

# Enhancing Operational Efficiency at SPRING-8

## Automated Operation Mode Scheduling and Proposal task management for Measurement Proxy

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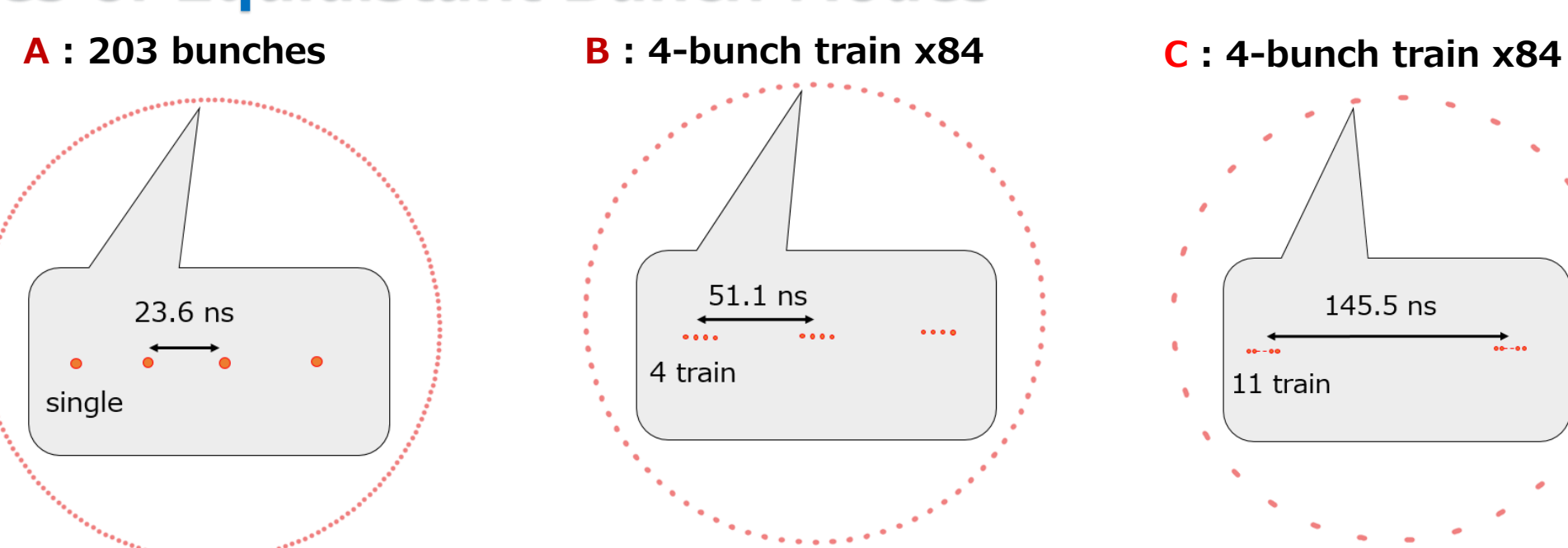
### Abstract

At SPRING-8, we have automated the scheduling of accelerator operation mode. This automation uses mathematical optimization to dynamically generate schedules based on user constraints, improving flexibility, cost-efficiency, and fairness. Additionally, a web-based management system for proposal task management at Structural Biology Beamlines automates tasks such as guidance dispatch and sample verification, reducing staff workload and improving service quality and user satisfaction. These advancements streamline operations and elevate the overall operational efficiency of the facility.

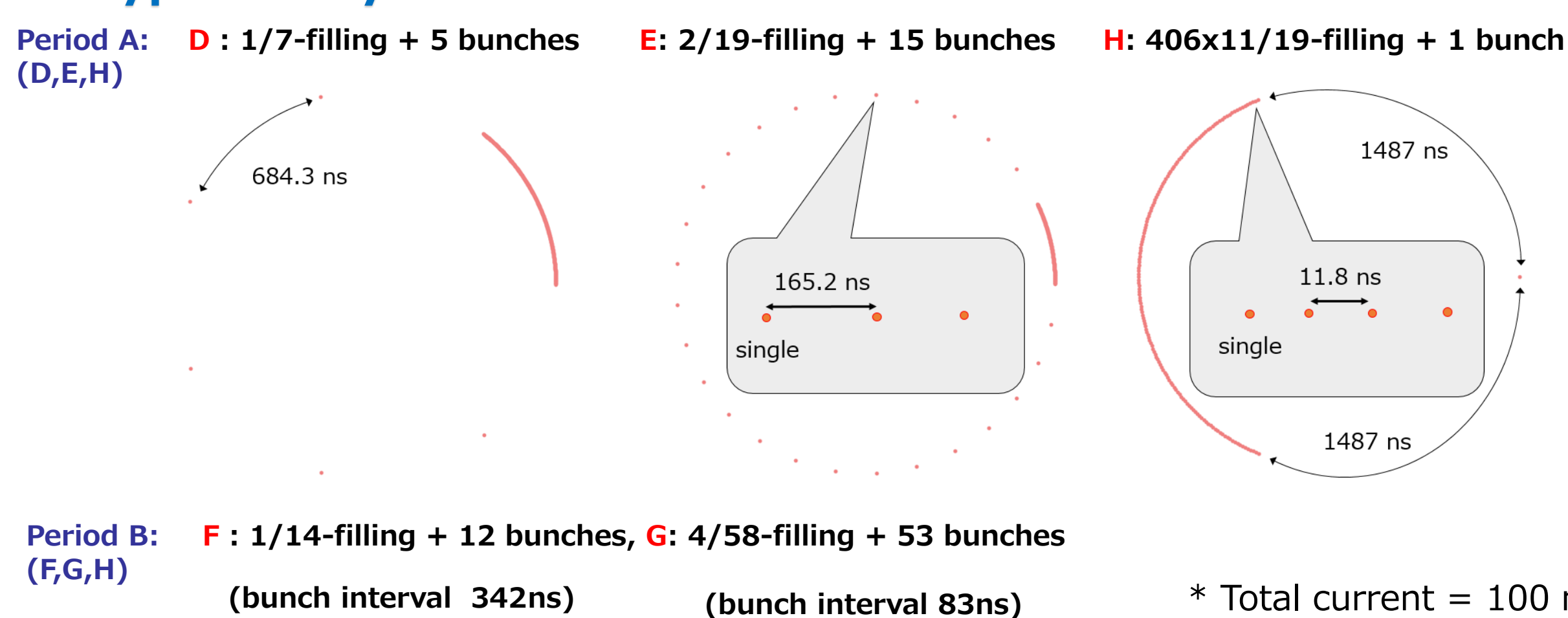
### Accelerator Operation modes and Scheduling at SPRING-8

#### Multiple Bunch filling pattern modes\*

##### 3 Types of Equidistant Bunch Modes



##### 5 Types of Hybrid Bunch Modes



Multiple modes to support Wide Range of SR experiments

#### Equidistant modes (A,B,C):

Ideal for measurement not requiring time-resolved setups, and those needing evenly spaced X-ray pulses

#### Hybrid modes (D,E,F,G,H):

Tailored for Time-resolved measurements etc.

#### Accelerator Operation Mode Scheduling

##### 2023B period example

Cycle	Period	Mode
4a	10/3 (Tue.) 10:00 - 10/16 (Mon.) 10:00	A
4b	10/17 (Tue.) 10:00 - 10/25 (Wed.) 10:00	H
	10/25 (Wed.) 10:00 - 10/30 (Mon.) 10:00	A
4c	10/31 (Tue.) 10:00 - 11/7 (Tue.) 10:00	C
	11/7 (Tue.) 10:00 - 11/13 (Mon.) 10:00	B
4d	11/14 (Tue.) 10:00 - 11/27 (Mon.) 10:00	F
4e	11/28 (Tue.) 10:00 - 12/8 (Fri.) 10:00	A
	12/8 (Fri.) 10:00 - 12/14 (Thu.) 10:00	H
5a	1/22 (Mon.) 10:00 - 1/30 (Tue.) 10:00	A
	1/30 (Tue.) 10:00 - 2/5 (Mon.) 10:00	H
5b	2/6 (Tue.) 10:00 - 2/14 (Wed.) 10:00	C
	2/14 (Wed.) 10:00 - 2/21 (Wed.) 10:00	A

Various constrains are considered:

- User requests** during proposal submission:
  - Preferred mode and number of beamtimes (in 8-hour units) for each proposal
- Operational Efficiency:**
  - Mode Switching on business days
  - Limiting number of modes switches per cycle
- Other factors**
  - Ensuring Hybrid mode scheduling is evenly distributed without bias

#### Current Situation:

The operation mode manager manually draft the schedule twice a year

#### Key Challenges:

- High time and effort costs to accommodate diverse user requests
- Ensuring fairness and transparency
- Maintaining continuity when personnel changes occur
- Inefficient manual data collection for mode preferences

### Automated Scheduling of Operation Modes

#### Optimized Scheduling using Integer Programming

• Operation Mode Assignment Variables:  $X_{m,d} \in \{0,1\}$

• Task Start Variables:  $Y_{m,d} \in \{0,1\}$

m: mode index  
d: date index

#### Example of Constraints:

One operation mode per day

$$\sum_m X_{m,d} = 1$$

Desired days for each operation mode

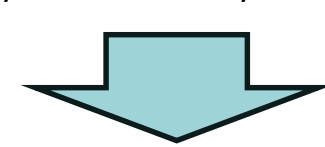
$$\sum_d X_{m,d} \geq \#(\text{Desired days for each mode})$$

Switching Operation Modes on Business days

$$Y_{m,d} = 0 \text{ for } d \in \{\text{Saturday, Sunday and Holidays}\}$$

• Definition of Task Start Variables Y

- $X_{m,d} - X_{m,d-1} \leq Y_{m,d}$
- $Y_{m,d} \leq 1 - X_{m,d-1}$
- $Y_{m,d} \leq X_{m,d}$



#### Derived Optimal Schedule Solution



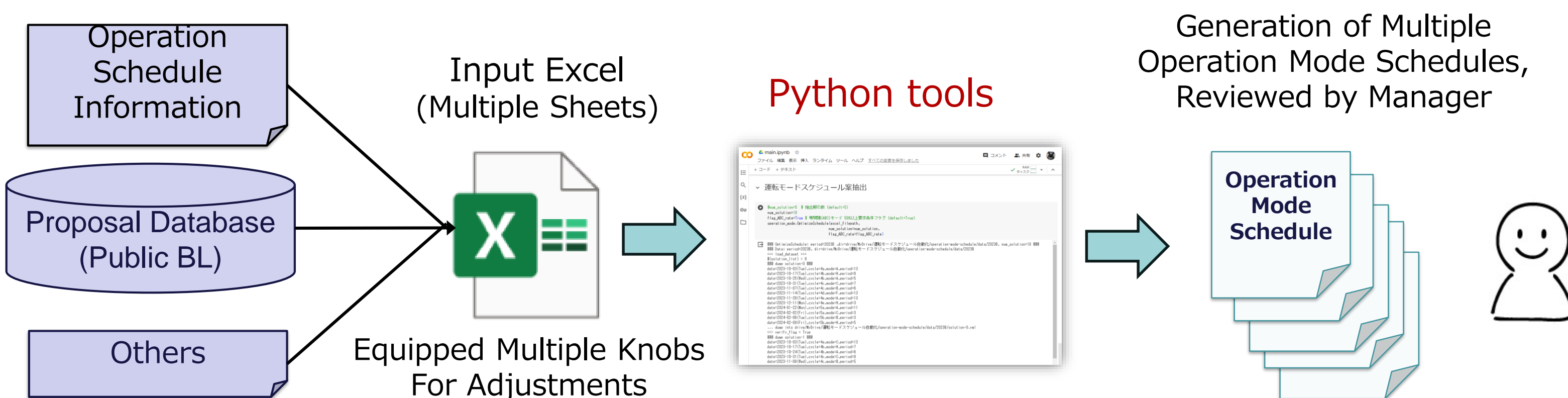
#### Support for Various Models

- Linear Programming (LP)
- Mixed Integer Programming (MIP)
- Integer Programming (IP)

#### Support for Various Solvers

- Cbc(Coin-or-branch cut) Utilized [OSS]

#### Automated Scheduling Workflow



#### Efforts Toward Practical Implementation

- A prototype was developed, capable of handling past data (2011A-2023A)
- Trial use has been promoted since 2023B period
- Efficient scheduling process allowing us to complete adjustments comfortably in one-week
- Currently, generated scheduling is used as a reference, with final manual adjustment made
- Continuous improvements are being made to enhance usability

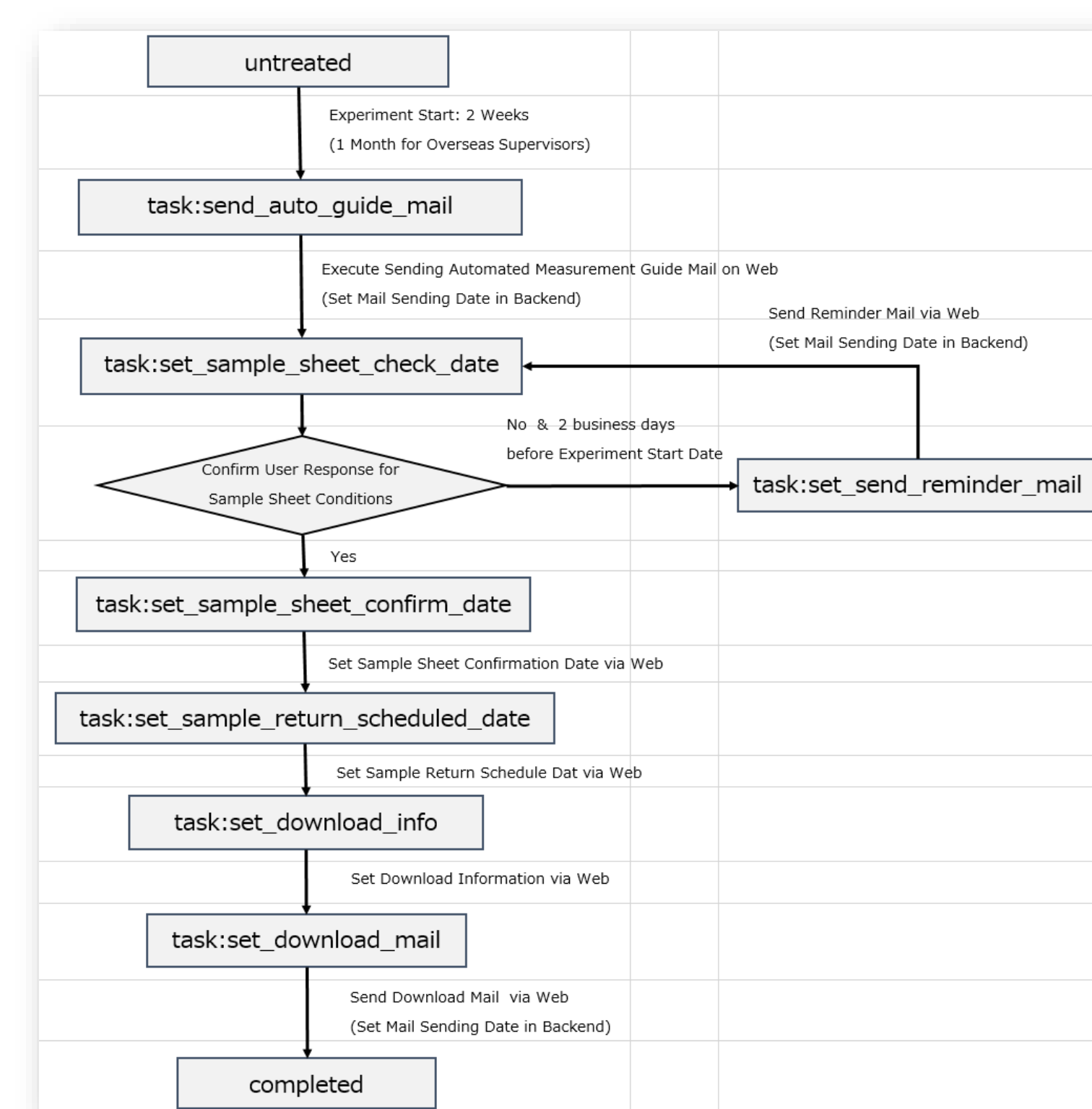
#### Challenges Ahead

- Automatic Preparation of Input Data
- Identifying causes when no feasible schedule solution is found
- Recommending optimized adjusted proposal schedule for each beamline

### Automated Measurements Task Management for Structural Biology Beamlines

#### Reducing BL staff effort and Enhancing Efficiency in Automated Measurements

##### State Transition Diagram for BL staff



#### BL staff must handle the following tasks for each proposal measurement

- Measurement schedule notification to users
- Verify sample conditions
- Perform automated measurements
- Notify users of data download
- Return samples

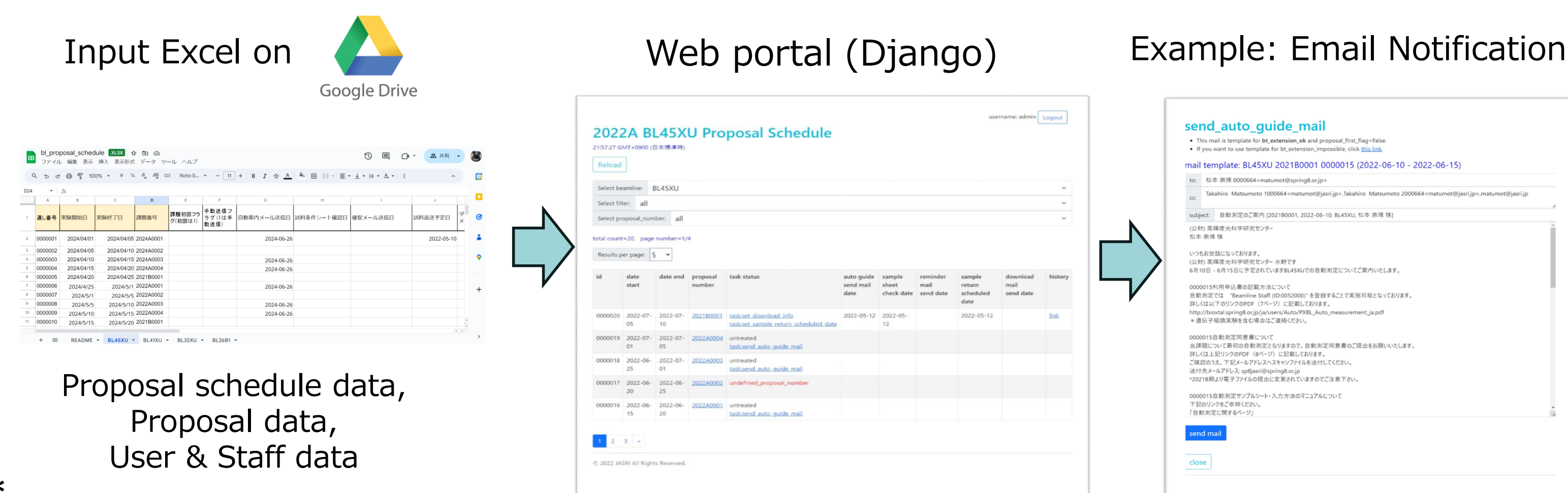
We developed a system that visualizes task progresses, making it easier for staff to complete tasks\*



Spring-8 BL41XU

\*Targeted for BL45XU, BL41XU, BL32XU, BL26B1

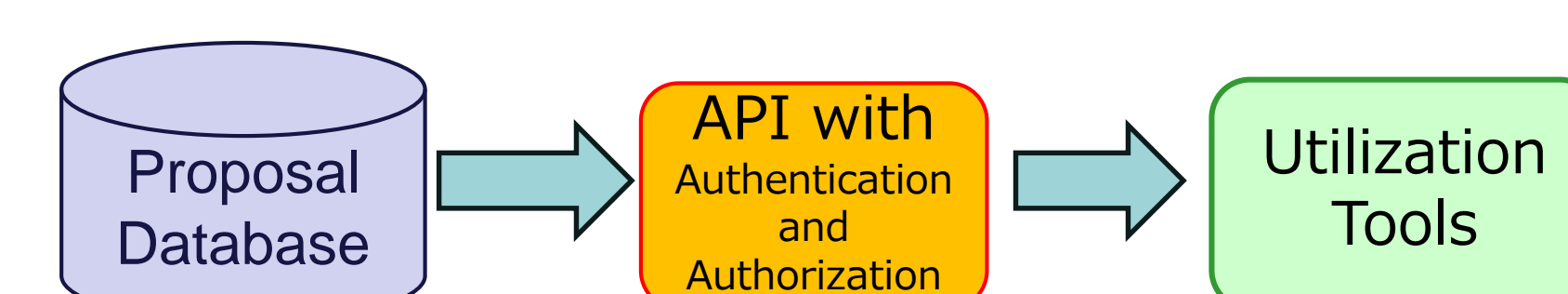
#### Optimized Web-based Workflow with Task Visualization



Launched in FY2022, Automated mail notification begin this fiscal year

#### Challenges Ahead

Making use of the proposal database for automatic input



Building a flexible framework for data utilization, including Task management for Proposal measurements, Operation mode scheduling etc.