ANALYSIS OF NEUTRON TIME-DELAY HISTOGRAMS FROM CHANGVAN LATITUDE SURVEYS

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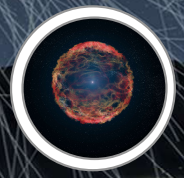
Cosmic rays

The sun

Active galactic nuclei

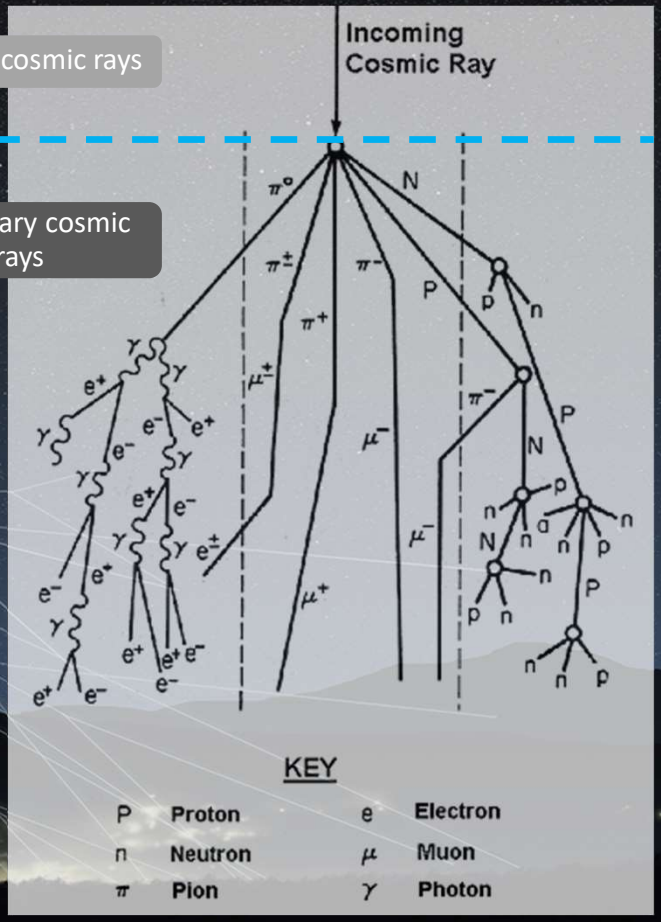


Supernova

Primary cosmic rays

Earth's Atmosphere

Secondary cosmic rays

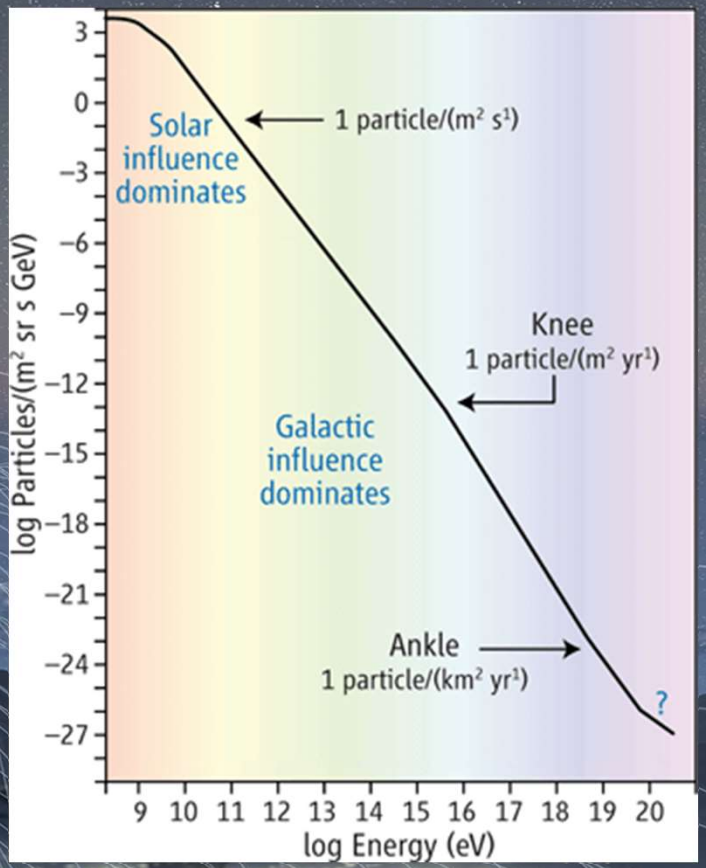


Cosmic ray spectrum

The sun

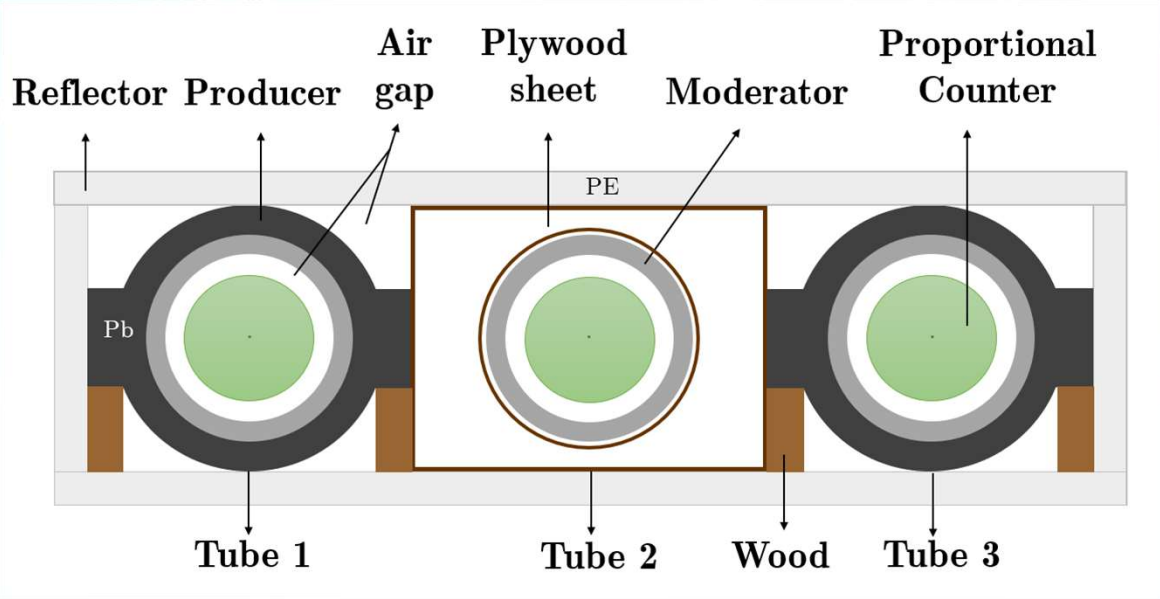
Active galactic nuclei

Supernova



Picture from: https://science.sciencemag.org/content/314/5798/429/F1

Changvan neutron detectors



Drawing of the Changvan monitor. Tube 1 and Tube 3 are leaded detectors. Tube 2 is unleaded neutron counter hold onto three supported wooden plates.

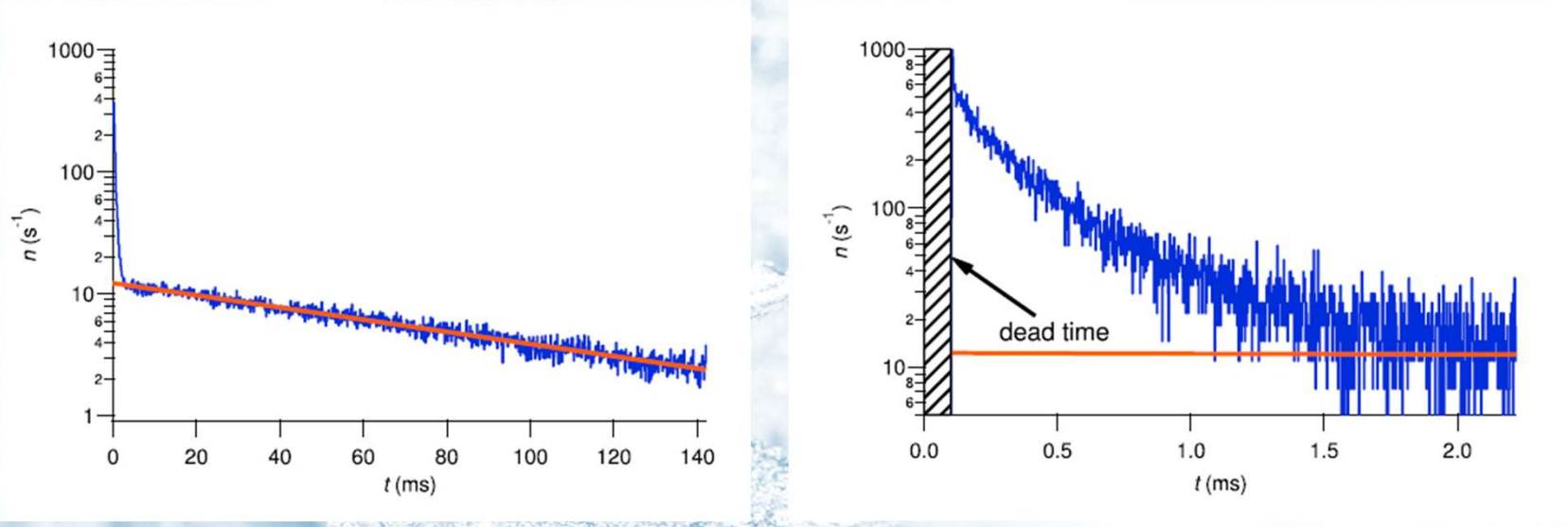
CHANGVAN LATITUDE SURVEY

The latitude surveys in 2018-2019 (CN35) and 2019-2020 (CN36)

Figure from : Miss Sidarat Khamphakdee

TIME-DELAY HISTOGRAMS

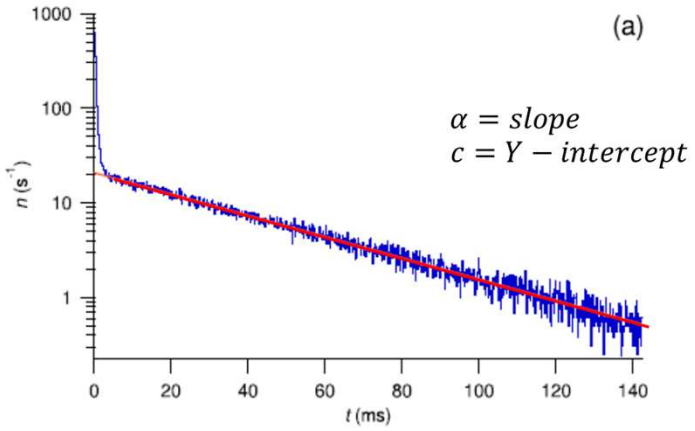
- Distribution of the time delay between successive neutron counts at one counter tube recorded during one specific 1 h interval. (left) Long time delays show the exponential distribution typical of unrelated events, while (right) short time delays deviate substantially from the exponential function (red line). The electronic dead time is typically $t_d \sim 80 - 90$ µs.



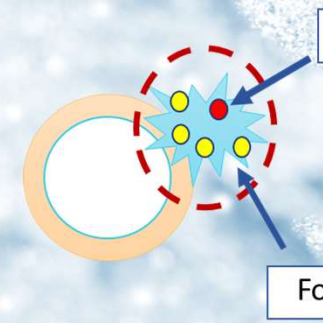
Ruffolo et al., 2016

Leader fraction

- Leader fraction (L) refers to neutron counts that do not follow a preceding neutron count in the same counter from the same atmospheric secondary particle
- We statistically calculate the leader fraction (L) from histograms of time delay that related to cosmic ray spectral index.
- Amplitude of exponential tail (red) indicates rate of "leaders" arriving by chance, not "following" in temporal association with preceding count.

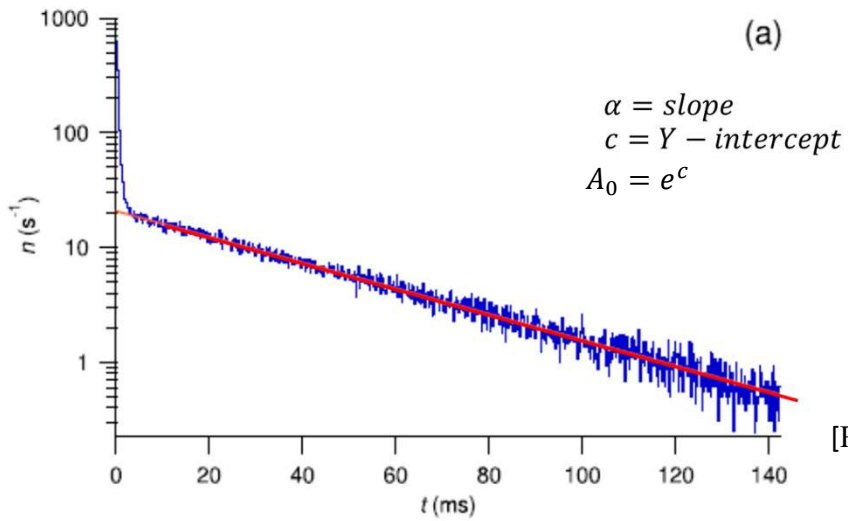


Ruffolo et al., 2016



$$\text{Leader Fraction} = \frac{\text{First count (Leader)}}{\text{All pulse (Leader + Followers)}}$$

Leader fraction calculation



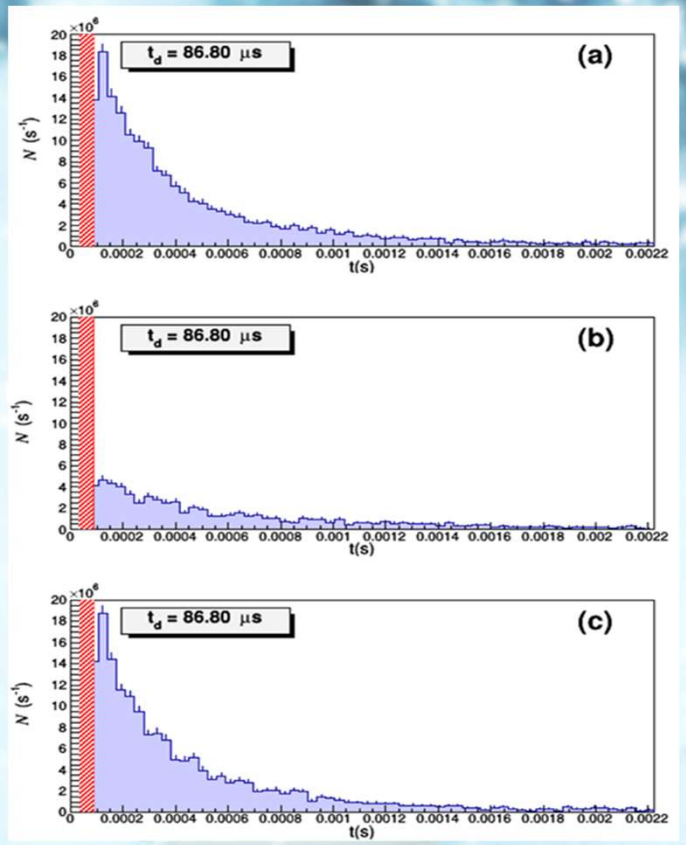
[Ruffolo et al., 2016]

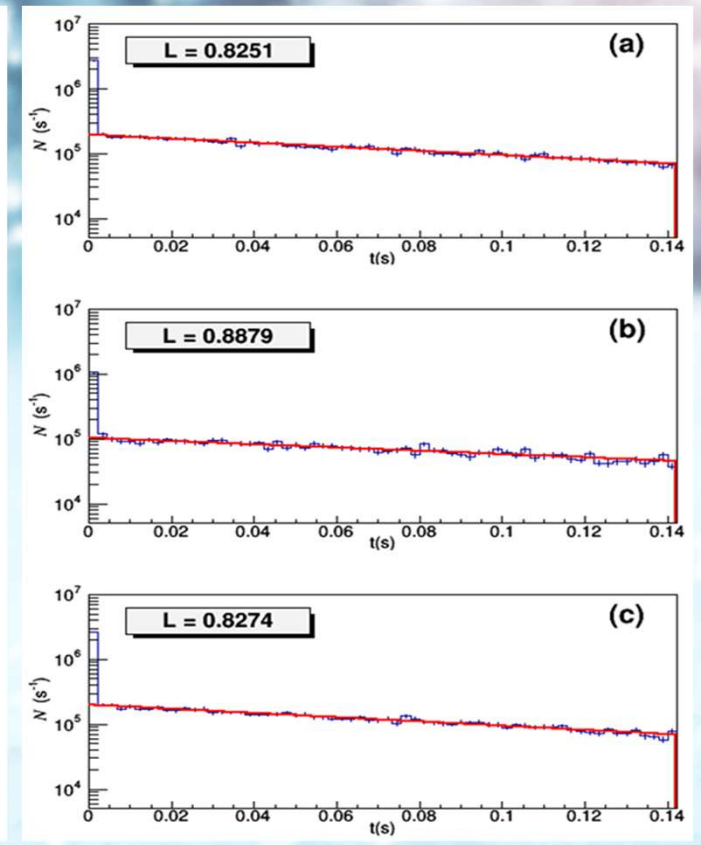
$$L = \frac{\frac{A_0}{\alpha} e^{-\alpha t_d}}{\sum_{t=t_d}^{t_0} N_t + \frac{A_0}{\alpha} e^{-\alpha t_0}}$$

where α and A_0 are the parameters from the hourly long-time histogram fit. $t_o = 0.142$ s is the overflow time in the electronic system, and dead time $t_d = 87$ μs . The term $\sum_{t=t_d}^{t_o} N_t$ is the sum of the neutron pulses for all time bins from t_d to t_o from the recorded histogram files

Result

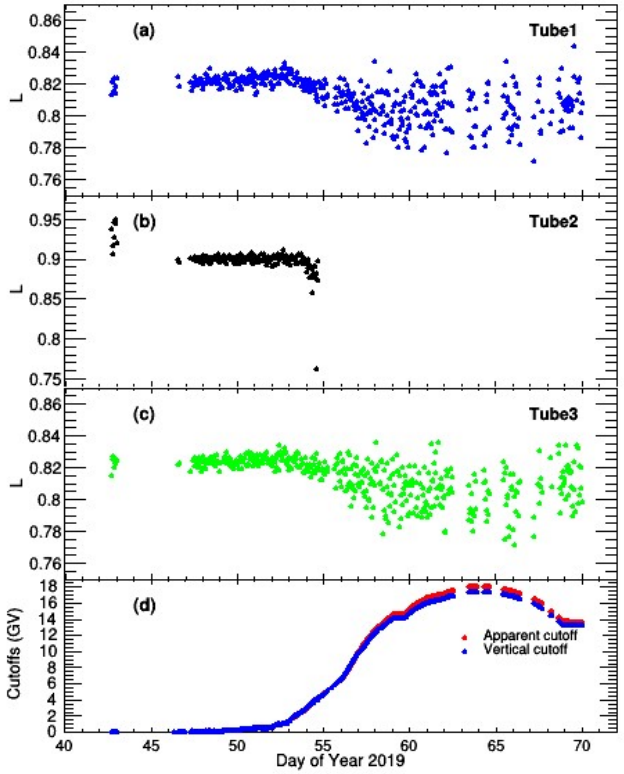
Time-delay histogram of 2nd hour UT on the 20th December 2019 of the survey year 2020



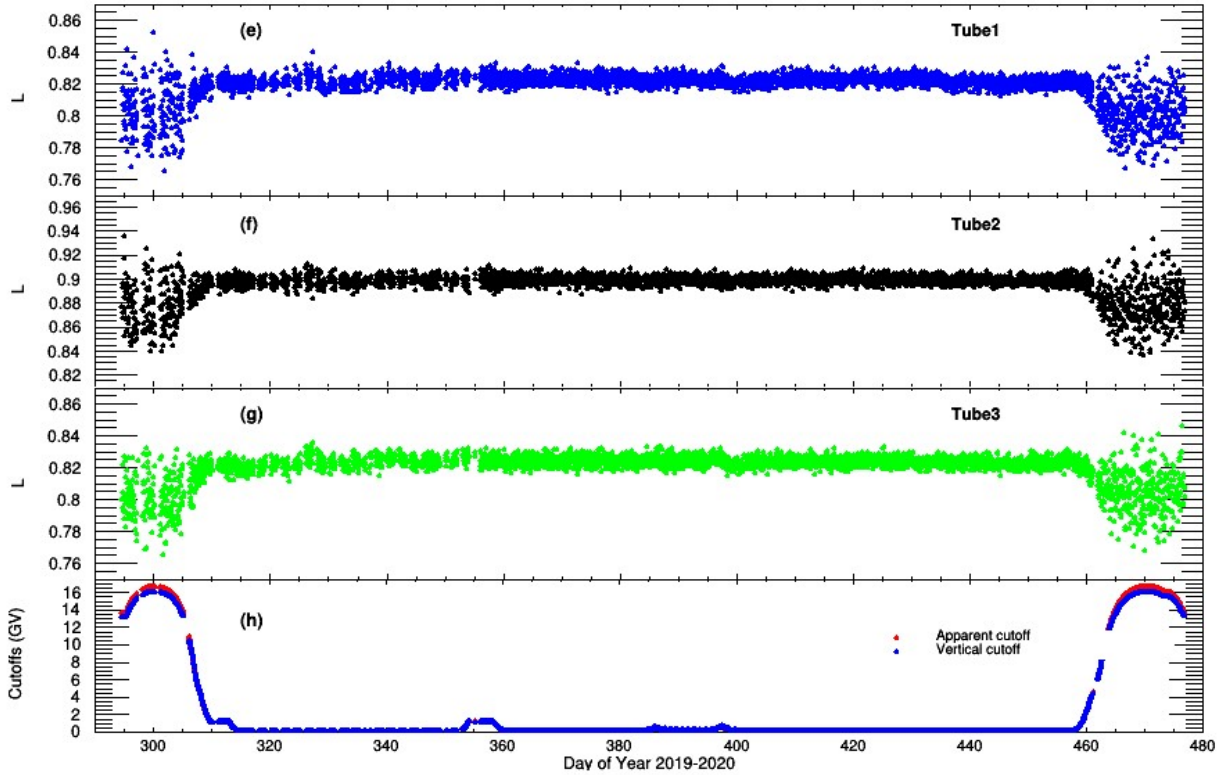


Result

Leader fraction of single-tube in the survey year 2018-2019



Leader fraction of single-tube in the survey year 2019-2020



Result

Data set of the survey year 2019 (a)-(d) and (e)- (h) of the survey year 2020, as a function of time.

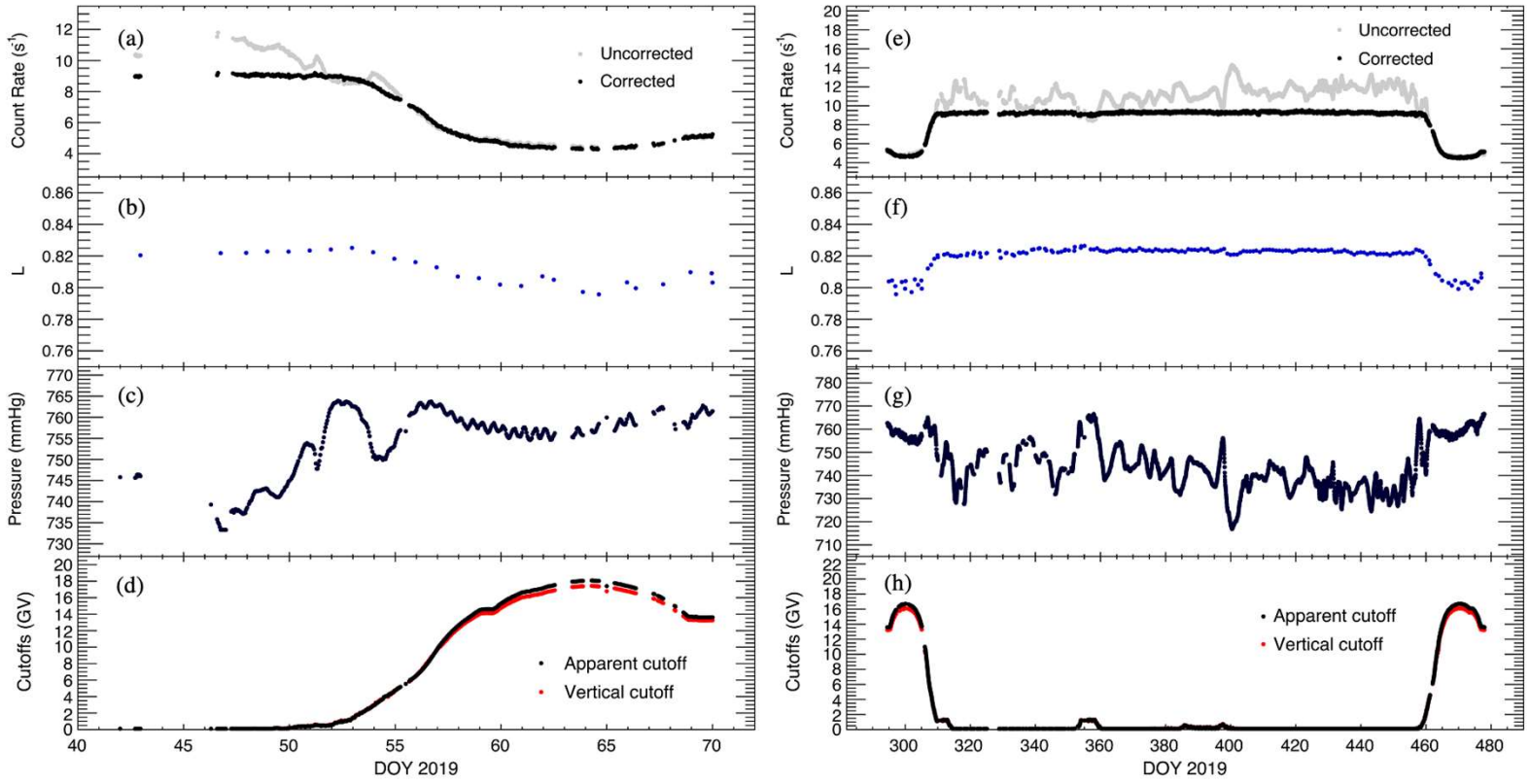
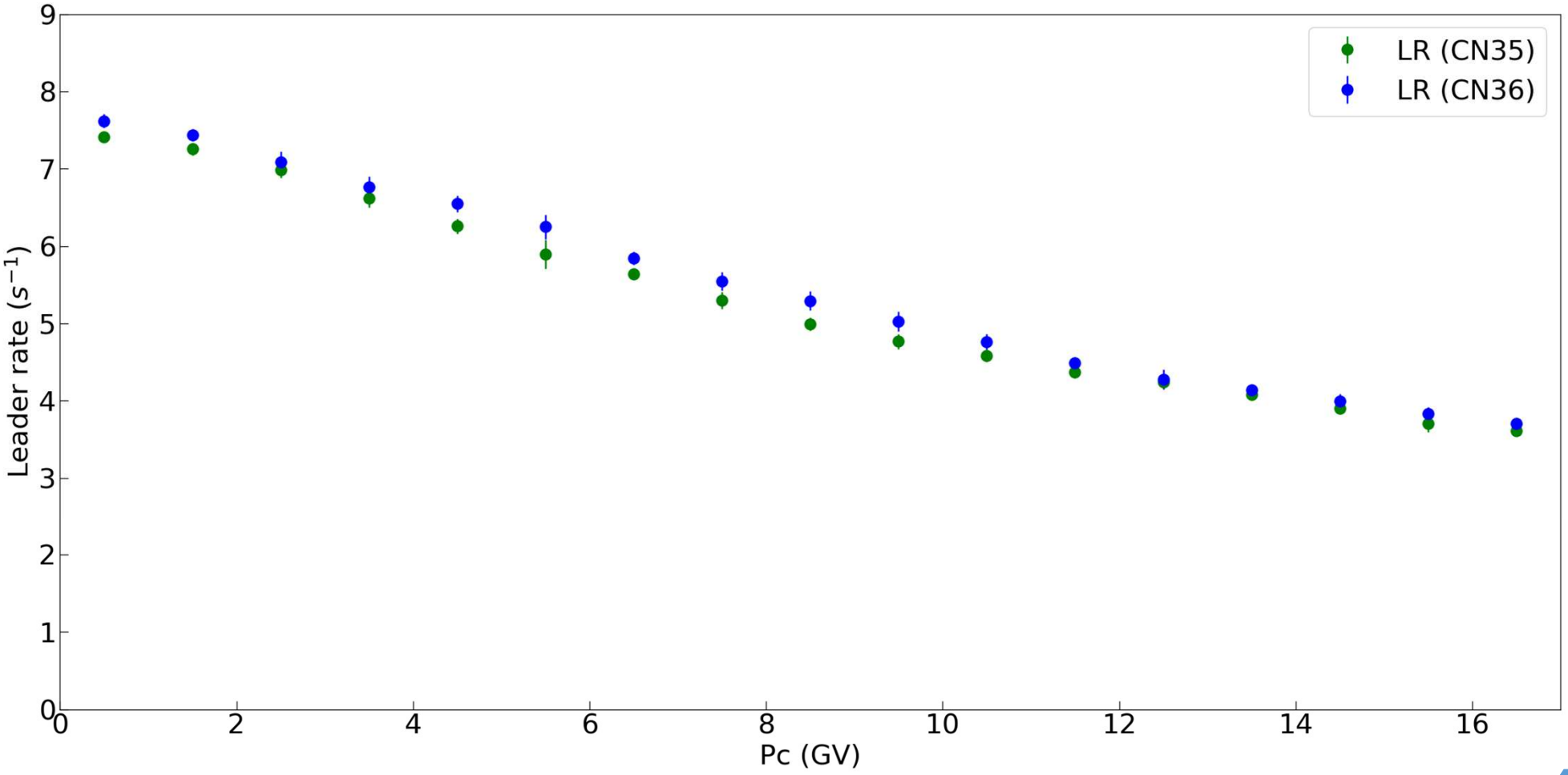


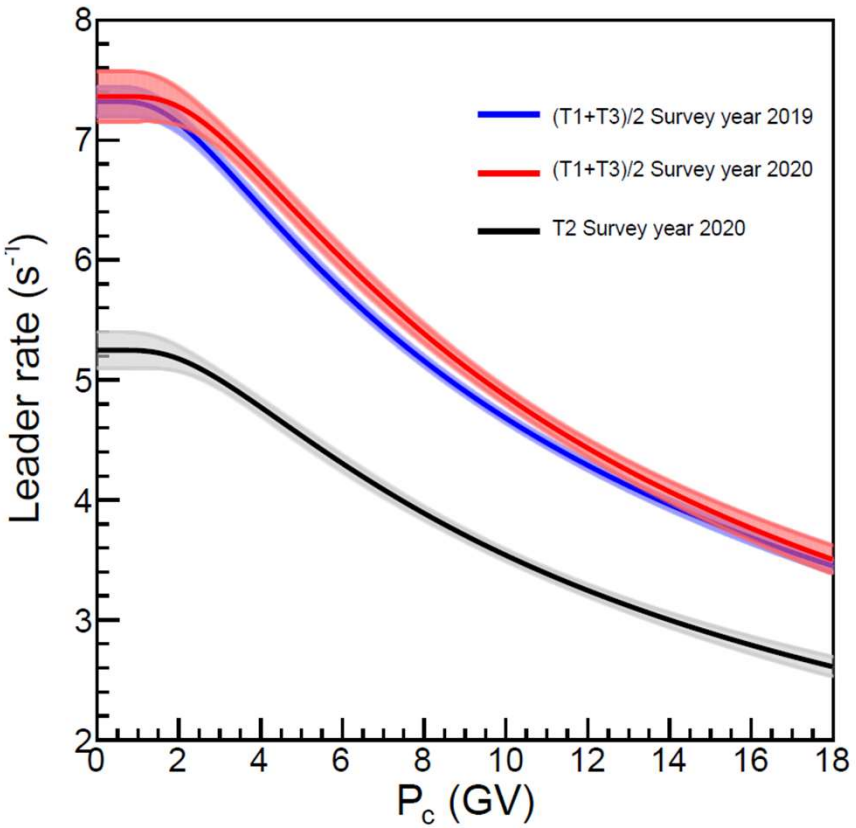
Figure from : Miss Sidarat Khamphakdee

Leader rate


LR (CN35)
LR (CN36)
Leader rate (s^{-1})
Pc (GV)
0
1
2
3
4
5
6
7
8
9
0
2
4
6
8
10
12
14
16

Result

Dorman functions to fit Leader rate vs apparent cutoff rigidity for the survey year 2019 (CN35) and the survey year 2020 (CN36)



Survey Year	Analysis	R_0	α	κ
2018-2019	(T1+T3)/2	7.320	6.434	0.7999
2019-2020	(T1+T3)/2	7.363	8.140	0.8769
2019-2020	T2	5.249	7.611	0.8317

we apply the Dorman function for the leader rate:

$$R = R_0\left(1 - e^{-\alpha P_c^{-\kappa}}\right),$$

can be differentiated to determine the Differential leader rate response function (*DLF*):

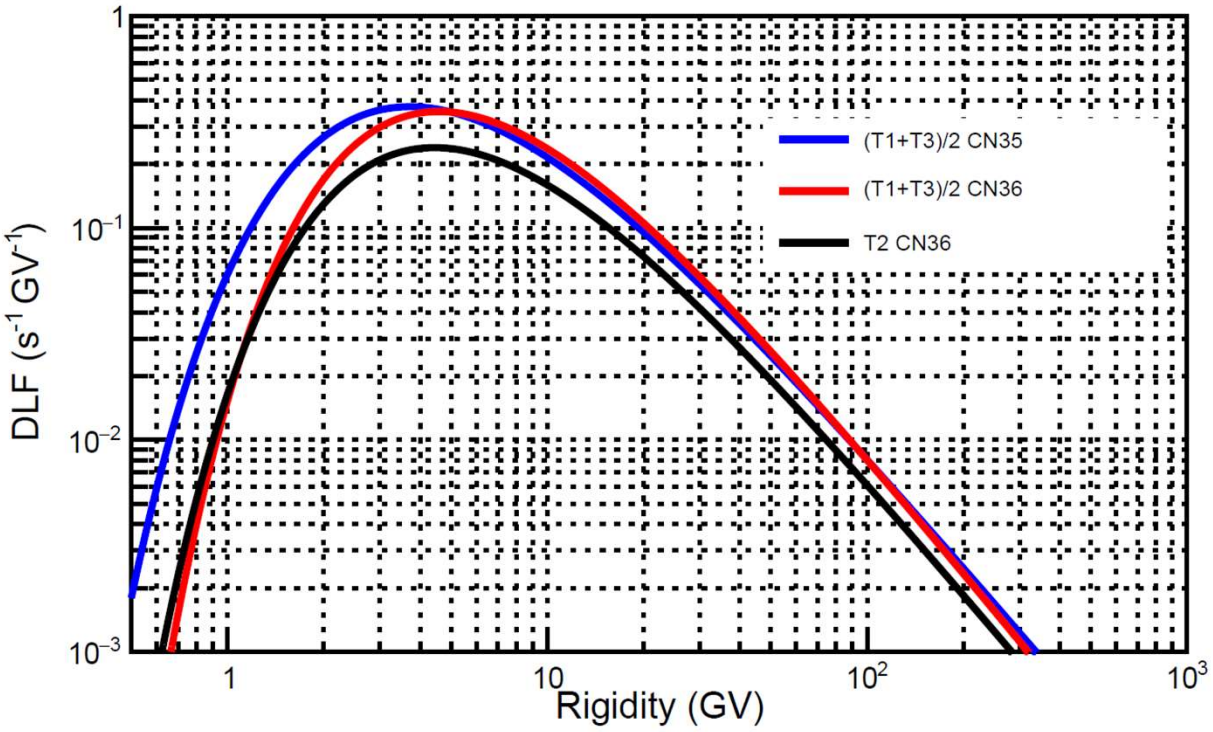
$$R = \int_{P_c}^{\infty} (DLF)dP$$

$$DLF = R_0\alpha P^{-\kappa-1}(e^{-\alpha P^{-\kappa}})$$

Where R_0, α, and κ are free parameters.

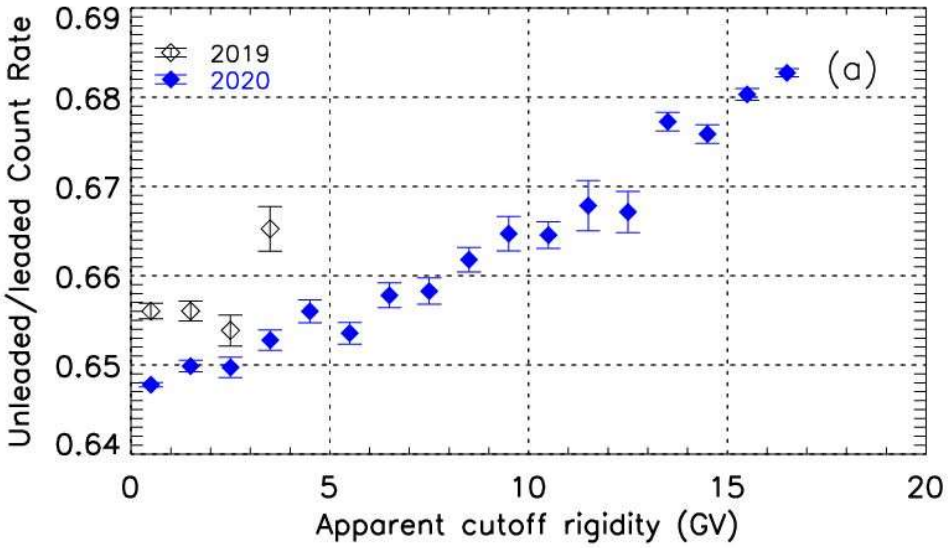
Result

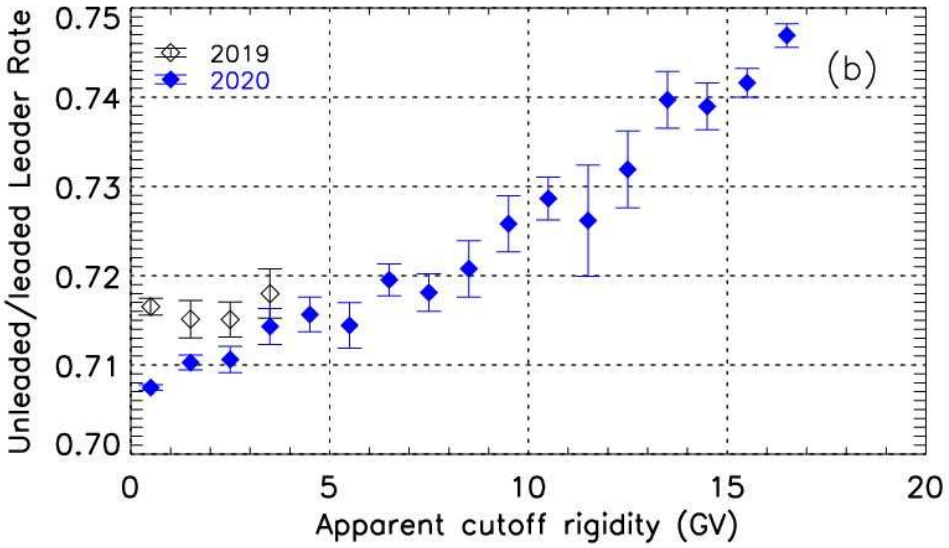
Differential leader rate response function for the survey year 2019 (CN35) and the survey year 2020 (CN36)



Result

The count rate (left) and leader rate (right) ratio of unleaded vs. leaded counters as a function of apparent cutoff rigidity for the 2019 and 2020 survey years.

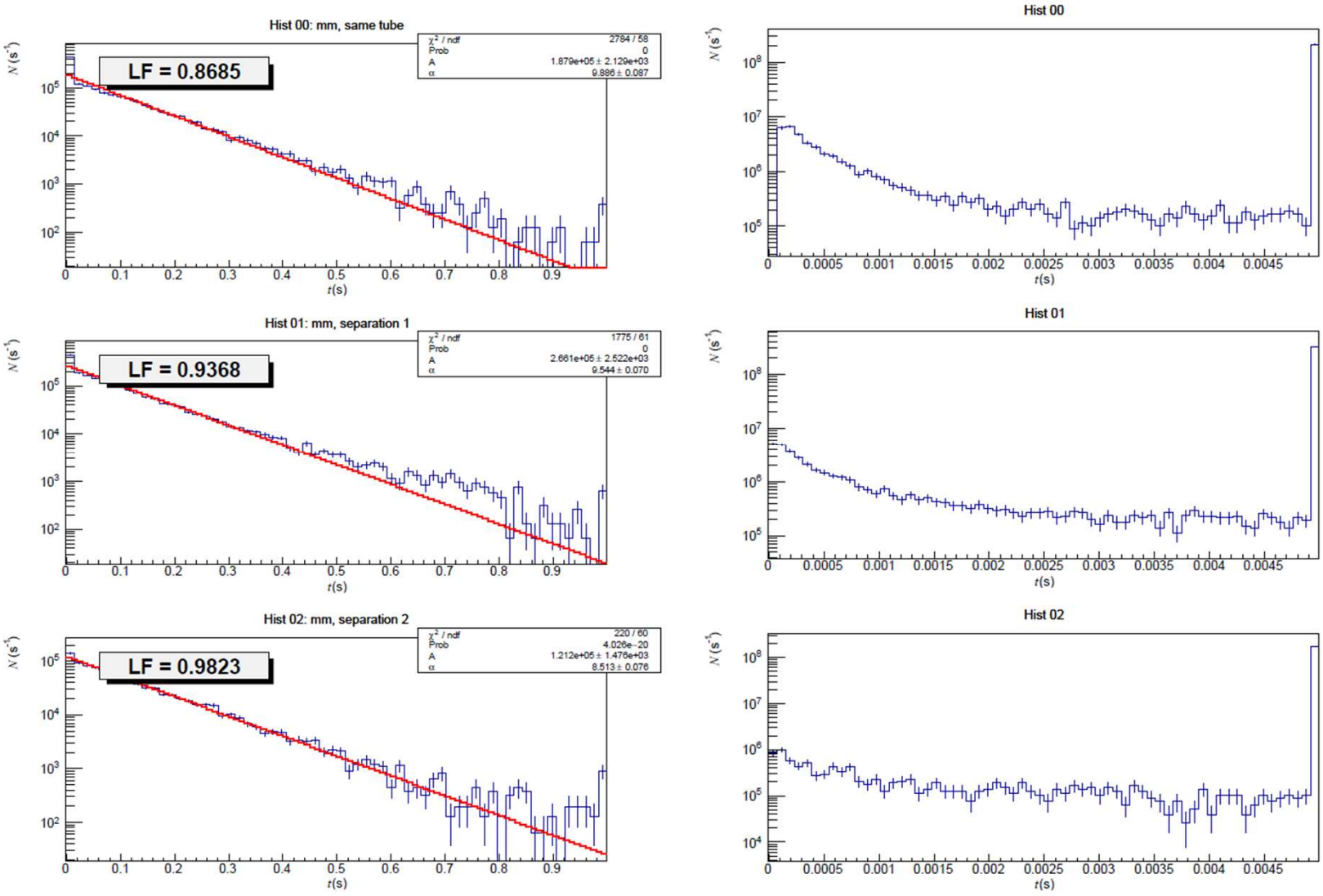




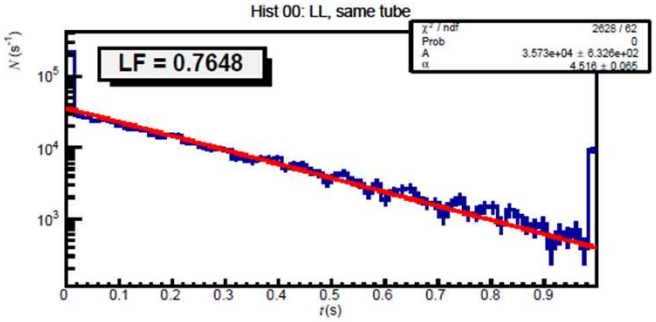
Leader fraction of cross-tube

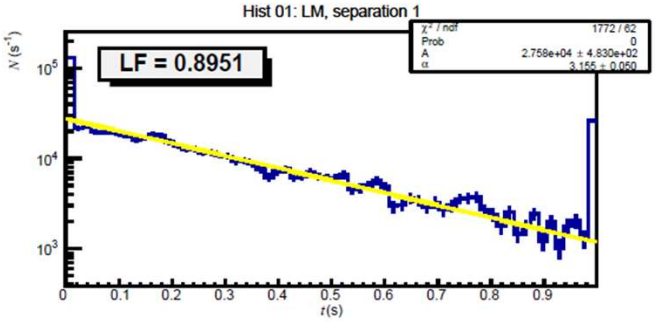
- Changvan latitude survey 2018-2019
- Changvan latitude survey 2019-2020

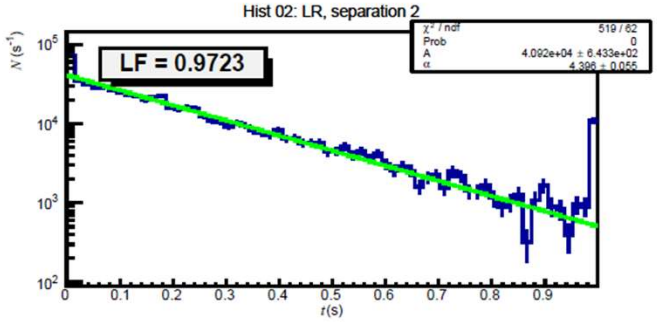
Long and Short time delay histogram of cross –tube of 17th hour UT on the 11th February 2019 of the survey year 2018-2019 (CN35)

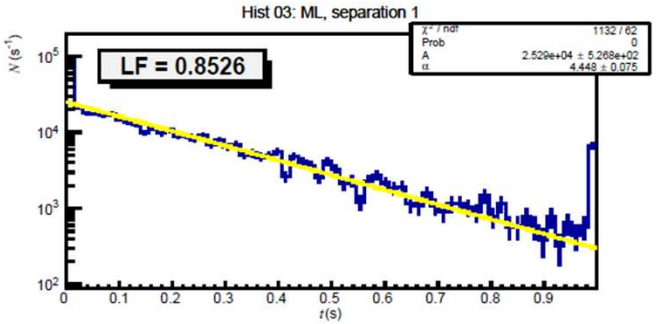


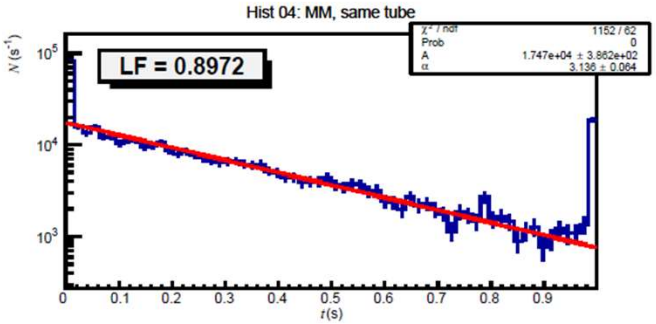
Long-time delay histogram of cross –tube of 9th hour UT on the 3rd September 2019 of the survey year 2019-2020 (CN36)

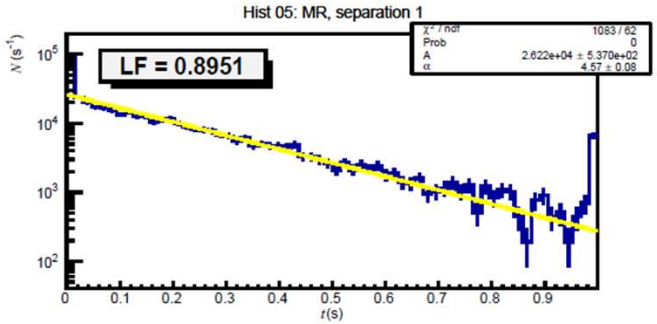


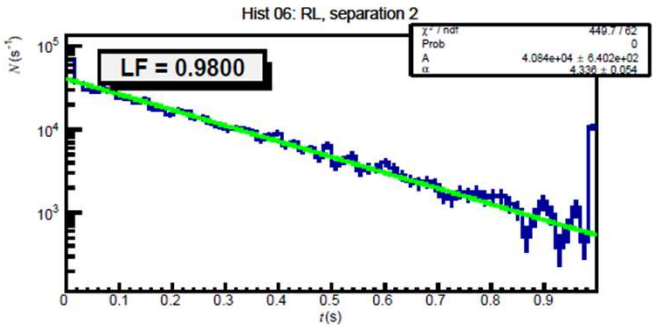


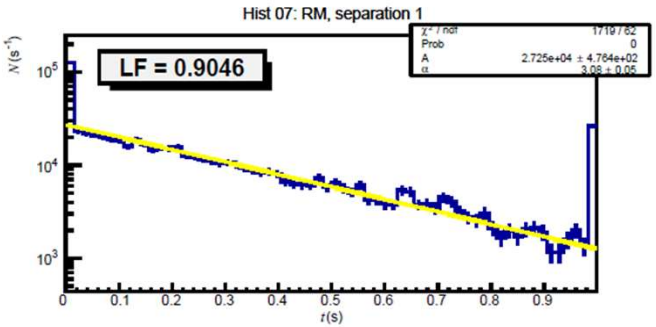


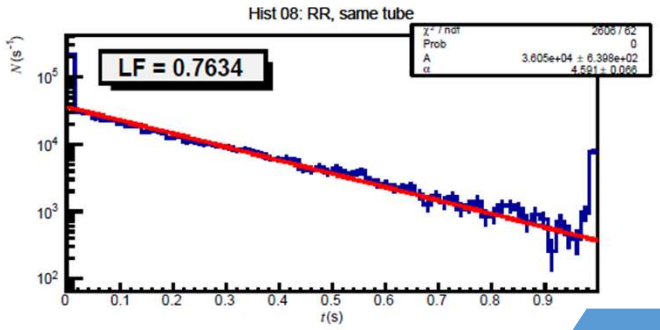




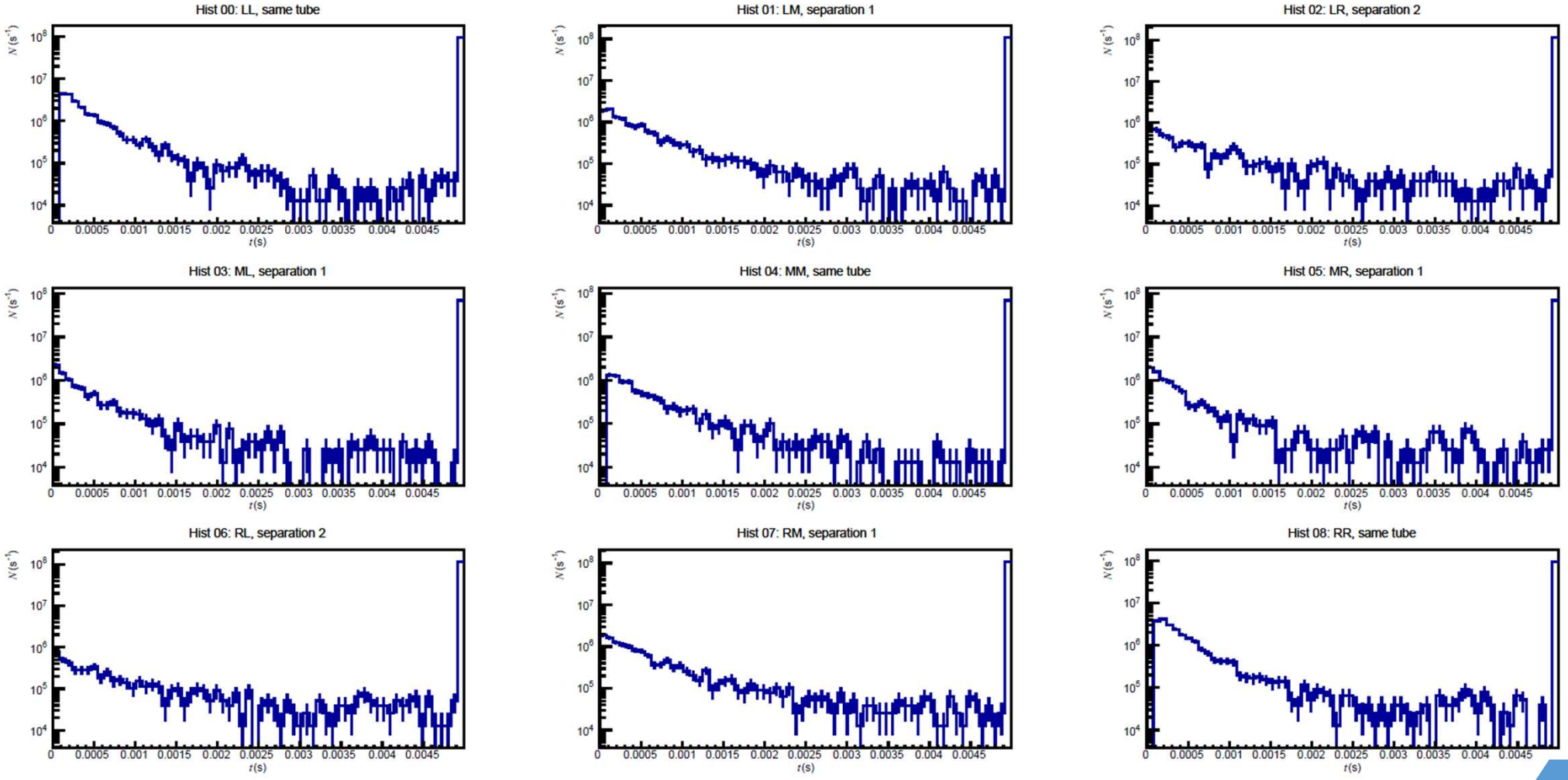




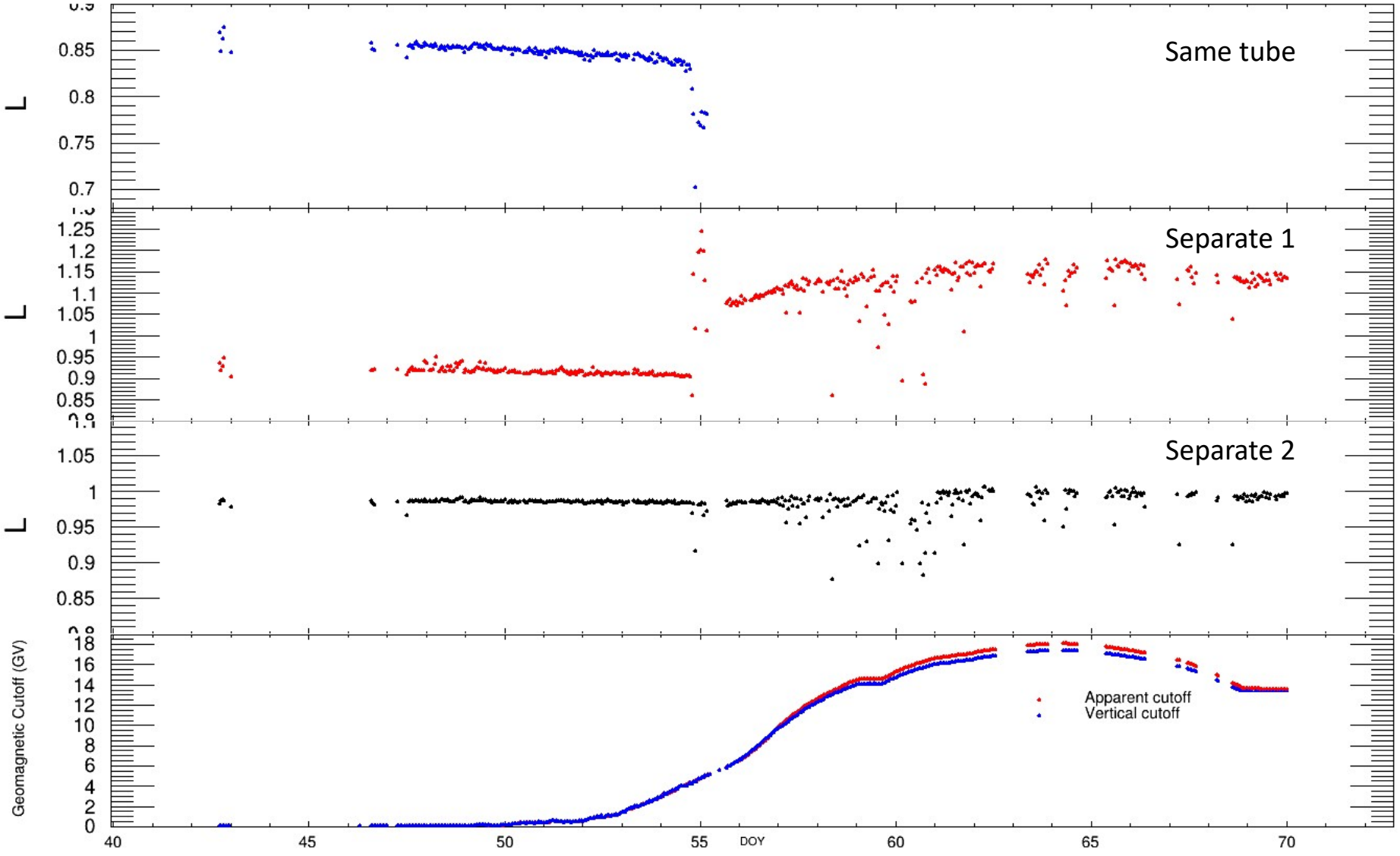




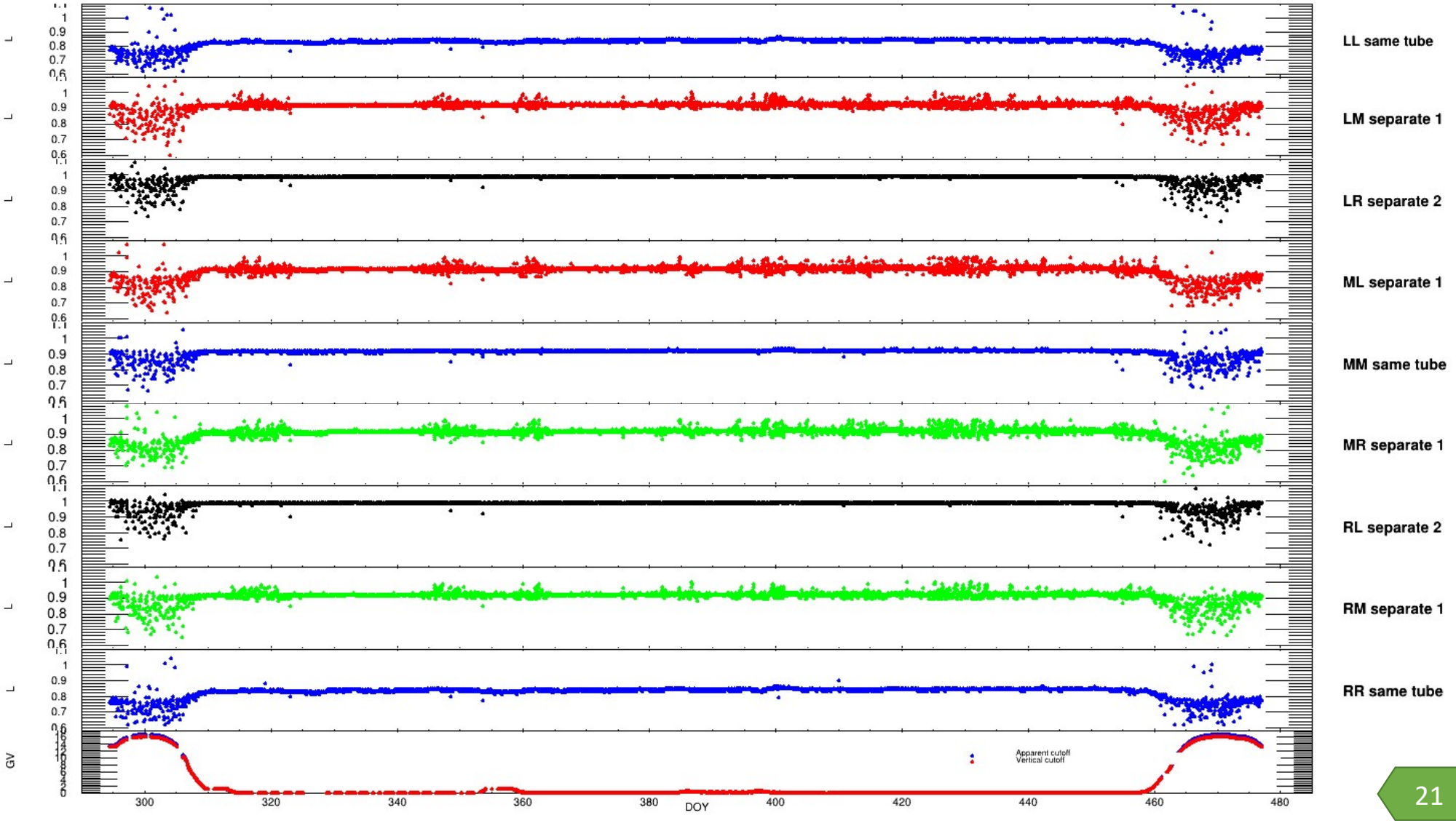
Short-time delay histogram of cross –tube of 9th hour UT on the 3rd September 2019 of the survey year 2019-2020 (CN36)



Leader fraction of cross-tube in the survey year 2018-2019 (CN35)



Leader fraction of cross-tube in the survey year 2019-2020 (CN36)



Next plan

Leader fraction of cross-tube (Changvan and South pole)

- Pressure Correction
- Temperature Correction

- Integral Response function / Differential Response function


THANK YOU FOR
YOUR ATTENTION