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"Snowflake" divertor configuration with reversed PF1B coil current

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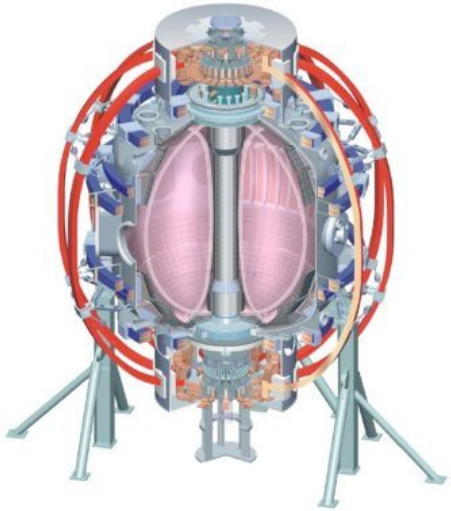
Advanced scenario and Control Break-out Session

NSTX Research Forum

Princeton, NJ

2 December 2009



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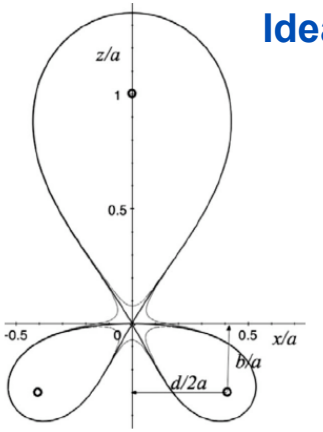
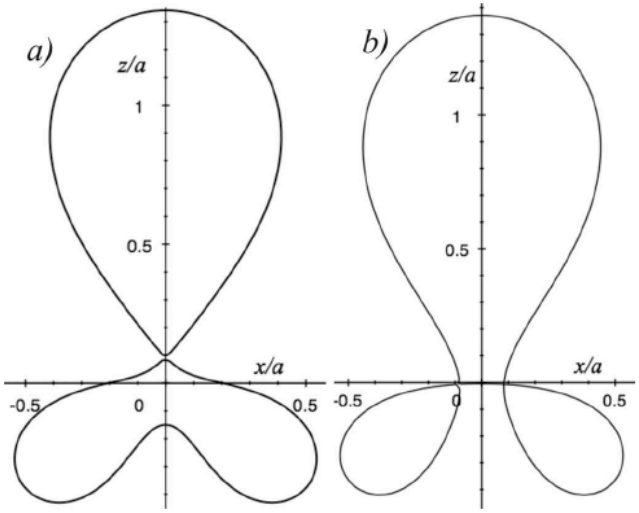
"Snowflake" divertor configuration: theory predicts many attractive edge physics features

- "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 (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
  - Nearly full detachment of divertor OSP
  - No core confinement degradation

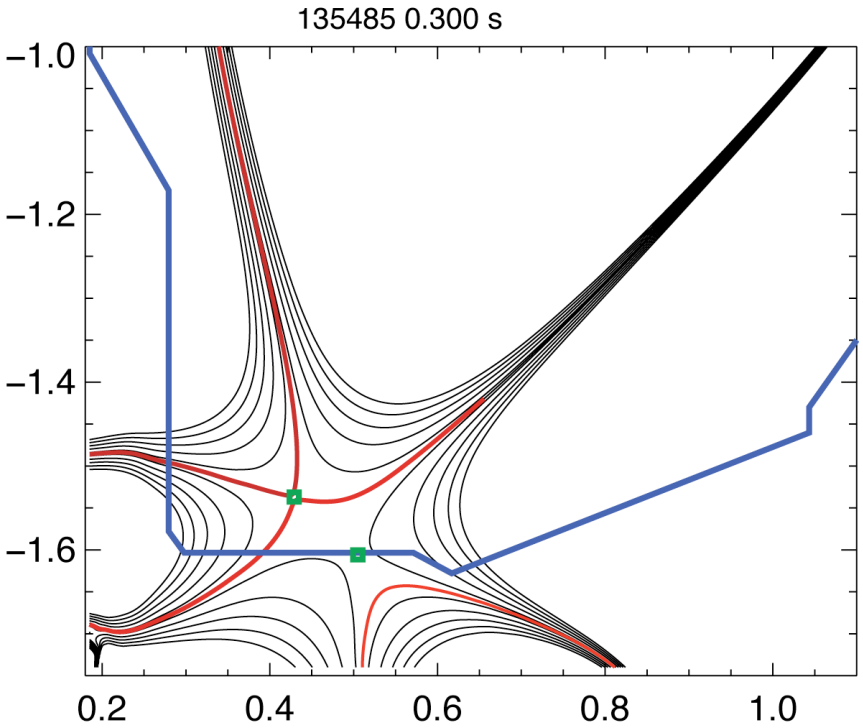
- On-going effort in collaboration with GA and LLNL on snowflake divertor configuration control development
  - E. Kolemen's proposal in this session

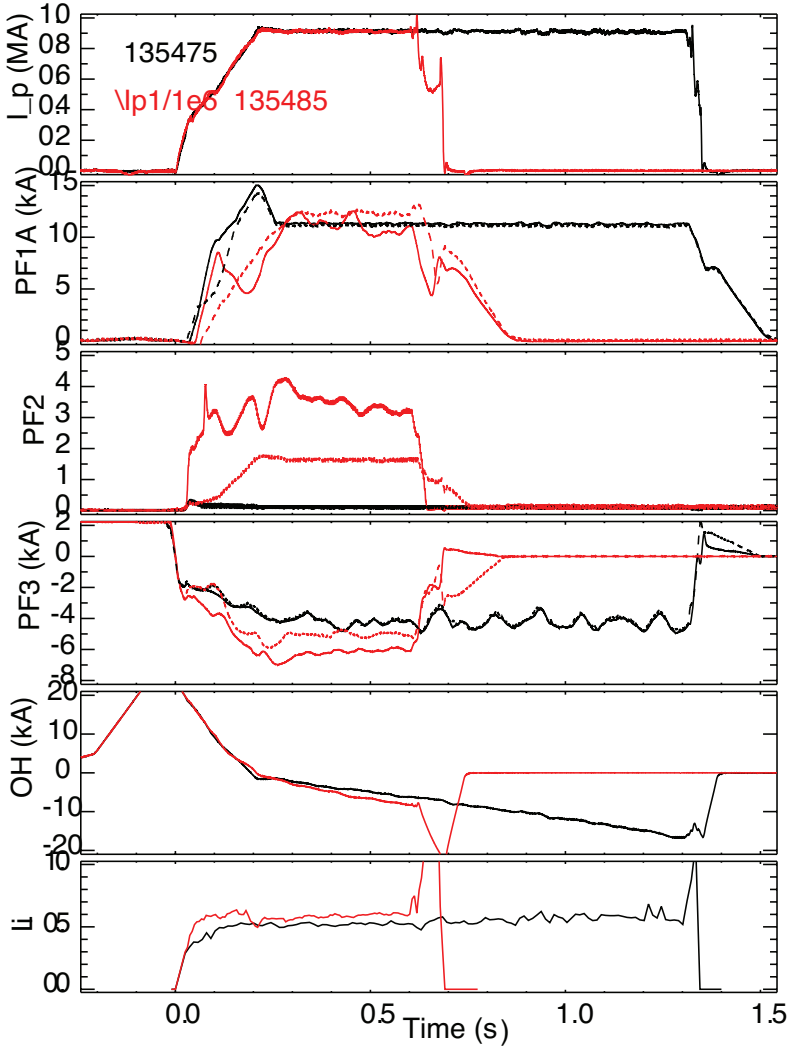
- NSTX is making a unique contribution among high-power medium and large tokamaks
  - TCV has been experimenting with "snowflake" divertor

- "Snowflake" configuration is a candidate for heat flux mitigation in NSTX-U

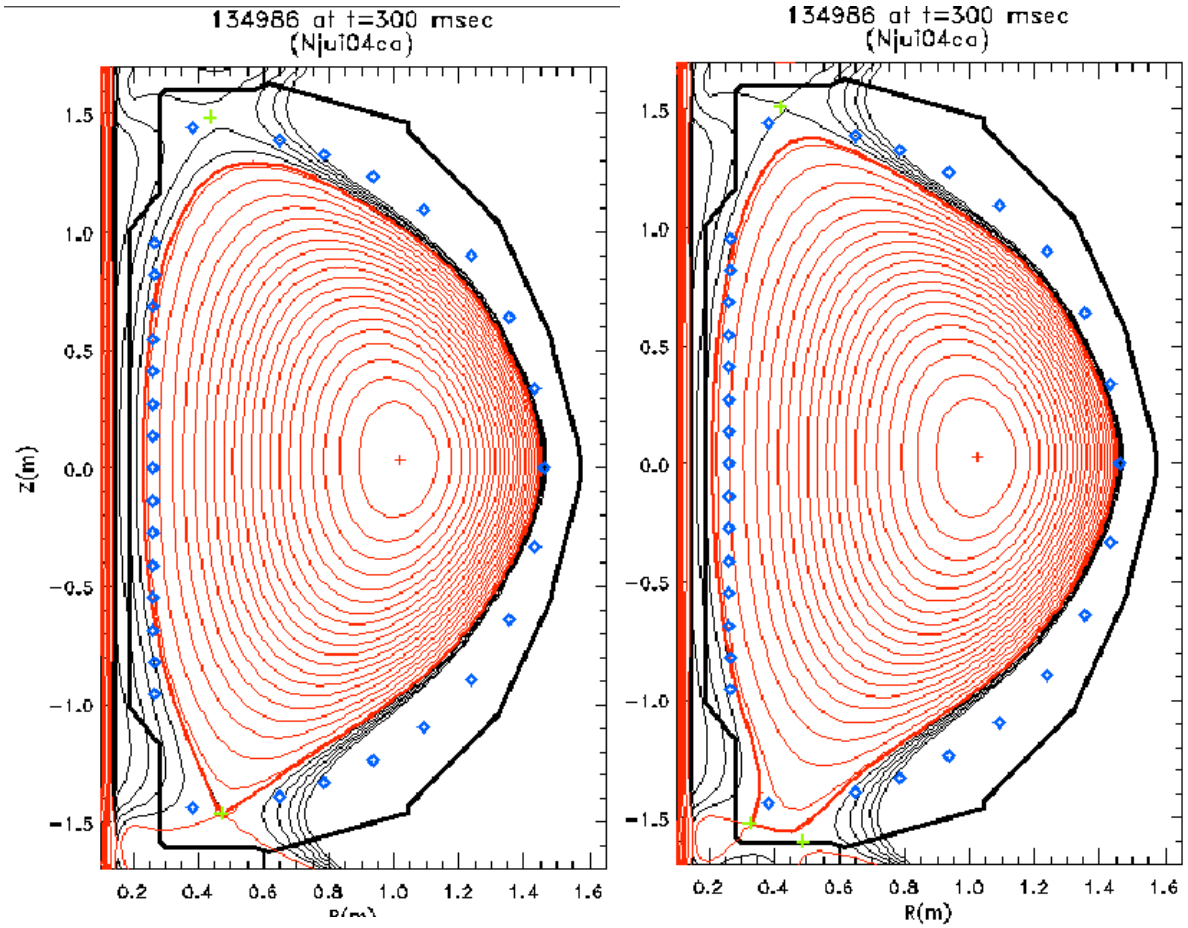
XP 924 demonstrated near-steady-state "snowflake" divertor configurations

- Used PCS strike point (SP) control on both inner and outer SPs
- Scanned OSP between 0.44 to 0.69 m
- Best SFD was obtained with R_{OSP} ~ 0.55 m





ISOLVER code modeling shows improved "snowflake" with PF1B reversed current



PF1A+PF2L snowflake PF1A+PF2L+rev. PF1B

- ISOLVER - predictive free-boundary axisymmetric equilibrium solver developed by J. E. Menard
  - ☑ normalized pressure and current profiles and boundary shape as input
  - ☑ matches a specified plasma current and β,
  - ☑ computes coil currents as output

Reversed PF1B current helps in creating snowlfake-like (both "plus" and "minus") configurations

Create and use PF1B reversed current capability for improved "snowflake" configuration stability and control

- Reversed PF1B current capability is expected FY2010 mid-run, pending completion of Engineering tasks (R. Hatcher)
  - Check/test PSRTC software
  - Check/test configuration software
  - Check coil protection (hardware and software)
  - Check forces analysis
  - Perform ISTP

- Request 1 day for configuration development
  - First 0.5 day – confirm predicted impact of rev. PF1B on "snowflake" divertor configuration obtained with PF1A and PF2L
    - add PF1B in flat-top to the existing "snowflake" scenario
    - Scan PF1B current between 0.5 kA and 3 kA
    - Scan OSP radius between 0.4 m and 0.58 m using PCS strike point control
  - Second 0.5 day – optimize snowflake stability based on first 0.5 day
    - Add PF1B in OSP control algorithm?
    - Control OSP and X-pt instead of both ISP and OSP?