



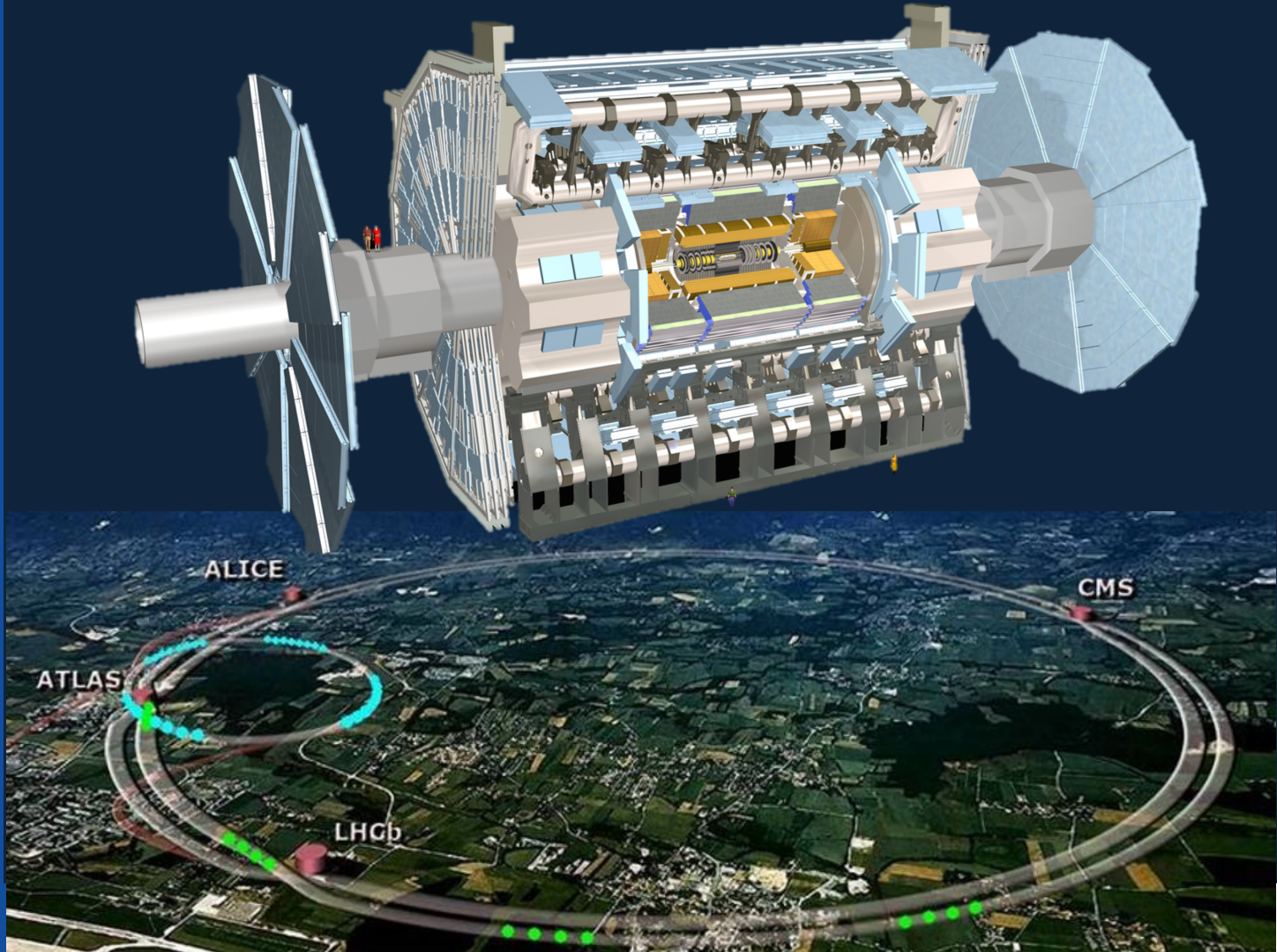
LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

PhD Possibilities at ATLAS



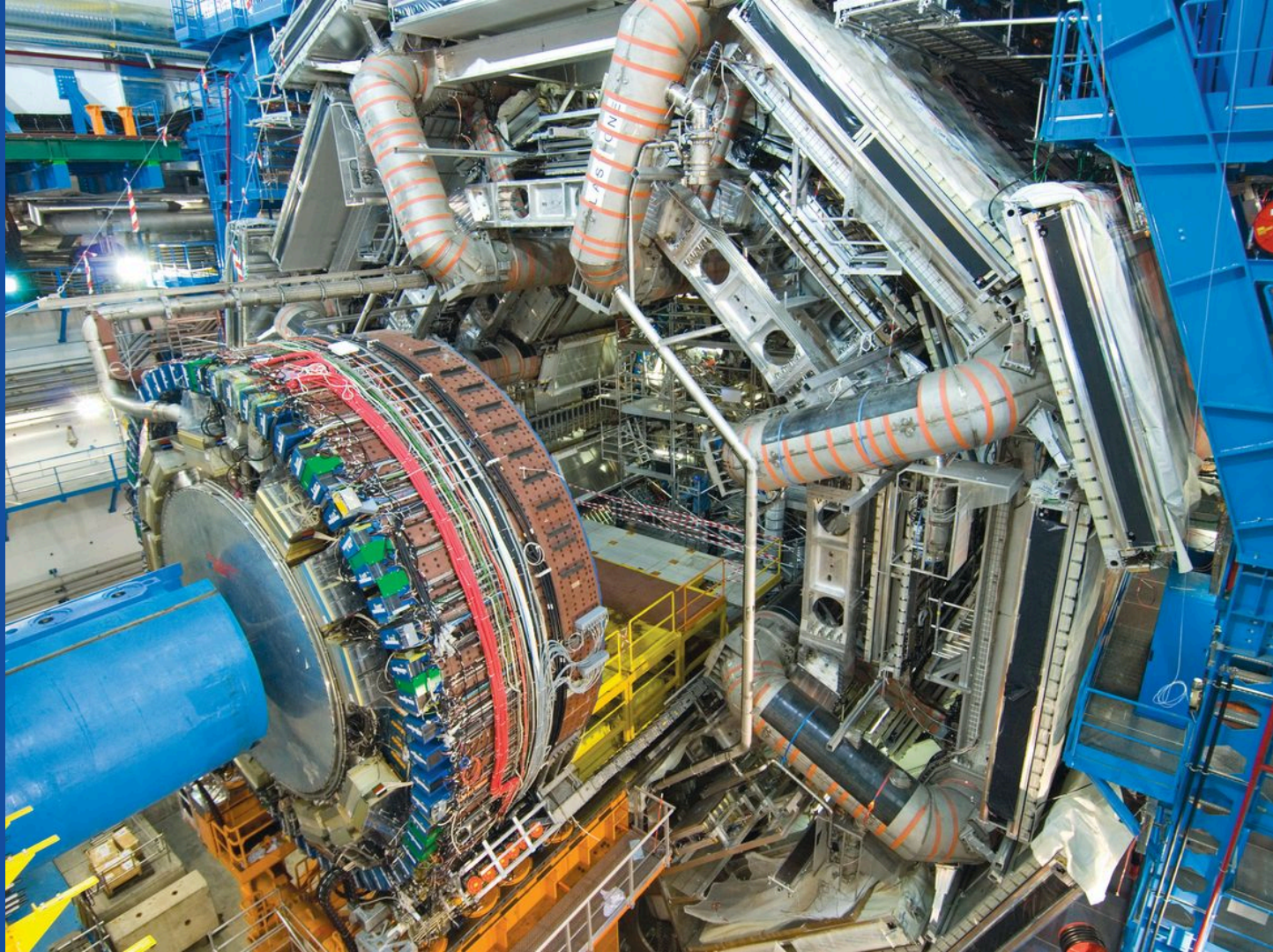
Patricia Conde Muíño
(IST, LIP)

The ATLAS Experiment



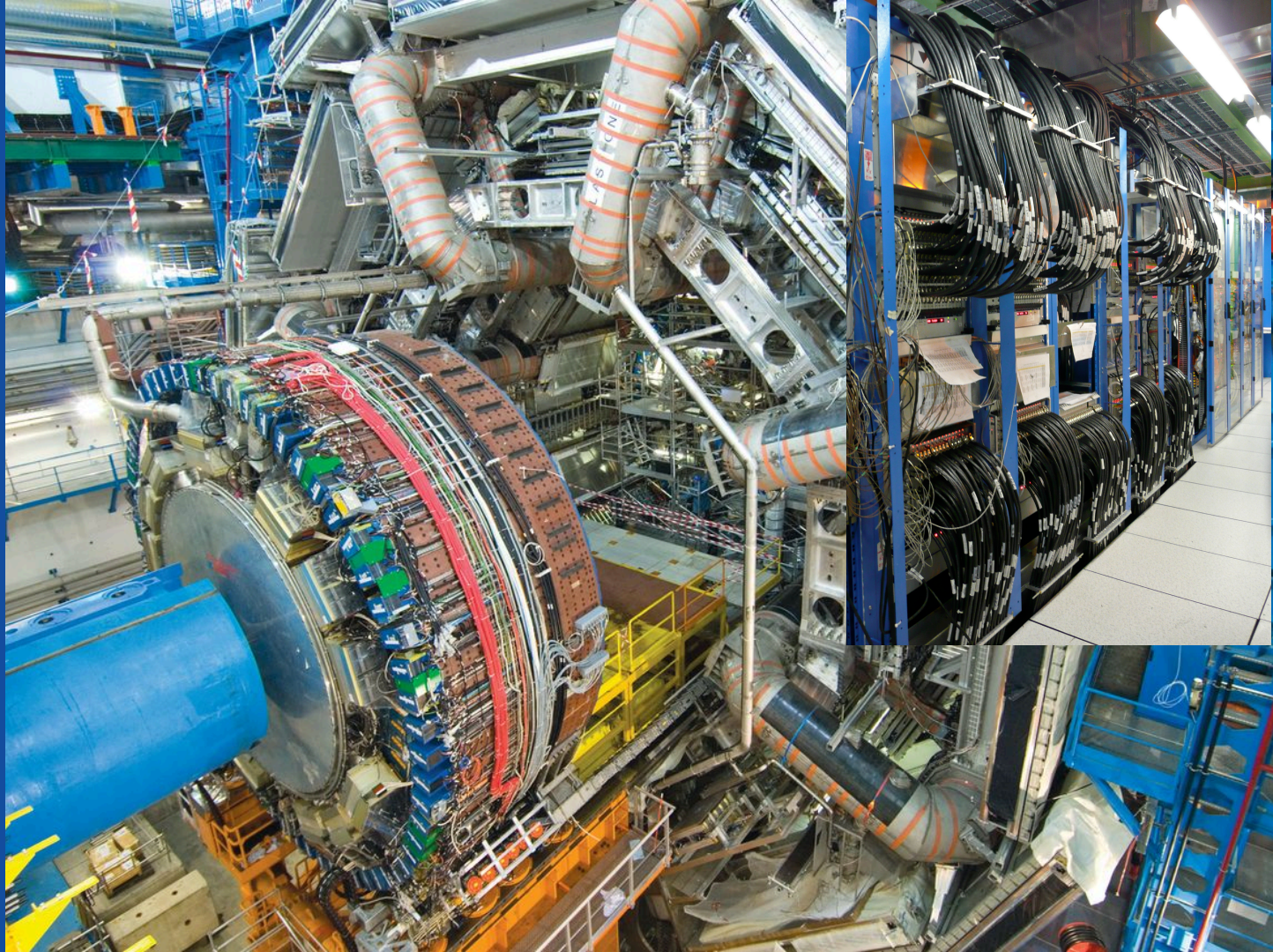
The ATLAS experiment

- Specialised detectors
- Cutting edge technology
- 10^8 electronic channels
- Home made fastest electronics



The ATLAS experiment

- Specialised detectors
- Cutting edge technology
- 10^8 electronic channels
- Home made fastest electronics



ATLAS Collaboration

- Truly global:
- 181 Institutes,
- 38 countries

Composed of:

- >5000 members
- >3000 scientists
- ~1000 PhD students



Status: November 2018

ATLAS Collaboration

181 institutions (231 institutes) from 38 countries

ATLAS Collaboration

- Truly global:
- 181 Institutes,
- 38 countries

Composed of:

- >5000 members
- >3000 scientists
- ~1000 PhD students



Argentina	Morocco
Armenia	Netherlands
Australia	Norway
Austria	Poland
Azerbaijan	Portugal
Belarus	Romania
Brazil	Russia
Canada	Serbia
Chile	Slovakia
China	Slovenia
Colombia	South Africa
Czech Republic	Spain
Denmark	Sweden
France	Switzerland
Georgia	Taiwan
Germany	Turkey
Greece	UK
Israel	USA
Italy	CERN
Japan	JINR

ATLAS Collaboration

181 institutions (231 institutes) from 38 countries

The Portuguese ATLAS team



National group:

LIP (Lisbon, Coimbra, Minho)

FCUL, IST, FCTUC, U. Minho,

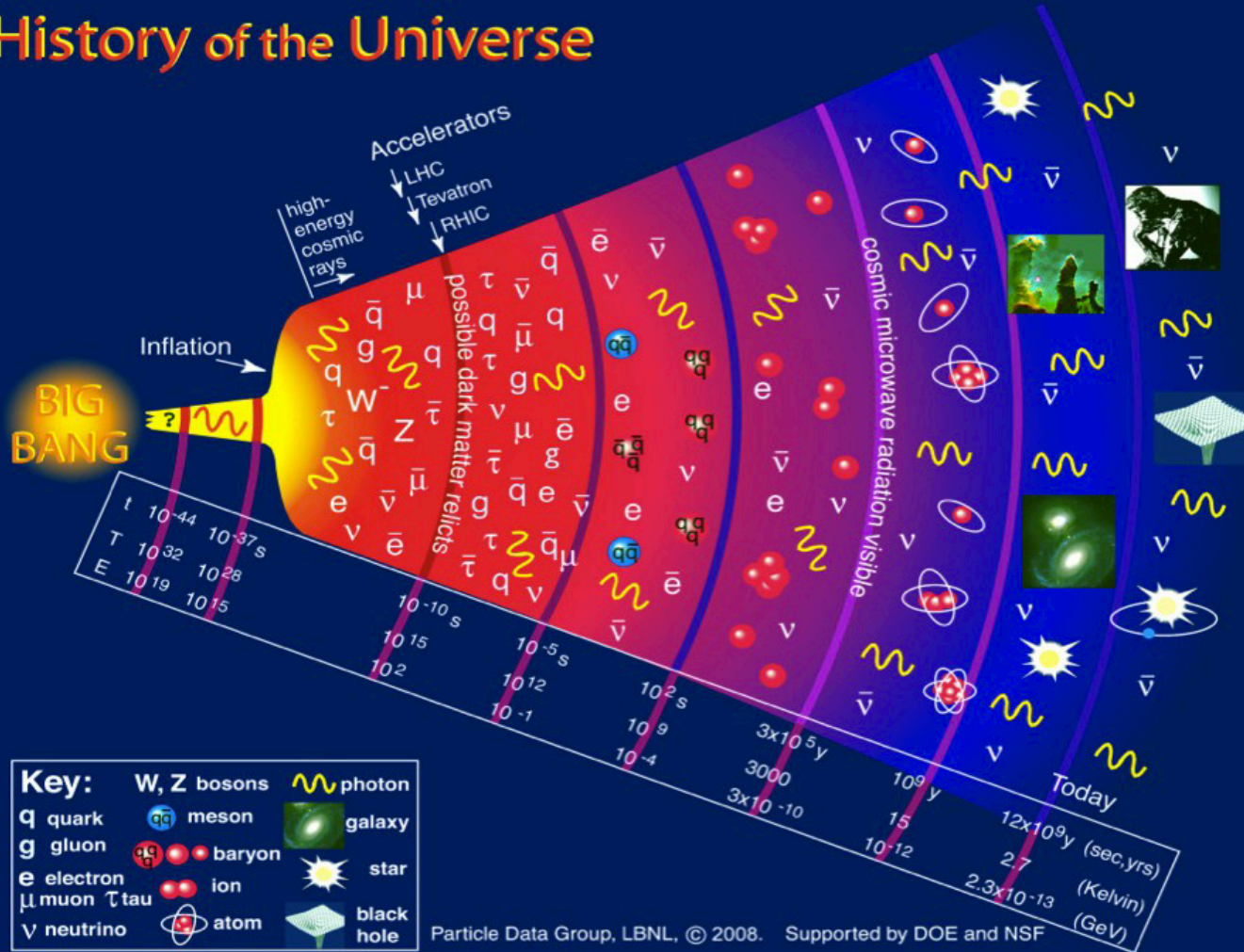
CEFITEC/UNL, INESC, CFMC, IBEB

AdI engineers training program

Physics topics

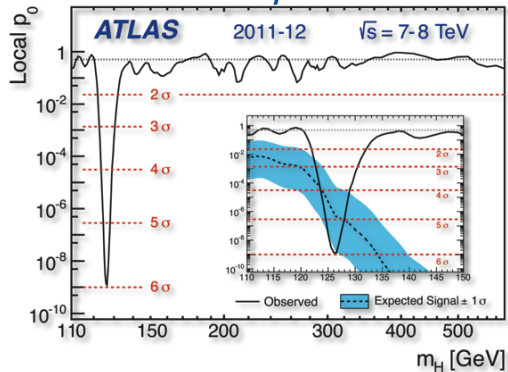
- Higgs couplings to quarks
 - Spin/CP properties
- B-jet suppression as probe of the Quark Gluon Plasma
- Quartic Gauge Boson Couplings

History of the Universe



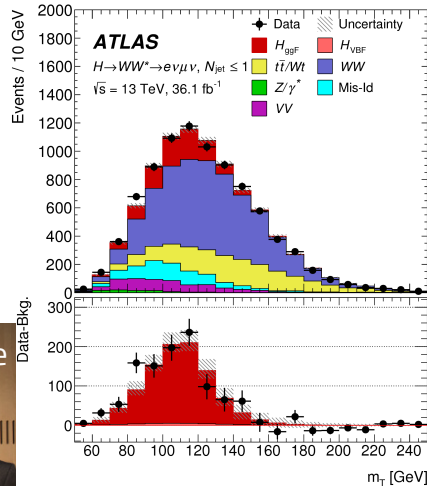
From discovering the Higgs to measuring its properties

Discovery (2012)



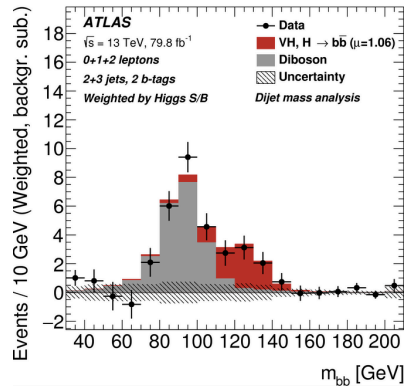
2015

First observation of $H \rightarrow WW \rightarrow \ell\nu\ell\nu$



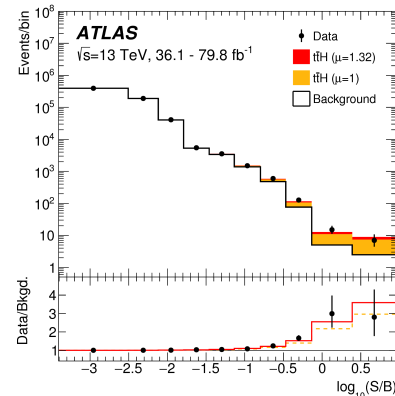
2018

First observation of $H \rightarrow b\bar{b}$



2018

First observation of $t\bar{t}H$ production



And now what?

Measure couplings even more precisely

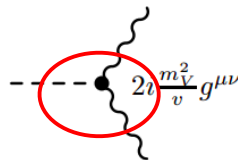
- Spin/CP properties of the vertices
 - ▶ Angular observables
- Probe SM predictions
- Search for new physics
 - ▶ Are they new particles in the loops?
 - ▶ Other Higgses?



$$\mathcal{L}_{SM} = D_\mu H^\dagger D_\mu H + \mu^2 H^\dagger H - \frac{\lambda}{2} (H^\dagger H)^2 - (y_{ij} H \bar{\psi}_i \psi_j + \text{h.c.})$$

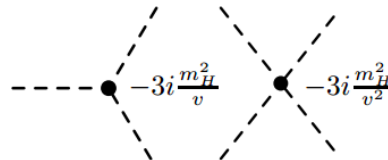
Couplings to
EW gauge bosons

$$[m_W^2 W^{\mu+} W_\mu^- + \frac{1}{2} m_Z^2 Z^{\mu 0} Z_\mu^0] \cdot (1 + \frac{h}{v})^2$$



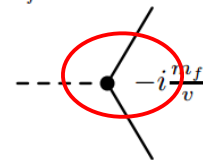
Higgs
self-couplings

$$-\mu^2 h^2 - \frac{\lambda}{2} v h^3 - \frac{1}{8} \lambda h^4$$

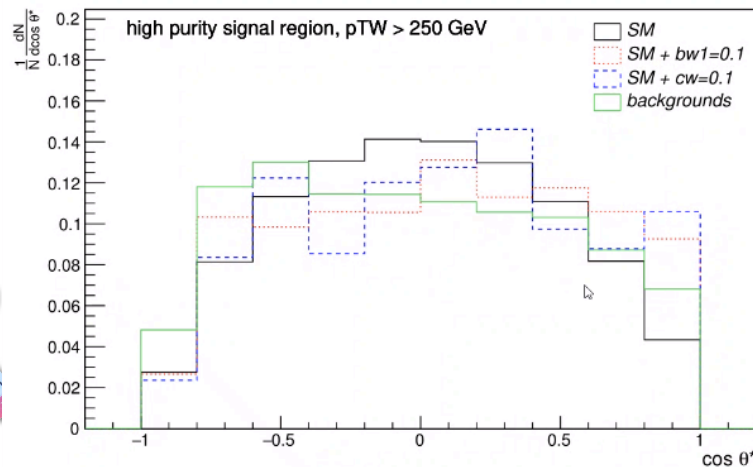


Couplings to
fermions

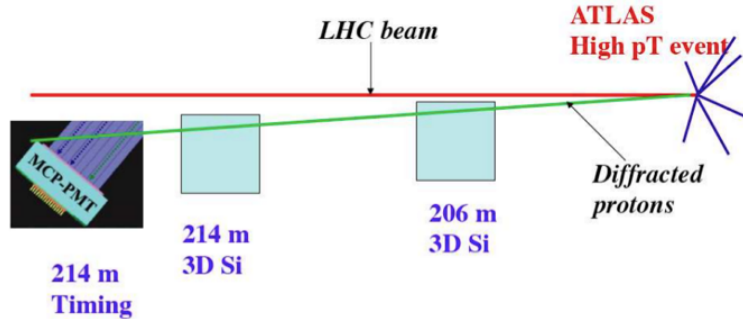
$$-\sum_f m_f \bar{f} f (1 + \frac{h}{v})$$



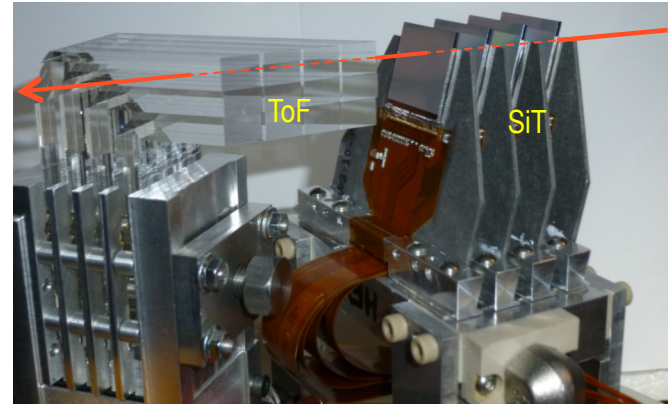
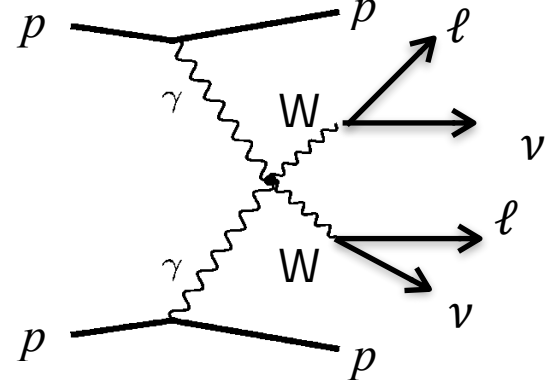
$$m_H = \sqrt{2}\mu = \sqrt{\lambda}v \quad (v = \text{vacuum expectation value})$$



Quartic Gauge Boson Couplings $\gamma\gamma \rightarrow WW \rightarrow \ell\nu\ell\nu$

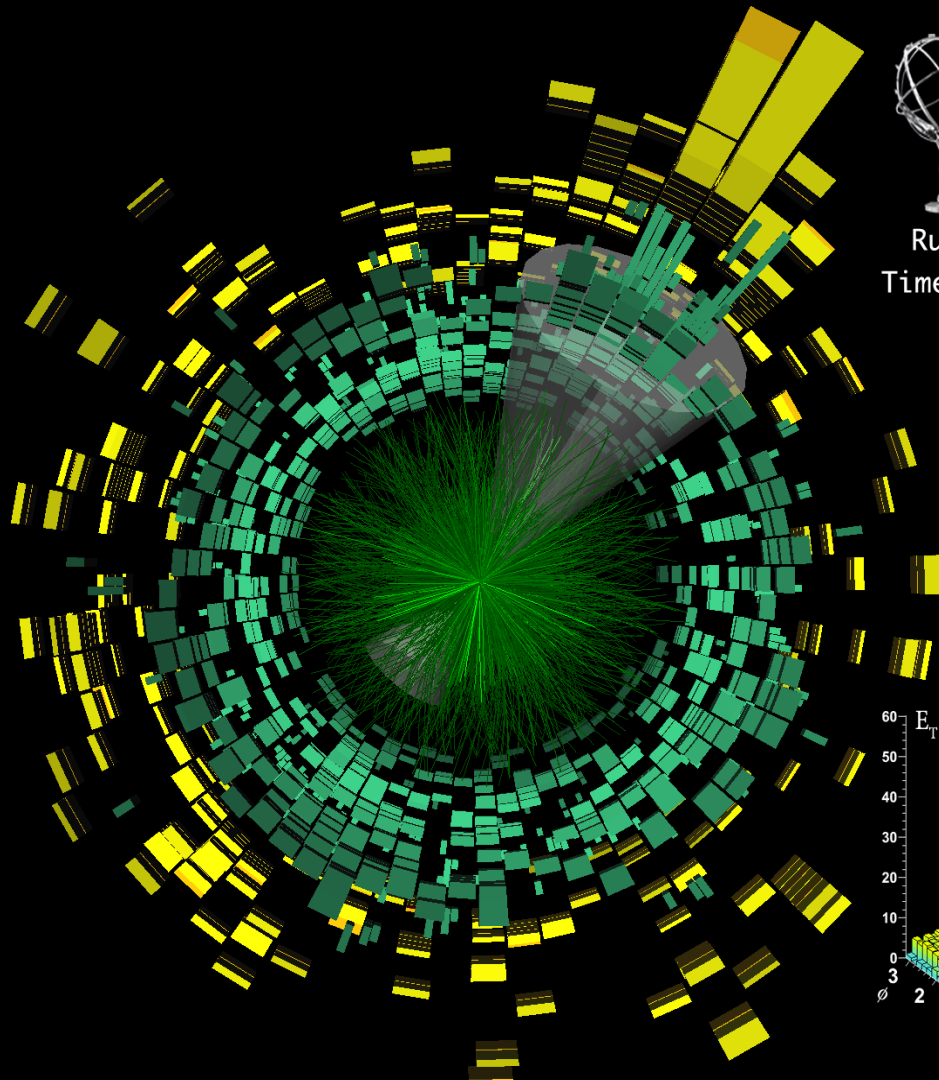


- Forward detectors transform the LHC in a $\gamma\gamma$ collider!
- QGBC: very precise SM predictions
 - Can be probed!
 - Search for WW in photo-production
- Same final state can be used to search for dark matter!
 - Need dedicated trigger

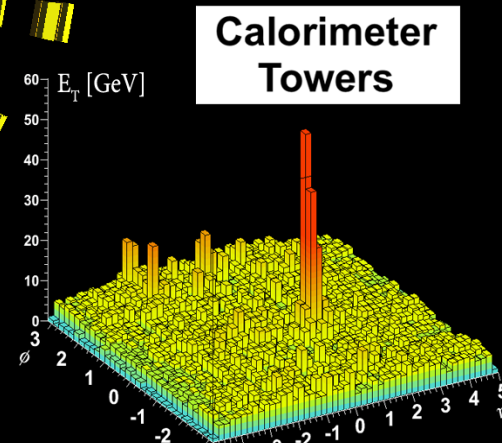


Jet suppression in Heavy Ion Collisions

- First observation in 2010
- Probe of Quark-Gluon Plasma



 **ATLAS**
EXPERIMENT
Run 168795, Event 7578342
Time 2010-11-09 08:55:48 CET

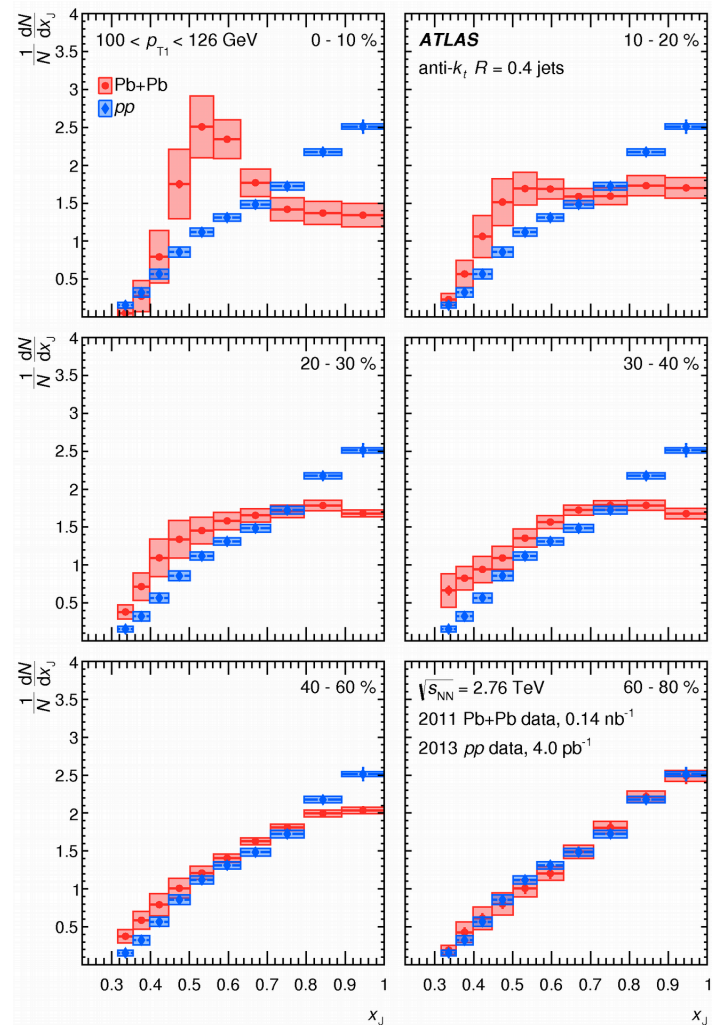
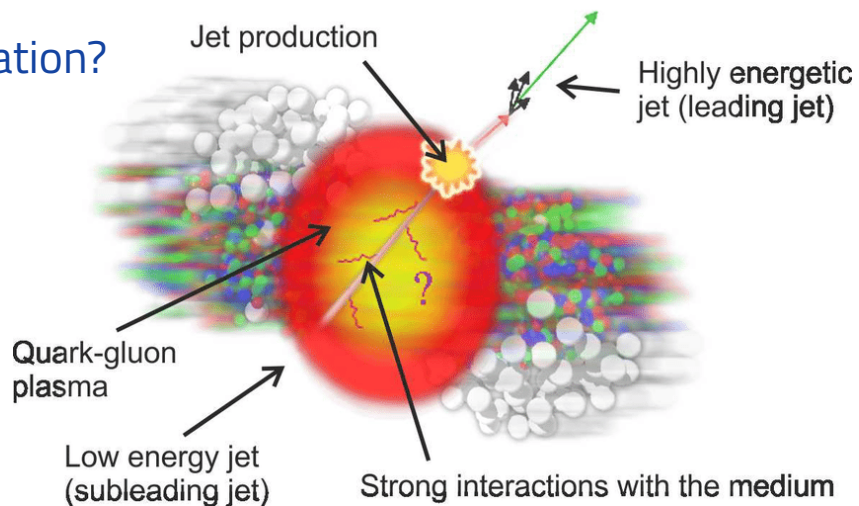


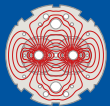
b-jet suppression to probe the QGP

- Distinguish the nature of the energy loss

- ▶ Collisional?

- ▶ Radiation?



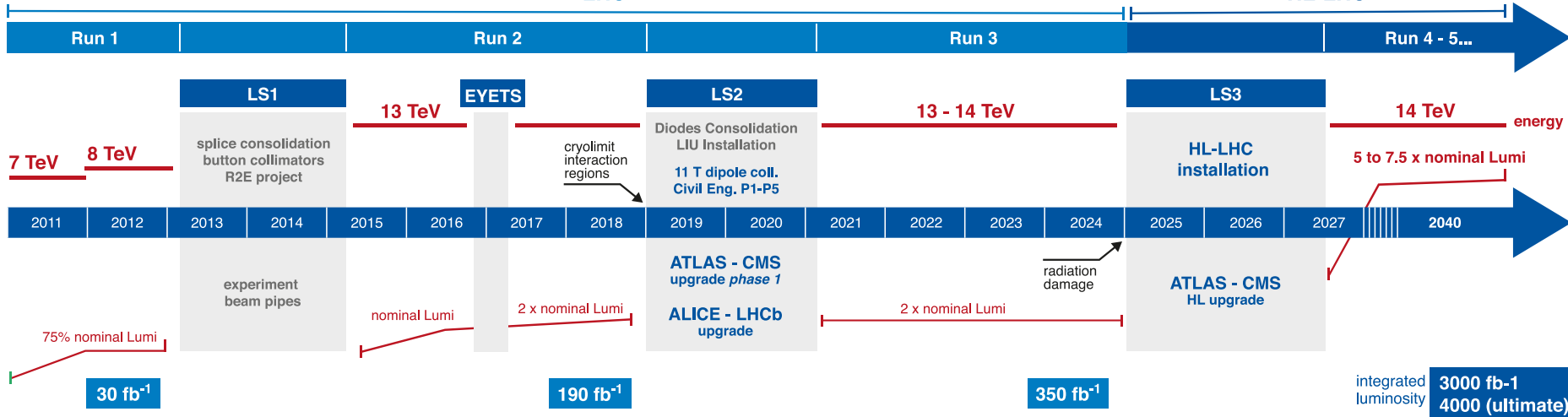


LHC / HL-LHC Plan



LHC

HL-LHC



HL-LHC TECHNICAL EQUIPMENT:

DESIGN STUDY



PROTOTYPES

CONSTRUCTION

INSTALLATION & COMM.

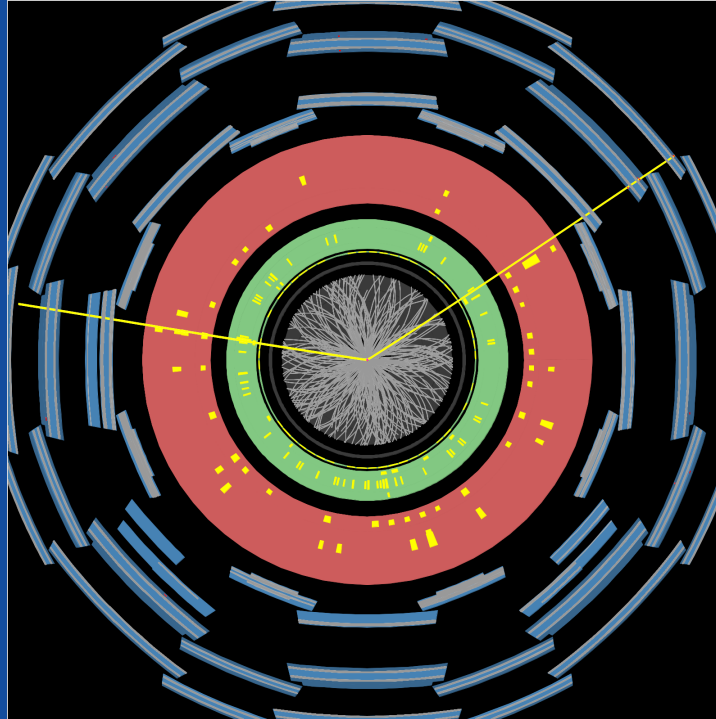
PHYSICS

HL-LHC CIVIL ENGINEERING:

DEFINITION

EXCAVATION / BUILDINGS

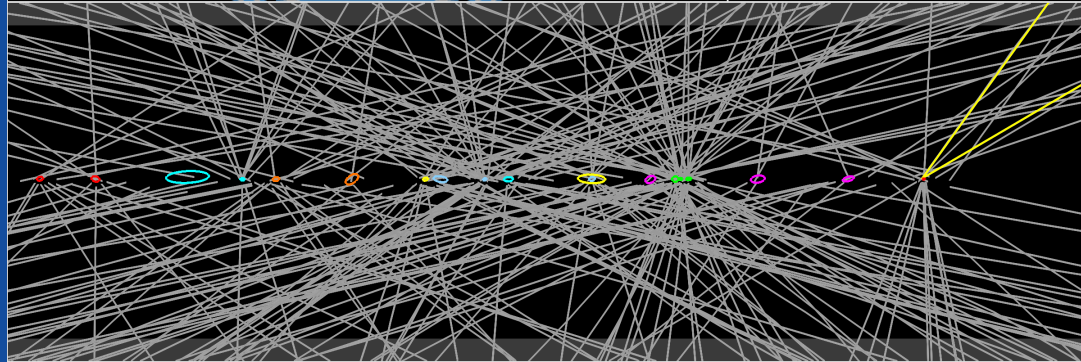
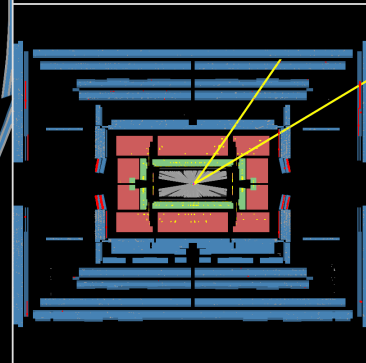
$Z \rightarrow \mu\mu$ event with 20 pile-up interactions



 **ATLAS**
EXPERIMENT

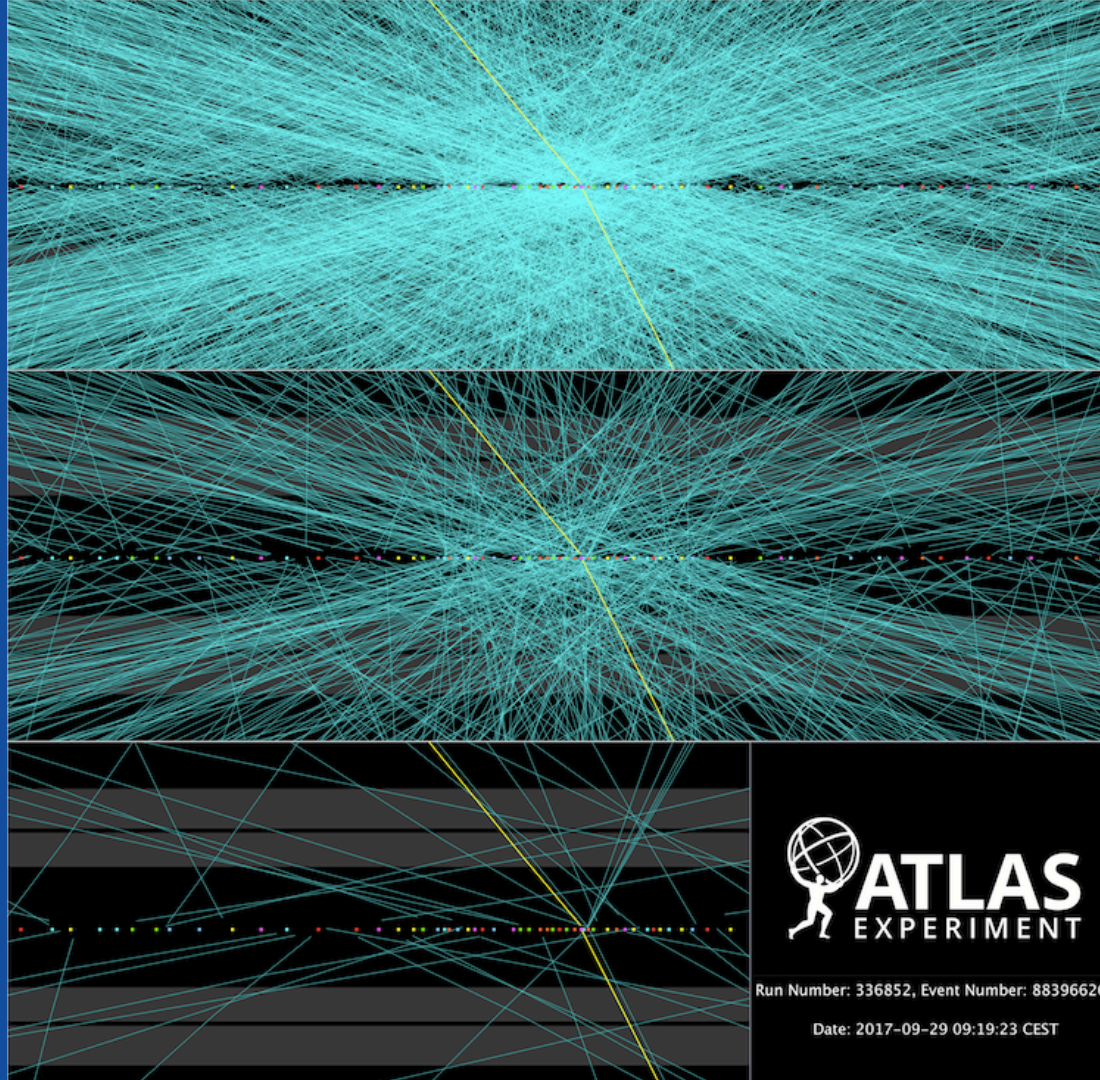
Run Number: 189280, Event Number: 1705325

Date: 2011-09-14 02:47:14 CEST



Upgrade challenges

- Huge detector occupancy
- Evento com um decaimento $Z \rightarrow \mu\mu$ e mais outras 65 colisões pp

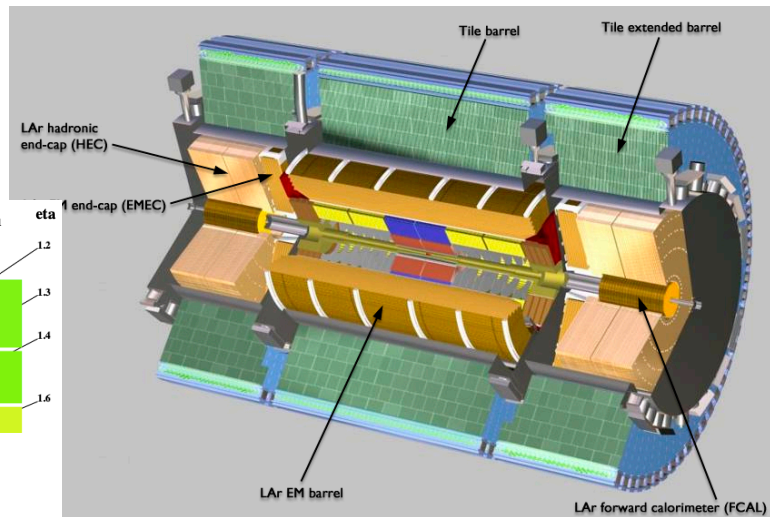
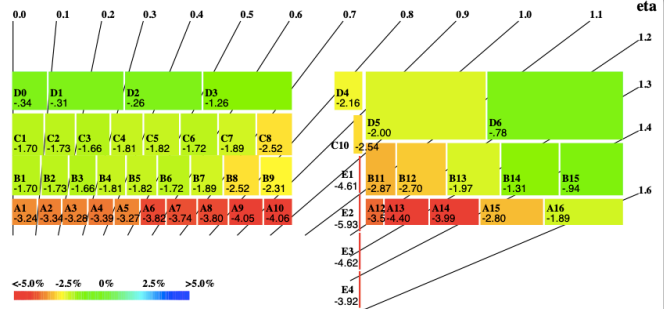


TileCal hadronic calorimeter

- Calibration
 - Optimize performance
- Study radiation hardness with pp collisions
 - Use ML to optimize results
- HV distribution system
- Detector Control System

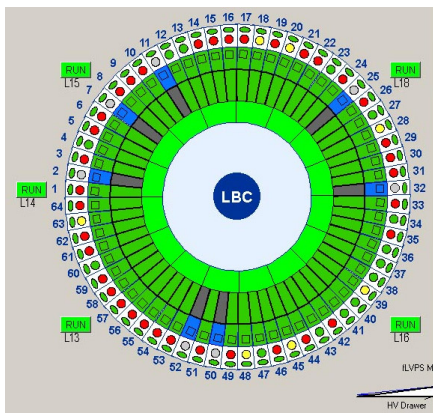
TileCal calibration

ML to study TileCal ageing
Impact in FCC detector design!



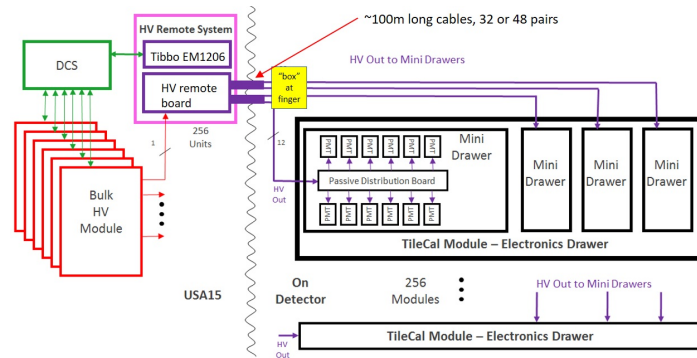
DCS

Leading TileCal DCS

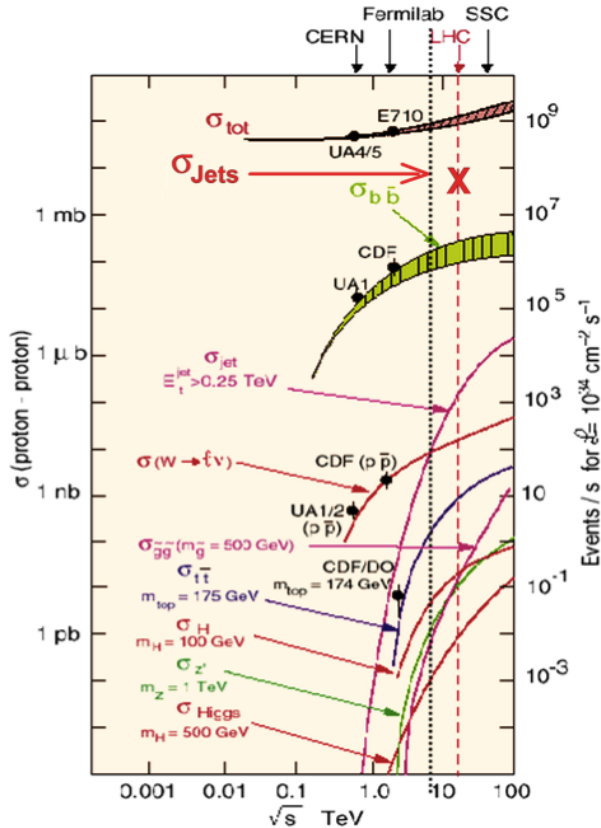


Upgrade HV distribution system

Full responsibility



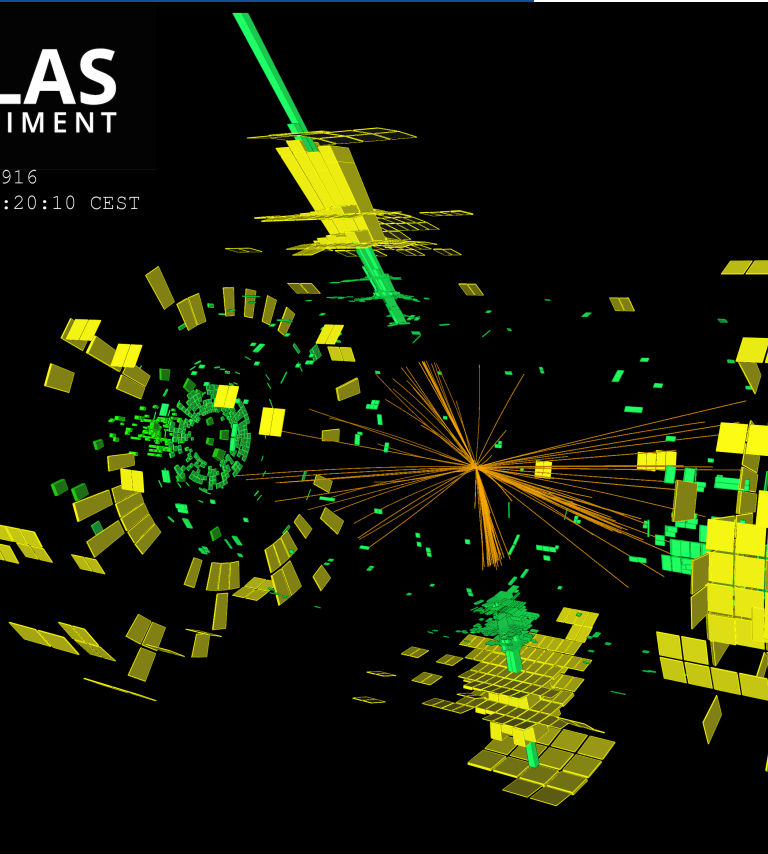
LHC Upgrade Challenges



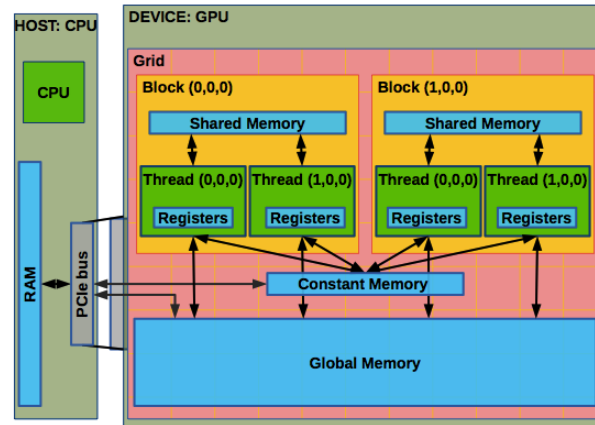
- Interesting processes have small cross-sections
- Need to process & select interesting events in real time
- 40 MHz event rate
- Very large number of interactions/event

	Run 2	Run 3	Run 4
Energy (\sqrt{s})	13TeV	14 TeV	14 TeV
Max. Luminosity ($\text{cm}^{-2}\text{s}^{-1}$)	$1\text{-}2 \times 10^{34}$	$2\text{-}3 \times 10^{34}$	$5\text{-}7 \times 10^{34}$
Interactions/event	40	55-80	140-200
Bunch crossing rate	40 MHz	40 MHz	40 MHz
Offline storage rate	1000 Hz	1500 Hz	1500 Hz
Bunch spacing	25 ns	25 ns	25 ns

GPUs for Accelerating Jet Trigger Algorithms



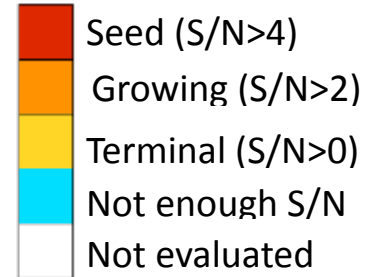
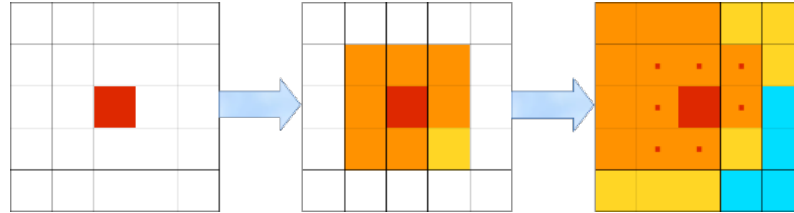
- Exploit parallelism
- New paradigm: single instruction-multiple data
- Calorimeter clustering on GPUs
 - ▶ 1st prototype demonstrated great potential
 - ▶ New framework update and optimisation ongoing



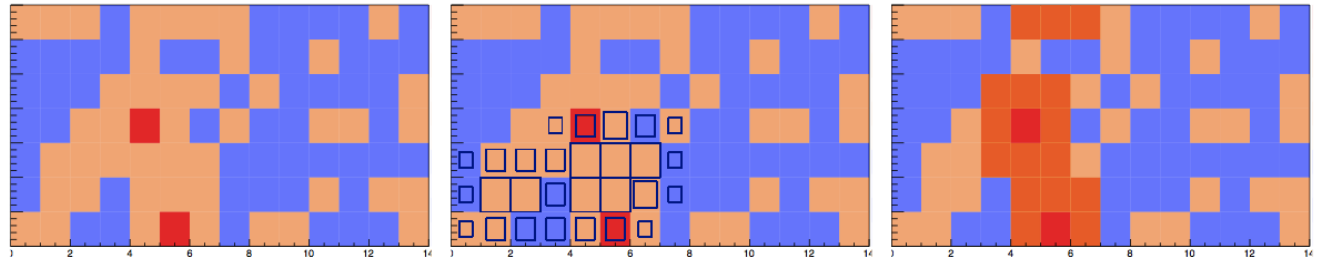
- Study also FPGAs as alternative

Topo-Automaton Clustering (TAC)

- TopoClustering:
Groups neighbours
according to signal/noise



- TAC:
 - Maximize parallelism:
 - Data organised in cell pairs
 - Use cellular automaton
 - Propagate flag on a grid of elements (cell pair)
 - Cells get the largest flag on each iteration



More information:



- atlasinfo@lip.pt
- www.lip.pt/atlas
- pconde@lip.pt



Thanks!

- Acknowledgments



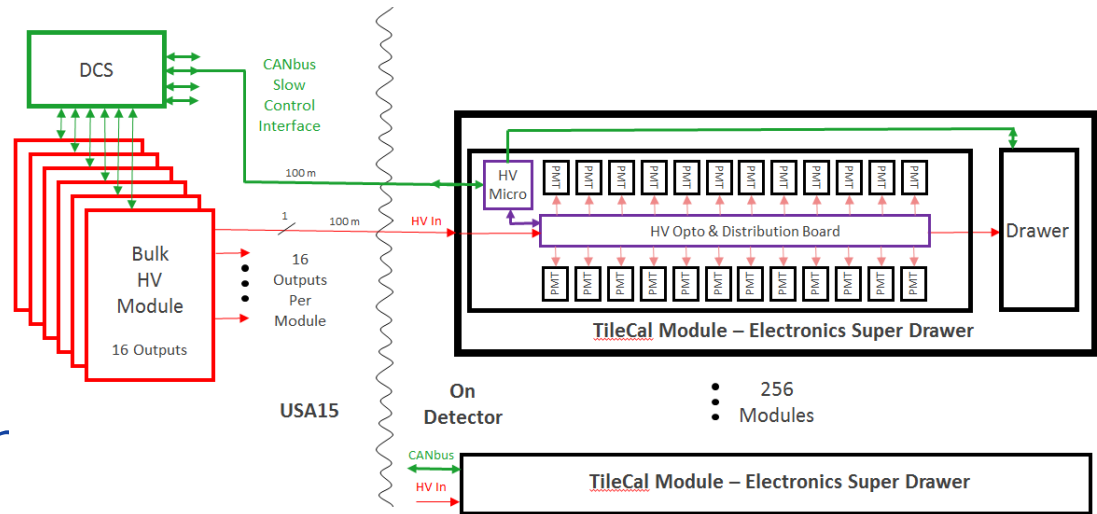
REPÚBLICA
PORTUGUESA

FCT

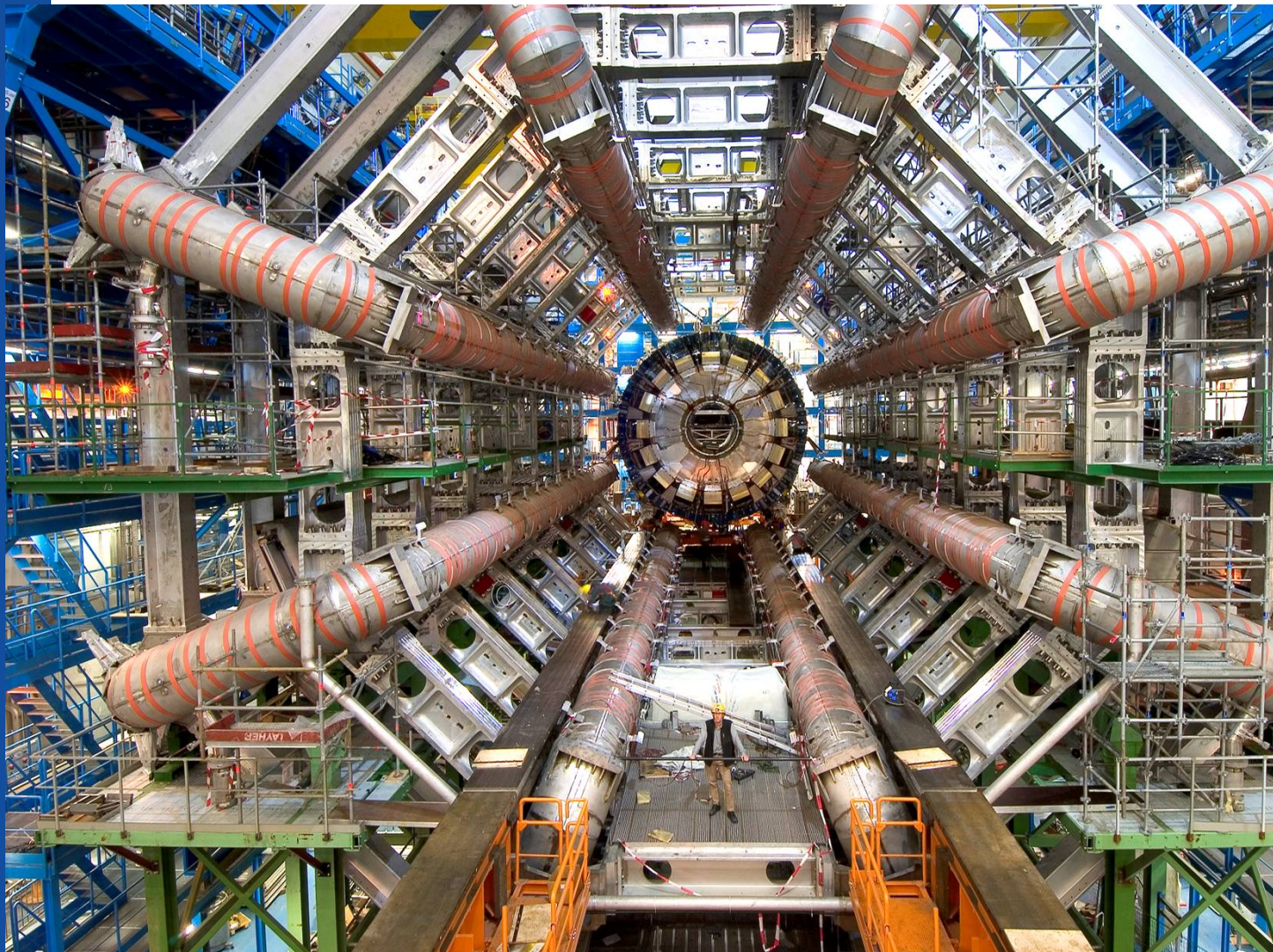
Fundação
para a Ciência
e a Tecnologia

TileCal current HV regulation system

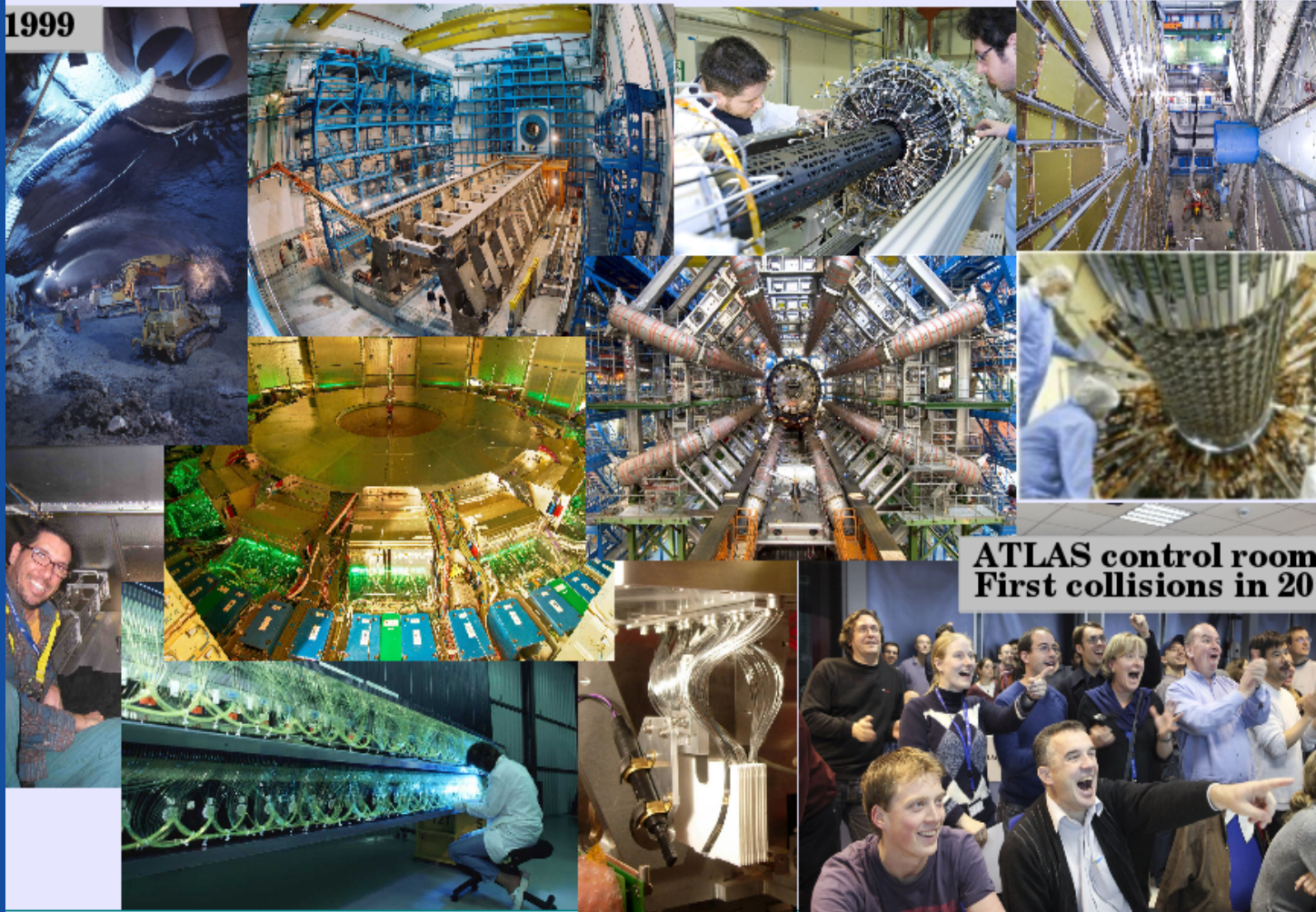
- Located inside the detector
- Will become old and difficult to maintain
- Not expected to survive to Phase II radiation
-



The ATLAS Experiment



1999

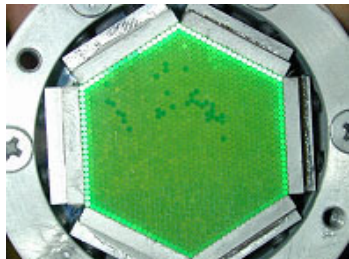


More than 25
years of
continuous
work

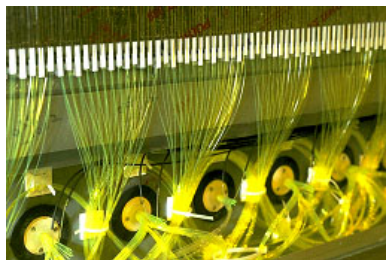
Portuguese contributions to ATLAS construction

TileCal hadronic calorimeter

600 k WLS fibres
aluminized



Design of the cells
and fibres routing

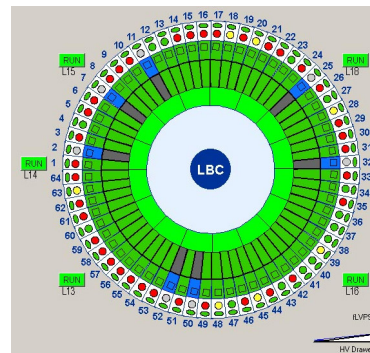


Fibres insertion with robot
in 15 k plastic profiles

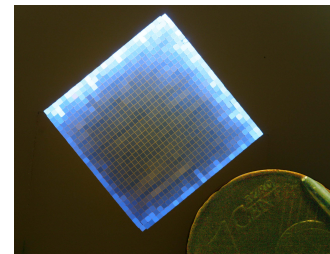


In addition: scintillators, laser calibration, PMT quality control, instrumentation of the modules, calibration, certification and commissioning

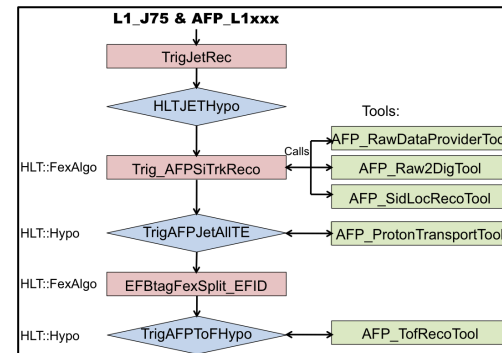
Detector Control System



Forward detectors



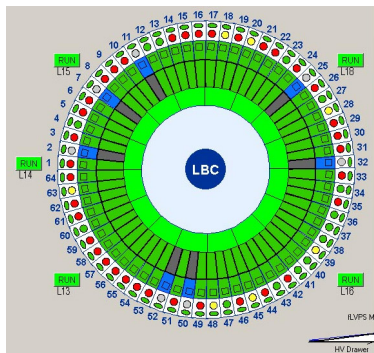
Trigger/DAQ



Current Portuguese Responsibilities

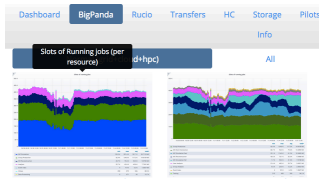
in ATLAS

TileCal
Calibration,
DCS



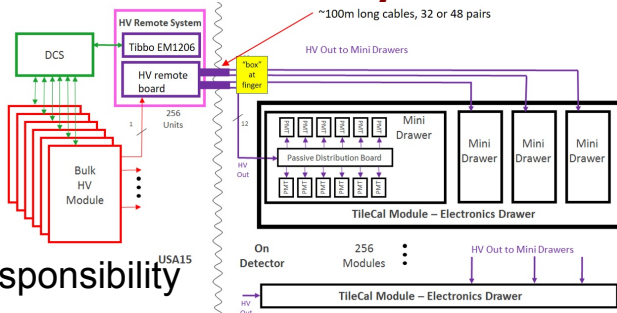
Leading TileCal DCS

Distributed computing

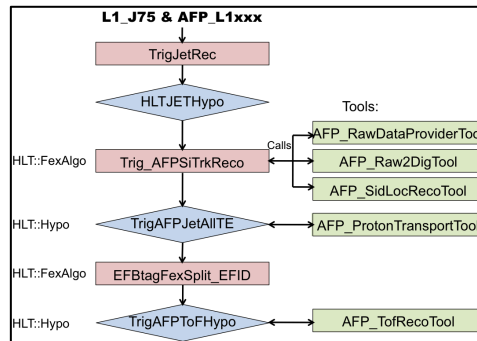


Iberian Cloud Coordination

TileCal Upgrade
HV distribution system



Jets HLT

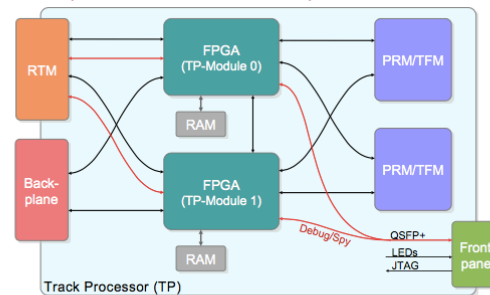


ATLAS Roman Pot DCS
and HLT



Co-leading ARP DCS

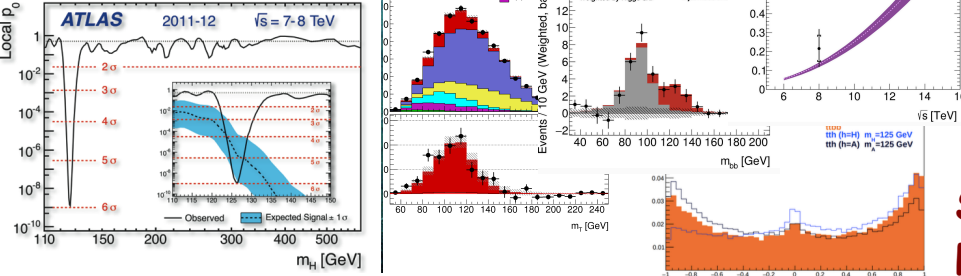
Trigger Upgrade: HTT
DCS, simulation, mezzanine production



Portuguese contributions to ATLAS Physics Results

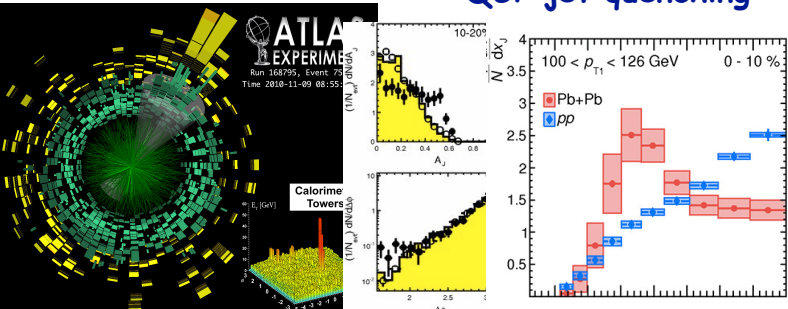
Higgs boson discovery and properties

$H \rightarrow WW, H \rightarrow bb, \tau\tau H$ Spin/CP properties



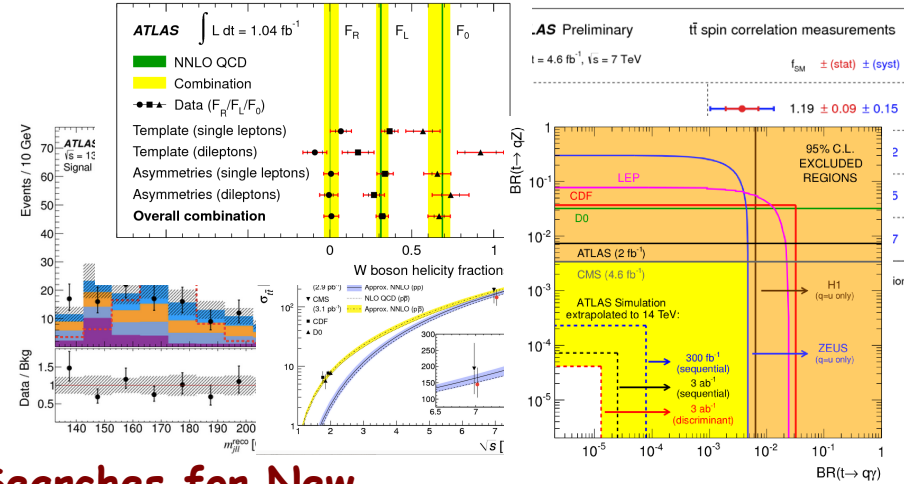
Heavy Ion Physics

QGP jet quenching



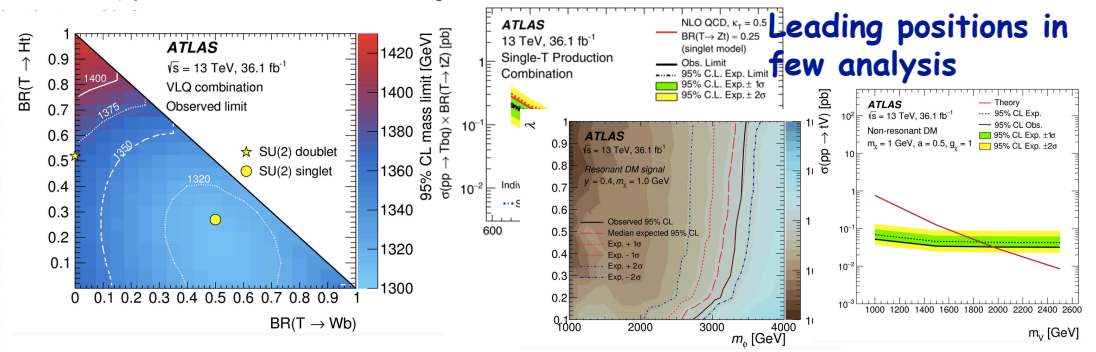
Top quark properties

Comprehensive programme of top properties measurements



Searches for New Particles & Interactions

Vector-like quarks, FCNC, dark matter, ...



Leading positions in few analysis