NSTX-U

Supported by

U.S. DEPARTMENT OF ENERGY | Office of Science

Snowflake divertor configuration control and scenario development

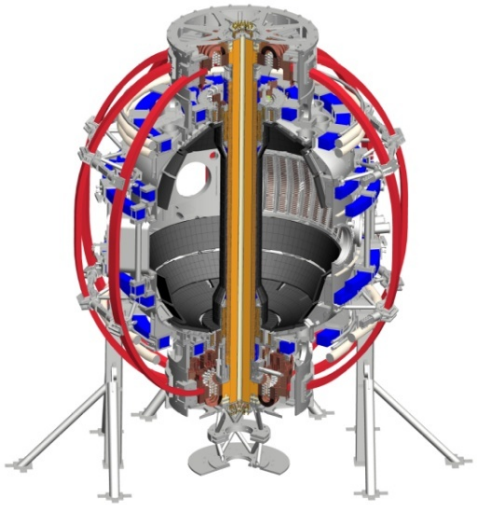
Vlad Soukhanovskii

and the NSTX Research Team

NSTX-U FY2015 Research Forum
Princeton, NJ
24 February 2015

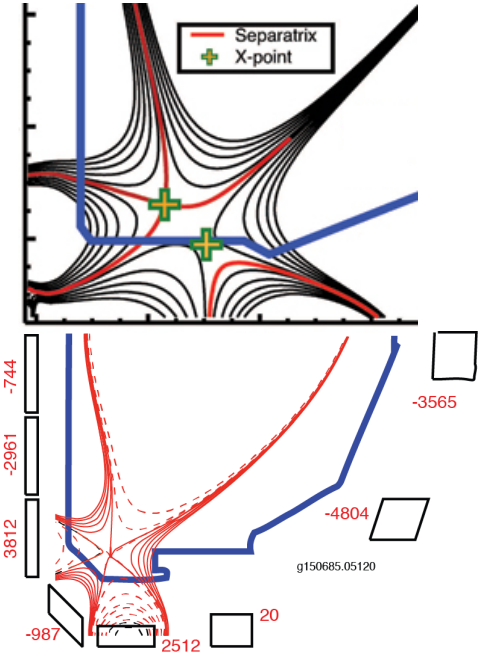
Coll of Wm & Mary
Columbia U
CompX
General Atomics
FIU
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Lehigh U
Nova Photonics
ORNL
PPPL
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Tennessee
U Tulsa
U Washington
U Wisconsin
X Science LLC

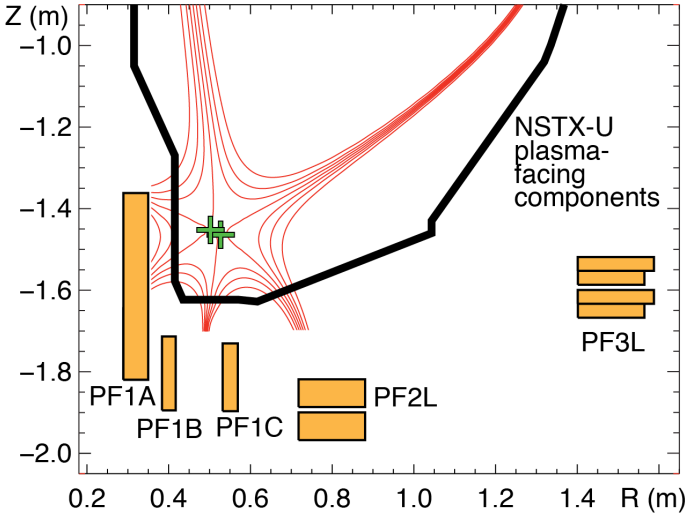
Culham Sci Ctr
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Inst for Nucl Res, Kiev
Ioffe Inst
TRINITI
Chonbuk Natl U
NFRI
KAIST
POSTECH
Seoul Natl U
ASIPP
CIEMAT
FOM Inst DIFFER
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep



Snowflake divertor is a leading candidate for divertor heat flux mitigation in NSTX-U

- Status of snowflake control
  - NSTX (2009-2010)
    - Strike point PCS control + pre-programmed PF1B
    - Pre-programmed PF1A, PF1B, PF2L
  - DIII-D (2012-2014)
    - Strike point PCS control + pre-programmed coild currents
    - Initial work on feedback-controlled d_{xx}, θ_{xx}
  - TCV (2009-2014)
    - Pre-programmed coil currents
  - NSTX-U
    - New coil layout
    - Near-term coils: PF1A, PF1C, PF2L
    - Longer term- up-down snowflake

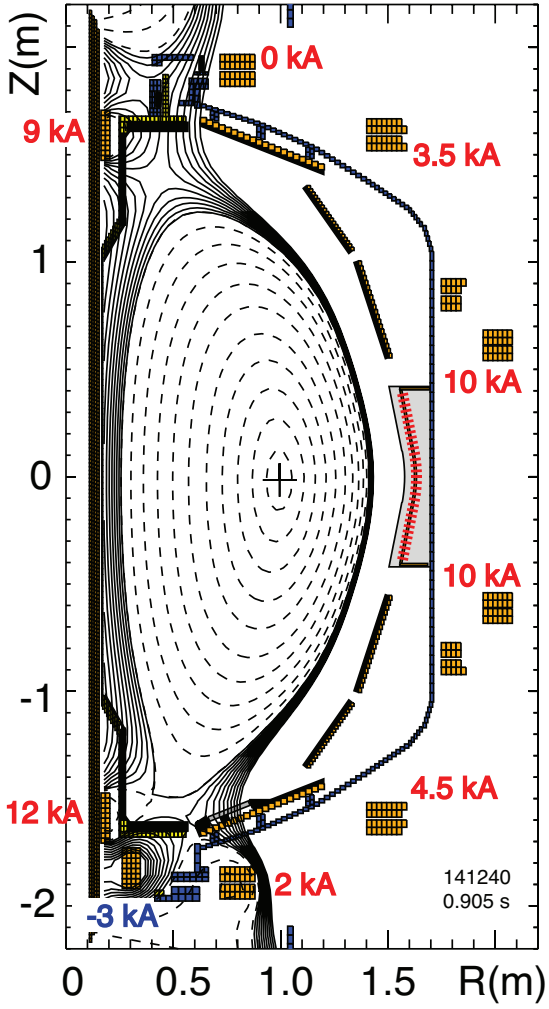


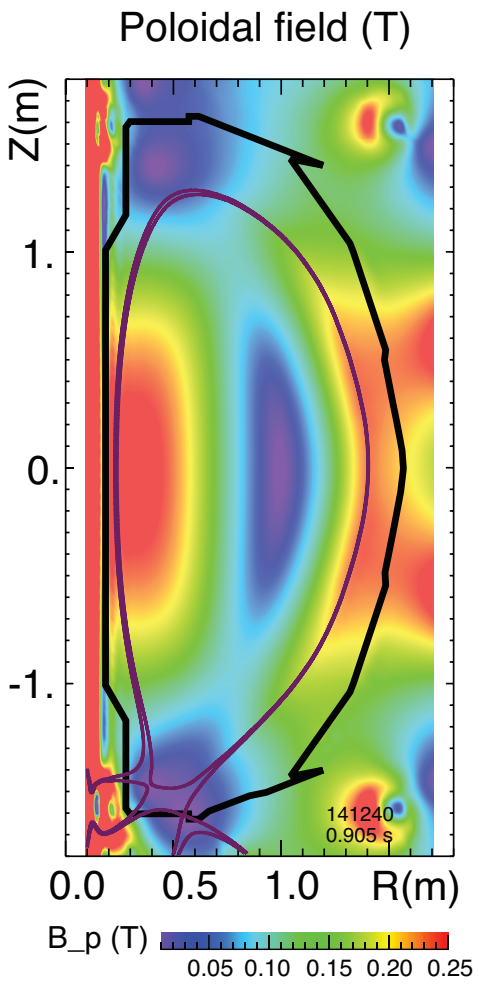


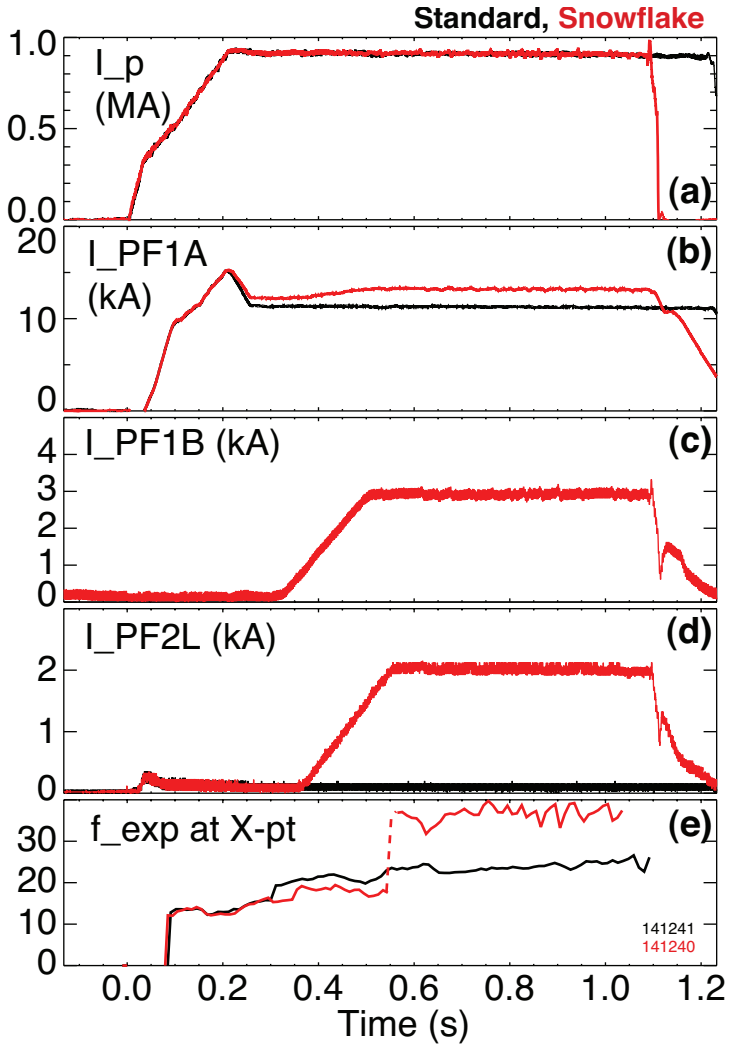
Two-pronged approach to snowflake control is proposed to enable initial data in FY15 and timely development for R16-1

1. Obtain SF configurations with pre-programmed currents (submitted Enabling/Cross-cutting XP)
   - Use gap control initially, then X-point or SP control from PCS
   - Verify coil current targets from ISOLVER models
   - Verify vertical stability, configuration stability beyond 0.5 s, etc
2. In parallel, start developing PCS feedback control of snowflake-plus and snowflake-minus
   - 1) Implement Makowski null-point tracker
   - 2) Develop and implement null-point seniority (what is the primary null, what is the secondary null)
   - 3) Implement inter-null distance control
     - Keep null-point orientation fixed at 45 or 45 degrees corresponding to snowflake-plus and snowflake-minus.
   - Exact snowflake will be obtained in the asymptotic limit of inter-null distance ->0 (as limited by PCS spatial grid resolution)

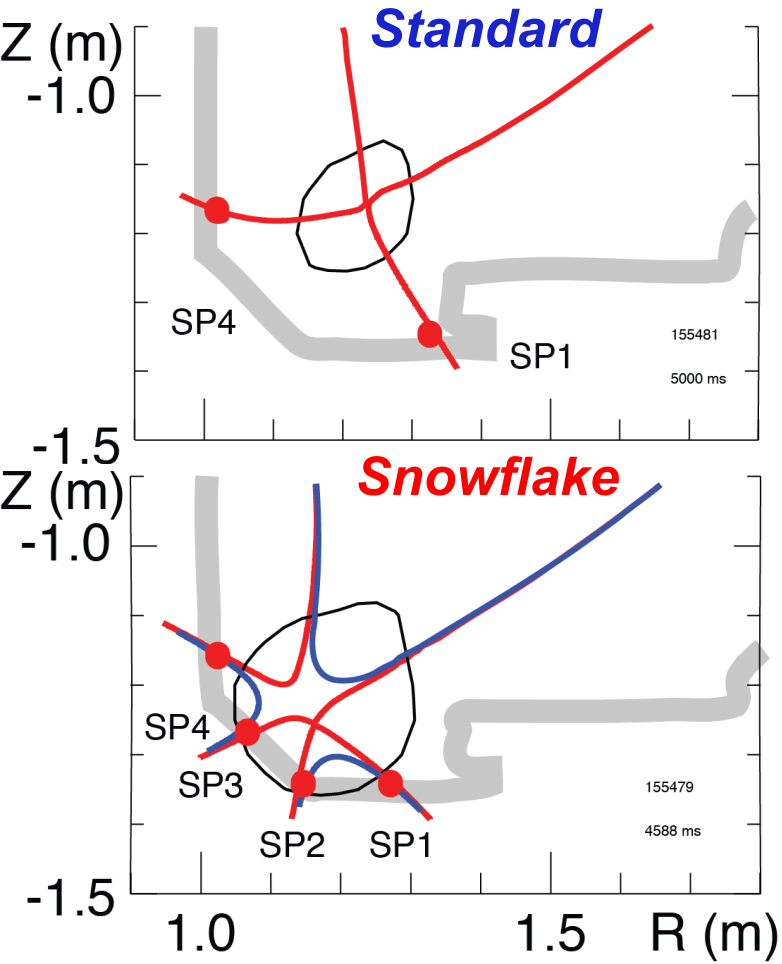
Snowflake-minus divertor configurations obtained with existing divertor coils in NSTX, maintained for up to 10 τ_E







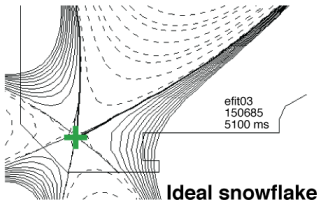
Large Region of Low B_p Around Second-order Null in Snowflake Divertor is Predicted to Modify Power Exhaust

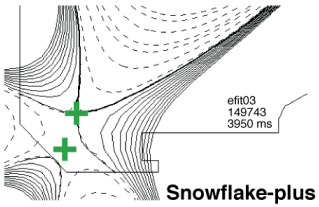


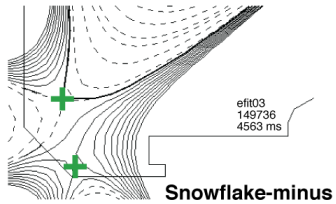
Low B_p contour: 0.1 B_p/B_p^{mid}

- ***Geometry properties***
  - ***Criterion: $d_{XX} \leq a\,(\lambda_q/a)^{1/3}$***
  - *Higher edge magnetic shear*
  - *Larger plasma wetted-area A_{wet} (f_{exp})*
  - *Larger parallel connection length $L_{||}$*
  - *Larger effective divertor volume V_{div}*
- ***Transport properties***
  - ***Criterion: $d_{XX} \leq D^* \sim a\,(a\,\beta_{pm}/R)^{1/3}$***
  - *High convection zone with radius D**
  - *Power sharing over four strike points*
  - *Enhanced radial transport (larger λ_q)*

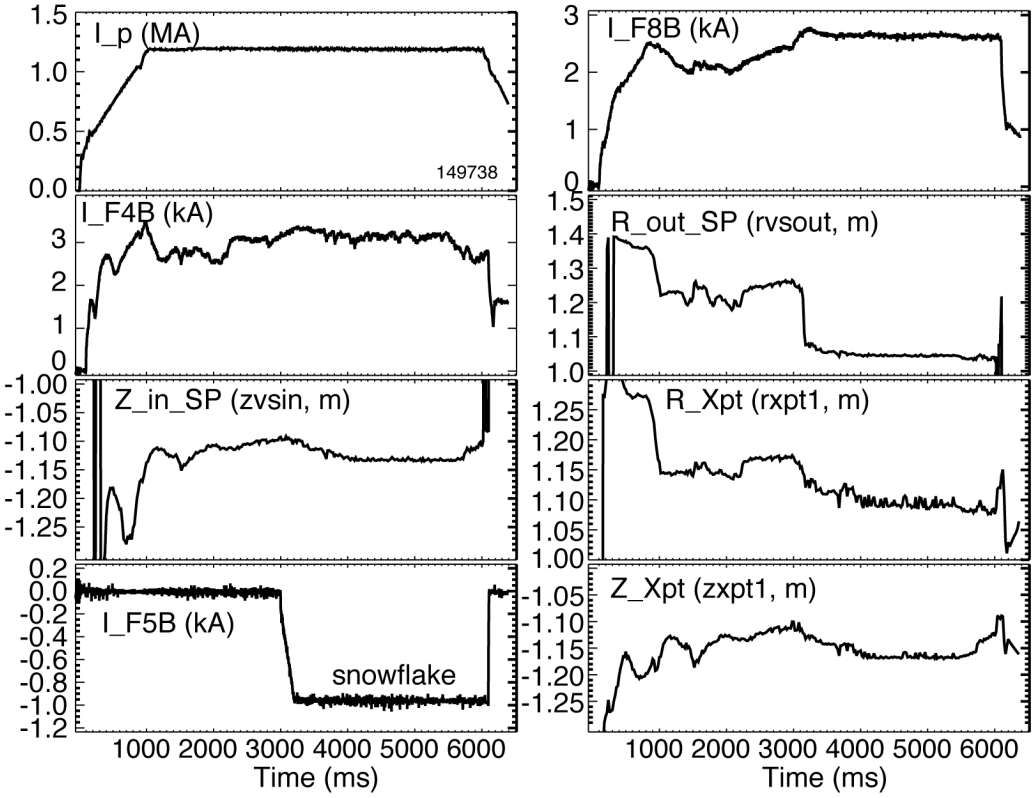
"Laboratory for divertor physics"

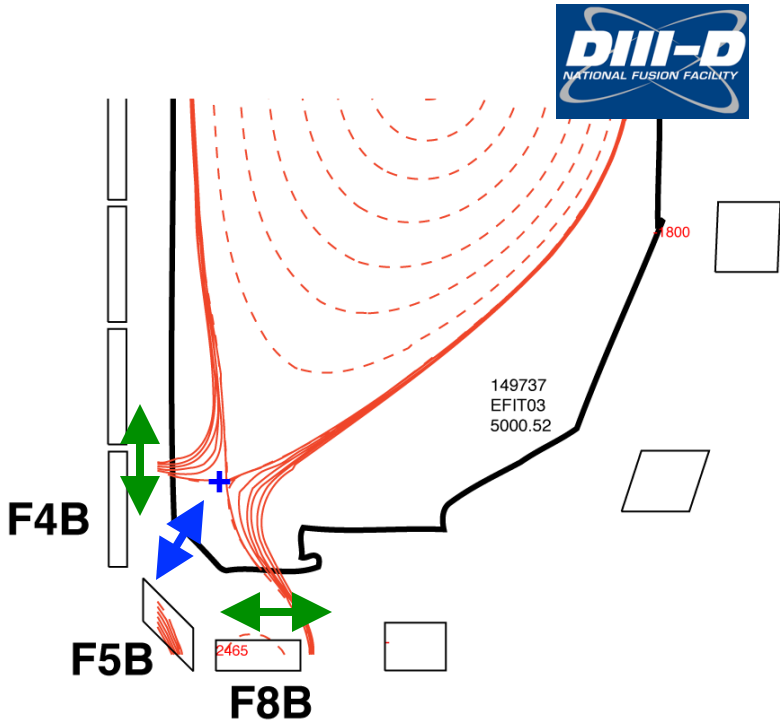






Snowflake configurations obtained in DIII-D from the standard divertor using an algorithm developed at NSTX





- Grad-Shafranov equilibria modeling of possible configurations
- Inner and outer strike point positions controlled by PCS using F4B and F8B coils
- Secondary null-point formed and pushed in using F5B