NR & ER Discrimination

Atul Prajapati

Configuration used for the simulation and reconstruction

- Noise Run : 3944
- Detector : LIME
- Detector dimension : 33 cm x 33 cm x 50 cm
- Camera : Orca Fusion
- Pixel width: 0.152 mm
- Algorithm : Chan Vese
- Diffusion length : 25 cm
- Gas Mixture: He:CF4
- Pressure: 1 atm

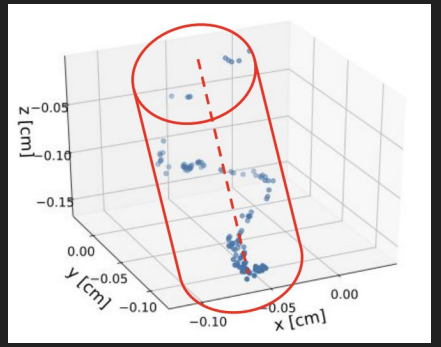
Observables

Observables for recoil identification in gas TPCs
arXiv:2012.13649v1

- Standard Deviation of Charge Distribution (SDCD):

$$SDCD = \sqrt{\frac{\sum_{i=1}^{N}(\mathbf{r_i} - \bar{\mathbf{r}})^2}{N}}.$$

- Charge Uniformity (ChargeUnif):
  - For each point within the charge distribution, find the average distance to all other points.
  - ChargeUnif is standard deviation of values computed in step 1.
- Maximum Density (MaxDen):
  - MaxDen is the value of most intense pixel.
- Cylindrical Thickness (CylThick):
  - For each charge , calculate the squared distance from the principal axis.
  - CylThick is the sum of all squared distances.



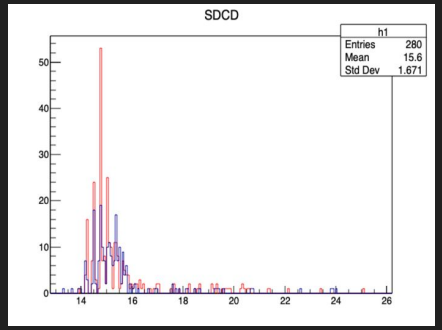
Source: Majd Ghrear presentation in Physics and Analysis meeting

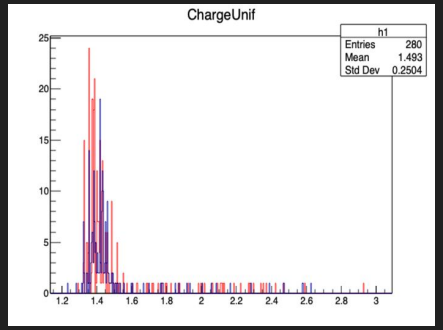
Observables

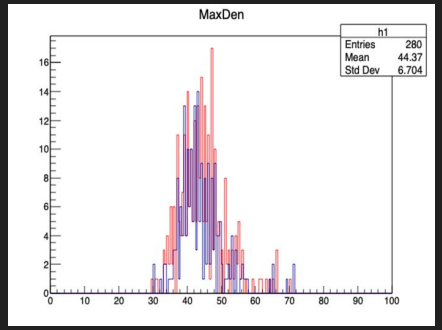
- Length Along Principal Axis (LAPA):
  - Project all the points in the charge distribution on to the principal axis.
  - LAPA is the difference between maximum and minimum projected value.
- eta:
  - MaxDen divided by length (found by skeletonization)
- Light Density:
  - Ratio of sc_integral over sc_nhits
- Skeleton length (thin_track):
  - Length in mm found by skeletonization
- Slimness:
  - Ratio of sc_length over sc_width

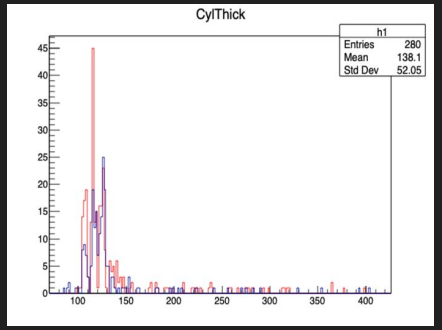
GEM-based TPC with CCD Imaging for Directional Dark Matter Detection
arXiv:1510.02170v3

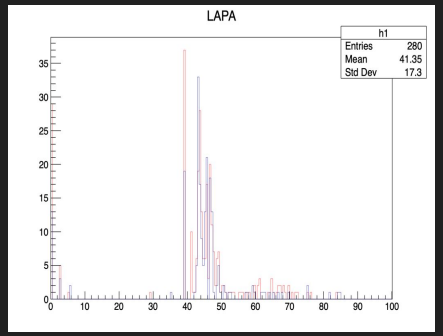
3 keV ER & NR

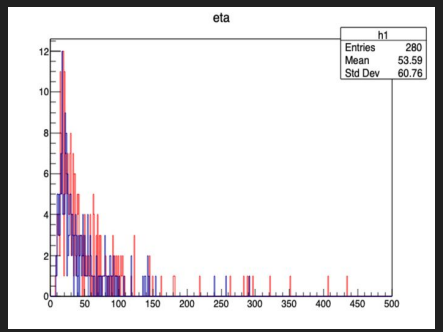


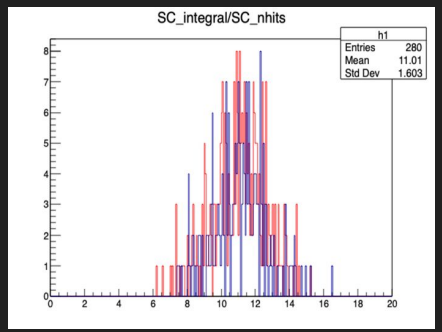


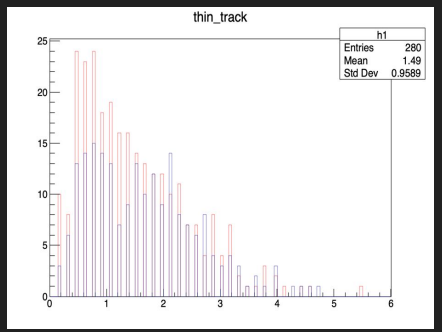






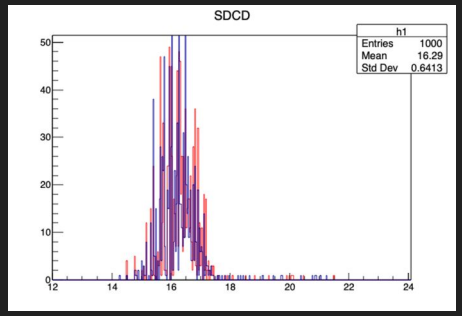


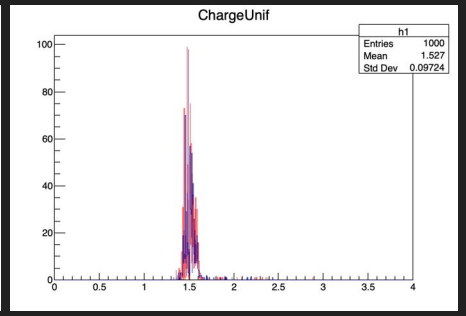


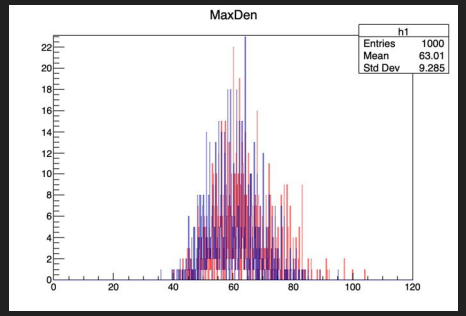


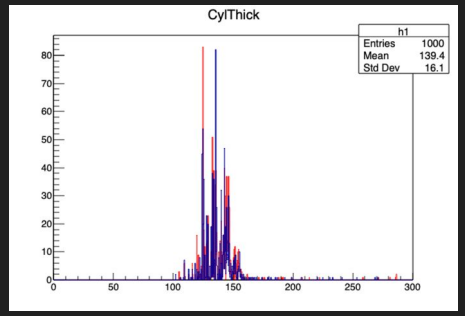
- RED : NR BLUE : ER

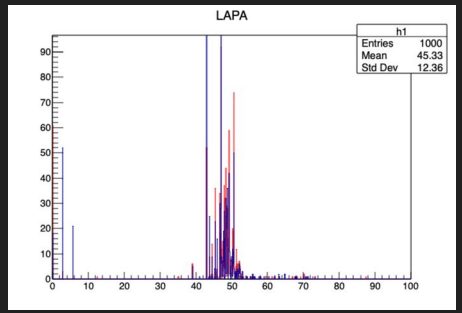
6 keV ER & NR

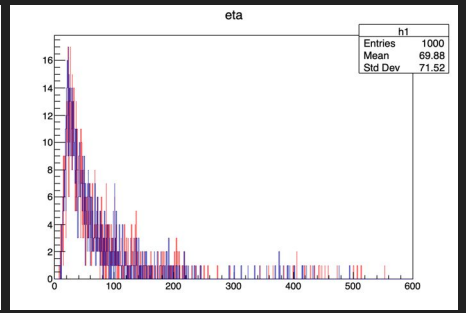


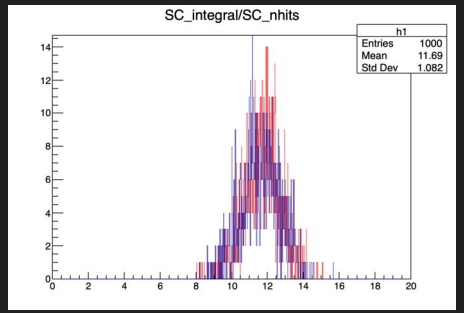


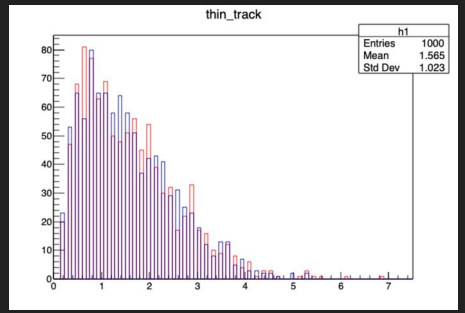






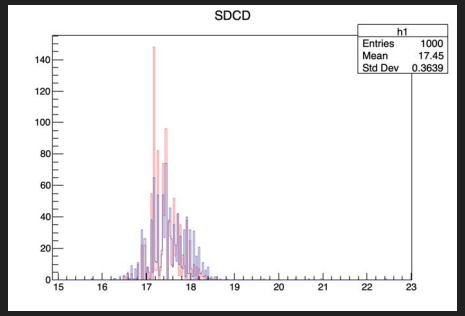


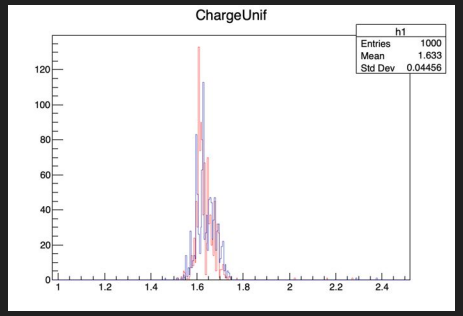


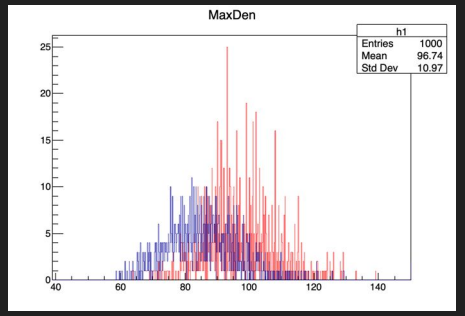


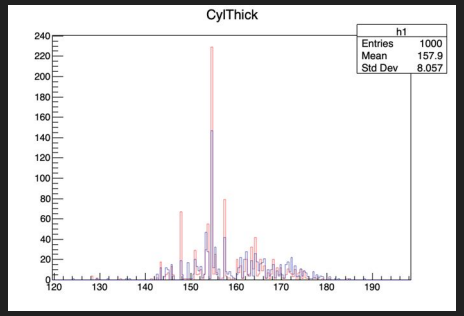
- RED : NR BLUE : ER

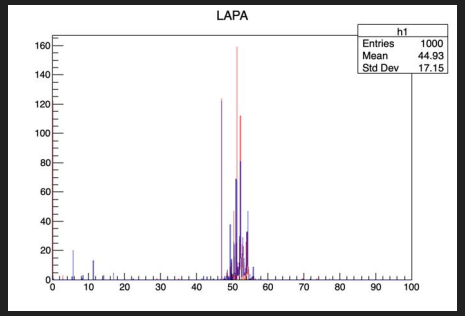
10 keV ER & NR

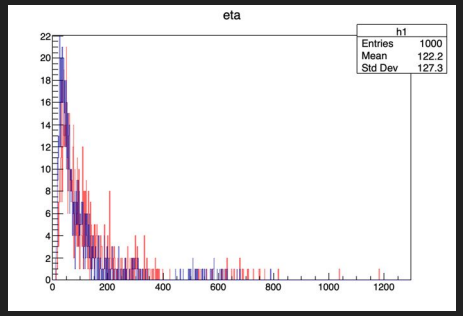


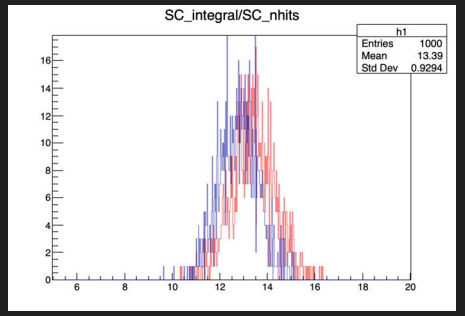


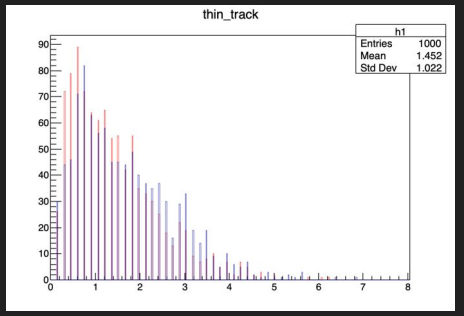






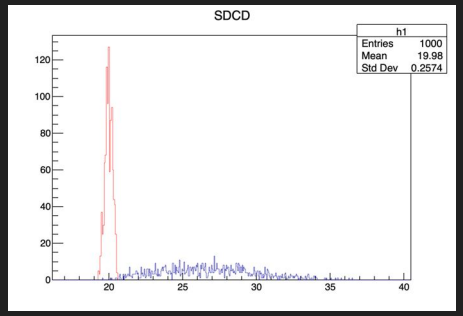


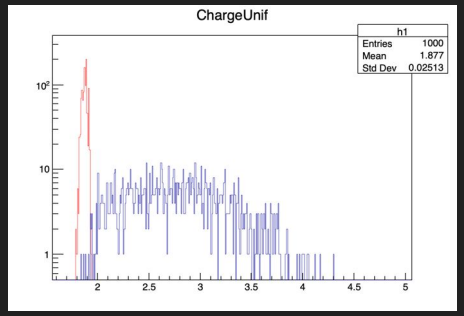


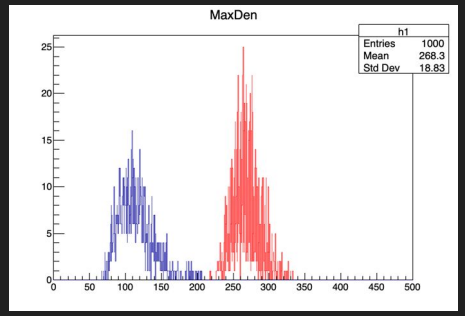


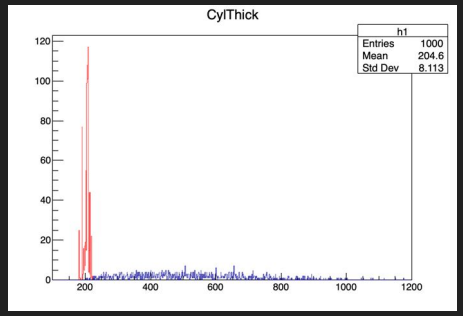
- RED : NR BLUE : ER

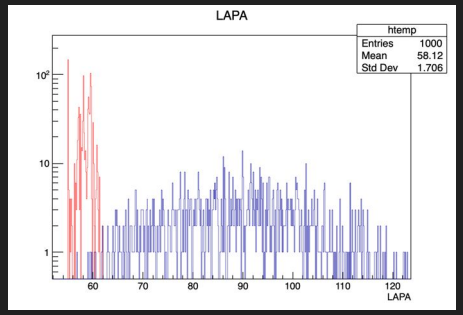
30 keV ER & NR

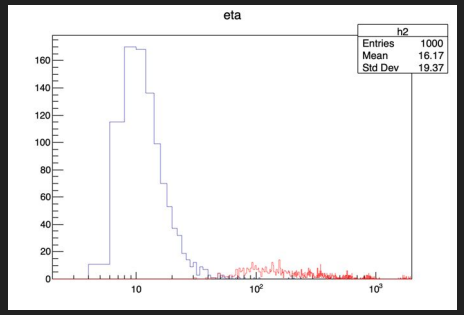


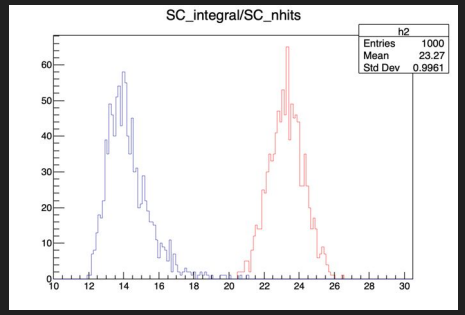


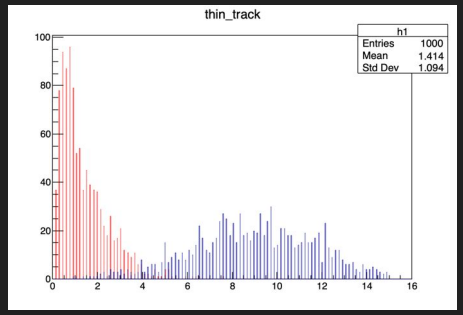






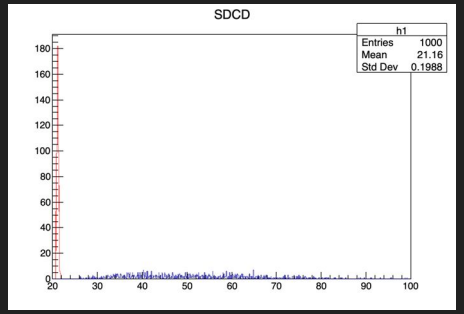


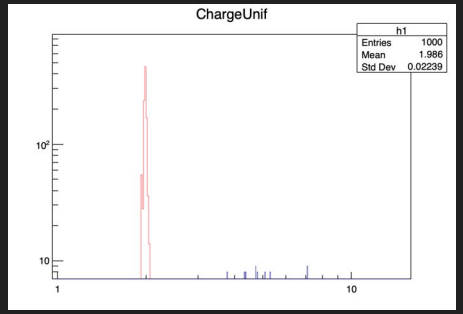


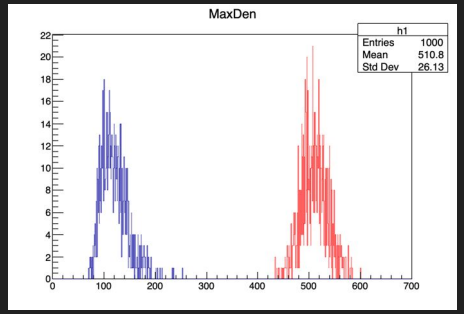


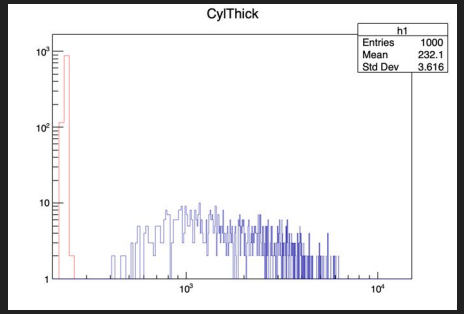
- RED : NR BLUE : ER

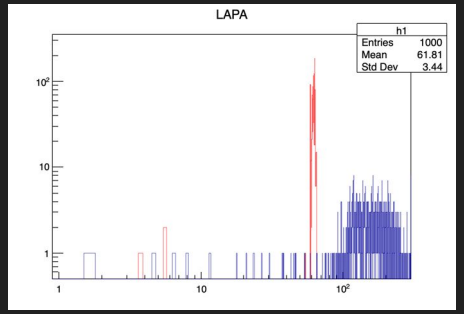
60 keV ER & NR

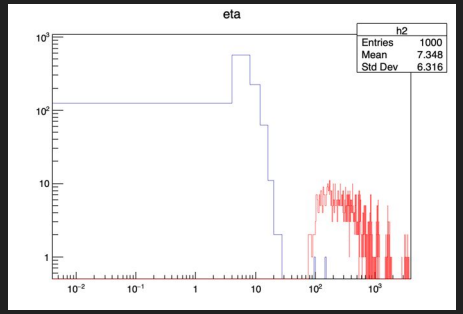


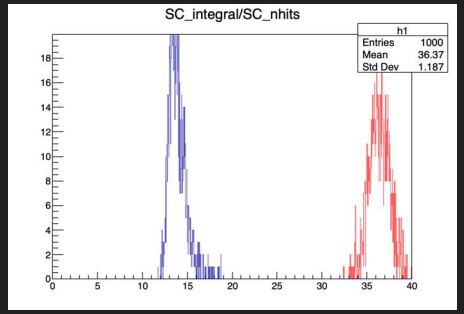


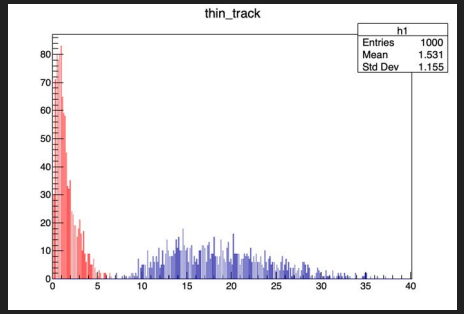






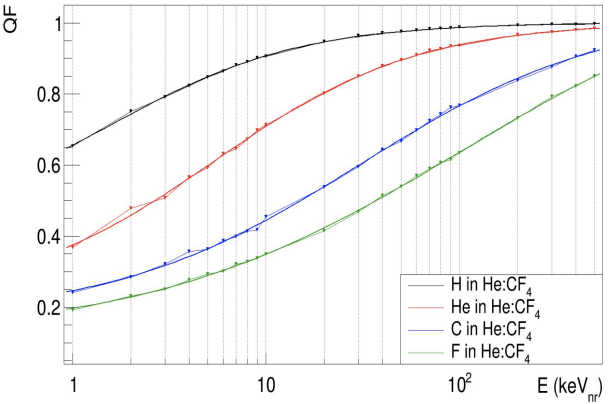


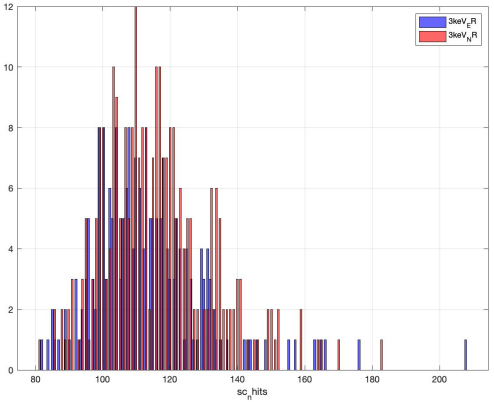




- RED : NR BLUE : ER

3 keV ER and 6 keV NR





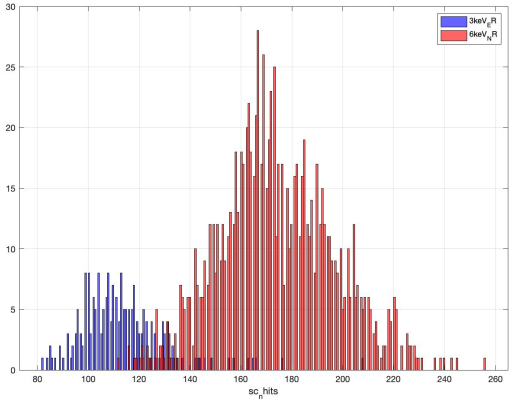
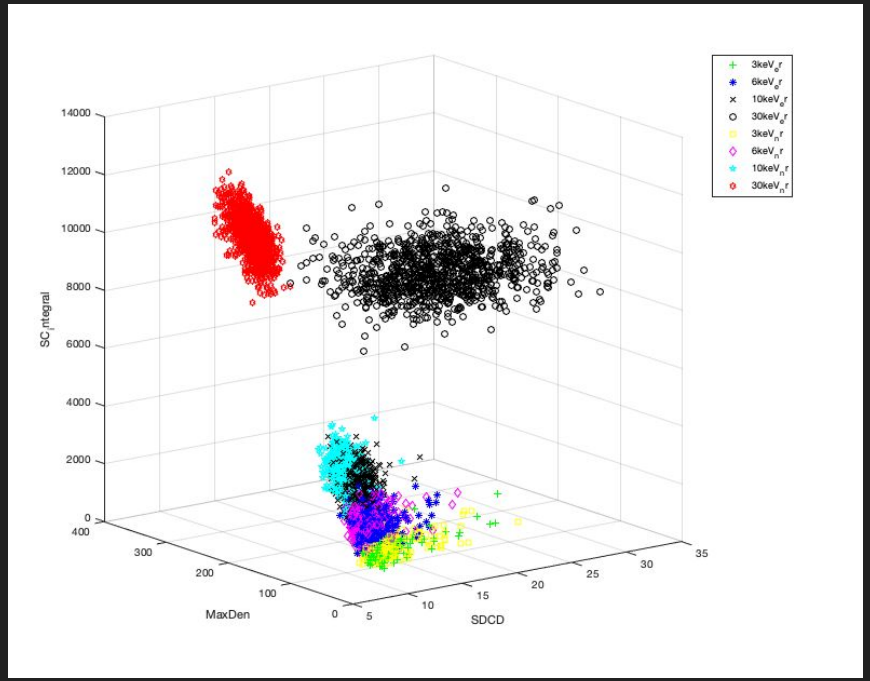
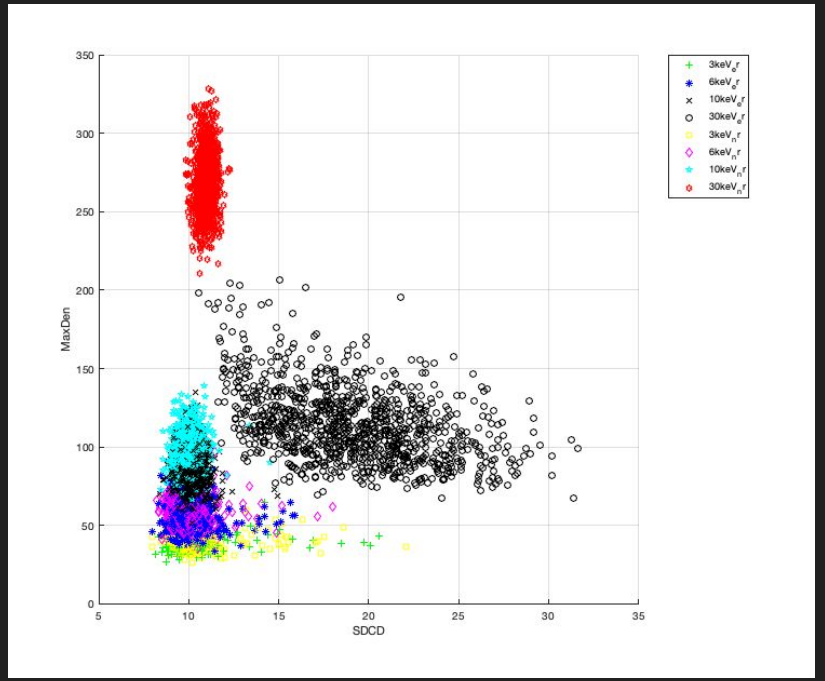
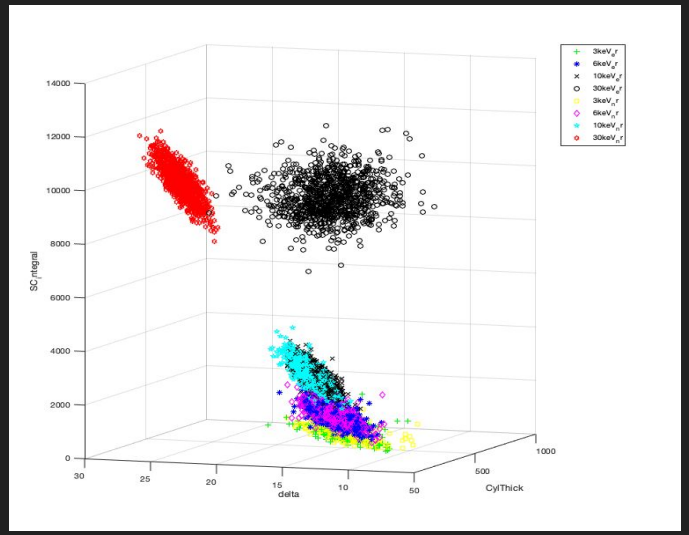


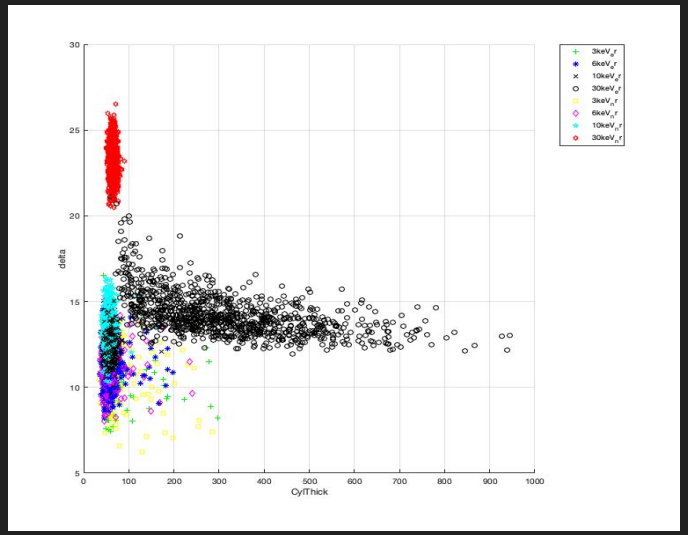
Figure 1: Quenching factor for NR
Figure 2: 3 keV ER and 3 KeV NR can not be discriminated.
Figure 3: 3 keV ER and 6 keV NR can be discriminated, 6 keV NR is quenched and the observed energy would be around 3.5 keV. So there is a good discrimination at 3 keV ER and 3.5 keV NR (Observed energy).

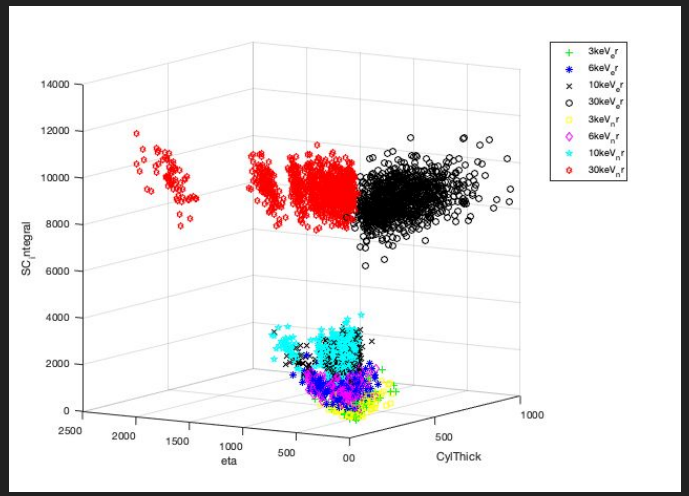
Discrimination in 3D based on Energy

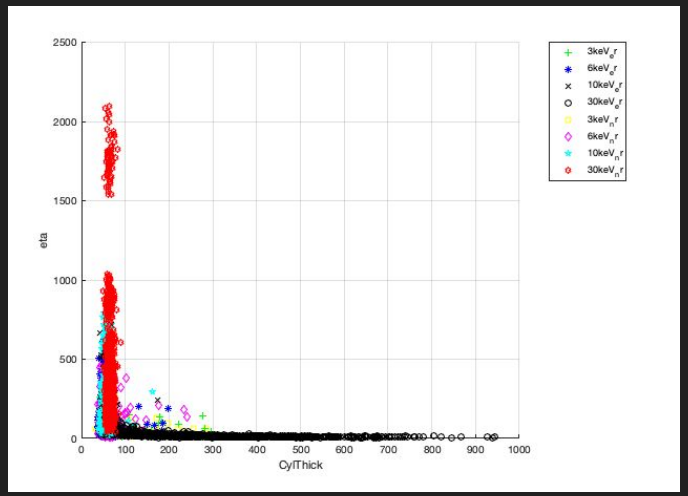




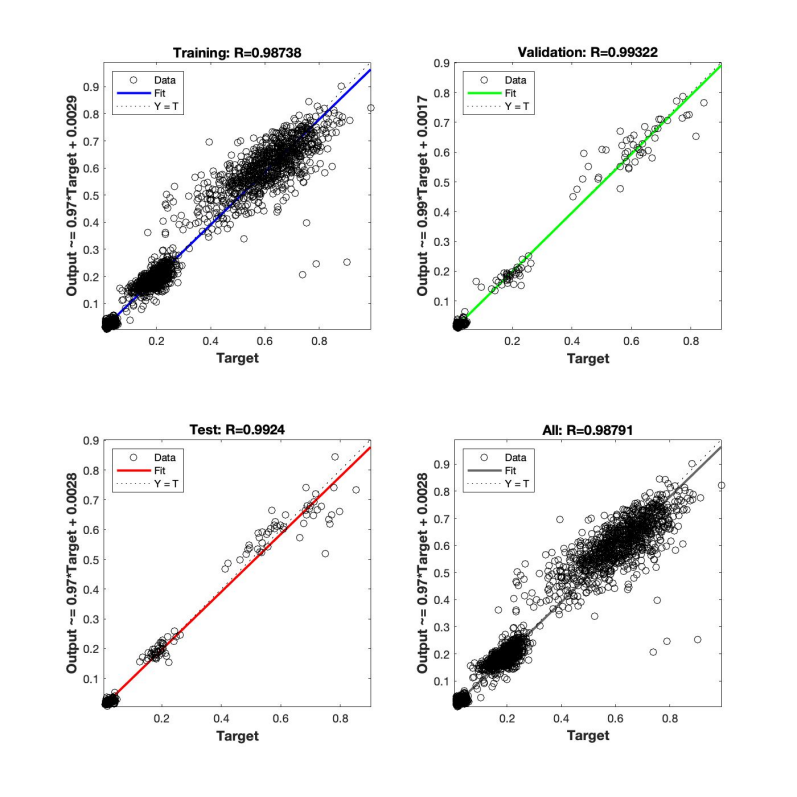

SC_ntegral
delta
CylThick
3keV_e_r
6keV_e_r
10keV_e_r
30keV_e_r
3keV_n_r
6keV_n_r
10keV_n_r
30keV_n_r


delta
CylThick
3keV_e_r
6keV_e_r
10keV_e_r
30keV_e_r
3keV_n_r
6keV_n_r
10keV_n_r
30keV_n_r


SC_ntegral
eta
CylThick
3keV_e_r
6keV_e_r
10keV_e_r
30keV_e_r
3keV_n_r
6keV_n_r
10keV_n_r
30keV_n_r


eta
CylThick
3keV_e_r
6keV_e_r
10keV_e_r
30keV_e_r
3keV_n_r
6keV_n_r
10keV_n_r
30keV_n_r

Neural network to predict length



- All the variable computed earlier was fed to the network as input.
- Target of the network was 2D tracklength computed from MC simulation