27th European Cosmic Ray Symposium

Nijmegen, The Netherlands 25 - 29 July 2022

27th European Cosmic Ray Symposium

Topics:
Cosmic Ray Physics,
Gamma Ray Astronomy,
Neutrino Astronomy,
Dark Matter Physics,
Solar and Heliospheric Physics,
Space Weather,
Astroparticle Physics Theory and Models,
Experimental Methods, Techniques, and Instrumentation

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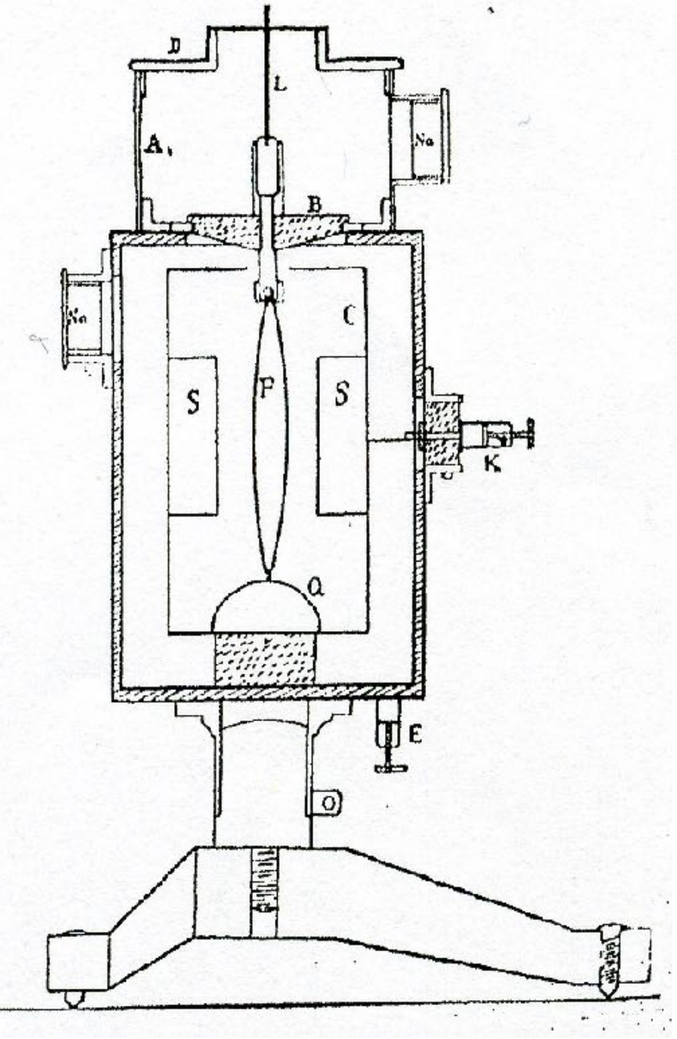
Physikalische Zeitschrift. 10. Jahrgang. No. 8. (1909) 251



Ein neues Elektrometer für statische Ladungen.

Dritte Mitteilung [1]).

Von Th. Wulf.

Die vorliegende Mitteilung enthält einige Verbesserungen des früher beschriebenen Apparates, besonders zur Erhöhung seiner Transportfähigkeit.

Theodor Wulf

He taught physics at Valkenburg, a Jesuit University from 1904 to 1914 and 1918-1935.

Clay: Latitude Effect

RESULTS OF THE DUTCH COSMIC RAY EXPEDITION 1933

II. THE MAGNETIC LATITUDE EFFECT OF COSMIC RAYS
A MAGNETIC LONGITUDE EFFECT

by J. CLAY, P. M. VAN ALPHEN and C. G. 'T HOOFT

Natuurkundig Laboratorium, Amsterdam

journey from Holland to Java
intensity changes with latitude

cosmic rays are charged particles

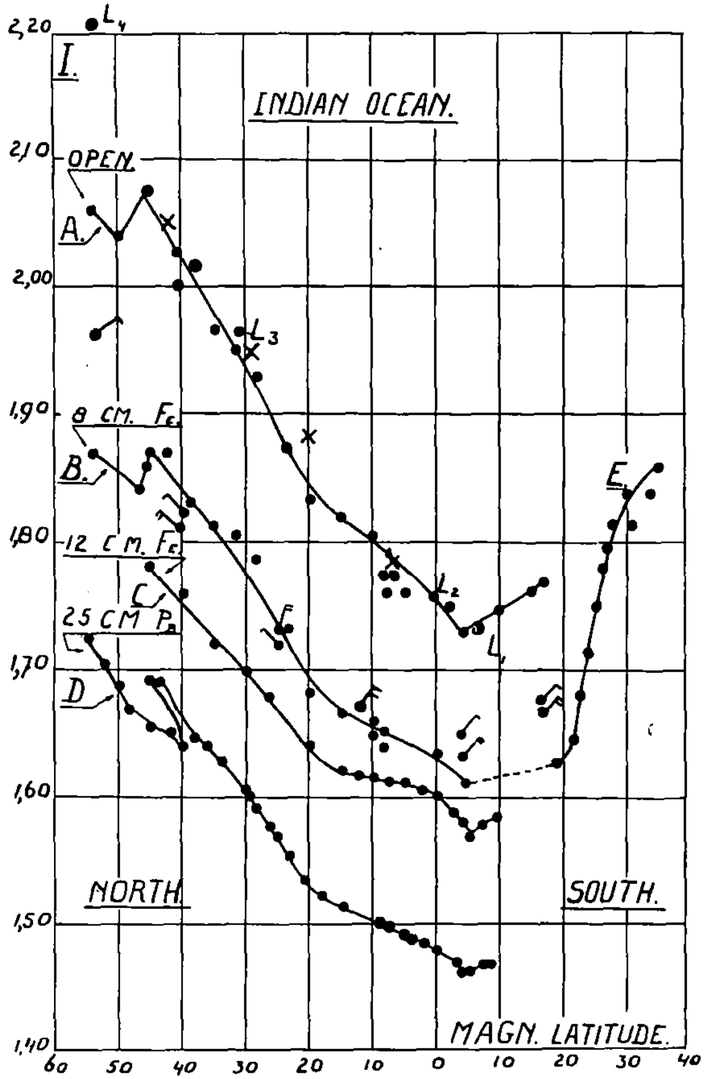


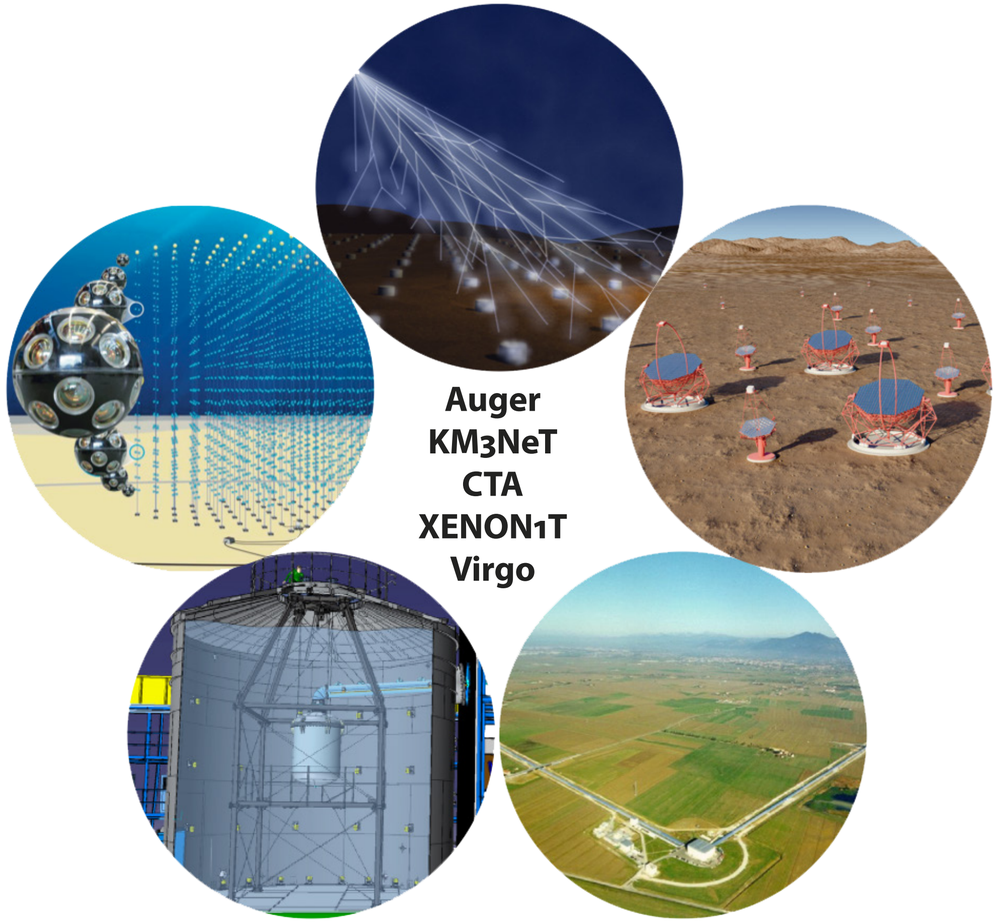
Fig. 1. Records of the variation of Cosmic Radiation with latitude on two different routes under different shielding with different instruments

× ····· × results with instrument D open (Amsterdam—Batavia)

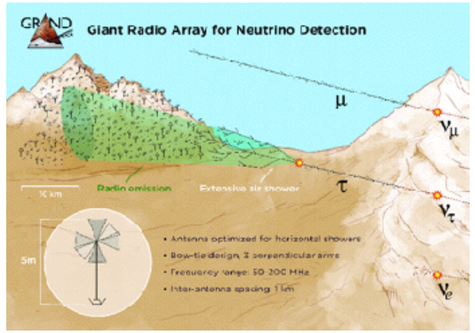
(L_1, L_2, L_3, L_4) results with instrument D_1 open (Batavia—Amsterdam)

Results 1928 and 1929.

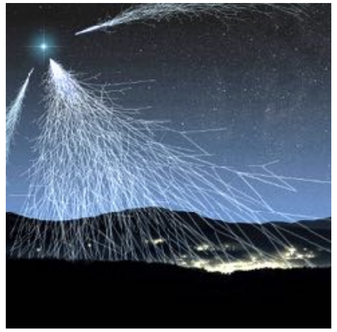
J. Clay et al., Physica 1 (1934) 376; 2 (1935) 183



Einstein Telscope



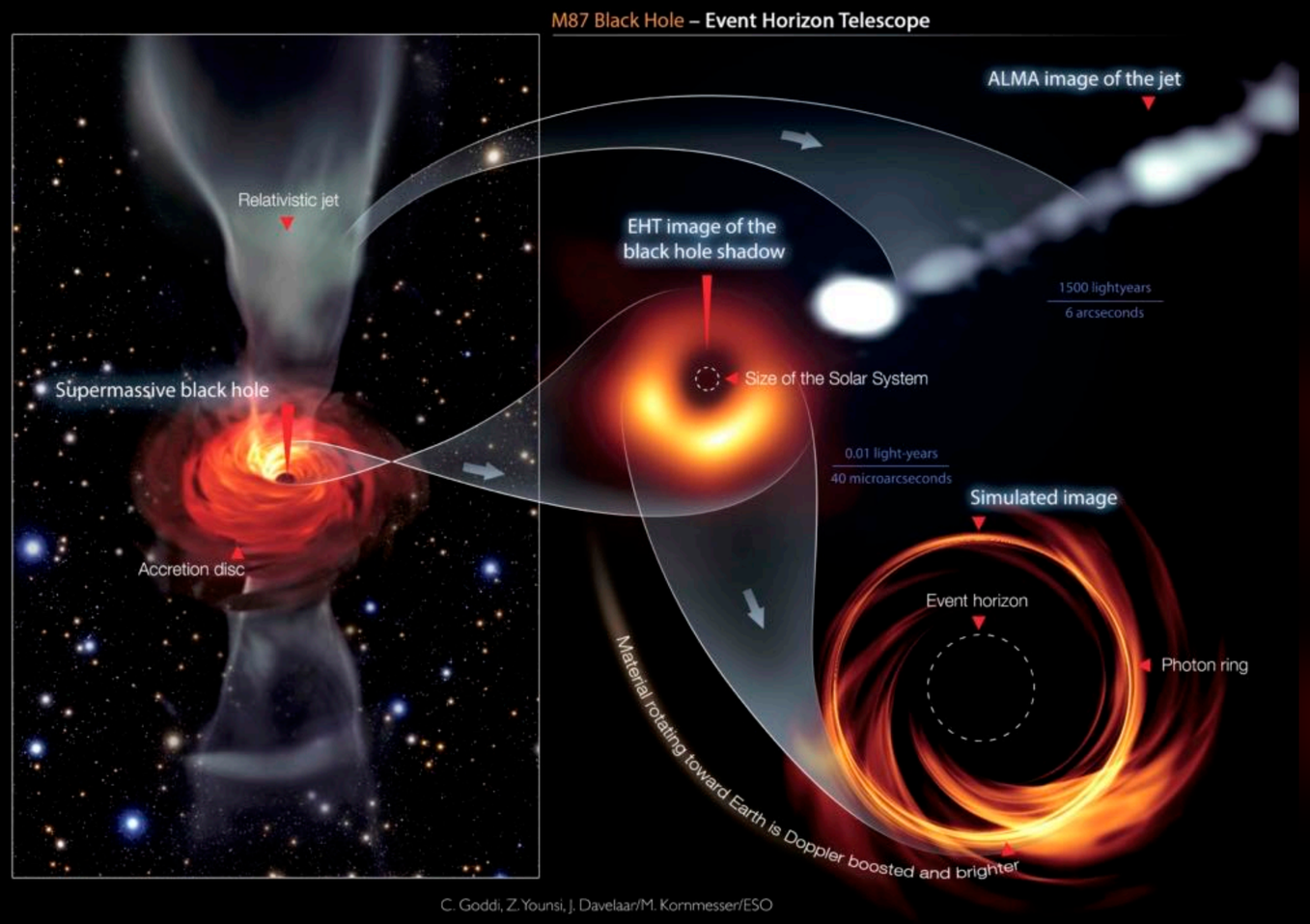
GRAND



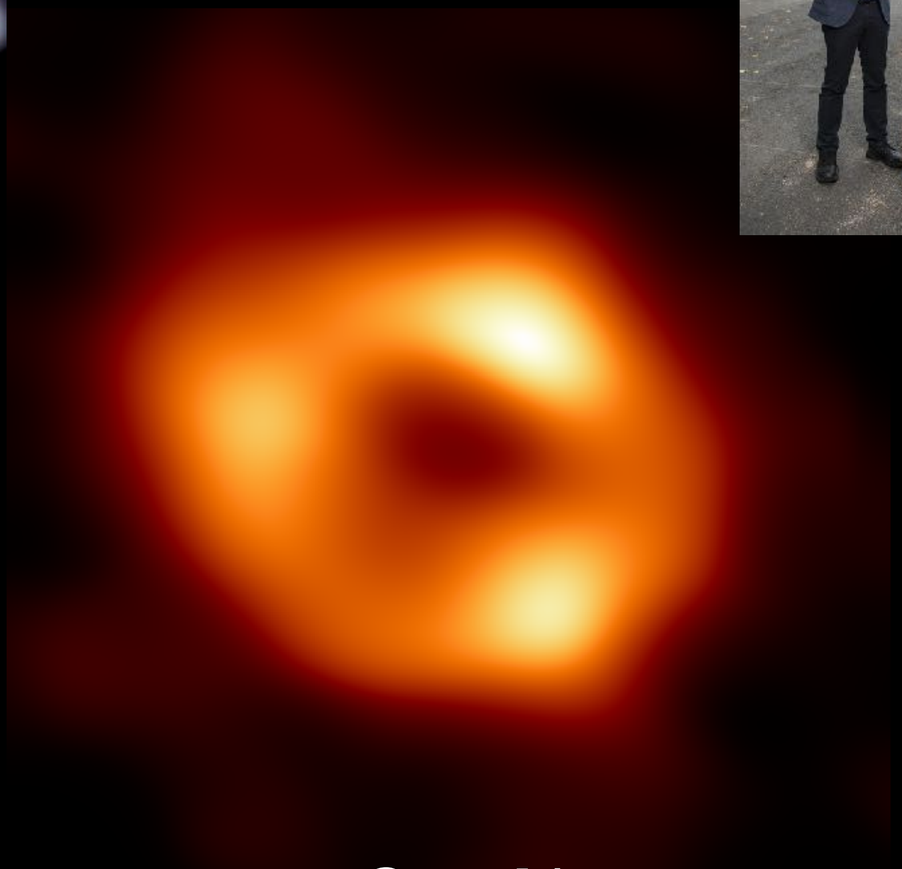
GCOS

http://www.astroparticlephysics.nl

Event Horizon Telescope



M87



Sag A*

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Faculty of Law
Radboud University Medical Centre
Nijmegen School of Management
Faculty of Philosophy, Theology and Religious Studies
Faculty of Social Sciences
Faculty of Science

~25000 students

5886 FTE staff
3343 FTE academic staff
350 FTE professors

Institute for Mathematics, Particle Physics and Astrophysics (IMAPP)
Department of High Energy Physics
Department of Astrophysics
} Astroparticle physics

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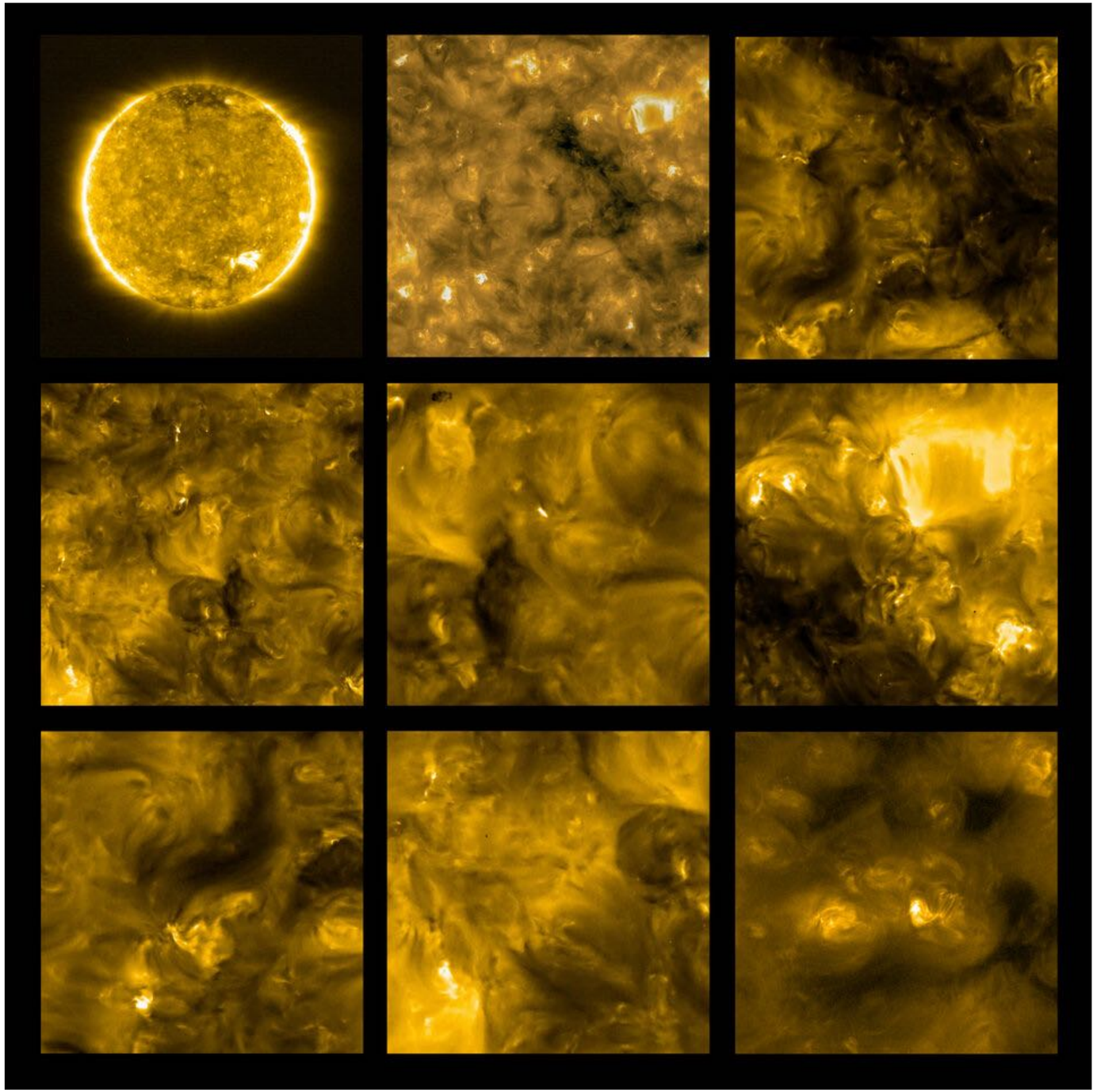
Solar Orbiter



Taking the closest ever images of the Sun, observing the solar wind and the Sun's polar regions like never before, unravelling the mysteries of the solar cycle

Living Reviews in Solar Physics (2022)19:2
https://doi.org/10.1007/s41116-022-00033-8

REVIEW ARTICLE

Extreme solar events

Edward W. Cliver[1,2] · Carolus J. Schrijver[1] · Kazunari Shibata[3,4] · Ilya G. Usoskin[5]

Received: 12 January 2021 / Accepted: 12 January 2022

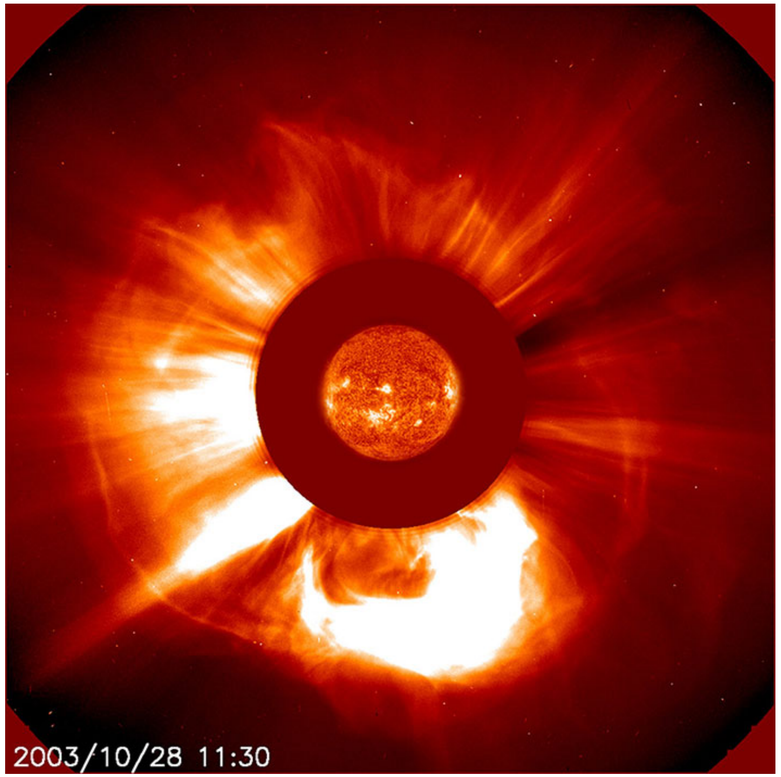


Fig. 35 CME observed on 28 October 2003 during the Halloween storms (Gopalswamy et al. 2005a, b; Webb and Allen 2004). The measured linear speed was 2,459 km s^{-1} versus an average CME speed of $\sim$ 450 km s^{-1}. The CME was associated with both an extreme geomagnetic storm and a severe solar proton event (G5 and S4, respectively on the NOAA Space Weather Scales (http://www.swpc.noaa.gov/noaa-scales-explanation). (LASCO CME image and Extreme-ultraviolet Imaging Telescope (EIT; Delaboudinière et al. 1995) image of solar disk. Image reproduced with permission from https://sci.esa.int/web/soho/-/47806-lasco-c2-image-of-a-cme, copyright by ESA & NASA

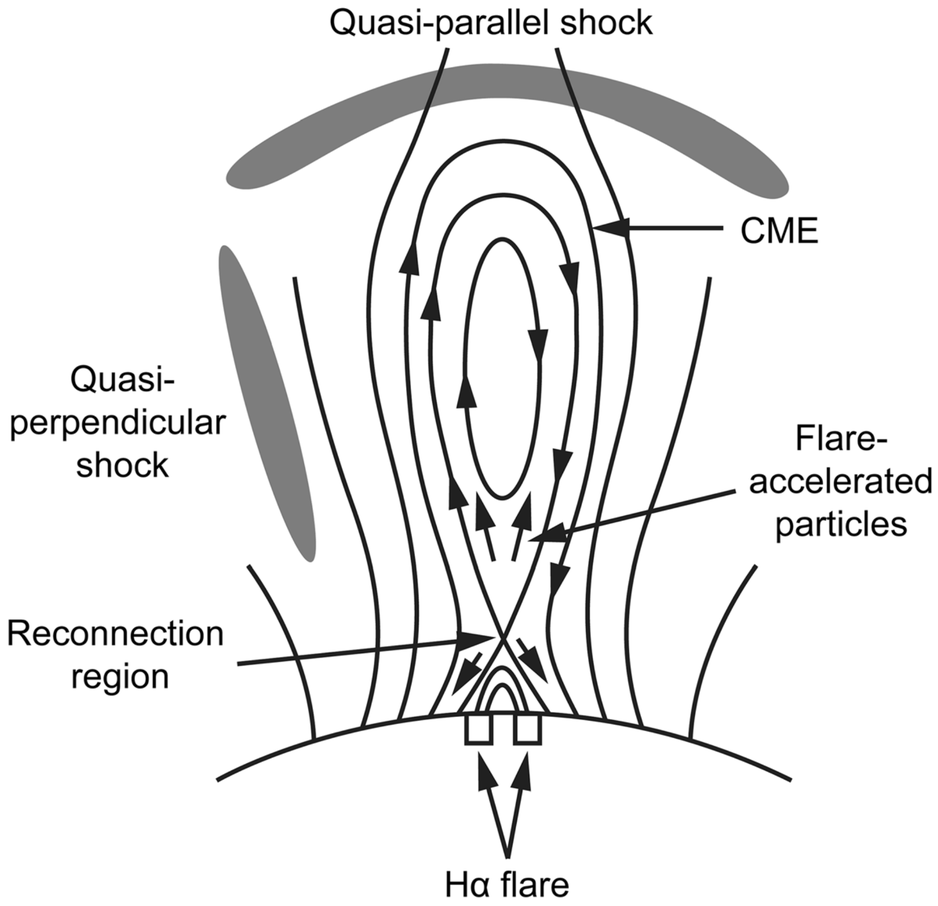


Fig. 44 Standard CSHKP-type model for eruptive flares showing the flare-resident particle acceleration site at an X-type reconnection point above the flare loops and below the disconnected CME (over time, the X-point will develop into a neutral current sheet between the flare loops and the CME) and CME-driven shocks (quasi-parallel and quasi-perpendicular). Image adapted from Cliver et al. (2004)

Article

Detection of a particle shower at the Glashow resonance with IceCube

https://doi.org/10.1038/s41586-021-03256-1

Received: 28 July 2020

Accepted: 18 January 2021

Published online: 10 March 2021

Check for updates

The IceCube Collaboration*

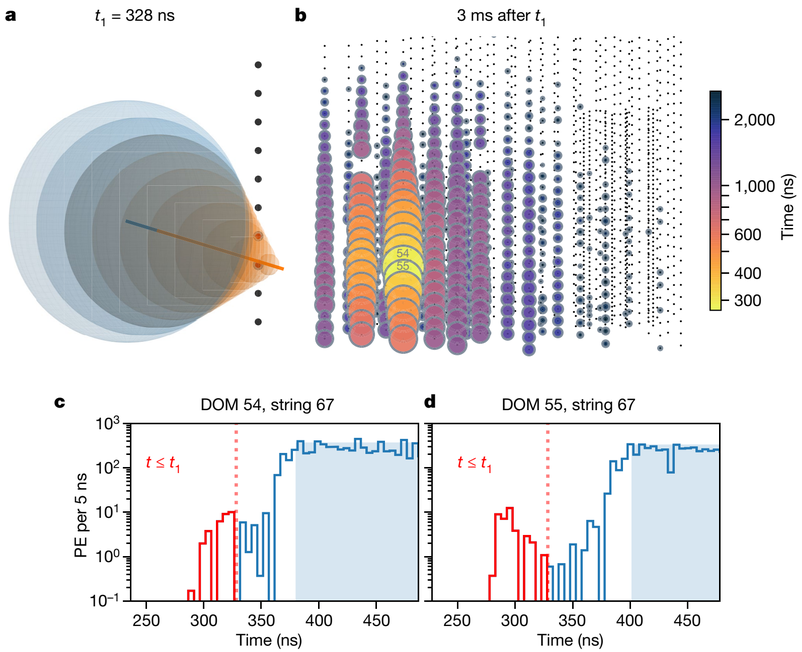


Fig. 1 | Visualization of detected photons at different times and distribution of early pulses. a, Schematic of an escaping muon travelling at faster than the speed of light (in ice) and its Cherenkov cone (orange). The muons reach the nearest modules (DOMs 54 and 55 on string 67) ahead of the Cherenkov photons produced by the EM component of the hadronic shower (blue) as these travel at the speed of light in ice. The blue line is associated with the average distance travelled by the main shower, while the orange line extends further and is associated with the muons. Each black dot arranged vertically is a DOM on the nearest string, with the two (slightly larger) dots inside the orange cone the first two to observe early pulses. The time t_1 indicates the approximate time elapsed since the neutrino interaction at which this snapshot graphic was taken. **b**, Event view, showing DOMs that triggered across IceCube at a later time. Each bubble represents a DOM, with its size proportional to the deposited charge. Colours indicate the time each DOM first triggered, relative to our best knowledge of when the initial interaction occurred. The small black dots are DOMs further away that did not detect photons 3 ms after t_1. **c**, **d**, Distributions of the deposited charge over time on the two earliest hit DOMs, 54 (**c**) and 55 (**d**). The dotted red line is at t_1 = 328 ns, the instant shown in **a**. The histogram in red (blue) shows photons arriving before (after) t_1, and the blue shaded region denotes saturation of the photomultiplier tube.

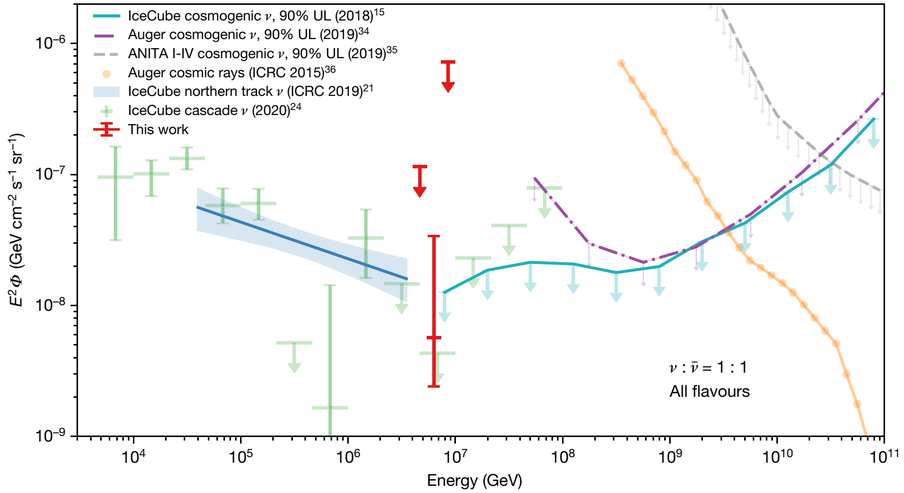
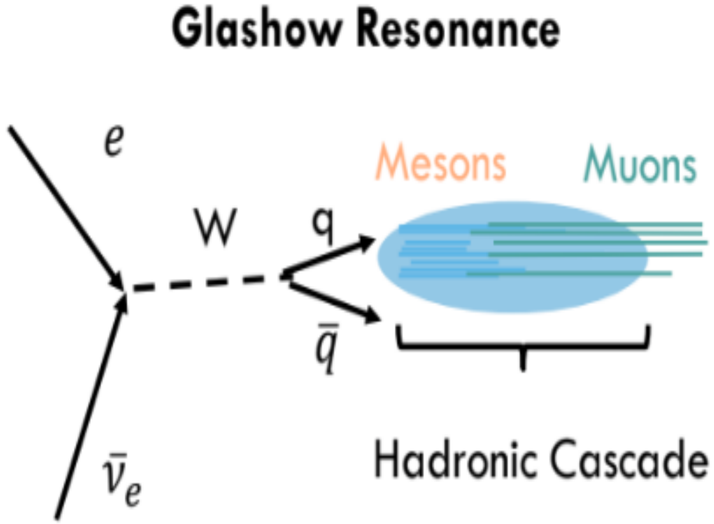


Fig. 4 | Measured flux of astrophysical neutrinos. Global picture of astrophysical neutrino flux measurements[21,24], cosmogenic neutrino upper limits (UL)[15,34,35] and the ultra-high-energy cosmic-ray spectrum[36]. The y axis is given in terms of the energy, E, squared times the flux, Φ. We assume the ratio $\bar{\nu} : \nu = 1 : 1$, a flavour ratio of 1:1:1 at Earth, an astrophysical spectrum measured



IceCube Nature 591 (2021) 220-224

Article

Ultrahigh-energy photons up to 1.4 petaelectronvolts from 12 γ-ray Galactic sources

https://doi.org/10.1038/s41586-021-03498-z
Received: 21 October 2020
Accepted: 26 March 2021
Published online: 17 May 2021
Check for updates

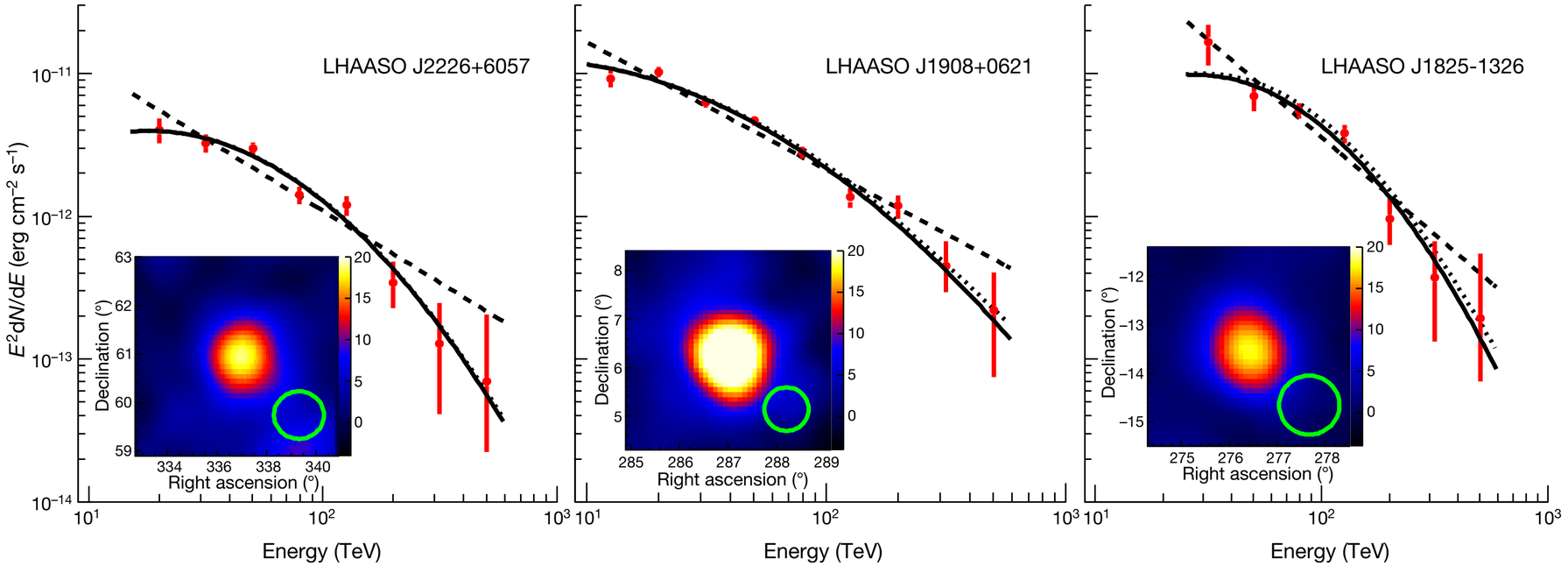


Fig. 1 | Spectral energy distributions and significance maps. a–c, Data are shown for LHAASO J2226+6057 (**a**), LHAASO J1908+0621 (**b**), and LHAASO J1825-1326 (**c**). Spectral fits with a log-parabola function (solid lines) in the form of $[E/(10\ \mathrm{TeV})]^{-a-b\log[E/(10\ \mathrm{TeV})]}$ are compared with the power-law fits $E^{-\Gamma}$ for: $a = 1.56$, $b = 0.88$ and $\Gamma = 3.01$ (**a**); $a = 2.27$, $b = 0.46$ and $\Gamma = 2.89$ (**b**); and $a = 0.92$, $b = 1.19$ and $\Gamma = 3.36$ (**c**). The dotted curves correspond to the log-parabola fits corrected for the interstellar γ–γ absorption (see Methods for the radiation fields and Extended Data Fig. 6 for the opacity curves). The comparison of the power-law (PL) model and the log-parabola (LOG) model with the Akaike Information Criterion[20] (AIC) gives: $\mathrm{AIC_{LOG}} = 12.3$ and $\mathrm{AIC_{PL}} = 24.4$ for LHAASO J2226+6057; $\mathrm{AIC_{LOG}} = 15.1$ and $\mathrm{AIC_{PL}} = 30.1$ for LHAASO J1908+0621; and $\mathrm{AIC_{LOG}} = 11.6$ and $\mathrm{AIC_{PL}} = 14.8$ for LHAASO J1825-1326. The insets show the significance maps of the three sources, obtained for γ-rays above 25 TeV. The colour bars show the square root of test statistics (TS), which is equivalent to the significance. The significance ($\sqrt{\mathrm{TS}}$) maps are smoothed with the Gaussian-type point spread function (PSF) of each source. The size of PSFs (68% contamination regions) are shown at the bottom right of each map. We note that the PSFs of the three sources are slightly different owing to different inclination angles. Namely, the 68% contamination angles are 0.49° for LHAASO J2226+6057, 0.45° for LHAASO J1908+0621 and 0.62° for LHAASO J1825-1326. Error bars represent one standard deviation.

LHAASO, Nature 594 (2021) 33–36

PHYSICAL REVIEW LETTERS **125,** 121106 (2020)

Editors' Suggestion | Featured in Physics

Features of the Energy Spectrum of Cosmic Rays above 2.5×10^{18} eV Using the Pierre Auger Observatory

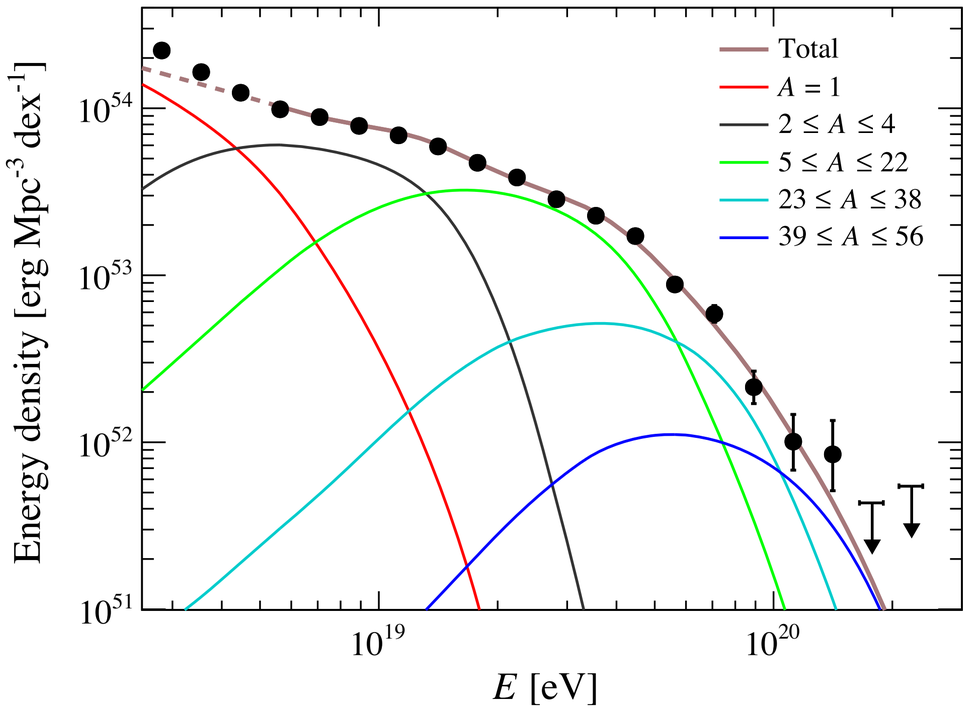


FIG. 2. Energy density obtained with the best fit parameters of the benchmark scenario used for illustration, as described in the text. The dashed curve shows the energy range that is not used in the fit and where an additional component is needed for describing the spectrum.

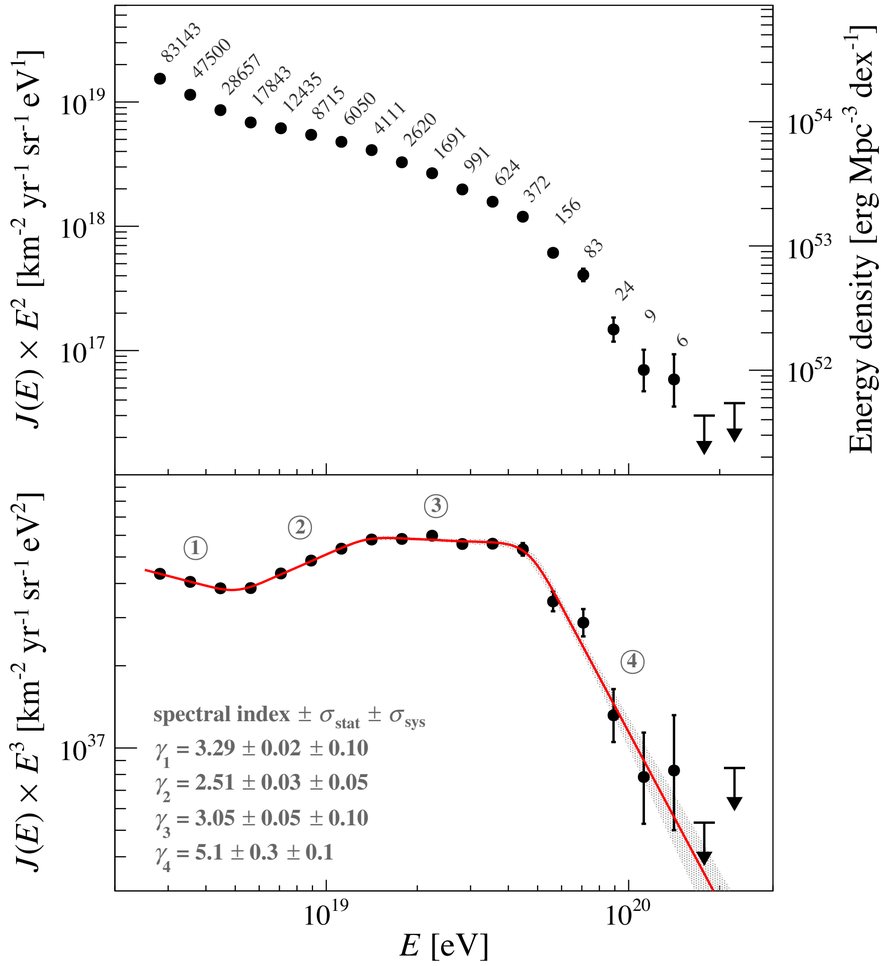
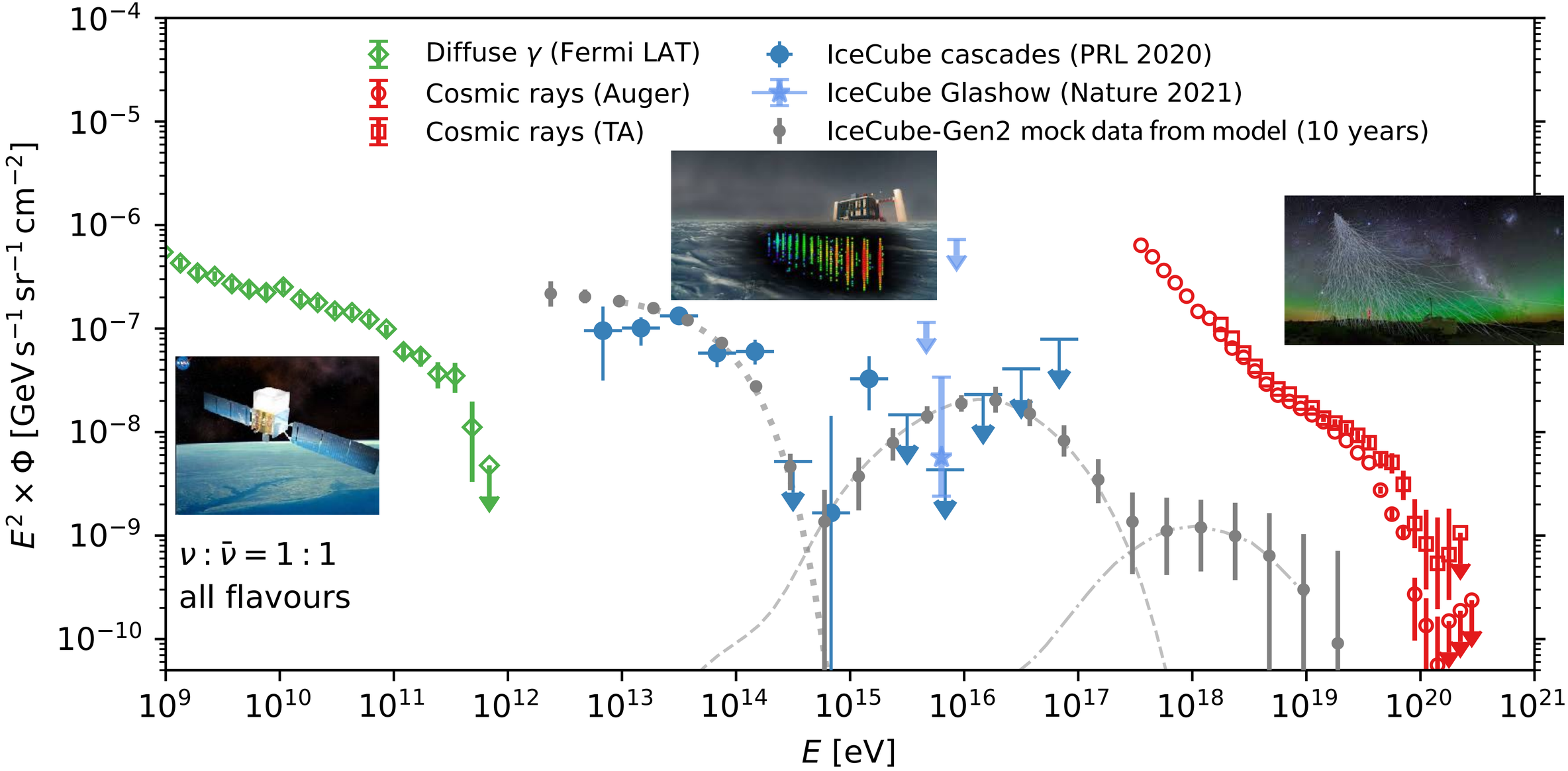


FIG. 1. Top: energy spectrum scaled by E^2 with the number of detected events in each energy bin. In this representation the data provide an estimation of the differential energy density per decade. Bottom: energy spectrum scaled by E^3 fitted with a sequence of four power laws (red line). The numbers ($i = 1, \ldots, 4$) enclosed in the circles identify the energy intervals where the spectrum is described by a power law with spectral index γ_i. The shaded band indicates the statistical uncertainty of the fit. Upper limits are at the 90% confidence level.

Auger, PRL 125 (2020) 121106

Multi-messenger astroparticle physics



arXiv:2205.05845v3

RESEARCH ARTICLE SUMMARY

NEUTRINO ASTROPHYSICS

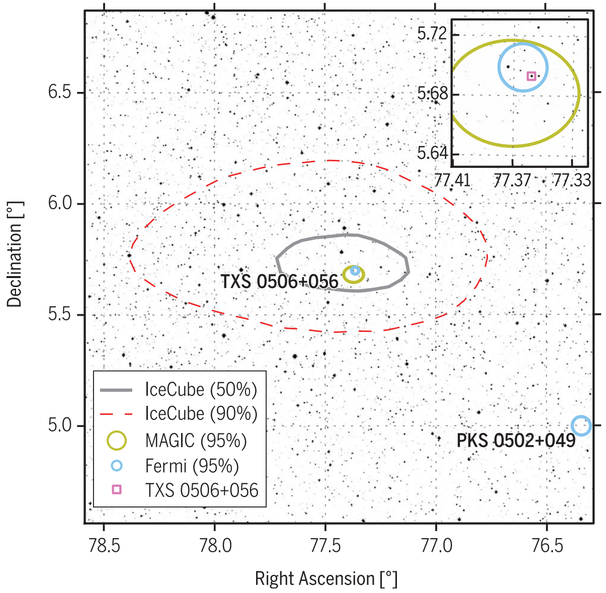
Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A

The IceCube Collaboration, *Fermi*-LAT, MAGIC, *AGILE*, ASAS-SN, HAWC, H.E.S.S., *INTEGRAL*, Kanata, Kiso, Kapteyn, Liverpool Telescope, Subaru, *Swift/NuSTAR*, VERITAS, and VLA/17B-403 teams*†

INTRODUCTION: Neutrinos are tracers of cosmic-ray acceleration: electrically neutral and traveling at nearly the speed of light, they can escape the densest environments and may be traced back to their source of origin. High-energy neutrinos are expected to be produced in blazars: intense extragalactic radio, optical, x-ray, and, in some cases, γ-ray sources characterized by relativistic jets of plasma pointing close to our line of sight. Blazars are among the most powerful objects in the Universe and are widely speculated to be sources of high-energy cosmic rays. These cosmic rays generate high-energy neutrinos and γ-rays, which are produced when the cosmic rays accelerated in the jet interact with nearby gas or photons. On 22 September 2017, the cubic-kilometer IceCube Neutrino Observatory detected a ~290-TeV neutrino from a direction consistent with the flaring γ-ray blazar TXS 0506+056. We report the details of this observation and the results of a multiwavelength follow-up campaign.

RATIONALE: Multimessenger astronomy aims for globally coordinated observations of cosmic rays, neutrinos, gravitational waves, and electromagnetic radiation across a broad range of wavelengths. The combination is expected to yield crucial information on the mechanisms

mic rays. The discovery of an extraterrestrial diffuse flux of high-energy neutrinos, announced by IceCube in 2013, has characteristic properties that hint at contributions from extragalactic sources, although the individual sources remain as yet unidentified. Continuously monitoring the entire sky for astrophysical neutrinos, IceCube provides real-time triggers for observatories around the world measuring γ-rays, x-rays, optical, radio, and gravitational waves, allowing for the potential identification of even rapidly fading sources.



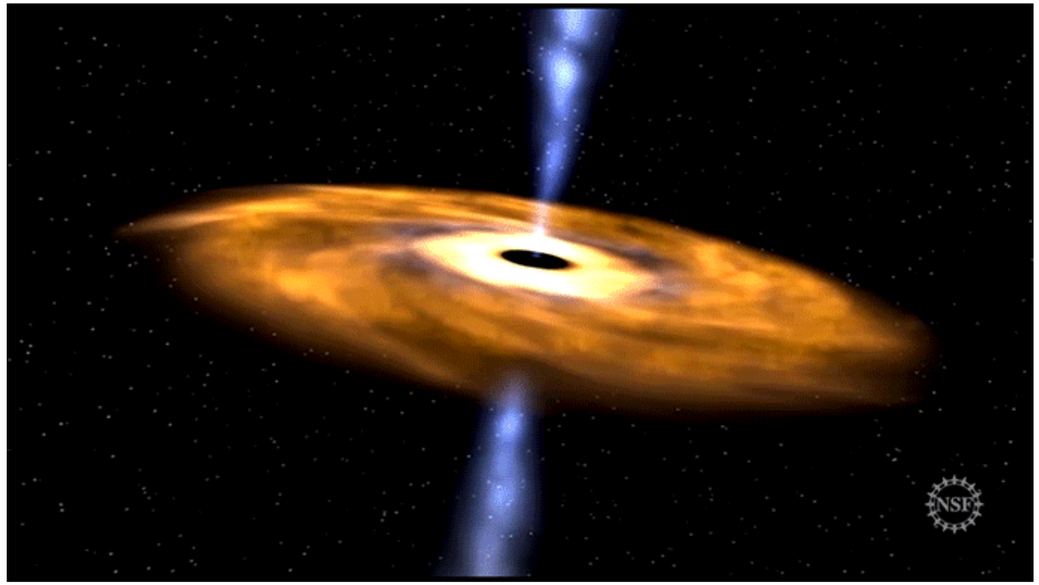
Multimessenger observations of blazar TXS 0506+056. The

RESULTS: A high-energy neutrino-induced muon track was detected on 22 September 2017, automatically generating an alert that was distributed worldwide within 1 min of detection and prompted follow-up searches by telescopes over a broad range of wavelengths. On 28 September 2017, the *Fermi* Large Area Telescope Collaboration reported that the direction of the neutrino was coincident with a cataloged γ-ray source, 0.1° from the neutrino direction. The source, a blazar known as TXS 0506+056 at a measured redshift of 0.34, was in a flaring state at the time with enhanced γ-ray activity in the GeV range. Follow-up observations by imaging atmospheric Cherenkov telescopes, notably the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescopes, revealed periods where the detected γ-ray flux from the blazar reached energies up to 400 GeV. Measurements of the source have also been completed at x-ray, optical, and radio wavelengths. We have investigated models associating neutrino and γ-ray production and find that correlation of the neutrino with the flare of TXS 0506+056 is statistically significant at the level of 3 standard deviations (sigma). On the basis of the redshift of TXS 0506+056, we derive constraints for the muon-neutrino luminosity for this source and find them to be similar to the luminosity observed in γ-rays.

ON OUR WEBSITE

Read the full article at http://dx.doi.org/10.1126/science.aat1378

CONCLUSION: The energies of the γ-rays and the neutrino indicate that blazar jets may accelerate cosmic rays to at least several PeV. The observed association of a high-energy neutrino with a blazar during a period of enhanced γ-ray emission suggests that blazars may indeed be one of the long-



Science 361 (2018) 6398

The Astrophysical Journal Letters, 848:L12 (59pp), 2017 October 20 https://doi.org/10.3847/2041-8213/aa91c9

Multi-messenger Observations of a Binary Neutron Star Merger*

LIGO Scientific Collaboration and Virgo Collaboration, Fermi GBM, INTEGRAL, IceCube Collaboration, AstroSat Cadmium Zinc Telluride Imager Team, IPN Collaboration, The Insight-HXMT Collaboration, ANTARES Collaboration, The Swift Collaboration, AGILE Team, The 1M2H Team, The Dark Energy Camera GW-EM Collaboration and the DES Collaboration, The DLT40 Collaboration, GRAWITA: GRAvitational Wave Inaf TeAm, The Fermi Large Area Telescope Collaboration, ATCA: Australia Telescope Compact Array, ASKAP: Australian SKA Pathfinder, Las Cumbres Observatory Group, OzGrav, DWF (Deeper, Wider, Faster Program), AST3, and CAASTRO Collaborations, The VINROUGE Collaboration, MASTER Collaboration, J-GEM, GROWTH, JAGWAR, Caltech-NRAO, TTU-NRAO, and NuSTAR Collaborations, Pan-STARRS, The MAXI Team, TZAC Consortium, KU Collaboration, Nordic Optical Telescope, ePESSTO, GROND, Texas Tech University, SALT Group, TOROS: Transient Robotic Observatory of the South Collaboration, The BOOTES Collaboration, MWA: Murchison Widefield Array, The CALET Collaboration, IKI-GW Follow-up Collaboration, H.E.S.S. Collaboration, LOFAR Collaboration, LWA: Long Wavelength Array, HAWC Collaboration, The Pierre Auger Collaboration, ALMA Collaboration, Euro VLBI Team, Pi of the Sky Collaboration, The Chandra Team at McGill University, DFN: Desert Fireball Network, ATLAS, High Time Resolution Universe Survey, RIMAS and RATIR, and SKA South Africa/MeerKAT
(See the end matter for the full list of authors.)

Received 2017 October 3; revised 2017 October 6; accepted 2017 October 6; published 2017 October 16

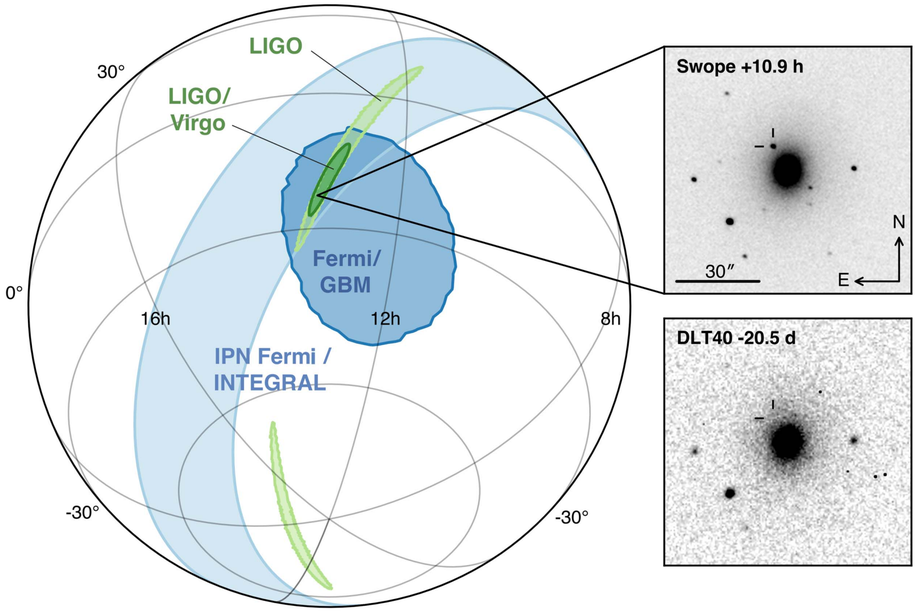


Figure 1. Localization of the gravitational-wave, gamma-ray, and optical signals. The left panel shows an orthographic projection of the 90% credible regions from LIGO (190 deg^2; light green), the initial LIGO-Virgo localization (31 deg^2; dark green), IPN triangulation from the time delay between *Fermi* and *INTEGRAL* (light blue), and *Fermi*-GBM (dark blue). The inset shows the location of the apparent host galaxy NGC 4993 in the Swope optical discovery image at 10.9 hr after the merger (top right) and the DLT40 pre-discovery image from 20.5 days prior to merger (bottom right). The reticle marks the position of the transient in both images.

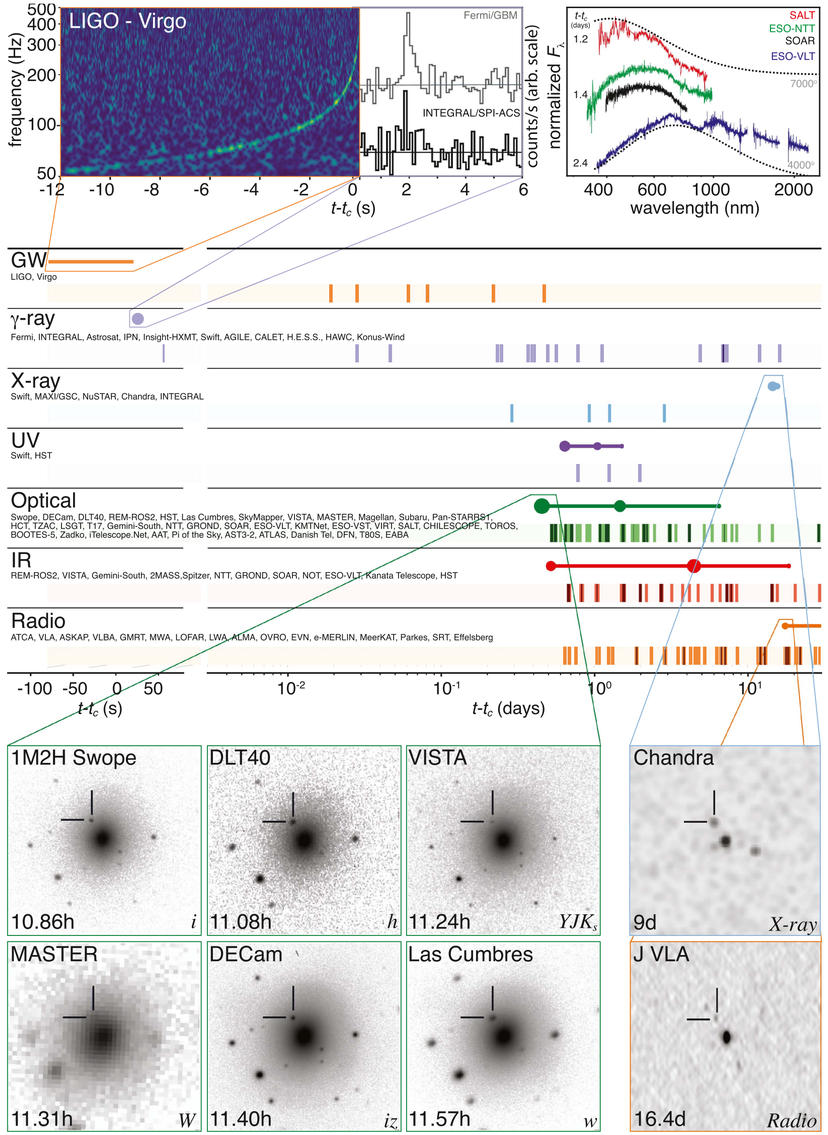
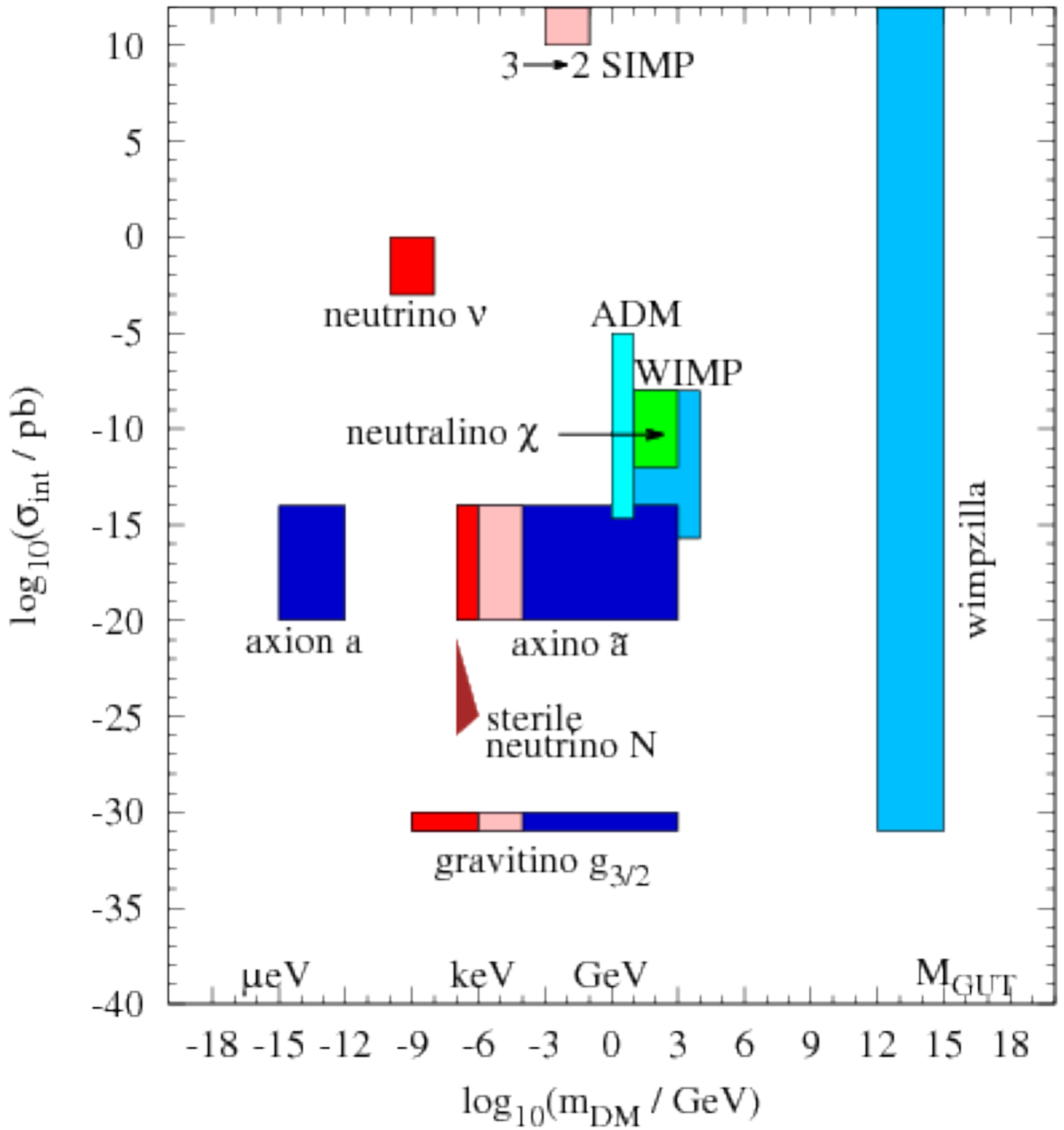


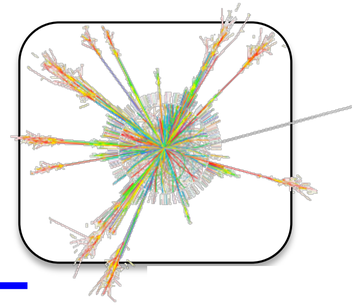
Figure 2. Timeline of the discovery of GW170817, GRB 170817A, SSS17a/AT 2017gfo, and the follow-up observations are shown by messenger and wavelength relative to the time t_c of the gravitational-wave event. Two types of information are shown for each band/messenger. First, the shaded dashes represent the times when information was reported in a GCN Circular. The names of the relevant instruments, facilities, or observing teams are collected at the beginning of the row. Second, representative observations (see Table 1) in each band are shown as solid circles with their areas approximately scaled by brightness; the solid lines indicate when the source was detectable by at least one telescope. Magnification insets give a picture of the first detections in the gravitational-wave, gamma-ray, optical, X-ray, and radio bands. They are respectively illustrated by the combined spectrogram of the signals received by LIGO-Hanford and LIGO-Livingston (see Section 2.1), the *Fermi*-GBM and *INTEGRAL*/SPI-ACS lightcurves matched in time resolution and phase (see Section 2.2), $1'.5 \times 1'.5$ postage stamps extracted from the initial six observations of SSS17a/AT 2017gfo and four early spectra taken with the SALT (at $t_c + 1.2$ days; Buckley et al. 2017; McCully et al. 2017b), ESO-NTT (at $t_c + 1.4$ days; Smartt et al. 2017), the SOAR 4 m telescope (at $t_c + 1.4$ days; Nicholl et al. 2017d), and ESO-VLT-XShooter (at $t_c + 2.4$ days; Smartt et al. 2017) as described in Section 2.3, and the first X-ray and radio detections of the same source by *Chandra* (see Section 3.3) and JVLA (see Section 3.4). In order to show representative spectral energy distributions, each spectrum is normalized to its maximum and shifted arbitrarily along the linear y-axis (no absolute scale). The high background in the SALT spectrum below 4500 Å prevents the identification of spectral features in this band (for details McCully et al. 2017b).

Dark Matter searches

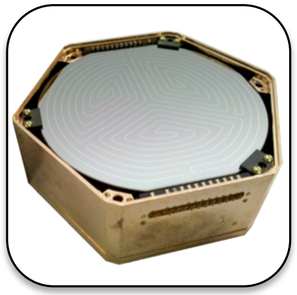
Baer et al. 2014

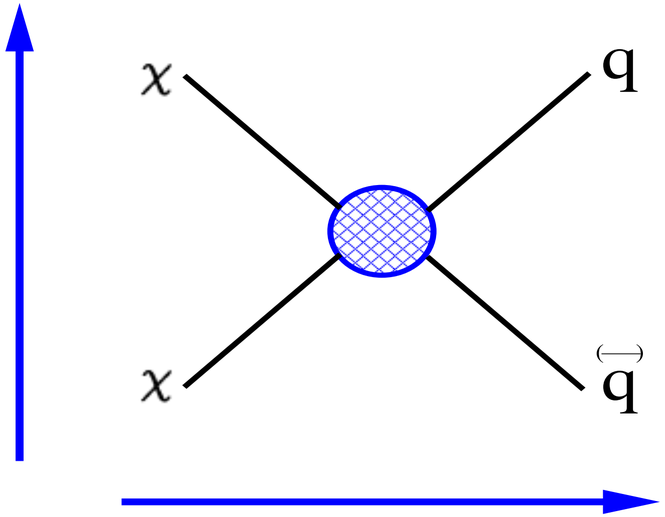


Accelerator Searches (production)



Direct Detection (scattering)





Indirect Detection (annihilation or decay)

27th European Cosmic Ray Symposium

Nijmegen, The Netherlands 25 - 29 July 2022

Topics:
Cosmic Ray Physics,
Gamma Ray Astronomy,
Neutrino Astronomy,
Dark Matter Physics,
Solar and Heliospheric Physics,
Space Weather,
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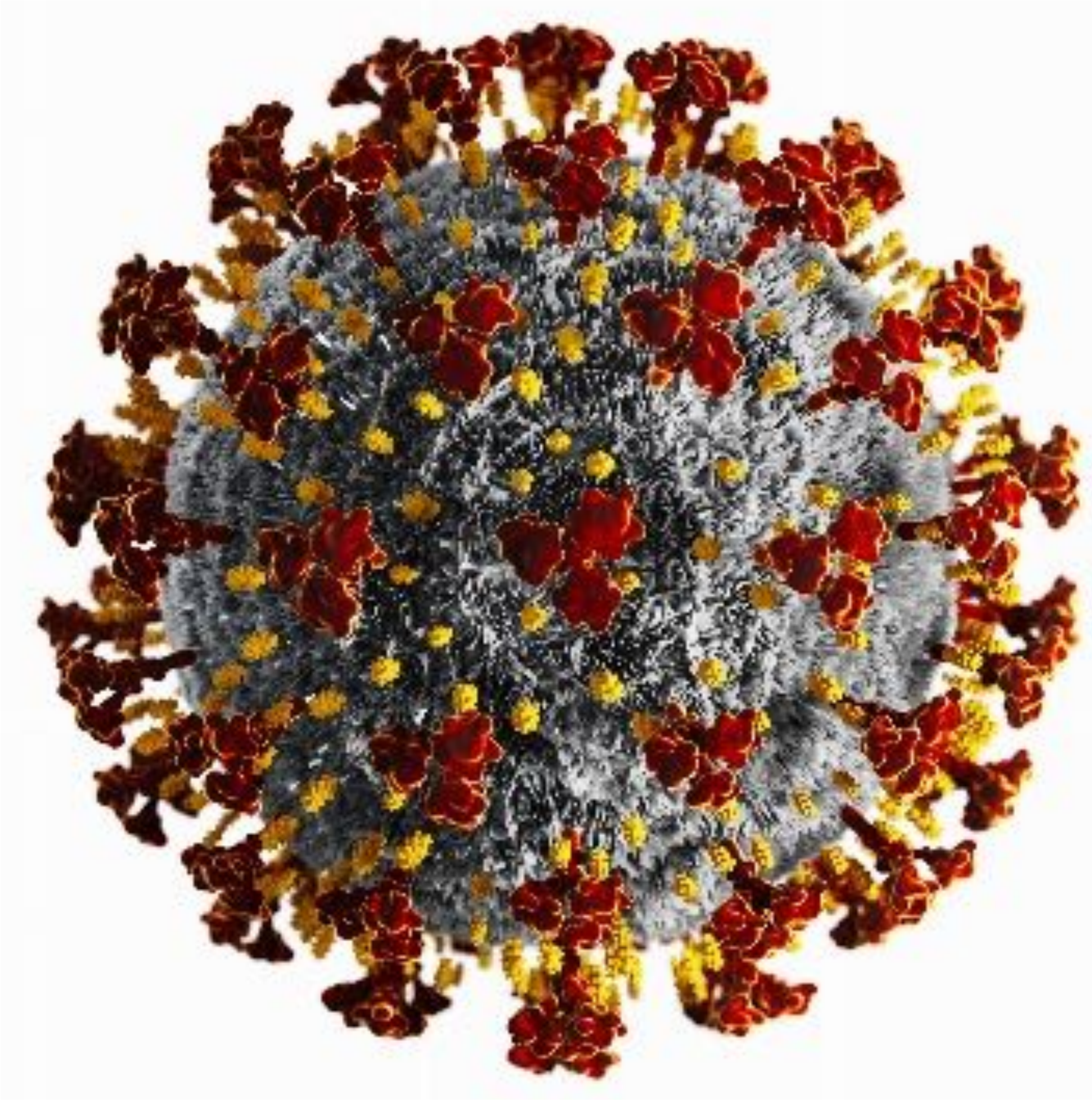

IUPAP Statement on the events occurring in Ukraine

We are consternated by the news regarding the Russian military offensive in Ukraine and the terrible consequences that this has on the lives of our colleagues in Ukraine. We extend our deepest sympathy and solidarity to them and to all the Ukrainian people at this difficult time. We praise the large number of Russian colleagues who have expressed their sympathy for their Ukrainian colleagues and demanded peace for their countries.

In our 100th anniversary this year, we note the critically important historical role that IUPAP has always strived to play in bringing physicists together across political divides even during our most difficult years in the past. IUPAP continues to embrace and promote scientific collaboration across the world as a driver for peace.

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Olga Malandraki, GEO - Cosmic rays at Earth and planets
Monica Laurenza, SW - Space weather
Manuela Vecchi, CRD - Direct measurements of cosmic rays
Antonella Castellina, CRI - Indirect measurements of cosmic rays
Elena Orlando, THEO - Acceleration, propagation, origin of cosmic rays
Michael Unger, EAS - Air shower physics and hadronic interactions
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Anna Nelles, INSTR - Future measurements, instrumentation and methods
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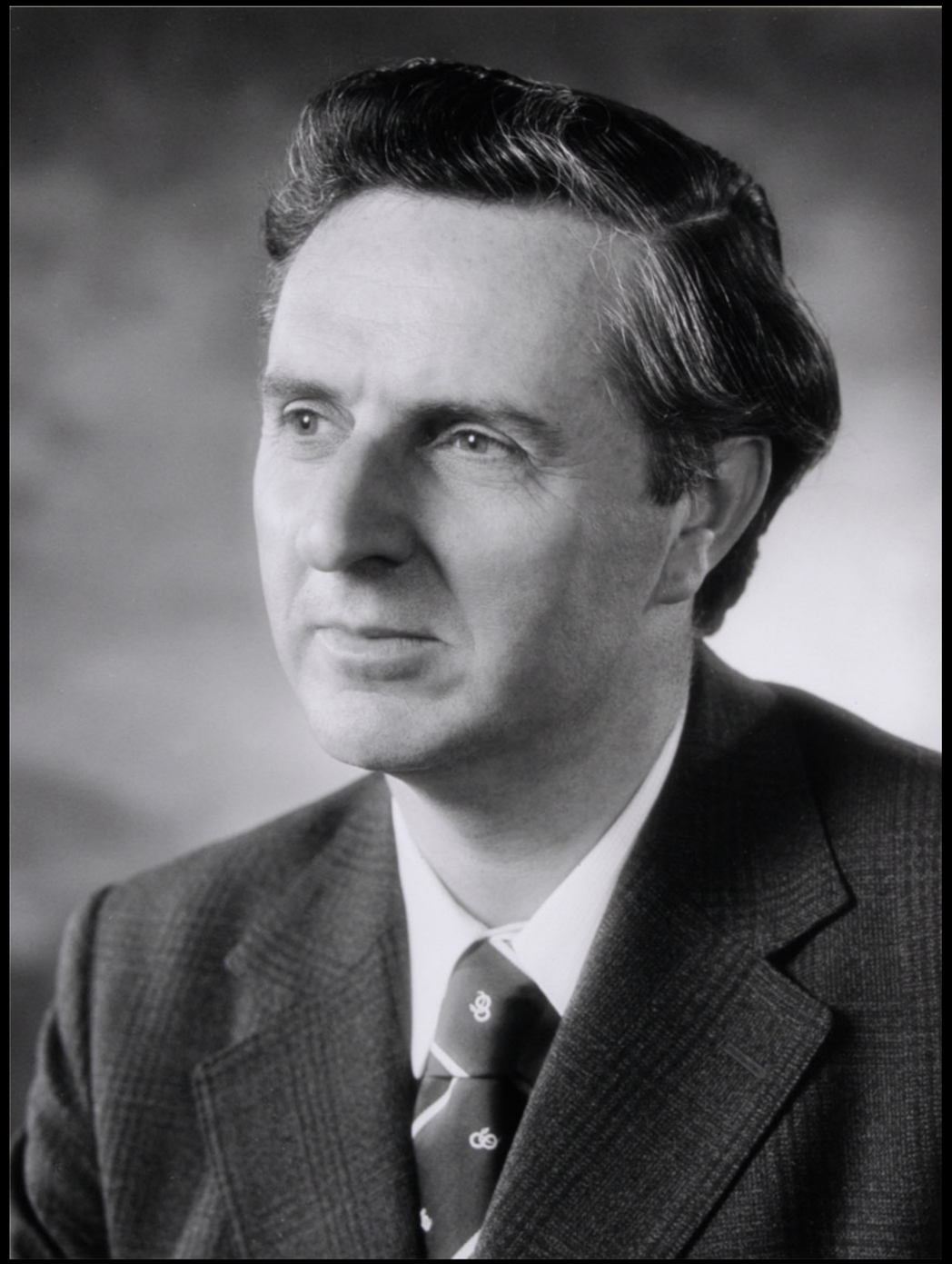
Previous Symposia

26th ECRS 2018 Barnaul, Russia
25th ECRS 2016 Torino, Italy
24th ECRS 2014 Kiel, Germany
23rd ECRS 2012 Moscow, Russia
22nd ECRS 2010 Turku, Finland
21st ECRS 2008 Kosice, Slovakia
20th ECRS 2006 Lisbon, Portugal
19th ECRS 2004 Florence, Italy
18th ECRS 2002 Moscow, Russia
17th ECRS 2000 Lodz, Poland
16th ECRS 1998 Alcala de Henares, Spain
15th ECRS 1996 Perpignan, France
14th ECRS 1994 Balatonfüred, Hungary
13th ECRS 1992 CERN, Geneva, Switzerland
12th ERCS 1990 Nottingham, United Kingdom
11th ECRS 1988 Balaton, Hungary
10th ECRS 1986 Bordeaux, France
9th ECRS 1984 Kosice, Czechoslovakia
8th ECRS 1982 Rome, Italy
7th ECRS 1980 Leningrad, Sovjet Union
6th ECRS 1978 Kiel, Germany
5th ECRS 1976 Leeds, United Kingdom
4th ECRS 1974 Frascati, Italy & Lodz, Poland
3rd ECRS 1972 Göttingen, Germany & Paris, France
2nd ECRS 1970 Amsterdam, Netherlands & Leeds, UK
1st ECRS 1968 Bern, Switzerland & Lodz, Poland

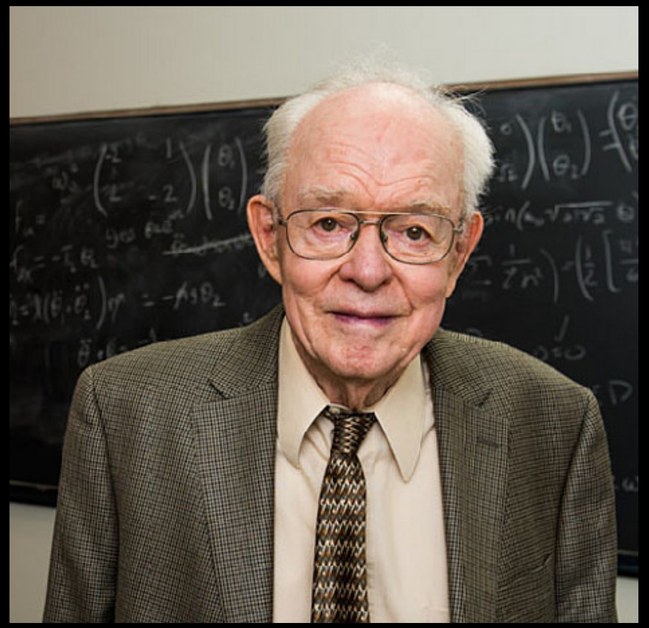
Sir Arnold Whittaker Wolfendale

25 June 1927 — 21 December 2020



Mikhail Igorevich Panasyuk

14 August 1945 – 3 November 2020



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Receipts

If you need certain details on your receipt, please contact our secretary, Sandra

27th European Cosmic Ray Symposium

WiFi

network: Van der Valk – Meetings

password: 66636663AN

27th European Cosmic Ray Symposium

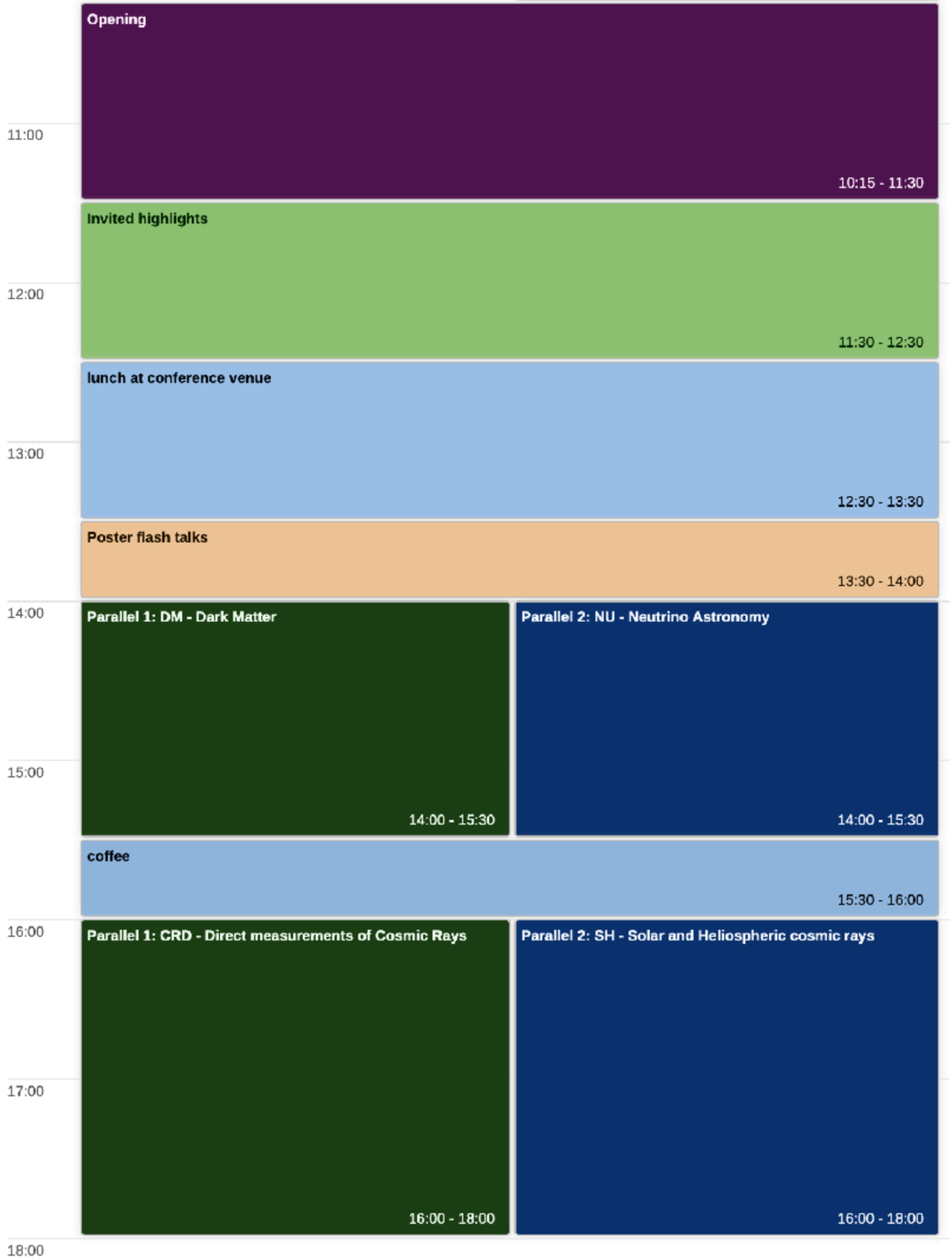
Breaks

coffee (morning+afternoon) in foyer

lunch (Mo-Fr) at restaurant

Monday: reception at Fort Lent
Tuesday: dinner at restaurant
Wednesday: dinner at restaurant
Thursday: boat trip

please wear your name batch!



hybrid format
(this is an experiment, we will see how it works out)

poster flash talks

parallel sessions

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