# Deep learning for 40 MHz scouting with Level-1 trigger muons for CMS at LHC run-3

CERN openlab online summer intern project presentations

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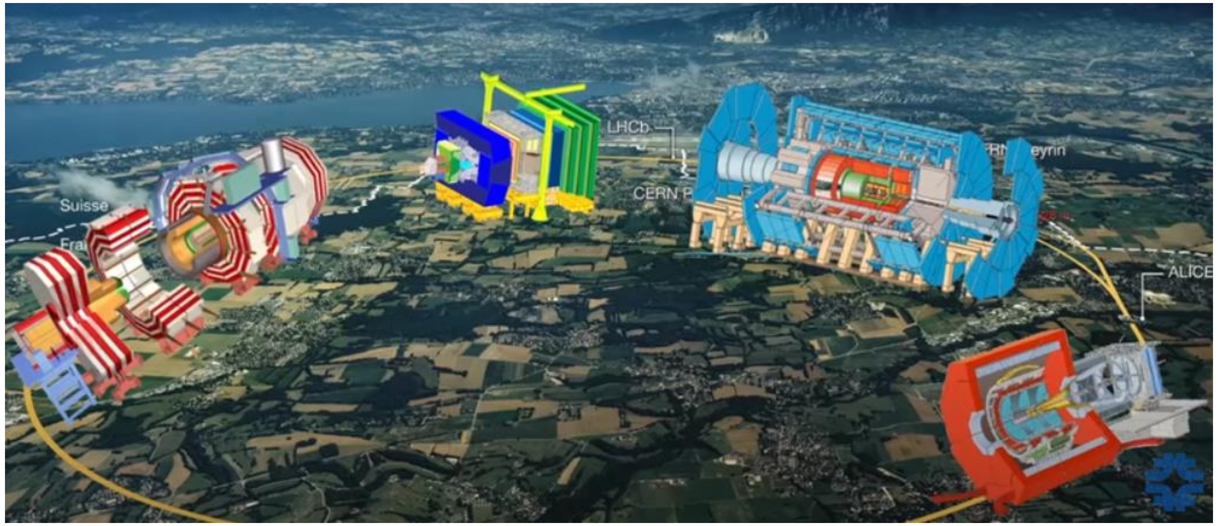
24/09/2020

# Introduction

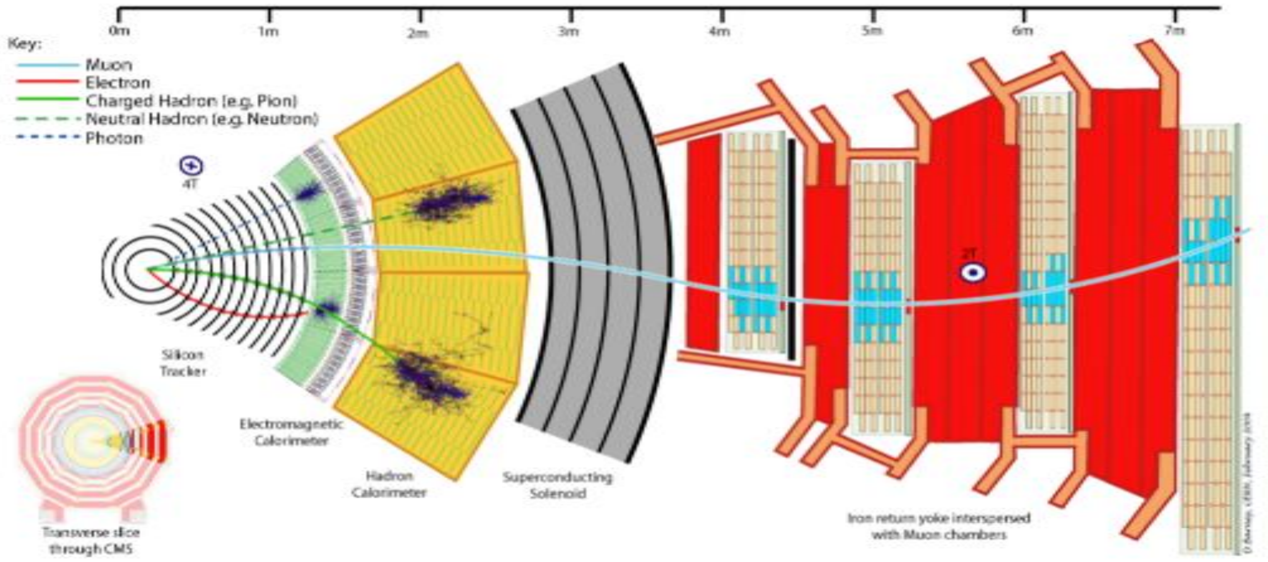



## Compact Muon Solenoid (CMS)

- Attempts to measure everything that comes out from the collisions
- Record 1000 full events per second to permanent storage

## The Large Hadron Collider(LHC)

- the largest and most powerful particle accelerator ever built
- it accelerates protons to nearly the speed of light and collides them at 4 locations, producing new particles




A transverse view of the CMS detector

# Introduction

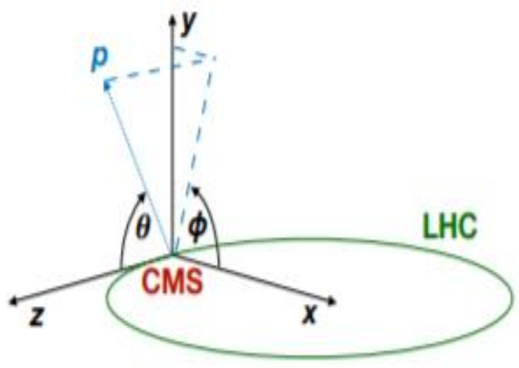
## Muons are measured in pseudorapidity range |η| < 2.4

$$\eta = -\ln \tan(\frac{\theta}{2})$$

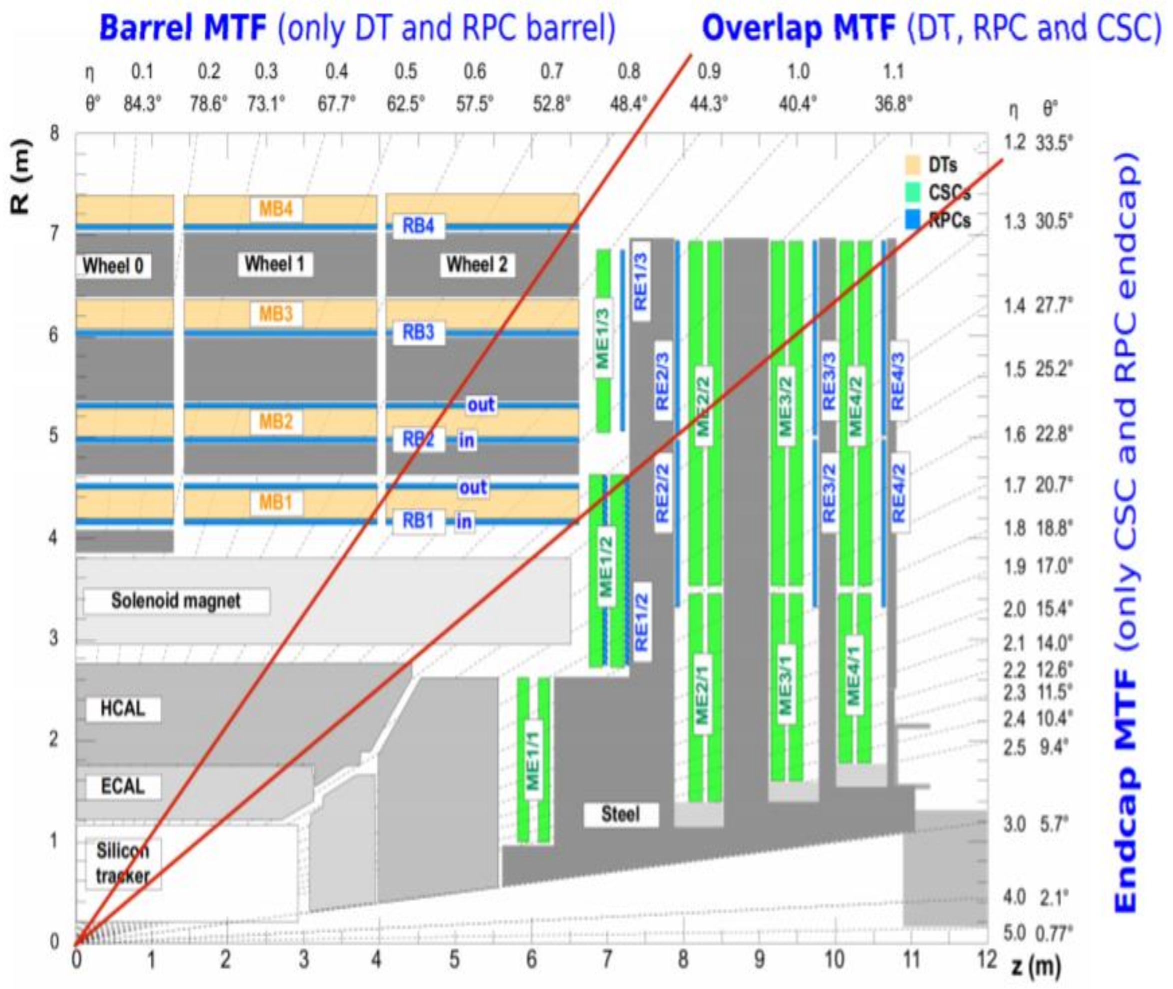
$$p_T = p \times \sin\theta$$

## azimuthal angle Φ

## Reco values = reconstructed values




CMS coordinate system




Regions at the CMS detector

# Motivation

We analyzed the muon parameters from the GMT system with the goal of recalibrating them to make them useful for physics analysis.

We recalibrated them with a simple **linear regression** (LR) and with a **deep learning model**.

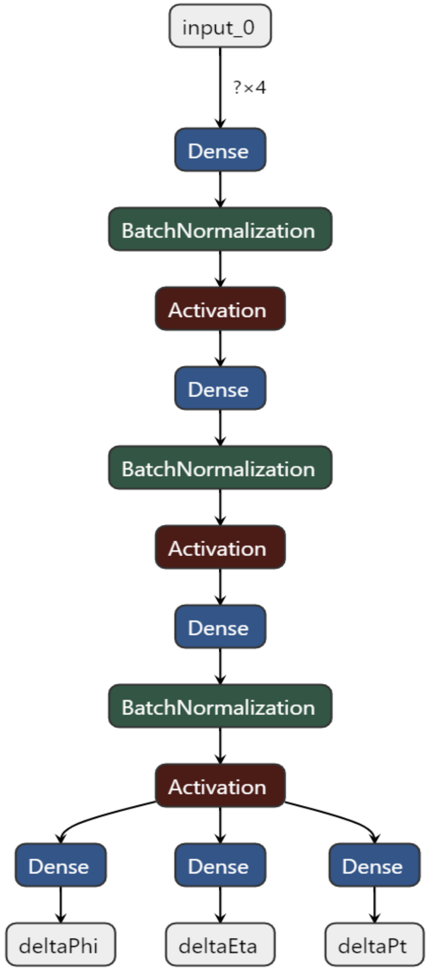
# Linear Regression vs Deep Model

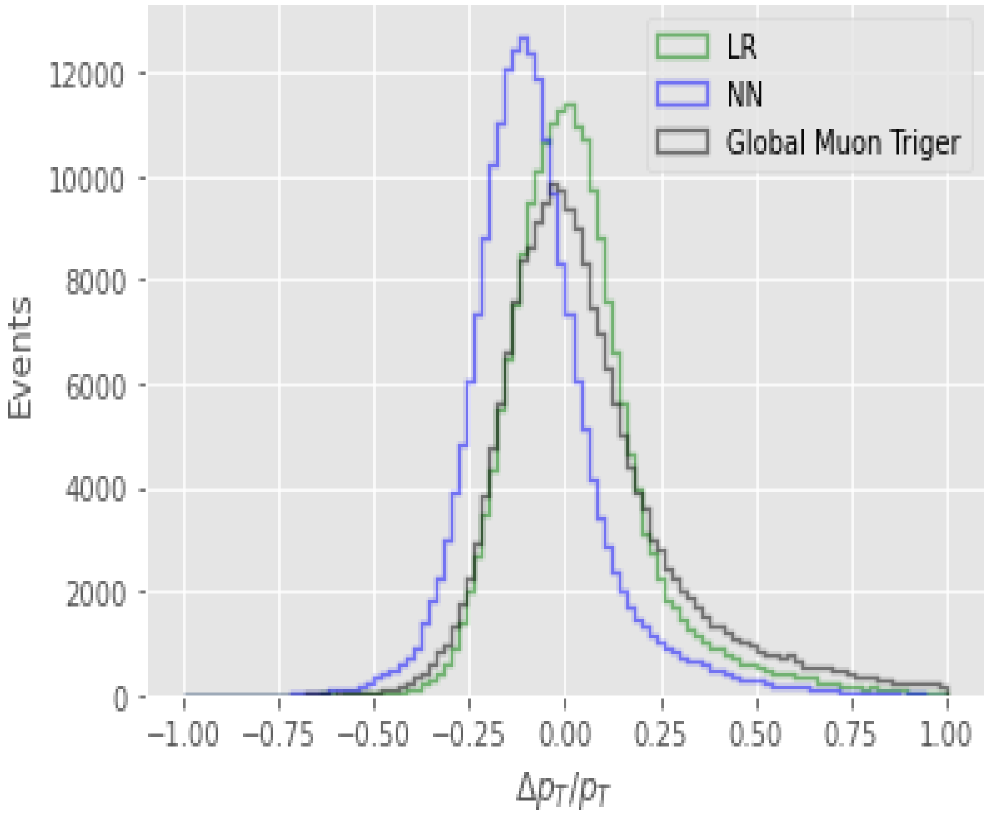
## Deep Model:

- Inputs: $\eta$, $p_T$, $\Phi$, **charge**
- 3 hidden dense layers with 32 nodes each

## Linear Regression:

- Input: $\mathbf{p_T}$
- Estimates: $\mathbf{p_T}$**Reco**



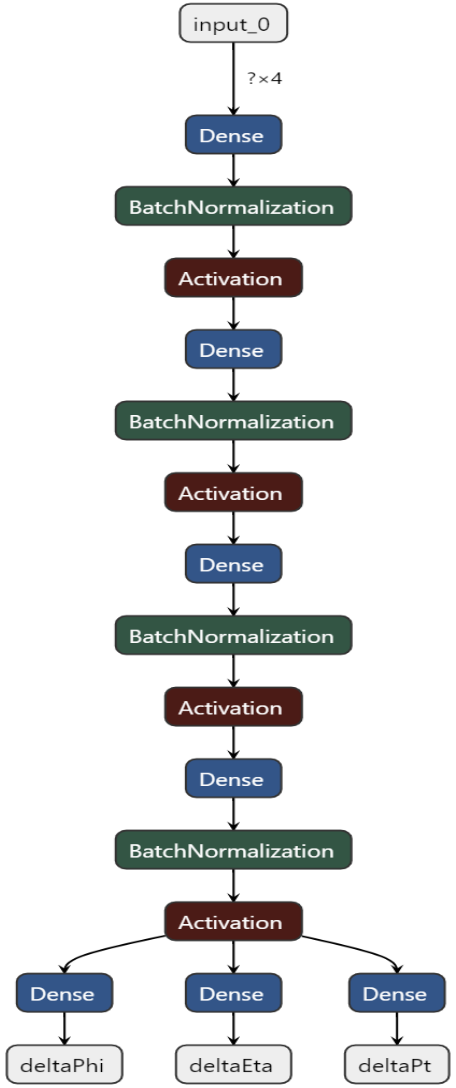



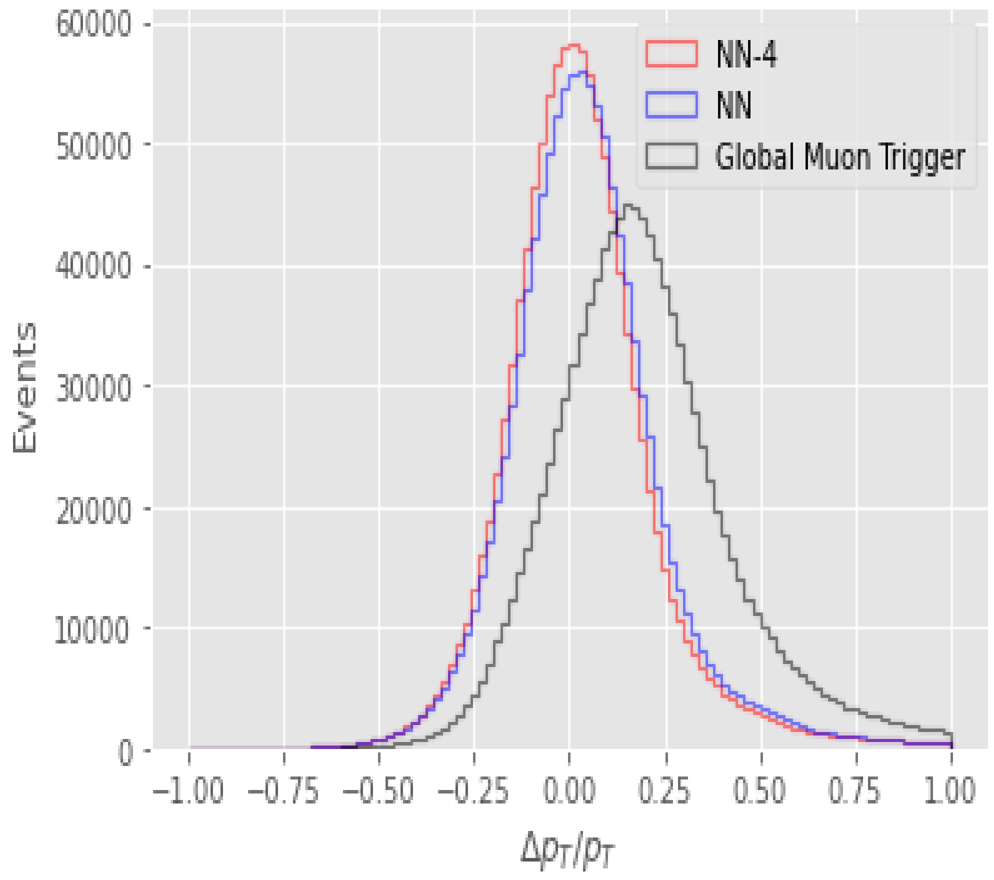

Linear Regression vs Deep Model for the barrel region

# New deep model vs Baseline model

## New deep model:

- Inputs: $\eta$, $p_T$, $\Phi$, **charge**
- 4 hidden dense layers with 128 nodes each




Complex model vs Baseline model on combined dataset (barrel + overlap + endcap )

# Summary

**We found that the simple LR improves on the raw GMT values.**

**The NN considerably improves on the raw GMT values, being also better than simple linear fit.**

**Making the NN more complex by adding hidden layers and increasing the number of nodes doesn’t improve the performance too much.**

# Thank you for your attention!

I would like to thank

- my supervisors

  Thomas James

  Emilio Meschi
- technical student

  Ema Puljak

And the organizers that made the summer program feasible under these conditions

# QUESTIONS?

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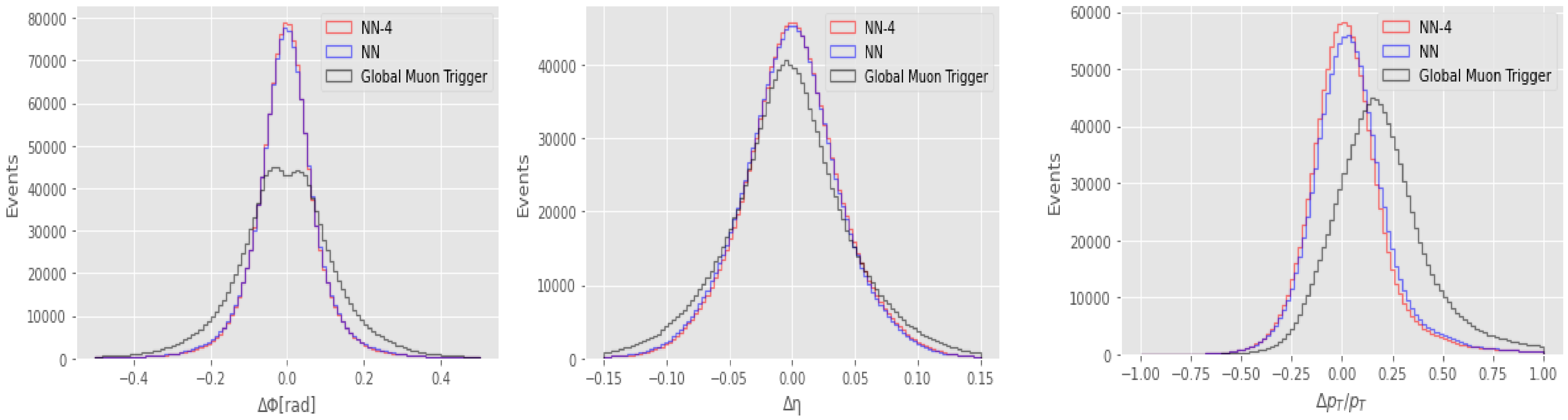
# Complex Model vs Baseline Model

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