GFLASH - Parameterized Showers at CMS

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LPC Simulation Meeting
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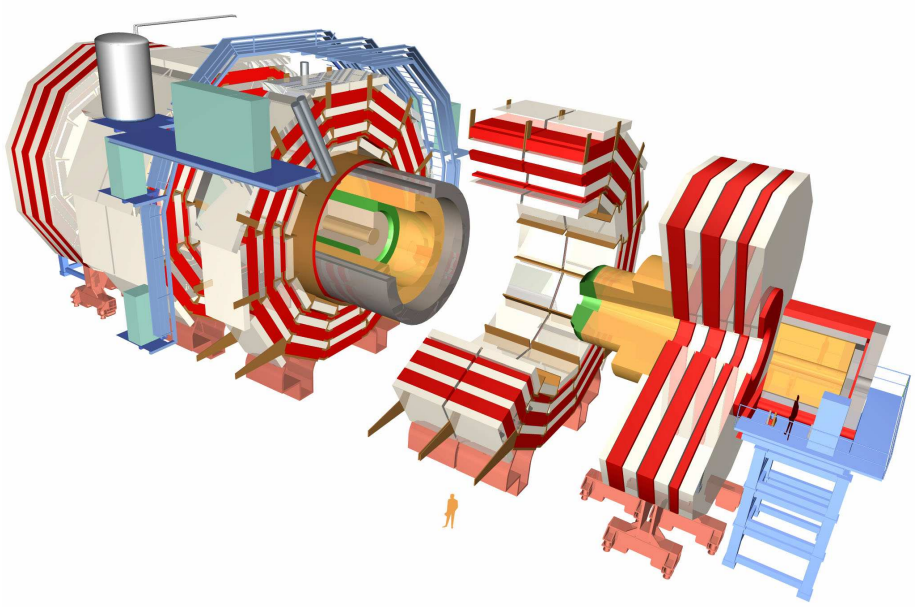


GFLASH Introduction

☐ The spatial energy distribution of EM showers is given by

3 Probability Distribution Functions (PDFs) :

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

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)

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

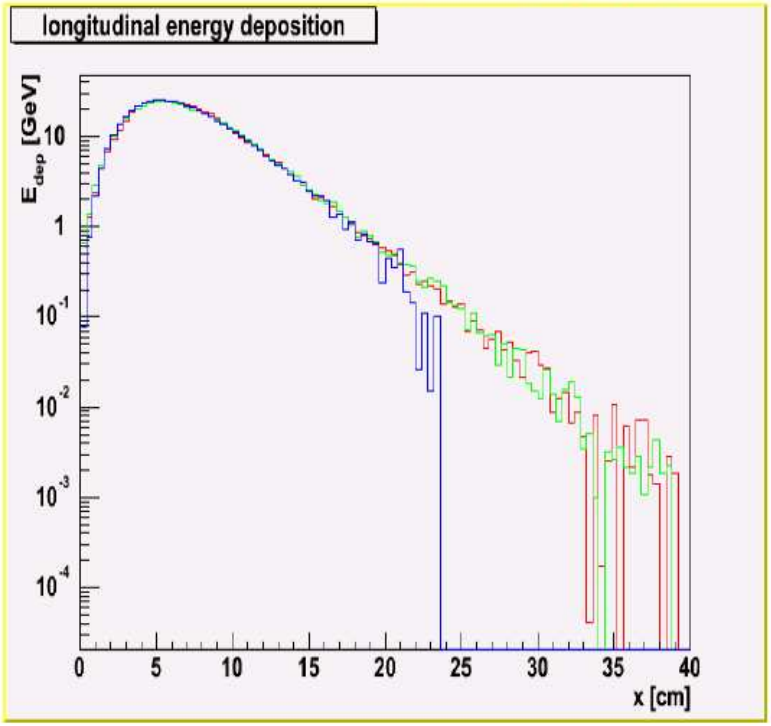
GFLASH Approach

- GFLASH uses a homogeneous media as Parameterization Envelope
  - If a shower is below a minimum energy (user defined) or
  - If a shower is above a maximum energy (user defined) or
  - If a shower is not fully contained in the envelope (95%) then

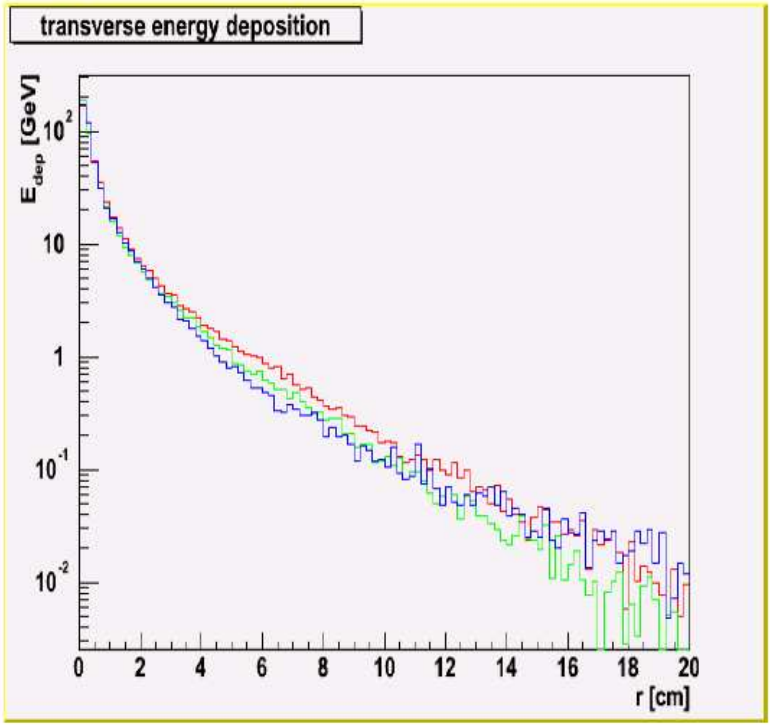
    $\hookrightarrow$ use a fully G4 simulation
- Particles are tracked with full G4 simulation until they reach calorimeter volume then they are parameterized
- The secondary particles are parameterized by default
- Photons as soon as they produced $e^{\pm}$, they are parameterized if they satisfied above condition

Simulation Comparison of 10 GeV Shower

(Geant 3 , Geant 4, GFlash 4)



Longitudinal

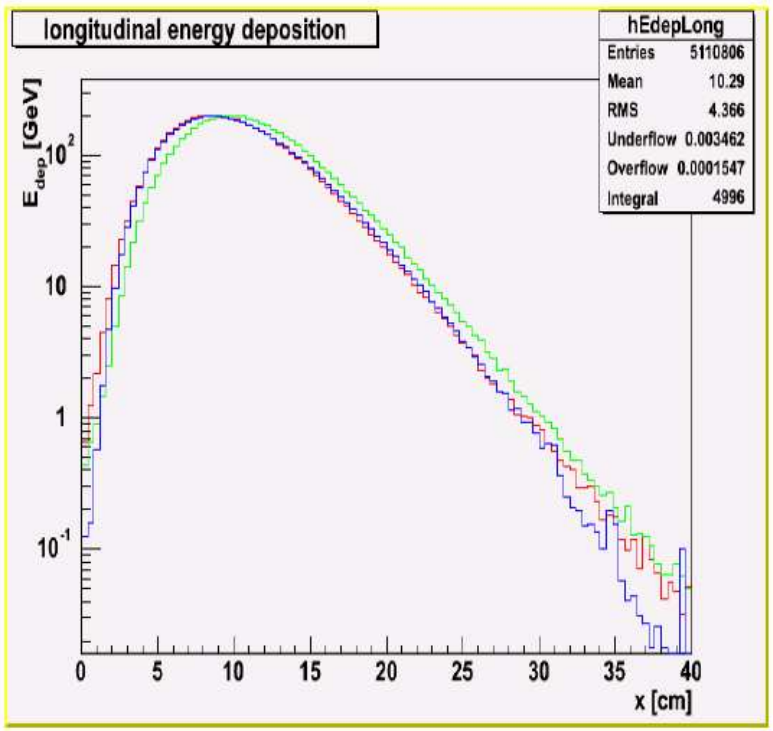


Radial

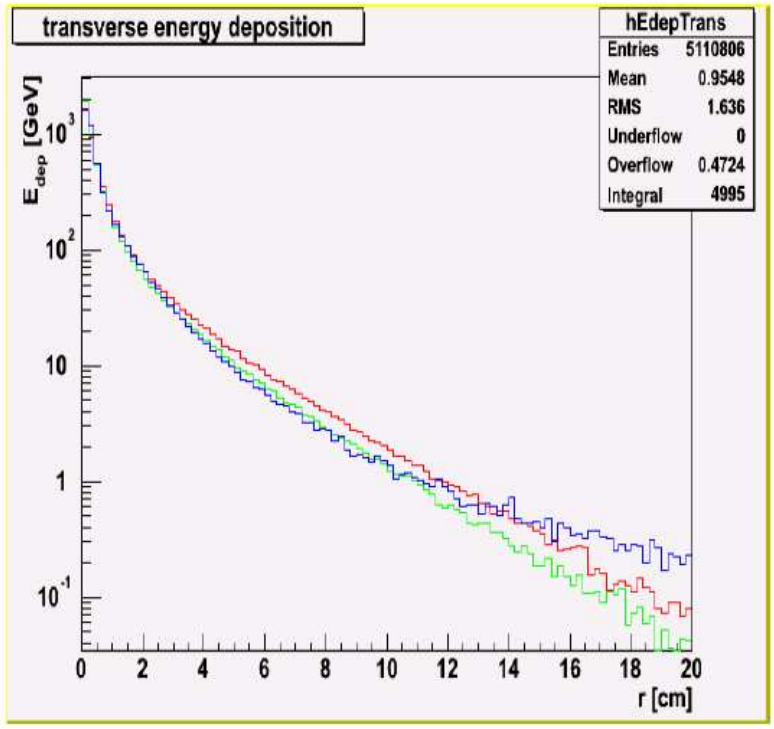
- 10 GeV Electron shower in PbW04
- Done by J. Weng using OSCAR

Simulation Comparison of 500 GeV Shower

(Geant 3 , Geant 4, GFlash 4)



Longitudinal



Radial

- 500 GeV Electron shower in PbW04
- Done by J. Weng using OSCAR

GFLASH in CMSSW

I am using GFLASH in CMSSW 1_2_0_pre4 (new) compare with the full GEANT4 shower simulation in CMSSW 1_1_0 (reference)

- I applied the validation suite in ECAL (Thanks to Xingtao)
- Seems ECAL is stable in both versions, no significant changing
- Also at the moment, we only have reference data of CMSSW 1_1_0
- In GFLASH code, we echo the information when one used GFLASH:

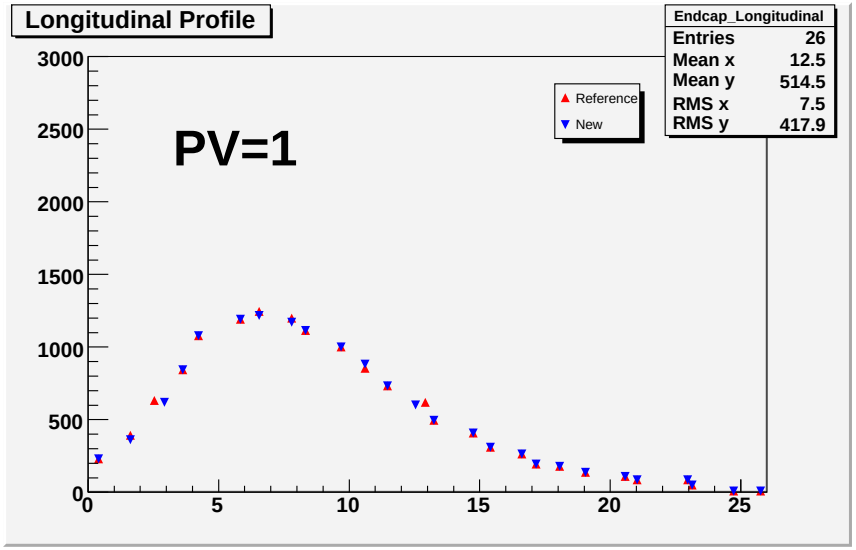
  (photon) : "You are using the simulation engine: QGSP 2.8 + CMS GFLASH"

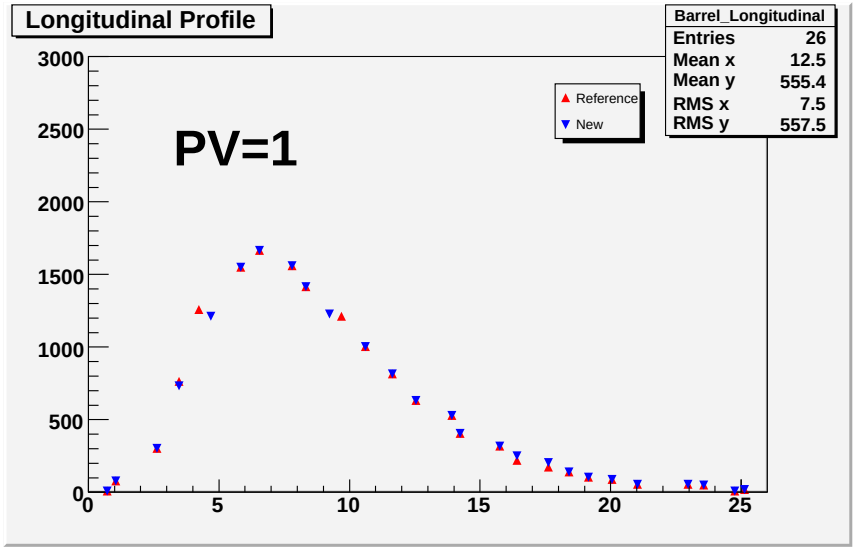
  (others) : "You are using the simulation engine: QGSP 3.1 + CMS GFLASH"

- I am comparing 30 GeV photons, 400 GeV photons, and 60 GeV pion (Pt)

GFLASH Longitudinal Profile

GFLASH longitudinal profile in ECAL

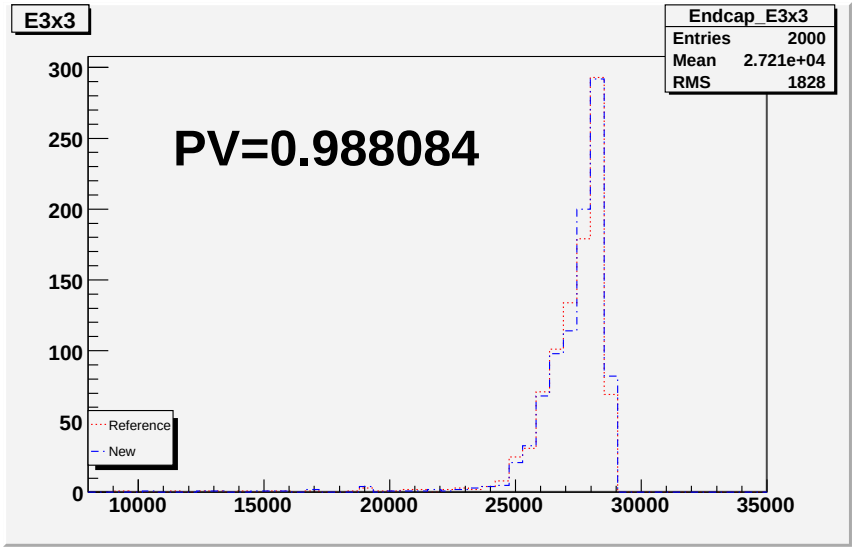


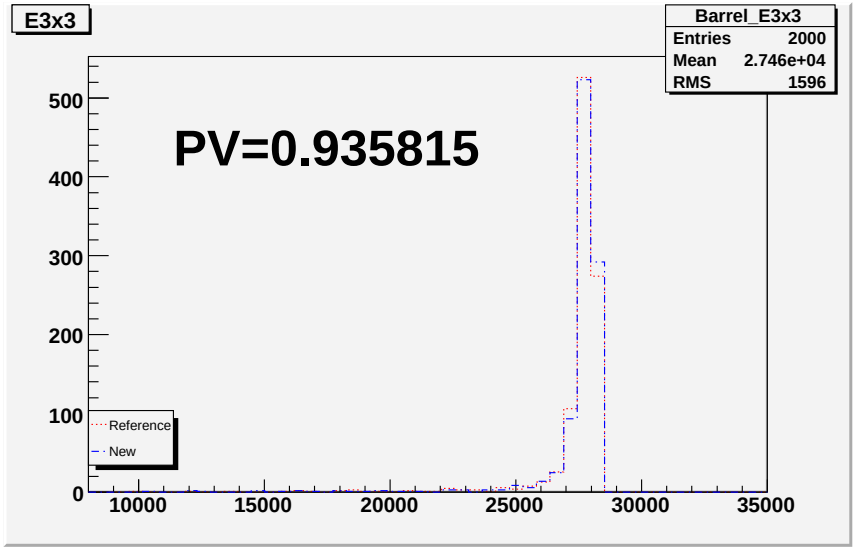


- (left) Longitudinal profile of 30 GeV energy of photons in endcap ECAL
- (right) Longitudinal profile of 30 GeV energy of photons in barrel ECAL
- PV is the probability value estimated with χ^2 calculation

GFLASH Energy Deposited Spectrum

GFLASH energy deposited spectrum in ECAL

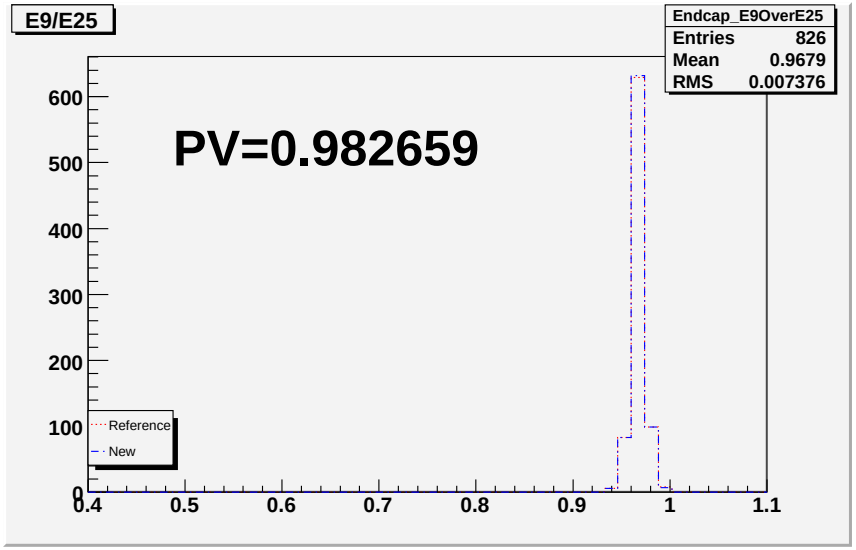


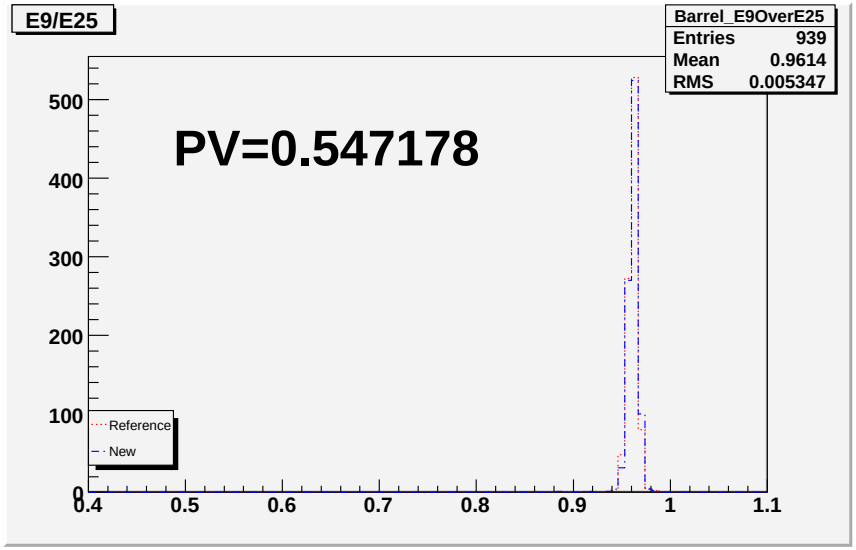


- (left) Energy deposited spectrum of 30 GeV energy of photons in 3 x 3 endcap ECAL
- (right) Energy deposited spectrum of 30 GeV energy of photons in 3 x 3 barrel ECAL

GFLASH Energy Deposited Spectrum

GFLASH energy deposited spectrum in ECAL



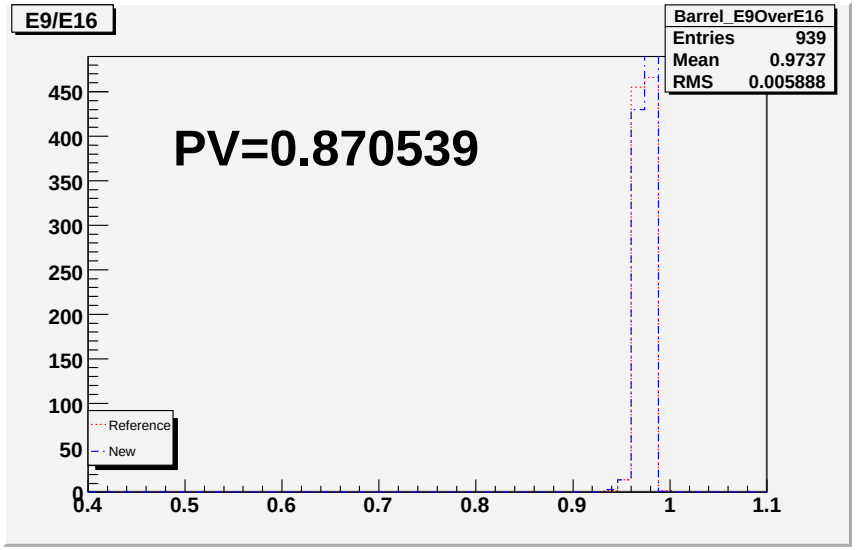


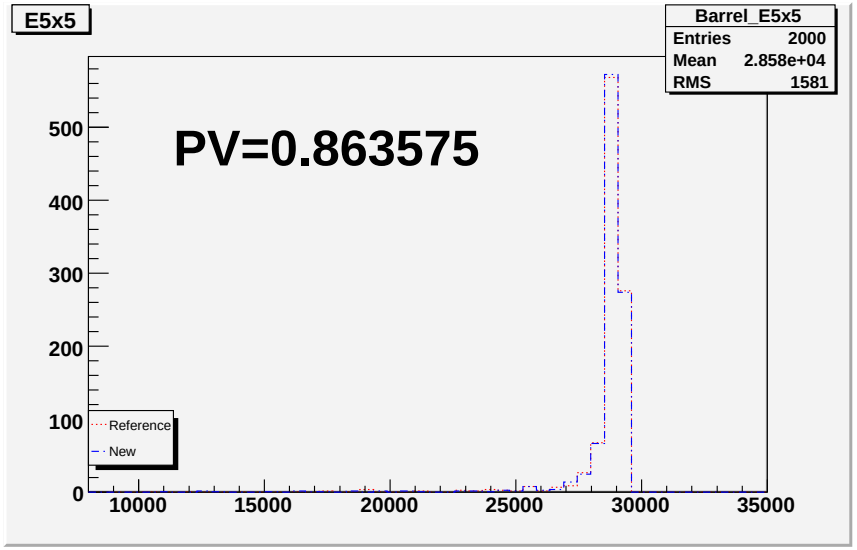
- (left) Energy deposited ratio of 30 GeV energy of photons in 3 x 3 over 5 x 5 endcap ECAL

- (right) Energy deposited ratio of 30 GeV energy of photons in 3 x 3 over 5 x 5 barrel ECAL. Why the PV is worst in barrel ?

GFLASH Energy Deposited and Ratio

GFLASH energy deposited spectrum and its ratio in ECAL

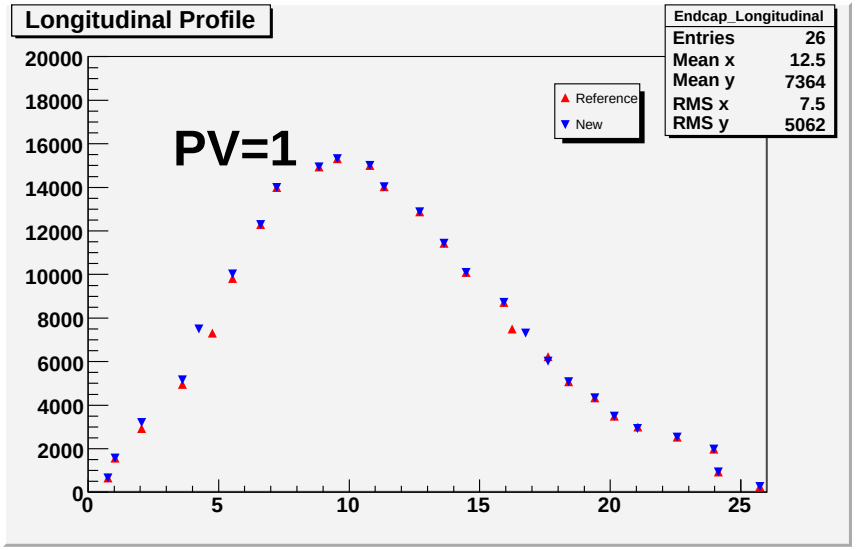


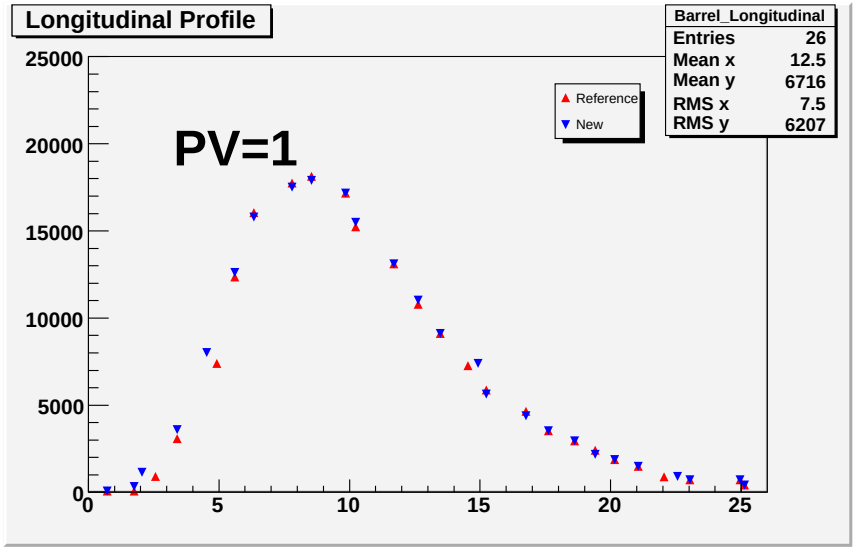


- (left) Energy deposited ratio of 30 GeV energy of photons in 3 x 3 over 4 x 4 barrel ECAL
- (right) Energy deposited spectrum of 30 GeV energy of photons in 5 x 5 barrel ECAL

GFLASH Longitudinal Profile

GFLASH longitudinal profile in ECAL

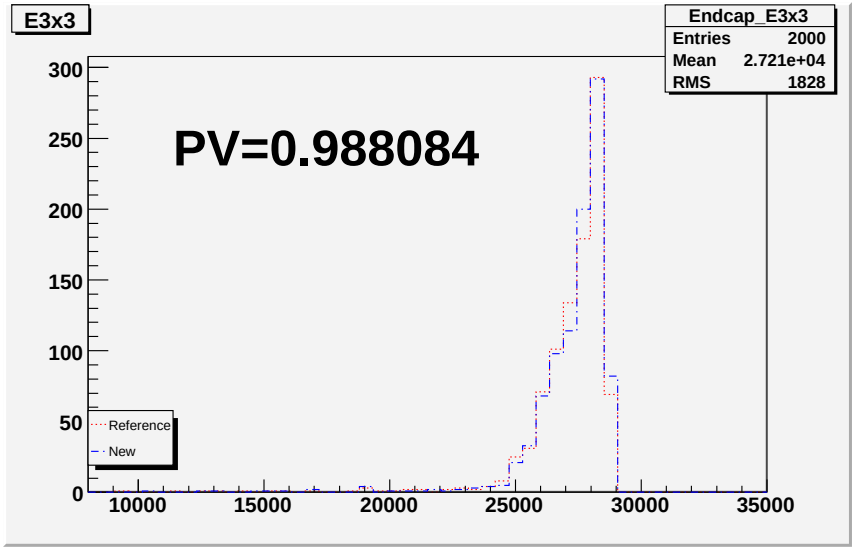


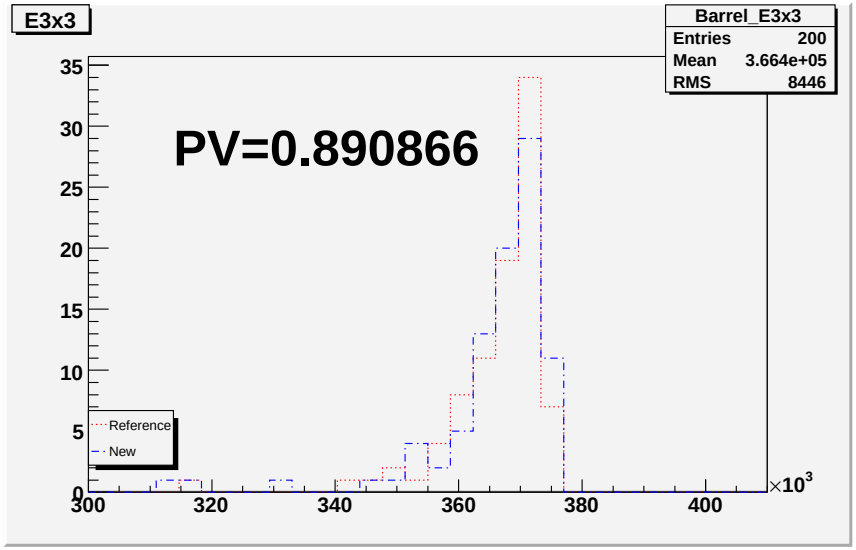


- (left) Longitudinal profile of 400 GeV energy of photons in endcap ECAL
- (right) Longitudinal profile of 400 GeV energy of photons in barrel ECAL

GFLASH Energy Deposited Spectrum

GFLASH energy deposited spectrum in ECAL

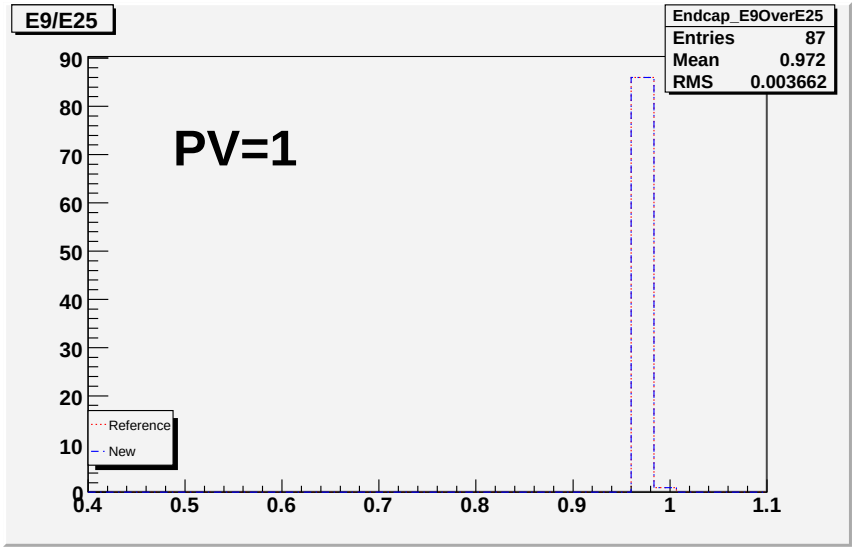


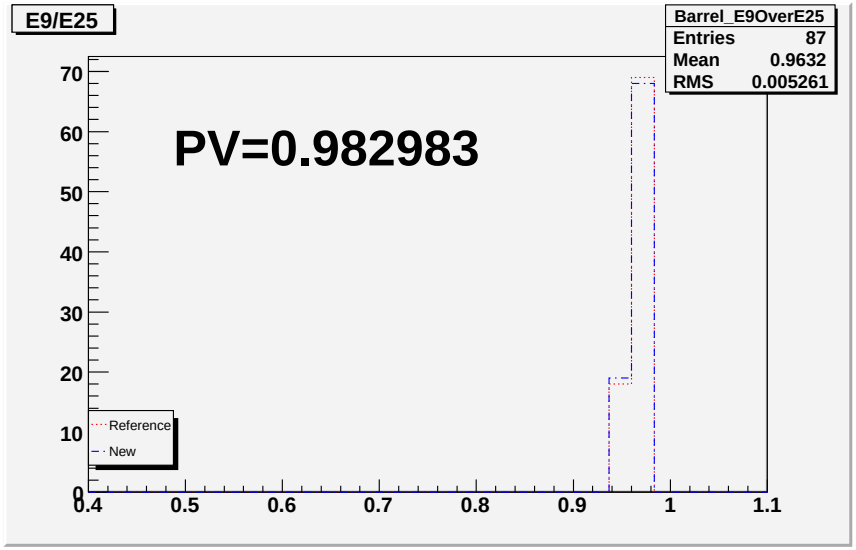


- (left) Energy deposited spectrum of 400 GeV energy of photons in 3 x 3 endcap ECAL
- (right) Energy deposited spectrum of 400 GeV energy of photons in 3 x 3 barrel ECAL

GFLASH Energy Deposited Spectrum

GFLASH energy deposited spectrum in ECAL





- (left) Energy deposited ratio of 400 GeV energy of photons in 3 x 3 over 5 x 5 endcap ECAL

- (right) Energy deposited ratio of 400 GeV energy of photons in 3 x 3 over 5 x 5 barrel ECAL. The PV is fine in barrel

Summary and Plan to Do

- This is the first step to test and check the GFLASH in CMSSW
- The GFLASH is seems properly installed in CMSSW
- Need to investigate why the PV for 30 GeV photons is worst in E9/E25 barrel but not E9/E16 barrel, 3 x 3 barrel, and 5 x 5 barrel
- Plan to study the GFLASH code and its implementation in detail
- Plan to compare the GFLASH with the test beam data