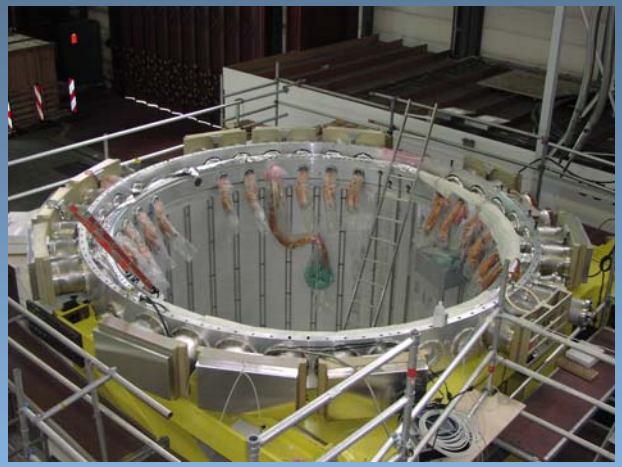
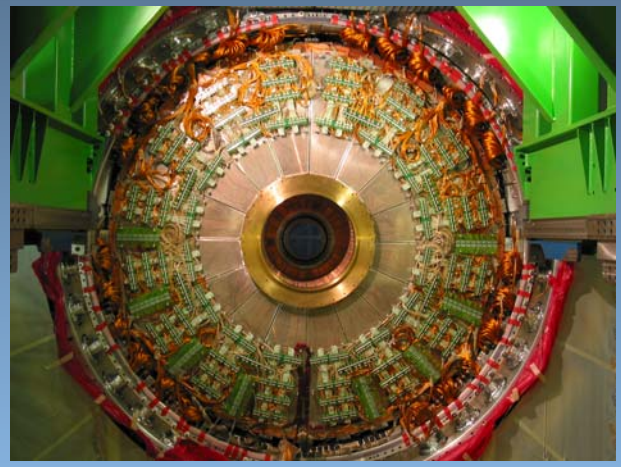
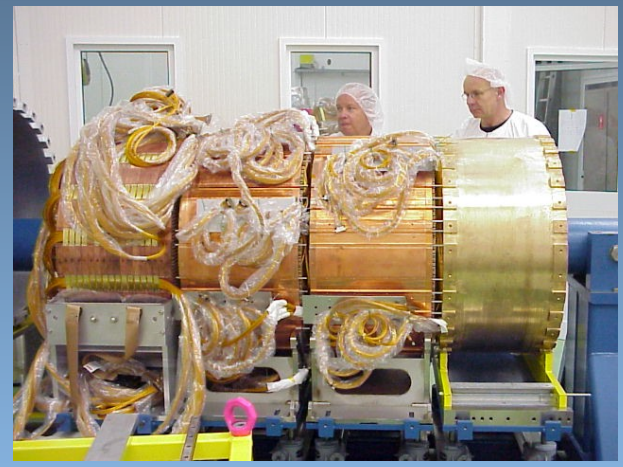
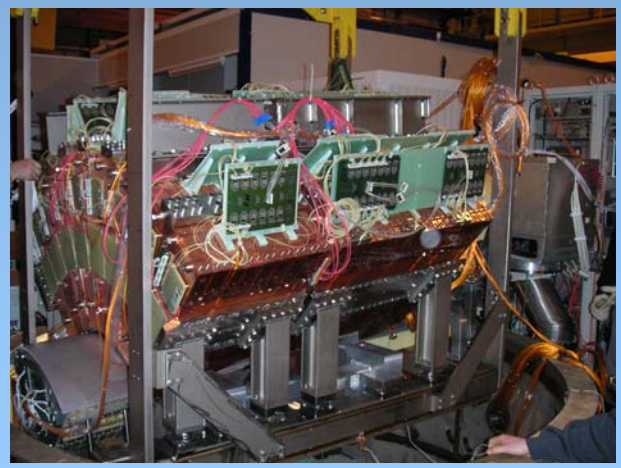
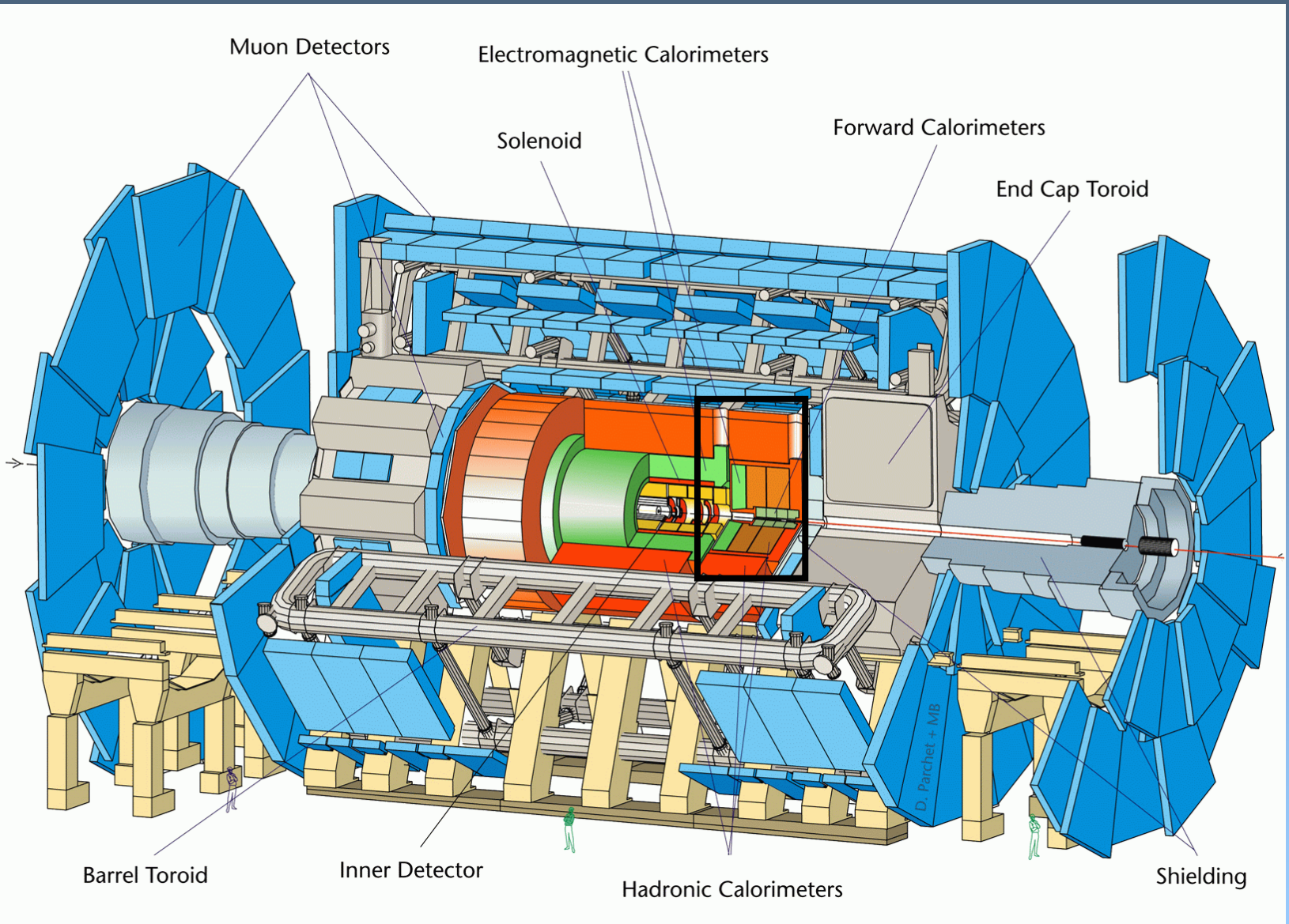
The ATLAS Detector at the Large Hadron Collider

Peter Krieger IPP/University of Toronto


The ATLAS Detector at the Large Hadron Collider



The ATLAS Canada Collaboration

Alberta
Carleton
Montreal
Simon Fraser
Toronto
TRIUMF
UBC
Victoria
York

32 University/Lab Physicists
80 People, including engineers, technicians and students

Educational Role

20 Undergraduate students
25 Graduate Students
16 Postdocs

this talk + calorimeter testbeams

Focus on Liquid Argon Calorimetry

Four NSERC funded projects:

Hadronic Endcap Calorimeter

Hadronic Forward Calorimeter

Endcap Signal Cryogenic Feedthroughs

Front-End Board Electronics

Other Important Activities

Radiation Hardness Studies

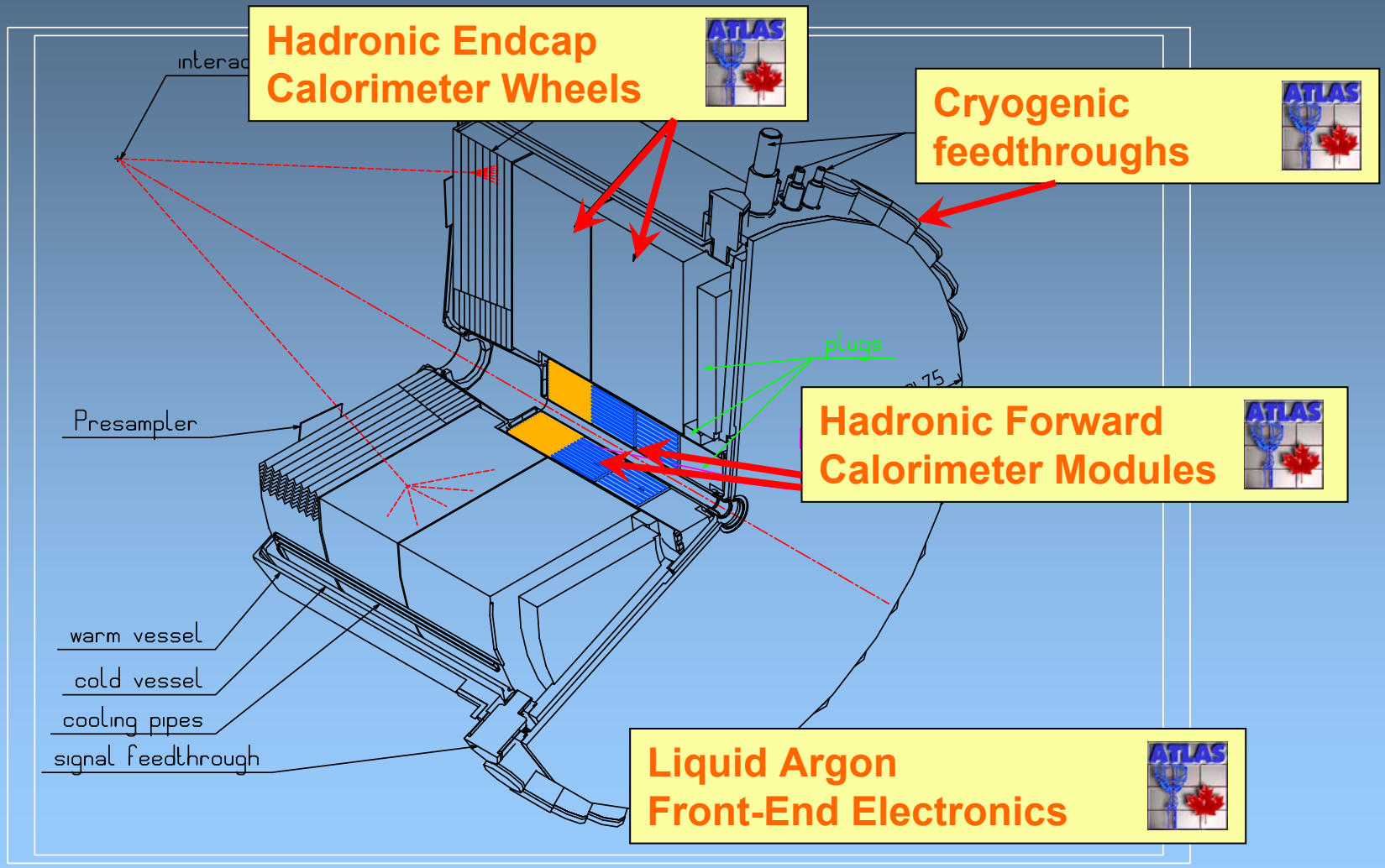
Physics Studies

Event Filter Processor Farm

ATLAS Computing

Pixel Testing and Assembly

ATLAS Canada NSERC-funded Construction Projects



The Large Hadron Collider at CERN

proton-proton collider being installed in existing 27km circumference LEP ring at CERN in Geneva Switzerland

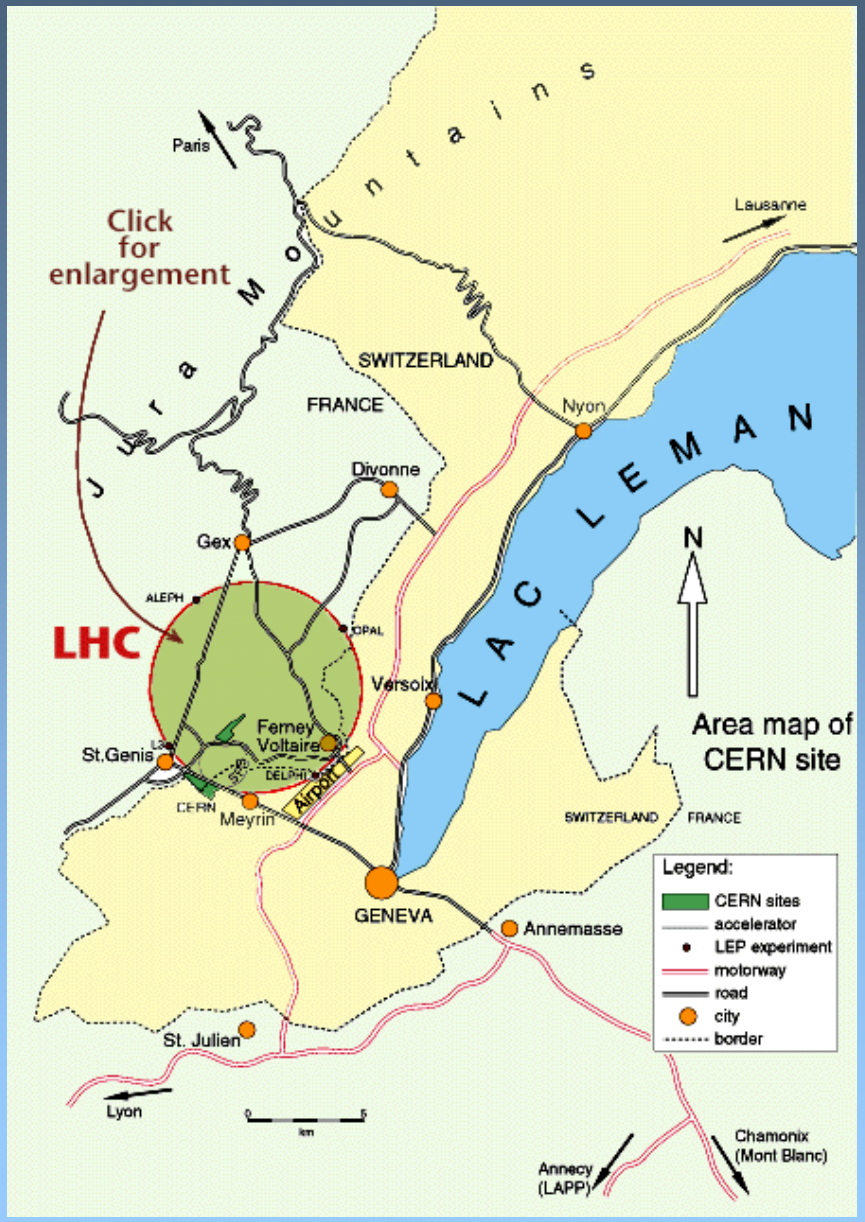
- pp centre-of-mass energy of 14 TeV
- constituent centre-of-mass energies ~ 1-2 TeV
- $\mathcal{L}$ = 10^{33} cm^{-2}/s (low luminosity)

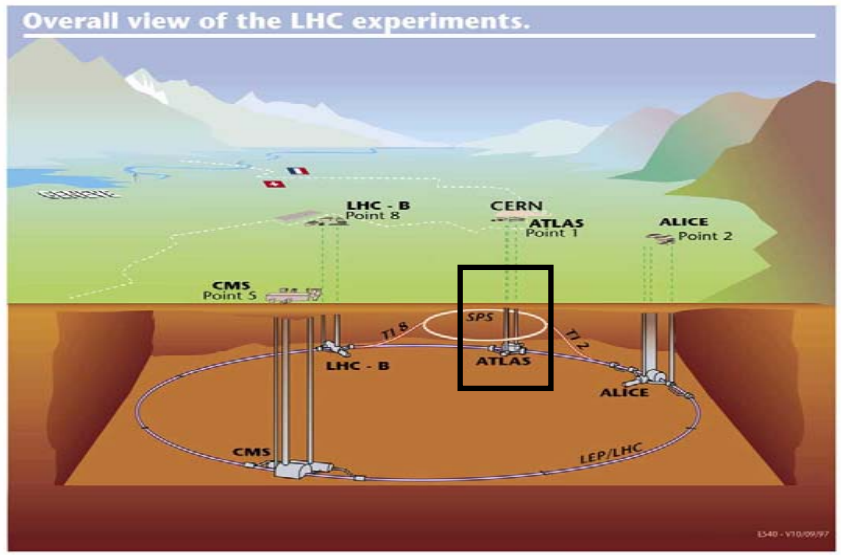
  10^{34} cm^{-2}/s (high luminosity)
- proton bunch spacing of 25 ns (40 MHz collision frequency)

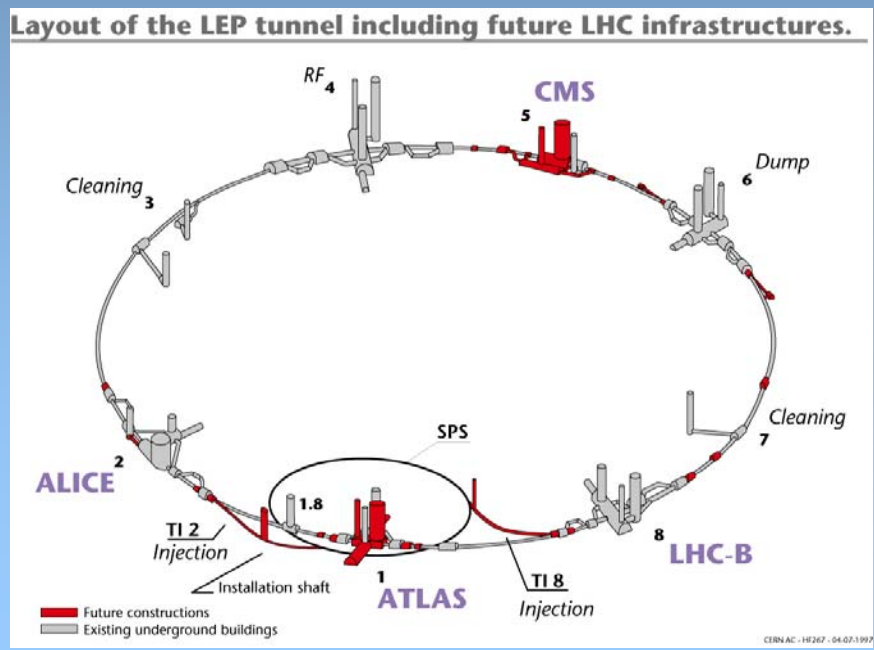
Physics Goals: whatever TeV scale physics is there to be discovered

- Higgs boson
- Supersymmetry
- Large extra dimensions
- Extended gauge theories
- Compositeness
- B Physics (oscillations, CP violation)

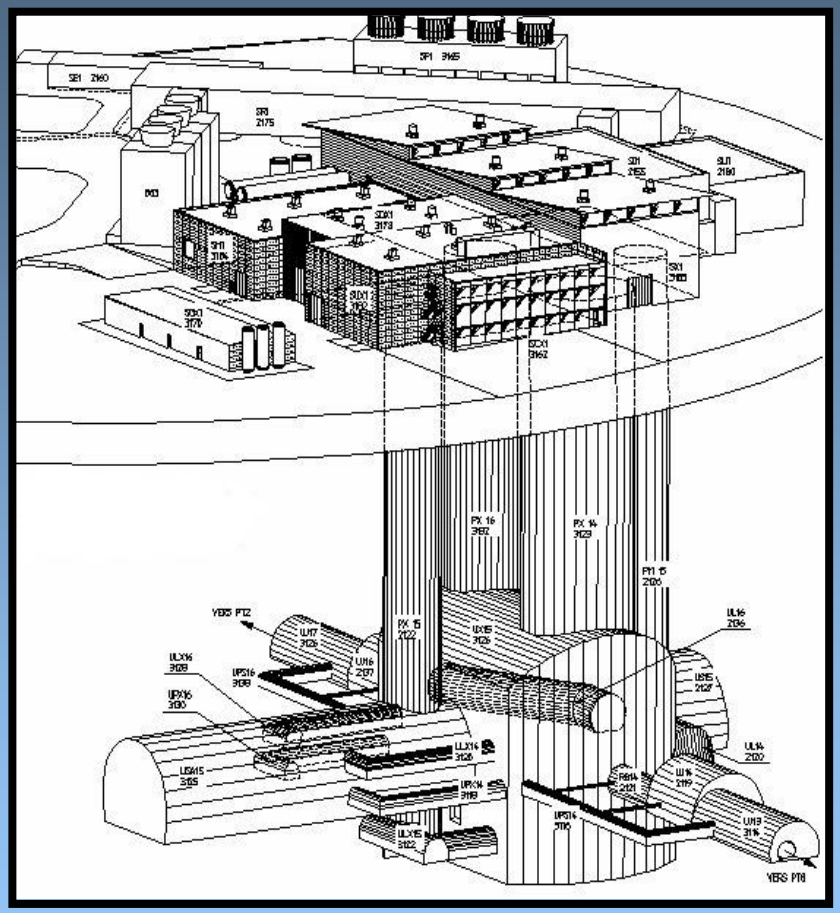
The Large Hadron Collider at CERN

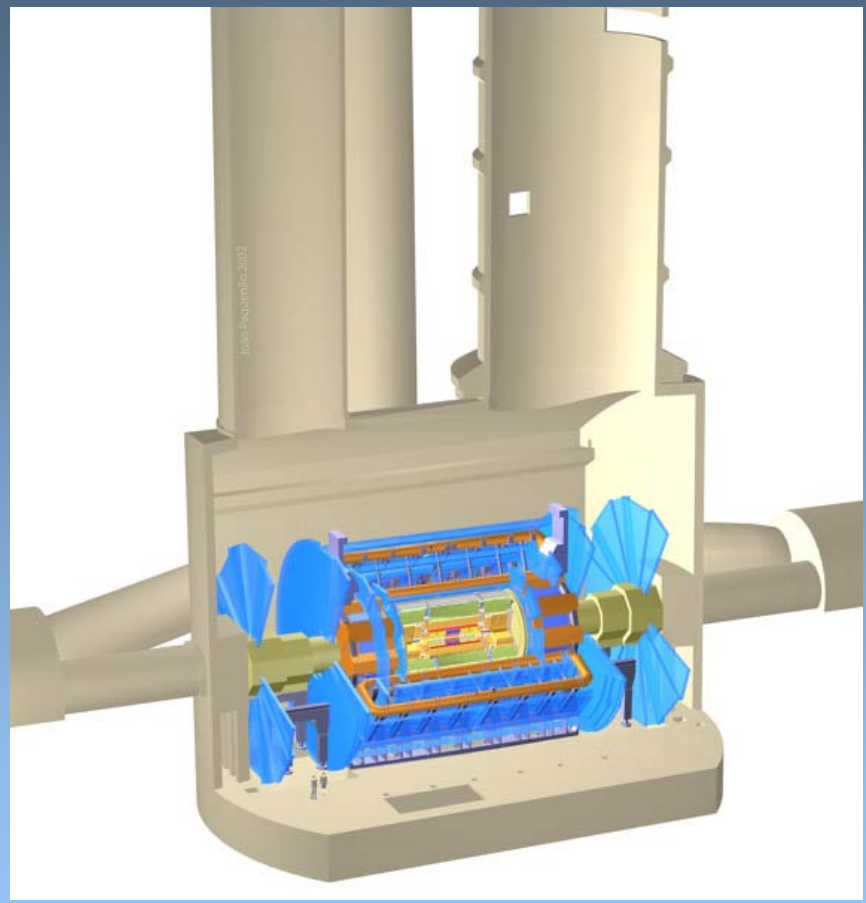






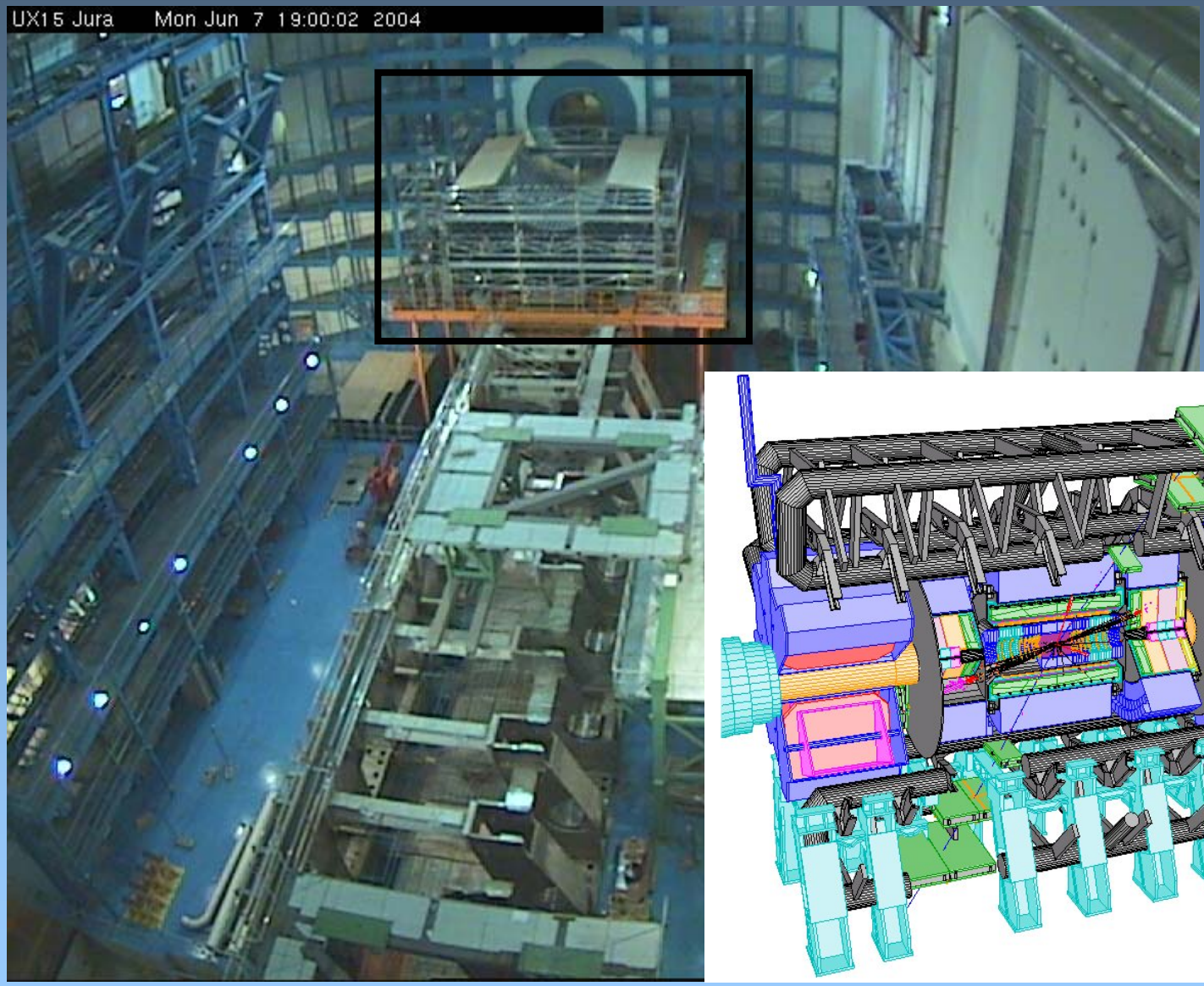
The ATLAS Cavern



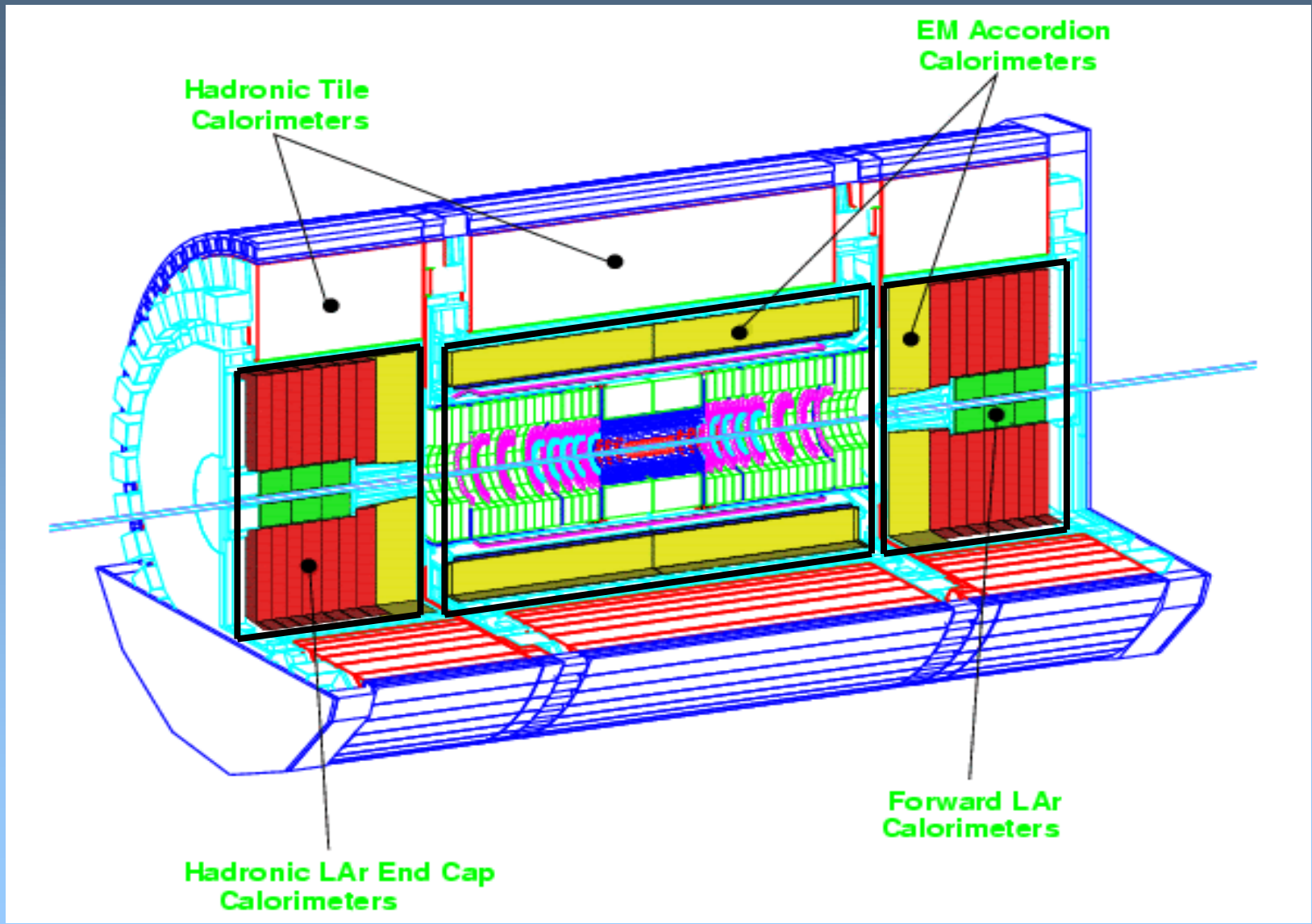


The ATLAS Cavern, 1 Year Ago Today

The ATLAS Cavern June 7, 2004



The ATLAS Calorimeters



ATLAS Barrel Cryostat: Solenoid Insertion

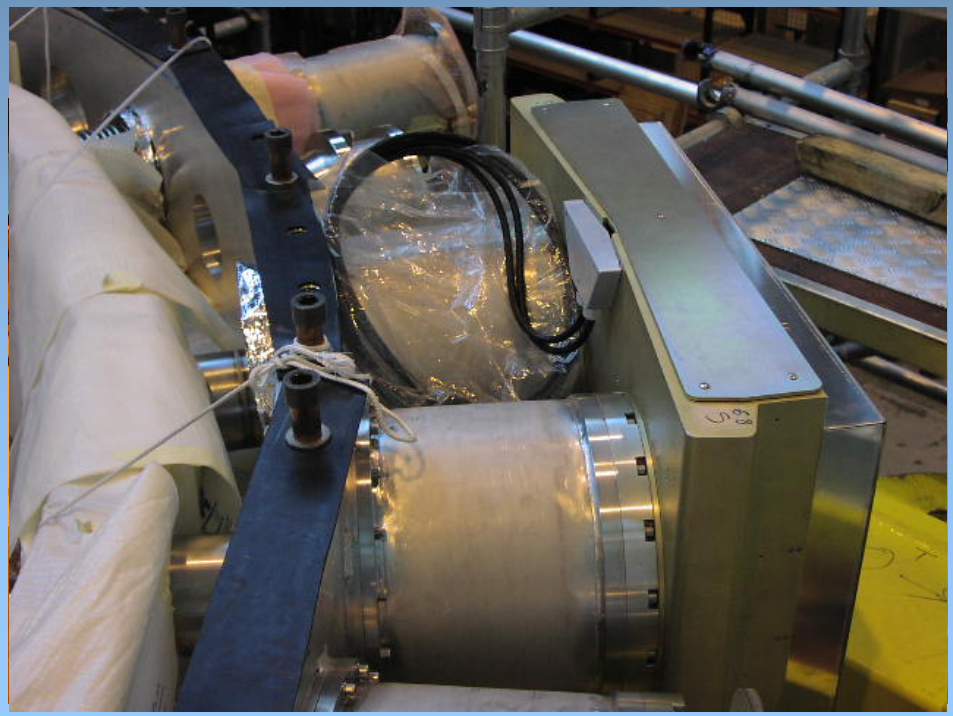
Endcap Signal Cryogenic Feedthroughs

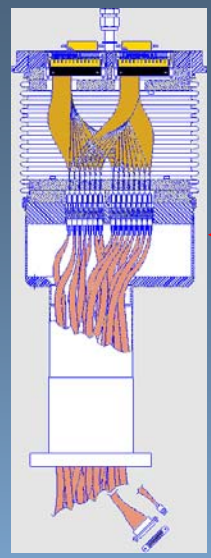
ATLAS liquid argon calorimetry has over 180k signal channels which must come through the walls of the cryostats

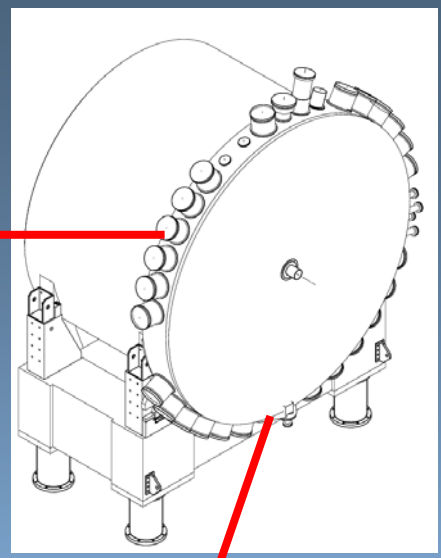
Each feedthrough unit carries 1920 electrical channels.

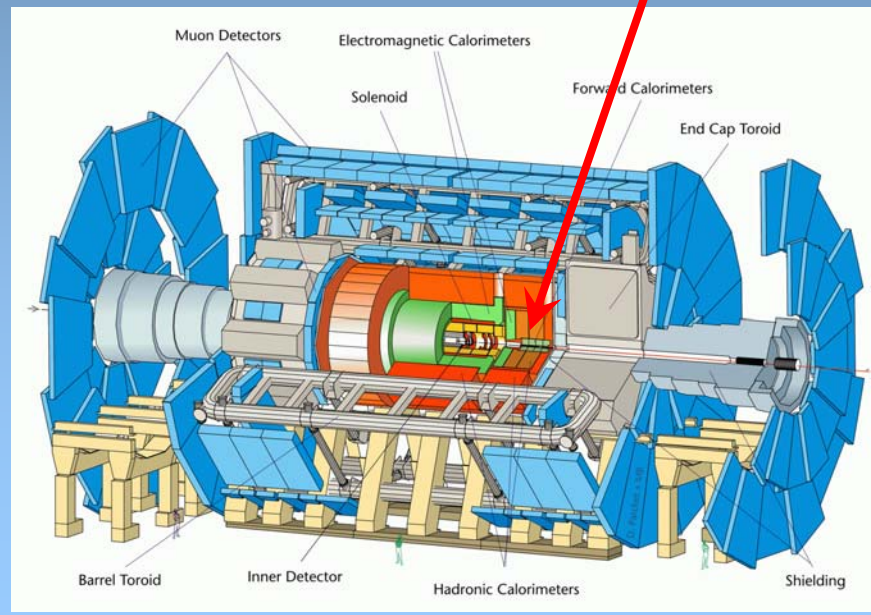
Barrel: 64 feedthrough units (+spares)

Endcap: 50 feedthrough units total (+5 spares)



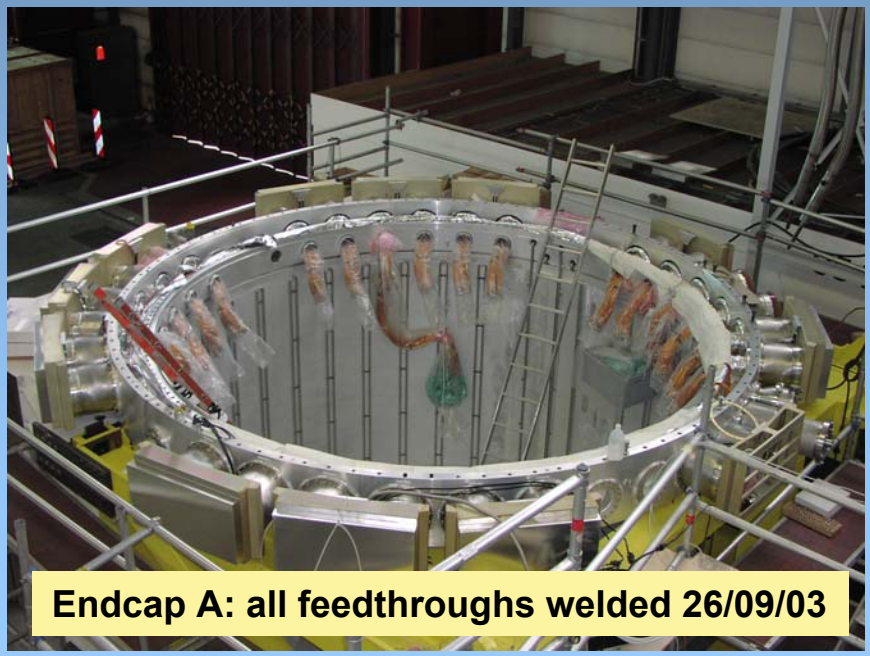






Feedthrough Installation and Testing Complete

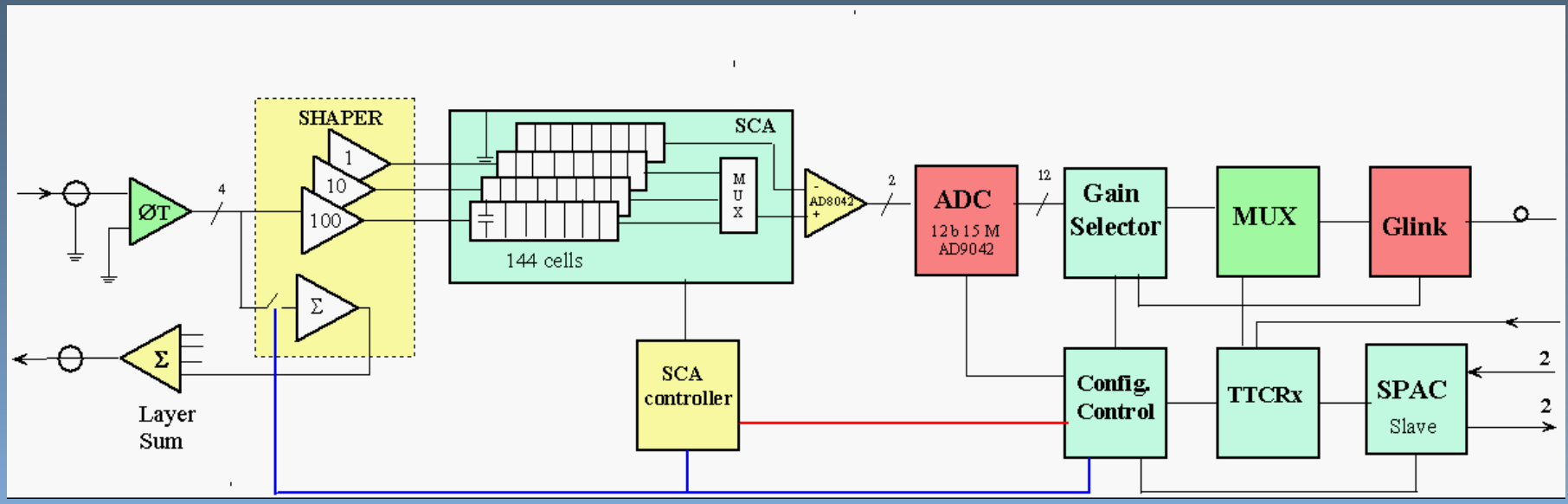
Feedthrough construction in Victoria completed	October 2002
Endcap C feedthrough installation completed	January 2003
Endcap C cabling and electrical testing completed	April 2003
Endcap A feedthrough installation completed	Sept 2003
Endcap A warm cabling and electrical testing completed	October 2003



Endcap A: all feedthroughs welded 26/09/03

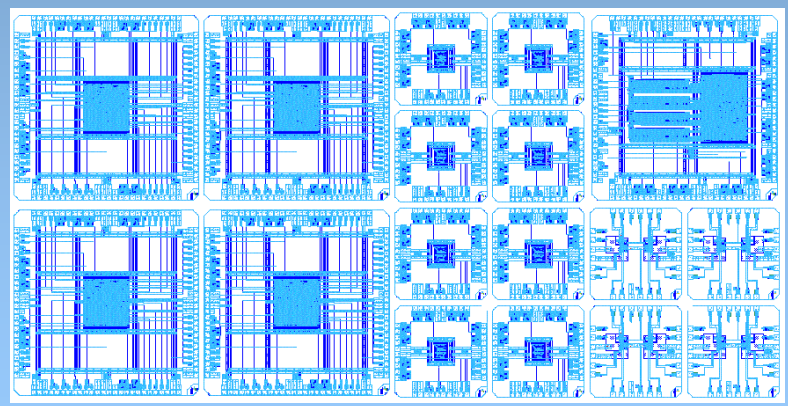
Endcap A feedthrough electrical testing

Liquid Argon FEB Electronics

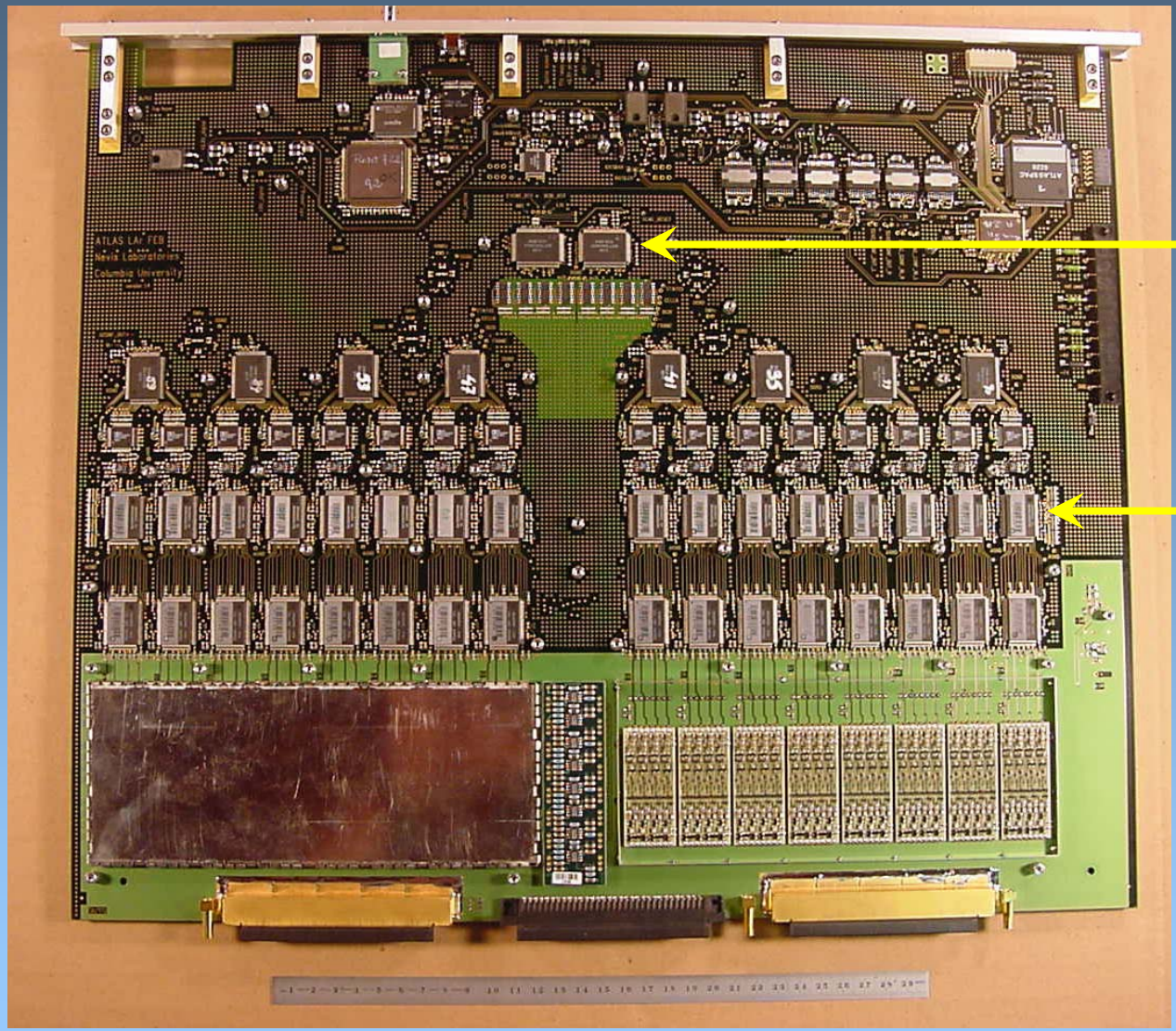


ATLAS Canada responsibilties:

- ✓ All Switched Capacitor Array Controllers
- ✓ All other deep sub-micron chips
  - ✓ gain-selectors
  - ✓ clock fanout



Liquid Argon FEB Electronics

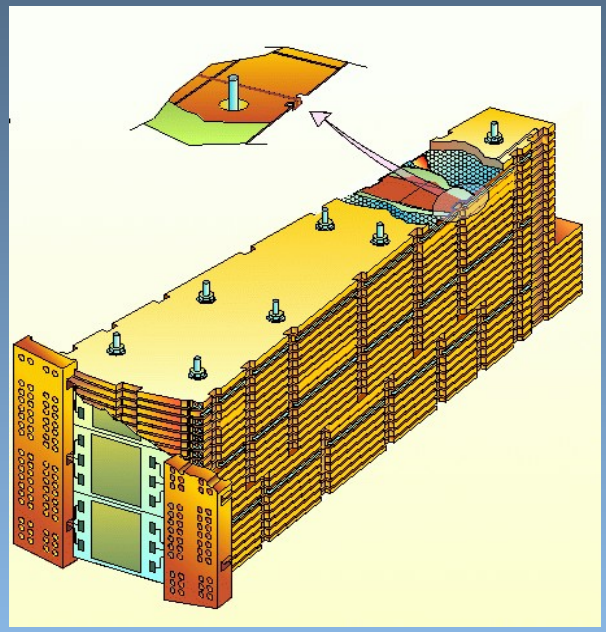


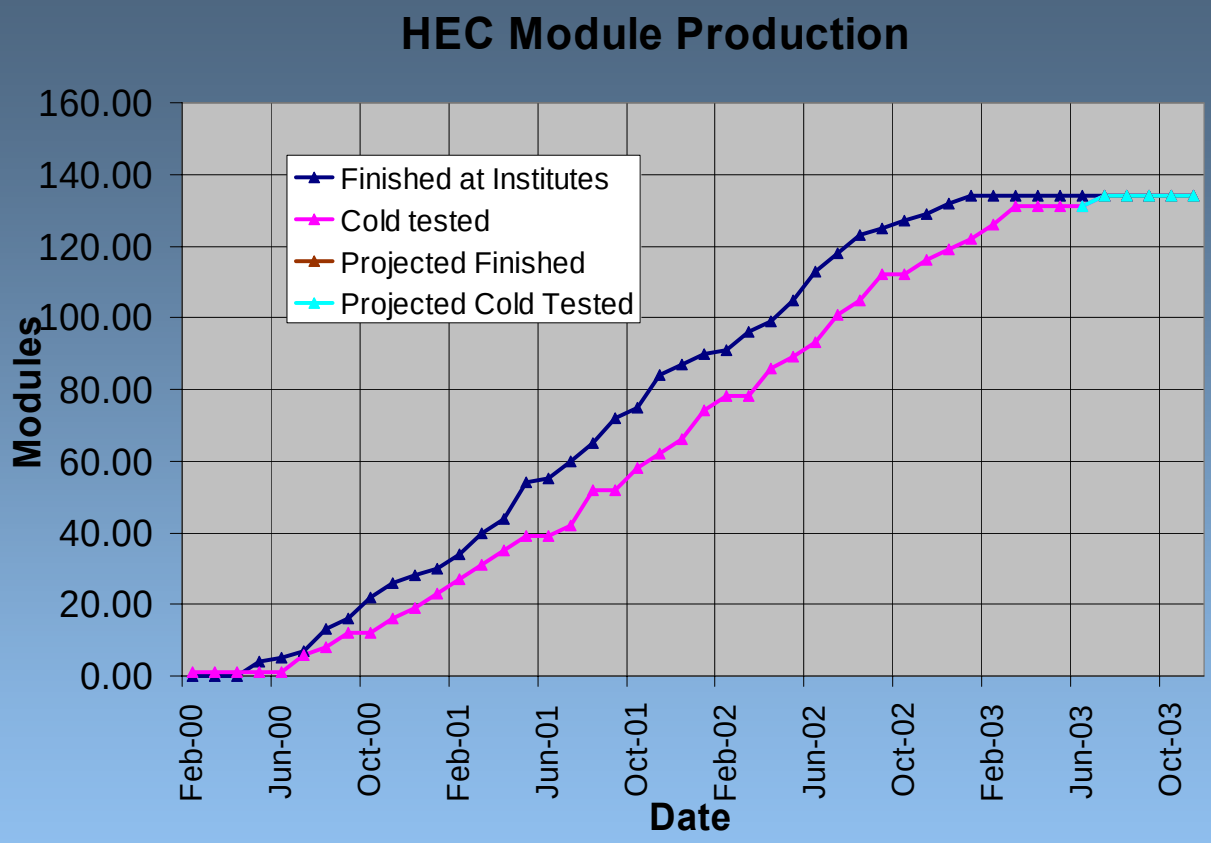
All chips have been delivered and await FEB construction:

To start ~ July 2004

HEC Module Production

32 modules / wheel





- ✓ Module Production Completed
- ✓ Coldtesting completed Fall 2003
- ✓ HEC Wheel construction completed
- ✓ Construction of special modules for combined testbeam completed

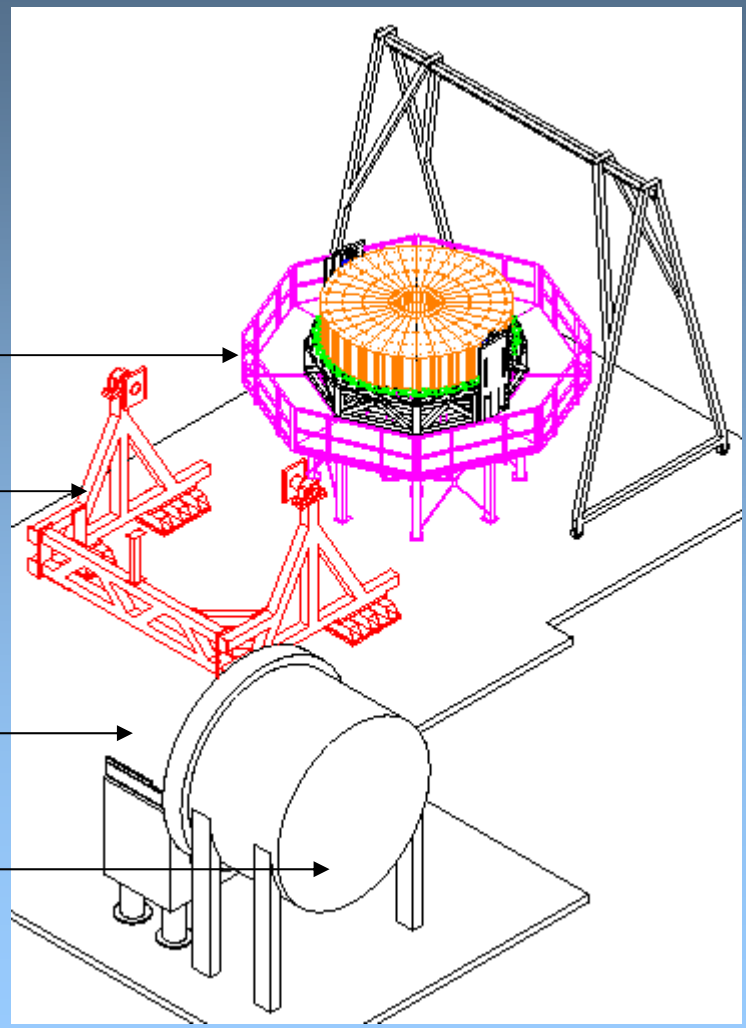
HEC Wheel Assembly Procedure

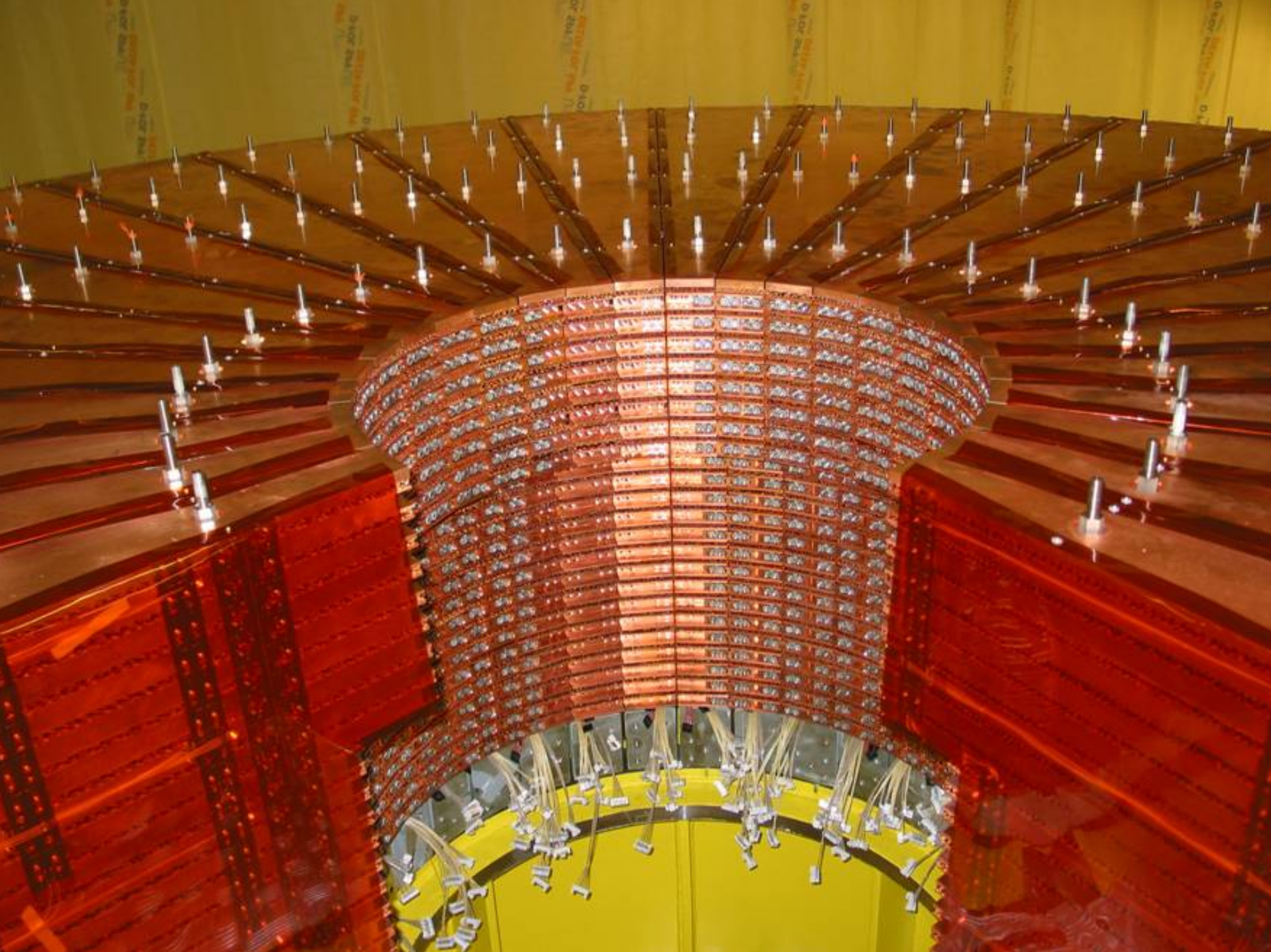
Wheel assembly on *Assembly Table*

Wheel rotation with *Rotator*

Wheel Storage on *T6/T6A*

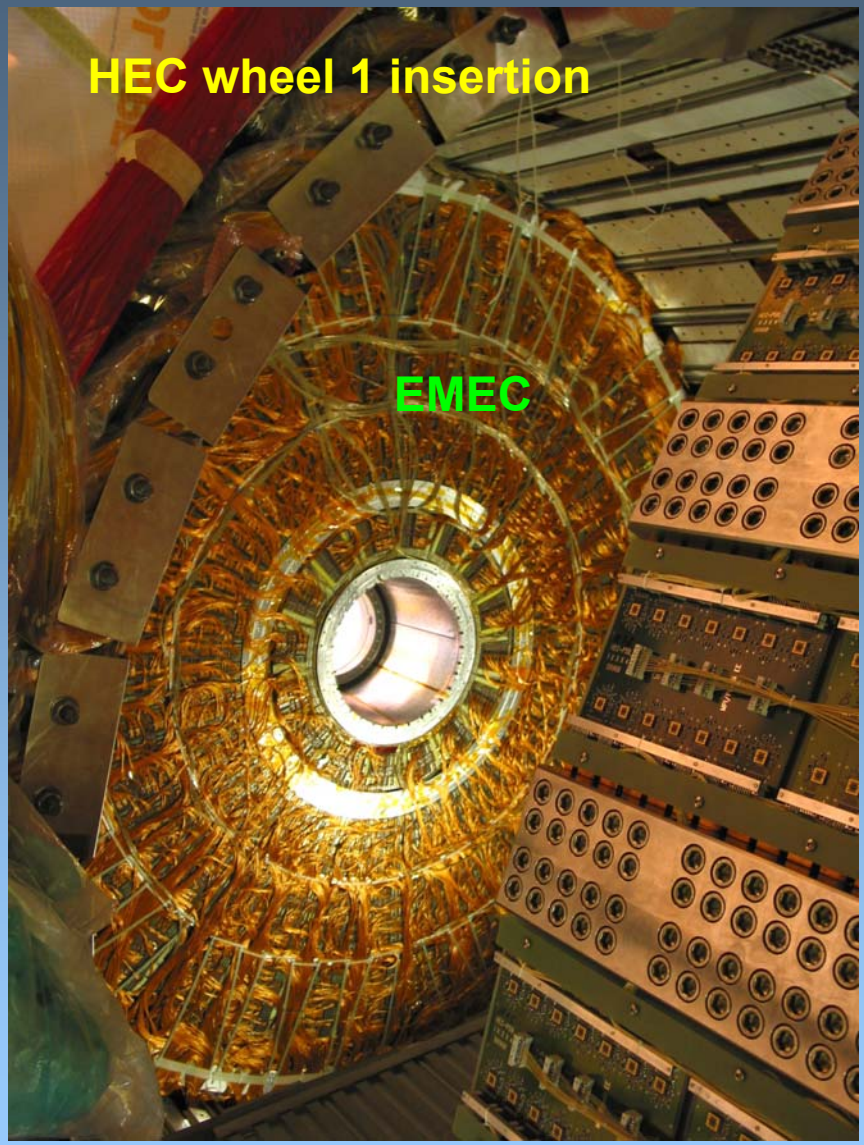
Wheel Insertion into *Endcap Cryostat*

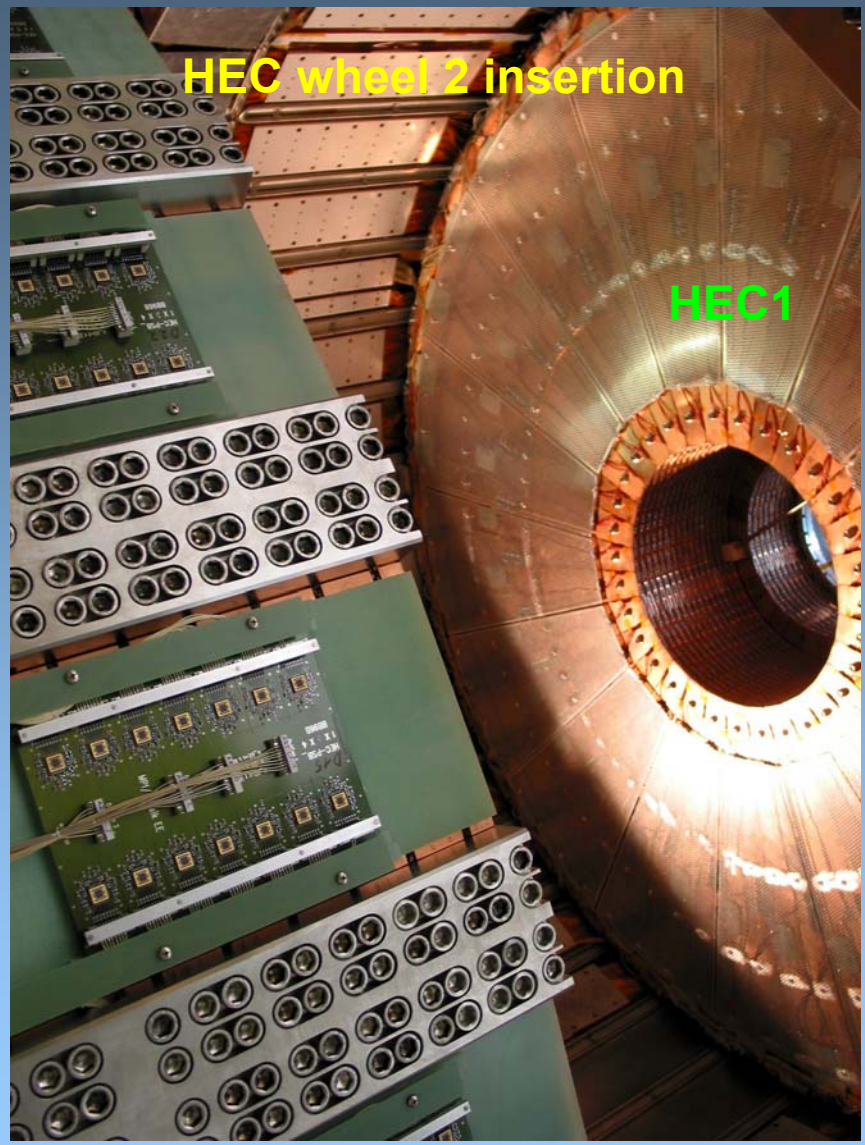


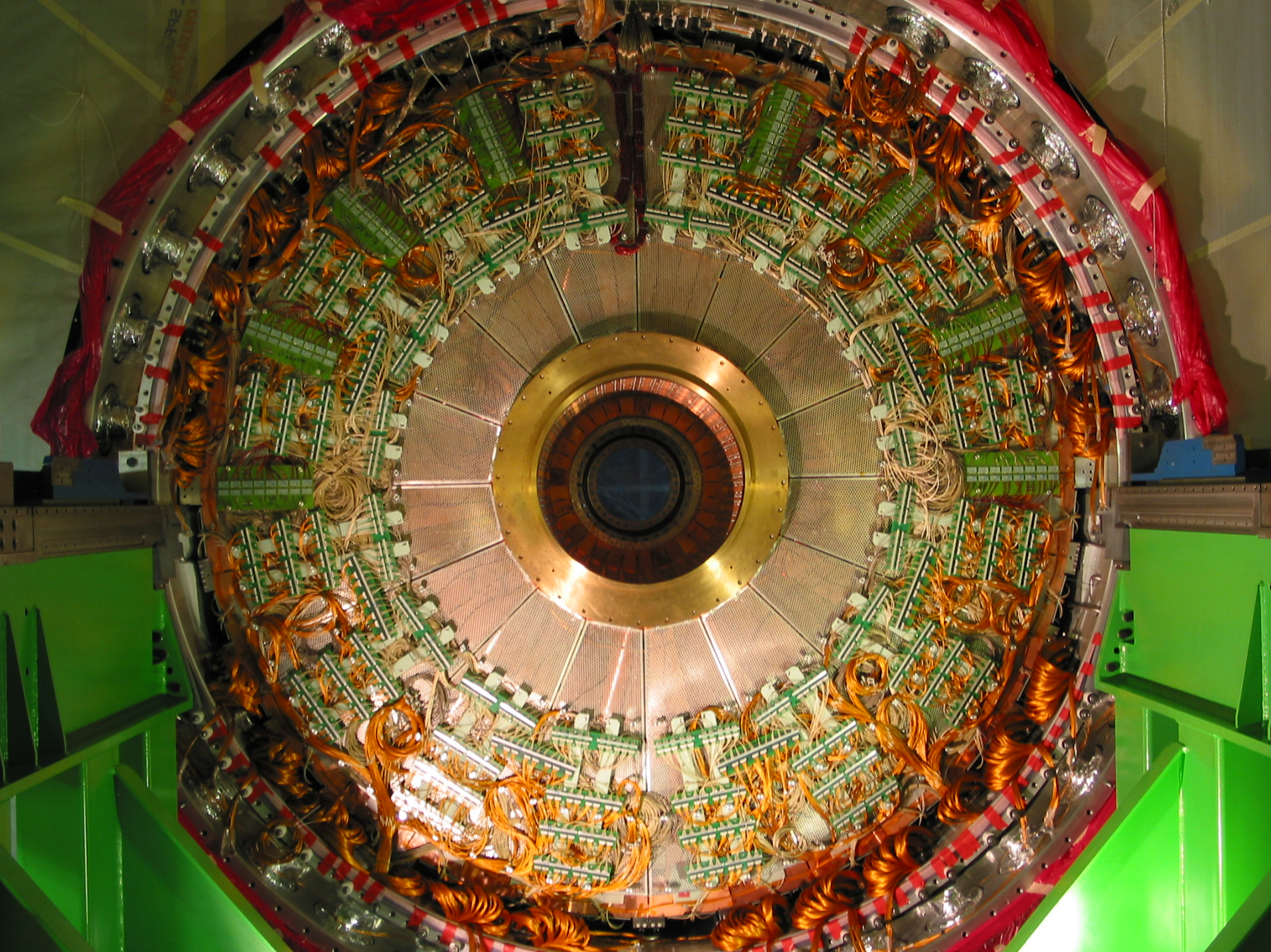


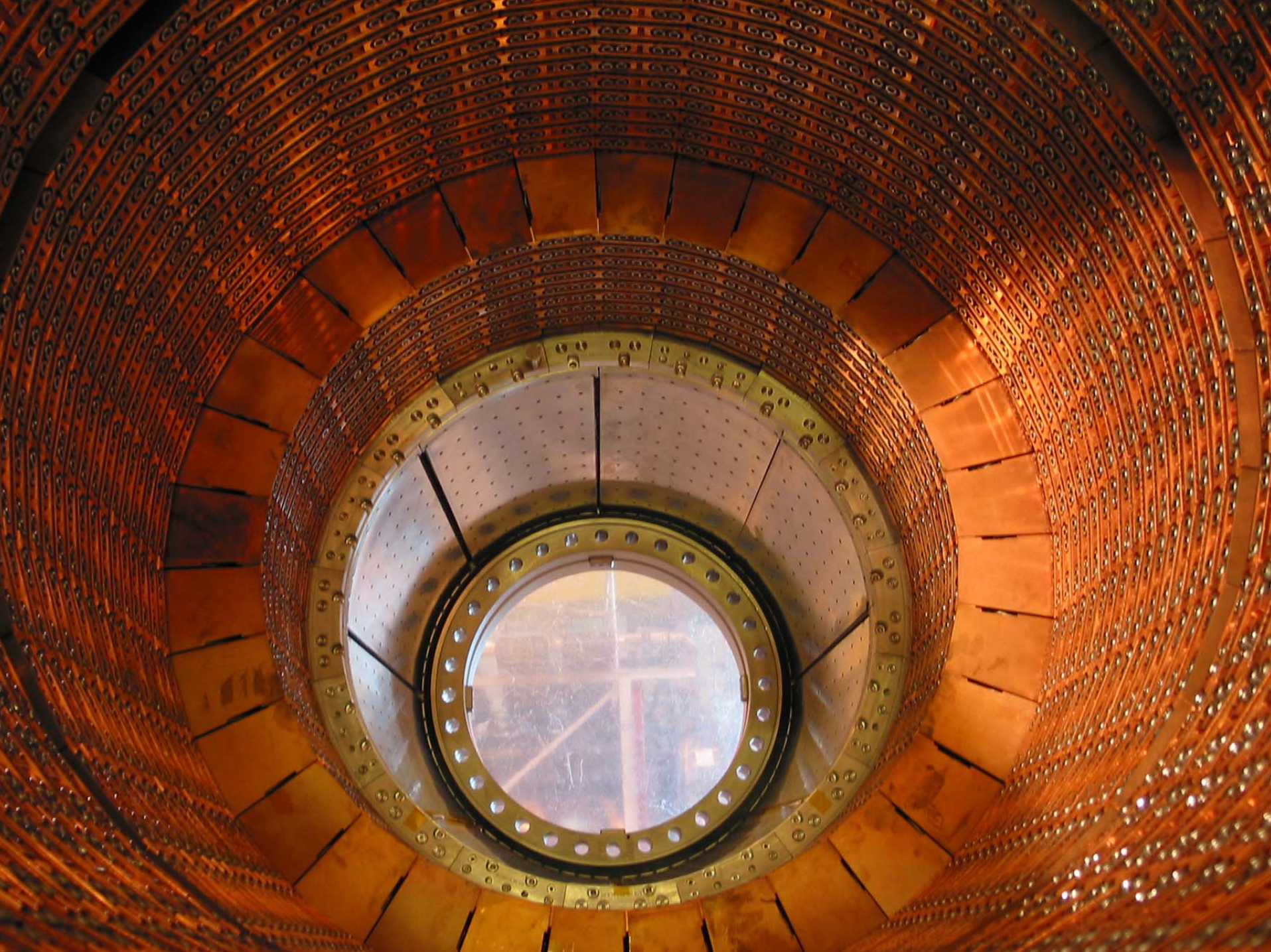
HEC 1C and 2C Modules on T6A Tooling

HEC Insertion Endcap C

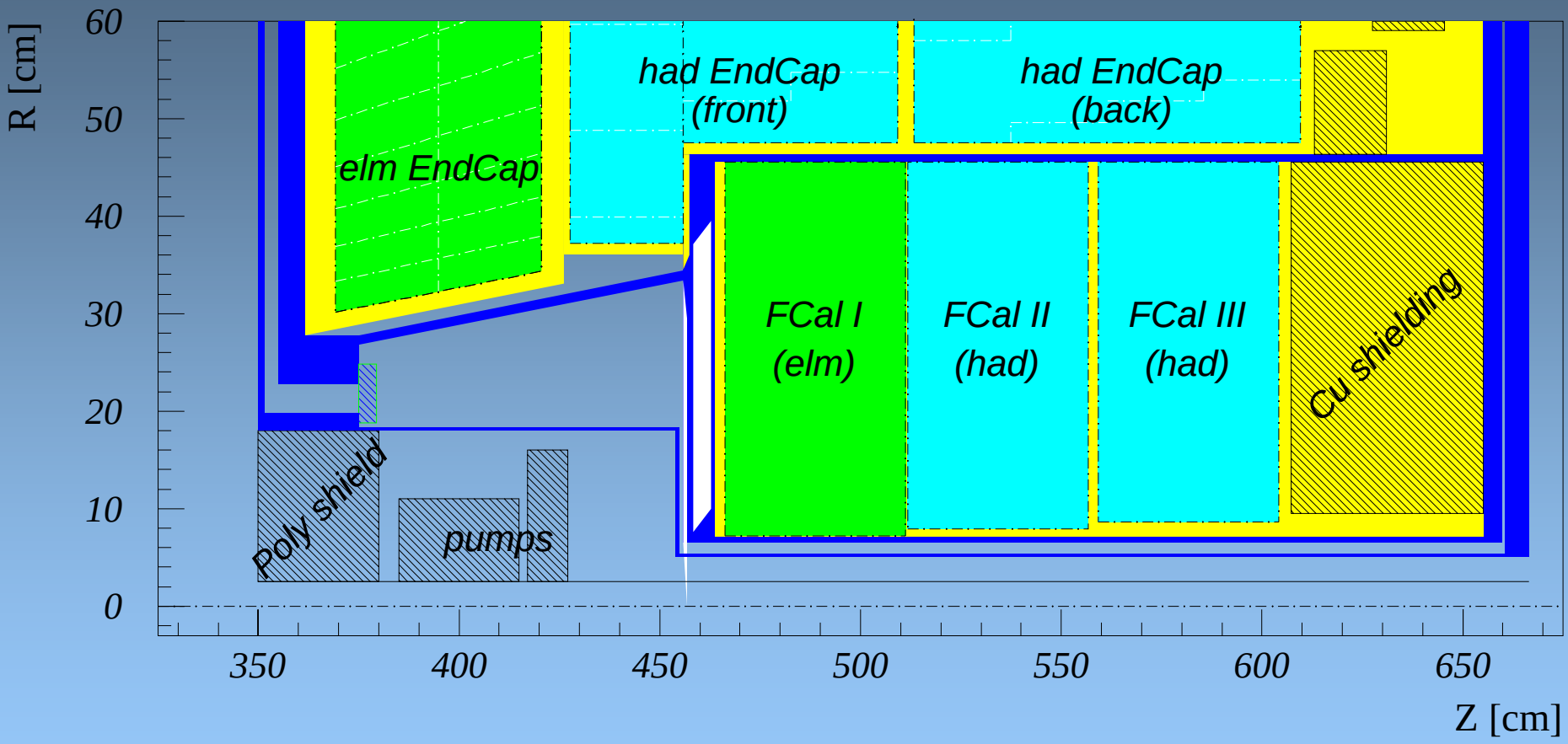




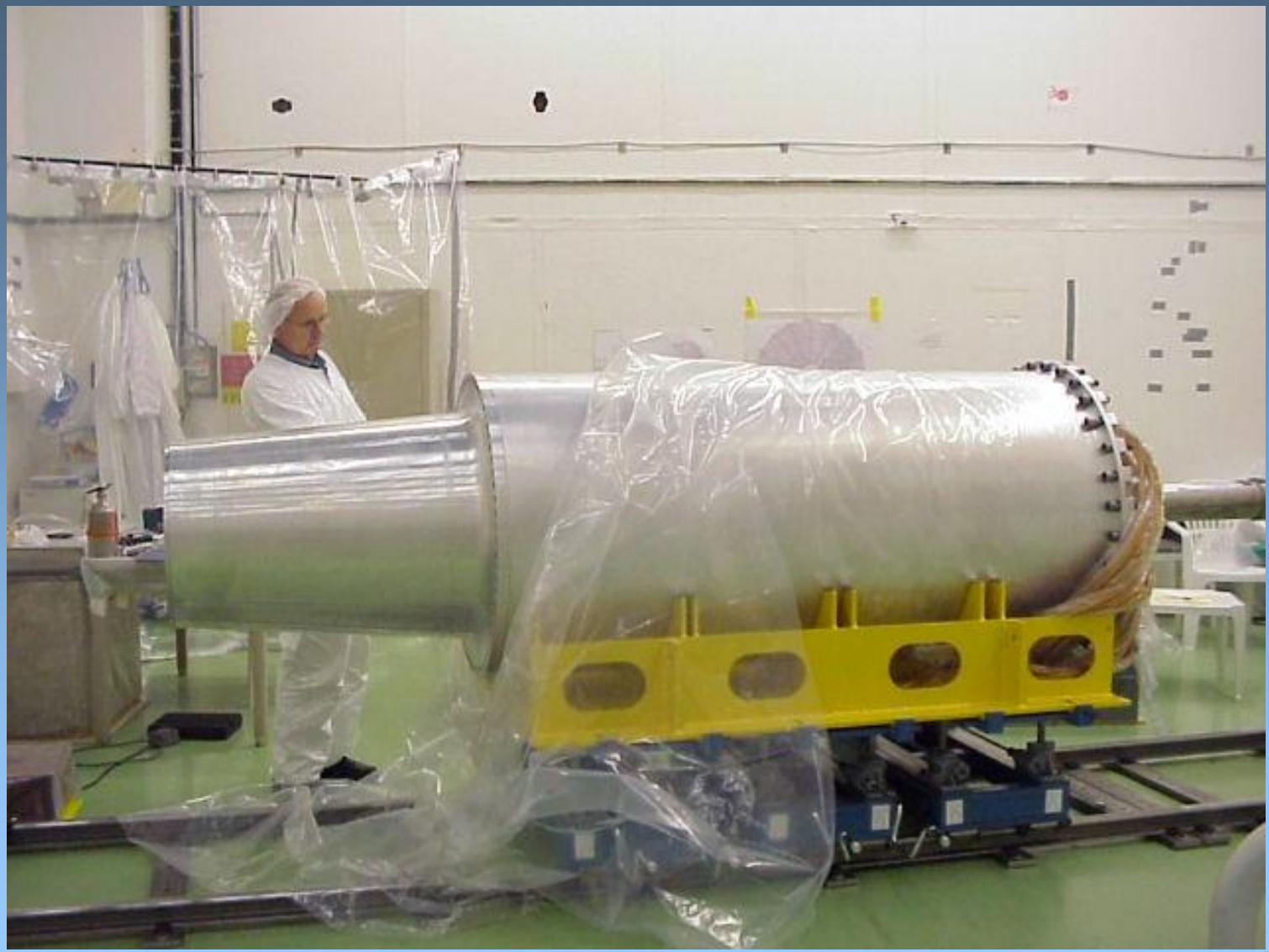




The Endcap Calorimeter System



Endcap C Forward Calorimeter

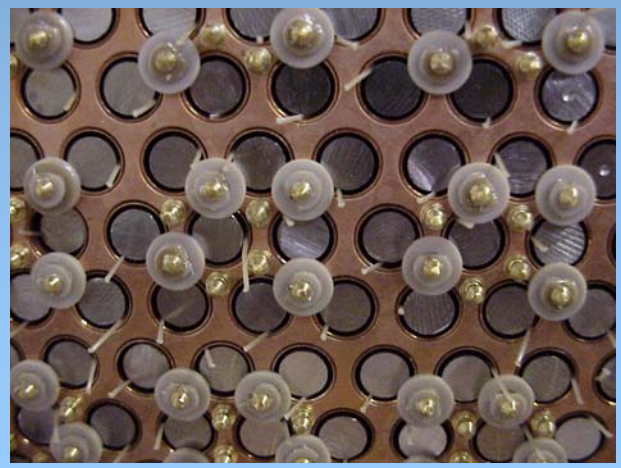


FCal Insertion Into Endcap Cryostat

cryostat cold cover

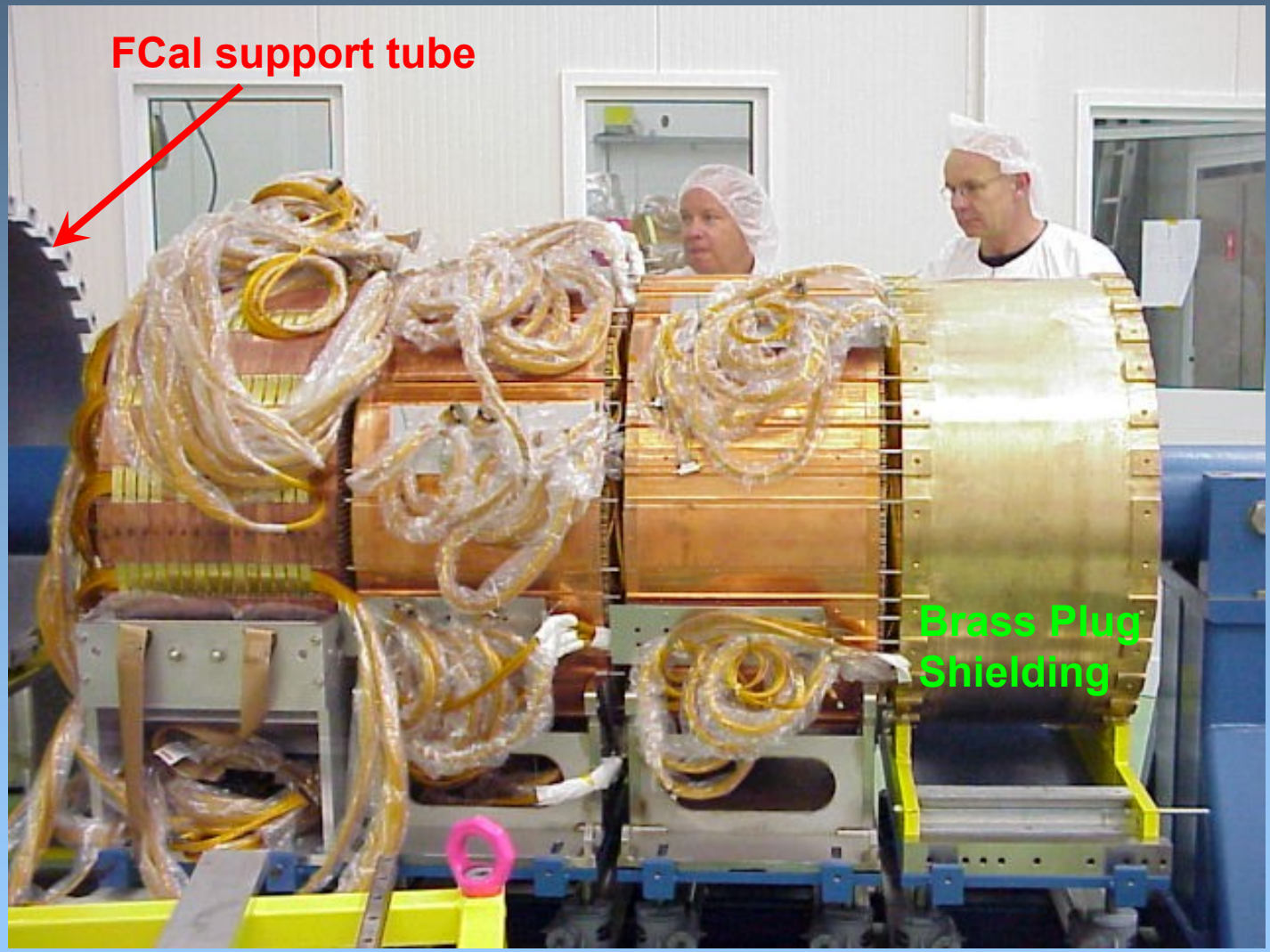
Forward Calorimeter Construction Status

- ✓FCal module construction completed May 2003
- ✓FCal calibration testbeam (using C end modules) Summer 2003
- ✓FCal C final assembly completed Fall 2003
- ✓FCal C integration into Endcap C cryostat scheduled for later this year
- ✓FCal A module coldtesting completed January 2004
- ✓FCal A final assembly scheduled for later this year
- ✓FCal Module0 refurbishing for endcap combined testbeam finished Fall 2003

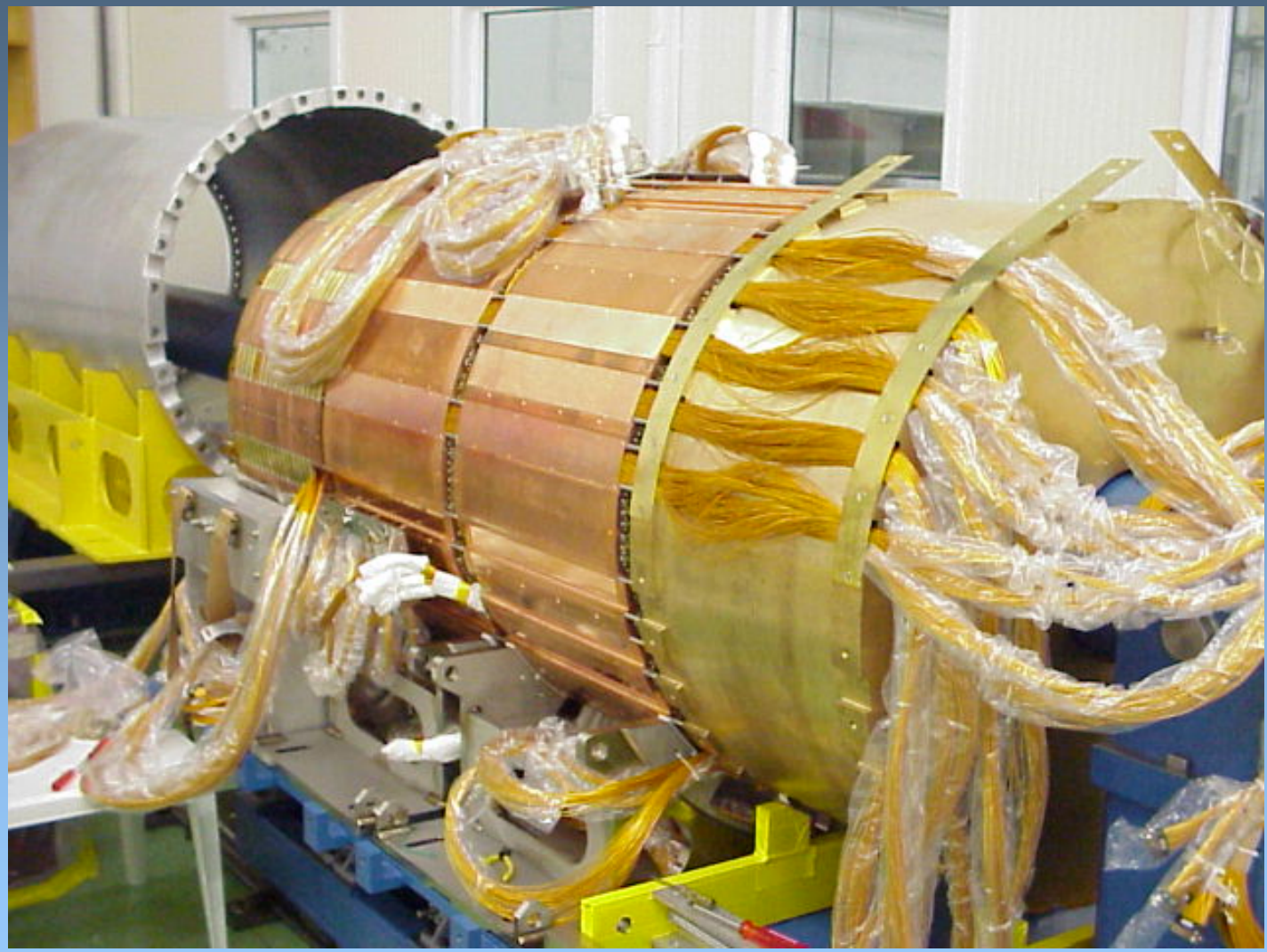


Module Alignment: FCalC Final Assembly

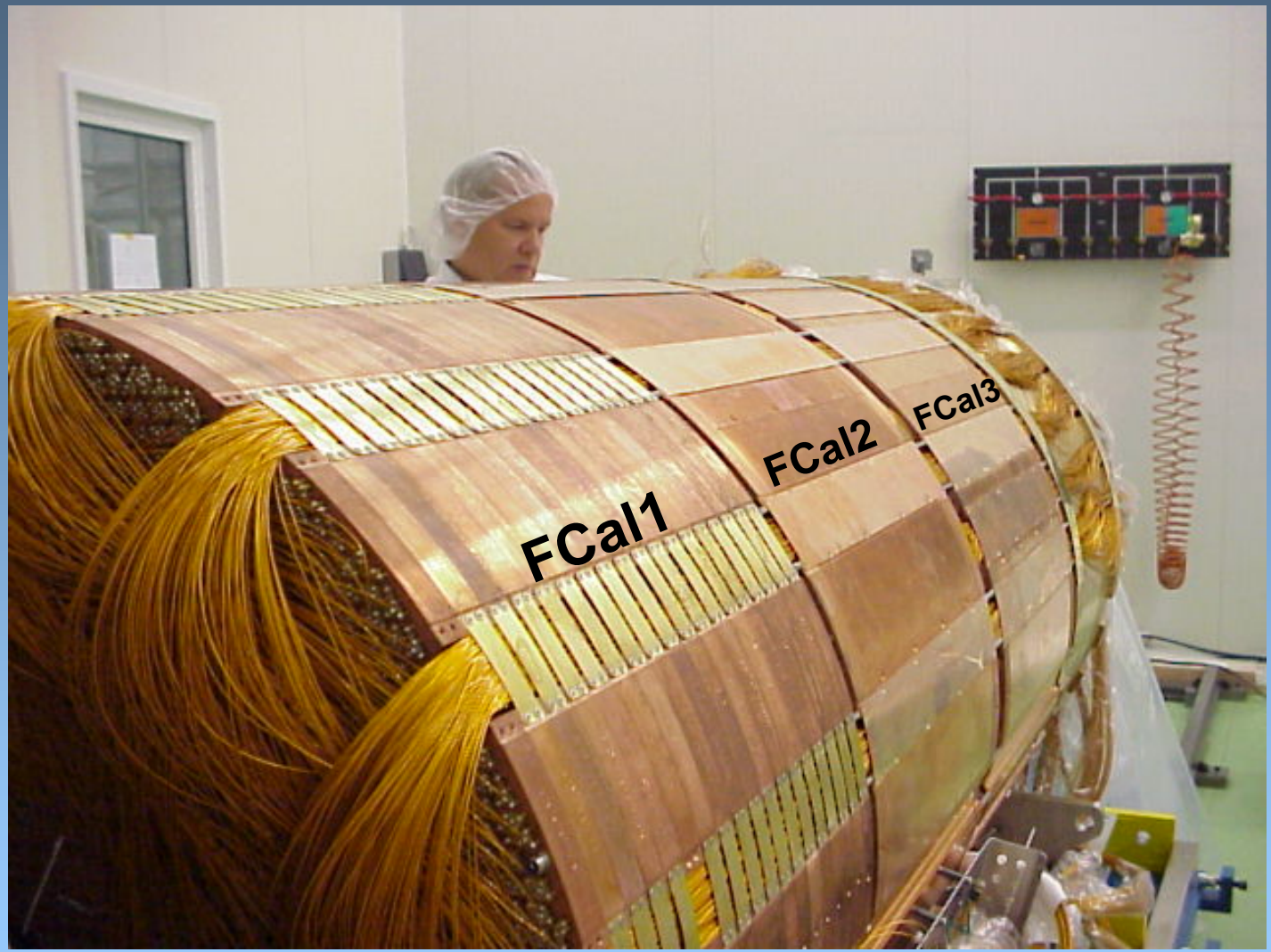
FCalC Prior to Cable Dressing



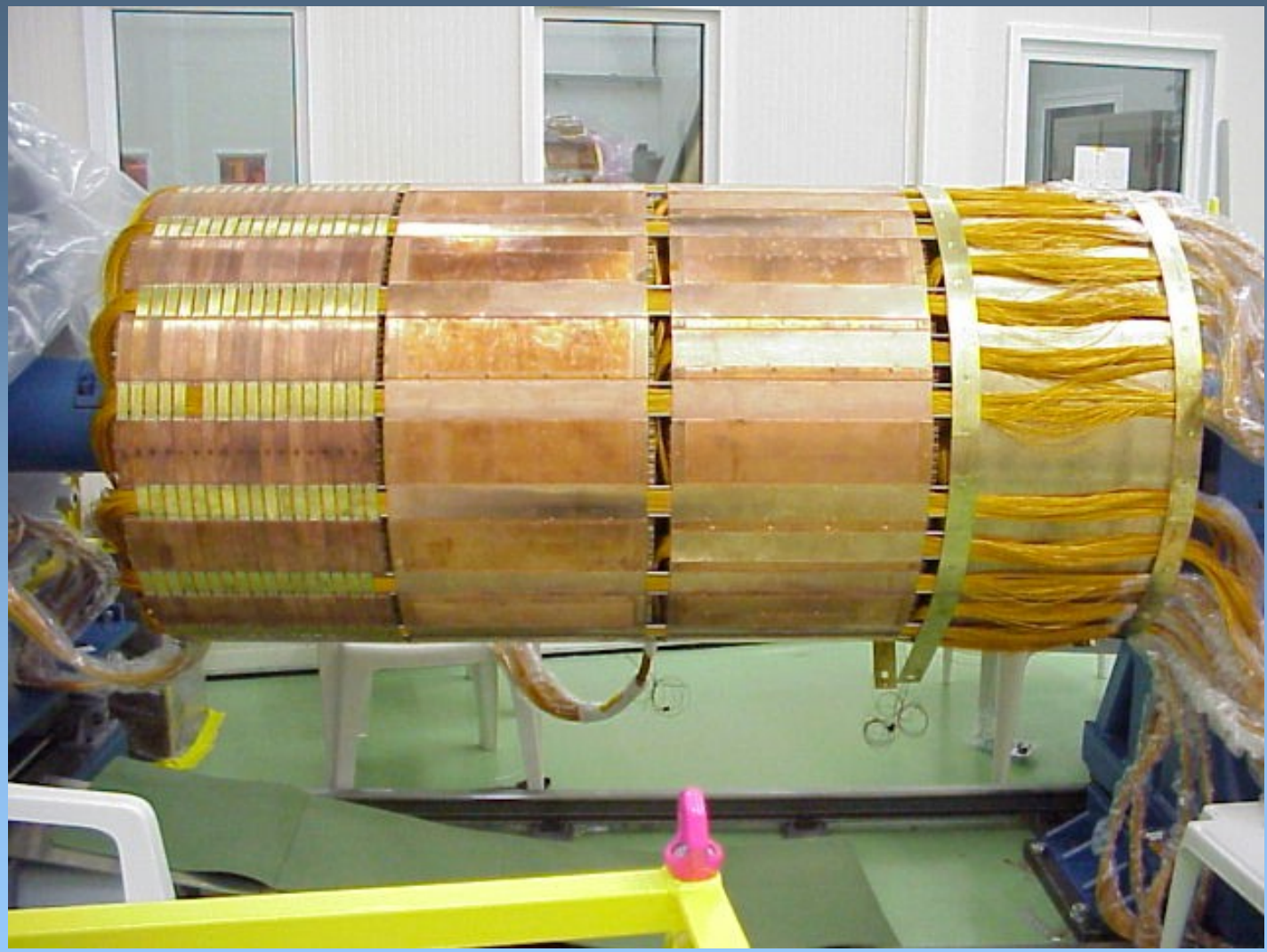
FCalC Cold-cable Dressing



FCalC Cold-cable dressing



FCal Cable Dressing Nears Completion

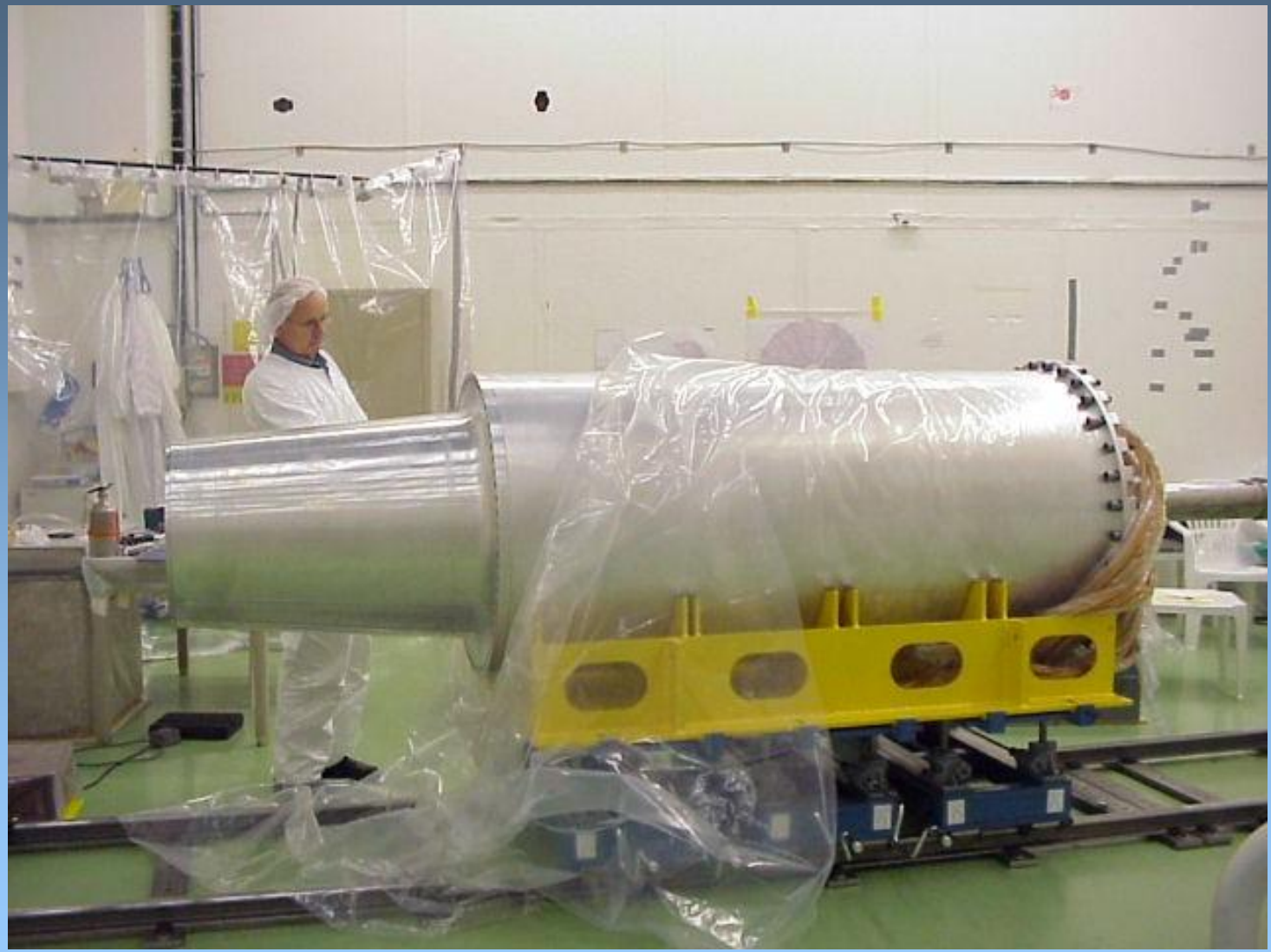


FCal Kapton Wrap / Ready for Insertion

Insertion into Cold Tube Begins

Insertion Almost Complete (3cm left)

Endcap C Forward Calorimeter



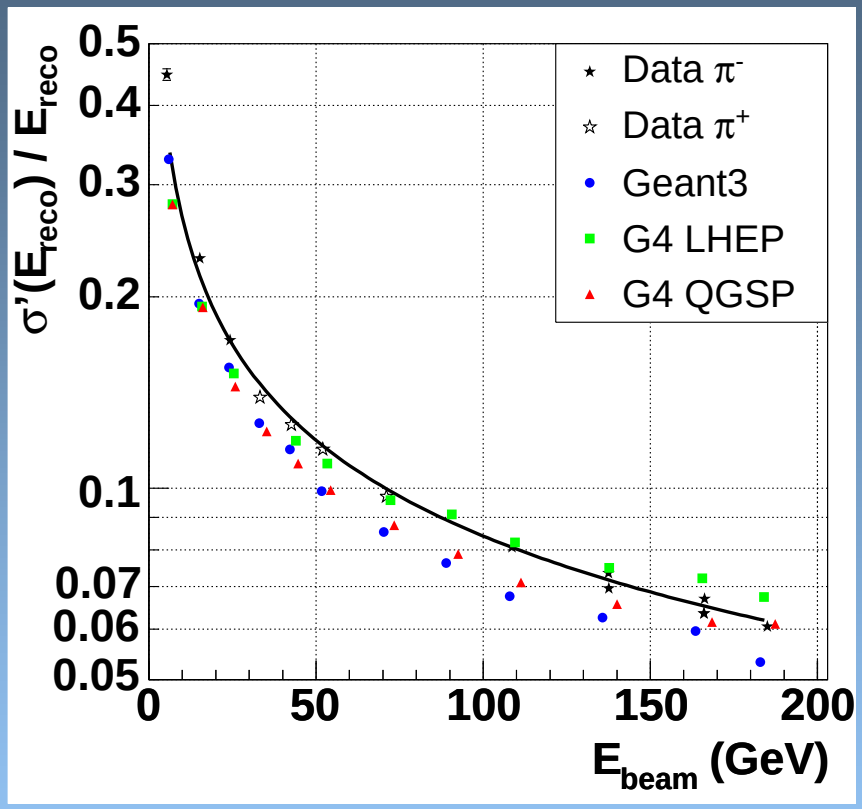
Liquid Argon Calorimeter Testbeams

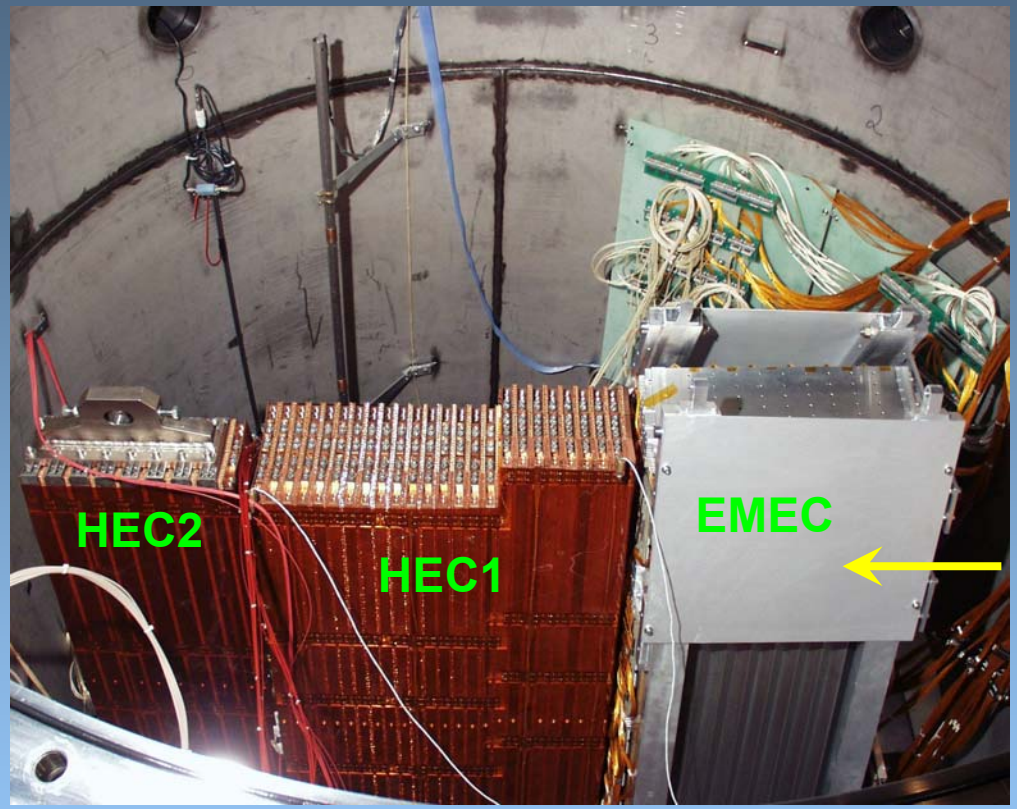
- **Measure initial ATLAS calibration constants**
  - ✓ **essential for good "day 1" performance**
  - ✓ **often superceded later (usually requires tracking information)**
  - ✓ **no tracking in front of FCal, so testbeam calibration particularly important**

- **Calibration "crack" region (transition from EMEC/HEC to FCal: $\eta \approx 3.2$**
  - ✓ **Important for understanding calorimeter intercalibrations (energy sharing)**
  - ✓ **Important for dead-material corrections (tune MC using testbeam data)**

❖ HEC/EMEC Combined Testbeam	2002
❖ FCAL Calibration Testbeam	2003
❖ HEC/EMEC/FCal Combined Testbeam	2004

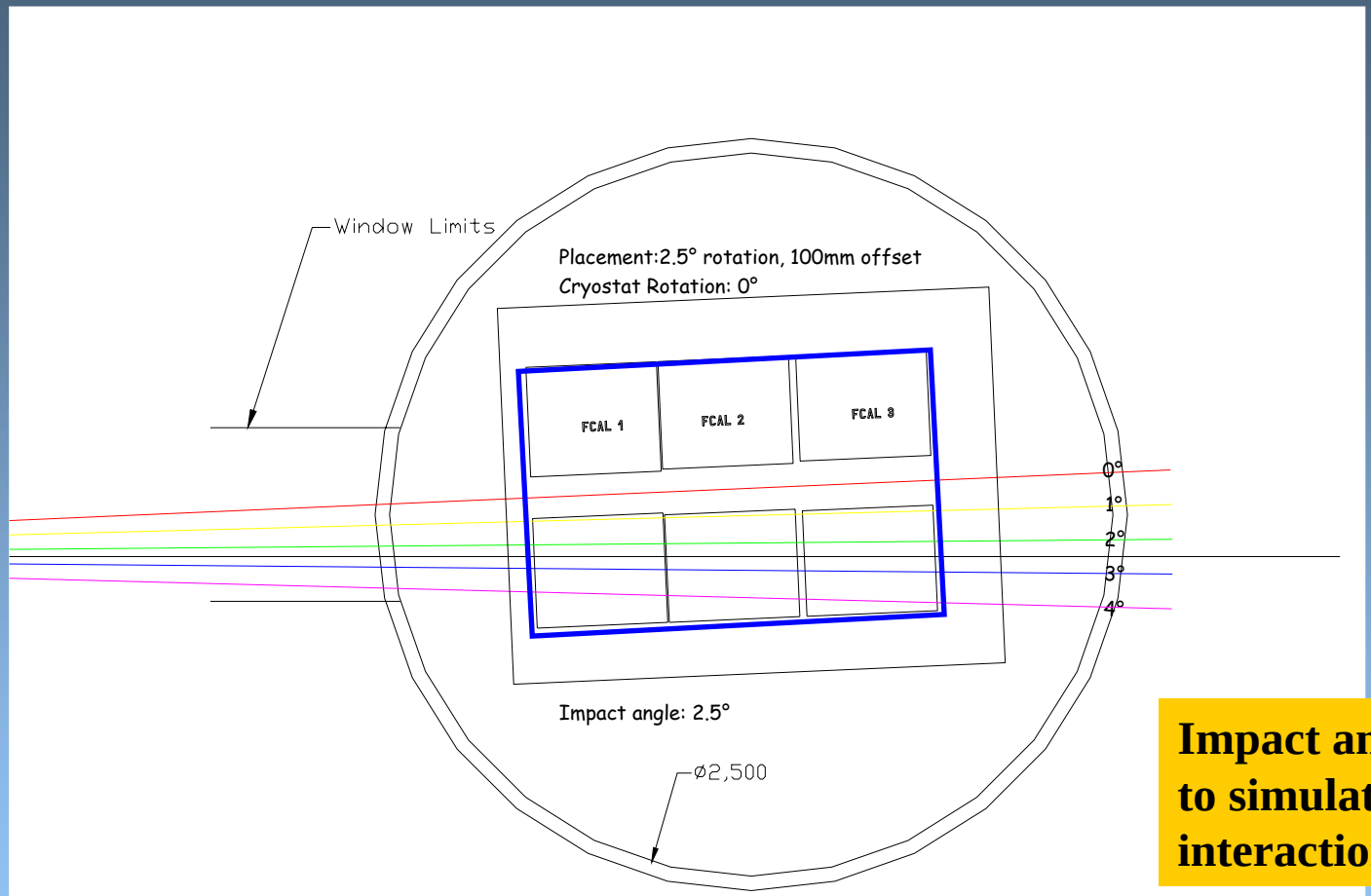
HEC/EMEC Combined Testbeam 2002





NIM Draft exists

FCal Calibration Testbeam Summer 2003

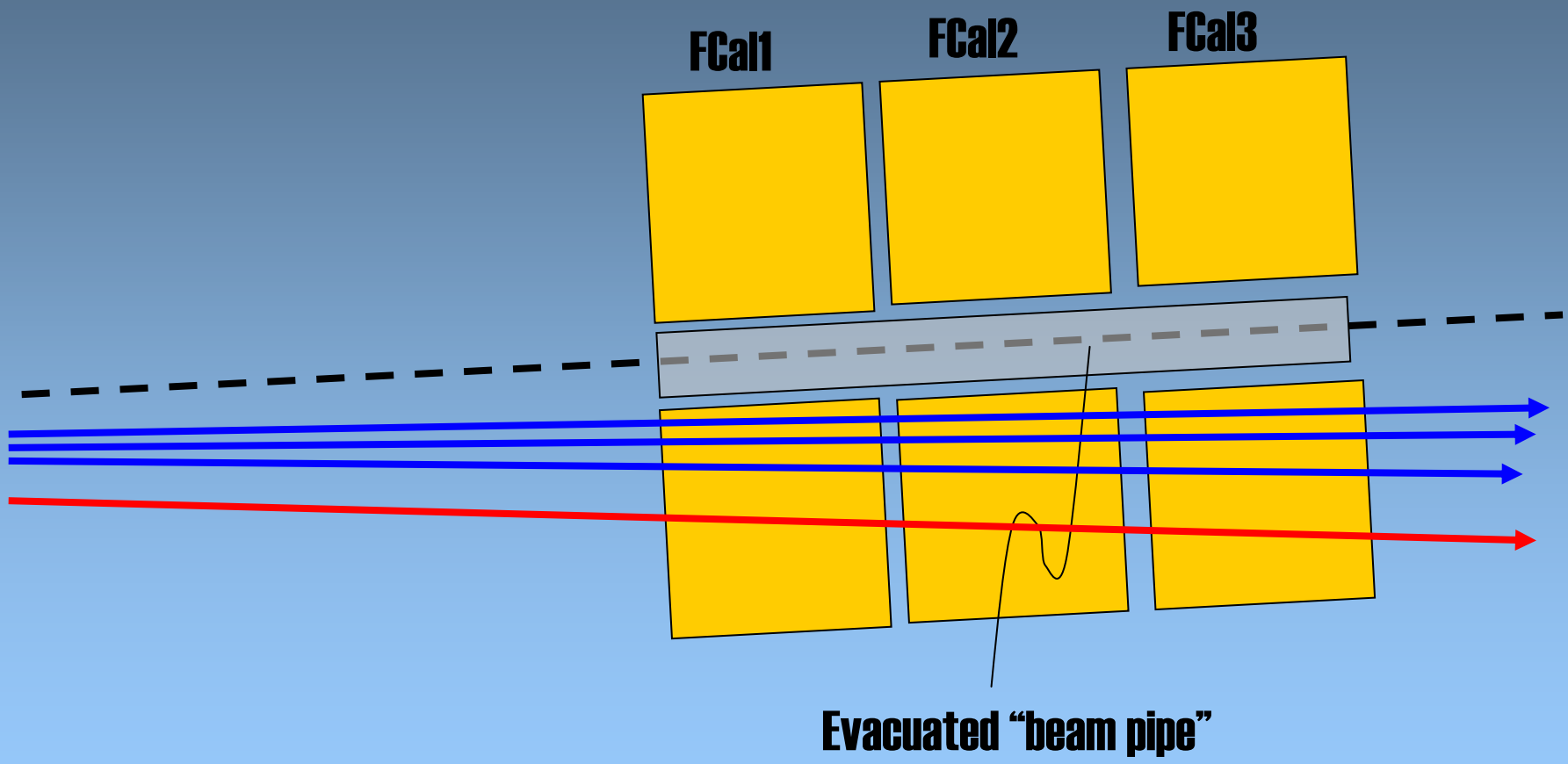


Impact angles adjusted to simulate beam from interaction point

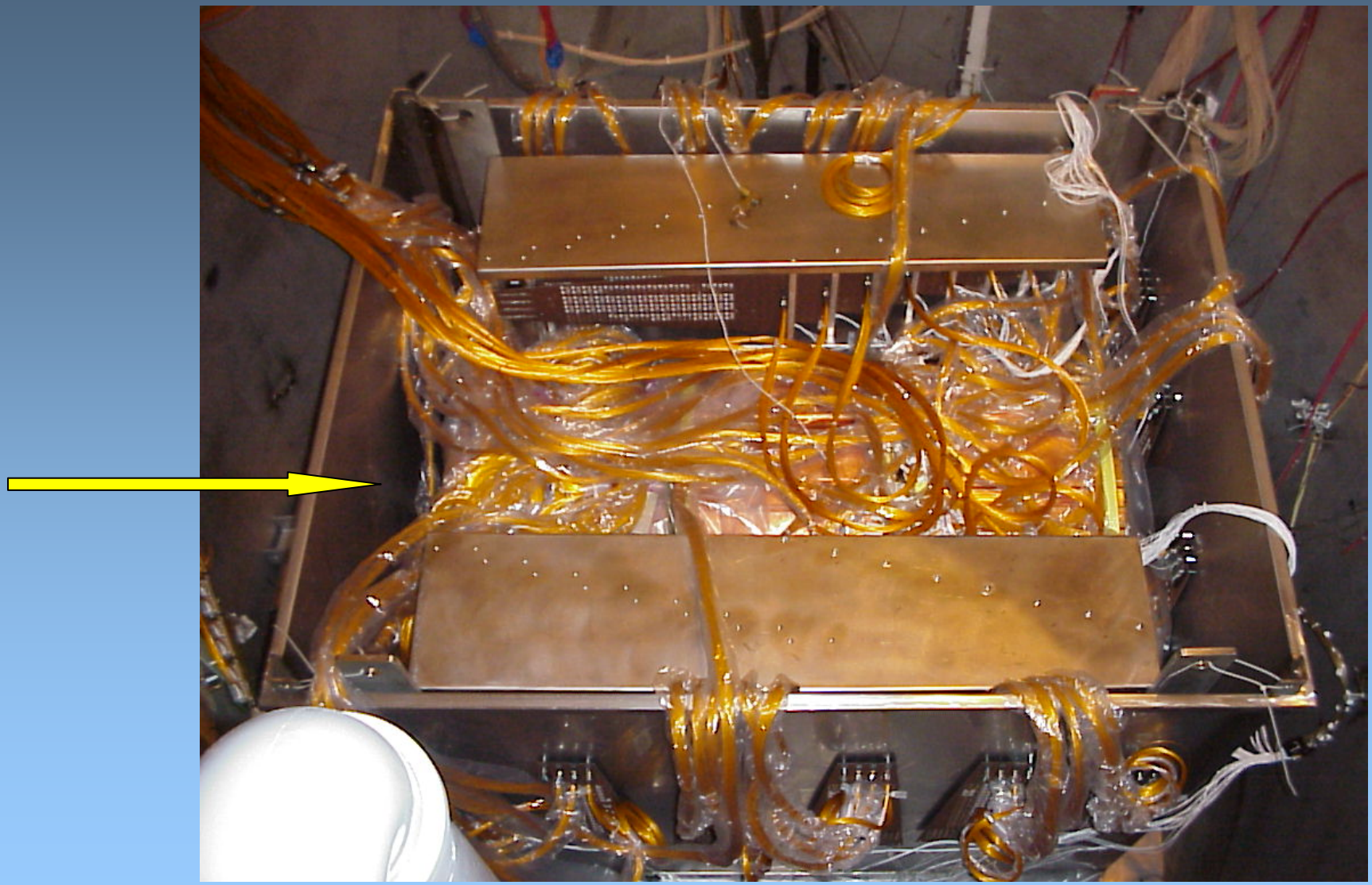
H1 cryostat in H6 beamline at CERN

***e*, π, μ** 10–200 GeV **from CERN SPS**

Module Package Orientation for Calibration Testbeam

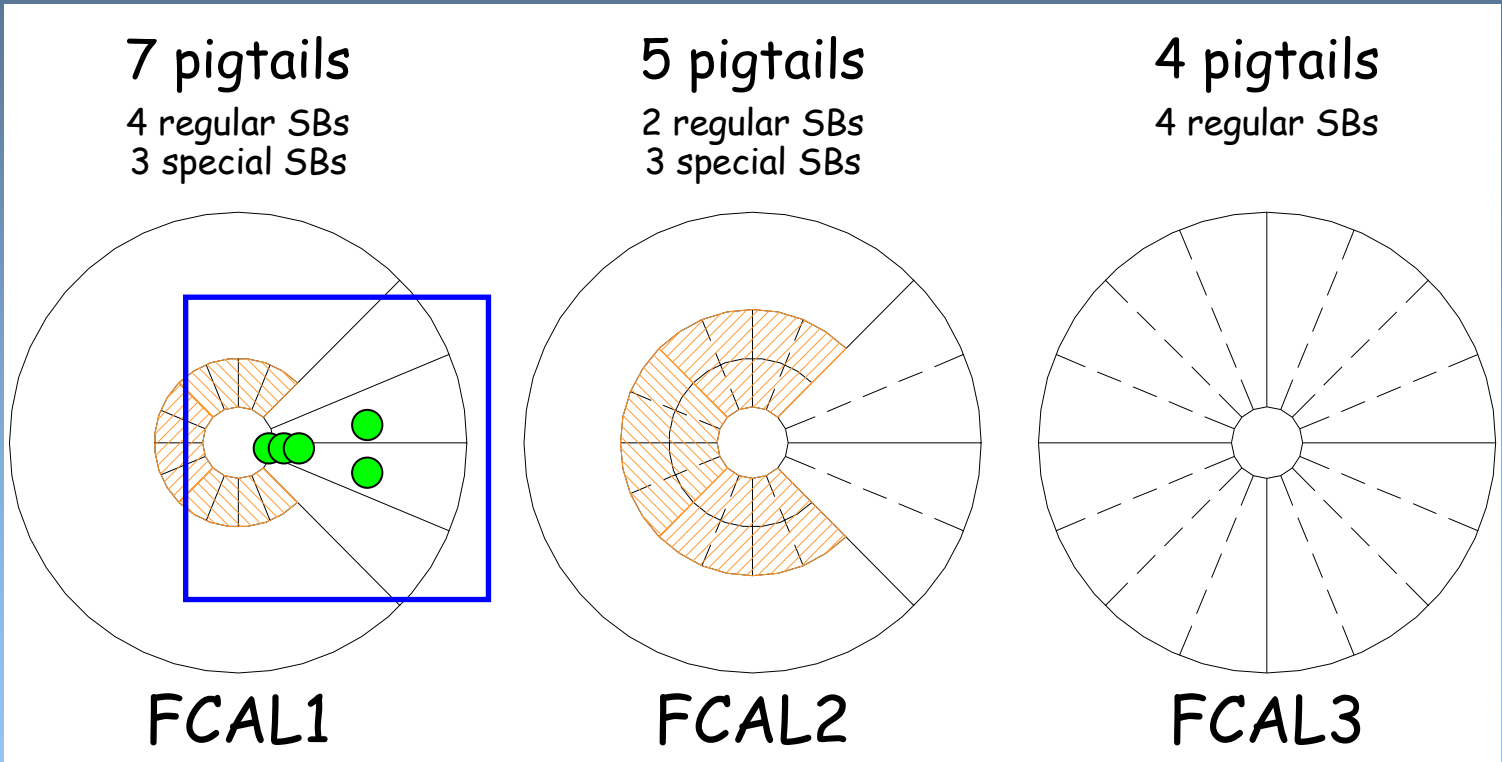


FCal Package for Calibration Testbeam

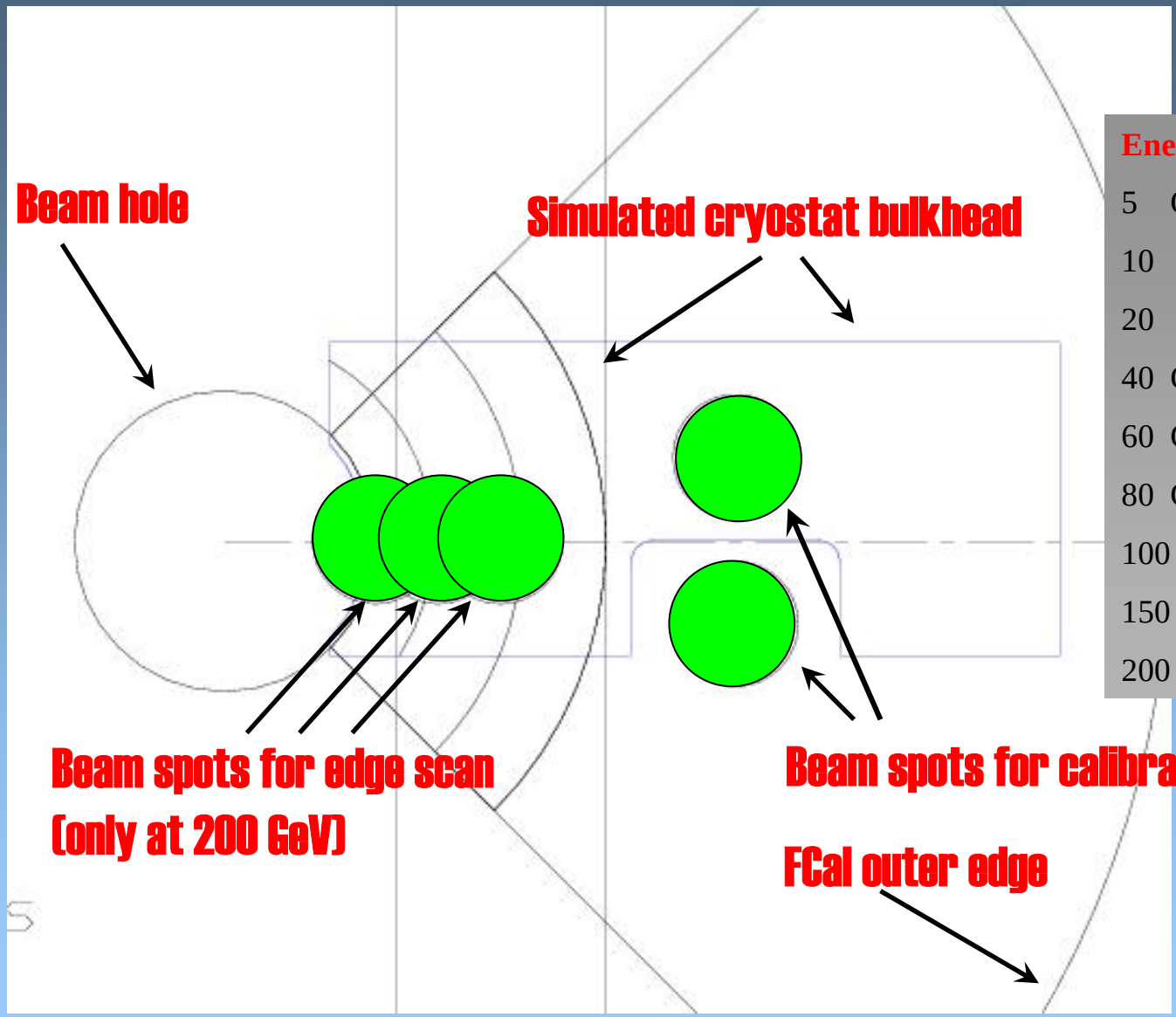


Forward Calorimeter Calibration Testbeam

Not enough cable harnesses / electronics available for readout of all channels.



FCal Calibration Testbeam Beam Impact Positions

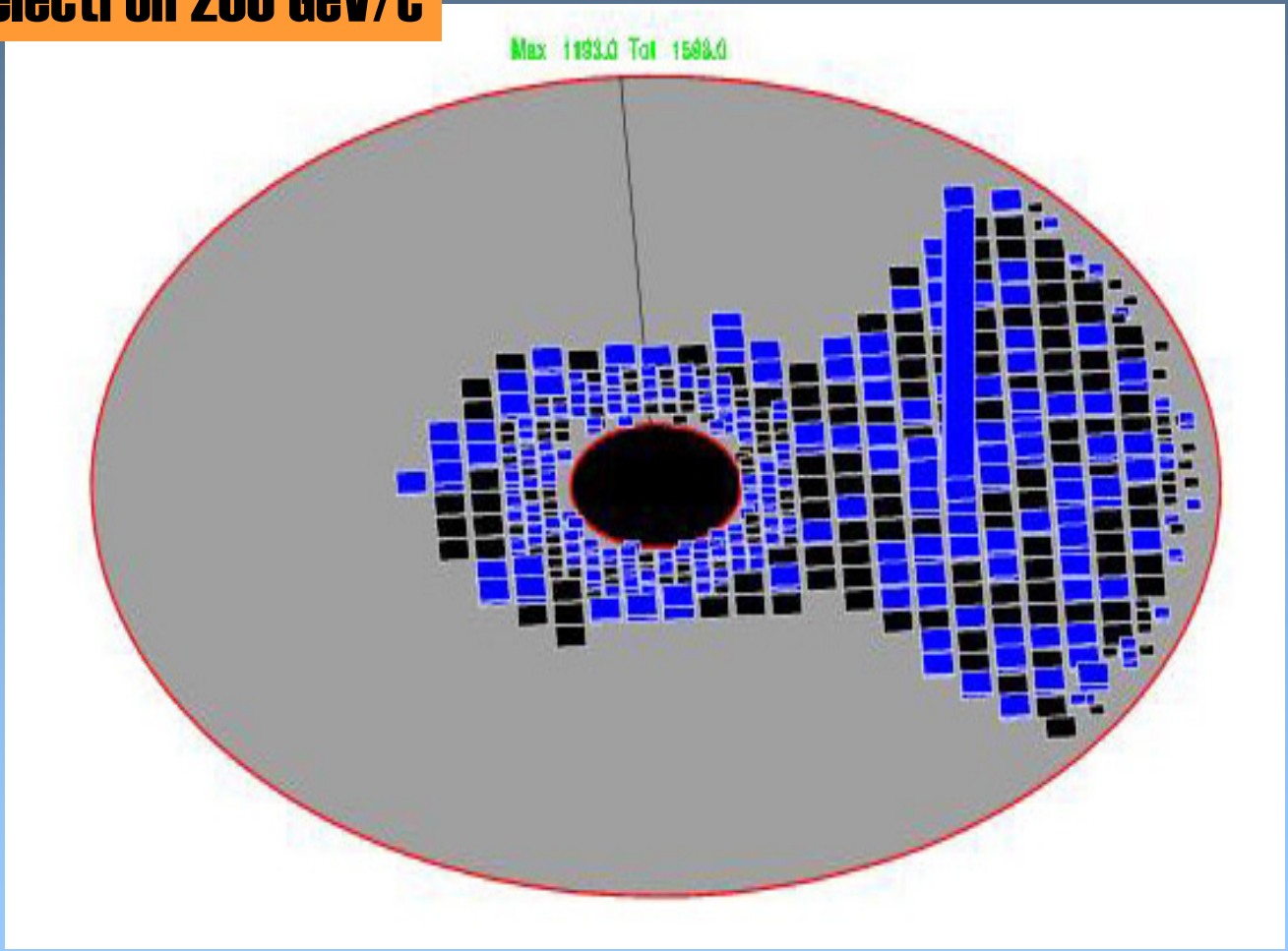


Energy Scan Data Points

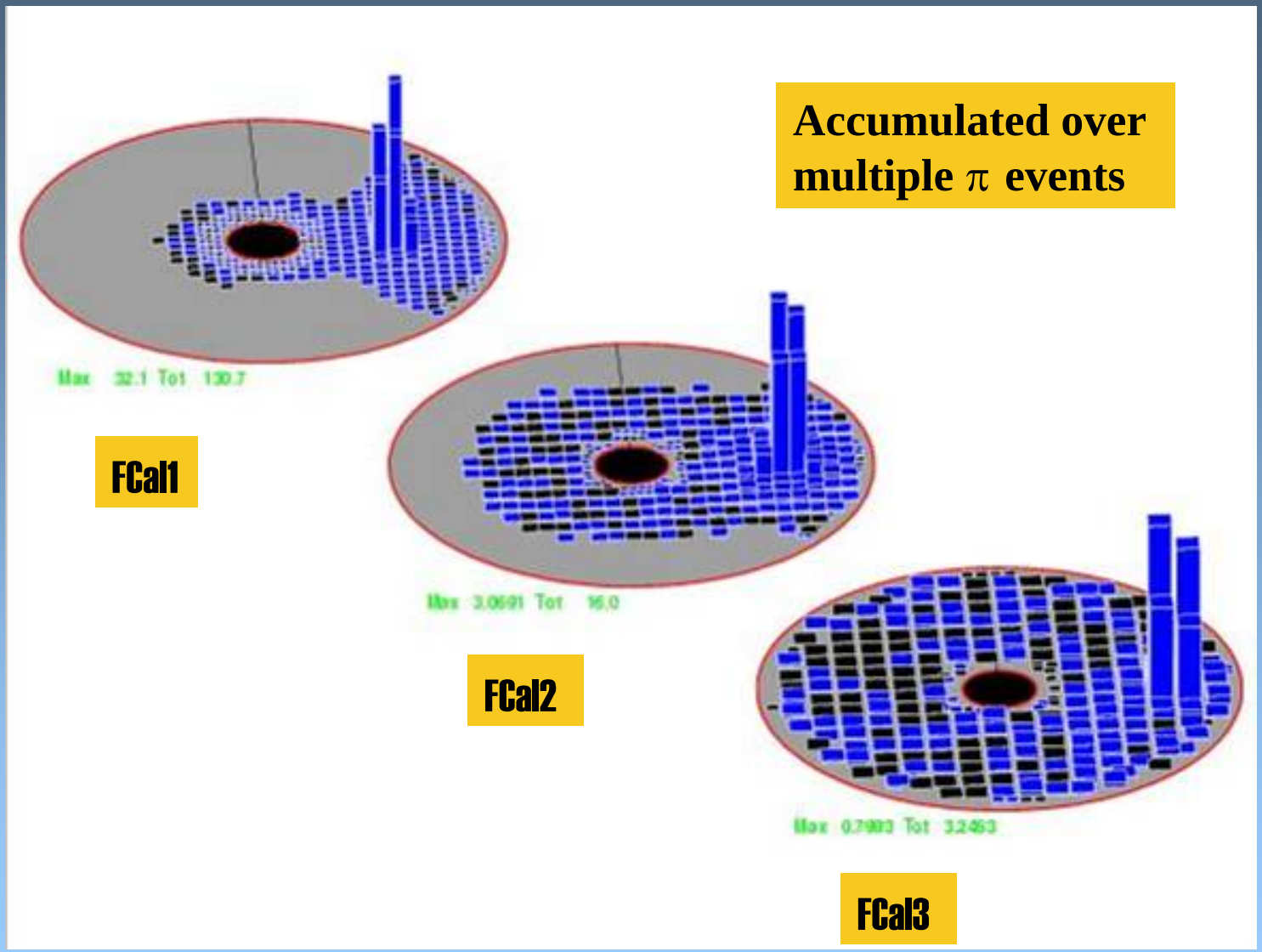
5 GeV	electrons
10 GeV	electrons, pions
20 GeV	electrons, pions
40 GeV	electrons, pions
60 GeV	electrons, pions
80 GeV	electrons, pions
100 GeV	electrons, pions
150 GeV	electrons, pions
200 GeV	electrons, pions, μ

Forward Calorimeter/electron event display

FCal1 : Single electron 200 GeV/c



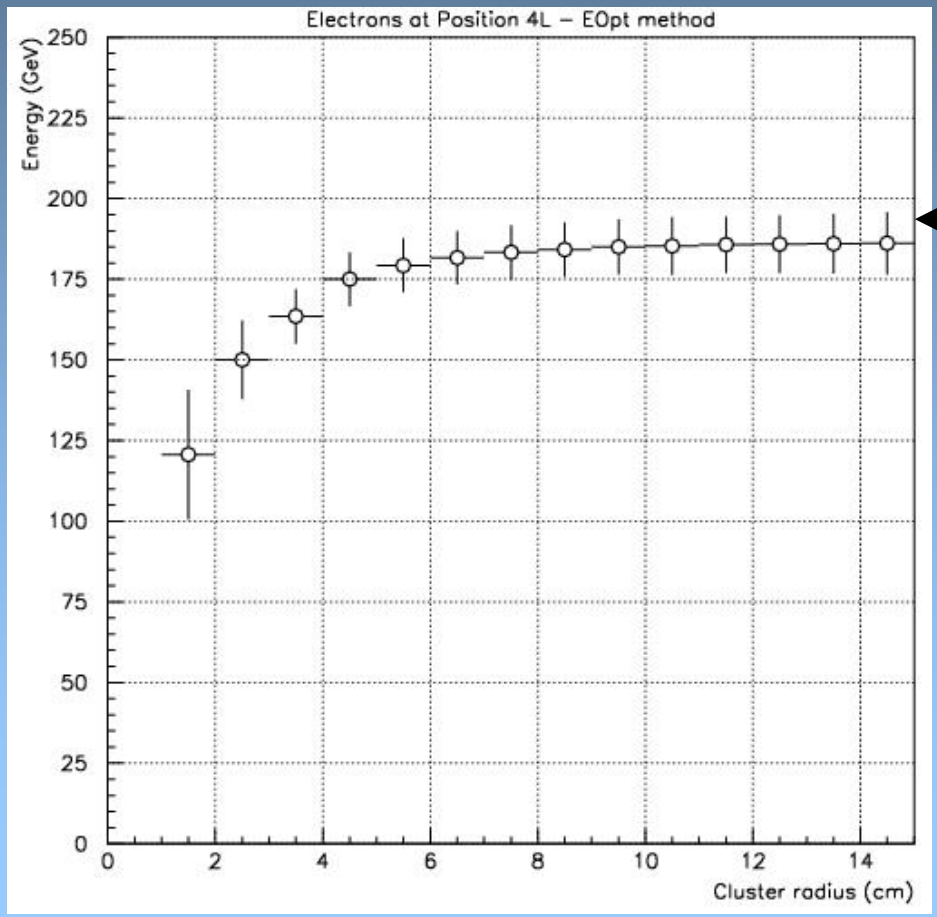
Energy Deposits in FCal1, 2, and 3 due to 200 GeV π's



Energy reconstruction for electrons

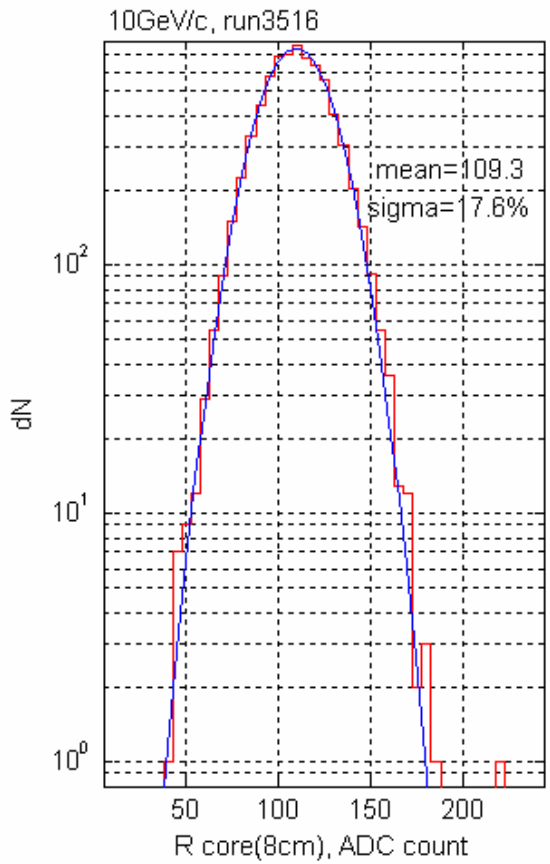
Energy reconstruction for electrons:

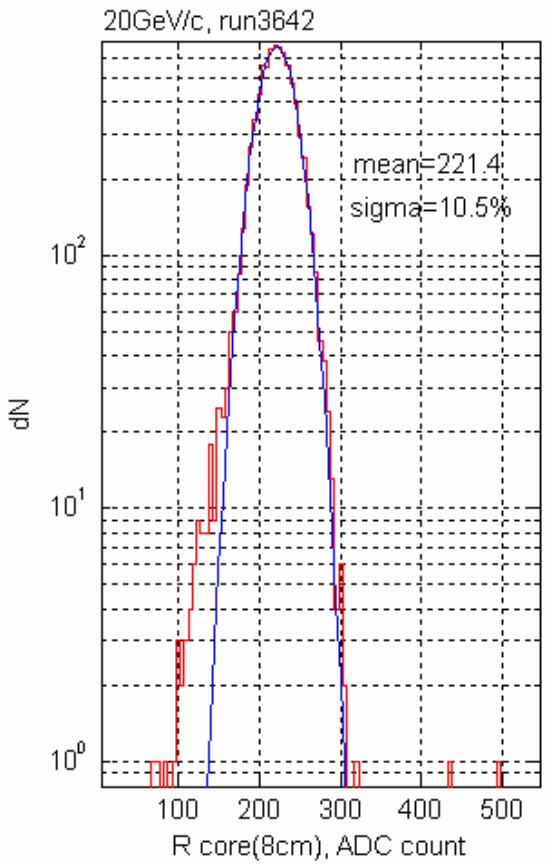
- **Sum over whole calorimeter (add noise from channels with no signal)**
- **Sum over channels within some radius of a seed channel**

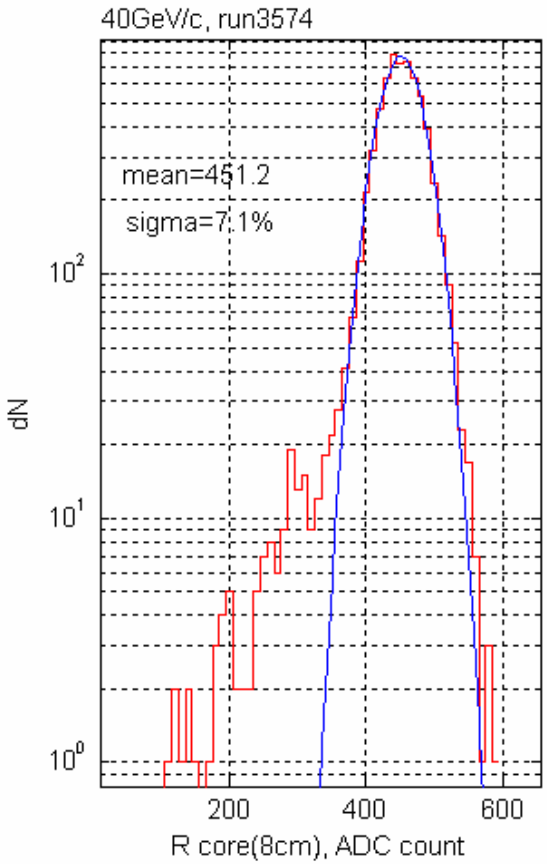


193.1 GeV

FCal Electron Response 10, 20 and 40 GeV

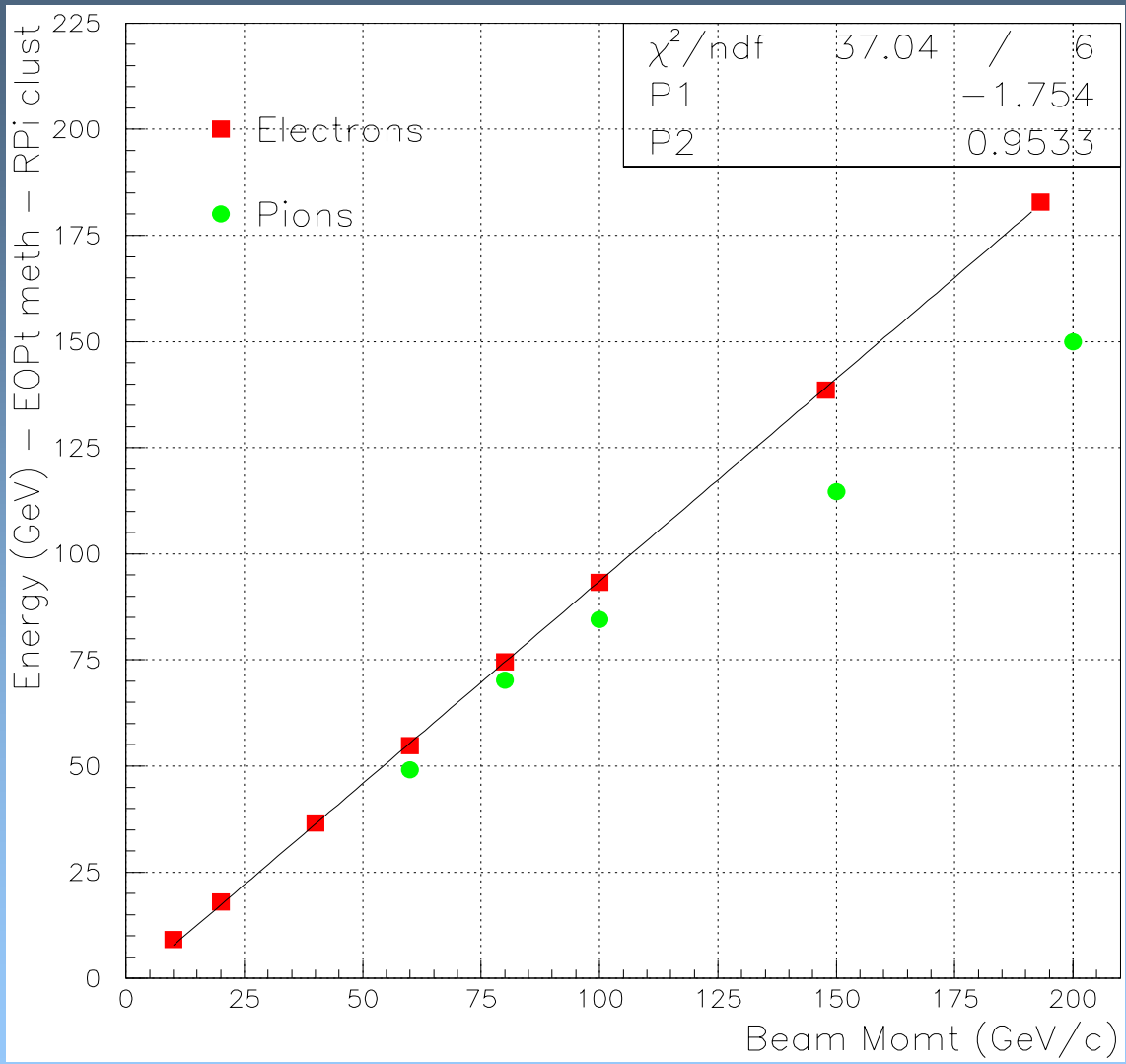




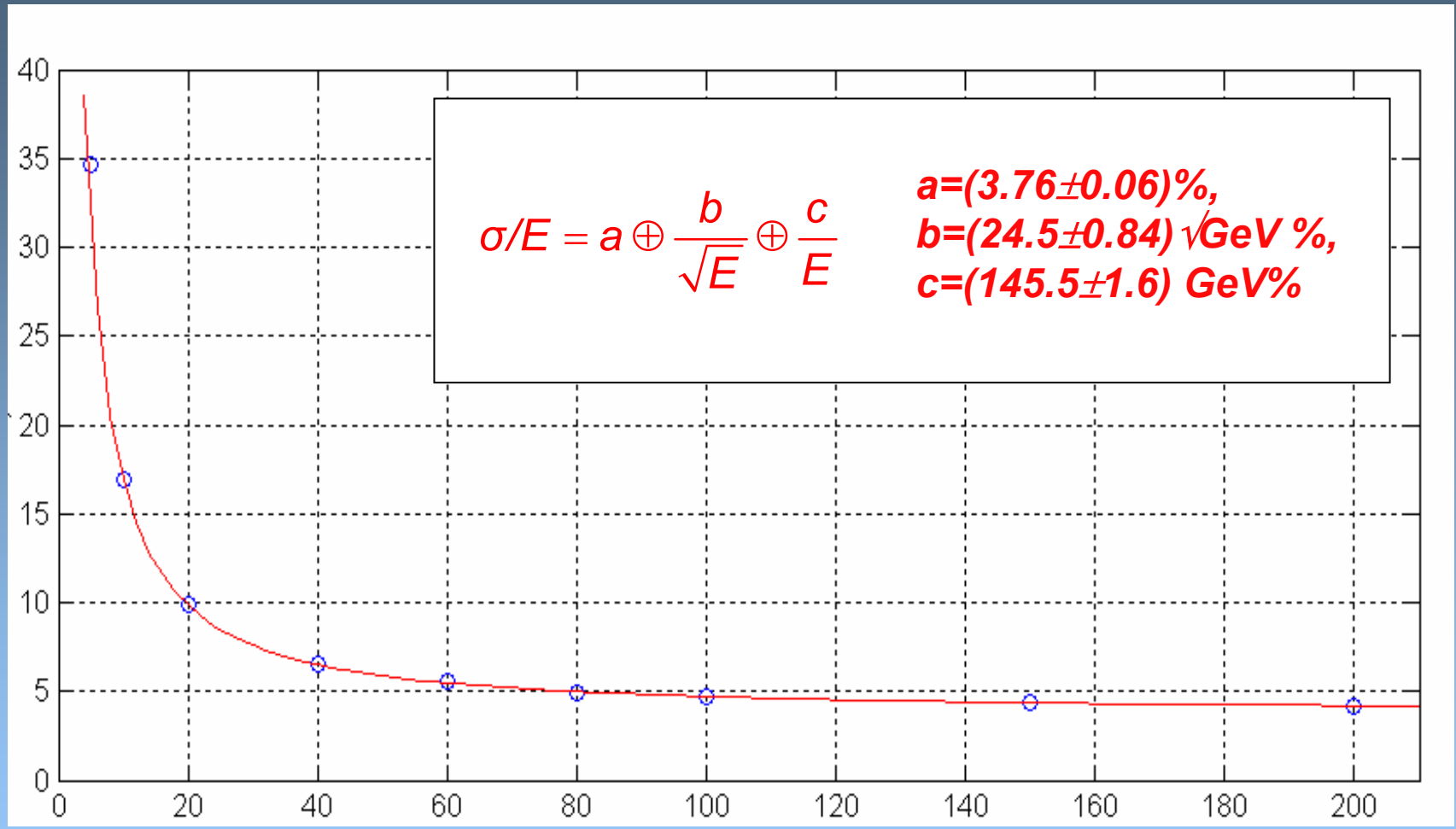


Beam particle selection criteria (here to eliminate pions) preliminary

Electron and pion linearity: Very Preliminary.....

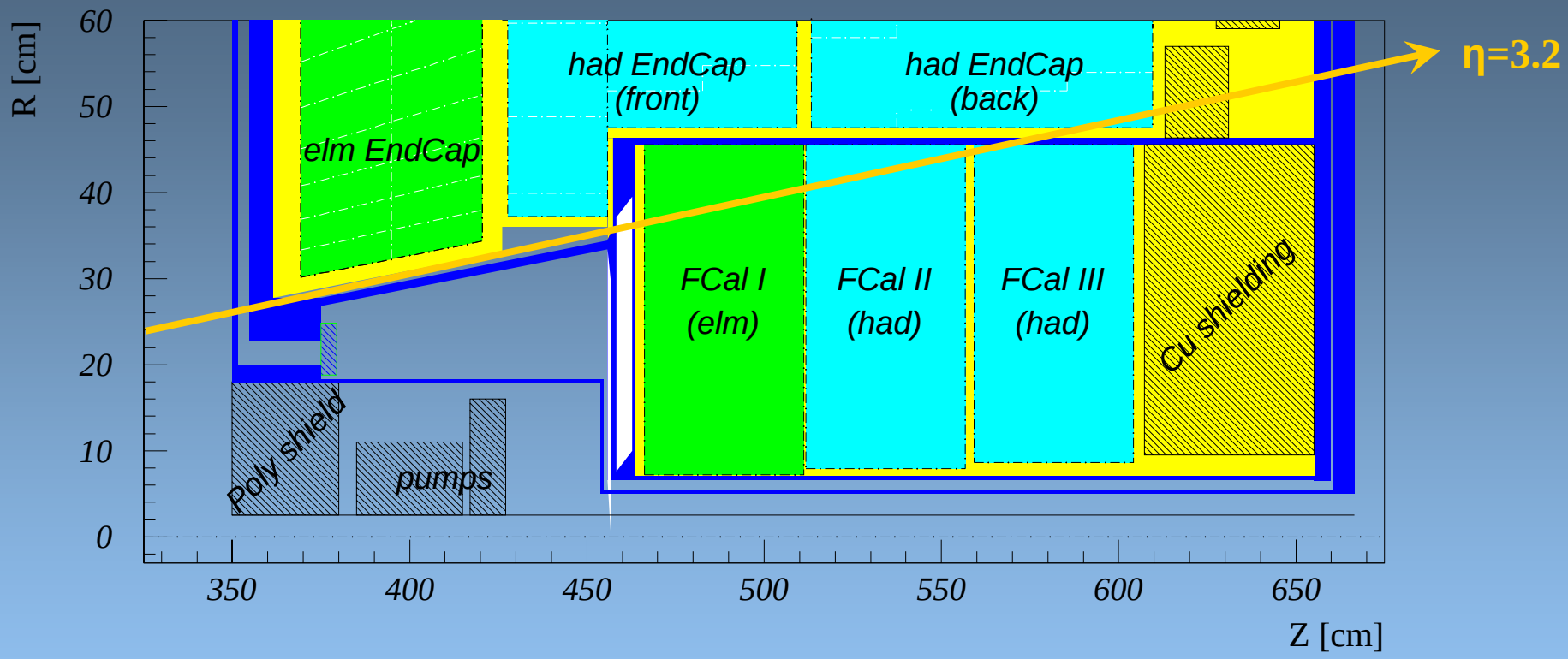


FCal Calibration Testbeam: Electron Energy Resolution



Analysis of pion results in progress

Endcap Combined Testbeam HEC/EMEC/FCal

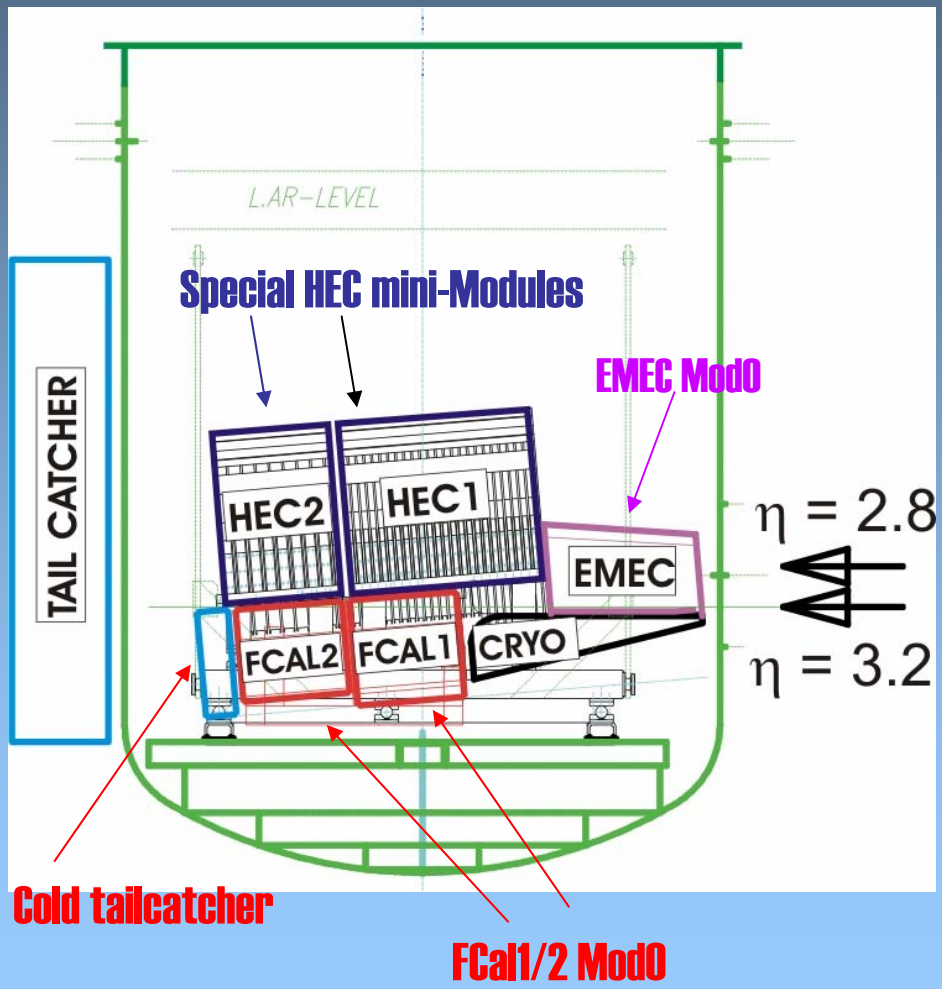


Intercalibration of endcap calorimeters

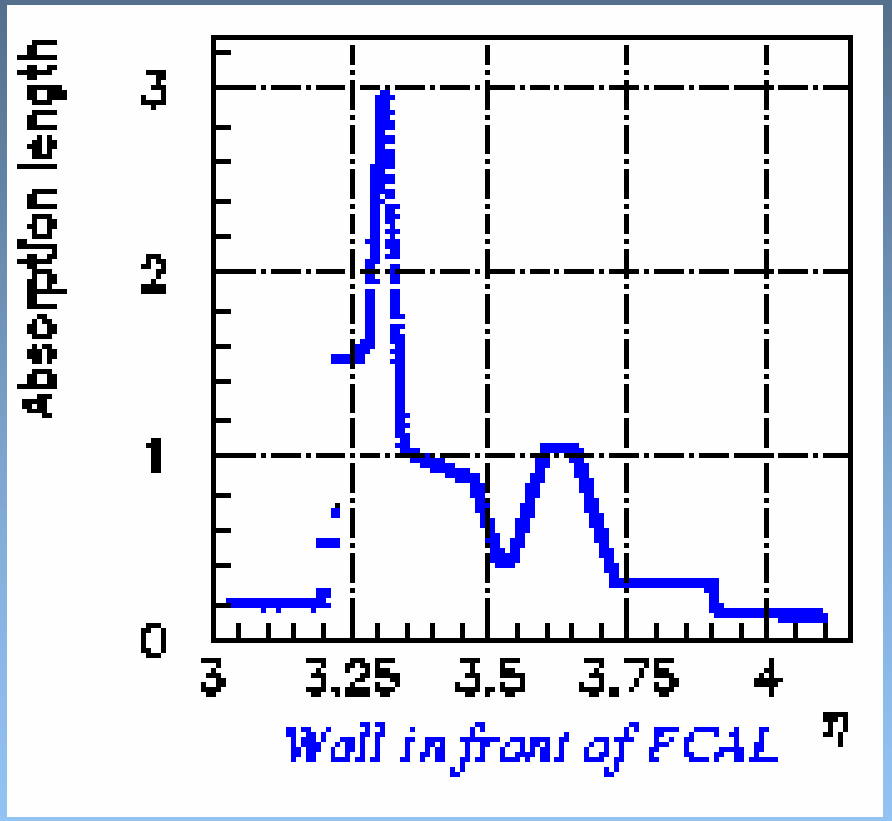
Corrections for energy losses in dead material (tune simulation to testbeam results)

HEC/EMEC FCAL Combined Testbeam

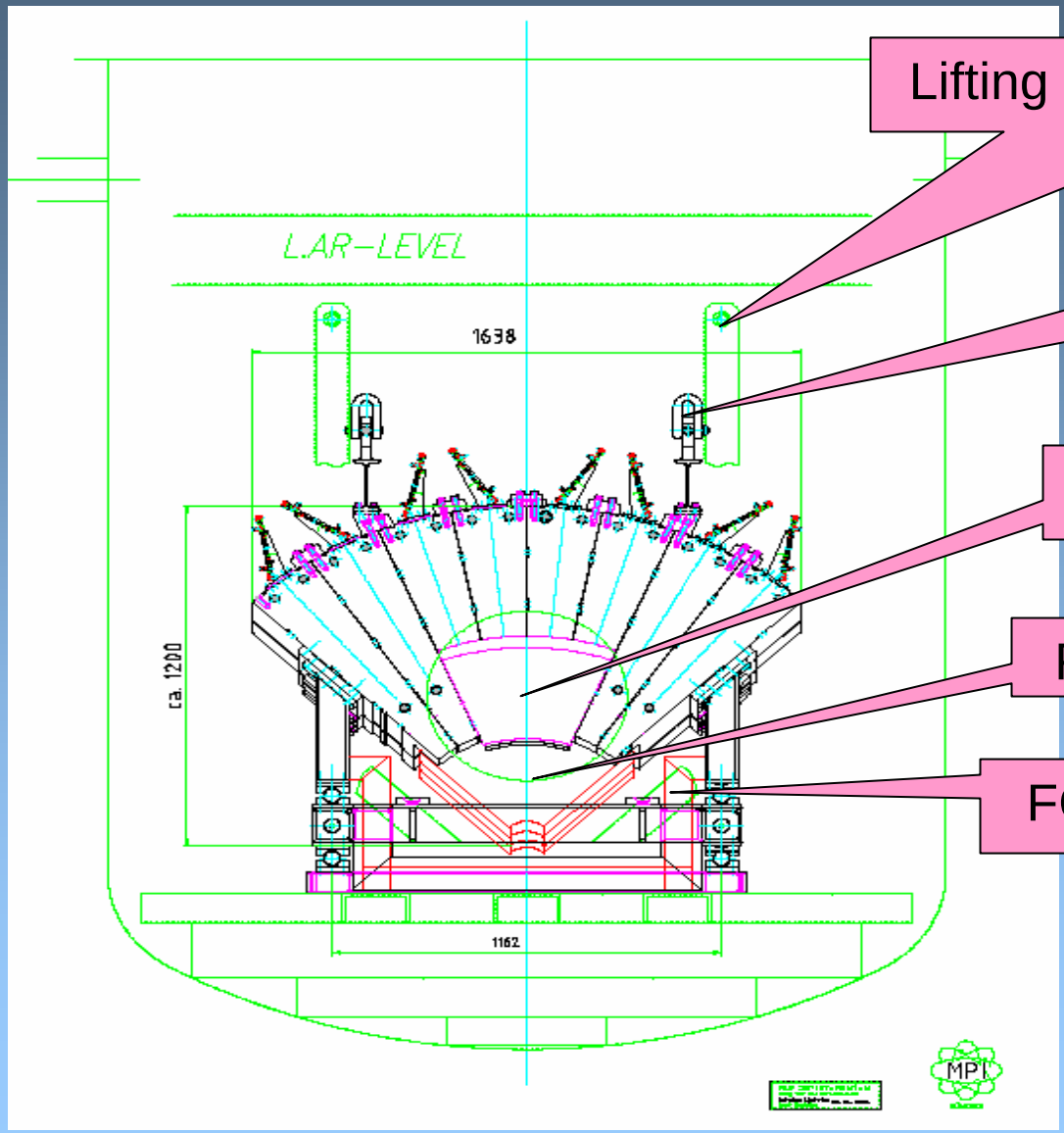
EMEC+HEC+FCAL Setup



Material studies



Set-up for η=3.2 Beam Test



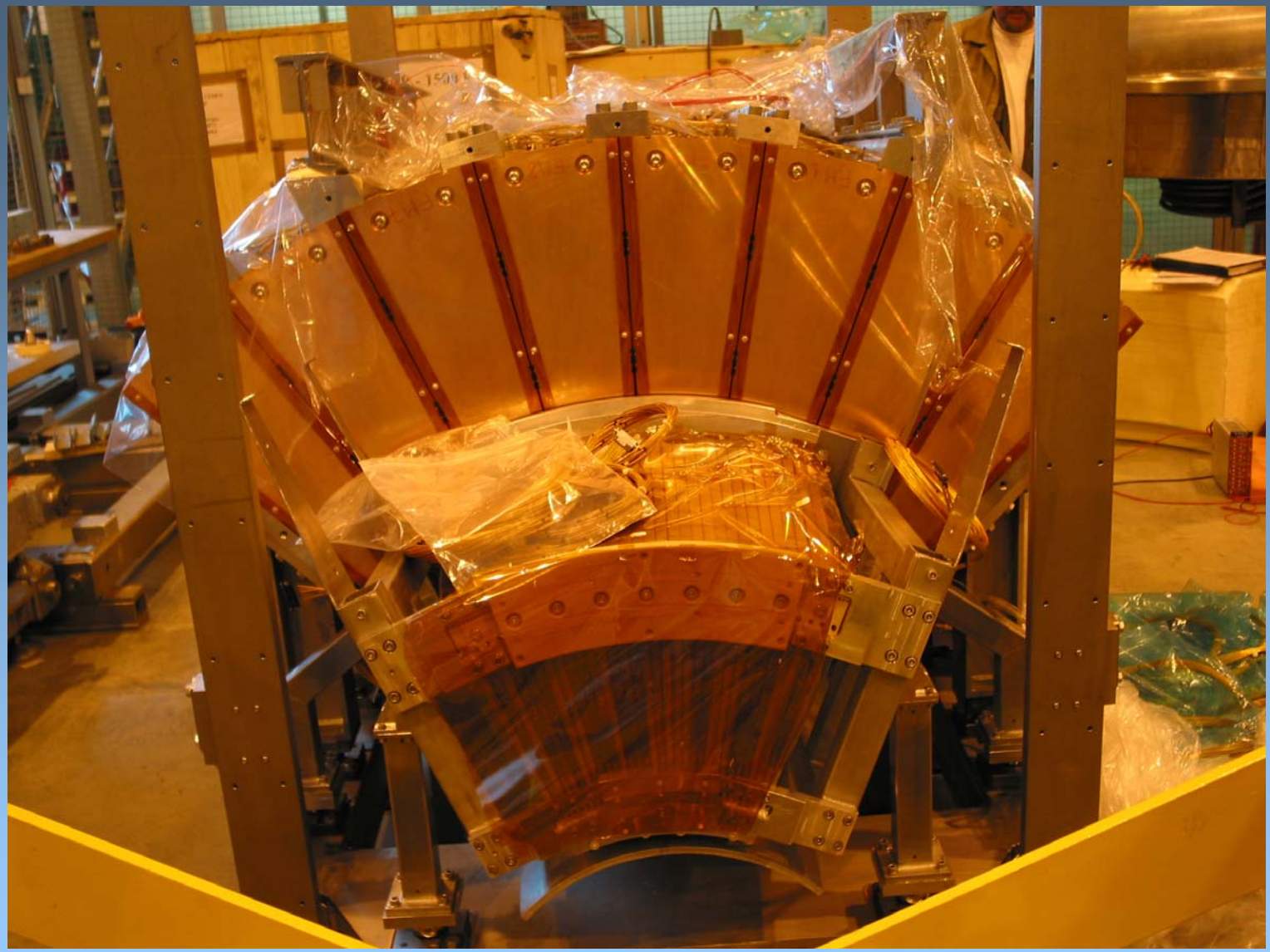
Lifting Tool for Complete Setup

Lifting Tool for HEC1 or HEC2

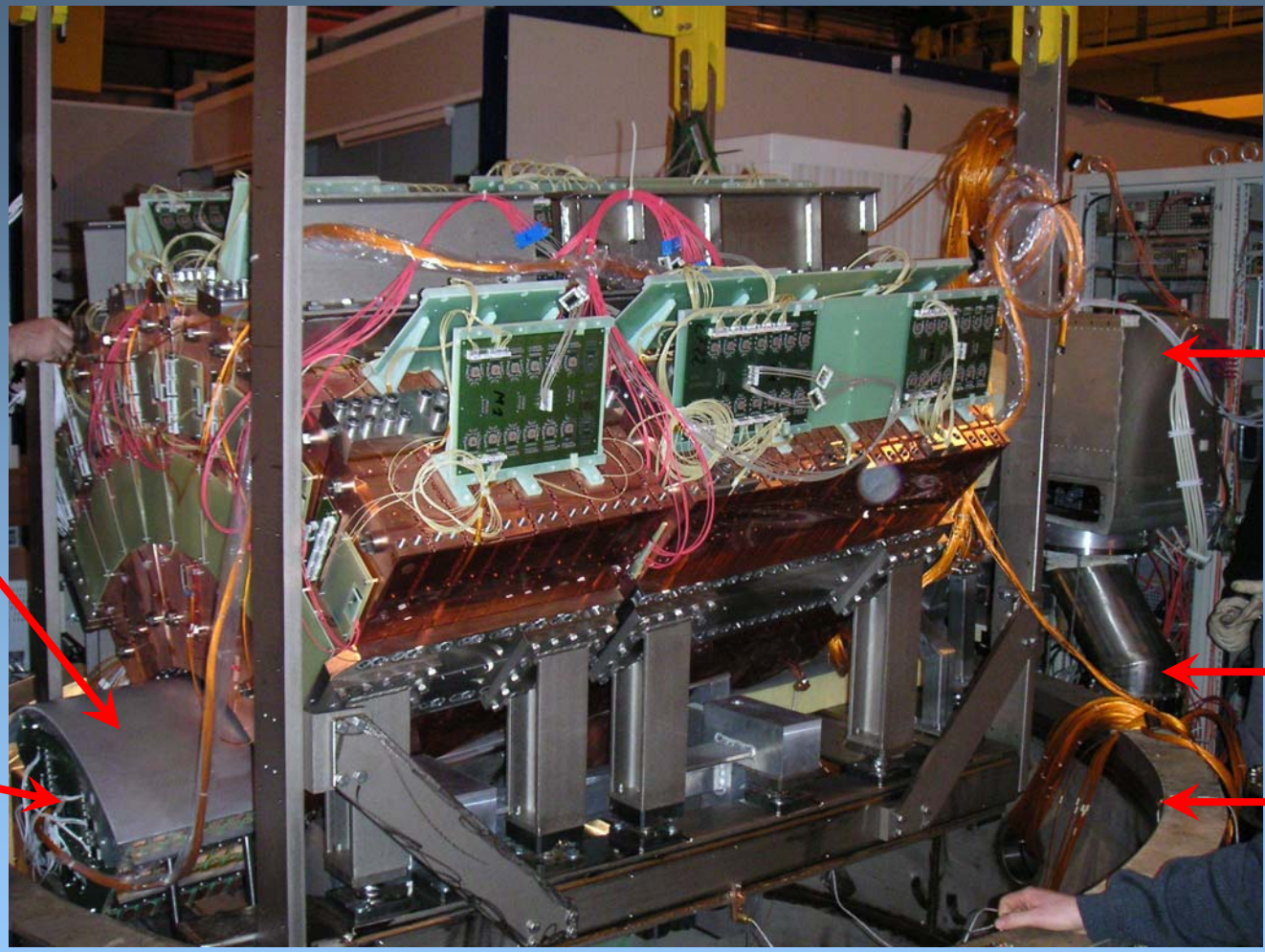
EMEC

FCAL

FCAL Frame



Endcap Combined Testbeam Setup



FCal1, FCal2, EMEC Modules not visible

Summary

- ATLAS Canada construction projects nearing successful completion
  - **Hadronic Endcap Calorimeter**
  - **Hadronic Forward Calorimeter**
  - **Liquid Argon Cryogenic Signal Feedthroughs**
  - **Liquid Argon Front-End Electronics**

- Other efforts underway
  - **Event Filter**
  - **ATLAS computing / Data challenges**
  - **Radiation Studies**
  - **ATLAS pixels**

- Detector integration / installation is proceeding well

- Testbeam programs have been very successful
  - **NIM draft of 2002 testbeam (HEC/EMEC) exists**
  - **Analysis of FCal calibration testbeam data analysis continues**
  - **Combined testbeam currently underway**

…… and of course we all look forward to first data taking in 2007 !