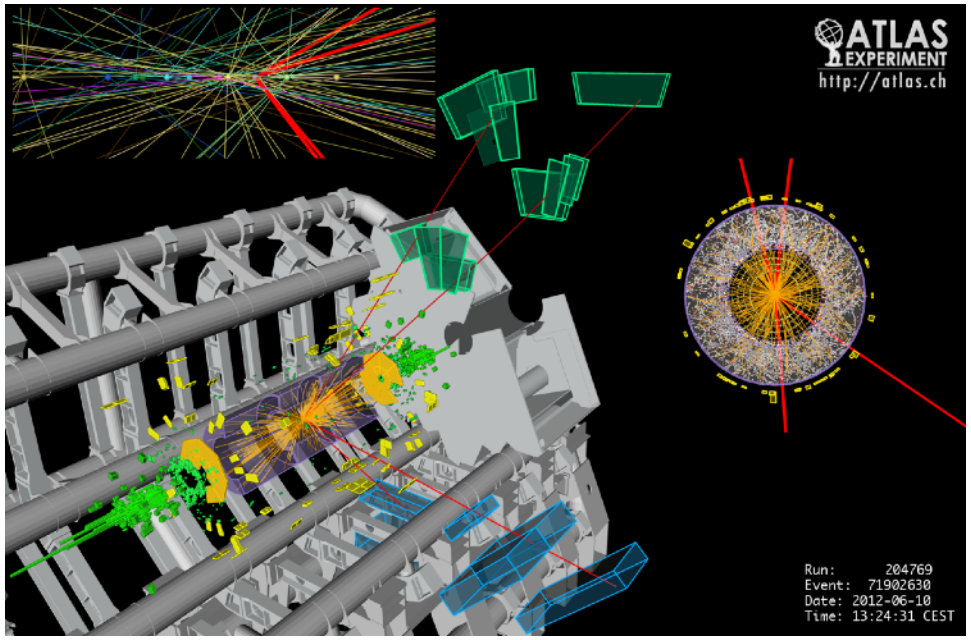
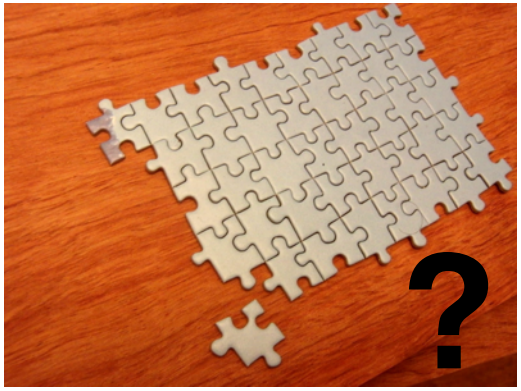




ATLAS Highlights

The Portuguese ATLAS team

The Portuguese ATLAS Team

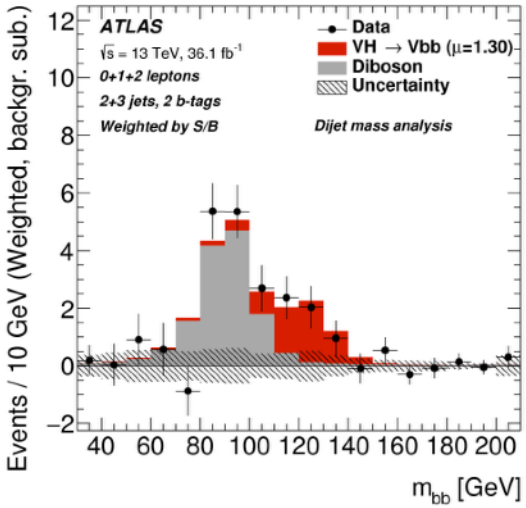
National group:

LIP (Lisbon, Coimbra, Minho)

FCUL, FCTUC, U. Minho, CFNUL, CEFITEC/UNL,

INESC, CFMC, IBEB, AdI trainee engineers

Physics Activities



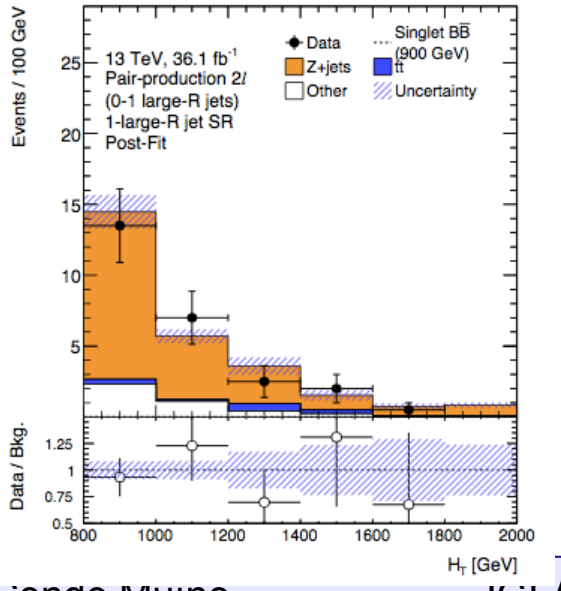
Organized in subgroups lead by a senior member

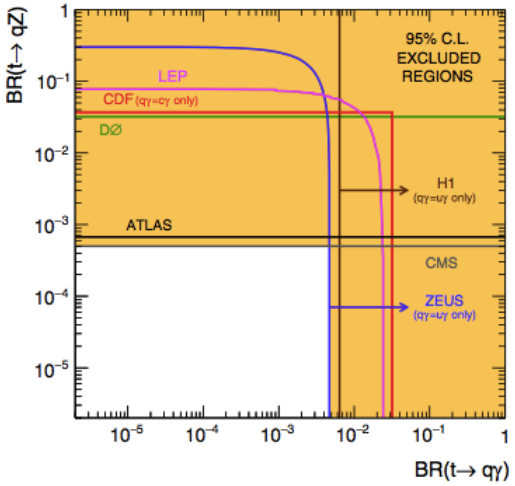
Higgs Boson Physics
P. Conde,
R. Gonçalo

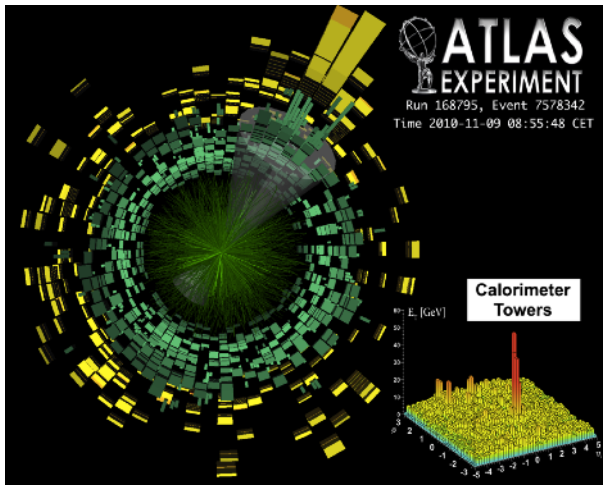
Top Quark Physics
A. Onofre
F. Veloso

Exotics Physics Searches
N. Castro

Heavy Ions Physics
H. Santos







Detector Activities

TileCal

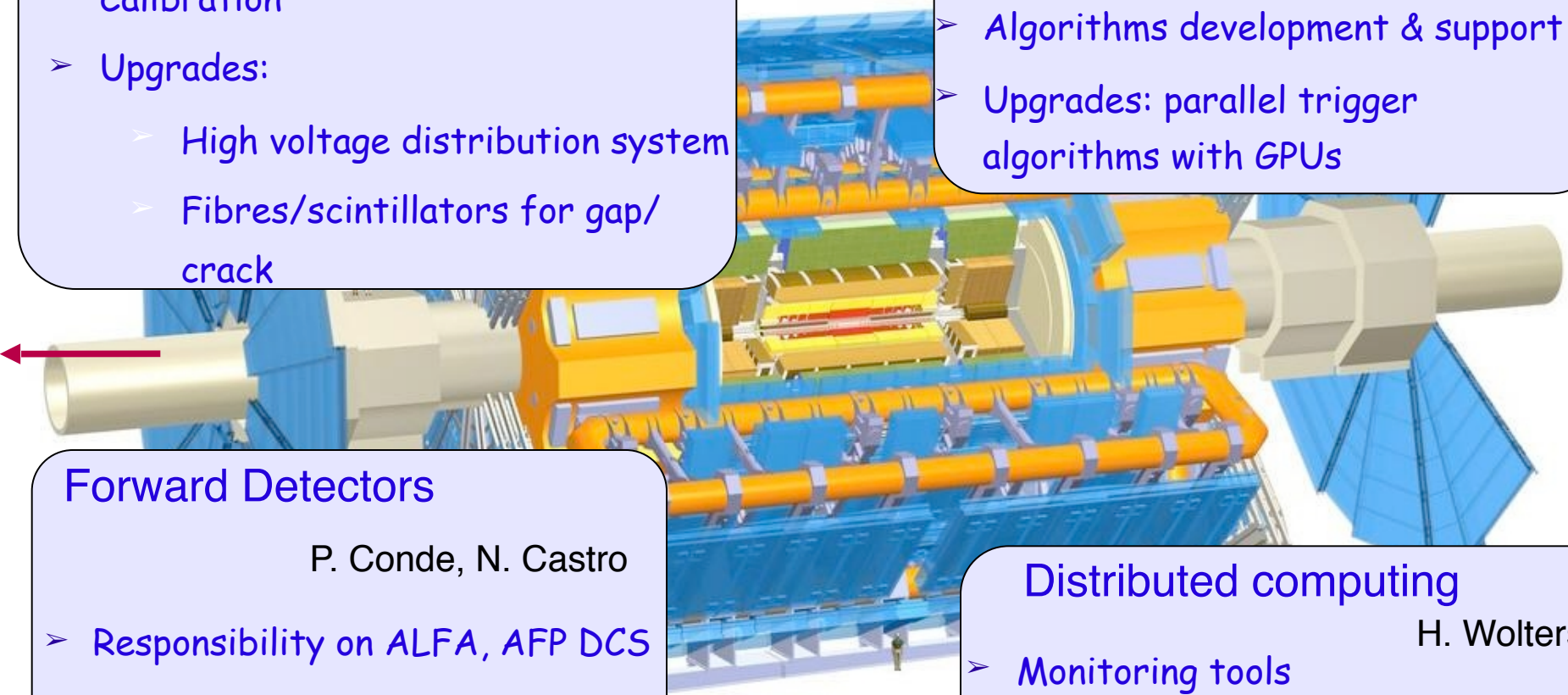
A. Gomes, A. Maio

- DCS (detector control system)
- Calibration
- Upgrades:
  - High voltage distribution system
  - Fibres/scintillators for gap/ crack

Jets trigger

R. Gonçalo, P. Conde

- Algorithms development & support
- Upgrades: parallel trigger algorithms with GPUs



Forward Detectors

P. Conde, N. Castro

- Responsibility on ALFA, AFP DCS
- Central exclusive di-jet triggers

Distributed computing

H. Wolters

- Monitoring tools
- Tier 2 infrastructure responsibility
- Iberian Cloud coordination

Detector Activities

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  - High voltage distribu
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  crack

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R. Gonçalo, P. Conde

- Algorithms development & support
- Upgrades: parallel trigger
  ith GPUs

Large variety of activities!

Will only show few examples today

Forward Detectors
P. Conde, N. Castro

- Responsibility on ALFA, AFP DCS
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Distributed computing
H. Wolters

- Monitoring tools
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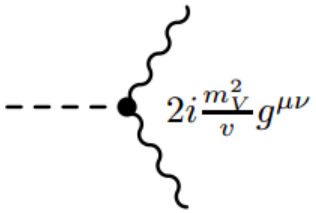
Higgs boson couplings to quarks

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

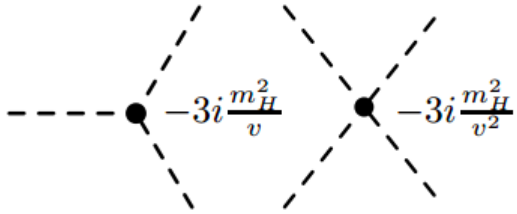
Couplings to EW gauge bosons

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



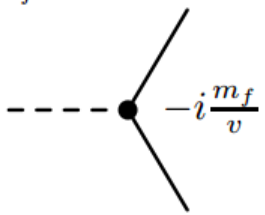
Higgs self-couplings

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



Couplings to fermions

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



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

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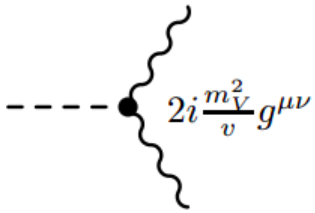

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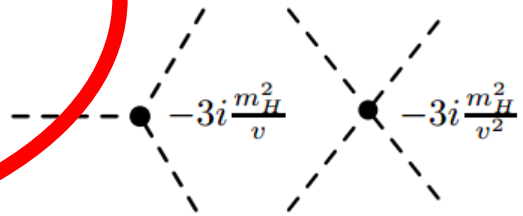

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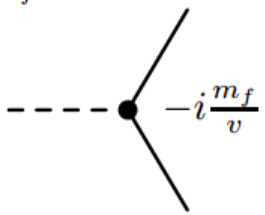

$$m_H = \sqrt{2}\mu = \sqrt{\lambda} v \quad (v = \text{vacuum expectation value})$$

- First observation and most measurements done in bosonic decay modes
- Sensitivity in individual channels @ 13 TeV reaching Run 1 results

$$\mu = \frac{\sigma \times \mathcal{B}}{\sigma_{\text{SM}} \times \mathcal{B}_{\text{SM}}}$$

$H \to WW$	μ_{ggF}	μ_{VBF}
ATLAS+CMS Run 1	0.84 ± 0.17	1.2 ± 0.4
ATLAS Run 2	$1.21^{+0.22}_{-0.21}$	$0.6^{+0.37}_{-0.36}$

Higgs boson couplings to quarks

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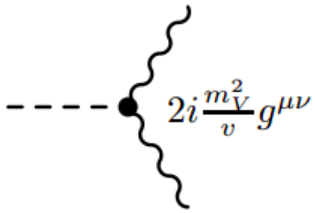

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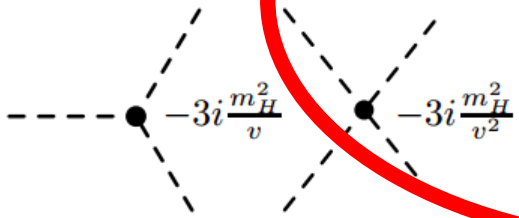

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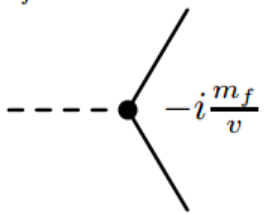
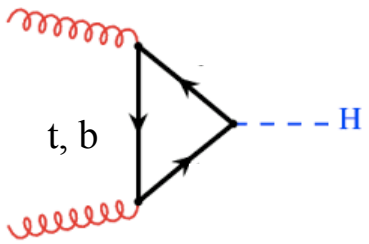


$m_H = \sqrt{2}\mu = \sqrt{\lambda} v$ (v = vacuum expectation value)

Fermion couplings:

- H→ττ decay observed at ATLAS and CMS
- Coupling to quarks

  Only indirect measurements
- Search for H→bb and ttH associated production



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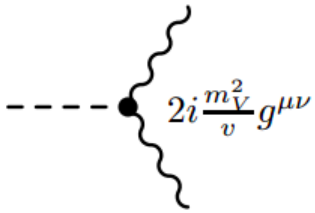

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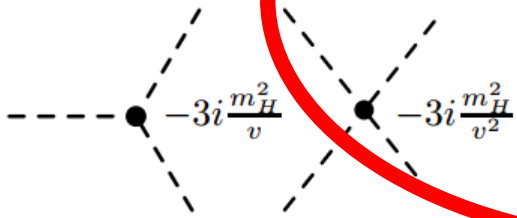

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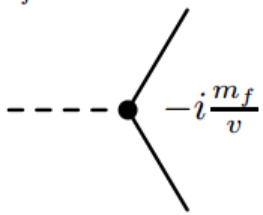

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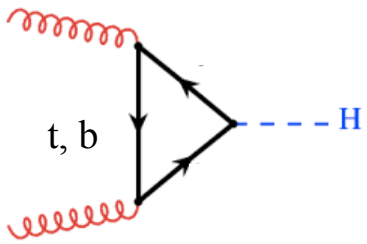


Talk of Emanuel

H → bb searches at ATLAS

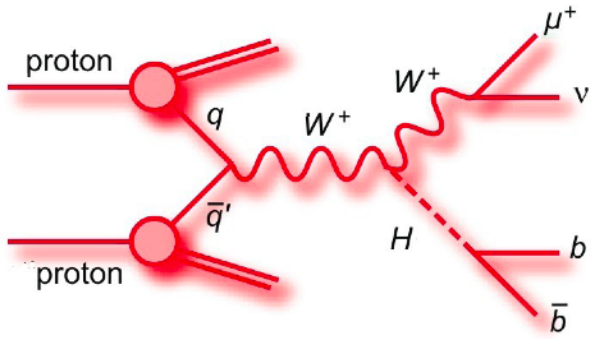
- Explore non-dominant production modes

  Associated production with W or Z

  Trigger on e/μ from W/Z decay

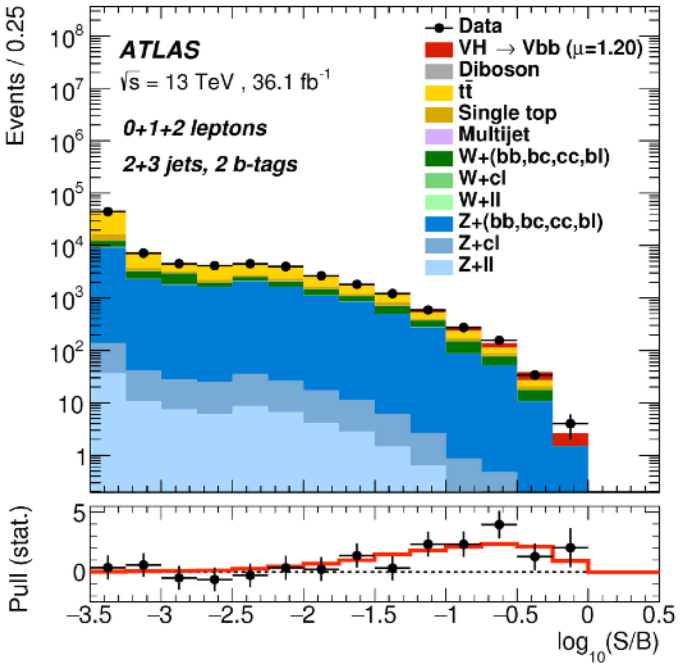
- First evidence of the H→bb decay

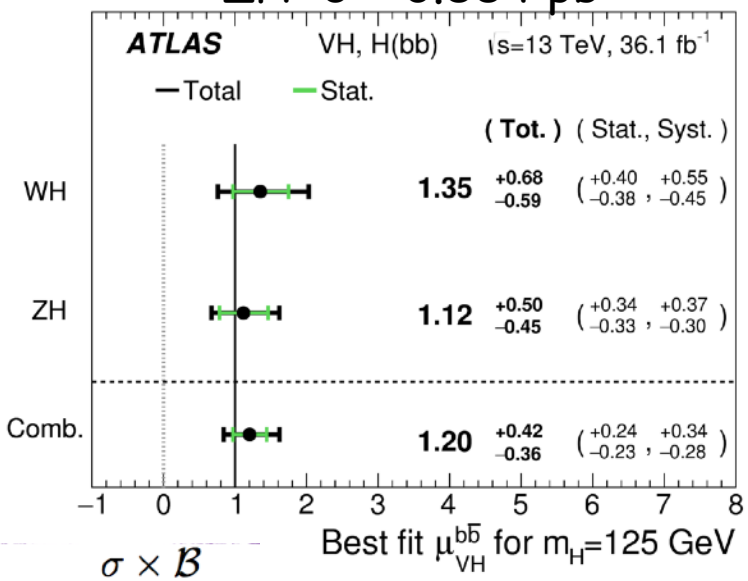
  3.5σ observed (3σ expected)



WH: σ = 1.373 pb

ZH: σ = 0.884 pb

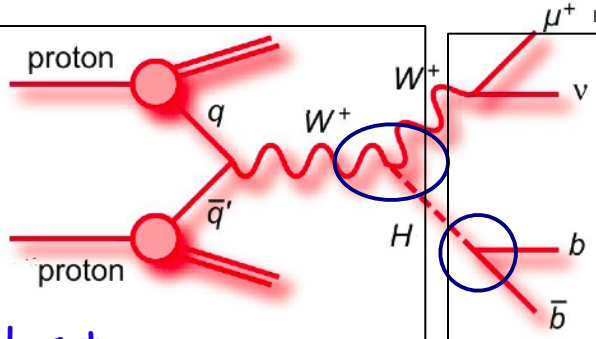




$$\mu = \frac{\sigma \times \mathcal{B}}{\sigma_{\mathrm{SM}} \times \mathcal{B}_{\mathrm{SM}}}$$

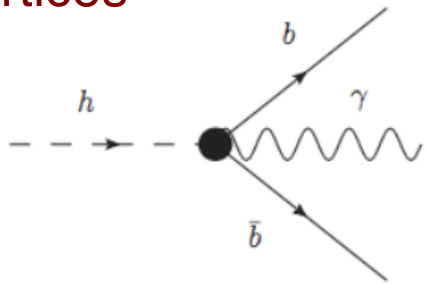
Future: probe vertex structure

HWW vertex



- Use angular variables to discriminate anomalous Spin/CP components
- Boosted topologies more sensitive

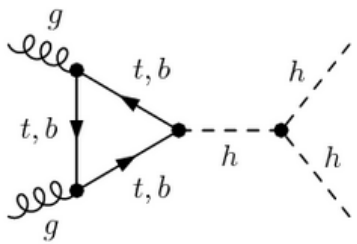
Hbb and Hbbγ effective vertices



- EFT: anomalous contributions to these vertices may come from dimension 6 operators
- Explore ATLAS sensitivity to new physics

pp → HH → bb bb

- Higgs self coupling



- Phenomenological studies in collaboration with theorists.
  R. Santos, P. Ferreira, D. Azevedo

Rare top quark decays

- Top quark: heaviest elementary particle

  Important role in searches for new physics

- FCNC in top quark decays (t→Zq)

  Strongly suppressed in SM

  36 fb^{-1} of pp collisions @ 13TeV analysed

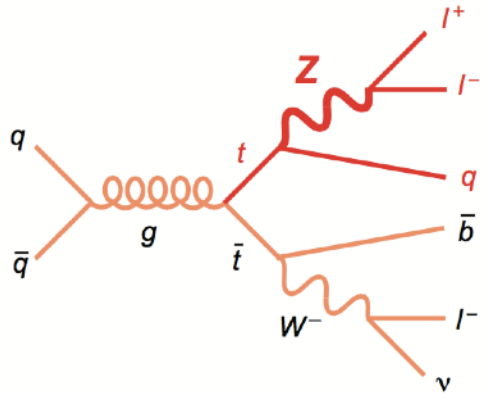
  No signal seen → derived 95% CL limits

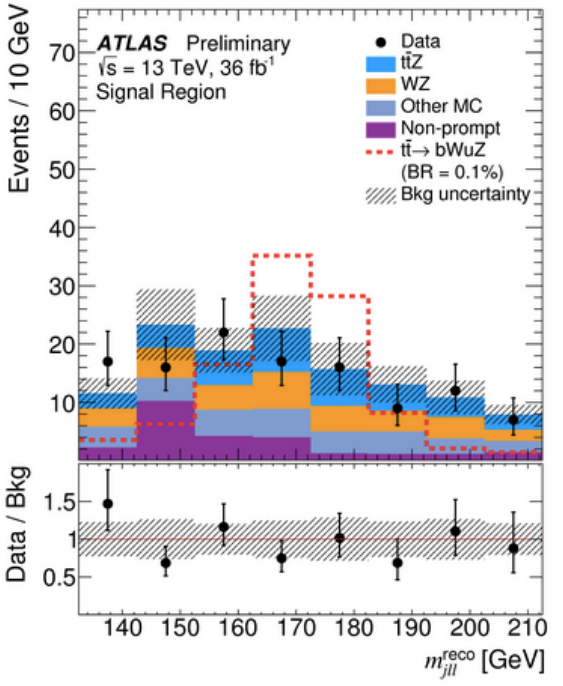
	BR(t->uZ)	BR(t->cZ)
observed	1.7×10^{-4}	2.3×10^{-4}
expected	1.7×10^{-4}	2.2×10^{-4}

  Most stringent limits to date!

- Measurement BR(t→Ws)

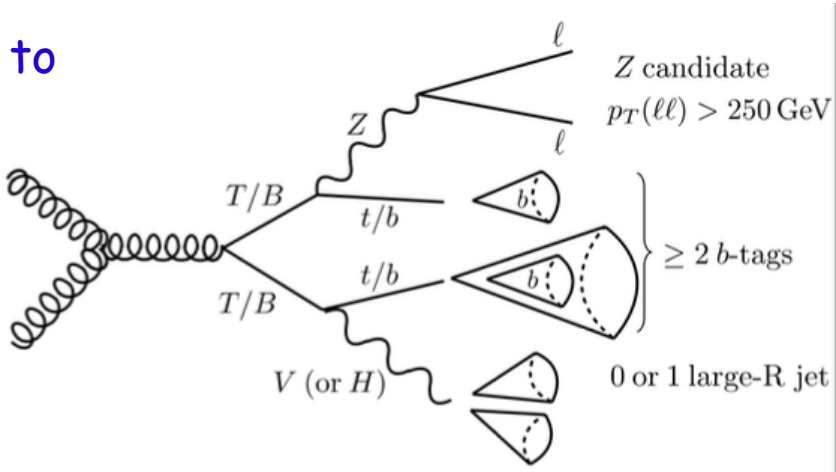
  Test of the Vts vertex



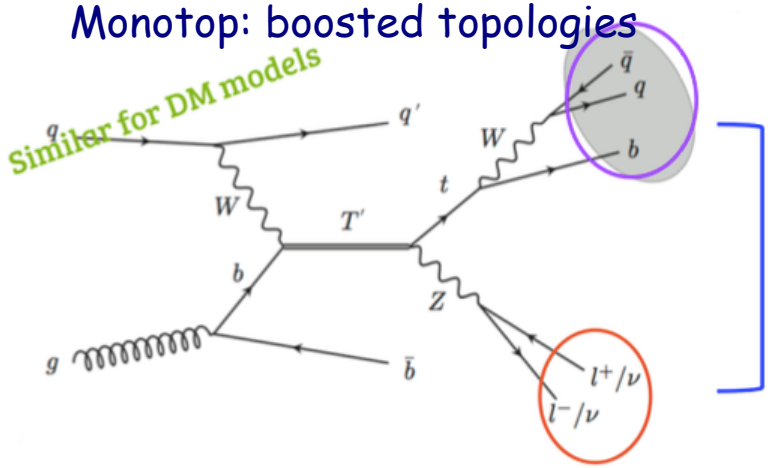


Exotics physics searches

- Vector-like quarks appear in many models to cancel Higgs mass divergencies
  - Left-handed and right-handed components transform in the same way under SU(2)
- Two channels:
  - Z+bjets final states
  - Monotop
    - Sensitive also to dark matter!

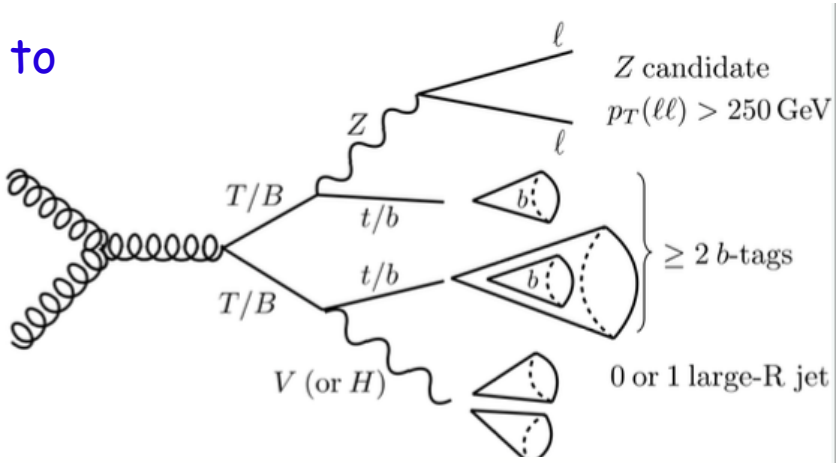


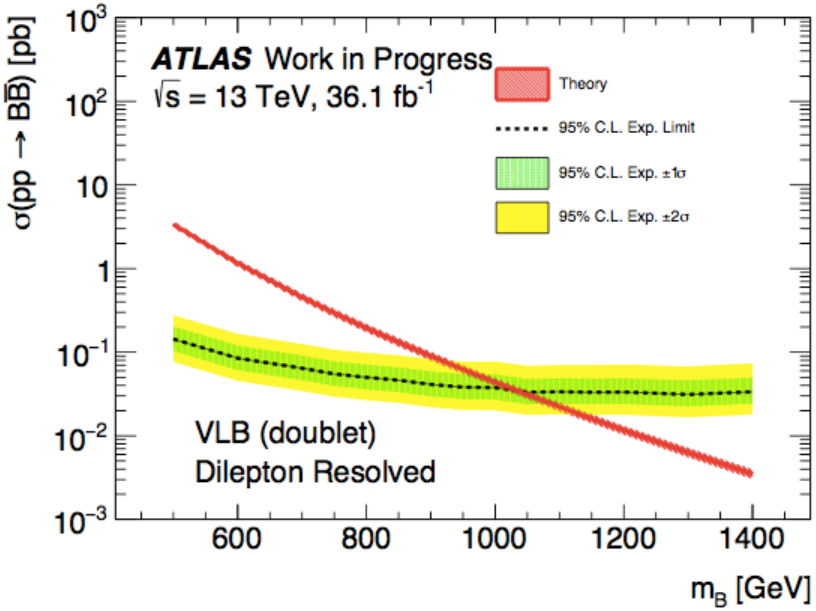
Monotop: boosted topologies



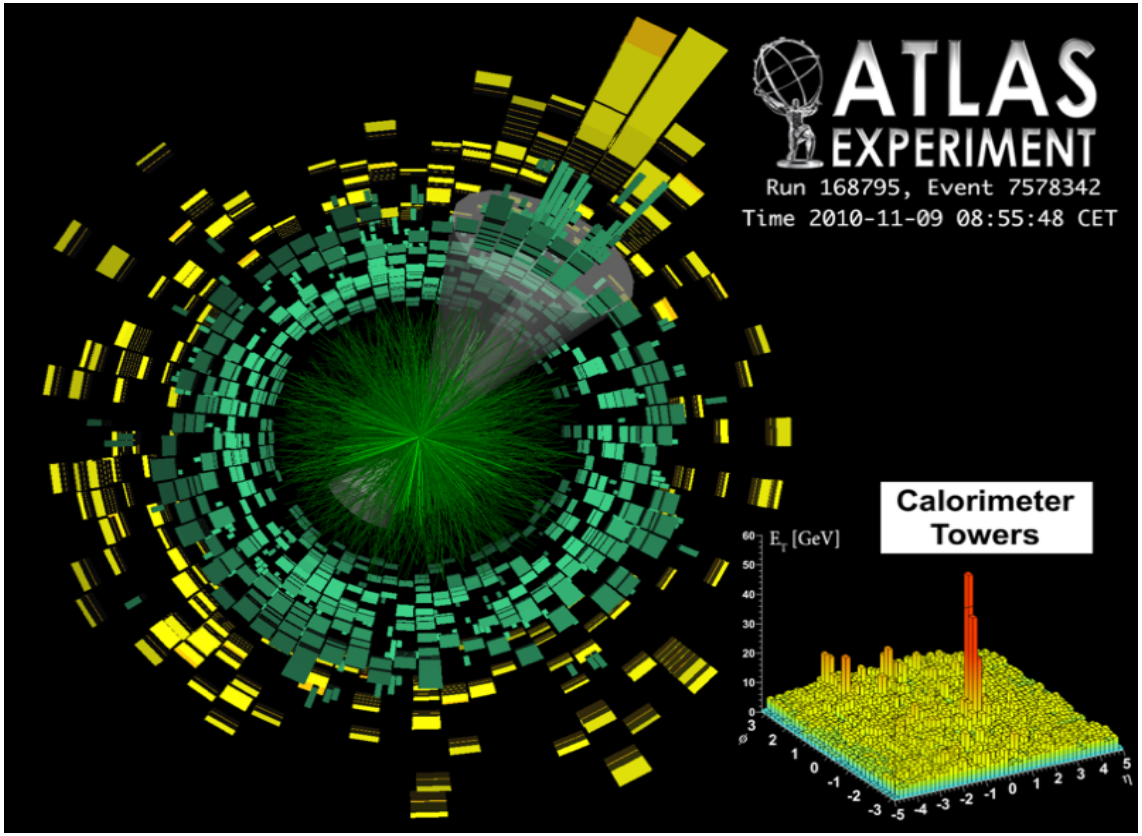
Exotics physics searches

- Vector-like quarks appear in many models to cancel Higgs mass divergencies
  - Left-handed and right-handed components transform in the same way under SU(2)
- Expected low mass limits for Z+bjets analysis (stats only)
  - Singlet (doublet) B: 864 (1034) GeV
  - Singlet (doublet) T: 746 (850) GeV
- Similar final state
  - Search for FCNC in top quark production → Ana's talk





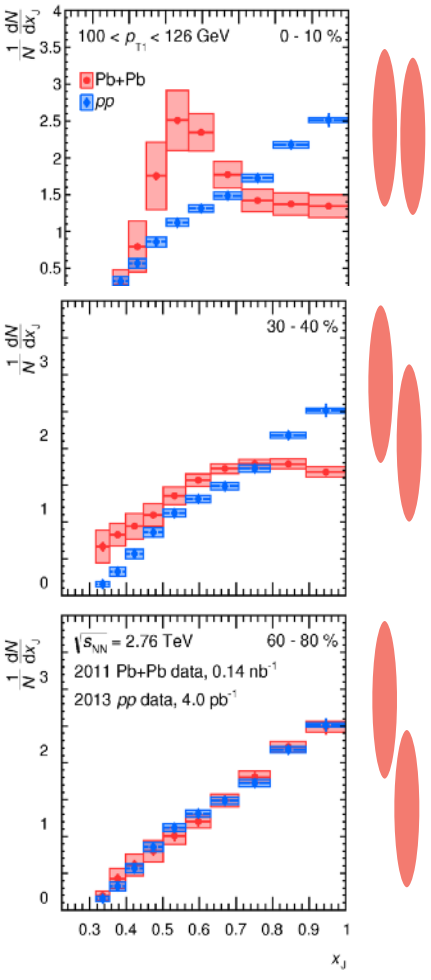
QGP tomography with jets in Heavy Ion collisions



Di-jet asymmetry in Heavy Ion collisions

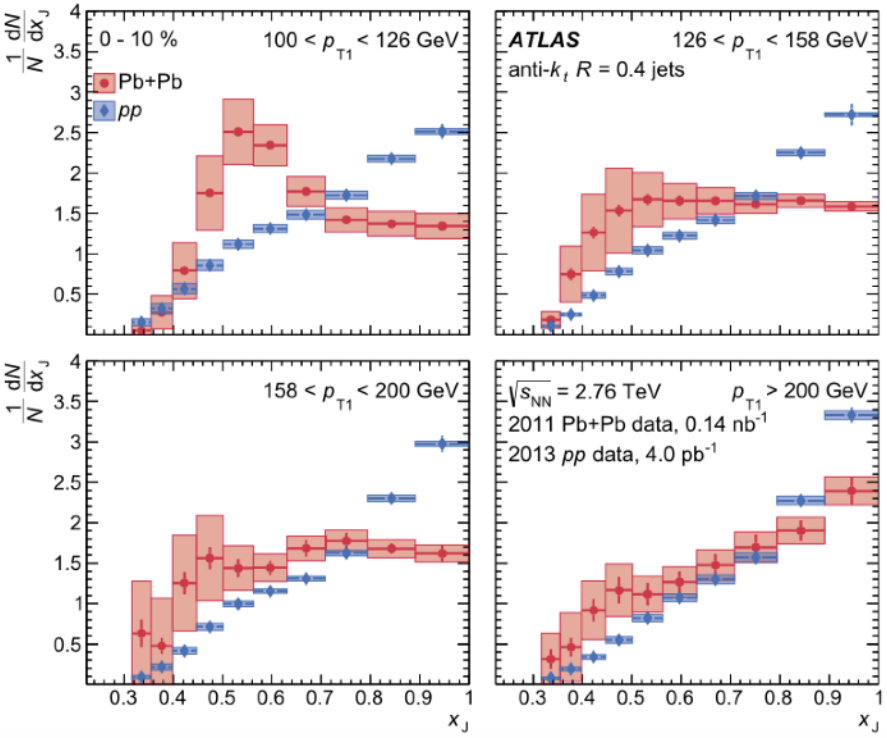
Run 1- results

Physics Letters B 774 (2017) 379



- Probes jet quenching due to QGP
- Unfolded $x_J = p_{T2}/p_{T1}$ distributions

  Corrected by detector effects and underlying event
- Asymmetry increases with centrality but decreases with p_T



Heavy flavour di-jet asymmetry

- b-jet asymmetry sensitive to the nature of energy loss

  Smaller medium-induced gluon radiation with increasing q mass

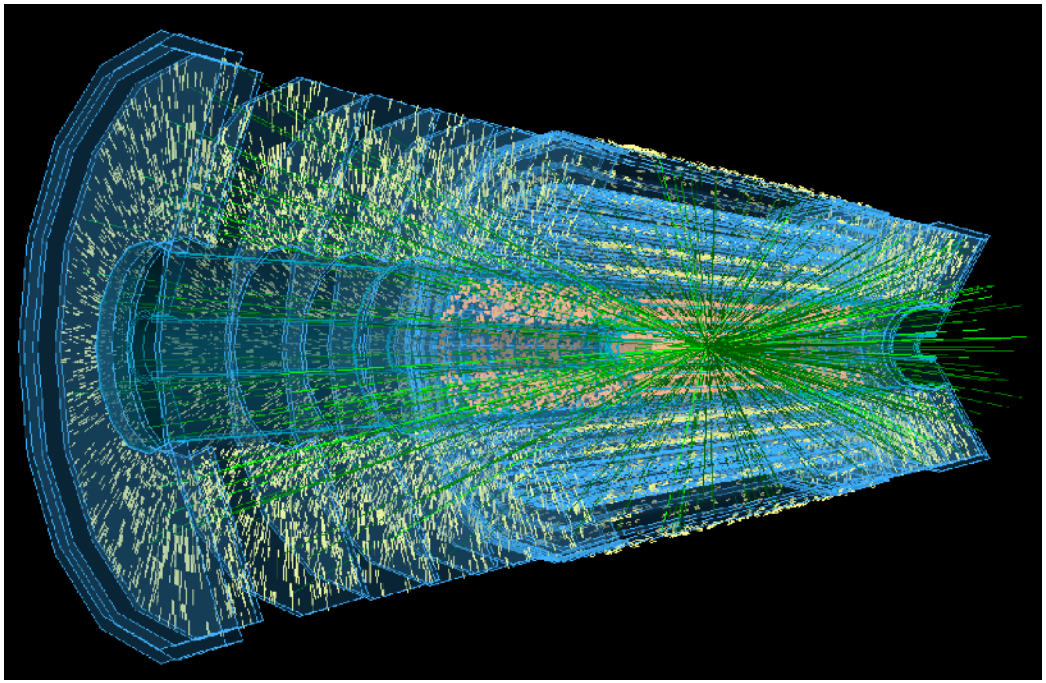
- Study b-jet pT asymmetry as a function of pT

  Compare to light quark results

- Development of

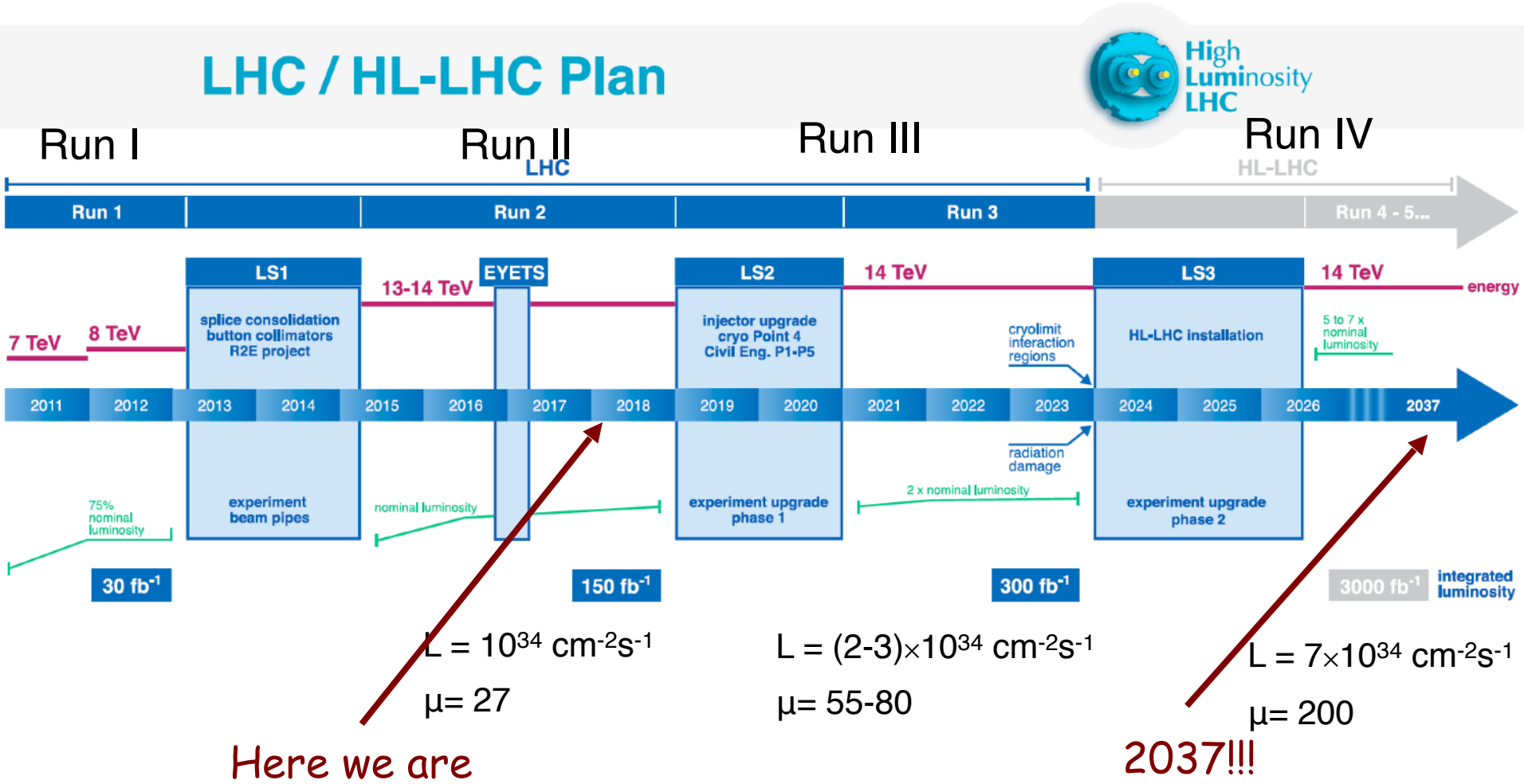
  b-tagging algorithms for very dense HI environment

  b-jets trigger menus



Detector Upgrades

LHC and detector Upgrades schedule



$L = 10^{34}$ cm^{-2}s^{-1}

μ= 27

Here we are

$L = (2\text{-}3)\times10^{34}$ cm^{-2}s^{-1}

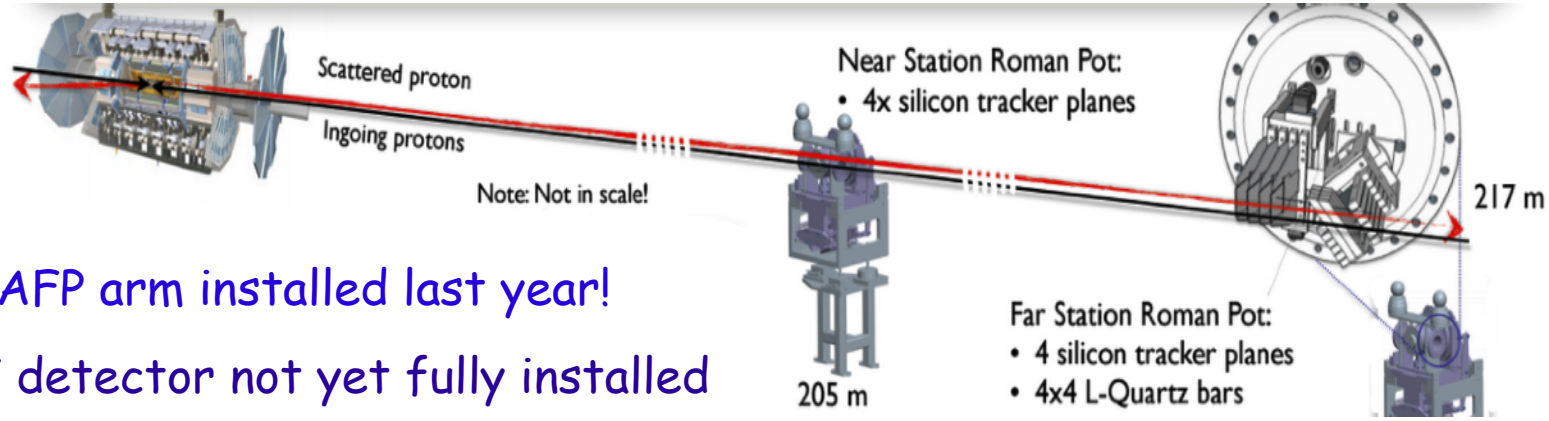
μ= 55-80

$L = 7\times10^{34}$ cm^{-2}s^{-1}

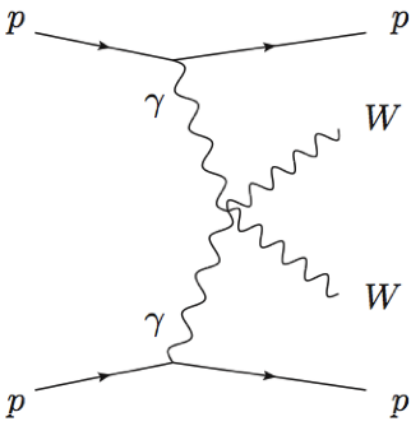
μ= 200

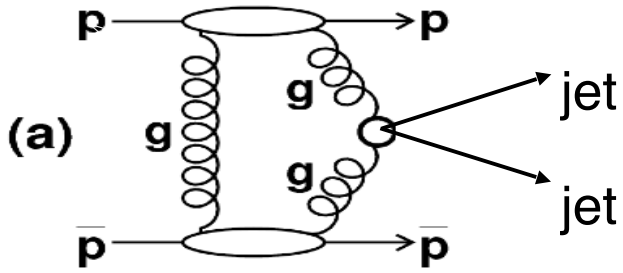
2037!!!

ATLAS Forward Proton tagging detectors

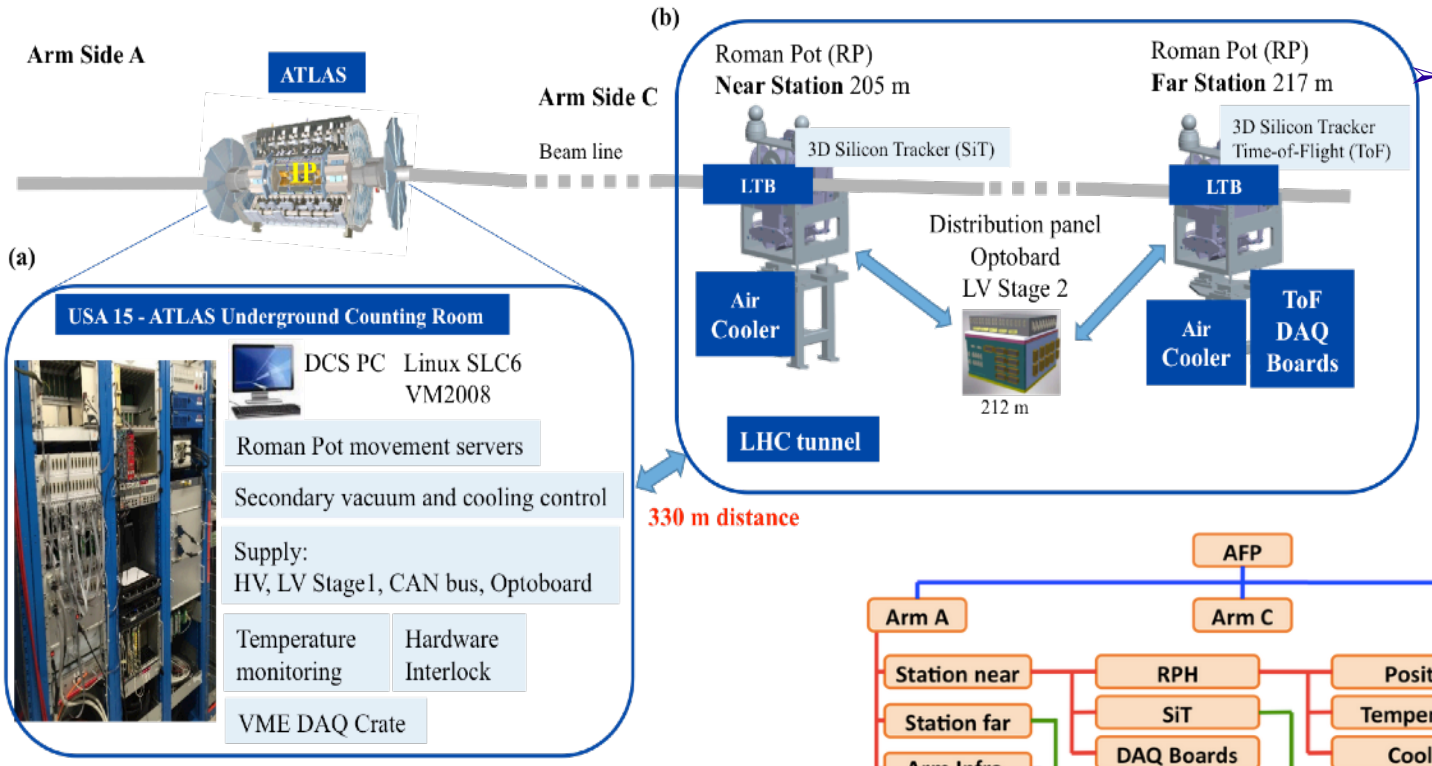


- Second AFP arm installed last year!
  - ToF detector not yet fully installed
- Converts the LHC in a photon-photon collider!
- Central exclusive di-jet trigger
  - Important for QCD physics studies
  - Two protons + 2 jets, nothing else in the detector
  - Requires dedicated triggers

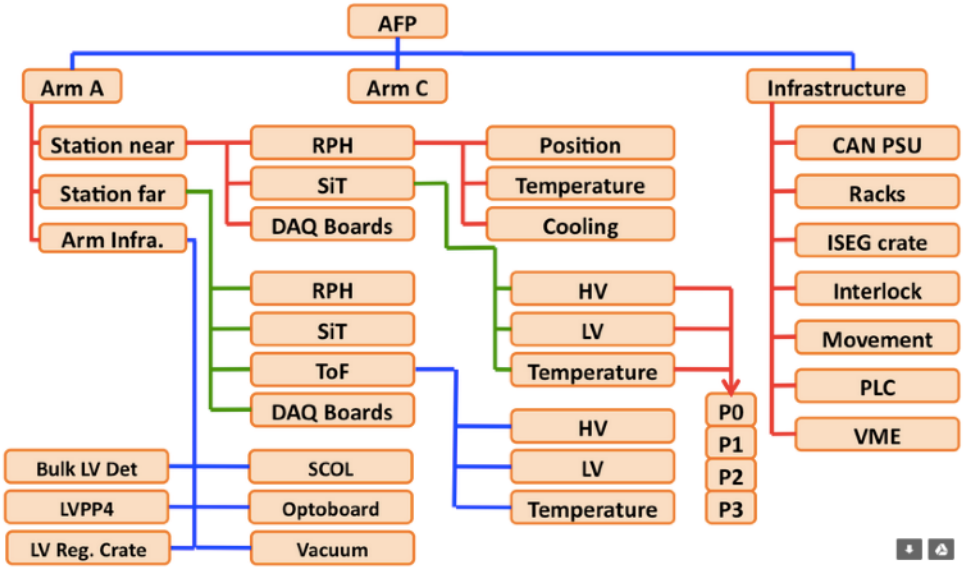




AFP Detector Control System



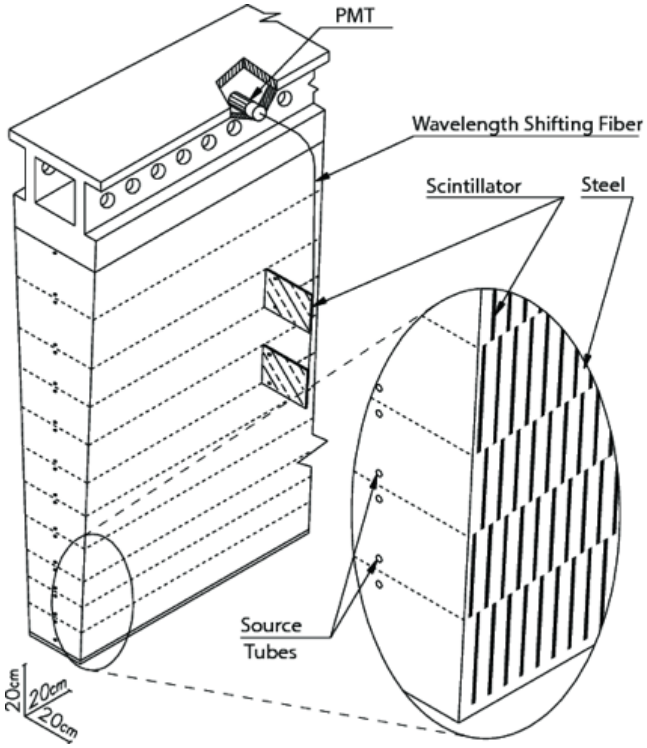
➢ Main challenge: cope with the large variety of sub systems



➢ Provides tools and services for detector operation:

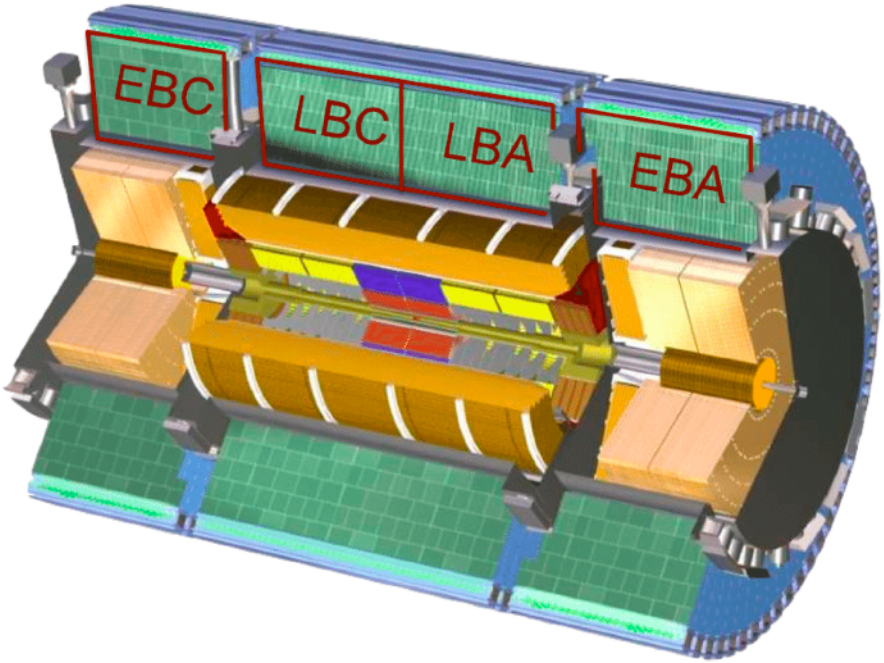
FiniteStateMachine, archiving, alerts, graphical user interfaces

ATLAS Tile hadronic calorimeter

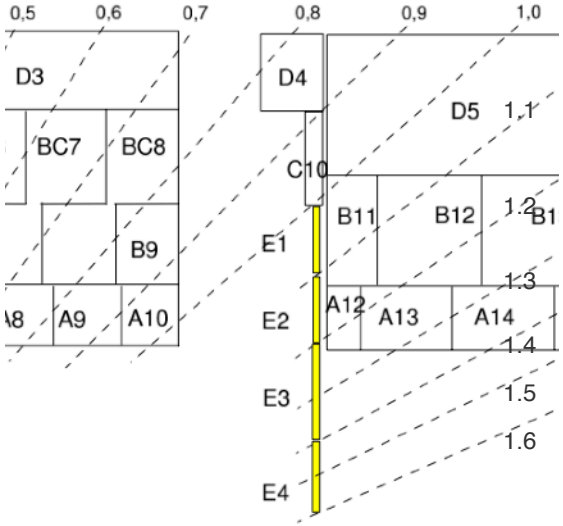


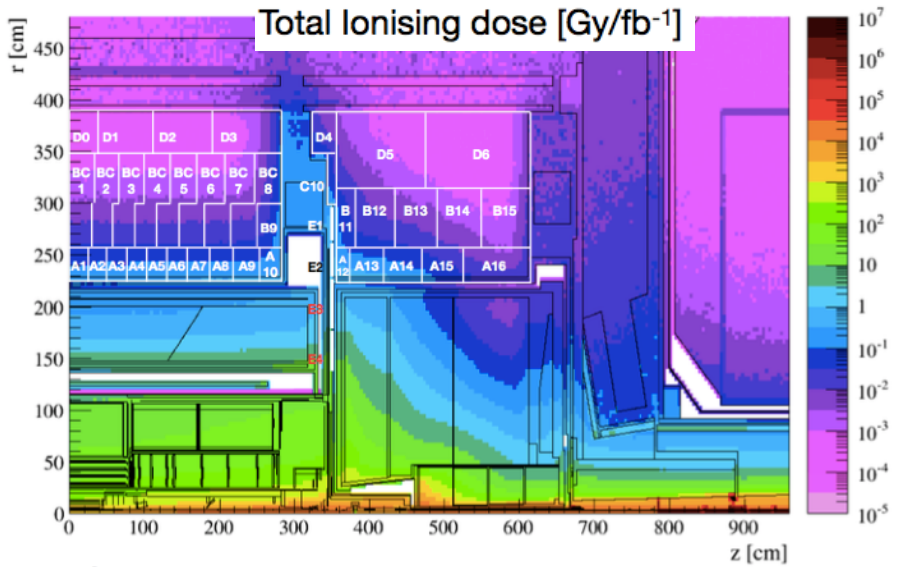
TileCal:

- Sensitive material: plastic scintillator tiles
- Steel as absorber
- Readout by wavelength shifting fibres & PMTs



Phase I gap/crack optics replacement

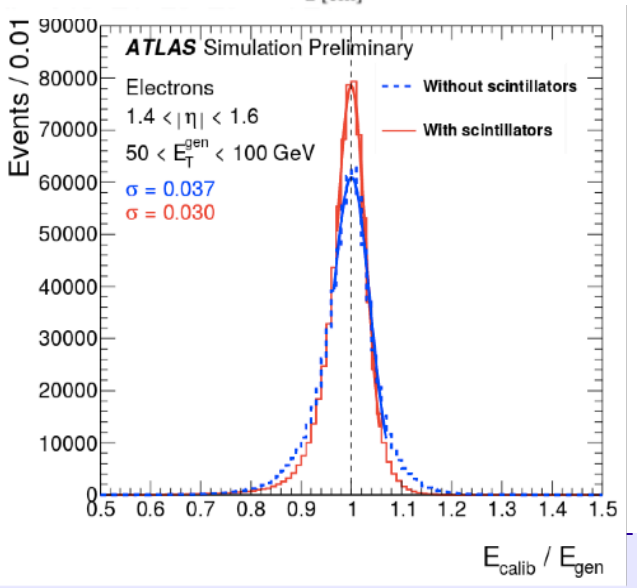




Extension to 1.75

- Gap/crack scintillators+fibres very affected by radiation damage

  Replacement possible
- Aluminization of WLS fibres at LOMAC
- Very important for e/γ and jets performance



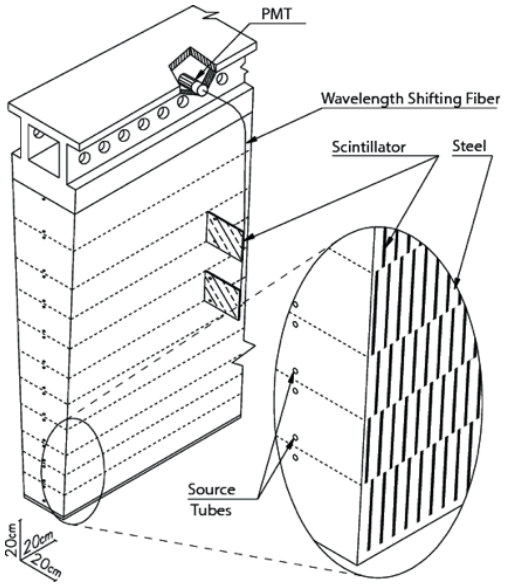
LOMAC facilities

- Dedicated test benches
  - Optical characterisation of Optical fibres (Fibrometer)
  - Optical characterisation of Scintillators (Tilemeter)
  - PMTs characterisation
- Sputtering setup for top aluminization of fibres
- Oven for accelerated natural ageing
- Milling machine (to be repaired/replaced)

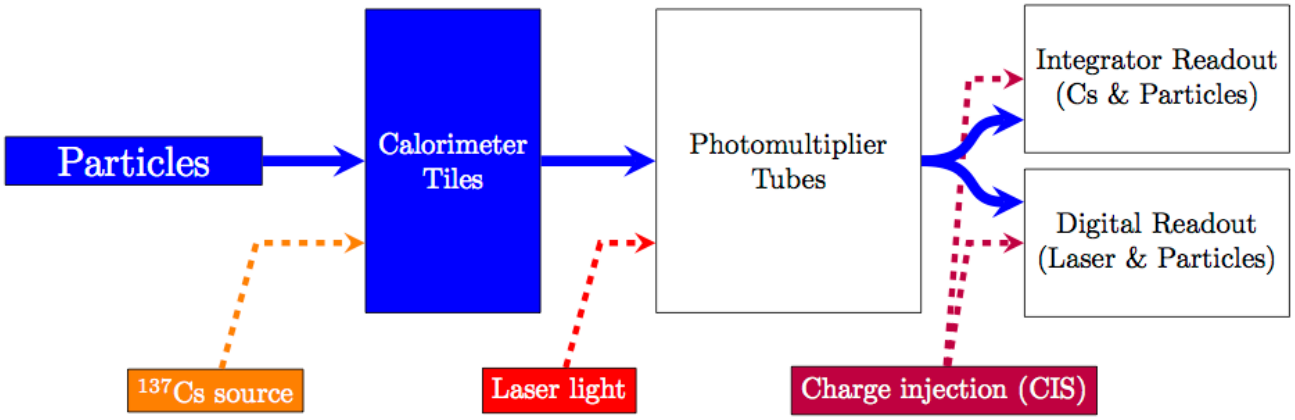
Ageing of TileCal scintillations & fibres

Detector scintillators and fibres cannot be replaced

- Fundamental to evaluate ageing for the HL-LHC era
- Use TileCal calibration system



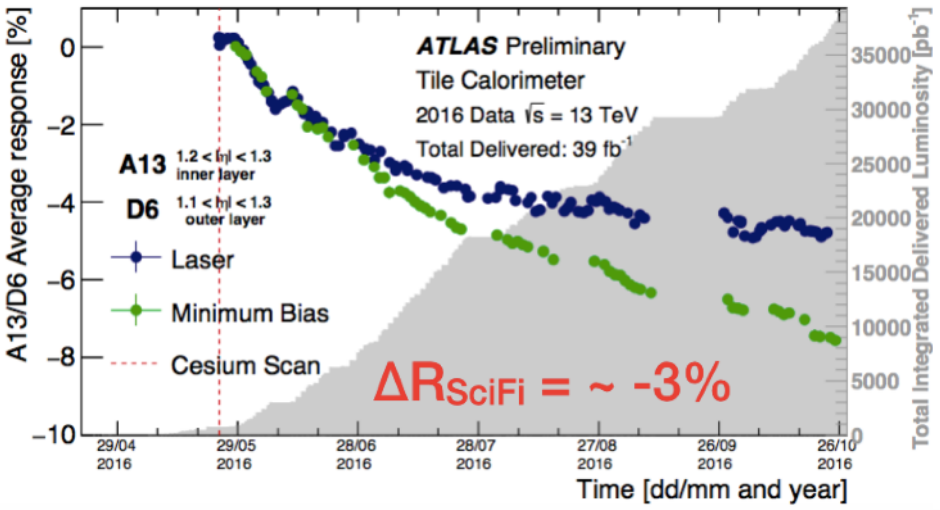
TileCal calibration system designed to monitor each step of the readout chain independently

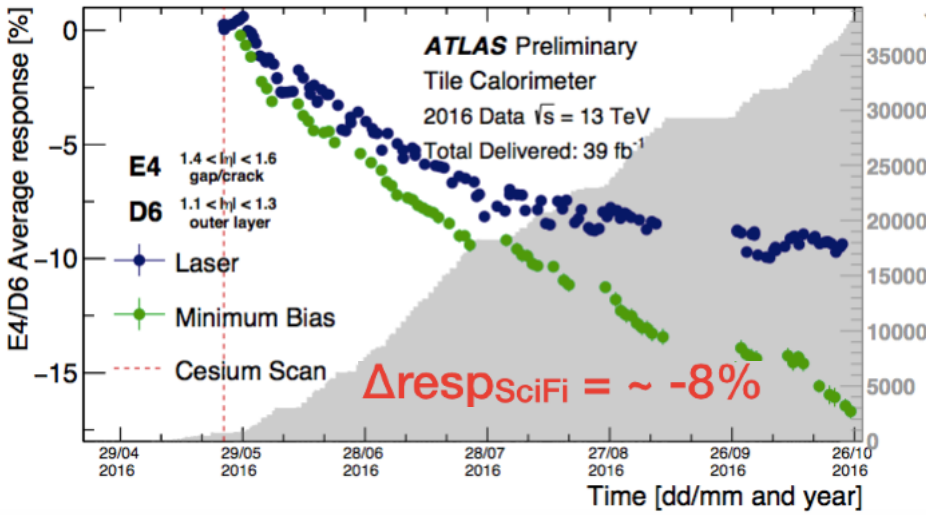


Ageing studies with pp collisions data

- Minimum bias data also used as monitoring system:
  - Energy deposition proportional to instantaneous luminosity
  - Factorise dependence by normalising to least irradiated cell
- PMT response measured with laser calibration system

$R_{SciFi} = R_{MB} - R_{Las}$ interpreted as response variation of scintillators & fibres

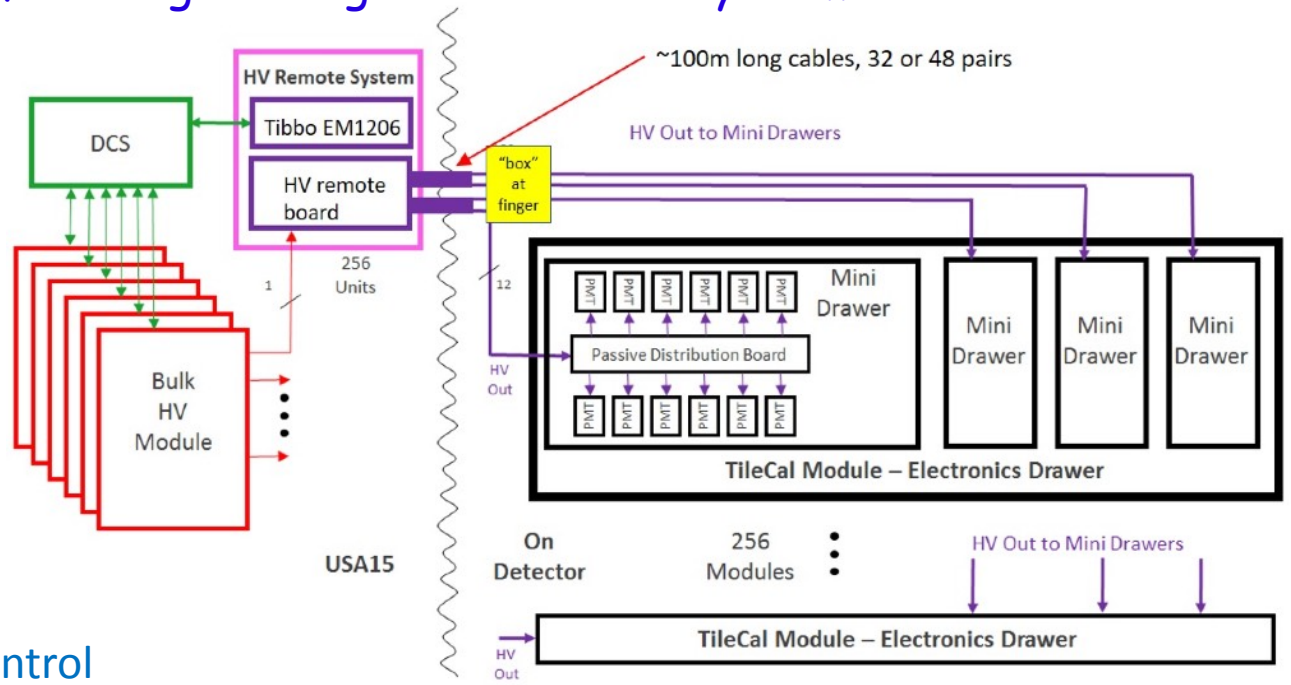




TileCal High Voltage Distribution system

- Current electronics will not survive Phase II
- Re-design of the high voltage distribution system

- **Easy maintenance**
- **No radiation**
- **Always accessible**



Regulation and control system off detector at USA15
Under development at LIP/FCUL

~20 000 wires
<- 100m long cables →
Narrower cables
produced at Cabelte

HVbus (passive distribution board) in detector

Trigger GPGPU demonstrator prototype

- HL-LHC challenges for the trigger

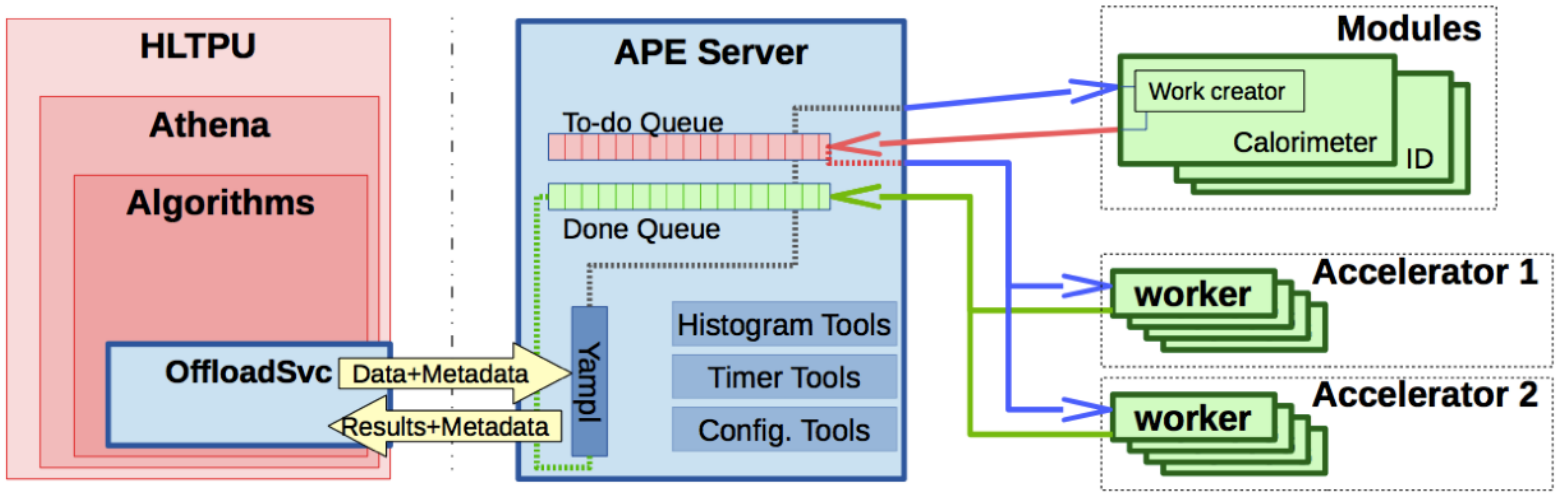
  Huge increase in rates and event sizes —> Larger processing times

- Explore General Purpose Graphical Processing Units at trigger level

  Single-instruction-multiple-data paradigm

- Implementation of a demonstrator prototype

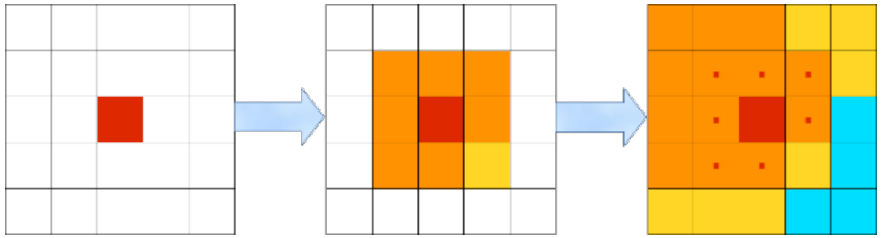
  Responsibility on the calorimeter clustering reconstruction

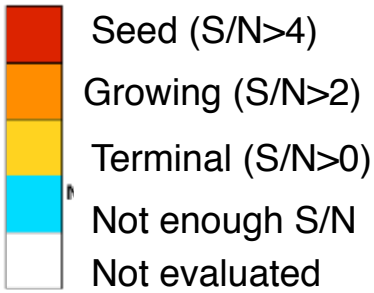


GPGPU Calorimeter Clustering Algorithm

- TopoCluster reconstruction on CPU (~8% of total time)

  Group cells in 3-dimensions according to their signal/noise ratio



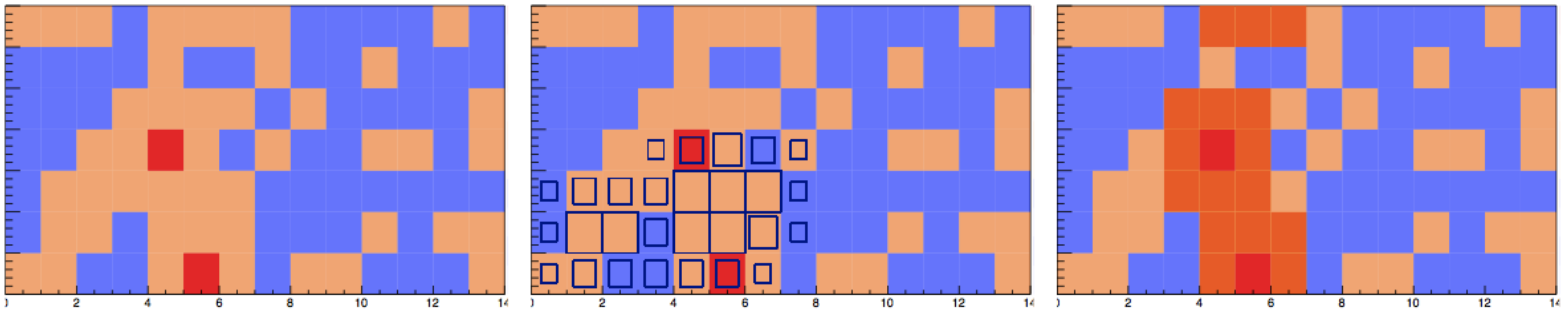


- TAC: Topo-Automaton Clustering

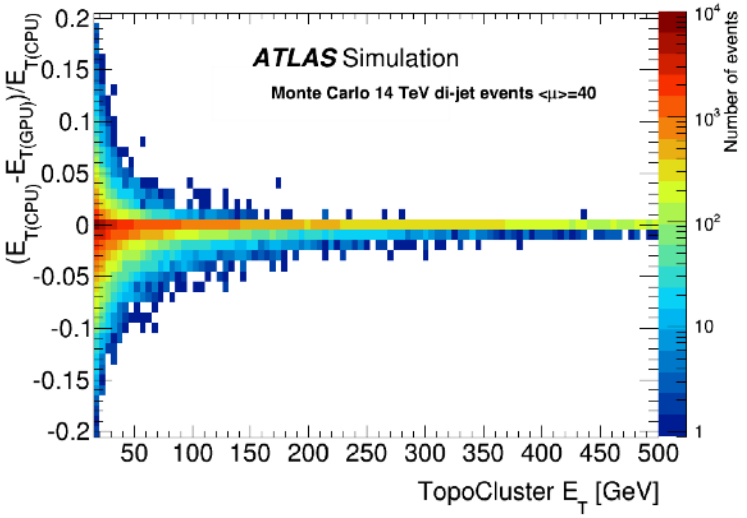
  Use a cellular automaton for the GPU (maximize parallelism)

  Propagate tag on a grid of elements (cell pair)

  Process all cells pairs until no tag changes



GPGPU Calorimeter Clustering Performance

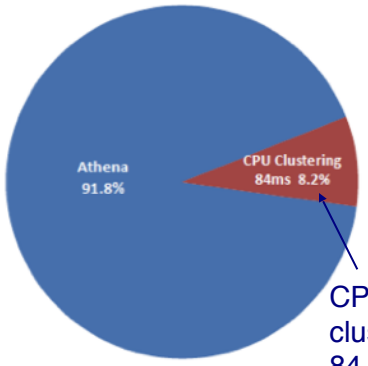


- Energy difference <5% for most clusters
- Cluster growing time reduction factor:

Sample	Pile-up	Reduction factor
tt-bar	138	2
tt-bar	46	2
di-jets	40	1.3

- Up to a factor five time improvement when including splitting!!

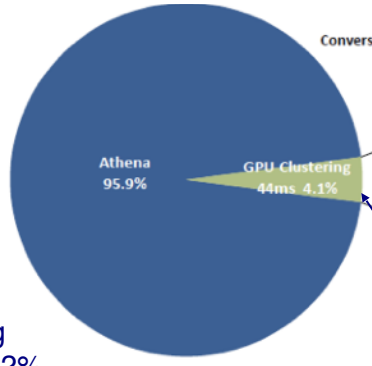
Calorimeter clustering on CPU



CPU clustering 84 ms, 8.2%

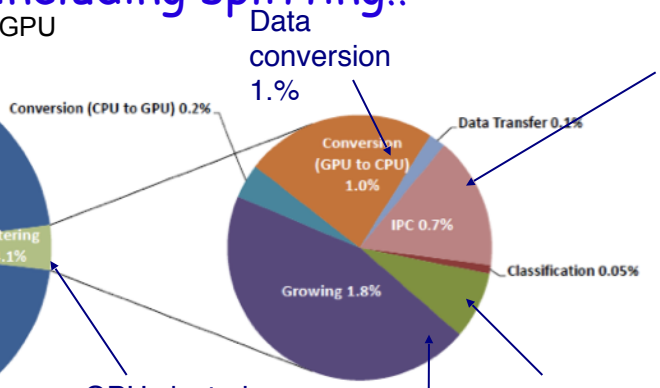
Time per event 1.02 s

Calorimeter clustering on GPU



GPU clustering 44 ms, 4.3%

Time per event 1.06 s



Data conversion 1.%

IPC 0.7%

Tagging

Growing 1.8%

Summary and conclusions

- Exploring the pp and PbPb collisions produced by the LHC
  - Probe the Standard Model and search for new physics
  - Higgs, top, exotics, QGP

- The Portuguese ATLAS team has expertise/interest on a large variety of activities

  Calorimetry, jet performance and reconstruction

  Fibres and scintillator detectors

  Detector control systems

  Real time trigger software

Backup

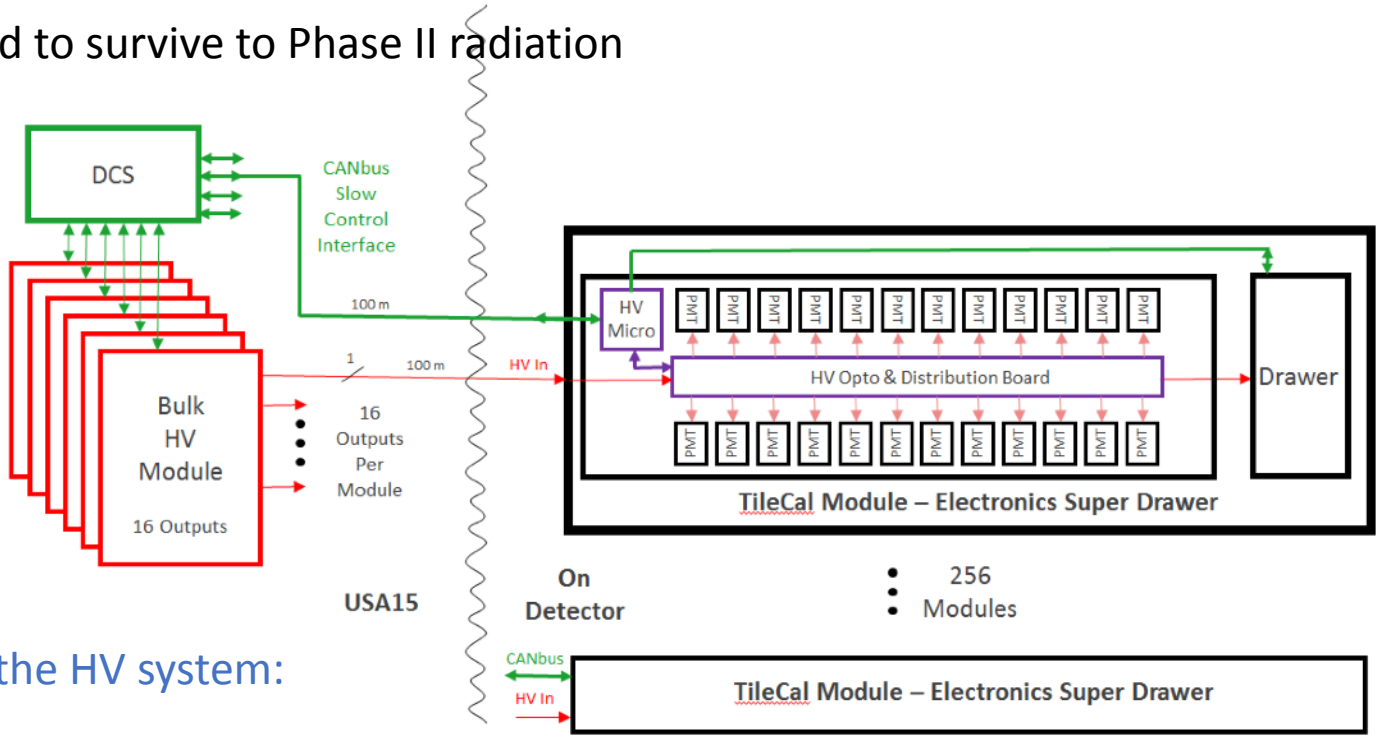
Motivation for HVPS upgrade

TileCal HV regulation system is currently located inside the detector

Needs only 256 HV cables, 1 external HV enough to produce 48 HVs for the PMTs

Needs to be replaced for Phase II since

- it is old and it will become difficult to maintain
- not expected to survive to Phase II radiation



TileCal HV system

Specifications for the HV system:

~10 000 PMTs,

HV < 900 V (average ~750 V)

Individual currents < 400 μA

HV stability < 0.5 V rms

AFP CEP di-jet trigger