CSI Presentation

Liquid Argon Calorimeter software development and update on search for new physics in the dilepton channel

Supervisor : Tetiana Hryn’ova
CSI : Fawzi Boudjema from LAPTH & Corinne Goy from LPSC
Tutor : Edwige Tournefier

PhD in the ATLAS experiment

OUTLOOK

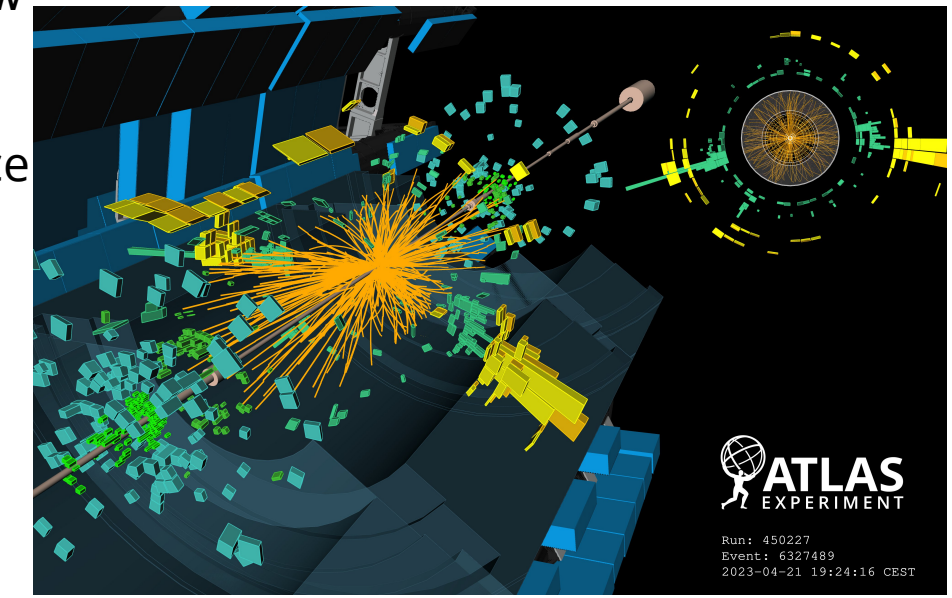
- Qualification task —> Become ATLAS author
  - **Liquid Argon Calorimeter** project : **Development** in the LArgOnline software.

- Main topic of my PhD
  - Search for new physics in the dilepton final state

Qualification task :

I - RUN-3 LHC running condition

- Since 2022, **LHC** has restarted after 2 years of shutdown, and is now delivering beams at **6.8 TeV**
- The number of protons interacting at 40 MHz has **increased** since Run 3 (up to 60 interactions)
- Higher **occupancy** makes it more difficult to identify interesting events
- During **LS2**, a new trigger readout with **finer granularity** was installed for the liquid Argon Calorimeter



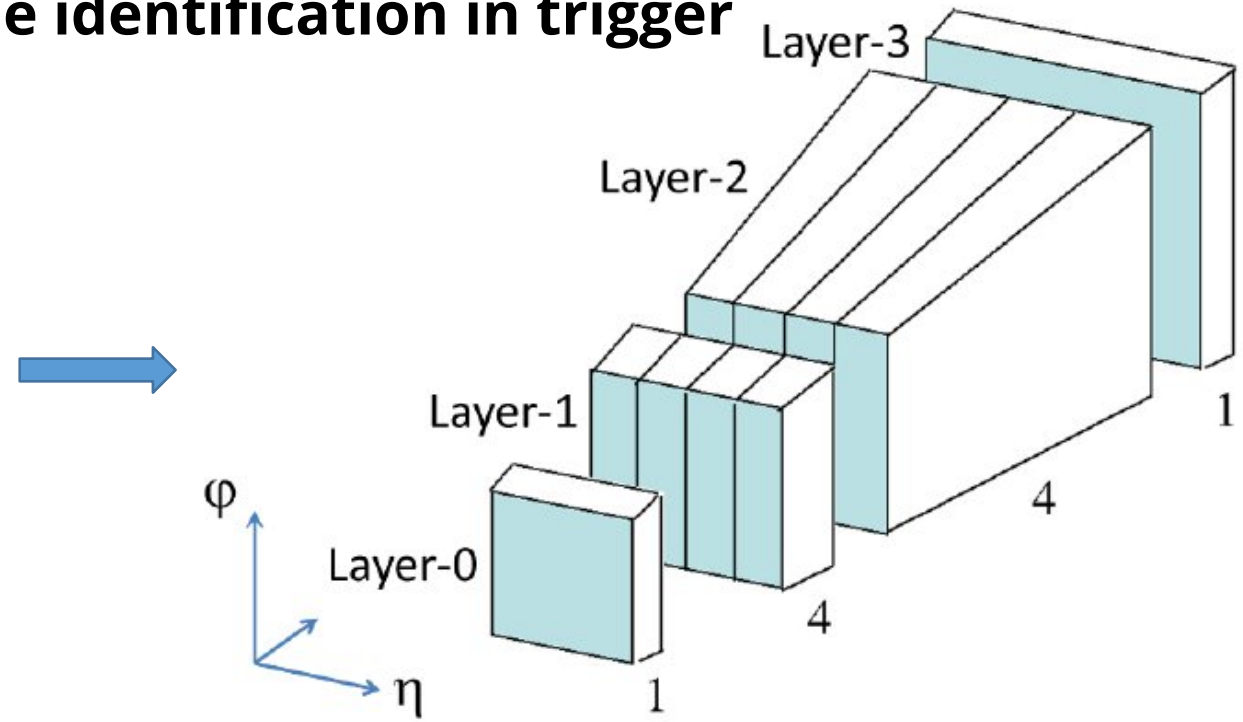
Event display of a collision event (Run number 450227, Event number 6327489) recorded by the ATLAS experiment on 21 April 2023, when stable beams of protons at the energy of 6.8 TeV per beam were delivered to ATLAS by the LHC.

Qualification task

II - Development in the LArgOnline software
II - 1 - Phase-1 Upgrade

- Passing from ~**7k** Trigger Towers to ~**34k** Super Cells
- Allows to have a **better particle identification in trigger**

Sub division of 1 Trigger tower into 10 Super cells

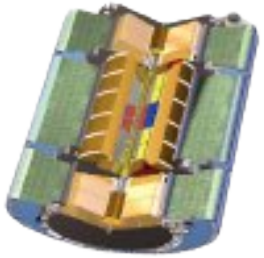


Qualification task

II - Development in the LArgOnline software

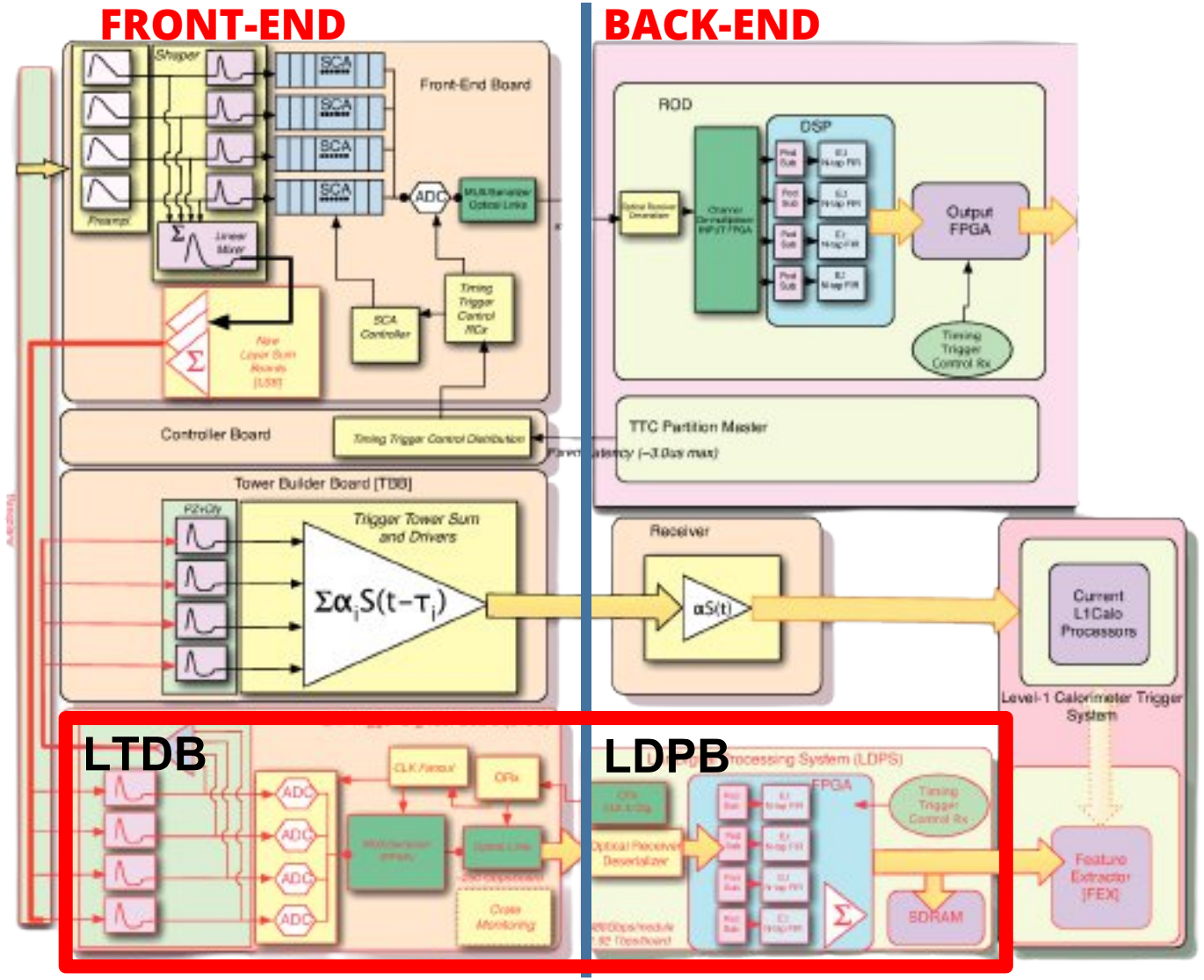
II - 1 - Phase-1 Upgrade

LAr Calorimeter cells



Legacy readout system

Digital trigger readout system

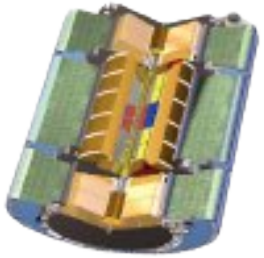


Qualification task

II - Development in the LArgOnline software

II - 1 - Phase-1 Upgrade

LAr Calorimeter cells



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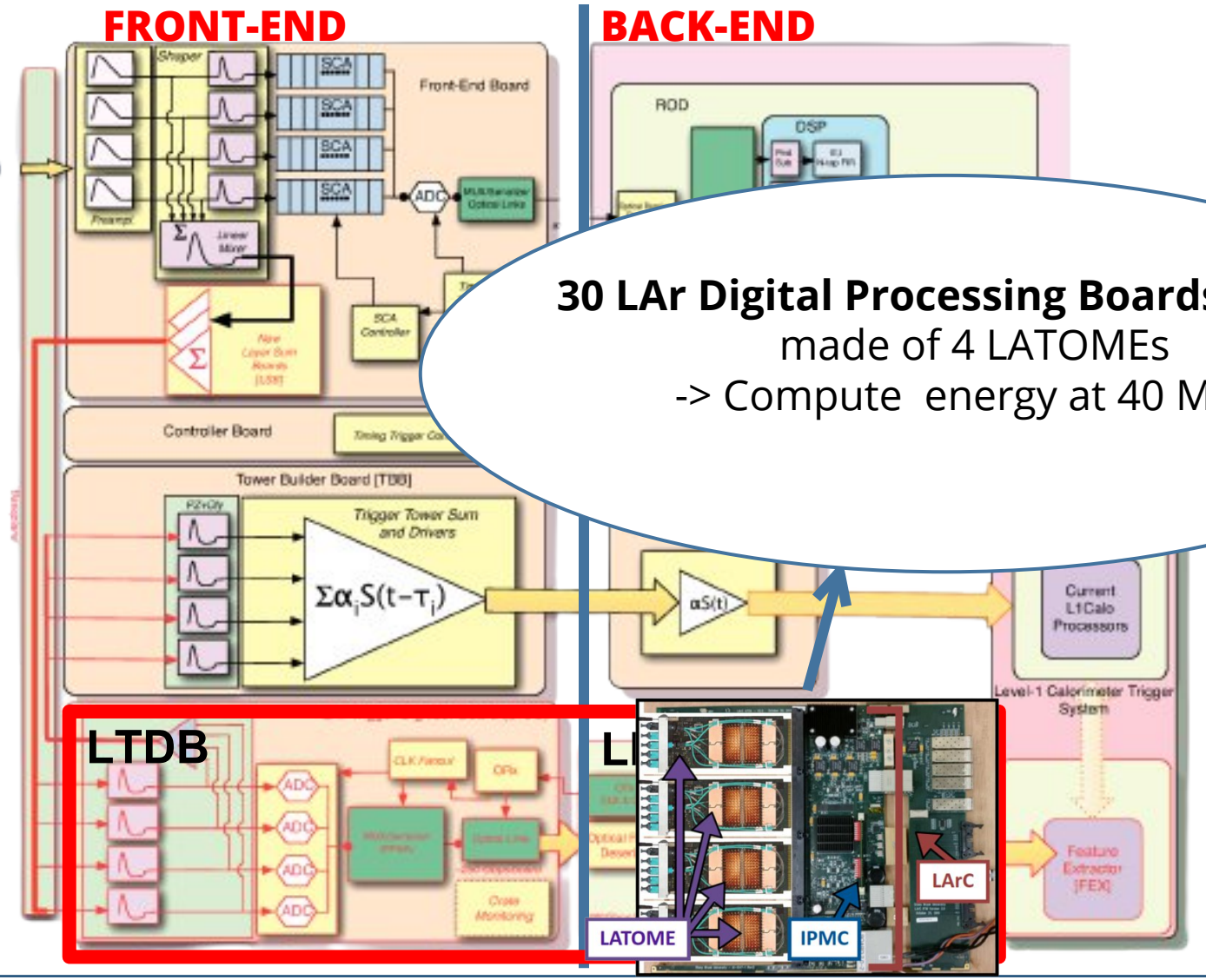


30 LAr Digital Processing Boards (LDPBs)
made of 4 LATOMEs
-> Compute energy at 40 MHz.

Qualification task

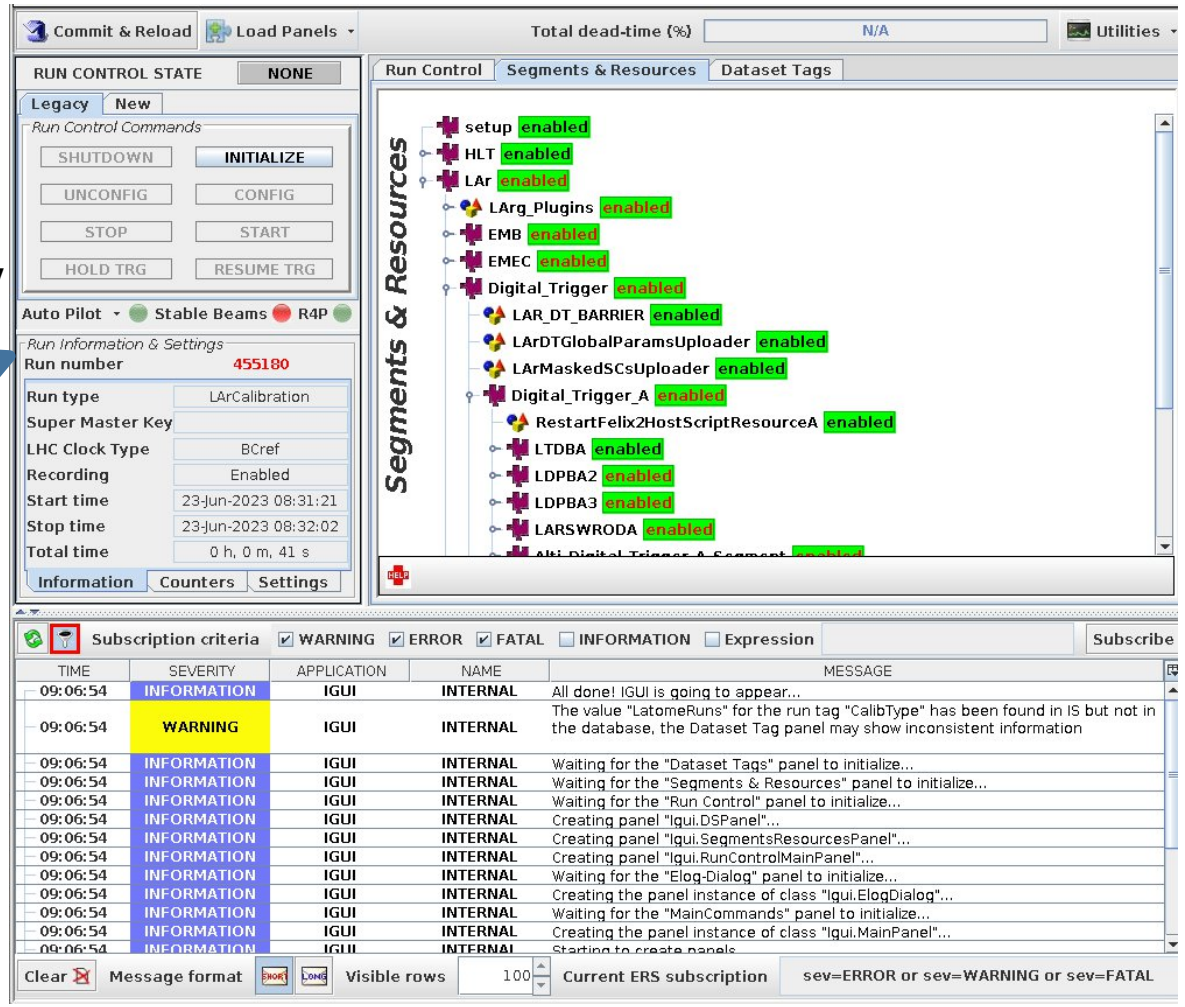
II - Development in the LArgOnline software
II - 2 - LArgOnline software

- Physicist/engineers at LAPP have been in charge of the development of many packages of the **LArgOnline** software
  - Responsibility of the LAr LAPP group to maintain it

- Software allows to perform the data-taking —> **99/98% efficiency** during Run 2/3

- Designed in 2004:
  - 185400 C++ lines of code
  - 30100 JAVA lines of code
  - Spread over 54 packages

- Performs :
  initialization : automatic
  configuration : depend on expert inputs
  calibration : perform by shifter (expert request)
  monitoring : implement by expert for shifters (plots, alarms..)

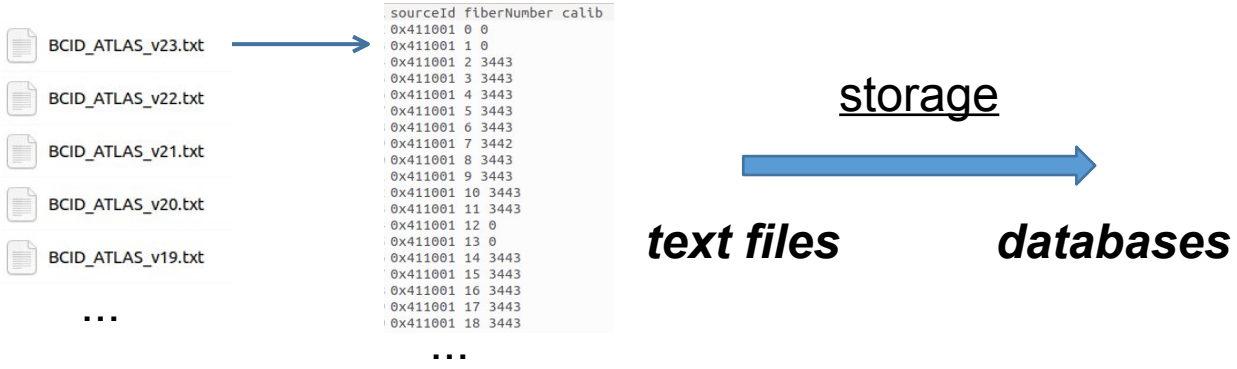


Qualification task

II - Development in the LArgOnline software
II - 3 - Updated procedure to configure the LATOME boards

- Developed new code for the **configuration** of **Latome boards** (116 in total).

Some configuration parameters are time dependant



Time stamp IOV

0:/LAR/Configuration/SCConfig/BCID

ChannelId	Since:[Run|Lumi Block]	Until:[Run|Lumi Block]	BCIDconstants
0	399640 | 0	403910 | 0	Blob
0	403910 | 0	414514 | 0	Blob
0	414514 | 0	416220 | 0	Blob
0	416220 | 0	418257 | 0	Blob
0	418257 | 0	424311 | 0	Blob
0	424311 | 0	424431 | 0	Blob
0	424431 | 0	427083 | 0	Blob
0	427083 | 0	431177 | 0	Blob
0	431177 | 0	438099 | 0	Blob
0	438099 | 0	438410 | 0	Blob
0	438410 | 0	2147483647 | 429496...	Blob

object packing the values of the parameters for a given IOV

Databases allow to have a record with a **time stamp IOV** for the values of each parameters

- Dedicated package to decode the content of the **databases**

Added new functionality to read parameters moved from text files to databases

IOV : interval of validity

Qualification task

II - Development in the LArgOnline software
II - 4 - Parameters of interest

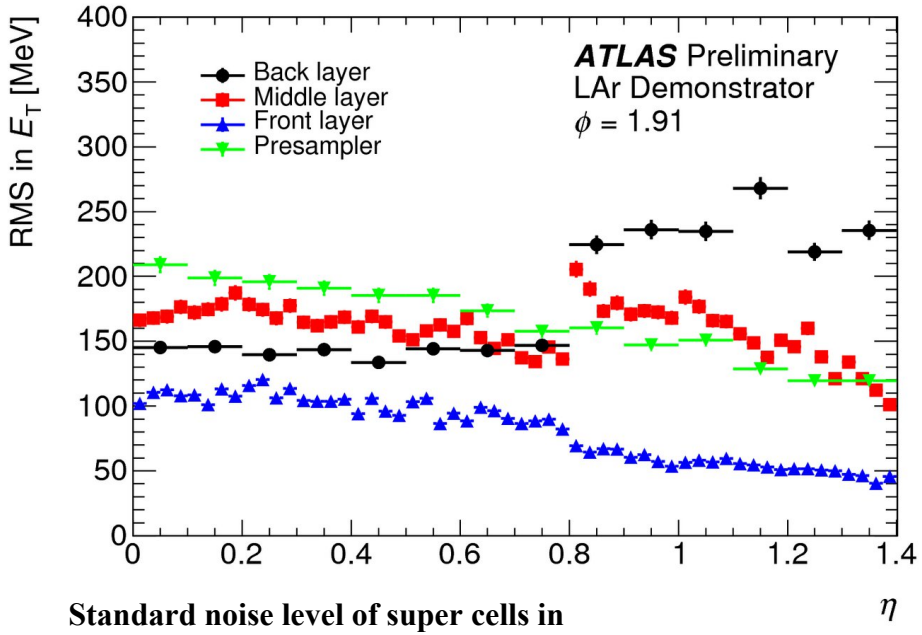
❖ Among these parameters, LAPP team worked on :

➢ **Masking of noisy Super Cells** and **Energy thresholds** :

- Super Cells can be noisy and therefore affect the computation of the energy that can trigger with an higher rate uninterested events.
- If the measured energy is above a certain threshold, need to apply a masking

Some are permanently masked (0.2%) and some are masked on-the-fly during data tacking.

If the noise is not persistent, they can be unmasked.

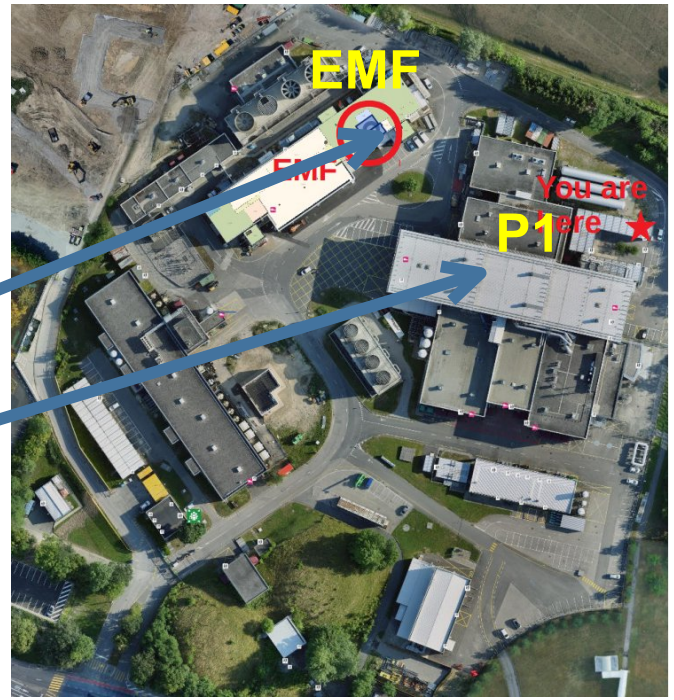


Standard noise level of super cells in transverse energy

➢ I worked on other parameters which are **hardware dependant**
  ➢ For example the change of optical fibers or LATOME boards

Qualification task

II - Development in the LArgOnline software
II - 5 - Testing



- **Integration** of new code :

During data-taking, ATLAS is running ~24/24h
Difficult to find a time slot for testing

-> EMF : Location of **Liquid Argon test setup**.

-> P1 : Location of the **ATLAS Detector**

development weeks : short break in data-taking (currently on)**.**

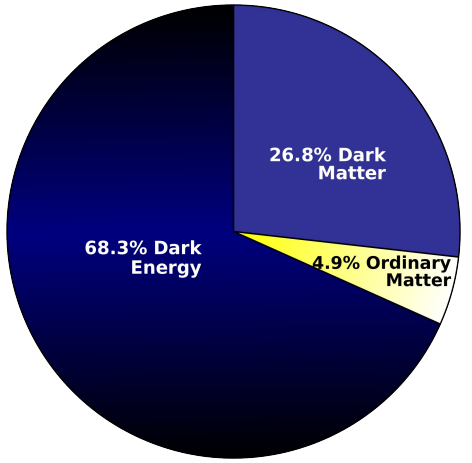
- The masking of super cells and the energy thresholds were implemented by the LAPP team few months ago
- I am working of the final implementation of the remaining parameters.
  - Tests at EMF were successful
  - The tests at P1 are underway

EMF : LAr Electronics Maintenance Facility

III - Search for new physics

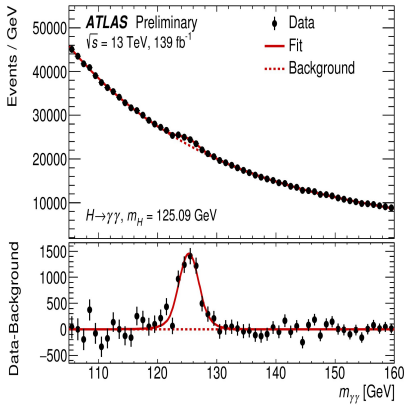
Standard Model is working very well
But... some questions remain...
dark matter, dark energy, gravity...

Need to look beyond !



Direct searches

New resonances



Indirect searches

Precision measurements of SM processes

e.g. : EFT approach

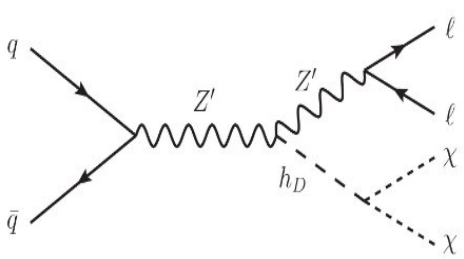
My Interest is final state with two leptons

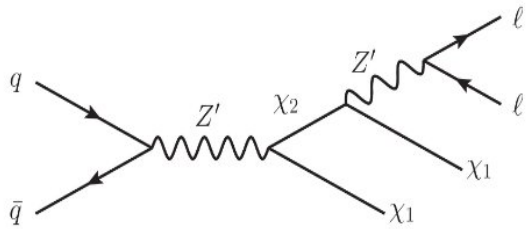
III - Search for new physics
III - 1 - dilepton final state + MET with RUN 2 dataset

Inclusive search : **pp -> ℓℓ**
no sign for new phenomena in the Run 2 data was found by ATLAS and CMS.

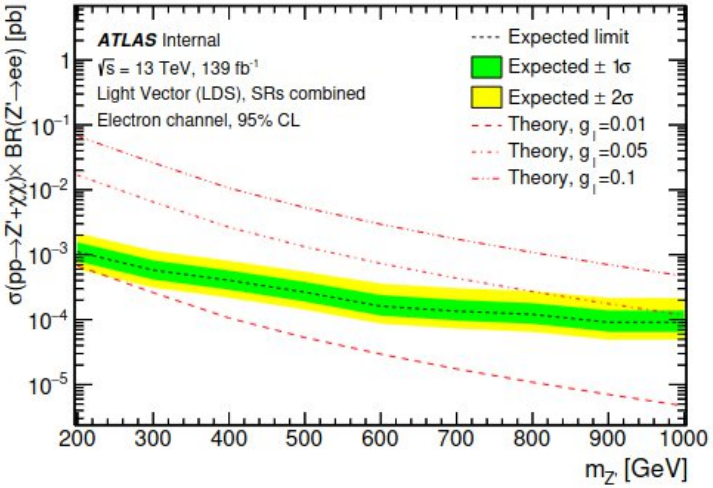
My focus : **Exclusive** search : **pp -> ℓℓ + X**

- Extra selections allow to **reduce** the **SM backgrounds** and have better sensitivity
- Following channels are investigated at LAPP
  - **X = dark matter particles**





Electron channel:



I done statistical interpretation of the results ✅ → **Unblinded results** presented **last wednesday**. **Public** results should be released soon !!

III - Search for new physics
III - 1 - dilepton final state + MET with RUN 2 dataset

Inclusive search : **pp -> ℓℓ**
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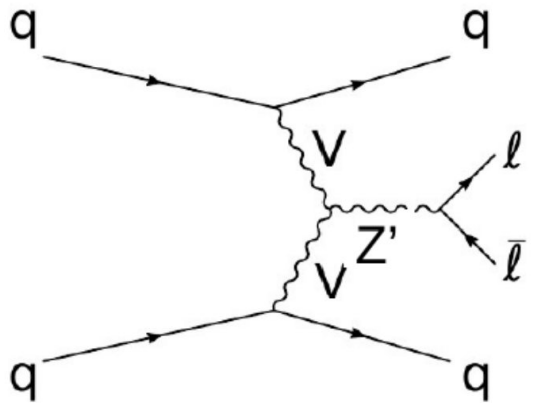
My focus : **Exclusive** search : **pp -> ℓℓ + X**

- Extra selections allow to **reduce** the **SM backgrounds** and have better sensitivity
- Following channels are investigated at LAPP
  - **X = dark matter particles**
  - **Vector boson fusion production X = 2 back-to-back jets**



Started contributed to this channel since few months
Aim to have it in the final paper together with the ll + MET channel

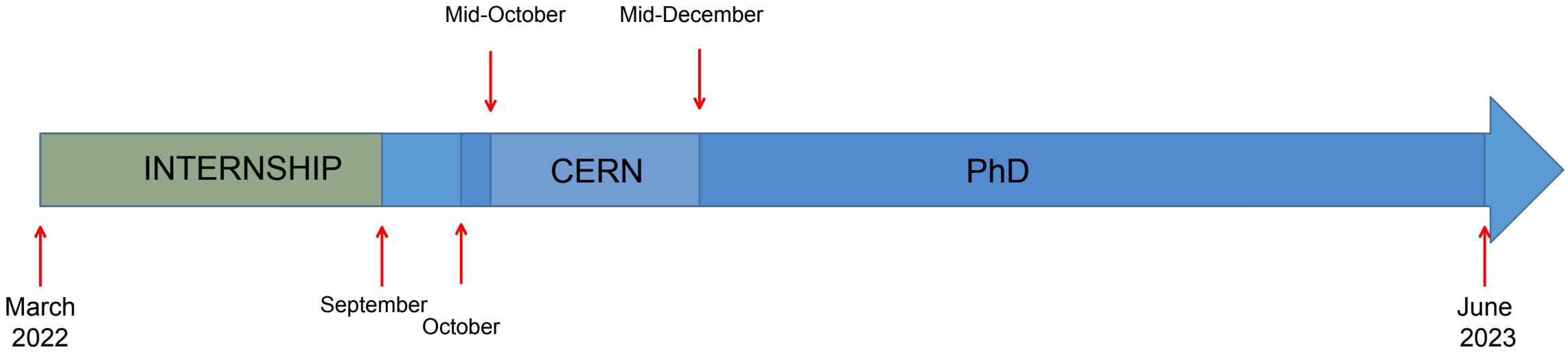
My responsibility is statistical interpretation of the results

IV - Future plans

- **Summer 2023** : Finilization of my Qualification Task
- **End 2023** - Start 2024 : Publish Z'+X searches paper
- **2024-2025** : Work on High Mass Drell-Yan with bjets Run 2 measurement

Additional task

Timeline overview

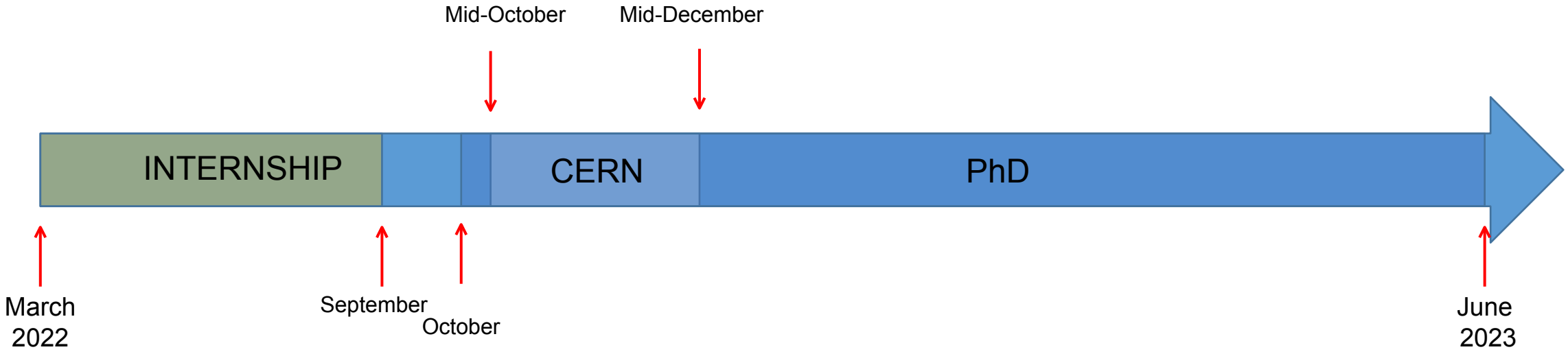


Additional task

Timeline overview

CERN

Followed daily operation meeting, monitoring implementation for shifters, QT work



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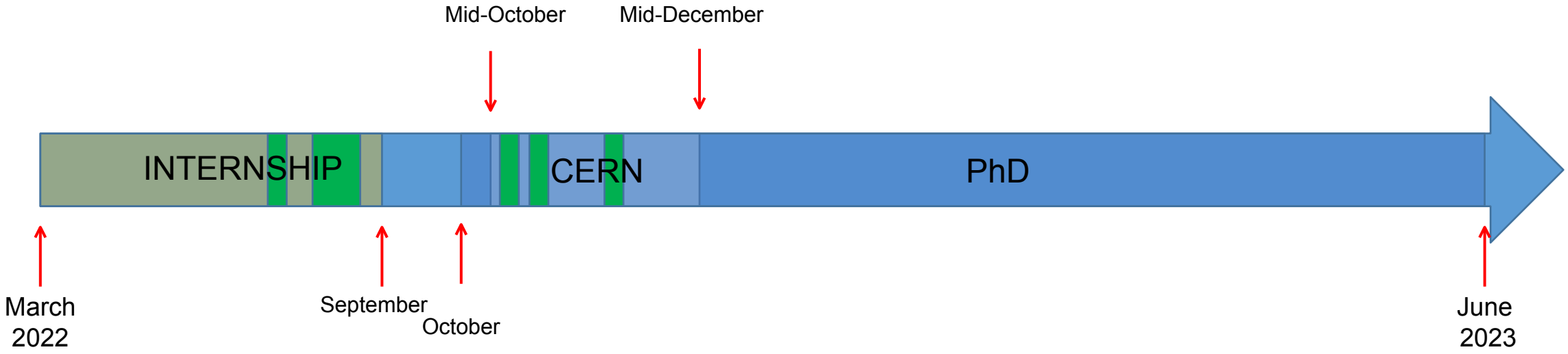

Shift at Calo/Forward detectors desk in the ACR
6x3jx8h (+training)

Additional task

Timeline overview

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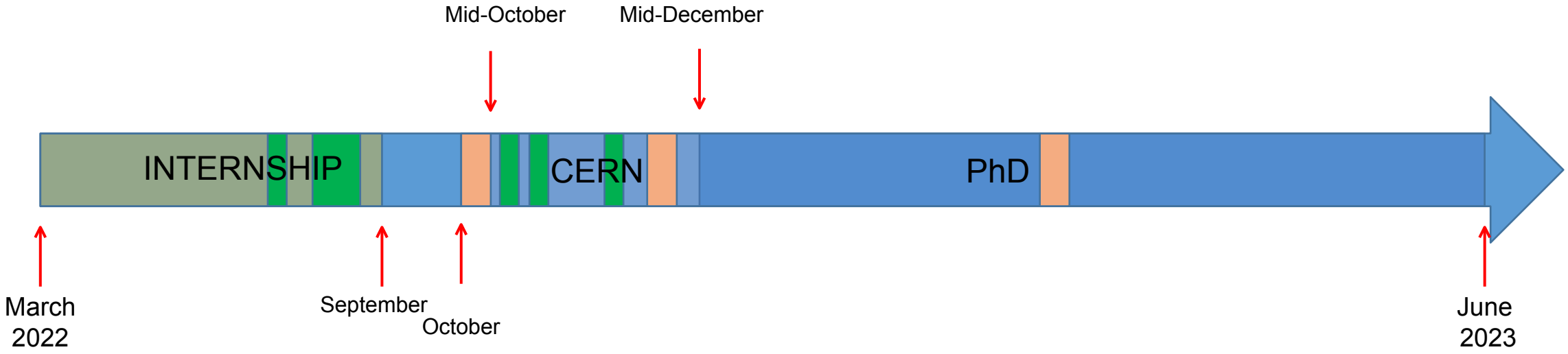

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LAr week

Additional task

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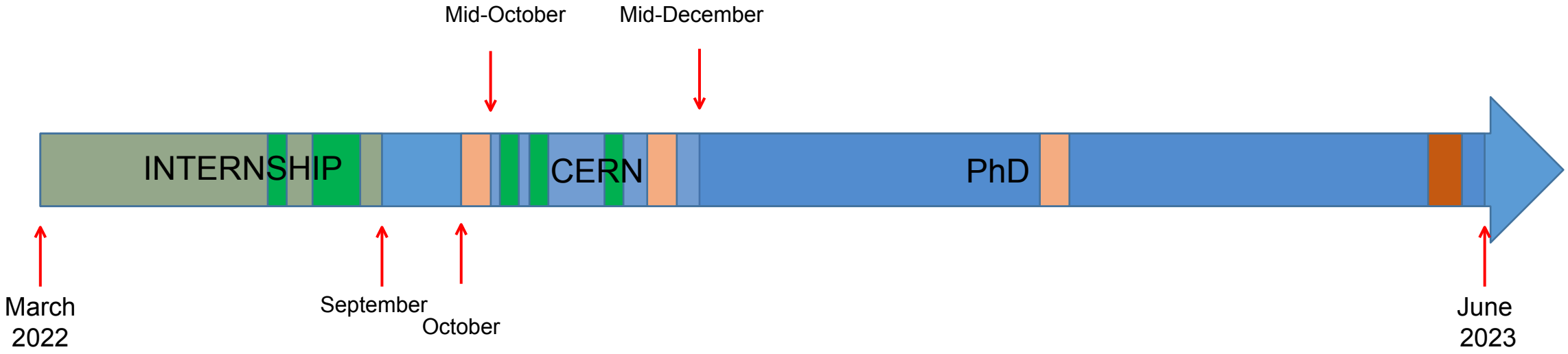


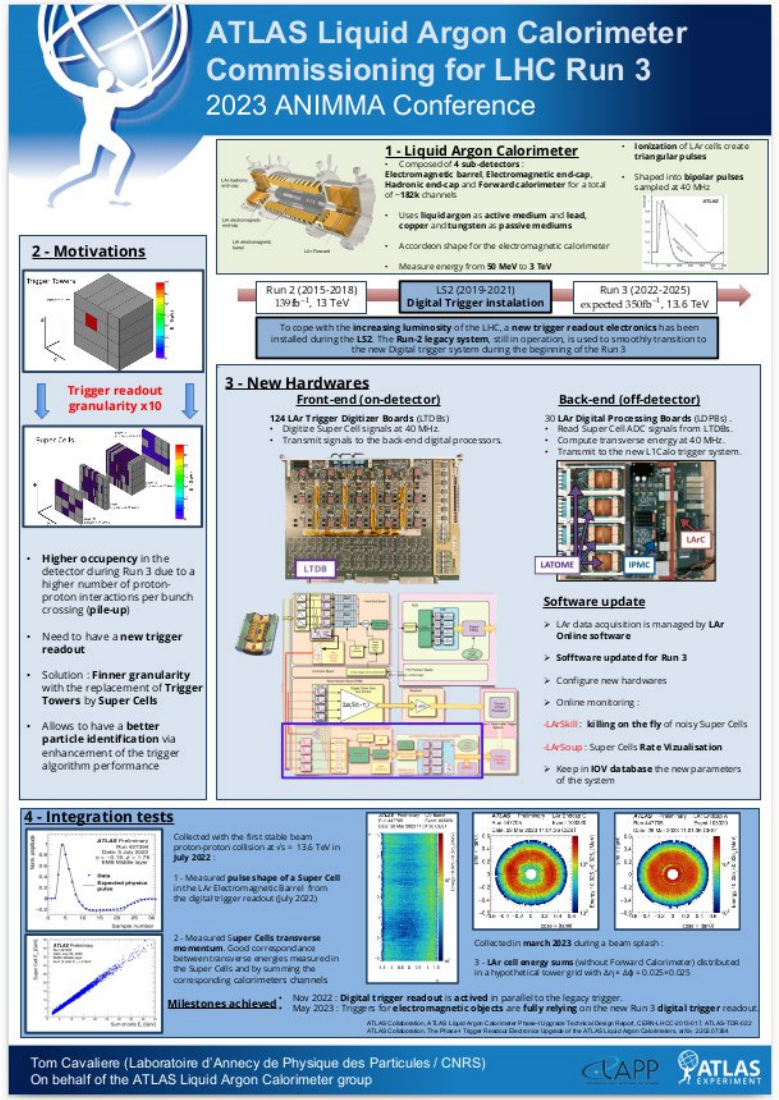
Shift at Calo/Forward detectors desk in the ACR 6x3jx8h (+training)

LAr week

ANIMMA conference in Lucca in Italie -> Poster presentation

Poster for ANIMMA conference in Lucca (12.06 -> 16.06)

ATLAS Liquid Argon Calorimeter commissioning for LHC run-3



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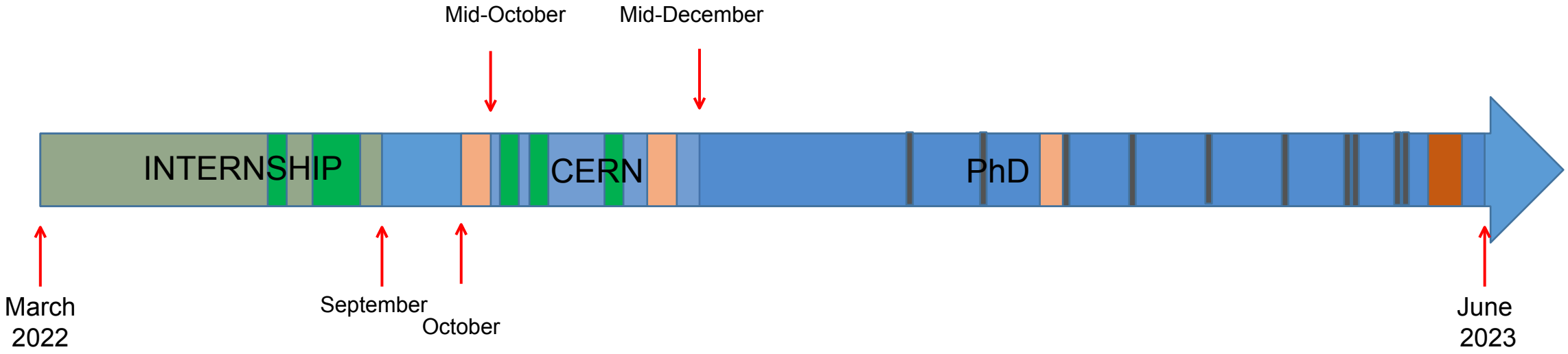


Shift at Calo/Forward detectors desk in the ACR 6x3jx8h (+training)

LAr week

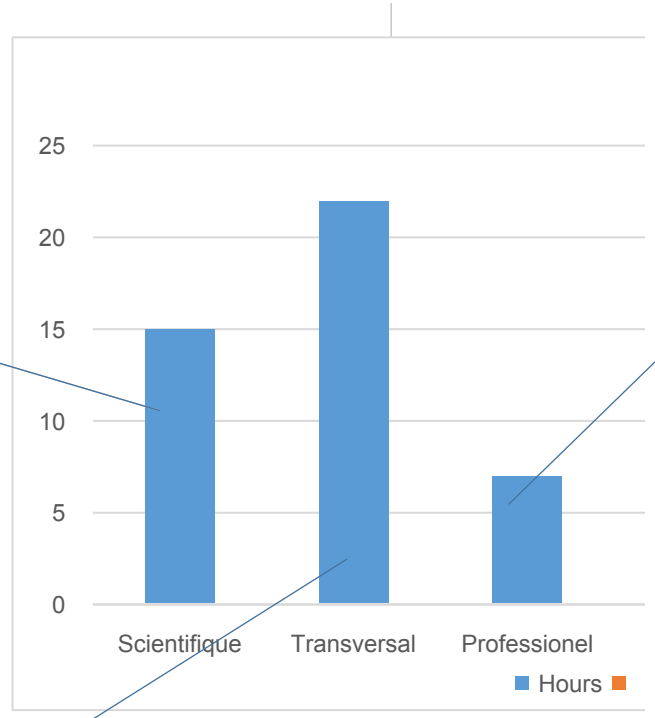
ANIMMA conference in Lucca in Italie -> Poster presentation

Teaching at IUT (TP outils mathématique 15h & Physique 6h)

Additional task

ADUM Formation

Goal : 40h for each category



- Group theory courses (January->June)
- ANIMMA CONF (June)
- GIF SCHOOL (September)
- JRJC (October)

- Teaching (2022-2023)
- Teaching (2023-2024)

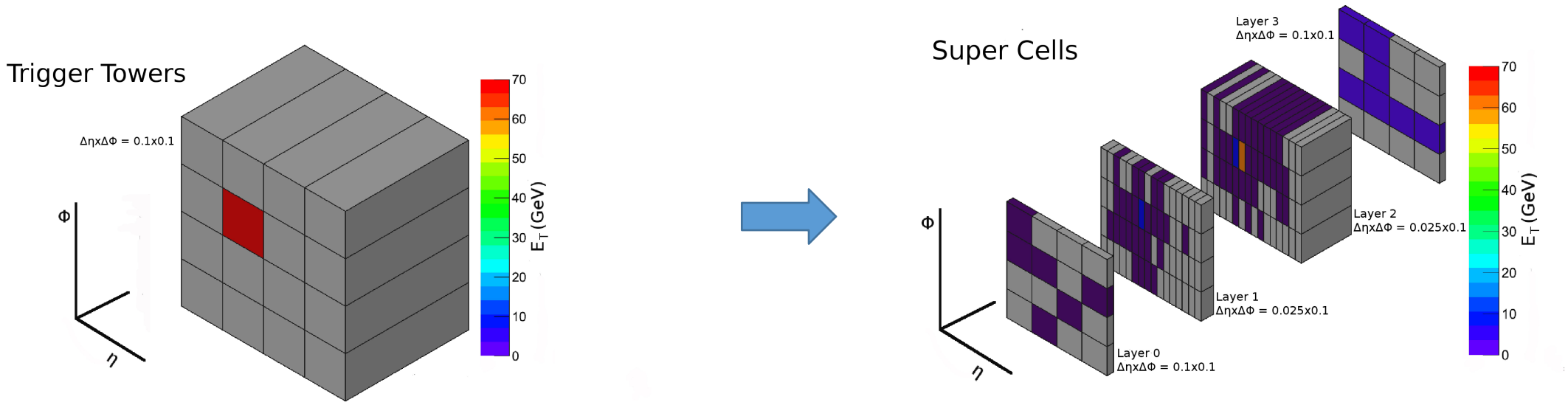
- Tribulations Savantes
- MOOC “Intégrité scientifique dans les métiers de la recherche”
- Other MOOC

END

Thank you for your attention !

Qualification task

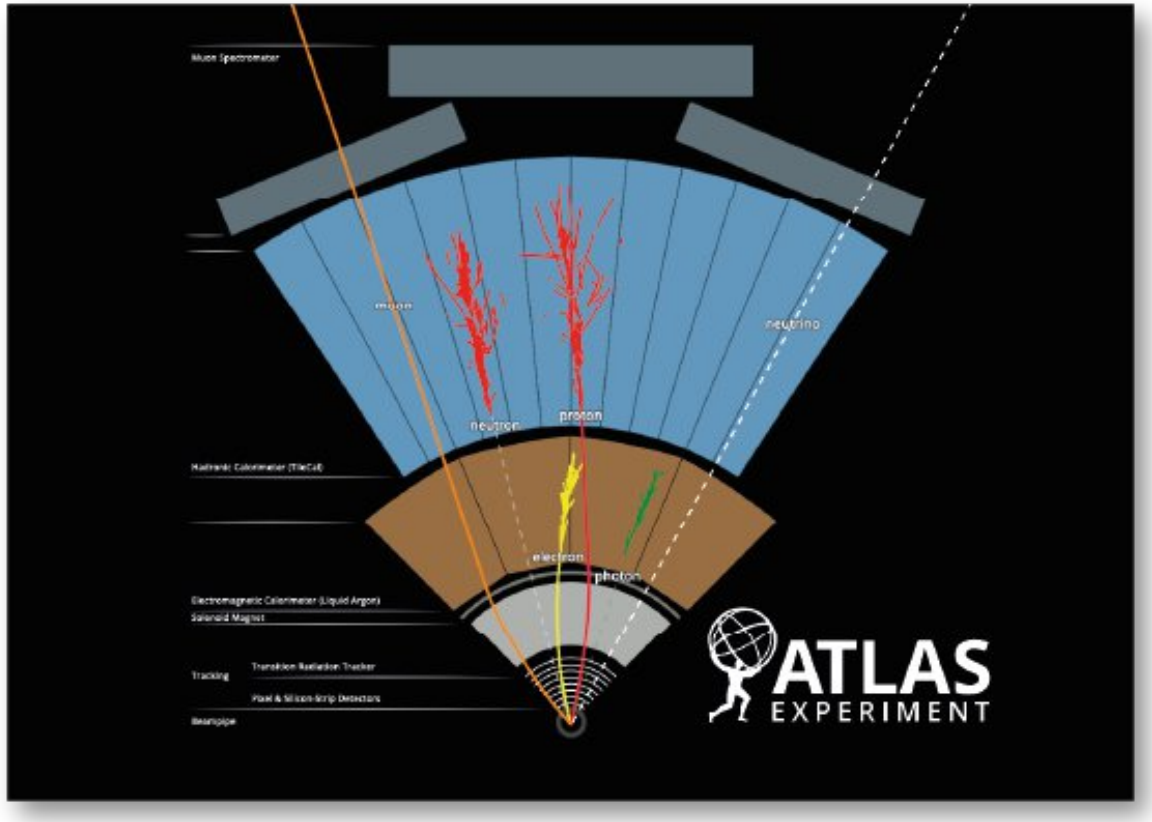
II - Development in the LArgOnline software
II - 1 - Phase-1 Upgrade



An electron (with 70GeV of transverse energy) as seen by the existing Level-1 Calorimeter trigger electronics and by the proposed upgraded trigger electronics .

0 - ATLAS detector

- **General purpose** detector located at one of the collision point of the LHC
- **probes** the **standard model** of particle physics and search for **new physics**
- Made of several sub-detectors (Tracker, **Calorimeters**, muon spectrometer), working together to **identify** and **measured** the **properties** of **particles** created during collisions.



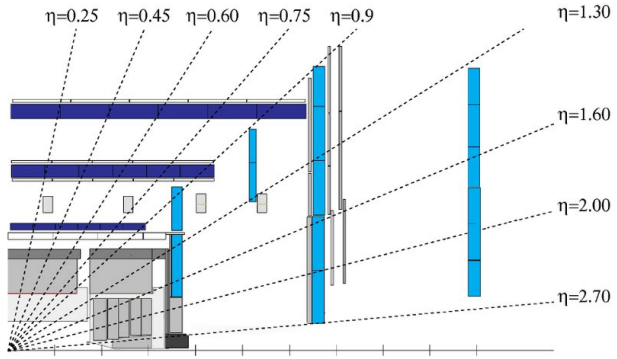
Qualification task :

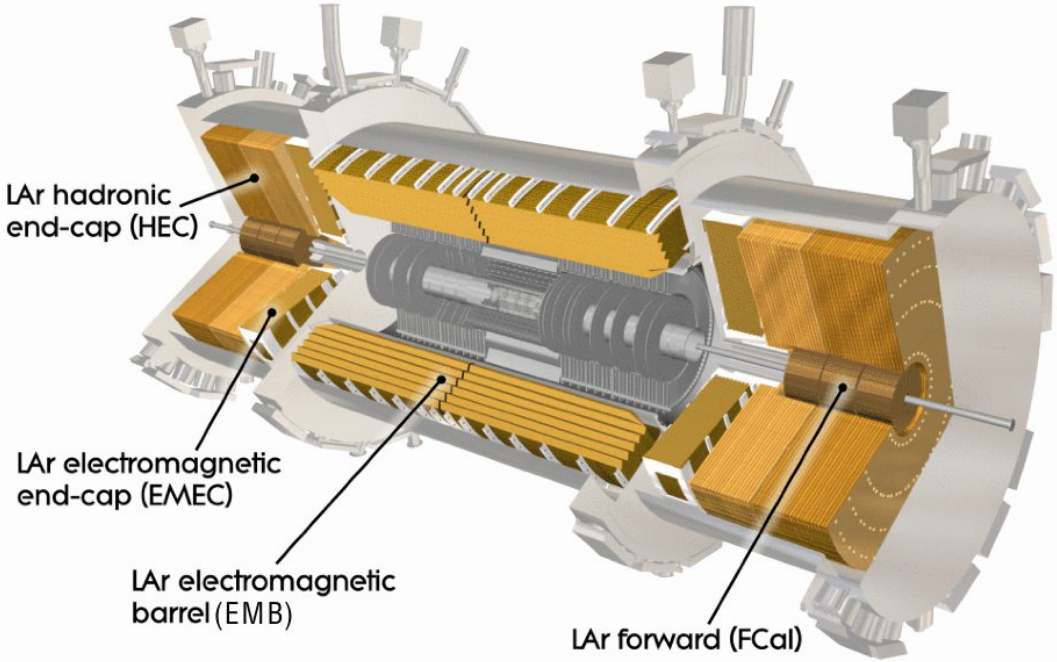
I - Development in the LArgOnline software
I - 1 - Liquid Argon Calorimeter

- ~**182k** (!) readout channels

- Divided into **4 regions** :
  - EMB : $|\eta| < 1.5$
  - EMEC : $1.4 < |\eta| < 3.2$
  - HEC : $1.5 < |\eta| < 3.2$
  - FCal : $3.1 < |\eta| < 4.9$

η : pseudorapidity

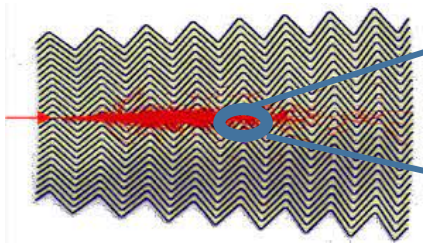


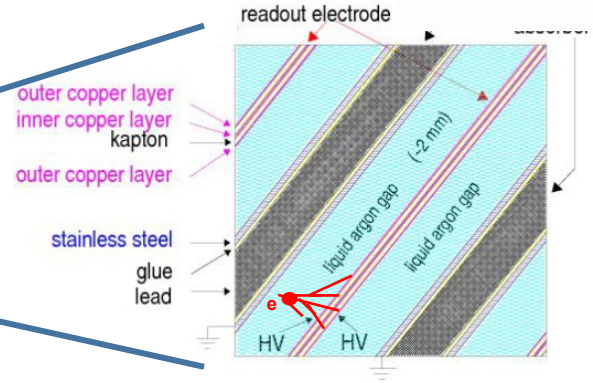


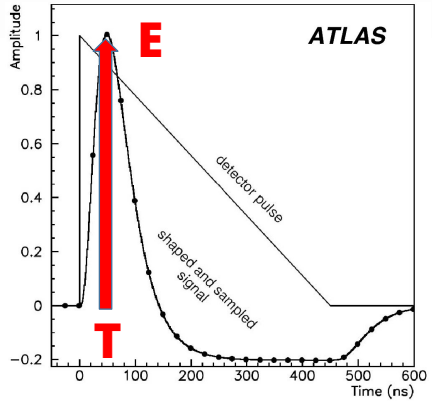
- Used mainly to measure **energy** and **position** of **electromagnetic objects** (photon, electron, positrons)

pp collision →

electromagnetic shower produced in liquid argon





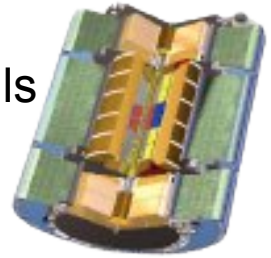


Qualification task

I - Development in the LArgOnline software

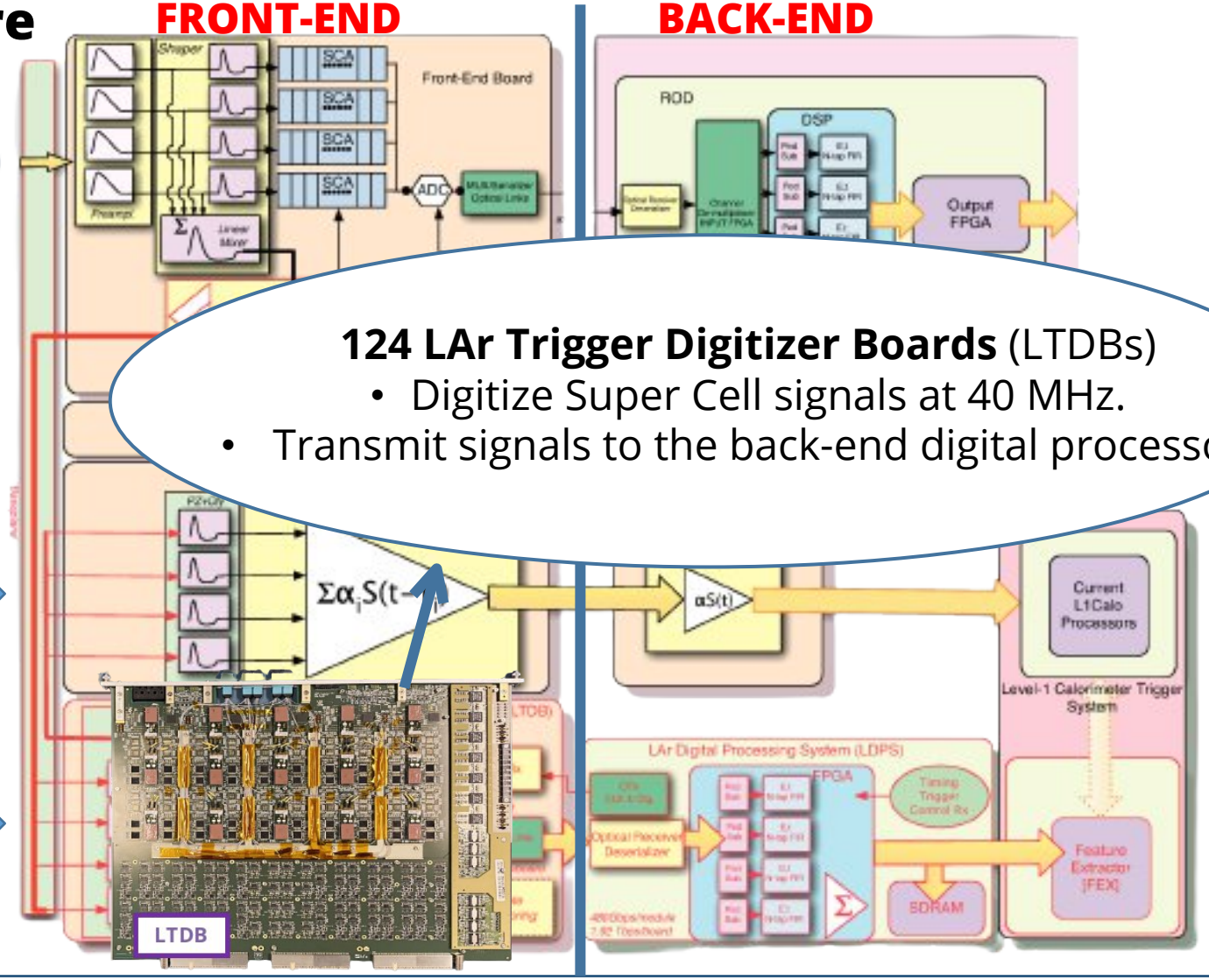
I - 3 - a - New Hardware

LAr Calorimeter cells



Legacy readout system

Phase-1 readout system



124 LAr Trigger Digitizer Boards (LTDBs)

- Digitize Super Cell signals at 40 MHz.
- Transmit signals to the back-end digital processors.

II - Development in the LArgOnline software
II - 3 - Parameters of interest

❖ Among these parameters, I worked on :

➢ **LVDS** links: Low Voltage Differential Signaling

Carry the TTC signals coming from the FELIX board and formatted by the carrier board
Need to be calibrated

➢ **BCID** : Bunch Crossing IDentifier
➢ **IS** : Input Stage

Incoming data are not in time one another due to the differences in time of flight and of fibre lengths.

However, the data corresponding to one bunch crossing have to be aligned since we need all the data corresponding to a BCID when we want to process them.