MVA techniques in MC energy calibration of the EM calorimeter of ATLAS

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Introduction

- Proper energy calibration of electrons and photons is important for many physics analyses including Higgs searches
- In this presentation I show:
    - overview of ATLAS calorimeters
    - description of EM calorimeter of ATLAS
    - what is energy calibration (and why we need it)
    - how multi-variate techniques can improve the calibration
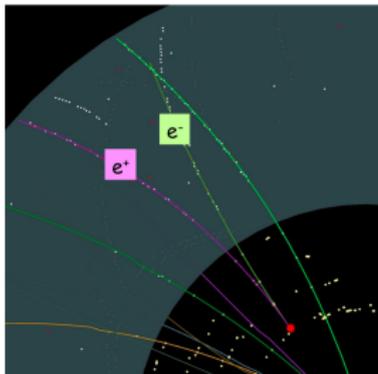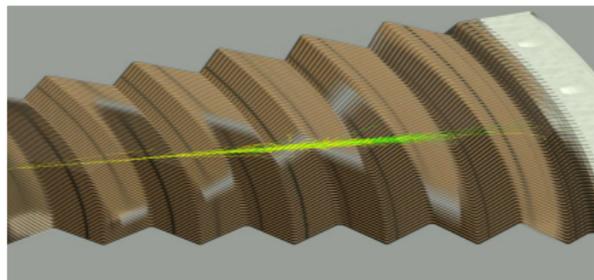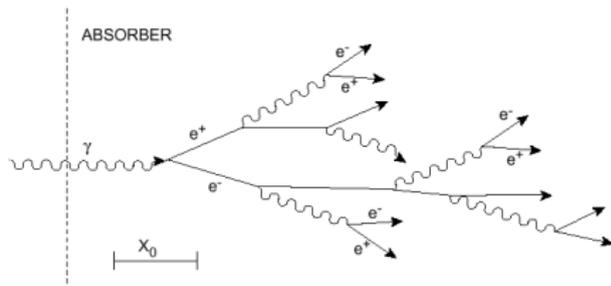
ATLAS Calorimeter System
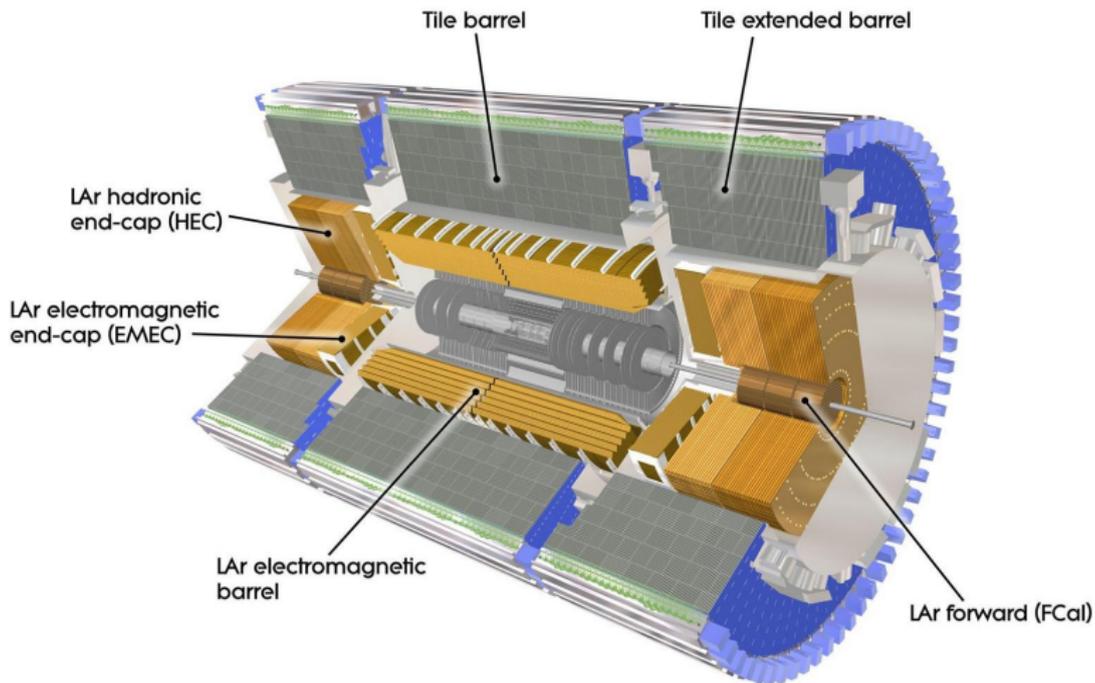
ATLAS EM Calorimeter

- Designed to measure mainly the energy of electrons and photons
- Longitudinaly segmented to 3 layers:
  - strips (finely segmented in η)
  - middle
  - back
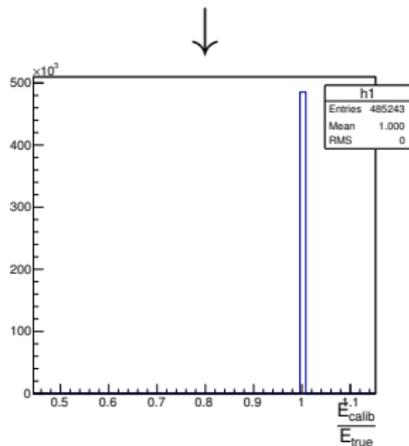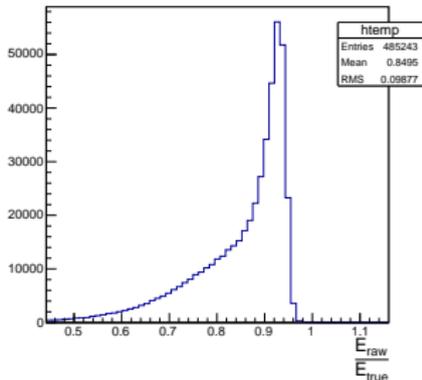- Segmentation in η and φ
- Accordion structure
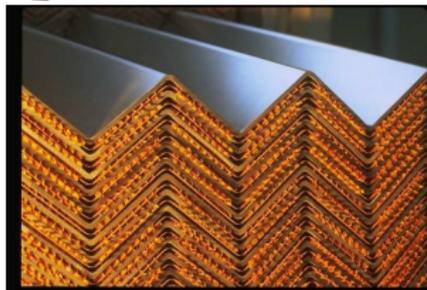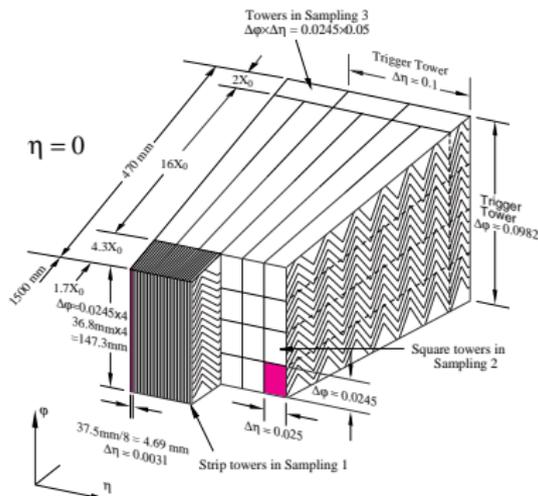
Shower Development and Photon Conversion

- Electromagnetic shower develops in EM calorimeter:
    - photon produces e^+e^- pair
    - charged particle produces bremsstrahlung photons
- Photon can produce e^+e^- pair also inside of the inner detector $\rightarrow$ *converted photon*

Energy Calibration

- Raw energy is obtained as a sum of particle energy depositions in the 3 longitudinal layers
- This energy is lower than particle true energy, because of:
  - energy lost in front of the calorimeter
  - energy deposited in dead material of the calorimeter (sampling fraction)
  - out of cluster energy (energy of particle is reconstructed in fixed window in $\eta \times \varphi$)
  - leakage into the hadronic calorimeter
- Purpose of the energy calibration is to correct for these energy losses and obtain true particle energy
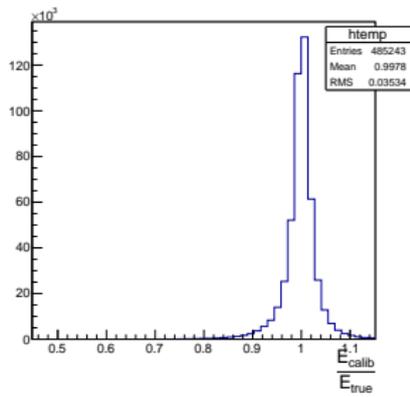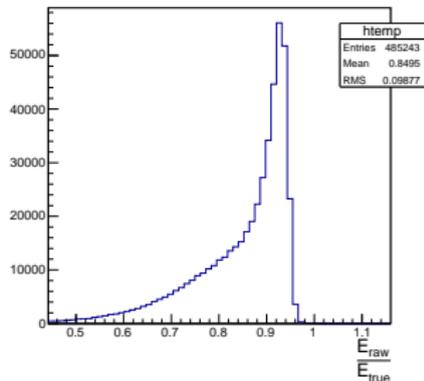- The calibration can be done using Monte Carlo


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Standard Calibration vs. MVA

- Monte Carlo calibration uses detailed simulation to estimate the energy losses
- In standard calibration, each of the four contributions to the energy loss is estimated individualy with dependence on few input variables (longitudinal barycenter, η postiton, presampler energy fraction, raw energy, η postiton in the cell) without using more than one at the same time
- Calibration using MVA regression can benefit from more input variables and has potential to signigificantly improve the calibration
- We are using *boosted decision trees* trained to provide correction coeficient ($\frac{E_{true}}{E_{raw}}$) using the same inputs as standard calibration + shower shapes, primary vertex position, conversion variables (radius, angle, $\frac{p_{t,1}}{p_{t,2}}$)...
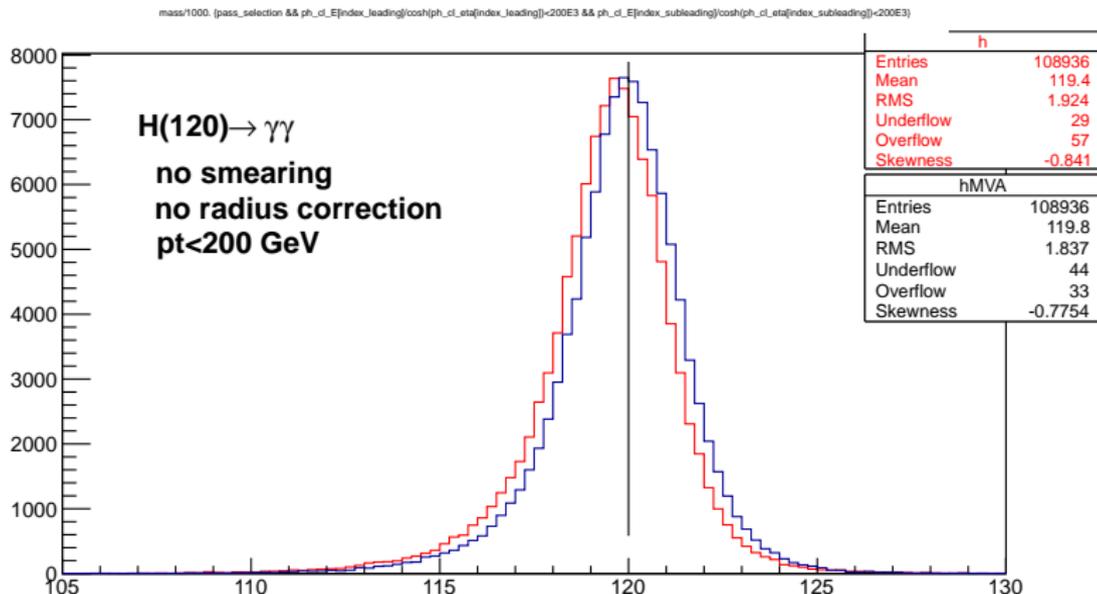
Comparison — electron
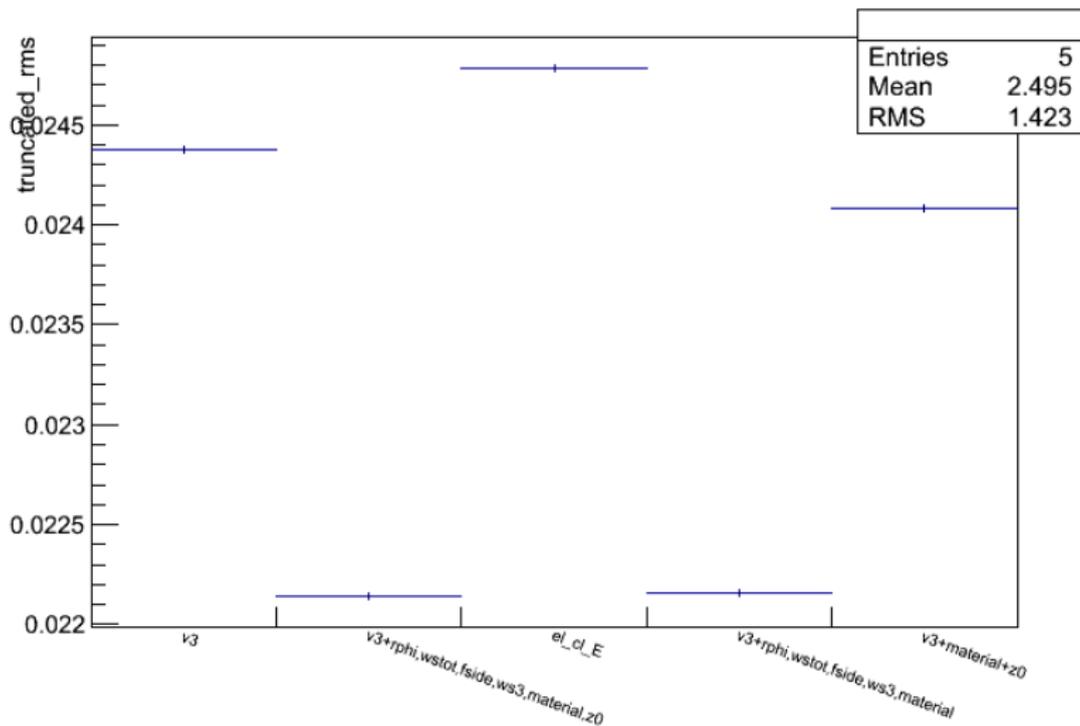
Comparison — converted photon
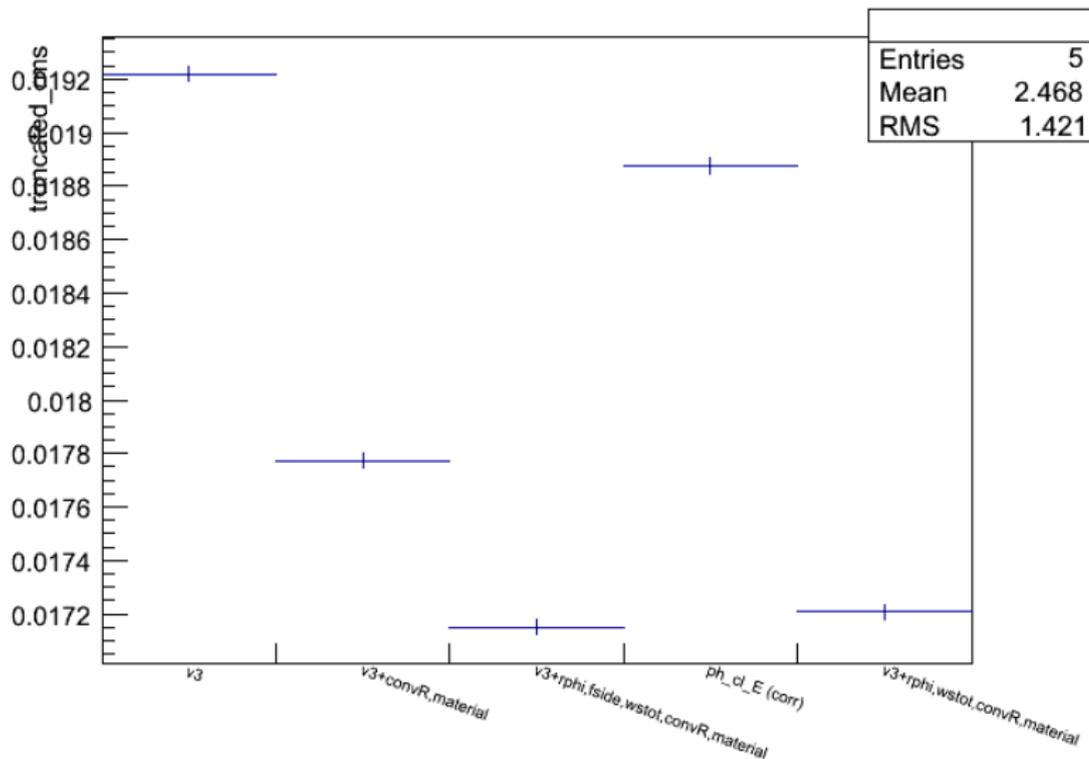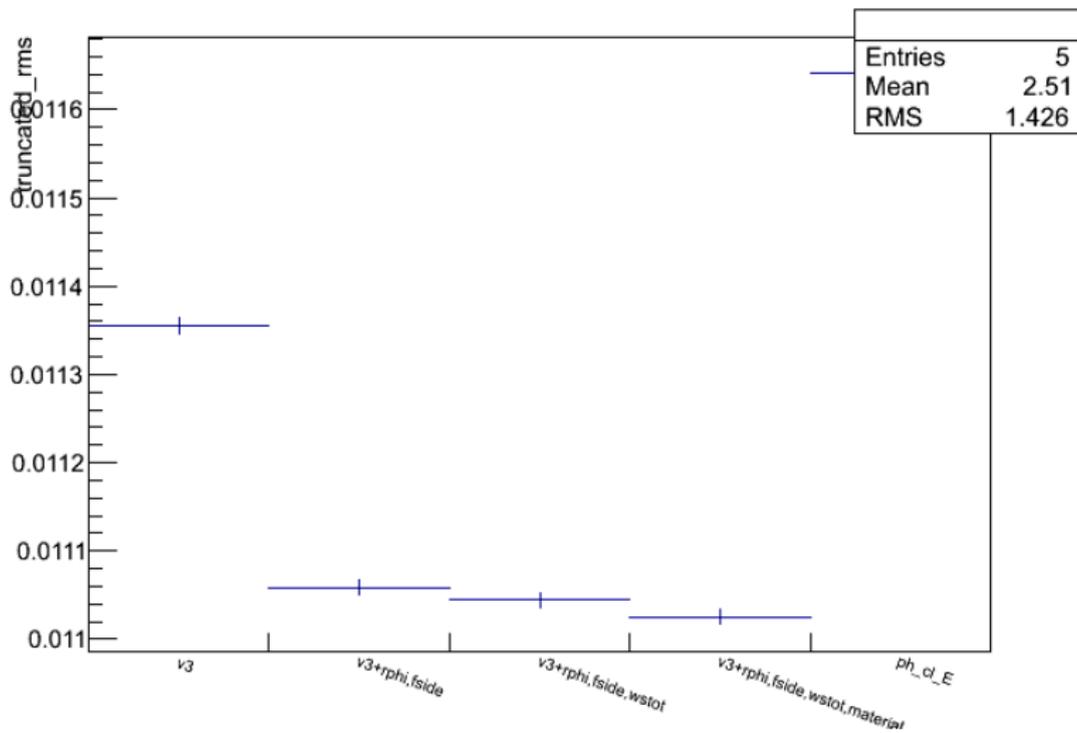
Comparison — H → $\gamma\gamma$

Conclusion

- Monte Carlo energy calibration corrects for energy losses before, in and after calorimeter and also for losses coming from reconstruction using fixed window
- MVA can use multiple variables while standard calibration uses only one at the time
- MVA provides improved calibration with better resolution

Thank you for your attention

Backup

Comparison — unconverted photon

Comparison — converted SiSi photon