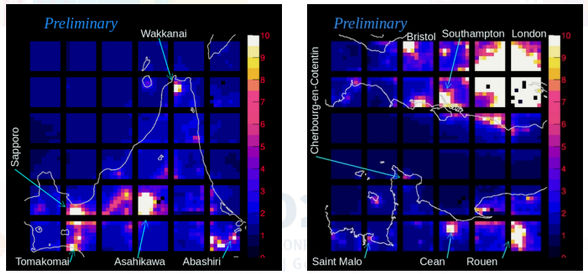
Measurement of UV light emission of the nighttime Earth by Mini-EUSO for space-based UHECR observations

K. Shinozaki[a,*], K. Bolmgren[b], D. Barghini[c,d], M. Battisti[c,e], M. Bertaina[c,e], F. Bisconti[c,e], G. Cambiè[f,g], F. Capel[b], M. Casolino[f,h], F. Fenu[c,d,e], A. Golzio[c], P. Klimov[i], V. Kungel[j], L. Marcelli[f], H. Miyamoto[c,e], L. W. Piotrowski[k], Z. Plebaniak[a], M. Przybylak[a], J. Szabelski[a], N. Sakaki[h], Y. Takizawa[h] for the JEM-EUSO Collaboration

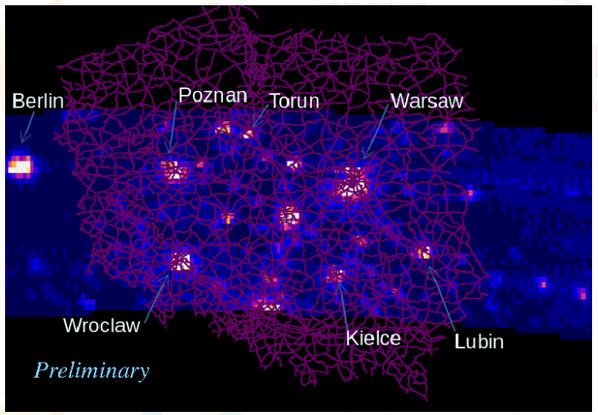
(a) National Centre for Nuclear Research, Poland; (b) KTH Royal Institute of Technology, Sweden; (c) Istituto Nazionale di Fisica Nucleare - Sezione di Torino, Italy; (d) Istituto Nazionale di Astrofisica - Osservatorio astrofisico di Torino, Italy; (e) Dipartimento di Fisica, Universitá di Torino, Italy; (f) Istituto Nazionale di Fisica Nucleare - Sezione di Roma Tor Vergata, Italy; (g) Universitá degli Studi di Roma Tor Vergata - Dipartimento di Fisica, Italy; (h) RIKEN, Japan; (i) Skobeltsyn Institute of Nuclear Physics, M.V. Lomonosov Moscow State University, Russia; (j) Colorado School of Mines, USA; (k) University of Warsaw, Warsaw, Poland. (*) Speaker E-mail: kenji.shinozaki@ncbj.gov.pl

The Mini-EUSO mission has been operated on the International Space Station (ISS) since October 2019 as the first space-borne experiment for the JEM-EUSO (see *M. Casolino talk #886 and M. Bertaina talks #385 July 15 1600UTC*) program aiming at the UHECR observation using wide FOV, UV sensitive fluorescence detectors in orbit. The instrument consists of 25 cm Fresnel optics with a prototype 2304 (=48×48) pixel photo-detector module capable of monitoring a ~300 km × 300 km area with time resolutions of 2.5 μs and 320 ms for the D1 and D2 trigger modes and of 40.96 ms for the continuous D3 mode. Operated above the airglow emission layer, Mini-EUSO can observes similar background condition expected in the future space-based UHECR observatories.



Snapshots of single frames (40.96 ms) of the D3 images obtained above Hokkaido Japan and on English Channel. The color scale hereafter is in units of counts per (pixel 2.5 μs).

These examples demonstrate a various scale populated areas are well identified, These D3 images obtained during the orbiting by the particular region may be composed on the geographical coordinates to create the UV light map.

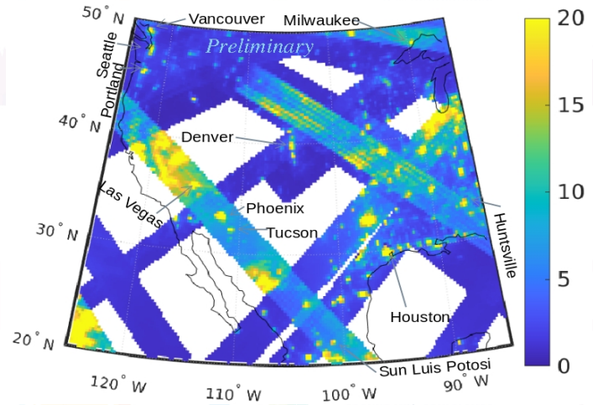


Combined Mini-EUSO D3 images on the Poland's road map. The data were acquired 3–4 min after passage of the English Channel. The color scale, as same as previous plots, shows the peak-hold value on the geographical grid points.

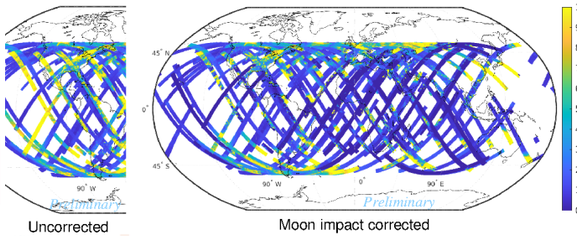
This example indicates good locating capability that is a relevant performance to determine the air shower geometry and observation exposure.

As the observation conditions vary in orbit, composing the data into a single map requires correction of various effects. The impact of the cloud presence is investigated (see *A. Golzio poster #417 Jul 16 1600UTC*). A typical example is the moonlight. The first order correction is applied to the measured count rates and averaged on the following maps.

Thanks to the ISS orbits with a 51.6° inclination, It has a potential to map ~78% of the Earth's area in the UV band. Now, the majority of the acquired data are still on the ISS. Their retrieval by the returning cosmonauts is planned in a few months.

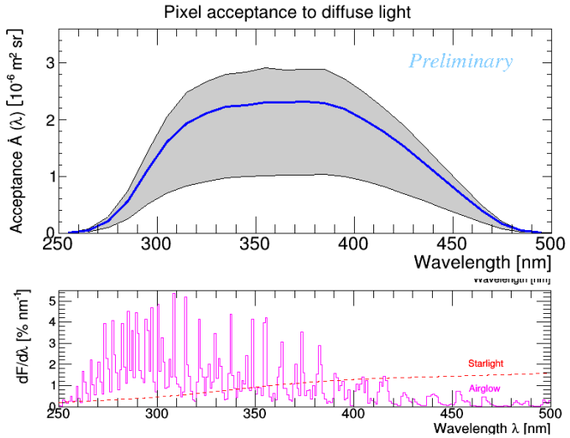


Combined Mini-EUSO D3 data imaged over North America from available data up to date. Preliminary correction of the impact of the moonlight is applied.



Combined Mini-EUSO D3 data imaged of available data up to date. Preliminary correction of the impact of the moonlight is applied. The left and right panels show uncorrected and moonlight-impact corrected average count rates projected on geographical grid points.

A typical count rate was 2.2 photoelectrons per (pixel 2.5 μs) for the moonless conditions above ocean. The measured count rates result from the mixtures of various light sources with unknown spectra. Thus, instrument simulations are made and the corresponding absolute intensities were deduced by assuming spectral models.



Top: "Acceptance" of one Mini-EUSO pixel to diffuse light intensities. The solid curve and shaded region are the average and maximum of all pixels. Boottom: spectrum models for airglow by UVES and startlight by Ch. Leinert et al. 1998.

The absolute intensity of the background light may be interpreted as an intensity of ~600 m^{-2} sr^{-1} ns^{-1} in the 250 – 500 nm band with the present knowledge on our instrument and its response simulations.

In the present contribution, we reported the preliminary result for the measurement of the UV light emission by Mini-EUSO. These results demonstrate fundamental performance for the future UHECR observations and Mini-EUSO science goals.