The MPEX near-term research plan and timeline to operations

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The Material Plasma Exposure eXperiment (MPEX) is a new linear plasma device currently being assembled at ORNL and will be coming on-line in 2027 [1]. MPEX's ultimate performance parameters will be able to recreate the plasma conditions (T_e, T_i, n_e) expected on a divertor target of a toroidal magnetic fusion reactor, including mimicking the surface to magnetic field line angles down to ~5deg, i.e., "tilted targets". MPEX will be a superconducting device with a total of 1 MW of heating power with continuous exposure times up to 10^6 seconds. It will have the capability to transfer targets from the plasma generator to a surface analysis station (with state-of-the-art surface diagnostics) intermittently, allowing analysis of the evolution of surfaces over very long pulses without exposing the sample to atmosphere. In addition, it will be able to handle hazardous materials, such as alkaline metal targets and neutron-irradiated materials. This presentation will give an update on the progress towards these capabilities.

Simultaneous with MPEX construction, the US program is developing a strategic long-range plan, culminating in a national fusion roadmap in late 2025 focusing on critical fusion technologies. Materials able to withstand the extremely harsh environments of a fusion pilot plant are one of these critical technologies. This national roadmap for fusion materials development will also need to be realized on a faster development track as demanded by US fusion industry deployment timescales. MPEX is a vital element in the development of plasma facing material and components within this roadmap, as it provides part of the rapid screening process for new plasma facing materials, which need to be exposed to fusion grade plasma conditions.

On-going research activities for MPEX are focused on impurity generation and transport in the plasma as well as the development of novel helicon window designs that allow for more robust long-pulse operation. These efforts include experiments on a downscaled prototype facility at ORNL and collaborations with PISCES-RF, both coupling experiments with modelling validation. In addition to these efforts, the initial MPEX research program is actively being developed. This development needs both US and international PMI community input. First experiments will be informed by the strategic roadmap and will drive early operations. These early priorities will be presented.

Work supported by US DOE under contract DE-AC05-00OR22725.

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[1] J. Rapp, et al., (2023) Fusion Sci. Technol. 79, 1113

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