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EUROpean Laboratories for Accelerator Based Science

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MILESTONE REPORT

DATA BASE HANDLING OF BEAM TIME AND IRRADIATION REQUESTS

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Abstract:

Within the scope of work-package 4.4, task 4.4.1 deals with the development, deployment, optimisation and evaluation of a database-driven software tool capable of handling the beam time requests, specifically for the users of the CERN PS & SPS test beam facilities. Within this document the process of developing the first operational version of this tool is descripted. Additionally, the status at the time of writing of this report and an outlook about the ongoing and planned future developments is given.

For more information on EURO-LABS, its partners and contributors please see https://web.infn.it/EURO-LABS/

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EXECUTIVE SUMMARY

CERN operates several beam lines in the Proton Synchrotron (PS) East Area (EA) and the Super Proton Synchrotron (SPS) North Area (NA). Users can request beam time from these accelerator complexes to perform various tasks, including detector R&D related activities. This document, summarizes the challenges and the recent developments of a tool handling the users beam time requests.

The project team attempted to handle the call for the beam requests in 2023, with a first version of the tool and therefore started with preparatory activities and planning tasks already before the official start of the project. The work towards a first data model and the selection of the software technologies and platforms started early in the process. Actual development started in late September / early October 2022 and was concluded in early December 2022.

Evaluation of the first implementation was performed within the scope of this call for beam requests which was successfully handled from December 7th, 2022, to January 14th, 2023. The number of activities and beam requests collected during this period provided feedback for planned improvements and further developments of the software that will be also discussed in this document.

1. INTRODUCTION

CERN operates a set of beamlines dedicated to High Energy Physics (HEP) particle detectors testing such as T8, T9, T10, and T11 in the Proton Synchrotron (PS) related East Area (EA) or the H2, H4, H6, H8, P42-K12 or M2 beamlines in the Super Proton Synchrotron (SPS) adjacent North Area (NA). Additionally, any resources provided within these two accelerator complexes to users have to be coordinated among themselves as well as with other infrastructures operating with the beams generated by the PS and SPS accelerators such as AWAKE, HiRadMat, the irradiation facilities (IRRAD, CHARM, GIF++) or nToF.

Over the years, the interest in these beamlines has grown considerably while on the other hand the number of available resources has generally not kept pace with these developments. As an example, consider Figure 1 which depicts the utilisation of the SPS NA over the previous three years.

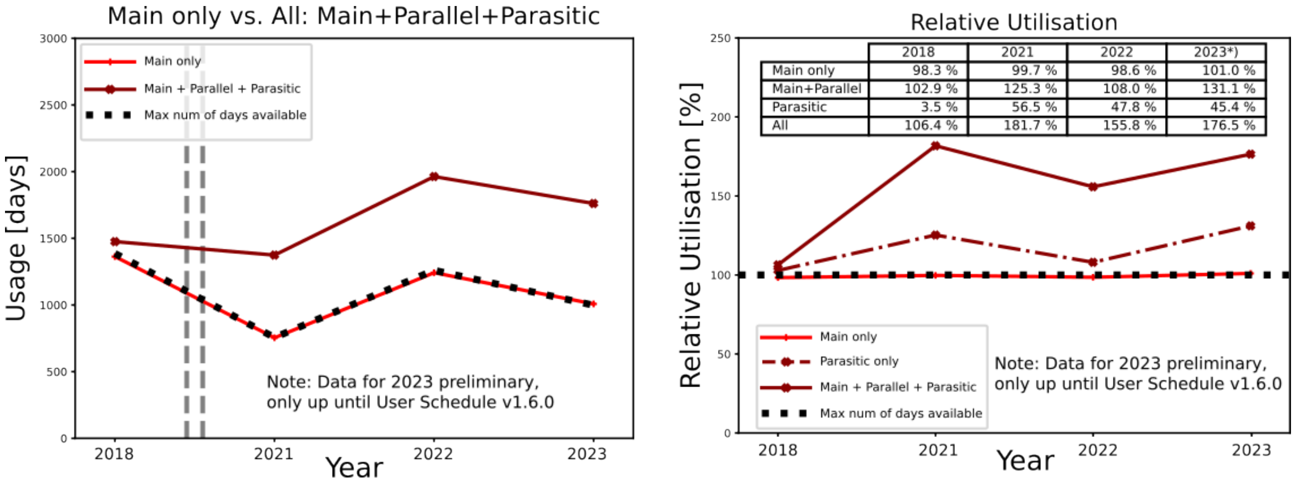

*Figure 1: **Left:** Utilisation of the SPS NA beamlines by main users expressed in days compared against the usage over all categories (main, parallel, or parasitic).*

***Right:** Utilisation expressed relative to the number of available days per year for main users in percentage.*

Note that the curve for *main* users follows the dashed black curve for the number of days available in total almost perfectly, indicating that the utilisation of these resources is close to 100% for that class of users. In order to accommodate larger numbers of possible users at the beamlines and in the experimental areas at CERN, access in the form of *parallel* and *parasitic usage*[1] is also granted. This results in machine utilisation figures across all categories reaching and even exceeding 150 – 180%. The amount of coordination and the complexity of managing the user requirements, changes and the overall schedules represent a real challenge.

1 **Main users** have, compared to parallel users, a higher priority for controlling the beam parameters, access to the experimental zones and the overall experimental program. **Parasitic users** generally only gather data using their equipment during the time of the main user and **parallel users** operate their equipment in their respective zone.

In addition to these complexities, the following issues and challenges also occur in the context of managing such substantial number of user beam requests:

- Handling acceptance or rejections of user requests require transparency, accountability, and consistency.
- Increasing numbers of activities scheduled in the beamline either depend on other activities (because of for example shared equipment or common members of team) or may depend on earlier or later visits within one period. Cancellations or rescheduling requests therefore can be also increasingly complex.
- Without a common and consistent data model, it is difficult to develop a coherent long-term picture of the accumulated user data, thus making it more difficult to derive *Key Performance Indicators* (KPIs) based on the data.
- The amount of manual and repetitive work involved in handling the ongoing maintenance and scheduling is substantial and is straining the limited resources available for user support.

Up until the beam period 2023, the tasks resulting from these processes have been handled manually using a dis-jointed collection of ad-hoc solutions, documents, scripts, spreadsheets, and email messages. The yearly call for beam request time for example has been handled by collecting MS Word documents using a document management system like MS Sharepoint or, for the 2022 period, a web-form based upon the Drupal webtool at CERN.

While the raw inputs and the resulting (published) revisions of the schedules have been preserved, (cf. the PS & SPS physics coordination homepage [7], specifically the archived schedule for 2022 and earlier years), a lot of the metainformation and data not directly captured in the schedules (such as *how* certain information was recorded and evaluated, rejected or withdrawn requests not appearing in the schedule, changes in project leadership or team composition, issues and problems arising during the respective beam times, the root causes for changes of the schedule, etc.) are less readily and consistently available. Also, even if data is available to the PS & SPS physics coordination, it is difficult to make this information available to the projects, experiments, and users of the facility.

All these problems, in combination with other issues and resource limitations, motivated the development of a database driven software tool to handle the beam requests and other managerial duties with respect to the user's beam time, therefore providing an improved service to the users. This report details the development and successful deployment of a first prototype during the first year of the EURO-LABS project.

2. Implementation Of A First Version Of The Tool

2.1. Definition Of Scope And Requirements, First Version Of A Data Model

Some preparatory tasks towards the development of a first iteration of the software tool already started before the official project launch in Q3 2022 since the project team of Task 4.4.1 had the goal to handle the call for the beam requests for the period 2023 already with an early version of the tool, well ahead of the schedule for the milestone 24 after 12 months of project duration. Therefore, the scope of this task was limited towards the features required to handle this step and to subsequently allow the creation of a user schedule.

These preliminary and preparatory tasks consisted of:

- Defining the requirements and constraints to successfully gather the beam requests from the users.
- Performing a (limited) market research and facilitating discussions with representatives of other test beam and irradiation facilities at the 10th *Beam Telescopes and Test Beam* (BTTB) workshop in Lecce, Italy (June 2022) towards better understanding the approach and scope of similar tools at other facilities.
- Research the beam request forms used in 2020 and earlier (before the CERN Long Shutdown 2) and the Drupal based tool used in 2021 to gather inputs for a first data model.

Based upon the outcome of these steps, the following major deviations were observed when comparing the new data model to the conventions and data structures related to the tools, forms, etc. used in previous beam request collections and can be summarized as follows:

1. In contrast to previous calls, beam requests will not have to be replicated for multiple runs / visits but can be submitted collectively for all runs within a period. This reduces the amount of work users to submit a beam request and allows for better understanding of requirements and dependencies between runs.
2. Also, the distinction between users of the EA and NA was weakened, users can request runs in both accelerator complexes within the same beam request.
3. The beam requests as such are implemented as so called *stateful object* i.e., users could return to them until completion. They also gain the ability to delegate parts of the creation to other users and allow read-only access for review, feedback, and correction.
4. Activities as data-model equivalents of experiments or projects have been introduced to prepare the re-use of information in subsequent years by associating the beam requests for multiple periods with the same activity.
5. The decision was made to treat runs requested within a beam request separately from runs that are eventually put into a user schedule. Specifically, it is possible that a single requested run will be implemented as a set of disjointed runs at the level of schedules. Also, adding runs (for example as part of the request for additional beam time in the form of parallel or parasitic runs) to the schedule for the activity can occur at any time during the year, even outside of the beam requesting period.

2.2. DESIGN AND IMPLEMENTATION

The decision was made to base the first version of the tool on software components that had already been used during the development of other entries in the wider ecosystem at CERN that are similar in scope and could, potentially, allow for future sharing of development efforts and reuse of code and components. These are shown in Figure 2.

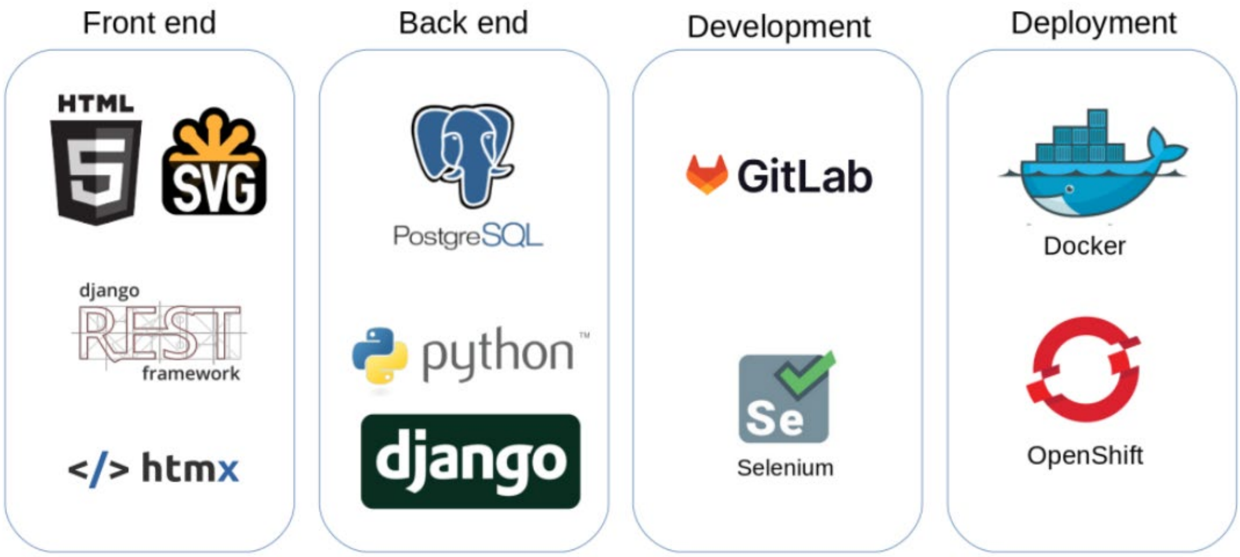

Figure 2: The initially selected components of the software stack for the development of the PS & SPS user schedule management tool.

The software components shared with projects such as the IRRAD Data Manager [4] or the RADNEXT [5] portal consist of:

- Django as the development framework and
- Python as the main programming language for implementing the business logic
- The CERN GitLab repository server for version management and (for the tool in question) issues and development task management
- OpenShift for deployment on the CERN PaaS platform as well as Docker for deployment locally during development and testing

Also, in relation to the previously mentioned tools, the following components have been evaluated and used specifically for the PS & SPS user schedule management:

- The relational database was implemented using PostgreSQL to gain experience with this relational database system, switching to different database server technologies in the future due to the abstractions in the software will be straight forward.
- Scalable Vector Graphics (SVG) is used as the native graphical output format for schedules and visualisations. The requirements to perform this type of visualisations is currently unique to this tool but developments towards these capabilities could be interesting for subsequent reuse and specialisation in other in-house developed tools based upon a similar software stack.
- A web-service interface was implemented at an early stage to enable the easier import and export of data into the data model and to allow the integration of the tool potentially also into other components of the overall software landscape at CERN.

The implementation of the concepts outlined above took the form of a web-based tool. It provides some necessary infrastructure for most of the stages in the iterative workflow depicted in Figures 3 and 4.

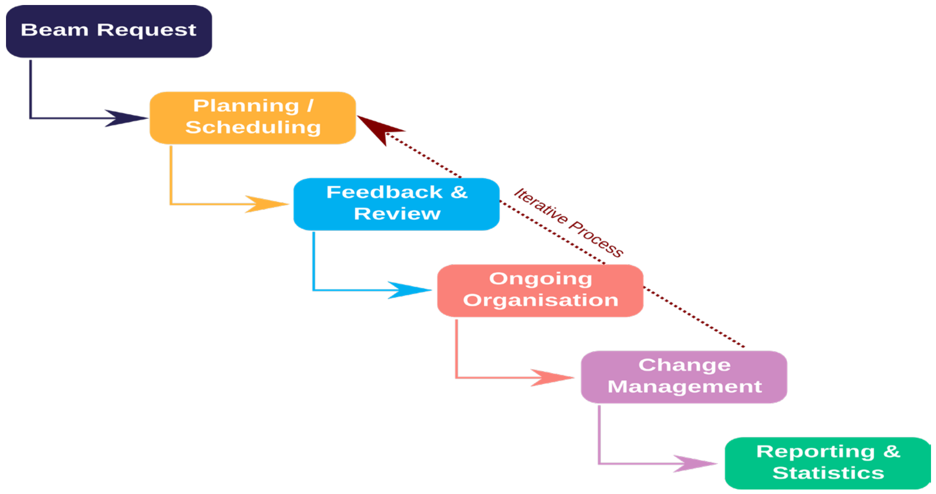

Figure 3: Schematic depiction of the iterative workflow of handling the beam request and test beam user schedule management.

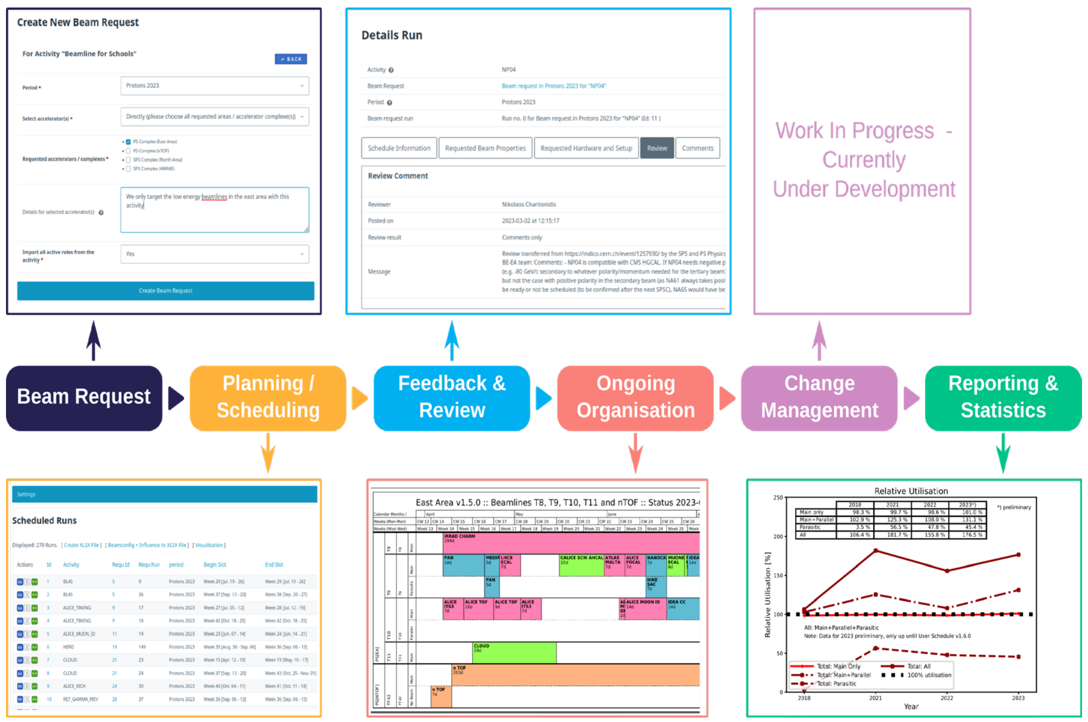

Figure 4: Corresponding UI elements and output generated by the first iteration of the PS & SPS user schedule management tool. The different views corresponding to the different stages of the workflow depicted in Fig.3 3.

3. CASE STUDY: HANDLING THE CALL FOR BEAM REQUESTS 2023

3.1 OUTCOME OF THE BEAM REQUEST CALL

For the duration from December 7th, 2022, to January 14th 2023, existing and potential users of the PS & SPS beamlines had the opportunity to submit their request for beam time for the 2023 periods. During this time span, the first iteration of the PS & SPS user schedule management tool [3] was used to collect

- in total 98 beam requests
- from 92 different activities
- with a total of 146 runs being requested.

These numbers do not lend themselves towards an easy direct comparison with the results from previous calls for beam requests submitted in previous years since, for example, in the past, users submitted multiple requests for a multi-visit measurement campaign. For 2022, most users were only submitting one beam request for all their requested runs in either the proton or ion measurement period 2022.

With that in mind, the number of beam requests was comparable to 2021 where in total 96 beam requests from a total of 91 different activities were submitted.

Based upon these submitted and processed requests for beam time, a first version of the schedule was created and the necessary infrastructure to create, maintain, and work with this schedule on an ongoing basis throughout the year was created as well.

We consider the state of the software tool corresponding to the release of version 1.0 of the user schedule for the year 2023 to fulfil the requirements towards completion of Milestone 24 according to the project plan.

3.2 LESSONS LEARNED

The experience of performing a full call for beam request plus a full iteration of the workflow leading up to schedule version 1.0 was extremely valuable and revealed a list of problems and opportunities for improvement and optimisation that we intend to address over the remainder of the project:

1) The first version of the data model did overall work as expected. But several aspects like for example capturing positive and negative user preferences for beam parameters, locations (i.e., beamlines or specific experimental zones), or time periods (i.e., to address the dependencies between different runs of the same request or the dependencies between different activities and beam requests) were, in general, not as clearly and structured described and entered by the users as anticipated.

2) The users made also generally make a heavy use of the free-text fields to communicate aspects of their beam requests and their hardware features. Also, with respect to the previous point, a

more structured way to capture these features of the dataset would allow easier further processing, searching and analysis.

3) The ability to generate graphical representations over sets of scheduled runs on the fly is powerful and practical and enables very agile workflows with respect to manipulating and maintaining the schedule. However, the implementation of the schedule would benefit from better defaults and the integration of additional information (such as the occurrence of planned maintenance or machine development cycles, planned and unplanned technical stops and interventions, etc.). Improvements towards a better and more versatile graphical representation of the schedules is planned.

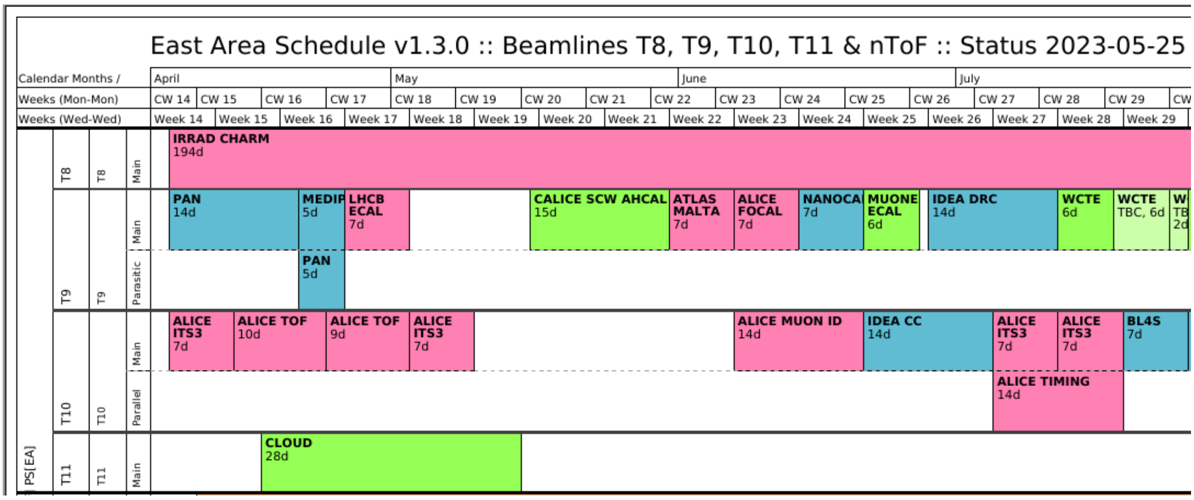

Figure 4: Graphical representation of the PS EA user schedule, as generated by the present PS & SPS user schedule management tool.

4) The ability for users to re-use existing hardware (setup) descriptions, forms containing safety related information, collections of beam parameters, etc. for subsequent beam requests (either in the same year but for example in the Ion period or for other activities) would further decrease the amount of repetitive information that has to be entered and that users could reuse. This usage pattern has been anticipated but not implemented yet with implementations allowing this reuse being planned for later releases in the project cycle.

5) First steps towards managing activities over the lifespan of a project have been made. In particular, the information about where in its life-cycle a given activity is (including when the next major milestones would be scheduled) has been asked for by the users. But additional aspects like user and permission management, record keeping about publications, milestones or approval by scientific committees and advisory boards are crucial aspects that should be reflected in the application.

4 DISCUSSION ABOUT ONGOING DEVELOPMENTS, OUTLOOK & CONCLUSIONS

The successful completion of the user beam request call for 2023 and the subsequent creation and release of the user schedule demonstrate that the goals set out for this task can be achieved with the selected technologies and approach. It has also helped to reveal several areas of improvements and has highlighted some actions that are required to solve some of the encountered problems and issues.

Specifically, the lessons learnt, and the improvements envisaged, including those outlined in the previous section, are currently evaluated towards implementation in time for the upcoming beam requests for the 2024 periods. Additionally, some ongoing developments that are intended to further expand and improve the user experience also deserve some specific mentions:

1. In summer 2023, a first exploratory study has been performed by Diego Vasquez, a participant in the CERN summer student program 2023. In his project, he demonstrated how components and modules between the wider Django based eco-system could be shared, thus fulfilling one of the goals of the task to leverage synergies and potentially share code and development efforts. The results of the summer student project will be used to better decouple and modularize the implementation of the tool, ideally leading to the implementation of reusable blocks of code for other tools and projects.

   The SVG based schedule visualisation for example has been already identified as a potentially interesting piece of infrastructure that could benefit from some abstraction and refactoring to make it usable outside of its current field of application.

   The IRRAD data manager [4] could for example benefit from an compact and expanded version of the graphical representation functionality displaying schedules while providing an interesting test case for the number of abstractions required to interoperate between applications with distinctly different data models that are otherwise based upon similar technology stacks.

2. First attempts have also been made to use the data stored in the PS & SPS user schedule management tool's database to improve and ultimately automate recurring routine tasks such as the preparation of meetings (like the weekly PS & SPS user meeting) or the generation of reports and statistics.

3. A related task is the development of a change tracking and logging functionality that should improve the ability to estimate the amount of turn over and to document the ongoing maintenance that is required to keep the user schedules and requirements arising from the users beam requests up to date.

Further developments and improvements will also be discussed in upcoming milestone reports and disseminated at workshops and work-package level meetings [1,2].

5 REFERENCES

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