

ILD reconstruction and JER/JES.

LCWS benchmarking days 2018
Arlington, Texas

[Rémi Ete](#)

DESY

October 25, 2018



Table of contents

- Status of reconstruction
- Current JER and JES performances
- Ongoing work on JER
 - MC clustering and jet clustering
 - *cc* and *bb* di-jets
- Input for the IDR on reconstruction and JER/JES



Status of reconstruction

Reconstruction workflow

- Background overlay
- Tracking
 - Digitization
 - Track reconstruction
- Calorimeter digitization
 - Barrels and endcaps
 - Forward calorimeters
 - Muon yoke
- PandoraPFA
- BeamCal reconstruction
- High level reconstruction
 - PFO properties (cov matrix, shape, PID, etc...)
 - $\gamma\gamma$ finder
 - Particle identification (Likelihood)
 - MC Thruth linker
 - Primary and secondary vertex finder (LCFIPlus)
 - Time-Of-Flight (0, 10 and 50 ps resolution)



Status of reconstruction

Reconstruction workflow

- Background overlay
 - Tracking
 - Digitization
 - Track reconstruction
 - Calorimeter digitization
 - Barrels and endcaps
 - Forward calorimeters
 - Muon yoke
 - PandoraPFA
 - BeamCal reconstruction
 - High level reconstruction
 - PFO properties (cov matrix, shape, PID, etc...)
 - $\gamma\gamma$ finder
 - Particle identification (Likelihood)
 - MC Thruth linker
 - Primary and secondary vertex finder (LCFIPlus)
 - Time-Of-Flight (0, 10 and 50 ps resolution)
- Overlay MC particles in event:
 - aa_lowpt (BB, BW, WB, WW)
 - ee-pairs
 - Status:
Nothing new, everything works !



Status of reconstruction

Reconstruction workflow

- Background overlay
 - Tracking
 - Digitization
 - Track reconstruction
 - Calorimeter digitization
 - Barrels and endcaps
 - Forward calorimeters
 - Muon yoke
 - PandoraPFA
 - BeamCal reconstruction
 - High level reconstruction
 - PFO properties (cov matrix, shape, PID, etc...)
 - $\gamma\gamma$ finder
 - Particle identification (Likelihood)
 - MC Thruth linker
 - Primary and secondary vertex finder (LCFIPlus)
 - Time-Of-Flight (0, 10 and 50 ps resolution)
- Digitization
 - Missing time info in hits
 - Fixed in
iLCSoft/MarlinTrkProcessors#33
 - Track reconstruction
 - See talk by F.Gaede on Friday



Status of reconstruction

Reconstruction workflow

- Background overlay
 - Tracking
 - Digitization
 - Track reconstruction
 - Calorimeter digitization
 - Barrels and endcaps
 - Forward calorimeters
 - Muon yoke
 - PandoraPFA
 - BeamCal reconstruction
 - High level reconstruction
 - PFO properties (cov matrix, shape, PID, etc...)
 - $\gamma\gamma$ finder
 - Particle identification (Likelihood)
 - MC Thruth linker
 - Primary and secondary vertex finder (LCFIPlus)
 - Time-Of-Flight (0, 10 and 50 ps resolution)
- Calo hit time in digitizer
→ Opened issue
iLCSoft/MarlinReco#41
 - Calibration done with LCCalibration
 - Separate constants for I5/s5
 - No calibration procedure for FCal
 - No calibration procedure for Muon Yoke



Status of reconstruction

Reconstruction workflow

- Background overlay
 - Tracking
 - Digitization
 - Track reconstruction
 - Calorimeter digitization
 - Barrels and endcaps
 - Forward calorimeters
 - Muon yoke
 - PandoraPFA
 - BeamCal reconstruction
 - High level reconstruction
 - PFO properties (cov matrix, shape, PID, etc...)
 - $\gamma\gamma$ finder
 - Particle identification (Likelihood)
 - MC Thruth linker
 - Primary and secondary vertex finder (LCFIPlus)
 - Time-Of-Flight (0, 10 and 50 ps resolution)
- Main energy correction is *software compensation*
 - Part of energy calibration procedure
 - To be investigated:
 - Track selection (too hard)
 - Use of non-constant B field
 - Issue with muon reconstruction
iLCSoft/ILDConfig#88



Status of reconstruction

Reconstruction workflow

- Background overlay
 - Tracking
 - Digitization
 - Track reconstruction
 - Calorimeter digitization
 - Barrels and endcaps
 - Forward calorimeters
 - Muon yoke
 - PandoraPFA
 - **BeamCal reconstruction**
 - High level reconstruction
 - PFO properties (cov matrix, shape, PID, etc...)
 - $\gamma\gamma$ finder
 - Particle identification (Likelihood)
 - MC Thruth linker
 - Primary and secondary vertex finder (LCFIPlus)
 - Time-Of-Flight (0, 10 and 50 ps resolution)
- Reconstruction of photons and electrons in BeamCal
 - Overlay background from root map
 - Run dedicated reconstruction
 - Issue in 500 GeV MC production
 - s5 samples uses 15 maps !
 - Reported here:
ILDAnaSoft/ILDDoc#17



Status of reconstruction

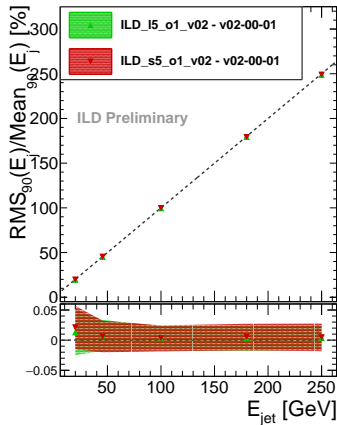
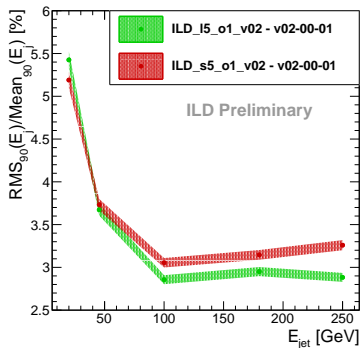
Reconstruction workflow

- Background overlay
 - Tracking
 - Digitization
 - Track reconstruction
 - Calorimeter digitization
 - Barrels and endcaps
 - Forward calorimeters
 - Muon yoke
 - PandoraPFA
 - BeamCal reconstruction
 - High level reconstruction
 - PFO properties (cov matrix, shape, PID, etc...)
 - $\gamma\gamma$ finder
 - Particle identification (Likelihood)
 - MC Thruth linker
 - Primary and secondary vertex finder (LCFIPlus)
 - Time-Of-Flight (0, 10 and 50 ps resolution)
- Particle ID likelihood
 - Option to include TOF estimators ?
 - Although needs re-training ...
 - Vertex finder issue
 - No beam spot constraints applied !
 - Both 500 GeV and 1 TeV production samples affected



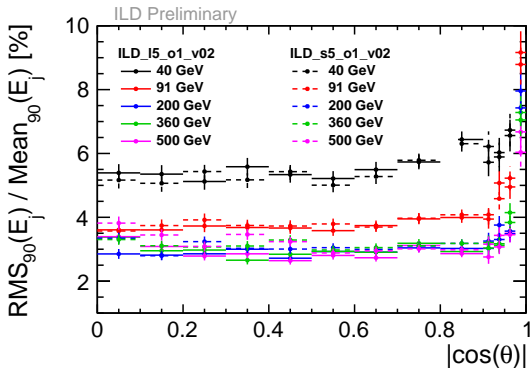
JER and JES with the ILD detector

JER and JES - ILD large vs small (v02-00-01)



JER and JES with the ILD detector

JER versus $\cos(\theta)$



Limited statistics per bins (~ 400 to ~ 700 events) causing fluctuations



A different look at jet energy

Alternative methods ?

Total energy method assumes jet energies are somehow equal.

→ Investigating new methods to quantify JER

- **MC clustering:** cluster jets using available MC information
- **Durham clustering:** jet clustering algorithm
 - forced to 2 jets
 - distance: $d_{ij} = 2 \min(E_i^2, E_j^2)(1 - \cos\theta_{ij})$

Use the MC clustering result for comparison with Durham clustering

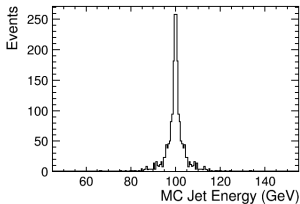
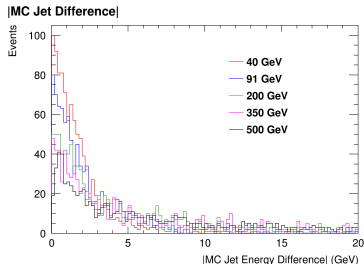
Niall MC Hugh



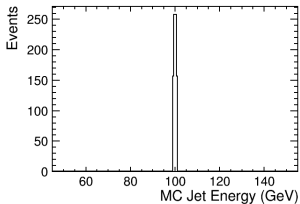
A different look at jet energy

MC clustering

- Energies of jets are not symmetric
- Apply cut on energy difference
 - Compromise between remaining asymmetry and statistics
 - $n\%$ of total energy?



No cut, CMS = 200 GeV



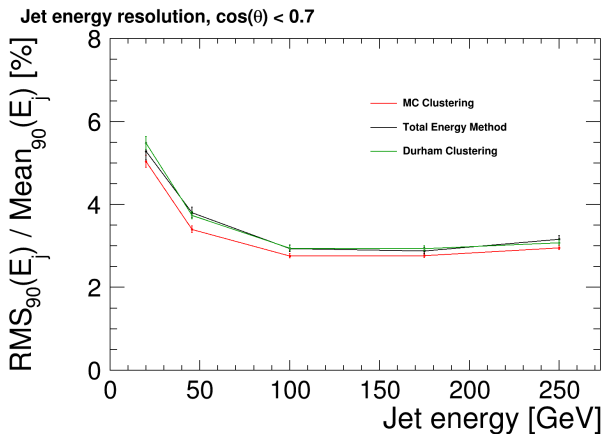
1% cut, CMS = 200 GeV

Niall MC Hugh



A different look at jet energy

JER - 3 methods comparison



Niall MC Hugh



A different look at jet energy

JER - 3 methods comparison

- 3 methods are compatible with uds
- No background + di-jet event topology
→ too simple for Durham clustering
- Use a physics channel ?
 - Background treatment: proper removal versus cheated removal
 - Effect of PFA: standard PFA versus perfect PFA
 - Jet clustering: FastJet versus perfect jet clustering
 - Example of channel: $e^+e^- \rightarrow H\nu\nu$



New uds(bc) generator samples

- Current uds di-jet samples are \gtrsim 15 years old
- Why new samples ?
 - MC particles history is different with Whizard 2
 - Must match our current analysis tools
 - Need more statistics and can't find out old settings
 - Currently no *bb* and *cc* samples
 - Need consistency between uds and bc samples

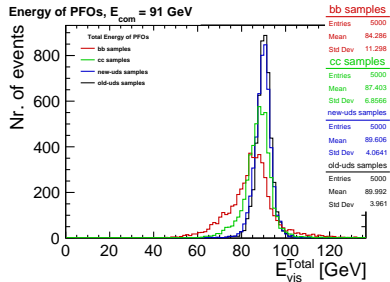
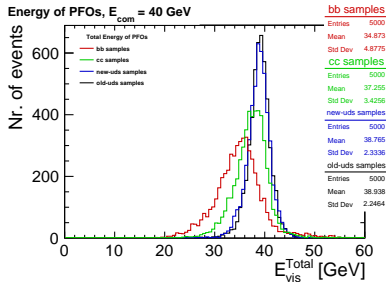
Produced new udsbc samples with Whizard 2

- No ISR
- No beam spectrum
- Pythia 6
- Whizard 2.6



New uds(bc) generator samples

Validation of new uds samples - Total energy



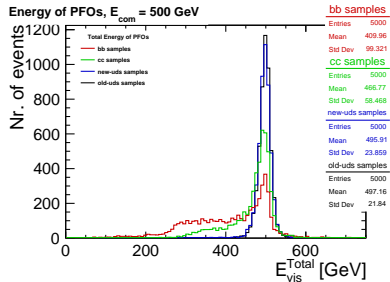
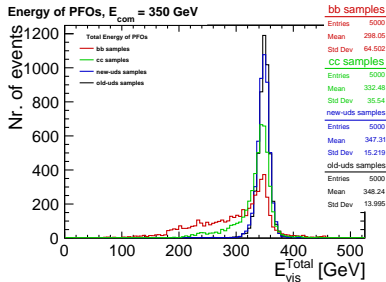
- uds: new versus old is compatible
- bb and cc: effect of neutrinos ? (see next slides)

Yasser Radkhorrami



New uds(bc) generator samples

Validation of new uds samples - Total energy



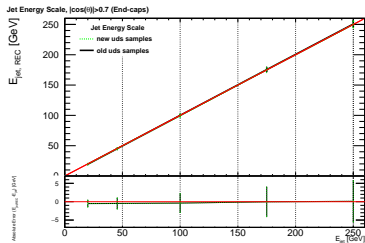
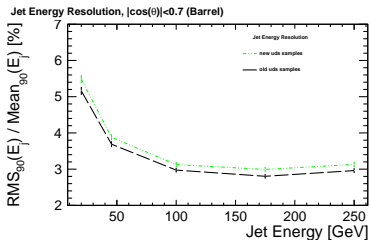
- uds: new versus old is compatible
- bb and cc: effect of neutrinos ? (see next slides)

Yasser Radkhorrami



New uds(bc) generator samples

Validation of new uds samples - JER and JES



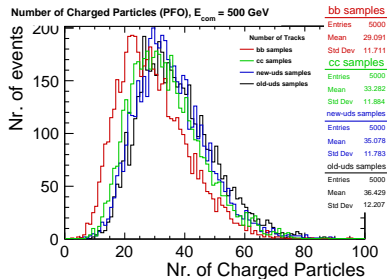
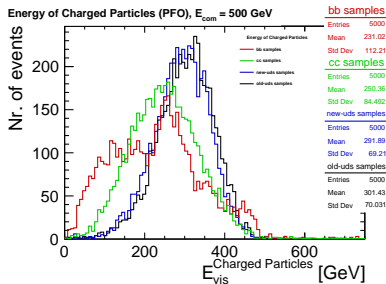
- Linearity is fine
- Small degradation of JER \rightarrow RMS_{90} increase !

Yasser Radkhorrami



New uds(bc) generator samples

First look at new bb and cc dijet events



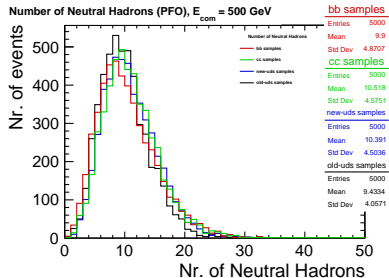
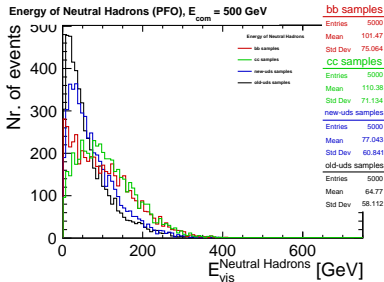
- Less charged particles \rightarrow less charged energy

Yasser Radkhorrami



New uds(bc) generator samples

First look at new bb and cc dijet events



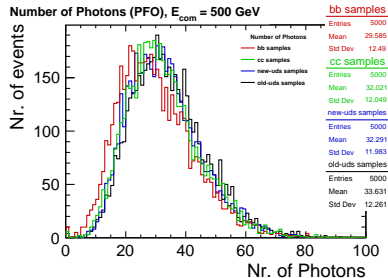
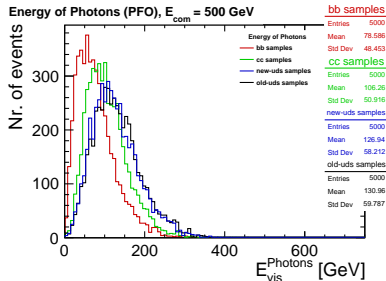
- Same number of neutral hadrons
- ... but more neutral hadron energy for cc and less for bb

Yasser Radkhorrami



New uds(bc) generator samples

First look at new bb and cc dijet events



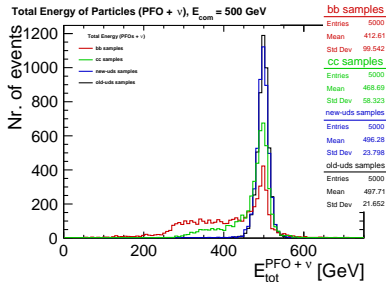
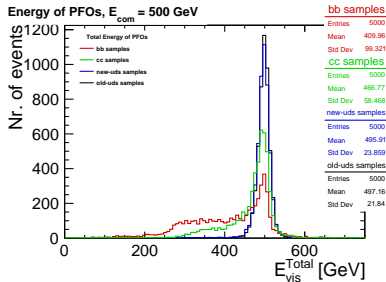
- Small shift in number of photons (less photons)... but less total photon energy
- **In total, less energy in all distributions**
- Boost in cc and bb jets ?
- More confusion for PandoraPFA ?

Yasser Radkhorrami



New uds(bc) generator samples

First look at new bb and cc dijet events



- Adding neutrino energy to total energy does not fix the problem
- Something fundamentally different with cc and bb jets ...

Yasser Radkhorrami



Input for IDR

- Standards:
 - JER, JES, JER vs $\cos(\theta)$, JES vs $\cos(\theta)$
- Dijet events are too simple to spot JER performance
 - Something more applied, more "*physics*" oriented
- Which channel ? $e+e- \rightarrow H\nu\nu$?
- Will have to deal with b/c jets or not ? → not yet understood
- Plotting JER and JES performance for
 - reco + jet clustering
 - cheated reco + jet clustering
 - reco + cheated jet clustering
 - cheated reco + cheated jet clustering

