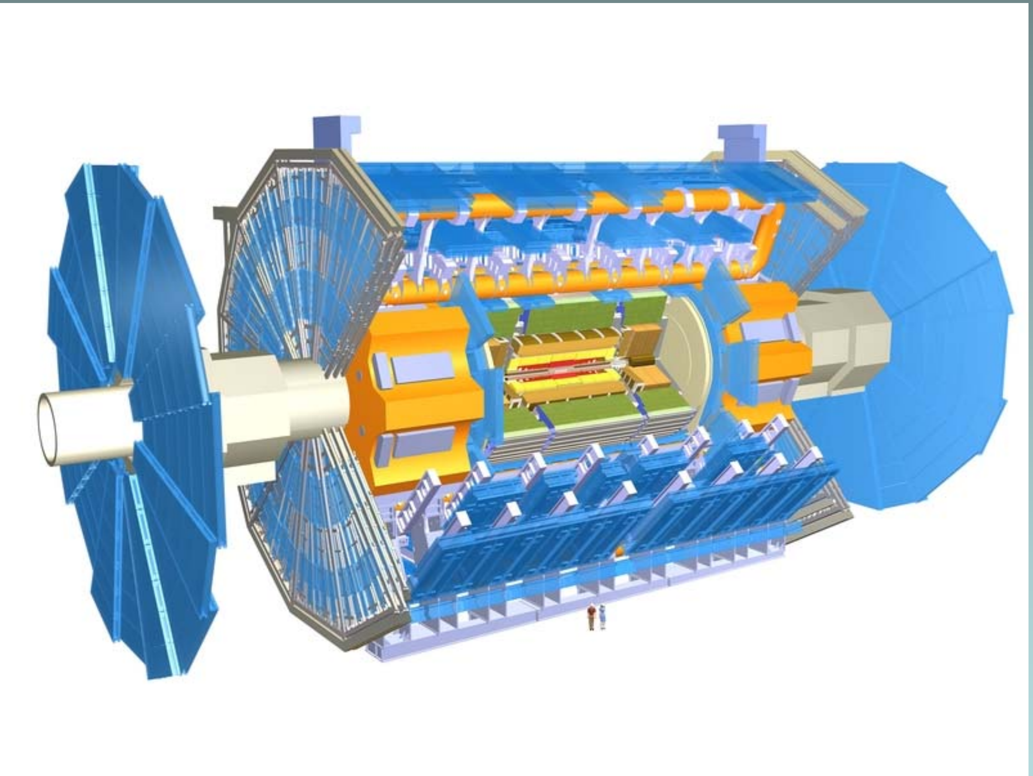
The ATLAS Liquid Argon Calorimeter

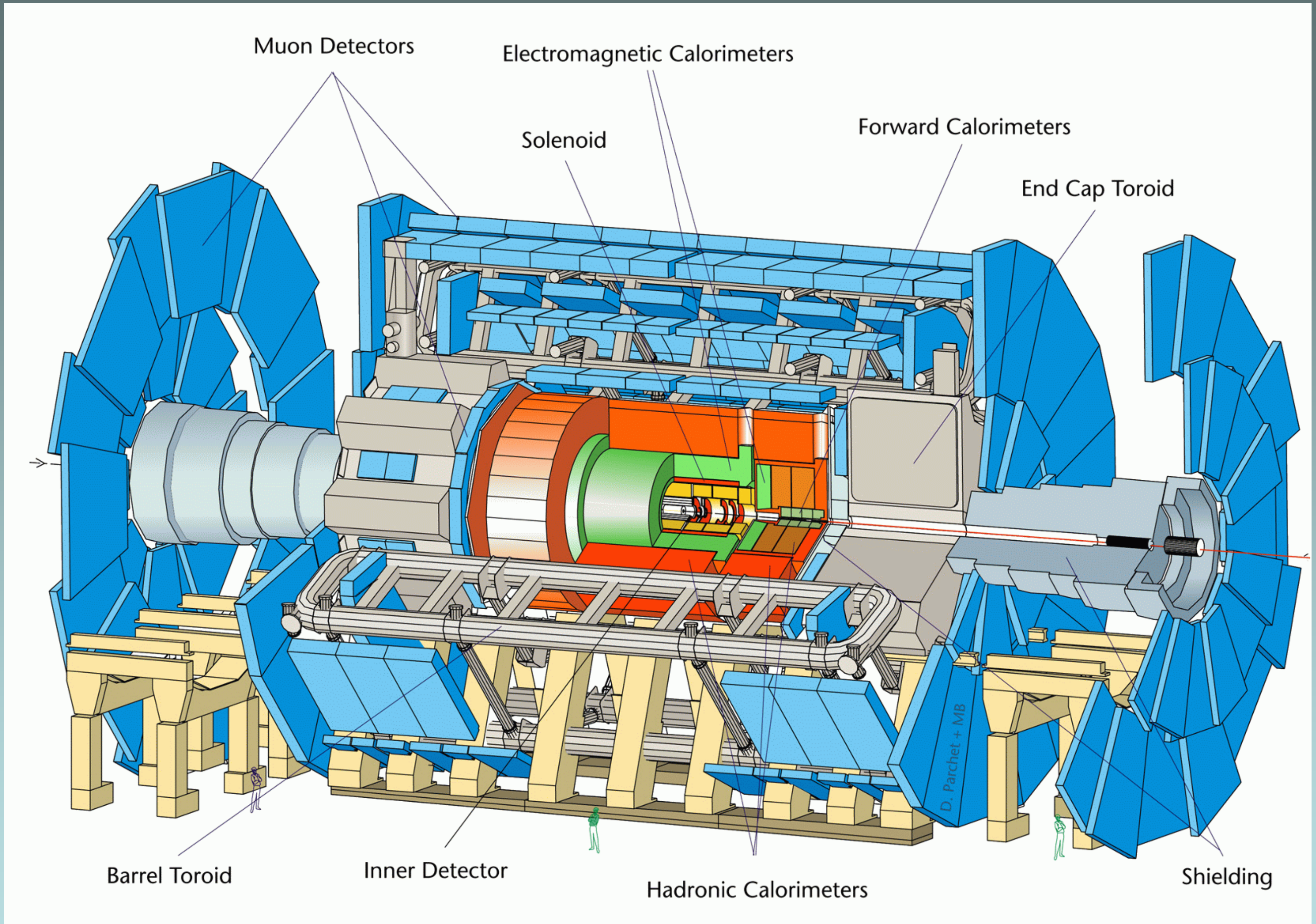
Peter Krieger , University of Toronto



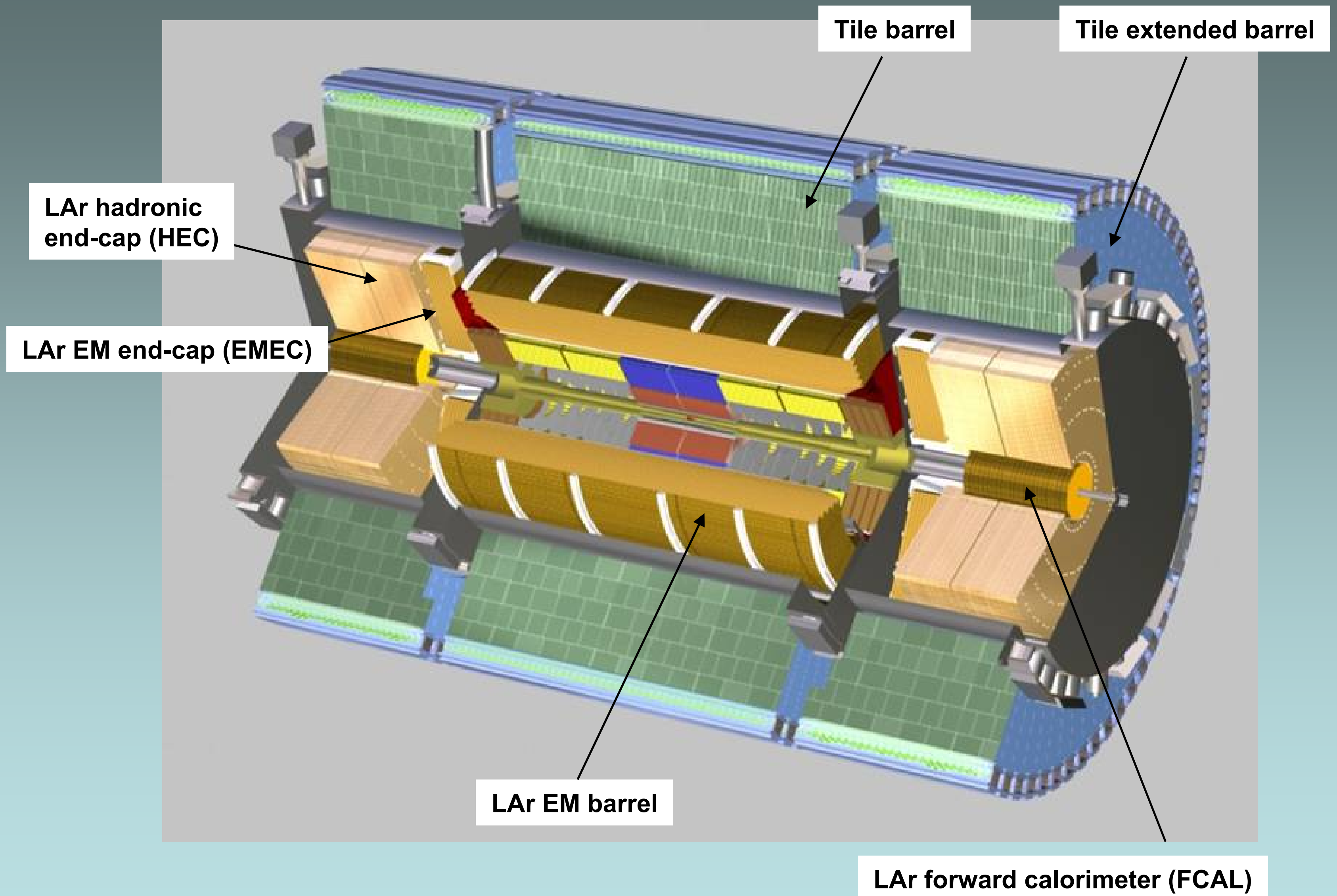
- Calorimeter Design/Construction
- Detector Integration Status

  & briefly….
- Testbeam Summary
- Commissioning Plans

The ATLAS Detector at the LHC

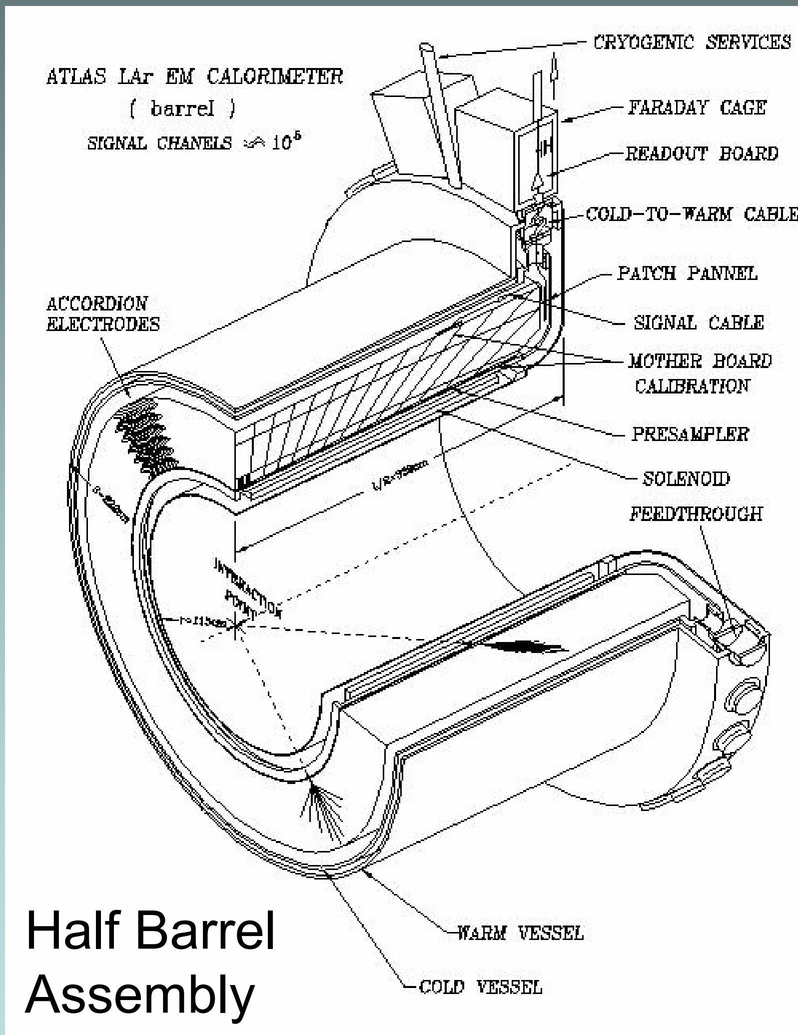


The ATLAS LAr and Tile Calorimeters

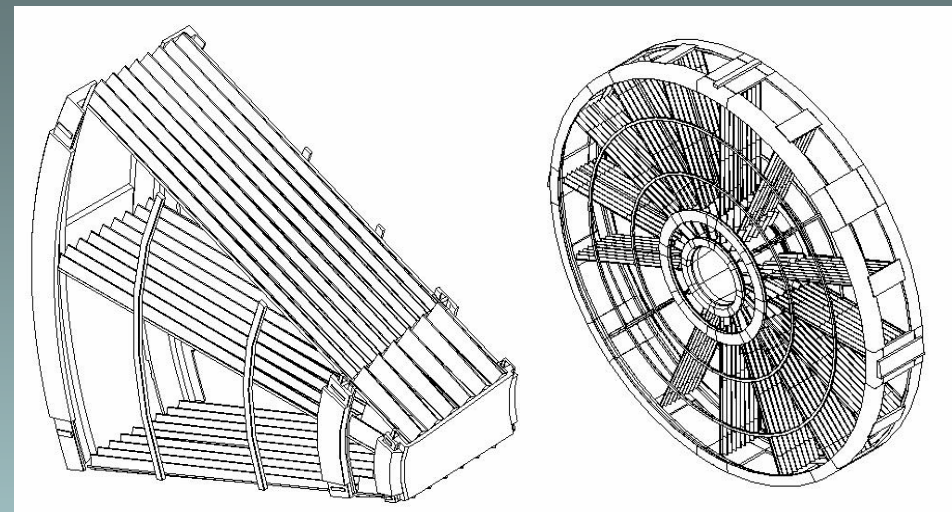


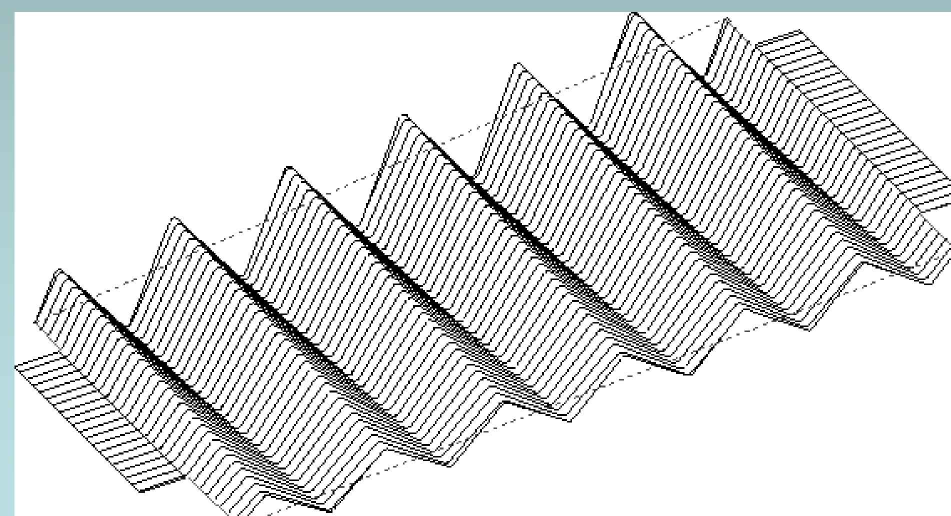
ATLAS EM Accordion Calorimeter

Electromagnetic Barrel (EMB)

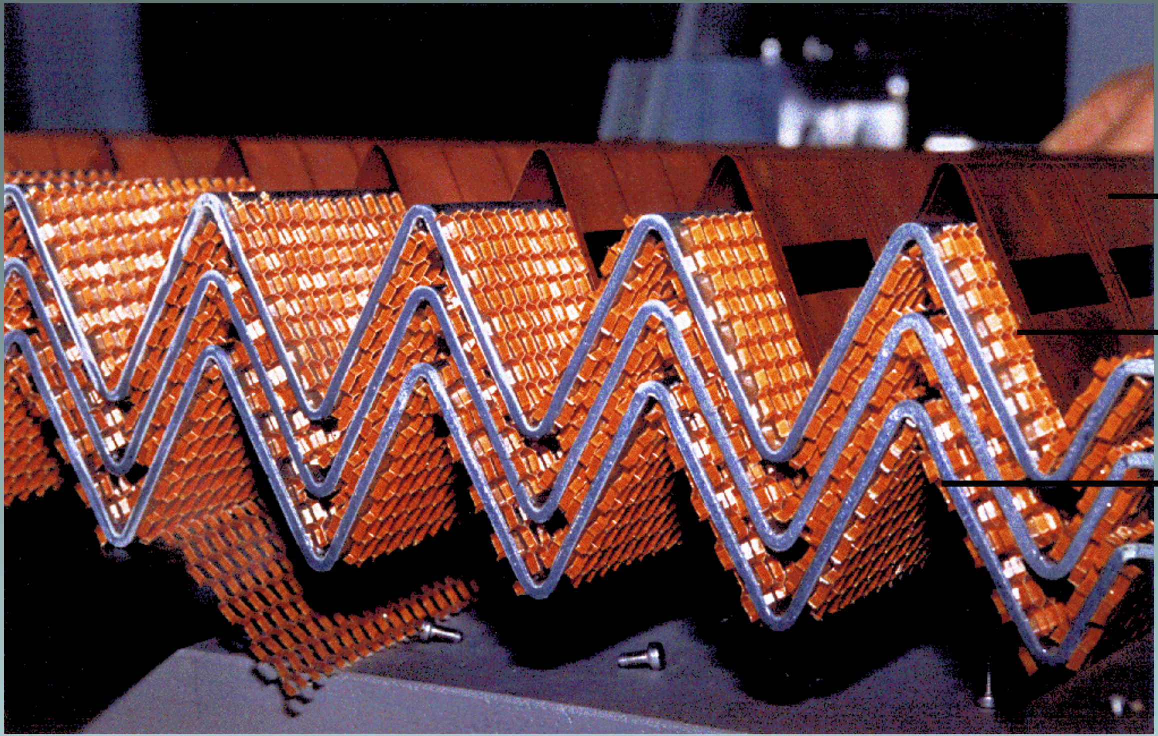


Electromagnetic Endcap (EMEC)





ATLAS Electromagnetic Barrel Calorimeter



|η| < 1.475

Cu/kapton electrode

Honeycomb spacer

Stainless-steel-clad Pb absorber plates

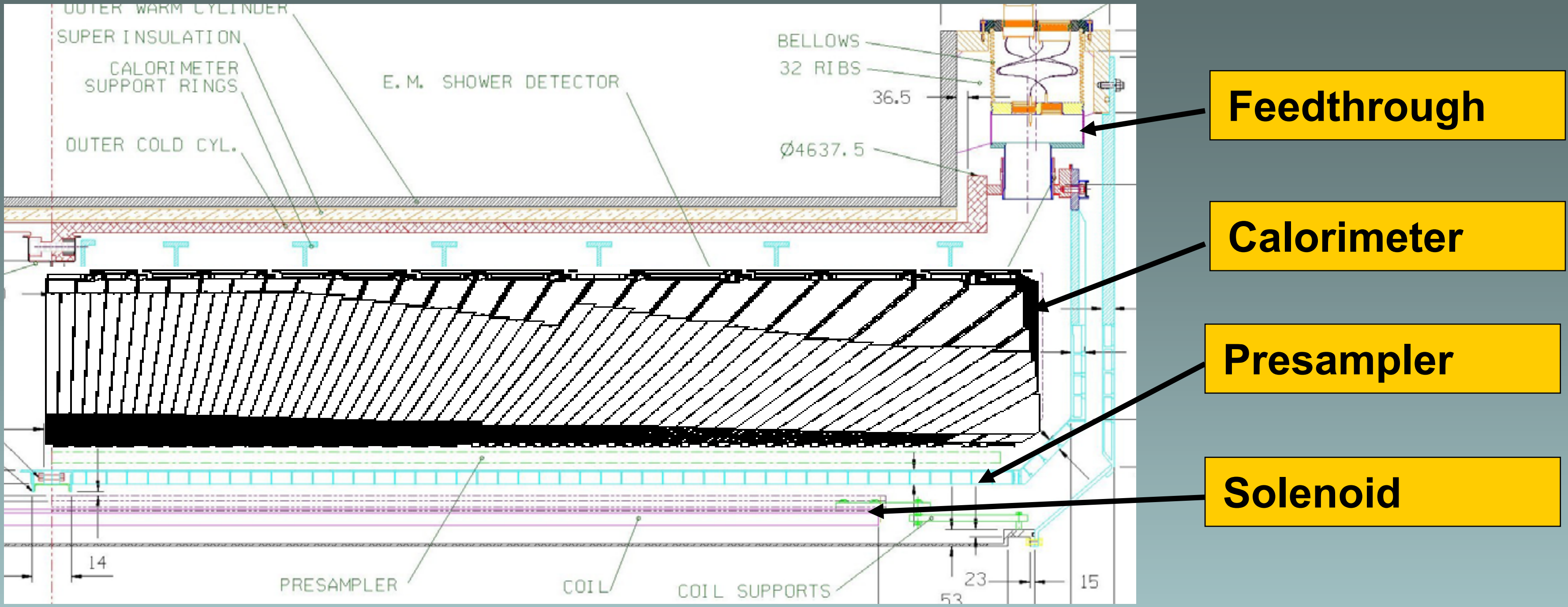
Detector design dictated by physics goals (high energy EM final states)

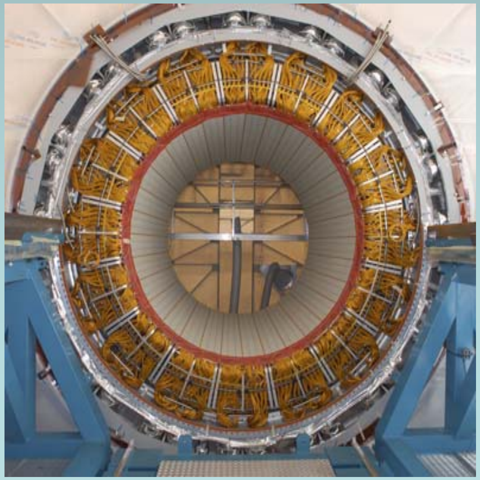
e.g. $H^0 \rightarrow \gamma\gamma, H^0 \rightarrow ZZ \rightarrow 4e,\ W' \rightarrow e\nu,\ Z' \rightarrow ee$

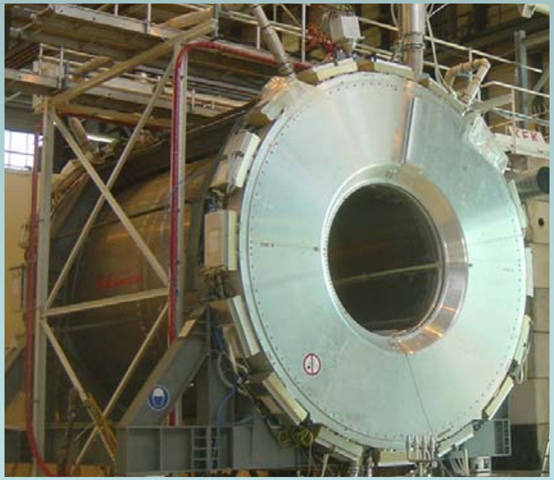
Accordion structure chosen to ensure azimuthal uniformity (no cracks)

Liquid argon chosen for radiation hardness and speed

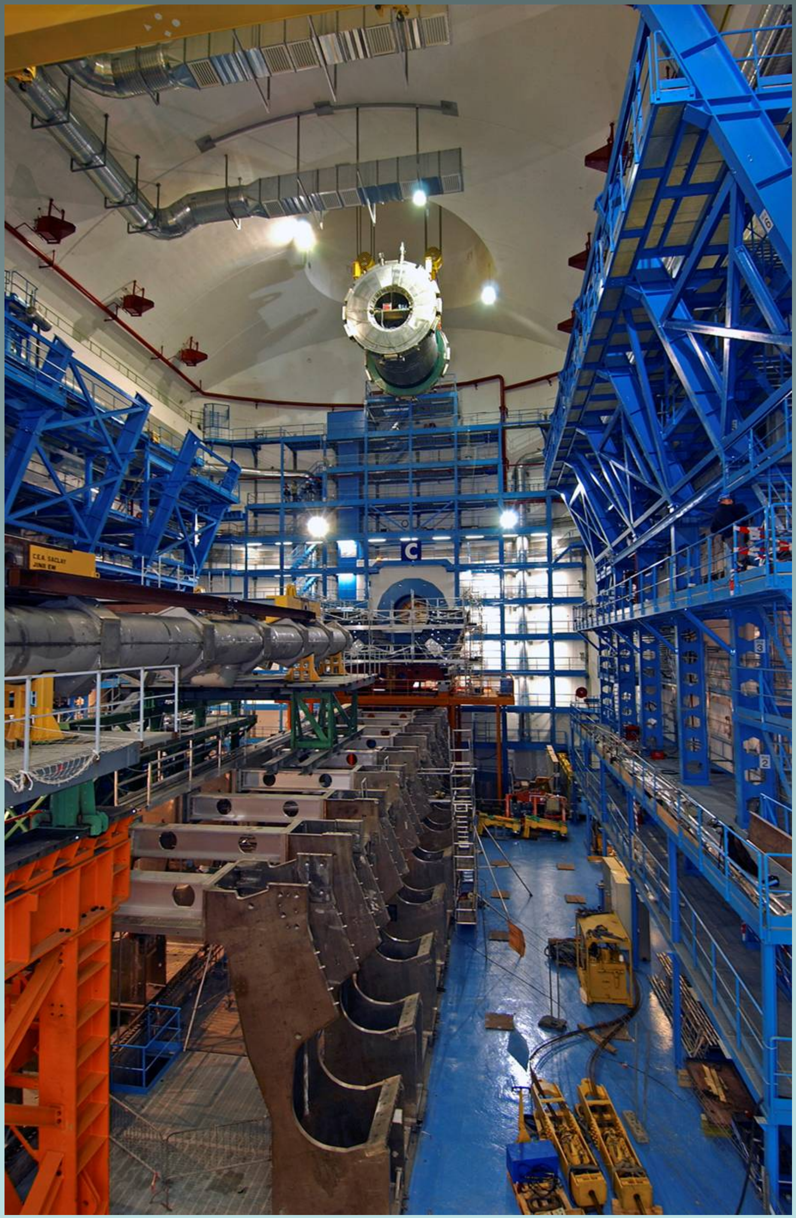
Electromagnetic Barrel Calorimeter



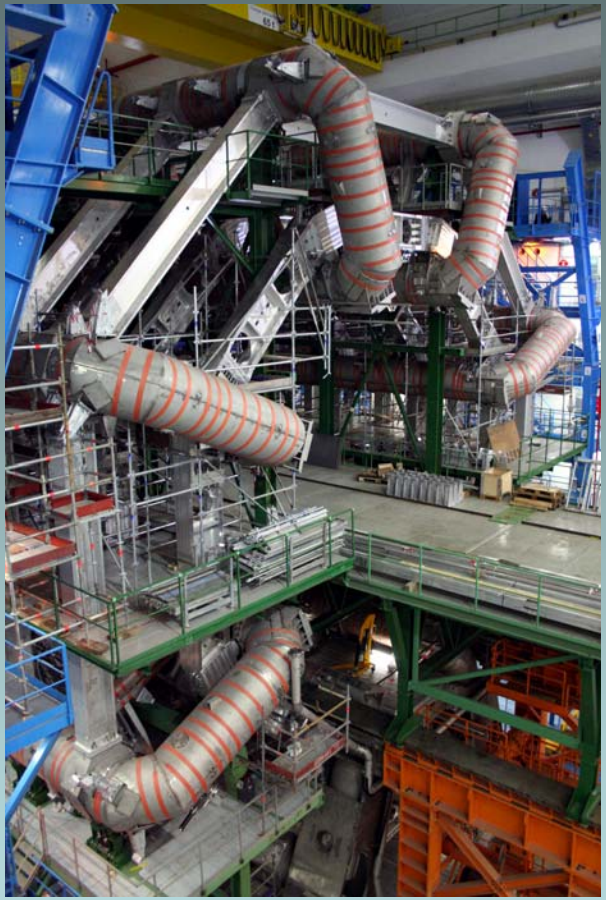


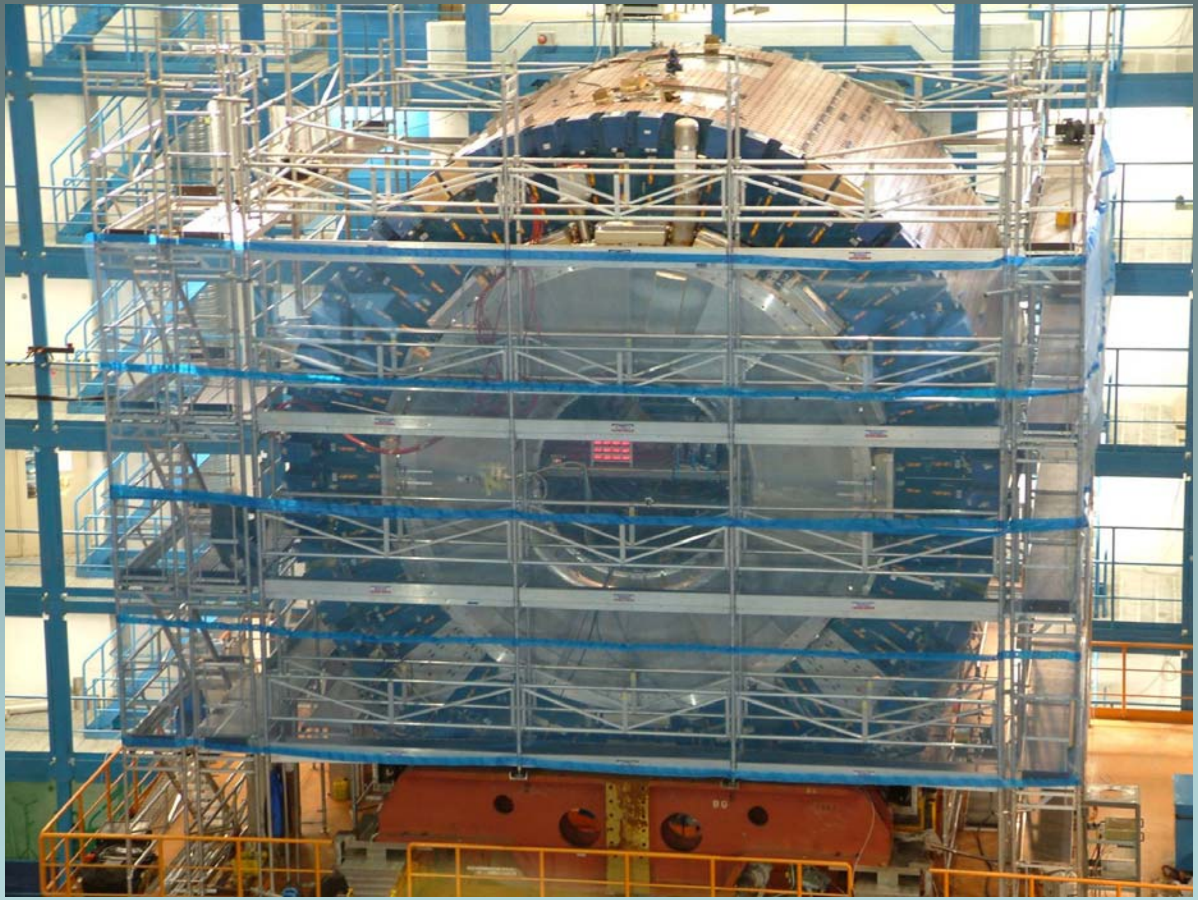


ATLAS Barrel Cryostat (October 2004)



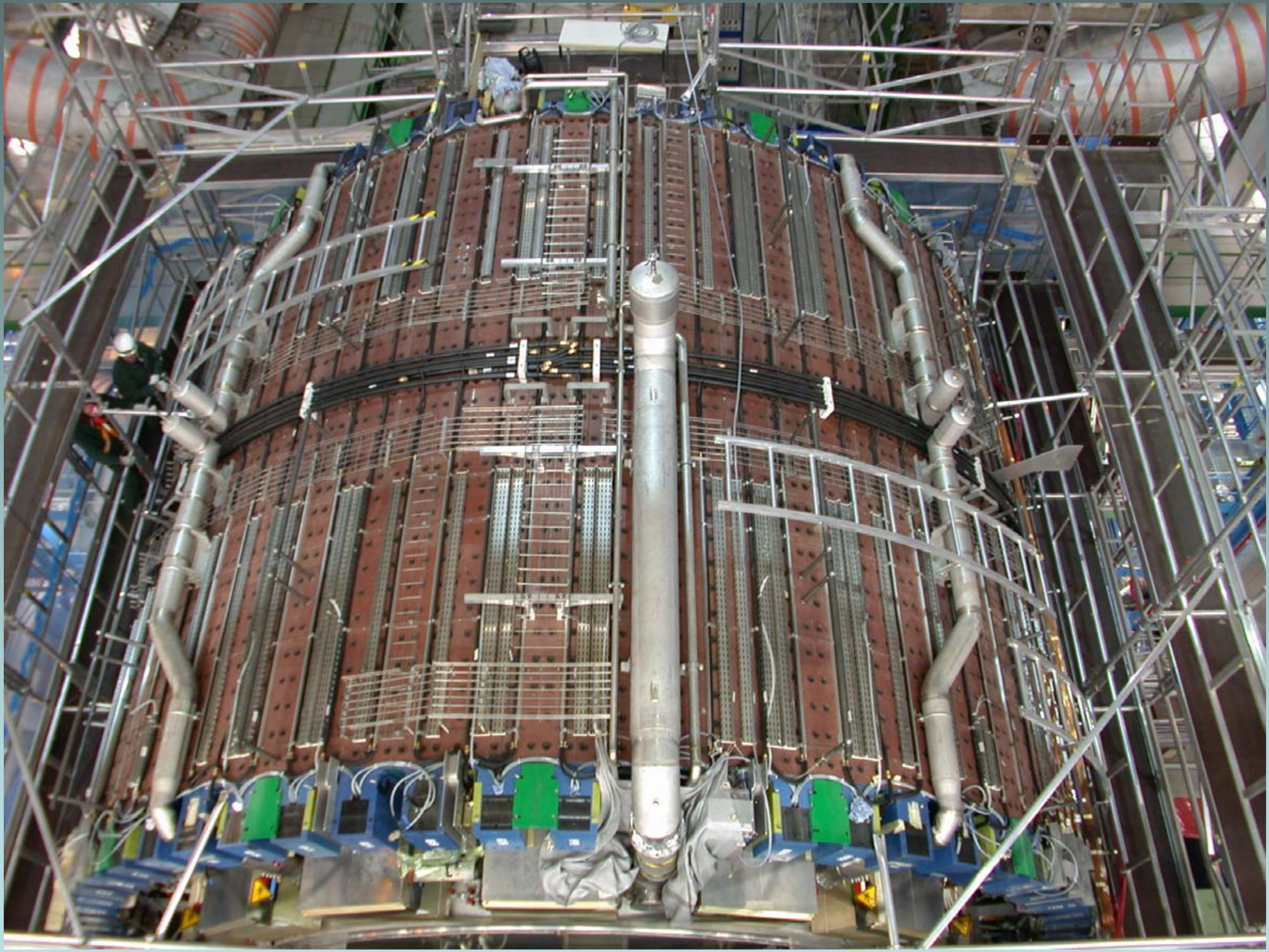
Barrel Toroids Ready for Barrel Calorimeter



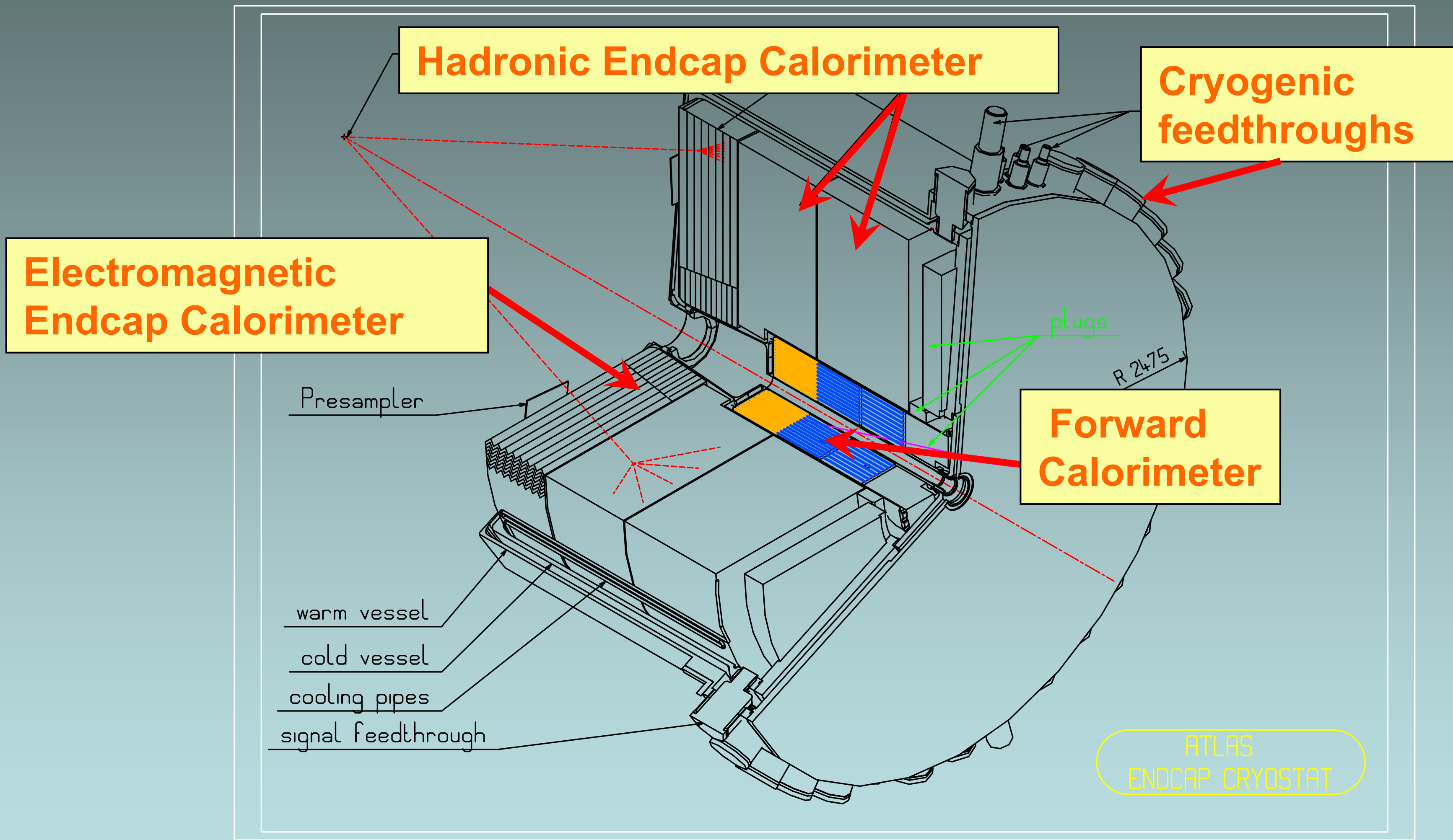


Calorimeter move to z=0 taking place today (Oct 26, 2005)

Installation of LAr Cryogenics



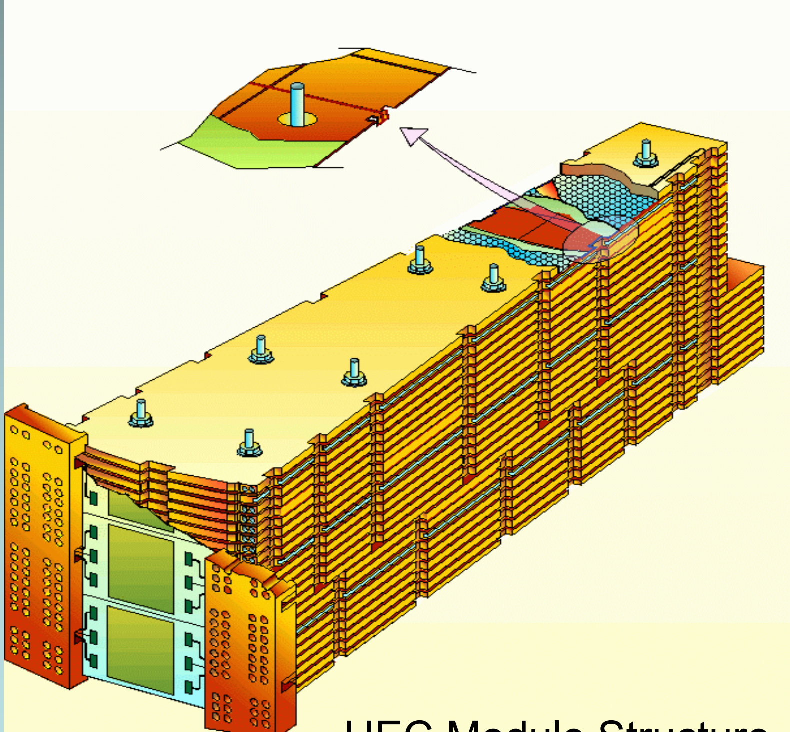
The ATLAS Endcap Liquid Argon Calorimeter



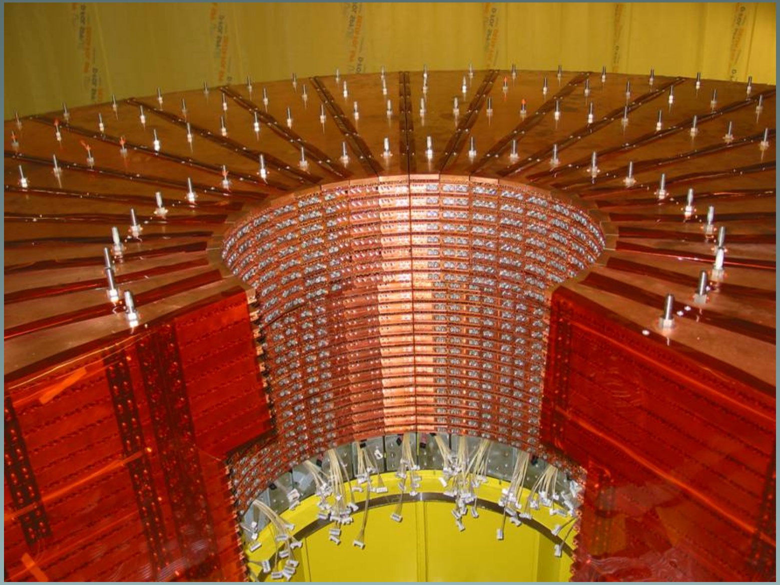
ATLAS Hadronic Endcap Calorimeter

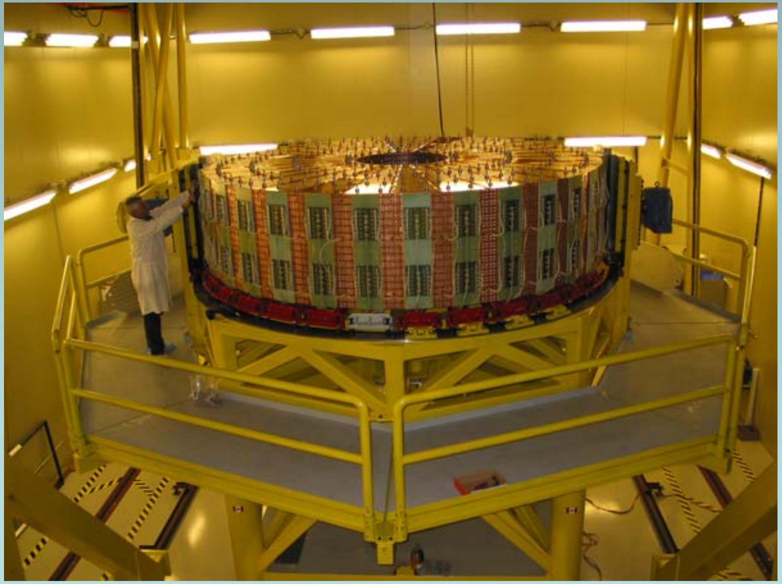
LAr-Cu sampling calorimeter covering $1.5 < \eta < 3.2$

Composed of 2 wheels per end, 32 modules per wheel

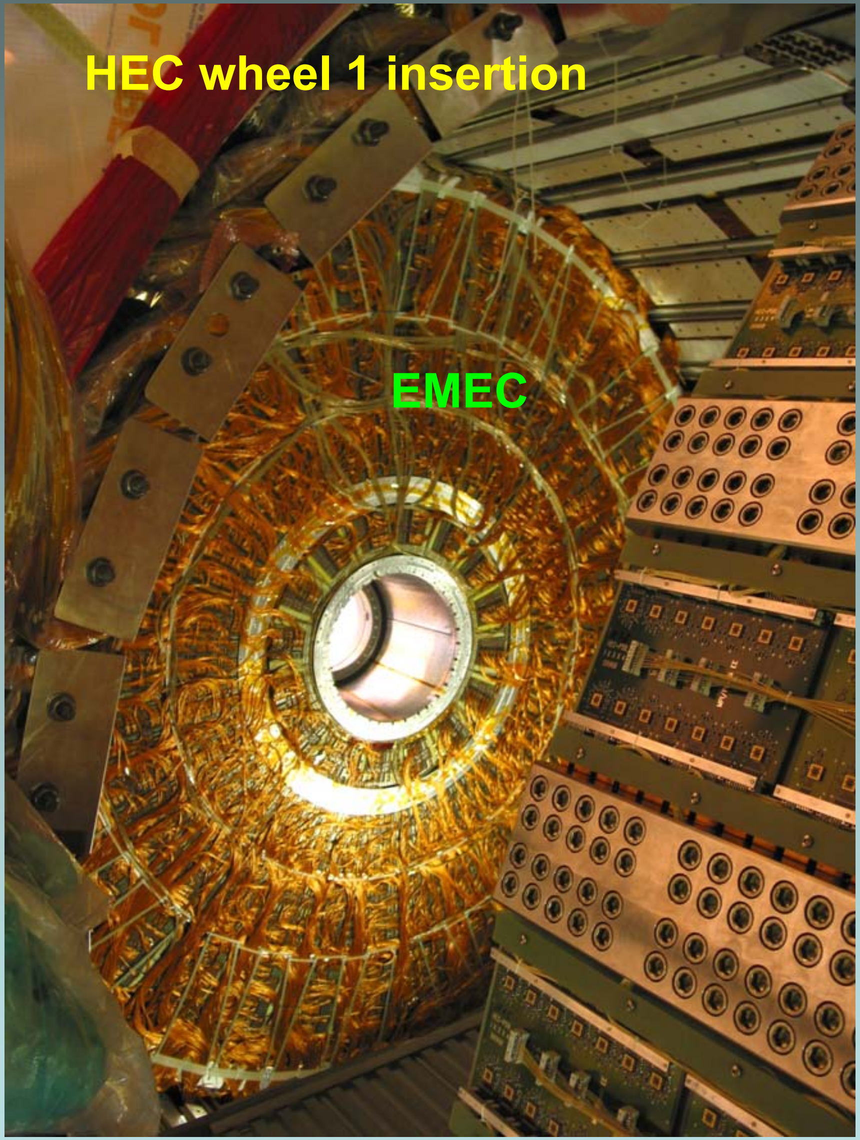


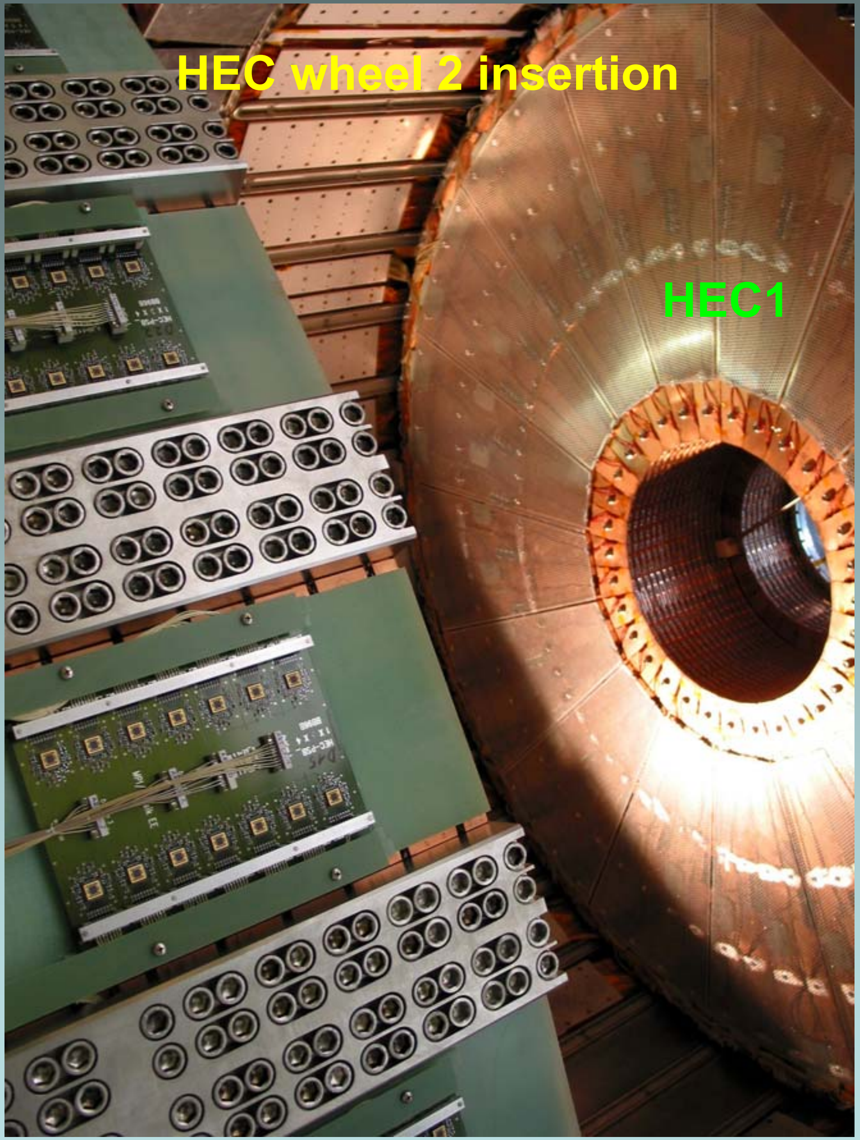
HEC Module Structure

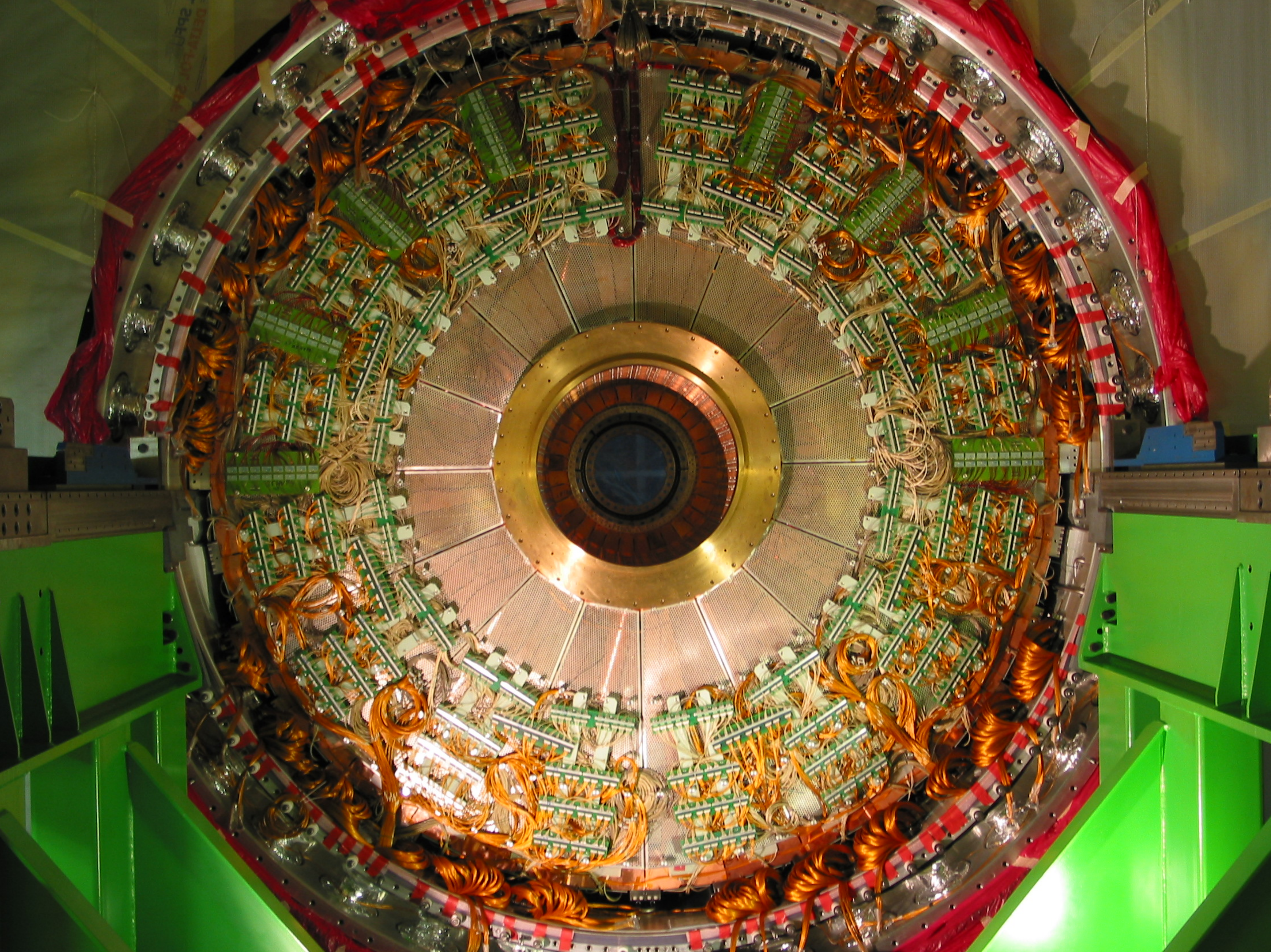




Endcap Calorimeter Insertion into Cryostat





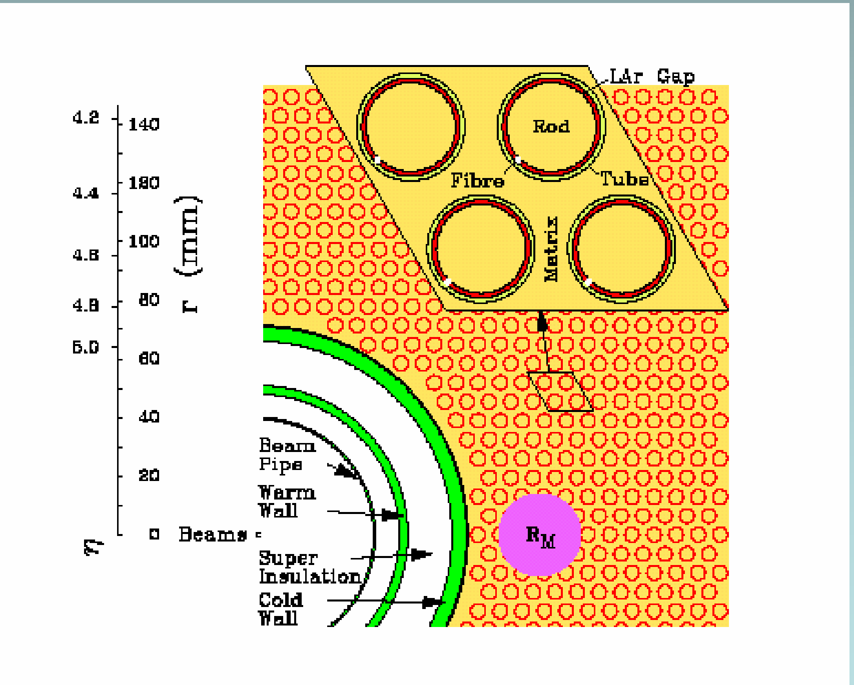


The FCal Calorimeter (η = 3.2-4.9)

Novel electrode structure → thin annular gaps formed by an tubes in an absorber matrix, which are filled with anode rods of slightly smaller radius

Gap maintained by helically-wound radiation hard plastic fibre (PEEK)

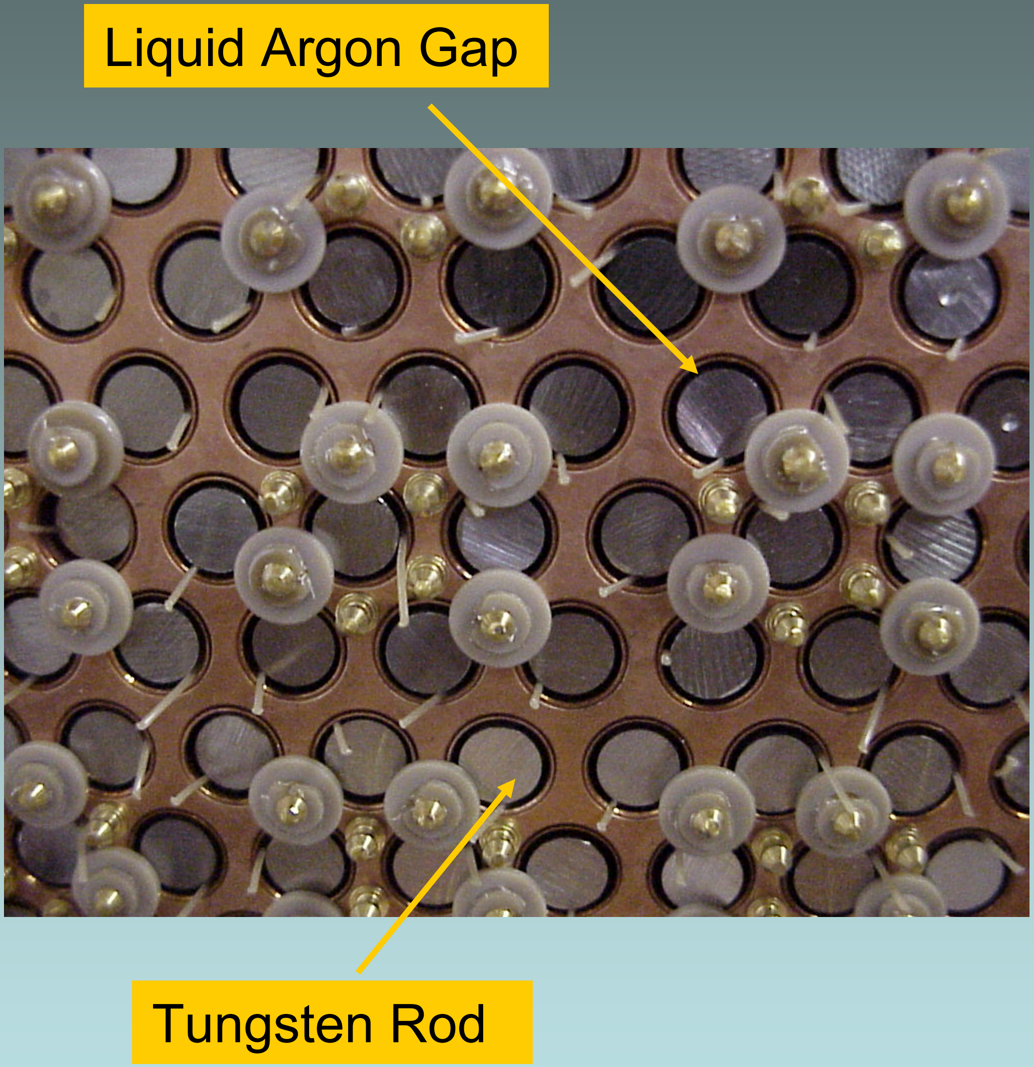
Three modules: 1 EM, 2Hadronic (ease of construction, depth segmentation)

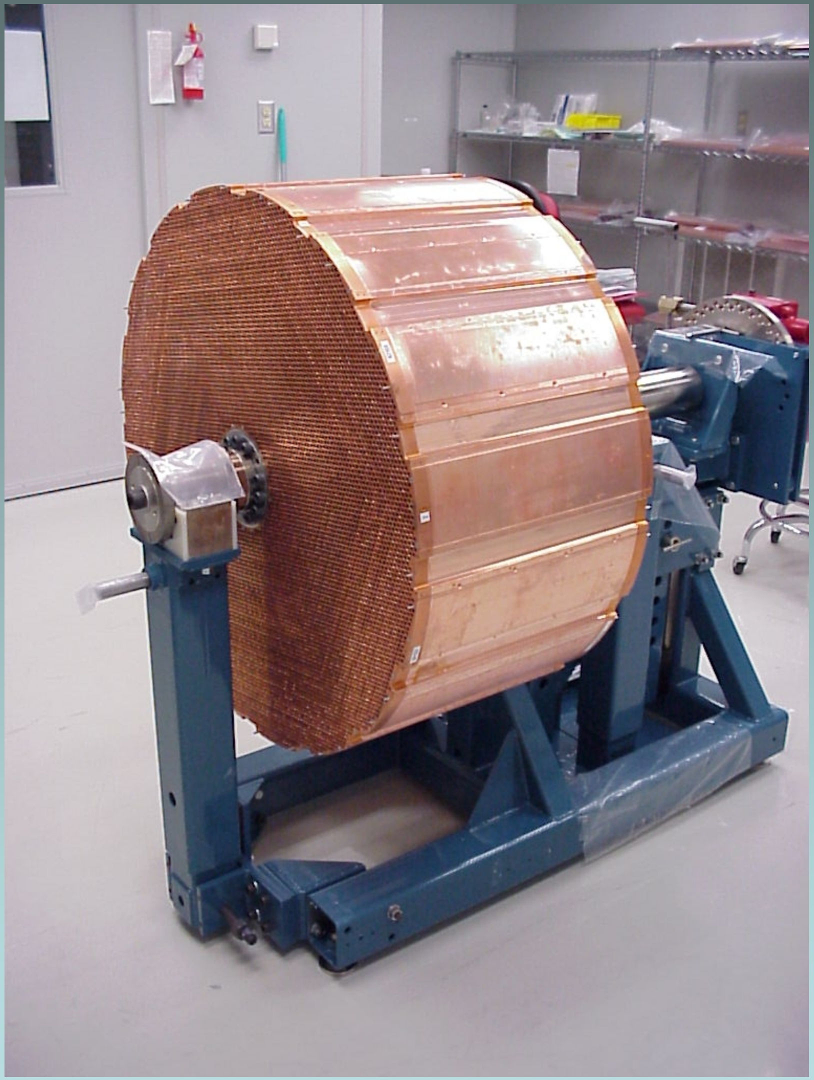


	Type	Absorber	Gap (μm)	Number of Electrodes
FCal1	EM	copper	250	12000
FCal2	HAD	tungsten	375	10000
FCal3	HAD	tungsten	500	8000

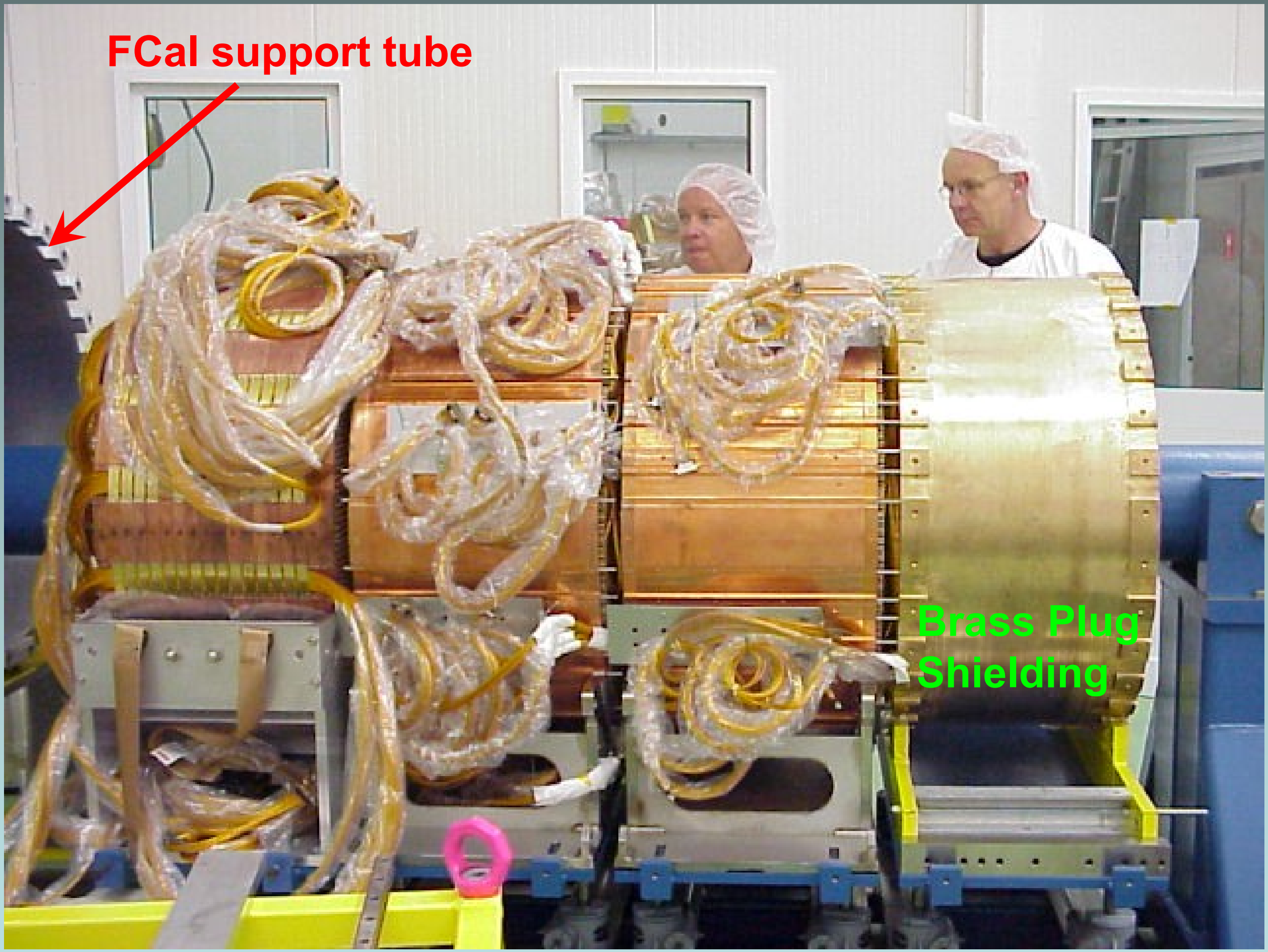
matrix and rods are part of the detector 'absorber' and are composed of the same material

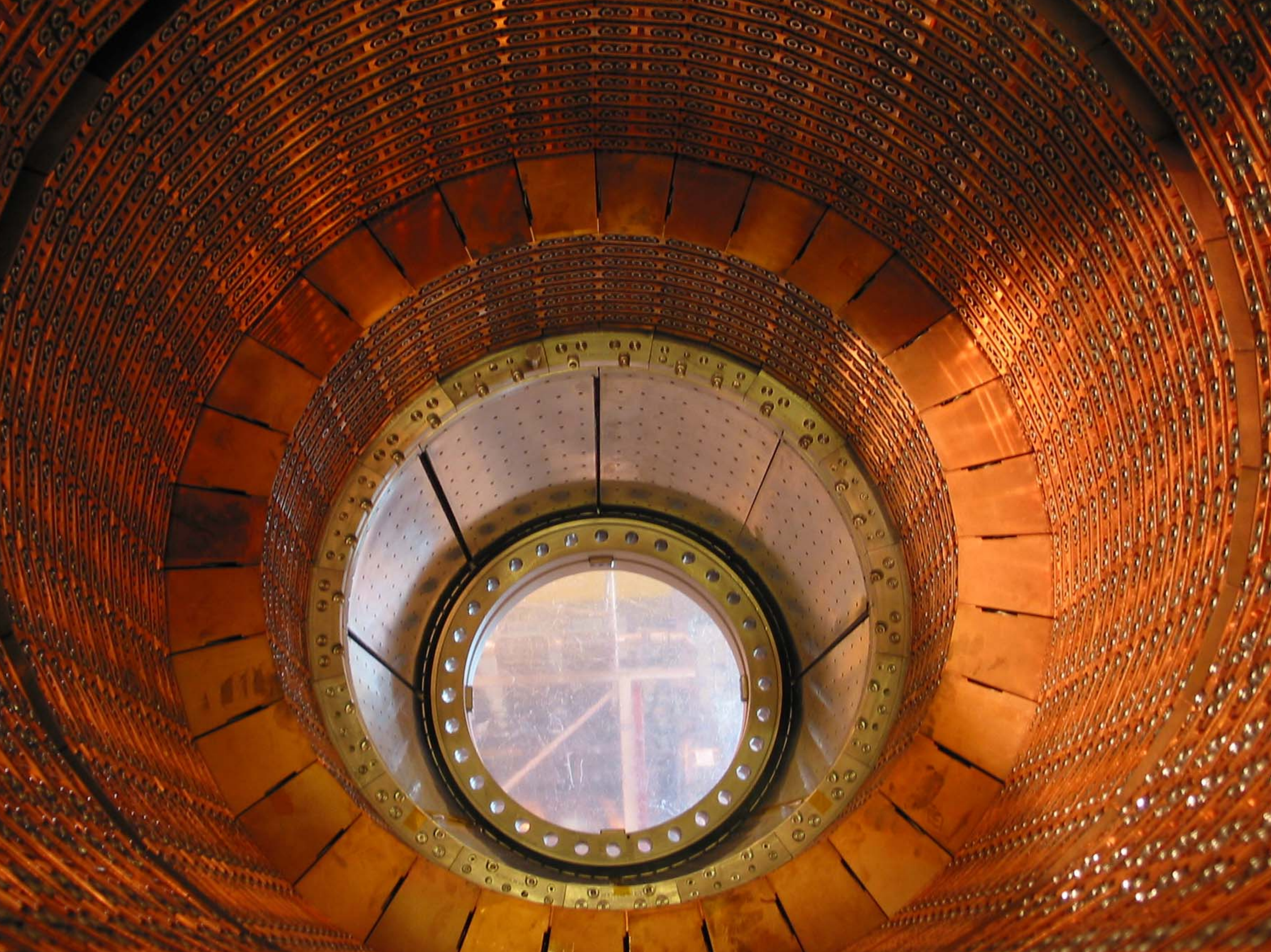
FCal2/3 Structure and Assembled Module



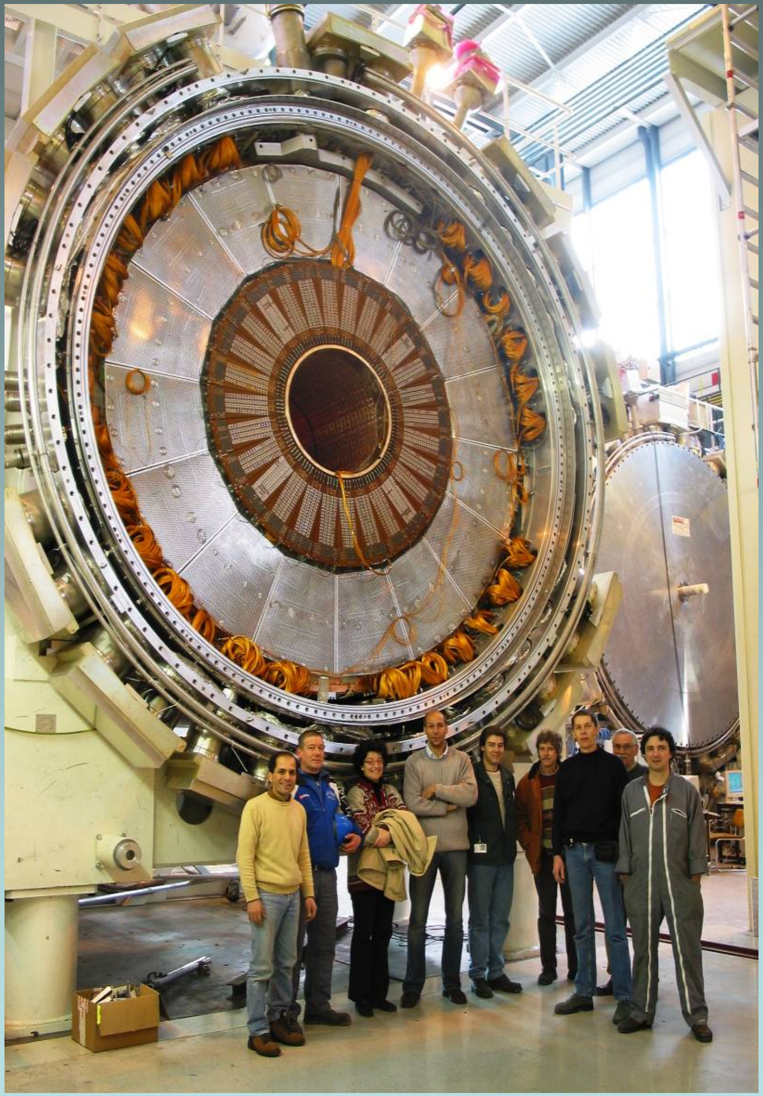


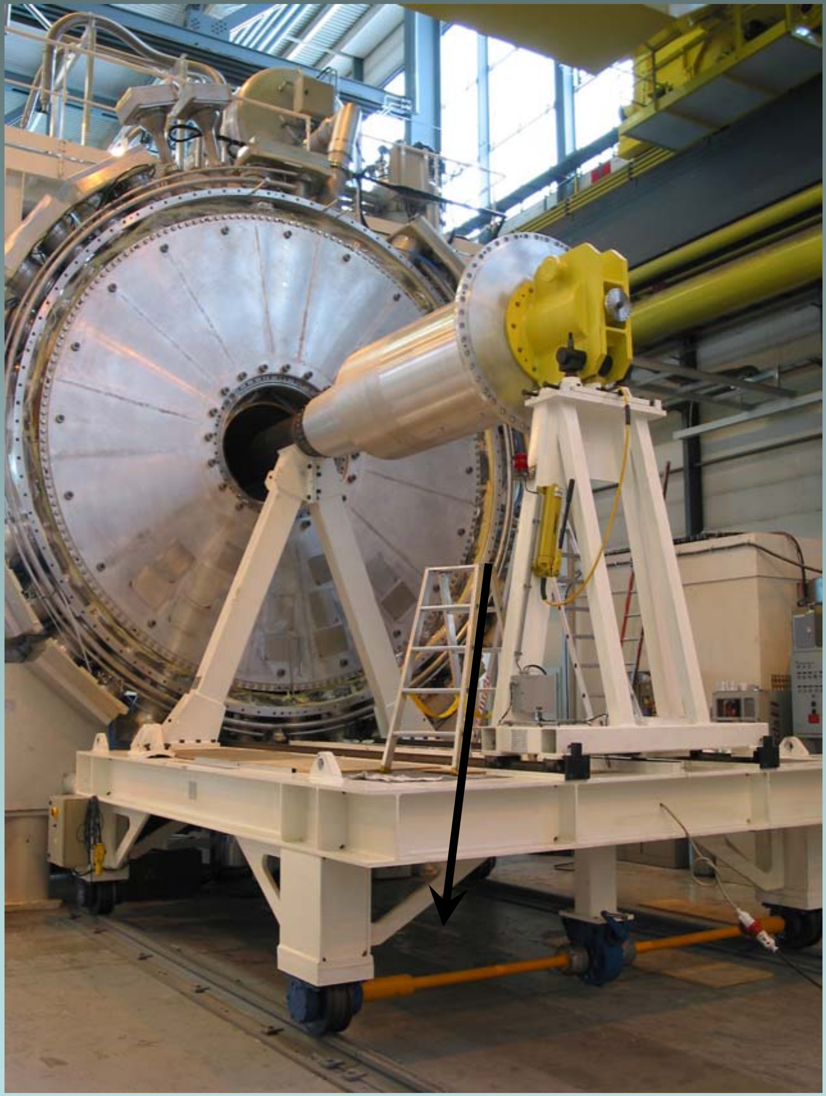
Forward Calorimeter Assembly



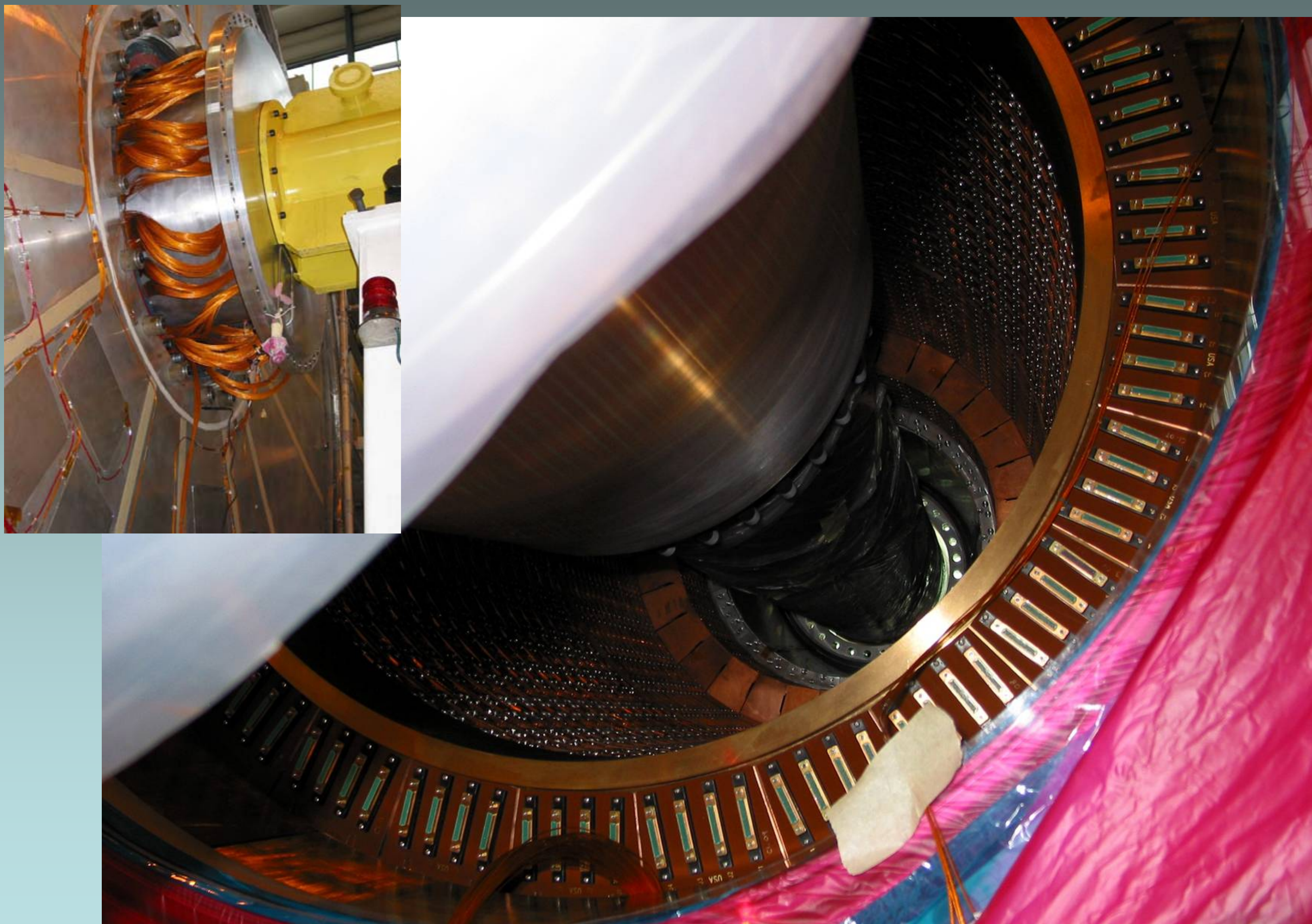


Forward Calorimeter Installation



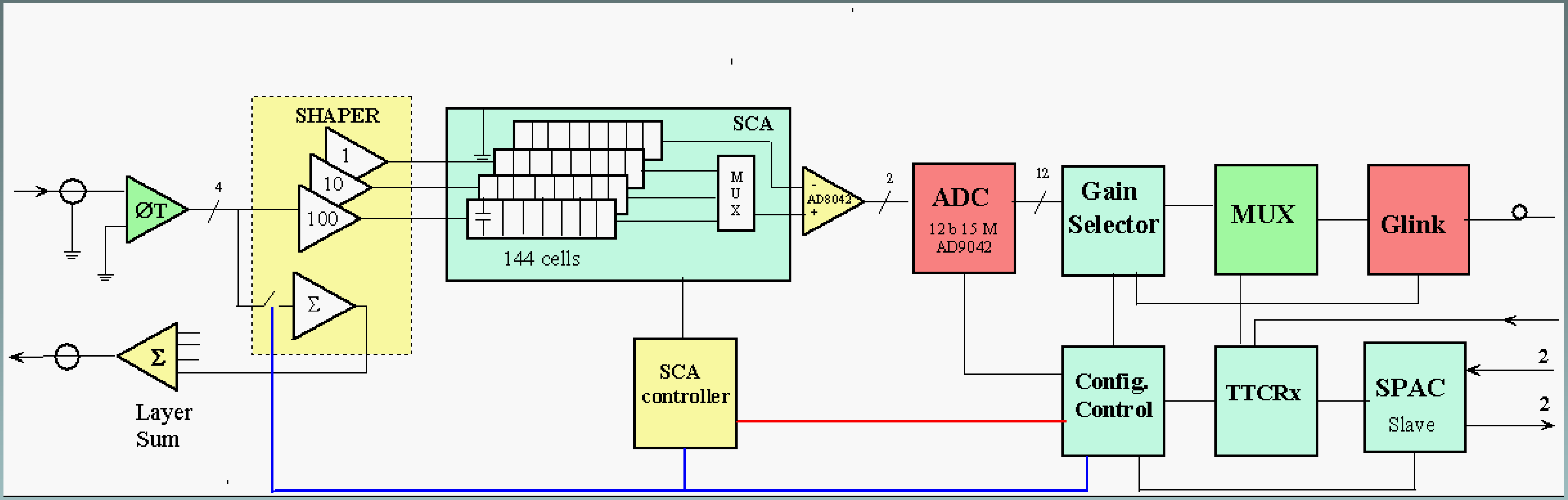


Forward Calorimeter Insertion



Endcap Cryostat Move To LHC Point 1

Liquid Argon Front-End Electronics

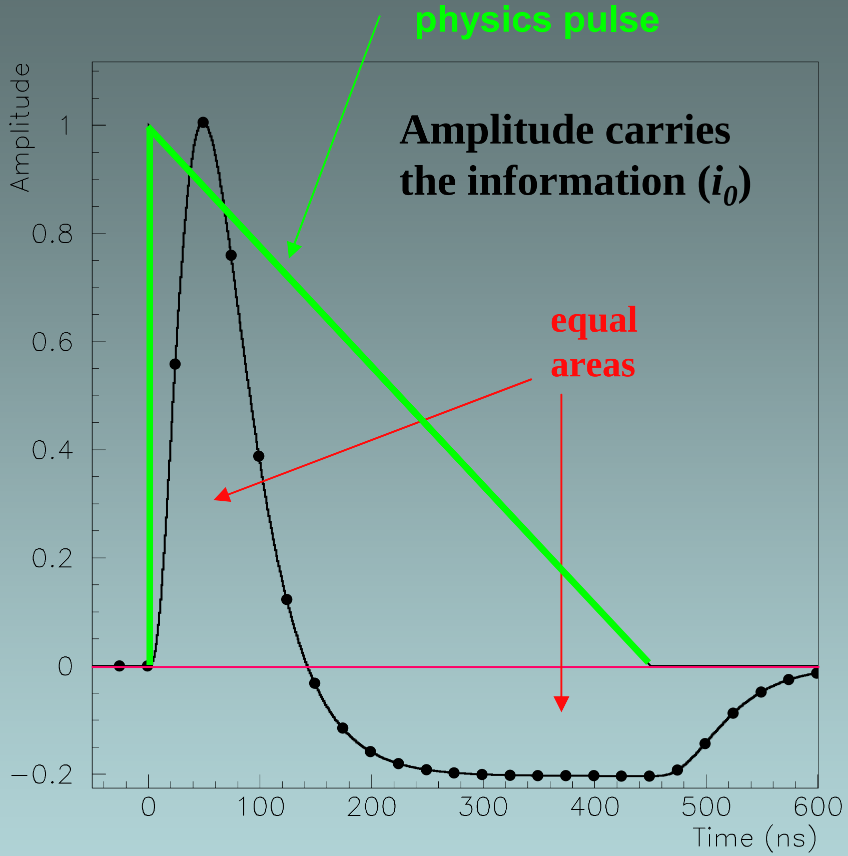


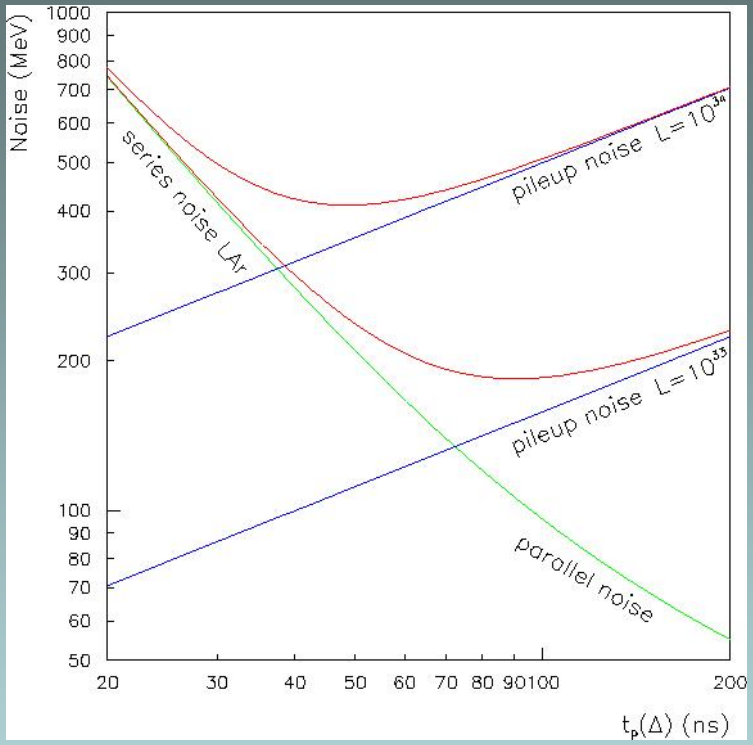
Common readout electronics for all LAr Calorimetry

except for cold (GaAs) preamplifier for Hadronic Endcap Calorimeter

Installation and testing of Front-End Crates currently underway in ATLAS cavern

LAr Bipolar Signal Pulse Shaping





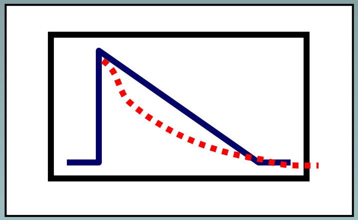
Pulse shape sampled every 25 ns
(eg. once / bunch crossing)

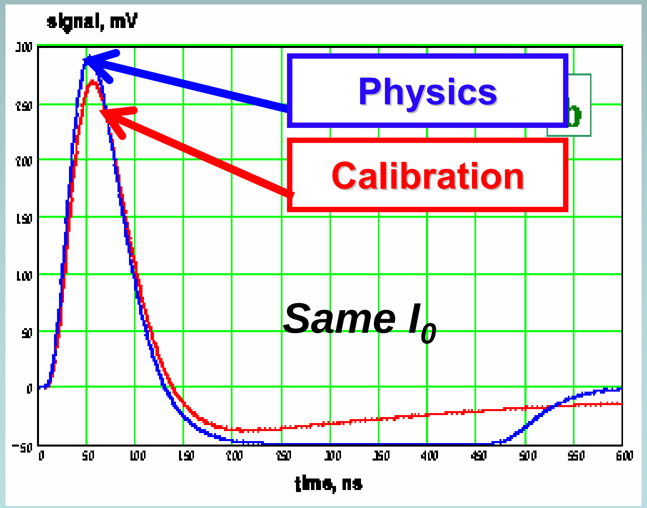
Optimal shaping time is an optimization problem.

Electronic Calibration

Pulse height samples → peak height via optimal filtering

- Optimal Filtering (OFC) coefficients E (ADC) = $\sum a_i \; (S_i - PED)$
- OFC calculation relies on detailed knowledge of the physics pulse shape
- Use calibration pulser: inject known current I_0 to calibrate response
- But …. Calibration pulse differs from physics pulse
  - Physics pulse: triangular
  - Calibration pulse: exponential





Calibration system requires detailed knowledge of the difference between the physics and calibration pulse shapes ADC[phys]/ADC[calib] for the same initial current I_0

This can be tricky…..

Procedure differs for different HEC, EM, FCal

LAr Calorimeter Testbeam Summary

Testbeam programme (recent):

- **HEC/EMEC combined (2002)** **(Combined π response)**
- **FCal Standalone (2003)** **(FCal Calibration)**
- **HEC/EMEC/FCal Combined (2004)** **(Combined Endcap Response)**
- **Barrel Combined Testbeam (2004)** **(Combined Barrel Response)**

Testbeams have served multiple purposes:

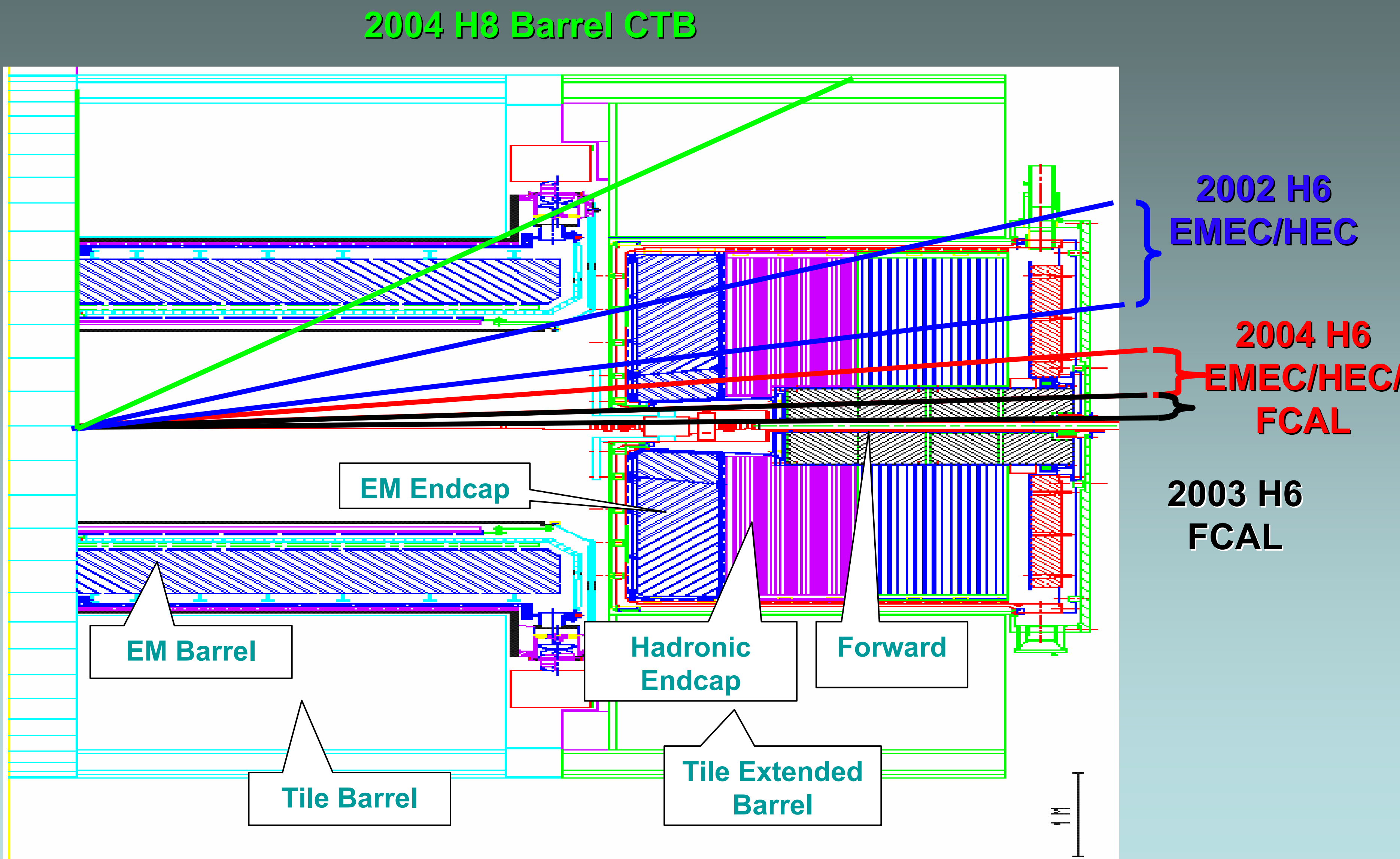
- **QC/QA during detector construction**
- **Initial energy scale calibration: detector resolution, linearity**
- **Investigation of crack/dead material effects**
- **Exercise ATLAS electronics chain**
- **Tests of online/offline monitoring/reconstruction software**

Calorimeter Commissioning Plans

- Coldtesting on the surface after detector integration (complete)
- Testing (warm) in the in ATLAS Cavern
- Coldtesting in the ATLAS Cavern
- Electronic calibration, noise studies…
- Commissioning/integration of trigger/DAQ system
- Data taking with cosmic ray events begins in early 2006
    - LAr Barrel (early 2006)
    - LAr Endcaps (summer 2006)
- Commissioning with single-beams in 2007
- Commissioning with colliding beams in 2007

Backup Slides for Testbeam Setups

Summary of Calorimeter Testbeams

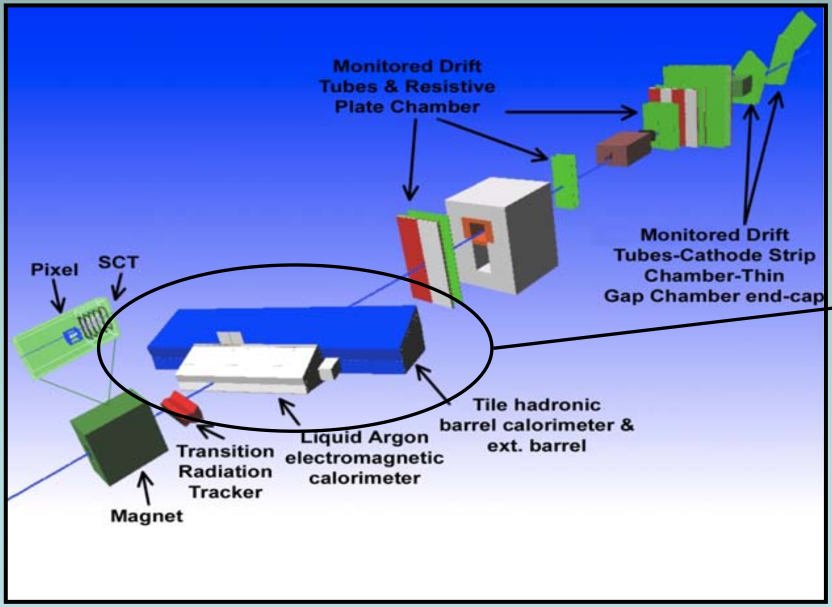


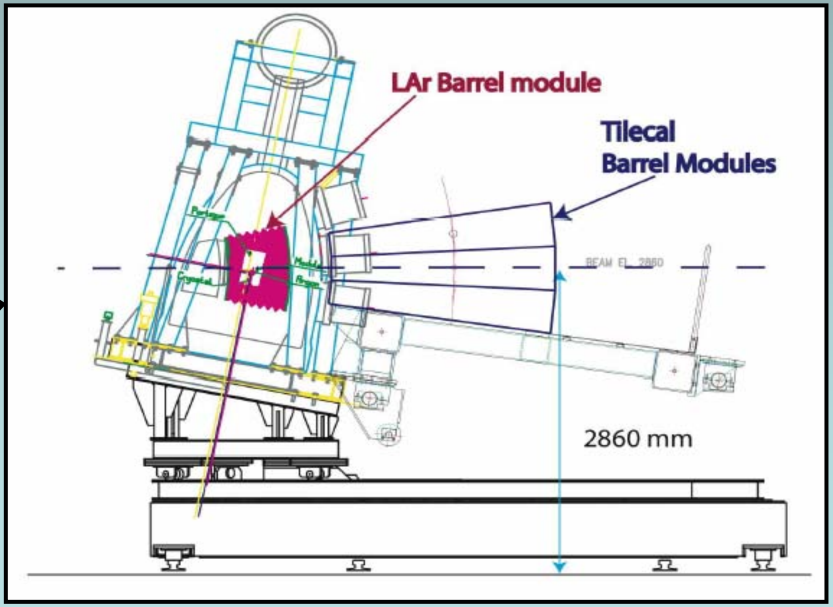
Barrel Combined Testbeam (ATLAS Full Slice)

Calorimeter component:

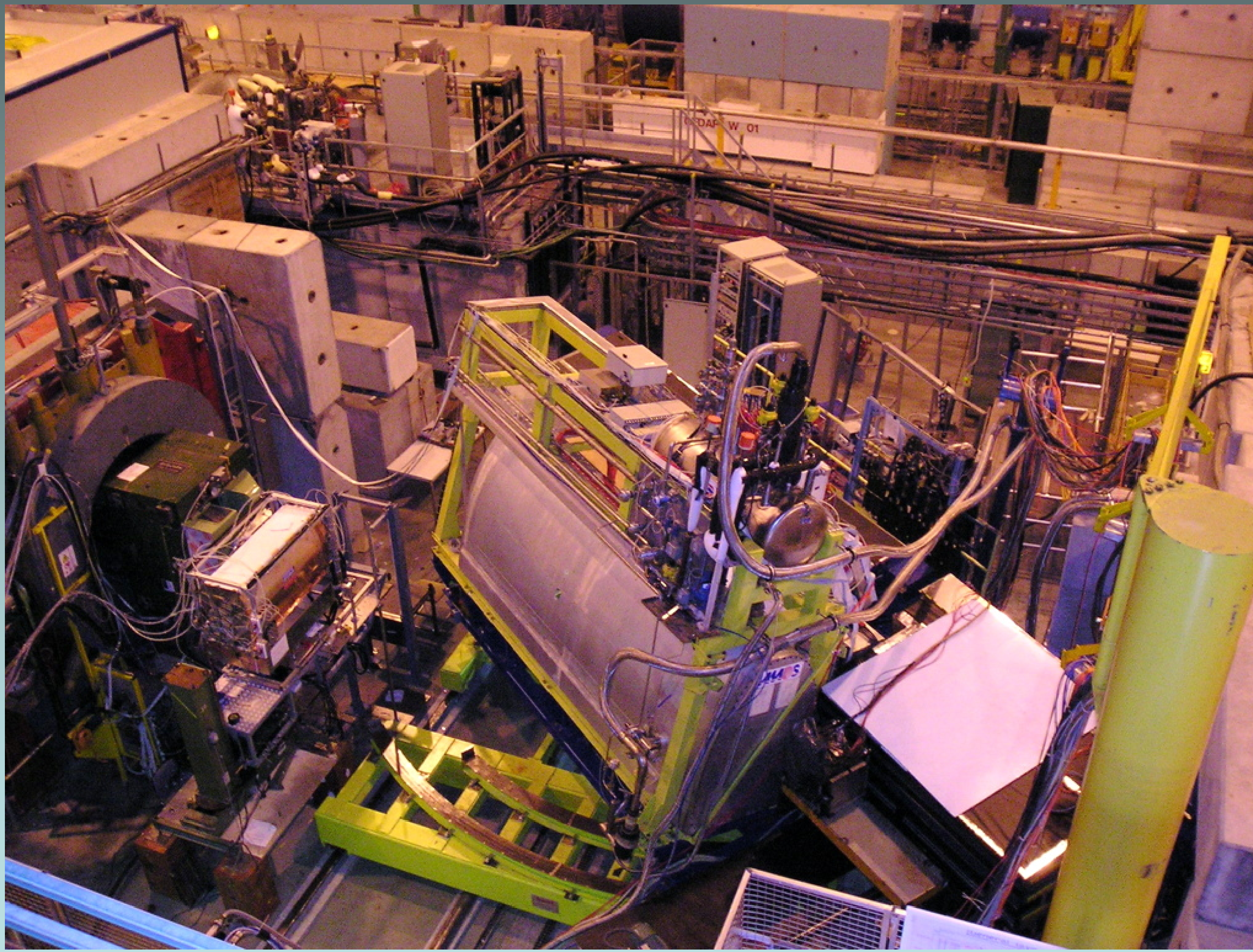
Experimental setup:

- **Tile barrel modules:**
  - Three radial layers (1.4 λ, 3.9 λ and 1.8 λ each)
  - Total number of cells: 134
- **LAr barrel module:**
  - Three radial layers + presampler (24 X_0 globally)
  - Total number of cells: 2031

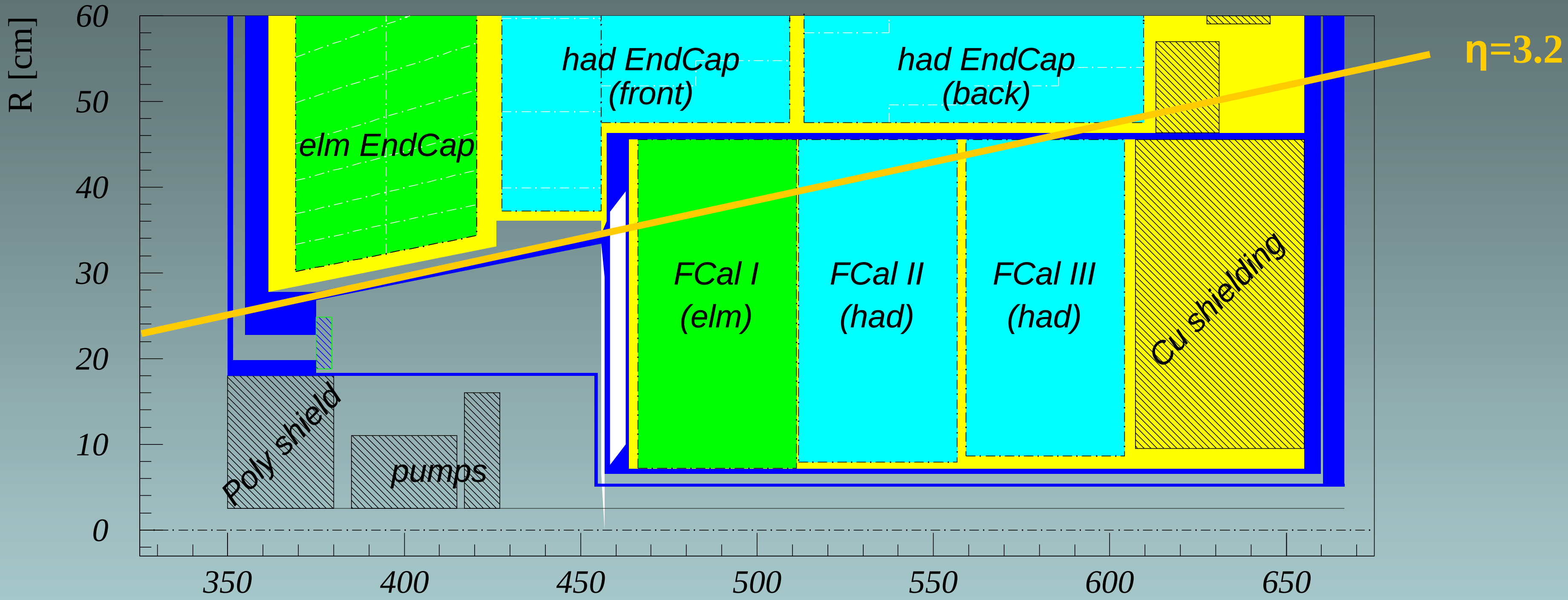




H8 Barrel Combined Testbeam Setup

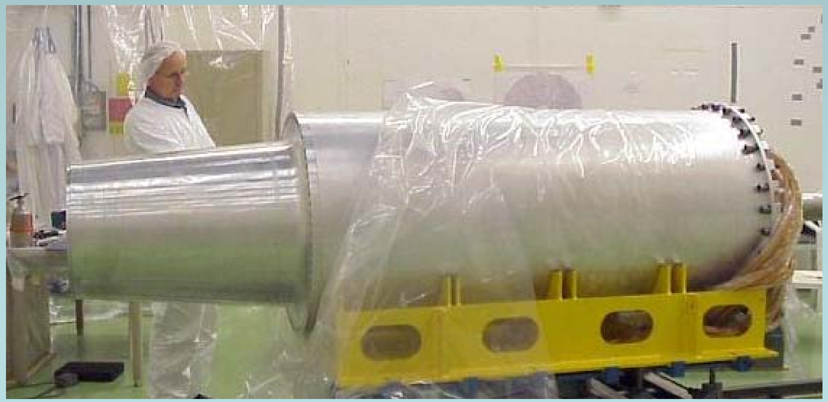


Endcap Combined Testbeam (Crack Studies)



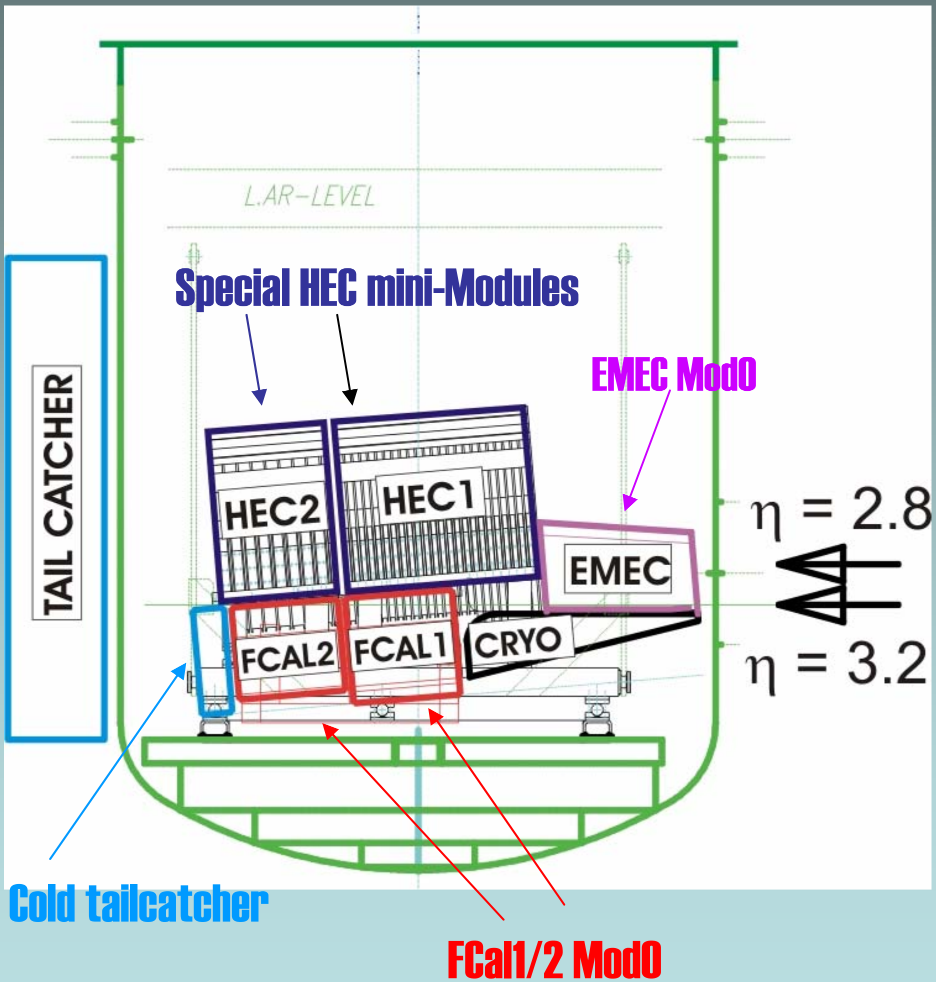
Forward cone ~ projective.
Dead material

Same region is overlap of HEC and EMEC: loss of response

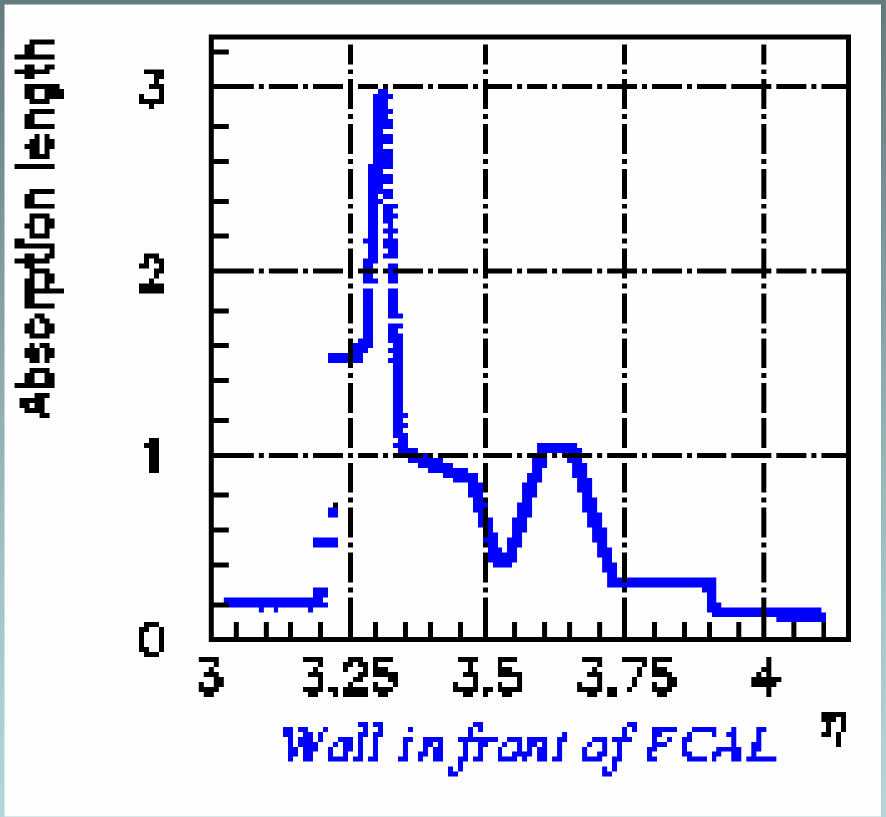


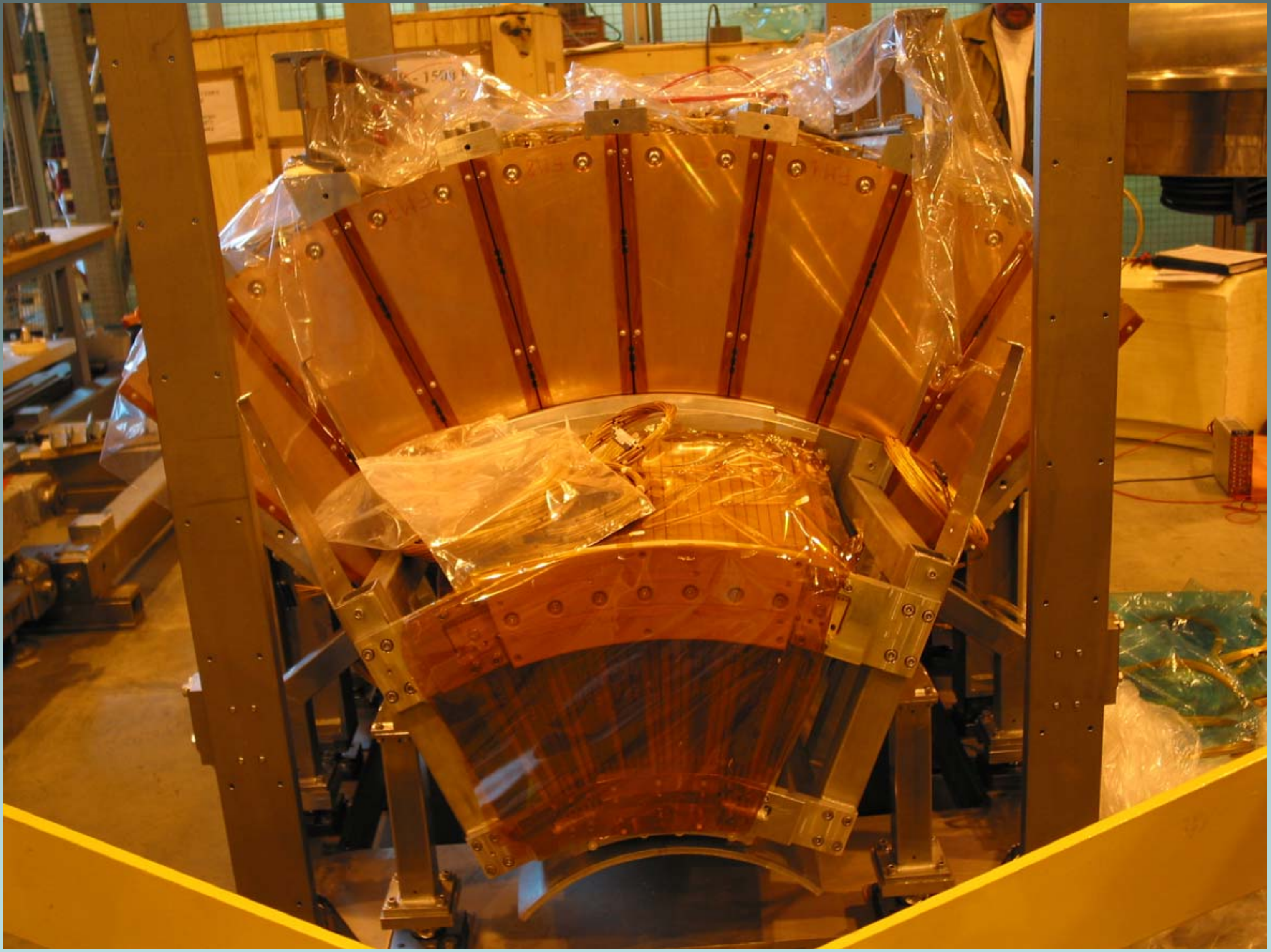
HEC/EMEC FCAL combined test beam run

EMEC+HEC+FCAL Setup



Material studies





HEC/EMEC Combined Testbeam (2002)

Hadrons, electrons and muons: E(beam) = 6-200 GeV η = 1.6 – 1.8
90° impact angle (unlike ATLAS)

Results now published

NIM A531 (2004) 481