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Calibration and Simulation of the CMD-3 Endcap BGO Calorimeter: Studies of Electronic Nonlinearity and Energy Resolution

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The CMD-3 detector at the VEPP-2000 collider studies physics of light hadrons in the electron-positron collisions. Its electromagnetic endcap calorimeter consists of Bismuth Germanate (BGO) scintillation crystals with readout by silicon PIN photodiodes and custom electronics.

A detailed analysis of the calorimeter's signal response revealed a systematic nonlinearity in its readout electronics at low signal amplitudes. This effect artificially inflated the measured pedestal level for most channels.

The data analysis software was updated to take into account the nonlinearity effect. The detail MC simulation based on GEANT4 package was carried out to study the impact of this electronic effect on physics analysis. The energy resolution σ_E/E was found to be almost unaffected while the usage of the calibration data should be updated. Crucially, this method has already been successfully implemented in the collaboration's reconstruction software, leading to a more accurate determination of energy deposition in the crystals.

The energy resolution was extracted from experimental data, collected wide energy range during recent years. The parameterization function is $\frac{\sigma_E}{E} = \sqrt{(4.372/E)^2 + (0.645/\sqrt{E})^2 + 0.029^2}$. The simulation parameters were adjusted to achieve good agreement between simulation and experimental data.

This work provided two key contributions:
1. The correct accounting of an electronics nonlinearity is implemented in detector data reconstruction software.
2. An updated energy resolution model are prepared for the detector simulation and physics data analysis.
Which enhance the precision of the CMD-3 results.

Author: DUBROVIN, Ivan

Presenter: DUBROVIN, Ivan

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