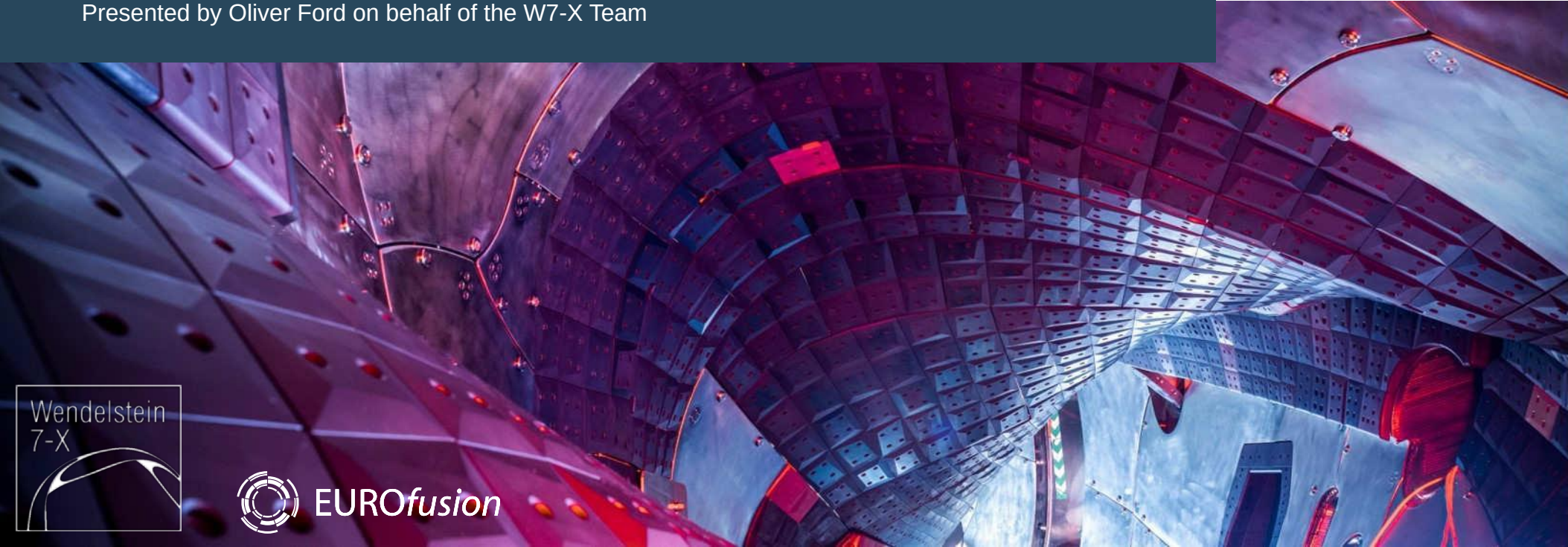




OP2 NBI+ECRH density peaking and performance

Presented by Oliver Ford on behalf of the W7-X Team



Topical Group Scenarios - May 2023

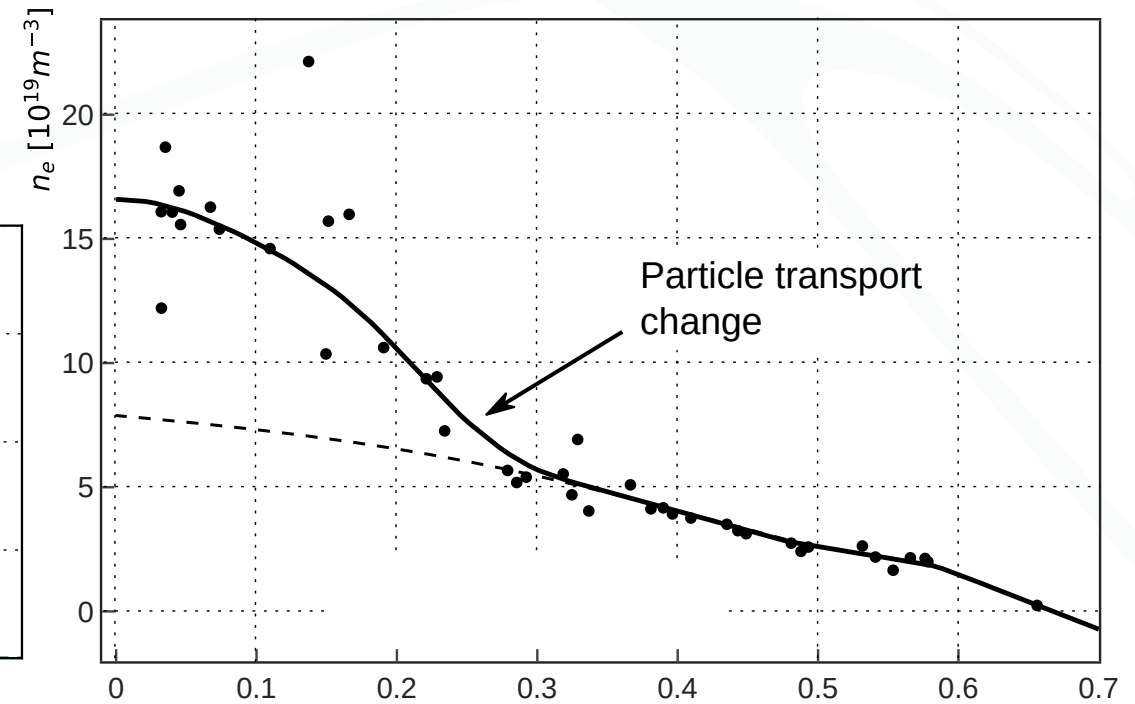
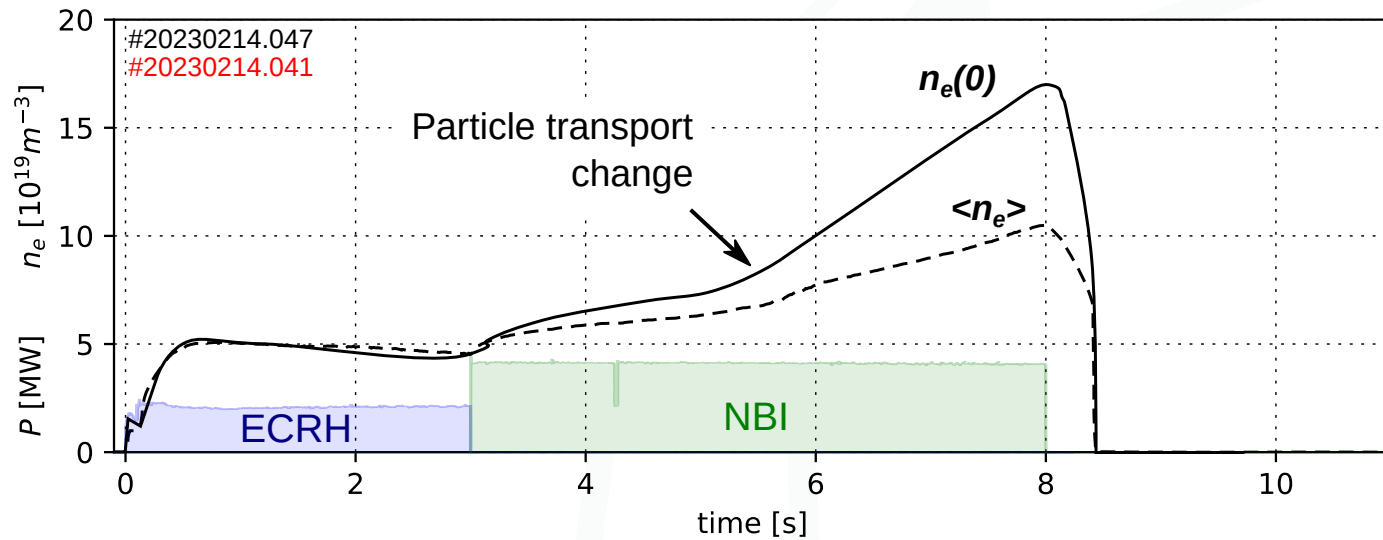


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NBI core density peaking

Core density peaking with NBI (observed in OP2.1b) examined in detail.

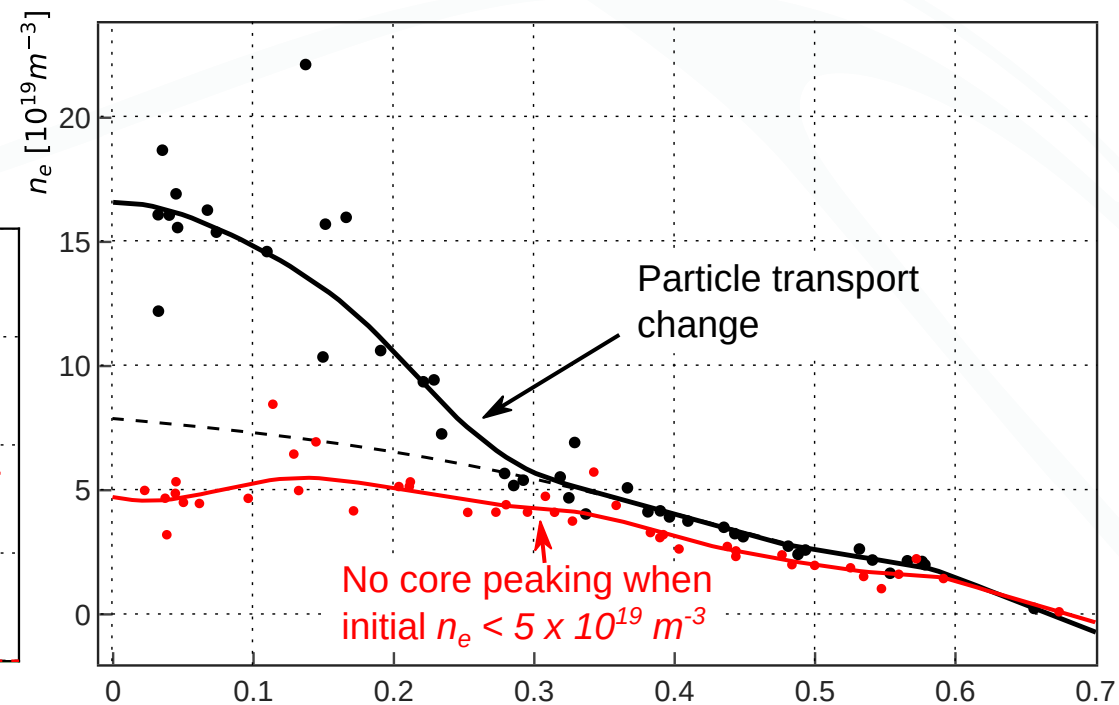
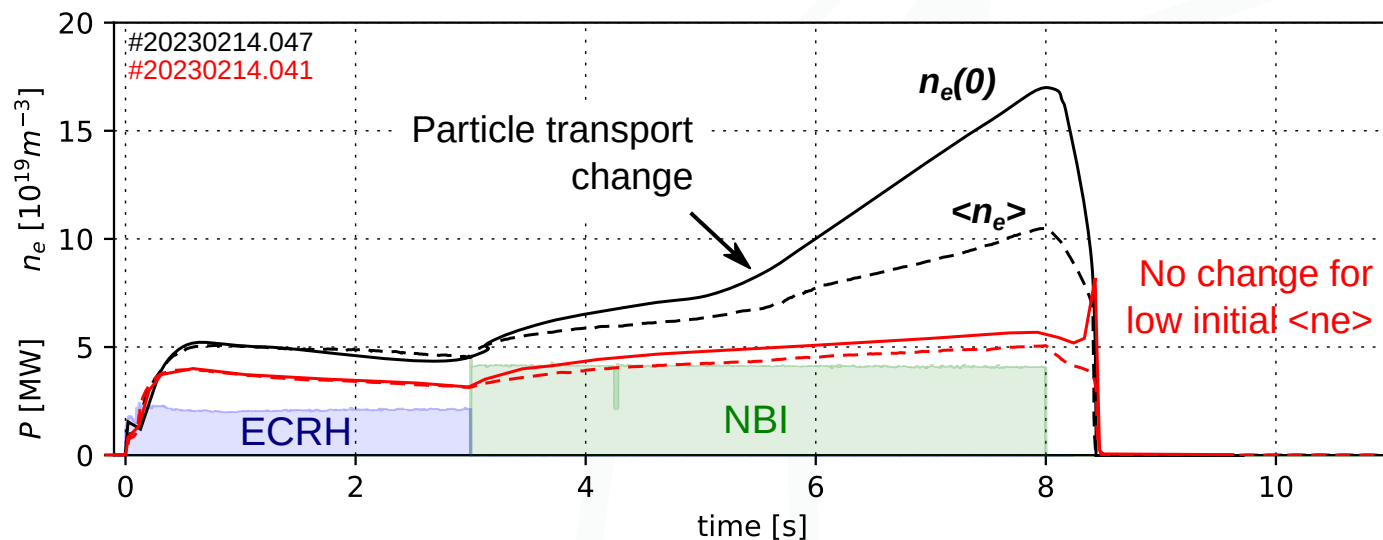
- Abrupt change of particle transport within fixed radius when passing some threshold.



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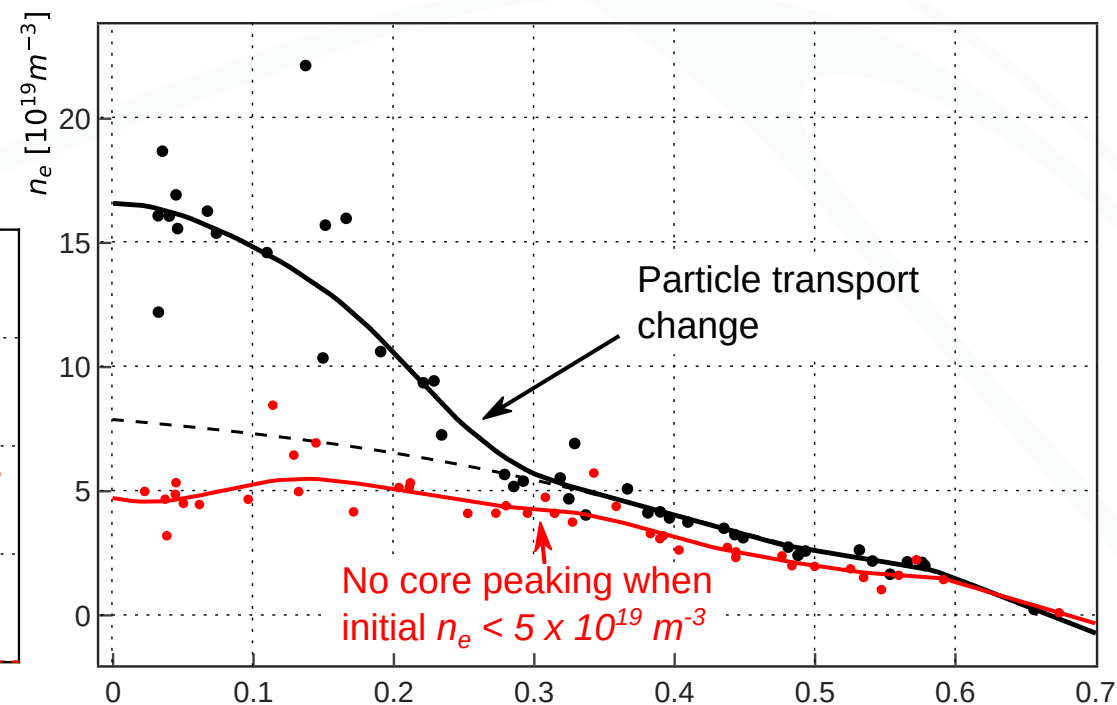
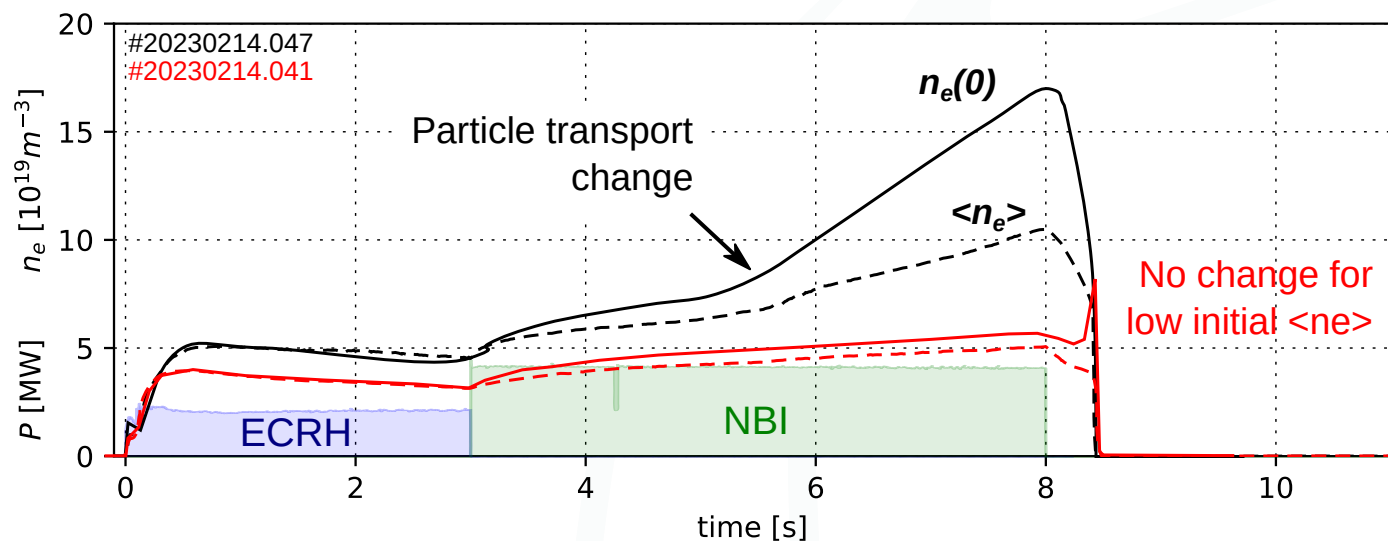
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- On-set dependence on initial density confirmed.



NBI core density peaking

Core density peaking with NBI (observed in OP2.1b) examined in detail.

- Abrupt change of particle transport within fixed radius when passing some threshold.
- On-set dependence on initial density confirmed.
- Radial location appears to change with configuration (maybe).
- Co/counter source selection has no significant effect.
- Scaling of peaking with source rate not clear (varied number of NBI sources).



ECRH pump-out

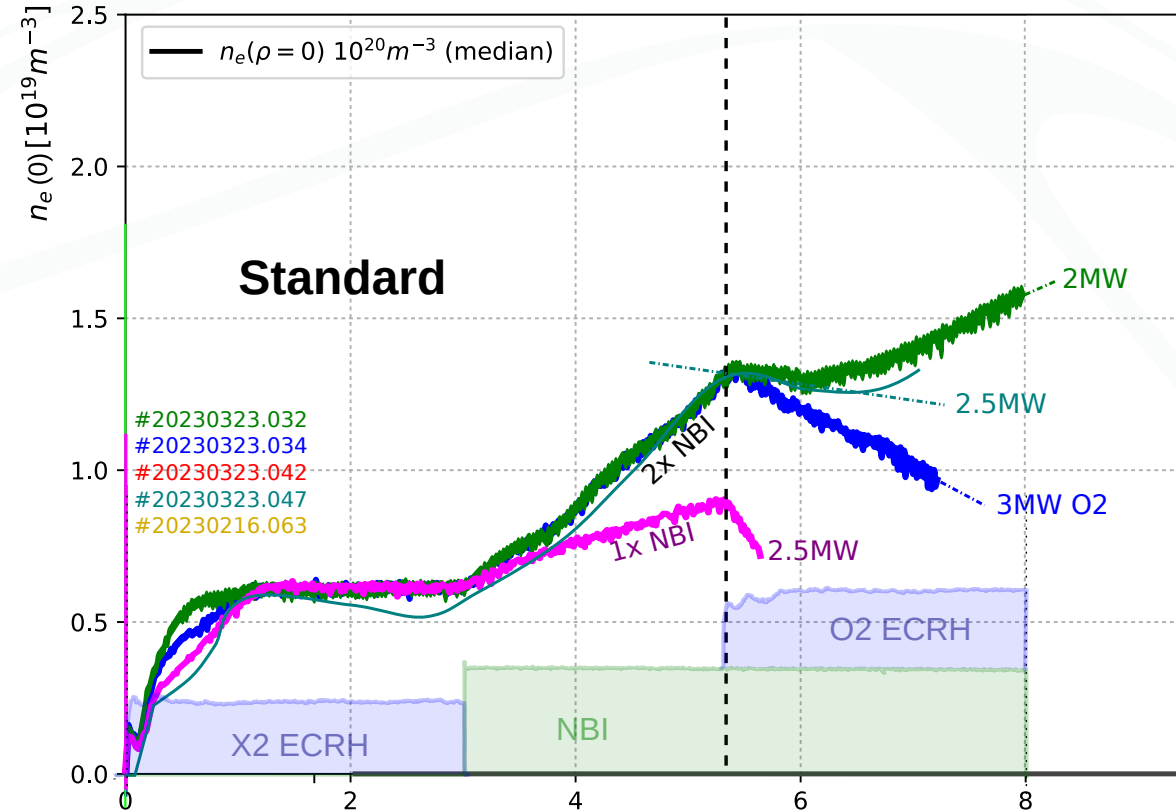
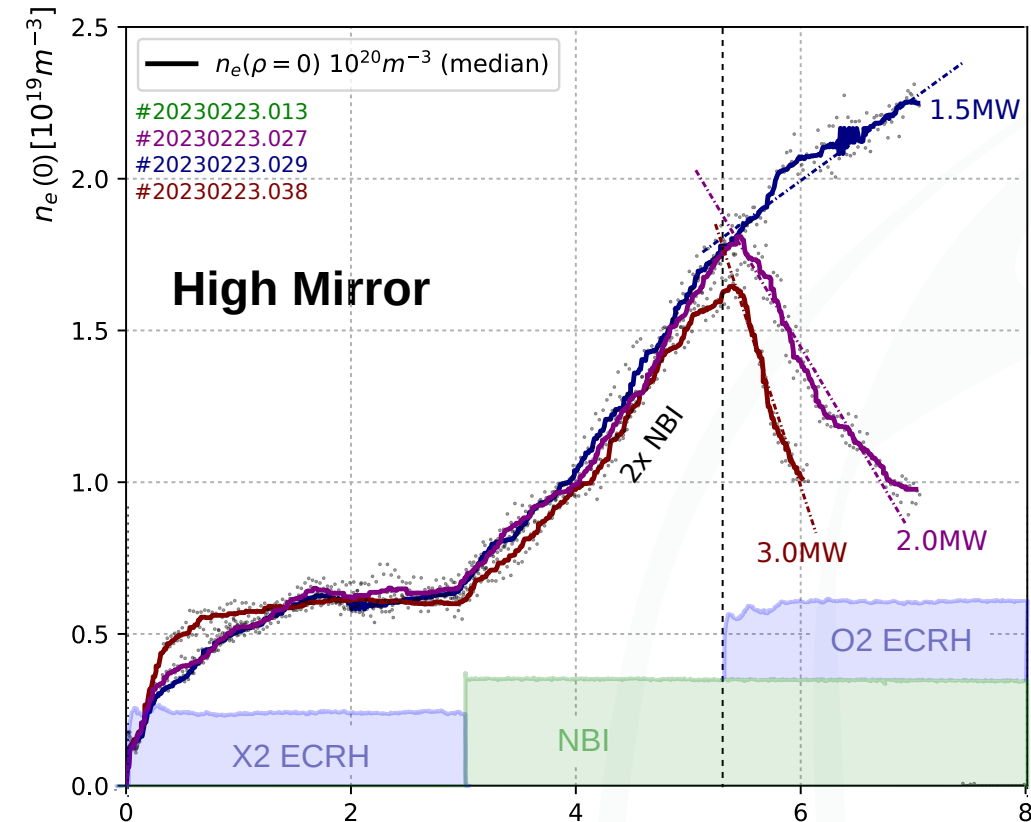
- Re-introducing ECRH pumps-out density and impurities.
- Investigated effects on pump-out rate:

Significant:

- ECRH power.
- NBI source rate
- Initial density
- Magnetic configuration

Not significant:

- O2 vs X2 absorption
- O2 off-axis (gyrotron choice)



ECRH pump-out

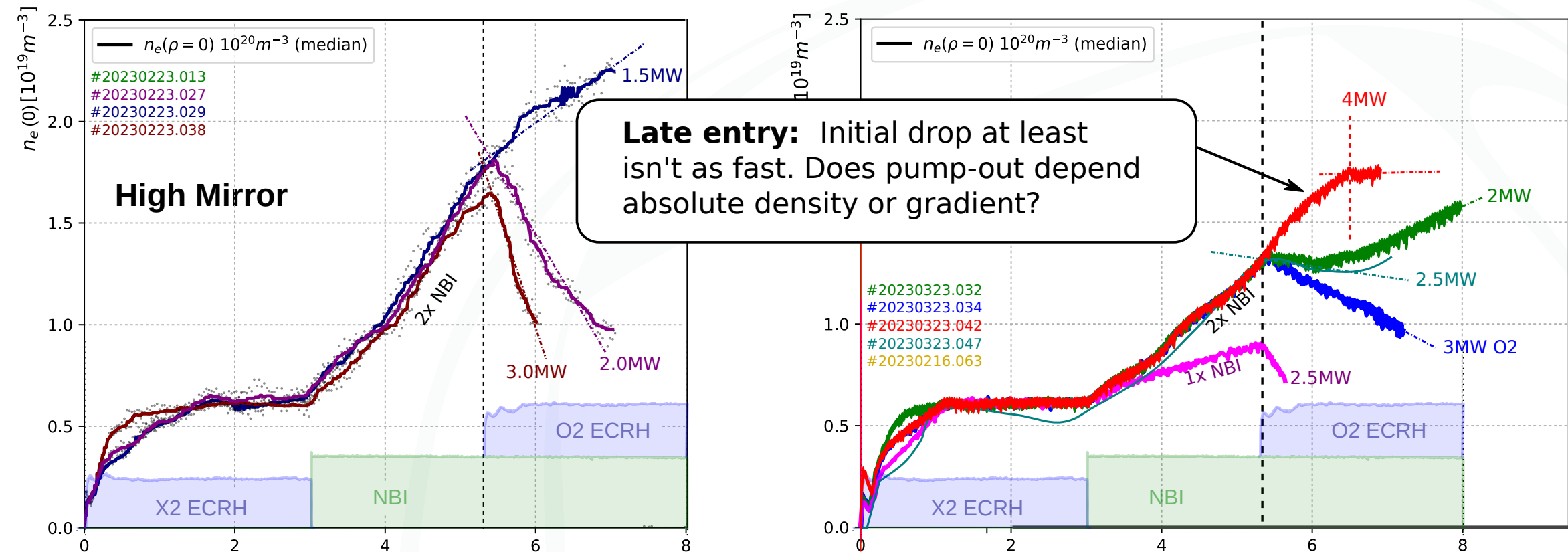
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ECRH pump-out

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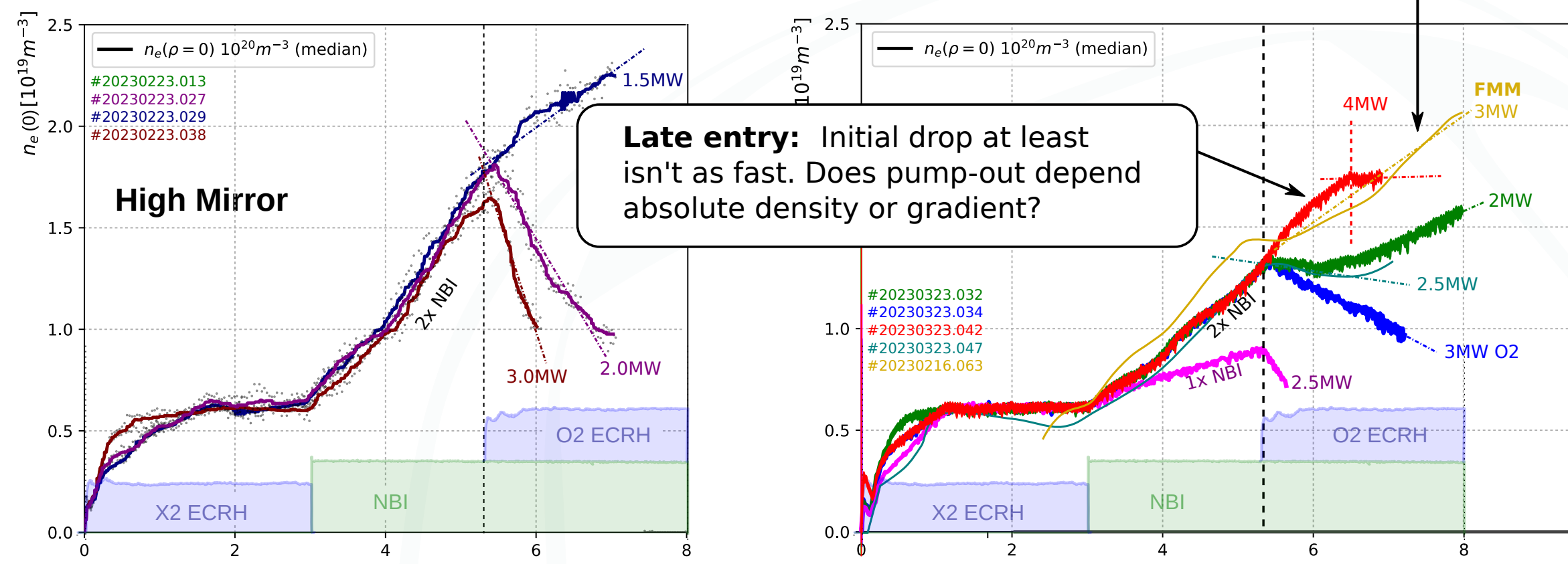
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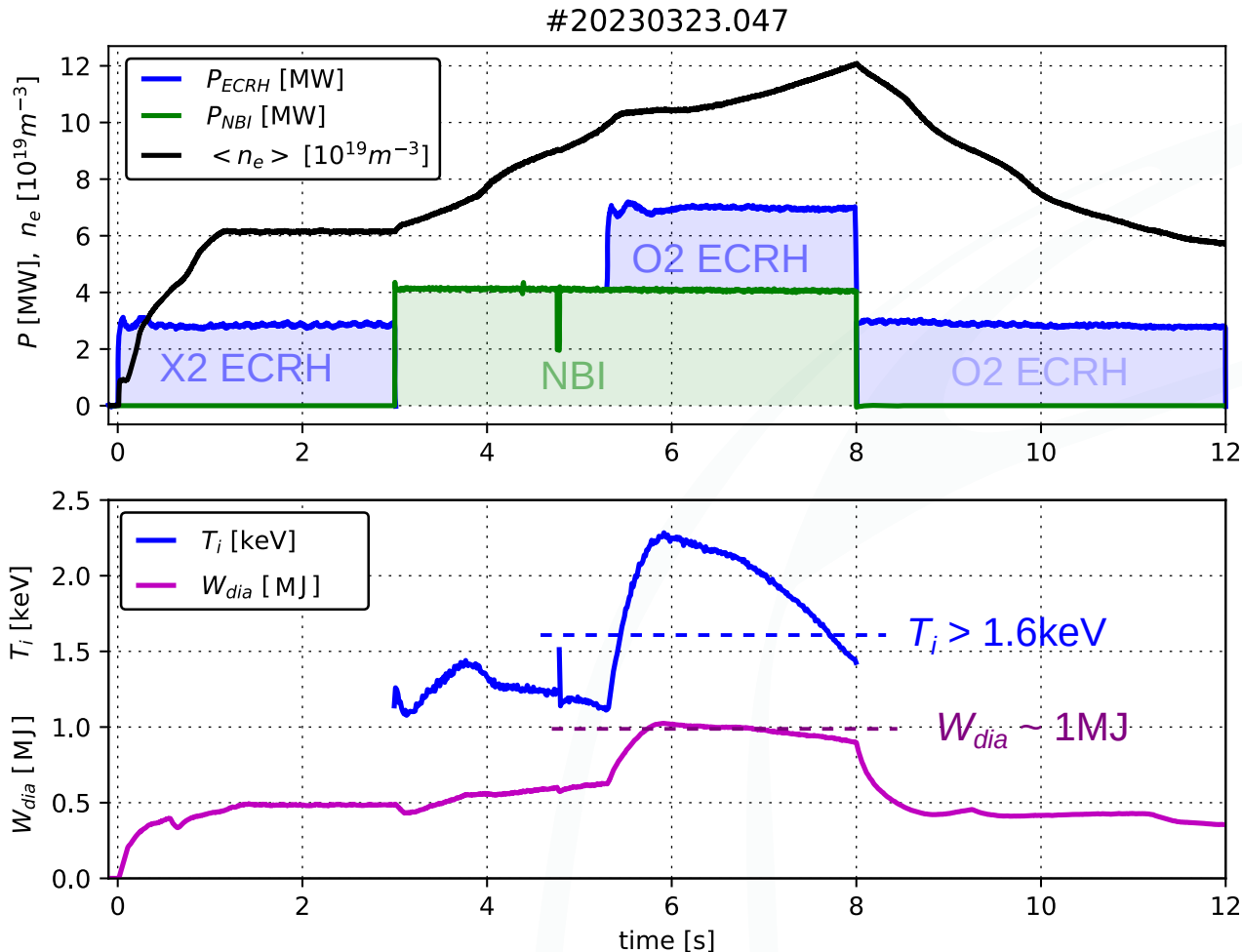
FMM configuration: Limited pump-out even at 3MW ECRH --> High-performance candidate.

Late entry: Initial drop at least isn't as fast. Does pump-out depend absolute density or gradient?



NBI +O2 ECRH reintroduction

- Find a balance of NBI core density peaking with ECRH:
 - Too much ECRH --> Gradients collapse --> Strong turbulent transport --> $T_i \sim 1.6\text{keV}$
 - Too little ECRH --> Reduced transport but density+impurity accumulation --> low power/particle --> $T_i \sim 1.6\text{keV}$

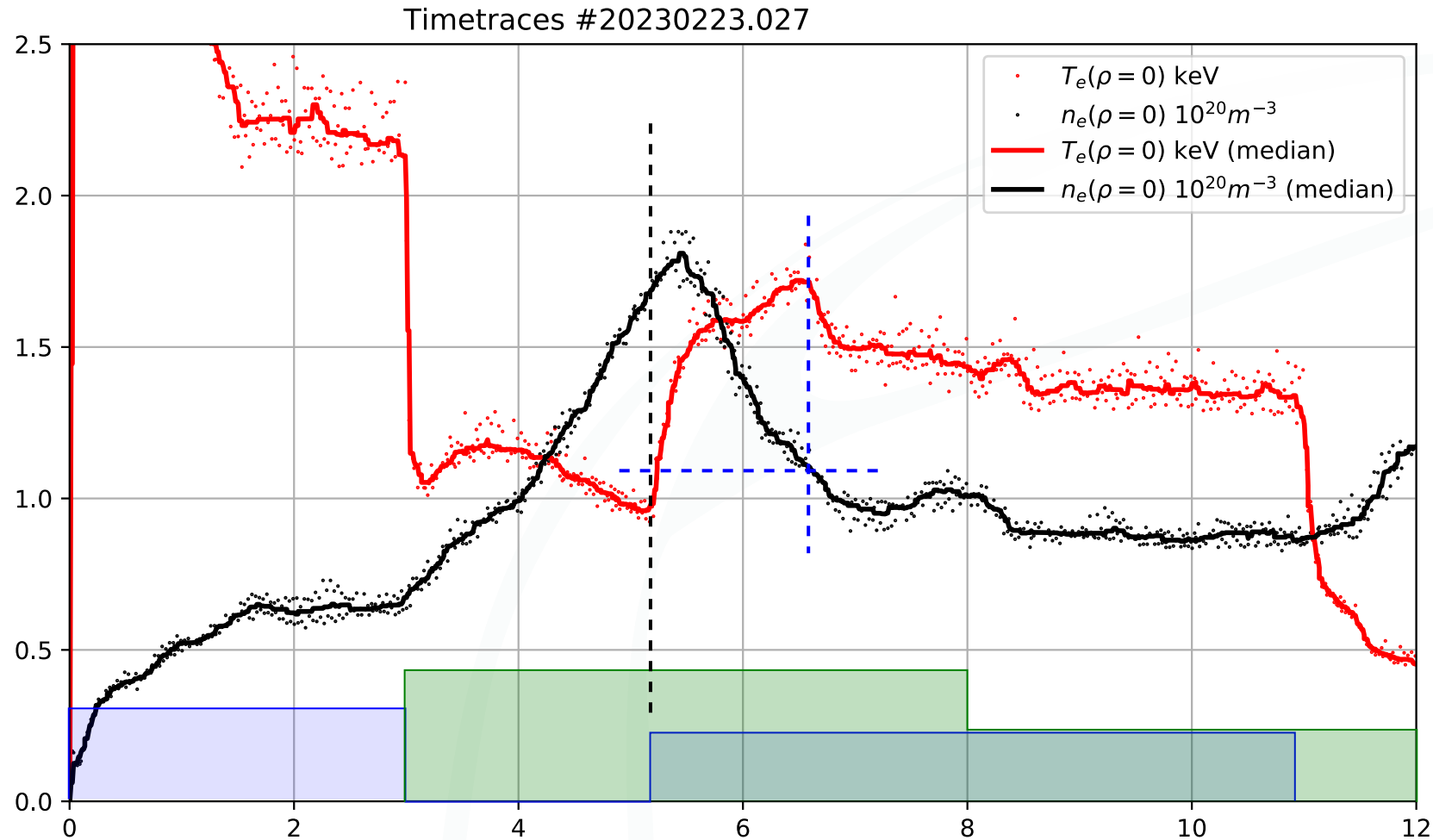


- Held $T_i > 2\text{keV}$, $W_{dia} \sim 1\text{MJ}$ for 1.0s before density rises further.
 - > Possible indefinitely with real-time control of ECRH power against central density.

In the meantime, we have a method to dial in reduced turbulent transport scenarios on relevant timescales ($t \gg \tau_E$).

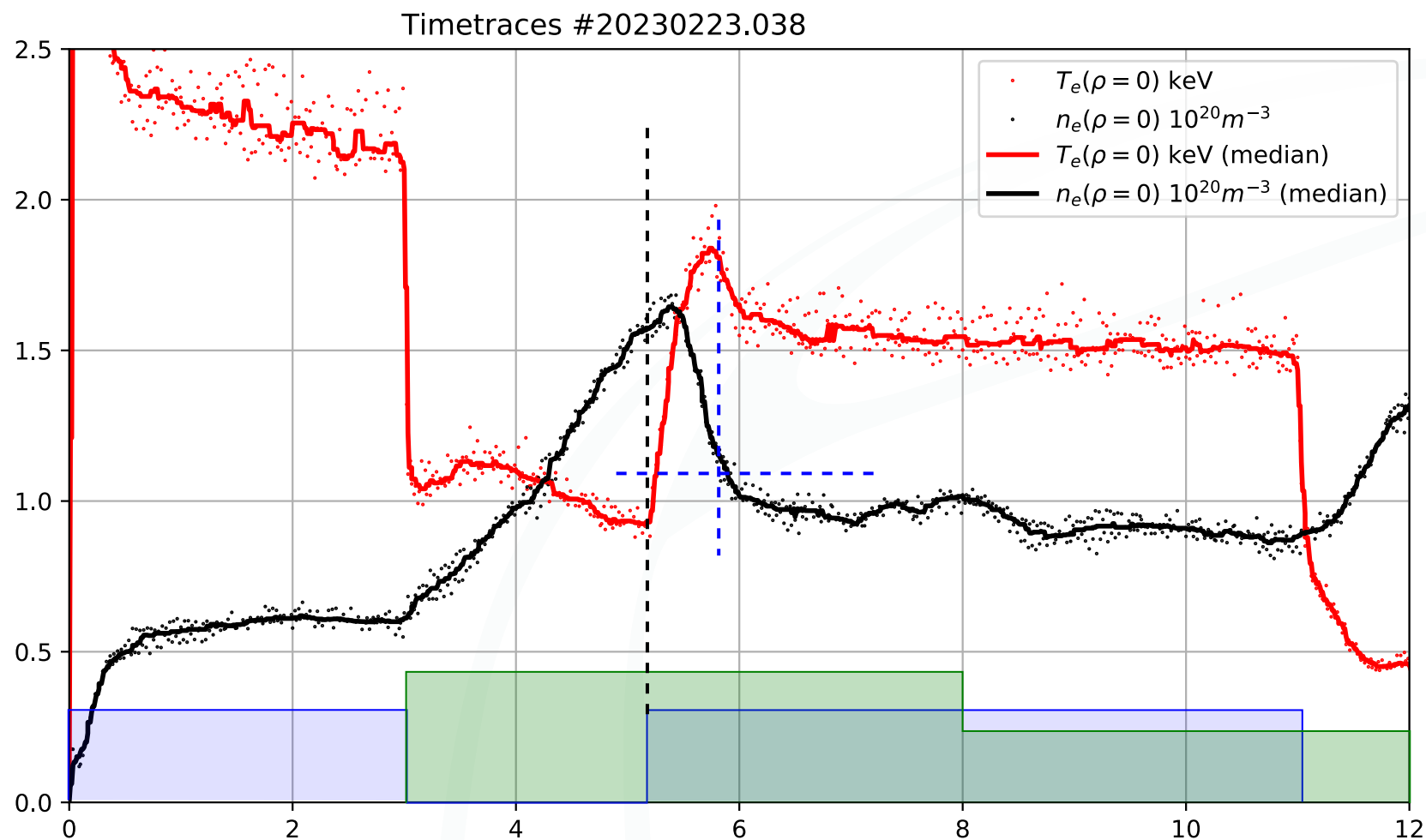
Back transition

- In OP2.1 we also see clearly the back-transition out of reduced turbulence as the density gradient reduces:



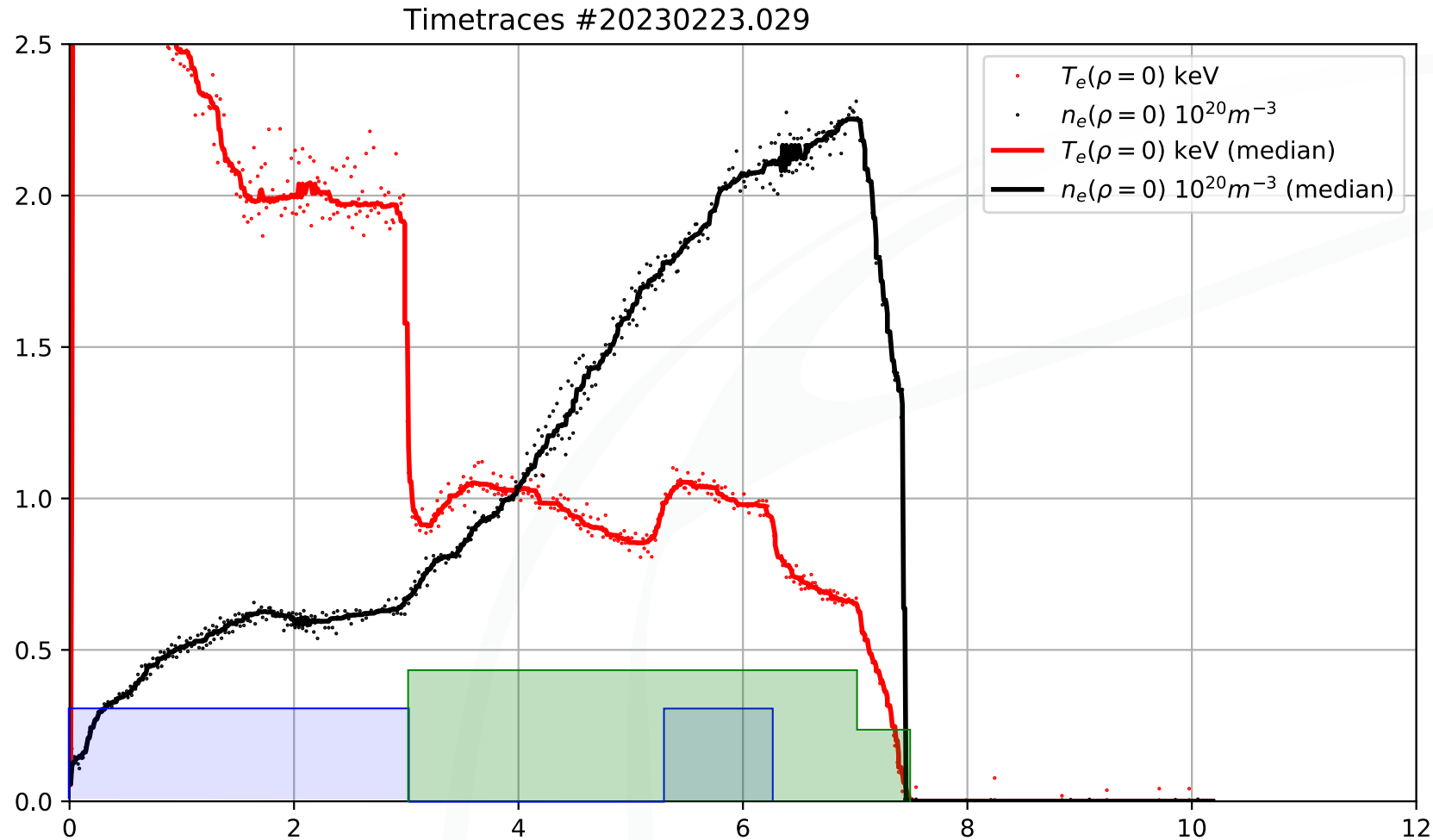
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- Density drop is faster/slower depending on ECRH power, but back-transition looks to be at a similar density level.



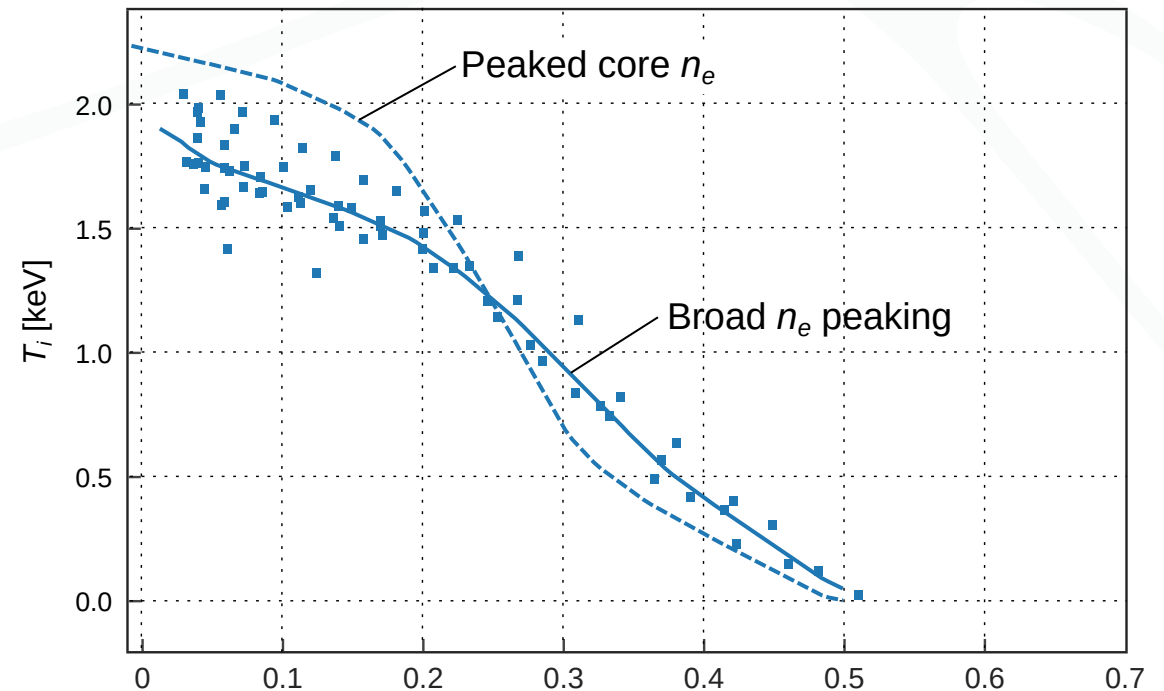
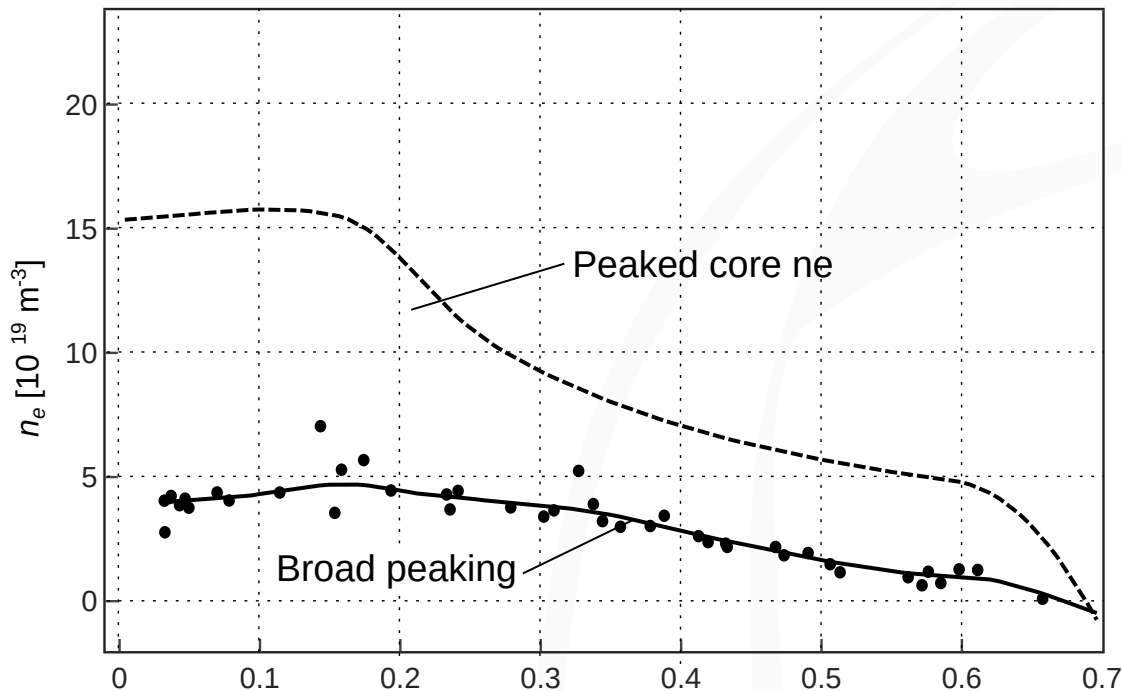
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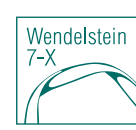


NBI+ECRH high performance

- Another scenario was found in OP2.1 with broadly peaked density (no strong core peaking!), but with higher T_i .
- Fully stable $T_i \sim 2\text{keV}$ (above 1.6keV clamping limit) for 4s, but lower $\langle n_e \rangle$ and W_{dia} .
- Not seen in high-mirror but also unable to reproduce in Standard due to gyrotron drop-out and then too high recycling (maybe?).
- Indicates importance of recycling conditions.
- Allows wider range of possible profiles:



NBI+ECRH high performance



- Just for info, I wouldn't show this!
- Slowly making progress....
- These are **very very** rough numbers! No dilution (Zeff), no integrals etc etc.

