Status Report for WPENR

3rd Tokamak Project Board | 14.03.2022

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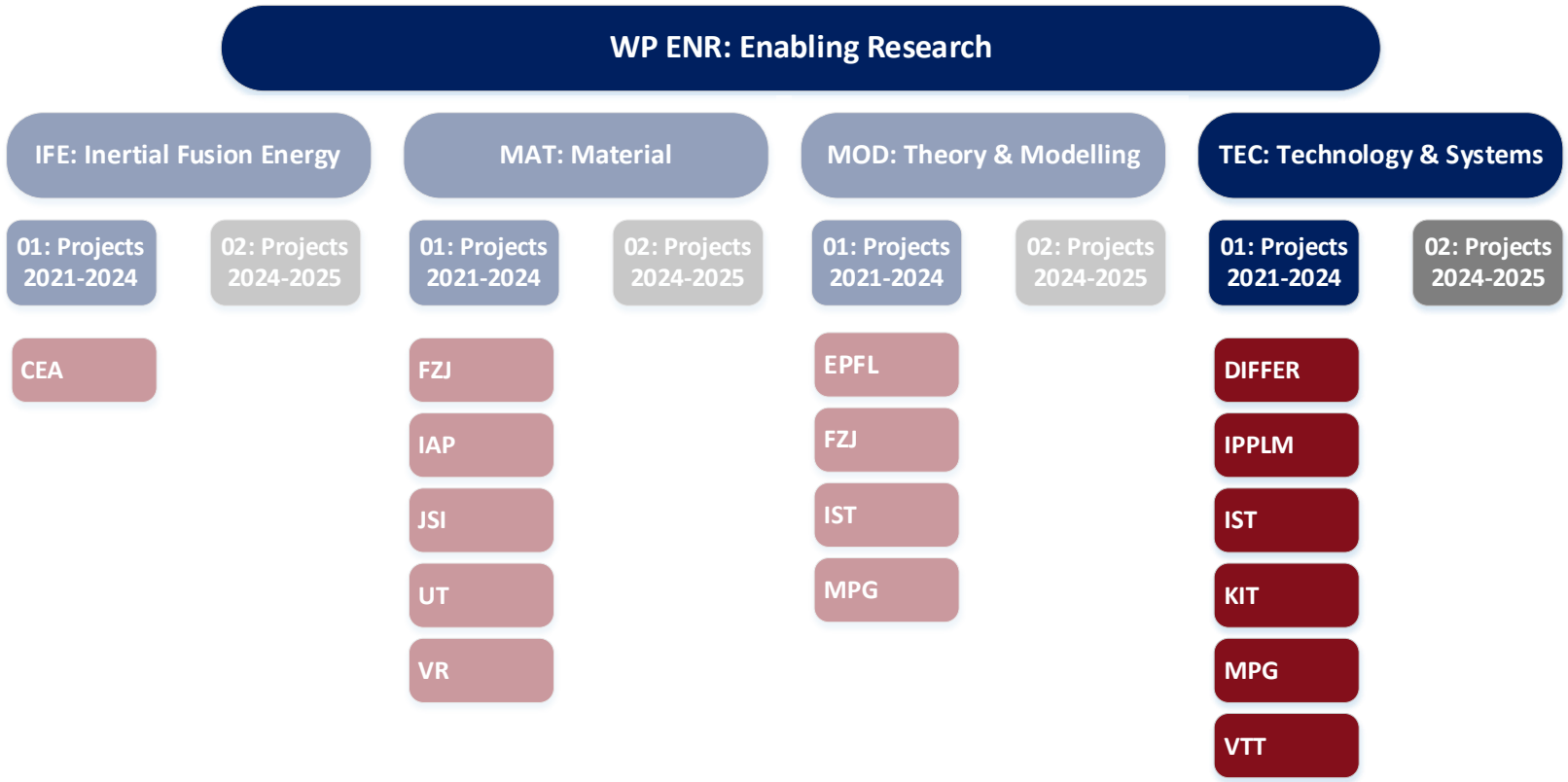
1 – WP Organization



No organizational changes

IPPLM project postponed the start to Jan.2022 (due to delay on the Grant Agreement signature)

2 – WP Main Objectives & Summary of Achievements (previous year)

Late start: projects were running for 6 months in 2021

Overall progress

- Preparatory activities:
  - *Kick off (establishment of interactions within the project team);*
  - *Preliminary simulations;*
  - *Definition of test/benchmark cases;*
  - *Collection of experimental data;*
  - *Start of component manufacturing*

ENR-TEC.01.DIFFER (M. van Berkel)

Multivariable feedback control of radiative loss-processes using multi-spectral imaging

2nd SB.ENR-TEC (Monitoring of 2021 activities)
https://indico.euro-fusion.org/event/1353/
Annual report
https://idm.euro-fusion.org/?uid=2P4K6E

Overview

Main goal: setting up for MIMO control with different MANTIS camera's

Delayed: main (full-time) person is missing and will start 1st March!

- **RT-image processing (based on past experiments):** Improve and make current algorithms real-time (not in the control system yet) for nitrogen and Balmer lines to determine recombination and excitation regions.
- **Qualitative RT-image processing:** Qualitative real-time algorithms for the observation of nitrogen, recombination and excitation (ionization) based on camera images only (based on ~ 5 cameras).

Hence, shifted focus to:

- **Simple-MIMO identification demonstration**: Demonstrate MIMO system identification algorithms developed in this proposal for the simplified case of D2 and N2. (initial testing RT-alg.).

Ongoing process:

- **Selection of control targets:** Scenario selection and determination on control targets is performed, ongoing process.
- **Integration DCS**: Integration of algorithms into the digital control system TCV and verify real-time algorithms.

DIFFER EPFL ENR team | ENR Project no. 11 | MIMO control of radiative loss-processes | 29-11-2021 | Page 7

ENR-TEC.01.IPPLM (M. Scholz)

Development of GEM detector as a compact neutron spectrometer for fusion plasmas

2nd SB.ENR-TEC (Monitoring of 2021 activities)
https://indico.euro-fusion.org/event/1353/
Annual report
https://idm.euro-fusion.org/?uid=2P3UFG

Development of the design requirements of the NS-GEM demonstrator and the measuring set-up at NG-14 MeV generator.

1. Theory and modelling: NS-GEM synthetic diagnostic: Assumptions and design requirements for ITER neutron spectrometers.
2. NS-GEM Demonstrator: Initial stage of MCNP NS-GEM system modelling and the technical design of NS-GEM demonstrator
3. Neutron generator NG-14 MeV: MCNP modelling of the radiation field in the NG-14 MeV hall and the technical design of the measuring set-up.

In 2021, all three tasks envisaged in the plan were implemented from 1 July 2021, although the EUROfusion Grant Agreement was signed only on 7 December 21. As a result, the planned purchases of materials, including tritium targets for ING-14, were postponed to 2022. Which may result in a shift of the experiments planned in 2022 to the ING-14.

2 – WP Main Objectives & Summary of Achievements (previous year)

ENR-TEC.01.IST (F. Da Silva)

Advances in real-time reflectometry plasma tracking for next generation machines: Application to DEMO

2nd SB.ENR-TEC (Monitoring of 2021 activities)
https://indico.euro-fusion.org/event/1353/
Annual report
https://idm.euro-fusion.org/?uid=2P4PGA

During 2021, the groundwork needed for the project in accordance with Task 1 – Preparation and systematisation of the project:

- T1.1 For all relevant scenarios, input datasets for REFMULF will be prepared and made available Deliverable to properly model DEMO (and IDTT).
- T1.2 Preparation of FDTD code REFMULF (REFMUL3 added) to handle the specific needs of the simulations.
- T1.3 Planning of the clock demonstration.
- T1.4 Planning the compact reflectometers

The planning is done and the subsequent work is already started.

Some difficulties are being felt in obtaining the official complete scenarios for DEMO and the most complete scenario is the one from 2015. Even for the 2015's, data is available just up to the separatrix. The SOL data is unavailable and had to be modelled. This data is refers only to the flattop. No data is available for ramp-up.

ENR-TEC.01.KIT (S. Illy)

New generation of megawatt-class fusion gyrotron systems based on highly efficient operation at the second harmonic of the cyclotron frequency

2nd SB.ENR-TEC (Monitoring of 2021 activities)
https://indico.euro-fusion.org/event/1353/
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To form a basis for efficient and stable operation at the 2nd harmonic, the following theoretical investigations have been performed in 2021:

- Operation at second harmonic for two different high-order operation modes based on single-mode and multi-mode simulations; the latter directly indicate that **2nd-harmonic operation without additional means is not possible due to the dominating first harmonic oscillation**.
- The possibility to stabilize 2nd-harmonic operation by injection locking; here the obtained results showed that a stable operation is difficult to reach, even at high levels of injected power. One major outcome of these investigations is the fact that relative high-power loading on the gyrotron resonator wall has to be expected caused by the injected signal.
- To overcome the stability/concurrency problems, the application of outer corrugations on the resonator wall has been suggested and initial investigations have been performed to find a sufficient design strategy connected to the outer corrugations (based on the analysis of eigenvalue-curves).
- A possible technical solution for the coupling in of the injected driving power has been investigated based on a proposed dual-beam quasi-optical output system; in addition, the KIT in-house code KarLESSS has been enhanced to support this

2 – WP Main Objectives & Summary of Achievements (previous year)

ENR-TEC.01.MPG (D.Moseev)

Reconstruction of 4D and 5D fast-ion phase space distribution functions in tokamaks and stellarators

2nd SB.ENR-TEC (Monitoring of 2021 activities)
https://indico.euro-fusion.org/event/1353/
Annual report
https://idm.euro-fusion.org/?uid=2P33XS

The 5D fast ion velocity distribution function was tomographically reconstructed from the synthetic W7-X data using NBI slowing-down distribution functions as a basis.

The results are promising, however a shift to more generic basis is needed and being performed. We currently try to expand the method by reconstructing real experimental distribution function from LHD.

The data from JET is being acquired, however their post-processing is needed and the work is in progress now.

ENR-TEC.01.VTT (A. Salmi)

Silicon photonics steady-state magnetic field sensor

2nd SB.ENR-TEC (Monitoring of 2021 activities)
https://indico.euro-fusion.org/event/1353/
Annual report
https://idm.euro-fusion.org/?uid=2P4U2N

Four key components are needed to implement the magnetic field sensor based on Faraday rotation effect with SOI PIC technology. At the beginning of the project the focus is put on each of the individual components (no systems integration, yet). Presently we optimise:

- straight 3 µm strip waveguide dimensions, coating etc. to achieve very low birefringence
- tight phase flipping 180 deg turns with TIR mirrors to allow Faraday phase accumulation with light travelling in opposite directions
- polarisation splitters to go from random state to pure TE/TM polarization states and to measure the polarisation rotation
- 3 µm interferometer development to convert Faraday rotation angle into spectrum

Multiple versions of each component have been designed and manufacturing with MPW process is in final stages and will be completed in Jan 2022. Component characterisation will begin right after to give feedback for the next MPW run with integration (SOI PIC). In addition, measurement setups are being tested and developed and modelling of light polarisation behaviour in the SOI 3 µm waveguides are underway to help in design and optimisation.

2 – Status of Grant Milestones & Grant Deliverables (previous year)

GA Deliverable No.	Title	Due Date	Status	Details on Status (in case of delays or issues)
D07.01	Joint progress report on the Enabling Research projects 2021	31/12/2021	Completed	

GA Milestone No.	Title	Due Date	Status	Details on Status (in case of delays or issues)
n/a				

3 – Risk & Mitigation Register: Current Status

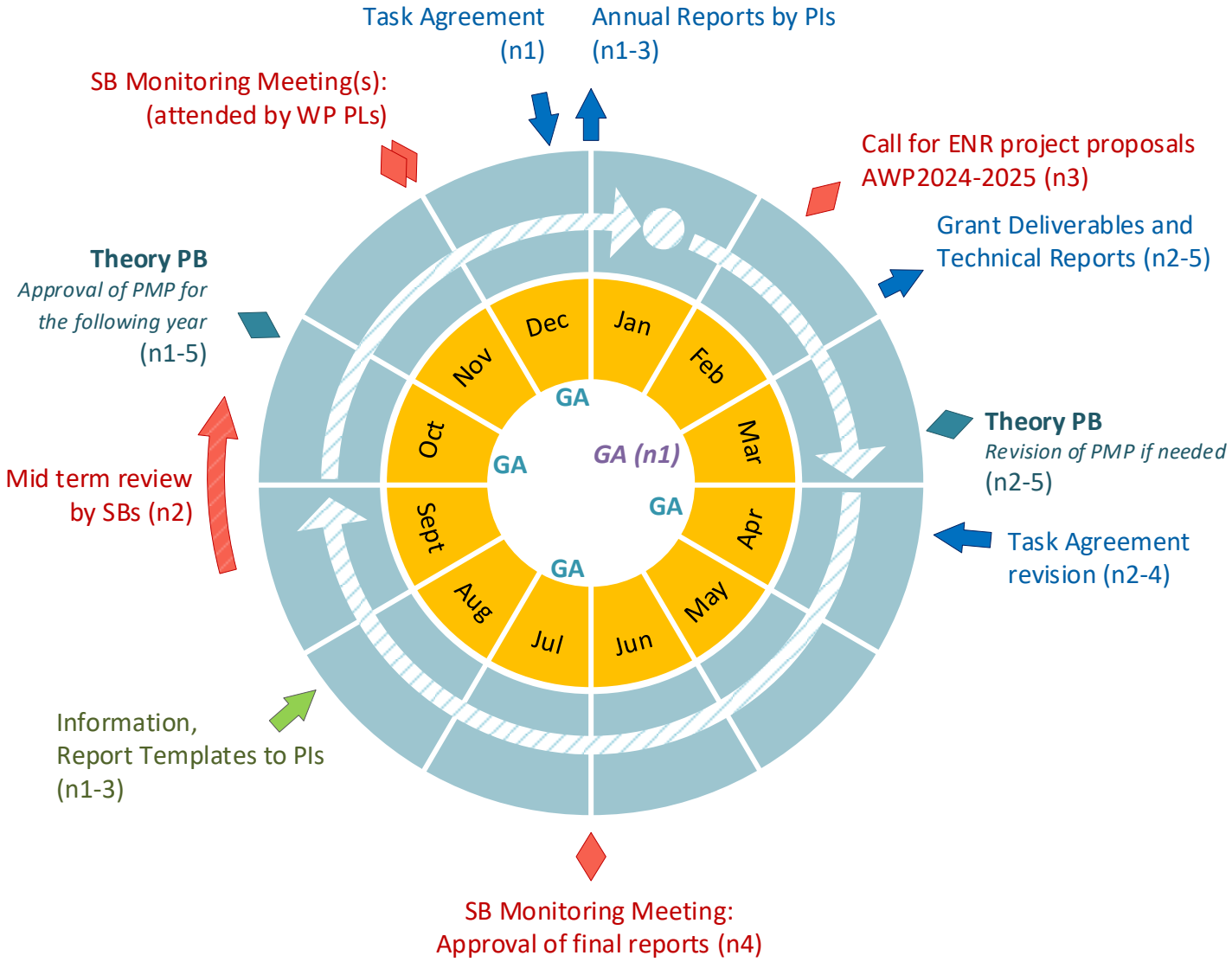
Description of Risk	Severity	Likely hood	Proposed Mitigation Action	Risk materialized ?	Mitigating Measures applied?	Comments
n/a						

4 – Project Change Requests & Other Items for Decision/Approval by PB

Decisions on PCRs

PCR Number	PCR Title	PCR Status	Comments
none			

5 – AOB (including lessons learnt)



At the end of 2022 the **Mid-term Review** of projects will be done by **SBs**

End of PB-Presentation slides