NSTX

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Separatrix Location as Determined by OEDGE Modeling

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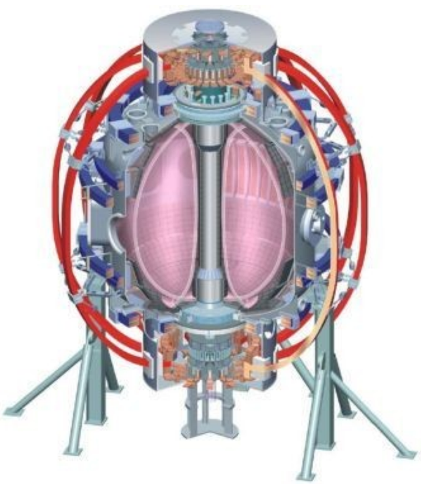
U Wisconsin

M.A. Jaworski, J. Kallman, B. LeBlanc, D. Stotler (PPPL), S. Sabbagh (Columbia), V. Surla (U-Illinois)

NSTX 2010 Result Review, Dec. 1, 2010 – B318 PPPL



Culham Sci Ctr
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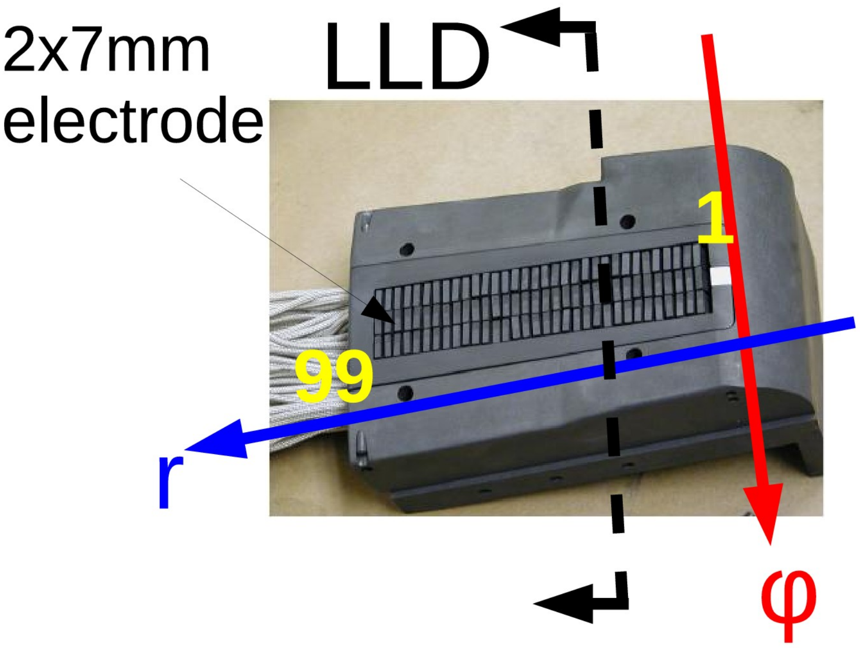
ASCR, Czech Rep
U Quebec

New Langmuir Probe Array for this Run

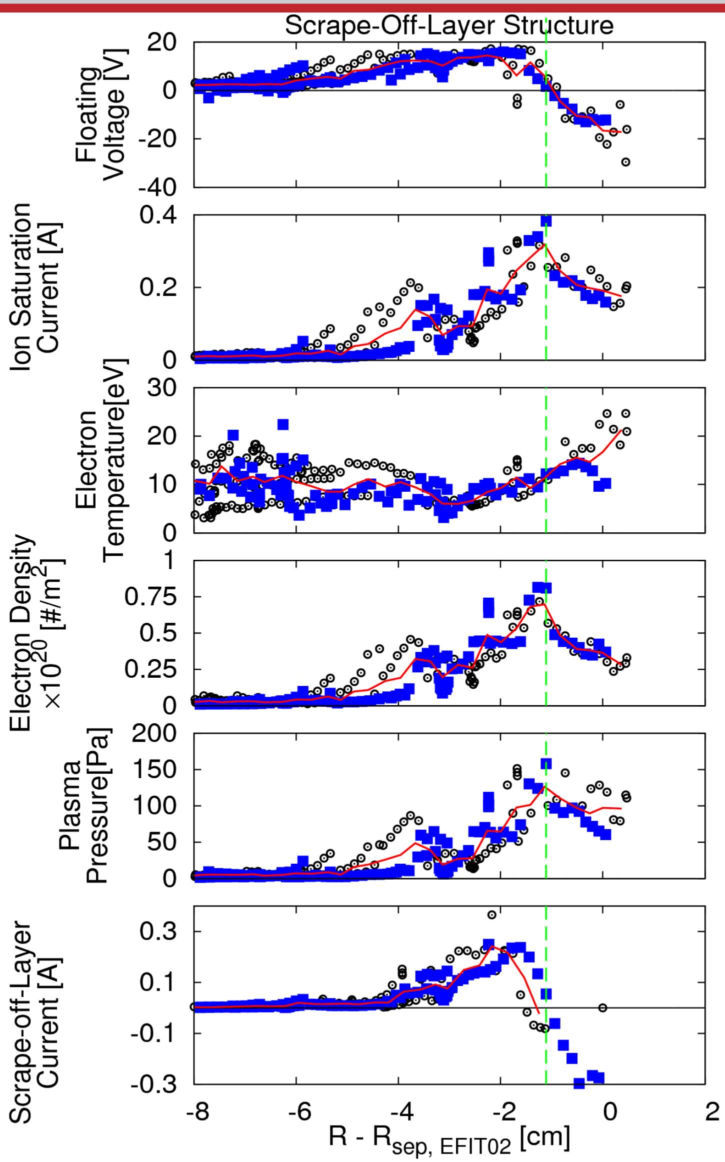
- Dense array of electrodes provides high spatial resolution
- Radially covers the LLD inboard leading edge
- Collaborative effort with U-Illinois (myself, V. Surla)
- Partially filled with standard swept probes, triple Langmuir probes and scrape-off-layer current monitors
- More recent work with the data is in APS posters by J. Kallman and V. Surla



Publications already out on HDLP:
J. Kallman, RSI, 2010
M.A. Jaworski, RSI, 2010

SOL Structure Obtained During Strike Point Sweeps

- Probe positions referenced to magnetic reconstruction
  - **Blue** points = single probe
  - **Black** points = triple probe or SOLC probe
  - **Red** line = Binned average
- Allows SOL structure to be obtained during a strike-point sweep over the array
- Provides additional means of locating the **separatrix**
  - Make use of plasma pressure peak to define separatrix location
  - Zero crossing of V_f and SOLC coincide – need more statistics

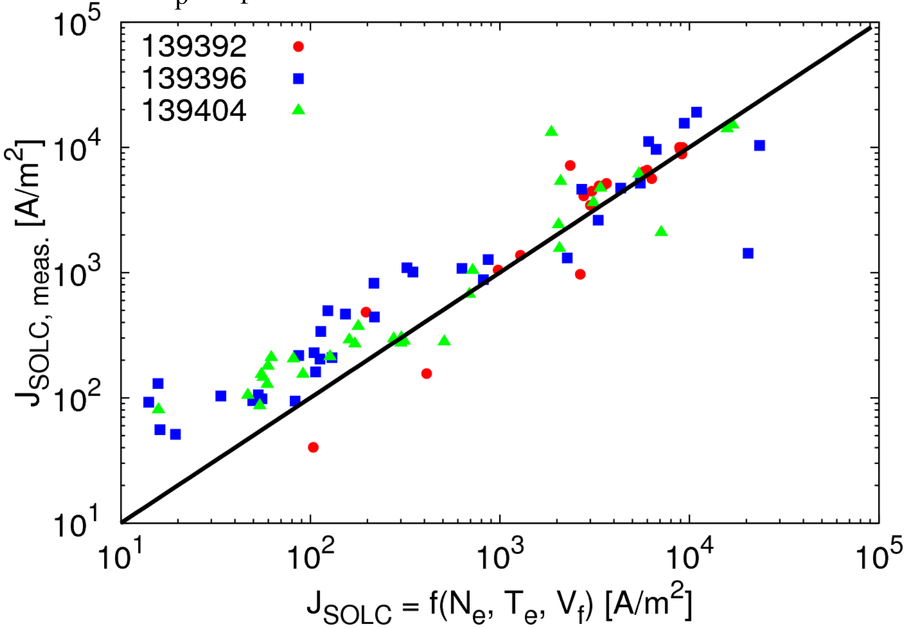


Probe Interpretation Sanity Check #1

- Local floating potential and Scrape-Off-Layer Currents intimately tied
  - Floating potential must adjust to be consistent with currents flowing to surface
  - Equivalent to biasing (w.r.t. plasma potential) the PFC to drive a current
- Langmuir probe I-V interpretation compared to independent current measurement
  - I-V characteristic gives plasma N_e, T_e, V_f
  - Dedicated probes measure SOLC in addition to swept
  - Probe data shown consistent over four orders of magnitude
- Scrape-off-layer currents play role in other PMI processes via V_f
  - Sheath heat-transmission coefficient
  - Ion impact energy through sheath

Assumptions:

S.E.E. = 0 (oblique angle of inc.)
Deuterium dominant species
$T_i/T_e = 1$
V_p-V_f given by "classical" formula



$$\gamma(V_s) = -\frac{eV_s}{kT_e} + 2.5\frac{T_i}{T_e} + 2\left[\left(1+\frac{T_i}{T_e}\right)\left(\frac{2\pi m_e}{m_i}\right)\right]^{-1/2}\exp\left(\frac{eV_s}{kT_e}\right)$$

OEDGE Code Suite for 2D Description of SOL

- **O** – Onion-skin method (OSM)
  - Generalization of the 2-point model – integrates fluid equations along a flux-tube
  - Assumes parallel transport >> perpendicular transport
  - Integration **from** target less sensitive than solution from midplane
- **E –** Eirene (neutral transport code)
  - Determines background neutral pressure in machine and interaction with plasma solution – yields chord-integrated line emission
  - Takes a wall model as part of the input for calculating the recycling from each surface – will provide more rigorous recycling analysis
- **D** – DIVIMP (impurity transport code)
  - Monte Carlo impurity model – utilizes sputtering tables to determine launch probabilities – tracks impurities, chord-integrated line emission
- OEDGE used to address several divertor/SOL issues
  - C^{13} transport during impurity injection on DIII-D (Elder, McLean)
  - Fueling and detached plasma description in Alcator C-MOD/DIII-D (Lisgo)
  - X_{perp} extraction from JRT plasmas on DIII-D (Elder, APS2010)

General Onion-Skin Method Compared with 2-Point Model

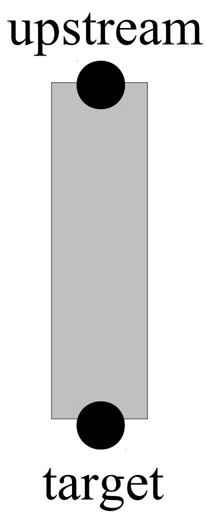
- Comparison with 2-point model
  - Straightened out plasma (no B variation) vs. equilibrium recon.
  - All ionizations at PFC vs. distributed source definition
  - No radiation (simple 2-PM) vs. distributed radiation
- Reduced complexity model (SOL13) until neutral solution operating (EIRENE)
  - 2/7 power makes end-point integration robust (boon of OSM methodology) $2^{(2/7)} \rightarrow 20\%$
  - Solves for density and velocity after integration of temperature and flux
  - SOL22 simultaneously solves all three conservation equations (particles, momentum, power)
- Provides sanity check #2

2 point model

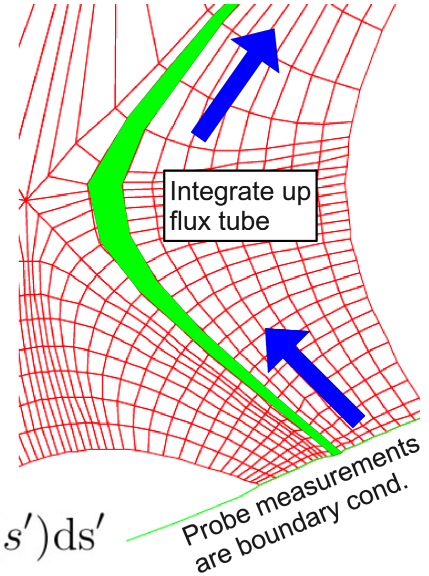
$$2n_t T_t = n_u T_u$$

$$T_u = \left[T_t^{7/2} + \frac{7}{2} \frac{q_{\parallel} L}{2\kappa_{0e}} \right]^{2/7}$$

$$q_{\parallel} = \gamma(V_s) n_t k T_t c_{st}$$



vs.



$$\Gamma(s) = n_0 c_{s0} + \int_0^s S_p(s')\mathrm{d}s'$$

$$p_0 = n(s)\left[kT_e(s) + kT_i(s) + mv(s)^2\right]$$

$$T_e(s) = \left[T_{e0}^{7/2} + \frac{7}{2\kappa_{0e}} \left(q_{\parallel,0} s + \int_0^s P_{rad}(s')\mathrm{d}s' \right) \right]^{2/7}$$

Probe Data Integration Yields Upstream Quantities → Separatrix Properties at Midplane

- Separatrix location defined from crossing of upstream quantity with MPTS profile
  - Mid-plane density crossing consistent with T_e and P_e in SOL13 model vs. 2-PM
  - Calculation quantities consistent with discontinuity (T_e, P_e) in MPTS profiles
- Variance from equilibrium reconstruction observed at both target and upstream
  - Pressure peak consistently inboard of magnetics answer
  - Only one shot analyzed this way so far – more on the way