Compact Stellarator Approach to DEMO

J.F. Lyon for the US stellarator community

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Compact stellarators address DEMO Issues

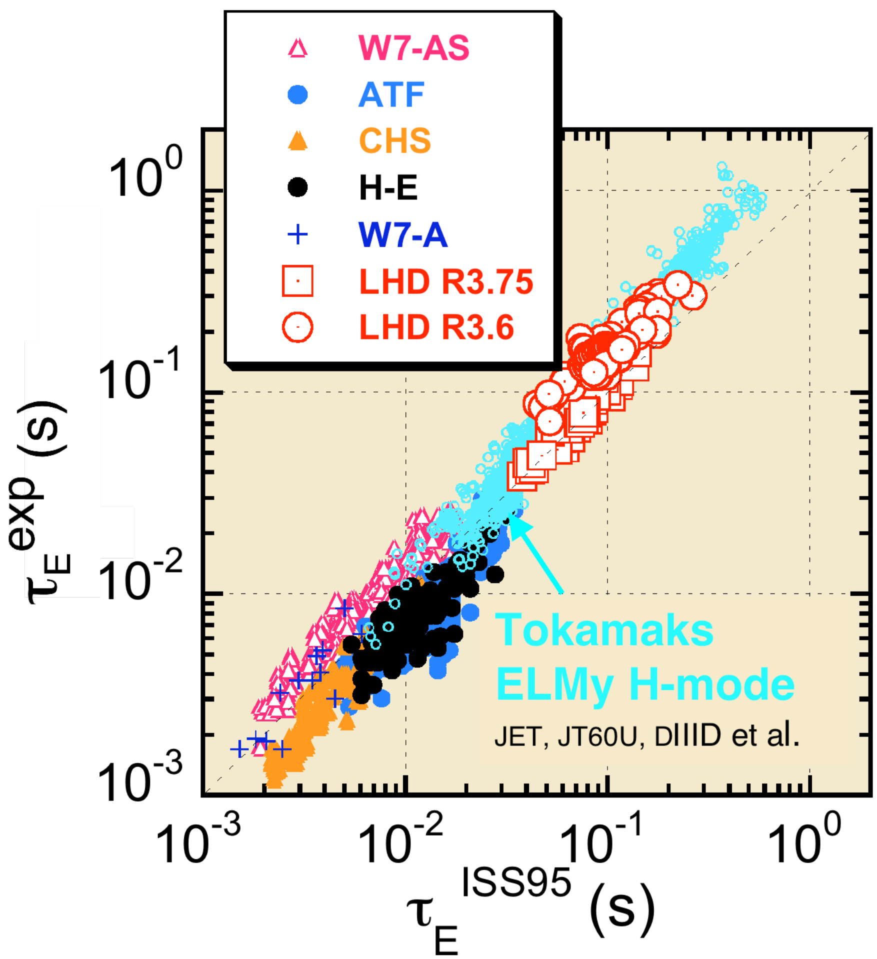
- Compact stellarators $\Rightarrow$ confinement physics as in tokamaks
- Crucial advantages for steady-state reactors
  - quiescent, steady-state, high-β, disruption-free
  - no power input to sustain current or rotation $\Rightarrow$ true ignition
  - no profile control or close fitting walls
  - high density limited only by power
    - reduced α slowing-down time $\Rightarrow$ reduced α instability drive
    - less energetic particle fluxes to wall
  - 3-D shaping of plasma edge
    - optimal control of spatial distribution of particle fluxes, radiation losses
- Features shown in high-R/a, non-symmetric stellarators
- Develops important tools for 3-D control of tokamaks
  - ELMs, RWMs, disruptions, plasma-wall interactions

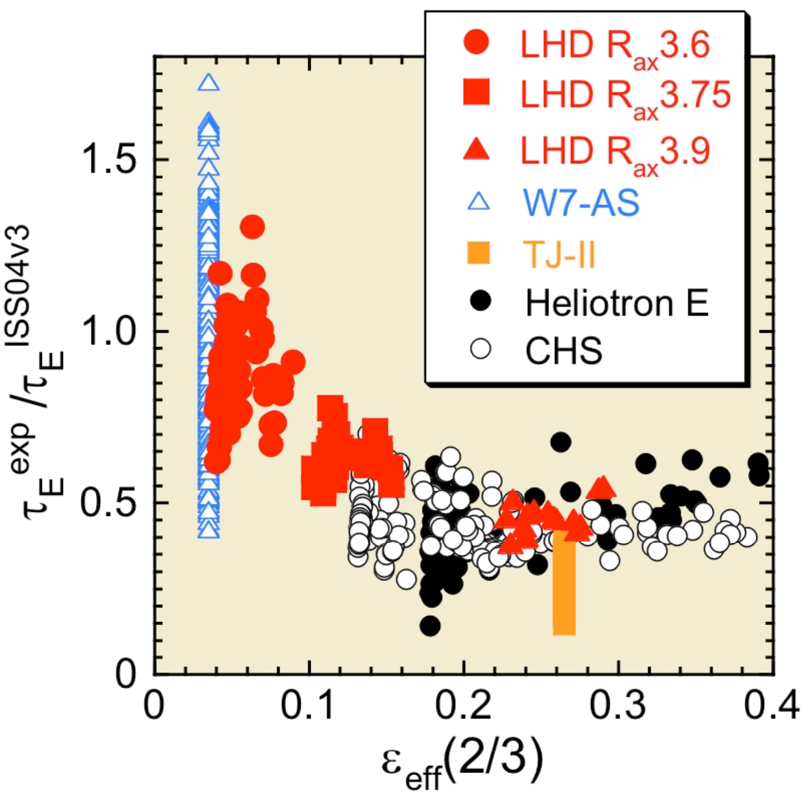
Quasi-symmetry ⇒ key to compact stellarator

- Quasi-symmetry ⇒ minimize variation of |**B**| in symmetry direction in straight field line coords ⇒ *tor., pol or helical*
  - conserved canonical momentum as in axisymmetic system
    ⇒ good orbit confinement
  - reduced effective field ripple along **B**
    ⇒ reduced neoclassical transport (depends only on |**B**|)
    ⇒ allows strong rotation transform at lower R/a
  - reduced viscous damping in symmetry direction
    ⇒ promotes lg **E** x **B** flow shearing ⇒ reduced anom. xport
- Exploits physics commonality with tokamaks
- Reduced viscosity, neocl. xport demonstrated in HSX

Stellarator confinement similar to tokamak

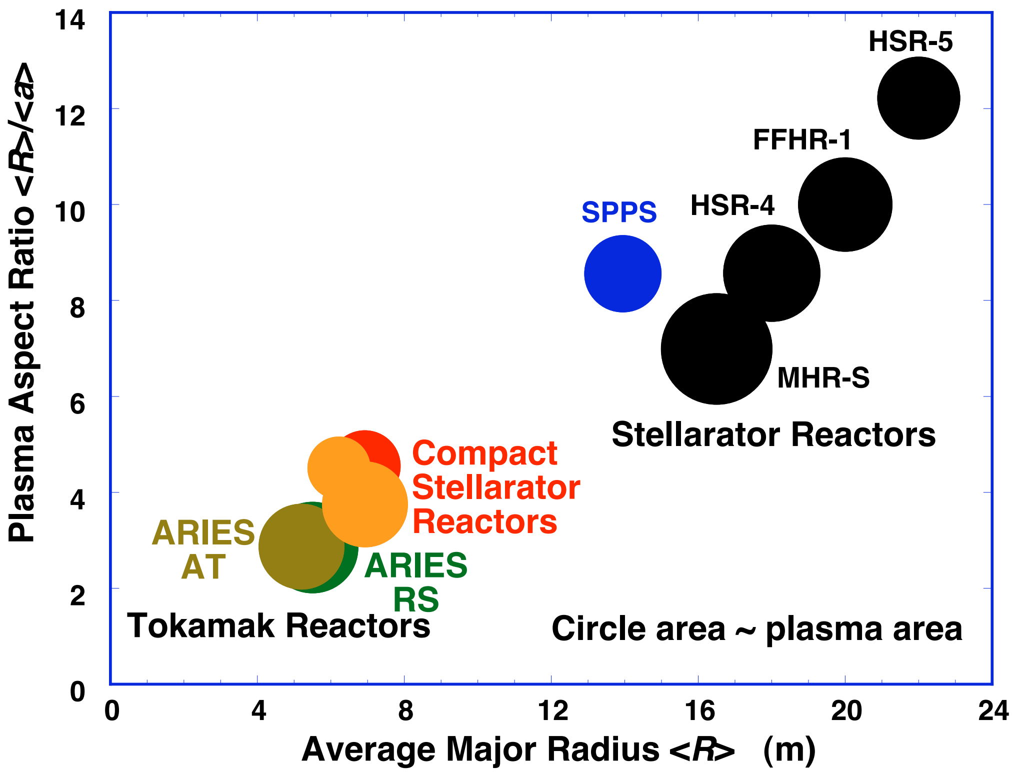
- Comparable plasma for same volume, field & power
- Very low effective ripple (ε_{eff}) in compact stellarator $\Rightarrow$ enhance confinement ?

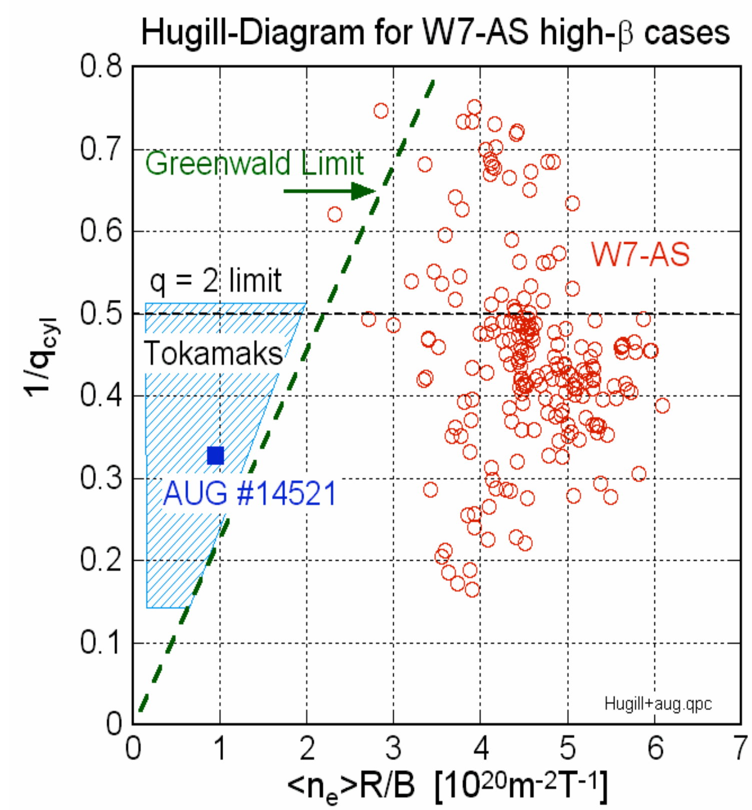




ARIES-CS reactors⇒competitive w/ tokamaks

- Costing approach, algorithms as in other ARIES; updated mat'l costs
- CoE comparable to ARIES-AT & ARIES-RS
- Main issues: coil complexity & divertor geometry
- High density operation reduce α losses, reduces divertor load





Issues to be addressed before CS DEMO

- **Physics issues include**
  - size scaling at a/ρ_i relevant to DEMO
    $\Rightarrow$ adequate thermal confinement and α confinement
  - workable steady-state divertor
  - simpler coil design, cheaper construction
- **How can issues be addressed?**
  - build on results from ITER, other tokamaks; overseas stellarators; and materials & component development programs
  - results from US compact stellarator program: NCSX, QPS, HXS, CTH
  - results from large, next-generation compact stellarator
    - extend parameters to fill gaps
    - D-T operation needed . . . or simulate α's with tail ion heating ?
    - supercond. coils?, or extrapolate from LHD and W 7-X?
    - experience constructing large, superconducting stellarators and ITER sufficient to develop reliable cost estimates for a compact stellarator DEMO?

Start now on study of Next Generation Compact Stellarator (NGCS)

- US compact stellarators + foreign stellarators (LHD, W 7-X) ⇒ development of NGCS to overlap with ITER
  - integrate burning plasma experience into a compact stellarator configuration better suited for a DEMO
- Study can begin now to
  - assess options for NGCS based on
    - NCSX and QPS physics principles
    - 3-D plasma theory & simulation
  - explore tradeoffs, sensitivity; costing models
  - optimized configurations with simpler coils, enhanced flows, improved confinement, robust flux surfaces & high β limits
  - integrate full 3-D plasma, RF heating, divertor & boundary physics in assessing NGCS performance