

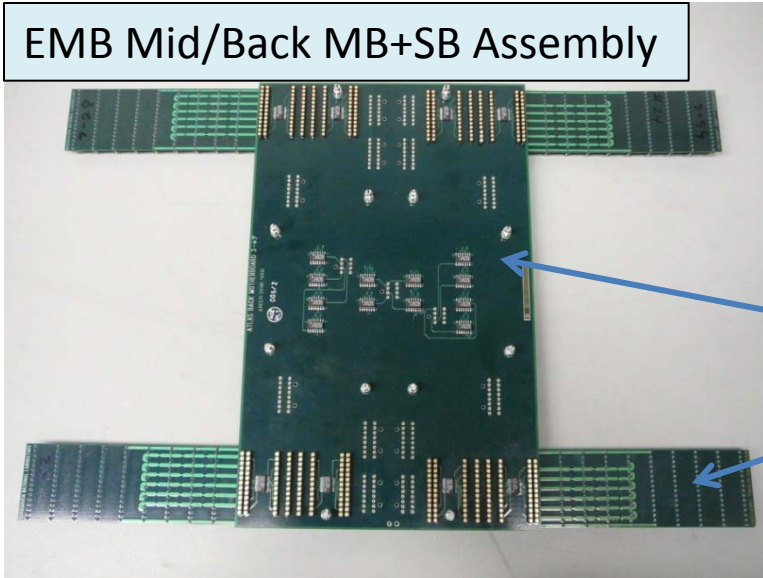
Electronics Reliability under Thermal Cycling:

- Fully assembled circuit boards with plastic packages, passive components, surface mount solder joints, BGAs, connectors, etc.
- The most severe thermal stress for assemblies of many diverse components is ***temperature cycling of completed circuit boards by alternating immersion in LN₂ and bringing to room temperature by hot air.*** All ~10,000 boards for ATLAS LAr calorimeter have been cycled 5-10 times each. (ATLAS LAr barrel calorimeter has 110,000 channels with several connectors each between the electrodes and the cold side of the feedthrough).
- Compared to such testing, operation in LAr is tranquil as evidenced by virtual absence of failures in several experiments involving cold electronics over long periods of time. The risk of failure (mostly of the connections) during detector assembly is much higher than during operation. The number of dead channels in ATLAS cryostat is 0.02%, most from the start of the operation in 2008.

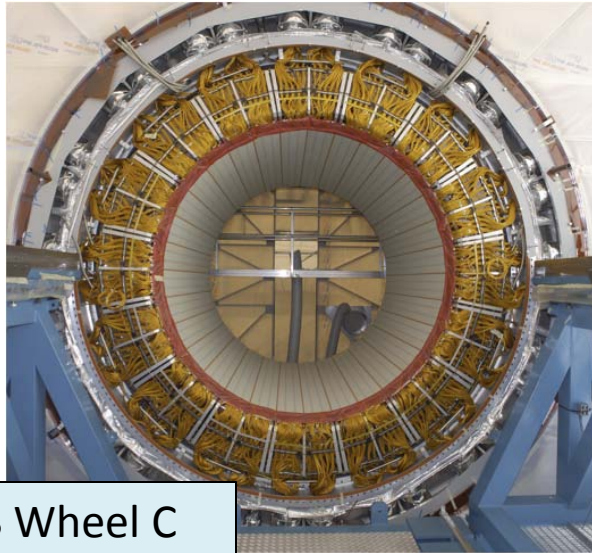
Reliability of Cold Electronics wrt thermal contraction-expansion

PCB and Cold Electronics in ATLAS:

EMB Mid/Back MB+SB Assembly

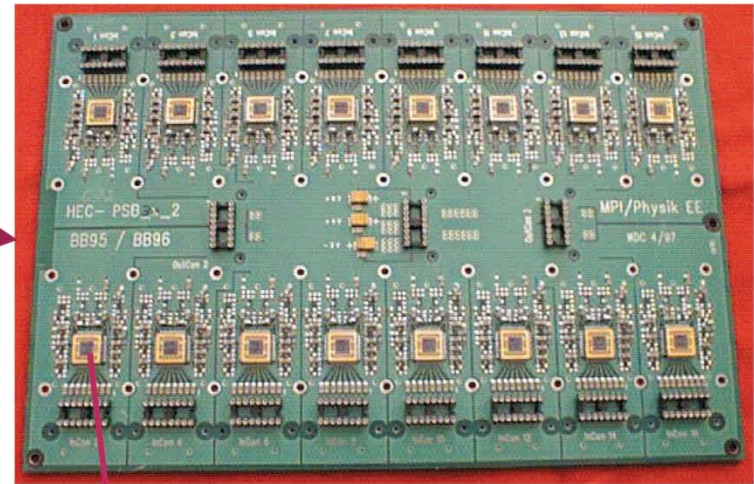
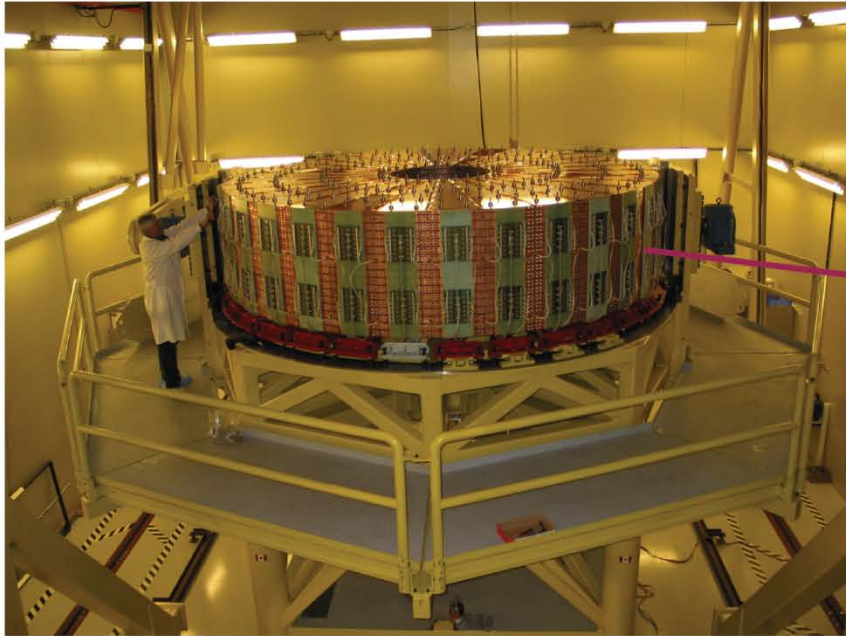


- ATLAS LAr Calorimeter
 - **182,468** readout channels
- EM Barrel Mother Board and Summing Board
 - EMB has **~110,000** detector channels read out by 896x128-ch FEBs
 - **960** Mother Boards (MB)
 - **7,168** Summing Boards (SB)
 - **20,480** resistor network chips, **0.1%**
 - **~110,000** protection diodes on MBs/SBs
- EM Barrel Calorimeter has been cold since 2004
 - Operation: **7 years** so far
 - MB/SBs will remain in operation without upgrade for super LHC
- **'Inoperative' channels <0.5%,** as of 05/10/2011 (outside the cryostat)
- **Dead channels in the cryostat ~0.02% since 2008**



EMB Wheel C

ATLAS HEC Cold Electronics



- GaAs TriQuint QED-A $1\mu\text{m}$
- Stable operation at cryogenic temperatures

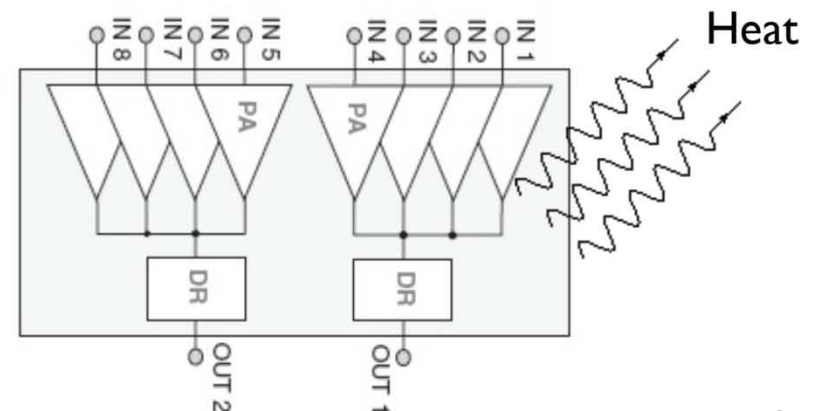
35840 preamps , 8960 summing amp,
5632 read-out channels

In 2005 first commission in cold: 5 dead channels
($< 0.1\%$). None due to preamps.

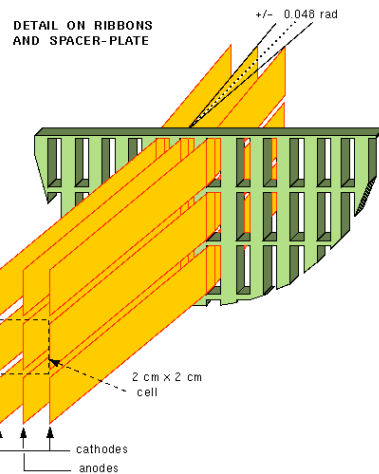
Two due to sum amp (already at warm).

In 2011 still 5 dead channels:
stable after 6 six years of operation.

High reliability of this cold electronics



Liquid Krypton calorimeter in **NA48-NA62**



- **JFET preamplifiers in LKr: 13,212** channels; surface mounted components
- Operated at very high voltage
 - Tested up to 7kV, operated at 3kV
- Failures
 - ~50 because of an HV accident in 1998
 - ~25 cold electronics failures after 1998,
< 0.2% in 13 years
 - The last failure recorded was more than 3 years ago
- Always kept at LKr temperature since 1998
- Operation
 - **13 years** so far
 - Plan to run until 2015, expected to be in operation for **17 years**