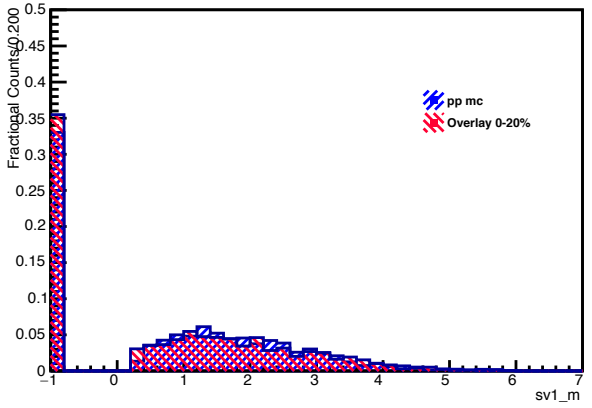

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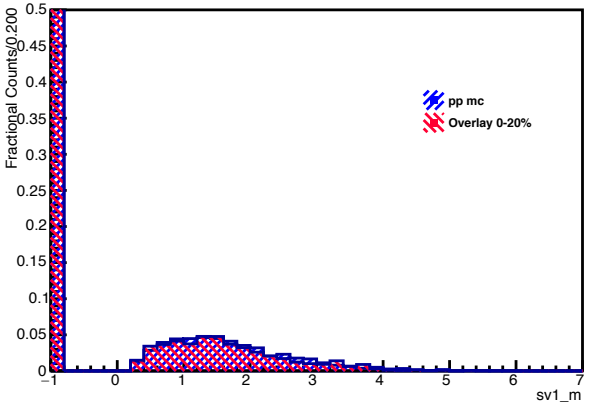

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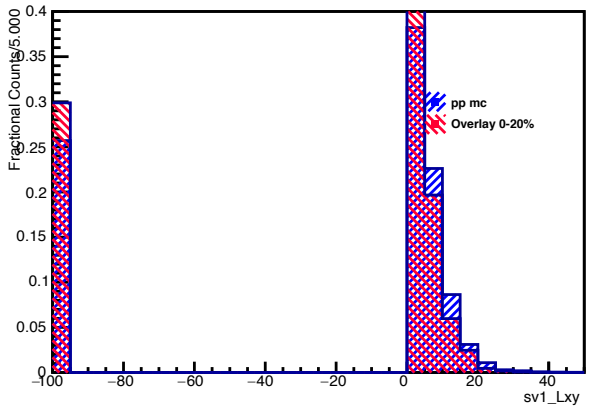

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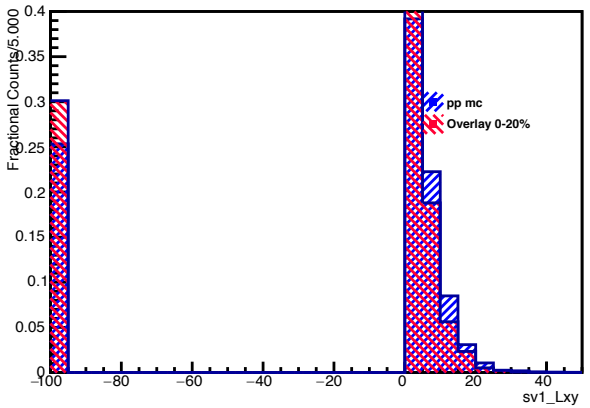

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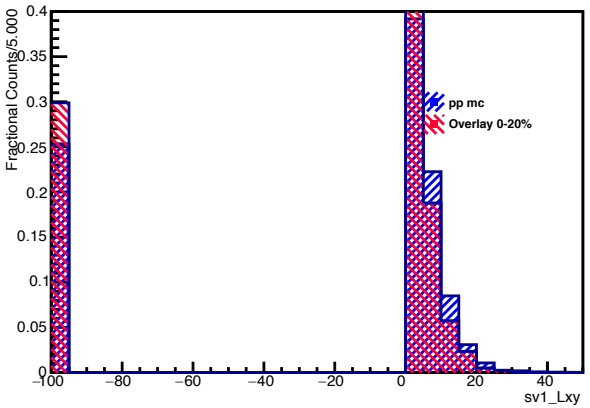

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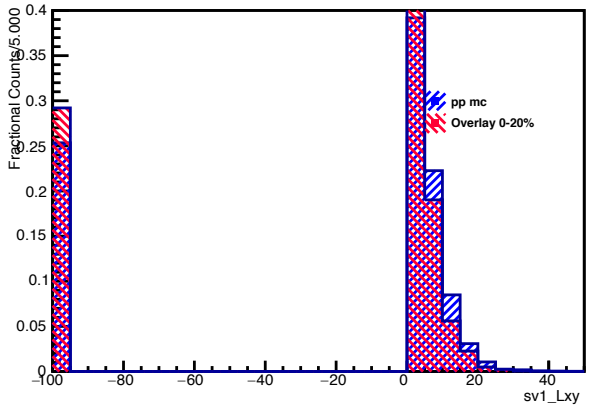

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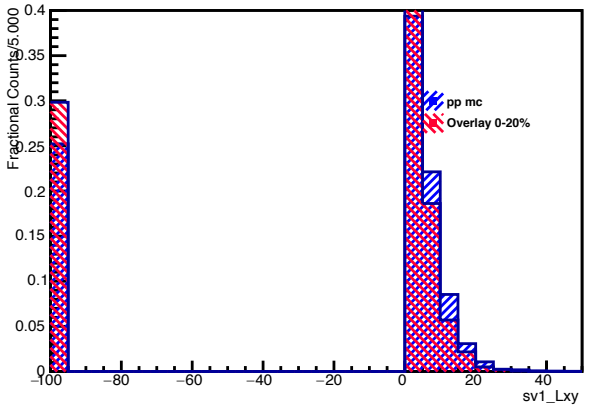

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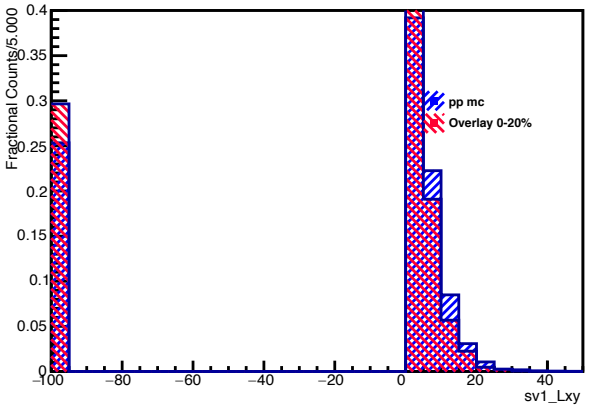

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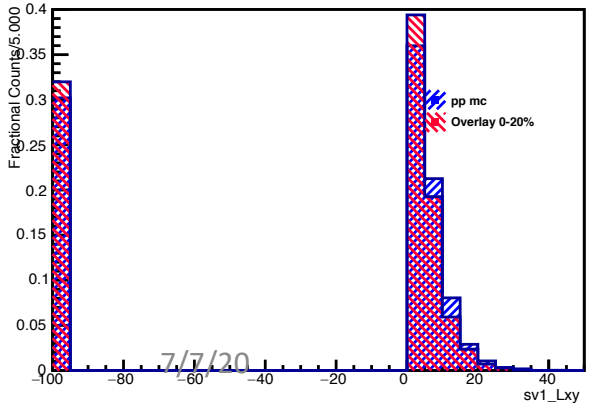

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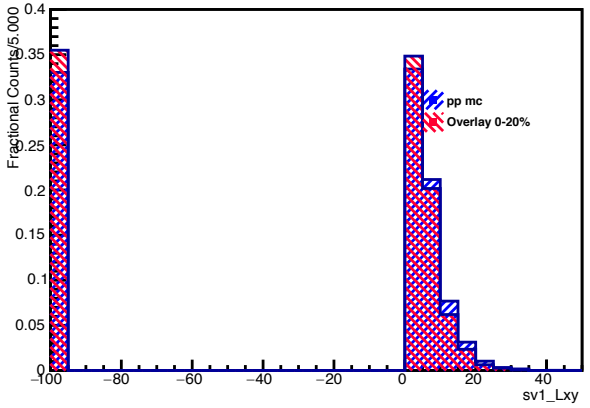

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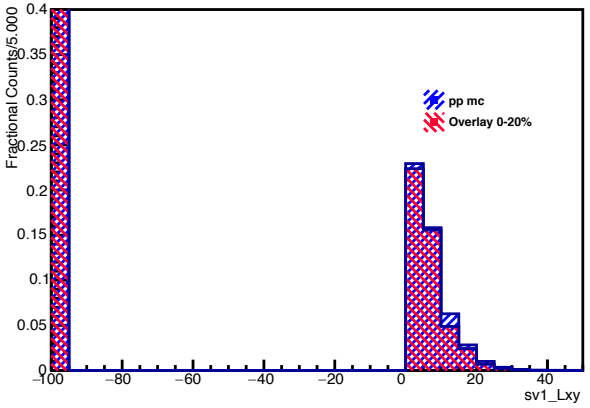

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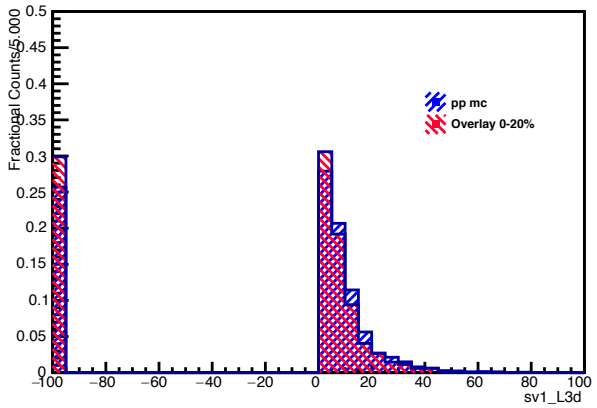

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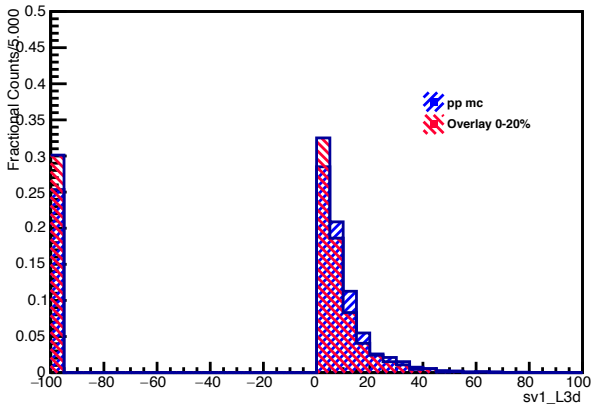

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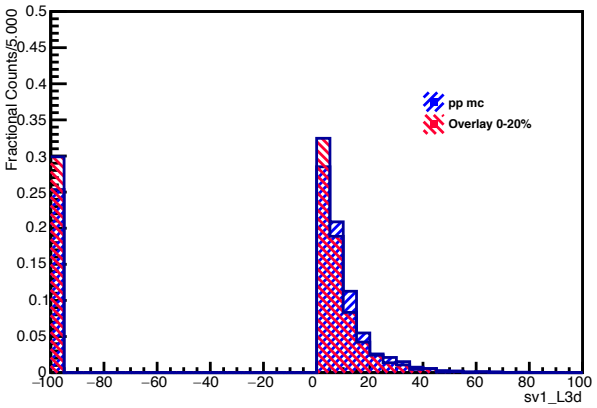

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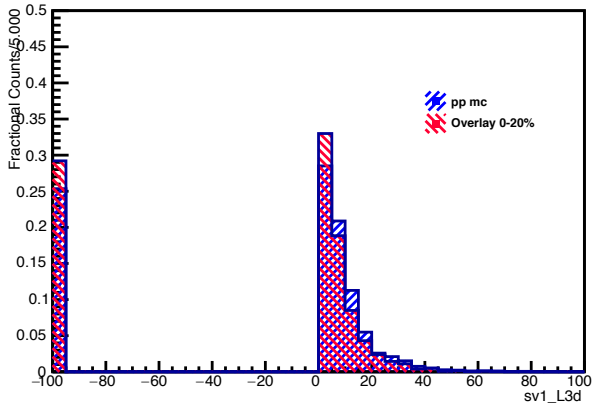

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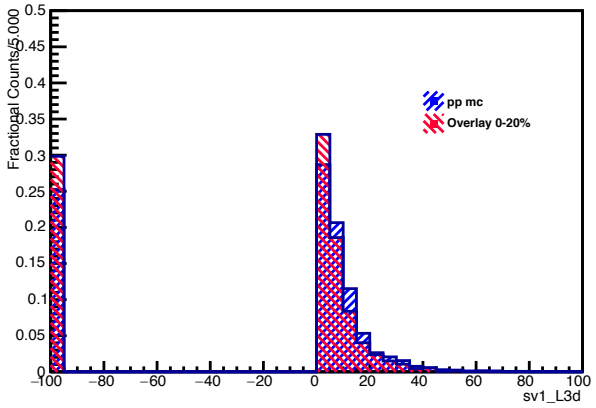

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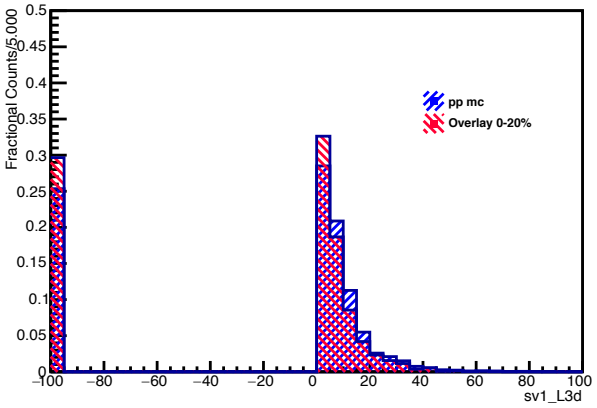

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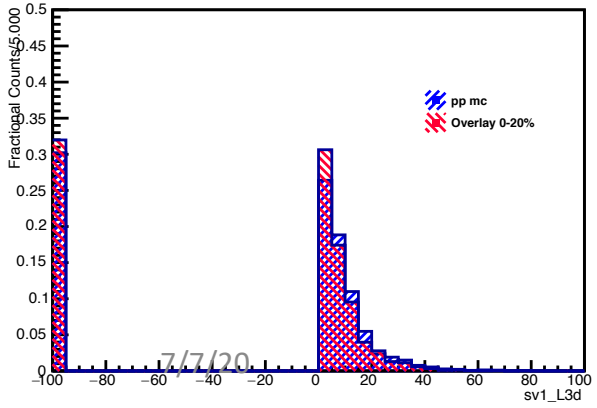

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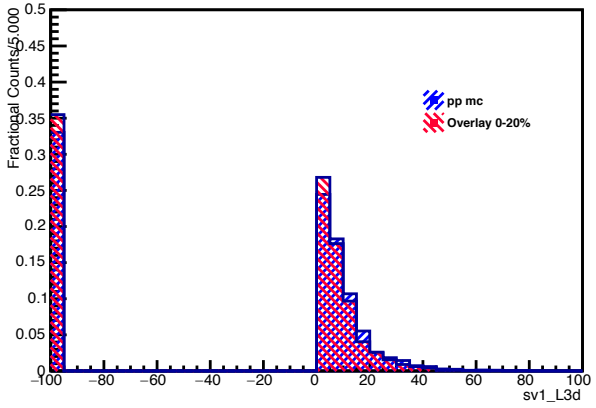

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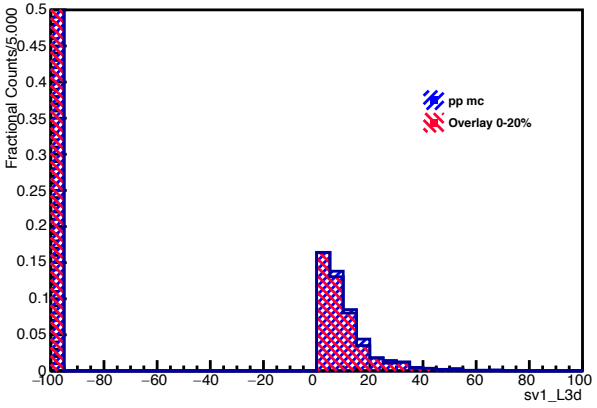

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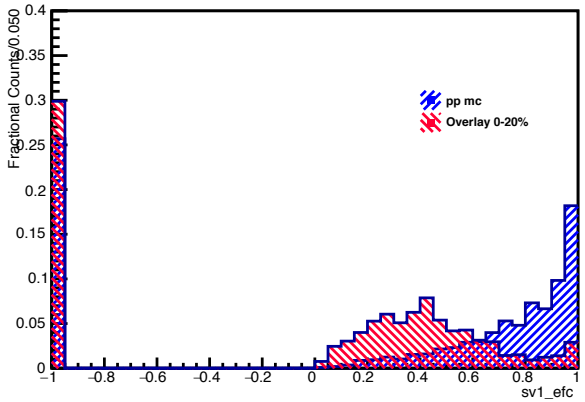

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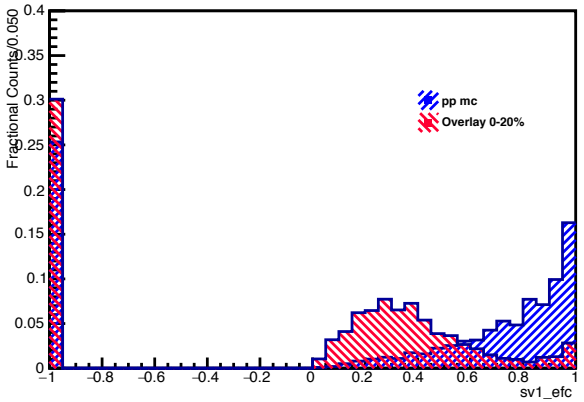

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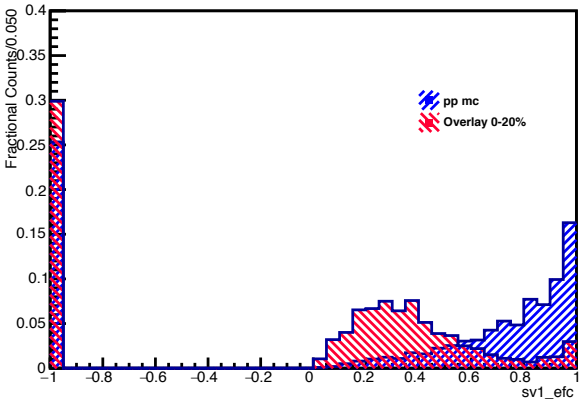

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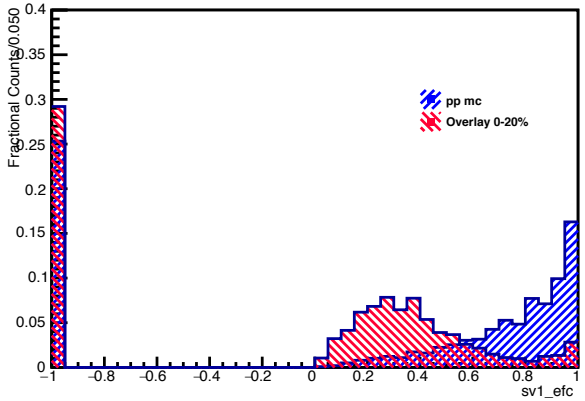

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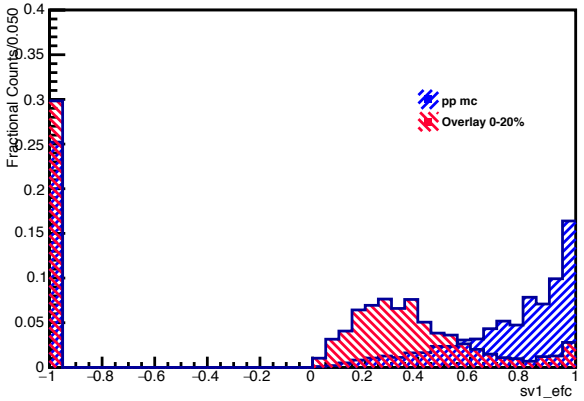

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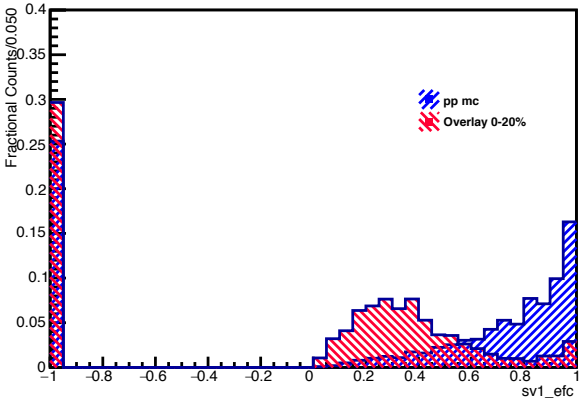

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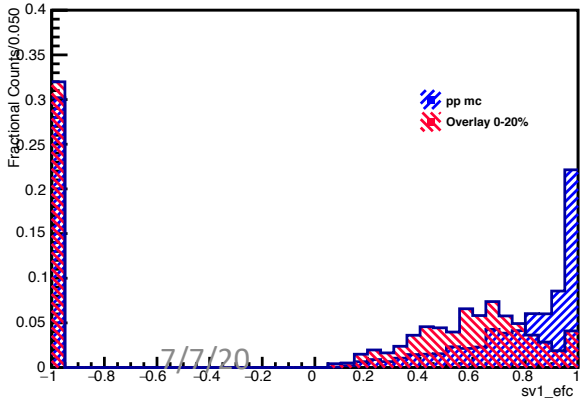

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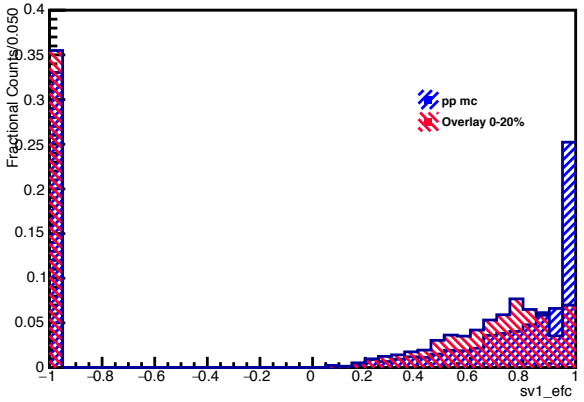

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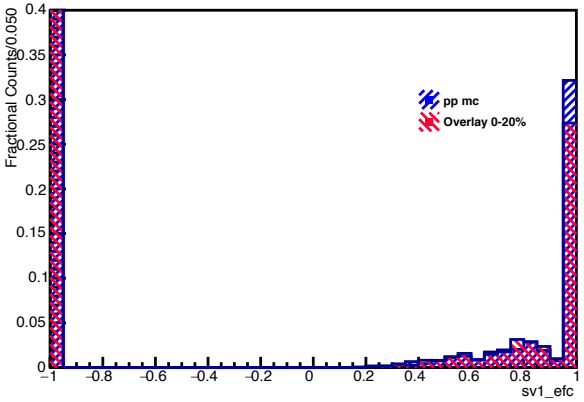

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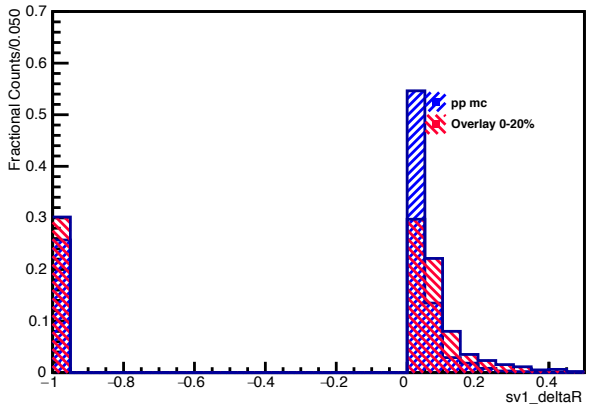

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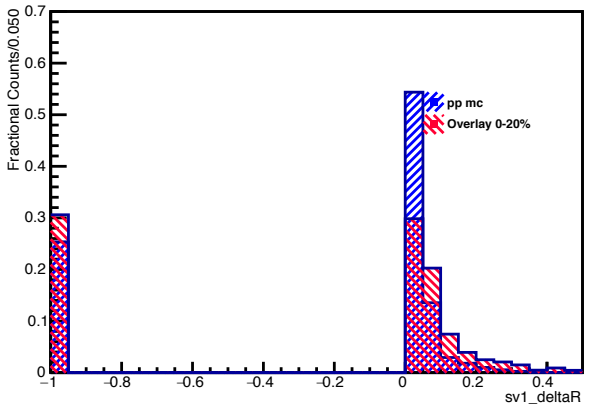

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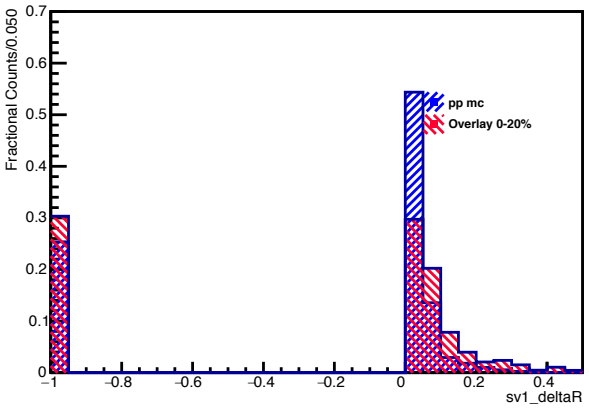

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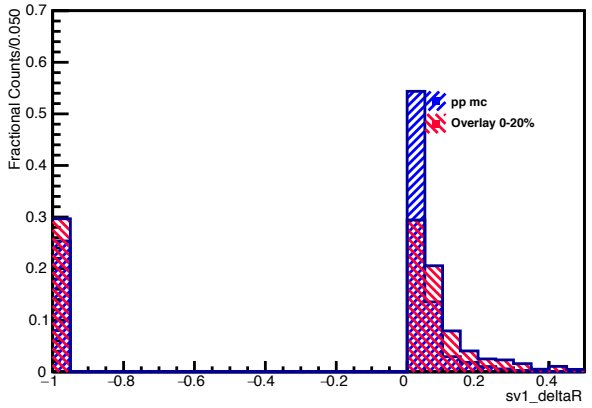

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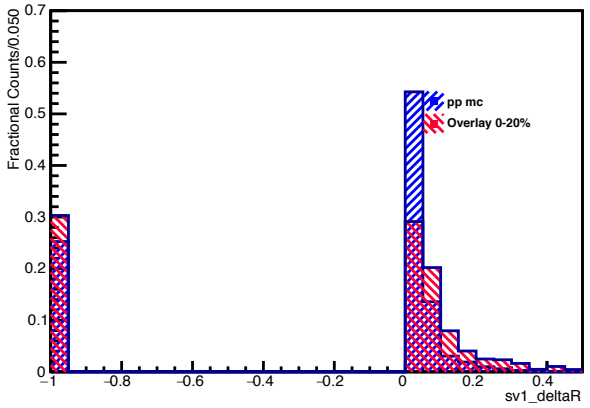

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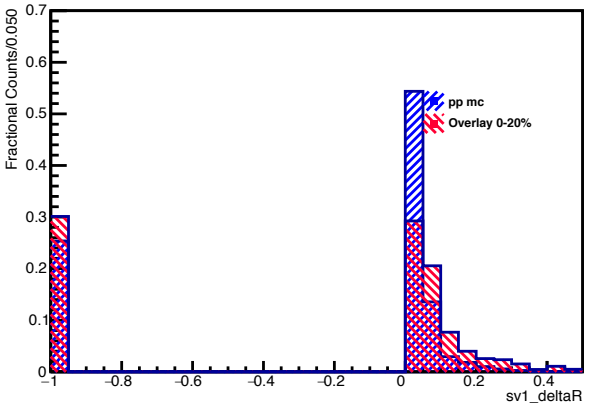

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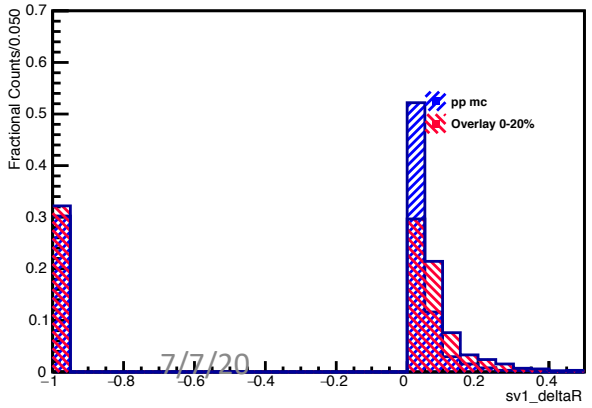

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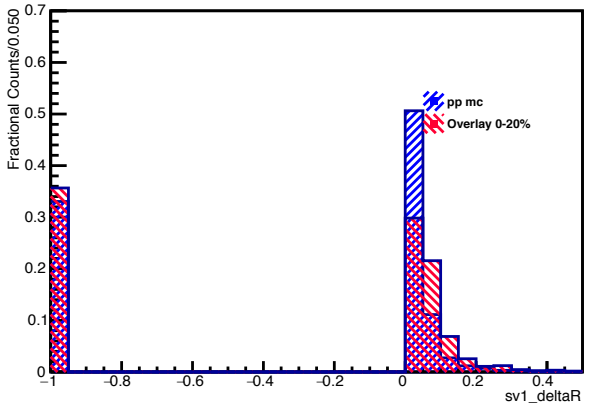

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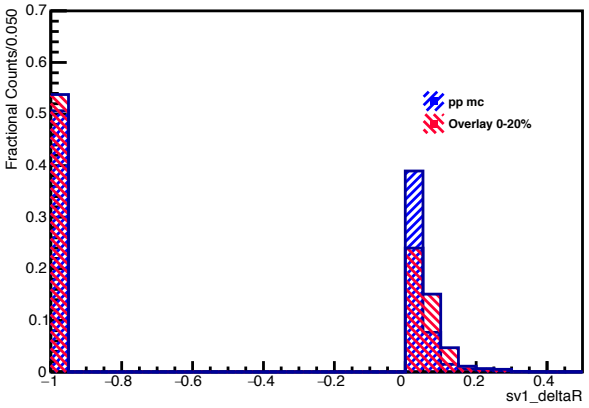
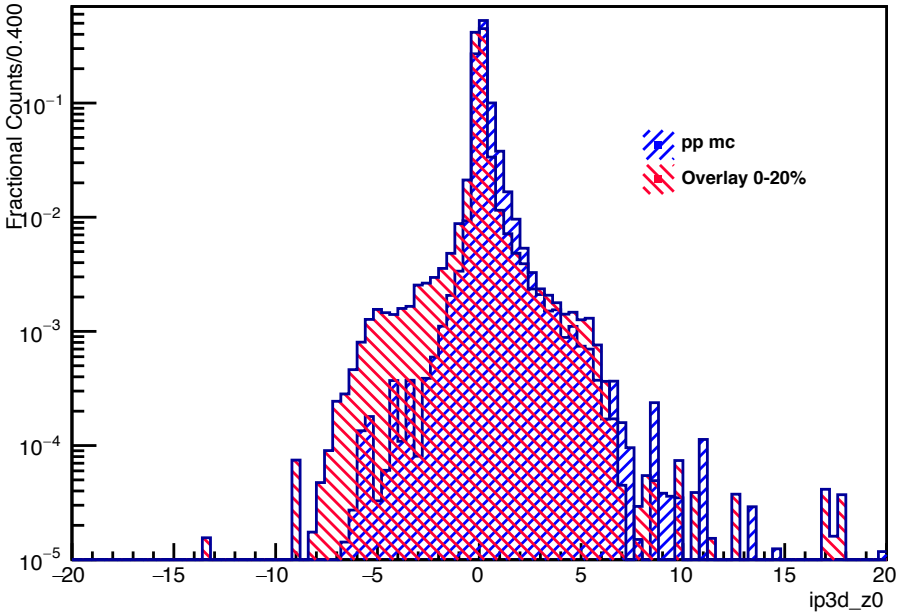
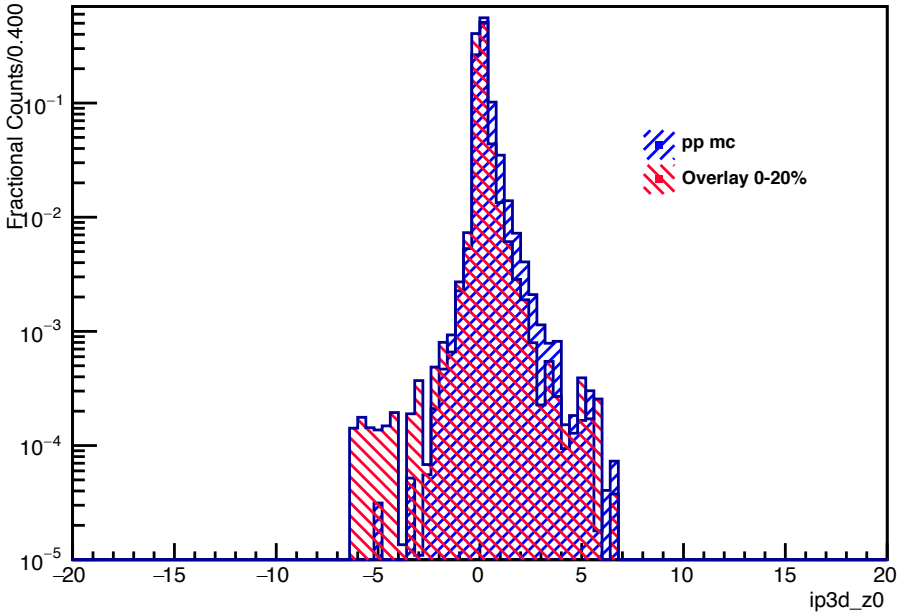


IPxD

Default Cuts Shrinking Cone



Pre-tagging min pT 1.5 GeV FC4



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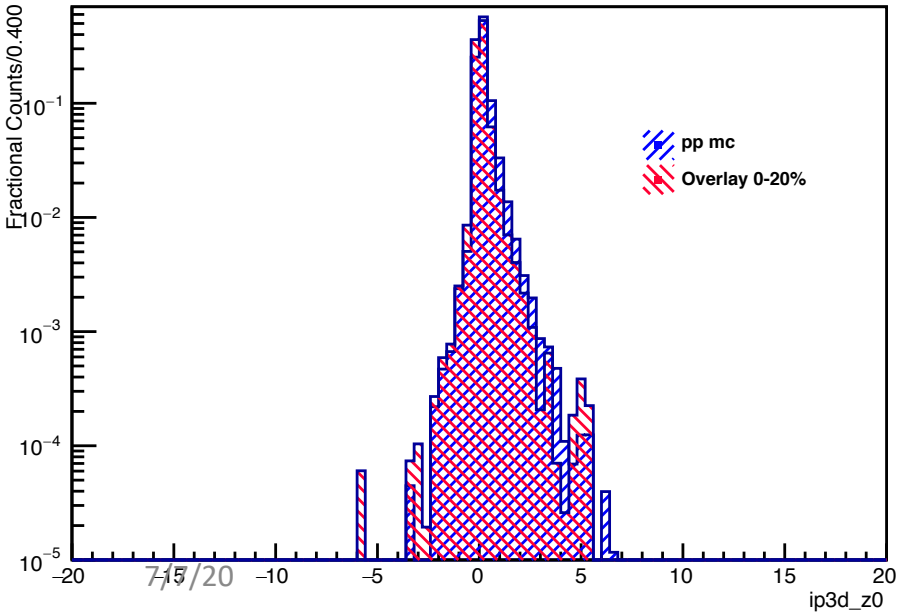

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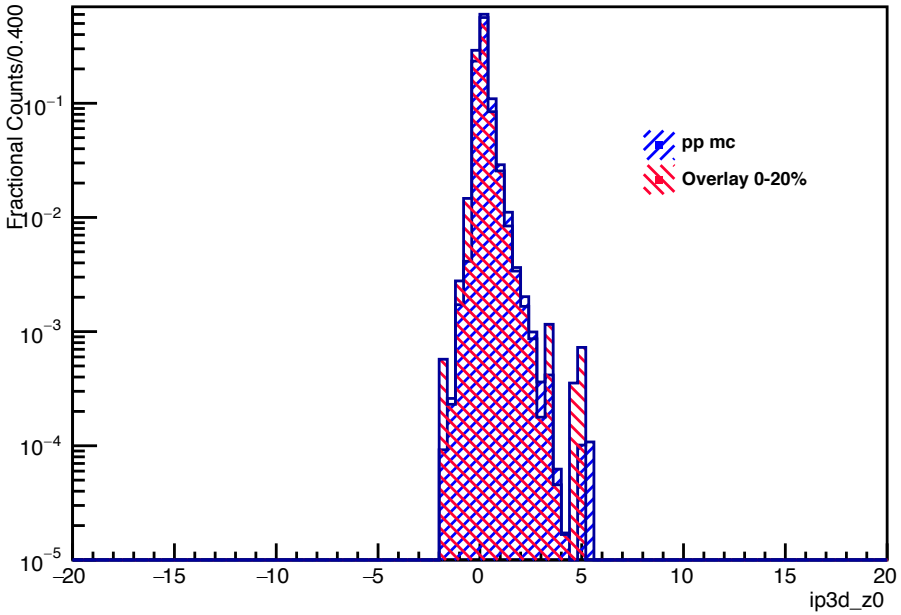
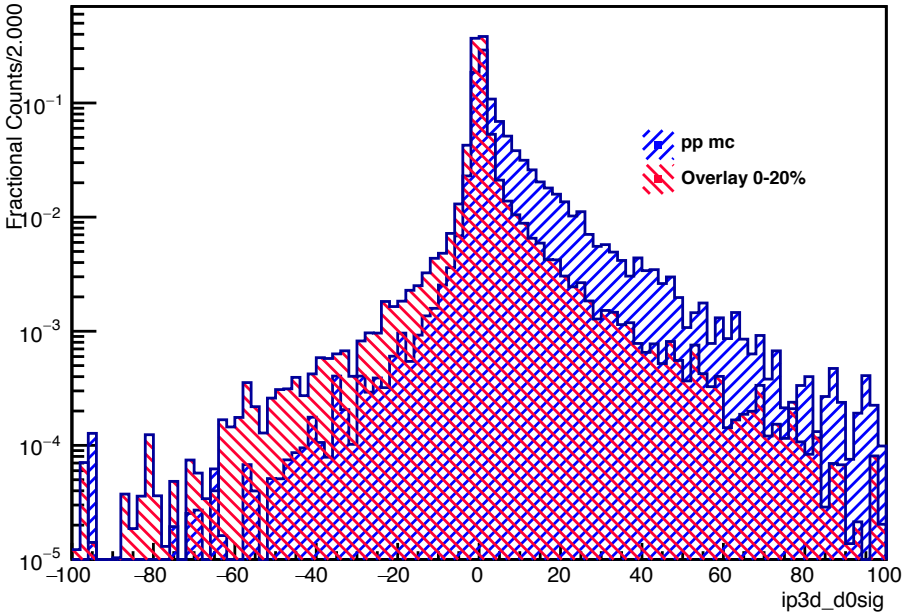


Default Cuts Shrinking Cone



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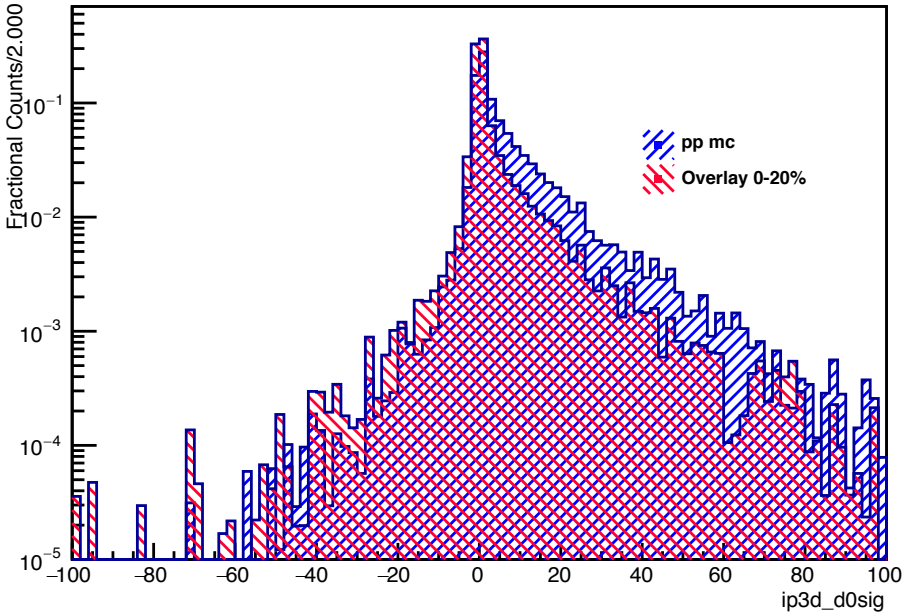

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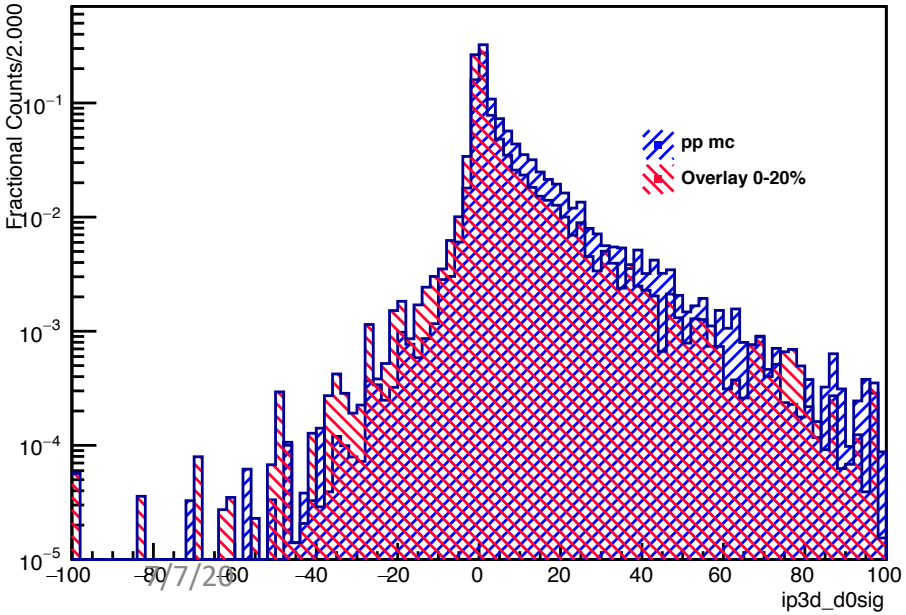

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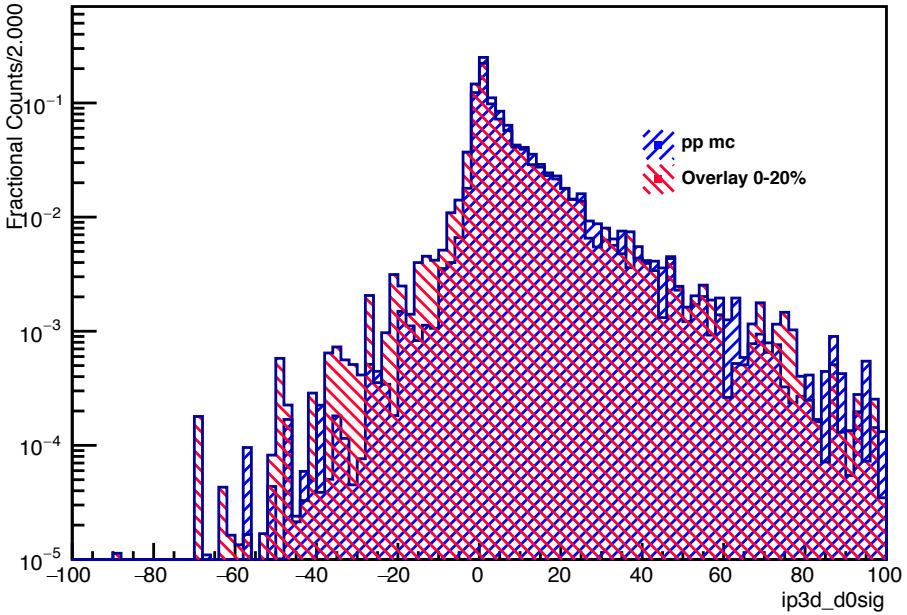
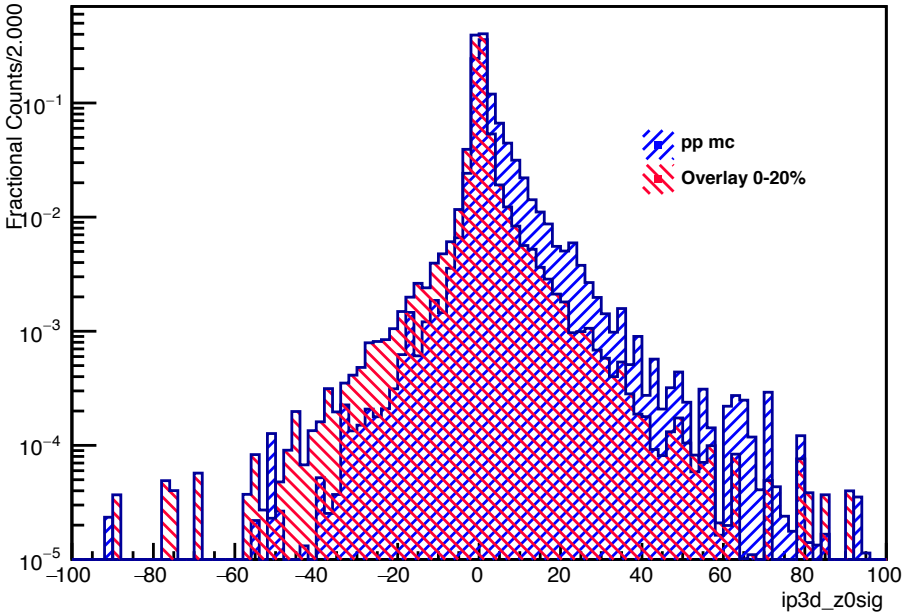


Default Cuts Shrinking Cone



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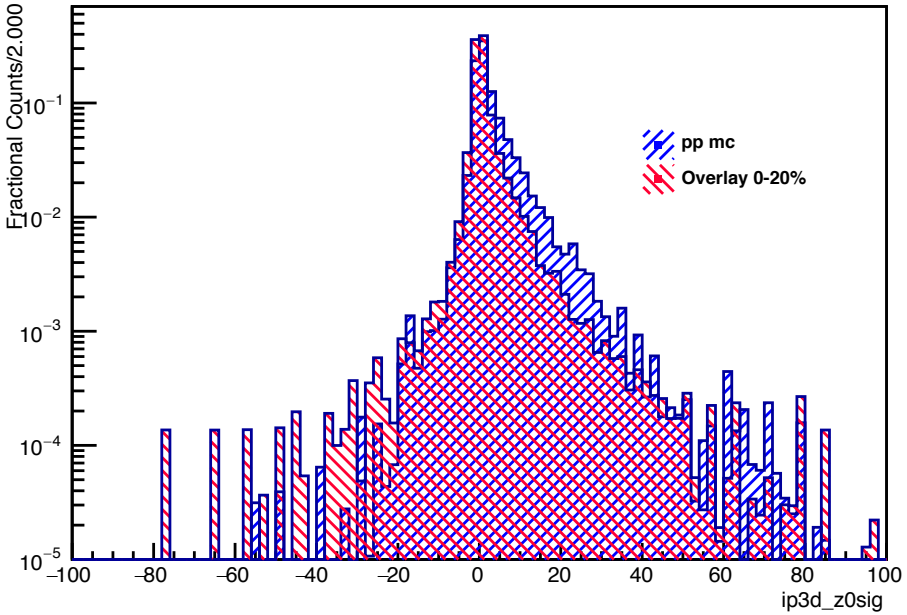

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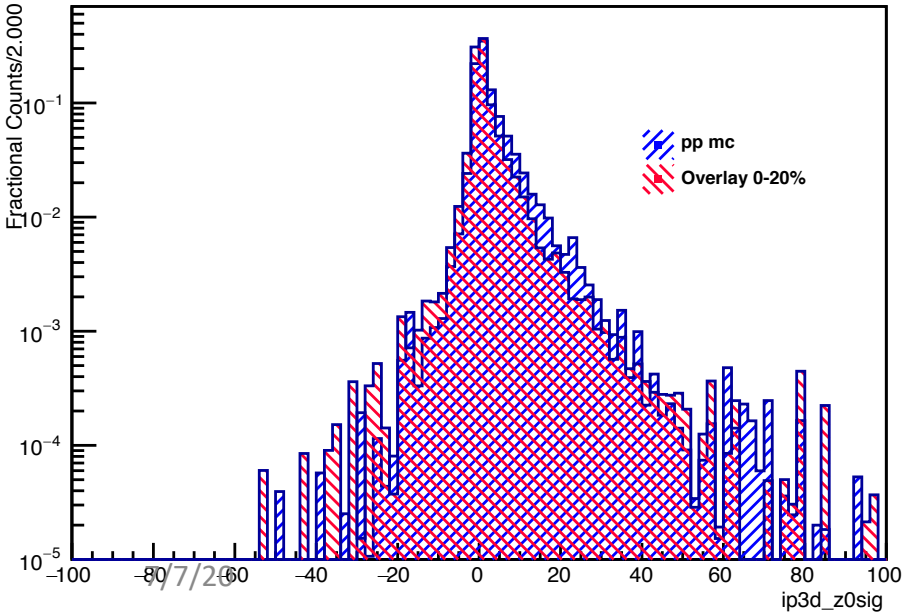

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