Overview of HSX Stellarator Experiments

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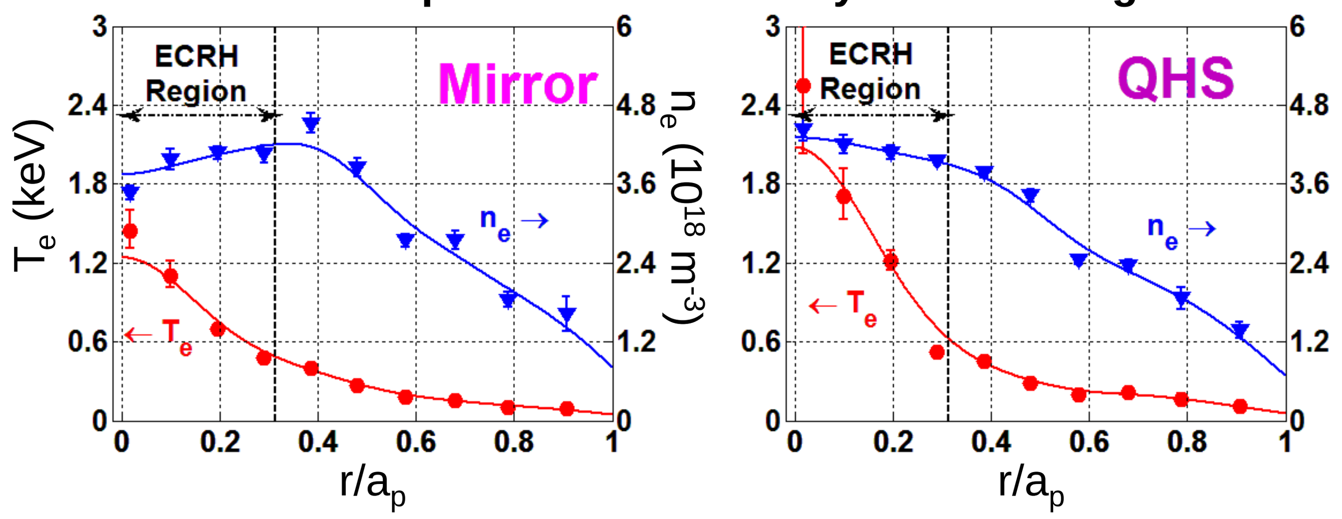
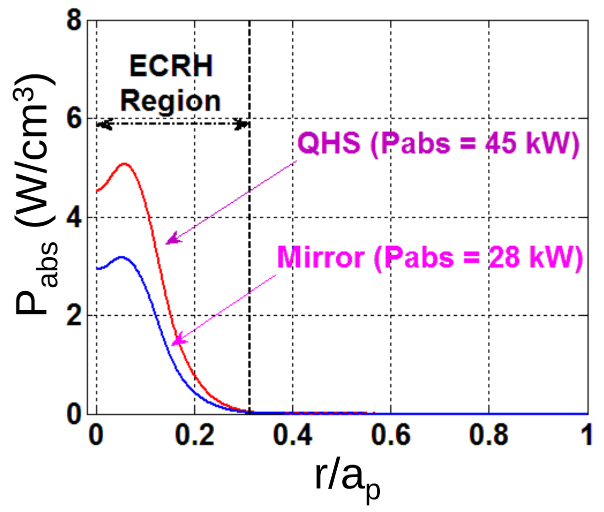
Summary

Electron Temperature and Density from TS diagnostic



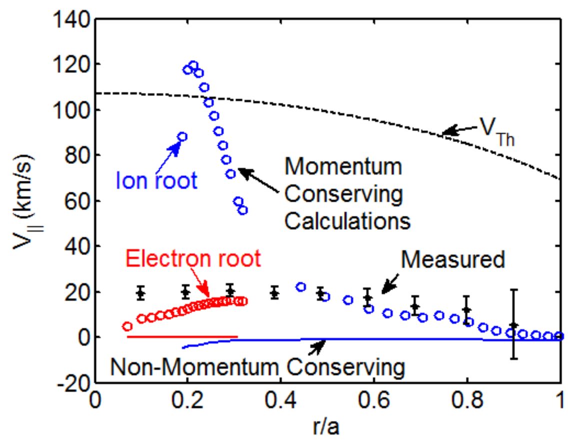
Absorbed Power Profile



- At 100 kW of launched power the central electron temperature in QHS is above 2 keV while in Mirror mode the maximum T_e value does not exceed 1.4 keV; this results is, primarily, due to better confinement in QHS than in Mirror
- Emphasis now is investigating anomalous and neoclassical electron transport by heating electrons to low collisionality regime at higher power level; the second ECRH system will be available shortly
- Momentum conservation between species must be taken in account to predict the parallel velocity in HSX measured by CHERS diagnostic
- When a bias is applied to the plasma, a signature of zonal flow has been detected in HSX
- V3FIT code used for plasma equilibrium reconstruction predicts a broad pressure profile
- Measured toroidal current matches the estimated value by PENTA code with E_r that corresponds to the neoclassical ion root solution
- Impurity transport is a key issue for stellarators; HSX is starting an investigation using a laser blow-off technique with bolometry and soft X-ray diagnostics
- We use VMEC, PENTA, GNET, SIESTA codes to model the HSX experiment

Parallel Velocity and E_r

Parallel Velocity Profile

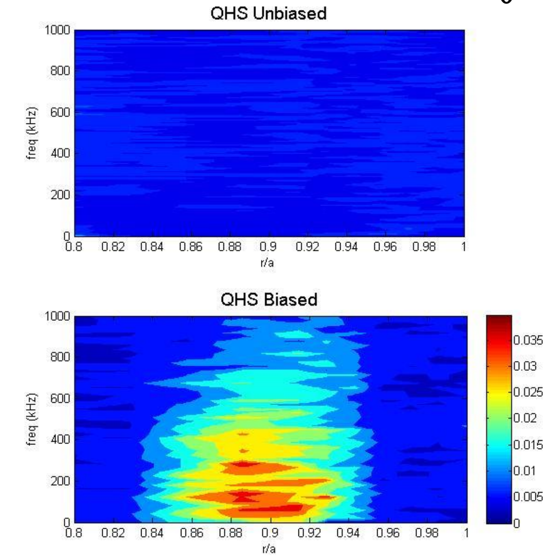


See poster by Alexis Briesemeister

- Large parallel flow (~15 km/s) observed for QHS configuration, often neglected in neoclassical calculations
- Non-momentum conserving calculations under-predict $V_{||}$ by an order of magnitude compared to measured values
- Derived radial electric field corresponds to that in the neoclassical ion root regime

Zonal Flow

Total bi-coherence of E_θ

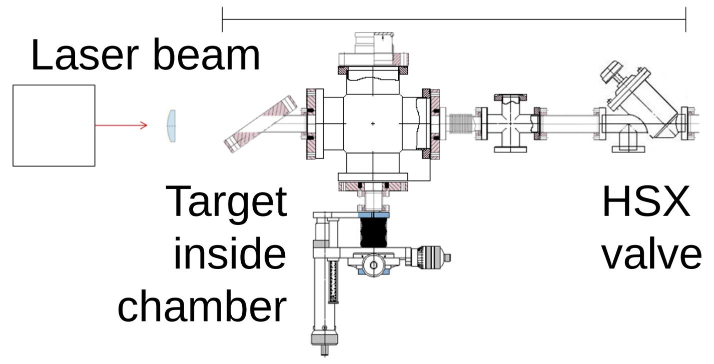


See poster by Robert Wilcox

- Zonal flow levels predicted to be higher in configurations optimized for reduced neoclassical transport
- A presence of zonal flow can be found through the wave coupling; high bi-coherence indicates three waves interaction into a plasma
- In HSX, high bi-coherence and long-range correlations of potential fluctuations in the region of the induced radial electric field are consistent with zonal flow formation

Impurity Transport

Laser Blow-off Diagnostic

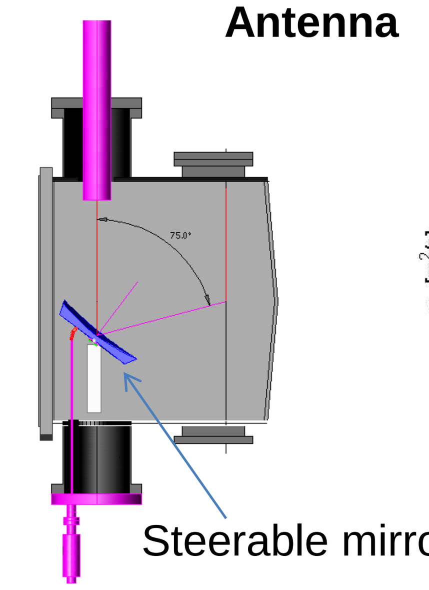


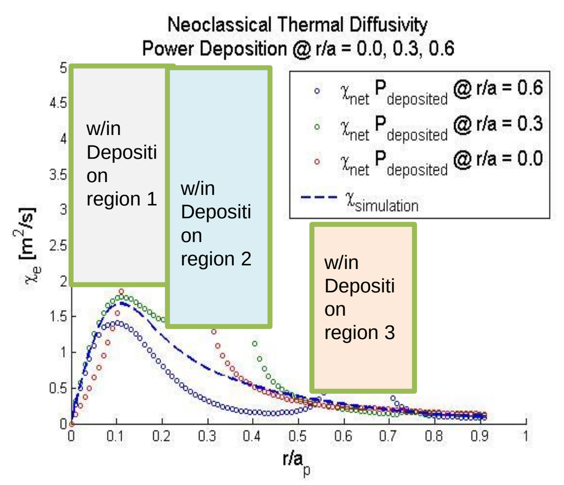
See posters by Chris Clark and Kan Zhai

- About 1% of aluminum will be injected into plasma by a laser blow-off technique
- Time evolution of the Al+ radiation will be measured by a set of bolometers and SXR detector arrays
- Impurity diffusivity and convective velocity will be found with the STRAHL code and a nonlinear optimization algorithm
- Thomson Scattering diagnostic is being upgraded to get three snapshots of plasma profiles in each discharge

Second ECRH System and ECE

New Launching Antenna



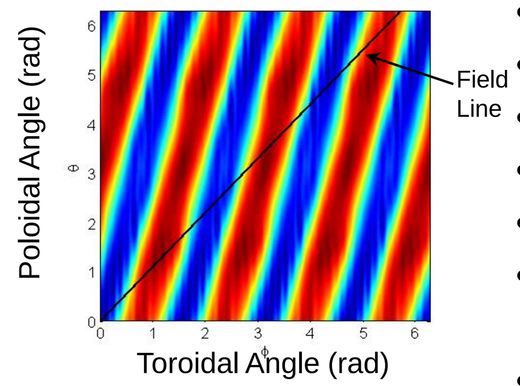


See poster by Gavin Wier

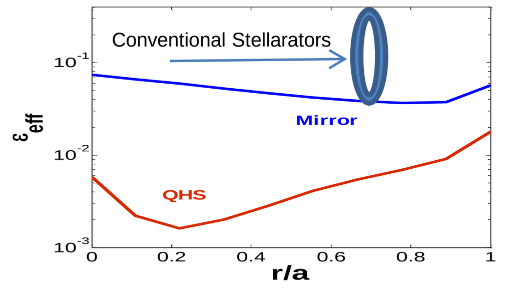
- Second ECRH system is to be operational early next year; second gyrotron has been tested on a dummy load; assembly of the second transmission line is expected to complete in this December
- Additional 200 kW will be available
- To shift the ITB region the steerable mirror is designed for off-axis heating
- To study an electron diffusivity the second heating source can produce a power modulation in a heat pulse propagation experiment
- 1-D modeling of T_e perturbations in HSX plasma has been made
- Next steps on ECE diagnostic: (1) to improve sensitivity of some ECE channels; (2) to model ECE signals from the modeled T_e perturbation

HSX Device

HSX Magnetic Field Strength



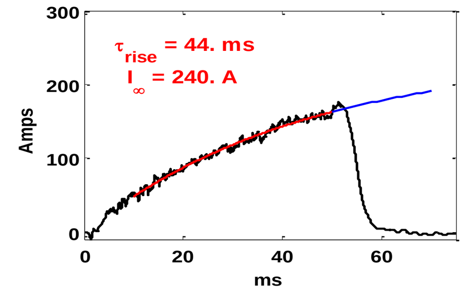
Magnetic Field Ripple



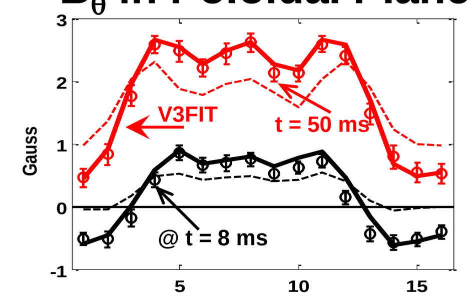
- Major radius of equivalent torus - 1.2 m
- Averaged minor plasma radius - 0.12 m
- Magnetic field on plasma axis - up to 1.1 T
- Rotational transform - 1.05 (axis) => 1.12 (edge)
- ECRH power from one source - up to 100 kW
- Total number of coils - 96
- 48 Modular coils produce the quasi-helically symmetric (QHS) magnetic configuration
- There is almost no toroidal curvature in the QHS configuration that with a high effective transform (ι_{eff} ~ 3) results in small banana widths, low plasma currents and low neoclassical transport
- 48 Planar coils can alter the main configuration to degrade the QHS symmetry increasing magnetic field ripple, viscous damping and neoclassical transport to a higher level. Magnetic configuration with a broken symmetry is called Mirror

Equilibrium Reconstruction

Time Evolution of I_{tor}



B_θ in Poloidal Plane

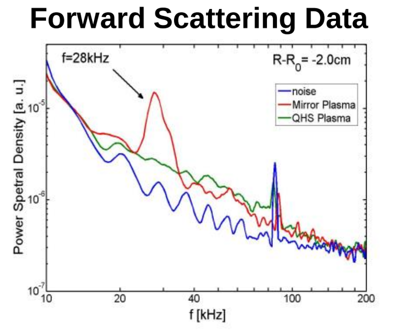


See poster by John Schmitt

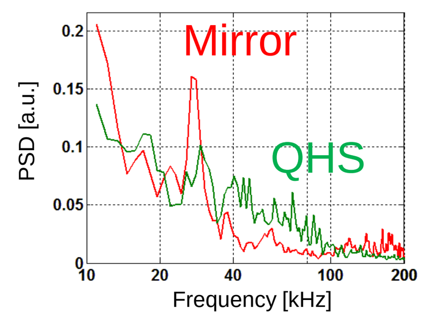
- The steady-state neoclassical bootstrap current is calculated by PENTA and the evolving current profile is modeled by a diffusion equation with a 3D susceptance matrix
- Toroidal current matches or exceeds the neoclassical ion-root solution for most cases
- A set of small coils outside the HSX vessel provide data for 3-D equilibrium reconstruction and current profile by the V3FIT code
- At the beginning the dipole-field from the Pfirsch-Schlüter current is detected ; later a contribution from the bootstrap current is measured as well

Density Fluctuations

Density Fluctuation Spectrum Forward Scattering Data



Reflectometer Data



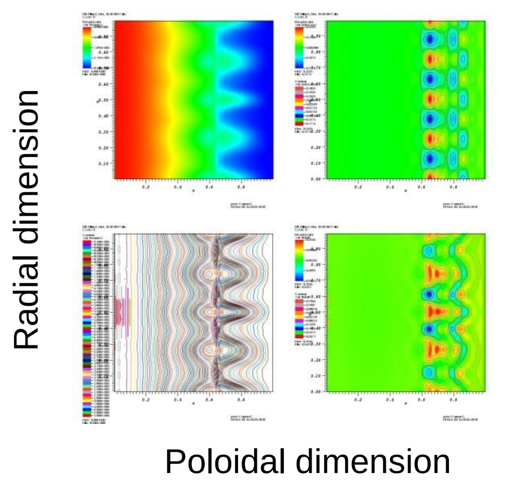
See poster by Chuanbao Deng

- In HSX, density fluctuation spectrum is measured by the interferometer (forward scattering) and the reflectometer
- Density fluctuation spectrum in QHS and Mirror are almost identical except a narrow feature at 28 kHz; T_e profile in QHS is peaked with central temperature ~ 1.2 keV and Mirror plasma with core T_e ~ 500 eV does not manifest a steep T_e gradient

Equilibrium with Islands

See poster by Carson Cook

Plasma Pressure / B•J Contours



- Using SIESTA, equilibrium can be resolved in finite-beta plasmas; the code also will be used for optimization of 3-D magnetic configurations
- Due to the strong helical shaping in HSX, a large number of modes and pseudo-spectral points are required within SIESTA

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