HGTD - Interlock

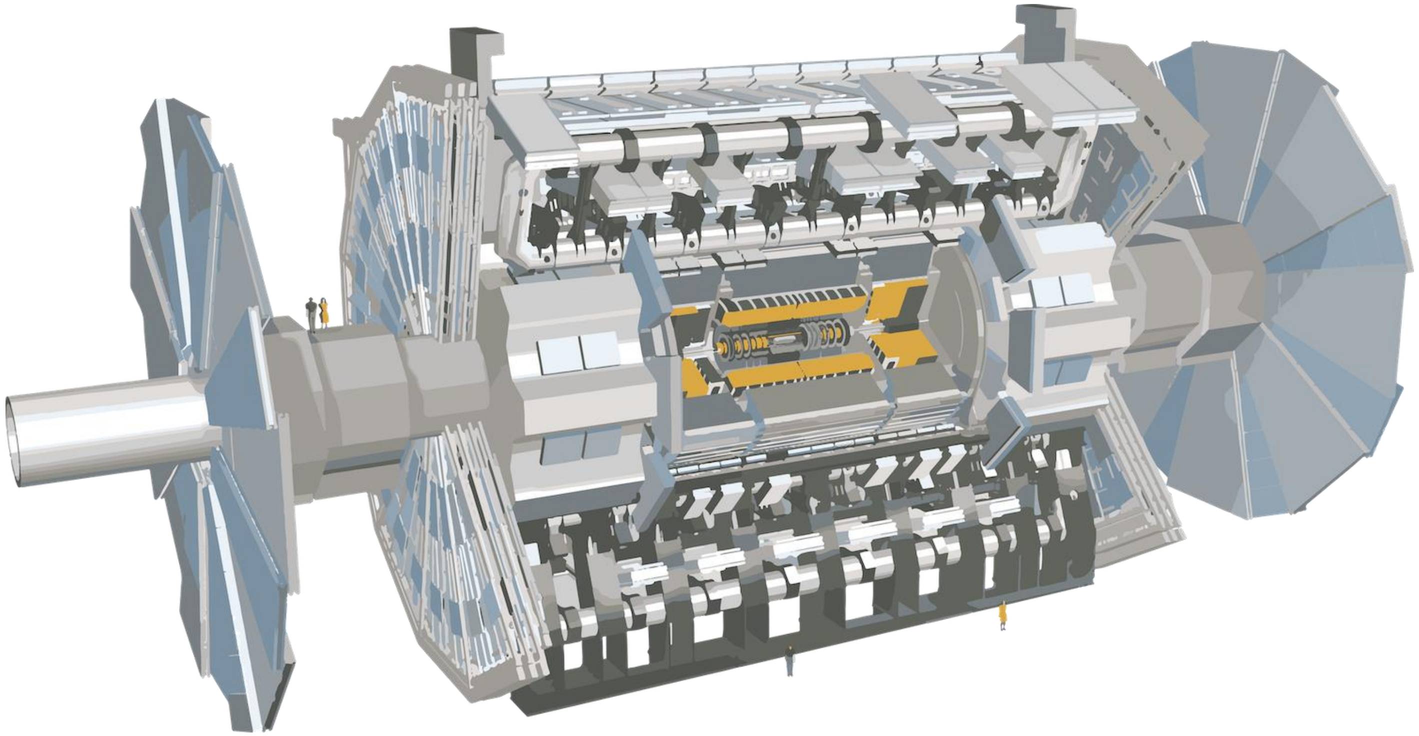
LIP Summer Internships 2023

Joana Rodrigues

LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS

Altas detector

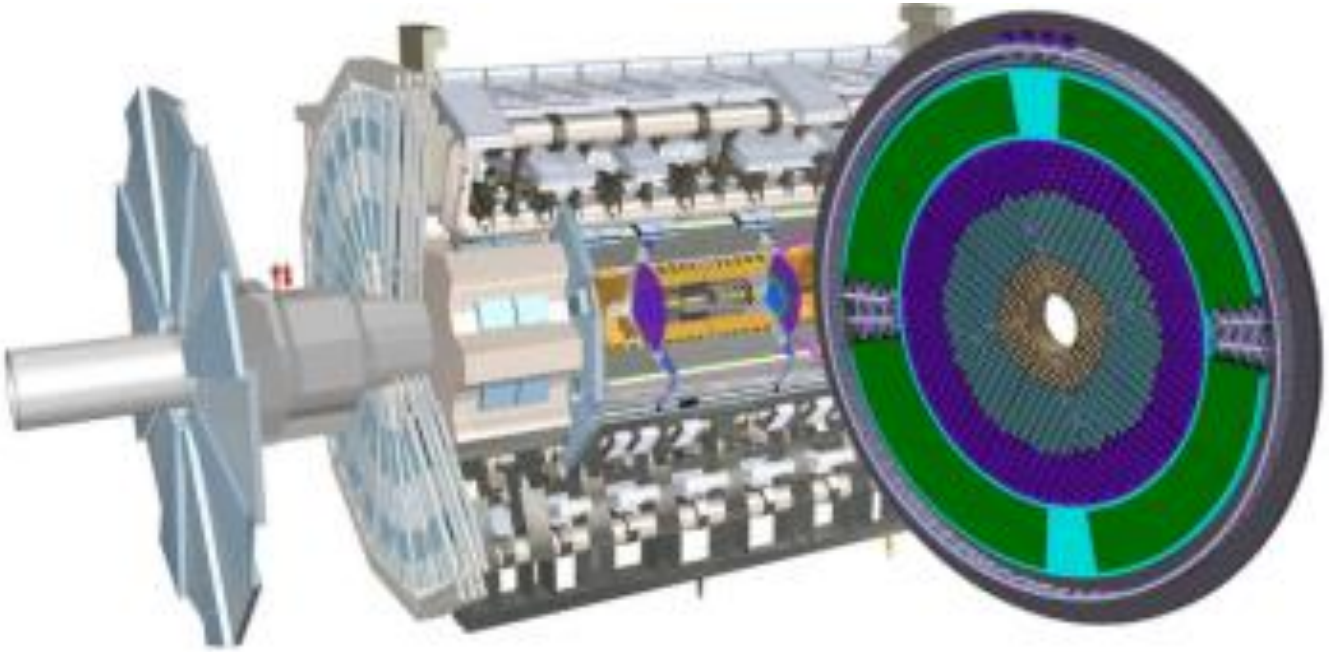
ATLAS is one of two general-purpose detectors at the Large Hadron Collider (LHC). It investigates a wide range of physics, from the Higgs boson to extra dimensions and particles that could make up dark matter. At 46 m long, 25 m high and 25 m wide, the 7000-tonne ATLAS detector is the largest volume particle detector ever constructed.



High Granularity Timing Detector - **HGTD**

The purpose of the High Granularity Timing Detector (HGTD) is to measurement of track time with an accuracy of better than 50 ps and provide information about luminosity.

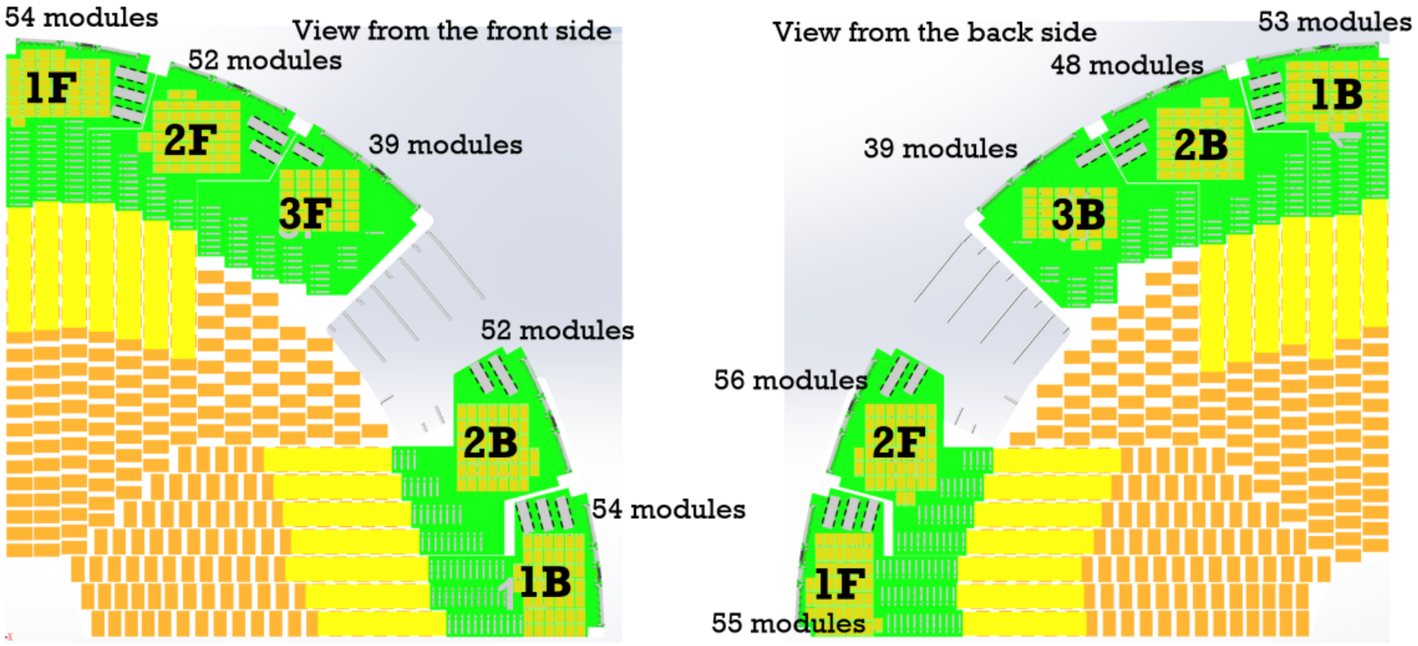
The HGTD consists of two hermetic vessels. These vessels have cylindring shape with inner holes. Inside each vessel, there are two cooled disks on both sides at which Low-Gain Avalanche Detectors (LGAD) are mounted.



High Granularity Timing Detector - **HGTD**

HGTD sensors use Low Gain Avalanche Detector (LGAD) technology, connected via flex cables to Peripheral Electronic Boards (PEB) for control. These sensors are mounted in electronic boards and receive high voltages (900 V). Low voltages for digital components are also needed.

Each quadrant and side of the HGTD is handled by five different PEBs, as shown bellow.



High Granularity Timing Detector - **HGTD**

In general, these are the components that exist in the HGTD:

- PEBs: 160 (80 per vessel)
- Modules with mounted LGADs: 8032
- LV channels: 320 (2 per PEB)
- LV modules: 40 (each with 8 channels)
- HV crates: 40

It is very important to know their locations and distribution in order to determine which components to disconnect in case of a failure or overheating.

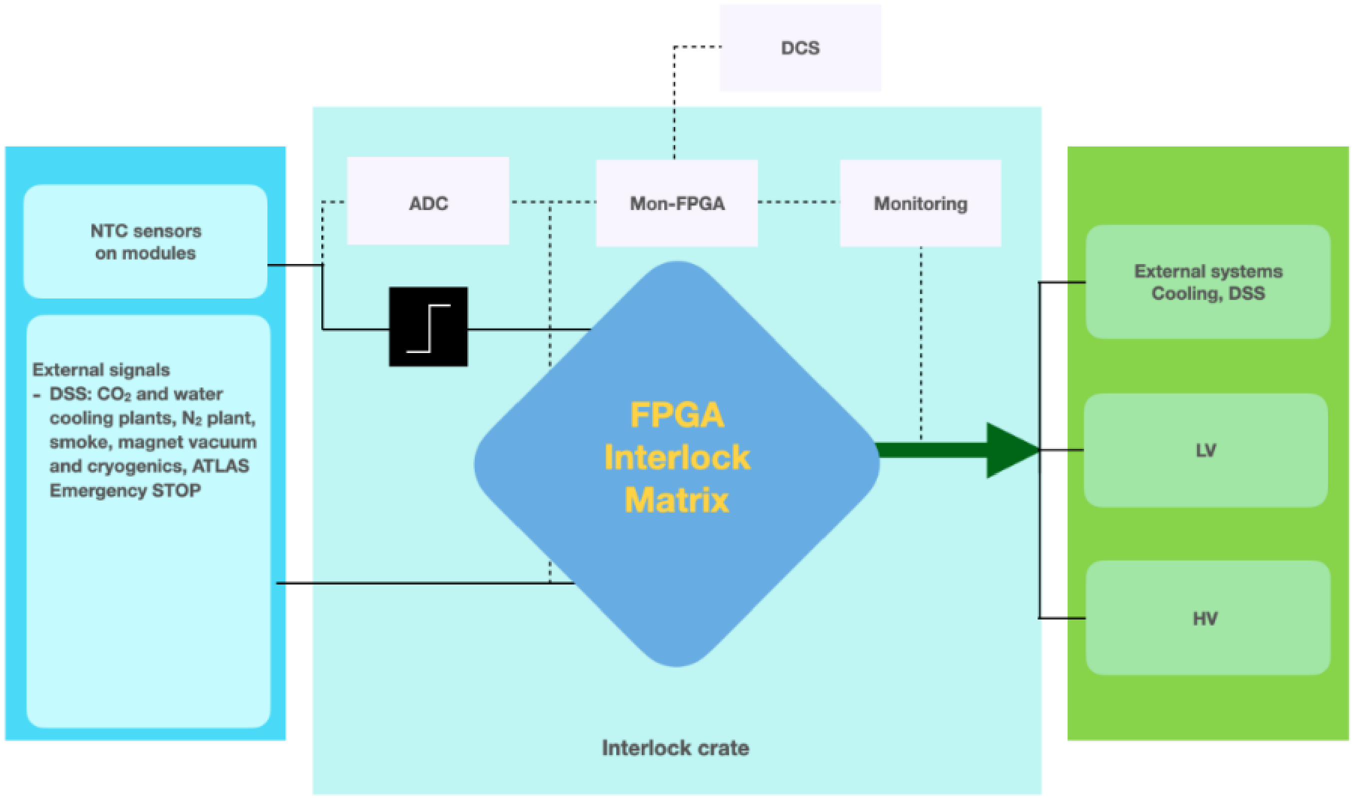
HGTD Interlock System

The HGTD Interlock System (HIS) is a standalone safety system that protects the detector against a variety of risks.

There are primarily 2 kinds of dangers to be handled by interlocks:

- Overheating;
- Danger to the entire detector due to unstable beam, a failure in the cooling system, or smoke etc;

HGTD Interlock System

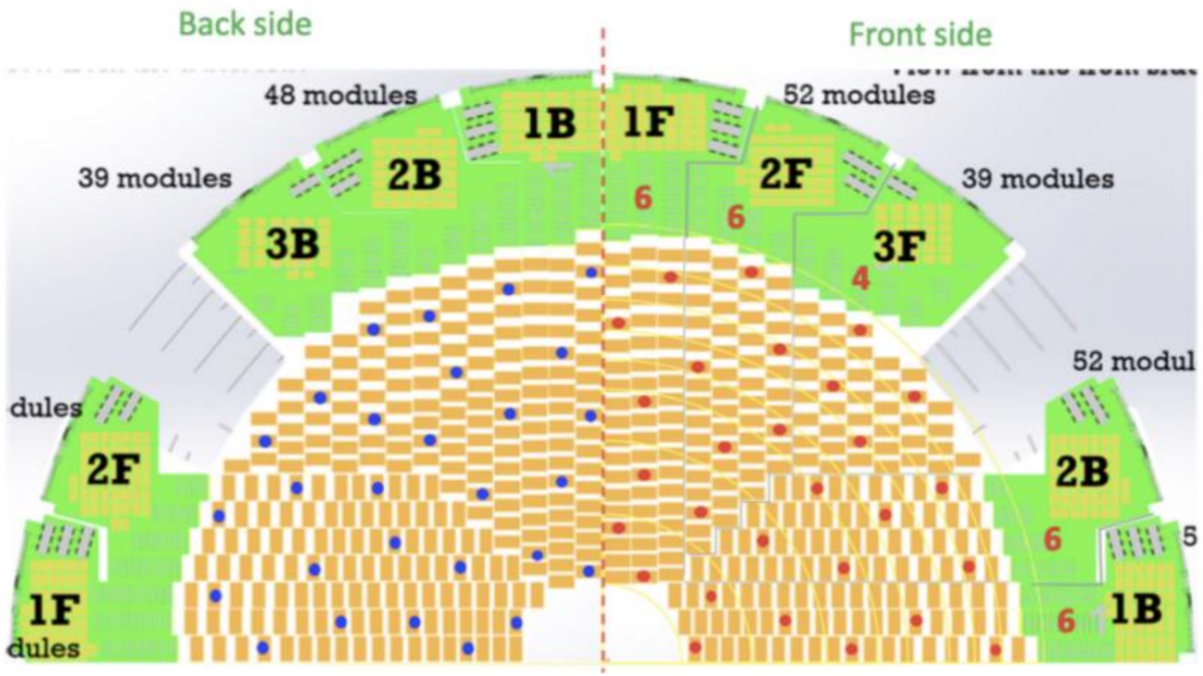


- On the left there are detectors that recognize threats from which protection is needed.
- On the right are the devices that should be switched off.
- The central part is the interlock crate, which contains FPGA, the program of which defines the interlock matrix.
- For debugging purposes, the monitoring system built keeps track of analog values from temperature sensors, signals transmitted to power supplies, and all signals from/to external systems.

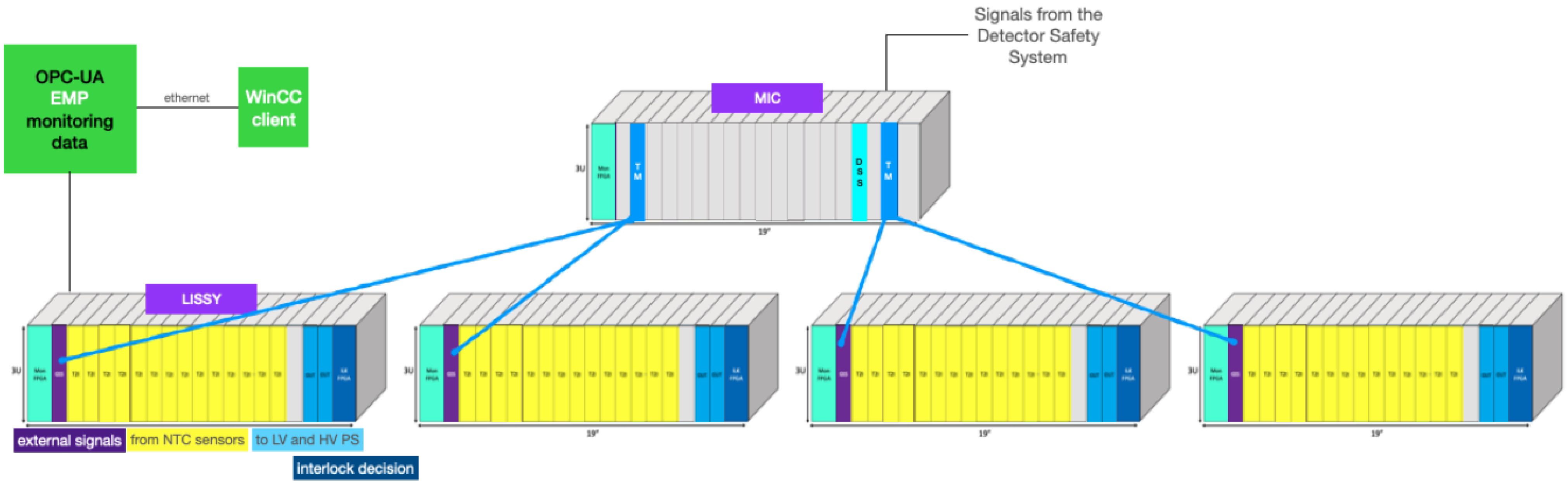
HGTD Interlock System

Thermistors with a negative temperature coefficient (NTC) will be used as temperature sensors on module FLEXes due to their high radiation hardness and the large signal they produce, which allows signals to be transmitted over long distances. These NTCs will be connected to the PEBs.

Due to cable limitations, there will only be one NTC for every 9 modules.



HGTD Interlock System



The HGTD Interlock system consists of one Main Interlock Crate (MIC) and 4 Local Interlock & Safety SYstem (LISSY) crates.

The LISSY houses one Interlock Logic (ILock-FPGA) module, one Monitoring (MON-FPGA) module, one Global Safety Signals (GSS) module, and up to 17 IO modules: Temperature to Interlock (T2I) modules and interlock output (OUT) modules.

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The work I conducted this summer consisted in the organization of all the components and their associated with an NTC so that they can easily be disconnected when necessary.

PEB	nº of PEBs	LV channels	nº of modules (Front-side)	nº of NTCs (Front-side)	nº of modules (Back-side)	nº of NTCs (Back-side)
1F	8	16	216	24	220	24
2F	8	16	208	23	224	25
3F	4	8	156	18	-	-
3B	4	8	-	-	156	18
2B	8	16	208	23	192	21
1B	8	16	216	24	212	24
Total	40	80	1004	112	1004	112

Distribution for one disk.

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Next, it was necessary to separate the Low Voltage channels into modules and distribute the High Voltage crates. This is essential because of the Interlock functionality with granularity of 6–8 channels.

First vessel				Second vessel			
nº of PEBs	LV channels	LV modules	HV crates	nº of PEBs	LV channels	LV modules	HV crates
16	32	4	4	16	32	4	4
16	32	4	4	16	32	4	4
8	16	2	2	8	16	2	2
8	16	2	2	8	16	2	2
16	32	4	4	16	32	4	4
16	32	4	4	16	32	4	4

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Finally, I developed a C program that determined the location of the NTC and indicated the specific Low Voltage and High Voltage connections for the LGADs around that NTC.

To achieve this, I assigned a name to each NTC. For example,

```
Enter the name: VC2BPEB2BNTC607

Vessel C, Quadrant 2B, PEB type 2B, NTC 607.

The LGADs modules around this NTC are connected to the LV module 29 and HV crate 29C.
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With this program, when an NTC sends a danger signal, it's possible to determine immediately which LV module and HV crate have to be disconnected.

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- This internship allowed me to gain a deeper understanding of the work conducted at LIP.

 - It also improved my capacity to select and organize information;

-Working on this project was very interesting and I would like to develop more projects in this field.