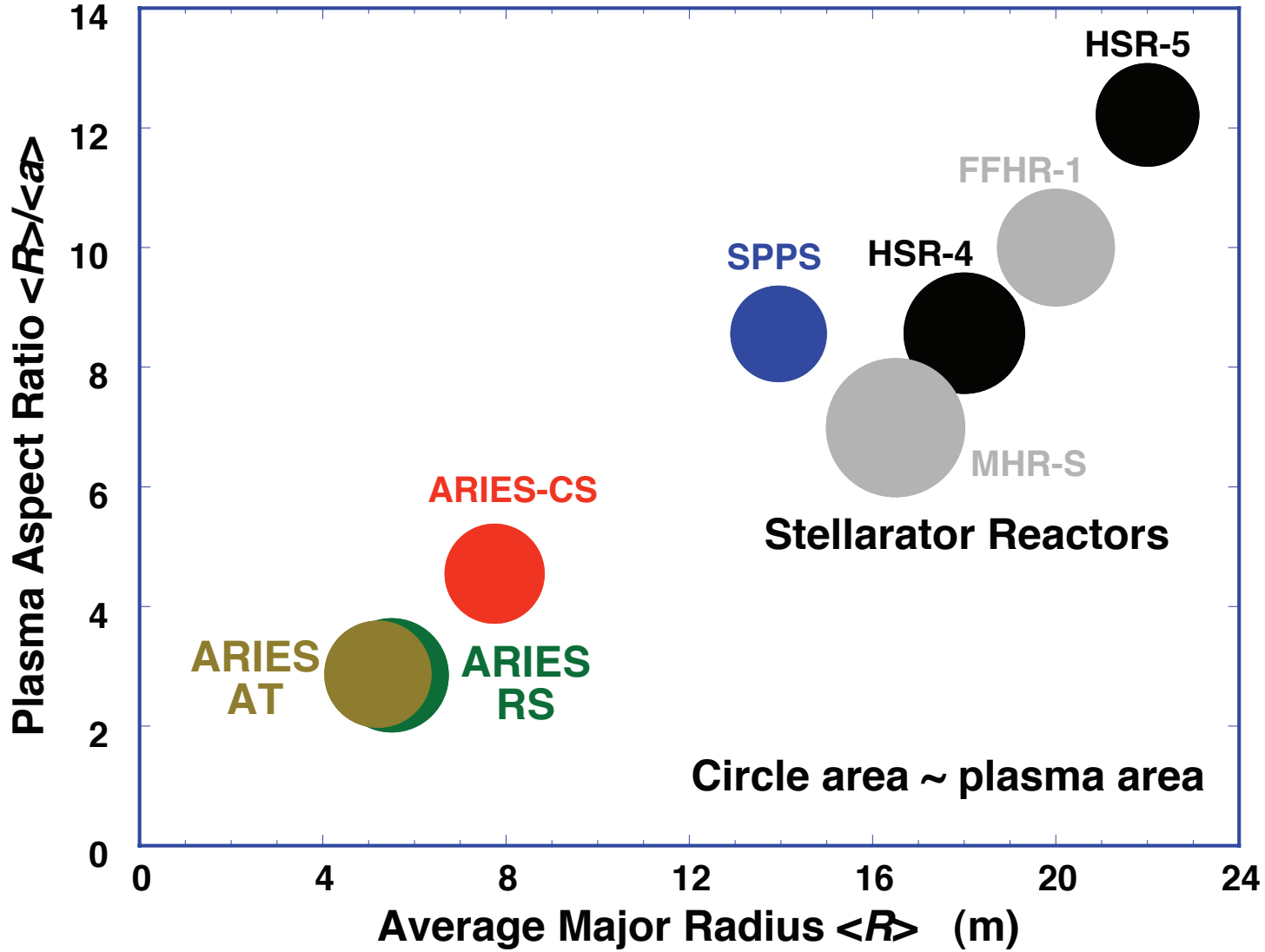
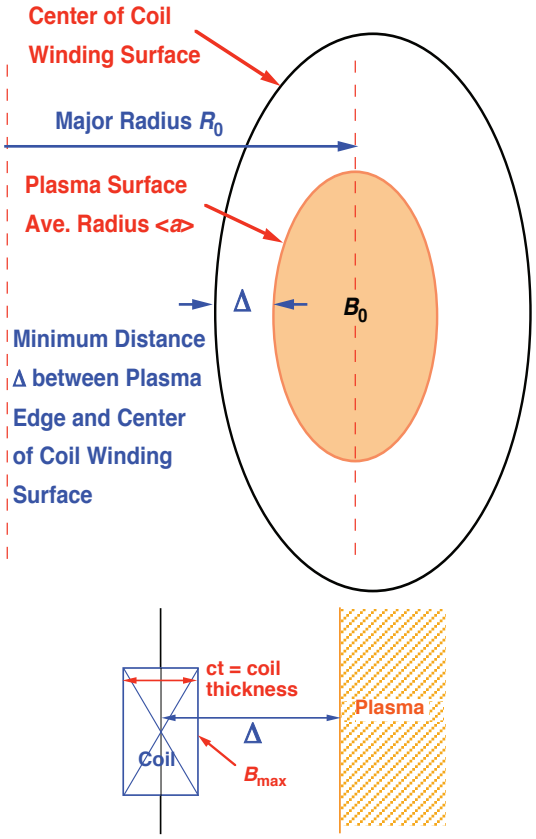
# Compact Stellarator Reactors Closer in Size (and Cost) to Tokamak Reactors



# Minimum Stellarator Reactor Size (and Cost) Is Determined by Aspect Ratios $R/a$ and $R/\Delta_{min}$

- Certain minimum distance $d$ is needed between plasma edge & center of coil pack for plasma scrapeoff layer, first wall, blanket, shield, vacuum vessel, assembly gaps, coil case and half-depth of coil $\Rightarrow$ $\boldsymbol{R_{min}} = (R/\Delta_{min})d$




- Then $a_{min} = (R/a)R_{min} = (R/a)(R/\Delta_{min})d$
- $P_{fus} \sim \beta^2 B^4 \mathrm{Vol}$
  - $B$ is set by $\beta$ requirement and $B_{max,coil}/B$
  - If $B_{max,coil}/B$ too high, decrease $B$ & increase $\beta$
  - If $\beta$ is too high for $B_{max,coil}$, increase $R$
- If $R/\Delta_{min}$ low you have high wall loading
- If $R/a$ low and $B_{max,coil}/B$ is OK, then you have a low COE

  $\Rightarrow$ a given piece of wall, backed up by a blanket, shield and coil, on all of which you are paying a mortgage, is making a lot of electricity

# Low *R*/*a* Reduces Cost of Electricity (CoE)

- CoE = $[(\mathbf{C_{cap}} + C_{O\&M} + C_{replace} + C_{fuel})/(8760 \mathbf{P_{e,net}} f_{avail})]/N_{FPY} + C_{D\&D}$
- Contributions to the CoE (in yr-1992 mills/kWhr) for **ARIES-CS case** are **50.2 (Cap)**, 8.0 (O&M), 2.6 (fw/bl/sh/BW replace), 0.5 (D&D), 0.03 (fuel)
- Major capital (and development) costs depend on component volumes
  = thickness x area $\approx c R(a + d/2) \approx c' a^2 (R/a)$;
  coil volume = $L_{coil} A_{coil} \propto a RB/j_{coil} \propto a^2 (R/a) B/j_{coil}$
  coil structure thickness $\propto B^2 Ra \propto B^2 a (R/a)$
  $B$ = ~ 5-6 T and $a$ ~ 2 m are approximately same for all reactors
- Costs of replaced components approx. independent of $\langle p_{n,wall} \rangle \propto 1/R^2$
  - cost per m$^2$ of blanket is approximately independent of $p_n$, so cost of blanket ~ area ~ 1/Pn
  - but replacement rate ~ $p_n$, so cost x rate is approx. independent of $p_n$
- As has been known for a long time, $p_n$ and recirculating power fraction are key determinants of COE -- stellarators have always had low $P_{recirc}$, now they have high $p_n$ as well