

Cross-cleaning in SUSY events

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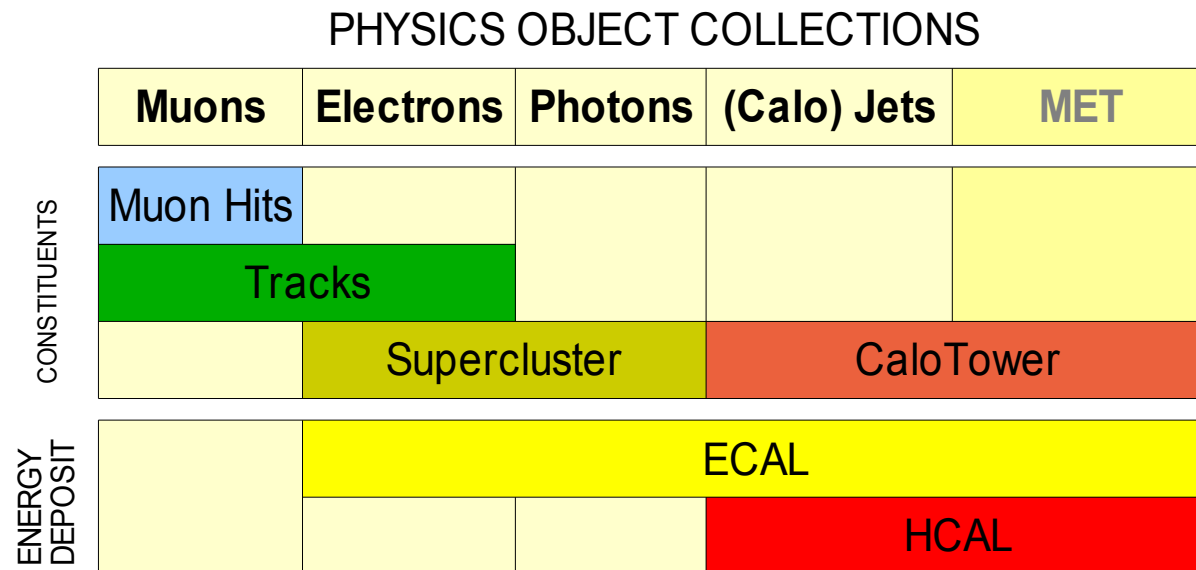
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Outline

- 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 $\Rightarrow$ each **electron** is also a **photon**
 2. High energy **electron/photon** makes a **jet**
 3. **Jet** EM energy is reconstructed as an **electron/photon**
 4. **Muons/electrons/photons** produced inside a **jet** (isolation issue)

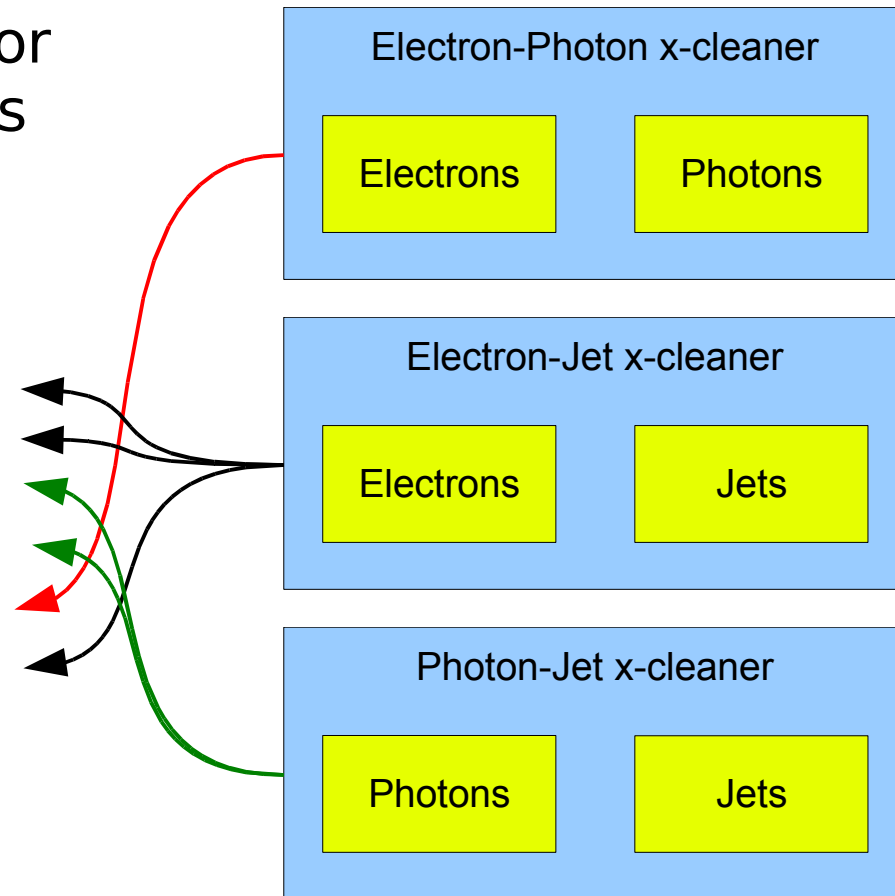
X-cleaning Steps I

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



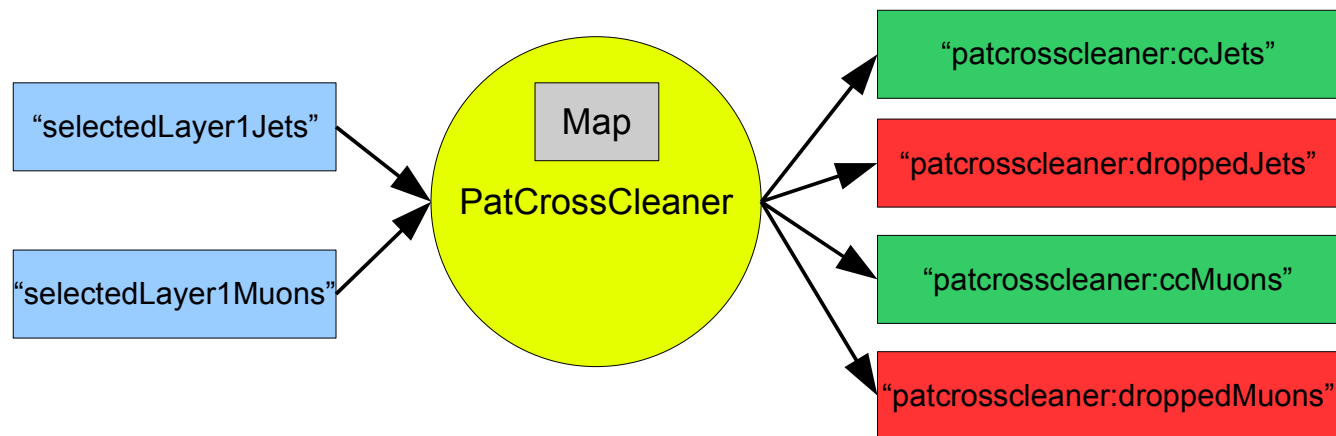
- Takes care of interferences
(a removed object does not modify another one)

- 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

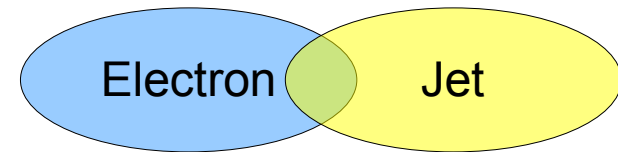
Calculation of shared energy:

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:

$$(E_{\text{callso}} + H_{\text{callso}} + \text{TrackerIso}) / p_T$$



$$E_{\text{shared}} > 0$$

Isolated
Electron

Non-Isolated
or non-identified
Electron

$$E_{\text{shared}} > 0.7 * E_{\text{Jet}}$$

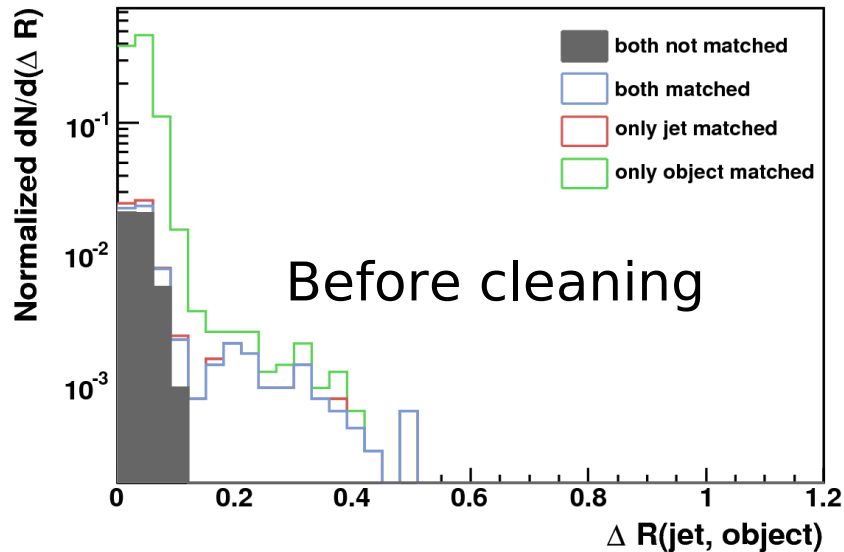
$$E_{\text{shared}} < 0.7 * E_{\text{Jet}}$$

Remove jet

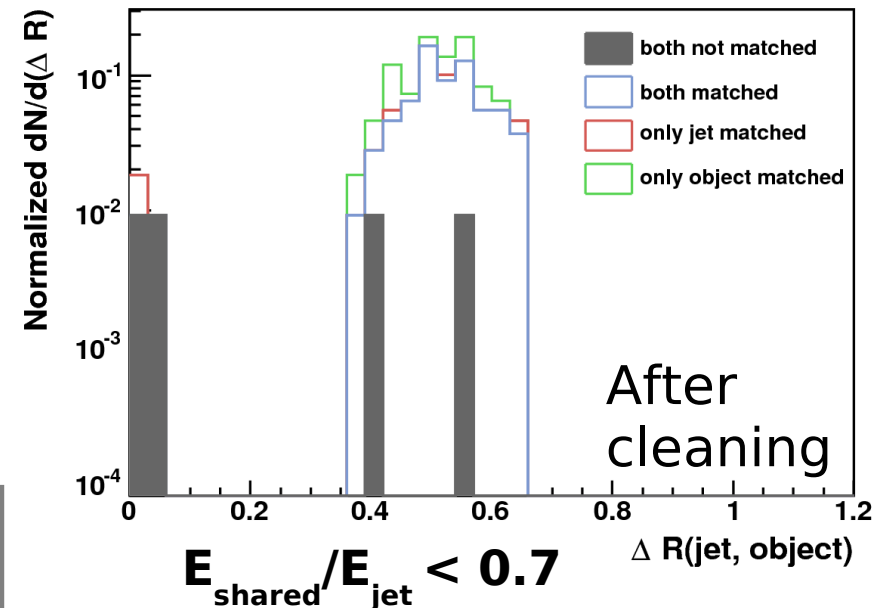
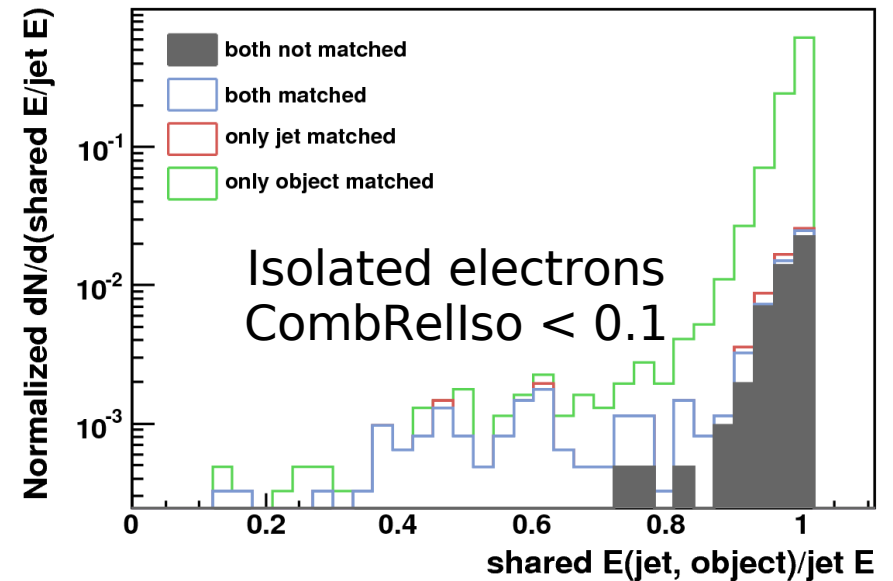
Modify jet by $- E_{\text{shared}}$

Remove Electron
Modify jet by
 $E_{\text{Electron}} - E_{\text{shared}}$

Test Electron-Jet Cleaning

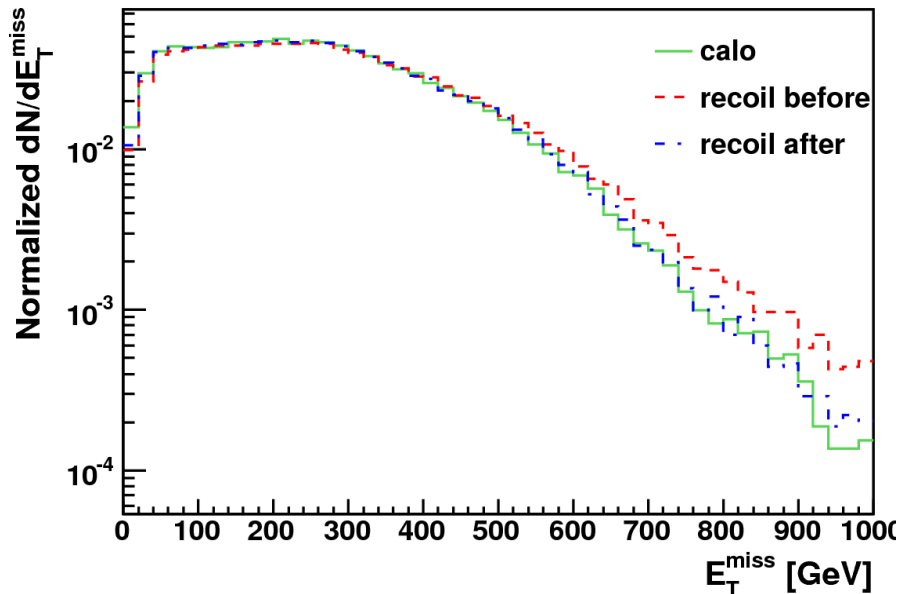
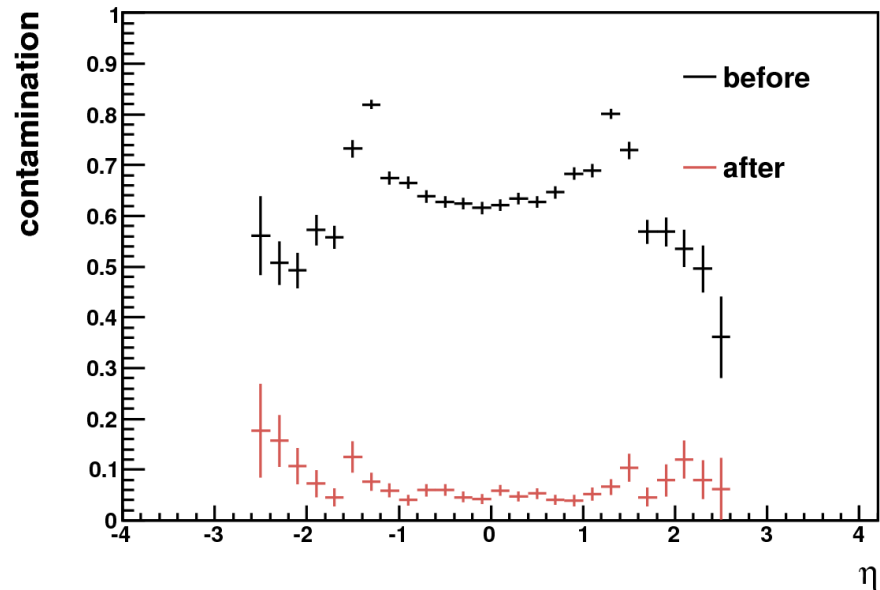


- Many electron-jet pairs with small ΔR in SUSY sample
- For matched electrons $E_{\text{shared}}/E_{\text{jet}}$ is close to one
- Jets and electrons separated in ΔR after the cleaning



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

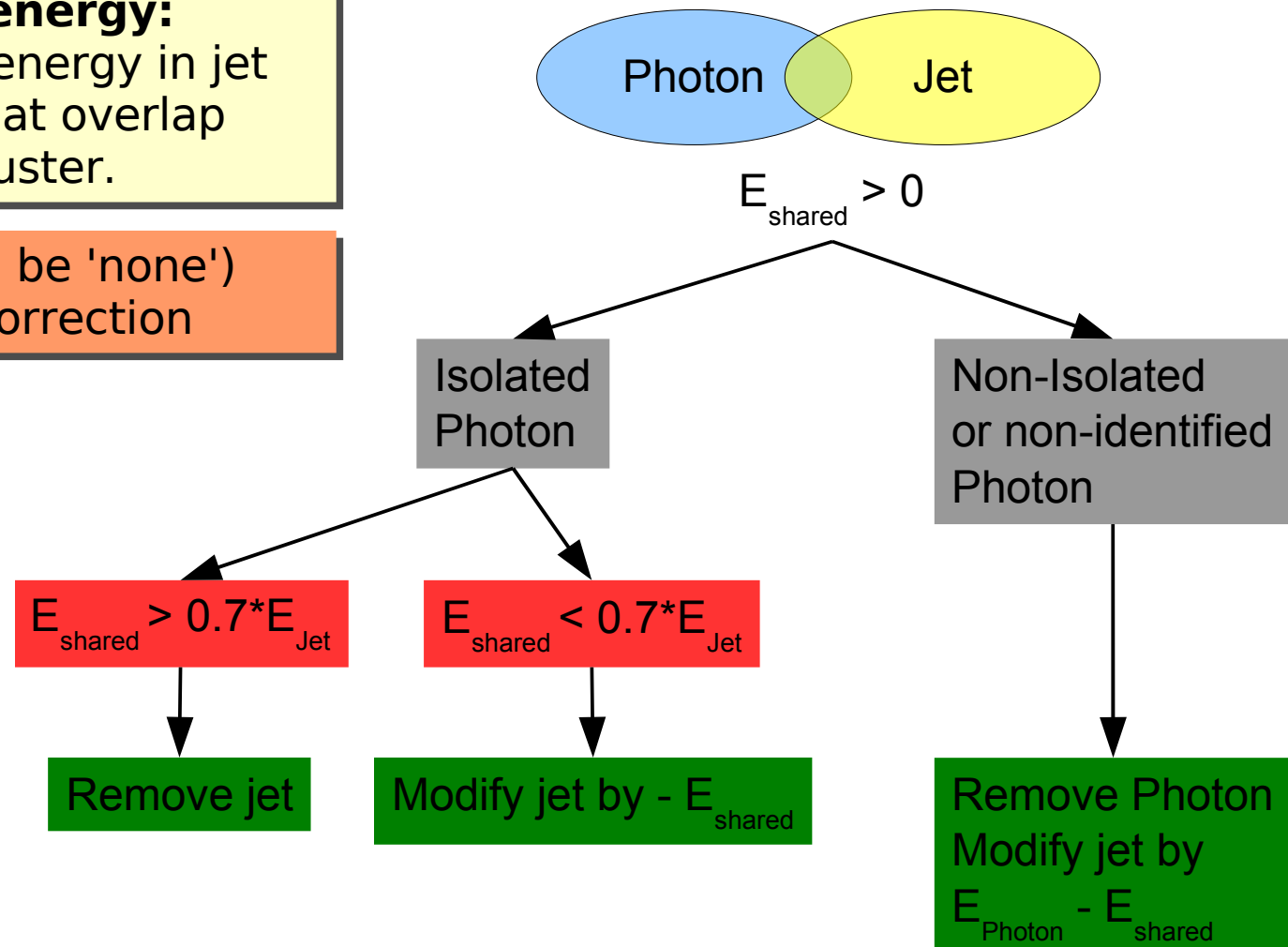
Photon-Jet Cleaning

- Along the lines of 'SusyAnalyzer' cleaning

Calculation of shared energy:

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

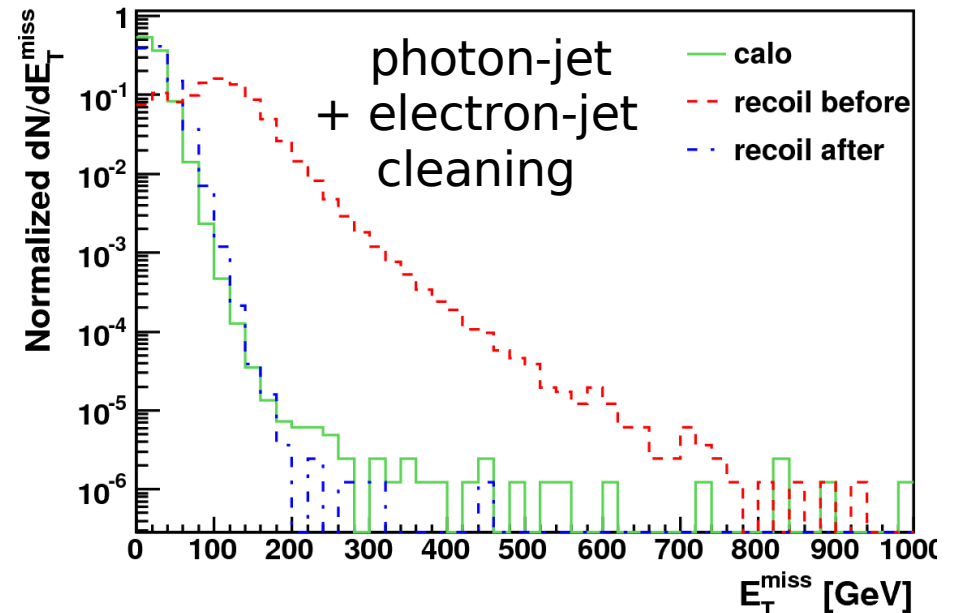
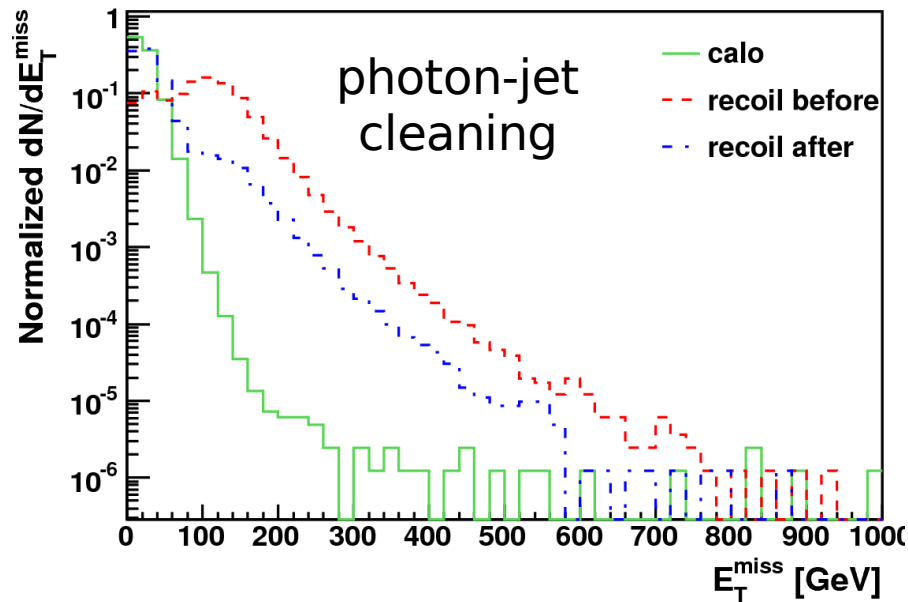
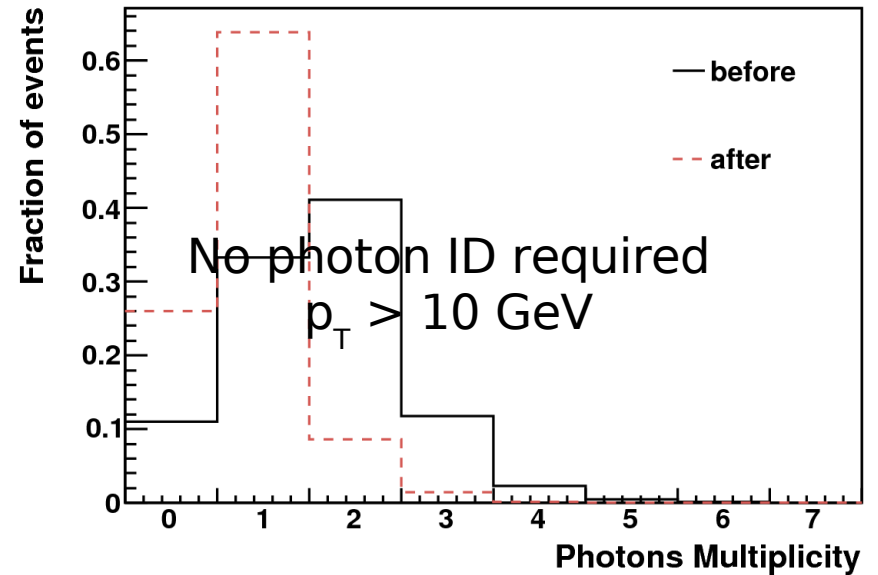
- Check of photon ID (can be 'none')
- Vectorial addition and correction



Effect of Photon-Jet Cleaning

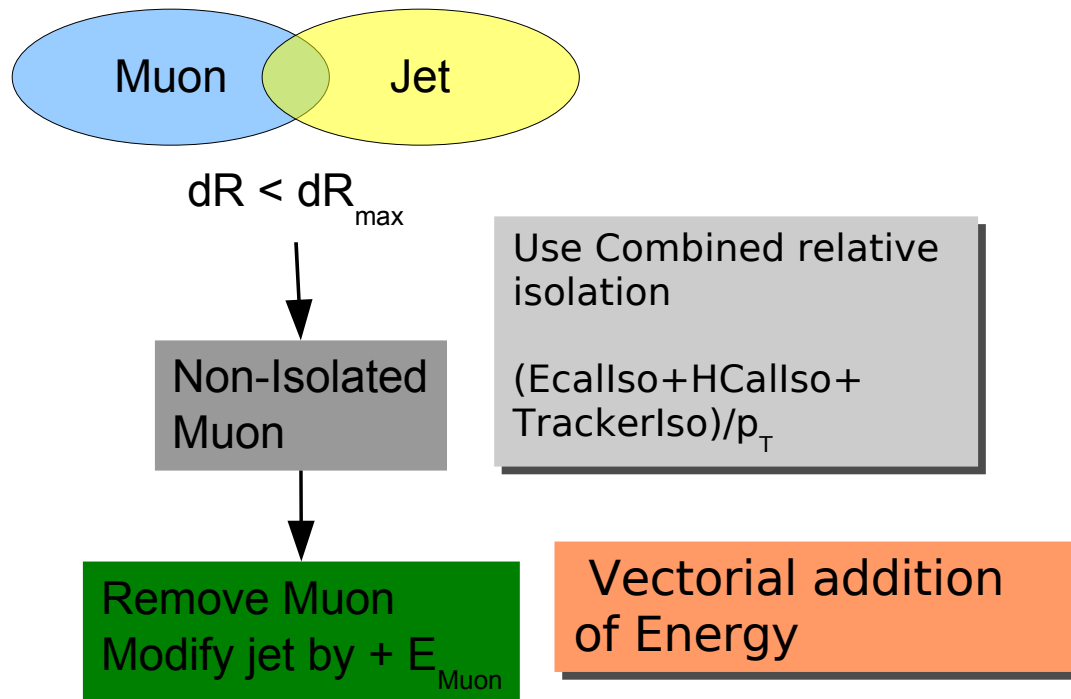
γ -Jet events ($p_T > 80$)

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

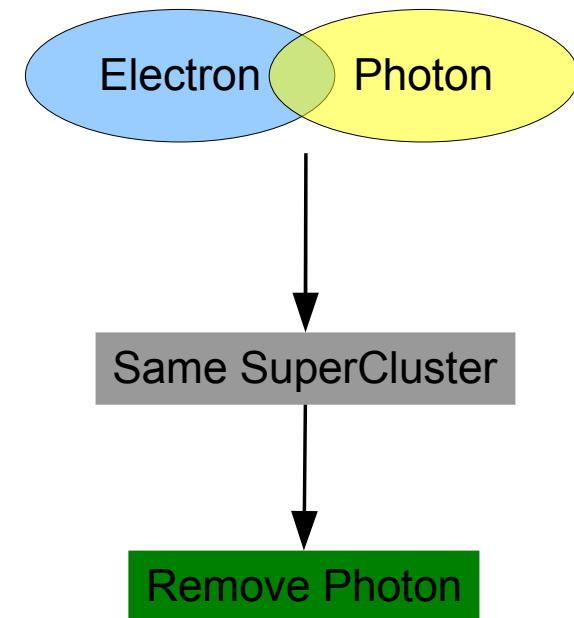


Other Cleaners

- Muon-Jet



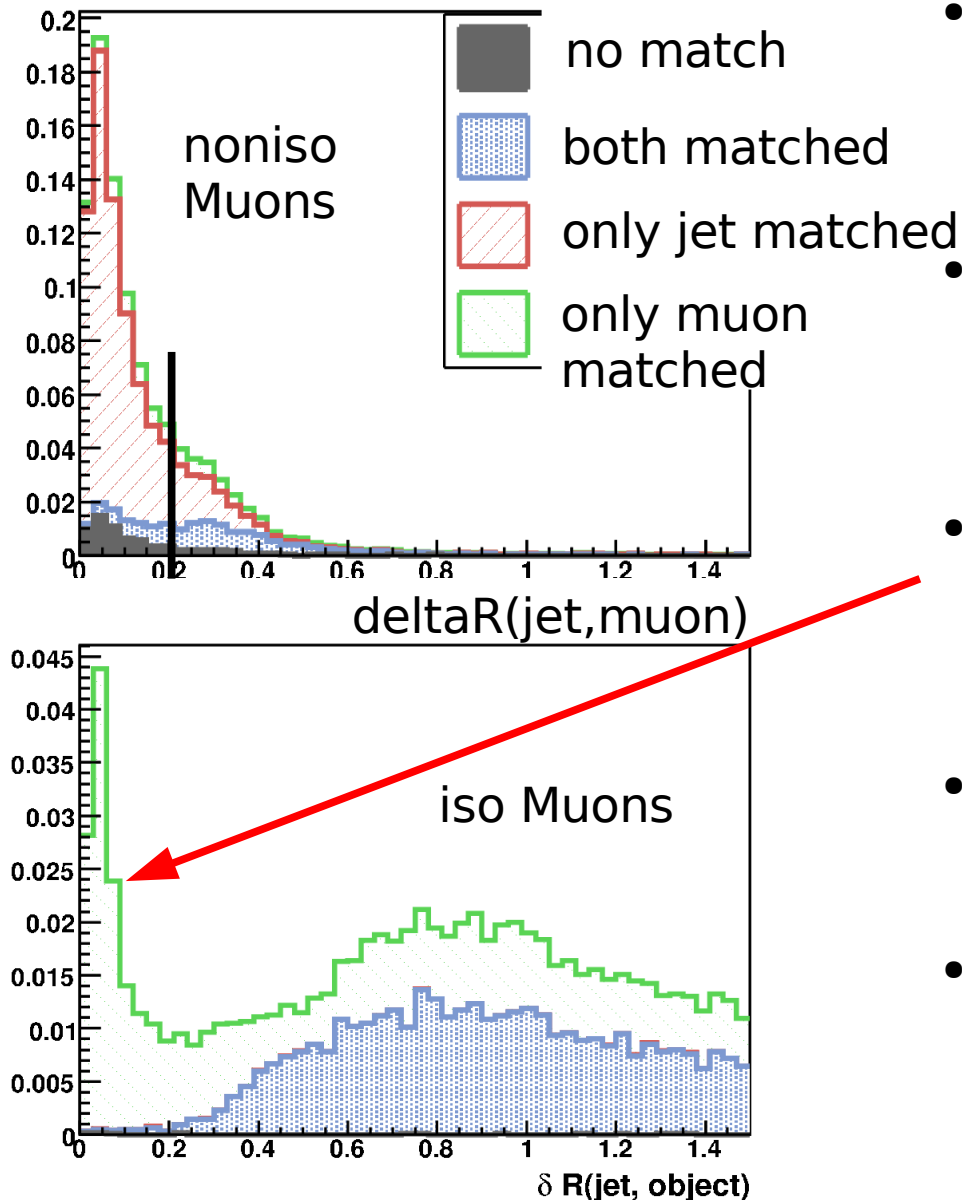
- Electron-Photon



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 $\sim 15\%$ of all isolated muons (in LM4) sample
- $\sim 25\%$ of these muons have a photon from final state radiation in $dR < 0.3$
- $\sim 25\%$ of these muons have other particles in $dR < 0.3$
- Rest is caused by non-hard-process interactions

Summary

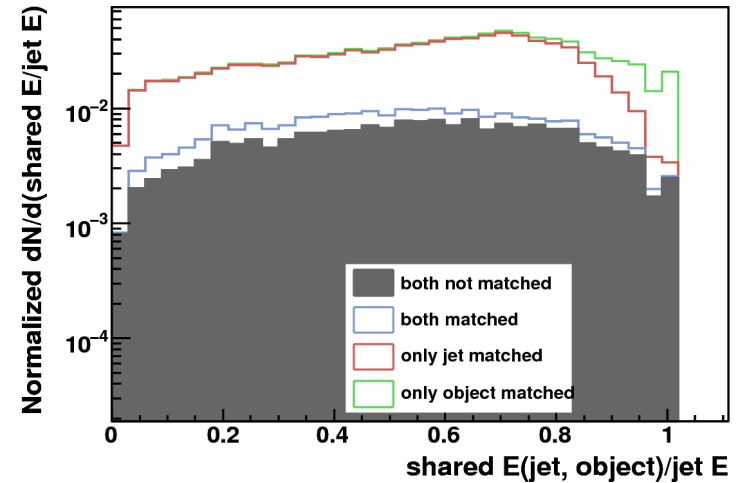
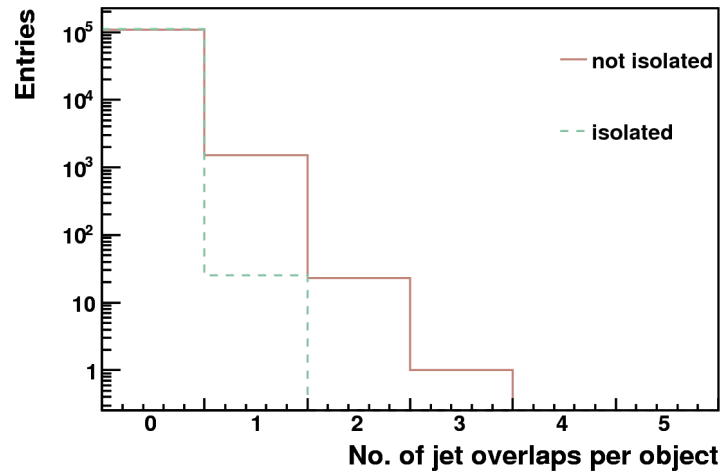
- Overlap among reco objects of different types
- Configurable cross-cleaning module for PAT collections to
 - find these conflicts
 - resolve them
- Cleaning of electron, photon, jet and muon collections
- Complements selection of 'good' objects
- Reduces fake rates
- Improves event energy balance (recoil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

Documentation

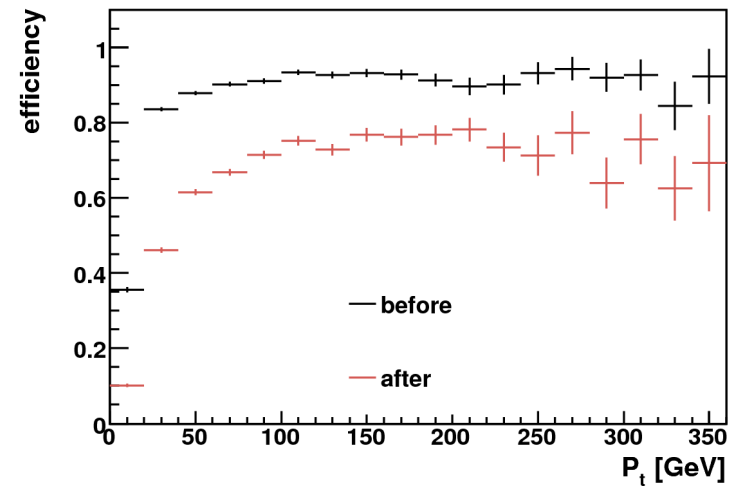
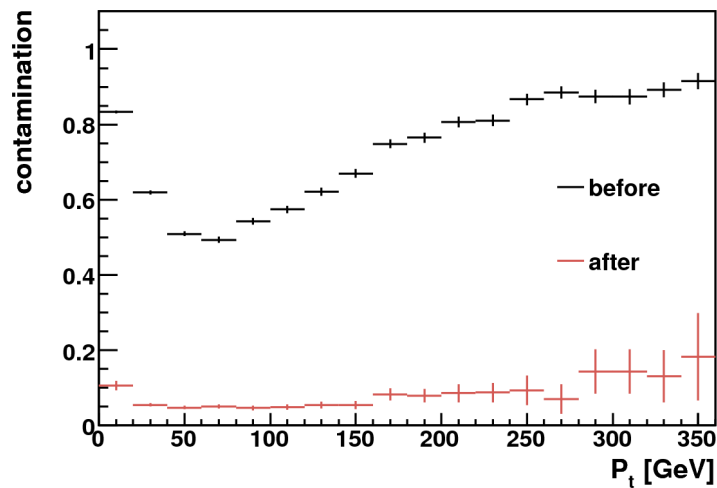
- <https://twiki.cern.ch/twiki/bin/view/CMS/SusyPatCrossCleaner>
 - Description of cleaning procedure
 - Instructions how to use it
 - Details on Configuration
 - How to access cleaned collections
 - Link to doxygen code documentation
- Coming soon
 - Internal Note with details on the package and its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

BACKUP SLIDES

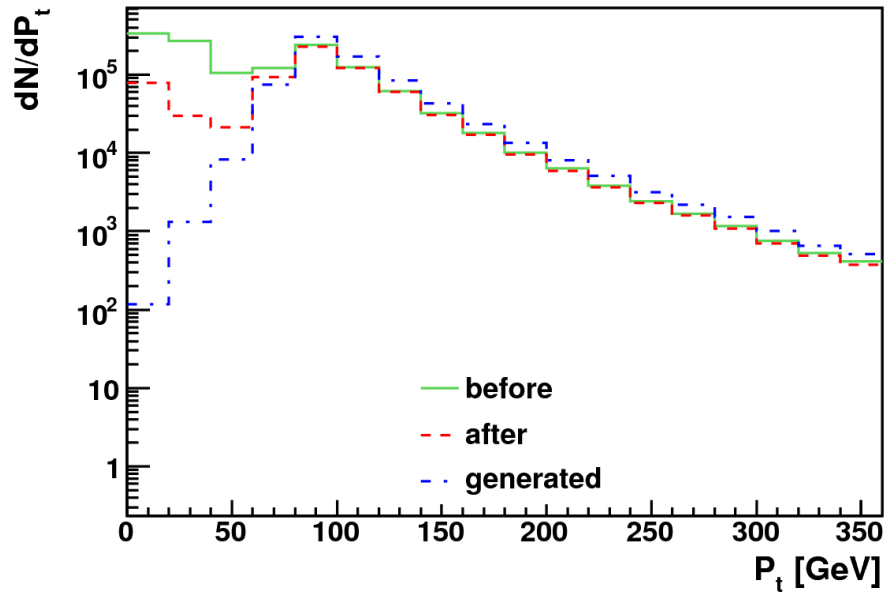
Electron-Jet Cleaning



Non-isolated electrons



Photon-Jet Cleaning



Muon-Jet Cleaning

