FIRE Divertor-Plasma Simulations with UEDGE

The roles of nonuniform anomalous diffusion and impurity radiation

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Outline

1. Basic parameters and geometries

2. Possible bifucation on inner plate for spatially constant diffusion coefficients

3. Elimination of bifurcation by lower diffusion on inboard side

4. Effectiveness of beryllium and neon to reduce heat load at outer plate

5. Radiation heat loads on the side wall

6. Summary

Basic parameters

- Core-edge conditions are as follows:

  density = 1.5e20 m^{-3}

  power = 28 MW into whole SOL, split evenly between ions and electrons

  anomalous diffusion coefficients -
  D=0.33 m^2 /s, chi_e,i = 0.5 m^2 /s

- On the divertor plates:

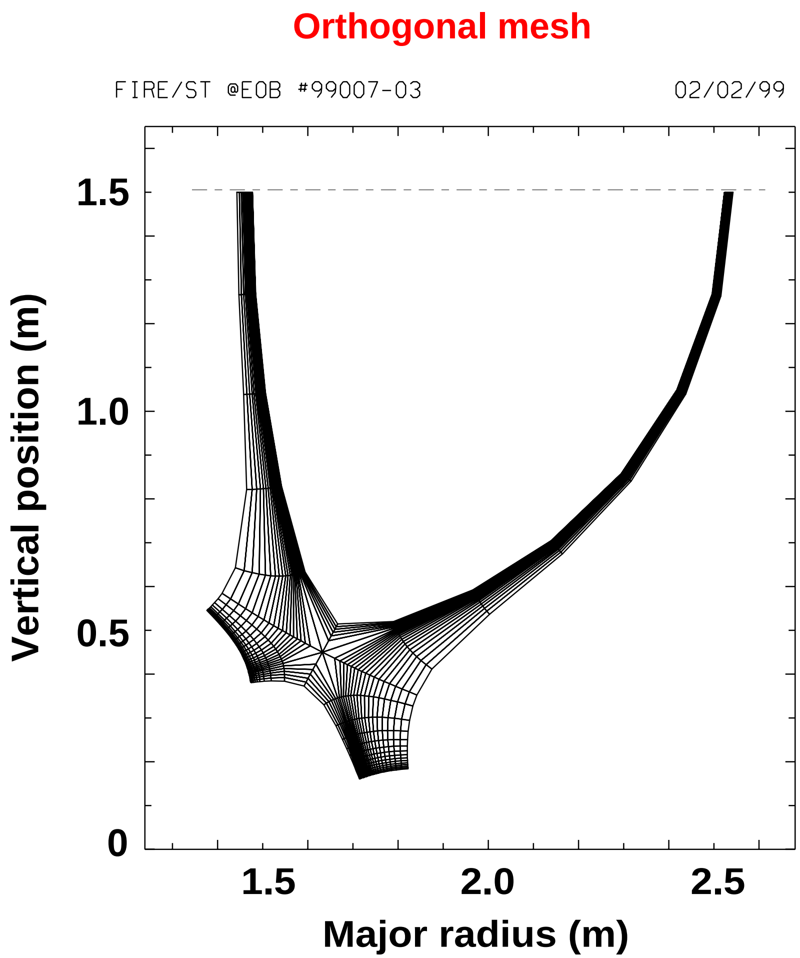
  Recycling coefficient R = 1.0

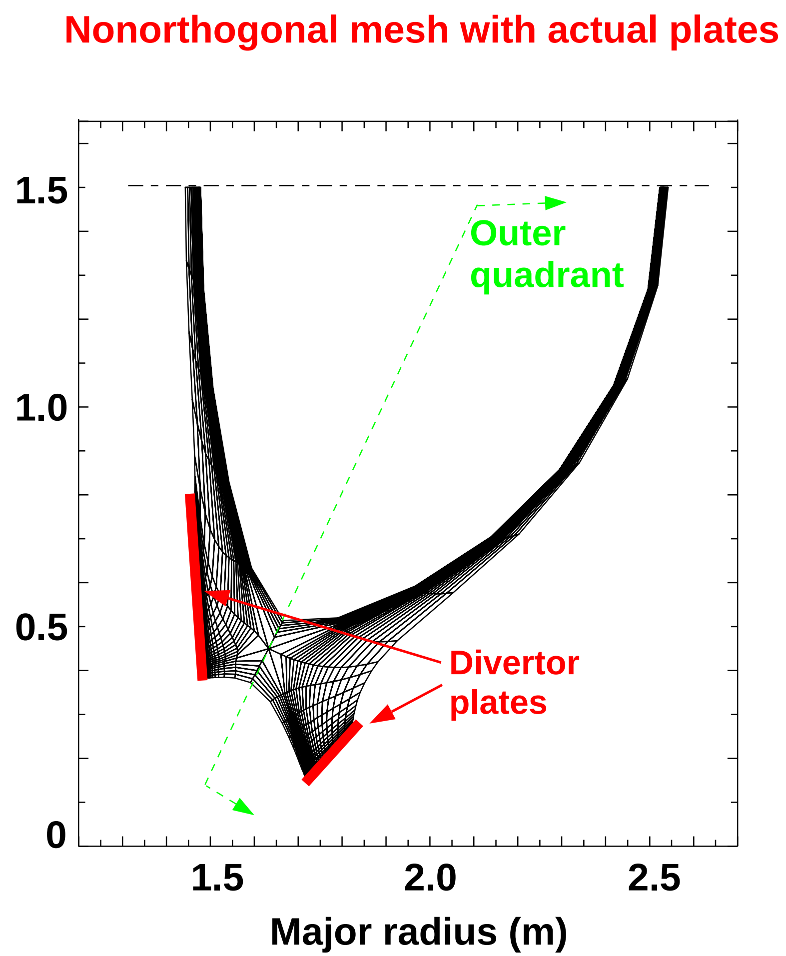
  electron energy transmission factor = 5

  ion energy transmission factor = 3.5

- Three variants of geometry shown in next viewgraph

FIRE edge region and divertors comparing basic orthogonal mesh with more detailed tilted plate geometry

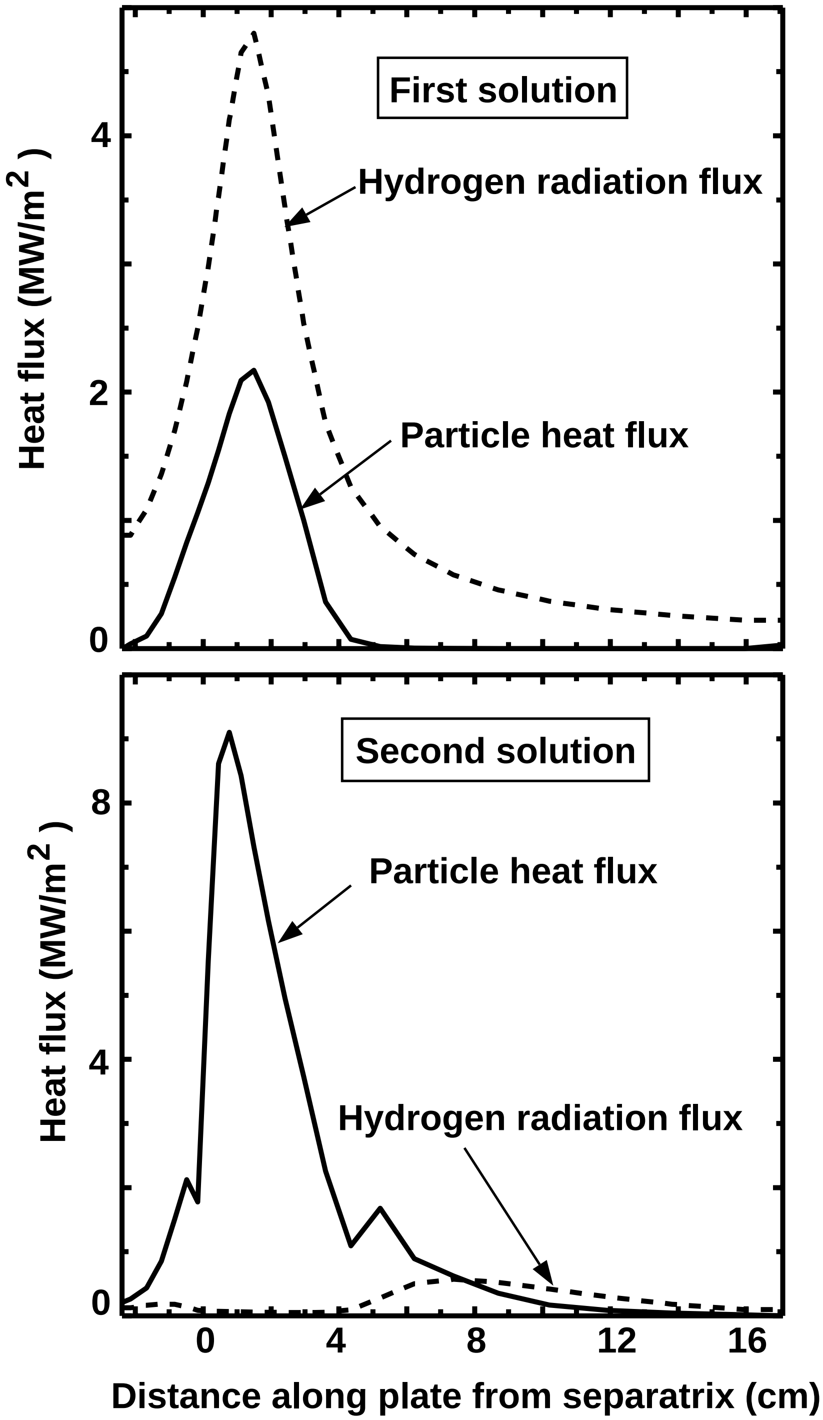




Two solutions appear for uniform radial diffusion coefficients

Largest difference is on inner plate, shown here for orthogonal divertor plate case

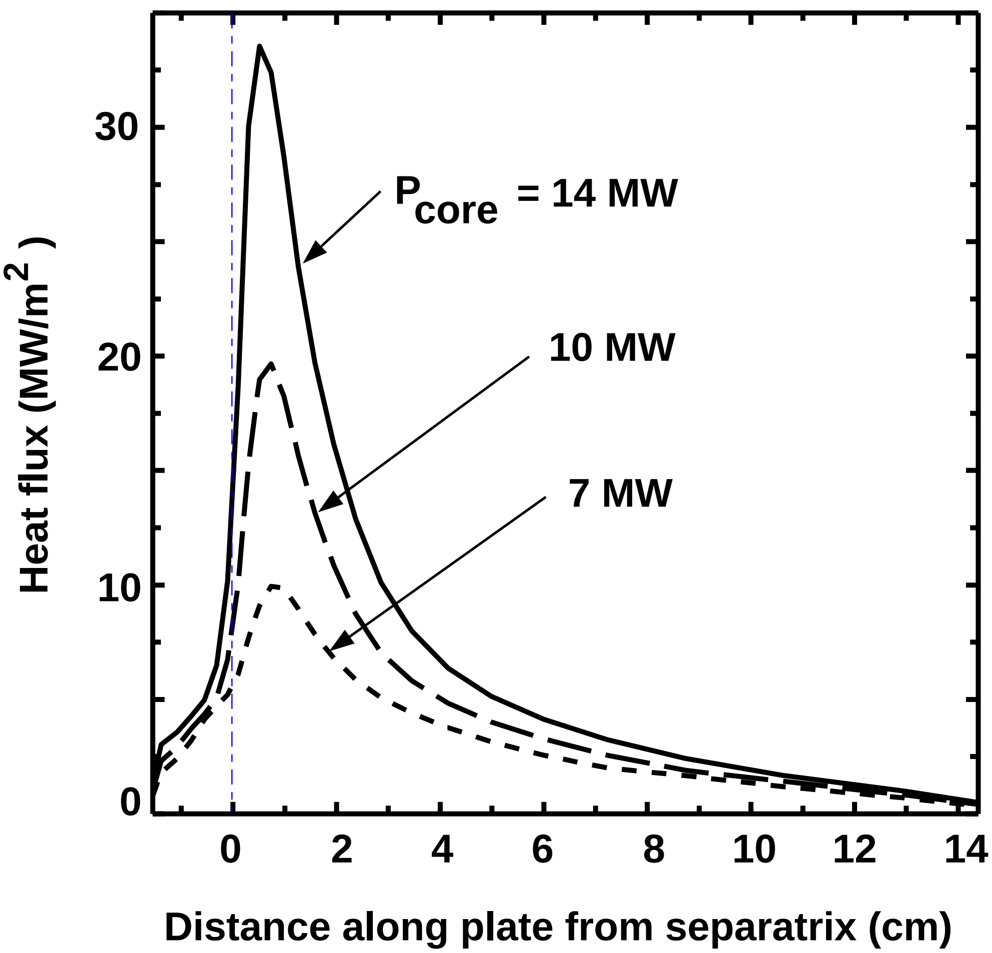
Caution: hydrogen radiation needs improved transport model



Peak plate heat-flux is sensitive to power flowing into the scrape-off layer

Power from core could be reduced by core-edge radiation

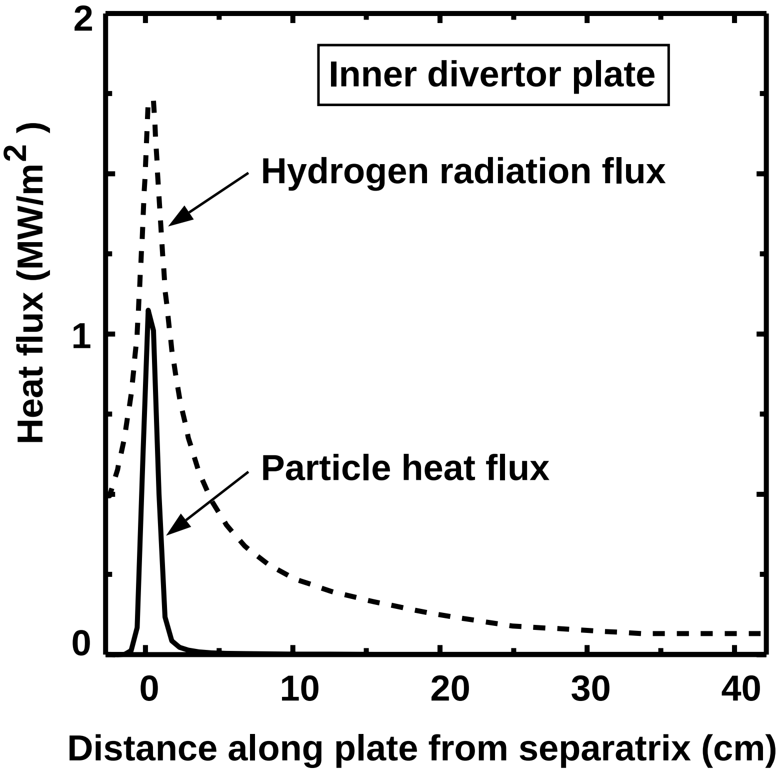
Outer-quadrant only - double powers for total

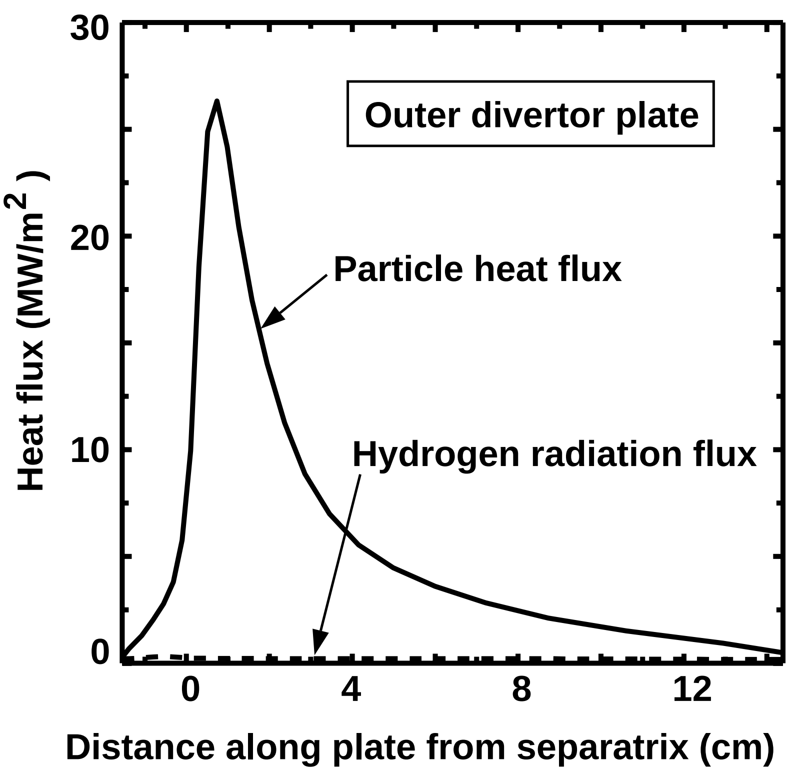


Heat flux for 10-fold reduction in inner D's and χ's decreases on inner plate

Nonorthogonal plate geometry
Second solution seems to disappear

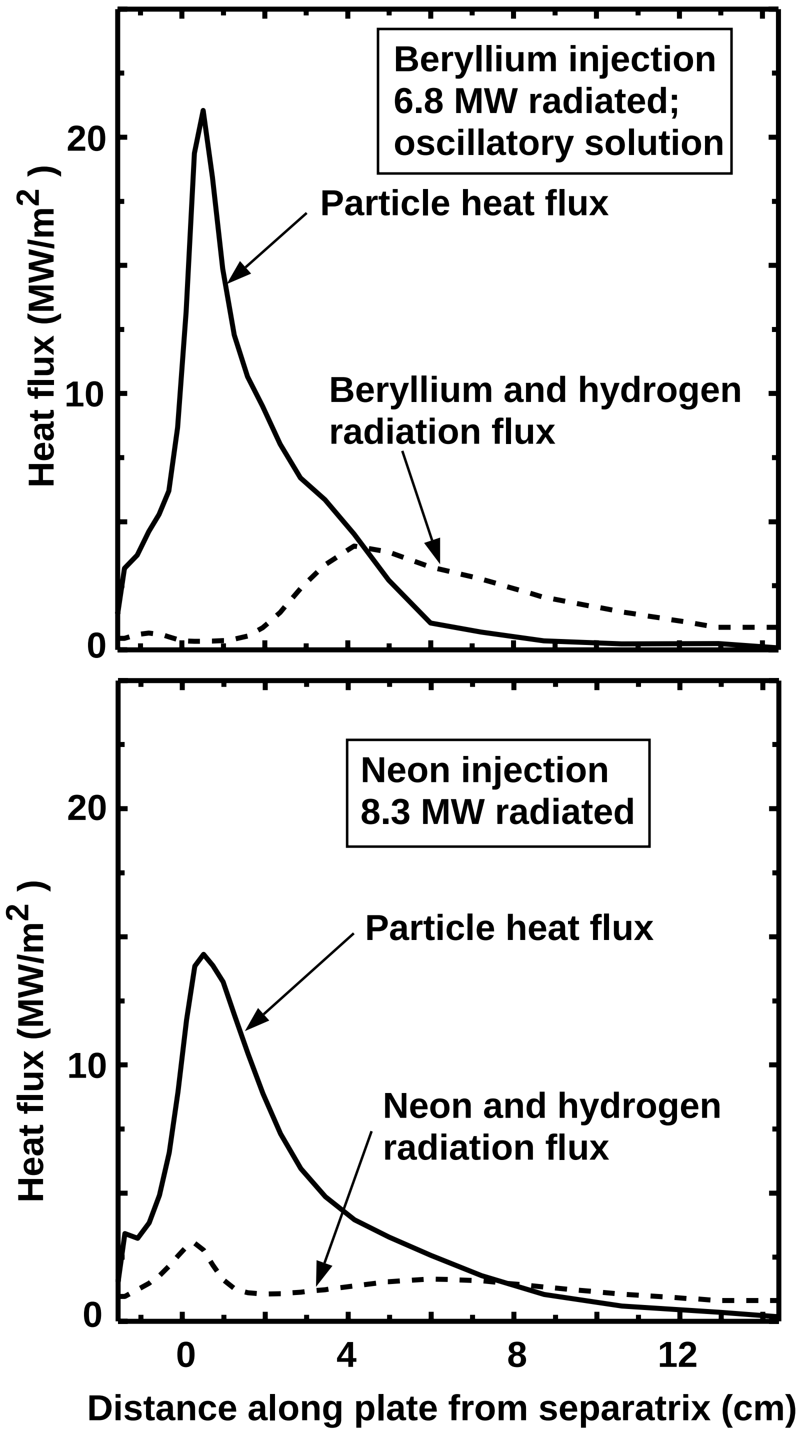
14 MW into lower half



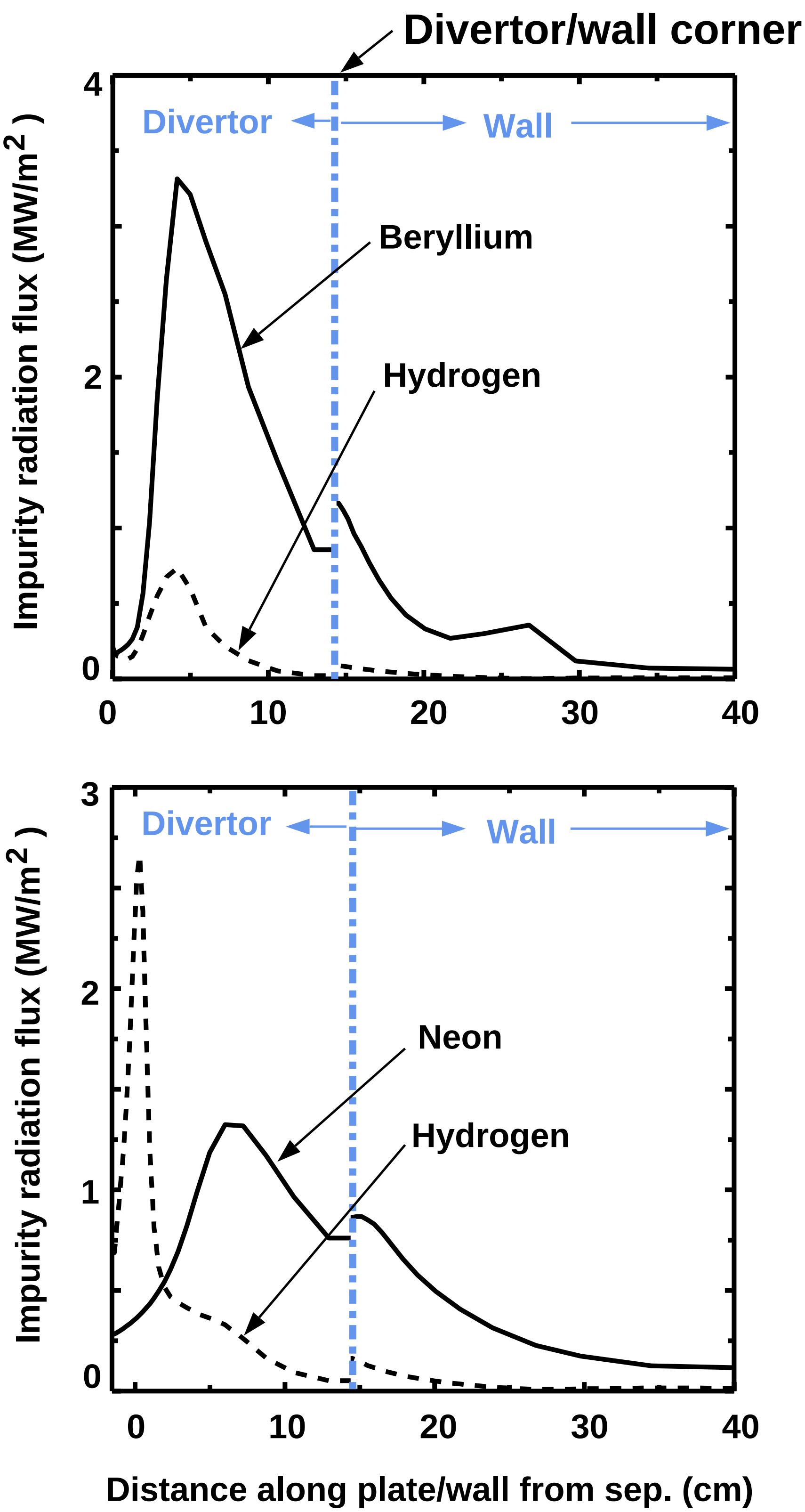


Neon injection gives somewhat broader heat flux reduction

Outer-quadrant simulation with 14 MW into SOL - (corresponds to 28 MW into whole outer SOL)



Combined divertor/wall radiation heat flux profiles show moderate flux in corner region



Summary

- A bifurcation affecting mainly the inner plate is found for spatially uniform anomalous diffusion
- The bifurcation disappears when the inboard diffusion is reduced relative to that outboard; turbulence simulations show this is a reasonable procedure
- The peak heat flux on the outer plate is reduced by either beryllium or neon injection, but behavior differs
- Beryllium solutions are oscillatory beyond a modest level; long-time changes may occur here
- Neon solutions are steady state; the radiation is not as localized to the plate region as for beryllium; neon would likely be easier to control
- Both Be and Ne give moderate power flux to the lower side wall of ~1 MW/m^2