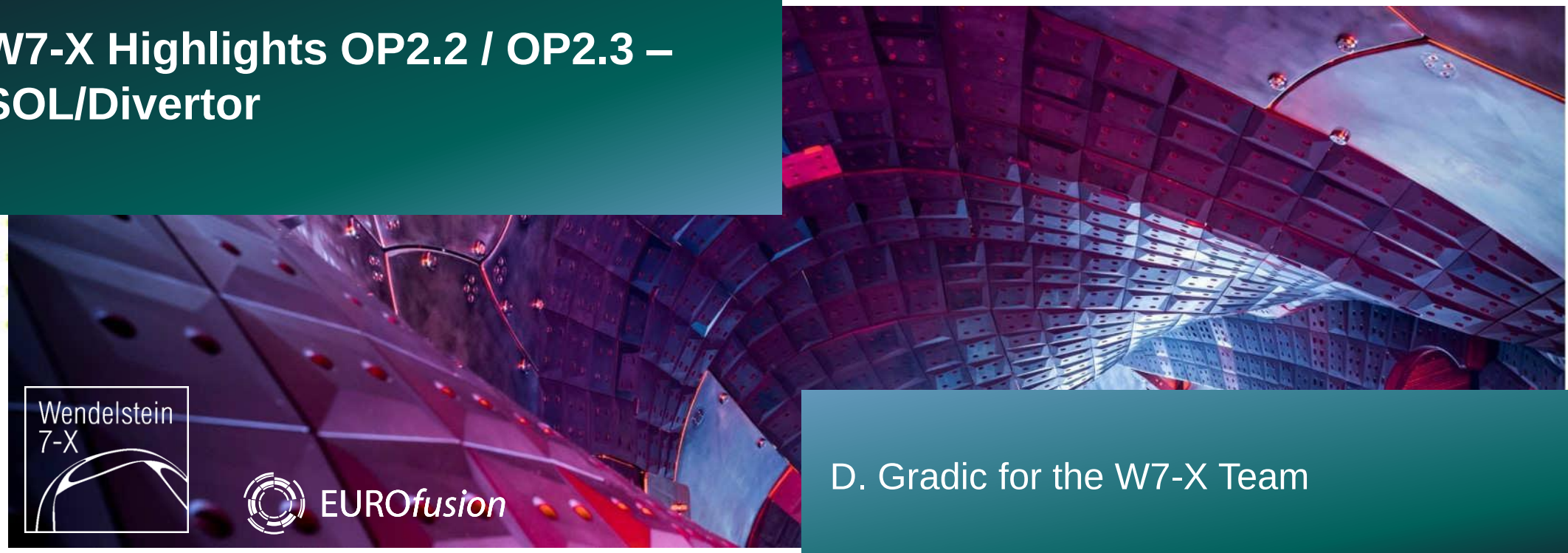
MAX-PLANCK-INSTITUT
FÜR PLASMAPHYSIK

W7-X Highlights OP2.2 / OP2.3 – SOL/Divertor



D. Gradic for the W7-X Team

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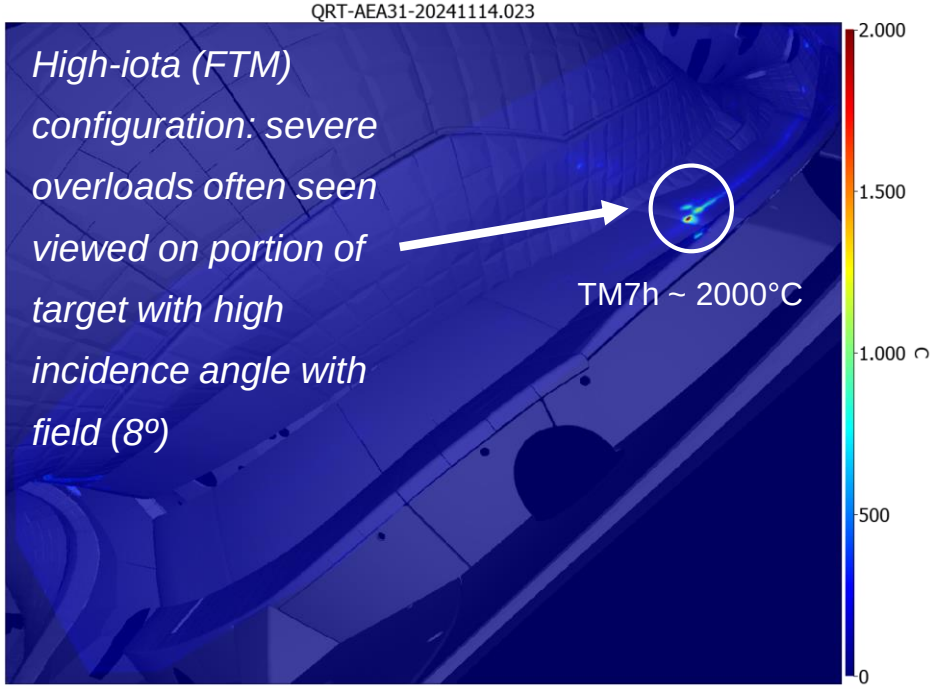
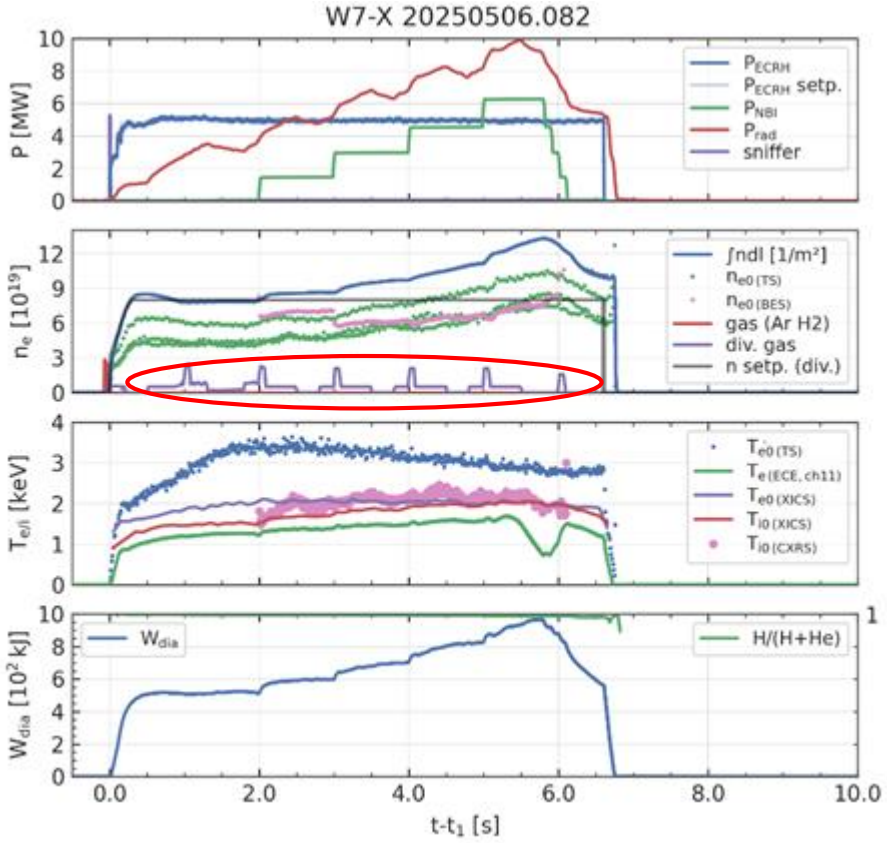
Addressing divertor overloads

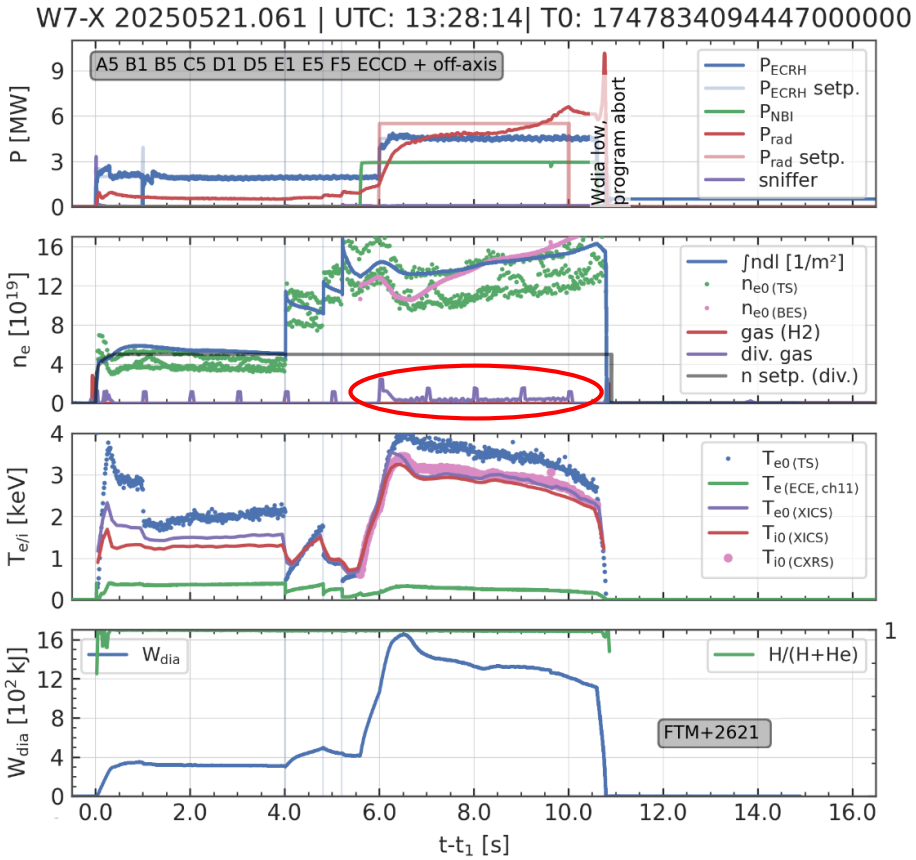
- **Higher heating powers (≥6 MW) caused divertor overloads limiting operation in several configs, most critical in FTM**
  - Overloads were often in shadowed regions where deposition was not anticipated by early modeling
- **Mitigation strategies developed and tested**
  - Modify edge topology with control coils/planar coils
  - Sweep strike lines with AC current in control coils
  - ECCD to control strike line location
  - **Impurity seeding: <u>most reliable and universally applicable approach</u>**



Seeding in combination with High power/high performance programs → safe divertor



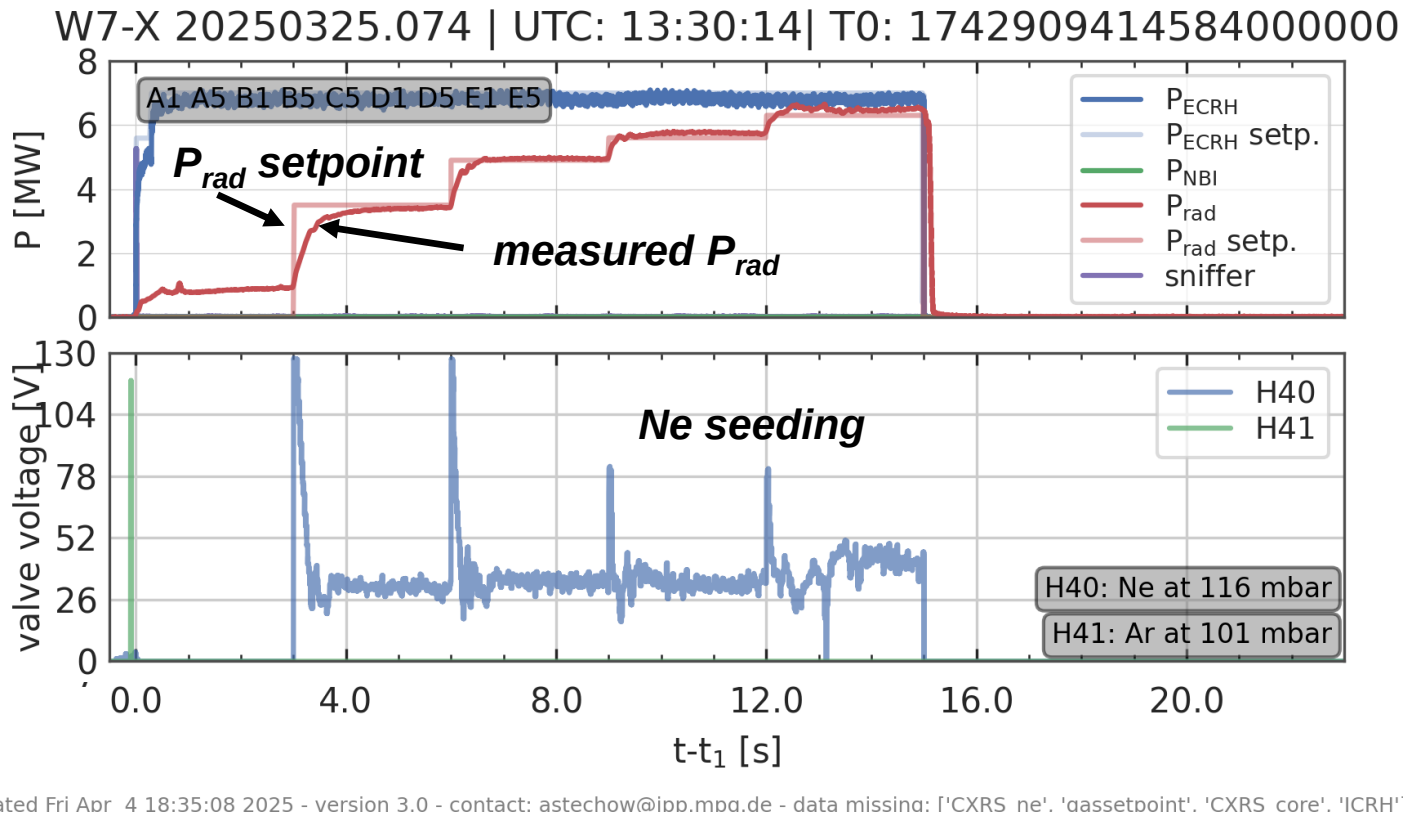
High power (12 MW), **feedforward** Neon seeding with safe divertor in FTM



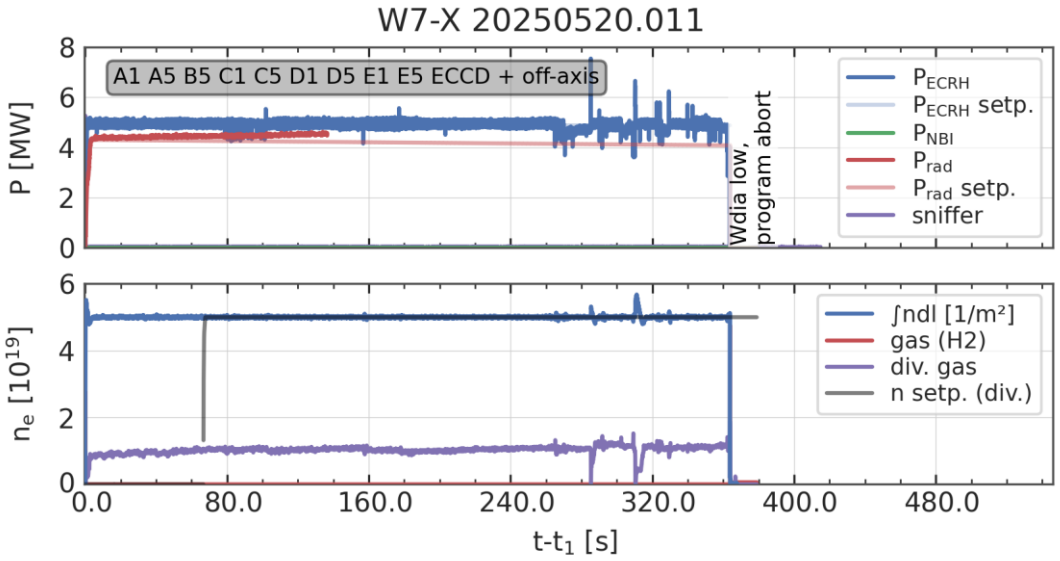
High performance with **feedback** Neon seeding with safe divertor in FTM

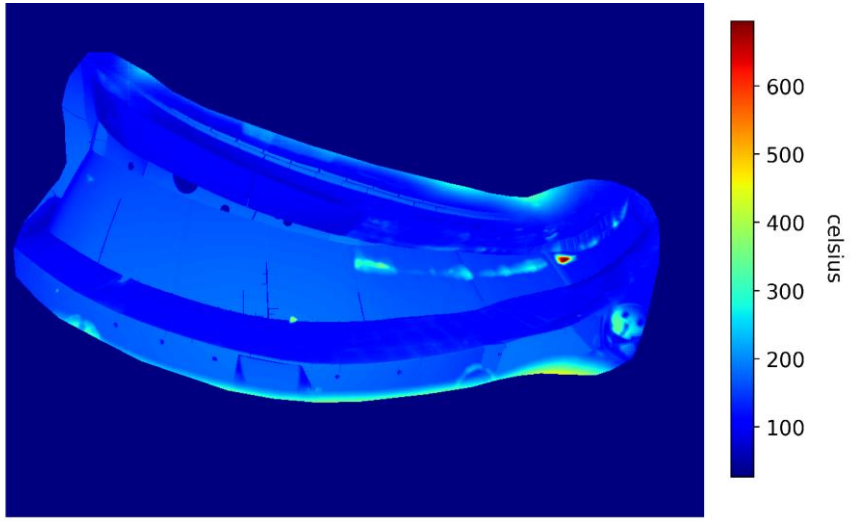
Direct control of radiated power P_{rad} through feedback-controlled impurity seeding

- P_{rad} determined in real time from bolometer signal
- Seeding valve voltage adjusted with PID controller to admit impurity gas (neon or nitrogen) to achieve desired P_{rad}
- P_{rad} values up to 6 MW have been achieved and steadily maintained, sustaining fully-detached plasmas



1.8 GJ injected energy record with “detached scenario”





6 min plasma (363s) with P=4.9 MW → **new injected energy record of 1.785 GJ**

Use of Feedback-regulated Neon seeding (Prad-target = 4.3 MW) to keep divertor safe → radiative detachment

Use of all 11 gyrotrons in „power stabilisation mode“

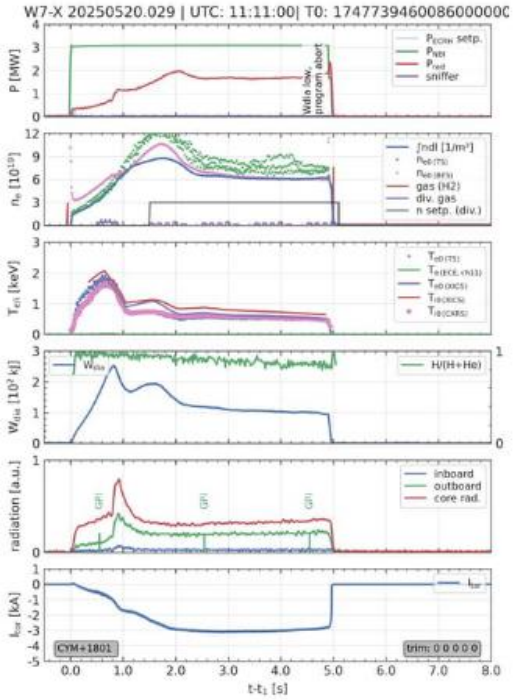
Program stopped by ECB cooling water rise from 18°C up to 29°C within 360s

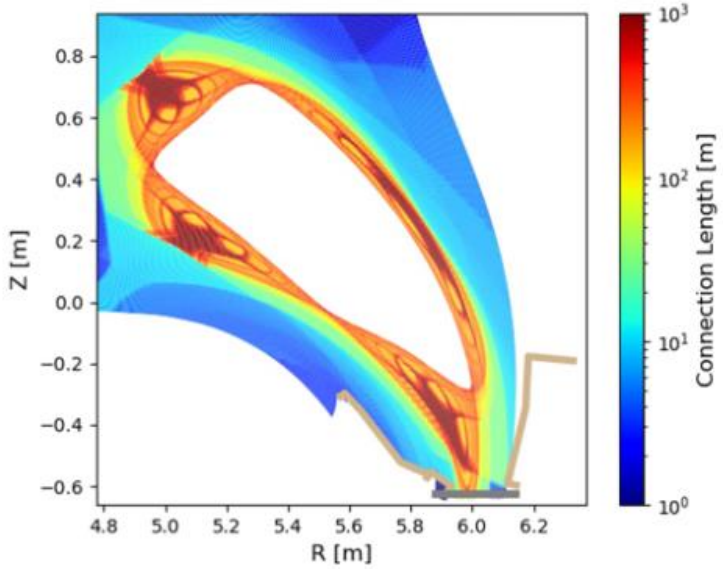
Good machine condition: Neon-seeding & H-fueling, impurity radiation fronts and intensities stable within SOL

First Look into a non-resonant divertor configuration at W7-X

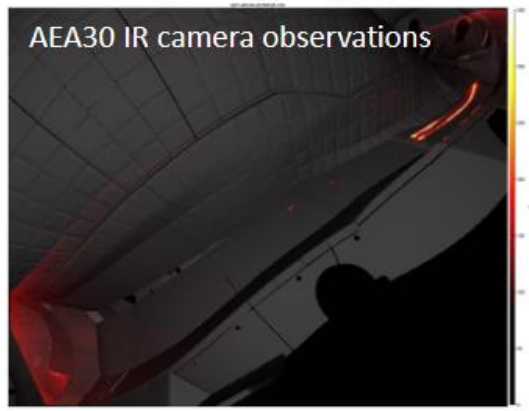
NRD studies in CYM000+1810, all discharges succeeded at the first attempt!

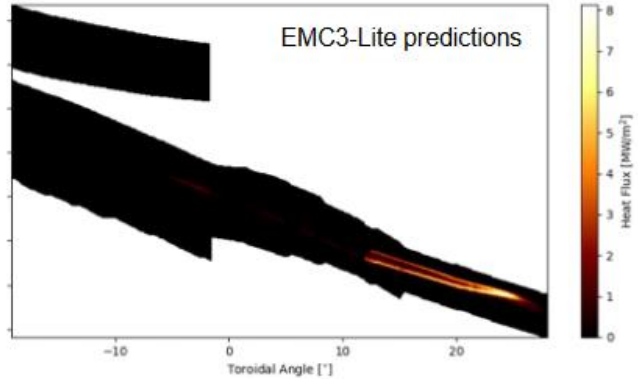
- 20250520.29: NBI S4 1.8 MW + S8 1.8 MW
- 20250520.30/ 20250520.32: NBI S4 1.8 MW/ NBI S8 1.8 MW
- 20250520.31: NBI S4 1.8 MW + S8 1.8 MW modulated
- 20250520.33: NBI S4 1.8 MW modulated + S8 1.8 MW modulated





XP20250520.029 @1.1s





courtesy of Amit Kharwandikar

Only attempted in low-field (1.8 T), SOL radiation and divertor loads seemingly not affected by Itor but observation hampered