# Energy Calibration with ML

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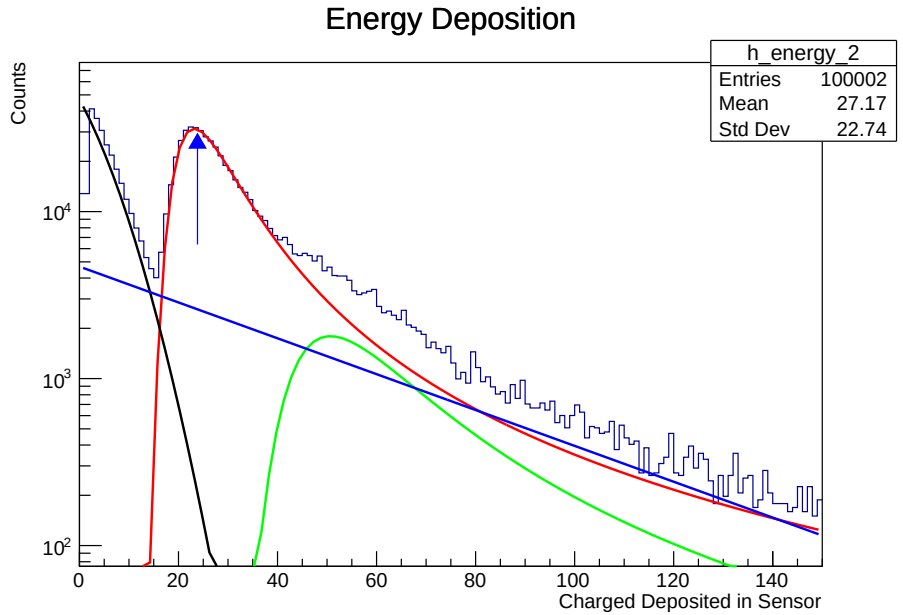
## Energy Calibration

- Sensors in EmCal calibrated by looking for minimum ionizing particles (MIPs)
- Charge deposited by MIPs follows Landau distributions:

$$\text{Signal} = \text{Landau}_0(\mu_0, \sigma_0) + \text{Landau}_1(\mu_0, \sigma_0)$$

- Shown as Red, Green
- Background is composed of a Gaussian pedestal (Black)
  + high Energy particles (exp,blue), which are signal for analysis, but BG for calibration
- Regression complicated by zero-supression, which cuts a square notch in a random location between 0 and 10
- Challenge: Fit 200,000 sensors, all with differently shaped signal and background
- Find Most Probable Value ($\mu$) of MIP Landau (Blue Arrow)

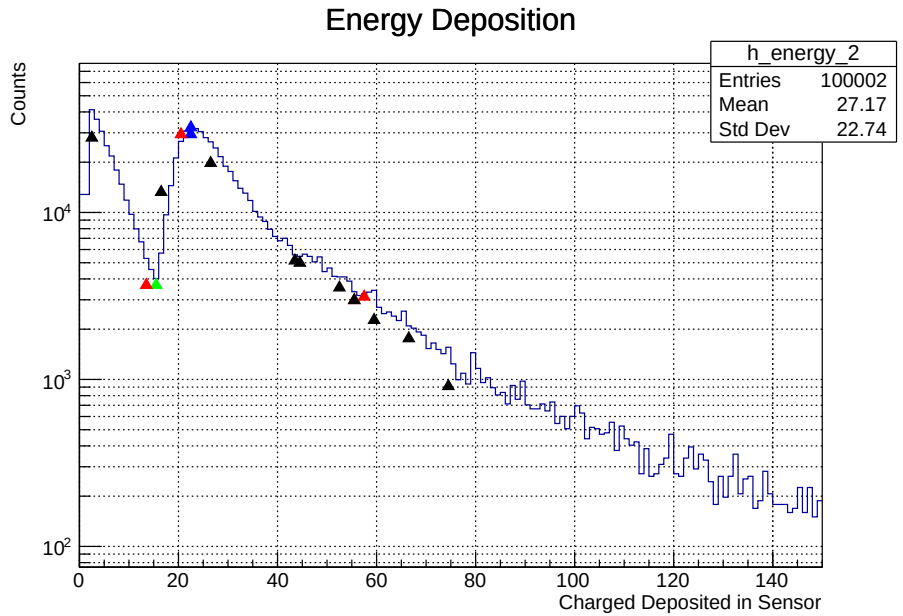
Example of charge disposited in single sensor



## Feature Selection

- Naively fitting using regression with entire underlying functional form fails
- Due to the large number of fit parameters
- Can fit after seeding using features discribing histograms shape
- Find following features:
- Local Minima (Green) and Maxima (Blue)
- Locations where $\frac{dy}{dx} = 0$ (Red)
- Locations where $\frac{d^2y}{dx^2} = 0$ (Black)

Example of charge disposited in single sensor



## Finding MIP using kNN

- Find MIP location (MPV) using k-Nearest Neighbors
- Feartures used as predictors
- Predictors: Minima, Mixima, $\frac{dy}{dx} = 0$
- MIP location (MPV) used as response

## Difference between true and predicted MIP location