

Some Low Energy Concerns for Large Water Cherenkov Detectors

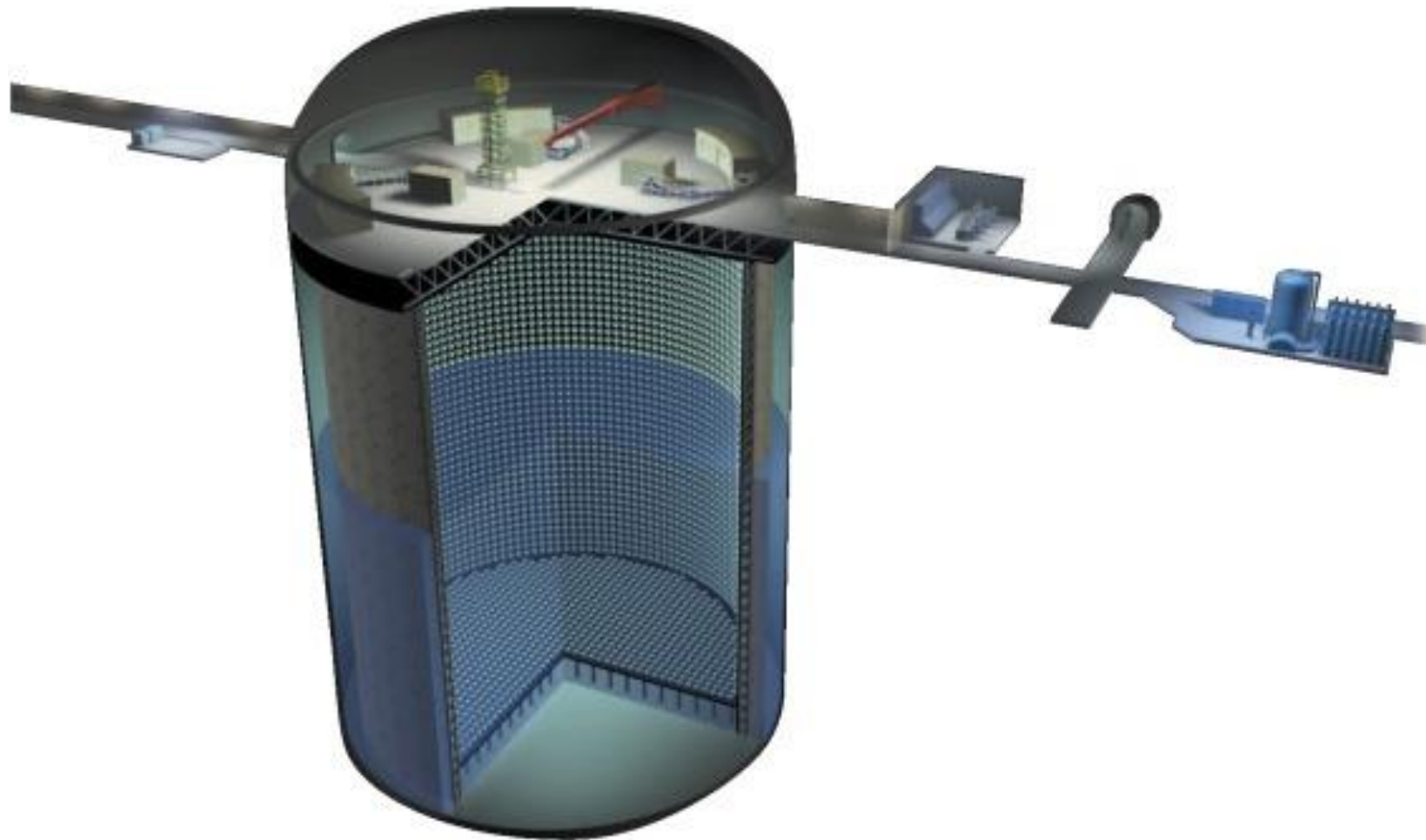
Thomas Leplumey

2 Main Topics

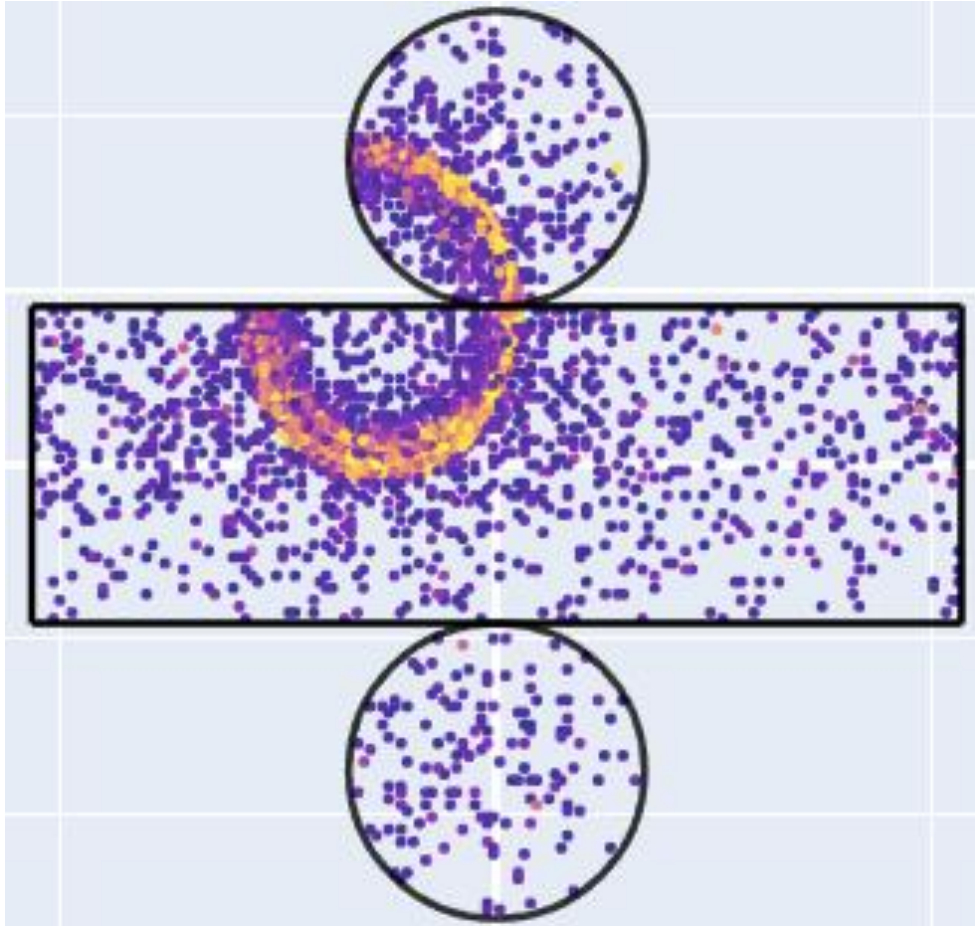
1. Study on the PMT dark rate
2. Study on neutron tagging with neural networks

Study on PMT dark rate

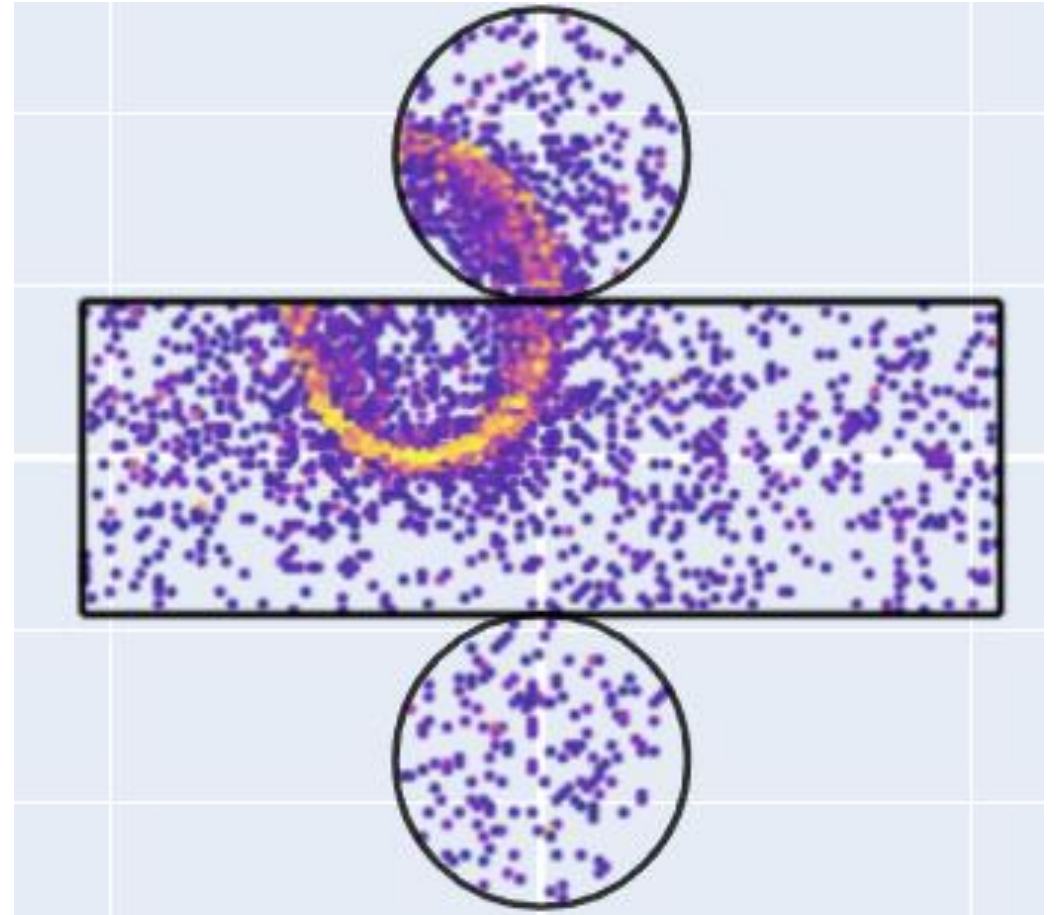
Large Water Cherenkov detector



Cherenkov rings : 1 GeV

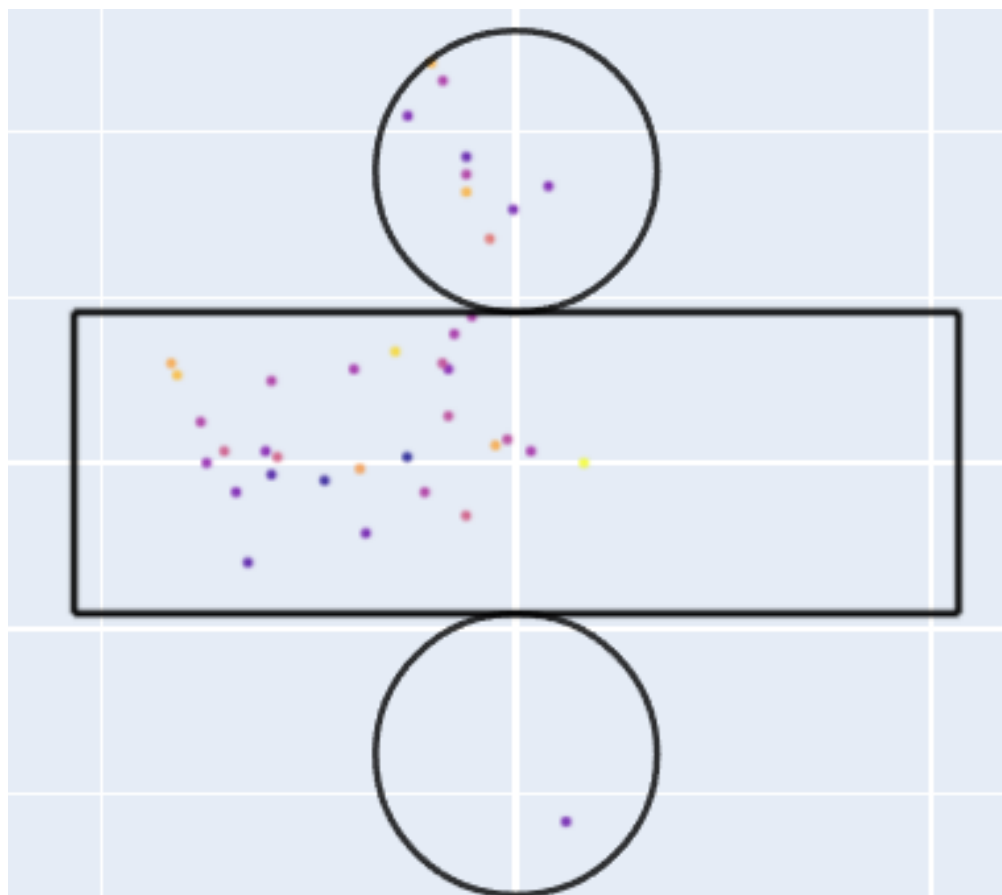


Without noise

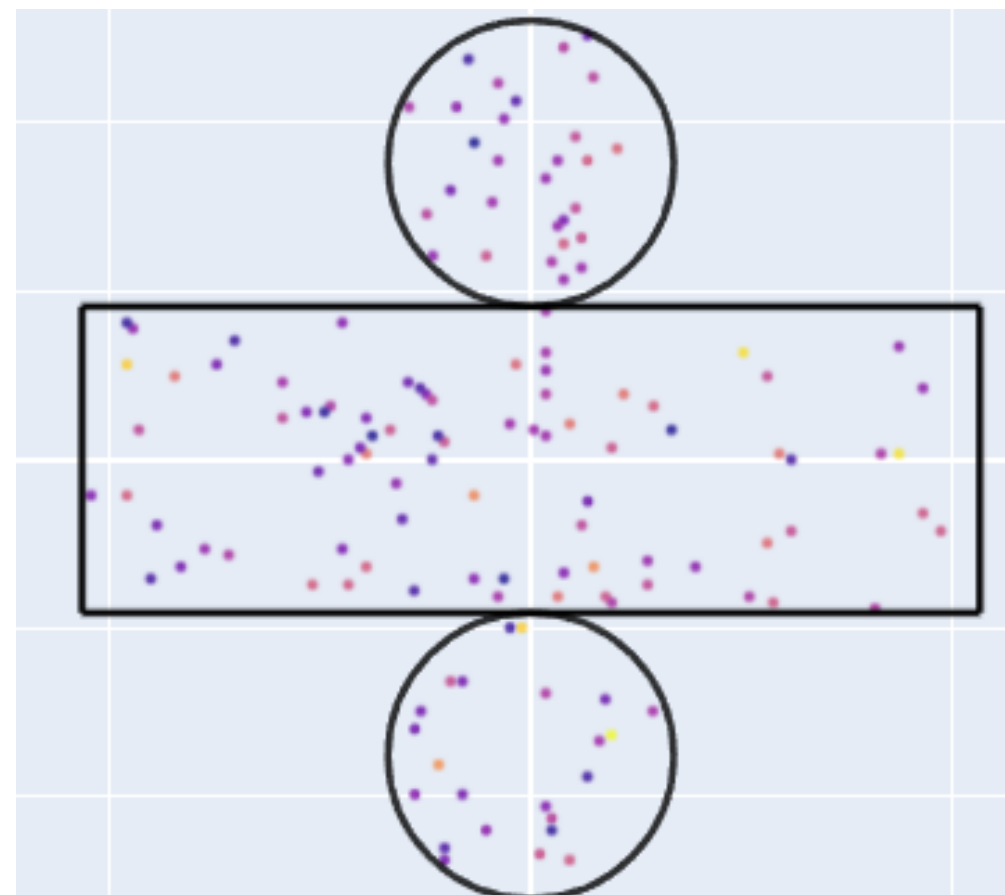


With noise

Cherenkov rings : 8 MeV

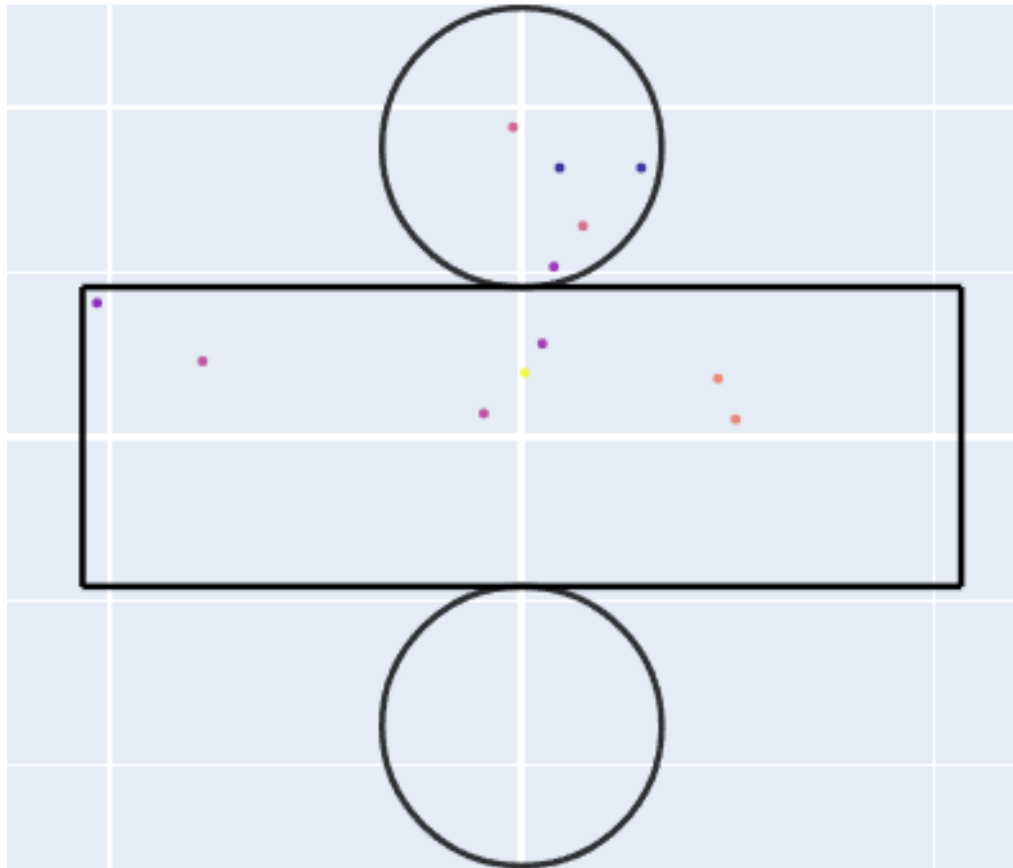


Without noise

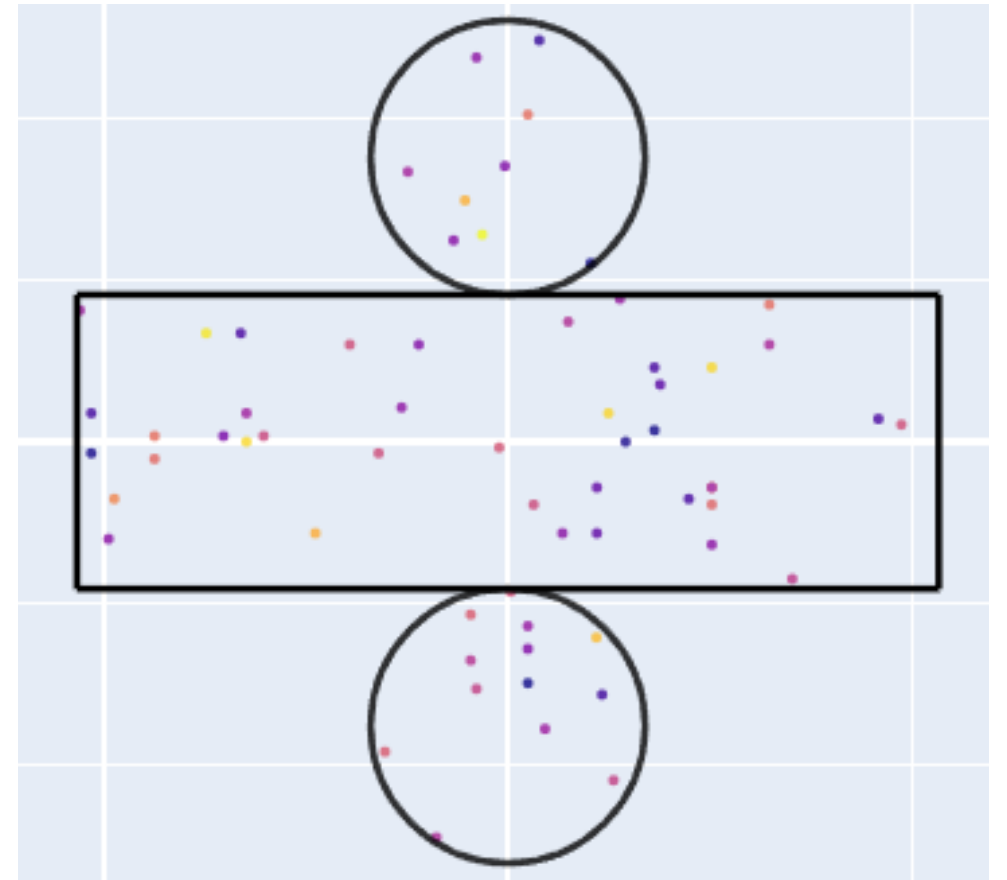


With noise

Cherenkov rings : 2.2 MeV

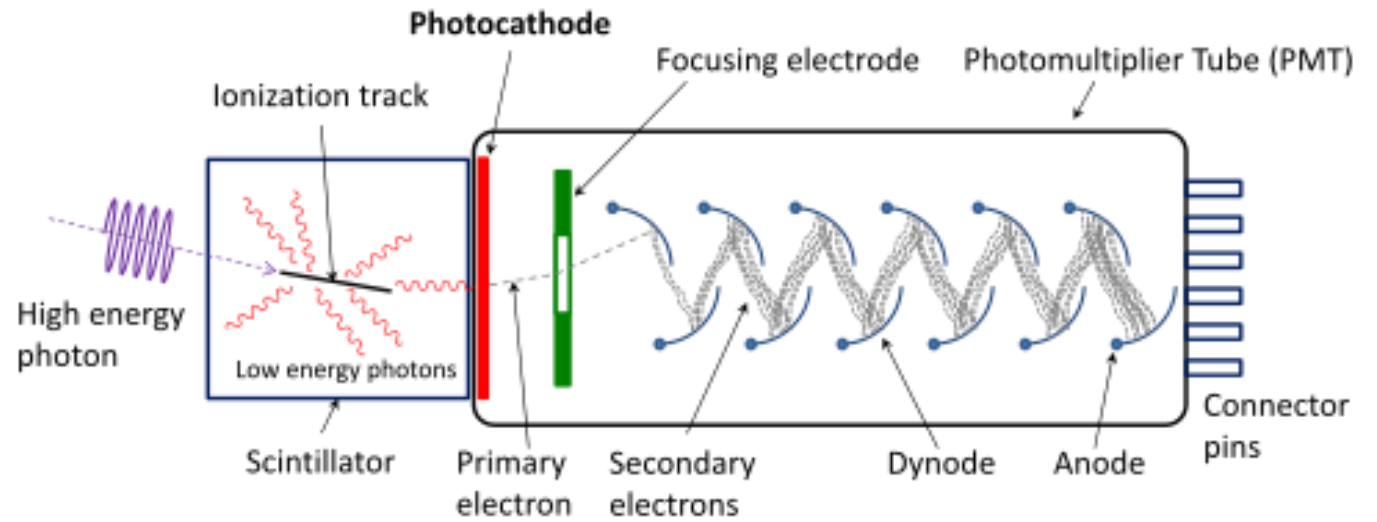


Without noise

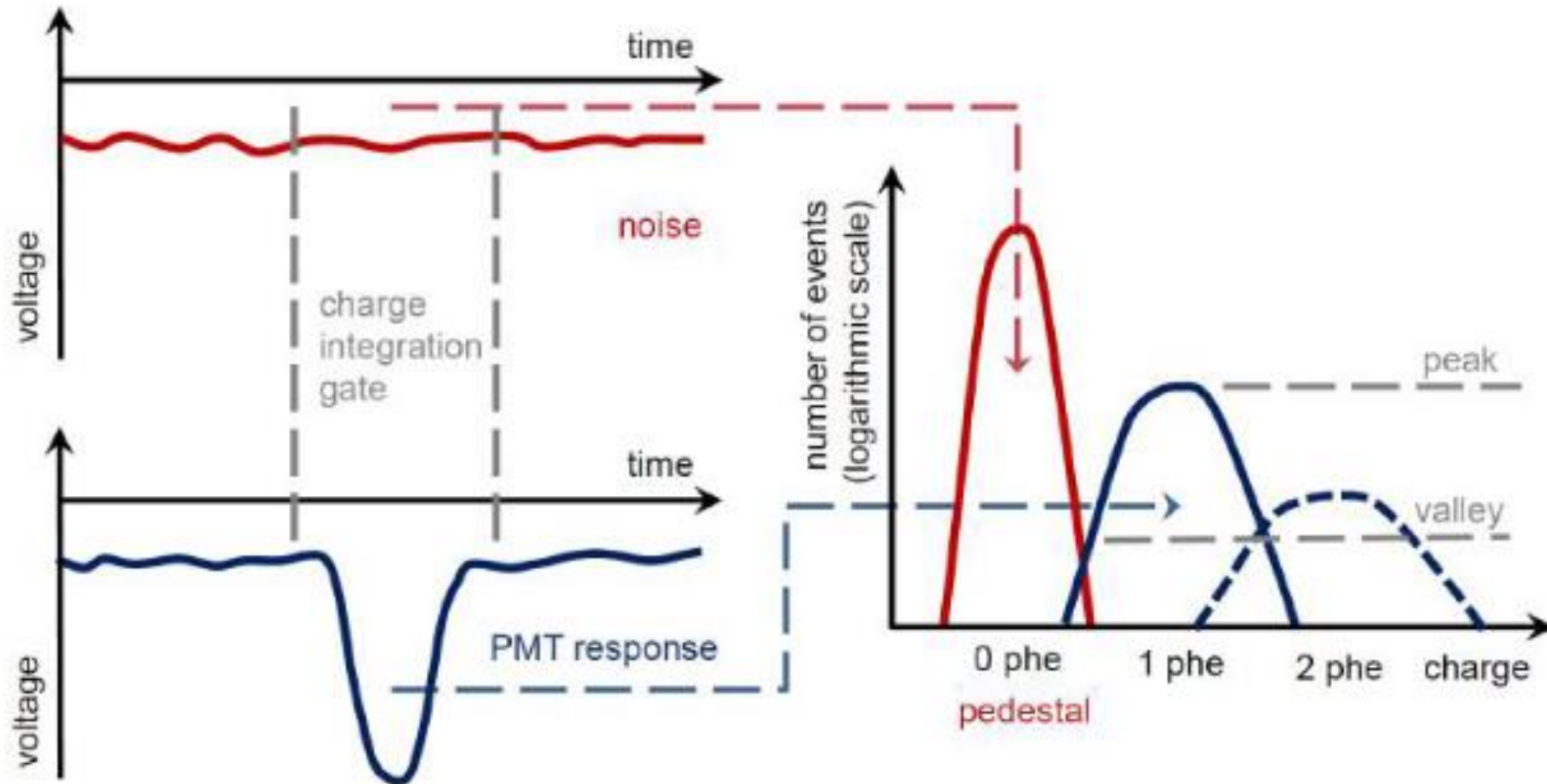


With noise

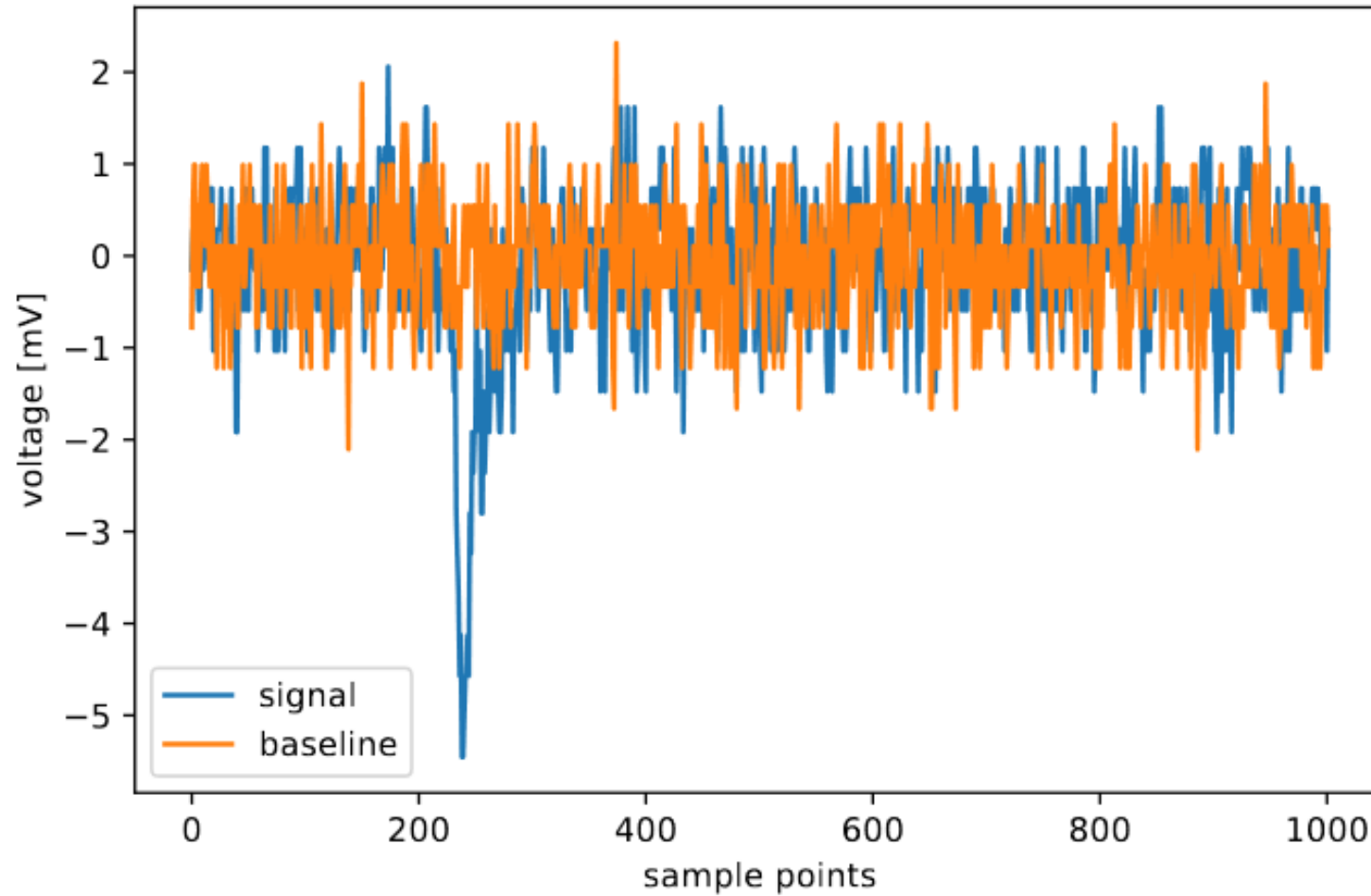
Photomultiplier tubes



PMT measurement



PMT dark rate

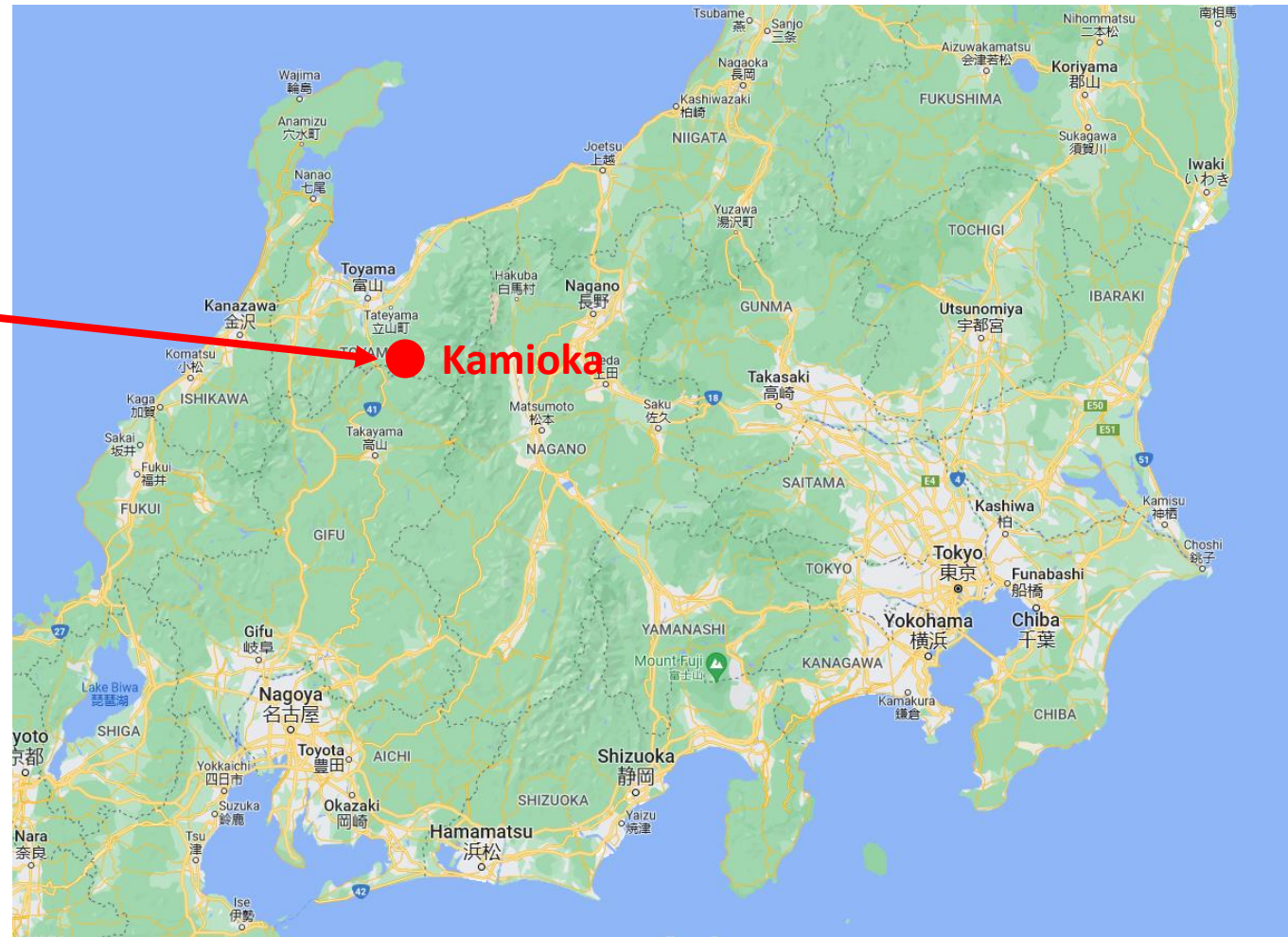


Dark rooms



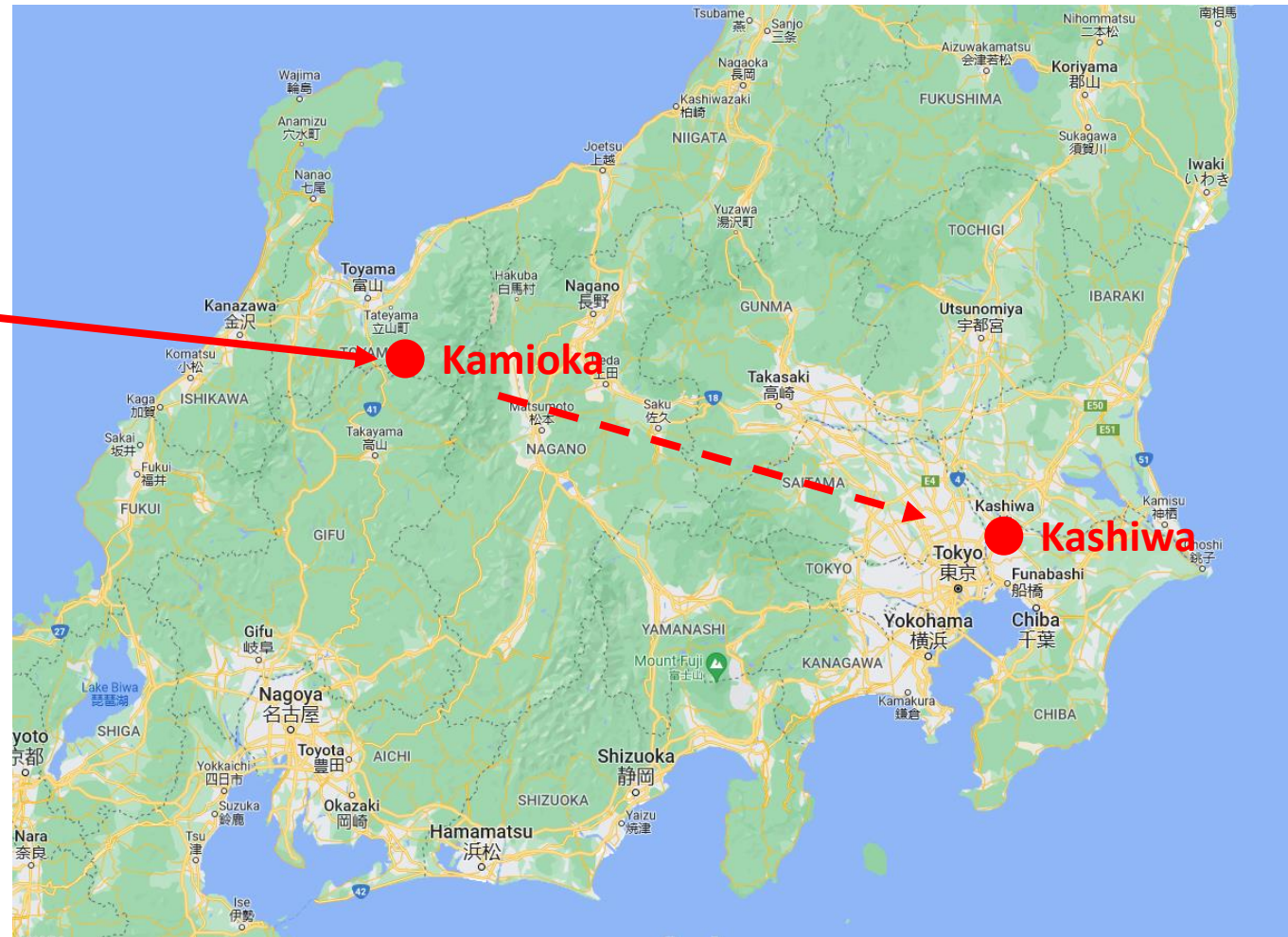
Dark rate measurements

Dark Rate = 8 kHz

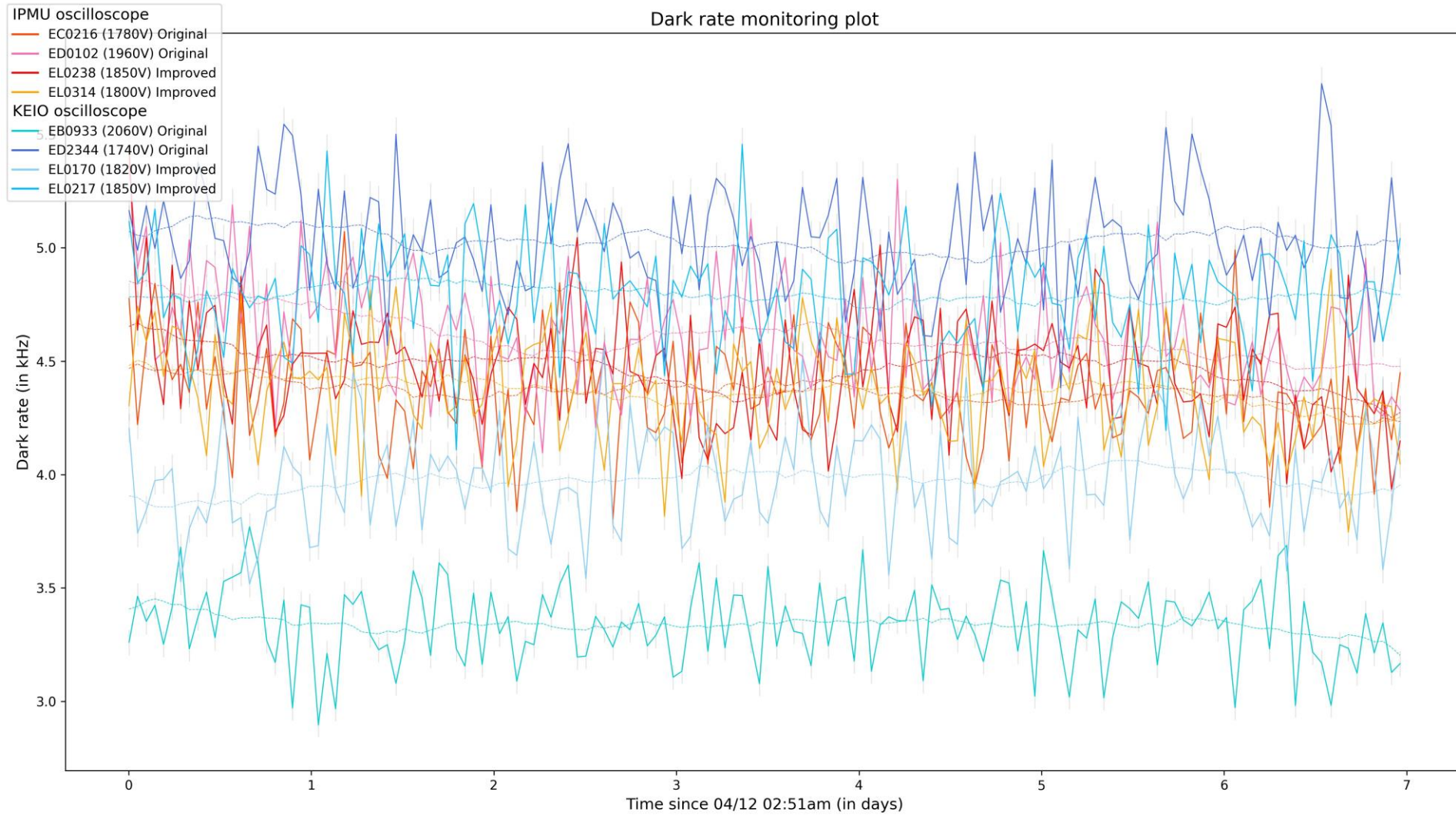


Dark rate measurements

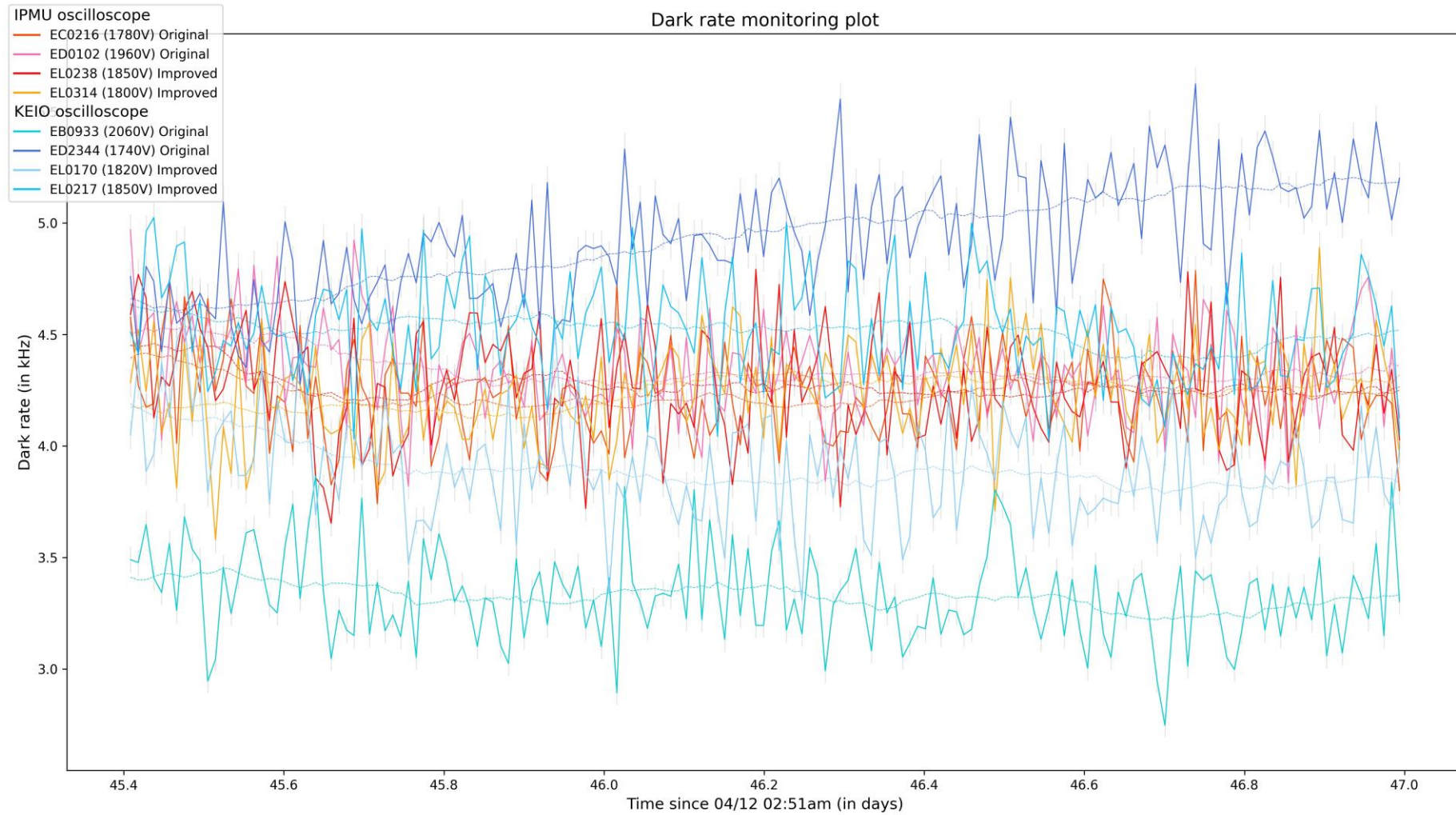
Dark Rate = 8 kHz



Dark rate monitoring

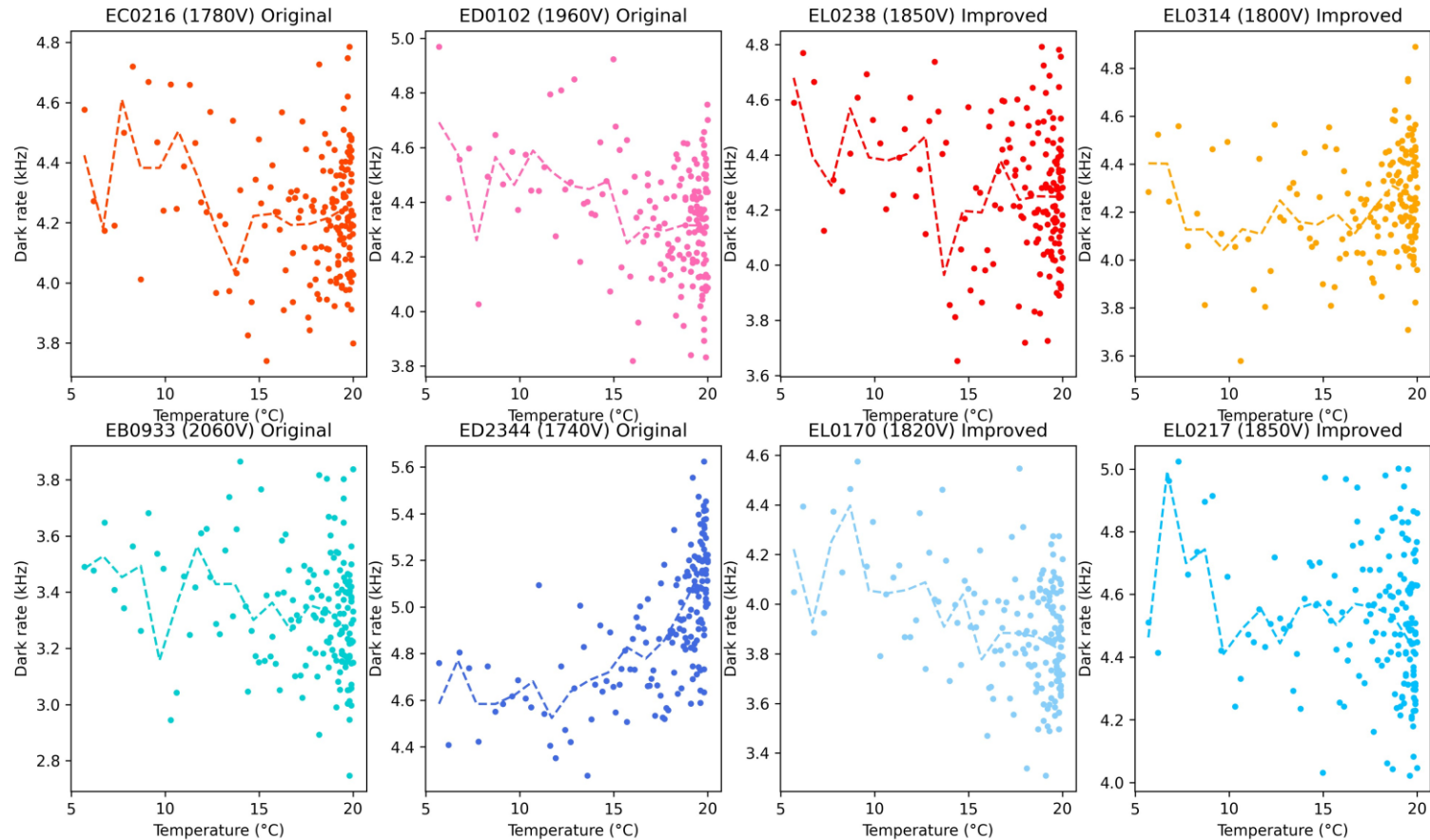


Dependance on temperature

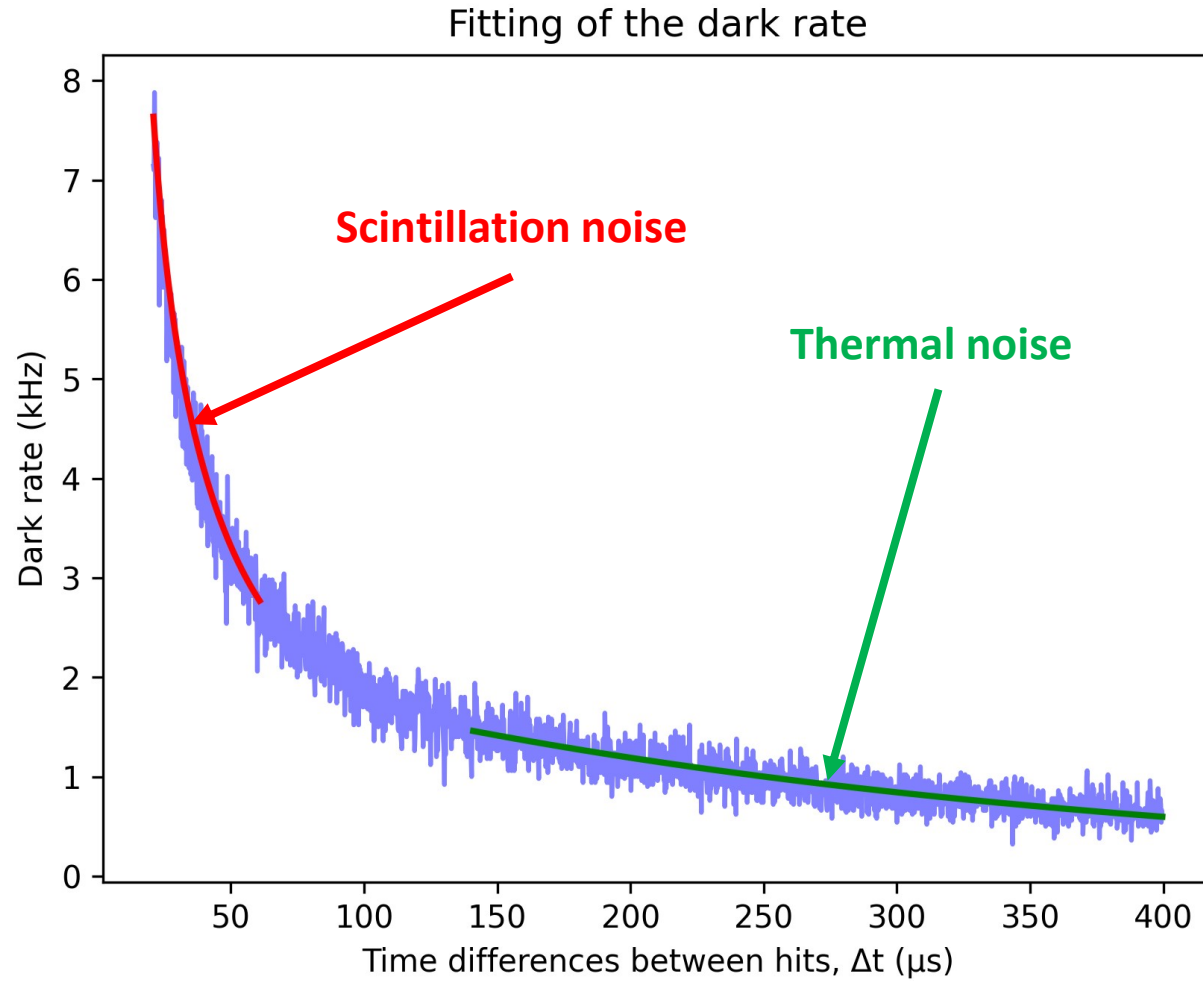


Dependence on temperature

Correlation plot between temperature and dark rate

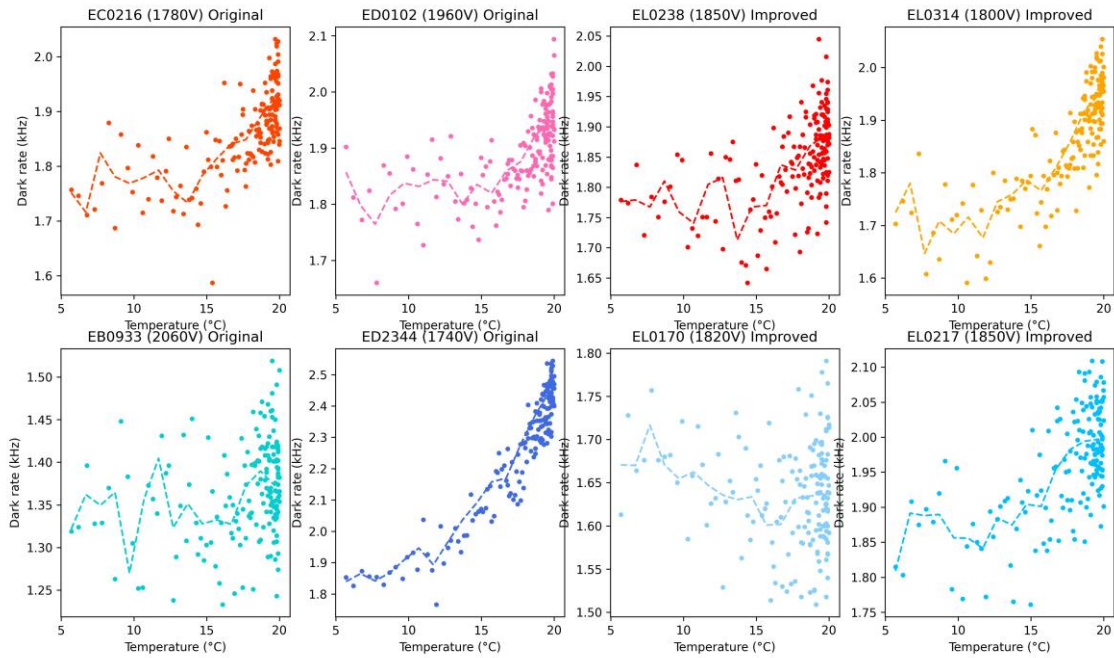


Dark rate separation

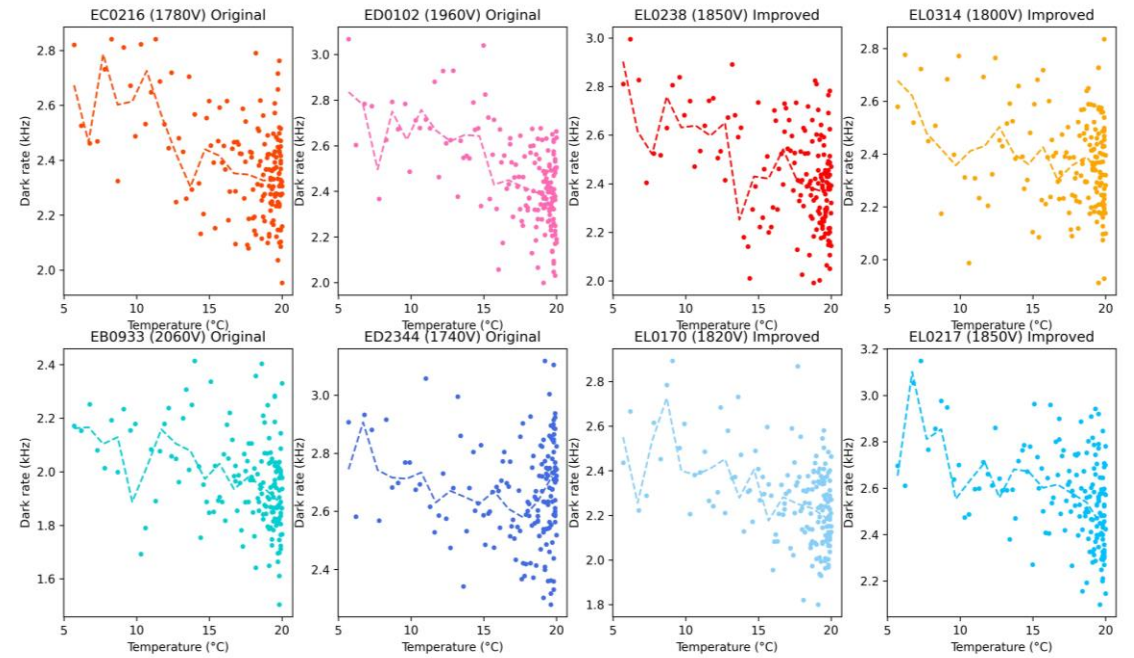


Correlations after separation

Correlation plot between temperature and dark rate (for $\Delta t > 50\mu\text{s}$ hits)



Correlation plot between temperature and dark rate (for $\Delta t < 50\mu\text{s}$ hits)

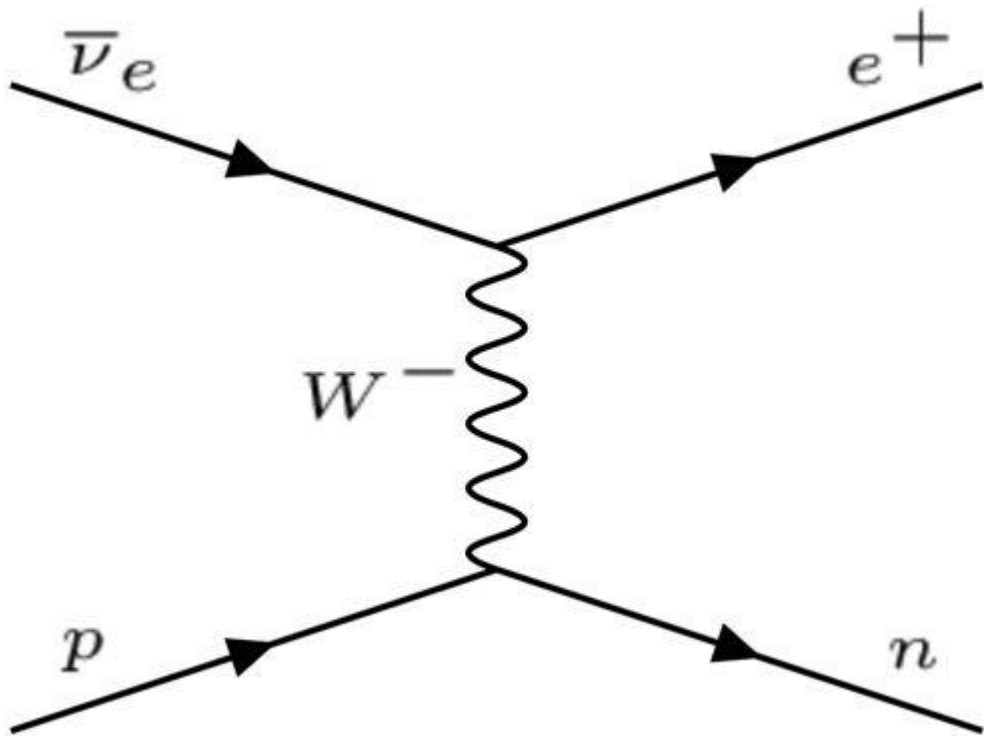


Conclusion on PMT dark rate

- Random noise in the PMT signal generate *fake hits*
- This noise is characterized by the **dark rate**
- 2 origins for the dark rate :
 - Thermal electrons : purely random, depends on electronics
 - Scintillation : correlated hits, depends on PMT glass
- Everything is fine for Hyper-K

Neutron tagging with graph neural networks

Inverse beta decay



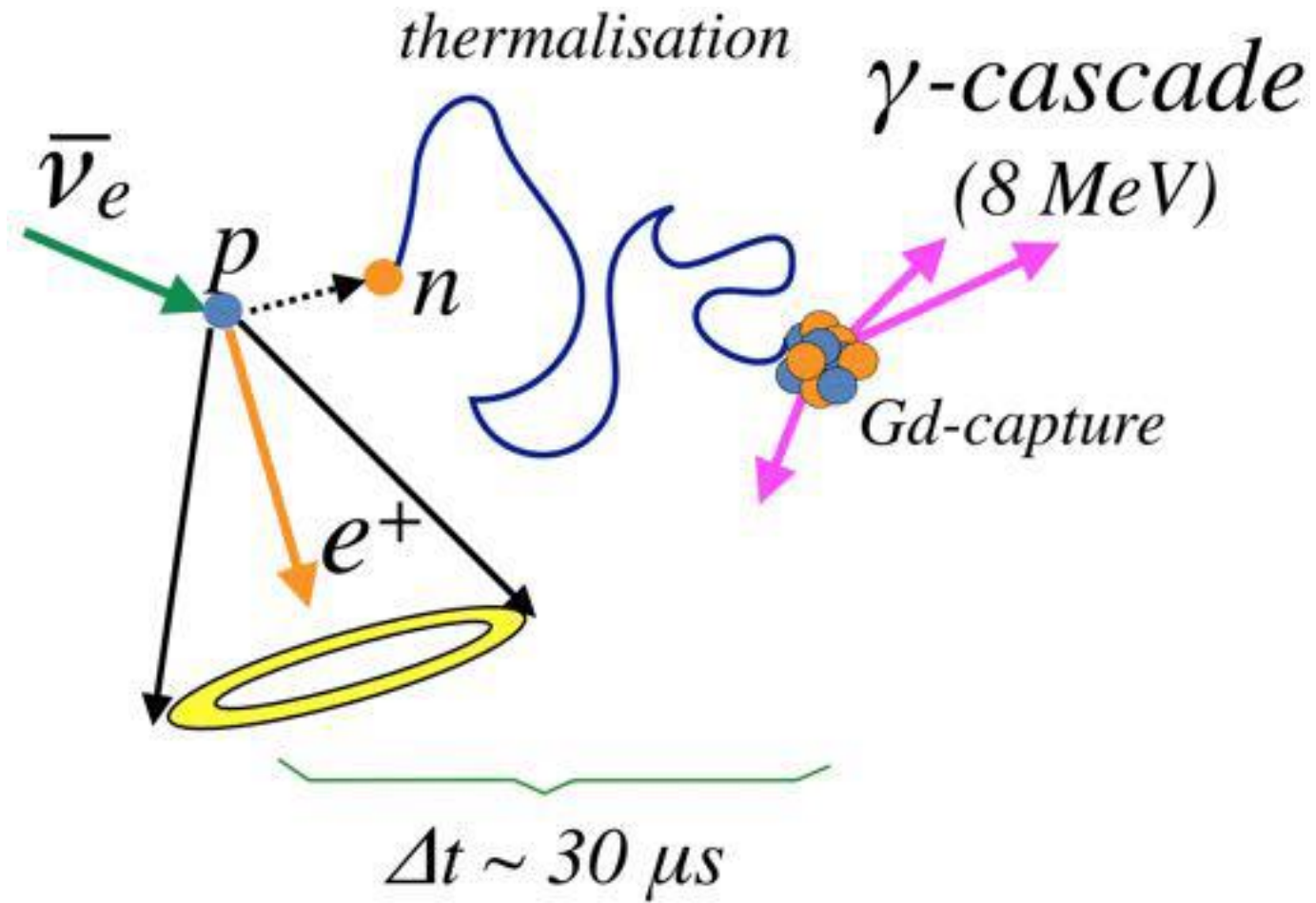
- Neutrino induced :

$$\nu_e + n \rightarrow e^- + p$$

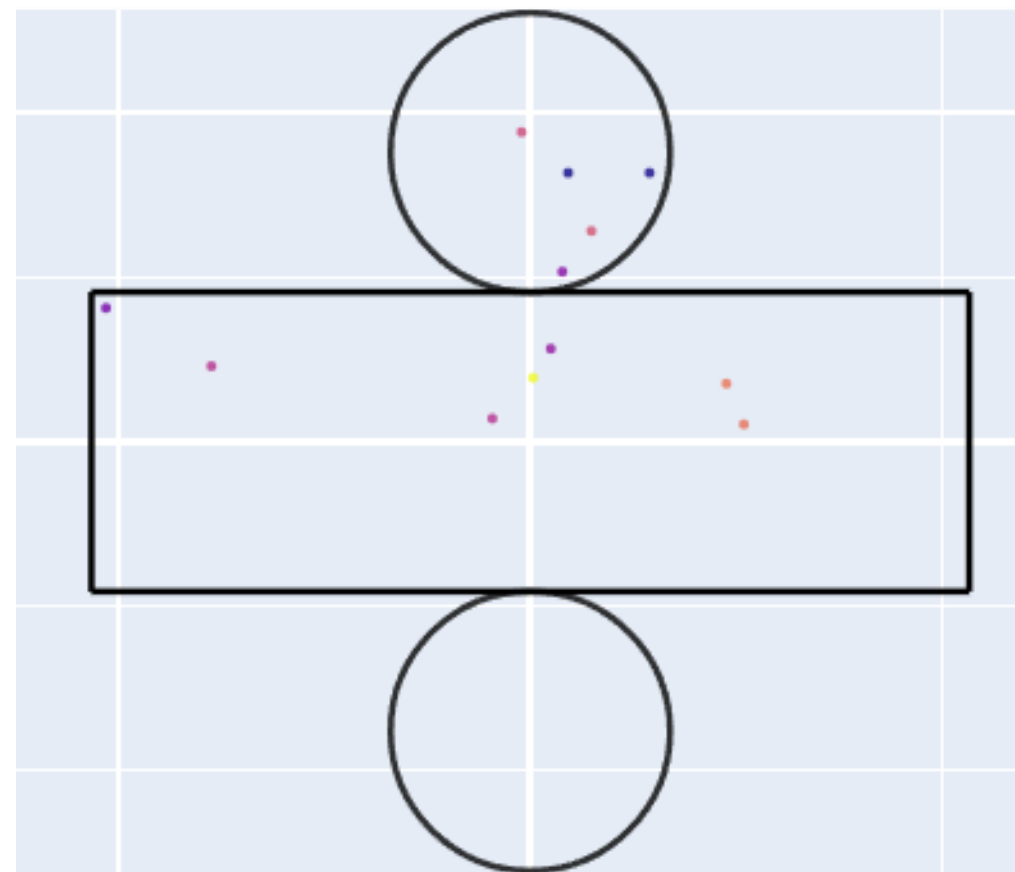
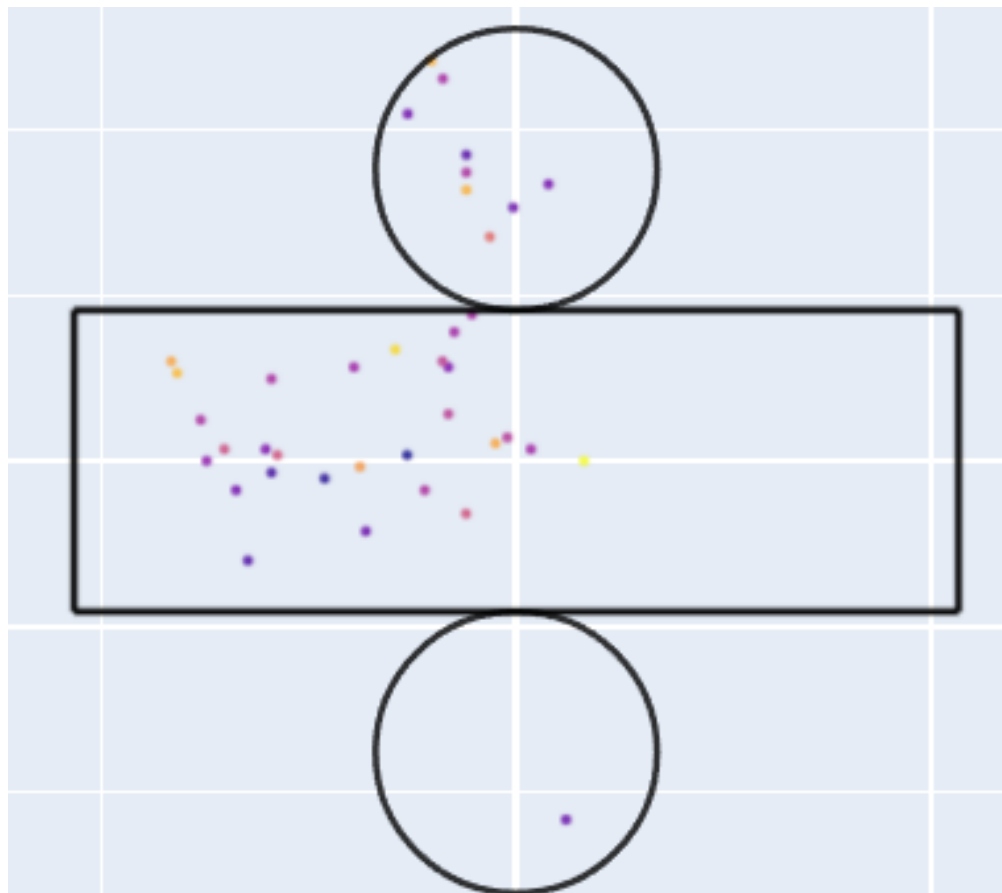
- Antineutrino induced :

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

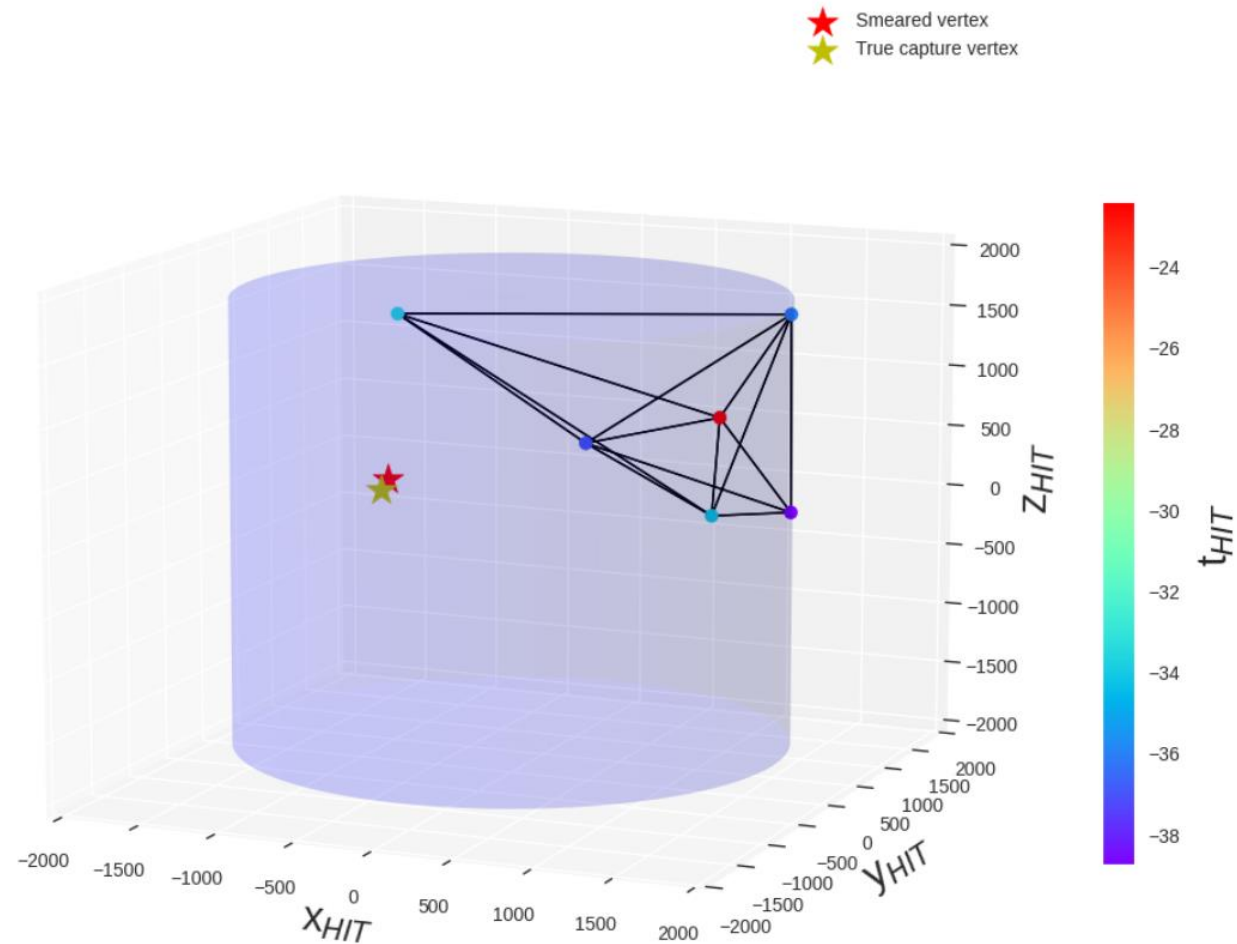
Neutron capture



Neutron capture events



Graph neural networks



Conclusion on neutron tagging

- Neutron tagging helps identify anti-neutrinos events
- Neutron tagging is hard due to PMT noise
- Graph neural networks perform well for this task
- Results incoming...