Edge plasma model results and issues for the ACT-1 divertor*

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Overview of edge/divertor plasma modeling for ARIES

- In April, Marv Rensink showed results from the single-null ARIES-RS configuration and a few double-null ARIES-AT results
- Here, we shift to ACT-1 double-null edge plasma modeling results including geometry and impurity injection

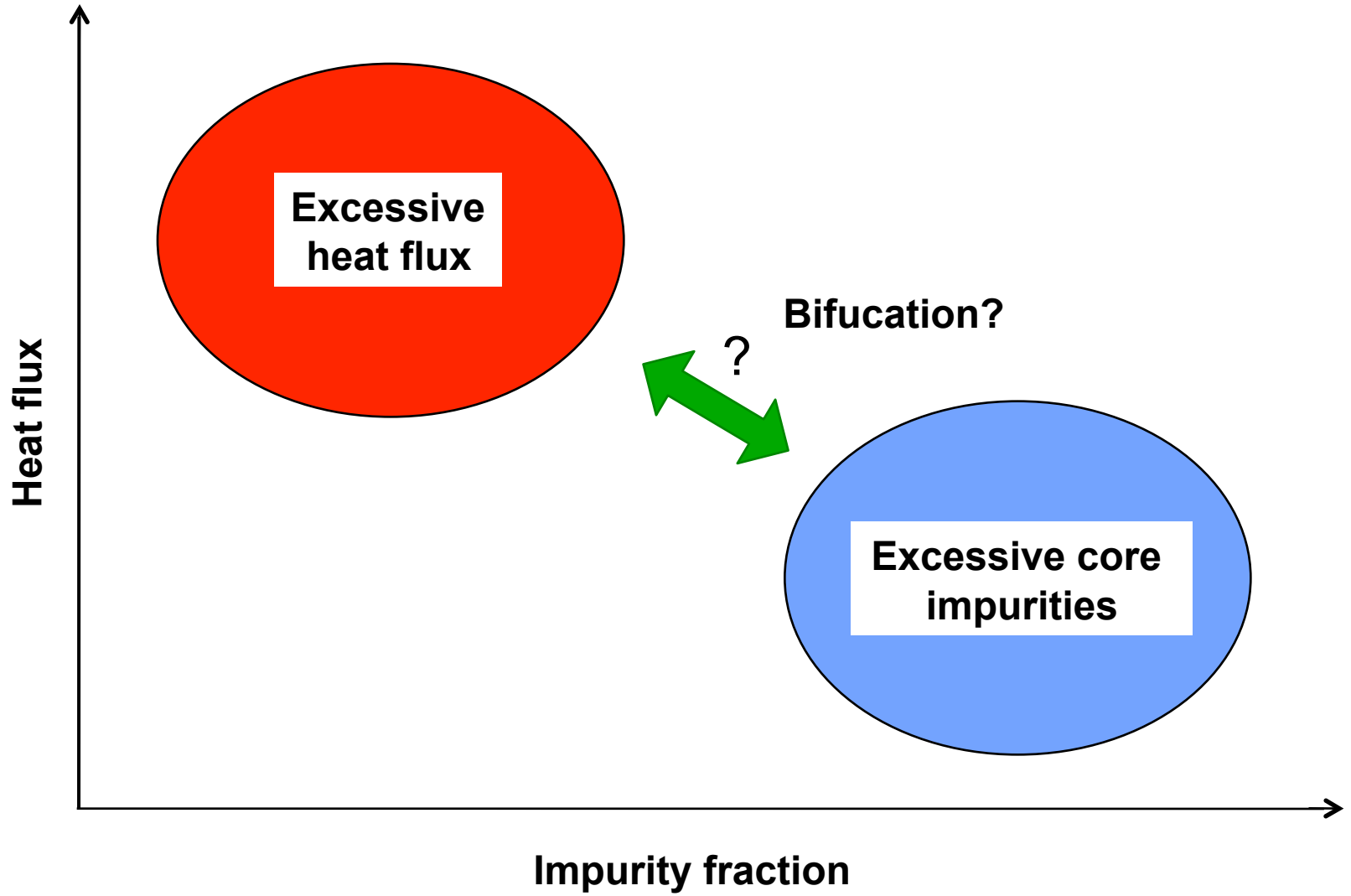
Outline

1. **ACT-1 heat loads without strong impurity radiation**
   - orthogonal divertor plates
   - tilted plates
   - approximate ACT-1 multi-plate divertor

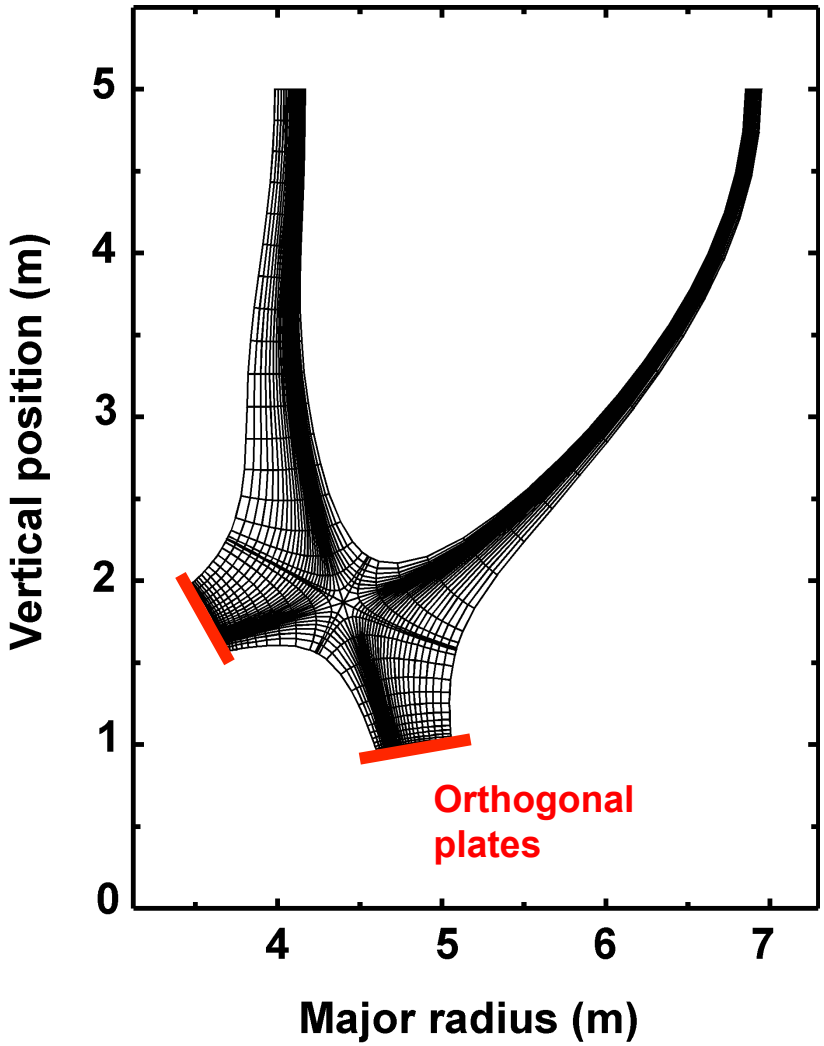
2. **Pedestal plasma model control via transport barrier**

3. **ACT-1 high-density radiative neon divertor solutions**
   - orthogonal divertor plates
   - tilted divertor plates

We gave been able to establish two limits, but need to find the middle ground

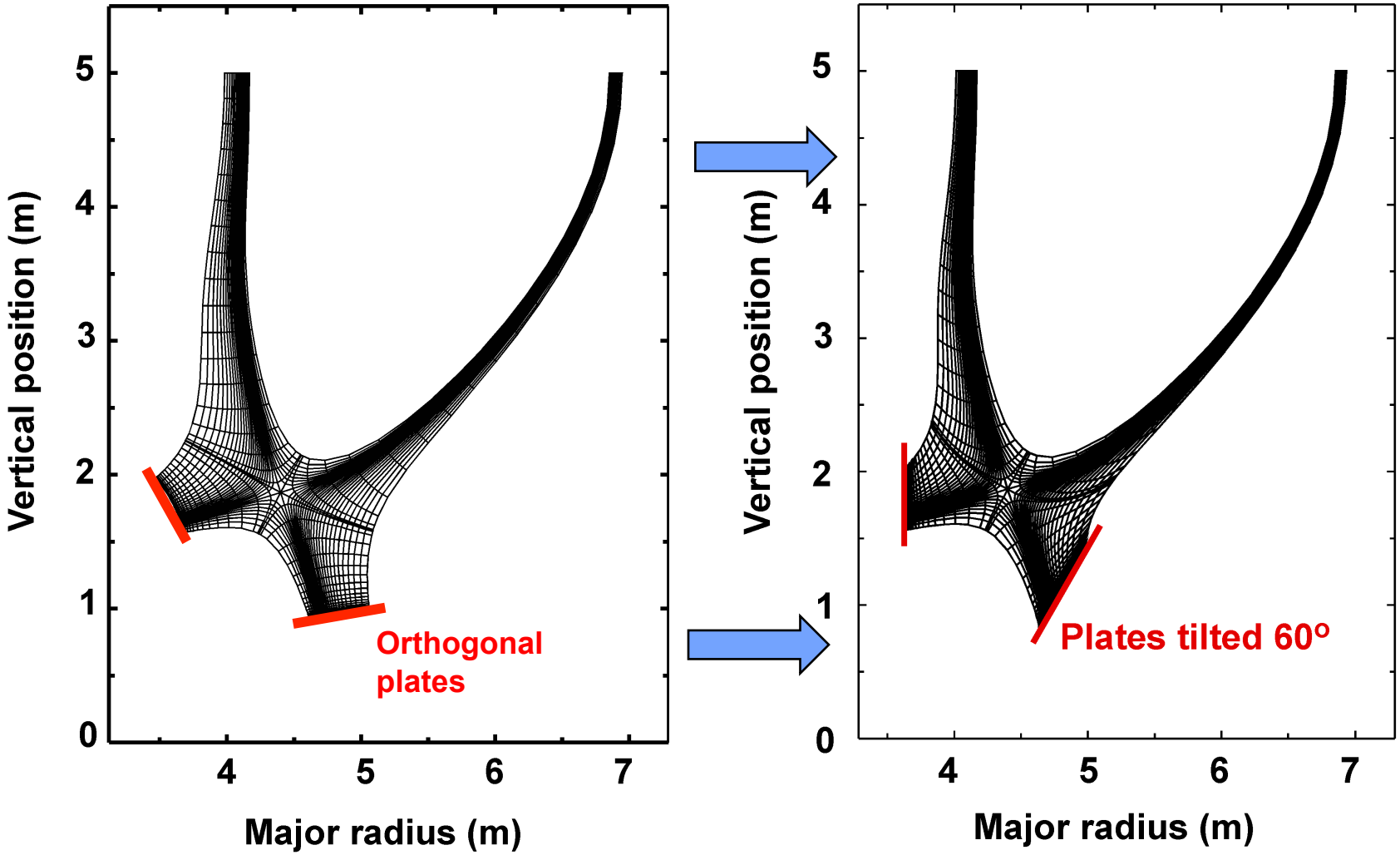


ACT-1 geometry (simple divertor) and parameters

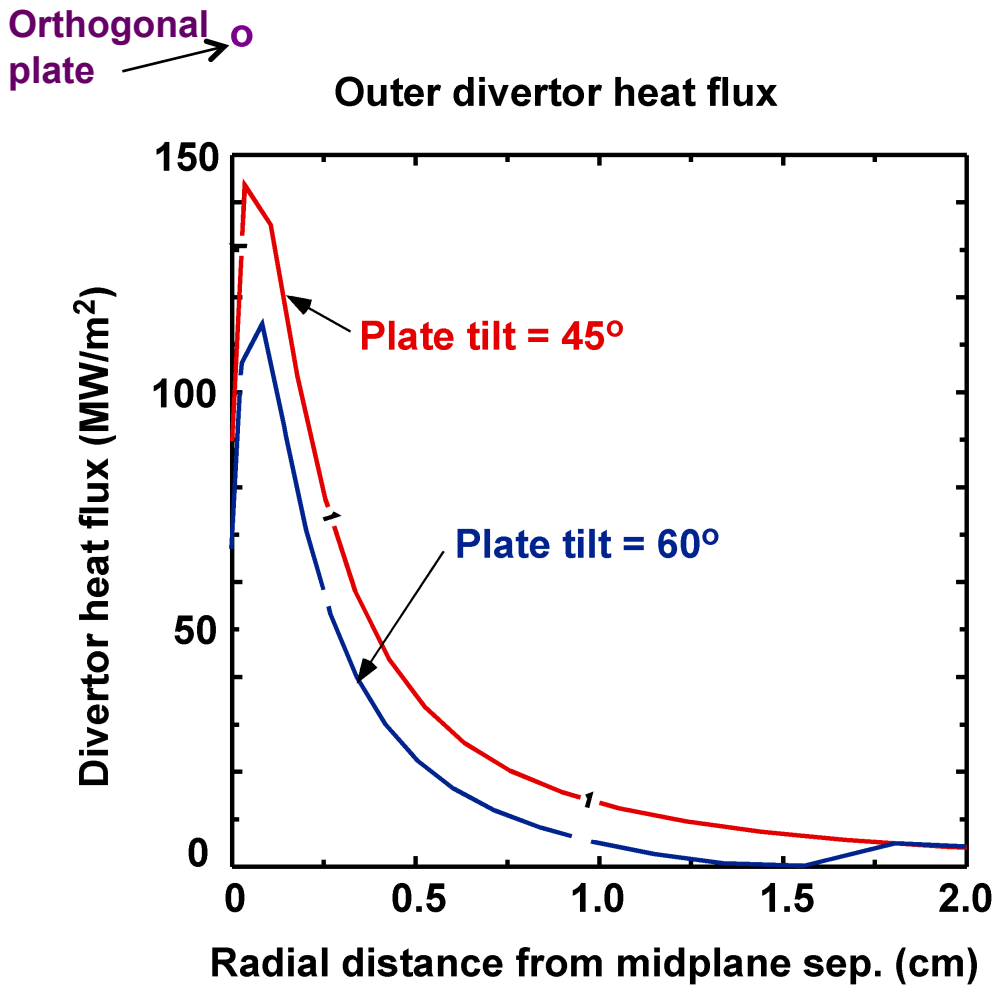


- **Magnetic equilibrium from Kessel**
- **Symmetric double null**
- **Power from pedestal**
  ~400 MW
- **Pedestal density**
  1-3x10^{20} m^{-3} ($n_{GW} \approx 2x10^{20}$)
- **Radial transport coeff. (ITER-like)**
  D = 0.33 m^2/s
  $\chi_{e,i}$ = 0.5 m^2/s

Tilting divertor plates for reduced heat flux



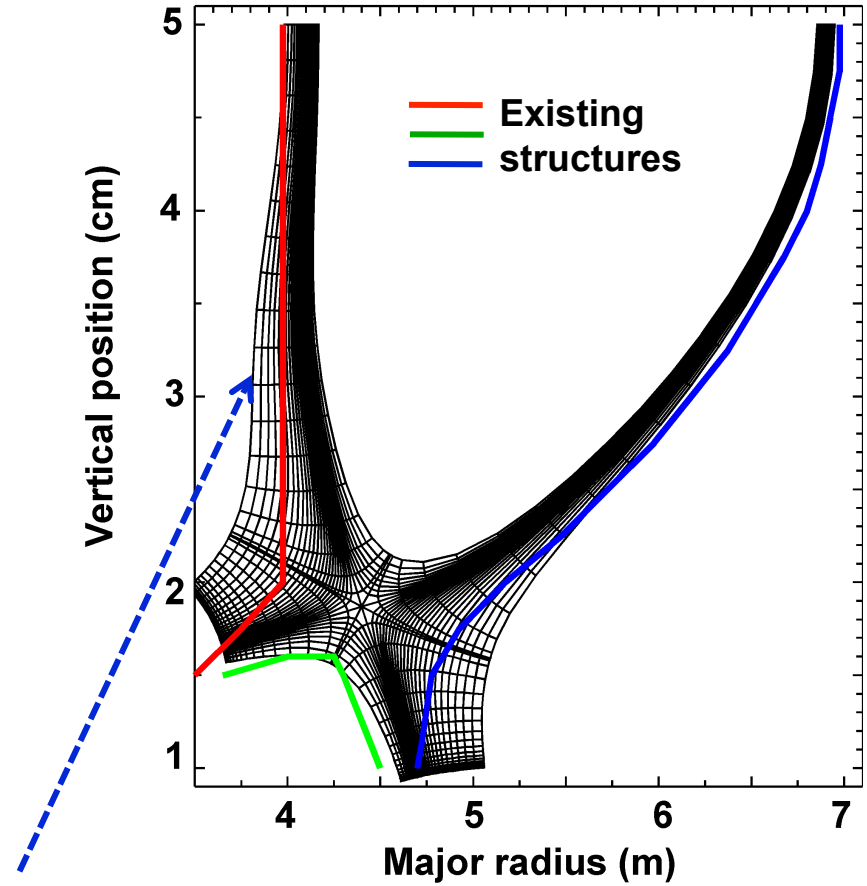
Without any impurity radiation, heat flux is much too large



- **Total power input to SOL**
  320 MW
- **Power split to divertors**
  2 outer divertors ~ 75%
  2 inner divertors ~ 25%
- **Inner divertors are not very effective for sharing power & turbulence asymmetry will make imbalance larger**

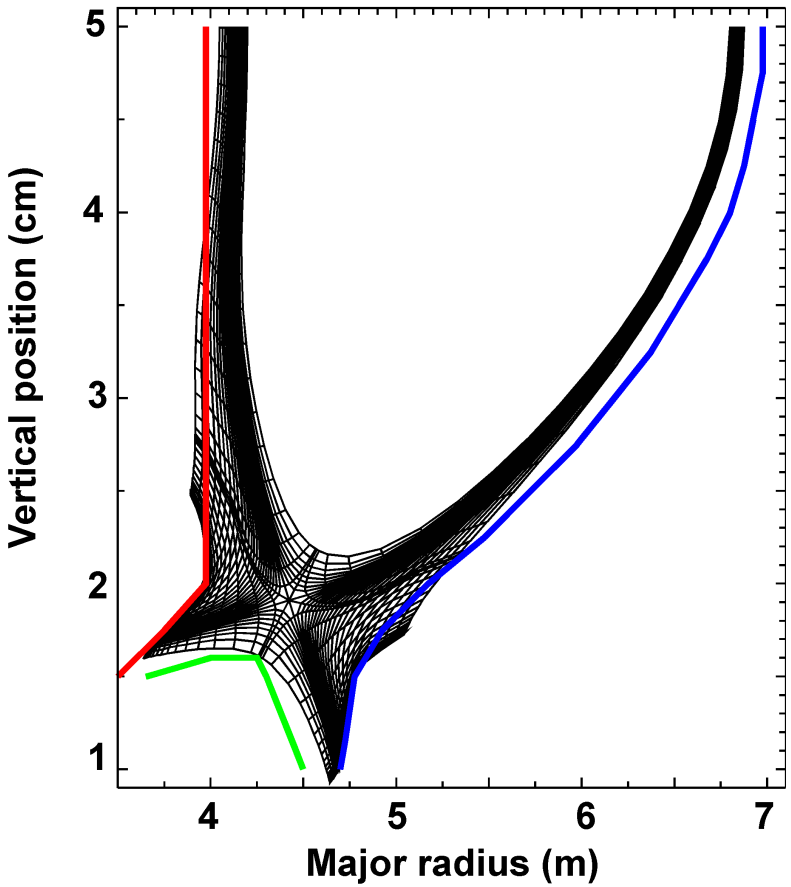
Using existing divertor structure has been approximated in UEDGE

Original mesh with divertor/wall structures



The "Kessel" bulge

Modified mesh with divertor/wall structures



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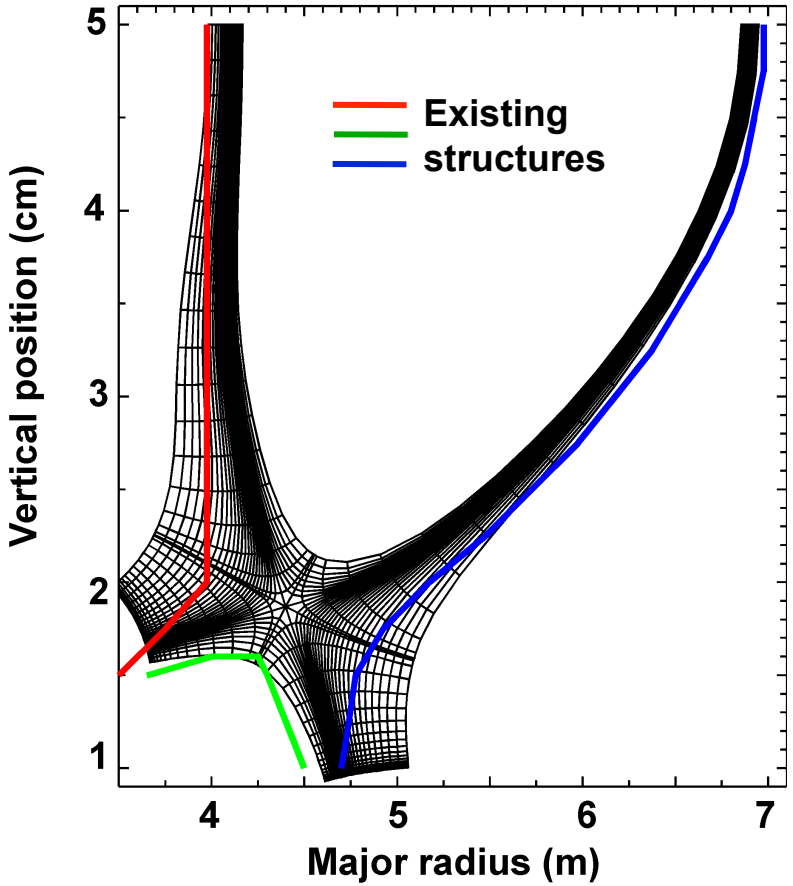

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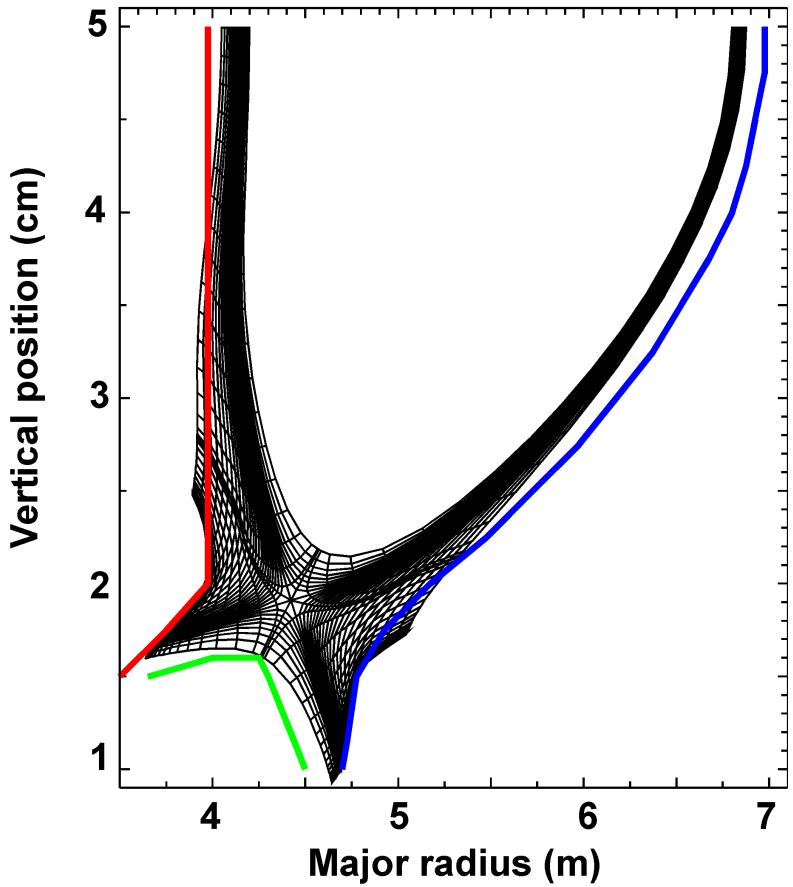
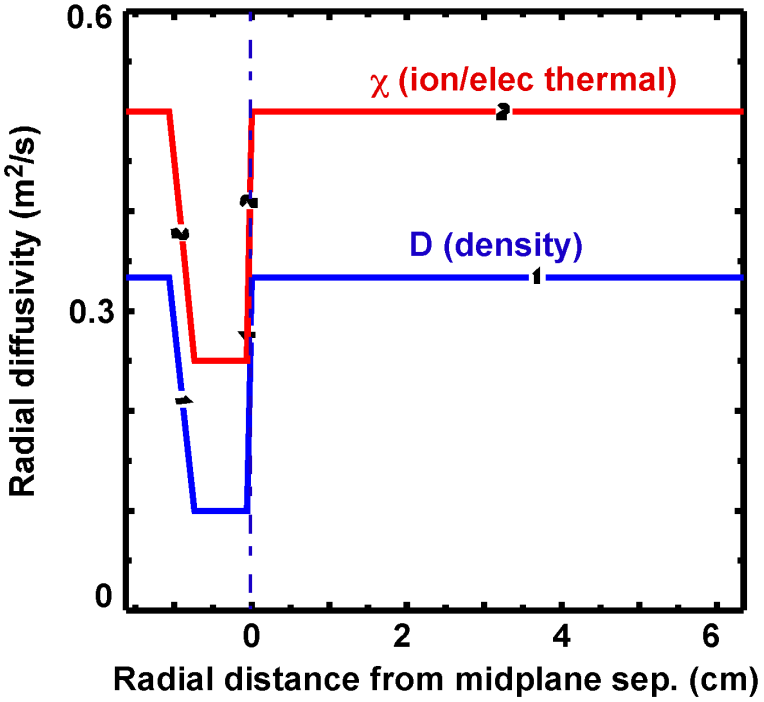
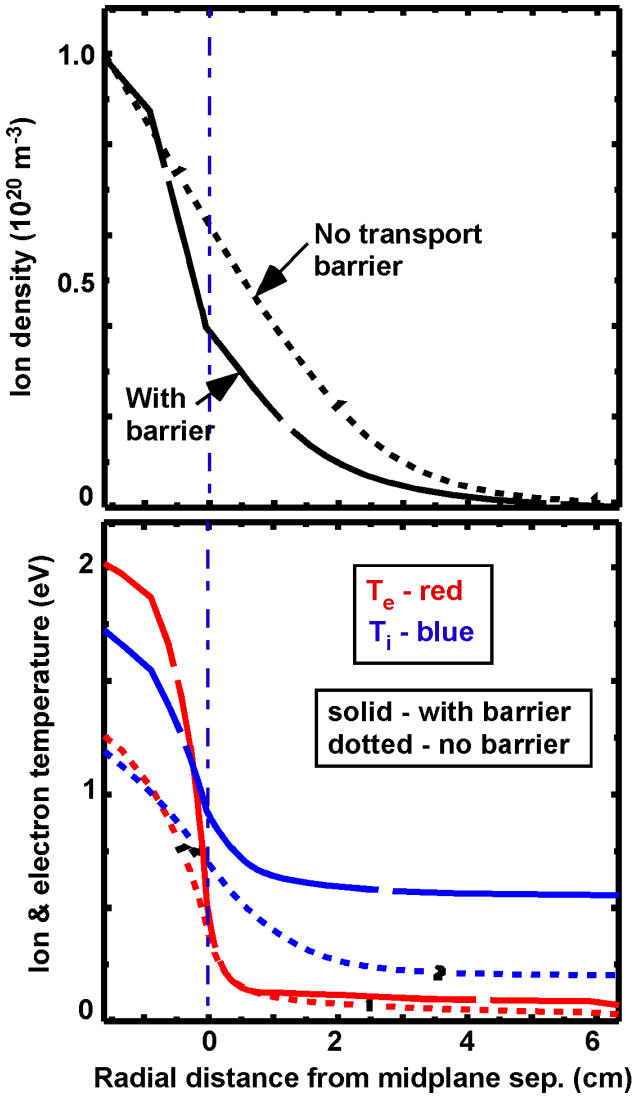
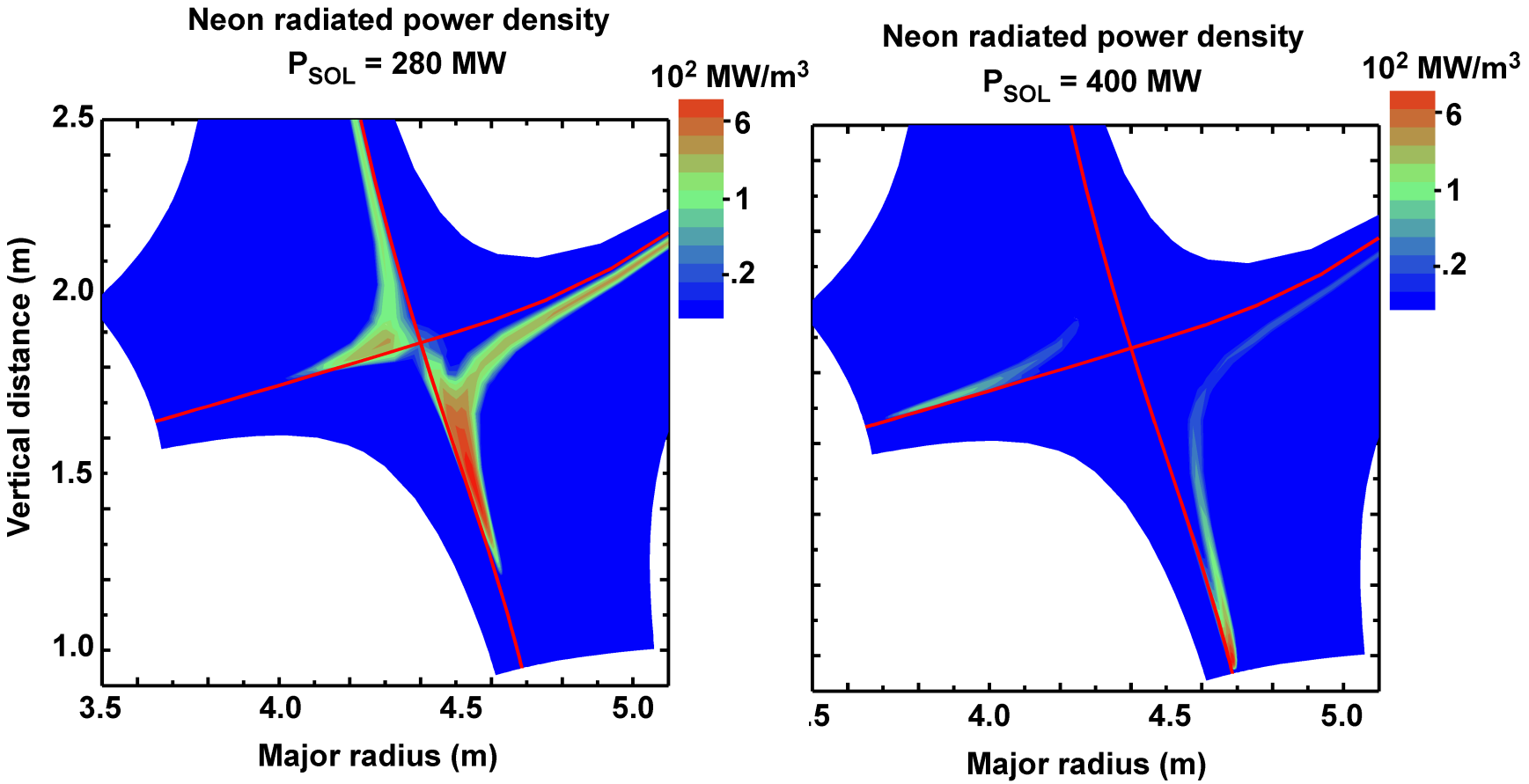


Transport barrier just inside separatrix regulates the pedestal plasma

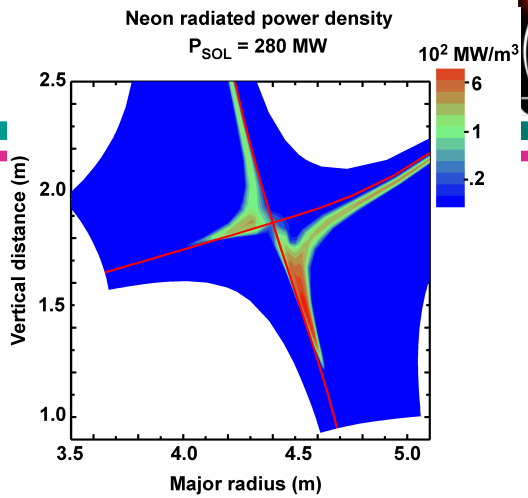


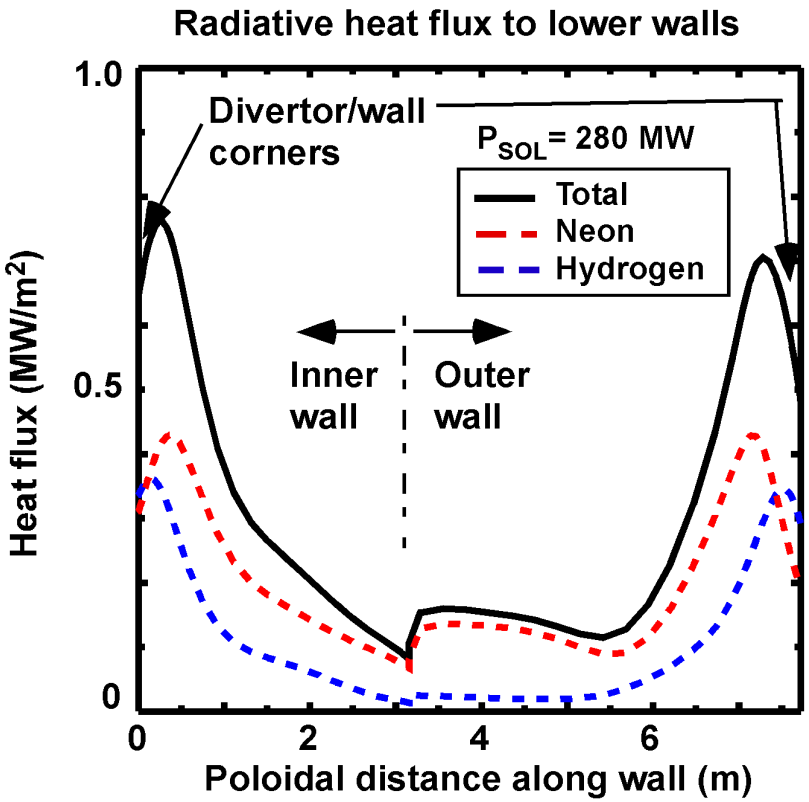


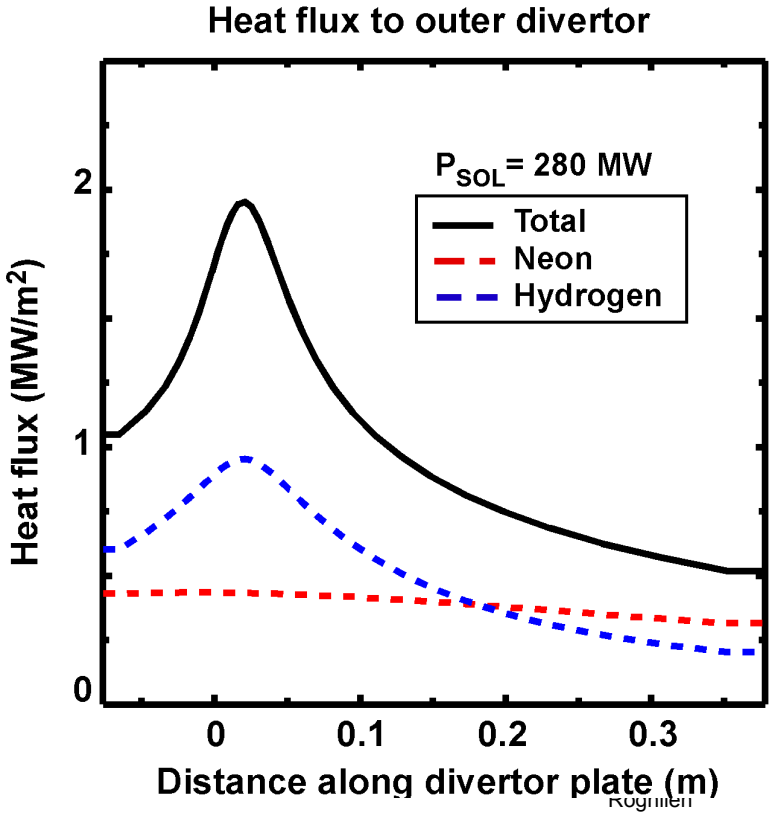
Shifting to the high density, neon impurity cases; a range of acceptable radiating SOL cases



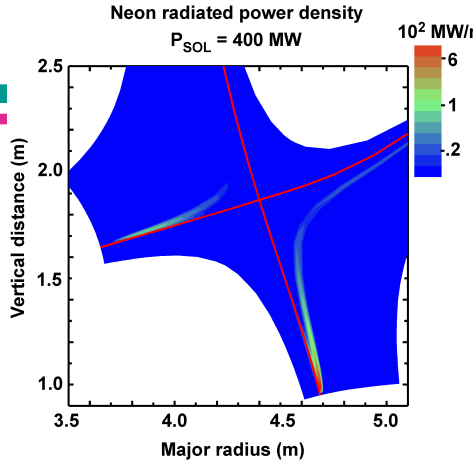
A 280 MW case shows acceptable heat loads

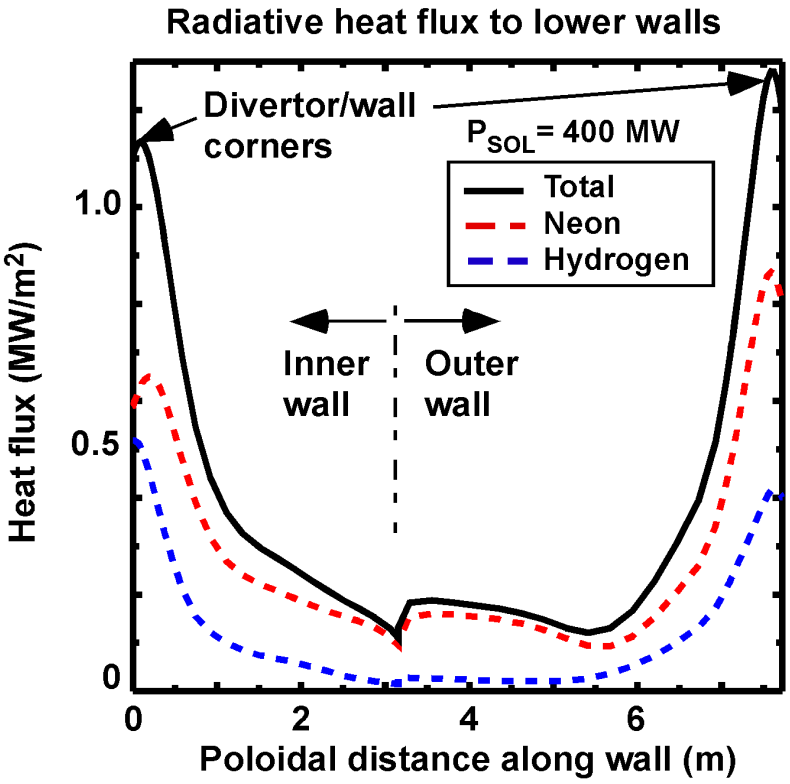


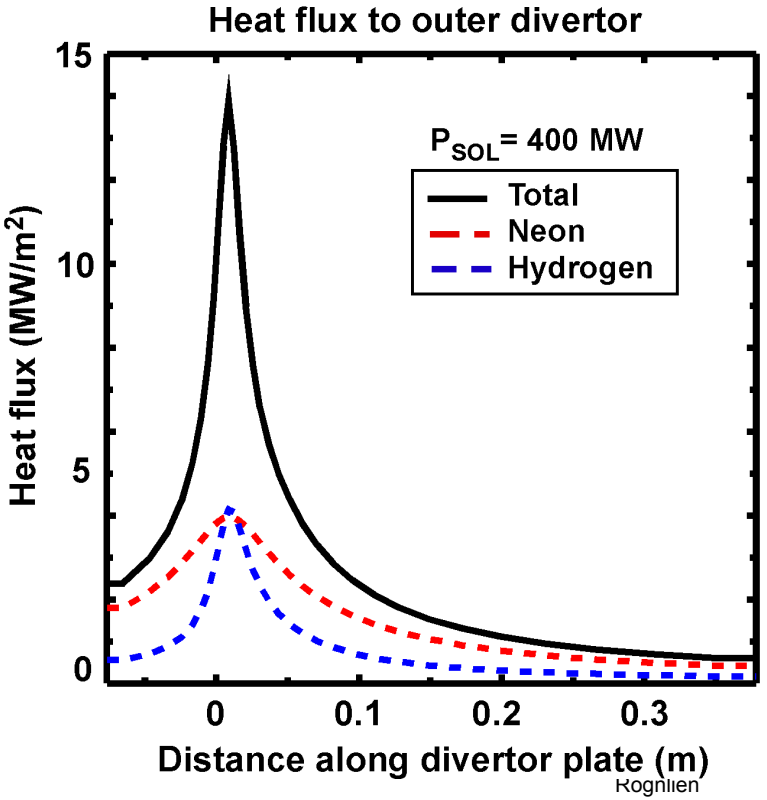




Corresponding 400 MW case is modestly over 10 MW/m^2 limit

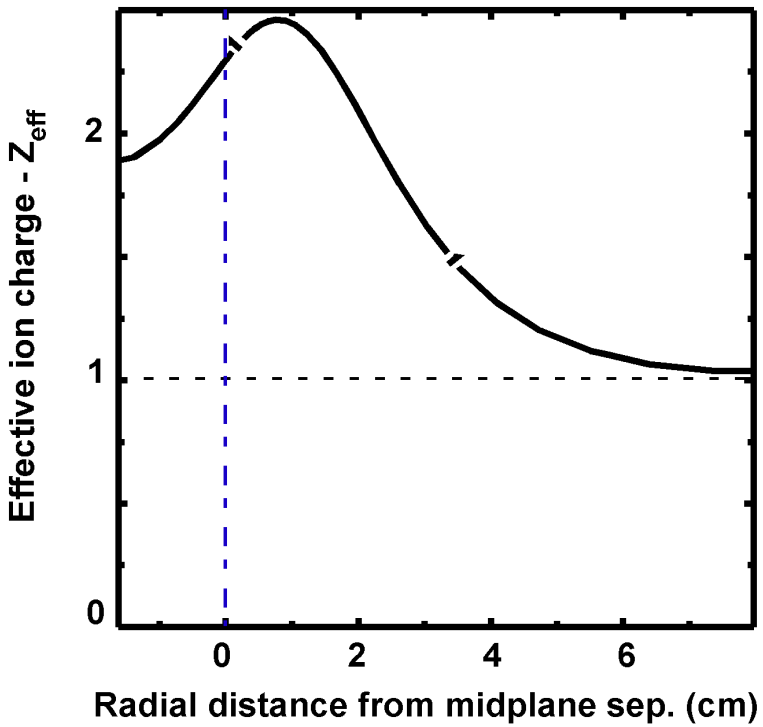




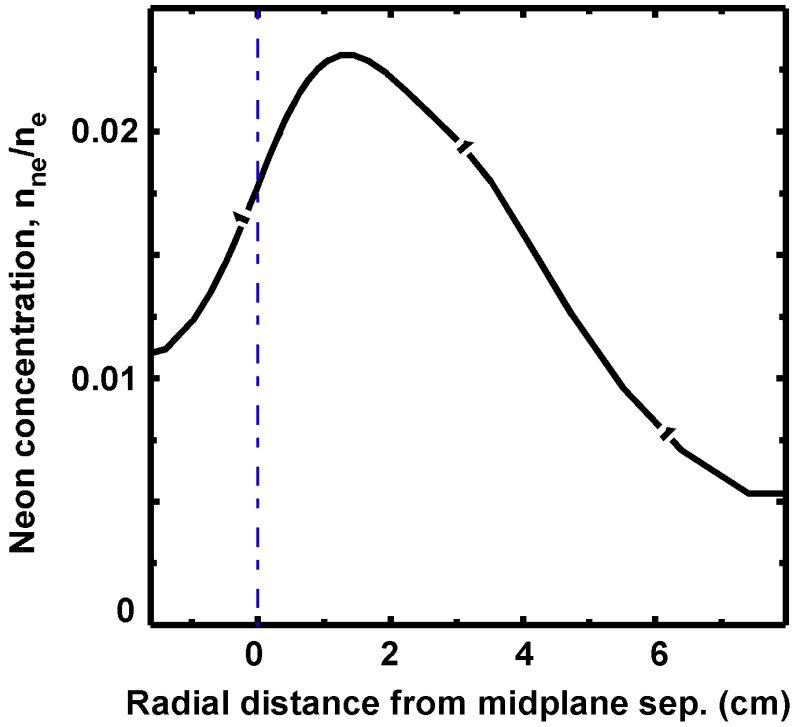


Neon impurity for sufficient SOL power loss results in significant core concentration

Z_{eff} profile for 400 MW case



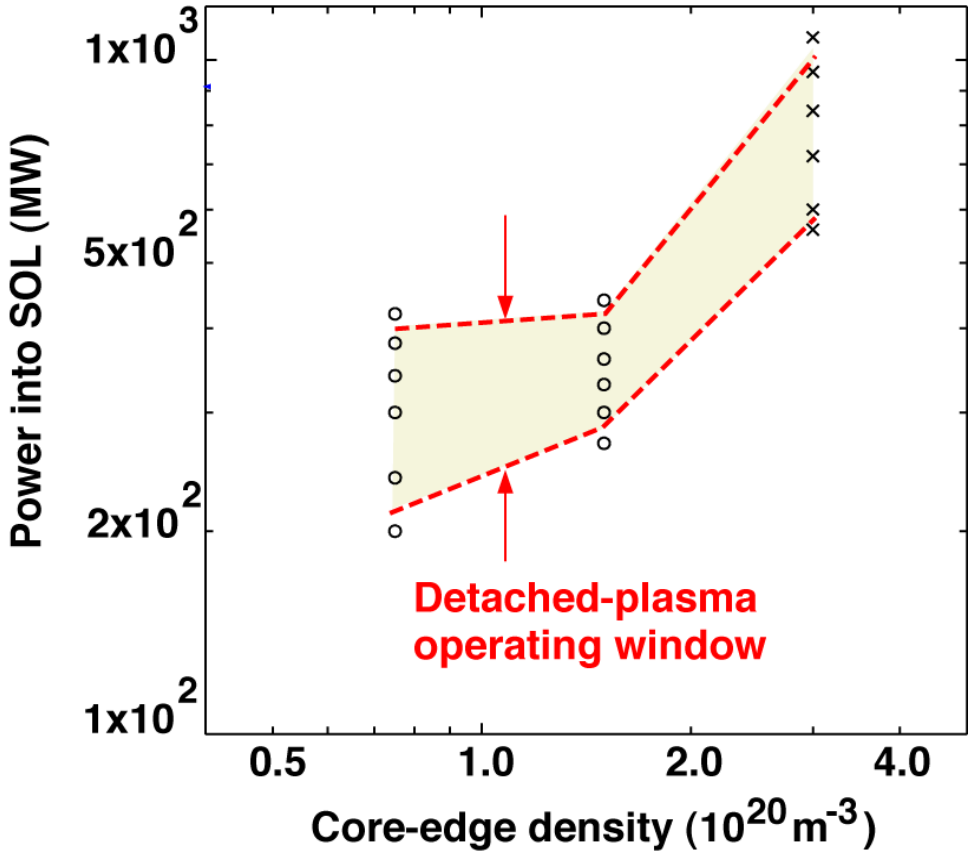
Neon concentration



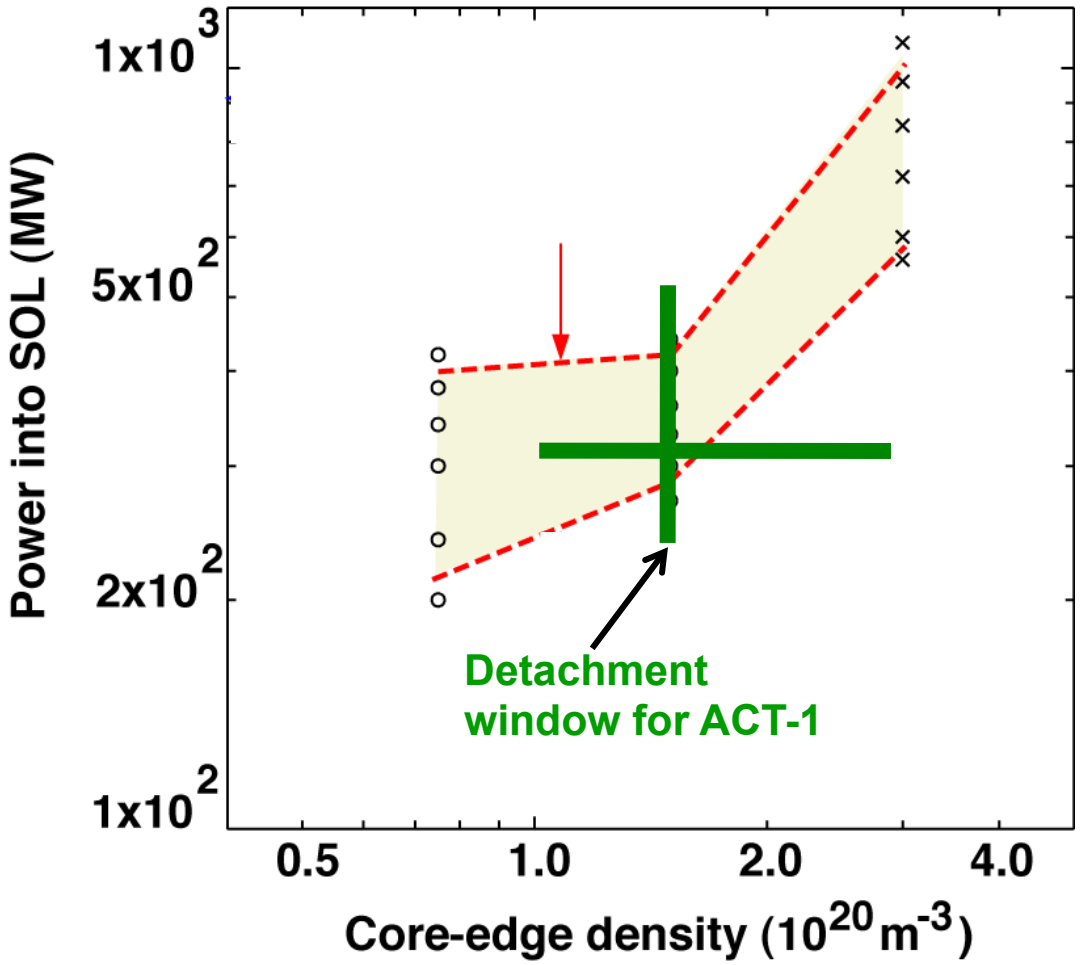
Core impurity concentrations are substantially larger for double-null cases than previous single-null (ARIES-RS) cases; edge flows are different

Previous results for single-null ARIES-RS showed a wide operating window

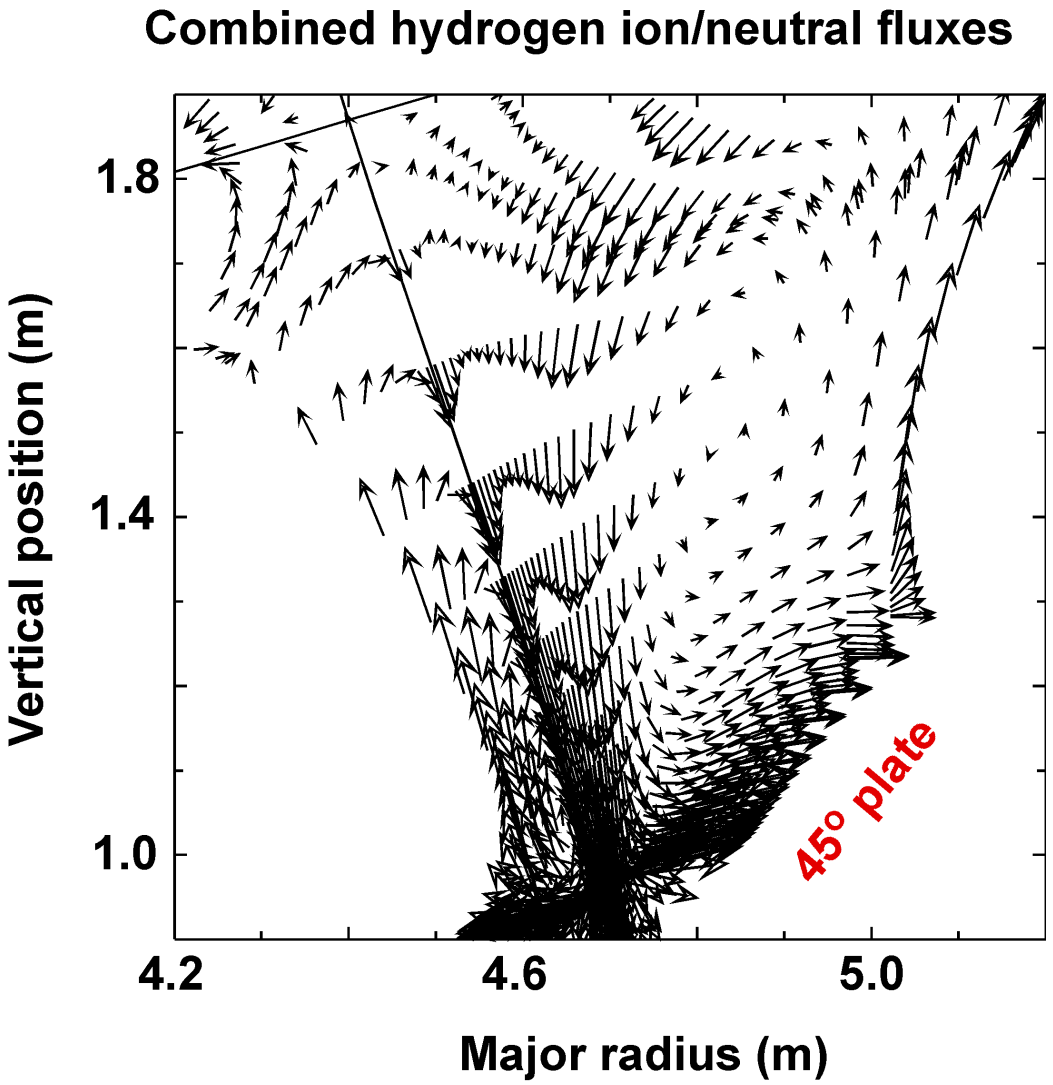
- **Radiating plasma prefer high density owing to $P_{rad} \sim n_{imp} x\ n_e$**



New results for double-null ACT-1 are shifted to higher density



Strong circulating convective flow pattern exists in outer divertor leg



Summary

- **Two types of divertor plasma solutions found for ACT-1**
  - low impurity radiation, but much too high divertor heat flux
  - high impurity radiation that pushes core impurity levels
- **Intermediate impurity levels are desirable**
  - may not exist because continuous impurity level bifurcates?
  - oscillating solutions found, or numerical limitation – will continue looking
- **Pedestal structure can be included, but requires specifying structure of transport barrier**
  - may couple to EPED1-type model described by Kessel
- **Full divertor geometry (strongly tilted plates) need to be assessed**
  - improved mesh resolution?