CONFINEMENT PHYSICS ISSUES AND FLOW-DAMPING IN QUASI-POLOIDAL STELLARATORS

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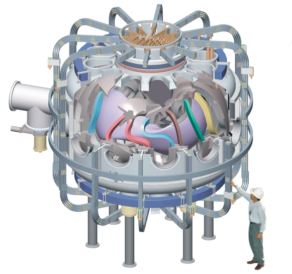
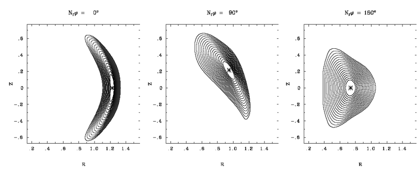
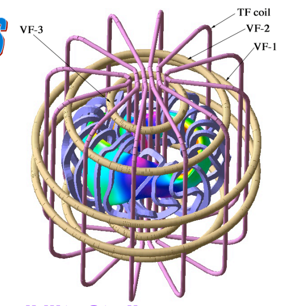
14th International Stellarator Workshop, Greifswald, Germany, Sept. 22 - 26, 2003



$\langle R_{pl}\rangle$ = 0.95–1 m $\langle a_{pl}\rangle$ = 0.3–0.4 m
I_{plasma} < 50 kA V_{pl} = 2–3 m³
B_{mod} = 1 T (1.5 s) B_T = ± 0.15 T
P = 2–4 MW rf





Flexibility Studies

QPS Flexibility Studies

- Flexibility is a significant advantage offered by stellarator experiments
- Flexibility will aid scientific understanding in:
  - –Flux surface fragility/island avoidance
  - –Neoclassical vs. anomalous transport
  - –Transport barrier formation
  - –Plasma flow dynamics
  - –MHD stability
- QPS offers flexibility through:
  - –5 individually powered modular coil groups, 3 vertical field coil, toroidal field coil set, Ohmic solenoid. Variable ratios of Ohmic/bootstrap current

1-D Performance Predictions

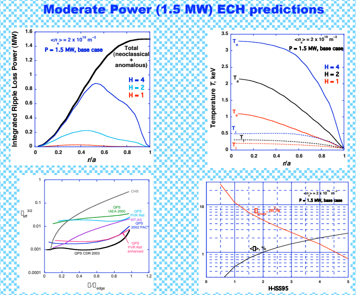
- 1-D transport model
- Fixed density/power deposition profiles
- Neoclassical: Shaing-Houlberg E_r dependence with overall $\epsilon_{eff}^{3/2}$ scaling
- Anomalous: ISS95 transport scaled to give various H factors

Case	H-ISS95	$\chi_{anom.}$ (m²/sec)	$\langle\beta\rangle$ (%)	$T_e(0)$	$T_i(0)$
0.15 MW	1	3.9	0.2	0.27	0.2
ECH	2	1.5	0.4	0.61	0.4
2x10¹⁹m⁻³	4	0.5	0.8	1.08	0.6
1.5 MW	1	11.3	0.5	1.1	0.2
ECH	2	4.8	1.0	2.15	0.31
2x10¹⁹m⁻³	4	1.5	2.0	3.3	0.49

The following cases require development of high density heating techniques.

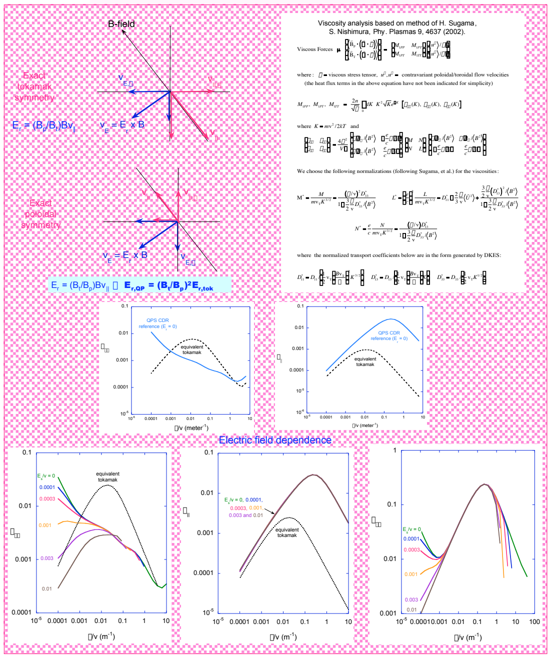
Case	H-ISS95	$\chi_{anom.}$ (m²/sec)	$\langle\beta\rangle$ (%)	$T_e(0)$	$T_i(0)$
2 MW	1	7	1.3	0.36	0.3
EBW/ICR	2	2.9	2.6	0.78	0.62
10²⁰m⁻³	4	1.2	5.2	1.5	1.0
4 MW	1	10	1.7	0.53	0.38
EBW/ICR	2	4.2	3.4	1.14	0.74
10²⁰m⁻³	4	1.7	6.8	2.0	1.1

Moderate Power (1.5 MW) ECH predictions

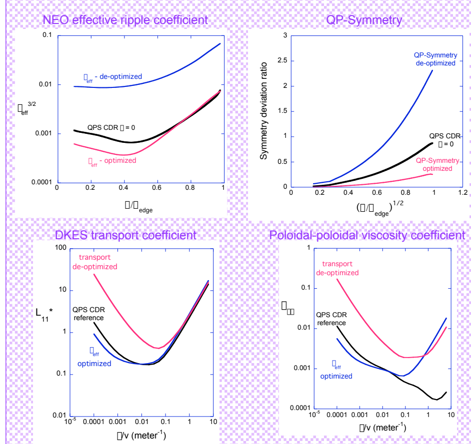


Viscosities/flow damping

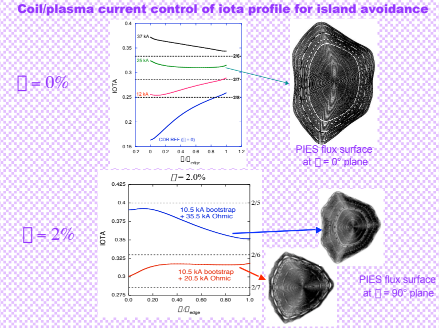
- Exact QP $E_r\,(B_{tor}/B_{pol})^2$ larger than that in a tokamak
- QPS (multi-helicity) poloidal viscosity factor of 10 < tokamak
- Potential for greater control over E_r shear/confinement enhancement



Variation of transport criteria with coil current optimization/de-opt.

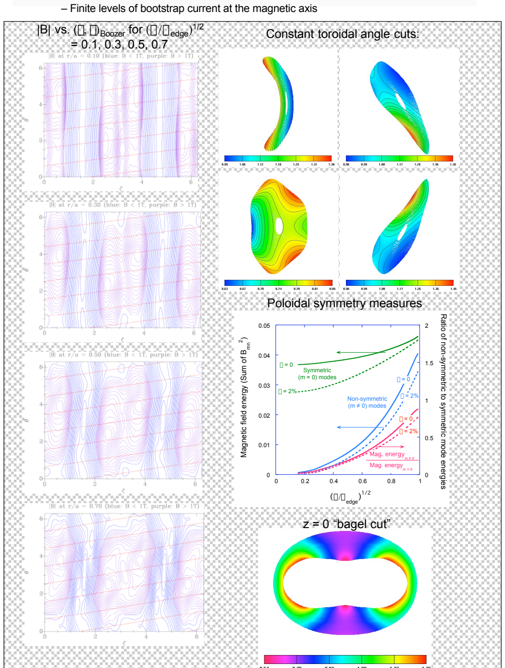


Coil/plasma current control of iota profile for island avoidance



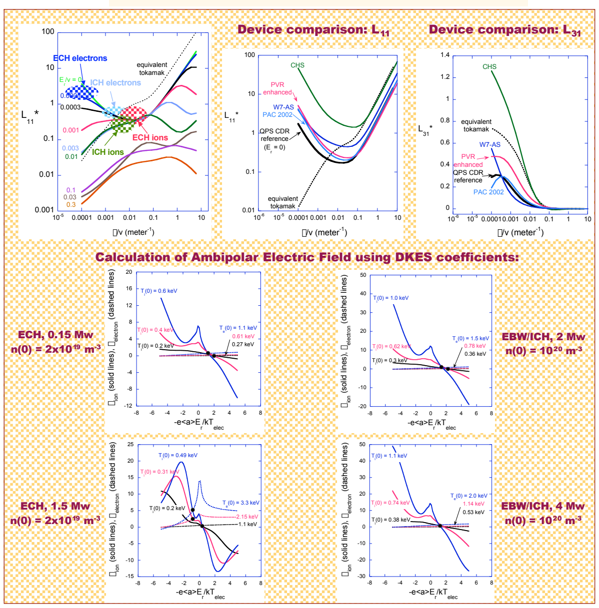
QPS Magnetic Structure

- Exact poloidal symmetry would make P_θ a constant of the motion
  - –banana width ~ gyroradius in toroidal rather than poloidal field
- Finite value of m = 0 modes at magnetic axis allows
  - – high degree of poloidal symmetry near axis (m≠0 modes go to 0 at axis)
  - – Finite levels of bootstrap current at the magnetic axis



Transport coefficients

- Low collisionality: ϵ_{eff} from NEO code*
- Finite collisionality: L_{11}, L_{13}, L_{33} from DKES
- Ambipolar electric field roots
- Will be integrated into 1-D model

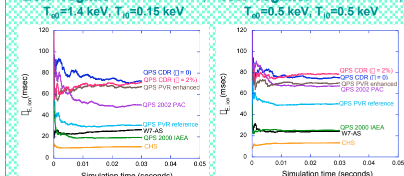


Monte Carlo assessments

- Global Monte Carlo includes diffusive and nonlocal losses
- Current QPS design shows improved $\tau_{E,ion}$ over earlier designs and existing devices
- Flexibility studies show $\tau_{E,ion}$ can be varied by a factor of 2

Monte Carlo configuration comparisons

ECH regime: n = 1.8x10¹⁹m⁻³, T_{e0}=1.4 keV, T_{i0}=0.15 keV **ICH regime:** n = 8.3x10¹⁹m⁻³, T_{e0}=0.5 keV, T_{i0}=0.5 keV



Monte Carlo flexibility studies

(using coil current variation)

ECH regime **ICH regime**