JetMET Status and Plans

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February 10, 2011

Outline

- JetMET Organization and Papers
- Status and Plans for 2011
  - MET
  - Jet Energy Corrections
  - Jet Algorithms
  - JetMET DQM
  - Trigger
- Service and Management
- Conclusions

JetMET Organization Chart

Feb. 4, 2010

JetMET
Daniele del Re, Robert Harris

Jet Energy Corrections
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Jet Algorithms
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MET
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Contacts

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Jet Software: Sal Rappoccio, Hartmut Stadie, Harold Nguyen

MET Software: Frank Golf, Dayong Wang

Datasets: Philipp Schieferdecker

JetMET DQM
Artur Apresyan
Joanna Weng

Trigger
Shabnam Jabeen
Gheorghe Lungu

https://twiki.cern.ch/twiki/bin/viewauth/CMS/JetMET

PAS and Papers

- JetMET is a service organization that also produces **public results**
  - PAS and papers to support both CMS and the careers of our young physicists !
  - 9 PAS approved on 2010 data so far.

- PAS and papers coming up for approval soon
  - Jet Energy Resolution PAS (JME-10-014)
  - MET JINST Paper (JME-10-009)
    - Impressive compendium on MET pre-approved this week.
  - Jet Calibration and Resolution Paper (JME-10-011)
    - Planned to document our data-driven determinations of jet performance.

- Work in JetMET and **get your results published** !

Status and Plans
for each Sub-Group

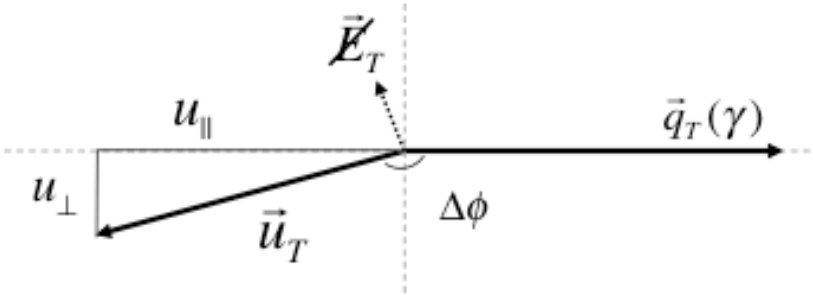
MET Top 5 Missions in 2011

1. Publish MET JINST before 2011 run:
   - ⇨ MET scale and resolution in γ + jets, Z+ jets, dijets events using 36 pb^{-1}
2. Study Pile-Up Effects

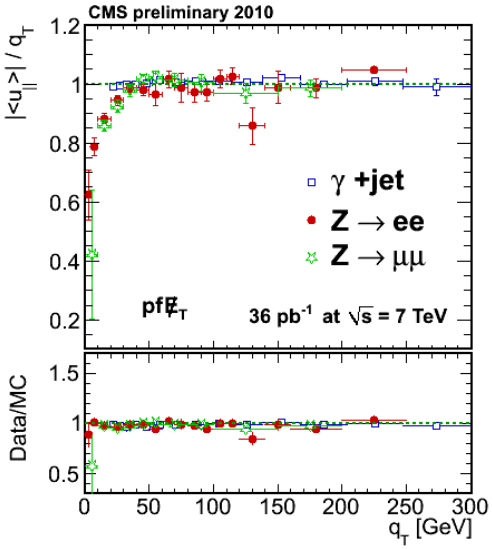
   PF MET resolution is worsened by $\sigma \sim \sqrt{n} \times 3$ GeV for n pileup events
3. Study MET tail
   - ⇨ Launched "MET Hotline" prompt feedback team with DPG's (MET Scanners)
   - ⇨ MET tail due to anomalous signals in calorimeter, jets in boundary, masked towers/cells, beam halo is understood for 2010
4. Improve MET
   - ⇨ Uniform noise cleaning on all MET objects: PFclusterMET
   - ⇨ Type I and II correction for PFMET in addition to CaloMET
   - ⇨ MET significance based on PF
5. MET& MHT triggers (with PFlow)

MET Scale and Resolution

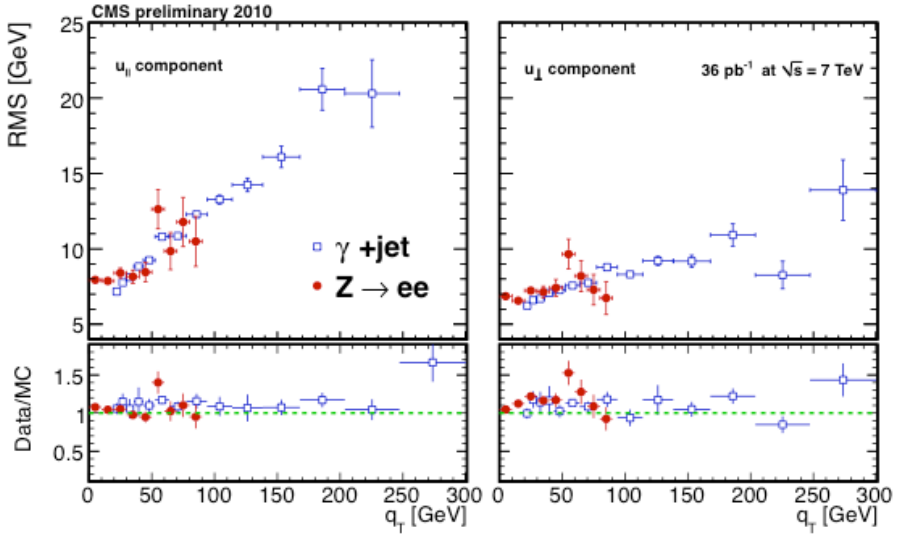
- CMS precisely measures MET scale and resolution using γ and Z events
- Scale uncertainty for these events (5%). Help needed to translate uncertainty to other events: see
  - https://twiki.cern.ch/twiki/bin/view/CMS/MissingETUncertaintyPrescription



Response with 1 PV



Resolution (|| and ⊥) with 1 PV



JME-10-009: MET JINST

MET resolution with pile-up

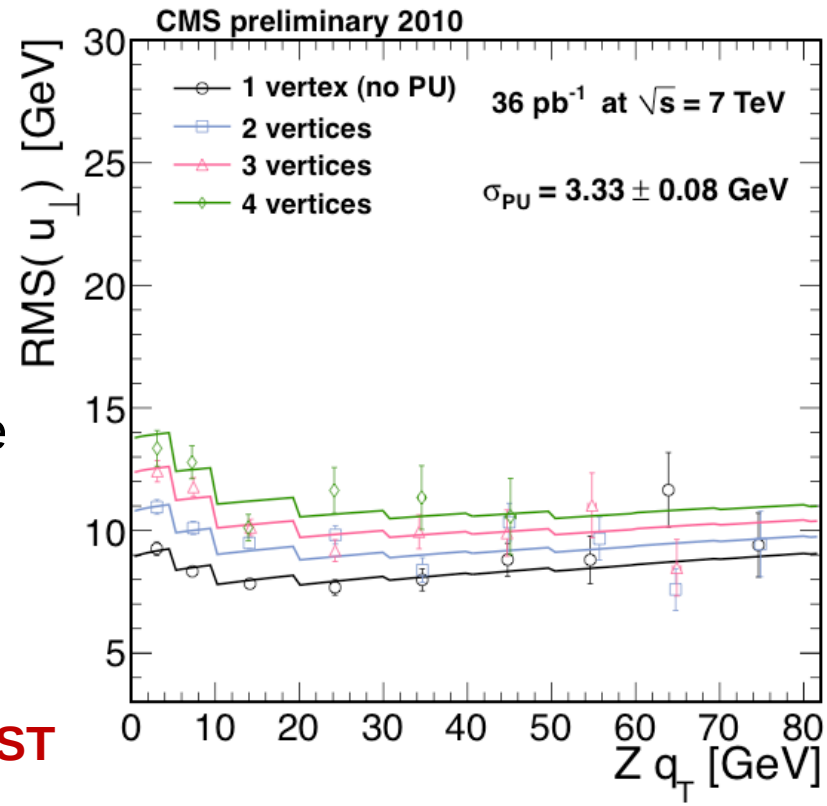
- MET Resolution given by the process, noise and **pile-up**

$$\sigma^2 = [a\, q_T + b]^2 + [\sigma_{noise}\, f_{ES}(q_T)\,]^2 + \mathbf{(N-1)\,[\,\sigma_{PU}\, f_{ES}(q_T)\,]^2}$$

  - **N** is number of reconstructed primary vertixes
  - σ_{PU} ~ 3 GeV is the intrinsic pile-up resolution for pfMET or tcMET
  - $\mathbf{f_{ES}(q_T)}$ is the energy scale correction applied on each event

- With 15 interactions pile-up will dominate
  - Need better control for 2011 run
  - Working on this will be a MET priority

Resolution with Pile-Up (tcMET)

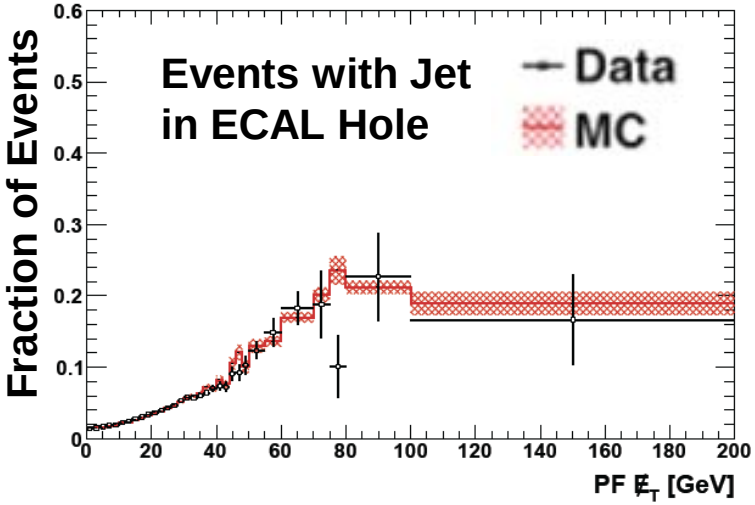


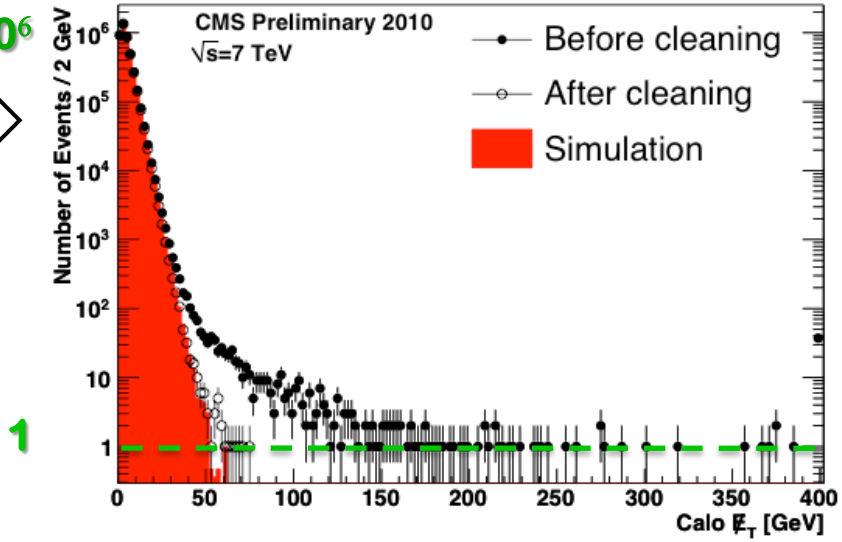
JME-10-009: MET JINST

MET Tails

- CMS understands how to tag and remove Beam Halo
- CMS understands the effect of dead channels and cracks on MET
  - Plan for Ecal hole corr (TPG) in future & **ongoing work is needed**
- CMS understands contributions of anomalous energies to 1 part in 10^6
  - But **more work needed** in cooperation with the DPG's
  - Work needed on tails when reco changes happen.
  - MET scanners meets weekly on Wednesday's at 14:30 (see MET hypernews and JetMET indico page).

Effect on MET of Dead Ecal Cells

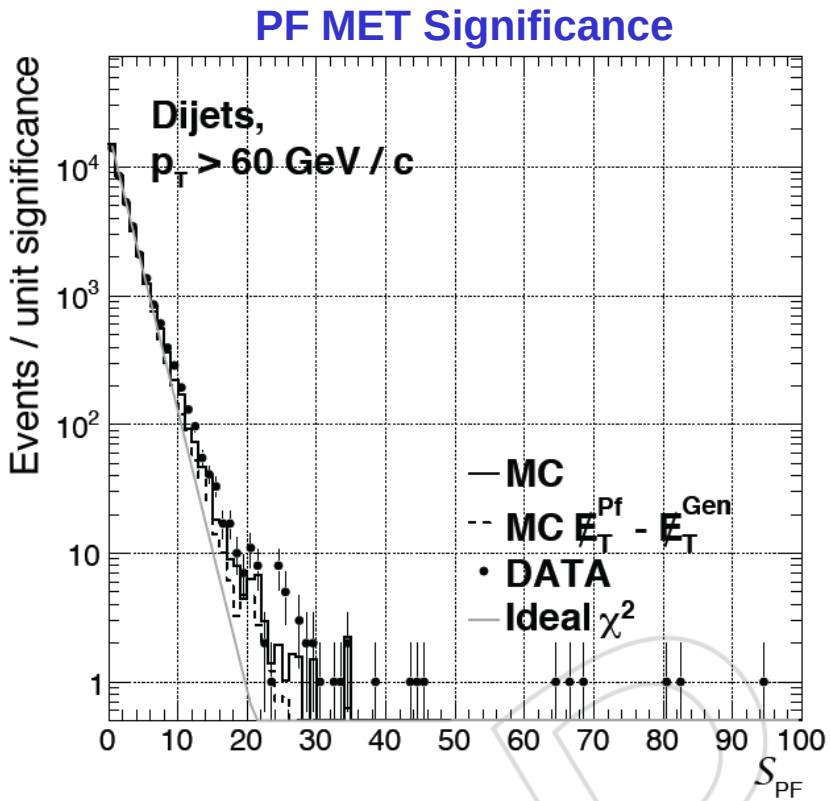


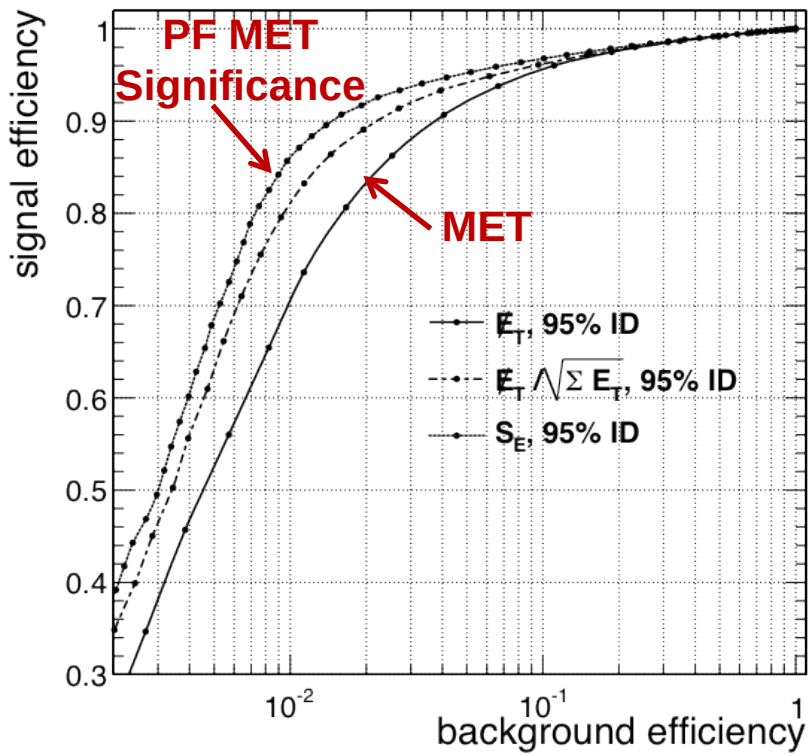


JME-10-009: MET JINST

MET Significance Using PF

- MET significance (S) quantifies the compatibility of MET with the object resolutions like a χ^2
  - χ^2 like behavior in jet events
- Improved separation of signal from background for W's
  - Better than MET
  - Better than MET / $\sqrt{\Sigma E_T}$





JME-10-009: MET JINST

Jet Energy Corrections

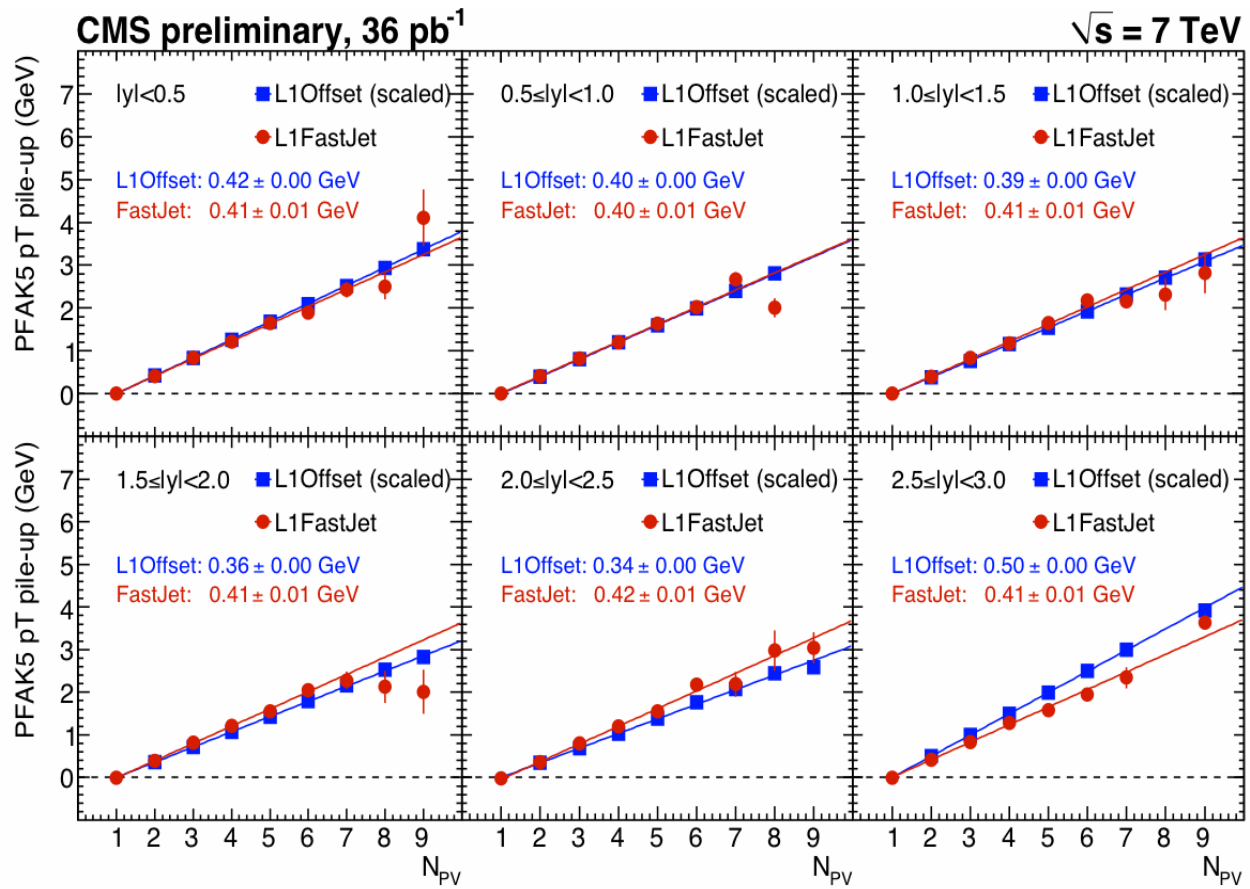
Jet Energy Correction Plans

- JEC + JER Paper
- Pile-Up Corrections (L1)
  - First data-driven corrections available (next slides) more work planned.
- Update relative (L2) and Absolute (L3) corrections for 2011
  - Critical work on data-driven residual corrections from dijet, γ+jet, Z+jet & top.
- Flavor Corrections (L5 and L7)
  - Plan to develop and release new flavor corrections soon
  - Additional uncertainty on b-jet scale recently reduced from 5% to 2-3%.
- Monte Carlo Truth
  - Corrections for both FullSim and now also FastSim are planned.
- Reduce Uncertainties
  - Goal of reducing current 3-5% uncertainties to about 1% level with 1 fb^{-1}

Pile-Up Corrections

- CMS has two methods for the correction which agree within systematics
  1) L1offset: subtract mean E_T, measured in zero bias events as a function of N_{PV}
  2) L1FastJet subtraction using median jet energy density and an estimate of UE.

Pile-Up E_T vs. N_{PV} from Offset and FastJet Methods



Pile-Up Recommendations

- Pile-up corrections will be needed for 2011 data analysis at high luminosity
  - Can be useful cross check for 2010 analyses that may be sensitive to pileup
- Use of both L1offset and L1FastJet are described in CMS workbook

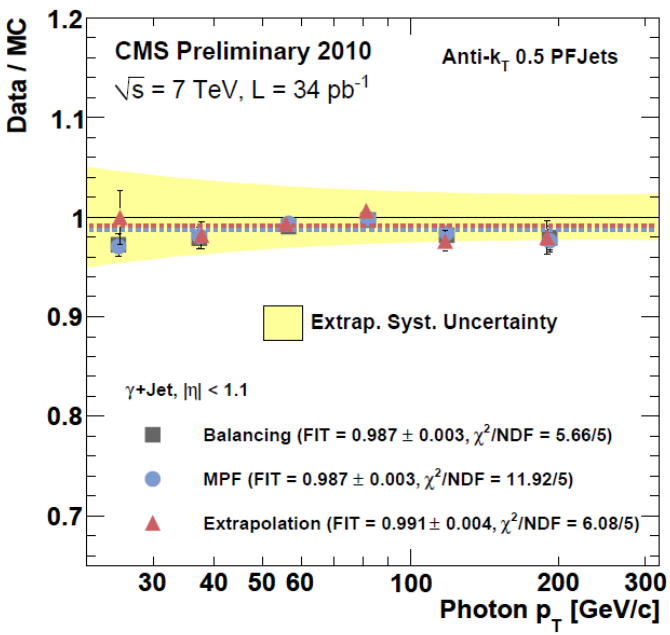
  https://twiki.cern.ch/twiki/bin/view/CMSPublic/WorkBookJetEnergyCorrections#OffsetJEC
- Baseline recommendation (L1offset):
  - Default JEC from MC Truth + **L1**L2L3Residuals in workbook
- Alternate recommendation (L1FastJet)
  - Default JEC from MC Truth + **L1Fast**L2L3Residuals in workbook
  - FastJet with CMS modification that restores UE, so only pile-up is subtracted
  - UE density ρ_{UE} = 1.07 GeV is manually set the same for all events
    - Need to understand possible dependence of ρ_{UE} with physical process.
- Can't use L1 corrections along with charged hadron removal (PFNoPU) yet
  - Implement this in the future when PFNoPU should be more widely used.

Absolute Calibration

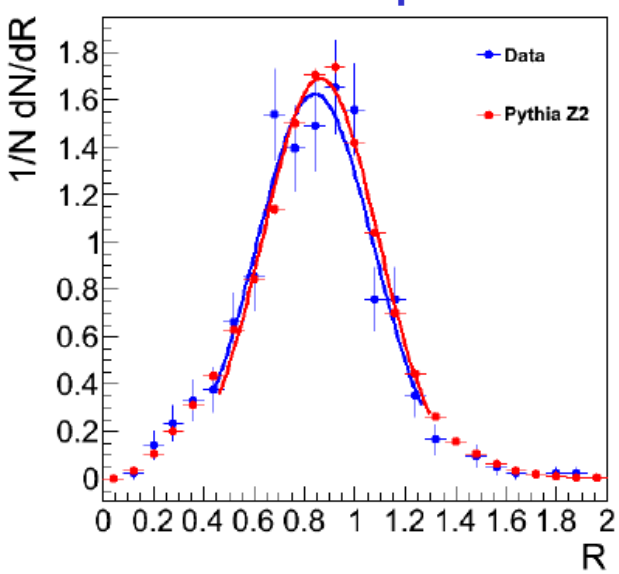
- Multiple calibration channels will be critical to reaching 1% uncertainty
  - → γ+jet most important channel with high statistics and established technique
  - → Z+jet is an essential cross check and the Z can be measured with tracker
  - → Top is starting to be used and should constrain the light quark energy scale
    - → Example of collaboration with Top PAG where analysis is being done.

- We plan to make use of all these channels in 2011 to reduce uncertainty

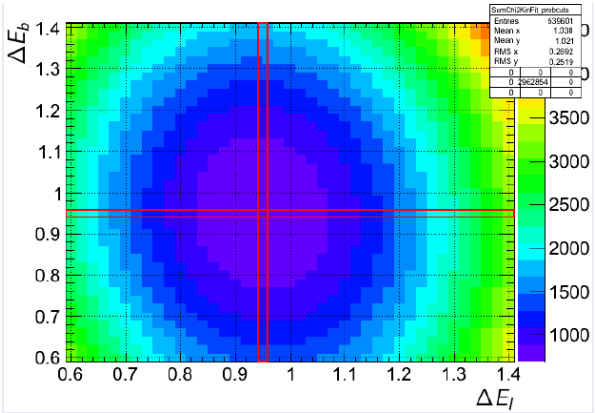
γ + Jet: Response vs PT



Z + Jet: Response



Top: Light Quark E



2010 Data: Light Quark E scale to 4% Stat Error

Jet Algorithms

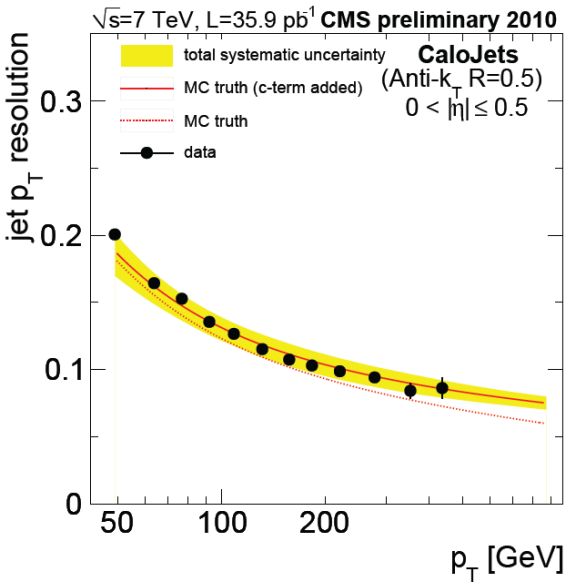
Jet Algorithms Plans for 2011

- JEC + JER Paper
- Jet Resolution
  - Measurements of jet resolution and its uncertainty for PAG use & publications.
  - Measure resolution in presence of significant pile-up.
  - Studies on improving jet resolution with HO
- Jet ID and Quality
  - Measurements of efficiency and background rejection for baseline jet ID
  - Developments in all area's to improve and understand jet quality
    - Impact of Ecal spikes, Hot, and Dead regions of the calorimeter
- Specialized Algorithms (no service points)
  - Jet substructure
    - Tagging and pruning to identify massive boosted objects (top, W, higgs, etc.)
  - Miscellaneous: algorithm dejour, quark-gluon separation, etc.
- Jet Algorithms needs additional contributors for 2011 effort !

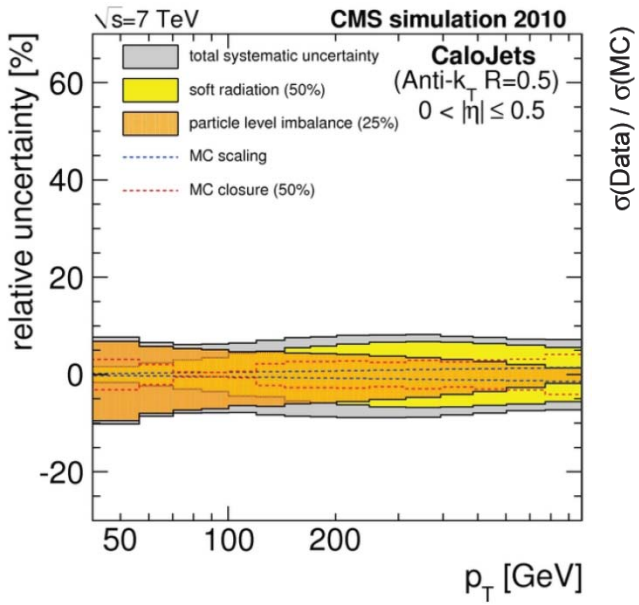
Jet Energy Resolution

- Measurement of Resolution and estimation of uncertainties
  - Both the Gaussian core (for QCD) and the tails (for SUSY)
  - Using both dijet and γ + jet events, which agree for both core and tails.
  - Comparison with MC and understanding of differences (ϕ calibrations, etc)
  - Example of DPG-POG-PAG collaboration in producing publishable results
- Plan to study pile-up dependence of resolution in 2011

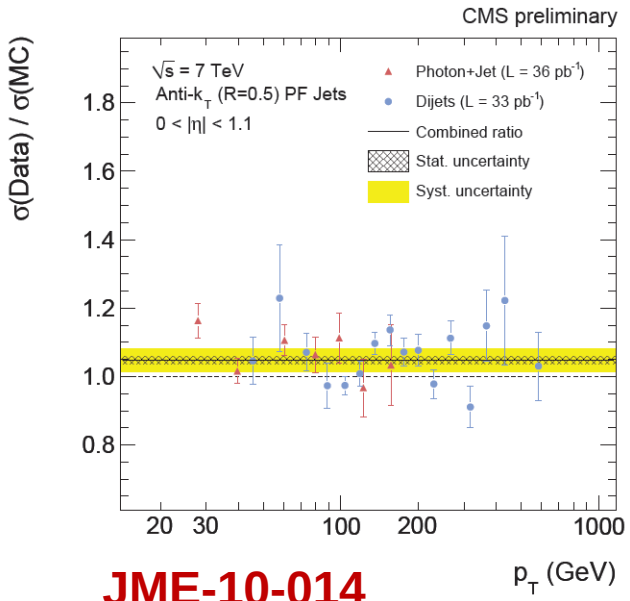
Resolution from Dijets



Systematic Uncertainty



γ + Jet and Dijet

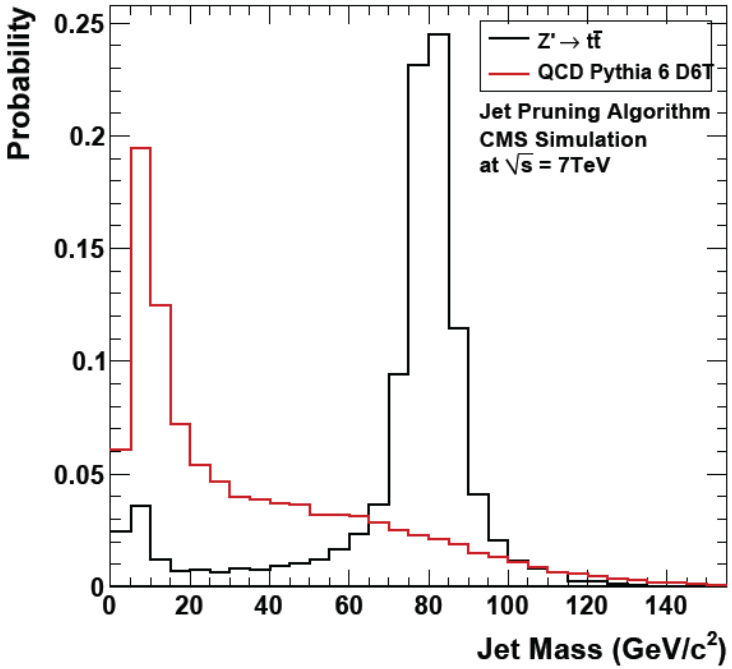


JME-10-014

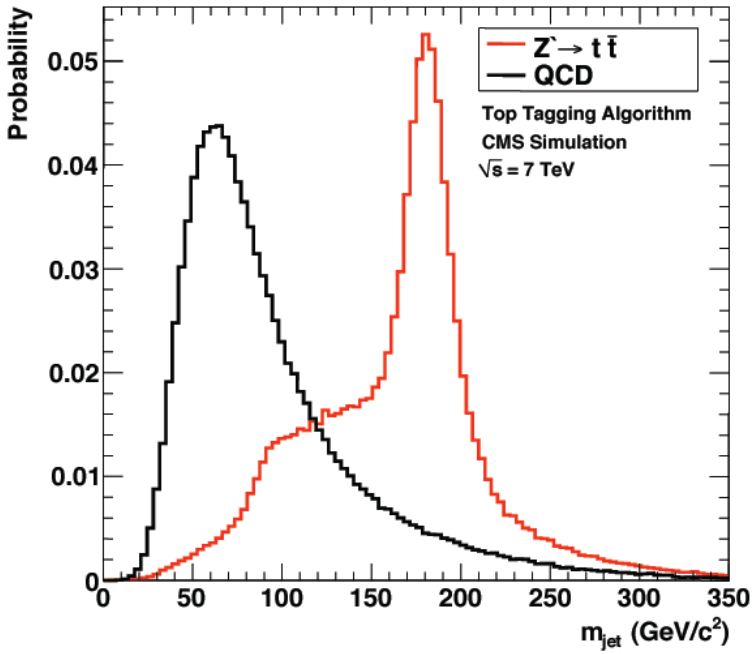
Jet Substructure Algorithms

- Tagging hadronic decays of boosted top and W on huge QCD background
  - Utilizes specialized Cambridge-Aachen algorithm that finds sub-jets within jets
  - Jet pruning used to reduce effects of soft radiation, UE & pile-up on mass reco.
- Critical tool for discovery of new physics: t tbar resonances, boosted higgs.

W tagging with Jet Pruning



Top Tagging



JME-10-013

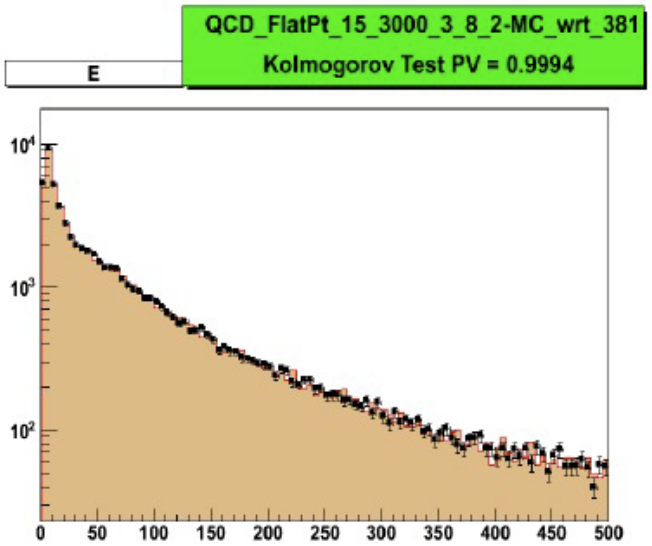
JetMET DQM

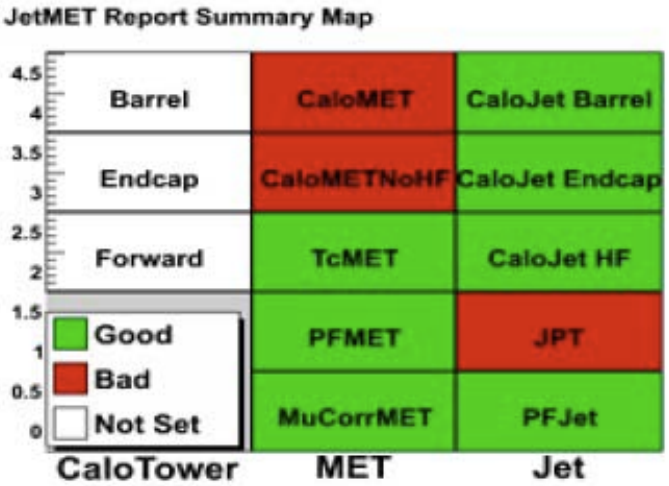
JetMET DQM

- Tasks
  - Weekly Data Certification
  - Data reprocessing Validation
  - MC release Validation
  - Special Requests
    - From DPGs and PVT
    - GFLASH and FastSim
  - Development of DQM Code

- All tasks earn **service points** !

- Official Role
  - JetMET DQM runs as part of the central CMS DQM
  - Contact for DQM Offline shifters
  - Close contact with DPGs and PVT





JetMET DQM Data Certification

- Great Experience for a Student
  - Develops hands on experience with data and know-how with JetMET objects
- Weekly Data Certification
  - Each person in the certification pool does the certification for one week.
  - History DQM plots
    - Look at trends (e.g. jet pt, MET, MEx, MEy mean & RMS) vs run numbers
  - KS tests of histograms against reference run
  - **We need 1-2 more people (students seeking service & experience)**
- Development of Automated Data Certification
  - Critical for robust, quick certification, reducing dependence on human factors.
  - **Urgently need one person for this Automation & DQM code maintenance.**
- Get **Experience** and **Service Points** doing data certification for JetMET !

JetMET Trigger

Trigger Summary

- 5E32 Menu is 15 Hz of Jets and 15 Hz of MET
  - Unprescaled Trig: Jet300U (5Hz), pfMHT150(3Hz), MET160_CenJet50U(6Hz)
- Jet triggers now based on AK5 CaloJets
  - Jet corrections planned for trigger and corrected single jet thresholds are known
- Very loose and safe CaloJet ID planned for trigger
  - Jet EMF >0.0001 & N90Hits > 1 more than 99.9% efficient
  - Unprescaled high pt jet trigger will have a path without Jet ID for extra safety
- Removing HF from MET paths at both L1 and HLT
  - Recommend unprescaled MET trigger with high threshold for safety
- Plan to explore pile-up effects
- Put to work 3 new people from PAGs (Thanks!) but **more people needed**.
  - Trigger sub-group is dangerously low on people given its critical mission.
- For more details see Trigger Review talks on Monday

Service and Management

Service Points

- JetMET provides service points for its service work

- Much of the work in JetMET is clearly service work
  - Data quality monitoring and scanning
  - Trigger, software, and MC dataset support
  - Calibrations, resolutions and systematics provided to PAGs
  - General support of the standard jet and MET objects needed by CMS
  - Maintenance work as well as development is important
  - CMS requires this support to function and do physics

- Some of the work is not service work
  - Studies of highly specialized jet or MET algorithms especially for exotic signals

- Please come do service work for JetMET & we will give you service points !

Workpackages & PF Integration

- JetMET needs are documented in workpackages listed online at https://twiki.cern.ch/twiki/bin/view/CMS/Internal/POGWorkpackages#JetMET
- Each workpackage is linked to a detailed description collected together at https://twiki.cern.ch/twiki/bin/view/CMS/JetMET/JMEworkpackages
- We need more **people to work on maintenance** as well as development.
- Many of the workpackages involve PF integration tasks
  - See status of all PF integration tasks in the backup. Some examples:
    - Charged/neutral hadrons calibration (maintenance)
    - Exploit particle content in Jets and MET (development)
  - Improve and maintain the incredible performance of PF Jets and MET
- JetMET has led in PF measurements but now we must lead in PF support
  - PF is widely used for both jets and MET at CMS and needs our help
- We need more **people to work on PF support** as well as development.

Coordination with PAG and DPG

- JetMET has been benefiting from close contacts with both DPG and PAG

- PAGs
  - QCD: Extensive and ongoing collaboration on jet calibration.
  - SUSY: Collaboration on jet resolutions and MET
  - Top: Collaboration on jet energy scale for b quarks and from top quarks
  - Many PAGs are contributing people for the JetMET trigger effort

- DPGs
  - Close coordination via bi-weekly convener meetings of Hcal, Ecal and JetMET
  - Working with HCAL / ECAL on MET scanning and feedback on calibrations
  - Close collaboration with HCAL on PF integration issues

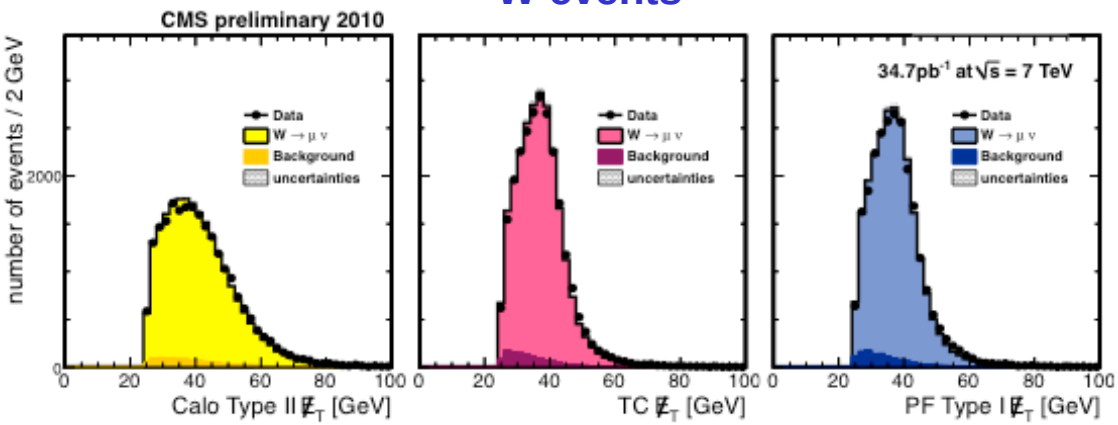
Conclusions

- JetMET has published significant results with the 2010 dataset
  - We will have 10 PAS and plan for 2 JINST Papers
- JetMET plans for 2011 include the following measurements and activities
  - MET tails, MET pile-up studies, and MET improvements.
  - Jet calibrations of pile-up, flavor, and reducing uncertainties
  - Jet resolution, Jet ID and Jet Algorithms for new physics
  - Data Quality Monitoring, Certification and Release Validation, Trigger Studies
- Join us at JetMET
  - Get **service points**
  - Work in a friendly environment
  - Produce **publications**
  - More people needed for both development and maintenance.
  - There are many open tasks in all sub-groups and we **need your help!**
- JetMET is looking forward to the exciting and demanding 2011 dataset !

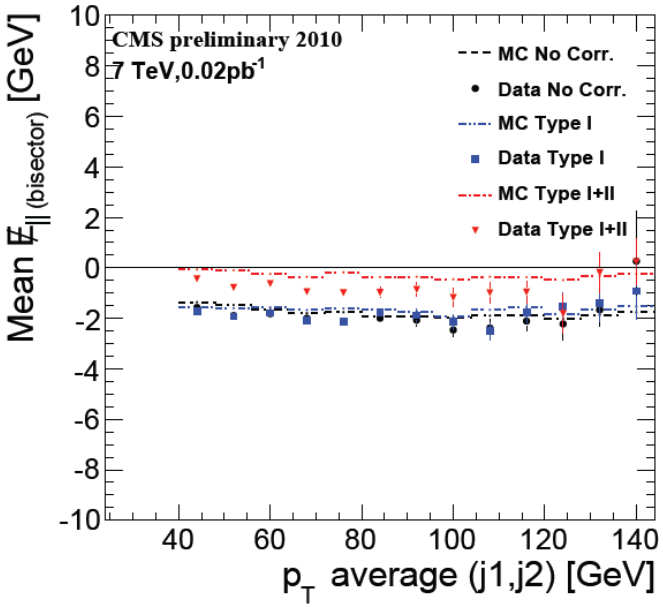
Backup

MET performance

W events

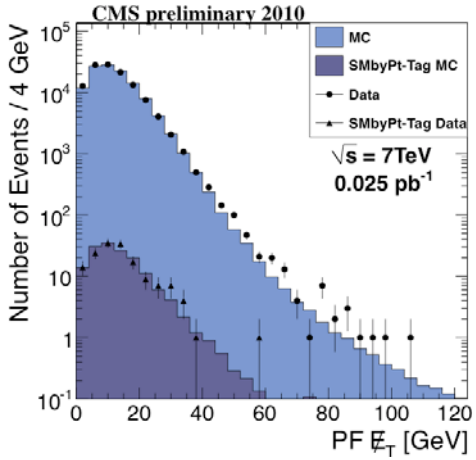


Dijets: Mean PF MET || vs PT (Raw, Type I & Type II Corr.)

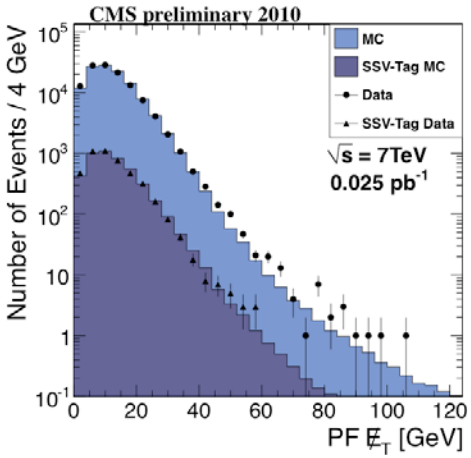


b events

Leptonic tag



Displaced vertex tag



Can we maintain this excellent understanding with high pileup and in all interesting corners of phase space? More work needed.

JME-10-009: MET JINSTJME-1