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# 1 Motivation

# 2 Soft Lepton Identification

## 2.1 Soft Electron Identification

We identify soft electrons using a method adapted from the B-Group's soft electron tagger. For every track in the event, we require that it passes track quality cuts and fiducial-ity cuts:

- 20 axial and 20 stereo COT hits
- At least 2 COT superlayers with 6 hits
- Track is fiducial to CES, CPR, and calorimeter
- Track $|\eta| < 1$.
- Track $p_T > 1$ GeV

After these cuts, we use a likelihood-based calculator to identify tracks that come from electrons. The likelihood calculator is trained completely on data, using conversions as a pure electron training sample and generic tracks (after electron removal) as a pure fake dataset.

### 2.1.1 Training Sample Selection

We use identified conversions as a training sample of real electrons. Using the 8-GeV electron trigger, we obtain a pure sample of conversions by looking for pairs of tracks that match the following criteria: (see Figure 1 for an illustration of the variables)

- Opposite sign
- $|Sep| < 0.2$ cm
- $\Delta\cot(\theta) < 0.1$
- $R_{Conv} > 8$

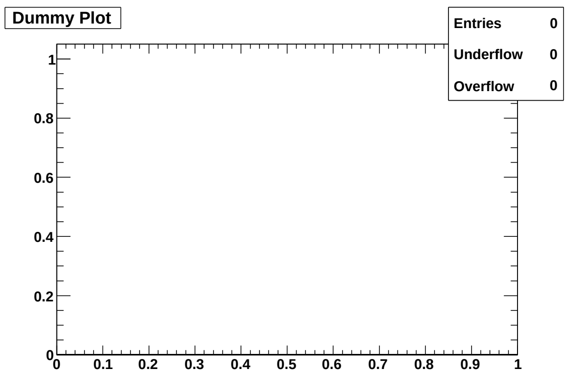


Figure 1: Conversion identification variables

After these cuts, we fit the $\Delta\cot(\theta)$ distribution to determine the non-conversion background under the peak. We use the sideband of the distribution ($0.06 < |\Delta\cot(\theta)| < 0.1$) to subtract out this background.

Since the higher-$p_T$ leg of the conversion will be trigger-biased, we train the likelihood function using the soft leg. We also don't use conversion pairs in which the hard leg extrapolates to the same calorimeter towers that are used for the soft leg, since those conversions have a very different $E_{em}/p$ distribution.

We use generic tracks as the background sample for the likelihood. Using the 20-GeV muon trigger, we eliminate all tracks that pass a conversion filter: (with different cuts than above, since we're trying to eliminate all conversions instead of find a pure sample of them)

- Opposite sign
- $|Sep| < 0.2$ cm
- $\Delta \cot(\theta) < 0.03$
- $R_{Conv} > 0$

To further reduce the contamination of this 'fake' sample by real electrons, we ignore all events that have any identified hard electron (using standard CDF cuts) or any secondary vertex b-tag. We only use tracks that are in jets, since those are the only tracks in our analysis for which we have a background expectation. (See Section ??)

#### 2.1.2 Electron Likelihood

We use seven discriminating variables in our likelihood calculation: $\frac{dE}{dx}$, $E_{EM}/p$, $\frac{E_{Had}}{E_{EM}}$, $E_{CPR}$, $E_{CES}$, $\Delta X_{CES}$, and $\Delta Z_{CES}$. The CES variables are calculated using the 2-dimensional CES shower algorithm (described in Section **??**). The calorimeter variables are calculated using a narrow, two-tower wide section of the calorimeter.

We calculate a likelihood for each variable and multiply these likelihoods together to get the final likelihood. With different cuts on this likelihood, we can get a different efficiency vs. fake rate of the likelihood. This is shown in Figure ??.

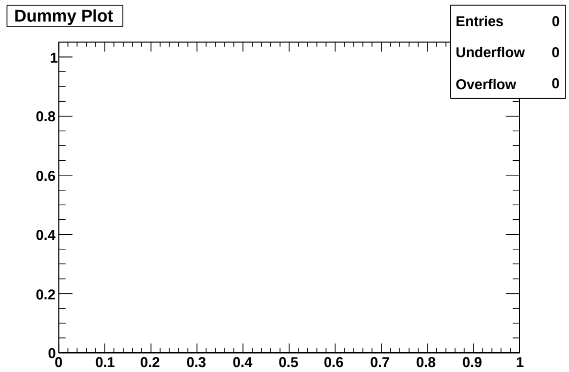


Figure 2: Electron efficiency and fake rate

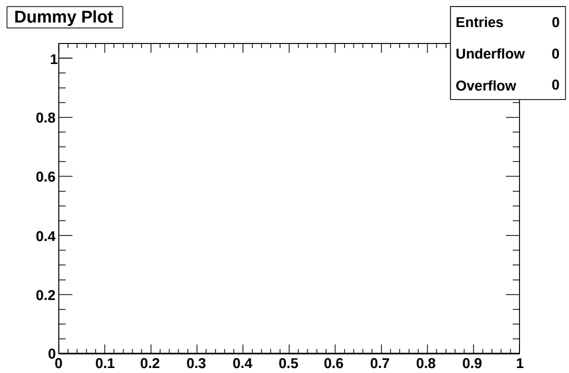


Figure 3: Muon efficiency and fake rate

### 2.2 Soft Muon Identification

## 3 Event Selection

## 4 Background Estimation

### 4.1 Electroweak Background

### 4.2 QCD Background

### 4.3 Soft Lepton Background

The soft lepton likelihood calculations don't work in the Monte Carlo, since they depend on the precise response of the detector at very low energies, which isn't modeled very well. Instead, we calculate the efficiency and fake rate of the soft lepton identification as a function of $p_T$ and $\eta$ (and track isolation for the electrons). We apply this efficiency or fake rate to each taggable candidate in the MC to find the predicted number of identified leptons.

There are multiple sources of background for these soft leptons. In order to be sure that we calculate the correct expectation for each background category, we fit for the conribution from each source in the one-soft-lepton events, (where we don't expect to see a significant new physics contribution) then extrapolate that expectation to the multiple-soft-lepton events.

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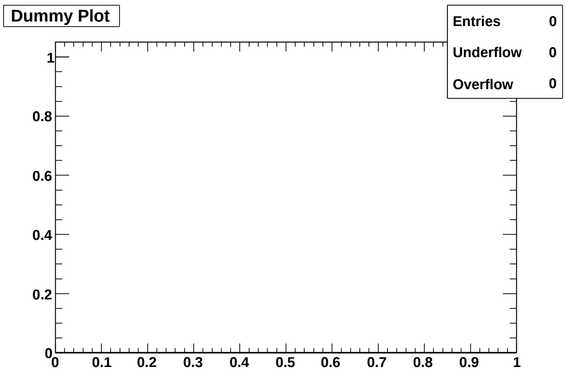


Figure 4: 3-component fits

# 5 Results

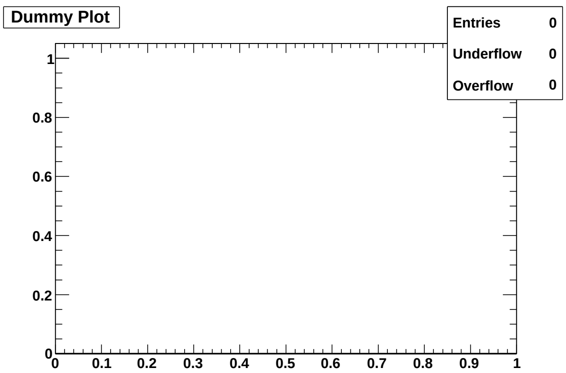


Figure 5: Final Plots