Update on EDGE2D-EIRENE simulations for the ER pedestal project – 2nd Oct 2015

Presented by A. E. Järvinen

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Parameter scans with EDGE2D-EIRENE conducted

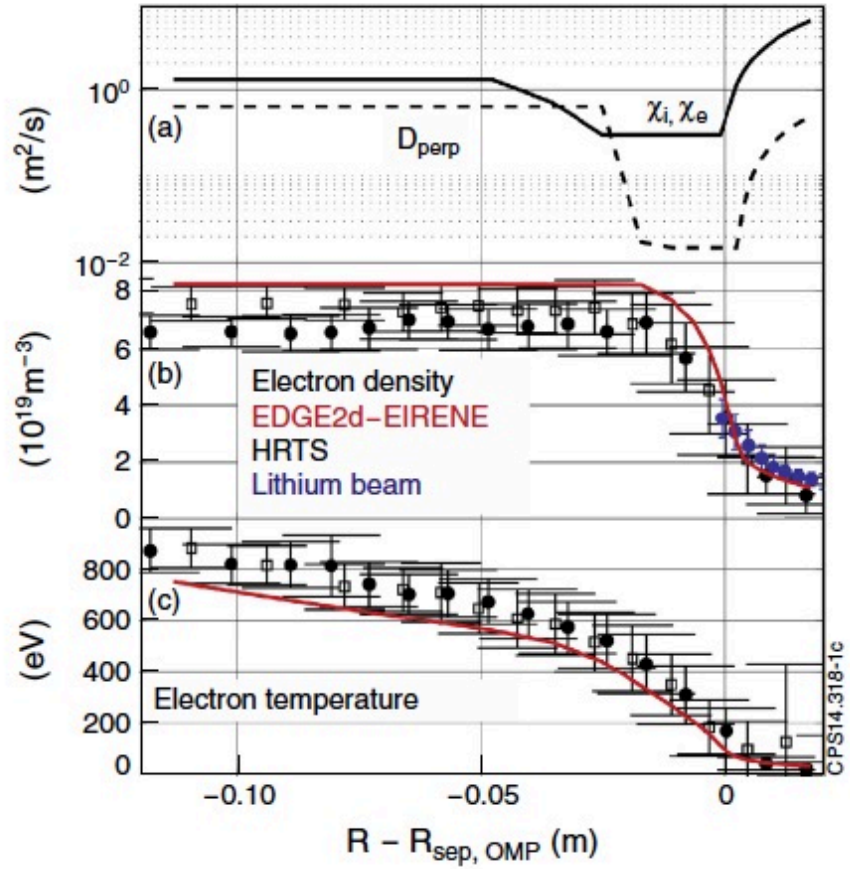
- **Base:** Base case boundary conditions & transport coefficients from [1].
- **What is being done:** linear parameter variations (sensitivity studies) were conducted

✓ Last time (June 2015)

- $n_{e,sep}/n_{e,ped}$-ratio and $T_{e,sep}$

✓ This talk (Oct 2015)

- Impurity profiles (radial + poloidal)



[1] Jaervinen, JNM 2014

June 2015: EDGE2D-EIRENE predicts typically $n_{e,sep}/n_{e,ped}$ about 0.4 – 0.6

	$n_{e,sep}/n_{e,ped}$	$T_{e,sep}$ (eV)
Basecase (horizontal LFS target)	0.4 – 0.5	77 – 87
N_2-seeding	0.35 – 0.45	80 – 100
Vertical LFS target	0.5 – 0.6	95 – 100
50% increase P_{SOL}	0.45 – 0.6	85 – 100
$D_{perp,SOL+ETB}$ x5	0.4 – 0.45	70 – 80
$X_{perp,SOL+ETB}$ x0.5	0.4 – 0.5	90 – 100

The questions raised by S. Saarelma (June 2015) – EDGE2D-EIRENE modeling

1. How sensitive are the **predicted impurity density profiles and Z_{eff}** to the
   1. Assumed pedestal diffusivity?
   2. N_2-injection rate?
2. What kind of **poloidal asymmetries** are predicted for the **impurity and electron density profiles**
   - ✓ What are the **physics mechanisms affecting the poloidal asymmetries**?

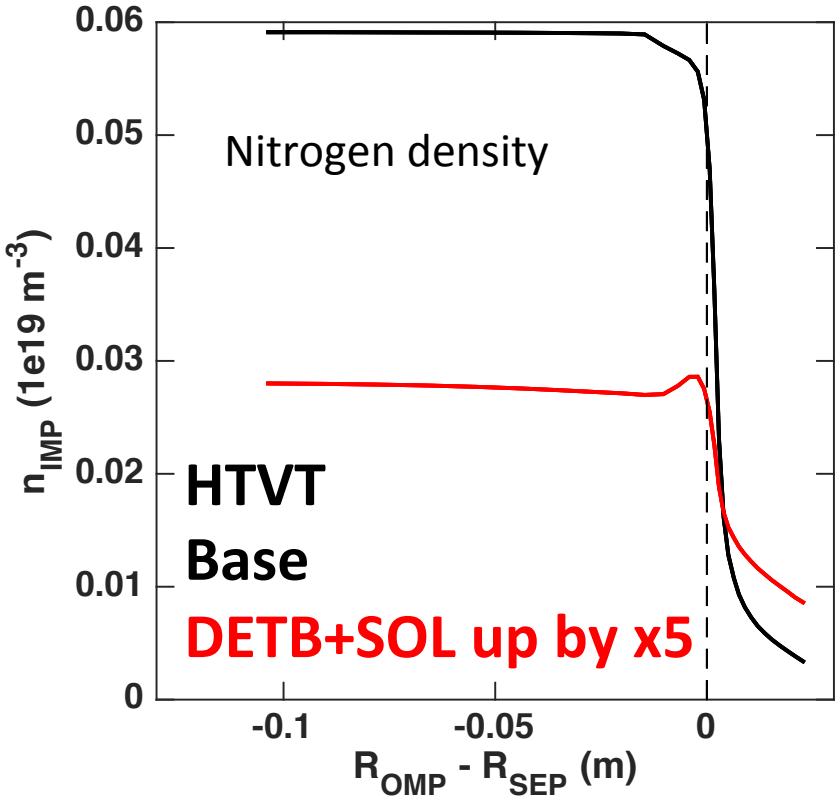
Part I

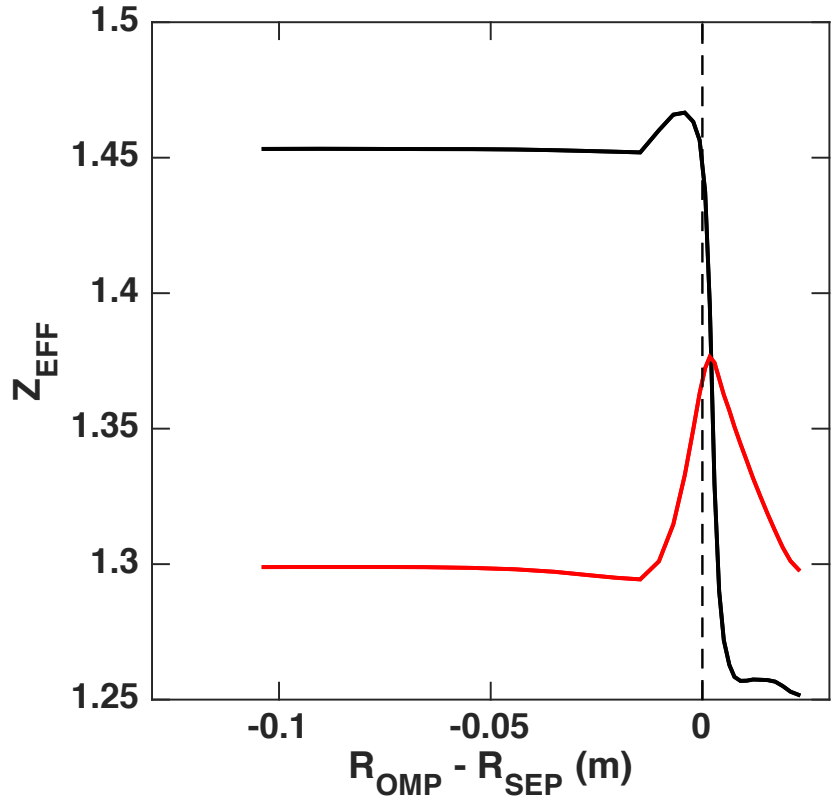
How sensitive are the predicted impurity density profiles to the assumed pedestal diffusivity?

- **Multiply the D_{perp} in SOL and ETB by a factor of 5:**
- **Predicted Z_{eff}, and $n_{impurity}$ profiles at the LFS mid-plane (for a single N-radiation level)**
  - **Strong impact on ETB gradients outside separatrix + absolute n_{IMP} at the pedestal**

Predicted LFS mid-plane profiles show…

- Increase of SOL n_{IMP} and Z_{EFF} values. Reduction of the same parameters inside the separatrix
- Expected result when increasing the diffusive transport across the separatrix and SOL



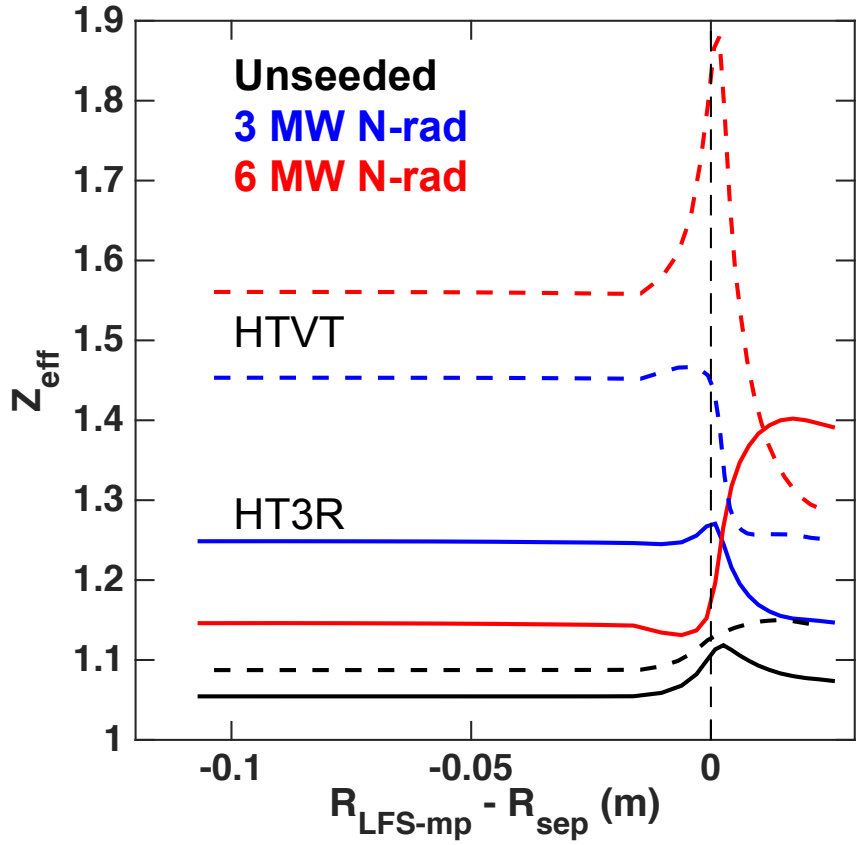


Part II

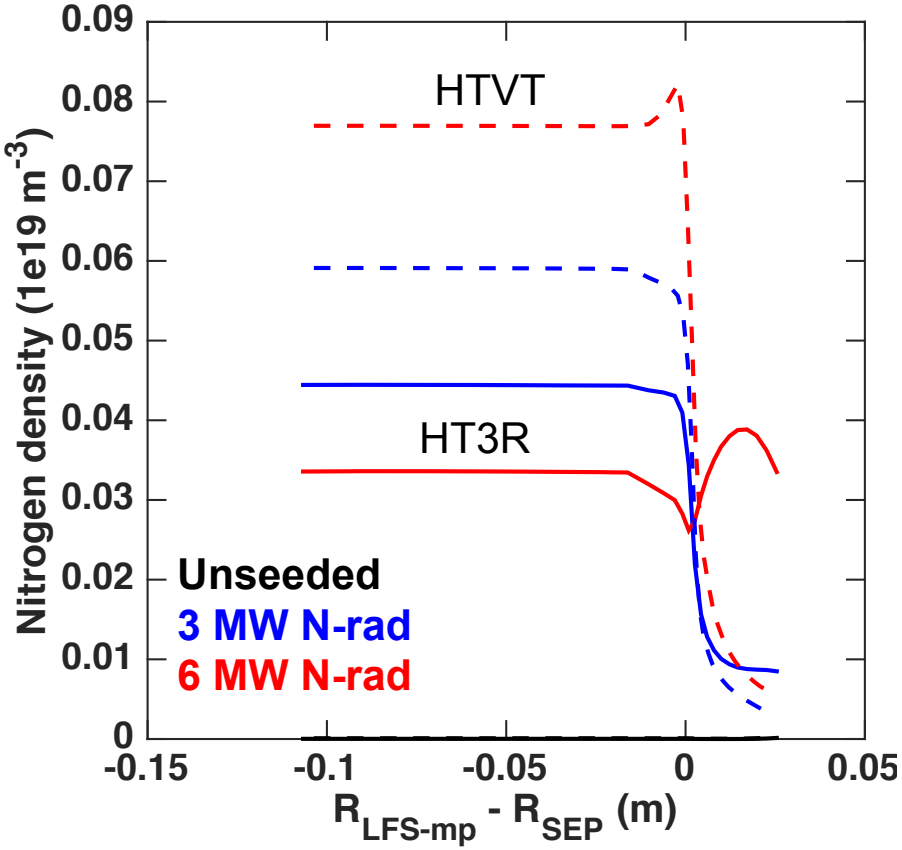
How do the predicted impurity density and Z_{eff} profiles vary with N_2-injection rate?

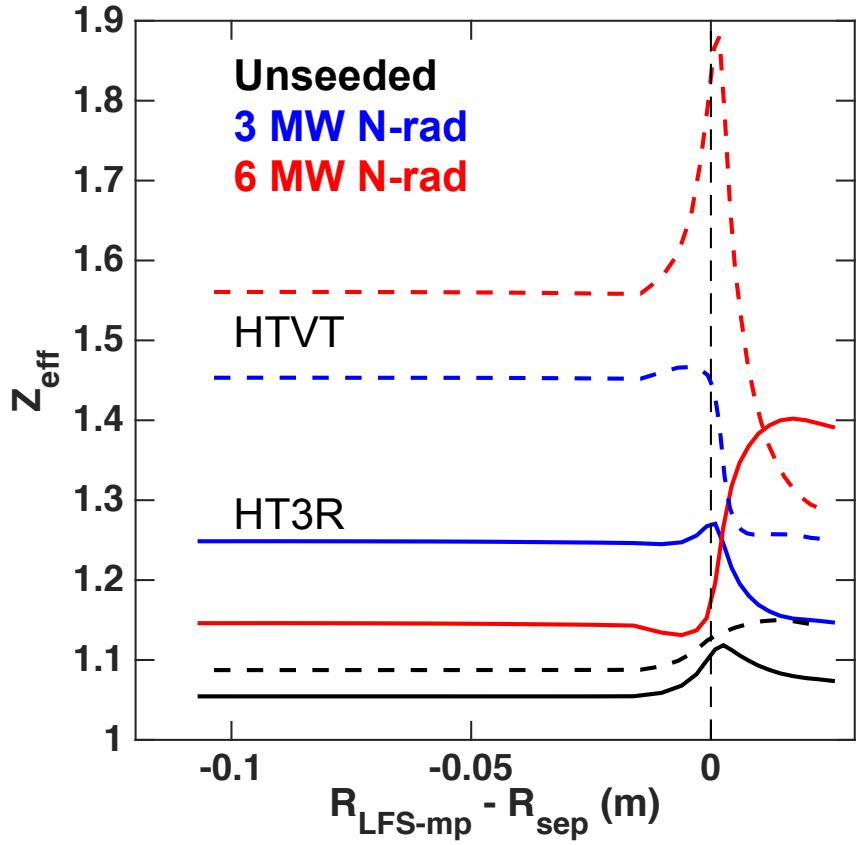
- Monotonic increase of pedestal Z_{EFF} and n_{IMP} inside the separatrix with seeding rate in HTVT
- Roll-over of Z_{EFF} and n_{IMP} inside the separatrix with seeding rate in HT3R following detachment

Monotonic increase in pedestal Z_{eff} predicted in HTVT. Roll over with seeding in HT3R.



Monotonic increase in pedestal Z_{eff} predicted in HTVT. Roll over with seeding in HT3R.





- Also for the absolute nitrogen density, EDGE2D-EIRENE predicts monotonically increasing densities in HTVT and a roll-over of nitrogen density inside the separatrix with detachment in HT3R. The physics reasons for the roll-over are not obvious at the time of completing this report. Could, presumably, be related to increase in the background ion out-flux effectively, ‘flushing’ nitrogen out.

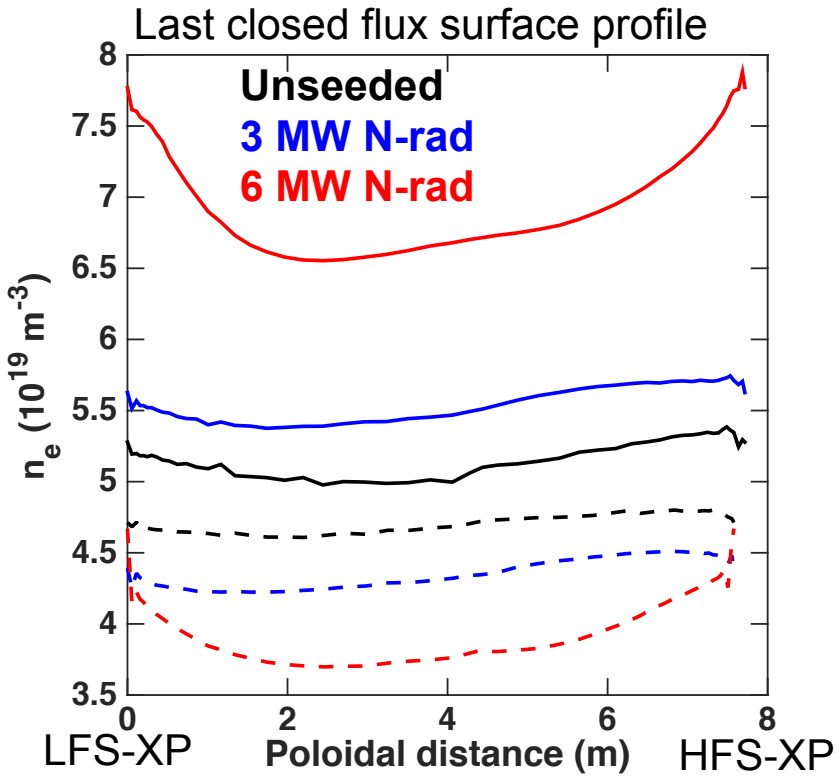
Part III

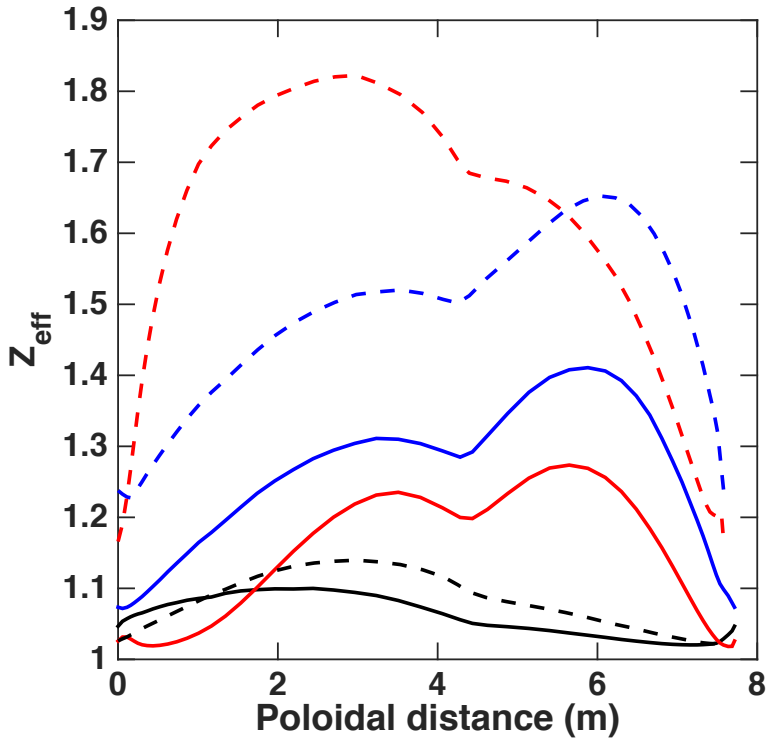
What kind of poloidal asymmetries are predicted for the impurity and electron density profiles

What are the physics mechanisms affecting the poloidal asymmetries?

1. **Peaking of Z_{EFF} and n_{IMP} above the mid-plane**
   - ✓ Peak n_{IMP} up to a factor of 4 higher than minimum n_{IMP} along LCFS
   - ✓ Ionization driven poloidal $n_e/T_e/T_i$ asymmetries ⇒ accumulation of impurities away from the active X-point (towards higher temperatures)
2. **Asymmetries vanish with reducing minor r:** poloidally flat n_e, Z_{eff} profile beyond pedestal

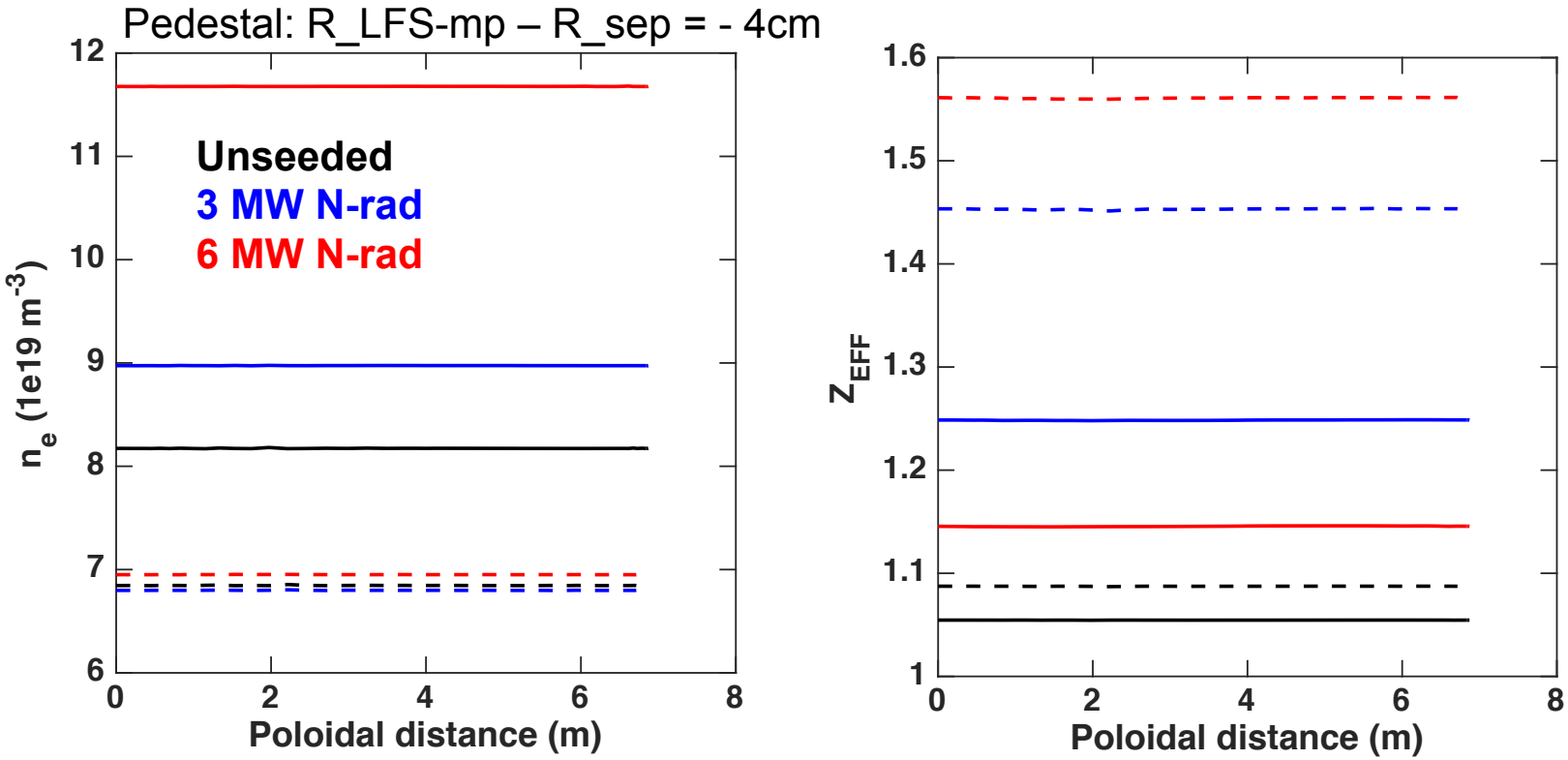
Along the LCFS, Z_{eff} is predicted to peak in the region above and around LFS mid-plane





- n_e predicted to peak close to X-point – **Proximity of the divertor neutral source**
- Pressure conserved ⇒ **Temperature gradient along LCFS** ⇒ **Ion temperature gradient force** pushes impurities towards mid-plane and above
- Low flow velocities (M < 0.1) inside the separatrix ⇒ **low frictional drag on the impurity ions** ⇒accumulation of impurities at around mid-plane and above

The poloidal asymmetries vanish beyond pedestal as a function of reducing minor radius



- Strong poloidal asymmetries are only present close to the LCFS, where the 2-D neutral ionization distribution drives n_e/T_e/T_i asymmetries leading to temperature gradient forces and impurity accumulation around the upper half of the poloidal cross section.

Conclusion

1. How sensitive are the **predicted impurity density profiles and Z_{eff}** to the

   ETB profiles relax with increasing ETB diffusivity (as expected) ⇒ impact on predicted n_{IMP} at pedestal

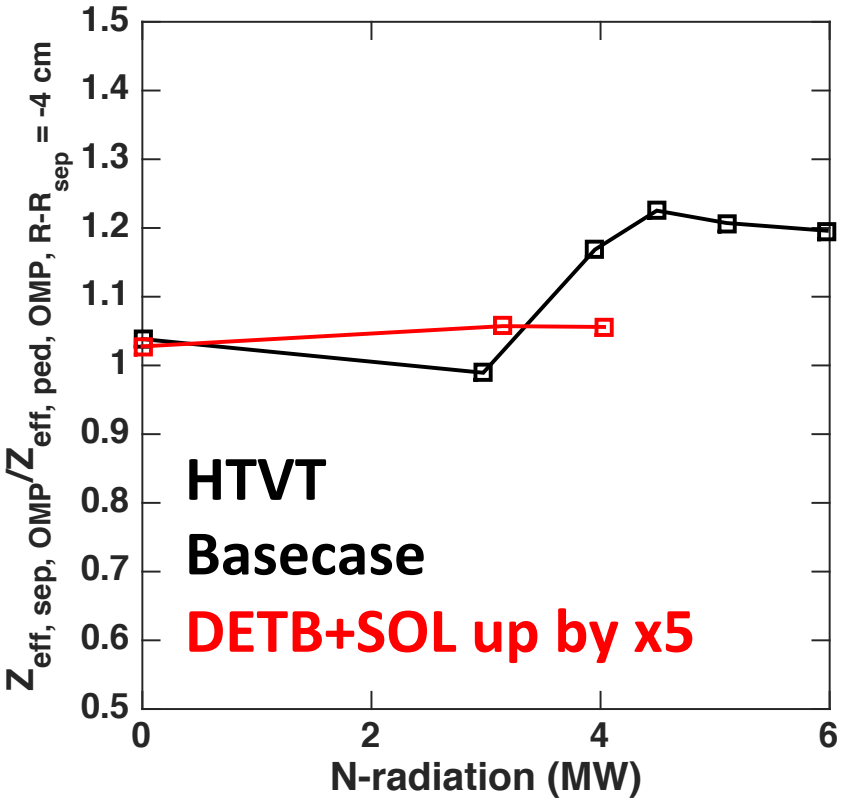
   Increase of pedestal Z_{EFF} with increasing N_2-injection ⇒ Roll-over of pedestal Z_{EFF} with detachment in HT3R (physics reasons not clear yet)

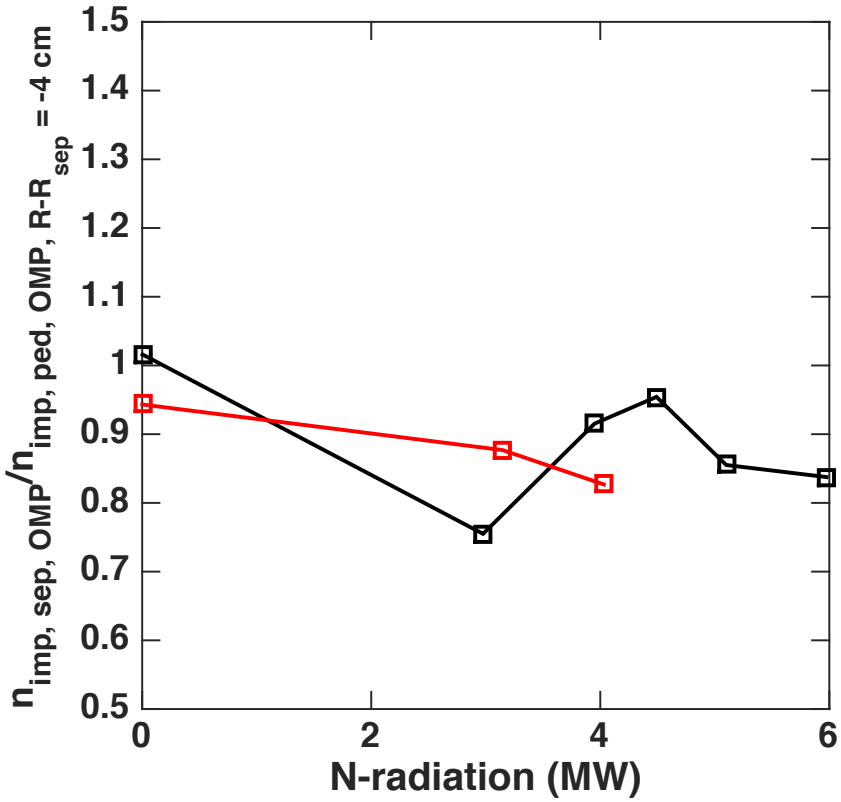
2. What kind of **poloidal asymmetries** are predicted for the **impurity and electron density profiles**

   Accumulation of impurities above mid-plane. Ionization driven $n_e/T_e/T_i$ asymmetries + temperature gradient forces.

Back up

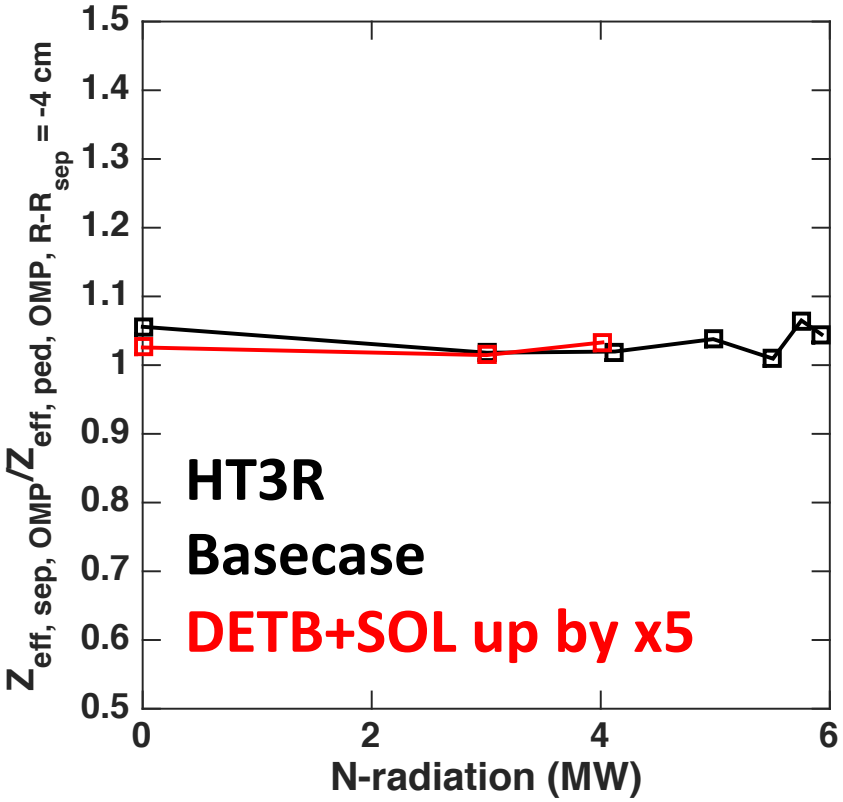
Pedestal and SOL D_{perp} up by x5 ⇒ pedestal to sep ratios of Z_{eff} and n_{imp} remain the same within 5 – 10%

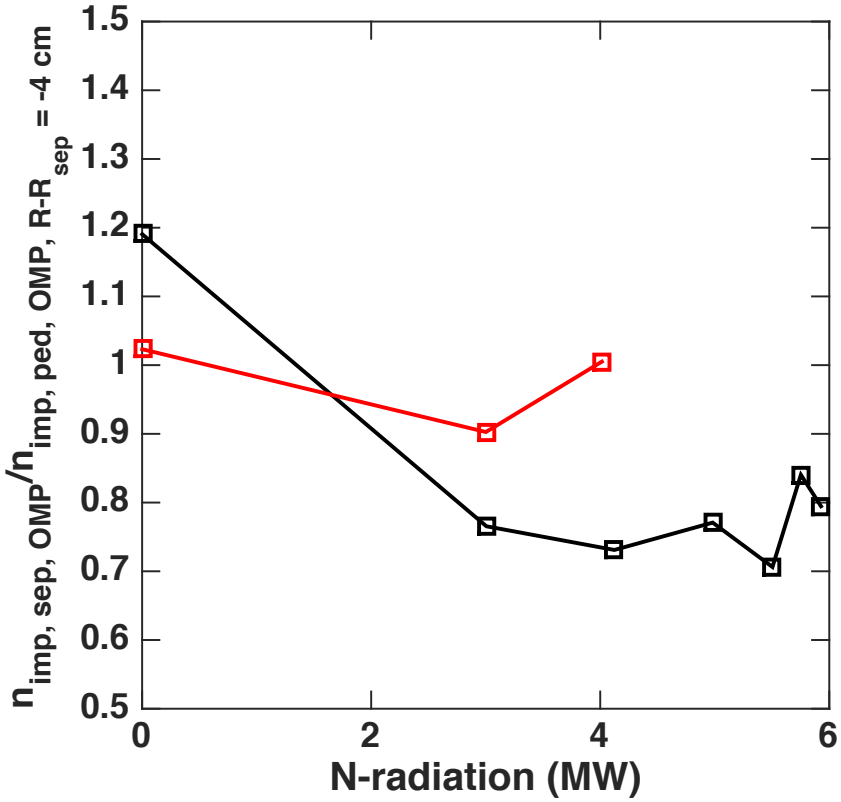




- Small impact on the **ratio of separatrix to pedestal values**
- However, strong impact on the **ratio of mean SOL and pedestal values** ⇒ Next slide

In HT3R, no change in Z_{eff}-ratios. However, the n_{imp} ratios (with N-injection) shift to larger values

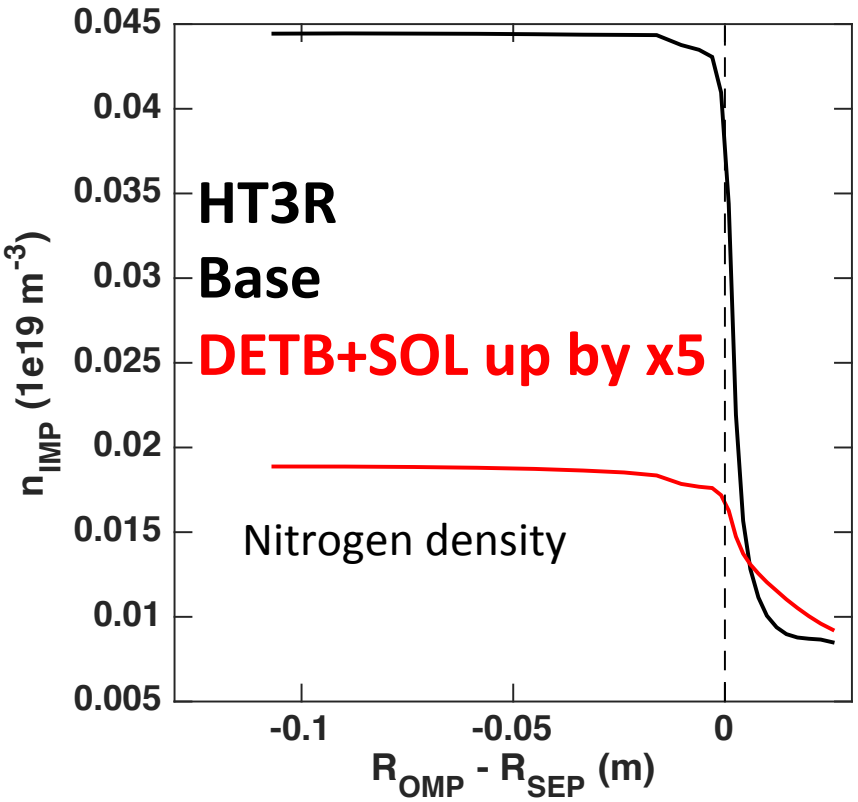


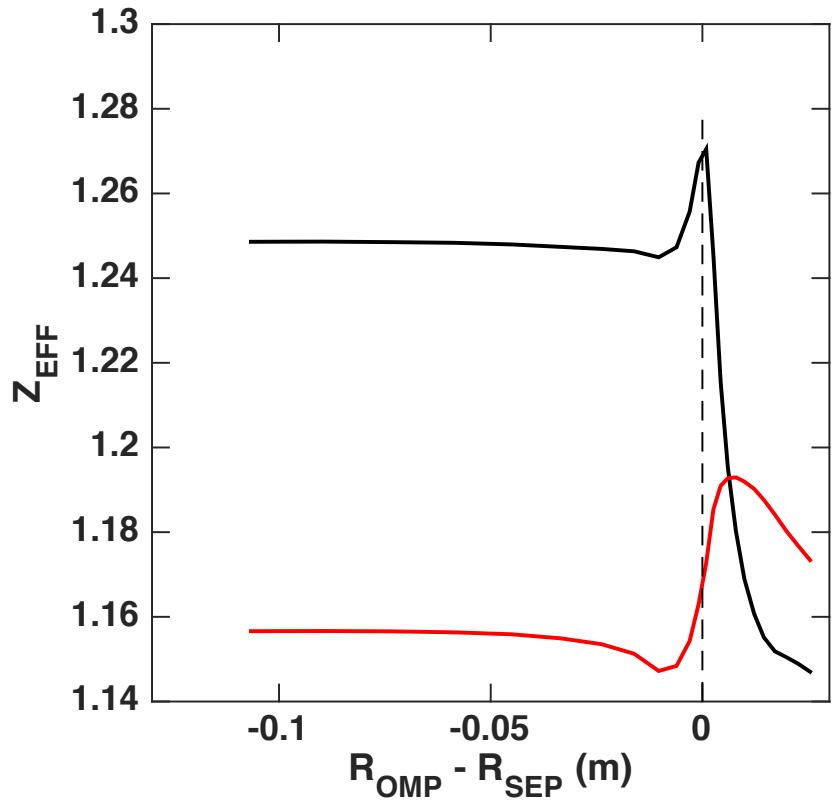


- However, similar to HTVT, the most significant impact of multiplying the $D_{ETB+SOL}$ is seen in the mean SOL vs. pedestal values ⇒ next slide

Predicted LFS mid-plane profiles for the N-rad = 3 MW simulation case, show…

- Increase of SOL impurity densities and Z_eff values, and reduction of the associated values inside the separatrix
- Expected result when increasing diffusive transport across the separatrix and SOL





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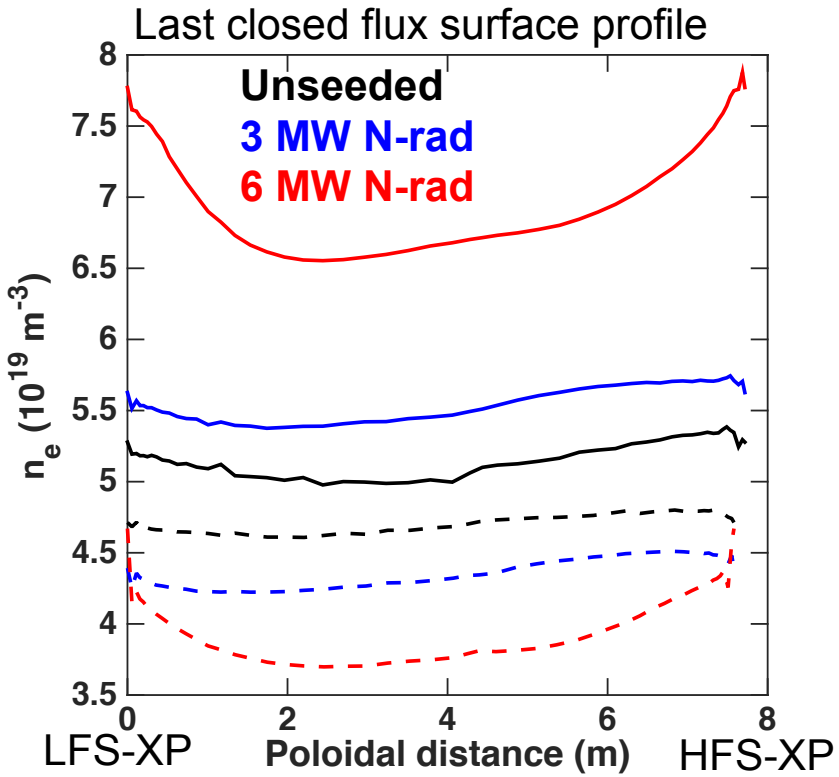

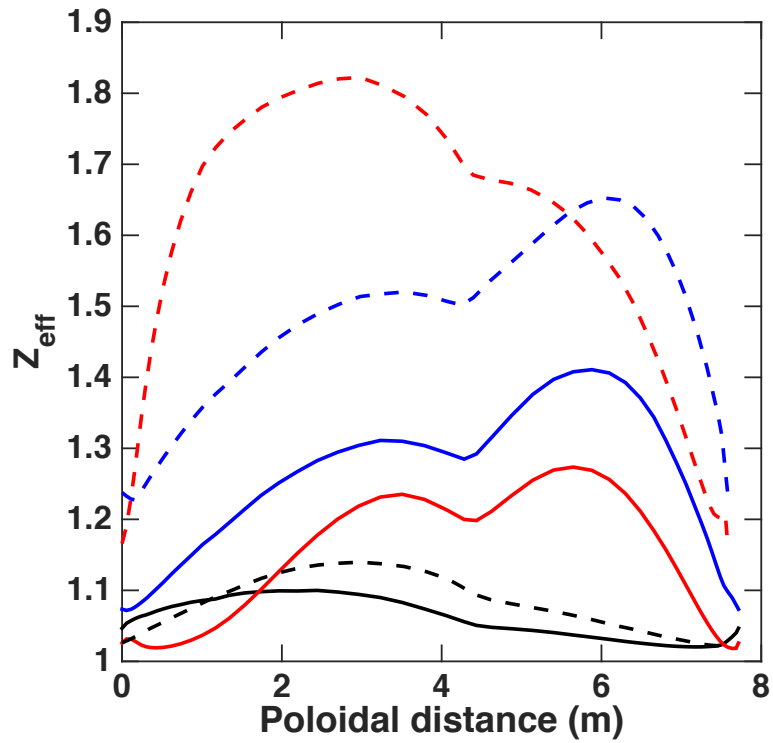

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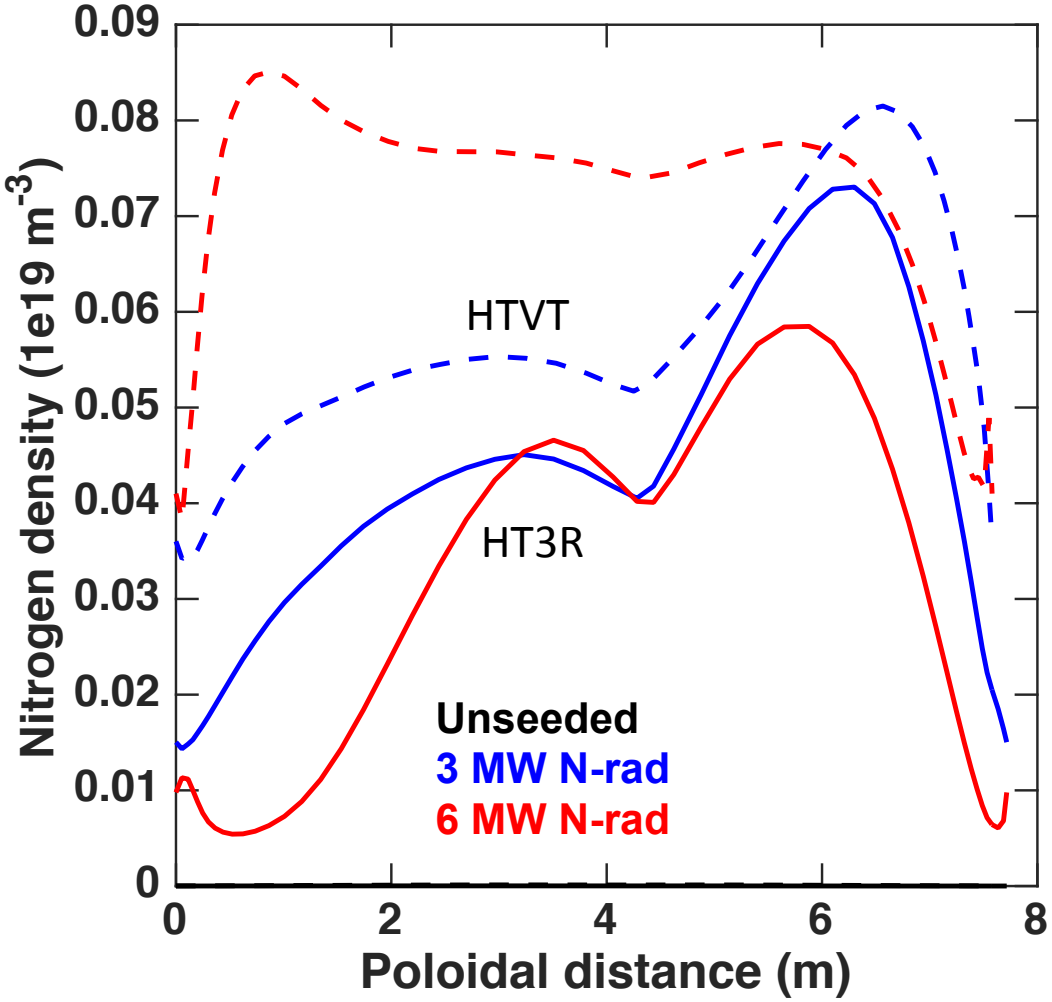
Nitrogen density profiles predicted to peak in the region above and around mid-plane



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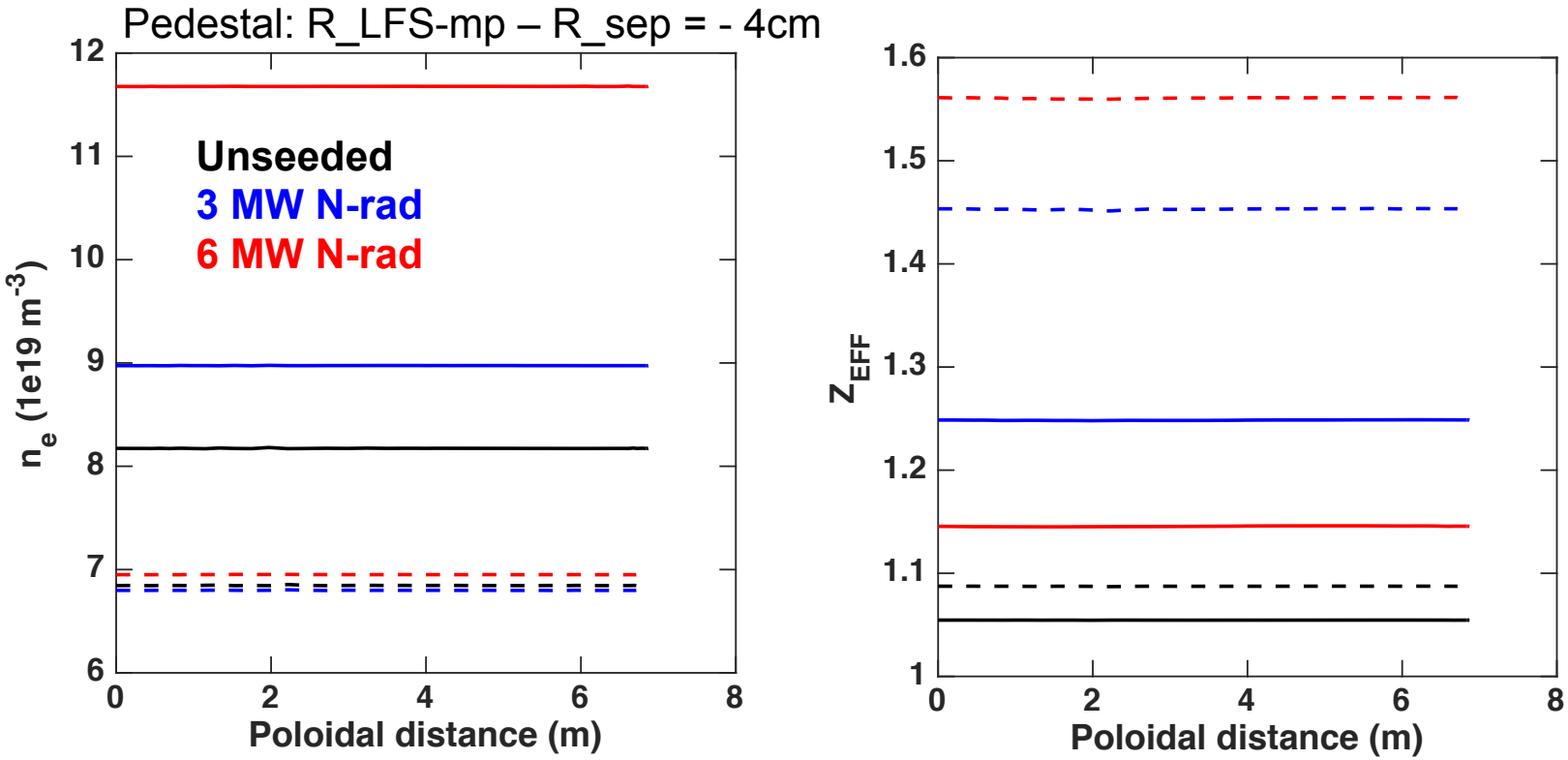

- Strong poloidal asymmetries are only present close to the LCFS, where the 2-D neutral ionization distribution drives n_e/T_e/T_i asymmetries leading to temperature gradient forces and impurity accumulation around the upper half of the poloidal cross section.