ATLAS Pixels – Lessons

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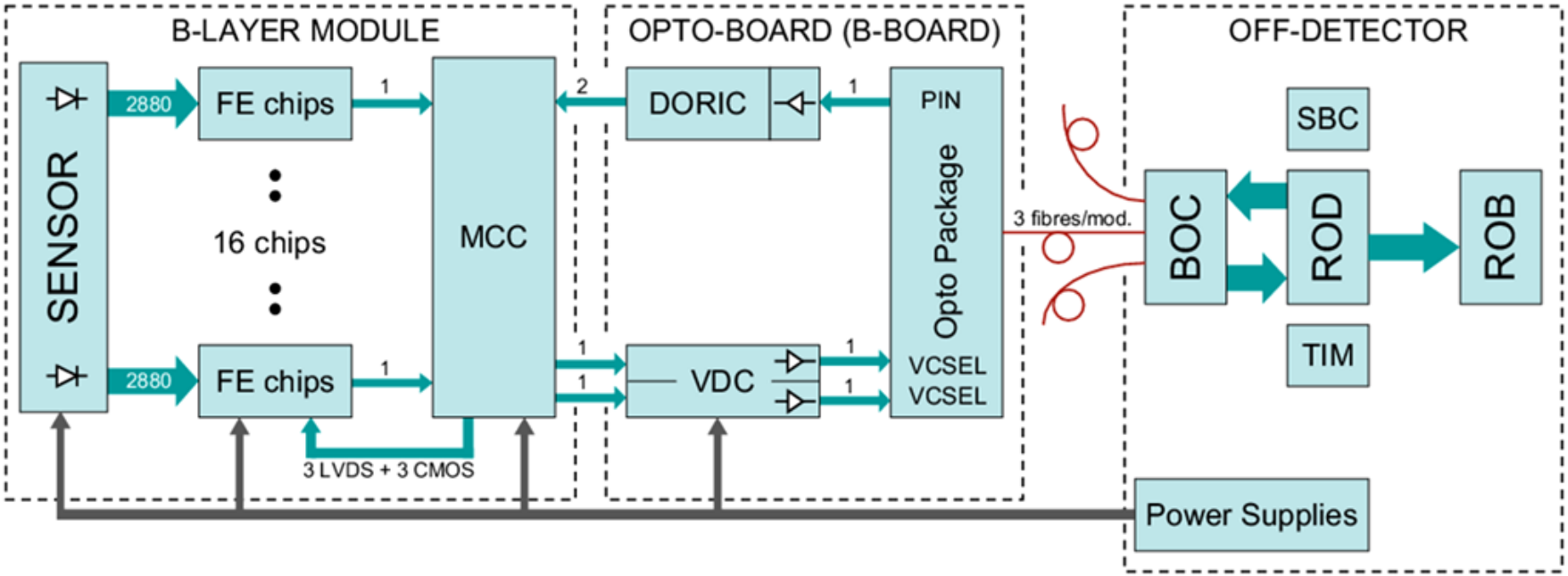
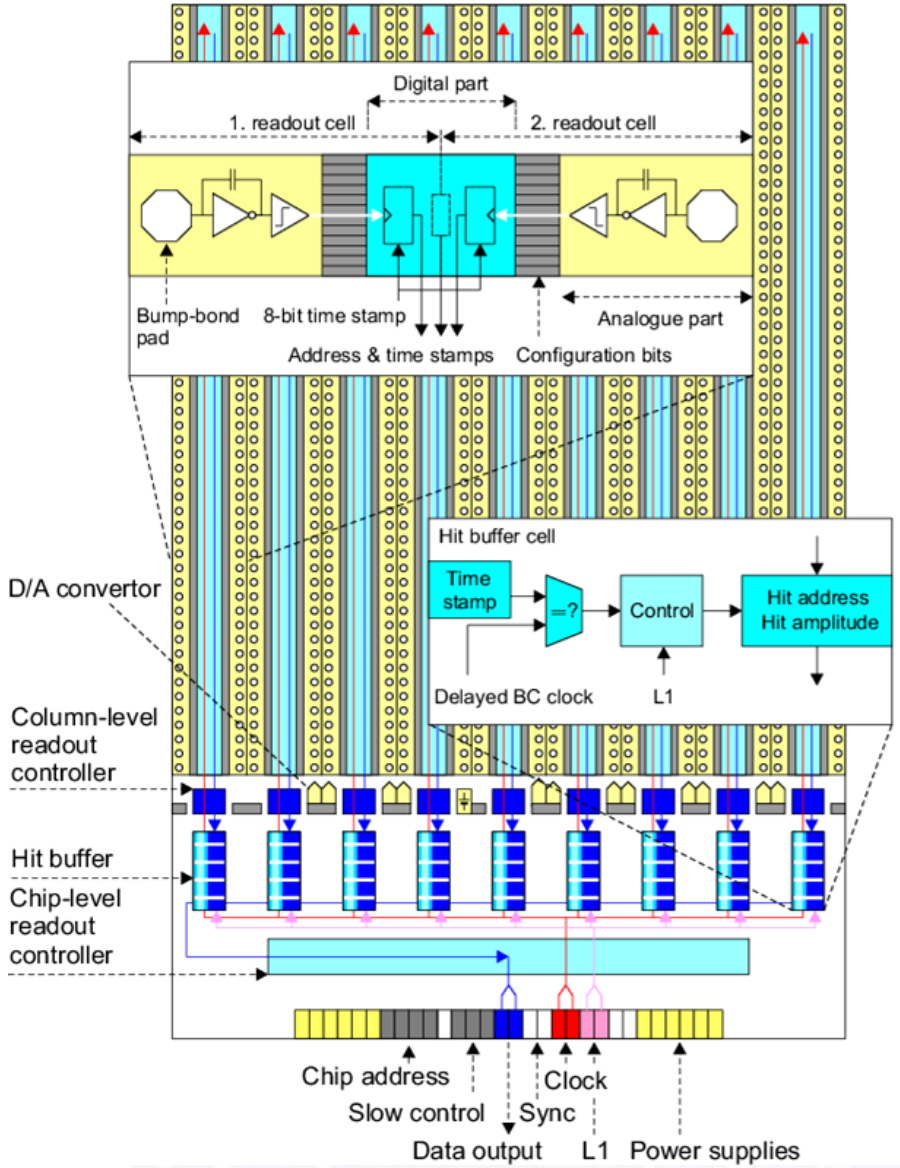
Readout Scheme



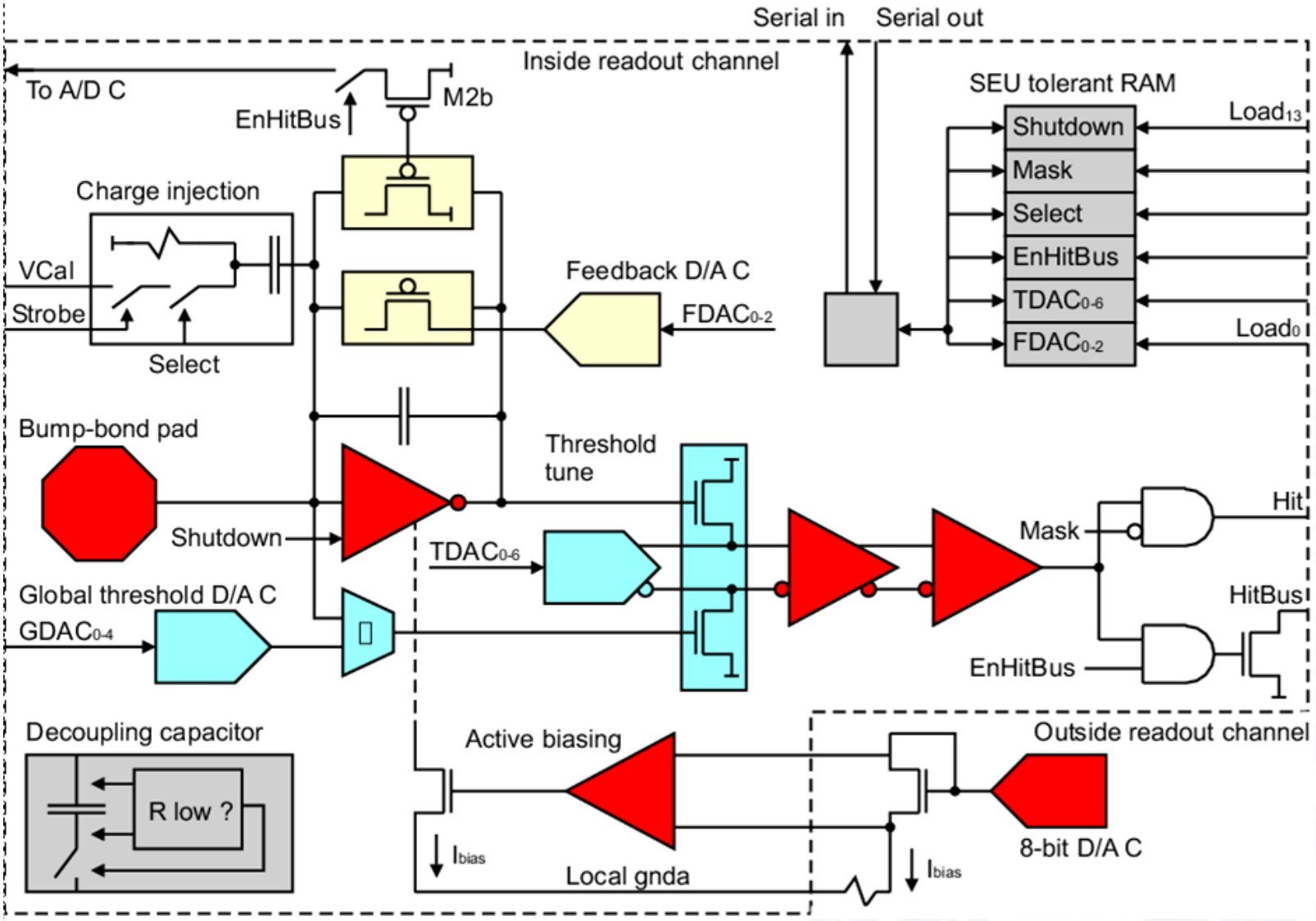
- Each module has 16 FE-chips and 1 module controller chip
- Data transferred to and from modules via 80m optical link
  - 1 downlink per module, 1 uplink for L1, L2, Discs, 2 uplinks for B-Layer
- Each VCSEL array services 6 or 7 modules (both on-detector and off-detector)

The ATLAS Pixel FE-Chip (FE-I3)

- Matrix with 18 x 160 pixels
- Each pixel has preamp, discriminator, readout and control logic
- Column drain readout
- Hits stored in EOC buffers until trigger decision
- Charge measurement with time over threshold

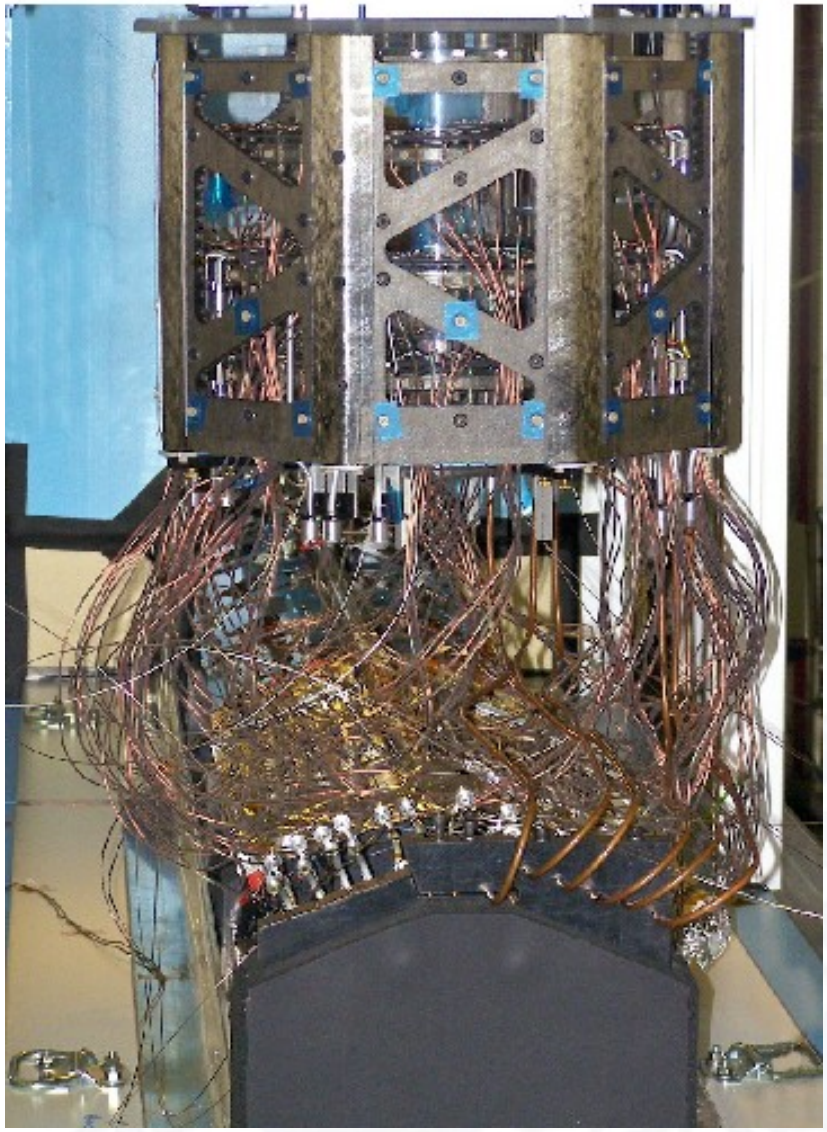


The ATLAS Pixel FE-Cell



System Test

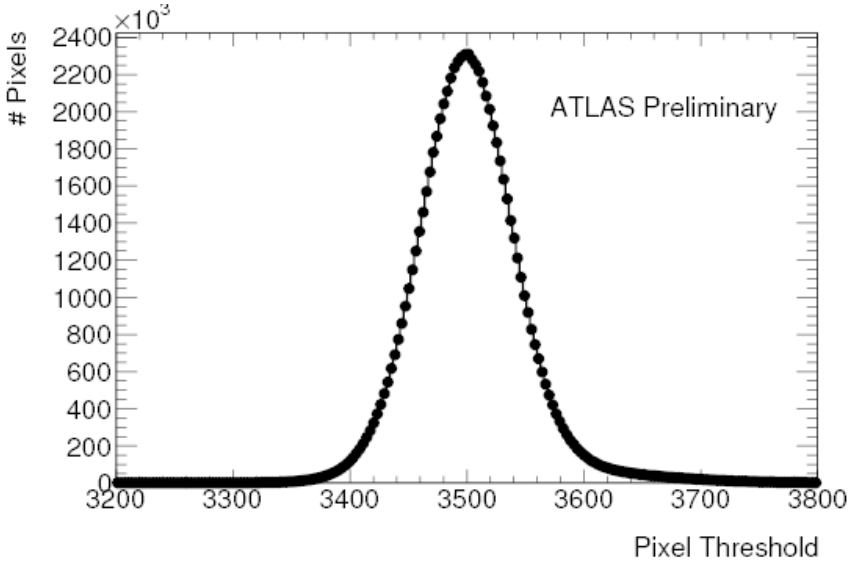
- Lesson 0: System test was an invaluable experience
  - Test with realistic setup and one endcap before installation
  - Calibrations and cosmics data taking
  - Lead to discovery of optoboard / optotuning problems and introduction of resistive heaters for the optoboards

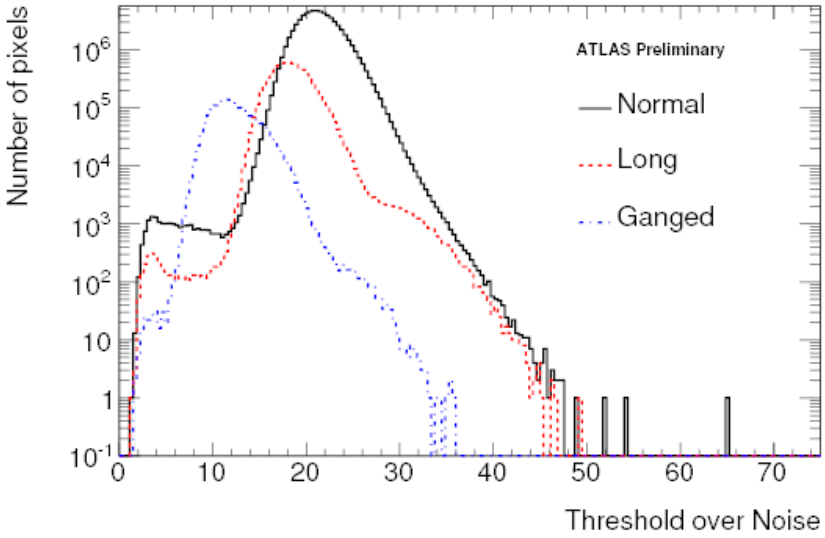


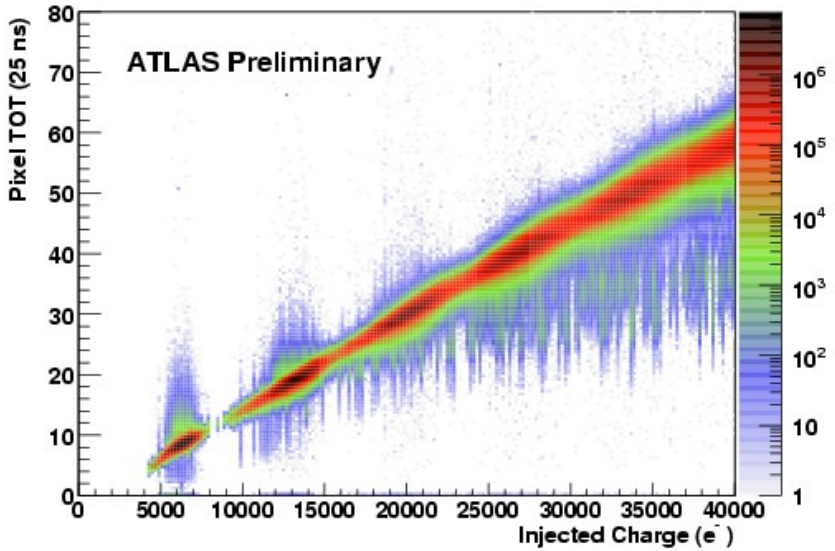
Detector Operation I

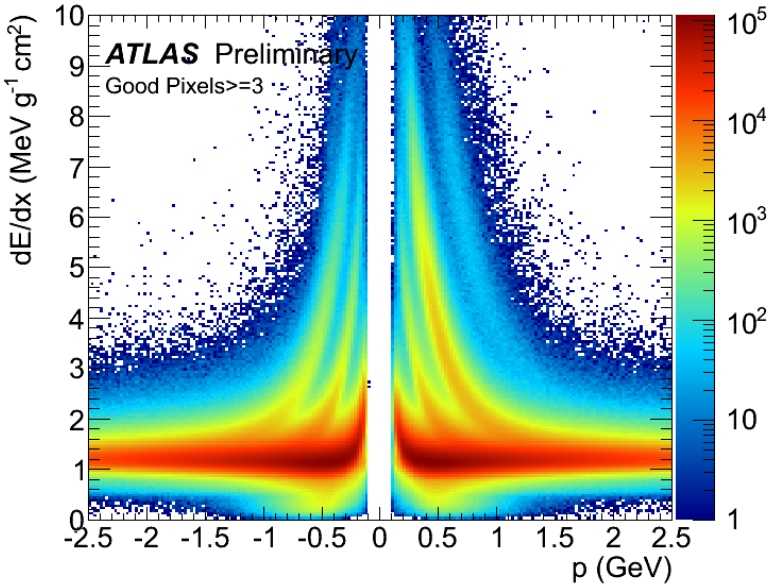
- Lesson 1: Setting up unirradiated pixel detector modules to reliably “see” particle signals is extremely straightforward
- Lesson 1b: Most demanding step on the way to a stable baseline configuration for all modules: tuning of the optical links
  - Laser power can only be regulated for 6/7 modules at a time; mitigated by optoheaters which reduce the spread in power between the different laser channels

Detector Operation II









Summary of the Experience

- It was surprisingly (?) easy to switch on the detector
- Currently 97.2% of modules active
  - Main source of inefficiency: open HV lines, opto links
- We have seen effects of the LHC beam background in various flavours and have implemented solutions to avoid DAQ timeouts
- We learned very well how to *operate* the detector, now we need to worry about *understanding* the detector to be able to operate it in the future
  - Some ongoing / open issues on the next slides …

Threshold

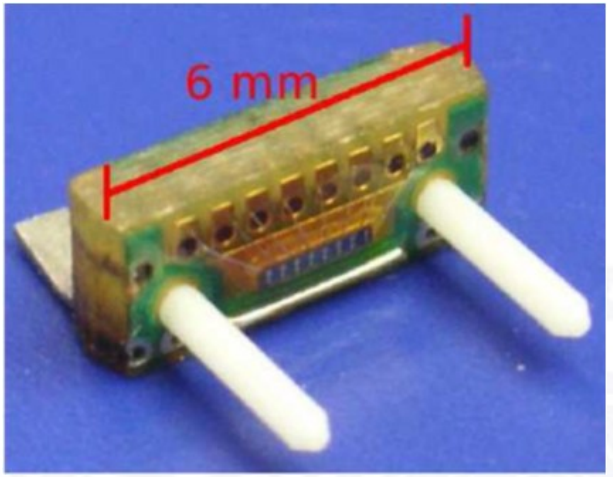
- Current ATLAS approach: tune all pixels to the same target threshold (as opposed to tuning each module/pixel to its individual lowest possible threshold)
- 4000 e threshold working out of the box
- Current operating setting: 3500 e, modest increase of masked pixels (~ 0.1%)
- 3000 e has been done as a quick exercise which was interrupted by the arrival of the beam
- First impression for 3000 e and lower: might need to give up uniformity and treat pixels (pixel classes) individually

Ageing and Radiation Damage

- Bump bonds: we have indications for bump defects on the 0.1% level. There is no indication of an increase but this needs to be monitored vs. time
- Radiation damage: we do not see any indication of radiation damage yet (masked by the sensor temperature), but need to study this better
  - Currently installing current monitoring boards with 10 nA sensitivity
- In the same context, we need to carefully develop a cooling / warmup scenario for the coming years

The VCSEL Puzzle

- We have a massive problem with dying Tx-lasers
  - Known mechanisms, unknown causes
  - VCSELS are the same on- and off-detector
  - Unclear whether on-detector lasers will be affected
  - Currently several tests on impact of humidity are ongoing
- Move lasers in more serviceable places
- Lasers used do not pass the standard reliability test (1000 h at 85% / 85ºC)
  - Use more reliable lasers in the future?



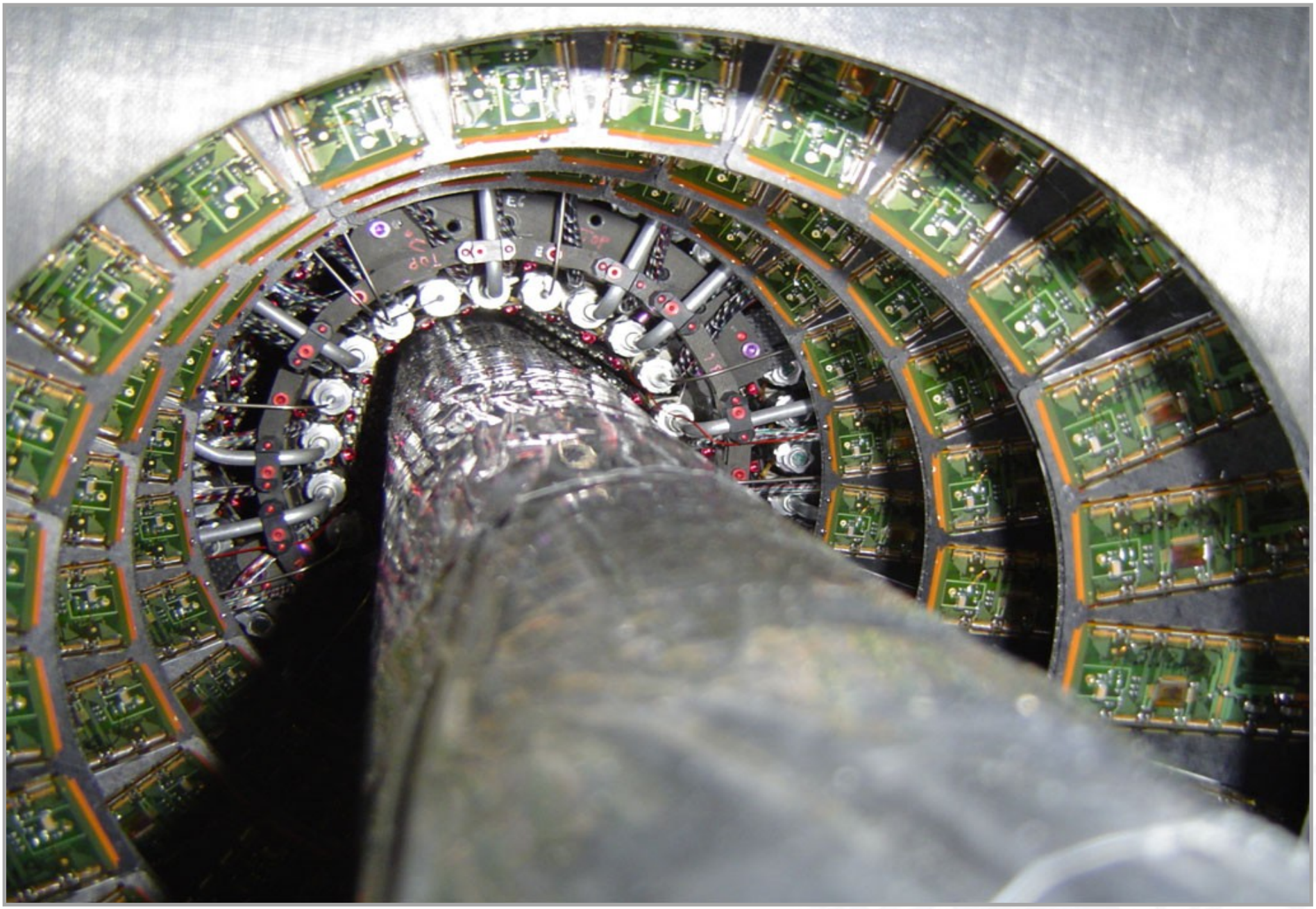
Manpower

- One more lesson (again stating the obvious): As soon as there is data, it becomes extremely difficult to get enough people interested in studying the detector
- The same is true for DAQ and DCS developers

Safety

- A constant problem is to keep reminding that we must pay attention to safe operations
- The push for higher instantaneous efficiency is very high at expense of safety and what I would define long term efficiency
  - Spending one more minute to switch Pixel may allow to continue to use it for years and not loose it because of the overlooking of a dangerous situation
- A considerable effort has been dedicated in understanding the beam settings for safe operations (collimator settings and relevant magnet currents)
- The most irritating question: “if detector X is doing so, why Pixel is not doing the same?”

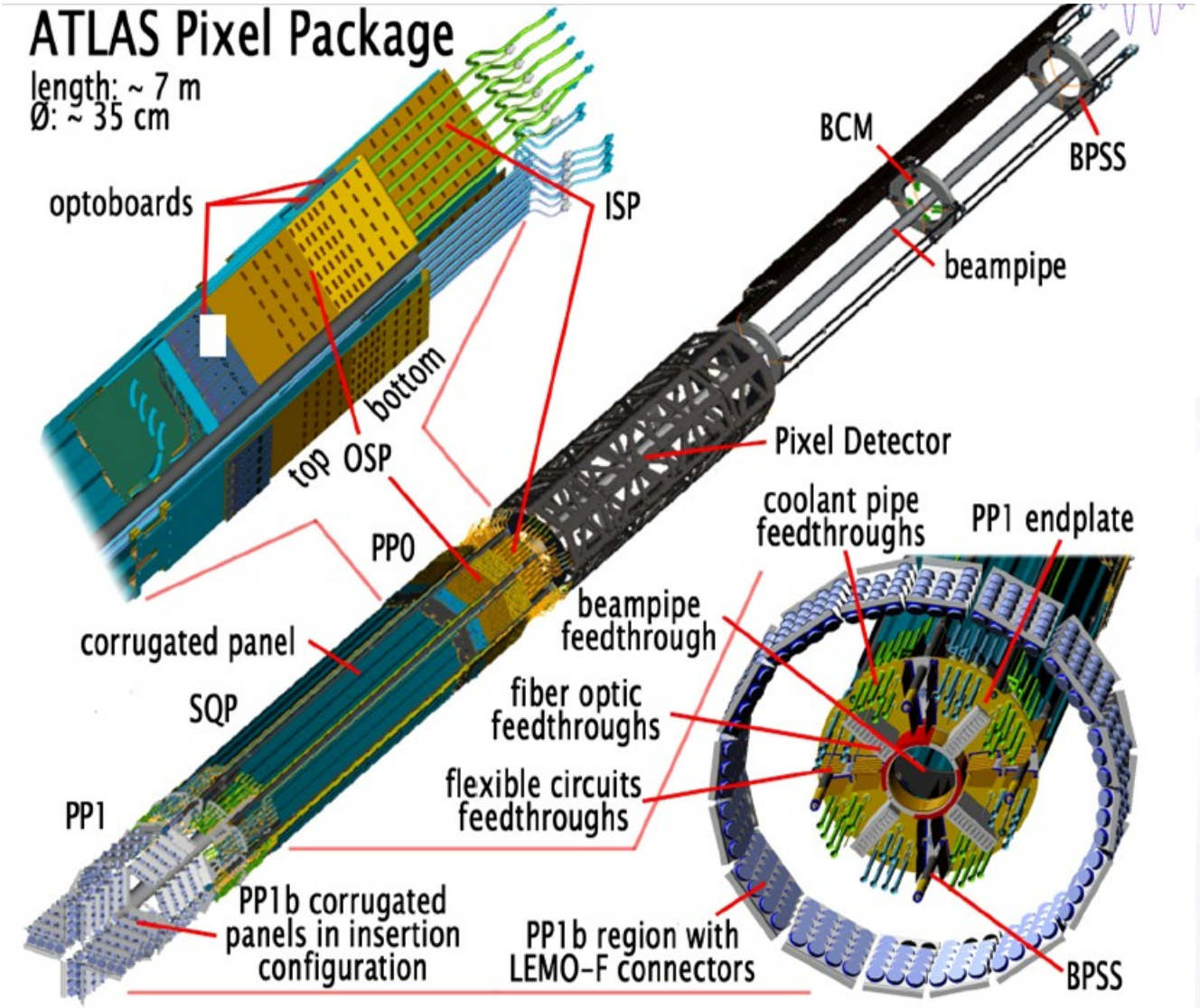
The (obvious) answer

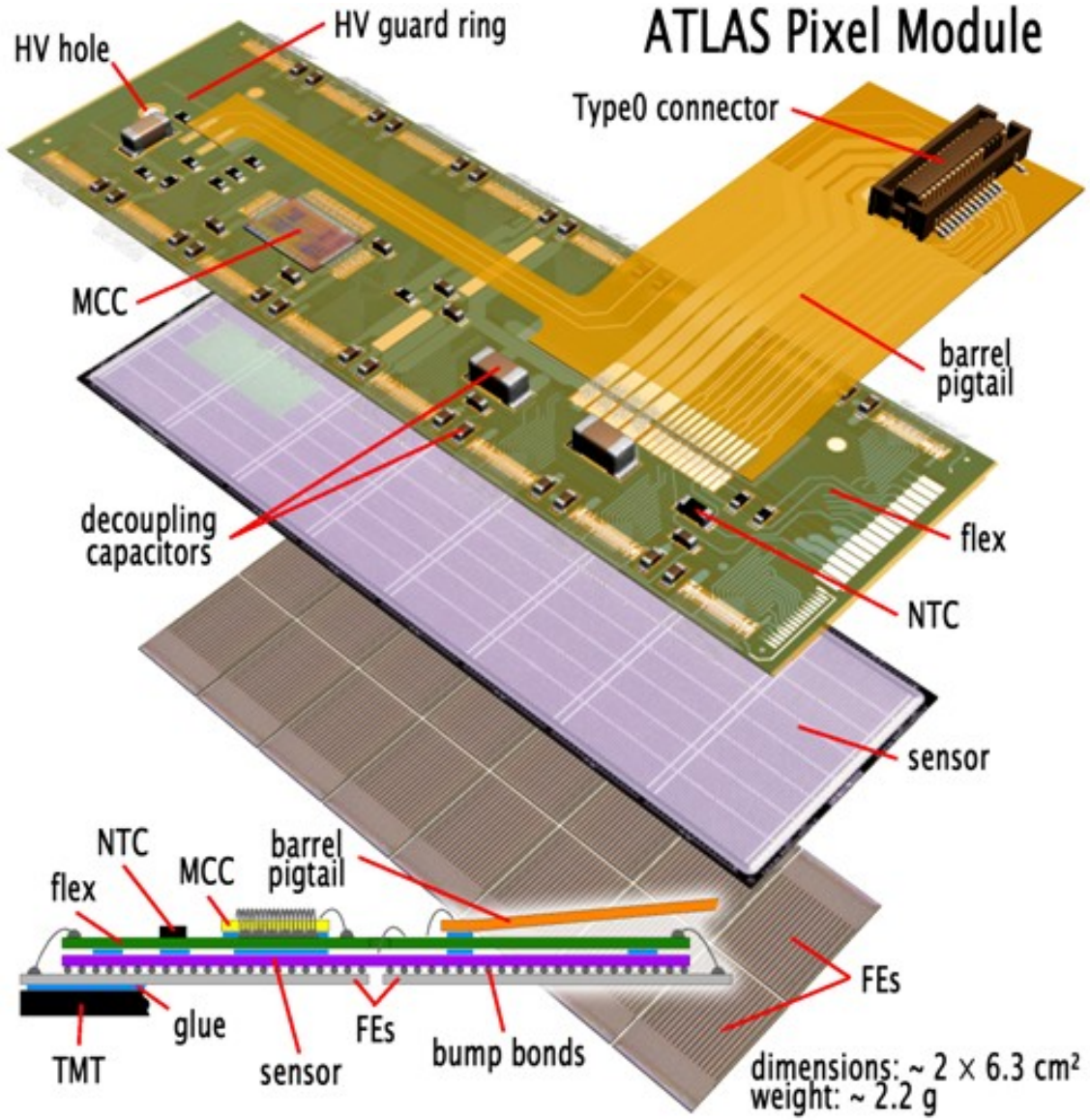


Summary

- In general pixel modules are very “well-behaved”
- Some more problems with the services
  - Some could be caught in the system test
  - Reliability tests needed for all parts of the system
- Issue during operation: make sure detector is understood and not only running

- Backup…


ATLAS Pixel Package
length: ~ 7 m
Ø: ~ 35 cm
optoboards
ISP
BCM
BPSS
beampipe
bottom
top OSP
Pixel Detector
PP0
coolant pipe
feedthroughs
PP1 endplate
beampipe
feedthrough
corrugated panel
SQP
fiber optic
feedthroughs
flexible circuits
feedthroughs
PP1
PP1b corrugated
panels in insertion
configuration
PP1b region with
LEMO-F connectors
BPSS


ATLAS Pixel Module
HV hole
HV guard ring
Type0 connector
MCC
barrel pigtail
decoupling capacitors
flex
NTC
sensor
NTC
flex
MCC
barrel pigtail
FEs
glue
FEs
bump bonds
TMT
sensor
dimensions: ~ 2 x 6.3 cm²
weight: ~ 2.2 g