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NA64 Experiment: Pile-Up Study

Rocio Carrera[1,2], Orlando Soto[1,2]

[1]Universidad de La Serena [2]Instituto Milenio SAPHIR

1. Introduction

The NA64 experiment at CERN is a fixed-target setup designed to search for dark photons and other particles in the dark sector. Using high-energy electron beams, the experiment investigates rare processes and performs precision measurements. Accurate energy reconstruction in the electromagnetic calorimeter (ECAL) is essential for event identification and detector calibration. This study focuses on analyzing the effects of pile-up signals in ECAL1, assessing their impact on energy measurements.

2. Experimental Setup

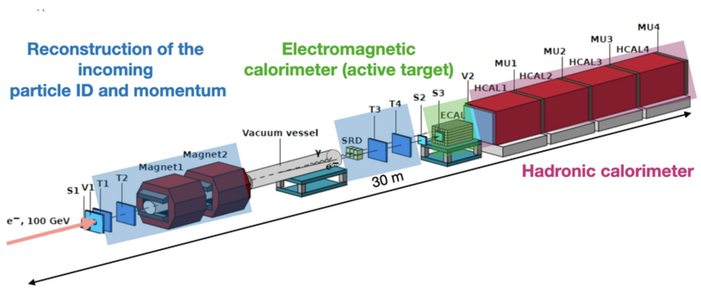

Figure 1: Experimental setup for NA64e invisible mode.

- **ECAL**: A high-efficiency electromagnetic calorimeter composed of alternating layers of lead and scintillator, used to measure the energy of incoming particles.
- **HCAL**: A hadronic calorimeter that helps distinguish muons from electromagnetic showers by detecting their energy deposition.
- **SRD**: Scintillators for precise energy measurements in the beam, used for event selection and pile-up identification.

3. Motivation

This study aims to determine whether pile-up effects distort energy measurements in ECAL. By analyzing overlapping signals, we assess their influence on energy reconstruction and evaluate whether corrections are necessary for improving detector performance. On a bigger scale, this is part of assessing systematic errors.

4. Methodology

- **Modified Code:**
  - Obtain pedestals from existing code environment.
- **Script Integration:**
  - Built upon M. Kirsanov's code by adding the `TSpectrum` peak-search method from ROOT.
- **Data Selection:**
  - Processed data from period 2023A of NA64e.
- **Peak Search Tool:**
  - Utilized the `TSpectrum` library to detect peaks in the ECAL waveform, providing precise pedestal signal analysis.

What is a Pedestal? In particle detectors, a pedestal represents the baseline signal recorded in the absence of a true event. It accounts for intrinsic electronic noise and ensures that small fluctuations are not misidentified as real signals.

What is a Pile-Up? A pile-up occurs when overlapping signals from separate events are detected within the same time window. This overlap increases the apparent signal amplitude and can distort measurements in the detector.

5. Results and Discussion

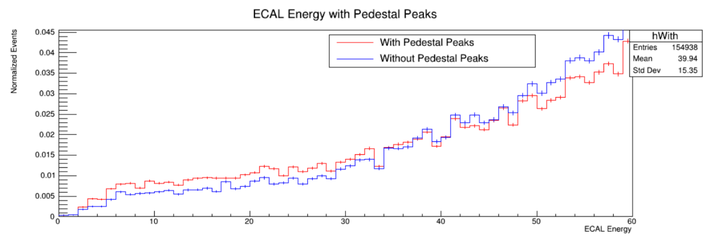

Figure 2: Normalized histogram of ECAL for events withut and without pile-up in pedestal.

First there was analyzed if pedestal pile-ups affected energy spectra, as seen in figure 1, there is visible effectc but no obvious trend.

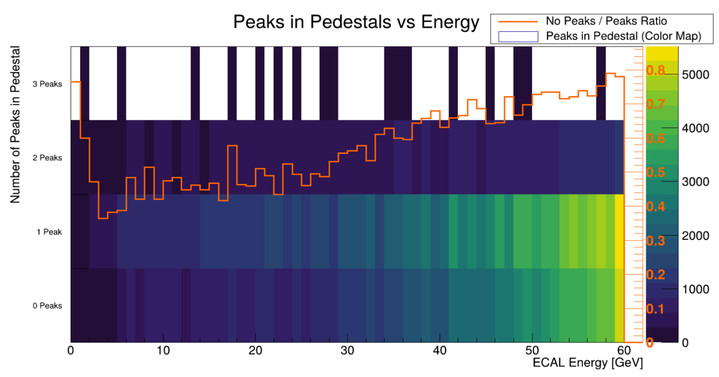

Figure 3: Superimposed graphs of peaks as a function of energy. Color map shows the event density per energy per peak and orange line shows the no peak/peak ratio per energy.

Furthermore, there is no obvious relation between deposited energy in ECAL and the behaviour of pedestal peaks. The ratio of events without peaks and events with peaks is irregular (see figure 3).

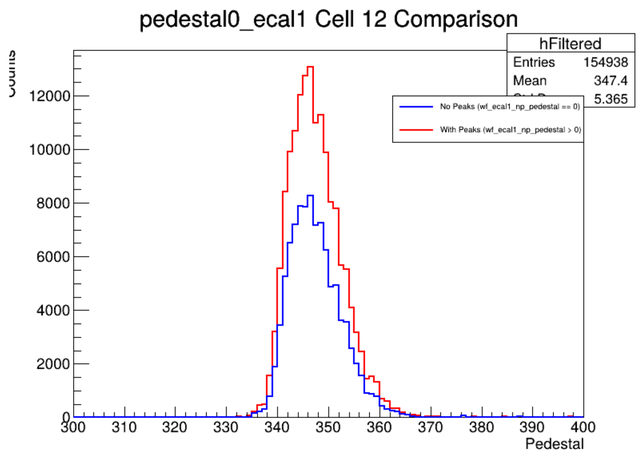

Figure 4: Even pedestal of ECAL central cell with and without pile-ups.

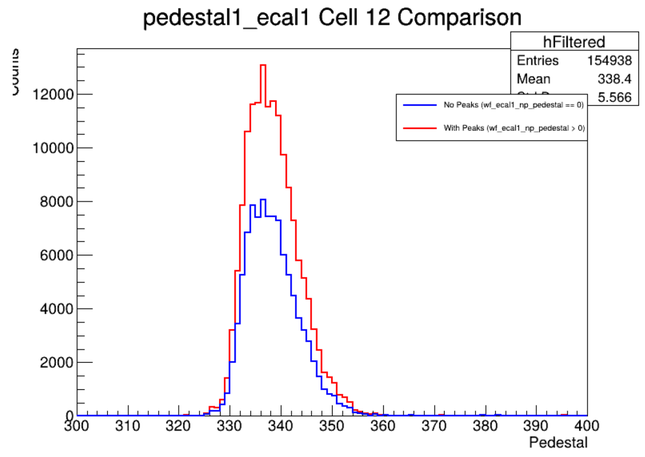

Figure 5: Odd pedestal of ECAL central cell with and without pile-ups.

However figures 4 and 5 show that the mean of the pedestals remains virtually unshifted with and without pile-ups. Results for 30 cells of ECAL are summarized in table 1.

Pedestal	Mean Without Peaks	Mean With Peaks	Mean Difference
0	338.638	338.651	0.031773
1	348.848	348.889	0.059624

Table 1: Overall Pedestal Statistics

6. Future Work

- Extend the analysis to other sub-detectors in NA64.
- Further investigate pile-up effects in energy spectra utlizing runs with higher and lower intensities.

7. Conclusions

Pedestal stability: Pile-ups do not significantly affect pedestal values. **Change in energy spectra**: Further studies are needed to refine the understanding of pile-up corrections in NA64, such as RMS effects and work with different beam intensities

8. Acknowledgments

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References

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