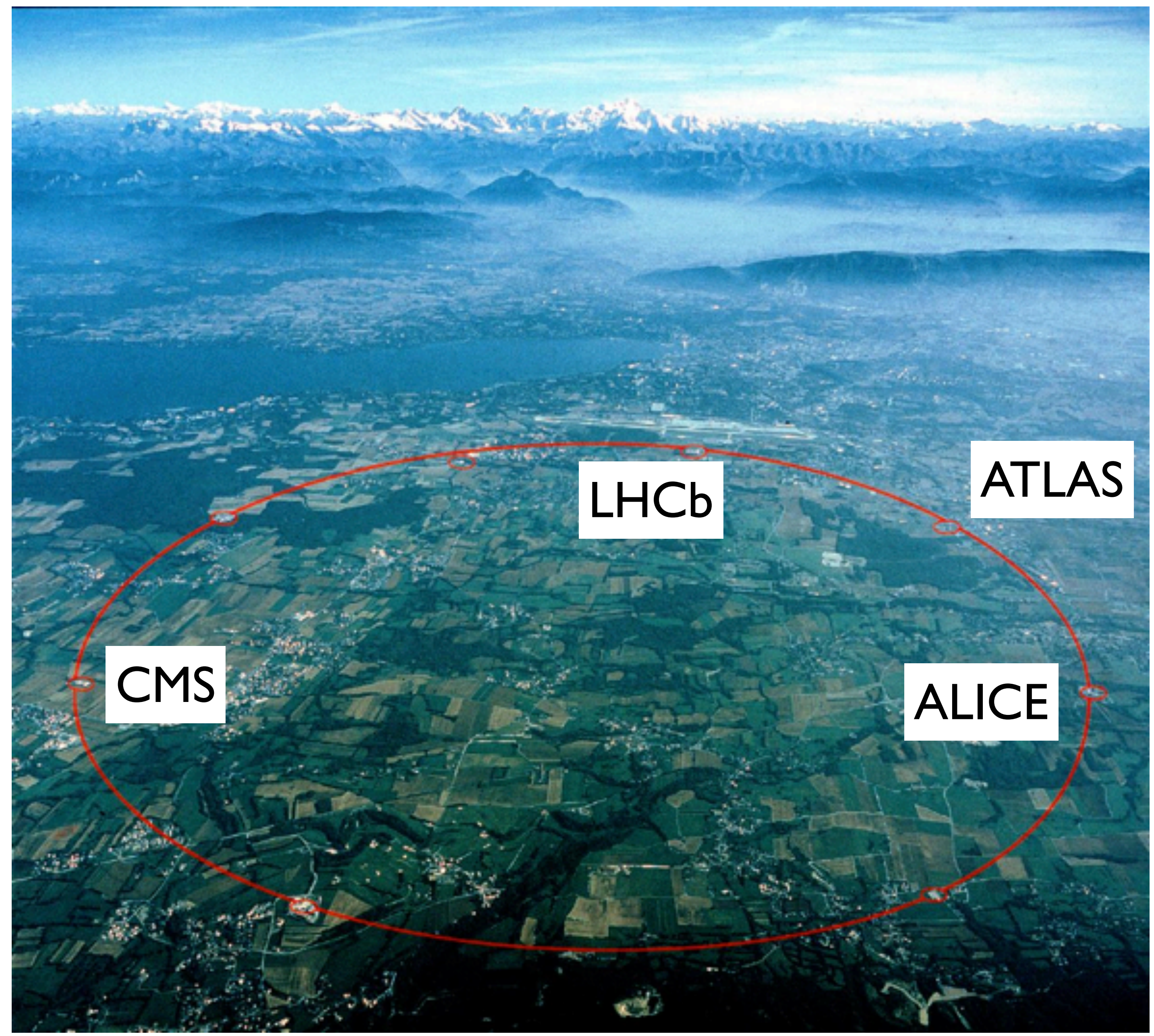
Overview of the ATLAS Insertable B-Layer (IBL) Project

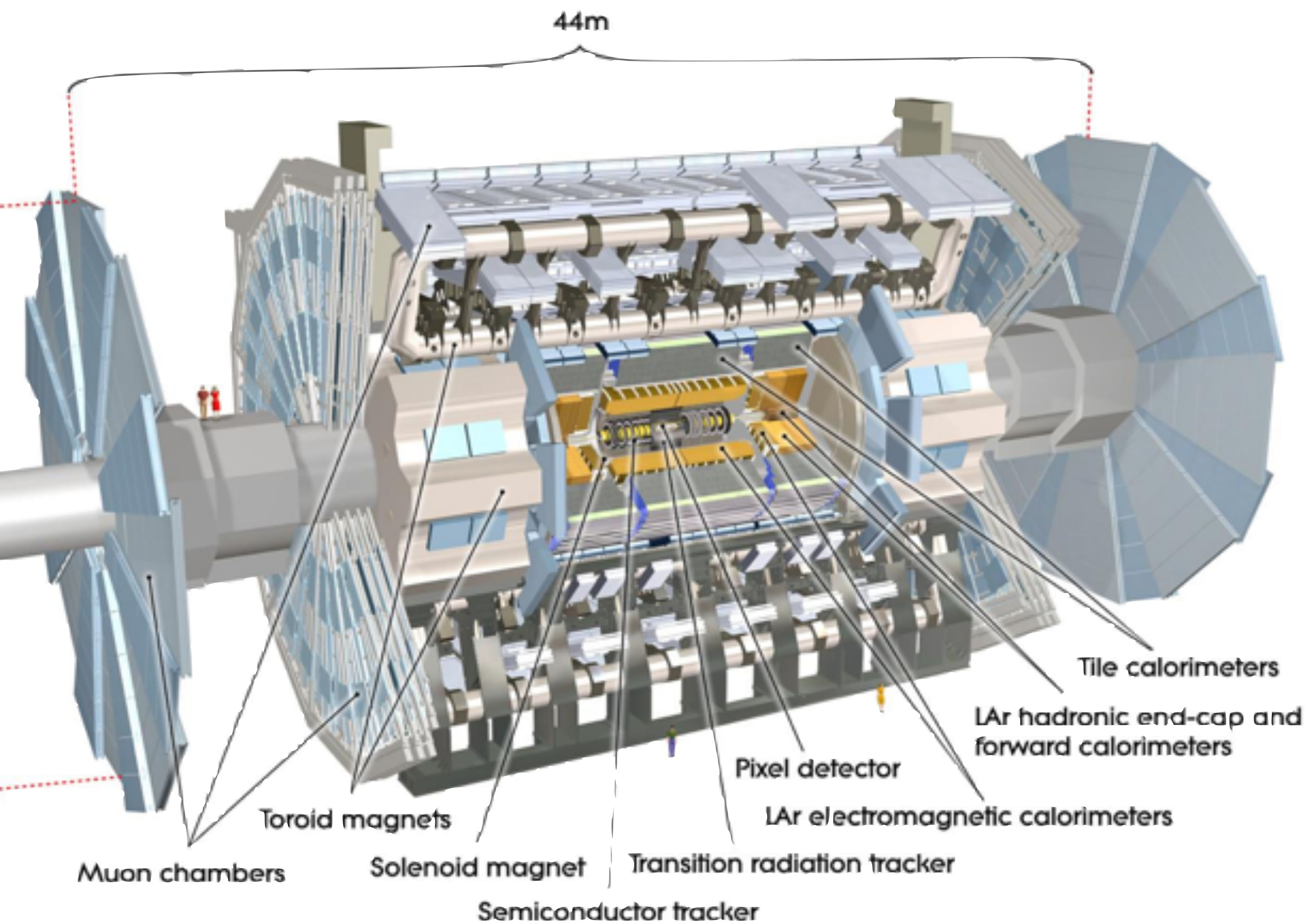
Jens Dopke (CERN)
for the ATLAS Collaboration

Large Hadron Collider

- 27 km circular accelerator, ~100m underground
- 4 big experiments
- 2 general purpose detectors, ATLAS and CMS
- Reached 8 TeV centre of mass energy with ~$0.7 \cdot 10^{34} \frac{1}{cm^2 s}$ luminosity
- Design energy and bunch crossing rate to be reached after its first long shutdown



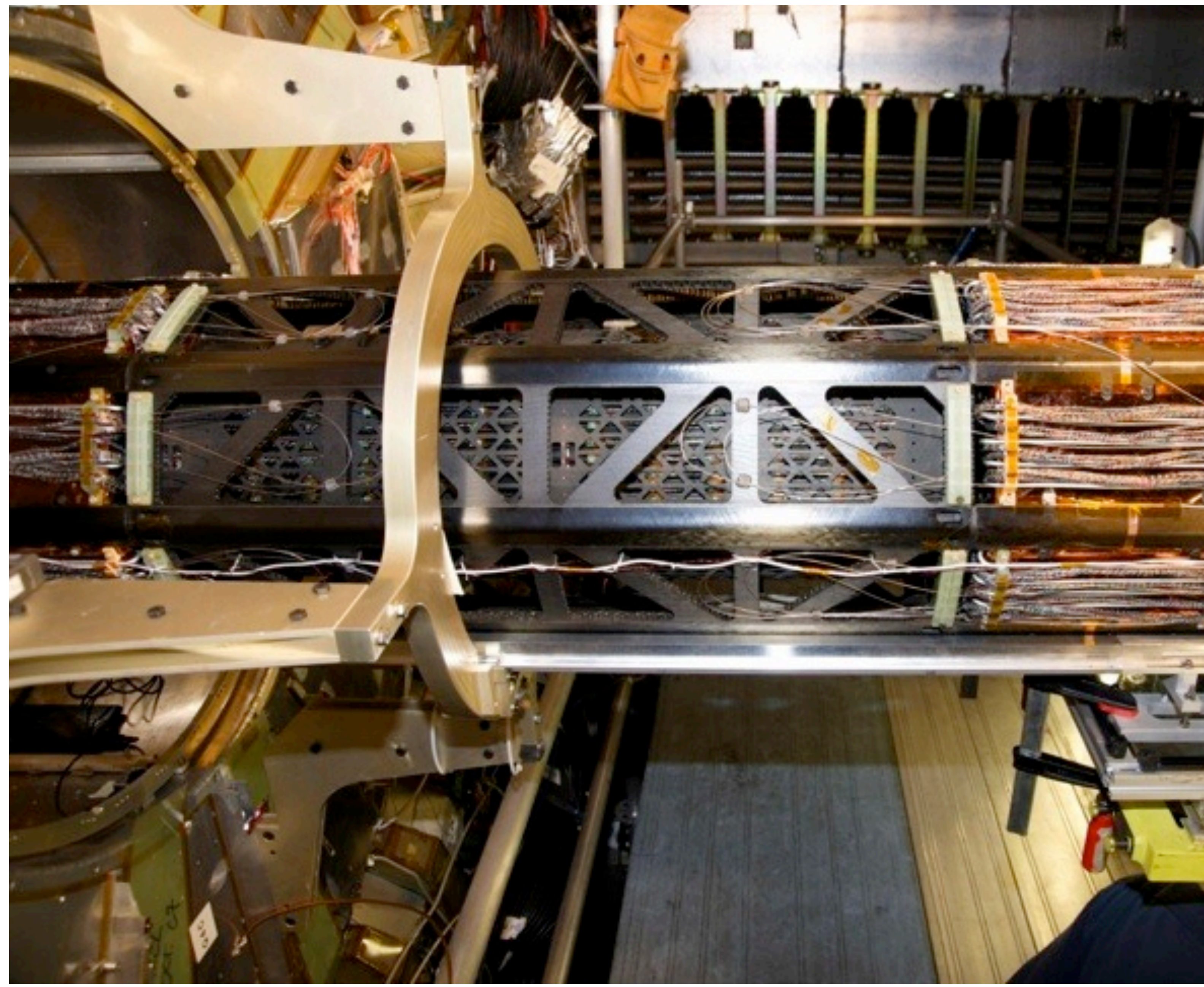
The ATLAS Experiment



- General purpose detector
- Two magnet field systems: inner Solenoid and outer Torroid
- Two silicon and one straw tube tracker system, transistion radiation identification
- Electromagnetic and Hadronic calorimeter systems with a very Forward calorimeter
- 4 different muon detector systems, allowing fast trigger and high precision
- 3 stage trigger system

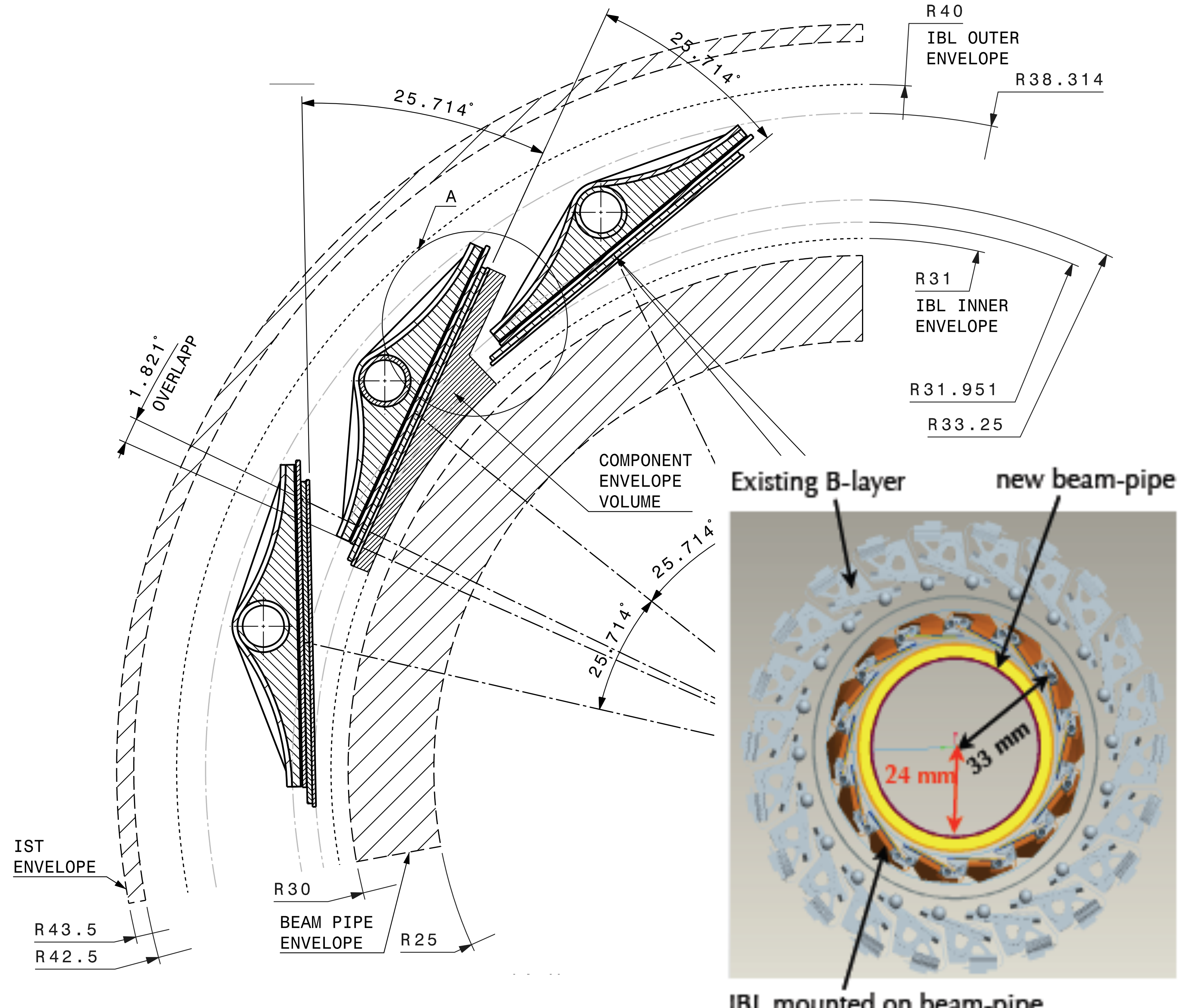
Present Pixel Detector

- 3 Barrel layers at radii 5, 8 and 12 cm
- 3 disks per side
- >= 3 spacepoints per track
- Pixel size 50 x 400 (um), giving ~14 μm resolution in R×φ, ~115 μm in z
- Modules tilted to compensate for Lorentz angle and create overlap
- 1744 modules total, 1645 working without problems
    - Shutdown intervention currently estimates 90% of the inoperable modules to be restored to function
- ~80 million channels, 80% of the full ATLAS channel count

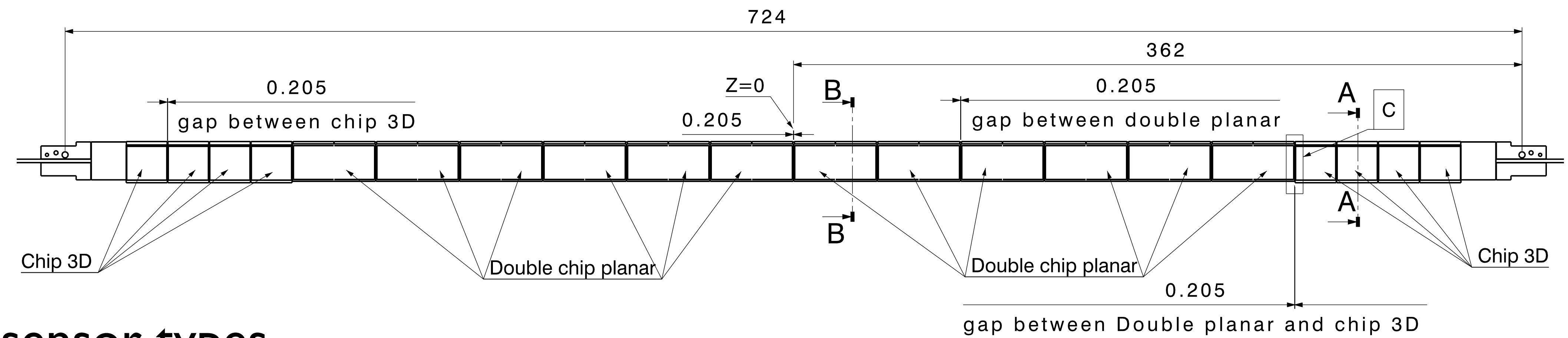


Insertable B-Layer (IBL)

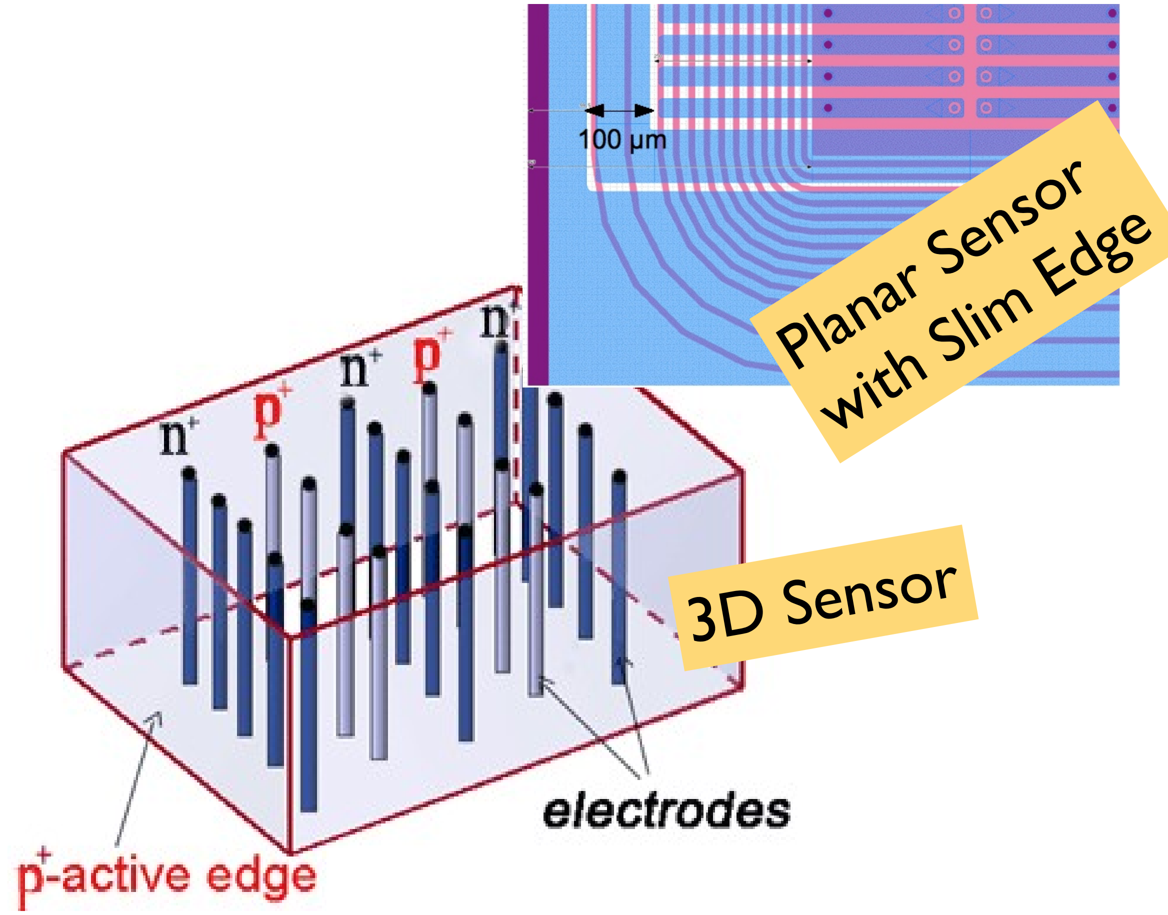
- First upgrade of the ATLAS tracker
- New Pixel Layer on a new, smaller radius, beampipe: mean radius 3.3cm
- Insertion of the support tube separating the IBL from the remaining Pixel Detector happens on the surface
- 14 support structures (staves) to hold 32 new front-end chips each
- CO_2 based cooling system
- New readout system, planned to also upgrade the Pixel Detector readout rate



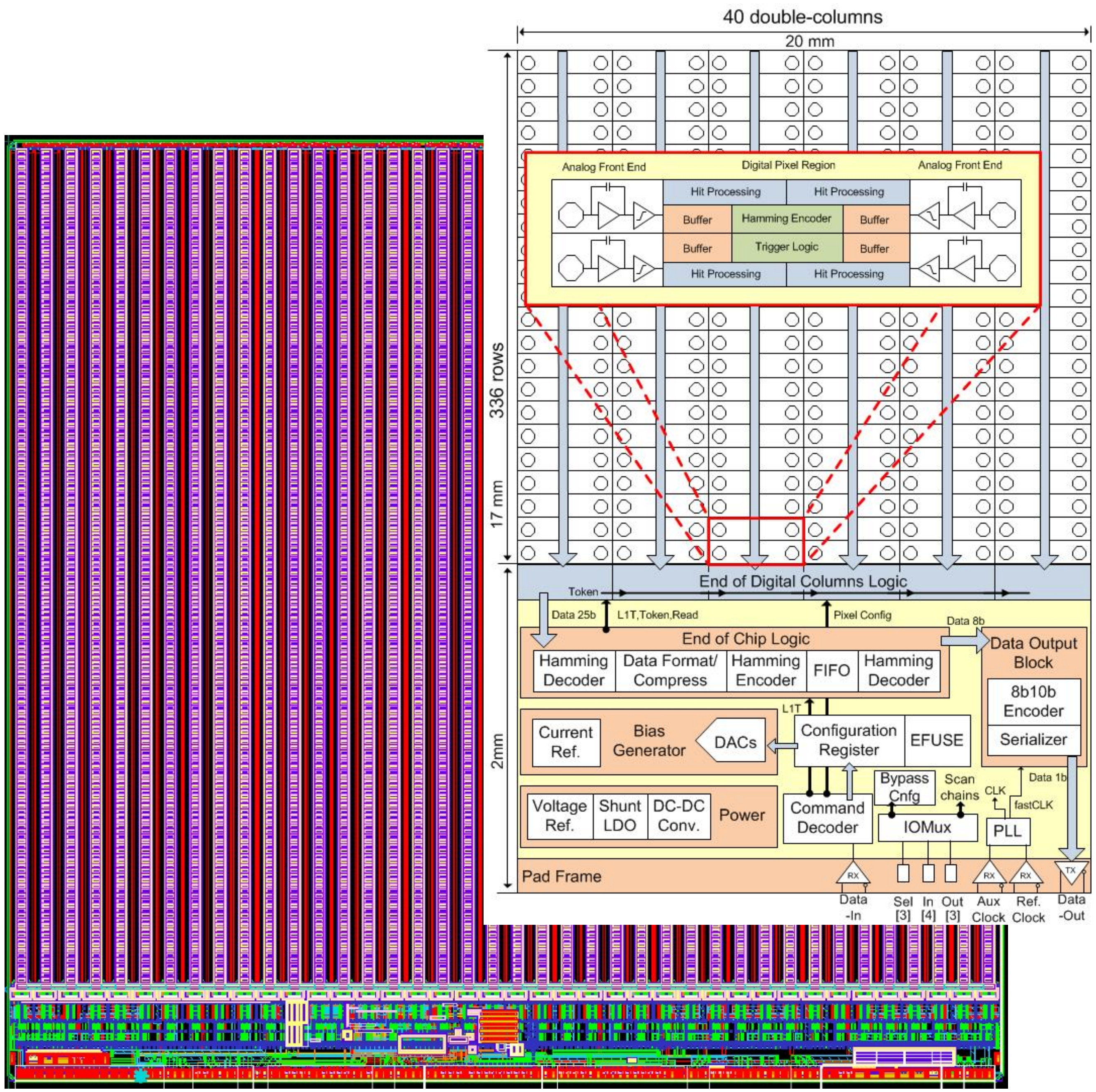
IBL in Numbers



- 2 sensor types
  - Planar silicon sensor, oxygenated n in n sensor, slim edge design
  - 3D silicon sensor with vertical electrodes, reduced collection time and depletion voltage
- Separation in eta (|η| ≈ 2.7)
- 26880 pixels per front-end i4 (FE-I4) chip
- ~12 million pixels for the total IBL



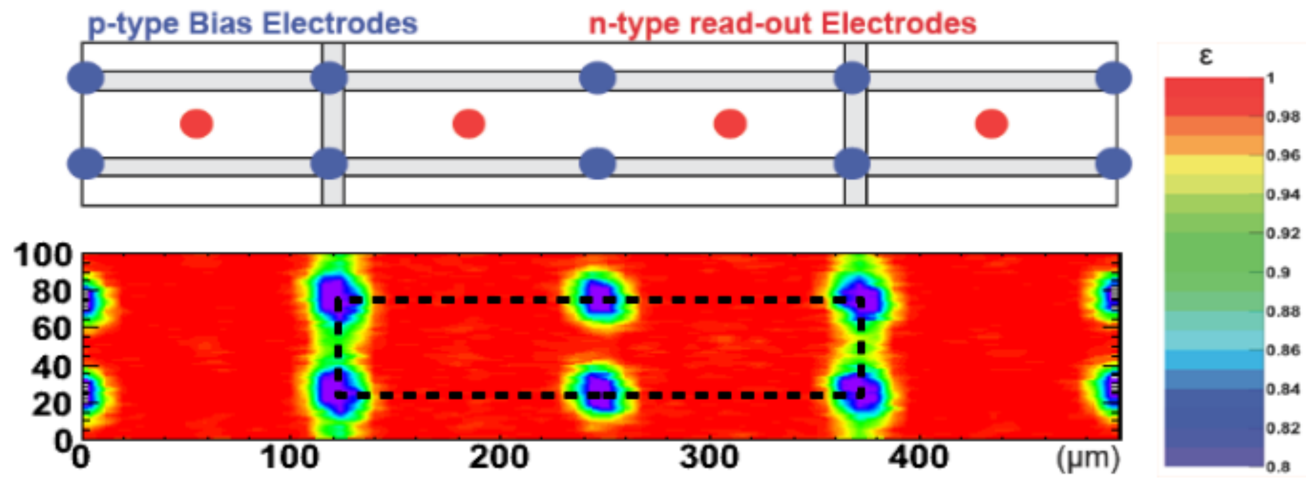
Front-end I4 (FE-I4)

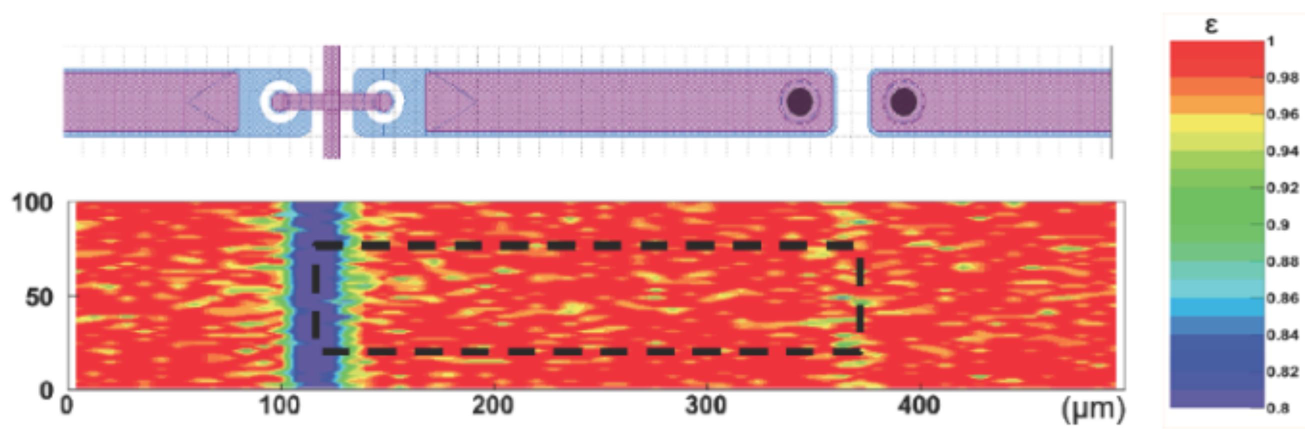


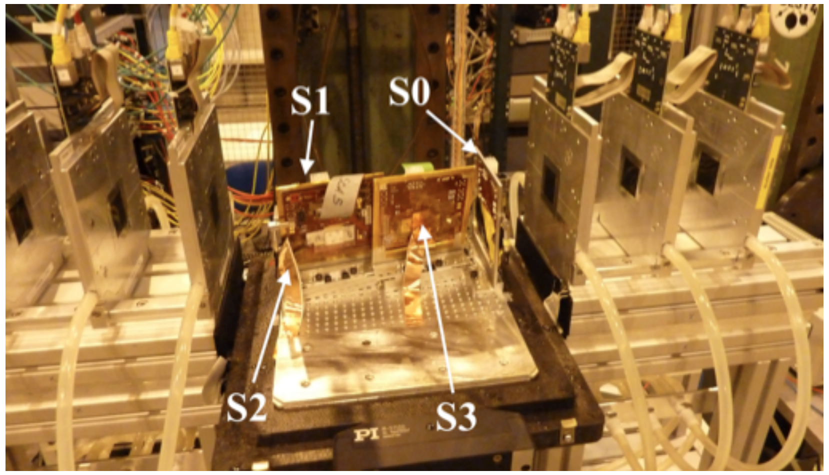
- New 130nm front-end chip to cope with higher radiation levels and larger occupancies
- 87 million transistors
- Smaller feature size with respect to previous FE-I3 allowed to:
    - Shrink pixel size to 50 x 250 (um)
    - Use local hit storage supporting higher occupancies without saturating
    - More efficient space usage, <u>active area is 89 %</u>
- Balanced output allows for higher data transmission rates
- Total chip size 19x20 (mm)

Testbeam results

- IBL Testbeams happened at DESY and CERN
- Results from running with EUDET telescope show high efficiency for both sensor types
- Results for cluster size, Landau shape and resolution as expected
- Simulation model is refined based upon testbeam results

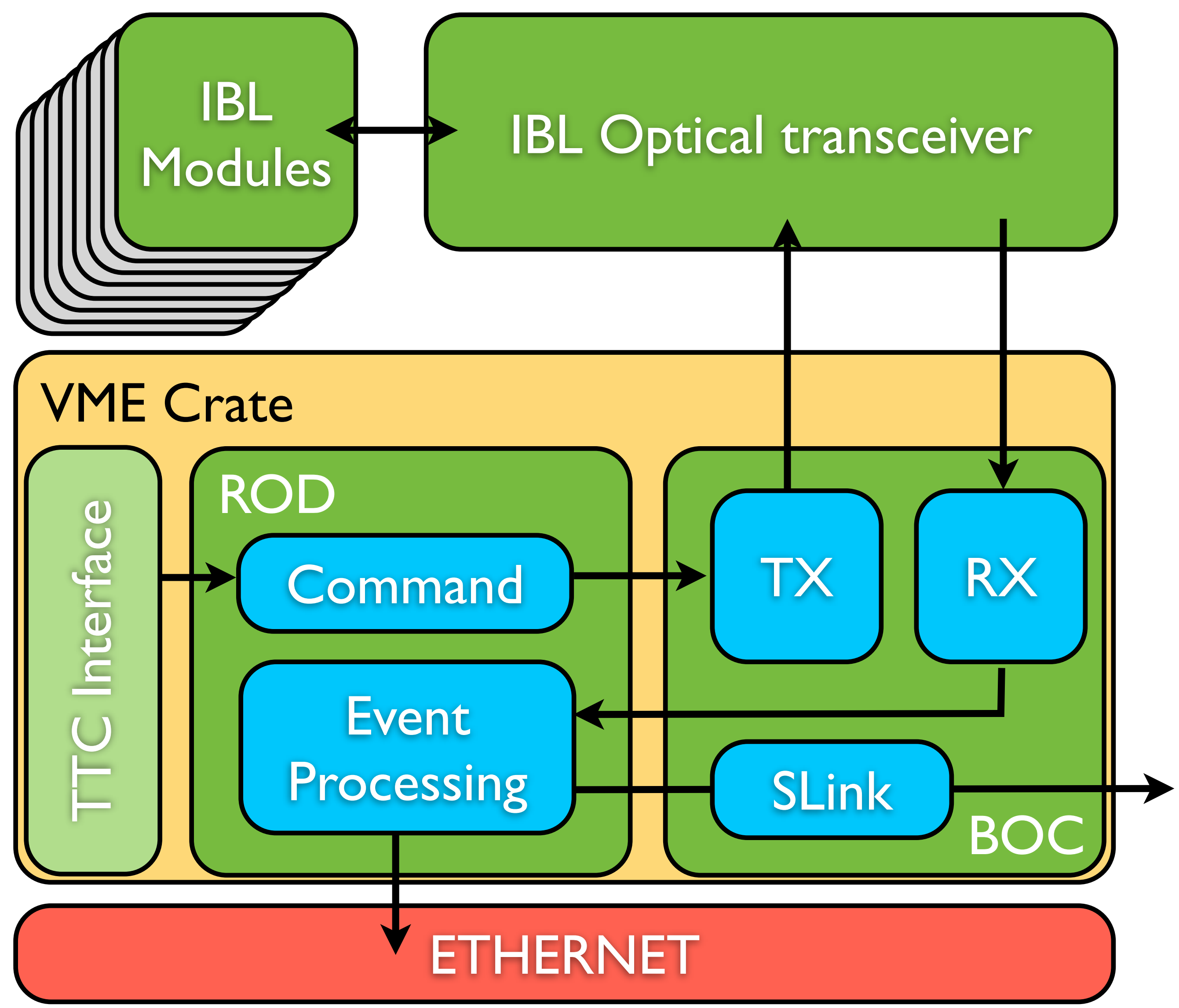




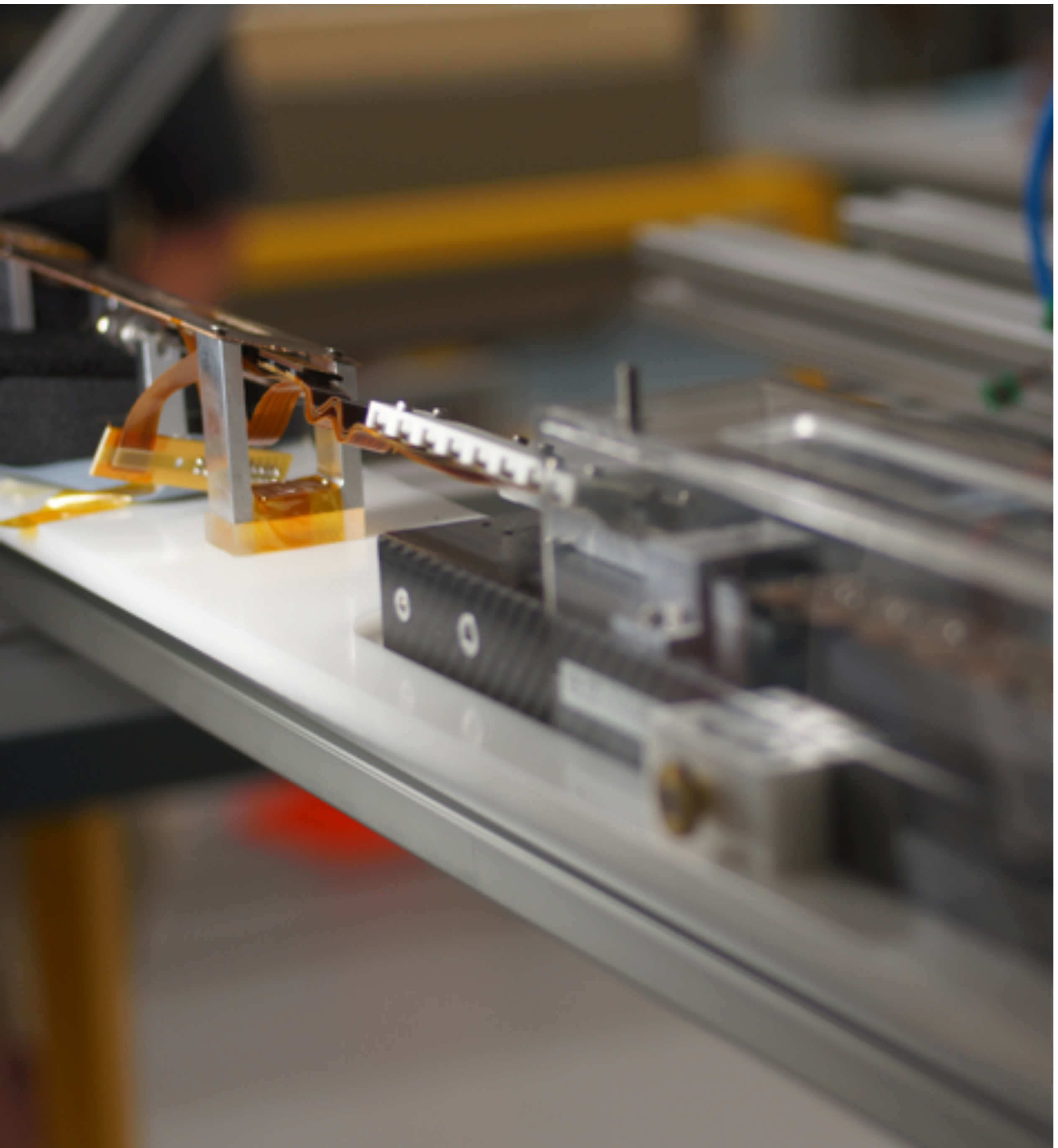


IBL Readout Structure

- New Readout Driver (ROD), new Back-of-Crate Card (BOC)
- Higher data flow density, ~ 6Gbit/s per card
- Off-the-shelve transceiver components for detector communication
- Network base-layer for control and calibration, overcoming the VME bottleneck



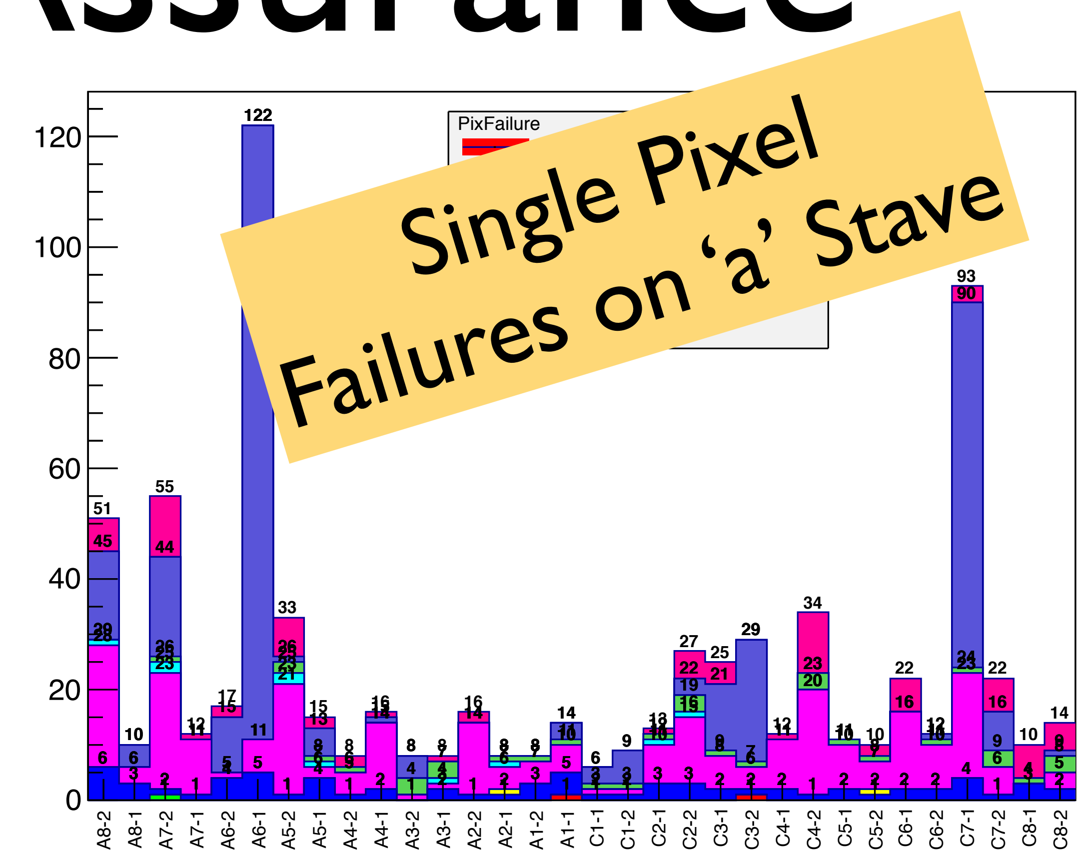
System Test

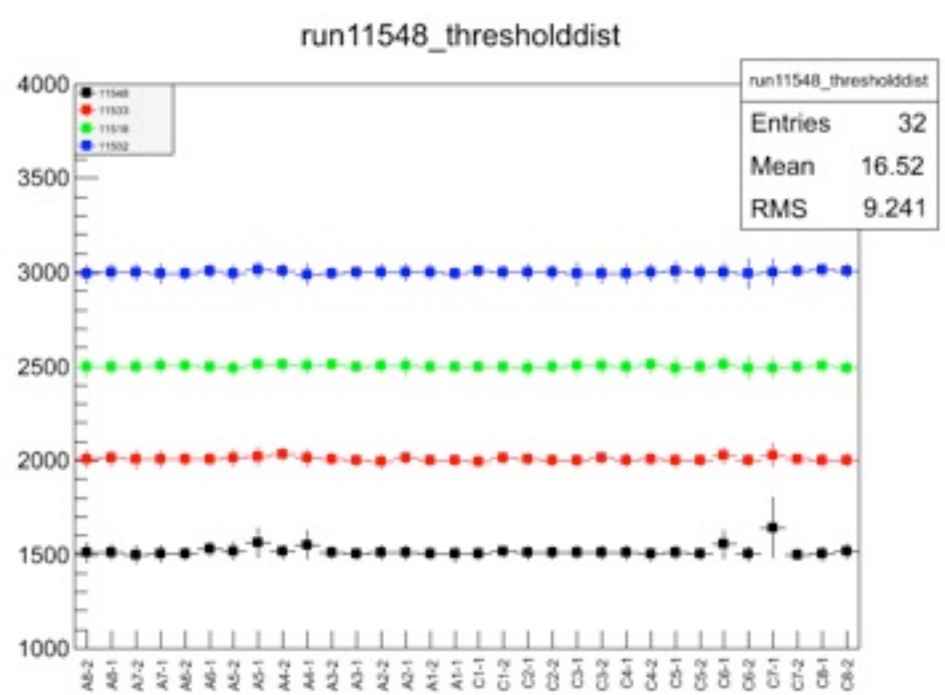


- Full component installation with a production quality stave at CERN, to allow for:
    - Component testing
    - Full system operation
    - Procedure evaluation, i.e. tuning, error search, shutdown behaviour
    - Software development
- Installation to later be used for debugging the system without interfering with operation

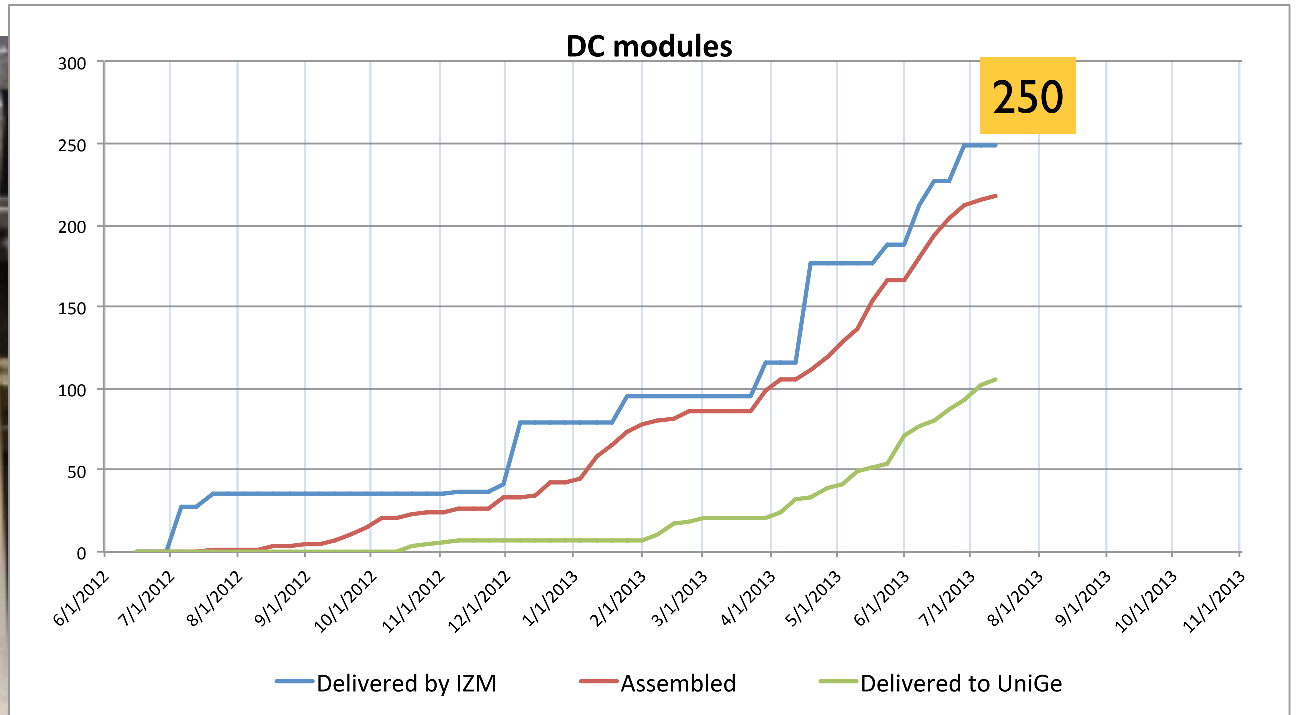
Stave Quality Assurance

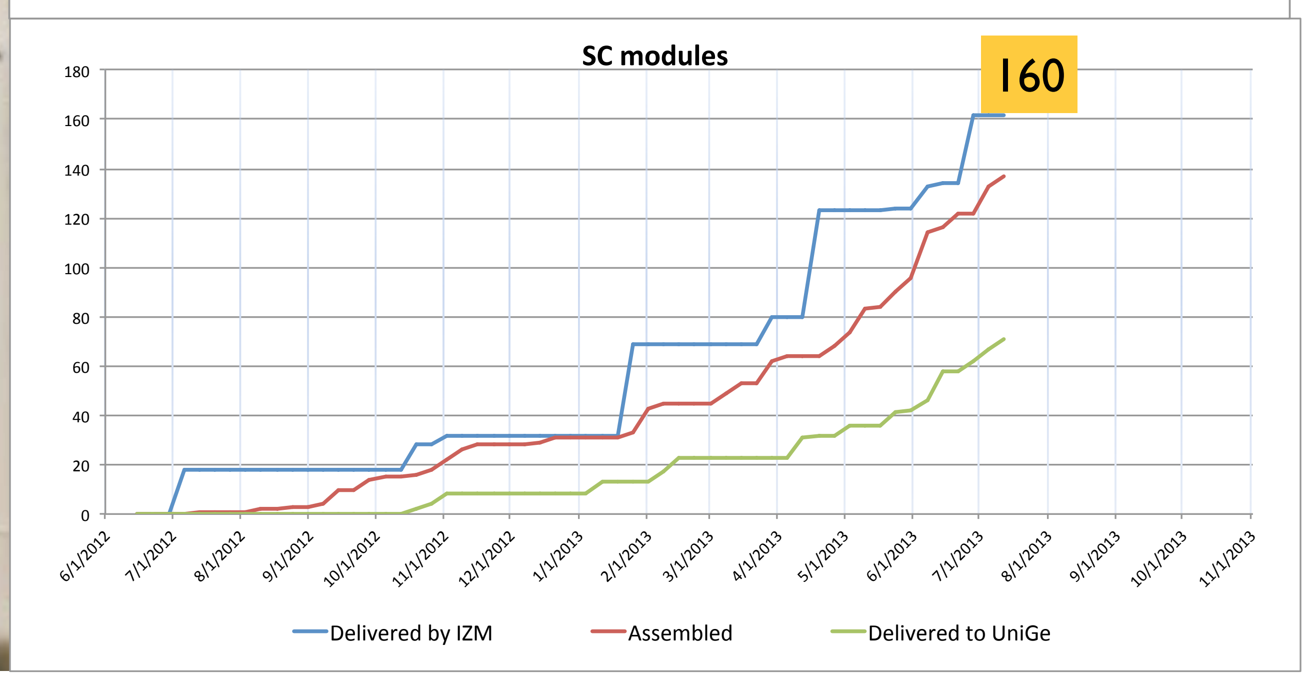
- Extensive QA procedures in place, in module and stave production sites, as well as in assembly and final integration site
- All staves subject of several tuning procedures, to scope out operation range
- Source scans with ^{241}Am and ^{90}SR to show pixel functionality and allow for charge calibration
- Cosmics are taken with all staves during weekends
- All final acceptance tests are run warm and cold (-20C)





Construction Status

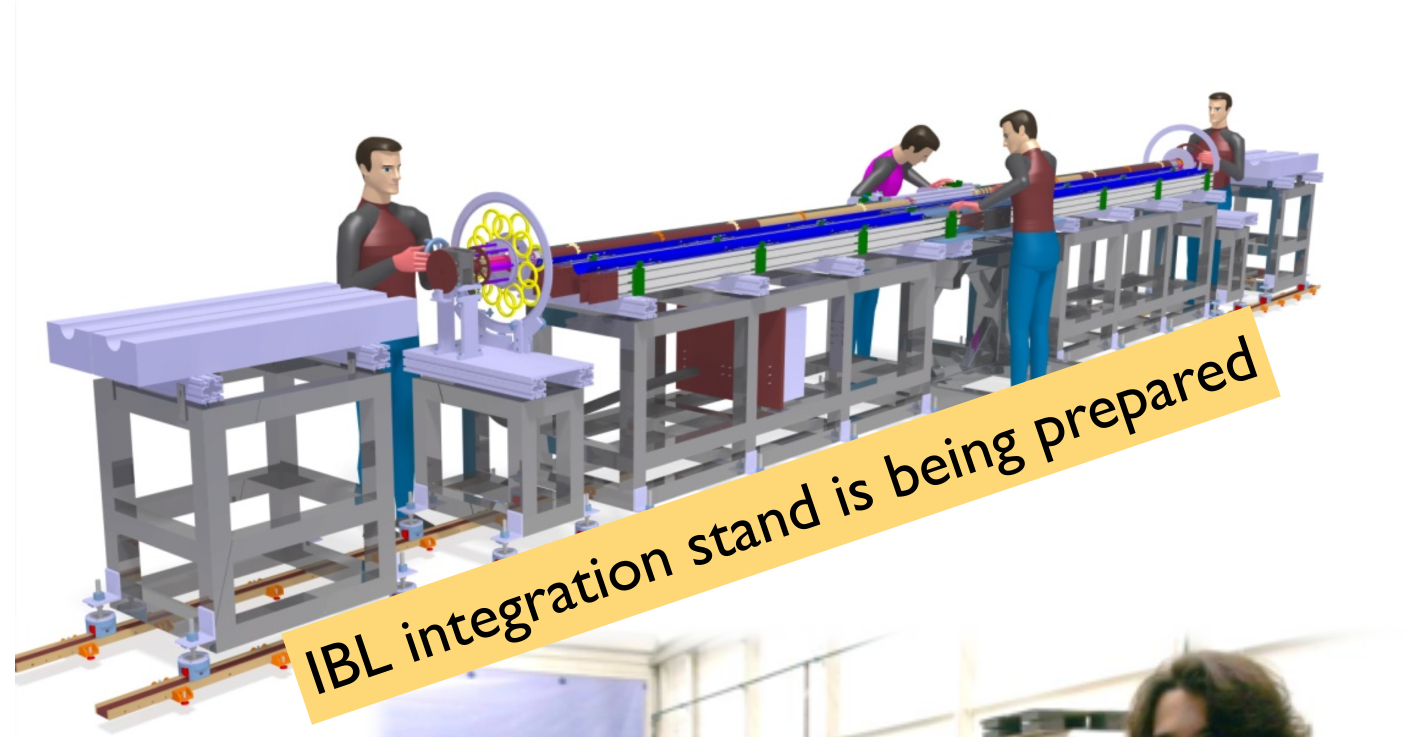




- 3 pre-production Staves delivered, allowing to set up the test stand
- 4 production staves delivered, 5th and 6th to arrive within the coming week
- All have been operated warm and cold and ran source scans
  - Software still needs fine-tuning for individual behaviour
- Module production more than half way done

Final Integration

- Final Integration to happen at CERN
- All tools are fabricated and currently being mounted
- IBL will be integrated with the beampipe on the surface
- Full assembly integration into ATLAS in the cavern in early 2014
  - The support tube for IBL is installed as part of the Pixel Detector package



Conclusions

- Early long shutdown has drastically shrunk the IBL schedule, but Project is well underway
- IBL will turn the ATLAS Pixel Detector into a 4-Layer pixel detector
- New FE-I4 shows very good results in testing and testbeam operation
- First large scale application of 3D sensor technology
- 4 out of 14 total staves delivered at CERN so far
  - 3 have already gone through the full acceptance test and are qualified for installation into the IBL package