Effective SOL particle lifetime, generation of SOLC and effects on the edge

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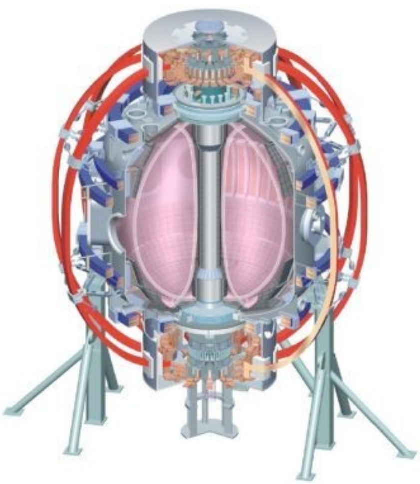

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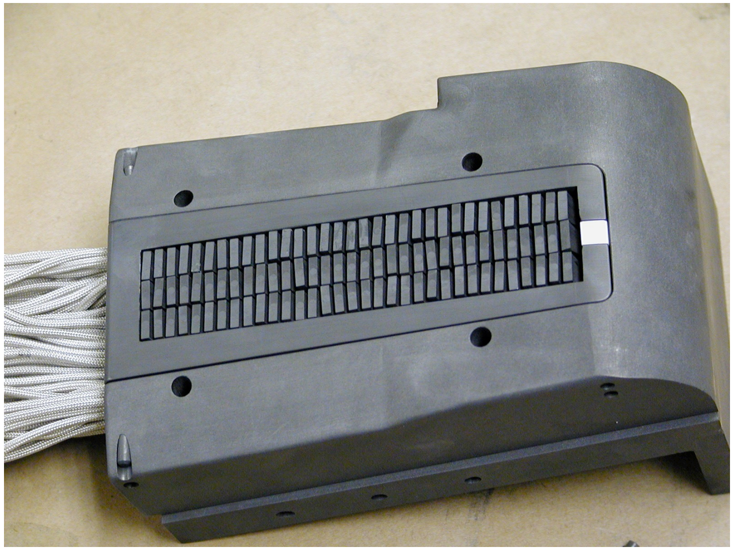
XP goals and benefits

- Commissioning of triple probe capability for dense probe array
  - U-Illinois biasing and data acquisition
- SOL plasma parameters and regime change
  - Gas puffing as transient control for SOL regime
  - Dependence of pumping on temperature (particle control milestone)
  - Gas species change as means of returning to high recycling plasma (future lithium studies)
  - Plasma at divertor target profile measurements
- Measurement of SOLC in NSTX (comparison to DIII-D)
  - Magnitude, spatially and temporally resolved
  - Axisymmetric or non-axisymmetric
  - Dependence on lithium pumping effectiveness
  - Controllable?
- Broader effects of SOLC
  - ELM correlation? Causation?
  - Dynamic error fields?
  - Edge and pedestal response?
- Provides measurements of Li wall conditioning effects tied to parameters testable on other machines (ν^*_{SOL} , $\tau^*_{p,SOL}$)

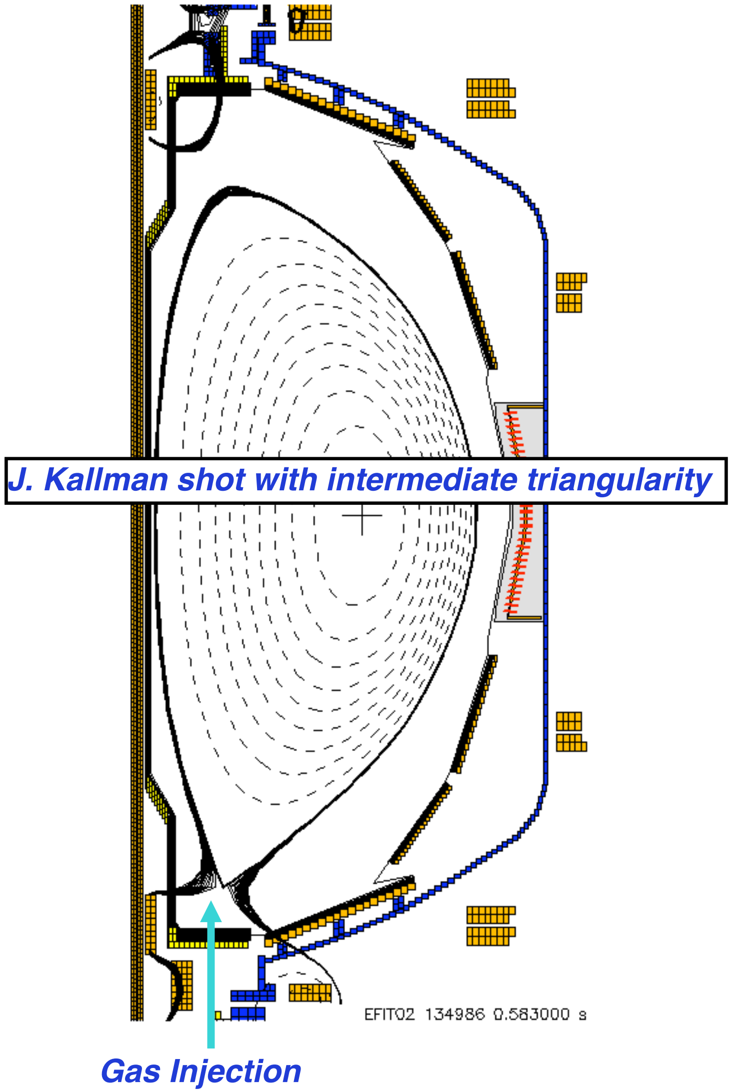
Attempt to excite non-axisymmetric SOLC with gas puffing and monitor with divertor Langmuir probes

- Dense array provides high spatial resolution
  - Addresses DIII-D spatial resolution issue
  - Triple probe system provides time resolved signals up to 125kHz (n_e, T_e, V_f)
  - Swept probes used as complementary measurements and aid interpretation
  - Limited set will be configured for direct SOLC measurements
  - Supplemented with halo sensors and BEaP for greater toroidal coverage
- Existing inboard probes to provide measure of inboard target temperature and density
- Temporal resolution of triple probes will measure density pump-out rate, $\tau^*_{p,SOL}$
  - Local puffs decoupled from core transport changes



Run plan (1 day total)

- Make use of commissioning and decommissioning shots in piggyback
  - Monitor plasma conditions during Li deposition
  - Determine if a critical density is found for sheath-limited operation in intermediate- and low-δ discharges
  - Monitor for SOLC and any relation to SOL collisionality
- Dedicated run time (24+ shots)
  - Use lower dome gas injection to puff in D2 and perform scan around any determined critical density (9 shots) (3 cold, 3 normal, 3 hot)
  - Repeat in intermediate- and low-δ discharges (+9 shots) (3 code, 3 normal, 3 hot)
    - No evaporation in between – does Li saturate (τ^*_{pSOL} degradation)
  - Compare with non-pumping gas: He (+6 shots) (2 cold, 2 normal, 2 hot + development)
    - Does liquid lithium pump He?
    - How much?



Backup

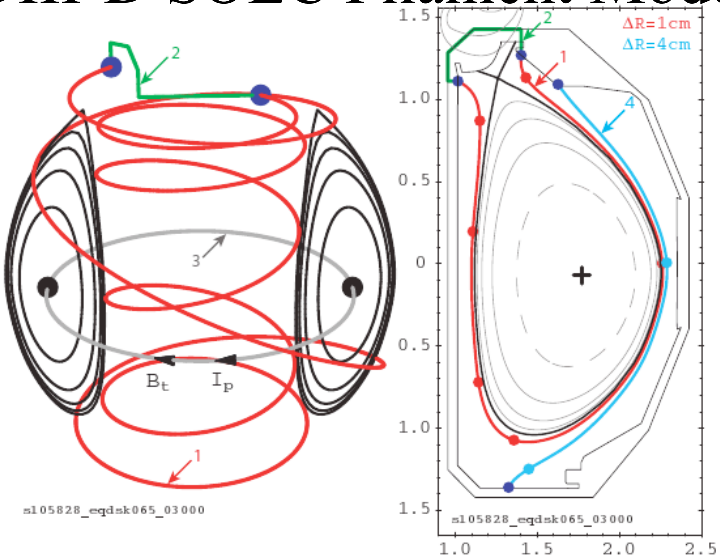
Overview

- Background
  - Scrape-off-layer currents (SOLC) observed on DIII-D and linked to ELMs (causal?) and other MHD events
  - Strongly pumped SOL may reach sheath-limited regime and reduce or eliminate thermoelectric drive mechanism for SOLC
  - Gas puffs can be used to create TE drive for controlled periods of time (SOL particle lifetime)
  - SOLC on demand provides new and unique tool for edge studies
- Goals
  - Measure SOL plasma parameters at divertor targets during Li operation
  - Determine particle lifetime $\tau^*_{p,SOL}$ (susceptibility to density fluctuations)
  - Measure or search for SOLC and associated effects
- Milestones
  - Li research R11-3 milestone on understanding the relationship between lithium surface conditions (pumping efficacy) and edge and core conditions
  - Boundary Physics R10-3 on understanding relationship between ELMs and lithium conditioning

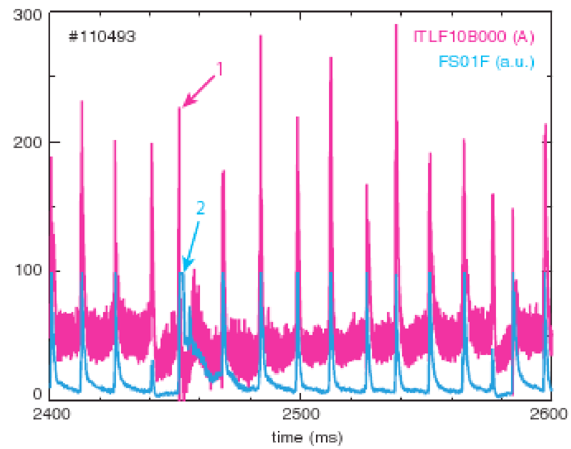
Background: Why measure a new particle lifetime? And why are SOLC important?

- Effective SOL particle lifetime:
  - Local perturbation to the divertor via gas puff (i.e. poor core fueling efficiency) is decoupled from any alterations to core transport
  - Determine, *directly,* effect of strong pumping on SOL perturbations (how fast are they pumped out)
- Scrape-off-layer currents
  - Measured on DIII-D
  - Several theories regarding relation between SOLC and edge recently proposed
    - SOLC-ELM causal relationship (Takahashi EPS 2005)
    - Coupling relation between PB and SOLC (Zheng PRL 2008)
    - Dynamic error field production and ergodization of the edge (Takahashi NF 2004, Evans JNM 2009)
  - Expanded divertor probe and sensor coverage makes extensive measurements possible in NSTX

DIII-D SOLC Filament Model



Dα and SOLC

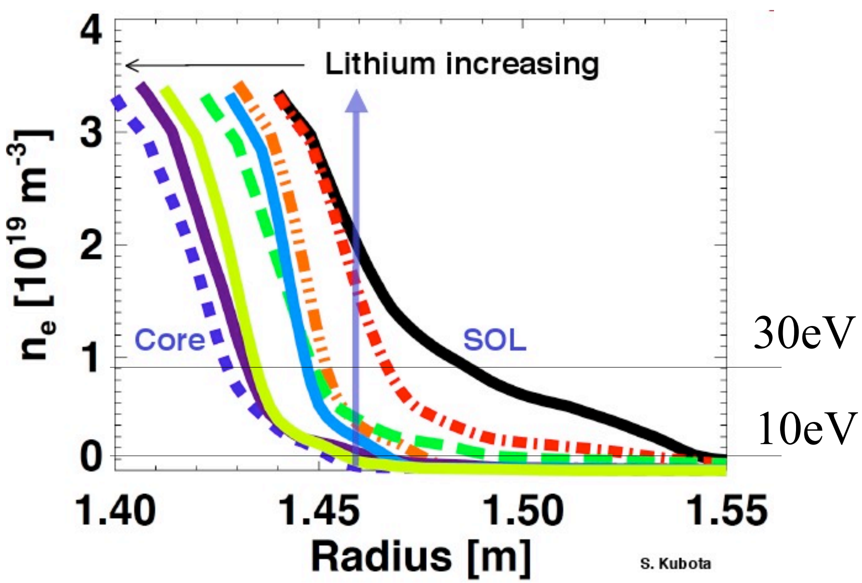


Overview

- Lithium wall conditioning already seen to pump discharges
- Effectiveness of lithium pumping surfaces may be linked to edge parameters via:
  - Thermoelectric scrape-off-layer currents (TE-SOLC)
  - Fast reduction (pump-out) of density perturbations
  - Reduction of potential for thermal instabilities *at the surface* feeding back into TE-SOLC and other SOL perturbations (ergodized edge)
  - *How do wall conditions reach out from a few microns of wall toward the core?*
- Goals:
  - Characterize lithium PFC pumping effectiveness via $\tau^*_{p,SOL}$ (effective particle lifetime) for cold ($T<T_{melt}$), normal and hot (T>350C)
  - Monitor effect of pump-out on SOL regime and SOLC
  - Correlate perturbation of SOL and SOLC to edge and global parameters
  - Develop non-pumping He shot to "recover" non-pumping discharge for comparison

Strongly pumped edge makes ideal test-bed

- Edge pumping with lithium already seen to reduce SOL density
  - Simple two-point model predicts reduction in parallel temperature gradients with reduced ν^*_{SOL}
  - Transition from conduction limited to sheath-limited at n~2e18m^{3} depending on mid-plane temperature
- Reduced temperature gradients should affect TE based SOLC
  - Reduction of drive term as $T_{in}/T_{out} \rightarrow 1$
- Particle lifetime, $\tau^*_{p,SOL}$, determines density perturbation lifetime
  - Provides controlled means of changing target temperatures transiently
  - On/Off control of SOLC?



R. Maingi, APS 2009 Invited Oral

Re-attachment of inboard divertor already observed as collisionality decreased. (Soukhanovskii APS 2009)

Addressing questions raised

- Claim: SOLC primarily generated by thermoelectric SOL effects
  - Measure T_e on inboard and outboard as density decreases alongside SOLC during quiescent MHD period
- Claim: SOLC generate dynamic error fields (Takahashi 2004)
  - Correlate direct measurements of SOLC with magnetics
  - Look for toroidal braking effects
  - Axi- vs. non-axisymmetric
- Claim: SOLC provide coupling mechanism for edge perturbation leading to ELM (Zheng 2008) vs. SOLC causes the ELM (Takahashi 2008)
  - Generate SOLC transiently (axi- vs. non-axisymmetric)
  - ELM immediately? ELM after critical time?
  - Edge plasma perturbation due to change from non-recycling to simulated recycling
- Claim: ELM/edge perturbation causes TE-SOLC (Evans 2009) vs. unstable hot spot formation (Pigarov 2009)
  - Correlation between midplane density rise and divertor density rise
  - Chicken and egg scenario

Indications in NSTX

- Examine Langmuir probe current at zero-voltage bias (machine wall potential)
- ELMing discharge before lithium deposition, ELM-free in 129038
- Same scales on SOLC and D-alpha signals in shot comparison
- Poor signal resolution due to sweep frequency
- Interpretation of SOLC signal during ELMs problematic – need better spatial and temporal resolution
- General reduction in SOLC without ELMs, drastic change in private flux region