Overview of Recent Results from HSX and the Planned Experimental Program

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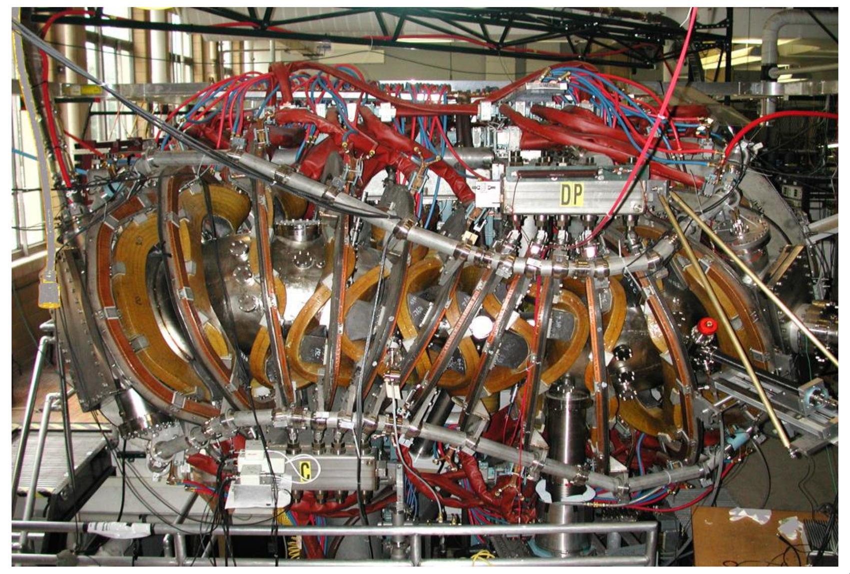
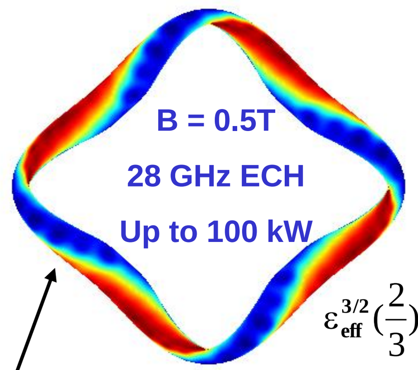
Goals of HSX

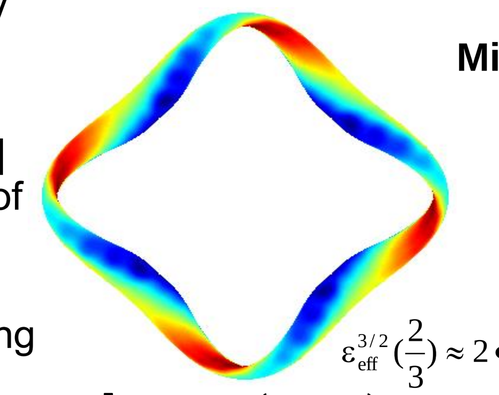
Demonstrate the potential benefits of quasisymmetry





$\varepsilon_{\rm eff}^{3/2}(\frac{2}{3}) \approx 3\bullet10^{-4}$

$B = B_0[1+\varepsilon_h \cos(N-m\iota)\phi]$

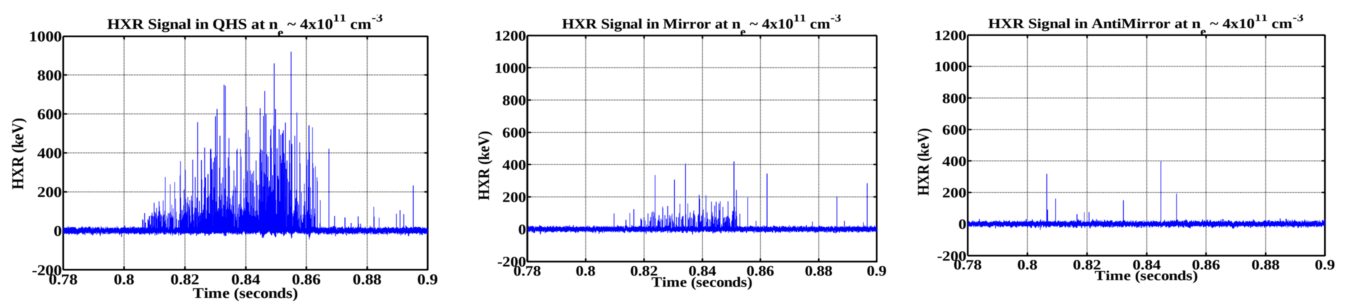


$\varepsilon_{\rm eff}^{3/2}(\frac{2}{3}) \approx 2\bullet10^{-2}$

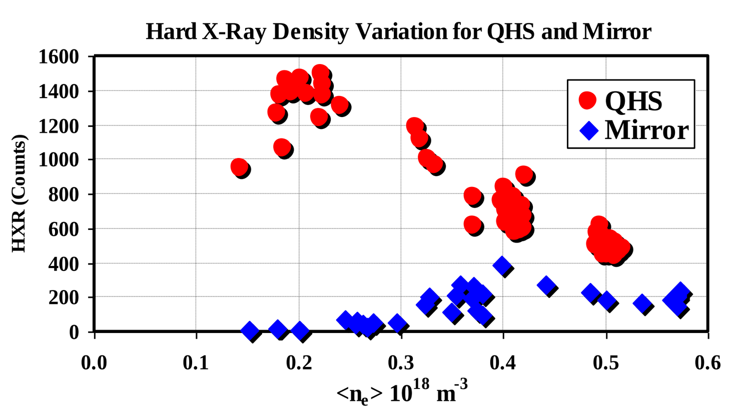
$B = B_0[1+\varepsilon_h \cos(N-m\iota)\phi + \varepsilon_M \cos(N\phi)]$

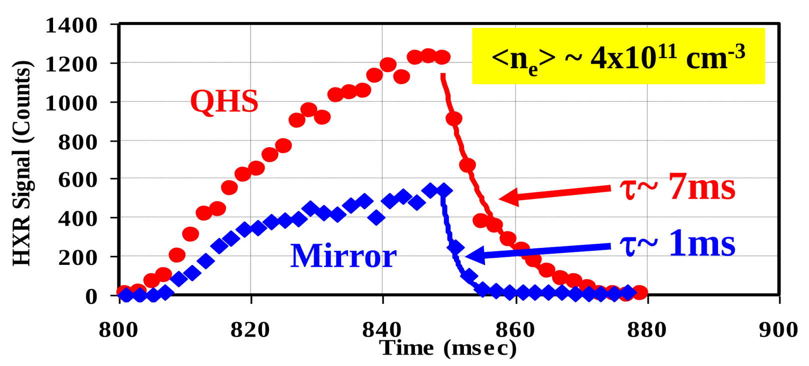
- HSX has a helical axis of symmetry in |B| and a resulting predicted very low level of neoclassical transport. ι_{eff} ~3
- For experimental flexibility, the quasi-helical symmetry can be broken by adding a mirror field.

Evidence for Improved Single Particle Confinement

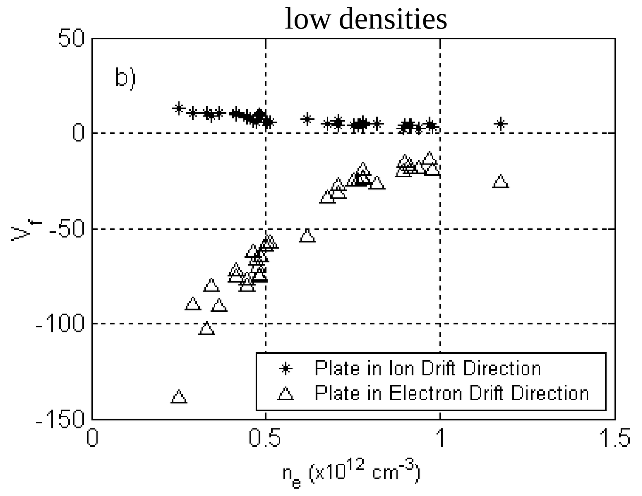


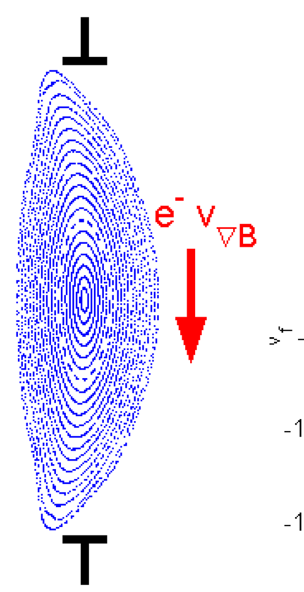
Energetic electrons produced by 2nd harmonic ECH are well confined with quasisymmetry and lead to intense hard x-ray signals **(See Poster by Abdou –this session)**



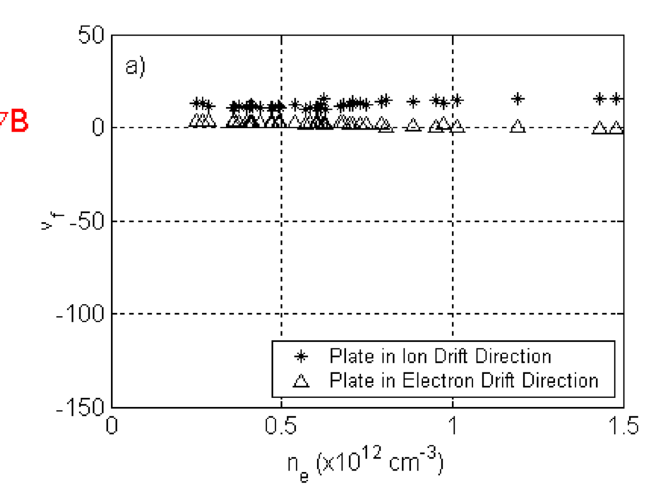


Without symmetry, the floating potential in electron BXVB direction driven negative at low densities



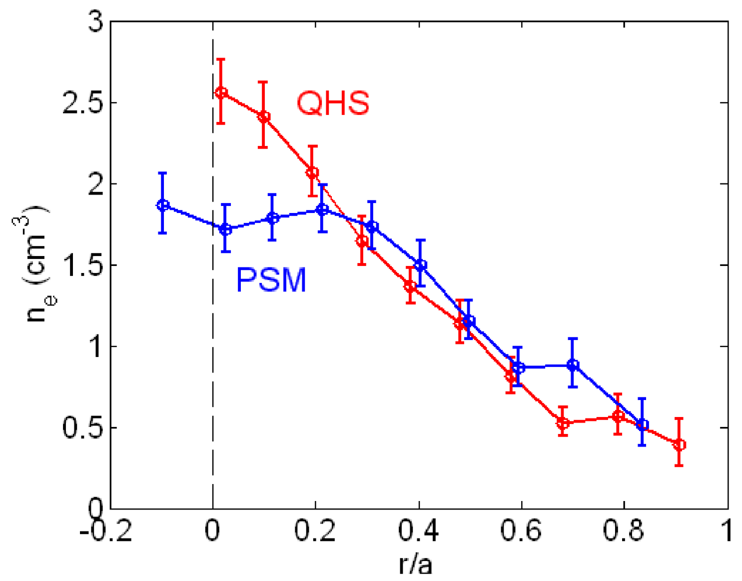


With symmetry, the floating potential is low and almost independent of direction

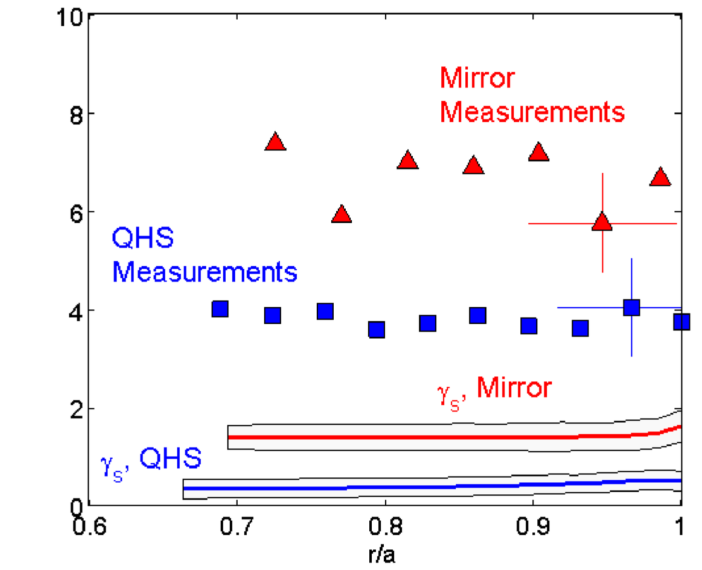


Symmetry Matters in Particle, Momentum and Energy Transport!

Peaked density profiles in QHS

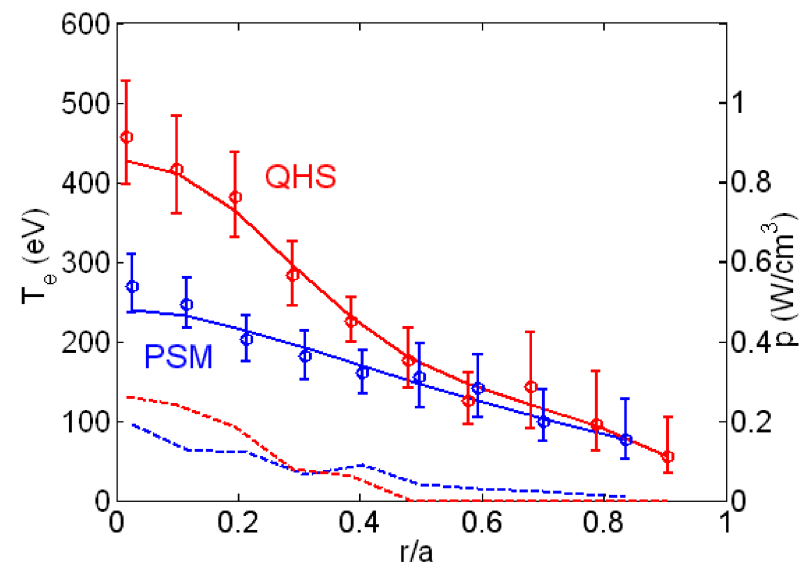


Parallel viscous damping reduced

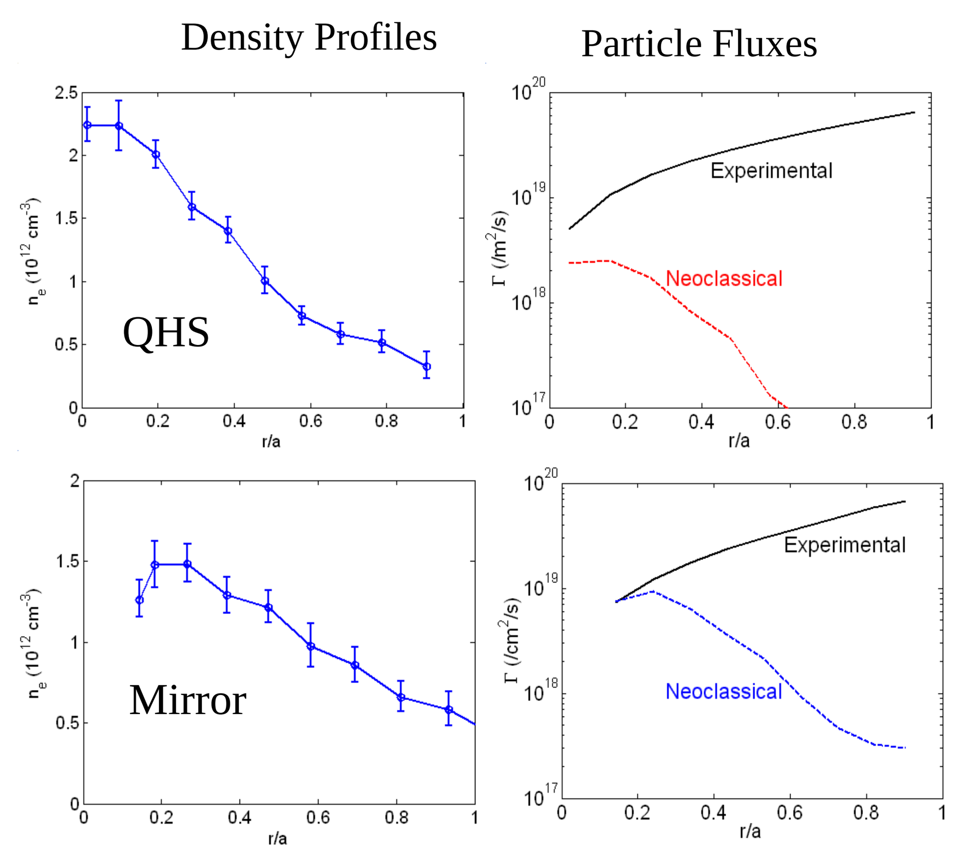


See talk by Gerhardt Fri. AM

Higher QHS T_e with same absorbed power

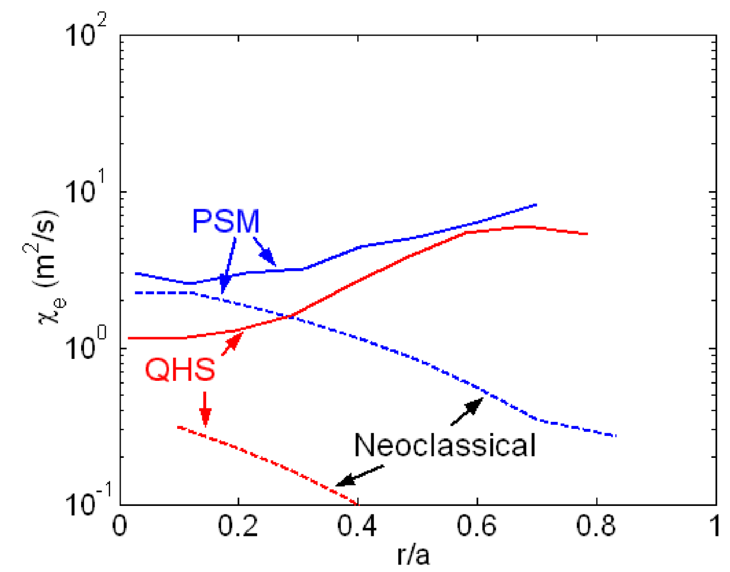


Particle Transport



- QHS neoclassical transport reduced below anomalous
- In Mirror, neoclassical thermodiffusion drives hollow profiles

Thermal Transport



Heating in QHS at r/a ~ 0.1 to mimic phase-shifted mirror (PSM) p_{abs} profile
- Total absorbed power in both configurations is ~ 10 kW

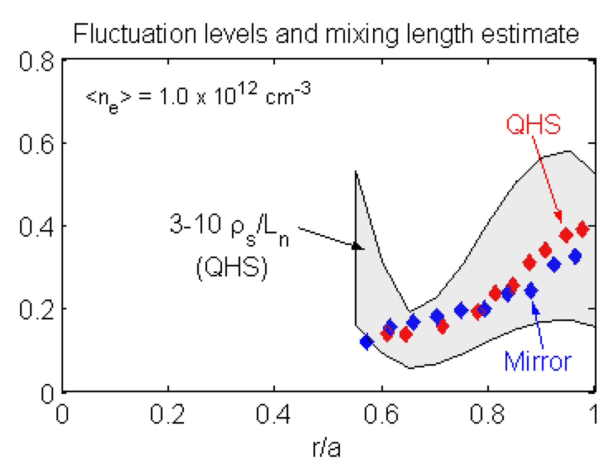
Central temperature in symmetric configuration ~ 200 eV higher

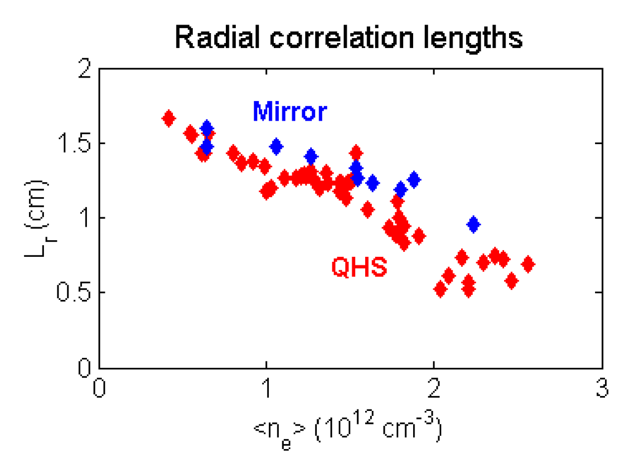
Thermal diffusivity at r/a~0.3 is reduced in QHS compared to Mirror (~1 vs. ~3 m²/s)

QHS has longer confinement time: τ_E^{QHS} ~ 1.5 ms, τ_E^{PSM} ~ 0.9 ms

See Poster by Canik –this session

Edge turbulence characteristics similar in QHS and Mirror under present operating conditions





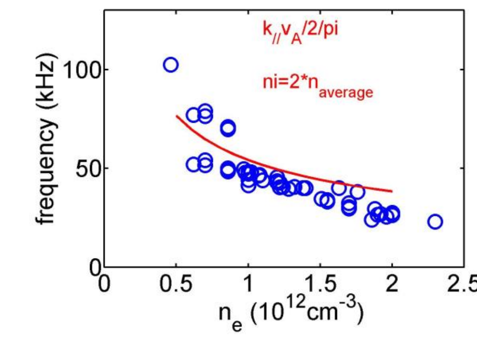
- Fluctuation levels (from ion saturation current) at the edge are same in QHS and Mirror – similar to mixing length estimates **(See Poster by Guttenfelder-this session)**.
- Correlation lengths ($L_r \approx k_\theta^{-1}$) and times are similar over a range of densities **(see Poster by Lechte-this session)**.
- Turbulent diffusivities (L_r^2/τ) are ~ 20 m²/s at high density – on the order of global transport analysis at the edge.

Energetic Particles Drive MHD

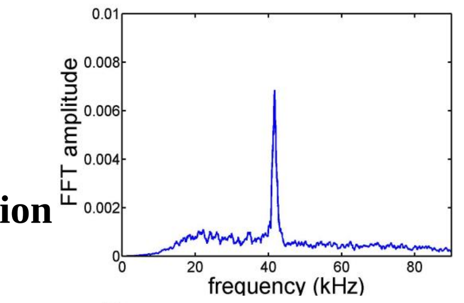
Possible n=1,m=1 GAE mode observed only in QHS discharges

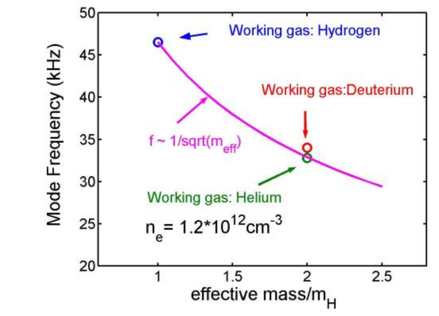
(STELGAP code D. Spong, ORNL)

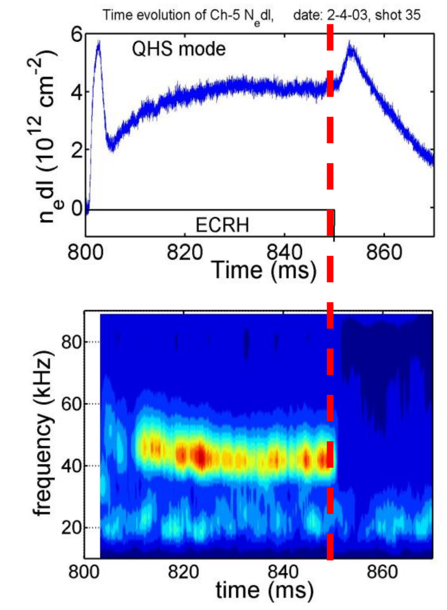
See Poster by Deng-this session



Mode observed only in QHS plasmas



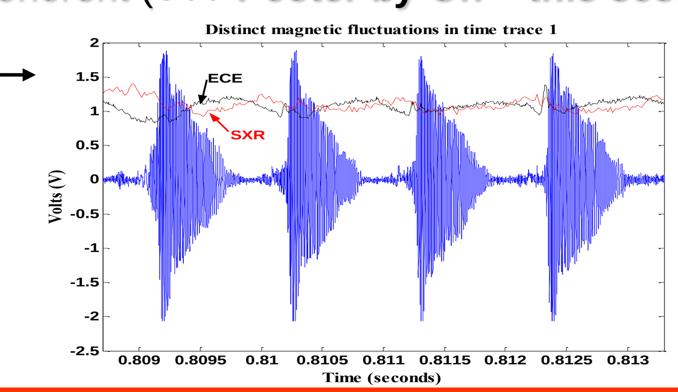




Scaling consistent with Alfvenic modes

Density fluctuations and magnetic signals coherent **(See Poster by Oh – this session)**

- "Fish-bone" like discharges are observed in low density QHS operation
- Crashes in the flux-loop stored energy during these discharges correlated with SXR and ECE and magnetic fluctuations.



Future Directions

High Density, High Power Operation

Increase operating field to B=1.0 T **(See poster S. Anderson – this session)**

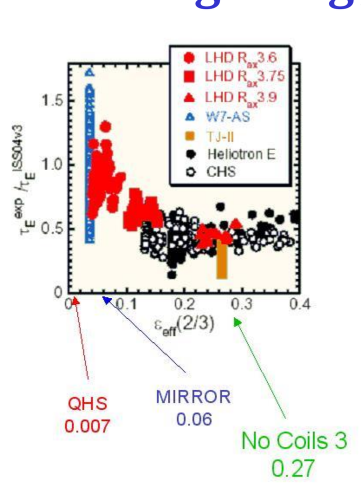
- O-mode operation at 1 T gives factor of 2 in n_e and reduction of tail population
- Reduction in anomalous transport

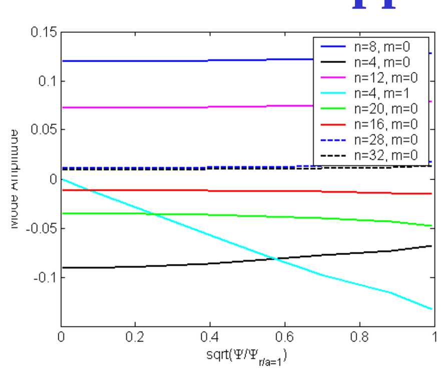
Presently installing upgraded ECH transmission line to bring system up to full power (200kW)

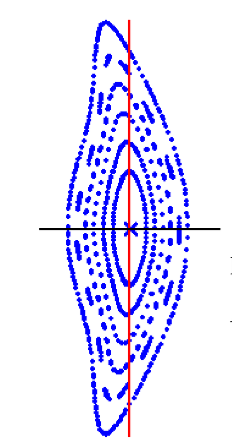
Implement a 2nd 28 GHz gyrotron **(See poster J. Radder – this session)**

- Available power increased from 200 to 400 kW
- Modulation of one tube to give electron thermal conductivity from heat wave propagation in addition to power balance; Steerable launcher to control heating location.

Increasing Range of Effective Ripple:







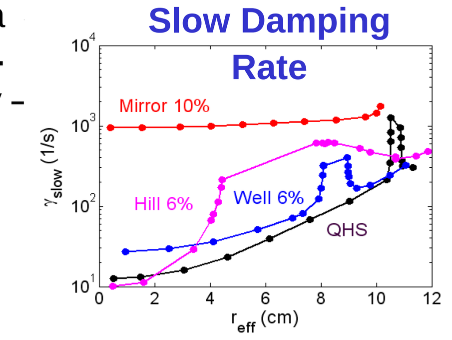
By varying the current in modular coil type 3 (of 6 per period) a broad range of effective ripple can be achieved with well-formed magnetic surfaces

HSX could then span an extremely large range of effective ripple

Magnetic Surfaces with no current in Coil 3

Alteration through VF under consideration

Slow Damping Rate



Parallel viscosity increased by the presence of magnetic islands in the plasma under investigation – **See poster by Schmitt**

New Diagnostic Initiatives

Implementing a CHERS system for measurement of the radial electric field **(See poster by Zhai – this session)**

-diagnostic neutral beam on loan to HSX from the MST Program

Reflectometer system is near completion for measurement of profile in the gradient region and density fluctuations

Upgrade ECE system to 16 channels to measure the whole profile including central values for B=1.0T; thermal conductivity with heat pulse propagation technique; measurement of absorbed power deposition; modeling of non-thermal contribution **(See poster by Likin)**

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