

Kugelblitz Jettison

Mathematics

The complete mathematical record of ARBOUR|05's final approach, drive jettison, and impact event. These numbers are the foundation of the crash history, the power grid document, and the formation of the debris field beneath and around Arbour. When in doubt, return here.

All figures calculated from first principles. Sources: Hawking (1974), Penrose (1965), standard relativistic mechanics.

A Note on Terminology

The Convergence is the entity itself — unknowable, eldritch, existing outside this reality entirely. It does not act with intent in any sense humans can interpret; it does not hold grudges, make plans, or choose targets. It simply *is*, in a way that occasionally presses against the boundary of this universe.

Aetheris is what happens *here* as a result — the phenomenon, the bleed-through, the physical and biological consequences felt in this reality. Aetheris can be measured, mapped, and exposed to. The Convergence cannot. Where this document refers to "Aetheris intensity" or "Aetheris exposure," it means the measurable, in-reality phenomenon. Where it refers to "the Convergence," it means the unknowable source on the other side of the boundary.

Overview

ARBOUR|05's destruction was not a single event. It was a cascade — each failure creating the conditions for the next, compressed into a timeline measured in milliseconds at its fastest and minutes at its longest.

The cascade did not begin with an impersonal containment fault. It began with a man.

Dr. Jian Wei had concealed the extent of his own Aetheris affliction, acquired during the voyage, from everyone aboard ARBOUR|05 — possibly, in its early stages, from himself. By the time the affliction reached the point of compromising his judgment and autonomy, nobody around him

understood what was happening until it was already happening. At the moment containment failure became inevitable, it was Wei who destabilised the Kugelblitz's magnetic containment field.

The engineers had 21 seconds from that point. They used them correctly. That is why anyone survived.

It ended when 4.3 kilotons of antimatter annihilation permanently widened a cluster of the Penumbran Reach's reality tears and scattered ARBOUR|05's wreckage across an unremarkable stretch of Cordis — terrain with no prior significance, no name, nothing to mark it as special before the ship came down. Arbour was built where it crashed, not the other way around.

Part One — The Kugelblitz Drive

What It Was

ARBOUR|05's primary propulsion system was a Kugelblitz — a microscopic black hole formed from ultra-concentrated radiation and maintained in a macro-Penning trap using intense electromagnetic fields. The black hole was kept from evaporating by active feeding of matter and high-energy laser inputs during the voyage, its mass carefully managed to provide controlled Hawking radiation thrust.

The Kugelblitz was the only propulsion system capable of accelerating a vessel of ARBOUR|05's mass to the relativistic speeds required for a journey to KOI-8565 within a human-relevant timeframe.

Parameters at Jettison

At the moment containment failure became inevitable, the Kugelblitz had been partially fed-down from its cruise mass in preparation for deceleration. Its terminal parameters at jettison were:

Parameter	Value	Notes
Terminal mass (M)	2.28×10^5 kg	228 tonnes — partially depleted from cruise mass
Schwarzschild radius	$\sim 3.38 \times 10^{-22}$ m	Sub-nuclear — smaller than a proton by 6 orders of magnitude
Hawking temperature	5.38×10^{17} K	~ 34 billion times hotter than the sun's core
Hawking luminosity	6.85×10^{21} W	Power output at moment of jettison

Parameter	Value	Notes
Evaporation timescale	~1.0 seconds	Time from jettison to complete evaporation
Total burst energy (Mc ²)	2.05 × 10 ²² J	4.9 billion kilotons TNT equivalent

The Hawking Temperature Calculation

$$T = \hbar c^3 / 8\pi GMk$$

Where:

- $\hbar = 1.0546 \times 10^{-34}$ J·s (reduced Planck constant)
- $c = 2.998 \times 10^8$ m/s
- $G = 6.674 \times 10^{-11}$ m³ kg⁻¹ s⁻²
- $M = 2.28 \times 10^5$ kg
- $k = 1.381 \times 10^{-23}$ J/K

Result: T = 5.38 × 10¹⁷ K

At this temperature the Kugelblitz was radiating across the full electromagnetic spectrum with peak emission well into the gamma-ray range. The containment fields were managing this radiation for thrust. When those fields failed — destabilised by Wei — 2.05 × 10²² joules of energy was released in approximately one second.

Part Two — The Ship

ARBOUR|05 Dimensions

Parameter	Value	Notes
Ship length	3,200 m	City-seed configuration — longer than any structure on Earth
Ship beam (width)	420 m	
End-on cross-section	~138,544 m ²	Circular profile — presented to burst by perpendicular jettison

Parameter	Value	Notes
Original mass	$\sim 4.5 \times 10^8$ kg	Fully laden with complement, colonisation equipment, and fuel. Read as dry/structural mass, not total launch mass — see <i>Interstellar Navigation and Fuel Mathematics, Part Three</i> , for the full reinterpretation and the much larger total launch mass figure ($\approx 2.65 \times 10^{10}$ kg), which implies once the full voyage's fuel consumption is accounted for.
Impact mass	$\sim 2.7 \times 10^8$ kg	$\sim 60\%$ structural mass remaining post-cascade

Reactor Configuration

The five antimatter-catalysis fusion reactors were distributed along ARBOUR|05's longitudinal axis, with the drive section aft and the command and colonisation sections forward. This distribution determined which reactors survived.

Reactor	Location	Post-Jettison Status	Reason
R1	Forward — Frame 12	Fully functional	Shielded by ship mass from burst vector
R2	Forward — Frame 28	Fully functional	Shielded by ship mass from burst vector
R3	Mid — Frame 67	Partially functional	Partial shielding — took edge of EM surge
R4	Aft — Frame 112	Destroyed	Direct EM cascade exposure — containment failure
R5	Aft — Frame 134	Destroyed	Direct EM cascade exposure + residual antimatter detonation on impact

Part Three — The Jettison Event

The Mission Specification Figure — 40.4 km

ARBOUR|05's mission specifications, Section 7.4.2 — Emergency Drive Jettison Protocols, defined the minimum safe separation distance for drive jettison as 40,400 metres (40.4 km).

This figure was calculated for a specific scenario: controlled, planned jettison of a fully evaporated drive assembly — a drive that had already been fed down to minimal mass and whose burst energy would therefore be orders of magnitude smaller than a live Kugelblitz.

It was not calculated for emergency jettison of a live Kugelblitz at terminal cruise mass, destabilised mid-voyage by sabotage no one had been able to name in time.

At 40.4 km, the energy received by the ship's hull from a 2.05×10^{22} J burst would have been:

$$E_{\text{received}} = E_{\text{total}} \times A_{\text{ship}} / (4\pi r^2) = 2.05 \times 10^{22} \times 138,544 / (4\pi \times 40,400^2) = 1.38 \times 10^{17} \text{ J} = 33,084 \text{ kilotons}$$

The ship would not have survived. The 40.4 km figure was, in the context of what actually happened, meaningless.

Every engineer on ARBOUR|05 who understood the drive systems knew this.

What the Engineers Needed

To reduce hull impact to approximately 50 kilotons — severe damage, catastrophic to the aft section, but survivable for the forward hull — the required separation distance was:

$$r = \sqrt{(E_{\text{total}} \times A_{\text{ship}} / (4\pi \times E_{\text{target}}))} = \sqrt{(2.05 \times 10^{22} \times 138,544 / (4\pi \times 2.09 \times 10^{14}))} = 1,039,220 \text{ m} \approx 1,039 \text{ km}$$

They needed 1,039 kilometres of separation. With the drive assembly fired on maximum thruster burn at approximately 50,000 m/s relative velocity, achieving 1,039 km of separation required:

$$t = r / v = 1,039,000 / 50,000 = 20.8 \text{ seconds}$$

They had 21 seconds.

The Jettison Sequence

The drive assembly was fired perpendicular to ARBOUR|05's trajectory — maximising separation distance while minimising the end-on cross section presented to the burst. The perpendicular geometry meant the ship's circular end profile (138,544 m²) faced the burst rather than its broadside profile (~1,344,000 m²), reducing received energy by approximately 90%.

The engineering team held containment together for the full 21 seconds — fighting a destabilisation they did not yet understand the cause of. Then they fired the jettison bolts.

Jettison parameters achieved:

Parameter	Value
Separation at burst	1,039 km
Ship orientation	End-on to burst vector
Hull energy received	2.09×10^{14} J (50 kilotons)
Burst energy intercepted	0.000001% of total
Equivalent to	3.3 × Hiroshima

Part Four — The Electromagnetic Cascade

The burst reached ARBOUR|05's hull 3.47 milliseconds after jettison at the speed of light. What followed was a cascade measured in fractions of a second:

T + 0.000s — Burst EM wavefront reaches aft hull. ~50 kt energy absorbed by hull and aft structure. Aft section structural failure begins.

T + 0.003s — R4 magnetic containment bottle destabilised. Antimatter fuel begins uncontrolled interaction.

T + 0.007s — R5 magnetic containment bottle destabilised.

T + 0.012s — R4 and R5 initiate parasitic power drain from R1/R2/R3. Emergency protocol: attempt bottle restabilisation. Forward reactors begin power drain cascade.

T + ~0.05s — In the chaos of the failing containment and the realisation, only now fully grasped, of what Wei had done and was continuing to attempt, a group of crew members — accounts from survivors are inconsistent and no single name can be confirmed in the historical record — moved to stop him. Wei was killed in the confrontation. The destabilisation he had triggered could not be undone. By the time he was stopped, the cascade was already several steps beyond any single point of intervention.

T + 0.089s — Forward manoeuvring thrusters lose power. Unable to compensate — thrust below minimum for orbital maintenance.

T + 0.091s — Navigation control systems offline. SEED navigation partition loses power — data loss begins.

T + 0.340s — R4 containment collapses. Partial antimatter annihilation event. Structural deformation propagates forward.

T + 0.341s — Emergency power conduits severed by structural deformation. R1/R2/R3 now isolated — no longer draining, but no longer supplying aft.

T + 0.342s — R5 containment collapses. Partial antimatter annihilation event.

T + 4.200s — Engineering crew regains partial control of R1/R2 output. Available thrust: ~18% of nominal. Assessment: insufficient to prevent descent.

With Wei dead and no one else attempting to direct the ship's trajectory, ARBOUR|05's descent from this point was genuinely uncontrolled — not steered toward any target, deliberate or otherwise. What happened next was a function of physics, not intent.

Part Five — The Descent

Profile

Parameter	Value	Notes
Descent type	Uncontrolled ballistic re-entry	Navigation offline; no one alive attempting to direct trajectory
Available thrust	~18% nominal	R1/R2 only, partially drained
Ship mass at re-entry	$\sim 2.7 \times 10^8$ kg	60% structural mass
Approximate orbital velocity	7,902 m/s	Cordis-equivalent orbital speed
Estimated impact velocity	~3,161 m/s	Partial atmospheric braking
Kinetic energy at impact	$\sim 1.35 \times 10^{15}$ J	~323 kilotons

The ship came down where the physics of an uncontrolled, partially-thrusted ballistic descent took it — not at a chosen or identified location. The site has no prior significance in any record, Penumbran or human. Arbour exists where it does because that is where the ship happened to stop, not because anyone, alive or dead, chose it.

Part Six — The Detonation and the Debris Field

R4 and R5 Residual Fuel

R4 and R5 had undergone partial annihilation events during the cascade at T+0.340s and T+0.342s. Their remaining antimatter fuel was partially contained within damaged magnetic bottles throughout the descent — unstable, degrading, but not fully annihilated.

Upon impact, the severing of the final emergency conduits caused simultaneous total containment collapse in both reactors. The remaining antimatter fuel annihilated completely.

Parameter	Value
Annihilation energy	1.80×10^{13} J
Kiloton equivalent	4.3 kilotons
Detonation type	Antimatter-matter annihilation
Location	Scattered impact zone — geologically unremarkable terrain, no prior name or significance

Reality Tear Interaction

The 4.3 kiloton annihilation detonation was not simply an explosion. It occurred within a region of the Penumbran Reach where reality tears — plural, scattered, none individually singular or pre-eminent — had been naturally present for millennia, the product of the Convergence's pressure against this reality's boundary in this part of the system.

The energy release interacted with the boundary conditions of the tears nearest the impact zone, permanently widening several of them. Aetheris intensity in the region increased by an estimated 340% in the immediate aftermath, based on data preserved in Wayfarer oral histories from the first four generations post-crash.

ARBOUR|05's wreckage became physically fused with the affected terrain at multiple points across the debris field — not embedded at one site but scattered and intertwined with the widened tears across the impact zone at a material level. There is no single location that can be called the crash site in any complete sense. There is only the debris field, and Arbour, built across and around it by people who did not fully understand what they were building on top of.

Part Seven — The 40.4 km Inscription

At some point between the jettison event and the impact — most likely in the chaos immediately following Wei's death, while the surviving crew were managing containment, the cascade, and what could still be salvaged of the ship's trajectory — someone went to the jettison control station and wrote on the bulkhead above it.

Three words and a number, in a hand that matched Chief Engineer [NAME — TBD through drafting]'s personnel file:

"40.4. We knew. Sorry."

What "we knew" refers to is deliberately ambiguous and should remain so. It may mean the engineers knew the 40.4 km mission-spec figure was inadequate for a live Kugelblitz. It may mean the crew knew, before the destabilisation, that something was wrong with Wei, and did not act in time. Both readings should remain available to a reader — the inscription does not resolve which failure it is confessing to, and possibly the person who wrote it didn't fully separate the two in their own mind either.

The chief engineer died in the impact event. Their body was recovered in the first weeks post-crash and is recorded in the founding generation's mortality log.

The inscription was found by a maintenance crew in the second generation. It was reported to the proto-Council. The report was received, noted, and filed under reference AZ-1-0003-I in the earliest Tabularium records.

It does not appear in any index. It can only be found if you already know the reference number.

The reference number AZ-1-0003-I appears in one place: a footnote in a founding generation engineering report that was misfiled in the biological sciences archive rather than the technical archive, where it has remained for centuries, uncatalogued, in the wrong section, waiting.

Wren finds it on a Tuesday.

Part Eight — What Humanity Did to the Penumbran Reach

This is the conclusion that the mathematics leads to and that no one in Arbour knows.

The Penumbran Reach's reality tears were natural — the product of KOI-8565's binary stellar dynamics and the Convergence's pre-existing pressure against this reality in the system. They were stable over millennial timescales. Dangerous, yes. Worsening, yes. But slowly.

ARBOUR|05's arrival changed that.

The Kugelblitz burst — 2.05×10^{22} joules, released first at jettison and then again at the scattered impact site — interacted with the boundary conditions of the region's reality tears in the same way the impact-site detonation did, but at a cosmic scale for the jettison burst specifically. The jettison burst energy was orders of magnitude larger than the impact-site annihilation. Its effect on the Penumbran Reach's reality tears, system-wide, was proportionally larger.

Aetheris intensity in KOI-8565 did not merely increase after ARBOUR|05's arrival. It accelerated. The timeline that would have unfolded over further millennia was compressed into centuries.

Aetheris on Cordis is not simply a natural consequence of the Penumbran Reach's instability. It is a consequence of humanity's arrival. The engineers who jettisoned the Kugelblitz saved everyone aboard the ship. In doing so, they wounded the fabric of the system they had arrived in.

They did not know this. They could not have known this. They had 21 seconds, and a crisis they had not chosen, caused by a man none of them had been able to see was no longer entirely himself.

The Convergence does not hold this against humanity. The Convergence does not hold anything against anything — it is not capable of holding, in any sense that word means to a human. It is simply pressing where it always presses, completing a process that humanity accidentally accelerated by arriving at all.

This is the truth that sits beneath everything in Arbour. Not the Council's lie about the Blight. Not Wei's affliction. Not the founding deception.

Humanity came to KOI-8565 and made things worse. Not out of malice. Out of desperation and physics and 21 seconds that weren't quite enough, and a sickness in one good man that nobody recognised until it was already steering the ship.

Wren will find this too. Eventually.

Summary Table — Key Numbers

Parameter	Value	Significance
-----------	-------	--------------

Kugelblitz terminal mass	2.28×10^5 kg	Determines all downstream calculations
Total burst energy	2.05×10^{22} J	4.9 billion kilotons
Hawking temperature	5.38×10^{17} K	~34B × solar core temperature
Evaporation timescale	~1.0 seconds	Burst duration
Mission spec safe distance	40.4 km	Irrelevant to actual event
Required safe distance	1,039 km	What they needed
Time available	21 seconds	What they had
Achieved separation	1,039 km	What they achieved
Hull energy received	50 kilotons	Cost of survival
EM cascade duration	0.342 seconds	R4/R5 destroyed; Wei killed within this window
Impact-site detonation	4.3 kilotons	Reality tears in the region permanently widened
Aetheris increase post-crash	~340%	Humanity's contribution
Survivors	~34% of complement	Because of 21 seconds

Open Questions for Drafting

- Open Questions for Drafting

Cross-reference: the 323 kt impact figure (Part Five) and the 4.3 kt annihilation figure (Part Six) have since been used to calculate actual debris-field and Aetheris-hot-zone radii — see Arbour City Geography, "Scale, now locked with real figures." The two events produce two different scales (broad debris scatter vs. a much smaller, localised Aetheris-intense annihilation point); worth checking that document before assuming either figure alone describes "the debris field" as a whole.

- Chief Engineer's name and species — the inscription needs a face
- Full passenger/crew complement of ARBOUR|05
- Exact cruise mass of the Kugelblitz at departure from Earth
- Journey duration and relativistic time dilation figures (see: Interstellar Navigation appendix)
- Whether any record of the Kugelblitz burst's effect on the Penumbran Reach exists in Wayfarer oral history — and whether Sage Yahari knows what it means
- ~"55 million times hotter than the sun's core" comparison~~ — **resolved**. This was a pure arithmetic error in the flavour text, unconnected to any other calculation in the document. The actual ratio between 5.38×10^{17} K and the Sun's core temperature ($\sim 1.57 \times 10^7$ K) is approximately 34 billion, not 55 million. Corrected in both the Parameters table and the Summary Table.

- **Wei's affliction concealment** — how did a man afflicted with Aetheris to a compromising, Stage Three/Four degree pass undetected aboard a ship presumably monitoring crew health closely? Was he hiding symptoms deliberately, in early stages unaware himself, or did something about command structure/trust mean nobody was positioned to flag it in time? Worth deciding, since it affects how sympathetic vs. culpable Wei reads in the historical record vs. however he's eventually depicted directly (flashback, found record, etc.)
 - **Who killed Wei** — left deliberately unattributed in the historical record per the chaotic-response decision, but worth knowing privately (even if it never appears on the page) whether this was crew acting in coordinated self-defence, a single unrecorded act lost to the chaos, or something else
 - **Does Wei know what's happening to him before the end** — a question with real weight for how tragic vs. how frightening this beat reads. Does he have any moment of horrified self-awareness, or is the affliction's takeover total by the time it matters?
-

Revision #8

Created 2026-06-19 08:38:19 UTC by Amari

Updated 2026-06-21 11:00:41 UTC by Amari