HSX Program Overview and Research Directions

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Overview

- **Current experimental program concentrated on 4 main areas: 1) turbulent transport, 2) equilibrium reconstruction, 3) plasma flows and electric fields and 4) edge transport and fueling.**
  - ❑ **Heat pulse propagation experiment demonstrates lack of stiffness in heat transport, in agreement with non-linear GENE 3-D gyrokinetic calculations using two kinetic species**
  - ❑ **Equilibrium reconstruction demonstrates evolution of bootstrap current, and bootstrap current generation of islands in Hill configuration.**
  - ❑ **Improvement in neoclassical theory are being used to examine impurity effects on bootstrap currents and flows which will be compared to experiments.**
  - ❑ **Differential counter-streaming Pfirsch-Schlüter parallel ion flow measurements provide a measure of E_r in the core.**
  - ❑ **Motional Stark Effect polarimetry measurement of the radial electric field profile in HSX has begun.**
  - ❑ **Edge studies show 2D density, flows and electric fields in edge island.**
  - ❑ **Particle balance studies in a limiter configuration aim to examine the fueling, recycling and particle balance.**
- **HSX plans focus on energetic ion confinement, ion root transport with hotter ions, turbulent transport mitigation through magnetics optimization and extensions to equilibrium reconstruction.**

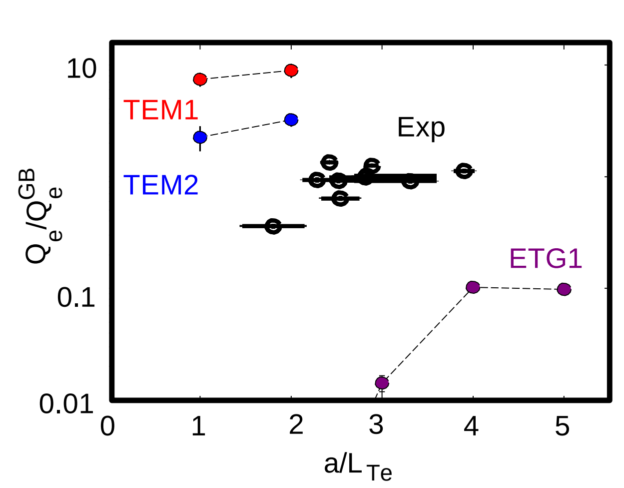
Turbulent Transport

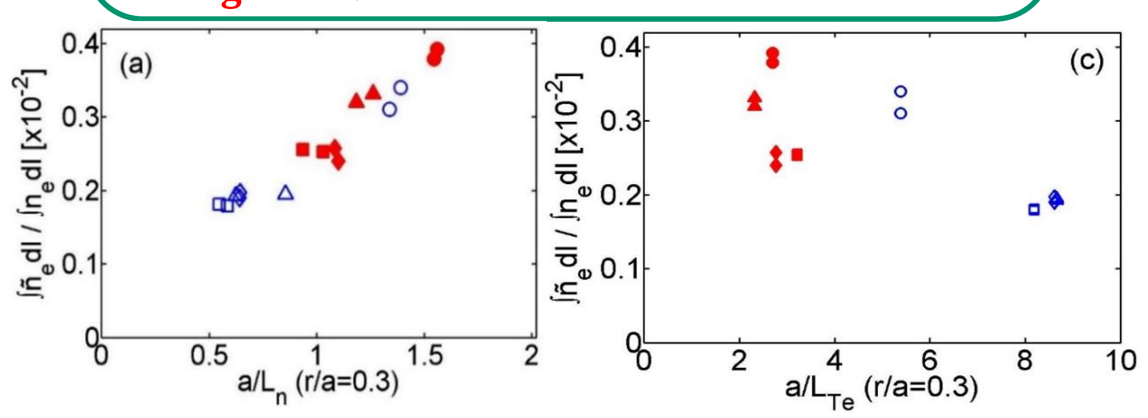
Theory and Modeling

- **GENE non-linear calculations confirm experimental lack of stiffness in core.**

Experiment

- **Pulse propagation experiments demonstrate transport is not stiff in core.**
- **Interferometer measurements of density fluctuations show increase with decreasing L_n (off-axis heating), consistent with TEM drive Deng CP12.00081**





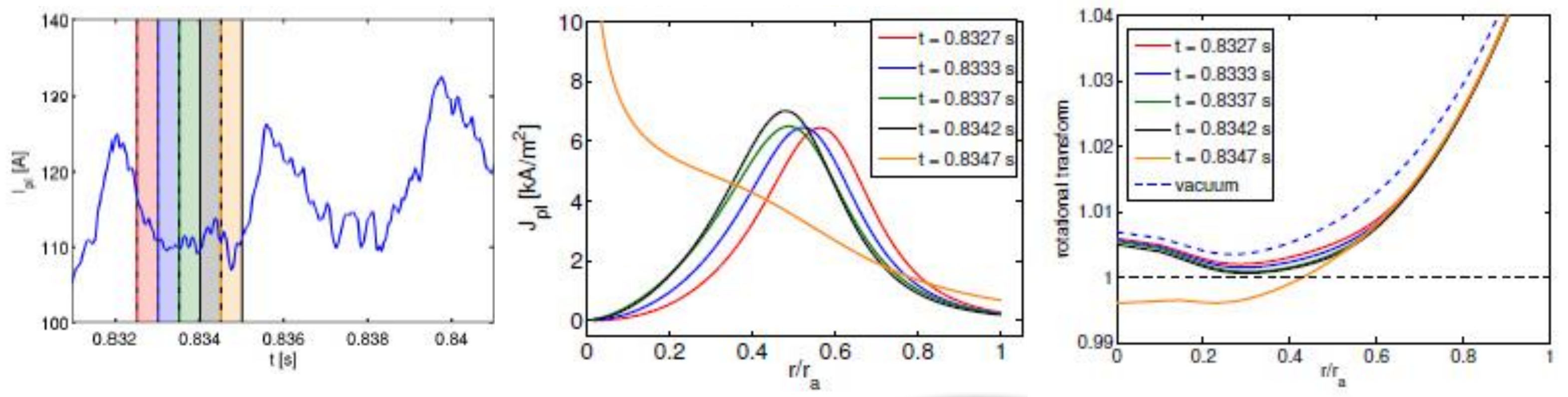
Equilibrium Reconstruction

Theory and Modeling

- **Optimized coil placement for bootstrap OR Pfirsch-Schlüter sensitivity**
- **Spark used to model vessel eddy currents**
- **V3FIT for reconstruction**

Experiment

- **Significant reduced profile uncertainty**
- **Eddy current modeling crucial for reconstruction**
- **Bootstrap current evolution & rational surfaces reconstructed for Hill operation**



Plasma Flow & Electric Fields

Theory and Modeling

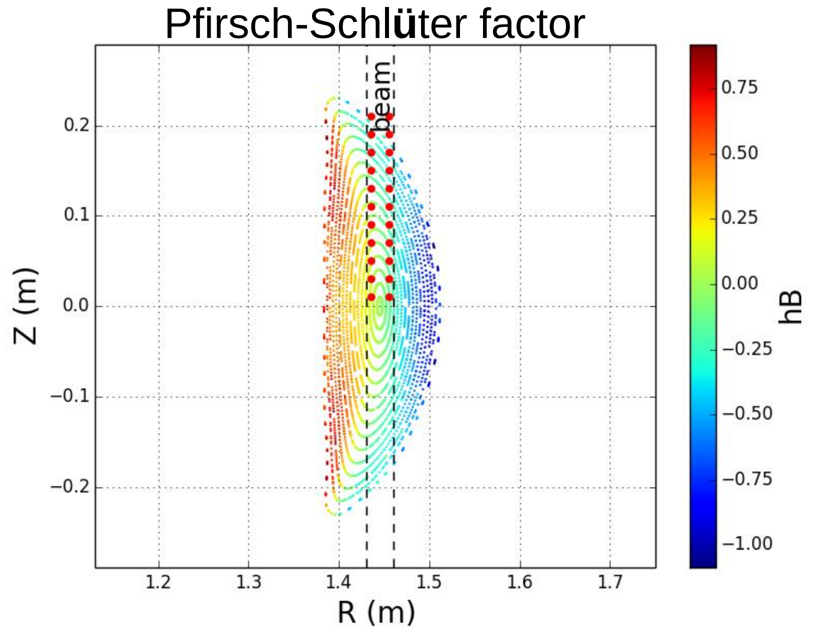
- **Compare DKES and PENTA codes, both assume mono-energetic distribution, to SFINCS (Landreman) and FORTEC-3D (Satake) which do not. Smoniewski CP12.00083**
- **Use SFINCS to model transport with impurities and flux-surface variation**

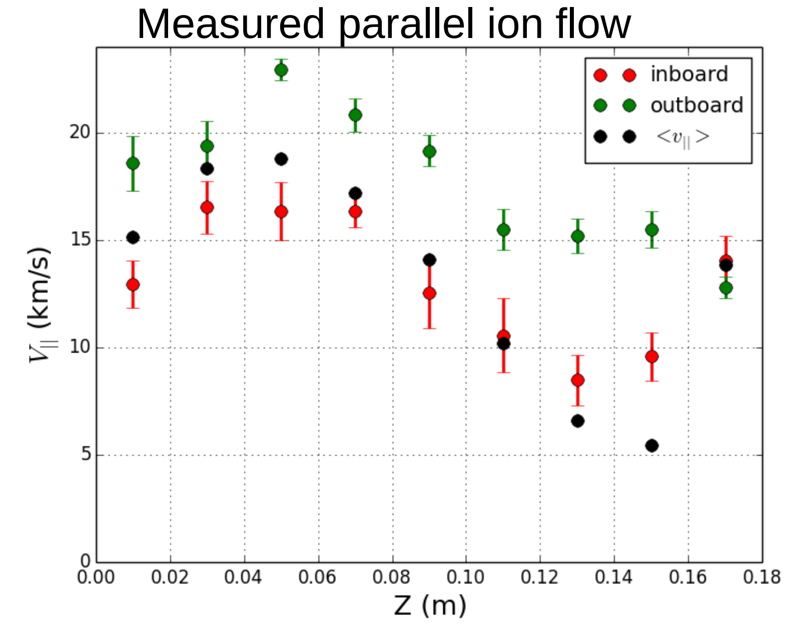
Experiment

- **Inboard/outboard CXRS measurement of Pfirsch-Schlüter flow indicates larger core Er than measured previously Kumar CP12.00080**

$$\vec{V}_{||} = \left(\frac{\langle V_{||}B\rangle}{\langle B^2\rangle}\right) + \left(\frac{1}{enZ}\frac{dp}{d\Psi} + \frac{d\Phi}{d\Psi}\right)h\Big)\vec{B}$$

- **Use Motional Stark Effect Polarimetry to measure Er profile directly Dobbins CP12.00082**





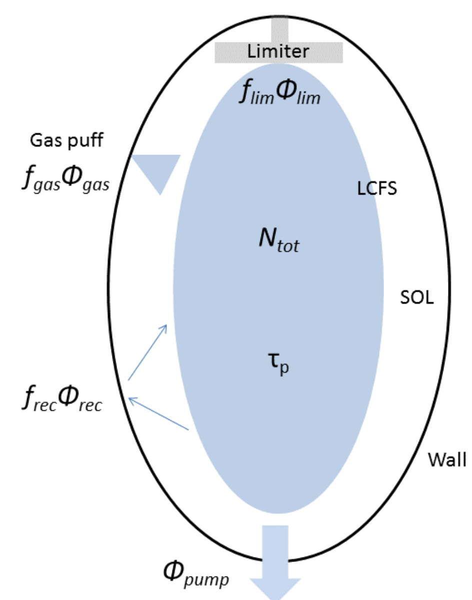
Edge Transport and fueling

Theory and Modeling

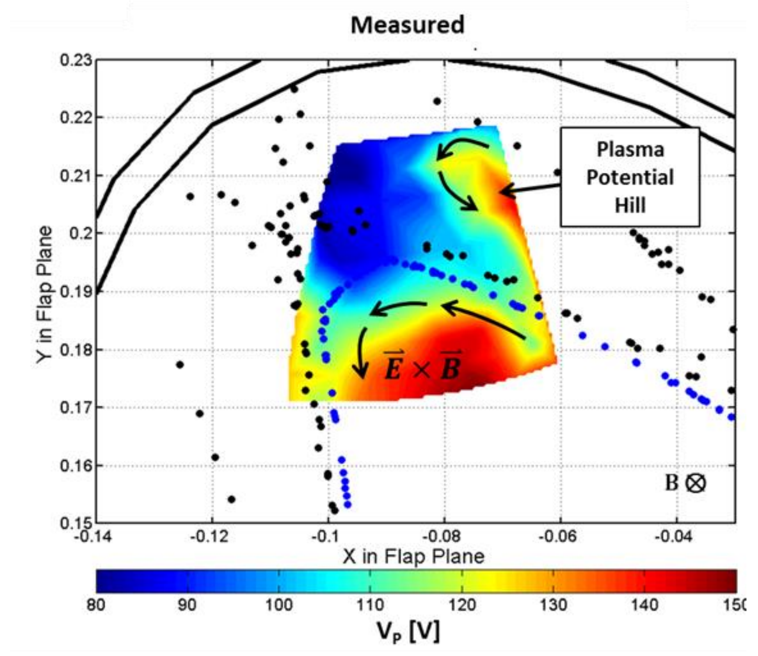
- **Model Te, ne and plasma flow at edge with EMC3-EIRENE for different HSX magnetic configurations**
- **Compare DEGAS neutral calculations to EIRENE and derive fueling efficiency (f) coefficients**
- **Develop single reservoir model to quantify particle balance Stephey CP12.00084**

Experiment

- **2D contours of n_e, T_e, $V_{||}$ and V_p measured in edge.**
- **Electric fields measured within islands that are not included in EMC3-EIRENE model Akerson CP12.00085**
- **Study neutral fueling and particle balance with limiter in HSX and W7-X Stephey CP12.00084**



$$\frac{dN_{tot}}{dt} = -\frac{N_{tot}}{\tau_p} + f_{rec}\Phi_{rec} + f_{gas}\Phi_{gas} + f_{lim}\Phi_{lim} = \Phi_{gas} - \Phi_{pump}$$



HSX Directions

- **Explore feasibility of optimizing magnetics for reducing turbulent transport**
  - **Builds on quasisymmetric topology which is optimized for improved neoclassical transport**
- **Increase ion temperature with 20kV 10ms neutral beam -- H or D**
  - **Study fast ion confinement with injection into high T_e plasma through D-D neutron production**
  - **Explore transport dependence on E_r in electron- and ion-root plasmas**
- **Bootstrap evolution current profile reconstruction comparisons to model**
  - **Examine Zeff and impurity injection effects on currents and current profiles – Laser Blowoff**
- **Improved fluctuation diagnostic capabilities for direct comparison to GENE turbulence predictions**
  - **Heterodyne interferometer for spatial density resolution, k resolution**
  - **Collective scattering upgrade to extend k sensitivity**
  - **Doppler reflectometer for density fluctuations and plasma rotation measurements**
  - **Correlated ECE for T_e fluctuation spectrum as related to n_e fluctuations**
- **Higher density operation with neutral source control and different fueling - SGI**
  - **Higher density core plasma and interface to scrape-off layer**
  - **Study impurity transport and exhaust in ion root E_r**

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