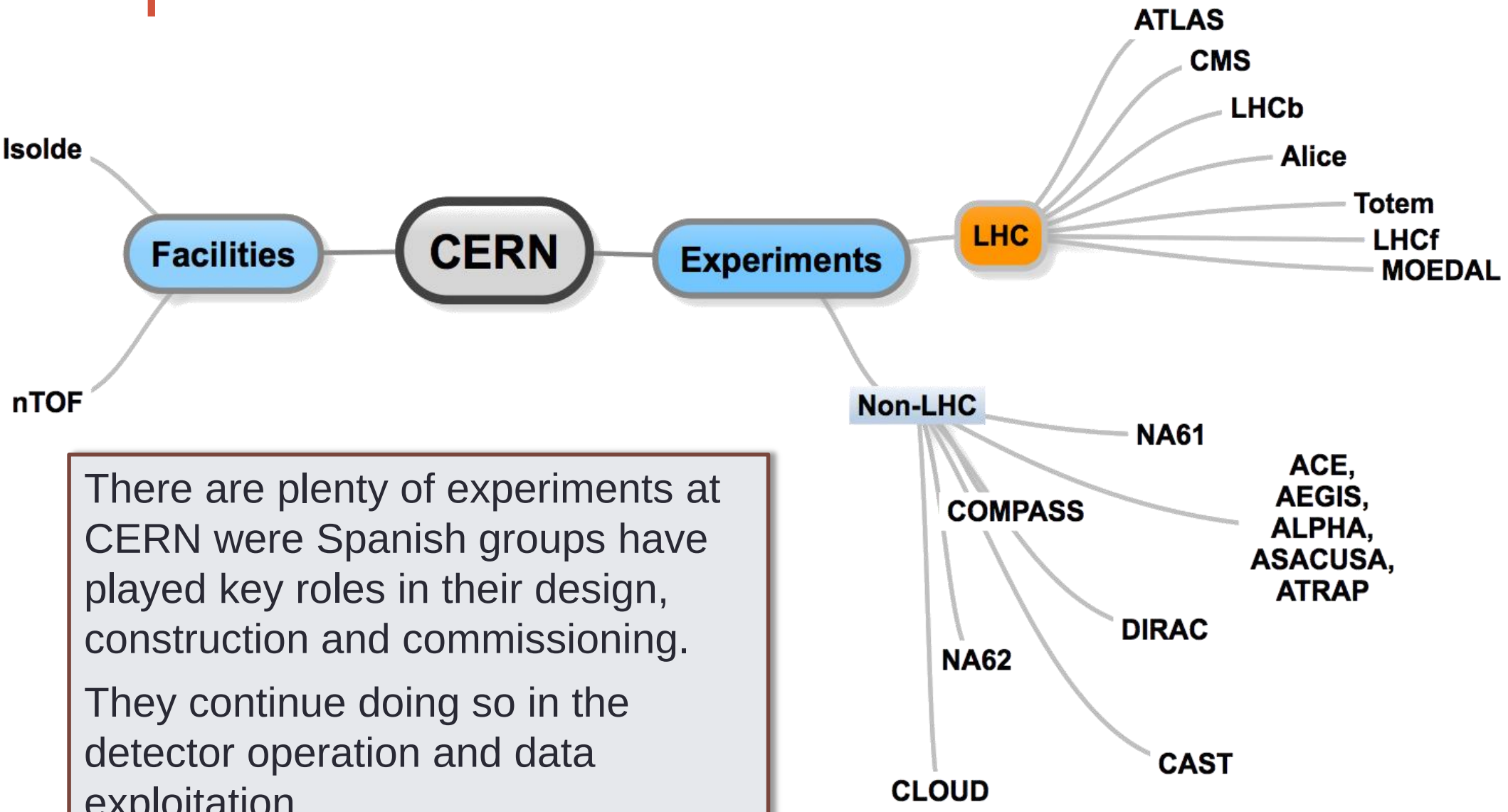
The Life Cycle Of An Experiment

The upgrade of the ATLAS strip tracker for the HL-LHC.

Carlos Lacasta - IFIC/CSIC-UV (Valencia)

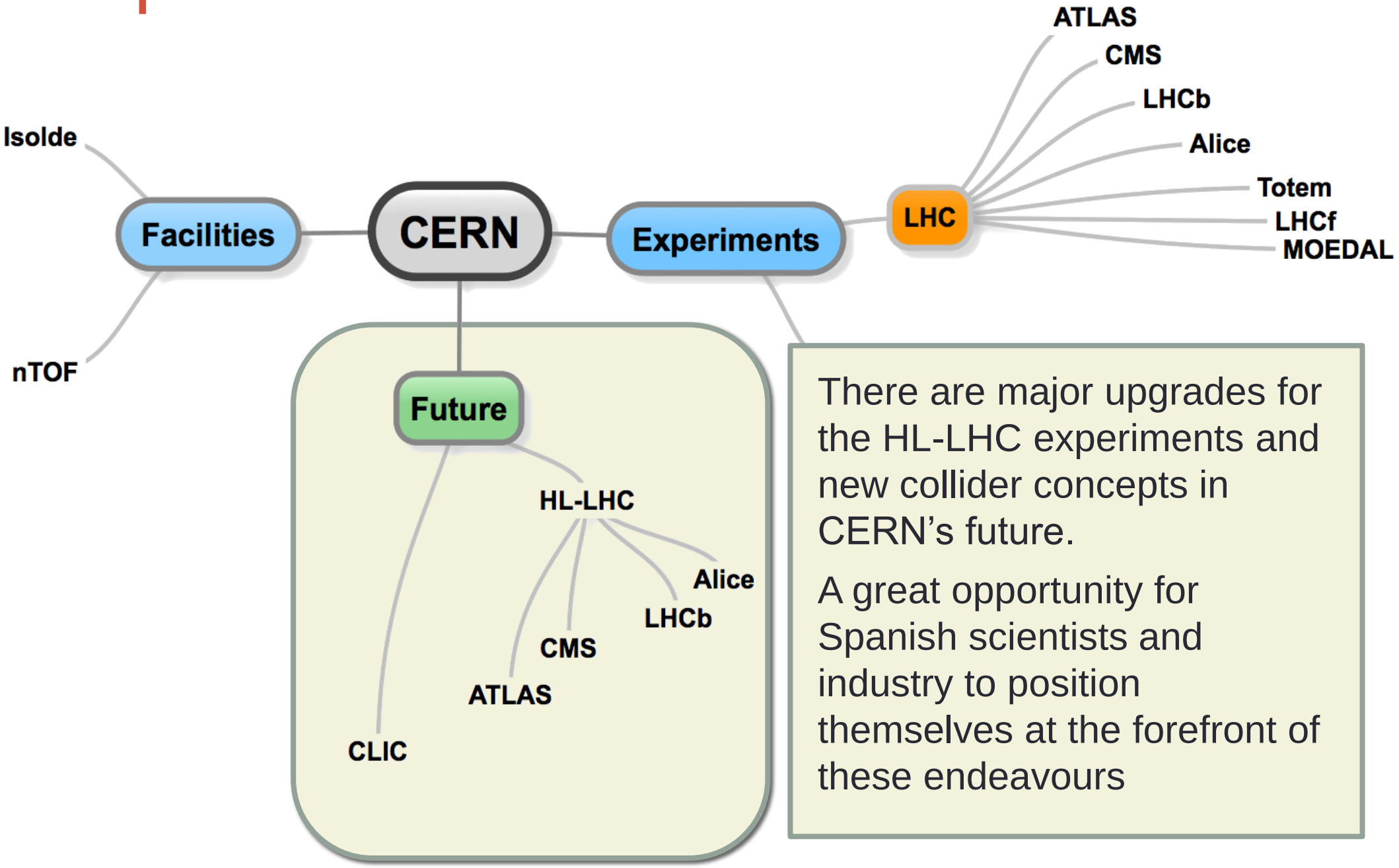
Experiments at CERN



There are plenty of experiments at CERN were Spanish groups have played key roles in their design, construction and commissioning.

They continue doing so in the detector operation and data exploitation.

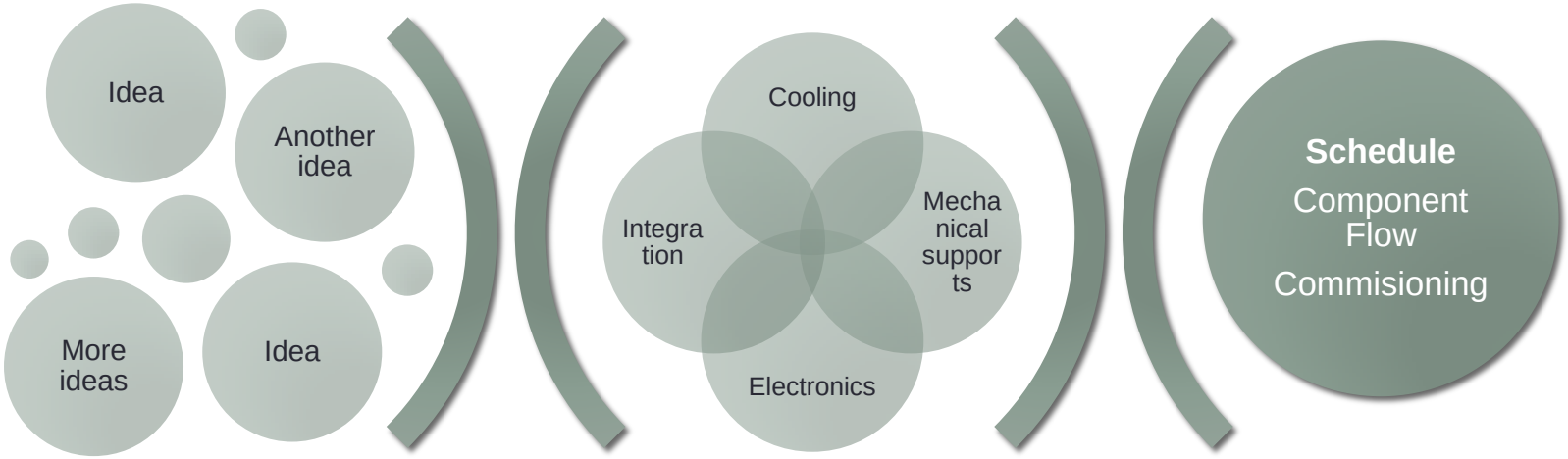
Experiments at CERN



There are major upgrades for the HL-LHC experiments and new collider concepts in CERN's future.

A great opportunity for Spanish scientists and industry to position themselves at the forefront of these endeavours

The life cycle of an experiment

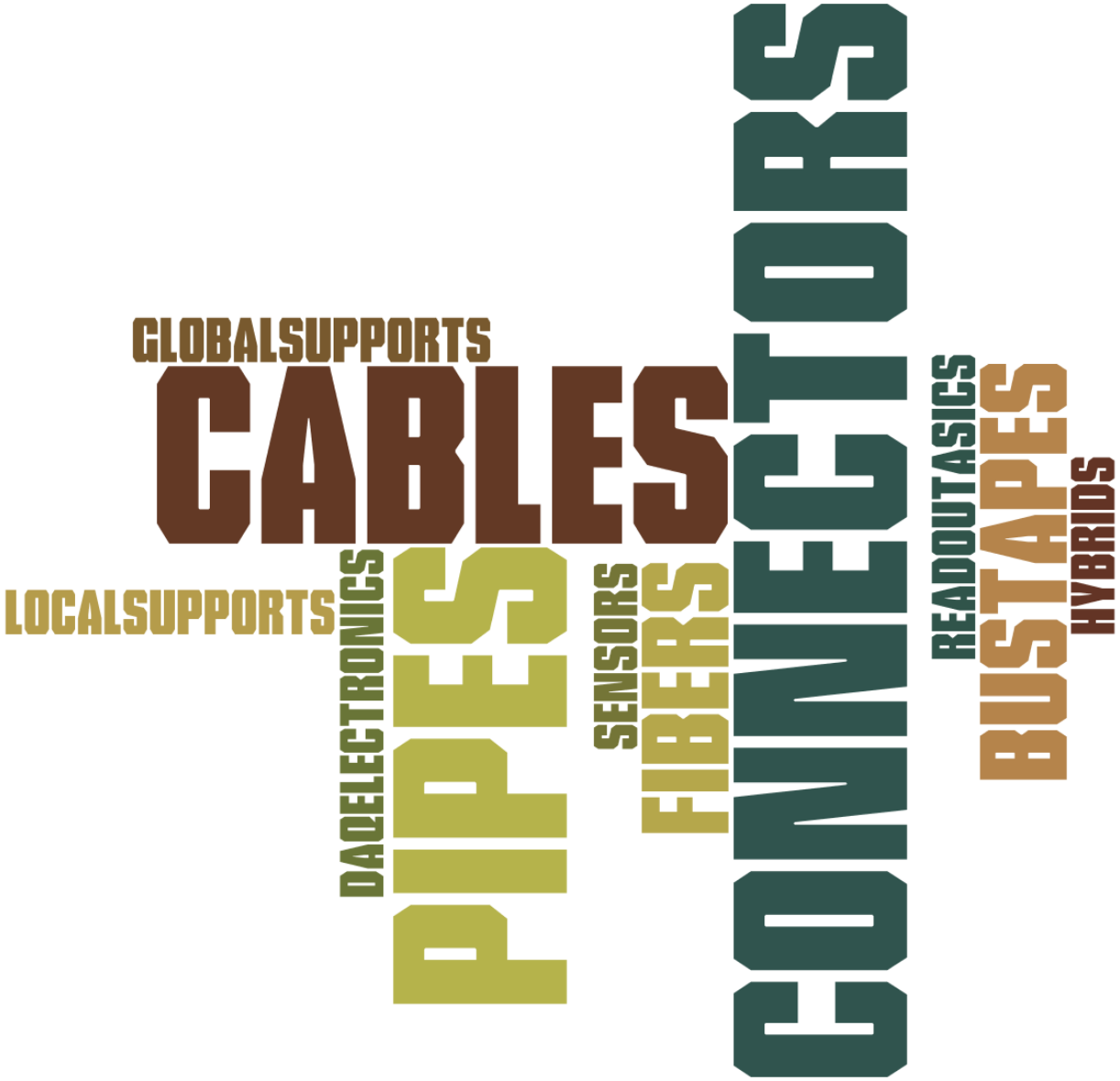


- ✓ The process can be very large: The ATLAS collaboration was formed in1992 and started operation in 2008.
- ✓ Collaboration between science and industry is not only patent creation and technology transfer (R&D phase).
- ✓ It can also be a fruitful collaborative process that starts with Technical Design and finishes with Production.

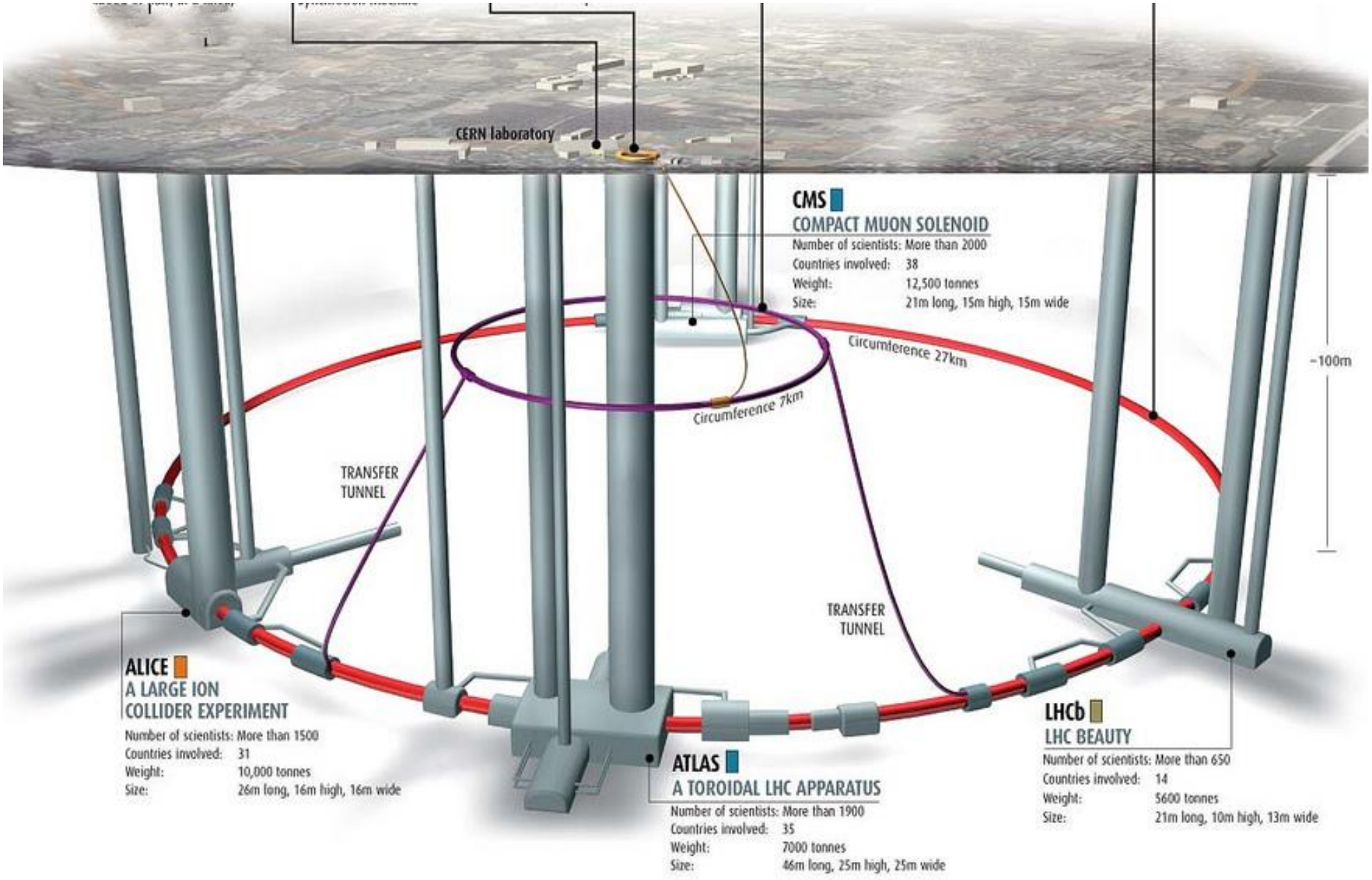
Science & industry: hand in hand

There is life beyond sensors and fancy R&D.

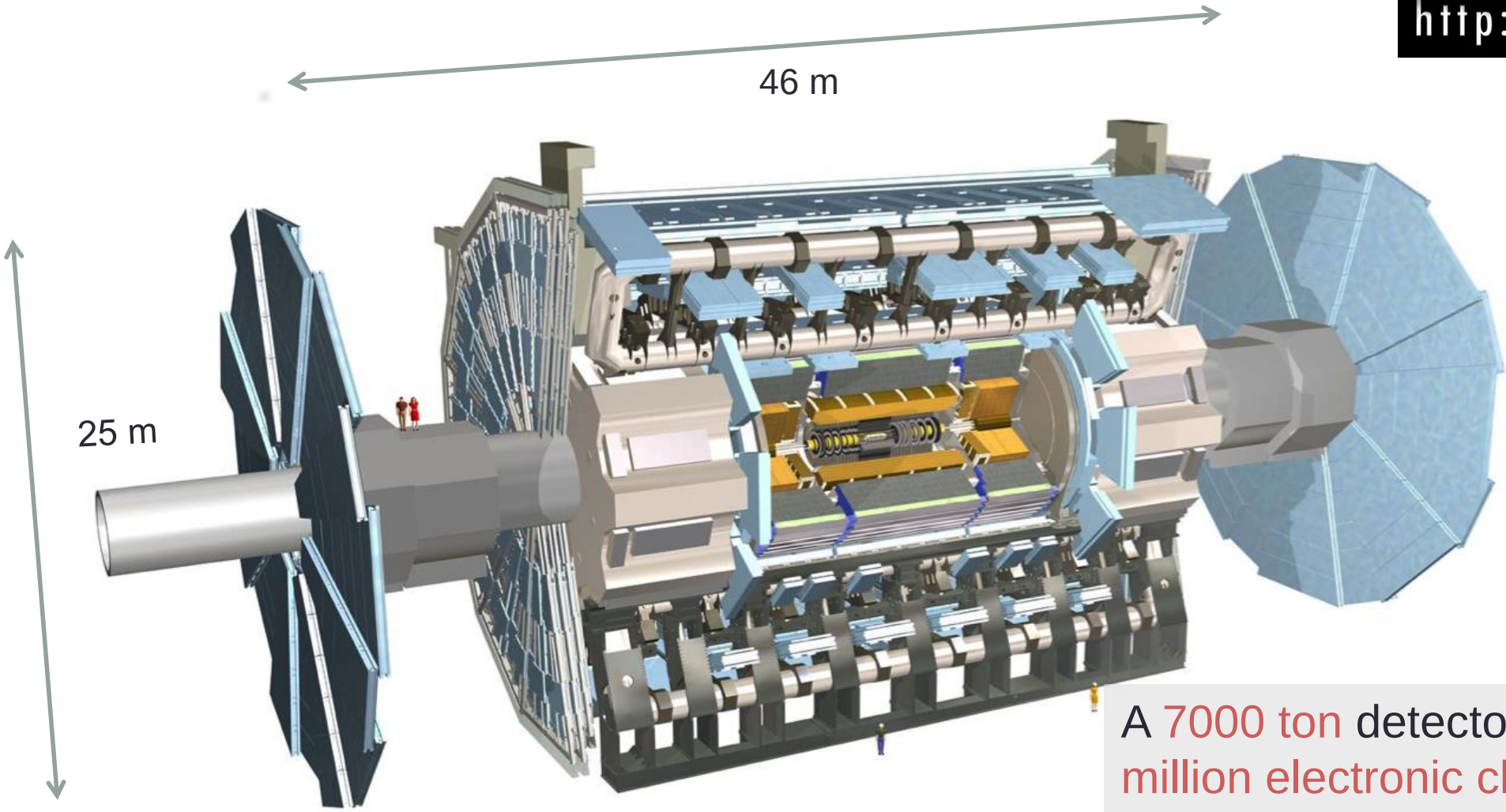
Use the ATLAS Tracker for the HL-LHC as an example of how science/industry can collaborate during the technical design and production periods.



Main Detectors at the LHC

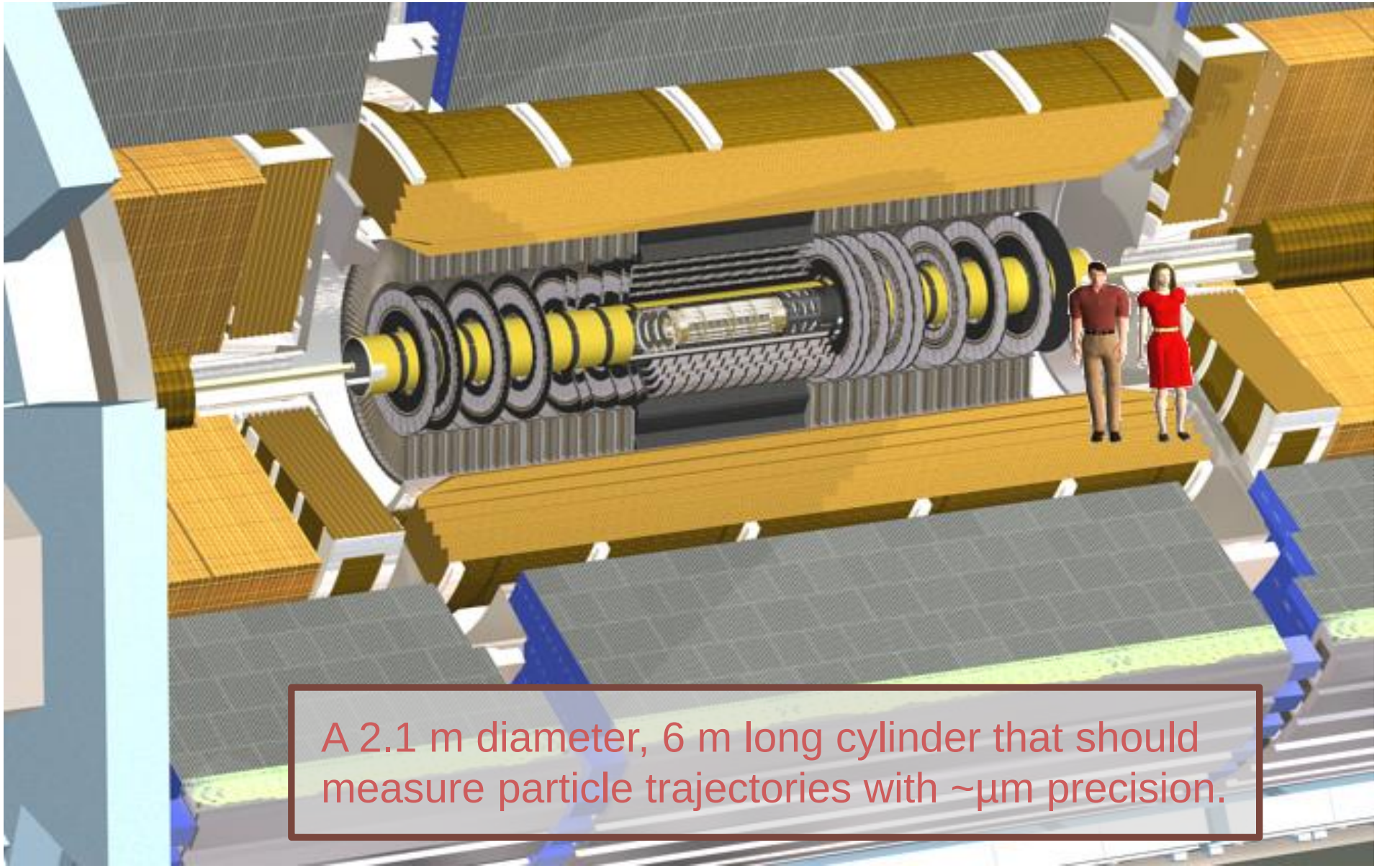


The ATLAS Detector



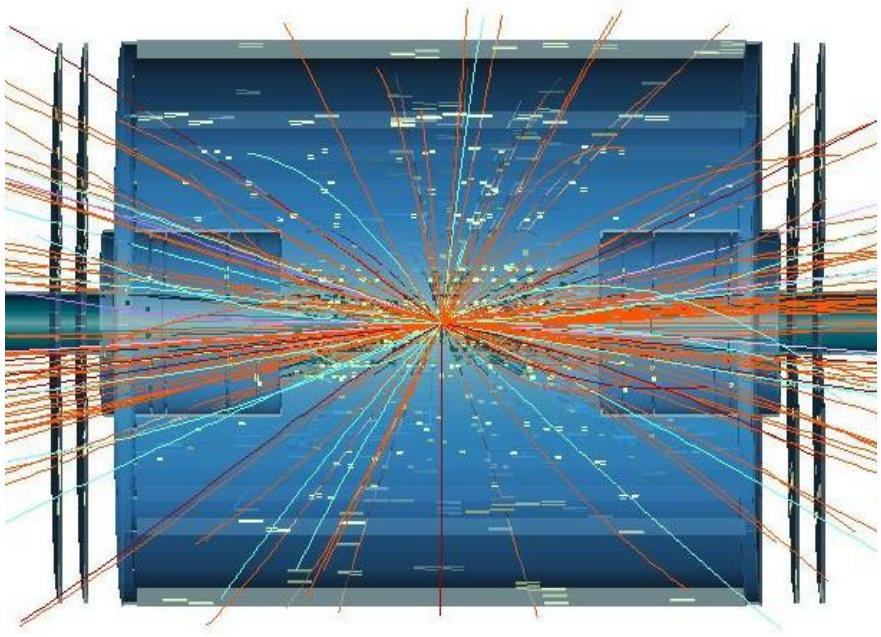
A 7000 ton detector with 100 million electronic channels and 3000 km of cables that could eventually float if a big enough bag could be found…

The ATLAS tracker detector

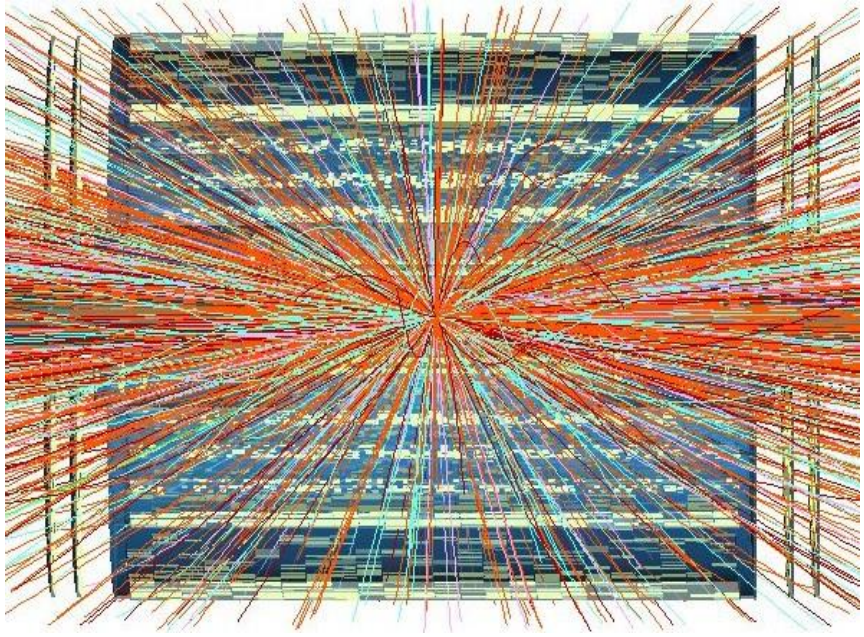


Why the detector upgrade ?

- ➔ The luminosity (number of particles per area and time to collide) will increase a factor 5.
- ➔ The detector occupancy will increase considerable (see figure)
- ➔ The detectors will be at their design limits…



LHC in 2011



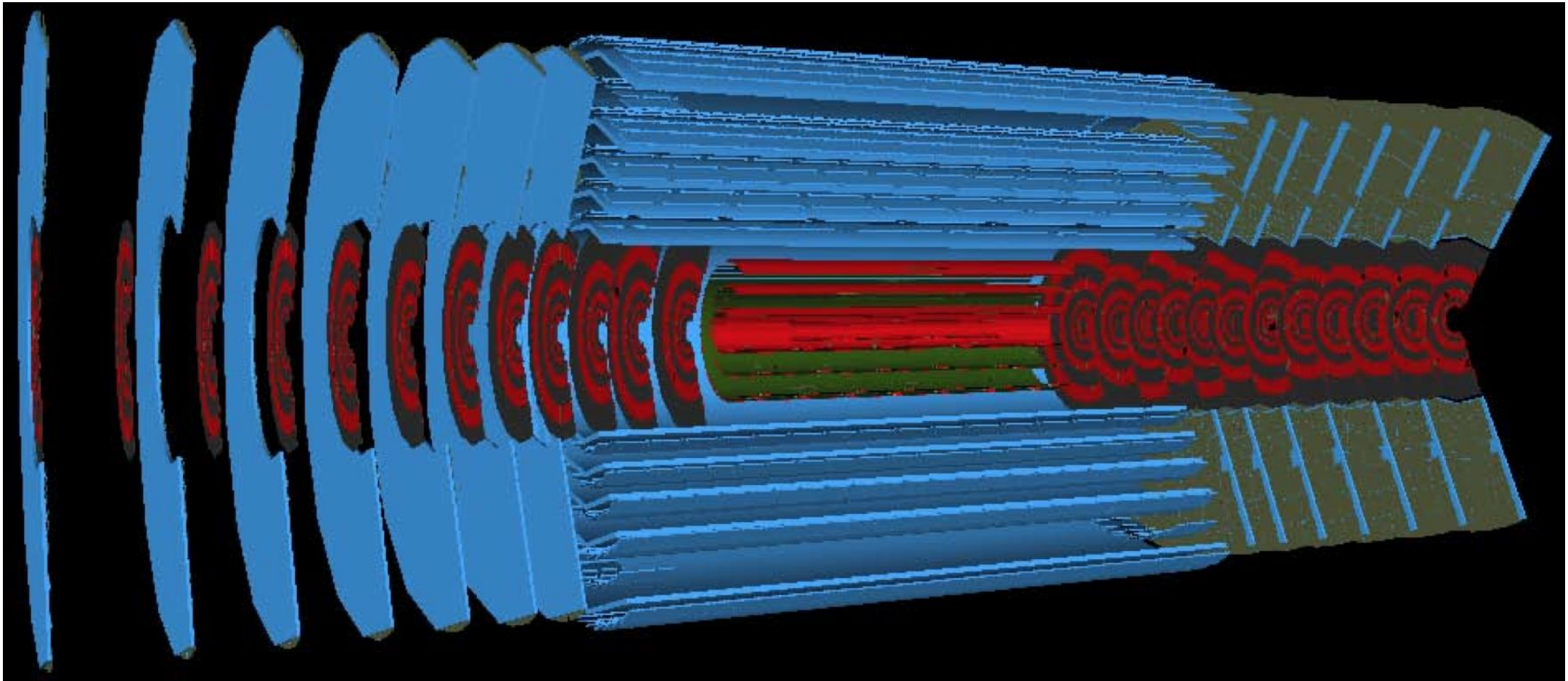
HL-LHC

The new ATLAS inner Tracker

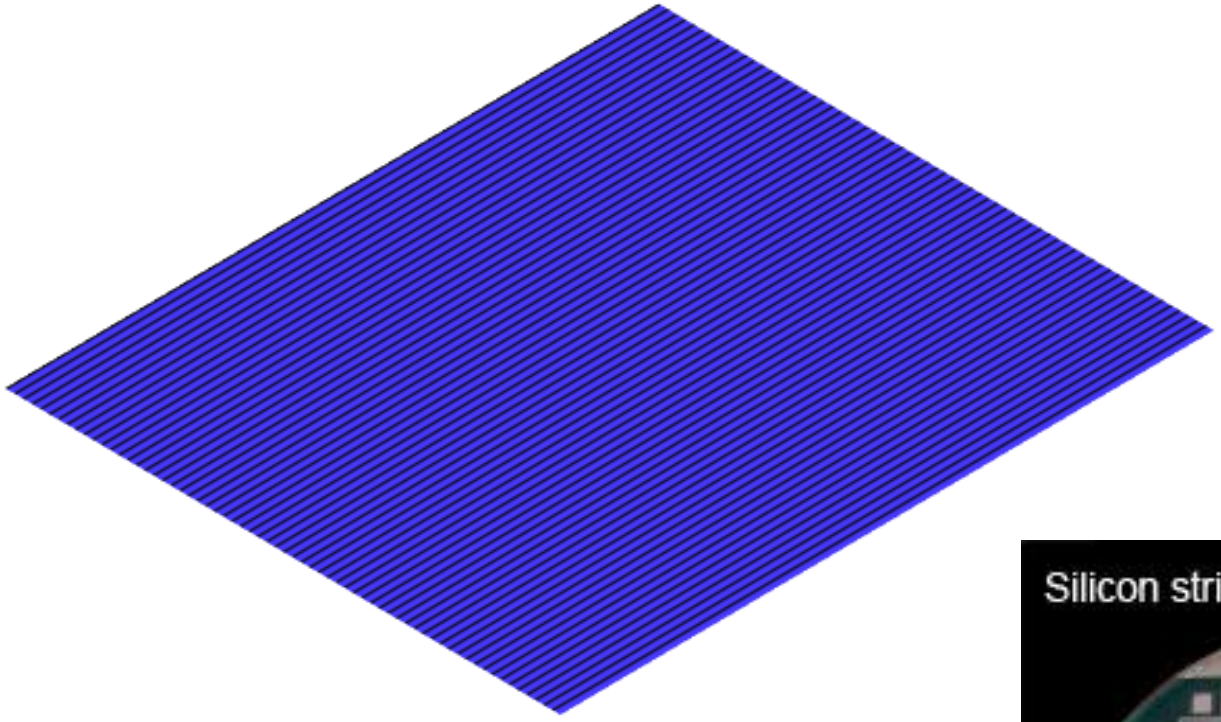
A silicon only detector having a granularity about 5 times larger with same space to bring in services (detector control signals, power, cooling) and sending out data.

Made of cylinders (barrel region) and disks (endcap region) of strip and pixel detectors.

We'll stay with the strip part of the tracker for the rest of the presentation



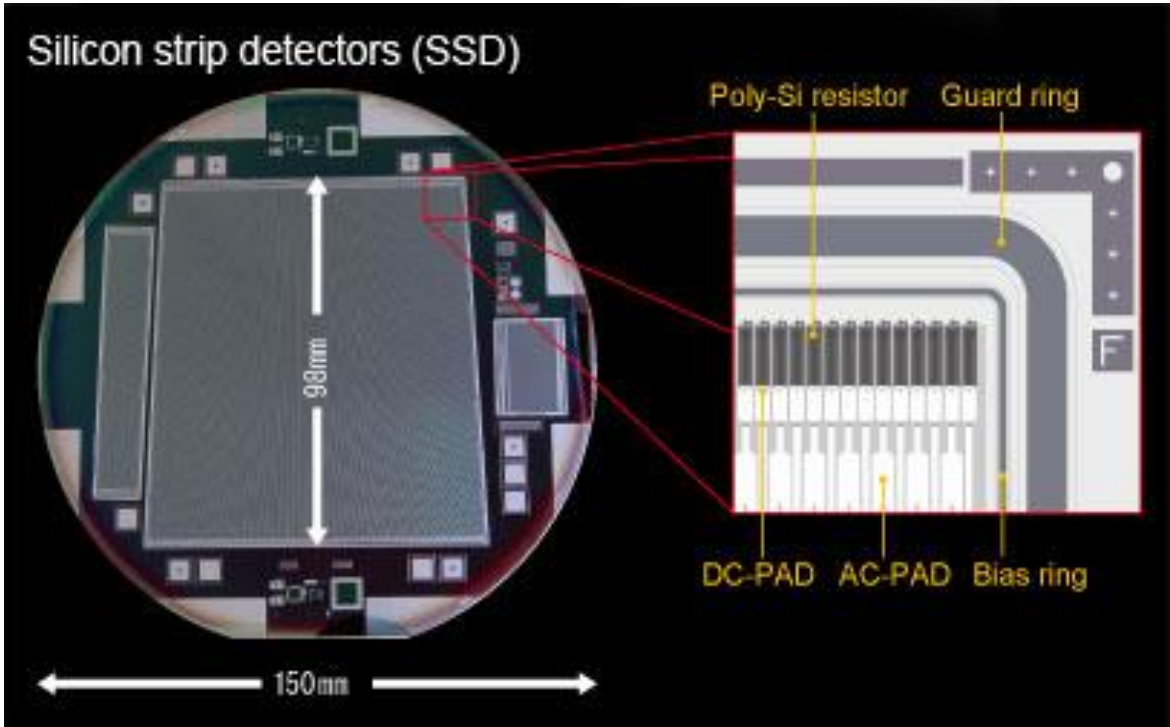
The building blocks: sensors



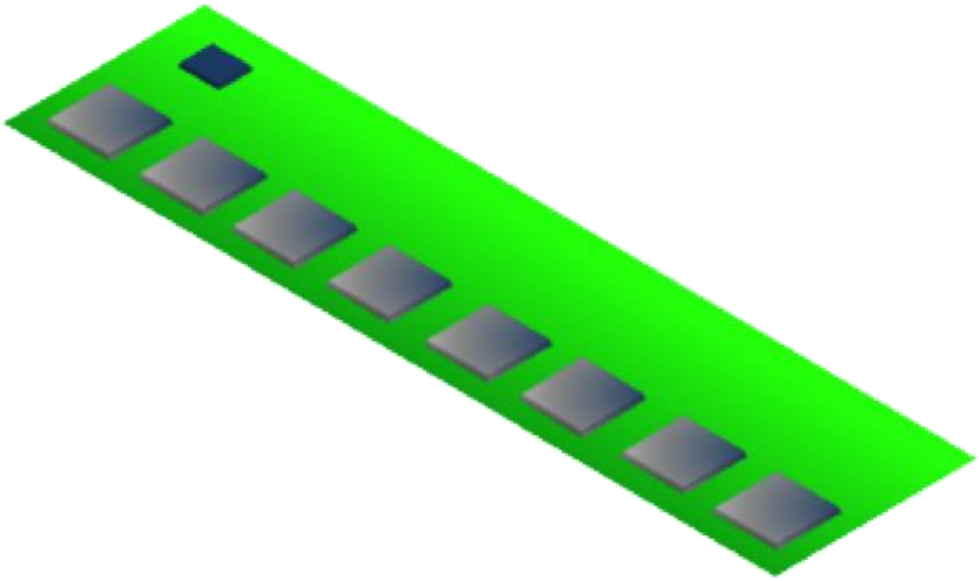
Silicon strip detectors provide the spatial information required to reconstruct the particle trajectory

12784 perfect barrel sensors, 120 m^2
8064 perfect endcap sensors, 70.5 m^2

Plus a some contingency…



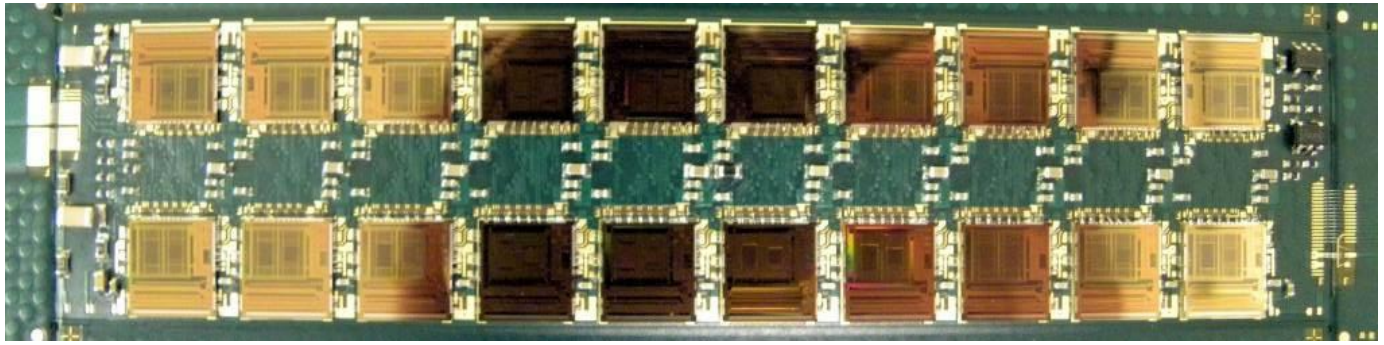
The building blocks: Hybrids



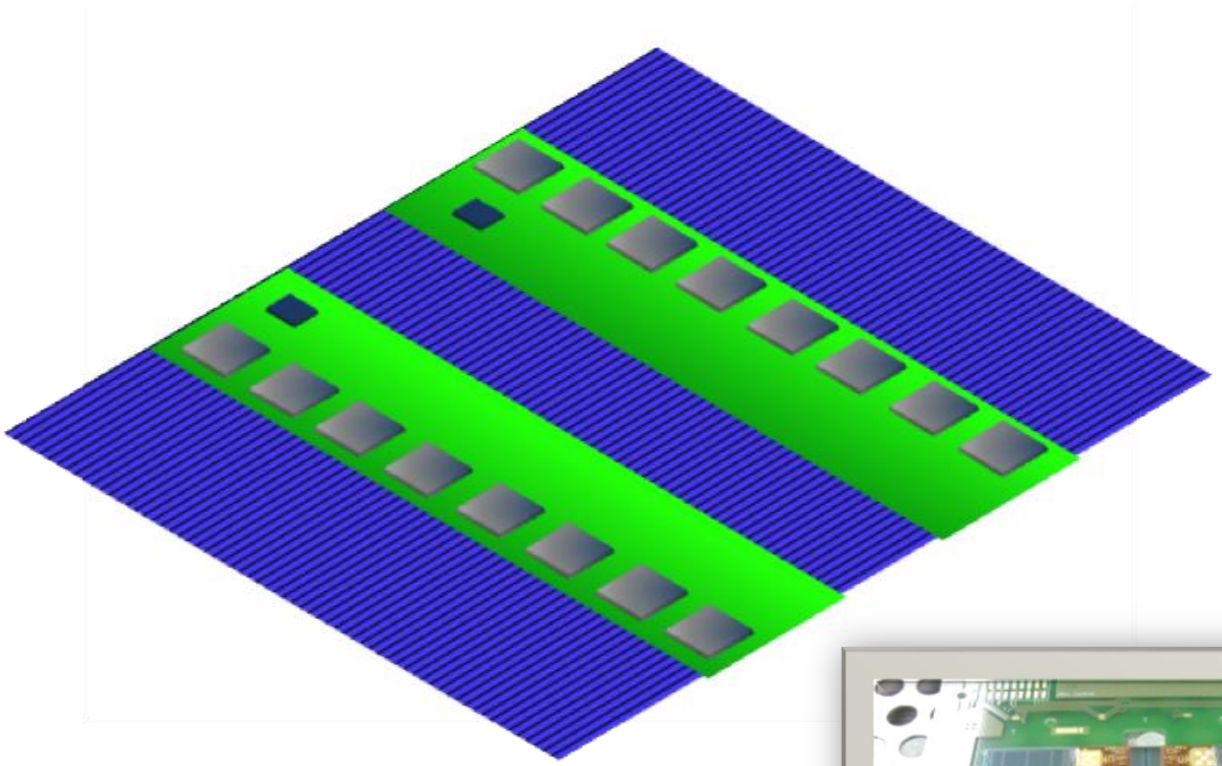
A polyimide multi-layer flexible PCB housing the readout ASICs

We need
18912 hybrids in the barrel
11648 hybrids in the Endcap

Plus contingency



The building blocks: The module

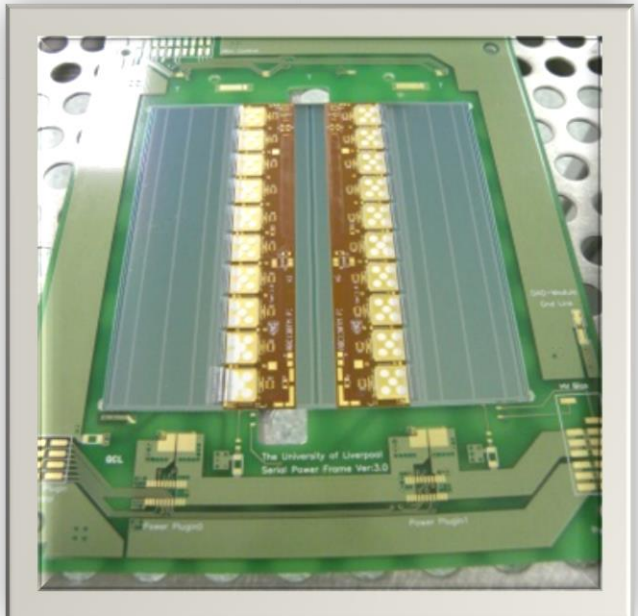


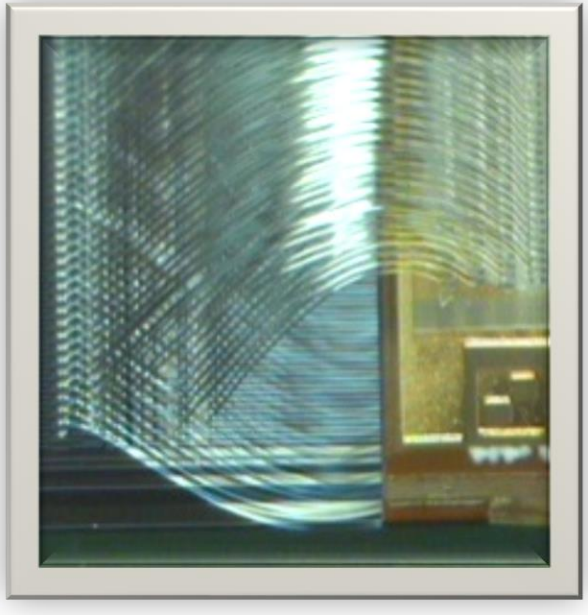
The module is the assembly that contains the sensor and the hybrids with the readout ASICs.

We need 20848 perfect modules

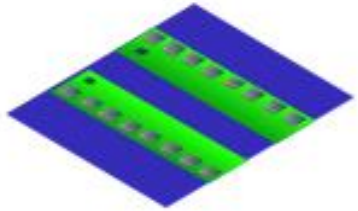
The hybrid is glued onto the sensor.

Connection between sensor and readout ASICs is made with four rows wire bonding



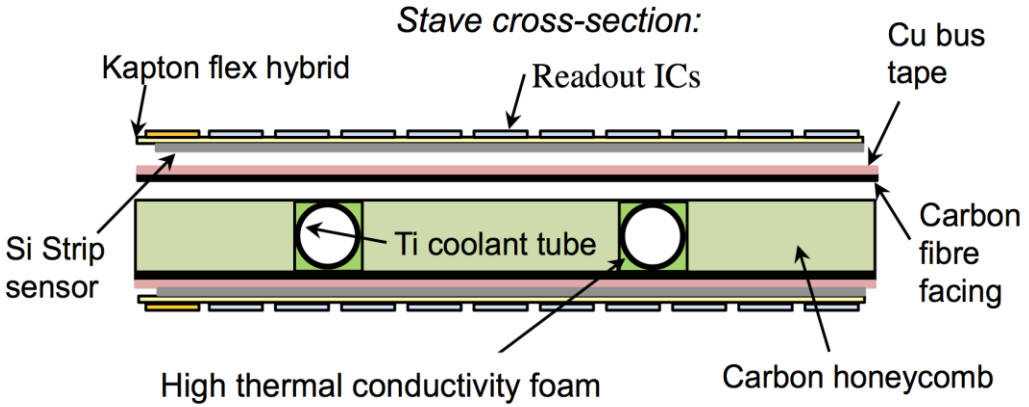


The building blocks: local support



Modules are glued into a local support. This is a high precision operation.

The building blocks: local support

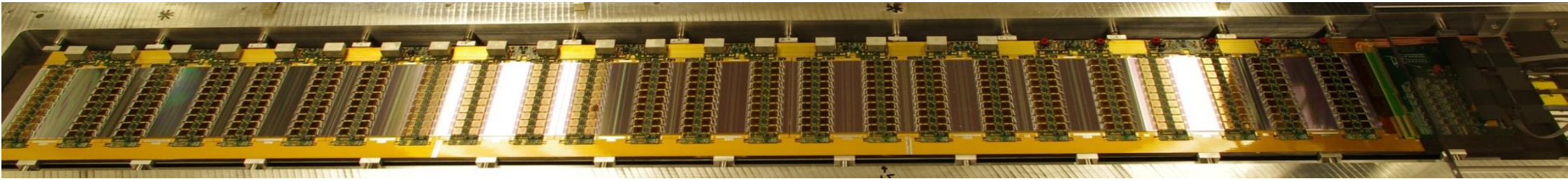


The local support is a double sided, 1.2 m long (for the barrel), 6 mm thick object

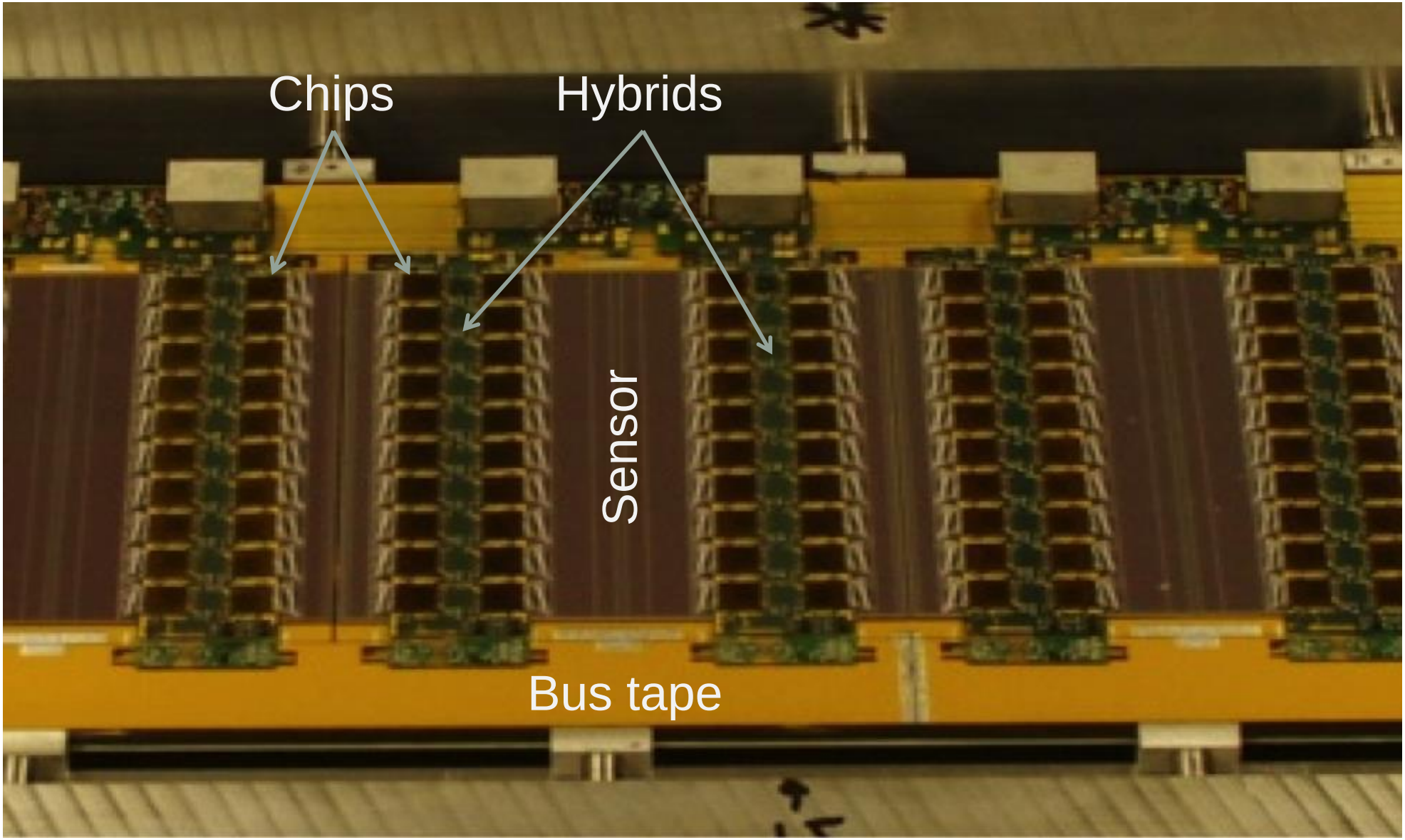
Building blocks: prototype staves

Double sided 8 module stavelet

12 module stave

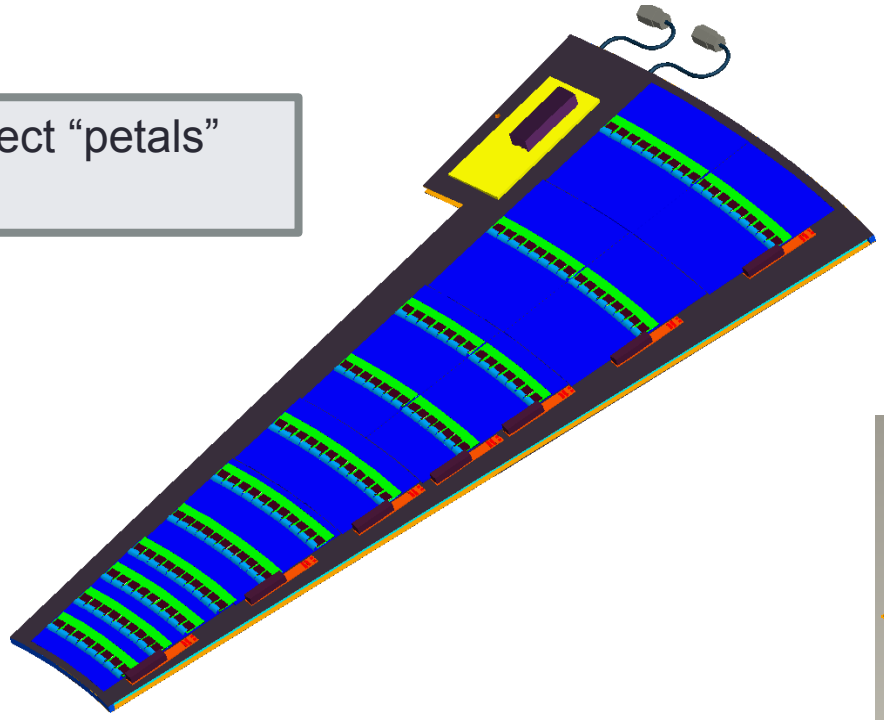


Building block: prototype staves

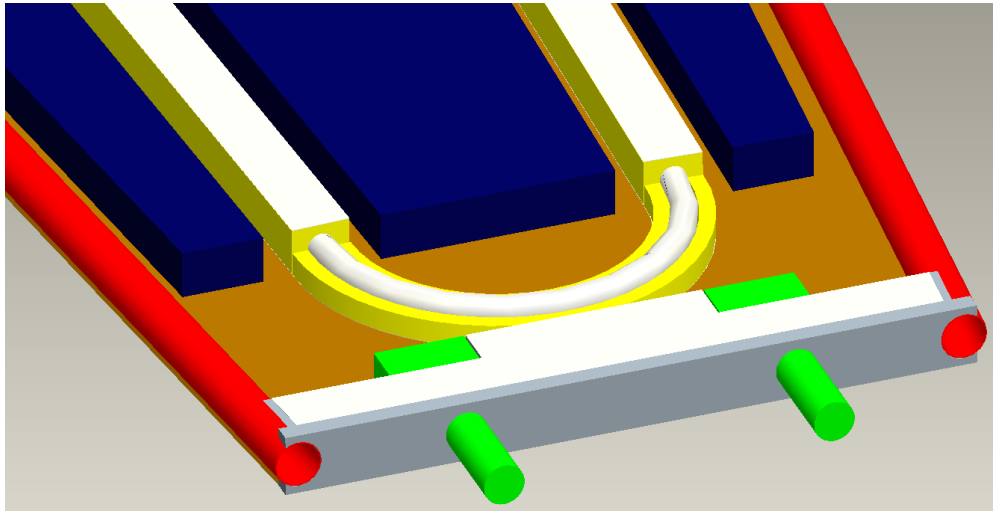


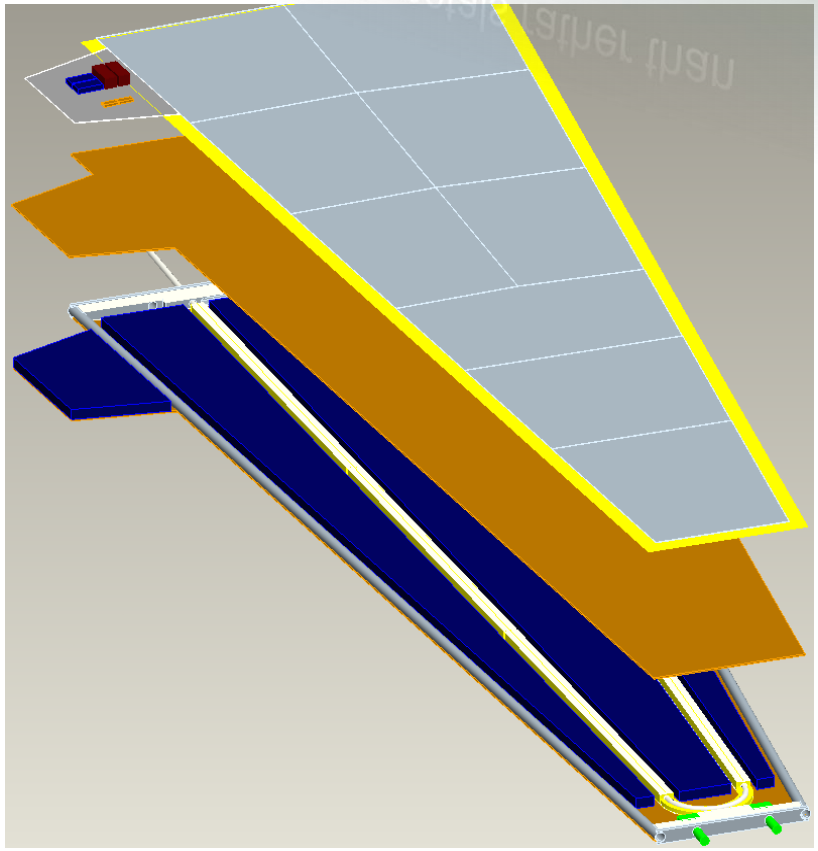
The building blocks: the petals

We need 448 perfect “petals” for the 2 endcaps

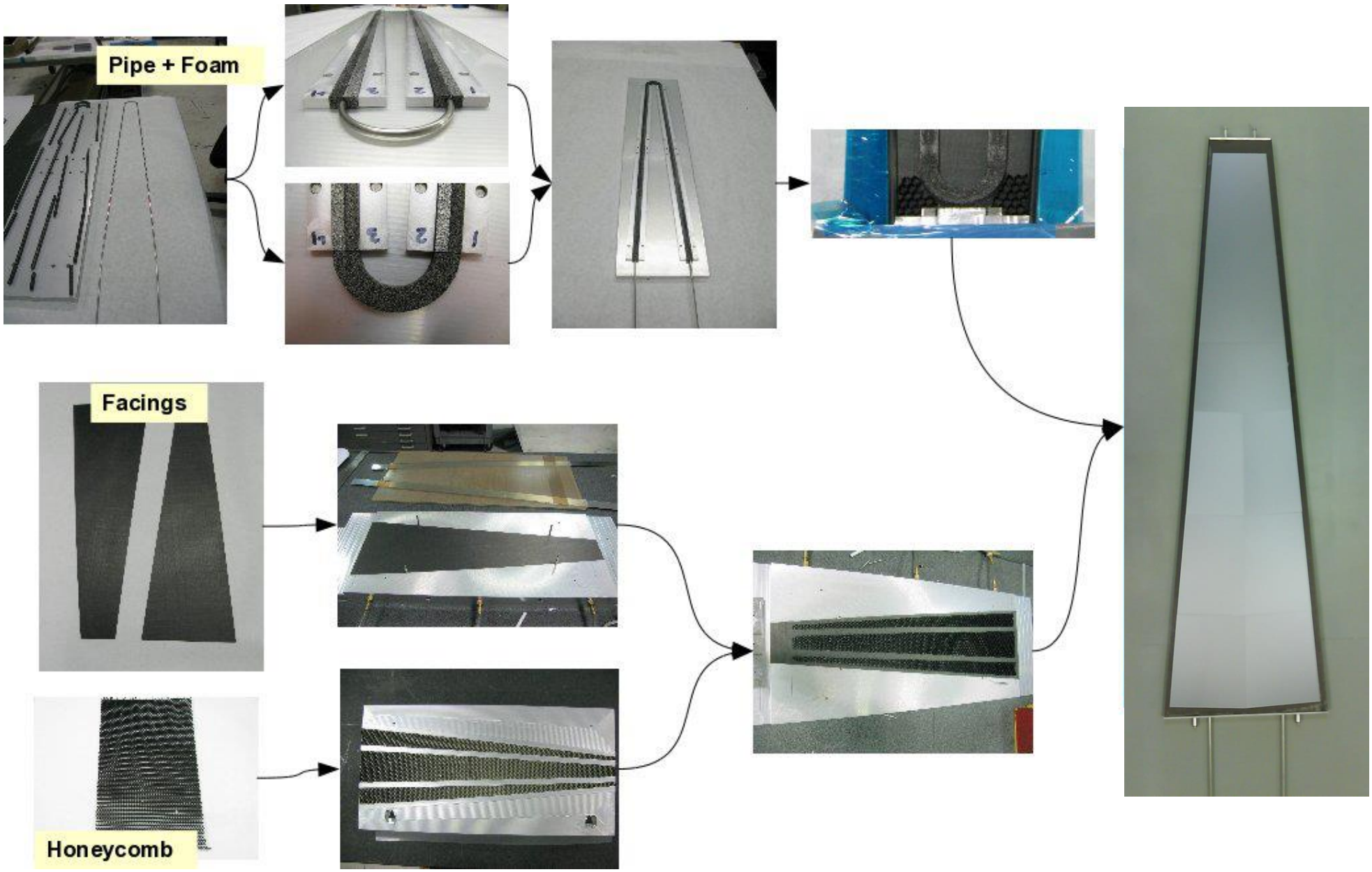


The concept in the endcap is very similar. We call the local supports petals rather than staves.

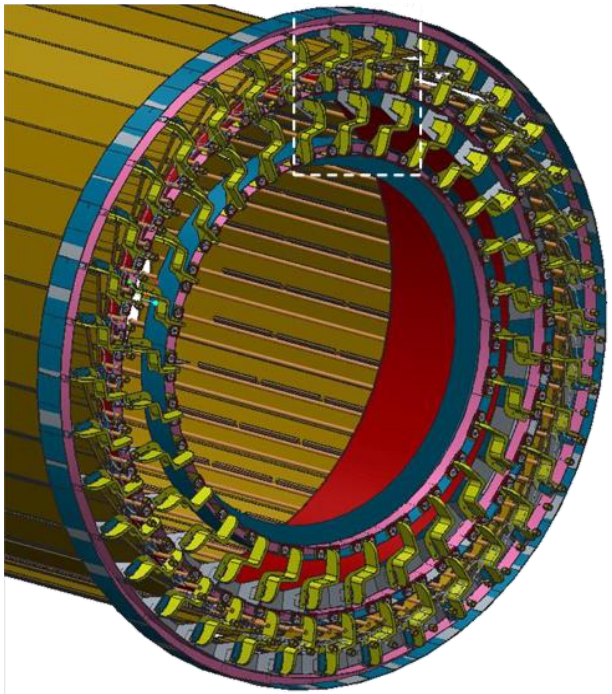


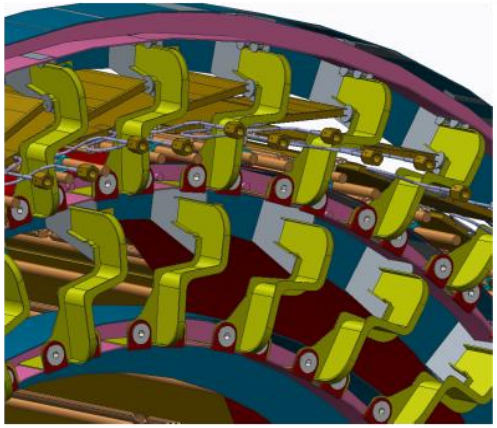


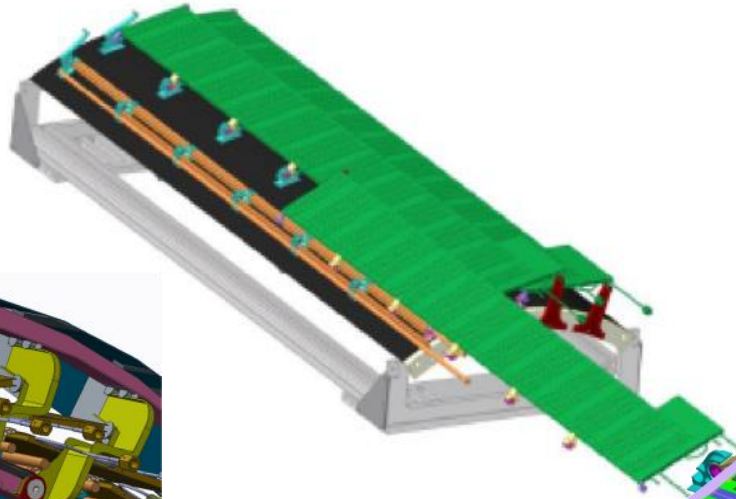
The building blocks: the Petals

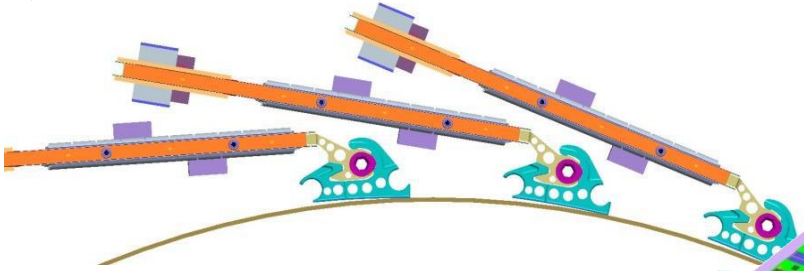


The Barrel





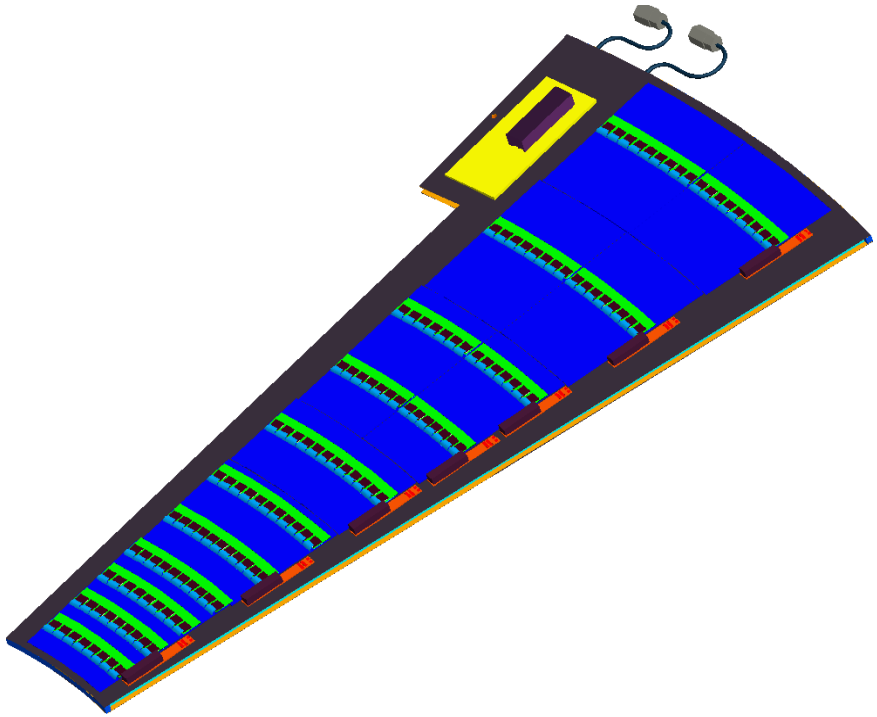


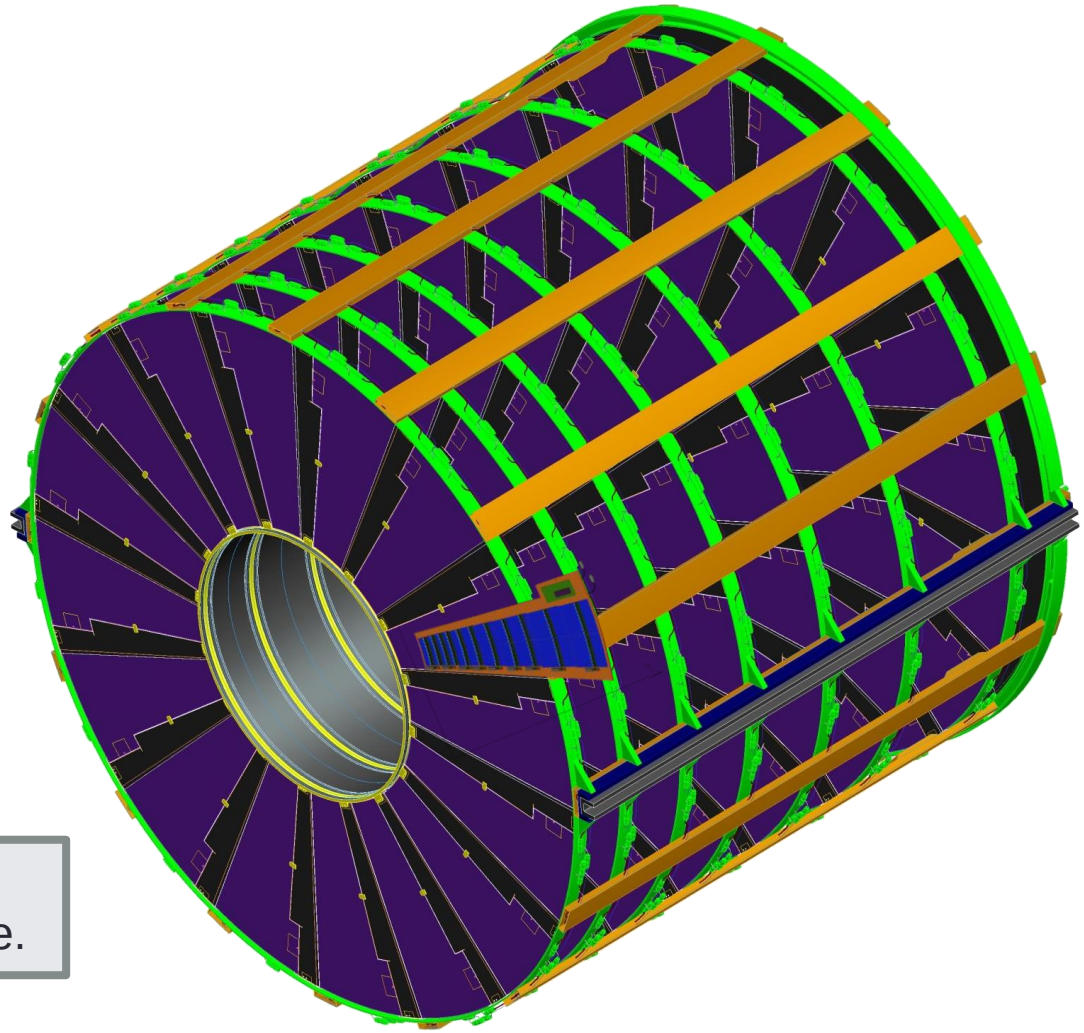


472 perfect “staves” are needed for the four cylinders in the barrel.

Of course we also need the cylinders, the interlinks …

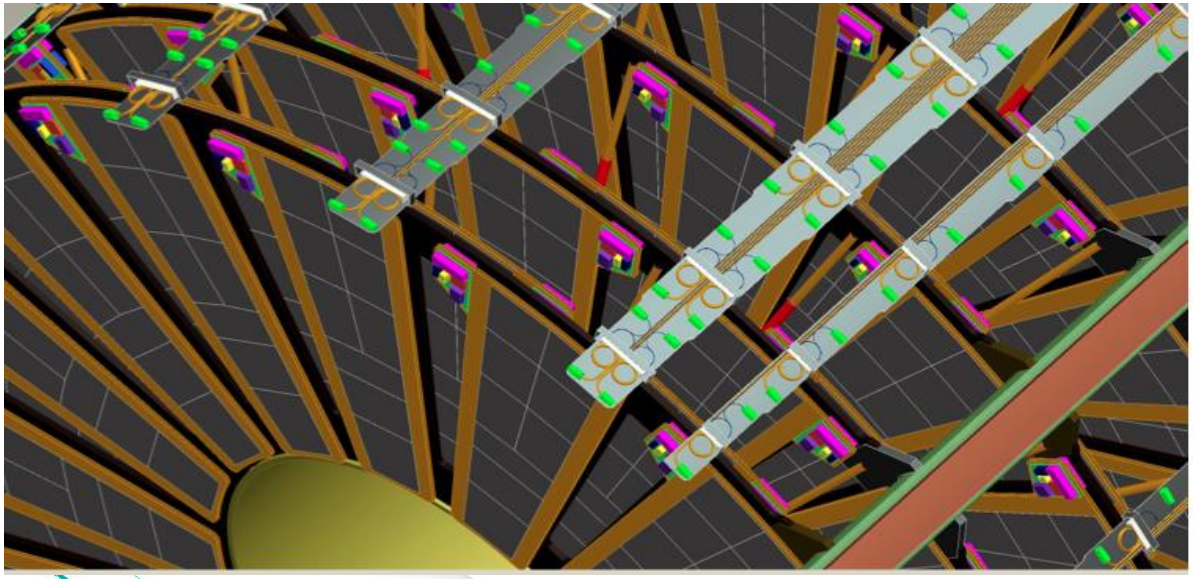
The Endcaps



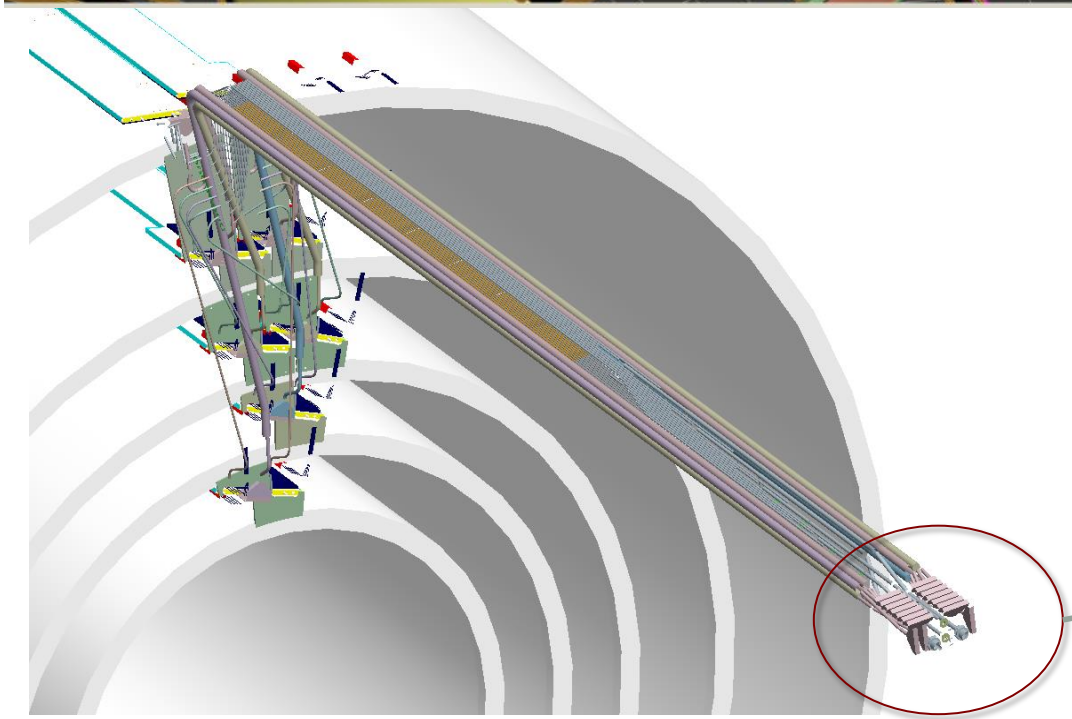


448 petals needed for the two endcaps
We have to build the disks, the structure.

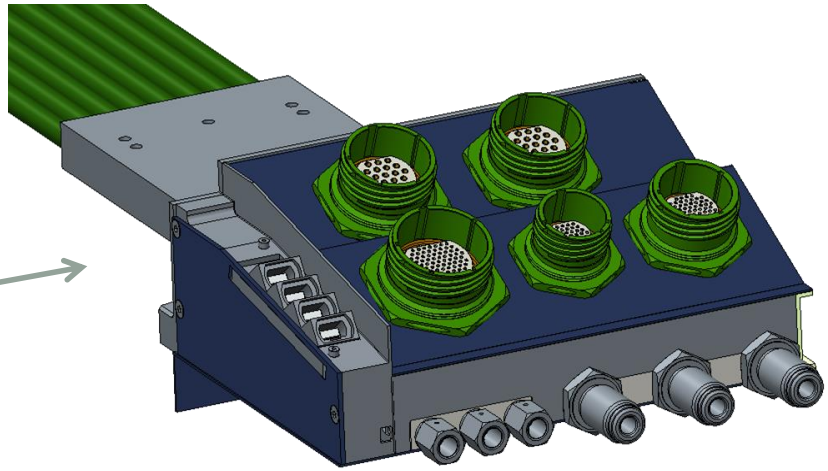
Services



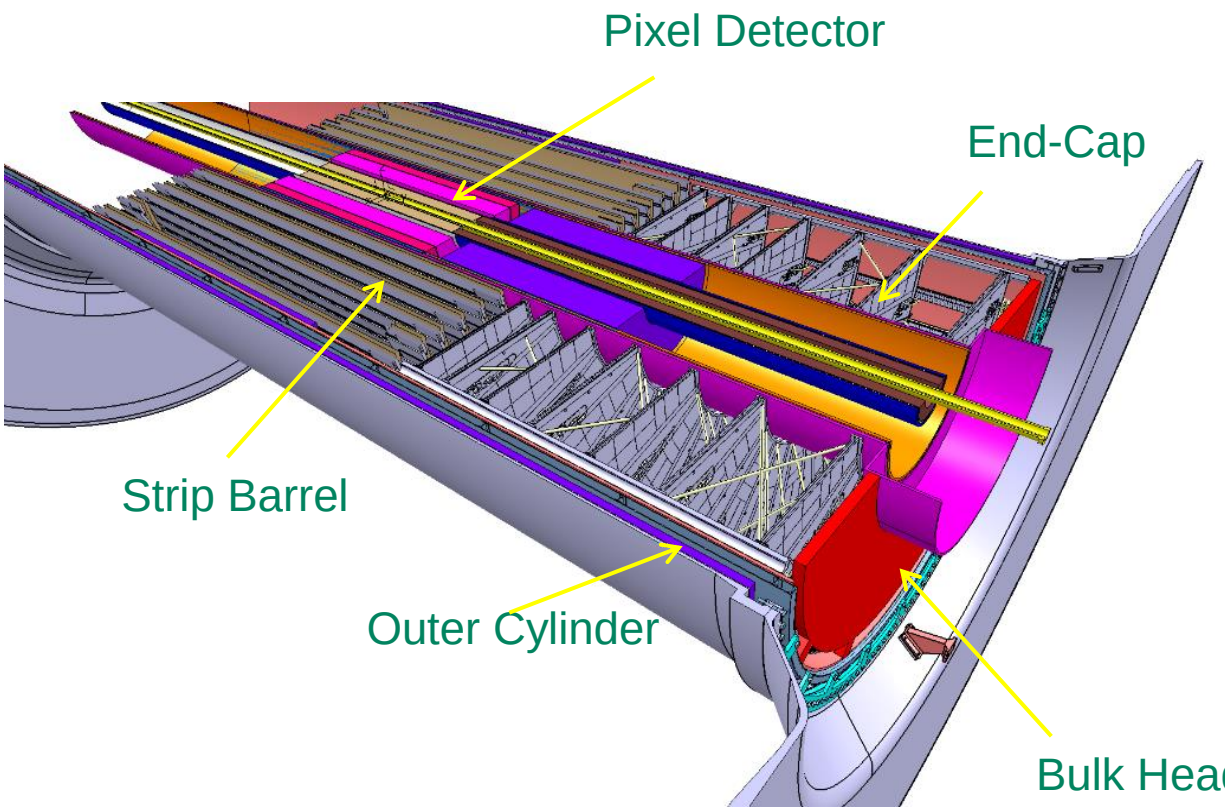
All these fancy objects need control signals, power, cooling and a way for the data… This is provided by the services.



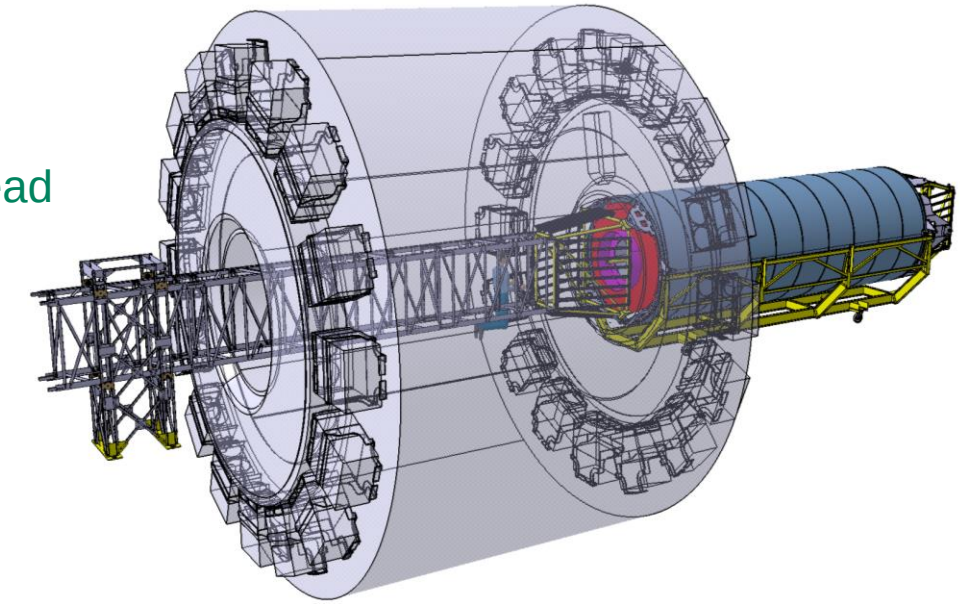
A large project that needs to be done hand by hand with industry where we need to design cables, connectors, etc.



The Outer Cylinder

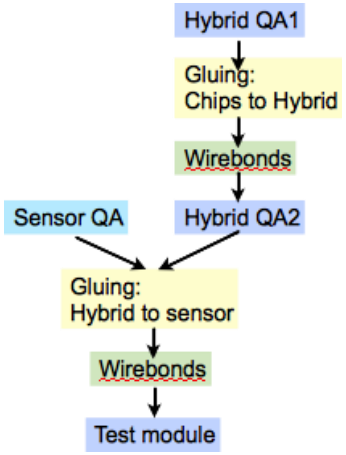


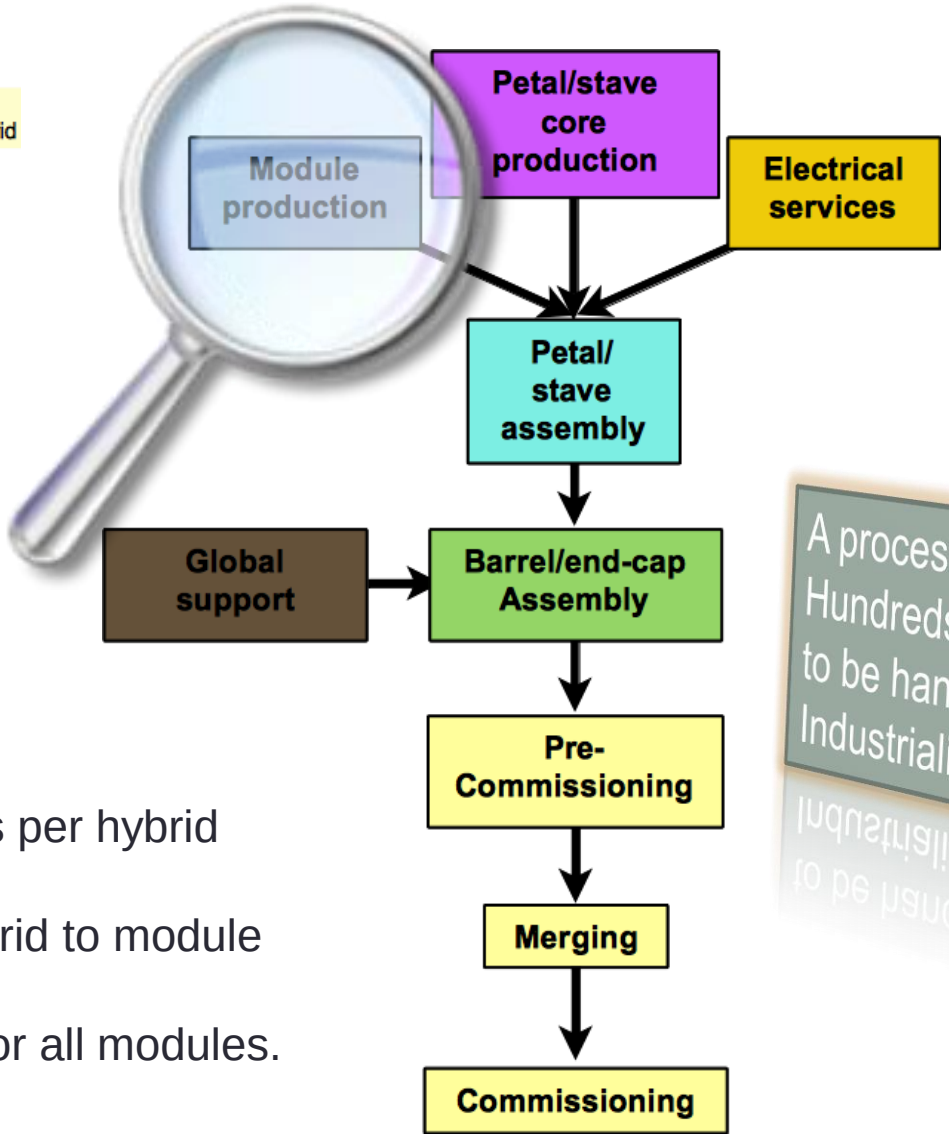
The 2 endcaps and the barrel are, together with the pixels, contained and supported by the Outer Cylinder.



This 6m long, 2.2 diameter assembly has to be stiff enough to now show deformations bigger than a few micro meters.

Organizing the production



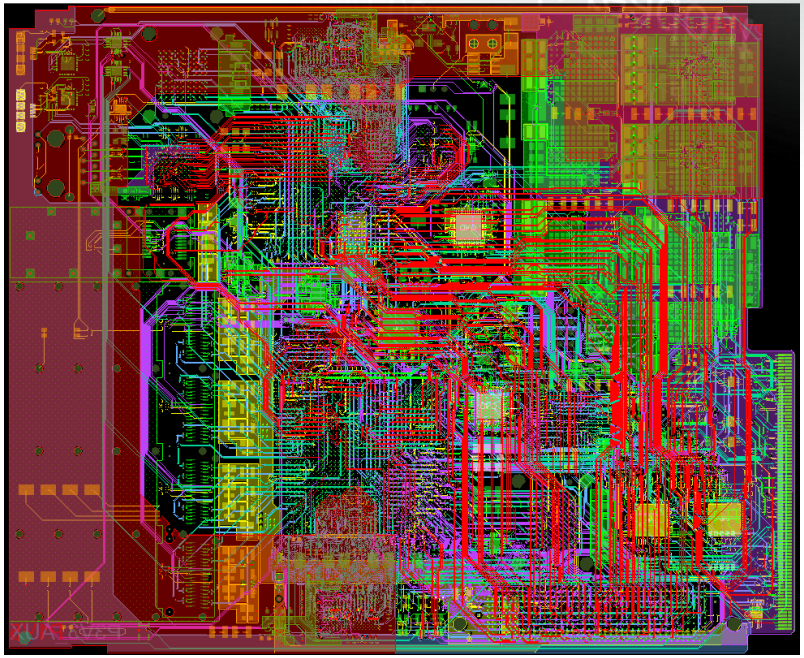


A process that needs about 3 years
Hundreds of thousands parts need to be handled
Industrialization is essential

- We need 24000 modules (barrel+endcap)*yields
- 37260 hybrids with ~10 chips per hybrid require 10-11 bonder years
- Additionally ~45 years of hybrid to module bonds.
- In total 50-55 bonder years for all modules.
- Quality assurance tests….
- ….

Other upgrades

Other parts of the detector do not need to upgrade the "sensing part", but need to upgrade the whole readout electronics



ATLAS Tile Calorimeter

Up Link only	Present	Upgrade
Total BW	~ 165 Gbps	~80 Tbps
Nb fibers	256	8192
Fiber BW	640 Mbps	10 Gbps
Nb RODs	32	32?
ROD Crates	4	4
In BW/ROD	5 Gbps	2 Tbps
Out BW/ROD $_{DAQ}$	2,56 Gbps	~ 5 Gbps
Out BW/ROD $_{L1}$	Analog FE	< 80 Gbps

Summary

- ➔ I believe there is also a lot to contribute during the production of the new detectors on the coming upgrade for the HL-HLC
- ➔ This was just an example, but I hope it gave the right picture. Things are very similar for all the experiments.
- ➔ This requires, however, a close collaboration with the scientists at home (Spain).

Spanish Groups at CERN's Experiments

ATLAS:

IFIC: Carmen García, Carlos Lacasta y Juan Valls
IFAE: Sebastian Grinstein, Mario Martínez,
UAM: Juan Terrón
CNM: Giulio Pellegrini

CMS:

IFCA: Ivan Vila,
CIEMAT: MaryCruz, Juan Alcaraz,
UAM: Jorge Fernández de Trocóniz,
Oviedo: Javier Cuevas

LHCb:

USC: Abraham,
UB: Eugeni,
U. Ramón Llull: Xavier Vilasis,
IFIC: Fernando Martínez

ALICE:

USC: Elena Ferreira

CAST:

CAST: Igor García Irastorza

En las facilities:

ISOLDE: Maria Jose
nTOF: Daniel Cano

GRID:

IFAE: Manuel Delfino (Tier1), Andreu Pacheco,
IFIC: Jose Salt,
UAM: Jose del Peso
IFCA: Francisco Matorras,
CIEMAT: Jose Flix (Tier1), José María Hernández
UB: Ricardo Graciani,
USC: Juan José Saborido