Strategic Planning for the DIII-D diagnostic and actuator Topical Area for 2024-2025

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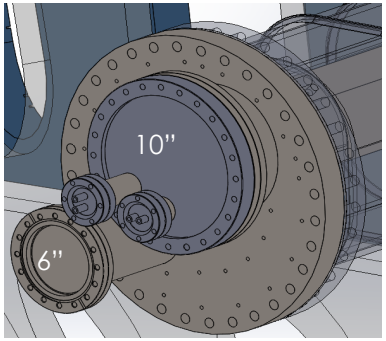
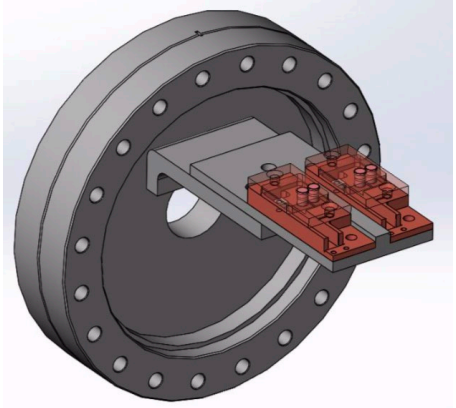
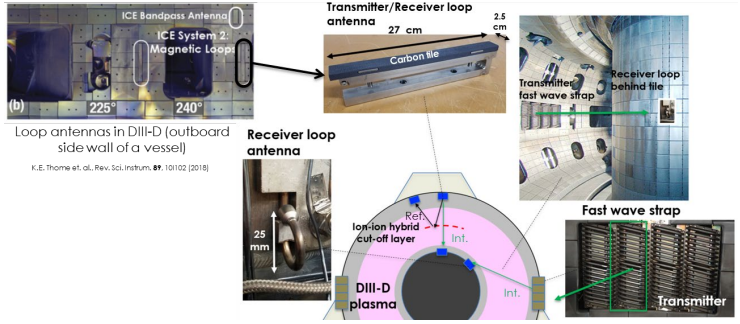
FPP Technology Strategic Planning Meeting

September 14, 2023



FPP test platform





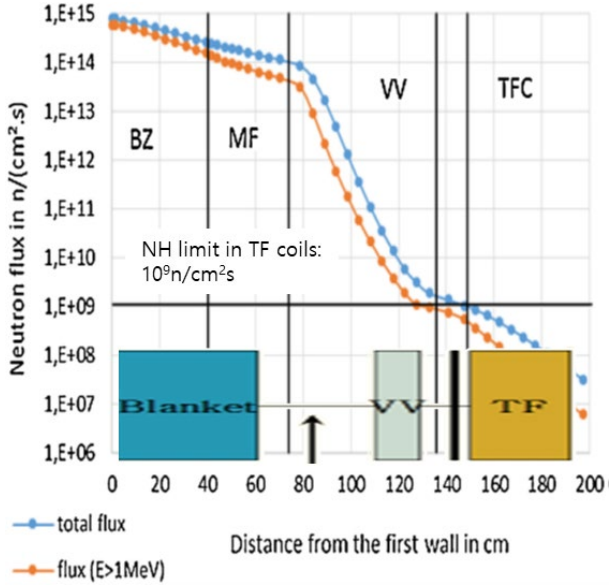
Loop antennas in DIII-D (outboard side wall of a vessel)

K.E. Thome et. al., Rev. Sci. Instrum. 89, 10102 (2018)

Fast Wave Interferometer and Reflectometer

Developing new reactor diagnostic technology:
FPP diagnostics will be very different from present-day and ITER

- **Diagnostics will be exposed to more harsh environments**
  - Neutron irradiation, higher heat and particle flux, thermomechanical stresses, relativistic effects
- **FPP will have a minimum set of diagnostics during the operation**
  - Very small and restricted spaces due to T breeding
  - **Miniaturization & modularization** of essential diagnostics

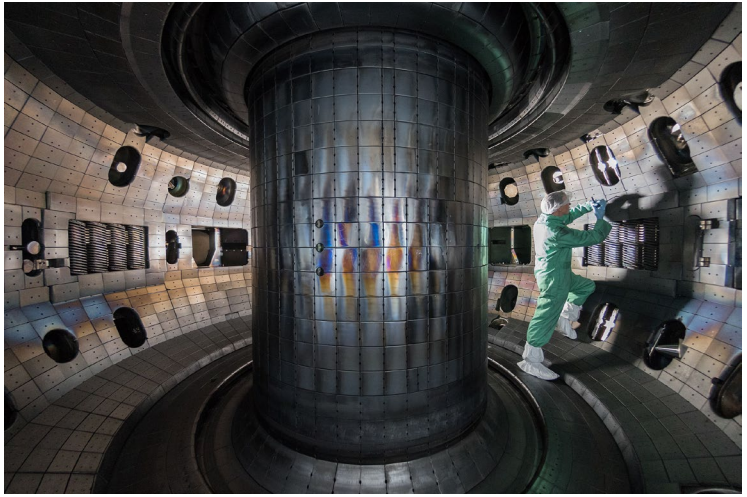


J.-C. Jaboulay et al. / Fus Eng Des 124 (2017) 896–900

Operating in the FPP reactor environment brings new challenges to the controls and diagnostics

DIII-D is the leading US platform to test reactor diagnostics

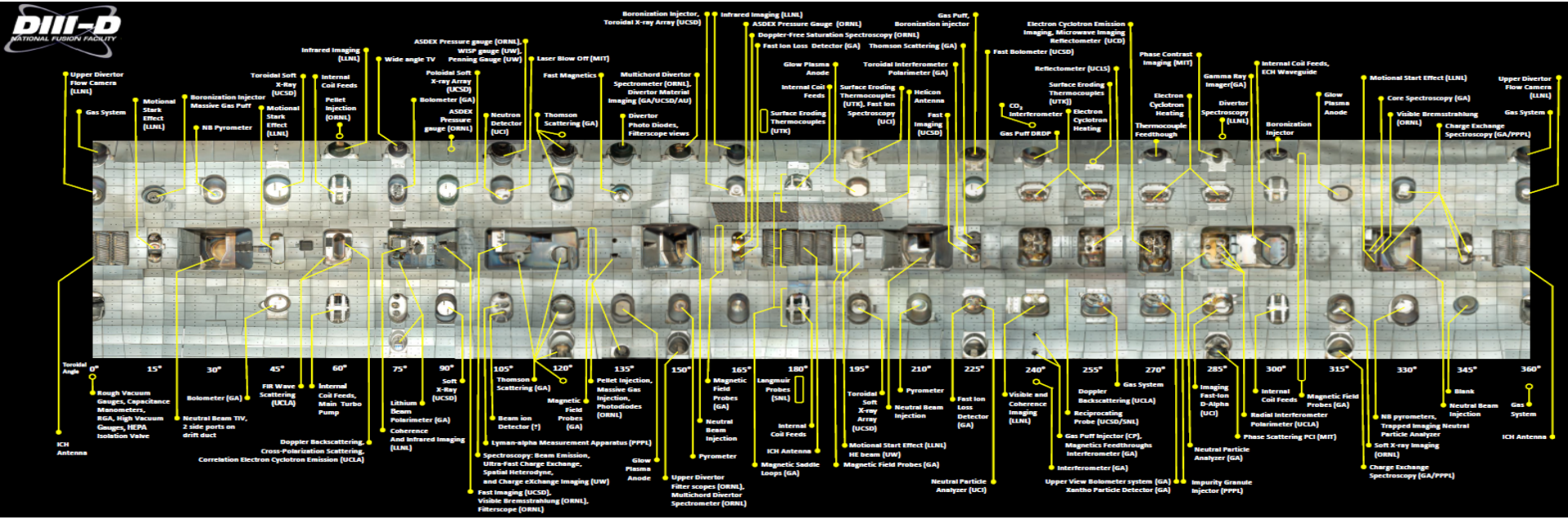
- Exceptionally flexible infrastructure to rapidly implement and assess new diagnostics
- Offers relevant plasma parameters
- Validate FPP techniques against existing proven systems
- Train next generation of FPP diagnosticians



DIII-D will establish new public-private partnership programs to develop FPP diagnostic systems

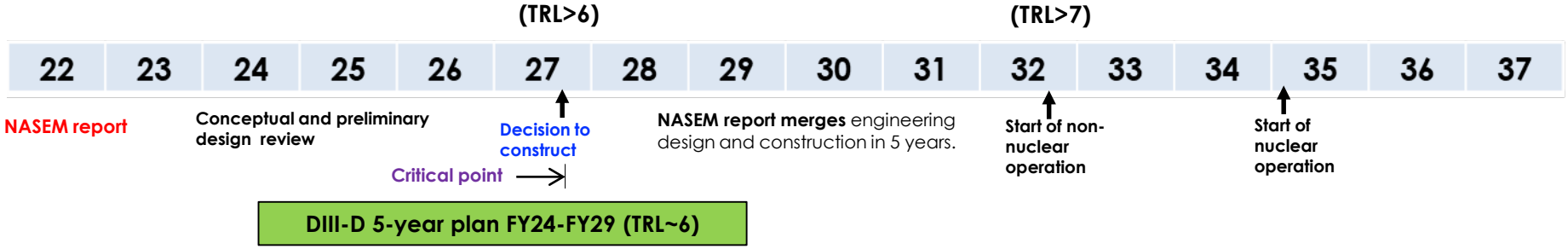
DIII-D world-leading diagnostic set is well suited and is capable of addressing and advancing the plasma interacting technology

As of May, 2022



DIII-D provides user platforms with excellent diagnostic tools for the verification/validation of new approaches

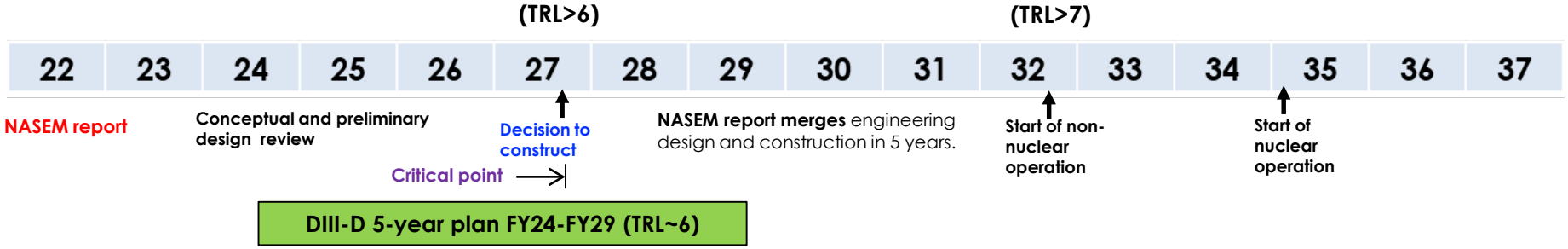
DIII-D will offer a flexible environment for the miniaturization, modularization, and standardization of essential diagnostics



- Diagnostic design must be fixed before the FPP engineering design phase (critical point).
- Synthetic diagnostics combined with validated models predict plasma behavior for the plasma control and machine protection.

A strategic planning for the FPP diagnostic development has to be set

Two-stage strategy for the FPP diagnostic development



- **Stage 1: Diagnostics for commissioning and non-nuclear phase**
  - Full set of diagnostics for a short period (3-6 months)
  - Less harsh, obtain data for synthetic diagnostic driven by AI/ML for PCS
- **Stage 2: Diagnostics for nuclear phase, pre-designed, steady-state plasma scenarios**
  - Reduced set of diagnostics measuring deviation from the steady state
  - Actuator/control rather than "diagnostics"

Strategies for each stage have to be set separately

Charge 1: Identify FPP diagnostics for stage 1 and 2

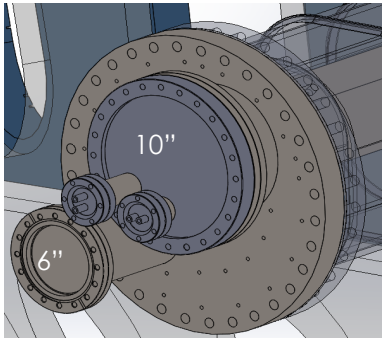
- **Determine a full and reduced set of diagnostics stage 1**
  - Full measurement for commissioning and operation in non-nuclear phase
  - Cross-check of measurement
  - Input for AI/ML

- **Determine a reduced set of diagnostics for stage 2**
  - Operation in nuclear phase
  - Reduced spec (spatial/temporal resolution, coverage) as actuator/control knob
  - Fully automatic, directly connected to PCS

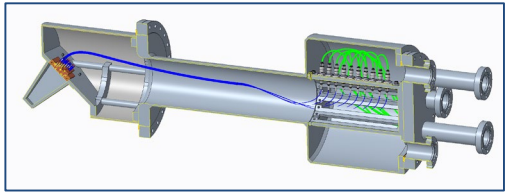
Long term deliverables: Sets of diagnostics suitable for each FPP stage

Charge 2: New FPP diagnostic development for stage 1 and 2

- **Dedicated reactor diagnostic port space and platform**
  - Cross-calibration with world-leading existing diagnostic set
  - Guidance and deep discussion with world-leading experts
- **Miniaturization and modularization of essential diagnostics**
  - Due to limited port space
  - Should be easy to replace
  - No maintenance and repair: Come out as nuclear waste
- **Standardization of essential diagnostics**
  - No machine dependency
  - Path to the commercialization should be straight-forward



Example of FPP test platform



Fiber optic bolometer

Long term deliverables: New, innovative diagnostics suitable for each FPP stage