2020 MST1 Review Meeting summary

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This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

Outlook

1. 2019/20 MST1 overview *[H. Mayer]*

2. News from MST1 tokamaks:
    1. ASDEX-Upgrade *[A. Kallenbach]*
    2. TCV *[S. Coda]*
    3. MAST-U *[A. Kirk]*

Our grant deliverables 2019 – 2020

2019	
GD-MST1-1	A proof of principle integrated system for disruption detection and avoidance based on a machine independent state observer and implementation on at least one MST1 device. (topics 6, 12 and 9)
GD-MST1-2	Demonstration of the control of the radiation front location for detachment and assessment of the application of the scenario for alternative divertor configurations. (topic 14)

Exceeded by implementing each on TCV and AUG

2020	
GD-MST1-3	**Assessment of the impact of the pedestal and SOL condition in MST devices for different methods achieving tolerable ELMs on their scalability to larger devices. (topics 1, 2, 3, 4, 5, 10 and 11)**
GD-MST1-4	**Comparison of the performance of specific alternative divertor configurations with conventional divertors with respect to exhaust performance in steady state and during transients. (topic 15)**

2019 Campaign was successful

- After a difficult 2018 AUG performed well for the extended 2018 and the following 2019 campaigns.
  - The first successful reversed B_t/I_p after 12 years.
    - Despite an intermittent vacuum leak good scenarios with high power could be performed.
  - Extra discharges were performed for a high priority ITER task on W fuzz in He.
- TCV had the first campaign with baffles
  - baffles fulfil (and exceed) predictions, improve operation and allowed for better cross comparison.
    - Opening H-mode operating space.
- Strong commitment both the AUG and TCV team.
- 2019 campaign had a good participation with well integrated teams.
  - Participation could be improved for Scenario oriented topics (T01, T04) in particular at TCV.

We are ready for 2020

- 2020 marks the end of FP8 ⟹ very tight budget.
  - Focussed on maximising experimental days.
  - Still the number of shot days needed to be reduced to fit in the budget.
- We have accepted 81 out of 101 proposed PPY for 376 out of 390 participants.

	AUG days	TCV days	MAST-U days
Planned after GPM 2018	31[1)]	20	50[2)]
Affordable programme	**22**	**20**	**25[3)]**

1) This is 3 days more than have been presented in 2018 as these lost days in December were transferred to the 2020 budget.
2) The shot days assumed on MAST-U in 2018 was unrealistic as the number of overall available shot days was to optimistic.
3) This is the absolute maximum that could be run in 2020 for MST1 on MAST-U.

Allocated shots per topic

Topic	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16	17	X01	total	contingency
AUG	36[1)]		18	23	26[1)]	32[1)]	26	8	20[1)]	18	27[1)]		43[1)]		13	8	4	302	14%
TCV	33	13		31	26	30	60			18	64	30	31	65	16			417	20%
MAST-U		22	45	25	26			29		27			81	85	22			362	10%

1) This allocation includes transfers from programme that could not be run in Dec 2019.

In 2020 we are running with reduced contingency increasing the risk for each topic.

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AUG extension planning till 2023

- thyristor group 7 for more power/energy/flexibility in progress (ready for use in autumn 2020)
- **AUG advanced upper divertor Div-IIo** in the framework of EUROfusion PEX installation planned to start early summer 2022, start of use Sept 2023

  NBI I: upgrade arc sources to RF parallel to Div-IIo 2022/23

SPI installation in 2020, operation from 2021 (not reported in these slides)

New diagnostics and actuators 2020

- Divertor Thomson scattering
  optimization of data evaluation, time resolution 4 Hz → 10 Hz
- Imaging heavy ion beam probe $\tilde{\phi}$, $\tilde{n}_e$, $\tilde{B}$ commissioning from Feb., full capabitities Nov.

AUG 2020/21 operation schedule

Tentative planning

- Operation till ~ end July 2020
  reversed Ip/Bt 6.2. - ~ 20.2.
  H / He 16.7.-23.7.
- restart Nov 2020
- experiments till end July 2021
- Large vent for alternative upper divertor Div-IIo
  to start in early summer 2022, restart in Sept 2023

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Calendar and new capabilities

J	F	M	A	M	J	J	A	S	O	N	D
Vent			Unbaffled operation	V e nt	Unb. op.	Vent		Baffled operation (same baffles or ½)			
1.3 MW, 1 s NBI (D or H)								1.3 MW, 2 s NBI (D or H)			
1.4 MW X2, 0.95 MW X2 or X3					1.4 MW X2, 1.9 MW X2 or X3, 0.9 MW lateral X3						
			Extended coverage for CXRS and FIDA								
			Upgraded DSS (Divertor Spectroscopy), lateral and vertical views								
			FILD								
					Upgraded bolometry, X-ray, AXUV tomography						
			Phased in ⇨		Fluctuation diagnostics (PCI, CECE, DBS/reflectometry)						

Practical infos

- If you plan to visit TCV, be aware of the required paperwork

Note: all requested documents, if applicable, should be sent at least 1.5 months before your arrival in Lausanne to this address

- if work period exceeds 8 days per calendar year:
  - a copy of the passport
  - a short CV
  - an employment certificate (ask to L. Gentili)
- if work period does not exceed 8 days per calendar year:
  - no requirements; however, to prepare for possible delays and extensions, it is recommended that you follow the same steps as if the period was longer than 8 days

Practical infos

- To require an account to access the TCV intranet and LAC servers (X2GO, NX)
- Detailed information on the machine status and operation here
- Updated list of available diagnostic here
- Several codes and routines are available on LACs
- TCV scientific meetings every Monday at 8h15 (streamed on FusionTV-CH.24). Short, informal reports on previous week's experiments are expected

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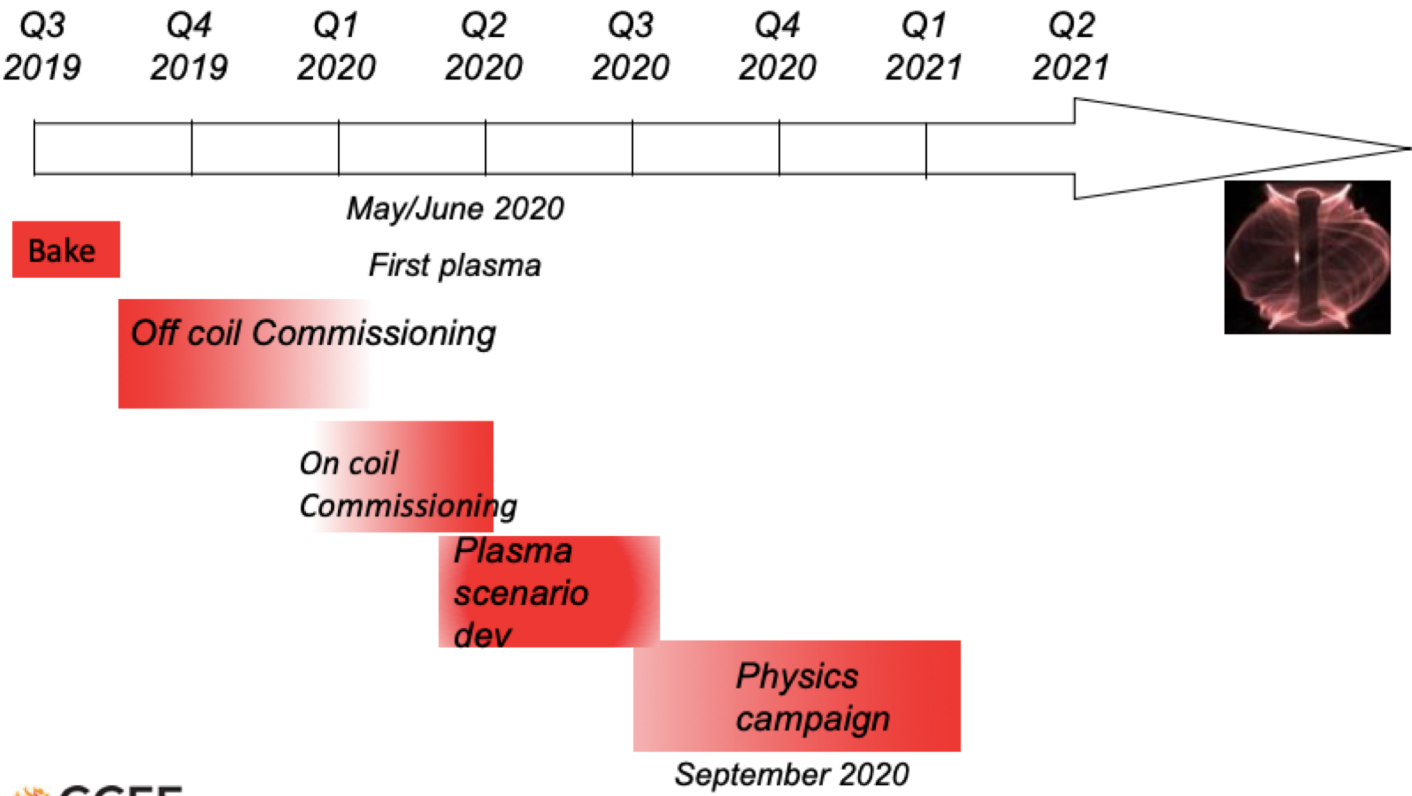
Summary of MAST-U status

- **Vacuum vessel conditioning**: bake completed, GDC in Super-X configuration
- **Off coil power supply**: commissioning almost complete, contractor problems with Toroidal Field and divertor coil power supply caused 3 month delay
- **Control system**: functionality tested but waiting for inclusion of divertor coils
- **NBI power supply**: minimal progress on commissioning due to priority given to JET NBI issues (will impact start of 1st campaign). Now large team allocated but it will have an effect when full beam power available (August 2020)

MAST-U future timeline



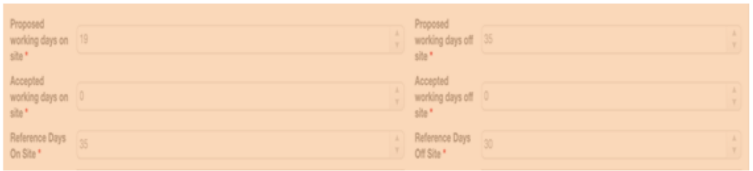
2020 MST1 campaign participation

- Communication from MST1 ROs

As you may know, the 2020 MAST-U campaign will be delayed ~3months due to a power supply issue. The exact experimental dates will be specified in June this year.

In the meantime your campaign participation request in IMS will be updated as follows:

- accepted working days on-site will be set to zero;
- accepted working days off-site will be set to zero (unless some preparatory activity is expected);
- reference and last proposed working days will stay untouched for future reference;
- all already approved MAST-U campaign visits will be set back to **pending** status.



Note that no action is required on your side until further notification.

We will ask you to check your visit dates and provide us the updates on your campaign participation proposal as soon as the information on operational time of MAST-U in 2020 is available.

Please do not hesitate to contact us if you have any further questions.

- A dedicated MST1 TFM to introduce MST1 campaign (not scheduled yet)

MAST Upgrade Enhancements

In April 2017 EUROfusion approved enhancements to MAST Upgrade as part of the Plasma EXhaust strategy

MAST-U in 2020

- **Increased toroidal field 0.5T → 0.8T (at 0.8m)**
- **New solenoid**
- **19 new PF coils**
- **Super-X divertor capability**
- **Off-axis NBI**

MAST-U with enhancements

- **Extra diagnostics (2020)**
  X-point Thomson scattering
  RT Langmuir probes
  Multiple extra IR cameras
  2 fast visible cameras
- **Flexible Fuelling (2020)**
  Pellet injector + 48 gas valves
- **Cryoplant (2021)**
  Divertor particle control
- **Double NBI Box (2022)**
  Additional 5MW auxiliary heating
- **Gyrotrons (2023)**
  Additional 2MW auxiliary heating

MAST Upgrade Enhancements