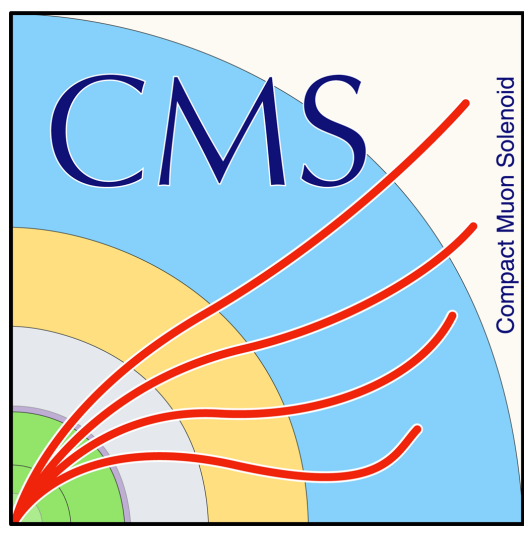


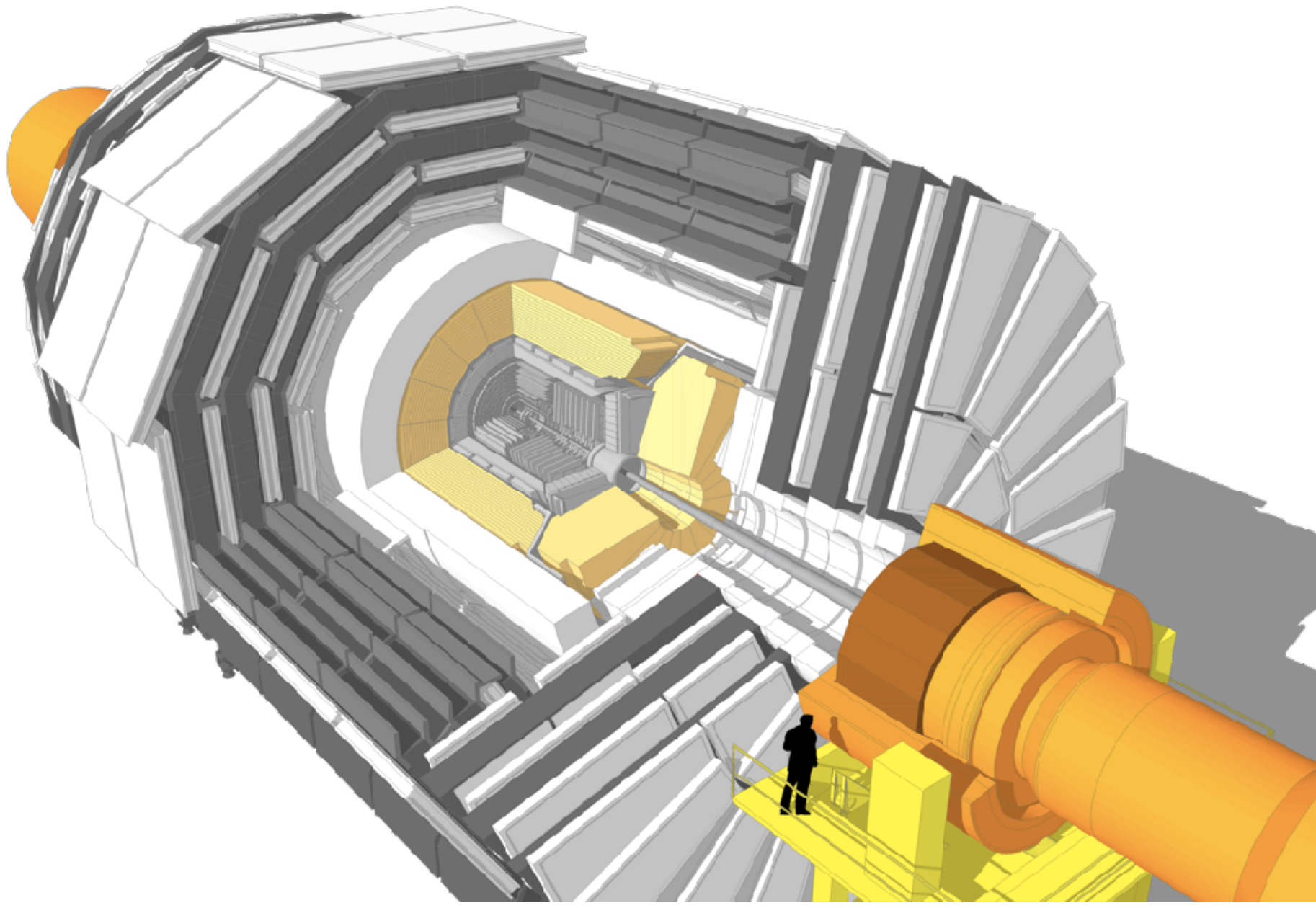
First results from SiPM+QIE11 readout in CMS for pp collisions



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Hadronic Calorimeter Upgrade



The CMS detector. Hadronic calorimeters are highlighted, with barrel and endcap in yellow, forward in orange.

The CMS hadronic endcap (HE) is a sampling calorimeter with alternating layers of brass absorber and plastic scintillator tiles. The scintillation light is collected by wave-length shifting fibers, and in the original detector fed onto hybrid photodiodes (HPDs), and read out by Charge Integrator and Encoder 8 (QIE8) cards.

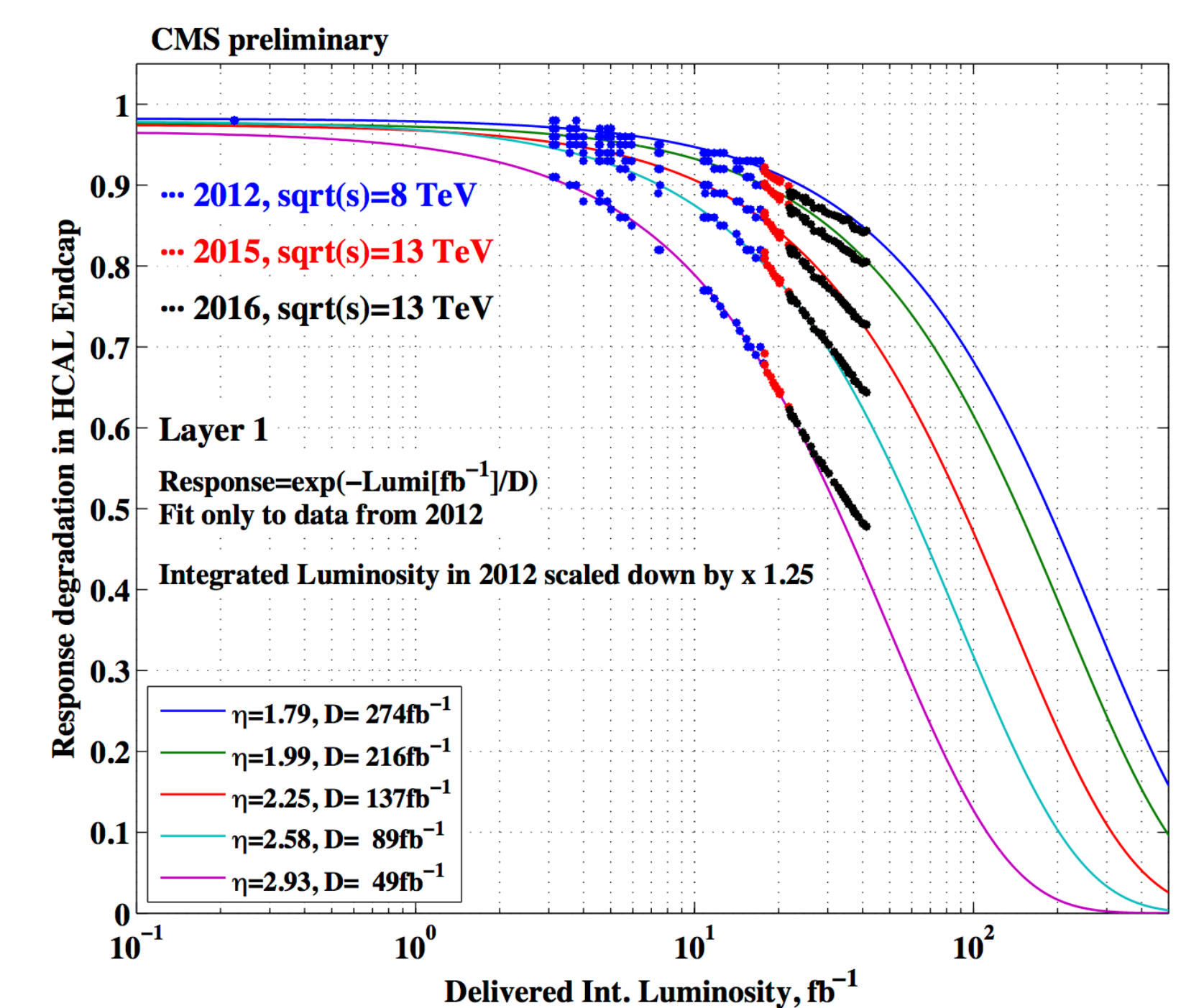
During the 2016-2017 year-end technical stop, one readout box (HEP17) was upgraded to use silicon photomultipliers (SiPM) and QIE11. The full endcap is being upgraded over the 2017-2018 YETS, with the barrel following in LS2.

Upgrade Motivation

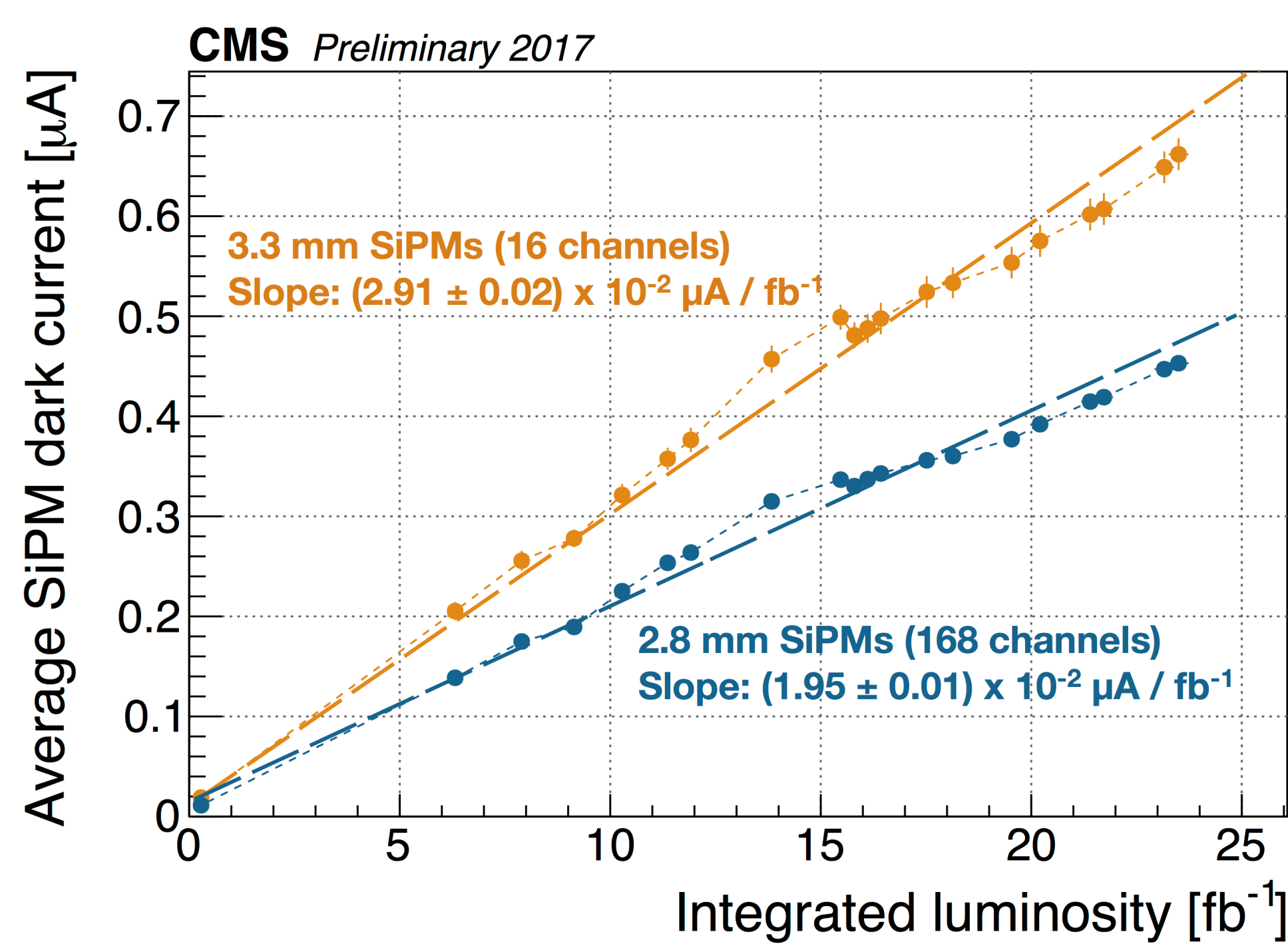
As the plastic scintillator accumulates radiation damage, the energy response decreases. This signal loss is monitored with a laser system for layer 1 (right) and layer 7.

The SiPMs mitigate this signal loss with three times higher photon detection efficiency. They also remove the high-amplitude noise and response drifts of the HPDs themselves.

The QIE11 chips have a nonlinear 8-bit ADC with 17-bit dynamic range and (new!) embedded TDC with 500 ps resolution.

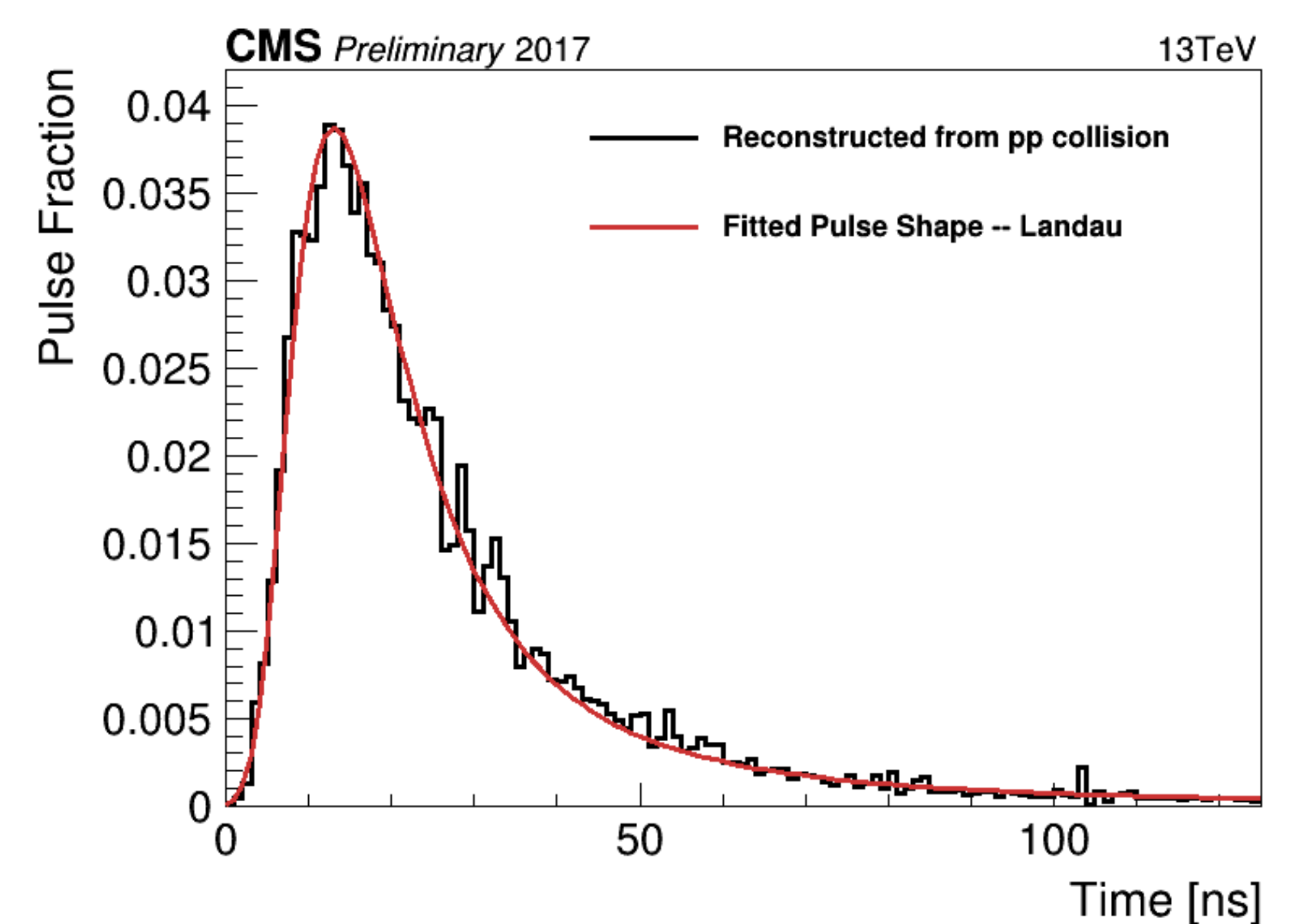


SiPM+QIE11 Performance



(left) SiPM dark current as a function of integrated luminosity exposure. Deviations from linearity from recovery in absence of beam and variations in instantaneous luminosity.

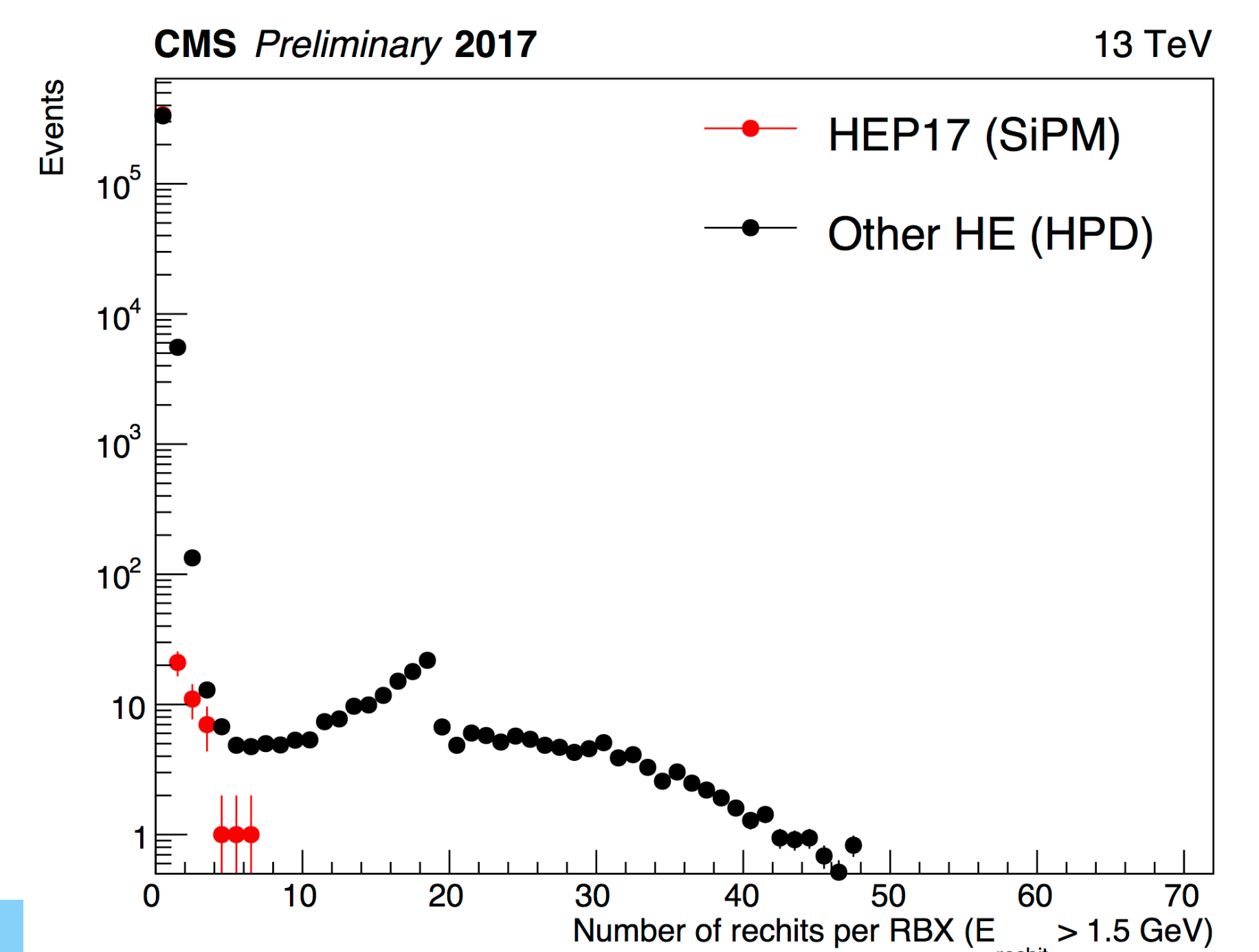
(right) In situ pulse shape measurement for complete signal readout chain (plastic scintillator, wave-length shifting fiber, SiPM, and QIE11).



Selected measurements of SiPM characteristics with 2017 data:

- SiPM dark current with integrated luminosity exposure, observe linear correlation (top left).
- In situ signal pulse shape measurement, exploiting TDC information from QIE11 readout (top right).
- Greatly reduced high-energy noise readout noise (right).

HEP17 performed as expected during 2017, and pilot installation experience has been invaluable for on-going full upgrade of HE.



HE energy distribution during cosmic running. HPD (black) exhibit two types of noise absent in HEP17 (red).

References

Measurement of Radiation Damage of HCAL Endcap Calorimeter (HE) using Laser data collected in Run1 (2012 data, sqrt(s) = 8 TeV) and in Run2 (2015, 2016 data, sqrt(s) = 13 TeV). CMS Collaboration. CERN-CMS-DP-2016-052. <https://cds.cern.ch/record/2203095>

HF and HEP17: phase1 upgrade performances. CMS Collaboration. CERN-CMS-DP-2017-042. <http://cds.cern.ch/record/2288359>