

W7-X Topical Group “Heating”

Kick-off meeting

13 January 2022

Y. Kazakov and J. Ongena

Meeting agenda

- Introduction: TG “Heating” scope
- Connection to Task Force objectives
- Initial list of ideas
- Schedule and date of future TG meetings
- AOB

OP2.1 & OP2.2 Scientific Operation and Discussion of Proposals

Scientific Operation



- organization of scientific operation follows closely the scheme of OP 1.2b
- all plasma discharges stem exclusively from scientific proposals
 - proposals will be collected during the *call for proposals* and evaluated/prioritized by TFL
 - the emerging program will be discussed in the framework of a W7-X program workshop with subsequent approval by the International Program Committee

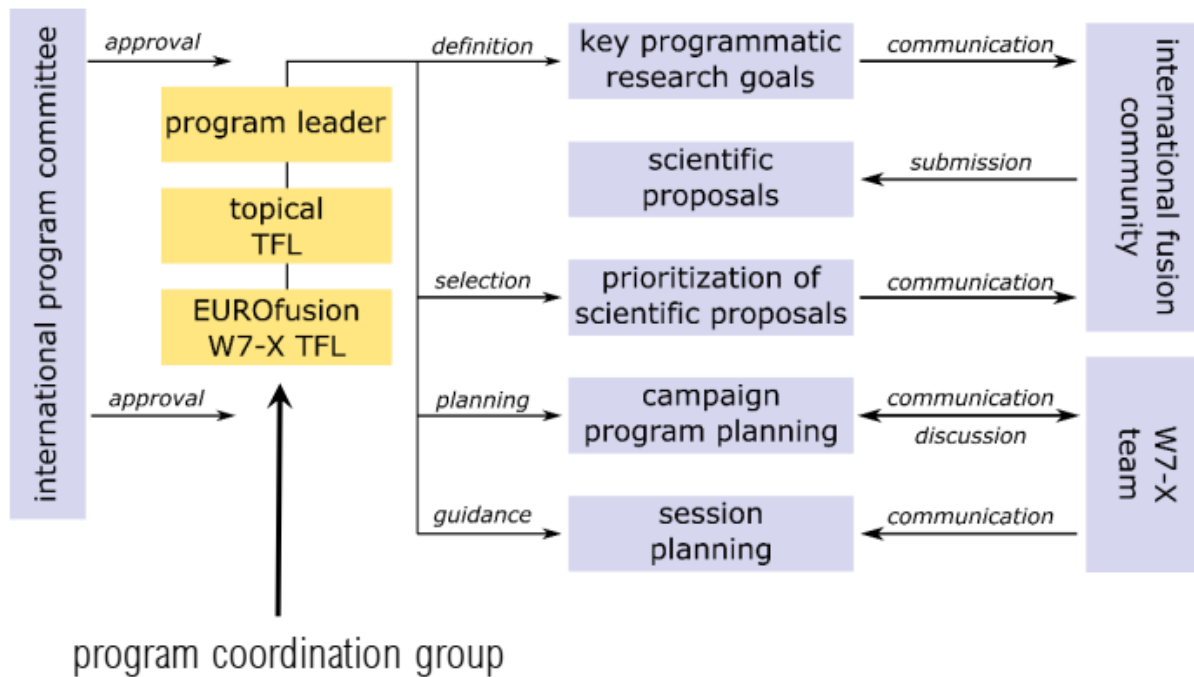
Discussion of Proposals



- the forum for the discussion of the physics content of scientific proposals are the respective *Topical Groups*
 - ⇒ one focus should be the proposal discussion related to key scientific campaign goals
 - ⇒ **it is strongly recommended to conduct the proposal discussion in the *topical groups* to increase program efficiency and transparency of physics rationale**
- the proposal discussion should span over both operation campaigns OP 2.1 & OP 2.2
 - ⇒ no major system changes foreseen between OP 2.1 and OP 2.2
 - ⇒ unclear how fast we can exploit the massive changes to their respective full capability
 - ⇒ mitigation of potential delays of system installation and commissioning

More details: O. Grulke, W7-X Physics Meeting, 27/10/2021

OP2.1 & OP2.2 Scientific Planning and Scientific Task Forces



TF I – Core Scenario development	
Felix	Warmer
Andreas	Langenberg
TF II – Edge Scenario Development	
Kenneth	Hammond
Dirk	Naujoks
TF III – W7-X Optimization	
Daniel	Carralero
Arturo	Alonso
Carsten	Killer
Program Leader	
Olaf	Grulke
EUROfusion TFL	
Andreas	Dinklage

More details: O. Grulke, W7-X Physics Meeting, 27/10/2021

New W7-X Topical Group “Heating”

22

Dez 2021

NEW W7-X TOPICAL GROUP „HEATING“

by Robert Wolf · [Leave a Comment](#) · [Edit](#)

As a result of recent discussions on how best to prepare for the next experimental campaigns and account for the upgrades and extensions of the heating systems, a new Topical Group will be established.

The primary responsibility of the topical group „heating“ will be to provide a forum for scientific and technical questions concerning the heating systems of Wendelstein 7-X: Electron cyclotron resonance heating, neutral beam injection and ion cyclotron resonance heating. The topical group coordinator will be Yevgen Kazakov (supported by Jef Ongena) from the Belgium fusion laboratory at the École Royale Militaire / Koninklijke Militaire School in Brussels. The topical group will start its work beginning of January 2022.

Posted in: [Allgemein](#), [Physik](#)

ECRH	NBI	ICRH
Upgrade: new 1.5MW gyrotron	Upgrade: second NBI box	New system

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TF I: Core scenario development

Task Force Leaders: Felix Warmer and Andreas Langenberg

Main Objectives Task Force I



Main Objective	Scientific Goal	Measures of success / deliverables
Exploration of reduced turbulence / high performance scenarios w.r.t. stationary plasma conditions, kinetic-, density-, and impurity-profile control	<ul style="list-style-type: none"> ▪ Demonstrate steady-state viability of increased performance scenarios after pellet / impurity injections as well as low ECRH/NBI heated plasmas ▪ Qualify actuators for the control of profiles and impurities 	<ul style="list-style-type: none"> ▪ High plasma performance in the order of seconds, including <ul style="list-style-type: none"> • T_i above clamping limit (1.5 keV) • τ_E equal or better to ISS04 scaling ▪ Avoidance of impurity accumulation ▪ Assess density profile control
Exploration of heating scenarios using upgraded plasma heating capabilities (ECRH, NBI, ICRH)	<ul style="list-style-type: none"> ▪ Extension of NBI operation space and preparation of fast ion diagnostics ▪ Observation and prediction of fast ion losses for machine safety and validation of simulation tools 	<ul style="list-style-type: none"> ▪ Demonstrate effective ion heating ▪ Exhaustive operational map of the W7-X configuration space incl. operation limits ▪ Safe operation w.r.t. NBI/ICRH induced fast ion losses ▪ Validation of fast ion loss simulation tools
Develop high beta plasma scenario by means of low field operation	<ul style="list-style-type: none"> ▪ Development of a plasma startup scenario @ B=1.7 T employing X3 / ICRH / NBI heating ▪ Fast ion confinement at high plasma-beta 	<ul style="list-style-type: none"> ▪ Reliable plasma startup scenario @ 1.7 T ▪ Demonstration of improved fast ion confinement of W7-X at high beta ▪ Develop capability to extrapolate B-field dependency to high-field reactor operation

More details: F. Warmer and A. Langenberg, W7-X Physics Meeting, 27/10/2021

TF II: Edge scenario development

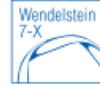
Task Force Leaders: Kenneth Hammond and Dirk Naujoks

Main Objective	Scientific Goal	Measures of success / deliverables
Integrated scenarios for long-pulse operation with PFC heat load control, efficient particle exhaust, and impurity screening	<ul style="list-style-type: none"> Control of divertor/baffle loads and actuation of heat load distribution Studies on particle exhaust and optimization of plasma fueling schemes 	<ul style="list-style-type: none"> Demonstration of safe divertor scenarios to avoid overloaded plasma-facing components Determination of trim and/or control coil currents required to correct error fields Demonstration of effective pumping, high divertor compression, and qualification of fueling actuators Demonstration of long-pulse operation (1 GJ energy turnaround)
Development of long, stationary divertor detachment scenarios with and without impurity seeding	<ul style="list-style-type: none"> Creating conditions for detachment by tailoring edge plasma conditions and impurity seeding Compatibility of stationary detachment with high-performance scenarios Development of detachment scenarios with efficient exhaust 	<ul style="list-style-type: none"> Demonstration of scenarios with long, stationary divertor detachment; in particular, for the high-mirror, high-iota and standard configurations Characterize the conditions under which detachment is possible Compatibility of detachment with high-performance scenarios Achieve rapid transition to detachment
Exploration of scenarios compatible with carbon-free operation and tungsten PFCs	<ul style="list-style-type: none"> Migration (erosion, deposition) of tungsten-based materials and assessment of operation limits Edge scenario development for metallic plasma-facing components 	<ul style="list-style-type: none"> Definition of the operation limits associated with plasma-facing components containing tungsten materials Characterize the scrape-off layer retention for tungsten impurities (eroded from baffle and heat shield) Determination of erosion effects due to seeding impurities
Development of wall conditioning procedures	<ul style="list-style-type: none"> Optimization of glow discharge cleaning, boronization, and qualification of dedicated wall conditioning discharges with ECRH/ICRH 	<ul style="list-style-type: none"> Condition walls to enable plasmas with high density gradients necessary for high performance

More details:
K. Hammond and
D. Naujoks,
W7-X Physics Meeting,
27/10/2021

**ECWC, ICWC:
collaboration with
the TG PWI (?)**

Task Force Leaders: Daniel Carralero, Arturo Alonso and Carsten Killer



Main Objectives for OP2.1/2.2 – TF-III

...and scientific goals

1. Complete the core transport and stability physics basis in the extended operational space

- *Identify fundamental heat and particle transport mechanisms*
- *Continue the assessment of W7-X optimization*

2. Complete the edge and SOL physics basis in the magnetic configuration space of W7-X

- *Characterize parallel and perpendicular SOL transport regimes and validate transport models*
- *Characterize three-dimensional edge + SOL profiles and asymmetries*

3. Exploitation of low-field high-beta scenarios to demonstrate W7-X optimization

- *Characterize MHD equilibrium and stability at high beta and beta/magnetic field effects on turbulent and neoclassical transport.*
- *Characterize magnetic field modification due to high beta and assess implications for edge plasma.*

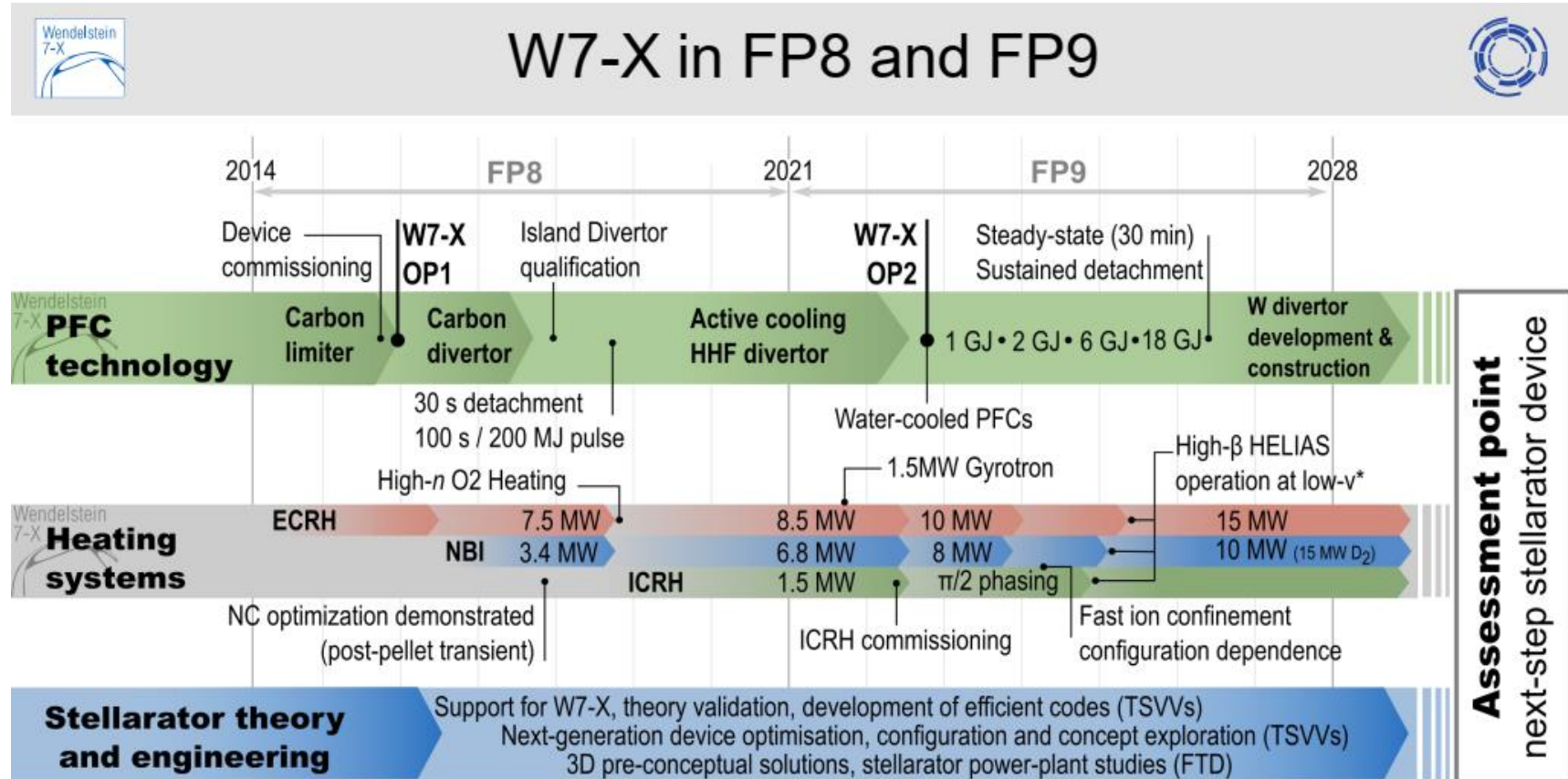
More details:

D. Carralero, A. Alonso and C. Killer, W7-X Physics Meeting, 27/10/2021

EUROfusion WPW7X: Preparation and Exploitation of W7-X Campaigns

EUROfusion TFL's: A. Dinklage, A. Alonso and I. Calvo

→ WPW7X objectives



WPW7X exploits W7-X campaigns to bring optimized stellarators to maturity

Source: A. Dinklage, WPW7X Board Meeting, 07/06/2021

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TG “Heating”: initial list of ideas (to be extended)

	Short description	Contributing partners
ECRH	<ul style="list-style-type: none"> • Demonstrate increased heating capabilities with a new 1.5MW gyrotron • New full-metal heat shield and reflector tiles • Wave physics experiments (beat wave, etc.) • ... 	IPP: H. Laqua, T. Stange
NBI	<ul style="list-style-type: none"> • Upgraded NBI system with the 2nd NBI box • NBI extension in different magnetic configurations • ... 	IPP: D. Hartmann, S. Lazerson Note: already discussed in the other TG's
ICRH	<ul style="list-style-type: none"> • System commissioning • Initial safe operation in different magnetic configurations • Preparation of the ICRF system for ICWC • Demonstration of plasma heating with ICRF • Preparation of scenarios for fast-ion generation • ICRH wave experiments, incl. ICE and instabilities • ... 	LPP-ERM/KMS: J. Ongena, Y. Kazakov , K. Crombe IPP: D. Hartmann, S. Bozhenkov
System synergies and additional applications:	1.7T start-up: ICRH+ECRH, ICRH+NBI+ECRH, ...	IPP: T. Stange KIPT (Ukraine): V. Moiseenko, Y. Kovtun LPP-ERM/KMS: J. Ongena, Y. Kazakov, K. Crombe NIFS (Japan): S. Kamio
	Optimizing plasma heating with different mixes of ECRH, ICRH and NBI systems: e.g. maximizing the fraction of ion heating with ICRF	IPP: D. Hartmann, H. Laqua LPP-ERM/KMS: Y. Kazakov, J. Ongena Synergies with TG “Fast Ions” (S. Bozhenkov), “Scenarios” (G. Fuchert), “Profiles” (M. Beurskens), ...
	Other ideas and synergies/overlap with other TGs	

TG “Heating”: initial list of ideas (to be extended)

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System synergies and additional applications:	1.7T start-up: ICRH+ECRH, ICRH+NBI+ECRH, ...	IPP: T. Stange KIPT (Ukraine): V. Moiseenko, Y. Kovtun LPP-ERM/KMS: J. Ongena, Y. Kazakov, K. Crombe NIFS (Japan): S. Kamio
	Optimizing plasma heating with different mixes of ECRH, ICRH and NBI systems: e.g. maximizing the fraction of ion heating with ICRF	IPP: D. Hartmann, H. Laqua LPP-ERM/KMS: Y. Kazakov, J. Ongena Synergies with TG “Fast Ions” (S. Bozhenkov), “Scenarios” (G. Fuchert), “Profiles” (M. Beurskens), ...

Next TG meeting

Note: distinguish between the W7-X commissioning phase and the physics operation phase

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TG “Heating” regular meetings

Discuss the most optimal day and time for future TGH meetings

- **Tuesdays, 13:30 (fits the agendas of ECRF and NBI colleagues)**

Meeting ID: 455 265 7470

Password: Yd08T4

<https://us02web.zoom.us/j/4552657470?pwd=QlU2cjBJUE91UFh2ZHQ0WmZBUjU0QT09>

Proposed TG meeting schedule

cw #3	10.01-14.01	Kick-off meeting (13/01/2022)
cw #4	17.01-21.01	
cw #5	25.01	Discussion: ICRF
cw #6	01.02	Discussion: 1.7T start-up
cw #7	07.02-11.02	tba
cw #8	14.02-18.02	tba
cw #9	21.02-25.02	tba

Expected information

At this stage, proposal ideas should not be very detailed, but should include the following essential information:

- Main idea
- Relevance for the high-level objectives
- Magnetic configuration(s)
- Requirements on the heating systems
- Required diagnostics

Please let us know your plans as soon as possible:

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