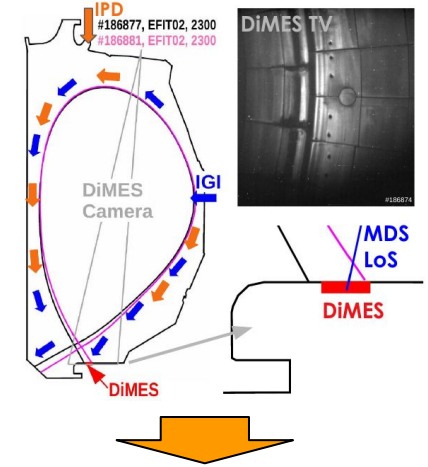
Thrust Proposal: Advanced Wall Conditioning Techniques

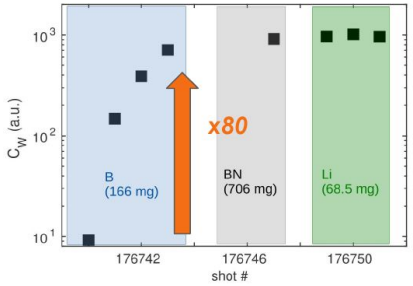
- **Long range goal:** Develop advanced wall conditioning techniques and understand their effect on mixed material build-up and fuel retention to scale methods for FPP and ITER.

- **Why DIII-D? Why Now?** DIII-D's suitable actuators and unique diagnostic capabilities for real-time coating & conditioning allow to address urgent PMI challenges for FPP and ITER success.
  - GDC, IPD, IGI, DiMES, MiMES, CPs, RF, ECH allow to study the effects of boronization, lithiumization, or siliconization for reactor-relevant scenarios
  - ITER's full-W wall decision calls for new & urgent efforts on conditioning (including IPD)
  - FPP predictions: "flow-through walls" & net erosion up to 10^5 kg/yr exceed current surface conditioning and slag management challenges *P C Stangeby et al 2022 Plasma Phys. Control. Fusion 64 055018*

Real-time material injection



Wall pumping factor $C_W = \Gamma_{D2} / \langle n_e \rangle$



Research priorities & deliverables

- **Priority for FY24-25 studies**
  - Coating deposition, erosion, redeposition, and distribution of coatings
  - Removal of mixed-materials, debris and dust resulting from surface conditioning
  - Fuel retention in coating layers, dust & debris
  - Formation and chemical composition of coatings & co-deposits on heated targets
  - Real-time siliconization & SiC formation for enhanced oxygen gettering
  - Apply IPD in conjunction with ECRH, and RF techniques in suitable scenarios and develop robust figures of merits to evaluate their impact on wall conditioning (e.g., effect on impurity levels and fuel retention)
- **Deliverables:**
  - New or optimized schemes for conditioning and slag management in an FPP & ITER
  - Data will serve new model development and validation of existing ones, in particular GITR, ERO, ITMC-DYN, SDTrimSP, DIS, DUSTT and Walldyn

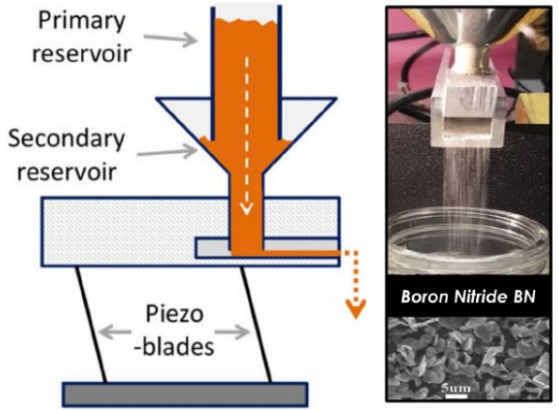
Risk, goal alignment & ressources

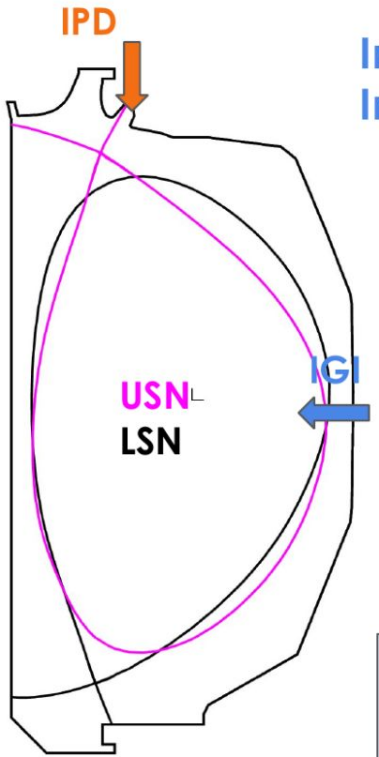
- **Risk:**
  - Real-time conditioning has been demonstrated for a few scenarios recently, disruptive discharge terminations due to excessive boron or silicon injections haven't had detrimental effects on machine conditions
- **Goal alignment:**
  - FWP 1.3.4 Advanced Materials Evaluation: develop methods for real-time wall conditioning
  - 5YP 3.6 Evaluate and Identify New Materials and Components Compatible with the Reactor Environment
- **Approx run days and years to result:** 7 days, 2 year effort
- **Preparation:** works with current hardware setup (but endorses PMI diagnostic upgrades like WITS, CX sensor, microbalances, dust collector probes etc)
- **Physics area(s) involved:** PIT/Plasma-Material Interactions (some cross-cutting with CEI regarding effects on plasma performance)

Appendix

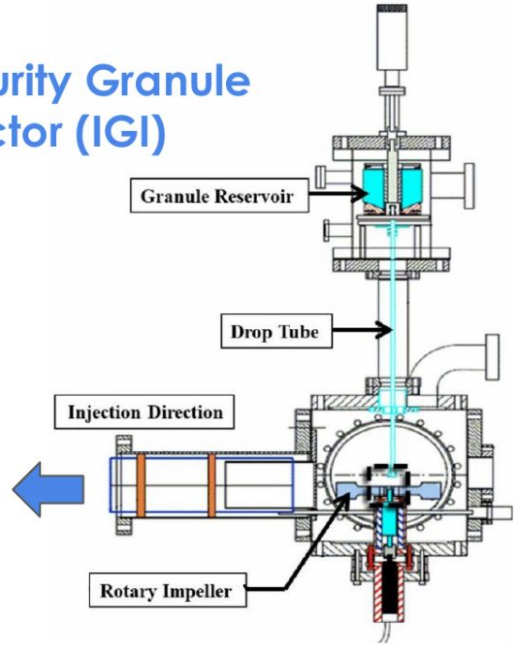
For material injection: two devices on top and at the outer midplane of DIII-D enable for real-time material injection

Impurity Powder Dropper (IPD)





Impurity Granule Injector (IGI)



Material properties

- B, BN, Li, B_4C, Si, SiC, …
- Particle size 5 µm - 1 mm

Injection parameters

- Mass flow 1-200 mg/s
- Speed ~5-200 m/s

A. Nagy et al 2018, Rev. of Sci. Instr. 89 (10) 10K121
M. S. Vorenkamp et al 2017, Fusion Sci. and Techn. 72, 488-495