Update on
Track Quality Study with MinBias 900 GeV Data/MC

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Tracking POG Meeting

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Outline

- Brief Introduction to AnalyticalTrackSelector
- MC Tracking FakeRates and Efficiencies
- Data/MC dz Significance comparison in 352
- Overall Loose/HP Selection Efficiency in 336p3
- Summary

Update talk for: http://indico.cern.ch/contributionDisplay.py?contribId=5&confId=87530

Documentation

Documentation

- "Optimal filtering of fake tracks": CMS IN-2008/017
- Twiki page

  https://twiki.cern.ch/twiki/bin/viewauth/CMS/SWGuideFinalTrackSelectors
- Package: CMSSW/RecoTracker/FinalTrackSelectors
- TRK-10-001 PAS and AN appendix

Disclaimer:
The results presented in this talk have the baseline event-selection as in TRK-10-001 approval talk without track level cuts on HighPurity, dzSignificance or ptErr unless specified

AnalyticalTrackSelector

- The goal is to remove tracks with bad fit-chi2 and bad compatibility with primary interaction
- Adapt the cuts to the *track η, pT and mostly importantly nLayers*:

1. min nLayers with valid hits
2. min n3DLayers (pixel layers or matched strip layers)
3. max nLayers with missing hits
4. normalized chi2
5. dxy significance (BS) with track error
6. dxy significance (BS) with expected error
7. dz significance (pixelVertex) with track error
8. dz significance (pixelVertex)with expected error

$$\chi^2/\mathrm{ndof} < \alpha_0 \cdot nLayers$$

$$|d_{xy}(BS)| < (\alpha_1 \cdot nLayers)^\beta \cdot \sigma d_{xy}$$

$$|d_{xy}(BS)| < (\alpha_3 \cdot nLayers)^\beta \cdot \sigma d_{xy}(pT)$$

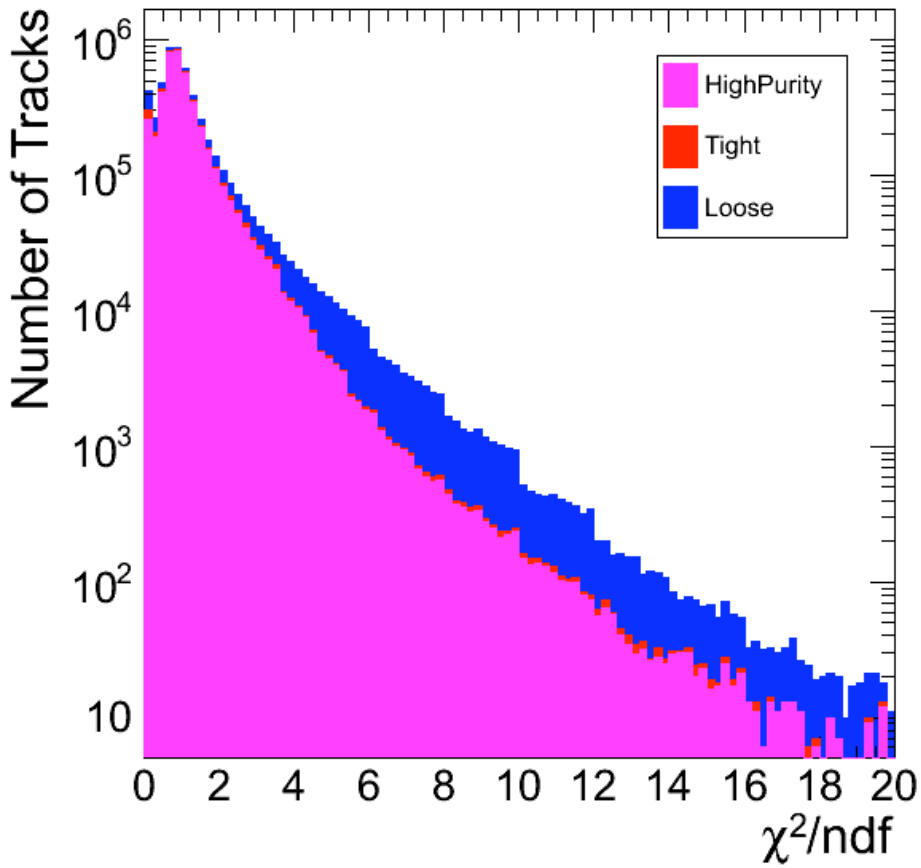
$$|d_z - z(\mathrm{pxlpvtx})| < (\alpha_2 \cdot nLayers)^\beta \cdot \sigma d_z$$

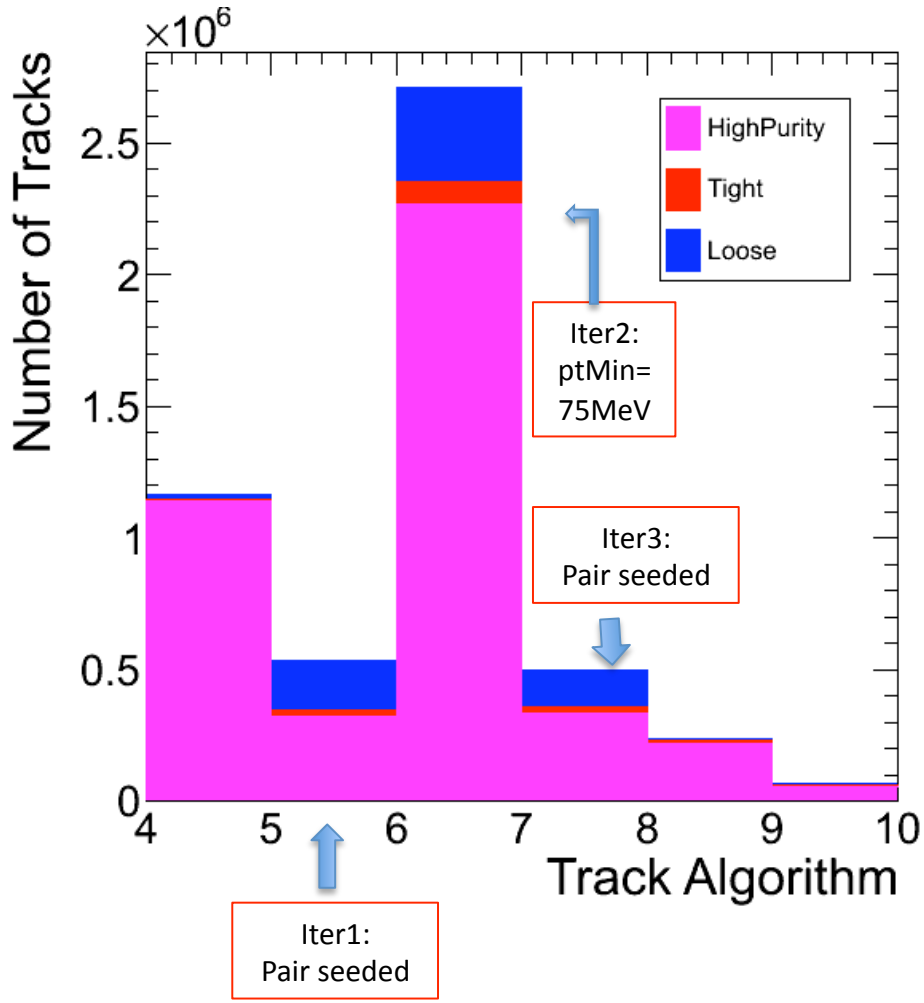
$$|d_z - z(\mathrm{pxlpvtx})| < (\alpha_4 \cdot nLayers)^\beta \cdot \sigma d_z(pT,\eta)$$

Iteration	n^{min}_{layers}	$n^{min}_{\text{3D layers}}$	$n^{max}_{\text{lost layers}}$	β	α_0	α_1	α_2	α_3	α_4
0	4	4	2	4	0.90	0.30	0.35	0.40	0.40
1	4	4	2	4	0.90	0.30	0.35	0.40	0.40
2_{TRK}	5	3	1	4	0.50	0.90	0.90	0.90	0.90
2_{VTX}	3	3	1	3	0.90	0.85	0.80	0.90	0.90
3_{TRK}	5	4	1	4	0.50	1.00	1.00	1.00	1.00
3_{VTX}	3	3	1	3	0.90	0.90	0.90	1.00	1.00
4	6	3	0	4	0.30	1.00	1.00	1.00	1.00
5	6	2	0	4	0.25	1.20	1.10	1.20	1.10

Normalized χ^2 and Algorithm

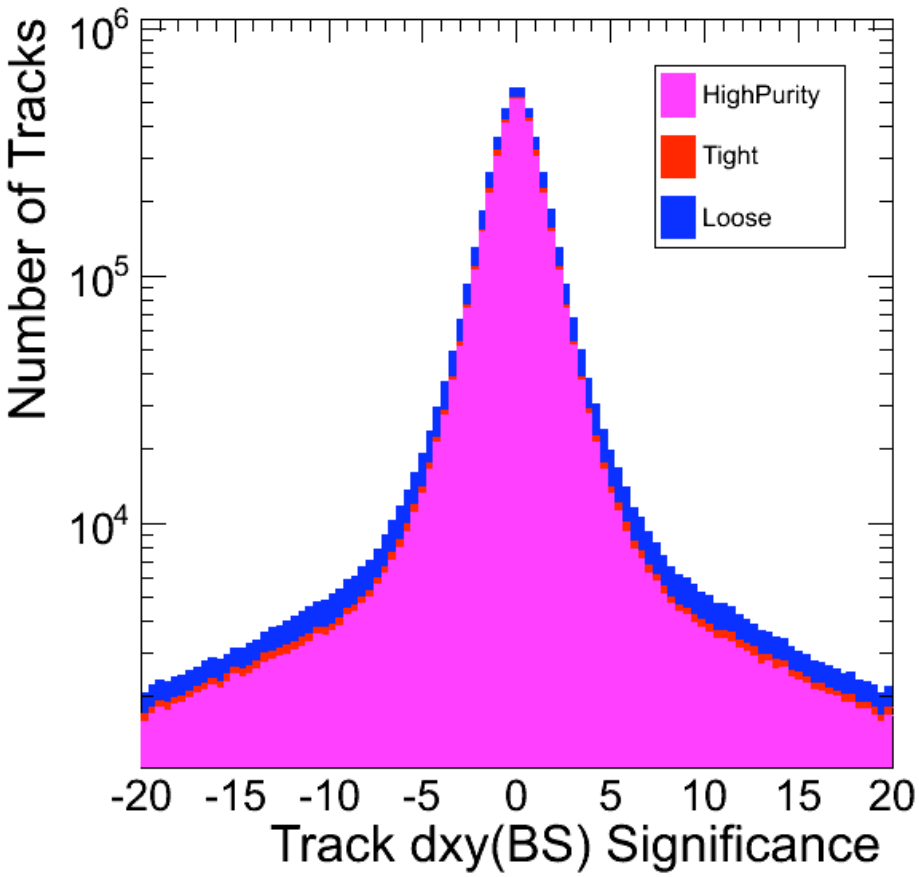
- HighPurity rejects tracks with large χ^2, especially in pair seeded and low pT seeding steps

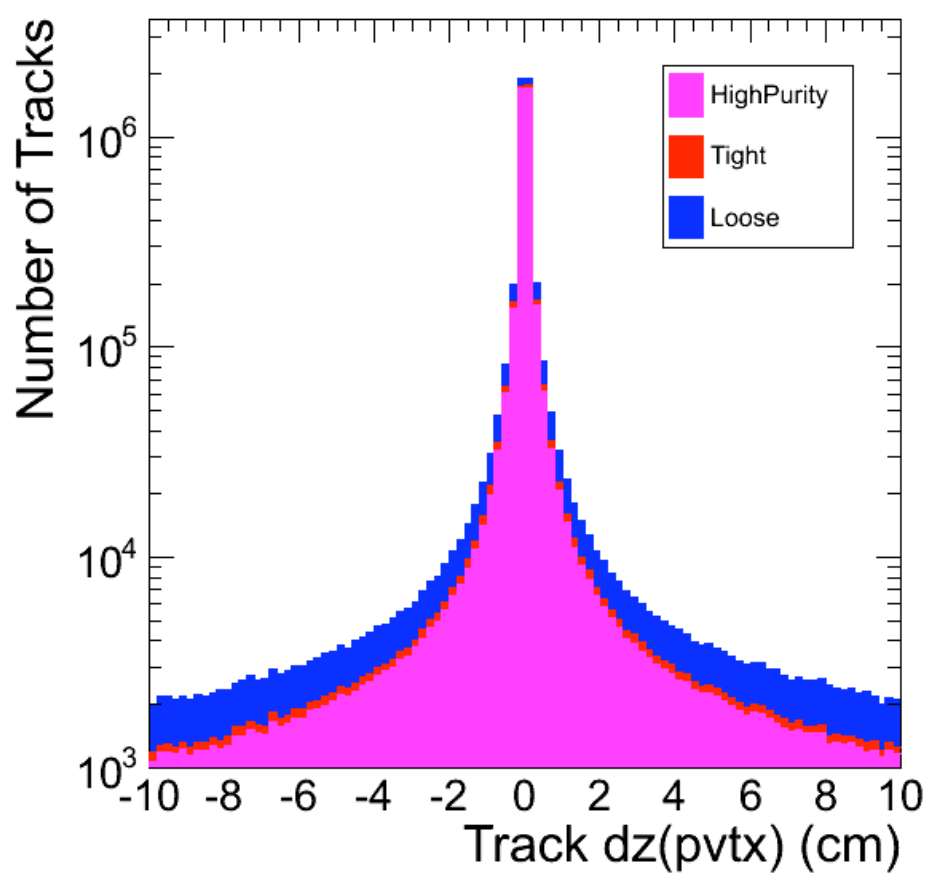




Impact Parameters

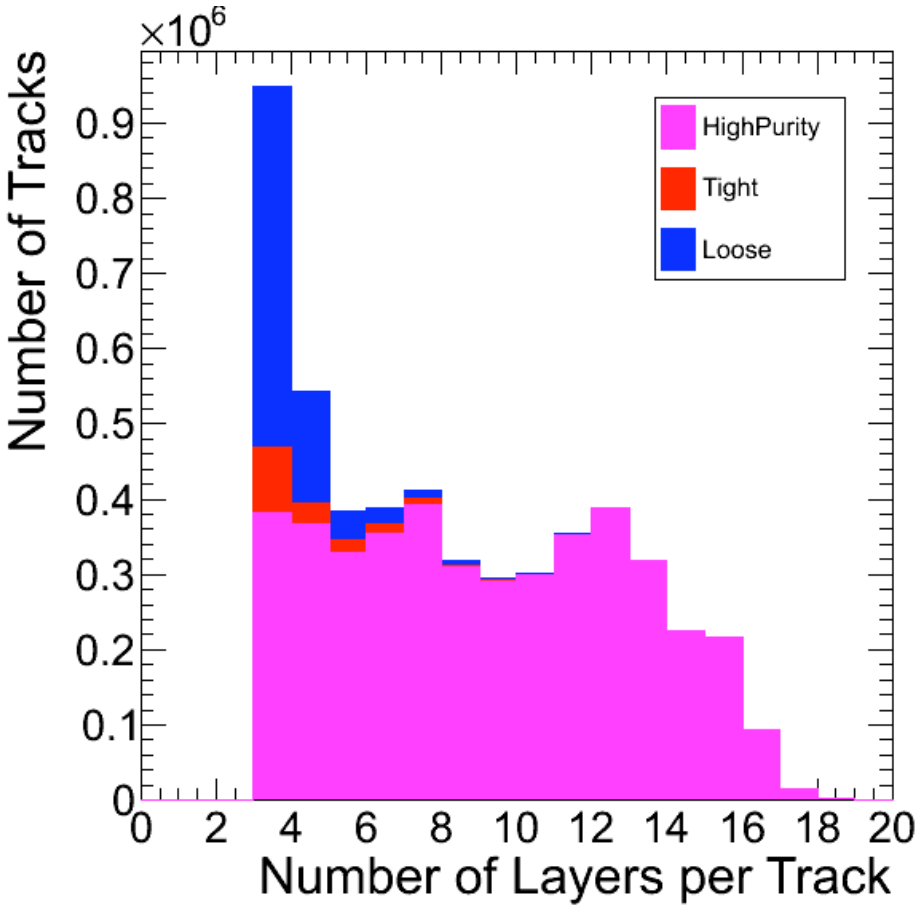
- HighPurity rejects tracks with large significance wrt to event interaction positions

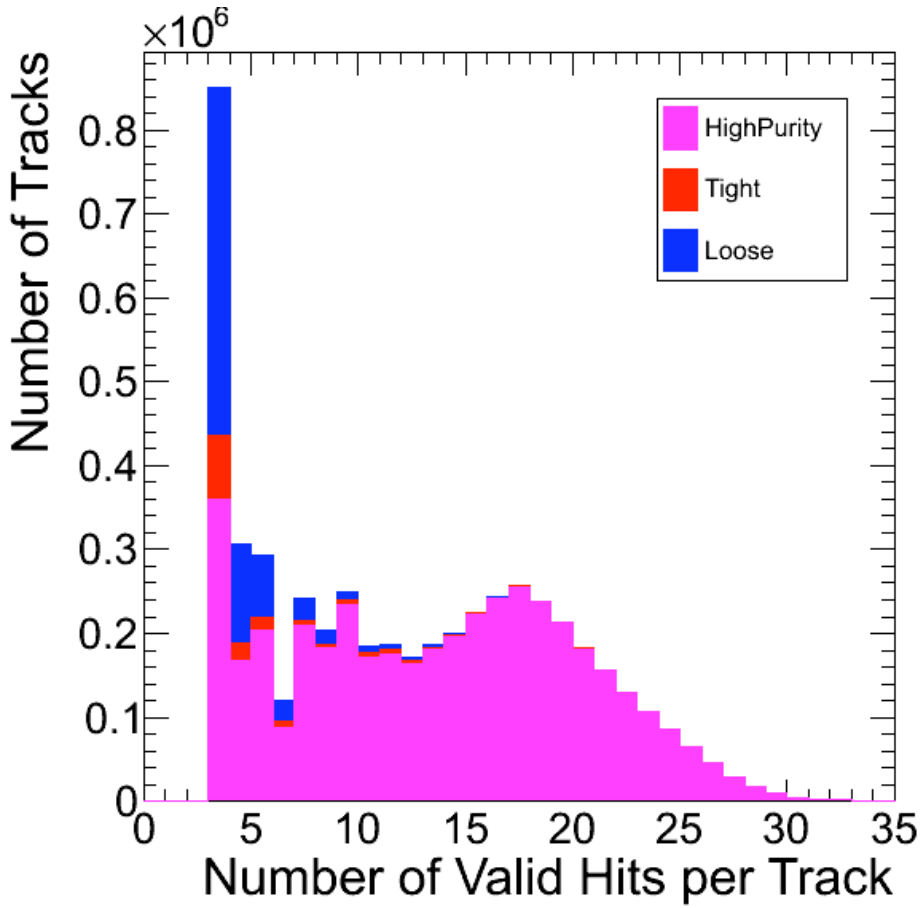




Number of Layers and Valid Hits

- GeneralTracks are at least loose tracks

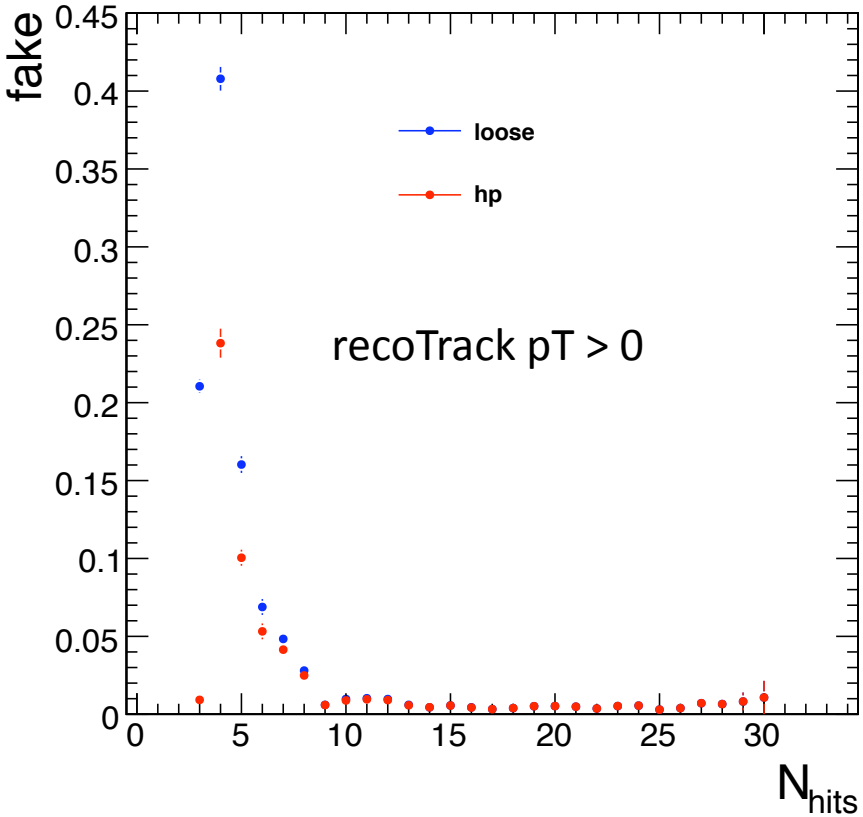


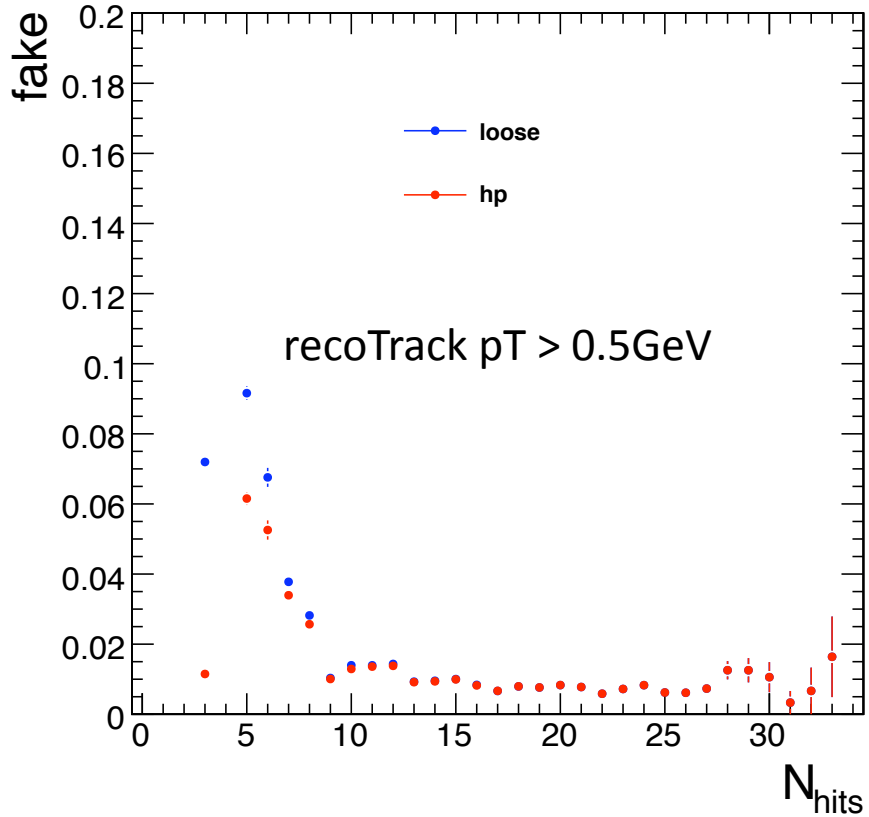


Tracking FakeRate and Efficiency from MC

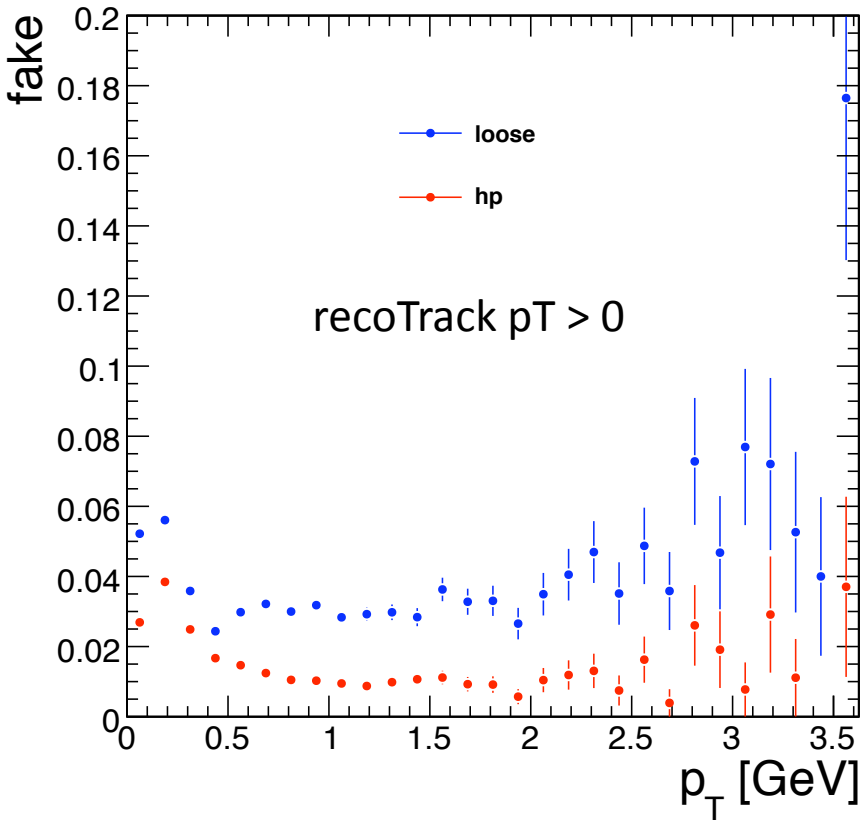
FakeRate vs nHits

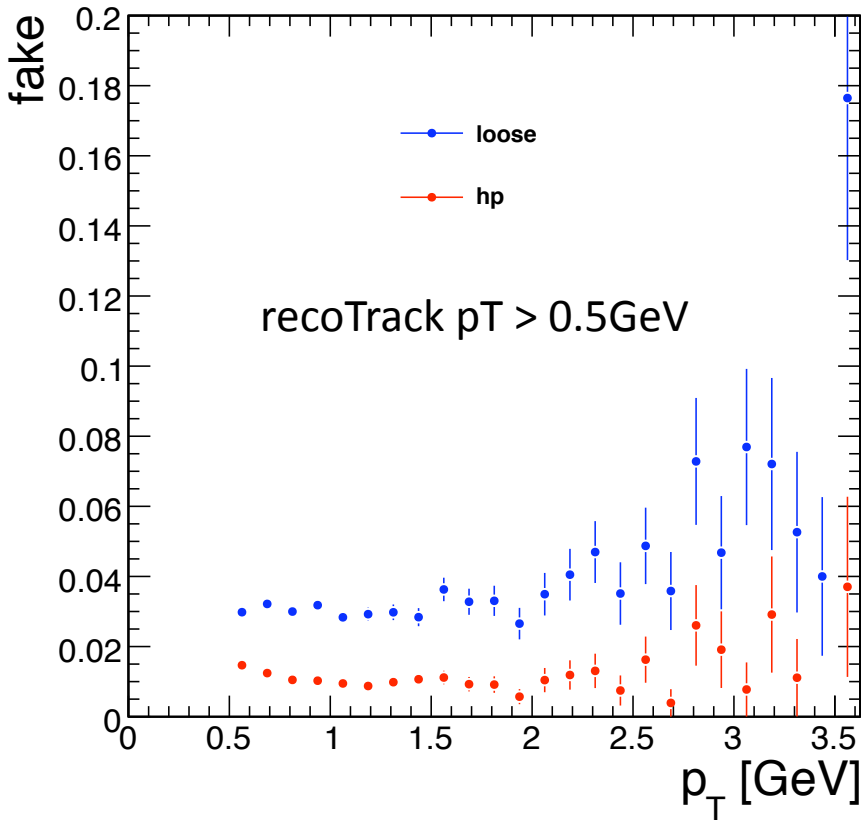
- TP cuts: pT>0.5, |eta|<2.4, status=1 (i.e. primaries)
- recoTrack cuts: pT>0 (left) and > 0.5 (right), |eta|<2.4, ≥3 hits, highPurity (only in the HP case)
- Event cuts: vertex within 15 cm from bs, at least 3 tracks



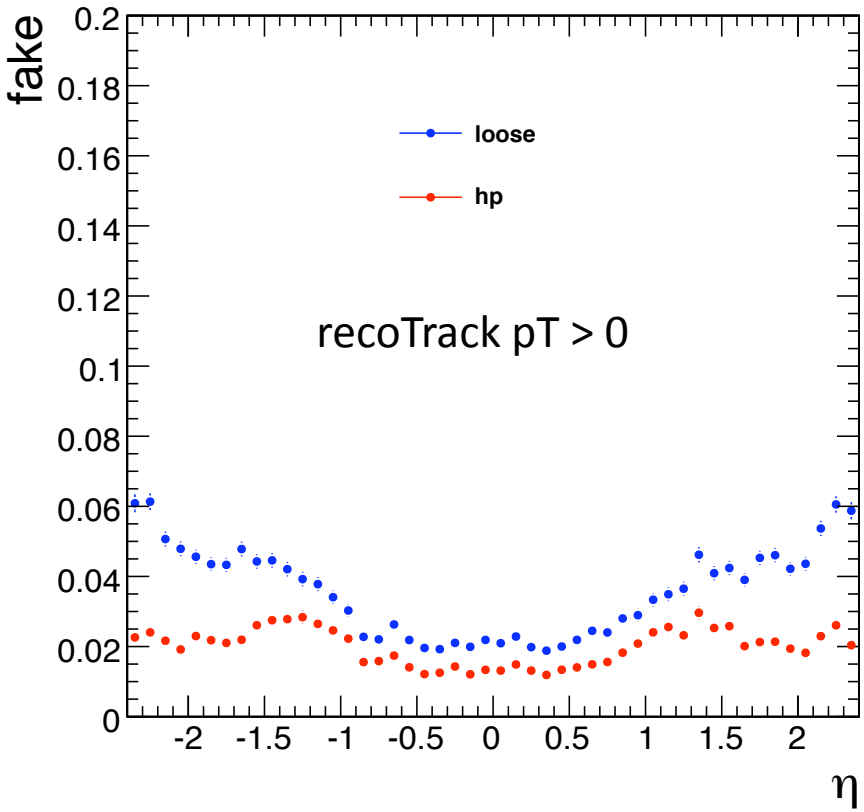


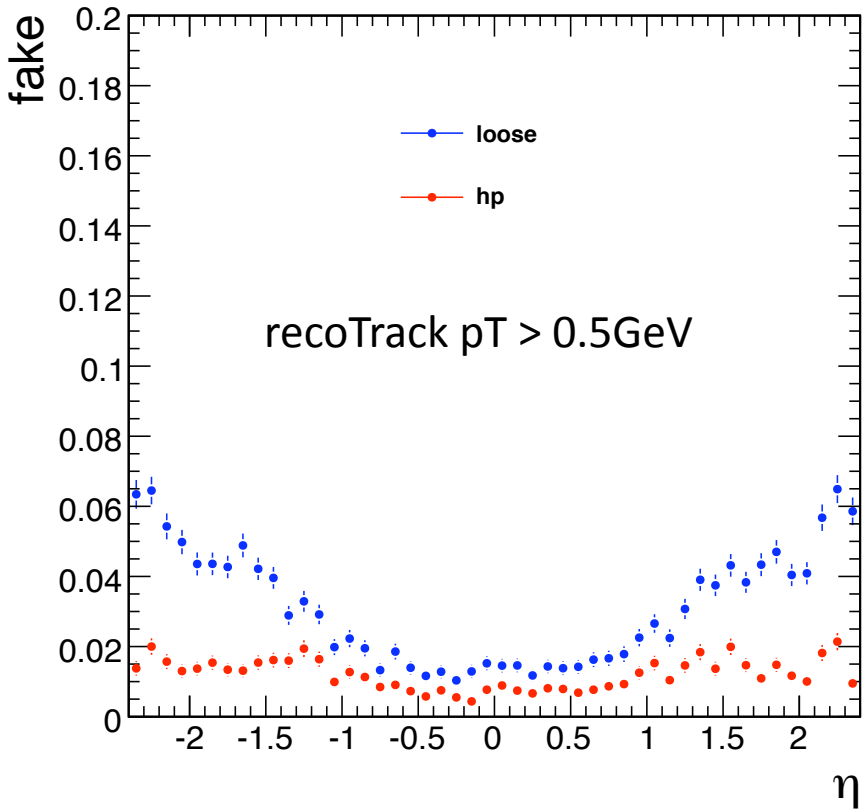
FakeRate vs pT



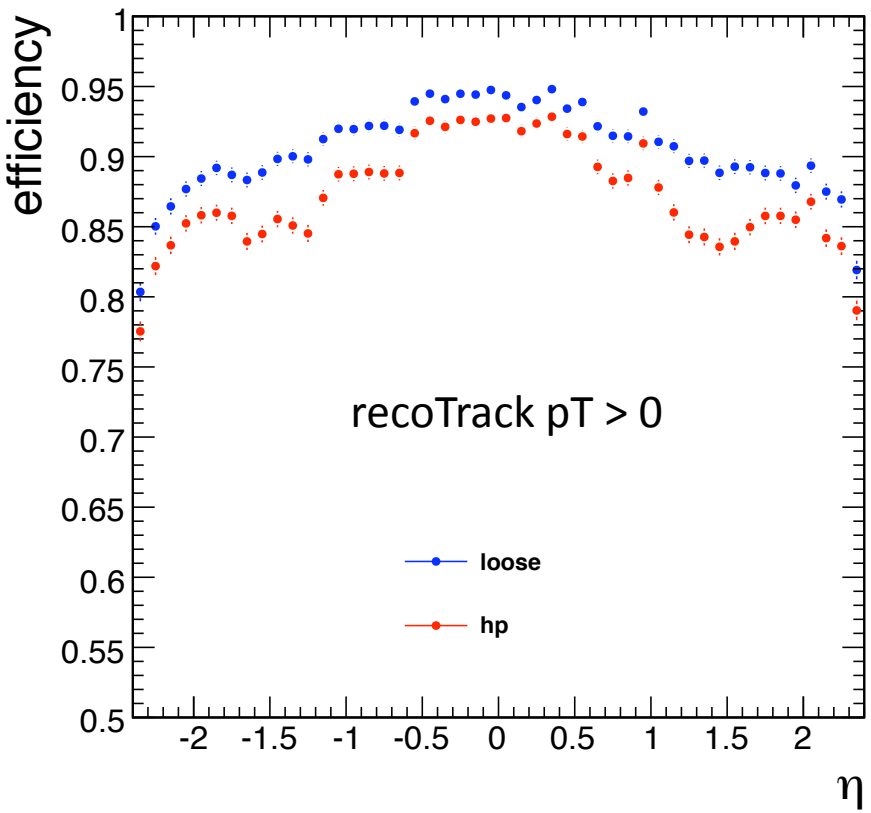


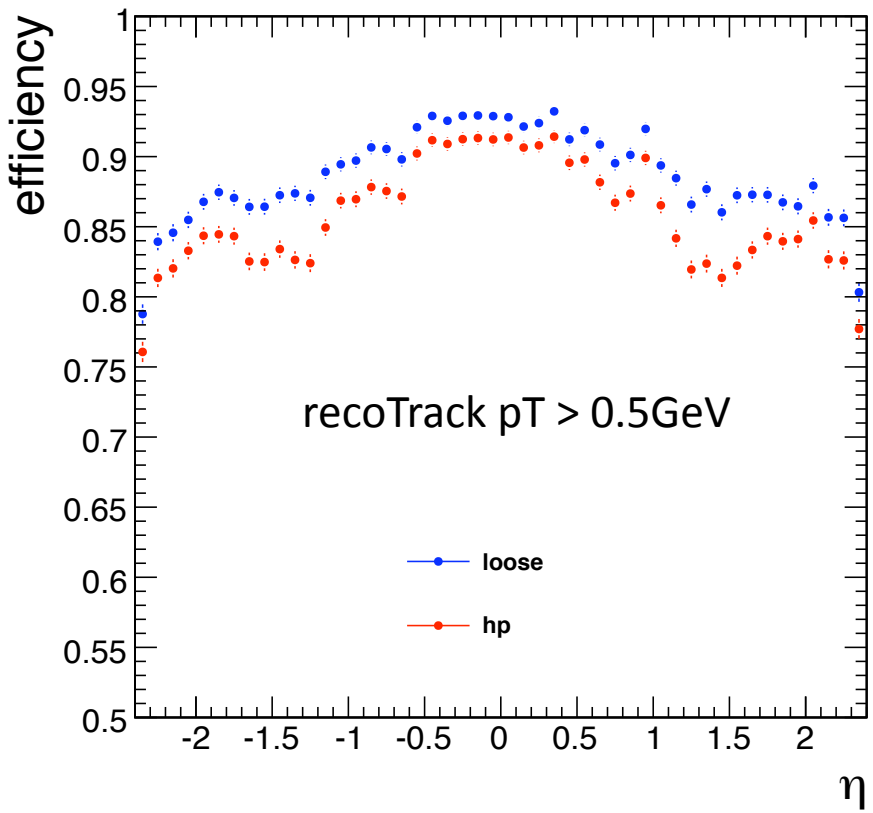
FakeRate vs eta





Efficiency vs eta



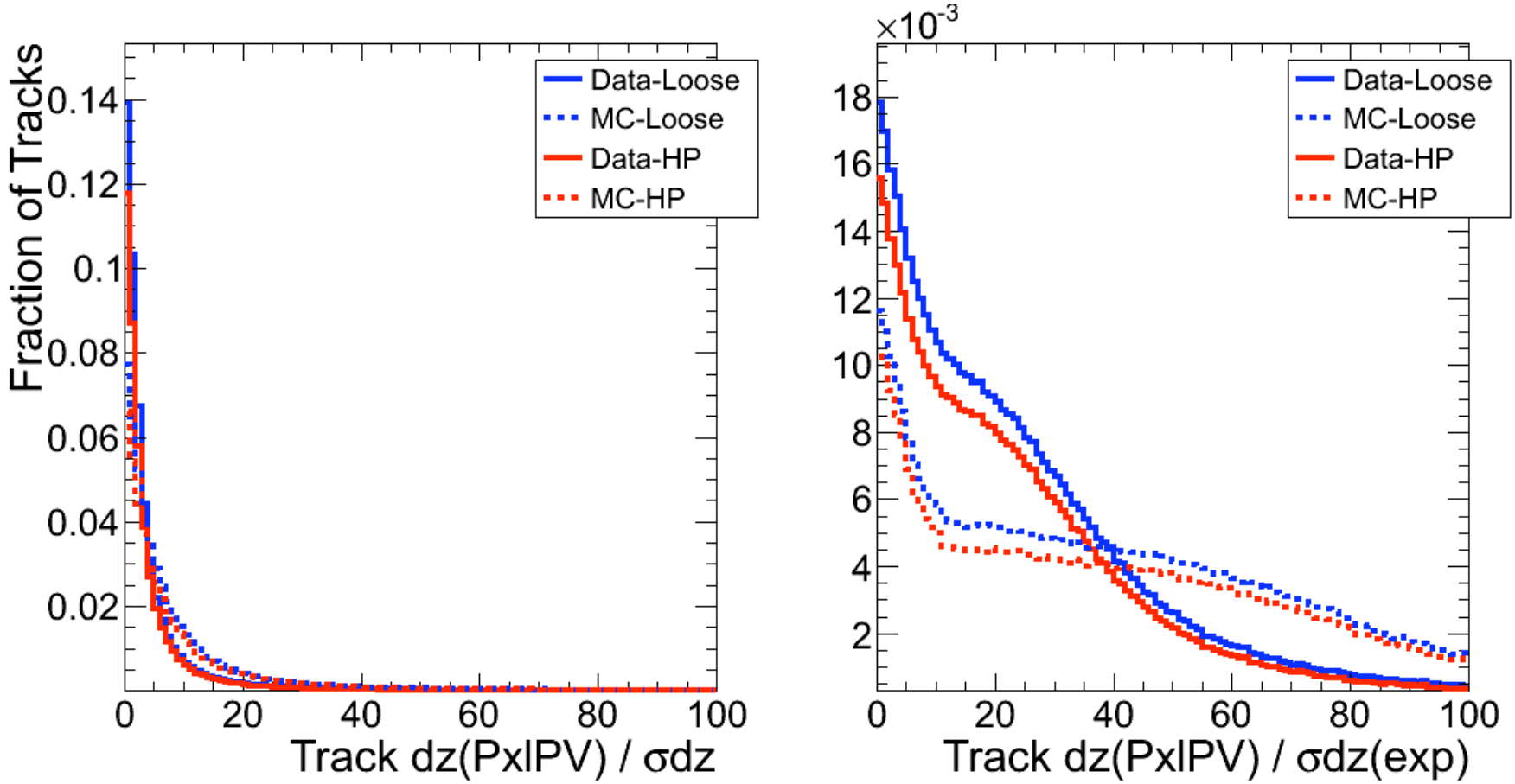


Data/MC Comparison of dz Significance

We compared the variables used in AnalyticalTrackSelector and observed good data/mc agreement in all variables *except for dz Significance*.

dz Significance Selection in 336p3 Dec19ReReco

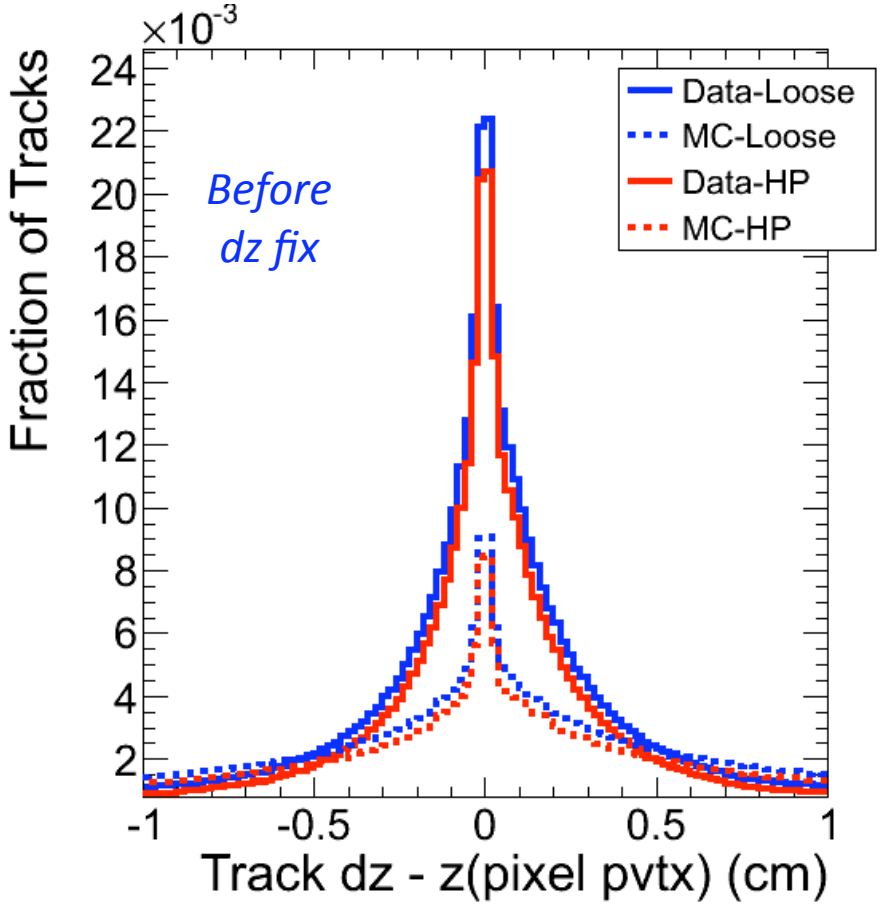
- Only applied when pixelVertex is available, otherwise a flat cut of 3*beamWidthZ is applied
- pixelVertex efficiency ~ 25% (15%) in Dec19thReReco Data (V8K MC)

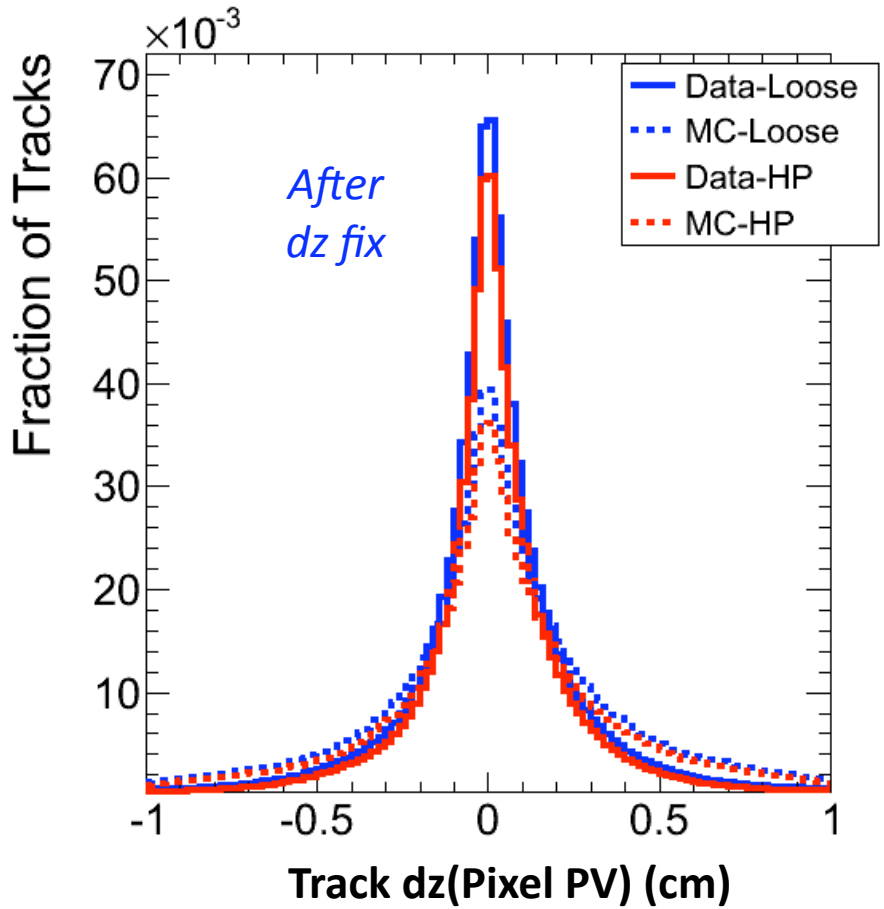


$$\frac{|d_z - z(\text{pxlpvtx})|}{\sigma d_z} < (\alpha_2 \cdot nLayers)^{\beta} \quad \& \& \quad \frac{|d_z - z(\text{pxlpvtx})|}{\sigma d_z(pT,\eta)} < (\alpha_4 \cdot nLayers)^{\beta}$$

Closer Look at dz(Pixel PV)

- The difference in the significance variable is traced back to *dz corrected by pixelVertex*





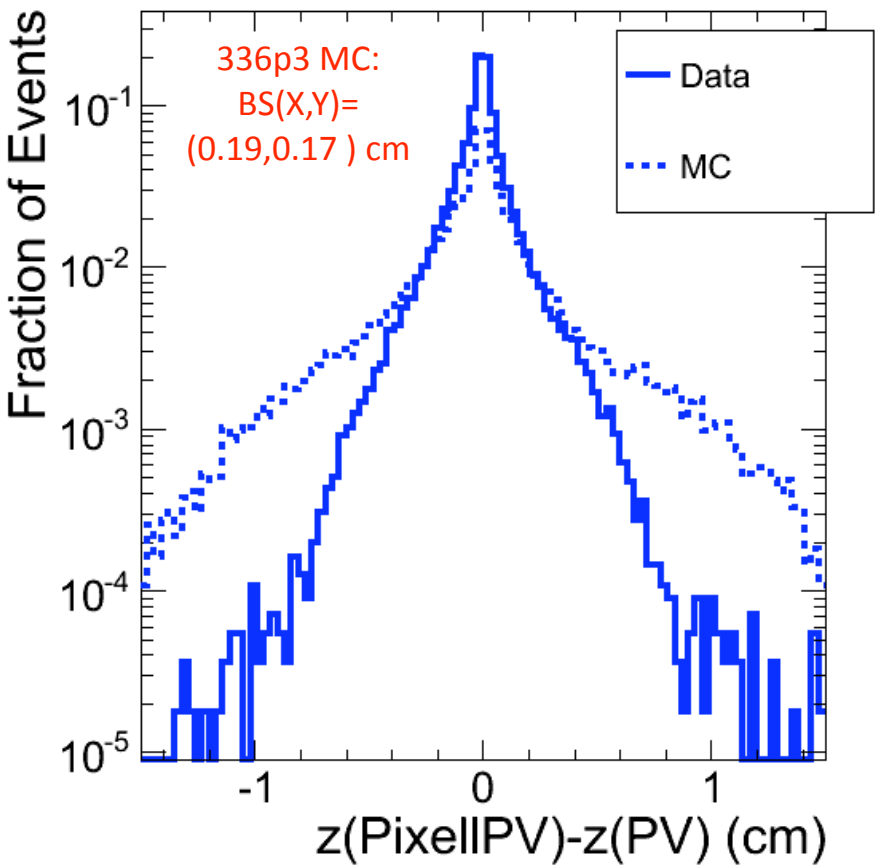
- BeamSpot impact in dz corrected by pixel PV calculation:

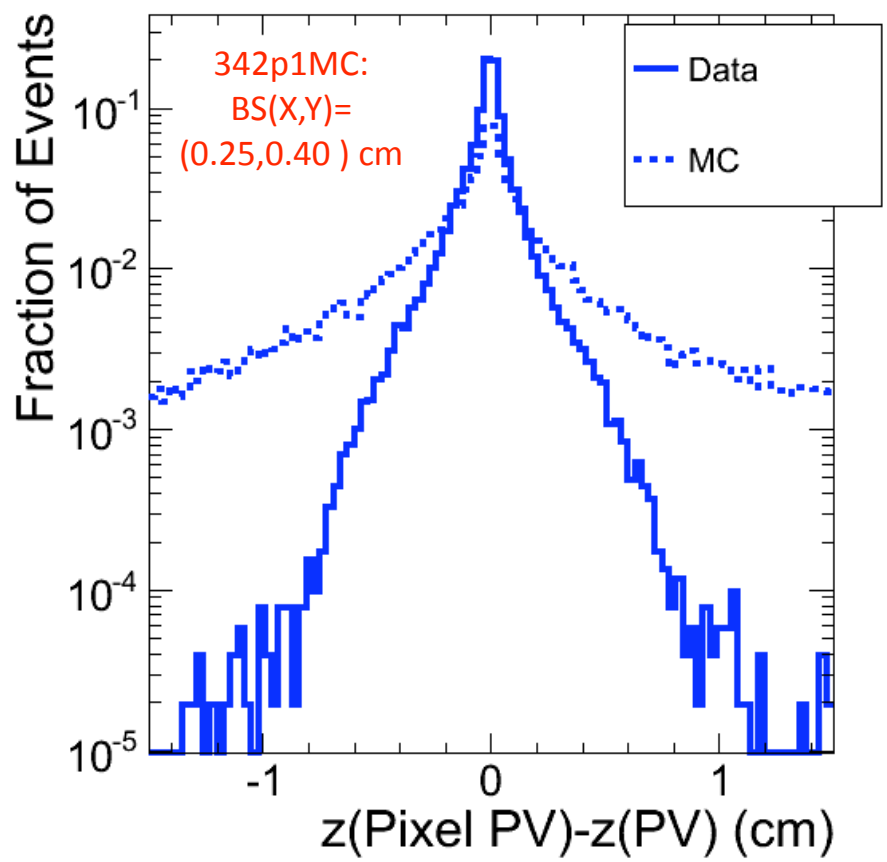
$$dz(\text{Pixel PV}) = dz - z(\text{Pixel PV}) + (BsX*\cos\phi + BsY*\sin\phi)*\sinh(\eta)$$

Compare z(Pixel PV) and z(PV)

- Before 352, z(Pixel PV) is not calculated correctly with larger BS offset in (X/Y)

See Marcin's talk : http://indico.cern.ch/contributionDisplay.py?contribId=18&confId=80864

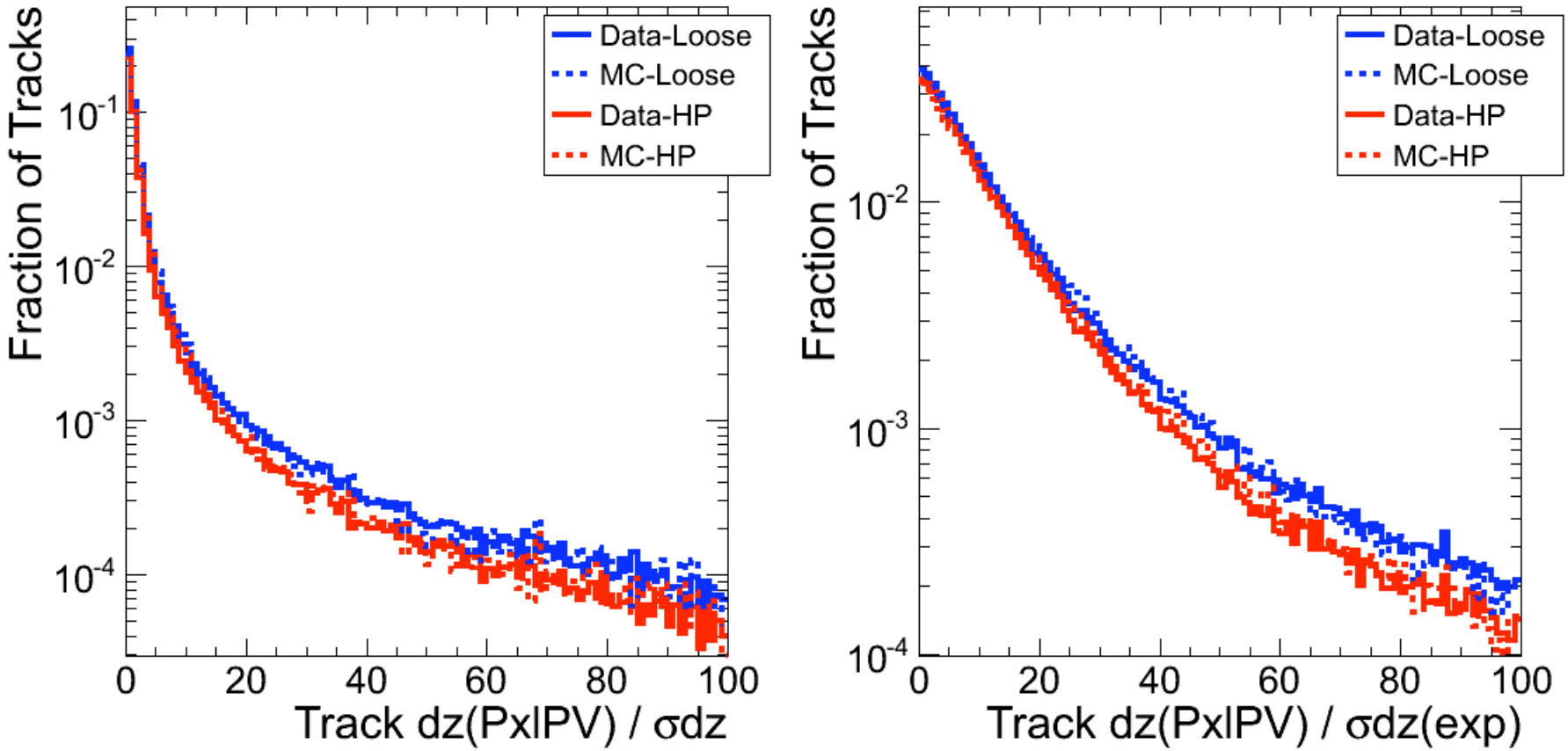




- With larger BS displacement in (X,Y), z(Pixel PV)-z(PV) distribution is broader

dz Significance Update in 352

- With 3D PixelVertexing and AnalyticalTrackSelector dz(Pixel PV) fixes, data agrees with MC



$$\frac{|d_z - z(\text{pxlpvtx})|}{\sigma d_z} < (\alpha_2 \cdot nLayers)^{\beta} \quad \&\& \quad \frac{|d_z - z(\text{pxlpvtx})|}{\sigma d_z(pT,\eta)} < (\alpha_4 \cdot nLayers)^{\beta}$$

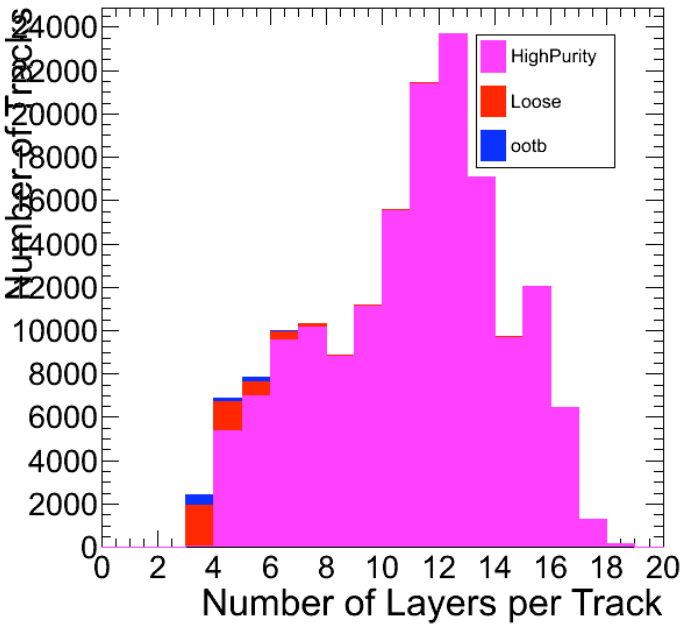
Relative Track Quality Selection Efficiency 336p3

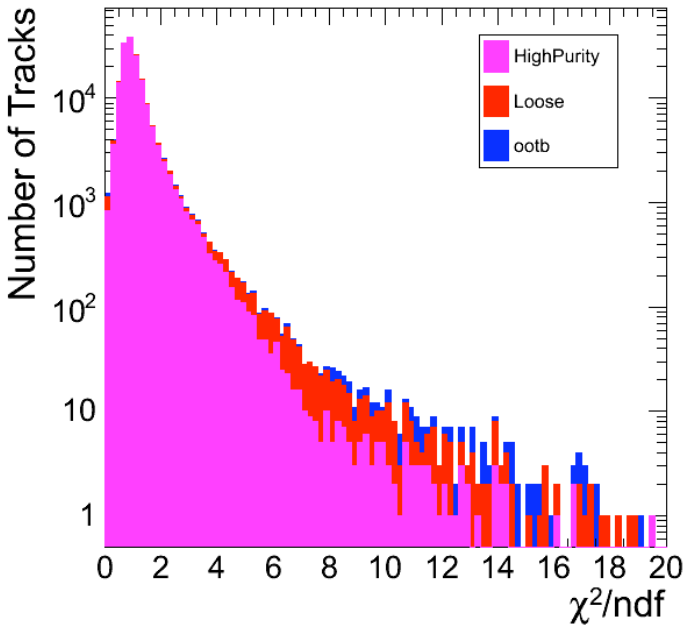
- We study overall "*loose*/*HP*"selection efficiency for tracks that pass all other requirement.
- *Take UE analysis as an example:*

Giuseppe: *http://indico.cern.ch/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=88147*

|η|<2.0, pT> 0.5, σpT/pT<5%, |dz(pvtx)/σdz|<5 , |dxy(pvtx)/σdxy|<5

- We perform reTracking of Run124024/MC keeping all tracks (*ootb*) for "loose" efficiency





Track Quality Selection ε for Data(MC) on top of all other cuts:

Loose: 99.4% (99.7%) *HP*: 96.6%(97.0%)

Summary

- AnalyticalTrackSelector selects tracks with good fit-χ^2 and compatible with primary interaction, using adapted cuts to *track η, pT and mostly importantly nLayers*

- The same techniques are applied at 3 levels (*loose, tight and highpurity*) with different parameters, "generalTracks" are loose tracks

- Compare TrackQuality selection variables between data/MC, only "*dzSign*" shows sizable discrepancy due to z(Pixel PV) bias in case of large BS(X/Y) in 336p3.

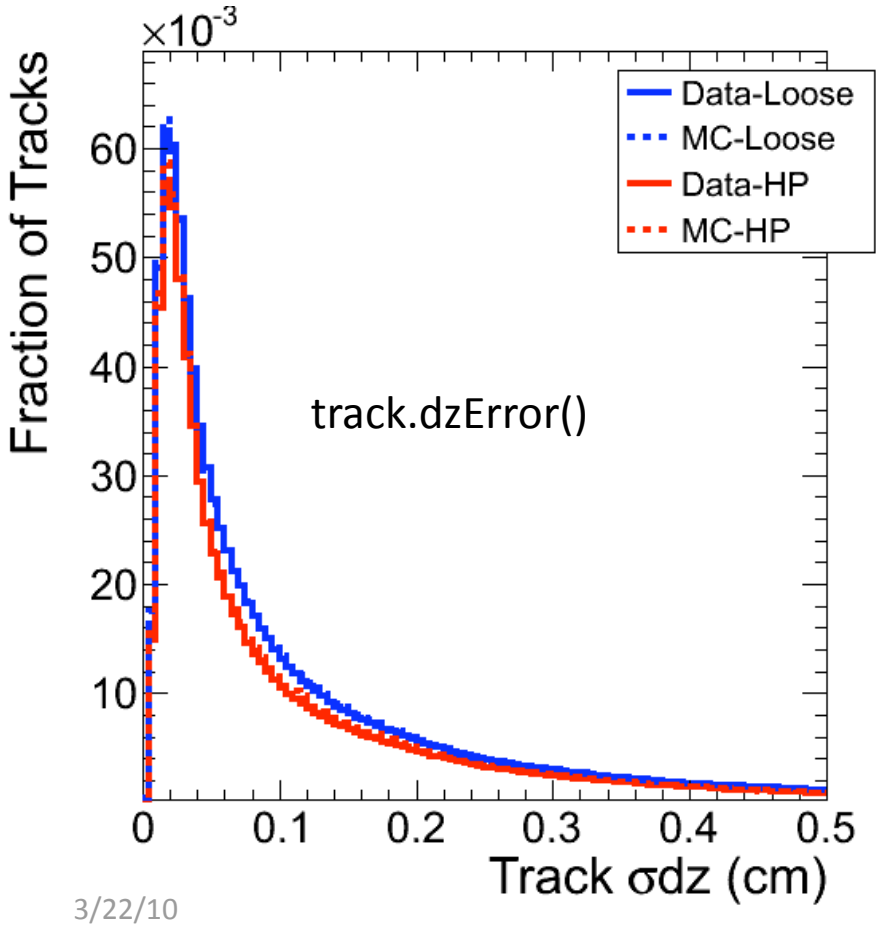
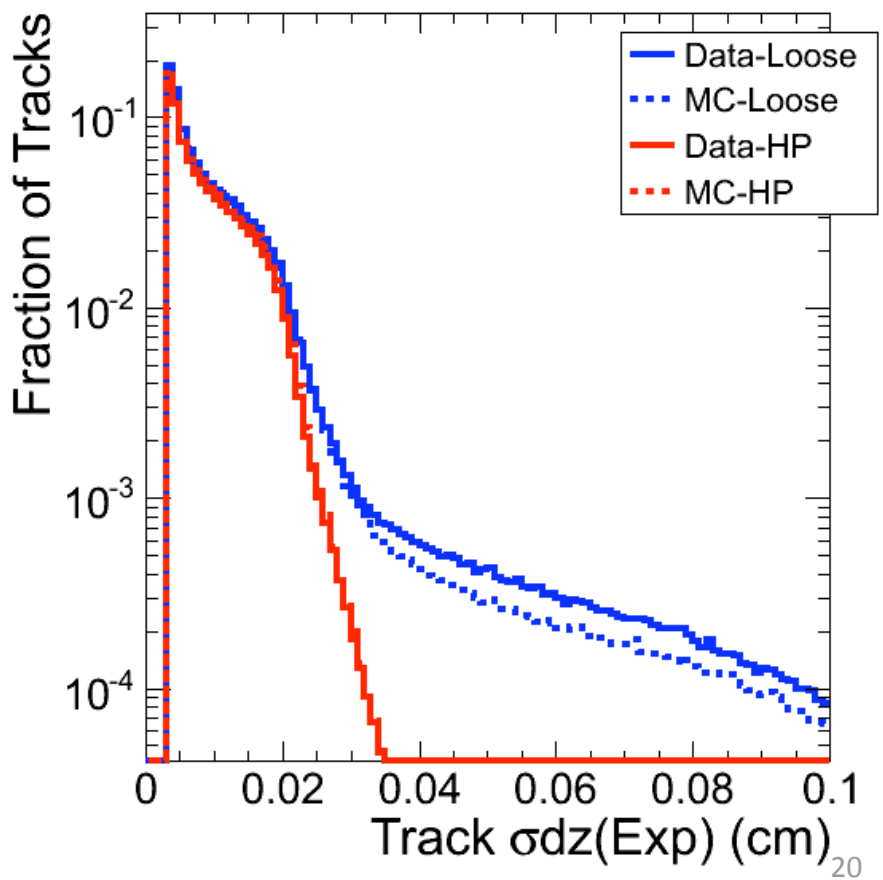
1) The disagreement disappear is fixed in 352 with the 3D PixelVertexing along with a small bug fix in the dzSignificance calculation

2) In 336p3, given additional track selections (UE Cuts on IP significance, pT>0.5, |η|<2, σpT/pT<5%), *loose/HP* relative selection efficiencies *differ 0.3%/0.4%* between data/MC

dz Track Error and Expected Error

- Error functions is fit from tracks with QCD 170-230GeV with better alignment

$$\sigma d_z(pT,\eta) = \cosh(\eta) \cdot \sigma d_{xy}(pT)$$

average pT = 0.5, σdxy < 0.04 (0.2) cm for HP(loose)

- Expected error is underestimated for MB900GeV => we cut tighter