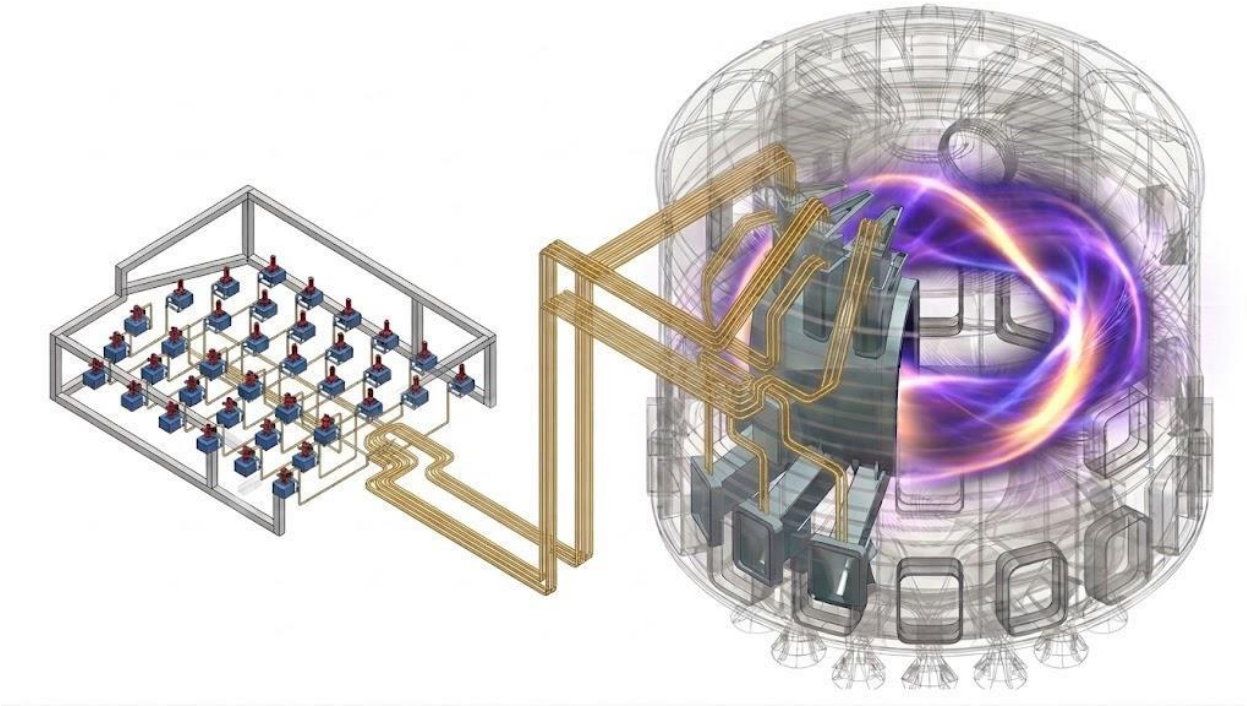
Swiss Fusion Industry Association

SFIA reporting Cluster 2: Heating Systems



Larmor mmWave Systems SA

Dr. Massimo Carpita, CEO

LARMOR mmWave systems

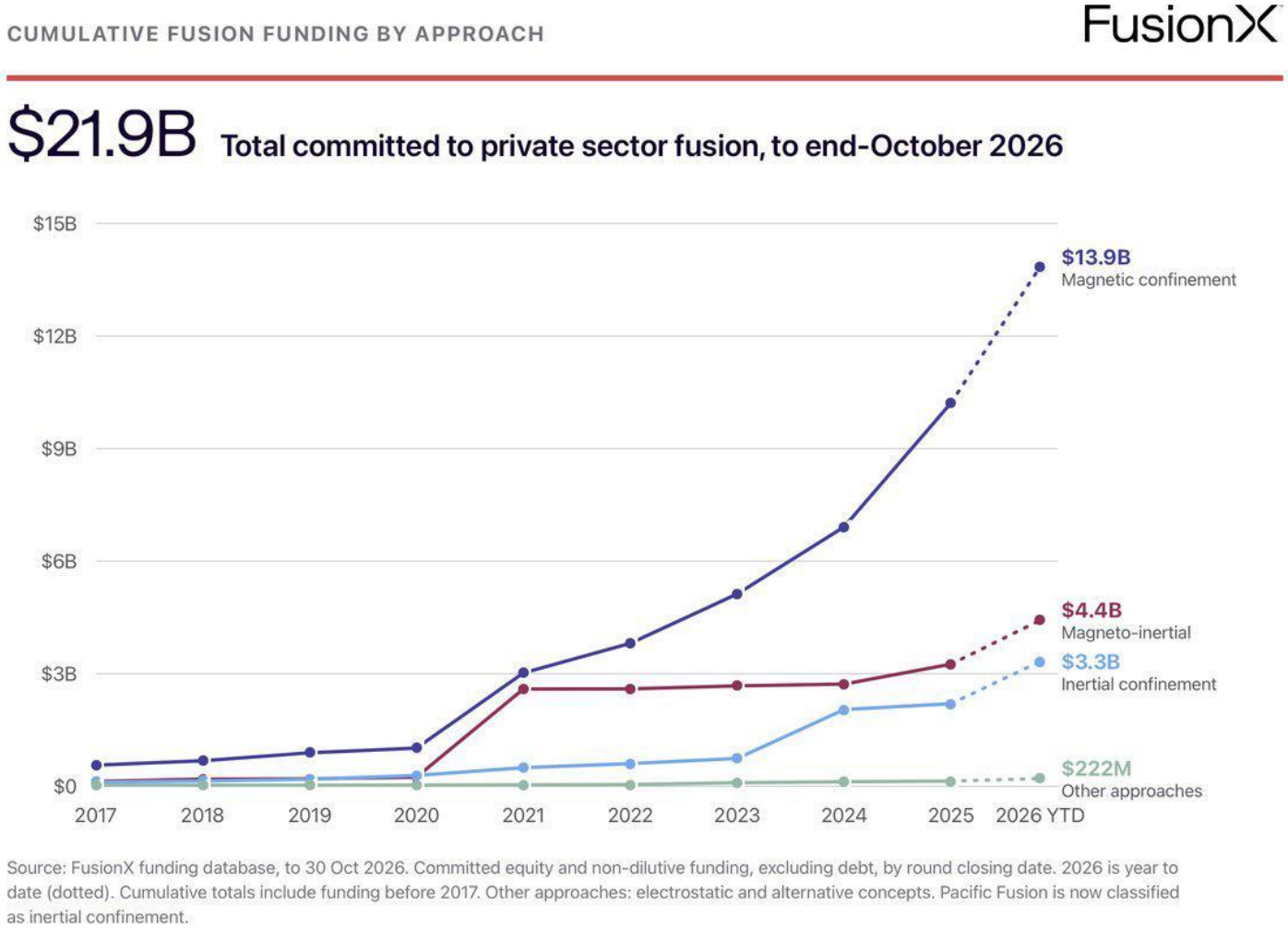
Heating in magnetic fusion

Most funding
63% of total committed to private fusion

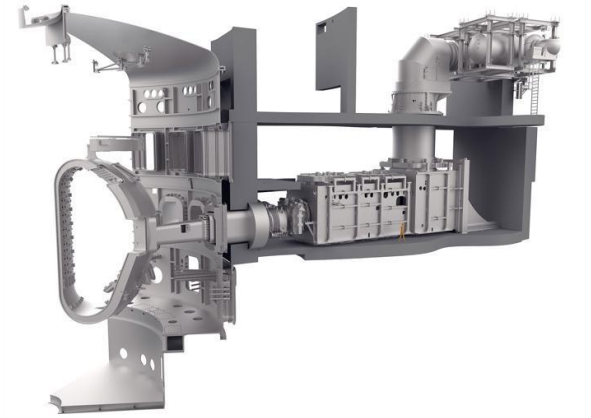
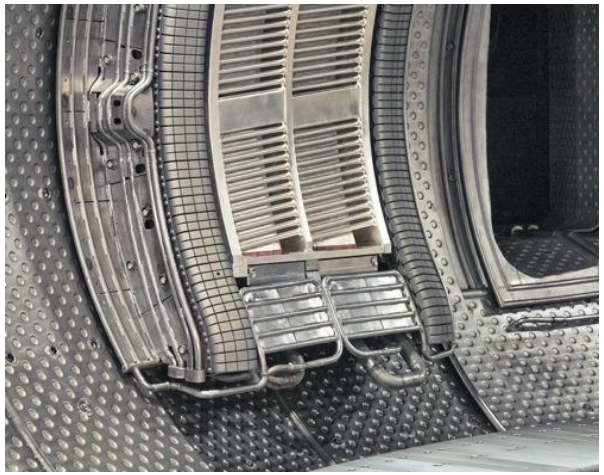
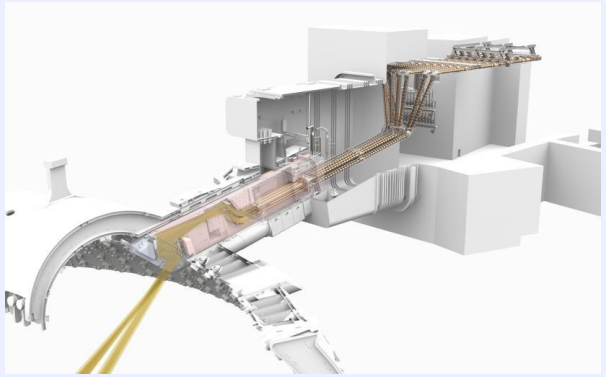
Largest number of companies
More than 30 private companies,
with different confinement approaches

Large and mature public projects
ITER, JT-60SA, DTT, W7X, AUG, TCV,
MAST-U, COMPASS-U, …

100 M° C
Heating systems bring the plasma to fusion temperatures and help control it.



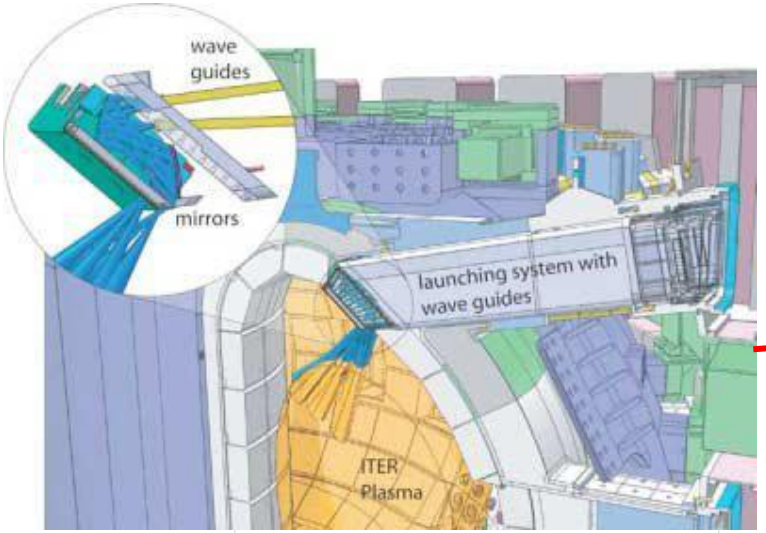
Three magnetic fusion heating schemes

	NBI (MeV-scale neutrals)	ICRH (10-100 MHz waves)	ECH (100-300 GHz waves)
			
Strength	Heats the ions (fuel) directly	Heats the ions (fuel) directly, efficiency up to 60%	Modular & outside nuclear area (maintenance, accessibility)
Position	**In the reactor building, plugged into the vessel**	**Inside the vacuum vessel, facing the plasma**	**Separate building, linked by transmission lines**
Main limit	Size, complexity, efficiency	Sensitive coupling, exposure to the plasma	Cost, supply, efficiency

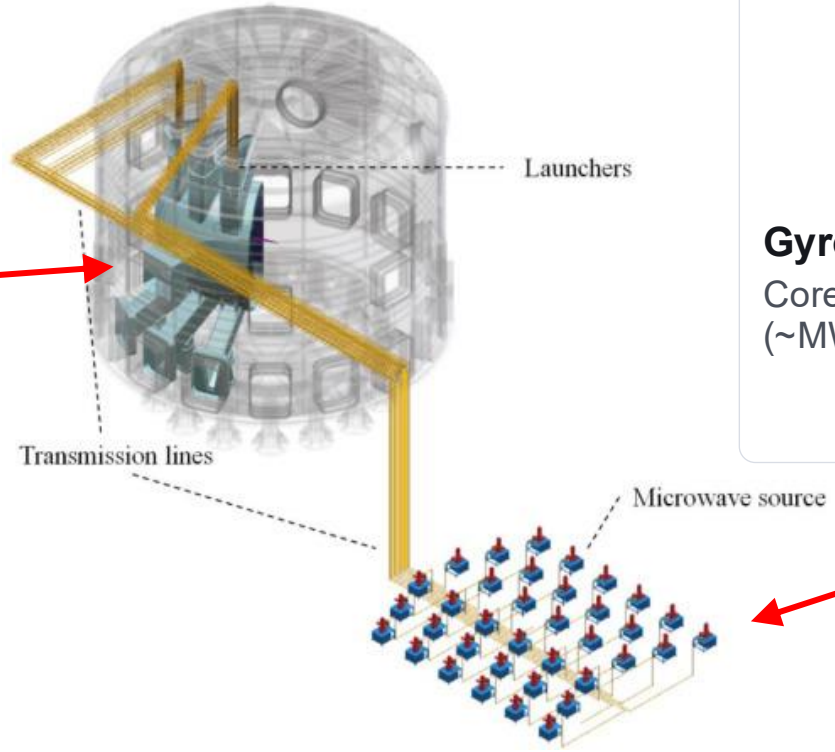
LARMOR mmWave systems

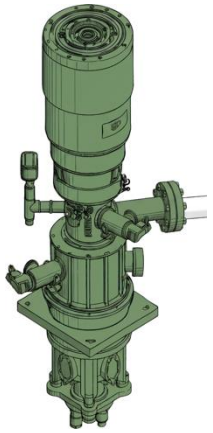
ITER re-baseline: increase significantly ECH capacity

Anatomy of an ECH system



Launcher
Steers and control beam towards the plasma





Gyrotron
Core microwave source.
(~MW x ~100 GHz)



Power supply
HVPS
(tens of kV, tens of A)

Close to the reactor: design-dependent

Launcher

Further away: more design-agnostic, can be standardized

Transmission lines · Diamond windows · High-vacuum seals · **Gyrotron** · Superconductors · Pumping systems · Cryogenic systems · **Power supply** · Control systems

ECH market opportunity today

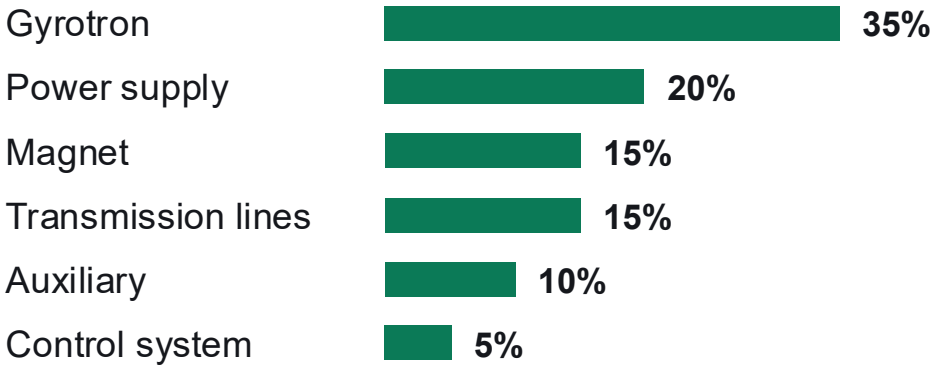
+750 MW ~10 BCHF

Microwave capacity demand announced publicly,
for projects planned by the **early 2030s**.



Reactor-agnostic system (launcher excluded)

10–15 MCHF per MW power installed



*Very simple estimate:
Exact breakdown may vary project by project.

A constrained supply chain

e.g. **< 20 state-of-the-art gyrotrons per year worldwide**

From components to competences

Competences an ECH system needs

- High-voltage, high-current power supplies
- Microwave physics
- Microwave engineering
- Material science (ceramics, copper alloys...)
- Ultra-high vacuum systems
- High-precision manufacturing (<10 µm tolerances)
- Cryogenics
- Magnetics
- System design

Already in the Swiss fusion landscape

Academia and research

EPFL | PSI | University of Basel | Empa

Industry

Ampegon | VAT | Kompaflex | DAES | INFICON

... many more ☺

Larmor mmWave Systems



Our goal

Commercialize EPFL's competence in ECH systems for fusion, leveraging 30+ years at the center of the supply chain in Europe

Photo: FALCON test facility, EPFL

Team

Massimo Carpita	CEO, co-founder. PhD experimental fusion, EPFL
Mack van Rossem	CTO, co-founder. PhD experimental fusion, EPFL
René Chavan	Senior tech consultant. Ex-head of microwave engineering, SPC-EPFL
Avelino Mas Sánchez	Senior microwave engineer (15y), ex-SPC-EPFL
Lucas Schlenger	Material engineer. 3D printing post-doc, EPFL

Advisors

Scientific	**Gyrotron group, SPC-EPFL** J.P. Hogge, T. Goodman, F. Braunmüller, J. Genoud, S. Alberti
Institutional	P. Ricci (Director, SPC-EPFL), A. Fasoli (Prof. EPFL; ex-GM EUROfusion), M. Hübner (Swiss ILO)
Business	P. Dutheil, A. Sethi (Innosuisse / PlatInn support)

Current status

Legal entity
Larmor mmWave Systems SA

Address
EPFL Innovation Park, Building C, 1015 Lausanne

Origin
Official spin-off of the Swiss Plasma Center at EPFL

Support
EPFL Startup Launchpad, Venture Kick I & II,
Founderful Campus, LADE / SPEI Canton Vaud

Active collaborations
Empa, Switzerland Innovation Park Biel/Bienne,
EPFL metallurgy lab

Traction

5	active disc. with customers, including ITER
5	LOIs from leading companies in the field
200k CHF	Non-dilutive funding
800k CHF	Innosuisse project, won
3.2 MCHF	EIC Fusion Tech Accelerator challenge, final stages
EU PPP	involved in the call on ECH systems
4 MCHF	**fundraising underway, funding first technical milestones**

At the center of EPFL and the Swiss network

Infrastructure access through EPFL

FALCON
ITER-grade gyrotron test facility

Subcomponent test stands
Test individual ECH and gyrotron subcomponents outside full system

Cryogenic and HVPS setup

TCV tokamak ECH system
A complete system, in operation

Talent pool

Large network of specialist talent in fusion and hardware in direct connection with us

~50

PhD students at SPC-EPFL

Connections with academia and industry: conversations started

EPFL Swiss Plasma Center — **Lausanne**

Empa Materials Science and Technology — **Neuchatel / Thun**

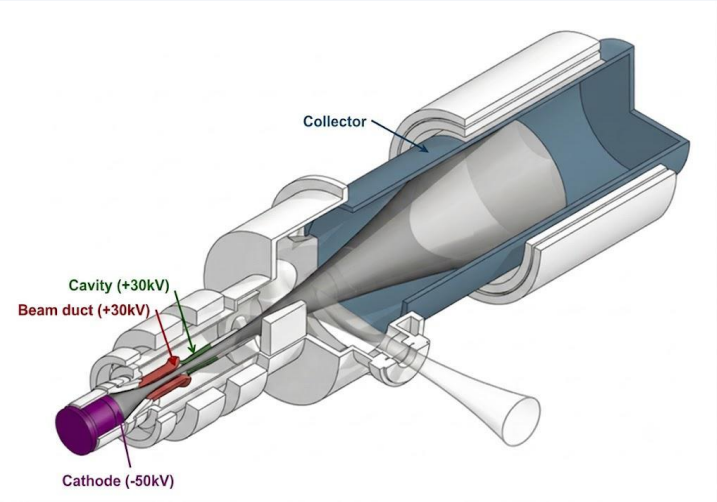
VDL ETG — **Trübbach / Villigen**

CERN — **Geneva**

SWITZERLAND INNOVATION PARK BIEL/BIENNE — **Biel/Bienne**

Our focus

Gyrotrons: subcomponent innovation



- **New architecture choices**
- **New manufacturing methods**
  e.g. 3D printing
- **New physics design**

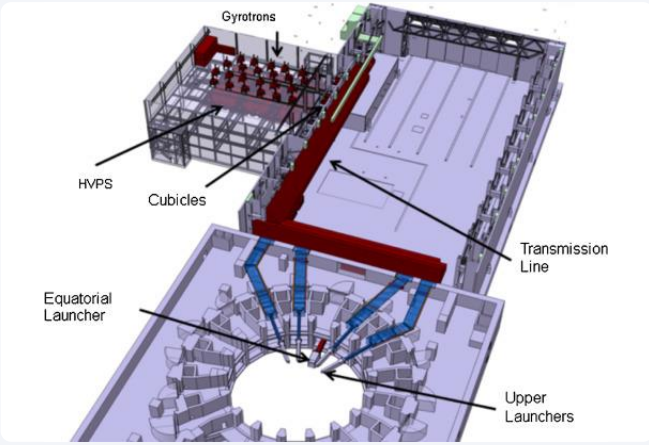
The goal of these subcomponent innovations

+50%
frequency at MW level

2x lower
capital and operating cost

2x lower
lead time and downtime

ECH design and integration services



High-level system design, project management

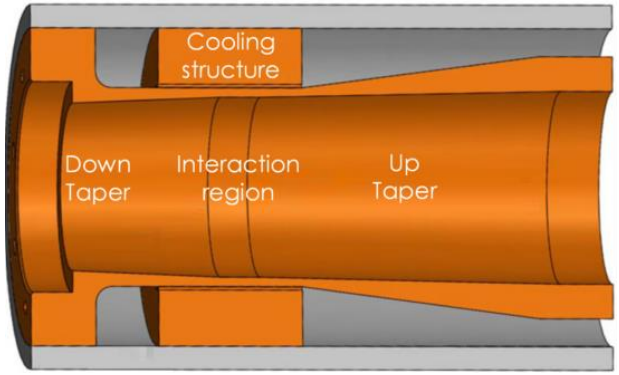
Transmission lines and launcher designs

Procurement decisions:
SFIA connections

Example: 3D printing the gyrotron cavity

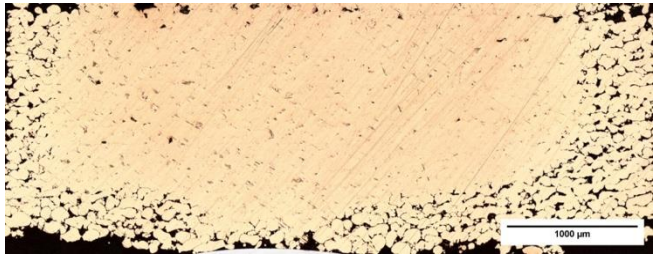
Why it matters

Cavity cooling is the main bottleneck to higher-frequency gyrotrons

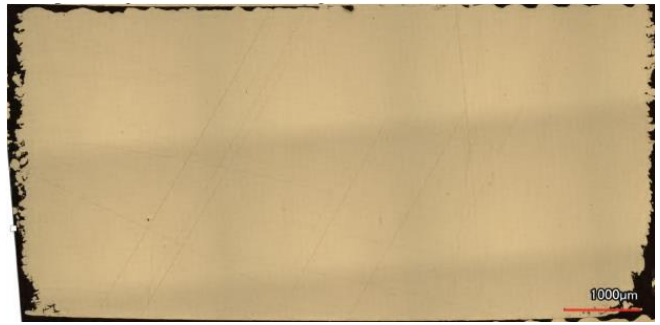


20 → 40 MW/m² wall heat load, today vs needed for 1 MW above 200 GHz

Current results



Infrared laser: ~97% density, deformed



Blue laser: up to 99.91% density

Next: optimization of process chain, from powder to full component, design of optimized cooling channels, and test in relevant environment

Jan 2026
EPFL funding

Mar–Aug 2026
Two master's theses at EPFL and Empa

Sep 2026
Innosuisse project accepted

Jan 2027–Mar 2028
Innosuisse project (800kCHF), bringing it to TRL 6

COLLABORATION WITH: EPFL-SPC, EMPA, EPFL-LMTM, SIPBB. Innosuisse project 140.650 IP-ENG.

Example: fusion PPPs - raising ECH system TRL

Horizon-Euratom call, 2026–27

32 M€ first 3 calls, split in 3 projects

- Magnets
- Diagnostics and control
- **Heating systems**

Focus on ECH systems (10 MEUR)

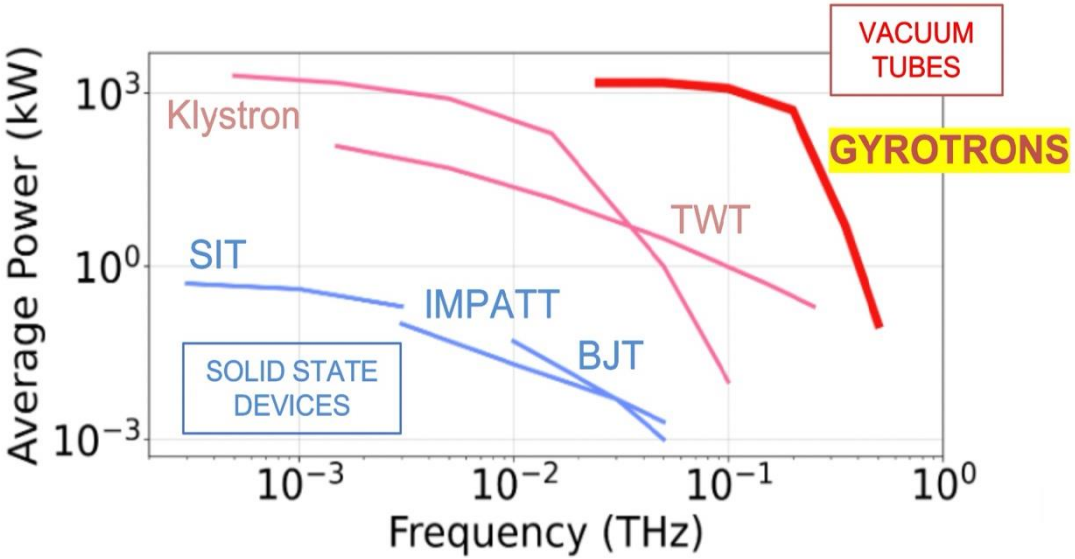
Semi-mature today → Target

TRL 4–6 → TRL 6–8

The goal of PPPs is to mature and industrialize existing solutions

Consortium between academia, startups, and established industrial partners that have supplied ITER

Spillover beyond fusion: New markets





Microwave drilling

Vaporizes rock without contact, to reach deep geothermal energy
Same hardware and subsystems as fusion.



Material processing

e.g. ceramic sintering

- Up to ~10x less time and energy
- ~500 M€/year in sintering ovens

Metrology systems



e.g. DNP-NMR ↔ ETH Zurich

- NMR sensitivity up by orders of magnitude
- ~3 B€ mm-wave instruments by early 2030s

LARMOR mmWave systems

ADDITIONALLY: Wireless power transmission, direct energy, radars, communication systems

Let’s collaborate

Co-develop technology

Joint development of the components and processes behind ECH systems

Pilot in adjacent fields

Pilot projects to expand market applications beyond fusion, anchoring new value

Map and share

Mapping competences and infrastructure access relevant to ECH developments

Seek public support

Applying together to Swiss and European programmes

LARMOR mmWave systems

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