PROCEEDINGS OF SCIENCE

A new neutron monitor DOMC in Central Antarctica at Dome C (Concordia station)

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A new cosmic ray detector has been installed in the inner Antarctic Plateau, at Concordia station (coordinates 75°06' S 123°23' E, 3233 meters a.s.l.). The detector consists of two fully independent measuring units: DOMC - a standard mini neutron monitor, and DOMB - a bare (lead-free) neutron monitor. The instruments were built by the North-West University (Potchefstroom, South Africa), are owned and operated by the University of Oulu (Finland), and hosted by the Italian-French Concordia station. The detector is placed in a thermo-stabilized "Physics" shelter, fully maintained all year-round by the Concordia station personnel. The Concordia station is an optimal location for the detection of solar energetic particles and low energy galactic cosmic rays. The detector's asymptotic acceptance cone is nearly perpendicular to the equatorial plane, pointing to the geographical southern latitudes $> 80^{\circ}$ for cosmic rays with energies above a few GeV, which is the most Southern polar direction among all the world station. The cosmic ray measurements started in mid-January 2015, and the instruments work properly. The average count rate is about 15 counts/sec and 4 counts/sec for DOMC and DOMB units, respectively. Every single hit is recorded by the data acquisition system with a time stamp allowing for an off-line analysis. The reference atmospheric pressure level is set to 650 mb. The preliminary barometric correction coefficients are -0.70 ± 0.02 and -0.73 ± 0.02 %/mb, for DOMC and DOMB units, respectively, but they will be defined more precisely by the Conference time, when a larger statistical database will be available. We are fully prepared for a solar energetic particle event once it appears. Meanwhile, time variability of cosmic rays is recorded on the routine basis. The data are still preliminary but will be publicly available, after verification, at the databases http://cosmicrays.oulu.fi and http://www.nmdb.eu.

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1. Introduction

A new ground-based cosmic ray detector has been installed in the inner Antarctic Plateau, at Concordia station (coordinates 75°06' S 123°23' E, 3233 meters a.s.l.). The proposed abbreviation name for the cosmic ray station is DOMC. It records the nucleonic component of a cascade induced by cosmic ray in the atmosphere. The primary goal of the Project is to conduct monitoring measurements of the nucleonic component of the cascade initiated by cosmic rays in the polar atmosphere. Two principal research topics are planned to be solved:

1. Continuous monitoring of the secondaries of the cosmic ray induced atmospheric cascade in the high-altitude site will provide unique information on the cosmic ray variability caused by solar magnetic activity.

2. Study of the possible relationship between the level of the ionization of the atmosphere (assessed through the cosmic ray flux monitoring) and the extent of New Particle Formation (NPF) processes, by simultaneous measurements of total and/or charged aerosol particles in the nm size range

The detector started its continuous operation in January 2015. The timing is favorable as the years of 2015–2017 are expected to correspond to the maximum and early decline phase of the solar activity cycle # 24 with enhanced variability of cosmic rays. This provides a great opportunity to study the possible cosmic ray – atmosphere connection, in comparison with the quiet periods.

2. Sensitivity to cosmic rays

The location of the station is the best possible over the globe for two reasons:

1. Polar location, proximity to the geomagnetic pole and high altitude guarantees the greatest variability of the cosmic ray flux. It also is ideal for detection of the solar energetic particles.

2. The extremely clean (in the sense of anthropogenic pollution) and fairly isolated (especially during the austral winter) from the other world troposphere provides the best conditions to study the aerosol changes (anthropogenic effects are almost excluded, and transport effect minimized), compared to other locations.

The formal geomagnetic cut-off rigidity for the DOMC station is zero, and its acceptance cone lies at high geographical latitude (see Fig. 1). As one can see, most of the polar neutron monitors (NMs) have acceptance directions, in the range of lower rigidities of about 1 GV corresponding to the effective energy/rigidity of a polar NM, in the low-mid latitude region. For example, the South Pole NM, which is located to the geographical South Pole, view cosmic rays with this energy coming from the tropical region. Among all the NMs, only the new DOMC station has the acceptance directions in the geographical latitudes above 80° South in the rigidity range above 1 GV. Thus, the DOMC NM is the only NM looking perpendicular to the equatorial plane in the South direction. This improves the concept of the Spaceship Earth [2] and is of particular importance for studying anisotropic solar energetic particle events.

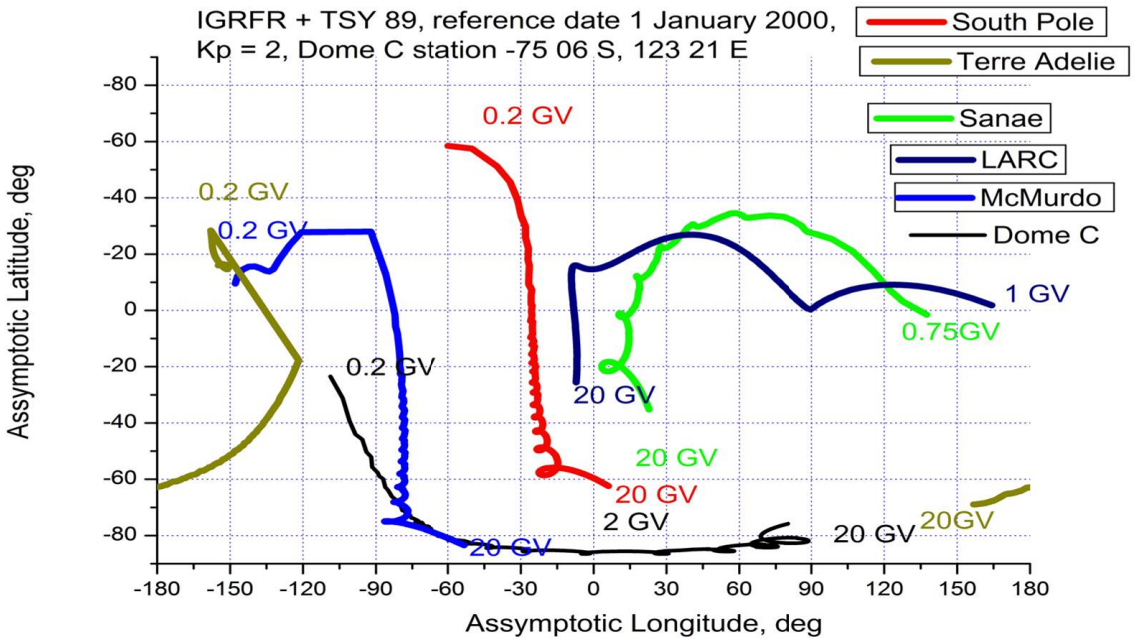

Figure 1: Map of the computed asymptotic directions (in the geographical coordinates) for polar NMs in the Southern hemisphere for weak geomagnetic activity (Kp=2). Computations were done using the MAGNETOCOSMICS tool with the IGRF model for the internal field and Tsyganenko-89 [1] model for the external field.

3. Technical parameters

The instruments were built by the North-West University (Potchefstroom, South Africa), are owned and operated by the University of Oulu (Finland), and hosted by the Italian-French Concordia station. The detector is placed in a thermo-stabilized "Physics" shelter, fully maintained all year-round by the Concordia station personnel. The detector includes two independent units, called DOMC and DOMB, as shown in Fig . 2. The detectors were designed and built by the Northwest University in Potchefstroom as a standard portable NM using BF_3 filled counters. DOMC measuring unit is a standard mini-NM [3] with a lead shield (weight $\approx$ 350 kg) and DOMB is a bare (lead-free) neutron monitor (weight $\approx$ 250 kg) which is sensitive to lower energy cosmic rays. Each electronics box contains its own high-voltage supply, pressure transducer (optional), data processor and internet communication port. It needs no infrastructure beyond standard outlet power, and is designed to be plug-and-play. The average count rate is about 15 and 4 Hz (counts/sec) for the DOMC and DOMB units, respectively.

The data acquisition system (DAS) records every single hit in the counter with a time stamp allowing for an off-line analysis. The 1-second, 1-minute and 1-hour count rates are then automatically computed.

The reference atmospheric pressure level is set to 650 mb.

The preliminary barometric correction coefficients are found to be -0.70 ± 0.02 and -0.73 ± 0.02 %/mb, for DOMC and DOMB units, respectively, but they will be defined more precisely by the Conference time, when more statistics are collected.

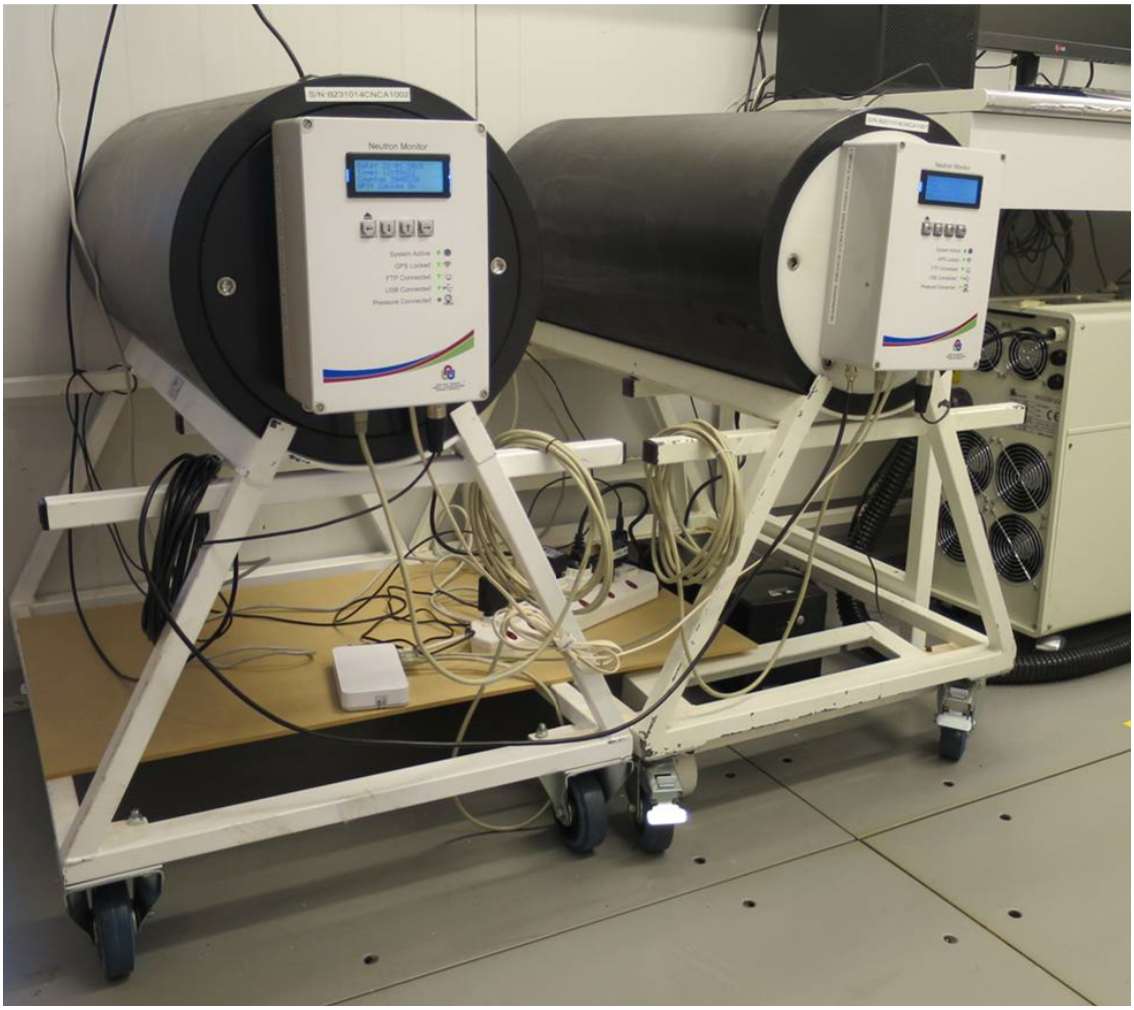

Figure 2: The two detectors DOMC and DOMB installed at the "Physics" shelter of the Concordia station. DOMC and DOMB detectors are on the right- and left-hand sides, respectively.

4. Data

The time series of the pressure-corrected count rate of the DOMC NM is shown in Fig. 3 along with the Oulu NM count rate for the period 06.01.2015 through 24.04.2015. One can see that the DOMC detector worked unstable before 24.01.2015 because of the settling the high voltage range. Since 24.01.2015 it works well and records the cosmic rays variability in sync with the Oulu NM data. The DOMB detector worked well from the very beginning. A spike on 08 UT of 12.02.2015 is an artefact likely caused by a radioactive source in the vicinity used for calibration of other experimental device. A clear Forbush decrease is observed on 17.03.2015. We note that the variability of the new detector's count rate is larger than that of the Oulu NM which is apparent considering its high altitude location and no cutoff rigidity. For example, while the Forbush decrease of 17.03.2015 was about 5% in the Oulu NM data, it was deeper in the DOMC data: $\approx 7\%$ and 8% in DOMC and DOMB units, respectively.

Another interesting event with an increase of count rate of $\approx 6\%$ and 4.5% for DOMB and

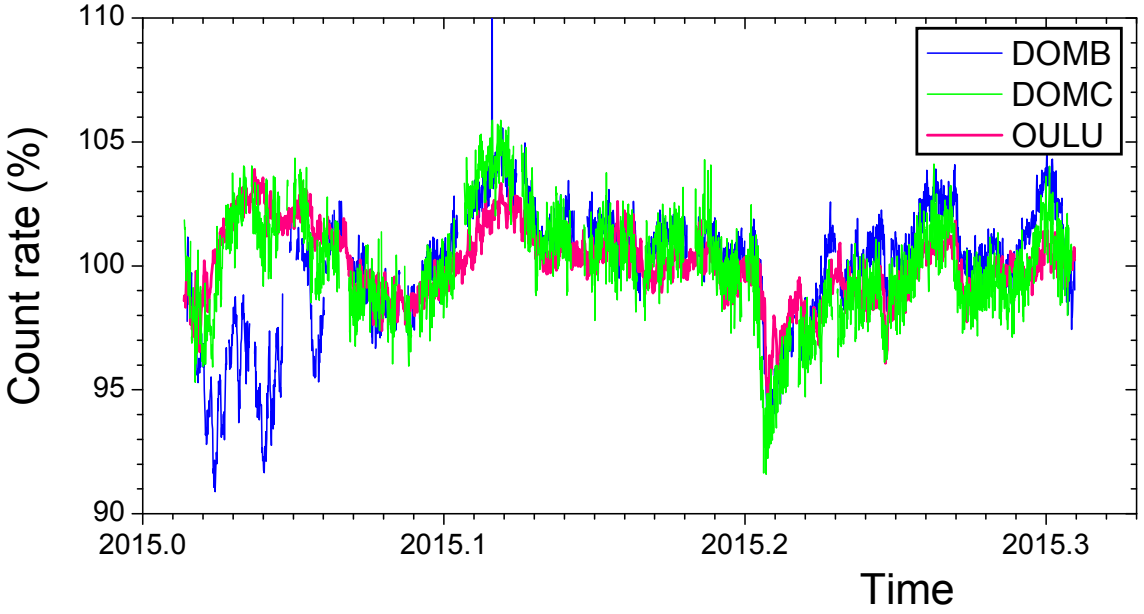

Figure 3: Hourly pressure-corrected count rate (in % to the mean) of the DOMC (blue) and DOMB (green) along with the count rate of the Oulu NM (pink), for the period 06-Jan through 24-Apr-2015.

DOMC, respectively, was observed on 07-Jun-2015 ca. 15:00 UT (Fig. 4) simultaneously with other Antarctic NMs. The origin of this events is still unclear and a further investigation is needed.

5. Summary

A new cosmic ray detector (a mini-NM called DOMC NM) has been installed in the inner Antarctic Plateau, at Concordia station. The detector consists of two fully independent measuring units: DOMC - a standard mini neutron monitor, and DOMB - a bare (lead-free) neutron monitor. The location of the DOMC NM is optimal for the detection of solar energetic particles and low energy galactic cosmic rays. The DOMC NM is the only NM with the asymptotic acceptance direction nearly perpendicular to the equatorial plane, pointing to the geographical southern latitudes $> 80^\circ$ for cosmic rays with energies above a few GeV. The cosmic ray measurements started in mid-January 2015, and the instruments work properly. The reference atmospheric pressure level is set to 650 mb. The preliminary barometric correction coefficients are -0.70 ± 0.02 and -0.73 ± 0.02 %/mb, for DOMC and DOMB units, respectively, but they will be defined more precisely by the Conference time, when more statistics are collected. The data are still preliminary but will be publicly available, after verification, at the databases http://cosmicrays.oulu.fi and http://www.nmdb.eu.

Acknowledgements

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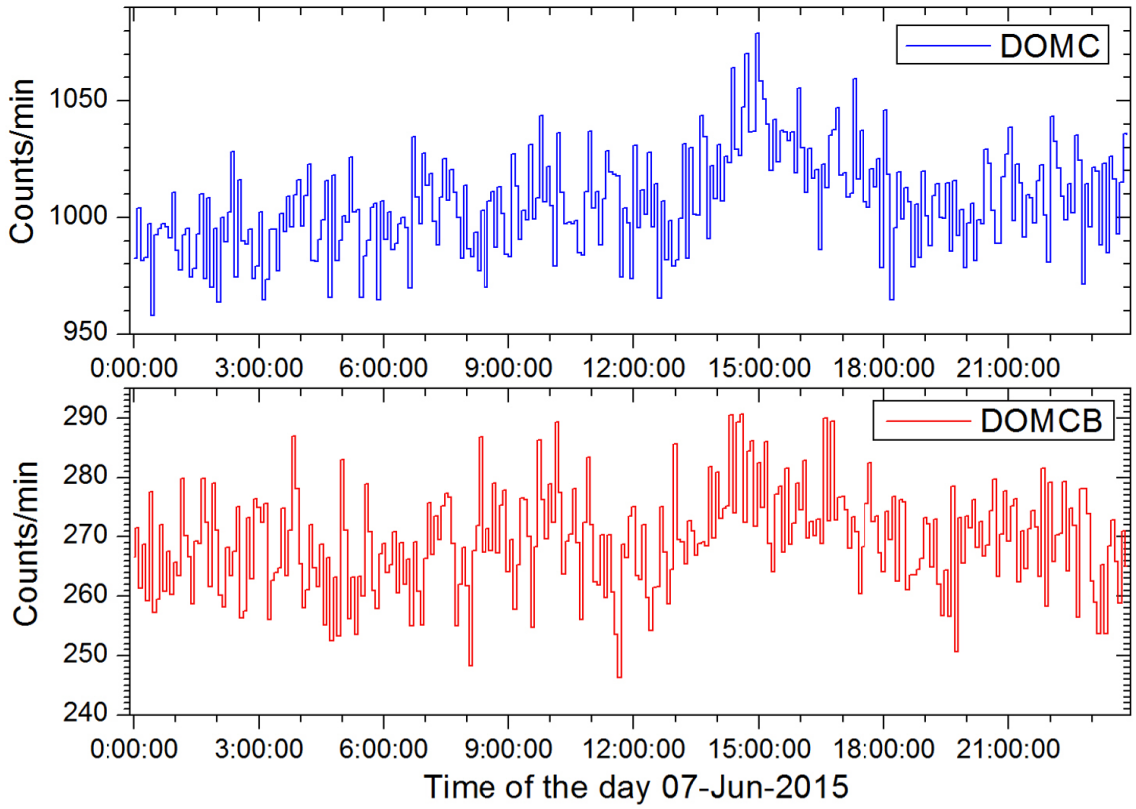

Figure 4: Count rate (5-min resolution) of the DOMB and DOMC for the day of 07-Jun-2015. An 3-hour long increase can be observed around 15:00 UT.

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