Report 12/11/2020

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EUROfusion

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Previously: 2D Inversion Results

- considering a given emissivity profile shape, there exists an ideal set of K factors constraining the ratio of poloidal and radial gradients according to the X^2 optimisation
- not necessarily the same as defined by the lowest 2D deviation and Pearson coefficient, whose optimisation also yields a set of K factors
- radial positioning of profiles is subject to the selection of K factors over the radius (and angular space)

Previously: 2D Inversion Results

- poloidaly distributed profiles are, so far the data set suggests, the hardest to reconstruct properly (especially on the inboard side)

- asymmetric characteristics can be property of the underlying emissivity profile to the tomography, however some are introduced due to the line of sight geometry

- combinations of profile shapes, especially poloidaly symmetric and any else become hard to distinguish from one another (see ring and island mimic)

Previously: 2D Inversion Results

- bright spots on-/off-axis and, e.g. bright rings can be separated from each other depending on the distance

- individual bright sheaths can no longer be reconstructed radially when closer than 0.2m

- reconstructions of forward calculated STRAHL simulations are largely accurate in position and value

- reference XP 20181010.032 difficult to reconstruct, subject to difference in forward and backward model?

QSB LabVIEW Routine Review (see CHANGELOG.md)

PROS

- added EPOCH timer to UI, timing mode that calculates EPOCH time at start
- added T1-T4 timing input to UI, added T0-T1 timer to UI (should at least be 30s)
- fixed wrong time base in calibration procedure
- DAC range setting file load or input via the UI
- **selected channel feedback output**, though with delay >10ms (single/multi channel)
- performance for 1-10 selected channels in feedback is fine
- overhaul of calibration parameter routines since detector response is more complex than a single peak and exponential decay
- full P_rad routine added for **after** the data acquisition to access power loss quickly (same as IDL/python)
- filter register settings fixed to match sample timings in milliseconds
- improved/implemented local-storage-mode-only, so no crash at upload
- upload of error corrected voltage input to archive as well (same as IDL/Python)

QSB LabVIEW Routine Review (see CHANGELOG.md)

CONS

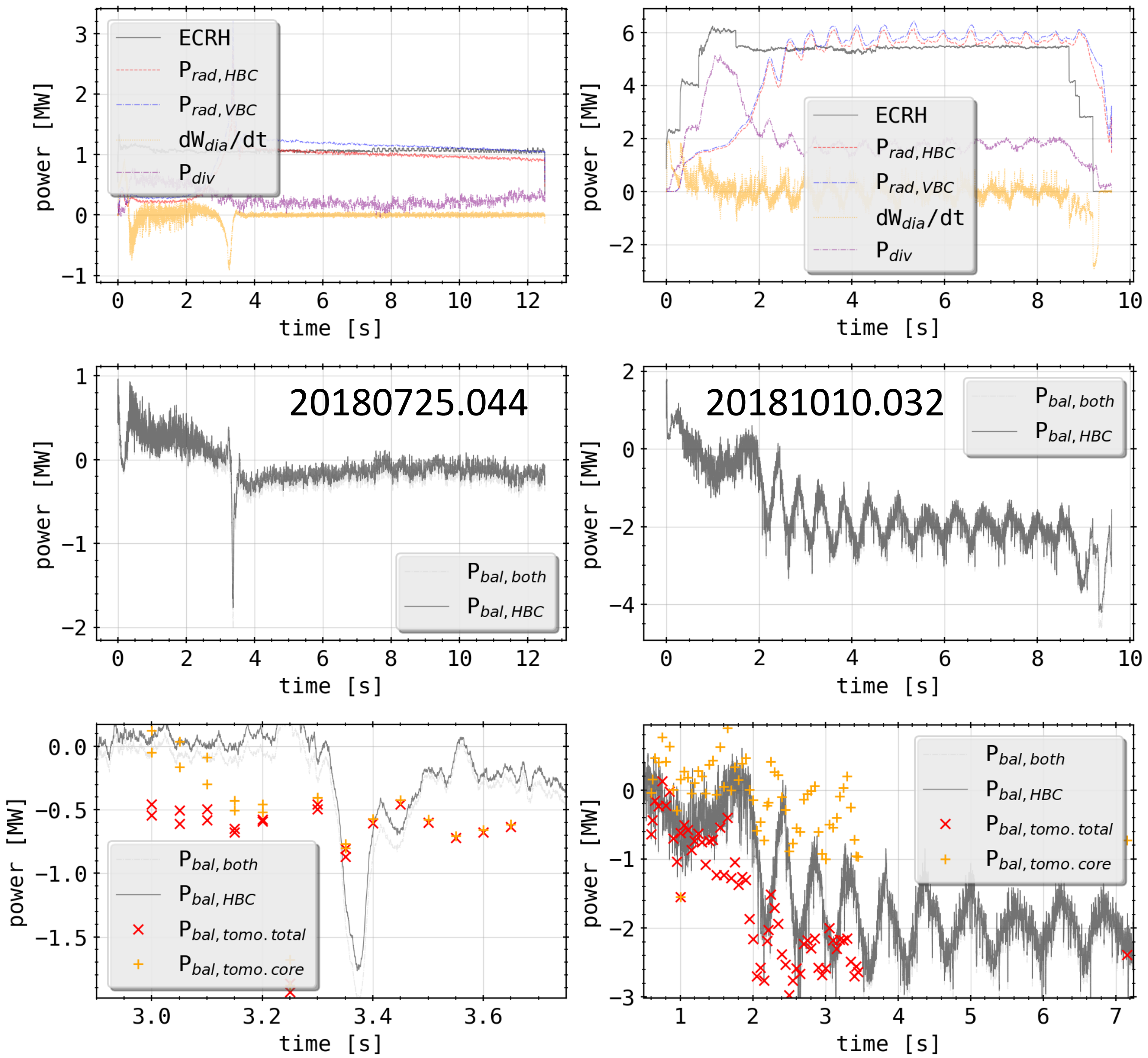
- DAQ routine now more prone to crashing, hiccups and **slow processing causing sample timing errors**
- ADC bit settings not fully understood, potentially not intended setting here (wrong documentation?)
- crashing with bad device status at memory overflow or uncompleted DAQ/upload, incosistent to recover
- hardware needs warm-up time of ~30min (before?)
- some small fixes needed to improve quality-of-life experience during experimental campaign (dials not working as intended, …)

Tomogram Statistics: Experiment Power Balance

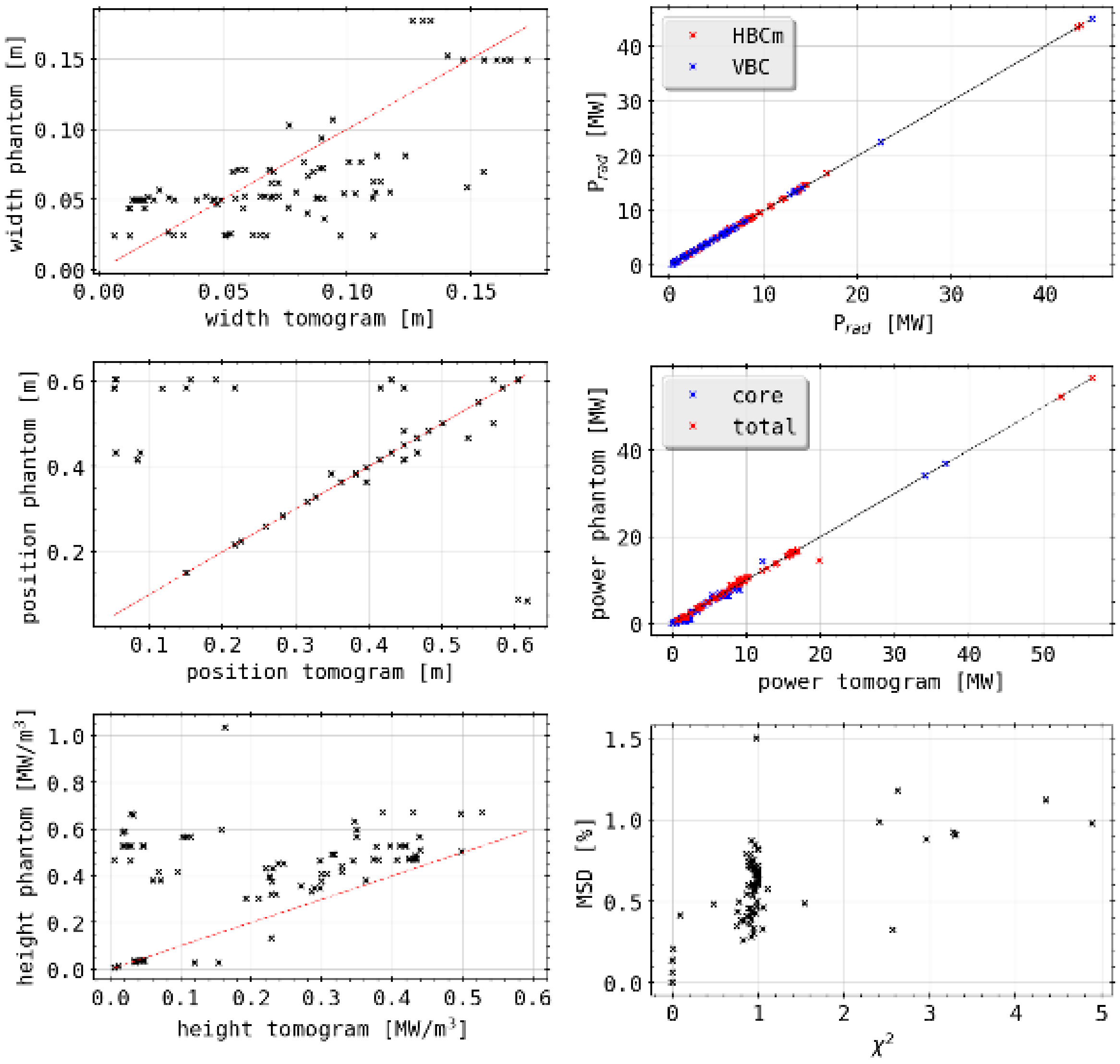
- compiled experiment data and parameters to calculate

$$P_{bal}(t) = P_{ECRH}(t) - P_{rad,HBC/VBC}(t) - P_{div}(t) - \frac{\mathrm{d}W_{dia}}{\mathrm{d}t}(t)$$

- also exchanged radiated power proxy from bolometer camera by 2D integrated power of tomogram (both core and total)

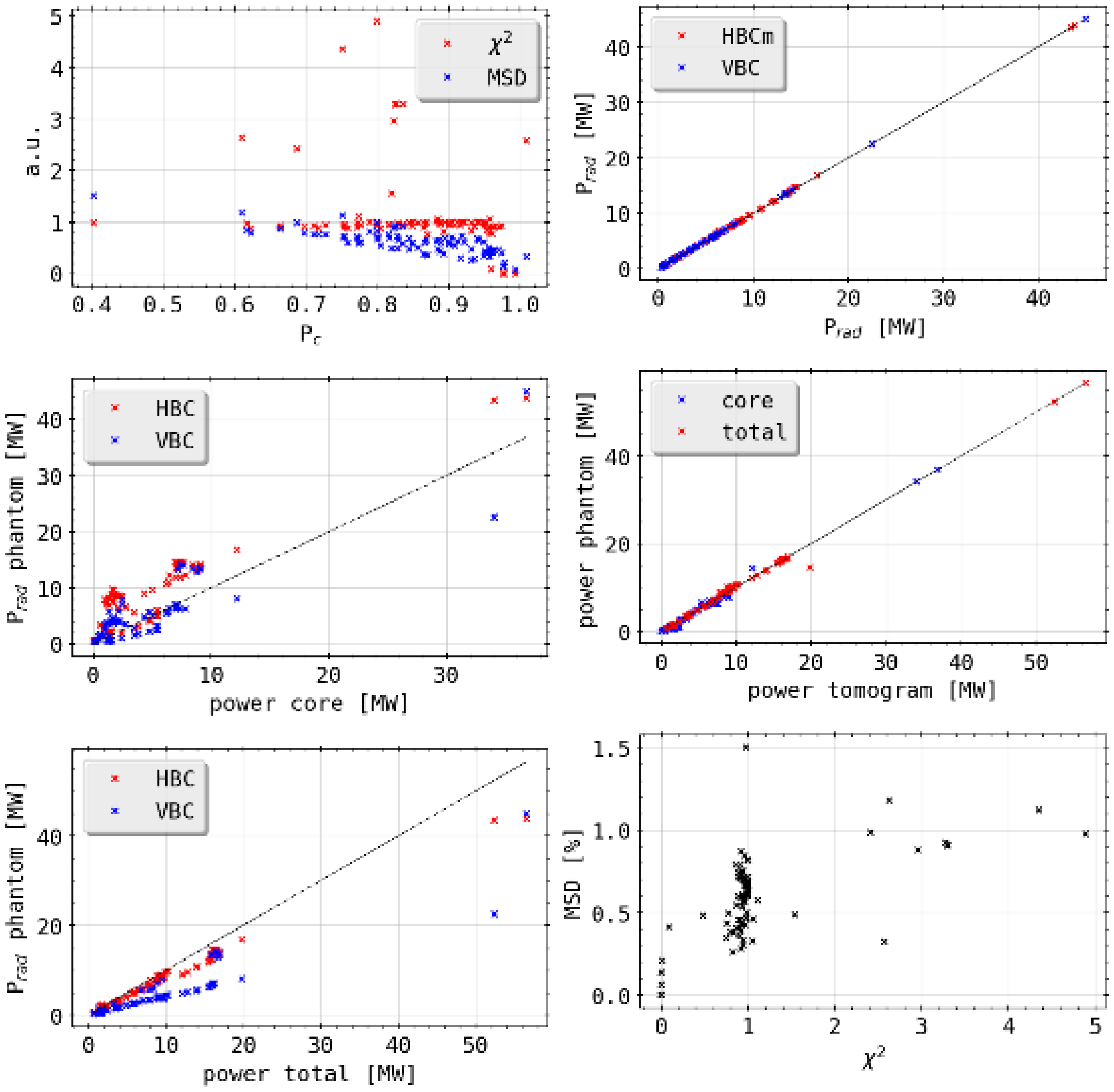


Tomogram Statistics: Phantom Reconstructions



- ➢radial profile positioning good, though width and height have small to large deviations
- ➢peak height comparison exhibits offset on phantom side: widened radial shape and longer decays (width)
- ➢P_rad and total/core power values match very well for phantom reconstructions
- ➢a slightly larger range of MSD values yields a 'good' X^2 of ~1.0
- ➢there seems to be an offset of MSD about 0.25% (minimum error between source and target to be expected?)

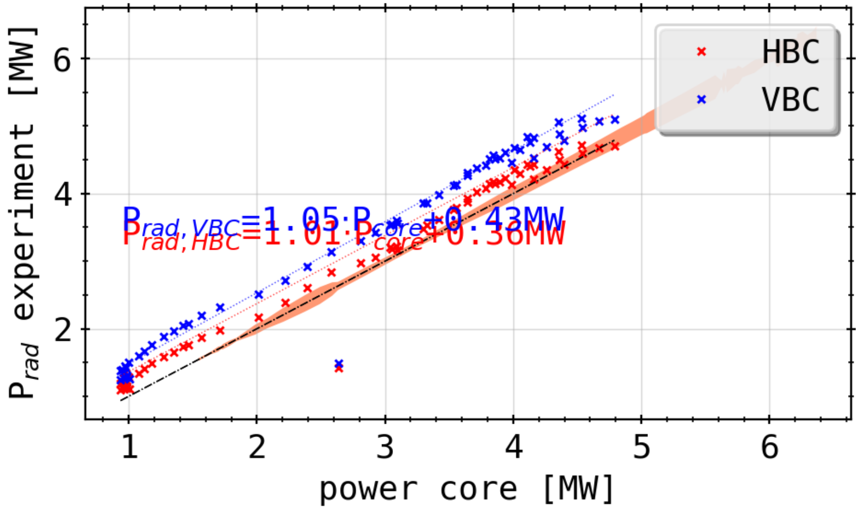
Tomogram Statistics: Phantom Reconstructions

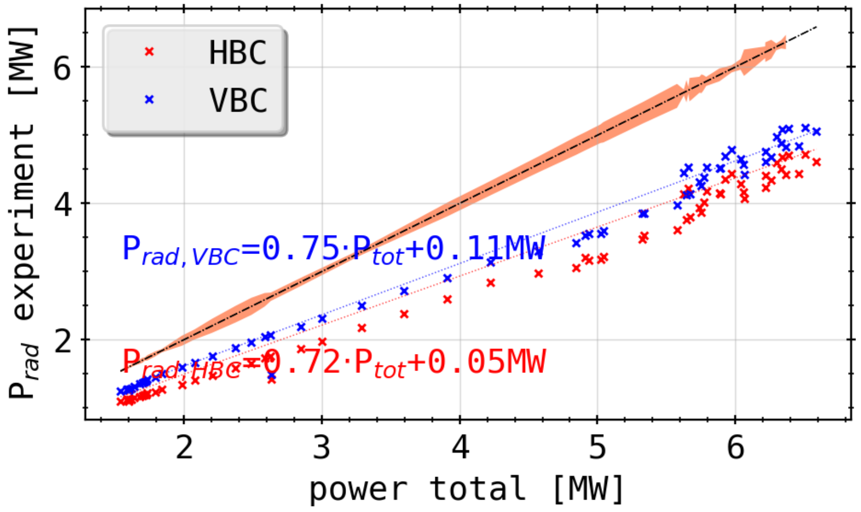


- ➢MSD approaches 0.0 if pearson coefficient reaches 1.0, as expected, while X^2 is around 1.0
- ➢P_rad over core/total 2D integrated power yield constant offsets and slopes
- ➢core power matches P_rad vor VBC(?) though is lower for HBCm as expected
- ➢total power is larger for both P_rad estimates, though with different proportionalities

Tomogram Statistics: Experiment Reconstructions Errorbar

20181010.032





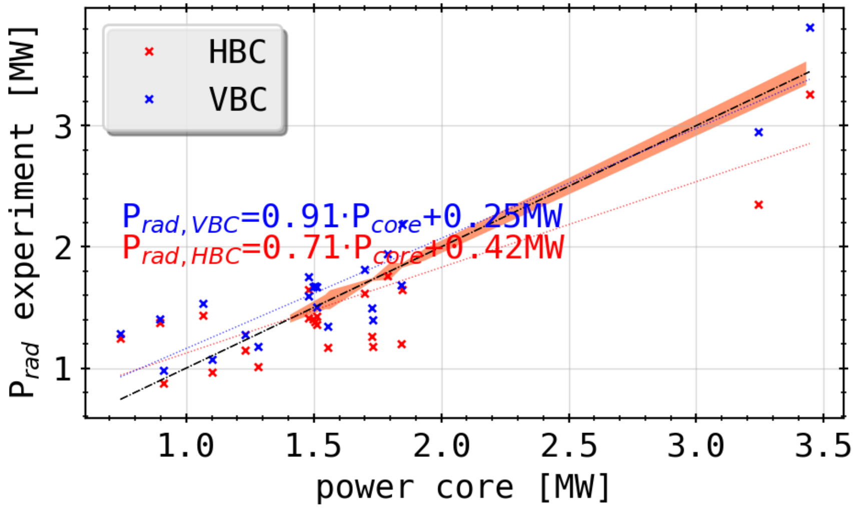
- extra slope in P_rad vs. total power by cutting negative results from reconstruction when limiting to only physically meaningful numbers ($P/m^3>0$)?
- increase of their impact is expected with overall higher radiation level to counteract errors in chordal profile

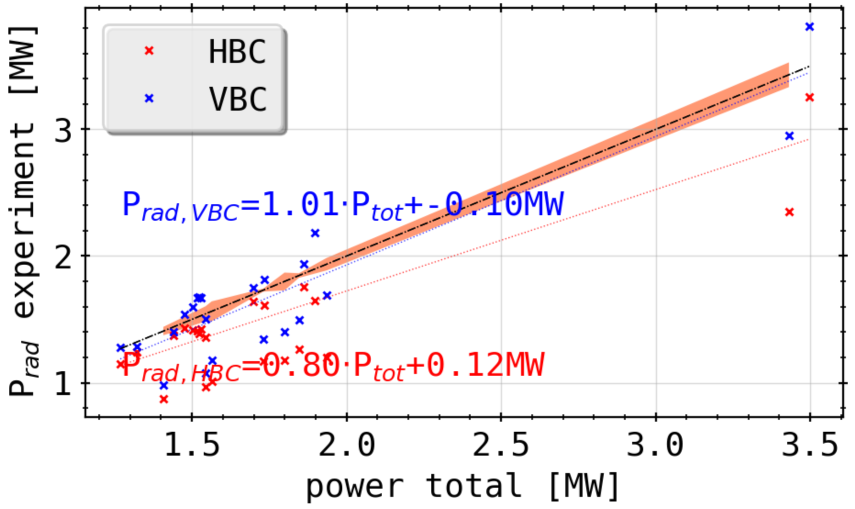
CONCLUSION

- impact of mathematical error is negligible across the power spectrum, but why?
- fit of integrated power values vs camera proxy yields interesting results (~0.4MW offset to core power, ~0.75 ratio to total 2D power)

Tomogram Statistics: Experiment Reconstructions Errorbar

20180725.044





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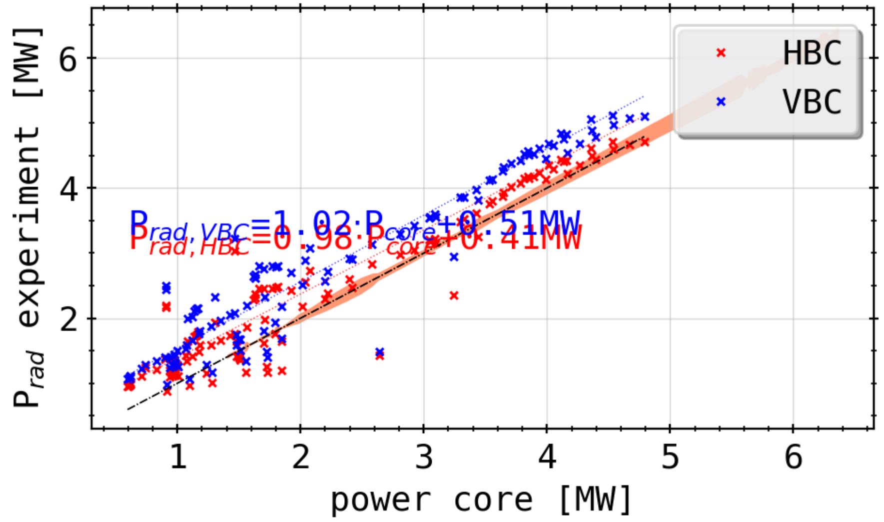
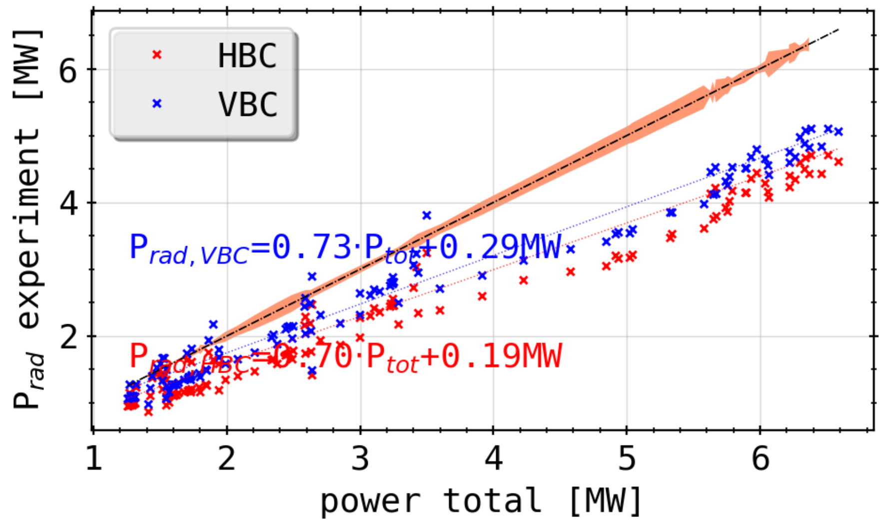
CONCLUSION

- impact of mathematical error is negligible across the power spectrum, but why?
- fit of integrated power values vs camera proxy yields interesting results (~0.4MW offset to core power, ~0.7 ratio to total 2D power)
- changes for different discharge types?

Tomogram Statistics: Experiment Reconstructions Errorbar

(combined)





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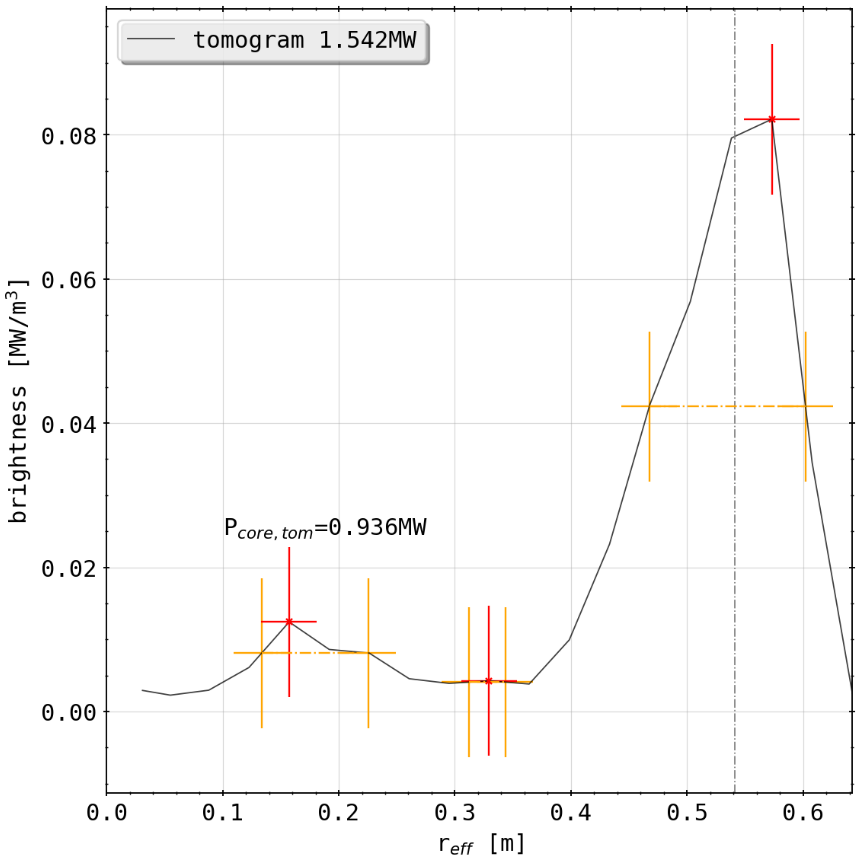
Tomogram Statistics: Experiment Reconstructions Errorbar

20180725.044@3.45s



- errorbar looks large here, because the total error for the tomogram (minimum value < 0.0 can be single cell or whole 'ring') has to assumed possible at every integration point

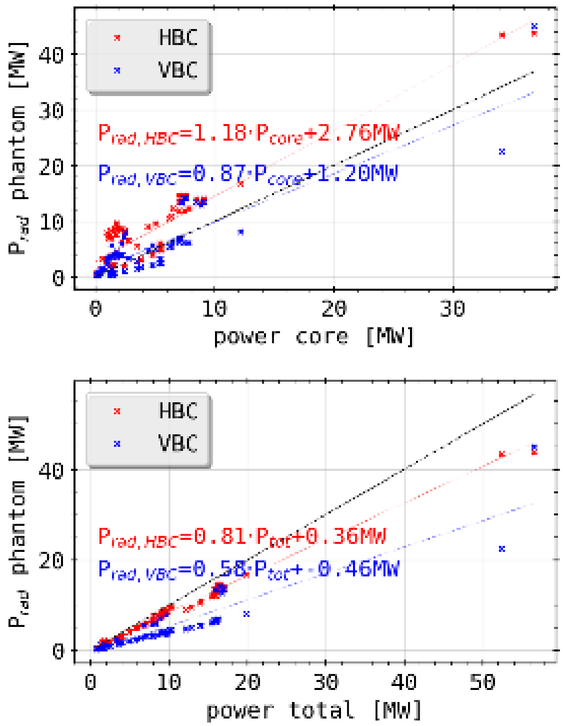
- e.g.: at powers (all X^2~1.0)

  total: 5.78 MW , neg: 66.63 kW

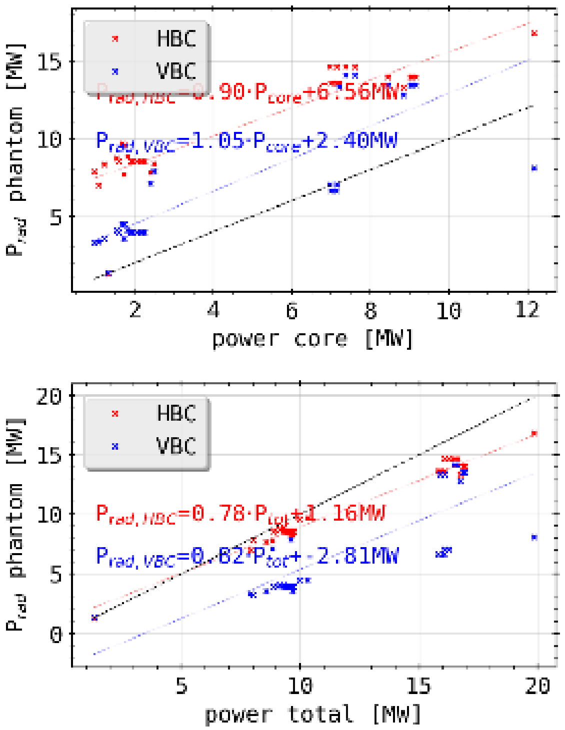
  total: 6.33 MW, neg: 61.68 kW

  total: 2.37 MW, neg: 121.51 kW

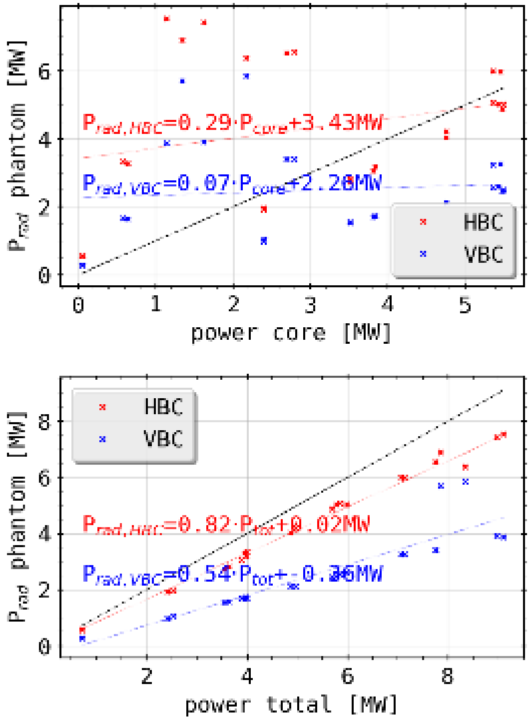
Tomogram Statistics: Phantom Reconstructions



(all phantoms)

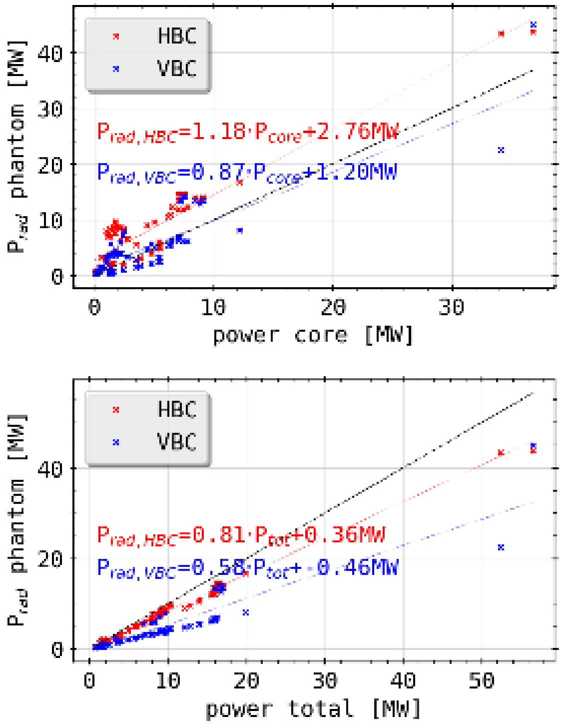


(island mimics)

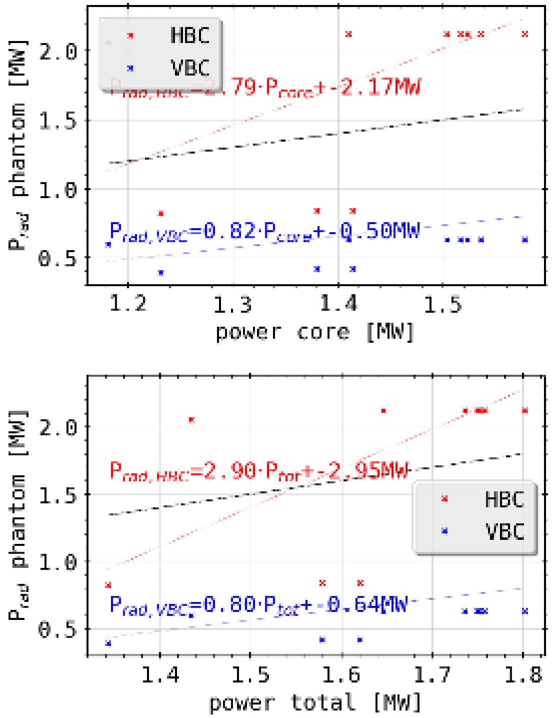


(radiation ring)

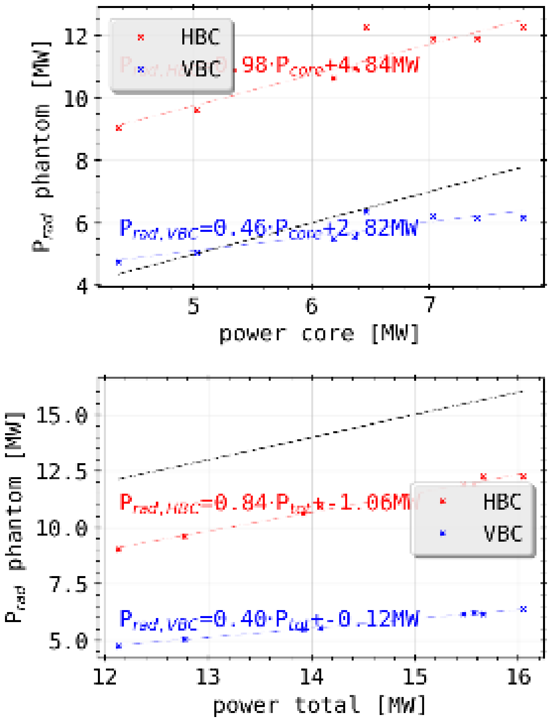
Tomogram Statistics: Phantom Reconstructions



(all phantoms)

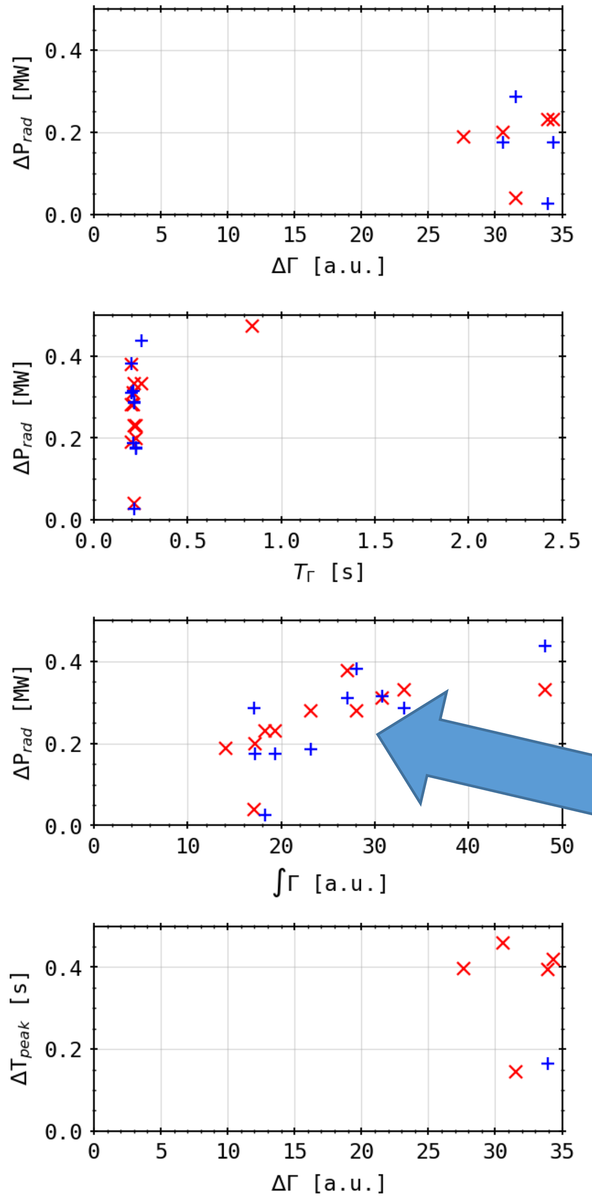


(radiation spot)



(double ring)

Peak Database: Plasma Parameters



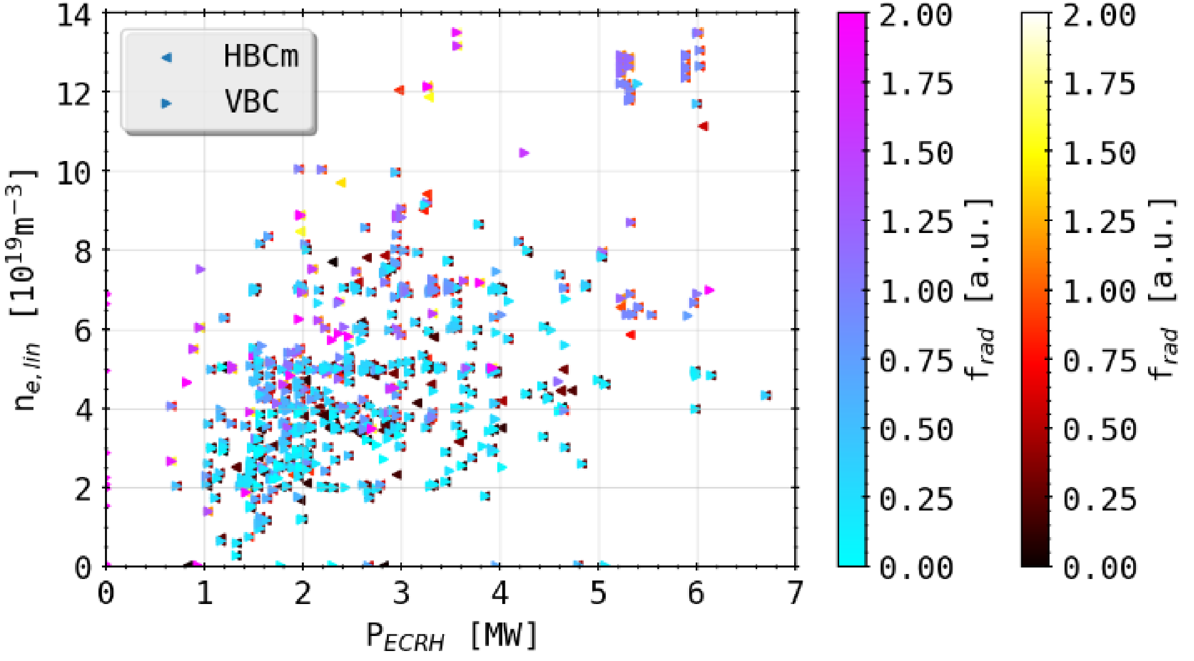
- results only shown for the feedback controlled discharge XPID 20181010.032
- used *feed-forward* and density control on the main gas valves and the thermal gas valve for radiation loss feedback (H2)

- ***'fix' temporal reaction delay of 200ms***
- linear correlation between puff and radiation reaction:

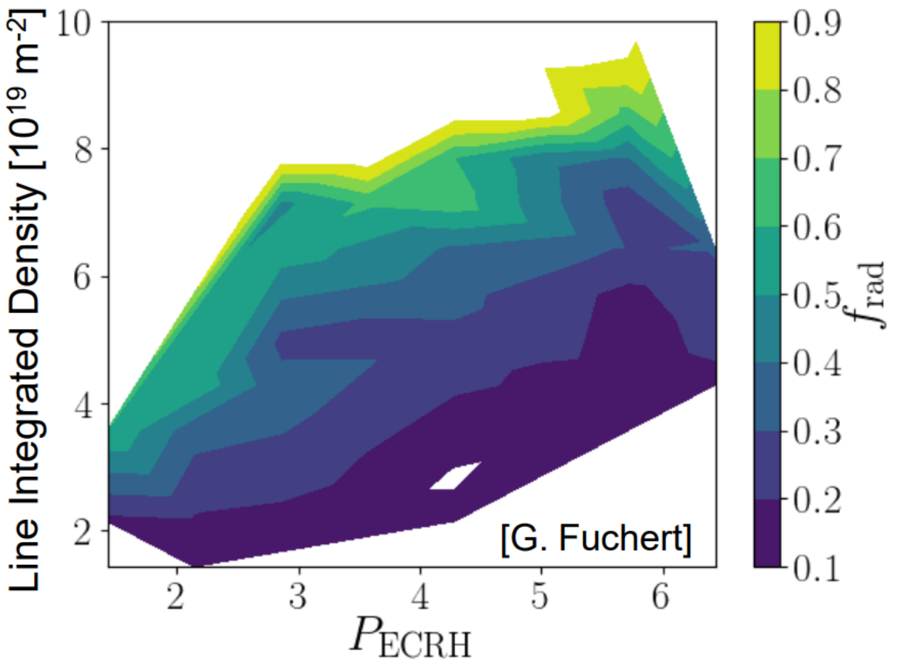
$$\Delta P_{HBCm}[MW] = (0.01187 \pm 0.0063)\,[MW] \cdot \int \Gamma_{QSQ}$$

$$\Delta P_{VBC}[MW] = (0.00978 \pm 0.0009)\,[MW] \cdot \int \Gamma_{QSQ}$$

Peak Database: Plasma Parameters



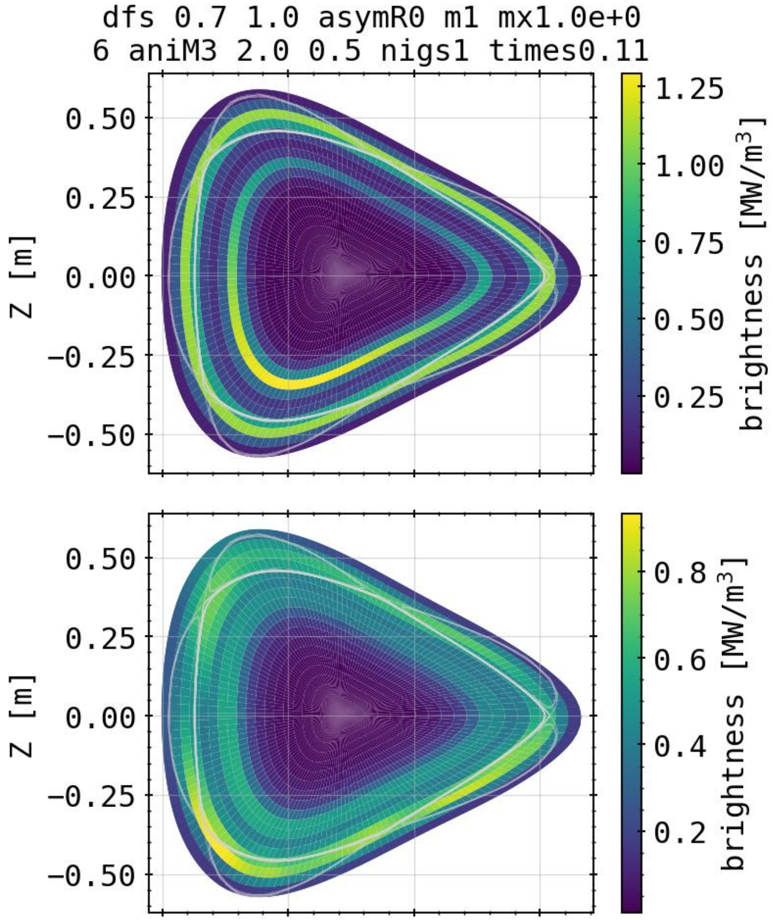
ordering?



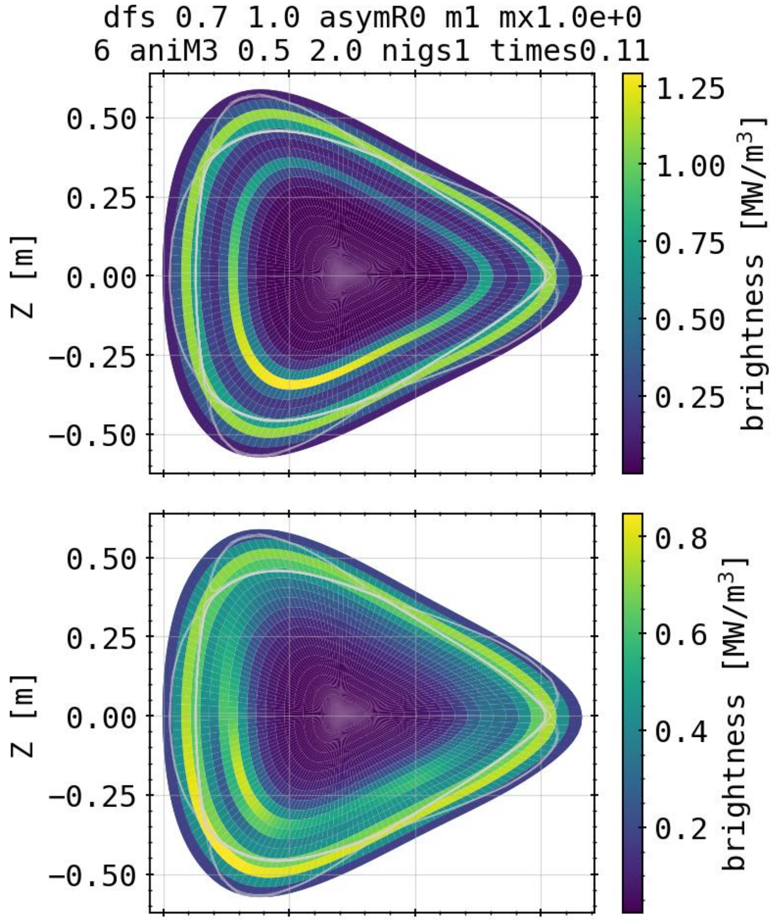
- expecting underlying order of plasma parameters (density, power and exhaust, i.e. energy confinement time)
- further refinement needed: W_dia filtering and confinement time ordering? how when looking at transient phases of gas puff feedback

Asymmetry Propagation: Phantoms

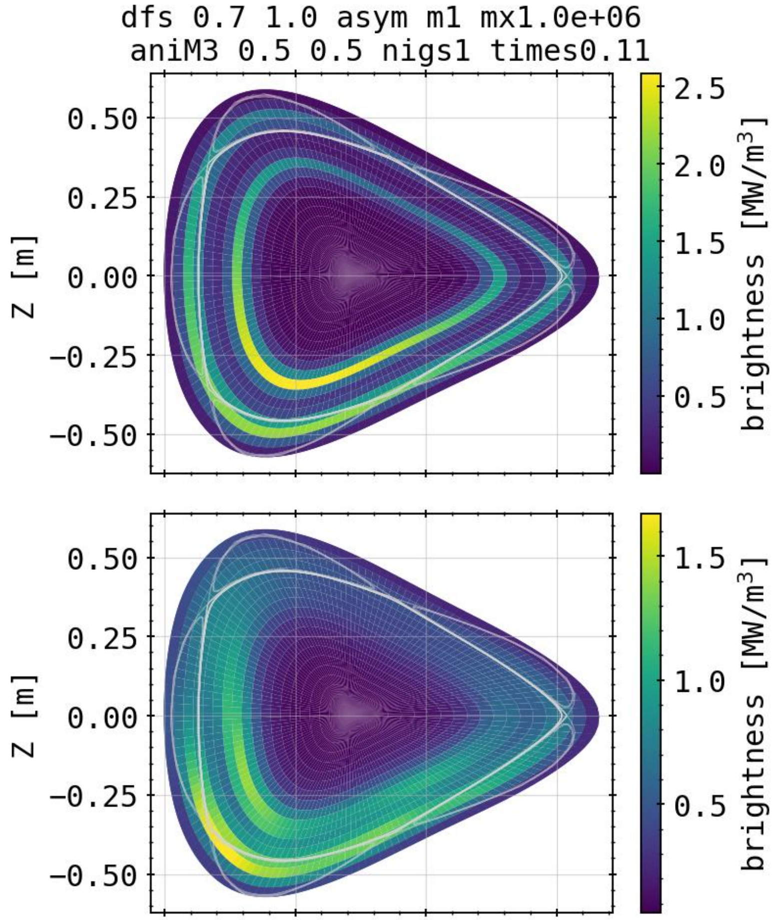
inside asymmetry,
assuming symmetry



inside asymmetry,
assuming asymmetry



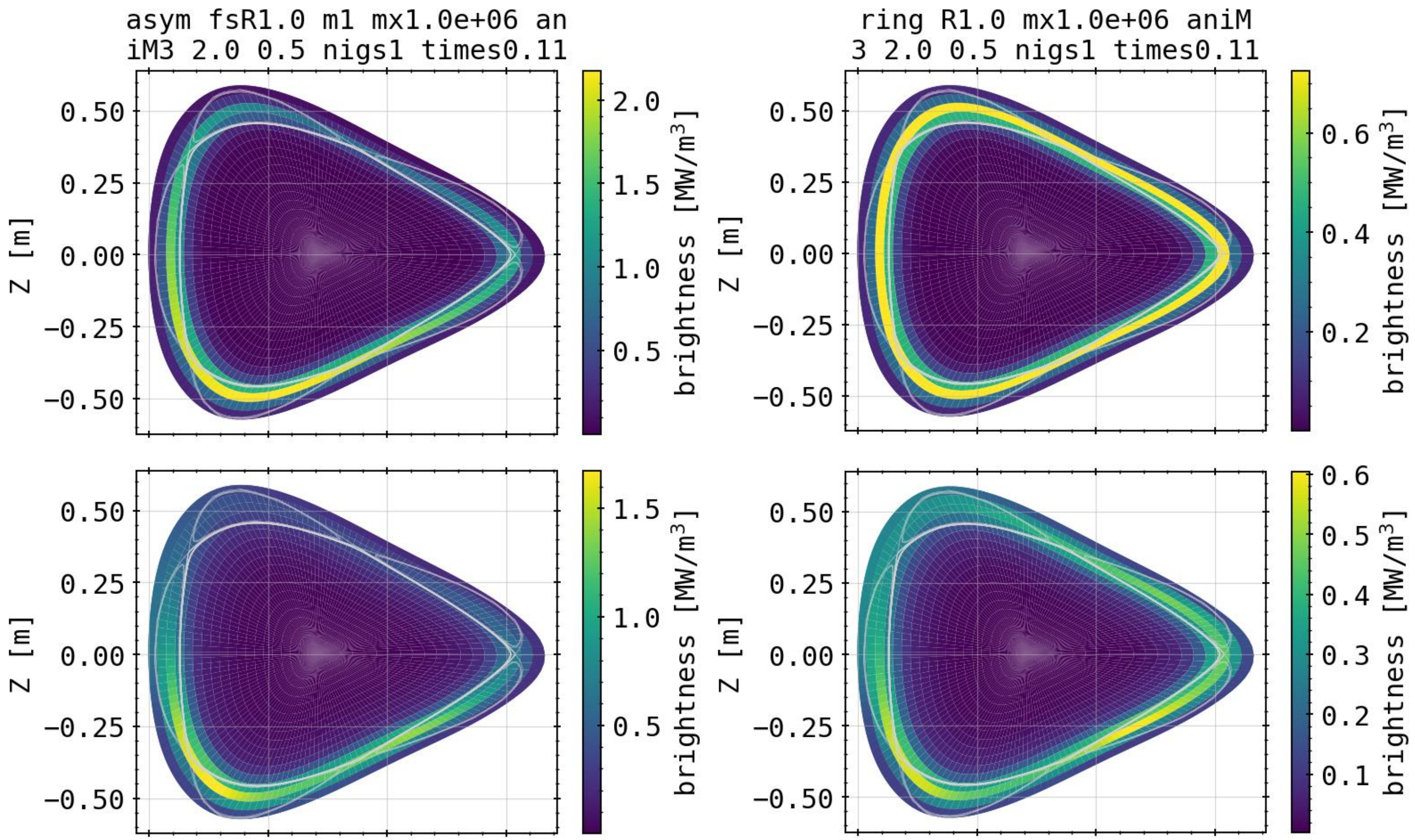
outside & inside asymmetry,
assuming asymmetry



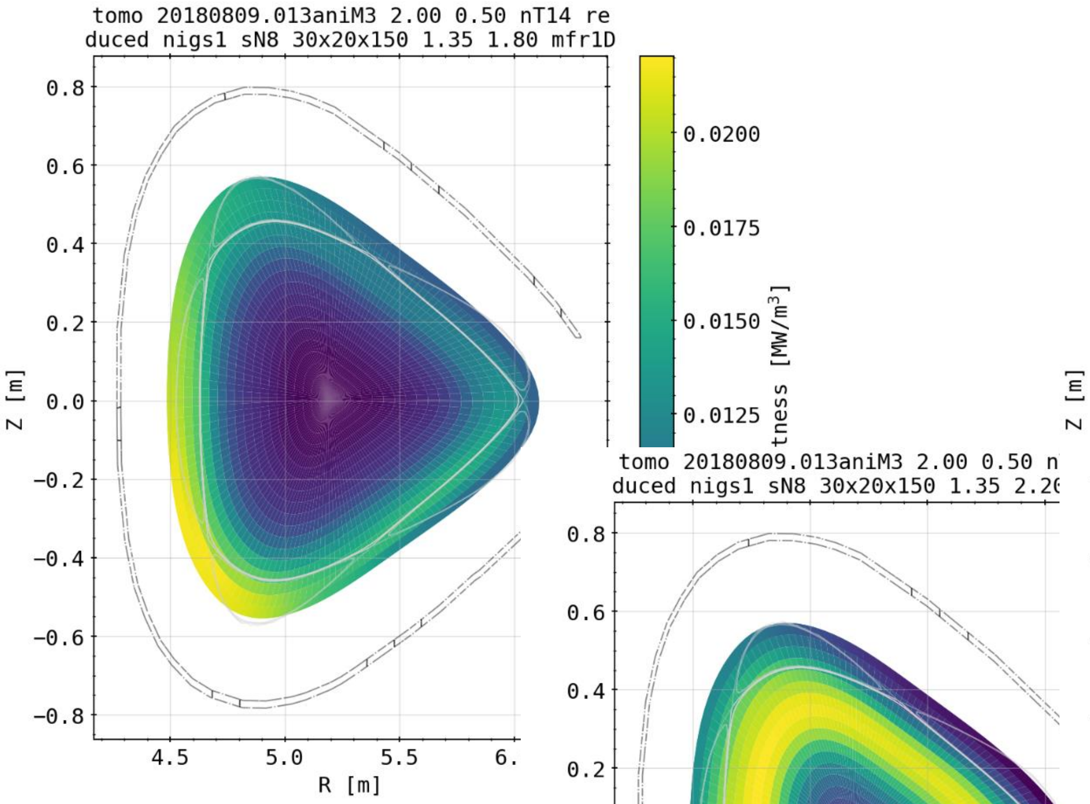
Asymmetry Propagation: Phantoms

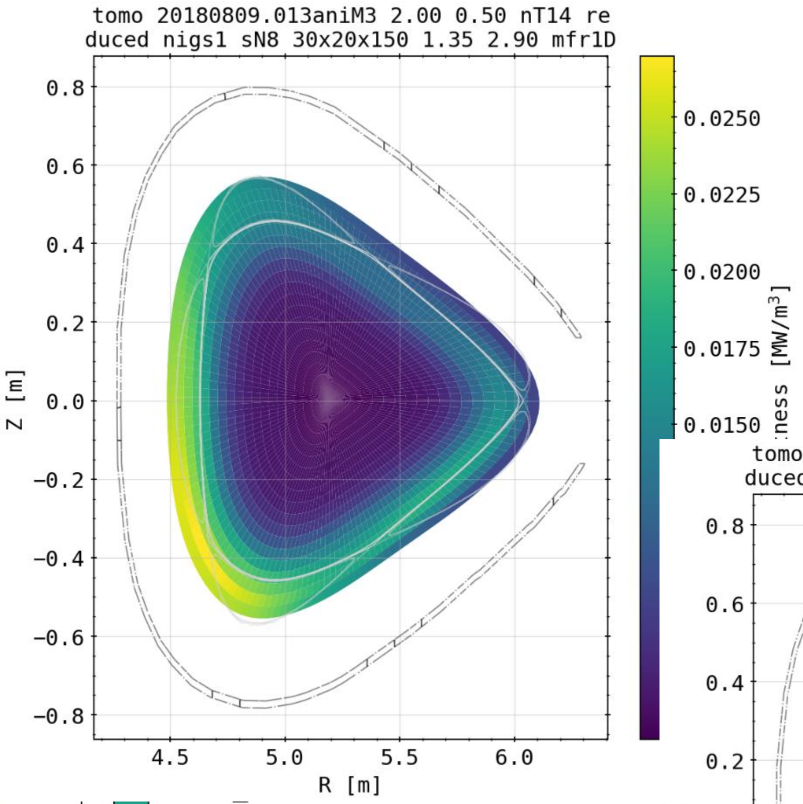
outside asymmetry,
assuming asymmetry

outside symmetry,
assuming asymmetry

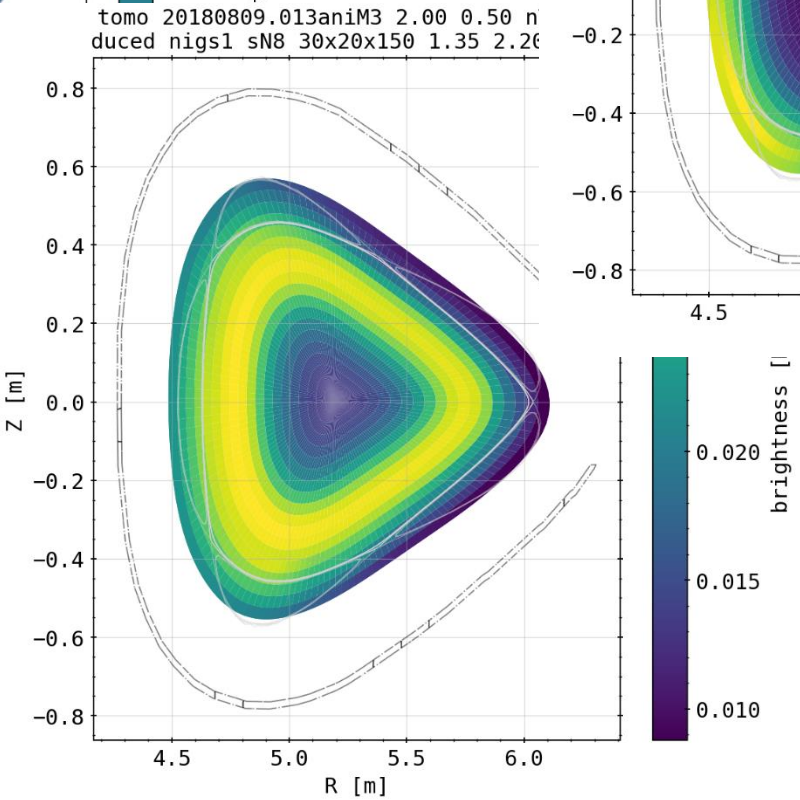


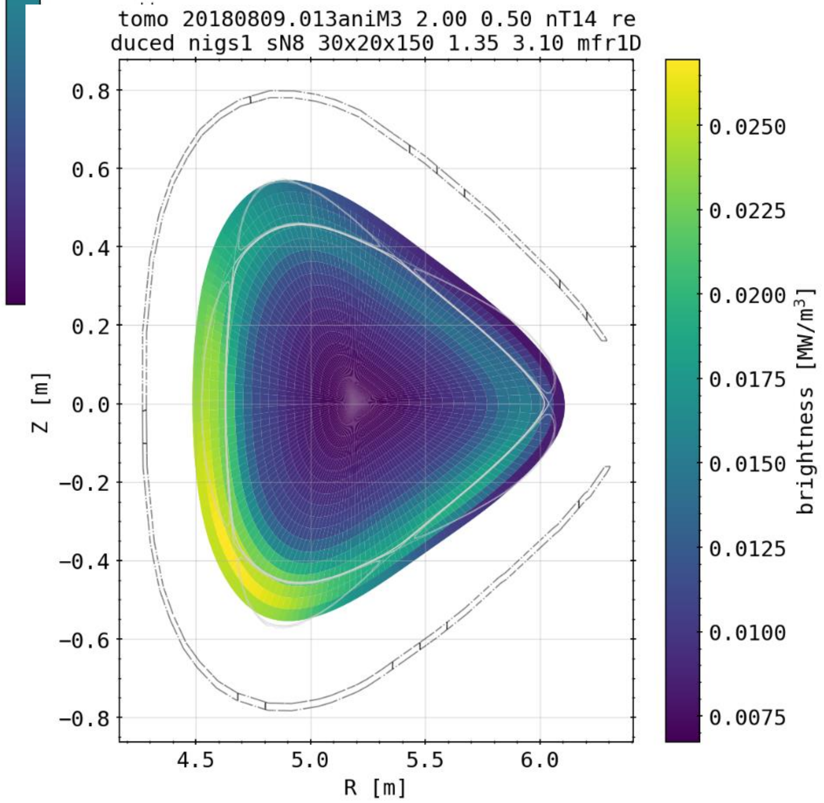
Asymmetry Propagation: 20180809.013





(core symmetric, SOL asymmetric)





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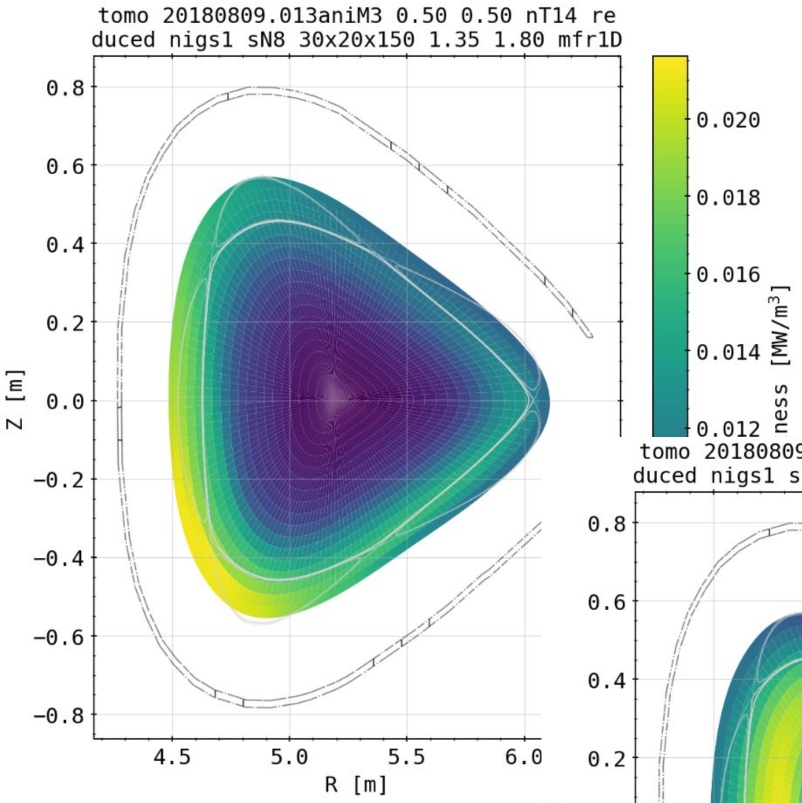
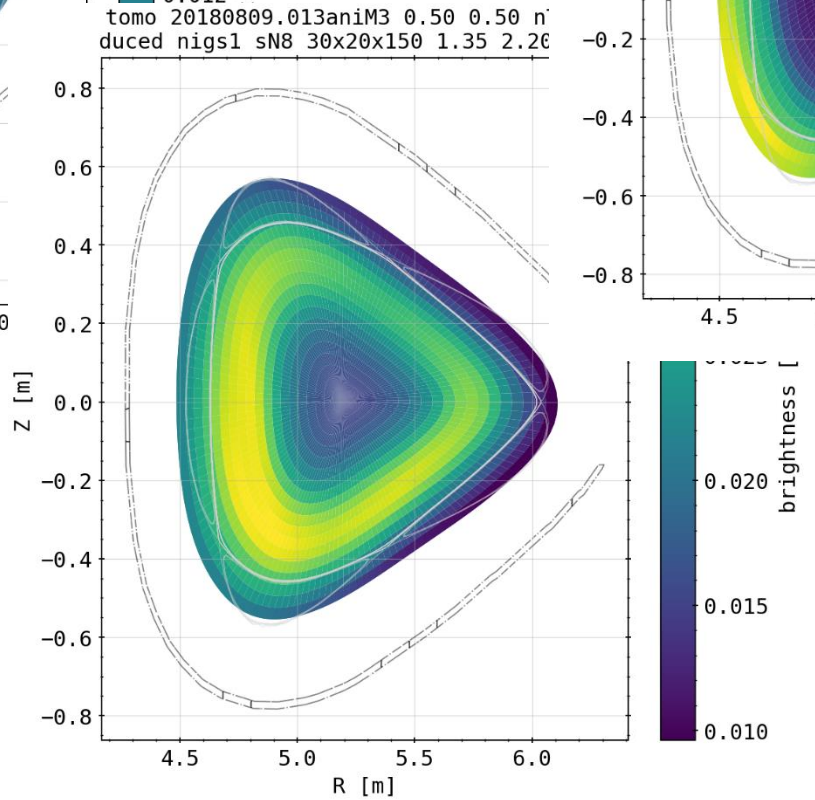
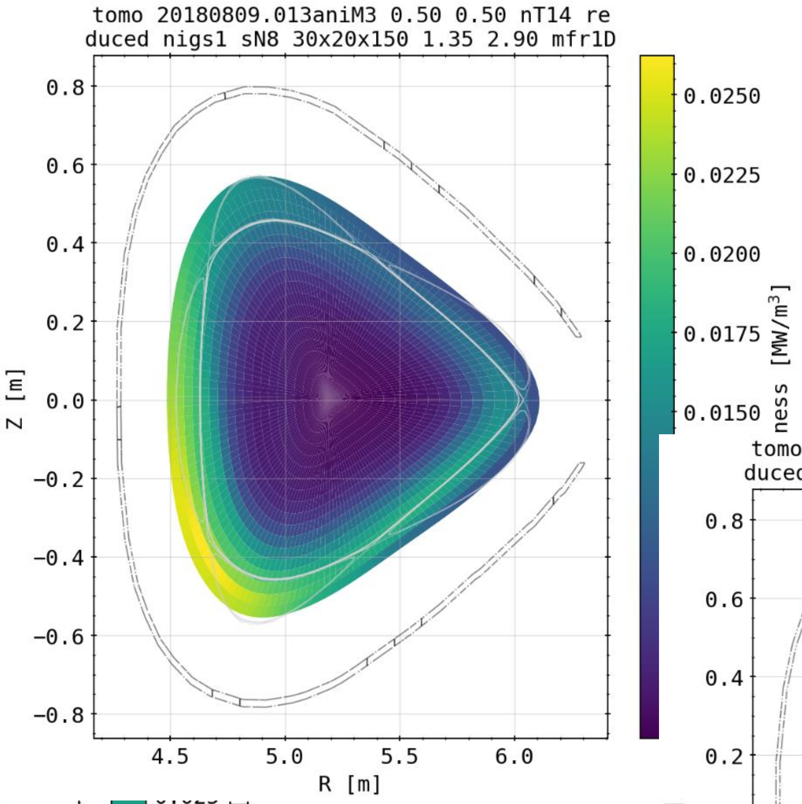
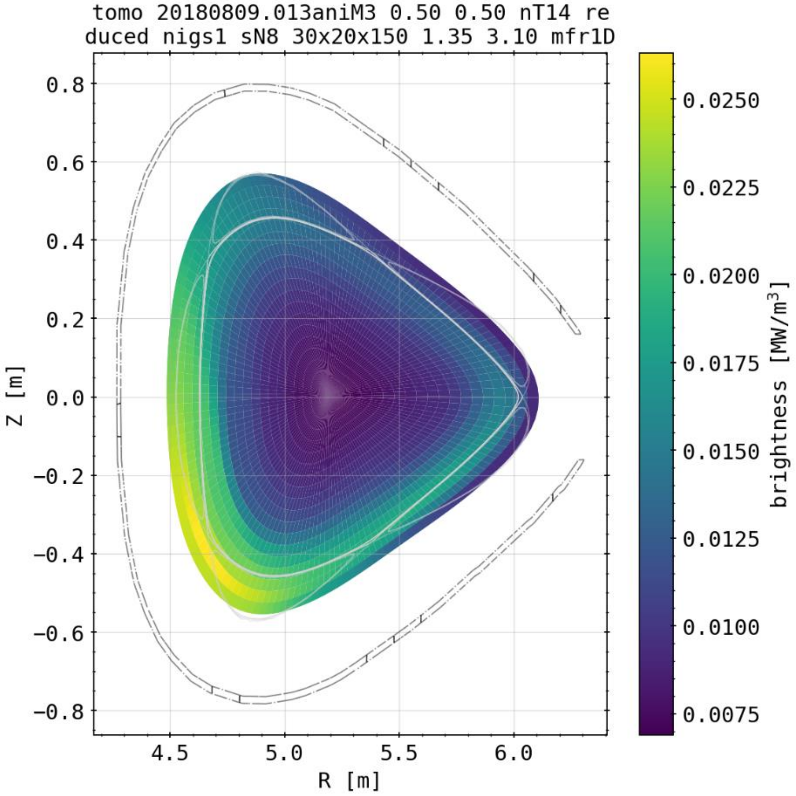






(core symmetric, SOL asymmetric)



Asymmetry Propagation: 20180809.013

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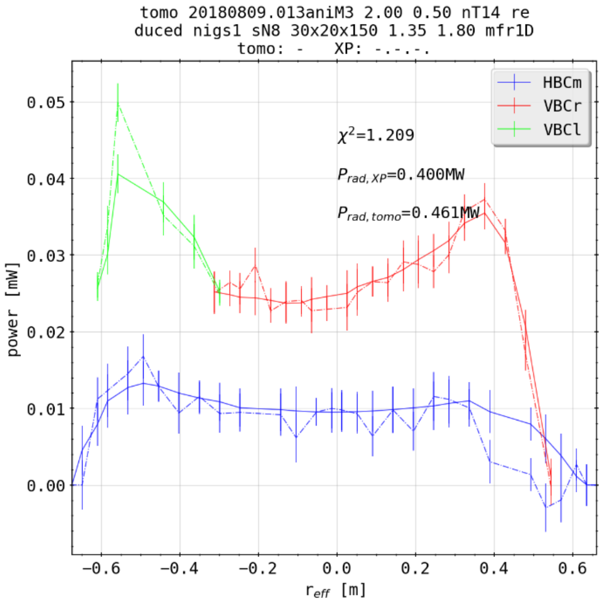
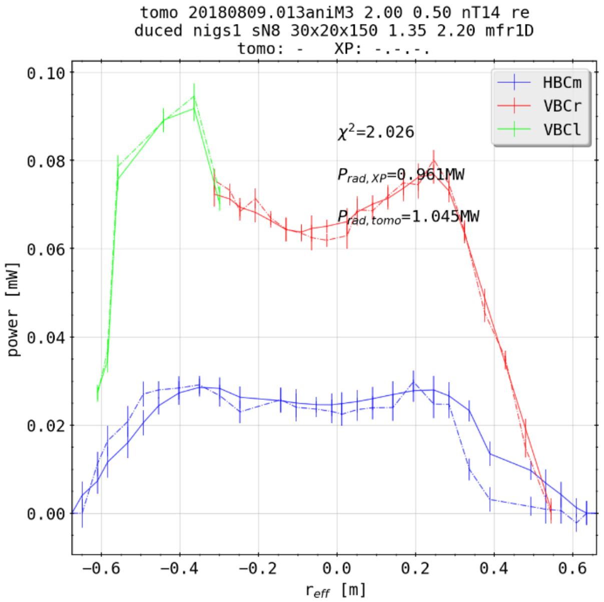
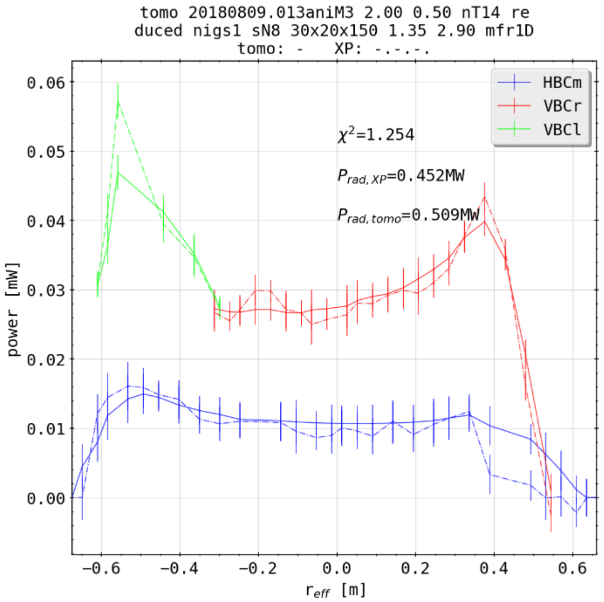
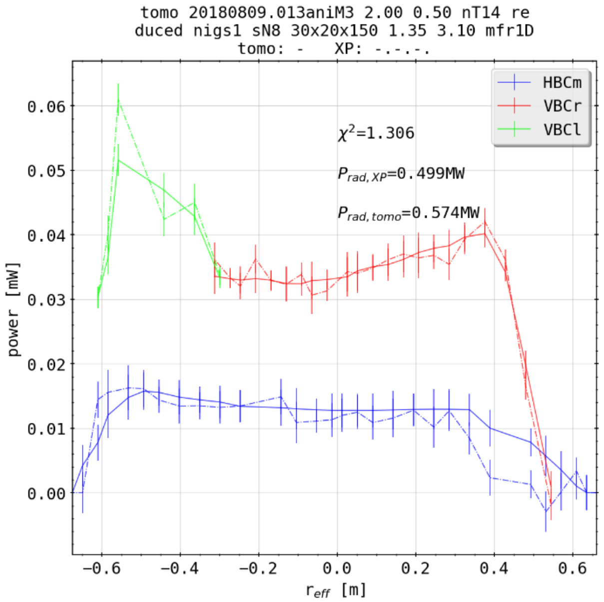
SOL asymmetric)



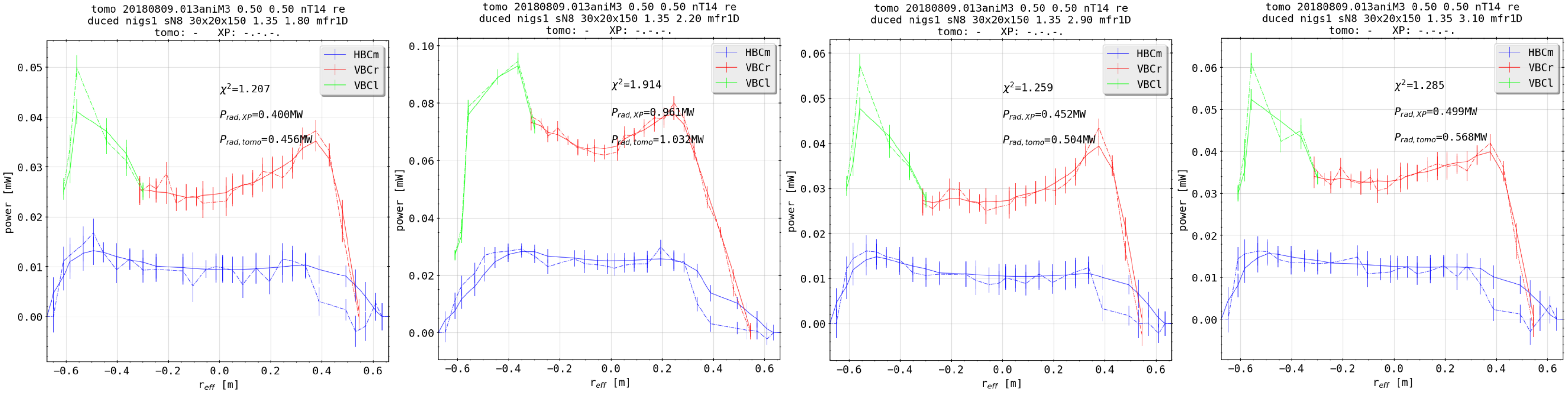






Asymmetry Propagation: 20180809.013

(core asymmetric, SOL asymmetric)



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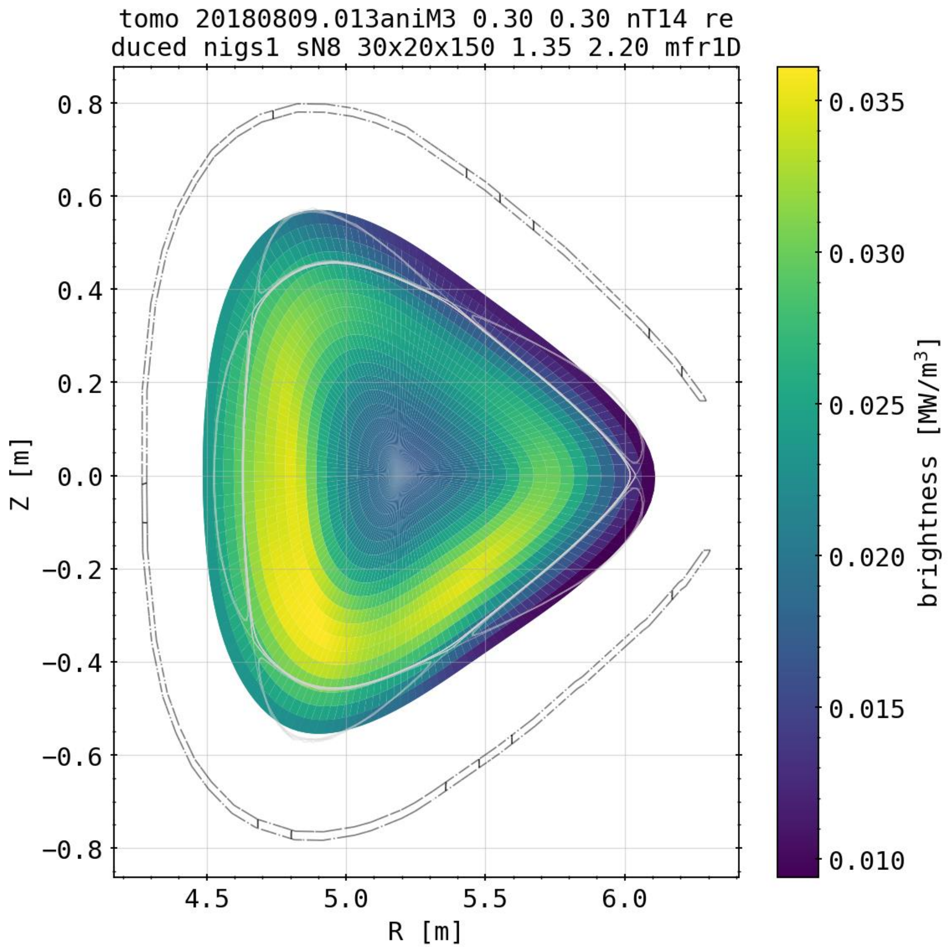
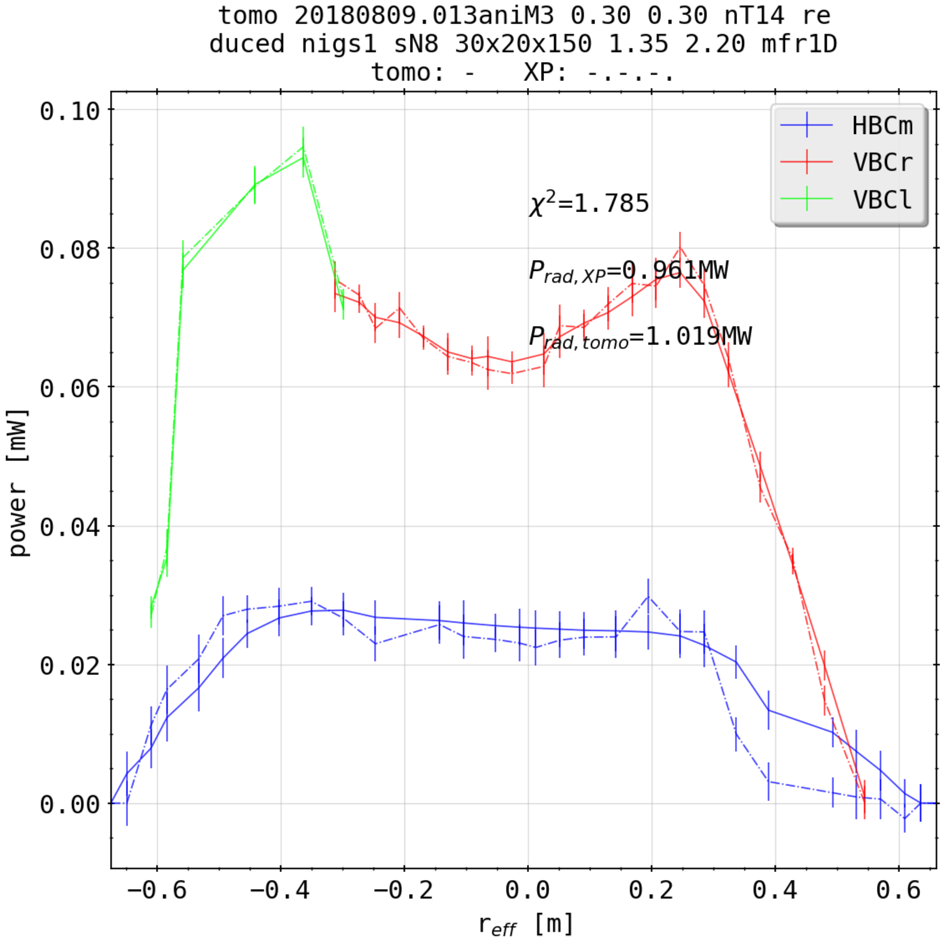


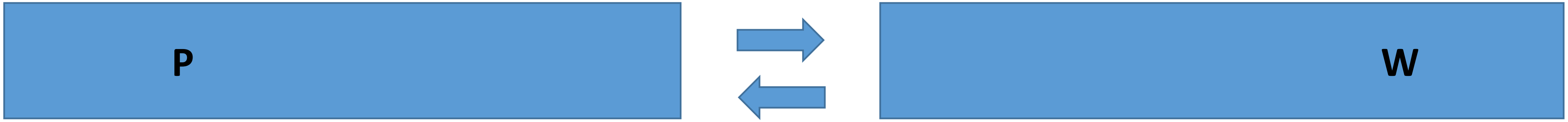


Impurity Seeding: Multi Chamber Model

two chamber model:

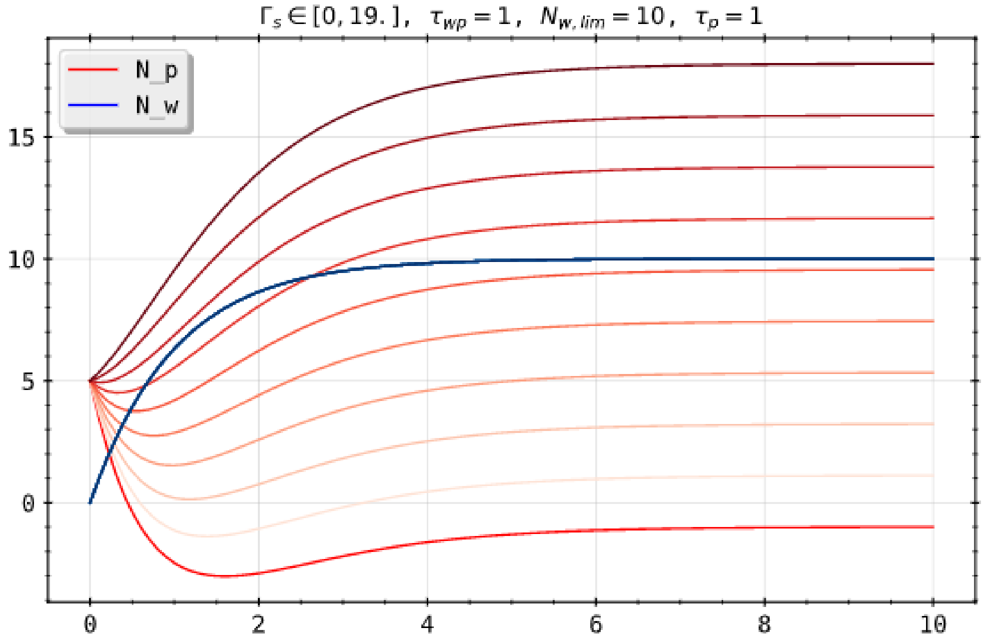
$$\dot{N}_p = \Gamma_s + N_w\,\tau_{w,p} - N_{w,lim}\,\tau_{w,p}\,N_p - N_p\,\tau_p$$

$$\dot{N}_w = (N_{w,lim} - N_w)\,\tau_{w,s}$$



seeding

pumping



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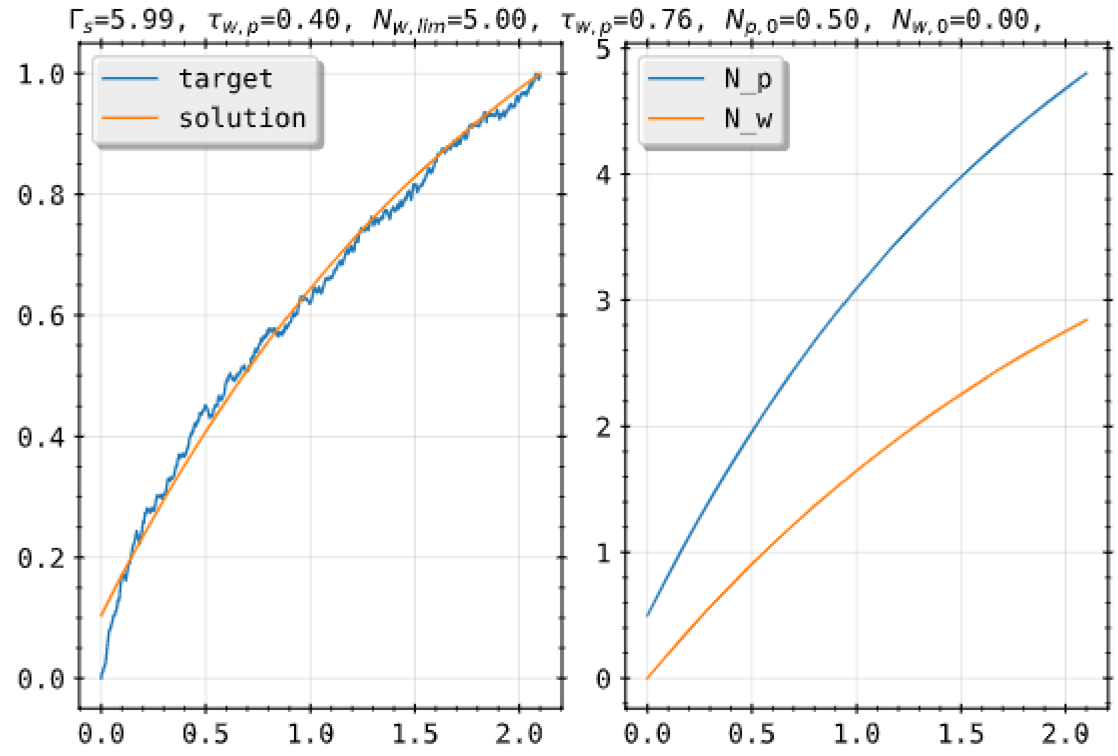
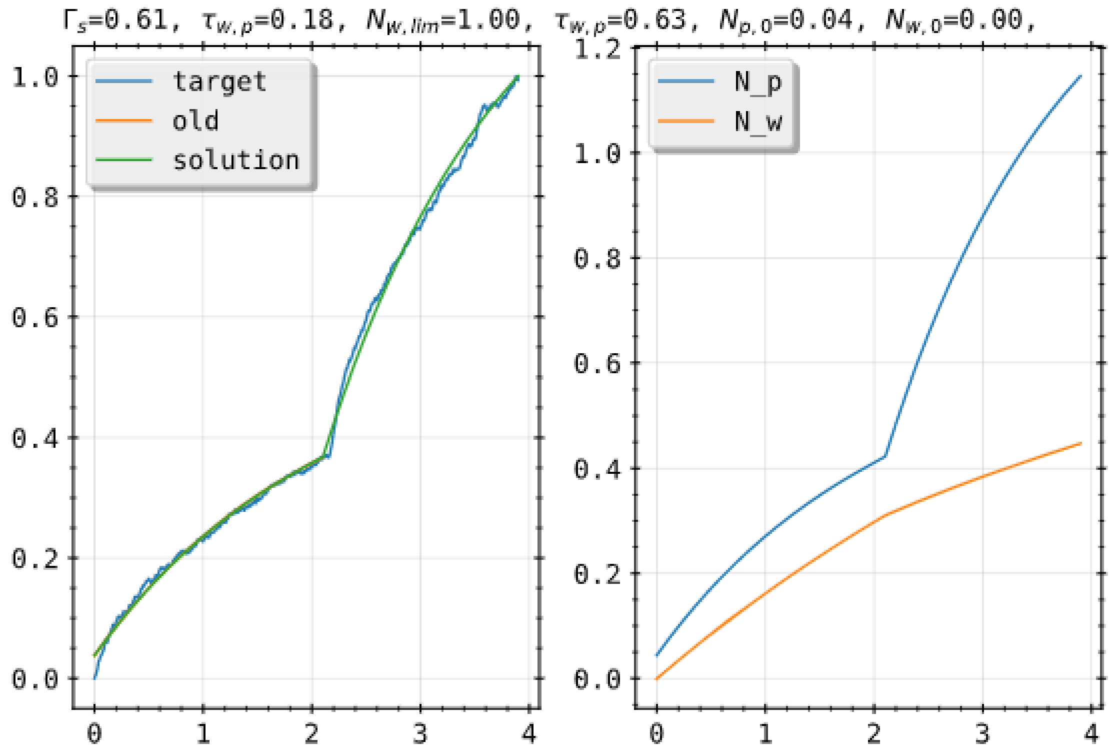
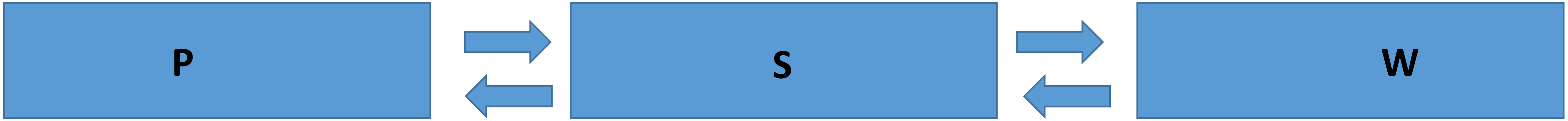




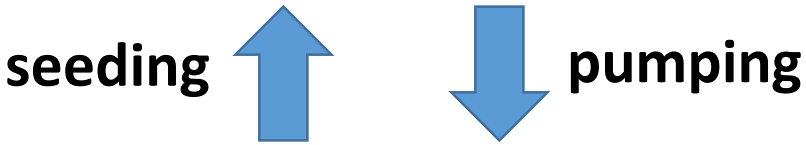
Impurity Seeding: Multi Chamber Model

three chamber model:

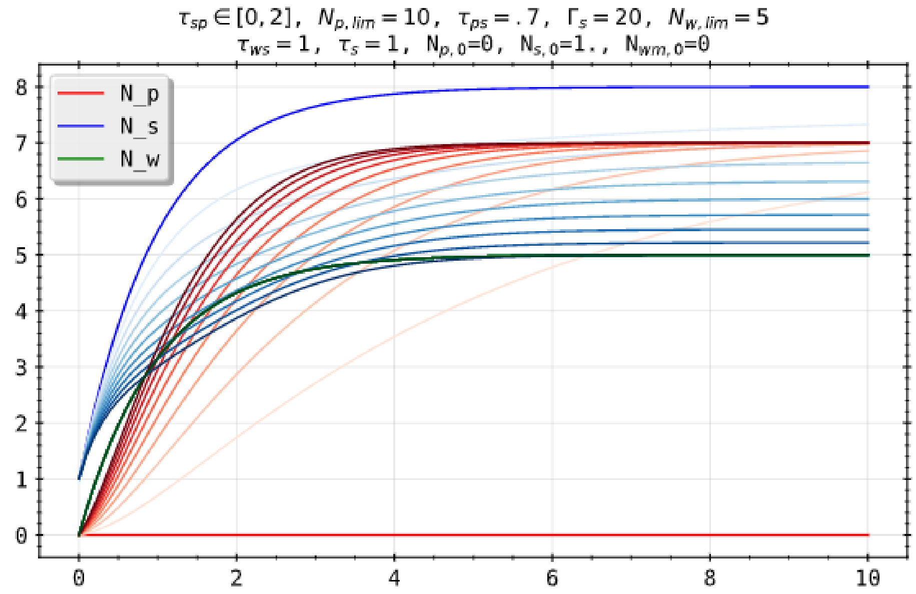
$$\dot{N}_s = \Gamma_s + \frac{N_p\, N_s\, \tau_{s,p}}{N_{p,lim}} - N_{w,lim}\, \tau_{w,s} - N_s\, (\tau_{s,p} + \tau_s)$$



$$\dot{N}_p = N_s\, \tau_{s,p} - \frac{N_p\, N_s\, \tau_{s,p}}{N_{p,lim}\, \tau_{p,s}}$$



$$\dot{N}_w = (N_{w,lim} - N_w)\, \tau_{w,s}$$



Impurity Seeding: Multi Chamber Model

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