

W7-X Experiment Proposal

Mechanism of detachment stability and operation limit with impurity seeding and with island size scan

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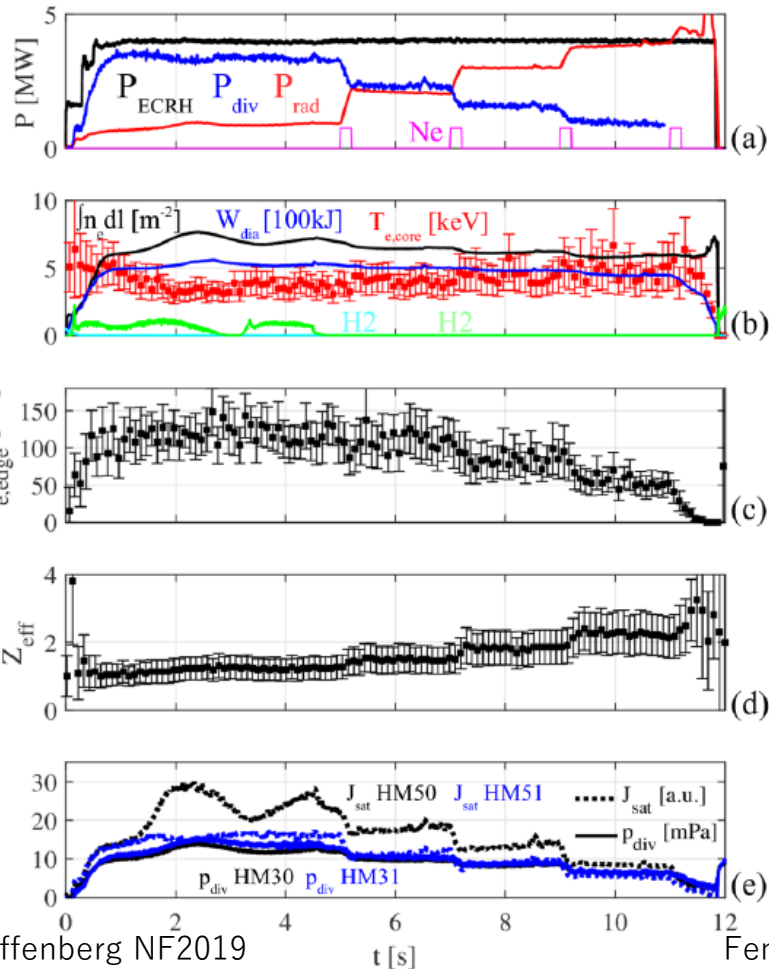
NIFS

Background, motivation, and goal

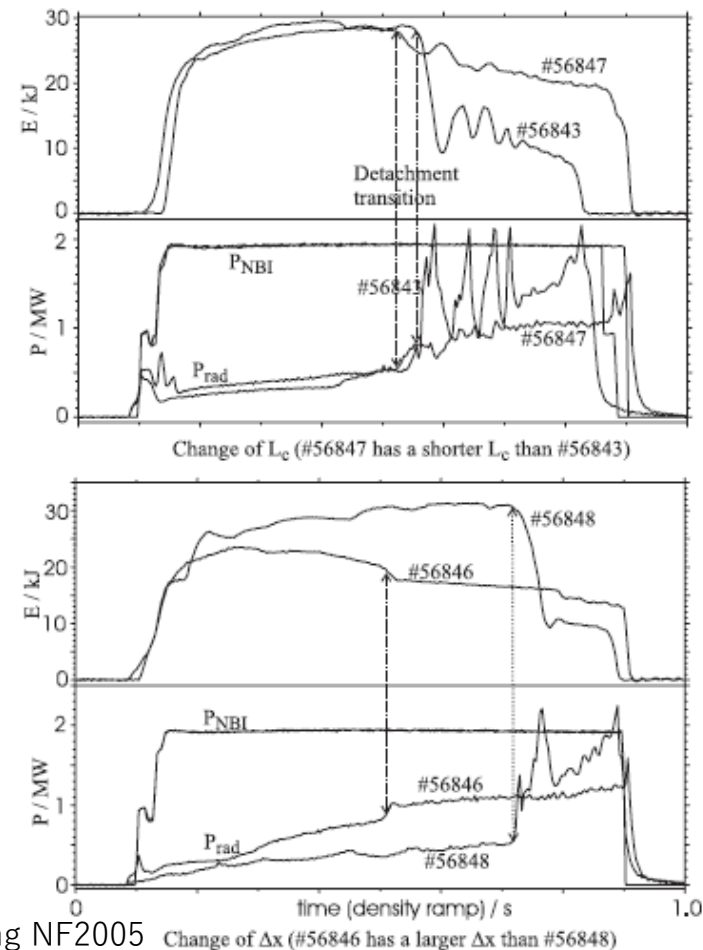
In W7-X, very stable detachment has been realized in W7-X with auxiliary impurity seeding and density ramp-up with carbon as a radiator [Effenberg NF2019, Schmitz NF2021, Jakubowski NF2022].

In W7-AS, the stable detachment is limited to a certain operation domain [Feng NF2005].

W7-X



W7-AS



This experiments aim at exploring mechanism of detachment stabilization by scanning island size and impurity puff amount:

1. Radiation level, spatial radiation pattern with respect to island size & impurity amount.
2. Comparison with experiments in LHD.
3. Common physics in toroidal confinement system.
4. Contributions from MHD activity & turbulence to detachment (thermal) stability.

Experiment configuration

Special diagnostics requirements:

Divertor probe

Thomson scattering,

Impurity radiation distribution measurement (bolometer: Daihong Zhang (daihong.zhang@ipp.mpg.de) and Felix Reimold (flr@ipp.mpg.de))

Divertor spectroscopy (??)

Magnetic probe,

Fluctuation measurement:

the phase-contrast imaging (PCI) diagnostic (contact: Adrian von Stechow, astechow@ipp.mpg.de)

the correlation reflectometer/radiometer (contact: Gavin Weir, gavin.weir@ipp.mpg.de)

the Doppler reflectometer (contact: Thomas Windisch, thomas.windisch@ipp.mpg.de)

the Electron Cyclotron Emission (ECE) radiometer (contact: Matthias Hirsch, matthias.hirsch@ipp.mpg.de)

Magnetic field

Magnetic configuration(s) to be used: Standard configuration

Trim coil operation beyond error-field correction? (yes, no, no preference): No

Control coil operation beyond error-field correction? (yes): Yes

Current ? +/-2.5kA (connection length changes, too. Should we fix it?), (impact on impurity transport)

Plasma density

Minimum density (m^{-3}): $3\text{e}19$

Maximum density (m^{-3}): $5\text{e}19$

Divertor state (select one: attached, detached):

Attached to detached with impurity seeding scan

Gases and fueling

Gas fueling (select one: yes): Yes

Pellet fueling (yes, no, no preference): No

Seeding (yes, no, no preference): Yes, Ne

The amount of Ne to be checked in advance.

Diagnostic use of a minority gas concentration (yes, no, no preference): Yes,
NBI blip needed.

Plasma heating

ECRH heating (select one: O2, X2, X3, none, no preference): X2 mode

4 to 6 MW (According to F. Effenberg et al., Nucl. Fusion vol.59 (2019) 106020. and O. Schmitz et al., Nucl. Fusion vol.61 (2021) 016026.)

ECRH off-axis heating (select one: yes, no, no preference):

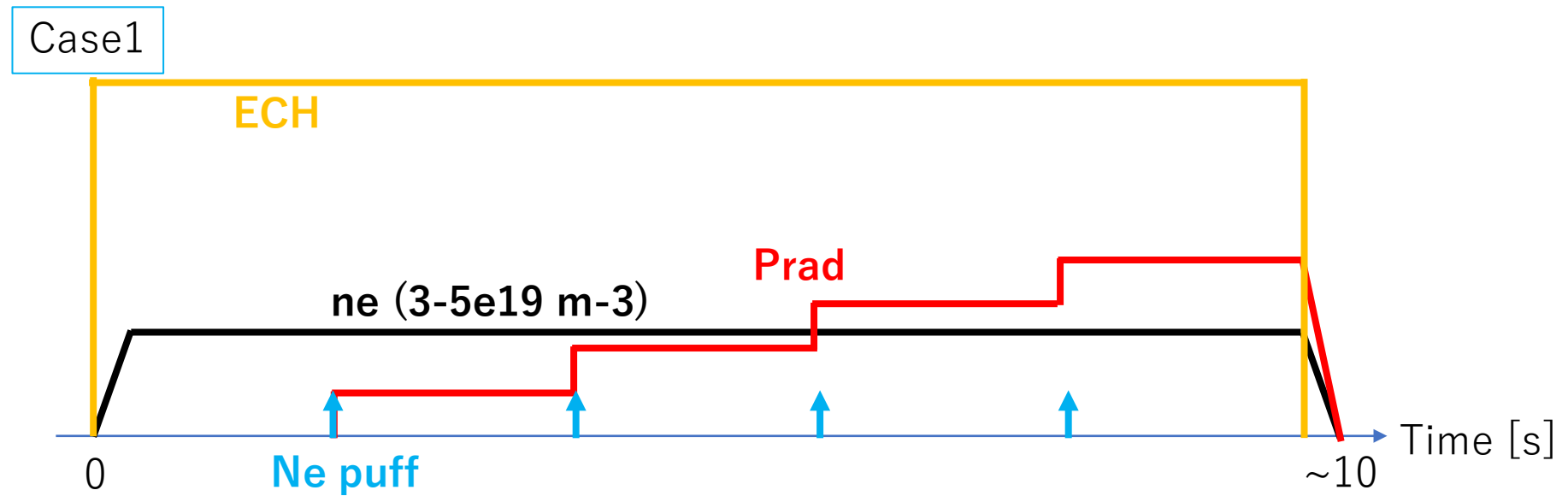
ECRH current drive (select one: yes, no, no preference): No

NBI heating (select one: yes, no, no preference):

NBI diagnostics blips allowed (select one: yes, no, no preference): No

ICRH (select one: yes, no, no preference):

Discharge layout

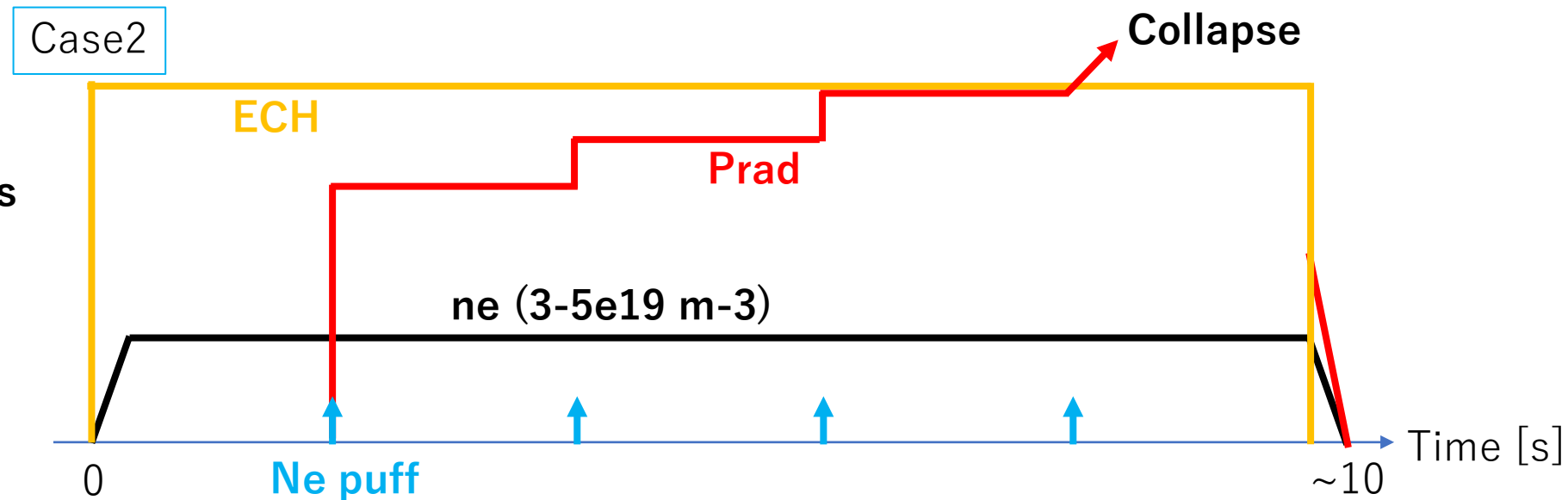


Island size scan: 5 steps

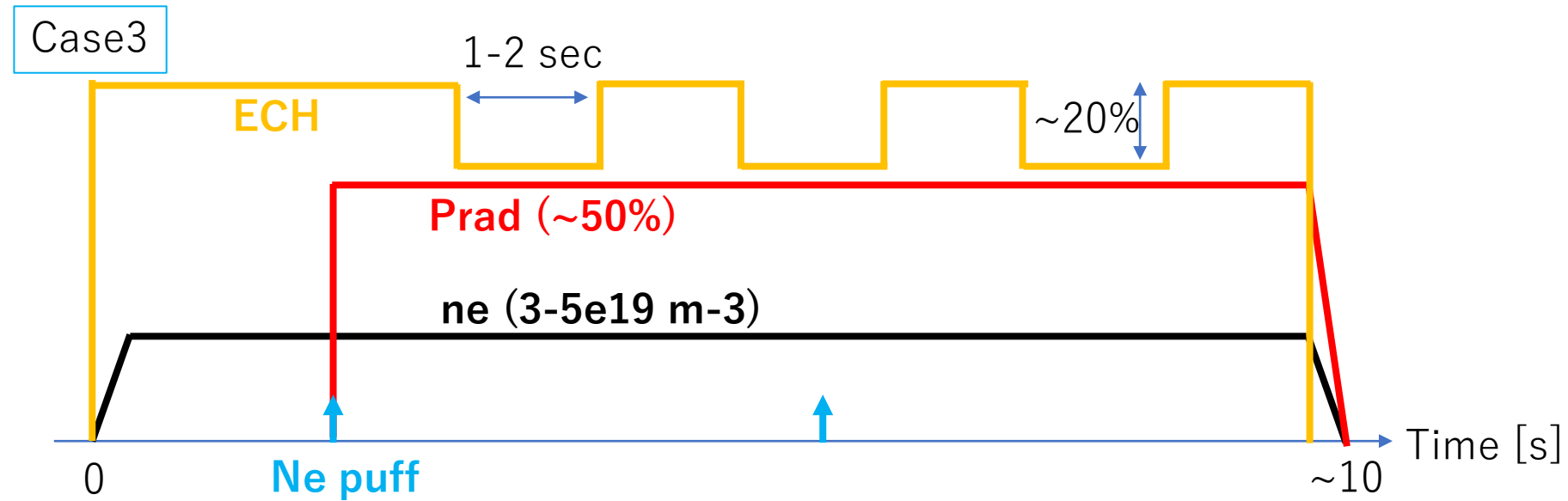
Ne seeding amount scan: 8 steps (4 steps in one discharge) → Case 1 & 2

ECH modulation: 5 island size with fixed Ne amount → Case 3

Total: $2 \times 5 + 5 = 15$ discharges



Discharge layout



Island size scan: 5 steps

Ne seeding amount scan: 8 steps (4 steps in one discharge) \rightarrow Case 1 & 2

ECH modulation: 5 island size with fixed Ne amount \rightarrow Case 3 (setup discharges needed to select optimum ECH & Prad.)

Total: $2 \times 5 + 5 = 15$ discharges