

Progress with commissioning the ICRH system for the large optimized stellarator Wendelstein 7-X (EX-H/P4-2834)

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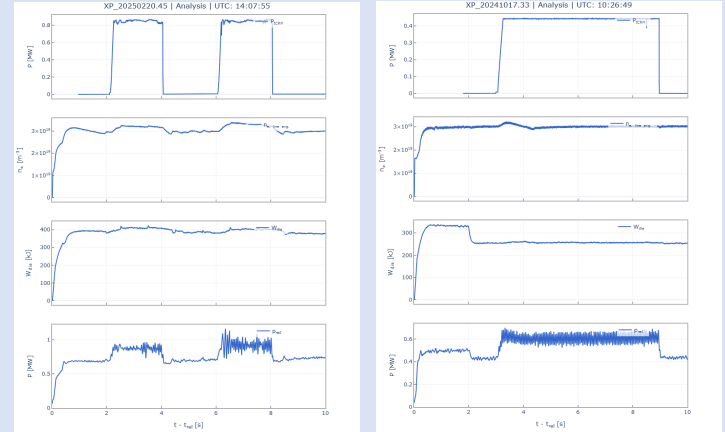
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LAYOUT OF ANTENNA AND USE OF ICRH FOR W7-X

- A two-strap antenna (without Faraday Screen !)
→ 3-D shaped (aligned with the LCFS for the standard configuration)
→ flexible RF current phasing between the straps ($k_{||}$ -spectrum and coupling)
- Frequency range $f = 25$ -38 MHz
- Pulsed mode operation: up to 10 s (every 3 minutes)
- Main Aim: fundamental test of the confinement of fast particles in view of a future fusion reactor of the Wendelstein 7-X type



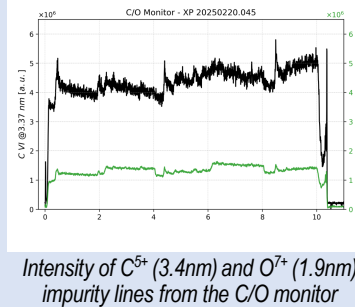
LONG PULSE AND HIGH POWER ICRH IN W7-X



Modulated 800 kW ICRH in ⁴He discharge W7-X #20250220.45 using two straps at 25 MHz in monopole phasing

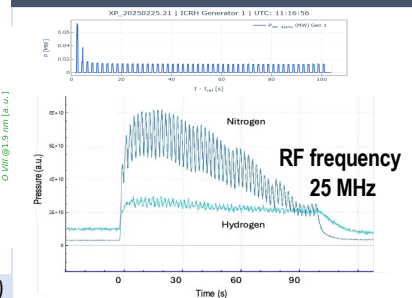
6s long pulse high power ICRH in H + 2% ³He discharge W7-X #20241017.33 with two straps at 25 MHz in dipole

VIEW OF THE ICRH ANTENNA INSIDE W7-X



Intensity of C⁵⁺ (3.4nm) and O⁷⁺ (1.9nm) impurity lines from the C/O monitor

IC WALL CONDITIONING IN W7-X



ICWC demo in ⁴He plasma W7-X #20250225.21 (dipole phasing, 37.5 MHz)

FAST ION STUDIES IN W7-X : PHYSICS REQUIREMENTS

Scaling criterion: orbit of fast ions must fit in the device

$$(\rho_L/a)_{W7-X} = (\rho_L/a)_{HELIAS}$$

→ Fast-ion energies needed in W7-X: $(Z^2/A)_i$ -dependent

E_a (reactor)	≤ 1 MeV	1-2 MeV	2-3 MeV	3-3.5 MeV
H, ⁴ He (W7-X)	≤ 17 keV	17-35 keV	35-52 keV	52-60 keV
D (W7-X)	≤ 9 keV	9-17 keV	17-26 keV	26-30 keV
³ He (W7-X)	≤ 23 keV	23-46 keV	46-69 keV	69-80 keV

Ion energies needed in W7-X to mimic fusion alphas of a future reactor:

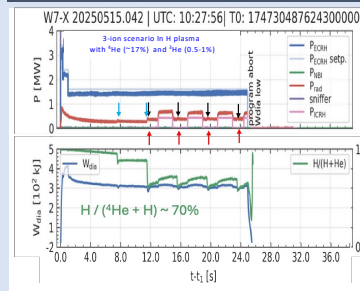
$$E_i \approx 30\text{-}80 \text{ keV}$$

Other system have difficulties providing simultaneously the necessary high particle energies and large pitch angle; ICRH can !

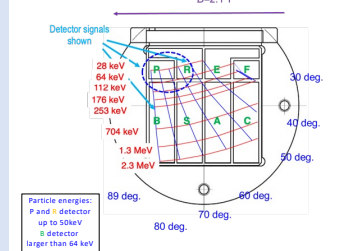
RESULTS OBTAINED WITH FIRST ICRH OPERATION ON W7-X

- Single and double strap operation
- Up to 800 kW launched in the plasma without breakdowns
- Modulated operation demonstrated
- ICRH assisted plasma startup at 300 kW (1.7 T)
- Despite absence of Faraday Screen: no visible wall interaction
- First observation of fast particle generation using 3 ion scenario

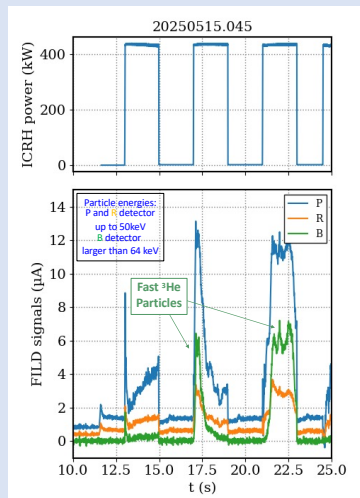
FAST ION GENERATION WITH ICRH IN W7-X



Operational scenario for the 3-ion scenario ⁴He-(³He)-H to generate fast ³He particles in W7-X (W7-X #20250515.42).



Layout of the FILD detector for ³He²⁺ ions



Signals detected with estimated ~ 17% ⁴He and $\leq 1\%$ of ³He in H plasma, as required for the three-ion scenario ⁴He-(³He)-H



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