Jet Energy Scale determination dans DØ

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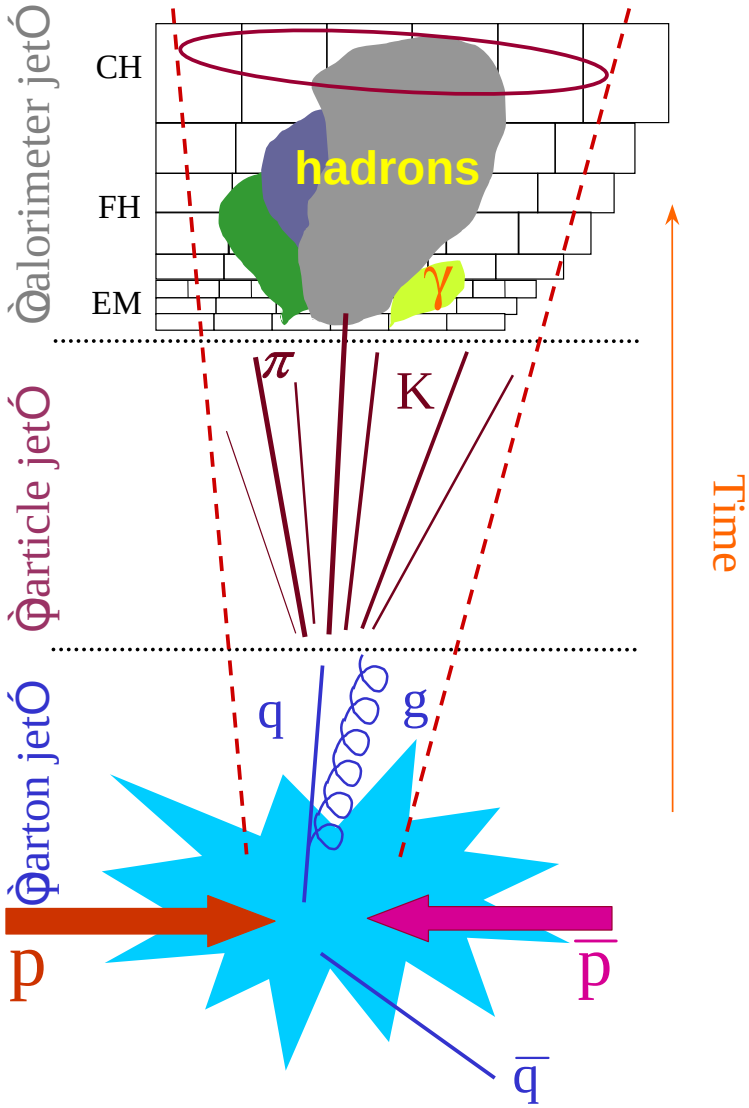
- Offset determination
- Jet response determination
- Showering determination
- Closure tests
- b JES

Jet energy scale: principle of calculation

Corrections down to particle level



Jet energy scale measurement

- $$E_{jet}^{corr} = \frac{E_{jet}^{uncorr.} - Off}{Show \times Resp}$$

- Off: offset corrections, related to uranium noise, pile-up..., Determined using zero-bias data
- Show: Showering corrections, takes into account the energy emitted outside of jet cone because of detector, dead material..., of course, does not take into account physics showering outside the jet cone, particles outside the cone
- Resp: Jet response, obtained using p_T balance in $\gamma+$ jet events, cross check using $Z+$ jet event

Offset Corrections

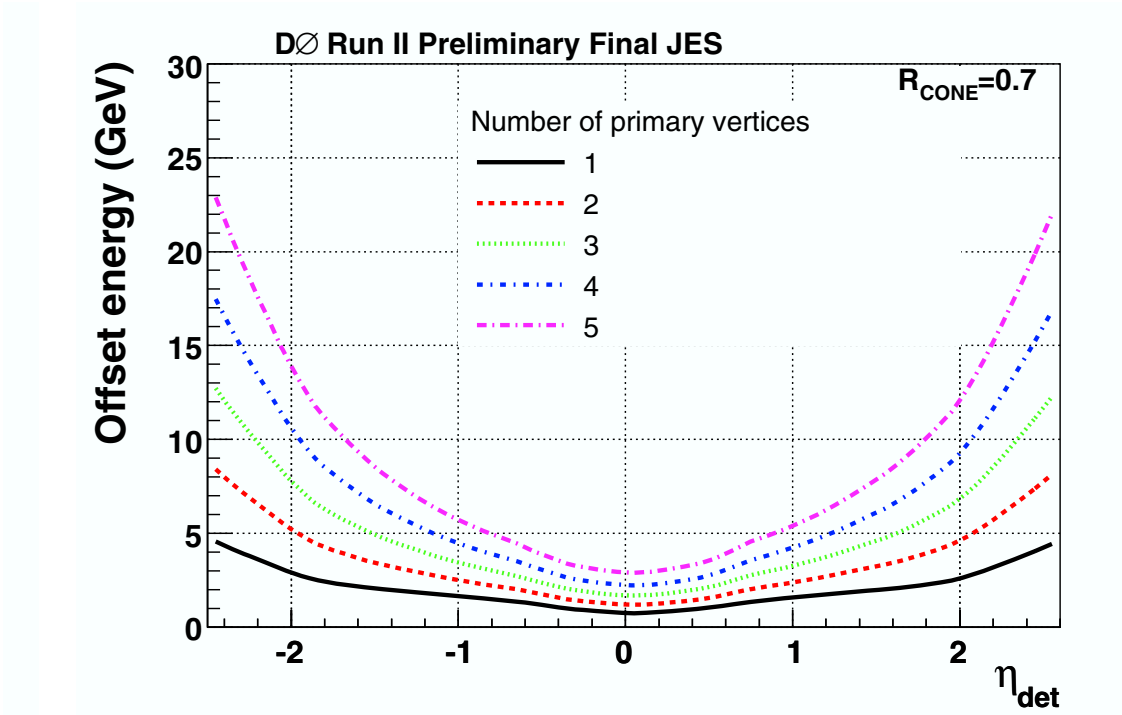
- Definition: energy not associated with the hard scattering
- Contributions: Electronic noise, uranium noise, pile-up, energy from additional interactions, (NB: shaping time in the DØ calorimeter preamplifier longer than the bunch crossing time, it is possible that, before the signal from an earlier bunch crossing dies, a new signal is formed and sits over the top of the previous signal)
- Perform the study as a function of instantaneous luminosity (number of reconstructed vertices)
- Determine energy density in min. bias / zero bias data and special runs taken without zero suppression for the calorimeter

Offset Corrections

- Offset energy consists of three parts:
  - UE: underlying events
  - NP: noise and pile-up
  - MI: multiple interaction
- Measure all components, Final offset will not include underlying event corrections
- How to measure the different components?
  - NP = ZB(0PV+LM veto)
  - UE = MB(1PV) - NP
  - MI = MB(n+1 PV) - MB(n PV)
- Time and luminosity dependence

Offset Corrections

- Aim: Correct for uranium noise, pile up effects, not for underlying events...:
- Luminosity dependence: via the number of reconstructed vertices

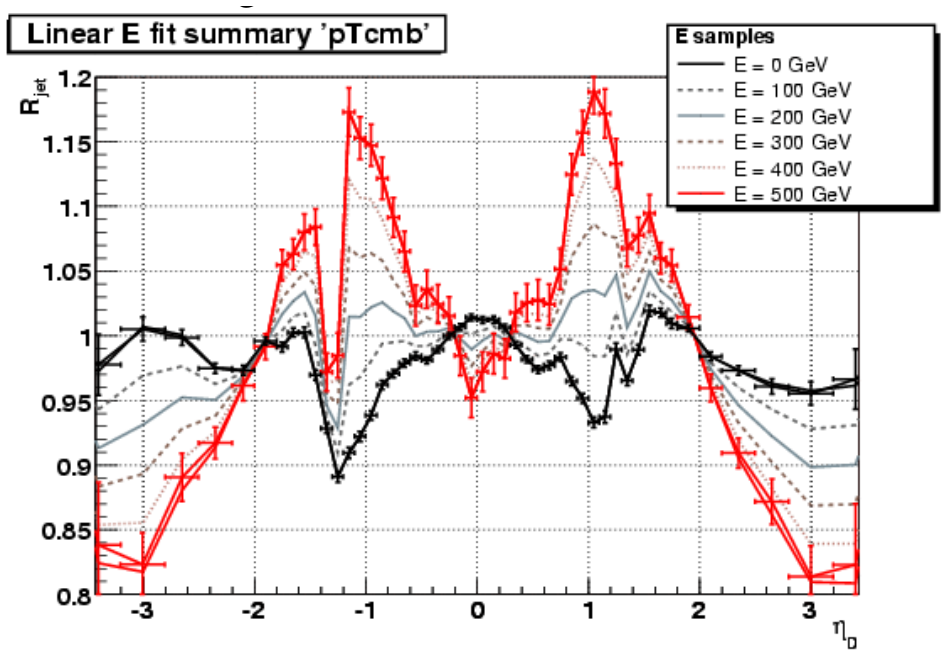


Response measurements: "MPF" method

- Study jet response using the "MPF" method: use γ+jet events, dijet events (here as an example for γ+jet)
- Theoretically: exact balance between photon and recoil jet:
  $E_{T,\gamma} + E_{T,recoil} = 0$
- In practice, take into account the response of EM and HAD detectors:
  $R_\gamma E_{T,\gamma} + R_{recoil} E_{T,recoil} = -E_{T,miss}$
- After EM calibration ($R_\gamma = 1$):
  $R_{recoil} = 1 + \frac{E_{T,miss} . n_\gamma}{E_T,\gamma}$ (projection on the γ direction)
- For very clean events: 1 photon and 1 jet, back-to-back:
  $E_{T,recoil} = E_{T,jet}$

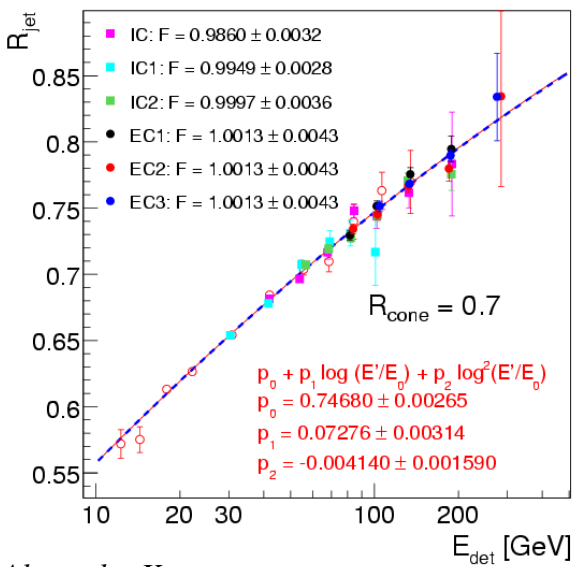
Eta dependent corrections: "MPF" method

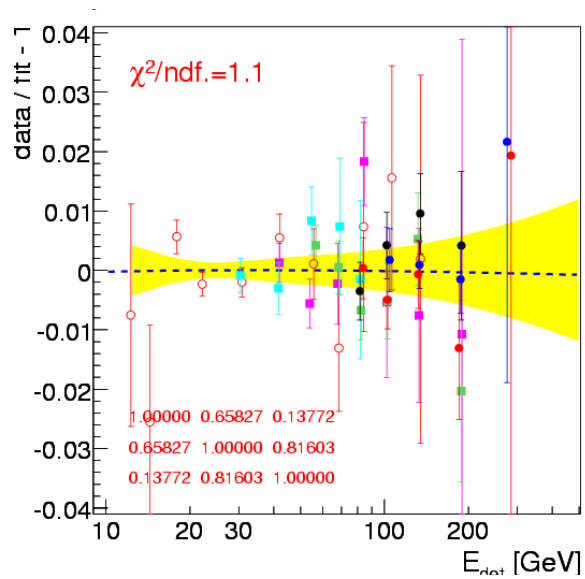
- Simple idea: equalize the response of the calorimeter as a function of rapidity
- Homogeneises the calorimeter to the same level as CC: use one single response curve as a function of energy
- Use MPF method for dijet events (more stats)
- Caveat: Different results for quark and gluon jets, depends on physics considered (top (quark dominated) or QCD (gluon dominated), $\longrightarrow$ two different corrections depending on the considered sample



Response measurements

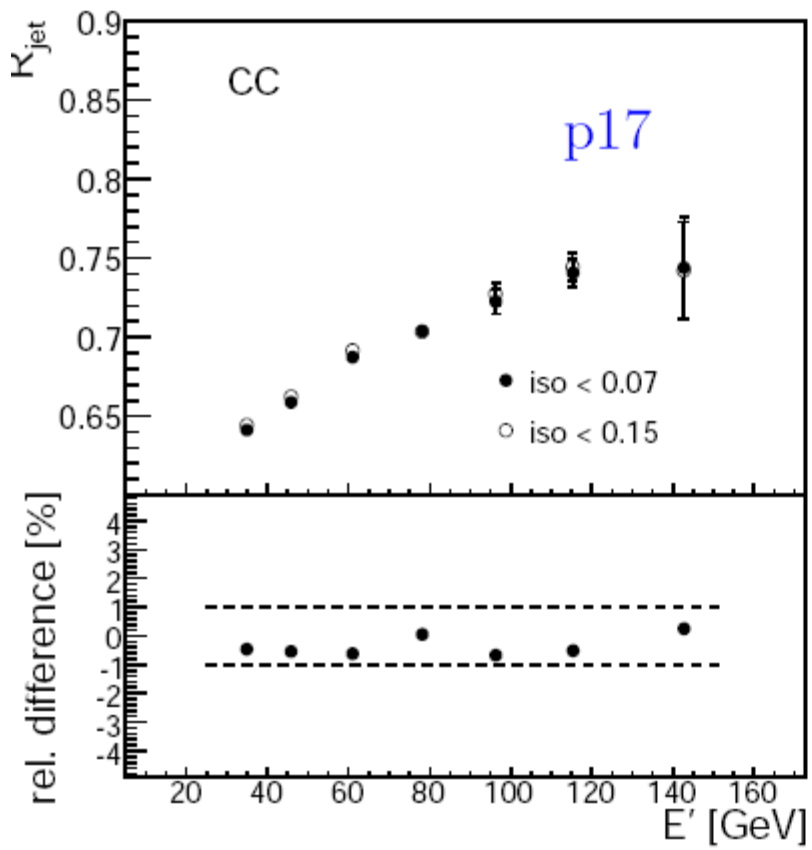
- Jet p_T response obtained using p_T balance in γ+jet events (MPF method)
- Single response curve for all calorimeter after offset and eta-dependent corrections
- Preliminary results shown with low luminosity, results being finalised



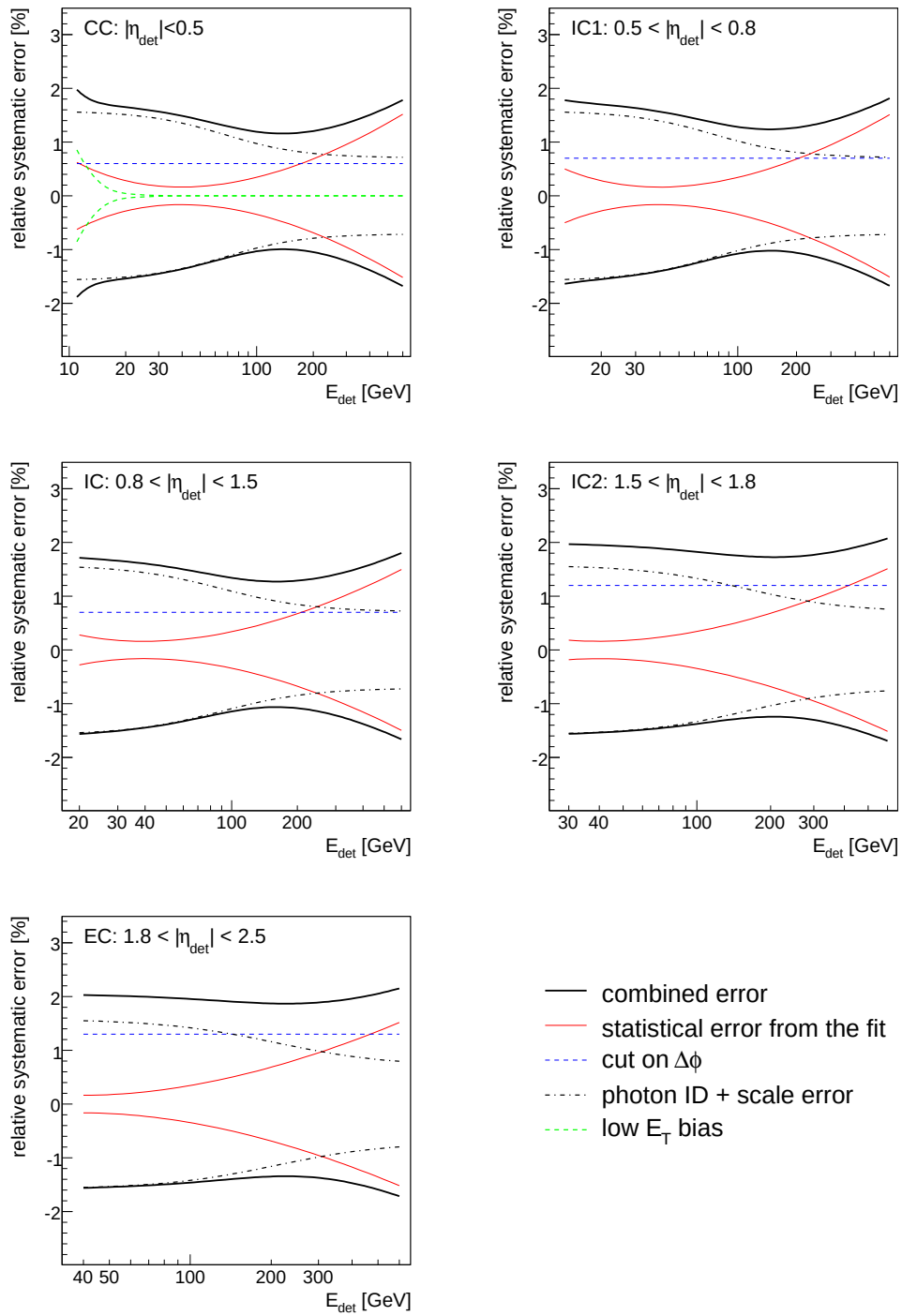


Response systematics and issues

- Main systematics and issue: difference between real γ and em like jets
- Example: two different cuts on photon isolation
- Different approach: Obtain independently the response from γ and EM like jets (either enriched samples in data with different Photon Ids, or MC based method)
- At the LHC: use Z+jet events, cleaner, not dependent on photon Id and purity



Response systematics

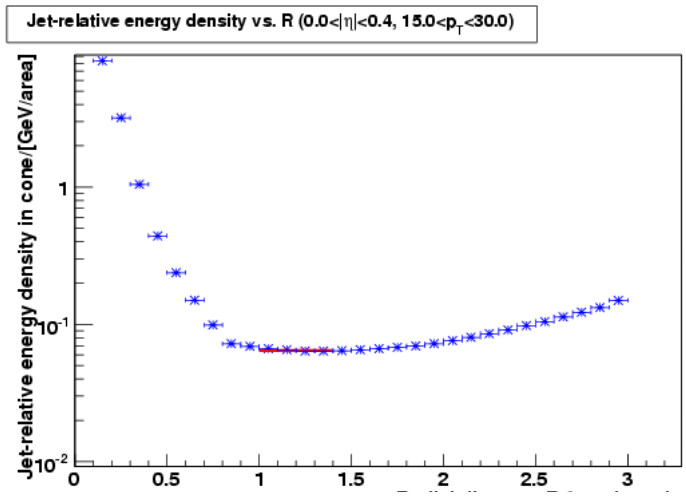


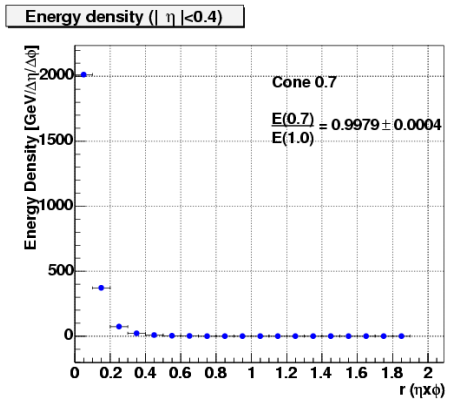
Showering determination

- Principle of showering corrections in data: Radiation emitted outside or inside the jet cone respectively by particles inside or outside the cone because of dead material
- Compute energy density in the calorimeter in η and ϕ bins around the jet directions
- Substract the offset and the showering effects in MC at generator level (particles emitted outside the cone)
- Compare with method using MC only: follow each particle through GEANT and measure the energy emitted outside the cone or inside the cone directly
- Showering corrections strongly related to the jet p_T response and to eta-dependent corrections: calorimeter calibrated relatively as a function of rapidity, and MPF method does not calibrate jets exactly but MET, part of the showering corrections are taken into account already by the method itself

Showering determination

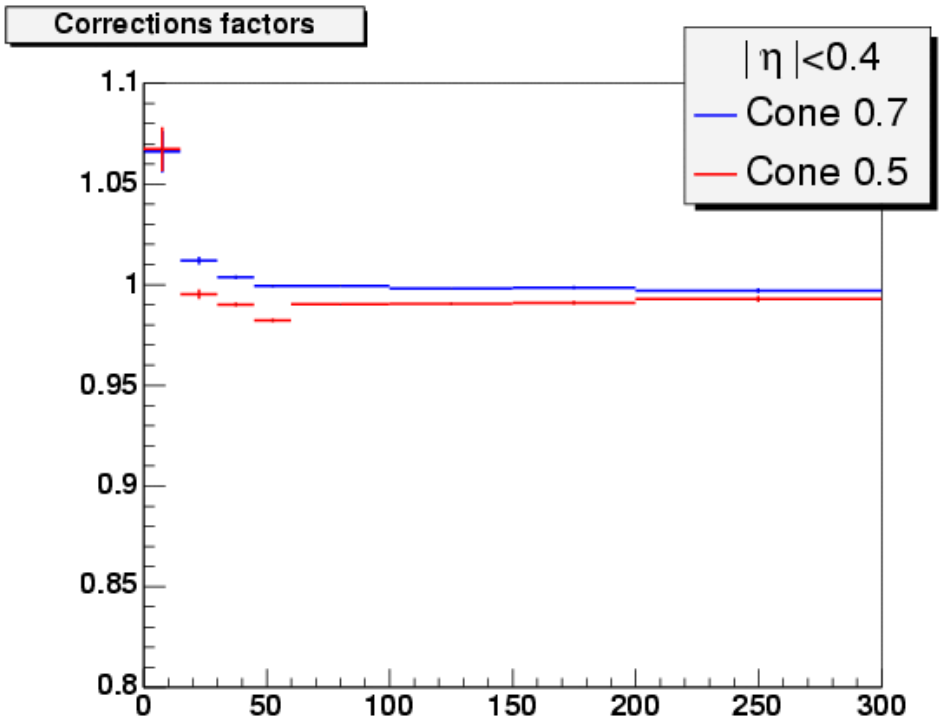
After MPF and eta dependent corrections → small showering corrections



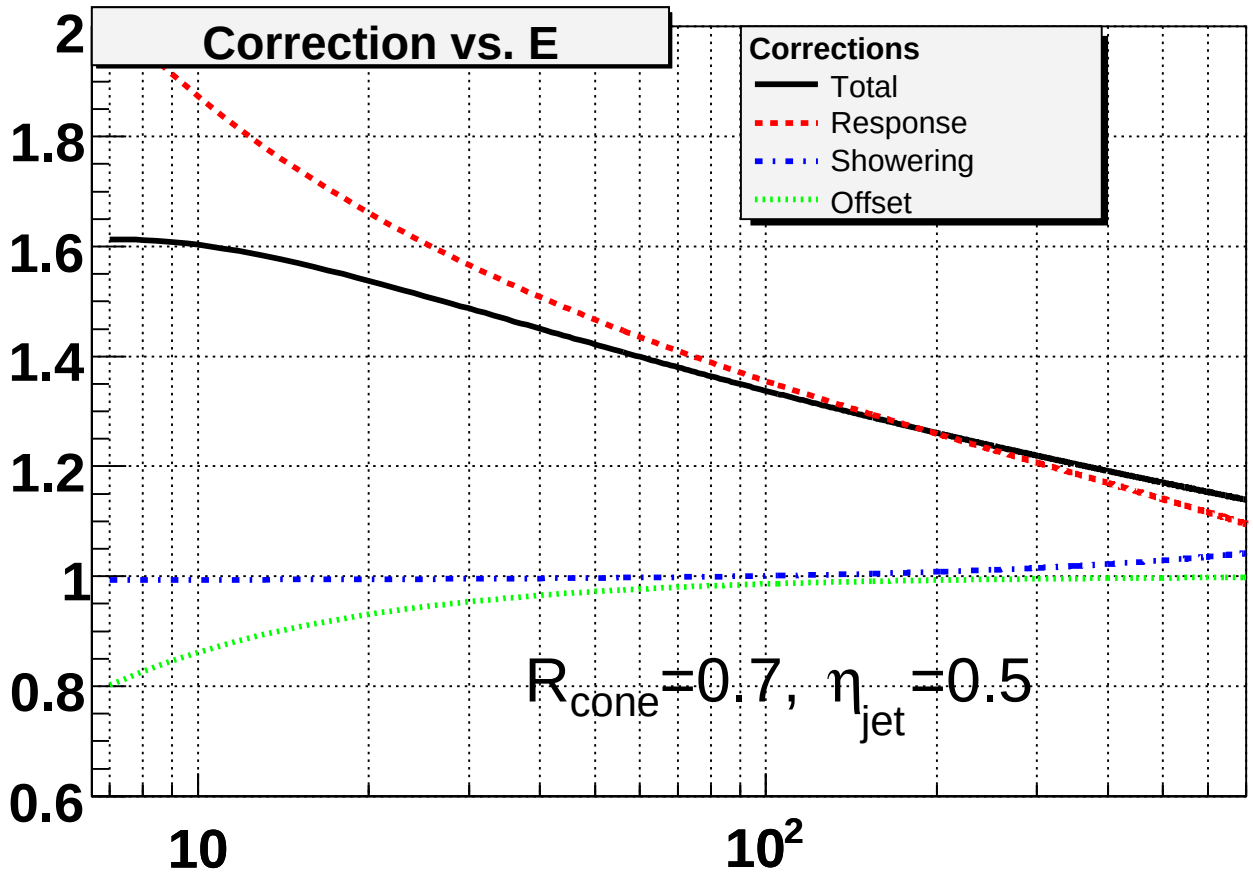


Showering determination

Showering corrections as a function of p_T

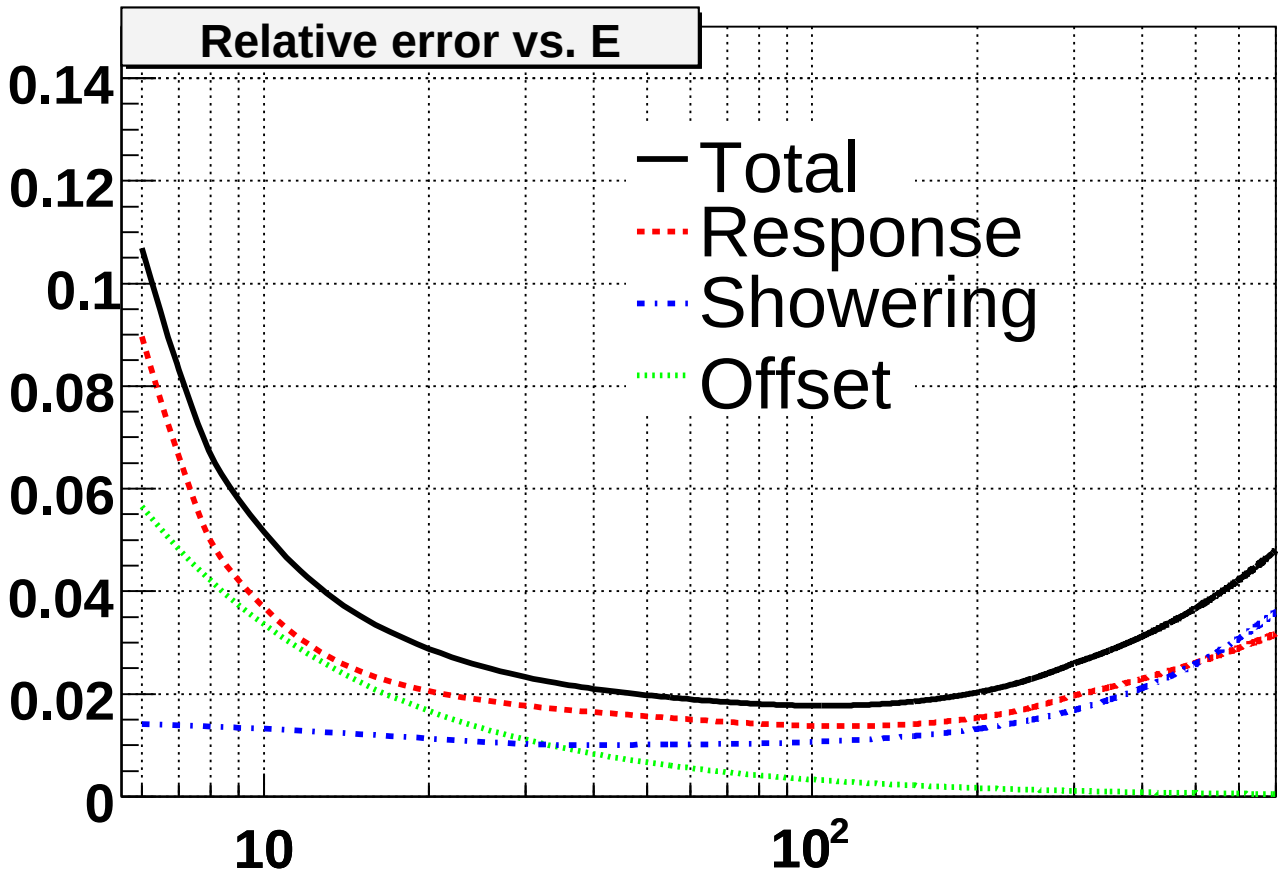


Preliminary JES corrections



Preliminary JES systematics

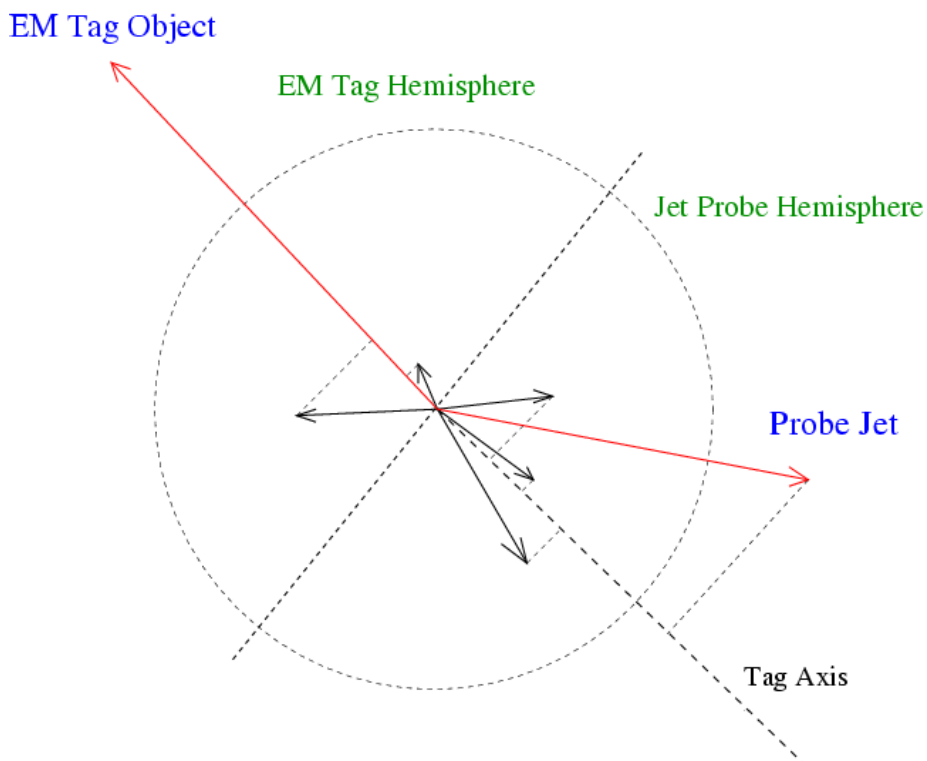
Systematics being further reduced at low and high jet p_T and high rapidity (limited by low stats



Closure tests

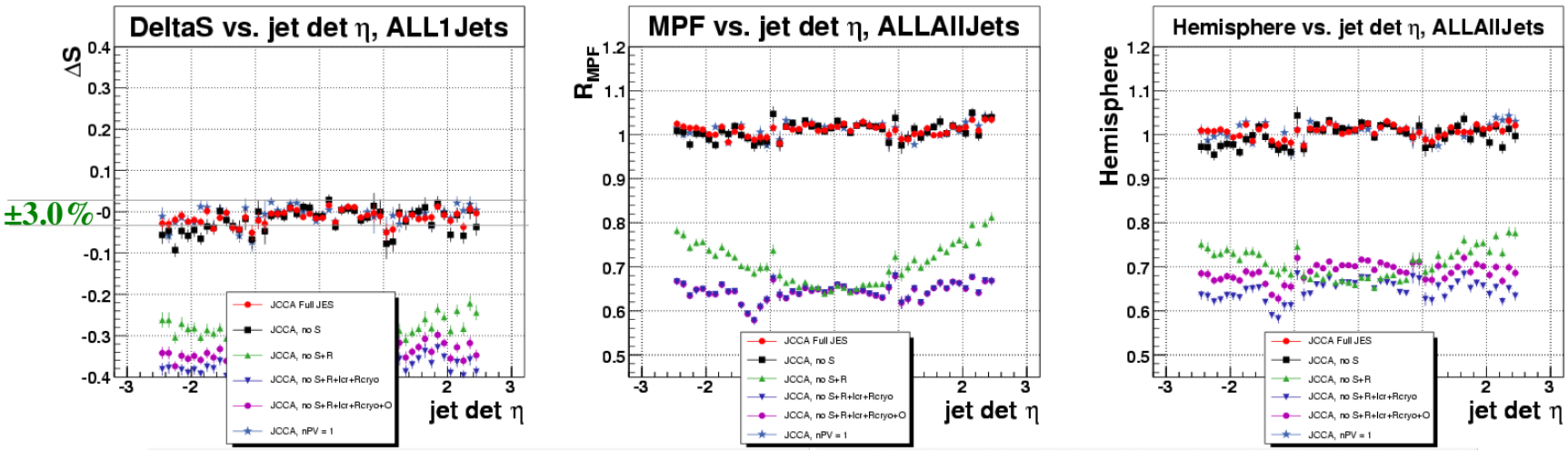
- Closure tests using MPF, ΔS and Hemisphere methods
-

$$
\begin{aligned}
R_{MPF} &= 1 + \frac{E_{T,miss} \cdot n_\gamma}{p_{T,\gamma}} \\
\Delta S &= \frac{p_{T,jet} - p_{T,\gamma}}{p_{T,\gamma}} \\
H &= \frac{\Sigma_{probe\ hemi.} |p_{T,i} \cdot n_{\gamma|}}{\Sigma_{tag\ hemi.} |p_{T,j} \cdot n_{\gamma|}}
\end{aligned}
$$



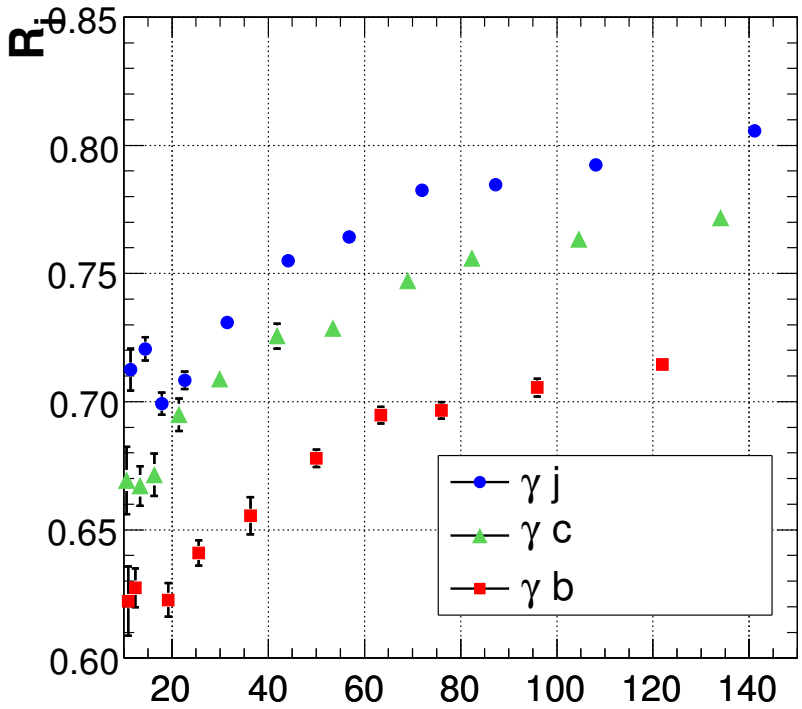
Results of closure tests

- Closure tests using MPF, ΔS and Hemisphere methods
- Important to do the comparisons both in data and MC: each method suffers from its own biases, and the biases should be the same in data and MC



b JES

- Special corrections needed for b jets
- Two kinds of corrections: when a muon is tagged in the final state or not
- Large corrections on jet response



Conclusion

- Description of JES corrections in DØ : offset, jet p_T response, showering
- Final JES in progress: ready soon, improving sytematics, performed using full luminosity available
- Main issues and caveats: Purity of the γ+jet sample (very much related to γ Id), correlations between corrections (eta dependent corrections and showering as an example)
- LHC: probably easier using Z+jet events