KMI2020: Group 9

Motivations and ideas on applying ML to our studies

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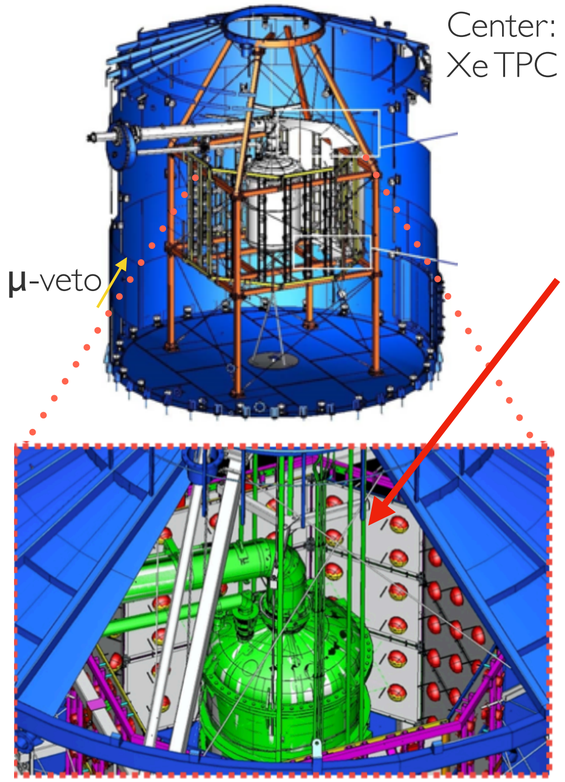
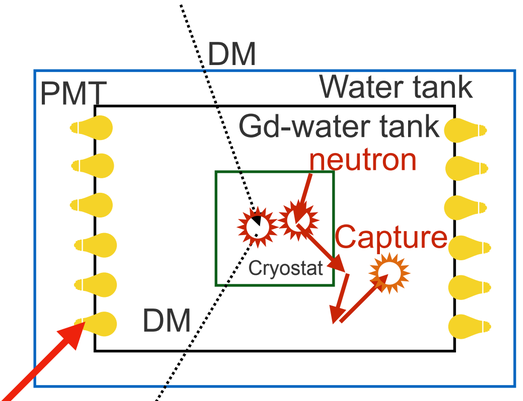
Motivation & Idea: ML for XENONnT neutron Veto detector

- XENONnT, one of the largest Time Projection Chamber for Dark matter search.
- XENONnT has outer **water Cherenkov detector** (120 PMTs) with Gd **to veto neutron background**.
- For the efficiency, the detector **surrounded reflector**
  - It's **difficult to reconstruct** Cherenkov shape by traditional, well-known methods
- I'm developing high-precision an optical Monte-Carlo simulation to generate DAQ waveforms.
  - There is a room to improve the extraction method by **ML technique**.
- Unfortunately, I haven't reach to make initial prototype for that… during the school I've tried to make inputs.
- I will try **RNN** for waveforms, **CNN** for PMT hit-map, and both. (But I would like to start by simpler model.)
- I'm happy to discuss about these ideas with you.
  Please talk with that on Zoom or Slack! Thank you.

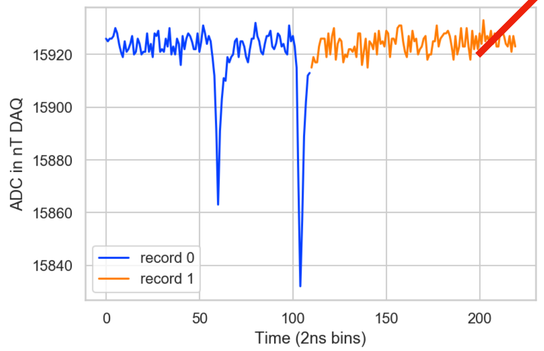


CAD image of XENON detector

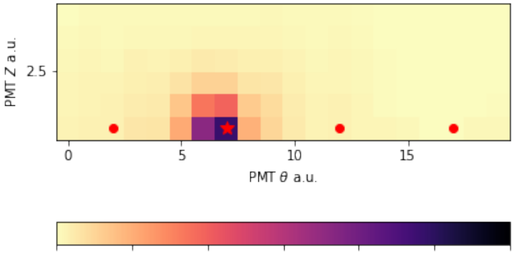
nVeto System (outer detector)
Gd-loaded water Čerenkov
120 PMT
Reflector (ePTFE, ~99%)



Concept of neutron Veto detector



Prototype of simulated waveform

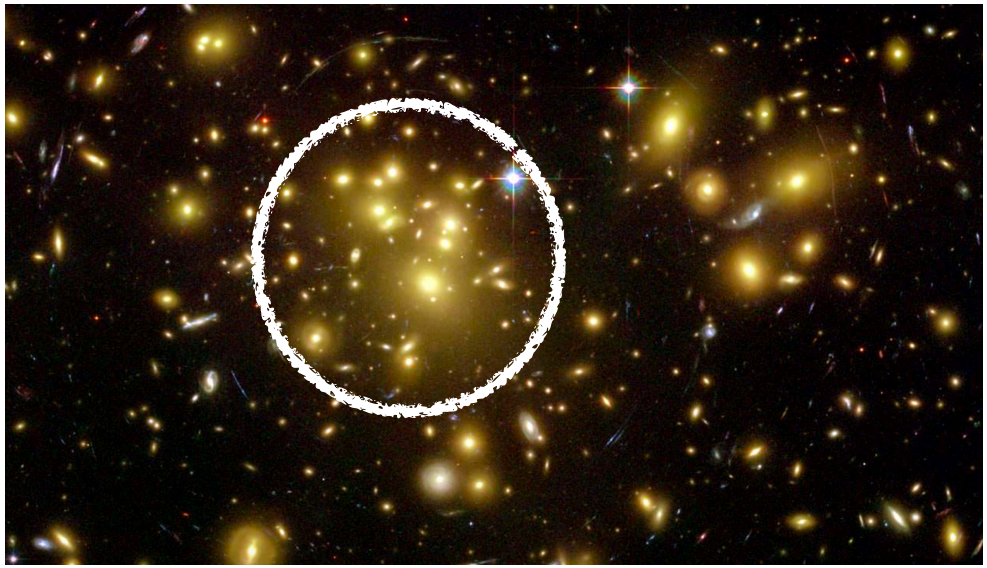


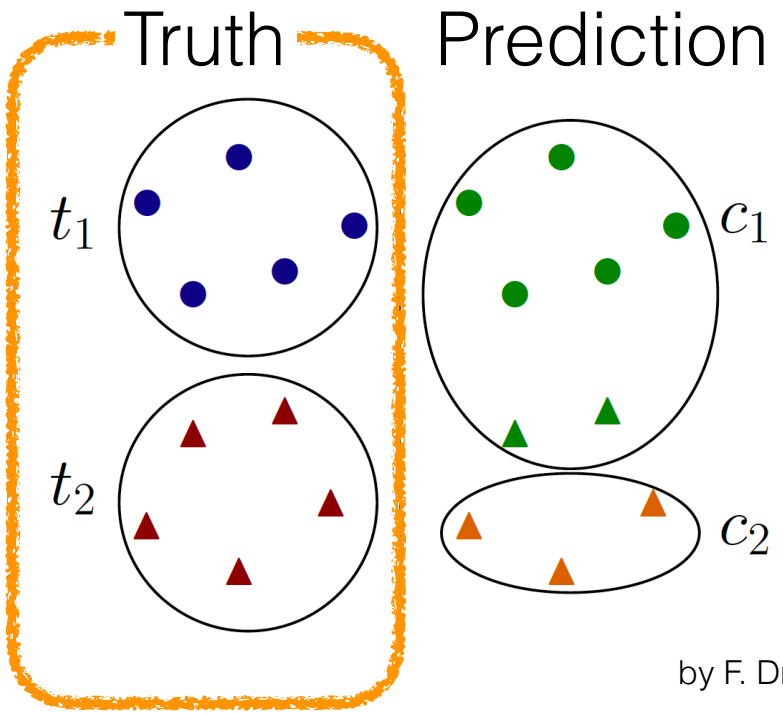
Prototype of simulated PMT hit-map

Identifying galaxy clusters using GNN Clustering

Can I use GNN clustering to identify galaxy clusters? (but we don't know "true" answers like the left group in the picture…)

Galaxy clusters are the most massive self-bound objects in the Universe…





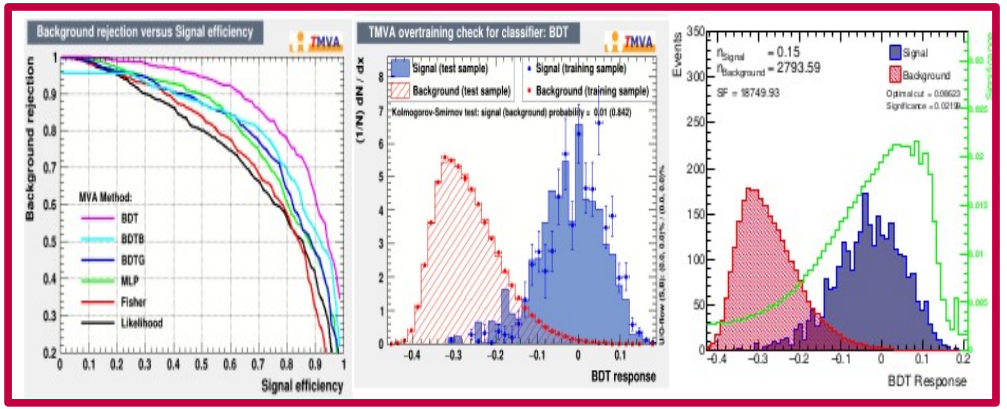
by F. Drielsma

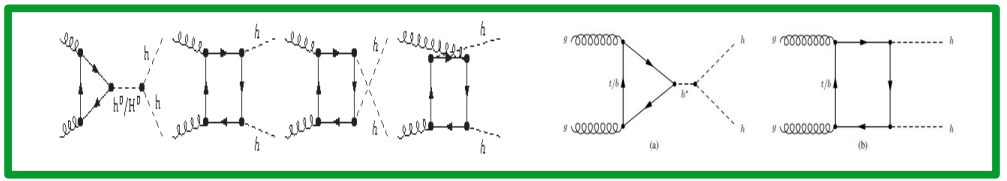
Identifying galaxy clusters from image is hard, because the distance from us has to be estimated by colors (i.e., large error).

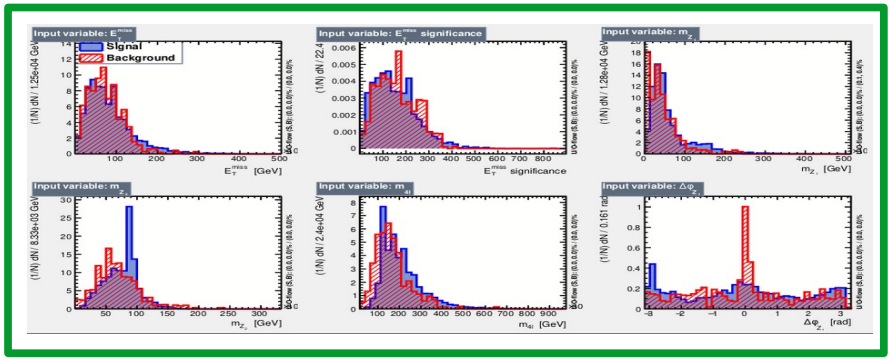
From "prediction", we can tell how well prediction grouped galaxies into clusters in statistical manner, but can't tell the purity of each predicted clusters. Can I do reinforcement learning by inputting the statistical purity and iterate the GNN clustering? What can be the best way?

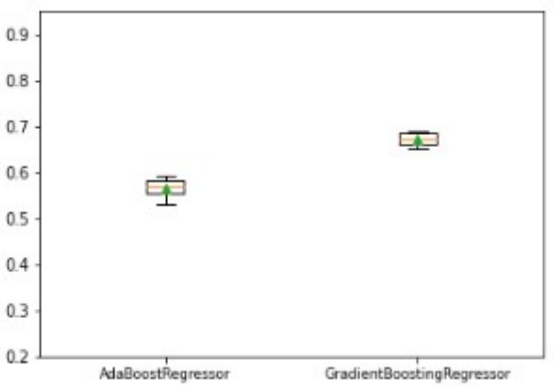
The application of Machine Learning in particle physics

- The idea is to implement what I've learn here on particle physics.
- I've already used TMVA techniques with different algorithm.
- The objective is to separate a tiny signal from a huge amount of backgrounds.









- From ML, we can see that BDTG is performing better thank BDT
- But TMVA is quite the opposite.

ML for nanosatellite capability enhancement

Image prioritization using CNN for cloudy image rejection

- Nanosatellite typically has low downlink speed
- Downloading cloudy images are unwanted
- Apply CNN to reject cloudy images onboard

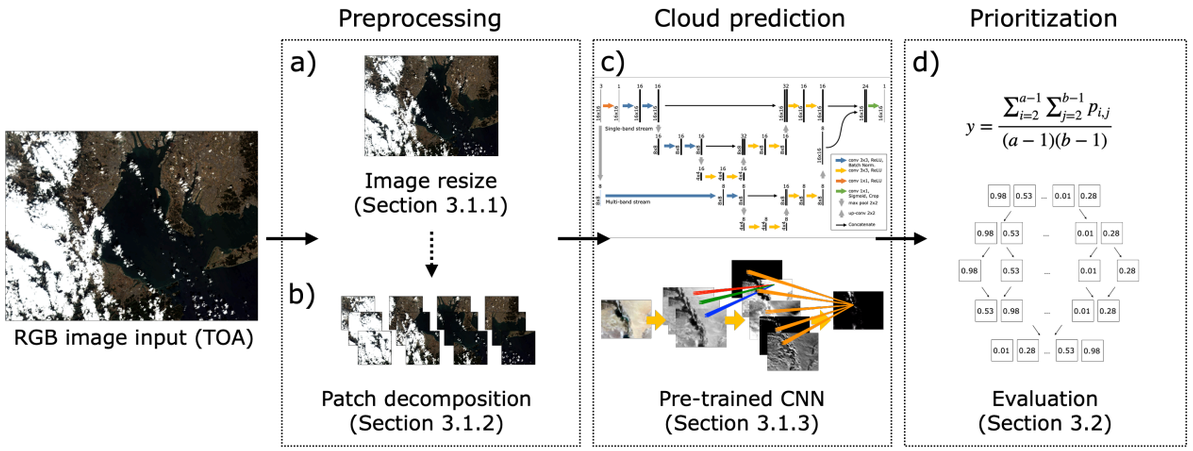


Figure 1. Flowchart of cloudy image rejection

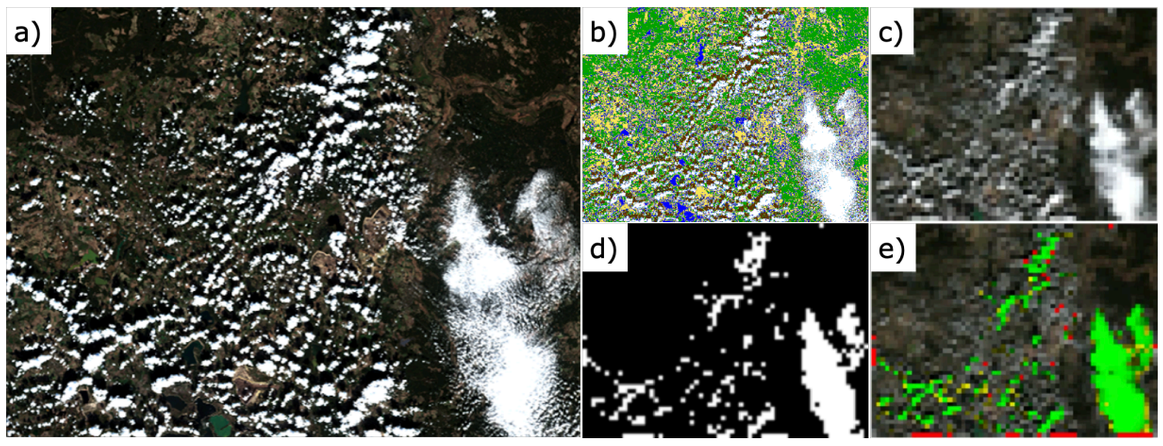
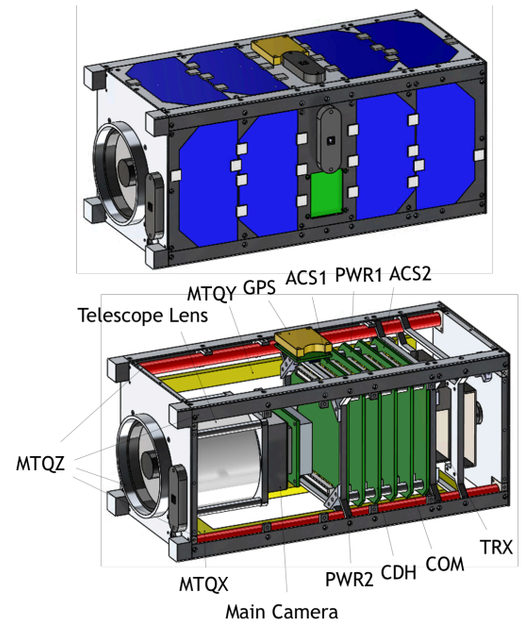


Figure 2. Example of image segmentation on cloudy scene

Particle classification for Solar Neutron and Gamma Ray observation payload

- The science payload for Solar Neutron and Gamma Ray Spectroscopy mission generates large data
- Events due to false trigger such as proton should be rejected to maximize significant data retrieval
- At the same time anomalous data (rare events) should have high priority over nominal events
- Apply ML methods to achieve false trigger rejection and anomaly data prioritization



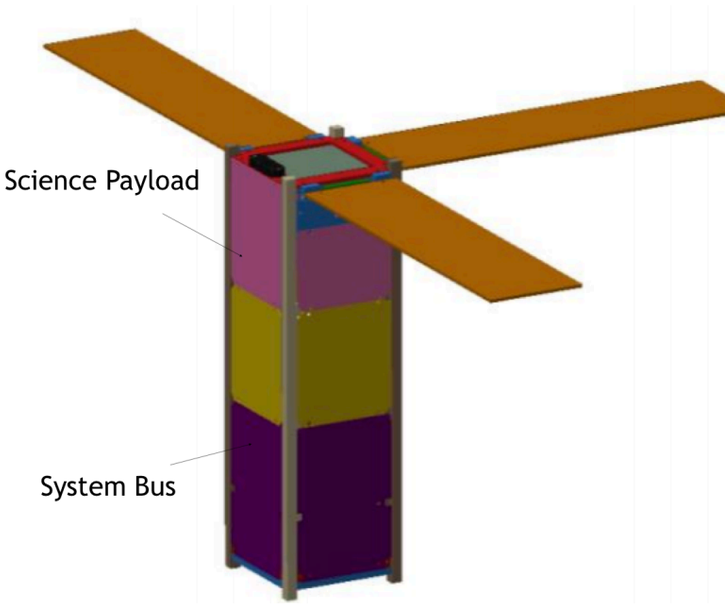
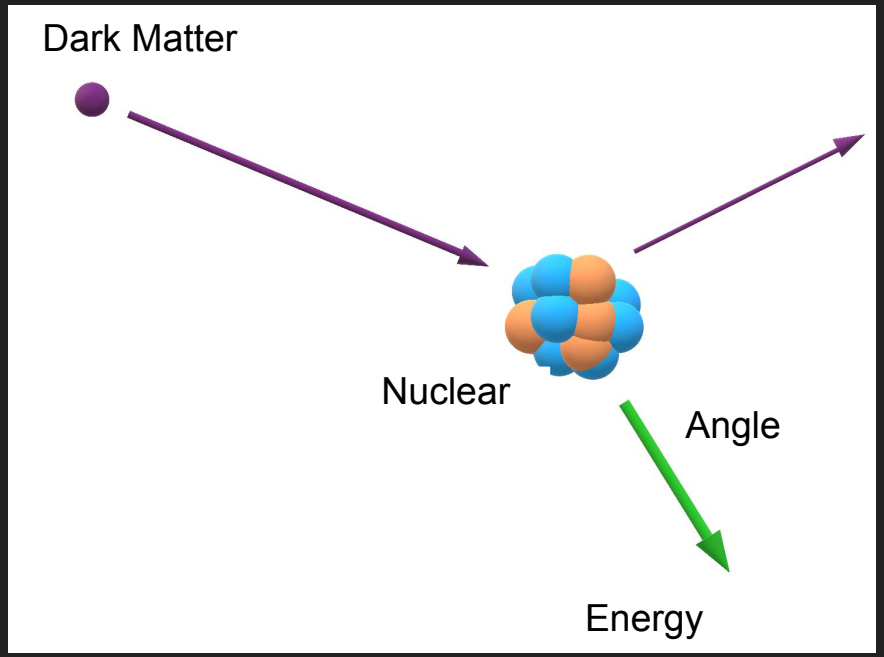


Figure 3. Target nanosatellites NUcube1 (cloudy image rejection) and SONGS (particle classificiation)

Discrimination using a random forest of dark matter



Dark matter and nuclei scattering.

The mass of dark matter and the type of nuclei can be changed.

The energy and angle data of the collided nuclei are obtained.

I would like to use the data to determine with what degree of accuracy we can determine the difference in masses and types of dark matter and nuclei using random forests!