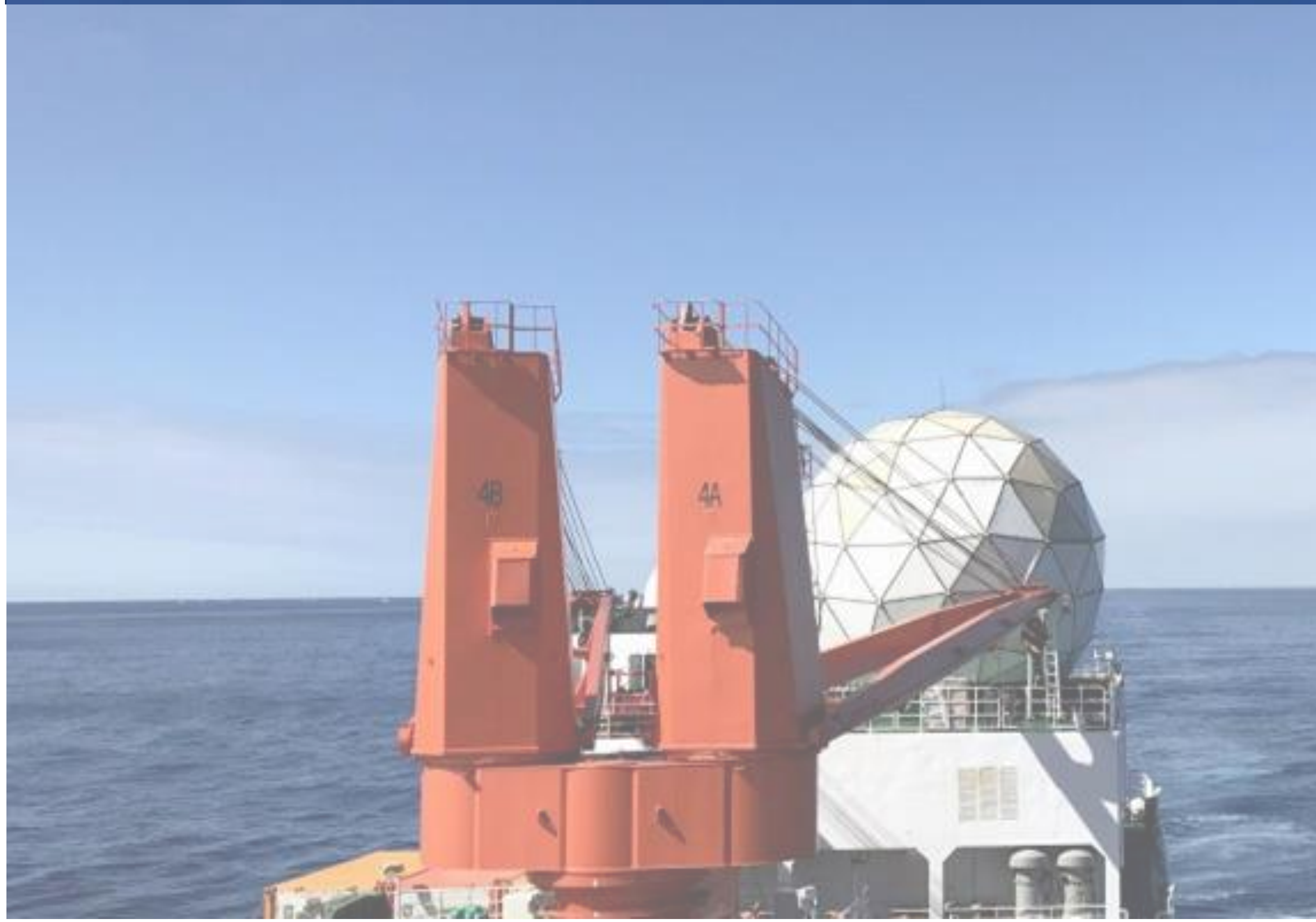
Analysis of the Changvan Neutron Monitor Operation in Latitude Surveys during 2019-2020

Sidarat Khamphakdee

Assistant Professor Dr. Waraporn Nuntiyakul

Department of Physics and Materials Science, Faculty of Science, Chiang Mai University

OUTLINE

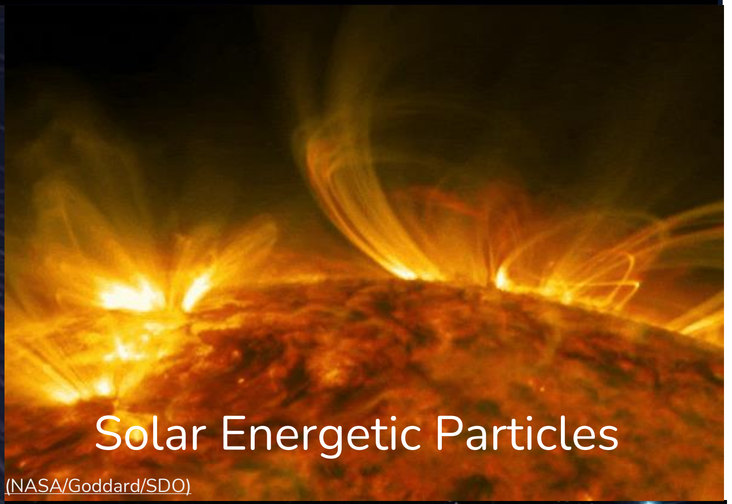


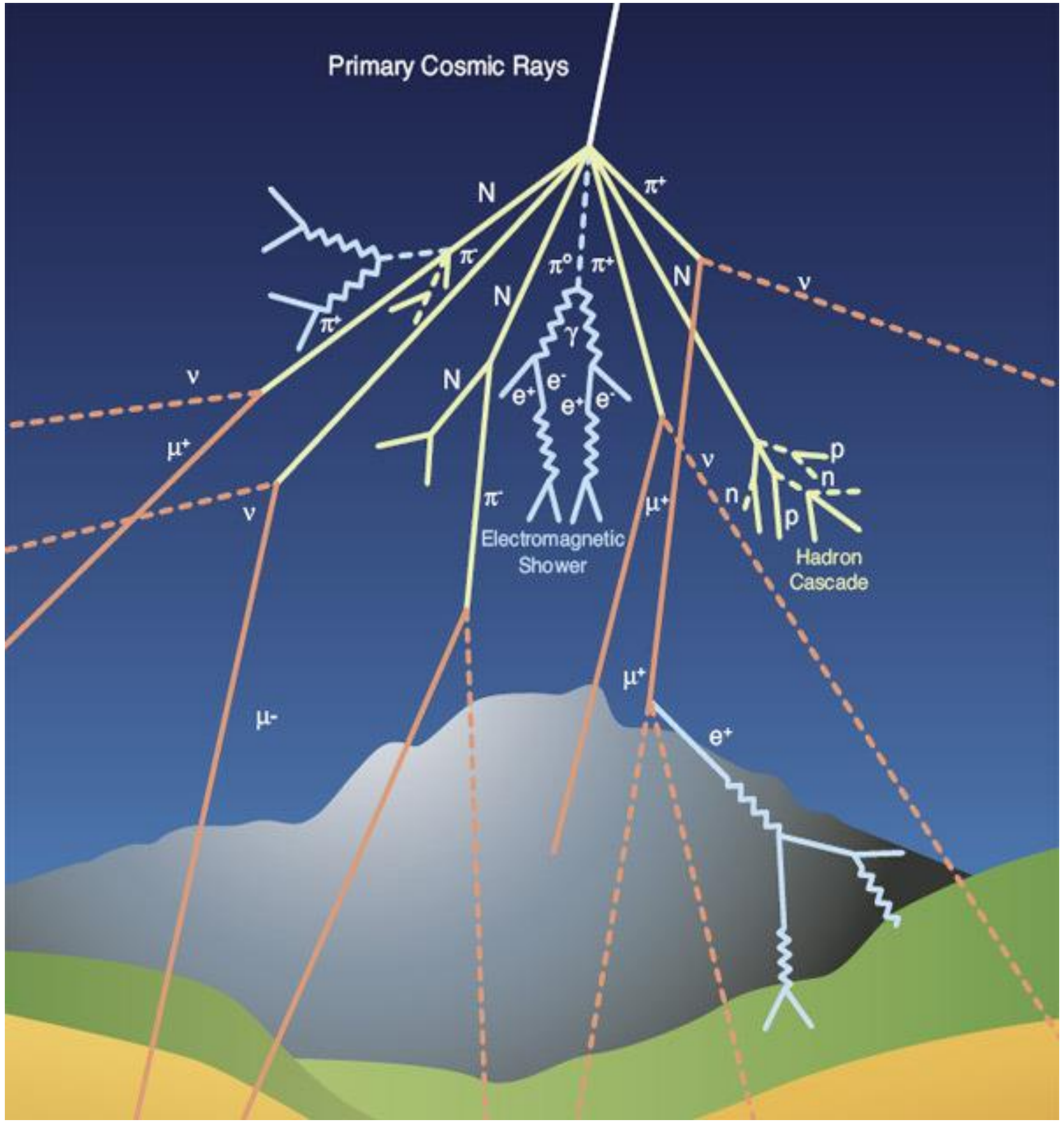
- **Introduction**
  - Cosmic Rays
  - Neutron Monitor
  - Changvan
  - Latitude Survey
- **Data Reduction**
- **Response Function**
- **Future Work**

INTRODUCTION

COSMIC RAYS

- Cosmic rays are high-energy particles composed of 90% protons, 9% alpha particles, and about 1% heavier nuclei.
- Cosmic rays move nearly light speed.
- Cosmic rays are divided into three main types based on their source and energy range.





COSMIC RAYS

- Primary cosmic rays are composed mainly of protons and alpha particles, with a small amount of heavier nuclei
- Upon impact with the Earth's atmosphere, cosmic rays can produce showers of secondary particles that sometimes reach the surface.

Changvan Neutron Monitor

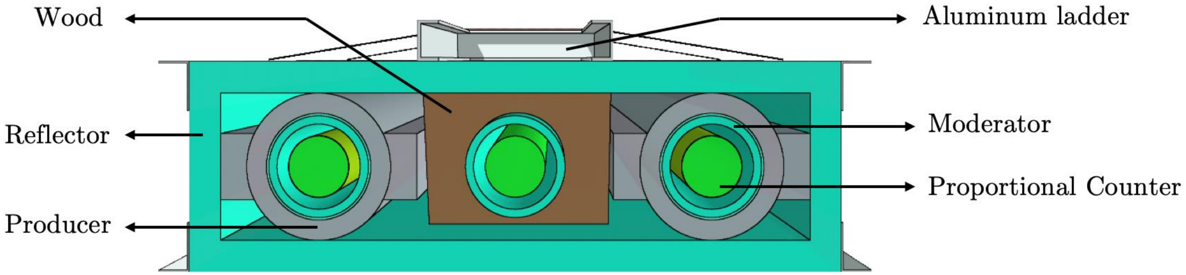
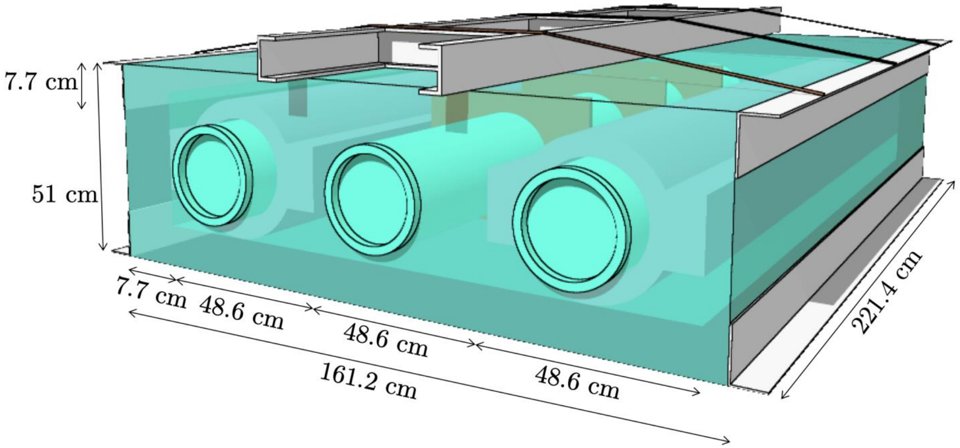
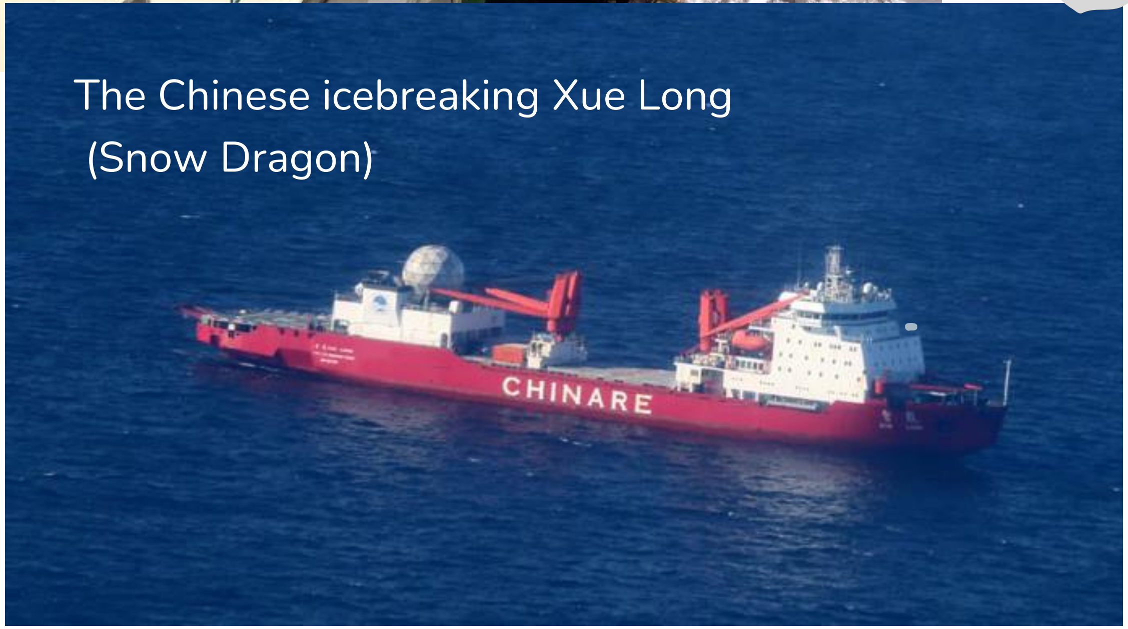


Image by Kanokkarn Fongsamut

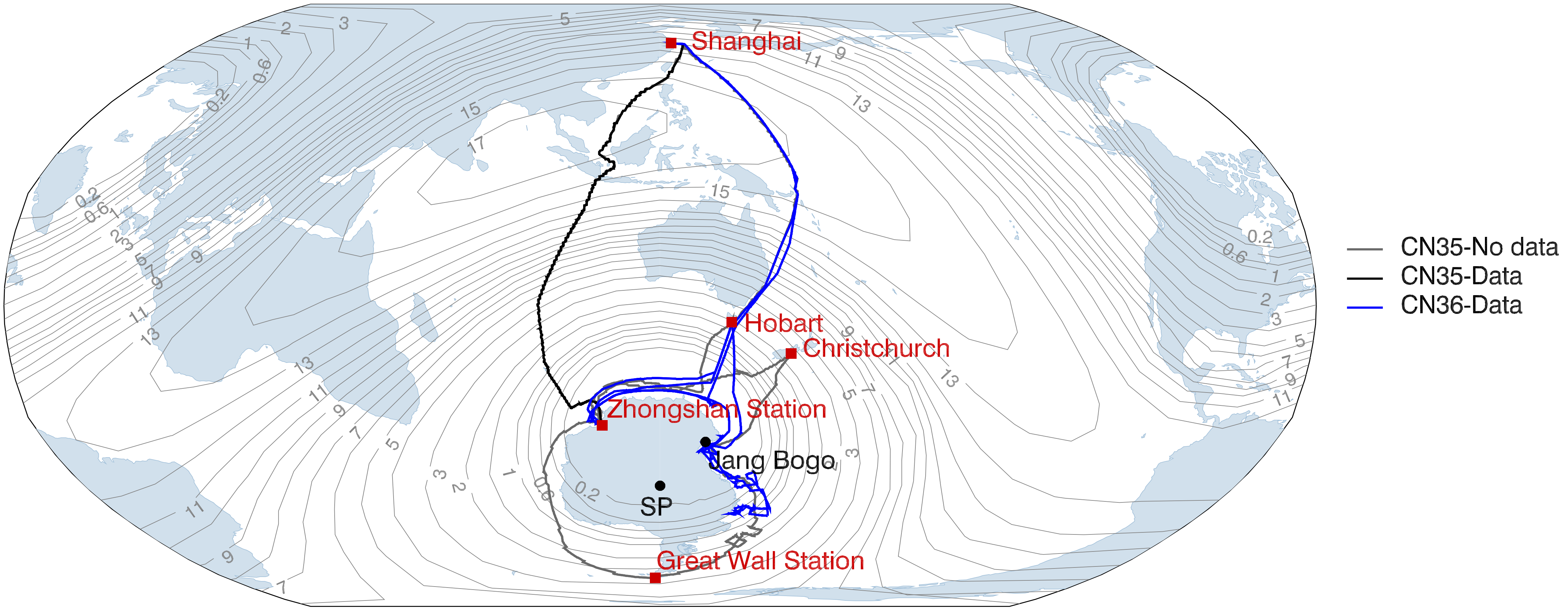




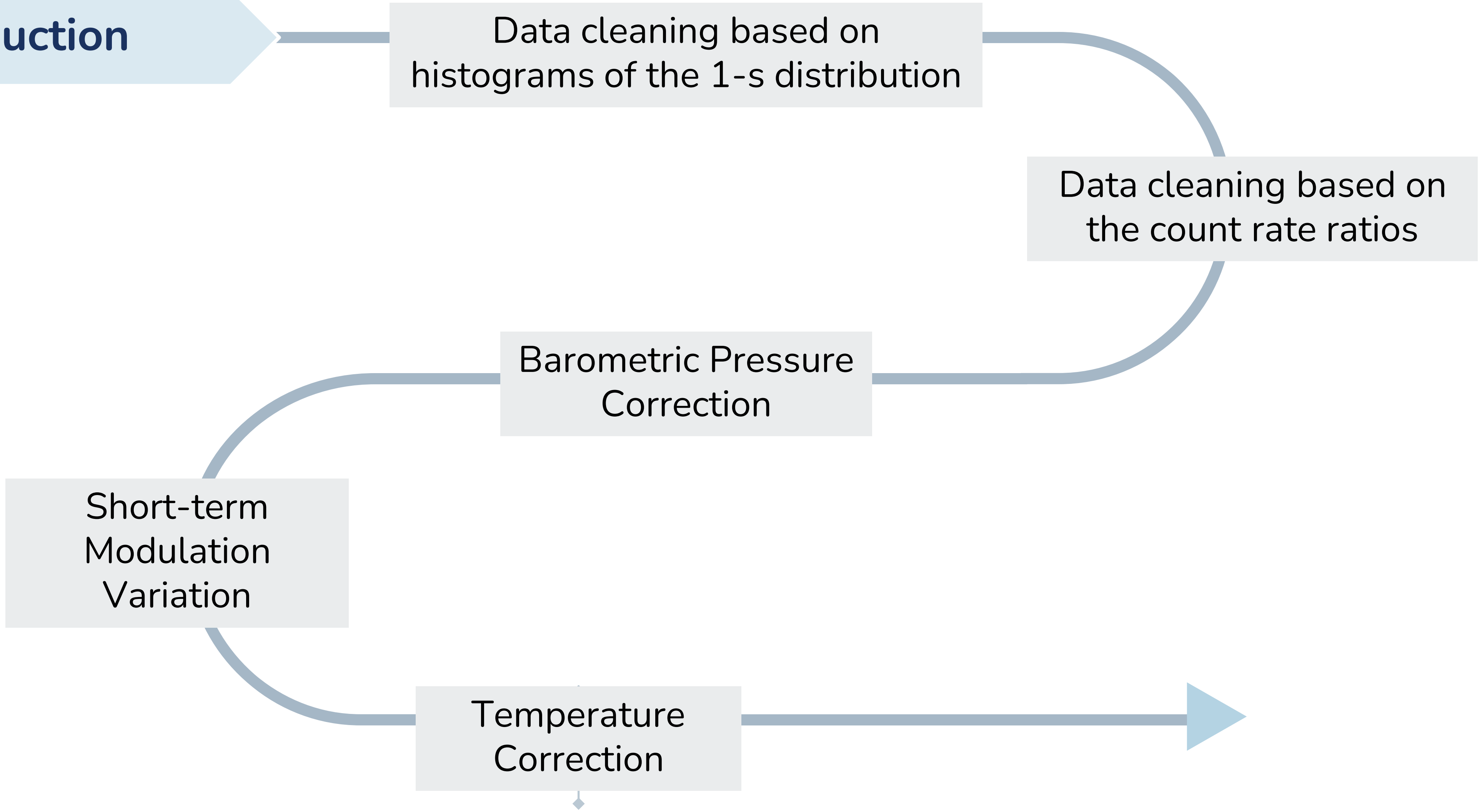
The Chinese icebreaking Xue Long
(Snow Dragon)

Latitude Surveys in 2018-2020

Latitude Surveys in 2018-2020



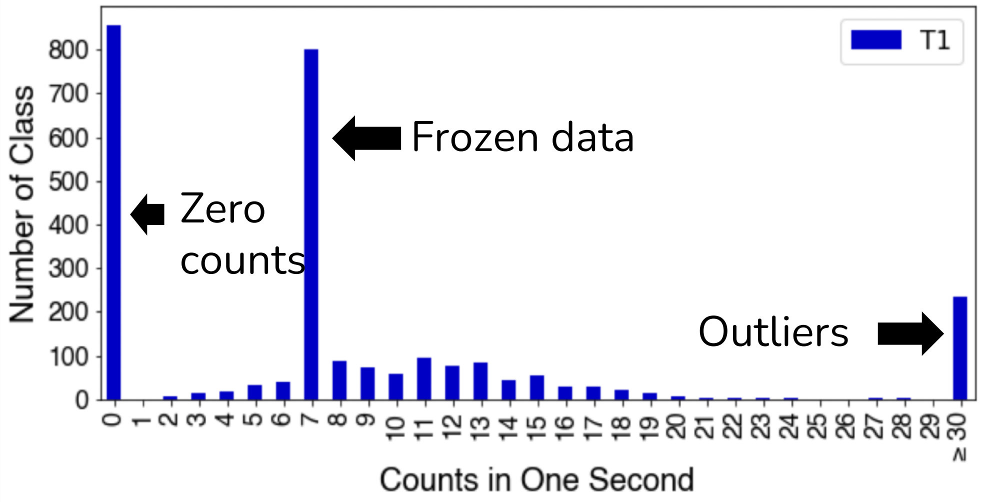
Data Reduction



Data cleaning based on histograms of the 1-second distribution

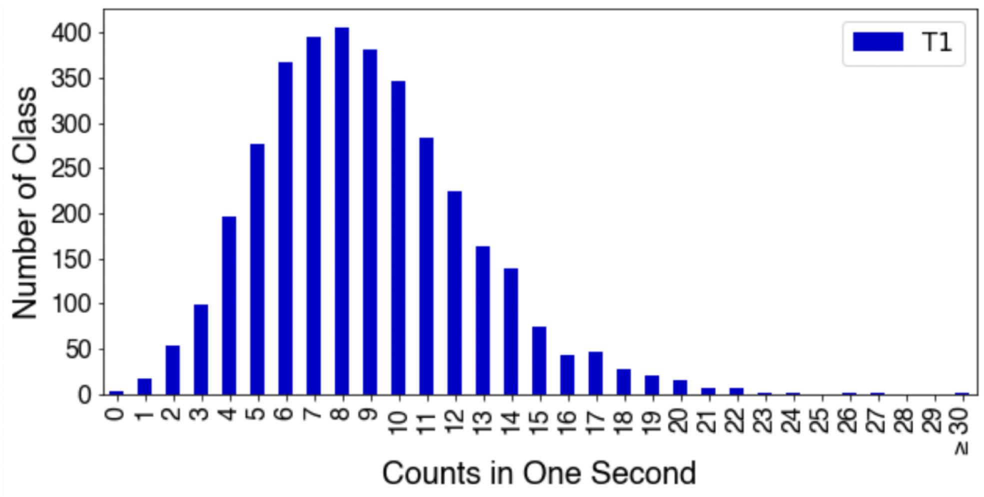
Distribution of a bad hours

- Obvious outliers >30 counts in the second
- Repeated counts consecutively 3 seconds (frozen data)
- All counts from three tubes appeared zero



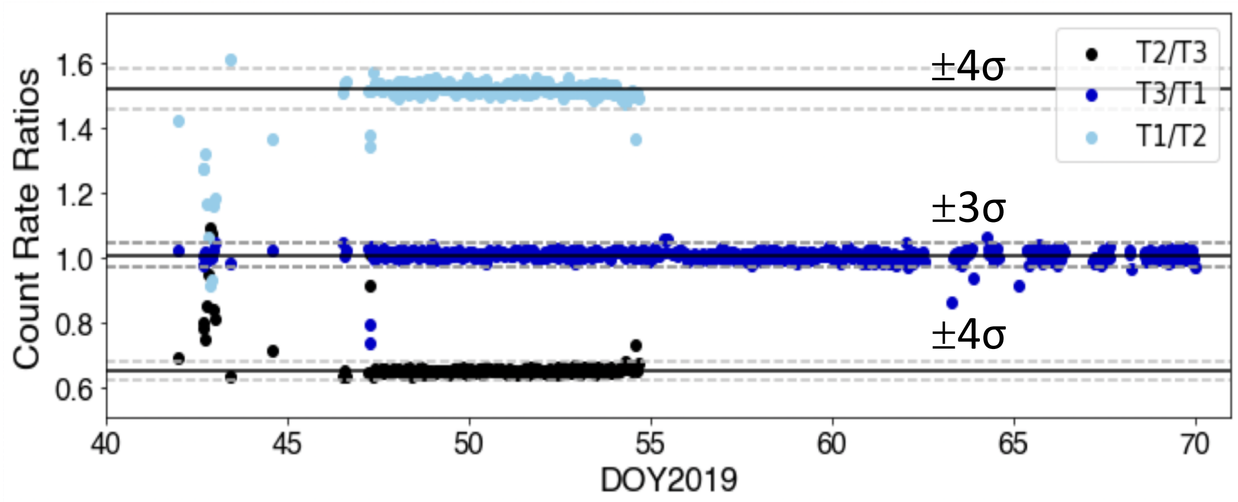
Distribution of the proper hour

- The distribution appears to be more nearly Poisson’s distribution



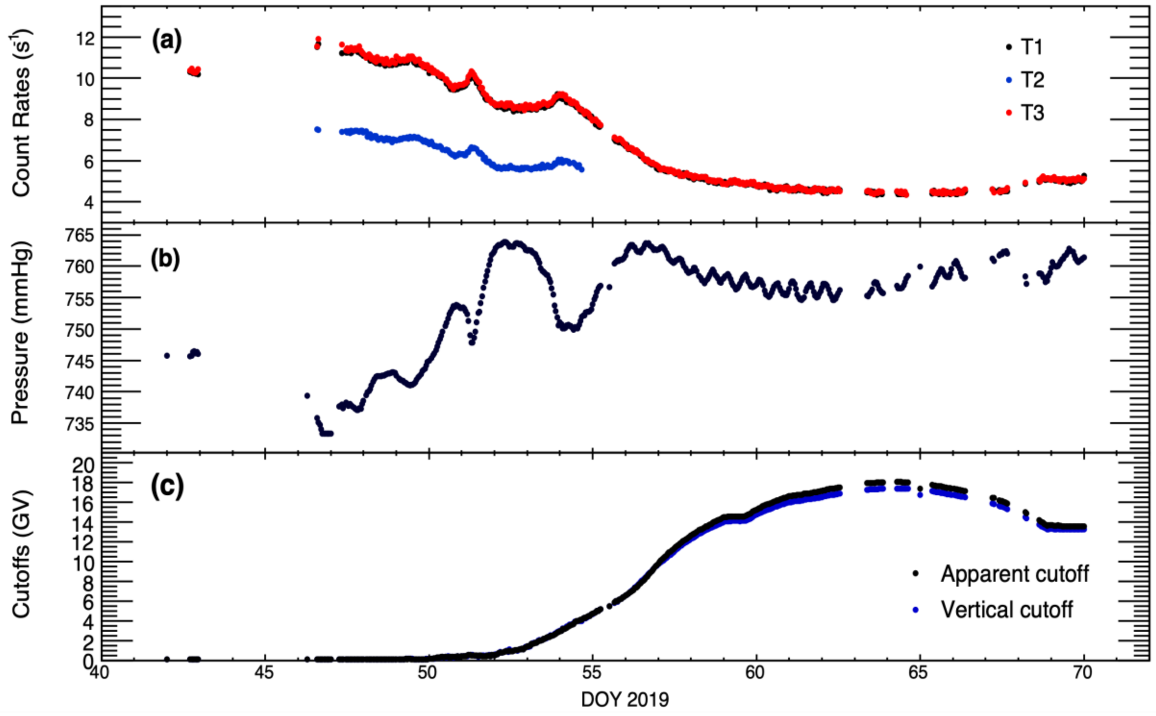
Data cleaning based on the count rate ratios

Survey Year 2019 (CN35)

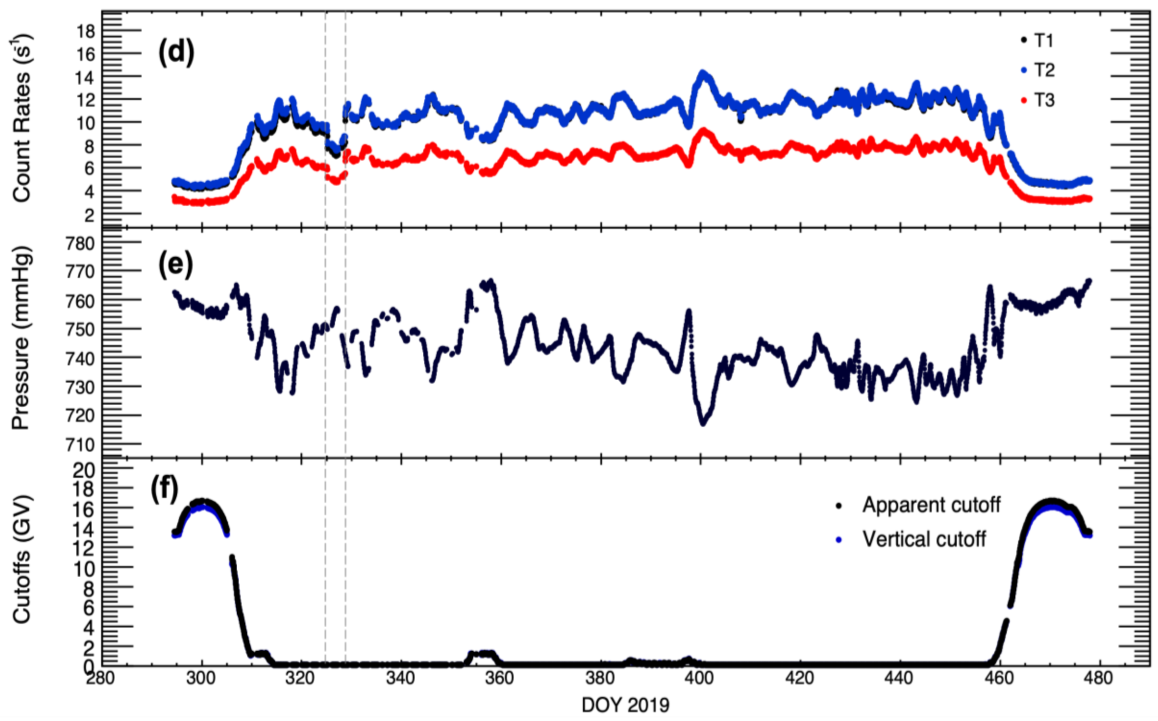


The horizontal black solid line
the mean value of the Gaussian distribution for each ratio

The grey dashed line
±4σ interval around the mean for the ratios T2/T3 and T1/T2
±3σ interval for the ratio T3/T1 (blue circle)



Survey Year 2019 (CN35)

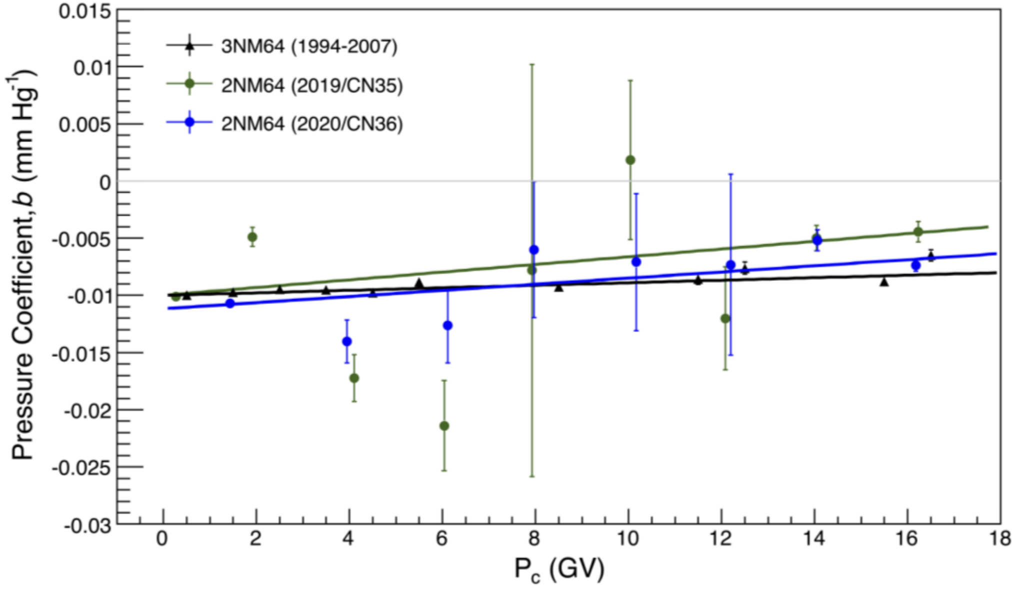


Survey Year 2020 (CN36)

BAROMETRIC PRESSURE CORRECTION

$$C = C_0 e^{-\beta(p-p_0)}$$

where C is the corrected neutron count rate for pressure, and C_0 is the uncorrected count rate. The p is the barometric pressure in units of mmHg, and p_0 is the reference barometric pressure (760 mmHg)



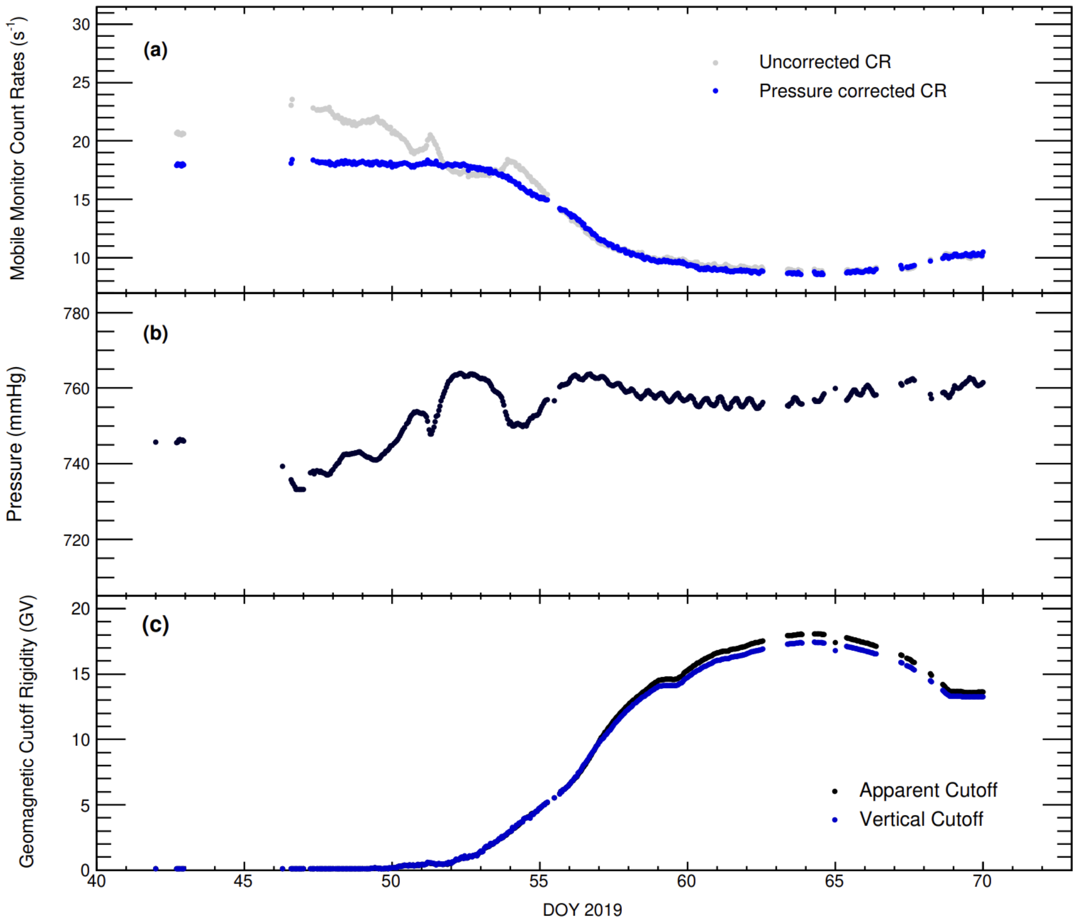
The pressure coefficient as a function of apparent cutoff Pc

$$\beta = 1.006 - 0.0153 P_c,$$ Nuntiyakul et al. (2014)

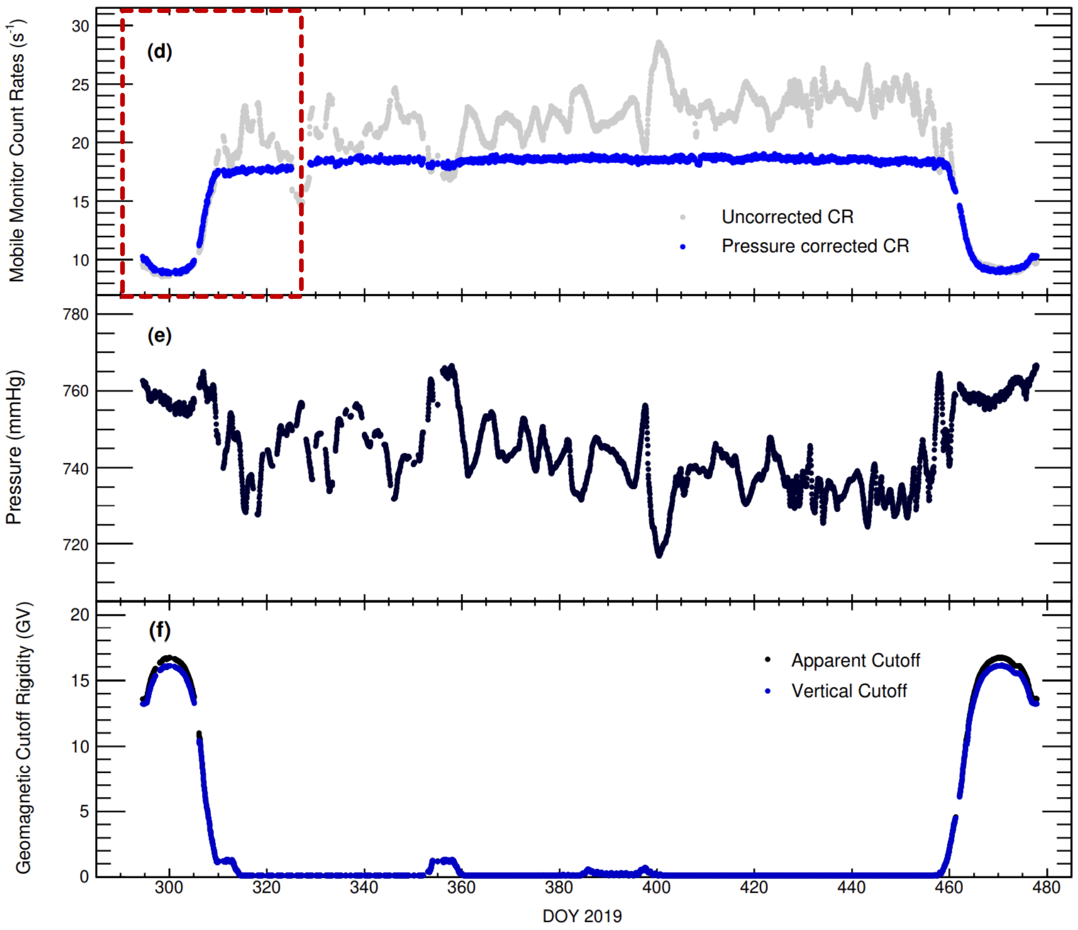
The large error bars in our data from two surveys because we have few data compared with 13 surveys from Nuntiyakul et al. (2014)

Barometric Pressure Correction

Survey Year 2019 (CN35)



Survey Year 2020 (CN36)



Short-term Modulation Variation

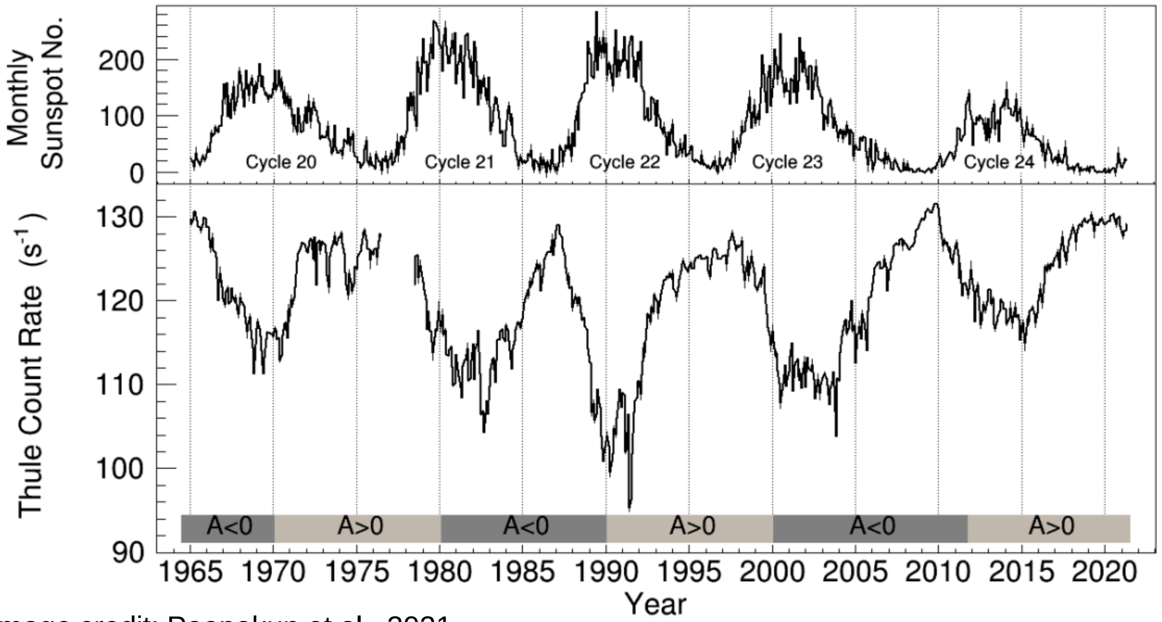
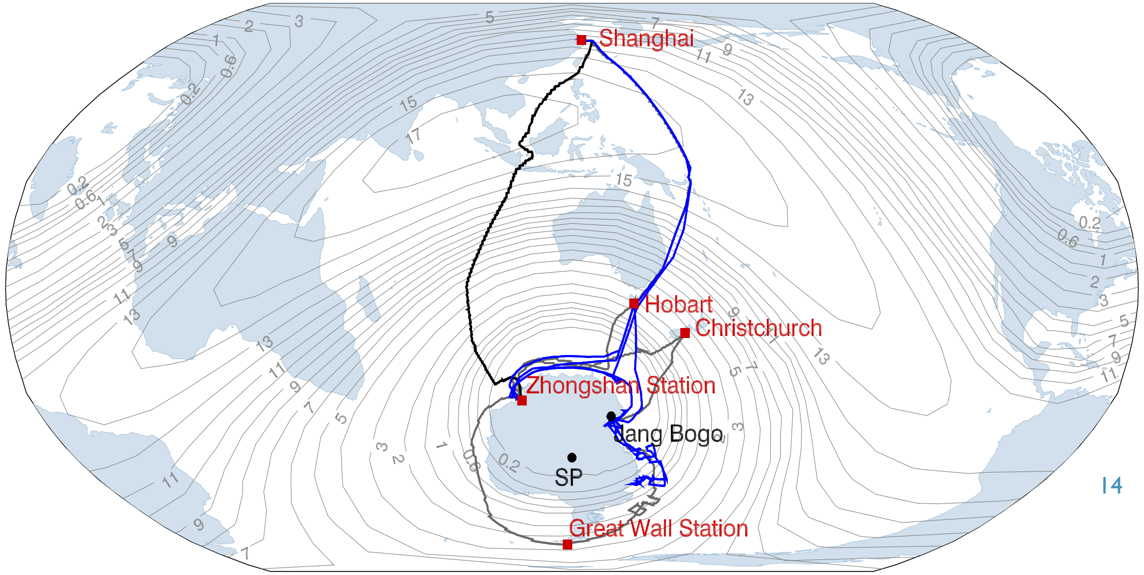


Image credit: Poopakun et al., 2021

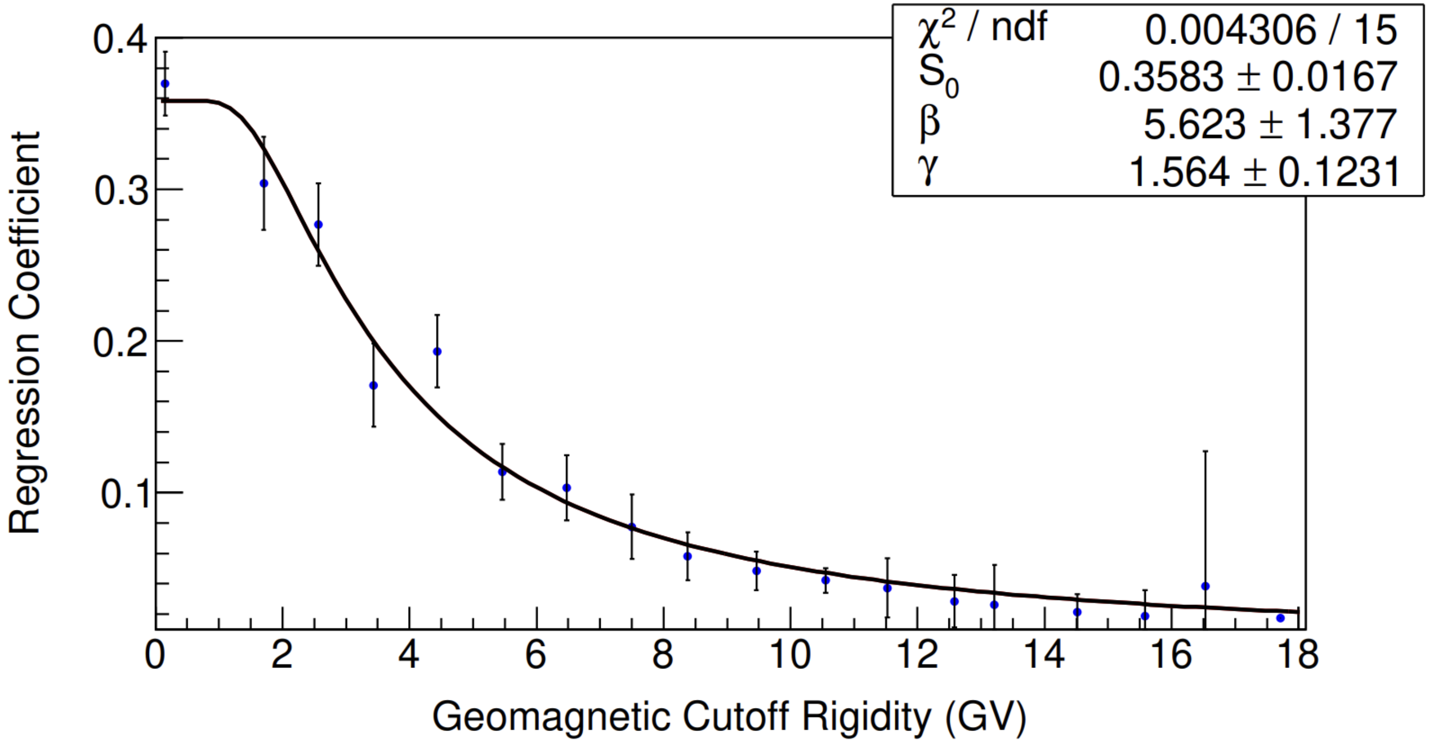
Solar modulation impacts the intensity of galactic cosmic rays. Solar modulation is typified by significant 11-year variations, the count rate recorded by the neutron monitor in Thule decreases (bottom panel).

In survey year 2019, the ship passed equator in the same route We then designed to calibrate northbound ship-borne data for the count rate of 2NM64 from the ratios of mobile with the southbound data when the ship passing the equator with the apparent cutoff from 16.30 GeV to 16.35 GeV. We obtained the normalization factors throughout the way back after 24 November 2019 for T1, T2, and T3 are 1.06022, 1.04353, and 1.03016, respectively.



Data scaling with 13 survey years in 2014-2007

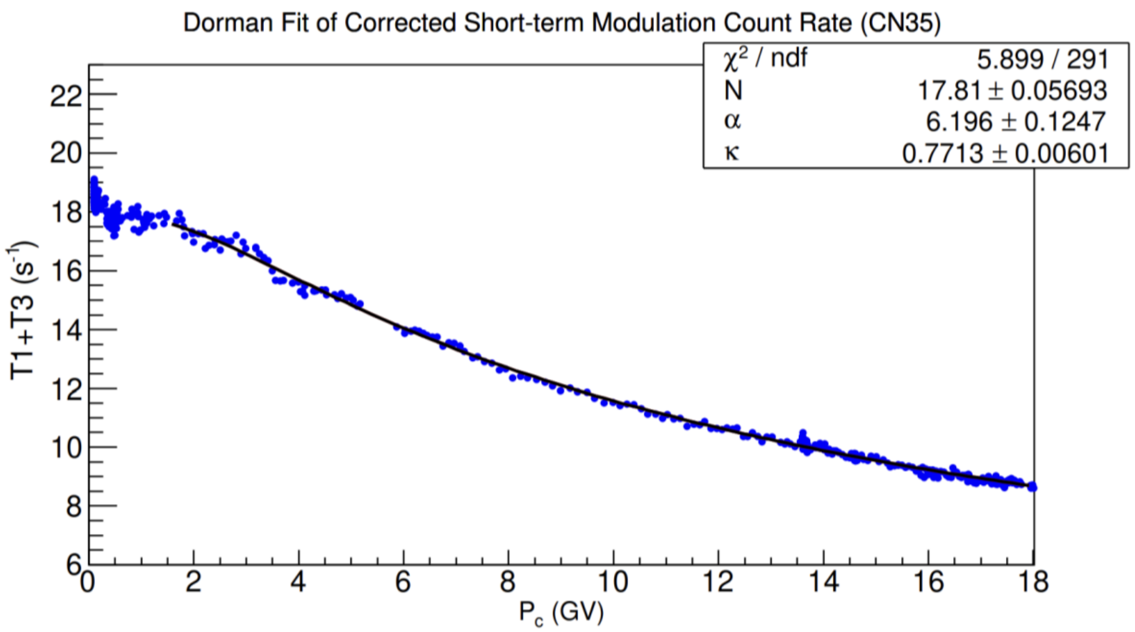
The scale factors from mobile monitor Tasvan used to apply in our data from latitude survey 2018-2020. We used the factor 1.8100 for scaling mobile Changvan data and 3.1603 for count rate data from Mawson station.



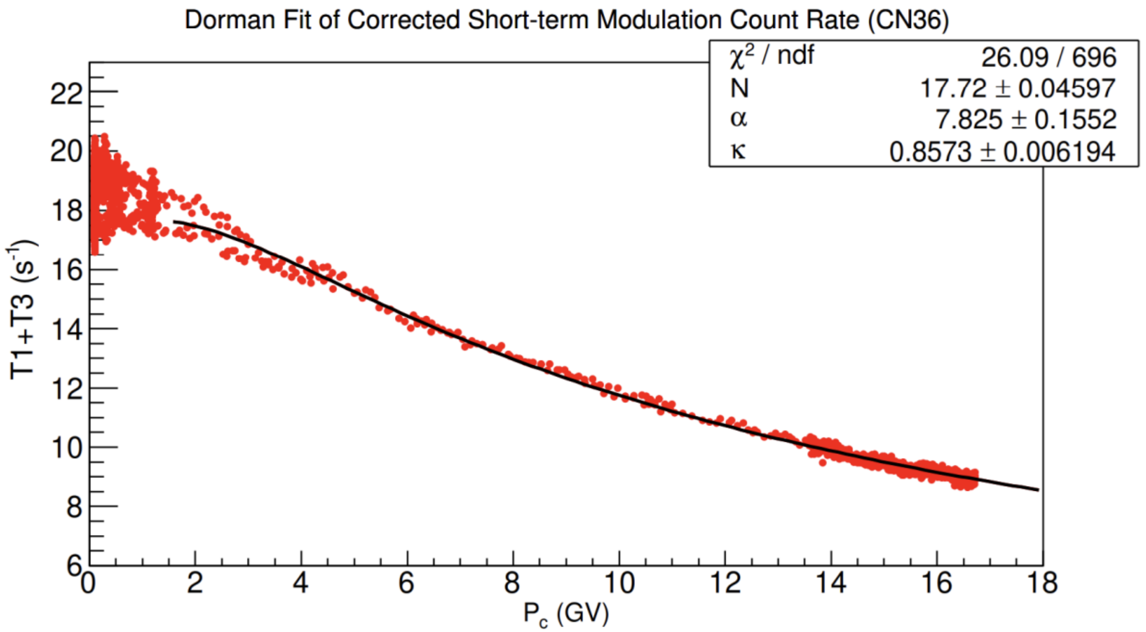
$$S = S_0\left(1 - e^{-\beta P_c^{-\gamma}}\right)$$

$$C_{PM} = C_P - S(m - \overline{m})$$

where C_{PM} is the normalized mobile monitor count rate corrected for pressure and short-term variations. The m is the fixed-station count rate, and $\overline{m}$ is the average count rate



Survey Year 2019 (CN35)



Survey Year 2020 (CN36)

RESPONSE FUNCTION

- **Integral response function**

The count rate (corrected for pressure) as a function of apparent cutoff rigidity.

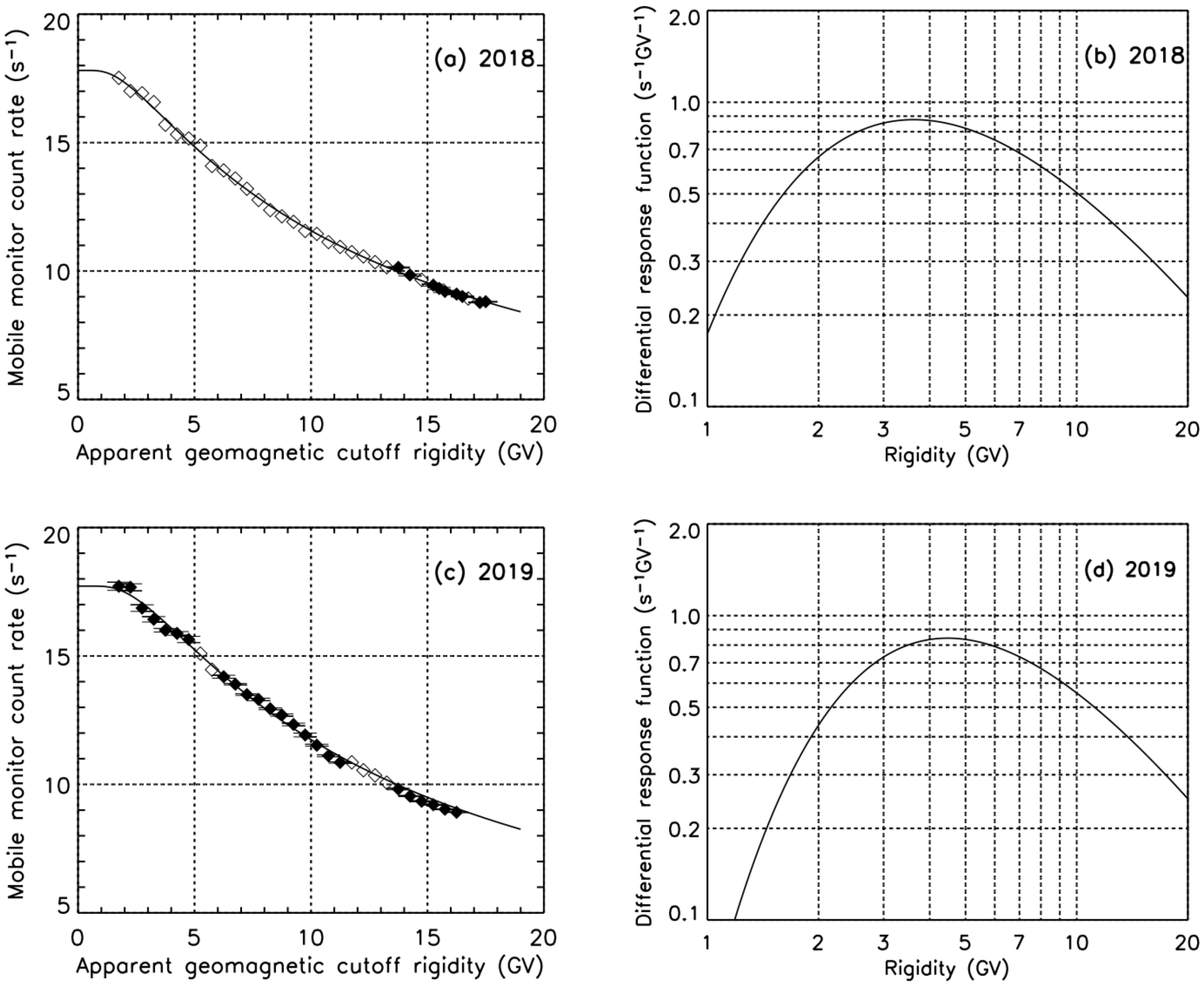
- **Differential response function (DRF)**

$$N(P_c) = \int_{P_c}^{\infty} DRF(P)dP$$

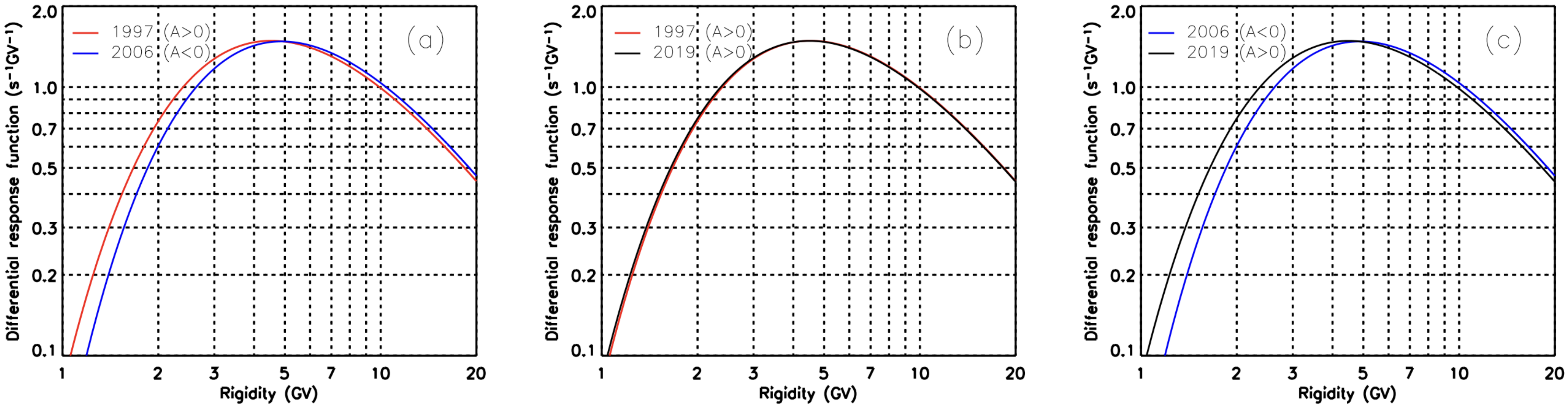
$$DRF = N_0 \alpha \kappa P^{-\kappa-1} \left(e^{-\alpha P^{-\kappa}} \right)$$

where N_0, α and κ are fitted parameters for count rate. The values of these three “Dorman parameters”

Survey Year	Name Tag	Analysis	N_0	α	κ
2018-2019	CN35	Count rate (T1+T3)	17.81	6.196	0.7713
2019-2020	CN36	Count rate (T1+T3)	17.72	7.825	0.8573


(a) 2018
Mobile monitor count rate (s⁻¹)
Apparent geomagnetic cutoff rigidity (GV)
(b) 2018
Differential response function (s⁻¹GV⁻¹)
Rigidity (GV)
(c) 2019
Mobile monitor count rate (s⁻¹)
Apparent geomagnetic cutoff rigidity (GV)
(d) 2019
Differential response function (s⁻¹GV⁻¹)
Rigidity (GV)

Crossover Analysis



FUTURE WORK

- We plan to correct the count rates based on the temperature inside counters in future work

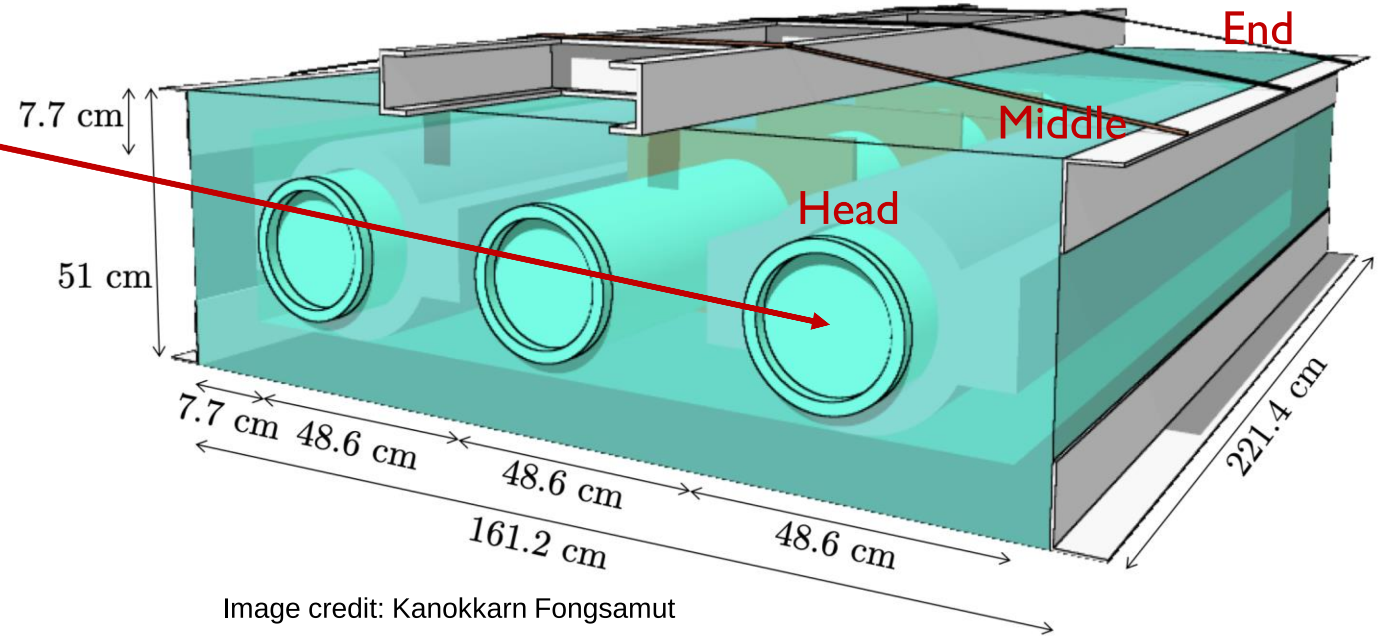
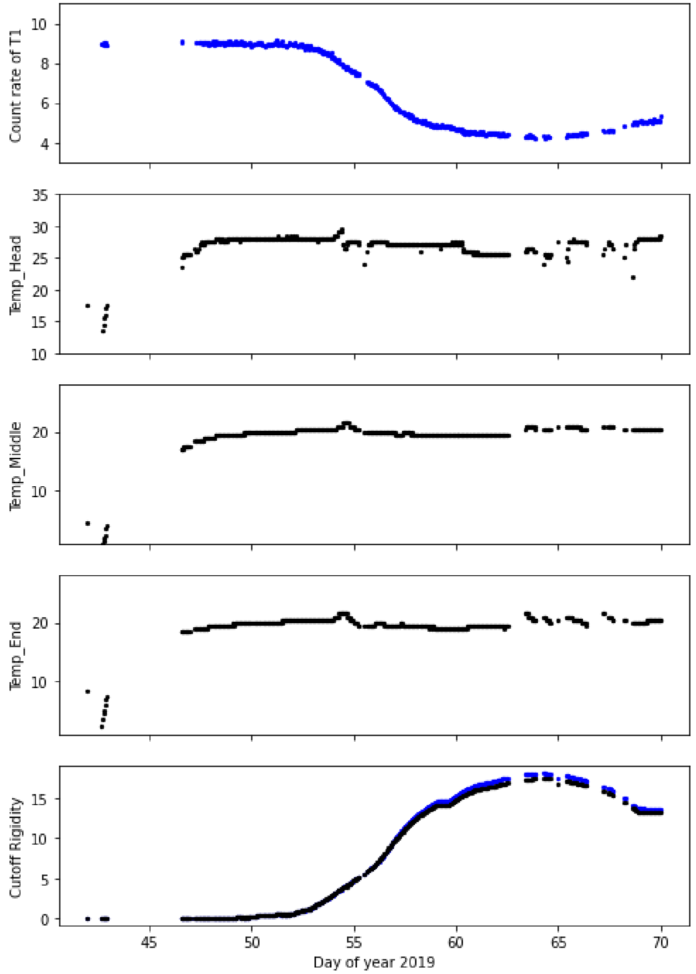
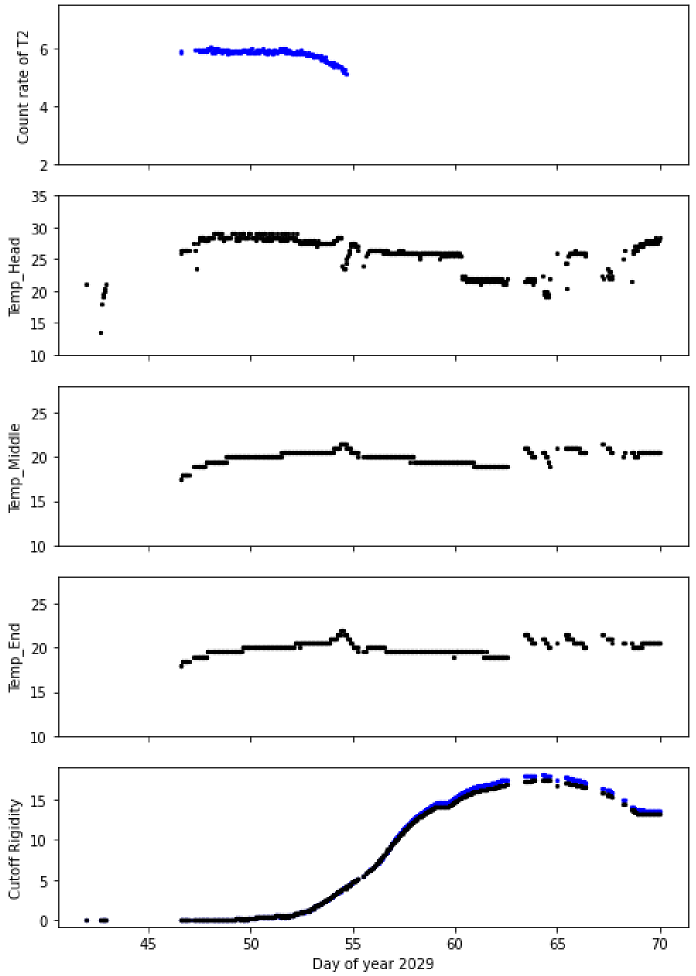


Image credit: Kanokkarn Fongsamut

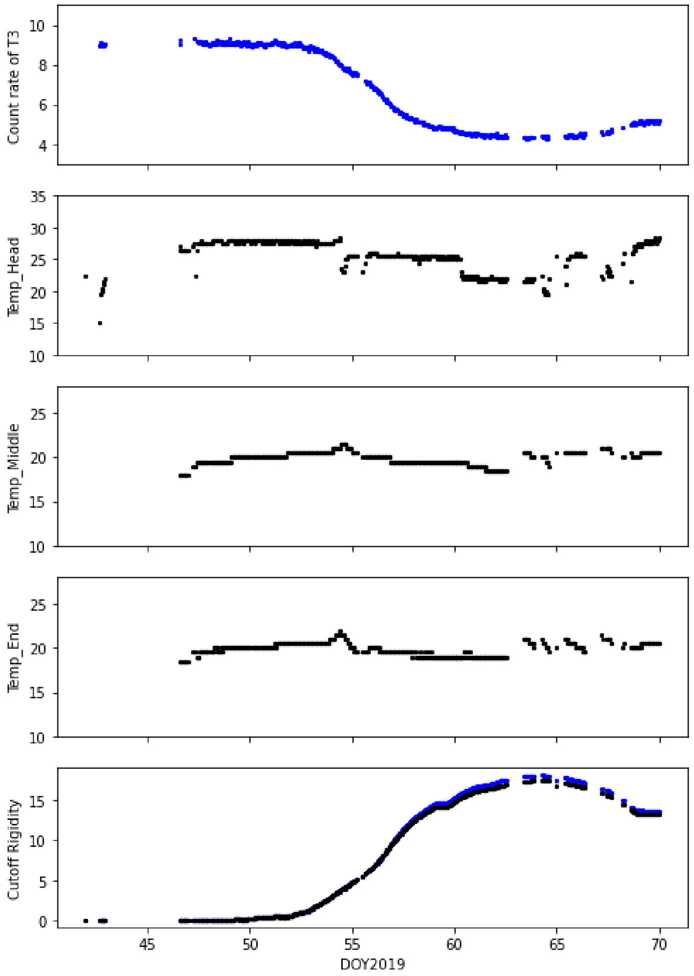
Survey Year 2020 (CN36)



T1: NM64

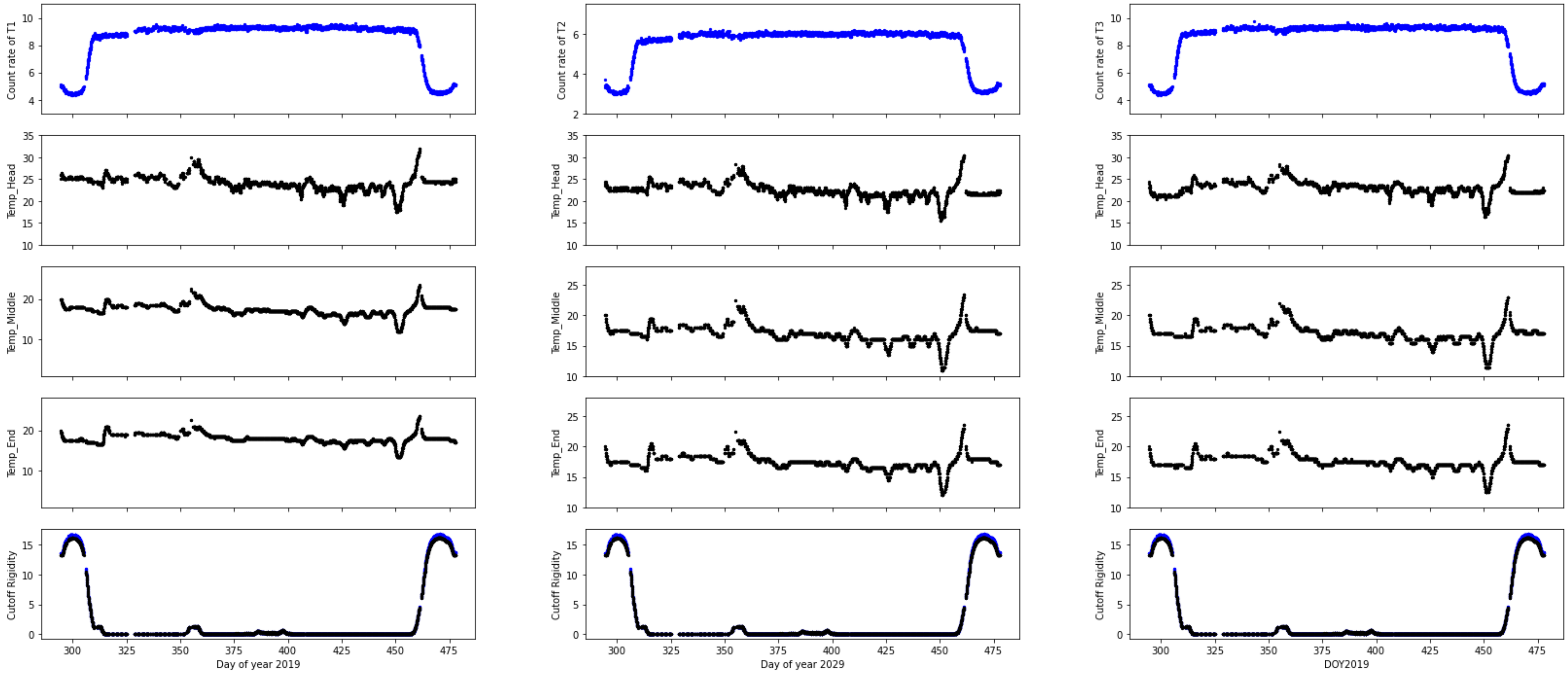


T2: lead-free NM64



T3: NM64

Survey Year 2020 (CN36)



T1: NM64

T2: lead-free NM64

T3: NM64

Thank you !
Do you have any questions?

RESPONSE FUNCTION

The count rate (corrected for pressure) as a function of apparent cutoff rigidity represents the integral response functions of the neutron counters.

$$N(P_c) = N_0 \left(1 - e^{-\alpha P_c^{-\kappa}}\right)$$

The DRF is defined as the integrate of the integral count rate response function:

$$N(P_c) = \int_{P_c}^{\infty} DRF(P) dP$$

$N(P_c)$ can be differentiated to determine the DRF

$$DRF = N_0 \alpha \kappa P^{-\kappa-1} \left(e^{-\alpha P^{-\kappa}}\right)$$