

IFMIF-DONES as key facility for HEXA breeding blanket qualification

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DONES Users Workshop 4TH Edition, October 2026

Agenda

01. Strategy update	Strategy update & overview of current activities
02. HEXA Breeding Blanket	Critical enabling fusion technology developed by Gauss to create a modular solution for industrial manufacture and maintenance
03. IFMIF-DONES for HEXA	Key facility for HEXA development as (1) qualifying platform, and (2) substantiation device within a milestone-based roadmap to increase breeding blanket TRL and unlock value for fusion

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What's special about Gauss? Unique combination of design choices, proprietary key technologies and industrial expertise

Combining breakthrough Stellarator design with world-class industrial know-how

Capital-efficient strategy & design, since conception

- **Strong positioning to secure fusion funding** leveraging on substantial national and EU non-dilutive funding
- **Value-accretive partnerships,** matured in partners' factories with >€1bn capacity, no unnecessary vertical integration
- **Early smart design choices:** scalable, manufacturable architecture based on industry experience and know-how

BRUKER

ALSYMEX ALCEN

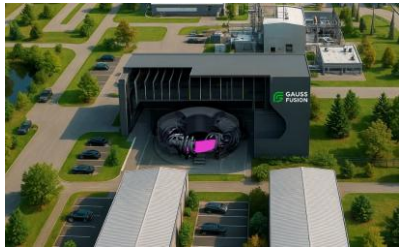
IDOM

research instruments

ASG SUPERCONDUCTORS

Maintainable, cost-efficient and scalable GIGA™ platform

- **Breakthrough GIGA Conceptual Design, peer reviewed** by independent industry experts and scientists (incl. IPP and others)
- **Uptime > 85%** due to high-field design (12T), demountable coils, modular breeding blanket and maintenance concept
- **Sweet spot between compactness and neutron loading** leading to a GIGA design with 50-years lifetime
- **'LCoE-as-spec'** design with LCoE ~5c/kWh
- **Not going the 'bridge too far'**, by agnostic, intelligent design choices exploiting existing supply chains where available

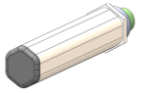


Modular and manufacturable proprietary key technologies

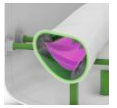
- **Demountable 'Mitchell' Magnets (DMM™)** key technology for manufacturing, transport, installation and maintenance of FPP - with RRP and/or HTS superconductors
- **HEXA™ breeding blanket:** sophisticated modular and integrated breeding to achieve self-sufficiency by tritium breeding ratio >1
- **PinkCap™** divertor technology with new toroidal concept to increase efficiency

Demountable "Mitchell" Magnets (DMMs)





Modular HEXA™ breeding blankets



Unique PinkCap™ divertor

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How to scale? Staged value creation based on clear milestones

Based on the modular GIGA™ platform and proprietary key technologies, Gauss industrially scales stellarator science to fusion power plants

MILESTONES

2023

Team and differentiated expertise assembled

Entrepreneurial leadership, fusion expertise and industrial delivery capability brought together around a focused execution model

Partnership highlights

BRUKER, ALSYMEX, IDOM, research instruments, ASG SUPERCONDUCTORS

Industrial

CERN, ENEA, JÜLICH FORSCHUNGSZENTRUM, KIT, IPP Max-Planck-Institut für Plasmaphysik

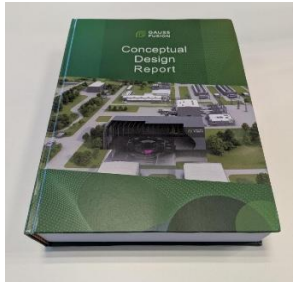
Scientific

2025

GIGA™ CDR completed and independently reviewed

A system-level foundation defining a modular, manufacturable and maintainable architecture, the GIGA™. platform

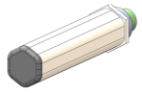
Critical design choices



2026 – 2029

Critical fusioneering technologies demonstrated

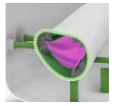
Demountable "Mitchell" magnets, HEXA™ tritium breeding and PinkCap™ divertor advanced to demonstrator-relevant capability



Modular HEXA™ breeding blankets

Demountable "Mitchell" Magnets (DMMs)



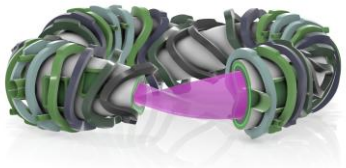


Unique PinkCap™ divertor

Mid 2030s

Gauss Industrial Demonstrator

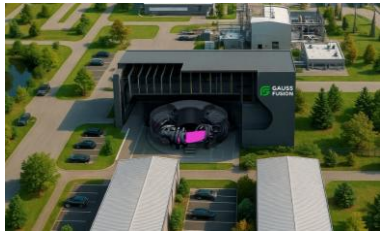
GID-170: An industrial demonstrator to validate high-field design choices (TRL 7) and to build the supply chains for scalable power plants



2040s

Scalable fusion power plants

Long-term 500 MW – 1 GWe NOAK-scalable fusion power plant architecture for secure and affordable baseload electricity



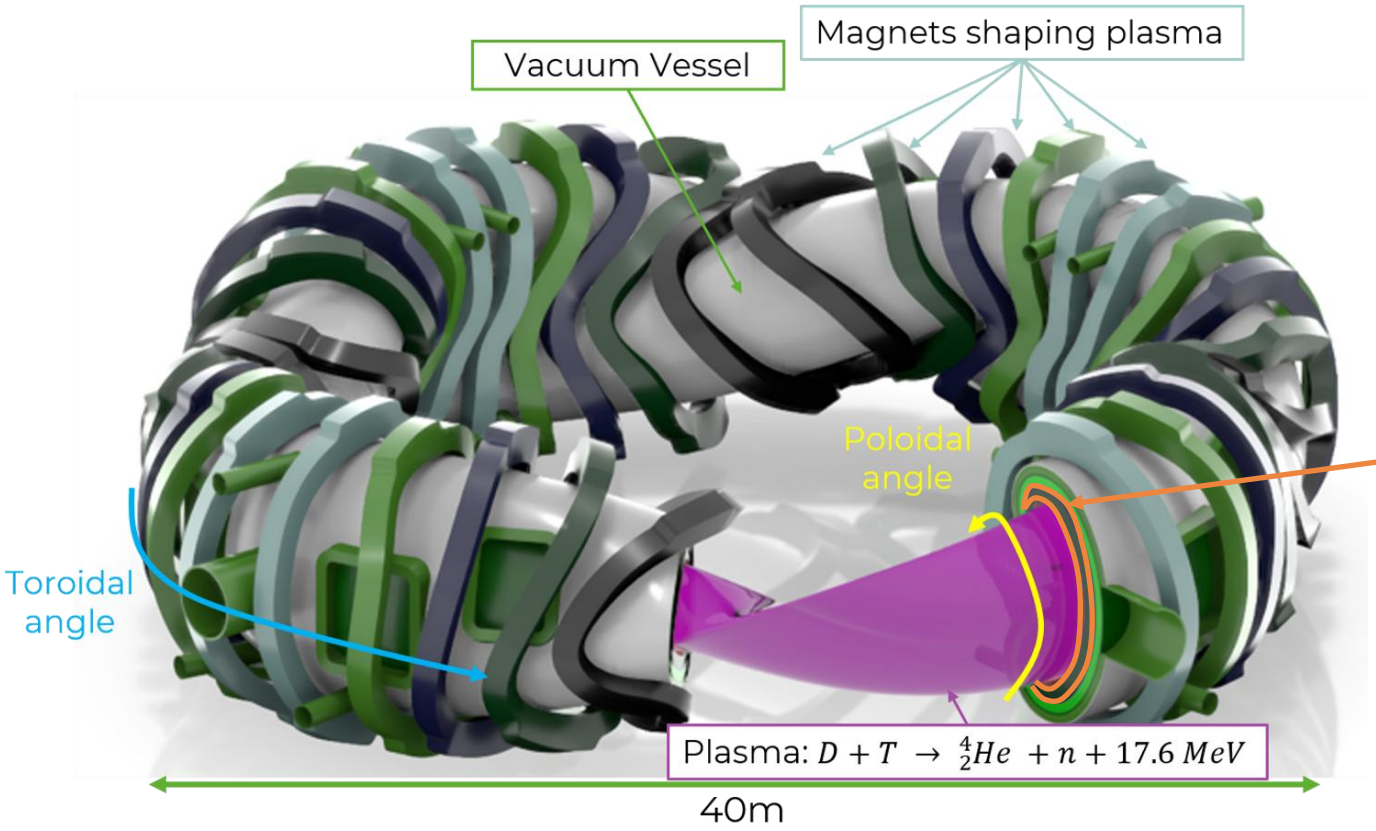
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Without tritium breeding, fusion energy cannot scale



- Produce more ***T*** than is burned
  - Surrounds plasma
  - Contains lithium (6Li)
  - Adding neutron multiplier
- Remove heat from plasma radiation and nuclear heating
- Shield lifetime components
  - Vacuum vessel (dpa in steel), magnets (fluence fast neutrons)
- BB must be incorporated into any commercial FPP, integrating maintenance and manufacturability to give build- and operation-credibility. Points of attention:
  - Non-uniform neutron wall load
  - Nuclear shielding, dose rates in different locations, He production in parts to be re-welded
  - Used/irradiated fuel management
  - Tritium start-up inventory
  - ….

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HEXA: Innovative and industrial HCPB-type architecture



HEXA (v6.0) concept design
3D printed model scale 1:1

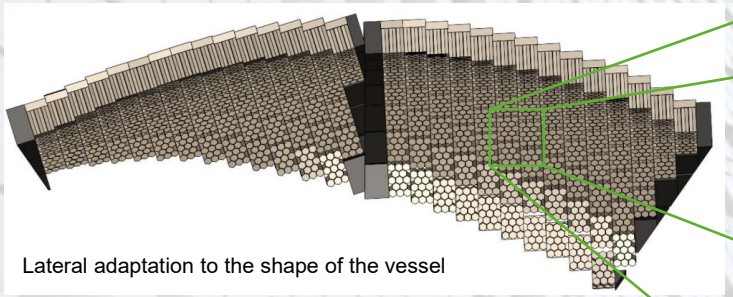


KEY BENEFITS

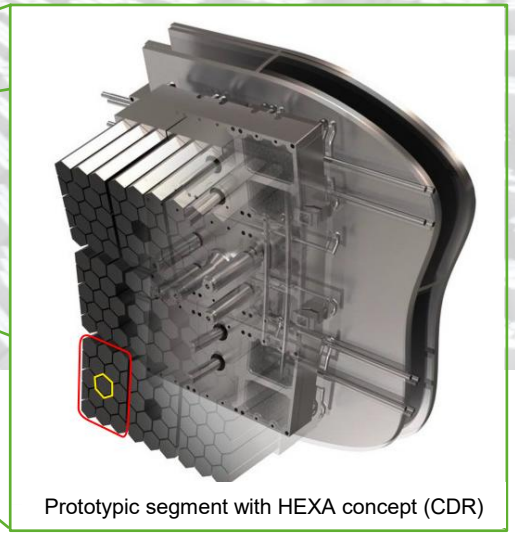
- *Built on helium-cooled pebble bed (HCPB) research*
- *Novel and highly adaptable architecture –highly scalable*
- *Suitable for magnetic and intertial/laser fusion devices*
- *Designed for integrated remote handling and manufacturability*
- *Materials selected for the full component life-cycle / circular economy to be exploited*
- *Phased qualification strategy to reduce risks through prototyping and testing*

POWERED BY BMFTR-PROJECT SYRBRETT WP2

Bundesministerium
für Forschung, Technologie
und Raumfahrt



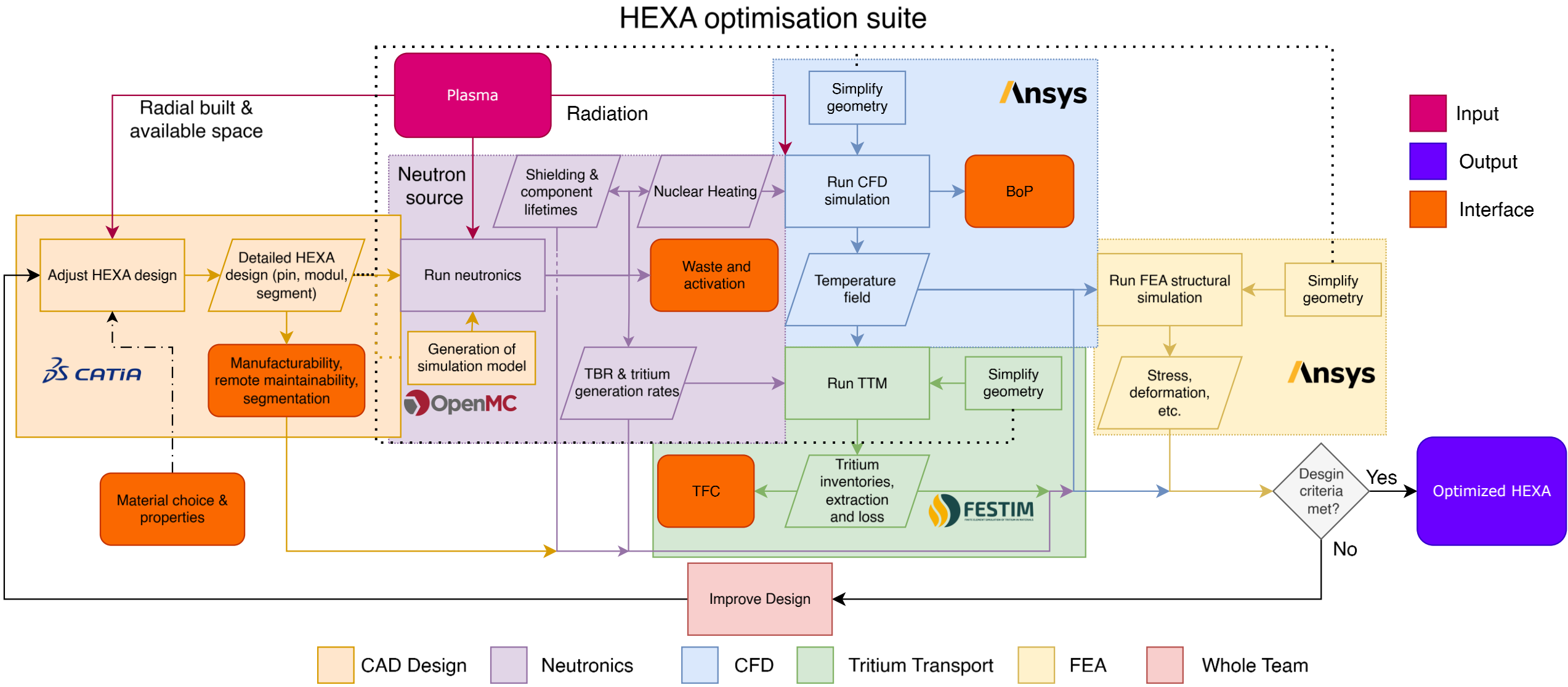
Lateral adaptation to the shape of the vessel



Prototypic segment with HEXA concept (CDR)

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HEXA optimization platform



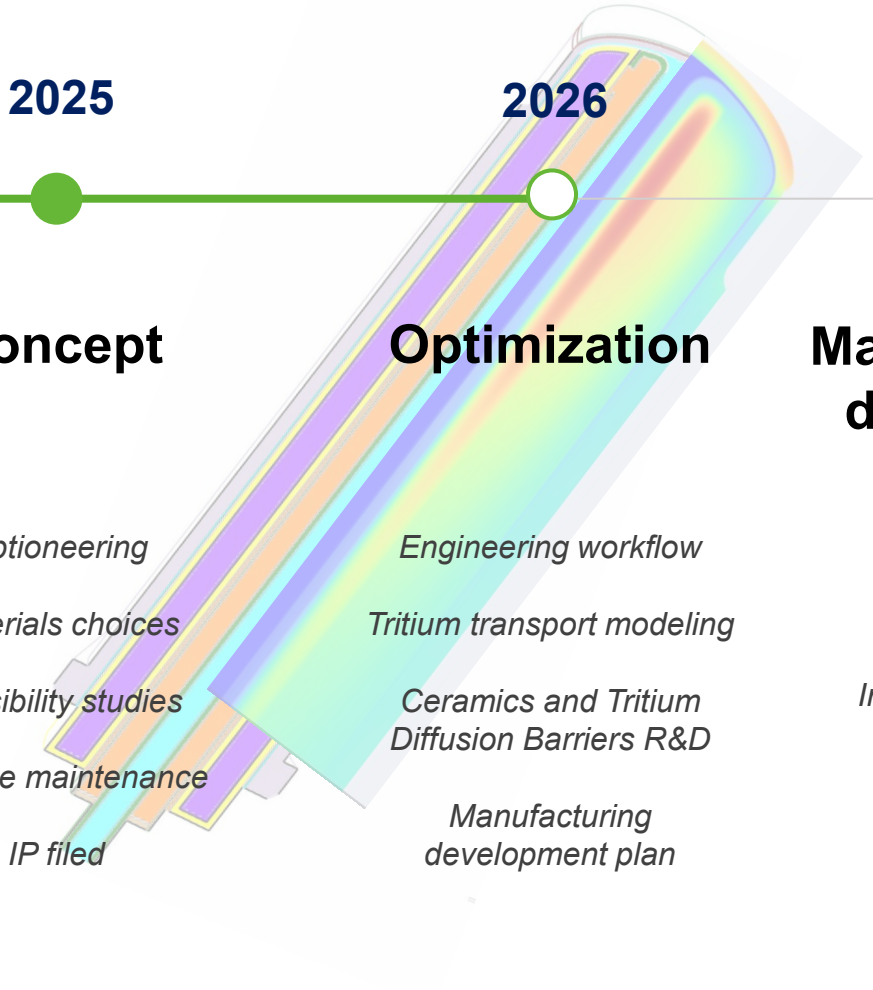
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Milestone-based qualification strategy



2025 — Concept

Optioneering

Materials choices

Feasibility studies

Remote maintenance

IP filed

2026 — Optimization

Engineering workflow

Tritium transport modeling

Ceramics and Tritium Diffusion Barriers R&D

Manufacturing development plan

2027 — Manufacturability demonstration

Manufacturing route

Mock-ups and trials

Instrumentation & safety

2029 — Non-neutron tech demonstration

Non-neutron testing

First functional testing- High Heat Flux

Coatings, First Wall, advanced breeders R&D

RH mock-ups

2030+ — Neutron tech demonstration

Neutron-testing, external testbeds

Simple and integrated multi-effects testing

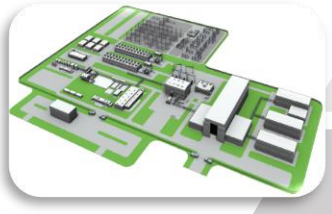
Operational environment

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Building blocks for HEXA qualification

Neutron environment (D-T spectrum)

GID-170 / FOAK GIGA PLATFORM





TRL9

TRL7-8

TRL5-6

Neutron testing facilities

Non-neutron testing facilities

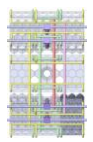
TRL3-4

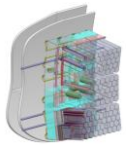
Product on market



Volume	Peak flux (n/cm2/s)	Neutron fluence accum (steel)	Environmental conditions

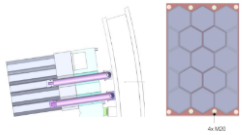
Pre-series system validated





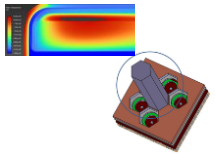
Segment/ module	10^{14}	5-50dpa	• Operational environment, limited range of loads • Middle-life / End-of-Life fluences

Prototype tested in representative environment



Module / pin	10^{13}	1-5dpa	• Fully integrated testing • Multi-effects testing

Basic prototype



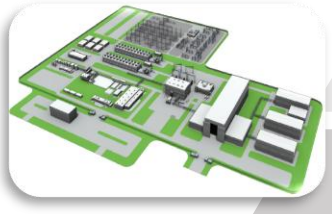
Pin / pin section	10^{12}-10^{13}	0.1-1dpa	• Single effect testing

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IFMIF-DONES as a key facility for HEXA qualification

Neutron environment (D-T spectrum)

GID-170 / FOAK GIGA PLATFORM







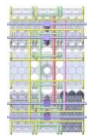
TRL9

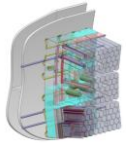
Product on market



TRL7-8

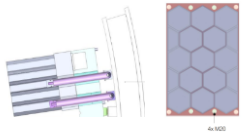
Pre-series system valid





TRL5-6

Prototype tested in repr

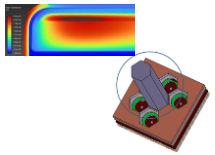


esting facilities

Non-neutron testing facilities

TRL3-4

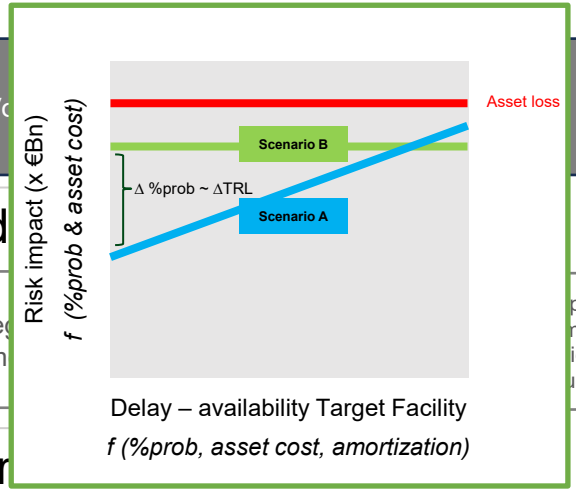
Basic prototype



Vc

Environmental conditions

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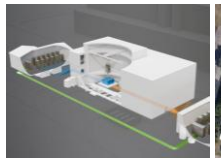
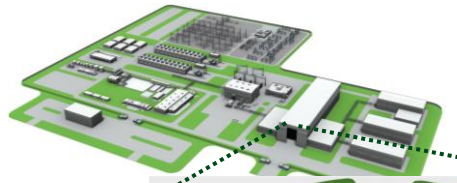
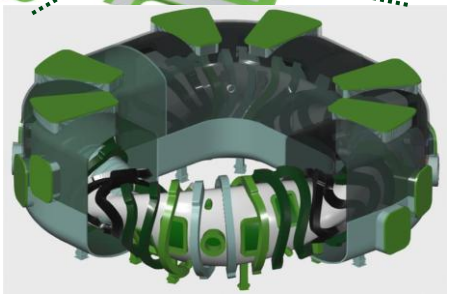
Limitations/ points to check:

- High-heat flux
- Cyclic loads
- Magnetic field
- High pressure?/ temperature compatibility
- Material compatibility
- Volume (segment)

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Milestone-based qualification strategy



2025	2027	2029	2030+		2039+
Concept	Mock-ups and trials	Semi-prototypes	Prototypes	GID-170	Full qualification
Feasibility studies	*Prove manufacturability*	*Non-neutron testing*	*Neutron testing*	*Industrial demonstrator*	*Operation in GIGA*
TRL3	**TRL3+**		**TRL4/5/(6)**	**TRL6/(7)**	**TRL(7)8/9**
			0.1-(5) dpa structural steel 10^{12}-(10^{14}) n/cm2/s pin/module	5-(10) dpa structural steel 10^{14} n/cm2/s module/segment	(10)-50 dpa structural steel 10^{14} n/cm2/s module/segment

IFMIF-DONES

GIGA platform

GAUSS FUSION

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IFMIF-DONES as a key facility for HEXA qualification

Qualifying platform

Enable partial integration testing to demonstrate HEXA breeding blanket functions with representative conditions, and therefore supporting TRL progression:

- Exploit capabilities: tritium production and testing of extraction systems, validation tritium permeation barriers, use of novel diagnostics, validation of tritium and neutronic models
- Manage limitations: high-heat flux, cycling loads, magnetic field, coolant/ purge gas pressure/temperature conditions



https://ifmif-dones.es/fusion-energy/about-ifmif-dones/

Substantiation device

Obtain material properties under relevant fusion neutron irradiation / conditions that will enable trajectory towards End-Of-Life assessments of baseline reactor materials for GIGA

Develop a materials substantiation methodology that is matched between exposures at DONES – and in GID / GIGA:

- Public program: Interesting for materials @ Gauss as we are considering baseline options
- Gauss substantiation program: Some Materials & Exposure conditions that are specific to GID / GIGA.

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Acknoledgements

Bundesministerium
für Forschung, Technologie
und Raumfahrt



IDOM

ALSYMEX
ALCEN

OXFORD
SIGMA

framatome

KIT
Karlsruher Institut für Technologie

JÜLICH
Forschungszentrum

UK Atomic
Energy
Authority

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GAUSS FUSION

The time is now to industrialise fusion



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