Cross-cleaning of Reconstruction Object Collections

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Hamburg CMS Meeting November 5th, 2008

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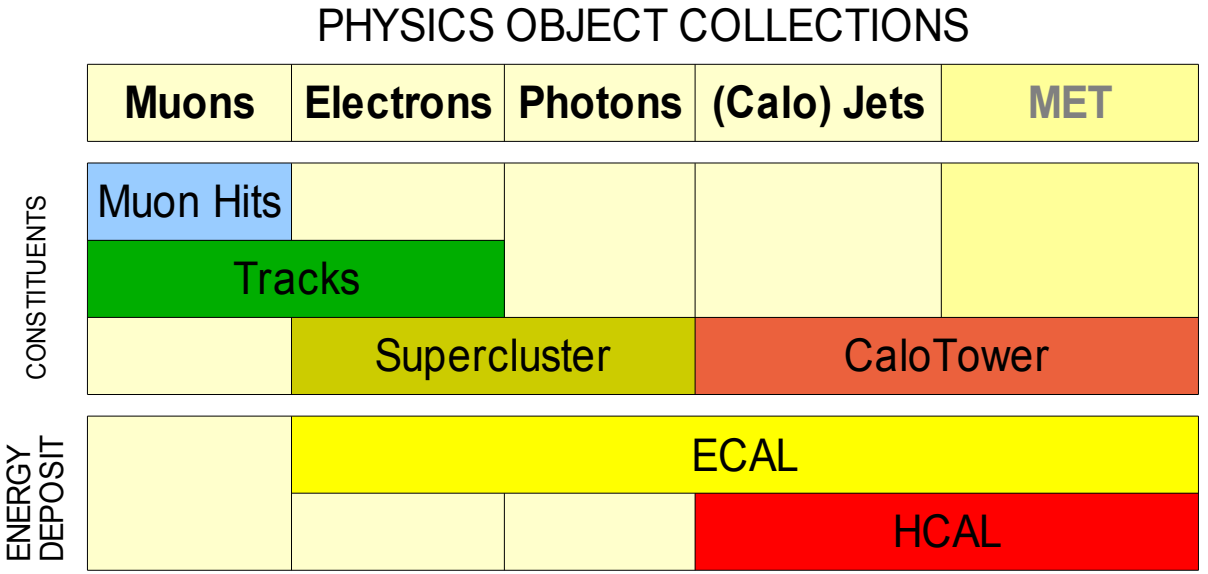
Outline

- Motivation
- Steps of the cross-cleaning
- Validation of electron-jet cleaning
  - Effects on Electrons
  - Effects on Jets & MET
- Summary & Outlook

Introduction

- A typical (SUSY-) analysis uses
  - a signature like: Leptons + Jets + MET
  - quantities calculated from objects, e.g. H_T, hemispheres
- Several collections of independently reconstructed objects are used



- Reconstruction is not unambiguous

Introduction

- Possible ambiguities (before object identification/cleaning):
  1. Each supercluster makes a photon and electrons are a subset of those ⇒ each electron is also a photon
  2. High energy electron/photon makes a jet
  3. Jet EM energy is reconstructed as an electron/photon
     - Applying object ID does not help in all cases

Number of electron-jet overlaps

no electron ID	`robust' ID	`loose' ID
~1/evt	~0.5/evt	~0.3/evt

(SUSY LM1, jet E_T > 20 GeV)

  4. (Muon and electron share the track/hits)
  5. Muons/electrons/photons produced inside a jet (isolation issue)

Introduction

- Look for overlaps and resolve them: **cross-cleaning**
- Cross-cleaning code using the PAT*:
  - Effort within the SUSY group to resemble functionality of old SusyAnalyzer code
  - Package for cross-cleaning and its validation set up (C.Autermann, J.-R. Vlimant, F. Nowak, C. Sander, B.M.)
  - Works with PAT Layer1 collections
  - CMSSW 1.6.12 and 2.1.x compatible

* Physics Analysis Toolkit: A centrally developped set of tools to facilitate common analysis tasks (https://twiki.cern.ch/twiki/bin/view/CMS/WorkBookPAT)

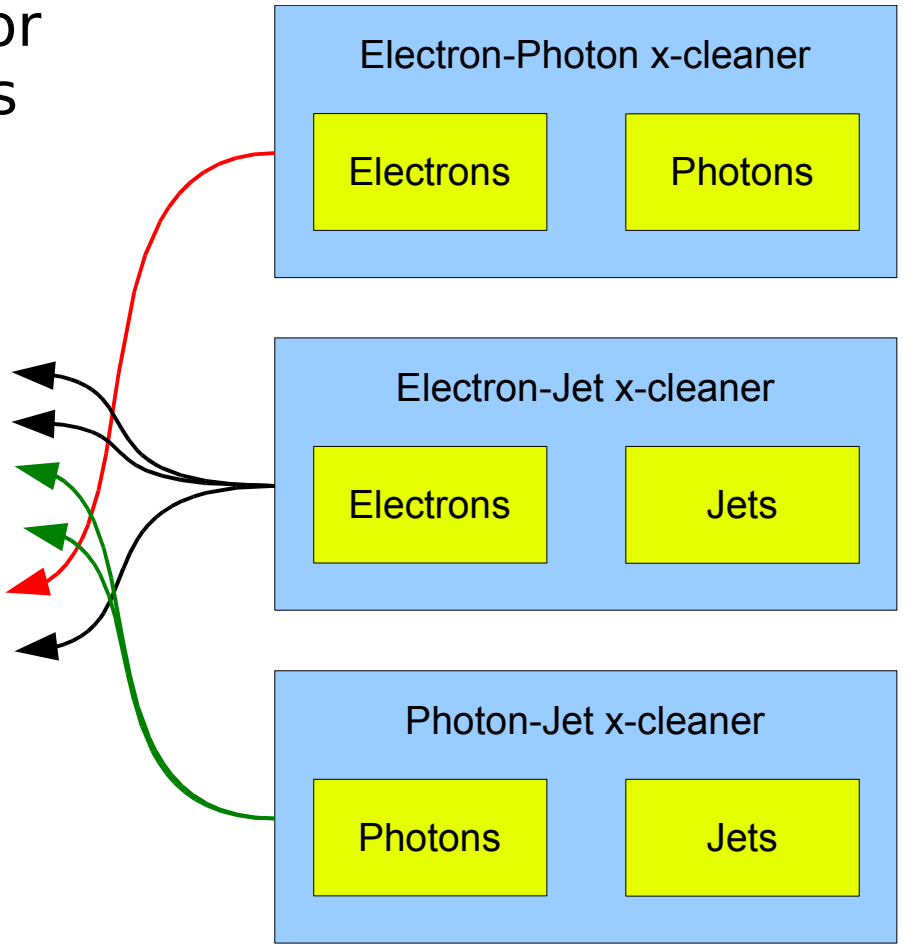
Documentation:
https://twiki.cern.ch/twiki/bin/view/CMS/SusyPat
https://twiki.cern.ch/twiki/bin/view/CMS/SusyPatCrossCleaner

X-cleaning Steps I

1. Create a map with all conflicting objects in an event
   - Individual procedure for each pair of collections

Cross Cleaner Map

Modify	because of	How?
jet x	electron y	remove
jet y	electron z	add 2 GeV
	photon a	add 3.1 GeV
	photon b	add 1.5 GeV
photon a	electron z	remove
electron x	jet z	remove

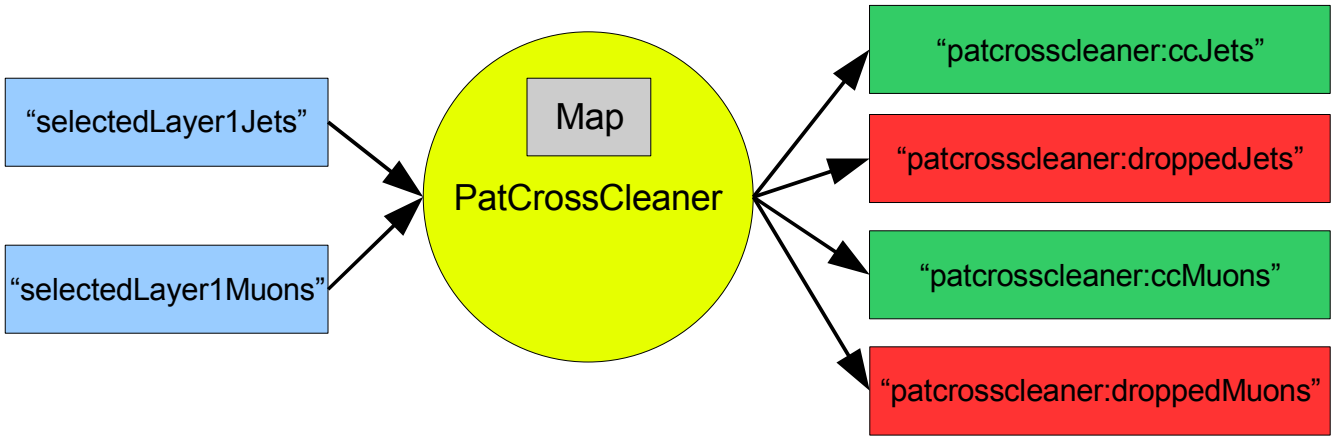


   - Takes care of interferences
     (a removed object does not modify another one)

Can be turned on/off as desired

X-cleaning Steps II

2. Create clean collections using this map
   - Loop over input collections
   - Check for each object if it is to be modified (take care of interferences)
   - Modify it according to the map, either
     - Change its energy if requested and put it in the clean collection
     - or put it in the collection of dropped objects



X-cleaning Steps III

- Cleaners are working with uncorrected jets
  - Apply new correction (ΔE^{new}) to changed jets
- Dropping or modifying a jet affects Missing E_T correction:
  - Type1 MET correction:

$$\Delta MET^2 = [\Sigma_{jets}(E_x^{corr} - E_x^{uncorr})]^2 + [\Sigma_{jets}(E_y^{corr} - E_y^{uncorr})]^2$$

$$\Delta MET^2 = [\Sigma_{jets}(\Delta E_x)]^2 + [\Sigma_{jets}(\Delta E_y)]^2$$

  - Update MET when changing/dropping a jet:

$$\Delta MET^2 = [\Sigma_{jets}(\Delta E_x^{orig} - \Delta E_x^{new})]^2 + [\Sigma_{jets}(\Delta E_y^{orig} - \Delta E_y^{new})]^2$$

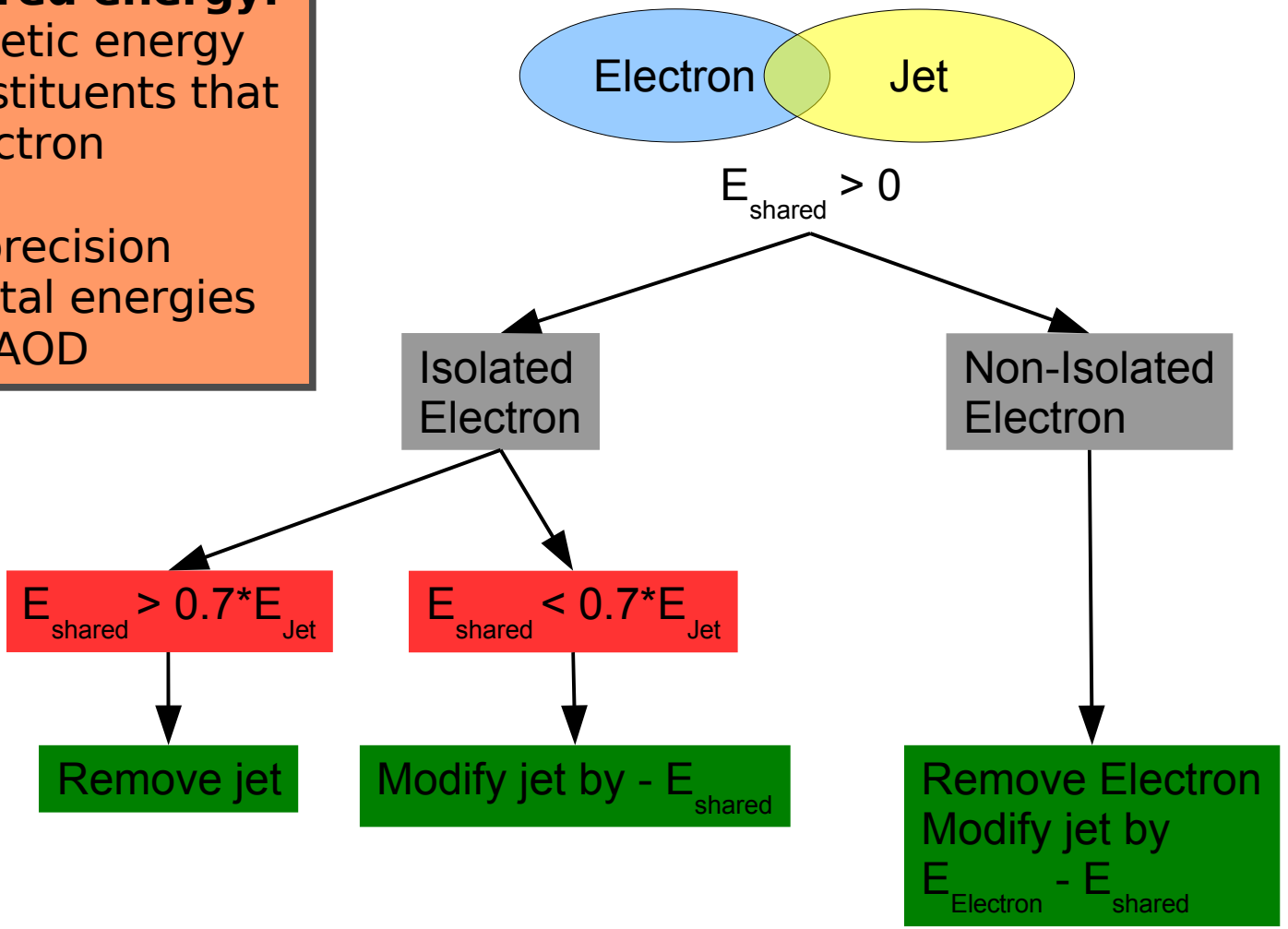
- PatCrossCleaner produces new MET collection
  - Specify in configuration which corrections to use

Electron-Jet Cleaning

- Along the lines of SusyAnalyzer cleaning

Calculation of shared energy:
Sum of electromagnetic energy in jet calotower constituents that overlap with the electron supercluster.
- implies limited precision
- single ECAL crystal energies not available in AOD

Chose isolation method in configuration

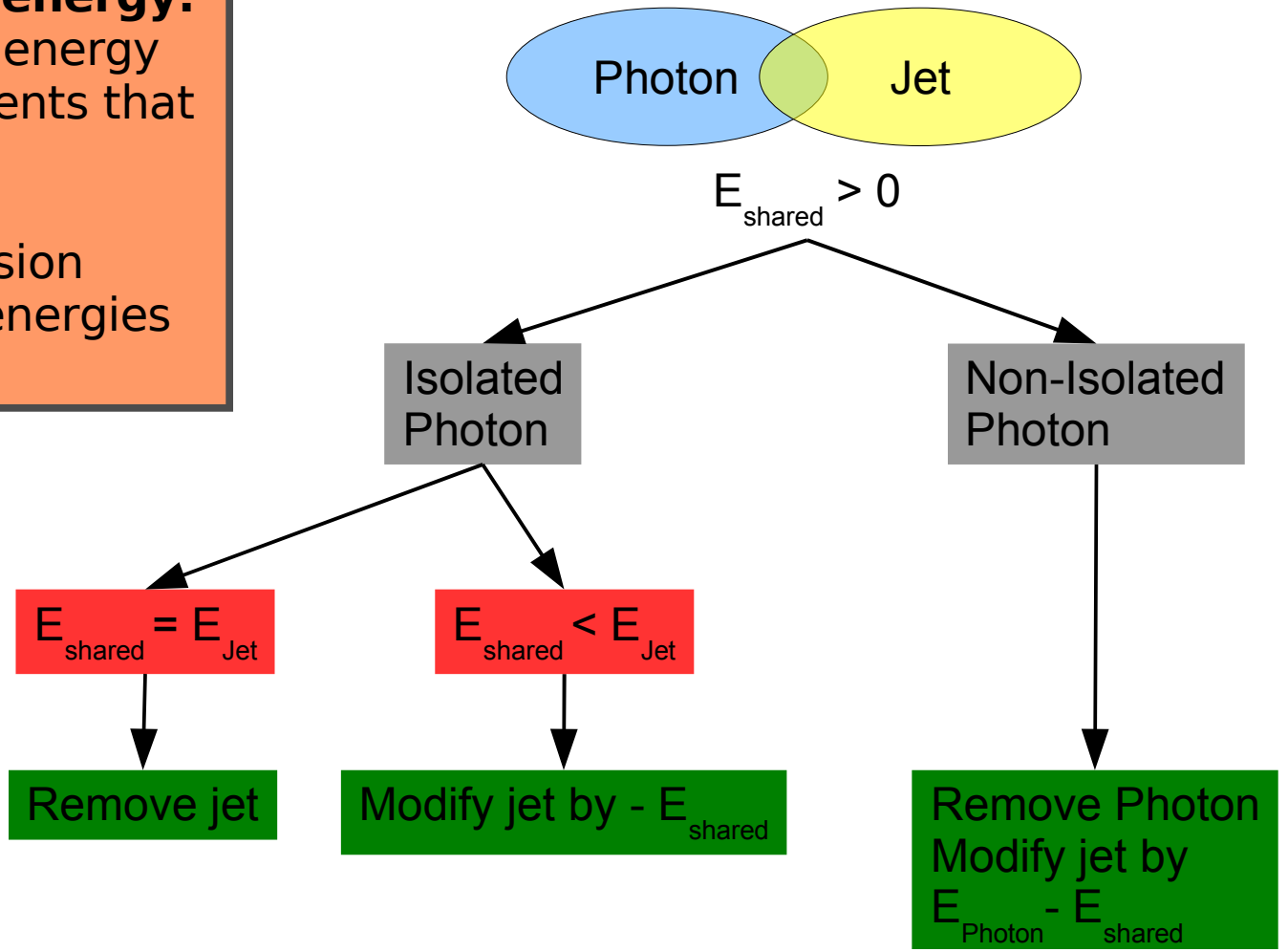


Photon-Jet Cleaning

- Along the lines of SusyAnalyzer cleaning

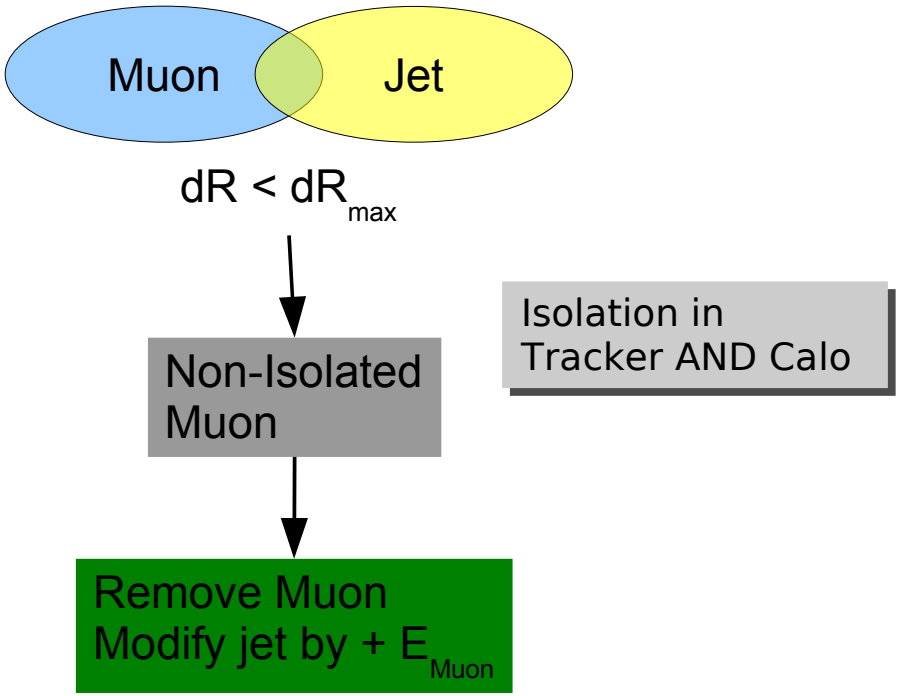
Calculation of shared energy:
Sum of electromagnetic energy in jet calotower constituents that overlap with the photon supercluster.
- implies limited precision
- single ECAL crystal energies not available in AOD

Chose isolation method in configuration



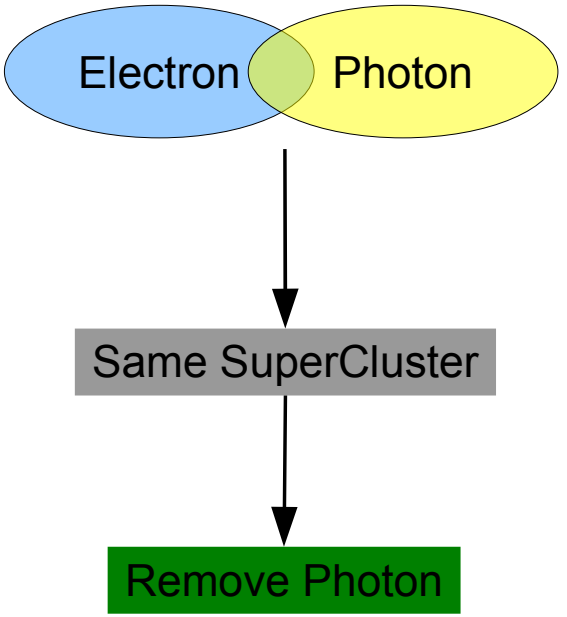
Other Cleaners

- Muon-Jet



- Electron-Photon

This information is in principle already available via the PAT overlap flag

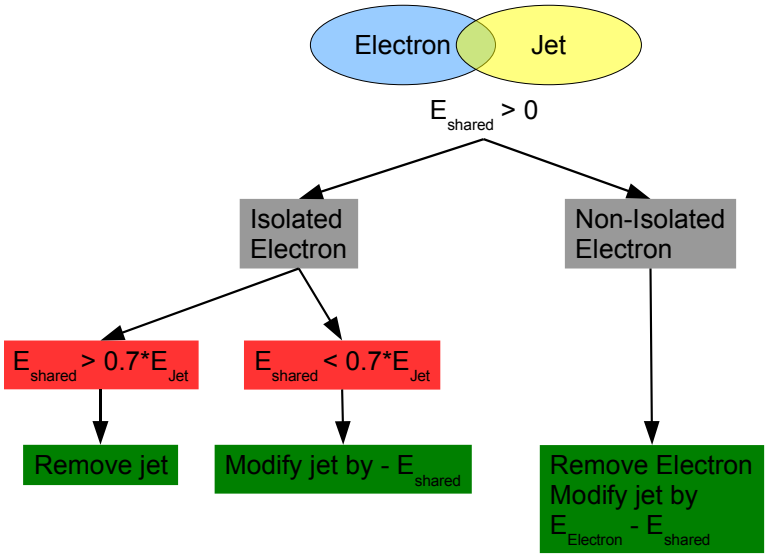


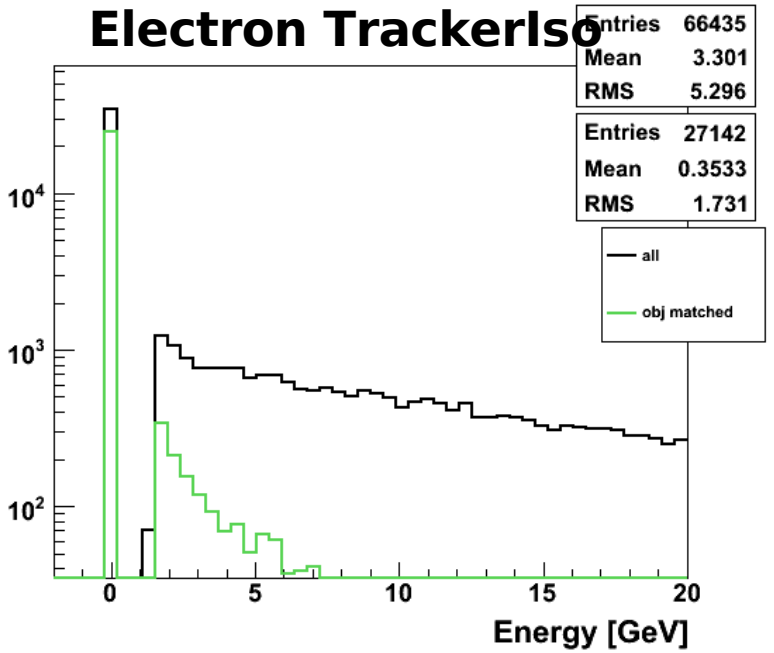
Validation

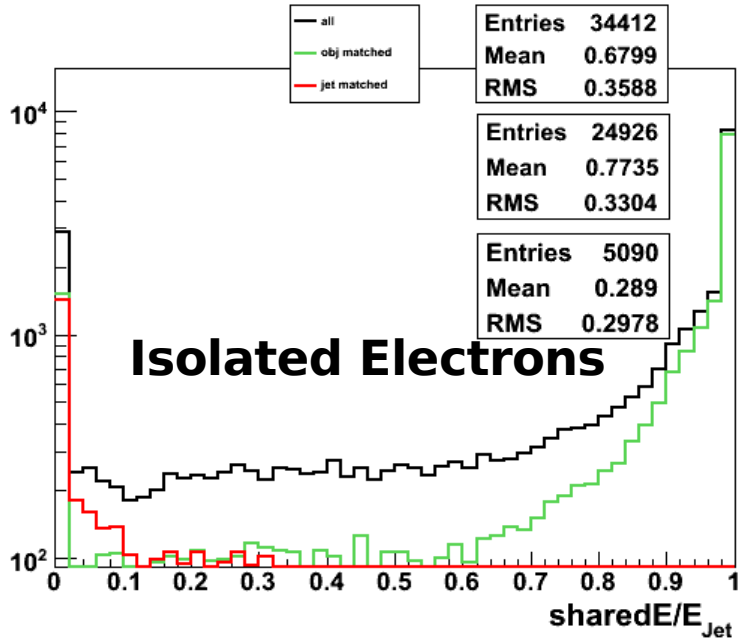
- Need to validate that x-cleaning improves the analysis
- Need criteria to tune the parameters
- Look at quantities before and after the cleaning, e.g.
  - Resolutions
  - Efficiencies for reconstruction
  - Reconstruction fake rates (Contamination)
  - Control plots of selection variables

(All plots shown here are for SUSY LM1 sample & using 'robust' electron ID)

Electron-Jet Cleaning

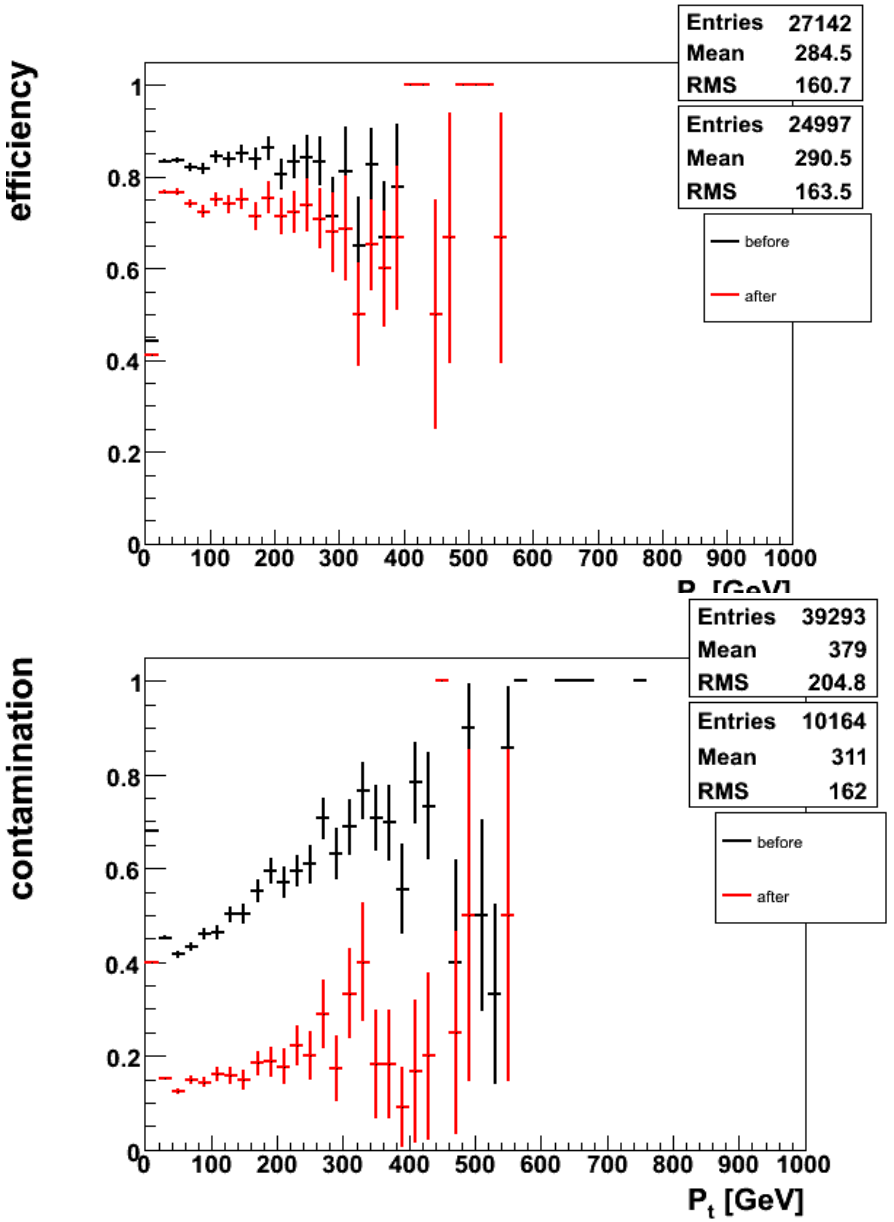






- Most matched electrons are isolated (PAT MC match)
- Cut on isolation determines final electron efficiency and contamination
- For matched electrons E_{shared}/E_{jet} is close to one

Effect on Electrons

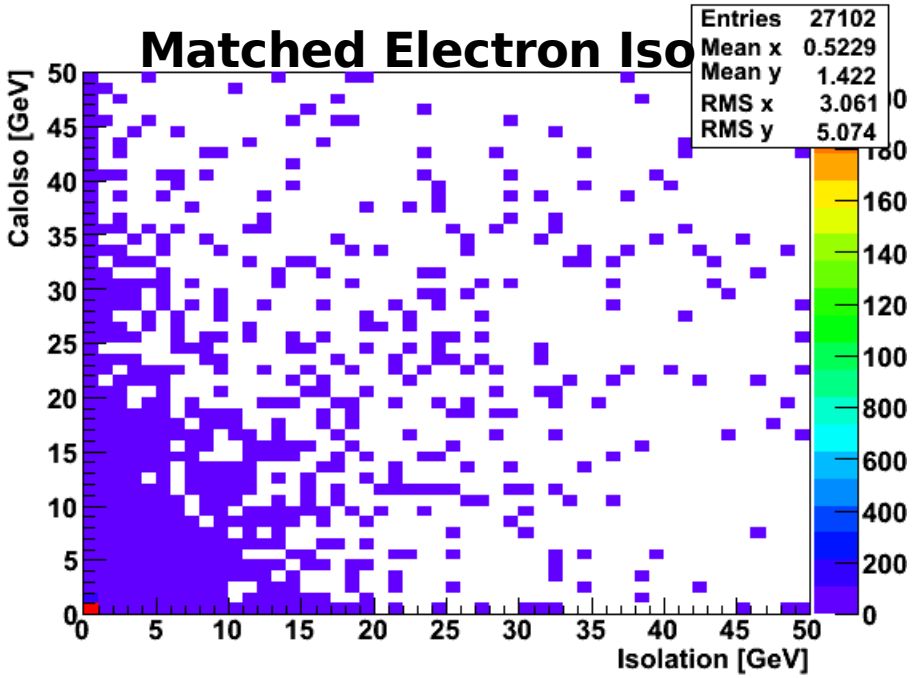


- Cuts:
  - Tracker Isolation < 1 GeV;
  - $E_{shared}/E_{jet} < 0.7$
- Reconstruction efficiency*:
  No. of matched / No. of generated**
  - Drops after cross-cleaning due to cut on isolation
- Contamination*:
  No. of unmatched / No. of reconstructed
  - Becomes significantly smaller

(* numbers depend on electron ID, matching efficiency, ...)

(** generated electrons include only those from the hard process)

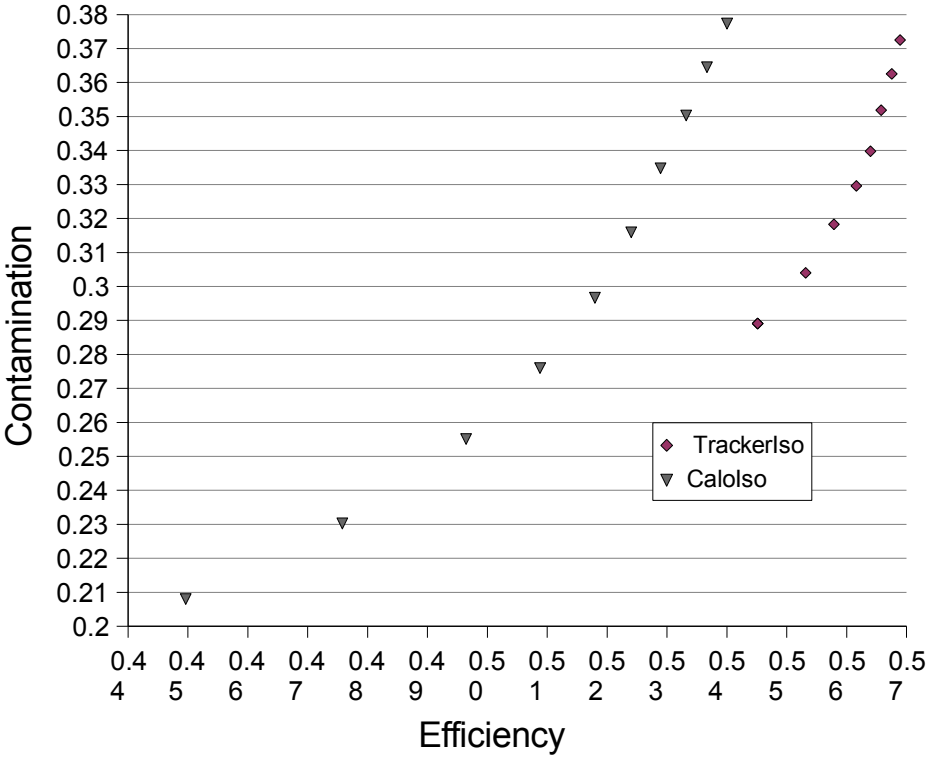
Effect of Isolation Method



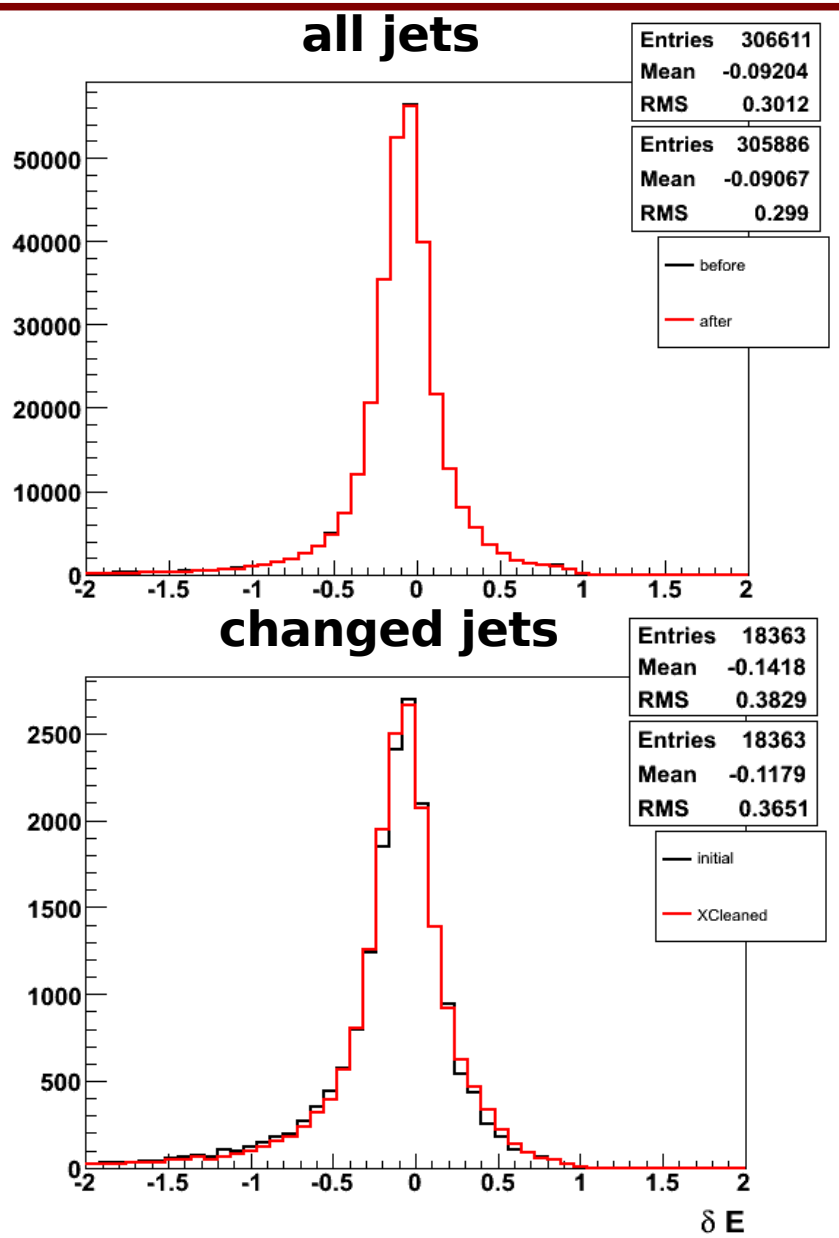
- Tracker isolation gives better efficiency to contamination
- Calo isolation yields lower absolut contamination (more electrons are dropped)

- Isolation more pronounced in tracker than in calorimeter

Variation of isolation cut (0.5-5. GeV):

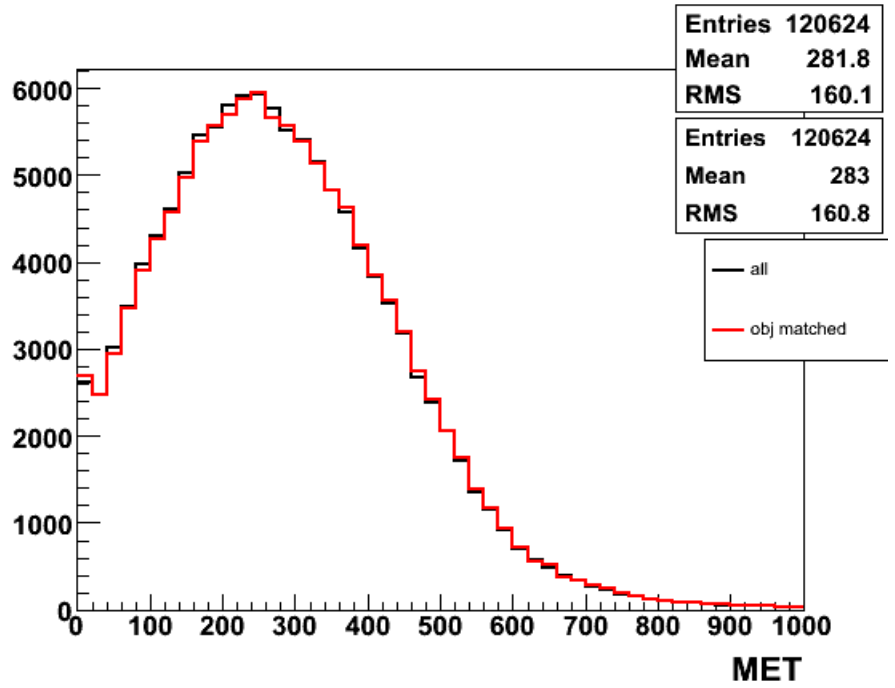


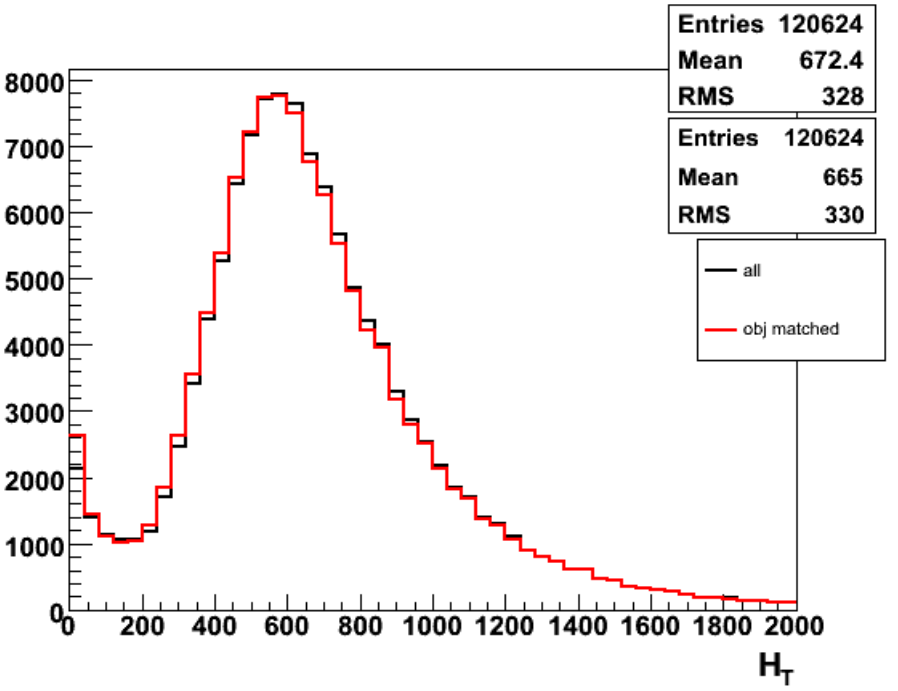
Effect on Jets



- Number of dropped jets <1% (Efficiency and Contamination stay basically the same)
- Only small number of jets modified
- Jet resolution defined on matching to partons: $\delta E=(E_{parton}-E_{jet})/E_{parton}$
  - unsignificant change in mean and width for all jets
  - tiny improvement for altered jets
  - resolution basically unaffected

Effect on MET





- Jet corrections of changed jets have small impact on missing E_T
- No significant effect

- H_T becomes smaller due to dropped jets
- Not a large effect

Summary

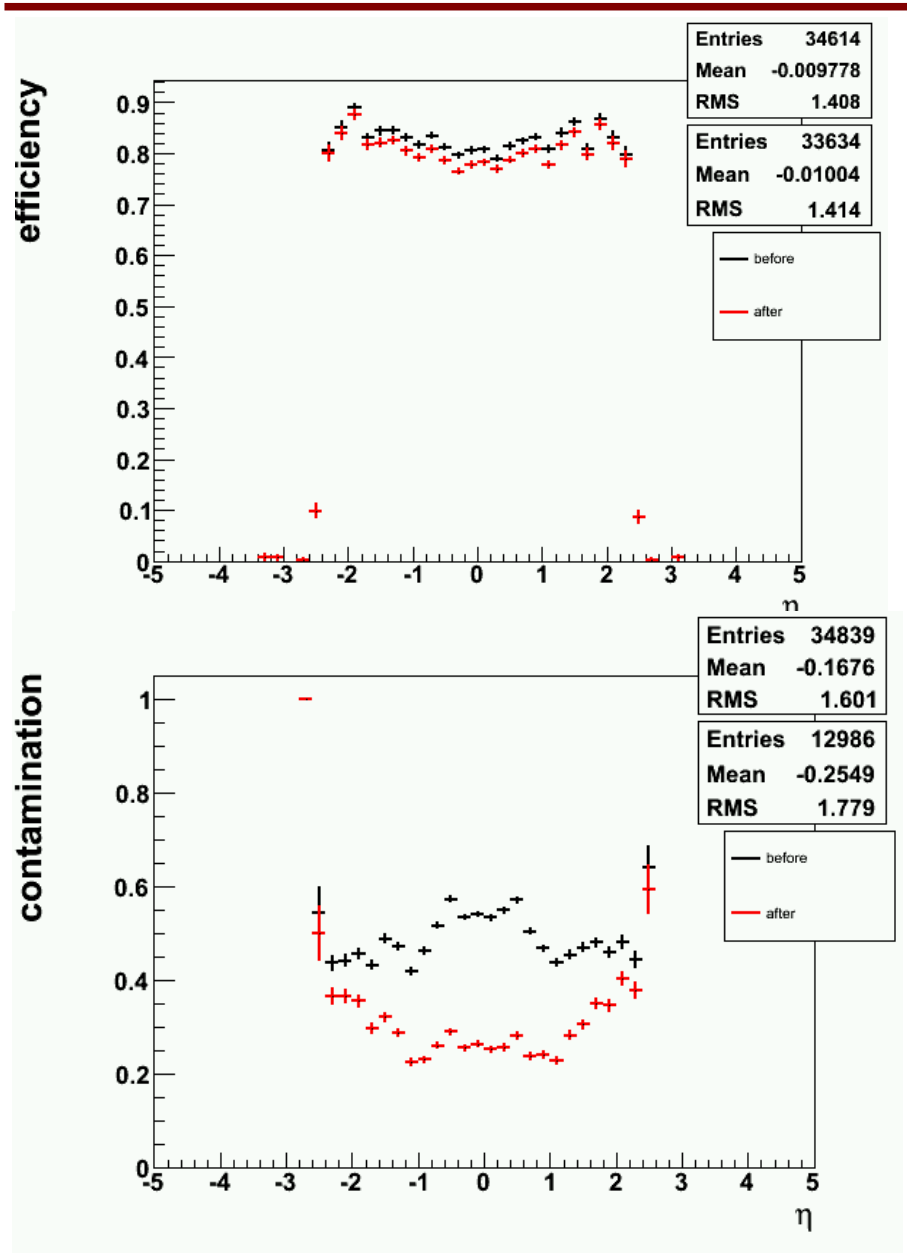
- SUSY searches with leptons+jets+MET require cleaning across object collections
- Package for cross-cleaning with PAT available
- Electron-Jet cleaning validation shows:
  - decrease of electron contamination while keeping good efficiency
  - better performance for tracker than for calo isolation
  - very small effects on jet reconstruction
  - very small effect on MET through jet corrections

Plans

- Define efficiency on Z-sample (tag&probe)
- Understand effect of muon-jet cleaning
- Validate photon-jet cross-cleaning
- Study isolated electrons with low E_{shared}/E_{jet} in order to improve selection.
- Study alternatives for electron-jet cleaning
- Idea: run jet algorithm after electron selection and exclude towers matching electrons
- Internal Note in preparation

BACKUP SLIDES

Effect on Muons

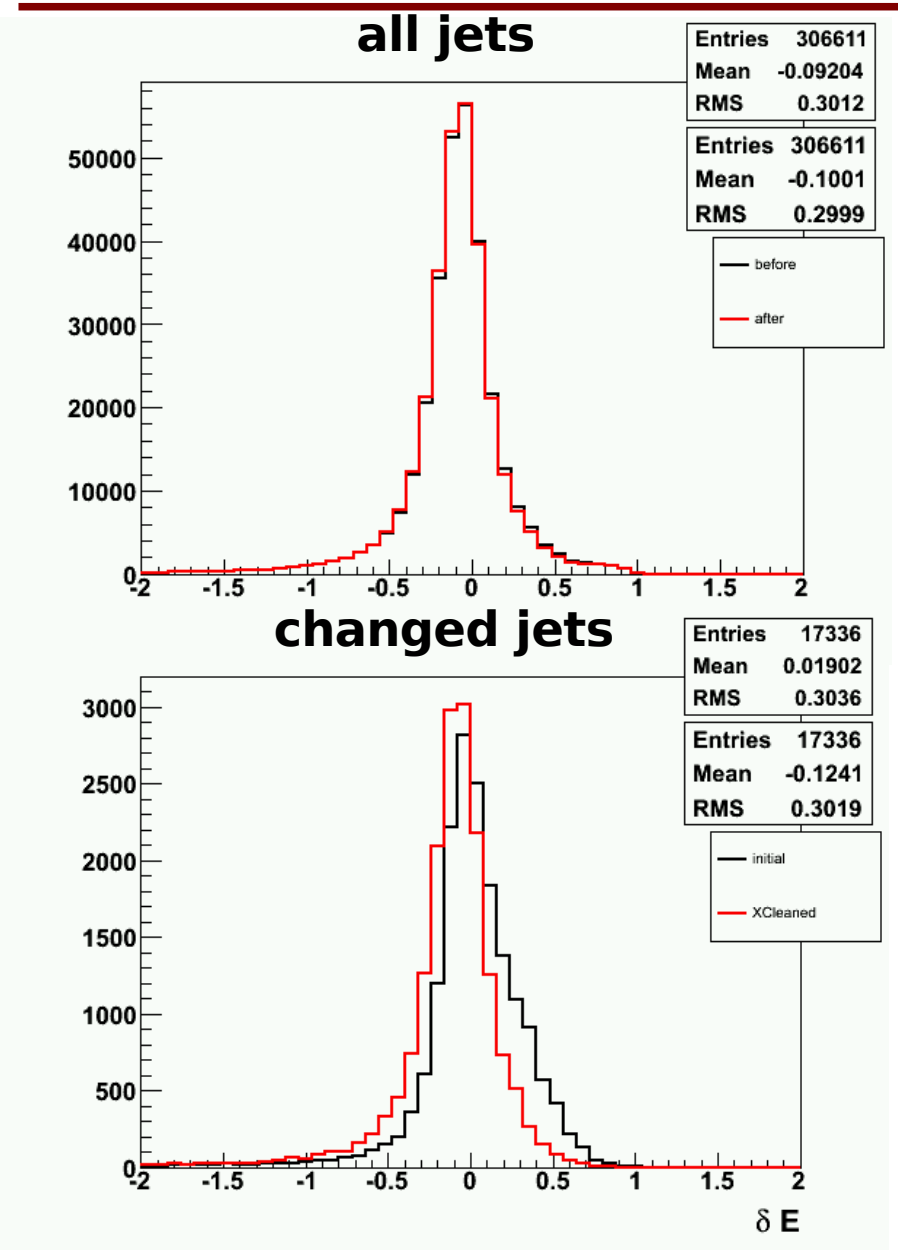


- Cuts:
  - Tracker Isolation > 10 GeV;
  - Calo Isolation > 10 GeV
- Reconstruction efficiency*:
  No. of matched / No. of generated**
  - Still very high afterwards
- Contamination*:
  No. of unmatched / No. of reconstructed
  - Becomes significantly smaller

(* numbers depend on electron ID, matching efficiency, ...)

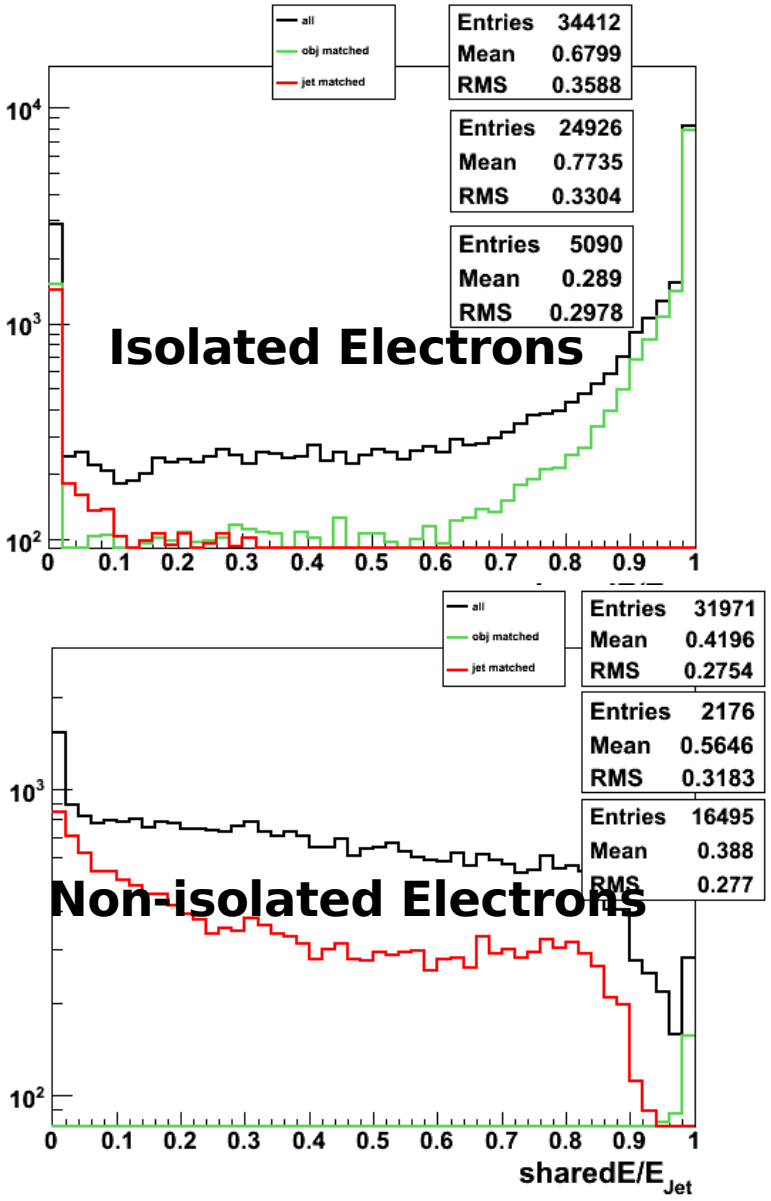
(** generated electrons include only those from the hard process)

Muons: Effect on Jets



- Only small number of jets modified
- Jet resolution defined on matching to partons: $\delta E=(E_{parton}-E_{jet})/E_{parton}$
  - unsignificant change in mean and width for all jets
  - altered jets show shift in resolution
    - negative mean → overcorrection?
    - check on heavy flavour jets only

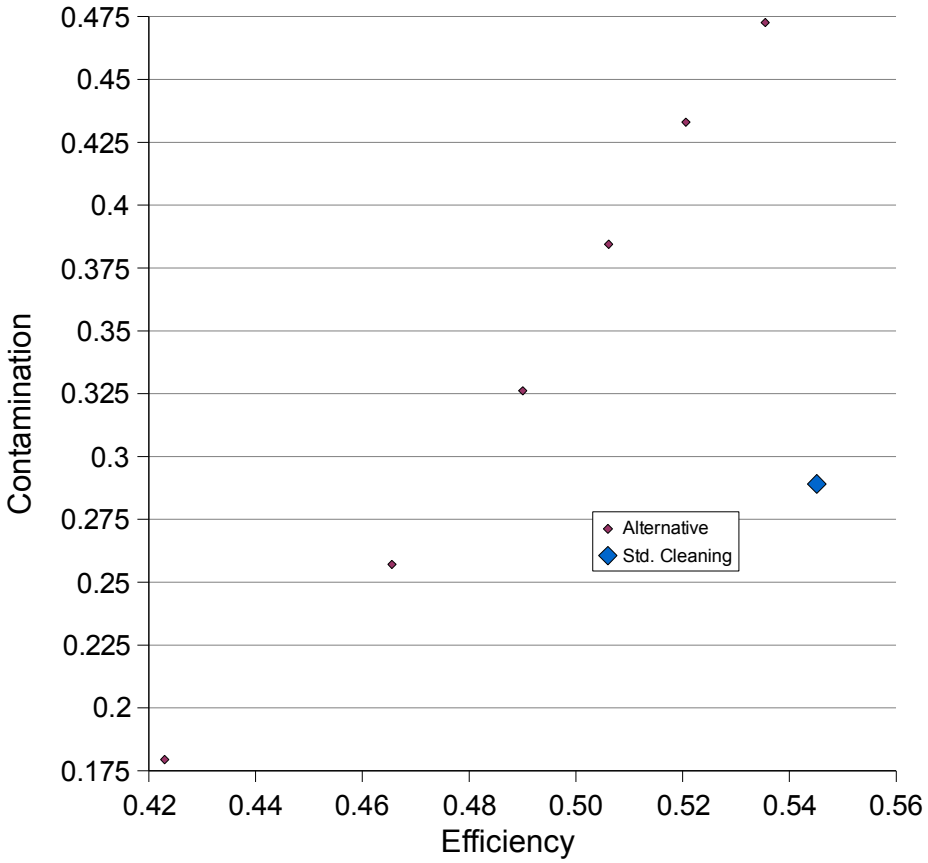
Alternative Cleaning



- E_{shared}/E_{jet} has the same feature for isolated and non-isolated electrons
  - Conflicts with matched electron peak at one (those at zero aren't further considered in the cleaning)
  - Conflicts with matched jet have smaller values
- Try cleaning without using isolation
  - Drop jet for $E_{shared}/E_{jet} > X$
  - Drop electron for $E_{shared}/E_{jet} < X$

Cleaning Comparison

Variation of E_{shared}/E_{jet} cut



- Variation has no effect for standard cleaning as expected
- Alternative cleaning has
  - Higher contamination for same efficiency
  - Lower Efficiency for same contamination
  - Reaches very low absolut contamination
- Study modifications to get optimal result