GFLASH - Parameterized Showers at CMS

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The spatial energy distribution of EM showers is given by

3 Probability Distribution Functions (PDFs):

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

where

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

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

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

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
    \[ \rightarrow \text{use a fully G4 simulation} \]

- 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)

10 GeV Electron shower in PbW04

Done by J. Weng using OSCAR
Simulation Comparison of 500 GeV Shower

(Geant 3, Geant 4, GFlash 4)

500 GeV Electron shower in PbW04

Done by J. Weng using OSCAR
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)
(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 $\chi^2$ calculation
(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
(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 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
  - PV = 0.870539

- **(right)** Energy deposited spectrum of 30 GeV energy of photons in 5 x 5 barrel ECAL
  - PV = 0.863575
(left) Longitudinal profile of 400 GeV energy of photons in endcap ECAL

(right) Longitudinal profile of 400 GeV energy of photons in barrel 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
(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