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Materials and Plasma-Facing Components TSG Discussion of Recovery Project impacts

MA Jaworski on behalf of the M&P TSG

NSTX-U Materials and PFCs Topical Science Group
B318 – PPPL – May 24, 2017

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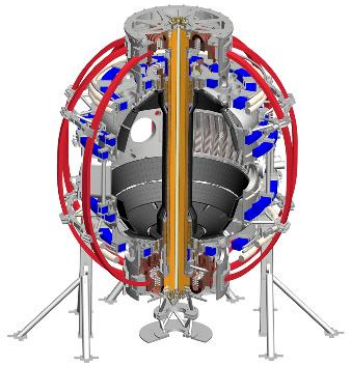
PPPL



Topical overview

- Brief summary of TSG shape/scenario requirements based on FY16/17 and 5/7 year plan
  - Review of 5/7 year research thrusts for M&P
  - Review of experimental capabilities for FY16/17 plans

- TSG summary of impact of polar regions modifications
  - Impact on PFC-testing shape requests
  - Impact of Recovery and polar regions on research thrusts

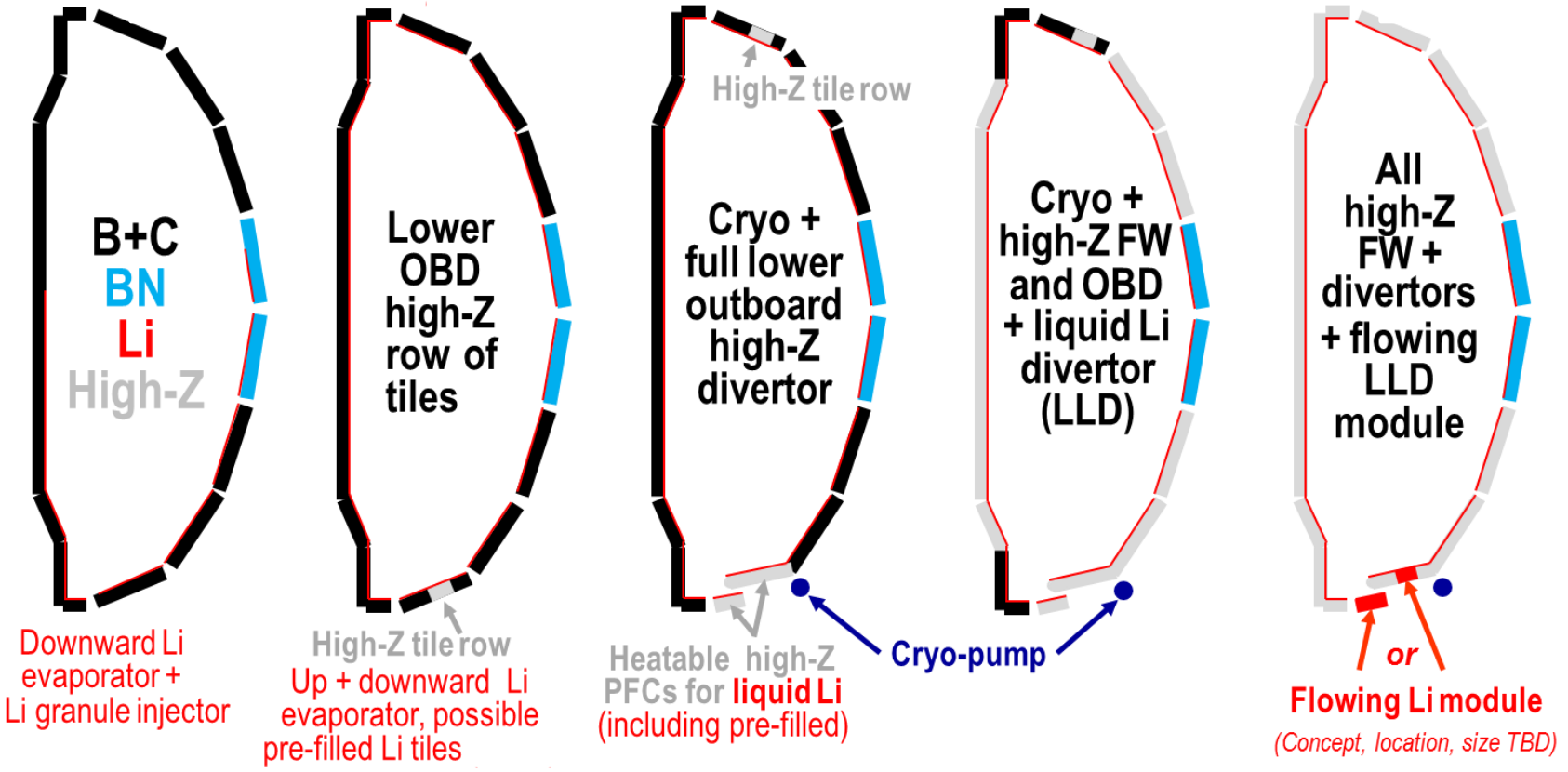
M&P research will develop understanding of material migration and heat-flux handling of high-Z and liquid Li PFCs

5-Year Plan Research Thrusts

- MP-1: Understand lithium surface-science for long-pulse
  - Assess impact of more complete Li coverage
  - Use the Material Analysis and Particle Probe (MAPP) and laboratory studies to link tokamak performance to PFC surface composition
- MP-2: Unravel the physics of tokamak-induced material migration and evolution
  - Confirm erosion scalings and evaluate extrapolations
  - Determine migration patterns to optimize technical solutions
- MP-3: Establish the science of continuous vapor-shielding
  - Determine the existence and viability of stable, vapor-shielded divertor configurations
  - Determine core compatibility and extrapolations for extended durations and next-step device parameters

Staged conversion mitigates risk and enables comparative assessment of both high-Z and liquid Li

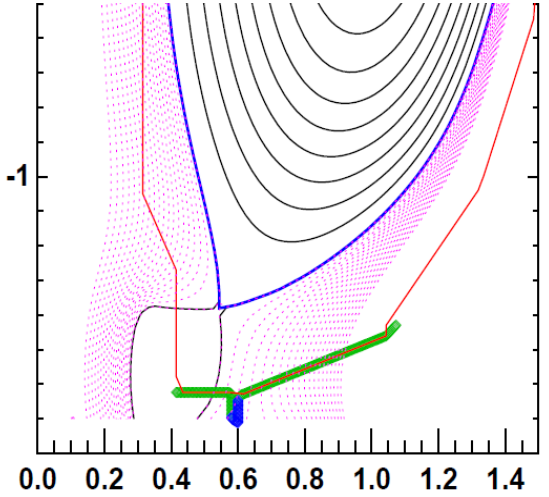
- Open divertor and flexible magnetic configuration enables multiple studies and material selection
- Single-variable experiment *in single campaign* enabled by conversion (i.e. high-Z vs. lithium PFCs)



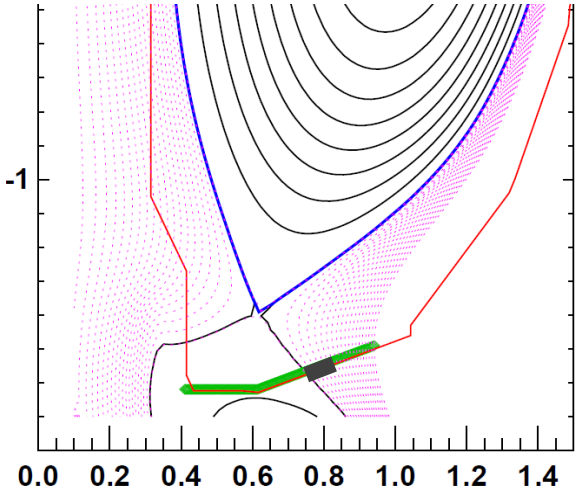
Reference shape requests enable exposure of novel PFC materials and utilizes MAPP diagnostic

- Shape developed to perform dedicated tests on outboard PFCs
  - Heat-flux figure of merit indicates 2/3 of high-performance heat flux on row 2
  - Does not reverse helicity on IBDH
- FY16 plans limited to 1s discharge at 10 MW/m^2
  - Can make MAPP measurements with discharges similar to 2016
  - Science aided by long pulse capability
- Reference shape request:
  - $0.73<R_{SP,out}<0.84$ (i.e row 2)
  - Q_{inc} = 10 MW/m^2 for 1s, & <max qualified for 5s>
- MAPP exposure shape request:
  - OSP close to/on MAPP R~1.04m
  - Q_{inc} = <max qualified for 5s>

High-performance discharge



PFC test reference discharge



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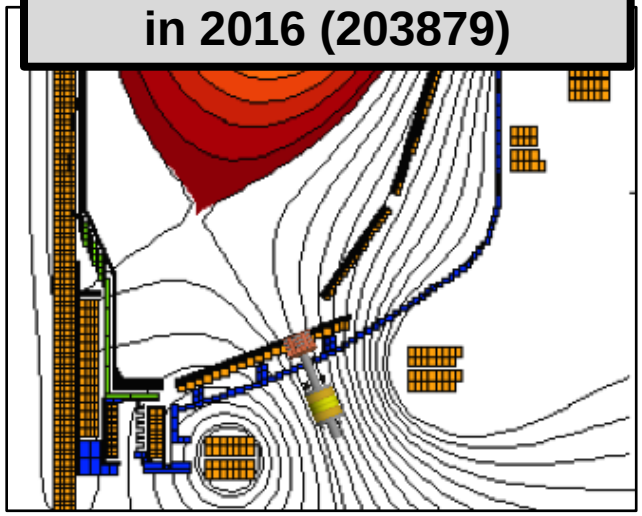
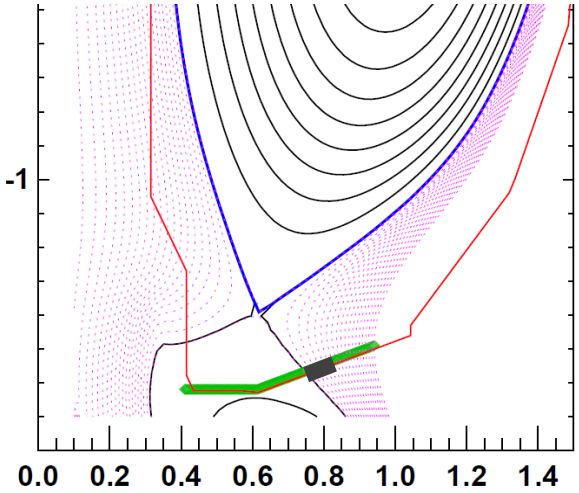
Shape already achieved in 2016 (203879)



High-Z reference discharge



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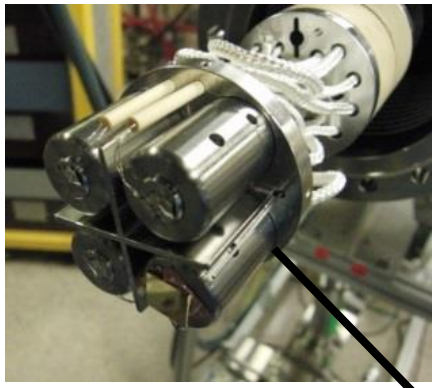
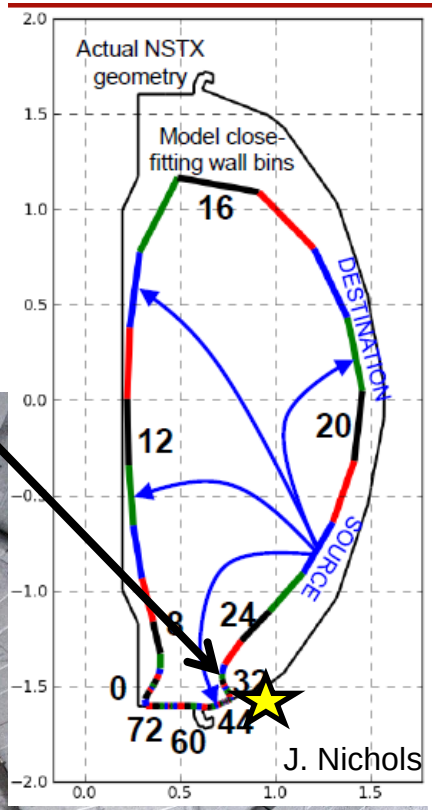
Research thrusts MP-1 and MP-2 not significantly impacted*

- M&P TSG meeting held May 11 to gather input
  - *Assuming diagnostic interpretation and implementation can be addressed
  - *Assumes B and Li conditioning will continue

- Diagnostic impacts
  - MAPP not affected (Kaita)
  - IR thermography and spectroscopic: needs analysis of spatial resolution (Vlad, Gray)
  - Witness plates & QCMs not affected (Skinner)
  - Langmuir probes; need redesign (Jaworski – included in PFC requirements draft document)



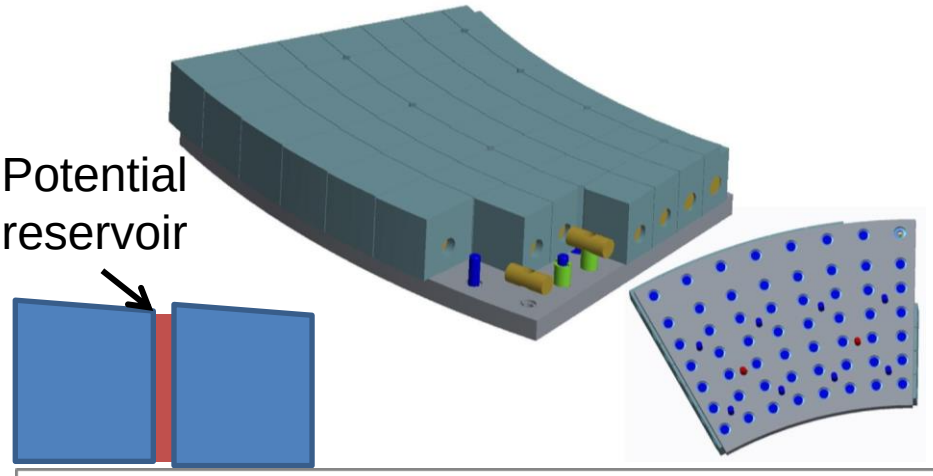
R. Kaita

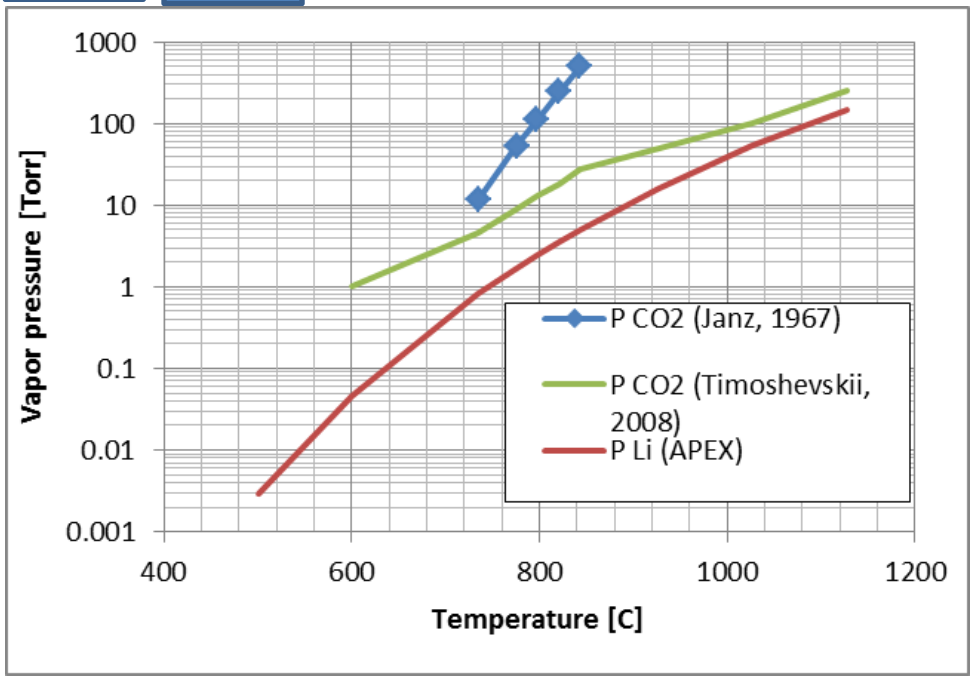


C. Skinner

Research thrust MP-3 can continue on general ablative materials

- Research plan modified by delay in high-Z and liquid Li
  - Expect restart with graphite PFCs
  - Accessible PFC temperatures far exceed NSTX
- Redeposited material can create reservoir for decomposition into plasma
  - Li_2CO_3 decomposition releases CO_2 and should cool plasma
  - Represents general case of **self-limiting material** by ablative shielding
  - Motivates evaluation in revised milestone 18-2 (text tomorrow)





Summary

- Materials and PFCs TSG group has identified impacts of the recovery activity
  - Diagnostic impacts brought forth by group
  - Research plans only require some specific shapes
  - Shapes for PFC testing already expected to be determined by material performance limits

- M&P TSG research thrusts partially impacted by polar-region changes
  - MP-1 and MP-2 can be conducted with attention to diagnostic impacts
  - Consideration of *general* material ablation can make MP-3 more applicable to a wider range of materials