Cross-cleaning in SUSY events

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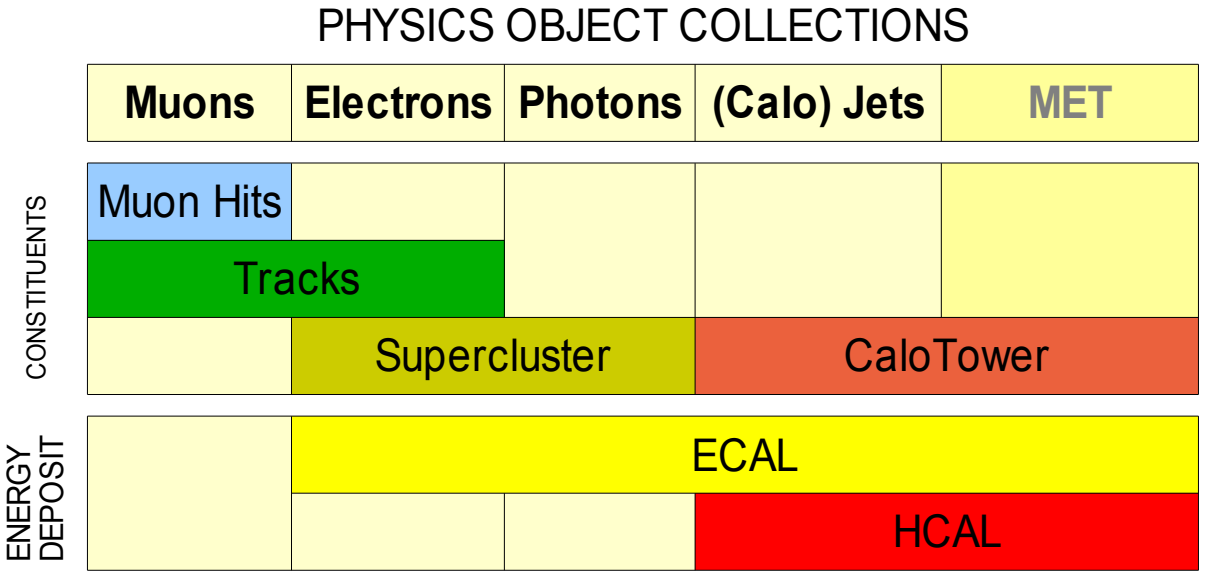
Outline

- Introduction
- Steps of the cross-cleaning
- Details and Validation
  - Electron-jet cleaning
  - Photon-jet cleaning
  - Muon-jet cleaning
- Summary
- Links to documentation

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 not unambiguous – objects 'share' energy

Introduction

- Avoid double counting of energy
- Find cases of object overlaps
- Resolve the conflicts
- Set up a cross-cleaning package for PAT Layer 1 collections

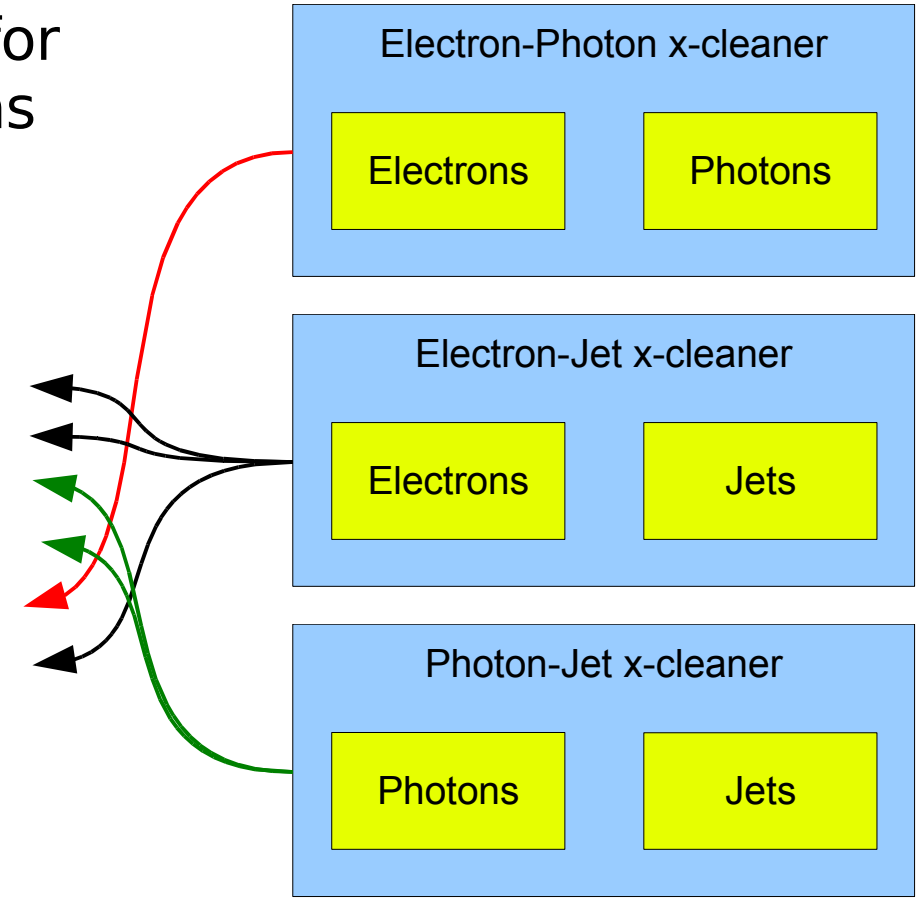
- Possible ambiguities (before object identification/cleaning):
  1. Each supercluster makes a photon and electrons are a subset of those ⇒ each electron is also a photon
  2. High energy electron/photon make a jet
  3. Jet EM energy is reconstructed as an electron/photon
  4. (Muon and electron share the track/hits)
  5. Muons/electrons/photons produced inside a jet (isolation issue)

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

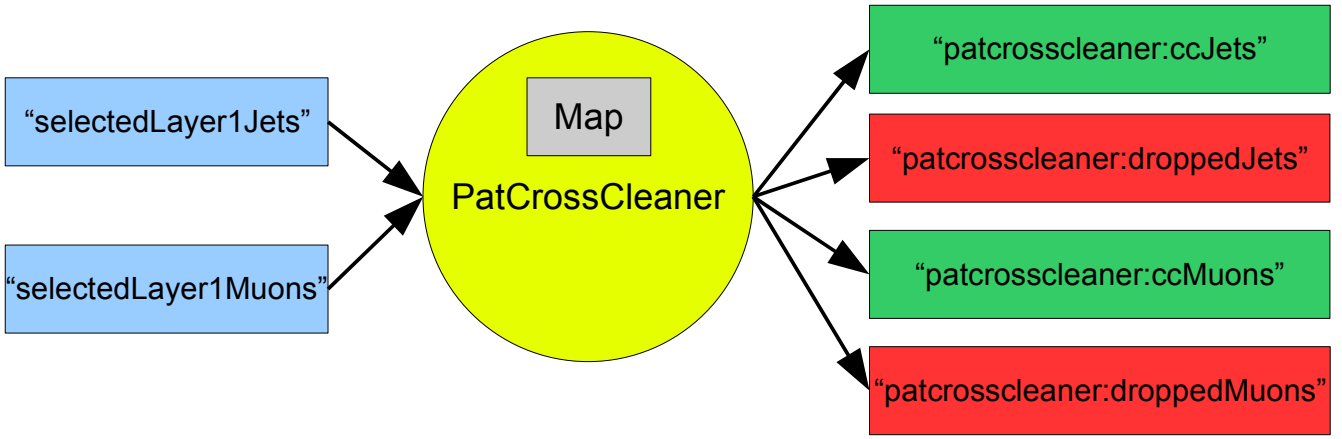


   - Takes care of interferences
     (a removed object does not modify another one)

- Also available: muon-jet cleaning
- Can be turned on/off as desired

X-cleaning Steps II

2. Create clean collections using this map
   - Loop over input collections
   - Modify each object 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
   - Create new MET collection with updated jet corrections



Electron-Jet Cleaning

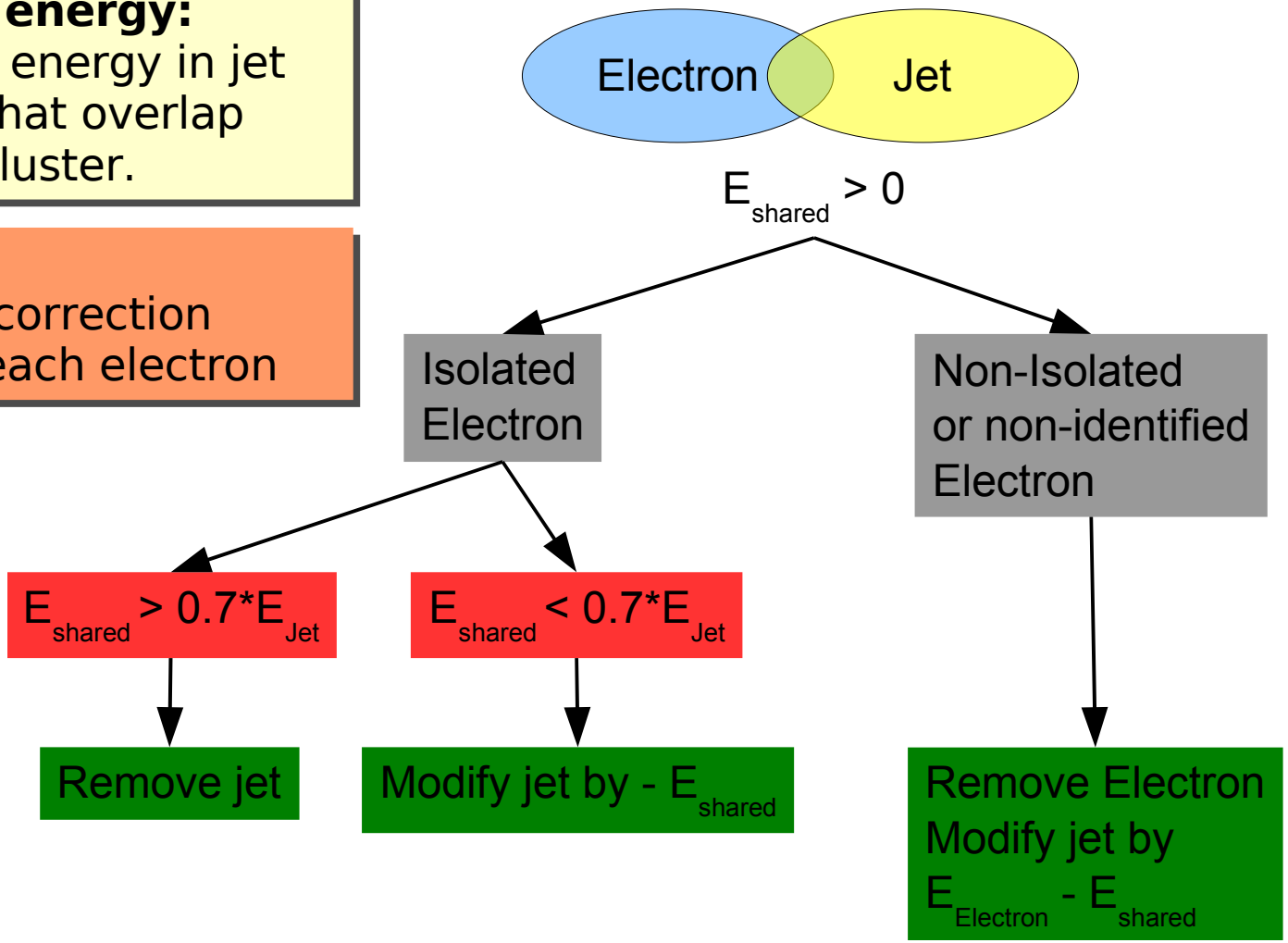
- Along the lines of 'SusyAnalyzer' cleaning

Calculation of shared energy:
Sum of electromagnetic energy in jet calotower constituents that overlap with the electron supercluster.

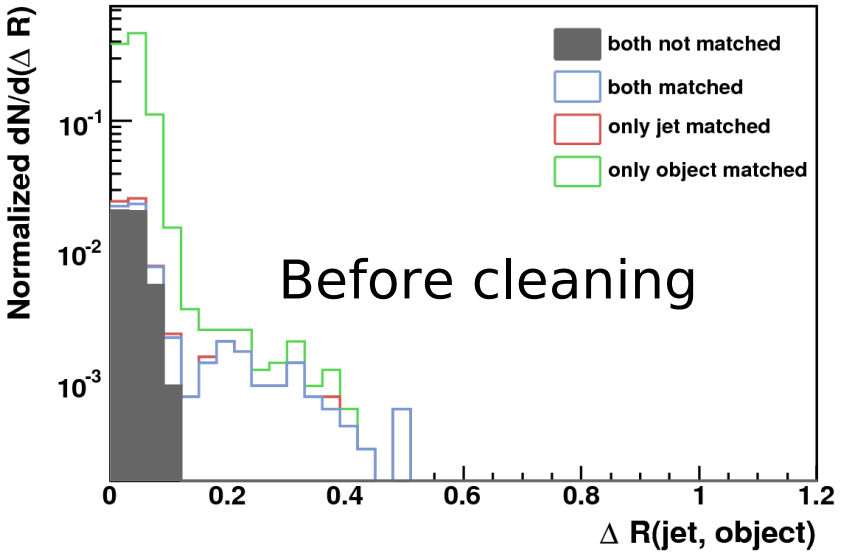
- Check of electron ID
- Vectorial addition and correction
- Check up to 3 jets for each electron

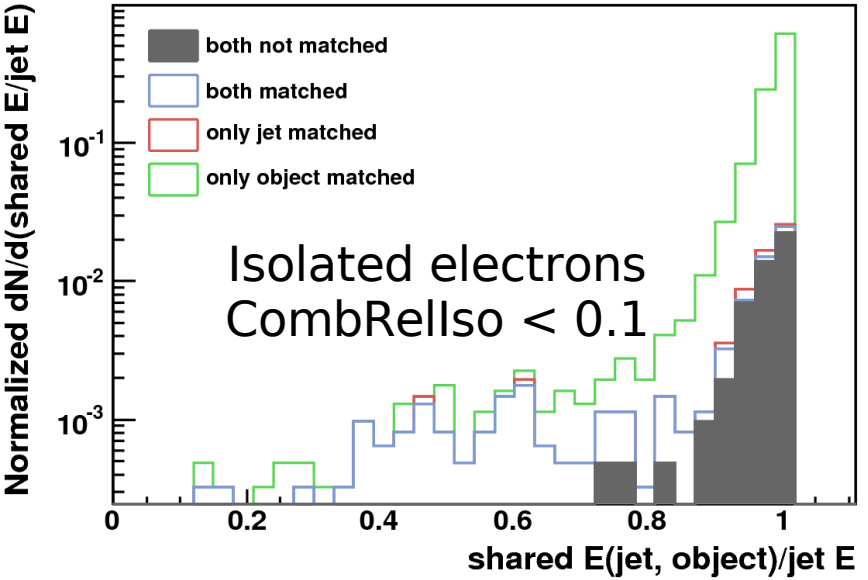
Use combined relative isolation:

(EcalIso+HCalIso+ TrackerIso)/p_T

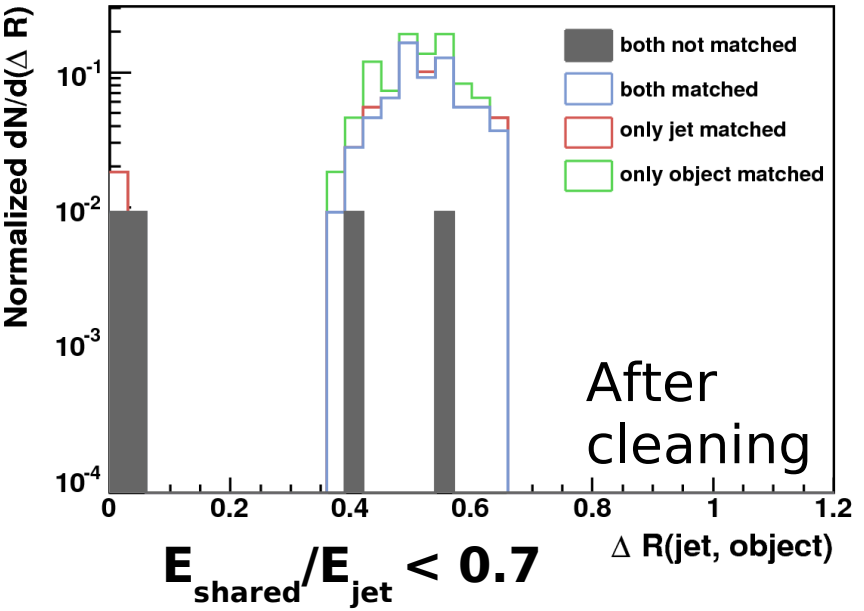


Test Electron-Jet Cleaning



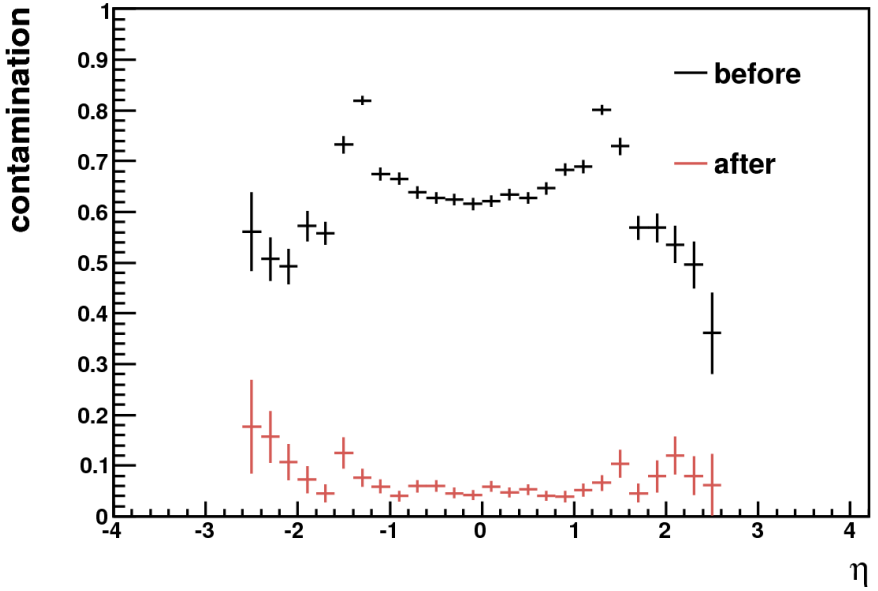


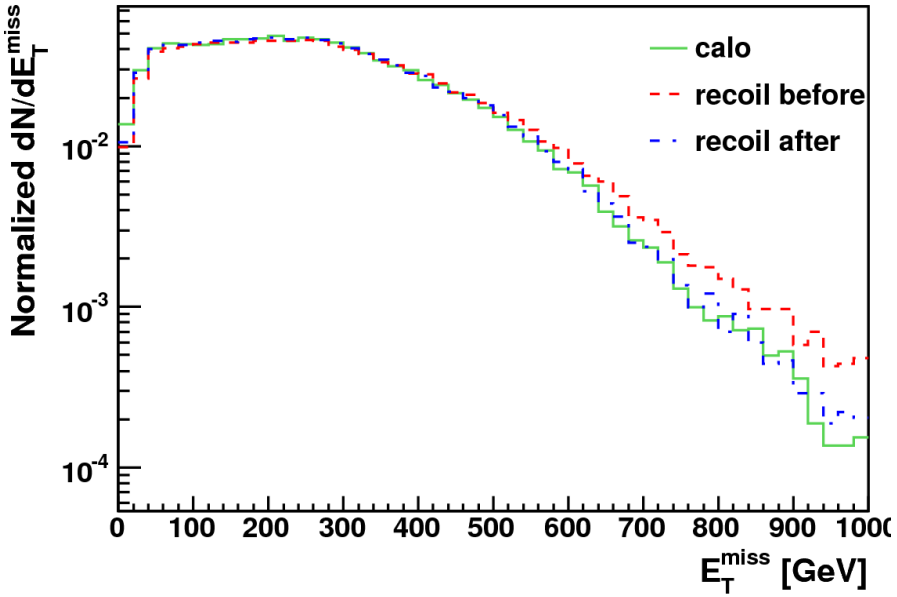
- Many electron-jet pairs with small ΔR in SUSY sample
- For matched electrons E_{shared}/E_{jet} is close to one
- Jets and electrons separated in ΔR after the cleaning



LM4 sample, 'eidRobustLoose' electrons with jet overlap

Effect of Electron-Jet Cleaning





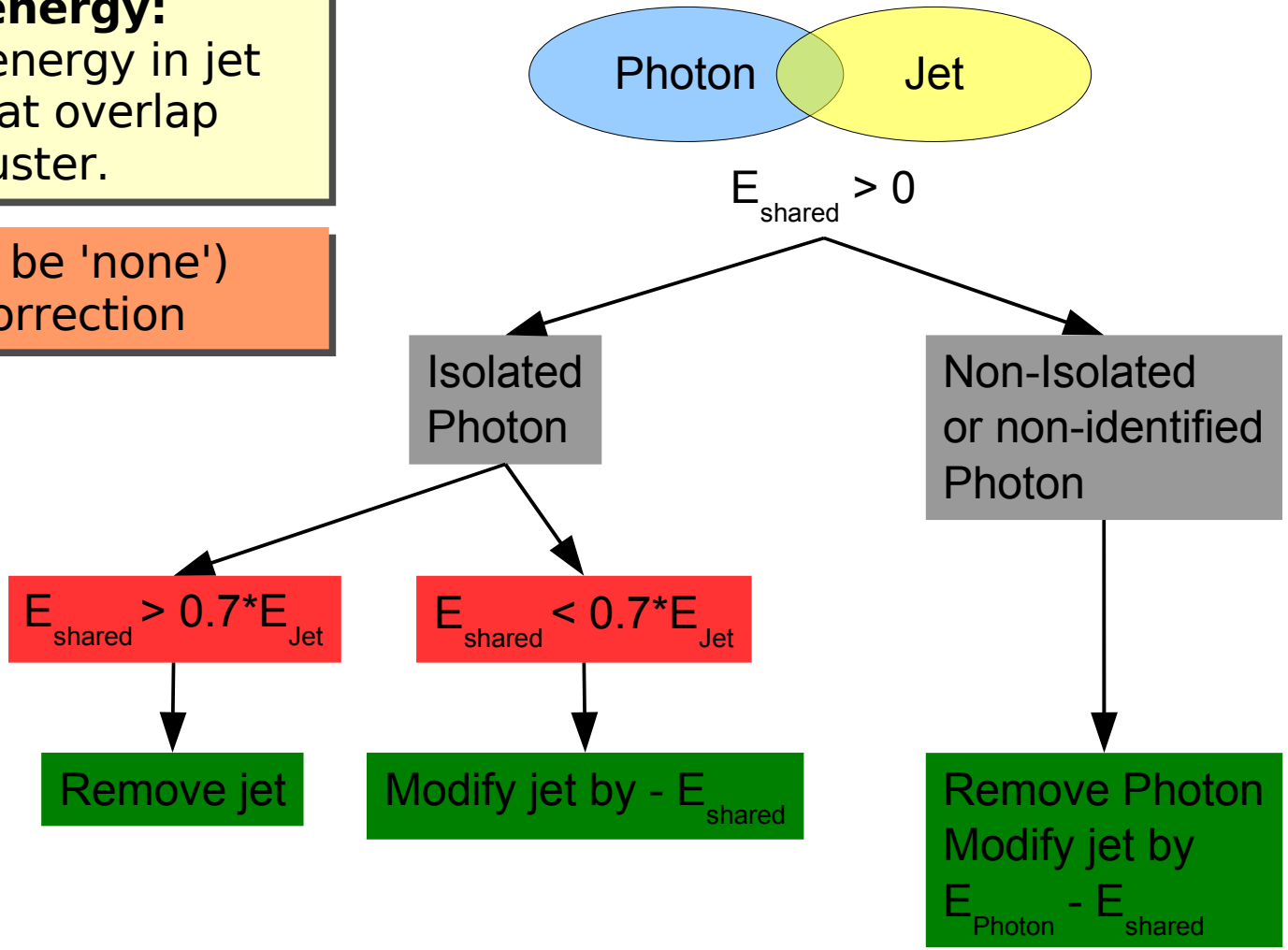
- Cut on isolation determines final electron efficiency and contamination
- Contamination (aka Impurity, No. of unmatched / No. of reconstr.)
  - Falls to very low level
  - Spikes in pseudorapidity removed
- Only small number of jets modified
- Tail in recoil MET (4-vector sum of all particles) reduced
- Better agreement with Calo MET shape after cleaning

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 electron supercluster.

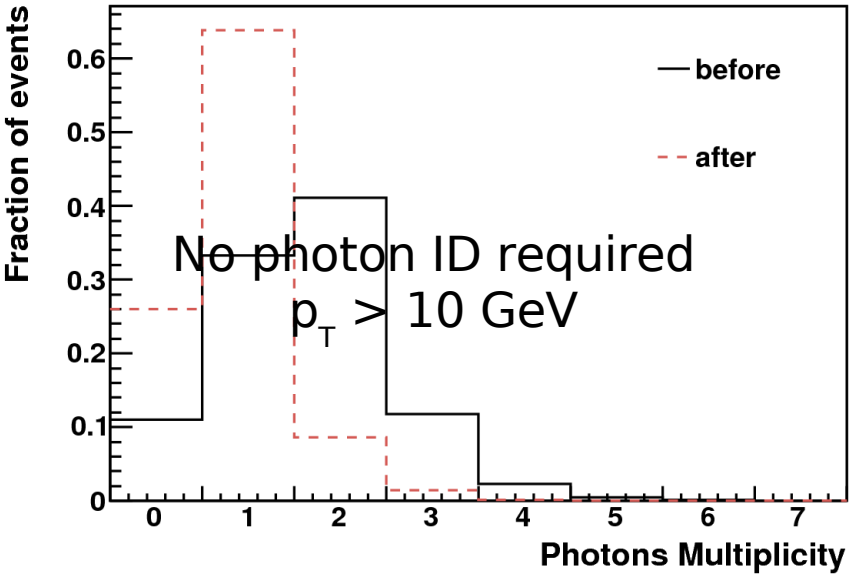
- Check of photon ID (can be 'none')
- Vectorial addition and correction

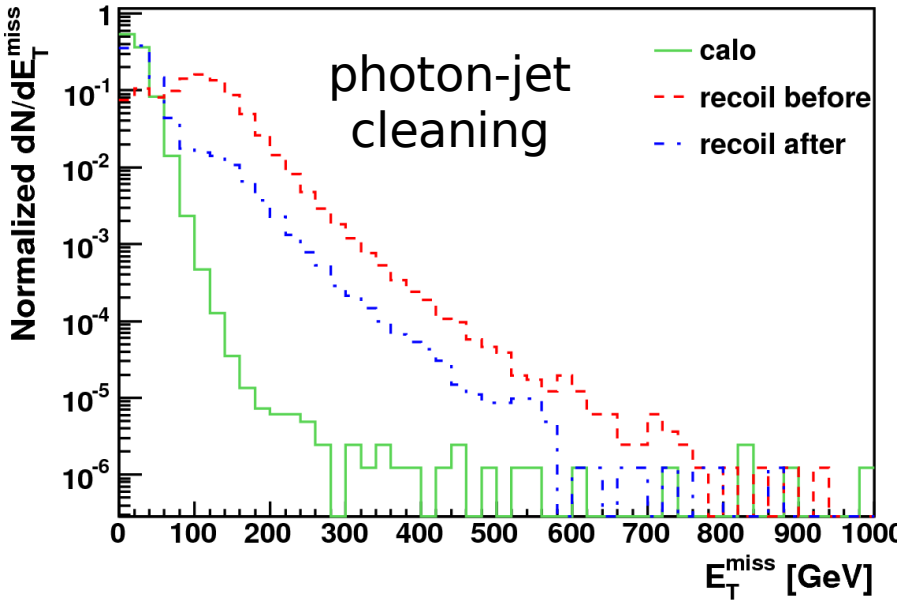


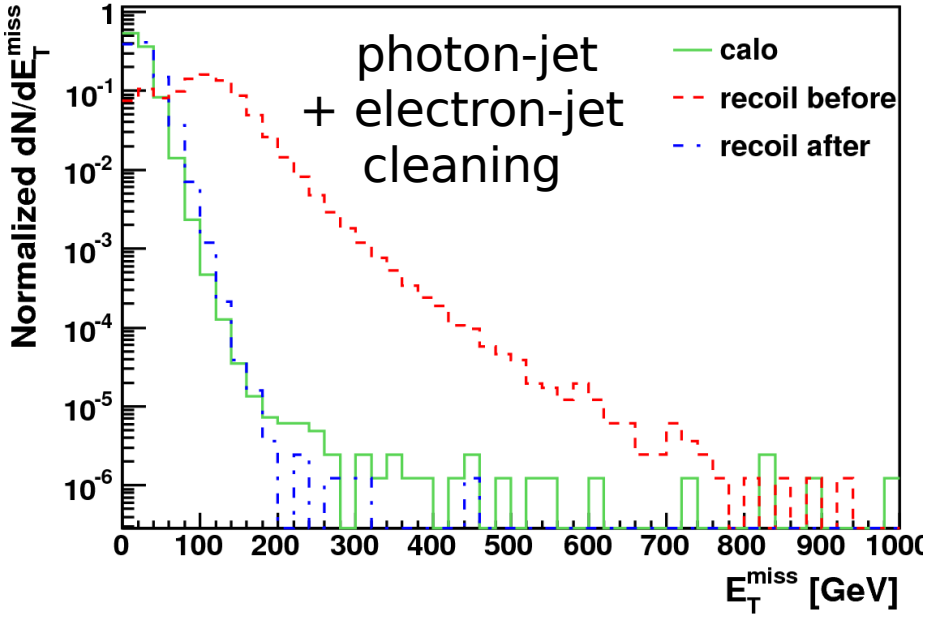
Effect of Photon-Jet Cleaning

γ-Jet events (p_T > 80)

- Peak in recoil MET: double counting of energy
- One photon left in most events after cleaning
- Need additional electron-jet cleaning to remove MET tail

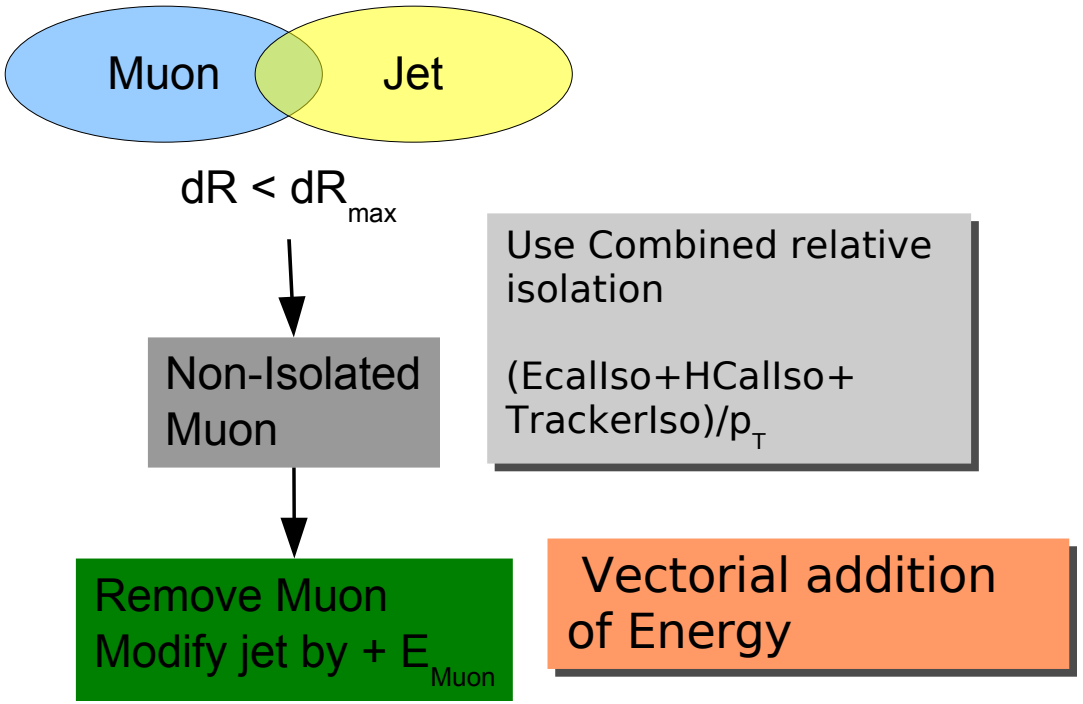




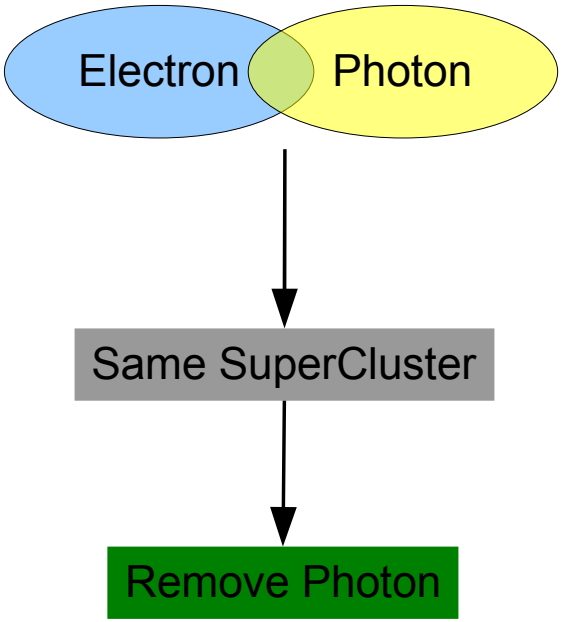


Other Cleaners

- Muon-Jet

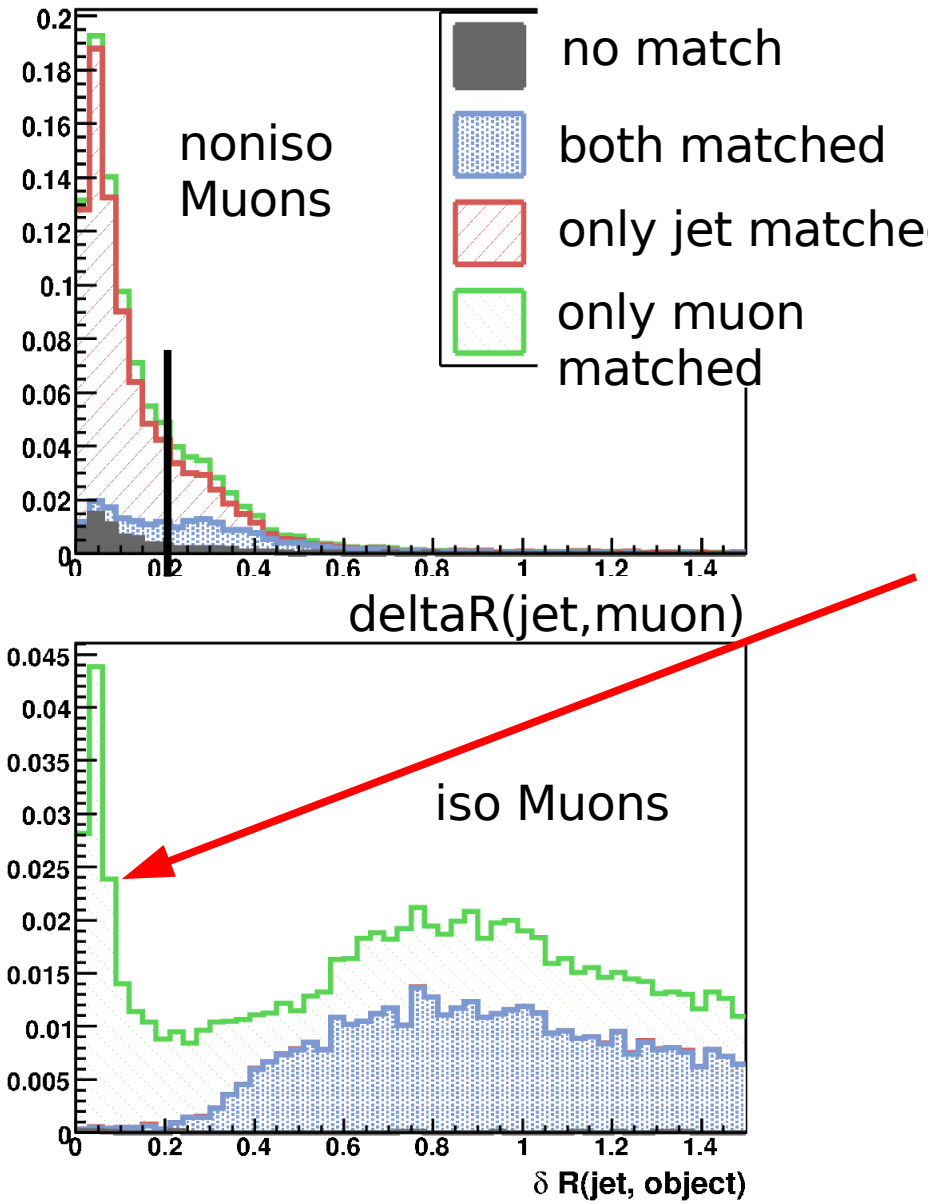


- Electron-Photon



Jet energy handling:
- Cleaners are always using uncorrected Jets
- Jet Corrections are recalculated at the end

Muon-Jet Cleaning



- Non-isolated Muons: in most of the pairs with dR<0.2 jet is the only object matched
- Peak at small dR for ~15% of all isolated muons (in LM4) sample
- ~25% of these muons have a photon from final state radiation in dR<0.3
- ~25% of these muons have other particles in dR<0.3
- Rest is caused by non-hard-process interactions

Summary

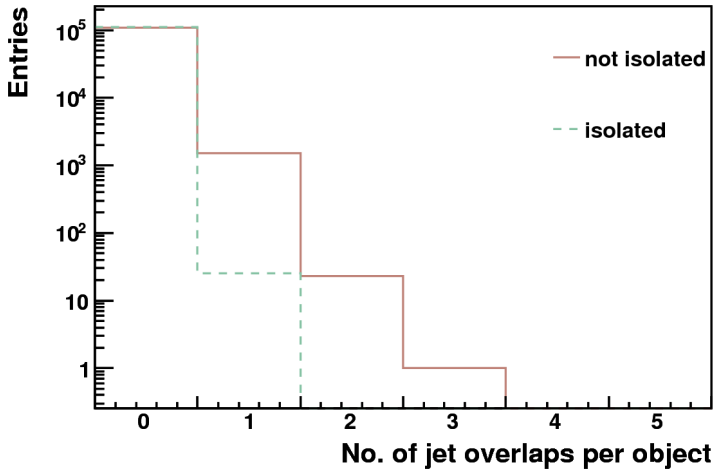
- Overlap among reco objects of different types
- Configurable cross-cleaning module for PAT collections to
  - find these conflicts
  - resolve them
- Cleaning of electron, photon, jet and muon collections
- Complements selection of 'good' objects
- Reduces fake rates
- Improves event energy balance (recoil MET)
- Needs to be tuned for each analysis

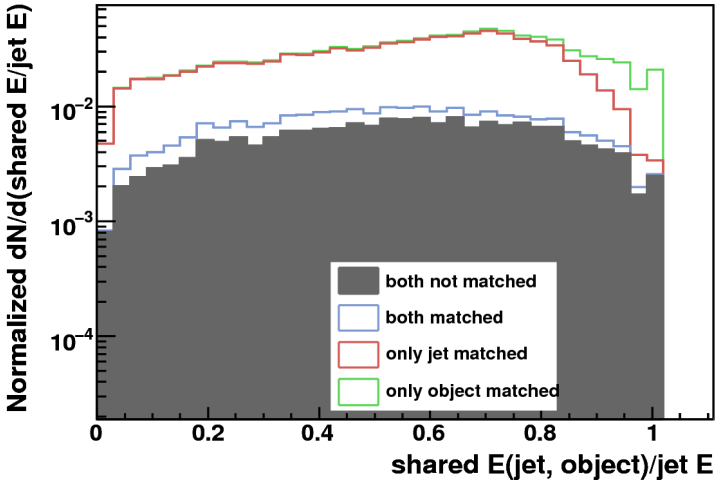
Documentation

- https://twiki.cern.ch/twiki/bin/view/CMS/SusyPatCrossCleaner
  - Description of cleaning procedure
  - Instructions how to use it
  - Details on Configuration
  - How to access cleaned collections
  - Link to doxygen code documentation
- Coming soon
  - Internal Note with details on the package and its validation

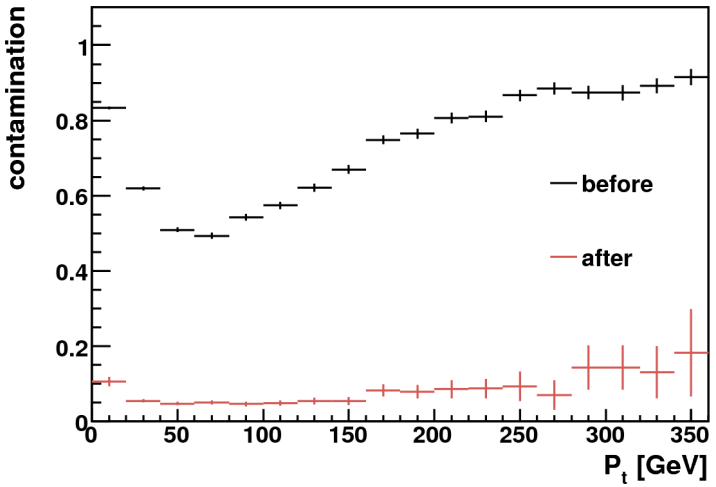
BACKUP SLIDES

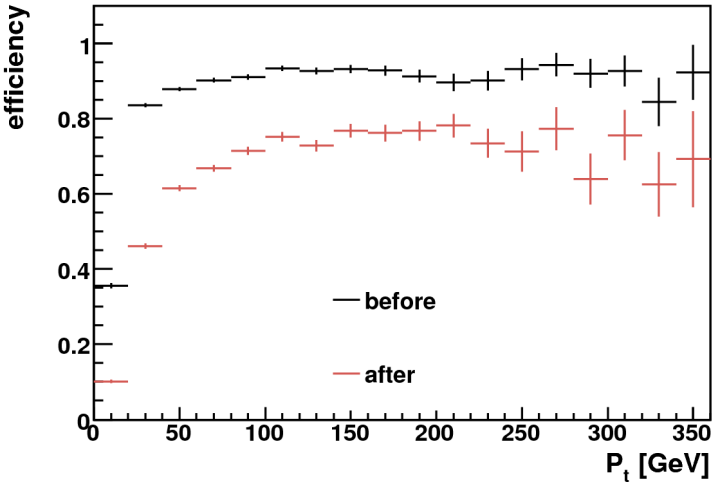
Electron-Jet Cleaning



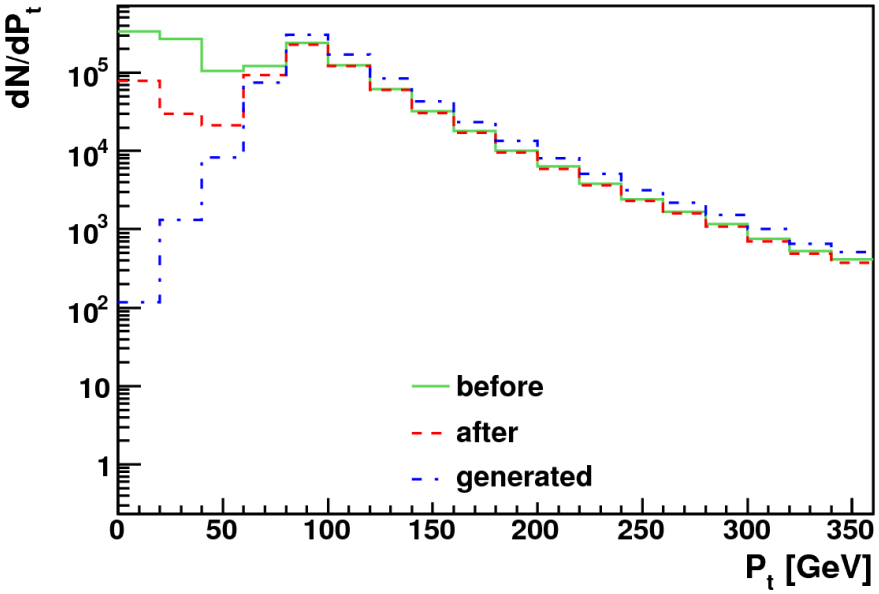


Non-isolated electrons





Photon-Jet Cleaning



Muon-Jet Cleaning