# Photon triggers performance of the ATLAS experiment at LHC

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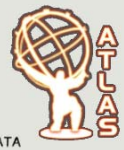



UNIVERSIDAD NACIONAL DE LA PLATA

# Outline

# ATLAS

## The ATLAS experiment

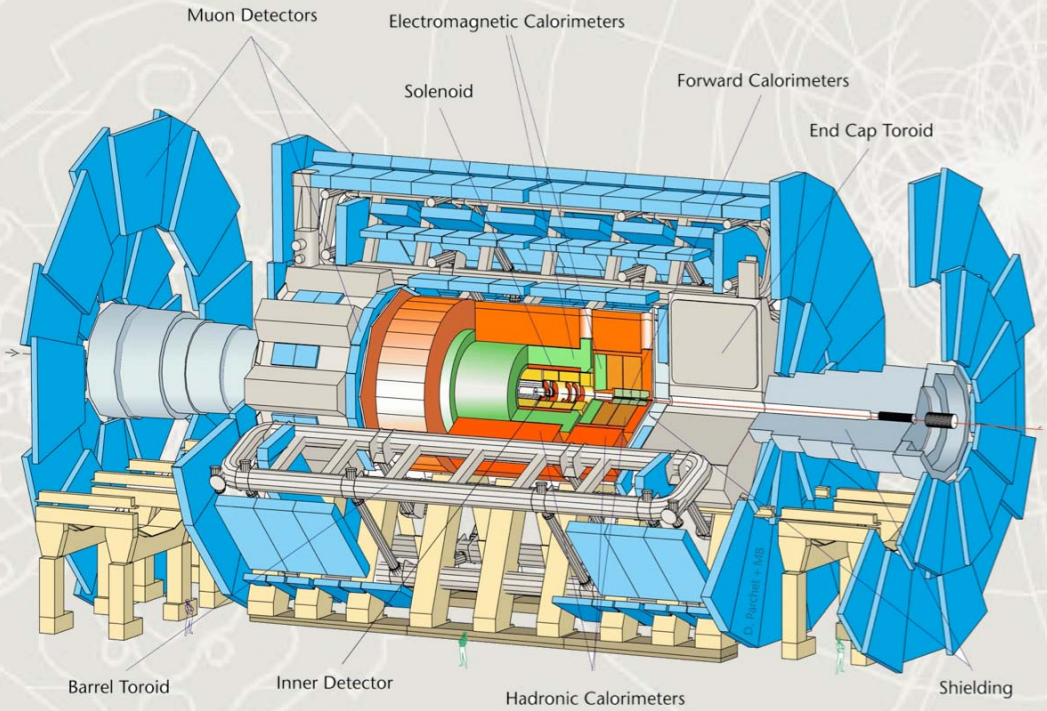
Is a multi purpose experiment @LHC, designed to:

- Discover new physics
- Validate or reject the available theoretical models: e.g. Higgs and supersymmetry
- perform high precision SM measurements
- Detect unpredicted physical signals.

# The ATLAS detector

The ATLAS detector is compose of the following subdetectors, each one is “sensitive” to different properties of different particles:

- Inner Detector
- EM and Had Calorimeter
- Muon Detector



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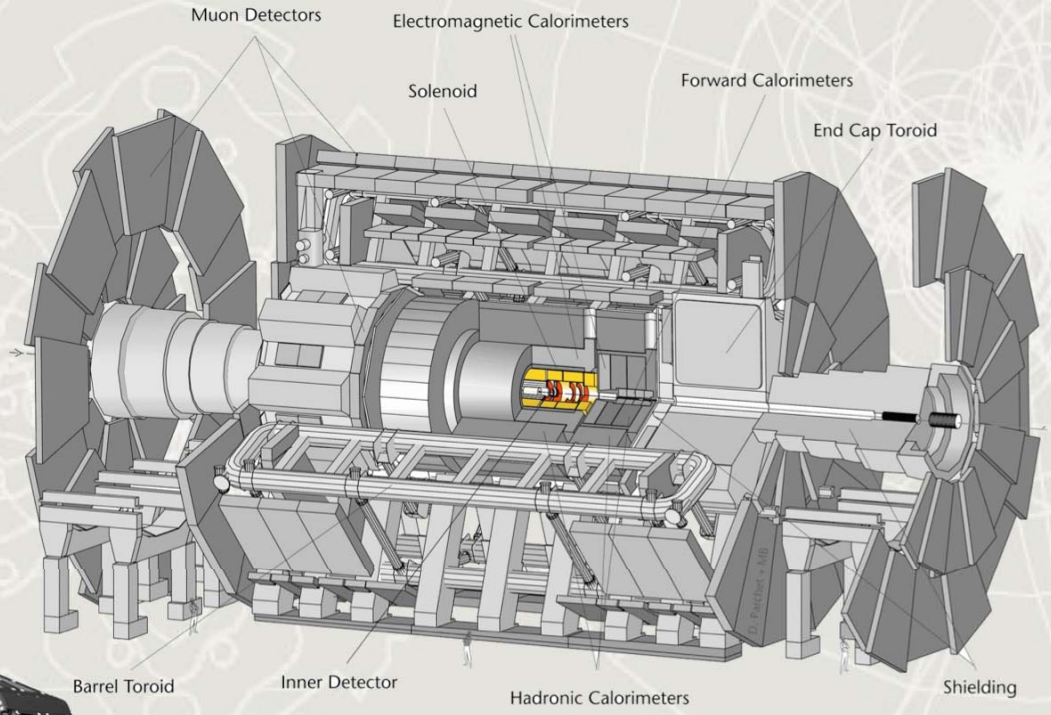


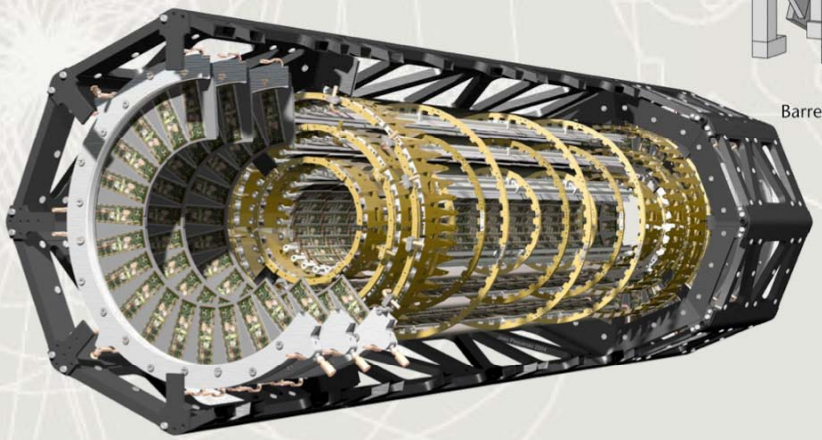

- Tracking: Composed by Pixel, SCT and TRT

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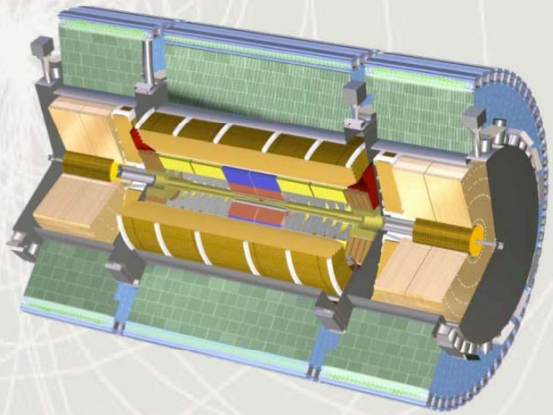

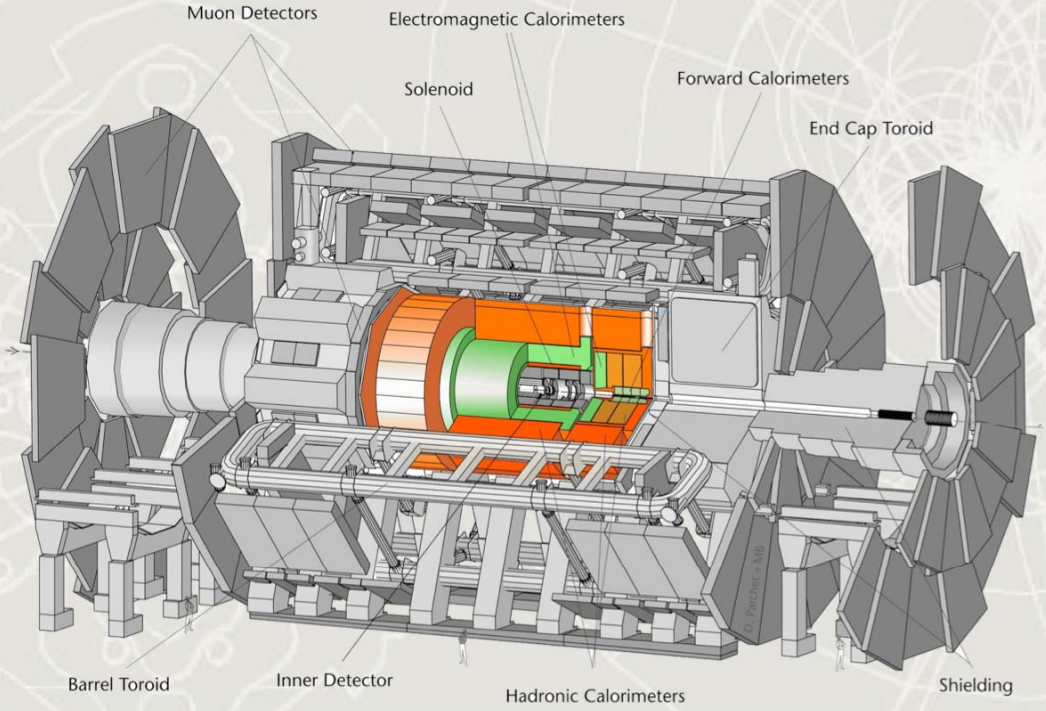


- calorimeters: EM Liquid Argon and Hadronic Tile detectors

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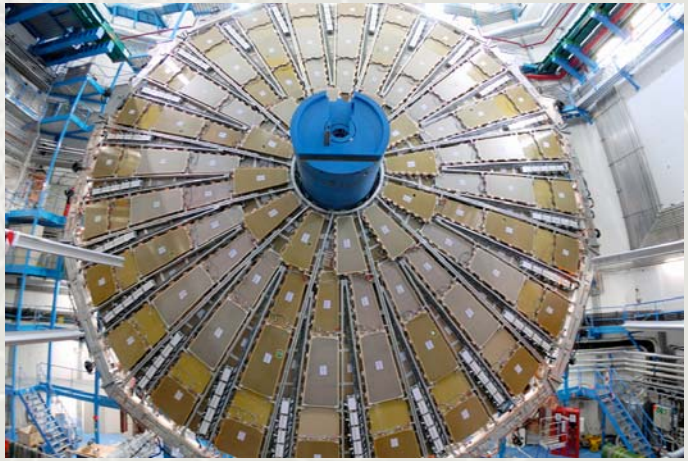
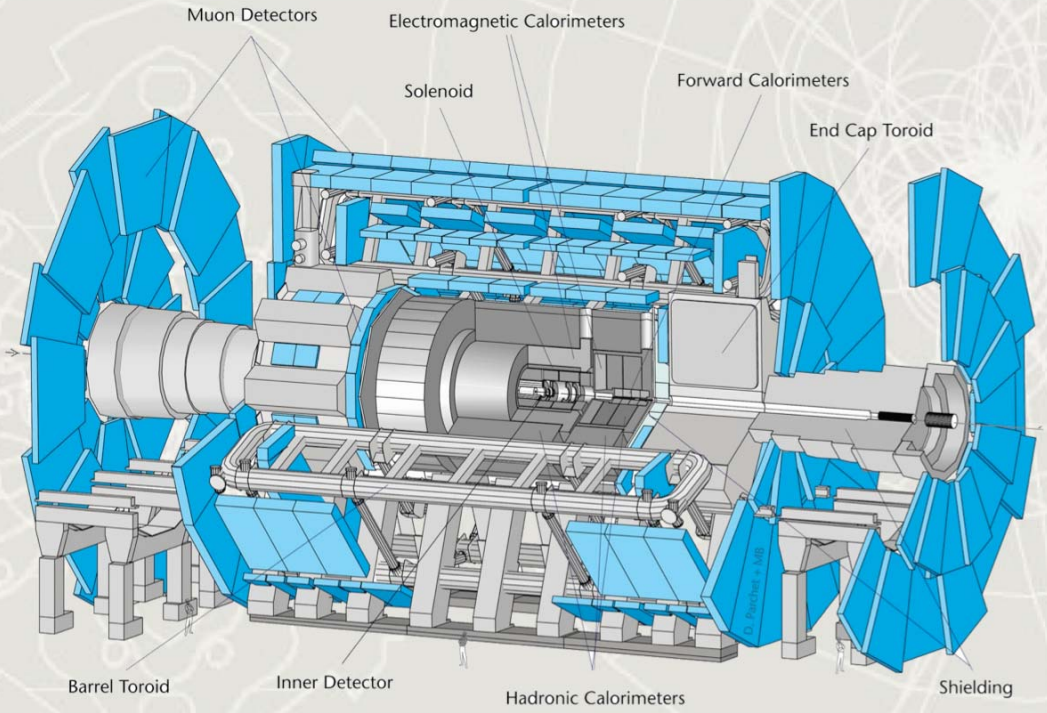





- muons: MDT and CSC chambers plus RPC and TGC trigger

# The Atlas Trigger system

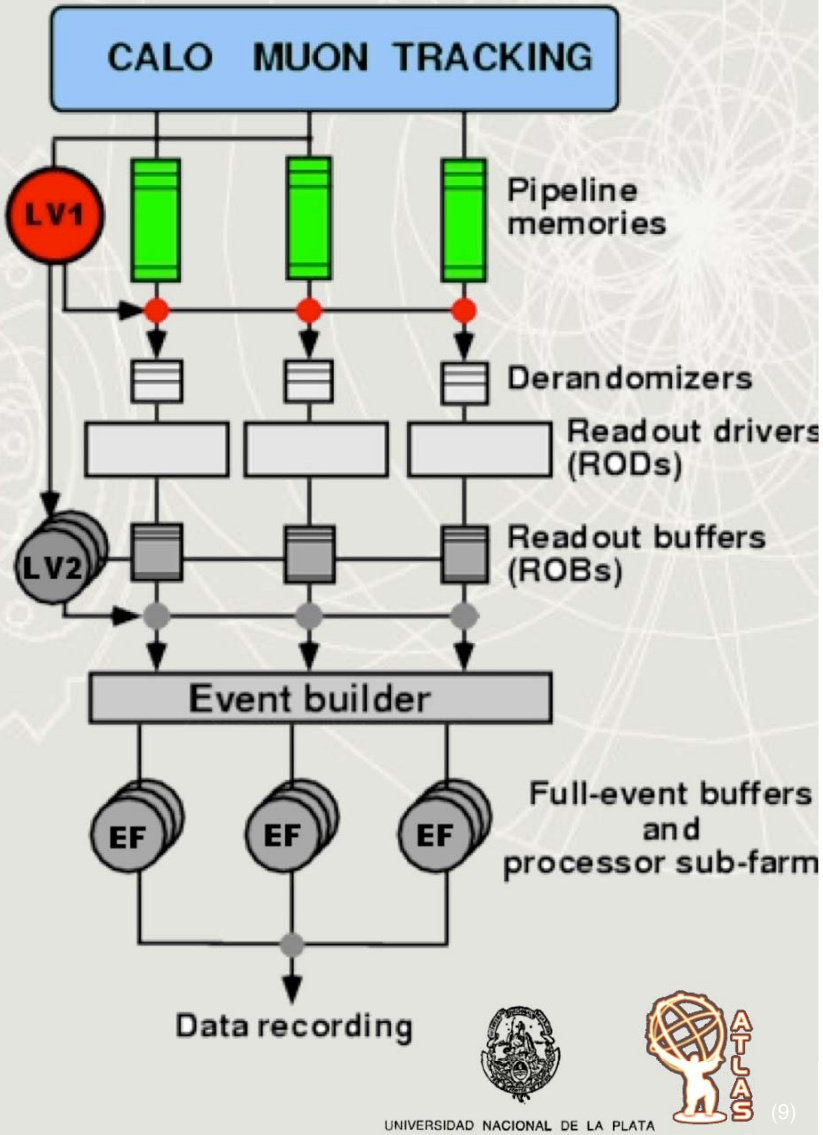
- In LHC $\rightarrow$ Bunch crossing @40MHz
- $\sim$ 23 interactions / bunch @ L=$10^{34} cm^{-2} s^{-1}$
- In atlas a full event size $\sim$ 1.5MB
- Store every bunch to disk $\rightarrow$ $\sim$50 TB/sec
- just 1 event in $10^{10}$ has interesting physics

- The task of the ATLAS Trigger System is to select the most interesting events and save them for later analysis.
- Only the trigger accepted events will be analyzed. Rejected by trigger means lost for ever!
- The ATLAS Trigger relays on a 3 level trigger system, that reduces LHC 40MHz bunch crossing rate$\rightarrow$ Mass Storage:

# The ATLAS trigger system

## L1 Trigger

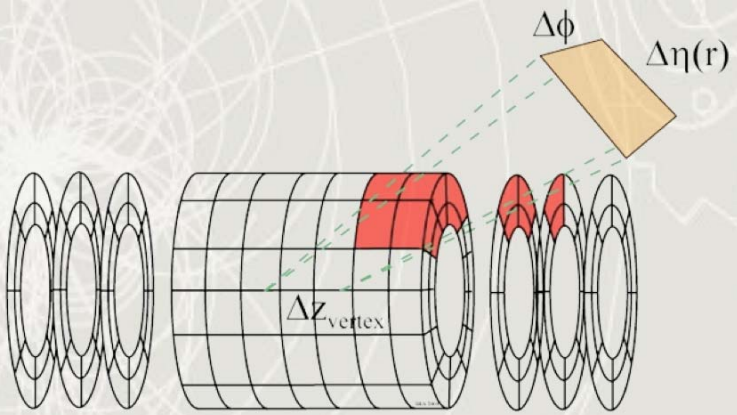
- hardware based
- coarse granularity calo/muon data;
- latency: 2$\mu$s
- output rate: 75kHz



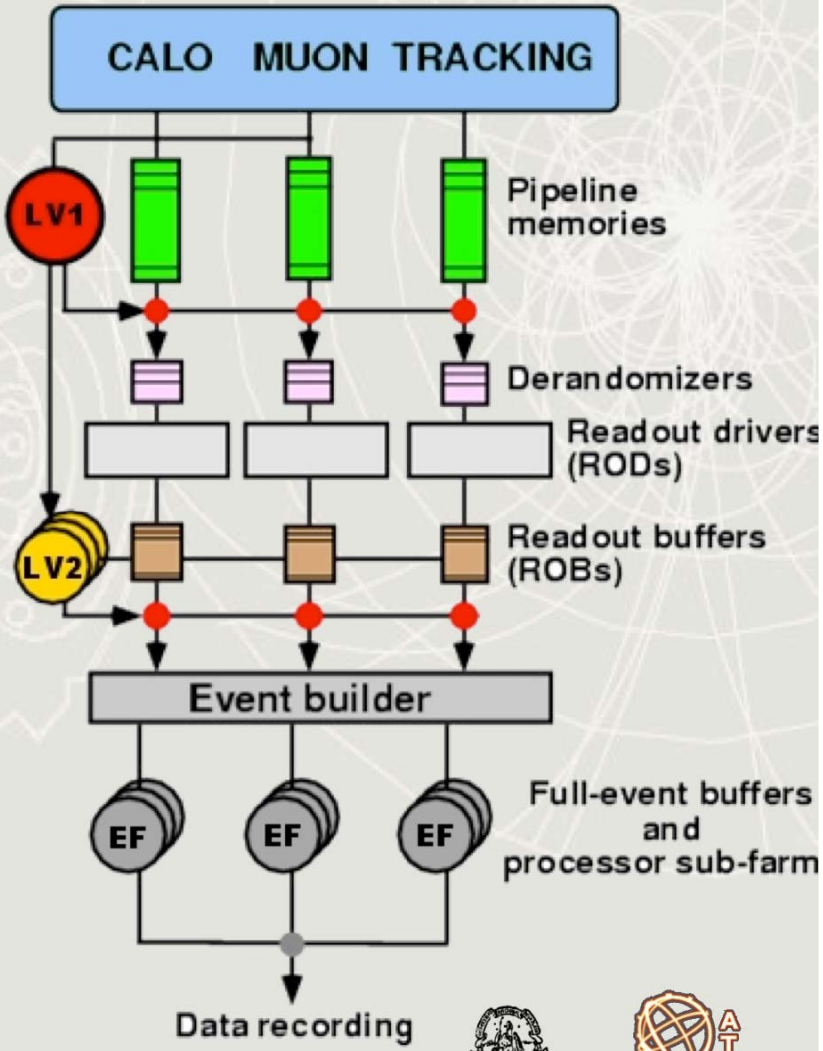
# The ATLAS trigger system

## L2 Trigger (HLT)

- detector sub-regions processed;
- full granularity for all subdetectors;
- fast rejection steering;
- latency: $\sim$ 10ms;
- output rate: $\sim$ 2kHz



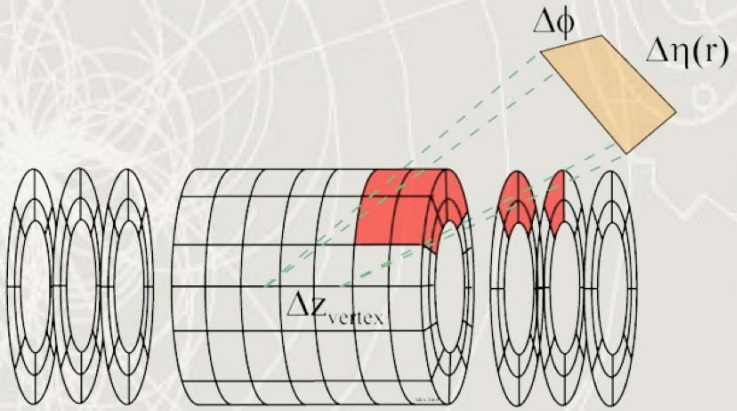

High Level Trigger



# The ATLAS trigger system

## Event Filter (HLT)

- seeded by L2 result;
- potential full event access;
- Offline-like algorithms;
- latency: $\sim$ 2s;
- output rate: $\sim$ 200Hz
- data storage: $\sim$ 300MB/s

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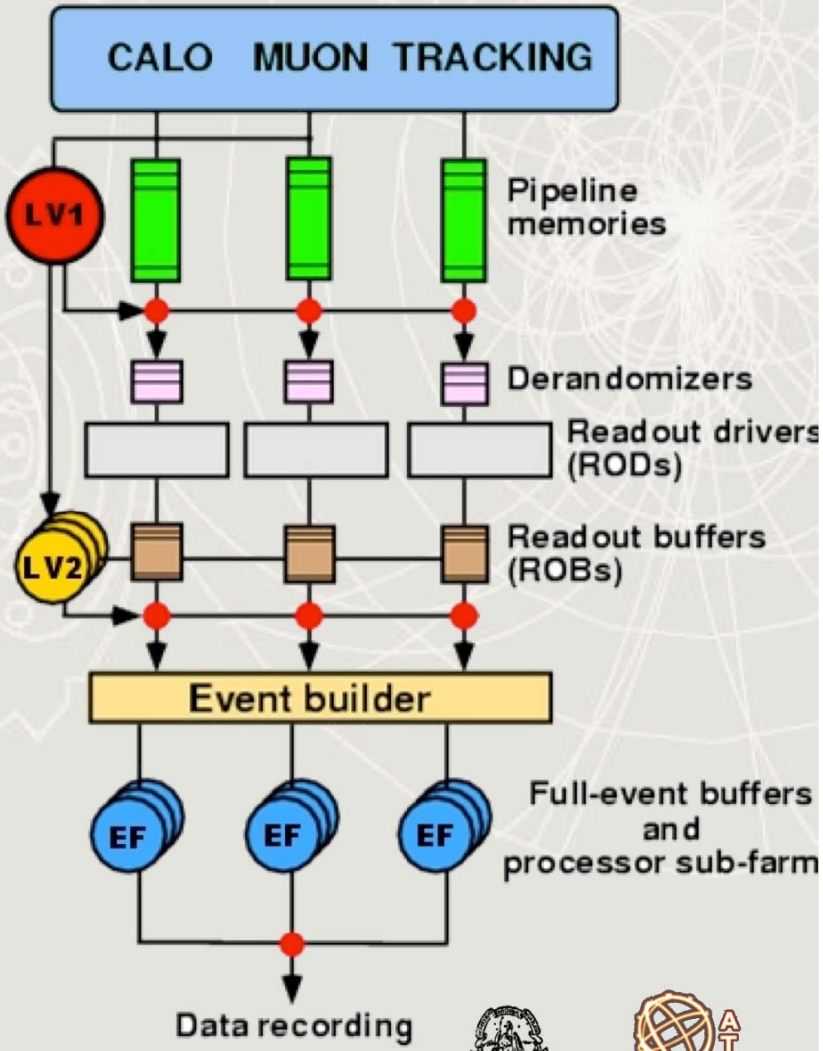
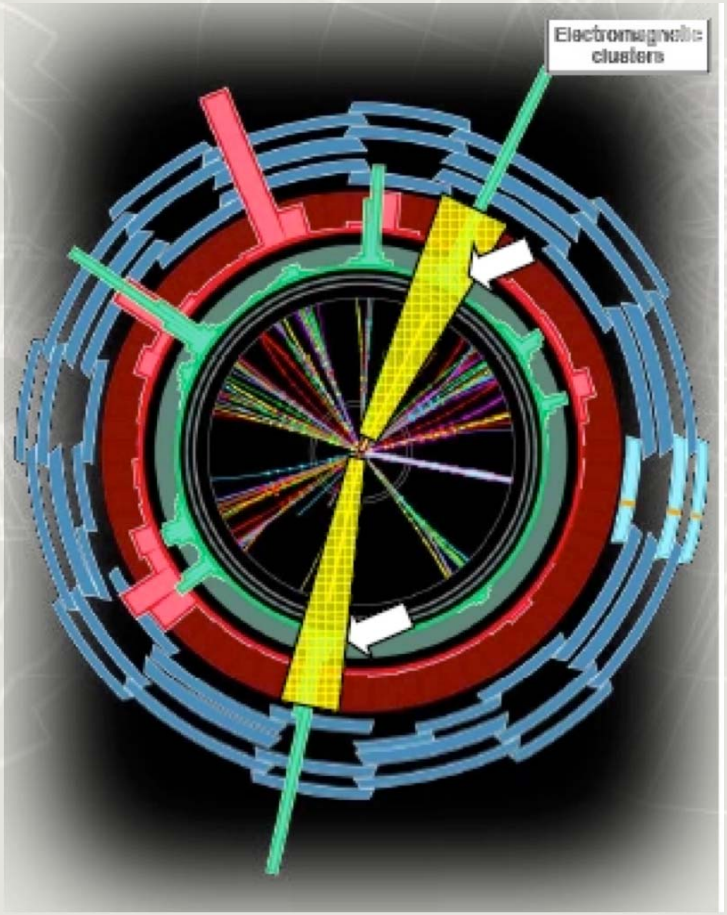


# HLT Event Selection

The main ideas behind the ATLAS event selection strategy are:

- Reconstruction in regions with activity in the detector
- alternate steps of algorithm reconstruction and object selection
- events can be rejected after any step if the reconstructed features do not fulfill required criteria (signature).
- goal: minimize processing time and network traffic.



# Signatures in ATLAS

e/$\gamma$ identification and measurement uses combination of ID tracking and EM calorimeter data

## Photon reconstruction

- isolated EM calo cluster
- track veto from the ID
- tracking recovery of converted photons

# Trigger Optimization

The trigger performance optimization of a trigger item is a compromise between several factors:

1. Trigger efficiency for signal
2. Background rate (constrained by total allowed HLT data stored rate)
3. Constrains of the average execution time at each trigger level
4. Efficiency after the last trigger selection step (EF) with respect to offline as high as possible: e.g. for photons 80% a factor 1000 of rejection

# Lumi scenarios

The photon triggers in ATLAS will be tuned while the LHC luminosity rises from initial (L=$10^{31} cm^{-2} s^{-1}$) to design luminosity (L=$10^{34} cm^{-2} s^{-1}$)

Table: Photon Triggers and their use at $10^{31} cm^{-2} s^{-1}$.

| Name | Prescaled | meant to trigger on |
|---|---|---|
| g15 | Yes | direct photon, B Physics |
| g10 | Yes | direct photon, B physics |
| g20 | No | direct photon |
| g150 | No | new physics |
| g105 | No | new physics |
| 2g20 | No | direct photon, diphoton, new physics |
| 2g15 | No | direct photon, diphoton, new physics |

All these triggers will ”evolve” with the LHC luminosity. Others may/will appear.
Will add isolation to these triggers (like 2g20i) when Luminocity rises.

# Triggering on direct photons

**Direct photons events will be used at the beginning for**

- commission the detector and trigger
- measure / estimate the machine luminosity
- constrain the proton PDFs
- study the $k_T$ effect

It is crucial to trigger on them and to know our efficiency

Table: Efficiency triggering on direct photons @ $10^{31} cm^{-2} s^{-1}$

| | g20 |
|---|---|
| L1 | 100±0 |
| L2 | 98.43±0.11 |
| EF | 97.51±0.14 |

# Performance triggering on $H_{120} \rightarrow \gamma\gamma$

The photon triggers are essentials for the discovery of the Higgs boson in its decay to $\gamma\gamma$

## To trigger on $H_{120} \rightarrow \gamma\gamma$

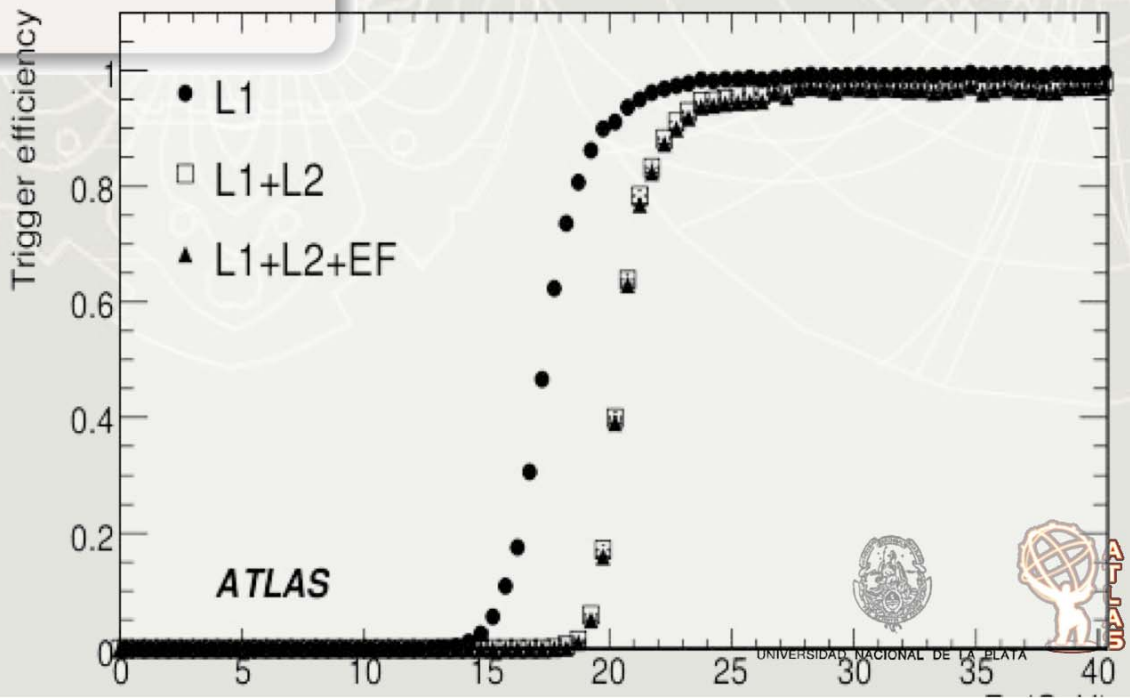
ATLAS will use 2g20i to trigger on $H_{120} \rightarrow \gamma\gamma$

- g: Is a photon trigger
- 2 photons (g) objects required in the event
- Their $p_T$ has to be at least 20GeV (at EF)
- they have to be isolated

| 2g20i | $H_{120} \rightarrow \gamma\gamma$ |
|---|---|
| L1 | $95.9 \pm 0.3$ % |
| L2 | $94.6 \pm 0.3$ % |
| EF | $93.0 \pm 0.4$ % |

Table: Efficiency triggering on MC SM Higgs decaying in two photons. $M_H = 120 GeV$

This plot shows the efficiency of the g20 triggering on photons of different $p_T$ coming from a Higgs decay.



# Triggering on new physics

ATLAS is design to search for new physics. The photon trigger performance has been studied for some scenarios.

**Example:**

Performance of the ATLAS photon trigger selecting extra dimensions Gravitons decaying in two photons

Trigger to be used: g105

| g105 | 500 GeV G$\rightarrow \gamma\gamma$ | 1 TeV G$\rightarrow \gamma\gamma$ |
|---|---|---|
| L1 | 100.0 % | 99.9 % |
| L2 | 99.7 % | 99.0 % |
| EF | 98.2 % | 97.2 % |

Trigger rate is negligible for these triggers. These gravitons would be seen quite early

# Towards data taking

## Photon trigger estimated rates for $10^{31} cm^{-2} s^{-1}$

### Photon Trigger Menu for initial running

| Name | Prescaled |
|---|---|
| g15 | Yes |
| g10 | Yes |
| g20 | No |
| g150 | No |
| g105 | No |
| 2g20 | No |
| 2g15 | No |

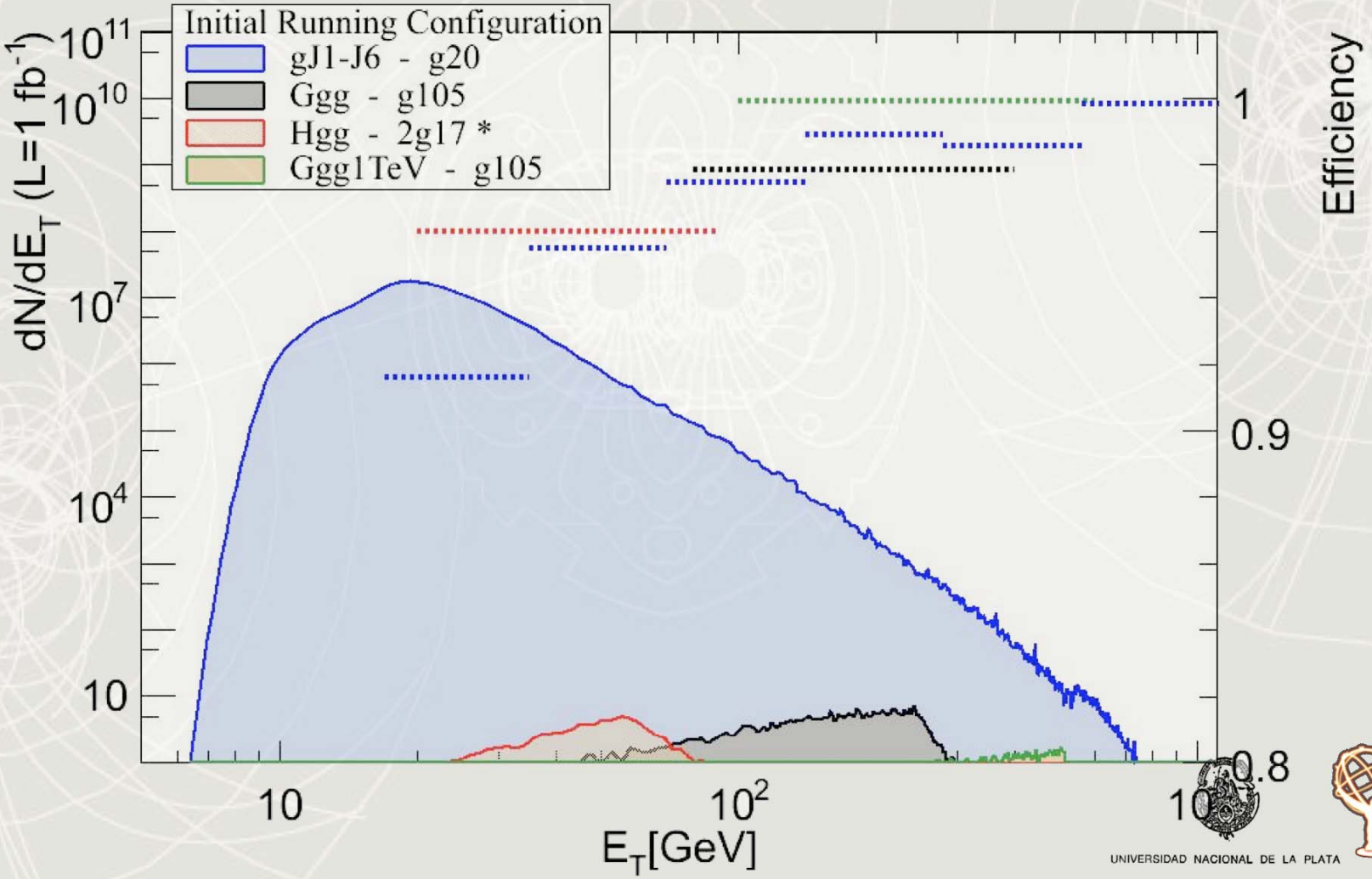
### Photon Trigger Menu Rate

| MinBias | |
|---|---|
| Trig LVL | Rate in Hz |
| Level1 | 5020 $\pm$38 |
| Level2 | 29.8 $\pm$2.9 |
| EF | 6.0 $\pm$1.3 |

Note: $\sigma_{jj}$ uncertenty $\sim$ 2.

# Photon trigger performance summary

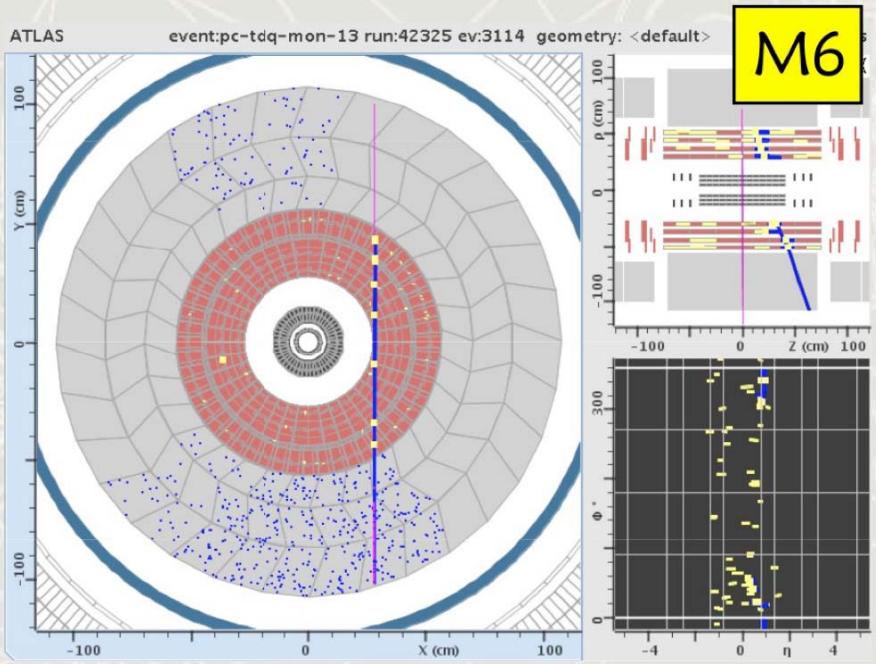
## Summary of photon trigger efficiencies and $p_T$ distribuions in 3 decades of

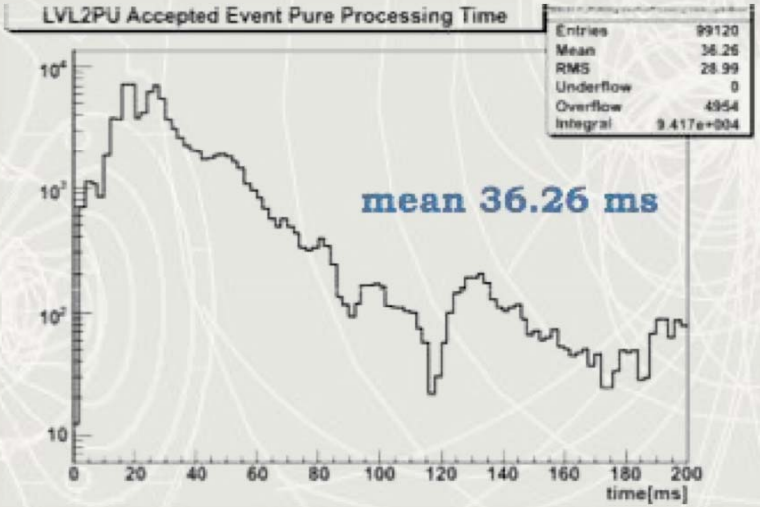


# Online System Performance

## The HLT algorithms have been tested online

- Technical runs in which simulated raw data are preloaded in to the readout systems played back through the HLT/DAQ system
- Cosmic rays events




- $\sim$ 10% of TDAQ final system tested with real network switches
- Simulated Monte Carlo $t\bar{t}$ events (mixture of events)
- **More than 200 trigger items tested online!!**

- LVL2 processing time measured online is compatible with the designed 40ms/event

# Conclusions

- The trigger selection has been already tested online:
  - Technical runs
  - Cosmic rays data taking
- The ATLAS photon triggers has been studied and setup for initial running at $10^{31} cm^{-2} s^{-1} \rightarrow$ *Ready to Go!*
- They show good performance in terms of signal efficiency and background rejection
  - If such a thing as a SM light $H_{120} \rightarrow \gamma\gamma$, exotic ED partiles (G$\rightarrow \gamma\gamma$) are there $\rightarrow$ HLT will trigger on them efficiently