Public engagement as a scientific tool to implement multi-messenger strategies with the Cosmic-Ray Extremely Distributed Observatory*

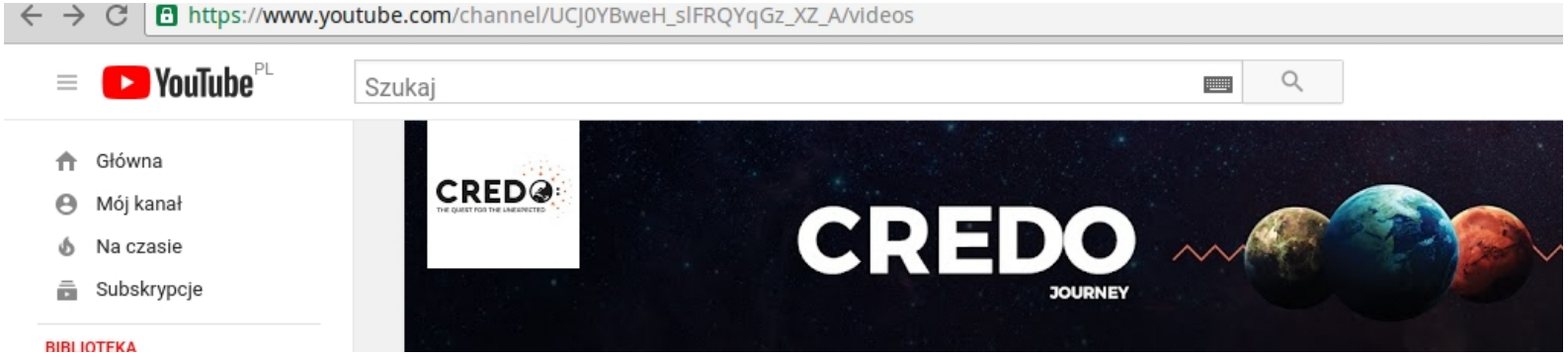
CREDO
THE QUEST FOR THE UNEXPECTED

Piotr Homola □

□) Institute of Nuclear Physics
Polish Academy of Sciences, Kraków, Poland
*) http://credo.science

take home physics:
$N_{ATM} >= 1$!

The new era of multi-messenger astrophysics,
Groningen, 27.03.2019



CREDO

CREDO

JOURNEY

Odtwórz

https://youtu.be/iqwDj4k3mC0

0:07 / 1:53

CREDO: the first $N_{ATM} >= 1$ observatory

Cosmic-Ray Extremely Distributed Observatory

Central database/interface: access to everything for everybody

Somewhere on Earth, 1000m^2: what is missing here?

$1000m^2$ → ~5000 muons in 0.03 s, penetrating!

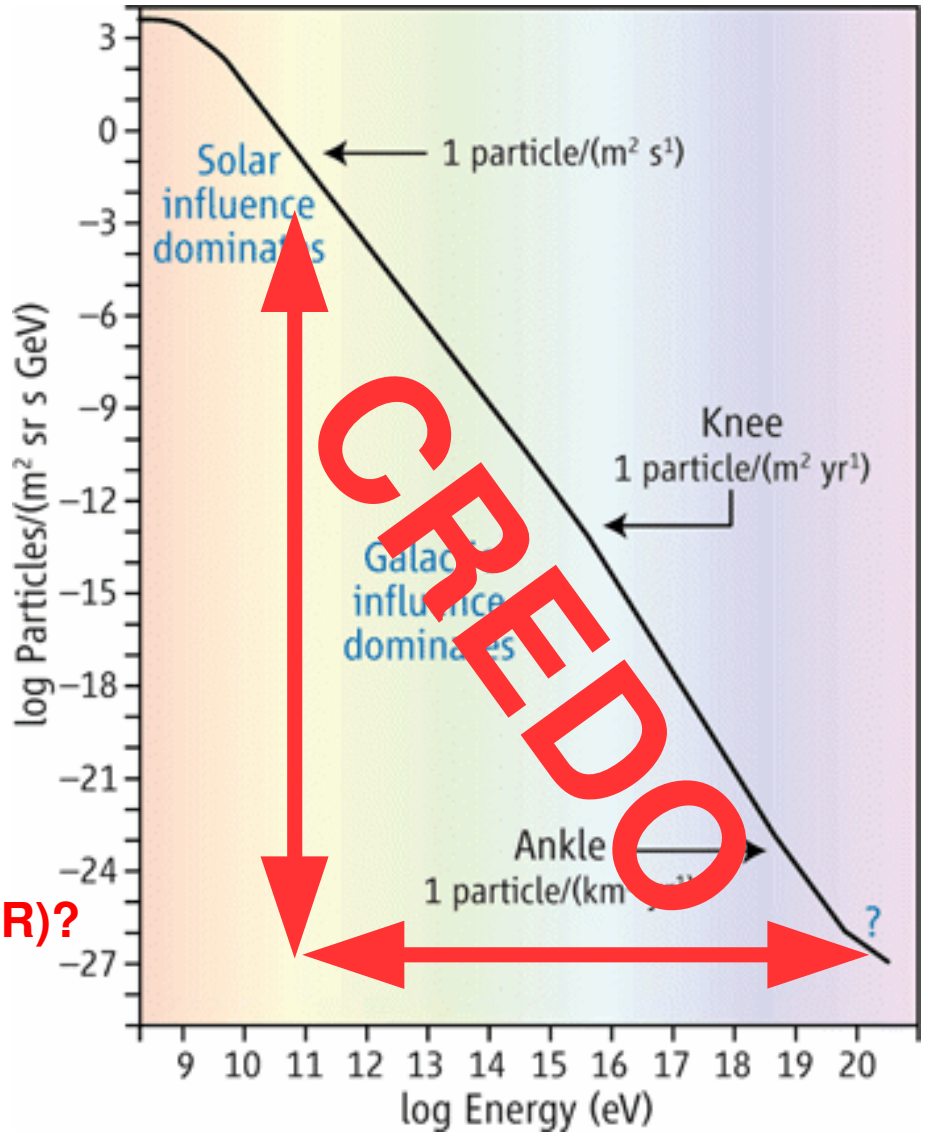
CR: under-explored field! Global search not yet tried!

Ranges:
energy: > 10 orders of magnitude
flux: > 30 orders of magnitude
→ diverse physics (sources)
→ diverse detection techniques

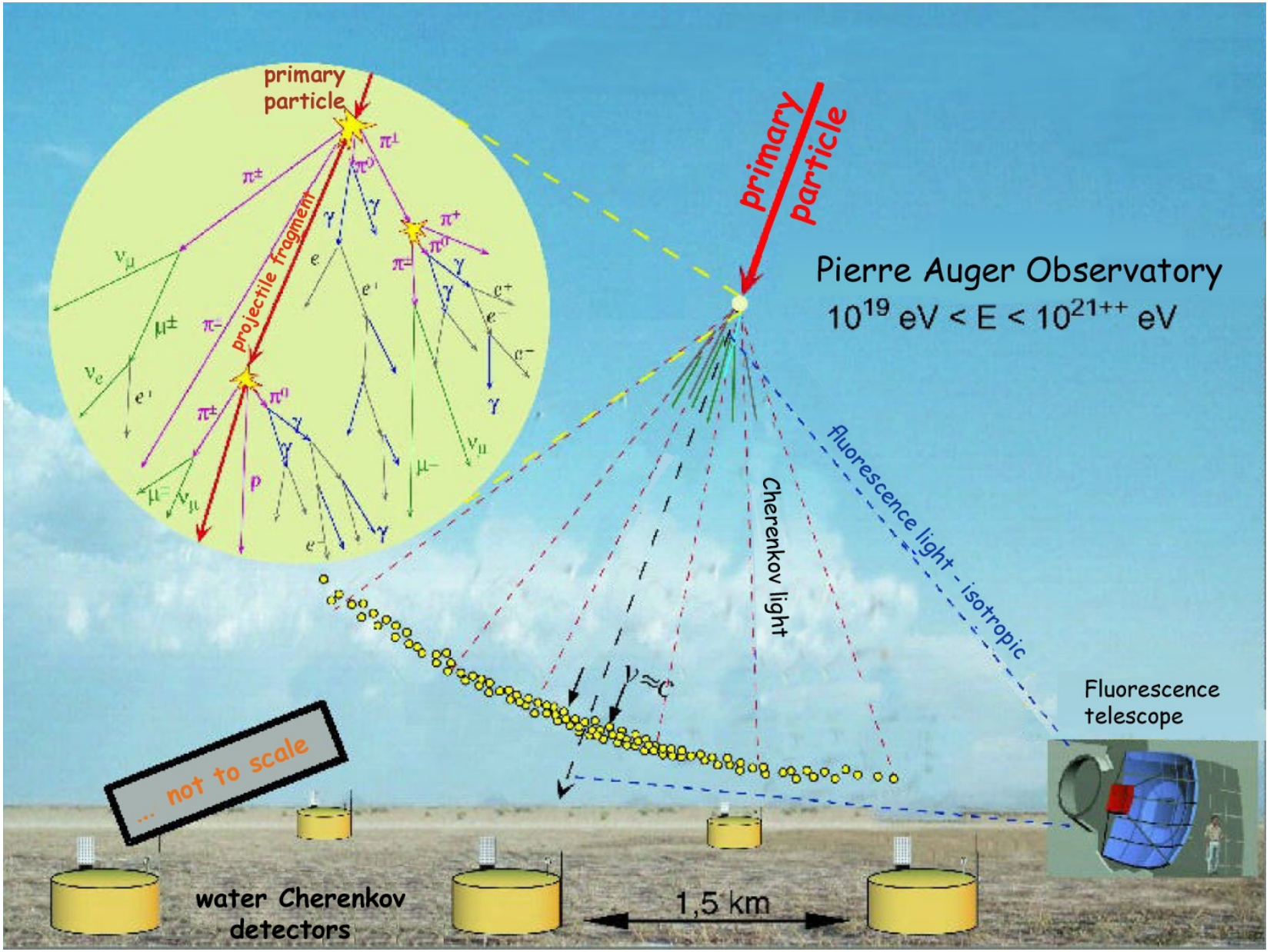
Flux rapidly decreases with energy (~10^{-3}),
Highest energies → the most demanding challenges:

→ technical:
extremely low flux (at E=10^{20}eV
1 particle / km^2 millenium), but now:
the Pierre Auger Observatory (~3000 km^2)

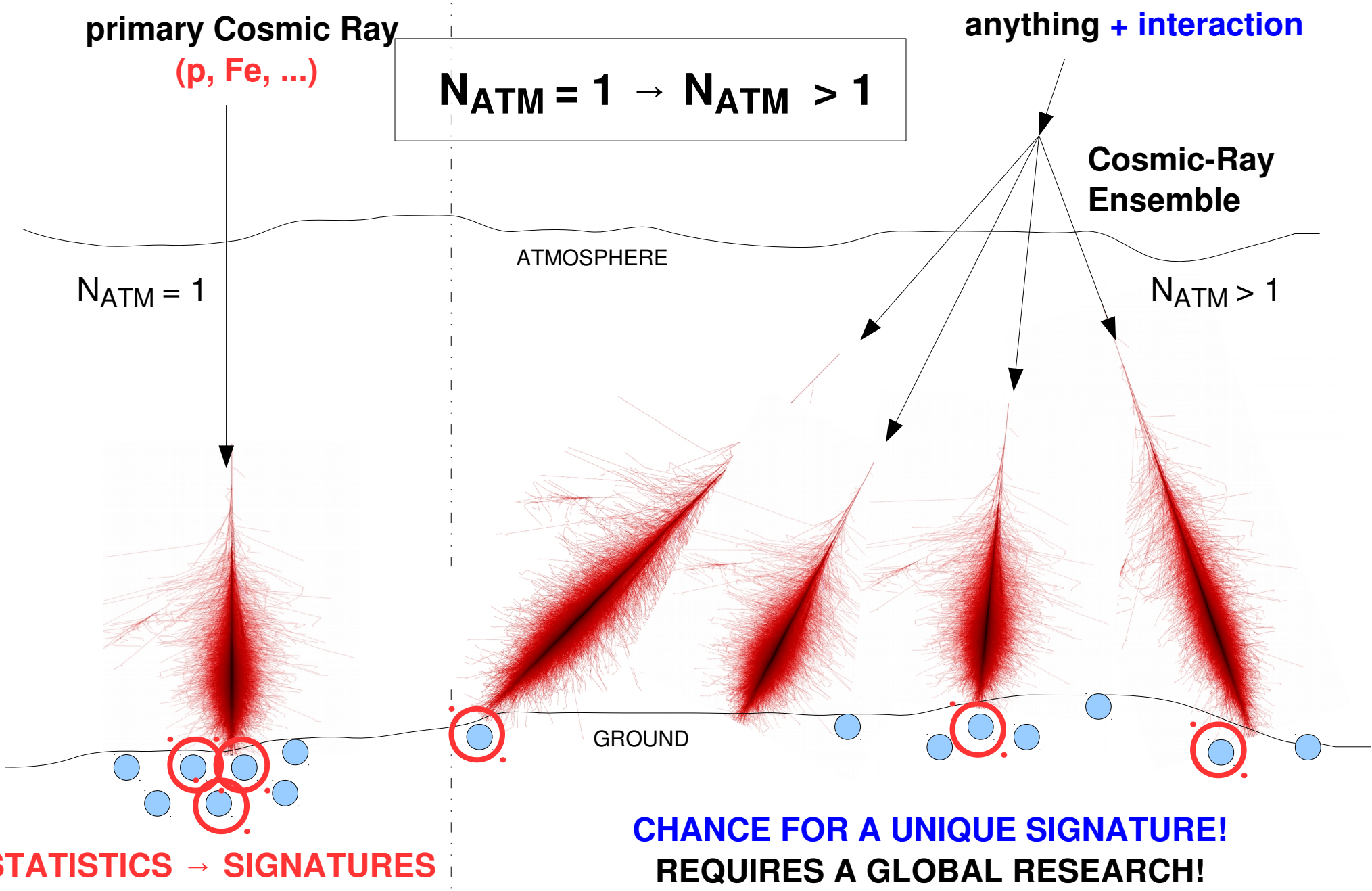
→ scientific:
What are Ultra-High Energy Cosmic Rays (UHECR)?
Where they come from?
How do they propagate?



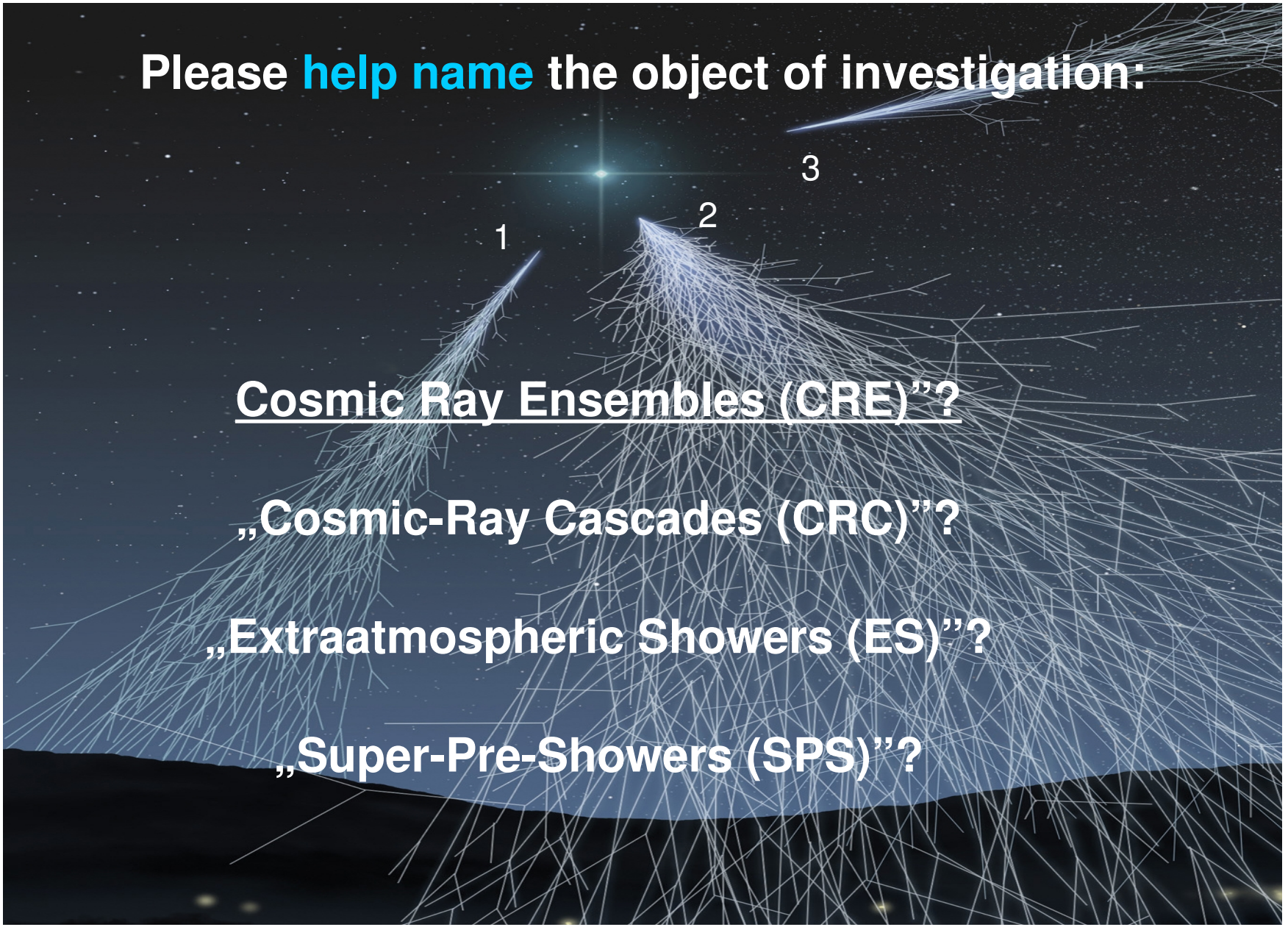
State-of-the-art detection of cosmic rays: $N_{ATM} = 1$



Generalized detection of cosmic rays: $N_{ATM} >= 1$



$N_{ATM} > 1$: new palyer on the multi-messenger stage!



$N_{ATM} > 1$ motivated by data! (1)

VOLUME 50, NUMBER 26 PHYSICAL REVIEW LETTERS 27 JUNE 1983

Possible Observation of a Burst of Cosmic-Ray Events in the Form of Extensive Air Showers

Gary R. Smith, M. Ogmen, E. Buller, and S. Standil
Physics Department, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

(Received 7 April 1983)

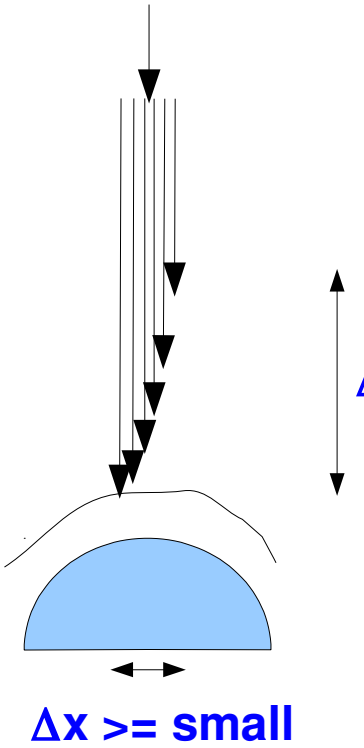
A series or burst of 32 extensive air showers of estimated mean energy 3×10^{15} eV was observed within a 5-min time interval beginning at 9:55 A.M. (CST) on 20 January 1981 in Winnipeg, Canada. This observation was the only one of its kind during an experiment which recorded 150 000 such showers in a period of 18 months between October 1980 and April 1982.

PACS numbers: 94.40.Pa, 96.Rc, 95.30.-k

Forgotten (!) treasure (?) no. 1

PH: Correlated cosmic rays?

$N_{ATM} > 1$?



Year = 1981
N_{obs} = 32
N_{exp} = 1
E = $3x10^{15}$eV

$N_{ATM} > 1$ motivated by data! (2)

VOLUME 51, NUMBER 25 PHYSICAL REVIEW LETTERS 19 DECEMBER 1983

Observation of a Burst of Cosmic Rays at Energies above 7×10^{13} eV

D. J. Fegan and B. McBreen
Physics Department, University College Dublin, Dublin 4, Ireland

and

C. O'Sullivan
Physics Department, University College Cork, Cork, Ireland

(Received 14 September 1983)

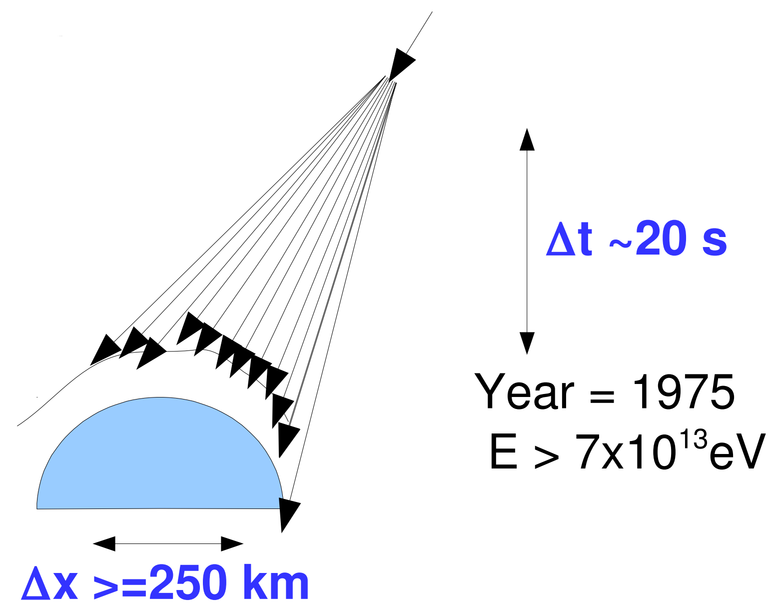
The authors report on an unusual simultaneous increase in the cosmic-ray shower rate at two recording stations separated by 250 km. The event lasted for 20 s. This event was the only one of its kind detected in three years of observation. The duration and structure of this event is different from a recently reported single-station cosmic-ray burst. The simultaneity of the coincident event suggests that it was caused by a burst of cosmic gamma rays. There is a possibility that this event may be related to the largest observed glitch of the pulsar in the Crab Nebula.

PACS numbers: 94.40.Pa, 95.85.Qx, 97.80.Jp

Forgotten (!) treasure (?) no. 2

PH: Correlated cosmic rays?

$N_{ATM} > 1$?



Quantum Gravity with gamma astronomy

https://www.ucdavis.edu/news/gamma-ray-delay-may-be-sign-new-physics

UCDAVIS

Quick Links

ABOUT US ADMISSIONS ACADEMICS RESEARCH CAMPUS LIFE NEWS

Gamma Ray Delay May Be Sign of 'New Physics'

Delayed gamma rays from deep space may provide the first evidence for physics beyond current theories.

The MAGIC (Major Atmospheric Gamma-ray Imaging Cherenkov) telescope found that high-energy photons of gamma radiation from a distant galaxy arrived at Earth four minutes after lower-energy photons, although they were apparently emitted at the same time. If correct, that would contradict Einstein's theory of relativity, which says that all photons (particles of light) must move at the speed of light.

"Everybody's very excited," about this result, said Daniel Ferenc, a physics professor at UC Davis and a member of the MAGIC collaboration. Ferenc cautioned that the results need to be repeated with other gamma-ray sources and that a simpler explanation had not been ruled out. But, "it shows that such measurements are possible," he said.

The researchers propose that the delay could be caused by photons interacting with "quantum foam," a type of structure of space itself. Quantum foam is predicted by quantum gravity theory, an attempt to unite quantum physics and relativity at cosmic scales.

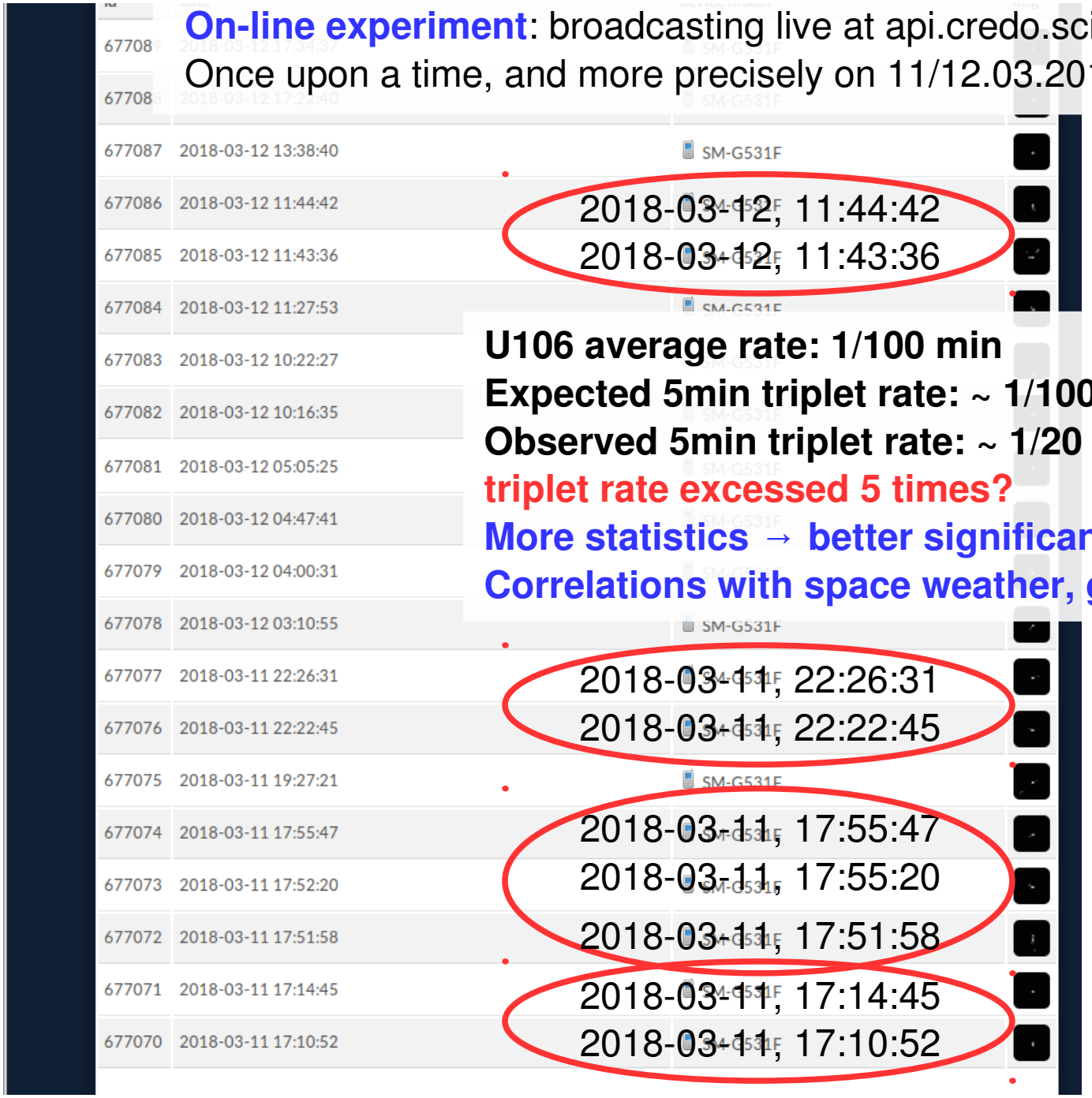
UC Davis Chancellor May Announces Emily Galindo and Rahim Reed to Fill Interim Leadership Roles
March 13, 2018

→ 4 min. delay could be the signature of a special space structure: Quantum foam

→ predicted by Quantum Gravity

Quantum Gravity Previewer with a smartphone!

On-line experiment: broadcasting live at api.credo.science
Once upon a time, and more precisely on 11/12.03.2018, at user's 106 house...



2018-03-12, 11:44:42
2018-03-12, 11:43:36

1 min 6 s

U106 average rate: 1/100 min
Expected 5min triplet rate: ~ 1/100 days
Observed 5min triplet rate: ~ 1/20 days
triplet rate excessed 5 times?
More statistics → better significance
Correlations with space weather, geomagnetic changes?

2018-03-11, 22:26:31
2018-03-11, 22:22:45

3 min 46 s

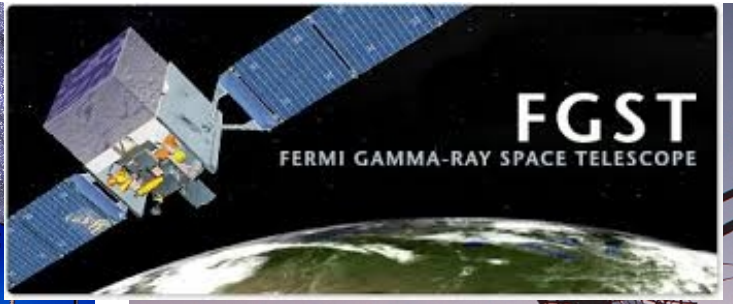
2018-03-11, 17:55:47
2018-03-11, 17:55:20
2018-03-11, 17:51:58

3 min 49 s (a triplet!)

2018-03-11, 17:14:45
2018-03-11, 17:10:52

3 min 53 s

CREDO science example: space-time structure



→ maximum photon energies < 10^{12} eV

→ testable scale of the space-time „grain” < 10^{-18} m

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→ maximum photon energies in CRE (ensembles) < 10^{20} eV +

→ Potential sensitivity to the the space-time „grain” < 10^{-26} m

More on Experimental Quantum Gravity

T. Jacobson, S. Liberati, and D. Mattingly, Annals Phys. 321 (2006) 150

Lorentz violation at high energy: concepts, phenomena and astrophysical constraints

Ted Jacobson [a], Stefano Liberati [b], David Mattingly [c]

[a] *Department of Physics, University of Maryland, USA*

[b] *International School for Advanced Studies and INFN, Trieste, Italy*

[c] *Department of Physics, University of California at Davis, USA*

extensive review). A partial list of such "windows on quantum gravity" is

- sidereal variation of LV couplings as the lab moves with respect to a preferred frame or directions
- cosmological variation of couplings
- cumulative effects: long baseline dispersion and vacuum birefringence (e.g. of signals from gamma ray bursts, active galactic nuclei, pulsars, galaxies)
- new threshold reactions (e.g. photon decay, vacuum Čerenkov effect)
- shifted existing threshold reactions (e.g. photon annihilation from blazars, GZK reaction)
- LV induced decays not characterized by a threshold (e.g. decay of a particle from one helicity to the other or photon splitting)
- maximum velocity (e.g. synchrotron peak from supernova remnants)
- dynamical effects of LV background fields (e.g. gravitational coupling and additional wave modes)

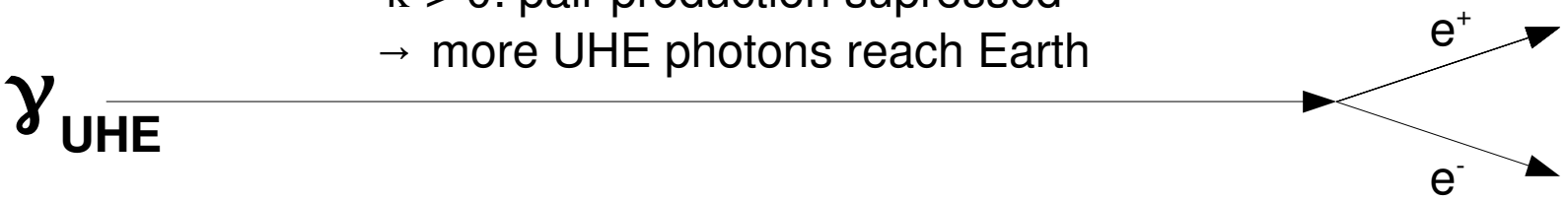
CRE and Lorentz Invariance Violation

Modified dispersion relation of a photon:

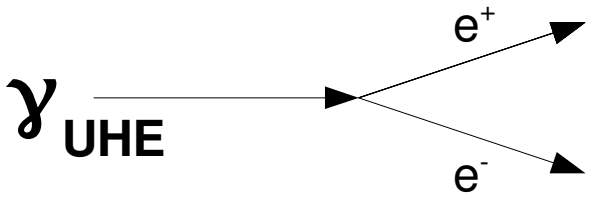
$$E_\gamma(\vec{k}) = \sqrt{\frac{(1-\kappa)}{(1+\kappa)}}|\vec{k}|$$

limits from gamma-ray astronomy,
98% C.L. (Klinkhamer & Schreck, 2008):
$6 \times 10^{-20} > \kappa > -9 \times 10^{-16}$

$\kappa > 0$: pair production supressed
→ more UHE photons reach Earth



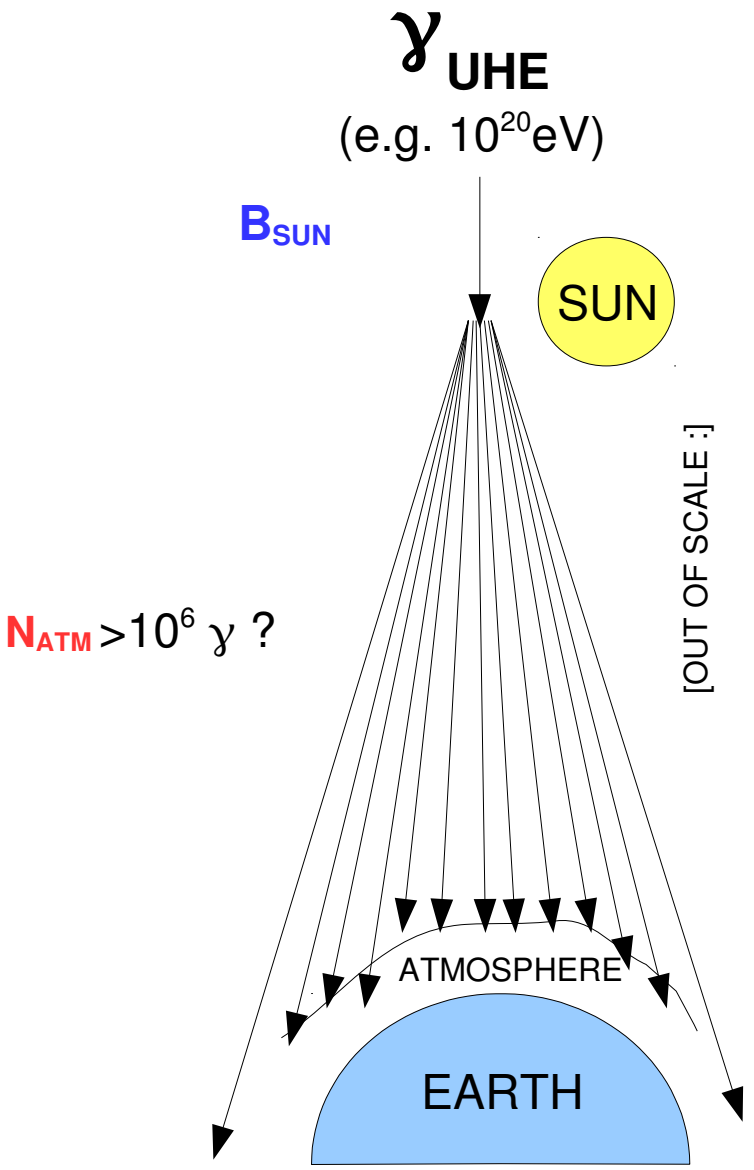
$\kappa = 0$: „normal" pair production



$\kappa < 0$: pair production enhanced
(photon lifetime ~ 1 sec.!)
→ no UHE photons reach Earth

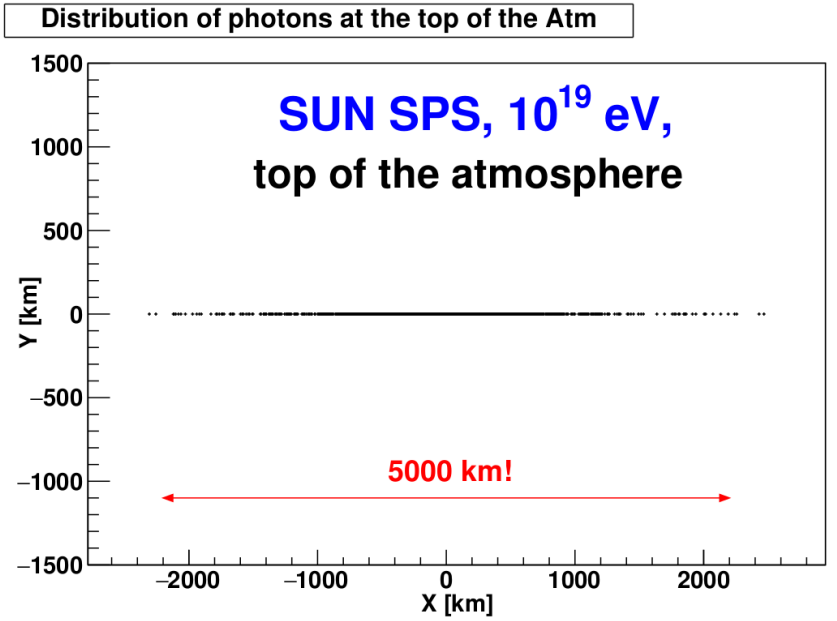
→ critical importance for the UHE photon search!
Observation of **photon cascades** would point to $\kappa < 0$!

Super-preshowers (SPS) from the vicinity of the Sun



→ First calculations: W. Bednarek 1999
low energies not treated: extent ~ tens of km

→ N. Dhital, 2018
complete energy spectrum: extent
~ thousands of km



Distribution of photons ($E > 10^{13}$ eV) at the top of the atmosphere.
$E_\gamma = 10$ EeV, Impact parameter $= 2.5 R_S$.

$N_{ATM} > 1$ → observable (line even 10000 km wide), **not yet tried**

the first paper on a CREDO scenario

status: submitted (https://arxiv.org/abs/1811.10334)

Cosmic ray ensembles as signatures of ultra-high energy photons interacting with the solar magnetic field

N. Dhital,[1,*] P. Homola,[1] D. Gora,[1] H. Wilczynksi,[1] K. Almeida Cheminant,[1] G. Bhatta,[12]
T. Bretz,[14] D.A. Castillo,[6] A. Ćwikła,[13] A.R. Duffy,[8] B. Hnatyk,[11] M. Kasztelan,[3]
K. Kopański,[1] P. Kovacs,[4] M. Krupinski,[1] V. Nazari,[6] M. Niedźwiecki,[5] K.Smelcerz,[5]
K. Smolek,[7] J. Stasielak,[1] O. Sushchov,[1] T. Wibig,[9,10] J. Zamora-Saa,[2] and Z. Zimborás[4]

(The CREDO Collaboration)

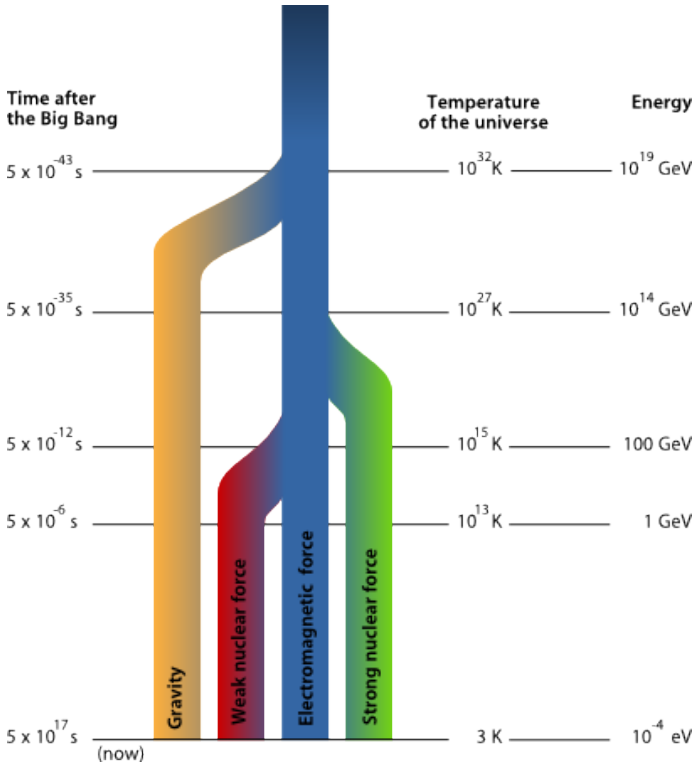
[1] *Institute of Nuclear Physics PAN, Cracow 31–342, Poland*
[2] *Universidad Andres Bello, Departamento de Ciencias Fisicas, Facultad de Ciencias Exactas, Avenida Republica 498, Santiago, Chile*
[3] *National Centre for Nuclear Research, 05-400 Otwock-Swierk, Poland*
[4] *Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Hungarian Academy of Sciences, H-1525 Budapest, Hungary*
[5] *Institute of Telecomputing, Faculty of Physics, Mathematics and Computer Science, Cracow University of Technology, 31-155 Cracow, Poland*
[6] *Joint Institute for Nuclear Research, Dubna, Russia*
[7] *Institute of Experimental and Applied Physics, Czech Technical University in Prague, Prague, Czech Republic*
[8] *Centre for Astrophysics and Supercomputing, Swinburne University of Technology, Hawthorn, VIC 3122, Australia*
[9] *University of Łódź, Faculty of Physics and Applied Informatics, 90-236 Łódź, Poland*
[10] *Cosmic Ray Laboratory, Astrophysics Division, National Centre for Nuclear Research, 90-558 Łódź, Poland*
[11] *Astronomical Observatory of Taras Shevchenko National University of Kyiv, Kyiv 04053, Ukraine*
[12] *Astronomical Observatory of the Jagiellonian University, 30-244 Krakow, Poland*
[13] *Cracow University of Technology, 31-155 Cracow, Poland*
[14] *RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany*

Propagation of ultra-high energy photons in the solar magnetosphere gives rise to cascades comprising thousands of photons. We study the cascade development using Monte Carlo simulations and find that the photons in the cascades are spatially extended over hundreds of kilometers as they arrive at the top of the Earth's atmosphere. We compare results from simulations which use two models of the solar magnetic field, and show that although signatures of such cascades are different for the models used, for practical detection purpose in the ground-based detectors, they are similar.

PACS numbers: 02.70.Uu, 13.85.Tp, 95.85.Ry

N_{ATM} >= 1 mission (briefly)

Scenarios AND Fishing



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Mission success more likely with:

→ large geographical spread

→ inter-collaboration cooperation

→ **massive public engagement**

Scientific tool!

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CREDO the 2nd Anniversary Symposium
IFJ PAN, Kraków, 4 October 2018

fot. Ireneusz Kochanek / FILMNET

CREDO Memorandum of Understanding

Cosmic Ray Extremely Distributed Observatory (CREDO)

This multi-beneficiary Memorandum of Understanding (MoU) is made

BETWEEN:

the Institutions named in Section 8: Signatories, henceforth referred to as "Parties", with the Effective Date being the date of signing by each of the Parties,

in relation to the Project entitled

COSMIC RAY EXTREMELY DISTRIBUTED OBSERVATORY (CREDO), henceforth referred to as "Project".

THEREFORE, IT IS AGREED THAT:

Section 1: Background

The Parties agree to cooperate in exploring the multidisciplinary potential of a widely distributed network of cosmic ray detectors, under the name of the Cosmic Ray Extremely Distributed Observatory (CREDO). As an initiative of the Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences the CREDO concept has been under development since 30th August 2016.

Section 2: Purpose

The purpose of this MoU is to stipulate, in the context of the Project, the relationship between the Parties. In particular, this concerns the distribution of work between the Parties, the management of the Project and the rights and obligations of the Parties.

CREDO institutional members 1.03.2019

- Australia (2)
- Czech Republic (2)
- Georgia (1)
- Hungary (1)
- Mexico (1)
- Nepal (1)
- Poland (8)
- Russia (1)
- Slovakia (1)
- Ukraine (2)
- USA (3)

CREDO Week 2018

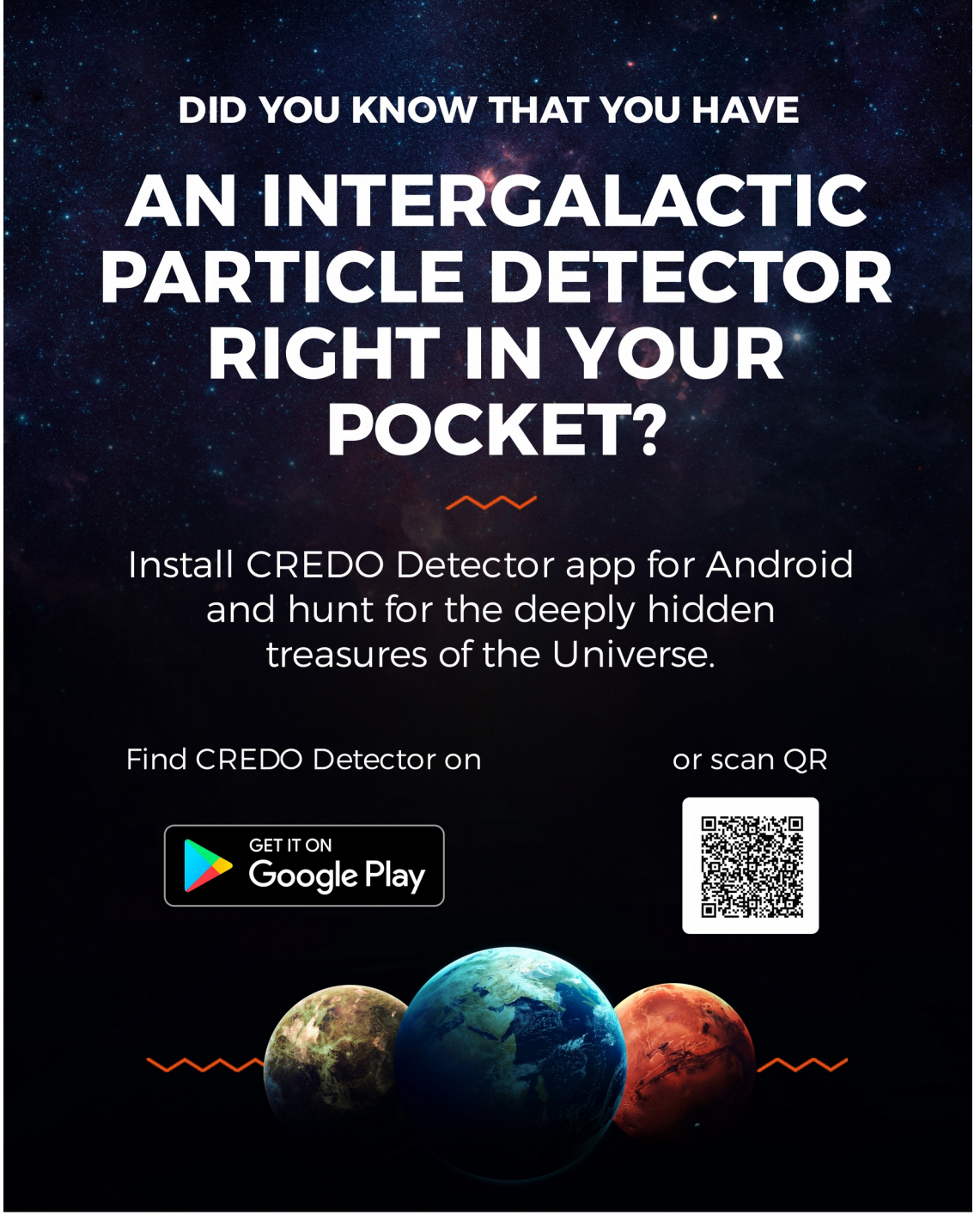
Cosmic-Ray Extremely Distributed Observatory: join a global effort to detect and study cosmic-ray ensembles.

Including:

- Discoverology Workshop
- The CREDO School
- Anniversary Symposium
- Collaboration Meeting

1-5 October, 2018, Kraków, Poland

The CREDO Detector



mobile application

https://play.google.com/store/apps/details?id=science.credo.mobiledetector

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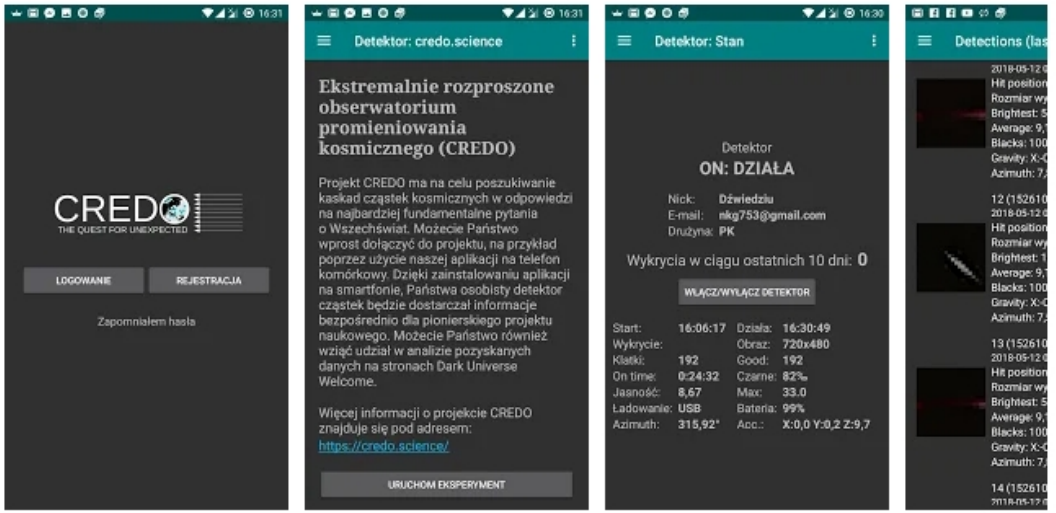
CREDO Detector

IFJ PAN Edukacja

Nadzór rodzicielski

Dodaj do listy życzeń

Zainstaluj



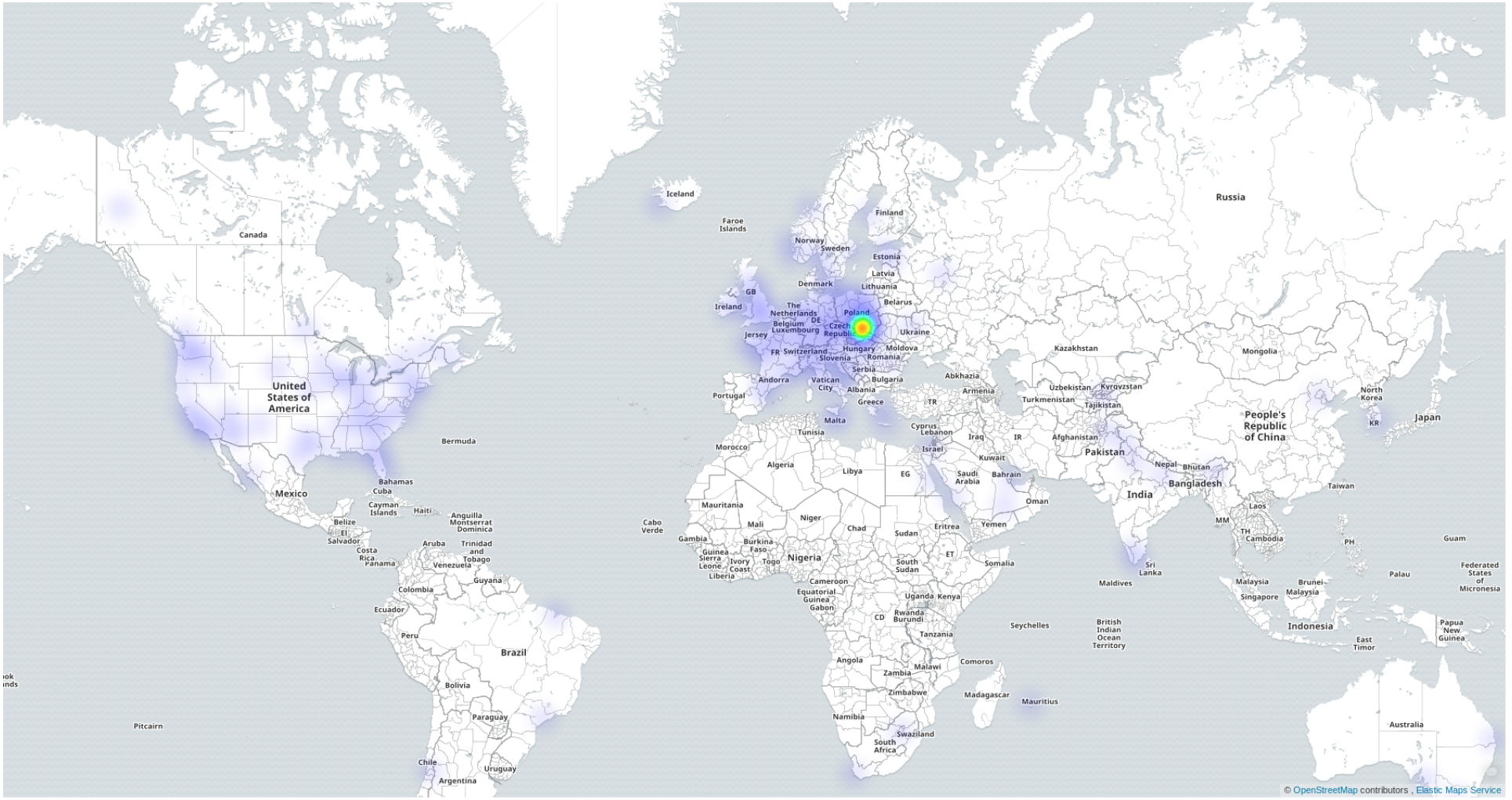
data acquisition!

CREDO Detector: examples

User: „smph-kitkat”, https://api.credo.science/web/user/smph-kitkat/
Device: Smasung SM-G357FZ, Android 4.4.4 (KitKat)
Average detection rate: ~10/hr
(flight to Kyiv on 29.05: 60/hr :)

Example images:

CREDO: planetary mission (24.10.2018)



From: M. Pawlik et al, CGW'18

The CREDO Detector App, status 4th October 2018

Some statistics

Update 27th Mar 2019:

- > 2,500,000 ~~390k+~~ visible detections (1.4m+ overall)
- 745k+ device pings (sums up to 48 years looking for particles)
- > 7,000 ~~2k+~~ users with at least 1 detection
- 4k+ devices
- 1k+ user teams
- 10s of GBs used for storage of data, metrics and backups

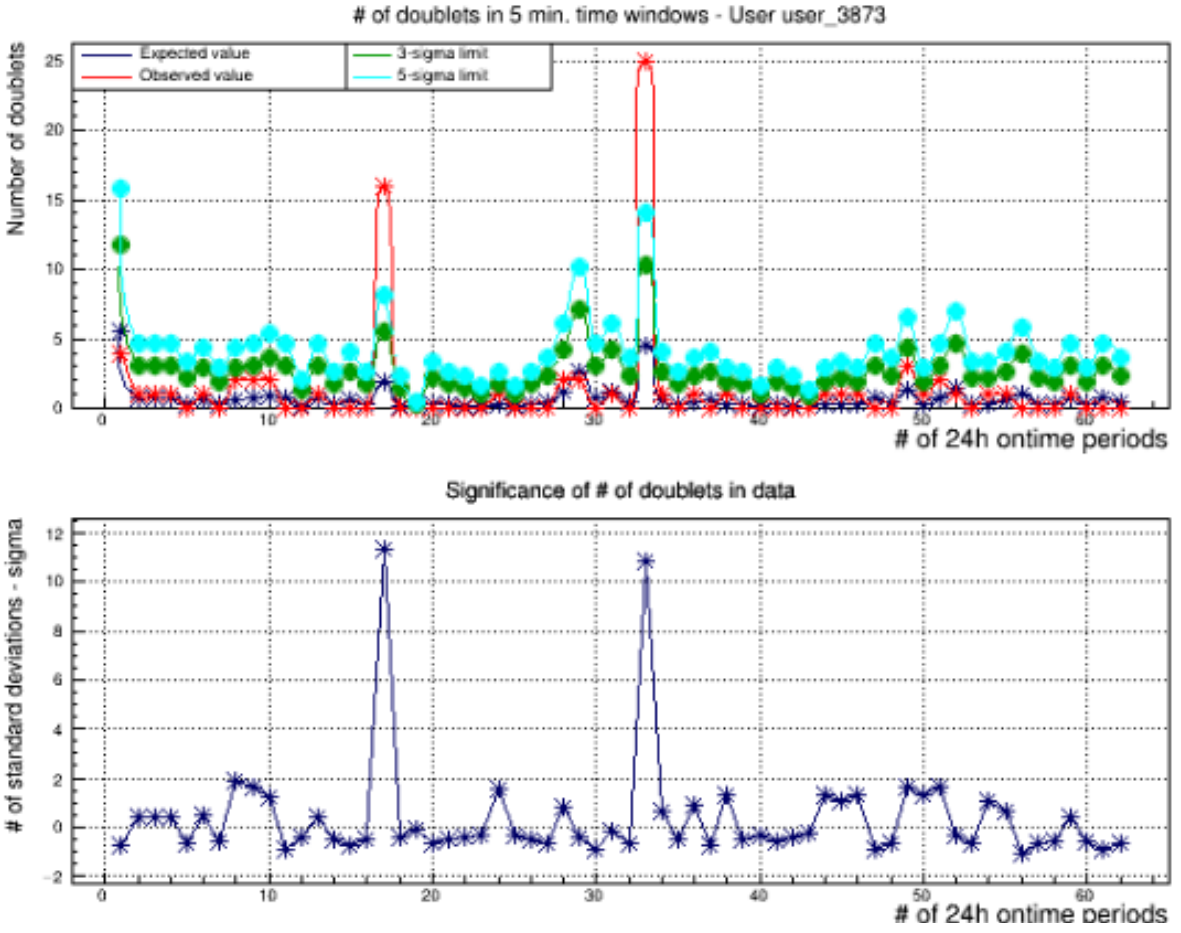
Credit: M. Magryś, ACK Cyfronet AGH

→ First Light in **Quantum Gravity Previewer**,
the first experiment on the CREDO infrastructure!

→ https://credo.science/quantum-gravity-previewer/

Quantum Gravity Previewer: online experiment!

Cumulative number of hit pairs („doublets”) within 5 min, in a single device



expected from random
observed

→ **10σ**

(significance)

Request zoom in, track back, investigate!
Privately, locally, and globally!
Get engaged!

by Kevin Almeida Cheminant, for the CREDO Collaboration

4 October 2018: CREDO's first light!

https://www.eurekalert.org/pub_releases/2018-10/thni-cfl100418.php

EurekAlert! The Global Source for Science News | AAAS

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PUBLIC RELEASE: 4-OCT-2018

CREDO's first light: The global particle detector begins its collection of scientific data

THE HENRYK NIEWODNICZANSKI INSTITUTE OF NUCLEAR PHYSICS POLISH ACADEMY OF SCIENCES

SHARE PRINT E-MAIL

Now everyone can become co-creator and co-user of the largest detector of cosmic ray particles in history - as well as a potential co-discoverer. All you need is a smartphone and the CREDO Detector application turned on overnight. Under development for over two years, the CREDO project is entering the era of its maturity. Today, at the Institute of Nuclear Physics of the Polish Academy of Sciences in Cracow, the "first light" of the

Media Contact

Dr. Piotr Homola
piotr.homola@ifj.edu.pl
48-126-628-341

http://www.ifj.edu.pl/?lang=en

More on this News Release

CREDO's first light: The global particle detector begins its collection of scientific data
THE HENRYK NIEWODNICZANSKI INSTITUTE OF NUCLEAR PHYSICS POLISH ACADEMY OF SCIENCES

FUNDER
International Visegrad Fund (IVF)

MEETING
The Cosmic-Ray Extremely Distributed Observatory (CREDO) Week

1st World Championships in Particle Hunting with Smartphones

18-19.05.2018, worldwide

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Level MAX:

fun and emotions

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… Particle Hunters League and Marathon!

Not only for schools!

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… Particle Hunters League and Marathon!

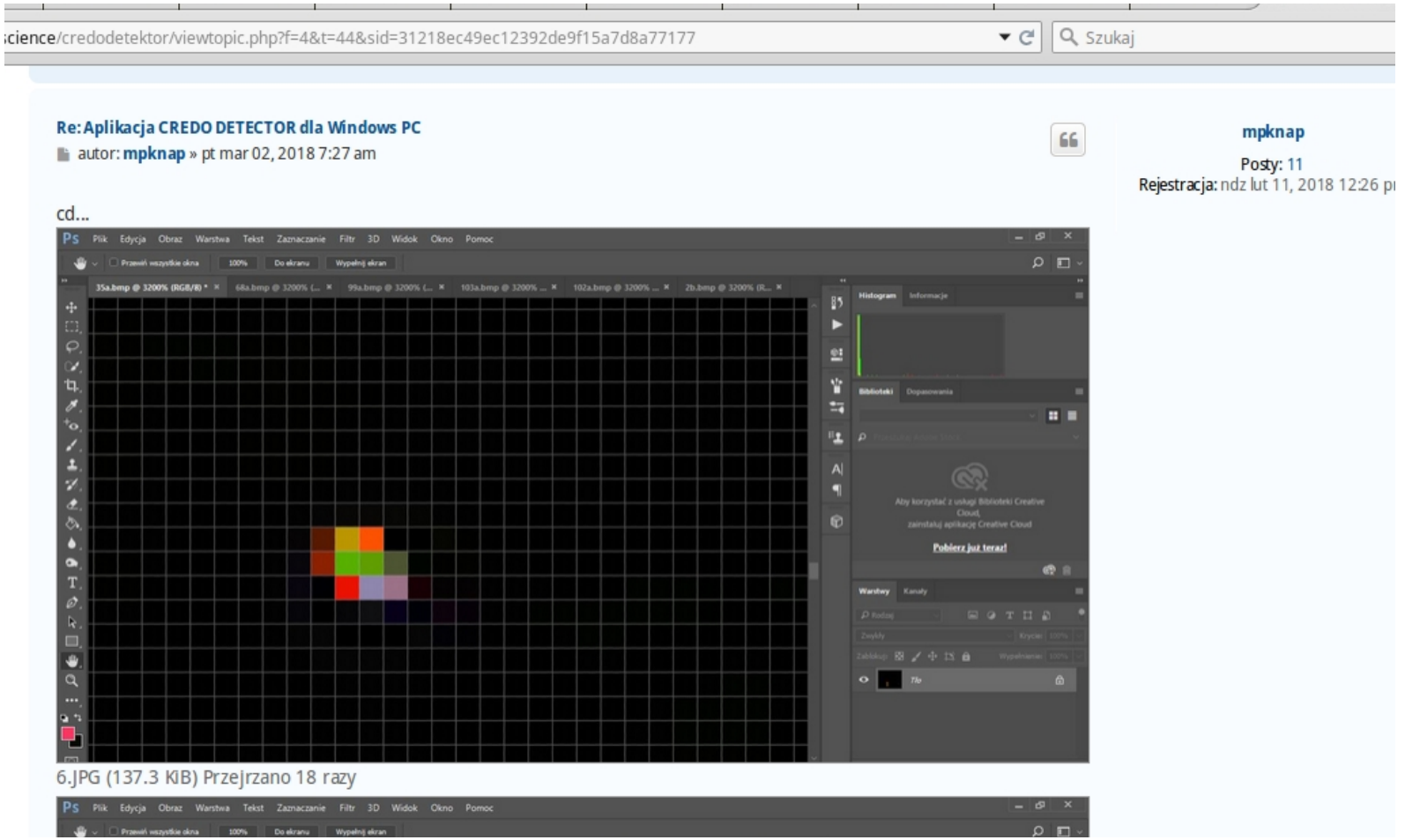
Not only for schools!

NAZWA ZESPOŁU	LICZBA PUNKTÓW ▲
XI LO Kraków	6486
ananasy z sp26krk	6249
CREDO ASP OXFORD	5093
Kwiatek	4784
sidzina	3799
CREDO 4LO KEN BB	3753
zseo tarnów	3590
12SPJasło	3448
13LO Kraków	2867
ŁazyGalactic	2857
credogosia	2773
FASOLKI	2556
Nakielanie	2506
lonisko	2385

March 2019: ~ 1200 participants from ~ 60 schools!

CREDO attracts... house-builders!

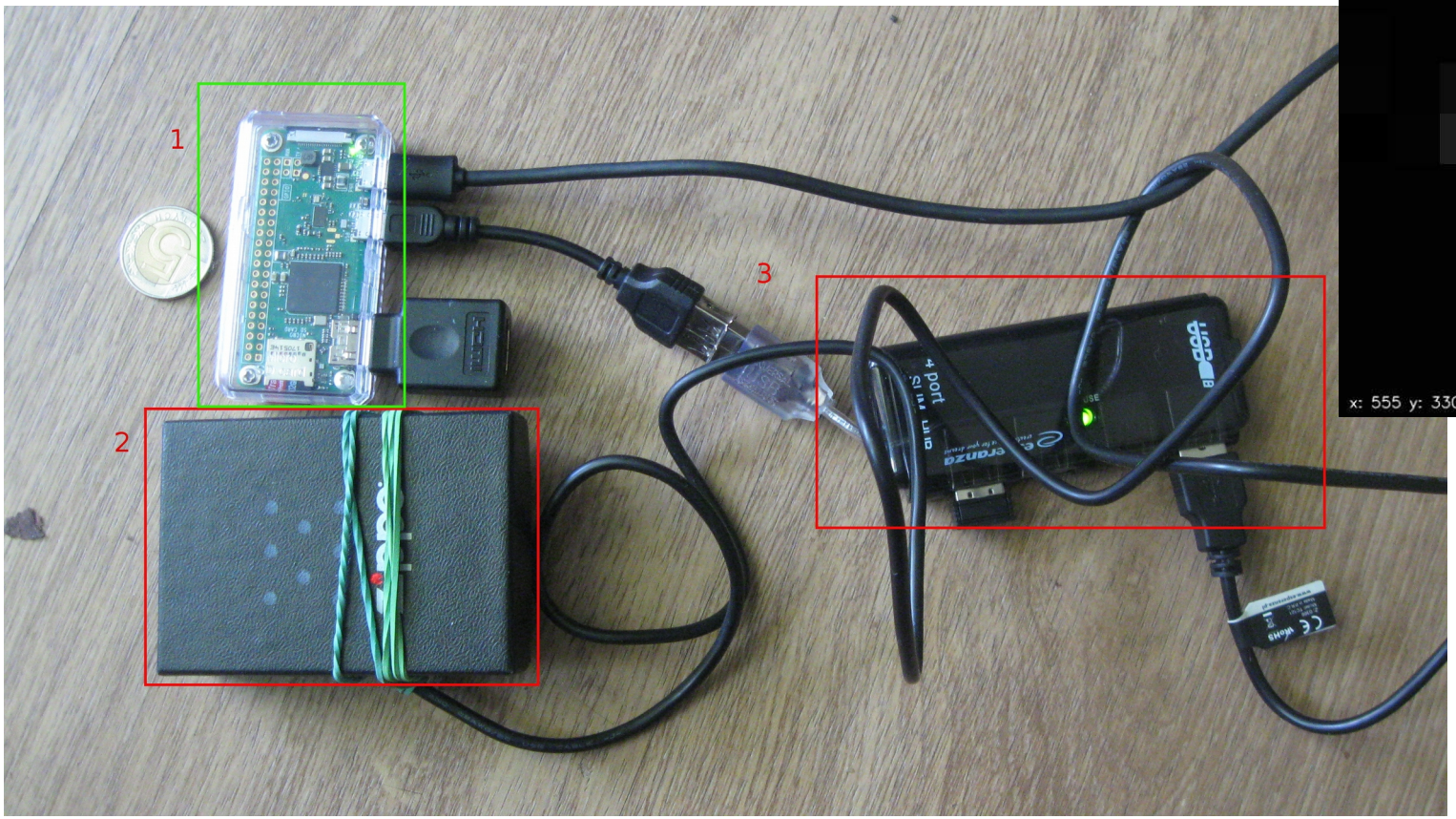
→ **PC application to catch particles with an internet camera, by a 41-year old science enthusiast!**

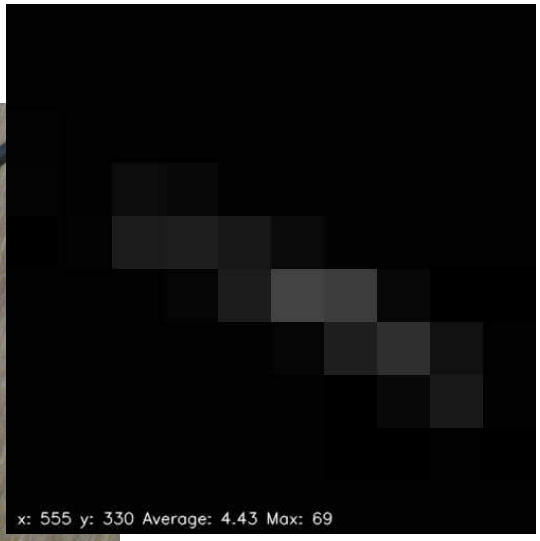


Info & download [author: Marek Knap]:
https://credo.science/credodetektor/viewtopic.php?f=3&t=45

CREDO attracts... archeologists!

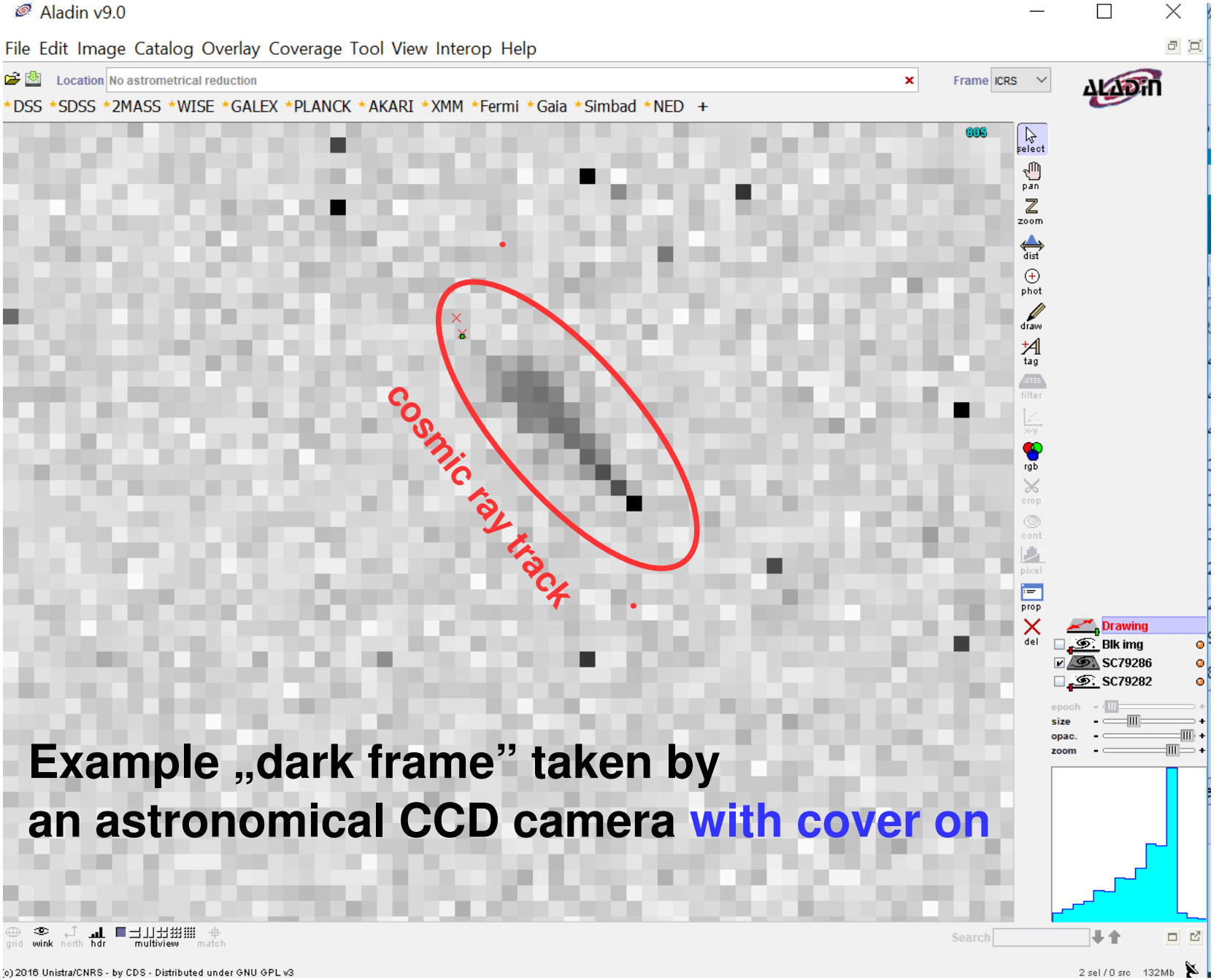
→ **PC application: linux version working with RasperryPi!**
By „TrueTom”





Info [author: Tomek/TrueTom]:
https://github.com/credo-science/Credo-detector-for-linux-desktop-and-Raspberry-Pi

CREDO attracts... astronomers!



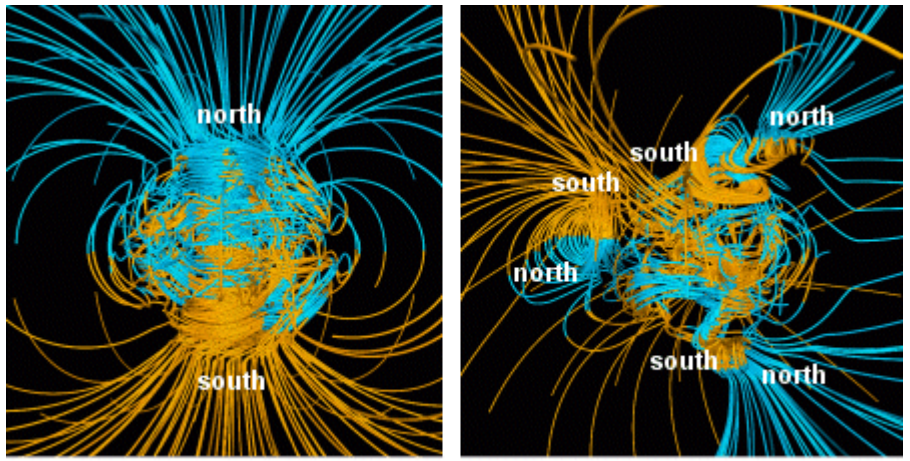
Credit & idea by Massimo Ramella (INAF)

… potential and beyond

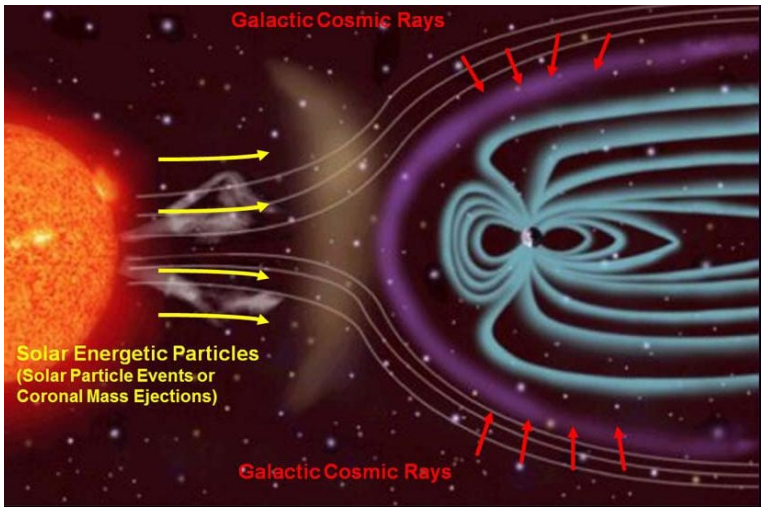
→ interdisciplinarity

Cosmic Rays and earthquake early warning?

Wikipedia: „Geomagnetic reversal”



Wikipedia: „Health threat from cosmic rays”



Earth outer core: Liquid (molten iron)
→ geomagnetism

↓

Impulse (tidal forces)
→ hydrodynamics: waves

↓

→ Mechanical wave upwards (slow, hours?)
→ Electromagnetic wave („instant”, ms)

↓

Local geomagnetic field vector changes
AND seismic effect might occur!

↓

Variation of the CR rate!

↓

Earthquake precursors?

OCTOBER 2018

VOLUME 319, NUMBER 4

SCIEN
AMEI

ON THE COVER
Three mathematicians spent several years and 146 pages proving that the "spectral gap" problem—the question of whether materials have a gap between their lowest energy level and first excited state—is undecidable. To reach this conclusion, the researchers investigated the computer science of Turing machines, the mathematics of bathroom floor tiles and the foundations of quantum physics.
Illustration by Mark Ross Studios.

SEISMOLOGY

Earthquakes in the Sky

The best early warnings of a big disaster may appear 180 miles above the ground, a controversial new theory says

By Erik Vance

Illustration by Maria Corte

Workshop on Observatory Synergies for Astroparticle physics and Geoscience

11-12 February 2019
IPGP
Europe/Paris timezone

- Overview
- Call for Abstracts
- Timetable
- Apply for a Grant
- Contribution List
- Speaker List
- Book of Abstracts
- Registration
- Participant List
- Venue
- Information

Timetable

Mon 11/02 | **Tue 12/02** | All days

Print | PDF | Full screen | Detailed view | Filter

09:00

Speed-of-light Seismology and Earthquake Early Warning Systems — *J-P Montagner et al.*
Amphithéâtre, IPGP 09:00 - 09:20

Time and frequency transfer over telecommunication fiber networks: a new research infrastructure for geoscience and astroparticle physics? — *P-E Pottie*

Geophysical noise in the Virgo gravitational wave antenna — *Irene Fiori*
Amphithéâtre, IPGP 09:40 - 09:55

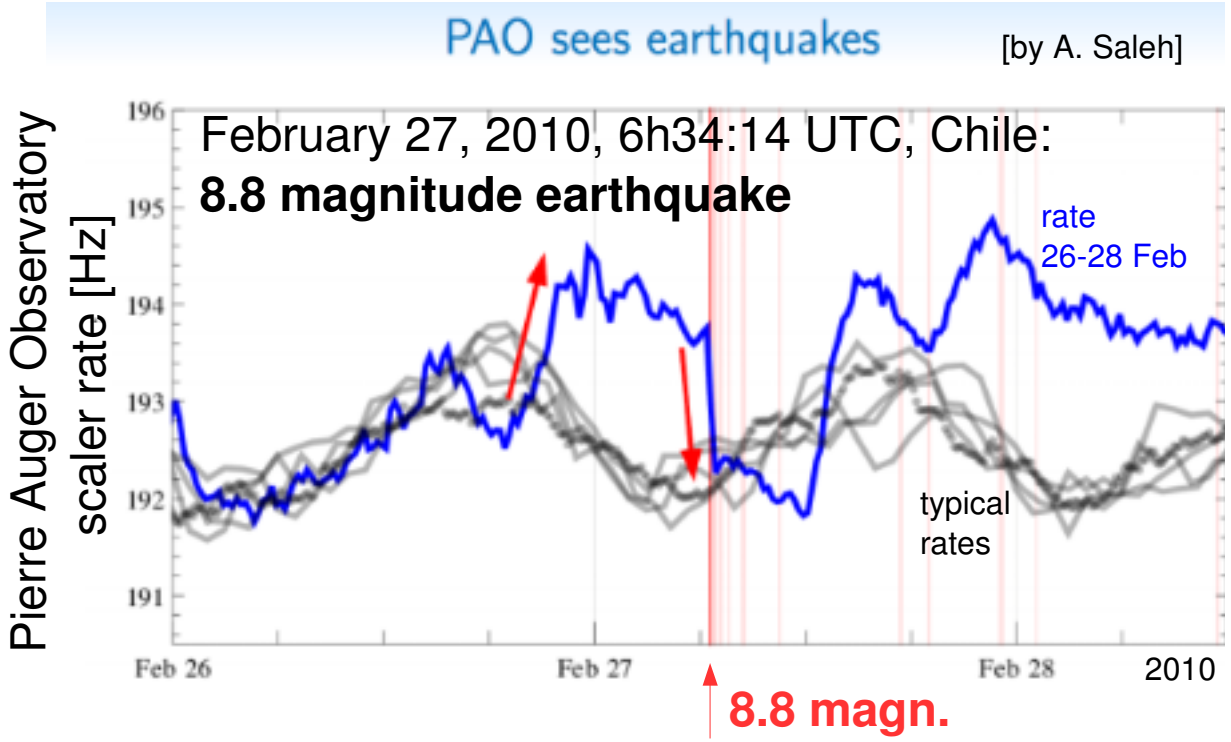
10:00

Seismic characterization of GW detector sites using an array of wireless geophones — *Soumen Koley*
Amphithéâtre, IPGP 09:55 - 10:10

CREDO

THE QUEST FOR THE UNEXPECTED

Scientific diversity: GEO



→ **CREDO-earthquakes task** [already existing]

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

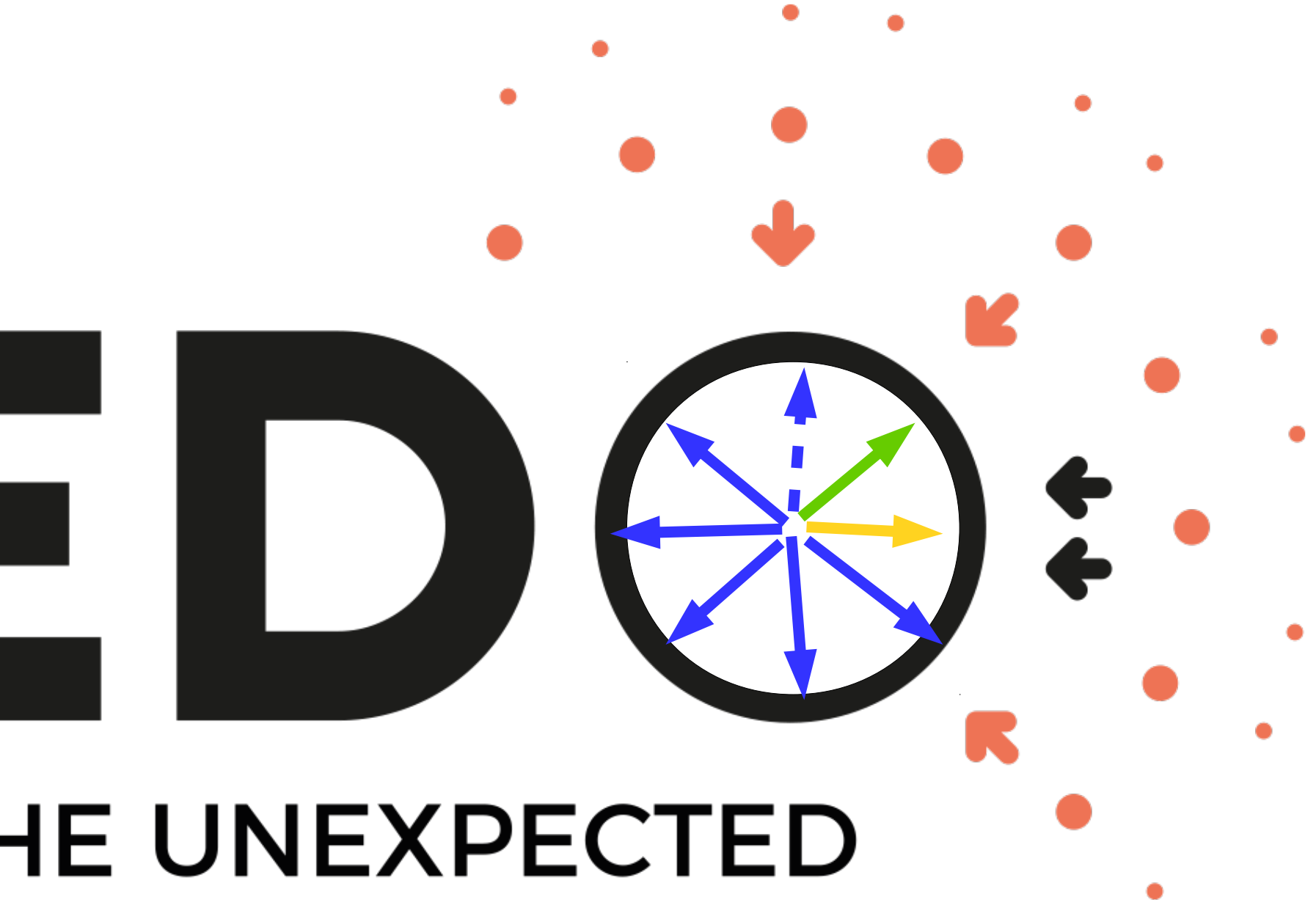
2,7 billion people

Science as a service to the human community?

Even the smallest chance to save lives

= **a must check!**

CREDO: astro/geo multimessenger infrastructure!



CREDO? Why?

10^{-35} m 10^{-5} m 10^{25} m

Space-time structure

CREDO

THE QUEST FOR THE UNEXPECTED

Cosmology, Dark Matter, ...

MICRO → MACRO

Success guaranteed?

Mission

N_{ATM} >= 1 → scenarios + fishing / education

Strategy

Spread globally & grow giant → „1 million scientific community”

Tactics

- tools: variety of detectors / citizen science
- users: young + old
- training: discoverology

Potential

- multidimensional: **beyond astrophysics, beyond science**

→ evokes **hot keywords** (big data, machine learning, AI, blockchain, decentralized autonomous organizations, cryptocurrency,...)

CREDO Theatre!

Trailer and Part I: CREDO YouTube, Part II: soon!

And what if we know the space-time structure?

e.g. …. keep calm and... **build spacetime tunnels?**

Fundament fundamentów - wyzwanie wyzwań

Czasoprzestrzeń jako scena

Gładka?

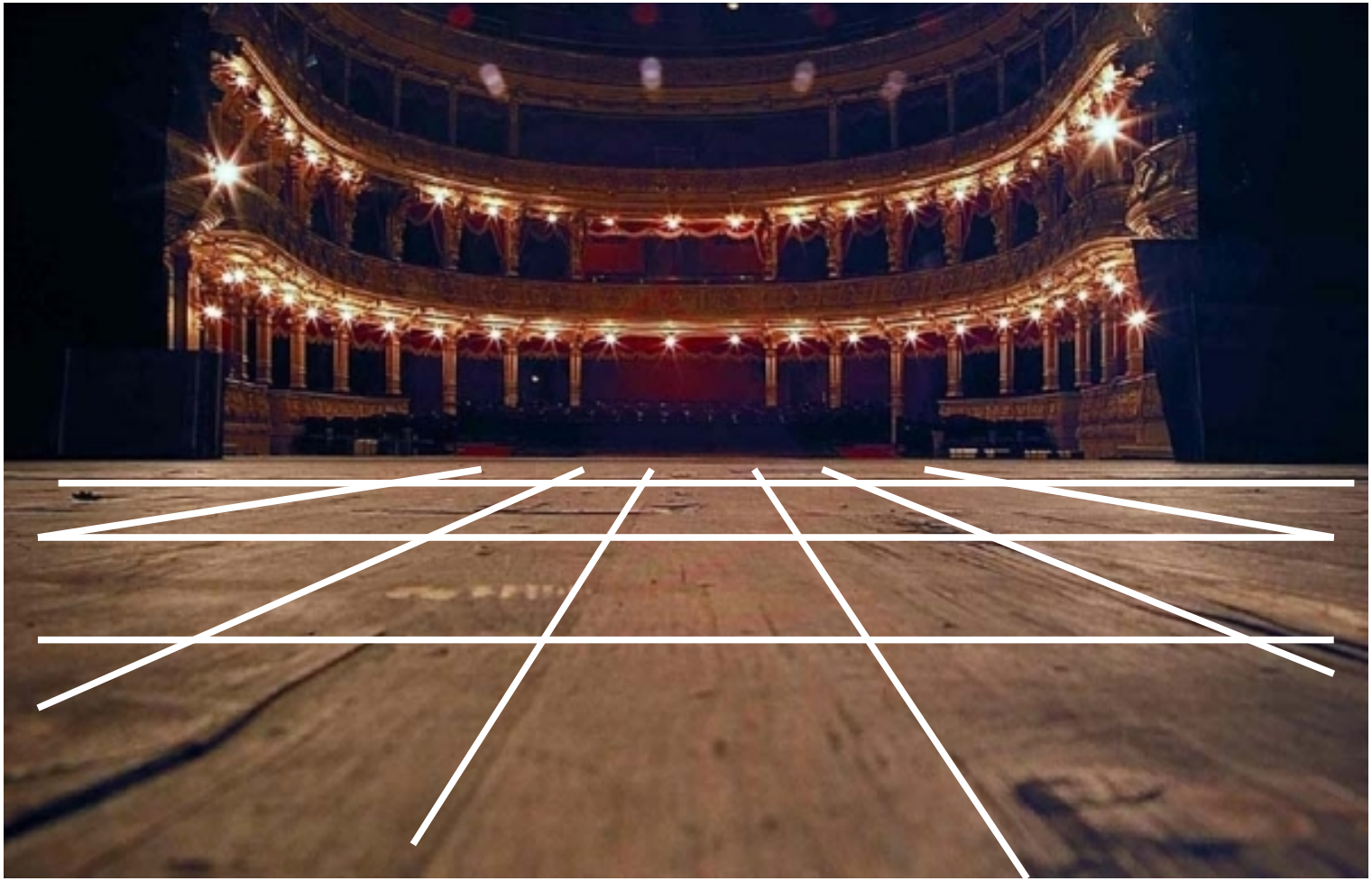
Fundament fundamentów - wyzwanie wyzwań

Czasoprzestrzeń jako scena

Dziury?

Fundament fundamentów - wyzwanie wyzwań

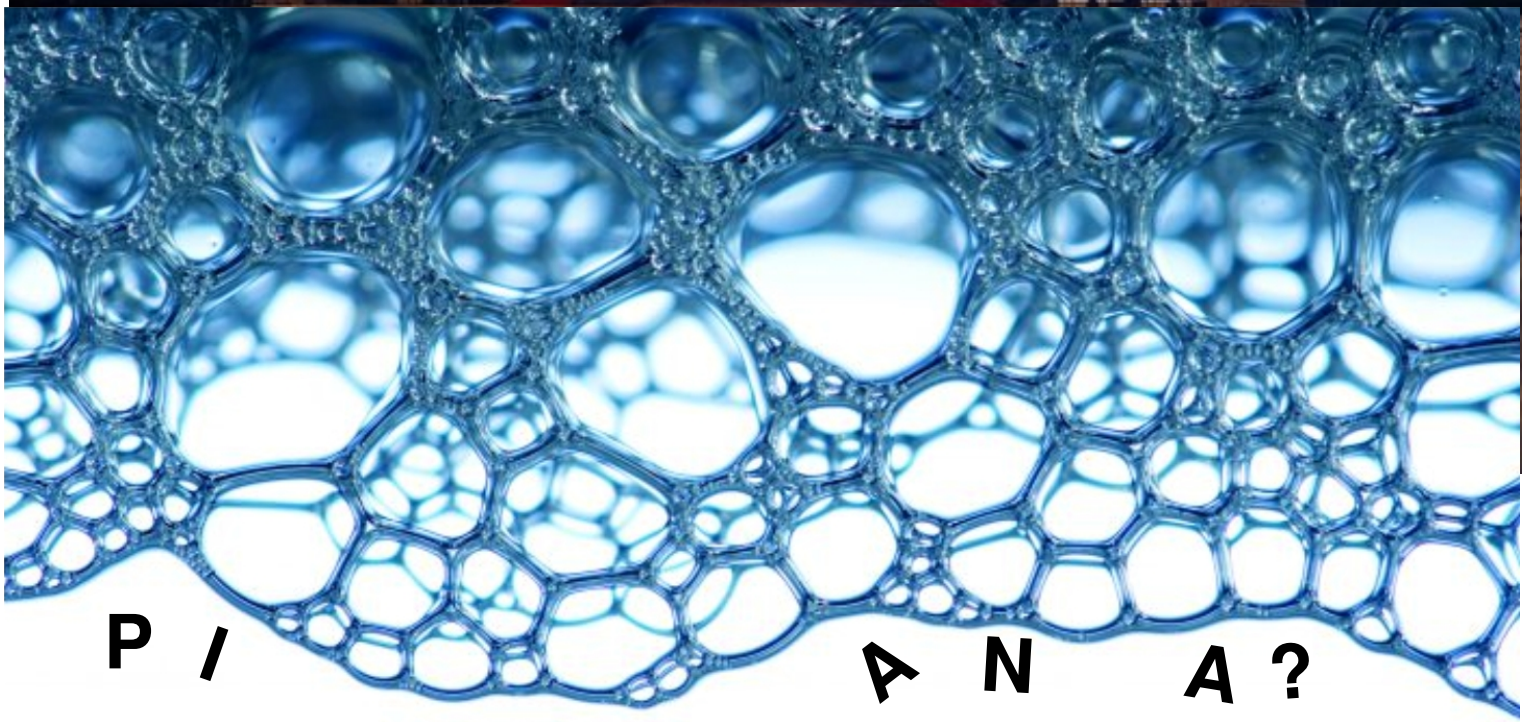
Czasoprzestrzeń jako scena



Sieć?

Fundament fundamentów - wyzwanie wyzwań

Czasoprzestrzeń jako scena



Big Wheel vs. Small Car (zespoły cząstek) jako testery sceny

Zespół promieni kosmicznych
o różnych energiach (CRE),
prędkość światła

START
(KOSMOS)

META
(ZIEMIA)

Czasoprzestrzeń: scena na której dzieje się Wszechświat?

Big Wheel vs. Small Car (zespoły cząstek) jako testery sceny

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Big Wheel vs. Small Car (zespoły cząstek) jako testery sceny

CRE

Zespół promieni kosmicznych o zróżnicowanych energiach (CRE): NOWY pomysł na testowanie struktury czasoprzestrzeni

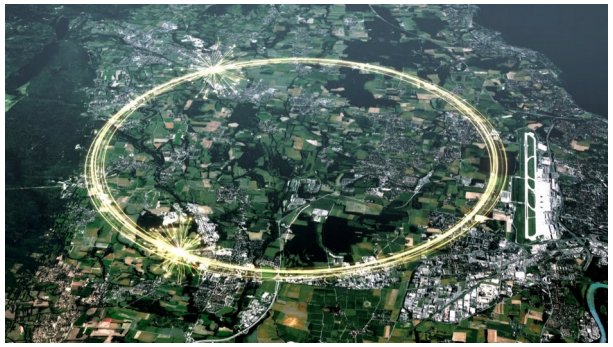
Niska częstotliwość - niska energia - duża długość fali (duże „koła”), → niska czułość na strukturę czasoprzestrzeni

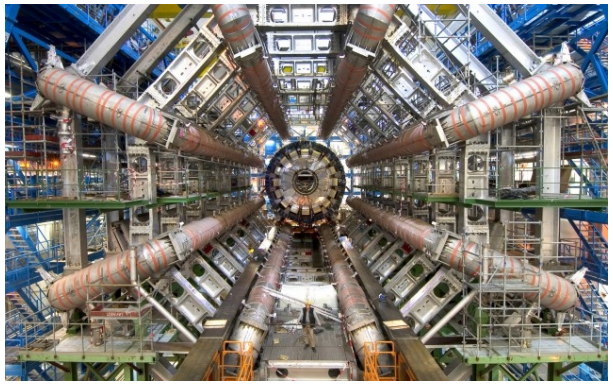
Wysoka częstotliwość - wysoka energia - krótka długość fali (małe „koła”), → wysoka czułość na strukturę czasoprzestrzeni

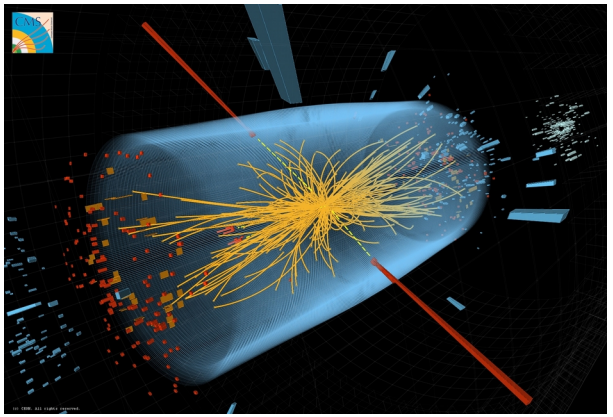
Where to find particles? A biased view

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

Laboratories (experiments)
accelerators & collinders







Investment:

~100 mld $ ~0 $

Energies

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

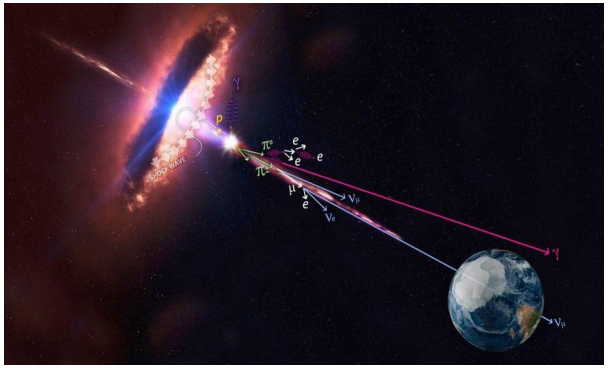
Availability:

Rich countries Everybody

Data flux:

huge small

Cosmos (observations)
accelerator & collider



Wolfram's Everything

blog.stephenwolfram.com/2015/12/what-is-spacetime-really/

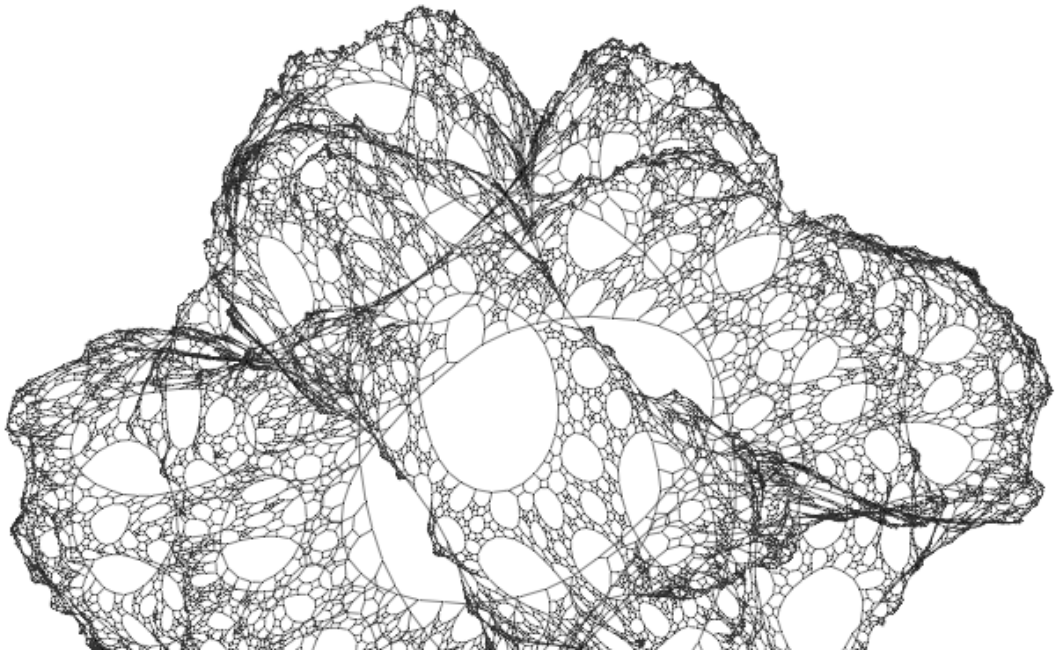
STEPHEN WOLFRAM | Blog

kelvin

ABOUT BLOG PUBLICATIONS MEDIA SCRAPBOOK CONTACT

What Is Spacetime, Really?

December 2, 2015



Search Blog

RECENT POSTS

We've Come a Long Way in 30 Years (But You Haven't Seen Anything Yet!)
June 21, 2018

Launching the Wolfram Challenges Site
April 12, 2018

Learning about the Future from *2001: A Space Odyssey*, Fifty Years Later
April 3, 2018

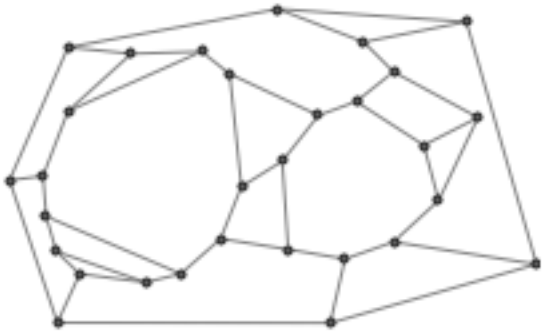
Buzzword Convergence: Making Sense of Quantum Neural Blockchain AI
April 1, 2018

Wolfram: simple ultimate theory?

Wolfram's Blog, What is Spacetime, Really?

A Simple Ultimate Theory?

In the abstract it's far from obvious that there should be a simple, ultimate theory of our universe.... what I discovered is that in the computational universe even extremely simple programs can actually show behavior as complex as anything. So then the question arises: could one of these simple programs in the computational universe actually be the program for our physical universe?

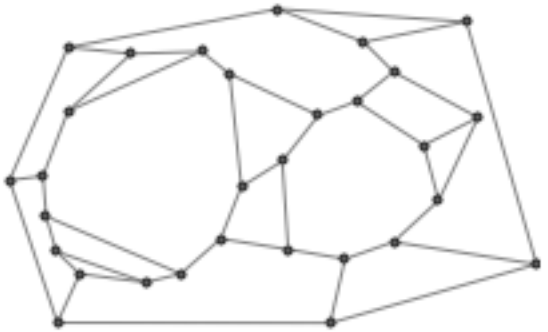


Wolfram: … “knots in the ether” ...

Wolfram's Blog, What is Spacetime, Really?

Maybe There’s Nothing But Space

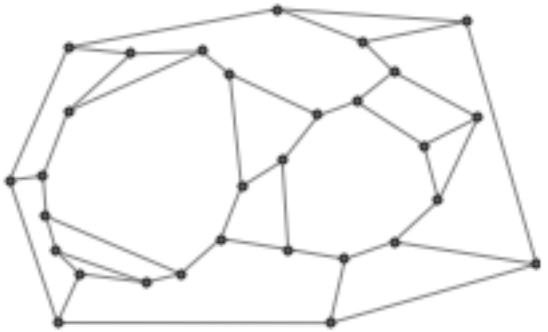
But, OK, if space is a network, what about all the stuff that’s in space? What about all the electrons, and quarks and photons, and so on? In the usual formulation of physics, space is a backdrop, on top of which all the particles, or strings, or whatever, exist. But that gets pretty complicated. And there’s a simpler possibility: **maybe in some sense everything in the universe is just “made of space”**.



Wolfram: … “knots in the ether” ...

Wolfram's Blog, What is Spacetime, Really?

Particles, Quantum Mechanics, Etc.
It’s wonderful to be able to derive General Relativity. But that’s not all of physics. Another very important part is quantum mechanics. It’s going to get me too far afield to talk about this in detail here, but presumably particles – like electrons or quarks or Higgs bosons – must exist as certain special regions in the network. In qualitative terms, they might not be that different from Kelvin’s “knots in the ether”.



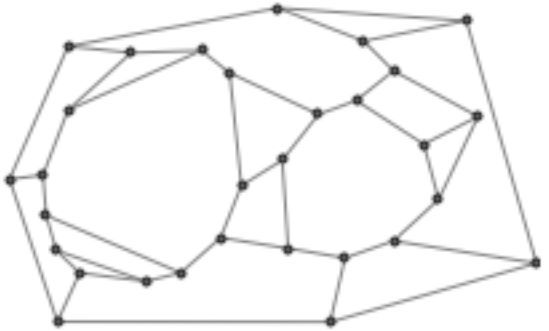
Wolfram and discoverology

Wolfram's Blog, What is Spacetime, Really?

To Do Physics, or Not to Do Physics?

...The first is simply, “You’ve got to do it!” They say that the project is the most exciting and important thing one can imagine, and they can’t see why I’d wait another day before starting on it. The second class of responses is basically, “Why would you do it?” Then they say something like, “Why don’t you solve the problem of artificial intelligence, or molecular construction, ... There’s also a third class of responses, which I suppose my knowledge of the history of science should make me expect. **It’s typically from physicist friends**, and typically it’s some combination of, **“Don’t waste your time working on that!”** and, **“Please don’t work on that.”** The fact is that the current approach to fundamental physics – through quantum field theory – is nearly 90 years old. It’s had its share of successes, but it hasn’t brought us the fundamental theory of physics. But for most physicists today, the current approach is almost the definition of physics. So when they think about what I’ve been working on, it seems quite alien – like it isn’t really physics. And some of my friends will come right out and say, “I hope you don’t succeed, because then all that work we’ve done is wasted.

We need new ideas!

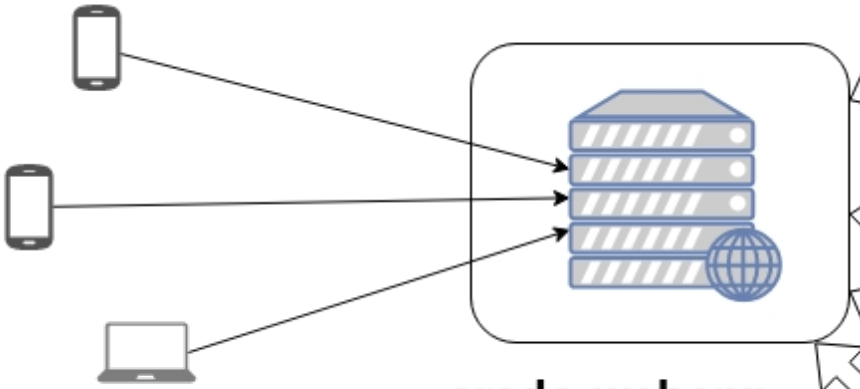


CREDO attracts... e.g. Ukrainian youth

ca. 250,000 talented youth! ca. 20% technical/scientific!

→ CREDO invited to discuss partnership!

Component diagram



User devices

- create new accounts
- send events
- request data exports

credo-webapp

- handle requests with new events
- handla data export requests
- basic visualization

python + django

Redis

- caching
- rate limiting
- leaderboards
- live detection filtering (hot pixels)

MariaDB

- user data and event storage
- authorative source of truth

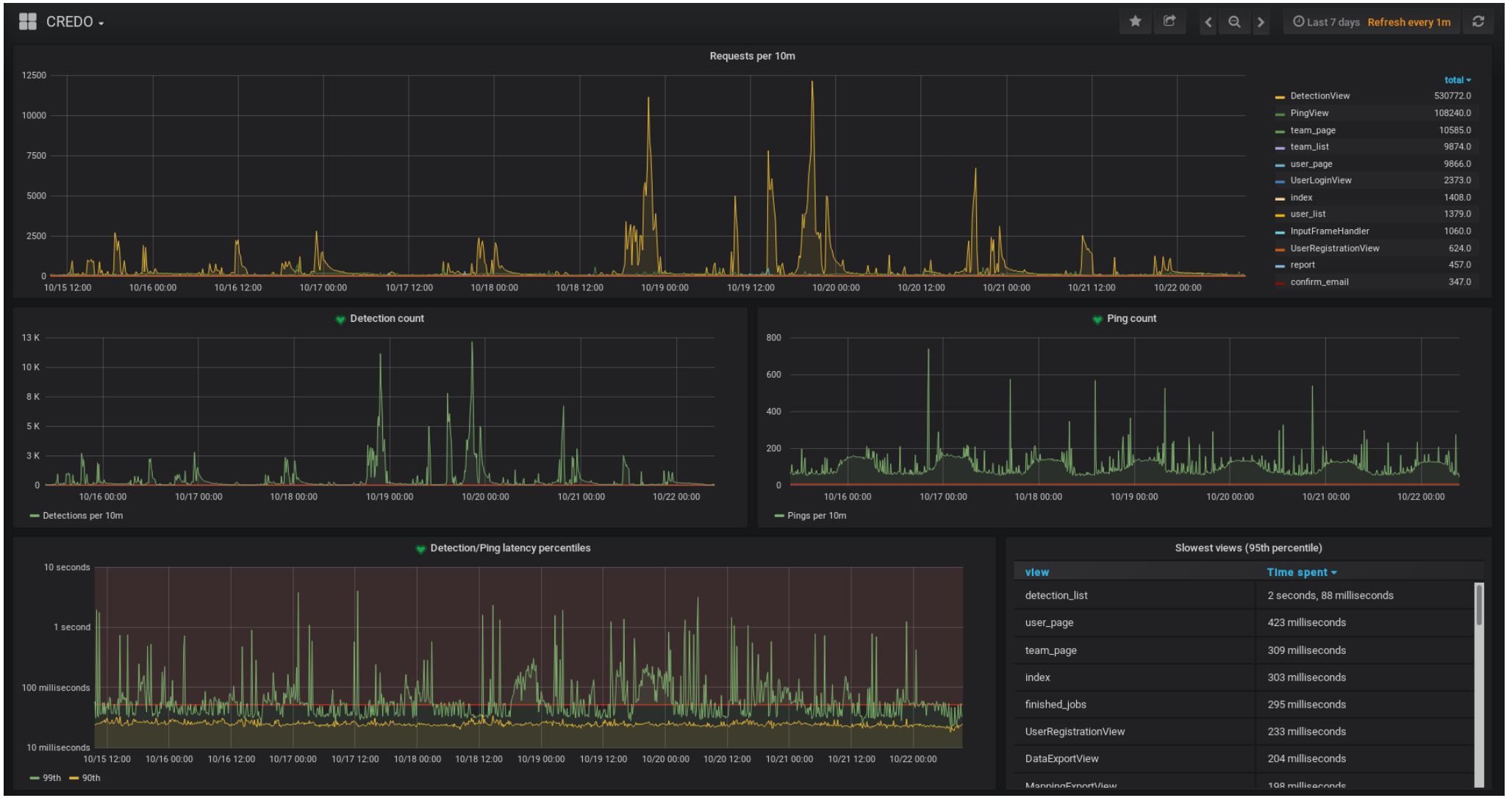
S3-compatible object storage

- data export storage
- backups

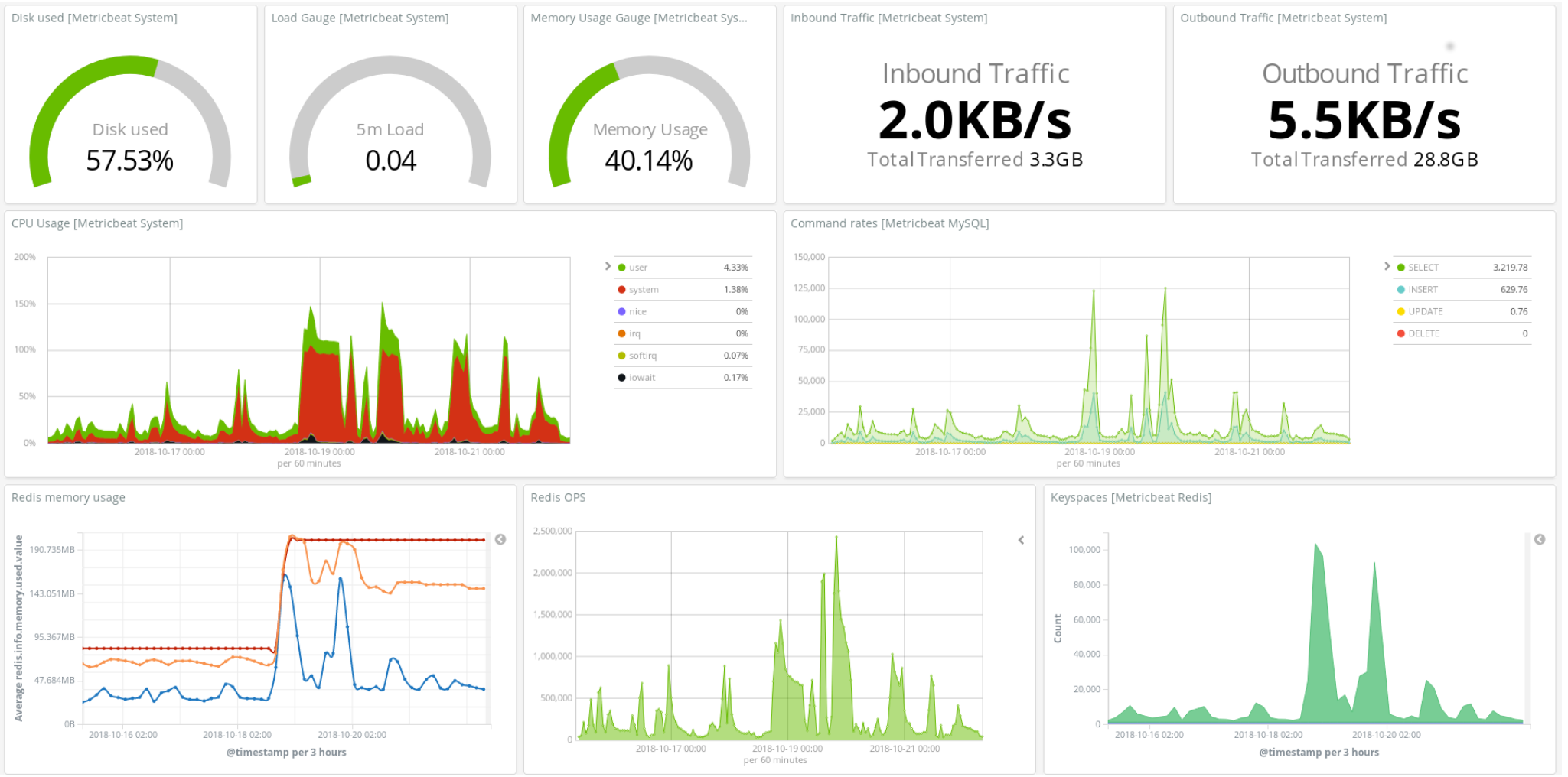
Other

- performance and server metrics
- monitoring

...



From: M. Pawlik et al, CGW'18



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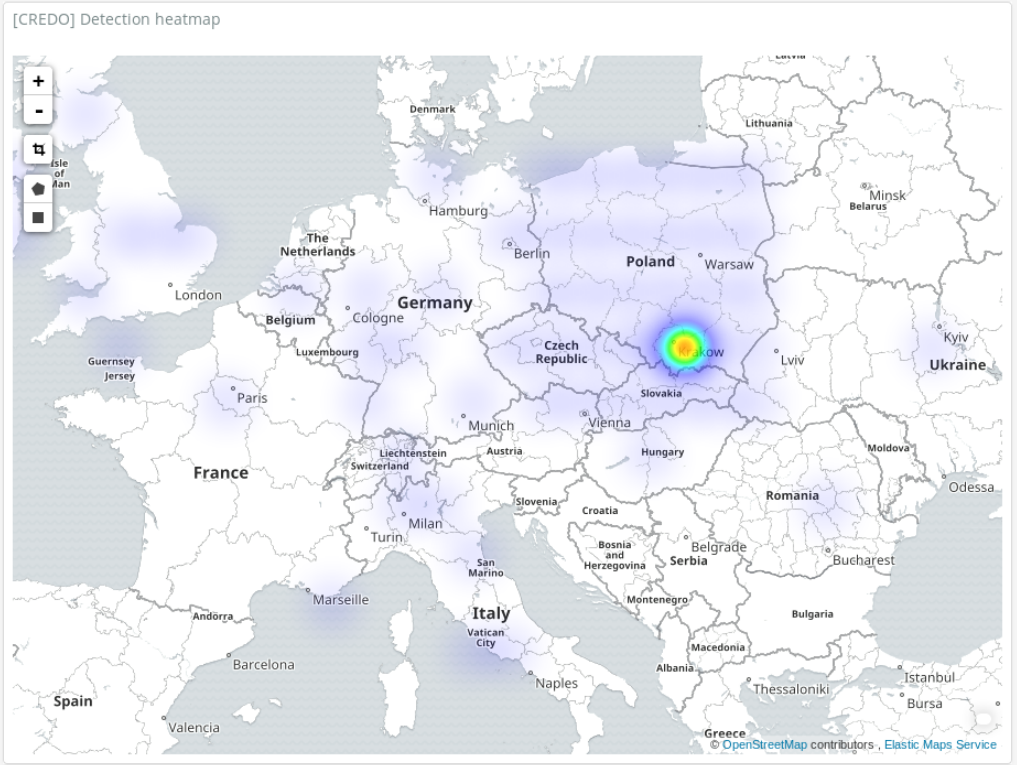
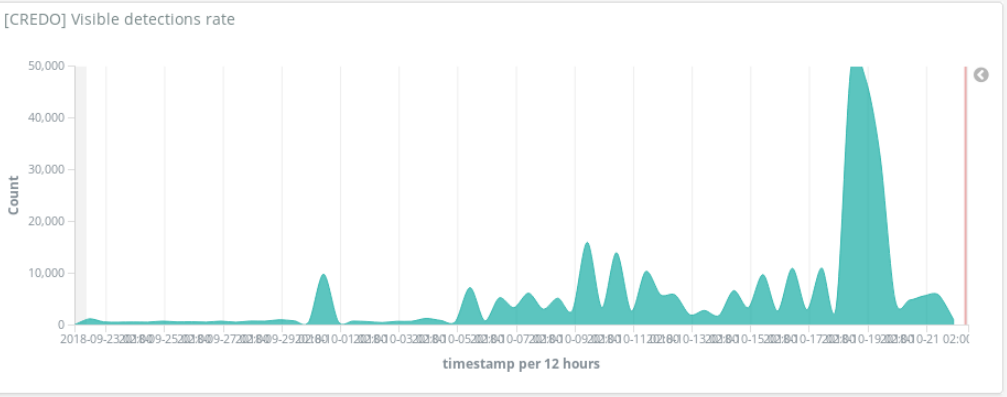
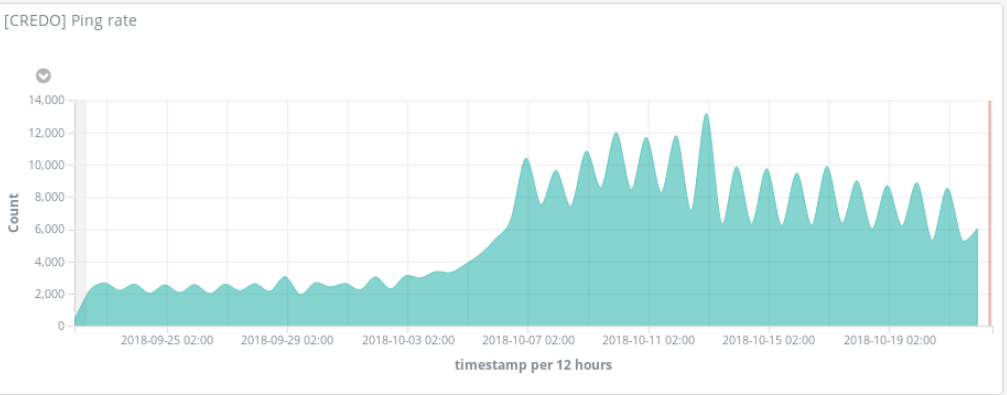






[CREDO] Top users (detection count)

User ID	Detection count
8006	32,992
8003	23,956
6983	17,389
8001	14,114
6977	11,462
Other	234,060
	333,973

[CREDO] Top users (by on time)

User ID	On time	Ping count
4980	3 months	13,868
4125	3 months	13,457
157	2 months	9,139
1163	2 months	4,288
7358	a month	4,708
Other	5 years	302,462
	6 years	**347,922**

From: M. Pawlik et al, CGW'18

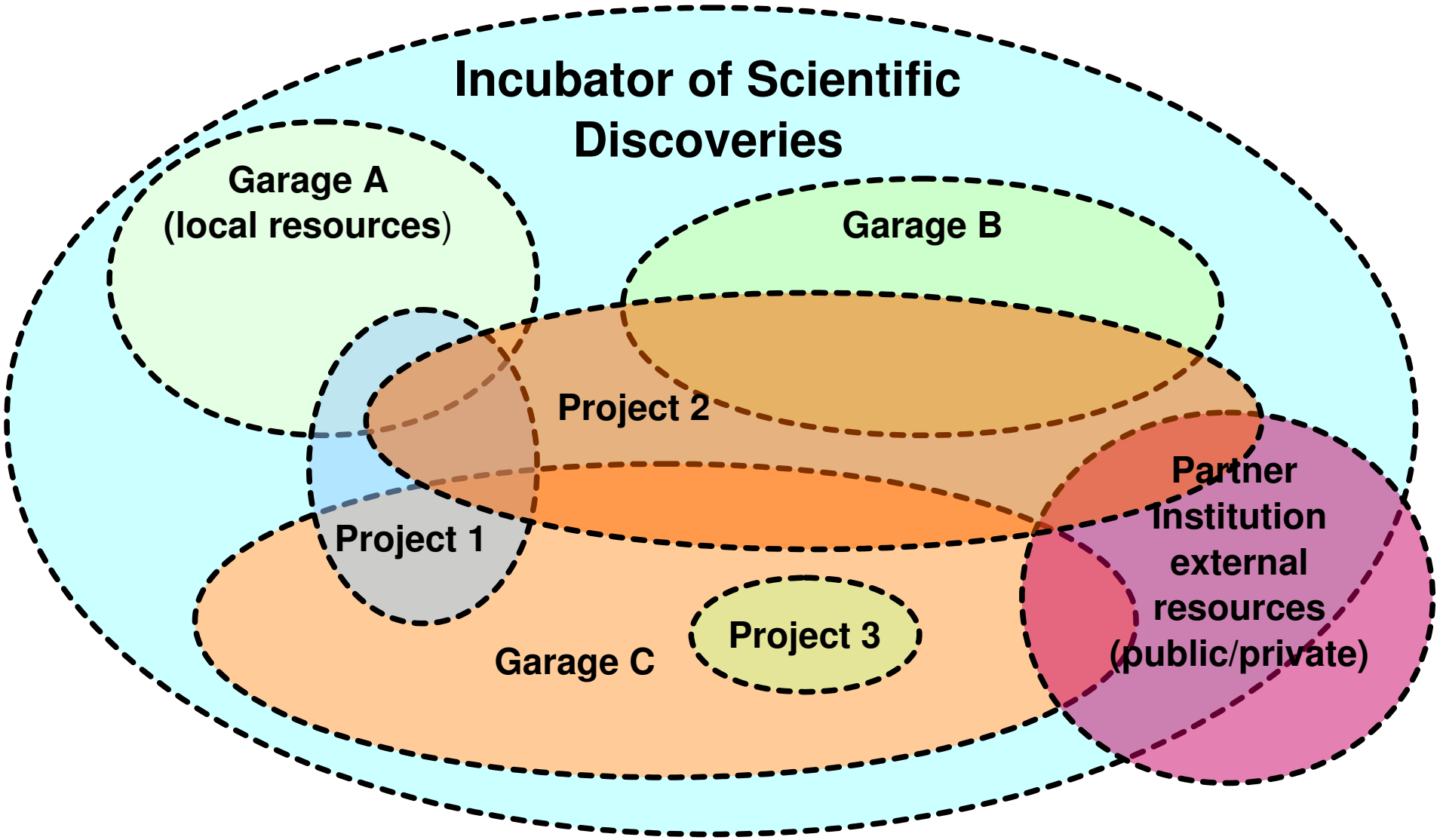
… as a gaming system enrooted in reality

- ambitious goals (spacetime structure, earthuake forewarning, biohazard alerting)
- tasks (detect, invite, educate, imagine ...)
- points (cryptocurrency: credos)
- profits (co-authorship, patent revenue, documented education/skills)
- gadgets (economy detectors, t-shirts, magnets...)
- distributed/decentralized (blockchain, cryptography)
- evolutive (self teaching, self defining)
- AI mamangement support (large scale!)
- crowdfunded

→ Participation!

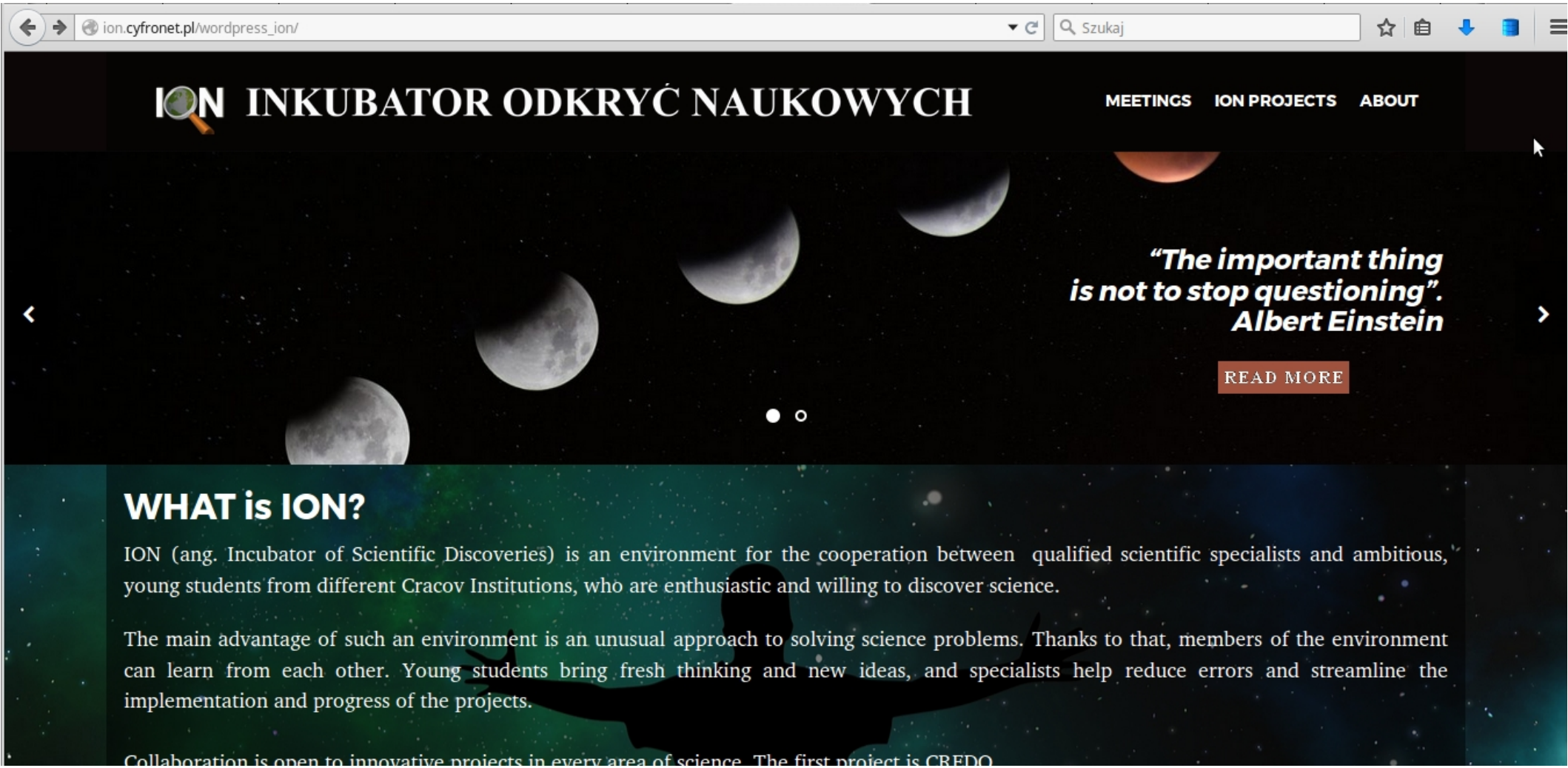
Coming soon!

Incubator of Scientific Discoveries: vision



Resources: money, space, tools, skills, competencies, advise, ...
Projects!: team, goal, road map, budget, action, reports, **continuity** → **discoveries!**
Distributed = access to more resources = **synergy** = better chance for discoveries.

Incubator of Scientific Discoveries



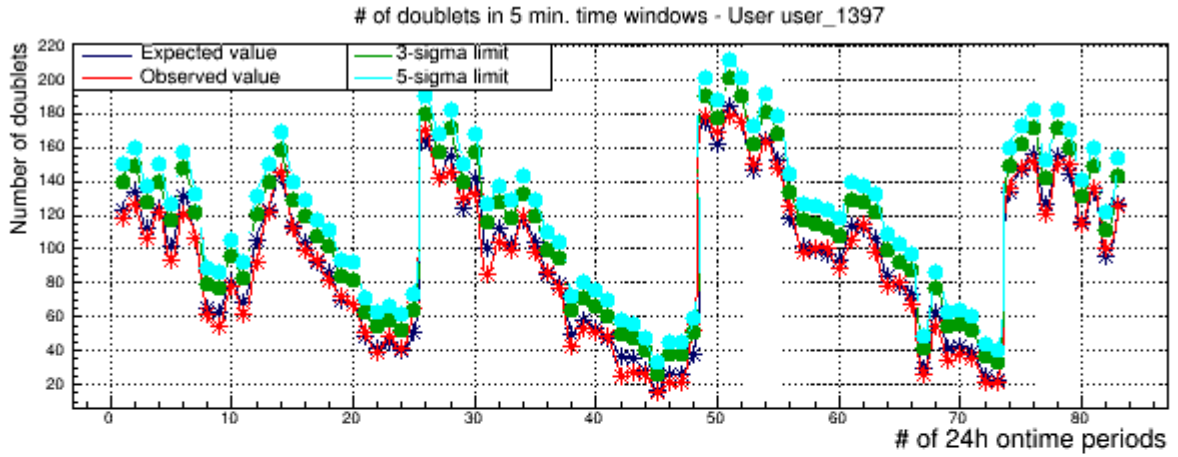
Begin your journey to the Nobel Prize early...

Example upcoming training: **"Mentality of discoverers" [psychology]**

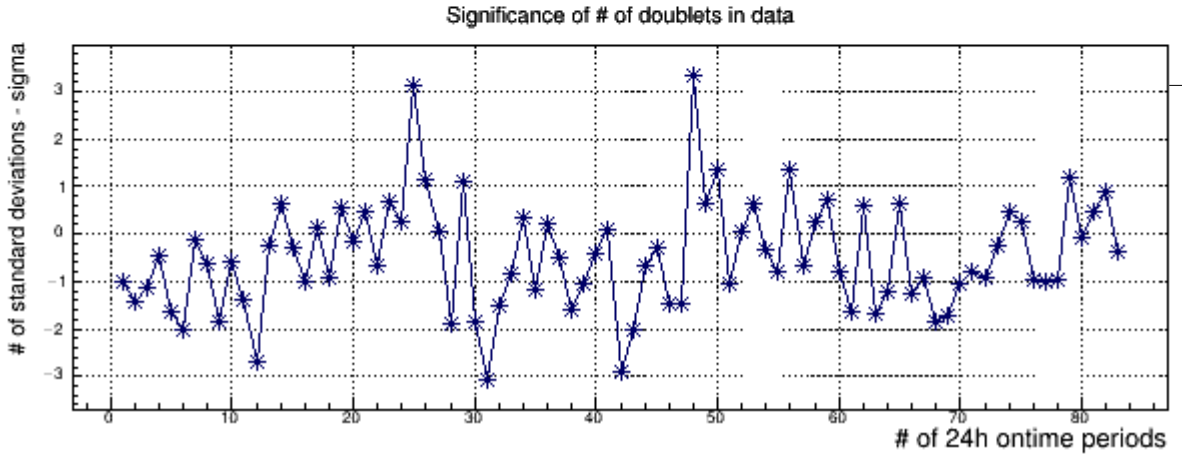
Quantum Gravity Previewer: online experiment!

Cumulative number of hit pairs („doublets”) within 5 min, in a single device, ~80 days

by Kevin Almeida Cheminant, for the CREDO Collaboration



expected from random
observed



3σ

(significance)

The first experiment on CREDO infrastructure!

Running since 17.05.2018! First Light 4.10.2018!

CREDO

THE QUEST FOR THE UNEXPECTED

Scientific diversity: BIO

[Livescience.com, October 11, 2016]

On a Long Trip to Mars, Cosmic Radiation May Damage Astronauts' Brains

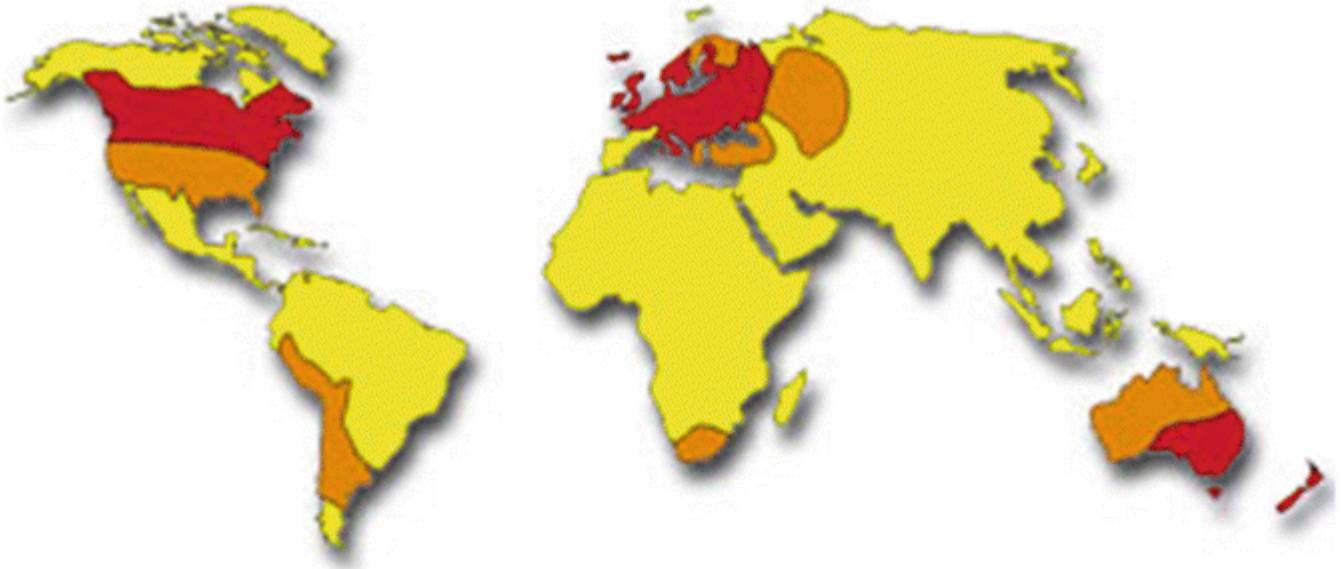
… and how can cosmic rays affect us on Earth?

Imagine a global network of cosmic ray detectors and global data on EEG...

CREDO

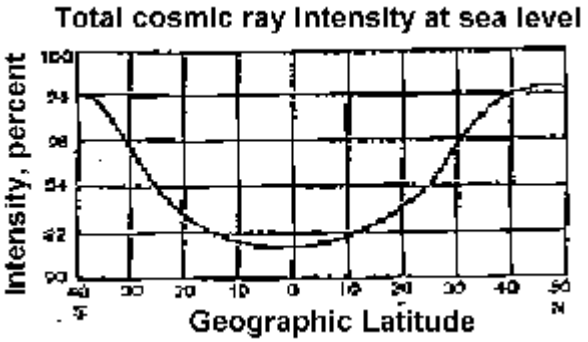
THE QUEST FOR THE UNEXPECTED

Scientific diversity: BIO



Worldwide distribution of MS

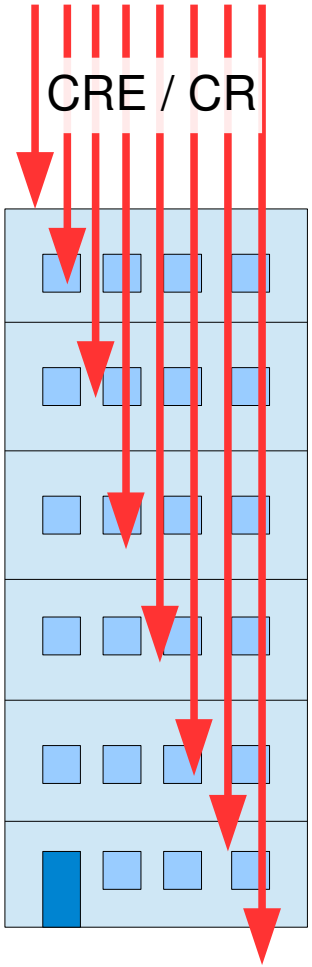
- Higher than 30/100,000
- Between 5/100,000 and 30/100,000
- Below 5/100,000



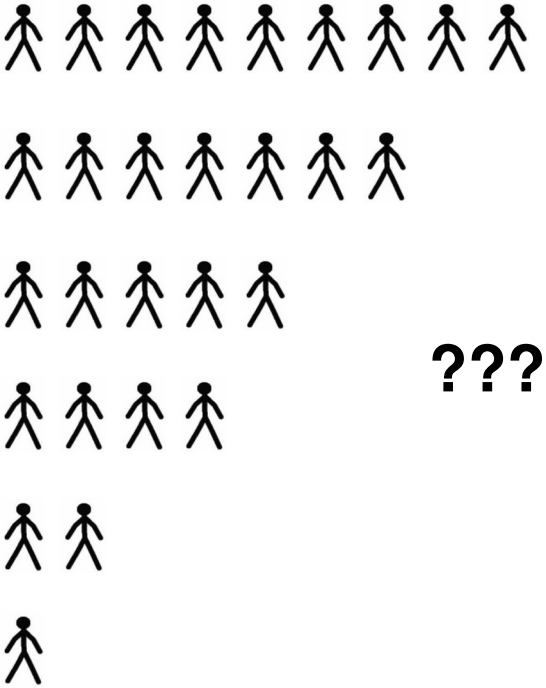
http://www.geoexplo.com/airborne_survey_workshop_rad.html

Costelloe L., Fletcher J., Fitzgerald D. (2016) Neuroinflammatory Disorders. In: Hardiman O., Doherty C., Elamin M., Bede P. (eds) Neurodegenerative Disorders. Springer, Cham, https://doi.org/10.1007/978-3-319-23309-3_15

multiple sclerosis and cosmic rays: the floor test???



or



???

Piotr Homola, Institute of Nuclear Physics PAN, Kraków, Poland, 2018-04-18, Piotr.Homola@ifj.edu.pl

Why high energy photons interesting?

- they should exist

- they should initiate large scale cascades

- detection of large scale cascades unattempted

Photons as cosmic rays: astrophysical scenarios

Astrophysical scenarios

acceleration of nuclei (e.g. by shock waves)
+ „conventional interactions", e.g. with CMBR

- sufficently efficent astrophysical objects difficult to find
- small fractions of photons and neutrinos – mainly nuclei expected

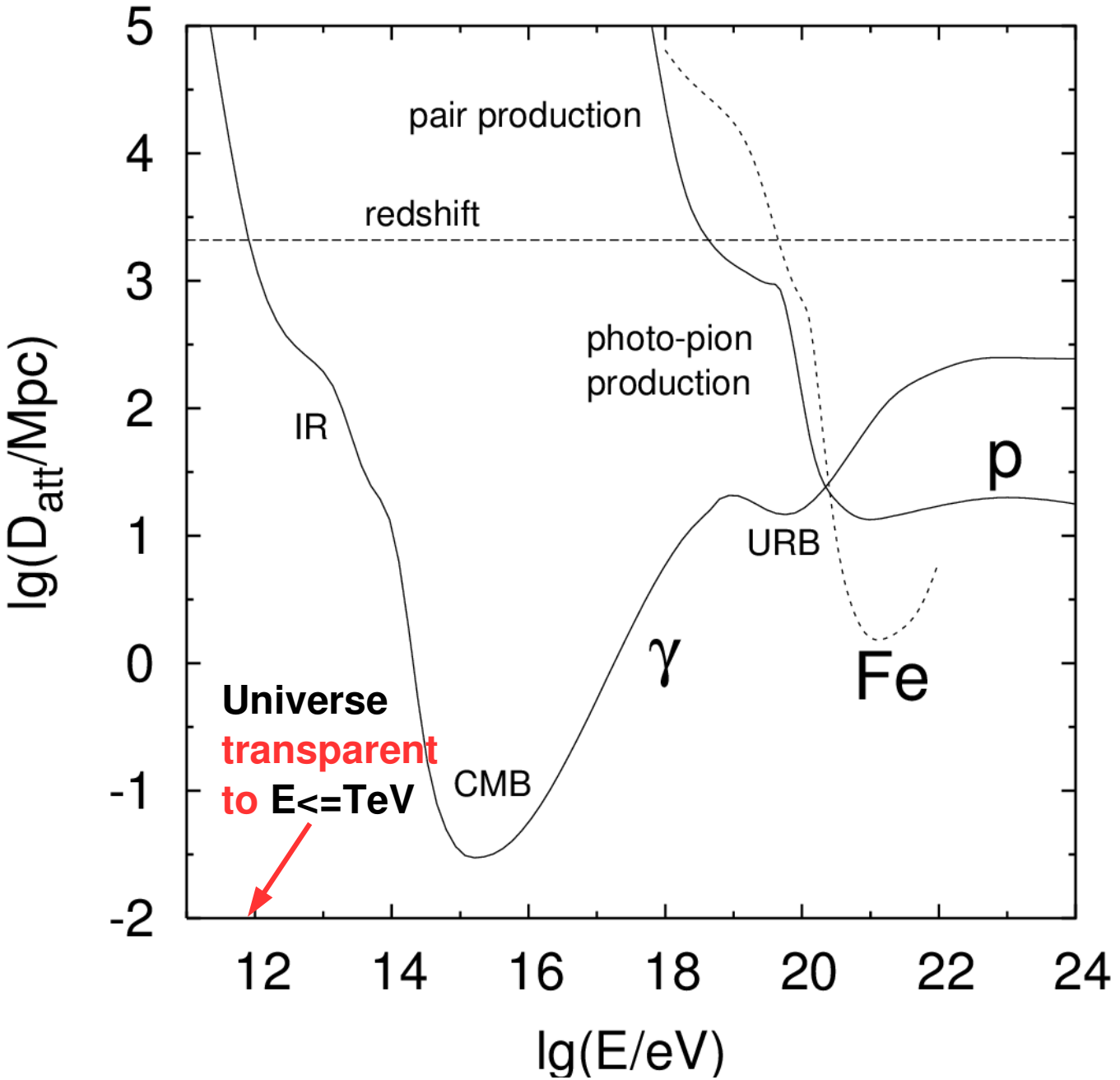
??? Exotic scenarios (particle physics) **???**

Decay or annihilation the early Universe relics
→ hypothetic supermassive particles of energies $\sim 10^{23}$ eV
→ decay to quarks and leptons → hadronization (mainly pions)

- large fraction of photons and neutrinos in UHCER flux

not the case?

γ_{UHE} travelling through the Universe: paradigm



2140 TFLOPS in CPUs + 256 TFLOPS in GPUs
2232 nodes, 53568 CPU cores, 279 TB RAM
10 PB usable disk space @ 180 GB/s

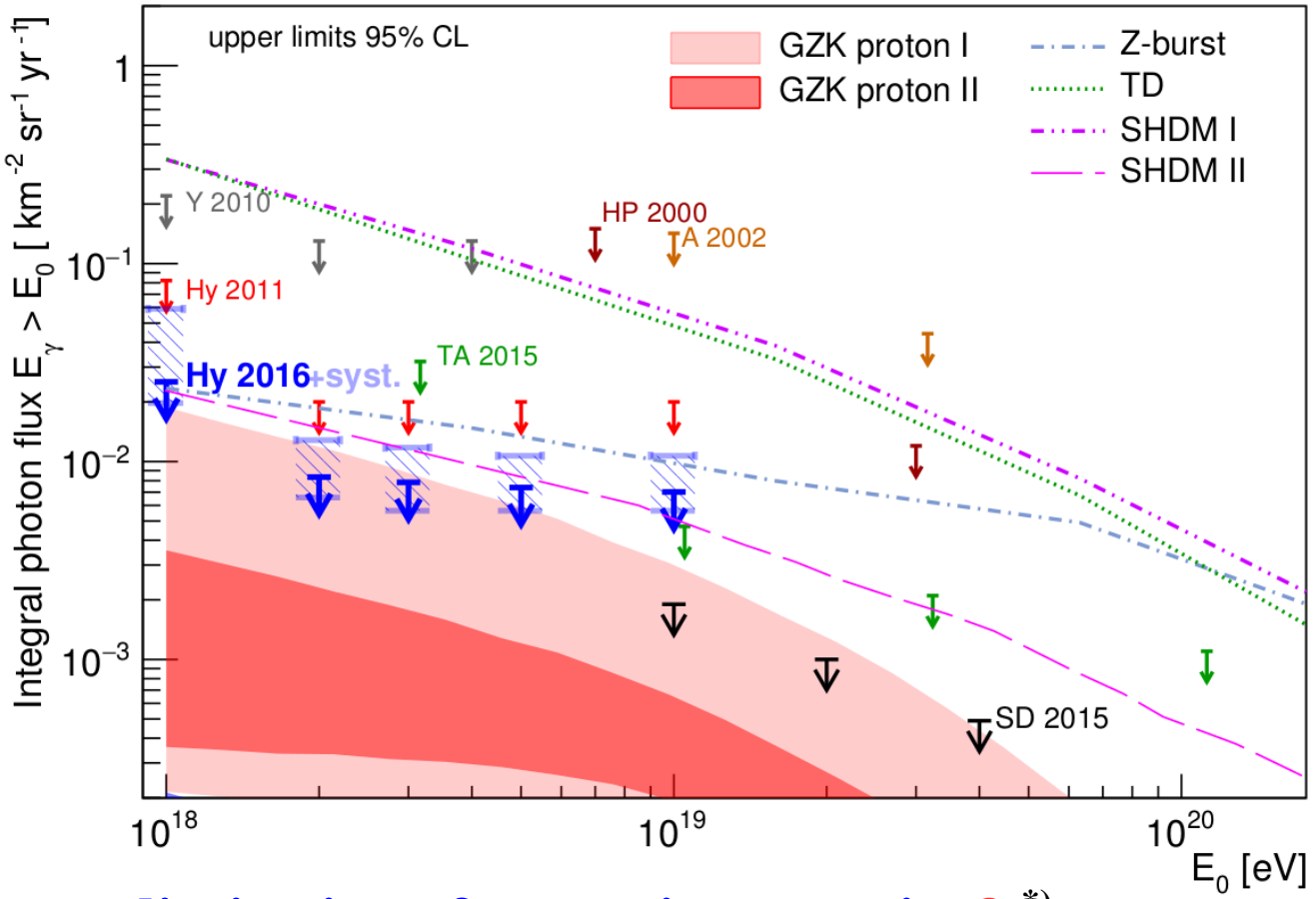
The CREDO heart :)

2.4 PFLOPS, #59 ON TOP500

Do UHE photons reach Earth?

UHECR COMPOSITION PARADIGM

At the highest energies photon fractions < 1%



→ **Severe limitations for exotic scenarios?** *)

→ **and for (special) Lorentz Invariance Violation?** *)

*) **Understand well**: limits apply to single photons, **assume no screening** e.g. within exotic models of interactions, structure of a photon, space-time structure that could manifets at UHE...

Experimental evidence about γ_{UHE}

γ_{UHE} —no interactions or screening→ **Earth**

NOT OBSERVED

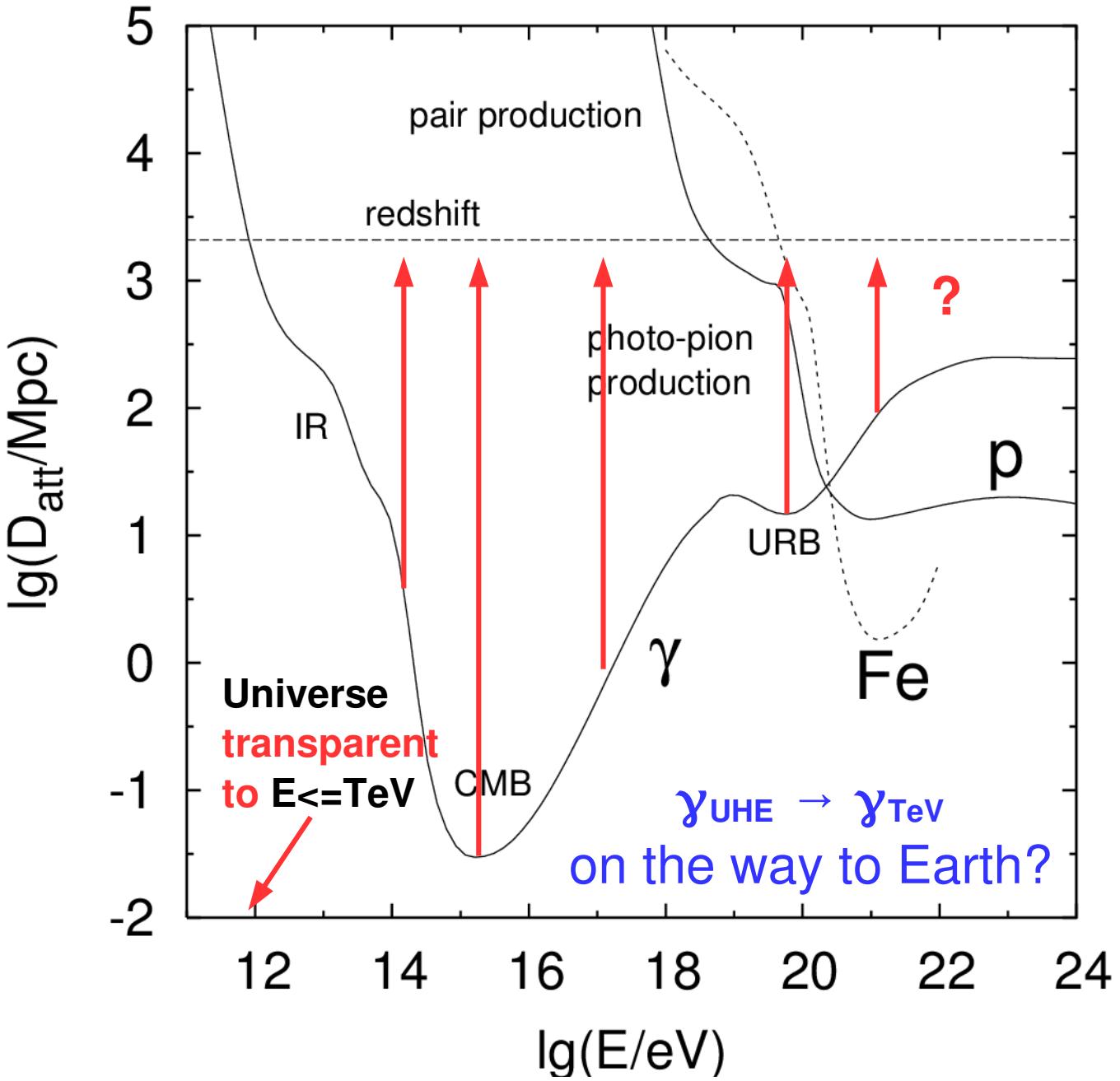
γ_{UHE} —unexpected interactions, screening, ...→ **ELECTROMAGNETIC CASCADES (COSMIC-RAY ENSEMBLES)** → **Earth**

NOT TRIED SO FAR...

↓

CREDO!

γ_{UHE} travelling through the Universe: photon decay?



Cosmic rays... any other surprises possible?

Particles (photons) coming to Earth from Space

1912. Electroscopes discharge faster with increasing altitude → rays of extraterrestrial origin: V. Hess (Nobel prize 1936).

1932. Discovery of antimatter (positron): C. Anderson (Nobel prize 1936).

1937. Discovery of muons: S. Neddermeyer and C. Anderson → particle physics begins.

1938. Extensive air showers (EAS) → $E > 10^{15}$ eV: P. Auger

1962. First EAS at 10^{20} eV: J. Linsley
→ what and why can have so huge energies???

.... high time for a next breakthrough?

Cosmic-Ray Ensembles (CRE): road map

Theoretical scenarios (ongoing)
non-exotic / exotic ✓

↓

CRE standalone simulations → particle distributions
at the top of the atmosphere (ongoing) ✓

↓

Air shower simulations (ongoing) ✓

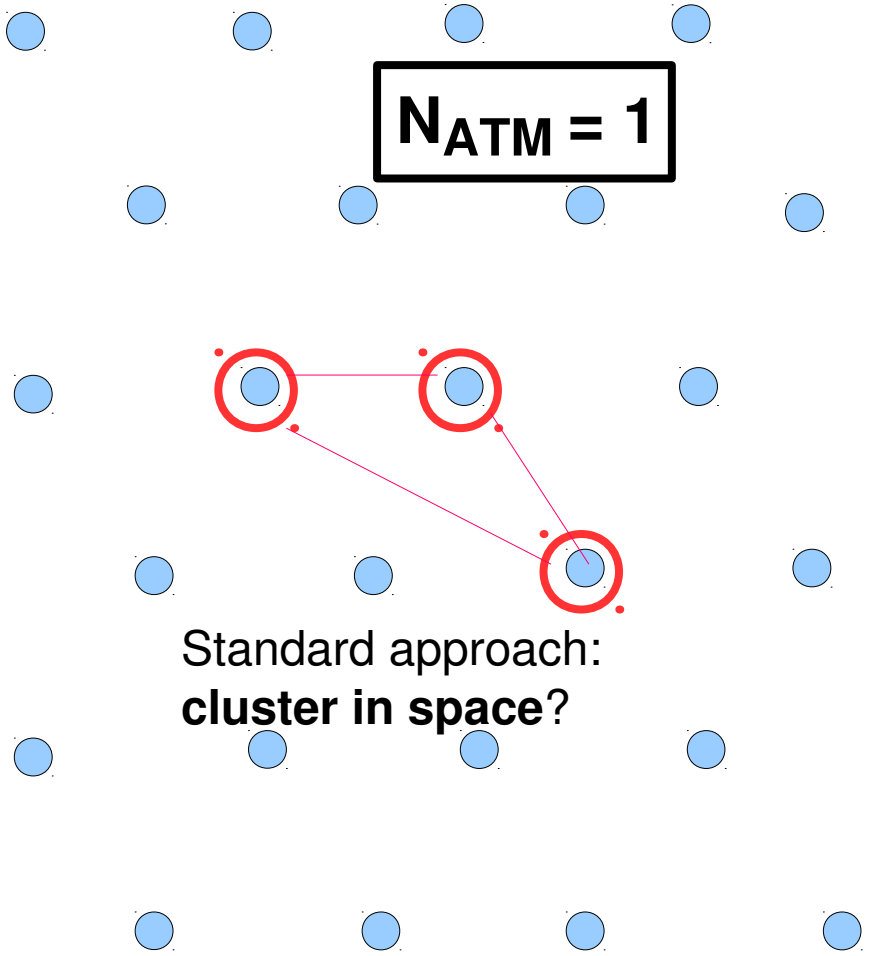
↓

Detector response (ongoing) ✓

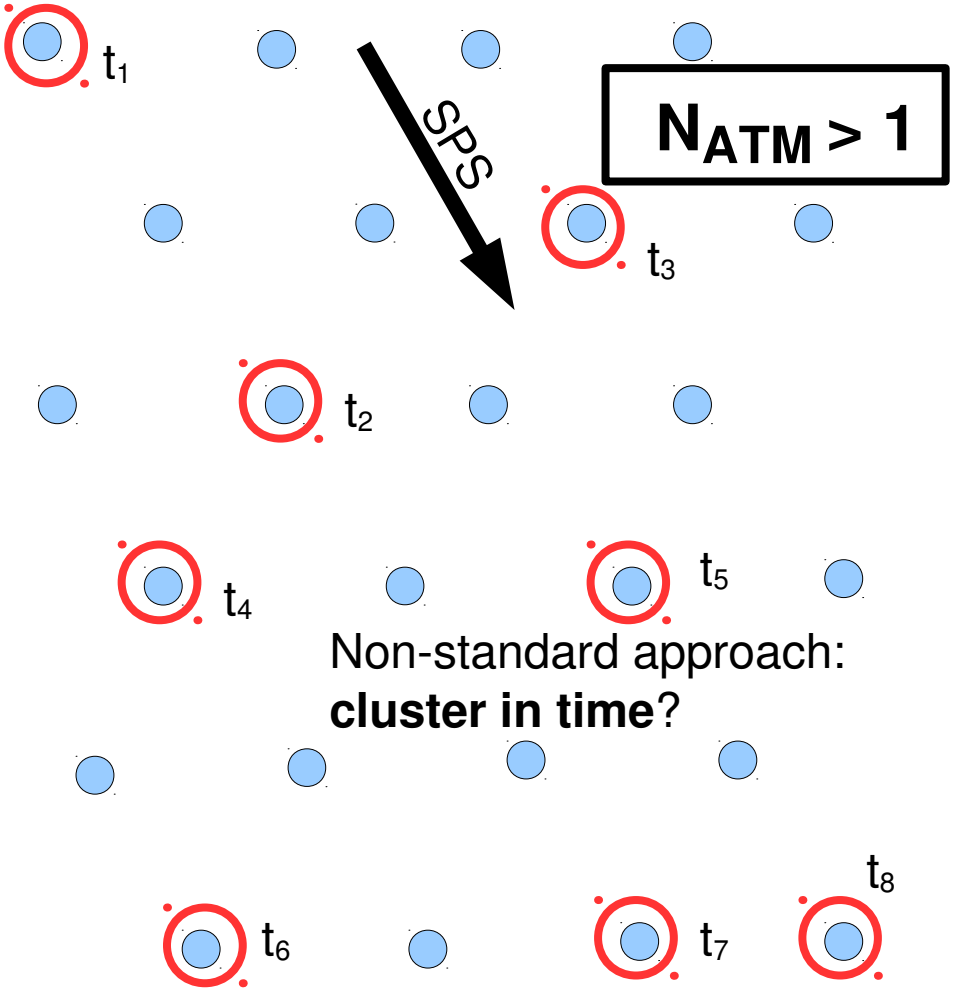
↓

observation / upper limits

A chance for a unique CRE signature



Standard approach:
cluster in space?



Non-standard approach:
cluster in time?

1) $t_n - t_1 <$ ~1 μs
2) $t_1 < \ldots < t_n$,

: a cosmic-ray detector

Cosmic-Ray Ensembles (CRE): shortcut road map

Theoretical review (ongoing) ✓

↓

CRE standalone simulations → particle distributions at the top of the atmosphere (ongoing) ✓

↓

Air shower simulations (ongoing) ✓

↓

Detector response (ongoing) ✓

↓

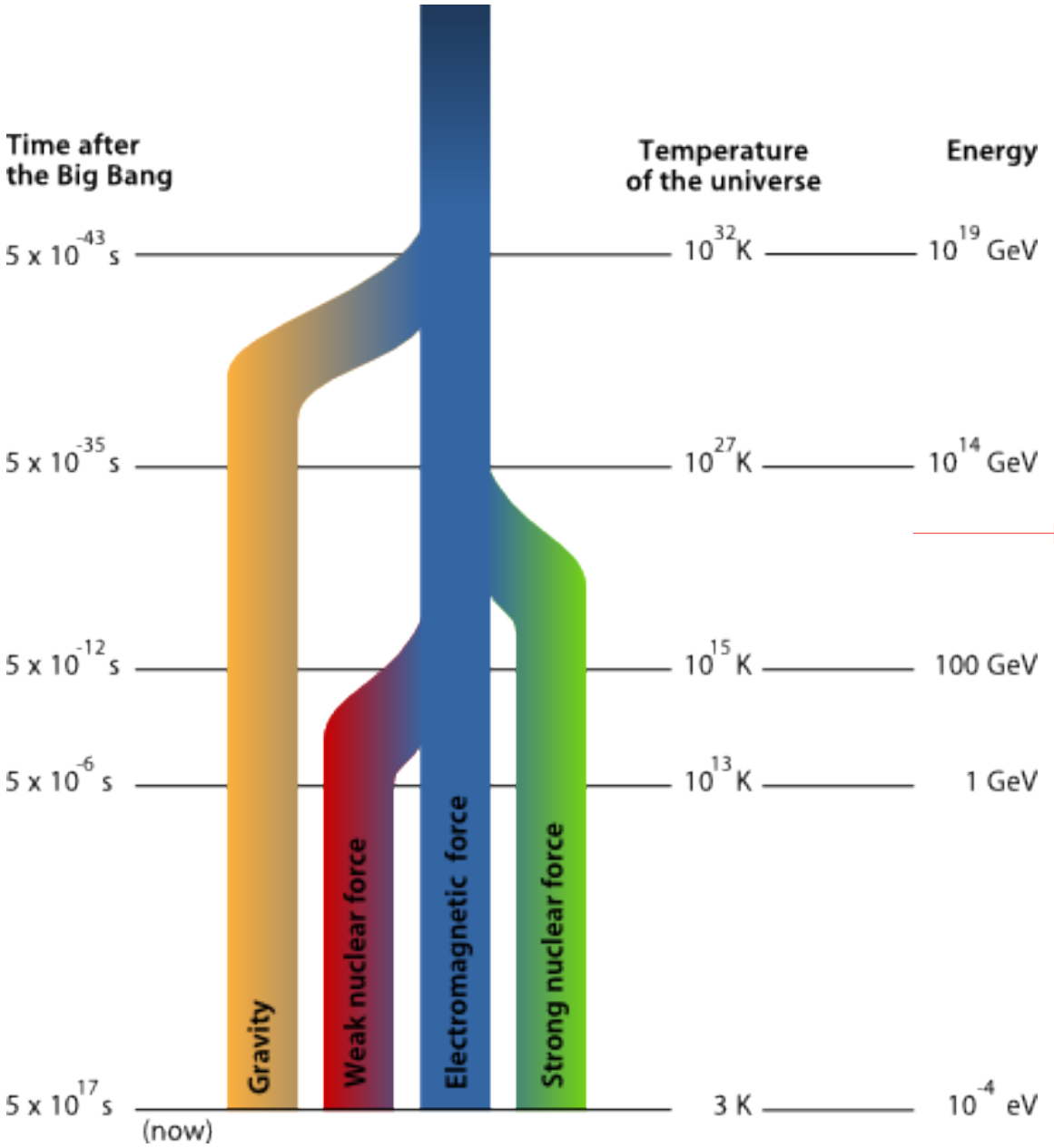
observation / upper limits

unique signature **fishing (ongoing)** ✓

Energy: the higher the better?

Theory of „Everything” (Qunatum Gravity)?

Grand Unified Theory?

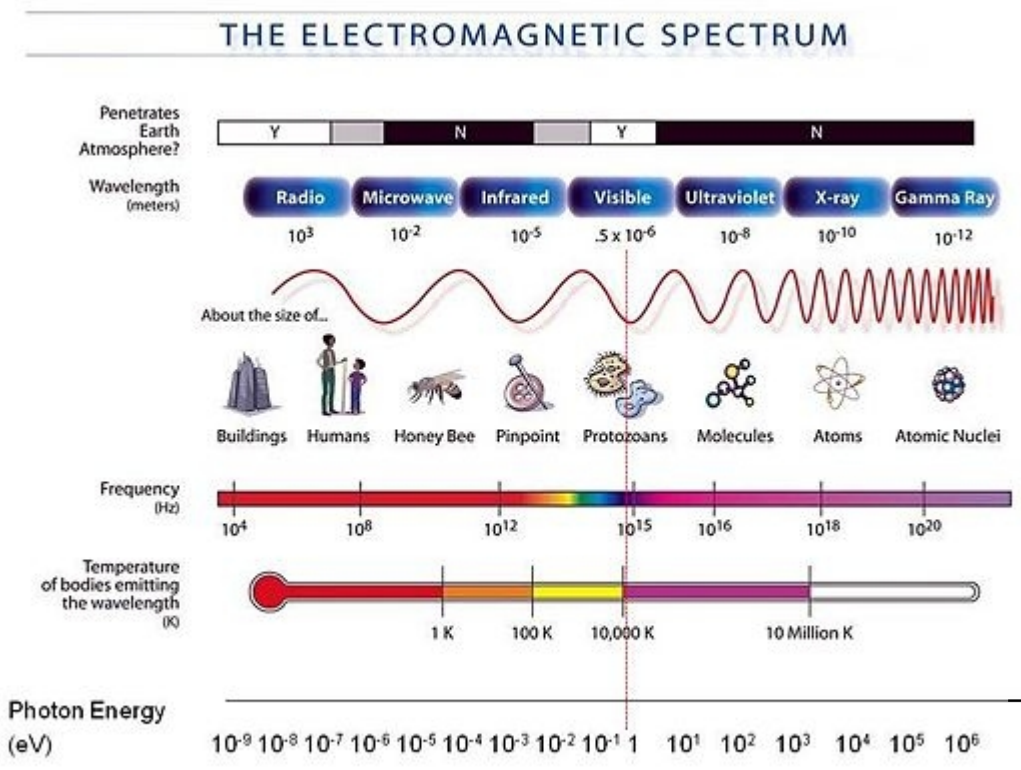


Planck scale

Ultra-high energies (10^{20} eV)

Energy!

Photons



Accelerators	Gamma astronomy	Cosmic rays	Planck scale
10^{-18}	10^{-21}	10^{-26} m	10^{-35} m
10^{26}	10^{29}	10^{34} Hz	10^{42} Hz
10^{12}	10^{15}	10^{20} eV	10^{28} eV

The highest energy of a particle ever observed

$\sim 10^{20}$ eV

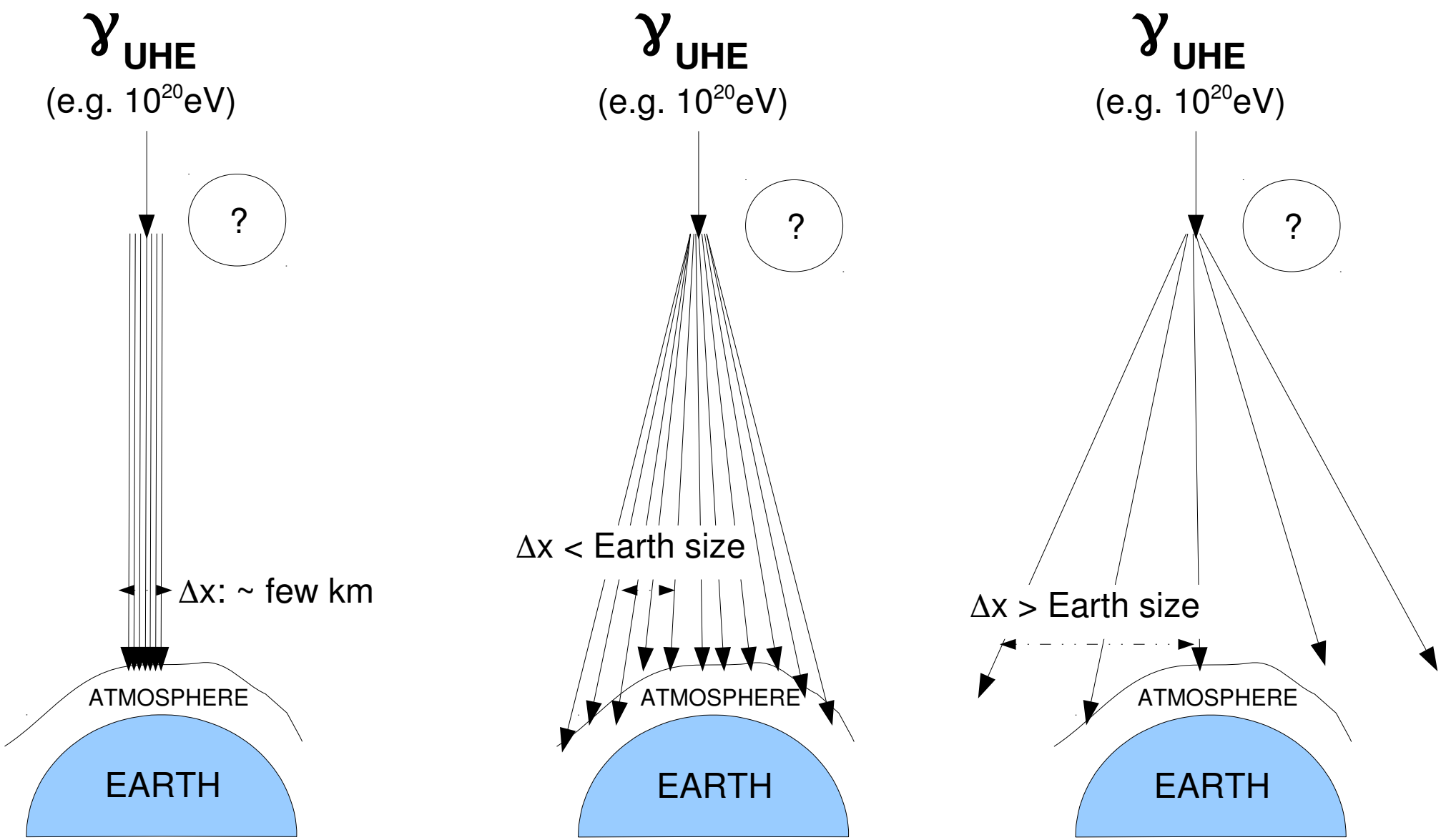
$\approx$16 J

(1 eV = 1.6×10^{-19}J)

$\approx$ 

150 km/h

N_{ATM} >= 1: untouched ground



… (public) engagement

Citizen Science! But ... science must be real

Citizen science

From Wikipedia, the free encyclopedia

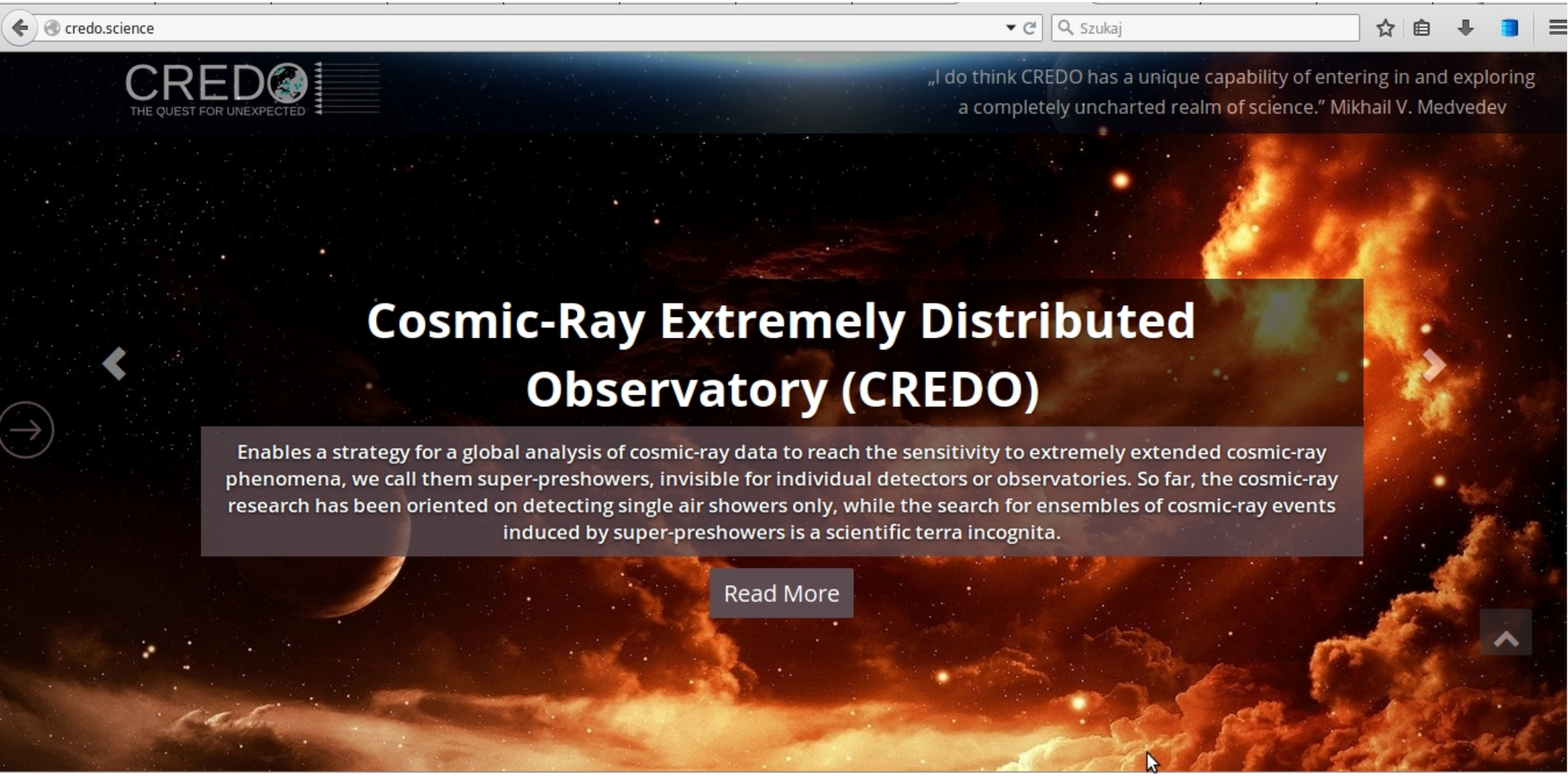
Citizen science (**CS**) (also known as **crowd science**, **crowd-sourced science**, **civic science**, **volunteer monitoring** or **networked science**) is scientific research conducted, in whole or in part, by amateur or nonprofessional scientists. Citizen science is sometimes described as "public participation in scientific research", participatory monitoring and participatory action research.[1]

CITIZEN SCIENCE **IS NOT** OUTREACH!

PUBLICATIONS!

CO-AUTHORS!

Visit credo.science...

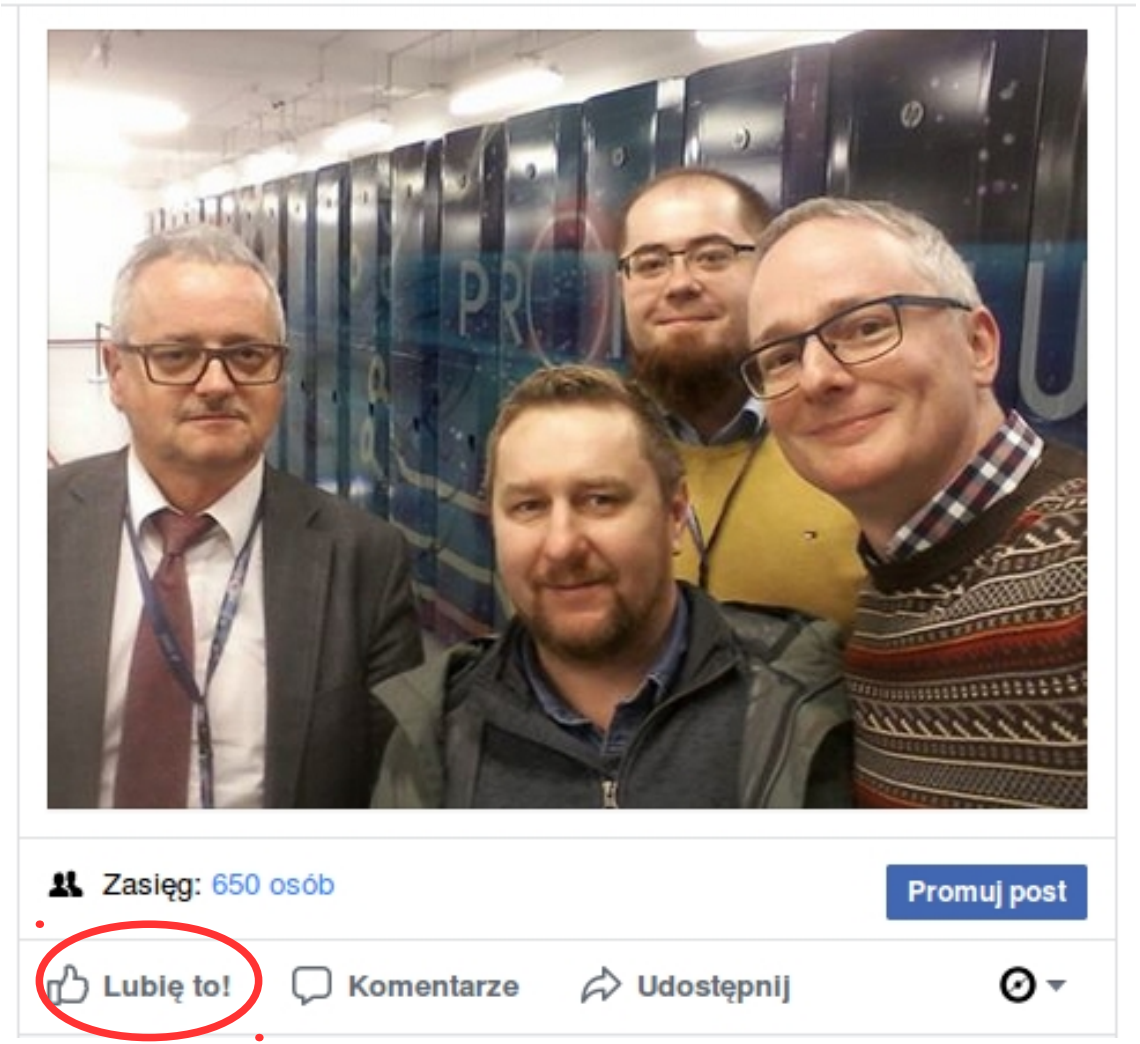


… and contribute to CREDO science.

CREDO

THE QUEST FOR THE UNEXPECTED

facebook /credo.science



Level 1:

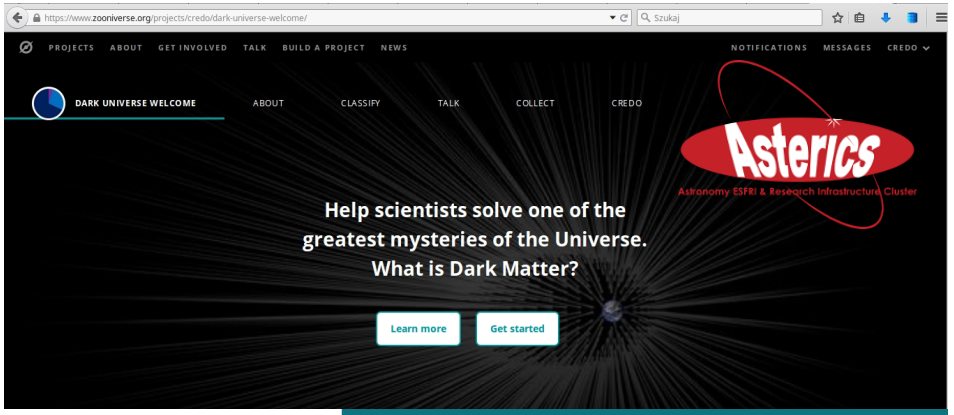
growth/scale generation

CREDO

THE QUEST FOR THE UNEXPECTED

Dark Universe Welcome

kategoria wiekowa: 7+



"Nobody has any idea what Dark Matter or Energy are, so working on this is really exciting! Dark Matter is responsible for the gravitational effects seen in galaxies, while Dark Energy may be the cause of the accelerating expansion of the Universe."

We've got a very big mystery on our hands! Everything we can see in the Universe; you, me, planets, stars and galaxies, only make up 5% of the mass of the Universe. We have very clear evidence that there is a lot more mass, more stuff, out there but we have no idea what it is.

This mysterious stuff is known by scientists as Dark Matter but even the smartest theorists and most advanced technology can't work out what it physically is. We many have a way of solving this mystery by looking for and grouping Dark Messengers - very high energy particle showers which exist because of Dark Matter. However, it's very difficult for us to predict what these groups will look like and how well hidden they are amongst other contaminants. We need your help to identify patterns in the world wide detections of high energy particles shared with the CREDO (Cosmic-Ray Extremely Distributed Observatory) collaboration so we can teach computers to better identify them.

Asterics

Dark Universe Welcome was developed with the help of the **ASTERICS Horizon2020** project. ASTERICS is a project supported by the European Commission Framework Programme Horizon 2020 Research and Innovation action under grant agreement n. 653477

9

Level 3:

data analysis

Quantum Gravity with gamma astronomy

https://www.ucdavis.edu/news/gamma-ray-delay-may-be-sign-new-physics

UCDAVIS

Quick Links

ABOUT US ADMISSIONS ACADEMICS RESEARCH CAMPUS LIFE NEWS

Gamma Ray Delay May Be Sign of 'New Physics'

Delayed gamma rays from deep space may provide the first evidence for physics beyond current theories.

The MAGIC (Major Atmospheric Gamma-ray Imaging Cherenkov) telescope found that high-energy photons of gamma radiation from a distant galaxy arrived at Earth four minutes after lower-energy photons, although they were apparently emitted at the same time. If correct, that would contradict Einstein's theory of relativity, which says that all photons (particles of light) must move at the speed of light.

"Everybody's very excited," about this result, said Daniel Ferenc, a physics professor at UC Davis and a member of the MAGIC collaboration. Ferenc cautioned that the results need to be repeated with other gamma-ray sources and that a simpler explanation had not been ruled out. But, "it shows that such measurements are possible," he said.

The researchers propose that the delay could be caused by photons interacting with "quantum foam," a type of structure of space itself. Quantum foam is predicted by quantum gravity theory, an attempt to unite quantum physics and relativity at cosmic scales.

UC Davis Chancellor May Announces Emily Galindo and Rahim Reed to Fill Interim Leadership Roles
March 13, 2018

→ 4 min. delay could be the signature of a special space structure: Quantum foam

→ predicted by Quantum Gravity

wyborcza.pl
KRAKÓW

to be available soon...

1 ZDJĘCIE

Projekt Credo (credo.ifj.edu.pl)

Krakowscy astrofizycy mają pomysł, chcą

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Trójwymiar

ostatnia aktualizacja:
30.08.2017 20:40

Eksperyment kosmiczny. Telefon w służbie nauki

TRÓJKA

Dzięki specjalnej aplikacji CREDO Detector każdy smartfon może, dzię
swojemu modułowi GPS, stać się częścią programu mającego na celu
ciemnej materii.

AUDIO | 1 plik

03'13 +

Eksperyment kosmiczny. Telefon w służbie nauki (Trójwymiar/Trójka)

pap Nauka w Polsce

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MENU

STRONA GŁÓWNA » NAUKA » BŁYSKI CIEMNEJ MATERII

BŁYSKI CIEMNEJ MATERII

MICHAŁ KRUPIŃSKI - | 25.07.2017 | CZYTA SIĘ 8 MINUT

Eksperyment polskich naukowców ma pomóc wyjaśnić, czym jest ciemna materia – jeden z najbardziej zagadkowych składników wszechświata. Każdy będzie mógł w nim wziąć udział – wystarczy mieć smartfon z GPS-em.