Nsep vs. Nbar from Langmuir Probes

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The Basic Two-Point Model

- Begins from the fluid equations and simplifies...
- Provides simple relations for upstream and target (PFC) plasma parameters
- Varying levels of complexity can be implemented
  - Fluid reconstruction via generalized 2-point (e.g. OSM/OEDGE code)
  - Coupling with Monte Carlo neutrals and impurities (e.g. DEGAS 2/EIRENE/DIVIMP)
- **Start with the basics**

Assume:
$T_e = T_i$ & $p = p_e + p_i$

$$\frac{d}{dx}\left[\left(\frac{1}{2}m_i v^2 + 5\mathrm{kT}\right)nv - \kappa_{0e} T_e^{5/2}\frac{dT_e}{dx}\right] = Q_R + Q_E$$

Assume:
Conduction Dominates
Neglect Sources

$$\frac{d}{dx}\left[-\kappa_{0e} T_e^{5/2}\frac{dT_e}{dx}\right] = 0$$

$$T_u = \left[T_t^{7/2} + \frac{7}{4\kappa_{0e}} q_t L\right]^{2/7}$$

P.C. Stangeby, ch. 5, 9, or 11, 2000, IoP.

Simple Extensions Attempt to Capture More Physics

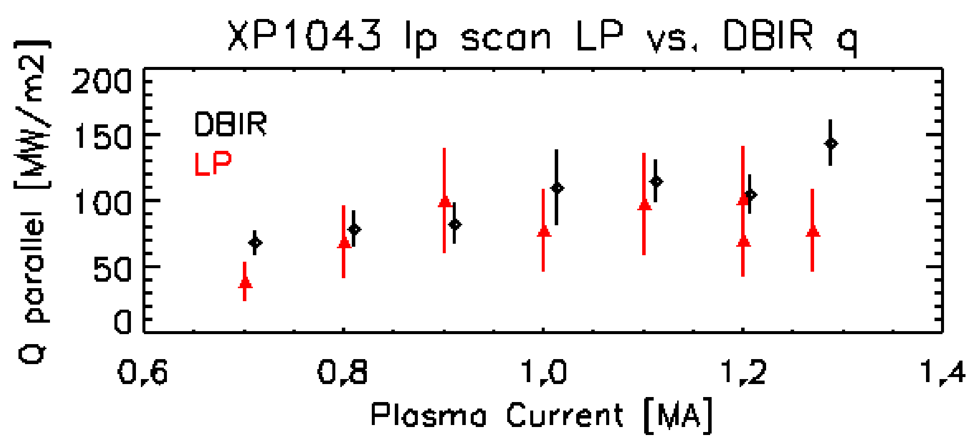
- Volumetric loss terms can be included via f_{power} term
- Term can be estimated with interpretative modeling in lieu of better div. Bolom. Coverage
- Comparison of nominal LP and DBIR results are encouraging
- Two values of fpower used following: 0 and 0.5

Radiation and charge-exchange

$$q_{rad} + q_{cx} = f_{power} q_0$$

$$\left(1 - f_{power}\right) q_0 = q_t = \gamma n_t c_{st} k T_t$$

$$\frac{T_t}{T_u} \propto \left(1 - f_{power}\right)^2$$



Updated Upstream Density

- Force balance in the ST requires modification to 2-PM
  - Typical formulation assumes “straight” flux tubes
  - 1.5m OMP vs. 0.5m target results in significant variation
- Flux-tube definition allows conversion of magnetic field to area
- Not yet consistently applied everywhere in calculations

$$F_u = F_t$$

$$P_u A_u = P_t A_t$$

$$N_u T_u = N_t T_t (1 + M^2) \frac{A_t}{A_u}$$

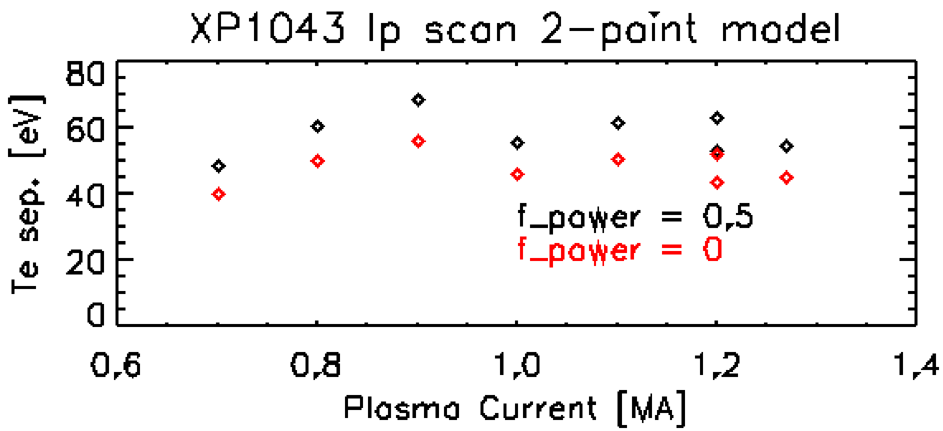
$M = v / c_s \geqslant 1$ Mach No. at sheath

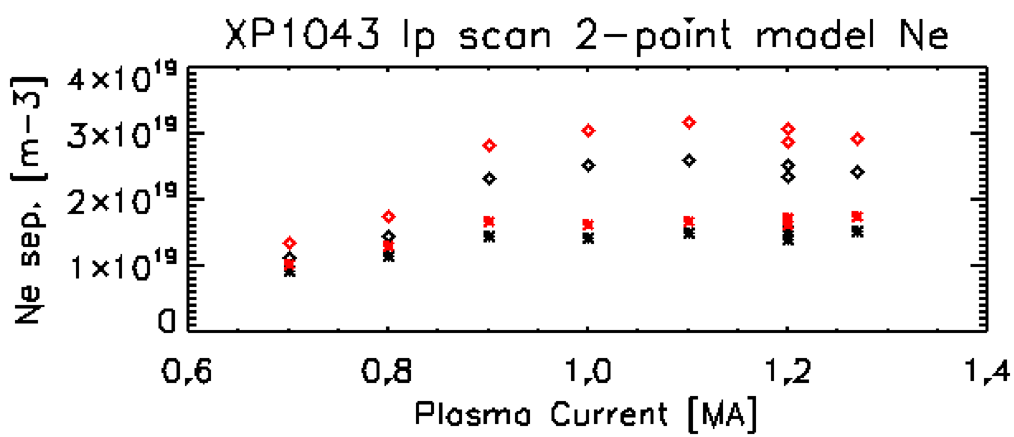
$$B A = \Psi_0 = const. \rightarrow \frac{A_t}{A_u} = \frac{B_u}{B_t}$$

$$N_u = \frac{N_t T_t (1 + M^2)}{T_u} \frac{B_u}{B_t}$$

Upstream Quantities Determined via 2-Point Model

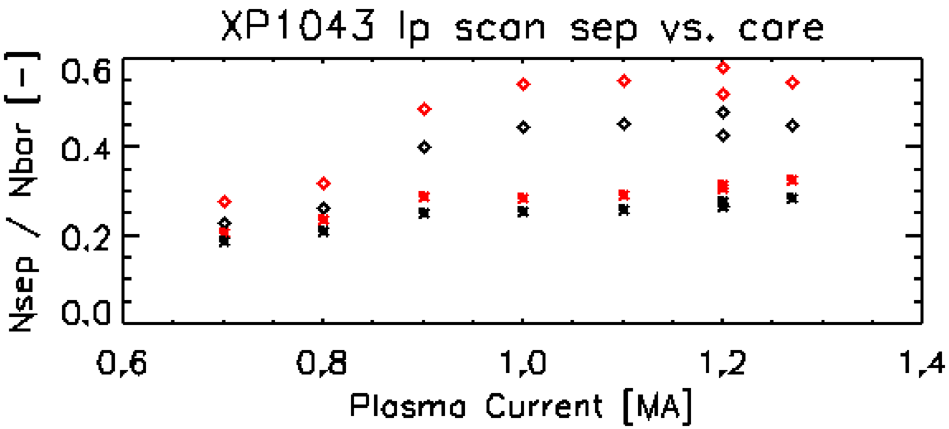
- Parallel connection length calculated from EFIT02
  - q_{peak} used to locate nominal Ψ_N value for integration
  - Solution not sensitive to variance in length (robust model from target)
- Interpolated MPTS density at the upstream temperature shown for comparison
- Uncertainty not yet propagated in calculations to determine significance in discrepancy





Separatrix Density is 1/5-1/2 of Mean Core Density

- $N_{e,bar}$ calculated from integrated particle content and plasma volume (EFIT02+MPTS)
- Ratio similar to values in literature
  - ~0.3 for ohmic, L-mode and ELM-free H-modes (ASDEX and DIII-D)
  - As high as ~0.7 in NBI heated discharges with ELMs (DIII-D)
- Time-averaged over flattop, no ELM removal



2-Point Model widely used due to simplicity but doesn't capture all the relevant physics. However, it still provides some estimates for comparison with other methods.

C.S. Pitcher and P.C. Stangeby, PPCF **39** (1997) 779-930.

Far-SOL Te Does Not Significantly Vary with Ip

- Triple probe used to determine Te (avoids turbulence issue)
- "Far-SOL" defined as beyond second sep.
- Variation in Te not statistically significant
- Not had time to look at power scan (and they all had 300mg Li)