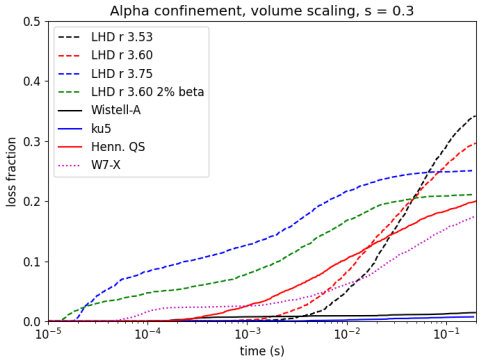
Alpha confinement in LHD-like equilibria

A. Bader, Y. Suzuki, M. Drevlak

Wistell 2021, Feb 17

Alpha particle confinement in LHD-like configurations

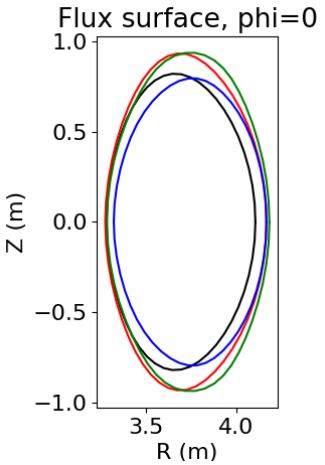


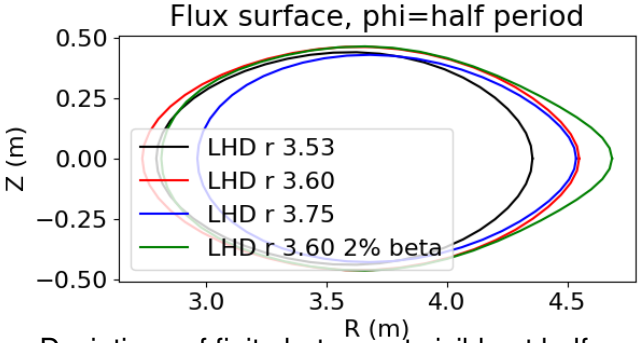
Inward shifted configurations from Mynick Phys. of Fluids 1983

Despite several caveats to the fidelity of the calculation LHD-like configurations show some expected trends

- Inward shifted configurations outperform outward shifted configurations significantly (and even some optimized configurations!)
- Confinement degrades with inclusion of plasma pressure

Unscaled (starting) LHD equilibria



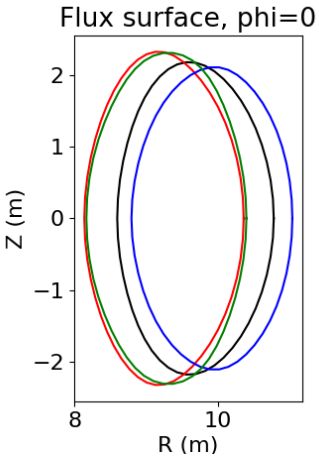


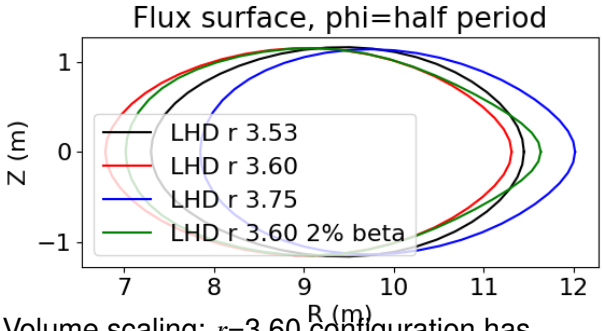
- Deviations of finite beta most visible at half period plane
- r=3.60 case has largest minor radius

General overview of scaling configurations

- Choose scaling parameter: volume or minor radius
- Choose scaling parameter: B0 or volume averaged B
- Fixed-boundary
  - Scale boundary coefficients, plasma pressure, and toroidal currents
  - Plasma pressure, β is held constant, by scaling pressure by B_t^2/B_0^2
  - To keep rotational transform profile fixed, plasma current is scaled by $a_t B_t / a_0 B_0$
- Free-boundary
  - Scale everything as above, and...
  - Scale coil file/mgrid
- With coils it is also possible to do vacuum simulations with the direct field

Scaled LHD equilibria

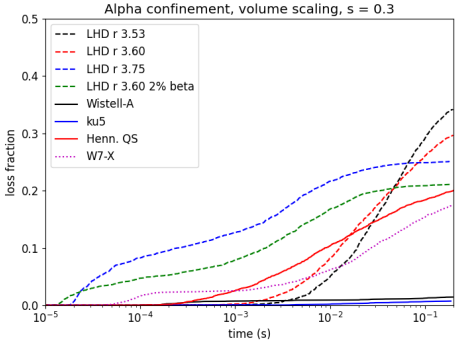




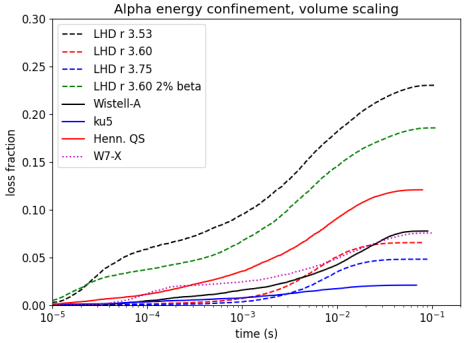
- Volume scaling: r=3.60 configuration has smallest aspect ratio giving it the lowest minor radius

In collisional calculations, LHD vacuum configurations outperform some optimized stellarators

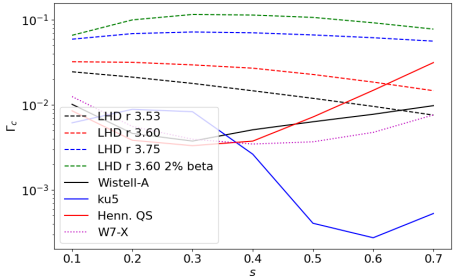
Collisionless

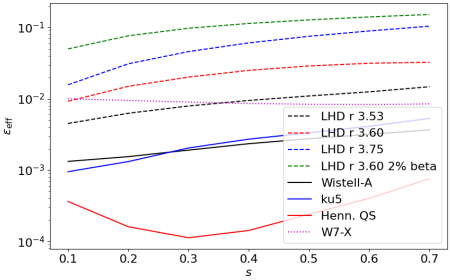


Collisional



Metrics do not seem to predict LHD performance well



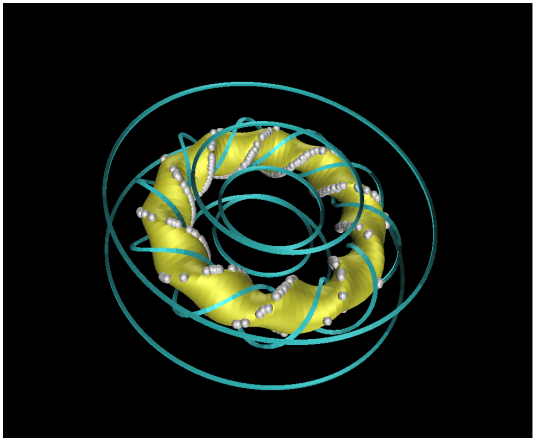


- Relative to other LHD configurations, the metrics have some predictive capability
- Based on Γ_c alone you'd expect LHD vacuum configurations to perform worse than they do

Methodology used for other equilibria may be less well suited to these LHD-like configurations

- Results may *overestimate* LHD losses because
  - Do not account for particles that leave and re-enter the equilibrium
  - Stochastic LHD edge can provide some confinement
- Results may *underestimate* LHD losses because
  - VMEC makes good flux surface where stochasticity is expected

Losses localized on helical stripes



- Configurations using helical coils have strong preference for specific exit locations
- Similar to non-resonant divertors

Picture courtesy of M. Drevlak

Next steps

- Calculation of vacuum field directly from coils (working on at present)
- Include wall, use vacuum fields, and test the amount of re-entering particles
- Can possibly consider more realisitic (i.e. non-VMEC) equilibria