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Power exhaust by core radiation at COMPASS tokamak

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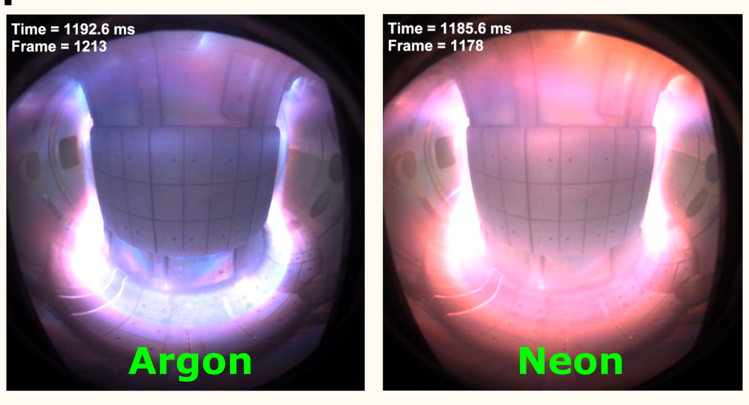
Motivation

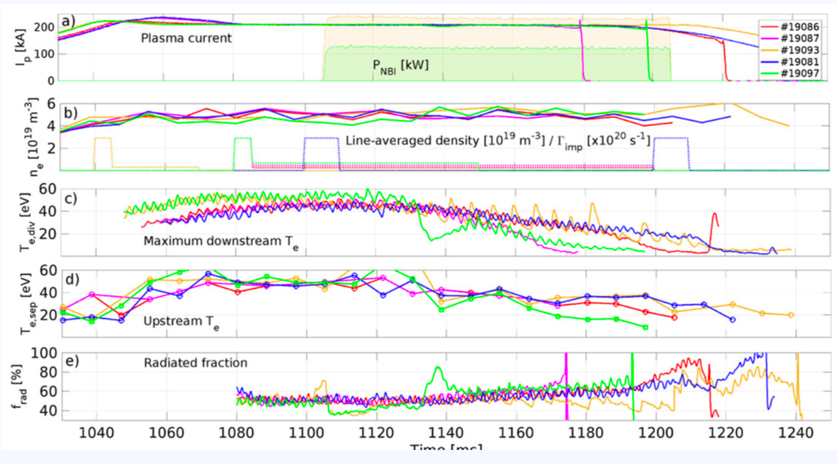
-- DEMO will require significant fraction of power to be **dissipated inside the separatrix** - this is in contrast with contemporary experiments with detachment
- What will be the effect of such radiation on the **heat flux footprints in the divertor**?
- We have perfomed **argon** and **neon** injection into L-mode discharges in **COMPASS tokamak** in order to study such regime

Experimental setup

- Reference scenario: I_p = 210 kA, B_T = -1.38 T, n_e = 4E19 m^{-3}
- **Ohmic discharges** (some NBI heating in specific cases)
- **No H-mode**: ELMy scenarios unstable with seeding
- **Argon or neon seeding** with pre-programmed waveform
- Principal diagnostics: LP+BPP probe array, HRTS, AXUV diodes, spectrometers



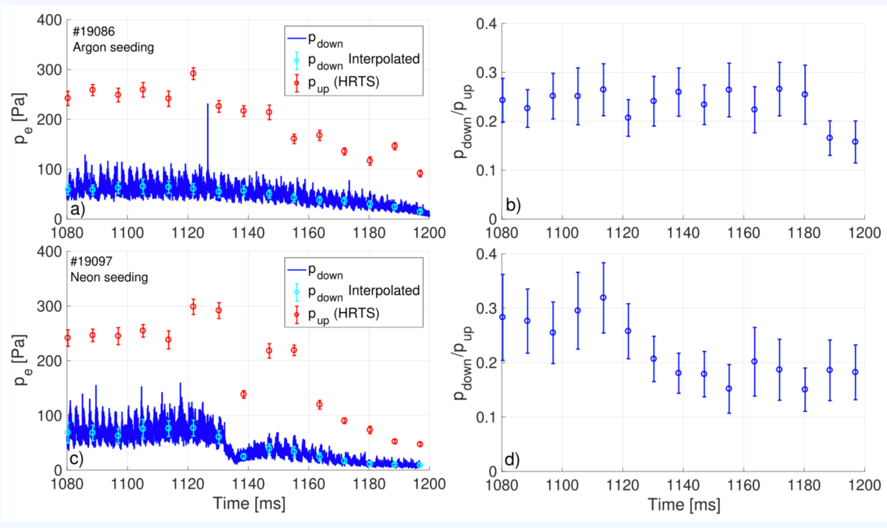
Argon and neon seeding at COMPASS



Discharge	Impurity	$\Gamma_{imp}[s^{-1}]$	t_{start} [ms]	t_{stop} [ms]	P_{NBI} [kW]	t_{disr} [ms]
#19081	Argon	2.9×10^{20}	1100	1110	0	1235
#19086	Argon	0.27×10^{20}	1080	1200	0	1220
#19087	Argon	0.47×10^{20}	1080	1200	0	1180
#19093	Argon	0.30×10^{20}	1040	1070	230	1245
#19097	Neon	0.67×10^{20}	1080	1150	120	1195

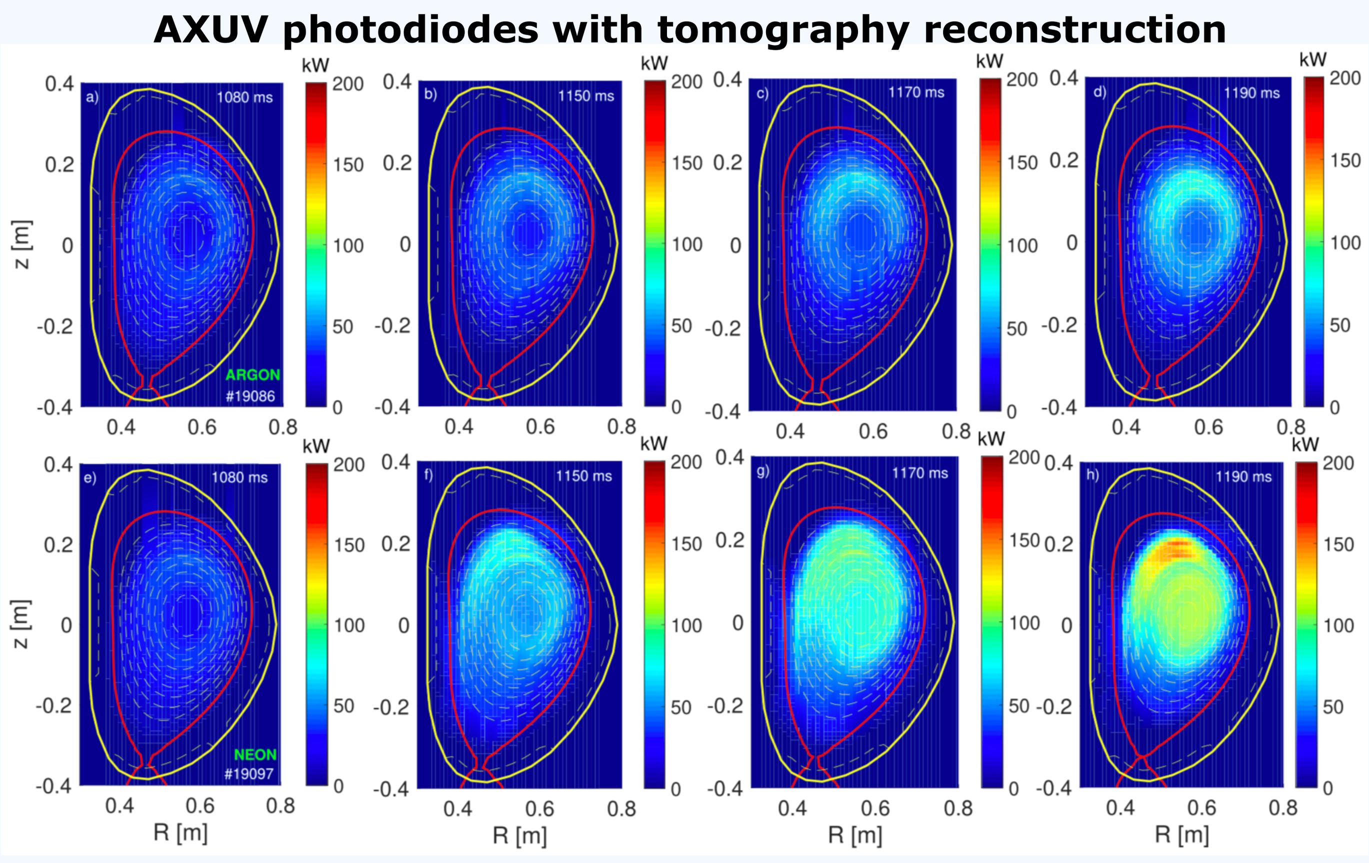
Unlike with nitrogen, the effect of inert gases remains for the duration of the discharge -> slow removal rate
Discharge duration can be extended by use of NBI

Measurements of upstream and downstream pressure



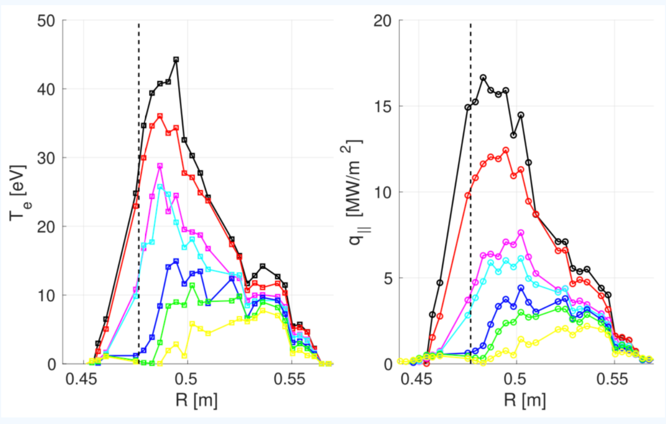
Although the downstream pressure (measured by div. probes) is significantly reduced, technically the plasma is not detached - upstream pressure (measured by HRTS) is reduced at equal rate (for argon).

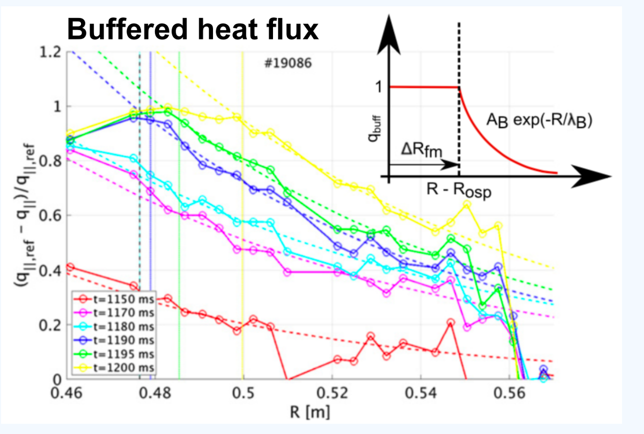
AXUV photodiodes with tomography reconstruction

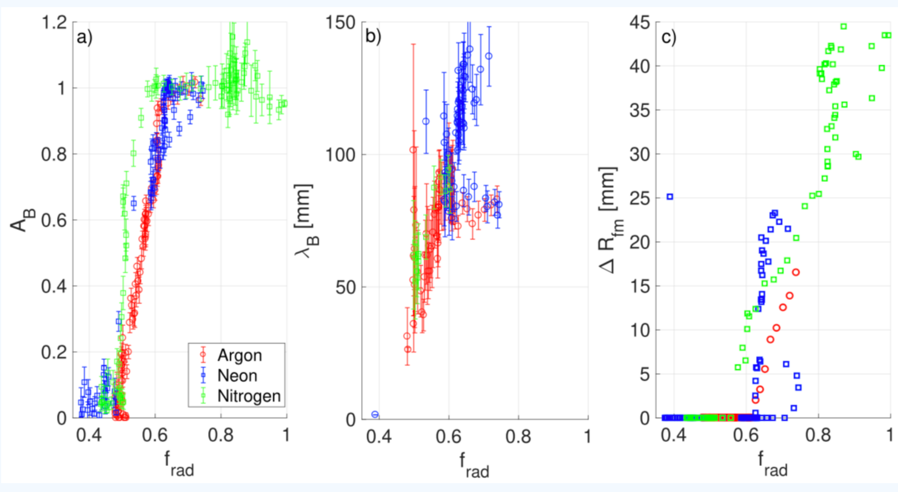


Argon creates a radiating mantle at ρ ~ 0.5
Neon also radiates strongly in the core - more difficult to interpret

Divertor heat flux footprint analysis

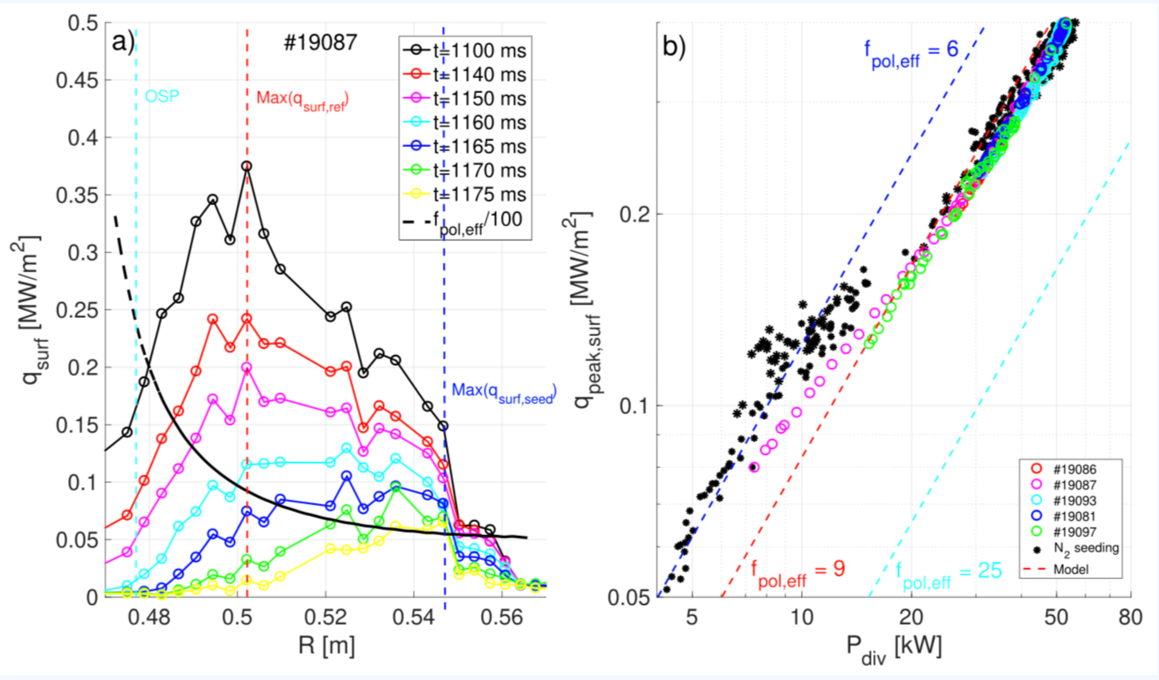






Parameters characteristing the **buffered heat flux** show linear evolution with frad, **just like in case of nitrogen seeding**. This is surprising since the power dissipation occurs in a **different location**.

Relation between surface peak heat flux and P_{div}



Despite deformations of the heat flux footprint, there is still a linear relation between q_{peak} and P_{div}.

$$q_{\mathrm{peak,\,surf}} = \frac{P_{\mathrm{div}} \sin\beta}{2\pi\lambda_q f_x R_t}$$

The only deviation occurs due to **change of flux expansion** as the location of the peak heat flux changes. This is not relevant to conventional divertors (e.g. with vertical targets) but can be an issue for **alternative divertor configurations** with **x-point close to the target**.

Summary

- Argon and neon seeding can significantly **reduce target heat fluxes** without detachment - **radiation in the confined region**
- Each impurity has a **distinct radiation pattern**, neon radiates more in the plasma center although it is a lighter element
- Inert impurities have significantly **longer time scale of removal from the vessel** than nitrogen - possibly a role of (missing) chemistry?
- **Buffered heat flux** can be characterised by the same function as with nitrogen seeding, jwith adding a zone close to the strike point where the heat flux is completely mitigated
- All parameters describing the buffered heat flux scale **linearly with radiated fraction**
- Despite **deformation** of the heat flux footprint, the **peak heat flux still scales linearly with the power reaching the divertor**

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