

Experiment planning and execution workflow at ASDEX Upgrade

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ABSTRACT

We present the current workflow from experiment proposals to the actual execution and evaluation of discharges at the ASDEX Upgrade tokamak. Requests for experiments are solicited from both within the IPP and from external collaborators in the yearly call-for-proposals, checked for feasibility and compliance with the project's research goals and collected in a proposal database. During the campaign shot requests are derived from the proposals and in weekly operation meetings the requests are mapped to a schedule (shot list). Before the execution of discharges a complete set of configuration data needs to be assembled. After the execution follows the analysis (including the evaluation of the discharge as to its usefulness for the underlying proposal) and logging of the attained parameters in a physics logbook. The paper describes processes, software tools, and information management showing how they ultimately lead to an improved scientific productivity.

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1. Introduction

The ASDEX Upgrade project looks back onto nearly 20 years of successful operation. It has recently been mentioned as one of the key experimental devices on the way to a nuclear reactor [1], and has experienced an increasing internationalization, characterized by extensive collaboration with other fusion laboratories and rising numbers of visiting scientists. Besides producing scientific results, one of the main present and future responsibilities is the training of session leaders and experimental fusion scientists for future devices. It is in this context, that we have decided to give a bird's eye view of the organization of experimental campaigns and of the experiences and best practices that have evolved at ASDEX Upgrade.

2. Campaign preparation

2.1. Proposals

To prepare for a (yearly) campaign (Fig. 1), the ASDEX Upgrade project leader issues an invitation to interested parties, asking for proposals for experiments (or for hardware enhancements, or for diagnostic operation and development). The "call-for-proposals" [2] (a few months before campaign start) sets a frame for the request by listing the task forces (TFs) representing

broad areas of research interest, major implemented hardware enhancements, technical boundary conditions (such as major plasma parameters), and the planned overall operation schedule. It also describes the criteria for acceptance/prioritization of the proposals and the procedure for preparation of the program.

Proposals are submitted to a proposal database via a web interface. The main informations of experiment proposals are:

- a description explaining the scientific rationale and experimental details (such as major plasma parameter ranges and required heating power);
- the number of requested discharges (or shots), classified according to criteria listed in the call-for-proposals.

2.2. Assembling the program

After the end of the proposal submission phase (~2 months after the call) the task force leaders meet to assess the proposals, grouping them into topics and assigning priorities. Highest priority is given to proposals which exploit new hardware enhancements. The result of the assessment serves as input to a program discussion (ASDEX Upgrade team and guests) where a coherent program for the campaign is prepared. The TF leaders then present the program to the ASDEX Upgrade program committee for final modifications and approval.

Once approved, the complete program for the campaign is available through a wiki on the ASDEX Upgrade web server (restricted access rights). Following ASDEX Upgrade's policy of flexibility and

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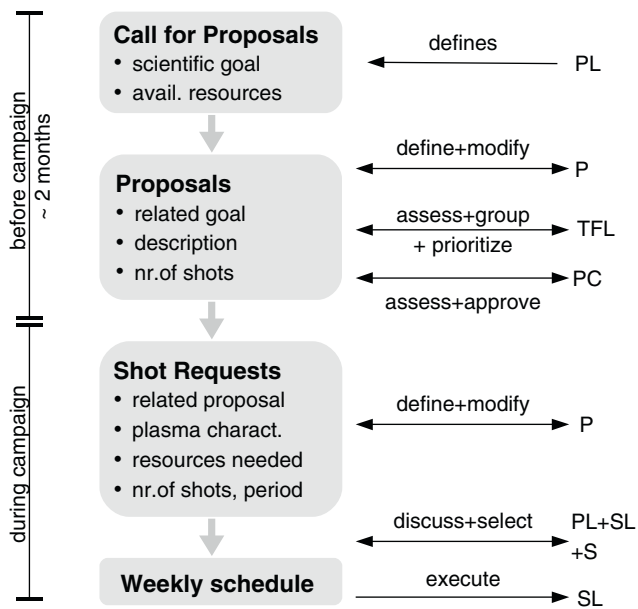


Fig. 1. Campaign planning workflow (PC, program committee; PL, project leader, TFL, task force leaders; SL, session leaders; P, proponents; S, scientists).

user friendliness, post-deadline proposals of interest to the project are accepted.

3. Campaign execution

3.1. Shot requests

During the campaign, the proponents issue concrete shot requests associated to their proposals by entering them into a shot request database (either directly or via an IPP contact person) using a dedicated web interface. A proposal may lead to several shot requests (e.g. for long-term observations) spread out over the entire campaign. Some important fields of the shot request database entries are:

- desired time span for the execution of experiments: not before...not after...;
- one or more parameter sets describing desired plasma and technical values (modifiable from shot to shot) and the number of requested shots for each parameter set;
- machine parameters and diagnostic and control requirements which require longer preparation and are expected to hold for all shots of the request.

In weekly physics operation meetings (with remote video participation via H.323) the results of previous experiments and the submitted and still open shot requests are presented and discussed. If accepted, subsequently the latter are compiled into a schedule of discharges (shot list) for execution during the various operation days of that experiment week. Factors such as available resources (plant systems and personnel), backlogs, guest status, upcoming conferences, deadlines for theses and the like are taken into account. Shot requests not related to a proposal are tolerated.

Shot requests are closed automatically when the number of requested useful shots is reached, but may be re-opened by the proponent in case more discharges should be needed. Requests may also be closed manually if further continuation of a proposal is not deemed appropriate.

3.2. Experimental environment and configuration

ASDEX Upgrade is equipped with ≈ 50 diagnostic plant systems evaluating plasma parameters, ≈ 20 technical plant systems operating the Tokamak's actuators (such as power supplies and magnets, heating and fueling, vessel conditioning, etc.), and a cluster of ≈ 5 controllers that form the discharge control system (DCS) [3,4].

Mapping the desired plasma parameters of a shot request to a valid configuration of plant systems and DCS are far from trivial and the essential part of experiment preparation [5].

Some large fusion experiments choose to define a unique configuration file for a discharge (e.g. JET pulse schedule, W7-X experiment program [6]). ASDEX Upgrade, however, distinguishes between parts of the configuration which have a long life cycle, such as consistent sets of plant system parameters (created by the plant system's responsible officers), or control parameter sets (e.g. feedback controller gains, computed by control engineers), and the frequently (even from shot to shot) modified discharge programs (DPs) – called discharge schedule in [7] – which contain segments with reference waveforms for achieving experimental scenarios.

The feedback control processes [4] of the DCS perform mapping of physics parameters to technical quantities (e.g. density to valve control voltages or plasma cross-section shape to currents of vertical field coils) and special actuator processes of the DCS map unspecific requests (e.g. 5 MW of heating power) to specific actuator systems (e.g. Neutral Beam Injector x or y), depending on their current availability. This allows for programming scenarios in terms of physics quantities and in technical quantities at sufficient level of abstraction.

By implementing standard ramp-up and event-handling segments (e.g. for soft-stop) as references or links, DPs will profit from developments (e.g. when major changes of the machine require new breakdown scenarios or when improved event handling strategies are developed). A parameter section of the DP permits to optionally override default control parameters for the scope of a discharge.

To perform its control and monitoring tasks, the application processes (APs) of the DCS need to know about plant settings and control parameter sets. To obtain these, APs query a parameter server which has access to all relevant plant system parameters and to a parameter database holding AP specific parameters (e.g. gain matrices) or functional descriptions of how to compute them. The parameter server also has the task of computing a small set of plant system parameters that directly depend on DP content (e.g. required energy from the fly-wheel generators, which depends on heating, plasma current and shape).

3.3. Experiment preparation

Before a shot can be executed, and preferably before the experiment day, the proponent (or a session leader designated in the proposal) needs to provide an adequate DP. Ideally a reference discharge is mentioned in the shot request, so a template DP can be retrieved from the DP repository [7], to which only minor modification have to be made. If this is not the case, the proponent can use a web interface to search the journal (or physics logbook) database for discharges with similar parameter ranges and scenarios as those of his/her shot request.

The DP editor [7] provides context by allowing to define collections of reference waveforms ("views"), select a reference DP and showing the differences to the current DP, or plot selections of pertinent reference waveforms. An interface to the parameter server is being implemented which will allow to visualize the current

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