

Engineering ITER Diagnostics

Industrial lessons for future fusion systems

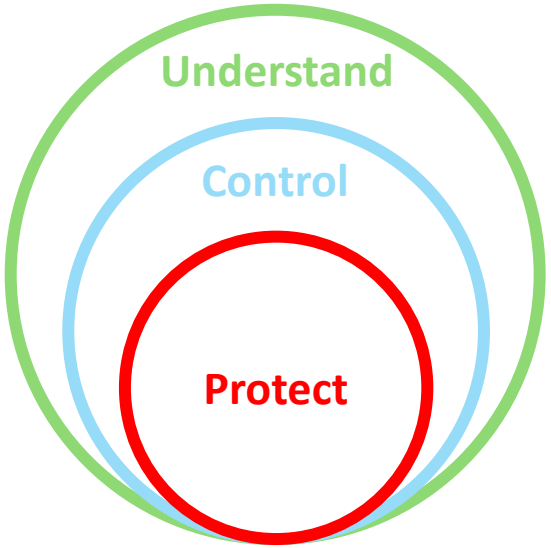
Lucas Moser, ITER Organization Diagnostic Engineer

with contributions from the ITER Diagnostics Program Team, DAs, Research Centers, Universities, and private industry

china eu india japan korea russia usa

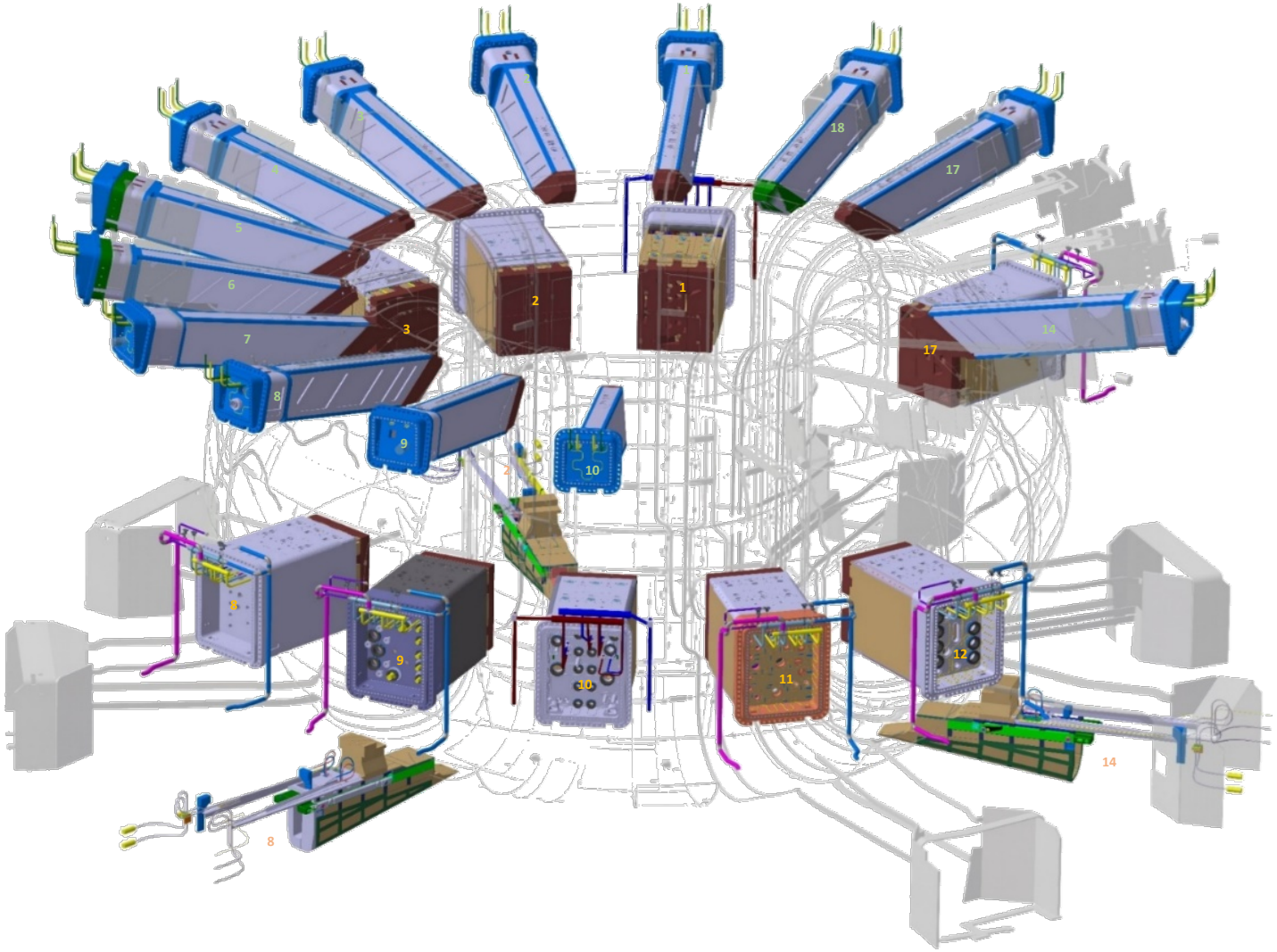
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Diagnostic systems in ITER



60 instruments measuring 101 parameters

- **Integrated in Equatorial, Lower and Upper Ports (26 ports)**
- **On the Vacuum Vessel (inside & outside)**
- **On the divertor**
- **On the First Wall blankets**

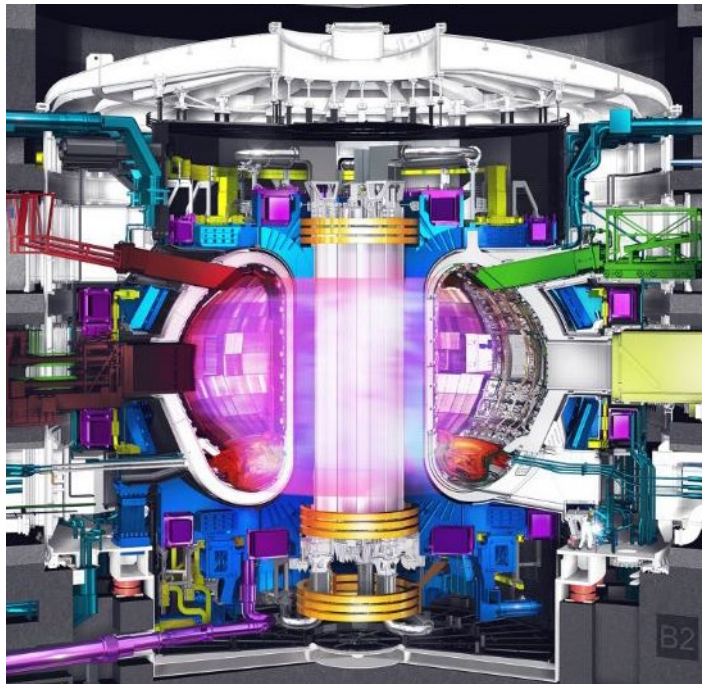


An ecosystem of measurement technologies

Magnetic Confinement and MHD
Current, equilibrium, shape, position and stability.

Density and temperature
Thomson scattering, interferometry / polarimetry, ECE and reflectometry.

Composition, flows and fast particles
Visible/VUV/X-ray spectroscopy, CXRS and particle analysis.



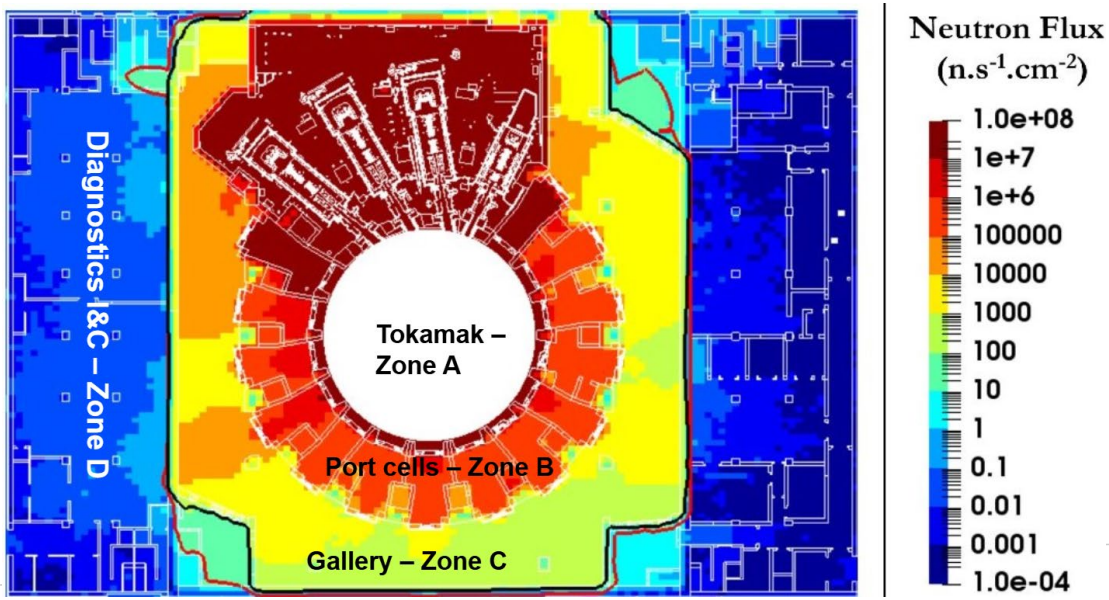
Fusion power and nuclear products
Neutron monitors, cameras, spectrometers and activation systems.

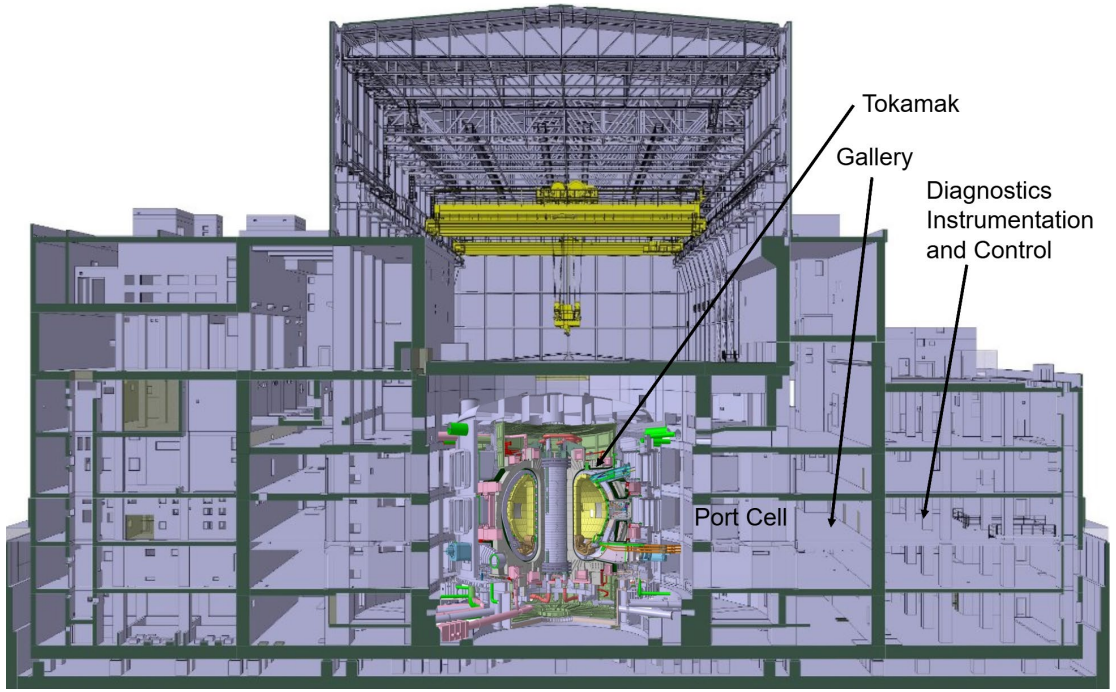
Radiation, boundary and exhaust
Bolometry, divertor spectroscopy, pressure and Langmuir probes.

Wall and machine protection
Visible/IR imaging, thermocouples, dust, residual gas and operational monitors.

Same measurement physics — a radically different environment

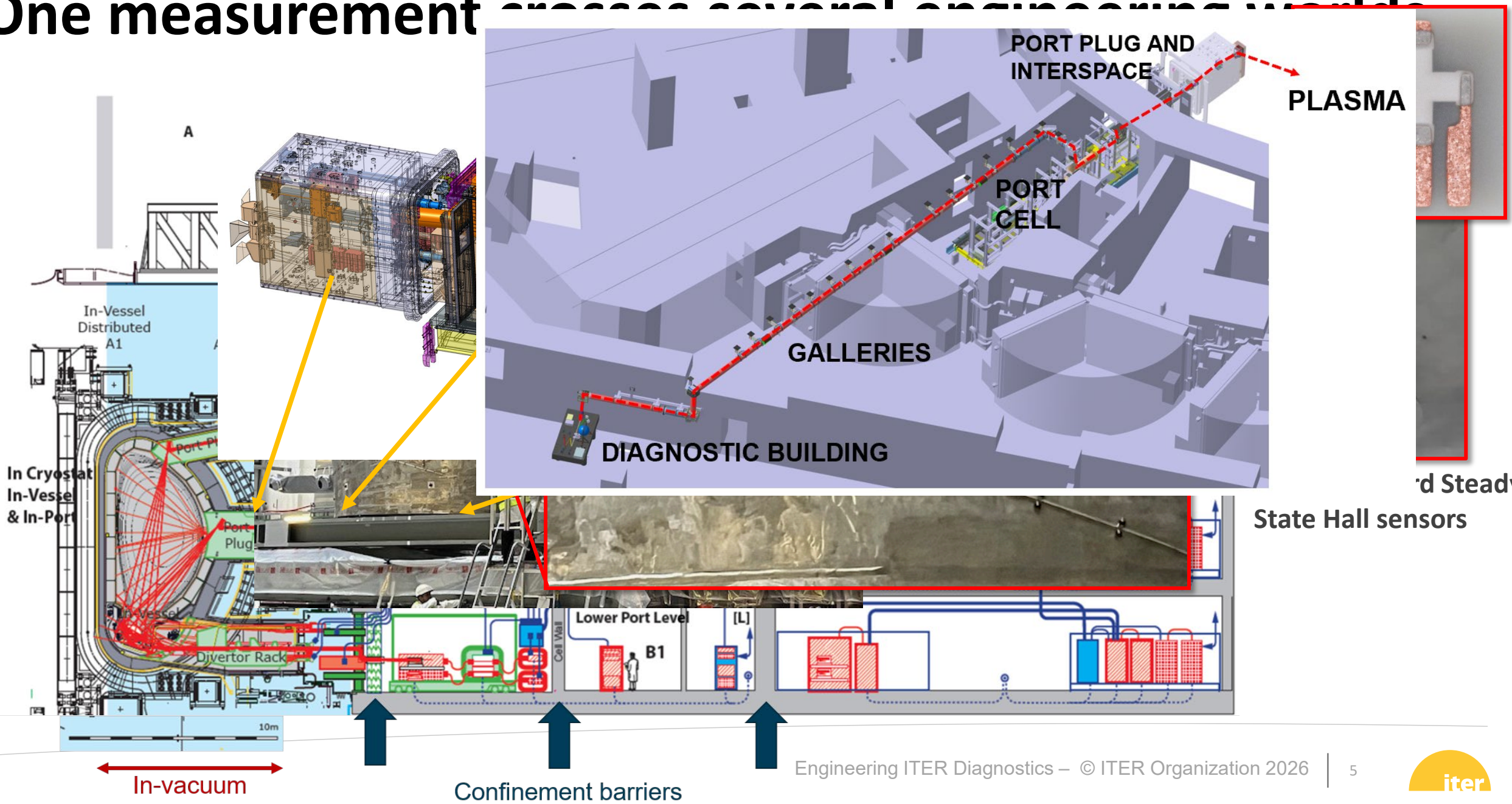
- Radiation
- Vacuum and Confinement
- Thermal loads





- Magnetic and EM loads
- Restricted access
- Long transmission paths

One measurement crosses several engineering worlds



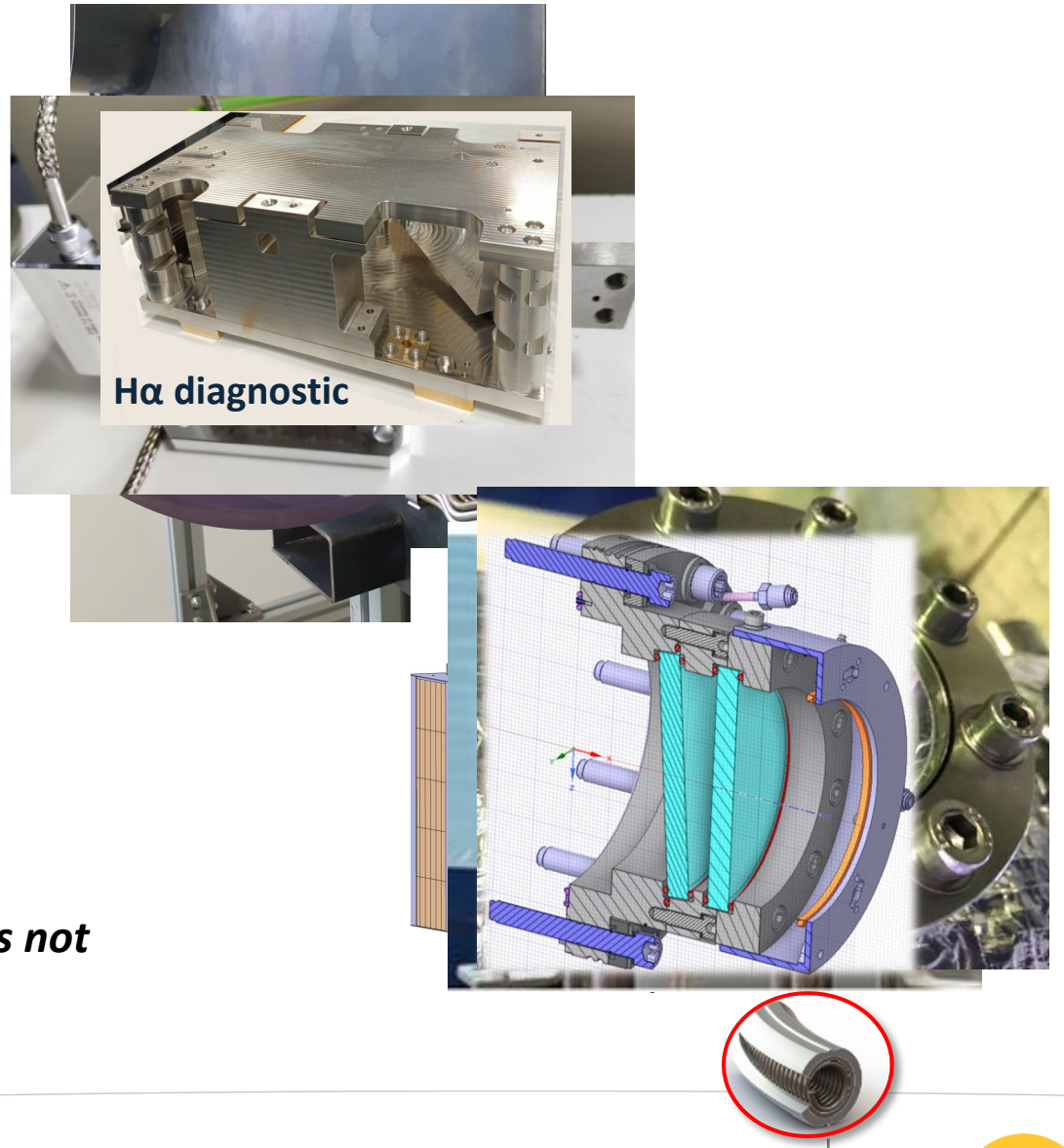
ITER’s engineering response

PROTECT
Radiation-hard materials & shielding

MAINTAIN
Replace · protect · recover · duplicate

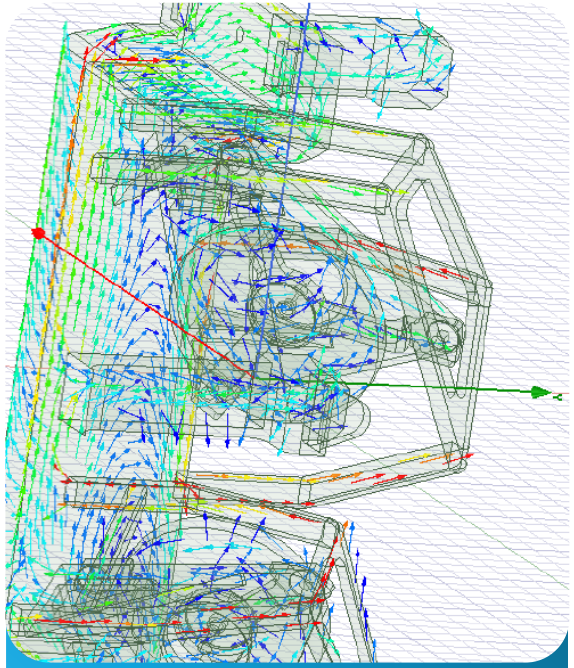
QUALIFY
Mock-ups · environmental tests · evidence

STANDARDIZE
Common architectures & proven components



The measurement may be unique. The engineering solution does not always need to be.

Diagnostics are now an industrial delivery programme



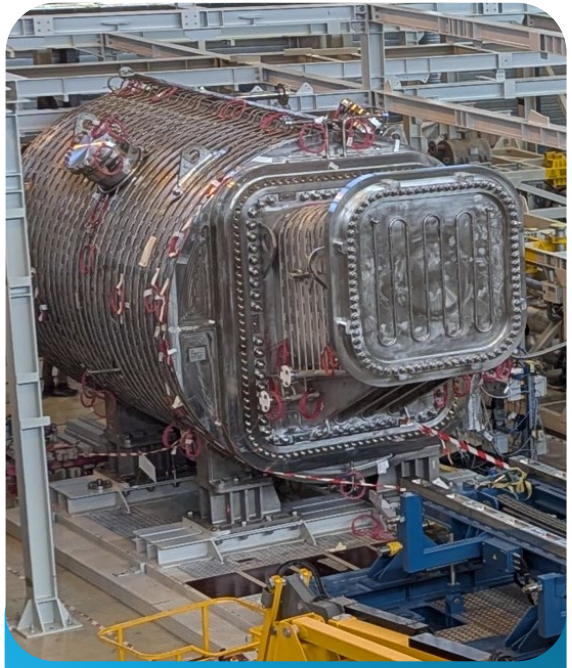
300+

Diagnostic design reviews held



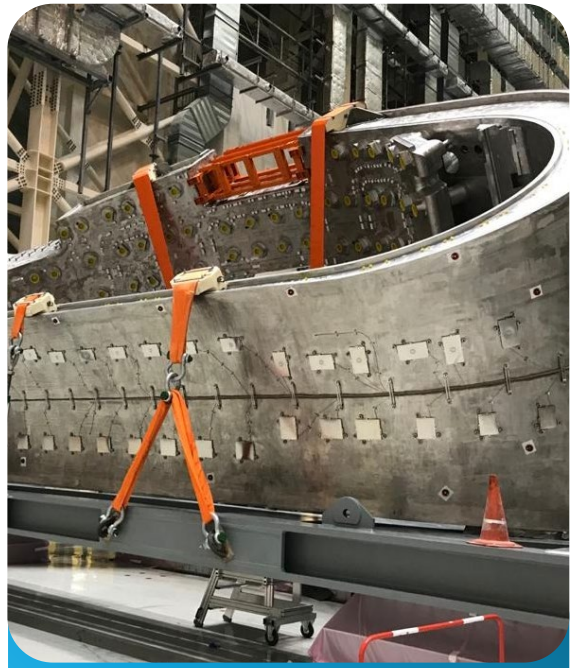
61+

Diagnostic projects currently in manufacture



58+

Diagnostic projects fully or partly delivered



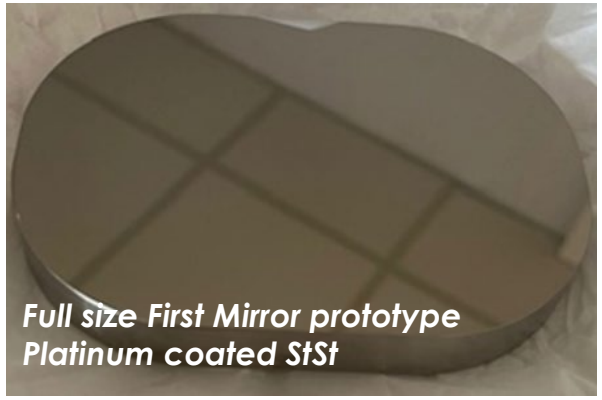
22+

Diagnostic projects fully or partly installed

55.E6: one diagnostic, many industrial technologies

IO scope, tangential Line of Sight spectroscopy system, currently in manufacturing stage. Mostly through single framework contract and associated sub-contracting.

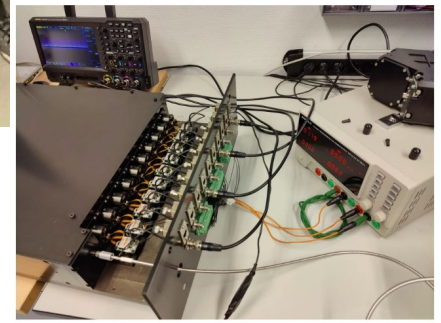
- ***A diagnostic is an integrated industrial chain – not one instrument.***

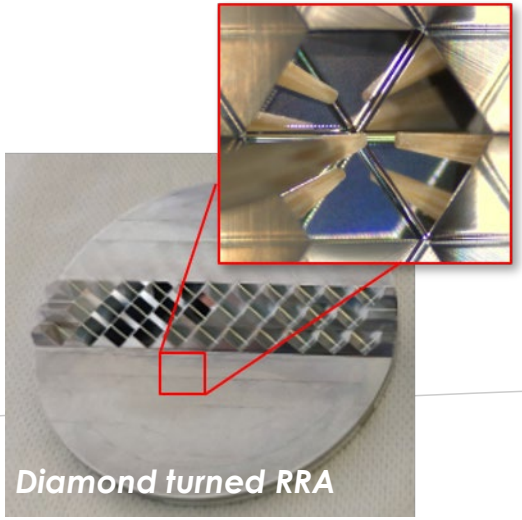










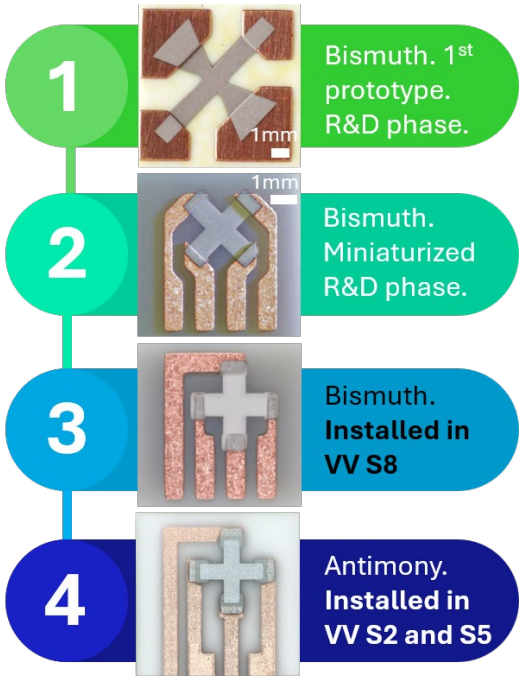


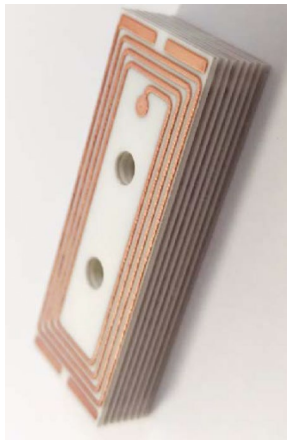


Three components — three industrial lessons

Next generation magnetic sensing

- The measurement principle remains the same. The manufacturing technology continues to evolve.



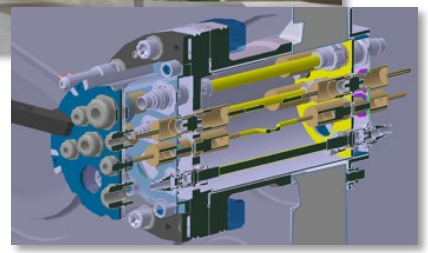


FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITY OF WEST BOHEMIA

Electrical Feedthroughs

- The complexity is not the connection itself. It is engineering and qualifying the complete interface.

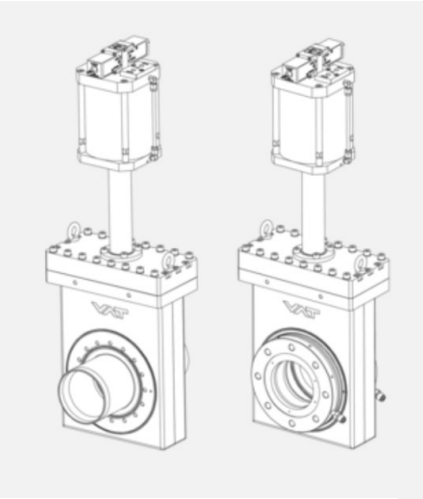


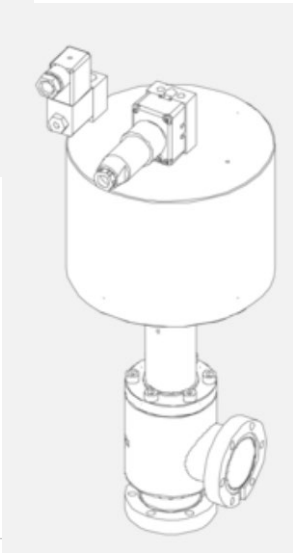


fischer CONNECTORS

VAT ITER valve catalogue

- Qualification can become part of the product.





VAT

From experimental coverage to a power-plant sensing spine

Experimental / risk-retirement machine	Fusion power plant
Broad measurement coverage	Narrower measurement purposes
Physics validation	Protection and closed-loop control
Overlapping techniques	Availability and maintainability
Campaign flexibility	Condition and Performance monitoring
Capability to investigate unexpected behaviour	Redundant reactor survivable implementations

Fewer measurement purposes – not necessarily fewer physical sensors

From qualified components to reusable fusion platforms

1. QUALIFIED PRODUCT FAMILIES
Reuse the product and its qualification basis
- Controlled materials and configurations
- Defined operating envelope
- Repeatable manufacturing and testing

Example: qualified valve or sensor families

2. STABLE INTERFACES
Reuse the integration
- Mechanical and vacuum
- Electrical and optical
- Data and control

Example: qualified feedthrough and cabling chain

3. REUSABLE PLATFORMS
Reuse the engineering architecture
- Common modules, spares and tools
- Maintainability and lifecycle support
- Reusable qualification evidence

Example: optical enclosure or complete signal-chain platform

Standardize the interfaces – not necessarily the measurement physics.

What could Switzerland industrialize for fusion diagnostics?

COMPONENT SUPPLIER
Sensors | Optics | Valves | Feedthroughs | Cables | Electronics
Specialized B2B supplier

SUBSYSTEM / QUALIFIED CHAIN SUPPLIER
Qualified sensing chains | Optical modules | Integrated electronics
Responsibility for a complete function

DIAGNOSTIC SYSTEM INTEGRATOR
Measurement → Transmission → Acquisition → Control → Calibration → Qualification → Commissioning
Full system responsibility

Where does Swiss industry want to position itself in the fusion diagnostics value chain?