# Pulse height-length analysis of data from neutron monitors DOMC/DOMB with a new data acquisition system

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**Abstract**
Two high-altitude polar neutron monitors DOMC and DOMB (Dome C, Concordia station, Antarctic plateau, 3233 m a.s.l.) received a major electronics upgrade in 2019. While a typical standard neutron monitor data acquisition (DAQ) system only registers the number of pulses from a cosmic-ray particle detector, the new system digitizes all pulses with 2 MHz sampling rate and stores this information in raw data files. This feature makes it possible to conduct a pulse height-length analysis of the neutron monitor data on a routine basis.

In this study, we have analysed several months of the cosmic-ray data recorded with the new DAQ system during 2019-2020 (more than 10 million pulses). We identified several pulse branches corresponding to different processes: (a) secondary particles from individual cosmic-ray cascades, (b) noise, (c) double pulses originated from particles of the same local cascade, (d) high multiple pulses likely related to atmospheric muons, (e) double pulses potentially caused by contamination by neutrons scattered in the neighbouring instrument. We also studied the waiting time distributions of pulses and have shown that two peaks can be clearly distinguished: (1) at about 1 millisecond, which is related to the intra-cascade particles, and (2) at 30-1000 milliseconds related to different uncorrelated cosmic-ray cascades. Our conclusions are supported by theoretical estimates of the waiting times in different scenarios.

**See for more detail**

- Similä et al. (2021). High-altitude polar NM with the new DAQ system as a tool to study details of the cosmic-ray induced nucleonic cascade. J. Geophys. Res. Space Phys., 126, e2020JA028959. doi: 10.1029/2020JA028959
- Strauss D.T. et al (2020). The mini-neutron monitor: a new approach in neutron monitor design. J. Space Weather Space Clim. 10, 39. doi: 10.1051/swsc/2020038.

**Acknowledgements**
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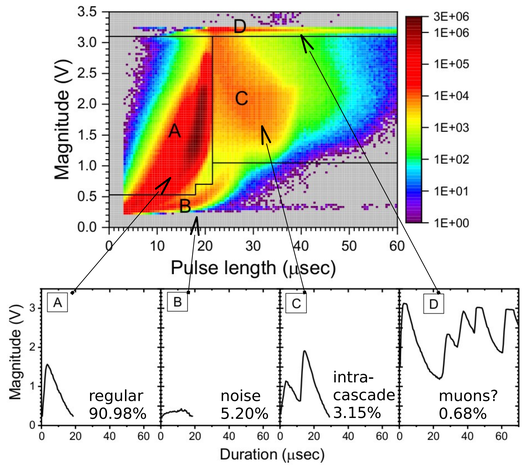
## Pulses in mini neutron monitors

Briefly:

- Routine pulse height-length analysis is possible now
- Several types of pulses are identified. They correspond to different processes.
- We can probably identify muons in neutron monitor counts
- Accurate routine multiplicity analysis is possible now
- Potential use of DOMC/B as a particle spectrometer

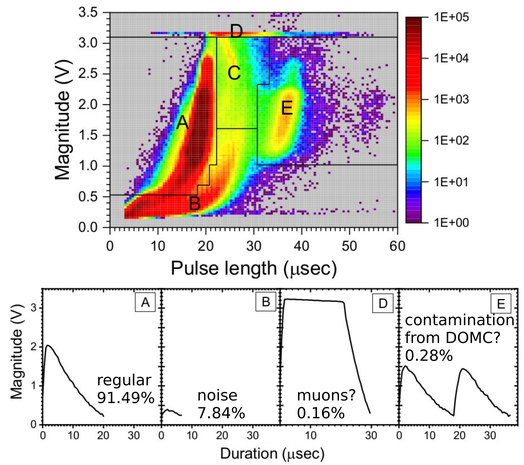
### DOMC

standard mini-NM

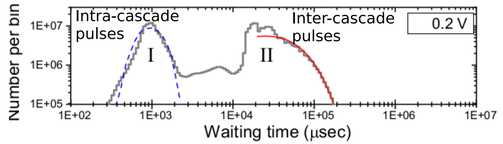



### DOMB

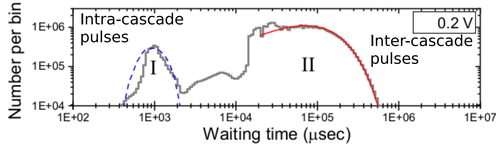
bare mini-NM




## Waiting time between pulses




Analysed data:
~$3\times10^8$ pulses, 01 Jan 2020 - 31 May 2020

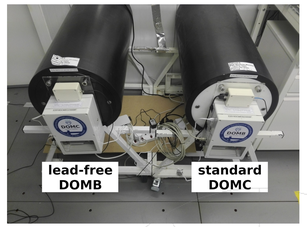


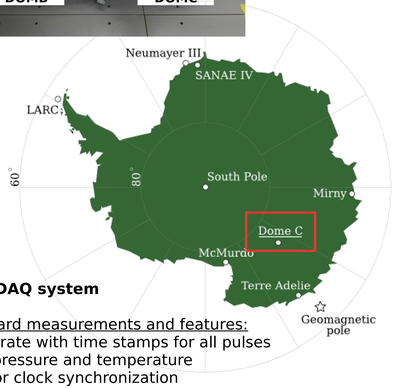

Analysed data:
~$4\times10^7$ pulses, 13 Aug 2019 - 31 Oct 2019

### DOMC and DOMB neutron monitors

- "Mini" design by the the North-West University, South Africa
- DOMC - standard NM with a lead layer
- DOMB - "bare" (lead-free) NM

- Installed at the Concordia research station, Dome C, Antarctica (3233 m above sea level)
- Exceptionally low cutoff energy (~300 MeV) for cosmic rays, thanks to the location
- In operation since January 2015




### New DAQ system

Standard measurements and features:
- count rate with time stamps for all pulses
- atm. pressure and temperature
- GPS for clock synchronization

Added with upgrade:
- Raspberry Pi-based, GNU/Linux
- Modular design (easy to upgrade/repair)
- Two temperature/pressure/humidity sensors
- Remote control of HV, discrimination, etc.
- Every pulse shape is digitized! 2 MHz sampling rate.