Progress with commissioning the ICRH system for the large optimized stellarator Wendelstein 7-X

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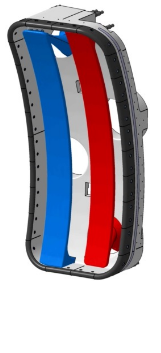
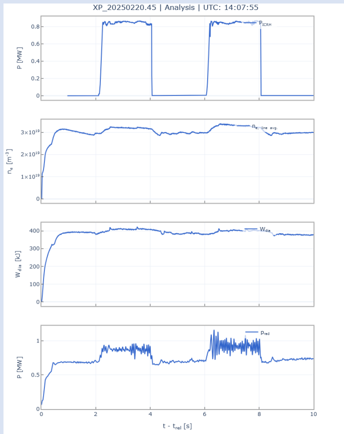
LAYOUT OF ANTENNA AND USE OF ICRH FOR W7-X

- **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 10s (every 3 minutes)**
- **Main Aim: fundamental test of the confinement of fast particles in view of a future fusion reactor of the Wendelstein type**

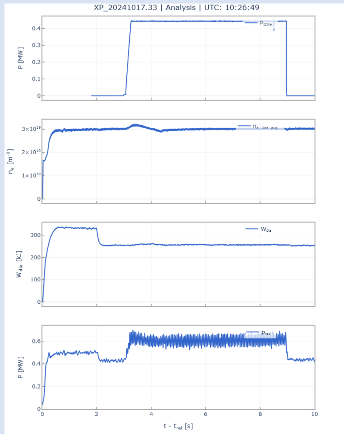


VIEW OF THE ICRH ANTENNA INSIDE W7-X

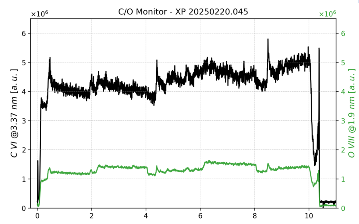
LONG PULSE AND HIGH POWER ICRH IN W7-X



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

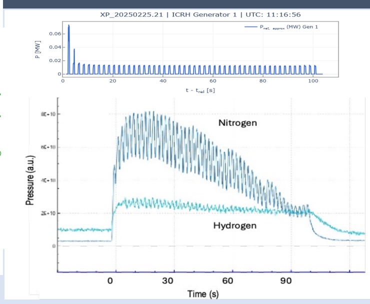


6s long pulse high power ICRH in H + 2% ^{3}He discharge W7-X #20241017.33 with two straps at 25MHz in dipole



Intensity of C^{5+} (3.4nm) and O^{7+} (1.9nm) impurity lines from the C/O monitor

IC WALL CONDITIONING IN W7-X



ICWC demo in ^{4}He 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

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

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

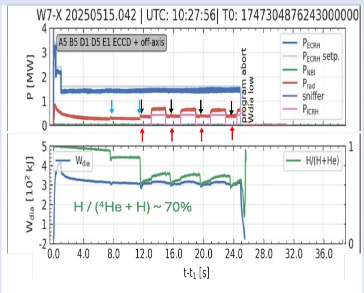
E_α (reactor)	≤ 1MeV	1-2MeV	2-3MeV	3-3.5MeV
H, ^{4}He (W7-X)	≤ 17keV	17-35keV	35-52keV	52-60keV
D (W7-X)	≤ 9keV	9-17keV	17-26keV	26-30keV
^{3}He (W7-X)	≤ 23keV	23-46keV	46-69keV	69-80keV

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

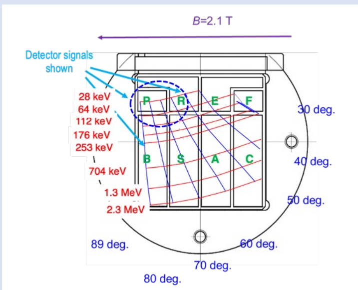
$E_i \approx$ 30-80keV

Other system have difficulties providing the necessary high particle energies; ICRH can !

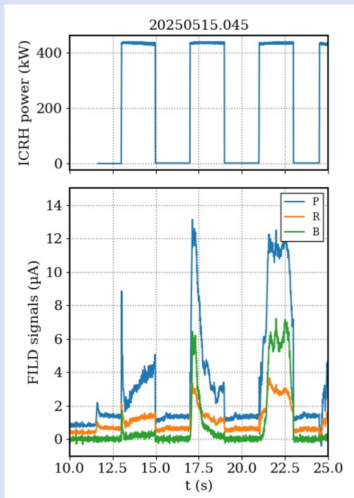
FAST ION GENERATION WITH ICRH IN W7-X



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



Layout of the FILD detector for $^3He^{2+}$ ions



Signals detected with estimatend ~ 17% ^{4}He and≤ 1% of ^{3}He in a H plasma, as required for the three-ion scenario ^{4}He-(^{3}He)-H

RESULTS OBTAINED WITH FIRST ICRH OPERATION ON W7-X

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