

PPPL 2018

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When is fusion needed?
Will the problem of sustainable energy be fixed by the
time it is ready?
Will it be too late?



Priority # 1, 2 and 3.

Bring NSTX back quickly and surely.
Baseline in February.



Our Fusion Priorities

- **Support ITER construction and prepare for operations.**
 - Extend our capability through ITER contracts.
 - Position US for important role in ITER ops.
 - Help scenario development for ITER ops. --- experimental scenario development; theoretical flight simulators, **Whole Device Modelling** etc.
- **Bring down the cost and scale of fusion reactors.**
 - Reactor optimization/innovation.
 - PPPL can lead innovation in several areas.
 - Power handling, exhaust, liquid metals
 - Innovative magnetic configurations
 - ST, Pilot plant studies. **This is why NSTX-U is important.**
 - Stellarator, W7X, very promising results. Optimize confinement – **manufacturing!**
 - Predictive modelling can lead design



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- **Reliability, Maintainability, Simplicity**
 - Systems code *Process* shows that availability is the greatest lever on Cost of Fusion Electricity.
Ward et. al. Fusion Engineering and Design 75–79 (2005) 1221–1227
 - ST, Pilot plant studies. **This is why NSTX-U is important.**
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People Priorities

- **Nurturing Excellence in Science and Technology**
 - Number of peer reviewed publications 350 -- KPI target 320
 - Growing the group of young fusion and plasma scientists – regeneration of US capability.
 - Retention of the best not a given.
- **Retaining and growing engineering excellence**
 - Training (recruiting) young cadre – graduate engineers
 - Apprentices, technician training



Sam Lazerson and
Nate Ferraro. DOE Early
Career Award winners

Compact Pilot Plants



Liquid metal PFC mission in NSTX-U

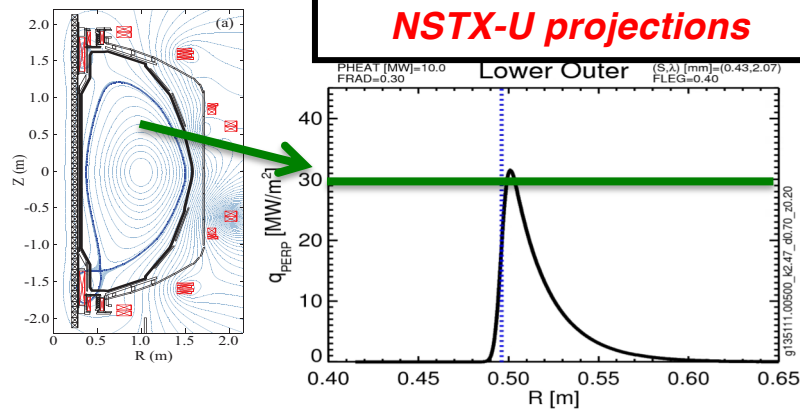
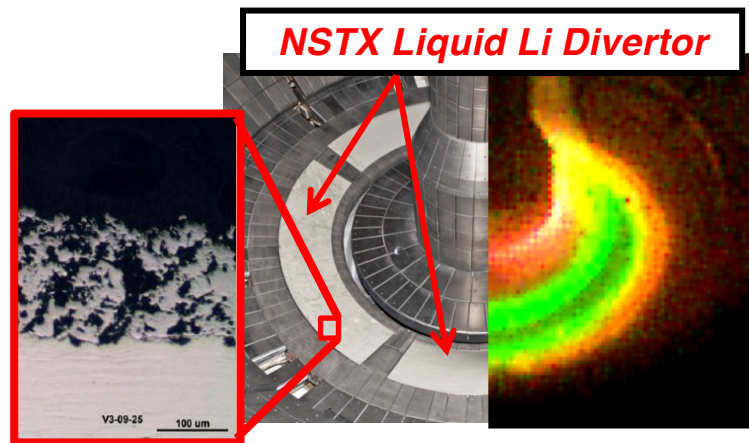
PPLAB May 2018

“The contributions of NSTX-U to the other initiatives should also be highlighted:especially the role of magnetic shape in the NSTX-U divertor, liquid metal boundaries, and lithium vapor box.”

NSTX PAC

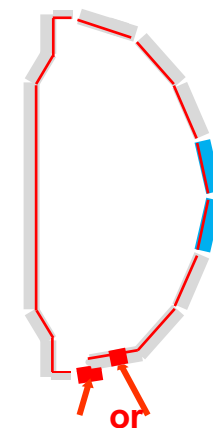
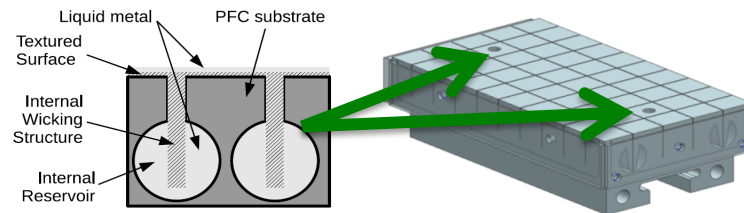
“The PAC acknowledges that graphite tiles may be needed to meet the near-term performance requirements of NSTX-U as a user-facility; however, this should not delay pilot-relevant PMI studies with lithium and high-Z walls.”

R. Miangi, et.al.



Possible Two stage liquid Li deployment in NSTX-U

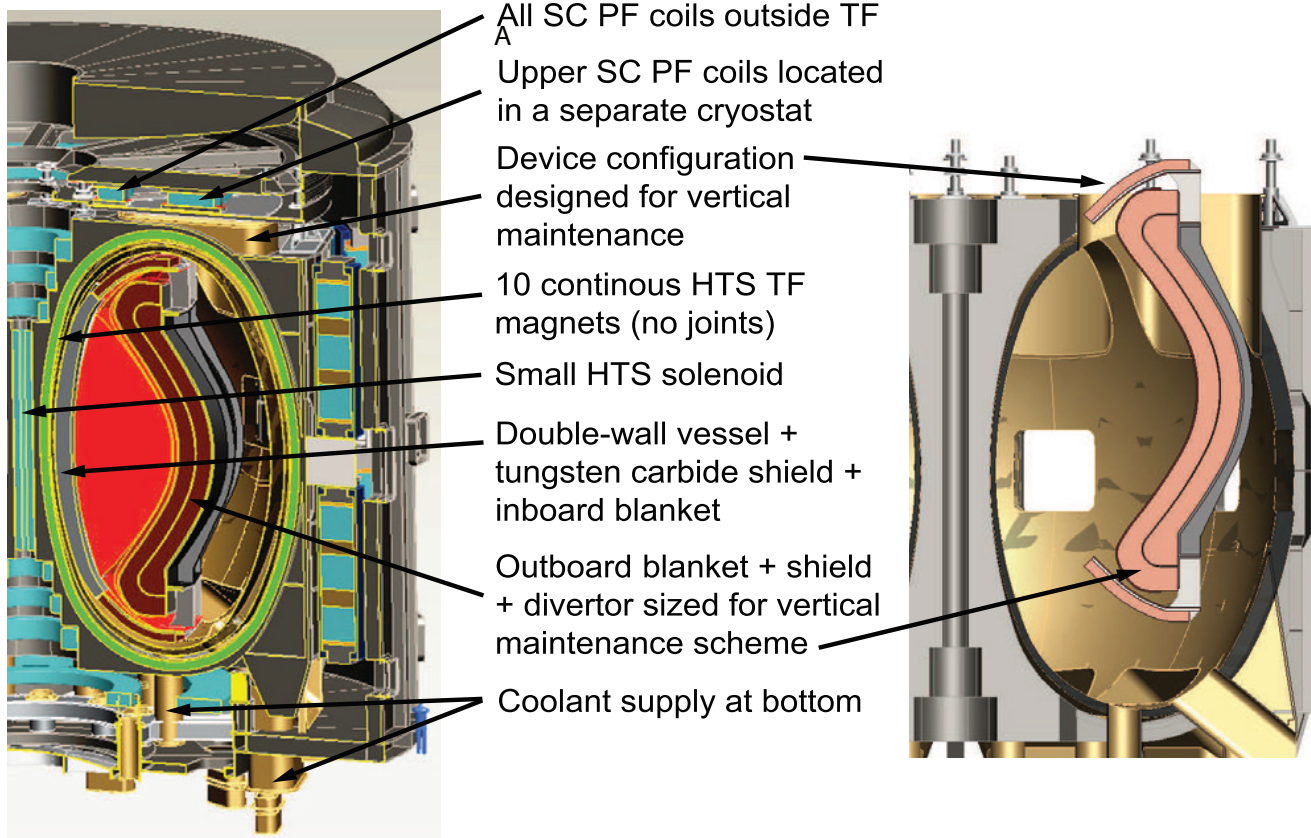
- **Stage 1.** Introduce Li atoms into divertor for particle and power exhaust 2023?
 - Pre-filled lithium plugs embedded in a high-Z substrate
 - Previously reviewed step (CDR) on path toward liquid metals in NSTX
- **Stage 2.** Full metal wall in NSTX 2025. Lithium vapor box etc.



**Flowing Li
module** (Concept,
location, size TBD)



ST Compact Reactor – Pilot Plant



Stellarator



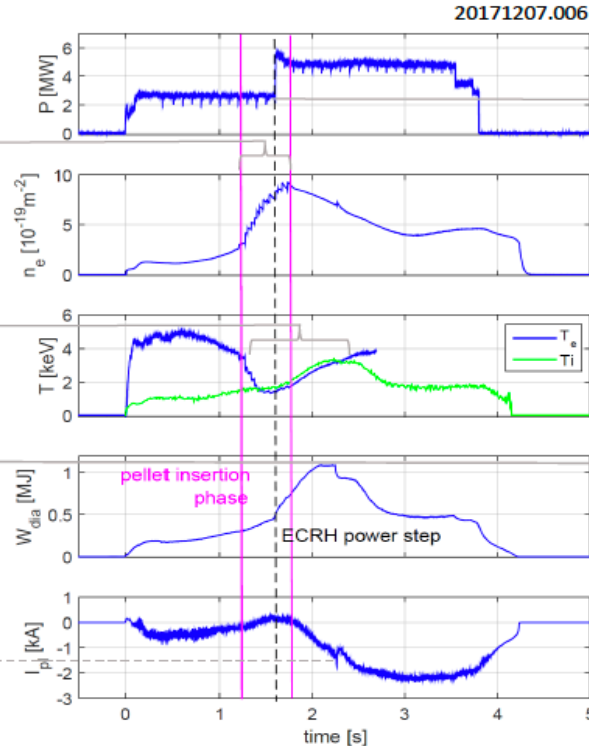
A record high performance plasma

hydrogen pellet injection
into helium target plasma

thermalization $T_e = T_i$

diamagnetic energy ≥ 1 MJ

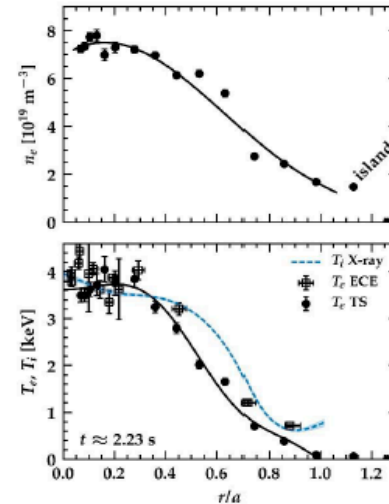
MHD event



X2 ECRH power doubled

record triple product
 $\geq 0.6 \cdot 10^{20}$ keVs/m³

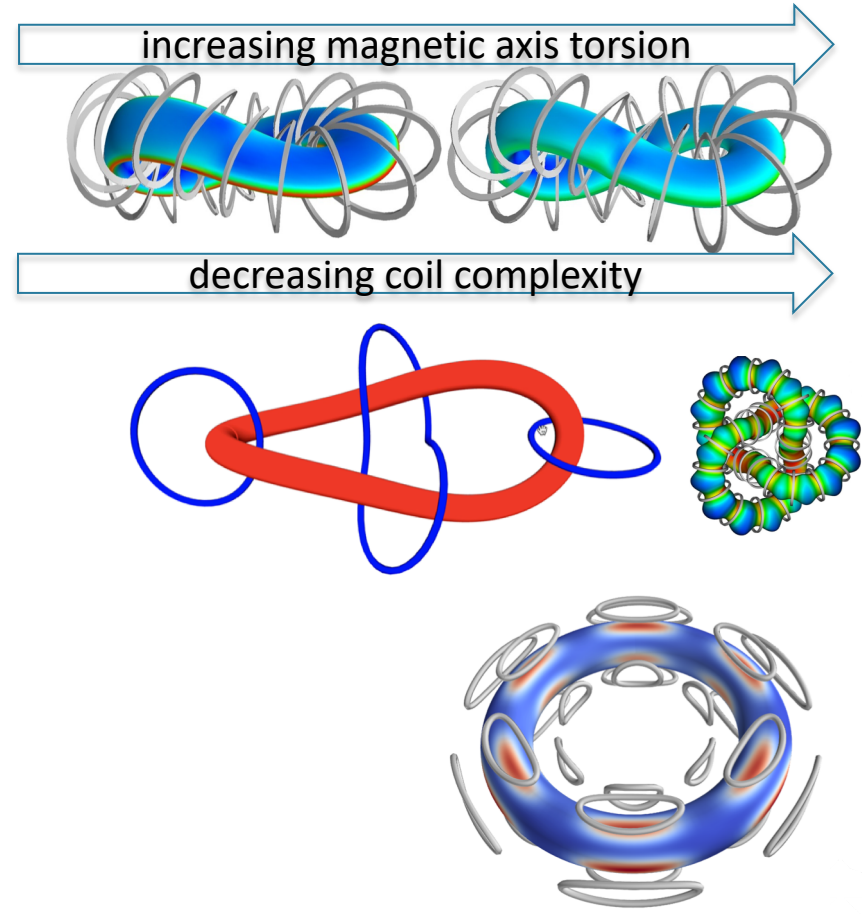
by courtesy of S. Bozhenkov



S. Bozhenkov EX/P8-8
O. Grulke EX/P8-9

Optimized Stellarator? Opportunity.

- It is unlikely that we have found the best Stellarator configuration. Optimizing for minimum turbulent transport is in its infancy.
- Simons Foundation supporting physics optimization of configuration "*Hidden Symmetries and Fusion Energy*,"
- Optimize for modern advanced manufacturing.



Strategy – Timeline.

