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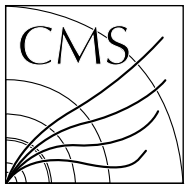

The Compact Muon Solenoid Experiment

CMS Performance Note

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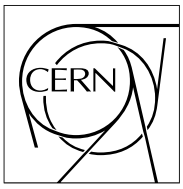

15 July 2024

Studies of ECAL Timing Reconstruction

CMS Collaboration

Abstract

Studies of ECAL Timing Reconstruction.

Studies of ECAL Timing Reconstruction

The CMS Collaboration

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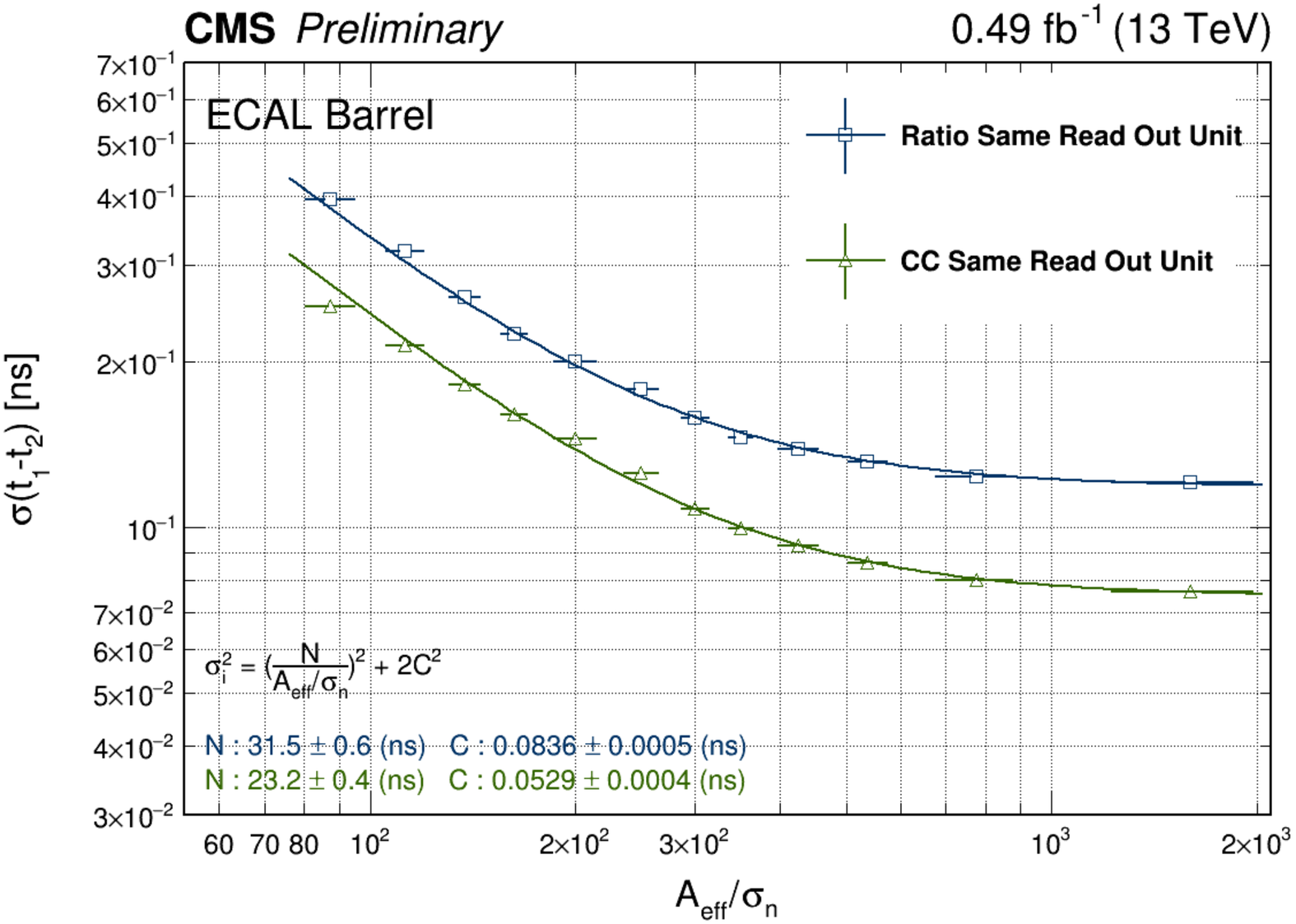
CC vs Ratio Time Resolution Comparison in Run 2



CC vs Ratio Time Resolution Comparison in Run 2 - Caption

Optimized time resolution for signals reconstructed in the ECAL barrel, with the time measured using either the Cross Correlation (CC) or the Ratio algorithm [1] for comparison of the two methods. The resolution is evaluated for signals reconstructed from the interactions of a single particle within the same readout unit with data from proton-proton collisions recorded in 2018 with electron and photon triggers.

The Cross Correlation algorithm mitigates the impact of multiple overlapping signals in the time reconstruction by subtracting the “out-of-time” signals out of the measured signal to recover the desired “in-time” signal. The “in-time” signal is then compared to the expected pulse shape using a cross correlation fit to reconstruct the time of arrival for the “in-time” pulse.

The time resolution is determined from the width of the difference in the reconstructed time of two signals that should have been detected in the ECAL simultaneously that is plotted as a function of the normalized geometric amplitude of those two signals (effective amplitude). Signals from two adjacent crystals in the same readout unit originating from a single particle are considered. The reconstructed time difference in each bin of effective amplitude is fitted with a Gaussian function. The sigma of this fit as a function of the effective amplitude is fitted to the following equation.

$$\sigma_i^2 = (\frac{N}{A_{eff}/\sigma_n})^2 + 2C^2$$

Here A_{eff}/σ_n is the effective amplitude, N is the noise term, and C is the constant term. The constant term in the equation is the time resolution.

An external calibration based on the average time of all reconstructed signals, channel by channel, is applied in order to make direct comparison of Ratio and CC time reconstructions. This calibration is derived from the same dataset as the resolution is calculated and results in an optimized resolution specific to a particular data taking period.

[1] “Time reconstruction and performance of the cms electromagnetic calorimeter,” Journal of Instrumentation, vol. 5, no. 03, T03011–T03011, Mar. 2010, ISSN: 1748-0221. DOI: 10.1088/1748- 0221/5/03/t03011. [Online]. Available: http://dx.doi.org/10.1088/1748-0221/5/03/T03011