Edge Model Results

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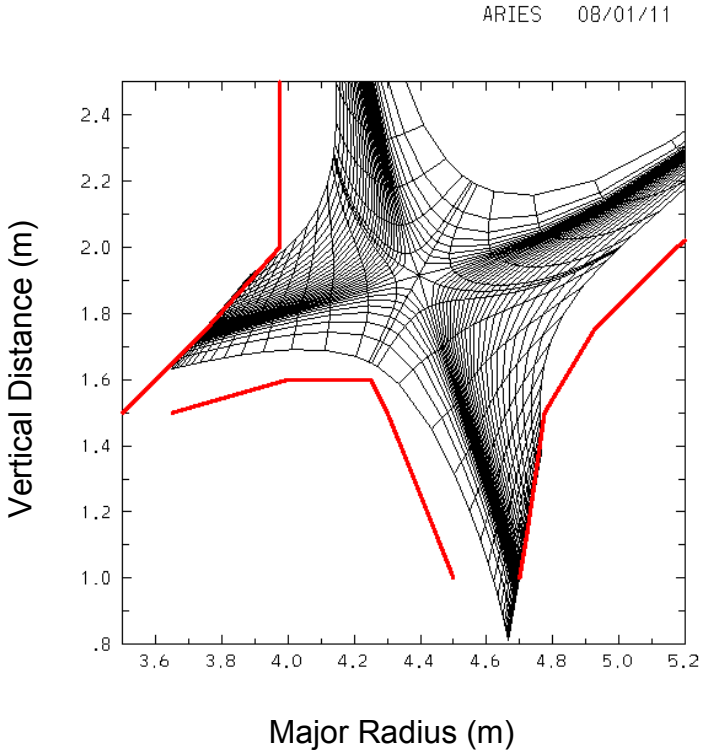
Topics covered in this presentation

- **Overview of techniques for reducing plate heat flux**
- **Details of Reference Case - attached plasma with strongly tilted divertor plates**
- **Details of Alternative Case - strongly radiating, detached plasma with orthogonal plates**
- **What model parameters can be varied to further reduce plate heat flux?**
- **Particle throughput and pumping details**

Overview of techniques for reducing peak heat flux on divertor plates

- Tilted plates increase the wetted area:
  - vary plate angles from orthogonal (90°) to strawman design configuration (25°)
- Impurity radiation:
  - core and mantle radiation reduces the plasma power into the SOL;
    simulations here do not explicitly model this radiation
  - divertor radiation distributes some of SOL plasma power to side walls;
    vary this by changing impurity concentration or gas puff current
- Detailed results for two cases illustrate these techniques using ACT-I strawman parameters for input

Reference Case: strongly tilted plates, attached plasma



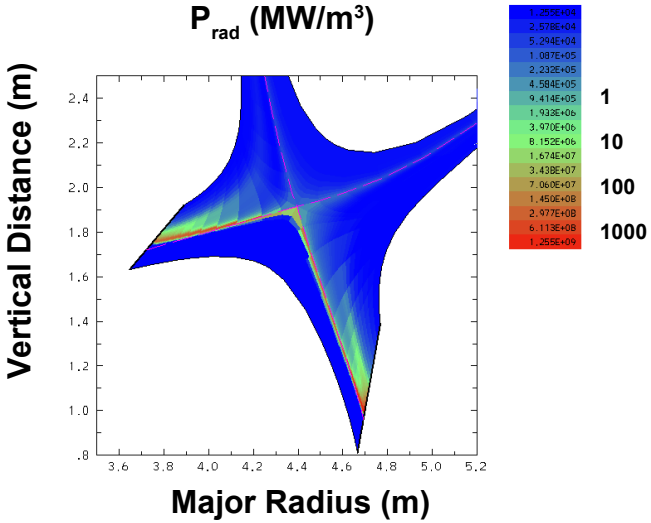
- Plate configuration conforms to strawman I
- pedestal density is 1.0 x 10^{20} m^{-3}
- P_{SOL} = 160 MW (lower half of double-null)
- neon impurity concentration 0.58 %

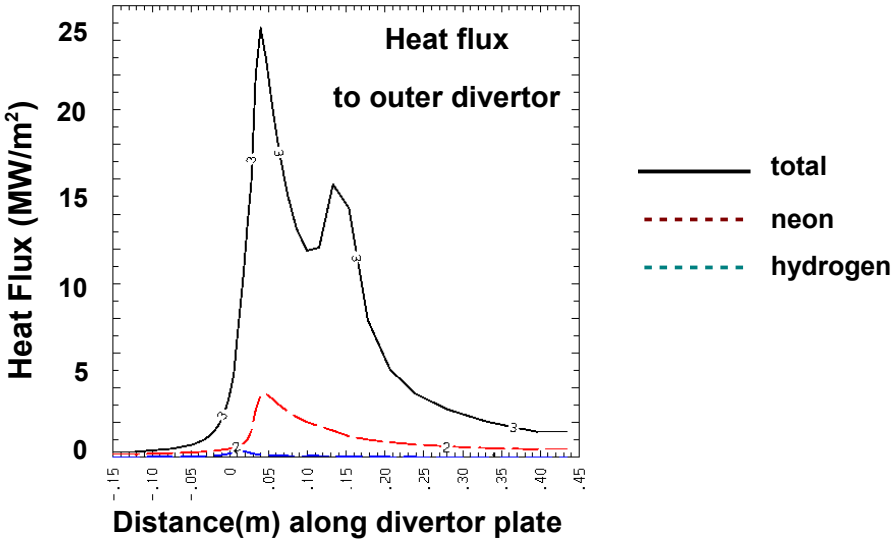
(limited by transition to non-steady state?)

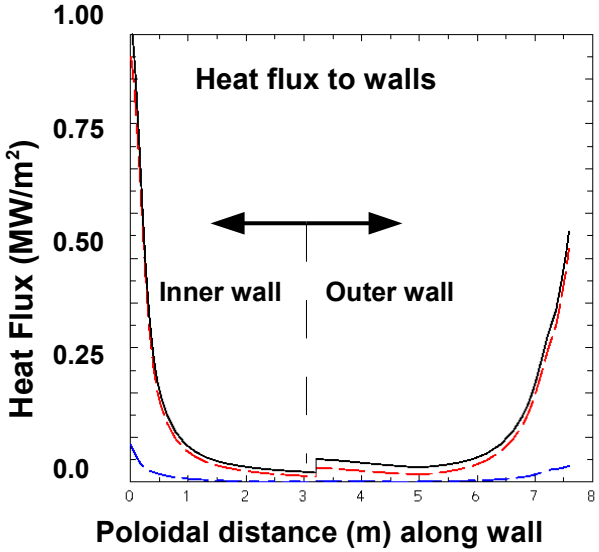
- total impurity radiation is 65 MW
- peak heat flux on divertor plates is 25 MW/m^2 (unacceptable);

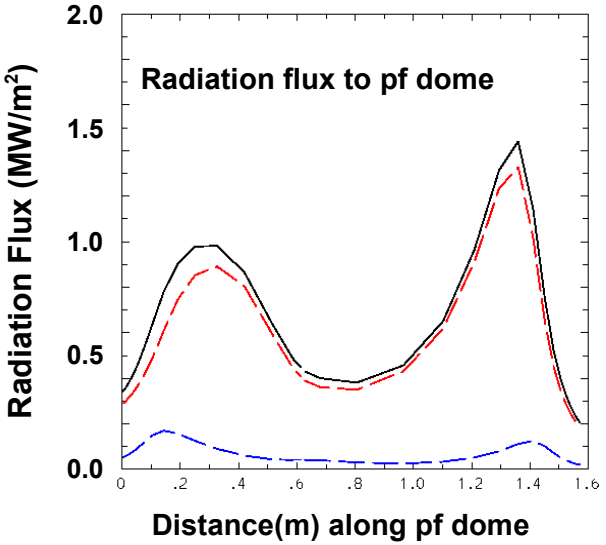
  peak heat flux on walls and pf dome is < 2 MW/m^2

Reference Case: strongly tilted plates, attached plasma (cont'd)



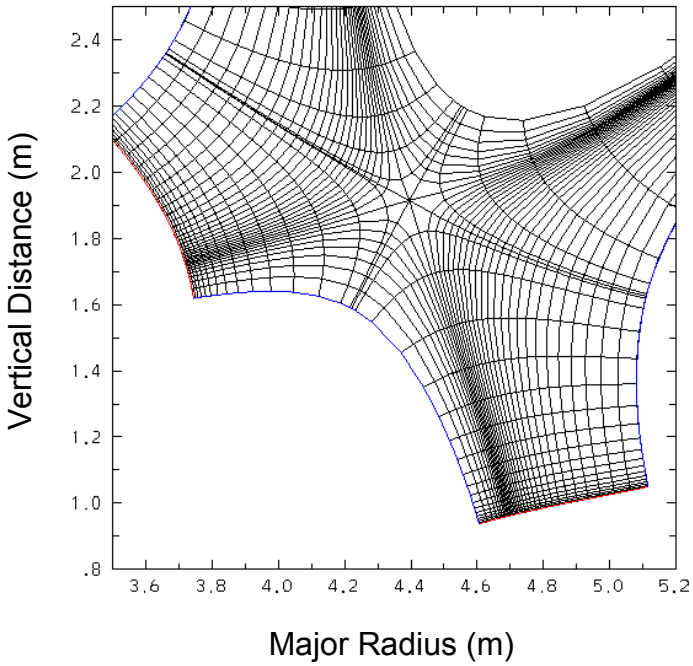




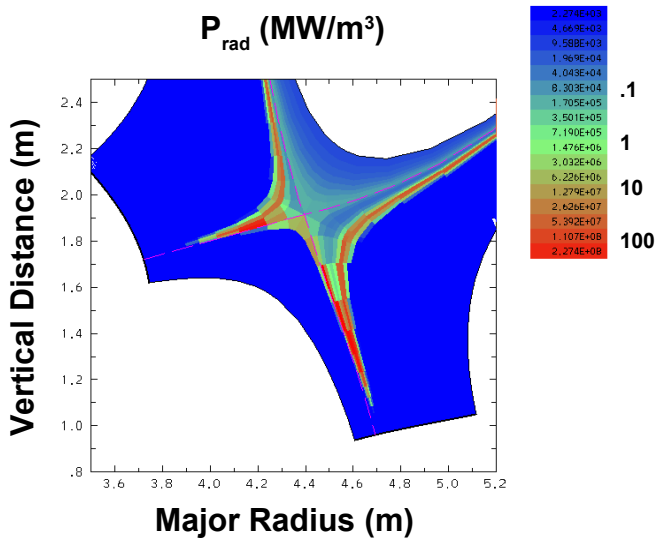


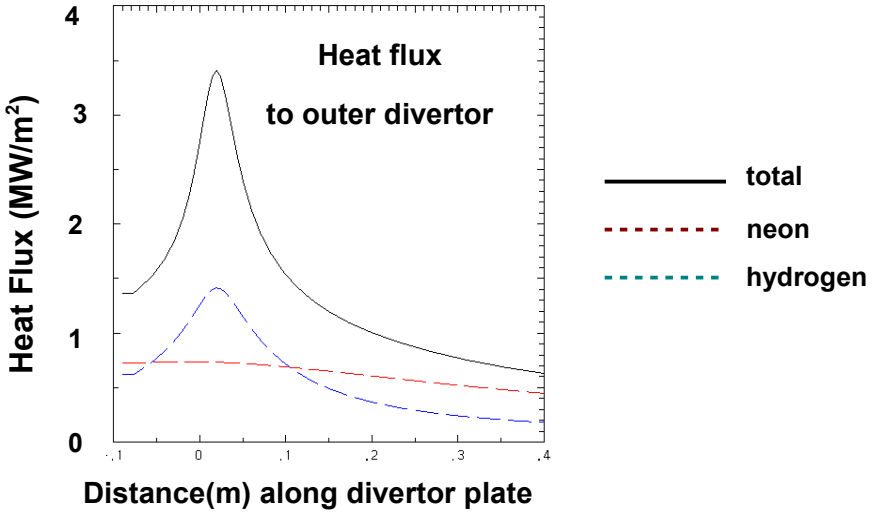
Alternative Case: orthogonal plates, detached plasma

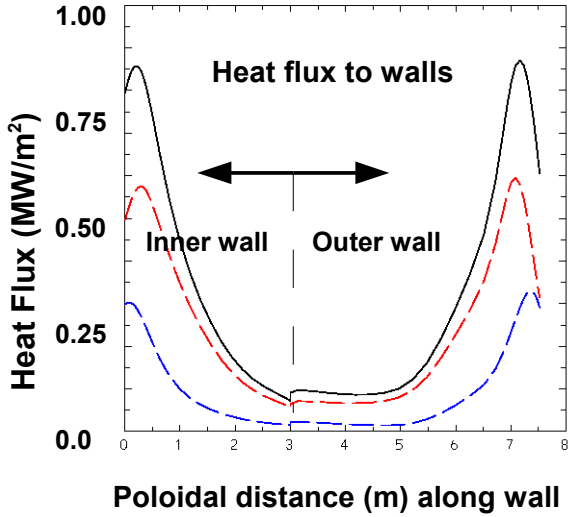
- pedestal density is 1.0 x 10^{20} m^{-3}
- P_{SOL} = 160 MW (lower half of double-null)
- neon impurity concentration 0.4 %
  (limited by transition to core MARFE)
- peak heat flux on outer plate is 3.5 MW/m^2
- total impurity radiation is 103 MW;
  peak heat flux on walls and pf dome is < 2 MW/m^2
- gas density in divertor is very high (~10^{22} m^{-3})

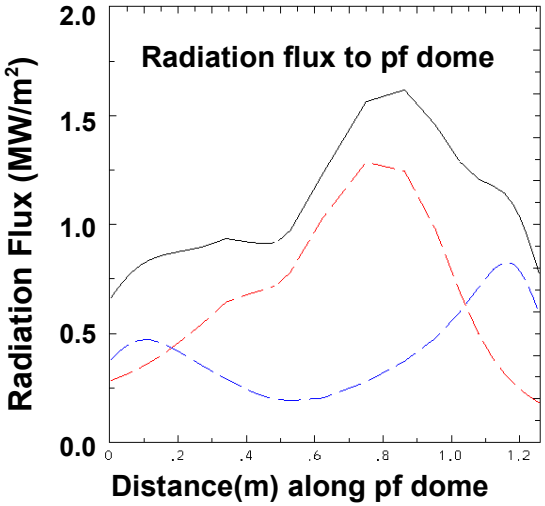


Alternative Case: orthogonal plates, detached plasma (cont'd)









Variations on reference case can yield improvements

What strawman parameters would we change?

- **P_{SOL} (core and mantle radiation)**

  P_{SOL} = 160 → 120 MW yields Q_{peak} = 37 → 27 MW/m^2

- **n_{ped} (pedestal density)**

  n_{ped} = 1.0x10^{20} → 1.2x10^{20} m^{-3} yields Q_{peak} = 37 → 30 MW/m^2

- **plate tilt angles**

Other edge model parameters that might be significant:

- **impurity species (Ne, Ar, Kr, Xe)**

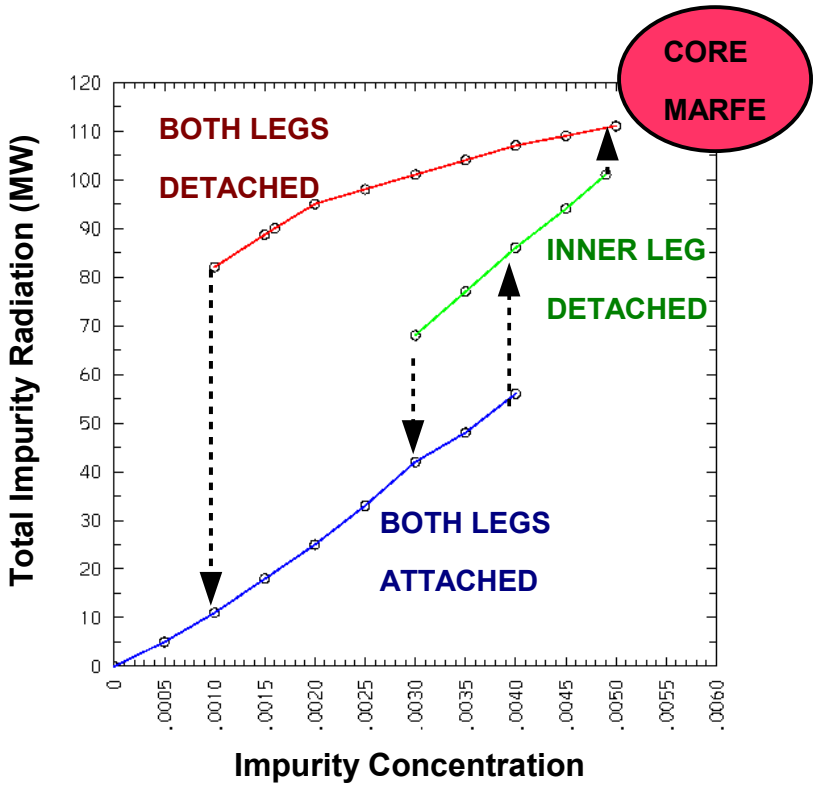
  Neon (0.40 %) → Argon (0.12 %) yields Q_{peak} = 37 → 29 MW/m^2

- **D, X_e, X_i radial transport diffusivities (presently use ITER-like)**
- **gas puffing and pumping (plate vs pf dome location)**
- **mesh refinement**
- **impurity model (fixed-concentration vs multi-charge)**

Note: There may be multiple plasma solutions for any set of input parameters.

There are multiple plasma states for the same set of inputs

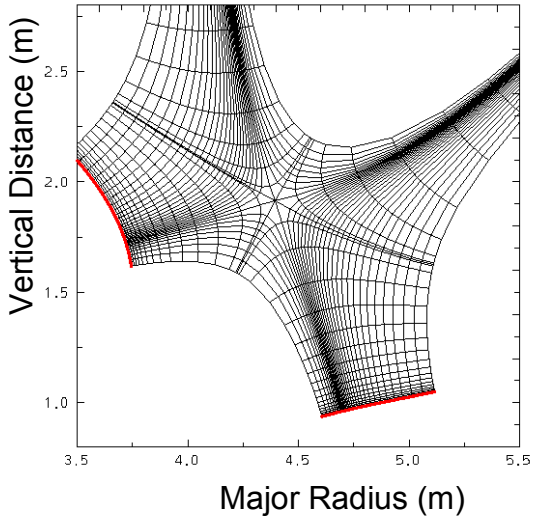
- Uniform concentration (Neon)
- Orthogonal divertor plates
- Pedestal density 1.5×10^{20} m^{-3}
- Power from pedestal 160 MW (lower half of double null)



Particle Throughput and Pumping Details

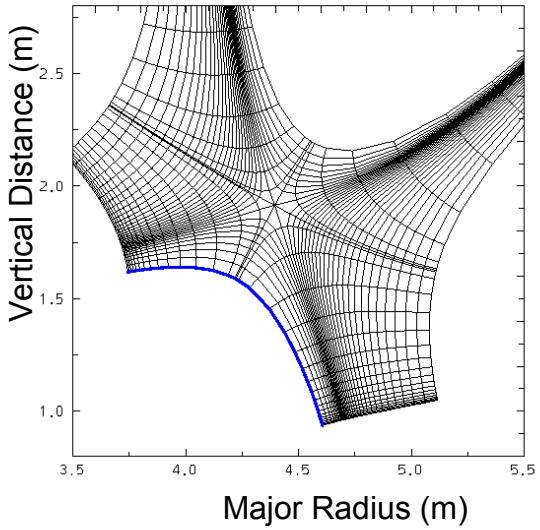
Hydrogen ions pumped at divertor plates

R_p = 0.99



Hydrogen neutrals pumped at pf dome

A_{pf} = 0.9999



Throughput varies significantly with detachment:

both legs attached:	I_{core} = 24.4 kA
inner detached;outer attached:	I_{core} = 20.1 kA
both divertor legs detached:	I_{core} = 1.6 kA

Unanwered Questions

- For a strongly radiating detached plasma with orthogonal plates:

  Why doesn't the plasma easily reach a steady state when the plates are tilted more strongly?

- For a weakly radiating plasma with strongly tilted plates:

  Why doesn't the plasma easily reach a steady state when the impurity concentration is increased?

Summary

- **Reference Case**
  - Plate configuration consistent with strawman
  - Weak divertor radiation leads to high plate heat flux
- **Alternative Case**
  - Orthogonal divertor plates
  - Strongly radiating detached plasma
  - High edge density
- **Variations on Reference Case could yield acceptable solution**
- **It is difficult to access strongly radiating detached plasma states**
  - Multiple plasma states for some input parameters
  - May require complex startup procedure
- **Particle throughput is significantly lower for detached plasmas**