Calorimeter Calibration for p17

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for the Cal. Calib. Task Force:
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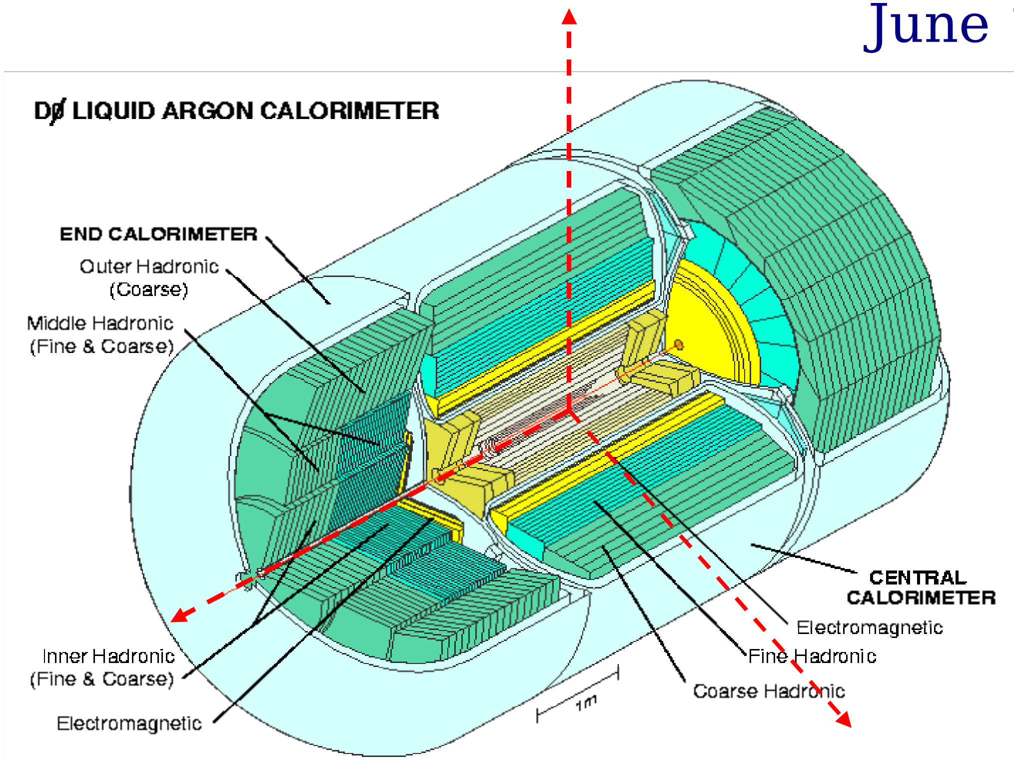
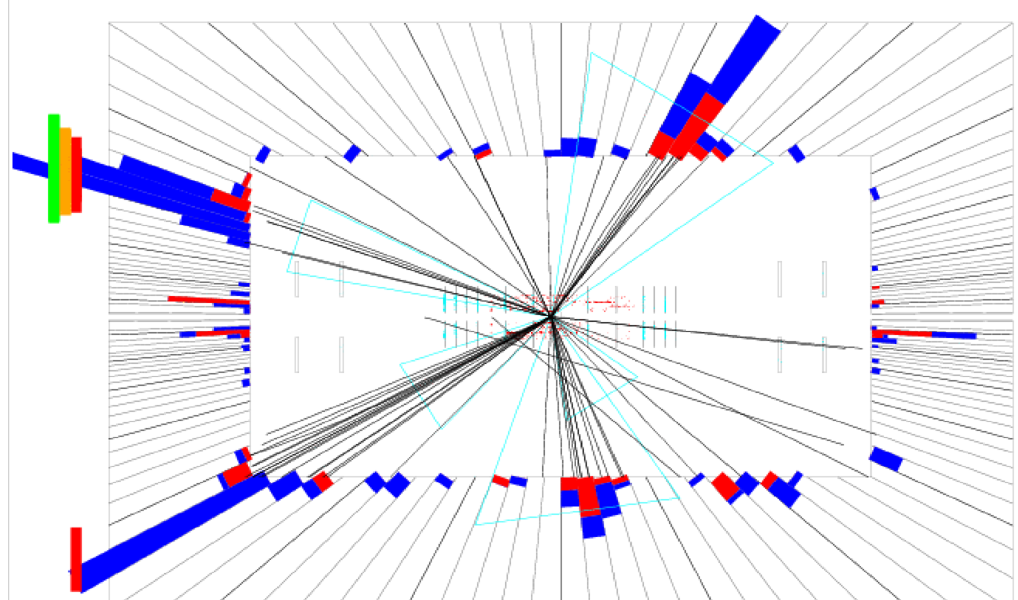
Krisztian Peters, Jiri Kvita, Andy Haas,
Mikolaj Cwiok, and Amnon Harel

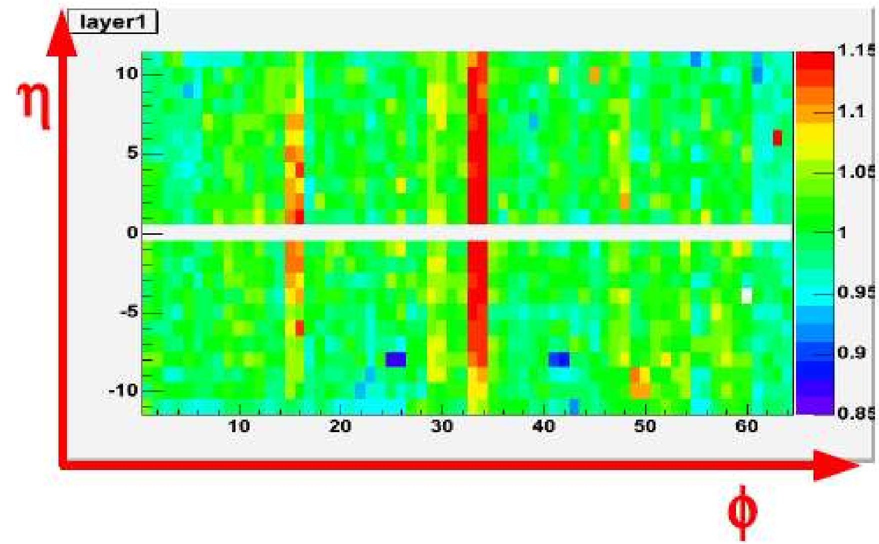
Vancouver Meeting
June 16, 2005

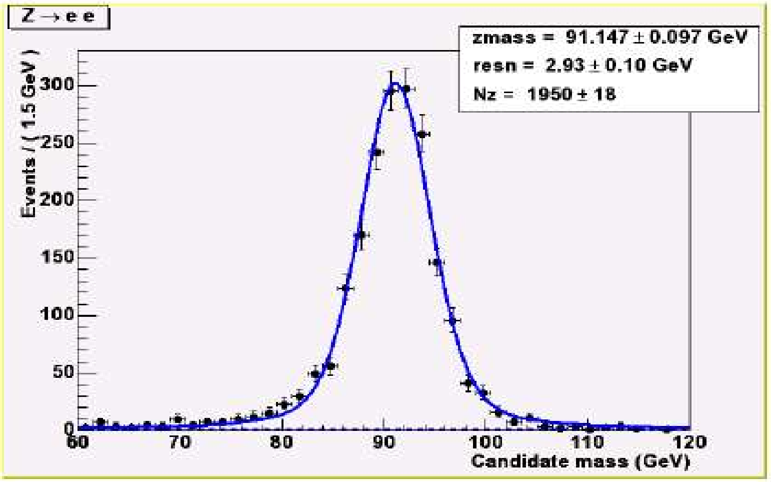




Introduction / EM Calibration

- **Determine a multiplicative calibration constant for each cell of the calorimeter**
  - maximize energy resolution
- Constants are measured using data, since calibration pulses do not account for all effects
- Divide task into EM and Hadronic calibration
- Initial EM calibration was completed a few months ago:
  Jan Stark and Matt Wetstein
  - Response normalized in phi at fixed eta using special calibration data
  - Response for each eta ring calibrated using Z->ee events, and known Z mass
- Significant progress was made in understanding the Z->ee resolution in data (2.9 GeV) vs. MC (2.0 -> 2.4 GeV)
  - Incomplete material description in MC (solenoid, etc.) is the main cause
  - Remaining difference due to charge collection effects?





Detector resolution improved from 3.35 to 2.9 GeV

13%!

Hadronic Calibration: 3 months ago...

The Calibration Group needs You

- Need 1 FTE for 2+2 months
- Urgent work, dedicated person (100% of time)
- Use tools developed for calibration of EM calorimeter
- Data for STEP 1 available soon, provided by Jan/Marco
- JES group to prioritize development of tools for CAF based analysis, make tools available
- CSG group will provide data for STEP 2
- Start working NEXT week

Put your picture here

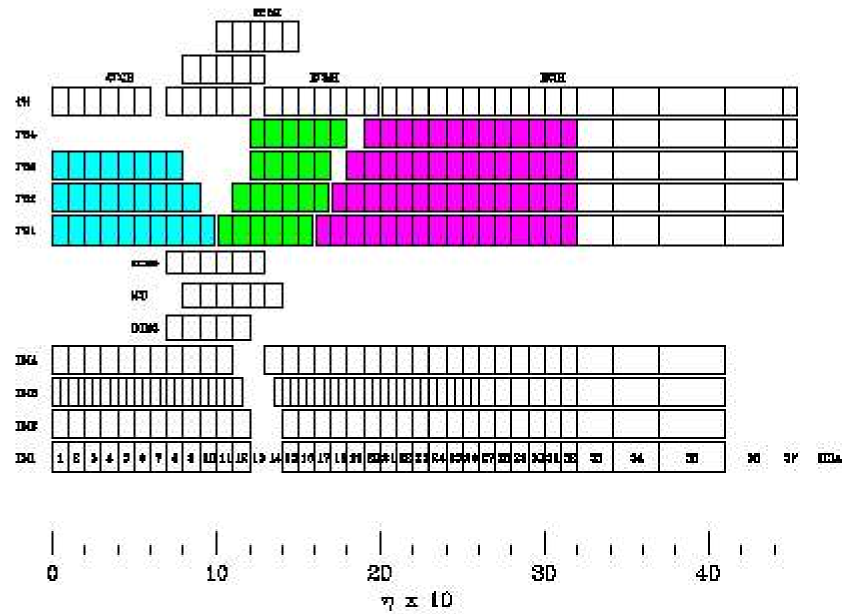
DØ Collaboration Week 03/04/05 15

Hadronic Calibration Overview

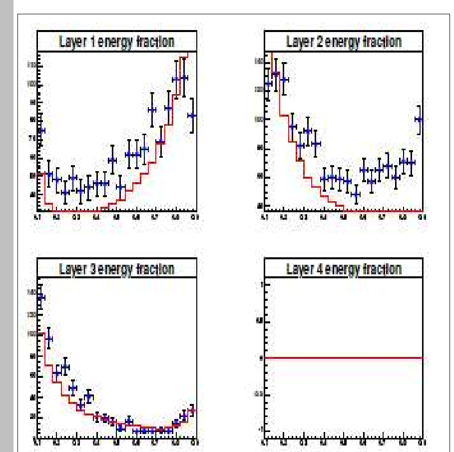
- Goal was to have constants available for p17 re-processing by July
- Task force was formed, divided in two groups, led by :
  Jan Stark and Marco Verzocchi
  - Inter-phi calibration :
    Krisztian Peters and Jiri Kvita
    - Normalize response in phi at each fixed eta for all layers, using special calibration data
  - Eta-ring / overall calibration :
    Andy Haas and Mikolaj Cwiok
    - Use phi/layer constants from inter-phi calibration
    - Provide a constant for each eta value and an overall hadronic energy scale
    - Use p17 di-jet data
  - Additional method being pursued by Amnon Harel based on jet profiles -- results will be cross-checked, where they can

Hadronic Inter-phi Calibration

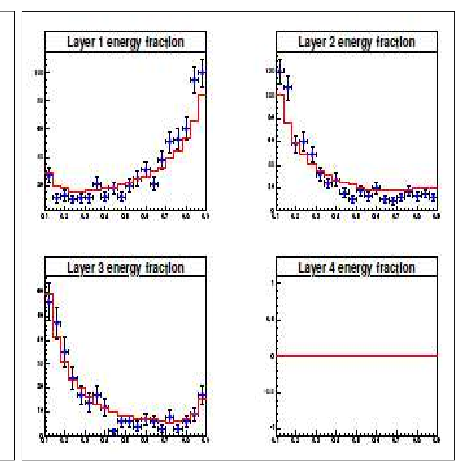
- Use same concepts and code that worked for the EM inter-phi calibration
  - Assume phi symmetry of energy deposition in detector
  - Count the number of times each cell has $E_T > 9$ GeV
  - Use average layer fractions to calibrate each layer of each tower
  - Special calibration data was collected during physics running, starting March 12, 2005
    - Nearly unbiased w.r.t. 9 GeV offline cut
      - L1 tower > 5 GeV
      - L2 tower > 5 GeV in fine hadronic (FH)
      - L3 precision tower > 7 GeV in FH
    - >15M events collected so far
  - Beware of “bad” cells
    - Dead trigger towers, dead towers, dead cells, low / high energy noisy cells…
    - These must not harm the calibration of other cells



|eta|



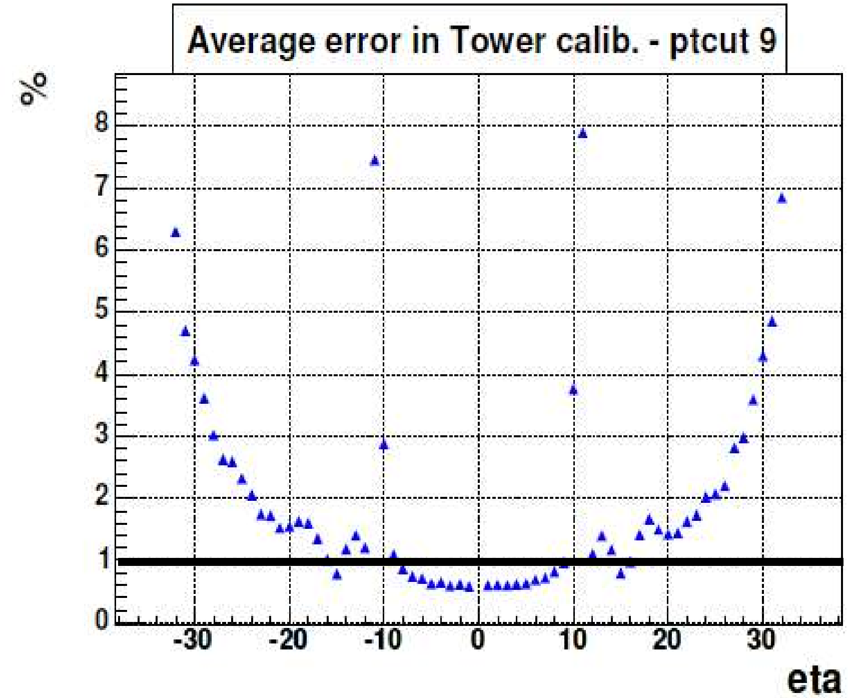
before…



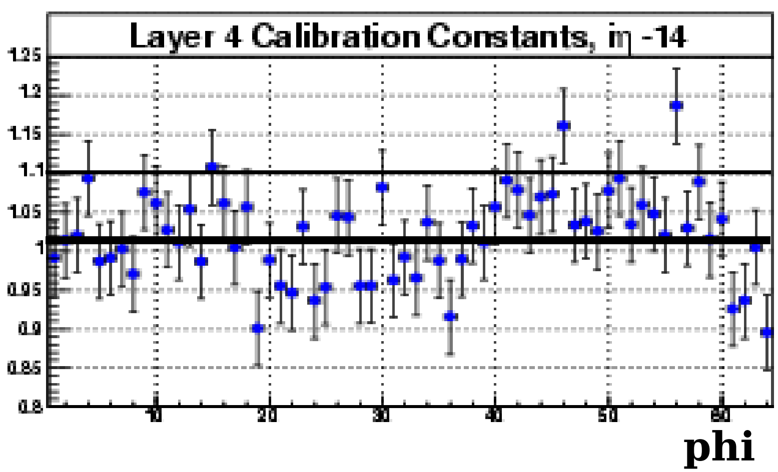
after…

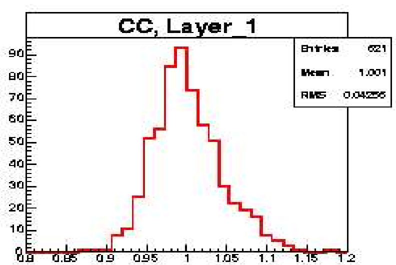
Hadronic Inter-phi Calibration Results

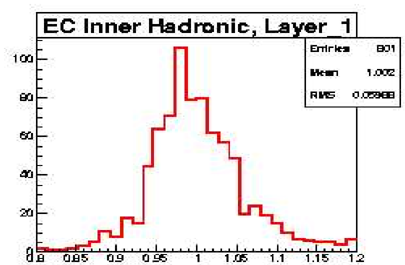
- So far, 6.5 M events are analyzed
  - Errors are <1% in CC
  - Towers used at high |eta| due to low statistics
- Constants vary by ~5% for good cells
  - A few miscalibrated modules found, by ~10%
  - Some long-range effects found, by ~5%
- No constants for CH or ICD cells, yet
  - Amnon's method does have access to these

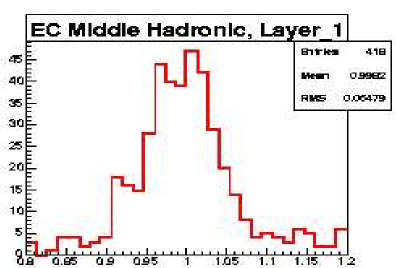


+10%





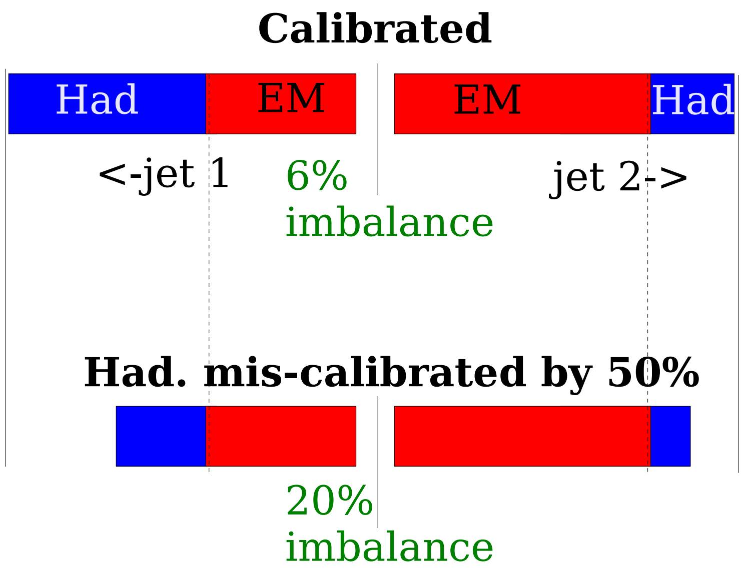




Constants have RMS=~5%

Hadronic Eta Calibration

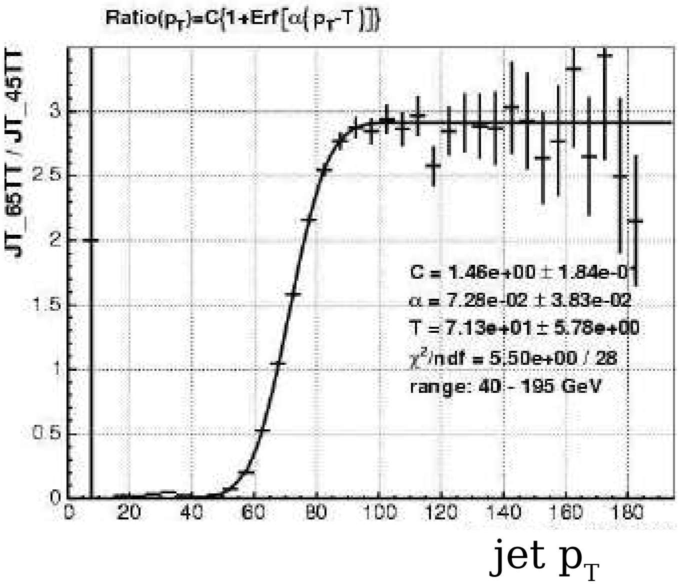
- Determine an overall calibration constant for each eta-ring
  - 64 constants from -3.2<eta<3.2
- Determine an overall constant for each layer within each eta-ring
  - Up to 6 constants for each eta-ring: ICR,FH1,FH2,FH3,FH4,CH
- Method: use QCD di-jet events, and minimize the total missing p_T fraction of the events, using the cells within the jets
  - Assume EM layers are calibrated
  - An overall Hadronic scale can be determined since the EM fractions of jets are uncorrelated in each event
- Also, Amnon has provided numbers based on jet profiles that we will cross-check with



Hadronic Eta Calibration: Event Samples, etc.

- p17 QCD data skim – 21M events, so far
  p14 QCD MC – about 1M events
- Special Rootuple maker that reconstructs cone 0.5, 0.7, 1.0 jets and keeps their associated cell info
- Perform a 64 parameter Minuit fit, to determine eta constants
  - Need to loop over all the events ~5,000 times, adjusting the eta calibration constants each time
  - Solution was to “pre-chew” the events
    - store only the events passing cuts
    - sum the cells in phi
    - discard info about EM sublayer
    - store all needed data in an STL structure in memory (~2 GB)
  - Result: can process at > 100kHz, iteration takes ~1 minute, full fit takes only ~1 hour

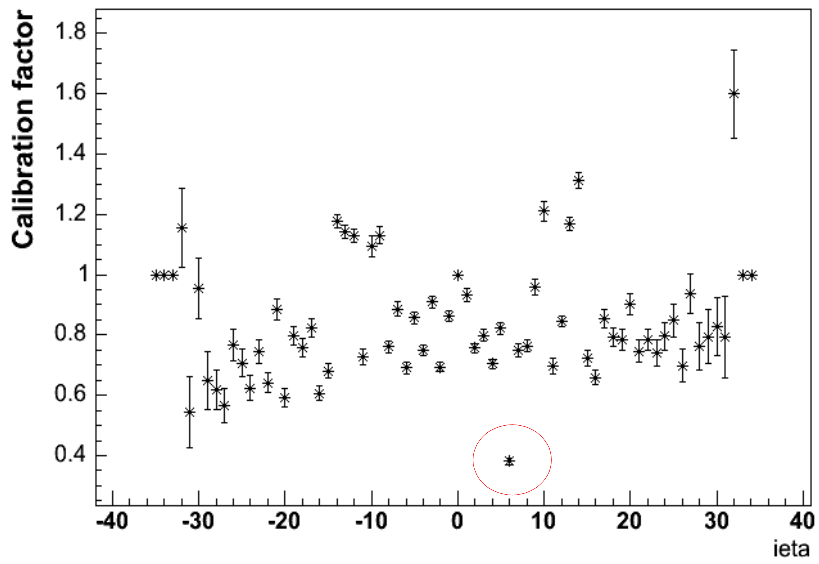
Loose selection cuts:
- Exactly 2 jets, both passing quality cuts
- Leading jet p_T above trigger bias

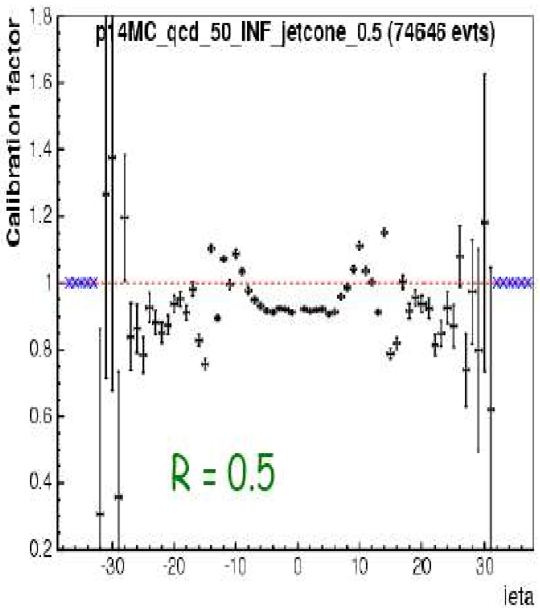


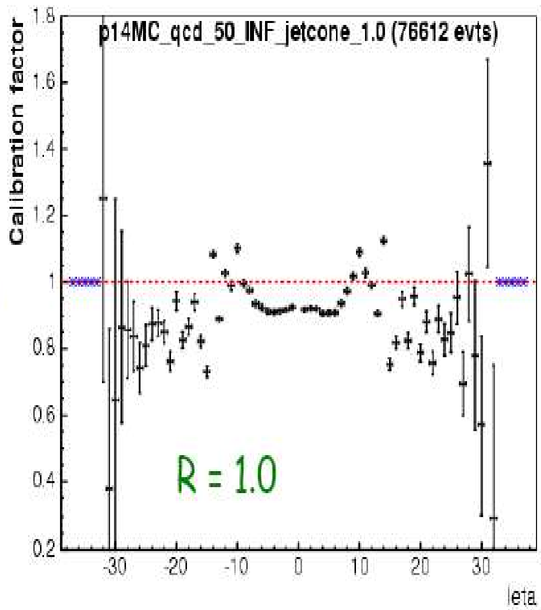
Additional tight selection cuts:
- ME_T < 50 GeV
- d-phi > 2.9 rad.
- |eta| of both jets < (3.2 - conesize)

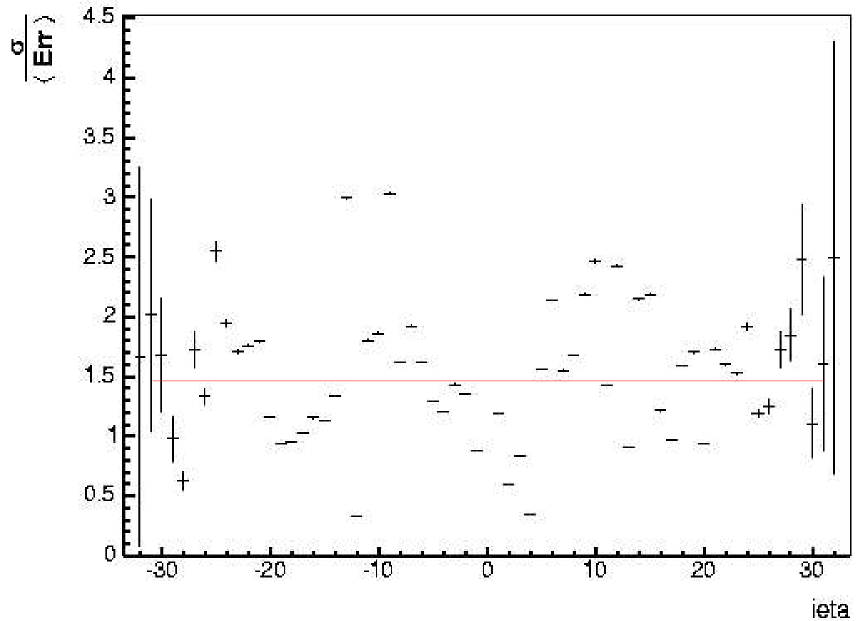
Hadronic Eta Calibration: A Few Checks

- Adding a miscalibration recovers the full miscalibration and does not effect other constants
- No significant dependence on the jet cone size used
- The statistical errors returned by the fit are close to the true statistical variation





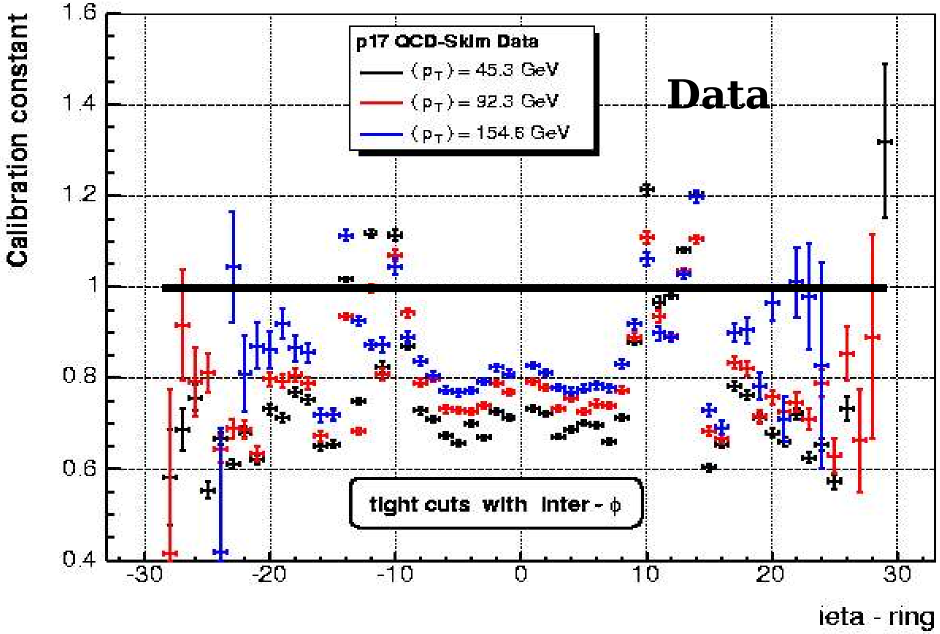


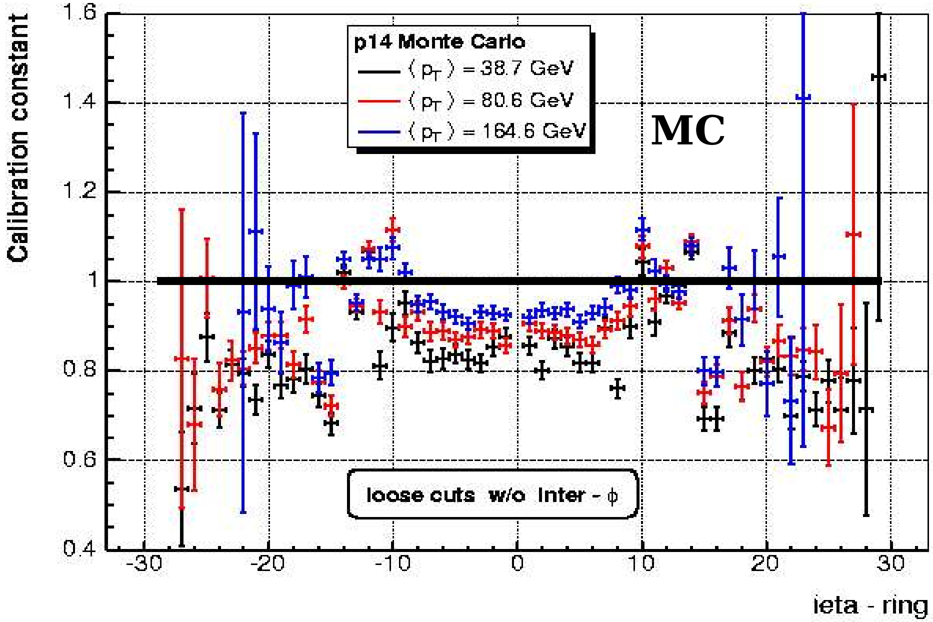


Hadronic Eta Calibration: Dependence on p_T

- For most eta-rings, the constant which maximizes resolution increases vs. jet p_T
  - A similar dependence is observed in data and MC
- What does this mean?
  - Weighting the hadronic cells more heavily includes more noise into the jets?
  - Non-compensation effects?
  - Essentially, the EM and Hadronic calorimeters have different performances for jets as functions of energy

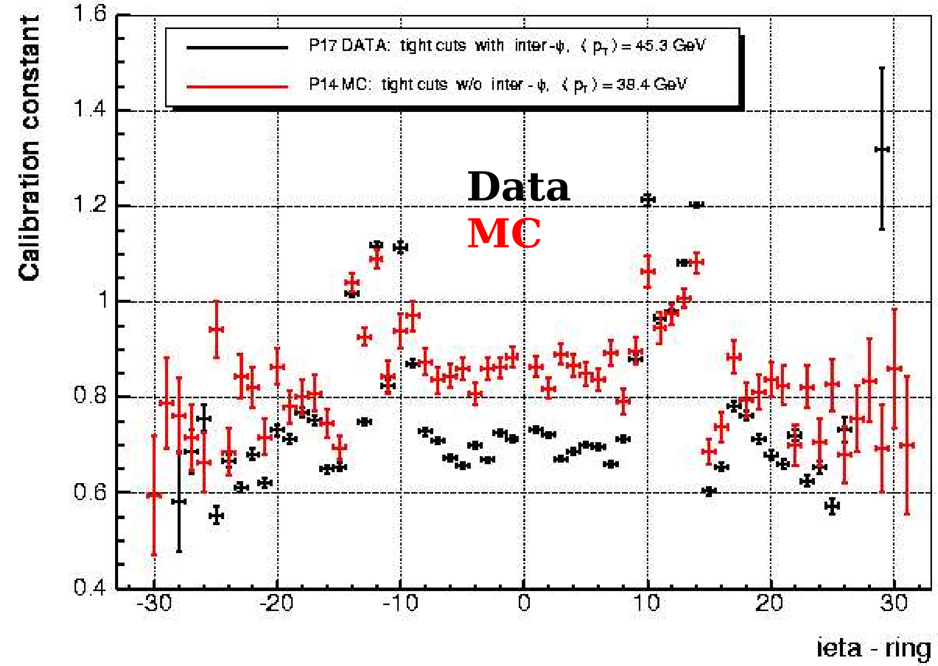
    A tradeoff between stochastic and constant terms in the energy resolution

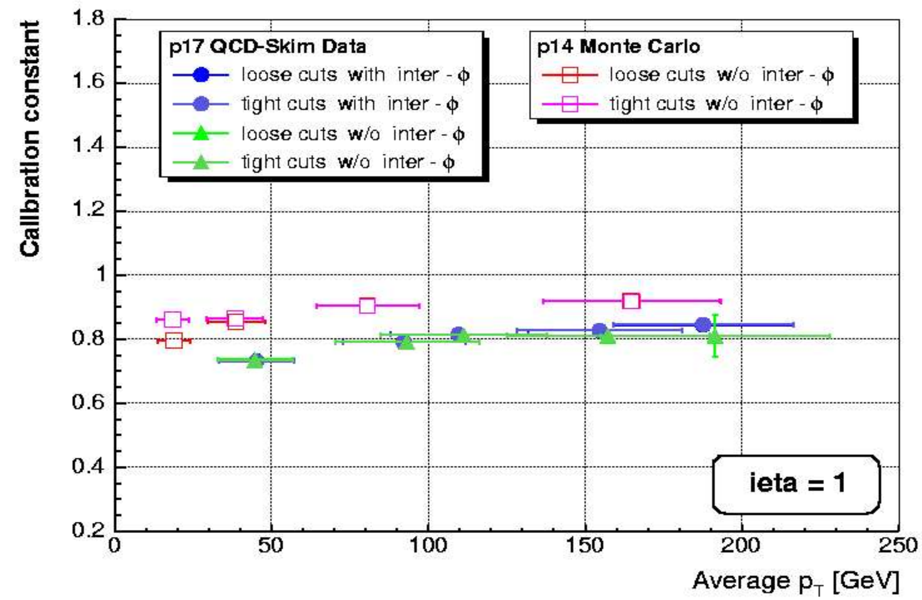




Hadronic Eta Calibration: Data / MC

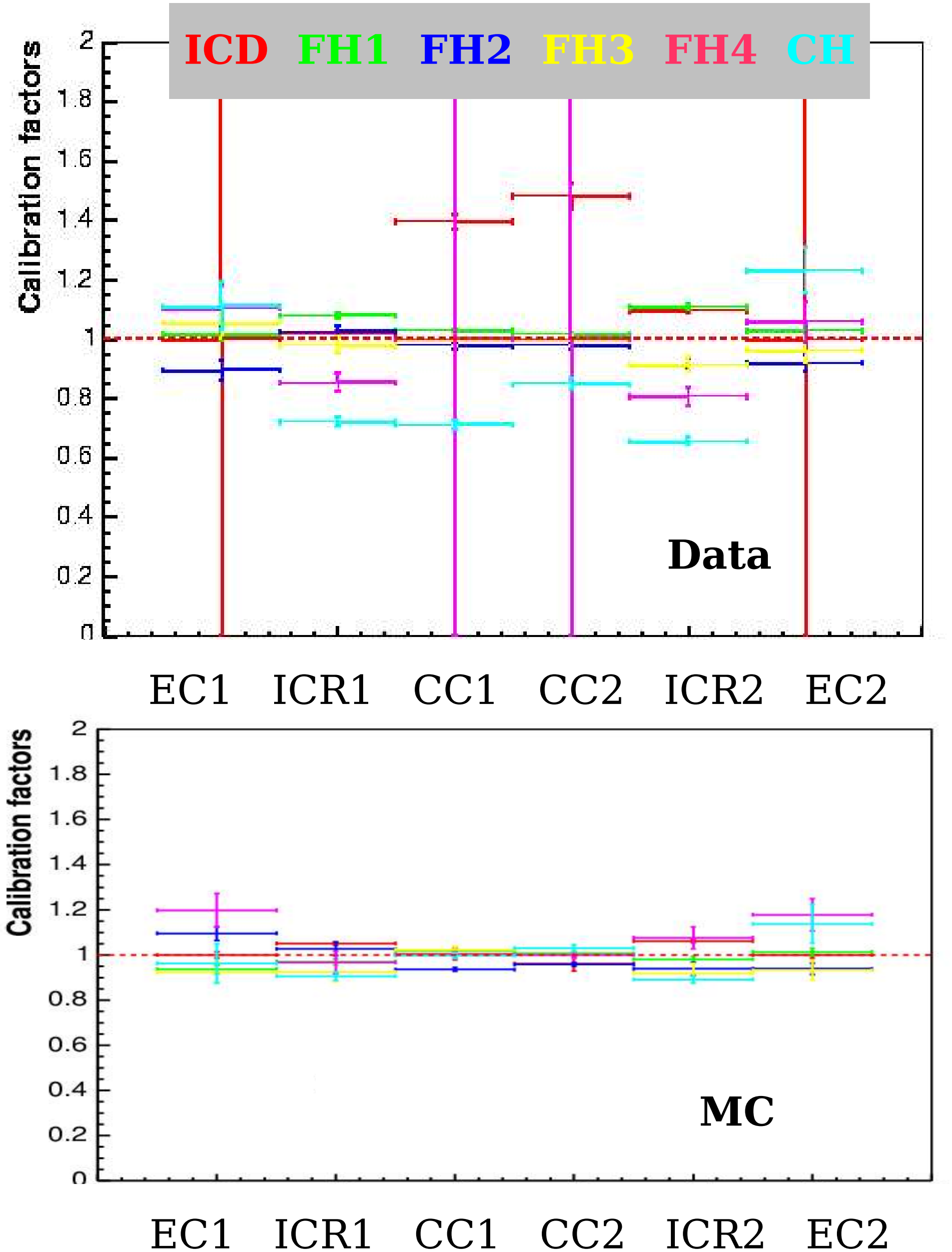
- At any given p_T range, data seems to be overweighted, compared to MC, for most eta-rings
  - 10% caused by known pulser problem? (Larger capacitances of hadronic cells leads to reflections in the calibration pulses.)
- The ratio of data / MC remains fairly constant vs. jet p_T range
- Even in MC, the eta-ring calibration factors would reach unity only for very high p_T jets (>500 GeV)
  - Current layer weights were determined using single pions with p_T = 20 GeV
  - Should we re-calibrate the MC ?!
- Is the cone jet algorithm optimal? Couldn't the calibration constants be adjusted for cells in a jet once an initial measurement of the jet energy is made?





Hadronic Eta Calibration: Layer Constants

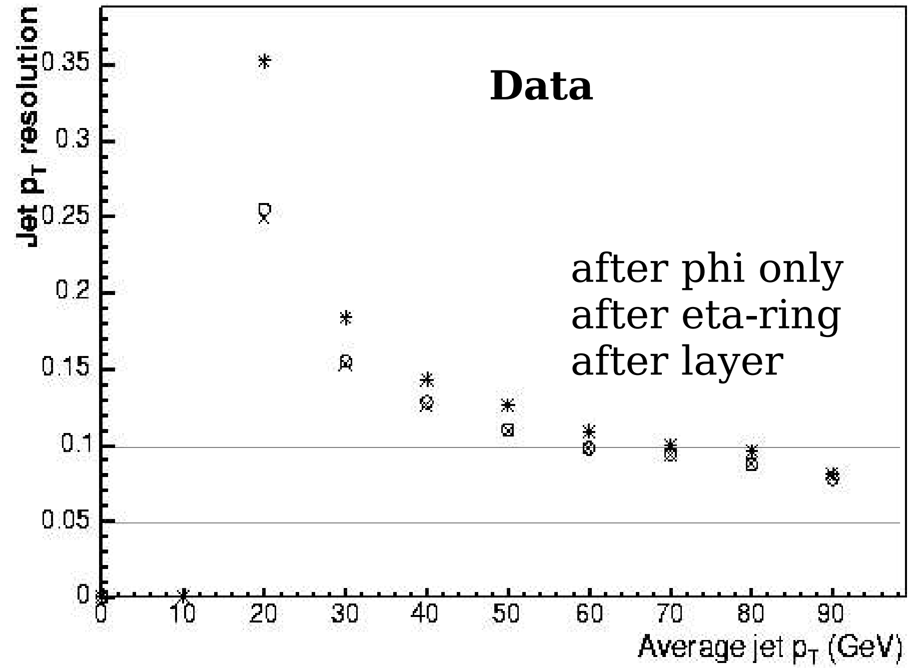
- Layer constants can be determined:
  - overall, averaged over all eta-rings
  - for each section: CC, ICR, EC
  - or for each eta-ring individually
- CH is disfavored in the central regions
  - Noisier?
- ICD/MG layers seem to be underweighted in the data

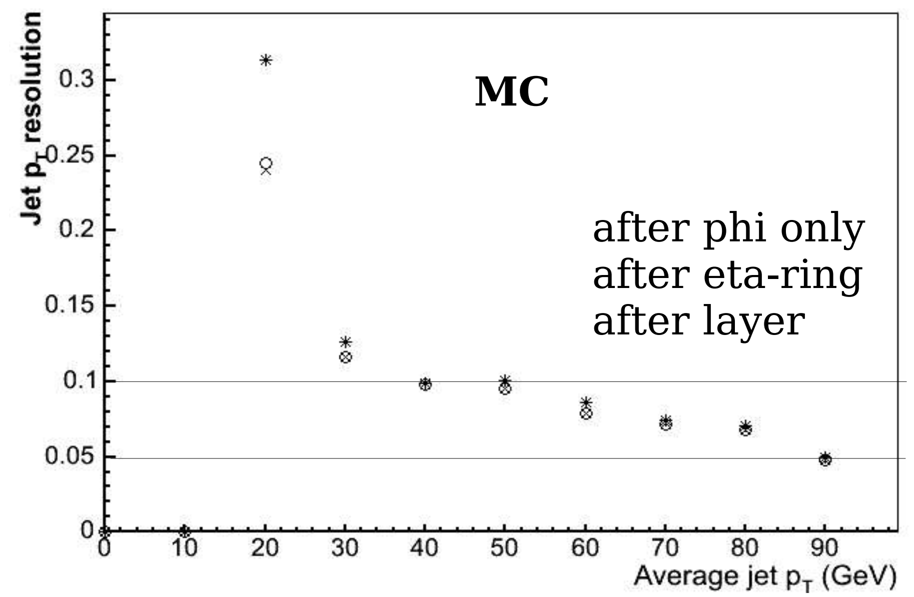


Hadronic Calibration: Jet p_T Resolution

- The phi-intercalibration has little effect on the overall jet energy resolution
  - This was surprising at first, but can be understood, since jets average over N cells… non-coherent effects will be reduced by a factor of ~1/sqrt(N)
- The layer weights seem to have little effect on the jet energy resolution… only the ICD/MG and CH have significant modifications
- The stochastic term can be reduced in data and also MC by the eta-ring calibration-> better resolution at low p_T
- The calibrations do not seem to improve the constant term -> little improvement for high p_T jets

  Why so much worse than MC? Run I?
  - Material effects? More non-compensating in Run II (different sampling time)? Less complete response to slow neutrons?



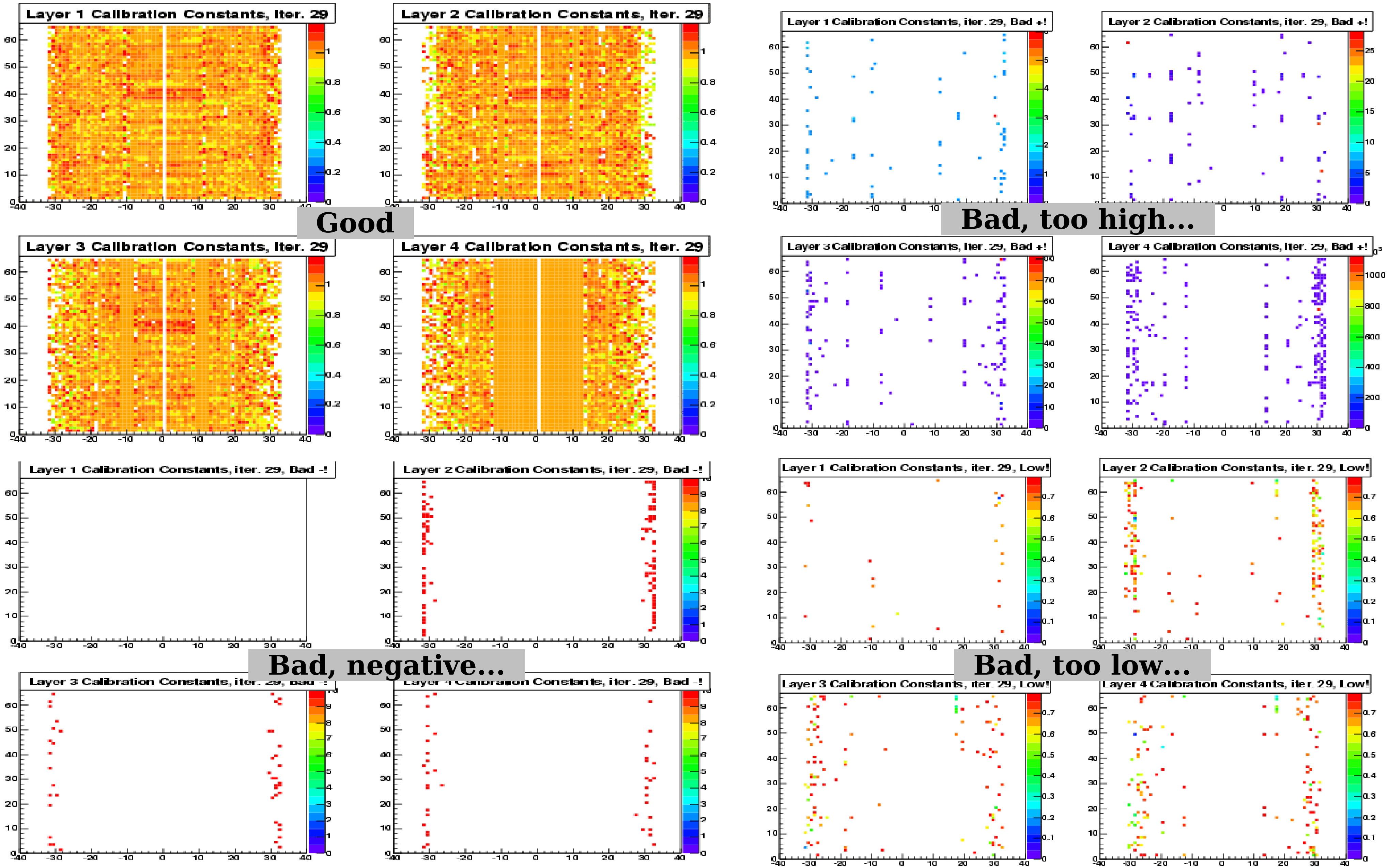


Conclusions

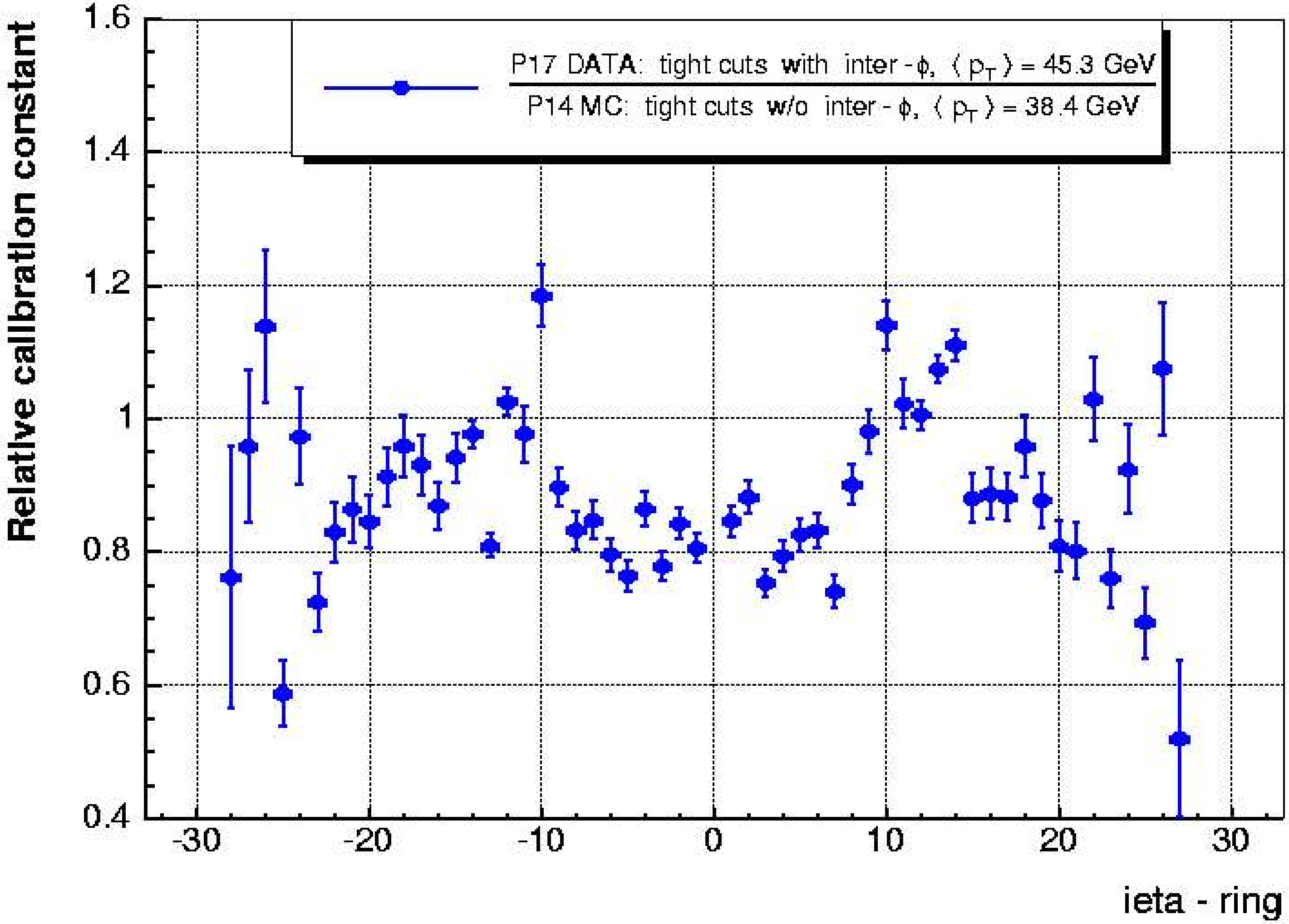
- p17 will have an improved calorimeter calibration, available in July
  - EM calibration
    - Z->ee resolution is ~13% better than p14
    - Better modeling of material in MC
    - To do: Check constants on more recent data, and verify stability
  - Hadronic calibration
    - The goal was ambitious: complete the calibration in ~3 months
      - But we will succeed, and on time!
      - The group works well together, and has good leadership
    - Better jet energy resolution. Better ME_T resolution?
    - To do:
      - Perform some final tests... constants stable over time?
      - Inter-phi: run over full 20M event special calibration sample
      - Inter-eta: run over a larger p17 QCD data sample
      - **Understand / interpret results in data / MC**
- **Longer term:**
  - Continue to take calibration data to the monitor stream
  - Document! We'll want to re-run the calibration for future data sets...
  - Try to understand the difference in the constant term between Run II data and MC
    - Perhaps an understanding will lead to a partial solution?

Backup Slides...

Hadronic Inter-phi Calibration Constants



Data/MC Ratios for Hadronic Eta Calibration



MC, with / without inter-phi

Adding wrong phi intercalibration constants to the MC has almost no effect on the jet pT resolution