ATLAS Experiment
Project Review

Project Review 2003

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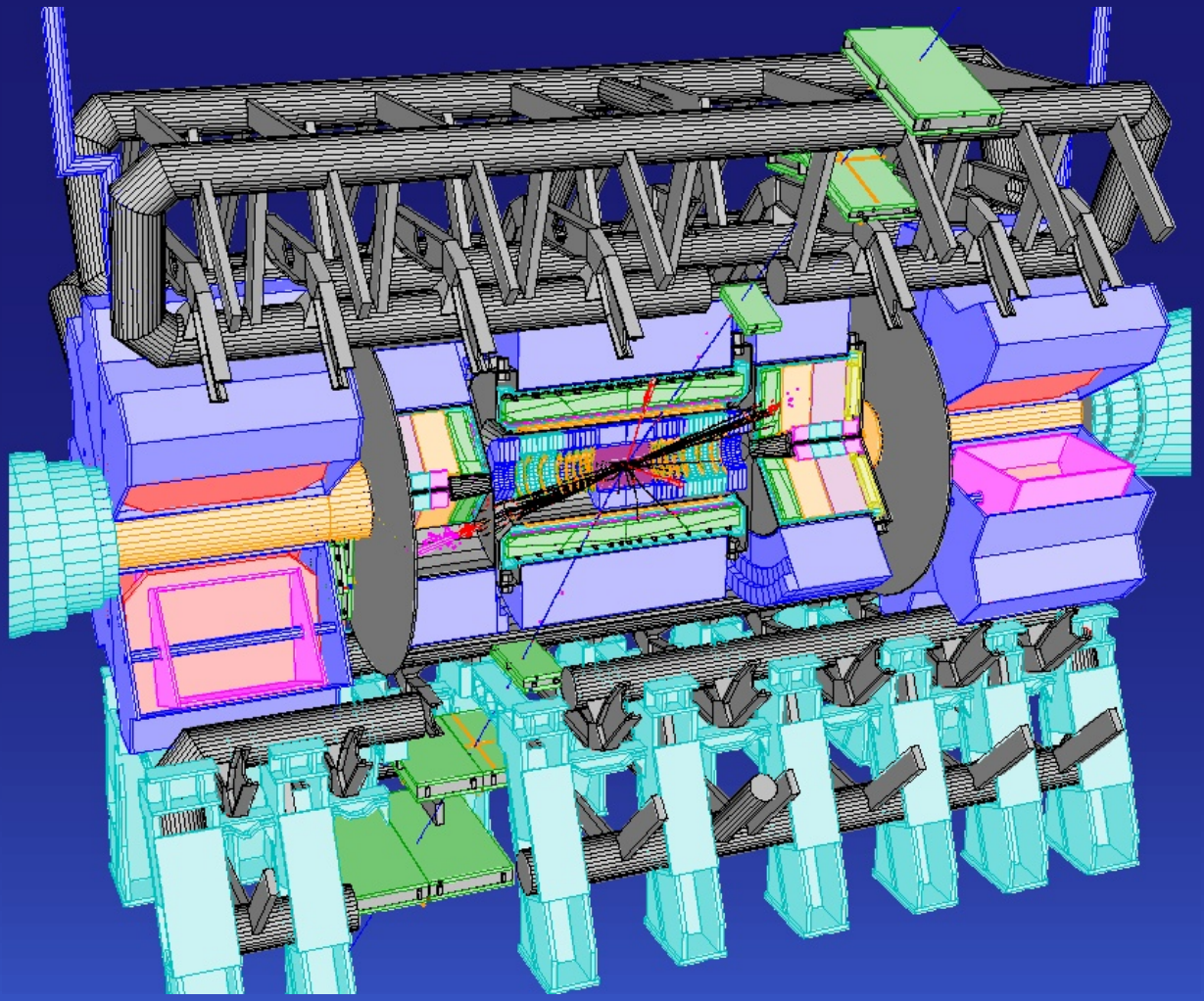
on behalf of the ATLAS Group @MPI

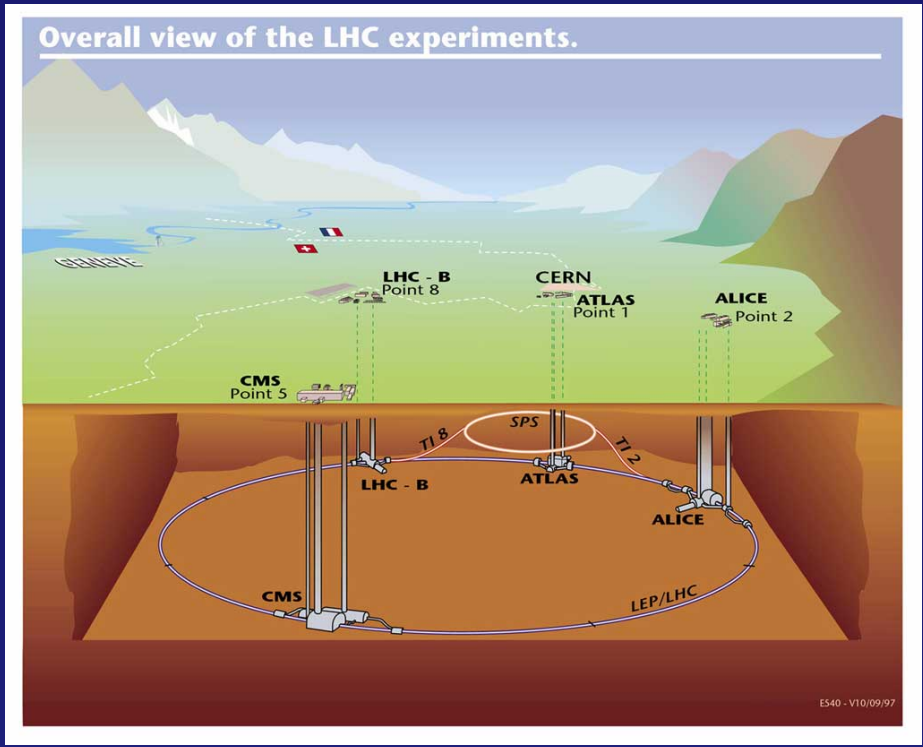
11. Dec. 2003, MPI München

- LHC and ATLAS
- MPI ATLAS Projects
  - Semiconductor Tracker – SCT
  - Hadronic End-Cap Calorimeter – HEC
  - Monitored Drift Tubes – MDT
- Physics with ATLAS
- Conclusions



LHC and ATLAS

- The Large Hadron Collider LHC @ CERN
  - 14 TeV pp collisions by 2007
  - 27 km collider in the LEP tunnel @ CERN

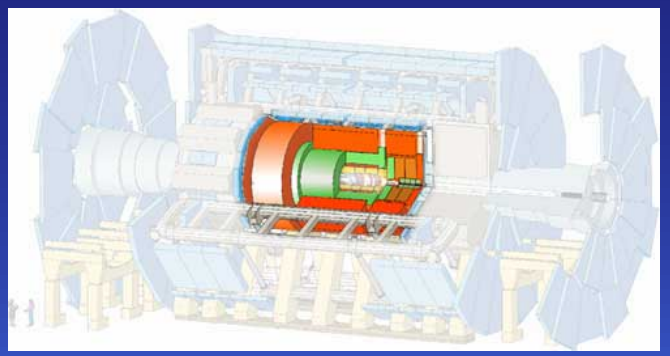


- ATLAS groups @ MPI

Inner Detector

SCT

Calorimeters



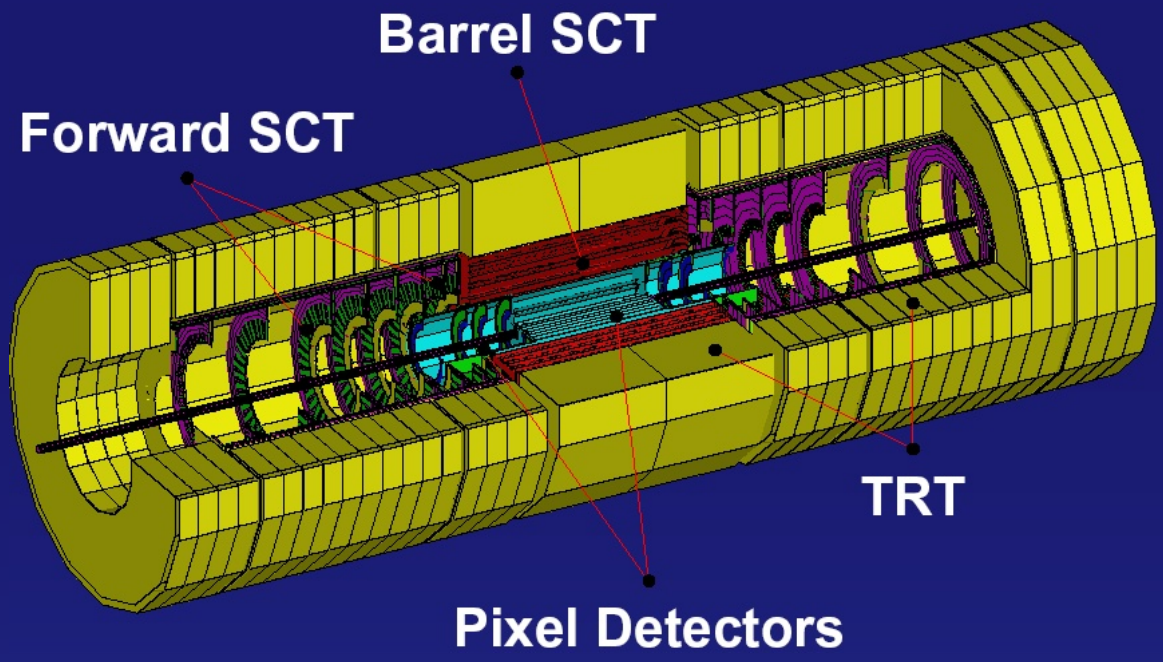
HEC

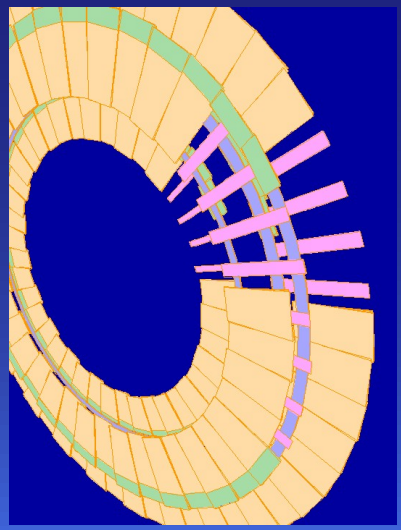
Muon System

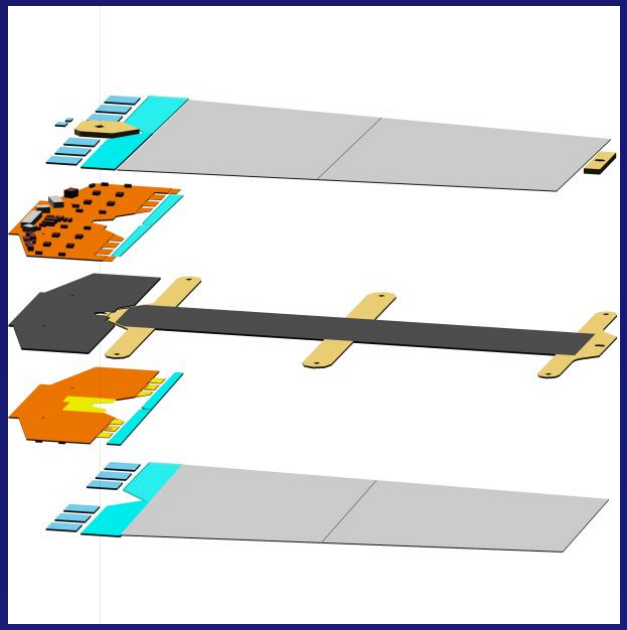
MDT

Semiconductor Tracker – SCT

- SCT layout
  - 4 layers, 18 disks
  - 4088 modules, 61 m^2 silicon
  - $\sigma_{R\phi} = 16\,\mu m$, $\sigma_{R,z} = 580\,\mu m$
- Module Production @ MPI
  - 400 of 640 middle modules for the disks
  - Site-qualification for serial production
- N_2 tests
  - SCT tests in nitrogen
  - Observations with the CIS detectors
  - Breakdown problem in special test environment
  - How to run @ 500 V
- Schedule

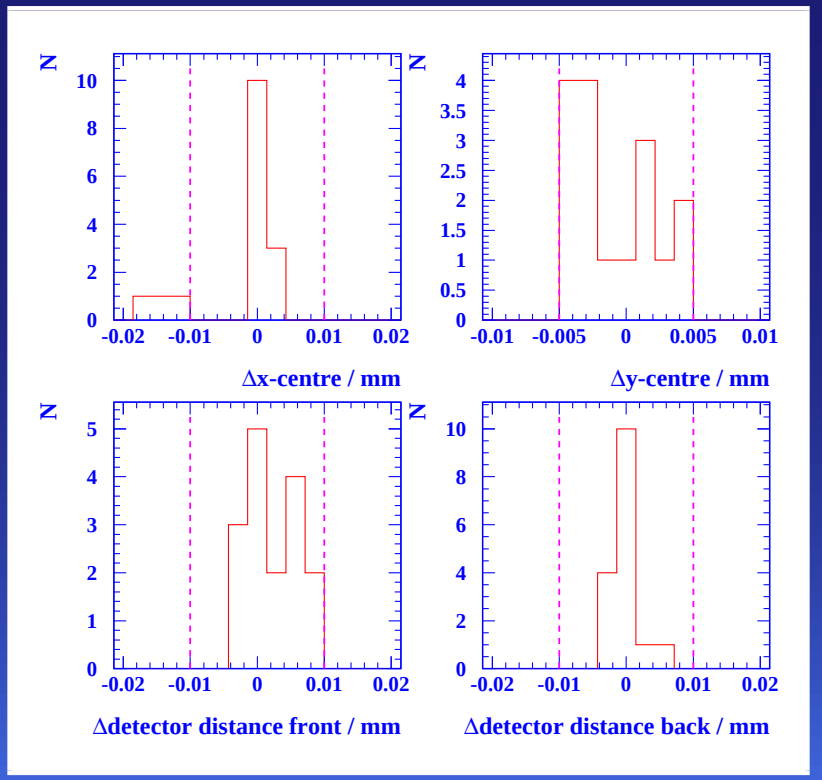






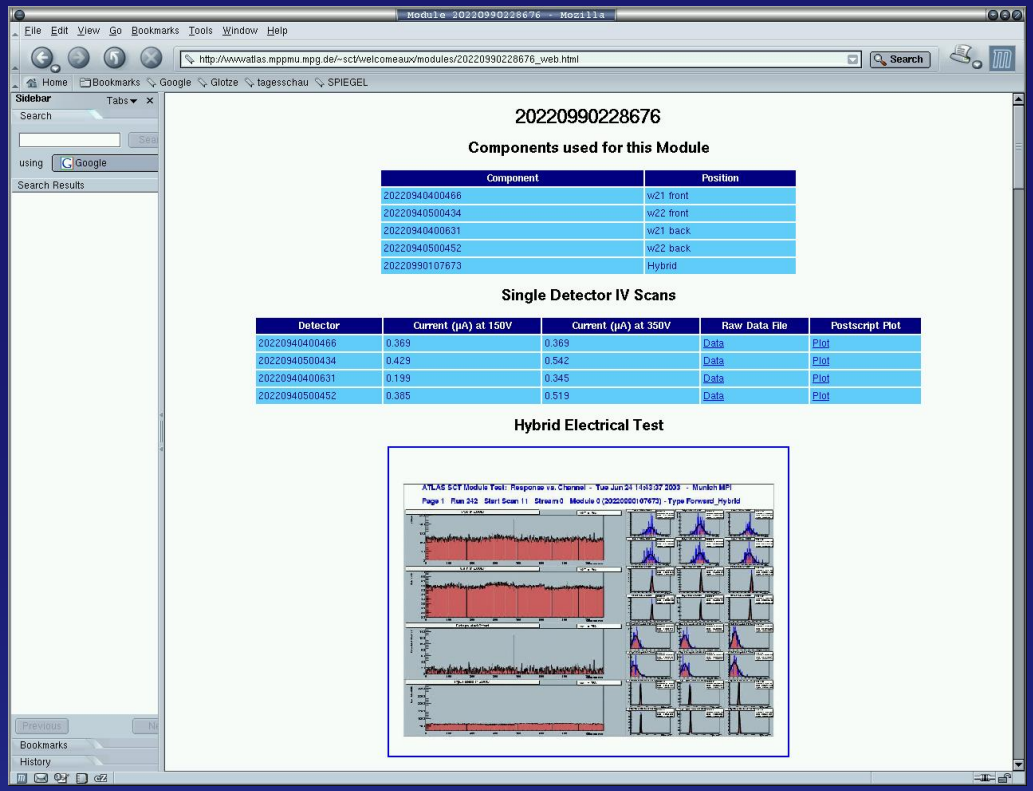
- SCT forward modules
  - 4 silicon strip-detectors are glued on a spine
  - with 5 μm precision (perpendicular to the strips)

- Mechanical QA numbers for the 16 pre-production modules
  - accuracy in and perpendicular to strip direction
  - front/back detector distances
  - similar plots for angular distortions and stereo angle



SCT ► Pre-Qualification

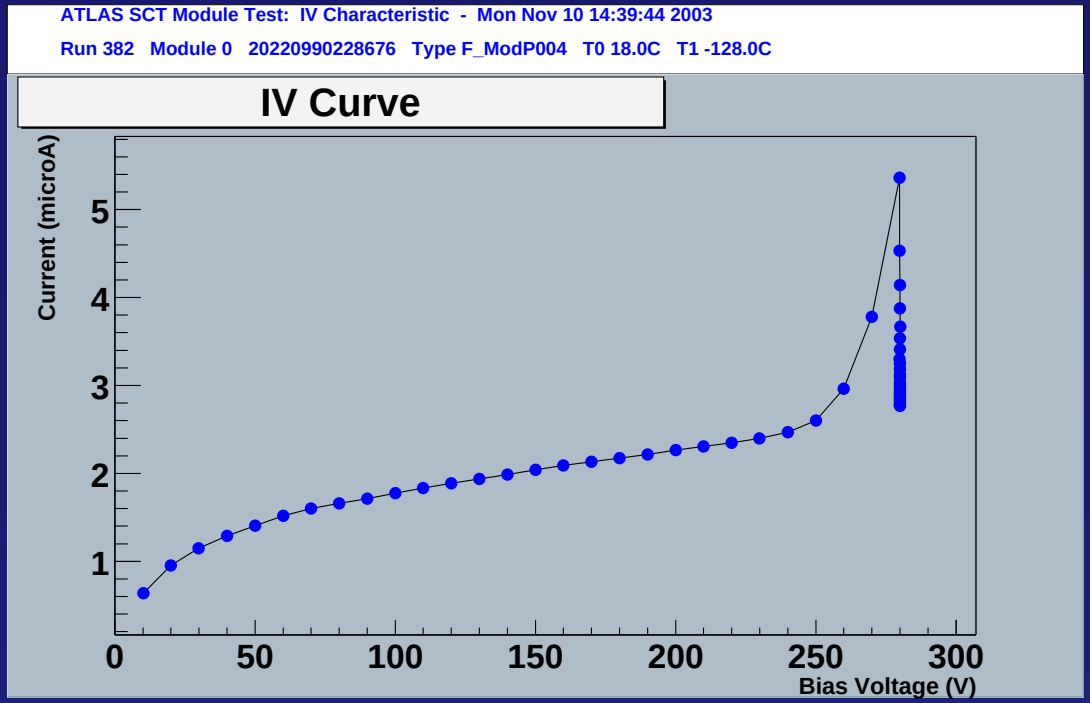
- http://wwwatlas.mppmu.mpg.de/~sct/welcomeaux/prequal.html



- The measured module characteristics are available online
  - components used
  - *IV* scans
  - Hybrid/Module electrical tests
  - *XY* surveys
  - General comments
  - N_2 tests

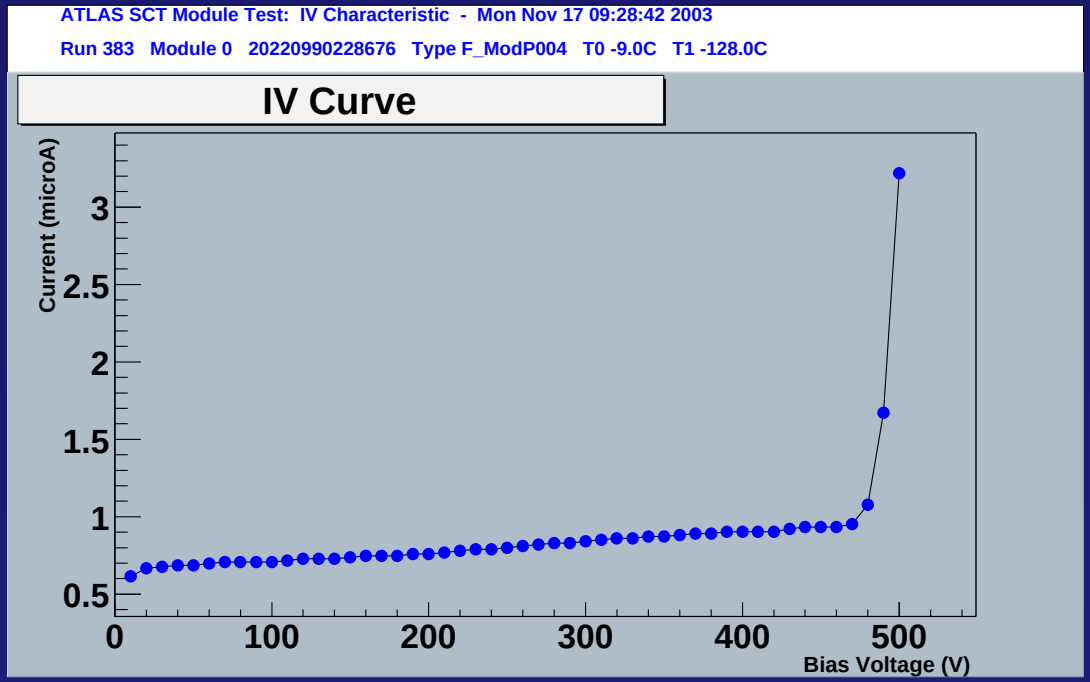
- 2 modules produced for pre-qualification
- next 5 modules will establish serial production
- New optical measuring machine from Mitutoyo
  - to comply with the QA rules of SCT

- Special SCT test problem
  - modules are mounted on a disk and ramped to 500 V in N_2 atmosphere
  - CIS detectors are specified to 350 V
  - Breakdown at 200 – 300 V observed in nitrogen
  - No breakdown observed in air

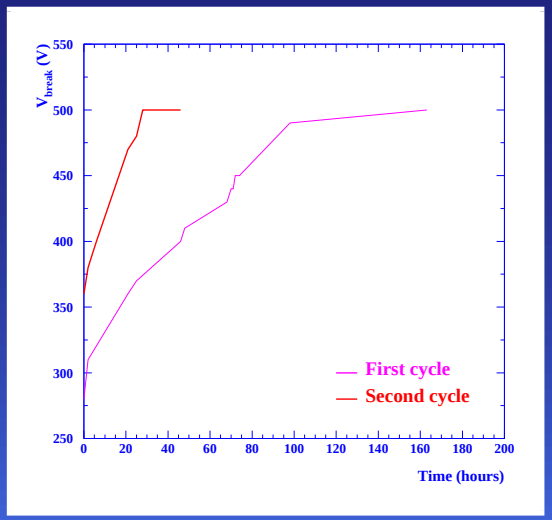


- The effect is attributed to charges on the surface passivation layer
  - charge decay time increases with decreasing humidity
  - the charges rebuild after power disconnect
- Fully irradiated detectors are demonstrated to operate at 500 V

- Module “training” in N_2
  - a module is put into a cooled climate chamber
  - flushed with 160 l/h nitrogen
  - HV ramped up in 10 V steps every 10 s until breakdown



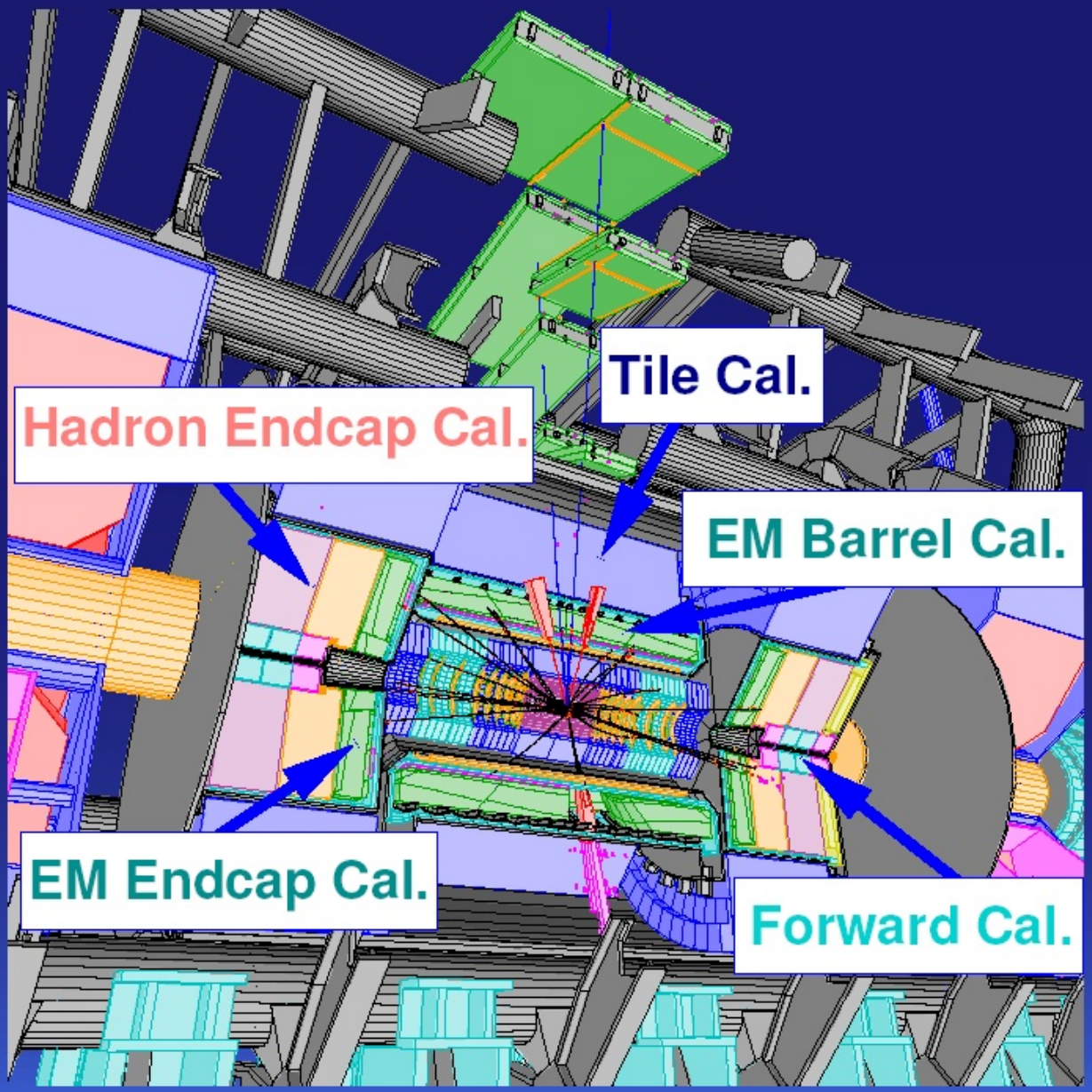
  - module is left in nitrogen at 200 V for some time after breakdown
  - ramp up HV again . . .
- Untrained module breaks down at 280 – 360 V
- Training brings module to 500 V after some time
  - module ramps still to 500 V if kept in nitrogen at 30 V for 72 h
  - needs retraining after switch off
  - trains faster in the second cycle



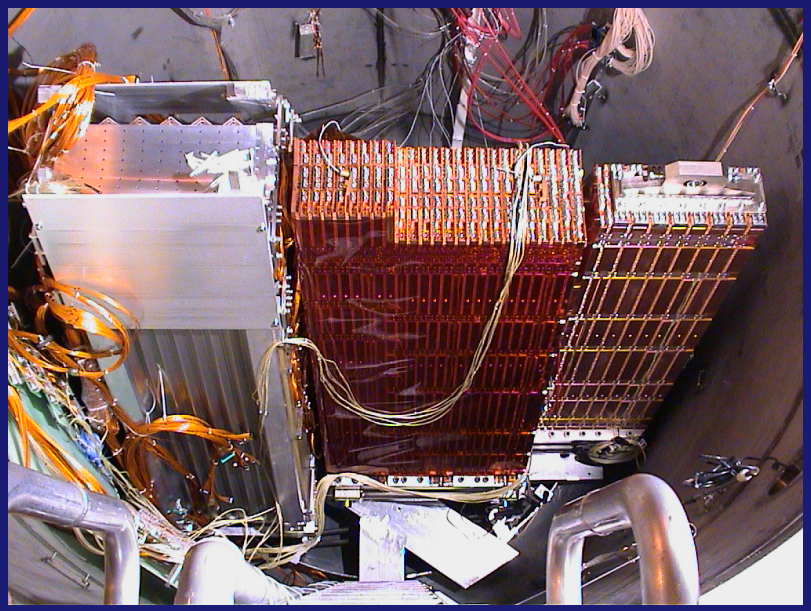
- “unofficial” SCT Schedule
  - `18-Mar-2005` SCT Endcap A arrives @ CERN
  - `04-Feb-2005` SCT Barrel assembled @ CERN
  - `15-Dec-2004` SCT Endcap C arrives @ CERN
- impact on Module production Schedule
  - `01-Feb-2005` last Endcap modules ready
  - `01-Apr-2004` first 40 middle modules (disk 8)
- MPI planing
  - `Jan-2005` end of module production
  - `Feb-2004` begin of serial module production
  - `Jan-2004` MPI qualifies for serial production

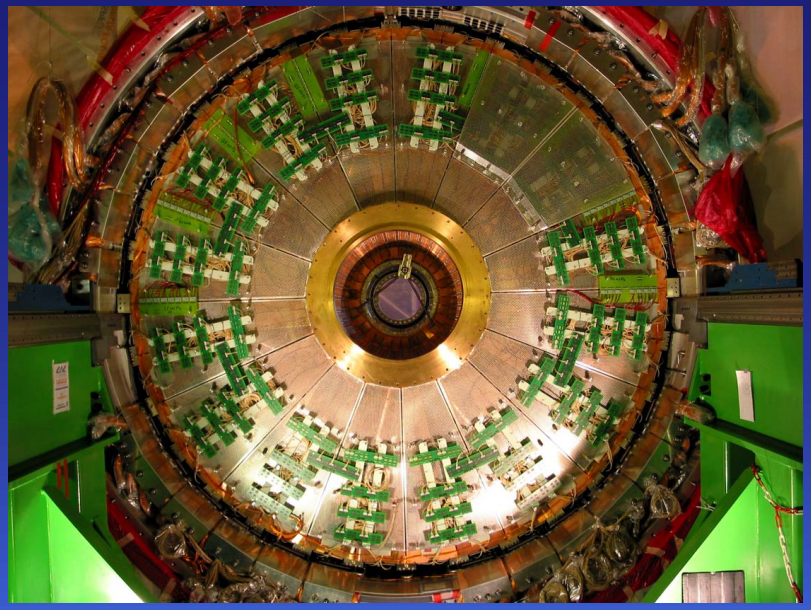
Hadron Endcap Calorimeter – HEC

- Layout of the ATLAS Calorimeters
- EM LAr-Pb accordion calorimeter
  - Barrel (EMB): $|\eta| < 1.4$
  - Endcap (EMEC): $1.375 < |\eta| < 3.2$
- Hadron calorimeters
  - Barrel (Tile): Scint.-Steel $|\eta| < 1.7$
  - Endcap (HEC): LAr-Cu $1.5 < |\eta| < 3.2$
- Forward calorimeter (FCal) $3.2 < |\eta| < 4.9$
  - FCal1: LAr-Cu
  - FCal2&3: LAr-W



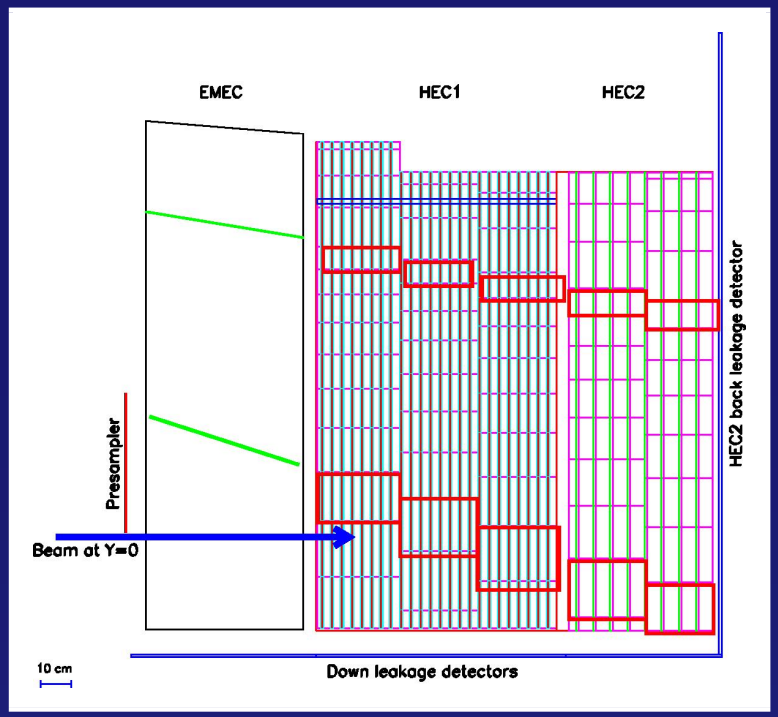
- Testbeam analysis and planing
  - EMEC and HEC combined test beam in 2002
  - EMEC/HEC/FCal combined test in 2004
- Reco and Simulation Software development
- Electronics and Detector Control





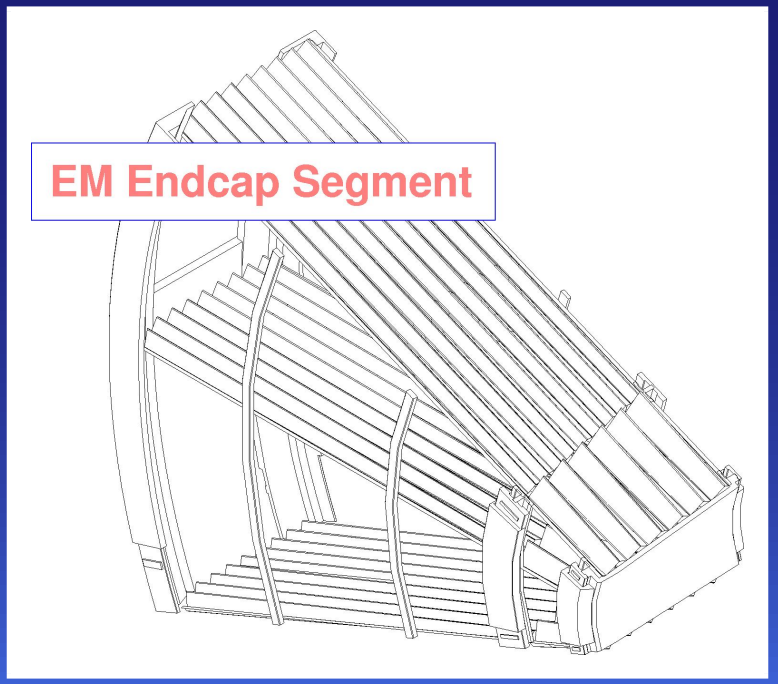
- Installation @ CERN
  - HEC wheel C insertion completed 22-Oct-2003
  - HEC1A assembled 28-March-2003, ready for insertion since 06-Nov-2003
  - HEC2A assembly started 12-Nov-2003, ready before X-mas
  - July (August) 2004 HEC1A (HEC2A) insertion
- Schedule

HEC ► beam test 2002 with EMEC

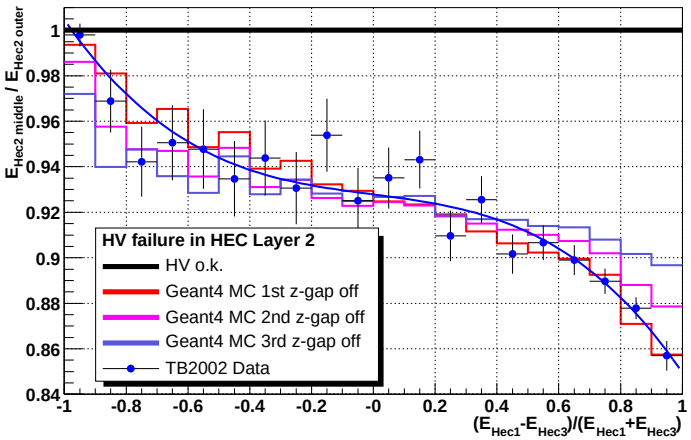


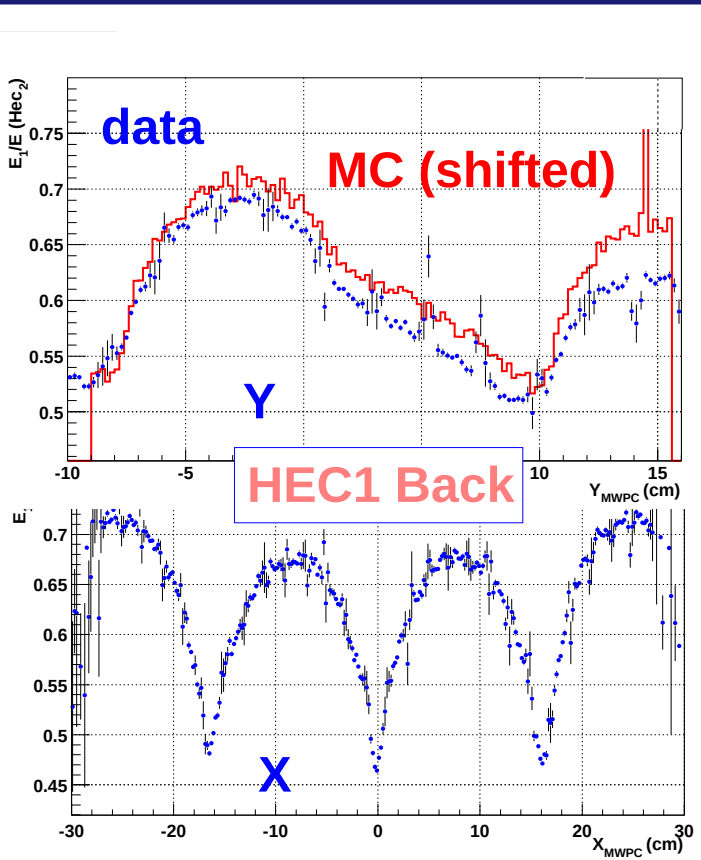
- first evaluation of combined performance
  - Optimal Filtering for raw signals
  - Calibration from ADC to nA
  - Corrections and Clustering
  - Simulation
  - Calibration from nA to GeV
  - Resolution for Electrons and Pions

- Special test beam problems
  - alignment
  - trigger time dependency
  - non-pointing beam in η
- Corrections common to ATLAS
  - EMEC accordion structure
  - single HV gap failures
  - non-compensating calorimeters



- HV failure in HEC Layer 2
  - signal shows dip in one of three ϕ-modules
  - measured over expected signal for 200 GeV pions vs. $(E_1 - E_3)/(E_1 + E_3)$

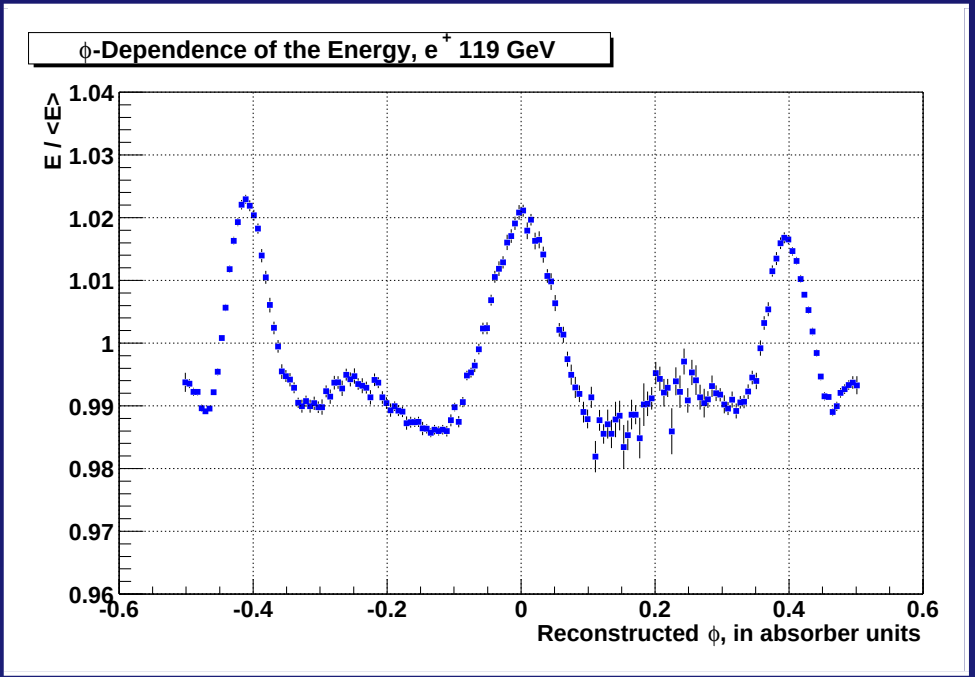


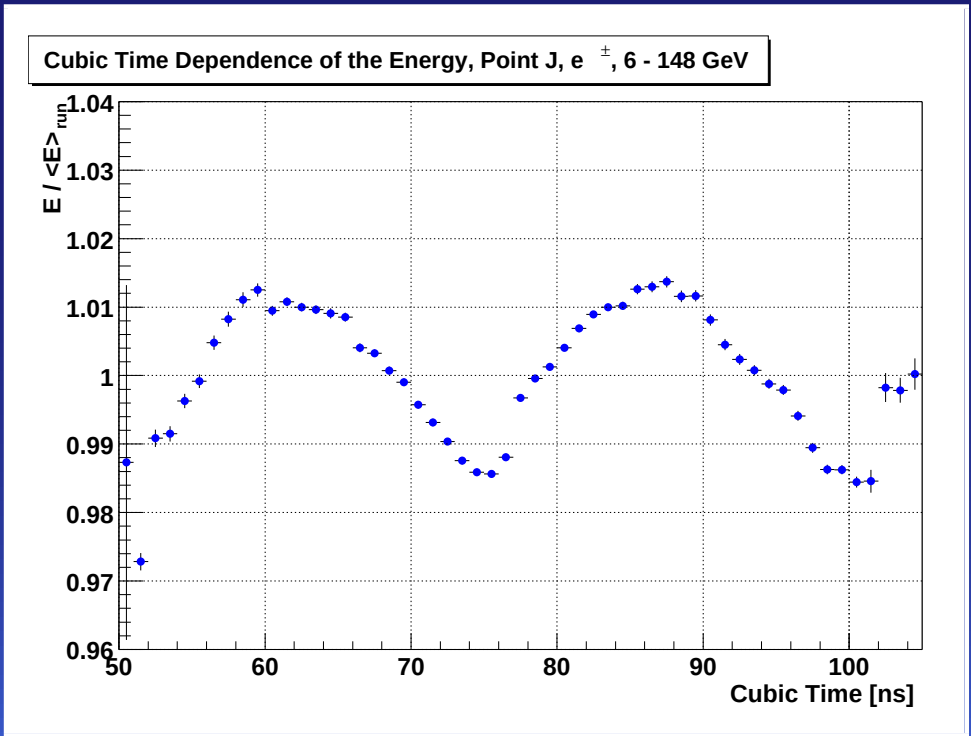


- Geant4 MC with disconnected 1st z-gap fits data best
- correction with signal in previous and next sampling

- Alignment
  - E_{max}/E_{tot} vs. $x(y)$
  - use pad/module boundaries for alignment in x (0 cm; PS: +1.3 cm)
  - use comparison with MC for alignment in y (+2.7 cm; PS: +2.5 cm)

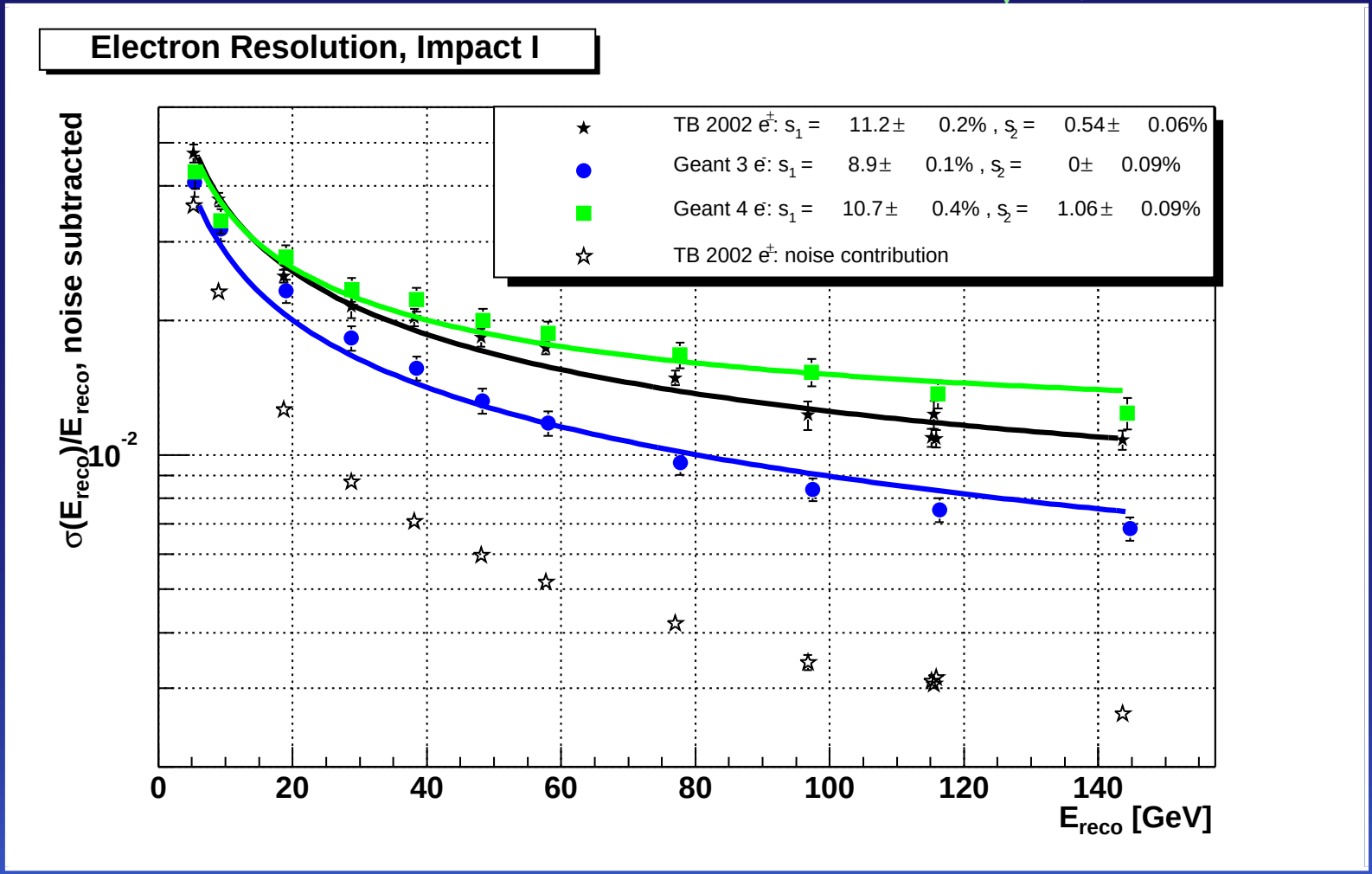
- study EMEC response to electrons first
- predict detector leakage with MC
- apply corrections





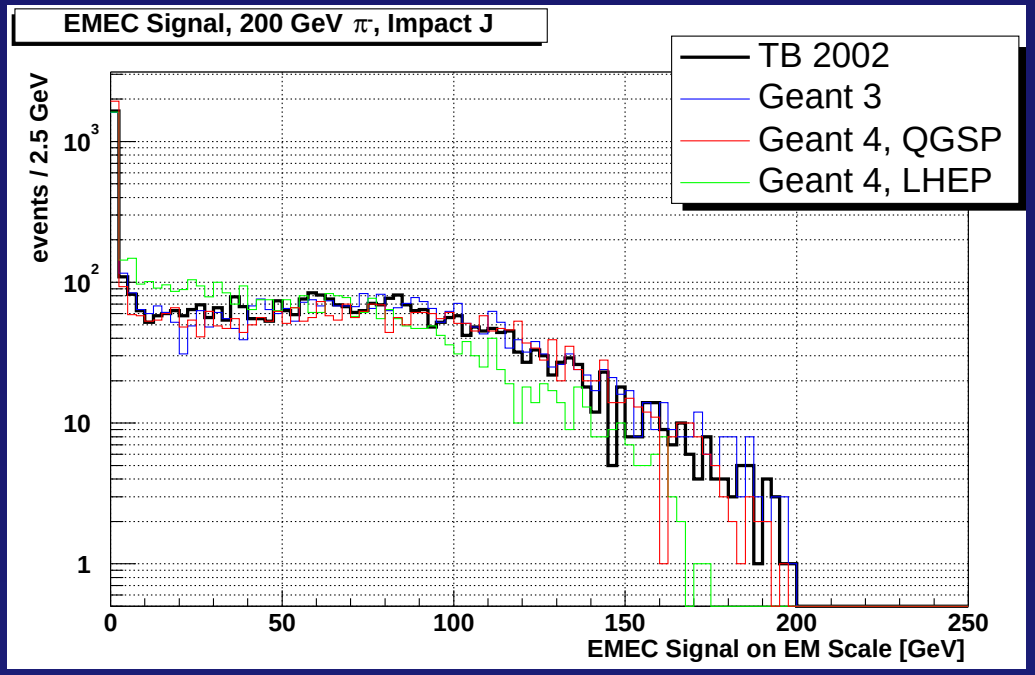
- ϕ correction due to non-uniformity in E-field and sampling variations of $\pm 1.5\,\%$
- correction due to residual variations with the trigger time of $\pm 1\,\%$

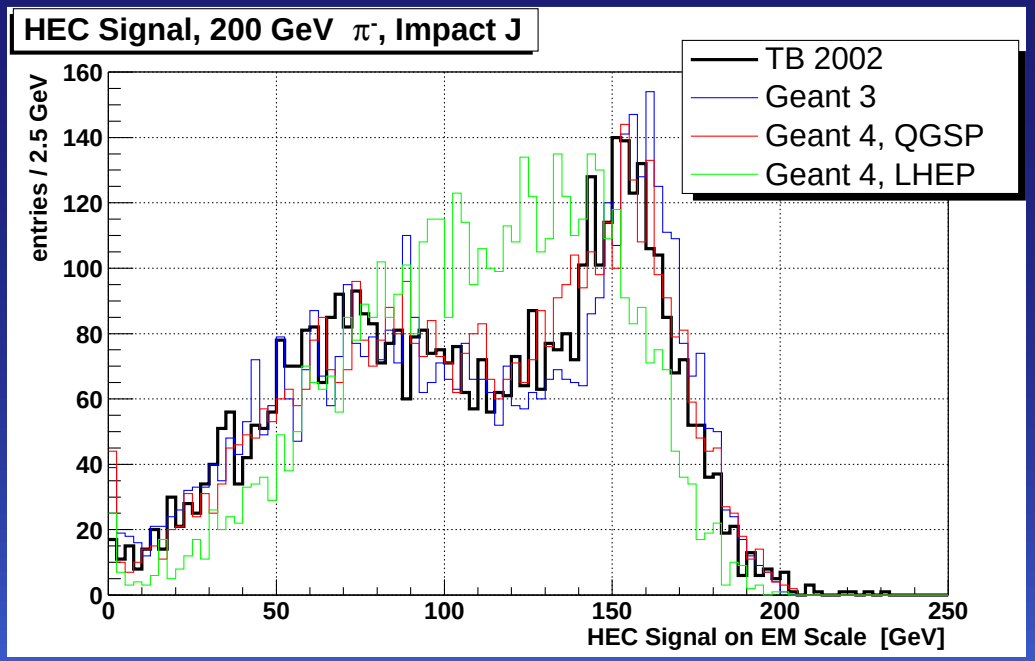
- σ_E/E (%) noise subtracted
  - data: $\frac{11.2 \pm 0.2}{\sqrt{E/\mathrm{GeV}}} \oplus 0.5 \pm 0.1$
  - Geant3: $\frac{8.9 \pm 0.1}{\sqrt{E/\mathrm{GeV}}} \oplus 0.0 \pm 0.1$
  - Geant4: $\frac{10.7 \pm 0.4}{\sqrt{E/\mathrm{GeV}}} \oplus 1.1 \pm 0.1$



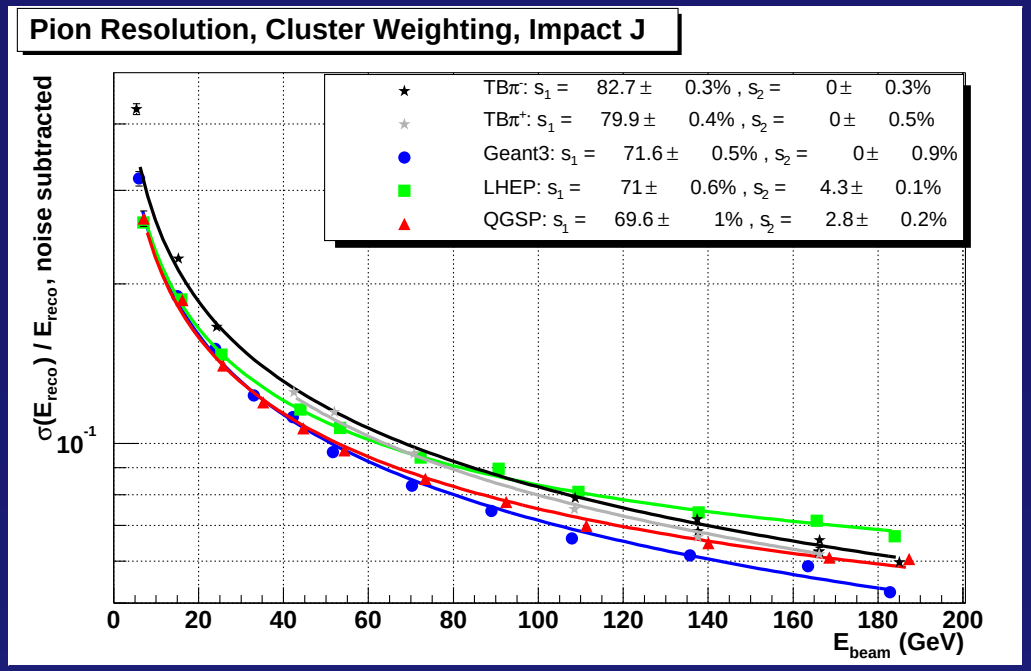
- noise: $\sigma_{\mathrm{noise}}/E \simeq 300\,\mathrm{MeV}/E$

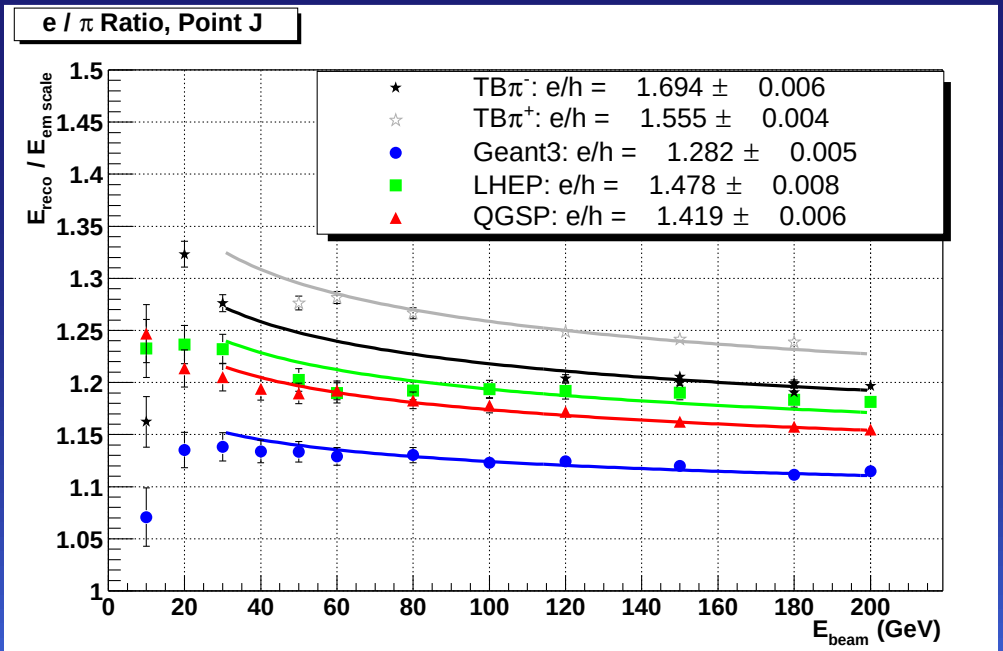
- No electrons in HEC only
  - Electromagnetic scale from previous HEC stand-alone TB
  - Modified by new electronics
  - Calculated value: $\alpha_{\mathrm{em}}^{\mathrm{HEC}} = 3.266\,\mathrm{MeV/nA}$
- Response to 200 GeV pions in data and MC on em-scale
  - upper plot shows EMEC
  - lower plot shows HEC
  - Geant3 and Geant4 QGSP describe data reasonably well
  - Geant4 LHEP deviates substantially





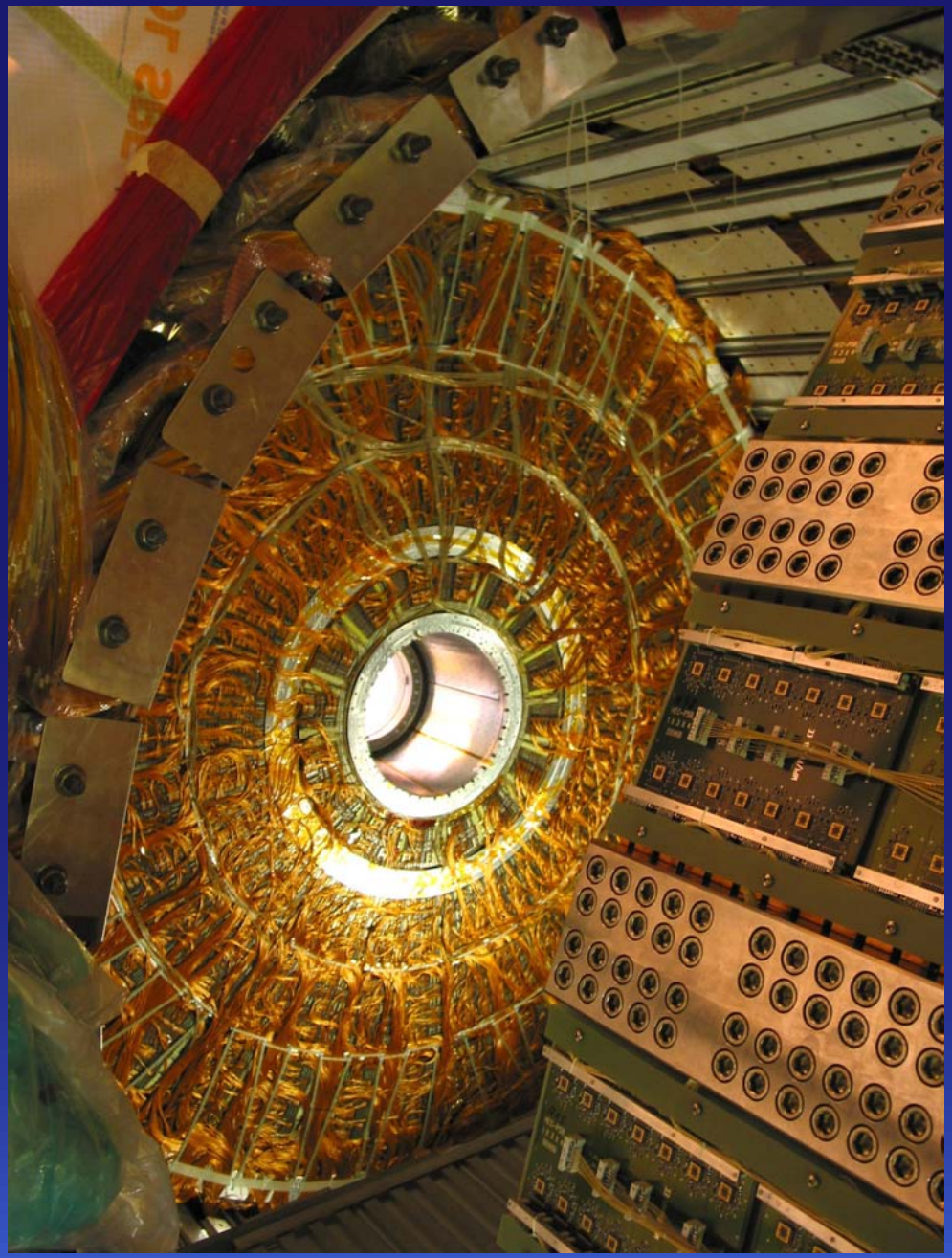
- σ_E/E (%) noise subtracted
  - data (π^-): $\frac{82.7 \pm 0.3}{\sqrt{E/\mathrm{GeV}}} \oplus 0.0 \pm 0.3$
  - data (π^+): $\frac{79.9 \pm 0.4}{\sqrt{E/\mathrm{GeV}}} \oplus 0.0 \pm 0.5$
  - noise: $\sigma_{\mathrm{noise}}/E \simeq 1 - 2.5\,\mathrm{GeV}/E$

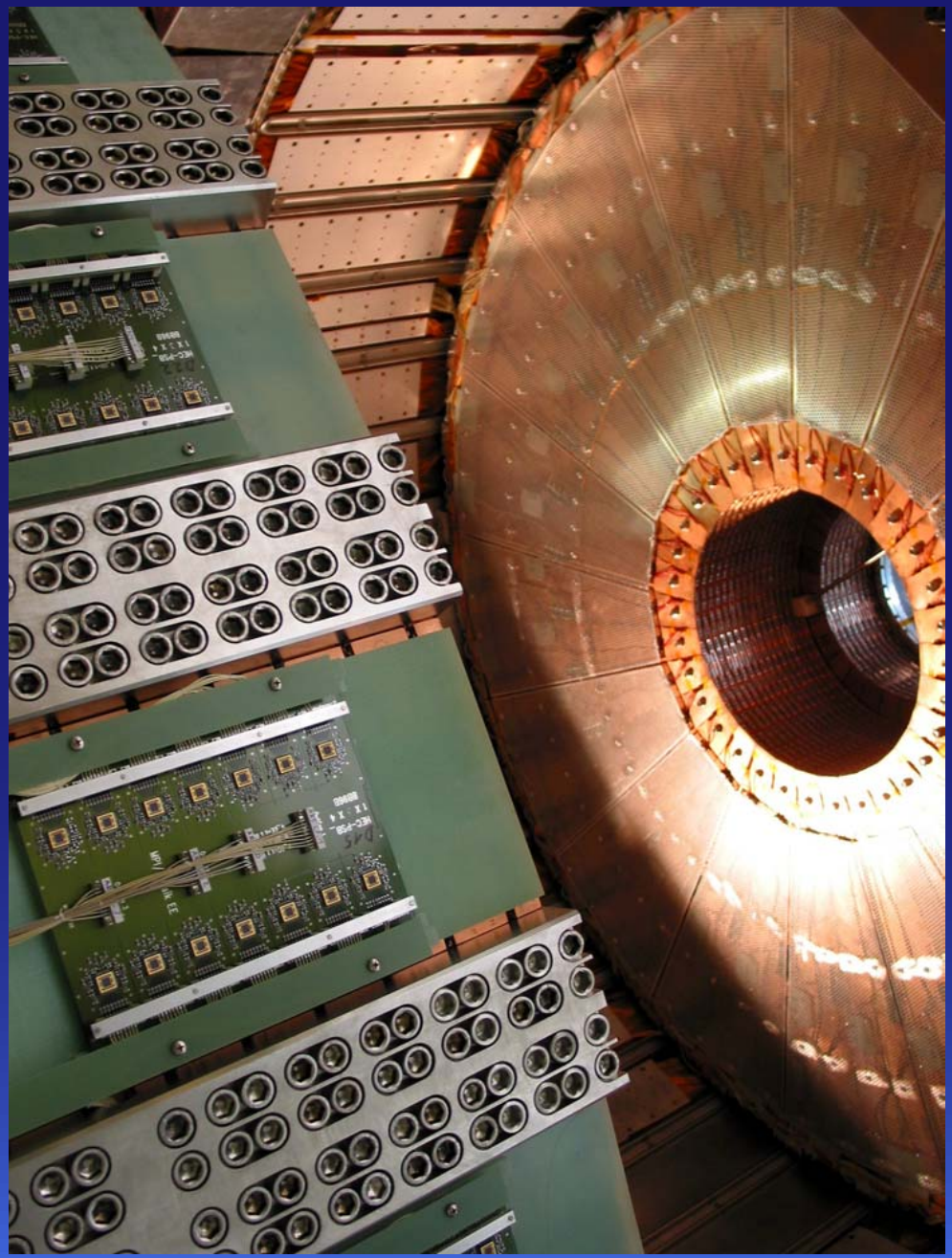




- Geant3 and all Geant4 models give similar results
- combined e/π ratio
  - shows total $E_{\mathrm{reco}}/E_{\mathrm{em}}$
  - indicates the amount of non-compensation
  - fitted e/h-ratios for combined HEC and EMEC have no direct interpretation

HEC ► Installation





HEC ► Installation II

- EMEC/HEC/FCal beam test 2004

May-to-Jul-2004	Beam runs
Aug-to-Sep-2004	
Feb-or-Mar-2004	Technical run

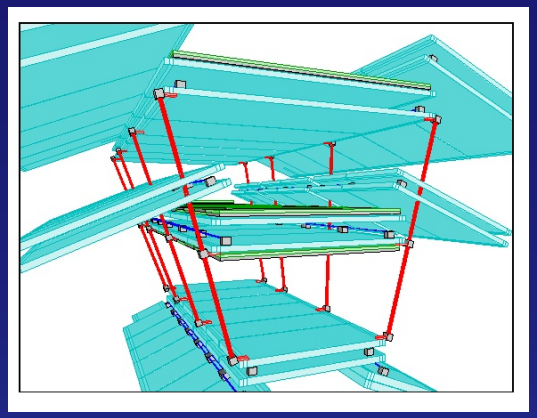
- Calorimeter installation

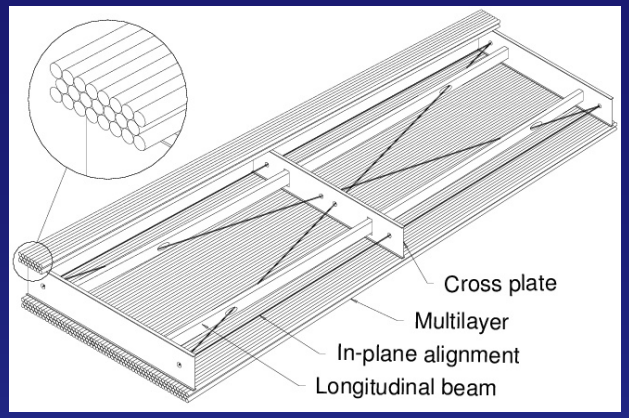
end-Mar-2005	Barrel calorimeter moved to final position
Jan-Feb-2005	Last BT coil delivered
mid-Oct-2004	Barrel calorimeter completed
begin-Aug-2004	LAr Barrel Cryostat lowering
01-May-2004	1st BT Coil ready for installation
01-Mar-2004	Tile Barrel installation starts
begin-Jan-2004	Tile & BT infrastructure installation starts

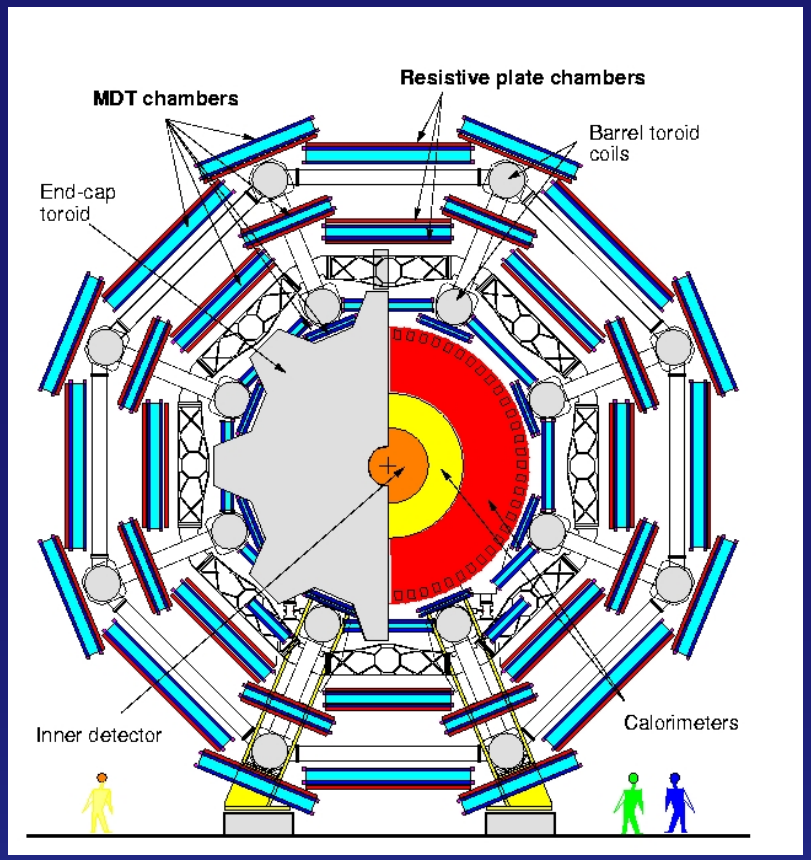
- due to shifts in Barrel schedule no new official Endcap installation schedule

Monitored Drift Tubes – MDT

- Muon Chambers layout
  - 5000 m^2 of precision muon chambers
  - Momentum resolution $2 - 10\,\%$ for $10 - 1000\,GeV$ muons
  - Optical monitoring of relative chamber positions with 30 μm accuracy

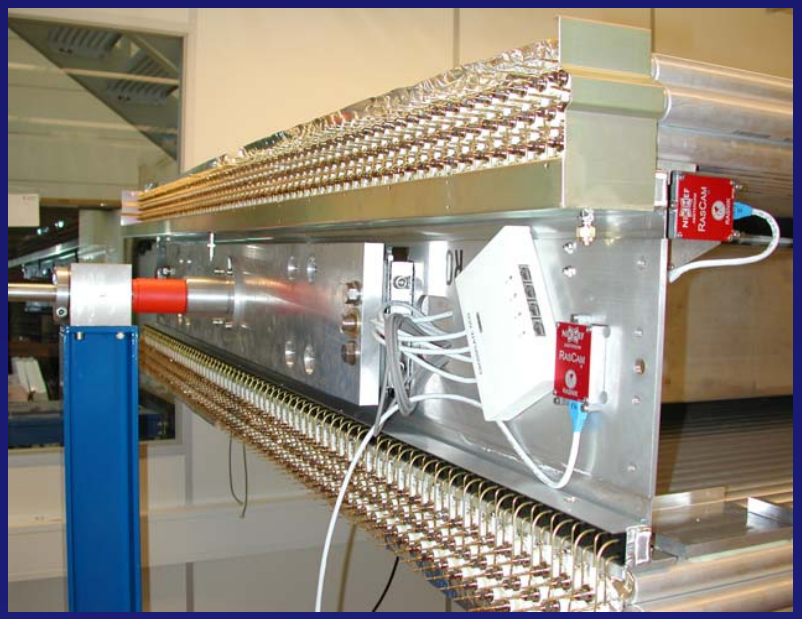




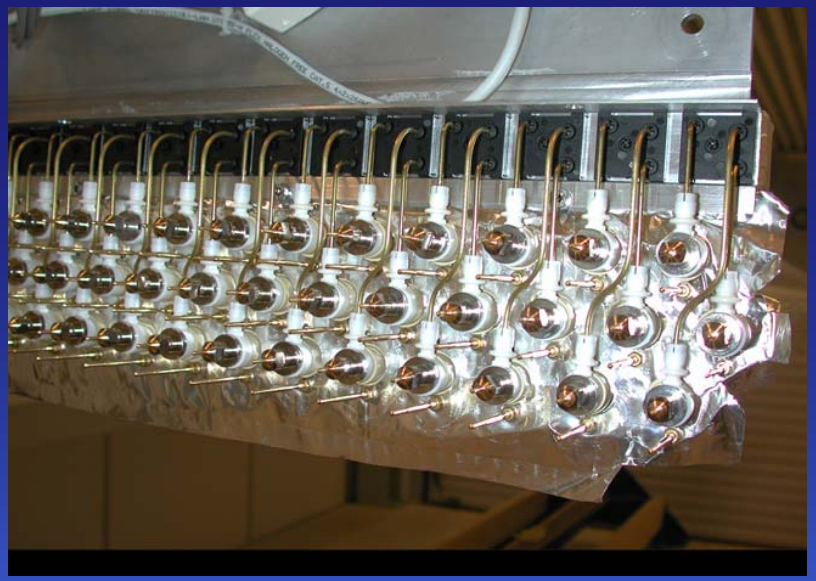


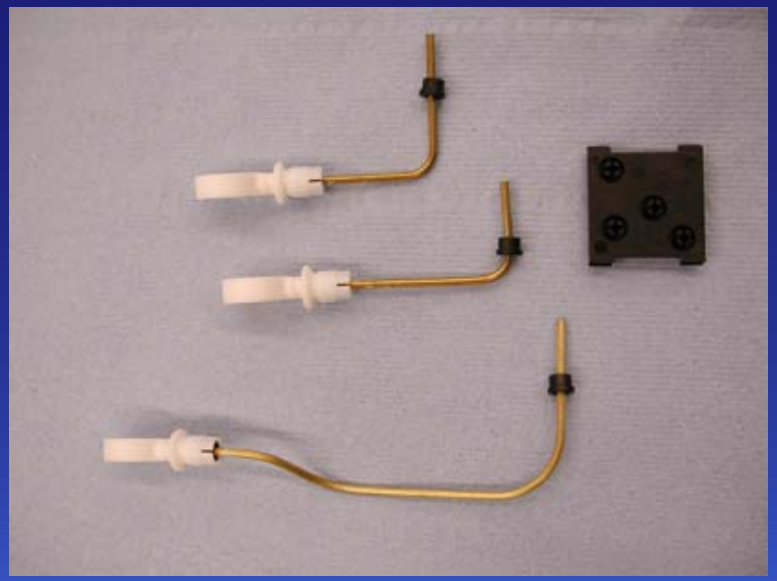
- Muon System commitments @ MPI
  - Construction of 88 MDT chambers (BOS) (15 % of active area)
  - Design and production of 104 MDT/RPC supports
  - Design and fabrication of 196 kin. mounts for endcap alignment system
  - Design of access tools for BOS chambers

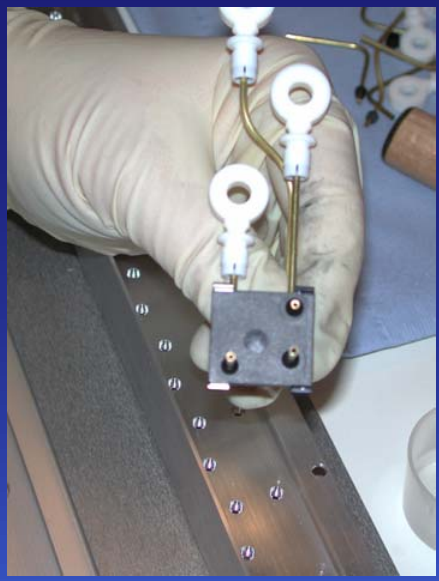
MDT ► Installation of gas connections

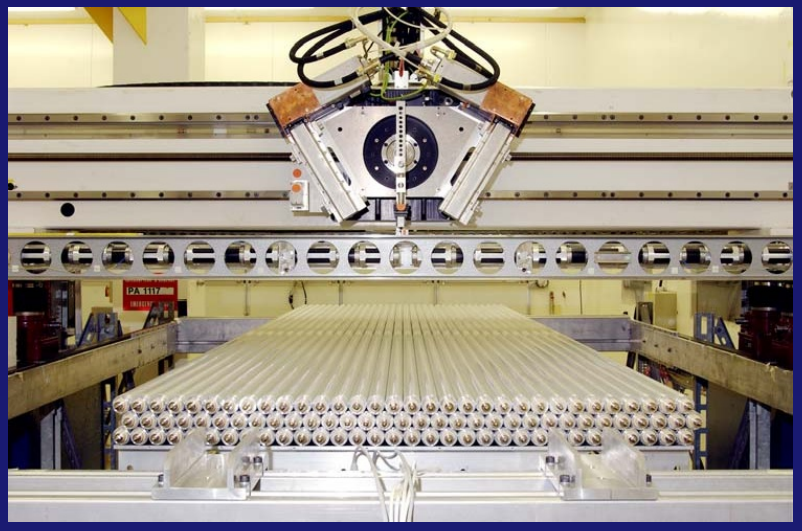


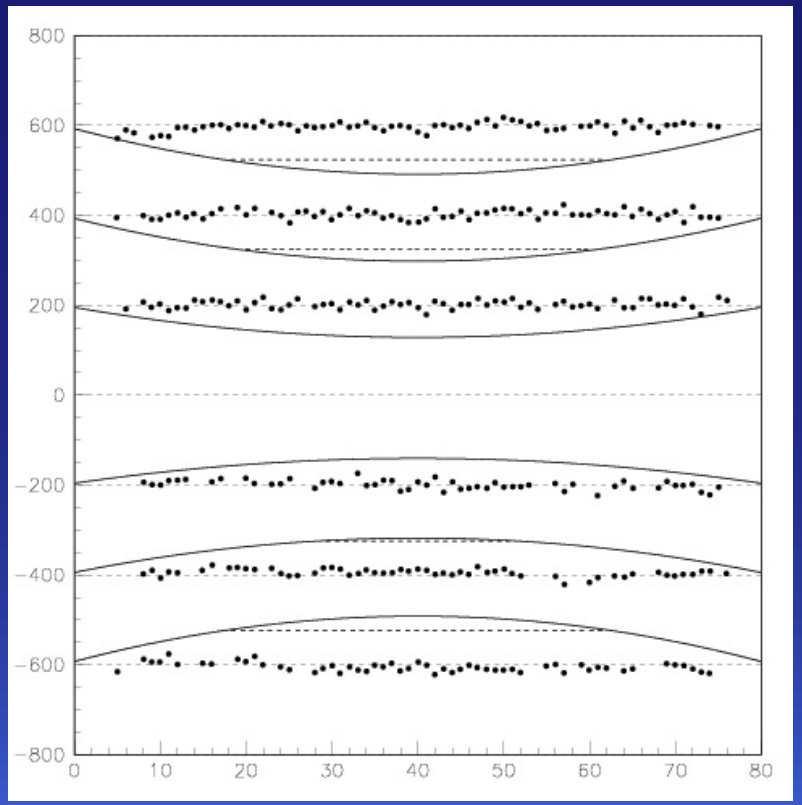
- MDT gas connections
  - 3500 O-ring seals per chamber
  - high gas tightness required
- 1.5 years delay due to corrosion of brass gas tubelets
  - replaced by stainless steel
  - 2 chambers/week required production rate starting Jan-2004





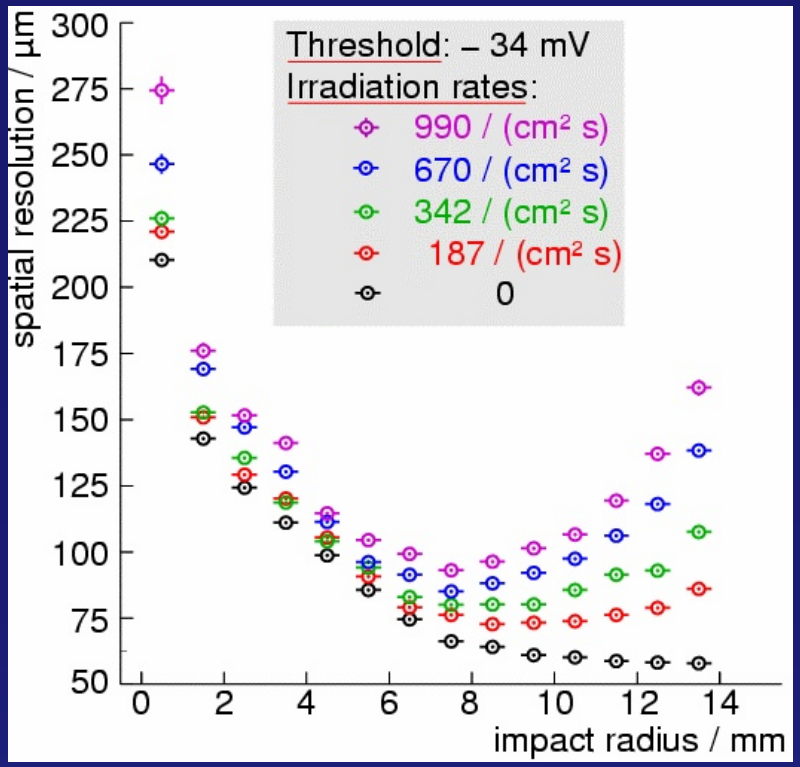




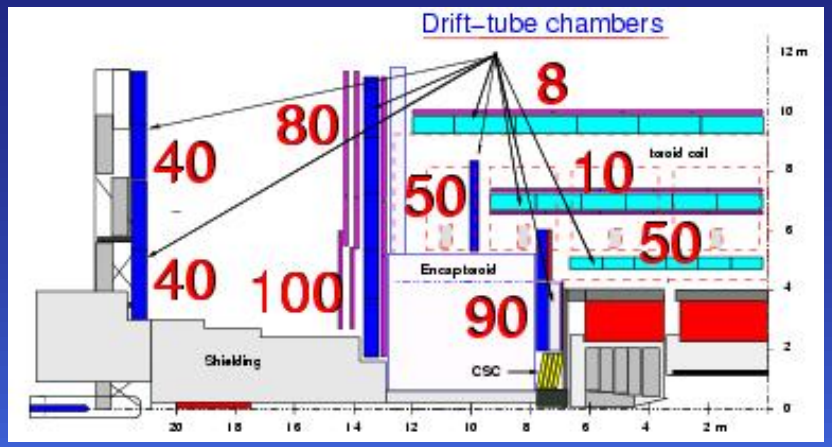


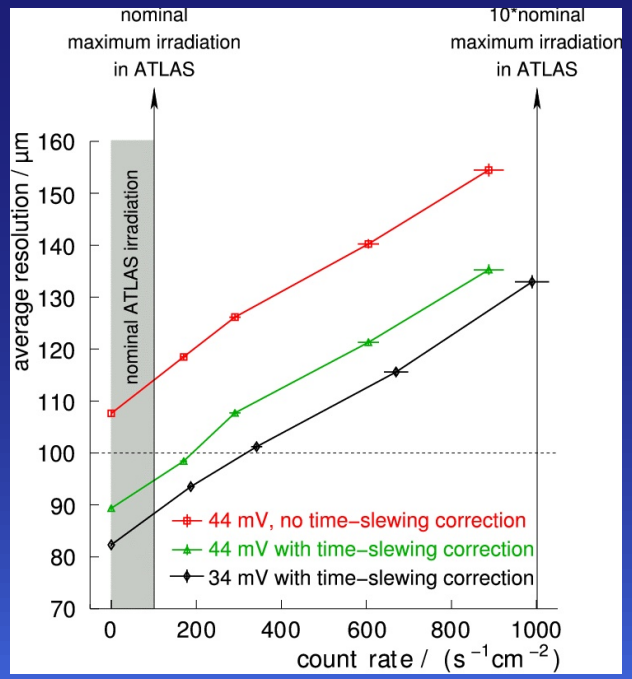
- Installation and Test of Readout Electronics
  - start Jan 2004 in Eching
- MDT/RPC common supports
  - assembly @ MPI Jan–May 2004
  - mounting of MDT and RPC on common support @ CERN
  - installation test @ CERN next week
- Chamber precision measurements
  - optically and mechanically during assembly with 10 μm accuracy
  - X-ray scans with 3 μm precision
- Start of chamber tests @ LMU
- Performance tests at LHC background levels

MDT ► Performance tests at LHC background levels

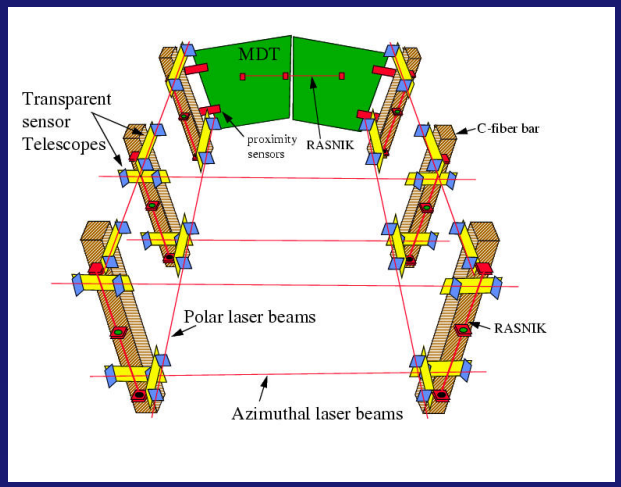


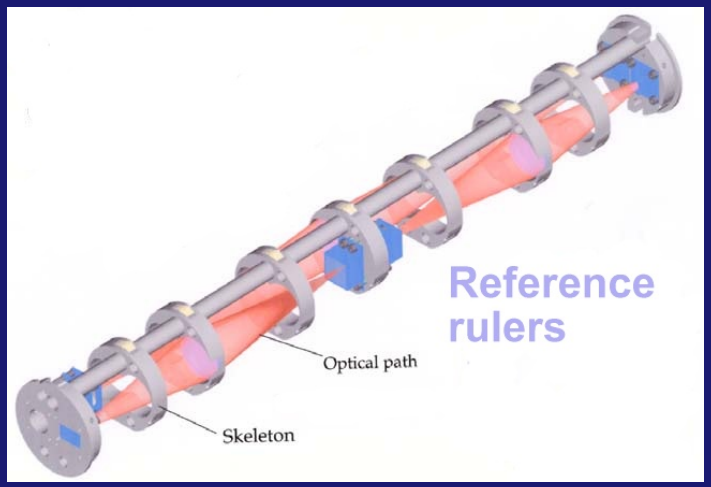
- Nominal rates up to $100\,\mathrm{Hz/cm^2}$
- X5/GIF testbeam and γ irradiation facility @ CERN 2002/2003
  - $100\,\mathrm{GeV}$ muon beam
  - silicon strip detector beam telescope
  - test up to $10\times$ nominal ATLAS background
  - MDT resolution $80\,\mu\mathrm{m}$ without irradiation

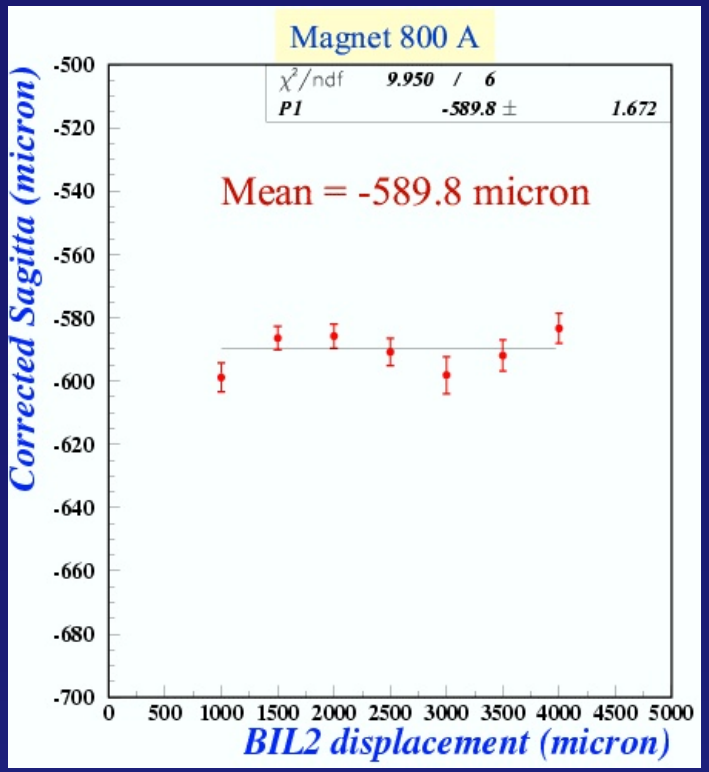




MDT ► Optical alignment system







- Concept by MPI
  - Misalignment corrections of track sagitta with 30 μm precision
  - for 20 μm sensor positioning accuracy

- Test of one sector @ CERN
  - muon sagitta reconstruction in 3 chamber layers
  - sagitta follows controlled movement
  - correction with alignment data yields stable sagitta within 20 μm

- Chamber Installation

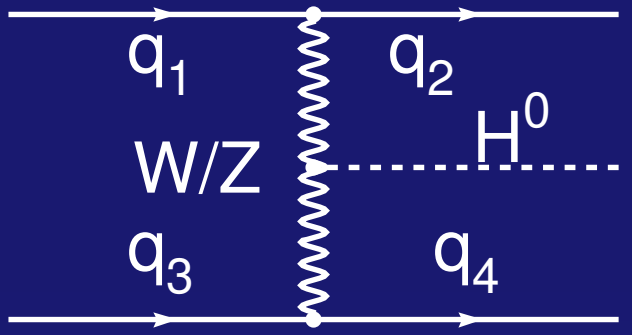
Jun-2005	Main installation (62)
Feb-2005	Feet installation 2 (22)
Oct-2004	Feet installation 1 (4)

- Chamber assembly and testing

Jun-2004-Dec-2004	MDT/RPC assembly & test @ CERN
Oct-2003-Nov-2004	test @ LMU
Oct-2003-Oct-2004	installation of gas connections
Jan-2003-May-2004	installation of readout electronics
until Aug-2004	complete chamber assembly

ATLAS Physics

- Physics program of ATLAS
  - Higgs searches
  - SUSY searches
  - t-physics
  - b-physics
- Recent development in Higgs searches
  - Weak Boson fusion gives excellent discovery potential for a wide Higgs mass range
  - Signature: 2 jets with large $\Delta\eta$, 1(2) high $p_\perp$ lepton(s), missing transverse momentum
  - jet reconstruction in EMEC/HEC/FCal important
  - lepton reconstruction with ID/Muon



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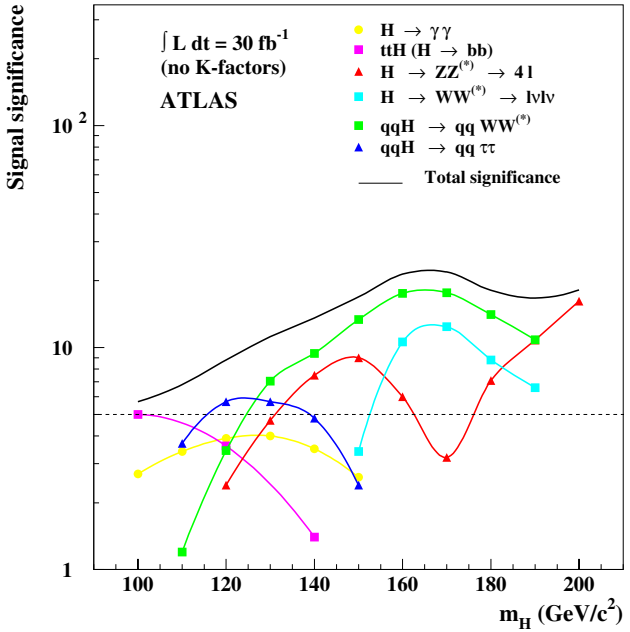

Conclusions

- MPI projects for ATLAS progressing well
  - SCT group qualifies soon for serial production
  - HEC group finished installation of one full endcap
  - MDT group solved gas-tube problem
- All three subsystems important for key physics topics with ATLAS
- Outlook: exciting combined performance tests in 2004