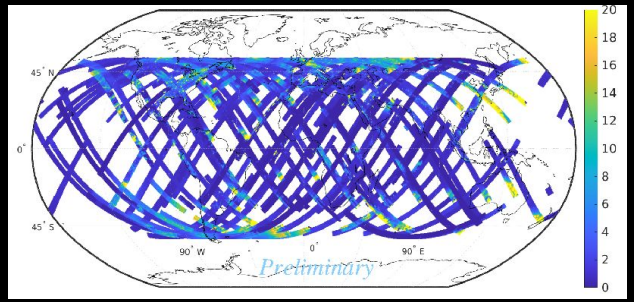
Presenter-Forum Number: 88 (July 16, 2021 1600UTC). ID #1165
The 37th International Cosmic Ray Conference (ONLINE Berlin) July 12−23, 2021

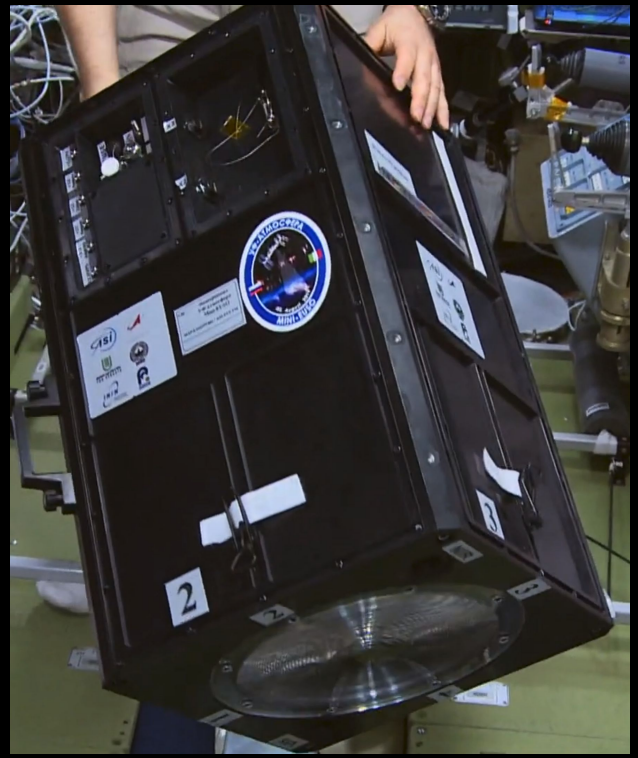
Measurement of UV light emission of the nighttime Earth by Mini-EUSO for space-based UHECR observations

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

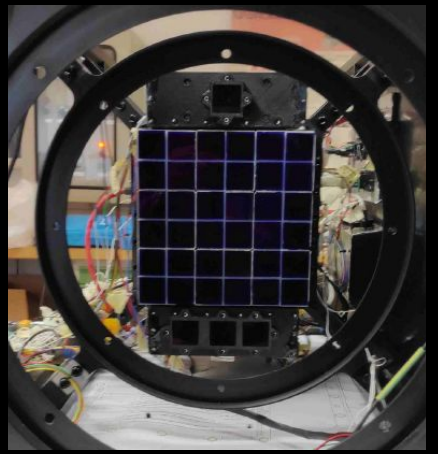
(a) National Centre for Nuclear Research, Poland
(b) KTH Royal Institute of Technology, Sweden
(c) Istituto Nazionale di Fisica Nucleare - Sezione di Torino, Italy
(d) Istituto Nazionale di Astrofisica - Osservatorio astrofisico di Torino, Italy
(e) Dipartimento di Fisica, Universitá di Torino, Italy
(f) Skobeltsyn Institute of Nuclear Physics, M.V. Lomonosov Moscow State University, Moscow, Russia
(g) Istituto Nazionale di Fisica Nucleare - Sezione di Roma Tor Vergata, Italy
(h) Universitá degli Studi di Roma Tor Vergata - Dipartimento di Fisica, Italy
(i) RIKEN, Wako, Japan
(j) Colorado School of Mines, Golden, USA
(k) University of Warsaw, Warsaw, Poland.
Full author list on Pos(ICRC2021) 385.

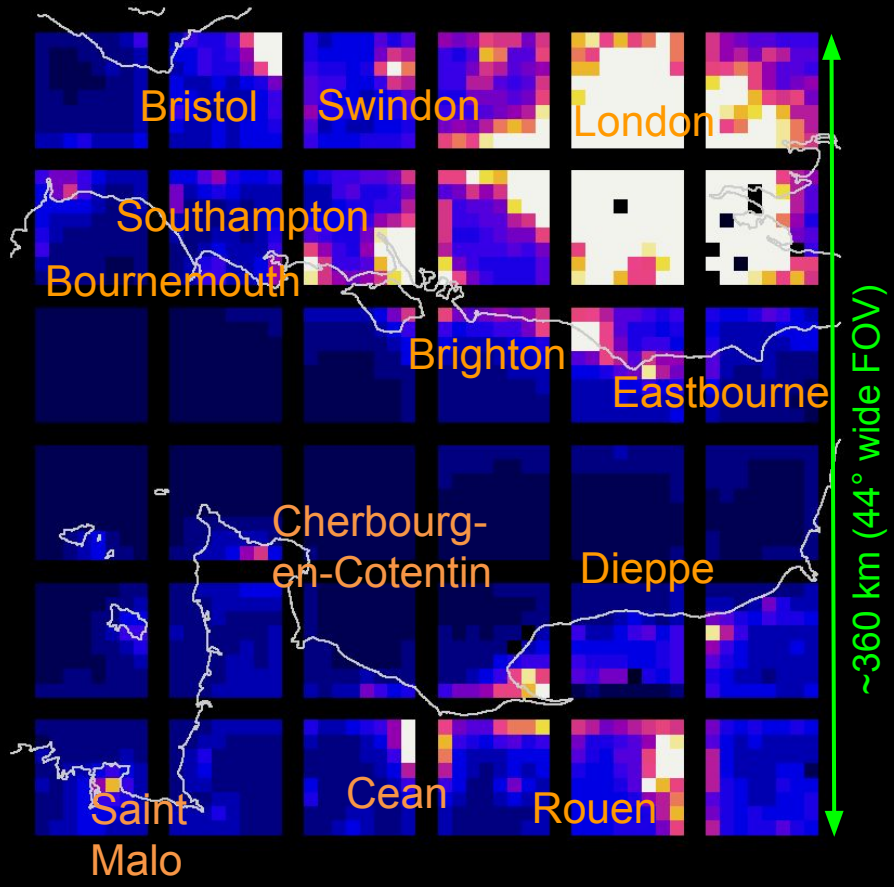
Photos: Bacholle et al. (2021) Astrophys. J. Suppl. 253, 36

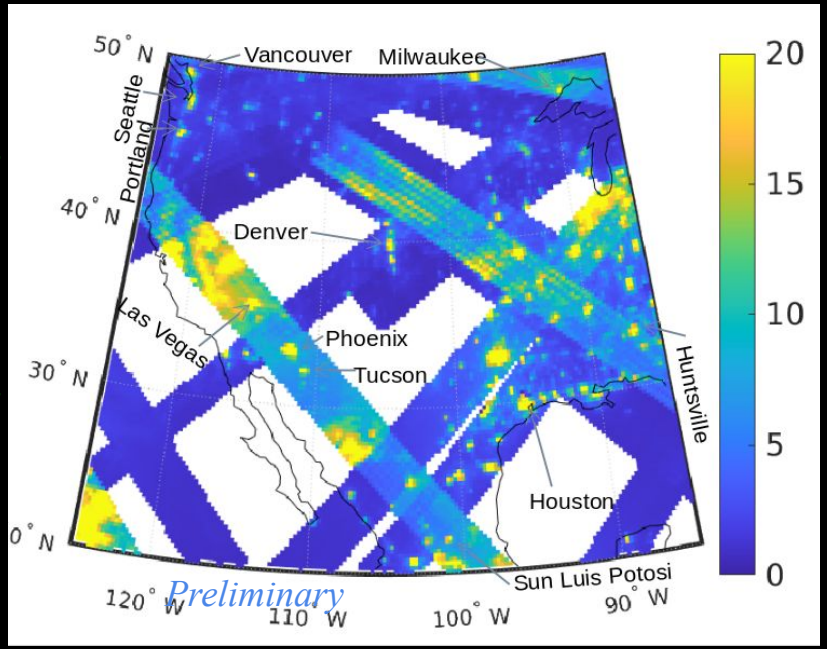


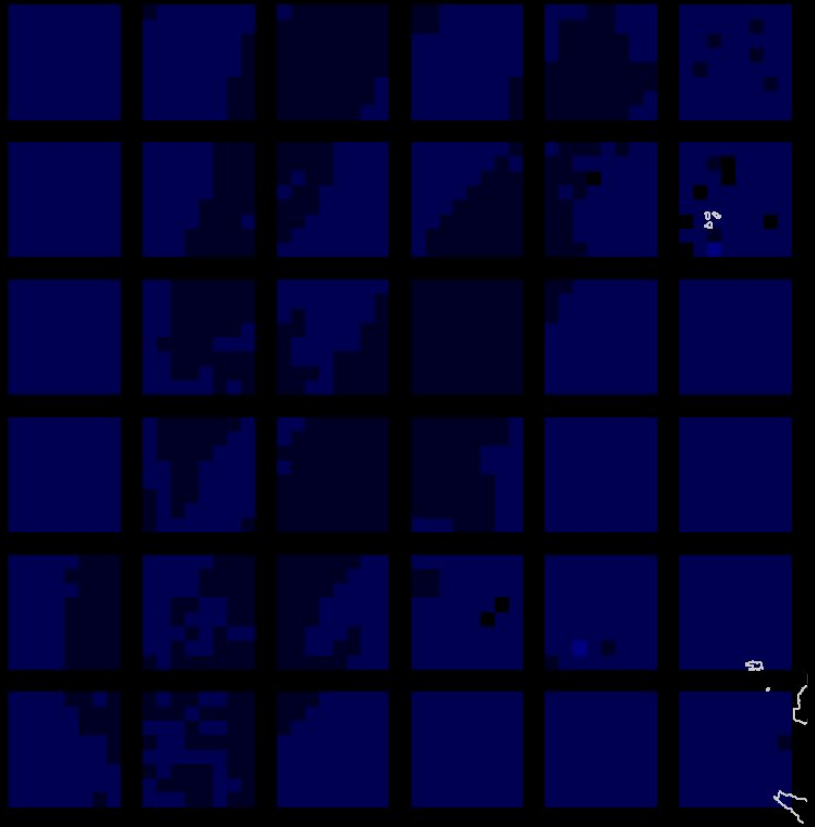


2304 channels in total
- Trigger modes at 2.5 μs & 320 ms time resolution
- Continuous mode at 41 ms

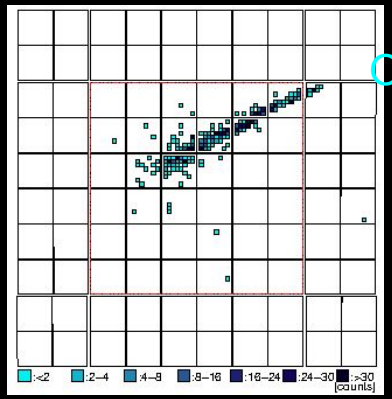


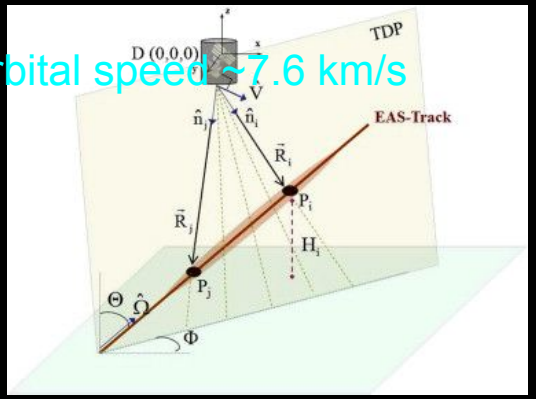

Bristol
Swindon
London
Southampton
Bournemouth
Brighton
Eastbourne
Cherbourg-
en-Cotentin
Dieppe
Saint
Malo
Cean
Rouen
~360 km (44° wide FOV)


50° N
40° N
30° N
0° N
120° W
110° W
100° W
90° W
Vancouver
Milwaukee
Seattle
Portland
Denver
Las Vegas
Phoenix
Tucson
Huntsville
Houston
Sun Luis Potosi
Preliminary
20
15
10
5
0



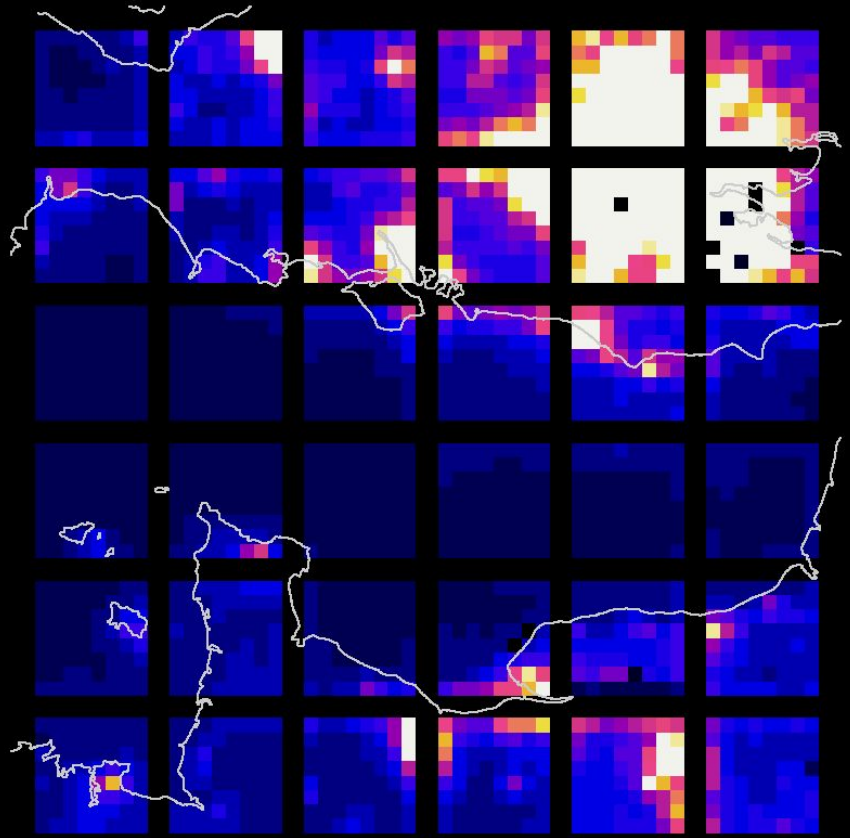
Revised from Adams et al. (2013) Astrophys. Phys. 44, 76 (left)
Bertaina et al. (2015) Adv. Res. Space 53, 1515 (right)





Applications to space-based UHECR missions

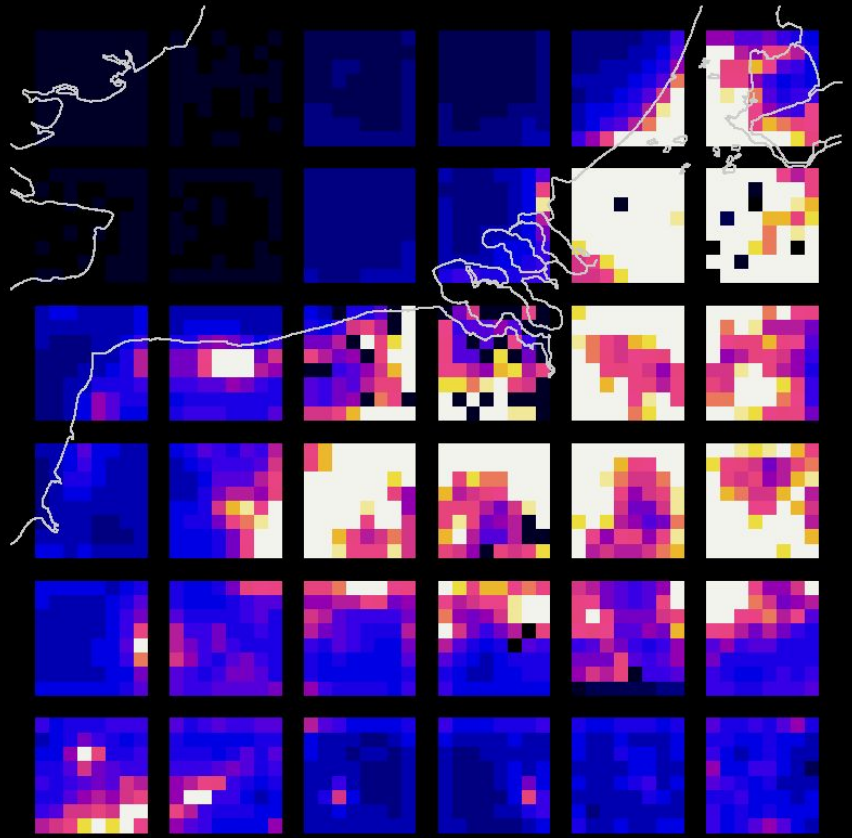
- Air shower reconstruction
- Exposure determination
- Global study of UV light background



Berlin

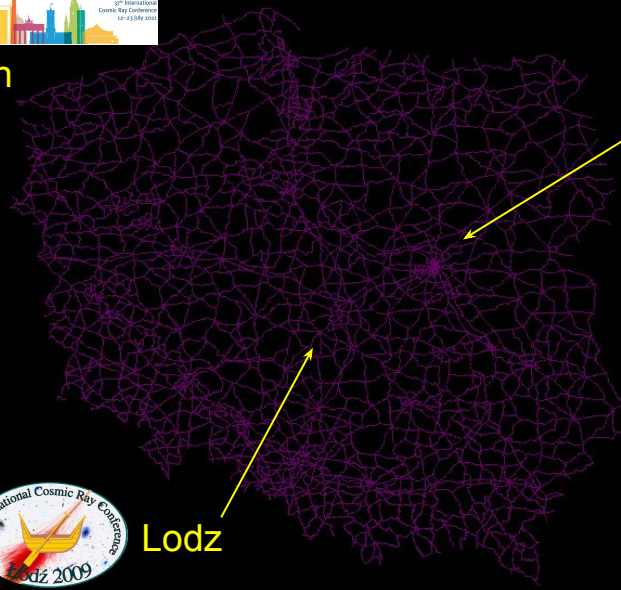
Warsaw

Lodz

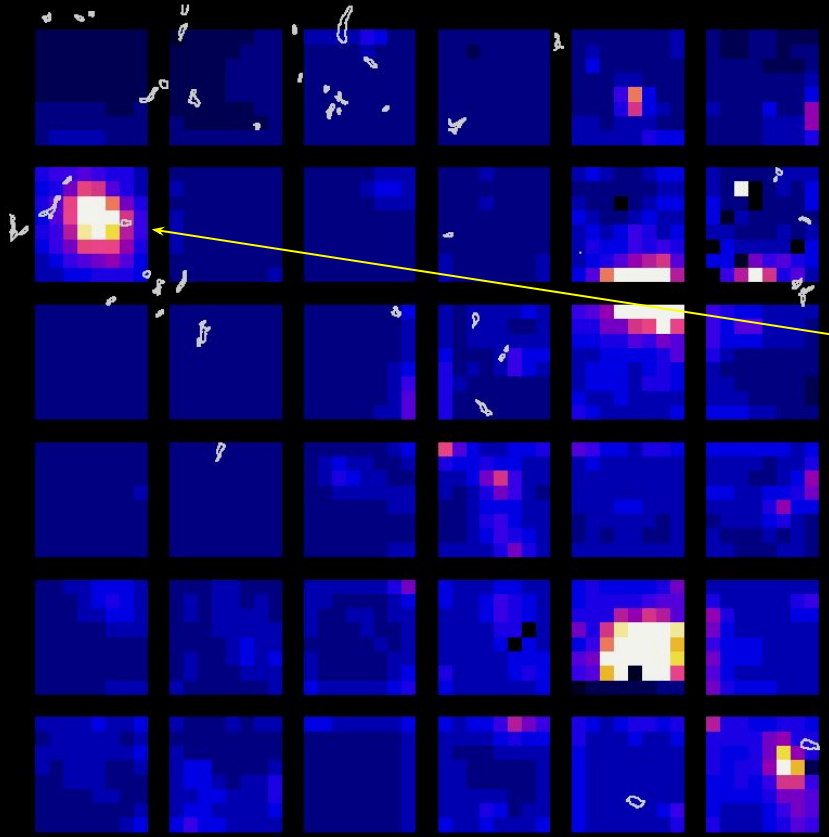


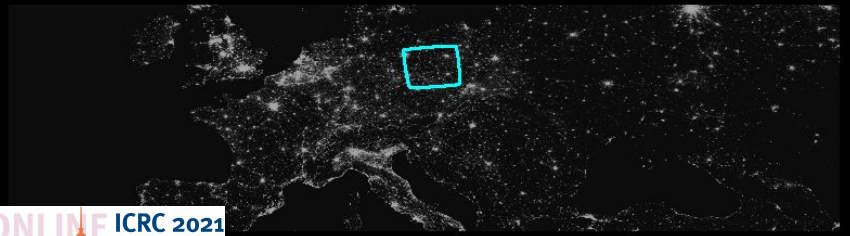
Berlin

Warsaw



Lodz

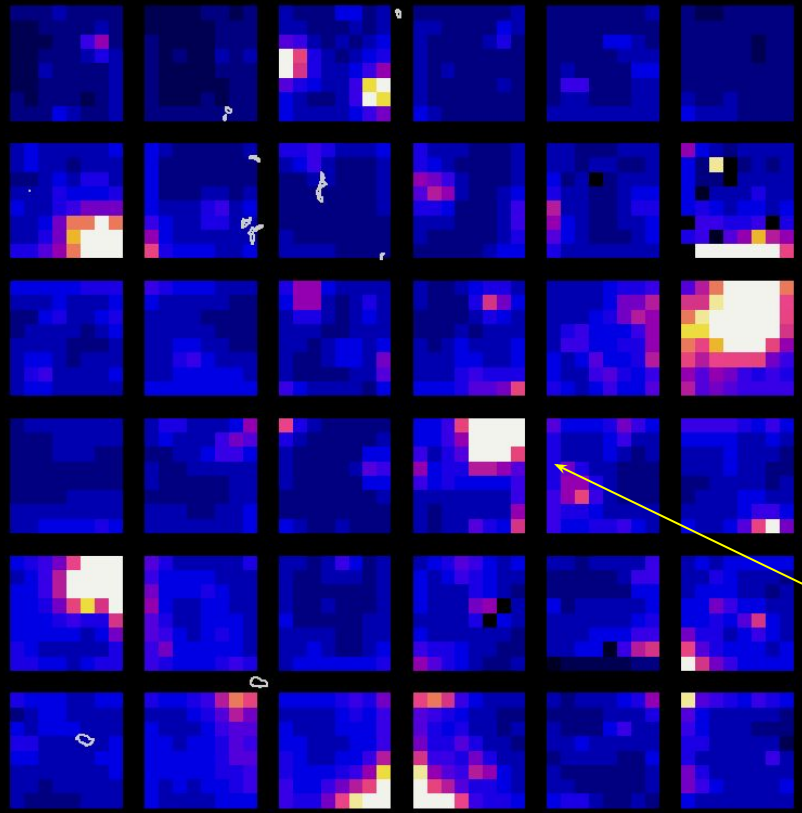


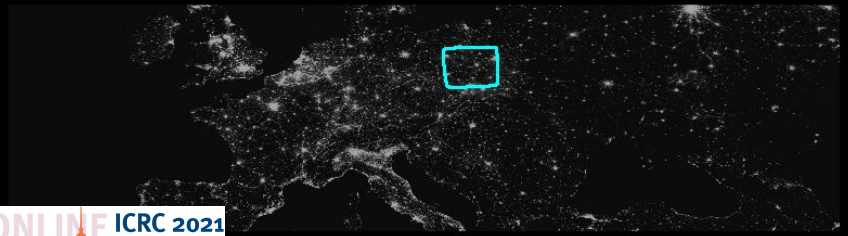


Berlin

Warsaw

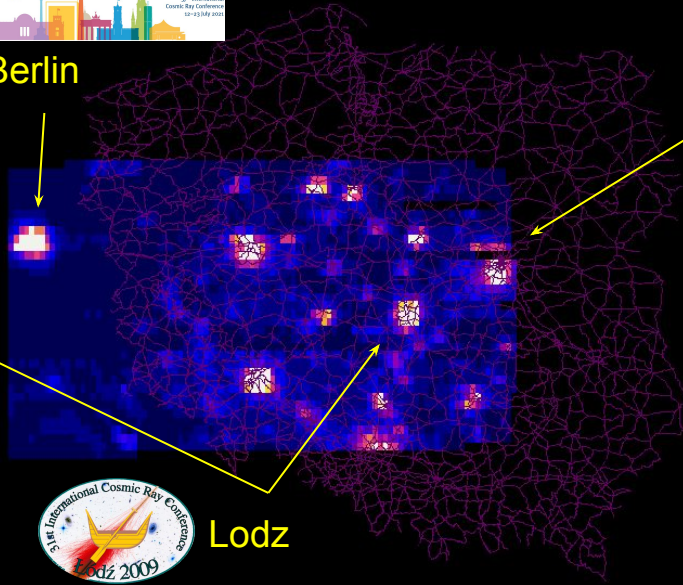
Lodz





Berlin

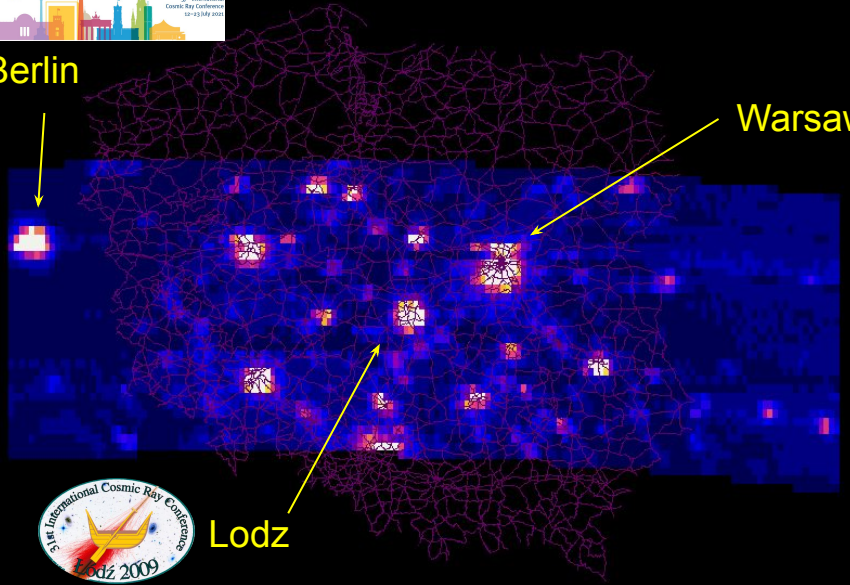
Warsaw



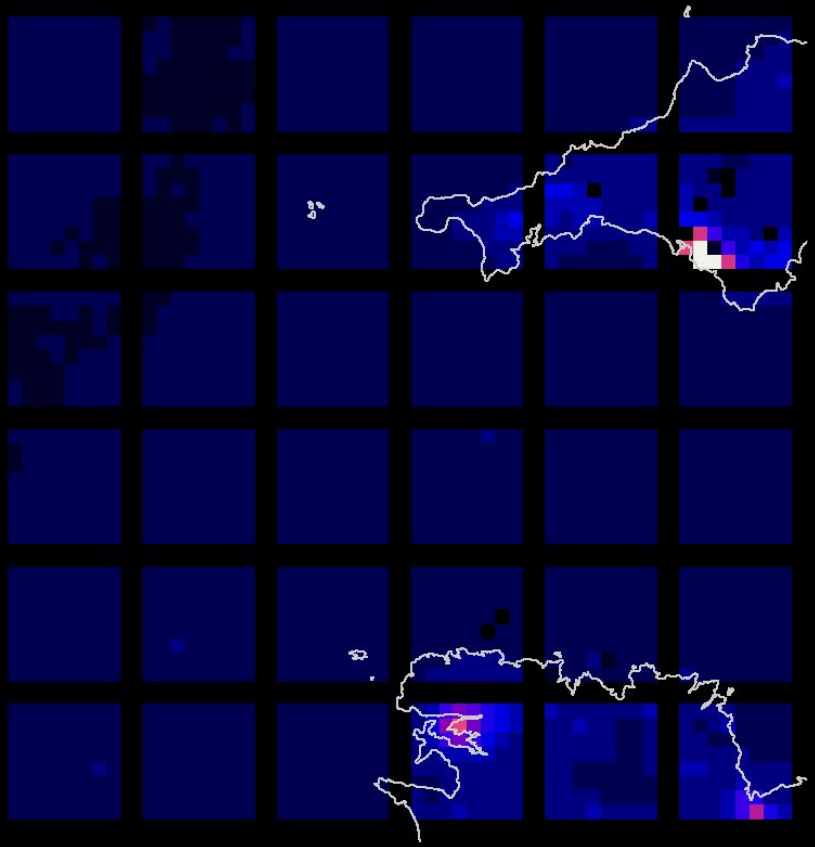
Lodz

Berlin

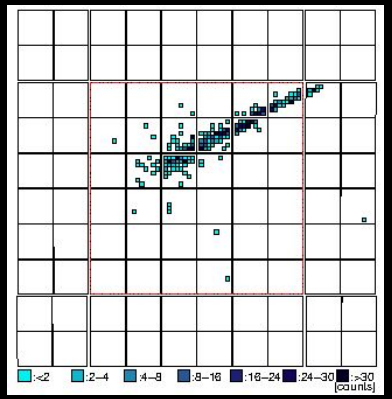
Warsaw

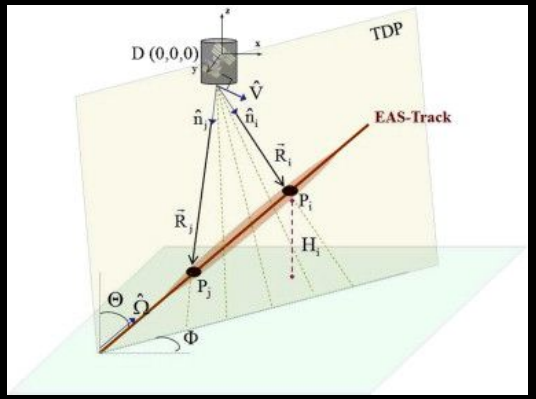


Lodz



Revised from Adams et al. (2013) Astrophys. Phys. 44, 76 (left)
Bertaina et al. (2015) Adv. Res. Space 53, 1515 (right)





Applications to space-based UHECR missions

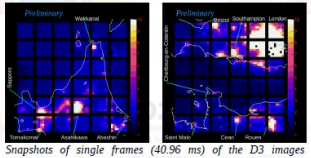
- Air shower reconstruction
- Exposure determination
- Global study of UV light background

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

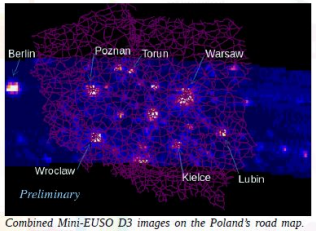
(a) National Centre for Nuclear Research, Poland; (b) KTH Royal Institute of Technology, Sweden; (c) Istituto Nazionale di Fisica Nucleare - Sezione di Torino, Italy; (d) Istituto Nazionale di Astrofisica - Osservatorio astrofisico di Torino, Italy; (e) Dipartimento di Fisica, Università di Torino, Italy; (f) Istituto Nazionale di Fisica Nucleare - Sezione di Roma Tor Vergata, Italy; (g) Università 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.

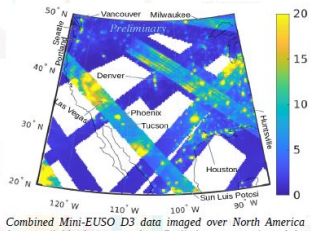


Combined Mini-EUSO D3 images on the Poland's road map. The data were acquired 3–4 min after passage of the English Channel. The color scale, as same as previous plots, shows the peak-hold value on the geographical grid points.

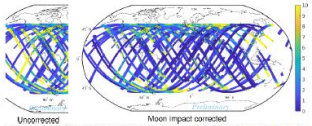
This example indicates good locating capability that is a relevant performance to determine the air shower geometry and observation exposure.

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.

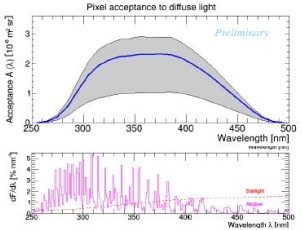


Combined Mini-EUSO D3 data imaged over North America from available data up to date. Preliminary correction of the impact of the moonlight is applied.



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.

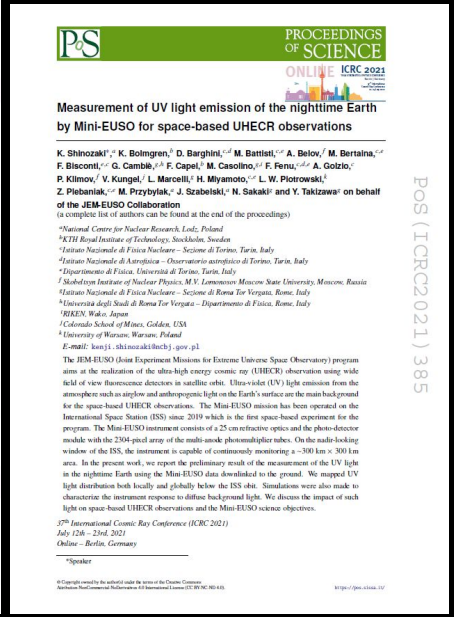
A typical count rate was 2.2 photoelectrons per (pixel 2.5 μs) for the moonless conditions above ocean. The measured count rates result from the mixtures of various light sources with unknown spectra. Thus, instrument simulations are made and the corresponding absolute intensities were deduced by assuming 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. Bootom: 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^{-2} 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.



PROCEEDINGS OF SCIENCE

ONLINE ICRC 2021

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] A. Belov,[f] 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,[f] V. Kungel,[f] L. Marcelli,[g] H. Miyamoto,[c,e] L. W. Piotrowski,[k] Z. Plebaniak,[a] M. Przybylak,[a] J. Szabelski,[a] N. Sakaki[l] and Y. Takizawa[l] on behalf of the JEM-EUSO Collaboration
(a complete list of authors can be found at the end of the proceedings)

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

The JEM-EUSO (Joint Experiment Missions for Extreme Universe Space Observatory) program aims at the realization of the ultra-high energy cosmic ray (UHECR) observation using wide field of view fluorescence detectors in satellite orbit. Ultra-violet (UV) light emission from the atmosphere such as airglow and anthropogenic light on the Earth's surface are the main background for the space-based UHECR observations. The Mini-EUSO mission has been operated on the International Space Station (ISS) since 2019 which is the first space-based experiment for the program. The Mini-EUSO instrument consists of a 25 cm refractive optics and the photo-detector module with the 2304-pixel array of the multi-anode photomultiplier tubes. On the nadir-looking window of the ISS, the instrument is capable of continuously monitoring a ~300 km × 300 km area. In the present work, we report the preliminary result of the measurement of the UV light in the nighttime Earth using the Mini-EUSO data downlinked to the ground. We mapped UV light distribution both locally and globally below the ISS obit. Simulations were also made to characterize the instrument response to diffuse background light. We discuss the impact of such light on space-based UHECR observations and the Mini-EUSO science objectives.

37th International Cosmic Ray Conference (ICRC 2021)
July 12th – 23rd, 2021
Online – Berlin, Germany

*Speaker

https://pos.sissa.it/

PoS(ICRC2021)385

For further details, please refer to our poster and proceedings paper. Thank you for viewing.