



# ICALEPCS

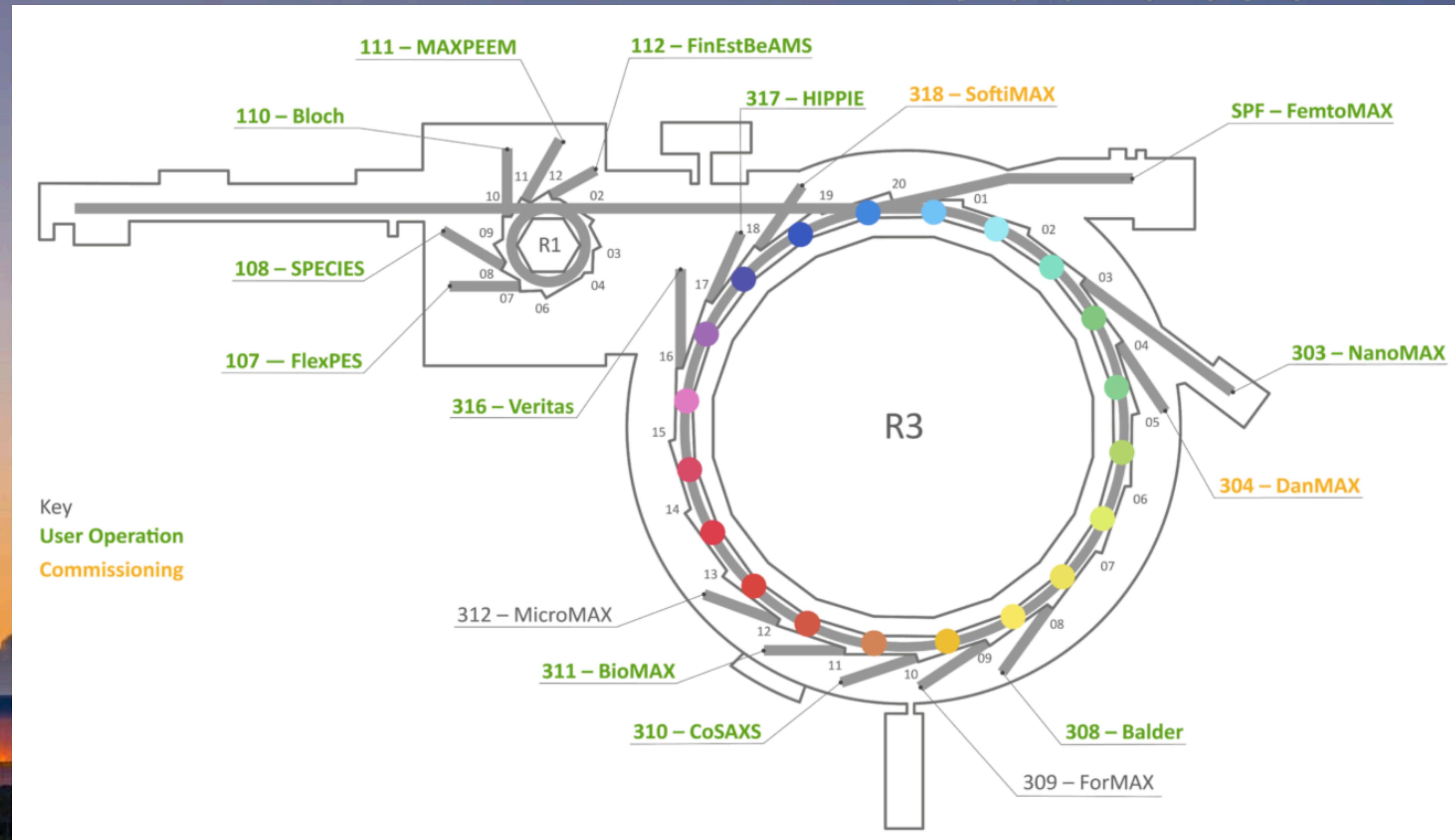
Maturity of MAX IV  
And Phase II development

Vincent Hardion, MOAL01, ICALEPCS 2021





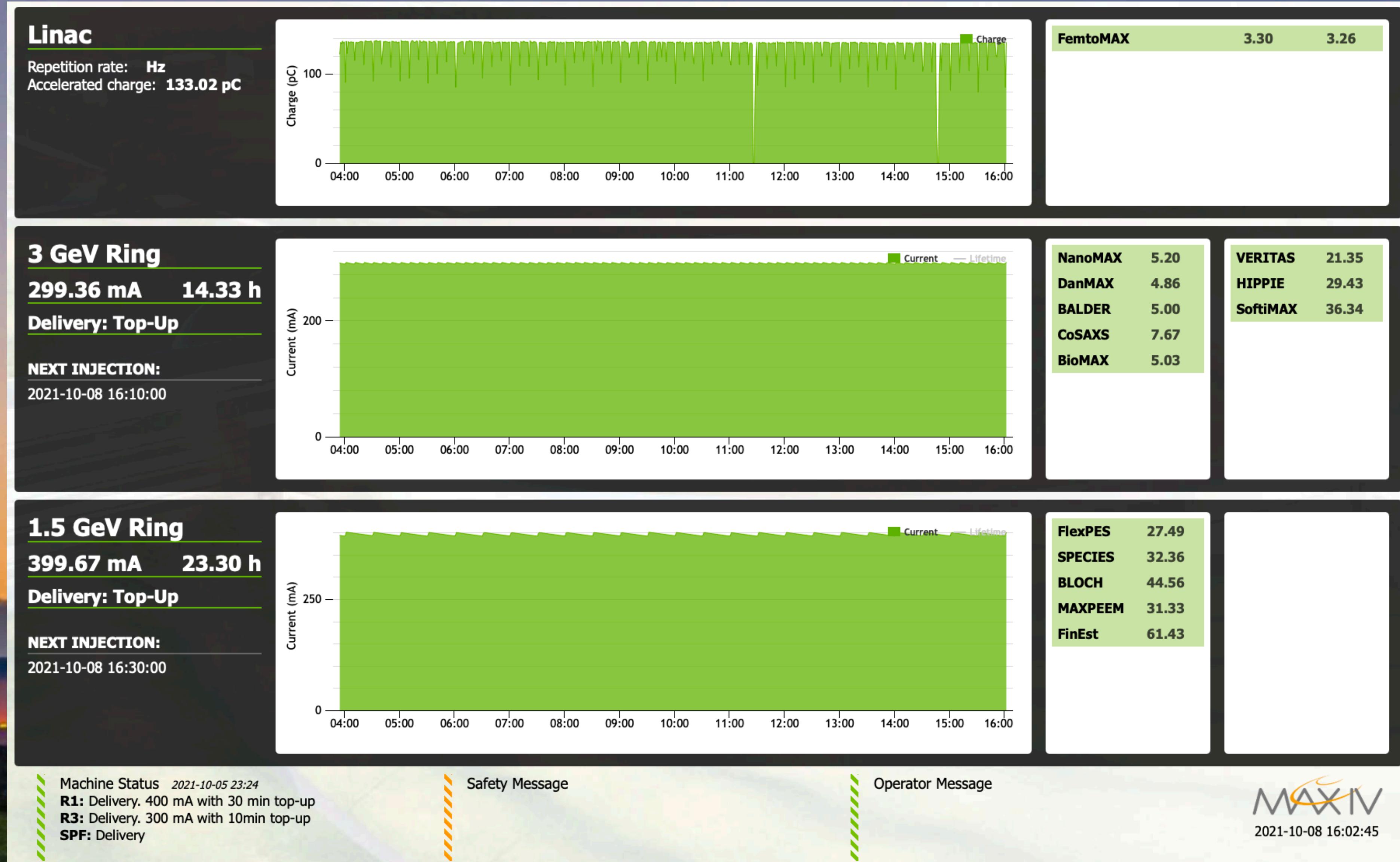
- MAX IV
- STATUS
  - Project Management
  - Operation
- KITS Improvement
- Future



# General Status



- MAX IV
- STATUS
  - Project Management
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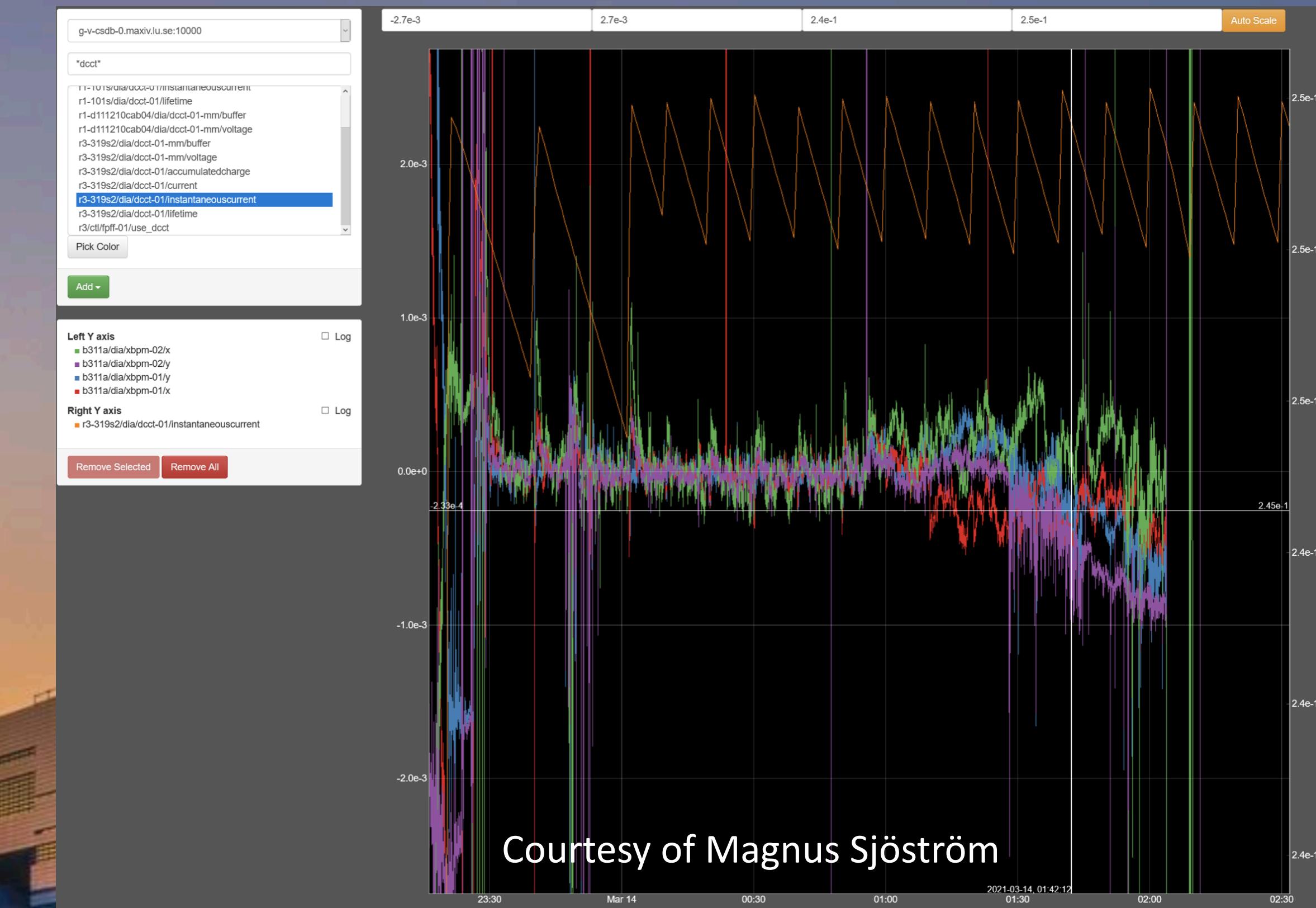
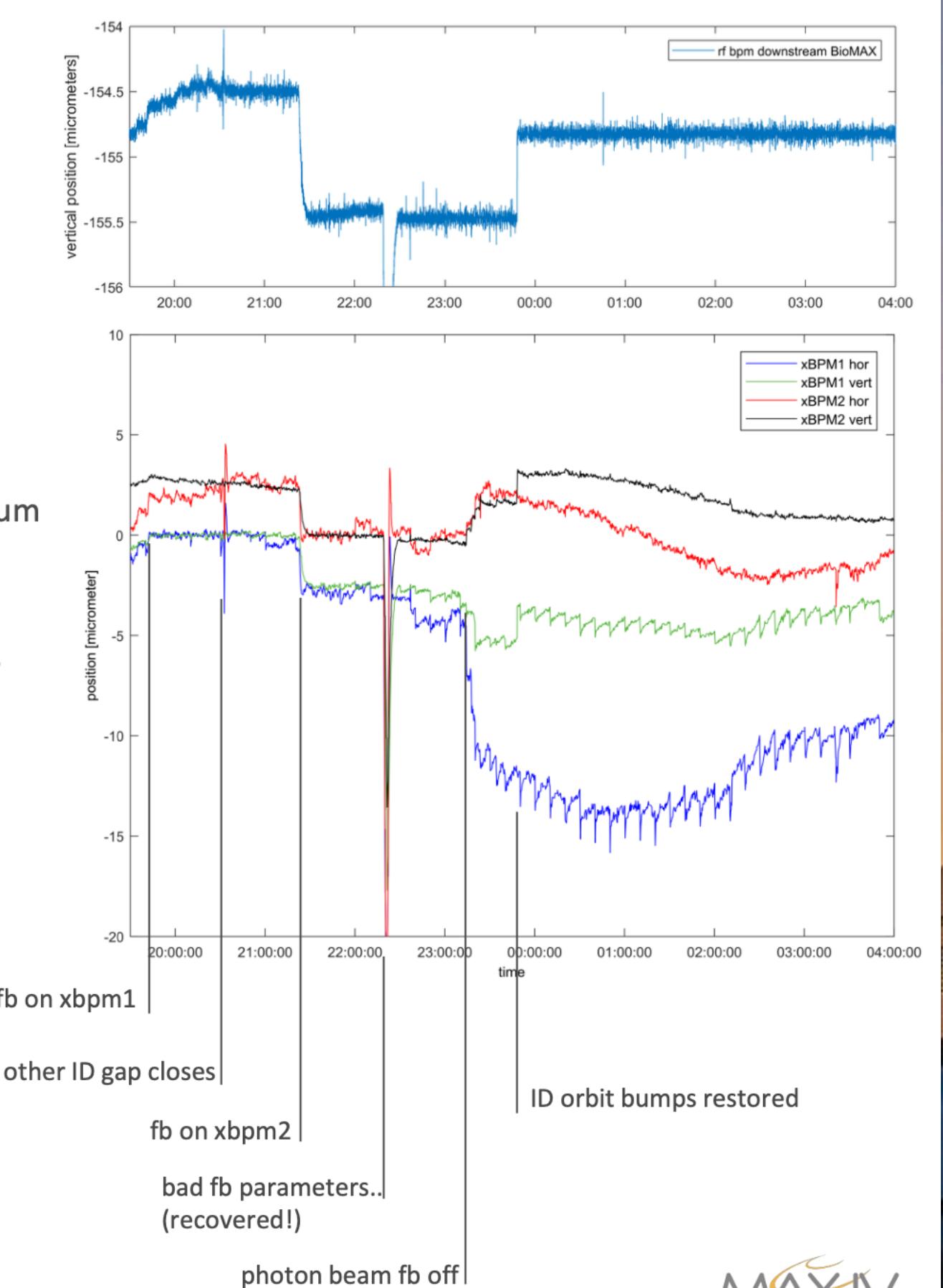


# Accelerators Status



## X-ray BPMs & orbit feedback

- Test of a photon beam based orbit feedback
  - correcting orbit angle in the long straights
  - update of the orbit reference values every 10 seconds
  - beamline and FE were **not** in thermal equilibrium during this test
  - ID orbit correction applied:
    - hor.: 0.17  $\mu$ rad on top of a 10  $\mu$ rad orbit bump
    - vert.: 0.14  $\mu$ rad on top of a -66  $\mu$ rad orbit bump
- Compensation of photon beam position drifts
  - top-up injections (every 10 minutes)
  - temperature transients
  - gap drifts
- Next steps
  - correction of position & angle
  - tests with beamlines
  - development and implementation of photon beam position feedback if required

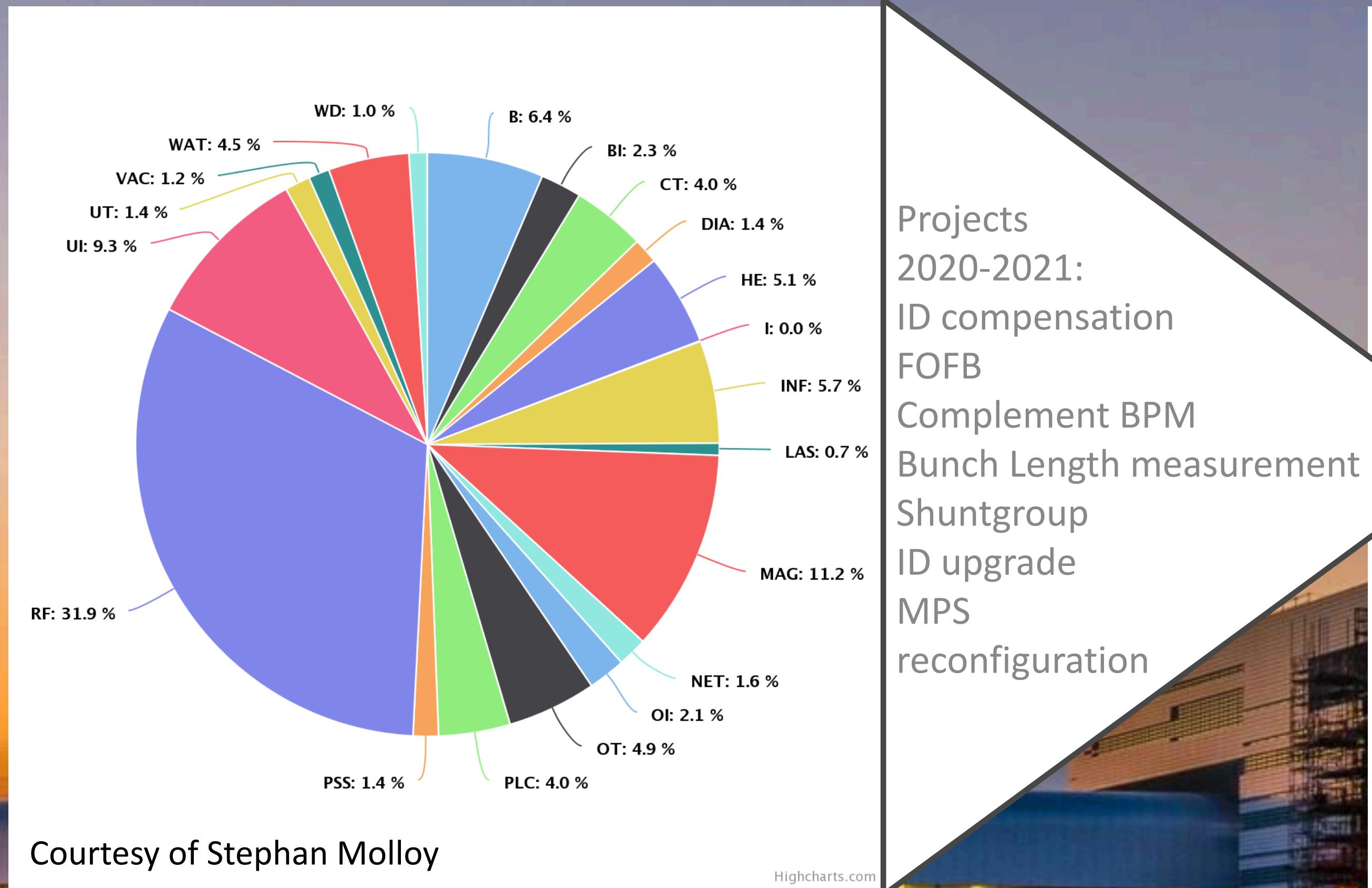


Courtesy of Magnus Sjöström

23:26: xofb on  
23:29 fofb fixed

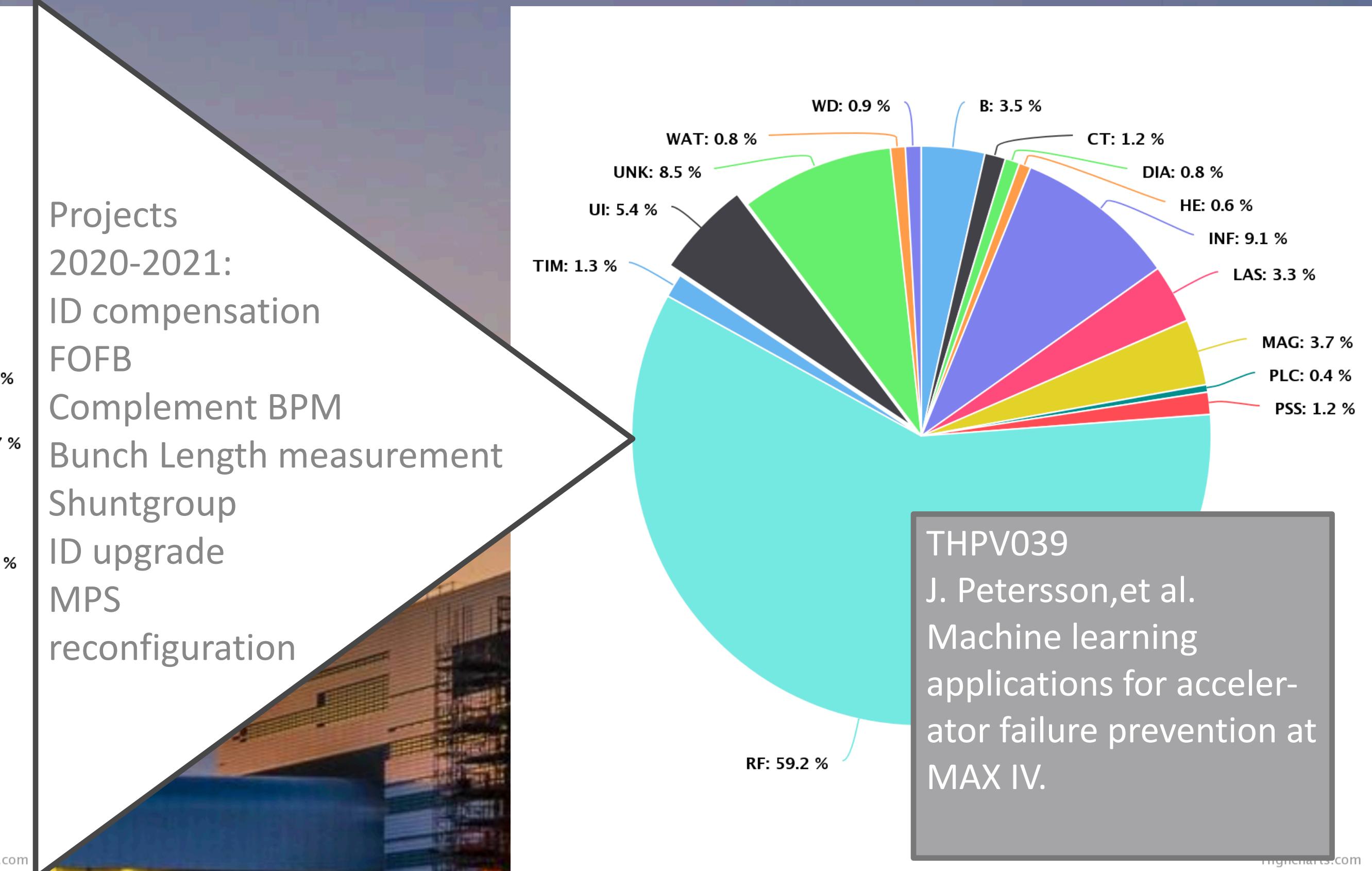
00:55 xofb goes off. plan is to keep the gap and the orbit where they are and record the drift for one more hour.

# Accelerators Status



Distribution of downtime per subsystem  
2020/01 -> 2020/12.

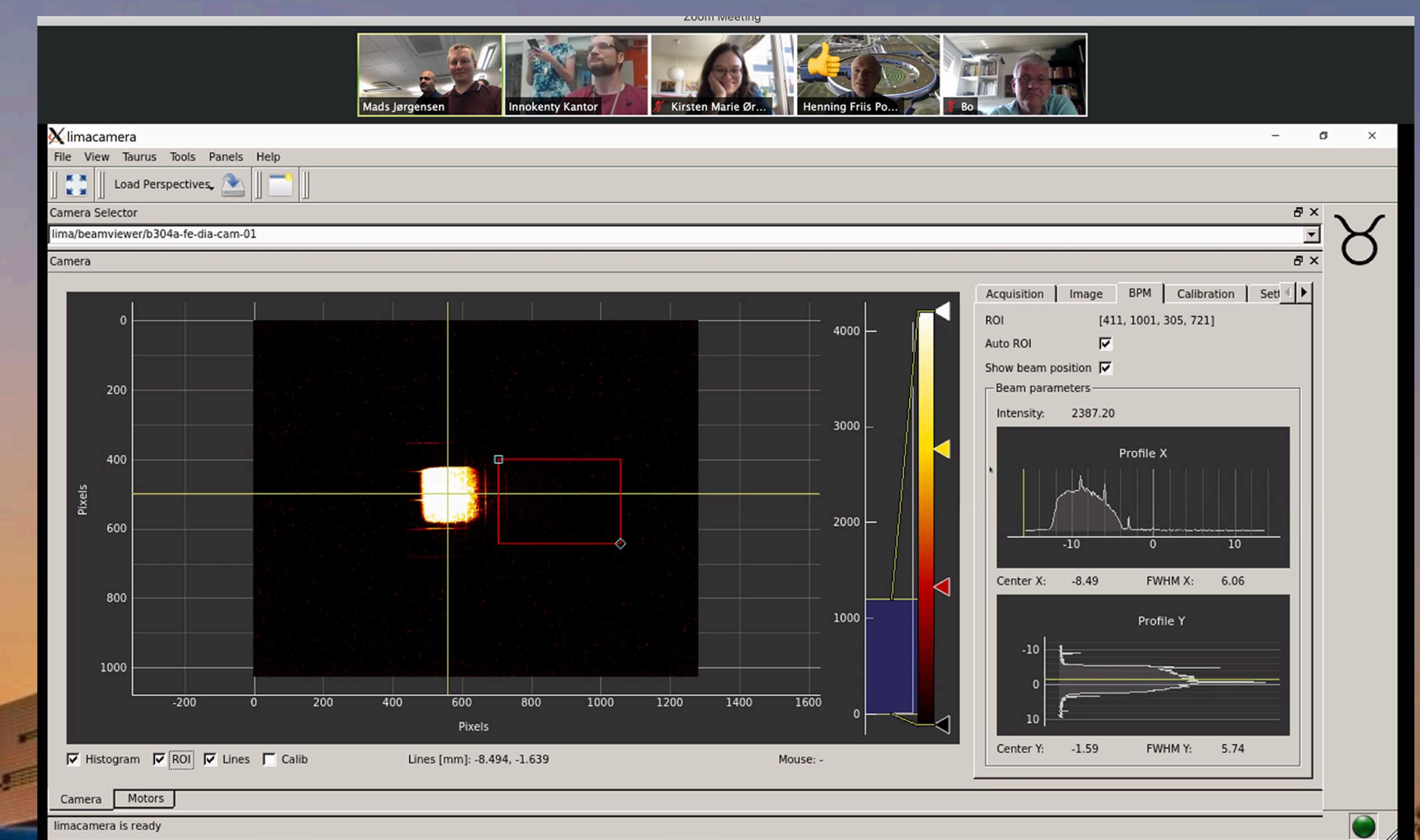
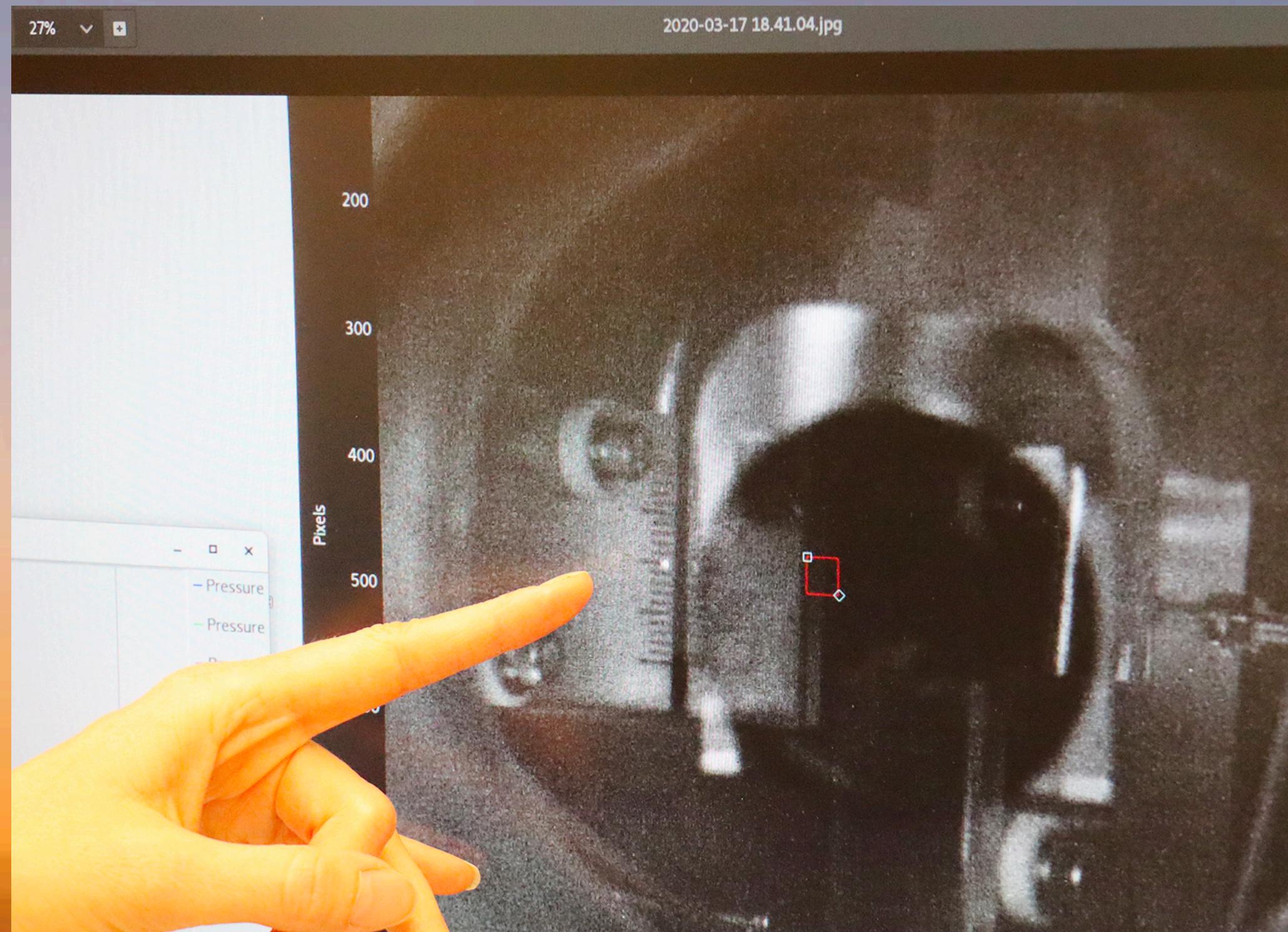
The downtime is mainly impacted by short interruption.



Distribution of downtime per subsystem  
2021/01 -> 2021/10.

Nowadays the downtime improvement focused on the system with long recovery time.

# Beamlines Status

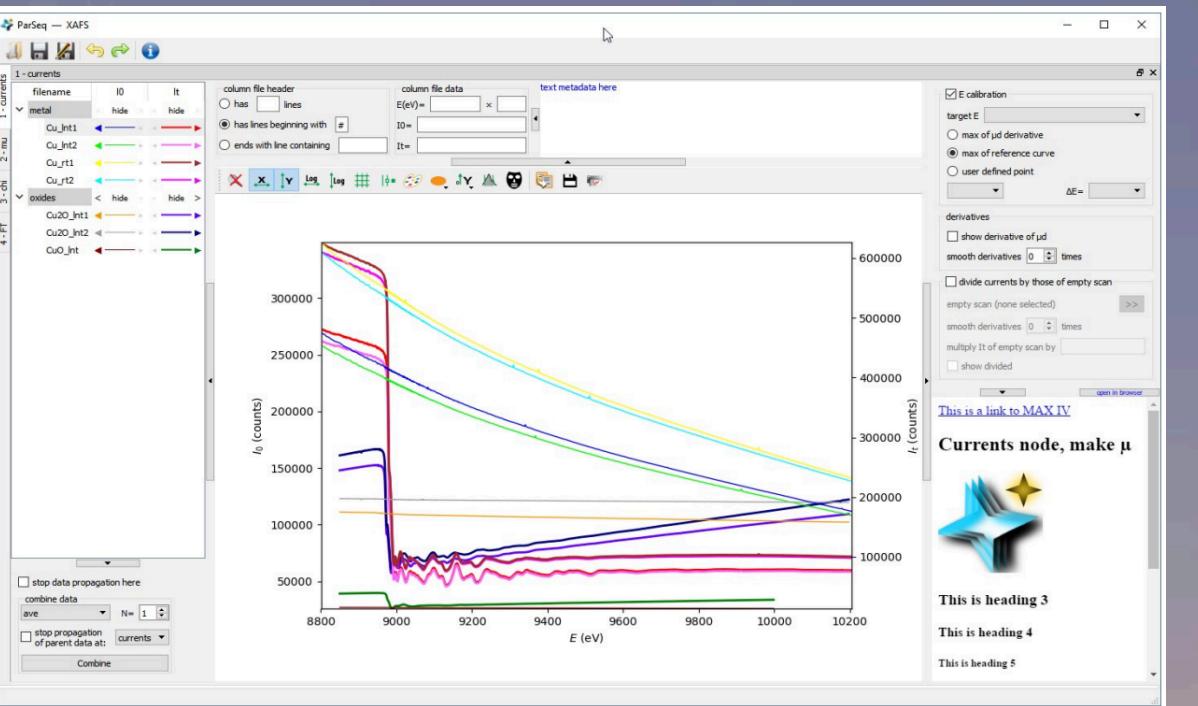
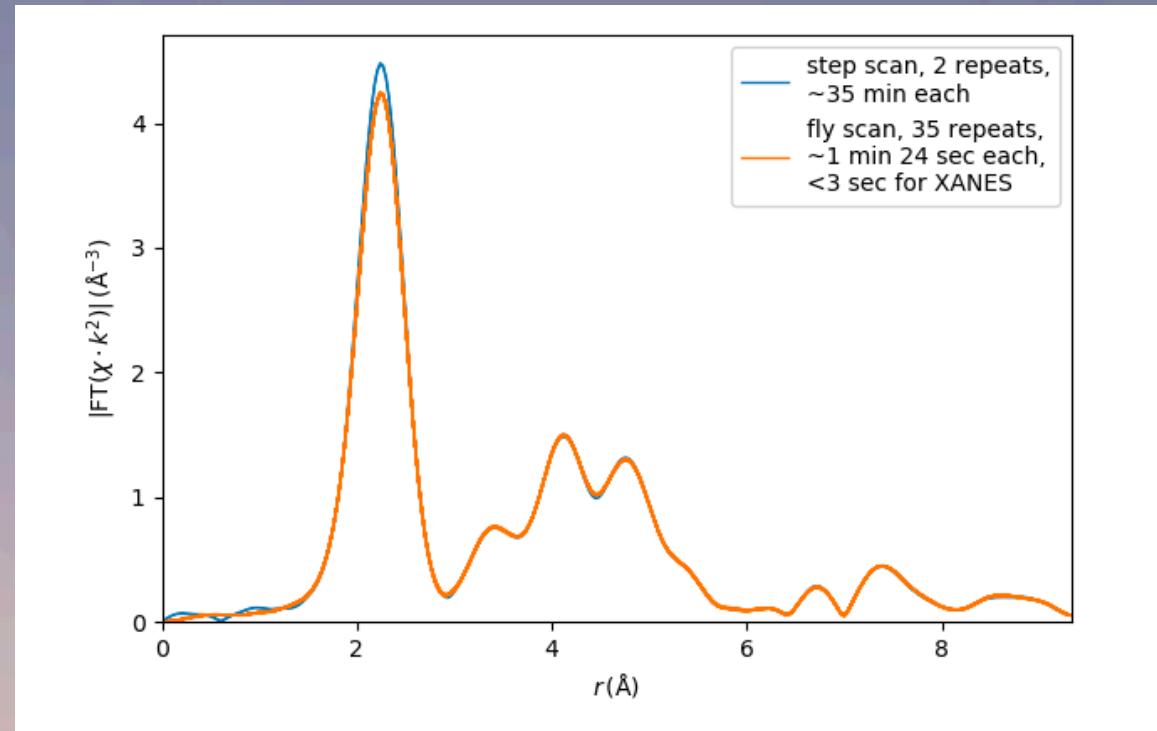


SoftiMAX is the 13th beamline to “see the light” at MAX IV. The synchrotron light was delivered all the way from the undulator to the monochromator within the first few hours after opening the shutter.

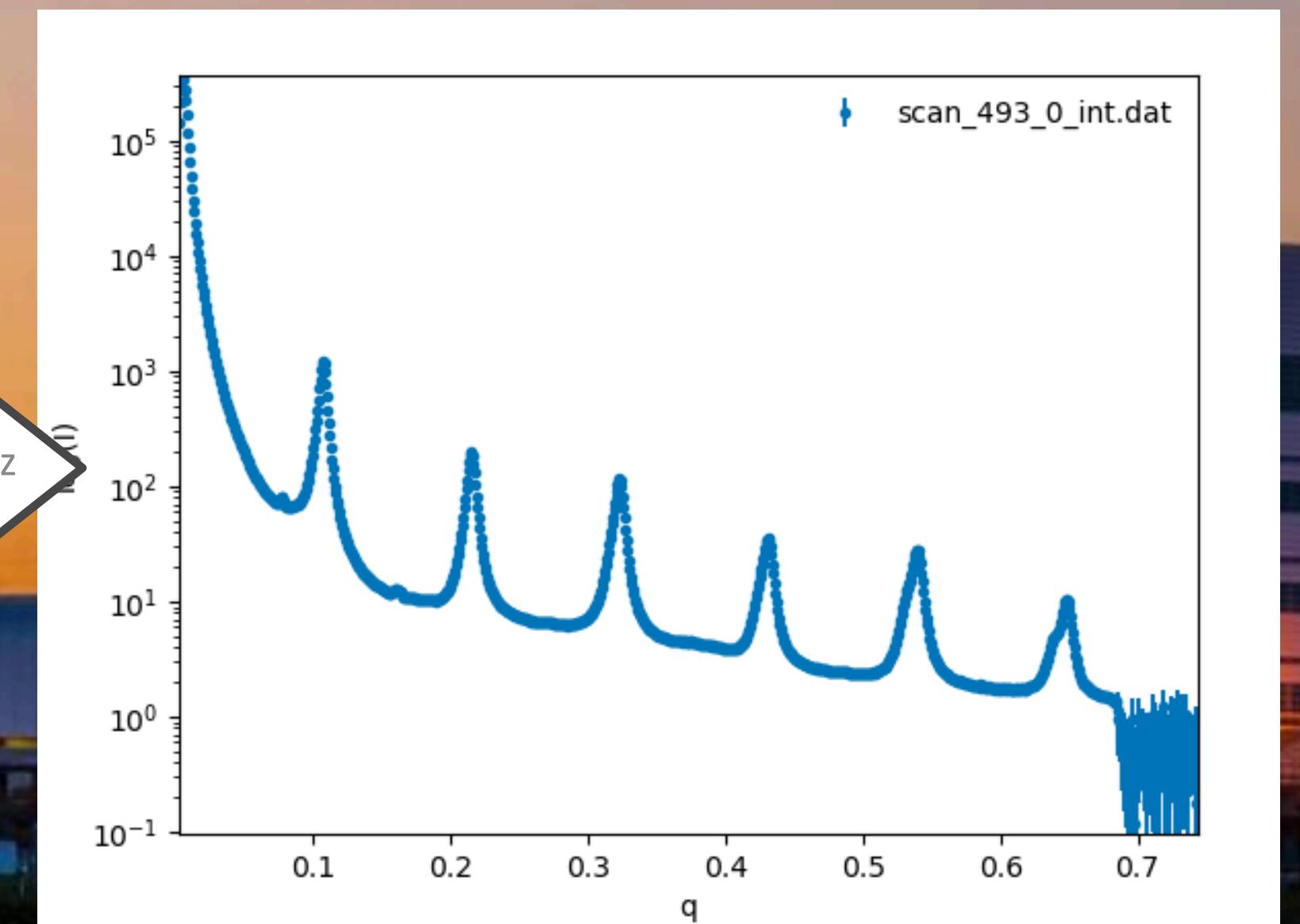
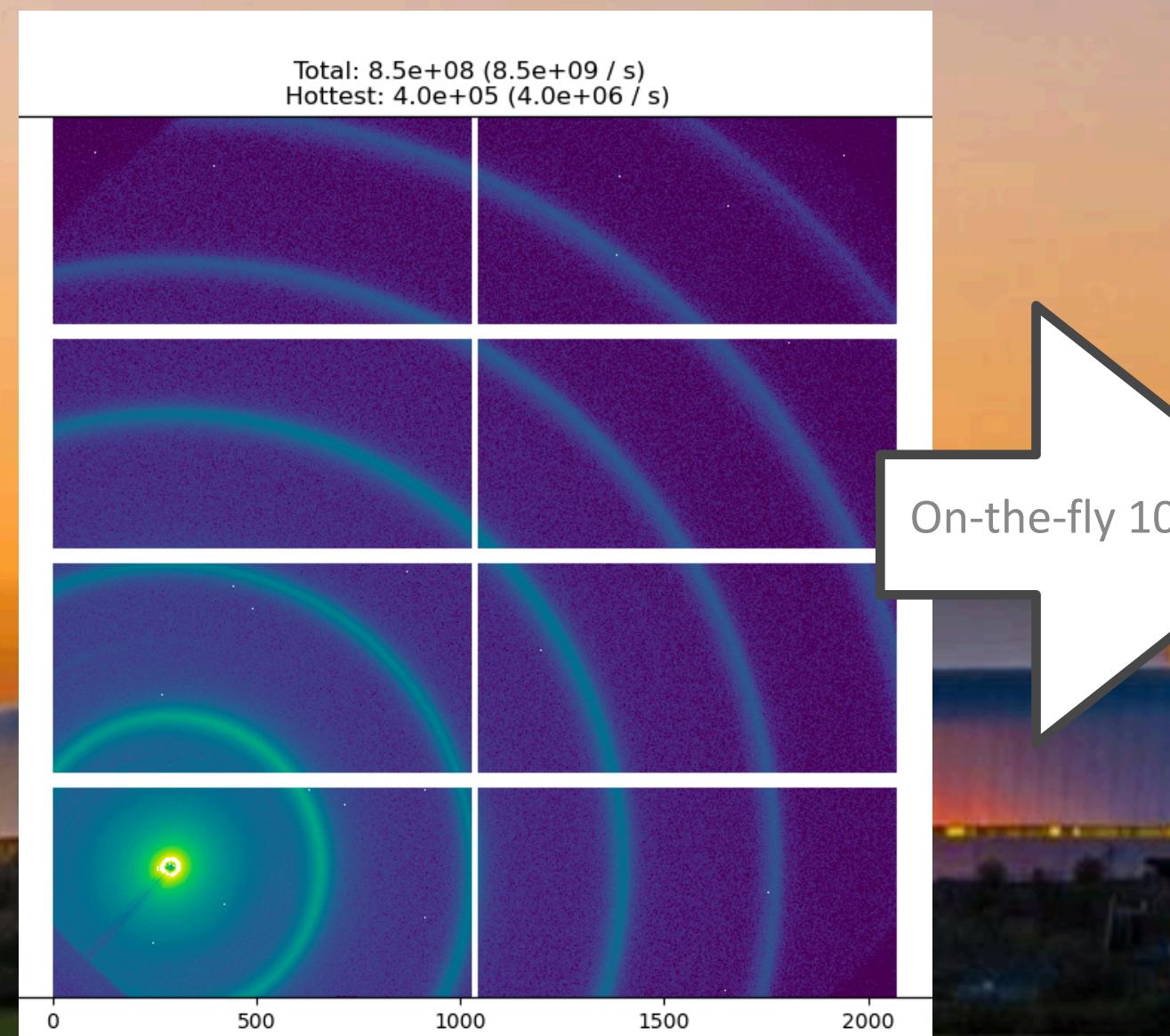
2 June 2020 the Danish beamline **DanMAX** saw first light. Representatives from DTU, Aarhus University and the University of Copenhagen followed the process online.



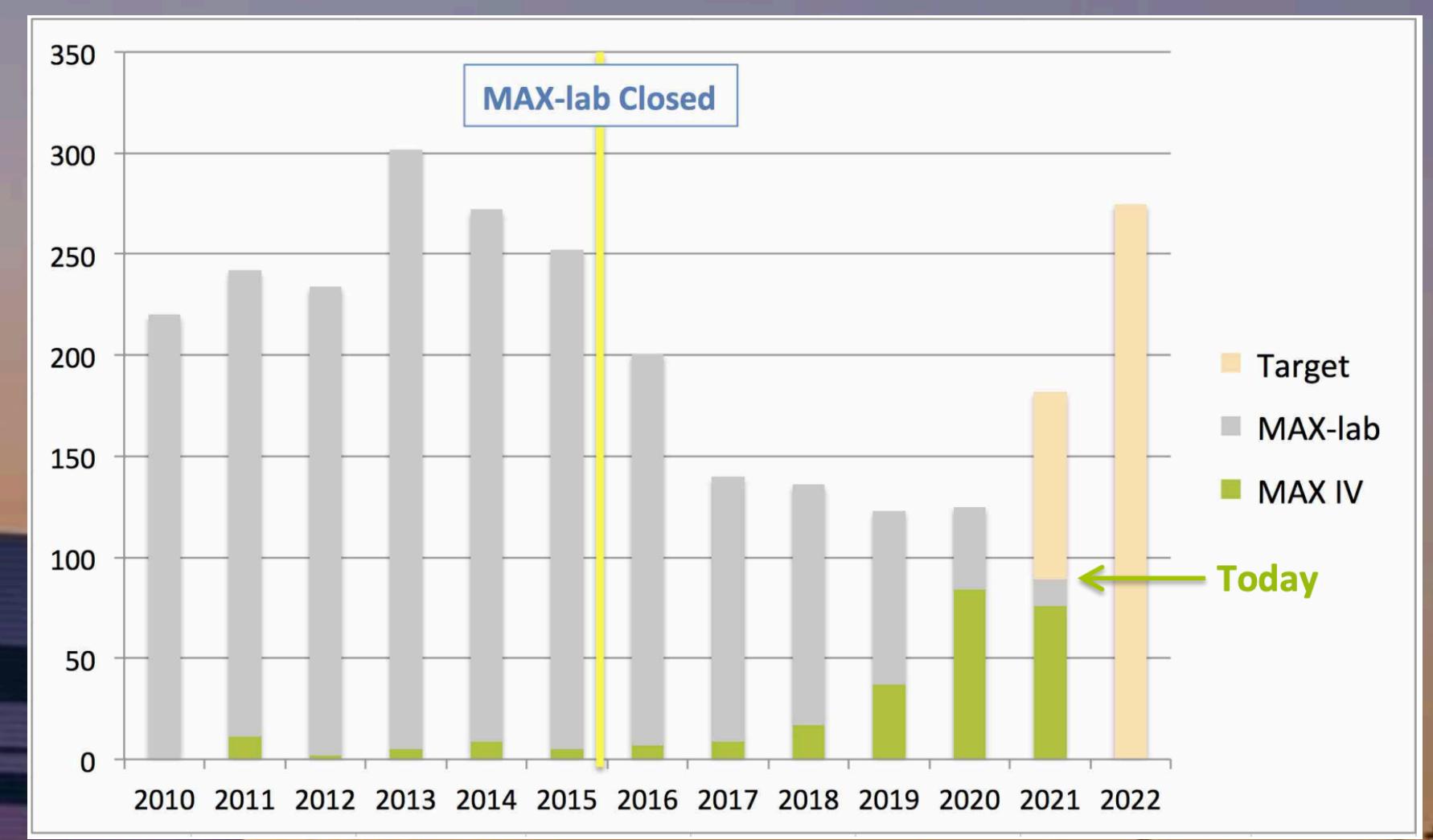
# Beamlines Status



Balder, Copper foil EXAFS, Fly scan with a total accumulation time down to ~30 sec per full EXAFS.  
Parallel Execution of Sequential Data Analysis (right) is done online.



CoSAXS, Silver behenate use to calibrate SAXS data at short sample-to-detector distance.  
The Azimuthal Integration (right) shown in linear plot is computed on the fly at 10 Hz. (A. Terry)

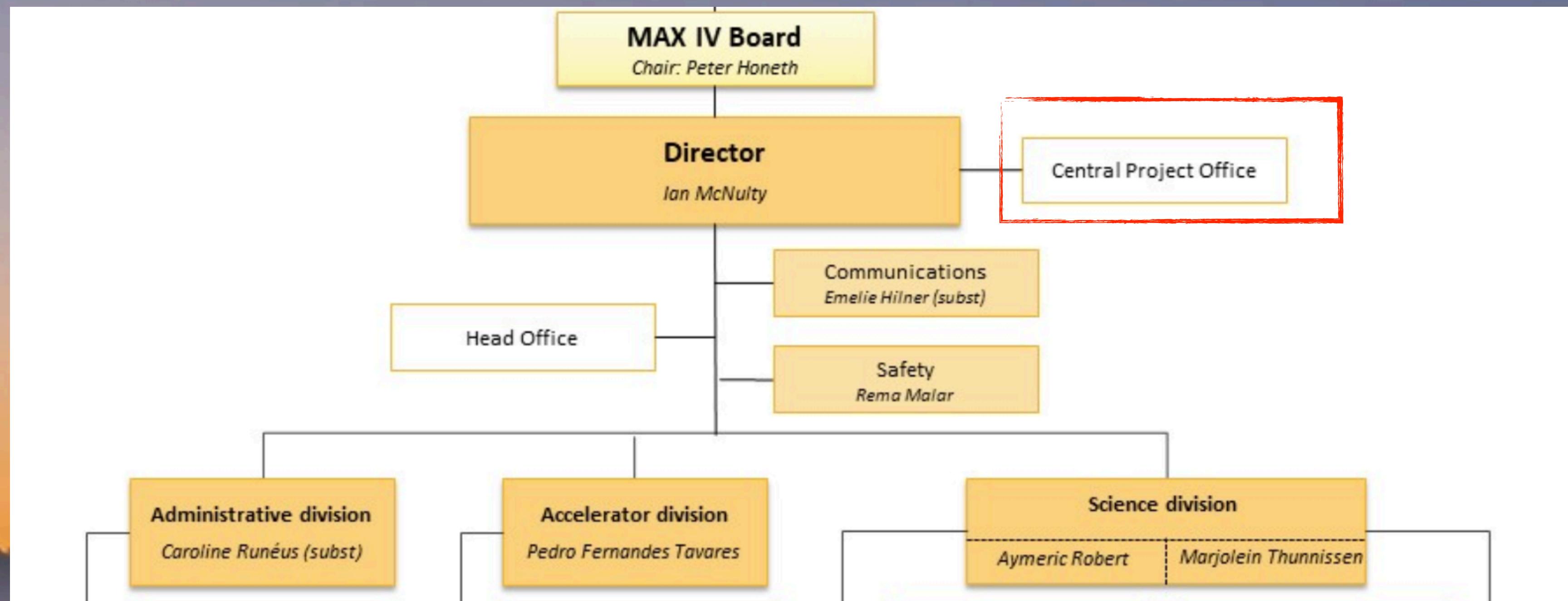


Publication of MAX IV Laboratory vs MaxLab.

# Project Management



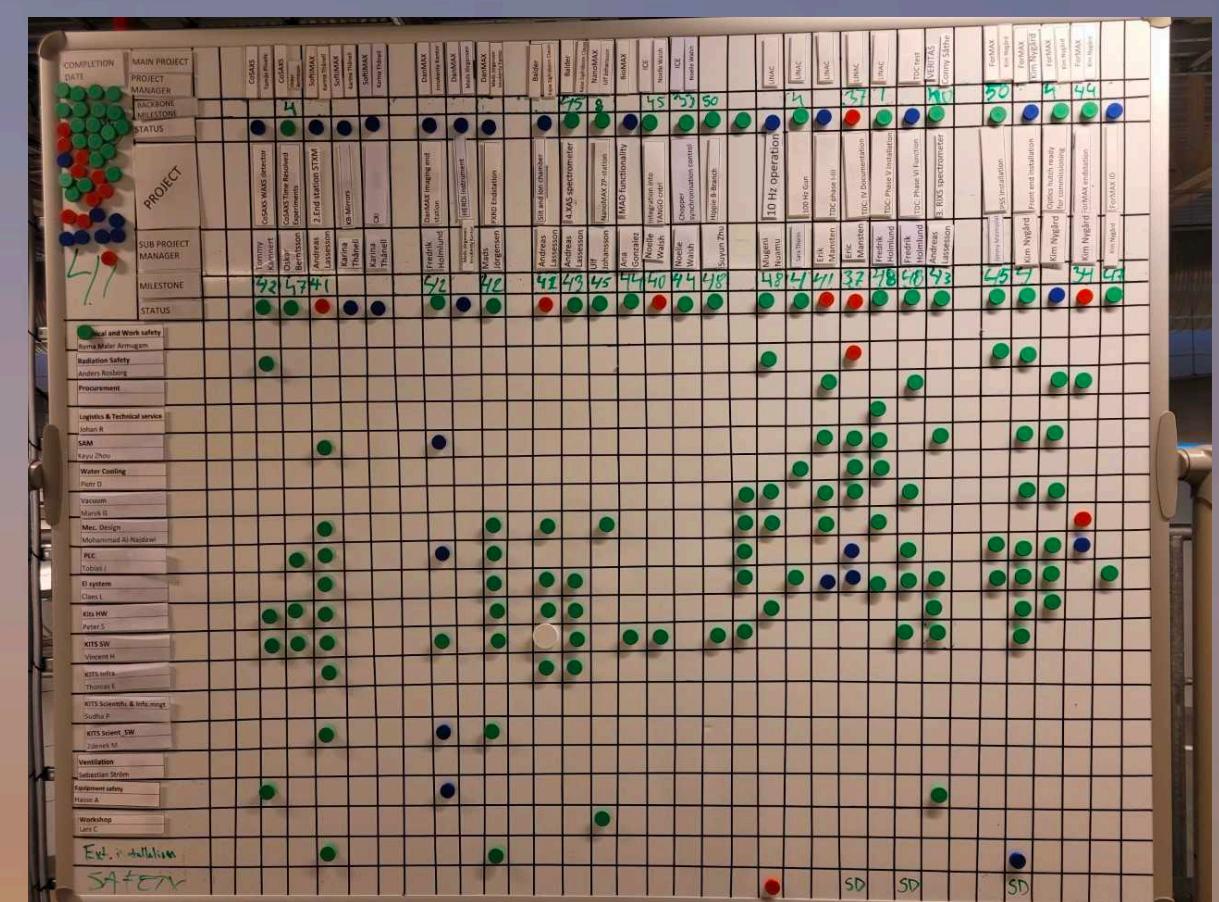
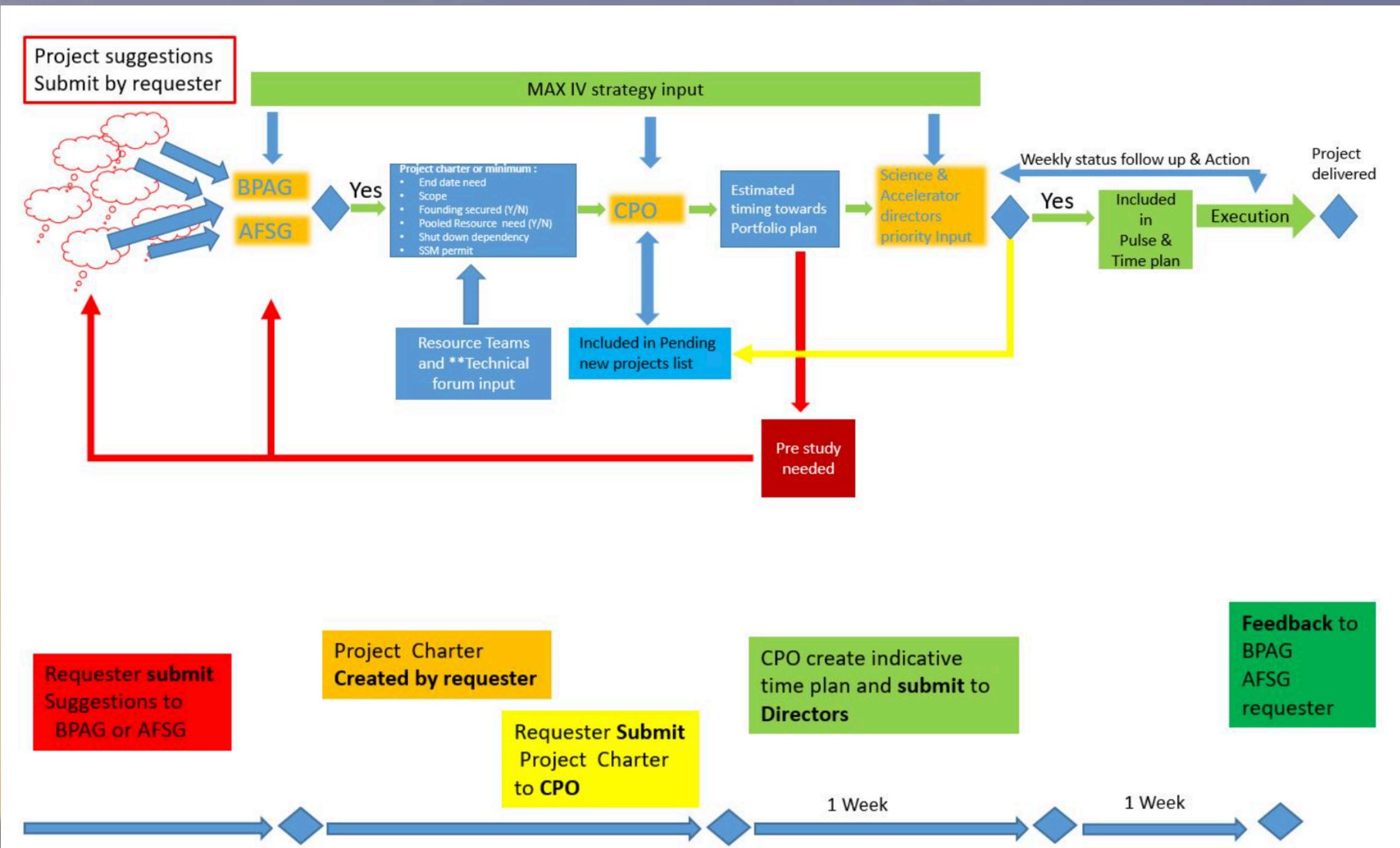
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# Project Management



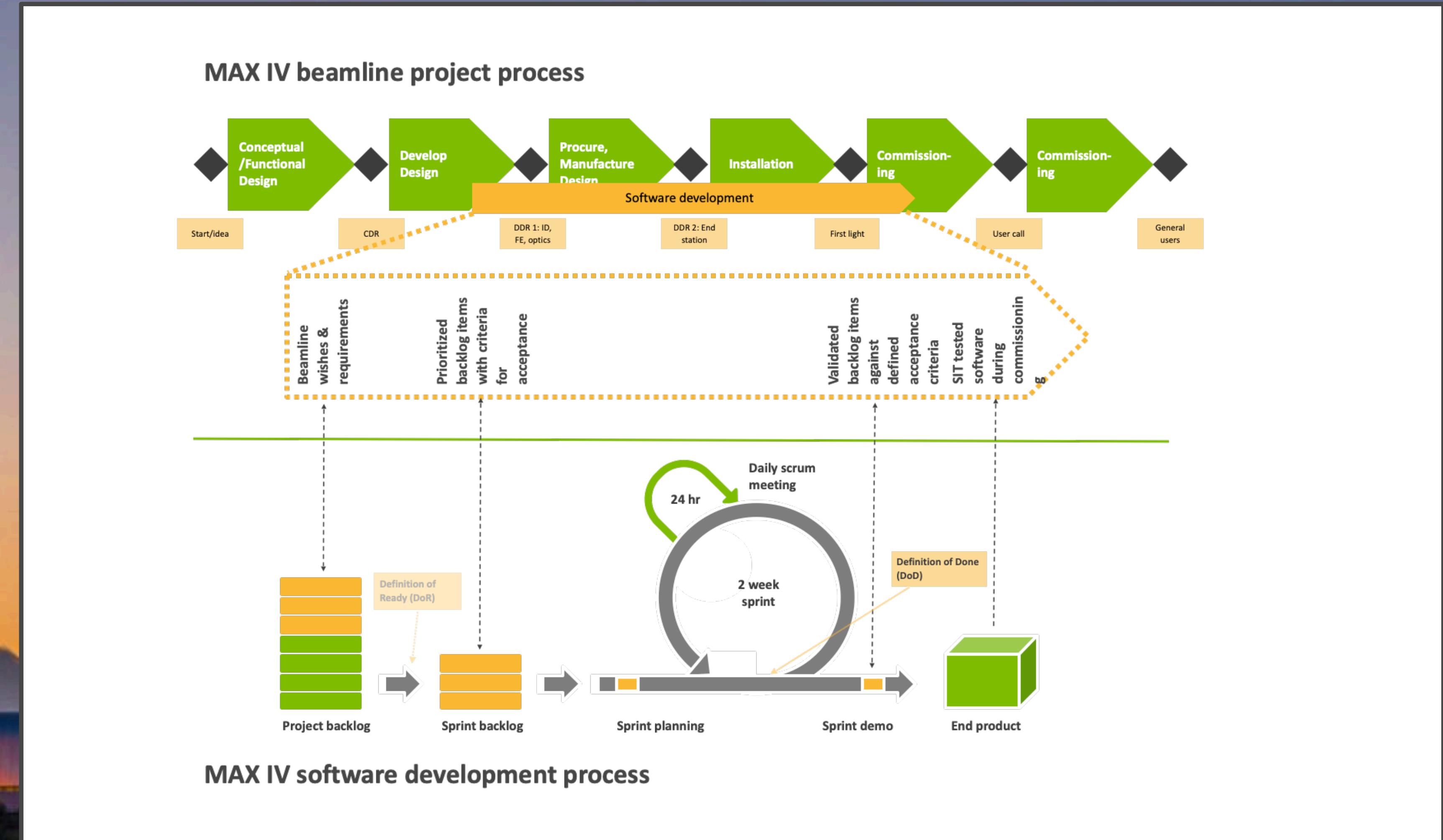
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# Project Management



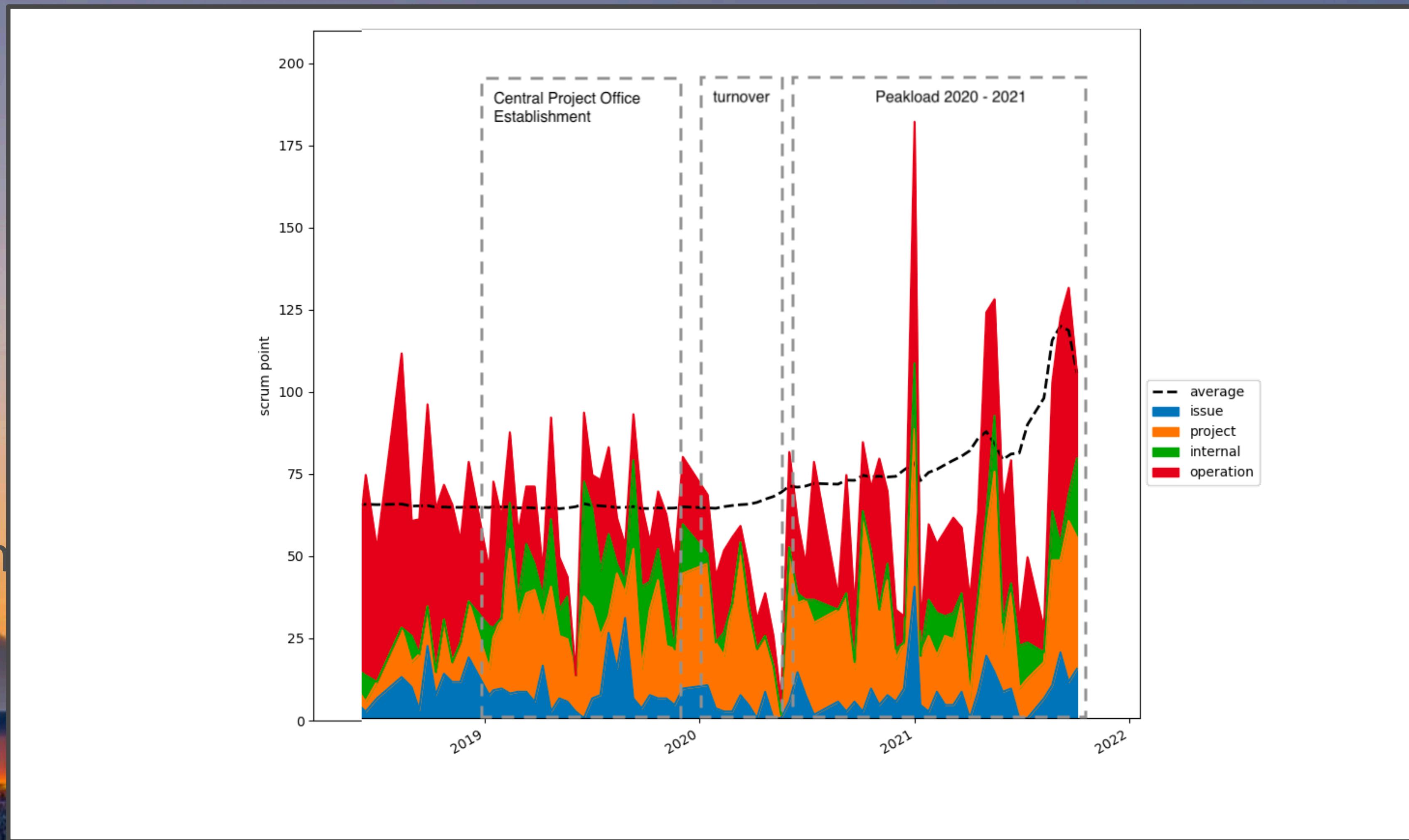
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# Operation

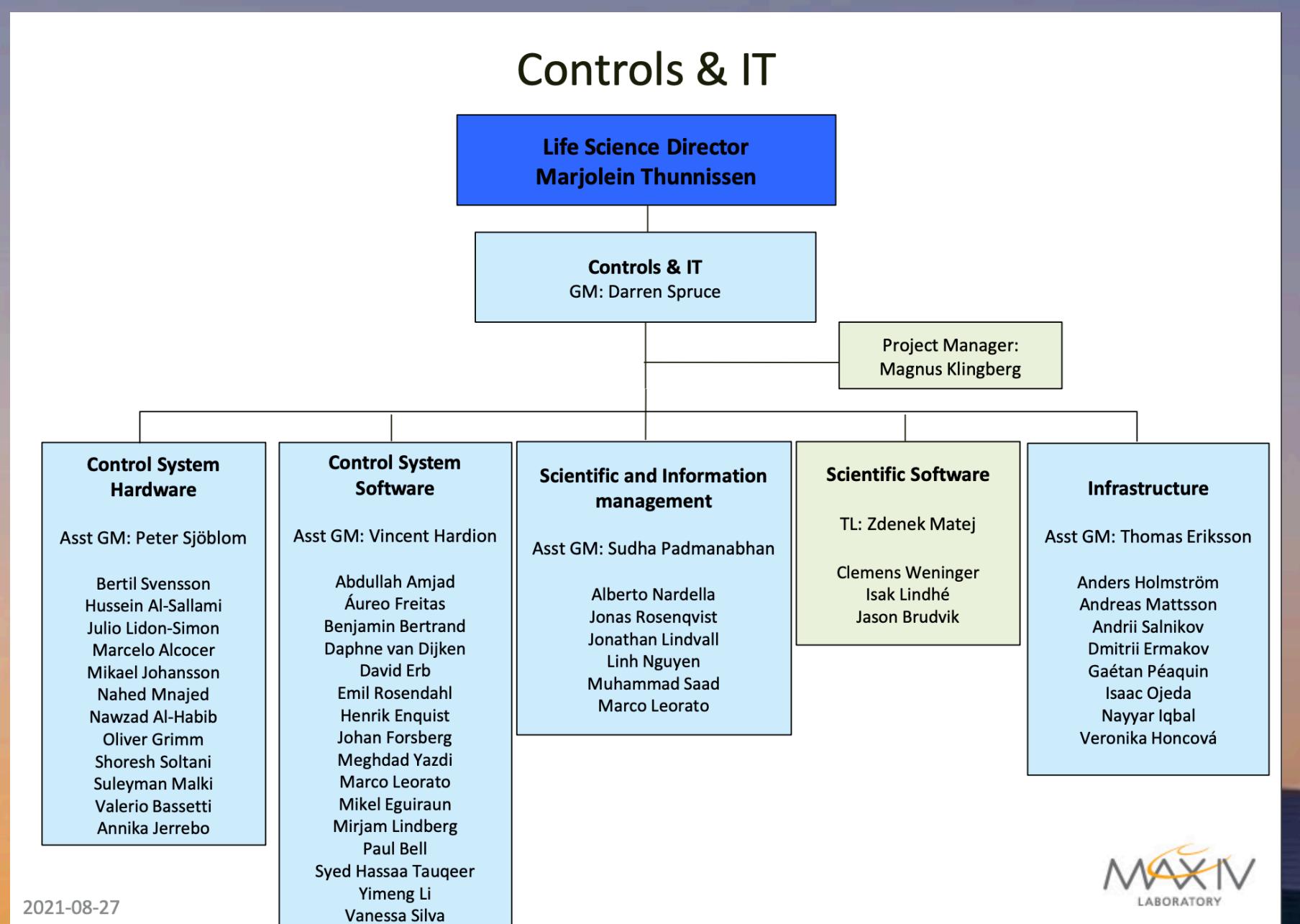


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# Operation

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ISSUES	CAUSE
RELIABILITY and PERFORMANCE	Project Priority on the Feature
ROBUSTNESS	Behaviour of the equipment not fully understood
USABILITY (User friendliness)	Limited commissioning time
SUPPORT RESPONSIVENESS	Lack of resource

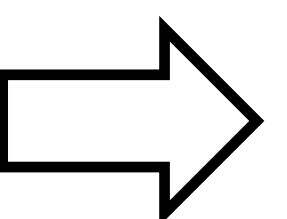
# KITS Operational Support



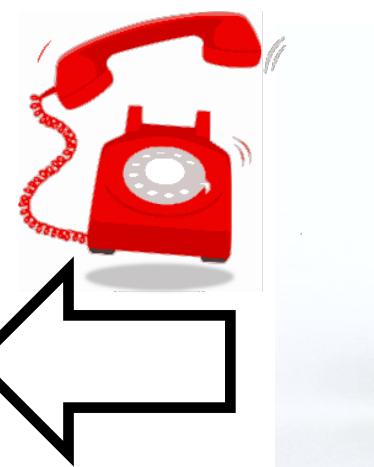
KITOS



Proactive monitoring



KITOS shift crew



Staff in user operation

Inspired by the XFEL Data Operations Center (DOC), users access the expertise through a single number on support

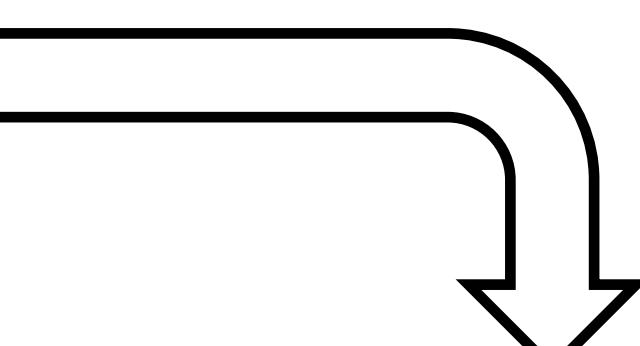


**PROJECT**

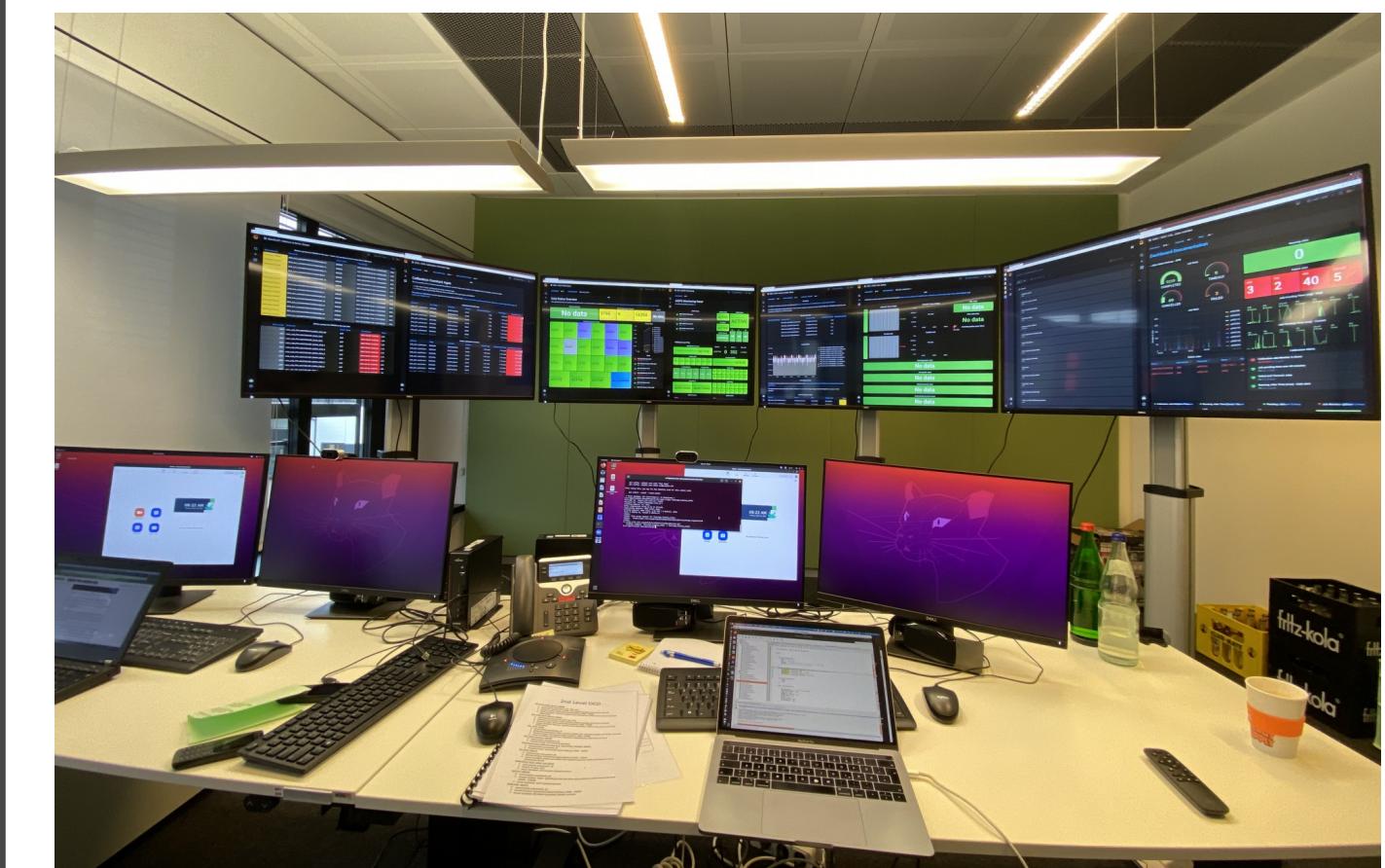
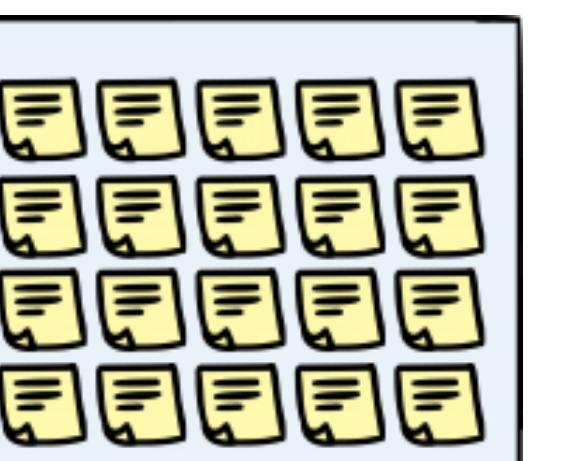
KITS teams  
Expert second  
line support



Courtesy of Mirjam Lindberg



Longer term  
follow-up



XFEL DOC has access to a state-of-the art proactive monitoring.

Courtesy of S. Aplin, S. Hauf and the DOC team, XFEL.

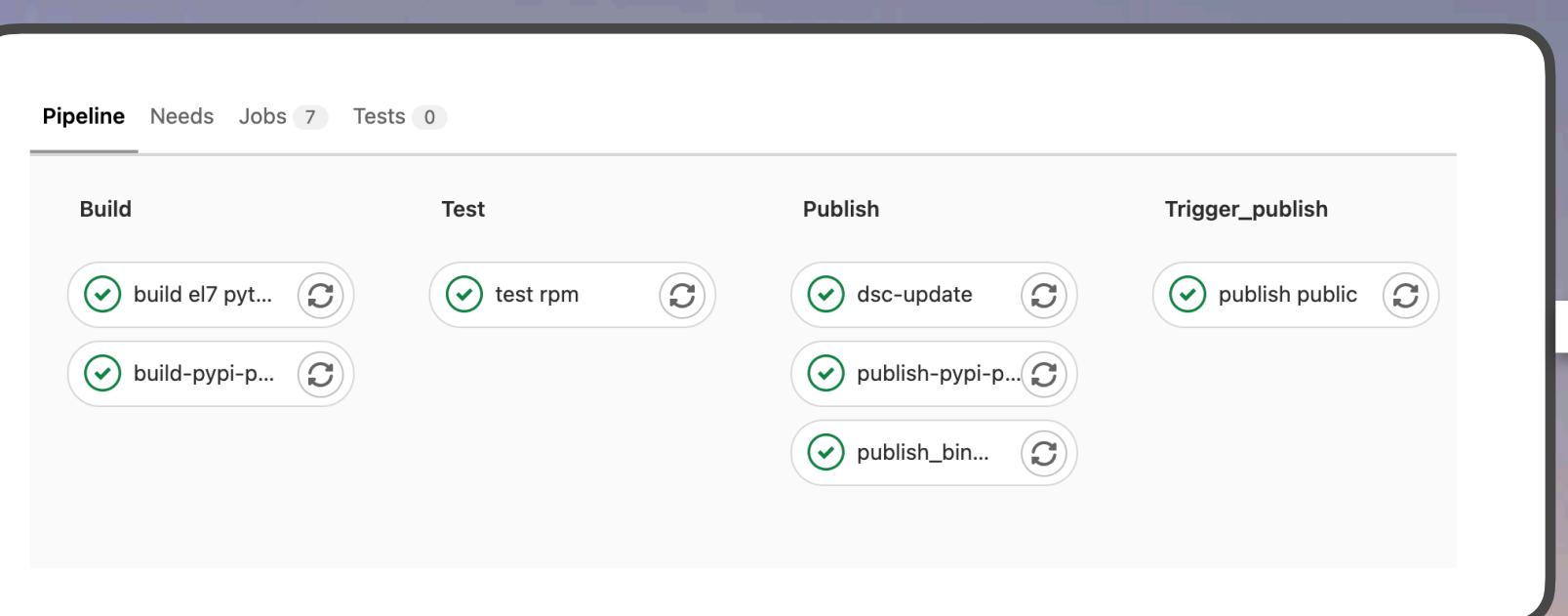
# KITS Improvement



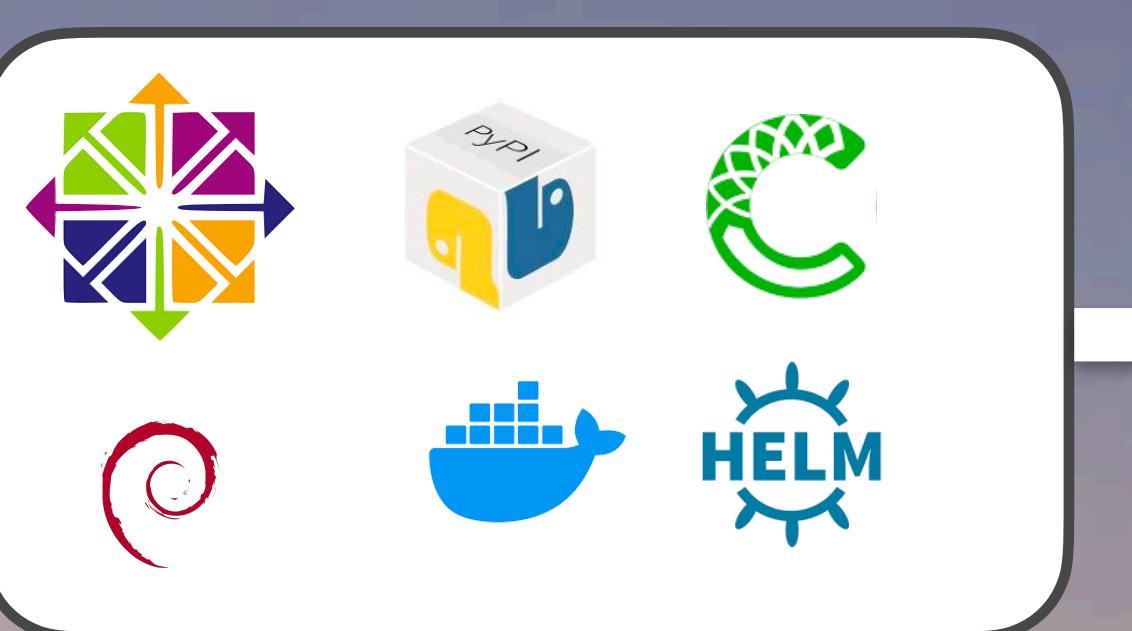
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# Deployment and Monitoring



# Continuous Integration with Gitlab pipeline



# Continuous Delivery



# Deployment with Ansible

## CONTROL SYSTEM MANAGEMENT AND DEPLOYMENT AT MAX IV

B. Bertrand\*, Å. Freitas, V. Hardin, MAX IV, Lund, Sweden

### Abstract

The control systems of big research facilities like synchrotron are made of hardware and software hardware and software parts. Deploying and maintaining the system is a complex process. Workflows and tools. MAX IV has been using Ansible to manage and deploy its full control system, both software and infrastructure, for quite some time with great success. All required software (i.e. tango devices, GUIs...) used to be packaged as RPMs (Red Hat Package Manager) making deployment and dependency management easy. Using RPMs brings many benefits (big advantage is that it will test packages compatibility) but also comes with a few disadvantages mainly the dependency to the release cycle of the Operating System. The Python ecosystem is changing quickly and using recent modules can become challenging with RPMs. We have been investigating conda as an alternative package manager. Conda is a popular open-source package, dependency and environment management system. This paper will describe our workflow and experience working with both package managers.

### INTRODUCTION

The Controls & IT group, also called KITS, is responsible for the whole IT infrastructure at MAX IV. This includes everything from control system hardware and software to data storage, high performance computing, scientific software and management systems. The system is divided into the Control System Software team managing all the software linked to the control system. With the accelerator and 16 beamlines, this represents more than 330 physical and virtual machines to configure and maintain. Ansible [1] was chosen for its simplicity of use as detailed in CONFIGURATION MANAGEMENT OF THE CONTROL SYSTEM [2] and is a great tool to administer the system. It is composed of many components that often have dependencies with each other: tango devices, controllers, GUIs... Building and being able to deploy each software individually without breaking another part is not straightforward. This requires some tools and is exactly why package managers were designed. One of their role is to keep track of dependencies between packages to ensure coherence and avoid conflicts. Using a package manager makes it easier to distribute, manage and update software.

### PACKAGE MANAGEMENT

#### RPM

The RPM Package Manager [3] (RPM) is the package management system that runs on Red Hat Enterprise Linux, CentOS and Fedora. As CentOS is the default Operating

System at MAX IV, using RPM to distribute internal software was an obvious choice.

RPM gives us access to a large number of high quality packages from the main CentOS repository and others like EPEL [4], the Extra Packages for Enterprise Linux. This provides solid foundation to build on and is one huge advantage of Operating System package managers.

**SPEC file** RPM creation is usually based on a SPEC file [5]. It is the recipe that rpmbuild uses to build an RPM. It contains metadata like the name of the package, version, license, as well as the instructions to build the software from sources with all the required dependencies as seen in Fig. 1.

```
Summary: Tango device for Linkan T96 heater
Name: tangod-s-linkan96
Version: 1.2.0
Release: 1%{?dist}.maxiv-lab
License: GPL
URL: http://www.maxiv.lu.se
Source: %name-%{version}.tar.gz
BuildRequires: linkan-sd-linkan-t96
Requires: libmaxiv-common-cpp >= 4.0.8
Requires: libglib2
Requires: libmaxiv-linkan-t96-devel
BuildRequires: linkan-sd-devel
BuildRequires: libmaxiv-common-cpp-devel >= 4.0.8
BuildRequires: linkan-sd-devel
# for page Makefile template:
BuildRequires: tango-java

%description
Tango device for Linkan T96 heater

%prep
%setup -q

%build
make

%install
[ -z %{buildroot} ] || rm -rf %{buildroot}

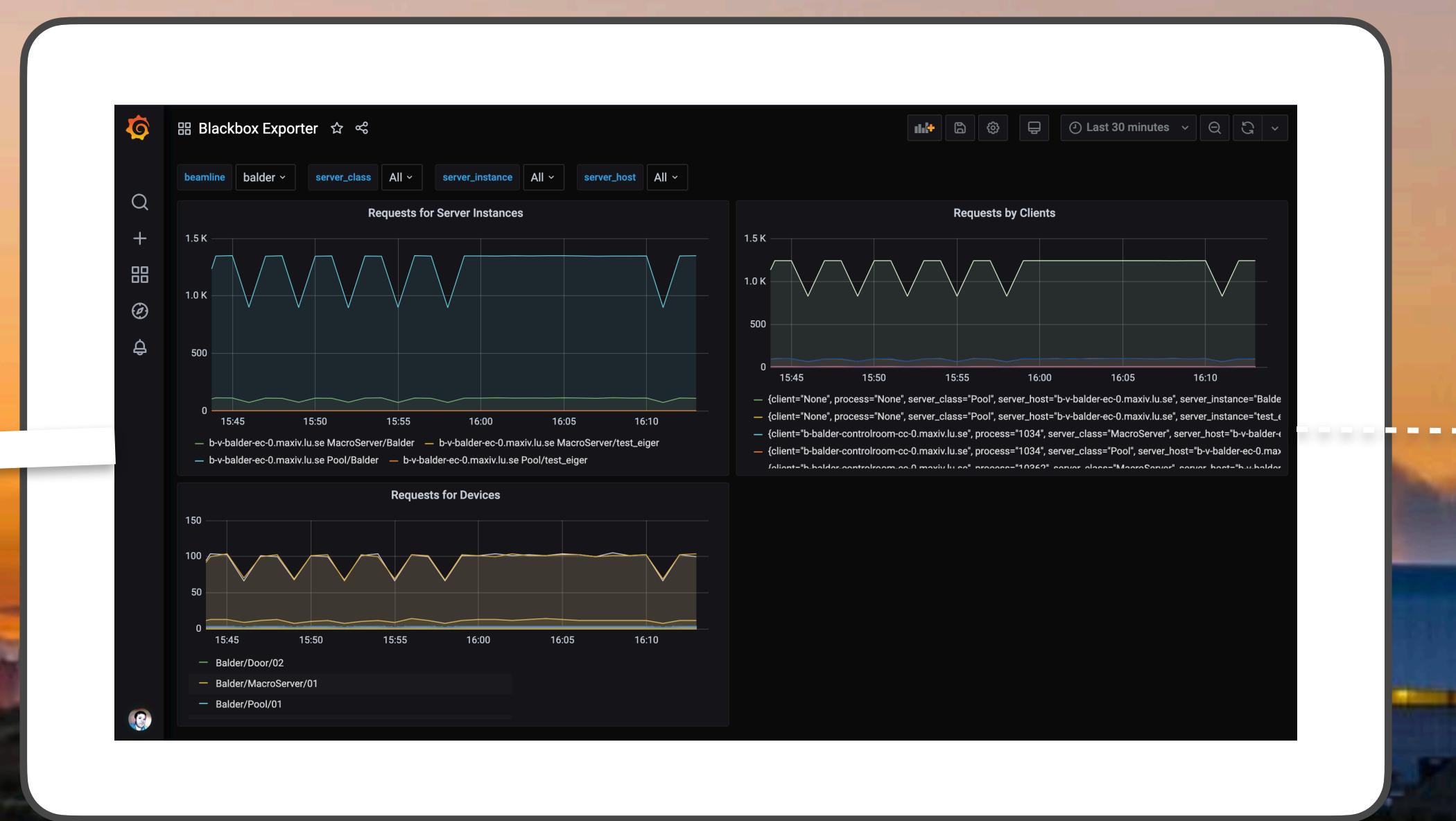
# install bins
pushd bin > /dev/null
for i in *; do
    install -D -m755 $%{buildroot}%{_bindir}/$i $f
done
popd > /dev/null

%files
%defattr (-,root,root,755)
%{_bindir}/*
```

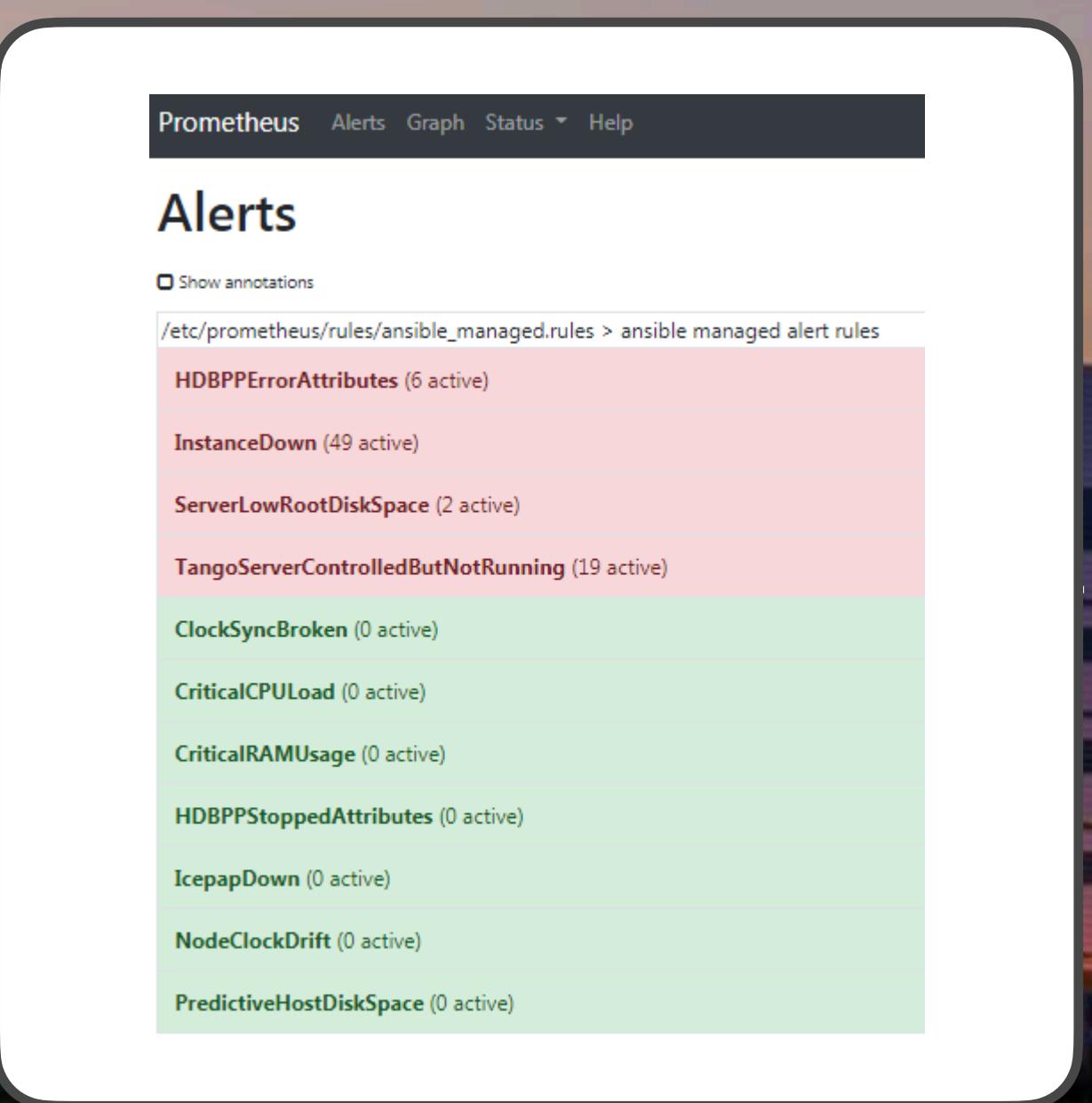
Figure 1: RPM SPEC file (extract).

C++ projects are packaged using a SPEC file. RPM creation is handled by a GitLab CI [6] pipeline using makpkg.

\* benjamin.bertrand@maxiv.lu.se



# Tango Performance Monitoring with Graphana (source ELK)



Prometheus alerts system showing  
the IcePAP controllers down (email  
alerts)

# THBL01

## B. Bertrand, et al.

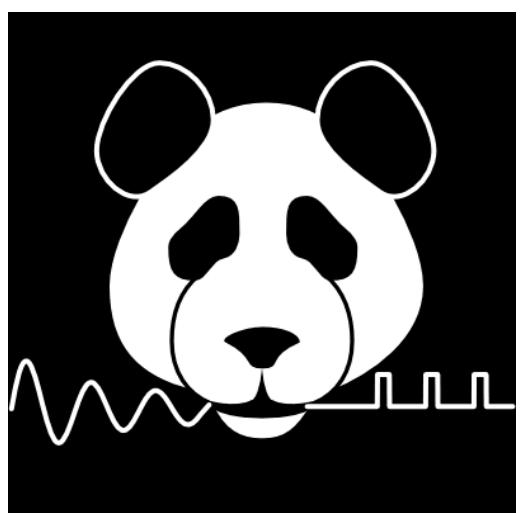
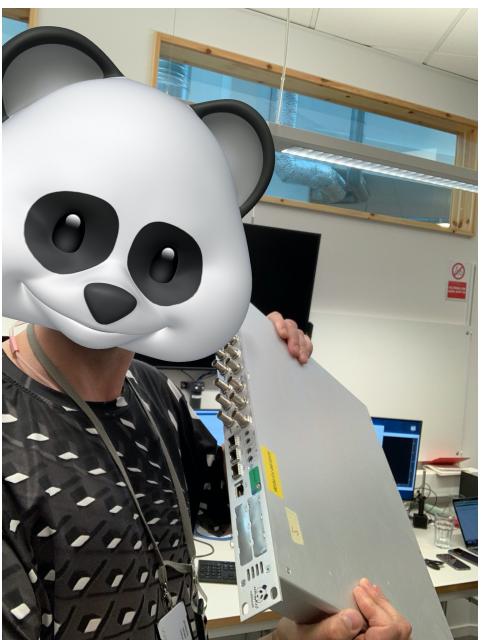
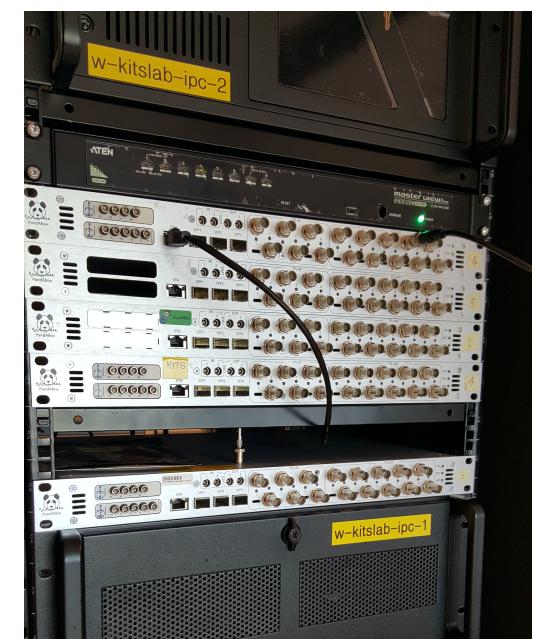
### Control System Management and Deployment at MAX IV.

# THPV011

## B. Bertrand, et al.

### Notifications With Native Mobile Application

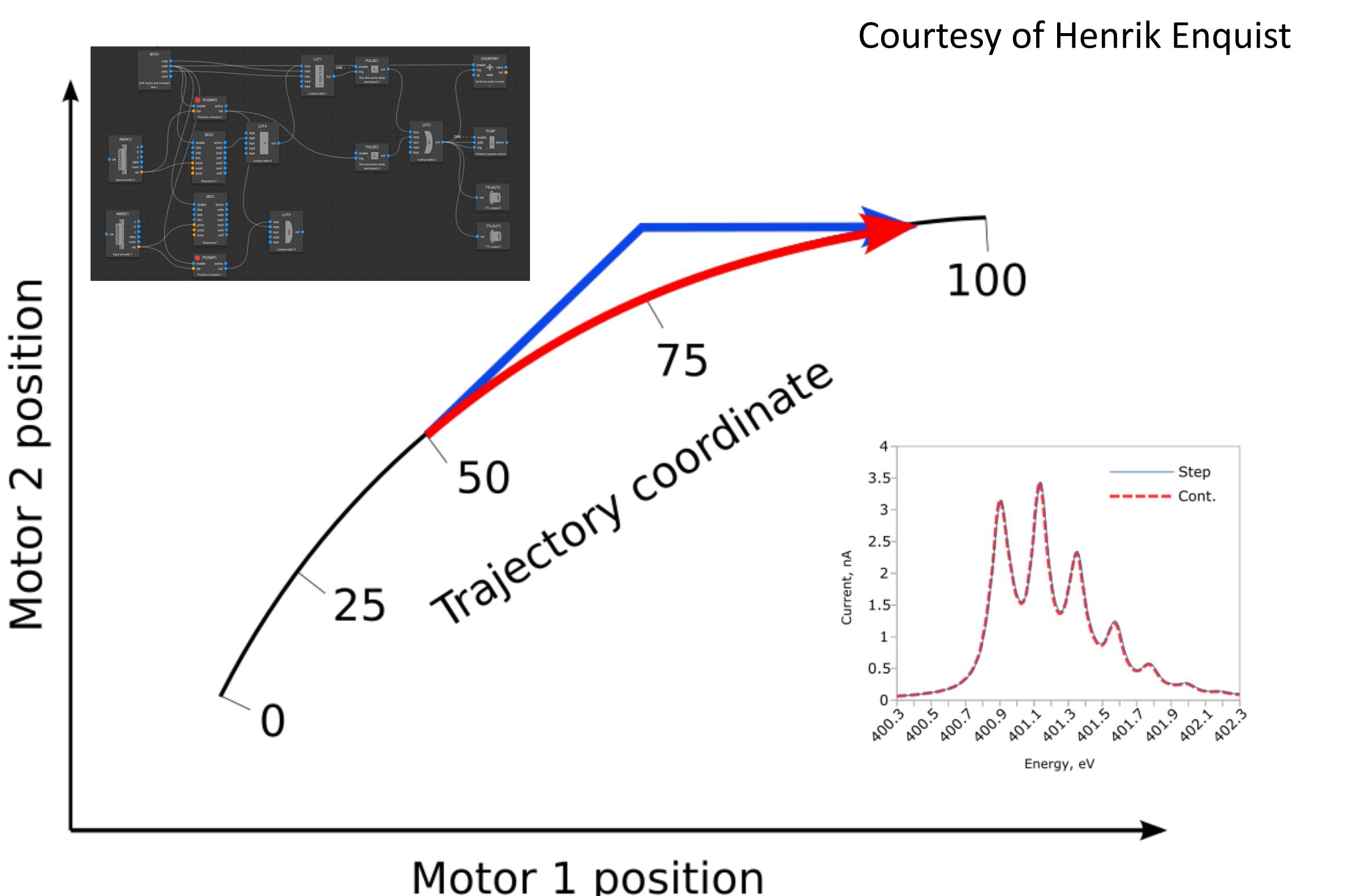
# Continuous Scanning



 diamond

 SOLEIL  
SYNCHROTRON

Upgrade of the Hardware Standard with PandABox (Credit SOLEIL/DIAMOND), replacing hard-to-maintain IOC.



Continuous Scanning is the standard type of scan to match the performance of the detectors.

## CONTINUOUS SCANS WITH POSITION BASED HARDWARE TRIGGERS

H. Enquist, A. Bartalesi, B. Bertrand, J. Forsberg, A. Freitas, V. Hardin, M. Lindberg, C. Takahashi, MAX IV Laboratory, Lund, Sweden

**Abstract**  
In traditional step scanning, repeated starting and stopping of motors leads to inefficient usage of the x-ray source. In addition to increasing measurement times, this also increases the risk of sample radiation damage. We have developed a hardware trigger system that allows us to continuously move the motors. To ensure stable repeatable measurements, the detector triggers are generated hardware free in the correct positions. Before the scan starts, a list of positions is generated. That is then used to generate the triggers when those positions are reached.

The solution is implemented with Tango and Sardana. The encoder signals from the motors are connected both to the IcapAP motion controller for closed loop operation, and a PandABox which is used as the trigger source. The scan is controlled by a TriggerGate controller, that calculates the motor positions and controls the PandABox. The scan can be either a single motor, for example a sample translation stage, or a combined motion like a monochromator. When combined motion are used, we use the parametric trajectory mode of the IcapAP. This enables continuous scans of coupled axes with non-linear paths.

**INTRODUCTION**  
Many experiments require performing scans to measure some quantity as a function of another. The easiest approach is to use a step scan, and although this is very commonly used, it has some disadvantages. One缺点 of moving the scanned axis to a certain position, then arming and triggering the detector, waiting for acquisition to finish, then moving the axis again, and the cycle is repeated for every step. Only the time spent acquiring the data is useful, while the rest can be considered deadtime. The same applies to the other scanned axis (typically one or several motors), and the arming of the detector can take a considerable amount of time. Under typical conditions, scans can run at a few points per second, so the deadtime tends to make up for the majority of the time required to perform the scan.

A more efficient way to keep the scan is to move continuously during the scan. This has previously been implemented using combinations of software and hardware solutions [1-3]. In this case, the scanned axis needs only to be started and stopped once. The acquisition loop then consists of only triggering the detector, waiting for acquisition to finish, and readout. Many detectors are able to read out the data in milliseconds, meaning the scan can run at hundreds of points per second. This is the approach we have taken this work. We have tried to implement a system that provides continuous motion and trigger generation completely in hardware.

**CONTINUOUS MOTION**

Letting the motion to run continuously during the scan is straightforward when the axis corresponds to a single motor that needs to run at constant speed. This is the case when for example a sample translation stage is the flat sample using a single motor. But in many cases the motion involves several motors, that can't simply be moved at the same time. To do this, we need to use a plane grating monochromator, both the mirror and grating positions must move according to some formula. The scan is controlled by a TriggerGate controller, that calculates the motor positions and controls the PandABox. The scan can be either a single motor, for example a sample translation stage, or a combined motion like a monochromator. When combined motion are used, we use the parametric trajectory mode of the IcapAP. This enables continuous scans of coupled axes with non-linear paths.

**Figure 1:** The difference between typical pseudorandom and parametric trajectories for a sample translation axis and parameter axis. The pseudorandom scan moves both motors at their nominal velocity. Once the first motor has reached its position, the second continues moving towards the target. The parametric trajectory on the other hand follows the trajectory the whole way by continuously adjusting the motor velocities.

**FRBR04**  
H. Enquist, et al.  
Continuous Scan with Position Based Triggers.

# Detectors and Streaming

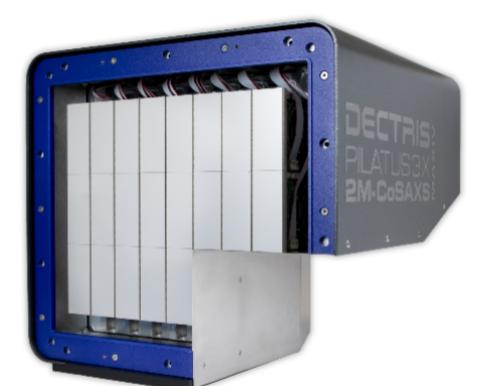
## Commercial solutions

All beamlines in operation so far use commercial detectors and cameras.

### Inventory 2021:

#### Hybrid Pixel Detectors

- 3x Dectris Eiger2 4M, 3x Eiger1 1M, 1x Eiger1 16M
- 1x Dectris Pilatus3 2M, 1x Pilatus2 1M
- **1x Dectris Pilatus3 2M (custom WAXS L-shaped)**



#### sCMOS cameras

- Numerous **Andor Zyla**, 1x Andor Balor
- 1x Tucsen "DhyanaX" (NB: Adapted for vacuum following Soleil)

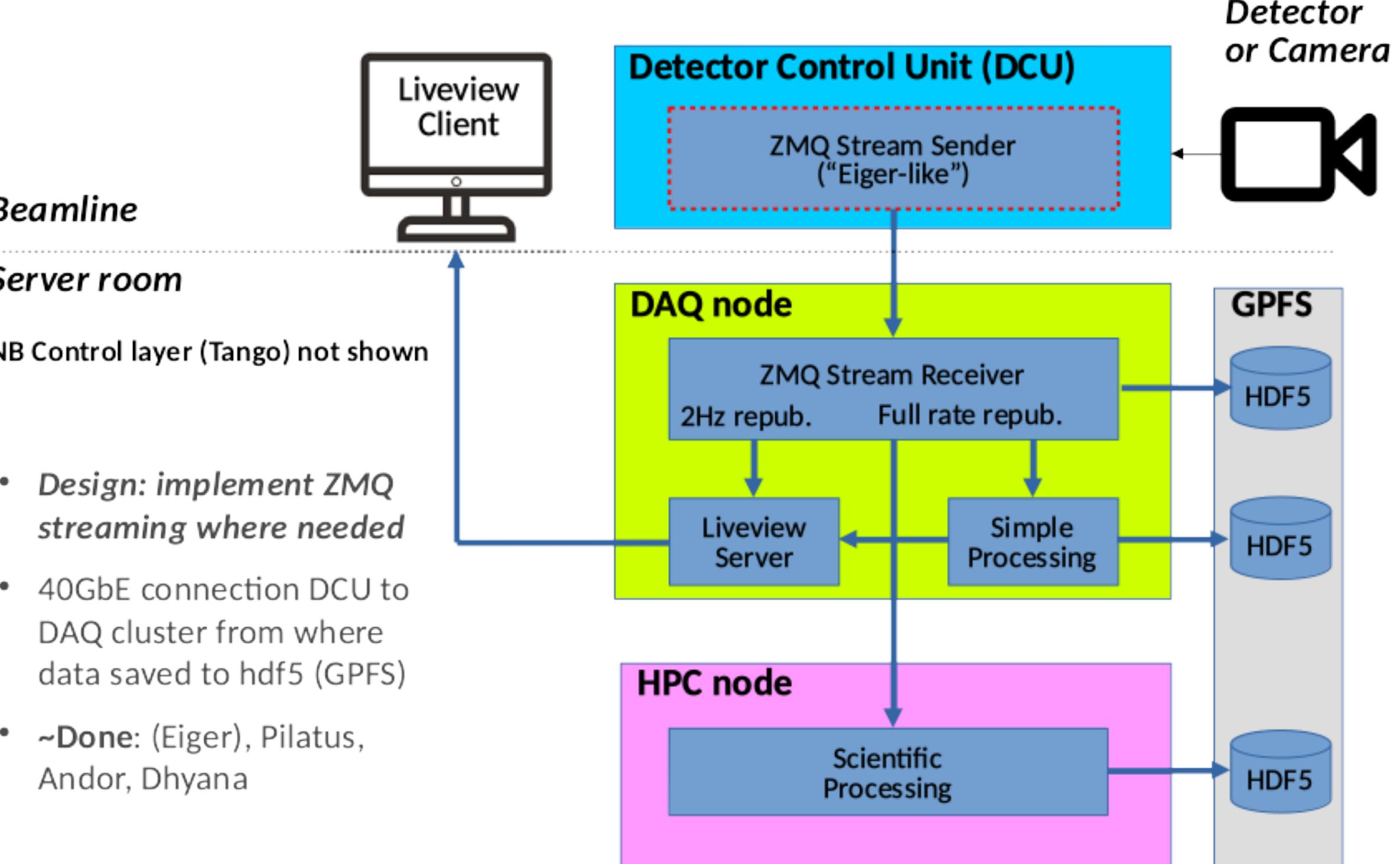


#### Energy resolving + pulse processors

- 2x Amptek XR-100 SDD via QD Xpress3
- 2x Rayspec SDD via QD Xpress3
- 1x Canberra/Mirion 7 element SDD / HPGe via QD Xpress3
- 1x Rayspec SDD Xia FalconX

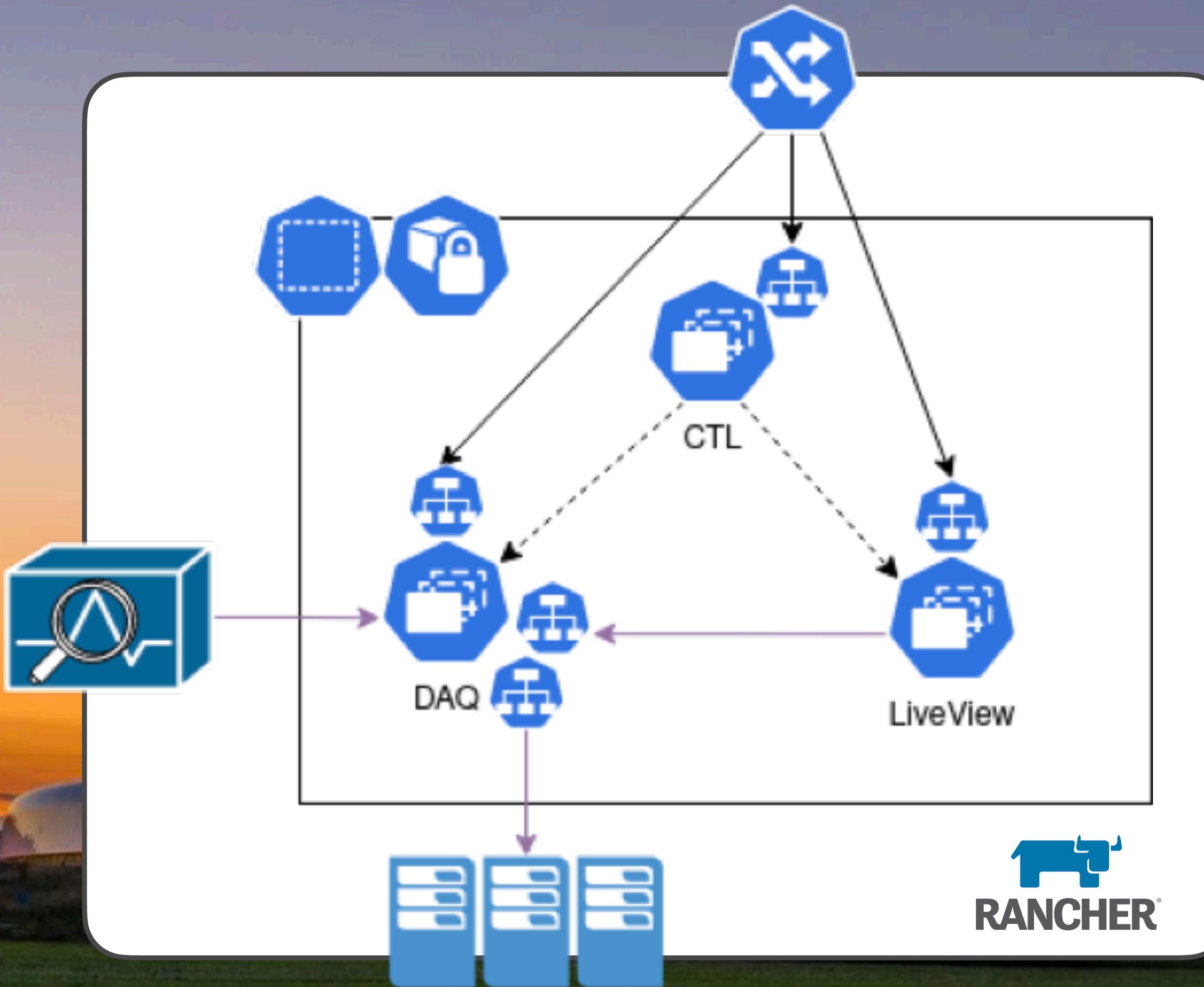
Particule Detectors are the most complex piece of hardware on the Beamlines. In 2019, a small team were dedicated to increase the KITS knowledge in Particle Detectors.

## MAX IV DAQ flow scheme

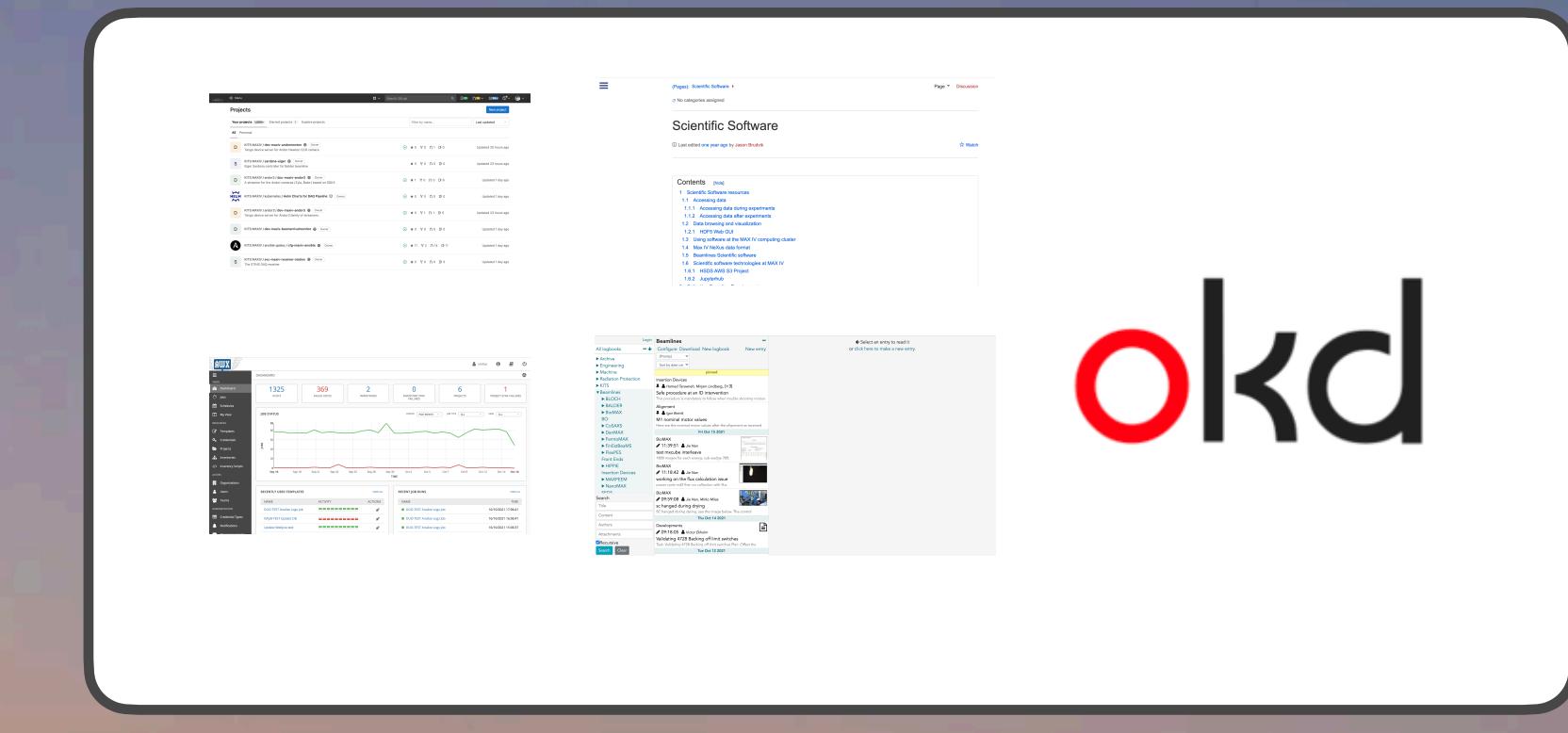


Approximately half the KITS software effort is now spent on data acquisition (DAQ), especially on the data and metadata streaming with ZMQ over 40G links to a central DAQ cluster.

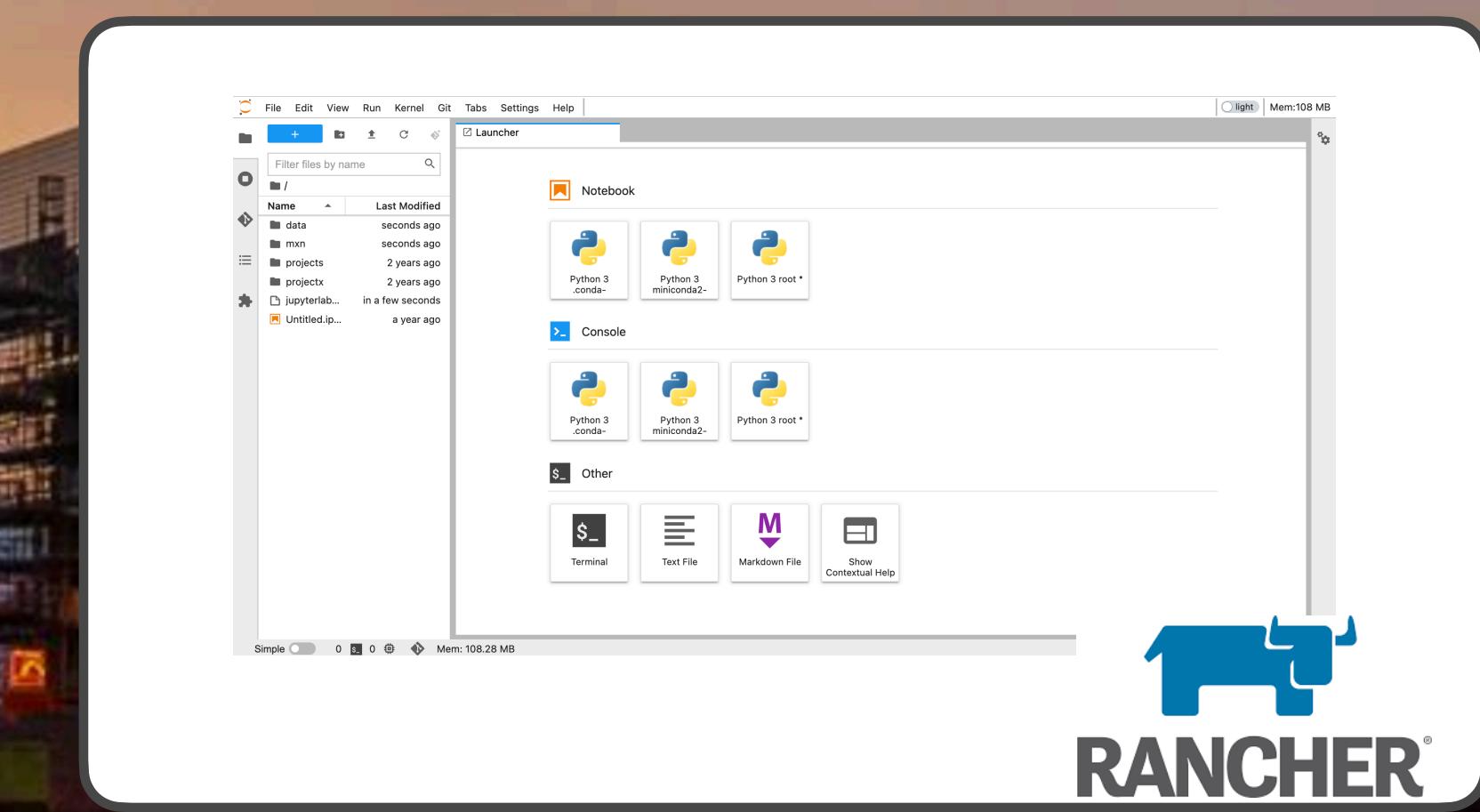
# Kubernetes Cluster



The kubernetes architecture for the Data Acquisition Cluster (DAQ Cluster).

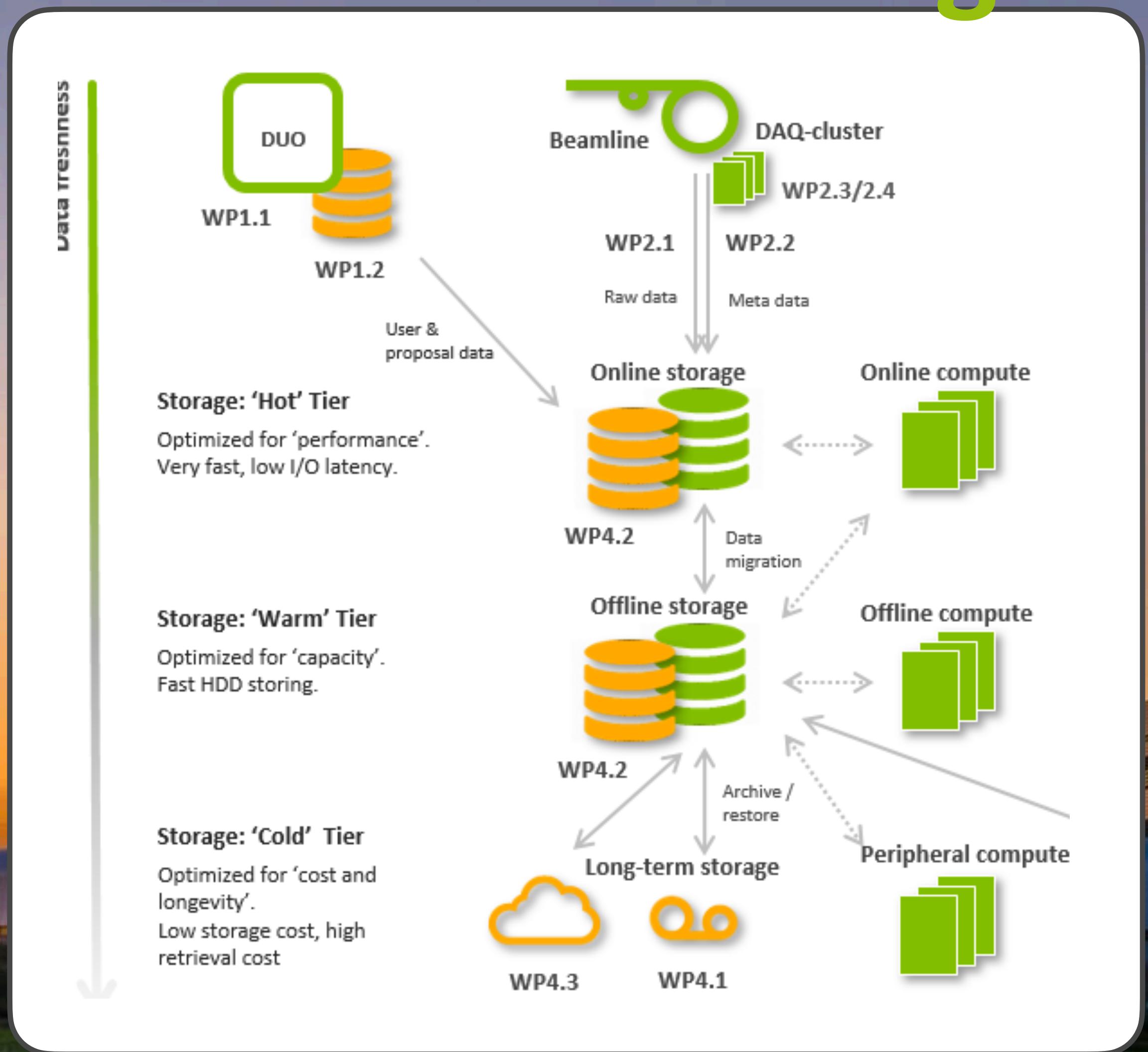


General web services run on OKD Cluster.



JupyterHub Cluster with GPU (similar DAQ Cluster Architecture).

# Data Management



Main Upgrade of the Data Infrastructure: Performance and 10 years retention

**SciCAT Metadata catalog**

The screenshot shows a table of dataset metadata. The columns include Name, Run No., Source Folder, Size, Start Time, Type, Image, Science Metadata, and a delete icon. There are 2895 items per page, with the current view being page 1 of 2895.

Name	Run No.	Source Folder	Size	Start Time	Type	Image	Science Metadata
LDPC data		.../ldpc/data	212 MB	2020-02-21 Fri 11:01	derived		No metadata found
Fe304		...ction/test	14 KB	2020-02-20 Thu 11:30	raw		No metadata found
V20 sample data		.../nfs/disk1	0 B	2020-02-06 Thu 14:02	derived		sample_temperature:300 kelvin wavelength:1-11 meters
Last Neutrons Ever at HZB.	2511	...v20/YC75Z5	203 MB	2019-12-11 Wed 13:48	raw		count_events:[object Object] elapsed_time:1404 seconds
WFM Low Res messing with chopper 1 and 2, slit2 pinhole, slit3 fully open.	2510	...v20/YC75Z5	81 MB	2019-12-11 Wed 13:37	raw		count_events:[object Object] elapsed_time:616 seconds
slitscan, slit2 scanning, slit3 fully open	2509	...v20/YC75Z5	116 MB	2019-12-11 Wed 12:54	raw		count_events:[object Object] elapsed_time:1857 seconds
slitscan, slit2 scanning, slit3 fully open	2508	...v20/YC75Z5	38 MB	2019-12-11 Wed 12:49	raw		count_events:[object Object] elapsed_time:176 seconds
slitscan, slit2 scanning, slit3 fully open	2507	...v20/YC75Z5	2 KB	2019-12-11 Wed 12:48	raw		file_name:[object Object] runNumber:
slitscan, slit2 scanning, slit3 fully open	2506	...v20/YC75Z5	37 MB	2019-12-11	raw		count_events:[object Object]

**PAUL SCHERRER INSTITUT**  
**ess**  
**EUROPEAN SPALLATION SOURCE**

SciCAT is currently deployed on 9 beamlines

# web Interfaces

The screenshot shows a Taranta web dashboard interface. On the left, there is a configuration panel with various parameters:

- 1 - primarydelay: example unit value
- 2 - primarylength: example unit value
- 3 - secondarydelay: example unit value
- 4 - secondarylength: example unit value
- 5 - secondaryintervaldelay: example unit value
- 6 - WavePeriod: value
- N - nsecondarypulses: example unit value
- pointsperstep: value
- alternatetriggers: example unit

On the right, there is a waveform diagram labeled "Panda wave form" showing a primary pulse and several secondary pulses. Below the waveform, there is a configuration panel with the following values:

- 1 - primarydelay: 1.00 s
- 2 - primarylength: 0.00 s
- 3 - secondarydelay: 0.10 s
- 4 - secondarylength: 0.00 s
- 5 - secondaryintervaldelay: 0.0100 s
- 6 - WavePeriod: 2.1110 s
- N - nsecondarypulses: 100 100
- SecondaryPulsesEnable: false
- SecondaryPulsesEnable: true Write
- alternatetriggers: 2
- LaserPulseEnable: true

Courtesy of Roberto Appio

An example of Taranta Dashboard created by the staff and immediately available

**TARANTA, THE NO-CODE WEB DASHBOARD IN PRODUCTION**

M. Eguiraun\*, V. Hardin, Y.L.M. Saad, A. Anjali, J. Rosequist, L. Nguyen, J. Forsberg  
MAX IV Laboratory, Lund, Sweden  
M. Campanelli, Istituto Nazionale di Ottica, Trieste, Italy  
H. Ribeiro, Atalar Innovation, Portugal  
V. Alberti, INFN-OATS, Trieste, Italy  
A. Dubey, Persistent Systems, Pune, India

**Abstract**  
The remote control and monitoring of accelerators and experimental setups has become essential when remote work has become the norm for the last two years. Unlike the desktop user interface, which is limited to the screen size and the need for physical workstations, web applications are naturally accessible remotely via the ubiquitous web browsers. On the other hand, the development of these web applications requires knowledge which has to be disseminated in the control system community. This paper presents the idea of Taranta, a no-code web dashboard for the Tango Control System, in line with the "no-code" paradigm. Taranta Suite is a collection of web applications, jointly developed by the MAX IV Laboratory, the MAX IV Observatory, for the Tango Control System, in line with the "no-code" paradigm. Taranta Suite is a collection of web applications, jointly developed by the MAX IV Laboratory, the MAX IV Observatory, for the Tango Control System, in line with the "no-code" paradigm. Taranta leverages the UI development to the end user.

**INTRODUCTION**  
There is no doubt about the usability and the optimized user experience of web interfaces and applications in everyday life. The last few years have seen an explosion of this kind of development. New tools have gained fame and new wide-spread applications have gained fame and names in the scientific community. However, scientific environments are usually built on traditional and well known infrastructures, lagging behind what is available in the general public. MAX IV, SKA facilities were pushing and promoting the usage of web applications for their users. This was a great success, leading to a joined effort and gave birth to Taranta, a web application for building user interfaces in a Tango ecosystem [1]. The Tango community has been using web technologies since the early 2000s for the creation of UI based on the definition of the domain in the model development driven approach. This new application is profiting from recent years of developments in the field of web technologies and frameworks. It provides an out of the box, modern and stylish environment for accessing the most important functions of the Tango Control System. Its main feature is the Device View [2]. Simple and powerful enough for fast access, it also provides a graphical representation of the device. All the infrastructure is given to the user. This paper will describe the system, its implementation, and the first usage of the different features.

There is a lot of advantage for the user to bypass the traditional software development chain. First of all, as users themselves, they know exactly what software should look like when it is finished. The user does not need to understand the requirements like in any development method, although in a no-code paradigm, the user needs to understand the requirements to make it available immediately to a larger audience of the same end-user group [3]. This way, the lead time to get a new user interface is very short. The software development and UI design have to be done in parallel. The user can share his/her ideas with the developer and then to make it available immediately. An operator can create a graphical user interface on-the-fly and can share it instantly. Authentication and security are also provided. All the infrastructure is given to the user. This paper will describe the system, its implementation, and the first usage of the different features.

**NO-CODE PARADIGM**  
The no-code paradigm is a way to bypass the traditional software development chain. First of all, as users themselves, they know exactly what software should look like when it is finished. The user does not need to understand the requirements like in any development method, although in a no-code paradigm, the user needs to understand the requirements to make it available immediately to a larger audience of the same end-user group [3]. This way, the lead time to get a new user interface is very short. The software development and UI design have to be done in parallel. The user can share his/her ideas with the developer and then to make it available immediately. An operator can create a graphical user interface on-the-fly and can share it instantly. Authentication and security are also provided. All the infrastructure is given to the user. This paper will describe the system, its implementation, and the first usage of the different features.

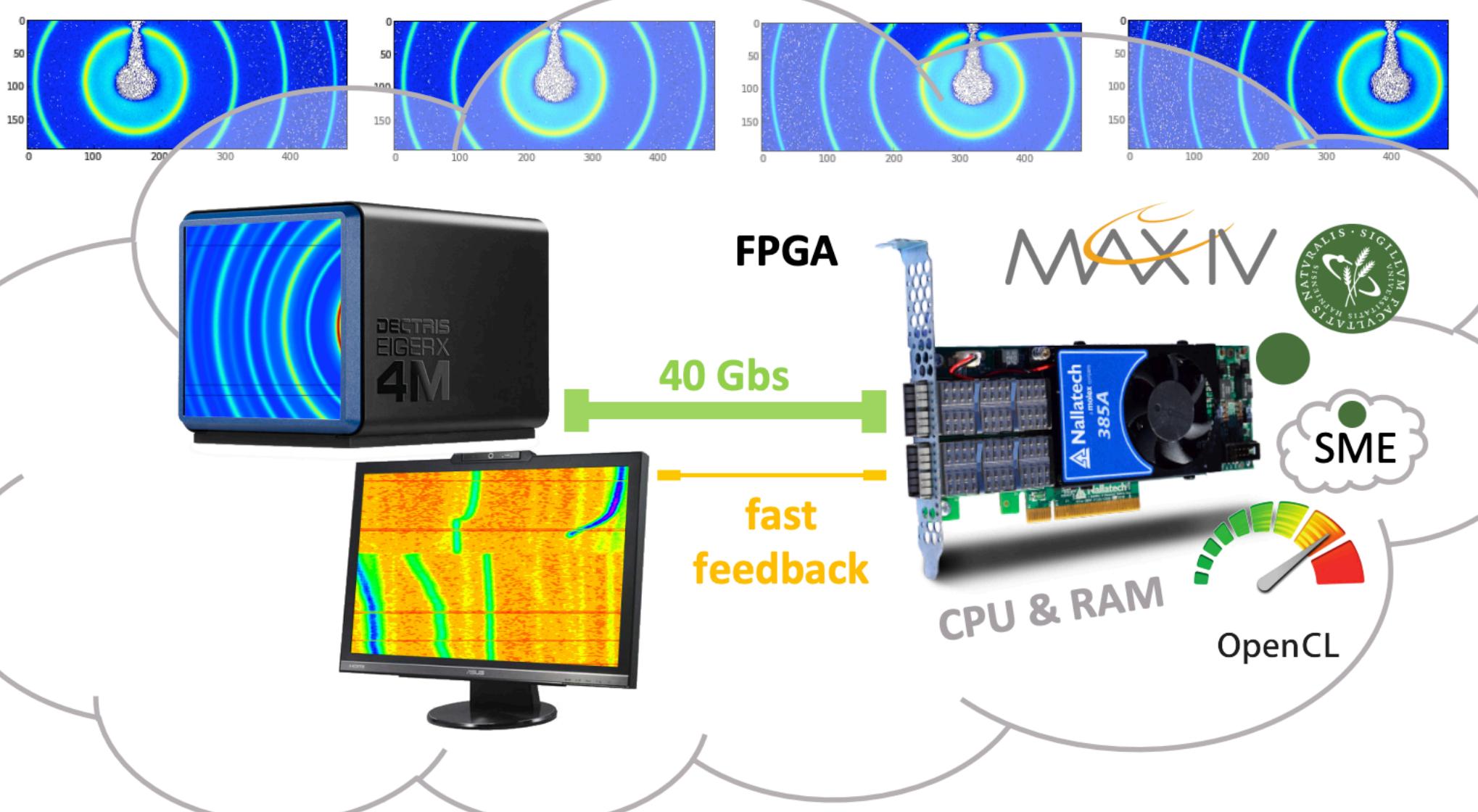
\* mikel.eguirau@maxiv.lu

**FRAR01**  
**M. Eguiraun, et al.**  
**TARANTA, THE NO-CODE**  
**WEB DASHBOARD IN**  
**PRODUCTION.**



# Scientific Software

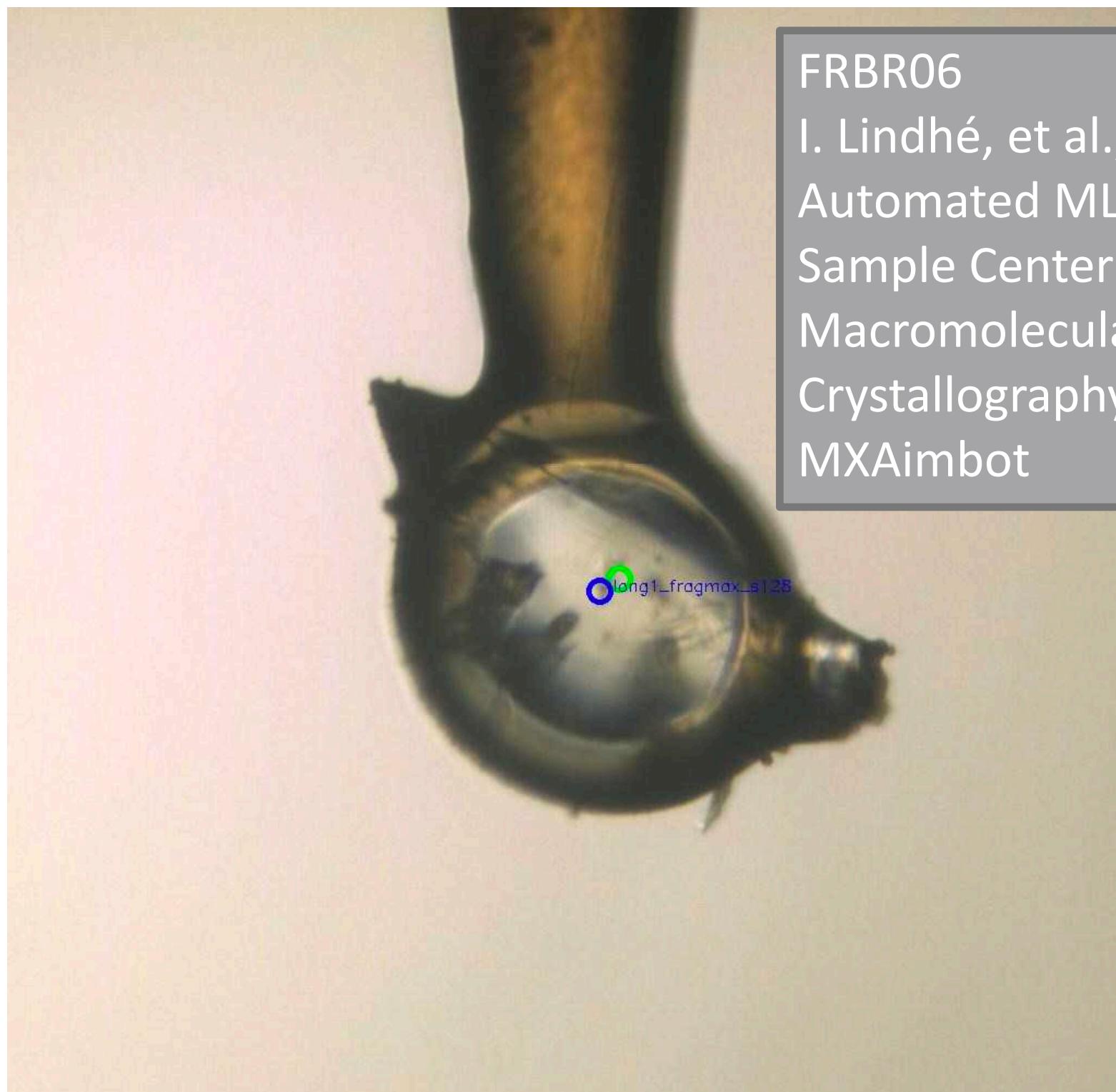
## Real-Time Azimuthal Integration on FPGAs



FRBL04  
Z. Matej, et al.,  
Real-Time Azimuthal  
Integration of X-Ray  
Scattering Data on  
FPGAs

4th generation synchrotron and performance of data acquisition moves the bottleneck to the data processing for a fast data quality assessment. FPGA can be programmed to process on-the-fly.

## Automated Sample Centering based on Machine Learning



FRBR06  
I. Lindh , et al.,  
Automated ML-based  
Sample Centering for  
Macromolecular X-Ray  
Crystallography with  
MXAimbot

One of the last human interaction in MX collection  
will be replaced by AI

# Remote Operation

**MXCuBE 3**

Sample Overview Data collection Sample Changer System log

Help RA Sign out

**User Info**

Name	Host	Type	Role	Control
caricarl (you)	b-v-biomaX-cc-1.maxiv.lu.se	remote	Observer	No control
anagon	b-biomaX-controlroom-cc-8.maxiv.lu.se	local	Master	

**RA Options**

- Enable remote access
- Timeout gives control

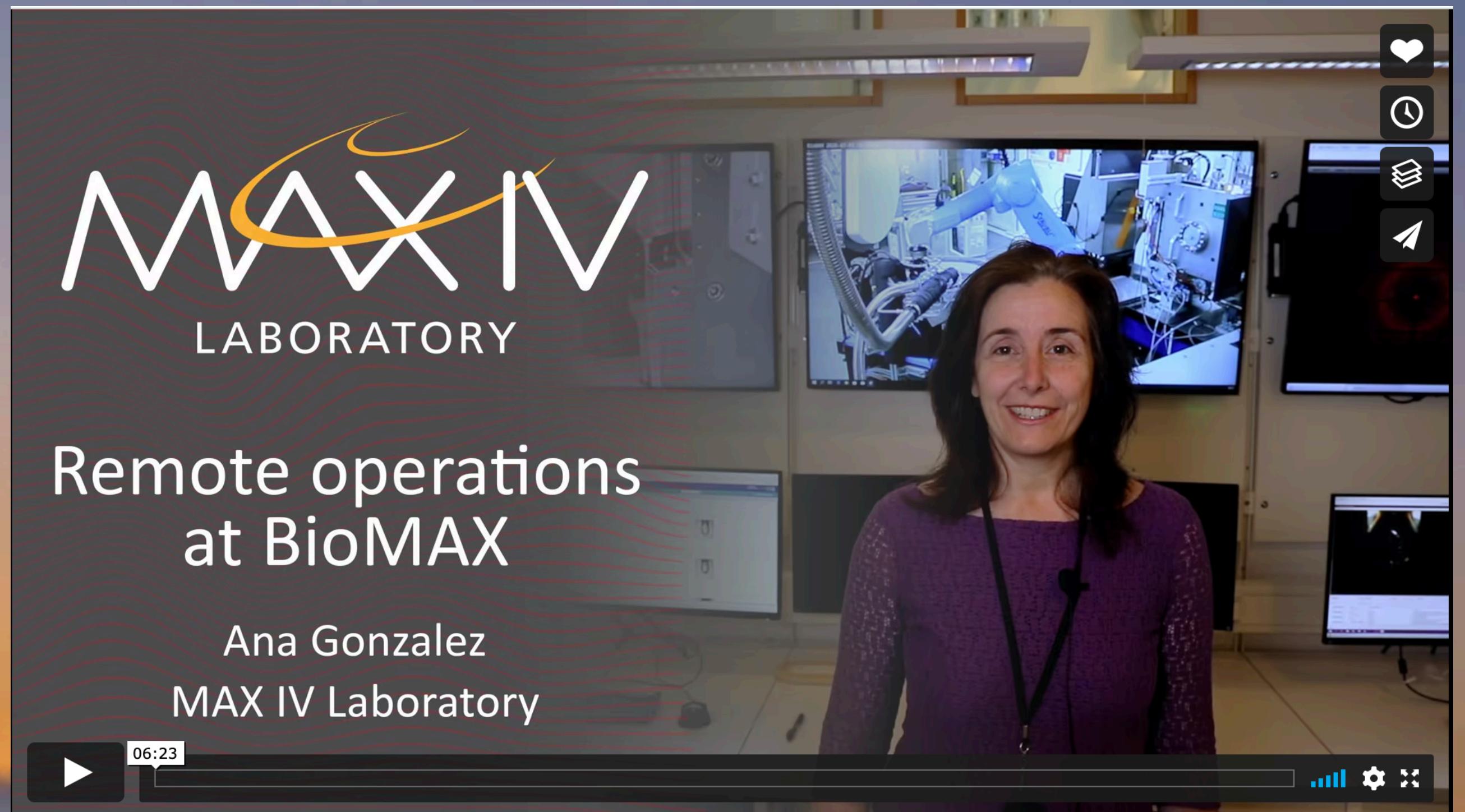
The host refers to the log in point:  
 - b-v-biomaX-cc-1 is the remote server (remote user)  
 - b-biomaX-controlroom\* is one of the machines on the beamline (local user).

Control options:  
 - The Master user can give control to any other user in the list.  
 - Staff can force log out any user.

Observers can click on 'Ask for control' to request the Master role.  
 Staff can use 'Take control' to take the master role in an emergency. This button is disabled for users.

Ask for control Take control

Remote Access view in MxCube3



Proposal

Beamtime with automatic VPN ACCESS

(SDM system doi:10.18429/JACoW-ICALEPCS2017-TUBPA04)

Offline cluster access

# Future plan

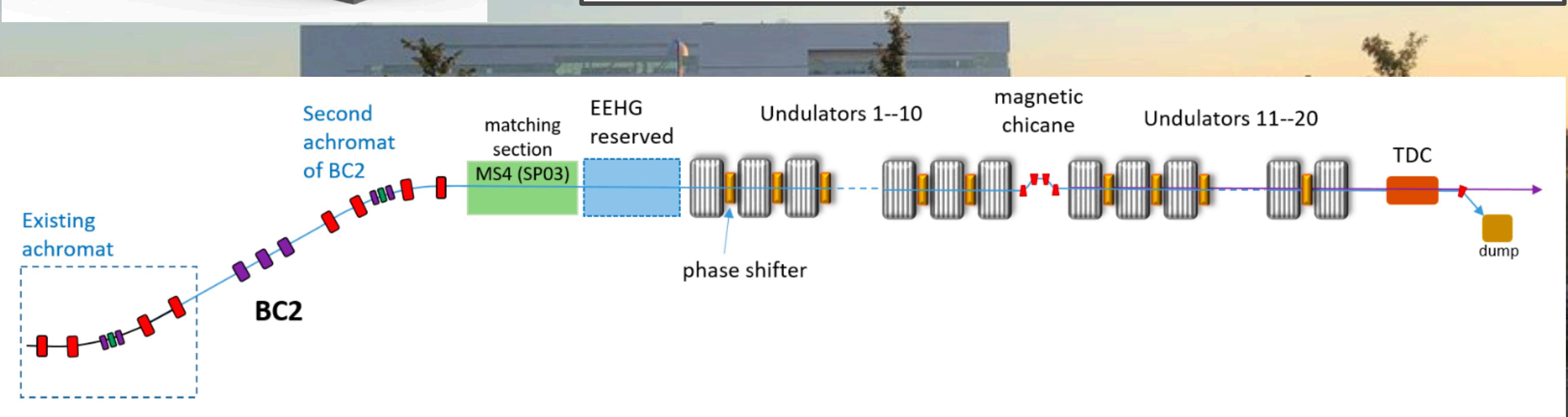
- MAX IV
- STATUS
  - Project Management
  - Operation
- KITS Improvement
- Future



# Soft X-Ray Free Electron Laser



A prototype of the APPLE X undulator is planned to be constructed in order to verify the feasibility of the design, the assembly process, and to find the most effective and efficient way of applying magnetic measurements and the subsequent tuning of the device. Funding for the prototype work has been secured through MAX IV and the LEAPS (League of European Accelerator-based Photon Sources) pilot program LEAPS-INNOV.



# Conclusion

FUTURE IS BRIGHT

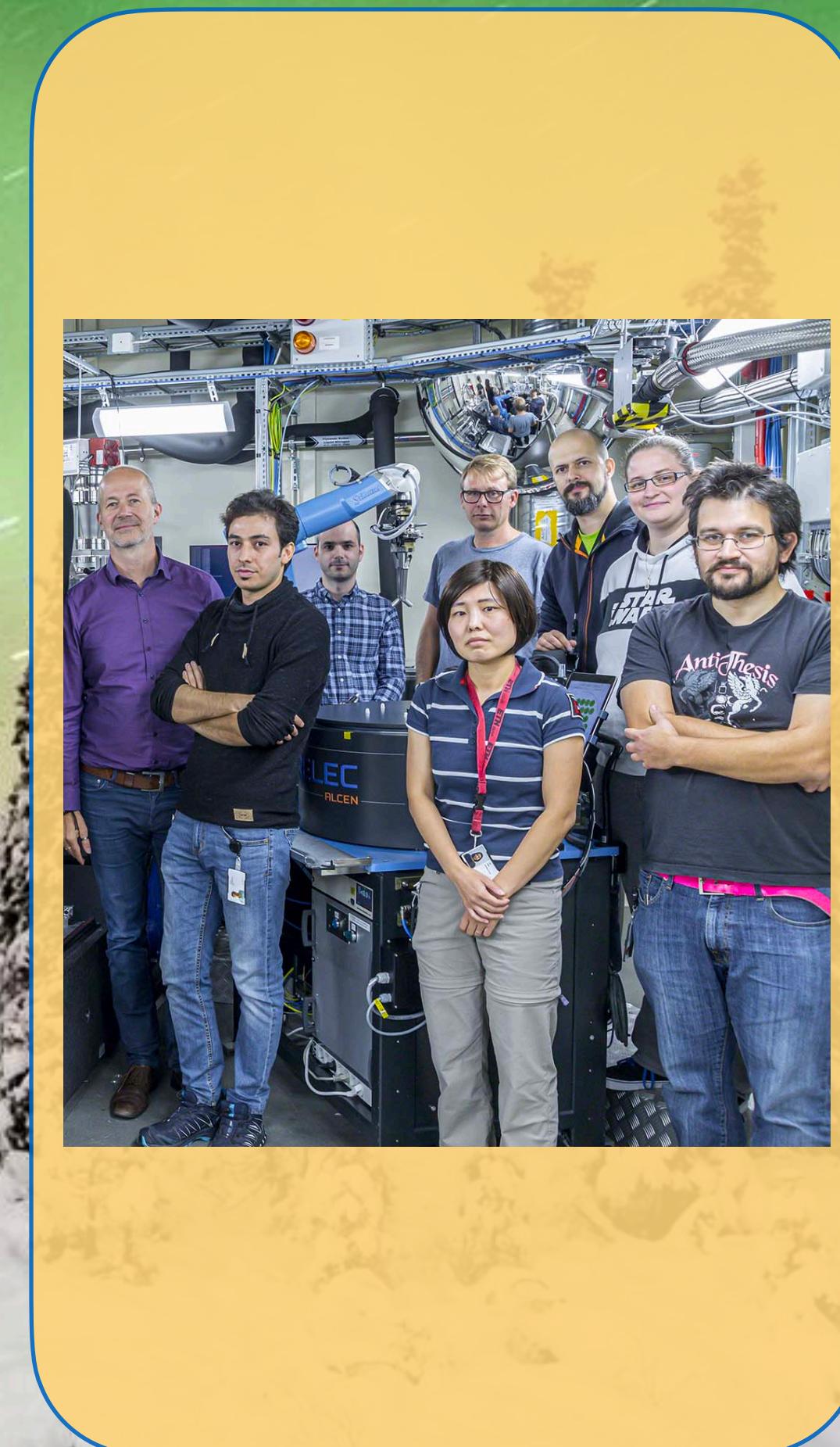
# Diversity



Public Domain, wikipedia.org



Hands Teamwork, truthseeker08,  
pixabay.com



Biomax team, [MAXIV.lu.se](http://MAXIV.lu.se)

# Acknowledgment

- The Controls and IT (KITS) group,
- The Beamline Office and the Accelerator Deputy at the MAX IV Laboratory, along with the physicists, engineers and beamline staff
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- XFEL (DOC), SKAO, PSI, ESS, TANGO COMMUNITY