Construction of an Active, Integration and Qualification IBL Prototype

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IBL Mock Up
Let's build it!

In the framework of the ATLAS Experiment, a new detector called "Insertable b-layer" is planned to be installed in 2013.
This poster gives an overview of the environment in which the detector is installed and of the technologies used to build its prototype: the IBL Mock-Up.

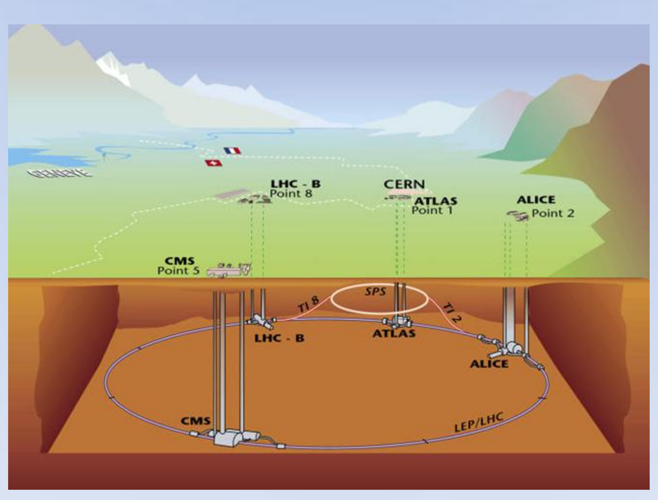
The European Organisation for Nuclear Research

CERN is one of the world's largest centres for scientific research. Its business is fundamental physics, finding out what the Universe is made of and how it works. At CERN, the world's largest and most complex scientific instruments are used to study the basic constituents of the matter — the fundamental particles. By studying what happens when these particles collide, physicists learn about the laws of Nature.

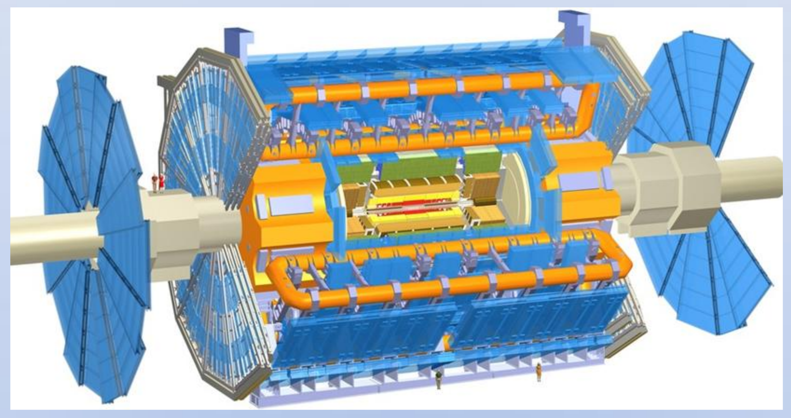
The instruments used at CERN
→Particle accelerators and detectors
→Accelerators boost beams of particles to high energies before they are made to collide with each other or with stationary targets. Detectors observe and record the results of these collisions.

The Large Hadron Collider LHC

→The largest particle accelerator
→27 km ring of superconducting magnet, 50 – 175m underground
→ Two beams of particles travel at close to the speed of light with very high energies before colliding with one collision every 25 ns
→The beams travel in opposite directions in separate beam pipes .
→They are guided around the accelerator ring by a strong magnetic field, achieved using superconducting electromagnets.

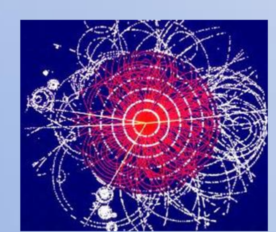


ATLAS : A Toroïdal LHC ApparatuS



A LHC detector

→46 m long, 25 m width, 25 m high
→ 7000 tons
→ Made of barrels and end caps



Some on going searches:

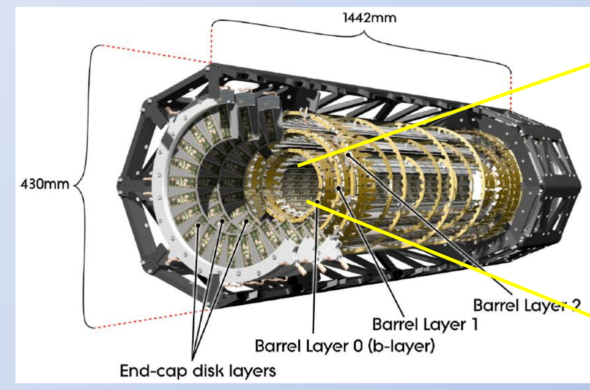
Higgs boson
Two of the greatest mysteries are how particles gain mass and how mass and energy are related.
To explain these mysteries, theories predict a new particle, the Higgs particle.
If this particle exists, ATLAS will discover it and provide great insight into the origin of mass.

Antimatter
At the very beginning of the Universe, equal amounts of matter and antimatter existed. If matter and antimatter were exact mirror images of each other, they would have completely annihilated to leave only energy.
But why was some of the matter left over to create galaxies, the Solar System with our beautiful planet, and us?
ATLAS will explore the tiny difference that exists between matter and antimatter.

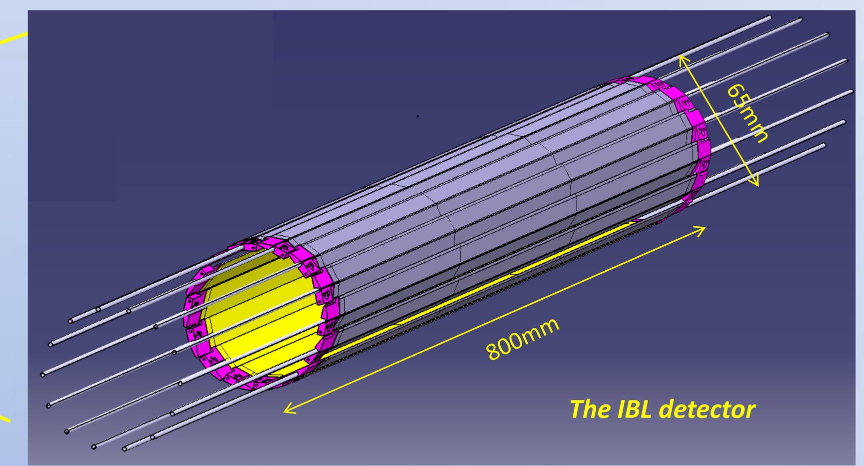
An anti-person meeting an ordinary person

IBL: Insertable b-layer

The IBL is a new particle detector added to the current ATLAS 'detectors. It is the most close-to the interaction point detector in ATLAS. IBL is a silicon detector.

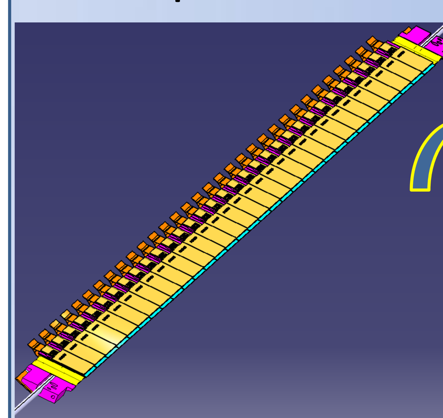


Centre of the Inner detector in ATLAS

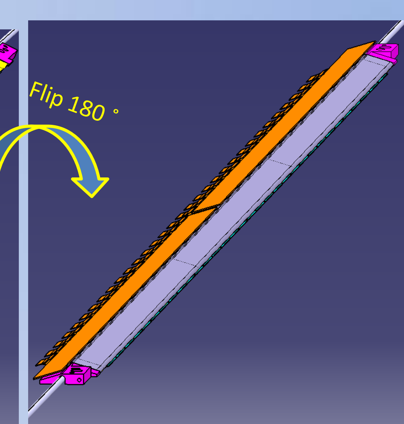


Detector principle
When a particule passes through silicon, it will pull out a crystal atom electron (Compton effect) giving to the silicon most of its energy. Electrical charges created are detected by electronic.

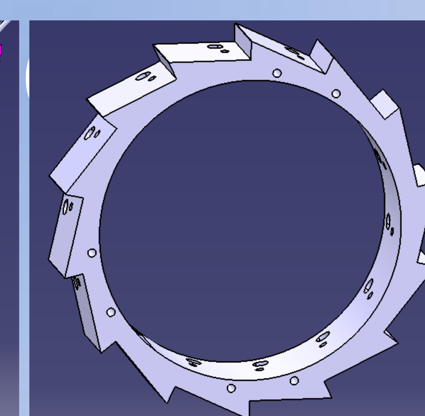
IBL components



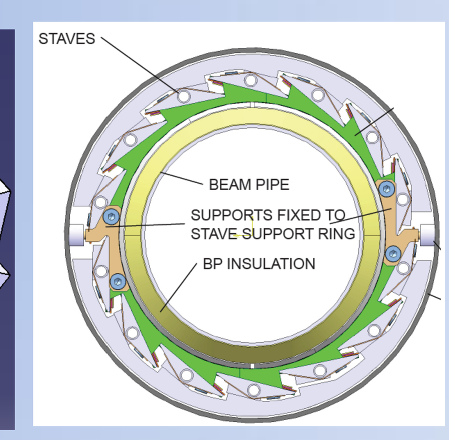
Silicon strips are glued in series



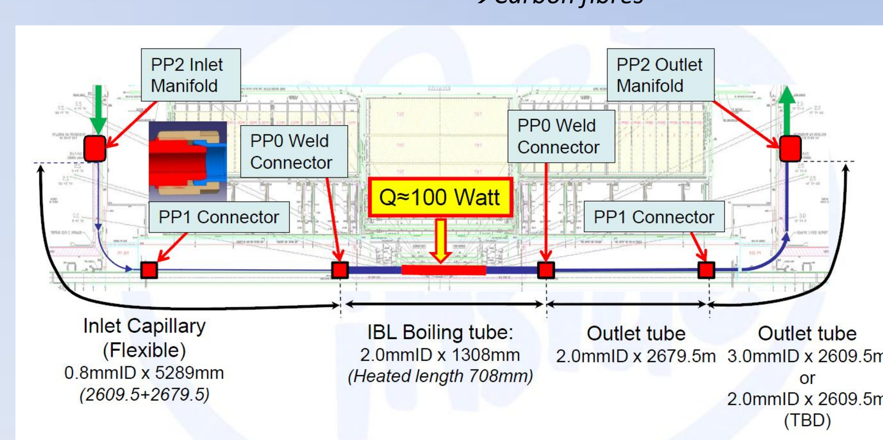
Stave = Silicon detector structure
→Carbon fibres



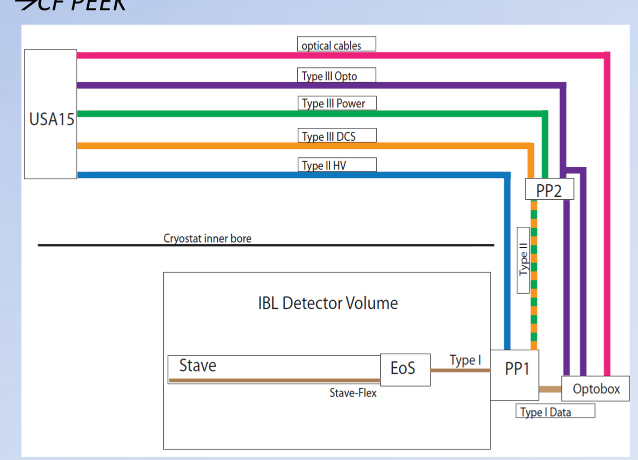
Stave ring = Stave structure
→CF PEEK



The IBL cross section



The IBL cooling system → CO2 evaporative : -40 °C



The IBL read out system

The IBL Mock Up

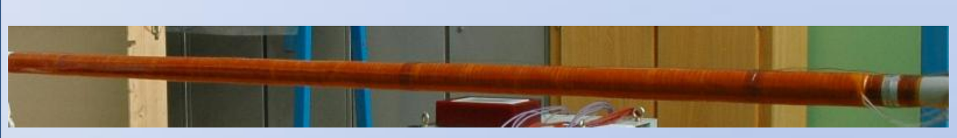
A challenging engineering project
Building a new detector requires a very high technology in terms of materials, cooling systems, assembly procedures and electronics. One of the main objective is to build a structure as light as possible. Indeed, while passing through matter, particles could loose their energy (electromagnetic radiation effect) which could lower the detector efficiency. In that framework, light materials such as carbon fibres, carbon foam, and titanium, have been selected.

IBL Mock Up objectives
Before installing the real detector in the ATLAS cavern, a scale one representative prototype has to be built in order to check integration and thermal behaviour of the new structure. Main objectives are to check thermo-mechanical simulations that have been performed by engineers. The IBL mock Up is composed by the IBL structure equipped with dummy silicon sensors. In addition, a thermally representative beam pipe has been built (with no vacuum inside), and all the mechanical structure around the detector is planned to be represented.

Mock Up manufacturing

Building a thermally representative BEAM PIPE

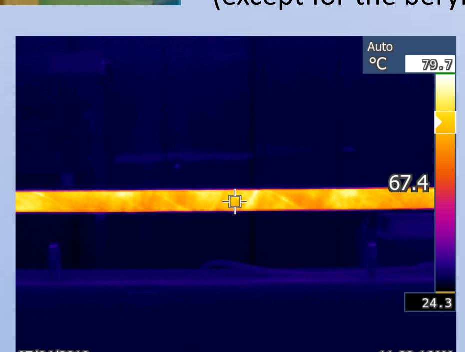
Only few millimetres separate the IBL detector with the beam pipe. It is compulsory to check that neither thermal nor mechanical conflicts exist between this two parts.

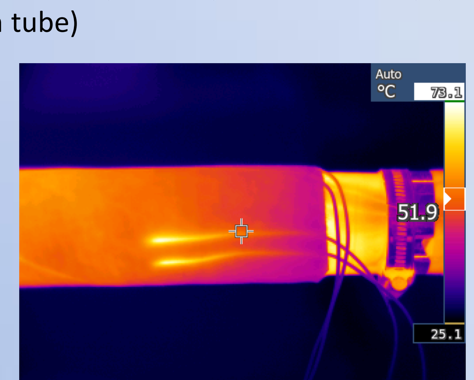


The beam pipe manufactured for the IBL Mock Up is made with the same materials currently used by the real beam pipe (except for the beryllium tube)

In real conditions, high vacuum is eventually achieved by heating up to ~230°C the beam pipe. We equipped the beam pipe mock up with heaters in order to simulate the dissipated heat.

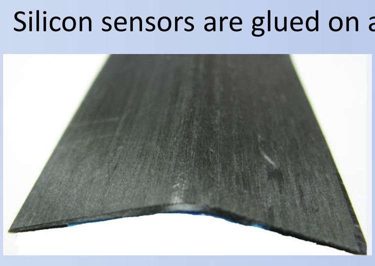
Thermography of the beam pipe →





Building real holders of the sensors: STAVES

Silicon sensors are glued on a composite structure called staves. There are 14 staves on the IBL detector.

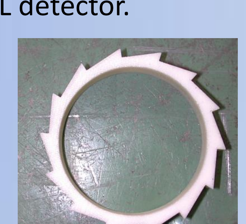


Unidirectional pre-preg
→High Stiffness

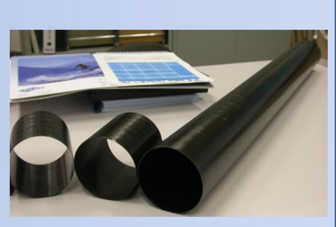
Titanium cooling pipes

Carbon foam around Ti pipe

Mechanical support PEEK

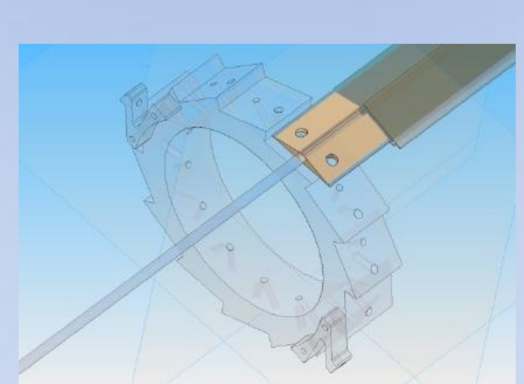


Stave ring ABS plus

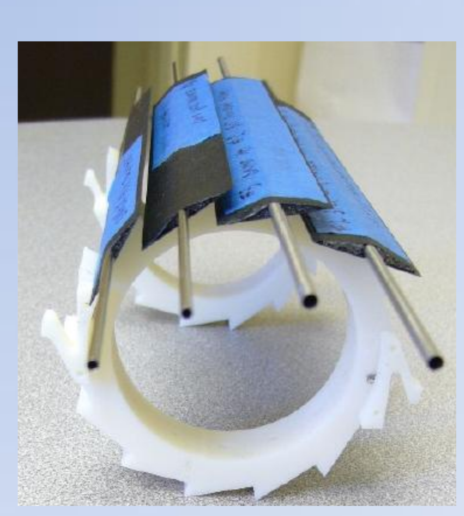


Inner support tube High mod. carbon fibres

First stave prototype



CAD analysis for integration

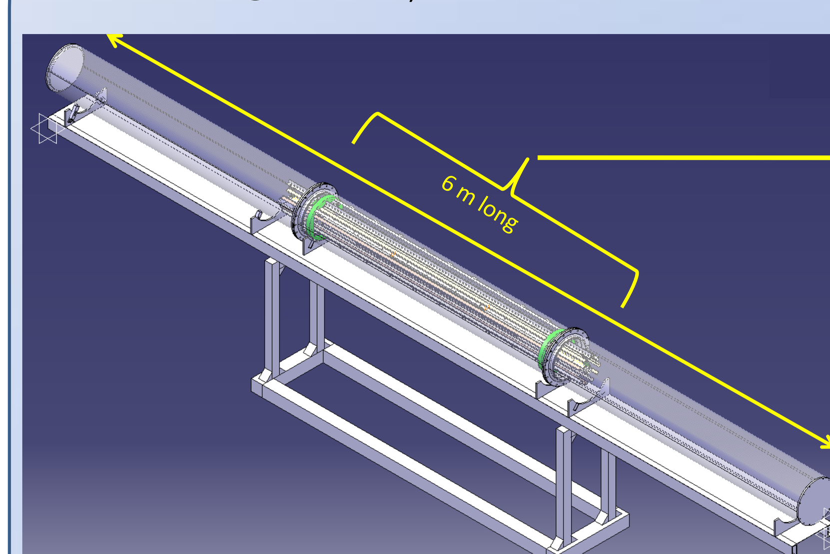


First IBL prototype

Thermal set up

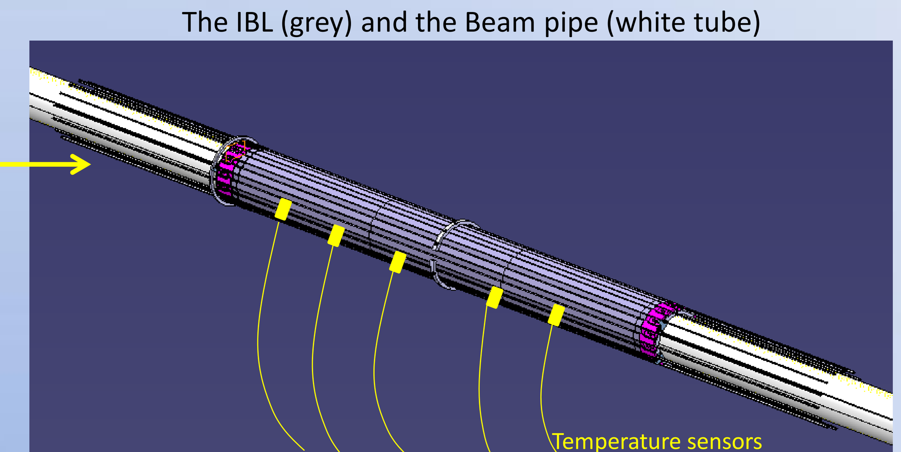
Building a fully equipped thermal set up

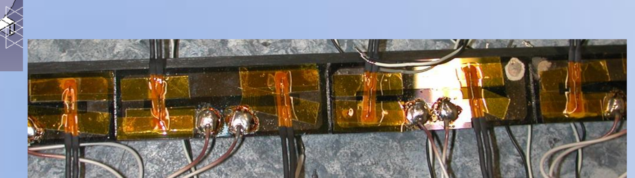
Checking the maximum temperature reachable on silicon sensors is compulsory to validate the feasibility of the detector. On top of that, it is mandatory to observe the shape of the detector structure once running at nominal conditions (-40°C on sensors, dry nitrogen environment @ about 0 °C).



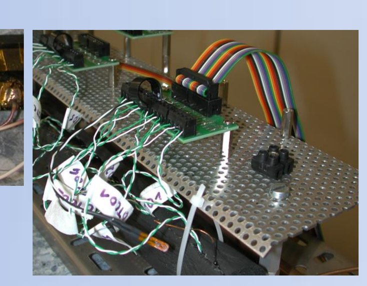
This test bench is linked to the CO_2 cooling plant and to the data acquisition system. It is also possible to perform some tests under partial vacuum, to prevent convective effects.

The IBL (grey) and the Beam pipe (white tube)



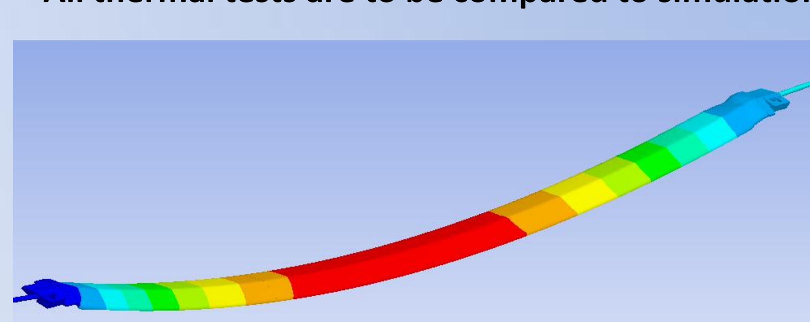


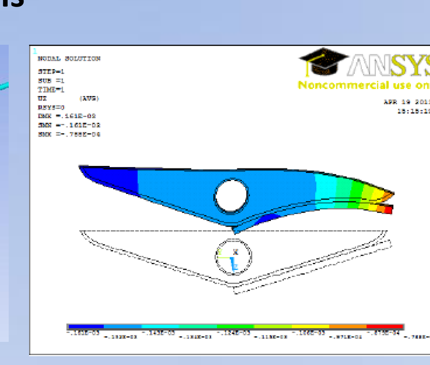
Each silicon sensor is equipped with temperature sensors.

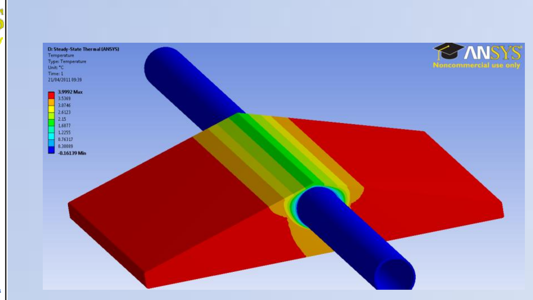


The read out system.

All thermal tests are to be compared to simulations







Stave thermal study
Ansys simulations are performed in parallel with tests in order to validate numerical models.

We try to understand the thermal behaviour of the detector structure.

Getting a close to reality model would allow us to simulate the future real IBL detector in deferent environments.