IMPROVING HF GFLASH SIMULATIONS AT CMS

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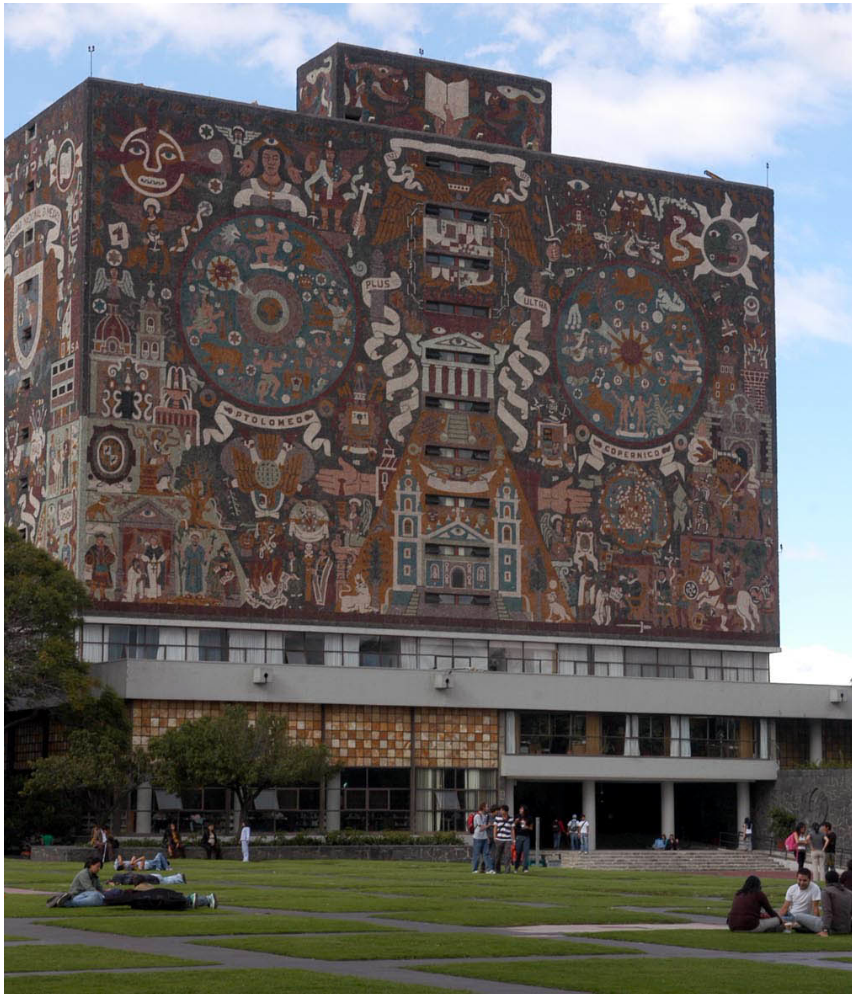
Brief introduction

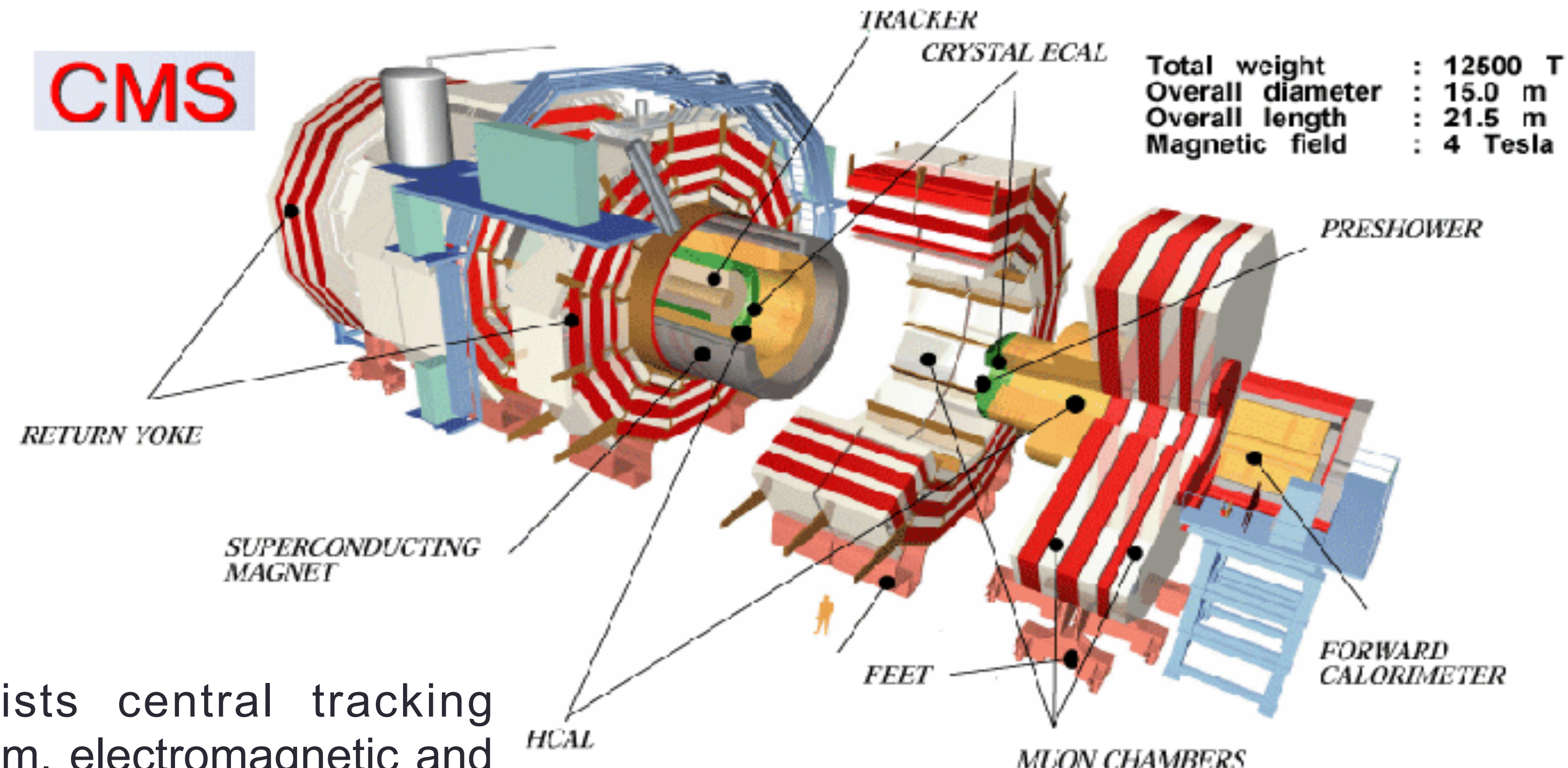
- Major in Physics
- Universidad Nacional Autónoma de México
- IPM Internship



LHC at CERN

- The Large Hadron Collider
- Near Geneva, where it spans the border between Switzerland and France about 100 m underground.

CMS

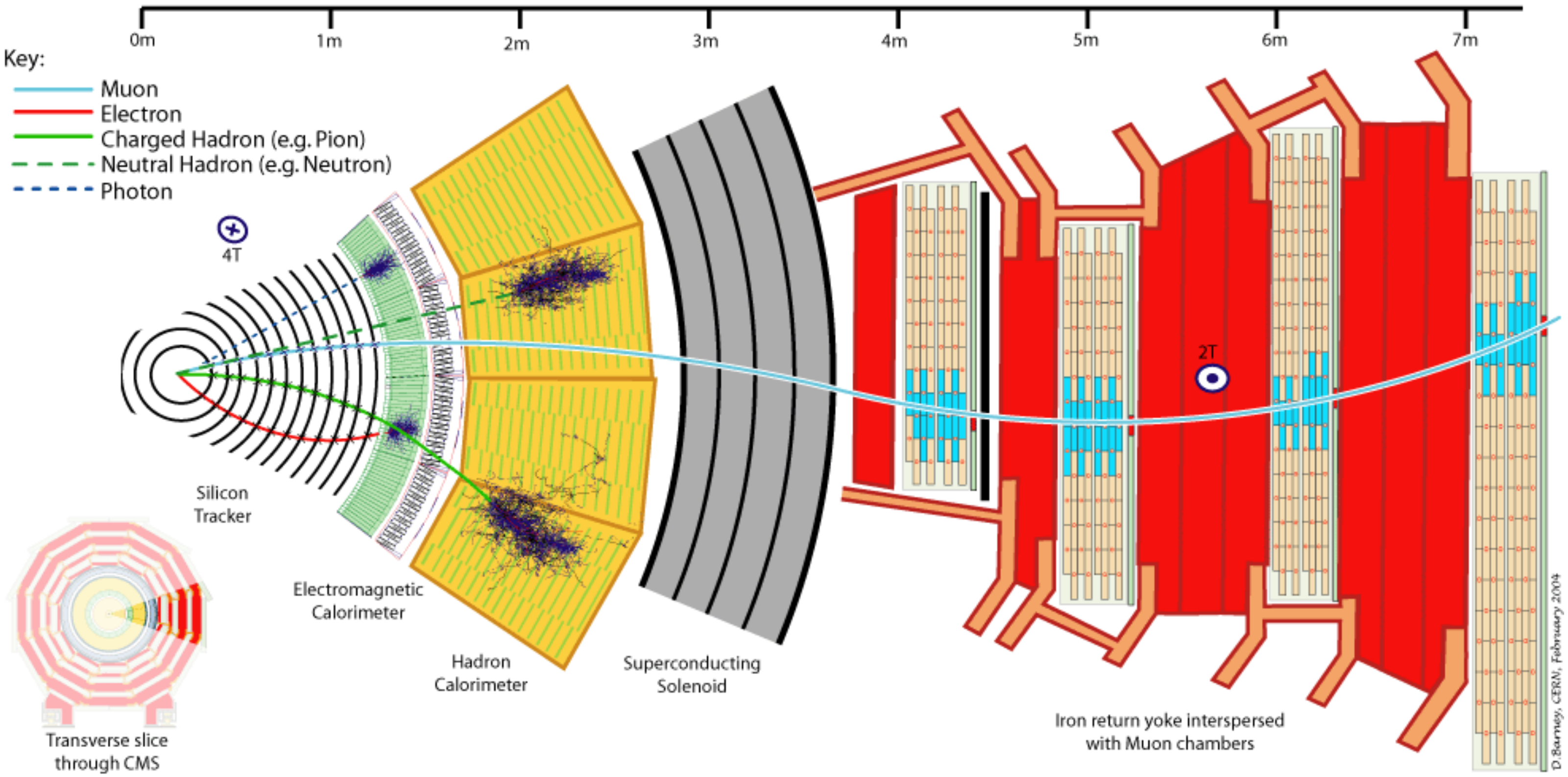


consists central tracking system, electromagnetic and hadronic calorimeters, superconducting magnet providing 4 Tesla magnetic field and muon system.

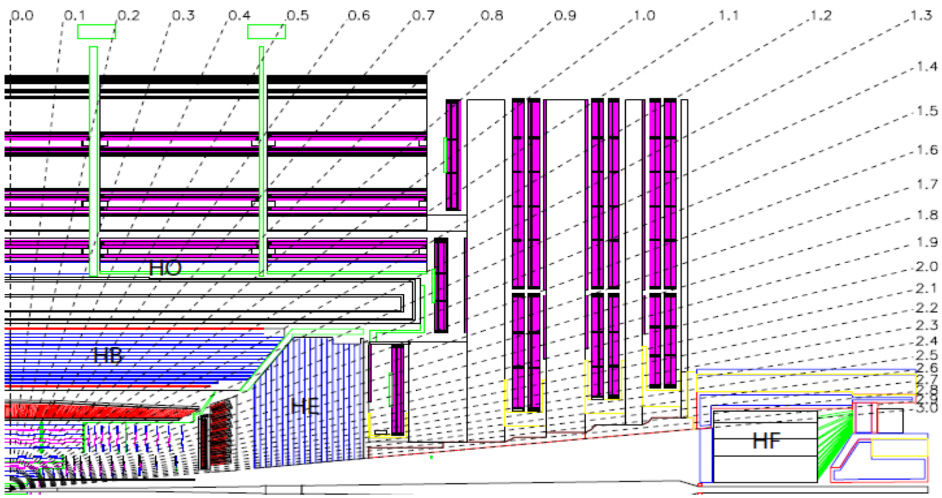
HF (Hadron Forward) calorimeter is a part of the HCAL and covers pseudo rapidity region 3 - 5

CMS

- Compact Muon Solenoid experiment
- 2 Hadron Forward (HF) Calorimeters



HF Calorimeters

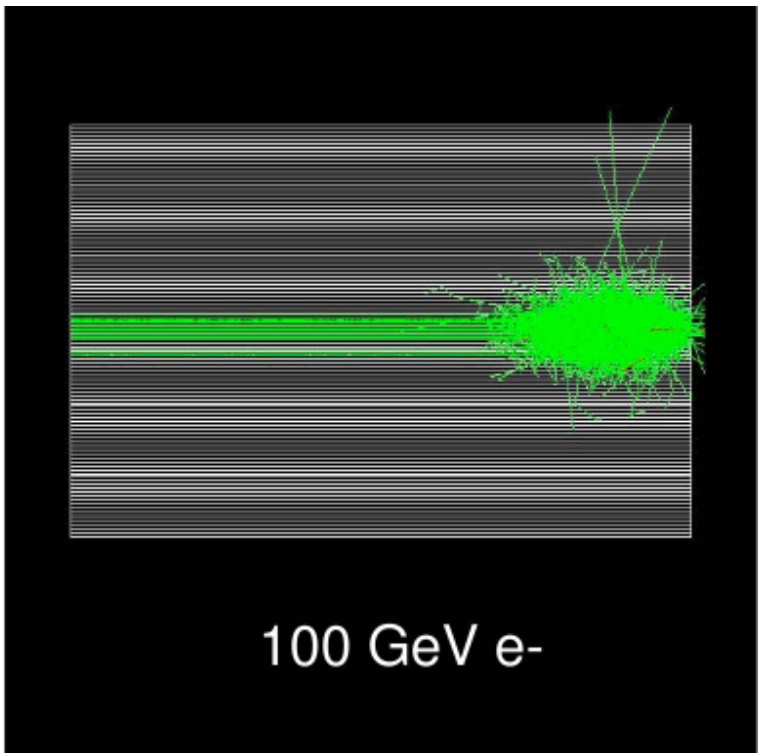


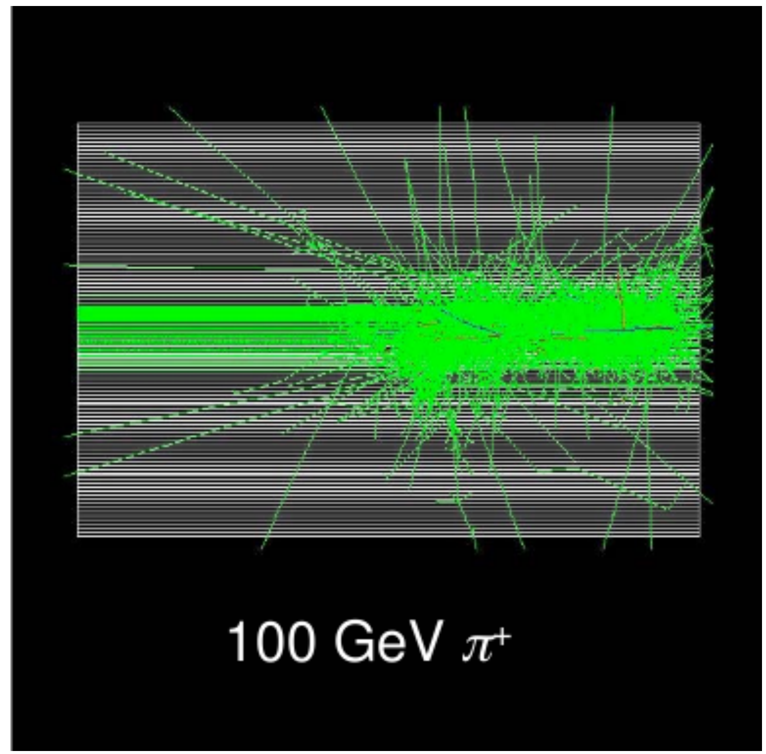
- $3.0 < \eta < 5.0$
- 11 m either side of the IP.
- Steel absorbers and quartz fibres.
- No other calorimeter in front of it.

Long and Short Fibers to differentiate shower from electromagnetic and hadronic particles

Long

Short





Beam

HF GFlash Simulations

- Why do we need G Flash?
  - Full Geant4 simulation → might need days to simulate 1 event.
  - Previous CMS Simulation has a problem to simulate HF Noise because it killed particles immediately when they entered detectors and replaced them with Shower Libraries.

GFlash

- Tested against:
  - Test Beam Data
  - Collision Data
  - Shower Library (previous HF CMS Simulation)
- Noises simulation
- Very high energy particles
- Better agreement to Test Beam Data
- Good agreement to CMS Collision Data

GFlash

- The spatial energy distribution of EM showers is given by three Probability Distribution Functions (PDF) :

$$dE(\vec{r}) = E\ f(t)dt\ f(r)dr\ f(\phi)d\phi$$

where

- t = the longitudinal shower distribution
- r = the radial shower distribution
- ϕ = the azimuthal shower distribution (assumed to be distributed uniformly)

- The average longitudinal shower profile : (in units of radiation length)

$$\left\langle \frac{1}{E}\frac{dEt}{dt} \right\rangle = f(t) = \frac{(\beta t)^{\alpha-1}\beta e^{-\beta t}}{\Gamma(\alpha)}$$

- The average radial energy profile : (in units of Moliere radius)

$$f(r) = \frac{1}{dE(t)}\frac{dE(t,r)}{dr}$$

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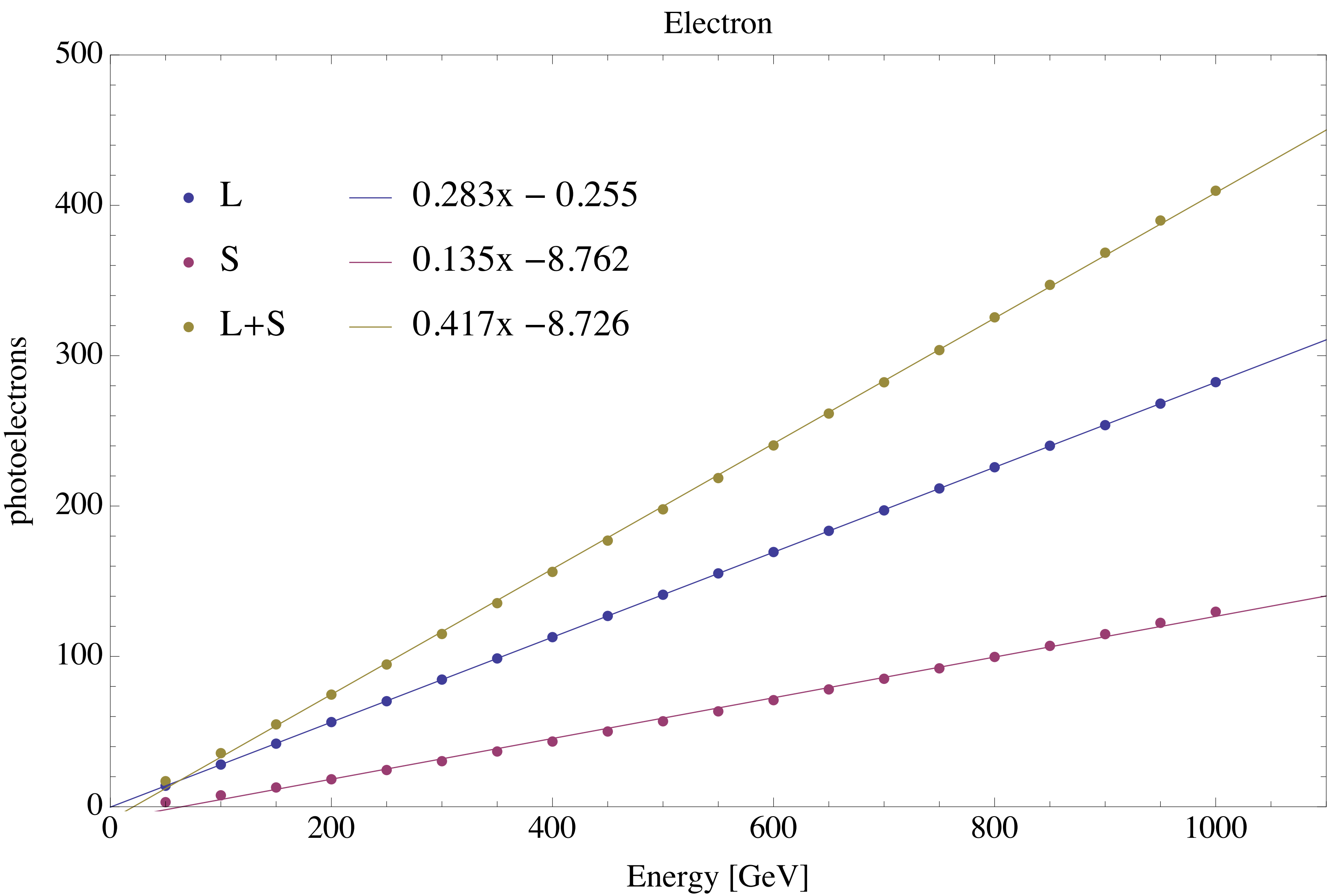
e^- simulations

- We shoot n=10,000 e^- to our detector ($3.95 < \eta < 4.05$)
- Incoming energies varies from 50 to 1000 GeV.
  - Step of 50 GeV
- We calculate the mean and RMS of the photoelectron counts in our detectors with ROOT.
- Finally we plot and fit our curve with Mathematica (Least Squares)
- Error bars gaussian aproximation $error \approx \sqrt{\frac{1}{n}}$

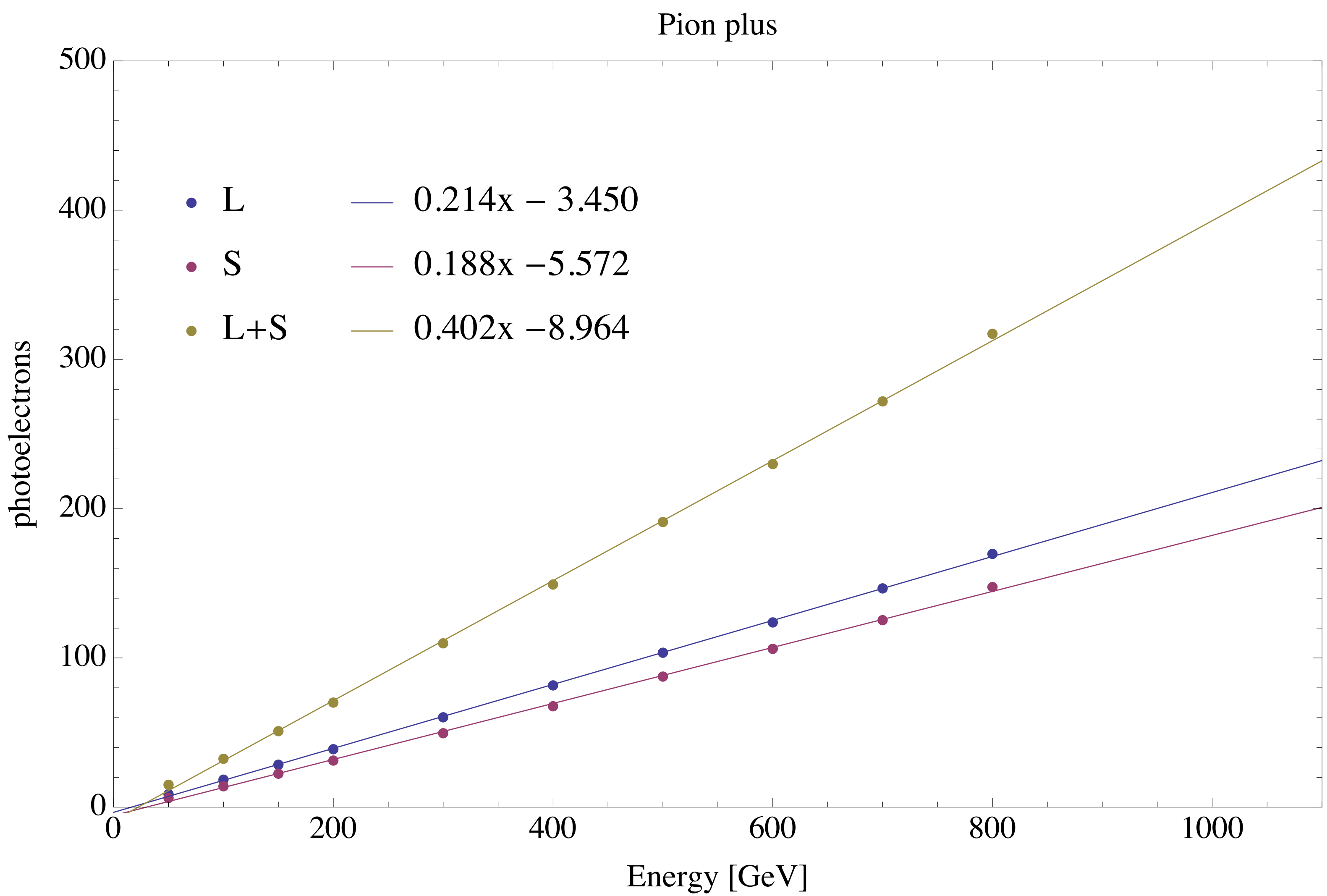
e⁻ EM Shower


Electron
photoelectrons
Energy [GeV]
0
100
200
300
400
500
0
200
400
600
800
1000
L
S
L+S
0.283x – 0.255
0.135x −8.762
0.417x −8.726

π^+ simulations

- We shoot n=1000 π^+ to our detector ($3.95 < \eta < 4.05$) .
- Incoming energies varies from 50 to 800 GeV.
  - Step of 100 GeV
- We calculate the mean and RMS of the photoelectron counts in our detectors with ROOT.
- Finally we plot and fit our curve with Mathematica (Least Squares)
- Error bars gaussian aproximation $error \approx \sqrt{\frac{1}{n}}$

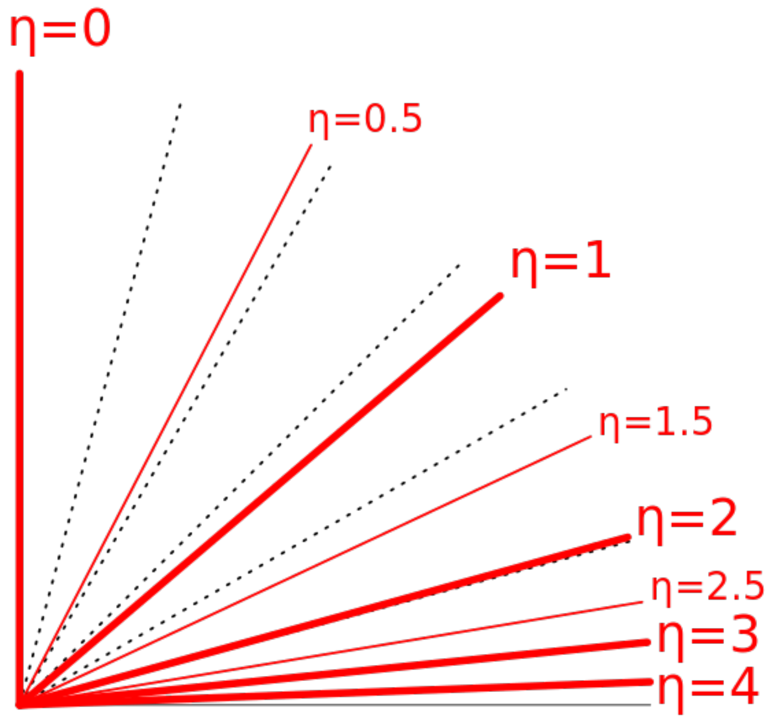
π^+ EM Shower



Pion plus
photoelectrons
Energy [GeV]
500
400
300
200
100
0
0
200
400
600
800
1000
L
S
L+S
0.214x – 3.450
0.188x –5.572
0.402x –8.964

Improvements to be done

- Simulate the full pion decay.
  - We don't want to still use GEANT 4 for following the pion.
- Improve η range.
- Attempt to make it more precise compared to real data.



References

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- The Parameterized Simulation of Electromagnetic Showers in Homogeneous and Sampling Calorimeters, G. Grindhammer and S. Peters, arXiv:hep-ex/0001020v1 10 Jan 2000.