An update on the cosmo-seismic correlations: an interplay of the geomagnetic and the solar wind of an external “third factor”?

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Piotr Homola

Institute of Nuclear Physics Polish Academy of Sciences

Cosmic Ray Extremely Distributed Observatory / CREDO.science

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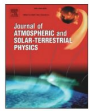

Research Paper

Observation of large scale precursor correlations between cosmic rays and earthquakes with a periodicity similar to the solar cycle

P. Homola [a,*], V. Marchenko [x], A. Napolitano [q], R. Damian [j], R. Guzik [j], D. Alvarez-Castillo [a], S. Stuglik [a], O. Ruimi [b], O. Skorenok [i], J. Zamora-Saa [c,d], J.M. Vaquero [g], T. Wibig [p], M. Knap [s], K. Dziadkowiec [j], M. Karpiel [f], O. Sushchov [a], J.W. Mietelski [a], K. Gorzkiewicz [a], N. Zabari [e], K. Almeida Cheminant [a], B. Idźkowski [h,z], T. Bulik [h,k], G. Bhatta [a], N. Budnev [r], R. Kamiński [a], M.V. Medvedev [t,u], K. Kozak [a], O. Bar [y], Ł. Bibrzycki [j], M. Bielewicz [w], M. Frontczak [l], P. Kovács [o], B. Łozowski [v], J. Miszczyk [a], M. Niedźwiecki [y], L. del Peral [n], M. Piekarczyk [j], M.D. Rodriguez Frias [n], K. Rzecki [j], K. Smelcerz [y], T. Sośnicki [j], J. Stasielak [a], A.A. Tursunov [m]

[a] Institute of Nuclear Physics Polish Academy of Sciences, 31-342, Kraków, Poland
[b] Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem, IL, 91904, Israel
[c] Departamento de Ciencias Físicas, Universidad Andres Bello, Fernández Concha 700, Las Condes, Santiago, Chile
[d] Millennium Institute for Subatomic Physics at High Energy Frontier - SAPHIR, Fernández Concha 700, Las Condes, Santiago, Chile
[e] AstroTectonic Ltd., Juliusza Słowackiego 24, 35-069, Rzeszów, Poland
[f] Astroparticle Physics Amateur, 34-500, Zakopane, Poland
[g] Departamento de Física, Universidad de Extremadura, Avda. de Elvas s/n, 06006, Badajoz, Spain
[h] Astronomical Observatory University of Warsaw, Al. Ujazdowskie 4, 00-478, Warsaw, Poland
[i] Taras Shevchenko National University of Kyiv, 01601, Kyiv, Ukraine
[j] AGH University of Krakow, al. Mickiewicza 30, 30-059, Kraków, Poland
[k] Astrocent, Nicolaus Copernicus Astronomical Center, Rektorska 4, 00-614, Warsaw, Poland
[l] Pedagogical University of Krakow, Podchorążych 2, 30-084, Kraków, Poland
[m] Institute of Physics, Silesian University in Opava, Bezručovo nám. 13, CZ-74601, Opava, Czech Republic
[n] Space and Astroparticle Group, University of Alcalá; Ctra. Madrid-Barcelona, Km. 33.7, E-28871, Madrid, Spain
[o] Wigner Research Centre for Physics, Konkoly-Thege Miklós út 29-33, H-1121 Budapest, Hungary
[p] Department of Theoretical Physics, Faculty of Physics and Applied Informatics, University of Lodz, Pomorska 149/153, PL-90-236, Lodz, Poland
[q] University of Napoli "Parthenope", Department of Engineering, Centro Direzionale, Isola C4, 80143, Napoli, Italy
[r] Irkutsk State University, Physical Department, K.Marx str., 1, Irkutsk, 664003, Russia
[s] Astroparticle Physics Amateur, 58-170, Dobromierz, Poland
[t] Department of Physics and Astronomy, University of Kansas, Lawrence, KS, 66045, USA
[u] Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, MA, 02139, USA
[v] Faculty of Natural Sciences, University of Silesia in Katowice, Bankowa 9, 40-007, Katowice, Poland
[w] National Centre for Nuclear Research (NCBJ), Soltana Str. 7, 05-400, Otwock, Świerk, Poland
[x] Astronomical Observatory, Jagiellonian University, Orla Str. 171, 30-244, Kraków, Poland
[y] Department of Computer Science, Cracow University of Technology, 31-155, Kraków, Poland
[z] SKA Observatory Jodrell Bank, Lower Withington, Macclesfield Cheshire, SK11 9FT, UK

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ABSTRACT

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 σ at local maxima. The precursor characteristics of the observed correlations point to a pioneer perspective of an early warning system against earthquakes.

* Corresponding author.
E-mail address: Piotr.Homola@ifj.edu.pl (P. Homola).

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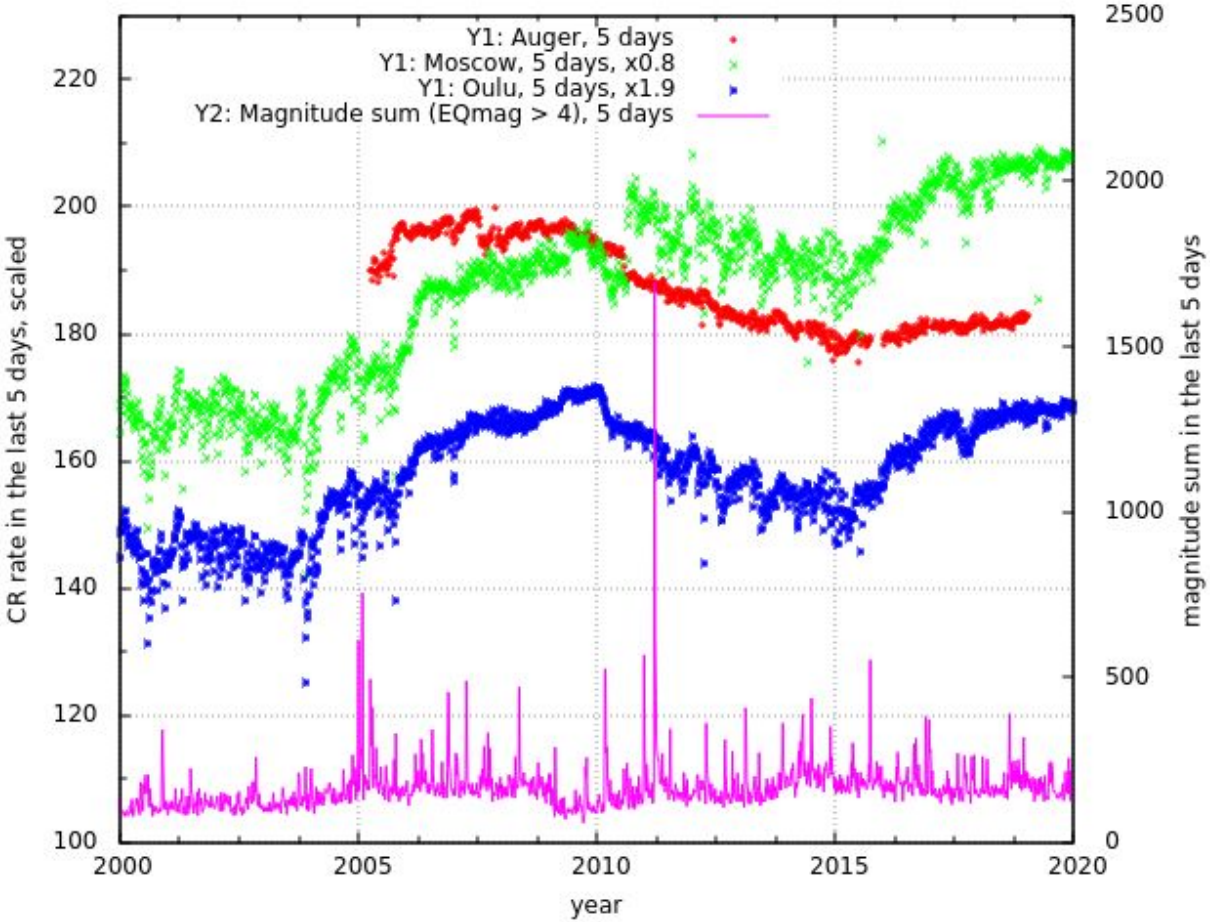
Observation of cosmo-seismic correlations: discovery > 6 σ!

"Astroparticle Physics Amateur"!

The data



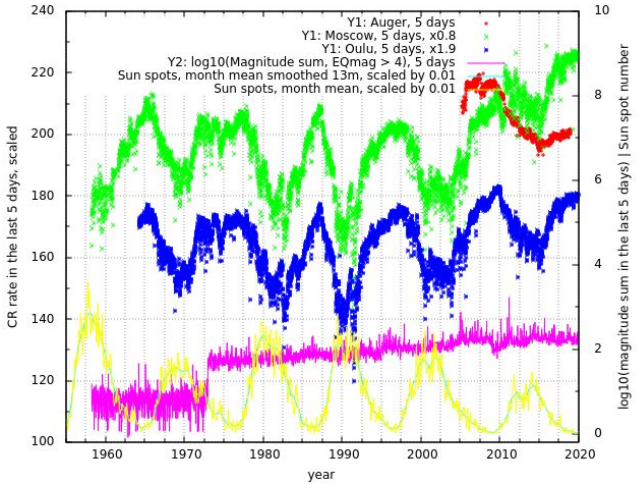
public resources of:

[Pierre Auger Observatory scaler data]

[Neutron Monitor Database]

[U.S. Geological Survey]

[Solar Influences Data analysis Center]

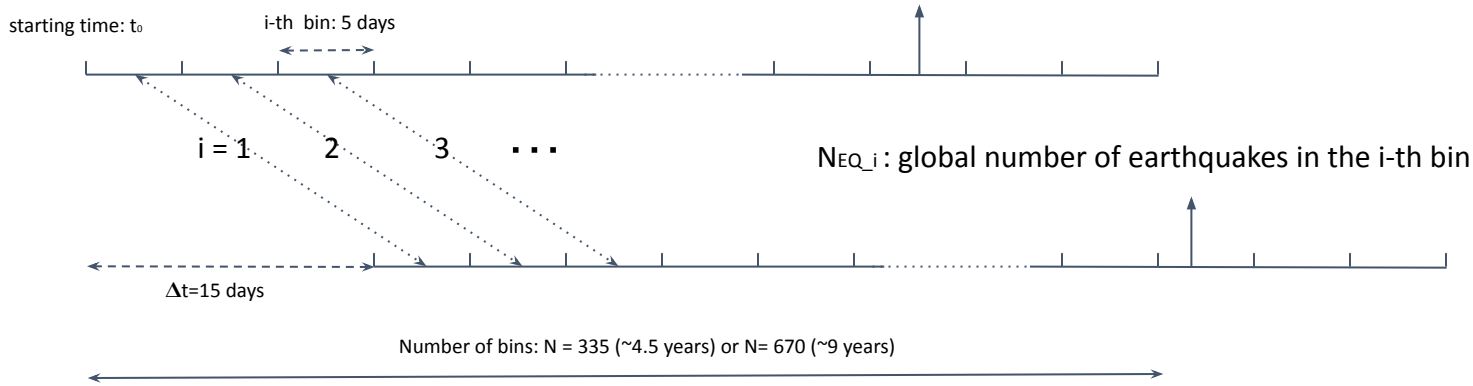


Checking for a correlation $|dN_{CR}|$ vs. $\Sigma magnitude_{EQ}$ using **5-day bins** over ~**4.5 yr windows**

Dichotomic correlation

cosmic rays (CR):
$dCR_i = |N_{CR\_i} - N_{CR\_i-1}|$

N_{CR_i} : local cosmic ray detection rate in the i-th bin



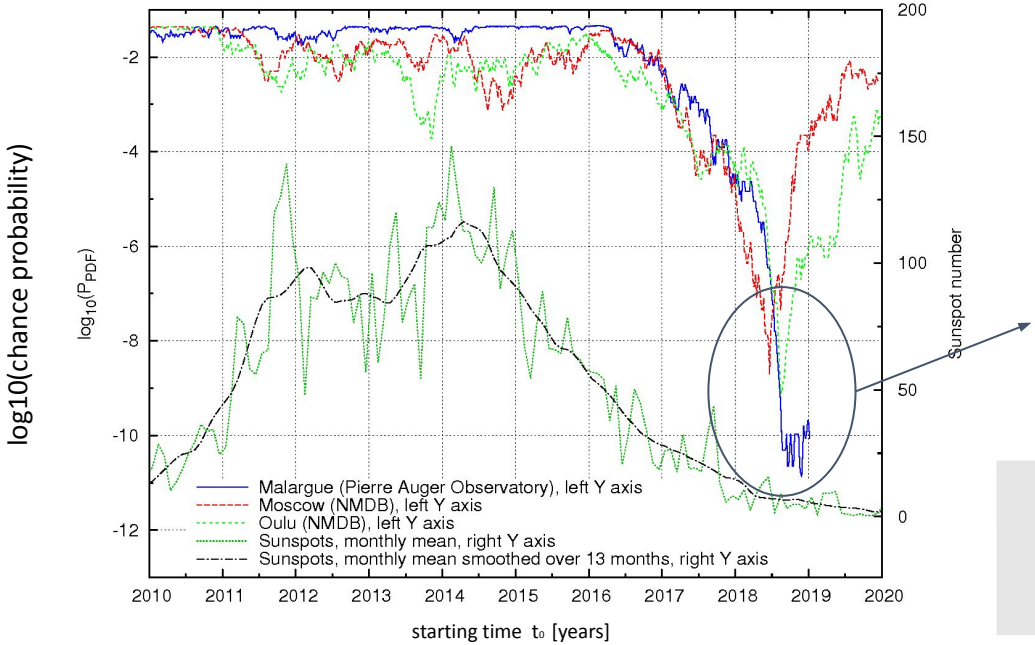
N_{EQ_i} : global number of earthquakes in the i-th bin

M_{CR}: median of the CR data
M_{EQ}: median of the EQ data
N_+: (($dCR_i > M_{CR}$) and ($N_{EQ\_i} > M_{EQ}$)) or (($dCR_i < M_{CR}$) and ($N_{EQ\_i} < M_{EQ}$))
N_-: (($dCR_i > M_{CR}$) and ($N_{EQ\_i} < M_{EQ}$)) or (($dCR_i < M_{CR}$) and ($N_{EQ\_i} > M_{EQ}$))

Chance probability:

$$P_{PDF}(N_{+/-} = k) = \left(\frac{n!}{k!(n-k)!}\right) p_{+/-}{}^{k} \left(1 - p_{+/-}\right)^{n-k}$$

Local cosmic dynamics vs. global seismicity: dependence on geographical location?



different cosmic ray sites see the **dichotomic** correlation effect differently? Need for more detectors?

analysis performed on "burning" data sample!

~6 σ significance of the effect in three technically independent CR data sets collected by the Moscow and Oulu NMDB stations, and by the Pierre Auger Observatory, compared to sunspot numbers. **Each point** illustrates the correlation effect during **the last ~4.5 years** (335 **five-day intervals**). All the significance curves were obtained after fine tuning of the parameter t_0 performed by applying 20 small shifts in time between 0 and 5 days.

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

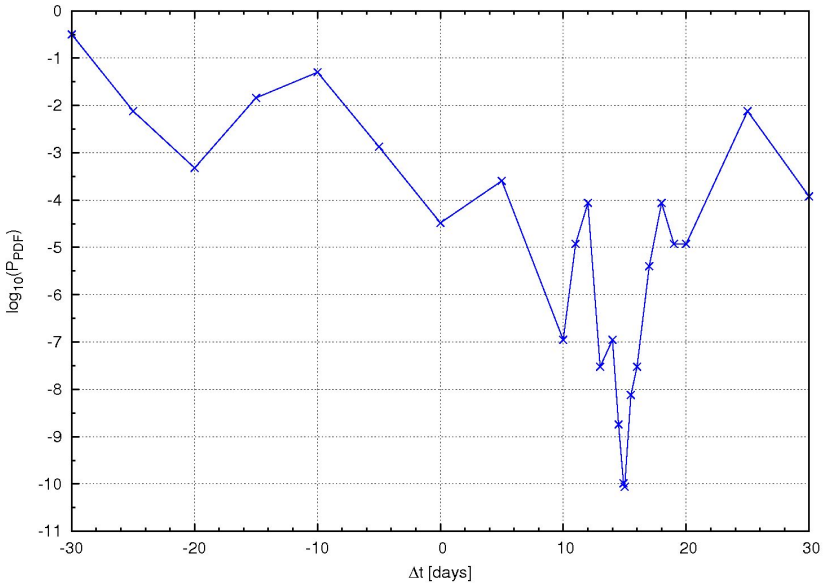
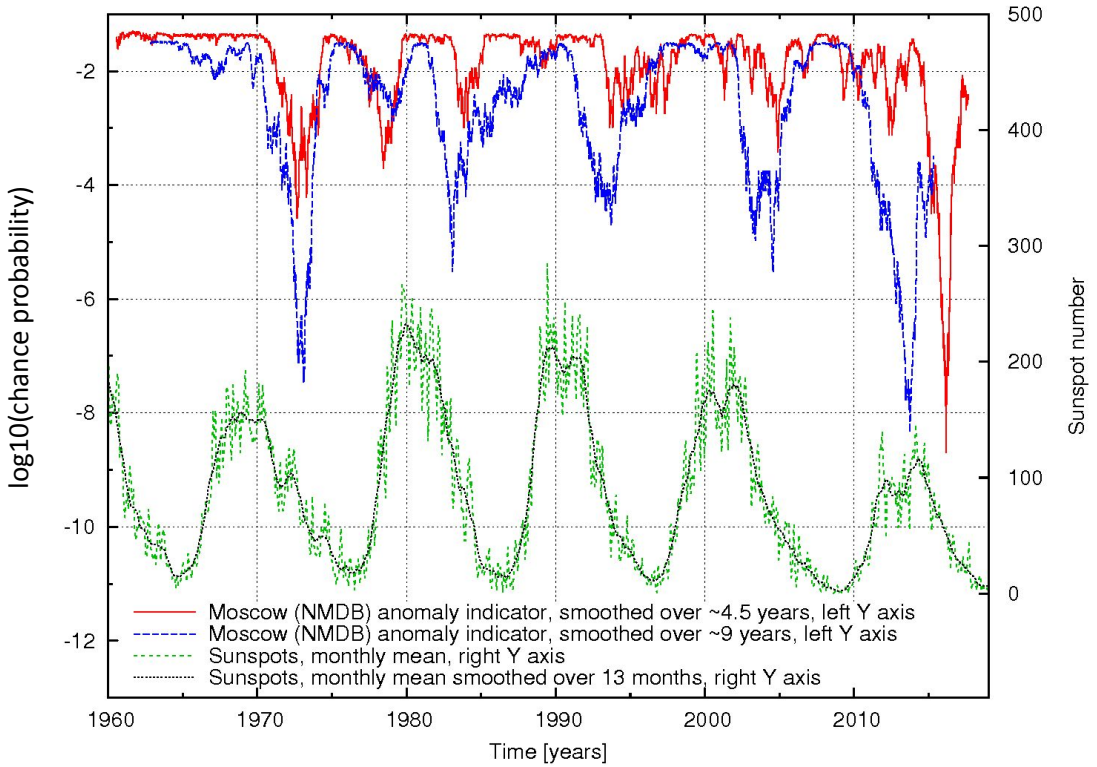


Fig. 3: The dependence of the significance of the *cosmo-seismic* correlations on the time shift t of the EQ data with respect to the Auger CR data, for the optimum free parameter set defined in Eq. 1. The positive or negative values of t correspond to the situations in which one compares the secondary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

Interpretation: Role of the Sun or….?

P. Homola et al., 2022: https://arxiv.org/abs/2204.12310



The anomaly indicator in the Moscow NMDB data set compared to the sunspot number. Each point on the correlation significance curves corresponds to the effect found over the smoothing window length of **~4.5 years (1675 days, in red)** and ~9 years (3350 days, in blue), with the curve points located at the centers of the windows.

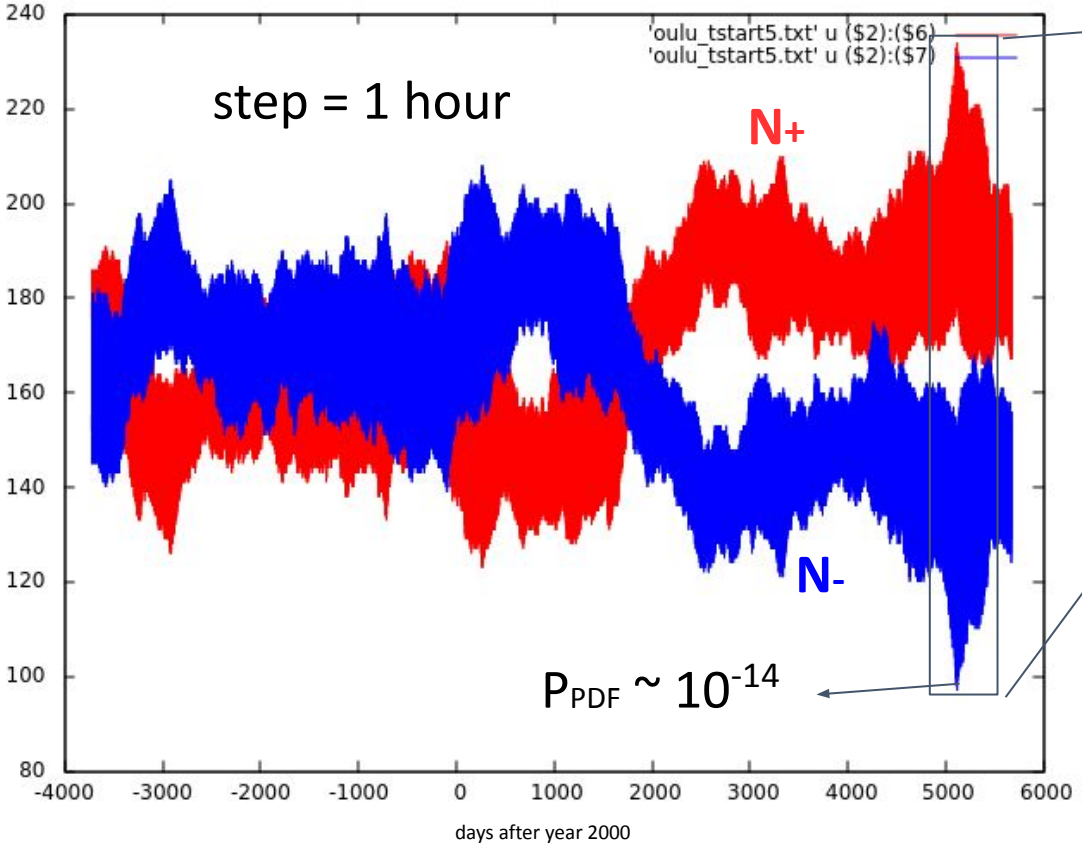
The key “peculiar” properties of the cosmo-seismic effect

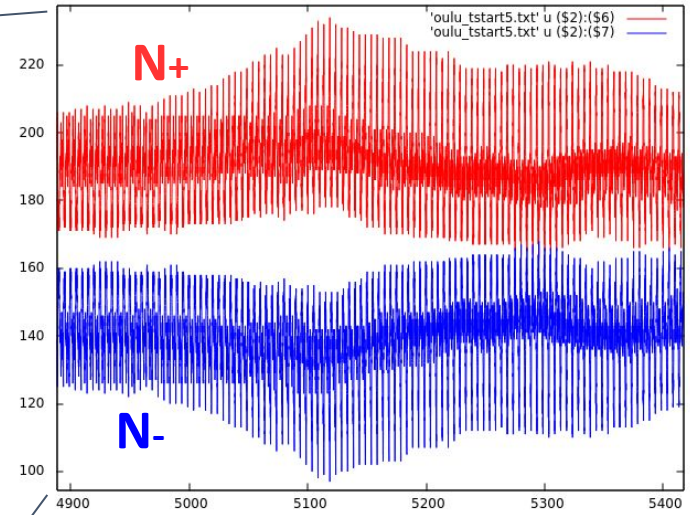
1. to sensitivity -> common periodicities & specific signal shape
2. dominant 24 h periodicity in EQs varying in time -> new EQ mechanism, Sun engaged magnetically!
3. EQs and non-tidal role of the Moon -> implies “third factor” active gravitationally
4. sidereal day periodicity in both EQ and CR data varying in time -> external stream + sensitivity to local conditions (or variations of the “third factor”?)
5. hemispherical / semiday EQ differences: external impact?
6. a special EQ week of the year at ~mid November: a specific external arrival direction?
7. radiation precedes earthquakes: a slower than light “third factor” capable of inducing radiation?

-> **charged dark matter stream** as the leading (only?) candidate physic scenario?

1. Sensitivity to very small t_0 shifts: a uniquely characteristic signal behind?

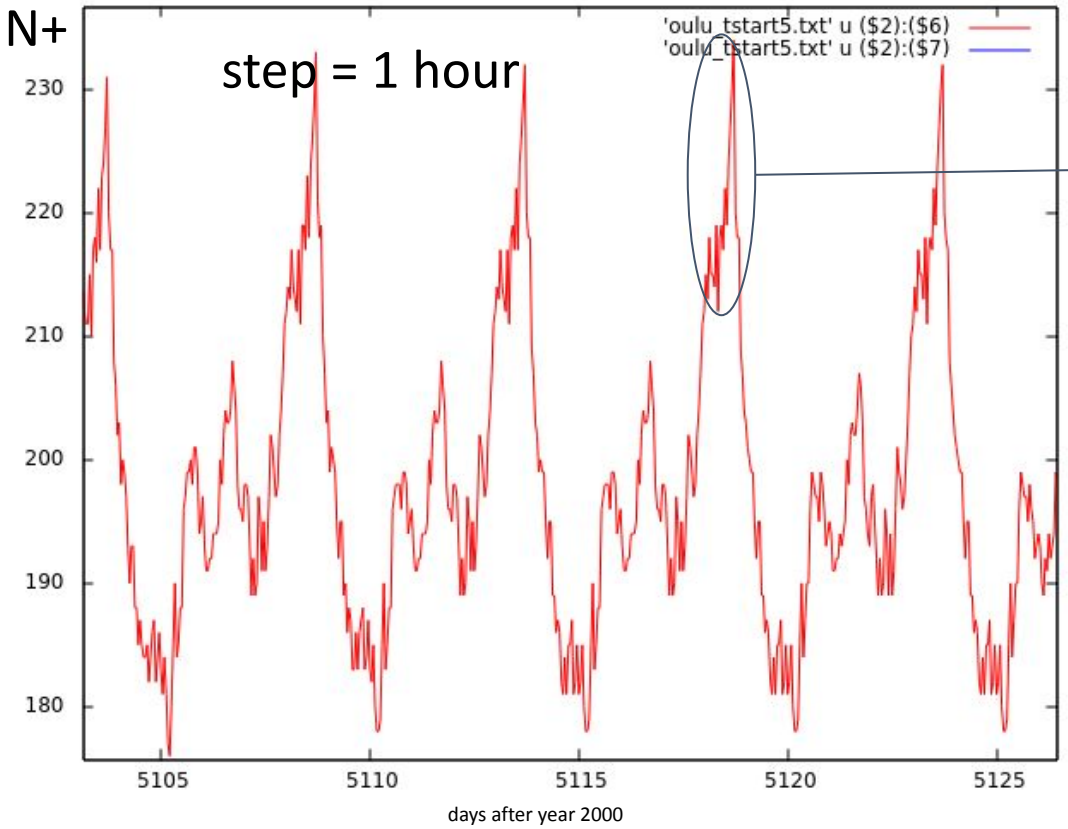
Sensitivity to very small to shifts

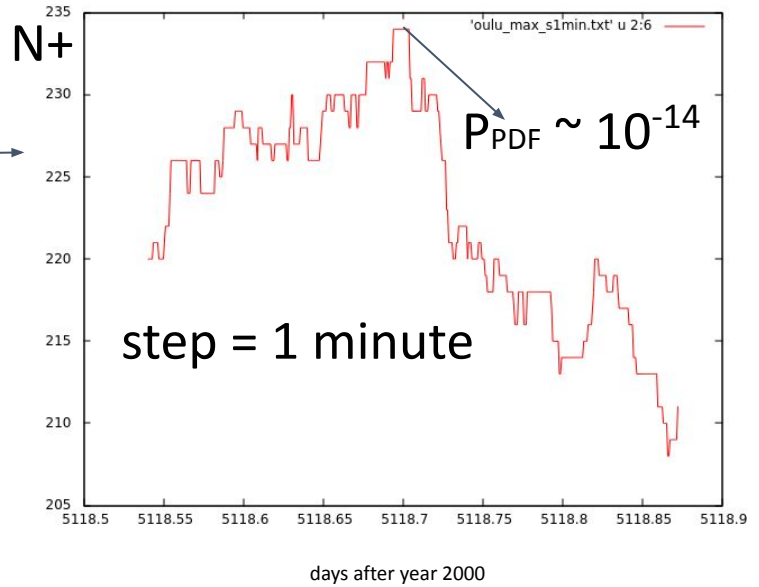




Oulu; CR data bins: 6hrs,
cosmo-seismic bin: f x 5 days;
f=0.999915

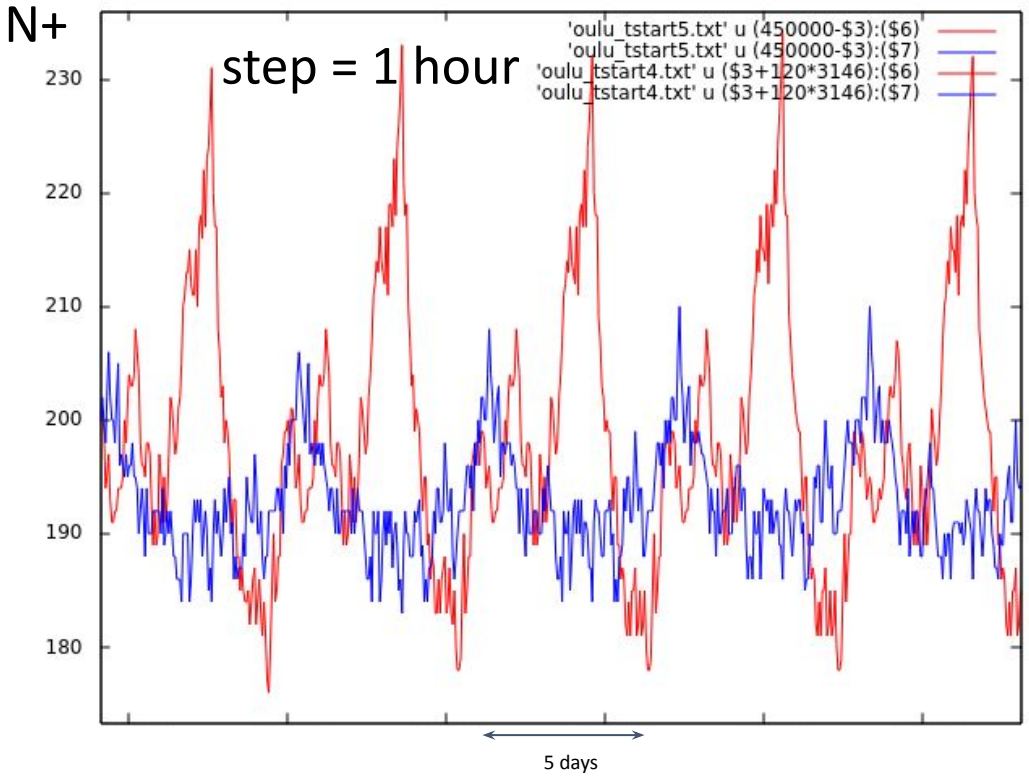
Sensitivity to very small t0 shifts





Oulu; CR data bins: 6hrs,
cosmo-seismic bin: f x 5 days;
f=0.999915
(similar for other sites and f=1.0)

Sensitivity to very small t_0 shifts



red: t_0=~2014

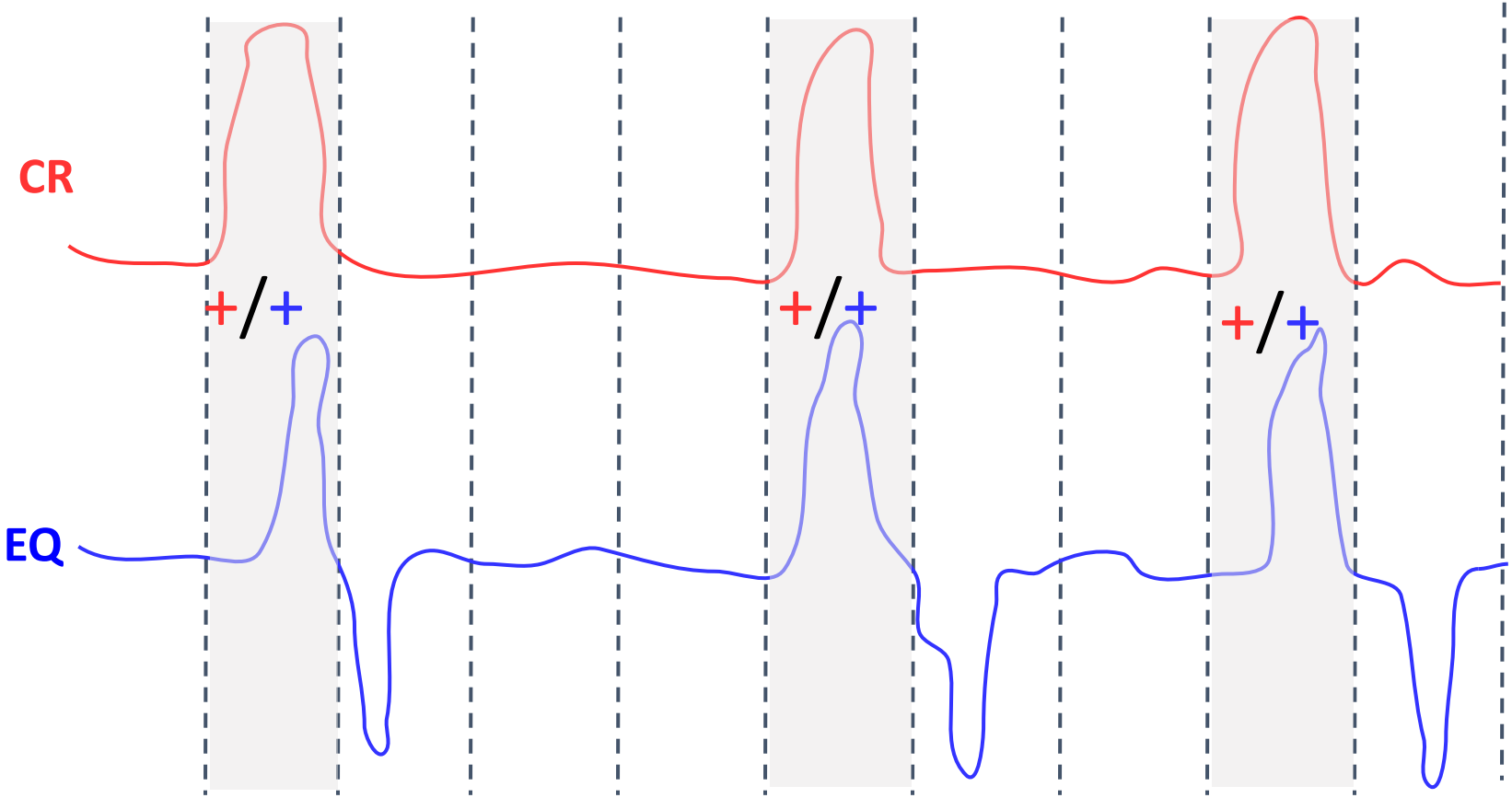
blue: t_0=~2006

-> optimum t_0 evolves in time!

-> EQ data responsible for the t_0 fine tuning effect?

Oulu; CR data bins: 6hrs,
cosmo-seismic bin: f x 5 days;
f=0.999915

“clicks” @ many points with just a small t0 shift?



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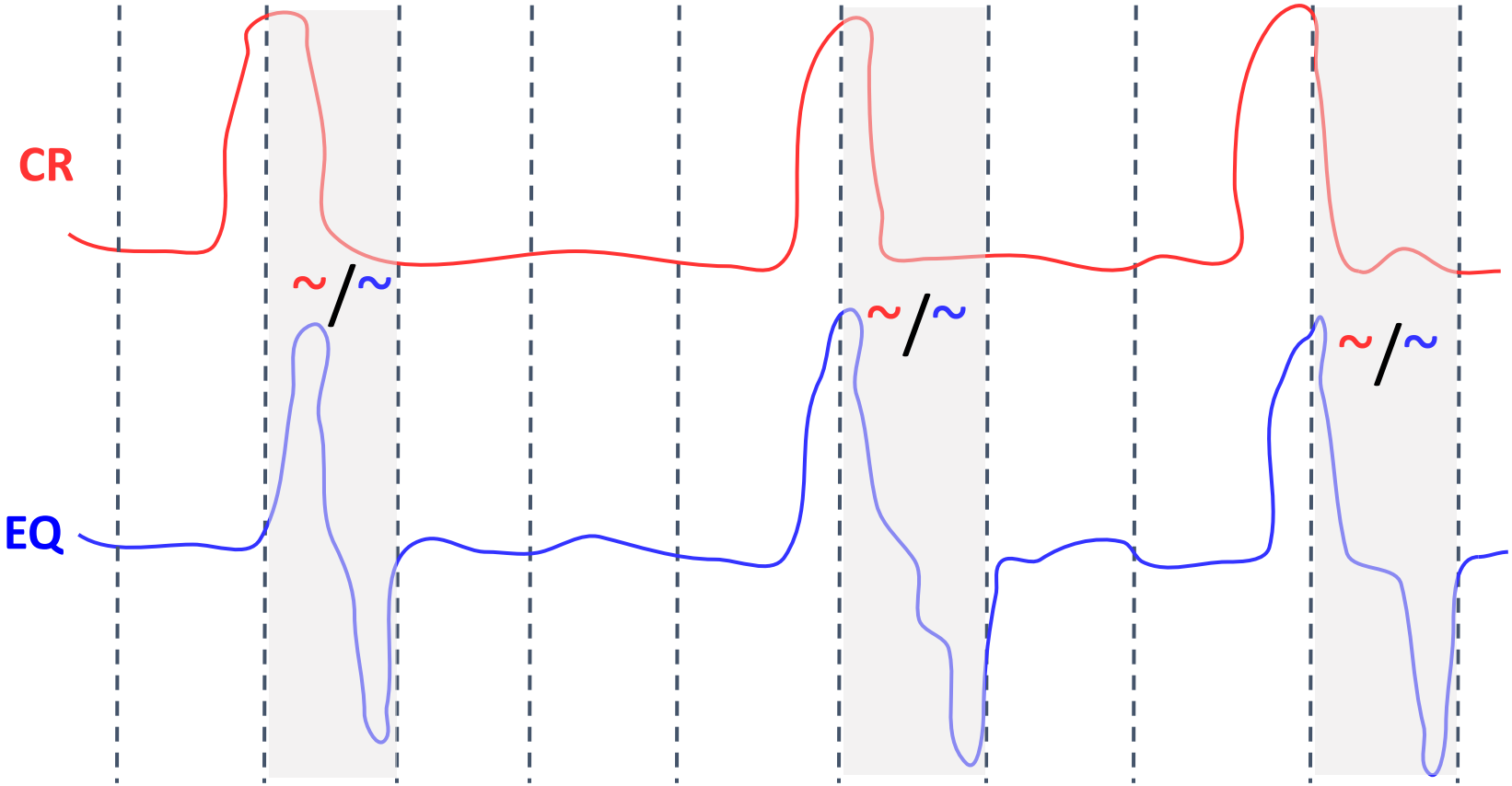
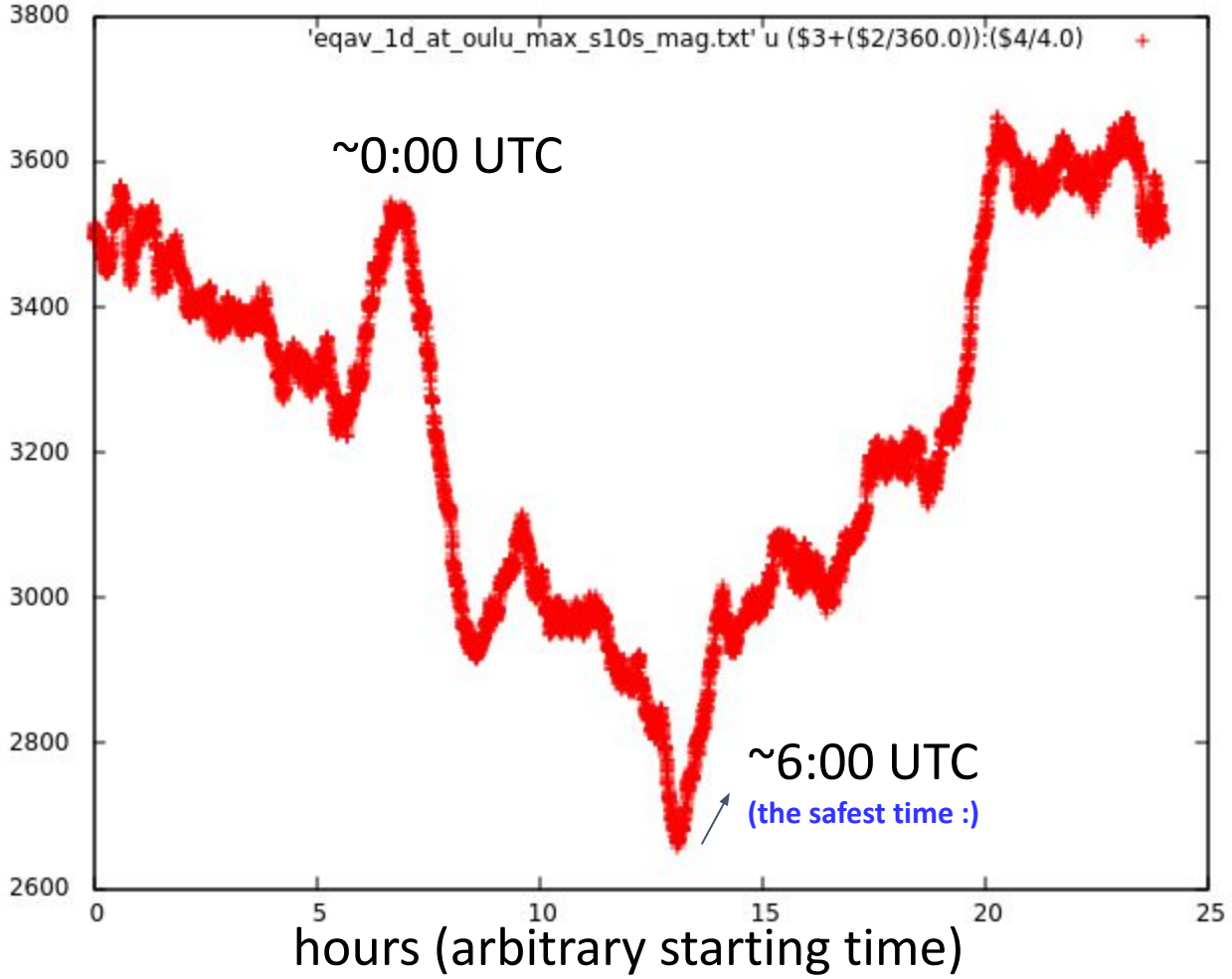


2. Dominant, time-dependent 24 hour periodicity in the EQ data: new EQ mechanism?

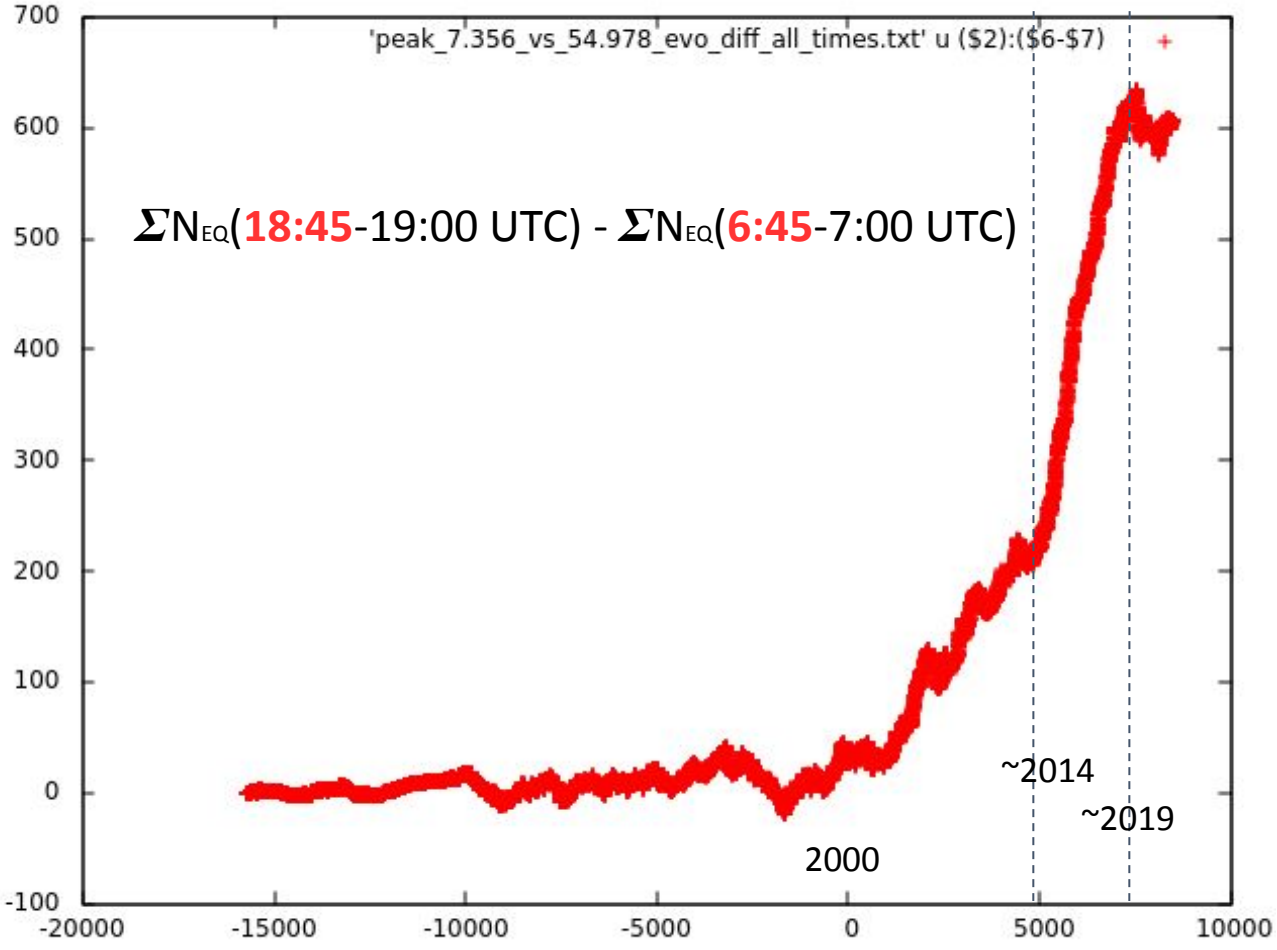


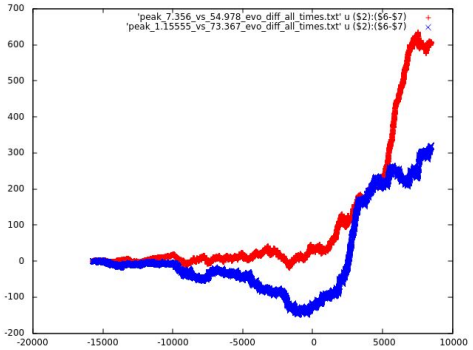
24 hour stacked N_{EQ}

- average 1 h bins
- 10 s sliding step
- ~2000 days since 2014
- **no or much weaker lunar day (24h 50 m) periodicity**

24 h periodicity -> **role of the Sun**

no lunar day periodicity -> **"third factor" sensitive to magnetism**

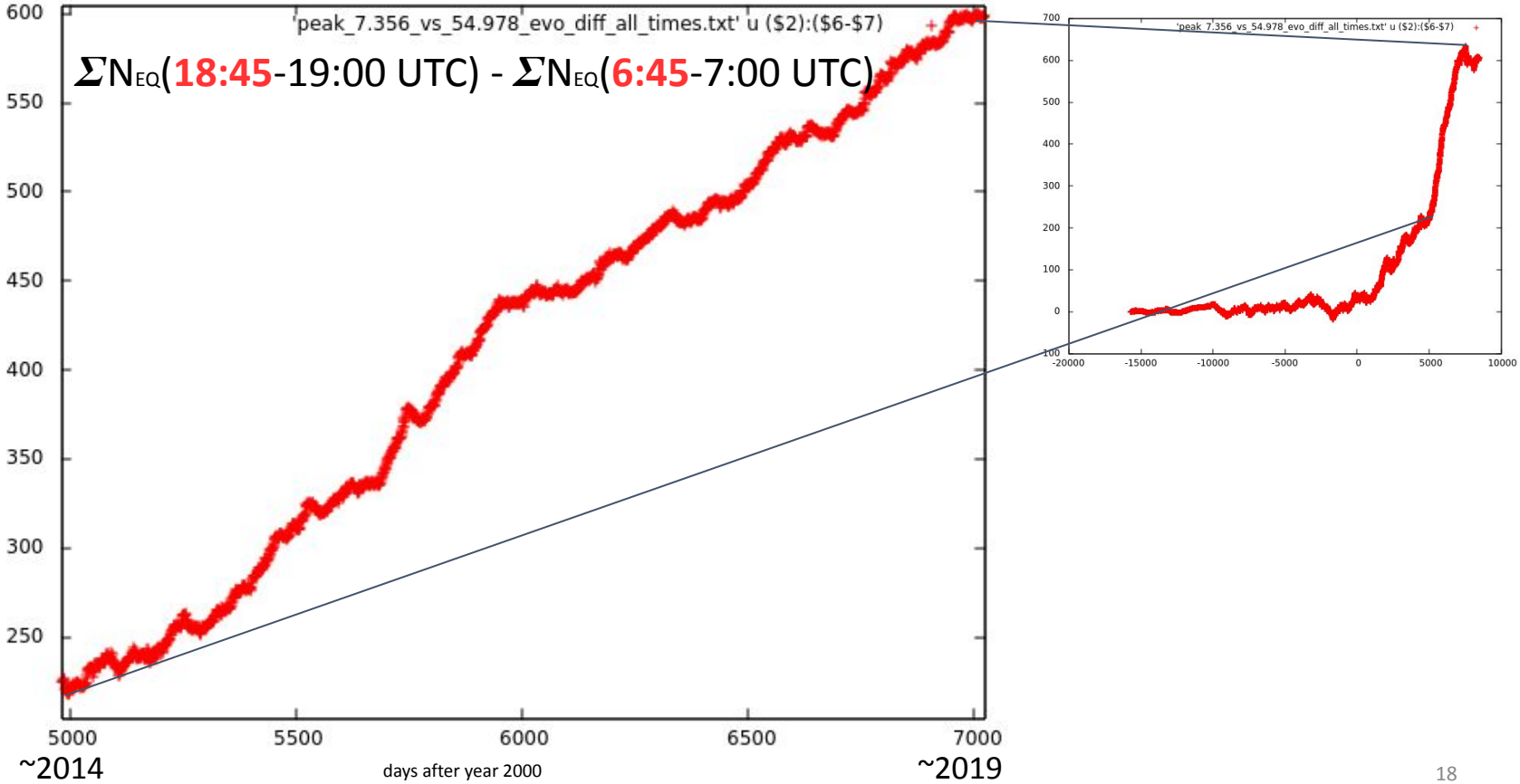


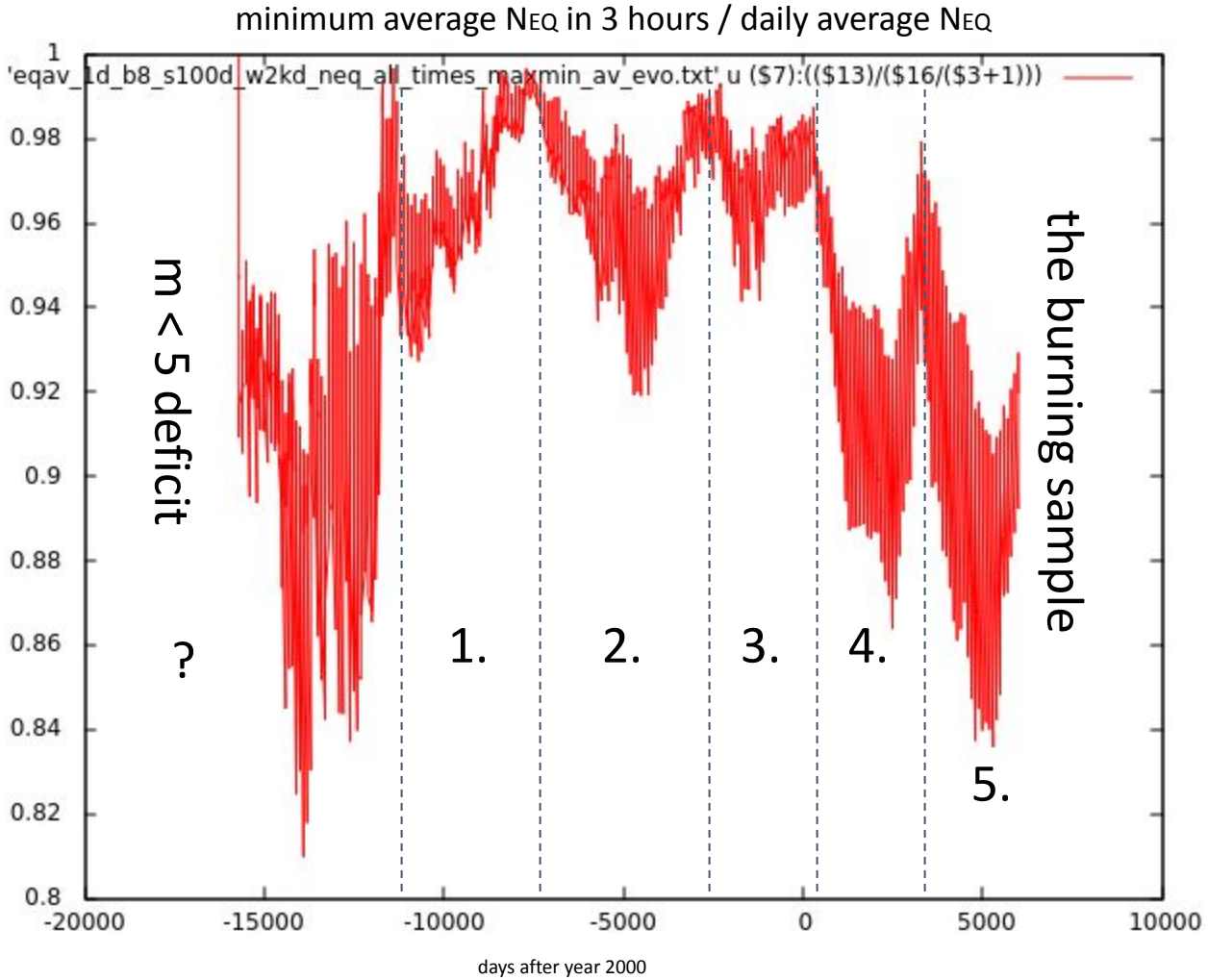


-> **"dramatic" 5 years** of increasing daily asymmetry for special time bins

-> **different bins: different time evolution** & "dramatic" time

~ uniform daily N_{EQ} asymmetry increase during the “dramatic” time



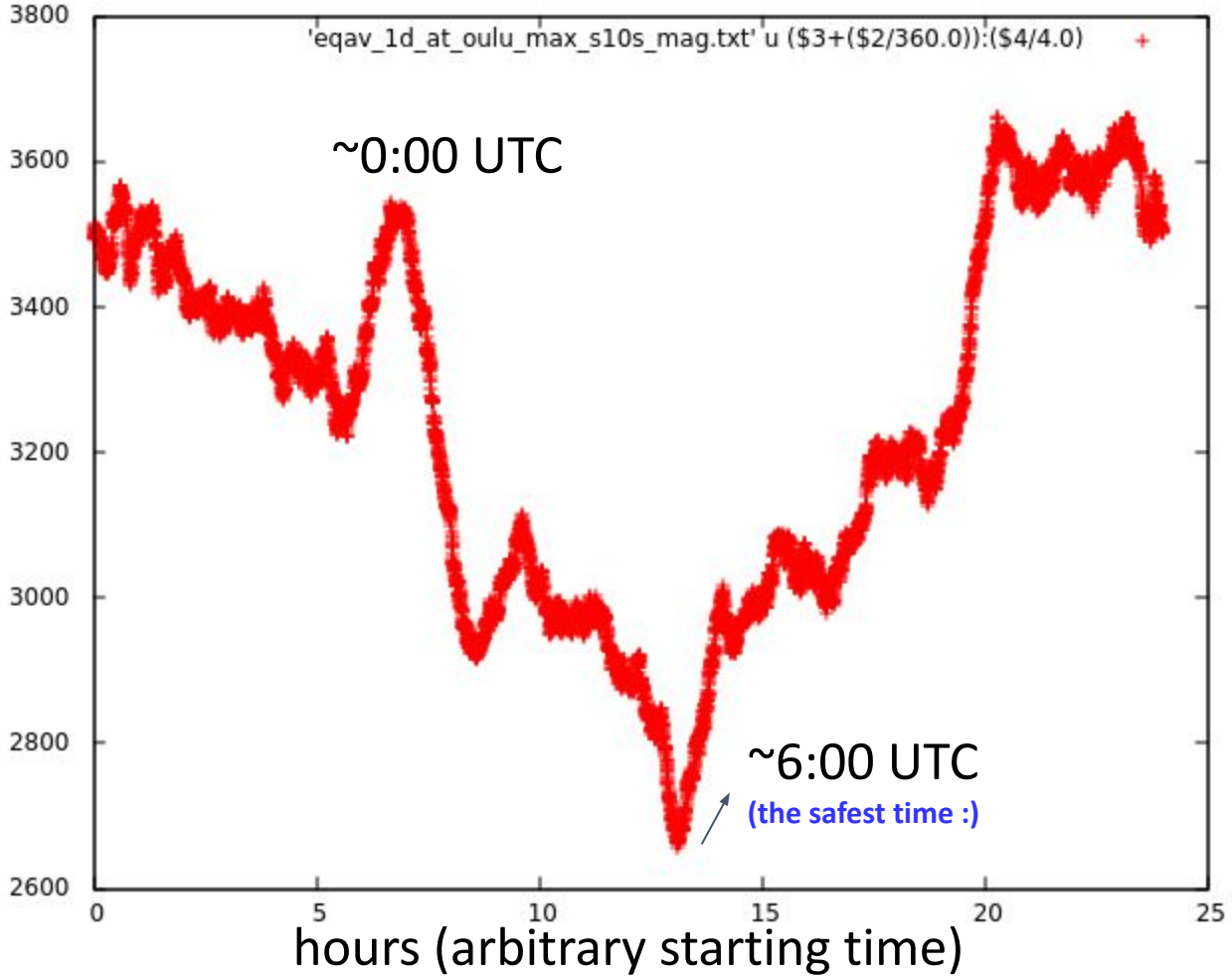


24 hour asymmetry of N_{EQ} evolves with time!

average 3 h bins.
averaged over time window of:
~2000 days
sliding step: 100 days

-> **different "eras" of 24h asymmetry?**
-> like Fig 4 (cosmo-seismic article)

-> **variations of the "third factor" or its sensitivity to magnetism**



24 hour stacked N_{EQ}

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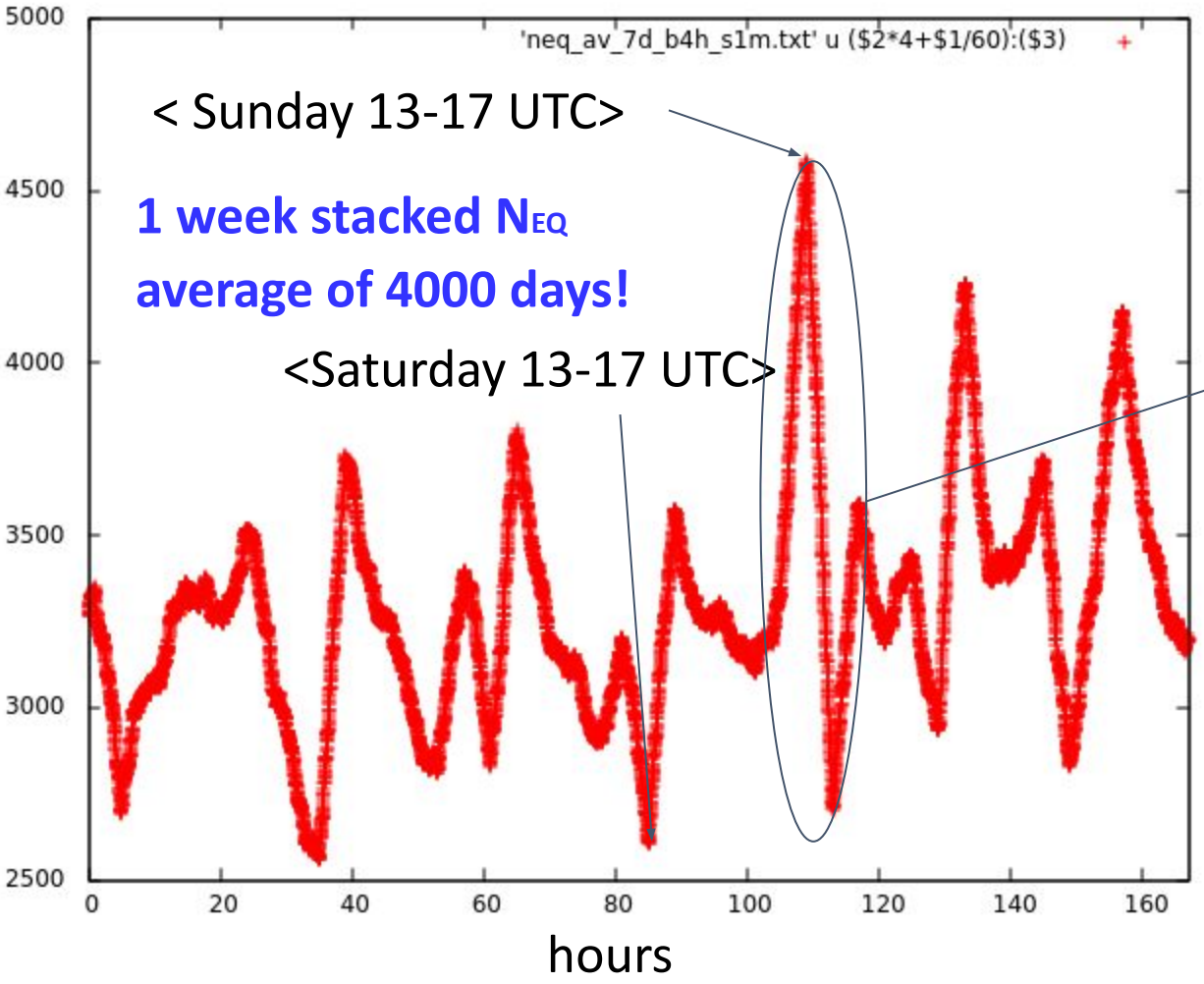
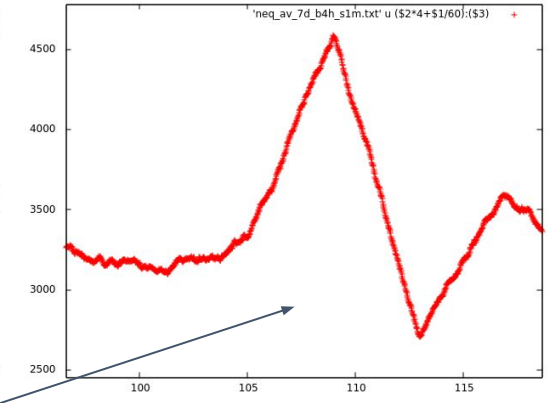
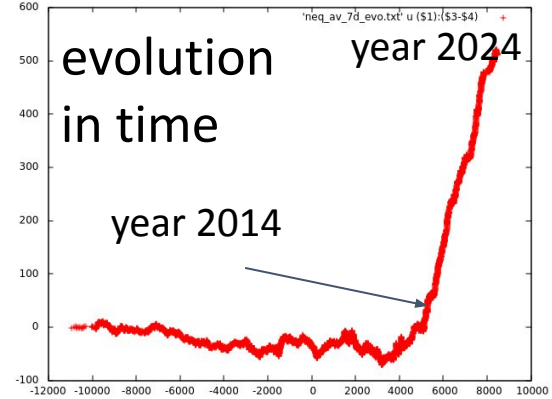
24 h periodicity -> **role of the Sun**

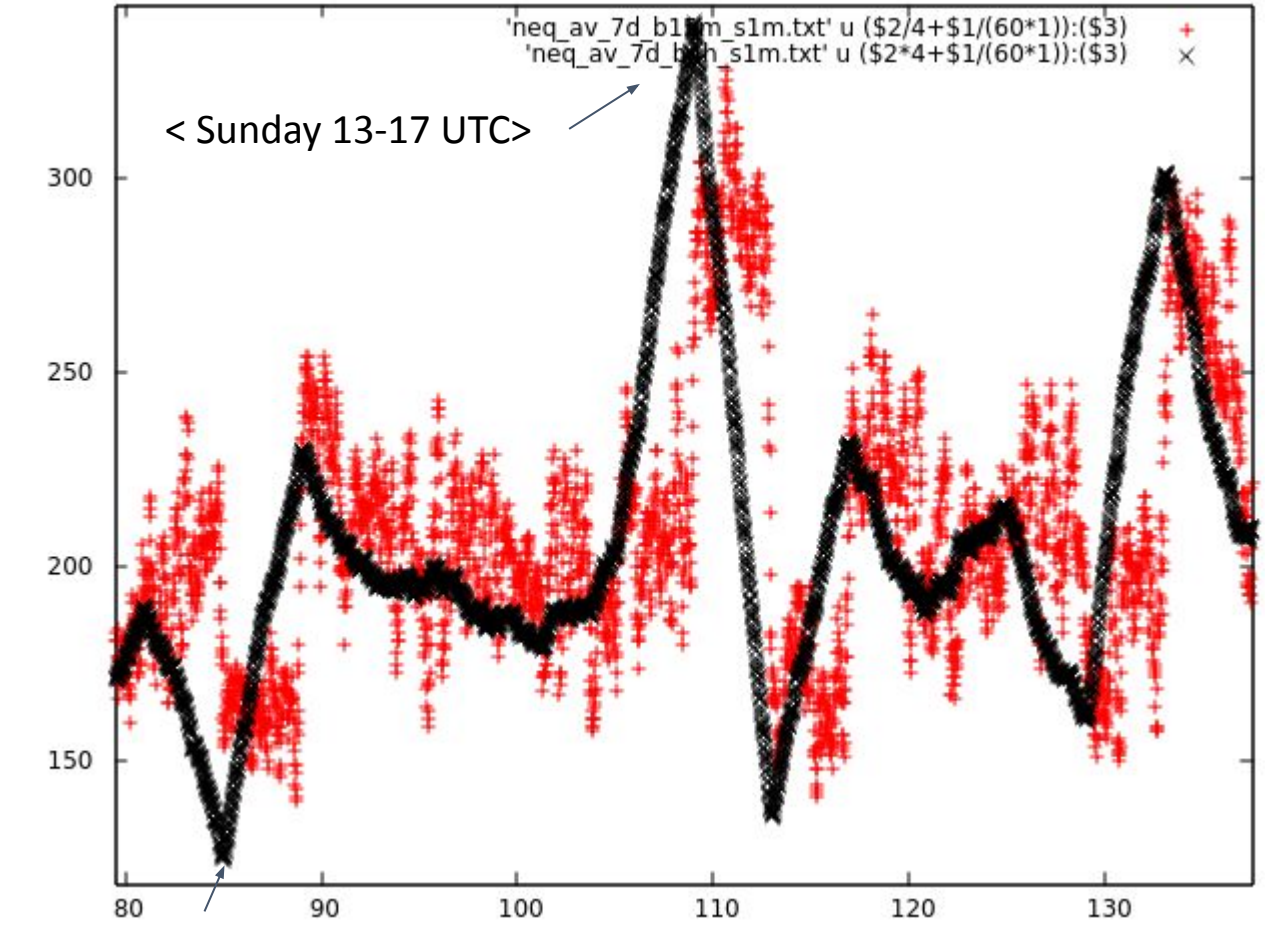
no lunar day periodicity -> **"third factor" sensitive to magnetism**







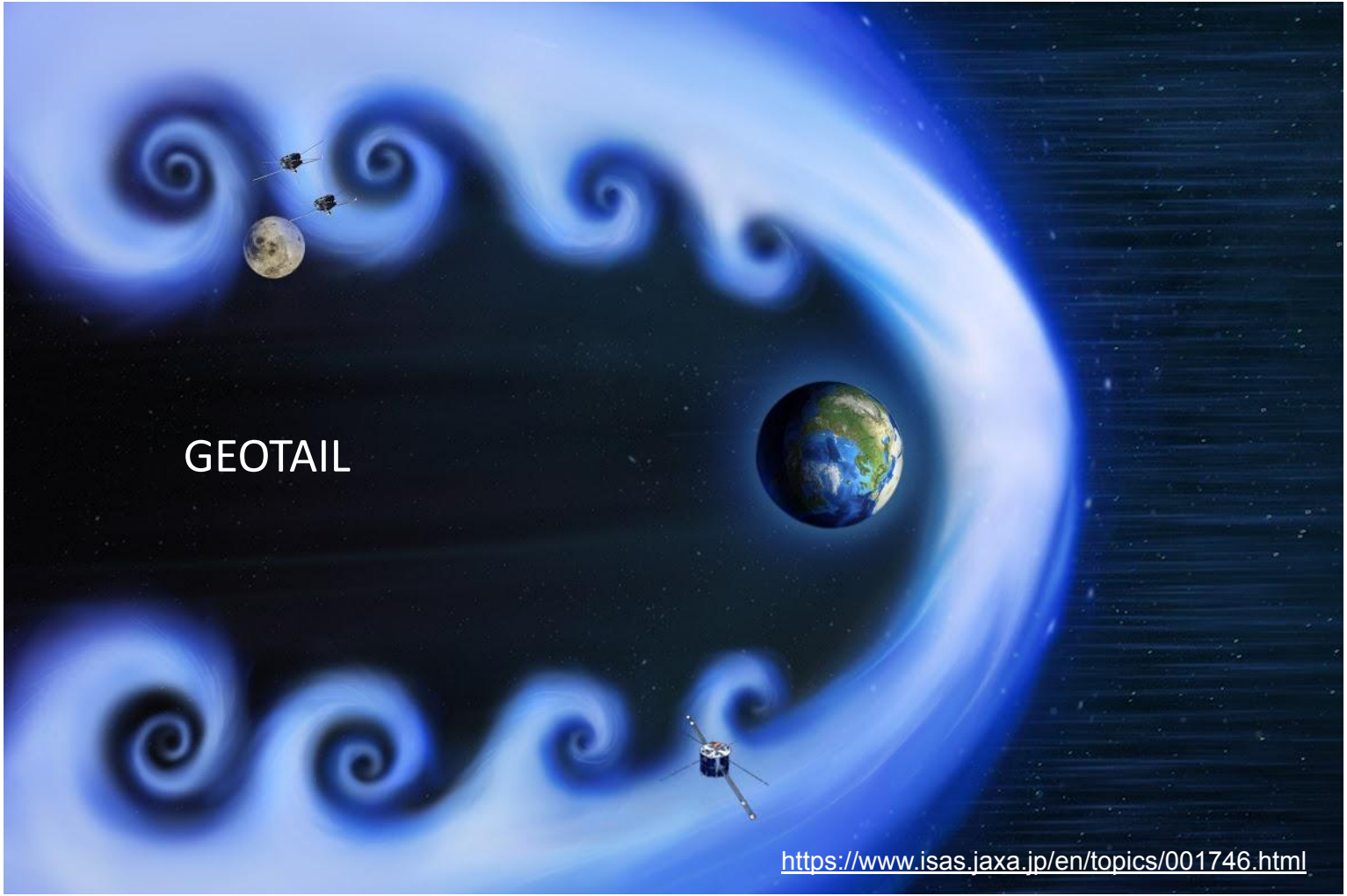
- average 4 h bins
- 60 s sliding step
- 4000 days since 2014



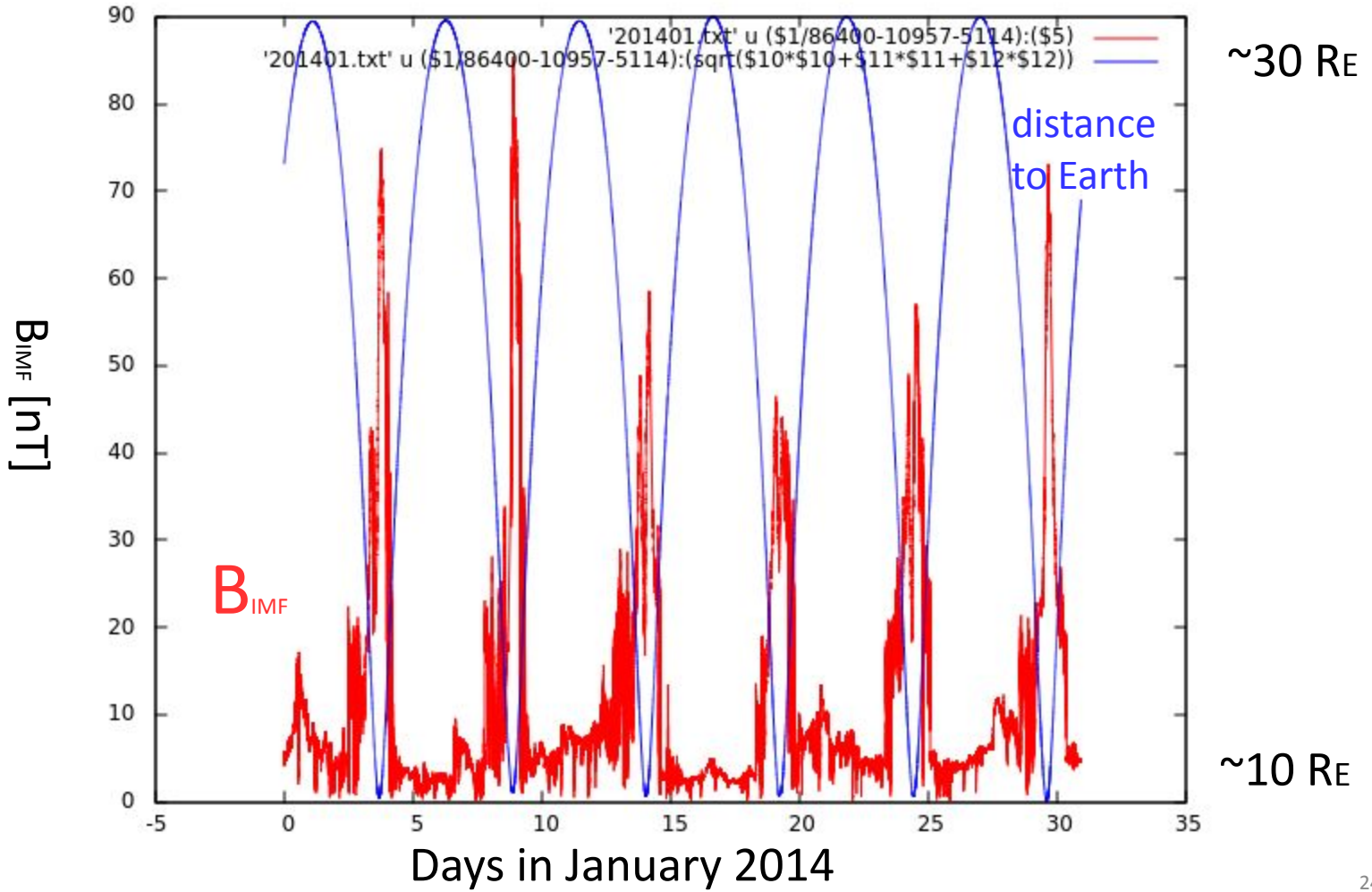
averave 4h (black)

vs.

average 15 minutes (red)



https://www.isas.jaxa.jp/en/topics/001746.html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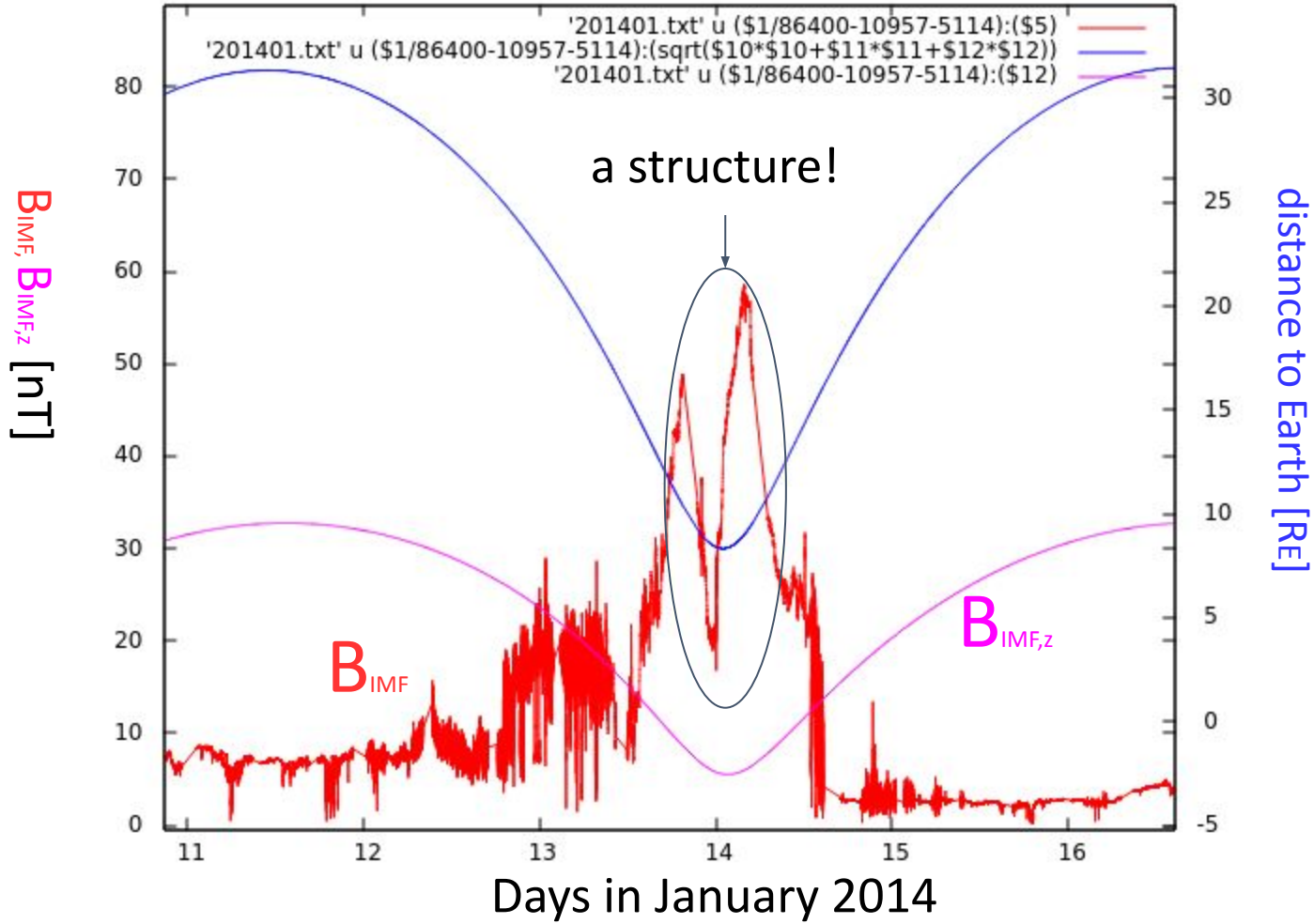
'201401.txt' u ($1/86400-10957-5114):(sqrt($10*$10+$11*$11+$12*$12))
distance to Earth
~30 RE
~10 RE
BIMF
BIMF [nT]
Days in January 2014
90
80
70
60
50
40
30
20
10
0
-5
0
5
10
15
20
25
30
35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'201401.txt' u ($1/86400-10957-5114):(sqrt($10*$10+$11*$11+$12*$12))
'201401.txt' u ($1/86400-10957-5114):($12)
a structure!
B IMF
B IMF,z
B IMF, B IMF,z [nT]
distance to Earth [RE]
Days in January 2014
0
10
20
30
40
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60
70
80
-5
0
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25
30
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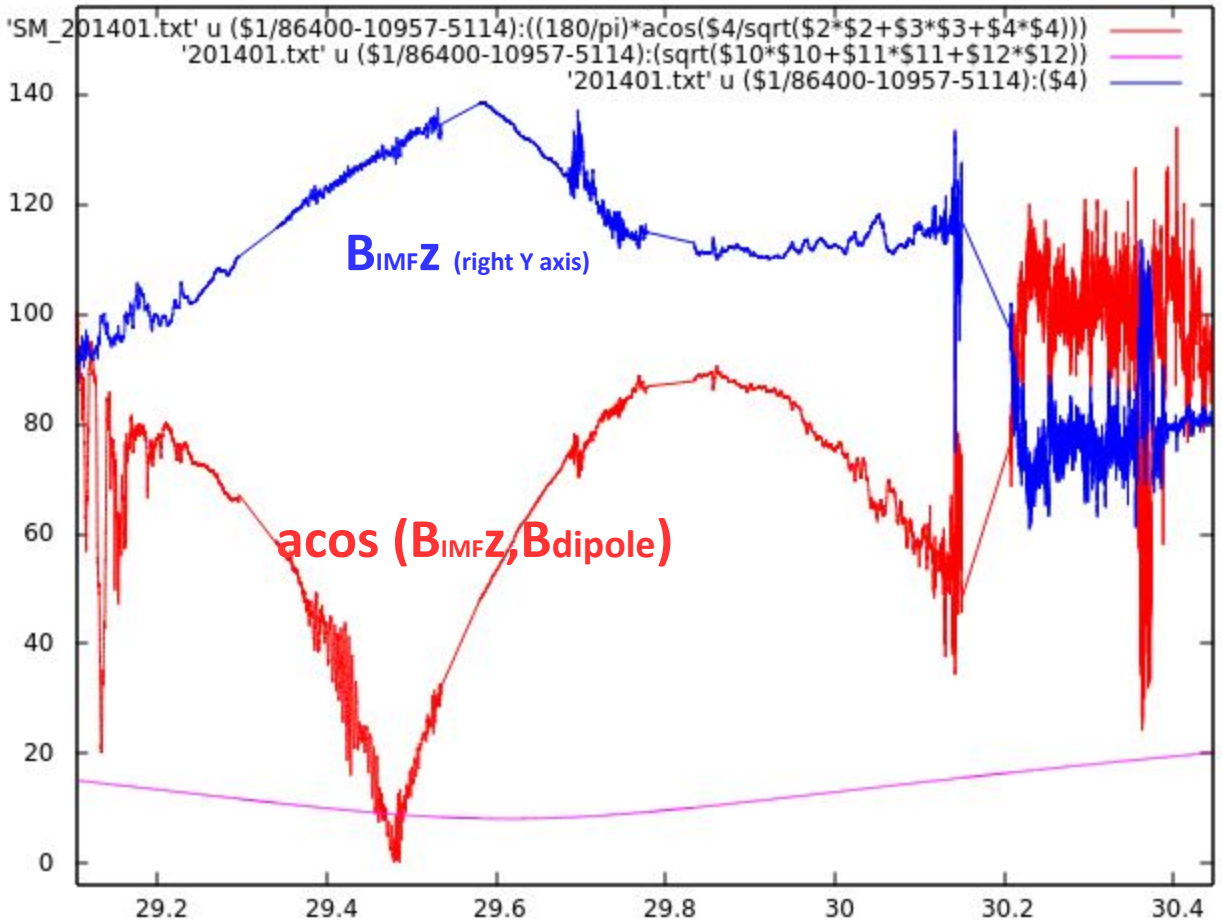
14
15
16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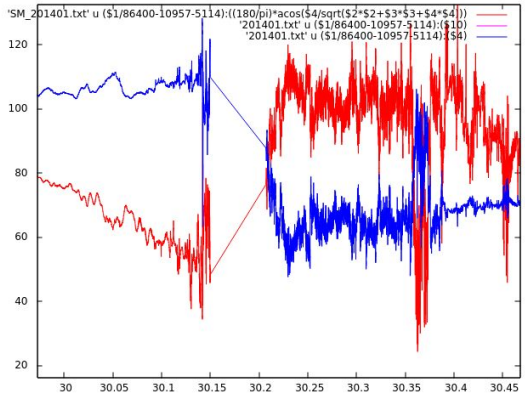
'201401.txt' u ($1/86400-10957-5114):(sqrt($10*$10+$11*$11+$12*$12))
'201401.txt' u ($1/86400-10957-5114):($4)
BIMFZ (right Y axis)
acos (BIMFZ,Bdipole)
140
120
100
80
60
40
20
0
29.2
29.4
29.6
29.8
30
30.2
30.4
Days in January 2014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'201401.txt' u ($1/86400-10957-5114):($4)
120
100
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20
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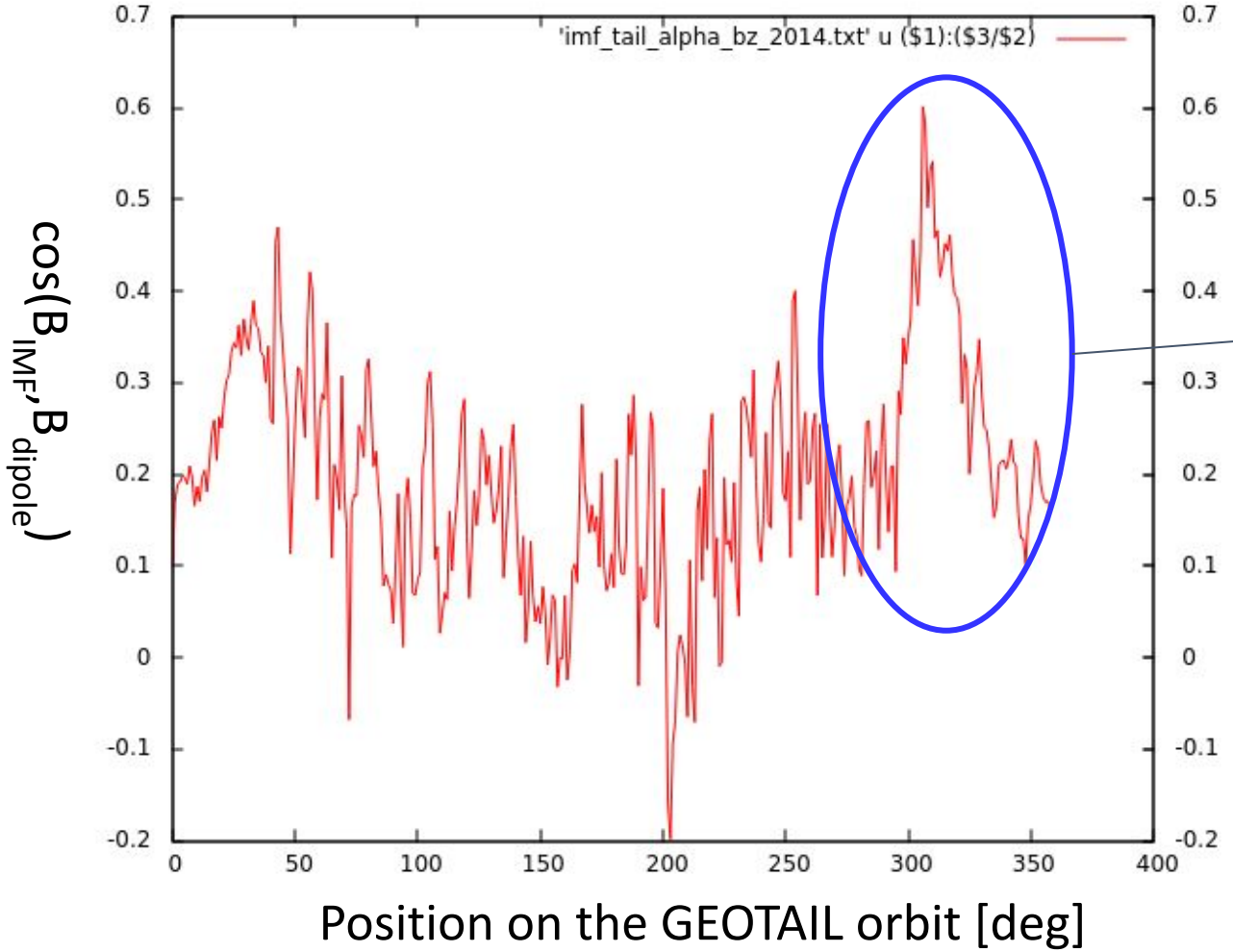
30.4
30.45



a daily feature in the relation of the Interplanetary Magnetic Fieldd (IMF) and the Earth dipole axis

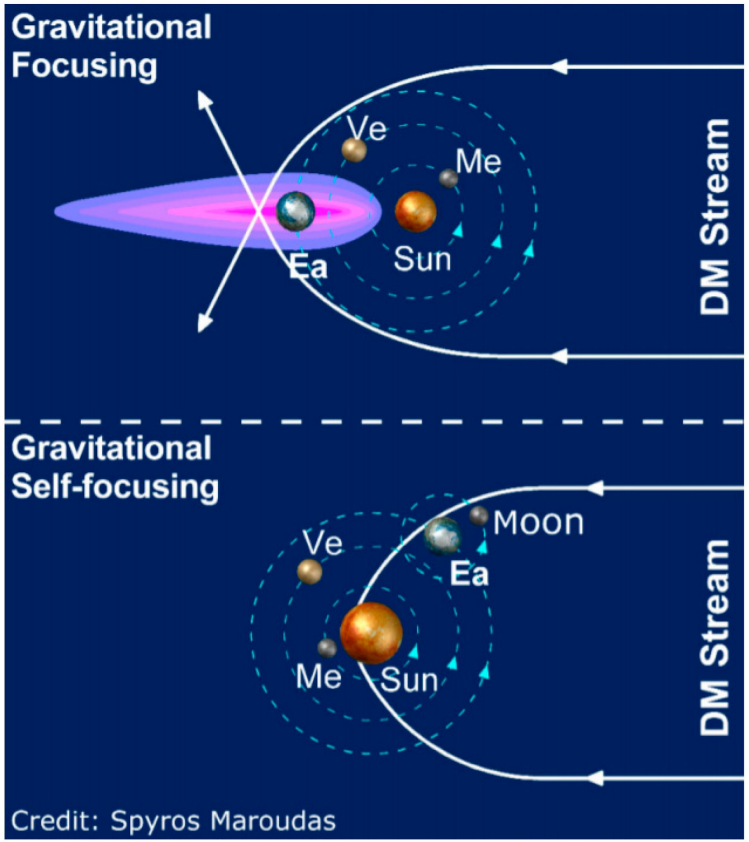
(credit to Sławomir Stuglik for data formatting)

Literature Support

- DM streams + focusing ~orders of magnitude
- super-heavy charged dark matter
- 24h Japan: “new EQ mechanism”, 2018
- spaceweather @ Radon (credit Brian)
- books: heliospheric current sheet, rotation of the Sun

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?

29

https://arxiv.org/abs/2210.07367

"For **streaming dark matter**, the **gravitational focusing** gives rise to spatiotemporal **flux enhancements of orders of magnitude** above the nominal DM density. Remarkably, due to Earth's rotation the derived flux enhancements appear as transient signals lasting about 10 seconds repeating daily for days or weeks."

credit to Brian McBreen for pointing to the article

PHYSICAL REVIEW D **100,** 035001 (2019)

Planck mass charged gravitino dark matter

Krzysztof A. Meissner[1] and Hermann Nicolai[2]

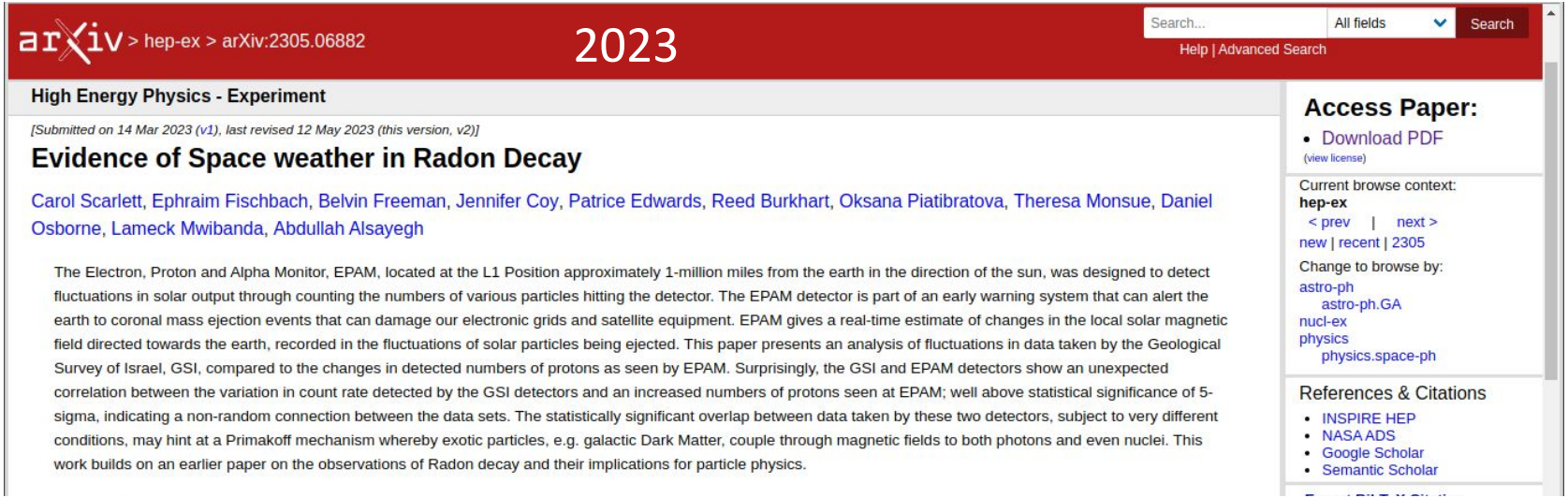
[1]*Faculty of Physics, University of Warsaw Pasteura 5, 02-093 Warsaw, Poland*
[2]*Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) Mühlenberg 1, D-14476 Potsdam, Germany*

(Received 19 April 2019; published 2 August 2019)

Following up on our earlier work predicting fractionally charged supermassive gravitinos, we explain their potential relevance as novel candidates for dark matter and discuss possible signatures and ways to detect them.

DOI: 10.1103/PhysRevD.100.035001

https://journals.aps.org/prd/pdf/10.1103/PhysRevD.100.035001 / https://arxiv.org/abs/1809.01441



arXiv > hep-ex > arXiv:2305.06882

2023

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High Energy Physics - Experiment

[Submitted on 14 Mar 2023 (v1), last revised 12 May 2023 (this version, v2)]

Evidence of Space weather in Radon Decay

Carol Scarlett, Ephraim Fischbach, Belvin Freeman, Jennifer Coy, Patrice Edwards, Reed Burkhart, Oksana Piatibratova, Theresa Monsue, Daniel Osborne, Lameck Mwibanda, Abdullah Alsayegh

The Electron, Proton and Alpha Monitor, EPAM, located at the L1 Position approximately 1-million miles from the earth in the direction of the sun, was designed to detect fluctuations in solar output through counting the numbers of various particles hitting the detector. The EPAM detector is part of an early warning system that can alert the earth to coronal mass ejection events that can damage our electronic grids and satellite equipment. EPAM gives a real-time estimate of changes in the local solar magnetic field directed towards the earth, recorded in the fluctuations of solar particles being ejected. This paper presents an analysis of fluctuations in data taken by the Geological Survey of Israel, GSI, compared to the changes in detected numbers of protons as seen by EPAM. Surprisingly, the GSI and EPAM detectors show an unexpected correlation between the variation in count rate detected by the GSI detectors and an increased numbers of protons seen at EPAM; well above statistical significance of 5-sigma, indicating a non-random connection between the data sets. The statistically significant overlap between data taken by these two detectors, subject to very different conditions, may hint at a Primakoff mechanism whereby exotic particles, e.g. galactic Dark Matter, couple through magnetic fields to both photons and even nuclei. This work builds on an earlier paper on the observations of Radon decay and their implications for particle physics.

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spaceweather (solar cycle) 1 million km above Earth

What is most fascinating and unexpected in this analysis, **the EPAM proton count rate** data shows a **strong correlation** with the count rate for gammas emitted from a chain **decay process of 222 Rn**, as seen by the GSI instruments.

radon (earthquake precursor) @ Earth

credit to Brian McBreen for pointing to the article

RESEARCH ARTICLE

National Science Review
6: 1016–1023, 2019
doi: 10.1093/nsr/nwy117
Advance access publication 8 October 2018

2018

GEOSCIENCES

Evidence for diurnal periodicity of earthquakes from midnight to daybreak

Jinlai Hao, Jinhai Zhang* and Zhenxing Yao

https://doi.org/10.1093/nsr/nwy117

"Our work suggests that the earthquakes have a **dominant diurnal period**, at least from mid-night to daybreak, which could be helpful to opening a **new window to explore the physical mechanism of earthquakes**."

Heliospheric Current Sheet (- like?) behavior?

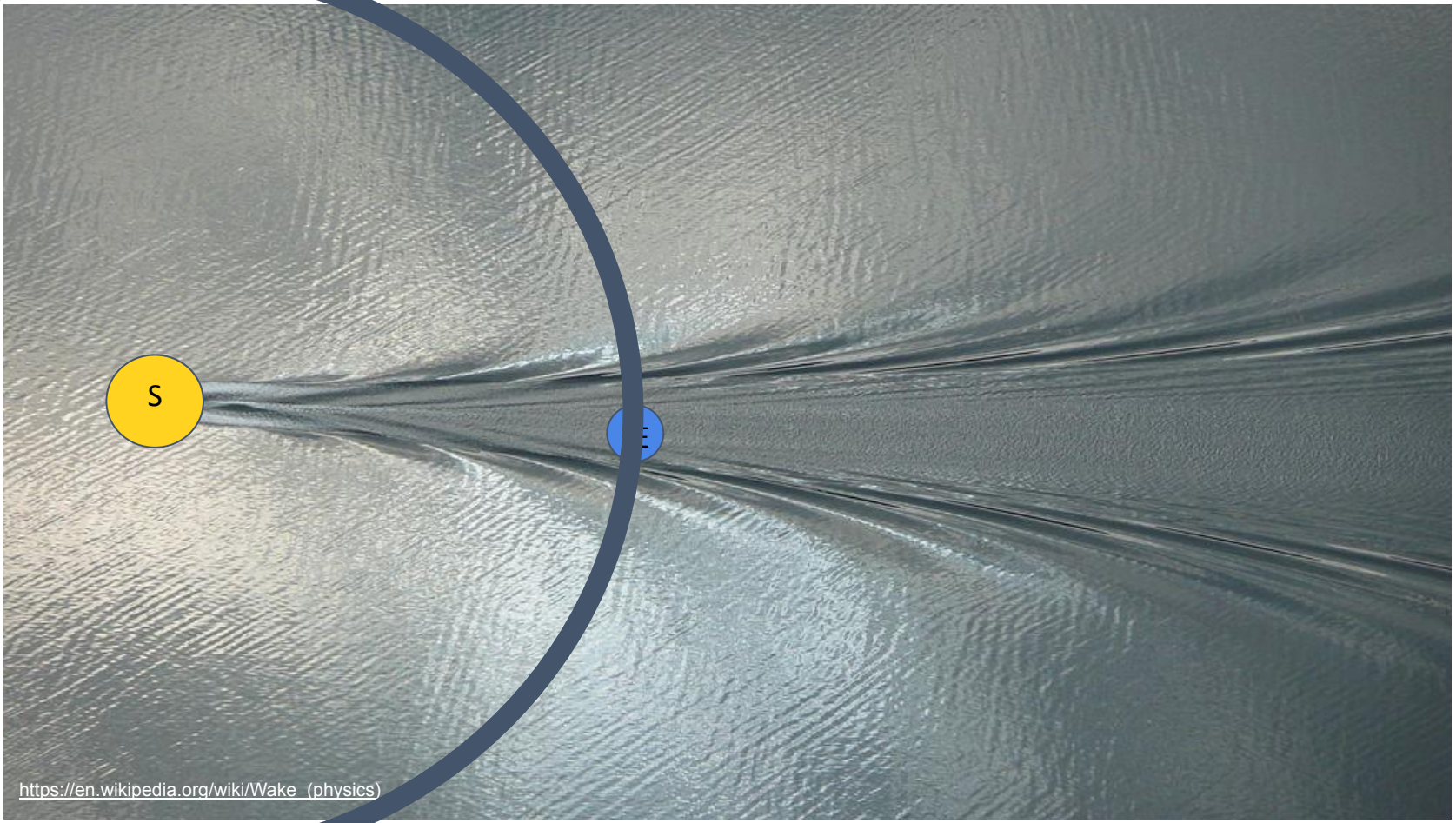
~10000 km thickness

~heavier particles required?

~periodicities close to 27 days, ½ x 27 days.

~opposite directions possible if both positive and negative charges involved?

… or Dark Fluid -> dark wake(s)?



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

Observable charged dark matter stream around?

- foundations of physics!
- predicting some earthquakes by monitoring cosmic ray sources moving within the Solar System!
- revisiting climate change models by considering the new external factor!