Compressed Higgsinos using tracks

Motivation

- Searches for new physics involving Weakly Interacting Massive Particles (WIMPs)

- Implemented in pMSSM - uses *only* 19 parameters.

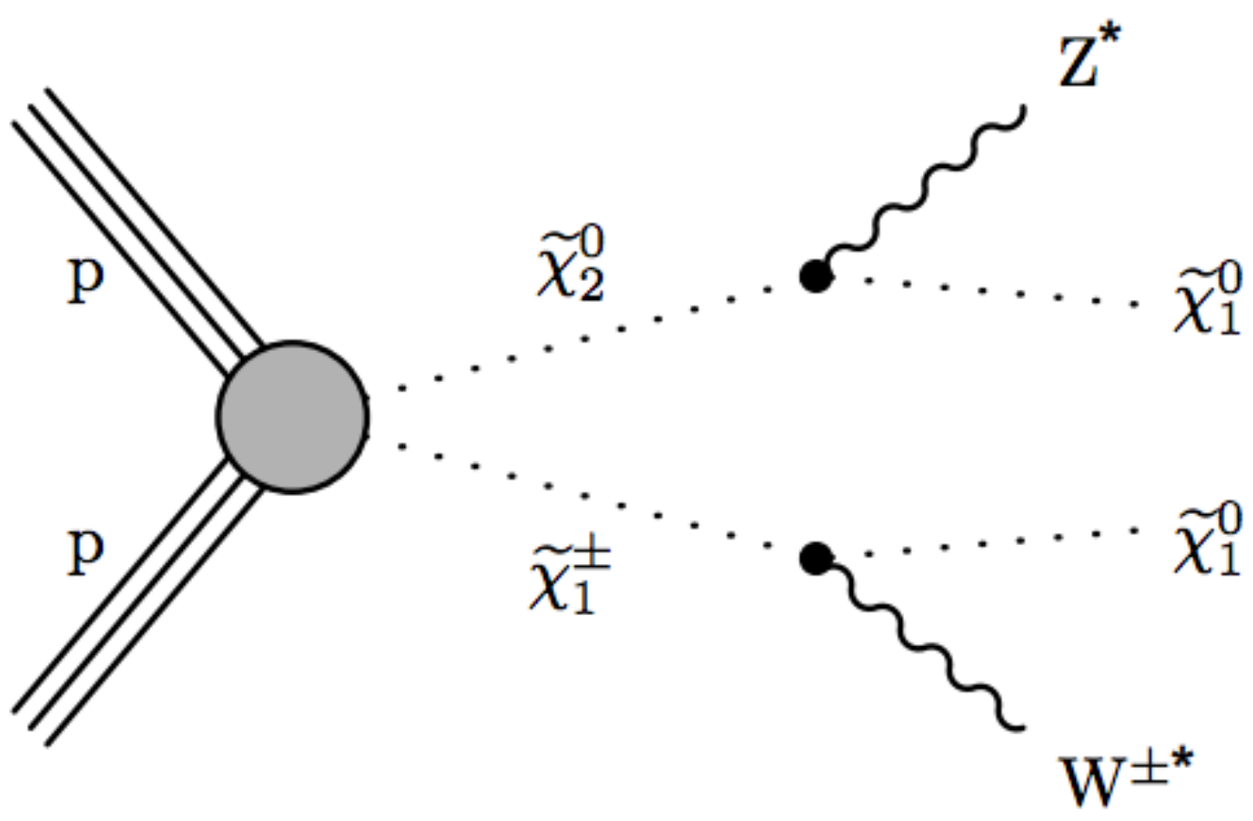
- Takes into account constraints from other aspects of physics such as direct searches for dark matter.

General Features

- Signatures that include large missing transverse momentum.
- Most momentum/energy is carried away by Neturolinos.
- Very soft leptons.
- Monojets (ISR) usually boost sensitivity.

Decay of an Electroweakino Pair

- Typical Process:



Compressed Spectrum

- Compressed = Degenerate in mass (e.x. W and Z bosons).
- Naturalness imposes constraints on the masses of Higgsinos
- Higgsinos remain light.
- $\tilde{\chi}_2^0$ and $\tilde{\chi}_0^{\pm}$ are set to be mass degenerate, and $\tilde{\chi}_1^0$ almost degenerate with ranging changing splitting (at this moment 20Gev, 13Gev, 7Gev).
- For the chargino-neutralino we assume a decay via Z* and W* into the LSP.
- We assume the W* decays hadronically and consider dilepton events.

Previous Work

- Previous analysis on this process has been done by arXiv: 1801.01846 at CMS.
- A lot of the work we've done was to try and reproduce those result which was very challenging due to lack of precise documentation and use of complex generic code.

Results of Previous Work

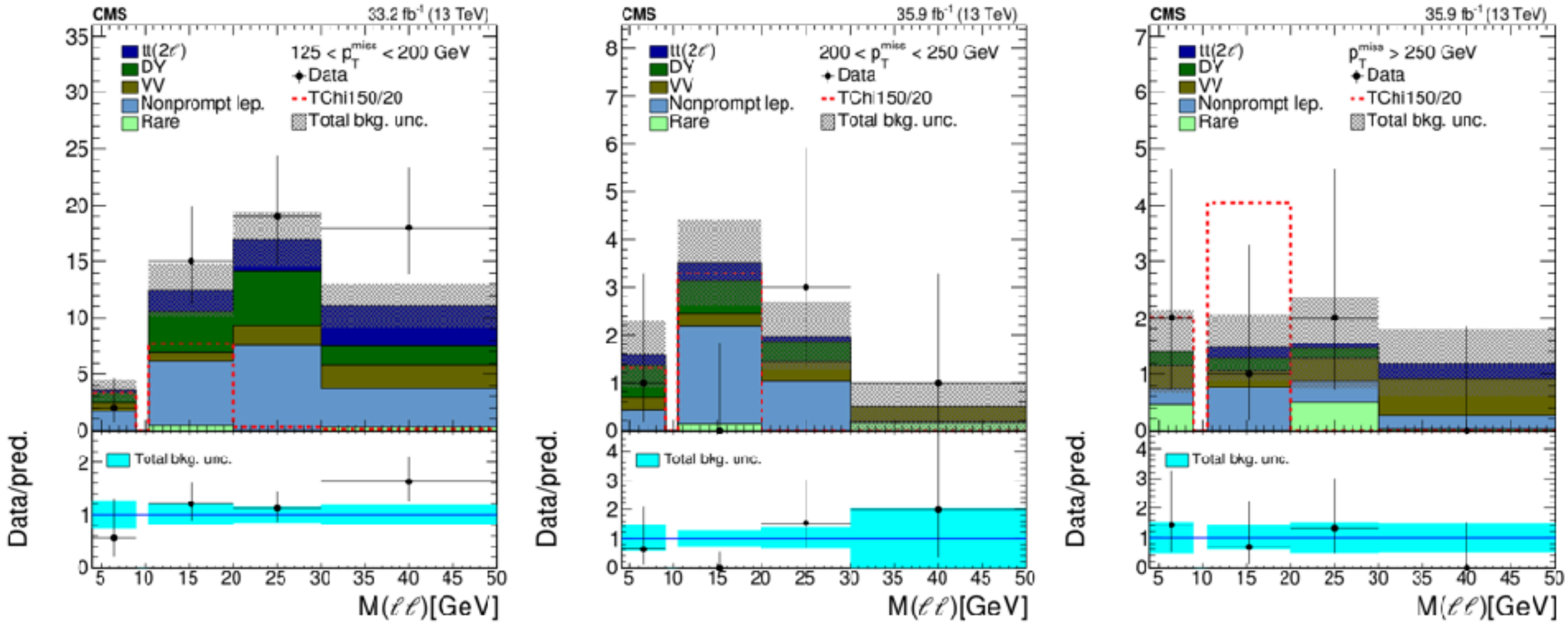
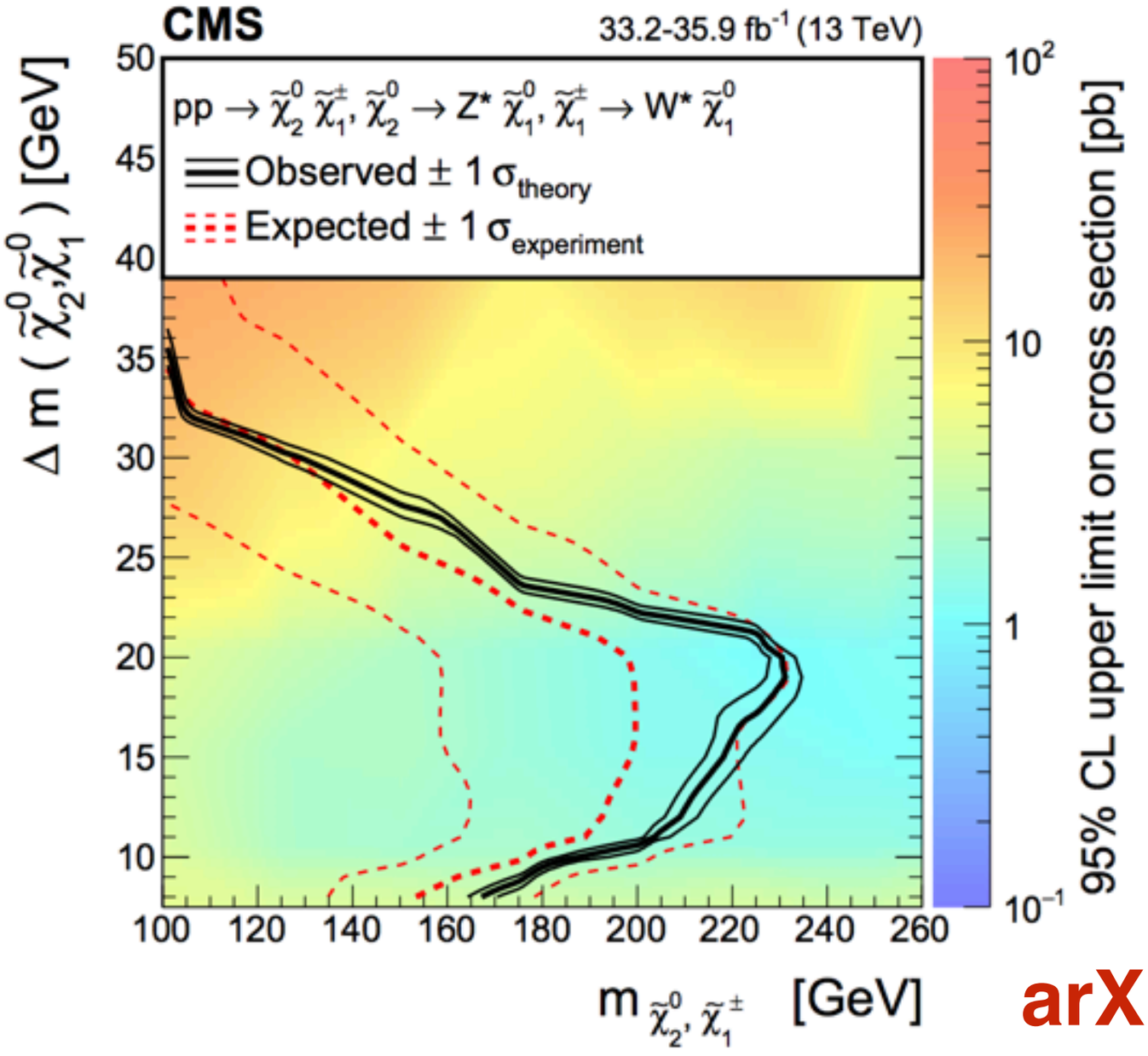


Figure 3: Left: electroweakino search regions in bins of $M(\ell\ell)$ for $125 < p_{\mathrm{T}}^{\mathrm{miss}} < 200\,\mathrm{GeV}$ (muon only channel) for $33.2\,\mathrm{fb}^{-1}$; middle: $200 < p_{\mathrm{T}}^{\mathrm{miss}} < 250\,\mathrm{GeV}$ (muon and electron channel) for $35.9\,\mathrm{fb}^{-1}$; right: $p_{\mathrm{T}}^{\mathrm{miss}} > 250\,\mathrm{GeV}$ (muon and electron channel) for $35.9\,\mathrm{fb}^{-1}$. A signal from neutralino-chargino ($\tilde{\chi}_2^0$-$\tilde{\chi}_1^{\pm}$) production is superimposed. The gap between 9 and 10.5 GeV corresponds to the Y veto.

arXiv:1801.01846

Results of Previous Work



arXiv:1801.01846

Figure 5: The observed 95% CL exclusion contours (black curves) assuming the NLO+NLL cross sections, with the variations corresponding to the uncertainty in the cross section for electroweakino. The dashed (red) curves present the 95% CL expected limits with the band covering 68% of the limits in the absence of signal. Results are based on a simplified model of $\tilde{\chi}_2^0\tilde{\chi}_1^\pm \to Z^*W^*\tilde{\chi}_1^0\tilde{\chi}_1^0$ process with a pure wino production cross section.

Current Work Motivation

- Previous work is based on traditional event selection rectangular cuts. Cuts has been “eyeballed”.

- MVA techniques hopefully will boost the sensitivity.

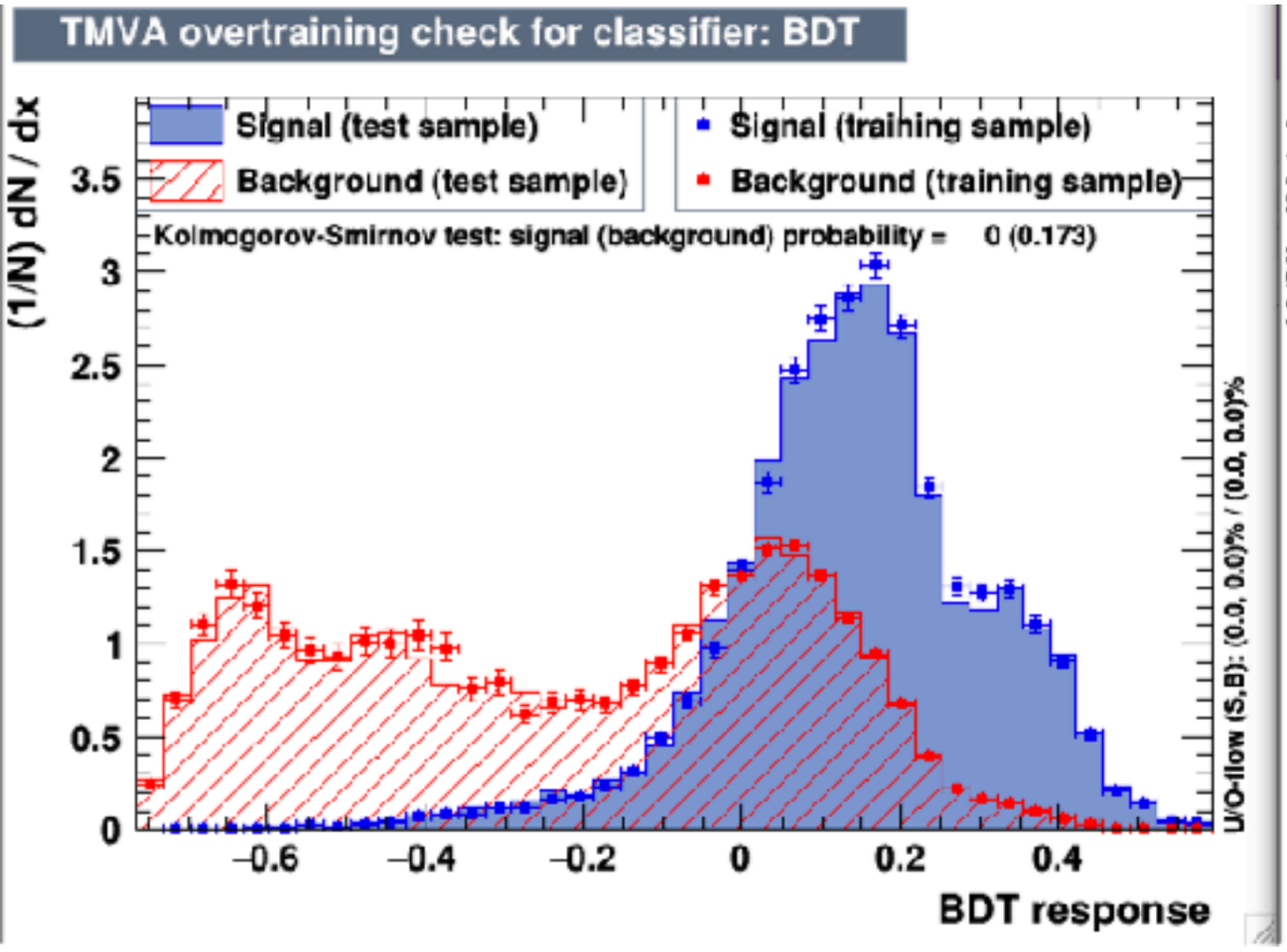
- We hope to be able to probe lower mass splitting using track information when leptons are too soft to reconstruct.

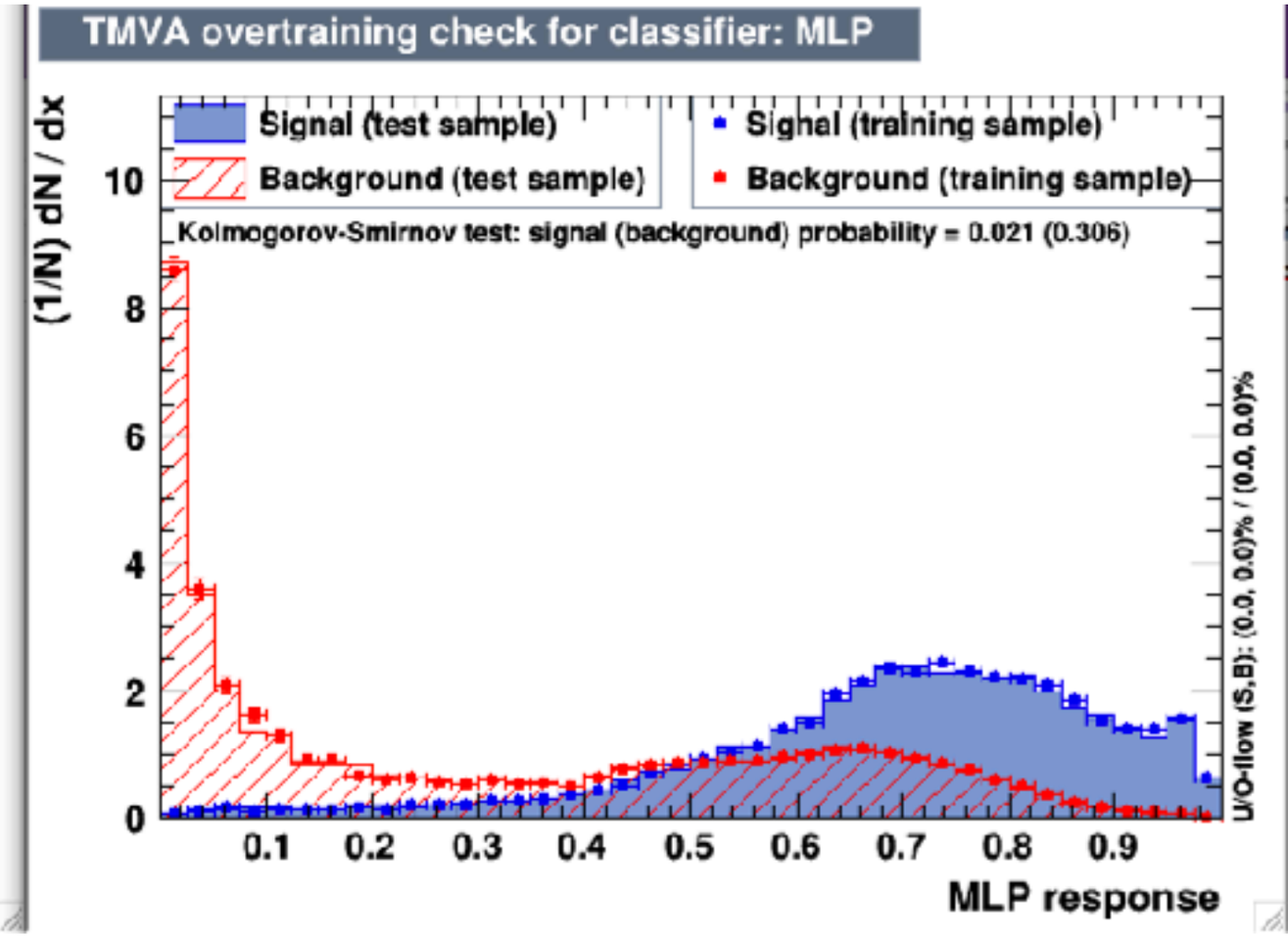
- Hope to be able to scan different values for the mass splitting rather than analysis a point (dm20 in the mentioned paper).

Work in Progress

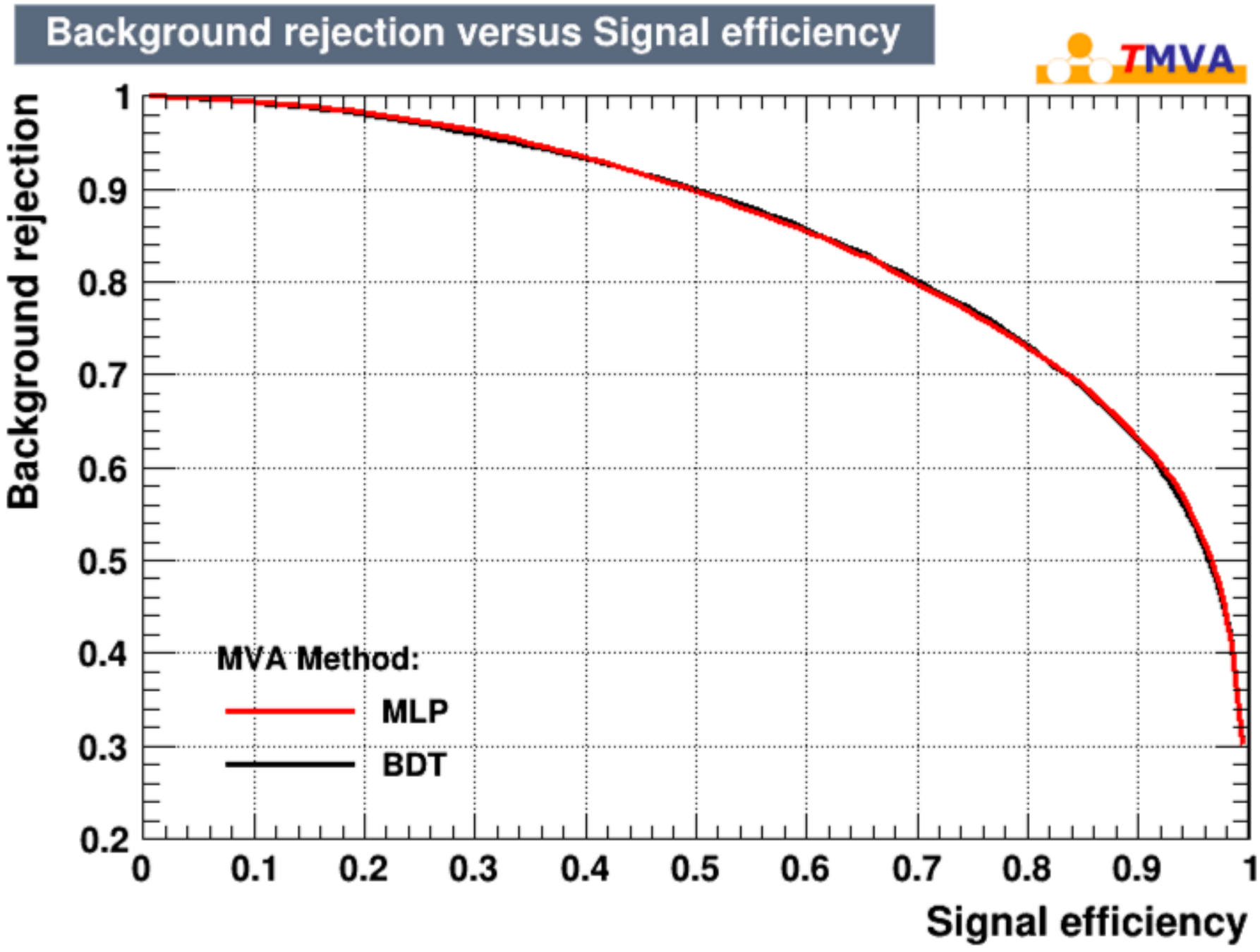
- After (partially and exhaustingly) reproducing the paper's (simulated) results - we attempt MVA approach to classify our simulations.
- Use three methods - BDT, MLP, RGS.
- As first step - we ignore all leptons to make the training as generic as possible as to not train for a specific model point.
- Combined for now 3 mass splitting signals (15, 13, 7).
- Running on all 3 of them simultaneously (wrongly assuming same CS).
- Training on: MET, NJets, HT, Met/HT, Mt2, LeadingJetQgLikelihood, MinDeltaPhiMetJets, MinDeltaPhiMhtJets

BDT and MLP Training

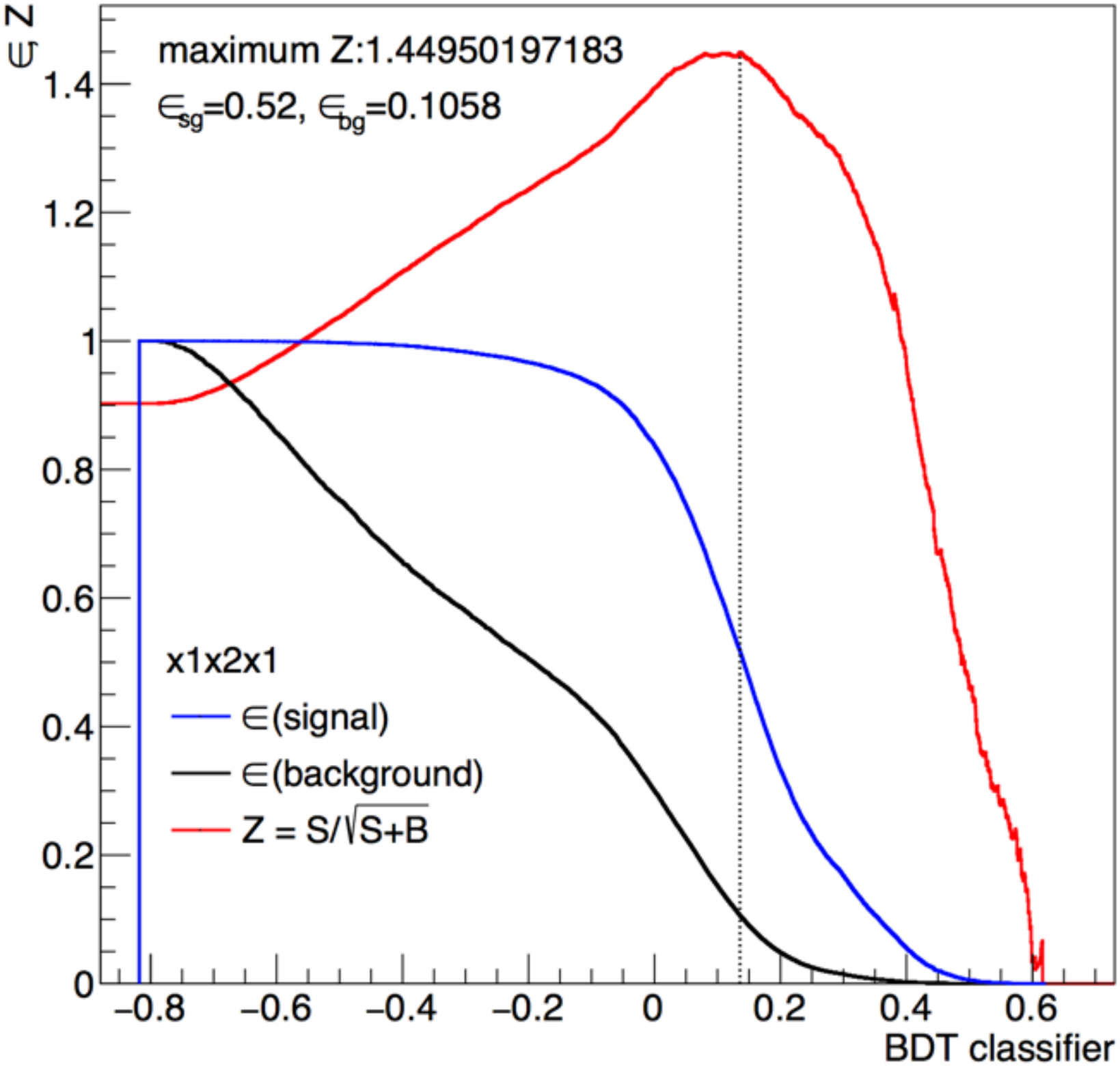




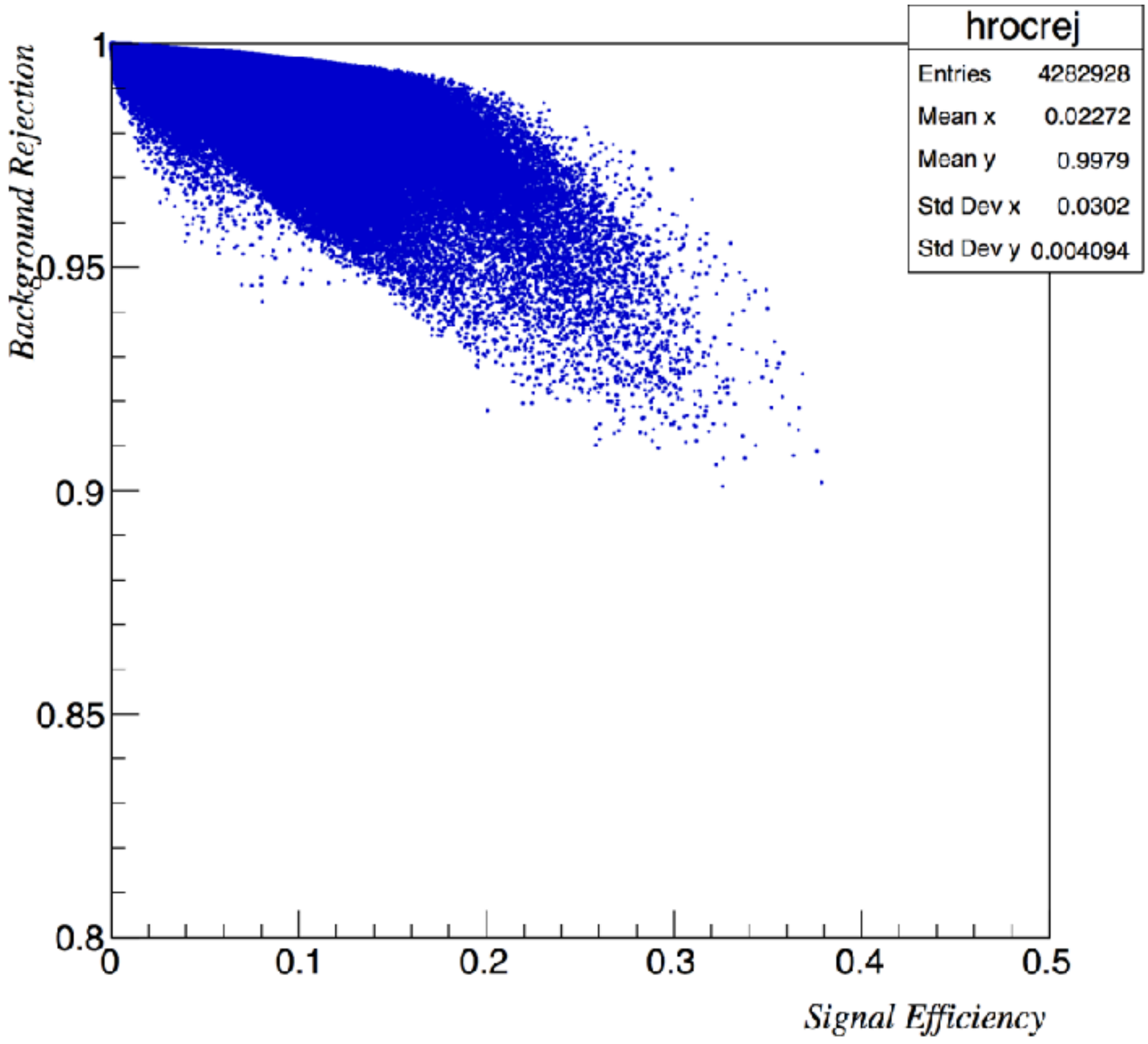
BDT and MLP Training



BDT and MLP Training



RGS

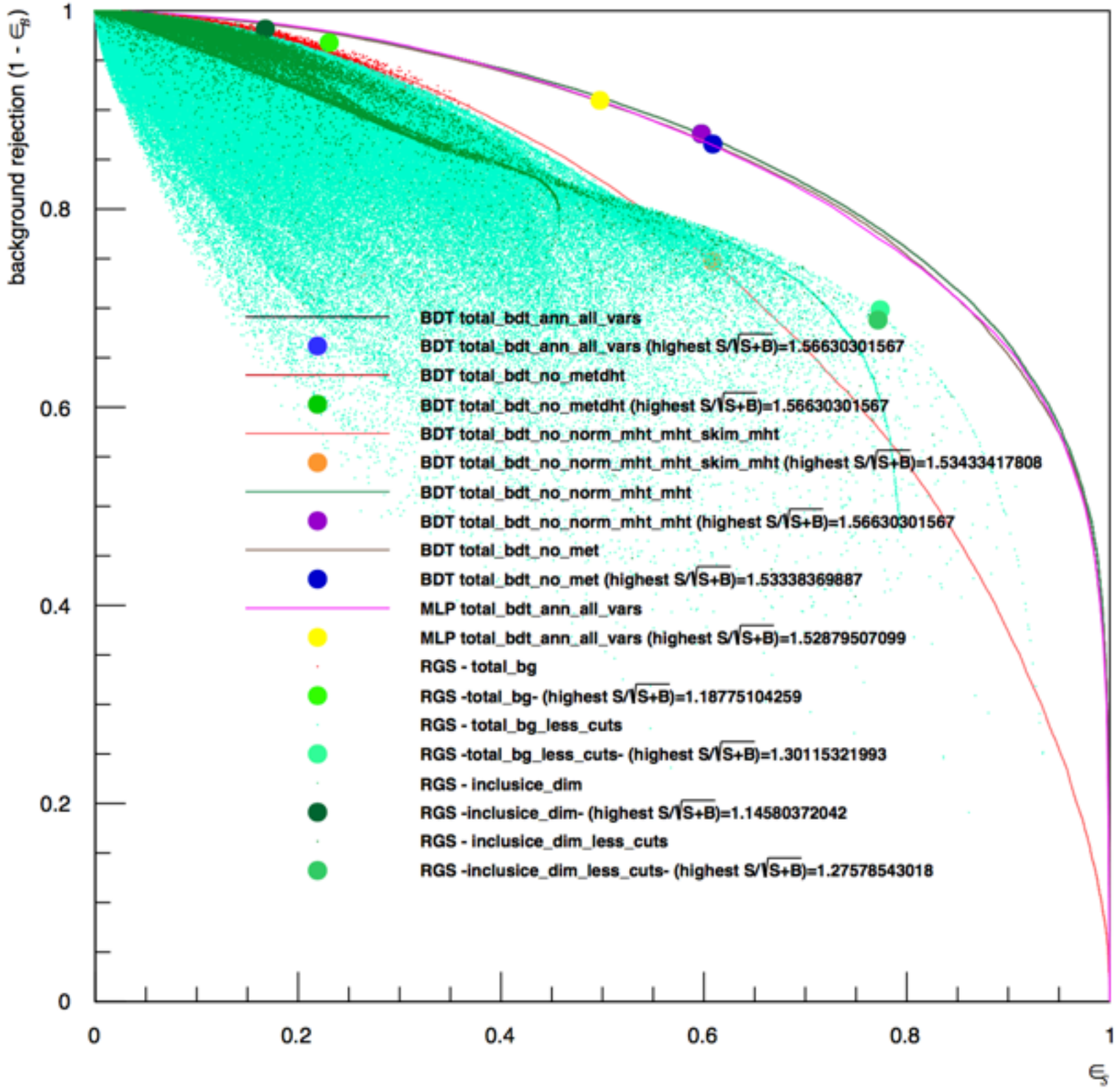

hrocrej
Entries 4282928
Mean x 0.02272
Mean y 0.9979
Std Dev x 0.0302
Std Dev y 0.004094
Background Rejection
1
0.95
0.9
0.85
0.8
0
0.1
0.2
0.3
0.4
0.5
Signal Efficiency

RGS

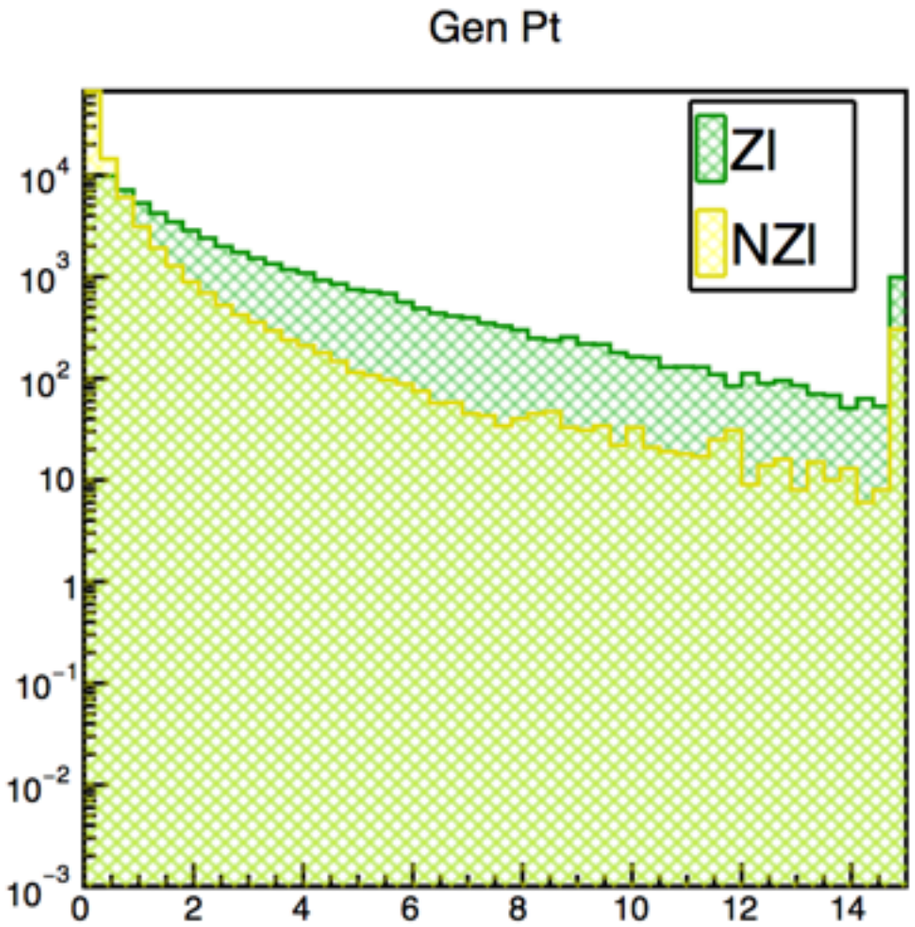
- Best Z for RGS: 1.9893025265

- (fs,fb) = (0.181130608559,0.00793677857493)

Roc Curves Comparisons



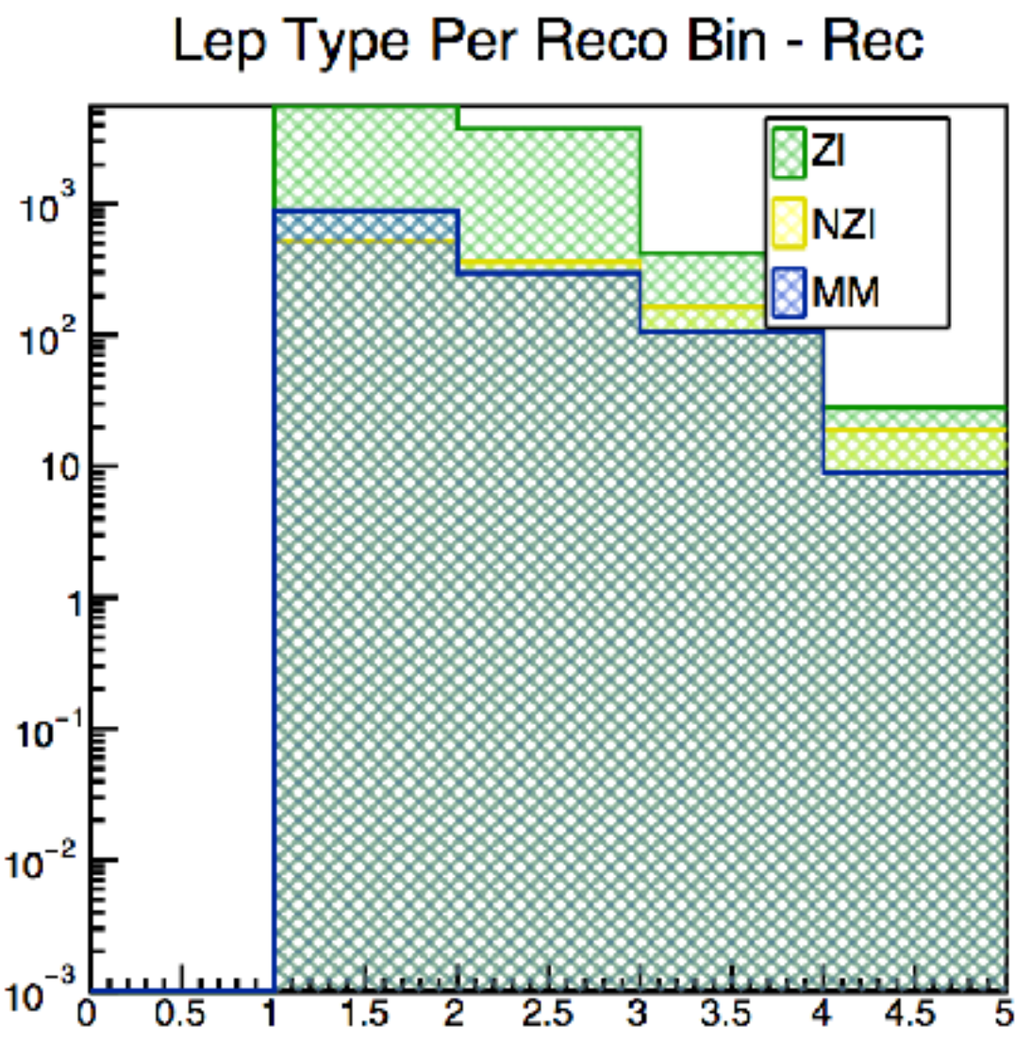
Generated Level Lepton

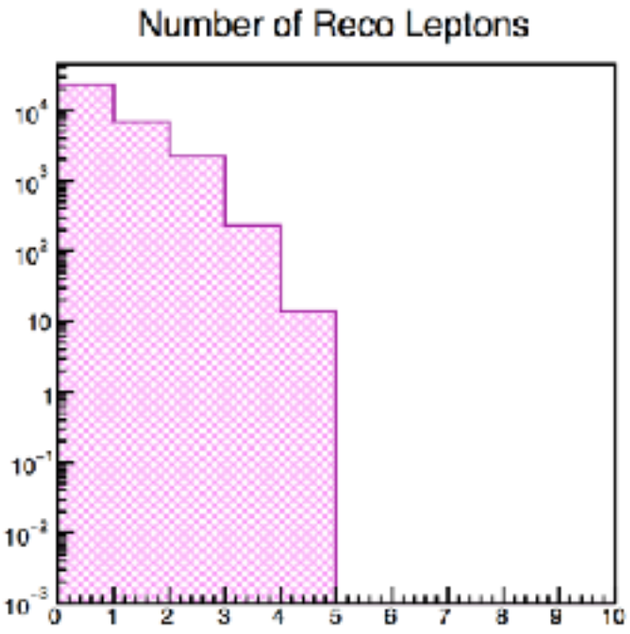


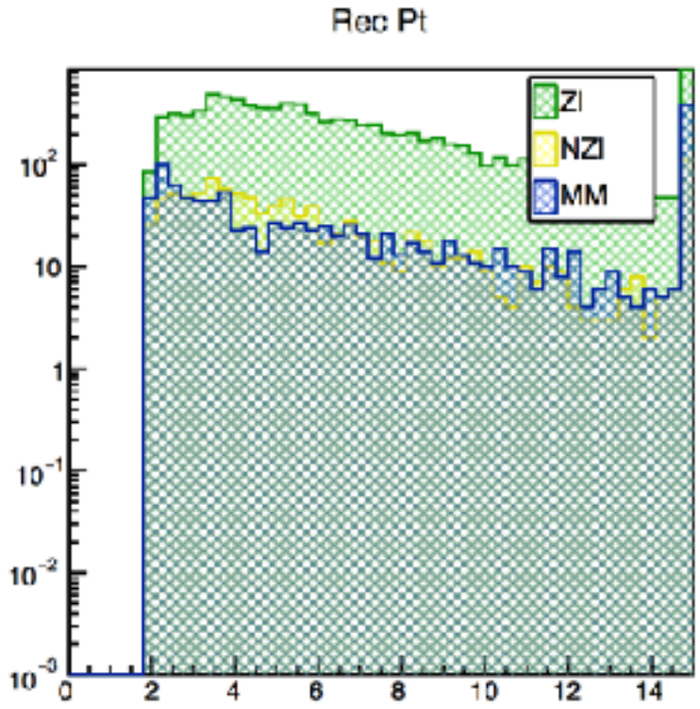
Matching Reco and Tracks

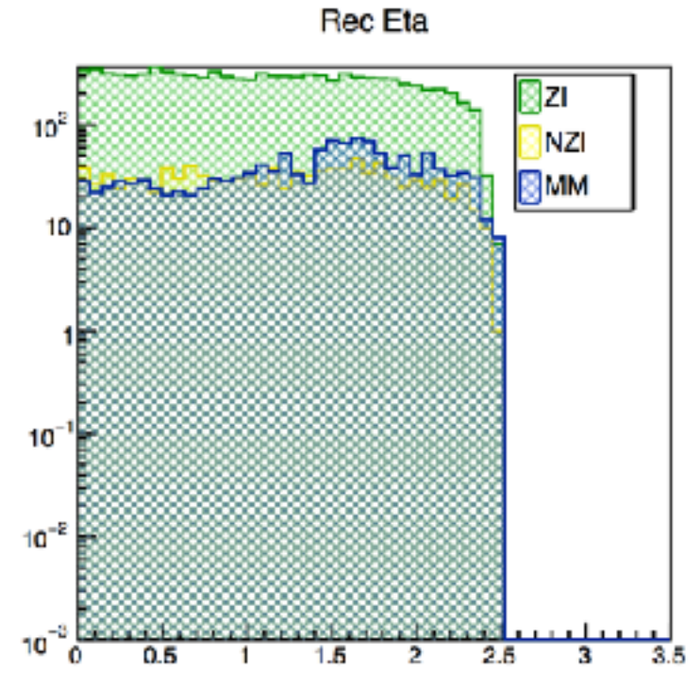
- For a reconstructed lepton to match we require:
- deltaR(gen, reco) < 0.01
- Correct flavour and charge.
- For tracks - only correct charge.

Reconstructed Leptons

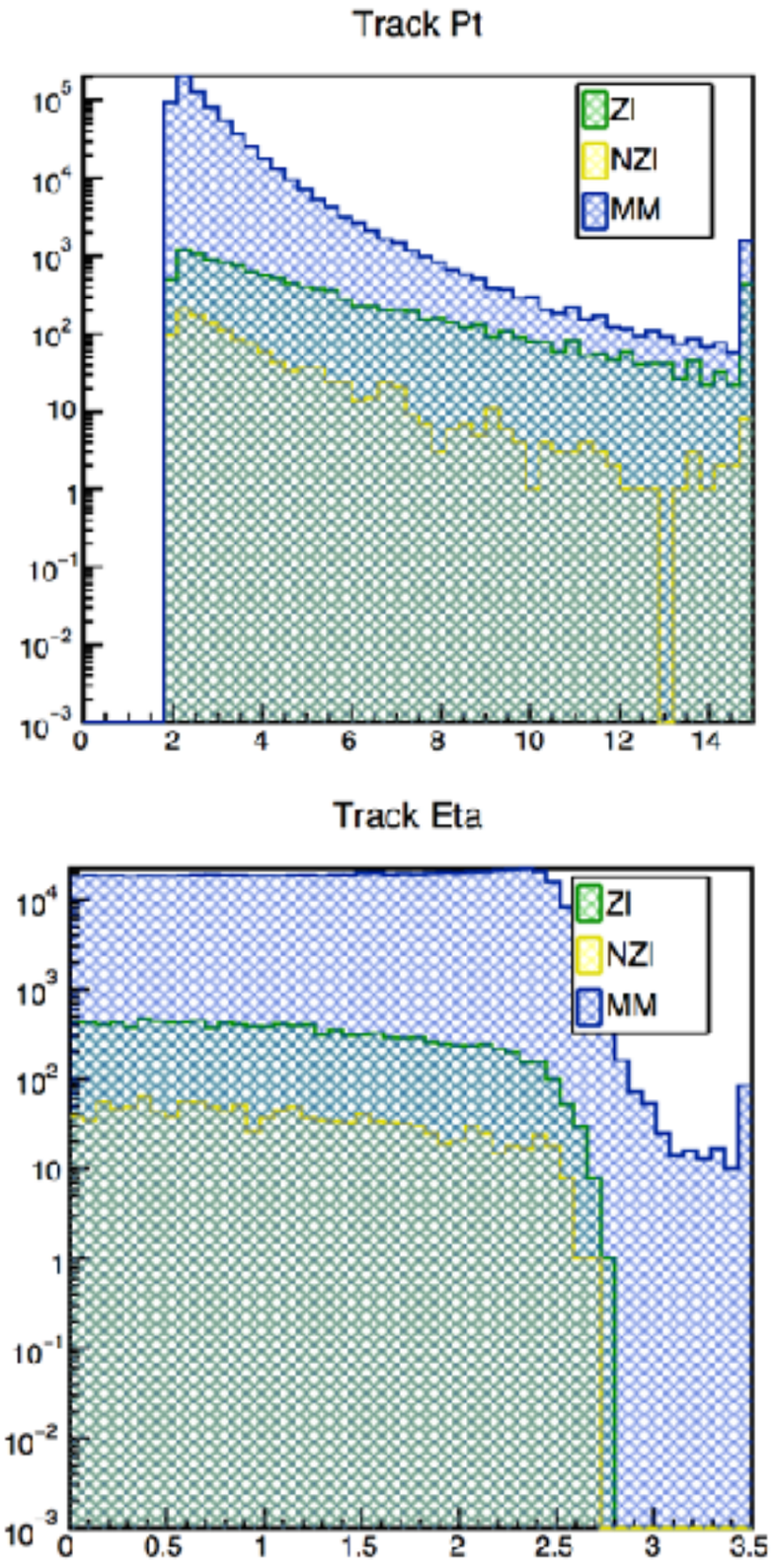


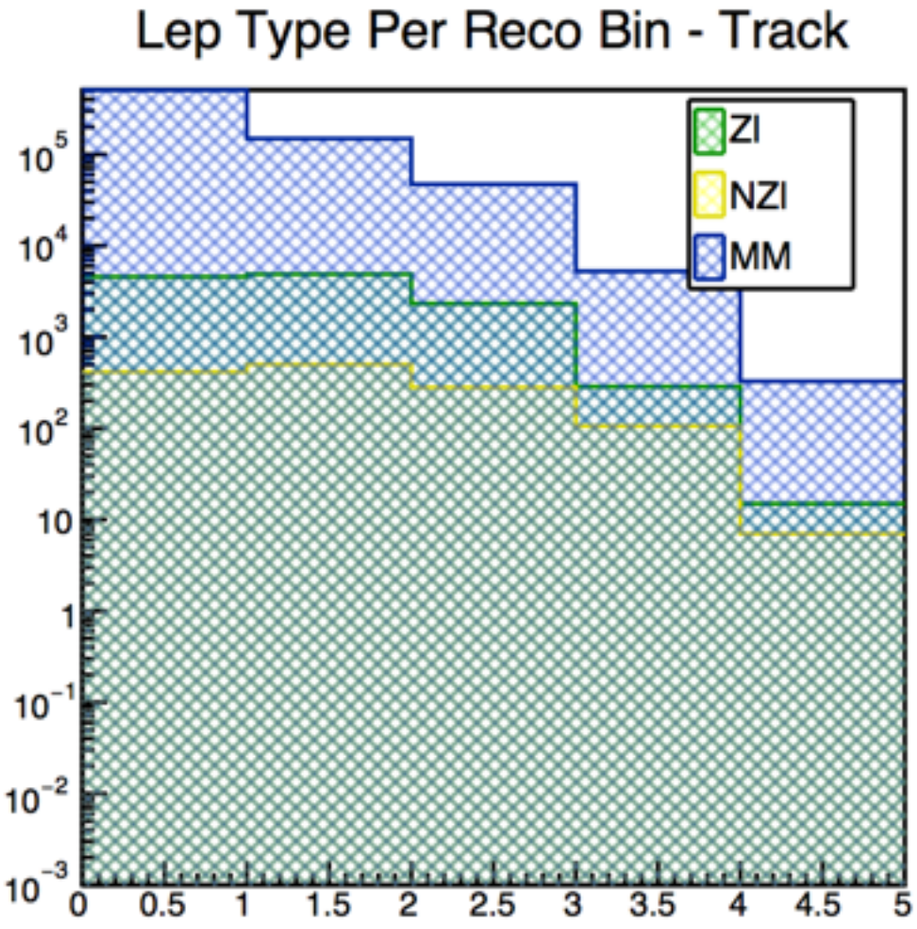






Tracks - No Cuts

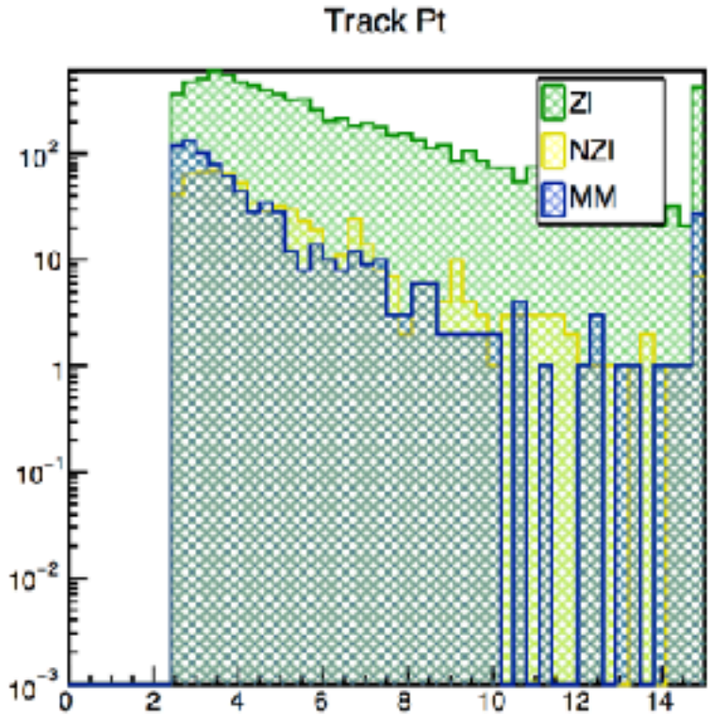


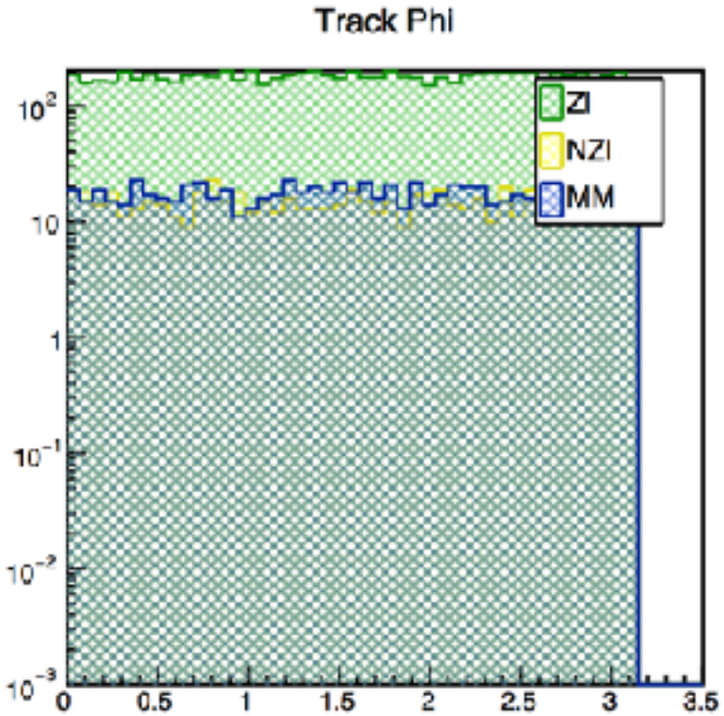


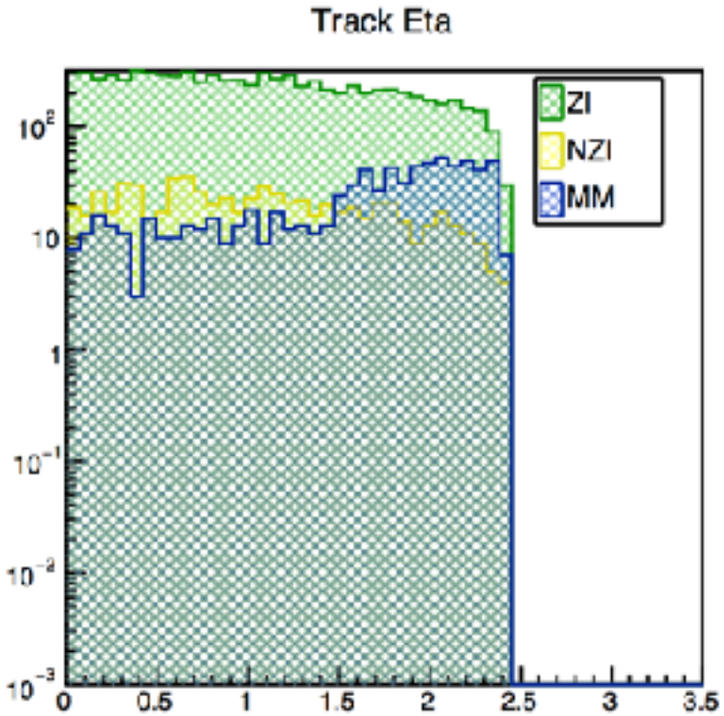
Tracks Selection

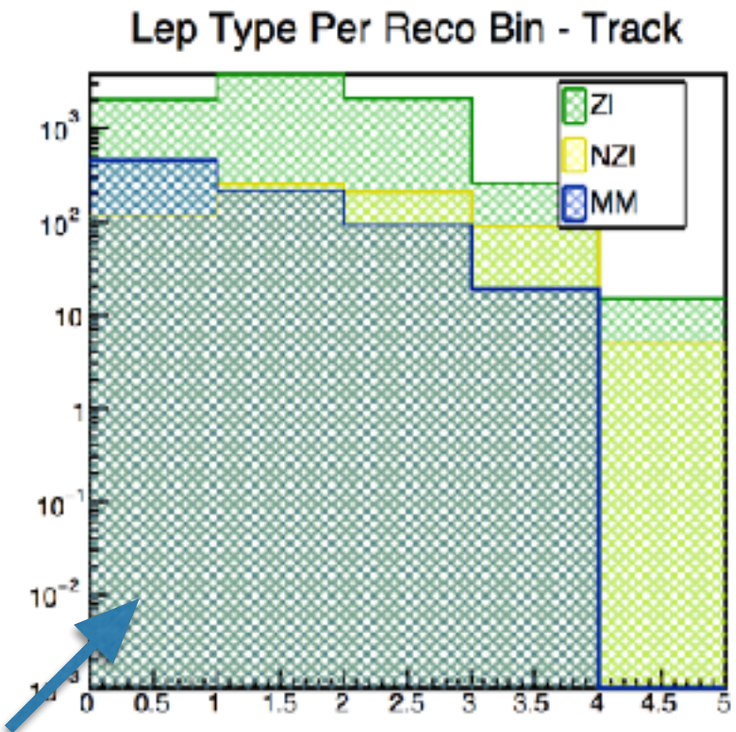
- trkRelIso < 0.01
- Eta < 2.4
- Pt > 2.5
- dz < 0.06
- dxy < 0.05
- trackLeptonIso < 0.02 (min DeltaR(track, vec<Leptons>)

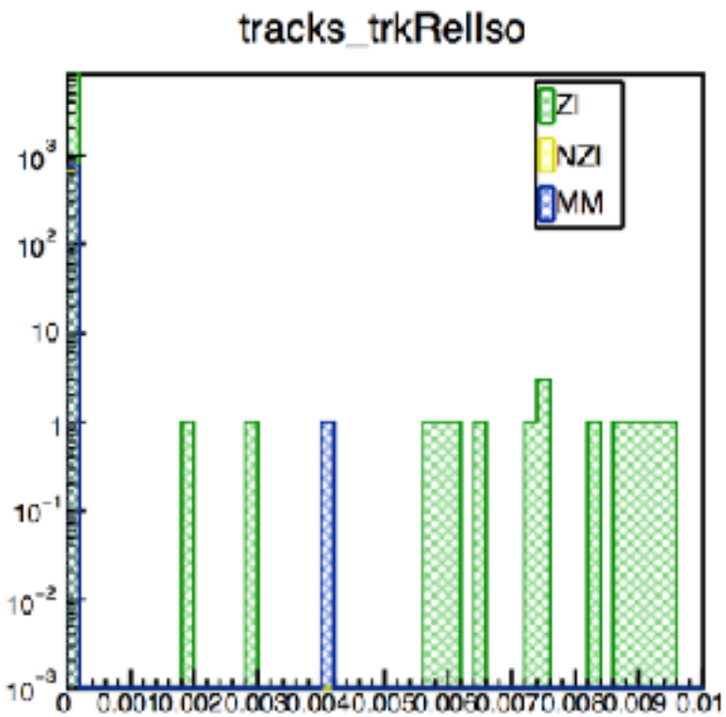
Tracks after Preselection

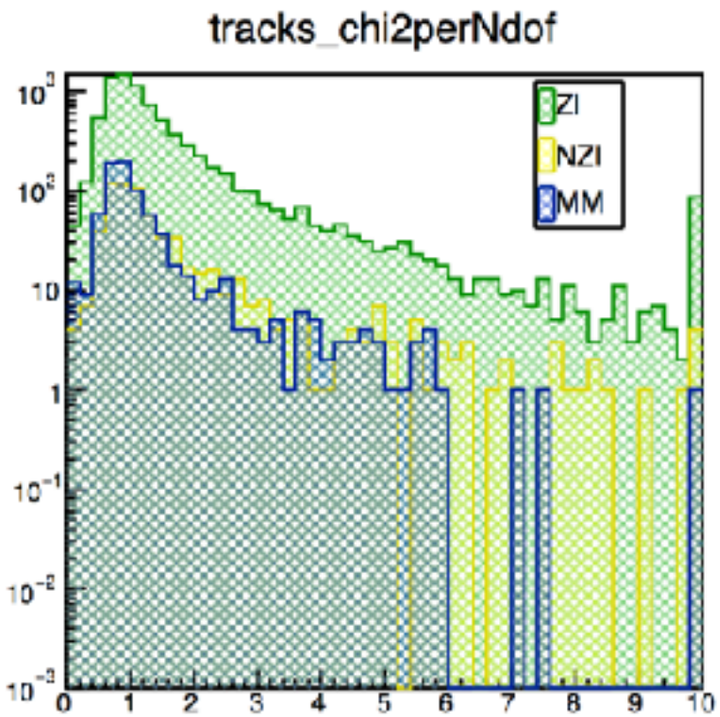




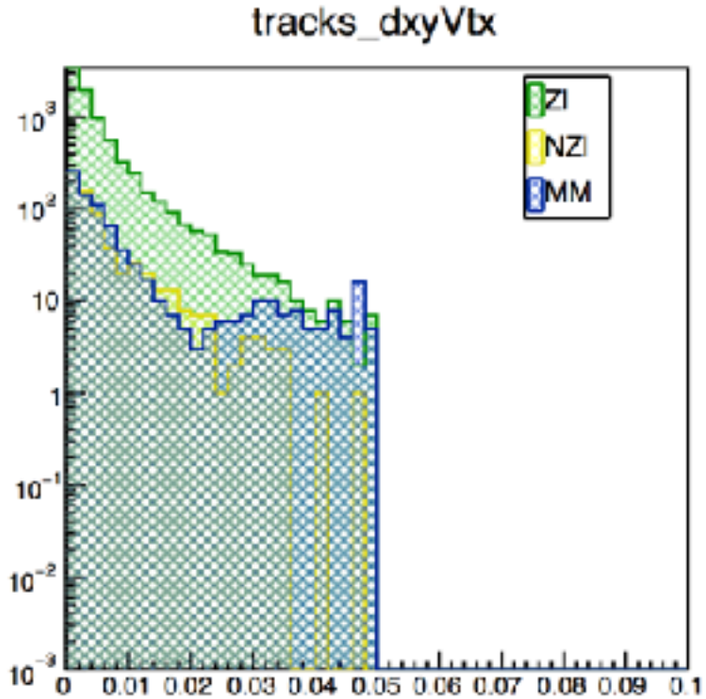


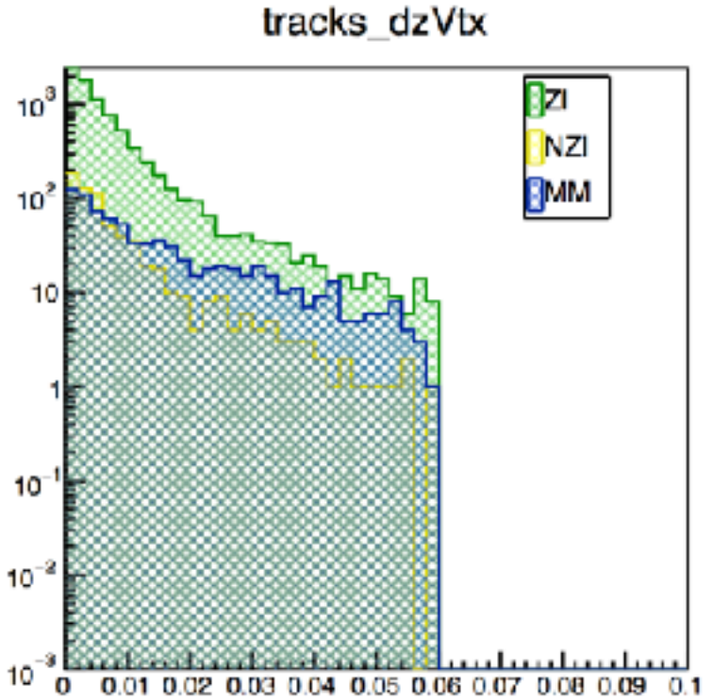


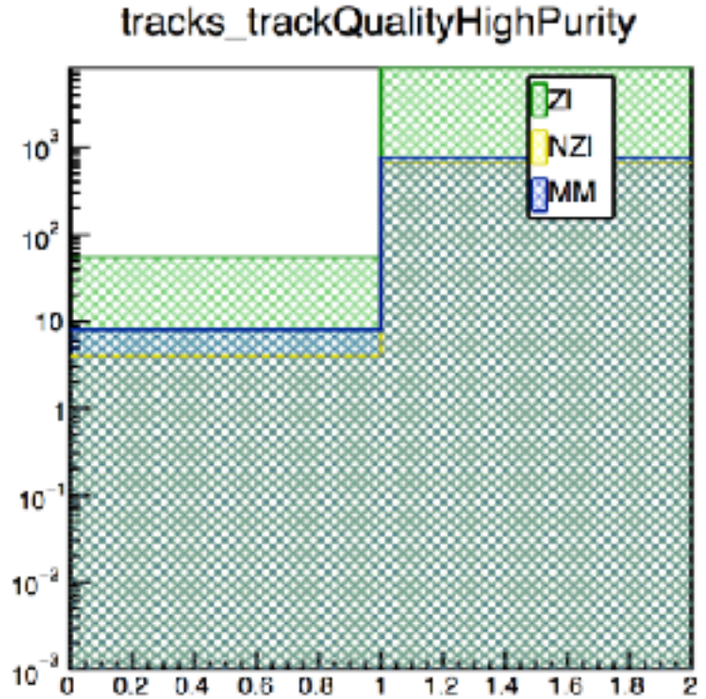


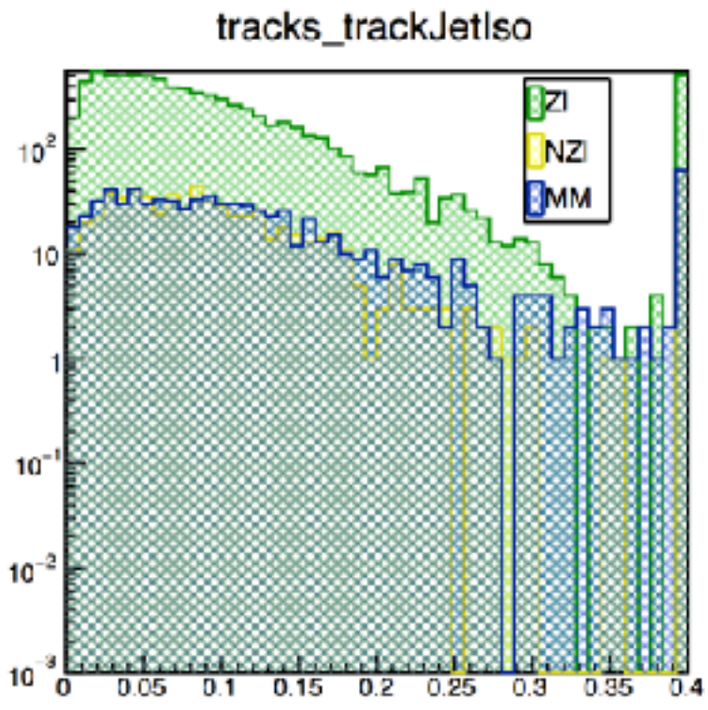


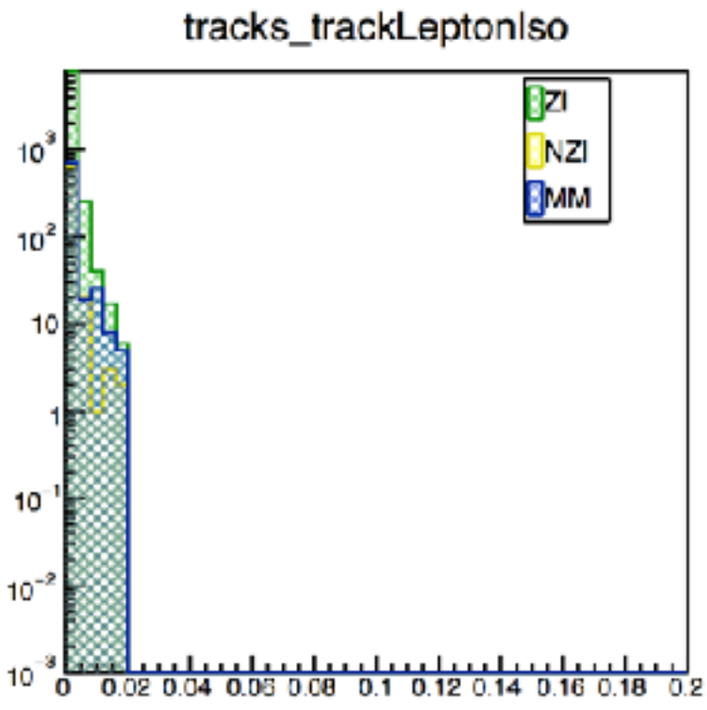
Tracks after Preselection

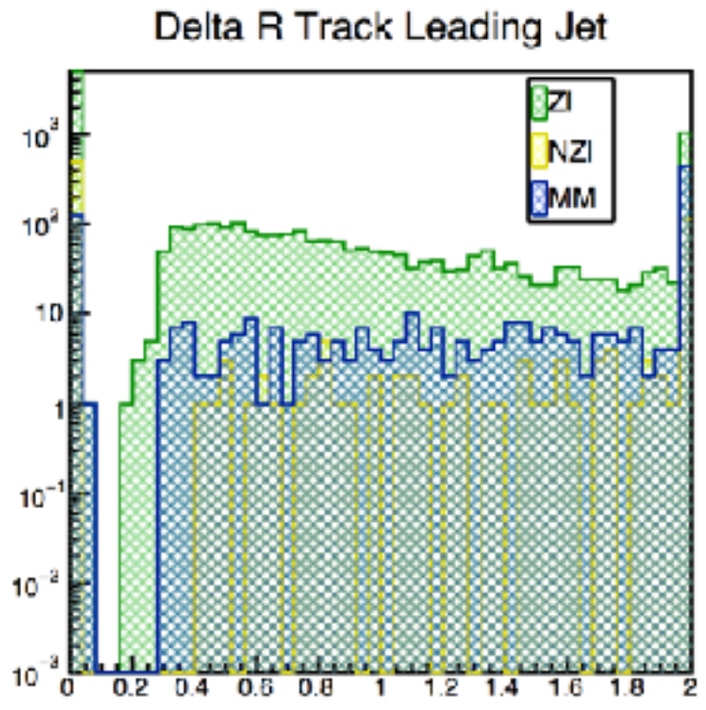




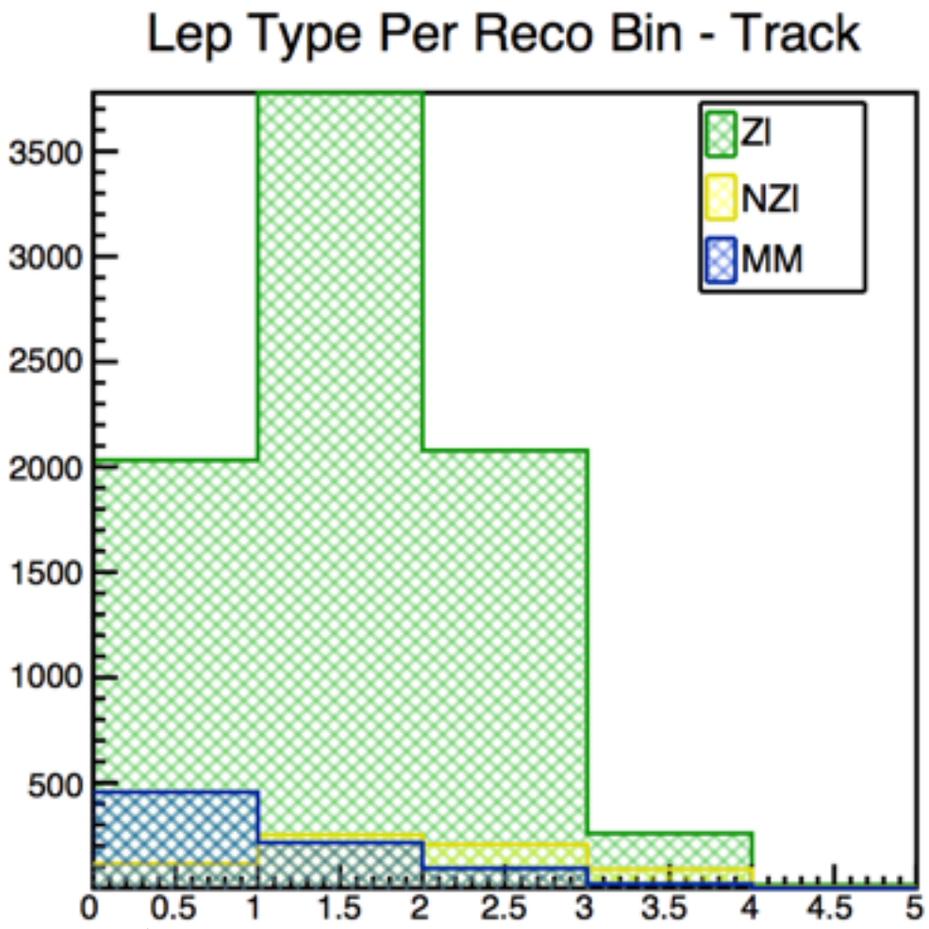


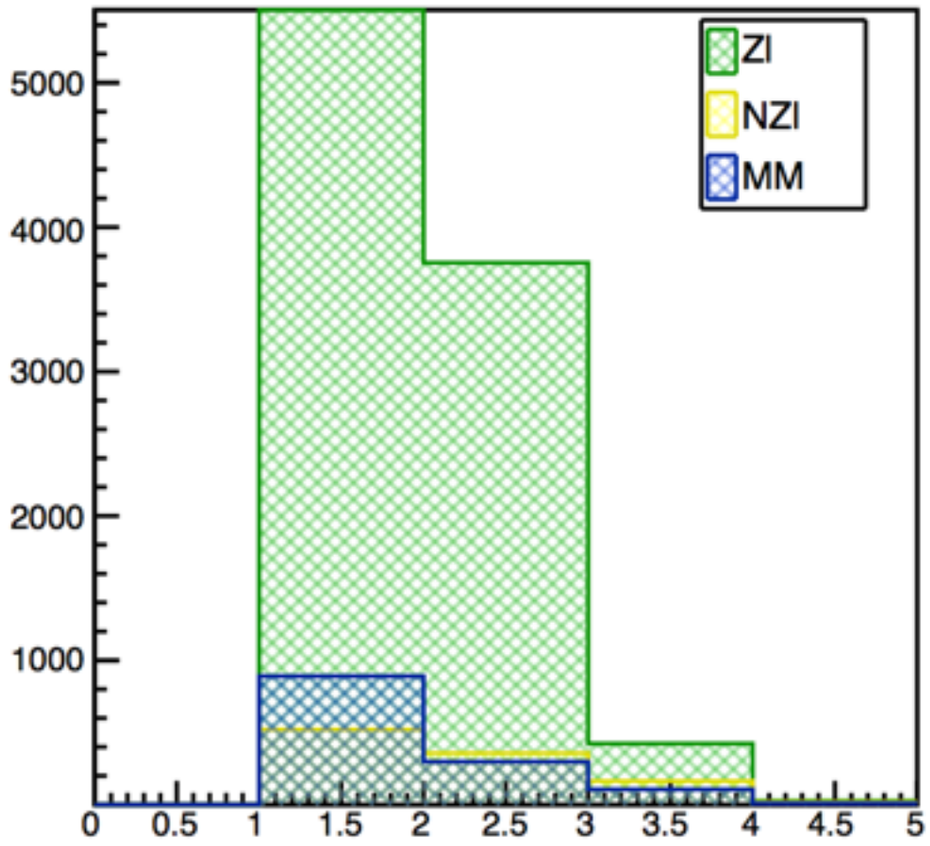






Non logarithmic comparison





~80% purity

Hopefully some of these were not reconstructed
(wishful thinking)

Change of Track Selection

- The previous selection performed very well because it was based on lepIso. The problem with that is that requiring small lepIso (deltaR between track and lepton) is that it will be small for softID leptons that were included in previous studies.

- New selection however seem to perform well as well.

Change of Track Selection

- Eta < 2.6
- Pt > 2.5
- dxy < 0.05
- dz < 0.06
- deltaEtaLL < 1
- deltaRLJ > 1.8
- deltaRLL < 1.1

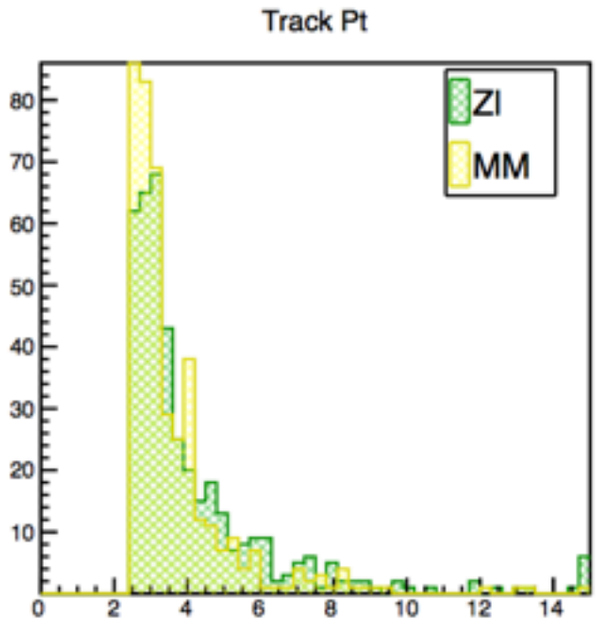
Change of Track Selection

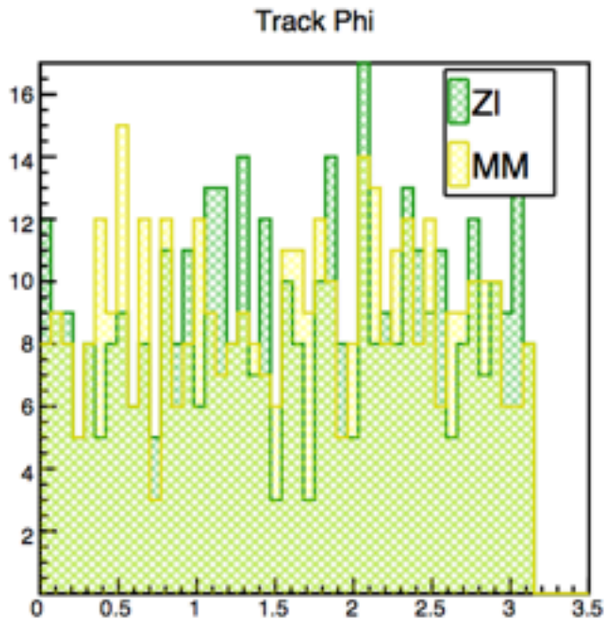
- Another change that was implemented is looking only at non reconstructed isolated tracks! This is very important in order to not get a too optimistic result.

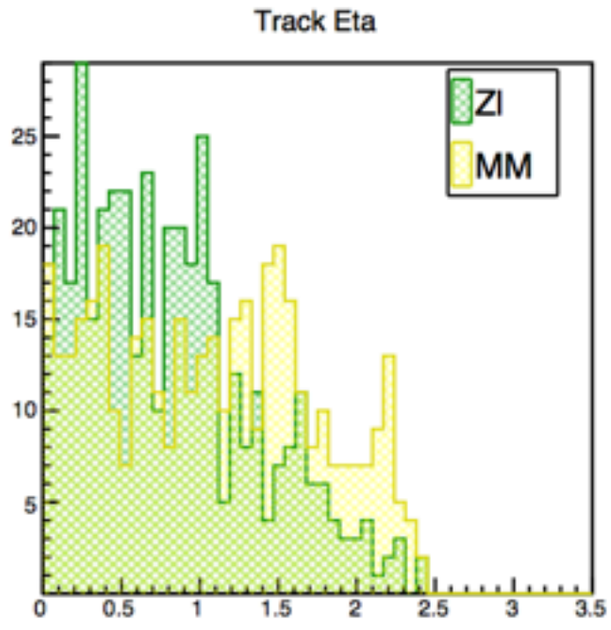
- Furthermore, in the following graphs - only the events with single reconstructed lepton were considered, since different lepton number bins performs entirely different under different cuts.

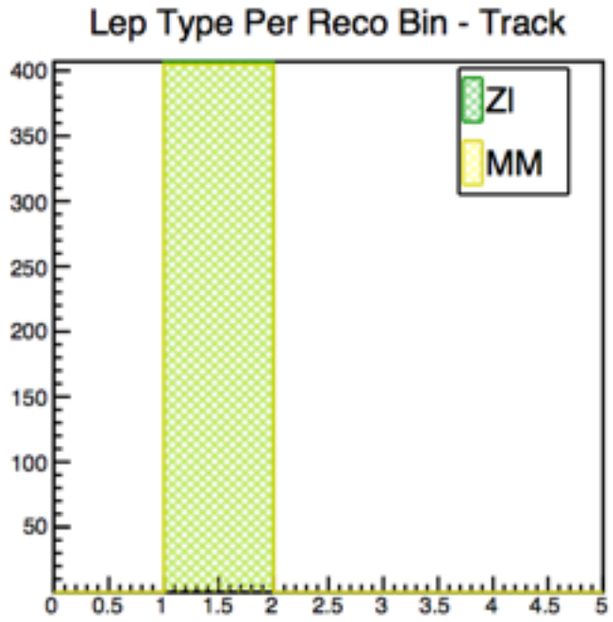
- We have achieved a purity of 51.4%.

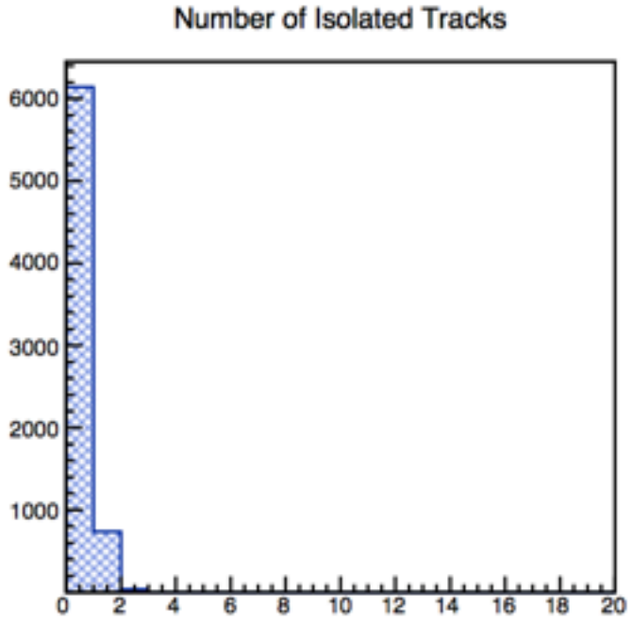
New Selection

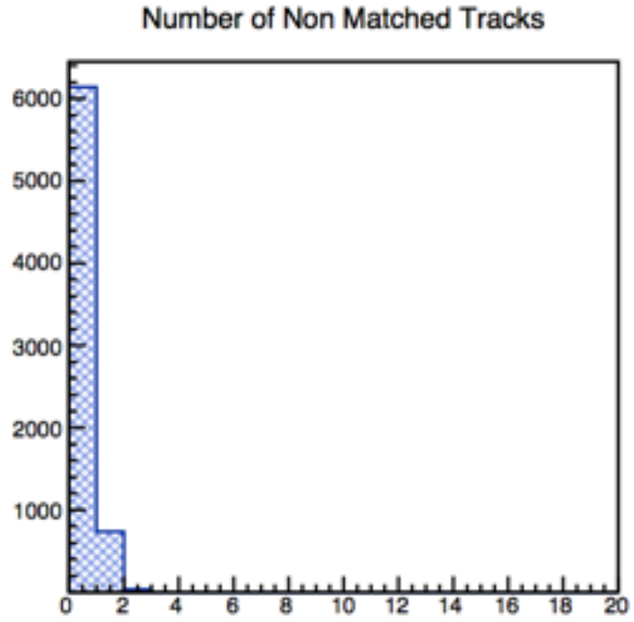




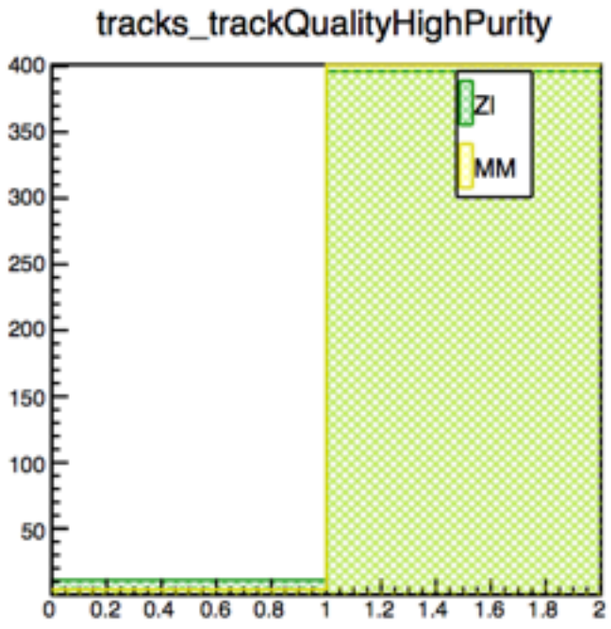


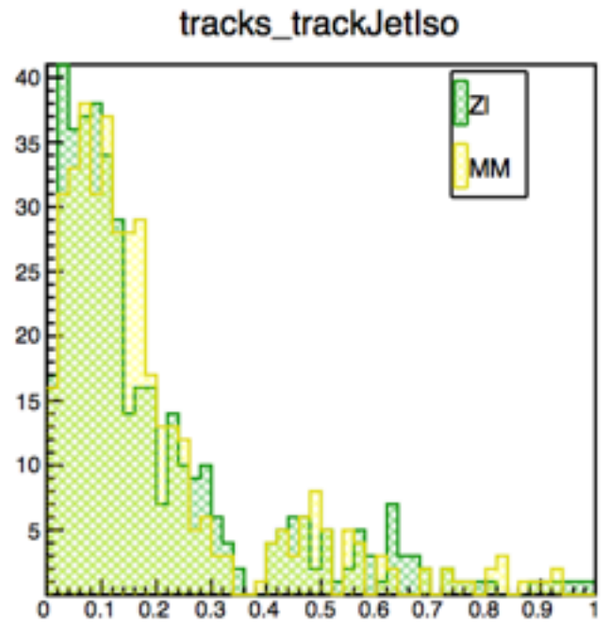


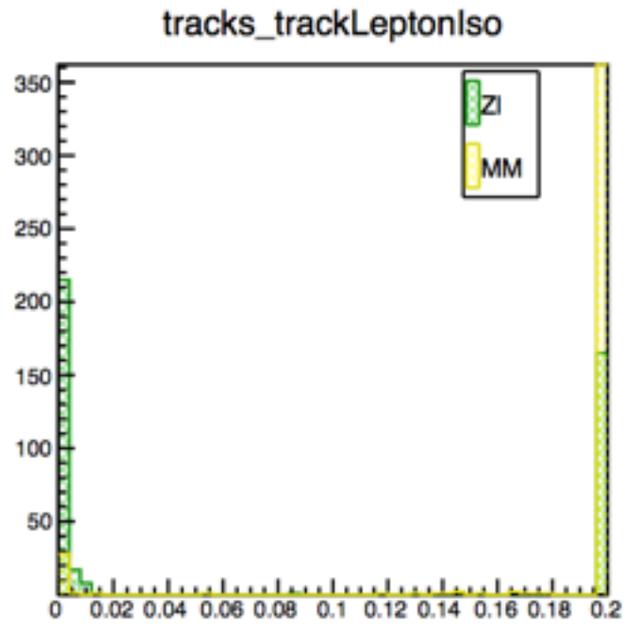


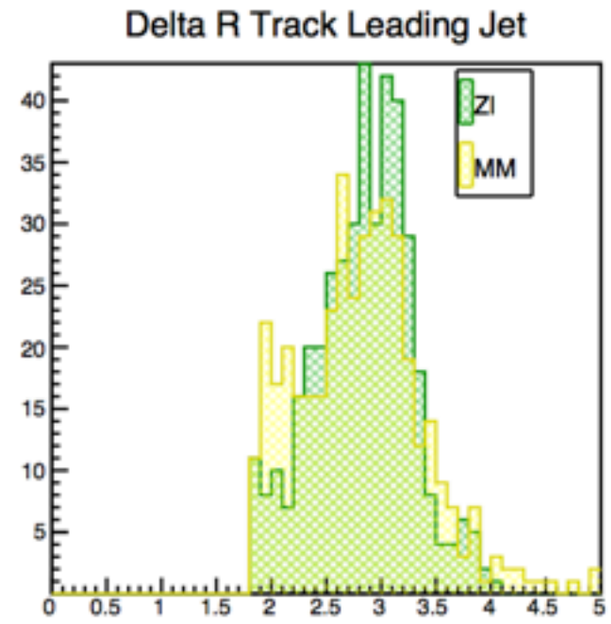


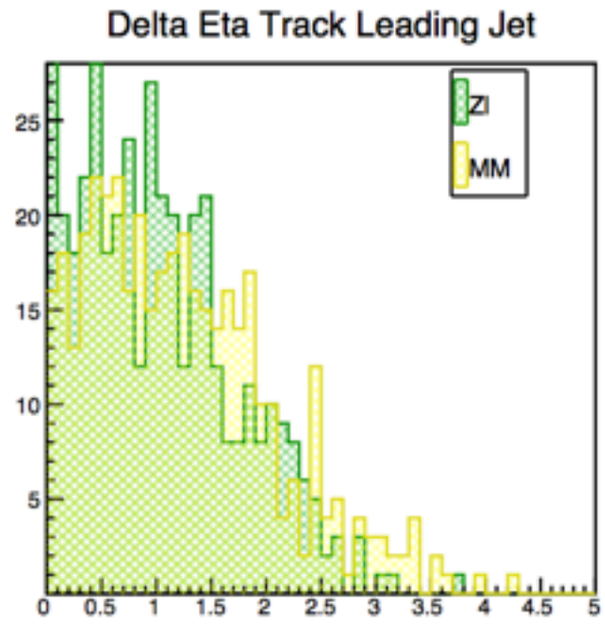
New Selection

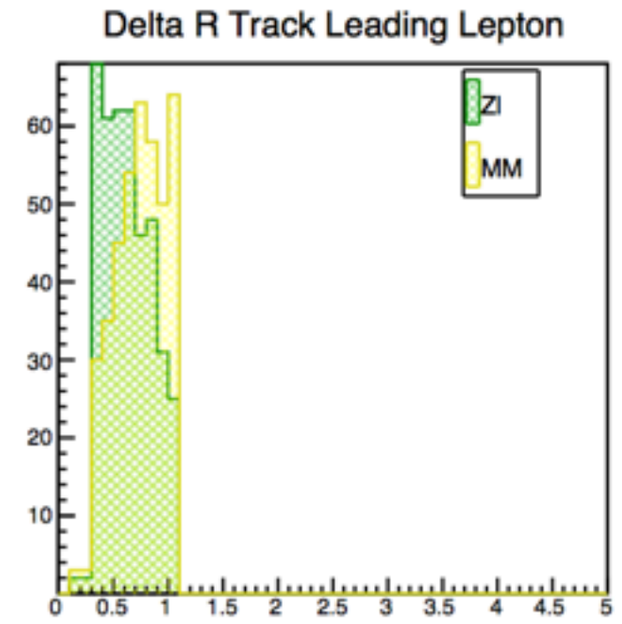




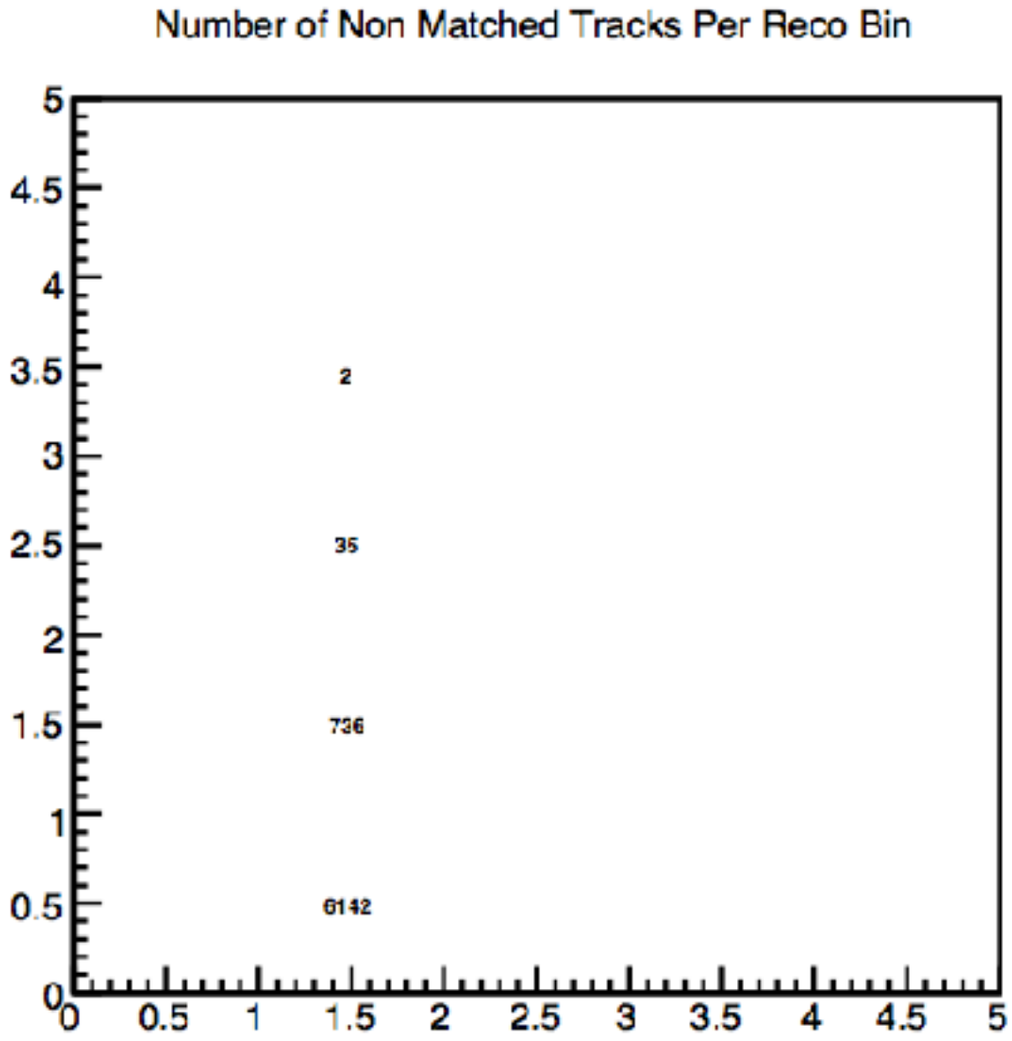


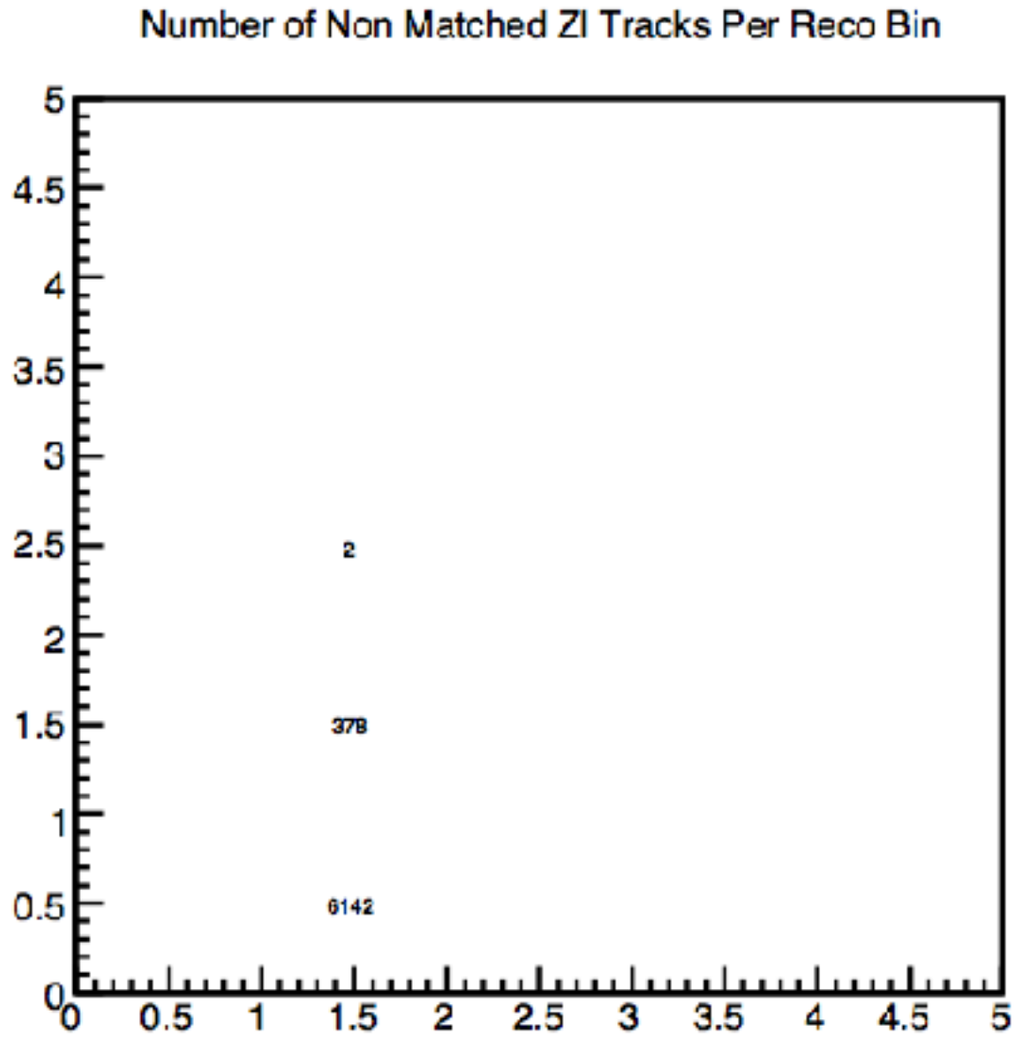






New Selection





To Do

- Calculate exact efficiencies and fakes for each reco bin.

- This small study have not imposed any preselection on the events. Ideally - add preselection and perhaps BDT output to get a more realistic estimation.

- Use RGS for the track selection :) :) :)

Backup