PAPER CHECK · SPACE WEATHER

A great storm, not a weaker field, made multi-MeV electrons inside the belts' barrier

Using Japan's Arase satellite, twenty researchers led from Nagoya University report that the May 2024 superstorm rapidly made multi-MeV electrons inside $L^* \approx 3$, the region of the radiation belts called an "impenetrable barrier" to them, and that a growing peak in the electrons' phase space density shows they were accelerated there rather than carried in from a weaker field. Other spacecraft saw related populations [15 Abstract][16 Abstract], and the barrier had given way before, in 1991 and 2003 [10 Abstract][7 Abstract]. SO Nemo's title sets "Next-Level Pole Shift Data" beside the breach without saying which item it describes [2], and nothing backs it: the paper and its references say nothing about the field's weakening, and the paper puts the breach down to the storm. We first checked the paper from its abstract and have since revised this page against its full text; the episode we could read only as its title and description.

By Fact-Checked Science · Published October 29, 2026 · Updated October 30, 2026

OUR ANALYSIS marks our own reasoning and calculations, including the dipole moments we interpolate from IGRF-14, the altitudes of the L shells on our chart, our tracing of the paper's Fig. 3b and our comparisons of storms, and the verdicts are our assessment. Everything else comes from the numbered sources. For the paper [1], read in full, it gives a page of the version of record, 5 a section and Fig. a figure; its key points, abstract and plain-language summary are on p. 1. For the press release [3], in Japanese, it gives a page of its PDF and we use our own words; elsewhere it gives a page, Fig. a figure, Ext. Data Fig. an Extended Data figure and Abstract the part of a source we quote.

Breached from the inside, by a great storm, not by a weaker field

OUR ASSESSMENT

L ≈ 2.8

the sharp inner edge, at L = 2.8 [6 Ext. Data Fig. 4], of the outer belt's electrons above 1 MeV, about 11,500 km above the equator by our conversion, that Baker and colleagues found in 20 months of NASA's Van Allen Probes data (Fig. 1 of [6], and called a barrier [6 Abstract]

5,000×

and more: how much the flux of 3.128 keV electrons rose at $L^* = 3$ in the storm proved, from about 1×10^6 at $L^* = 2.5$ and 5×10^6 at $L^* = 3.0$, per cm² sr s keV (1 [S1.3])

1.0%

how much weaker Earth's dipole was in May 2024 than in the Halloween storms of 2003, which also put multi-MeV electrons inside the barrier [9 Abstract][5 p. 2], by our calculation from IGRF-14 [S1]

THE CLAIMS

TRUE

"Impenetrable Barrier Breached"

The episode's title, and its label on the link to the paper [2]

In the paper's own words, "this barrier can be breached under extreme space weather conditions" [1 p. 1]: inside $L^* = 3$ the flux of 3.128 keV electrons rose more than 5,000-fold [1 [S1.3]], and the electrons "were not simply transported inward from higher altitudes" but "accelerated locally" [1 p. 1]. Spacecraft in low orbit saw related populations [15 Abstract][16 Abstract]; the barrier, which the authors' release calls a wall [5 p. 2], is an edge: the sharp inner limit of the outer belt's most energetic electrons, near L = 2.8 [6 Ext. Data Fig. 4], which its discoverers called "almost impenetrable" and found is not a boundary in Earth's own field [6 Abstract]. It had given way before, in March 1991 and in the Halloween storms of 2003 [10 Abstract][7 Abstract]. See sections 2 and 5.

UNSUPPORTED

"Next-Level Pole Shift Data"

The episode's title, which sets it beside the breach without saying which item it describes [2]

Neither of the episode's two linked sources backs it. This paper's full text and its 57 references say nothing about the field's weakening, the magnetic poles or an excursion, and the one long-term change in the inner belt it mentions, it has to the solar cycle [1 [S1.1]]; nor do the AMOC preprint and the article about it (our check). The authors put the breach down to the storm, which eroded the dense plasma that guards the barrier and, through a negative ionospheric storm, kept it thin, so that electrons were accelerated in place, likely by chorus waves [1 q4]. Between the breaches of 1991, 2003 and 2024 and the years when the barrier held, the dipole changed by only 0.4–1.8%, by our calculation from IGRF-14 [S1], and storms doesn't grow as the field weakens [7 Abstract]. See section 7 and our guide to the field.

TRUE

"the May 2024 superstorm rapidly generated multi-MeV electrons deep inside the inner magnetosphere"

The paper's abstract [1 p. 1]

The full text gives the numbers. In Arase's data the flux of 3.128 keV electrons at $L^* = 3$ rose more than 5,000-fold, to about 10^6 at $L^* = 2.5$ and 5×10^6 at $L^* = 3.0$ per cm² sr s keV; the 692 keV flux rose first, the 1,093 keV flux about half a day later and the 3.128 keV flux about a day after the first [1 [S1.3]]. Nothing comparable appears in Arase's record since 2017 [1 [S1.1]]. Spacecraft in low orbit saw related populations [15 Abstract][16 Abstract]. See section 3.

TRUE

"Phase space density profiles reveal the development of a local maximum at $L^* \approx 3$, providing evidence that local in situ acceleration established multi-MeV electron source before supplying inward and outward radial diffusion."

The paper's abstract [1 p. 1]

In the early recovery phase a peak in phase space density grew near $L^* \approx 3$, for electrons of about 2–3 MeV [1 q3.4], and, as the authors write, inward transport from outside "cannot by itself produce a growing local maximum" [1 q4]. Their key points say chorus waves did the accelerating [1 p. 1]; the evidence is chorus that persisted for days at $L^* \approx 3$ on the dawn side, in plasma whose density had fallen, with estimated resonant energies of about 1.5–2.5 MeV, which the paper calls "consistent with chorus-driven local acceleration" [1 [S1.5]], and it calls for modeling to weigh each process [1 q4]. A possible caveat: its L^* comes from the T505 storm-time model; [1 q1] built from storms no deeper than −300 nT, against −406 nT in May 2024, by our check [26 Abstract][24]. See section 4.

TRUE

"revealed for the first time in the world that relativistic electrons were newly accelerated within a region of Earth's radiation belts previously thought to be an 'impenetrable barrier'"

ISEE, Nagoya University, in its English news item on the paper [4]

As a direct measurement in space, near the equator, it is the first we found, and the paper says as much: "This is the first observation of such a process within the impenetrable barrier" [1 [S1.4]]. The Japanese release says it summary makes the same claim as the English item, while its key points and outlook say first by direct observation [5 p. 1][5 p. 3]. But acceleration inside the barrier region was not new to science: for the Halloween storms of 2003, a model showed waves at L ≈ 3 building a new belt of electrons above 3 MeV in the normally empty slot [9 Abstract], a precedent the paper itself recalls, presenting May 2024 as "direct observational evidence" for it [1 [S1.1] q4]. And for May 2024, Mev/cm² s sr MeV/nucleon; CIRBE's Mev electrons inside the barrier had been announced by CIRBE's team in July 2024 [6a] and reported in February and December 2025 [15 Abstract][16 Abstract]; the second study, with Arase data and ten of the paper's authors, already counted local acceleration among the steps [15 Abstract][1 [S1]]. See section 5.

1 · THE PAPER

Arase watched multi-MeV electrons appear inside the barrier, and a growing peak says they were made there

Twenty researchers from Japanese universities and institutes, Kyung Hee University and GFZ Potsdam, among them the Arase mission's project scientist and project manager, report what the satellite saw in the inner belts during the May 2024 superstorm [3][1]. The paper is peer reviewed and open access. We first checked it from its abstract, on 29 October 2026, and revised this page against its full text on 30 October, when the site's owner supplied it [1].

What the authors did

They used Arase's XEP instrument, "which measured the electron fluxes in the 0.5–4 MeV energy range", its magnetometer, and its plasma-wave instrument, which gave both the chorus waves and, from the upper hybrid resonance, the plasma's density [1 q3]. From the fluxes they computed phase space density at fixed M = 887.8 MeV/G and $K = 0.14\ G^{1/2}R_E$, electrons of about 2–3 MeV at $L^* = 3$ [1 [S1] [S1.1] q3.4], with L* from the T505 storm-time field model, "to ensure accurate drift-shell mapping under storm-time conditions" [1 q3]. Phase space density counts the electrons that share the same three quantities fixing their motion in Earth's field, so that profiles at different distances can be compared like with like [23 Abstract].

The spacecraft and its data

Arase, a JAXA satellite launched in December 2016, flies between about 400 km and about 32,000 km on an orbit inclined about 31°, so that it "explores the entire region of the radiation belts" [24]. During the storm its apogee was on the noon side, so it crossed the inner belts on the dawn and dusk sides; the radial profiles come mostly from dusk-side passes, which met the paper's chosen K more often [1 §2]. The paper lists the versions of the seven Arase data sets it used, which are public [1 p. 9][36], and its authors declare no conflicts of interest [1 p. 9].

The paper's case and its caveat, in the authors' words

("*" is a measure of distance from Earth, in Earth radii at the magnetic equator, that follows the electrons' drift through the field.

> *"Arase observations show that chorus waves locally accelerated electrons to multi-MeV energies deep inside this barrier in May 2024"*
>
> Miyoshi et al. (2026), Key Points (1 p. 1)

> *"…followed by a growing peak at $L^* \approx 3$ during the early recovery phase (Figure 3b), which is clear evidence of local in situ acceleration … This is the first observation of such a process within the impenetrable barrier."*
>
> Miyoshi et al. (2026) (1 §5.4)

> *"Deep plasmaspheric erosion from prolonged negative ionospheric storms and sustained chorus-wave activity appear to be key conditions enabling this acceleration, although further modeling is required to quantify the relative roles of radial transport, radial diffusion, local acceleration, and pitch-angle scattering"*
>
> Miyoshi et al. (2026) (1 §6)

WHAT WE READ

The full text

the version of record, 11 pages, supplied on 30 October by the site's owner, who downloaded it from the publisher; the page was first built from the abstract alone [1][2]

STATUS

Peer reviewed

received July 29, accepted September 18 and published October 26, 2026, in *Geophysical Research Letters* [3]

LICENCE

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so its figures may be adapted with credit, as its Fig. 3b is in section 6 [1]

OUR ANALYSIS

What the full text adds, and what it leaves out

It adds what the abstract lacked: the energies measured, from 0.5 to 4 MeV, and the field model, T505 [1 §2]; the size and order of the rise, and how long the electrons stayed, fading gradually until another severe storm in October 2026 [1 p. 3]; and the energy of the electrons the paper, about 2–3 MeV [1 q3.4], is now nothing about the field's long-term change, the poles, the South Atlantic Anomaly or an excursion, and none of its 57 references is about them; the one long-term change in the inner belt it mentions, it ties to "cosmic ray albedo neutron decay modulated by the solar cycle" [1 [S1]].

2 · THE BARRIER

An edge seen for 20 months, "almost impenetrable", and not a boundary in Earth's field

In 2014 Baker and colleagues reported "an exceedingly sharp inner boundary for the ultrarelativistic electrons", those above five megaelectronvolts, at the inner edge of the outer Van Allen belt [6 Abstract].

Where it sits

NASA's twin Van Allen Probes saw it in "A 20-month overview of electron fluxes within the Earth's Van Allen radiation belts" [6 Fig. 1]: "right at the inner edge of the trapping boundary at L ≈ 2.8" [6 Ext. Data Fig. 4]. For 72 MeV electrons in September 2013 the belt reached from about 2.8 to 3.5 Earth radii, and "inside 2.8 R_E there is an almost complete absence of electrons, resulting in the slot region" [6 Ext. Data Fig. 5]. The inner zone held none at MeV energies: "No electrons >900 keV were observed with equatorial fluxes above background … in the inner zone" [12 Abstract].

What makes it

Not the field itself: the barrier "does not arise because of a physical boundary within the Earth's intrinsic magnetic field". Baker and colleagues suggested "exceptionally slow natural inward radial diffusion combined with weak, but persistent, wave-particle pitch angle scattering deep inside the Earth's plasmasphere" [6 Abstract]. Others explain the steep edge "as a natural consequence of ultra-low frequency wave radial diffusion", limited by how long the solar wind drives it hard [14 Abstract], or tie it to a bubble of radio waves from ground transmitters whose outer limit "closely matches the position of an apparent barrier to the inward extent of multi-MeV radiation belt electrons near 2.8 Earth radii" [13 Abstract].

Two gatekeepers, in the authors' release

The authors' Japanese release calls the barrier an unbreakable wall and explains it with two gatekeepers. Earth's strong field slows the electrons' approach from outside; and the cold, dense plasma of the plasmasphere makes another kind of wave, hiss, that soon drops any electrons that do get in into the atmosphere [5 p. 2]. In May 2024, the release says, it was the second gatekeeper that failed [5 p. 3] (section 3).

OUR ANALYSIS

What "impenetrable" means here

It names an edge seen in a geomagnetically quiet stretch: the 20 months Baker and colleagues studied [6 Fig. 1], whose deepest storm reached −132 nT on 17 March 2013 [34], and the storm of 17 March 2015, when it held near 2.8 Earth radii [13 Abstract], the deepest of 2012–2015 at −234 nT [34]. Its discoverers called it "almost impenetrable" [13 Abstract] and "exceedingly sharp" [6 Abstract]. The paper's abstract calls the whole inner belt, $L^* < 3$, the barrier and says it "has long been considered" impenetrable [1 p. 1]; its introduction is more careful, calling the region "generally regarded as stable and containing few ultra-relativistic electrons, even under disturbed conditions", and it recalls 2003 [1 §1]. In Arase's own record since 2017, "MeV electrons were largely confined outside $L^* \sim 3$", and no other storm put comparable numbers inside it [1 §3.1]. The region is normally empty of such electrons [32 Abstract], but the name dates from 2014, and extreme storms had crossed it before it had one (section 5).

3 · MAY 2024, STEP BY STEP

The storm emptied the belts, pushed the dense plasma down to L ≈ 1.5 and kept it thin while chorus waves worked

A shock reached Earth at 17:05 UT on 10 May; at 02:00 UT on 11 May the storm reached −412 nT in the real-time Dst, "the second-largest storm since 1957" [13 p. 2], or −406 nT in Kyoto's provisional index [34]. The solar wind's density and speed exceeded 60 per cm³ and 1,200 km/s, and its magnetic field turned south by more than 44 nT [1 §3.2]. Our check of the May 2024 aurora has the storm's causes.

STEP 1

The belts emptied

The storm pushed the magnetopause in to about 4.9 Earth radii, "likely leading to rapid loss of outer belt electrons through magnetopause shadowing" [1 §3.2]. In the main phase, Arase saw "relativistic electron fluxes dropped by several orders of magnitude" [19 Abstract], and refilling took more than twice as long as in typical storms [1 §3.2]. Another study, with eight of the same authors, saw chorus at "unusually low L-shells near the earthward-displaced inner edge of the outer radiation belt" [22 Abstract].

STEP 2

The dense plasma shrank to L ≈ 1.5

Arase's density measurements put the plasmapause below $L^* \approx 1.5$ [1 §3.3]; "the plasmasphere contracted from L ~ 7.0 to L ~ 1.5 within 9 h after a sudden commencement", a related study found [21 Abstract]. With it went the hiss that guards the barrier, which before the storm filled a plasmasphere reaching $L^* \sim 5$ [1 §3.3] (section 2).

STEP 3

Chorus inside the wall

In the main phase "strong lower-band chorus emissions appeared between $L^* \approx 1.5$ and 3.5", and in the recovery "intense chorus activity persisted for several days at $L^* \approx 3$, where a growing PSD peak was observed", on the dawn side only [1 §3.5]. The density at $L^* \approx 3.0$ fell from several hundred to below about 200 electrons per cm³, and refilling took more than twice as long as in typical storms [1 §3.2]. Another study, with eight of the same authors, saw chorus at "unusually low L-shells near the earthward-displaced inner edge of the outer radiation belt" [22 Abstract].

STEP 4

A source inside, spreading both ways

The 692 keV flux rose first, the 1,093 keV flux about half a day later and the 3.128 keV flux about a day after the first, which the authors read as "gradual local energization from sub-MeV to multi-MeV energies over roughly one day" [1 §3.2]. Phase space density grew a peak near $L^* \approx 3$ in the early recovery phase, then flattened as the electrons spread inward and outward [1 §3.4]. The plasmasphere recovered "on a 4-day scale", much more slowly than in other storms driven by coronal mass ejections in the Arase years, which a study with eleven of the same authors ties to a strong negative storm in the ionosphere [35 Abstract].

The authors' three stages

The release sums up the event in three stages. Before the storm, the belt lies outside the wall and there are no chorus waves. As the storm begins, the plasmasphere shrinks sharply and strong chorus starts just outside the wall. In the recovery phase, with the plasmasphere's return held back by the disturbed ionosphere, the chorus persists, ultra-high-energy electrons are newly made inside the wall, and they spread inward and outward [5 p. 3]. The paper's Fig. 5 shows the same three stages [1 Fig. 5]; the release's drawing belongs to the ERG science team and is not reproduced here.

4 · MADE IN PLACE?

A growing peak in phase space density is the accepted test, with a possible caveat for a storm this deep

Electrons carried inward from outside give a phase-space-density profile that rises steadily outward; electrons accelerated in place make a peak that grows where the acceleration happens [24 Abstract]. Arase recorded such a peak, growing near $L^* \approx 3$ [1 §3.4].

A peak grows at the barrier's edge: phase space density along five passes of Arase

Adapted from Fig. 3b of Miyoshi et al. (2026), CC BY 4.0 (1 Fig. 3). Five of its ten radial profiles of phase space density, for electrons with M = 887.8 MeV/G and $K = 0.14\ G^{1/2}R_E$, about 2–3 MeV at $L^* \approx 3$ (1 §3.4), with L* from the T505 field model (1 §2). We traced the curves from the figure's own drawing coordinates in the published PDF and placed them on its axes by its grid lines. Only the figure's labels were read by eye, its tick values and each pass's time window; no value on a curve was. Times are UT, 2024; "later" counts from the main-phase pass. The shading marks the paper's barrier, $L^* < 3$. All ten profiles are in the file in section 6.

OUR ANALYSIS

What the traced curves show

At $L^* = 3.0$ the density was about 3×10^{-10} in the main phase, early on 11 May; about 3×10^{-9} ten hours later, when a peak of about 4×10^{-9} sat at $L^* \approx 2.85$, inside the barrier; and about 1×10^{-9} a day later, with the peak near $L^* \approx 3.1$ (1 Fig. 3). That is a rise of more than 3,000 times in a day, in our reading of the traced curves. Before the storm the profile rose outward, the mark of electrons supplied from outside, and by 15 May it was flat, which the authors read as the peak's electrons spreading inward and outward, perhaps joined by electrons diffusing in from higher L (1 §3.4).

The test

In the authors' words, inward transport "can modify the PSD gradient, but it cannot by itself produce a growing local maximum" [1 §4]. Transport toward Earth "produces monotonic gradients in phase space density (PSD)", while acceleration by waves "produces radially localized growing peaks in PSD"; in the Van Allen Probes years, "87% of the enhancement events" in the outer belt showed growing peaks [24 Abstract]. The same reading has found electrons heated in place to 7 MeV; "By considering the evolution of phase space density peaks in magnetic coordinate space, we observe distinct signatures of local acceleration and the subsequent outward radial diffusion of ultra-relativistic electron populations" [25 Abstract].

Why chorus, and why thin plasma

Plasma waves carry electrons to multi-MeV energies only when the plasma is thin; in one storm, "such acceleration is achievable only under extremely low plasma density conditions" [36 Abstract]. In 2003 too, "Compression of the plasmasphere during the main phases of the storm created preferential conditions for local acceleration during interactions with VLF chorus" [9 Abstract]. In May 2024 the plasmasphere was pushed in to $L \approx 1.5$ [25 Abstract], and the ratio of the plasma frequency to the gyrofrequency fell from about 9–16 before the storm to about 2.7–3.4 in the recovery, "favorable for chorus interactions with relativistic electrons" [1 q4.1]. For chorus at 0.3 of the gyrofrequency the authors estimate resonant energies of about 1.5–2.5 MeV, overlapping the 2–3 MeV electrons of the peak [1 §3.3]. Another study, with eight of the same authors, saw the low-L chorus and concluded: "Quantifying whether such chorus activity also contributes to local acceleration or slot filling requires future evaluation" of the waves, the plasma, diffusion coefficients and timescales [22 Abstract]. This paper takes a first step, estimating resonant energies, but computes no diffusion coefficients [1 §3.5].

OUR ANALYSIS

A possible caveat: a field model beyond its storms

Turning measured fluxes into phase space density "requires adoption of a magnetic field model", and "Phase space density estimates have, in the past, produced contradictory results because of limited measurements and field model errors" [23 Abstract]. The paper took its L^* from the T505 model "to ensure accurate drift-shell mapping under storm-time conditions", and mapped pitch angles to the equator with "a geomagnetic field model" it does not name [1 §2]. T505 is a model of strong storms, built "using space magnetometer data taken during 37 major events in 1996–2000", its curators "assumed to saturate during extremely large storms", and "only 3.7% of those data came from distances 2.5 ≤ R ≤ 4 R_E", the distances that matter here [38 Abstract]. The deepest storm of 1996–2000 reached −300 nT, on 16 July 2000, against −406 nT in May 2024, in Kyoto's index [34]. The paper reports no test of its peak with another field model, though Arase's orbit files offer new data (section 6).

5 · NOT THE FIRST TIME

The barrier gave way in 1991 and 2003, and in 2024 other spacecraft saw it go

Before it had a name, extreme storms had put electrons inside L ≈ 2.8 by two different routes: electrons above 15 MeV in 1991 [10 Abstract], and a new belt of multi-MeV electrons in 2003 [7 Abstract][9 Abstract].

March 1991: a shock

"On 24 March 1991 instrumentation aboard CRRES observed the almost instantaneous injection of electrons and protons with energies above 15 MeV into the L-region 2 < L < 3" [10 Abstract], with "the strong SSC of 24 March 1991", the storm's sudden commencement [31]. Another satellite found their remnants near L ≈ 1.9 from July 1992, fading with an "e-folding lifetime … in the range of six to twelve months" [11 Abstract].

Halloween 2003: waves

"From 1 to 10 November, the outer belt had its centre only ~10,000 km from Earth's equatorial surface", about L 2.6 by our conversion, and "The region between the belts became the location of high particle radiation intensity" [7 Abstract]. The belt "was depleted and then re-formed closer to the Earth", its electrons "accelerated more effectively by electromagnetic waves at frequencies of a few kilohertz" than by radial diffusion [8 Abstract]. A model put the acceleration at L ~ 3, in "a new radiation belt which is formed in the slot region normally devoid of high energy electrons" [9 Abstract]. The paper recalls 2003 as seen only from low orbit, with chorus measured only beyond L = 4, so that transport could not be told from local processes [1 §1] [9 §4].

May 2024: from low orbit

The Macau Science-Satellite-1 saw electrons above 1 MeV enter the inner belt just after the storm's peak and spread to L of about 1.5 within seven days; the barrier "has been significantly violated" [15 Abstract]. NASA's CIRBE found "two new radiation belts containing 13–15 MeV electrons around L ≈ 2.35–3.5 and 6.8–20 MeV protons around L ≈ 2" [16 Abstract], and PROBA-V found that "For the first time, four electron belts were observed during several weeks" [16 Abstract]. The paper cites the first two, describing CIRBE's result as MeV electrons "extending down to $L^* \approx 2$" [1 §1], where CIRBE's abstract gives L ≈ 2.5–3.5 for its new electron belt [16 Abstract]; it does not mention 1991 or PROBA-V.

Where the electrons were, by L shell and height above the equator

Drawn by Fact-Checked Science from numbers in the cited texts; no figure is reproduced. 2013: [6 Ext. Data Fig. 5]. 1991: [10 Abstract][11 Abstract]. 2003: [7 Abstract], its 10,000 km converted to L by us. The plasmasphere: [15 Abstract]. Arase: [1 p. 1] [1 §3.2] [1 q4]. MSS-1: [16 Abstract]; CIRBE: [16 Abstract][15]. The sources use different measures, Baker's L, the paper's L* and the L shells of satellites in low orbit, which agree in a quiet field and differ in a greater one, mainly in the paper's stretch to 3 R$_E$ and the paper's L* ≈ 3 phase the same edge. Heights are for a dipole field, L = 1 → 6,371 km above the equator, rounded (our analysis).

OUR ANALYSIS

A world first? Partly

ISEE's English news item says the team "revealed for the first time in the world" that electrons were newly accelerated inside the barrier [4]. What is new is the measurement: phase space density taken in space, near the equator, through the storm, "the first observation of such a process within the impenetrable barrier", as the paper puts it [1 §1.4], where the 2003 increase was seen from low orbit [9 p. 2][1 §4]. The Japanese release says both its summary makes the same unqualified claim, while its key points and outlook say first by direct observation [5 p. 1][5 p. 3]. The idea is older: for 2003, waves acting at L ≈ 3 were modelled building a new belt in the slot [9 Abstract][19 Abstract], and the paper presents May 2024 as "direct observational evidence" for that process [1 §4]. And for May 2024 the breach itself was reported first, from low orbit: by CIRBE's team, announced in July 2024 [6a] and published in February 2025 [16], and by MSS-1's, with Arase data and ten of this paper's authors, in December 2025 [15], which already counted local acceleration among the steps [15 Abstract][1 §1].

6 · HOW LONG THEY STAYED

Arase saw the electrons fade slowly until a storm in October 2024; CIRBE's new belt lasted more than three months

In Arase's data, "the ultra-relativistic electron flux in these low-L-shell regions exhibited a gradual decay until October 2024, when another severe geomagnetic storm occurred" [1 §3.3], about five months after the breach; that storm reached −333 nT on 11 October in Kyoto's provisional index [34]. How far in and how long the electrons stay inside the wall, the authors' release leaves to future simulations [5 p. 4].

ARASE, THIS PAPER

About 5 months

a gradual decay of the 3 MeV flux inside $L^* \approx 3$ from May until the storm of October 2024 [1 §3.3]

CIRBE'S NEW BELT, 2024

3+ months

"previous temporary belts lasted around four weeks"; this one "lasted more than three months", NASA says [17]

PROBA-V, 2024

Weeks

"For the first time, four electron belts were observed during several weeks": the longer-lived protons stayed for months [16 Abstract]

THE 1991 ELECTRONS

6–12 months

their e-folding lifetime near L ≈ 1.9, tracked from July 1992 [11 Abstract]

What came next

In Arase's data the decay ran on until the October storm [1 §3.3]. By our reading, by eye, of the colours of the paper's Fig. 1a, the May electrons at $L^* \approx 2.7$ had faded to about their pre-storm level by early October, and the October storm brought a smaller rise just inside $L^* \approx 3$ [1 Fig. 1]. CIRBE's electrons "seemed unaffected until a magnetic storm on 28 June 2024, perturbed the region" [16 Abstract]. In NASA's words, "One such storm at the end of June significantly decreased the size of the new electron belt and another in August nearly erased the remainder of that electron belt, though a small population of high-energy electrons endured." CIRBE itself was silent from 15 April to 15 June 2024, so it missed the storm [17].

Why it matters

The release counts these electrons among the space radiation that can damage satellites [5 p. 1], and NASA notes that spacecraft bound for geostationary orbit cross the belts several times on the way [17]. For a storm stronger than 2003's, a model foresaw electrons in the heart of the inner zone, where "strong fluxes may persist for several years after such a storm", which would "substantially decrease satellite lifetimes at LEO" [27 Abstract]. The electrons stay trapped thousands of kilometres up; those that ran into the atmosphere spend their energy far above the ground, where they destroy ozone (our check of the 2025 radiation storm: the Sun's extreme particle storms).

7 · POLE-SHIFT DATA?

Storm data, not pole-shift data: the field barely changed between the breaches

50 News titled the episode "Impenetrable Barrier Breached–Next-Level Pole Shift Data" [2], without saying which of its two linked items the second describes. This paper's full text and its 57 references say nothing about the field's weakening, the magnetic poles, the South Atlantic Anomaly or an excursion; its authors put the breach down to the storm, its strong convection and a negative ionospheric storm [1 §4], and so does their release [5 p. 4]. The episode's other link, a news article on a project about the Atlantic overturning, mentions none of them either (our check).

The breaches, the storms and the field

WHEN	MULTI-MEV ELECTRONS INSIDE L ~ 2.8?	STORM'S LOWEST DST	DIPOLE MOMENT, 10²² A · m²	MAY 2024 WEAKER BY
March 1991	Yes: above 15 MeV, injected into 2 < L < 3 [10 Abstract]	−298 nT	7.83	1.8%
Halloween 2003	Yes: a new belt in the slot [7 Abstract], above 3 MeV [9 Abstract], seen inside the wall from low orbit [9 p. 2]	−383 nT	7.77	1.0%
2012–2015	No: the barrier held in the 20 months studied and in the storm of 17 March 2015 [1 Fig. 1][13 Abstract]	−234 nT, 17 March 2015, the deepest of 2012–2015	7.72–7.73	0.4–0.5%
May 2024	Yes [1 §3.2][15 Abstract]	−406 nT, provisional	7.69	—

Our analysis. Dst: Kyoto's hourly index, final to 2020 and provisional for 2024 [34]; Mev 2024 marked −412 nT in real time [29 p. 2]. Dipole moment: IGRF-14, interpolated between the five-year values our guide computed [36]; the 2012–2015 row spans mid-2013, the middle of the 20 months behind the barrier's discovery, and 17 March 2015. The script is in section 6.

OUR ANALYSIS

What the tables shows

Between these storms the dipole changed by 0.4–1.8%; the storms differed far more. The barrier held through −234 nT and gave way at −298, −383 and −406 nT. Four storms make an illustration, not a law, and depth is not the whole story: the 1991 electrons came in with a single shock [11], and in Arase's record, whose deepest storm before May 2024 reached −213 nT, no other storm, not even October 2024's at −333 nT, produced a comparable rise inside $L^* \approx 3$ [1 §3.1][34]. From the start of the record, in March 2017 to May 2024 the dipole weakened 0.3% by our calculation [36]. Nothing in the record, or in the paper and its references, ties the breach to the field's weakening, and the only long-term change in the inner belt it mentions, it ties to the solar cycle [1 §1]; nor does the AMOC preprint and the article about it (our check). The authors put the breach down to the storm, which eroded the dense plasma that guards the barrier and, through a negative ionospheric storm, kept it thin, so that electrons were accelerated in place, likely by chorus waves [1 q4]. Between the breaches of 1991, 2003 and 2024 and the years when the barrier held, the dipole changed by only 0.4–1.8%, by our calculation from IGRF-14 [S1], and storms doesn't grow as the field weakens [7 Abstract]. See section 7 and our guide to the field.

8 · REPORT OUR NUMBERS

A script for our numbers, and the profiles traced from the paper's Fig. 3b

The script reads the IGRF-14 dipole series our guide publishes, interpolates it to the storms' dates and converts L shells to height. The dipole moment, the Kyoto's, within rise to with their dates [36][34]. The CSV file holds all ten profiles of the paper's Fig. 3b, traced from its drawing coordinates [1 Fig. 3].

PY **barrier_numbers.py**

The dipole moment at six dates, how much weaker it was in May 2024 and the height of each L shell, recomputed; the storms' Dst minima, listed as constants; and one number the page does not quote, the L shell of the release's 12,000 km; Python standard library only · 5 KB

CSV **fig3b_profiles.csv**

The ten radial profiles of phase space density in Fig. 3b of the paper, traced from the figure's drawing coordinates, with each pass's time window; adapted from [1 Fig. 3]. CC BY 4.0 · 11 KB

Run it

```
python3 barrier_numbers.py fetches the guide's numbers file from this site and says whether it matches the
version used here; python3 barrier_numbers.py magnetic-field-guide-numbers.json uses a copy you
downloaded.
```

9 · LIMITS

What this check could and couldn't see

First built from the abstract

This page was built on 29 October 2026 from the paper's abstract, when its text set behind the publisher's human-verification check, and revised on 30 October against the full text, which the site's owner supplied [1][1].

No transcript

The episode's own words could not be checked: we rate only its title and its label on the link to the paper [2].

No Arase data on this page

The mission's rules ask users to "contact instrument PI Mizuno, Project Manager (PM), and Project Scientist (PS) before using the data for any presentation and publication", and say "Redistribution of the data files is strictly prohibited" [41]. The agency's policy is that "open data can be used free of charge, either for commercial or non-commercial purposes" [42], but the election filled work of contamination from penetrating particles [36]. So we neither charted nor re-analysed the data files; the chart in section 4 redraws the paper's own figure, under its licence [1].

Numbers from abstracts

Every figure from the other studies of May 2024, of 1991 and of 2003 comes from their abstracts; PROBA-V's weeks and the 1991 electrons' lifetime among them [16 Abstract][11 Abstract]; CIRBE's three months come from NASA's news story [17].

What would change these verdicts

01
A test of the peak with another field model, such as the T89 or OP77Q L^* in Arase's own orbit files [36], or a simulation of the storm, which would test claim 4.

02
A study of the storm finding that the peak disappears in another storm-time field model, or that the electrons were carried in from outside, which would change claim 4.

03
The episode's transcript, which could tie "Next-Level Pole Shift Data" to one of its sources to this paper, which would make claim 2 Misread, or to another subject, or a published disprovers of the barrier on the dipole's strength large enough to matter at 1–2%.

OUR ANALYSIS

Bottom line: a real breach, in a rare storm, made from the inside, and nothing to do with the field's slow decline.

Multi-MeV electrons did appear inside the radiation belts' barrier in May 2024, more than 5,000 times as many as before at 3 MeV, as Arase recorded [1 §3.1], while spacecraft in low orbit saw related populations [15 Abstract][16 Abstract]; the paper's growing peak points to acceleration in place, likely by chorus, with the field model as the open question [1 §1.4] [1 q4]. The barrier had given way in the great storms of 1991 and 2003 [10 Abstract][7 Abstract], under a dipole 1–2% stronger than in 2024 [36]; the paper and its release put this breach down to the storm, and neither the paper nor its references say anything about the field's weakening [1 §4].

Related checks

FALSE **More auroras from less solar input?** The Disaster Cycle, Fact-Checked

UNSUPPORTED **A magnetic pole flip in the 2040s?** The Disaster Cycle, Fact-Checked

Sources

Numbered numbers refer to this list. For the paper [1], read in full, gives a page of the version of record, 5 a section and Fig. a figure; its key points, abstract and plain-language summary are on p. 1. The page was first built, on October 29, 2026, from the abstract its publisher supplied with Crossref [3], and revised against the full text on October 30. For the episode [2] the transcript was available we read its title and the links and labels in its description, and quote nothing else of it. For the press release [5], in Japanese, gave a page of its PDF, we summarized it in our own words, and quote only its English news item [4]. For the other sources, gave a page, Fig. a figure, Ext. Data Fig. an Extended Data figure and Abstract the abstract of the cited work; where only an abstract was read, the entry says so. L is the McIlwain L shell and L* Roederer's L*; both in Earth radii at the magnetic equator. Times are UT. Years are those of the printed issue where there is one, otherwise of online publication. Links checked October 30, 2026.

1. Miyoshi, Y., Kurita, S., Shinbori, A., Yamamoto, K., Jun, C.-W., Matsuda, S., Saito, S., Kataoka, R., Wang, D., Shoudara, S., Takashima, T., Mitani, T., Higashio, N., Matsuoka, A., Kasahara, Y., Tsuchiya, F., Kasahara, A., Hori, T., Kitamura, N., and Teramoto, M. (2026) Rapid Acceleration of Multi-MeV Electrons Inside Earth's Impenetrable Barrier During the May 2024 Superstorm. *Geophysical Research Letters* 53(20), e2026GL125879. Received July 29, accepted September 18, published online October 26, 2026. Peer reviewed;