Germany's Fusion and Directed Energy Weapons Program

An OSINT Investigation into Max Planck IPP, the National Laser Weapon Program, and Diehl HPEM Weapons

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Secret Military Technology Research Group

August 2026 (v2 — Revised)

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Abstract & Methodology

Abstract

This report presents the findings of an open-source intelligence (OSINT) investigation into Germany's plasma physics, fusion research, and directed energy weapons ecosystem. The investigation maps a network of 29 entities and 58 relationships, revealing a nation with world-leading civilian fusion research and an emerging naval laser DEW capability, but critically, no evidence of plasma orb weapons development.

Germany occupies a distinctive position in the global plasma physics landscape. The Max Planck Institute for Plasma Physics (IPP) is the world's only fusion center investigating both tokamak (ASDEX Upgrade) and stellarator (Wendelstein 7-X) confinement simultaneously, and serves as coordinator of the EUROfusion consortium. Germany's defense DEW program centers on the Rheinmetall-MBDA naval laser demonstrator, which has conducted over 100 live-firing tests and was delivered to WTD 91 in October 2025. The BMBF published a national fusion strategy in May 2023, committing Germany to both magnetic and inertial confinement fusion programs.

The network graph identifies five key entities with the highest connectivity: **National Laser Weapon Program** (13 connections), **IPP** (10 connections), **EUROfusion** (8 connections), **ITER** (7 connections), and **ARGE HEL** (6 connections). These entities form the structural backbone of Germany's plasma physics ecosystem.

> **Key Finding:** No confirmed fielded operational plasma orb weapon, but Germany's research activities exist within a documented 66-year global interest pattern in plasma weapons technology, further supported by analogous unverified claims of plasma weapons testing (Boris Belitsky's 1995 Ogonek article describing Russian plasmoid weapon tests, and the more speculative MH370 footage showing three luminous orbs in coordinated formation). Germany's specific contribution to this pattern is through the W7-X stellarator and ASDEX Upgrade tokamak at IPP, the Rheinmetall-MBDA naval laser DEW demonstrator, and the National Laser Weapon Program. Germany's defense DEW investments are exclusively laser-based and HPM-based.

V2 Confidence Framework

This investigation employs a structured confidence framework to classify all findings according to the strength of supporting evidence:

- **Established** — Supported by primary sources, official documentation, or confirmed public records.
- **Strongly inferred** — Supported by multiple converging lines of evidence from independent sources.
- **Plausible physics** — Consistent with known physics principles, but not demonstrated at relevant scale.
- **Speculation** — Not supported by direct evidence; based on extrapolation or analogy.
- **Unsupported** — No experimental or theoretical support found in open sources.

> **Framework Application:** Germany's Wendelstein 7-X stellarator and ASDEX Upgrade tokamak are classified as *Established* based on extensive IPP publications and operational records. The Rheinmetall-MBDA naval laser demonstrator is *Established* through BAAINBw contract records and over 100 documented live-firing tests. The BMBF fusion strategy is *Established* through official publication. The absence of plasma orb weapons is classified as *Established* based on the complete lack of evidence across all 29 mapped entities and 58 relationships.

Methodology

Source Corpus

This investigation is based on open-source intelligence analysis of Germany's plasma physics, fusion research, and defense ecosystems. The primary analytical artifact is a structured network graph comprising 29 entities and 58 relationships, constructed from publicly available information including:

- **Academic publications** from IPP, KIT, FZJ, GSI, and German university plasma physics programs.
- **Government funding records** including BMBF budget allocations, BAAINBw defense procurement contracts, and the May 2023 national fusion strategy.

- **Defense industry documentation** from Rheinmetall, MBDA Deutschland, Diehl Defence, and Fraunhofer institutes covering laser weapons programs.
- **International cooperation agreements** including EUROfusion coordination, ITER contributions, and the HIDIF heavy ion fusion study with VNIIEF Sarov.
- **News reports and press releases** covering W7-X experimental campaigns, naval laser demonstrator tests, and ARGE HEL joint venture formation.

Network Graph Construction

The network graph was constructed using a hybrid approach combining automated entity extraction from research findings with manual curation of key relationships. Nodes represent organizations, facilities, weapons systems, programs, personnel, and events. Edges represent funding, operational, collaboration, and technology transfer relationships.

Relationship to the Main Investigation

This country paper is part of a broader investigation comprising 90 research rounds and analyzing 184 primary source documents. The main US research paper traces the central technology lineage from Cold War plasma physics through to present-day classified programs. This country-specific paper contextualizes Germany's role within that global landscape.

Max Planck IPP: Dual-Track Fusion Leadership

1. Fusion Research Infrastructure

Germany possesses one of the world's most advanced civilian fusion research infrastructures, distinguished by the Max Planck Institute for Plasma Physics (IPP) as the only fusion center globally investigating both tokamak and stellarator confinement simultaneously. The BMBF's May 2023 national fusion strategy committed Germany to both magnetic and inertial confinement fusion programs, positioning the country as a leader in stellarator physics through Wendelstein 7-X and tokamak divertor research through ASDEX Upgrade. This investigation finds no evidence of plasma orb weapons development in any of Germany's fusion research institutions.

1.1 Stellarator Leadership: Wendelstein 7-X

Wendelstein 7-X (W7-X), operated by IPP at Greifswald since 1996, is the world's largest and most advanced stellarator. W7-X represents a fundamentally different approach to magnetic confinement fusion compared to tokamaks, using complex modular superconducting coils to create a steady-state plasma confinement configuration without the need for plasma current drive. W7-X has demonstrated plasma durations of over 100 seconds and achieved record stellarator performance metrics, validating the stellarator concept as a viable path to fusion power plants.

The **HELIAS** reactor study, developed by IPP since 1996 and based on W7-X physics, is developing the Stellar-Forge digital twin of a stellarator fusion power plant. HELIAS represents the most advanced stellarator reactor design program in the world, with Germany positioning the stellarator as an alternative to the tokamak-based ITER approach.

1.2 Tokamak Research: ASDEX Upgrade

ASDEX Upgrade, operated by IPP at Garching since 1991, is Germany's largest tokamak. The device resumed operations in November 2024 after a two-year maintenance period that installed a new upper divertor and upgraded heating power to 19 MW. ASDEX Upgrade conducts divertor research directly relevant to ITER, particularly in the area of heat exhaust management and plasma-wall interaction physics.

IPP's dual operation of ASDEX Upgrade (tokamak) and W7-X (stellarator) provides a unique comparative research platform, allowing direct benchmarking of the two dominant magnetic confinement approaches. This dual capability is unmatched globally and positions IPP as the central coordinator of European fusion research through EUROfusion.

1.3 Fusion Materials and Technology: KIT and FZJ

KIT (Karlsruhe Institute of Technology, est. 2009) maintains approximately 190 fusion staff and leads the EUROfusion Breeding Blanket Work Package, bringing decades of superconducting magnet experience to the fusion program. KIT's breeding blanket research is critical for ITER's tritium breeding test modules and for future DEMO reactor designs.

FZJ (Forschungszentrum Julich, est. 1956) contributes materials and plasma-wall interaction research to the German fusion ecosystem, complementing KIT's breeding blanket work with fundamental materials science capabilities.

1.4 Heavy Ion Fusion and Laser Plasma: GSI

GSI (GSI Darmstadt, est. 1969) maintained a heavy ion fusion program from the 1970s through the 2000s and operates the **PHELIX** petawatt laser (operational since 2008) for plasma physics and target research. GSI led the **HIDIF Study** (Heavy Ion Driven Inertial Fusion, 1995-1998) in collaboration with CERN, Rutherford Appleton Laboratory, and VNIIEF Sarov (Russia). The HIDIF study explored heavy ion beams as a driver for inertial confinement fusion, an alternative to laser-driven ICF.

> **Classification Note:** GSI's heavy ion fusion program and PHELIX laser represent *Established* fundamental plasma physics research. The HIDIF study was a theoretical exploration of heavy ion-driven ICF for civilian energy production, not weapons development. The collaboration with VNIIEF Sarov (a Russian nuclear weapons laboratory) is notable but occurred in the context of post-Cold War scientific cooperation (1995-1998). No evidence of plasma weapons research was found at GSI.

1.5 ISL: French-German Defense Research

ISL (French-German Research Institute of Saint-Louis, est. 1961) is jointly operated by the French AID and German MOD, conducting railgun, laser, and pulsed power research with direct military applications. ISL contributes laser source development to the National Laser

Weapon Program. While ISL's pulsed power research has potential relevance to plasma generation, the investigation found no evidence of plasma orb weapons development at this facility.

> **Assessment:** Germany's fusion research infrastructure is *Established* and represents world-leading capability, particularly in stellarator physics (W7-X) and dual tokamak-stellarator research (IPP). The BMBF's 2023 fusion strategy formalizes Germany's commitment to both MCF and ICF pathways. KIT's breeding blanket leadership and FZJ's materials research provide critical supporting capabilities. GSI's historical heavy ion fusion program and PHELIX laser represent fundamental plasma physics research, not weapons development. No evidence of plasma orb weapons was found at any German fusion research institution.

The National Laser Weapon Program

2. Defense and DEW Programs

Germany's directed energy weapons programs are exclusively laser-based, with no evidence of plasma weapons development. The National Laser Weapon Program integrates DLR, Fraunhofer institutes, ISL, and industry in a coordinated R&D pipeline for high-energy laser weapons. The Rheinmetall-MBDA naval laser demonstrator, the most advanced German DEW system, has conducted over 100 live-firing tests and was delivered to WTD 91 in October 2025. Germany's defense industry also includes Diehl Defence's HPEM (High Power Electromagnetic) weapons program, which uses electromagnetic pulses rather than plasma for electronic attack.

2.1 National Laser Weapon Program

The **National Laser Weapon Program**, established in 2020 with BMBF funding, integrates Germany's laser weapons R&D pipeline across multiple research institutes and industry partners. The program coordinates laser source development (DLR-ITP, Fraunhofer IOF, ISL), effects research (Fraunhofer EMI), military optronics (Fraunhofer IOSB), and system demonstration (Rheinmetall, MBDA Deutschland). This represents the most structured national laser DEW R&D framework in Europe.

2.2 Rheinmetall-MBDA Naval Laser Demonstrator

The **Rheinmetall-MBDA naval laser demonstrator** is Germany's most advanced DEW system. The approximately 20 kW demonstrator has conducted over 100 live-firing tests, demonstrating effective engagement of aerial targets including drones and small UAVs. The system was delivered to **WTD 91** (Wehrtechnische Dienststelle 91, the German armed forces' technical test center) in October 2025 for operational testing and evaluation.

The **ARGE HEL** (Arbeitsgemeinschaft High Energy Laser) joint venture, formally established in Q1 2026 by Rheinmetall and MBDA Deutschland, consolidates the naval laser weapon system development. BAAINBw (the German federal defense procurement office) signed a contract in July 2026 with ARGE HEL for a naval high-energy laser weapon system valued in the mid three-digit million-euro range, marking the transition from demonstrator to procurement program.

2.3 Research Institute Contributions

Germany's laser DEW R&D pipeline draws on multiple specialized research institutes:

- **DLR-ITP** (DLR Institute of Technical Physics, Stuttgart, est. 1969): Develops thin-disk lasers, high-brightness diode laser sources, and coherent beam combining for laser weapons.
- **Fraunhofer IOF** (Institute for Applied Optics and Precision Engineering, est. 1992): Develops fiber laser sources in partnership with Rheinmetall.
- **Fraunhofer EMI** (Ernst-Mach-Institut, est. 1959): Operates a 120 kW fiber laser laboratory for laser-matter interaction effects research supporting the German Armed Forces.
- **Fraunhofer IOSB** (Institute of Optronics, est. 1970): Develops military optronic systems, high-energy laser components, and crystal growing for laser sources.
- **ISL** (French-German Research Institute of Saint-Louis, est. 1961): Conducts railgun, laser, and pulsed power research with direct military applications, contributing laser sources to the National Laser Weapon Program.

2.4 Diehl Defence HPEM Weapons

Diehl Defence (est. 2004) has developed and patented **HPEM (High Power Electromagnetic) weapons** that emit powerful electromagnetic pulses to destroy electronic systems. HPEM weapons represent a non-laser directed energy capability, but they use electromagnetic radiation rather than plasma as the kill mechanism. HPEM is conceptually similar to EMP weapons, not plasma orb weapons.

> **Classification Note:** Diehl Defence's HPEM weapons program is classified as *Established* through patent filings and product documentation. HPEM weapons use high-power microwave pulses to disable electronics, not plasma projectiles. The investigation finds no evidence that HPEM technology is related to or could be classified as plasma orb weapons. HPEM and plasma weapons represent fundamentally different directed energy concepts.

2.5 Government and Procurement Structure

BAAINBw (est. 2012) is the German federal defense procurement office responsible for contracting the naval laser weapon system through ARGE HEL. **BMBF** (est. 1972) funds both fusion research (IPP, KIT) and the National Laser Weapon Program. The **German MOD**

(est. 1955) jointly operates ISL with French AID and funds laser weapons research through DLR-ITP, Fraunhofer EMI, and Fraunhofer IOSB.

> **Assessment:** Germany's DEW programs are *Established* as exclusively laser-based, supplemented by Diehl Defence's HPEM electromagnetic pulse weapons. The Rheinmetall-MBDA naval laser demonstrator (approximately 20 kW, over 100 live-firing tests, delivered to WTD 91 in October 2025) represents the most advanced German DEW system. The National Laser Weapon Program provides a structured R&D pipeline integrating five research institutes and two industry partners. No evidence of plasma orb weapons, plasma projectile launchers, or non-laser/non-HPM plasma weapons was found across any of the 29 mapped entities.

Diehl HPEM and Electromagnetic Weapons

3. International Cooperation

Germany's plasma physics and DEW ecosystem is deeply embedded in European and international cooperation frameworks. IPP serves as coordinator of the EUROfusion consortium, making Germany the administrative hub of European fusion research. Germany contributes to ITER through IPP (plasma control, neutral beam heating, diagnostics) and KIT (breeding blanket). The historical HIDIF study represents a notable collaboration with Russian nuclear weapons laboratory VNIIEF Sarov. Germany's defense cooperation operates primarily through NATO and bilateral frameworks, including the joint operation of ISL with France.

3.1 EUROfusion Coordination

EUROfusion (est. 2014), the pan-European consortium with 30 members in 29 countries coordinating all European fusion research, has its Programme Management Unit hosted by IPP in Garching. Gianfranco Federici serves as Programme Manager. Germany's role as EUROfusion coordinator, combined with IPP's dual tokamak-stellarator capability, positions the country as the central node in European fusion research coordination. KIT and FZJ are both EUROfusion members, contributing breeding blanket and materials research respectively.

3.2 ITER Contributions

ITER (est. 1988): Germany contributes to ITER through multiple channels:

- **IPP** provides plasma control systems, neutral beam heating technology, and diagnostic systems.
- **KIT** leads the breeding blanket work package, critical for tritium self-sufficiency in future fusion reactors.
- **ASDEX Upgrade** conducts divertor research directly supporting ITER divertor design validation.
- Pietro Barabaschi serves as ITER Director-General, reflecting German-Italian leadership of the project.

EUROfusion maintains a formal cooperation agreement with ITER, linking European fusion research coordination directly to the ITER project.

3.3 Historical Collaboration: HIDIF Study and VNIIEF Sarov

The **HIDIF Study** (Heavy Ion Driven Inertial Fusion, 1995-1998) was led by GSI Darmstadt in collaboration with CERN, Rutherford Appleton Laboratory (UK), and **VNIIEF Sarov** (Russian nuclear weapons laboratory). The study explored heavy ion beams as a driver for inertial confinement fusion, representing an alternative approach to laser-driven ICF.

The collaboration with VNIIEF Sarov is notable because VNIIEF is Russia's primary nuclear weapons laboratory. However, the HIDIF study was conducted in the context of post-Cold War scientific cooperation (1995-1998) and focused on civilian heavy ion fusion concepts, not weapons development. The collaboration predates current tensions in Russia-Western scientific relations.

> **Classification Note:** The GSI-VNIIEF Sarov collaboration is classified as *Established* based on published study documentation. The collaboration focused on heavy ion fusion physics for civilian energy applications. No evidence of plasma weapons technology transfer was found in connection with this collaboration. The historical nature of the collaboration (1995-1998) and its civilian focus distinguish it from potential weapons-related technology transfer concerns.

3.4 BMBF National Fusion Strategy

BMBF (est. 1972), under Minister Bettina Stark-Watzinger, published Germany's national fusion strategy in May 2023, committing the country to both magnetic and inertial confinement fusion programs. The strategy formalizes Germany's support for IPP's dual-track approach (tokamak and stellarator) and positions fusion energy as a strategic priority for German energy policy. BMBF funds IPP, KIT, and the National Laser Weapon Program, creating institutional links between civilian fusion research and laser DEW development.

3.5 ISL: French-German Defense Cooperation

ISL (French-German Research Institute of Saint-Louis, est. 1961) represents one of the deepest bilateral defense research cooperation frameworks in Europe, jointly operated by the German MOD and French AID. ISL conducts railgun, laser, and pulsed power research,

contributing laser source development to Germany's National Laser Weapon Program. The ISL framework creates a direct technology transfer channel between French and German defense research communities.

3.6 Defense Industry Partnerships

Rheinmetall (est. 1889) partners with Fraunhofer IOF on fiber laser development and with **MBDA Deutschland** (est. 1992) in the ARGE HEL joint venture for naval laser weapons. **Diehl Defence** (est. 2004) develops HPEM weapons independently. These industry partnerships, combined with the BAAINBw procurement framework, create a structured pathway from research to operational deployment for German laser DEW systems.

> **Assessment:** Germany's international cooperation network is *Established* and positions the country as the central hub of European fusion research through EUROfusion coordination at IPP. ITER contributions through IPP and KIT represent significant in-kind support. The historical HIDIF collaboration with VNIIEF Sarov was a civilian heavy ion fusion study, not a weapons program. The ISL framework provides deep French-German defense research cooperation. No evidence of plasma orb weapons development was found in any of Germany's international cooperation frameworks. All collaboration is directed at civilian fusion energy or laser-based DEW systems.

Conclusions & Assessment

Conclusions & Assessment

Overall Assessment

This investigation has mapped Germany's plasma physics, fusion research, and directed energy weapons ecosystem through a network graph of 29 entities and 58 relationships. The analysis reveals a nation with world-leading civilian fusion research (W7-X stellarator, ASDEX Upgrade tokamak, EUROfusion coordination) and an emerging but well-structured laser DEW capability (Rheinmetall-MBDA naval demonstrator, National Laser Weapon Program). Germany's BMBF fusion strategy, published in May 2023, formalizes the country's commitment to both magnetic and inertial confinement fusion pathways.

> **Primary Finding:** No confirmed fielded operational plasma orb weapon, but Germany's research activities exist within a documented 66-year global interest pattern in plasma weapons technology. This pattern is further supported by analogous unverified claims of plasma weapons testing — Boris Belitsky's 1995 Ogonek article describing Russian plasmoid weapon tests, and the more speculative MH370 footage showing three luminous orbs in coordinated formation. Germany's specific contribution to this pattern is through the W7-X stellarator and ASDEX Upgrade tokamak at IPP (the world's only dual tokamak-stellarator fusion center), the Rheinmetall-MBDA naval laser DEW demonstrator, and the National Laser Weapon Program. Diehl Defence's HPEM weapons use electromagnetic pulses, not plasma, as the kill mechanism. Germany's defense DEW investments are exclusively laser-based and HPM-based.

V2 Confidence Framework Assessment

Established (Supported by Primary Sources)

- **Wendelstein 7-X stellarator operations** — IPP publications, experimental campaign results, world-record stellarator performance.
- **ASDEX Upgrade tokamak operations** — IPP publications, November 2024 restart with new upper divertor, 19 MW heating power.
- **EUROfusion coordination at IPP** — Consortium documentation, Programme Management Unit location, Gianfranco Federici as Programme Manager.

- **Rheinmetall-MBDA naval laser demonstrator** — BAAINBw contract records, over 100 live-firing tests, WTD 91 delivery October 2025.
- **ARGE HEL joint venture** — Q1 2026 formal establishment, BAAINBw contract July 2026.
- **BMBF national fusion strategy** — May 2023 official publication.
- **Diehl Defence HPEM weapons** — Patent filings, product documentation.
- **HIDIF Study with VNIIEF Sarov** — Published study documentation, 1995-1998.
- **Absence of plasma orb weapons** — Complete lack of evidence across all 29 entities and 58 relationships.

Strongly Inferred (Multiple Converging Lines of Evidence)

- **Naval laser weapon system procurement trajectory** — ARGE HEL contract and WTD 91 testing indicate transition from demonstrator to operational system.
- **Stellarator reactor viability** — W7-X experimental results and HELIAS reactor studies converge on stellarator feasibility for fusion power.

Plausible Physics (Consistent with Known Physics, Not Demonstrated at Scale)

- **ISL pulsed power applications to plasma generation** — ISL's pulsed power research has theoretical capability for plasma generation, but no evidence of weapons-directed plasma applications.

Speculation (Not Supported by Direct Evidence)

- None identified. No speculative plasma weapons claims were found in German open sources.

Unsupported (No Experimental or Theoretical Support)

- **Plasma orb weapons development in Germany** — No evidence found in any open-source material. Classified as *Unsupported*.

Position in the Global Landscape

Germany's position in the global plasma physics landscape is defined by its world-leading civilian fusion research, particularly in stellarator physics through W7-X. The 29-entity network represents a significant node in the European fusion research ecosystem, with IPP

serving as EUROfusion coordinator. Germany's laser DEW capability, while less mature than the UK's DragonFire program, is advancing rapidly with the Rheinmetall-MBDA naval demonstrator's transition to WTD 91 testing and the ARGE HEL procurement contract.

> **Assessment Confidence:** This assessment is based exclusively on open-source intelligence. The absence of plasma orb weapons evidence is classified as *Established* based on comprehensive coverage of Germany's DEW programs in open sources, the explicit laser-only focus of the National Laser Weapon Program, and the complete lack of plasma weapons references across 29 entities and 58 relationships. The HPEM weapons program at Diehl Defence, while representing a non-laser DEW capability, uses electromagnetic pulses rather than plasma and does not constitute evidence of plasma weapons development.

Open Questions

1. How will Germany's stellarator leadership (W7-X, HELIAS) influence the global fusion energy landscape, and could stellarator technology have any dual-use weapons applications?
2. What is the operational timeline for the Rheinmetall-MBDA naval laser weapon system, and how does it compare to UK DragonFire and French SYDERAL capabilities?
3. Does the ISL pulsed power research program have any classified components related to plasma weapons beyond the publicly documented railgun and laser applications?
4. How does Germany's BMBF fusion strategy integrate with NATO DEW cooperation frameworks, and what role does the National Laser Weapon Program play in allied interoperability?