Introduction to the DIII-D Technology Group

by
Andrew Dvorak
w/ Tyler Abrams

Presented to
FPP Technology Strategic Planning Meeting

September 13th-14th, 2023

DIII-D NATIONAL FUSION FACILITY

First…

- Thank you very much for making time, we appreciate your involvement and value your time.

- We look forward to pushing the development of Fusion Technology.

Goal of the Strategic Planning Meeting

- **Identify how DIII-D can best support technology research for Fusion Pilot Plant, FPP for the next two years.**
- **Discuss goals and high priority research efforts for next two years**

Organization of Strategic Planning Meeting

Identify how DIII-D can support FPP needs

Discuss goals and research efforts

FPP Technology Strategic Planning Meeting - September 13-14, 2023

Remote Connection Information: Zoom Link

All times in Pacific Daylight Time (PDT)

Wednesday Morning - Overviews, Fusion Industry Needs			
Time	ID#	Name	Title
10:00	00	R. Buttery	Opening Remarks
10:05	01	T. Abrams	DIII-D Research Opportunity Forum (ROF) Process Summary
10:10	02	A. Dvorak	Introduction to DIII-D Technology Group and Facility Capabilities
10:30	03	D. Clark	Fuse Energy
10:40	04	M. Nakamura	Helical Fusion
10:50	05	B. Grierson	General Atomics
11:00	06	J. Pickles	Tokamak Energy
11:10	07	P. Carle	General Fusion I
11:20	08	C. Riberio	General Fusion II
11:30	09	T. Abrams	Summary of DIII-D Engagement with Fusion Industry
11:40	10	All	Fusion Industry Needs Open Discussion/Q&A
Noon			Lunch Break
Wednesday Afternoon - Disruption Mitigation (DisMit), Heating and Current Drive (H&CD)			
1:00	11	D. Shiraki	DisMit Overview
1:15	12	D. Shiraki	General Disruption Mitigation Thrust Idea
1:45	15	All	DisMit Open Discussion/Q&A
2:00	16	R. Pinsker	H&CD Overview
2:15	17		Thrust Proposal: LHCD commissioning with plasma
2:25	18		Thrust proposal: High-power helicon heating & current drive
2:45	20	All	H&CD Open Discussion/Q&A
3:00			Adjourn

Discuss goals and research efforts

Thursday Morning - Plasma-Materials Interactions (PMI), Diagnostics and Actuators (D&A)			
10:00	21	D. Rudakov	PMI Overview
10:15	22	S. Zamperini	Thrust Proposal: W in the Main Chamber
10:25	23	F. Effenberg	Thrust Proposal: Advanced Wall Conditioning Techniques
10:35	24	R. Kolasinski/J. Coburn	Thrust Proposal: Testing of Novel PFC Materials
10:45	25	All	PMI Open Discussion/Q&A
11:00	26	S. Hong	D&A Overview
11:15	27	Y. Zhu	Thrust Proposal: Real-time diagnostics and feedback control in harsh environment
11:25	28-29	D&A Thrust Proposers	D&A Thrust Proposals (5 minutes + 5 min discussion each)
11:45	30	All	D&A Open Discussion/Q&A
Noon			Lunch Break
Thursday Afternoon - New Ideas, Wrap-Up			
1:00	31	A. Dvorak/T. Abrams	New Technology Ideas Overview
1:10	32	All	New Technology Ideas Open Discussion/Q&A
1:45	33	A. Dvorak/T. Abrams	Summary, Wrap-Up, Next Steps
2:00			Adjourn

Contents

- Introduction of DIII-D
- Introduction of Technology Research Program, TRP
- Strengths of DIII-D program
- Overview of how to get involved in DIII-D
- Conclusion

DIII-D, an introduction

DIII-D National Fusion Facility

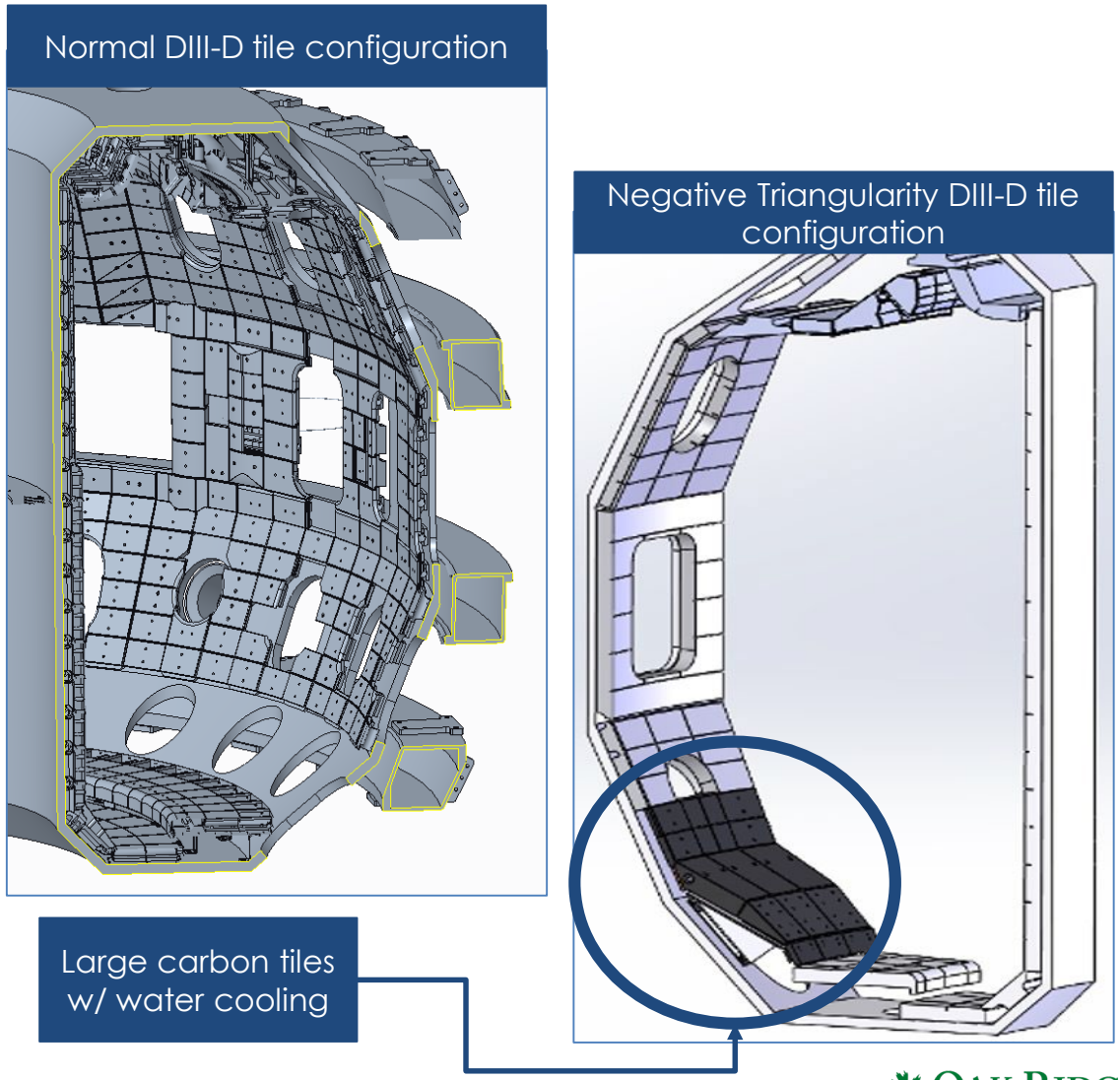
- Largest magnetic fusion user facility in US. Located in San Diego, CA
- Operations began in 1986. DIII-D team consists of ~130 institutions from all over the world to push science and technology development of Fusion Energy
- The programmatic goal is to develop the solutions for future fusion reactors. DIII-D can achieve this using the comprehensive set of high-resolution diagnostics, expert operations workforce, and pioneer research capabilities. DIII-D capabilities are ever evolving and improving.

DIII-D National Fusion Facility

- **DIII-D is a user facility of the U.S. Department of Energy, Office of Science.**
  - Federally funded facility available for external use to advance scientific & technical knowledge
  - The facility is open to all interested potential users without regard to nationality or institutional affiliation.
  - Allocation of facility resources is determined by merit review of the proposed work.
  - User fees are not charged for non-proprietary work if the user intends to publish the research results in the open literature. Full cost recovery is required for proprietary work.
  - The facility provides resources sufficient for users to conduct work safely and efficiently.
  - The facility supports a formal user organization to represent the users and facilitate sharing of information, forming collaborations, and organizing research efforts among users.
  - The facility capability does not compete with an available private sector capability.

DIII-D's major strength is the flexibility of the program

- **Although DIII-D has been around for many decades, it has stayed relevant because of the site's ability to change, adapt, and experiment in a collaborative environment.**
- **An example of this is the negative triangularity campaign.**
  - **The technical staff successfully reconfigured the tokamak's carbon tiles to experiment with negative triangularity**
- **DIII-D has the resources (scientists, engineers, machinists, welders, etc.) to rapidly innovate**



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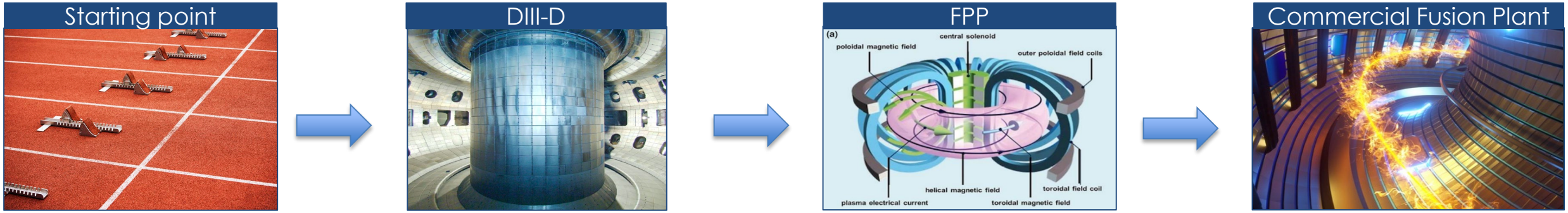
Fusion Pilot Plant, FPP is a DOE program to construct a fusion energy plant that produces electricity

- **FPP is a program to construct a fusion energy pilot plant**
  - Goal #1: Producing net positive electricity → demonstrate feasibility
  - Goal #2: Demonstrate safe, stable product viability → demonstrate commercial viability
- **FPP is step toward commercialization of fusion technology industrialization**
  - DIII-D, a federally funded site, is here as a stepping stone to de-risk FPP technologies
  - Our mission is to be available to Fusion Industry partners



DIII-D provides a reactor relevant test bed

- As well as using DIII-D for plasma physics studies, DIII-D will also be used as an experimental test bed to validate technology in a plasma interacting environment.

- The vision is to have clients come to DIII-D to validate and mature their technologies. As a federally funded User Site, our mission is to be available to partners to push FPP program.

Other services DIII-D can offer Fusion Industry

- **Work force development/apprenticeships**
  - Experienced staff that can pass on knowledge
- **Technical reviews & expertise**
  - World leading experts, integration experience, and design experience.
  - Experienced DIII-D personnel can help execute correctly.

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Technology Research Program

What is the Technology Research Program?

- TRP is a program that focuses & prioritizes FPP developments on DIII-D.

- Goal:
  - Develop crucial plasma-interacting technologies to accelerate the engineering maturity of the fusion pilot plant design space by demonstrating associated technologies, such as plasma actuators and control, plasma-material interactions, and sensors and diagnostics.

- Purpose: Maximized DIII-D utilization on the path towards FPP development

With the creation of the Technology Research Program, there is a shift in DIII-D programmatic mentality.

- **Technology development has become one of the primary DIII-D missions.**
  - Integration and testing of new technologies is expected to expand.
- **What does this mean?**
  - We will try new diagnostics, H&CD technologies, disruption mitigations, materials, control systems, etc. in a realistic environment to mature FPP technology.

Who is the Technology Research Program?

- **Tyler Abrams – GA plasma physicist w/ ~10 years of experience at DIII-D, who knows inter working of DIII-D to deliver projects**

- **Me (Andrew Dvorak) – ORNL Mechanical Engineer, Pellet Injector and Diagnostic design, with semi conductor industry experience.**

- **Having representatives of DIII-D and National Lab is an advantage.**
  - We want to position the program to leverage DIII-D, the National Lab System, and the benefits (including access to INFUSE funding, access to DIII-D resources, Tech Centers, etc.)

- **We are here to serve the FPP effort.**

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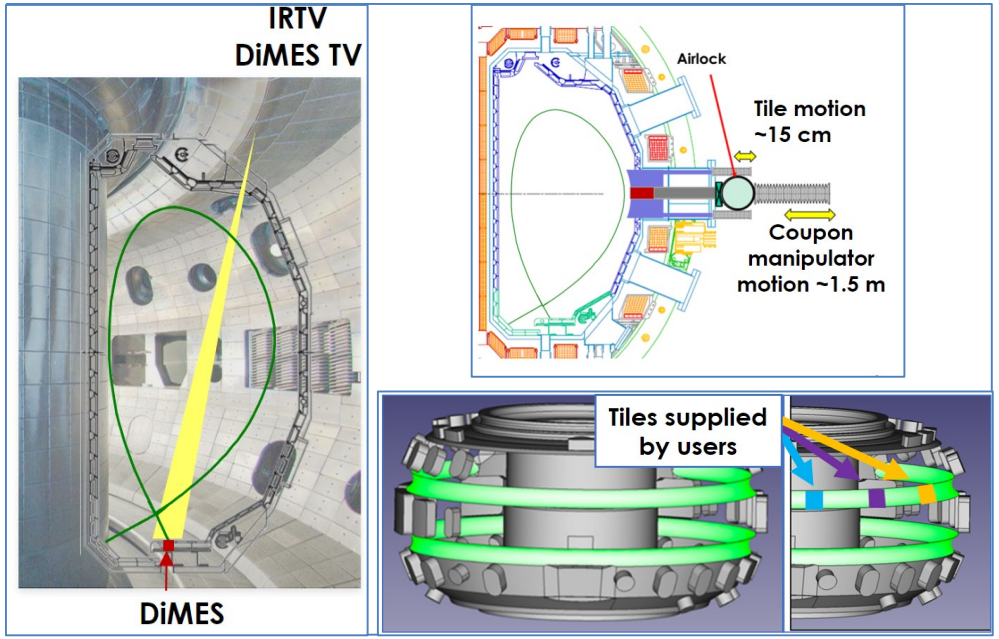
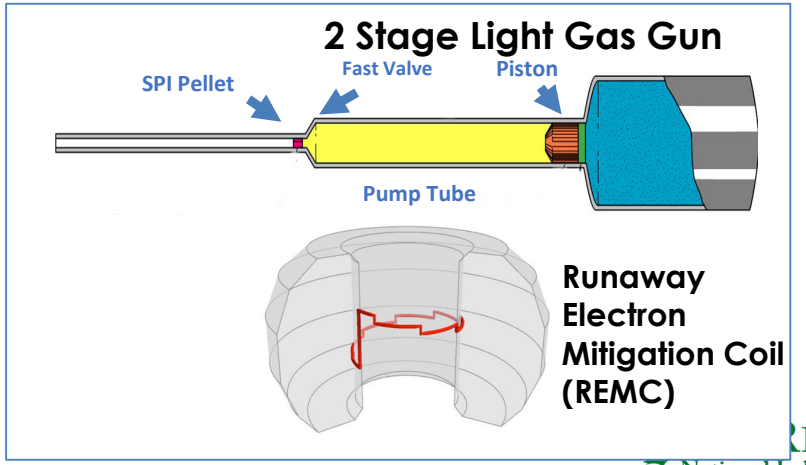
DIII-D Technology Programs and their respective strengths – an overview

- **Materials**
  - Test bed for trying new materials
  - Very useful near future tools → DIMES, WITS, Toroidal Limiters
    - *Ability to test novel materials and components at various toroidal locations*

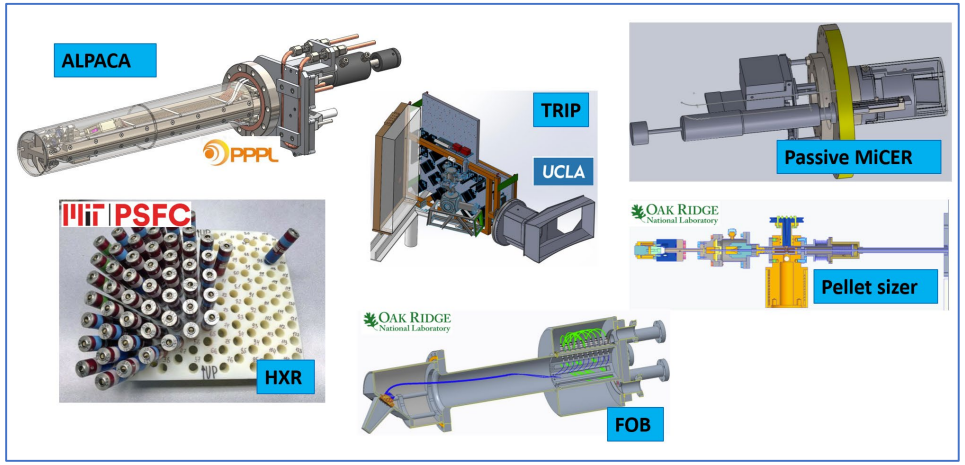


- **Disruption Mitigation**
  - Robust, mechanically strong tokamak with unique survivability
  - Testbed for alternative mitigation schemes

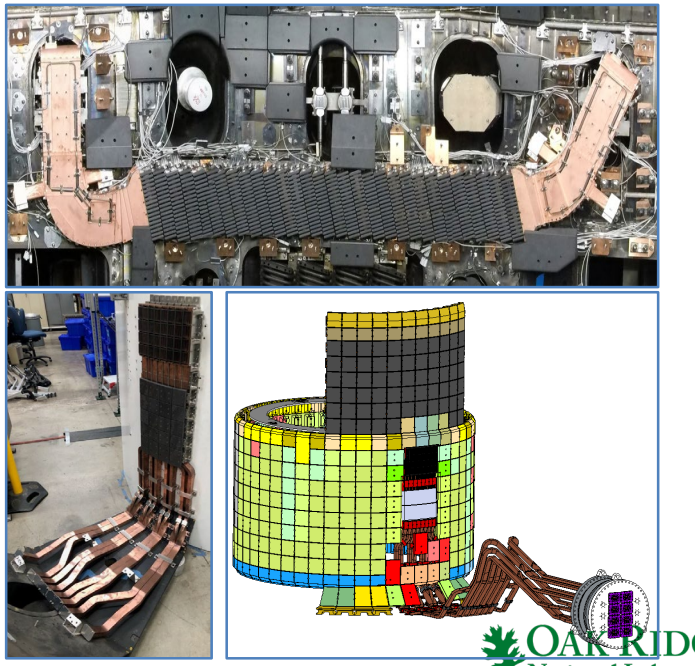


DIII-D Technology Programs and their respective strengths – an overview

- **Diagnostics**
  - Expose and validate diagnostics in DIII-D environment
    - *Utilizing expertise for review(if desired) and/or integrate*
  - Future developments for a diagnostic testing platform



- **Heating and Current Drive**
  - ECH Test bed
    - *DIII-D offers gyrotron sockets, transmission lines, and supporting components. This environment enables rapid iterations of designs at a low capital cost*
  - Novel H&CD methods
    - *Helicon and Lower Hybrid Current Drive are very interesting technologies. Our DIII-D community can help FPP developers design and implement these technologies*
    - *DIII-D community is here to help deploy these technologies.*



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Curious to get involved? How does it work?

DIII-D is an available facility for FPP Fusion R&D.

- **Partners (public and private) can integrate into our R&D ecosystem to quickly iterate technology and learn through actual experimentation**
- **Need not invest major resources instead use the DOE funded User Facility**
  - Two routes for DIII-D collaboration:

	Nonproprietary Route	Proprietary Route
Cost:	**No cost burden** for external org	External org responsible for operational costs
Requirements:	• Must pass design review for DIII-D community to understand risks to tokamak • **Publication of research data**. No requirement to share technological process.	• Must pass design review for DIII-D community to understand risks to tokamak • All **data is kept proprietary**.

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How to get involved in DIII-D experiments?

- **Step 1: Go to https://d3dfusion.org/become-a-user/**
  - Here you will find contact information, instructions, and forms
- **Step 2: Contact relevant group leaders (if you're unsure, contact Tyler or me (Andrew))**
  - Burning Plasma Physics: George McKee
  - Edge and Boundary Physics: Morgan Shafer
  - Integrated Plasma Scenarios: Chris Holcomb
  - Plasma-Interacting Technology: Tyler Abrams and Andrew Dvorak
- **Step 3: Get a GA host assigned → determine scope of work**
- **Step 4: Fill out forms from website**

Conclusion

- **DIII-D provides a reactor relevant plasma environment for technology development/validations**
  - Mentality has shifted to dedicate program resources for furtherment of FPP technology
- **The DOE milestone projects can use DIII-D as a steppingstone for technology development**
- **DIII-D has expertise and experience that should be leveraged.**
- **Private sector should utilize an operational US tokamak to further technology, train the next generations, and to retire FPP risks on our path to Fusion Energy.**

Thank you for your time.

Any questions?