GFLASH for ILC Calorimeter

CMS experience for ILC Simulation

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Outline

- Motivation & Introduction to Gflash
- Speed of Gflash
- Comparison to Test Beam Result
- Comparison to 7 TeV certified Collision Data
- Plan and Summary of Gflash for ILC Calorimeter

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 such as: H1, D0, CDF and CMS and ATLAS by now
- 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 in ILC HCAL/ECAL
- 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)

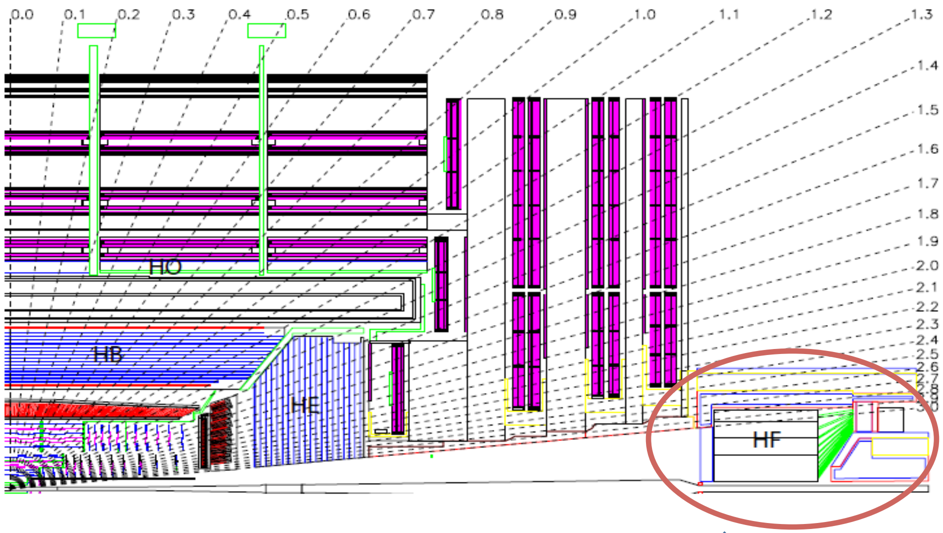
- The average longitudinal shower profile : (in units of radiation length)

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

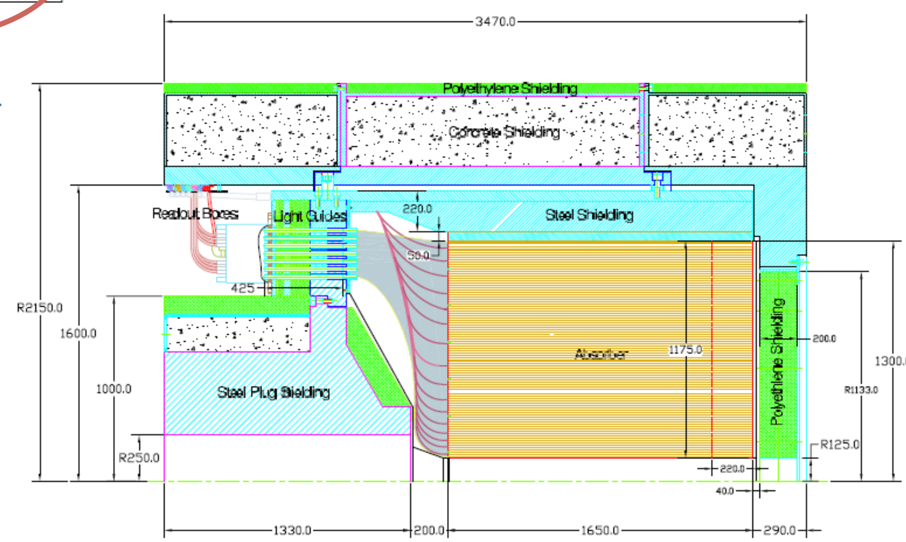
- The average radial energy profile : (in units of Moliere radius)

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

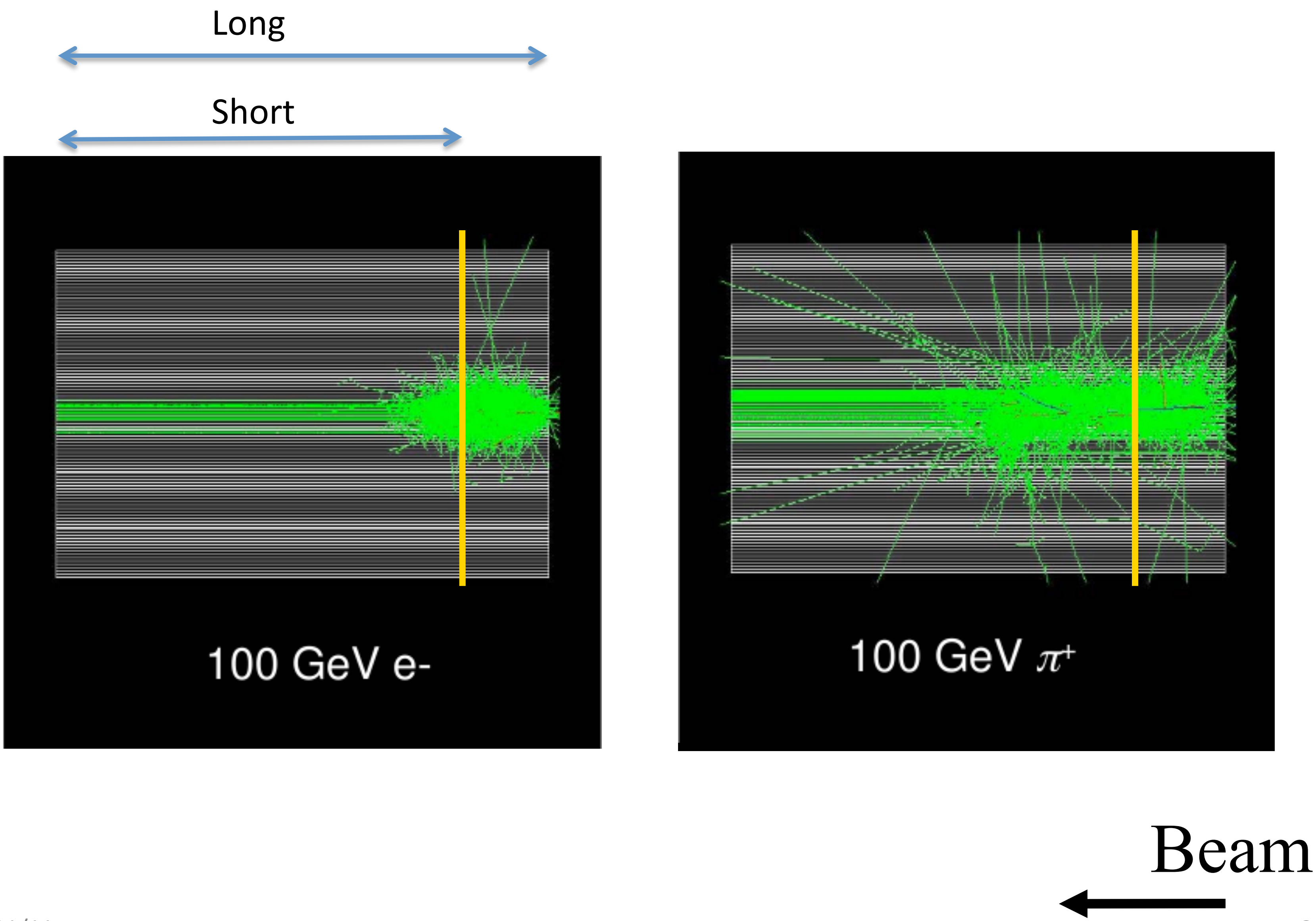
GFlash Application in CMS
Hadronic Forward Calorimeter(HF)



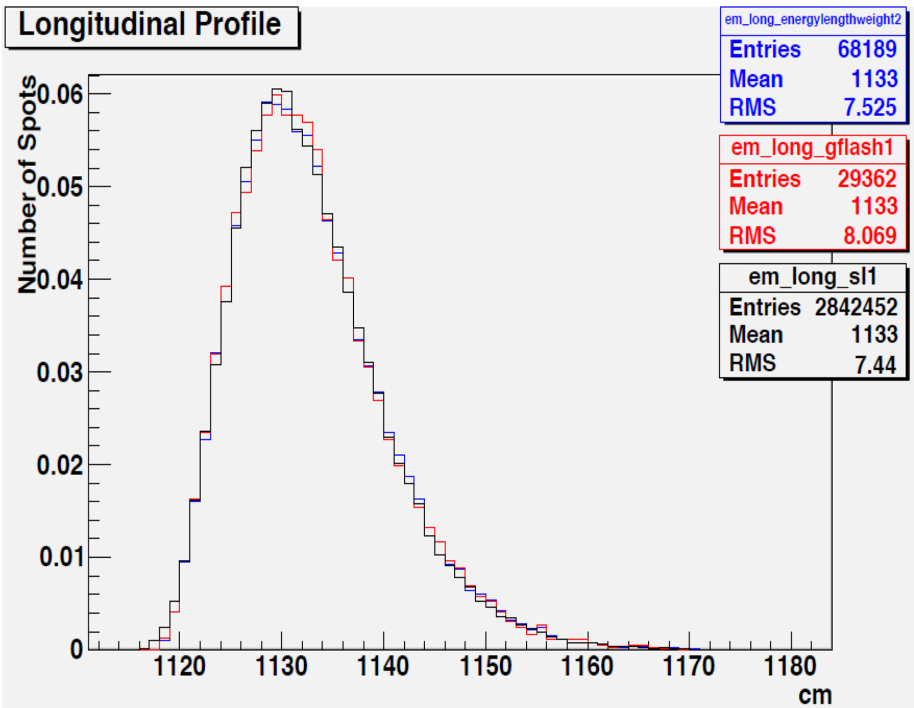
Hadronic Forward Calorimeter(HF) is placed about 11 m from interaction point and has 3 <|η|< 5. There is no other calorimeter in front of HF so that HF is a very good place to study Gflash.

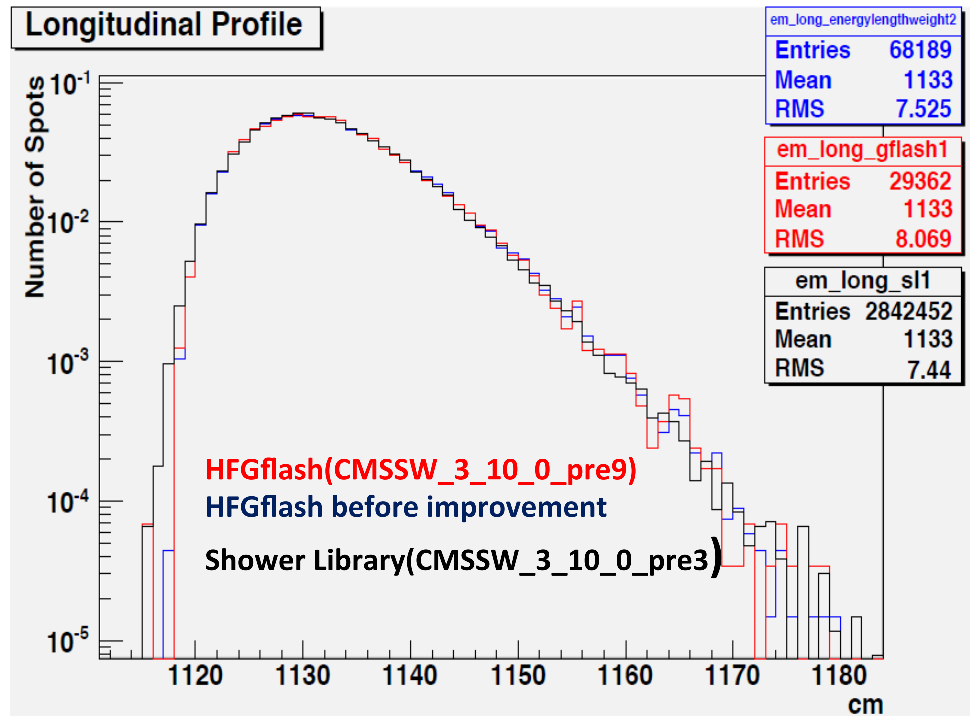


HF has **Long** and **Short** Fibers to differentiate shower from electromagnetic & hadronic particles



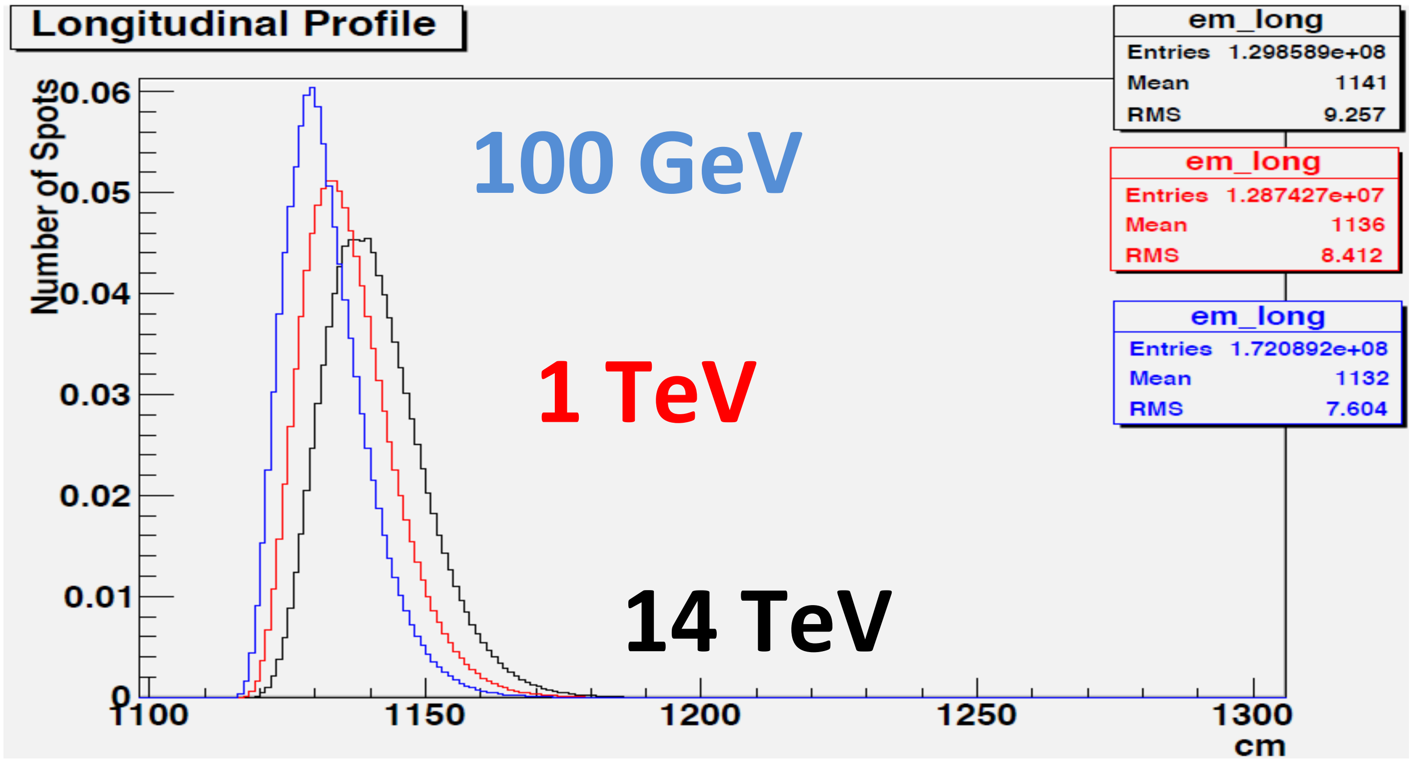
Current Agreement of Longitudinal Profile





Longitudinal profile produced by 100-GeV electron gun using HFGFlash, HFGFlash 2 and Shower Library(based on Geant4)

High Energy Longitudinal Profile



Geant4 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)

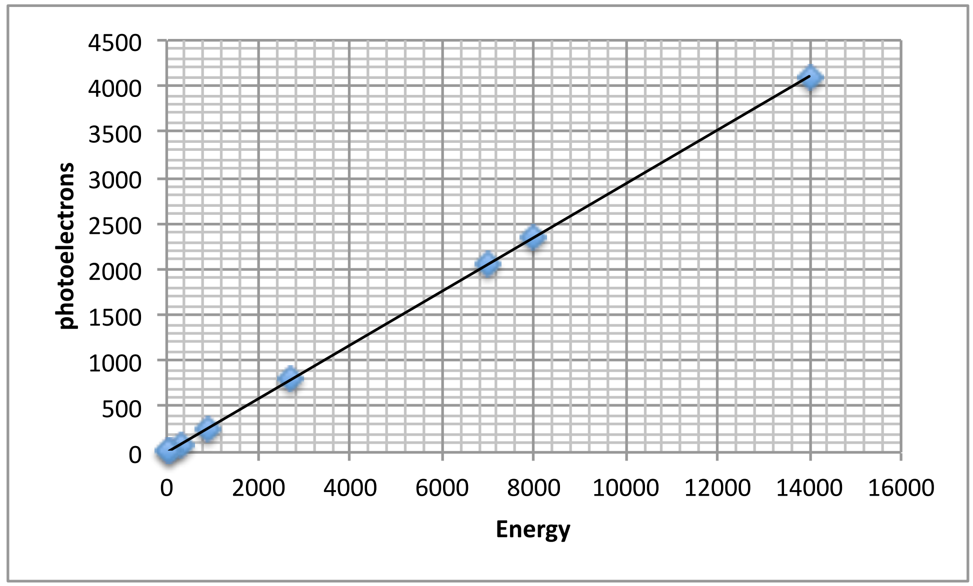
High Energy Test

- 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)

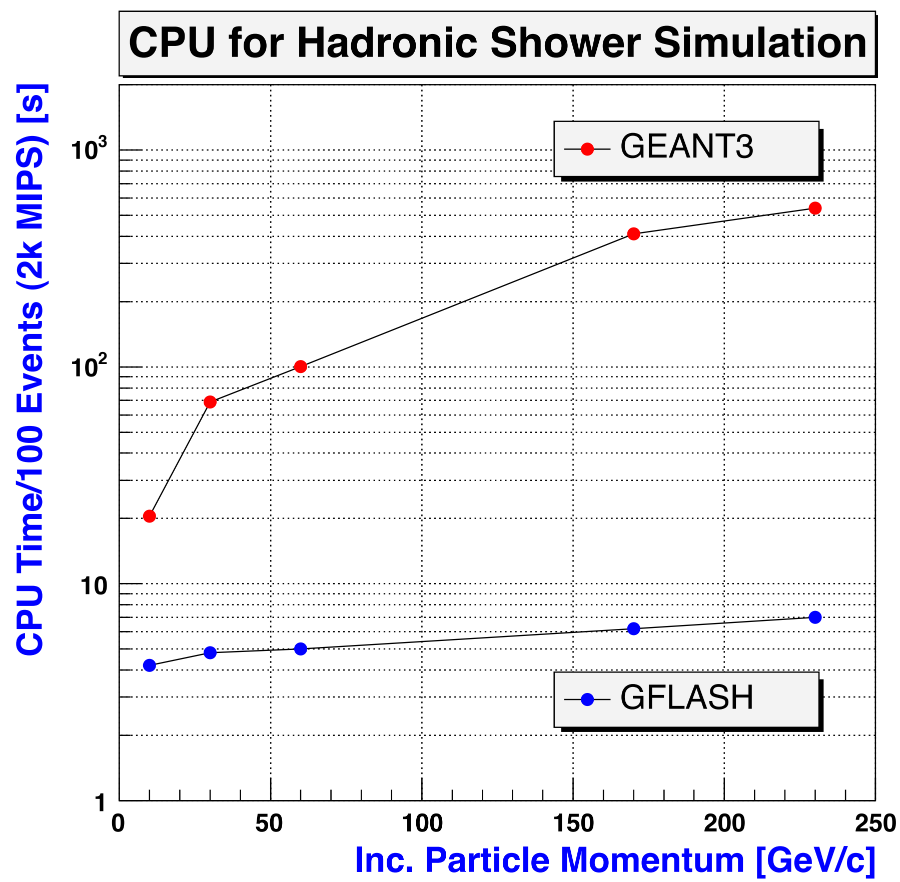
  Some results of High Energy Test

- 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

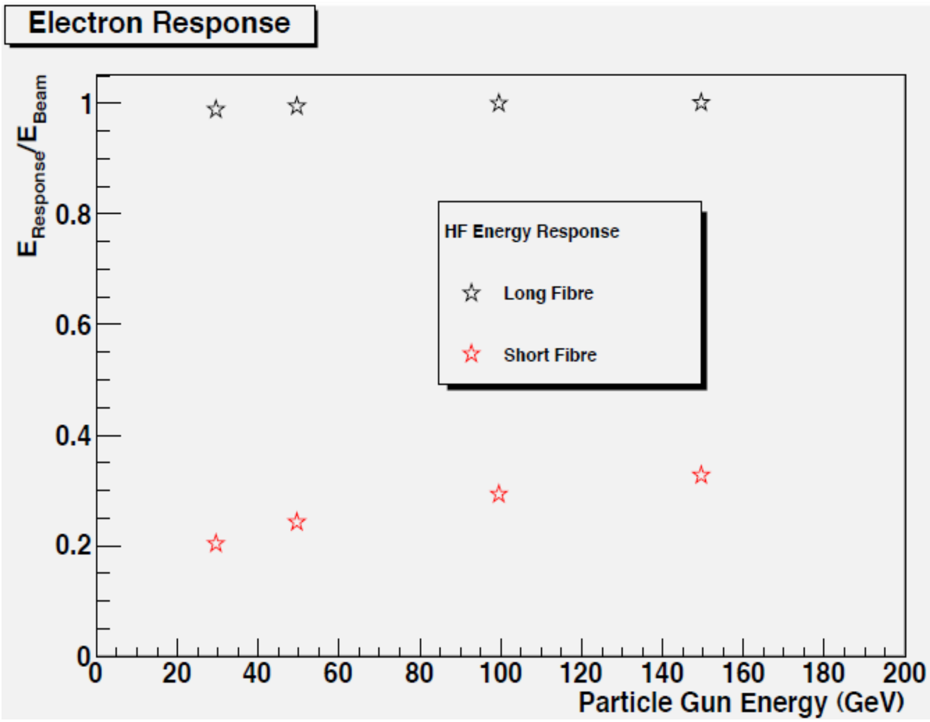


GFlash will save ILC computing time significantly

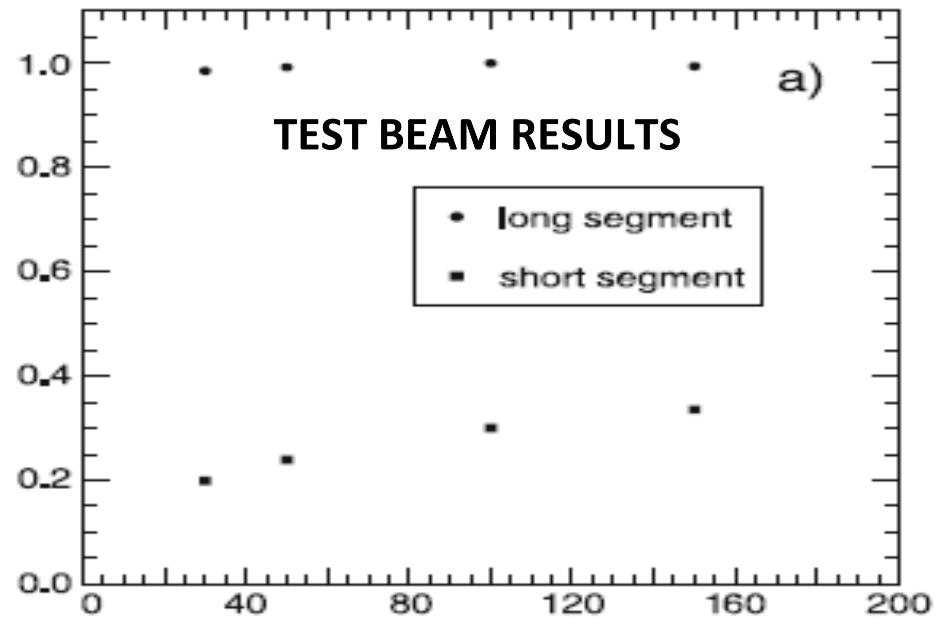
- G. Grindhammer, M. Rudowicz and S. Peters, *NIM* **A**290 (1990) 469-488
- H1 calorimeter for H1 at HERA
- Sophisticated, but fast
- Adapted for CDF calorimeter simulation at Tevatron Run–II
  - CPU gain up to 100 (CDF)
- Ideal for
  - simple geometry
  - repetitive sampling structure
  - single effective medium



Response of Electron gun



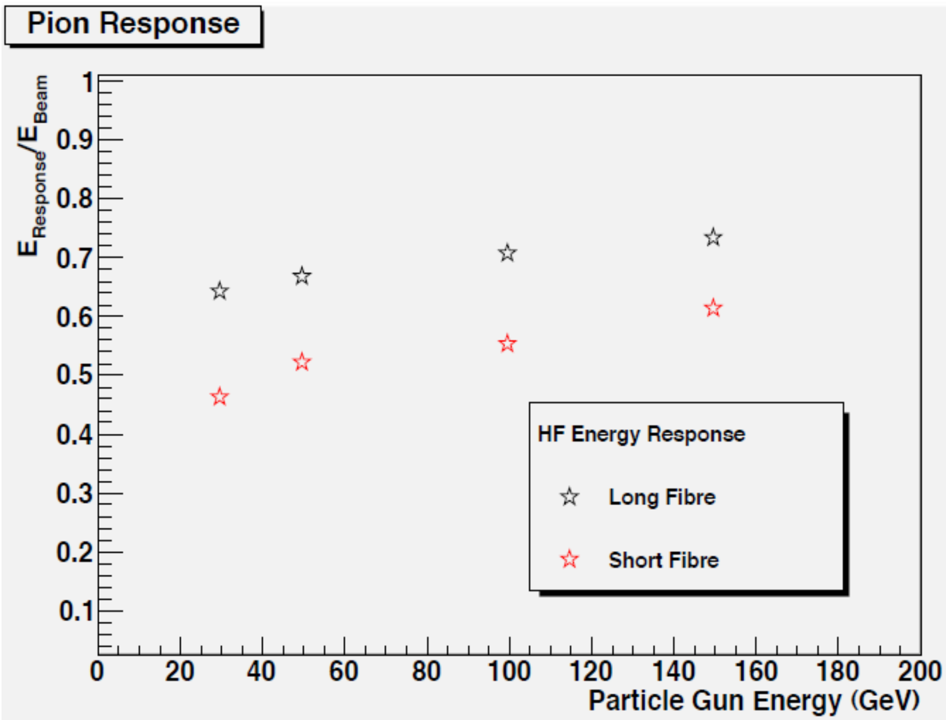
HFGflash(CMSSW_3_10_0_pre9)



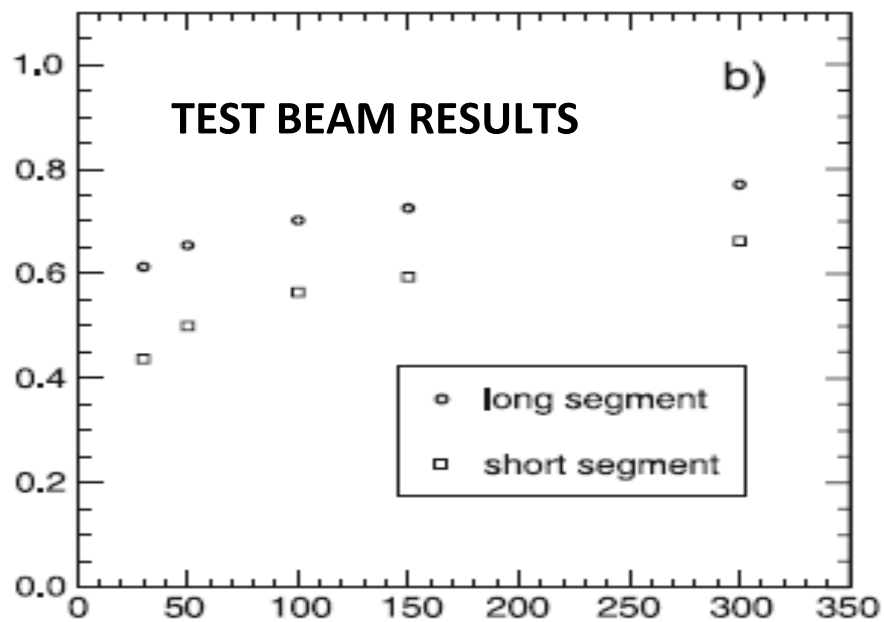
"Design, Performance, and Calibration of CMS Forward Calorimeter Wedges"
http://www.springerlink.com/content/f002u432m2453667/

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



HFGflash(CMSSW_3_10_0_pre9)



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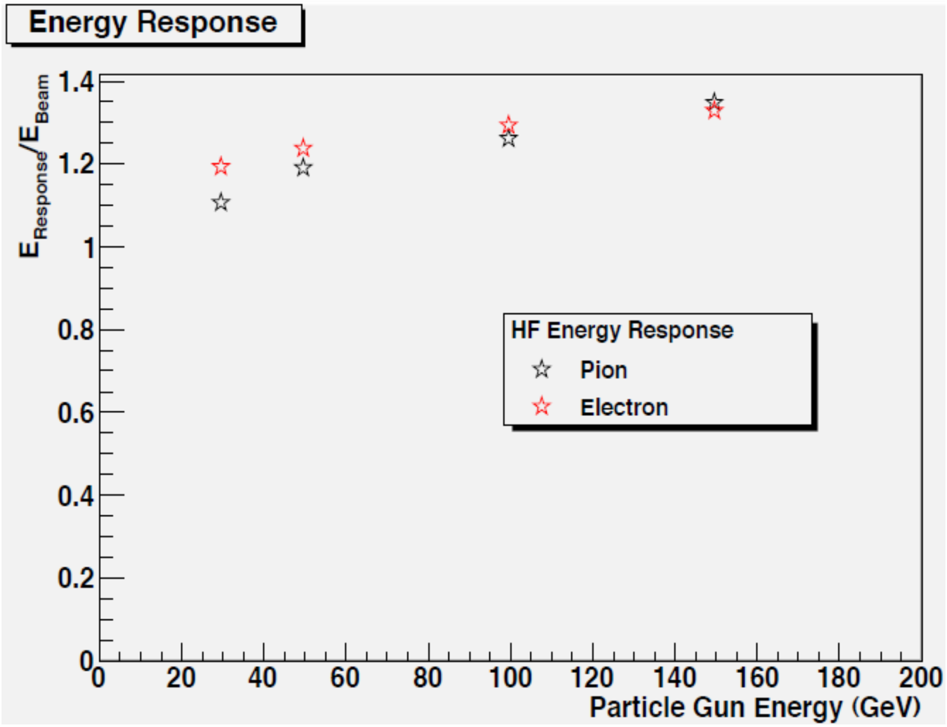
Comparison of HF Gflash and TEST BEAM RESULTS: The normalized response to pions (30, 50, 100 and 150 GeV). **HF Gflash has good agreement to Test Beam Data.**

Long+Short Energy Response



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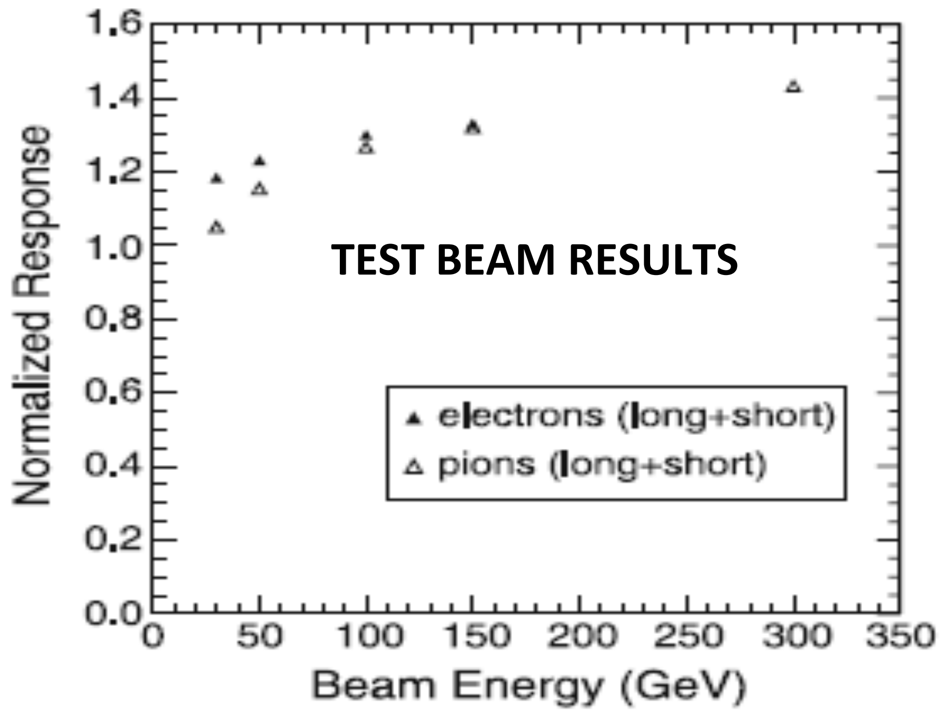

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Comparison of HF Gflash and TEST BEAM RESULTS: The normalized response to electrons and pions L+S(30, 50, 100 and 150 GeV). **HF Gflash has good agreement to Test Beam Data.**

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 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 Geant4

150 GeV Pions and Electrons

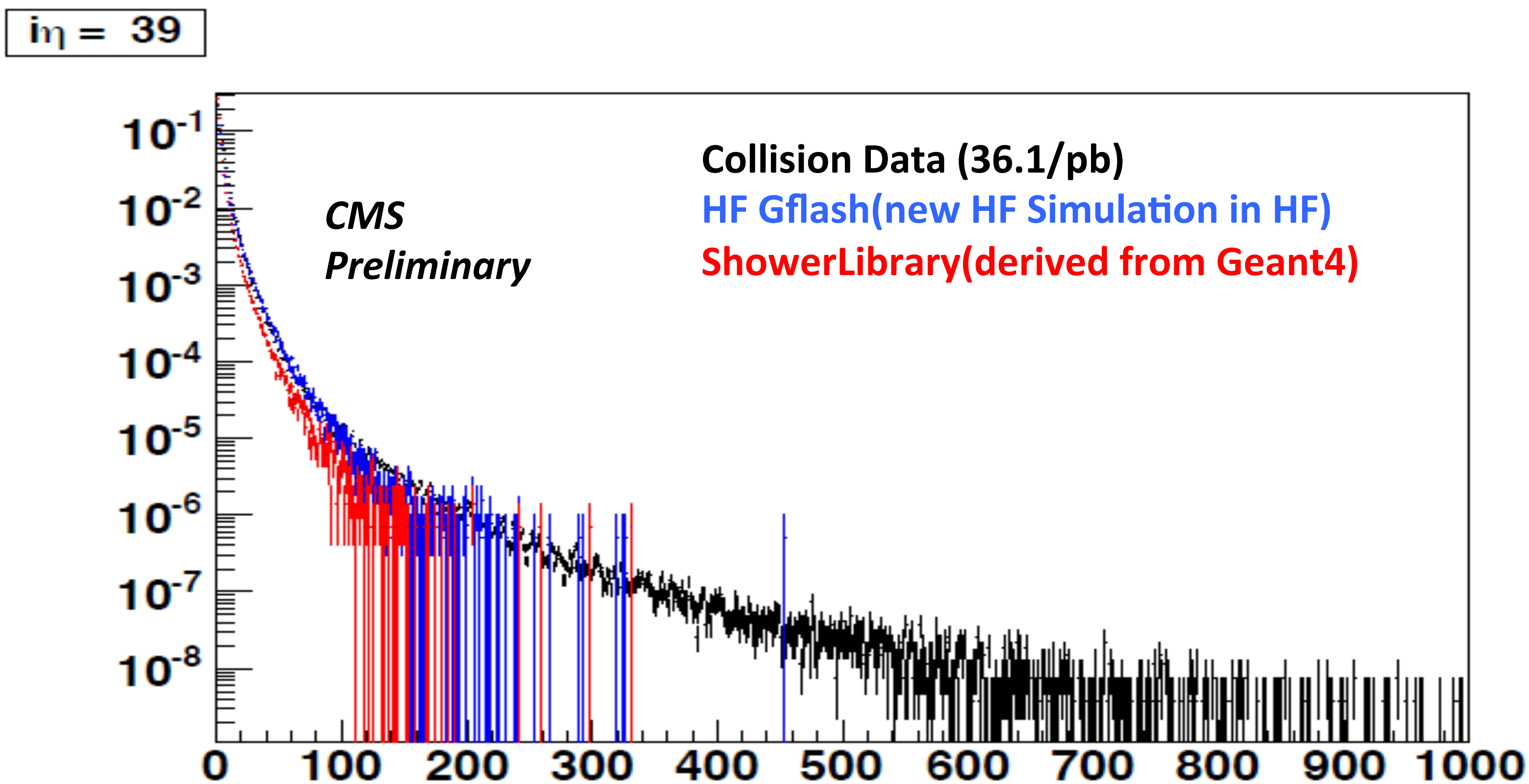
	HF GFlash	Test Beam	Shower Library (Geant4)
Se/Le	**0.33**	0.34	0.28
Lp/Le	**0.71**	0.73	0.70
Sp/Le	**0.59**	0.60	0.56
Sp/Lp	**0.83**	0.82	0.80

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 Geant4

Comparison with 36.1/pb good Collision Data from CMS

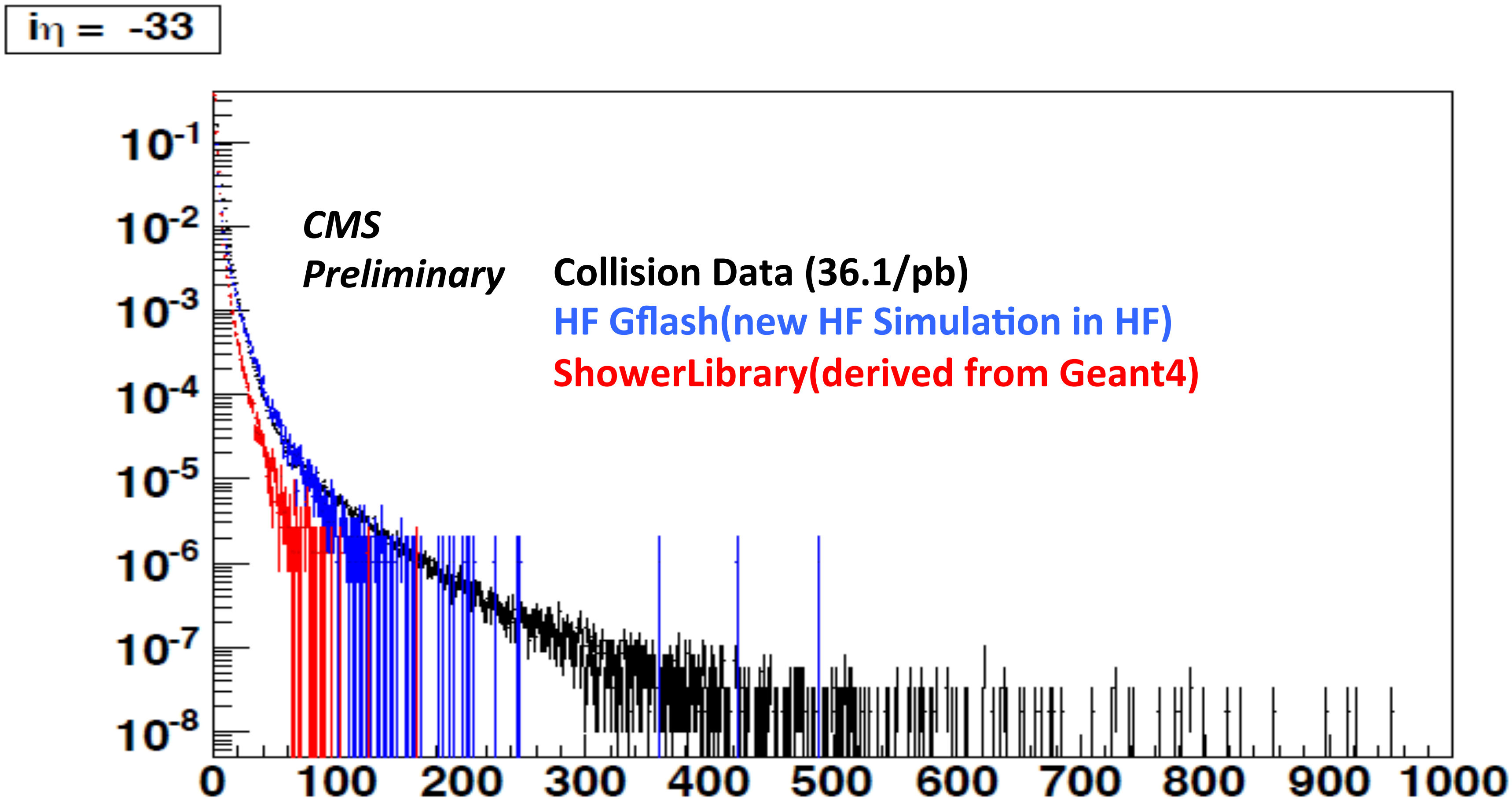
HF RecHit Energy at ieta=39



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

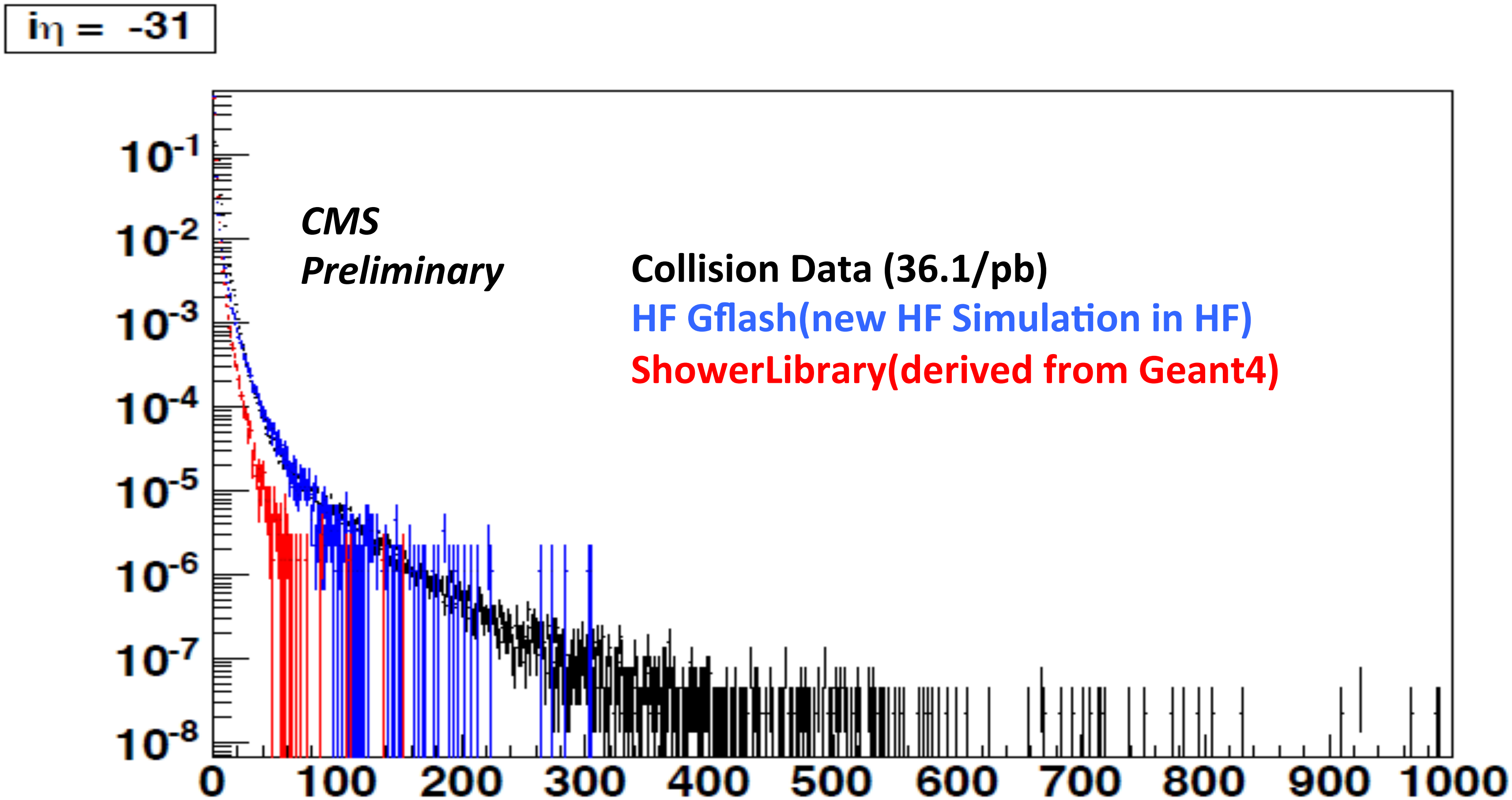
HF RecHit Energy at ieta= -33



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=-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)

- 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 better agreement 36.1 pb^{-1} CMS Collision Data

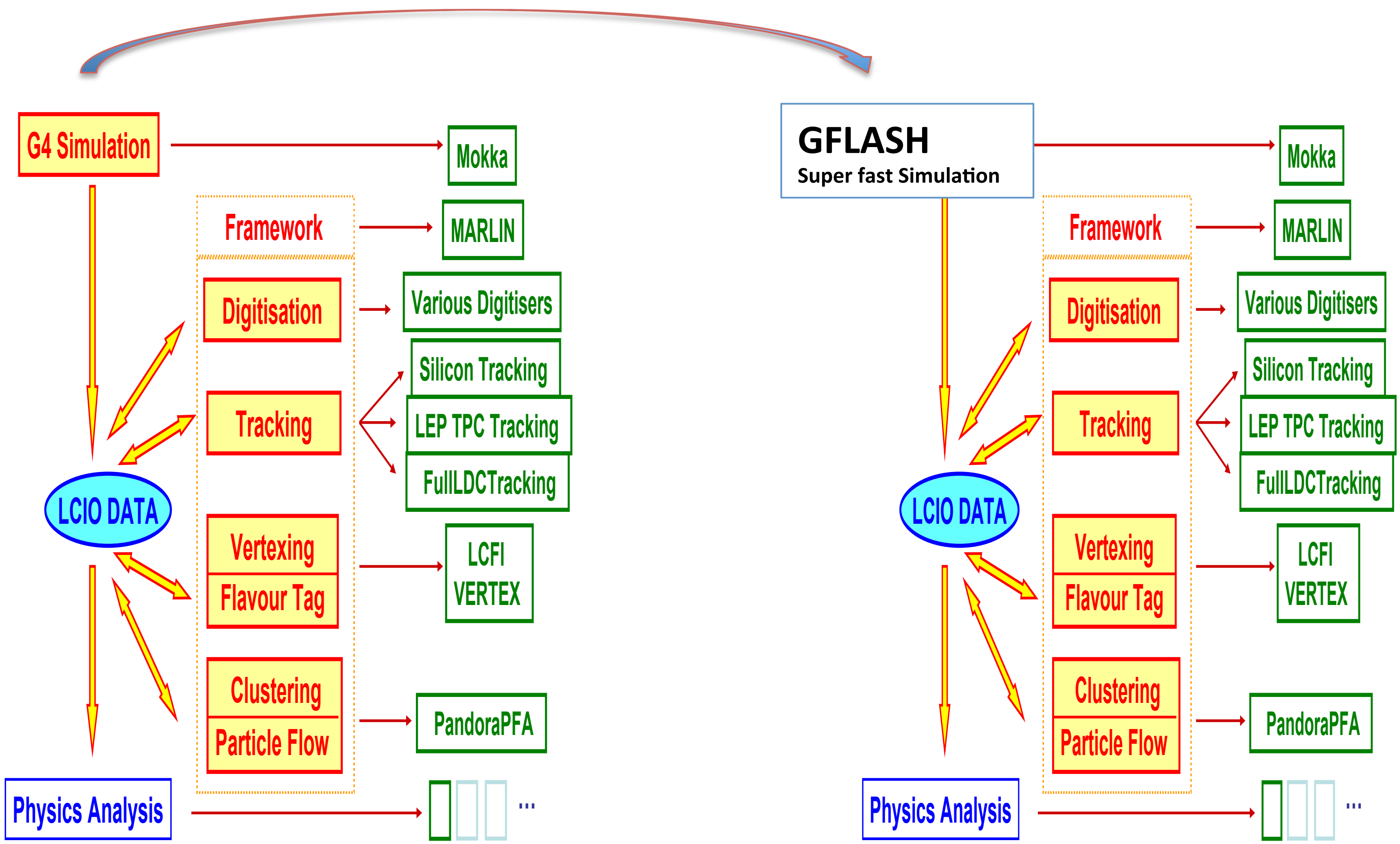
Plan for ILC

- We will try to use Gflash for ILC Calorimeter Simulation ECAL/HCAL
- If you use full Geant4, you will need days to simulate very high energy particles, fortunately Gflash has ability to simulate very high energy particles effectively and possibly better precision
- *Significant speed-up of simulation code. This could be crucial for ATLAS to make real MC production practical.*

  (excerpt: Sudong EPAC 06)

- Gflash will be able to to save computing time needed for simulation so that ILC can reduce the budget for computing and make ILC more compelling to funding agencies

Next Step



G4 Simulation
Mokka
Framework
MARLIN
Digitisation
Various Digitisers
Silicon Tracking
Tracking
LEP TPC Tracking
FullLDCTracking
LCIO DATA
Vertexing
Flavour Tag
LCFI
VERTEX
Clustering
Particle Flow
PandoraPFA
Physics Analysis
...
GFLASH
Super fast Simulation
Mokka
Framework
MARLIN
Digitisation
Various Digitisers
Silicon Tracking
Tracking
LEP TPC Tracking
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For more information: