Beyond Standard Model: From Theory to Experiment (BSM-2021)
organized by The Center for Fundamental Physics (CFP) at Zewail City of Science and Technology and Faculty of Engineering and Natural Sciences at Sabancı University.

Jet energy scale and resolution in the forward region using High Granularity Timing Detector in ATLAS upgrades at HL-LHC

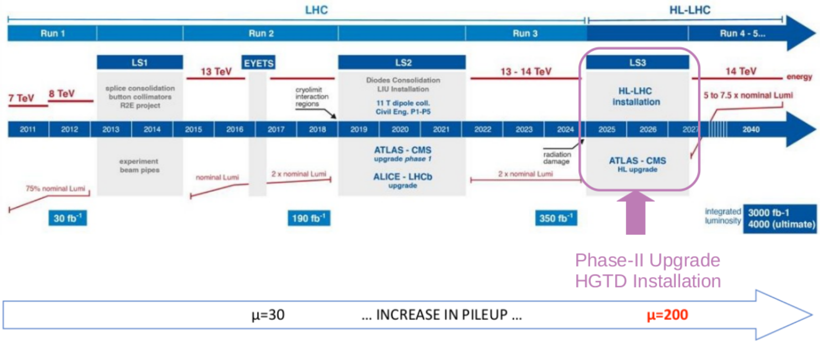
Asmaa Aboulhorma, Farida Fassi

Mohammed V University in Rabat

BSM
29-31
March, 2021

جامعة محمد الخامس بالرباط
Université Mohammed V de Rabat
Mohammed V University of Rabat

Motivation: HL-LHC

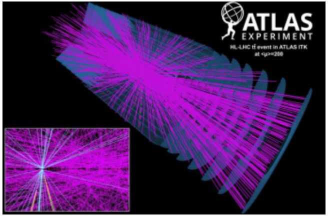


To extend the discovery potential, the LHC scheduled for an upgrade.

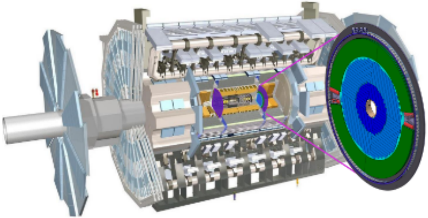
The HL phase is expected to start in 2027 reaching 5-7.5 x the design luminosity.

ATLAS detector will need major upgrades because of :

- Pile-up challenge : $|\eta|$ from $\sim$ 30 in Run 2 to 200
- Radiation tolerance
- Trigger rates

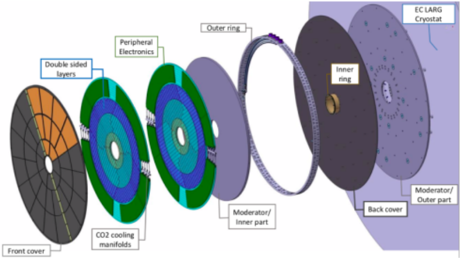


A High-Granularity Timing Detector (HGTD)



- New detector constrained by the space available : thickness of 12.5 cm between barrel and endcap at $|z| = 3.5m$
- Two symmetric parts around the interaction point, each part made of two disks with double-side instrumentation
- Active area : $12cm < R < 64cm$ and $2.4 < \eta < 4.0$

- Target time resolution :30-50 ps per track
- Impact on pile-up rejection, track and jet reconstruction, electron ID, b-tagging
- Resolve tracks belonging to close-by vertices



Why Large Rapidity for the HGTD?

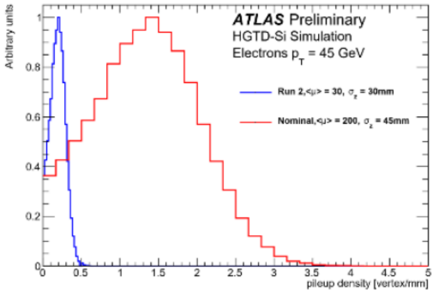
At 200 vertex resolution degrades dramatically in the end-cap region, with multiple vertices being merged.

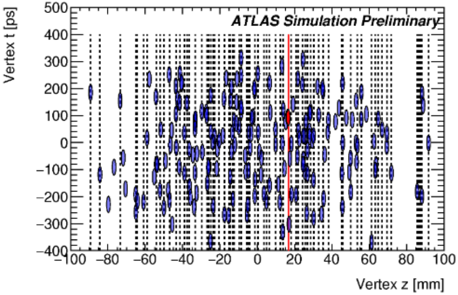
Time spread of vertices $\sim$ 175 ps

- Exploit time information in addition to space spread of tracks
- Extend pileup rejection capabilities in the forward region (2.4$<|\eta|<$4.0)
- Use track time to improve track-to-vertex association

With a time resolution of 30 ps :6× more PU rejection

- Improve physics and object reconstruction performance
- Reduce jets from pileup vertice
- Reduce tracks from pileup vertices being associated with hard-scatter jets



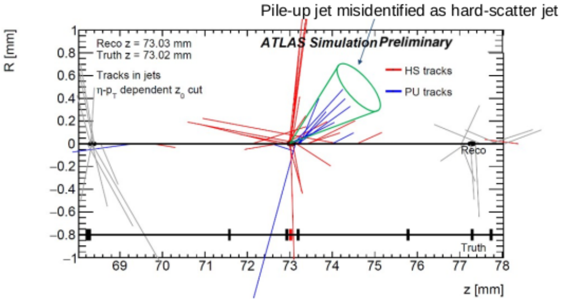


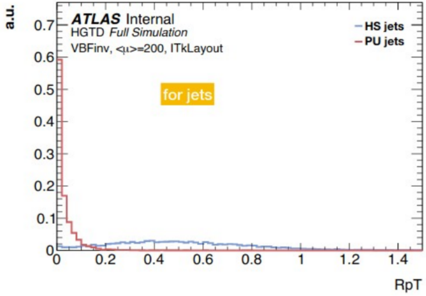
Suppression of pileup jets

- Pile-up local fluctuations within a same event can lead to fake pile-up jets:
  - Uniform distribution of particles from multiple interactions
  - Anomalous jet structure with no high pT jet core
- The key element to suppress pileup jets is the accurate association of jets with tracks and primary vertices.

$$RpT = \frac{\sum_k P_T^{Track_k}(PV_0)}{P_T^{Jet}}$$

- increase the separation power between HS and PU jets for the RpT variable





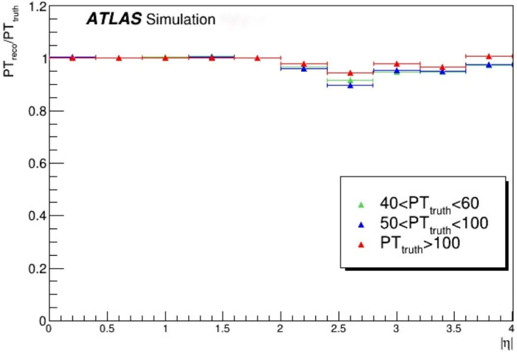
Jet energy response and resolution in forward region

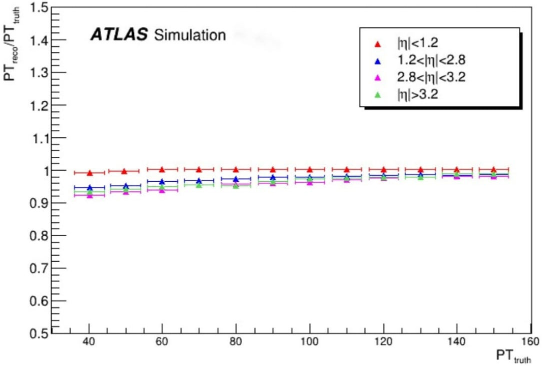
Overview

- The VBF process ($H \rightarrow ZZ \rightarrow$ 4 neutrinos plus 2 jets) has been used to perform this study.
- The jet energy response and resolution has been studied as a function of jet-eta and jet-pt.
- Pt-jet correction:
  - timing information is applied.
  - to drop the PU track, the association between the track and the vertex is performed based on the truth information.

Jet energy response

The ratio of the reco-jet over the truth jet energy.It is evaluated as the mean value μ of the Gaussian fit of the distribution $\frac{PT_{reco}}{PT_{truth}}$



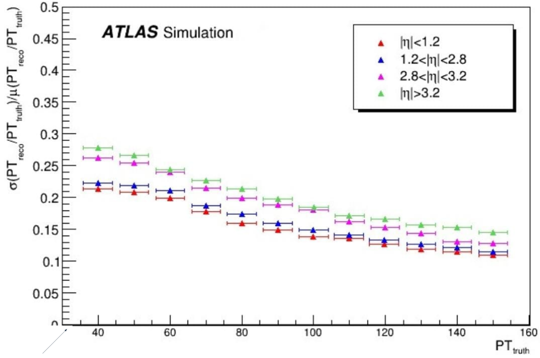


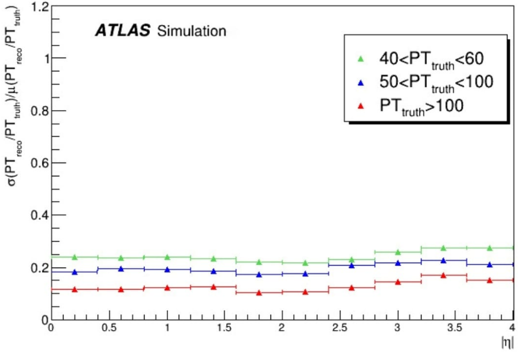
- The response is reducing in the forward region
- Good response for high PT

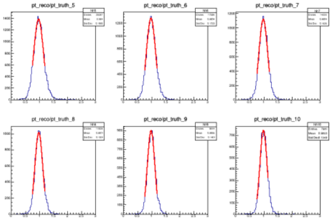
Jet energy resolution

It is defined as The ratio :

$$\frac{\sigma(PT_{reco}/PT_{truth})}{\mu(PT_{reco}/PT_{truth})}$$



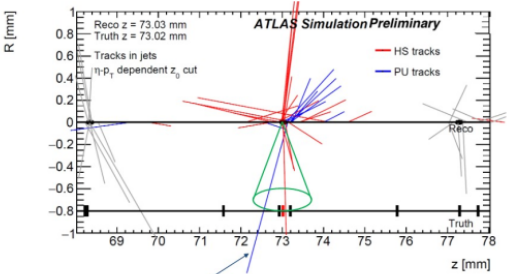




Pile-up suppression

The association of tracks to vertices relies on assigning tracks that are geometrically compatible in z with the vertex position

$$\frac{Z_0 - Z_{vtx}}{\sigma} < 2$$

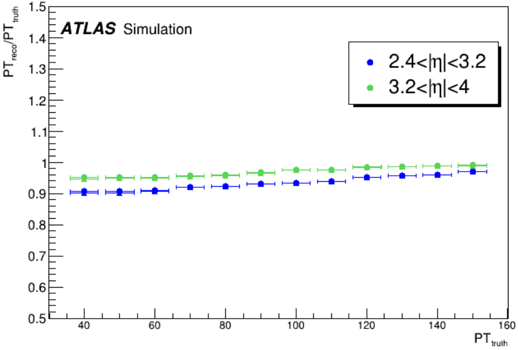


Pile-up track contamination in hard-scatter jets

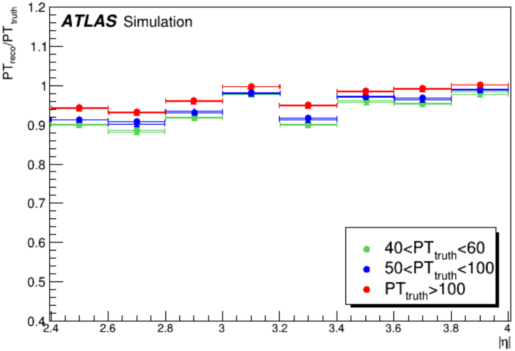
- Timing information is an additional handle to reject pile-up
- Looking at how to incorporate HGTD to reduce pileup contributions and improve the jet energy resolution.
- The Jet has been corrected as following:

$$PT_{Jet-corr} = PT_{Jet} - \sum E/P * PT_{PU-Track}$$

Jet energy response after correction



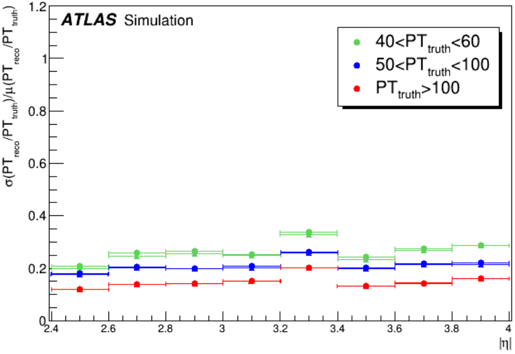
The ratio of the corrected jet over the truth jet energy.

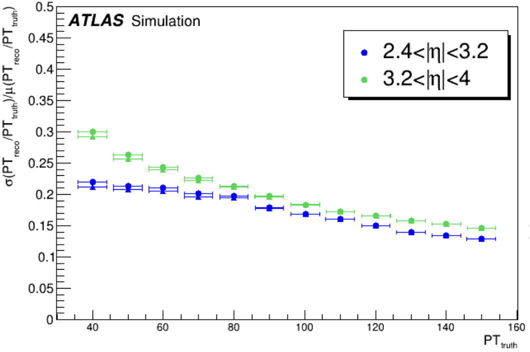


The response is decreased, as expected, after applying the correction as a function of eta-jet and PT-jet

Jet energy resolution after correction

For $2.4 < |\eta| < 3.2$ The resolution has been improved ruffly 3.5%, and 1.78% Respectively for $40 < PT < 60$ and $50 < PT < 100$





For $3.2 < |\eta| < 4$ The resolution has been improved ruffly 3.1% and 1.37%, Respectively for $40 < PT < 60$ and $50 < PT < 100$.

Summary

- At the HL-LHC, the pile-up will present an unprecedented challenge and the HGTD is expected to play a key role in ATLAS by adding timing information in the forward region.
- Promising results for pileup rejection in the high region for object reconstruction performance VBF and exotics will benefit, high purity for invisible searches.
- The impact of HGTD in reducing pileup track contamination has been study in the forward region.
- The performance is evaluated in terms of jet energy response and resolution as a function of PT-jet,and Eta-jet.
- Other method to correct PT-jet from PU-Track is on going.