Understanding the jet energy scale using pT balance for γ+jet events
(ATLAS release14.2.21)

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Calibration task force meeting

Motivation

- Check Jet/Gamma resolution and resolution biases for the release 14.2.21
- Look at γ+jet events and reconstruct pT balance
  - Can we use such events for jet calibration?
  - Do we have pT(jet) biases with respect to pT(γ) ?
  - With what precision pT(jet) can be reconstructed from PT(γ)?
- Update results discussed in the note ATL-COM-PHYS-2007-031

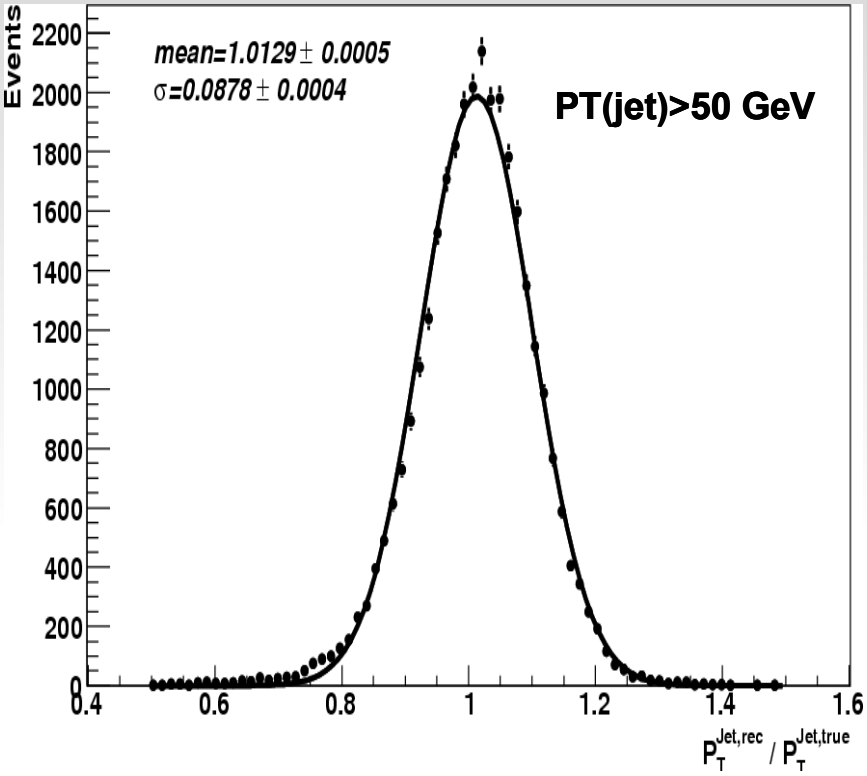
  "PT balance in Z+jet and γ+jet events"

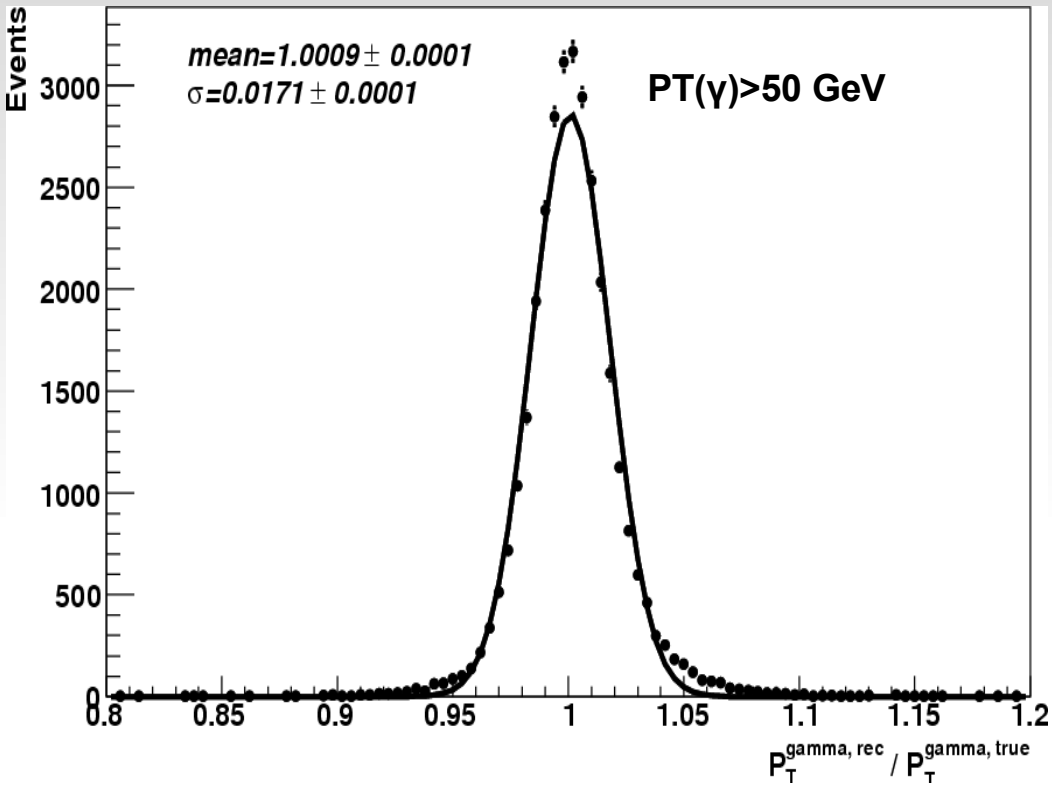
  by A.Gupta, F.Merritt, J.Proudfoot, A.Farilla, M.Verducci
- In this new talk:
  - atlas release 14.2.21
  - only `Cone4H1TopoJets`
  - only official MC08 Monte Carlo tunings and MC08 reconstructed samples

Technical details

- Release 14.2.21 for jet validation code (C++/athena)
- γ+jet AOD sample (CKIN(3)=15 GeV, asym. jet filter, PT(jet1)>30 & PT(jet2)>20 GeV)
  - **`mc08.106379.PythiaPhotonJet_AsymJetFilter.recon.AOD.e347_s462_r541`**
  - L ~ 23 pb-1
- Selection cuts:
  - HLT_g20 trigger
  - PT(γ)>50 GeV, |eta(jet)|<2.4
- Use **`Cone4H1TopoJets`** and **`Cone4H1TopoJets`** for truth level
- Use well isolated photons with isEM=0
- Only leading jet (or gamma) is considered

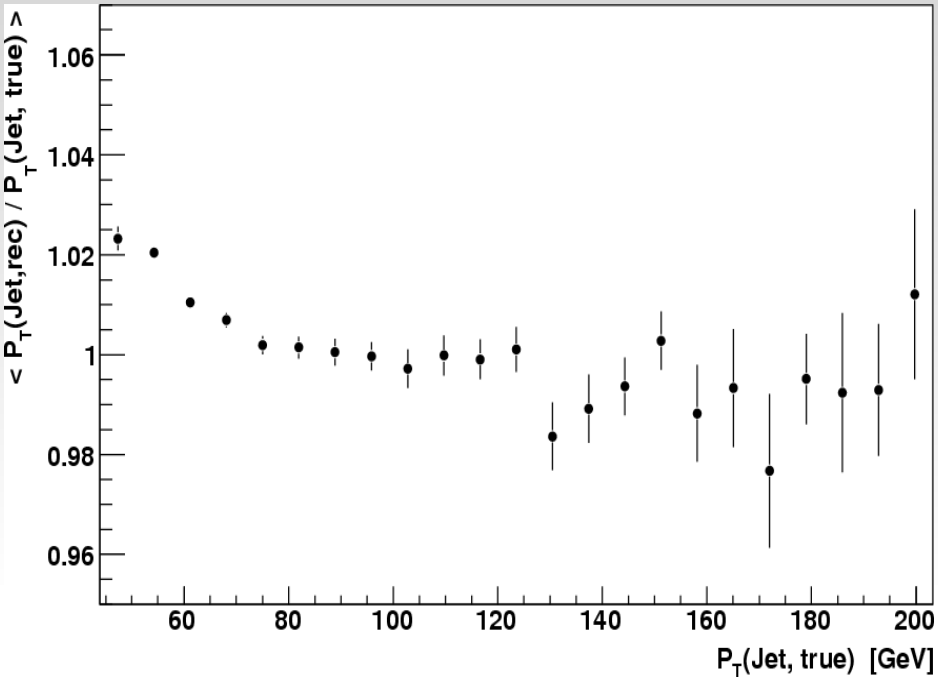
Jet and γ resolutions

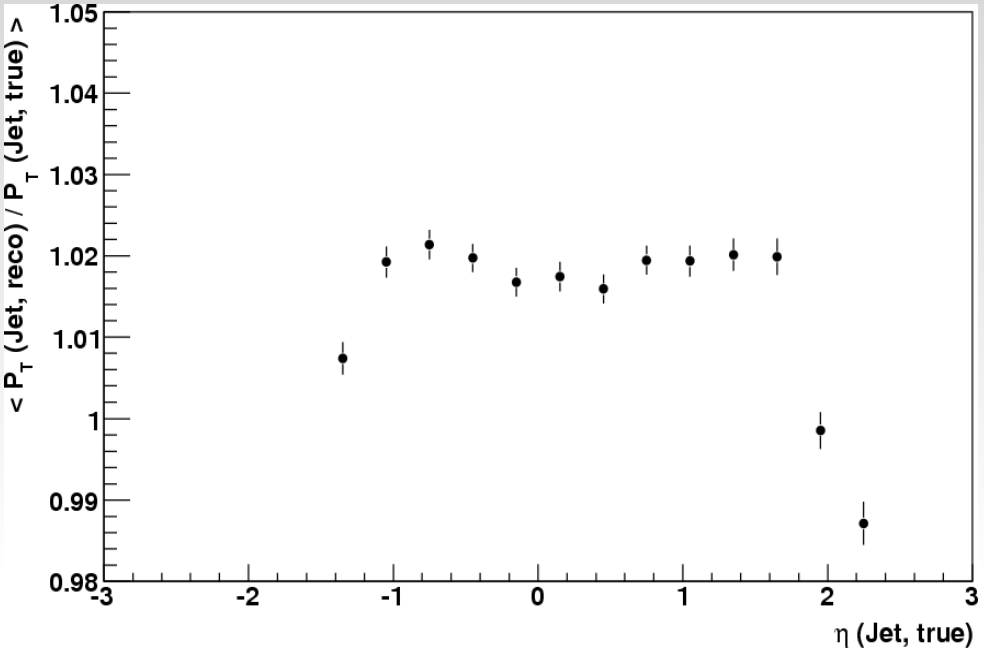


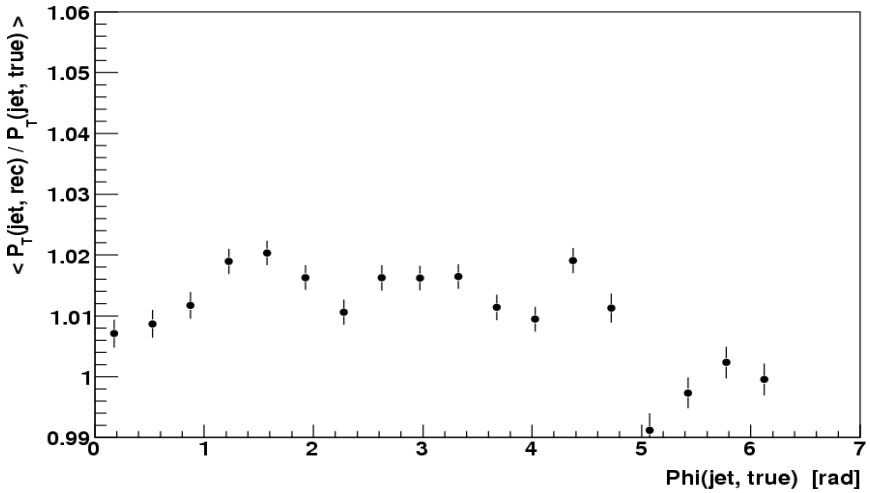


- Resolution for γ's is more than a factor 5 smaller than that for jets
- Resolution bias ~1.3% for jet and below <0.2% for γ
- Looks rather healthy. How about resolution biases as functions PT,Phi,Eta?

Jet resolution biases with respect to jet truth

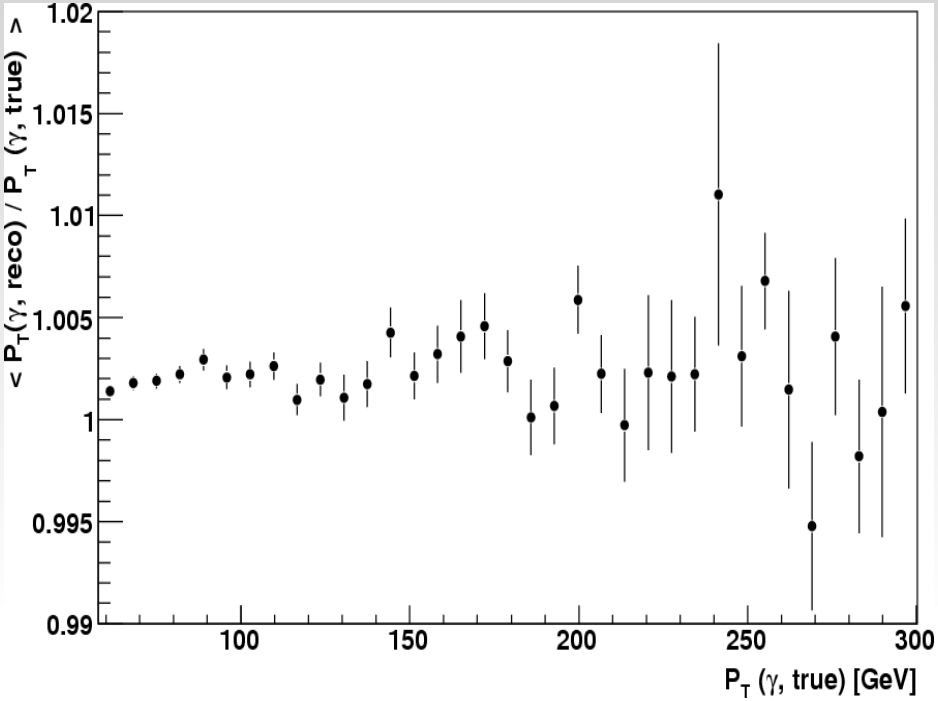


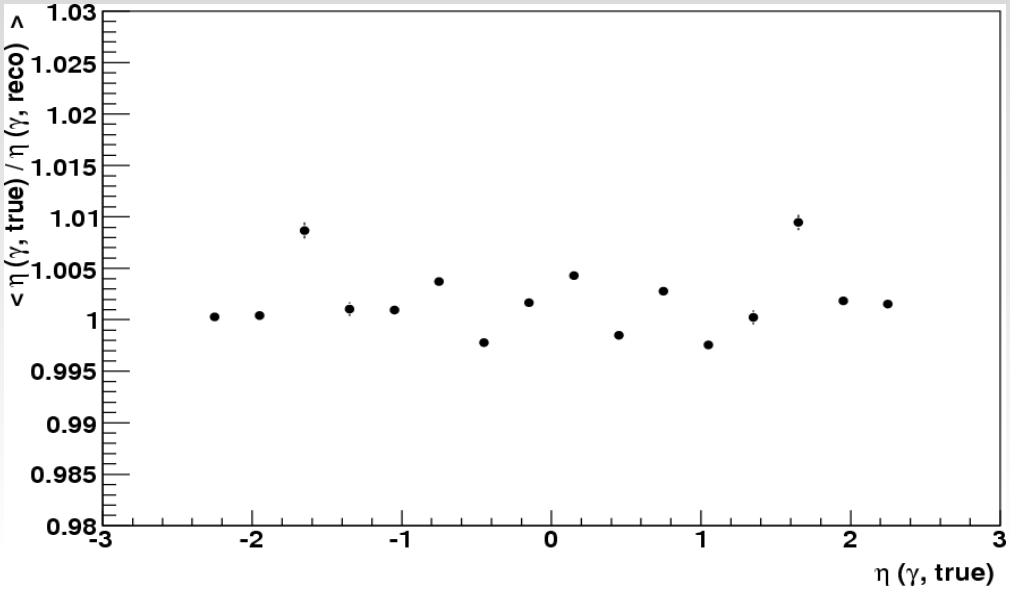


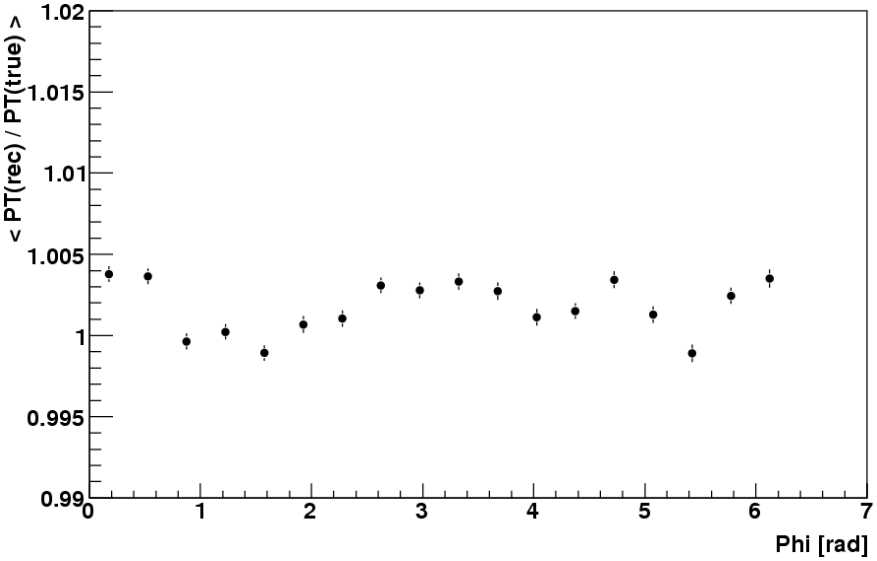


~ resolution biases below 2% for each region

γ resolution biases with respect to the truth





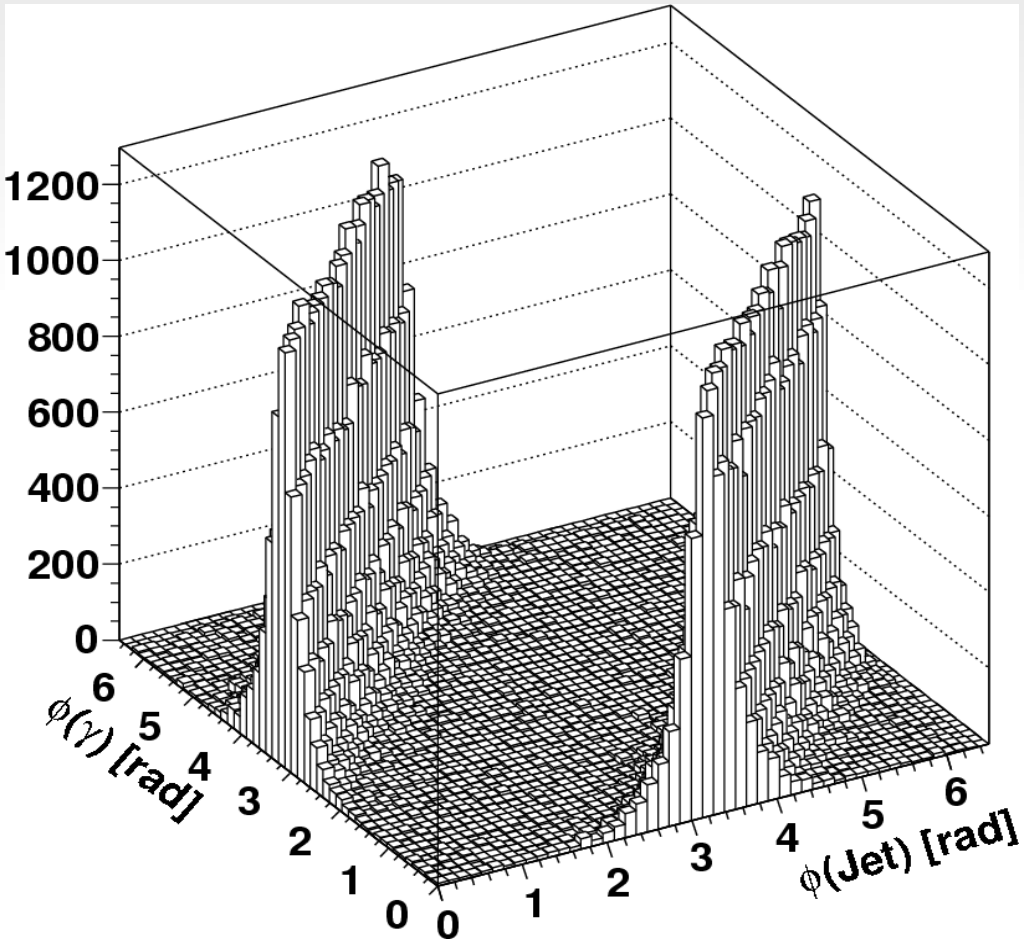


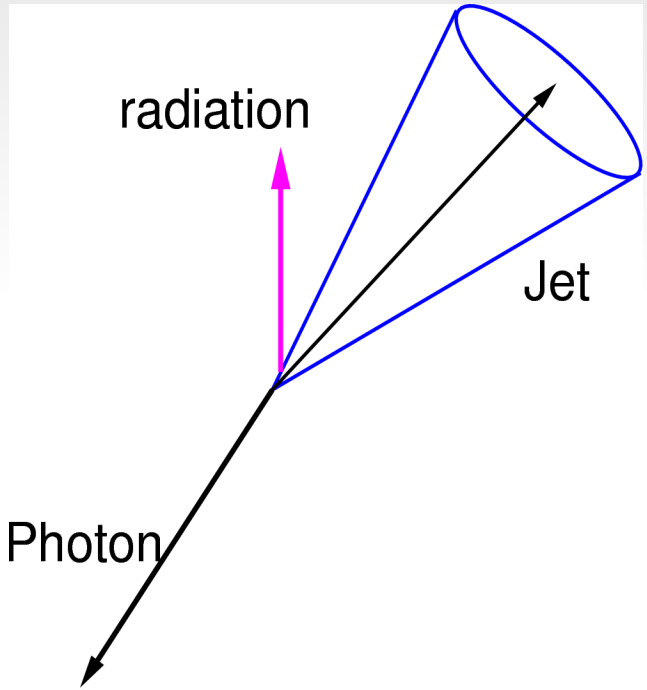
~1% effect for the CAL transition region

Below 0.5% for most regions

γ+jet sample

- Same cuts (PT>50 GeV). Events triggered using HLT=g20
  - isEM=0, |eta(gamma)|<2.4, Use track/cal isolation
- γ and jet should ~balance each other. Apply cut: |**phi(jet)-phi(γ)|>2.7** rad



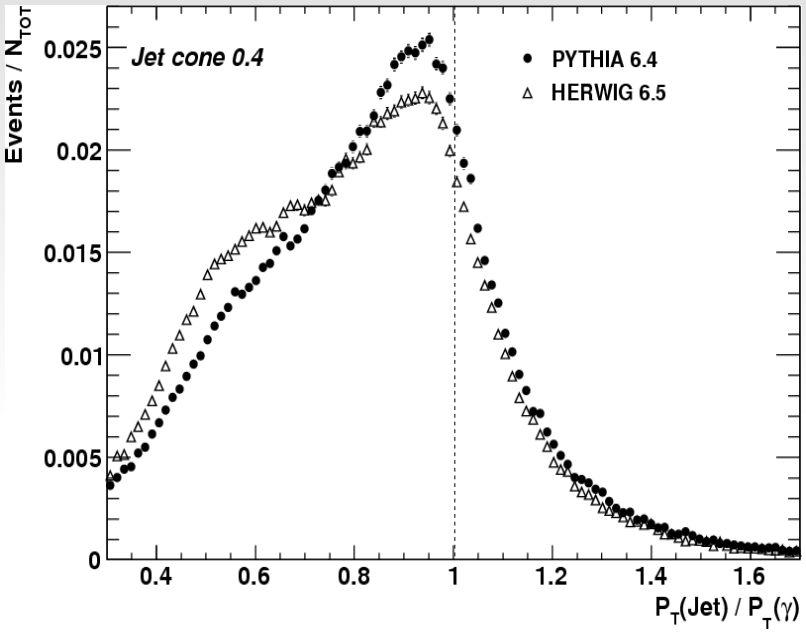


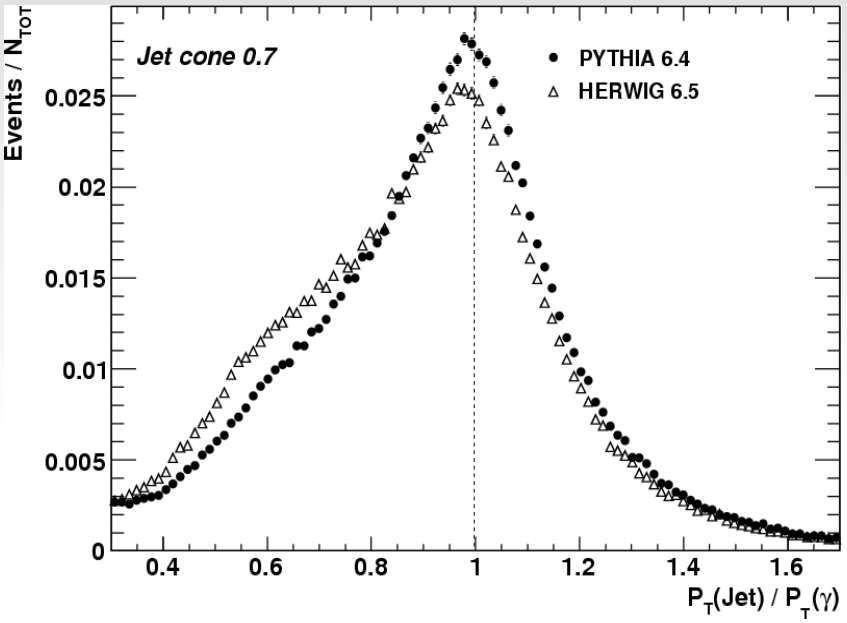
Effects leading to PT imbalance:

- **out-of-cone radiation**
- **multijets (high-order QCD)**
- **multiparton interactions, etc.**

Can we use PT balance for jet calibration?

Truth level studies were done by generating PYTHIA/HERWIG without any filter and using MC08 settings. MI and ISR are included by default



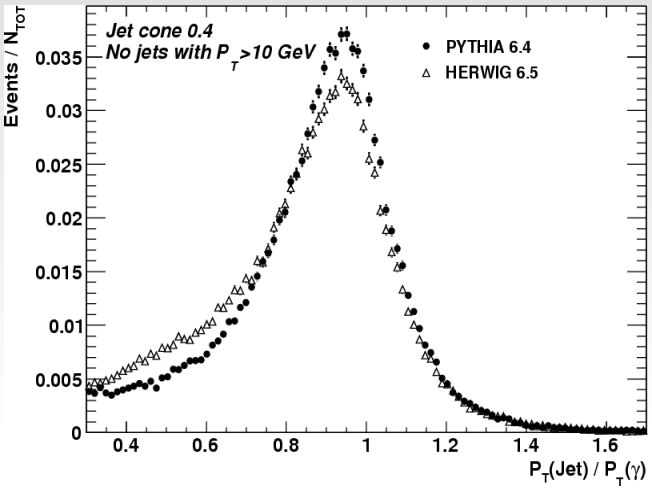


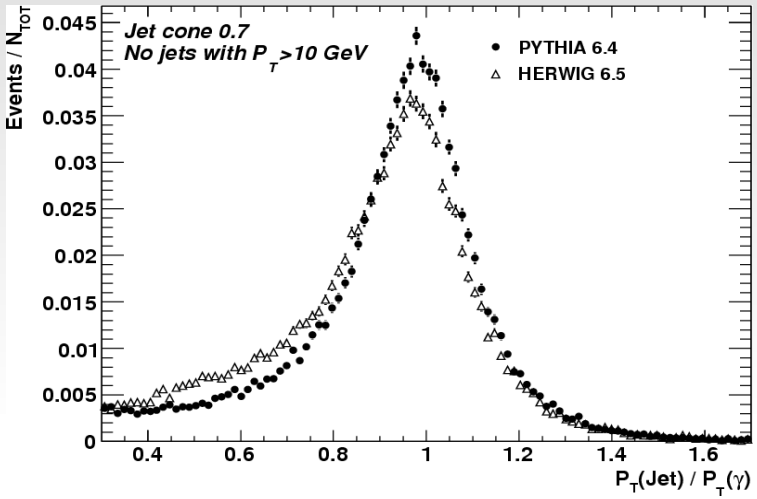
- No ideal PT balance
  - Smaller for larger Jet cone sizes (expected!)
  - Imbalance is larger for HERWIG
- Imbalance effects should be reduced and should be taken into account for the energy-scale studies using γ+jet (or Z+jet) events

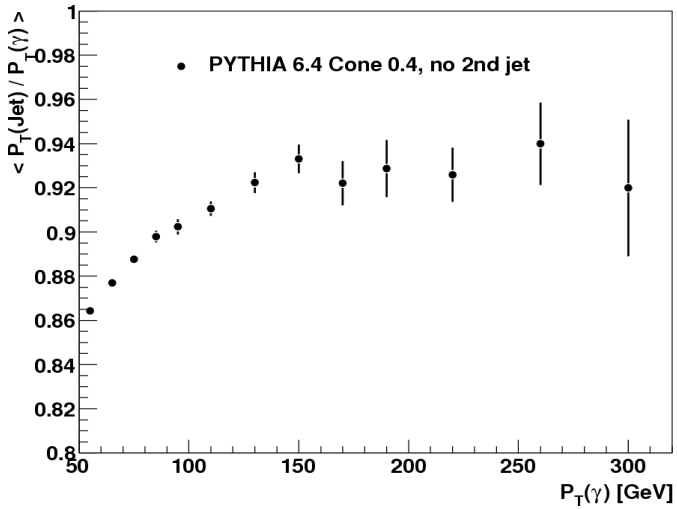
PT imbalance reduction

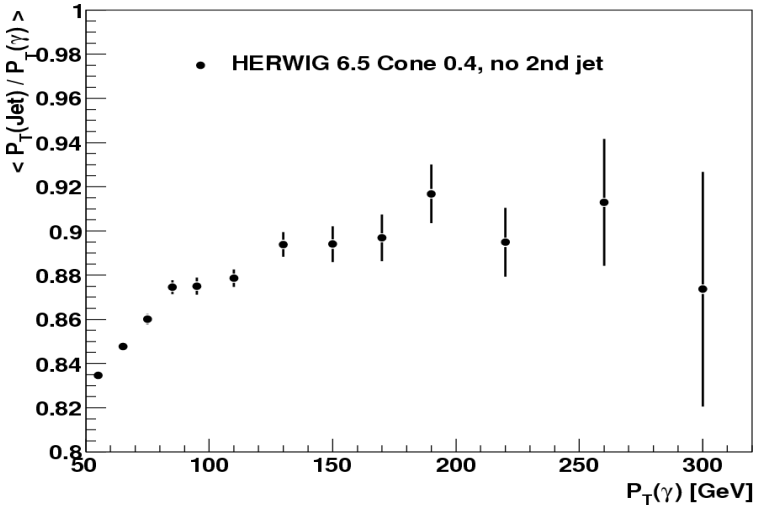
- Try to reject events with second jet below 10 GeV

(see note by A.Gupta, F.Merritt, J.Proudfoot, A.Farilla, M.Verducci, ATLAS-COM-PHYS-2007-031)





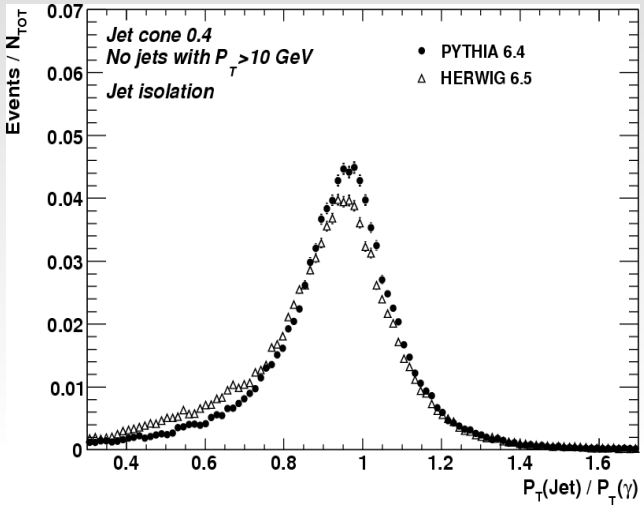


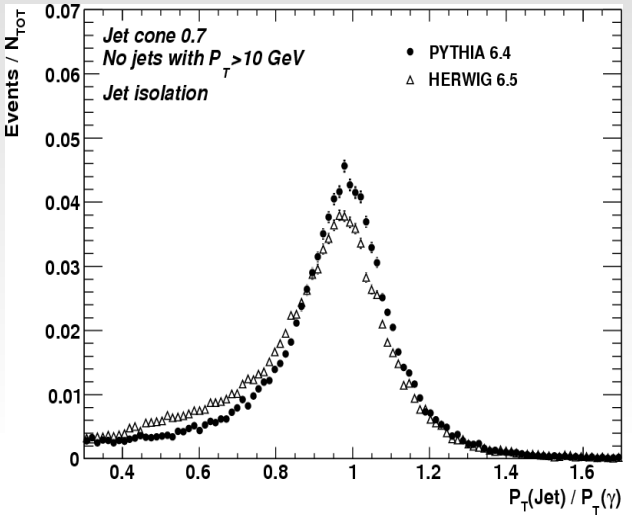


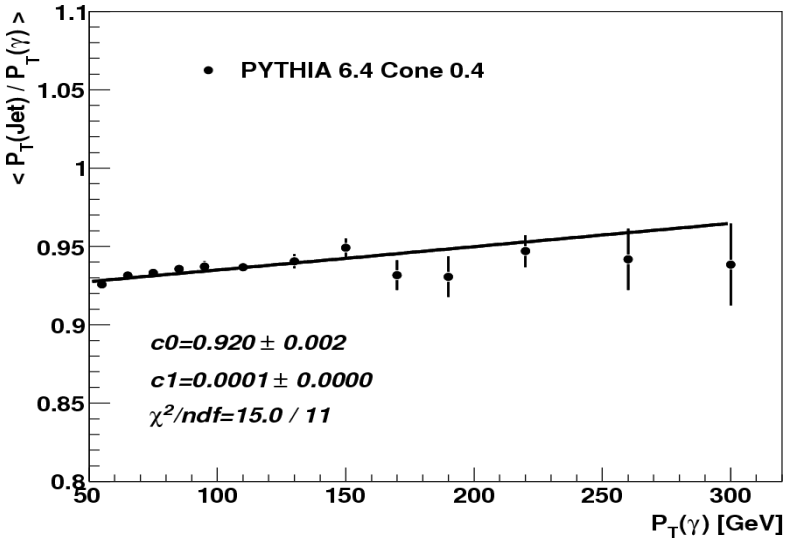
- **Imbalance ~15%. Still large but looks promising.**
- **Difference between PYTHIA and HERWIG ~3%**

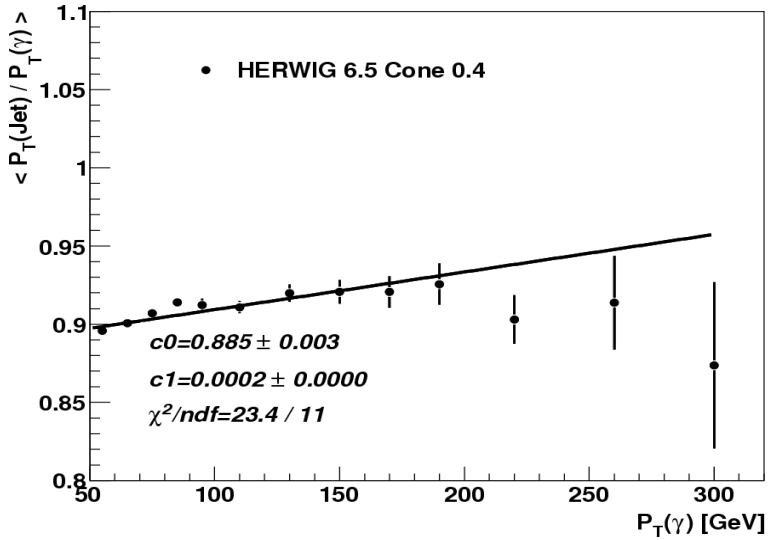
Trying more cuts..

- High gluon activity in the jet hemisphere can be reduced by putting some jet isolation: ET(jet)>0.9 ET(cone=1.0 around the jet axis)
- This really helps to improve the pT balance (and rejects only 10% of events)







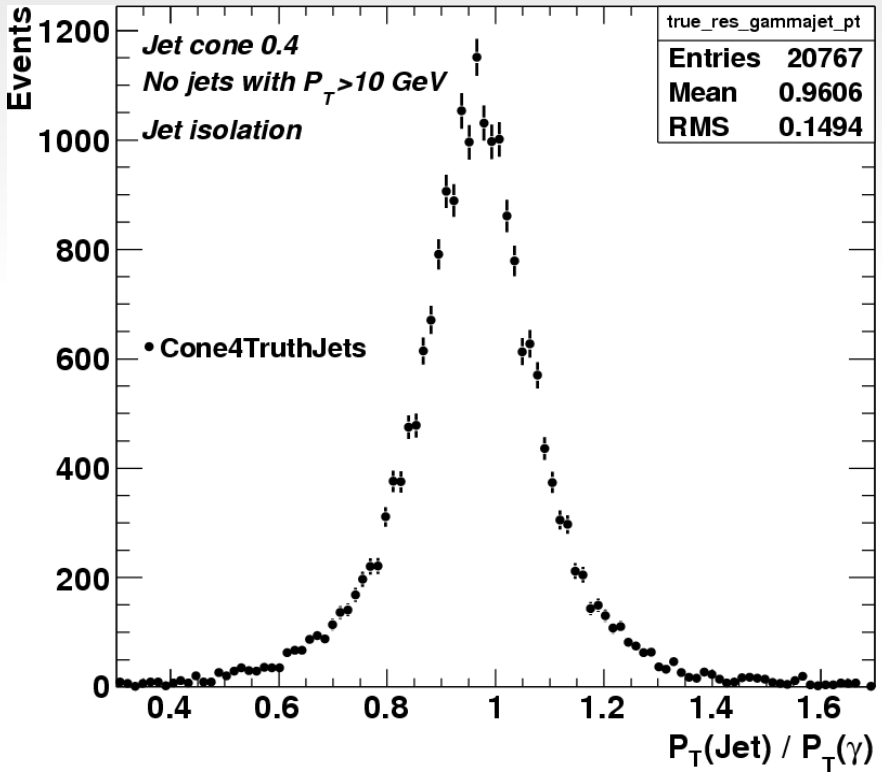


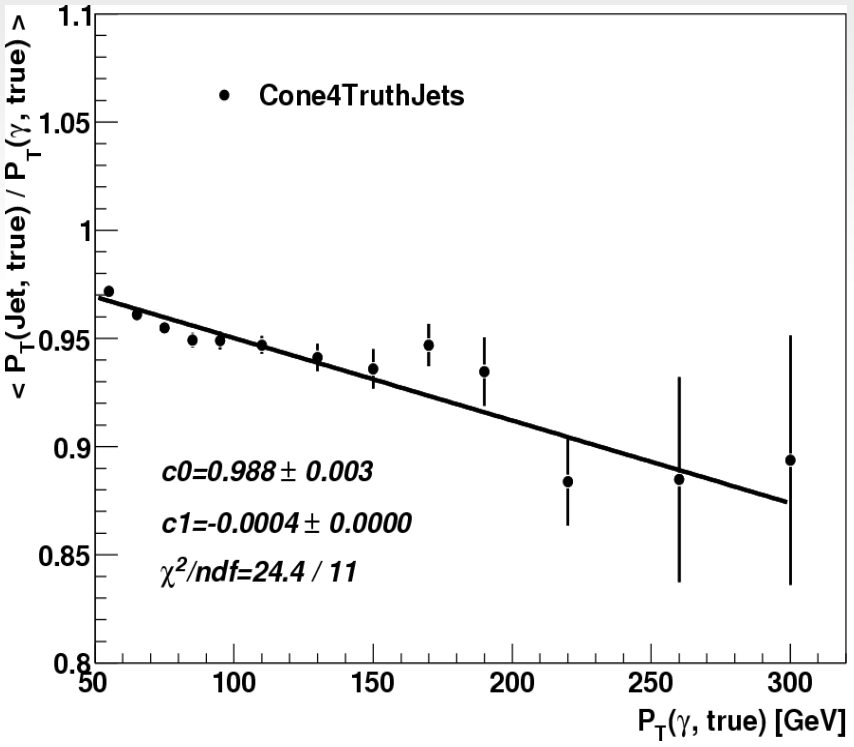
- Imbalance ~7%
- Difference between PYTHIA and HERWIG ~3%

Conclusion from the truth-level studies

- No ideal pT balance at the truth level
- Jet-energy scale calculations should include corrections from the truth-level MC to take out the imbalance effects, assuming that all such effects are properly simulated

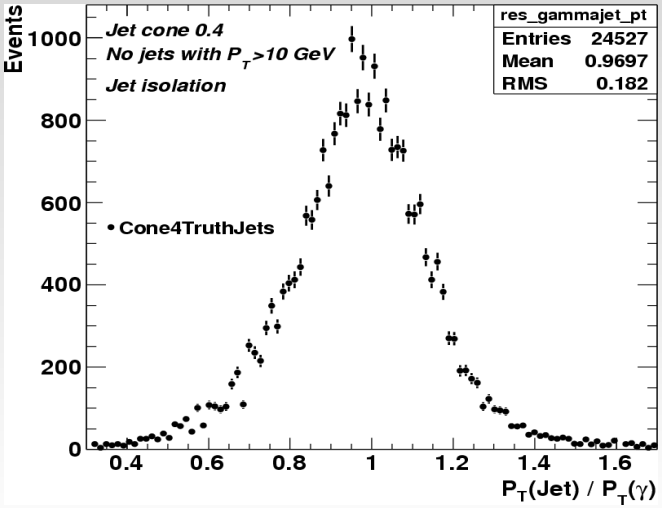
Now, look at the truth level of PythiaPhotonJet_AsymJetFilter:



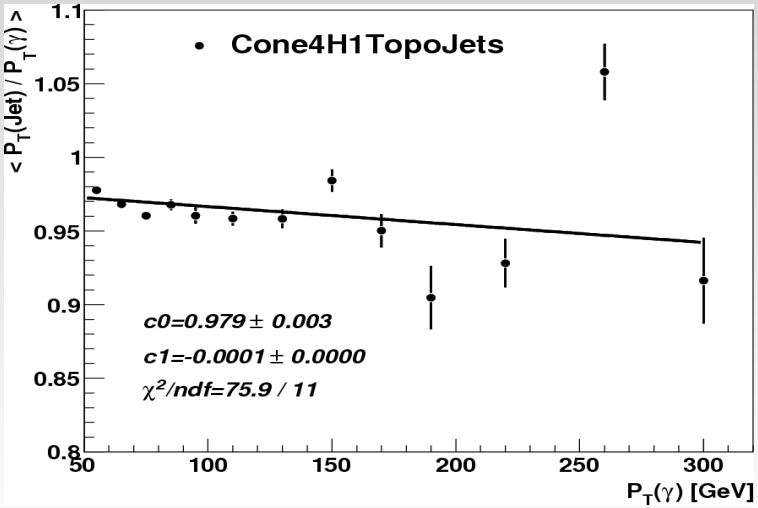


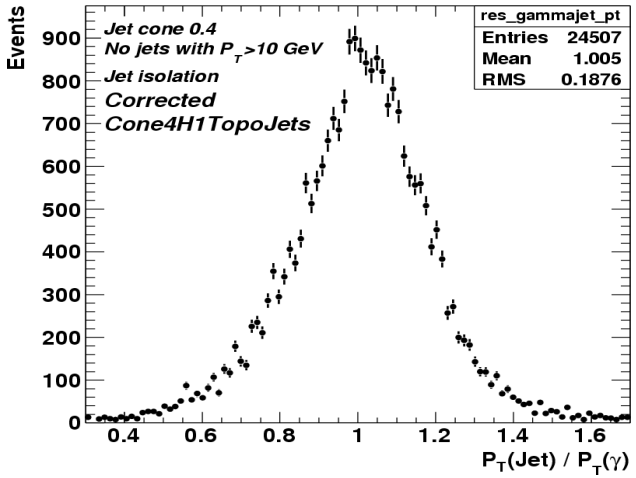
- ~4% imbalance. Small dependence on pT (negative slope, effect from the jet filter)

Applying corrections to the full detector simulation



Reconstructed (AOD) level before corrections

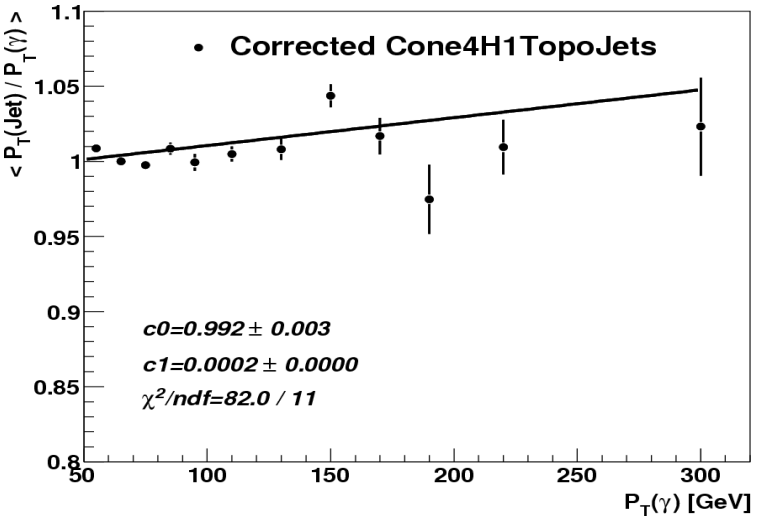




after the corrections:
pT(jet)=pT(jet)/[c0+c1*pT(γ)]

c0,c1 from the fit using truth-level MC

PT(gamma) – from the same reconstructed event



- After the correction, jet PT can be reconstructed within 1% of that of γ
- But ~3% systematic (model) uncertainty from HERWIG is expected (see previous slides)

Summary

- Resolution for gamma ~factor 5 smaller than for the jet
- Resolution biases for jets <2%, for γ ~0.5% (with respect to the truth level)
- A small imbalance for γ+jet on the MC truth is observed due to :
  - high-order QCD, multipraton interactions, the out-of-cone radiation ...
- Jet calibration using γ+jet can be done if:
  - the relation pT(jets) = C*pT(γ) is used

    where C~0.90-0.95 determined from the truth MC
  - Or a correction is applied from the truth level to remove events with imbalance restore pT(jet) = pT(γ)
  - if we understand the jet energy scale for gamma
- In this study, we have tried to restore the PT balance by applying a correction:
  - pT(jet) can be reconstructed from pT(γ) within 1% accuracy
- Model uncertainties on the imbalance correction is ~3% (estimated with HERWIG)
  - Probably can be reduced after fine tuning to real data
- The results generally agree with ATL-COM-PHYS-2007-03

Results are described in the ATLAS note: ATL-COM-PHYS-2009-042