

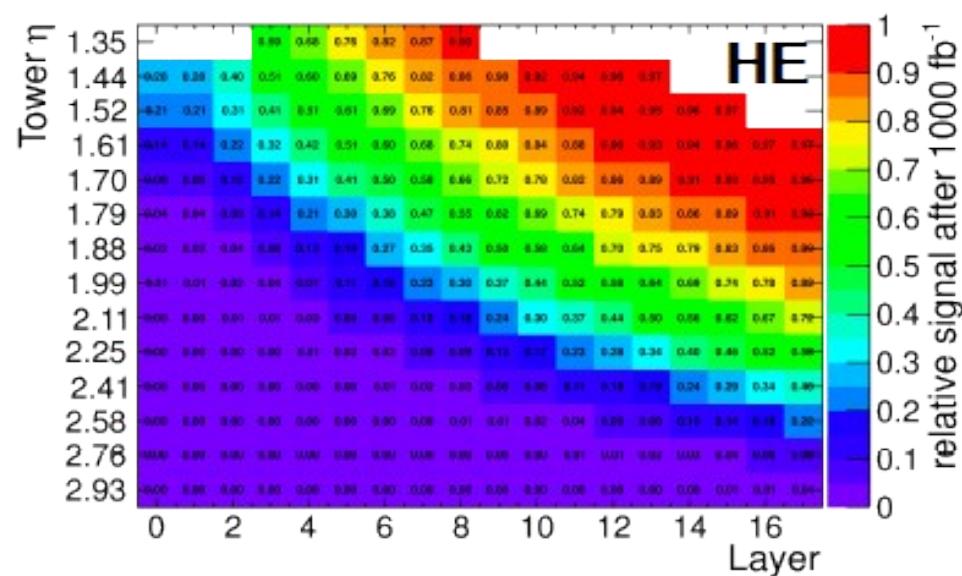
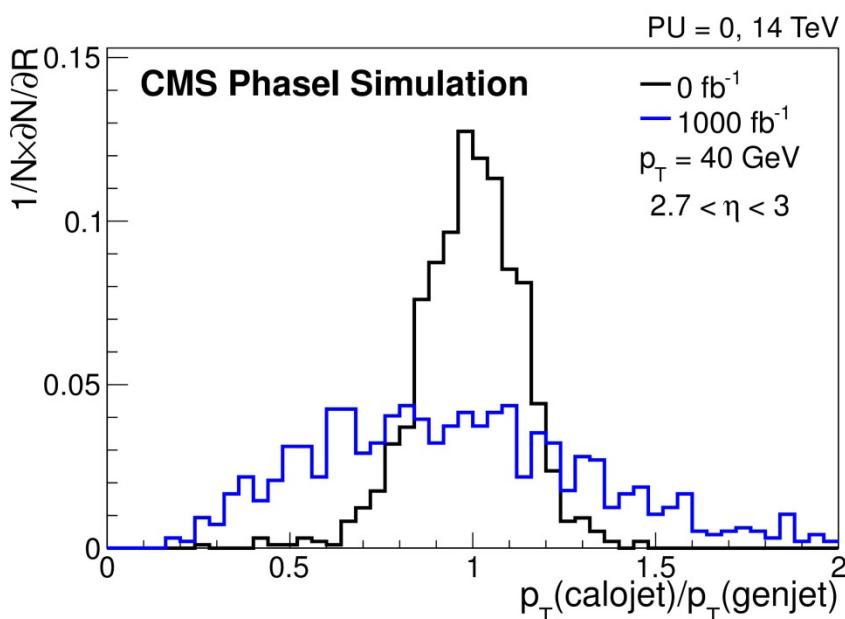
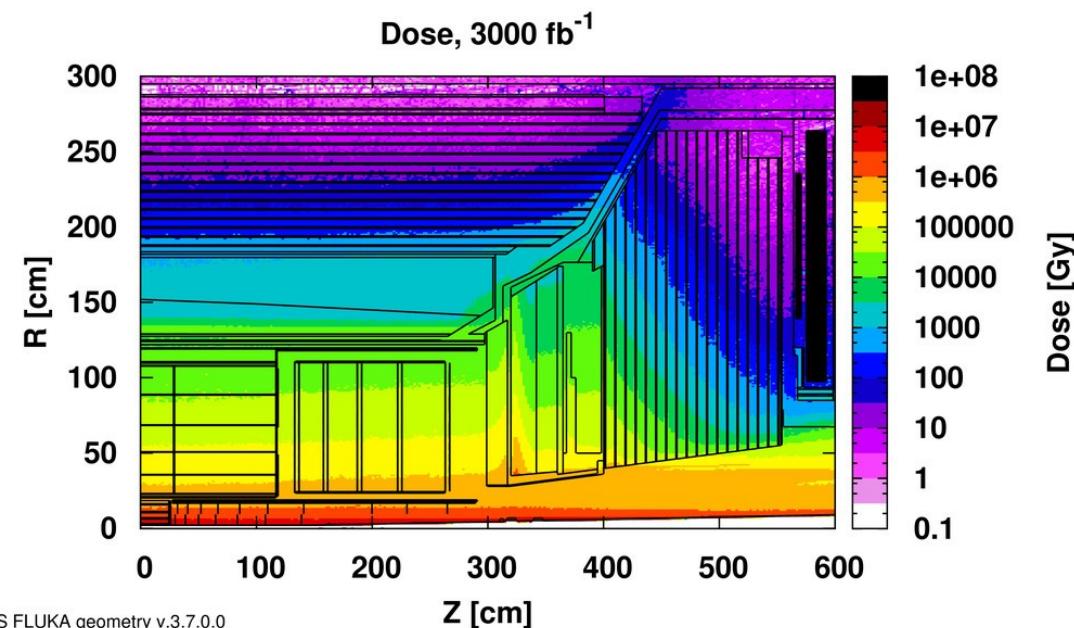
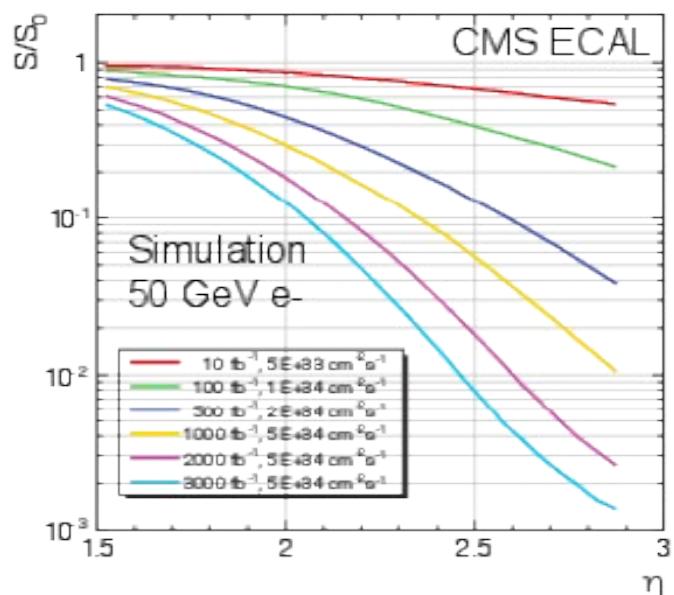


HL-LHC Calorimetry Techniques and Trends *A CMS Perspective*

Jeremiah Mans
June 8, 2015



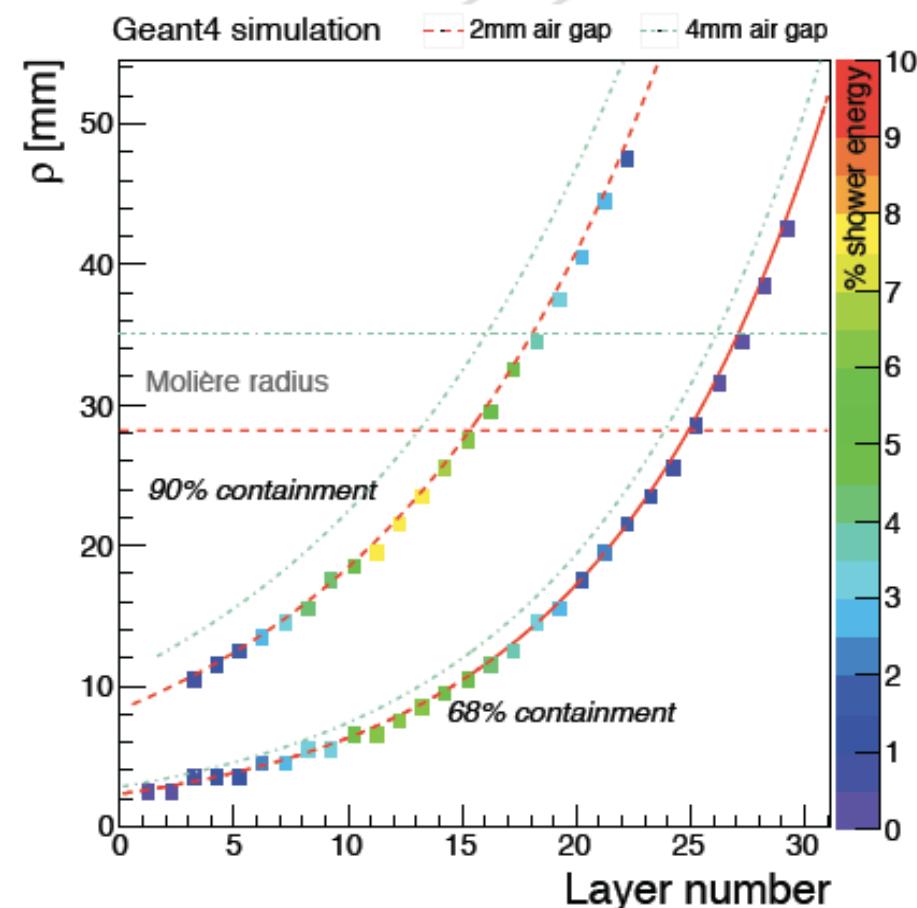
High Radiation/High Rate





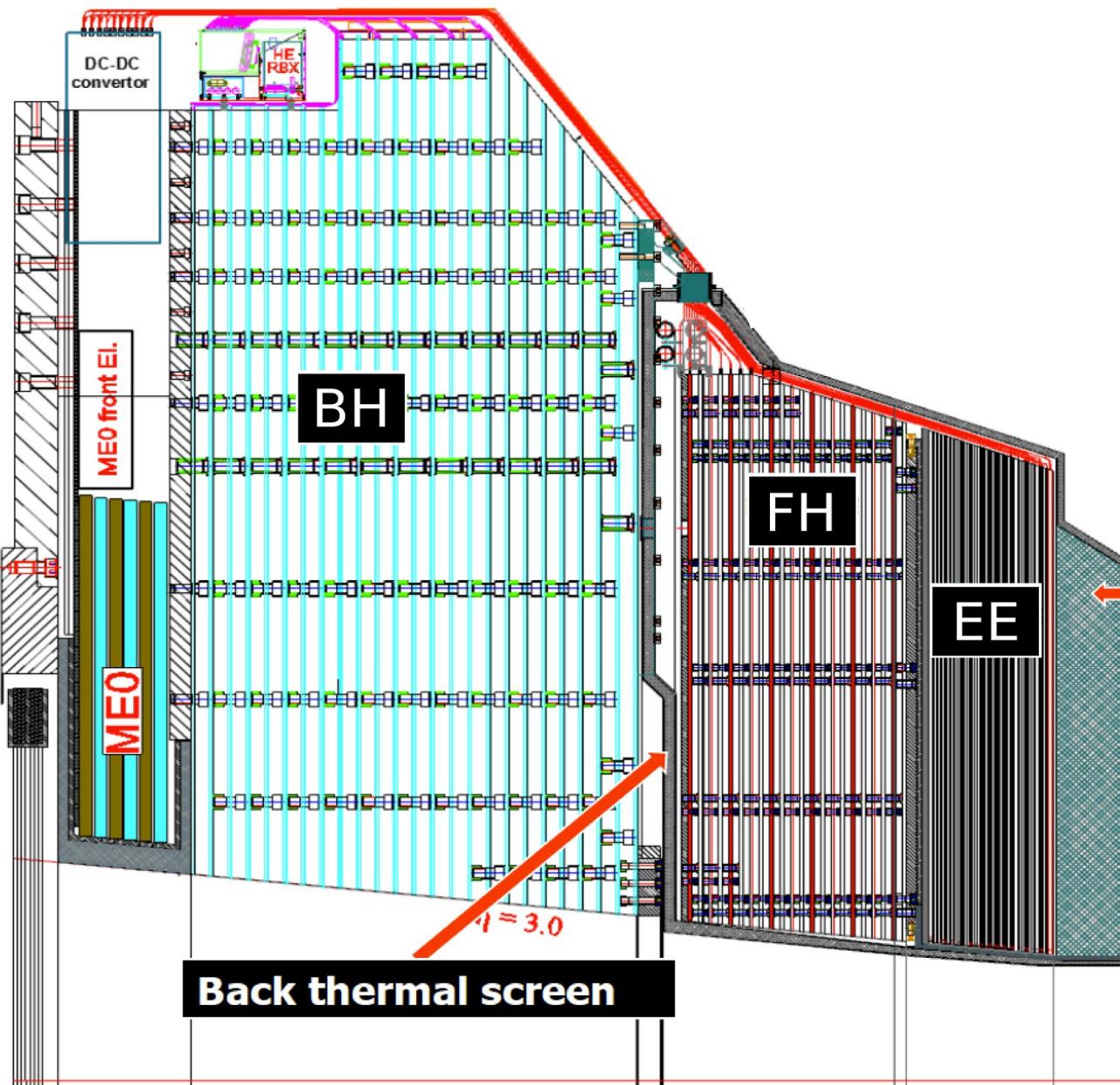
High Granularity Endcap Calorimeter

- Change from pure scintillator-based calorimetry in the endcap to silicon-based calorimetry backed with scintillators where the radiation doses are lower
- We understand how to make silicon take the very high radiation fluences required (10^{16} n/cm 2)
- Effective use of silicon in the HL-LHC environment requires small cells (1 cm 2 or 0.5 cm 2) and high depth segmentation
 - Provides a unique opportunity to manage pileup using very precise sampling of the showers





Detector Structure



- **EE**
 - 28 layers of silicon
 - Tungsten/copper absorber
- **FH**
 - 12 layers of silicon
 - Brass absorber
- **BH**
 - 12 layers of plastic scintillator
 - Brass absorber



Event Display



CMS Experiment at LHC, CERN
Data recorded: Thu Jan 1 01:00:00 1970 CEST
Run/Event: 1 / 101
Lumi section: 2

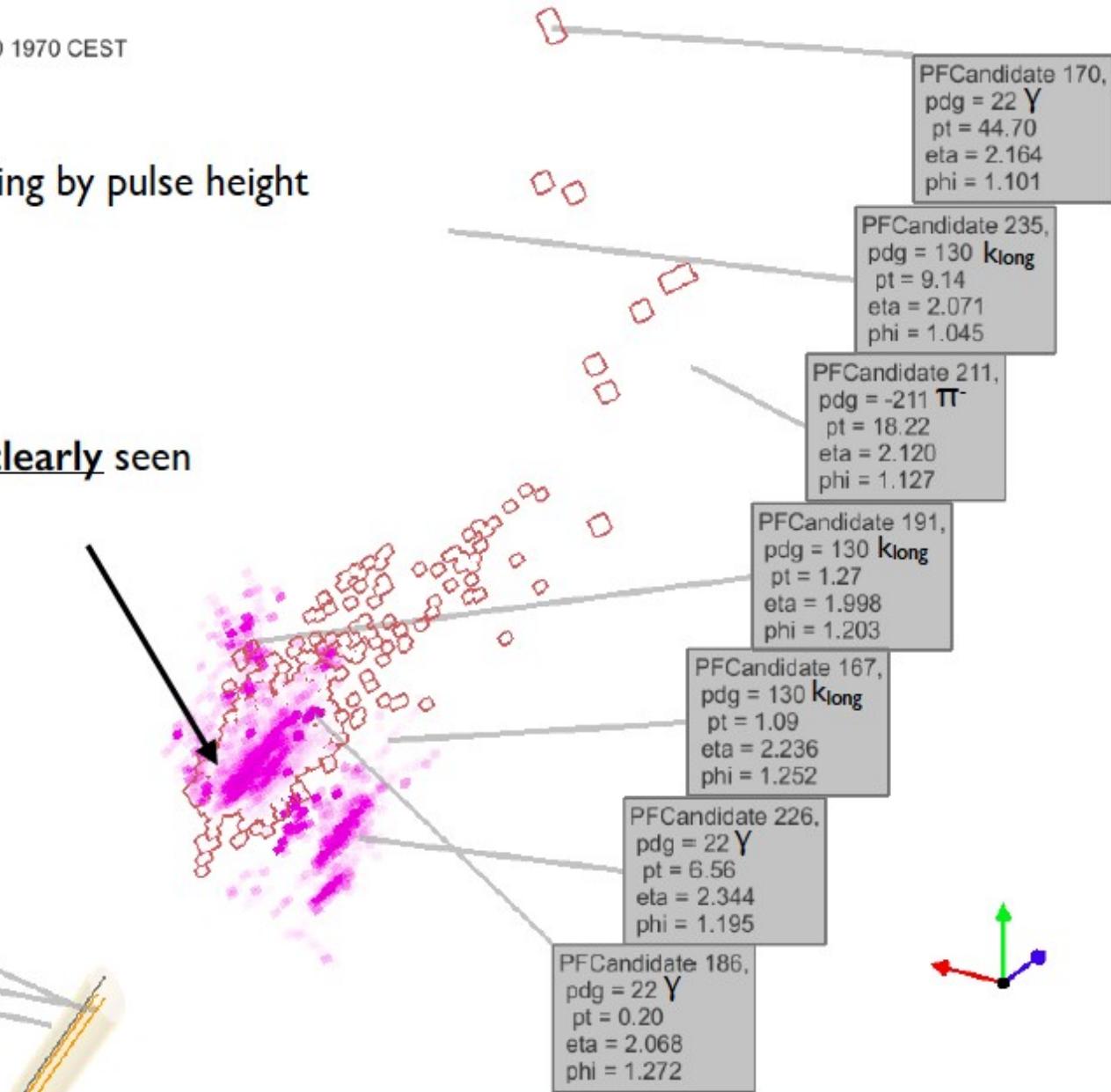
"x-ray" view of clusters with weighting by pulse height

Multiple narrow shower cores clearly seen

ak4GenJet 0,
et = 99.59
eta = 2.163
phi = 1.125

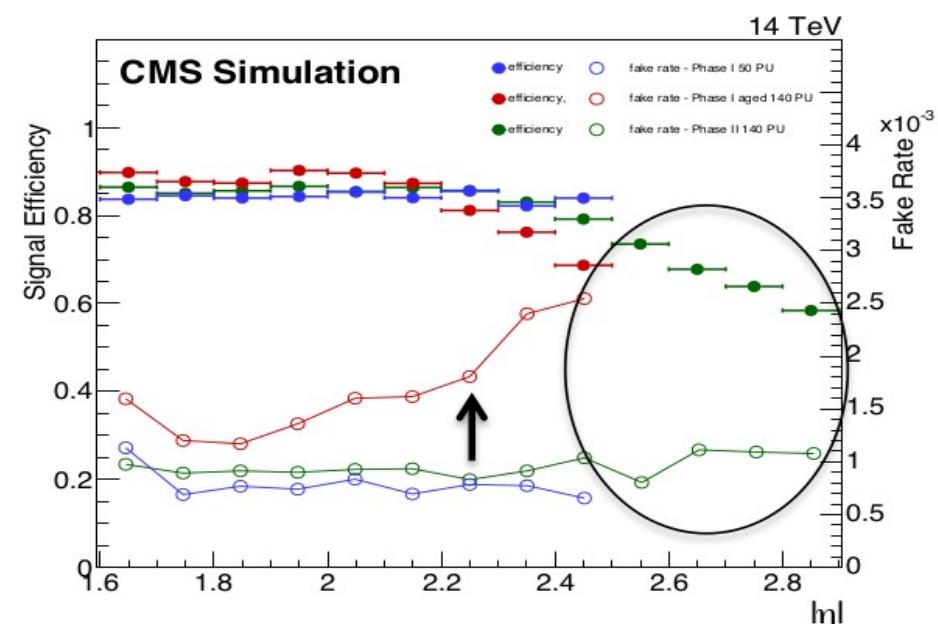
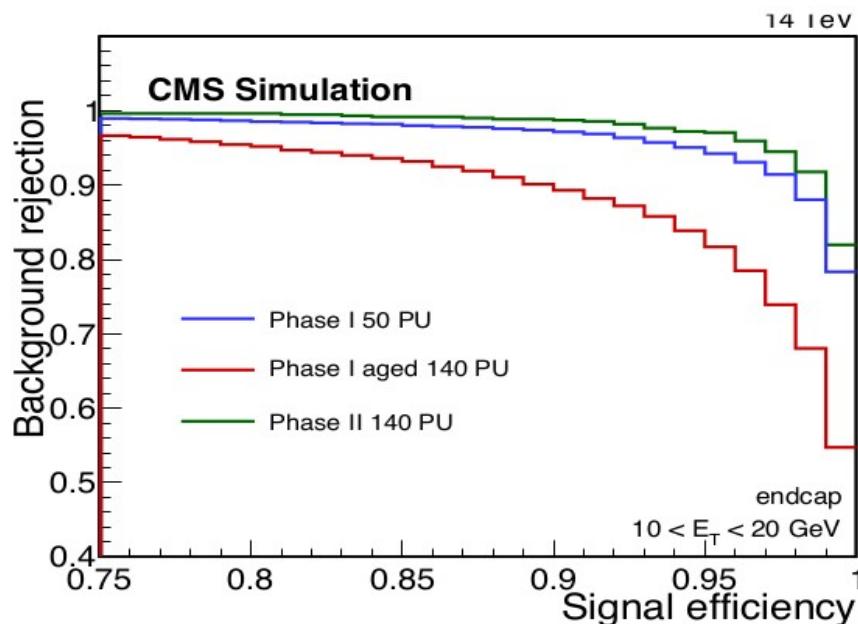
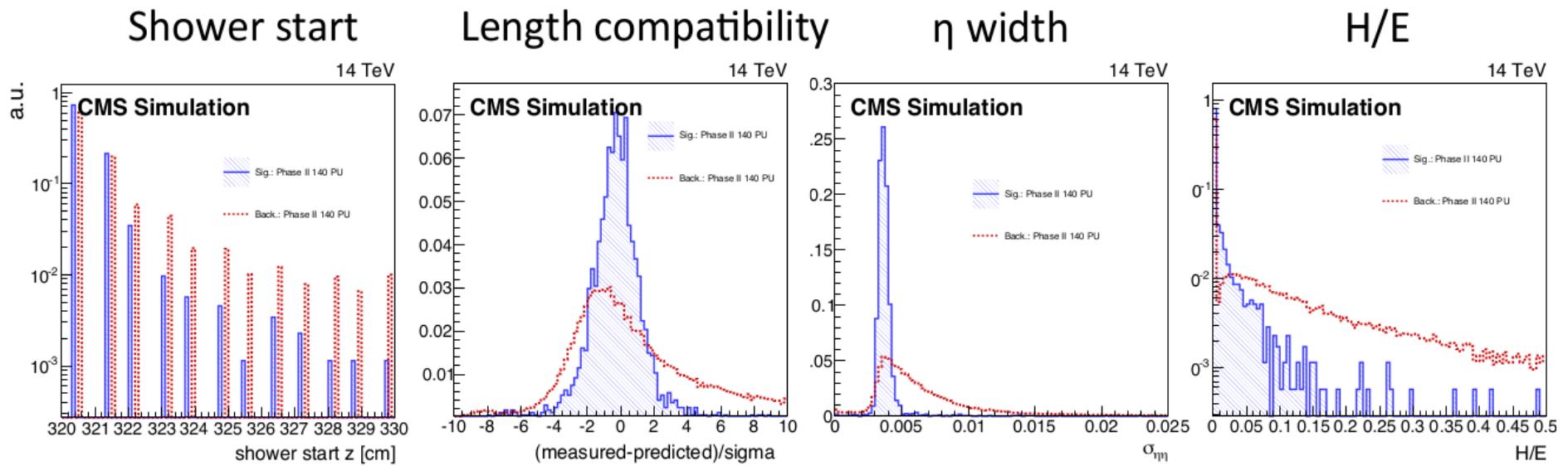
genParticle 15,
pdg = 2
pt = 70.51
eta = 2.143
phi = 1.113

genParticle 6,
pdg = 2
pt = 98.99
eta = 2.156
phi = 1.125





Initial results from electron id





Timing

- Another area of strong focus in HL-LHC calorimetry is the development of timing techniques to help suppress neutral pileup or even help with finite vertex resolution effects
 - New crystal EB electronics expected to have better than 100 ps cluster time resolution
 - HGCAL “Time Over Threshold” electronics should allow cluster time resolutions at the 40 ps level
 - R&D ongoing for possible “pre-shower” MIP-capable timing detector
- Exciting technique, particularly for any extended-lifetime heavy states and for photon analyses at high luminosity
- Exact mode of operation depends on mechanics of HL-LHC beam crossing





What does it mean for physics?

- VBF-type topologies
 - Narrow jets very well-resolved down to low pT in moderate forward region ($1.5 < |\eta| < 3.0$)
 - Higgs (including H invisible), vector boson scattering
- Exotic remnants
 - Very detailed shower structures available for displaced decays or decay-in-detector
- Timing
 - Photon association with jets/vertex at high pileup
 - Long-lived states