The global CREDO cosmic radiation research project and the synergy of its extensive scientific research and popularization activities

Robert Kamiński[a,b]

[a]Institute of Nuclear Physics Polish Academy of Sciences, Kraków

[b]Project CREDO (CREDO.science)

Görlitz XII 2023, CASUS conference

CREDO:

- definition

- how does it work?

- scientific goals

- citizen science

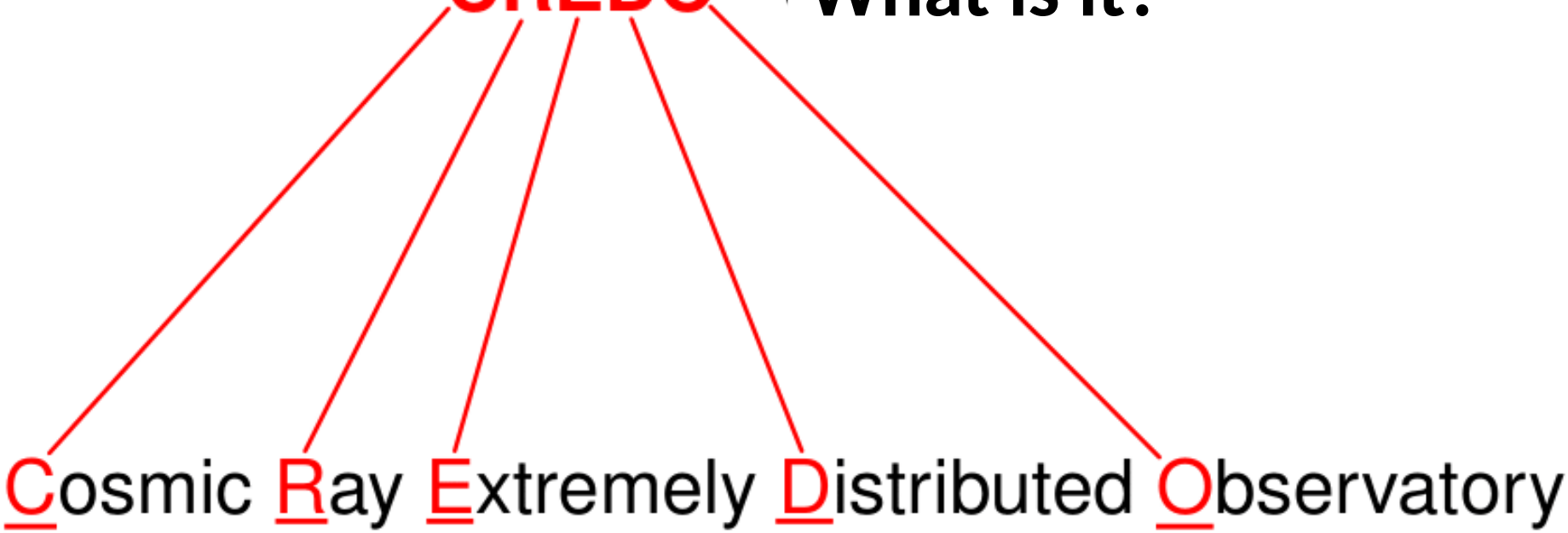
CREDO - What is it?

Cosmic Ray Extremely Distributed Observatory

The idea created in 2016 by Piotr Homola (INP PAS, Kraków)

(Division of Partice Physics and Astrophysics (N01)
Department of Cosmoc Rays and Neutrins (NZ15)

CREDO - What is it?



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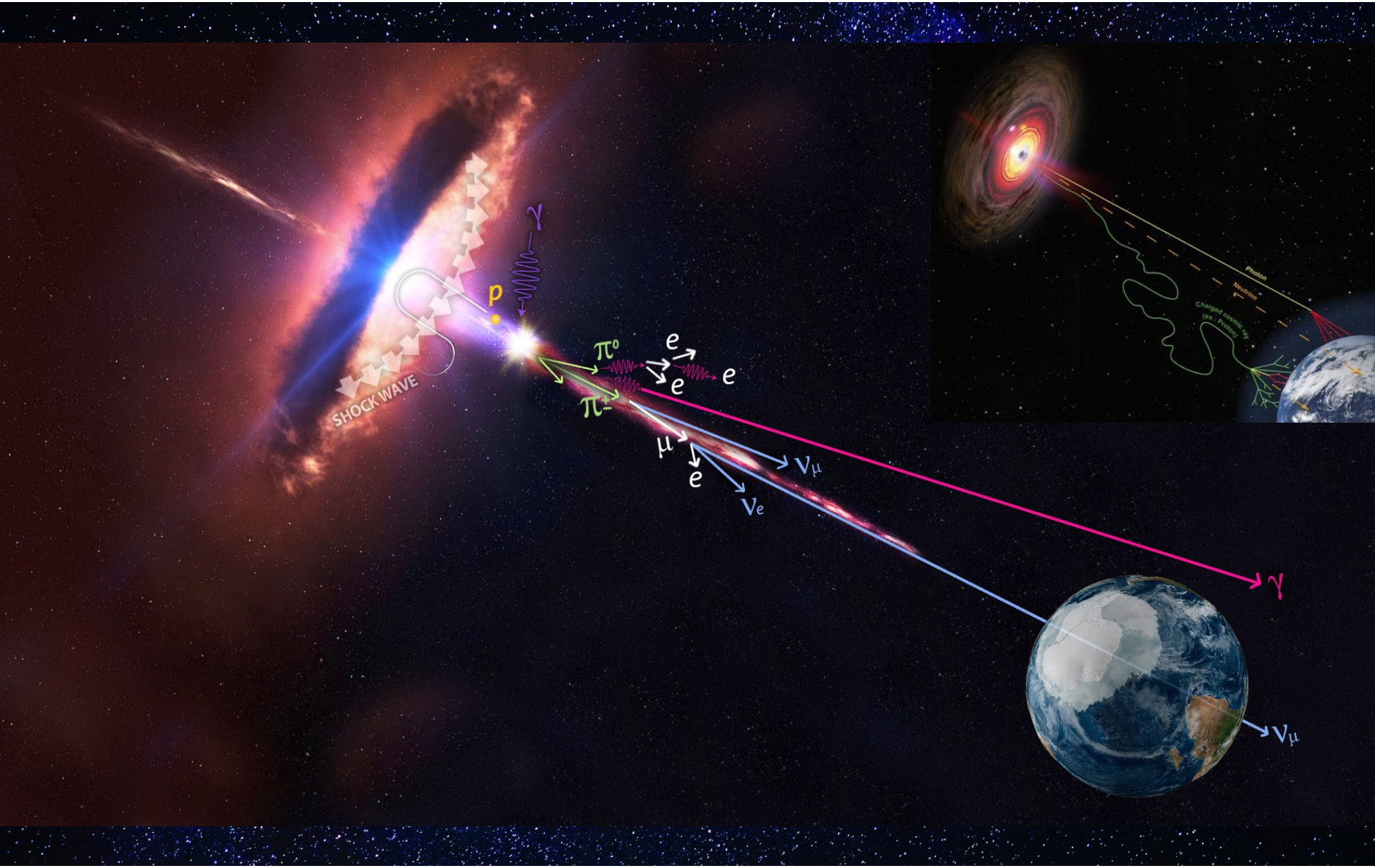
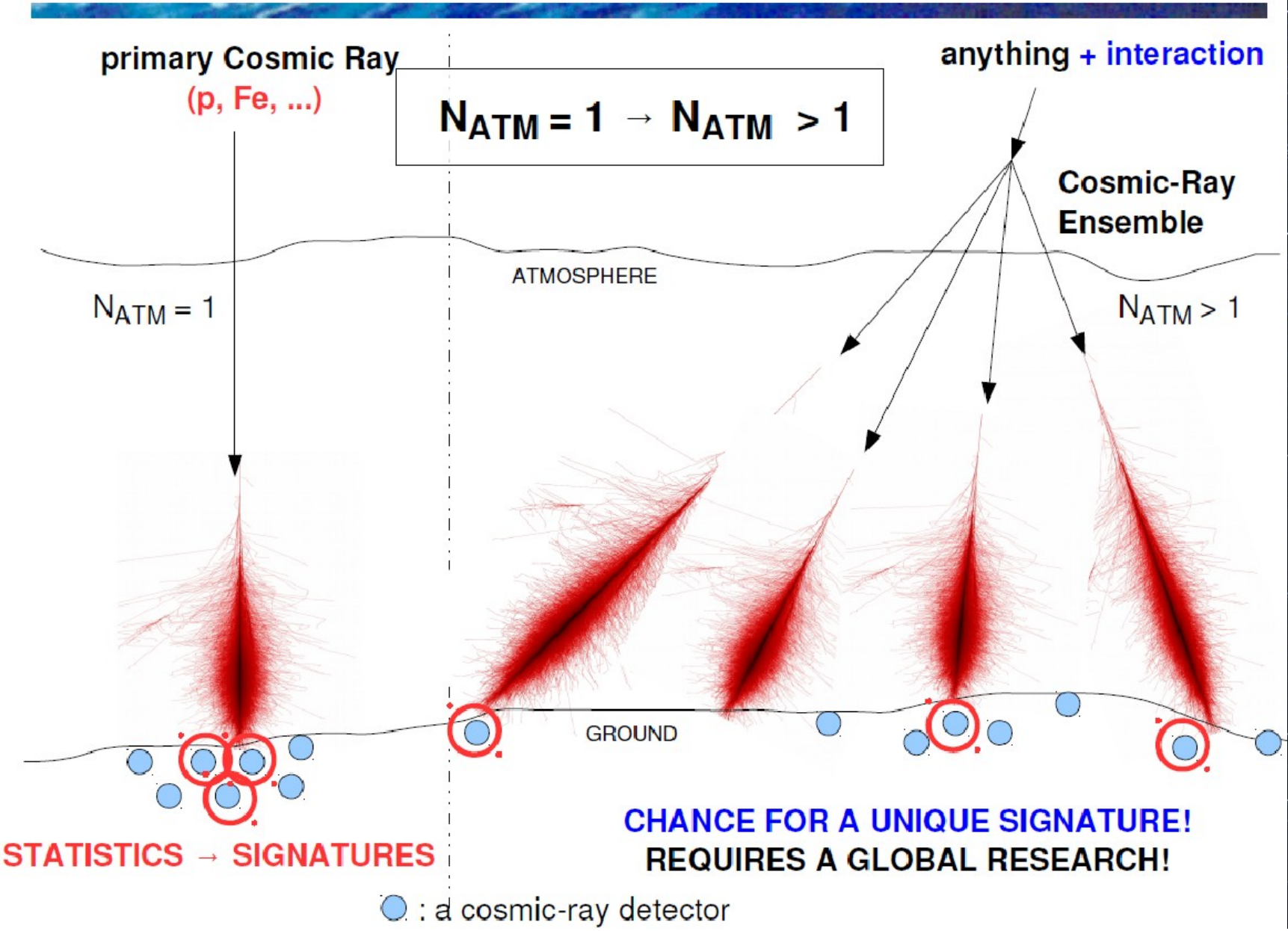
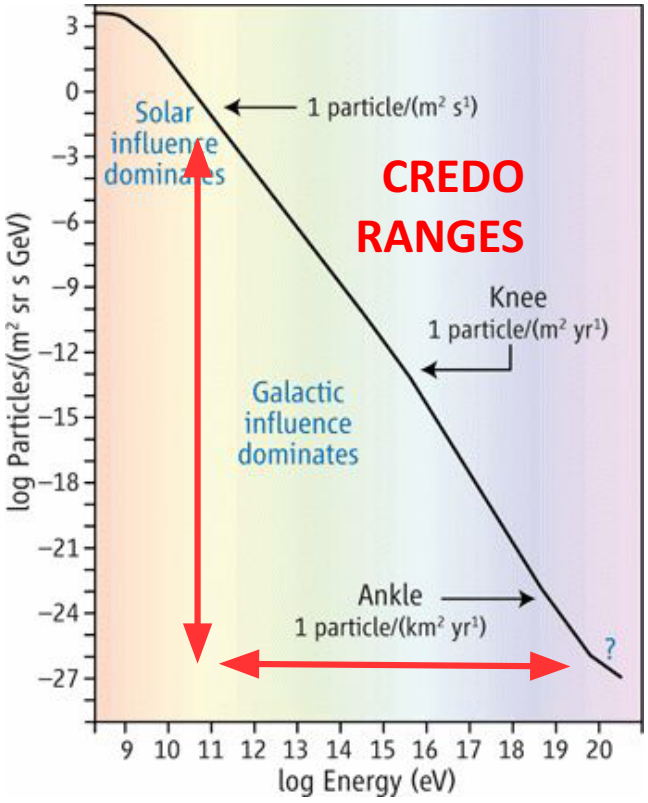

SHOCK WAVE
p
γ
π⁰
e
e
e
π⁻
μ
e
νμ
νe
γ
νμ
Photon
Neutrino
Charged cosmic ray
(ex.: Proton)

CREDO:
how does it work?


primary Cosmic Ray
(p, Fe, ...)
$N_{ATM} = 1 \rightarrow N_{ATM} > 1$
anything + interaction
Cosmic-Ray Ensemble
ATMOSPHERE
$N_{ATM} = 1$
$N_{ATM} > 1$
GROUND
STATISTICS → SIGNATURES
CHANCE FOR A UNIQUE SIGNATURE!
REQUIRES A GLOBAL RESEARCH!
: a cosmic-ray detector

Cosmic Ray Ensembles (CRE)! Full energy spectrum!



CREDO
THE QUEST FOR THE UNEXPECTED

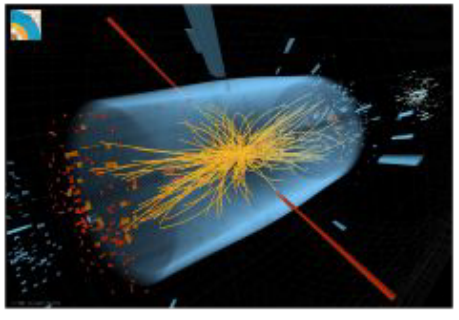
->

Cosmic Ray Extremely Distributed Observatory

Organizing cosmic observations?

production → (acceleration) → interactions → particle ensemble → conclusions

Laboratories (experiments)
accelerators & collinders



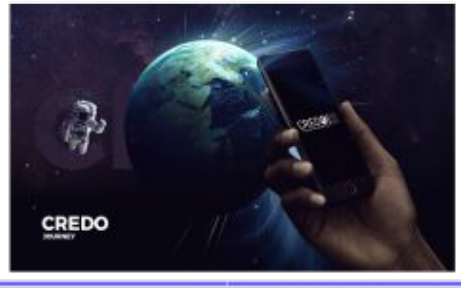
Investment:
~100 mld $ ~0 $

Energies
$<10^{12}$ eV $<10^{20}$ eV+

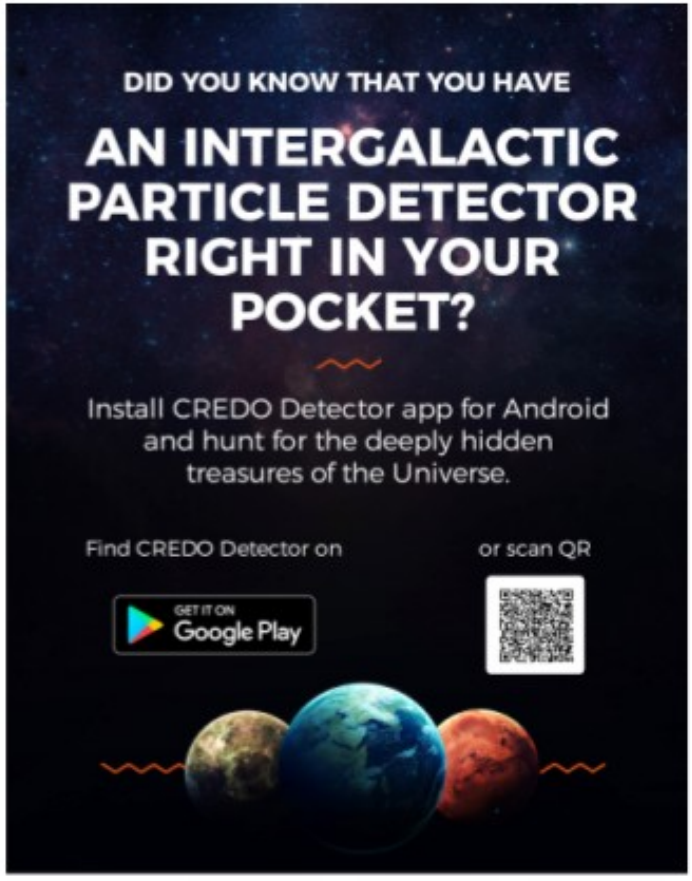
Availability:
Rich countries Everybody

Data flux:
huge small

Cosmos (observations)
accelerator & collider



Novel Global Solution: **cloud of clouds**



-> “new data”!

CREDO Detector: what do we see?

[work in progress, e.g. at IFJ PAN]

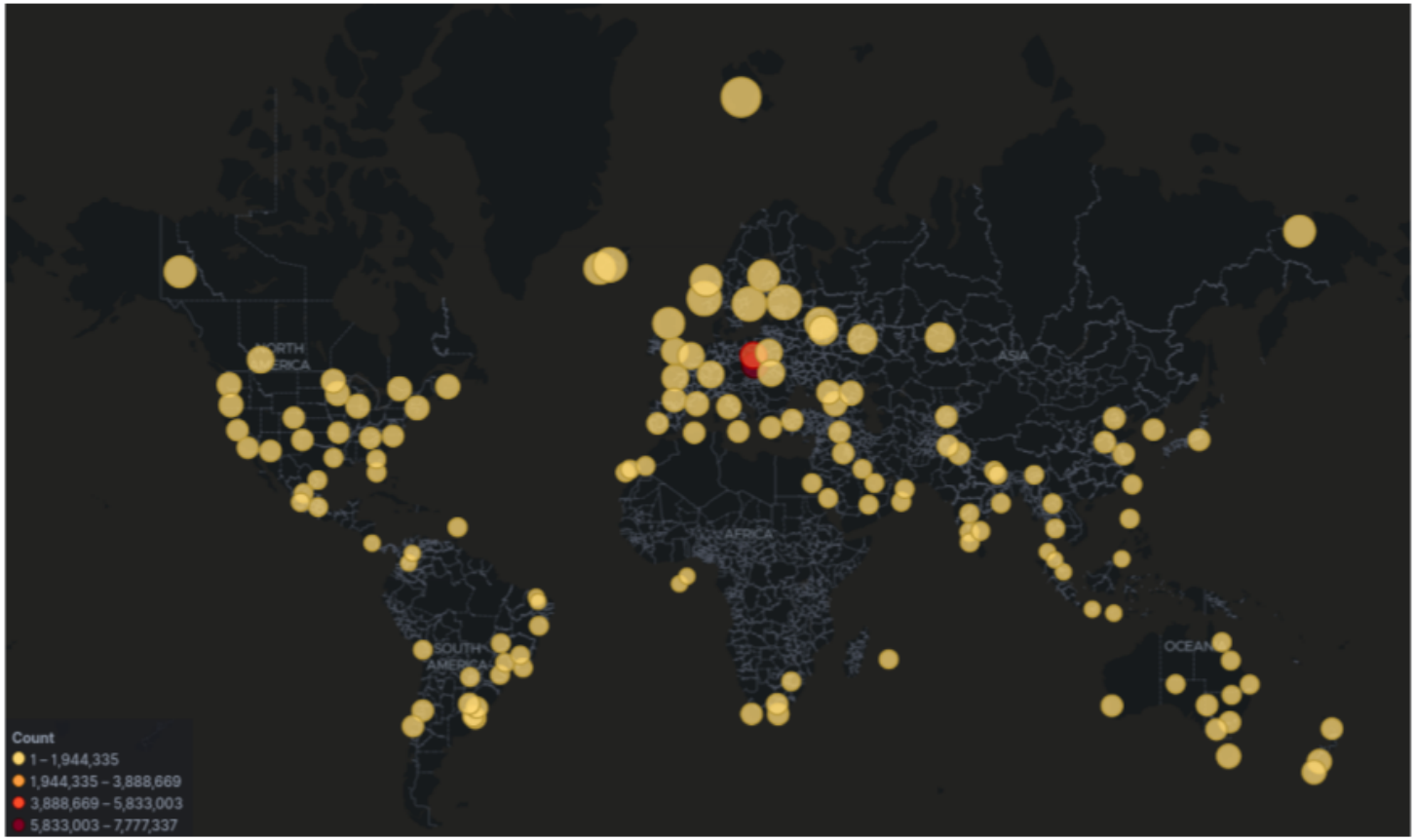
scenarios!

muons?

air showers ?

CRE?

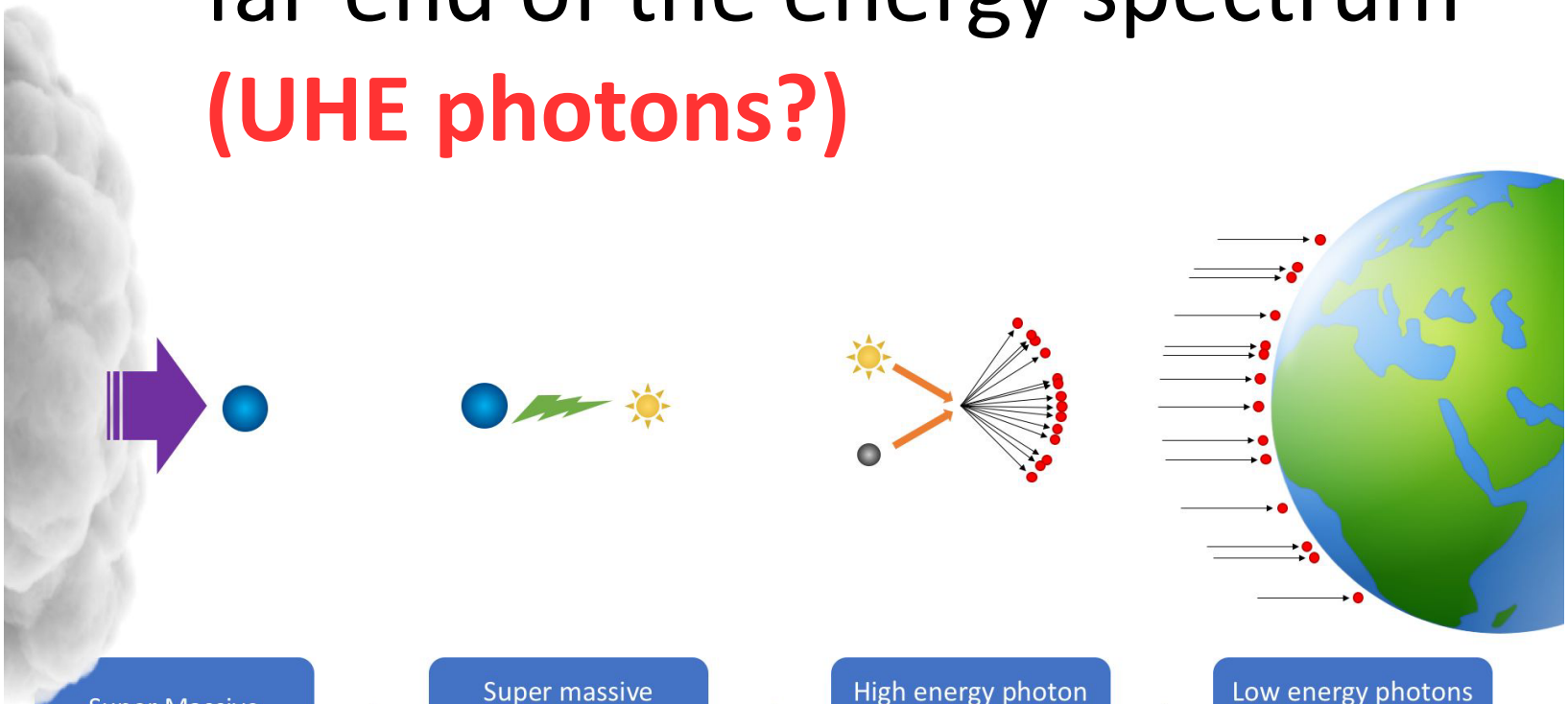
CREDO: already global



50 institutions / 20 countries / 5 continents / ~ 20 200 users / ~ 14 600 teams / > 14 100 000 smartphone detections / > 1250 smartphone work years

CREDO:
scientific goals

a. UHECR / Dark Matter (exotic) puzzle (puzzles) and the challenge in the far-end of the energy spectrum **(UHE photons?)**



b. Spacetime structure: probing with CRE

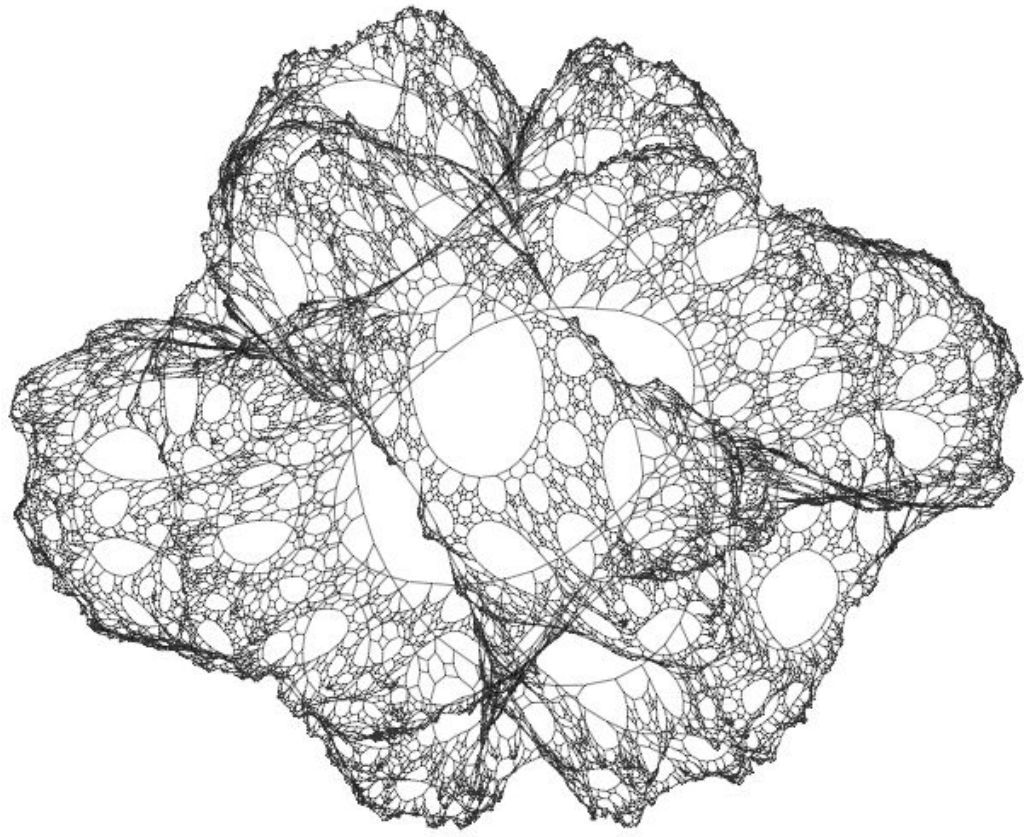
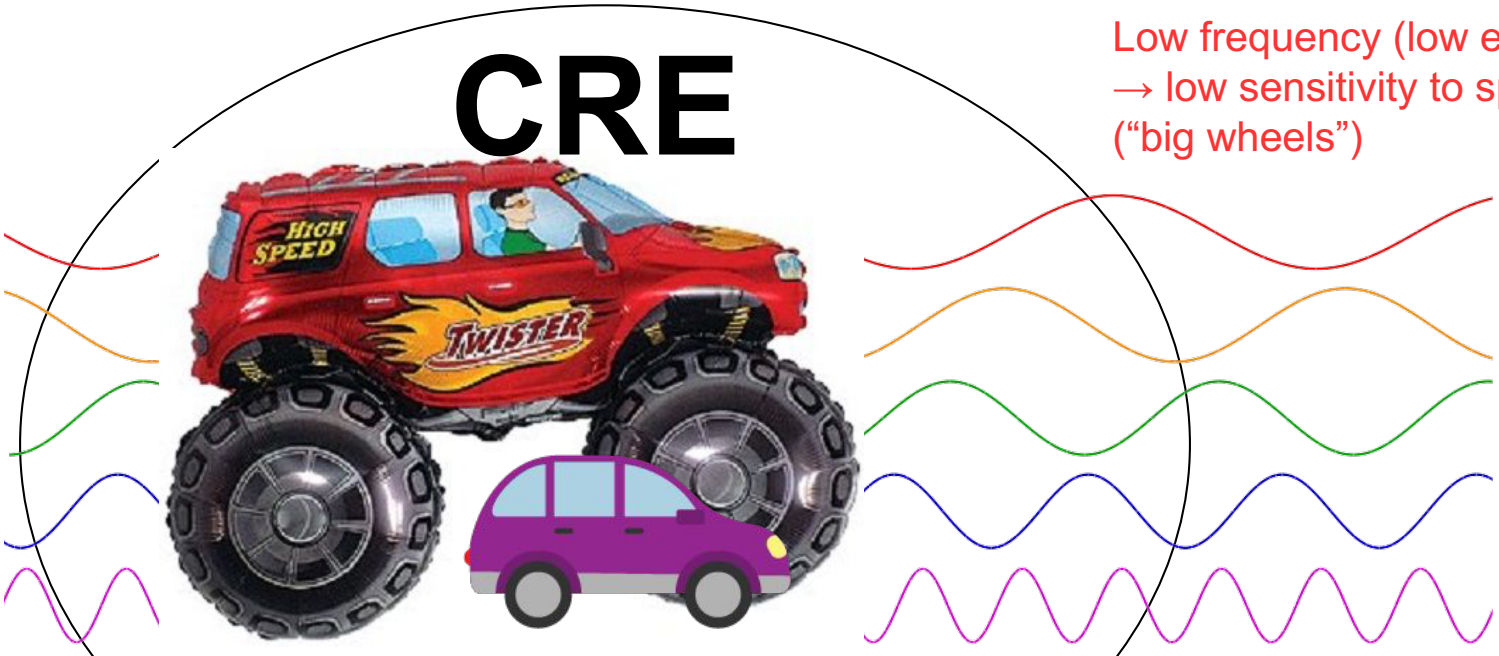
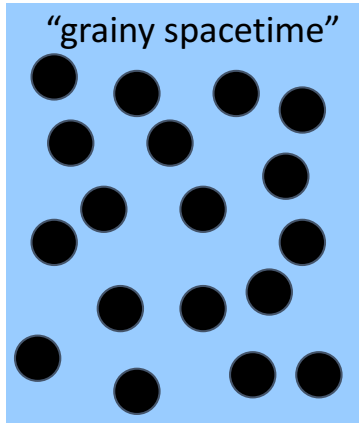


image source: https://writings.stephenwolfram.com/2015/12/what-is-spacetime-really/

Cosmic Ray Ensembles as spacetime probes



Low frequency (low energy)
→ low sensitivity to spacetime structure
("big wheels")

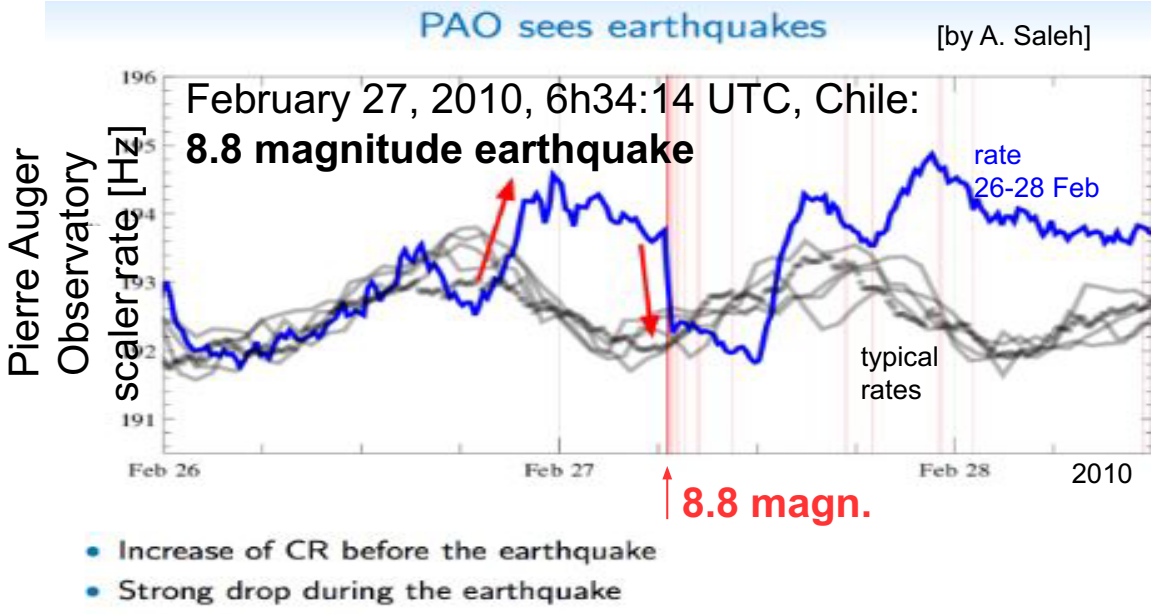


Cosmic Ray Ensembles composed of photons of significantly different energies: new potential of probing the spacetime structure

High frequency (high energy)
→ high sensitivity to spacetime structure
("small wheels")

c) CREDO-earthquakes task

The seismic precursor in cosmic rays: inspiration from the Pierre Auger Observatory



→ **CREDO-earthquakes task**

Inhabitants of territories threatened by earthquakes [= potential CREDO public engagement target]:

2,7 billion people

Science as a service to the human community?

Even the smallest chance to save lives

= **a must check!**

For all these scientific topics:

Interdisciplinary potential: contribution to earthquake early warning system?

Physics > Geophysics

[Submitted on 26 Apr 2022]

Observation of large scale precursor correlations between cosmic rays and earthquakes

P. Homola, V. Marchenko, A. Napolitano, R. Damian, R. Guzik, D. Alvarez-Castillo, S. Stuglik, O. Ruimi, O. Skorenok, J. Zamora-Saa, J.M. Vaquero, T. Wibig, M. Knap, K. Dziadkowiec, M. Karpiel, O. Sushchov, J. W. Mietelski, K. Gorzkiewicz, N. Zabari, K. Almeida Cheminant, B. Idźkowski, T. Bulik, G. Bhatta, N. Budnev, R. Kamiński, M.V. Medvedev, K. Kozak, O. Bar, Ł. Bibrzycki, M. Bielewicz, M. Frontczak, P. Kovács, B. Łozowski, J. Miszczyk, M. Niedźwiecki, L. del Peral, M. Piekarczyk, M. D. Rodriguez Frias, K. Rzecki, K. Smelcerz, T. Sośnicki, J. Stasielak, A. A. Tursunov

The search for correlations between secondary cosmic ray detection rates and seismic effects has long been a subject of investigation motivated by the hope of identifying a new precursor type that could feed a global early warning system against earthquakes. Here we show for the first time that the average variation of the cosmic ray detection rates correlates with the global seismic activity to be observed with a time lag of approximately two weeks, and that the significance of the effect varies with a periodicity resembling the undecenal solar cycle, with a shift in phase of around three years, exceeding 6 sigma at local maxima. The precursor characteristics of the observed correlations point to a pioneer perspective of an early warning system against earthquakes.

> 6 σ

Comments: 16 pages, 4 figures in the main article and 11 pages and 4 figures in the Suplementary Material

Subjects: **Geophysics (physics.geo-ph)**; Earth and Planetary Astrophysics (astro-ph.EP); High Energy Astrophysical Phenomena (astro-ph.HE); Solar and Stellar Astrophysics (astro-ph.SR)

Cite as: arXiv:2204.12310 **[physics.geo-ph]**

(or arXiv:2204.12310v1 **[physics.geo-ph]** for this version)

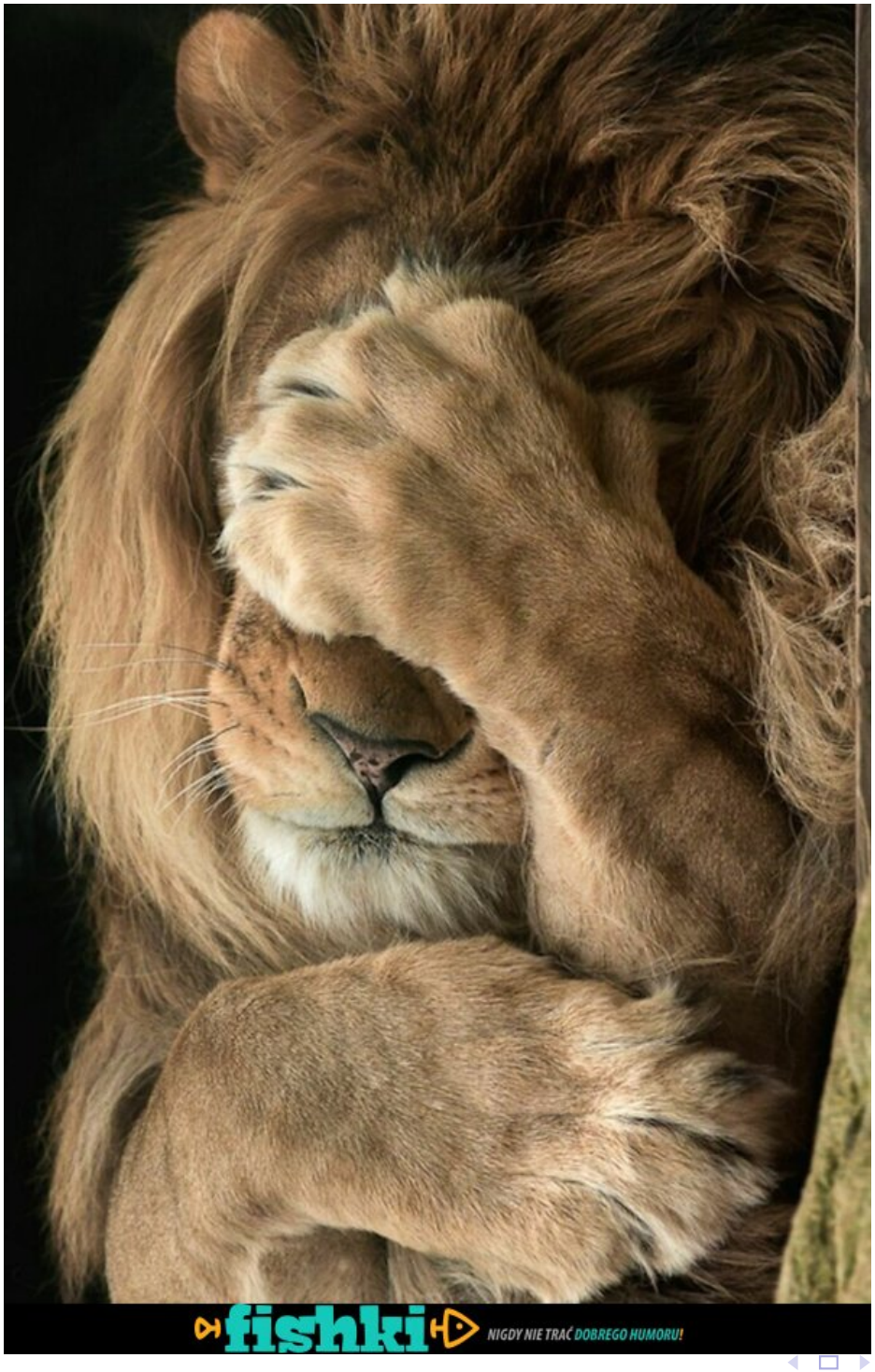
https://doi.org/10.48550/arXiv.2204.12310

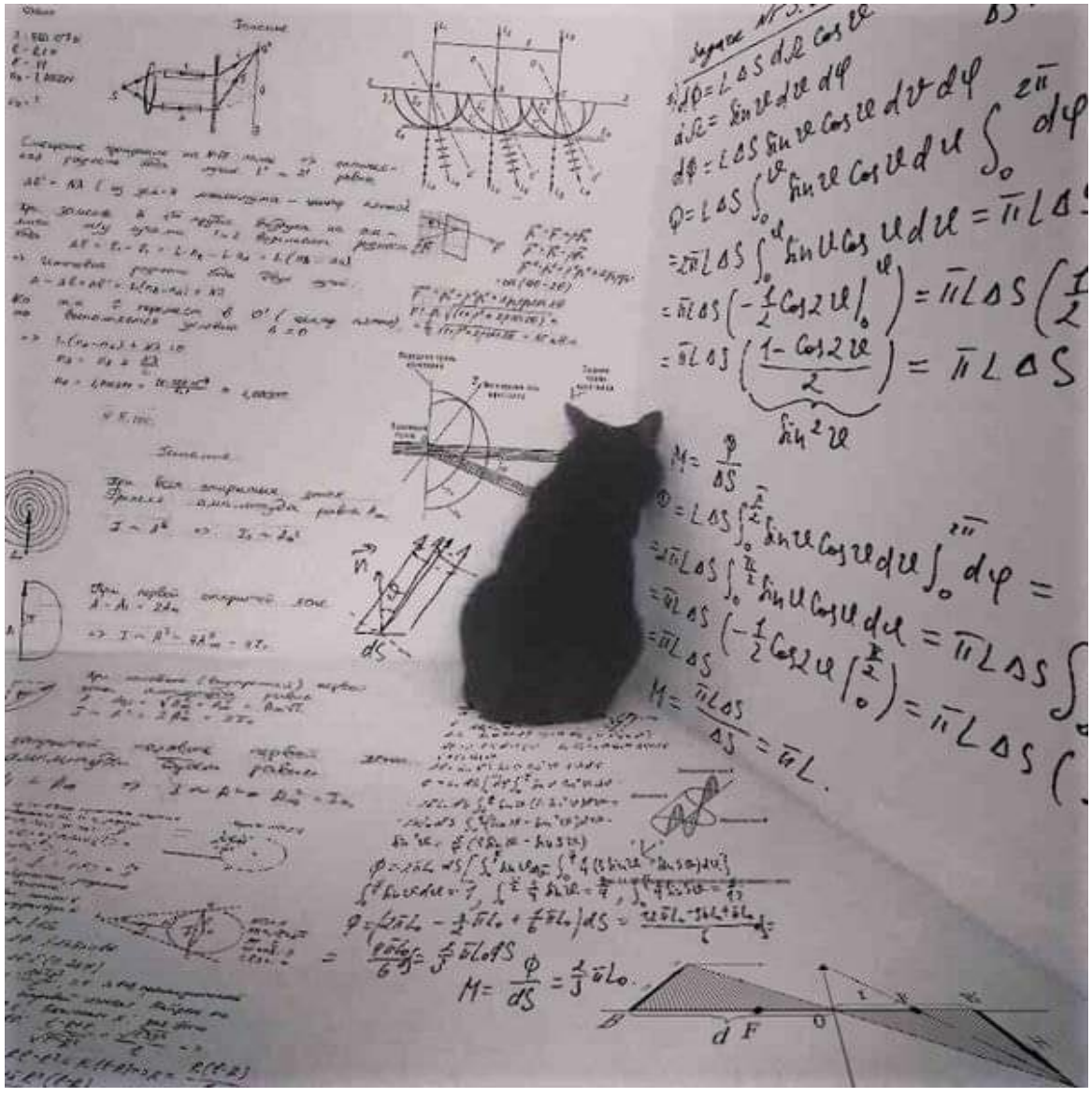
Submission history

From: Piotr Homola Dr. [view email]

[v1] Tue, 26 Apr 2022 13:37:03 UTC (1,085 KB)

(in review @ JASTP)


fishki
NIGDY NIE TRAĆ DOBREGO HUMORU!



Cosmic ray variation 15 days before the corresponding change in seismic activity!

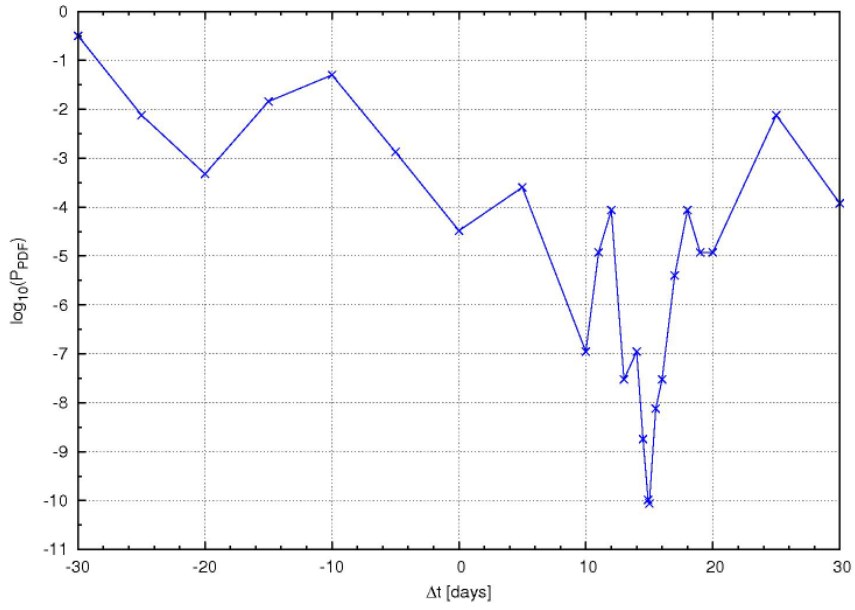
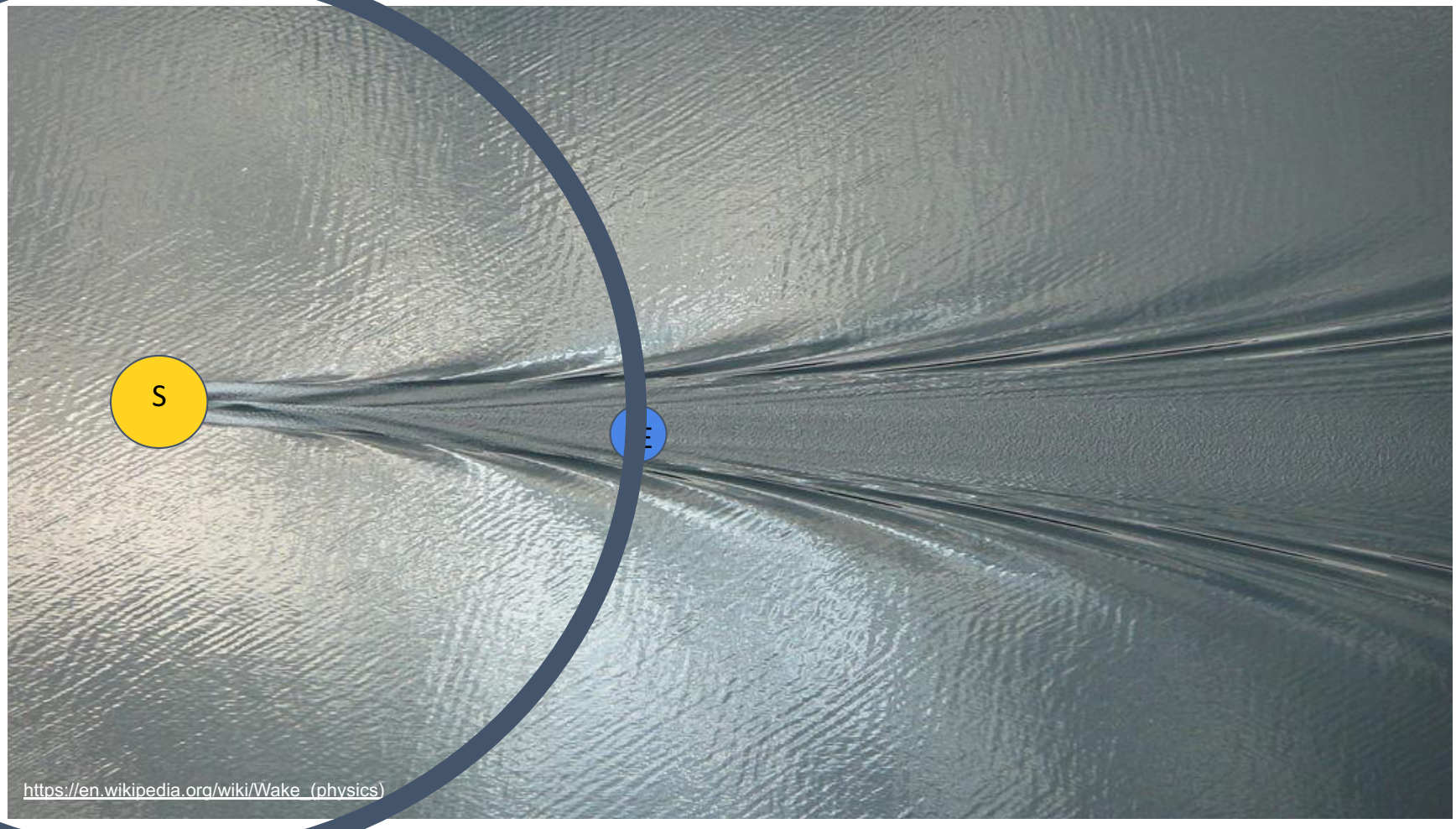


Fig. 3: The dependence of the significance of the *cosmo-seismic* correlations on the time shift t of the EQ data with respect to the Auger CR data, for the optimum free parameter set defined in Eq. 1. The positive or negative values of t correspond to the situations in which one compares the secondary cosmic ray data in a given time interval to the seismic data recorded in time intervals in the future or in the past, respectively.

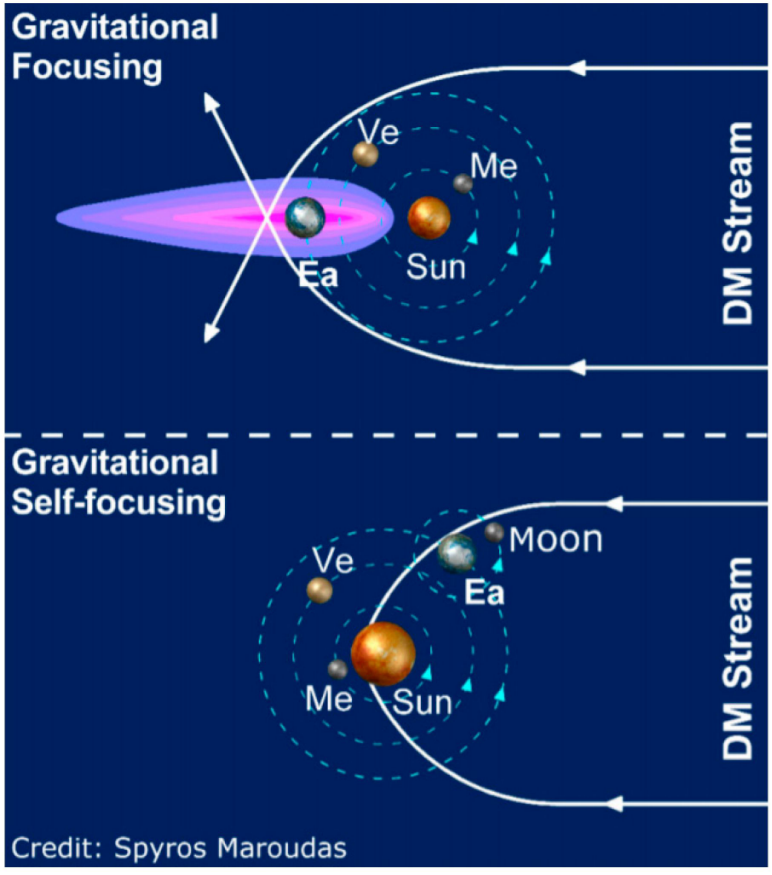
… or Dark Fluid -> dark wake(s)?



https://en.wikipedia.org/wiki/Wake_(physics)

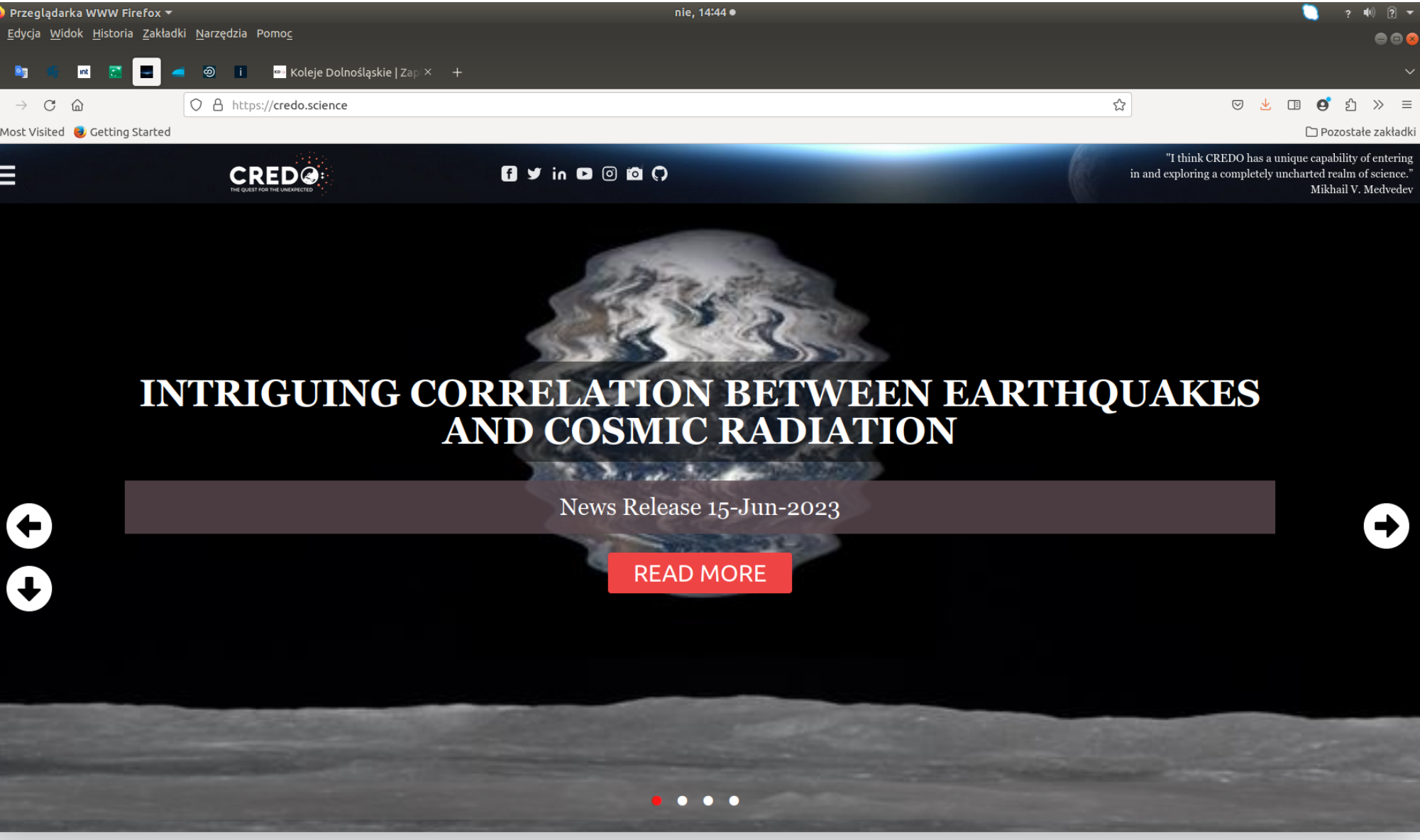
Interpretation: role of the Sun, or … Dark Matter stream?

K. Zioutas et al., 2021
Phys. Sci. Forum **2021**, *2*(1), 10; https://doi.org/10.3390/ECU2021-09313



PH: **(SH)DM overdensities:**
-> periodic (yearly?) CR variations?
-> delayed gravitational shocks?

13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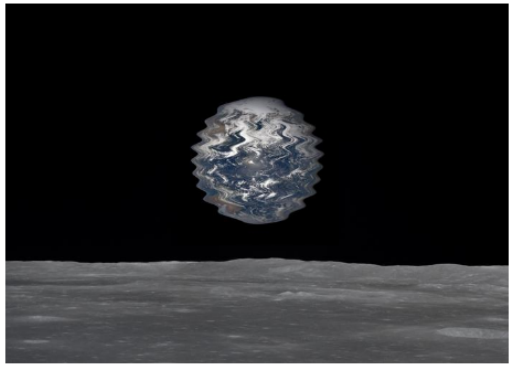


The cosmo-seismic article has a press release:
https://www.eurekalert.org/news-releases/992637
Enjoy reading and sharing! There has already been quite an impact in the media and first scientific effects like invitations to cooperation.
Big thanks the Instytut Fizyki Jądrowej PAN science popularization team for preparing and publishing the release!
The Polish version you can read on the portal:
naukawpolsce.pl

Other topics

- Ultra-high energy photons flux in the solar magnetic field
- Simulation of Cosmic-ray Ensembles
- Machine learning
- Muon flux variations
- Acceleration of ultra-high-energy cosmic rays by local supermassive black hole
- Detectors and analyses of the data

CREDO:
citizen science

- all institutions and private individuals,
- schools: "Particle Hunters" competitions,
- completely free and full access to CREDO data,
- three grants from the Visegrad Fund (each €28k) for popularization and DETECTORS,
- doctoral students, master's students, interns,
- articles: published/citable: 23/45, citations: 273/284

Black holes, neutron stars, gravitational waves and cosmic radiation in the CREDO project

dr hab. Robert Kamiński
Prof. IFJ PAN

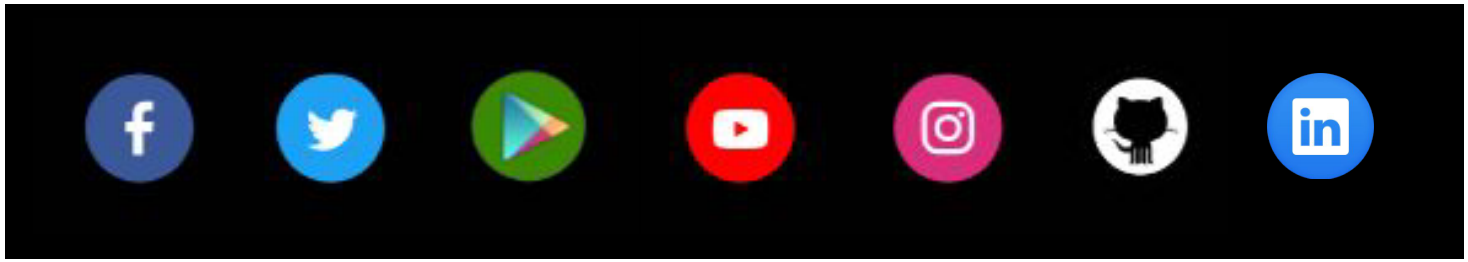
THE HENRYK NIEWODNICZAŃSKI INSTITUTE OF NUCLEAR PHYSICS POLISH ACADEMY OF SCIENCES

CREDO
THE QUEST FOR THE UNEXPECTED

mgr inż. Sławomir Stuglik
IFJ PAN

More about CREDO

https://credo.science



Topic examples (PH): https://credo.science/#/education/practices/

Personal contact:

Piotr Homola / the CREDO Project Coordinator /
Piotr.Homola@credo.science / +48 502 294 333

Thanks CASUS for possibility,

Thanks DB for invitation