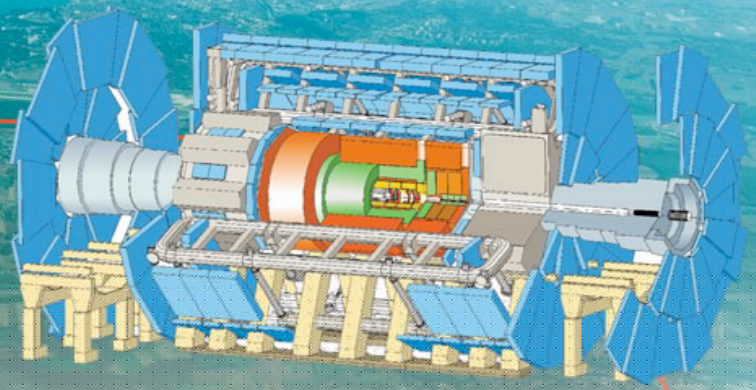
Chicago ATLAS Group

J. Pilcher

January 11, 2007



Introduction

- Very exciting time for the LHC program and ATLAS
  - First collisions later this year
  - ATLAS will be ready
- Chicago has participated in ATLAS since 1994
  - Tile Calorimeter test beam studies
    - 1994-2002, 2004
  - Hardware preparation
    - TileCal front-end electronics
  - Detector installation and commissioning
  - Software preparation
    - Calorimeter data reconstruction
    - Jet analysis
  - Physics studies
  - Organizational and leadership responsibilities

Overview of the Group

- Faculty
  - Young-Kee Kim (also CDF)
  - Frank Merritt
  - Mark Oreglia
  - JP
  - Mel Shochet (20% CDF)
  - Search underway for junior faculty member in experimental HEP
    - Might join ATLAS

Overview of the Group

- Research personnel (5.1 FTE)
  - Kelby Anderson
  - Erik Brubaker (0.5 FTE, also on CDF)
  - Monica Dunford (Fermi Fellow)
  - Rob Gardner (0.1 FTE)
  - Ambreesh Gupta
  - Giulio Usai
  - Kohei Yorita (0.5 FTE, also on CDF)
- Graduate students (5)
  - Martina Hurwitz
  - Imai Jen-La Plante
  - Eric Feng
  - Tudor Costin
  - Anton Kapliy

Overview of the Group

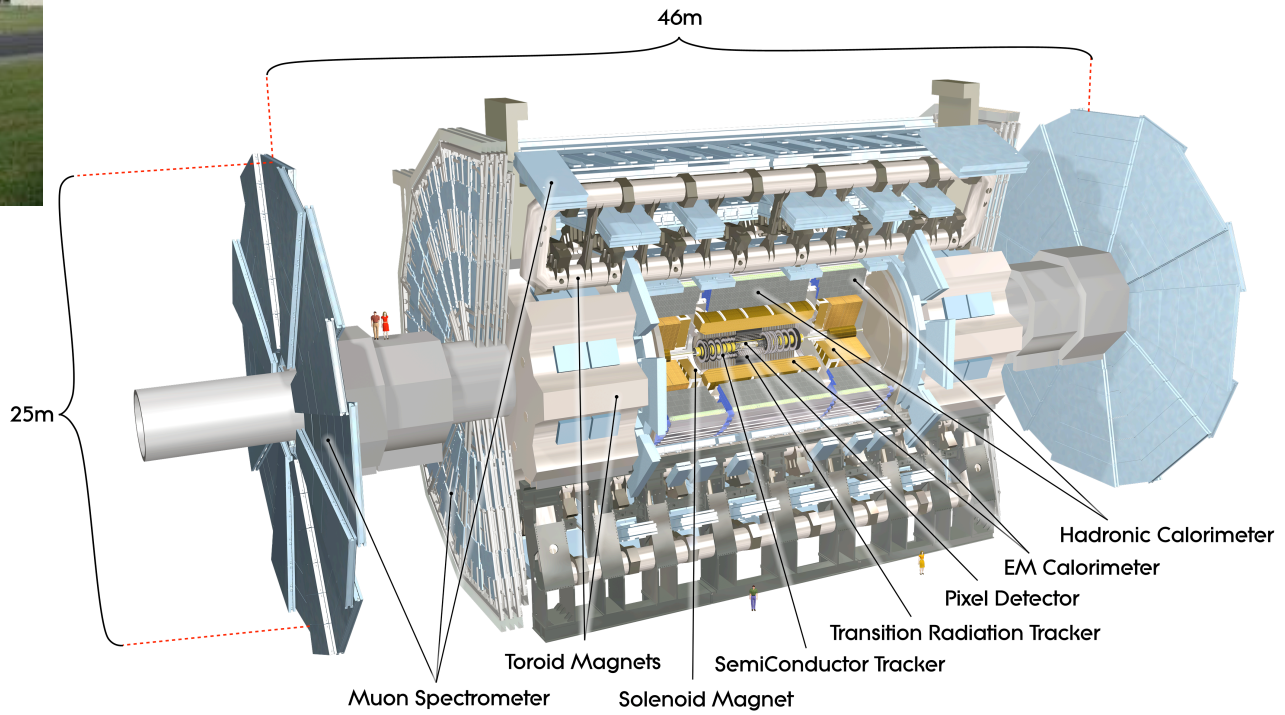
- The Chicago team based at CERN
  - Essential for detector commissioning, startup, early physics
  - 2 postdocs (Giulio, Monica)
  - 3 grad students (Martina, Imai, Eric)
  - Technical personnel supported by US ATLAS M&O funding
    - 2 junior techs
      - Chicago BSc graduates hired for 1 year
    - 1 senior tech
      - Russian applied physicist
      - Plays critical role in TileCal assembly, commissioning
  - Regular faculty visits
  - Weekly phone conference

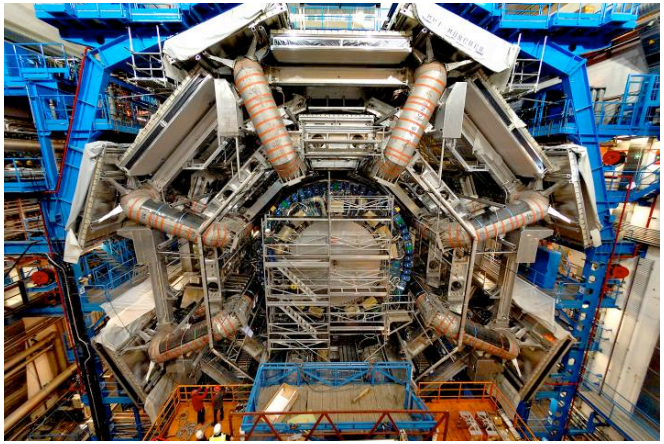
Overview of the Group

- Essential infrastructure at Chicago (see on tour)
  - Electronics Development Group
    - Hardware design and support
    - New work for sLHC
  - US ATLAS Tier 2 / 3 computing facility
    - Joint with Indiana University
  - Remote monitoring station
    - For remote hardware diagnostics, data quality monitoring, etc.
- Close cooperation with Argonne on ATLAS TileCal
  - ANL did mainly TileCal mechanics
  - Chicago did mainly TileCal electronics
  - Working closely on joint physics activities
    - Also joint US ATLAS computing projects
  - They operate mid-west analysis support center (US ATLAS funded)

The ATLAS detector

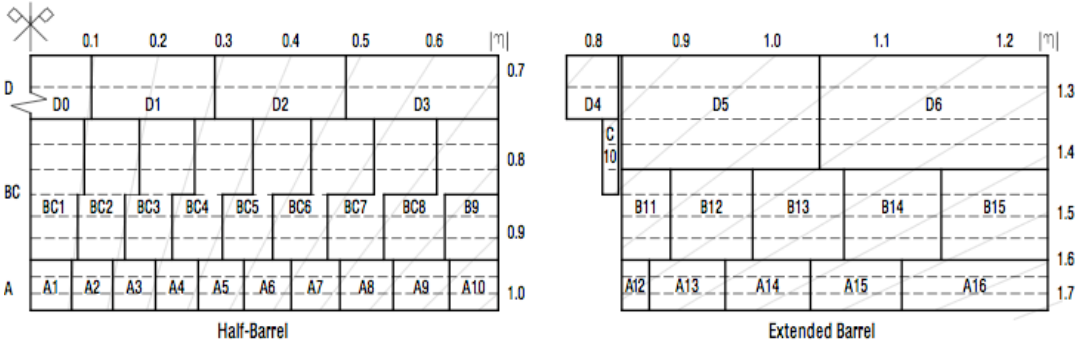
ATLAS superimposed to
the 5 floors of building 40

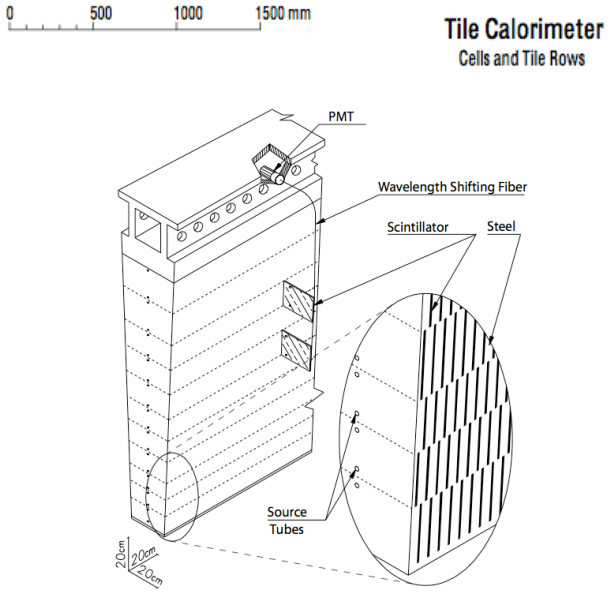


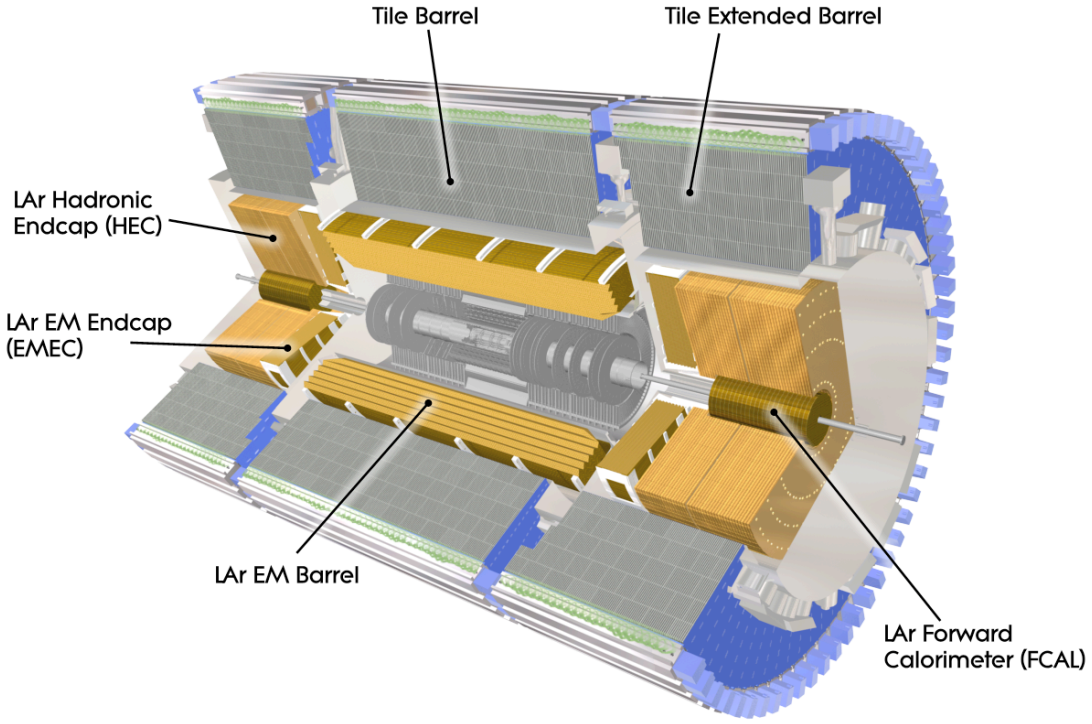


Diameter	*25 m*
Barrel toroid length	*26 m*
End-cap end-wall chamber span	*46 m*
Overall weight	*7000 Tons*

The Calorimeters

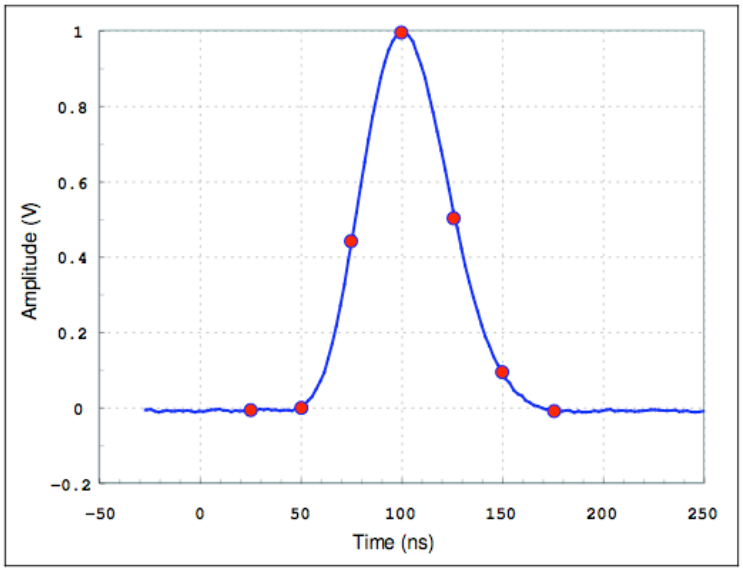


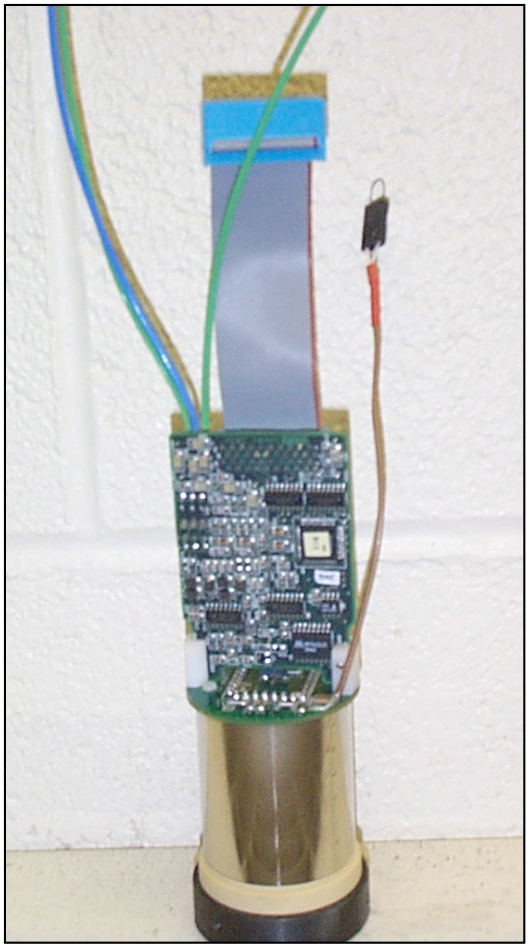




Chicago Hardware Responsibilities

- Electronics construction
  - Front-end 3-in-1 cards (10,600)
    - Condition PMT pulse for ADC
      - Sampled by ADC every 25 ns
    - Provide calibration pulse
    - Integrator for Cs source calibration
    - Analog trigger output

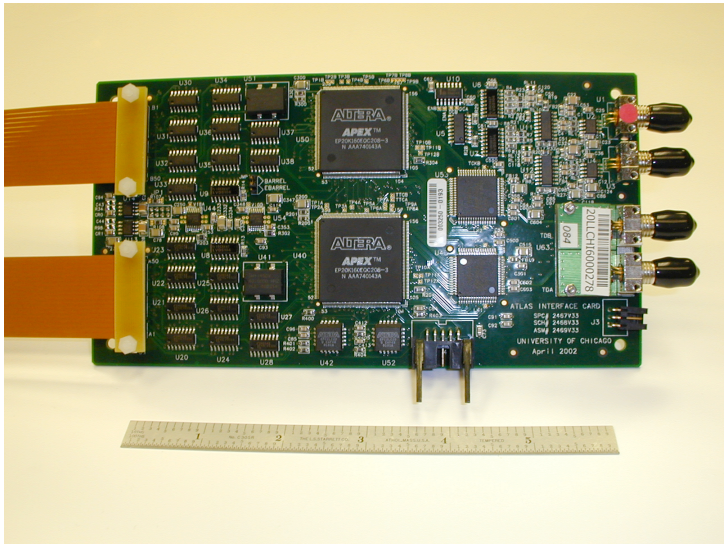




Chicago Hardware Responsibilities

- Electronics construction (cont.)
  - Mother Boards (276 sets)
    - For power and control of 48 3-in-1 cards (PMTs) in electronics drawer

  - Optical interface boards (280)
    - Couple electronics drawer to off-detector electronics
      - Input Timing Trigger and Control (TTC) signal on optical fiber
      - Output data over optical link for events satisfying LVL1 trigger
        - » to off-detector digital signal processors (RODs)

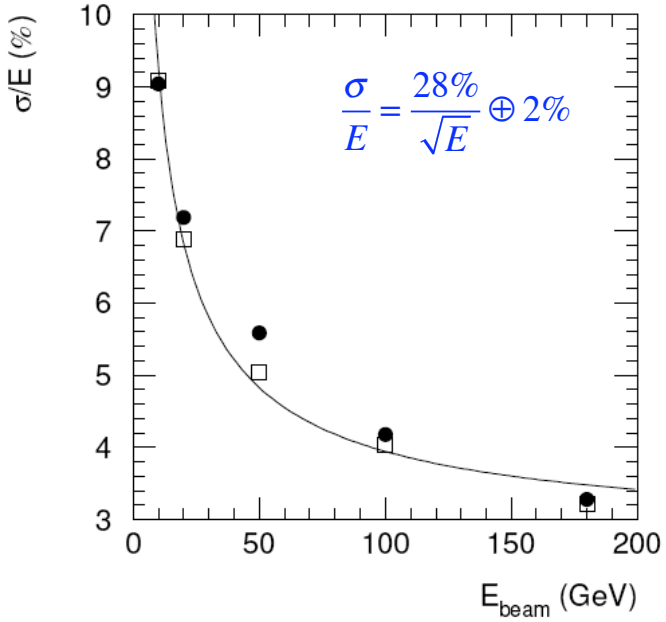


Chicago Hardware Responsibilities

- Hardware was completed on time and delivered to other collaborators for integration into the electronics drawer
- Our group's attention has shifted towards commissioning and set up of the detector
- We participated in test beam studies and calibration of production calorimeter modules
  - 12% of calorimeter modules were calibrated with electron and hadron beams

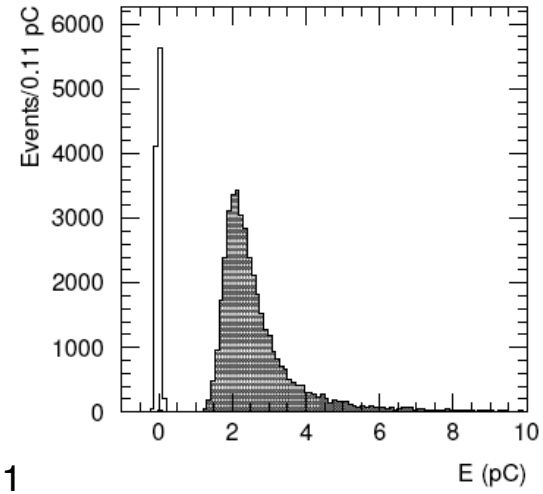
Chicago Test Beam Work

- Electron response of stand-alone hadron calorimeter
  - Establishes EM energy scale

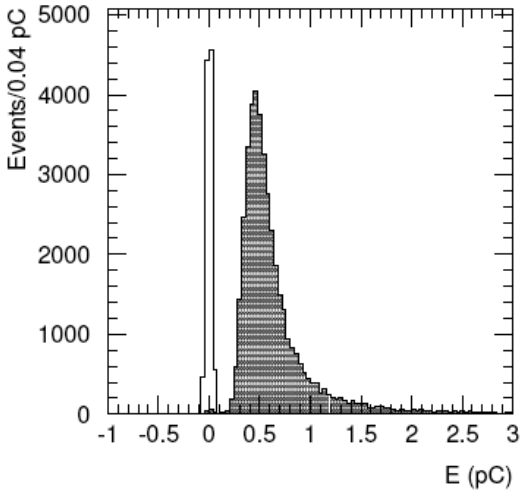


- Muon response

Full tower

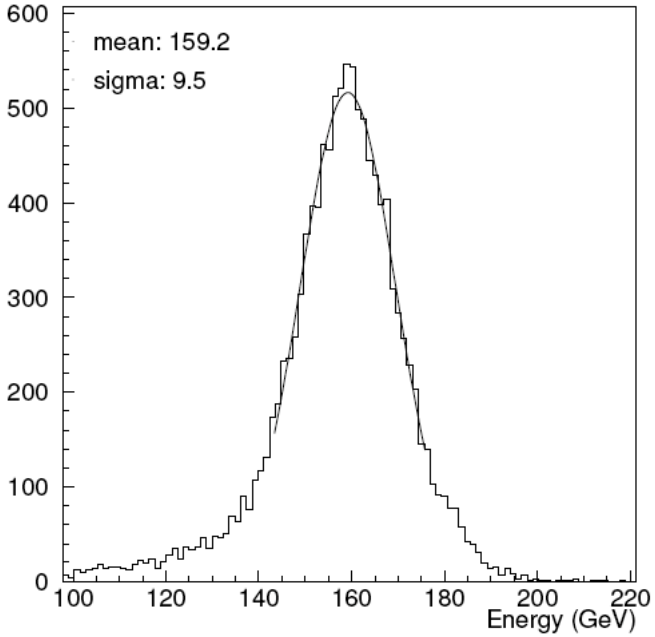


Last layer of tower

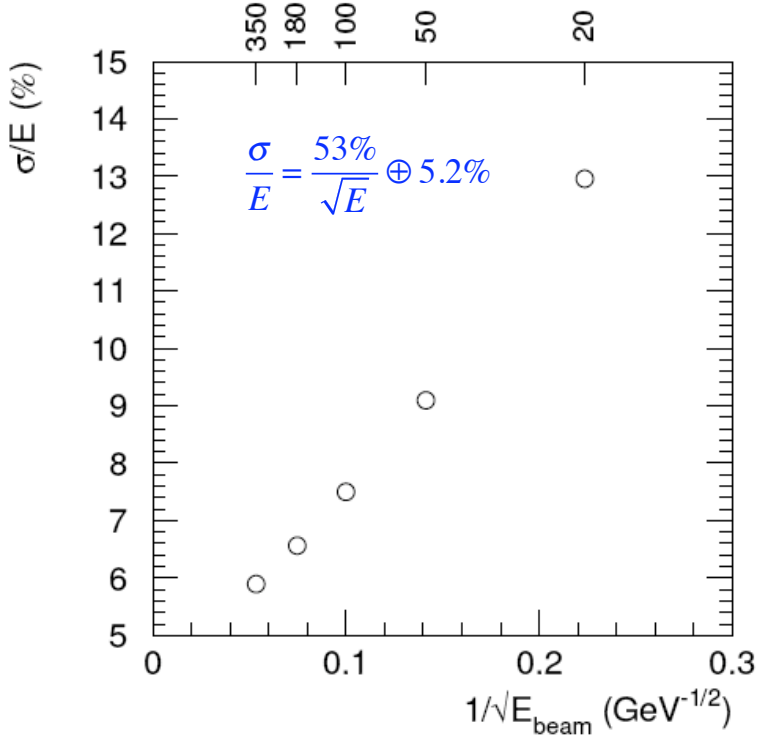


Chicago Test Beam Work

- Hadron resolution (stand-alone)



Line shape at 160 GeV



Energy variation of resolution

Chicago Test Beam Work

- Module-to-module uniformity of response to hadrons
  - for 9 modules

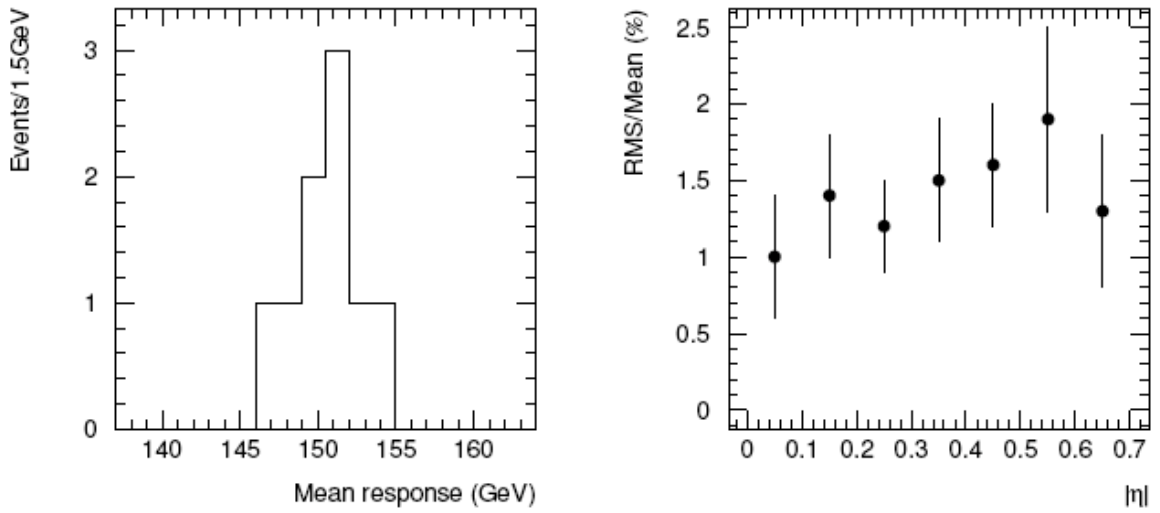


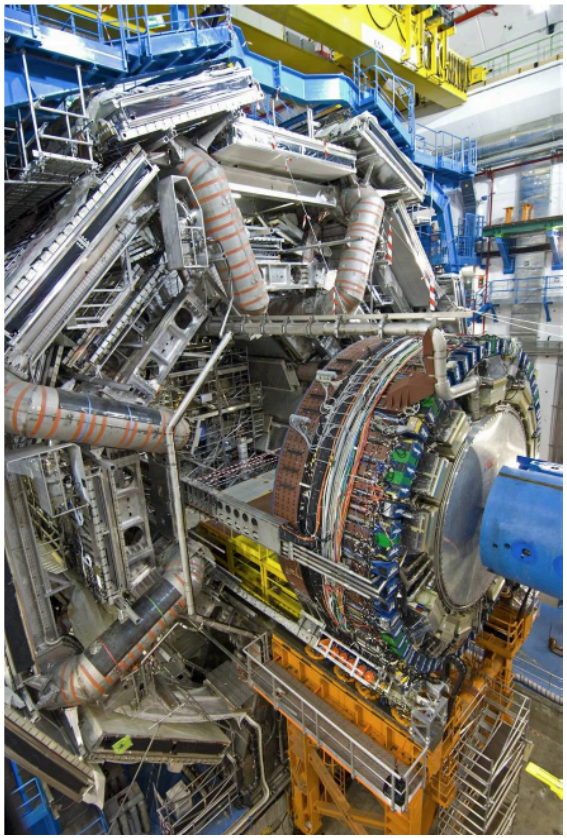
Fig. 35. Left panel: the module-to-module uniformity as obtained with 180 GeV hadron beams at $|\eta| = 0.35$ incidence, giving RMS $= 1.5 \pm 0.4\%$. The right panel shows the RMS of the response as a function of $|\eta|$, with an average value of $1.4 \pm 0.2\%$. In both plots $\pm\eta$ symmetry is assumed.

Installation in Underground Area

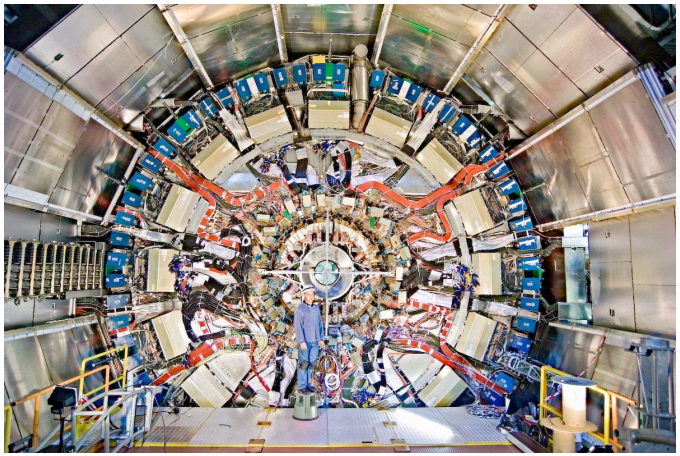
- Started ~2004
- "Ship in a bottle"
  - Subassemblies lowered into pit
    - Calorimeter modules
    - Magnet coils
    - Muon chambers
  - System assembly done in pit
- Almost complete
  - End-cap muon toroids installed last spring and summer
    - Final big system

At time of last NSF Site Visit

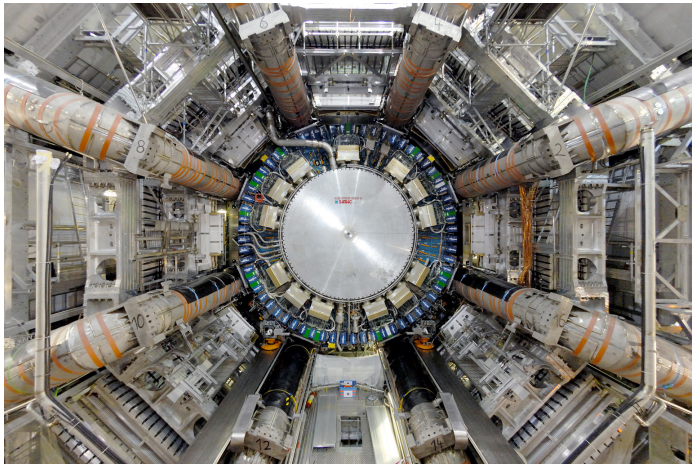
Recent Photos



End Cap Calorimeter extracted on the rails



Inner Detector installed and services connected



End Cap Calorimeter inserted Inside muon barrel toroid

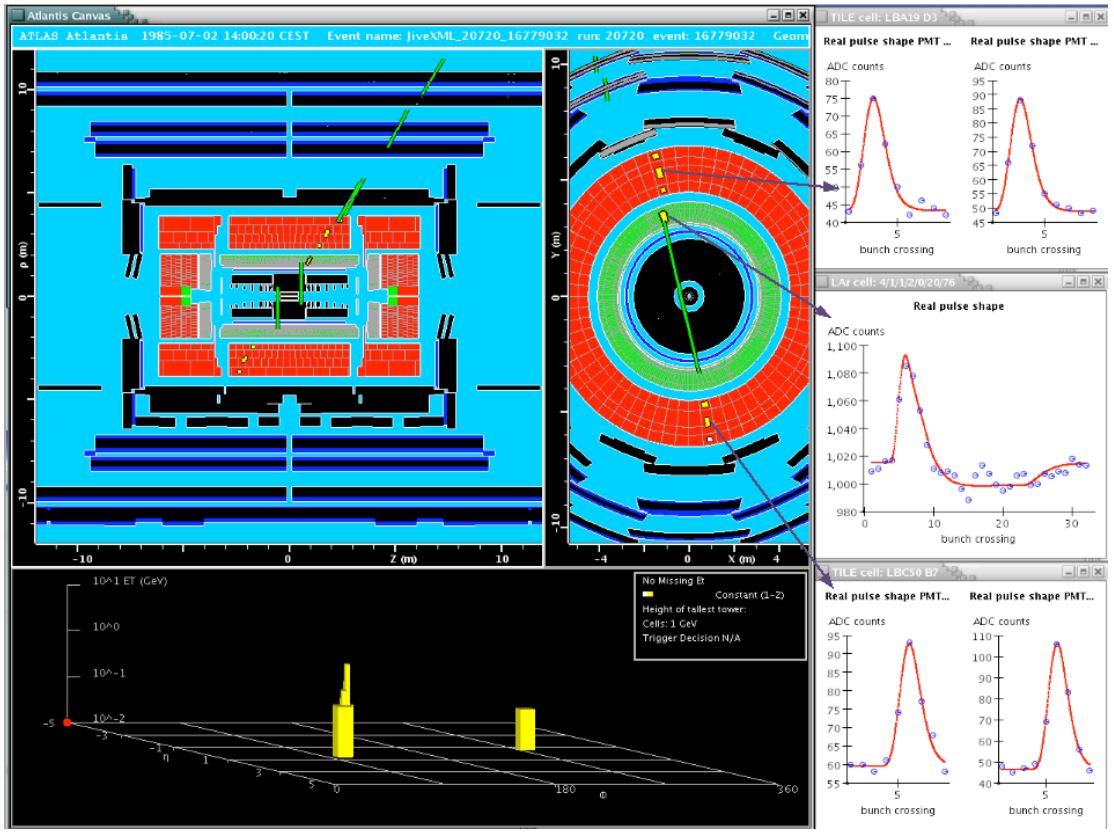
Milestone-Week Running on Cosmics

Cosmic ray runs every few months using as many detector systems as possible.
Runs last ~ 2 weeks.

All Chicago physics personnel at CERN take shifts.
Eric Feng did remote shift on M5 from Chicago.
Monica Dunford is TileCal run coordinator.

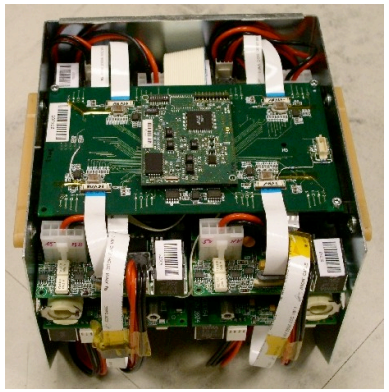
Runs use a calorimeter trigger based on custom Chicago trigger boards.

Standard ATLAS calorimeter trigger not designed to trigger on muons.



Chicago Commissioning Activities

- TileCal power supply problems
  - 256 power supply sets on-detector for front end electronics
    - Faulty design and construction
      - Unstable operation
      - Cases of over-voltage to electronics
    - All supplies now reworked and most reinstalled
      - Electrical performance excellent
      - Long term reliability still being studied
    - 1 Chicago FTE on this

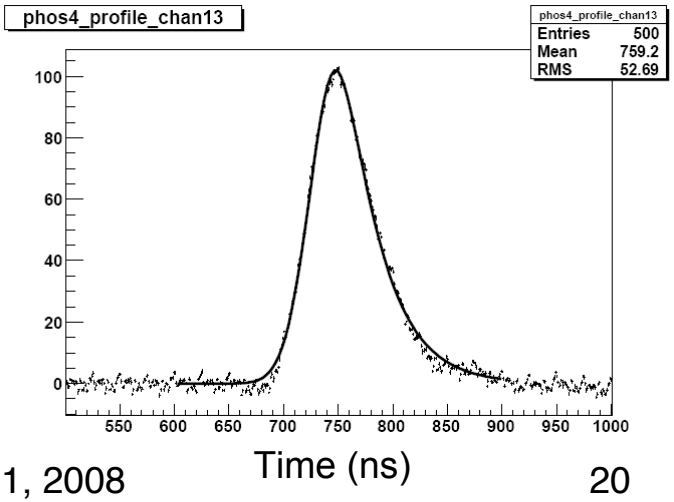


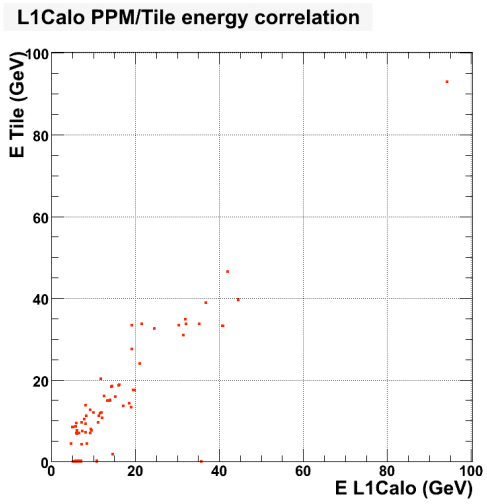
- Electronics drawer integration (on detector)
  - Many unreliable connections between PCBs, LVPS
  - Rework under way
    - 3-m-long electronics drawers must be extracted for access
    - ~ 1/2 of system redone so far
      - No failures so far on 130 reworked drawers
    - 3 Chicago FTE on this (our techs with trouble shooting by Giulio)

Chicago Commissioning Activities

- TileCal integration with Level 1 trigger system
  - Analog signals from ~5000 trigger towers delivered to LVL1
  - Calibration pulses from any cells possible over full dynamic range
    - Charge injection system in electronics
    - Laser to PMTs
  - Monica Dunford is TileCal interface person with LVL1 group
    - Works with LVL1 group on debug and checkout

Laser pulse digitized by LVL1 input module

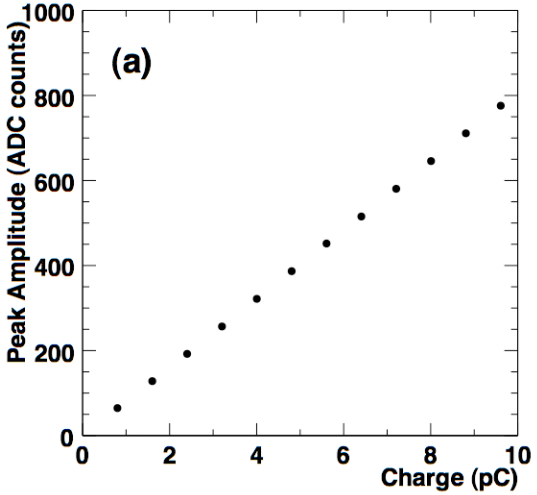


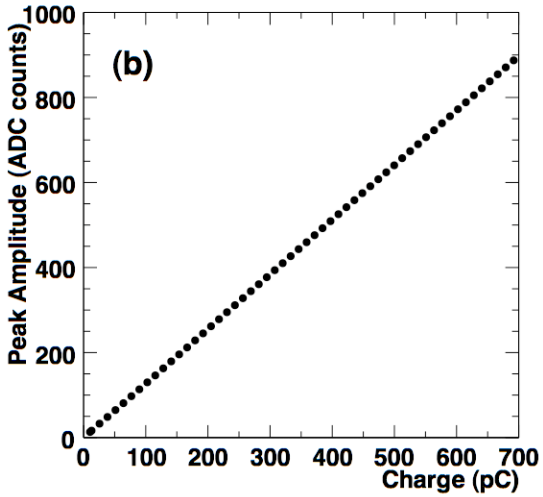


Correlation of LVL1 trigger signal with TileCal readout, for cosmic rays.

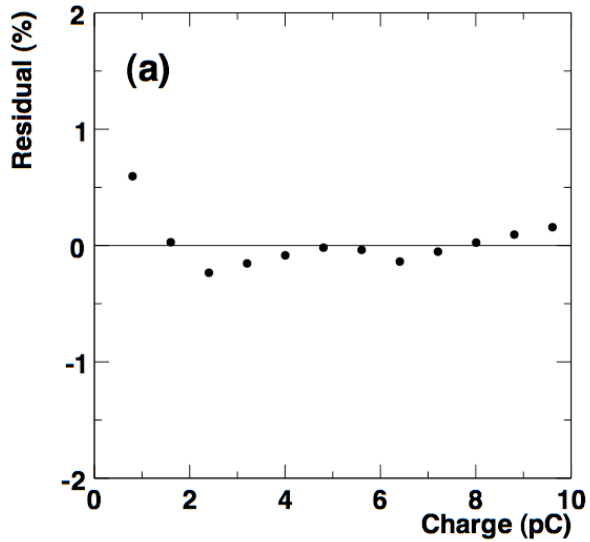
Other Hardware Work

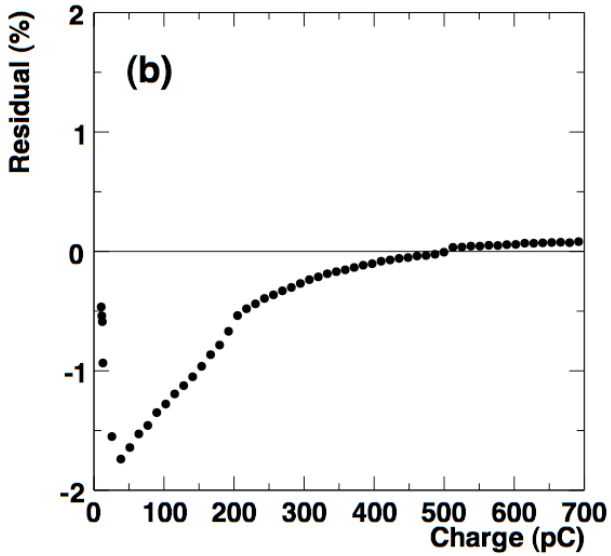
- Extensive testbeam studies of system
  - 12% of calorimeter modules calibrated with e^-, π, μ
    - Cs source system for PMT gain equalization and long term ref.
  - Some departures from expectation at level of ~ 5%
- Prompted careful look at readout system response using built-in charge injection system
  - Martina, Imai, JP
  - Two gain scales on each channel, each with 10-bit ADC





Other Hardware Work





- ~ 2% nonlinearity on low gain scale
  - Source is understood from lab tests and SPICE
  - Make second order correction to linear model using lookup table
- Many other systematics studied and characterized (<0.5%)
- Other 2% effects found in Cs calibration system
- Re-analysis of test beam data underway

Other Hardware Work

- Fast Track Trigger (talk of Mel Shochet)
  - Hardware to identify displaced vertices early in Level 2 trigger
  - Proposed as trigger upgrade for ATLAS
  - MJS, Erik Brubaker, Anton Kapliy, Kohei Yorita
- Upgrade planning for sLHC (Mark Oreglia)
  - sLHC to have 10X LHC design luminosity
    - Higher radiation levels
    - More pileup noise
      - ~ 100 MeV $\rightarrow \sim 300$ MeV
  - TileCal upgrade workshop at CERN Feb. 8-9
    - Jean-François Genat will participate (New EDG head)

LHC Schedule for 2008

- Machine to close by late March
  - Beam pipe installed, detector closed
  - We lose access to the detector at this point
- LHC checkout with beam: June 22 - July 21
- Pilot physics run: July 22 - Dec 21
  - 113 days scheduled for physics
  - Start with 43 bunches instead of 2800 to keep stored energy low while controls and beam dump are commissioned
  - Expected integrated luminosity low
    - Few 100 pb^{-1} ?

Preparing for Physics

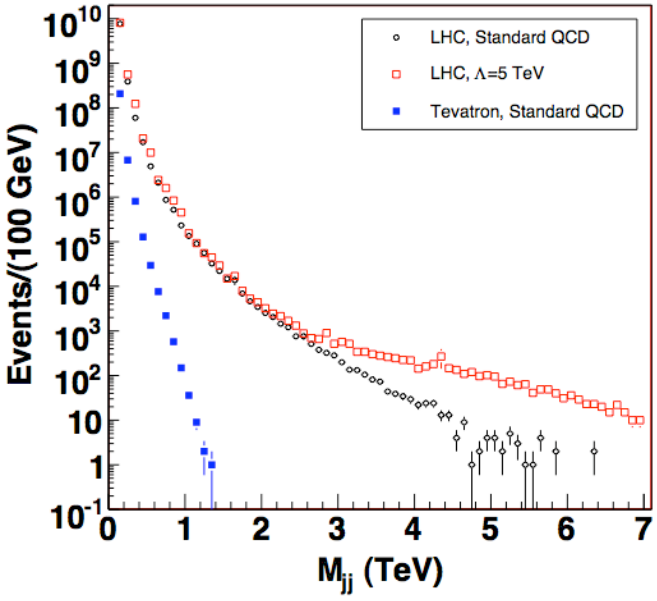
- CSC notes on physics channels and detector performance
  - Use software and simulation prepared for 2008 physics run
- Chicago participation in CSC notes
  - In-situ jet calibration with physics (AG, MH, FM, MO)
  - Di-Jet physics (MH, JP)
  - Inclusive SUSY search in leptons + E_t-miss channel (MD, IJL)
  - LVL1 Calorimeter Trigger Performance (MD)
  - Muon Identification in the Calorimeters (GU)
  - The Muon Trigger (soft muons in TileCal and isolation) (GU)
  - Minimum bias events (EF, JP)
  - Jet algorithm performance (AG, FM)
  - E_t-miss performance (AG, FM, GU)
- Data challenge this spring ("Full Dress Rehearsal" - FDR)
  - Transfer MC data from the pit through computing system for analysis by ATLAS community
    - FDR1 (10 hr run at 10^{31}, 1hr run at 10^{32}) => ~8M events

Jet Physics

- Martina Hurwitz will do thesis on the dijet cross section and angular distribution
  - Large cross section
    - Still feasible for much smaller luminosity sample
  - Closely tied to understanding the calorimeter
    - Di-jet events useful to check relative calibration of cells
      - Check balance vs EM fraction and multiplicity of jets
    - γ-jet events useful for absolute calibration relative to EM calorimeter
  - Essential preliminary to more complicated physics channels
  - Also has discovery potential
    - New contact interactions
    - Z' states (with few fb^{-1})

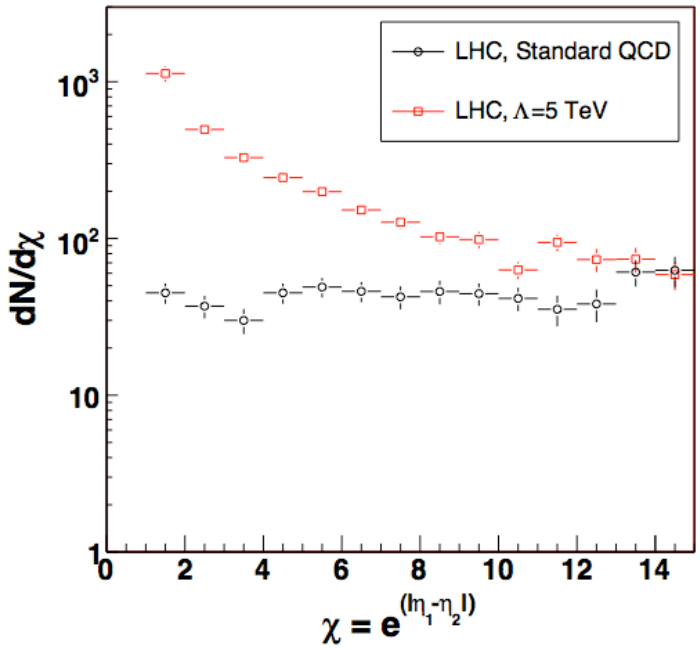
Jet Physics (MH)

- Jets very distinctive
- Higher CM energy opens new kinematic regime
  - Probe shorter distance interactions
- Plot corresponds to 1 fb^{-1}
  - Scale ordinate according to preference
- $d\sigma/dM$ measurement
  - Systematic limitations from knowledge of jet energy scale, resolution smearing
  - Interpretation limited by knowledge of parton distribution functions



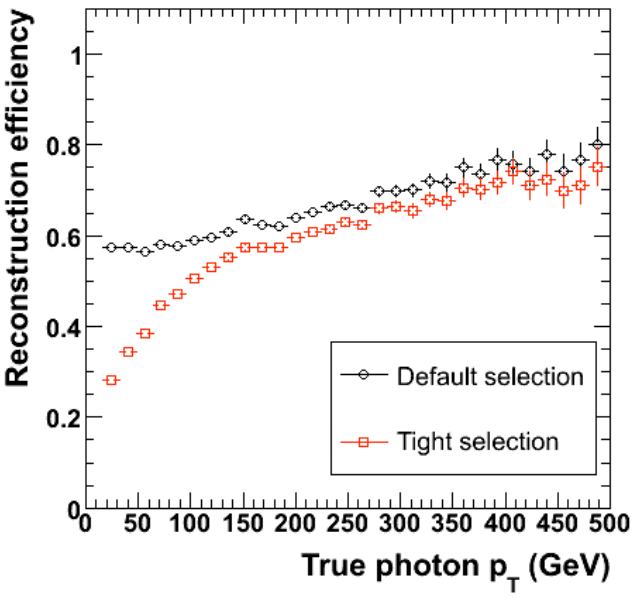
Jet Physics (MH)

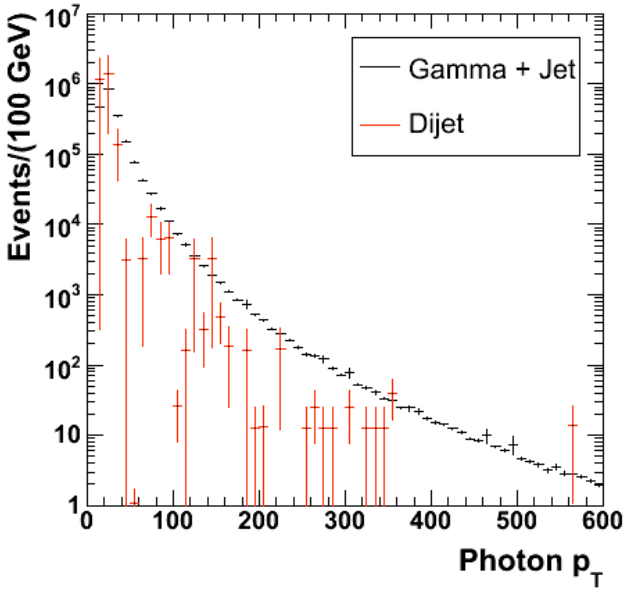
- Angular distributions less sensitive to this
  - For $2 \rightarrow 2$ scattering $\chi = (1+|\cos\theta^*|)/(1-|\cos\theta^*|)$
  - Relatively flat distribution for QCD
- Much less sensitivity to jet energy scale, parton distributions
- Systematic limitation from uncertainties in calorimeter response vs $|\eta|$



Jet Physics

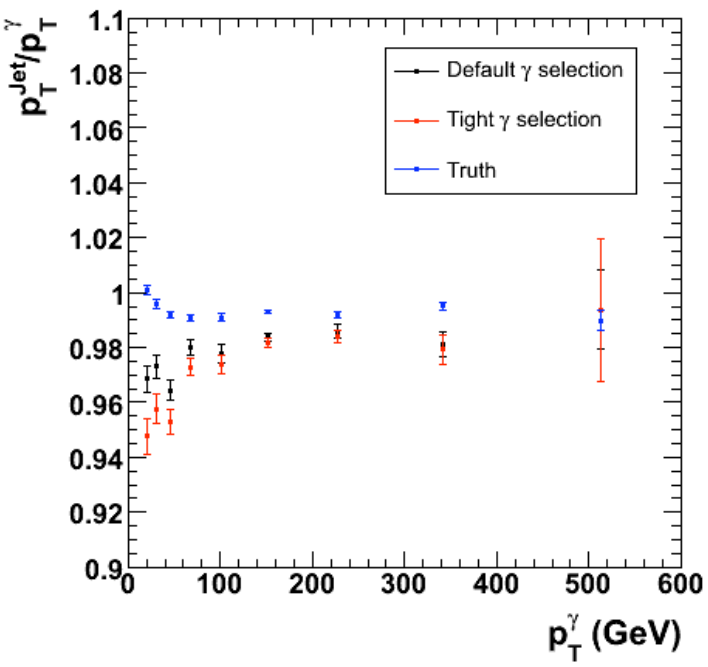
- How to calibrate jet energy scale?
  - MH & AG have studied γ-jet final states
  - σ(jet-jet)/σ(γ-jet) is ~ 10^3 so background suppression is very important
    - Require calorimeter energy isolation in gamma cone (< 5%)
    - Require track isolation (n < 3)
    - Plot scaled to 500 pb^{-1} sample

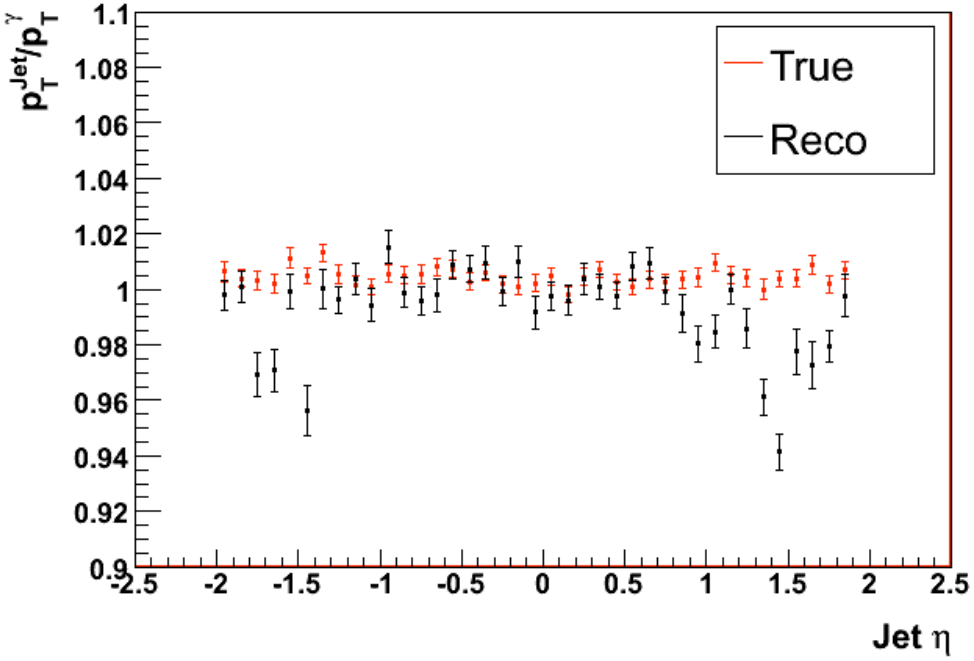




Jet Physics

- Study γ-jet balance without jet-jet background
  - Full MC detector simulation (G4)
  - ISR, underlying event, etc.
  - $|\eta| < 2$

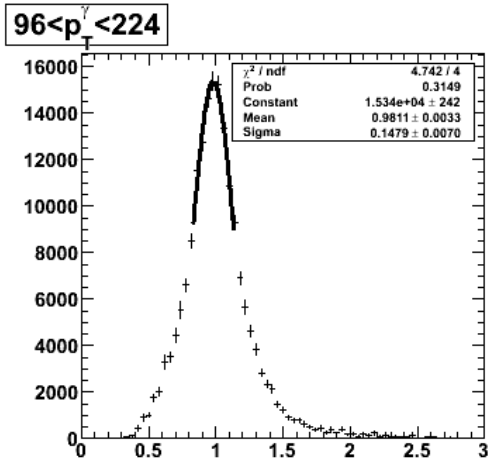


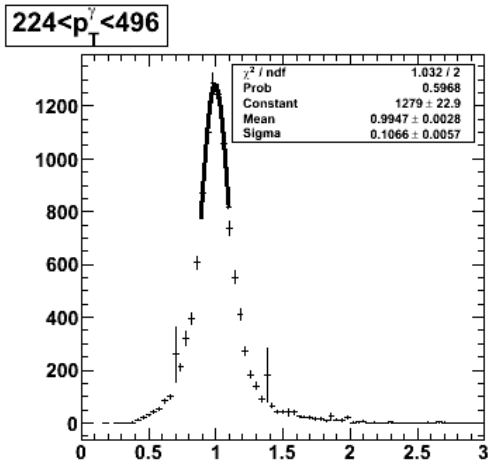


Jet Physics

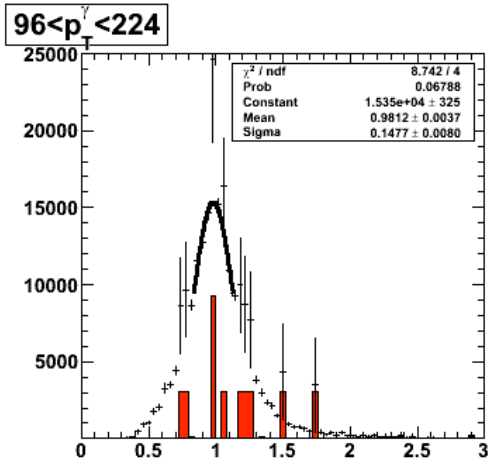
- Energy balance with background

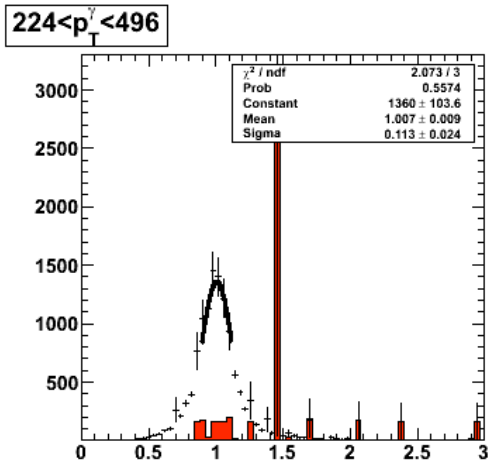
Signal only





Signal plus bkgd





Physics Activity

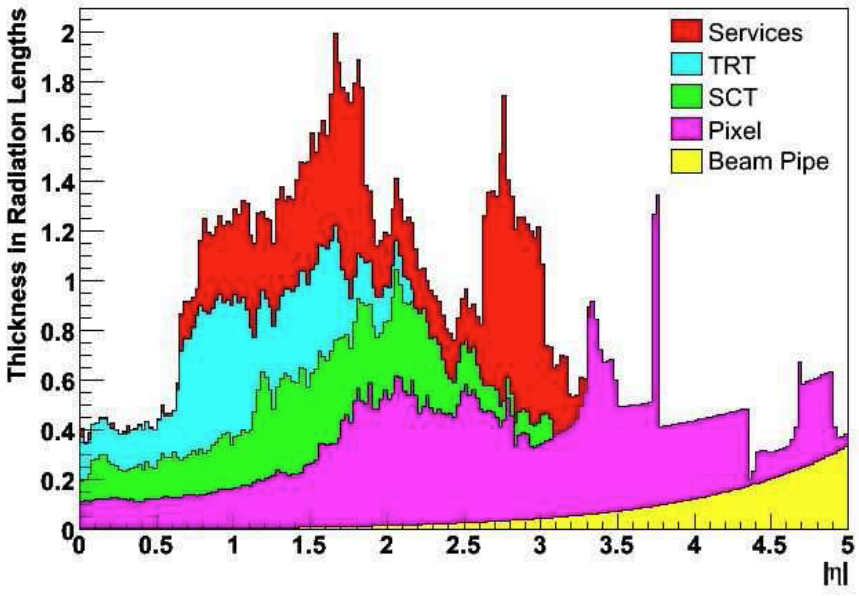
- This gives a flavor of one of the topics being pursued
  - Clearly additional work is needed
- Other speakers will give further examples
- Important now to devote additional effort to physics analysis topics
- Full dress rehearsal will be important activity this spring
- Full-detector cosmics run after beam-pipe closes
- Perhaps first physics data by fall!

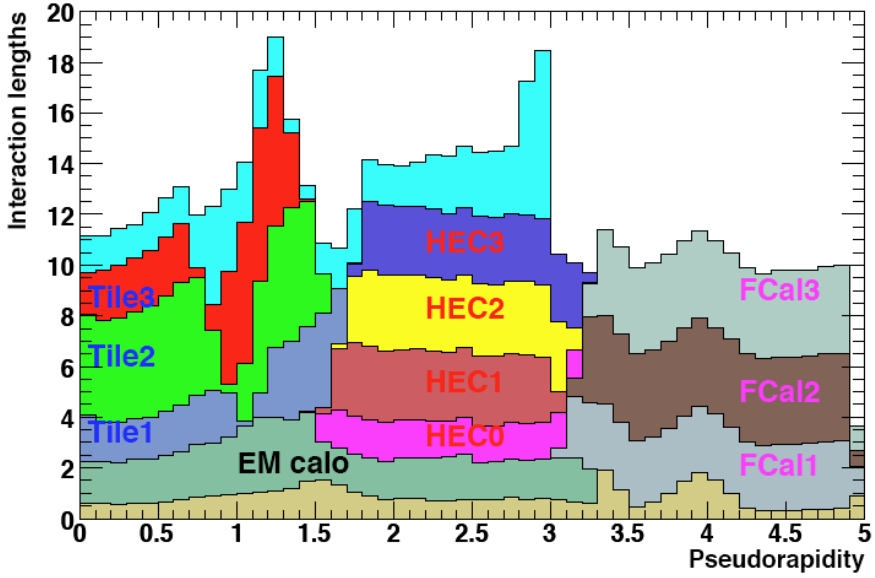
Conclusions

- Strong emphasis to develop a sound well-working detector
  - No physics without this
  - We are nearing the end of this work
- Physics effort has been focused on the important issues for early running
  - We need to demonstrate understanding of detector performance
- Early emphasis has been on physics related to the calorimeter
  - Jets, missing energy
  - This will evolve with time
- Very important to increase the number of graduate students in the group
  - We have the necessary number of faculty for supervision
  - The science is extremely attractive
  - Students are particularly productive on analysis issues
- High probability that a new junior faculty member will join the effort

Backup Slides

Material Thickness





Material in Inner Detector (radiation lengths)
- multiple scattering
- pair-production
- bremsstrahlung

Material in Calorimeters (nuclear interaction lengths)
- energy measurement
- hadron absorption for muon system