HF GFLASH

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Outline

- Motivation & Introduction to HF Gflash
- Shower profile of HF Gflash
- Speed of HF Gflash
- Comparison to Test Beam Result
- Comparison to 7 TeV certified Collision Data
- Plan and Summary of HF Gflash

Motivations

- Why do we need GFLash?

  Full Geant4 simulation in colliders is really time consuming and

  you may need days to simulate 1 event

- Gflash can speed up full detector simulation significantly without sacrificing its precision

- Gflash package has been used in many experiments

- In this talk, I will explain ***HF GFlash,*** an example of a successful application of Gflash in CMS Hadronic Forward Calorimeter (HF)that will be useful to save computing not only in CMS but also other physics experiments

- Reference: hep-ex/0001020v1 by G. Grindhammer & S. Peters

- CMS CR -2009/343 Parameterized Simulation of the CMS Calorimeter Using GFlash

Introduction to 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)

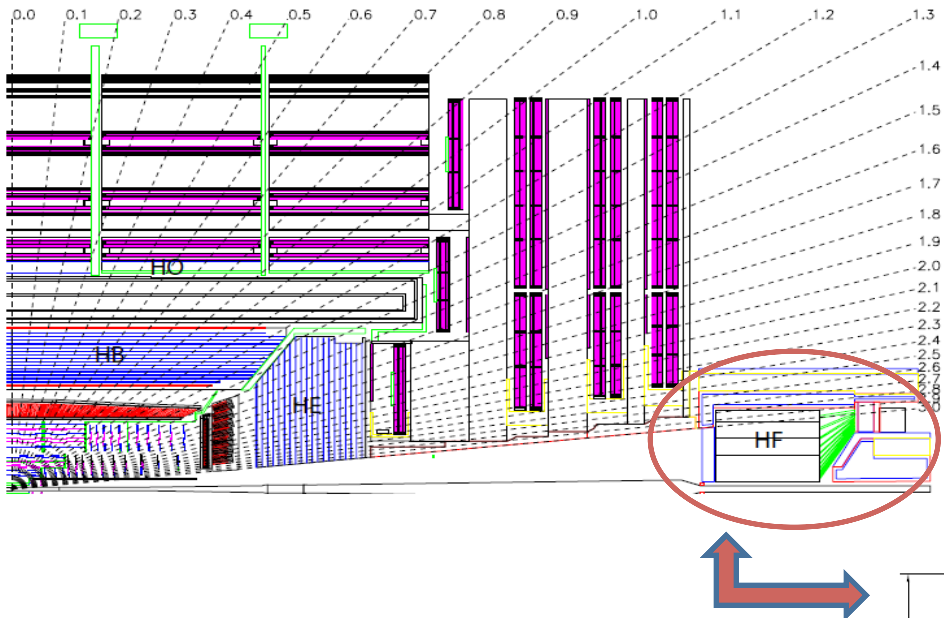
☐ The average longitudinal shower profile : (in units of radiation length)

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

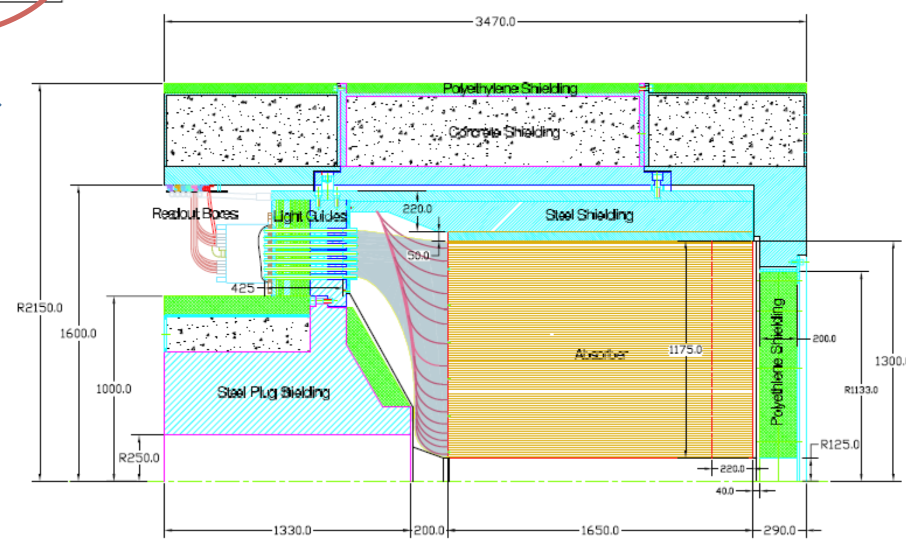
☐ The average radial energy profile : (in units of Moliere radius)

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

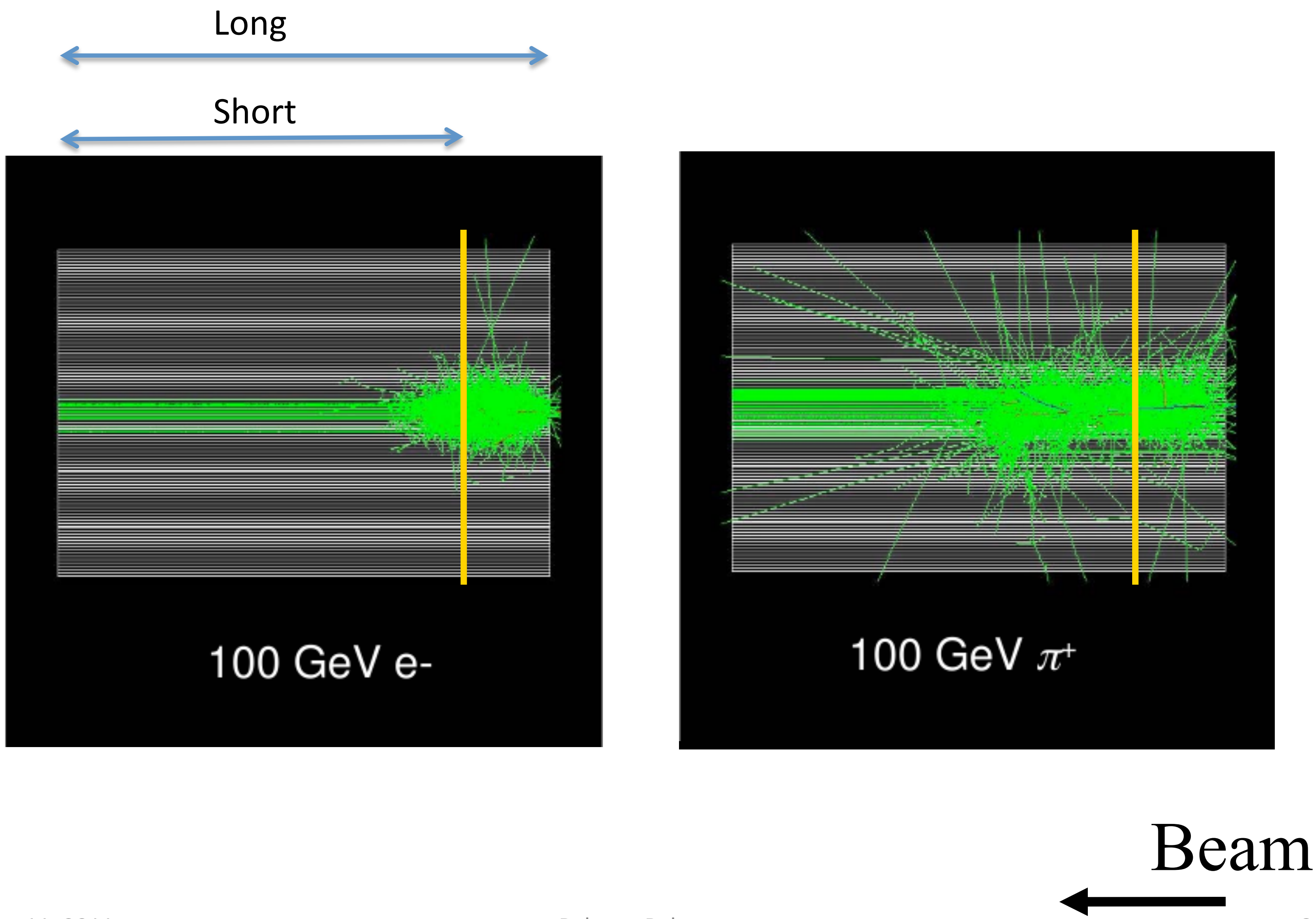
Hadronic Forward Calorimeter(HF)



Hadronic Forward Calorimeter(HF) is placed about 11 m from interaction point and has $3 < |\eta| < 5$. There is no other calorimeter in front of HF so that HF is a very good place to study Gflash.



HF has **Long** and **Short** Fibers to differentiate shower from electromagnetic & hadronic particles

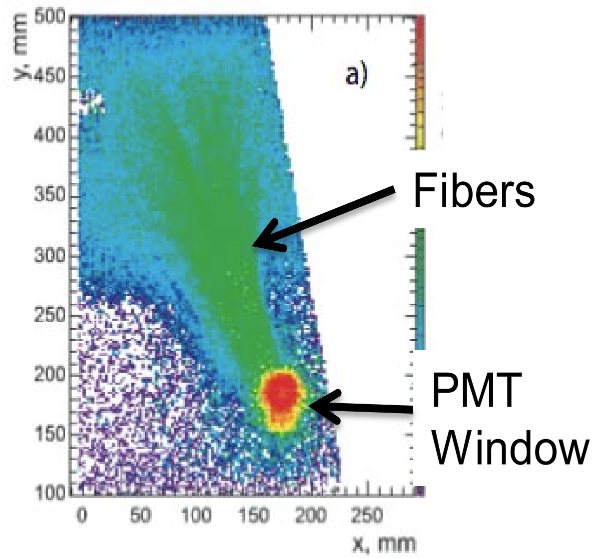


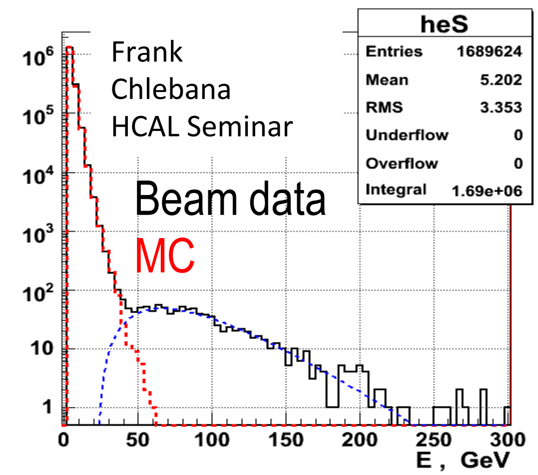
HF Noise

Anomalous signals were first observed in the 2004 test beam

Signals in HF L or S sections observed from particles interacting in the PMT window.

Eur.Phys.J. C53, 139-166 (2008)

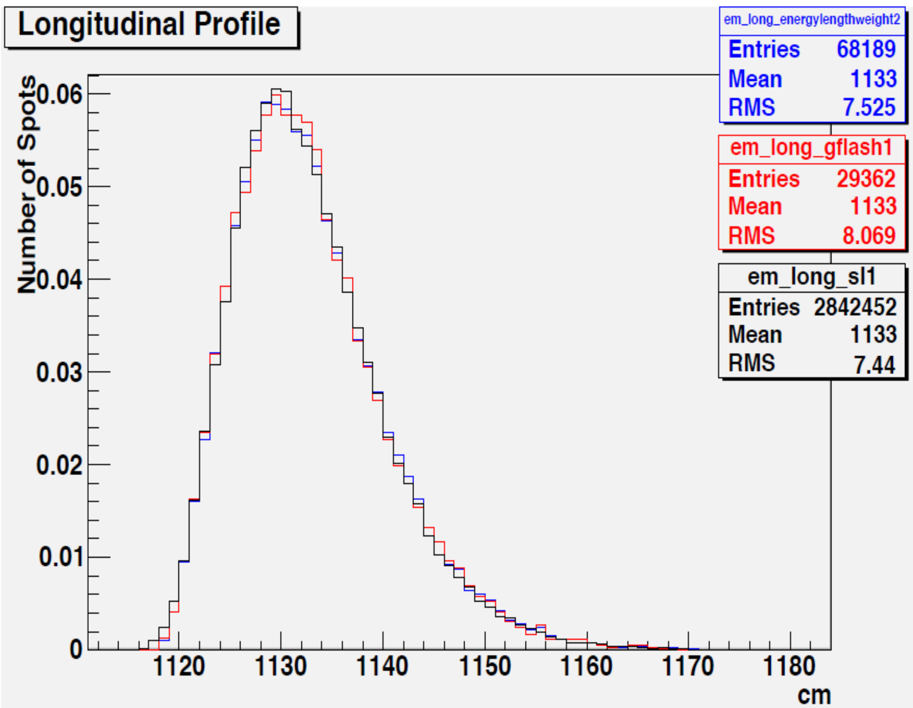


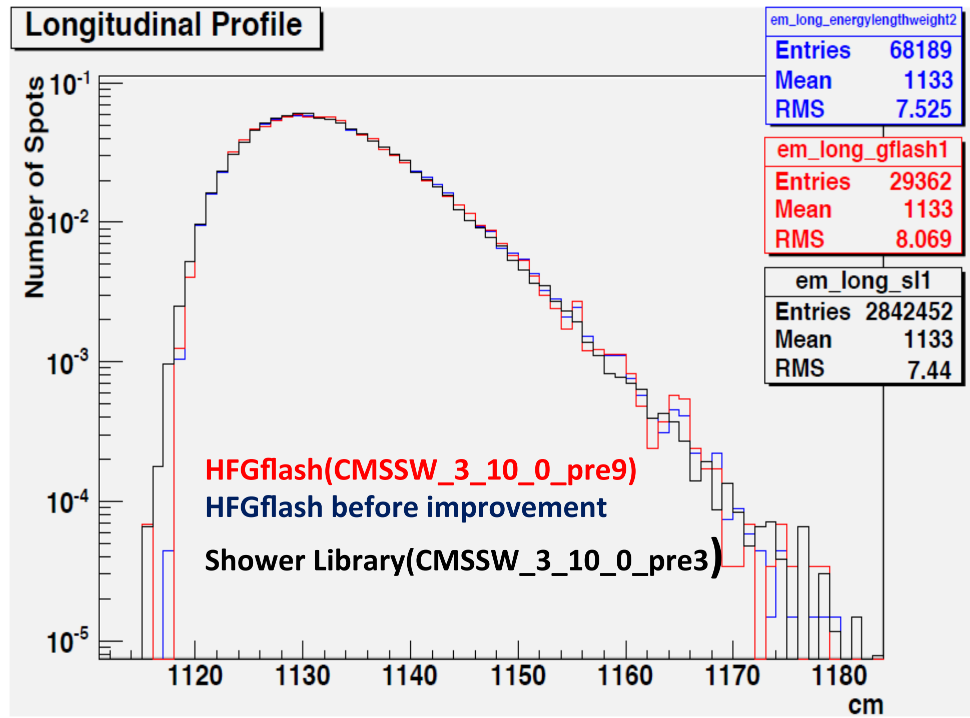


Previous CMS Simulation has a problem to simulate HF Noise because it killed particles immediately when they entered detectors.

HF GFlash was called to help simulate HF Noise produced by PMT Windows

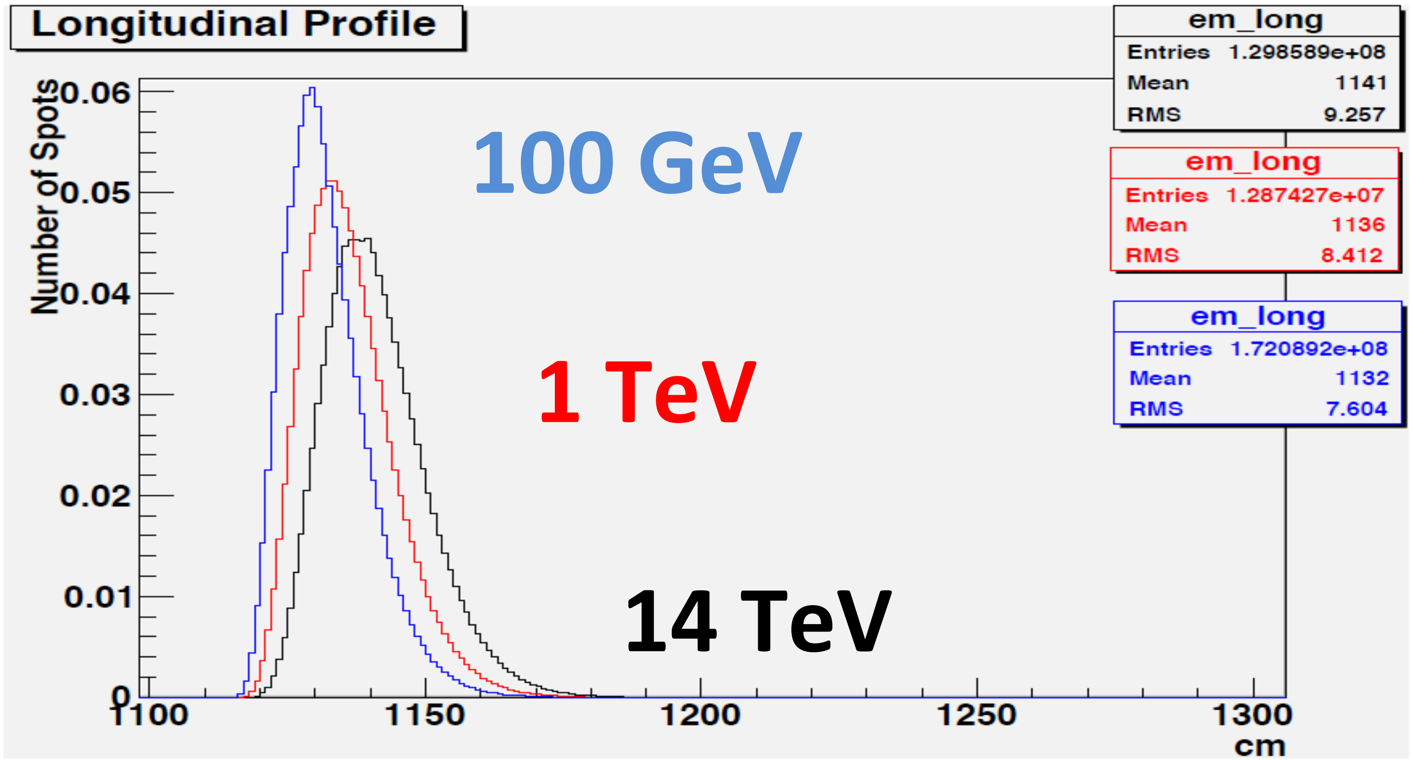
Current Agreement of Longitudinal Profile





Longitudinal profile produced by 100-GeV electron gun using HFGflash, old HFGflash and Shower Library(based on Geant4)

High Energy Longitudinal Profile



Geant4 will need days to simulate the shower profile of 1 TeV electron gun. Fortunately HF Gflash only need few seconds to simulate the interaction of very high energy particles with detector and gives good longitudinal profiles for very high energy particles(higher than 1 TeV)

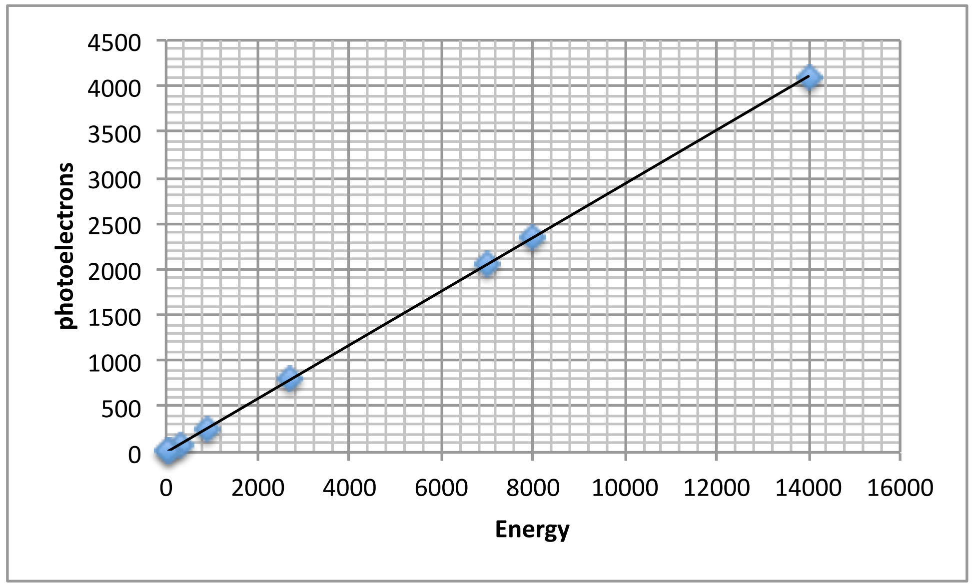
High Energy Test

- We test HF Gflash to handle up to 14 TeV particle guns and HFGflash has linear electromagnetic response up to 14 TeV

  (in pe = photoelectrons)

  Some results of High Energy Test

- 14 TeV 4106 pe
- 8 TeV 2348 pe
- 7 TeV 2052 pe
- 2.7 TeV 790.6 pe
- 900 GeV 263.2 pe
- 300 GeV 87.29 pe
- 100 GeV 29.8 pe
- 50 GeV 14.43 pe

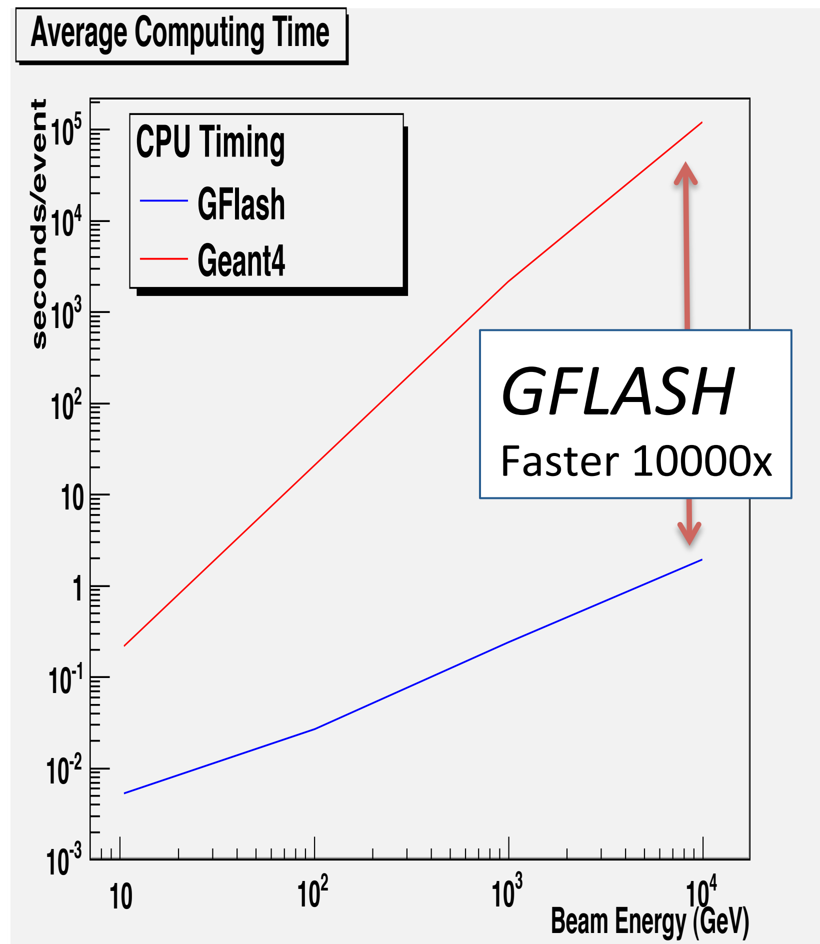


GFlash saves computing time significantly

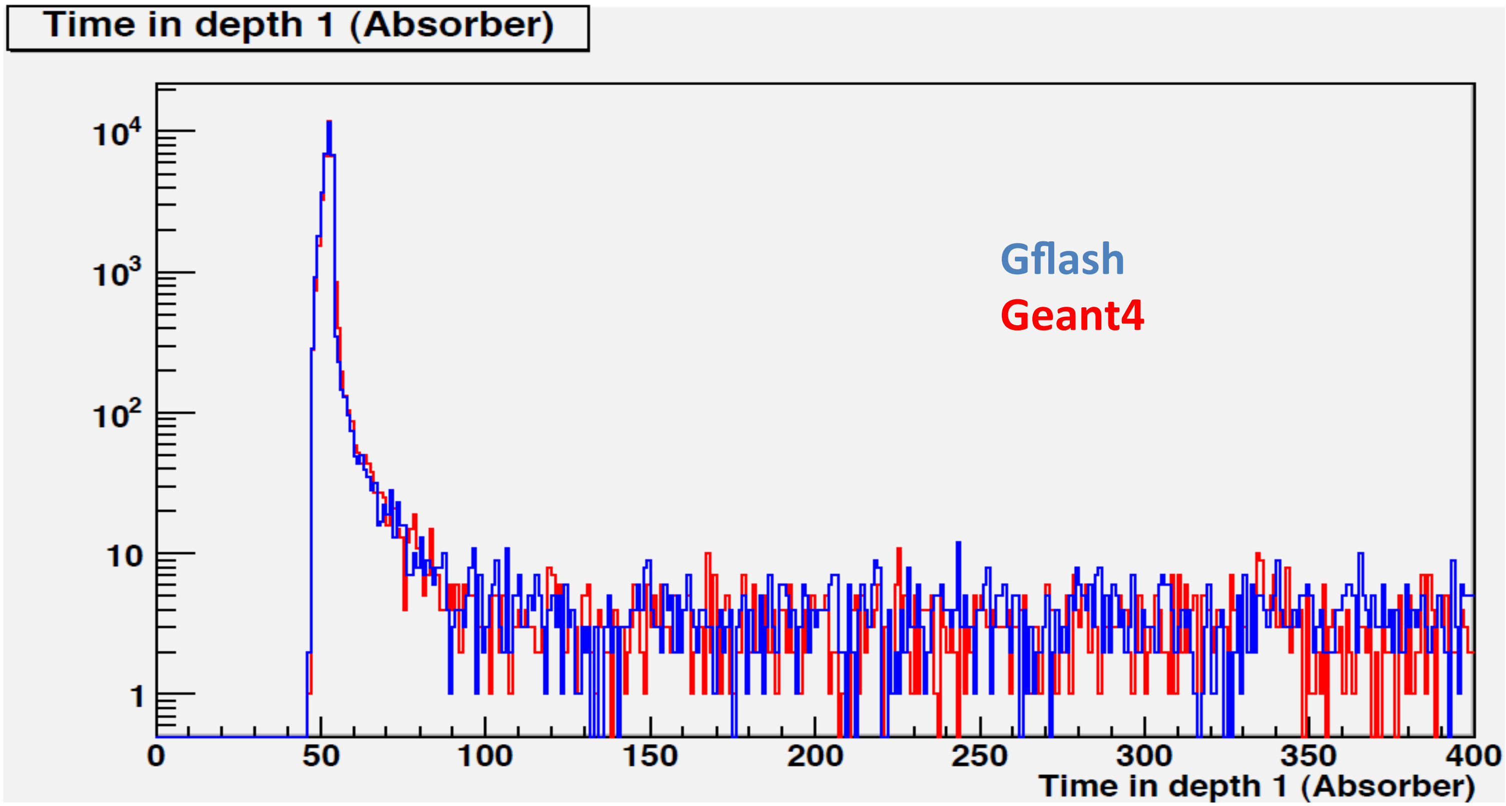
Gflash is not only can give you better precision, but also can make simulation about 10000x faster than Geant4 for very high energy particles.

MEAN: Instead of buying 10000 new computers, you can buy 1 new computer to simulate high energy particles

By using GFlash you will reduce pollution because it can finish simulation with less power/electricity

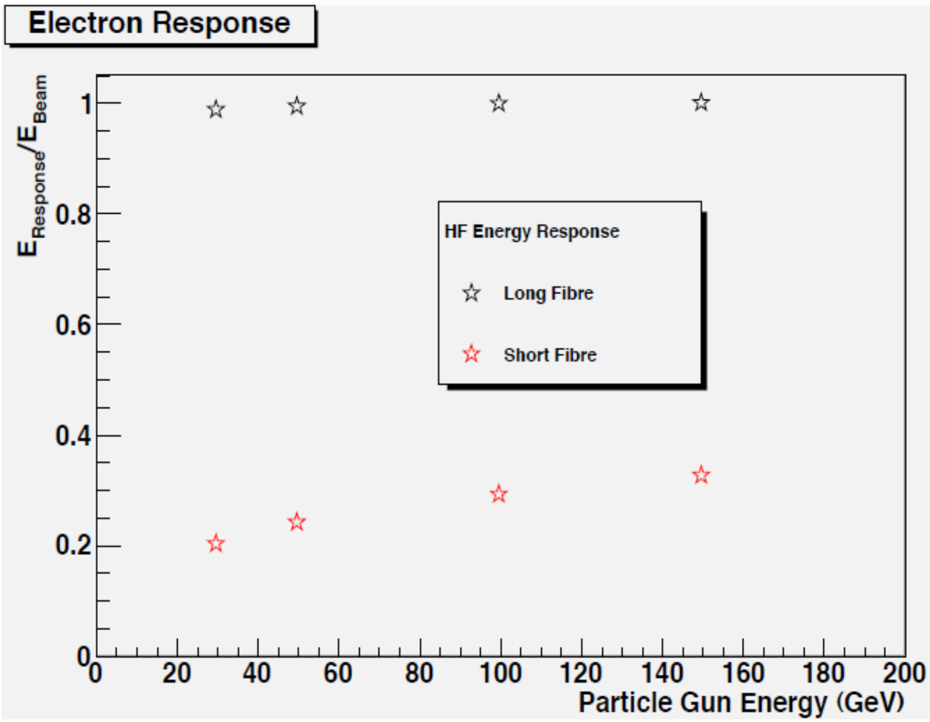


Time from IP to PMT(ns) Pion

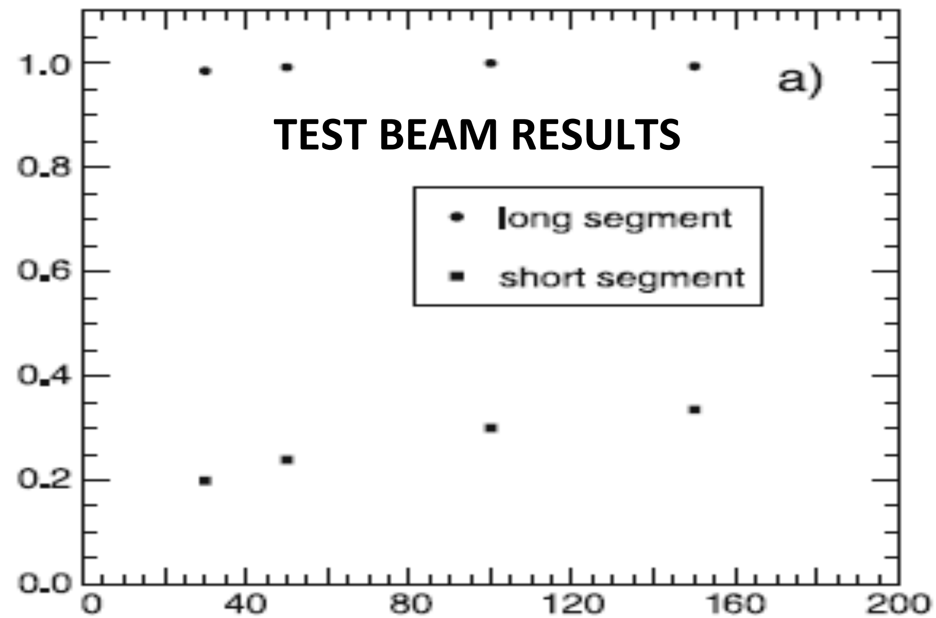


HF Gflash can perform timing simulation from interaction point(IP) to PMT very well with less electricity consumption

Response of Electron gun



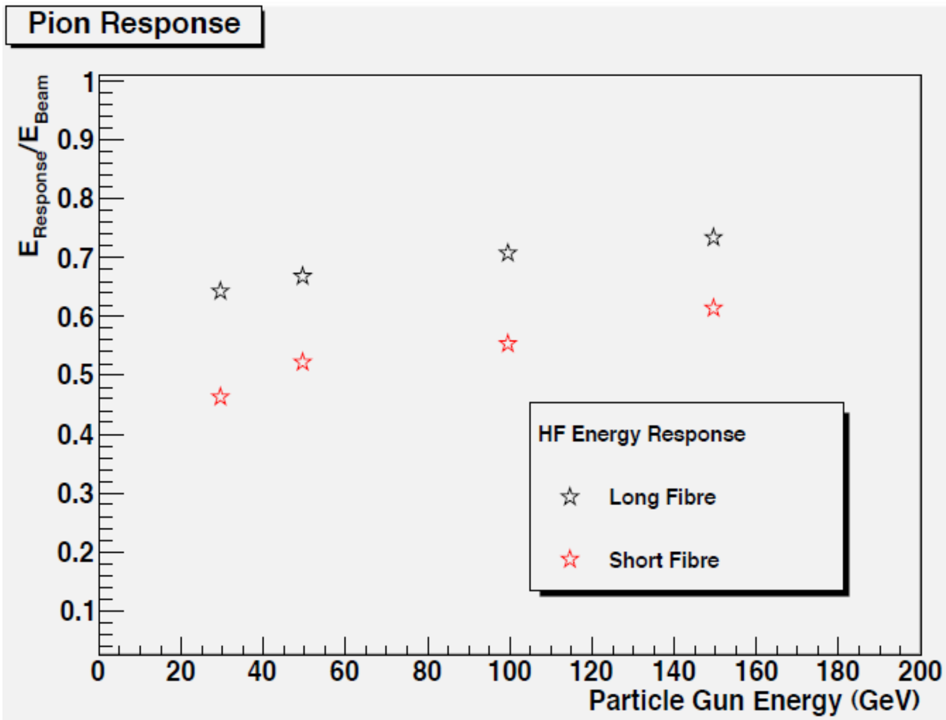
HFGflash(CMSSW_3_10_0_pre9)



"Design, Performance, and Calibration of CMS Forward Calorimeter Wedges"
http://www.springerlink.com/content/f002u432m2453667/

Comparison of HF Gflash and TEST BEAM RESULTS: The normalized response to electrons(30, 50, 100 and 150 GeV) for long fibers are linear. **HF Gflash has good agreement to Test Beam Data.**

Pion Energy Response



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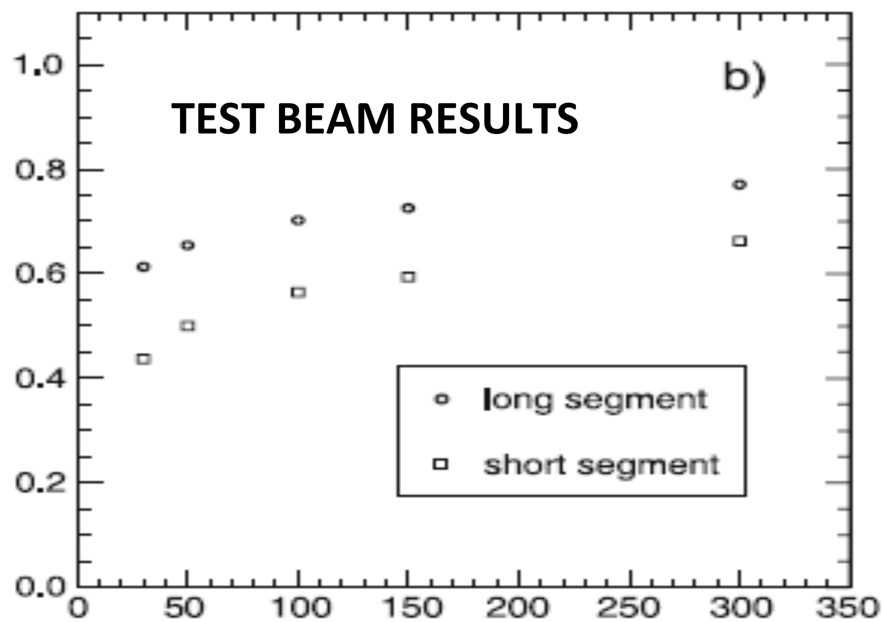

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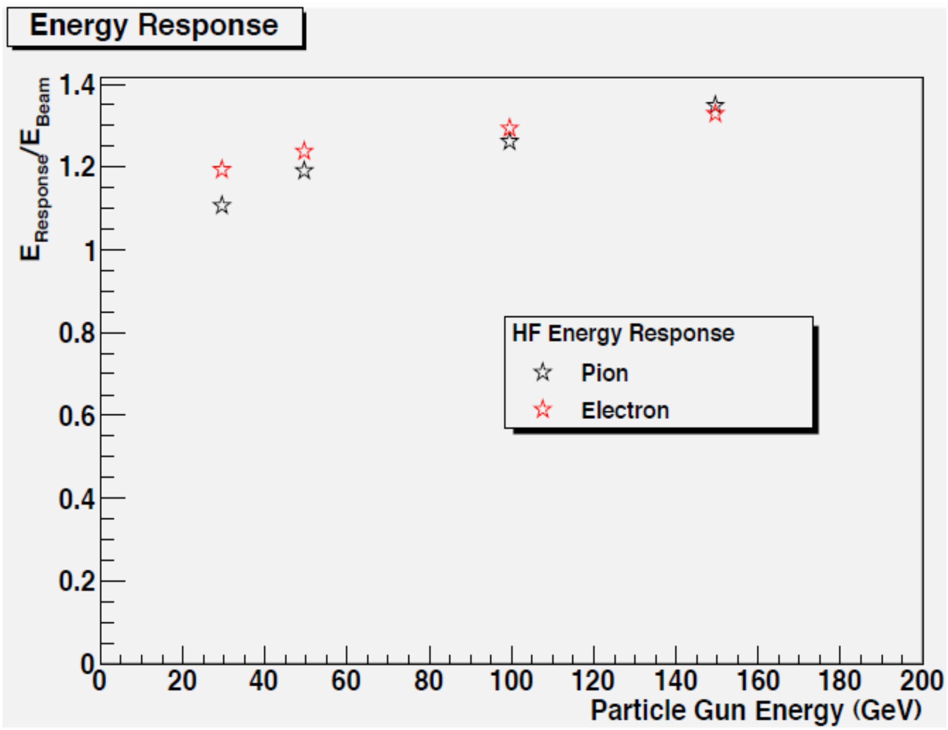
Comparison of HF Gflash and TEST BEAM RESULTS: The normalized response to pions (30, 50, 100 and 150 GeV). **HF Gflash has good agreement to Test Beam Data.**

Long+Short Energy Response



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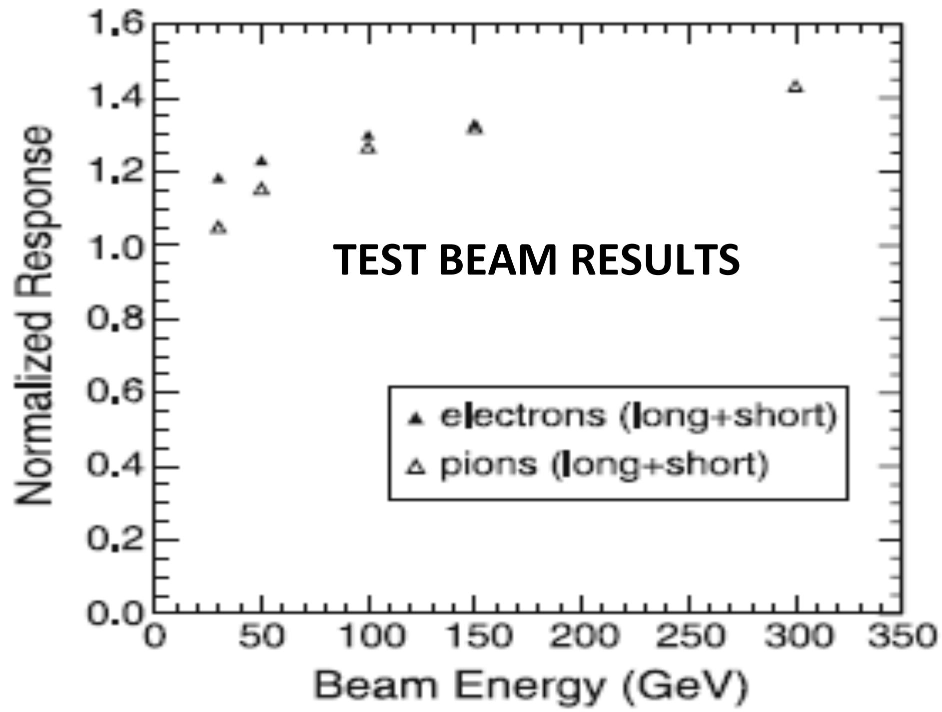

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Comparison of HF Gflash and TEST BEAM RESULTS: The normalized response to electrons and pions L+S(30, 50, 100 and 150 GeV). **HF Gflash has good agreement to Test Beam Data.**

50 GeV Pions and Electrons

	Gflash	Test Beam	Shower Library (Geant4)
Se/Le	**0.24**	0.24	0.20
Lp/Le	**0.67**	0.66	0.63
Sp/Le	**0.51**	0.50	0.51
Sp/Lp	**0.76**	0.76	0.80

Le = Energy deposited in Long Fiber from 10000 50-GeV electrons
Se = Energy deposited in Short Fiber from 10000 50-GeV electrons
Lp = Energy deposited in Long Fiber from 10000 50-GeV charged pions
Sp = Energy deposited in Short Fiber from 10000 50-GeV charged pions

HF Gflash has better agreement to experimental results compared to Shower Library(derived from Geant4)

100 GeV Pions and Electrons

	HF GFlash	Test Beam	Shower Library (Geant4)
Se/Le	**0.30**	0.30	0.25
Lp/Le	**0.70**	0.69	0.67
Sp/Le	**0.57**	0.55	0.56
Sp/Lp	**0.82**	0.80	0.84

Le = Energy deposited in Long Fiber from 10000 100-GeV electrons
Se = Energy deposited in Short Fiber from 10000 100-GeV electrons
Lp = Energy deposited in Long Fiber from 10000 100-GeV charged pions
Sp = Energy deposited in Short Fiber from 10000 100-GeV charged pions

HF Gflash has better agreement to experimental results compared to Shower Library(derived from Geant4)

150 GeV Pions and Electrons

	HF GFlash	Test Beam	Shower Library (Geant4)
Se/Le	**0.33**	0.34	0.28
Lp/Le	**0.71**	0.73	0.70
Sp/Le	**0.59**	0.60	0.56
Sp/Lp	**0.83**	0.82	0.80

Le = Energy deposited in Long Fiber from 10000 150-GeV electrons
Se = Energy deposited in Short Fiber from 10000 150-GeV electrons
Lp = Energy deposited in Long Fiber from 10000 150-GeV charged pions
Sp = Energy deposited in Short Fiber from 10000 150-GeV charged pions

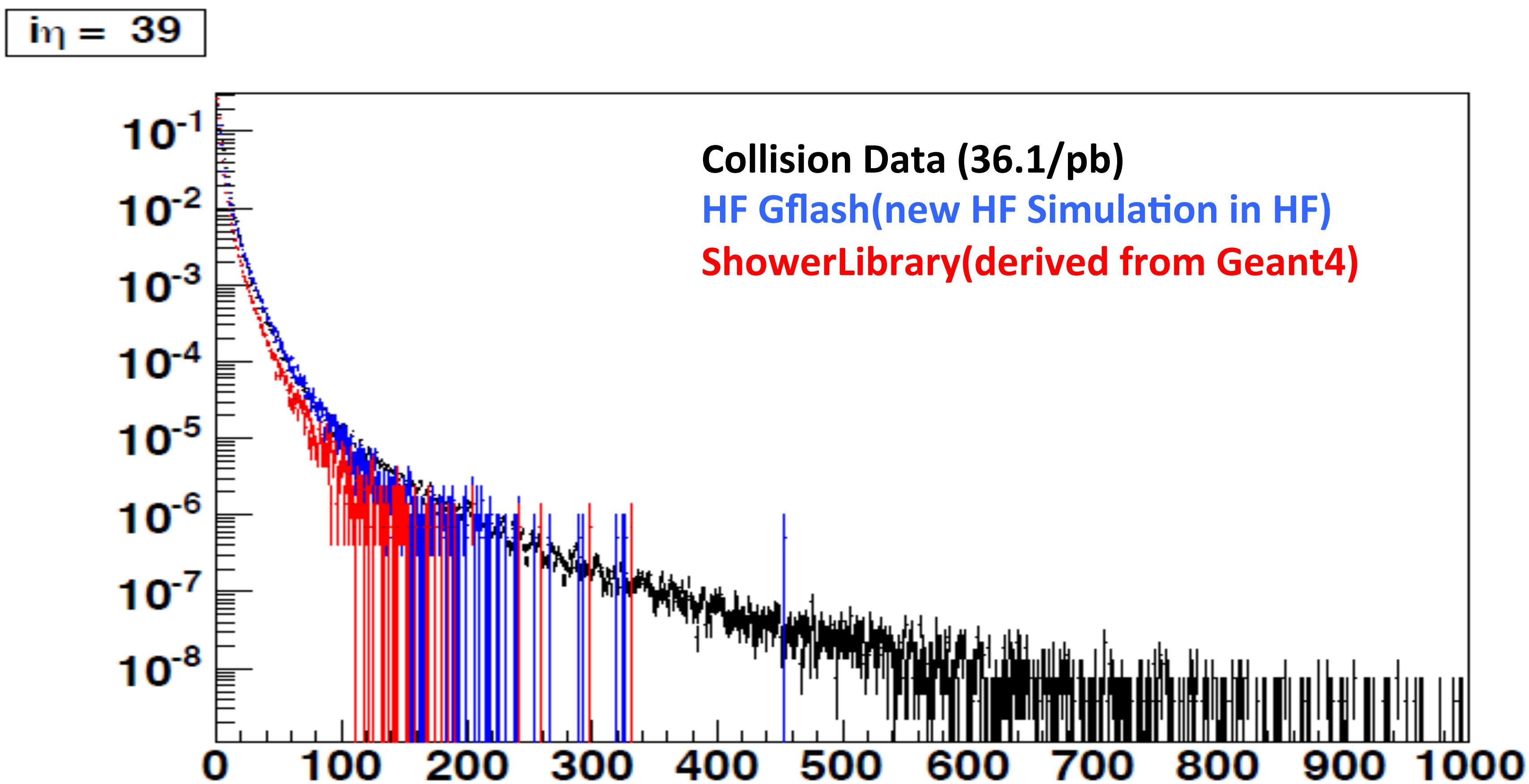
HF Gflash has better agreement to experimental results compared to Shower Library(derived from Geant4)

Comparison with Certified 36.1/pb Collision Data

- Muon Dataset triggered by muon (outside HF)
- Collected certified integrated Luminosity 36 pb^{-1}
- Requiring good vertex
- **Most towers show HF Gflash has better agreement to Certified Collision Data compared to Shower Library**

Comparison with 36.1/pb good Collision Data from CMS

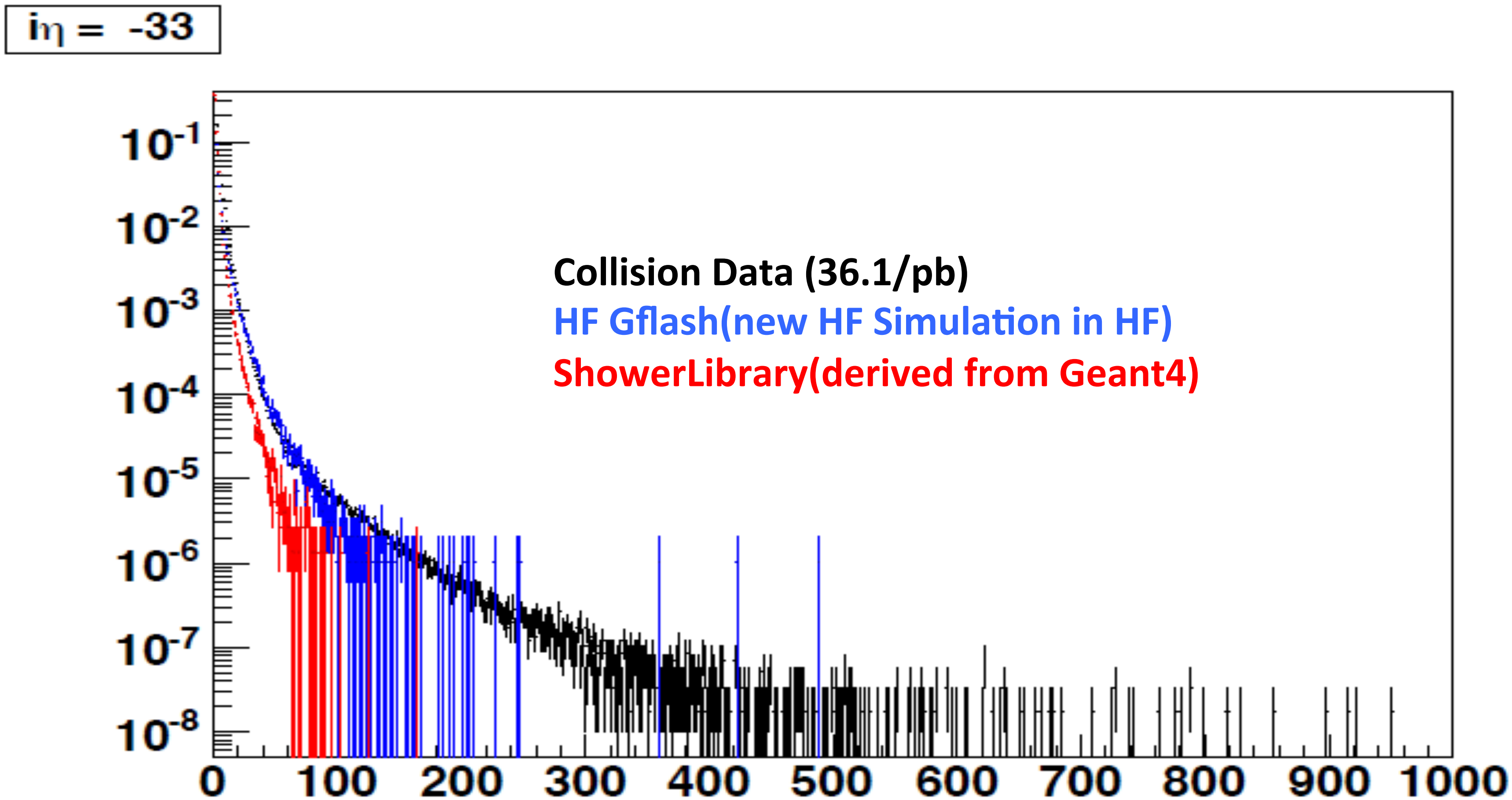
HF RecHit Energy at ieta tower=39



HF Gflash has better agreement to 36.1 pb-1 Collision Data compared to previous simulation

Comparison with 36.1/pb good Collision Data from CMS

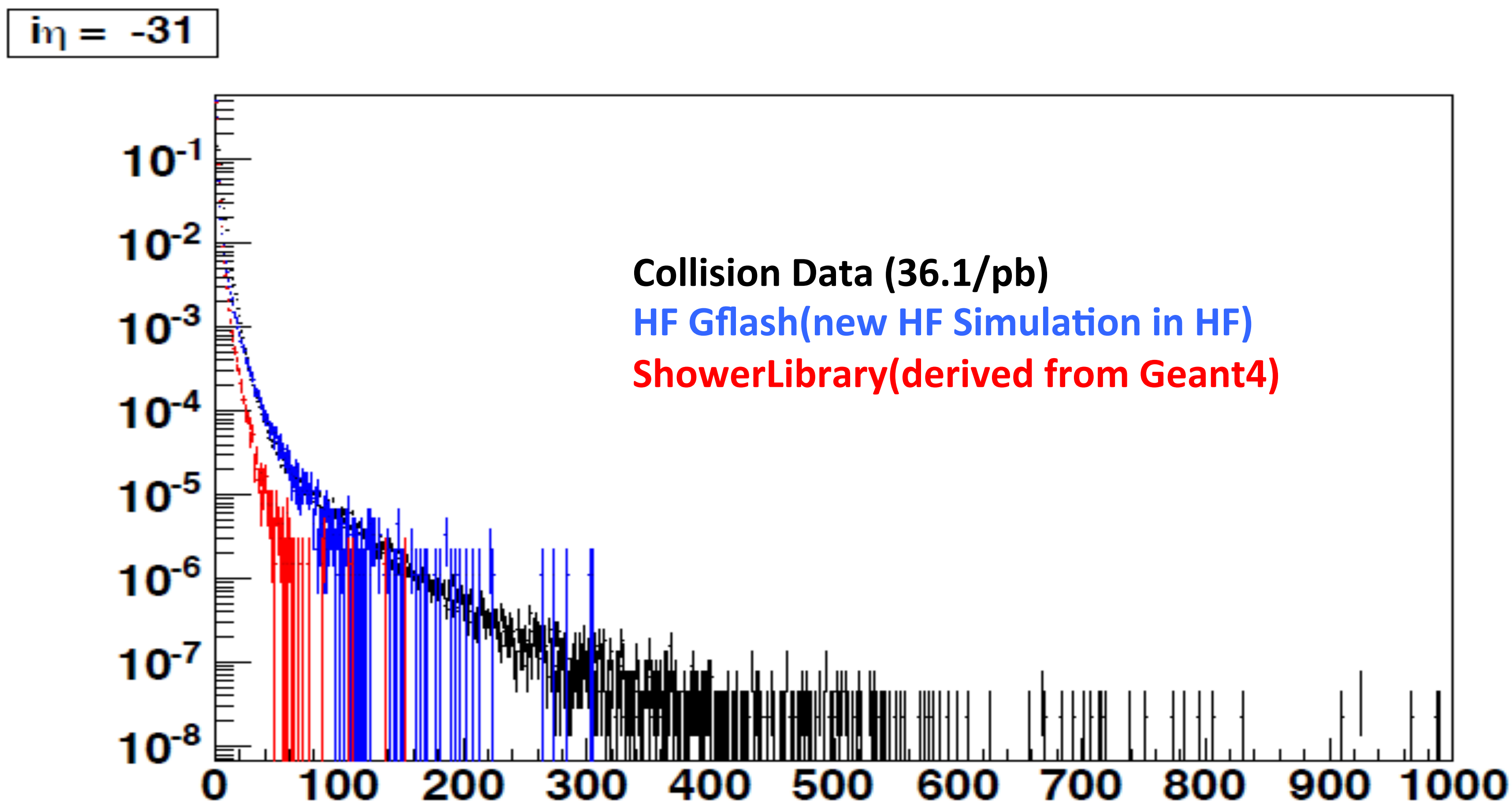
HF RecHit Energy at ieta tower= -33



HF Gflash has better agreement to Data compared to previous simulation

Comparison with 36.1/pb good Collision Data from CMS

HF RecHit Energy at ieta tower=-31



HF Gflash has better agreement to 36.1 pb-1 Certified Collision Data compared to previous simulation

HF Gflash Summary

We have tested HF Gflash against

1. Test Beam Data
2. Certified Collision Data
3. Shower Library (previous HF CMS Simulation)

We can show that

- HF Gflash has the ability to help Noises simulation
- HF Gflash has the ability to simulate very high energy particles
- HF Gflash has better agreement to Test Beam Data
- HF Gflash has good agreement to 36 pb^{-1} CMS Collision Data