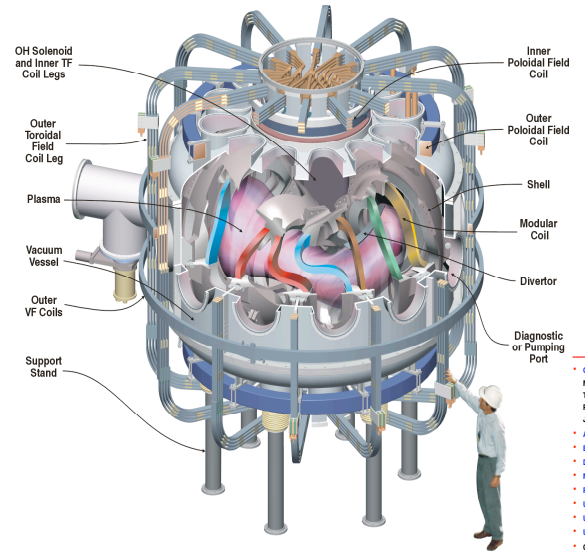
Overview of the Quasi-Poloidal Stellarator

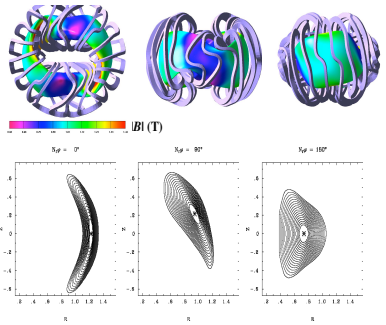
J. F. Lyon representing the QPS Team



- $\langle R_{pl} \rangle$ = 0.95–1 m
- $\langle a_{pl} \rangle$ = 0.3–0.4 m
- V_{pl} = 2–3 m^3
- B_{mod} = 1 T (1.5 s)
- B_T = ± 0.15 T
- P = 2–4 MW

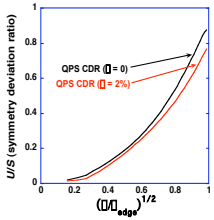
Multi-Institution QPS Team

- ORNL – L.R. Baylor, R.D. Benson, L.A. Berry, T.S. Bigelow, M. Carter, M.J. Cole, D. Fehling, P.J. Fogarty, D. Greenwood, E.F. Jaeger, T.C. Jernigan, D.L. Hillis, S.P. Hirshman J.F. Lyon, S.L. Milora, P.K. Mioduszewski, B.E. Nelson, R. Overbey, D.A. Rasmussen, J.A. Rome, D.A. Spong, D.J. Strickler, J.B. Wilgen, D.E. Williamson
- Alexander & Assoc. – G. Fortier
- BWXT Y-12 – K. Freudenberg, P. Goranson, G. Jones
- DevTech – T. Hargrove
- MK Technologies – G. Lovett
- PPPL – G.Y. Fu, D. Mikkelsen, D.A. Monticello
- U. Montana – A.S. Ware, E. Barcikowski, S. Wang, D. Westerly
- Universidad Carlos III de Madrid, Spain – R. Sanchez
- U. Tennessee – T. Shannon, D. Irick, M. Madhukar, M. Parang
- ORNL/GA/Auburn collaboration on equilibrium reconstruction



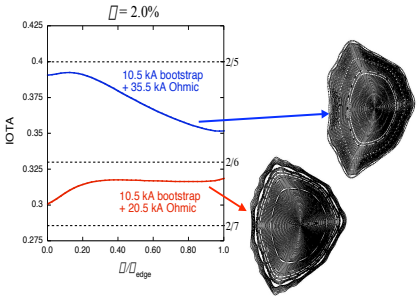
Quasi-Poloidal Symmetry

- The dominant $|B|$ Fourier components are poloidally symmetric in flux coordinates

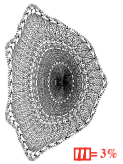


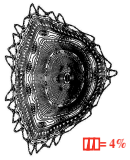
- Leads to reduced neoclassical transport and decreased poloidal viscosity (increased poloidal flows & electric field)

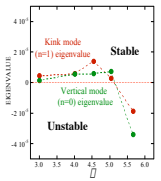
Can Obtain Good Flux Surfaces Using Ohmic Current to Avoid Low-Order Resonances



MHD Equilibrium and Stability at $\langle\beta\rangle$ > 2%



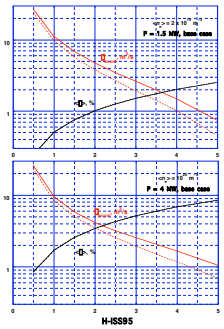




- infinite-n ballooning limit ~2.5%, ~3% with finite-n corrections
- exceeded in experiments?

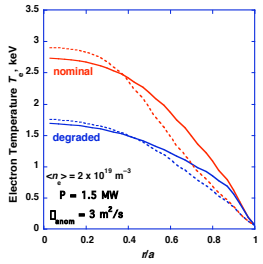
Performance Allows Relevant $\langle\beta\rangle$ Values

- 1-D transport calculations with self consistent radial electric field
- "H-ISS95" is the net confinement multiplier including both neoclassical and anomalous transport (Δ)
- Performance depends on degree of anomalous transport reduction, not sensitive to Δ profile
  - dashed curves parabolic Δ instead of constant Δ



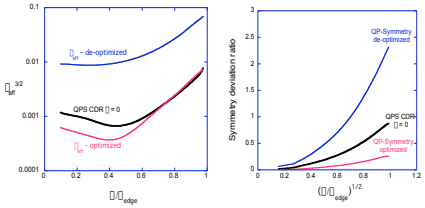
QPS Can Distinguish between Neoclassical and Anomalous Transport

- 1-D transport calculations with base (nominal) QPS configuration and with increased (degraded) effective ripple (Δ_{eff})
- Results not sensitive to Δ(r) (dashed curves parabolic Δ)



Configuration Flexibility

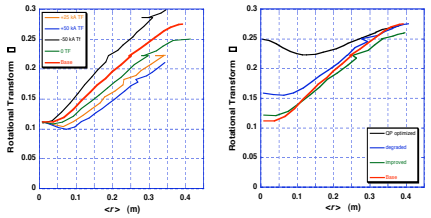
- Changes in coil currents allow ~25 variation in neoclassical Δ ($\Delta_{eff}^{3/2}$) and ~10 variation in deviation from quasi-poloidal symmetry



- Changes in coil currents allow 5-30 variation in poloidal viscosity

Rotational Transform Flexibility

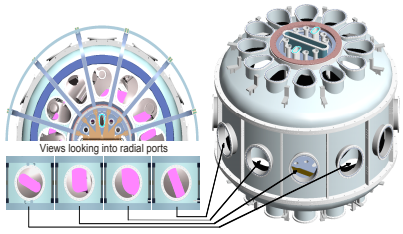
- Changing coil currents allows varying rotational transform profile



TF coil currents | Different coil currents

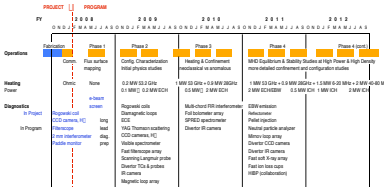
Simple Vacuum Vessel Has Good Access

- All ports consistent with hard seals



Experimental Program

- The main focus of the QPS program is the optimization of stellarator confinement at low aspect ratio R/a
  - reduction of neoclassical transport
  - reduction of anomalous transport
  - role of reduced effective ripple, quasi-poloidal symmetry, poloidal viscosity, fluctuations
- A secondary component is to study Δ limits and the character of MHD instabilities for a very low R/a, quasi-poloidal stellarator



Summary

- MHD equilibrium and stability
  - Can obtain good flux surfaces using Ohmic current to avoid low-order resonances
  - MHD equilibrium and stability for $\langle\beta\rangle$ > 2% (infinite- & finite-n ballooning, external kink & vertical modes)
- 1-D transport with self consistent electric field indicates that performance should meet QPS needs
- Ambipolar electric fields provide a source for self-generated ExB poloidal flows for reduction of anomalous transport
- Can distinguish between neoclassical and anomalous transport
- Can vary rotational transform, neoclassical Δ, quasi-poloidal symmetry, and poloidal viscosity over a large range

More information on the Quasi-Poloidal Stellarator (QPS) project is at http://qps.fed.ornl.gov/