DE LA RECHERCHE À L'INDUSTRIE

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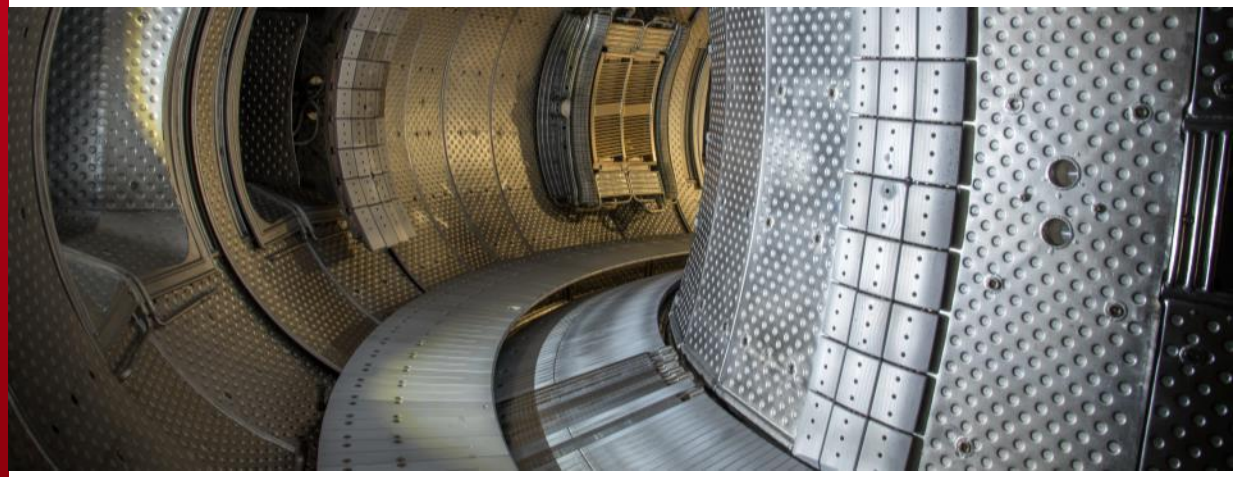
6th Meeting of the WEST Governing Board

WEST PLATFORM AND EXP. PROGRAM FOR 2020



Jérôme BUCALOSSI, on behalf of the WEST team

Château de Cadarache – May 17, 2019

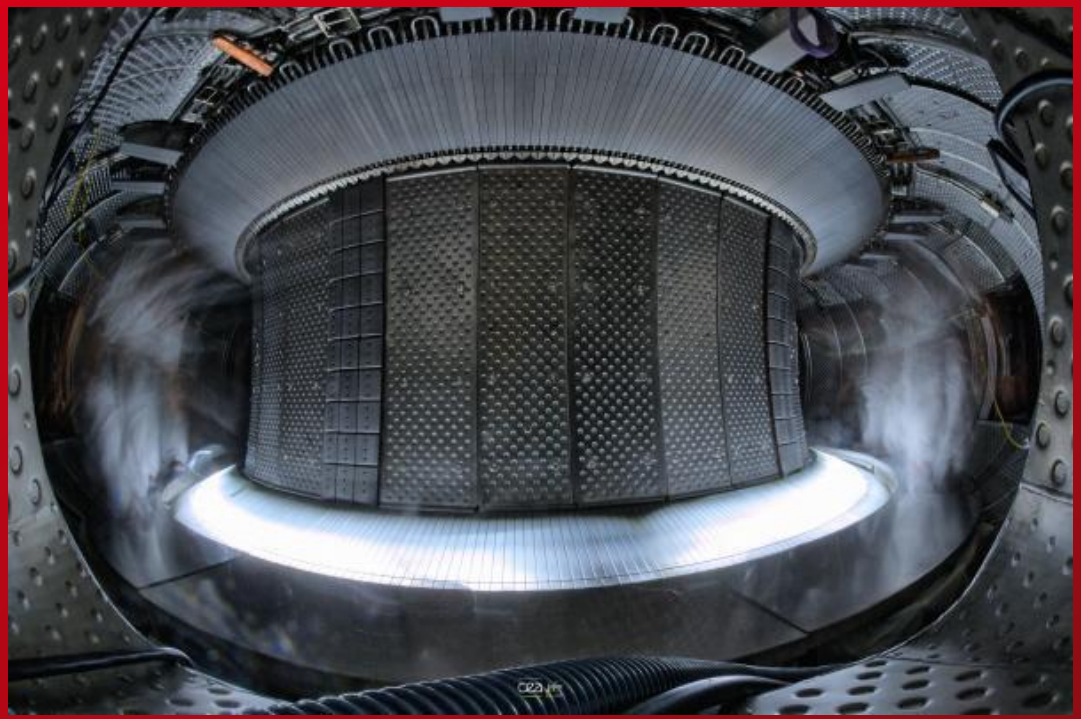
OUTLINE

The actively cooled lower divertor

Further upgrades

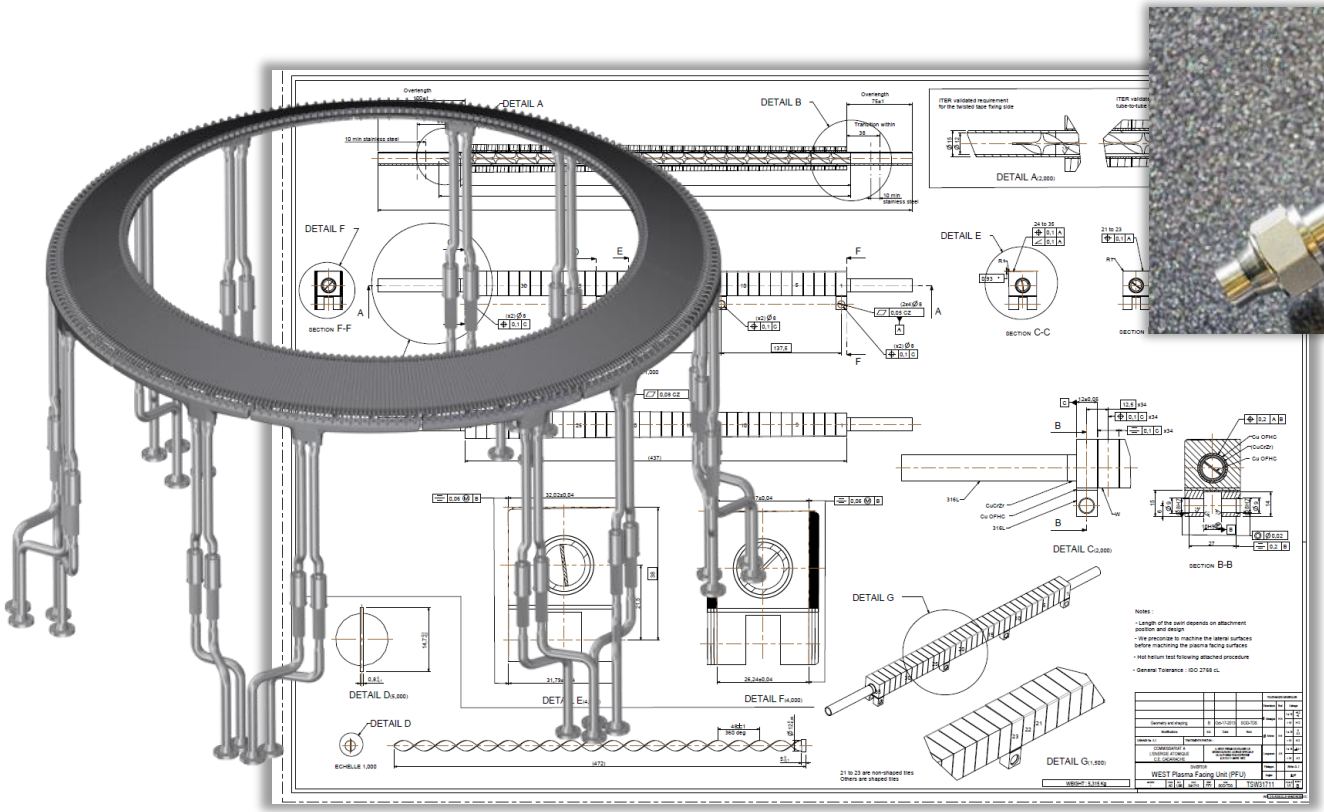
Schedule and experimental program for 2020

THE ACTIVELY COOLED LOWER DIVERTOR

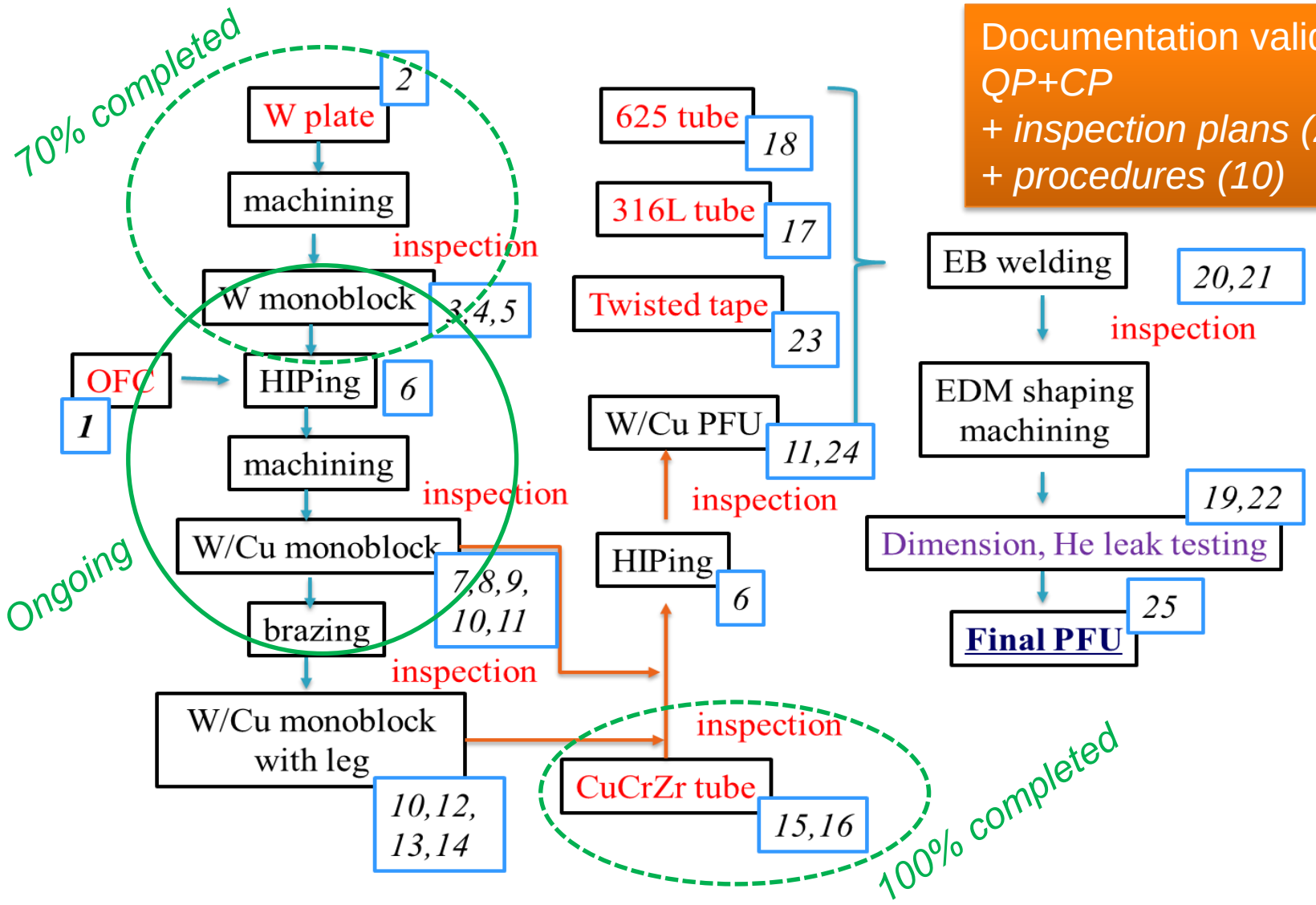


PFU MANUFACTURING CONTRACT AWARDED

- Contract for the manufacturing of 456 ITER-like PFUs awarded on **26 Nov. 2018**
- Kick off Meeting on 4 December 2018
- First batch expected in **July 2019** → full delivery in **Nov. 2019**
- Phase 2 restart with the full actively cooled divertor → **Spring 2020**

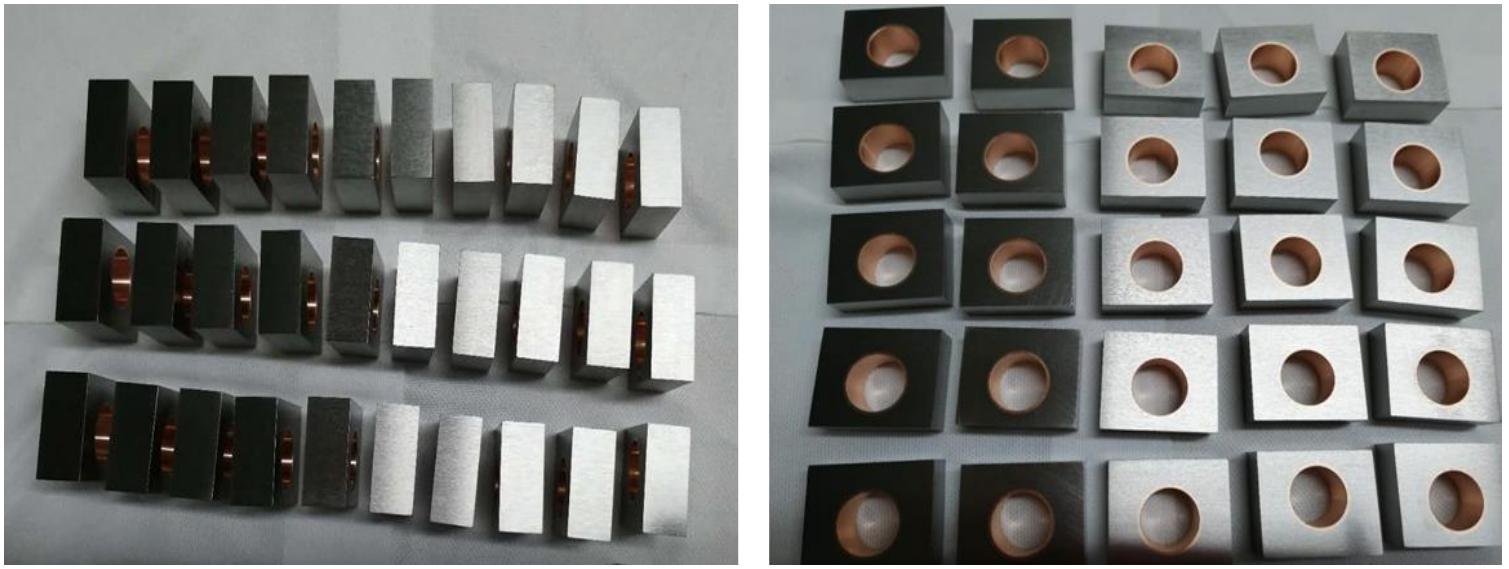


PFU SERIES PROCUREMENT (1/3)
FLOWCHART OF MANUFACTURING



PFU SERIES PROCUREMENT (2/3) MATERIALS

- **100% of raw (CuCrZr, OFHC-Cu, 316L, Inconel)** materials are purchased.
  - 100% of CuCrZr tube manufacturing is achieved : 4 cycles of rolling+ inlet/outlet machining + Eddy current inspection
- **~70% of raw (W)** materials are purchased.
  - ~210/300 W plates (laminated) / (~320 PFUs)
  - ~4000 W blocks with hole (machined) / (~115 PFUs)
  - ~280 W/Cu blocks (**HIP-1** + machining + NDT + dimensional control) / (~8 PFUs)



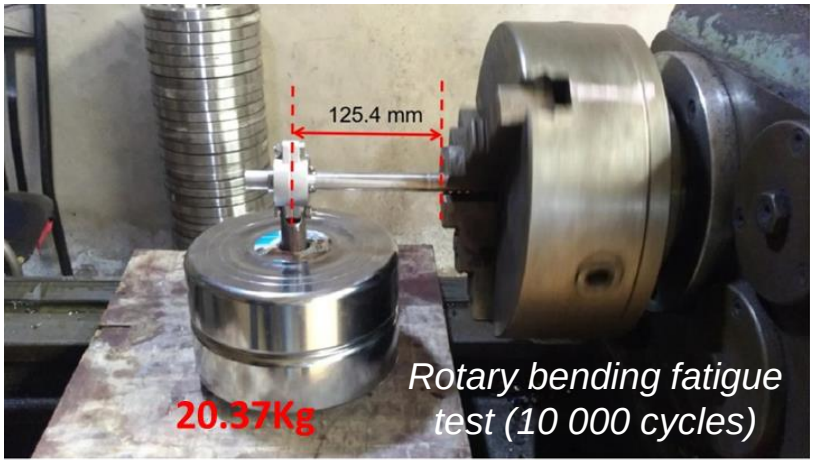
Blocks W/Cu after machining and UT

PFU SERIES PROCUREMENT (3/3)
SUCCESSFUL SPECIFIC QUALIFICATIONS

- **Monoblock attachment**: Brazed 316L on W block samples (Tensile test)
- **Heterogeneous tube-to-tube transition***: E.B welded multi-material samples CuCrZr/Inconel/316L (Tensile test and rotary bending fatigue test)

Attachment tensile test

Tube-to-tube transition tensile test



Rotary bending fatigue test (10 000 cycles)

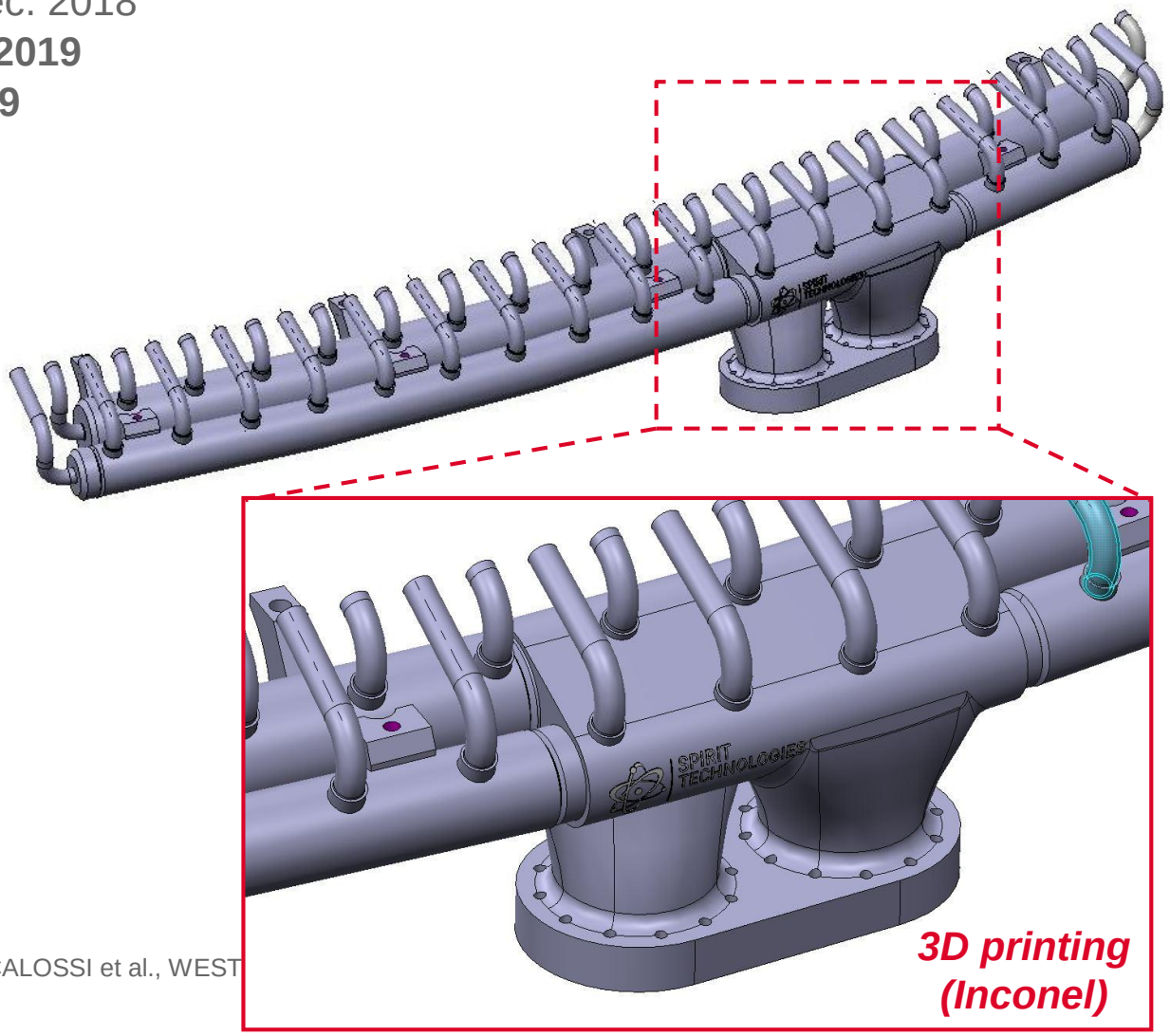
Hot He leak test

*Based on ITER requirements

DIVERTOR 30° SECTOR WATER MANIFOLD CONTRACT AWARDED

- Contract for the manufacturing of the 12 water collectors awarded on **3 Dec. 2018**
- Kick off Meeting on 6 Dec. 2018
- Prototype delivery **July 2019**
- Full delivery in **Dec. 2019**

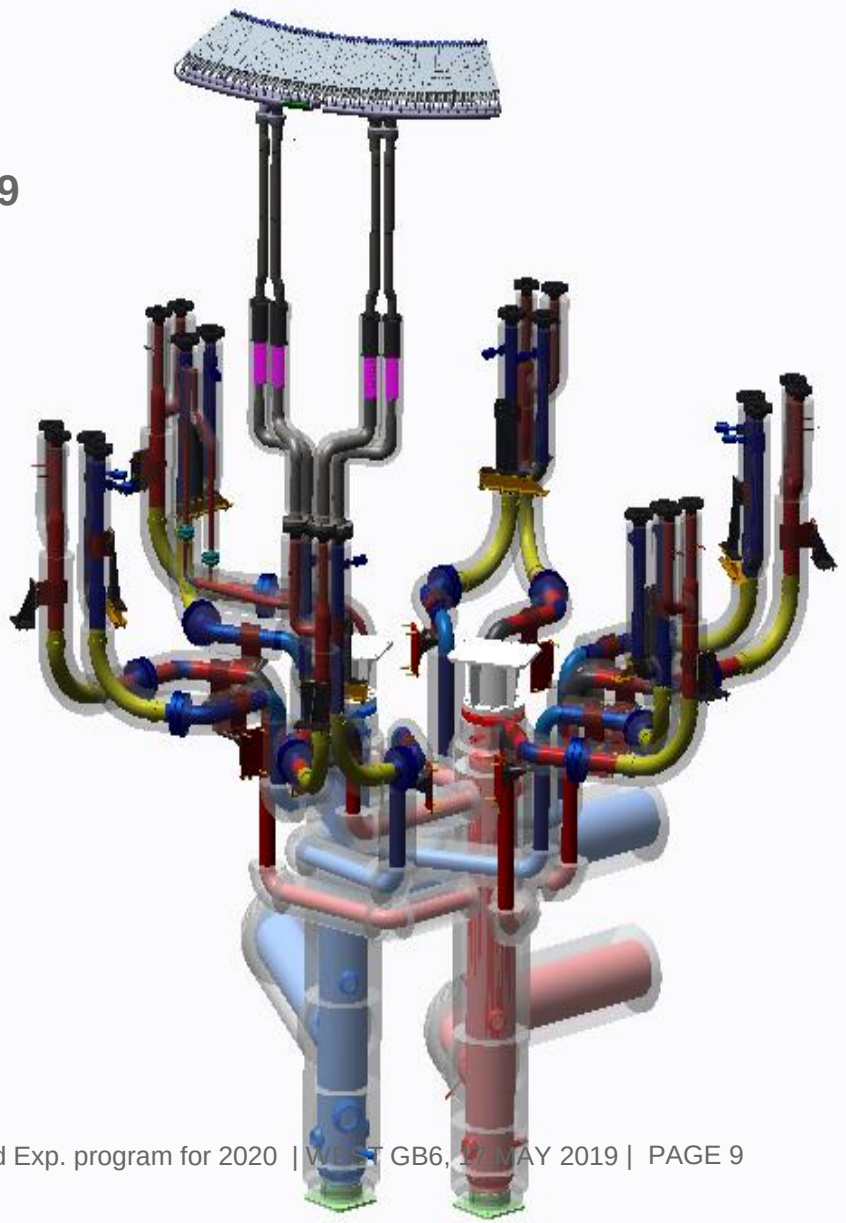
Prototype for welding validation



3D printing (Inconel)

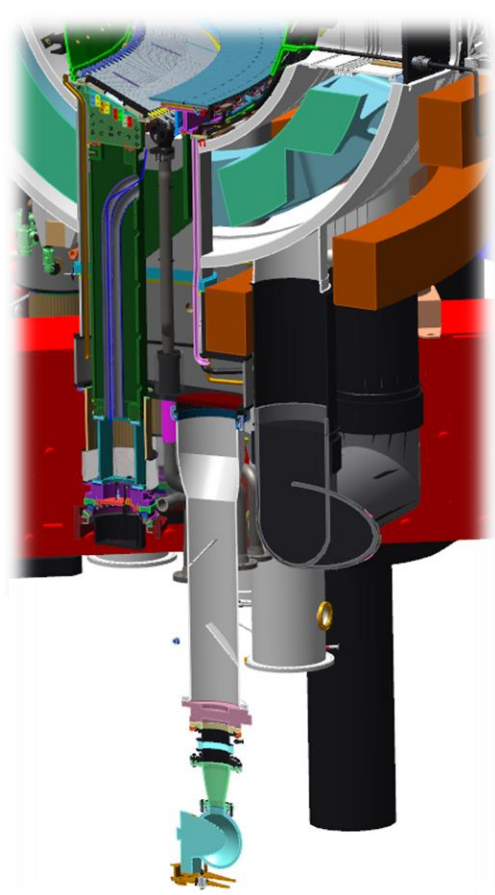
COOLING WATER NETWORK MODIFICATIONS
CALL FOR TENDER ONGOING

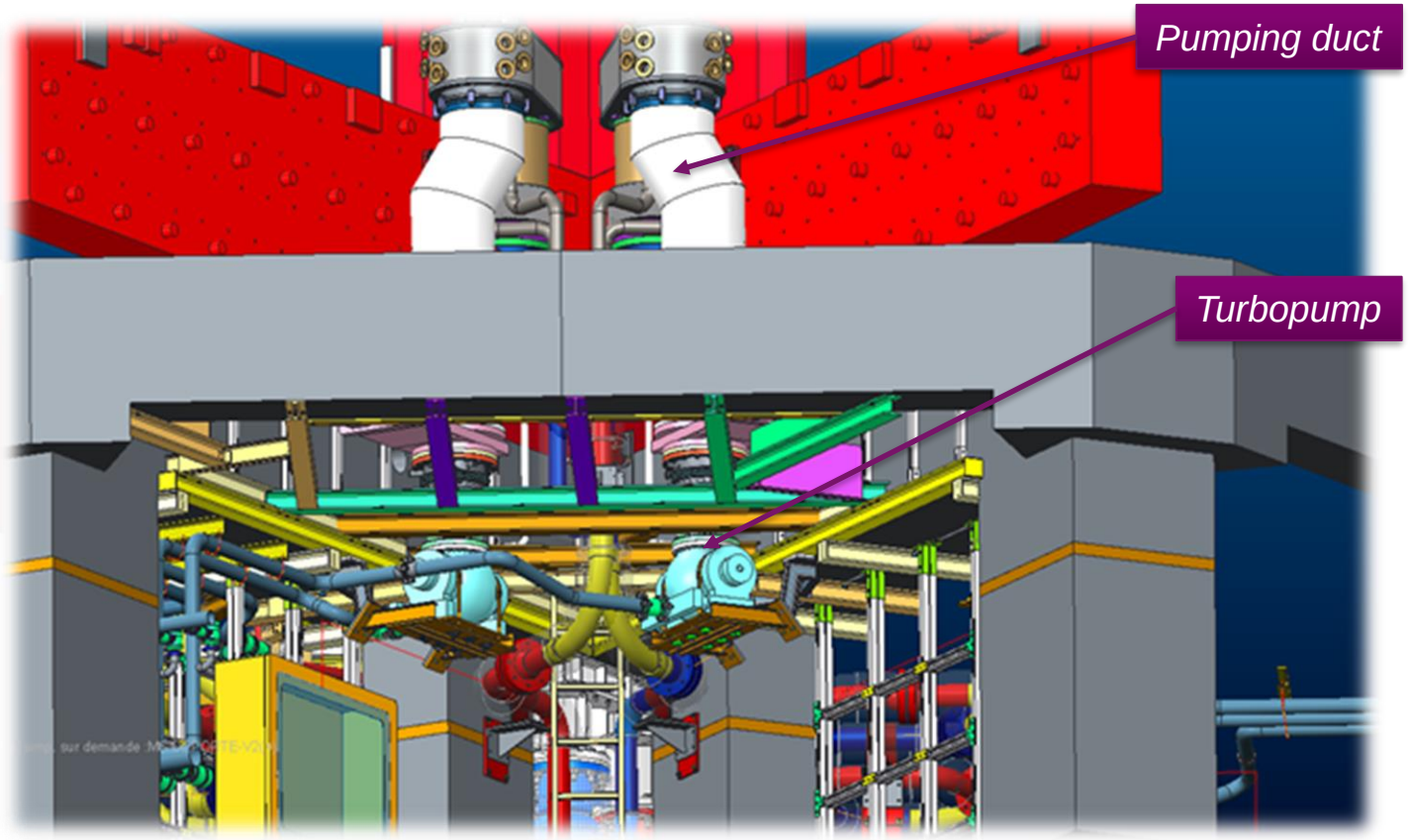
- Call for tender ongoing: offers on **20 May 2019**
- Contract award expected in June 2019
- Works on site **January-February 2020**



FULL DIVERTOR PUMPING
5 REMAINING DUCTS WILL BE INSTALLED

- **10 turbo pumps** installed for phase 2 with barometry (5 today)
- Reduction of the conductance between the baffled region and the main chamber
- **New mass spectrometer** in one divertor pumping duct



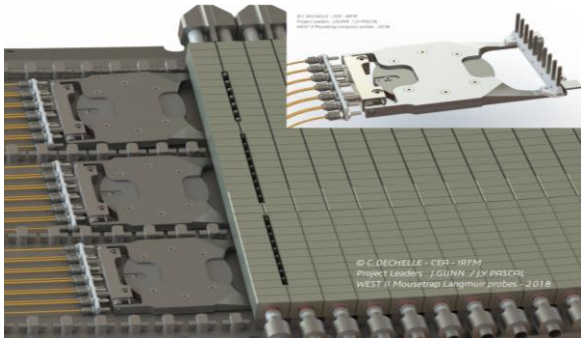


PFU INSTRUMENTATION (1/3)
NEW LANGMUIR PROBES SET

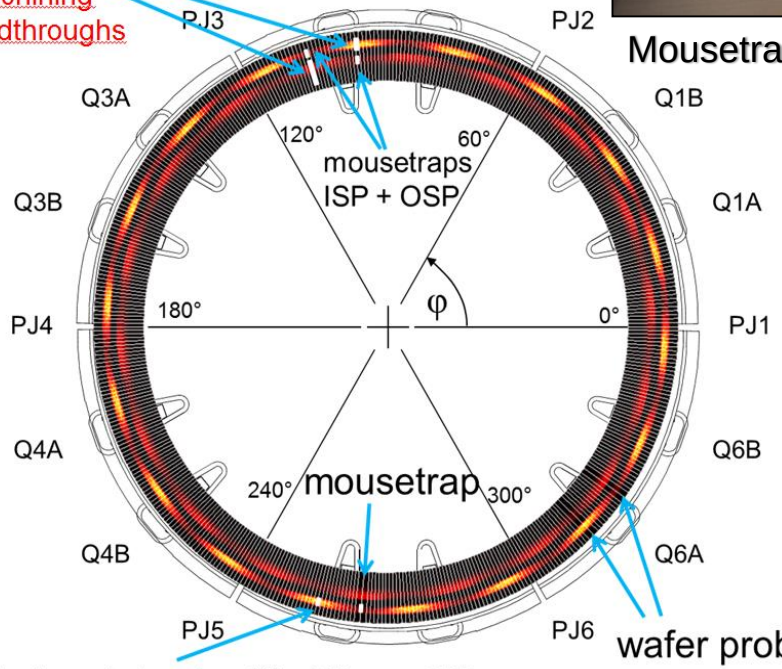
- Four concepts developed → FDR held on April 26
- Technical specifications for « Acquisition Systems » validated – CfT in progress

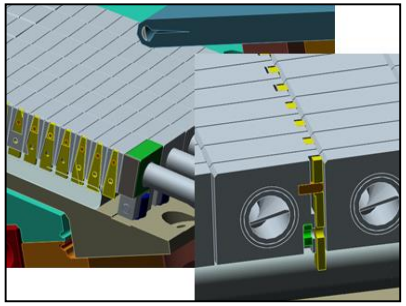
Mousetrap ***(2+1)***

pop-ups (10 OSP +20 ISP)
support plate machining
new flange + feedthroughs



Pop-ups ***(10+20)***



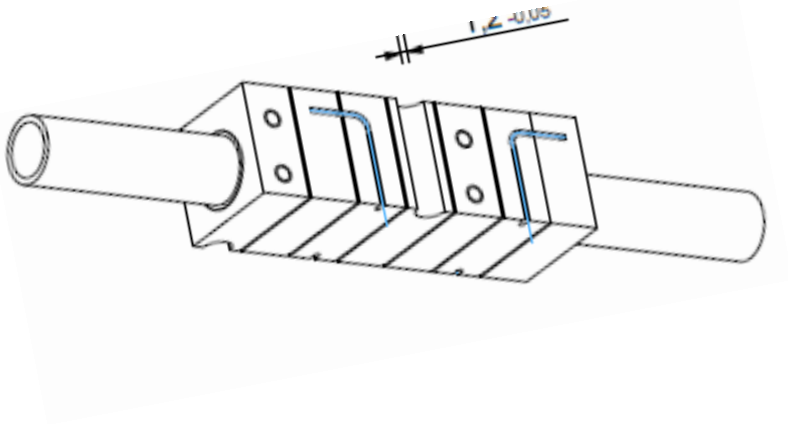


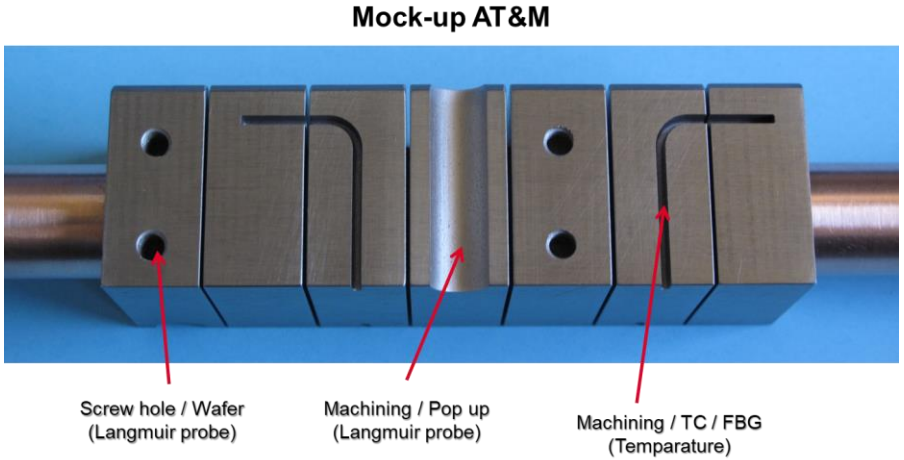
Wafer probes ***(28+28)***

Actively cooled probes (ASIPP)

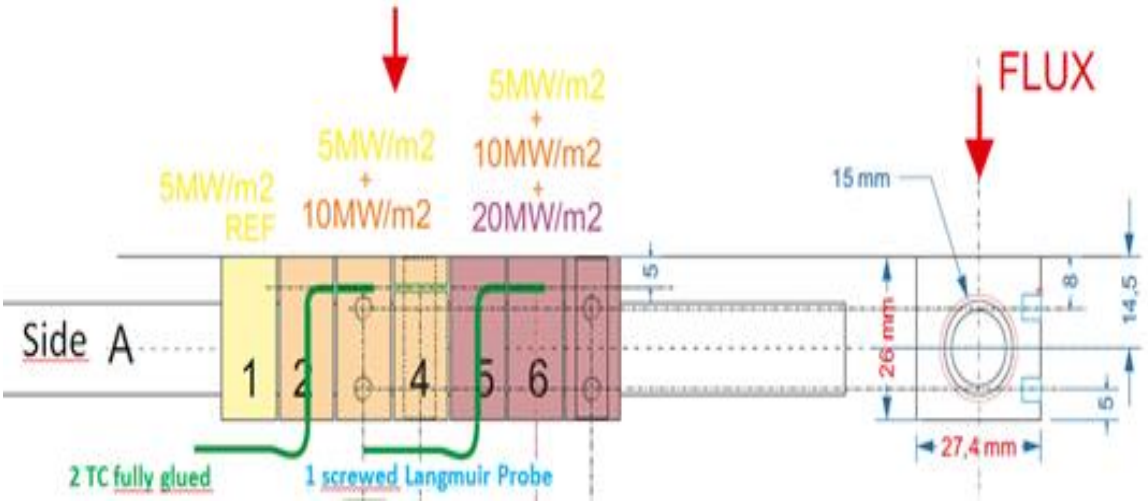
PFU INSTRUMENTATION (2/3)
EMBEDDED TEMPERATURE MEASUREMENTS

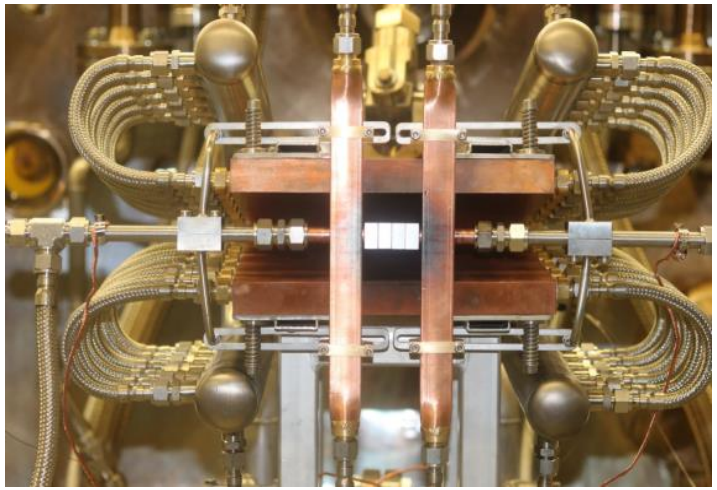
- Machining feasibility on mock-ups: delivered on March 13





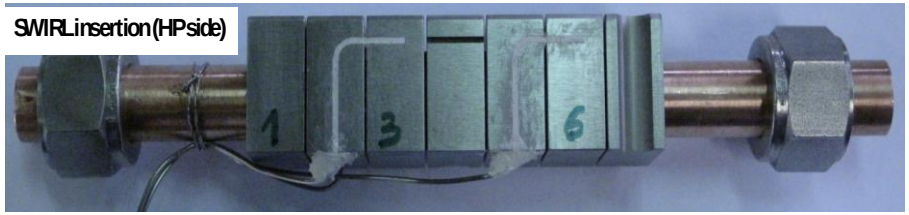
- High heat flux tests (fatigue testing): @ HELCZA (Czech Republic) on April 8-12



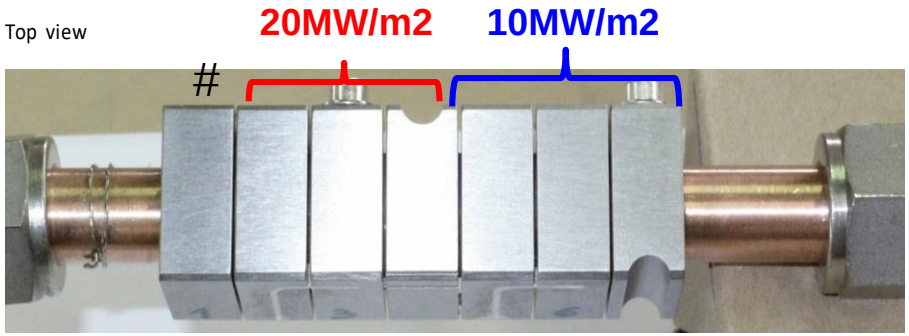


PFU INSTRUMENTATION (3/3)
HHF TESTS SUCCESSFULLY PASSED

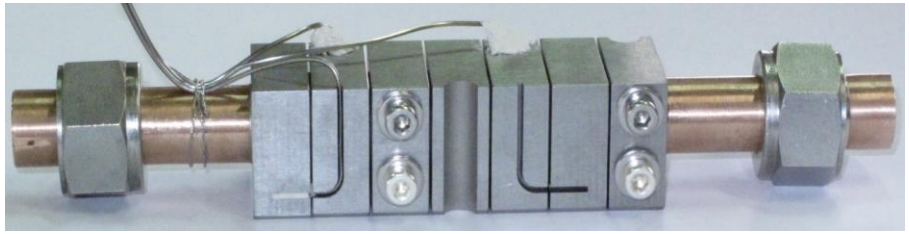
Side A



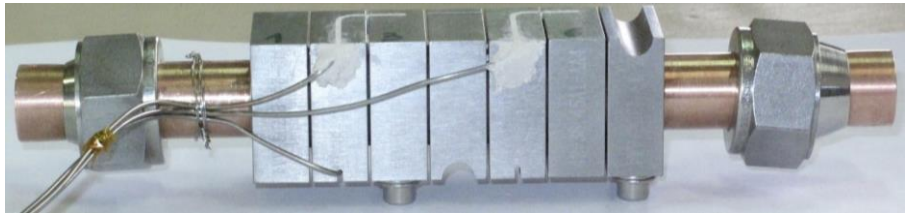
Top view



Side B



Bottom view

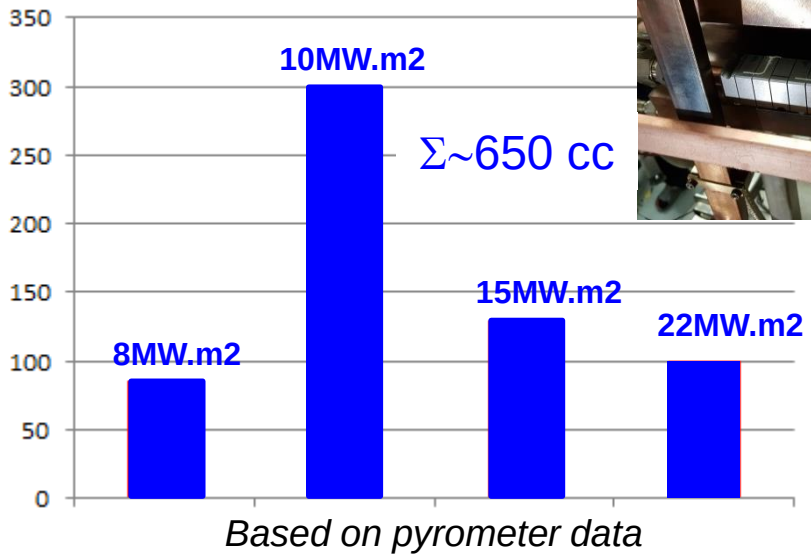


Initially planned

500 cc @10 MW/m2 (10s on / 10s off)

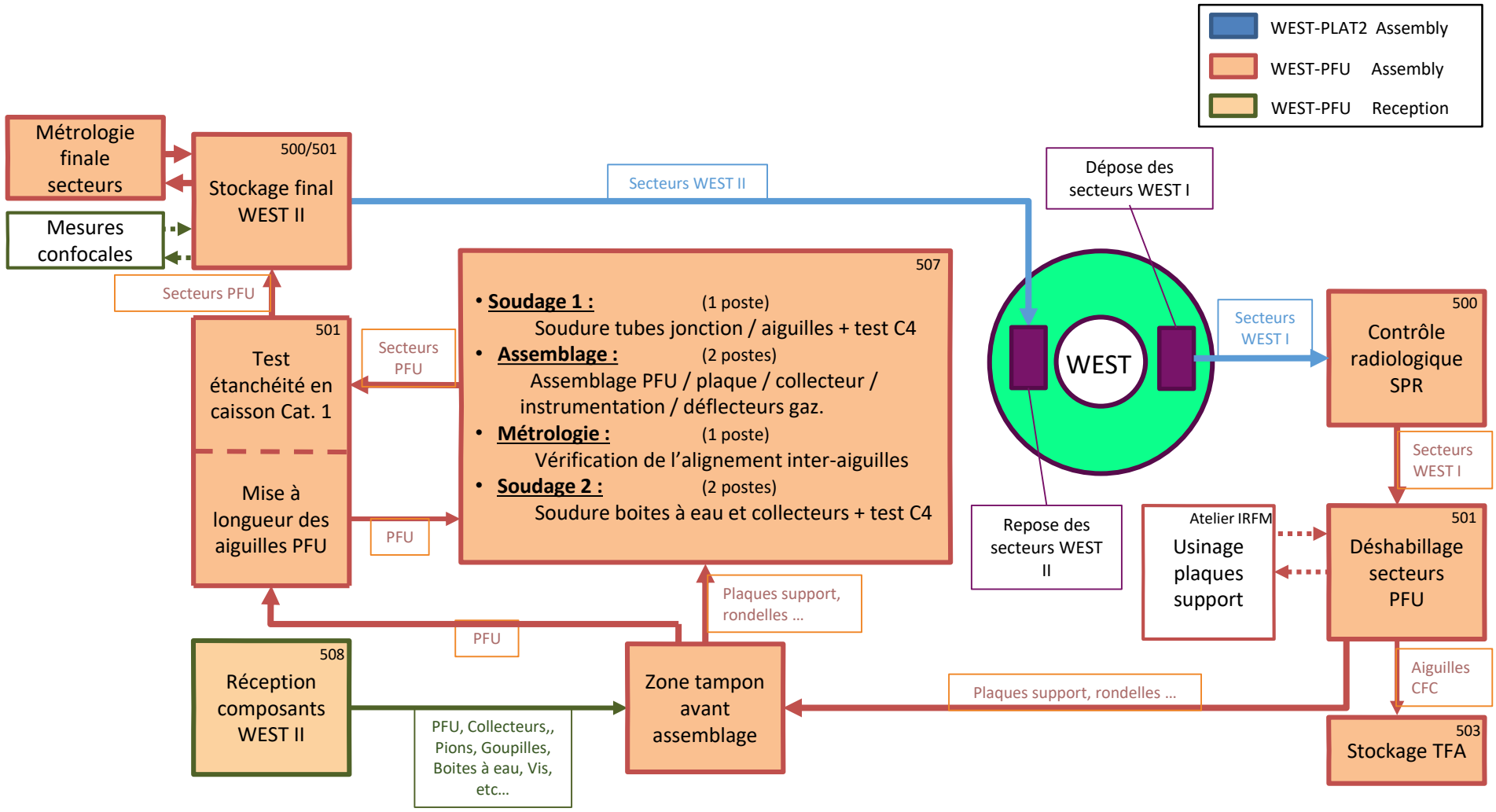
100 cc @ 20 MW/m2 (10s on / 10s off)
(extended to 50s for TC)

Performed on HELCZA



Based on pyrometer data

PFU INSTALLATION FLOWCHART

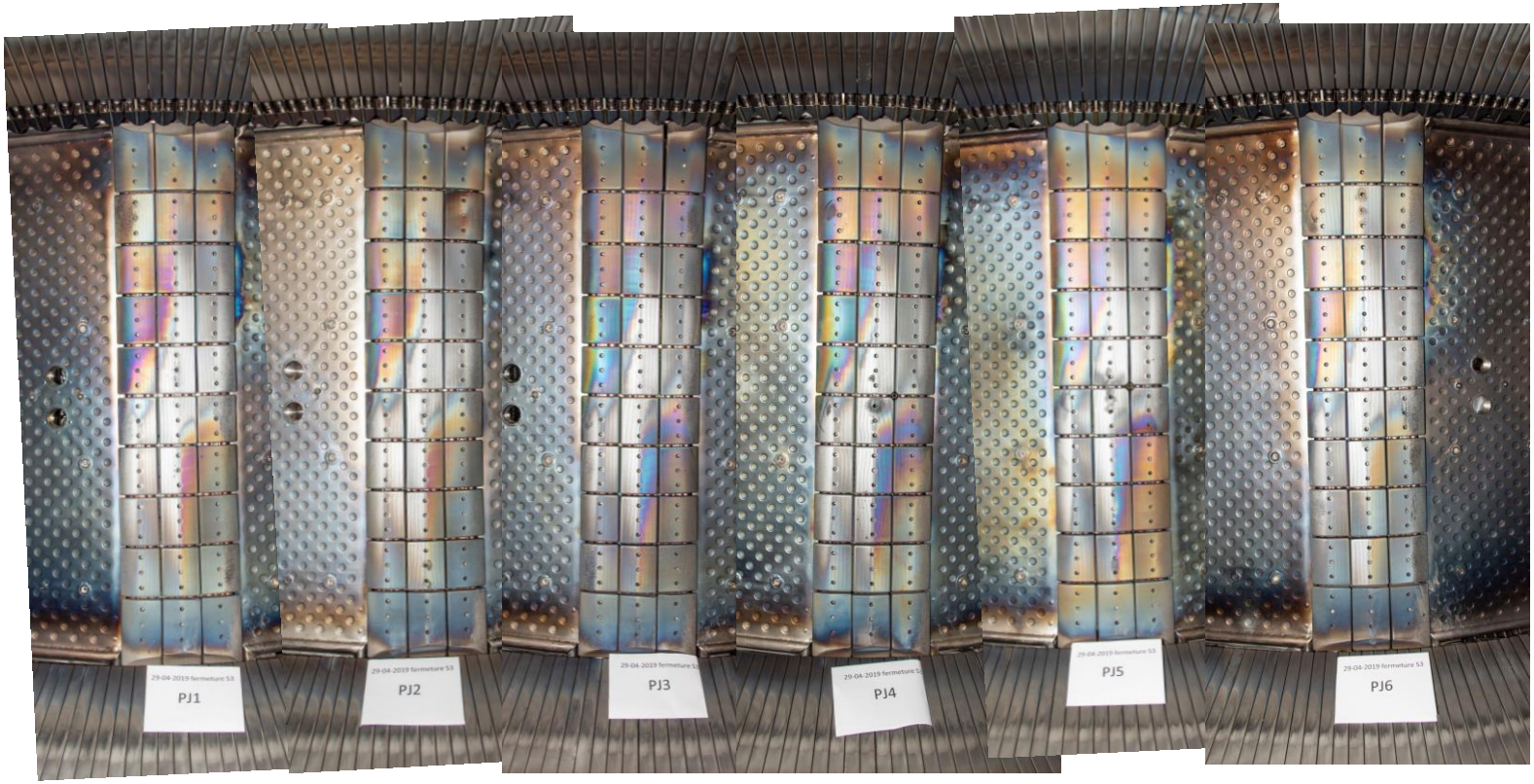


FURTHER UPGRADES

MASSIVE TUNGSTEN TILES FOR THE INNER WALL LIMITERS

- For C4 campaign → outer limiter W-coated CFC tiles replaced by massive W tiles
- For phase 2 → the 6 inner bumpers will be equipped with massive W tiles
- W-coated CFC only left on lateral protections of LH and IC antennas (W 80µm/ Mo 80µm)

Outer limiter with massive W tiles

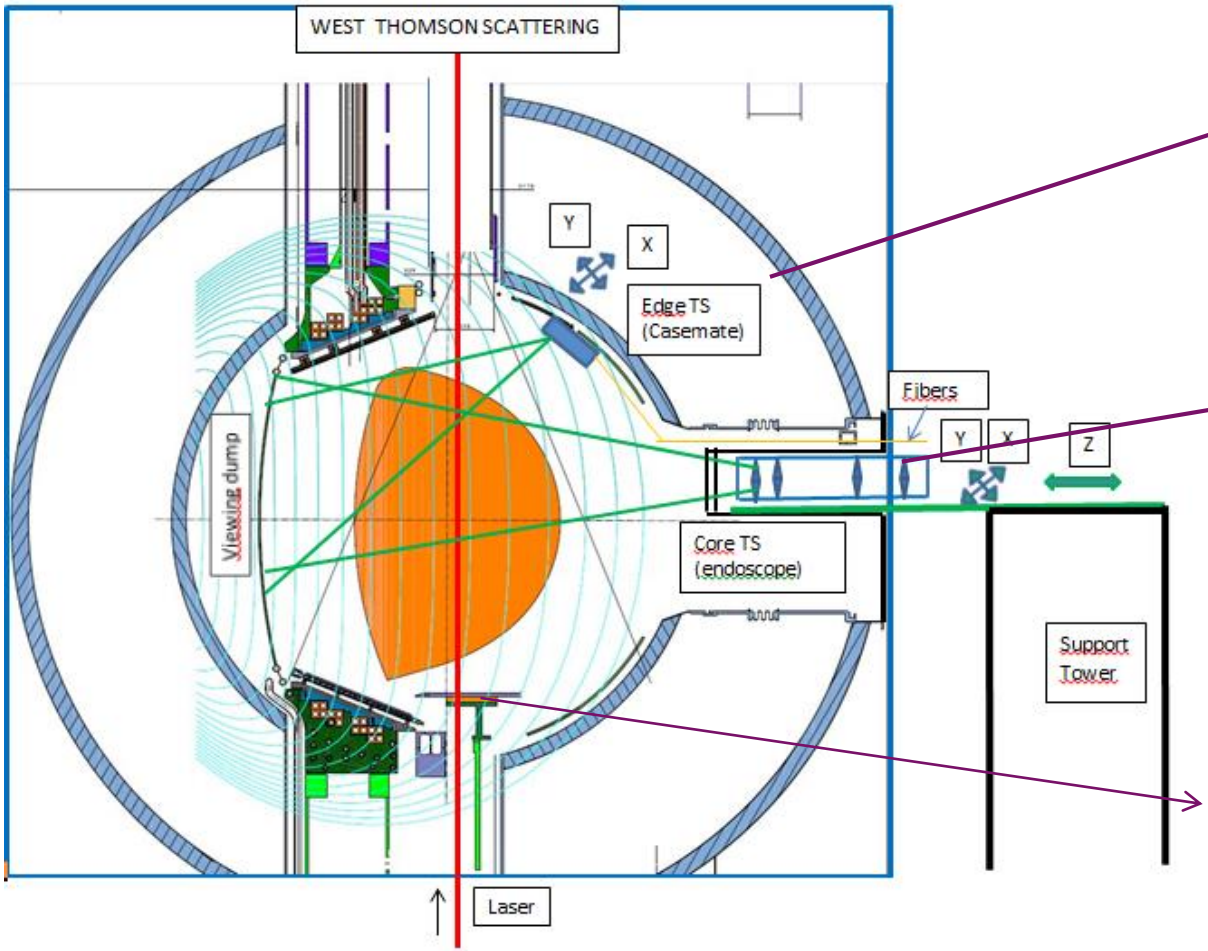


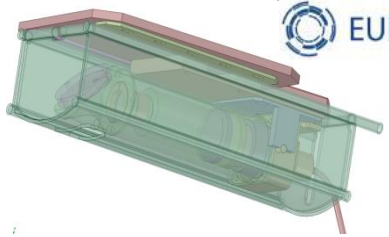
THOMSON SCATTERING DIAGNOSTIC

- Edge Thomson Scattering (Phase 1) ➔ final design to be completed in 2019
- Manufacturing and installation in 2020 ➔ commissioning in 2021 (C7)

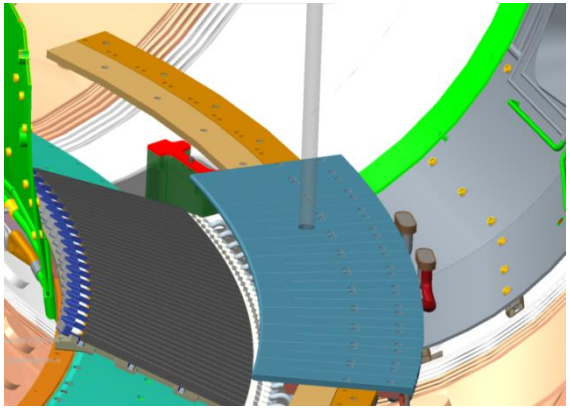
Phase 1

EUROfusion





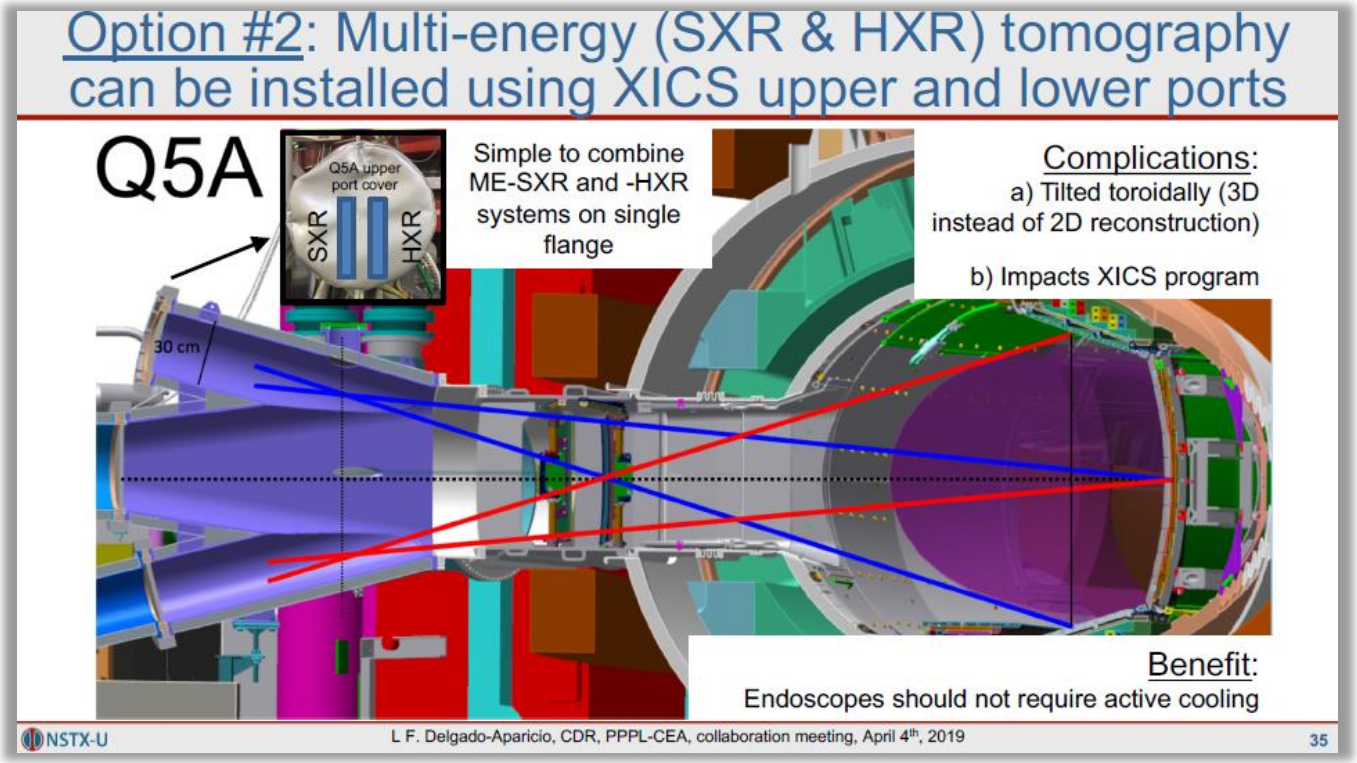
Phase 2



3 NEW X-RAY DIAGNOSTICS

- Compact x-ray imaging crystal spectrometer (cXICS): n_Z & δZ_{eff} profiles (Ar, Mo, Xe, W)
- Multi-energy soft x-ray system (ME-SXR): n_Z & δZ_{eff}, T_e, Z_{eff} profiles (Z-transport, accumulation & control studies)
- Multi-energy hard x-ray system (ME-HXR): $n_{e,fast}$ and T_e (RF power deposition and runaway formation studies)

From CDR April 4, 2019

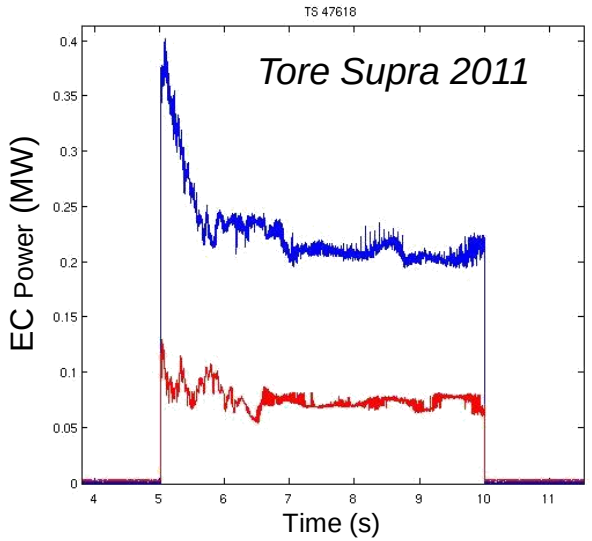


PENDING ON C4 RESULTS

ECRH system restarted

- 2 gyrotrons at reduced power to be used during plasma current ramp up to avoid deleterious MHD (hollow temperature profile)

ECRH antenna with actively cooled mirrors

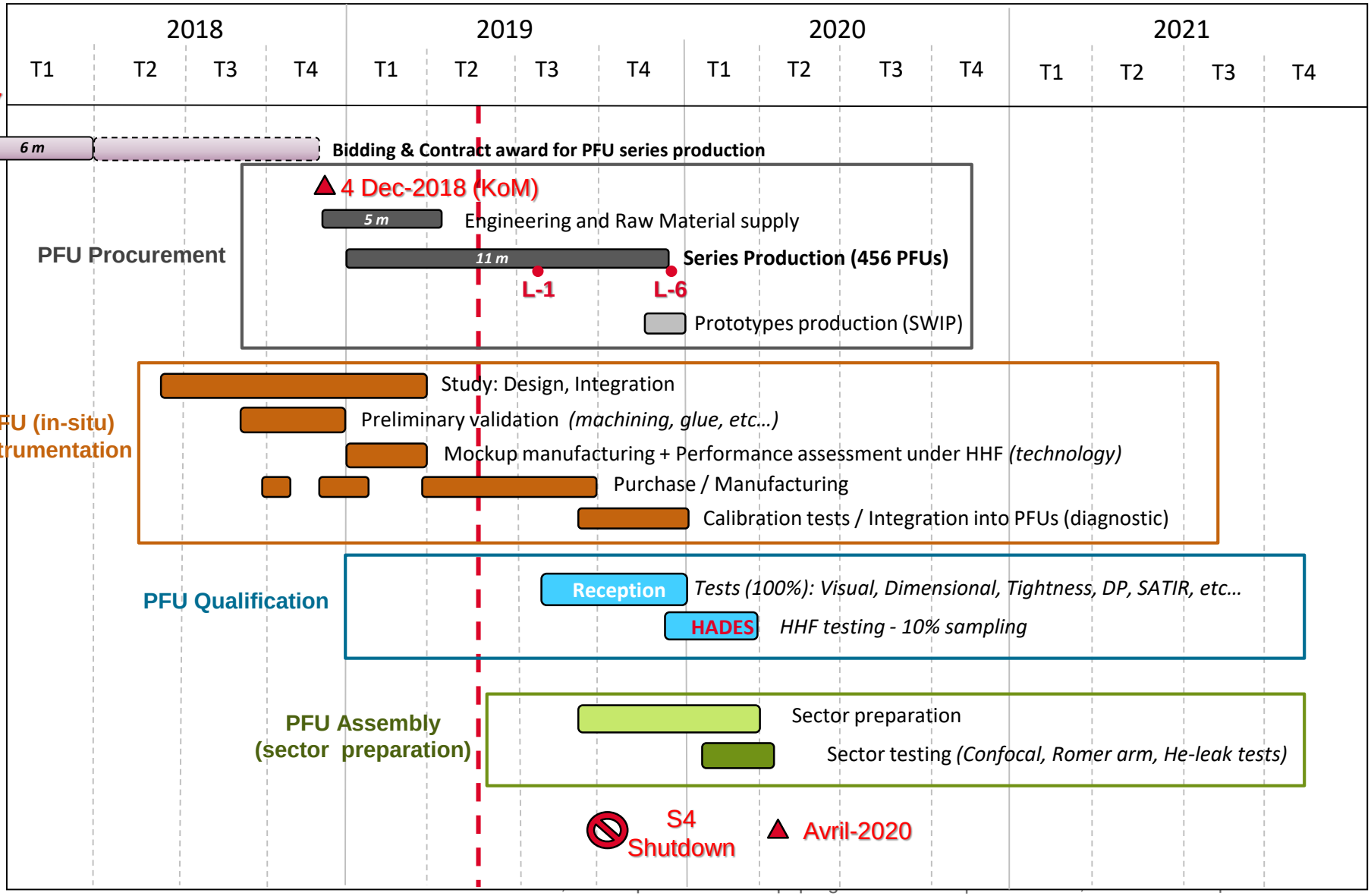


Boron coatings on RF antenna limiters

- To reduce tungsten source in outboard mid-plane region

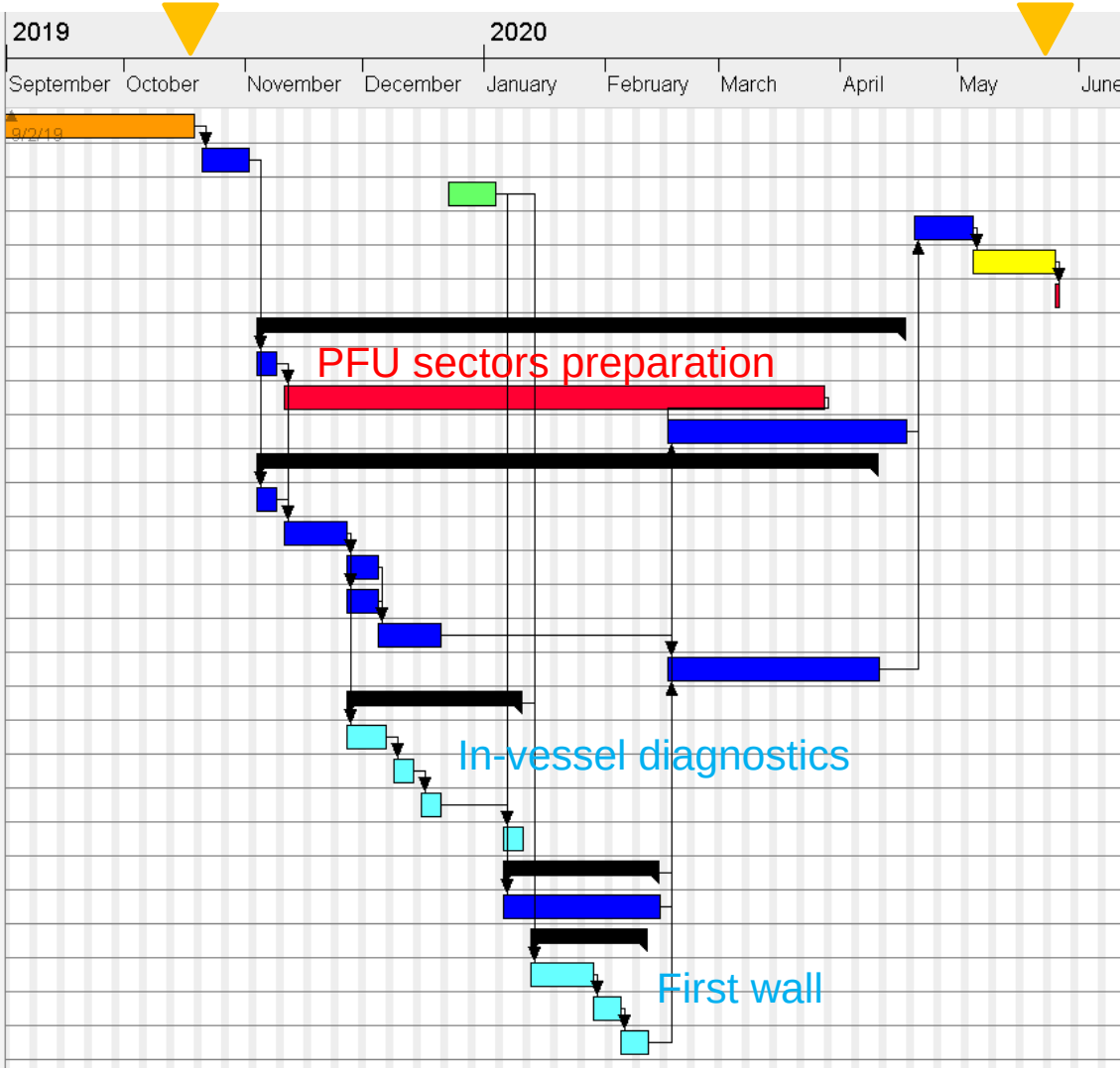
SCHEDULE AND EXPERIMENTAL PROGRAM FOR 2020

PFU OVERALL SCHEDULE



OVERALL SHUTDOWN SCHEDULE
PLASMA EXPECTED IN SPRING 2020

Name	Begin date	End date
C4 campaign	7/1/19	10/18/...
Vessel opening	10/21/19	11/1/19
End of year break	12/23/19	1/3/20
Vessel closing	4/20/20	5/4/20
Leak detectection and wall conditioning	5/5/20	5/25/20
C5 campaign	5/26/20	5/26/20
Divertor and baffle	11/4/19	4/17/20
Divertor and baffle sectors dismounting	11/4/19	11/8/19
Divertor sectors assembly and testing	11/11/19	3/27/20
Divertor and baffle sectors installation	2/17/20	4/17/20
Pumping ducts	11/4/19	4/10/20
Pumping ducts dismantling	11/4/19	11/8/19
Drilling of the boxes	11/11/19	11/26/...
Welding of handling supports	11/27/19	12/4/19
Welding of the inspection traps	11/27/19	12/4/19
Welding of the belows and PFU piping intro...	12/5/19	12/20/...
Pumping ducts mounting	2/17/20	4/10/20
Diagnostics	11/27/19	1/10/20
Visible spectroscopy	11/27/19	12/6/19
Inteferpolarmetry cooled mirrors	12/9/19	12/13/...
MHD measurements	12/16/19	12/20/...
Thermocouples	1/6/20	1/10/20
Cooling water loop	1/6/20	2/14/20
Network installation	1/6/20	2/14/20
First wall protection panels	1/13/20	2/11/20
Installation of vessel belows protections	1/13/20	1/28/20
Installation of outer limiter protections	1/29/20	2/4/20
Baffle protection panels connection	2/5/20	2/11/20



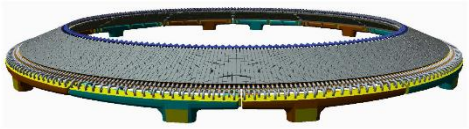
PROSPECTS FOR 2020

Phase 1 → ***WEST WKS3 (early 2020)***  → Phase 2

	2019												2020											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WEST	Shutdown S3 (IC3)								C4		S4 Phase 2 (Act. cooled W div.)							C5		S5		C6		

S3 shutdown

- ICRH #3
- 2 F4E PFU



Campaign C4

- D phase
- Dedicated He campaign

EUROfusion

S4 shutdown (phase 2)

- actively cooled W divertor

Campaign C5

- Divertor commissioning & scenario development for long pulse operation

Campaign C6

EUROfusion

- D long pulse / high fluence campaign
- Divertor detachment control / double null ➔ long pulse

STEPS FOR PREPARATION OF WEST PHASE 2 PROGRAMME

Call for experimental and modelling proposal

- Fall 2019

3rd WEST Experimental Planning Meeting

- **21-22 January 2020, Aix en Provence**
  - Discussion of the proposals received
  - Update of the research plan for phase 2
    → to be presented at the WEST GB 2020

Call for participation for C5 and C6

- Spring 2020

Session Leader training

- Spring 2020

Thank you for your attention

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OVERVIEW OF WEST DIAGNOSTICS (STATUS APRIL 2019)