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“Snowflake” divertor characterization in NSTX

V. A. Soukhanovskii, LLNL
and NSTX Team

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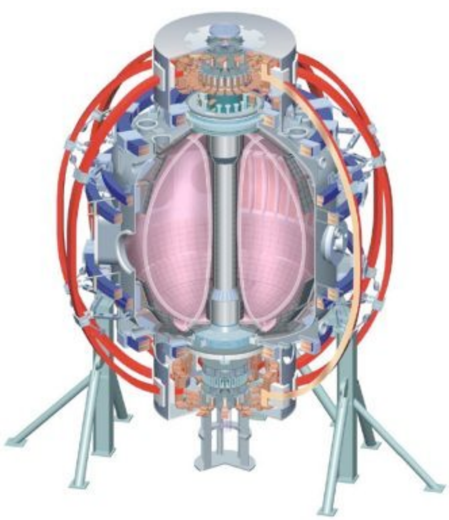

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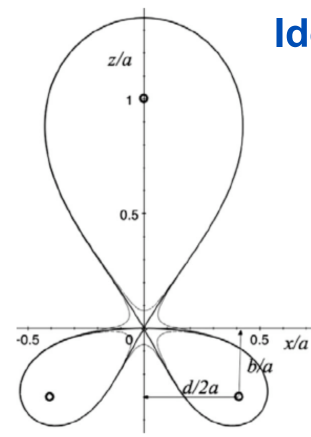
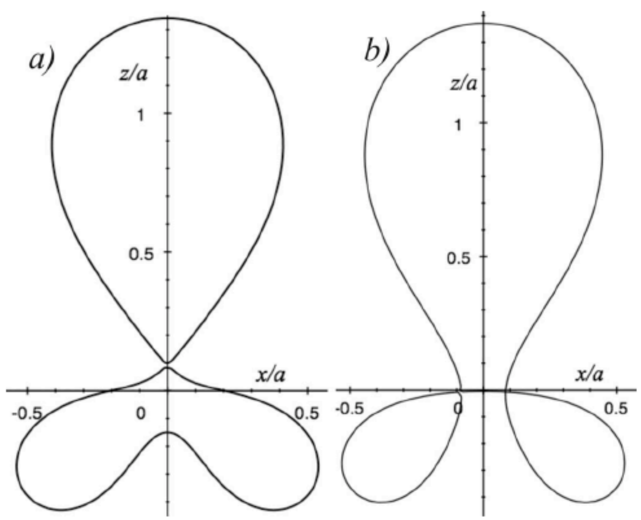
"Snowflake" divertor configuration: theory predicts many attractive edge physics features

- "Snowflake" divertor (SFD) configuration proposed and studied theoretically by D. D. Ryutov (LLNL)
  - Phys. Plasmas 14, 064502 (2007)
  - Phys. Plasmas, 15, 092501 (2008)
  - 34th EPS Conference on Plasma Phys. Warsaw, 2 - 6 July 2007 ECA Vol.31F, D-1.002 (2007)
  - Paper IC/P4-8 at IAEA FEC 2008
- SFD is obtained by creating a second-order poloidal null in the (lower) divertor **with existing divertor coils**
- Two cases – SFD-plus and SFD-minus
- Predicted properties
  - Large flux expansion ($\boldsymbol{B_p/B}$ small) and long parallel connection length
  - Null-pt flux tube squeezing – barrier for turbulence
  - Possibility of ELM control (increased edge magn. shear)
  - Enhanced null-point *grad B* drift (C. S. Chang's X-pt transport)

Ideal SFD





SFD-plus and SFD-minus

NSTX can make a large contribution to the novel divertor geometry development for future devices

- XP 924 (2009) - Initial “snowflake” divertor studies in NSTX (0.5 day)
  - Obtained “snowflake” configurations for 100’s ms
  - Magnetic configuration – very large flux expansion, longest connection length
  - Detachment of divertor OSP,
  - No core confinement degradation, reduced P_{rad}, reduced carbon density

- On-going effort to develop and improve “snowflake” control
  - Collaboration with GA and LLNL on snowflake divertor configuration control development (E. Kolemen et. al, proposal in ASC TSG session)
  - Work approved on NSTX to create reversed PF1B capability for improved snowflake stability and control development (Soukhanovskii et. al, proposal in ASC TSG session)

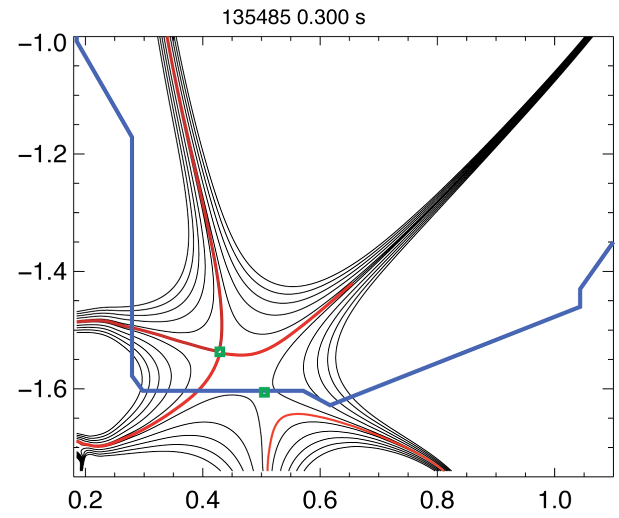
- NSTX is making a unique contribution among high-power medium and large tokamaks
  - TCV has been experimenting with “snowflake” divertor
  - “Snowflake” configuration is a candidate for heat flux mitigation in NSTX-U

Proposal would address "snowflake" divertor characterization in a 1 day experiment

- "Snowflake" dviertor configuration will be obtained as in 2009 by using PCS OSP control and adjusting PF3L (squareness)

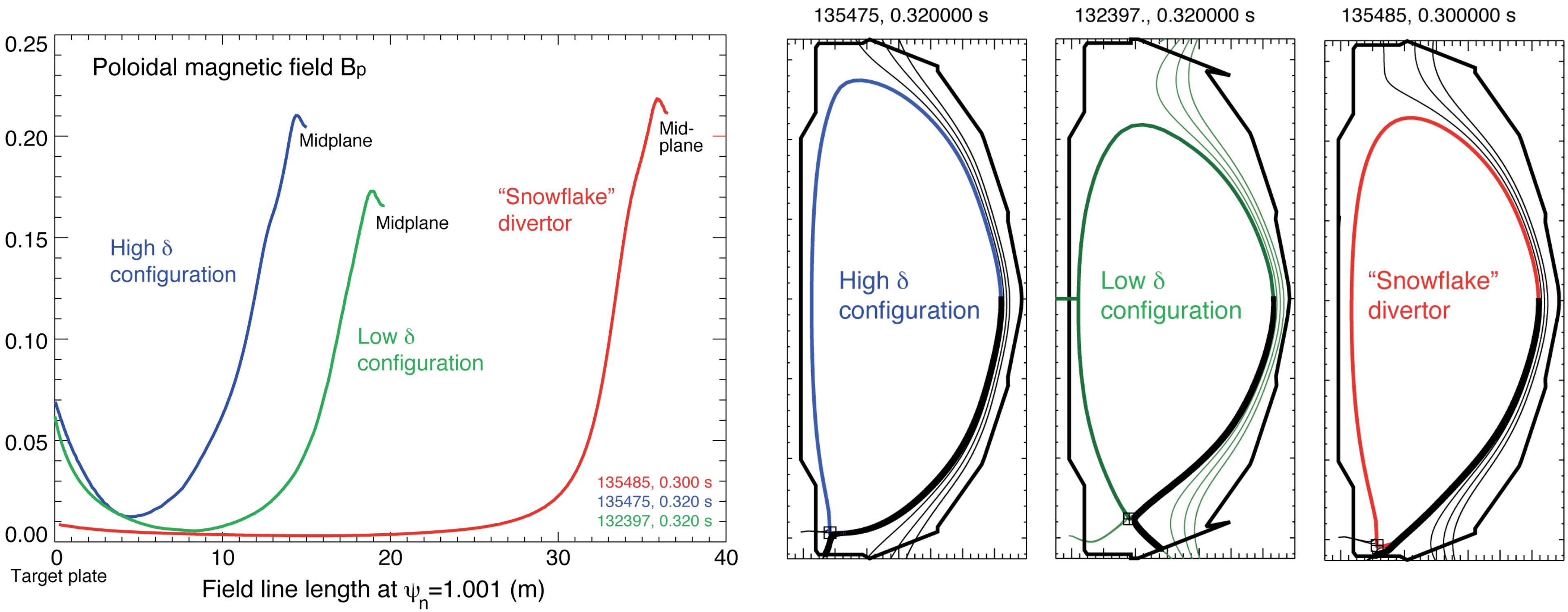
- SOL and divertor transport and turbulence
  - Heat flux reduction, heat flux scaling
  - Detachment characteristics
  - Impurity sources and transport
  - Comparison of midplane and divertor turbulence characteristics
  - Synergy with LLD pumping

- Pedestal stability
  - Magnetic shear measurements
  - Stability calculations (kinetic EFITS, edge MHD stability codes
  - ELM characteristics



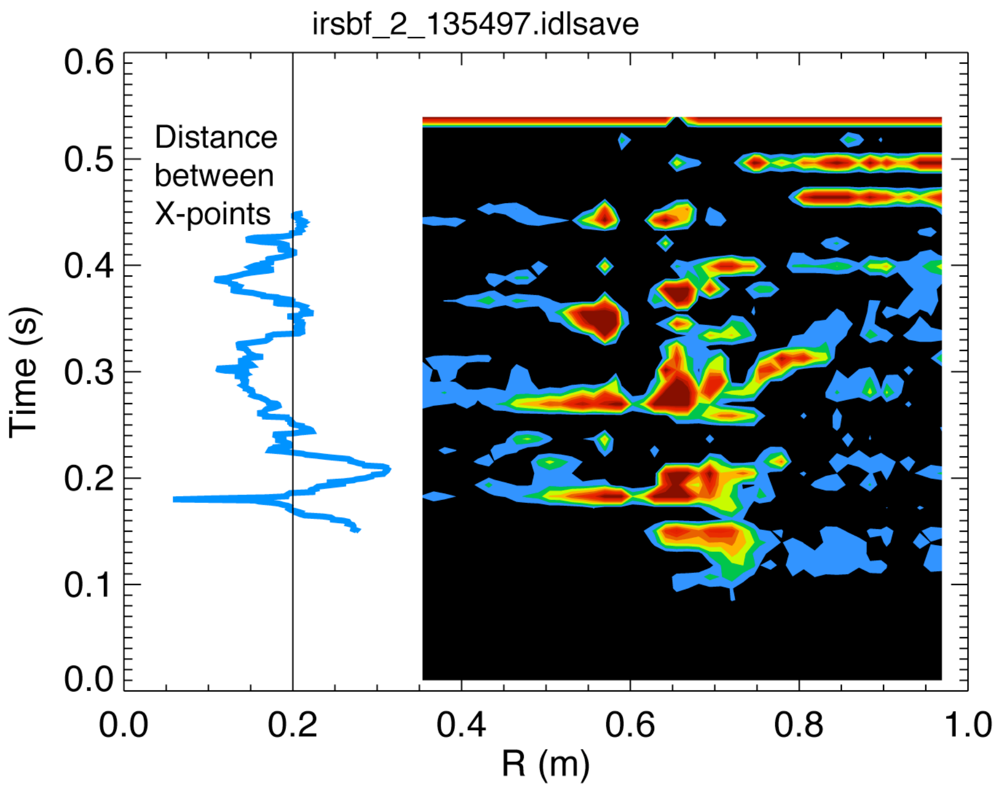
Backup

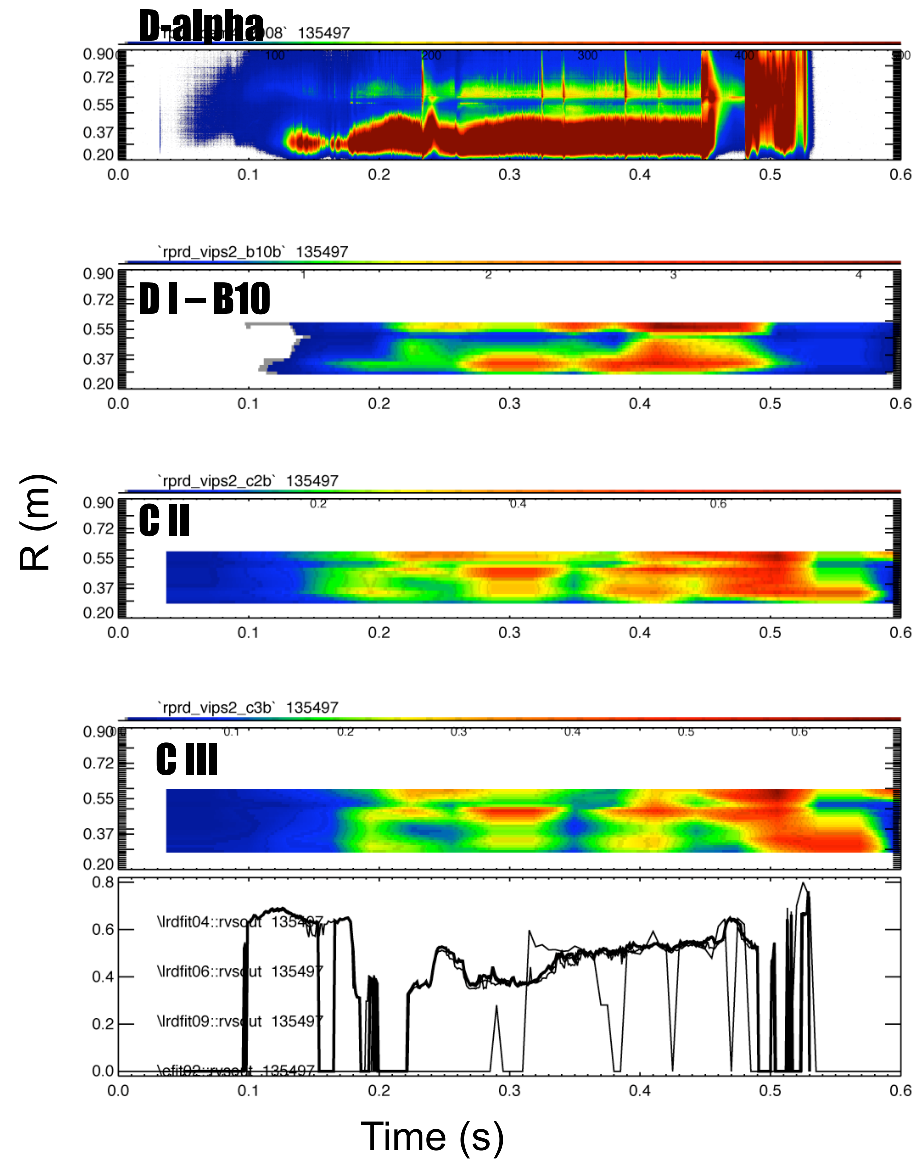
SFD configuration shows highest flux expansion at strike point and longest connection length



Configuration	Flux expansion	L_x (m)	L_{tot} (m)
SFD	68.1	16.3	36.5
Low δ	4.3	8.4	19.6
High δ	10.0	4.5	15.0

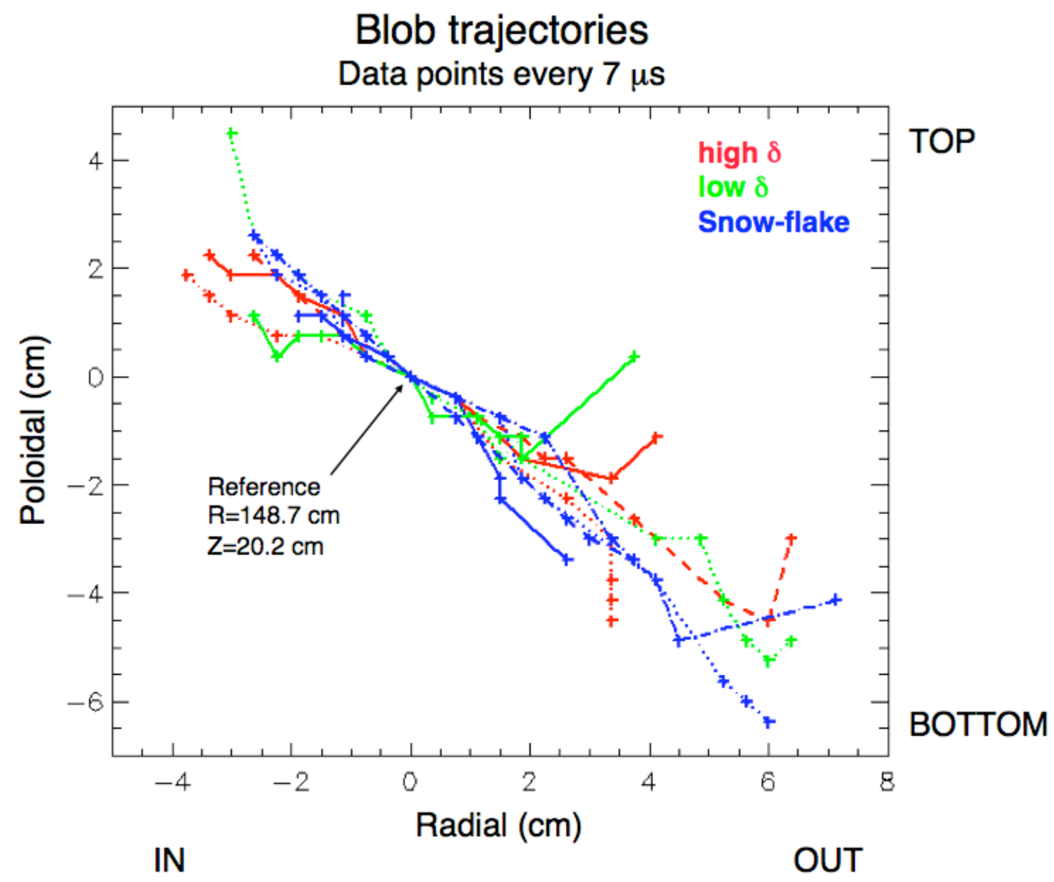
Divertor profiles indicate heat flux reduction, detachment of outer strike point region





Gas puff imaging shows that blobs move radially at the same velocity regardless of SFD or SD

- The "average" trajectories from the time-delayed cross correlations: each data point is the location of the maximum in the delayed cross correlation (relative to the reference point in the SOL).
- The time delays used are integer multiples of the framing time (7us).



Gas puff imaging of plasma blobs shows that blob sizes are similar in SFD and SD

- The first page is 50% contour plot of the 0-lag cross-correlation between a reference point in the SOL and all other points in the images.
- The poloidal and radial auto-correlation lengths are a sub-set of this data.
- The net result: in all cases blobs are ~4cm FWHM in both radial and poloidal dimension.