BEATS

Work Package 1

Management of the BEATS project

Notes of the 4th Annual Meeting

D1.12

June 2023

Funded by the EU's H2020 framework programme under

PROJECT DETAILS

PROJECT ACRONYM
BEATS

PROJECT TITLE
BEAmline for Tomography at SESAME

GRANT AGREEMENT NO:
822535

THEME

START DATE
01/01/2019

DELIVERABLE DETAILS

WORK PACKAGE 01

EXPECTED DATE: JUNE 2023

WORK PACKAGE TITLE: BEATS MANAGEMENT

DELIVERABLE TITLE REPORT ON THE BEATS 4TH ANNUAL MEETING

WORK PACKAGE LEADER: ESRF

DELIVERABLE DESCRIPTION: REPORT

DELIVERAVLE ID: D1.12

PERSON RESPONSIBLE FOR THE DELIVERABLE: A. KAPROLAT

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- ☒ R - Report
- ☐ P - Prototype
- ☐ D - Demonstrator
- ☐ O - Other

DISSEMINATION LEVEL

- ☒ P - Public

REPORT DETAILS

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STATUS

- ☐ Template
- ☐ Draft
- ☒ Final
- ☒ Released to the EC

CONTENTS

AGENDA

BEATS 4th and final Annual Meeting

To be held in hybrid mode (on location at SESAME, remote access possible) on 05/06/2023 from 14:00 – 16:00 CEST (15:00 – 17:00 Jordan time)

Welcome and introduction

14:00 – 14:05 Mirjam van DAALEN, chair BEATS Steering Committee

Project status, reports from the BEATS work packages (*chair: Mirjam van DAALEN*)

14:05 – 14:20 Status of WP2 „Sustainability and user community Building“

Jana Wolfram (DESY)

14:20 – 14:30 Status of WP3 „The x-ray source“

Andrea Ghigo (INFN)

14:30 – 15:05 Status of WP6 „Installation and commissioning of the BEATS beamline“

Gianluca Iori, Mostafa Zoubi (SESAME)

15:05 – 15:20 Status of WP7 „Data analysis and management“

Charalambos Chrysostomou (CyI)

15:20 – 15:30 WP1 „Management“ and overall project status

Axel Kaprolat (ESRF)

15:30 – 16:00 Closing remarks, wrap-up

NOTES OF THE MEETING

Jana Wolfram during her presentation on the results of work package 2

On 05th June, 2023, the BEATS project team met for the 4th Annual Meeting, hosted by SESAME in Allan, Jordan. Remote participation was offered via webex for those who could not travel. 35 participants from the BEATS member institutes joined the half-day event, which featured presentations from all BEATS work packages. The meeting marks BEATS' transition from the installation/commissioning phase into the operation phase.

Mirjam van Daalen, chairwoman of the BEATS Steering Committee, welcomed the participants and opened the meeting. In her opening address, she mentioned details concerning the inauguration ceremony for BEATS to be held the following day together with a BEATS workshop offering lectures on SR tomography and hands-on experience on the beamline for future users.

Project status, reports from the BEATS work packages

Jana Wolfram, representing Frank Lehner, leader of work package 2, first reminded the audience of the core efforts of WP2:

Science case and user community building as the central effort of WP2 resulting in the submission and endorsement by the SESAME Science Advisory Council of the BEATS science case document followed by a continuous organisation of various workshops and info days, this including the upcoming BEATS school and workshop, offering potential users real hands-on training and experience on the operating BEATS beamline.

Regarding **staff training**, Jana Wolfram gave an overview on the successful visits of staff member from BEATS beneficiaries to other facilities within the BEATS consortium, a remarkable achievement in particular in view of the framework conditions the project experienced (pandemic).

To help the BEATS beamline arriving at **sustainable operation conditions** even after the end of the BEATS project, the following action fields were successfully addressed by WP2: Identify and foster SESAME as a hub in the region for cultural heritage research, initiate continuous discussions with LEAPS stakeholders to advance the integration of SESAME into LEAPS via special twinning models, opening SESAME towards Africa for instance by fostering contacts with the African Light Source, and finally strengthening the German role as an observer at SESAME.

Andrea Ghigo, leader of work package 3, reminded the audience about the activities that lead to the successful installation of a well suited and functioning x-ray source for BEATS into the SESAME storage ring.

He explained the reasons for opting for a 3-pole wiggler (or wavelength shifter), the magnetic and mechanical design and the mechanical tests the device was subjected to.

After production, magnetic measurements were carried out at the supplier's site which yielded no adverse observations, therefore the device was installed at SESAME.

During the commissioning with electron beam only very small perturbing effects on the machine optics were observed which could easily be compensated by trim coils.

Since the observation of the first white beam at the entrance of the optics hutch following thorough alignment of both the device and the ID vacuum chamber in November 2022, the BEATS x-ray source is fully integrated into the SESAME storage ring and ready to supply photons to the beamline.

During the last months of the project, the main activity of the BEATS partners was, apart from the user community building, mainly devoted to the commissioning of the BEATS beamline, distributed over WP6, WP4, and WP5.

Gianluca Iori, BEATS beamline scientist and leader of work package 6, presented an overview of the final installation efforts and the commissioning undertaken since the last Annual Meeting (December 2022).

He reported on the finalisation of the procurement of the second BEATS sample station and explained its technical details before moving on to the commissioning activities, focusing on

- motion, vacuum and site acceptance tests of the double multilayer monochromator,
- tests of the beamline's graphical user interfaces,
- step-by-step beam propagation through all beamline components (from front end to experimental station),
- the ozone surveillance and extraction system, and the
- day 1 scanning modes (continuous and step scan with white / pink beam).

Gianluca Iori then presented the first 3d tomographic reconstruction obtained at BEATS on 11/05/2023, showing that the day 1 operation conditions as laid out in the technical design report have been achieved.

With the multilayer crystals arriving at SESAME end of July 2023, BEATS will then see, as planned, its first upgrade towards operation with monochromatic beam later in 2023 (post project)

In the first presentation from WP7, **Mustafa Ali Alzubi** (SESAME) focused on the data acquisition pipeline of BEATS in general and the TomoScan software suite used at the beamline: its main graphical user interface, its dashboard as well as critical issues that had to be addressed during the installation.

He then reported on particularities of the BEATS detectors (the PCO and the FLIR Org X camera) which presented a challenge during their integration into the beamline software pipeline.

Efforts will continue in extensive performance tests of the whole software and hardware structure of BEATS during the ongoing commissioning phase of the beamline as well as the implementation of fast data transfer between the GP file system and the data dispenser workstations.

Charalambos Chrysostomou, leader of work package 7, then reminded the meeting of the overall structure of the work package: the contributing beneficiaries, its tasks, and the deliverables.

The work package's activities during the last reporting period concentrated on updates of the computing infrastructure (task 7.3) and on the implementation of tomography applications (task 7.4).

Charalambos Chrysostomou reported in detail on the successful establishment of the BEATS pipeline and in particular the tomopy reconstruction software, tests with CPU and GPU nodes, and on the procurement of additional RAM needed for extended-field-of-view scans.

Regarding task 7.5 (Data analysis as a service), he presented the successful establishment of hardware / software / network connection between the BEATS partners SESAME and The Cyprus Institute allowing for the data analysis from workstations in both institutes.

Axel Kaprolat, project coordinator, gave an update on the activities within work package 1 (Management of the BEATS project) and on the overall situation of the project.

With reference to the presentations of the technical work packages, in particular the recently obtained first tomographic 3d reconstructions and the hands-on workshop on the beamline he judged the project to be on the final lap. He expressed his satisfaction with the fact that all beamline components were installed and functioning as foreseen for the day 1 operation.

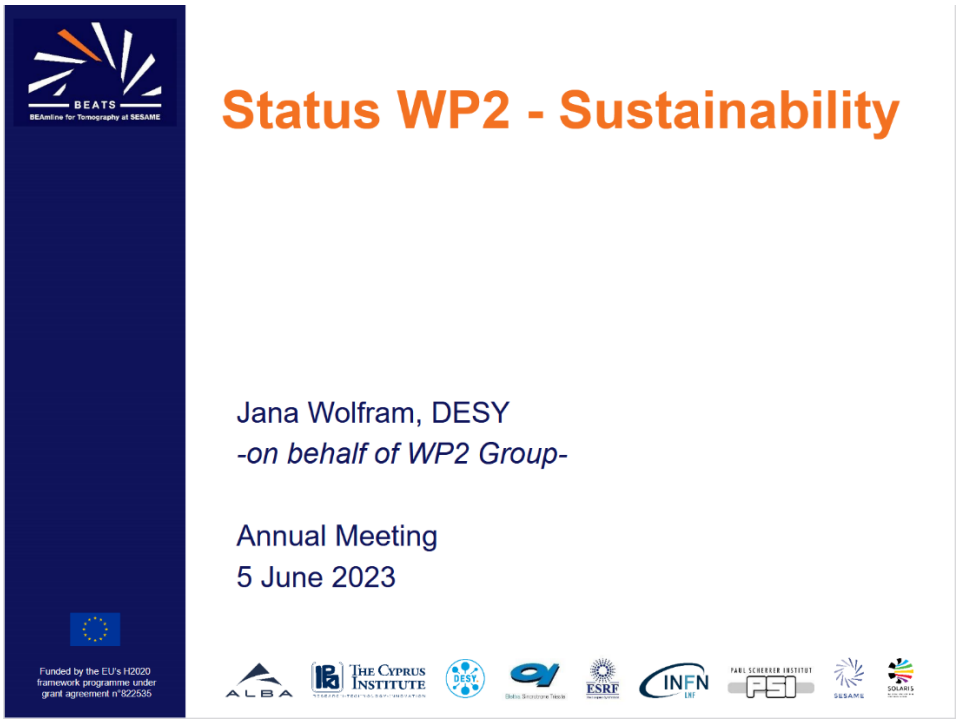
Axel Kaprolat then reminded the meeting of the outstanding deliverables to be established before the end of the project (30/06/2023) and explained the next steps to prepare for the establishment of the 3rd periodic report and the associated technical review.

Closing remarks, wrap-up

Before officially closing the meeting, Mirjam van Daalen expressed her satisfaction with the good progress the project has made so far, thanked all speakers for their high quality presentations and all participants for attending the meeting and contributing to the discussion.

ANNEX: PRESENTATIONS

Presentation WP2, Jana Wolfram



Task Overview

Task 1: Scientific case and user community building
- Task Leader: Kirsi Lorentz, CyI
- Involved institutions: CyI, ALBA, DESY, ESRF, PSI, SESAME, SOLARIS

Task 2: Procurement strategy
- Task Leader: Josep Nicolas, ALBA
- Involved institutions: ALBA, SESAME, ESRF, DESY, PSI, SOLARIS

Task 3: Staff Training
- Task Leader: Gianluca Lori, SESAME
- Involved institutions: SESAME, PSI, SOLARIS

Task 4: Sustainability / Stewardship Model
- Task Leader: Frank Lehner/Jana Wolfram, DESY
- Involved institutions: DESY, ESRF, SESAME

In 2021, tasks were re-aligned and sharpened to exploit more synergies.
Create central WP2 meeting platform, biweekly exchanges

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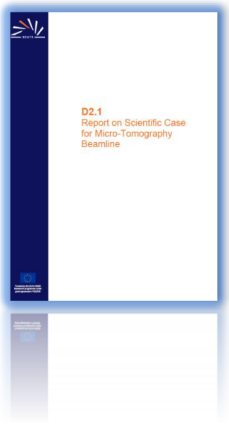
Task 1: BEATS Science Case and User Community Building (ongoing)

- This is the central effort in WP2
- core deliverable (cf. D2.1) was BEATS science case document in summer 2020, approved then by SESAME SAC
- captures the key science drivers after a formidable effort of the involved project team members and the science communities
- user community to be further strengthened through existing networks and via dedicated events, workshops and tutorials among the SESAME Members



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Events / Activities WP2

A few highlight events / activities over the past years:

- **SESAME-Palestine Workshop**, 16th November 2021; organized as a collaboration involving BEATS, HESEB, SESAME, and the Palestinian-German Science Bridge PGSB
- Online training sessions within the **IAEA-ICTP School** on Synchrotron Light Sources and their Applications 6-17 Dec 2021
- **SESAME Cultural Heritage Day** – 16 February 2022 (with SESAME, BEATS, HESEB)
- **SESAME-Africa Online Workshop** – 6 July 2022
- **SESAME-Germany Info Day** – 21 April 2023
- **BEATS workshop** at SESAME in conjunction with inauguration event – 6 June 2023
- plus many other events/conference for networking/visibility:
  - SESAME / Africa Round Table at AfLS, AfPS Forum – Dec 2021
  - SESAME at ICRI 2022 in Brno, CZ – October 2022
  - SESAME at Transatlantic Big Science Conference in Washington DC – November 2022
  - SESAME at World Science Forum, South Africa, December 2022
  - SESAME at SRI Congress, Africa Satellite Event, Port Elizabeth, June 2023

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SESAME-Germany Info Day
21 April 2023 (hybrid)

- increase in Germany the awareness and visibility of SESAME as a modern lightsource with its specific experimental capabilities.
- help to build up more user collaboration and joint proposals between German scientists and researchers from the SESAME region to exploit opportunities at the existing and upcoming new beamlines at SESAME.
- overview talks about SESAME, BEATS and HESEB
- presentation of selected research projects as well as plans for cooperation
- panel discussion on improvement of co-operation between Germany and SESAME region with researchers and German ministry

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Task 2: Procurement Advisory (accomplished)

- **Procurement Advisory Board** (PAB); provide guidance on procurement strategy and processes, define procurement standards and best practice exchange; Chair: Josep Nicolas (ALBA Cells)
- **Deliver a list of companies** with appropriate expertise in **SR instrumentation**, including end station components for micro-tomography (D2.2)

- Front End Units for the BEATS Beamline (deadline 20 December 2020)
- Lead Safety Hutches & Transfer Pipe Shielding for the BEATS Beamline (deadline 04 January 2021)
- Double Multilayer Monochromator System for the BEATS Beamline (deadline 17 February)
- centralized parallel file system storage, CPU-GPU cluster, InfiniBand switches and backend server for BEATS Beamline (deadline 31 May 2021, awarded in July-August 21
- White-Beam X-Ray Microscope System for the BEATS Beamline to SESAME (deadline 31st October 2021)
- …

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Task 3: Staff Training

Objective:

- training of SESAME staff in all aspects related to the new beamline
- enhancing the expertise of SESAME staff in commissioning and operating a modern light source facility

SYRMEP - Elettra, Trieste, Italy
- Gianluca Iori (BEATS Beamline Scientist): July/Aug 2020

ESRF, Grenoble, France
- Gianluca Iori (BEATS BL scientist): Aug/Sept 2020
- Abid Ur Rehman (Vacuum Engineer SESAME): Aug 2022

TOMCAT SLS - PSI, Villingen, Switzerland
- Gianluca Iori (BEATS BL scientist): Sept-Dec 2020
- Amro Aljadaa, Rami Khrais (Control Engineers SESAME): June/July 2022

ALBA, Barcelona, Spain
- Iyad Zahran (Radiation Safety Physicist SESAME): July/Aug 2022

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Task 4: Sustainability

Explore and study aspects of long-term sustainability in terms of funding and support/stewardship opportunities for SESAME with respect to EU and international cooperation

Action field 1: Cultural heritage as a main thematic driver

- SESAME as a hub in the region for cultural heritage science
- Bring representatives from governmental bodies for antiquities / cultural heritage sites to SESAME

Action field 2: Intensify links to LEAPS

- Continuous discussions going on with various LEAPS stakeholders to advance the integration of SESAME into LEAPS and to develop a special twinning model which could have reciprocal access and secondment schemes
- Welcome address from Jean Daillant on behalf of LEAPS members will be read at the inauguration

LEAPS League of European Accelerator-based Photon Sources

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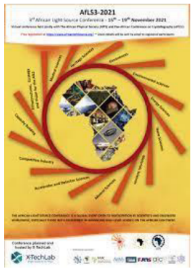
Task 4: Sustainability

Action field 3: Opening towards Africa



- Extreme fruitful contacts & discussions with AfLS
- Tap into potential of SESAME as a training / research hub for African research communities
- EU-Africa framework, exploit EU-Africa links and synergies, potential COST actions, foundations
- Connection SESAME-AIMS (African Institute for Mathematical Sciences)

Action field 4: Strengthening Observer Role

- Observer Role was successfully strengthened, together with HESEB project
- If other countries could also achieve this, it would strengthen the network

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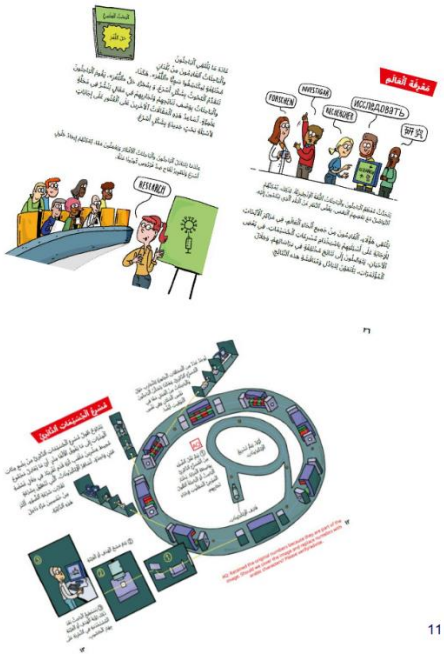
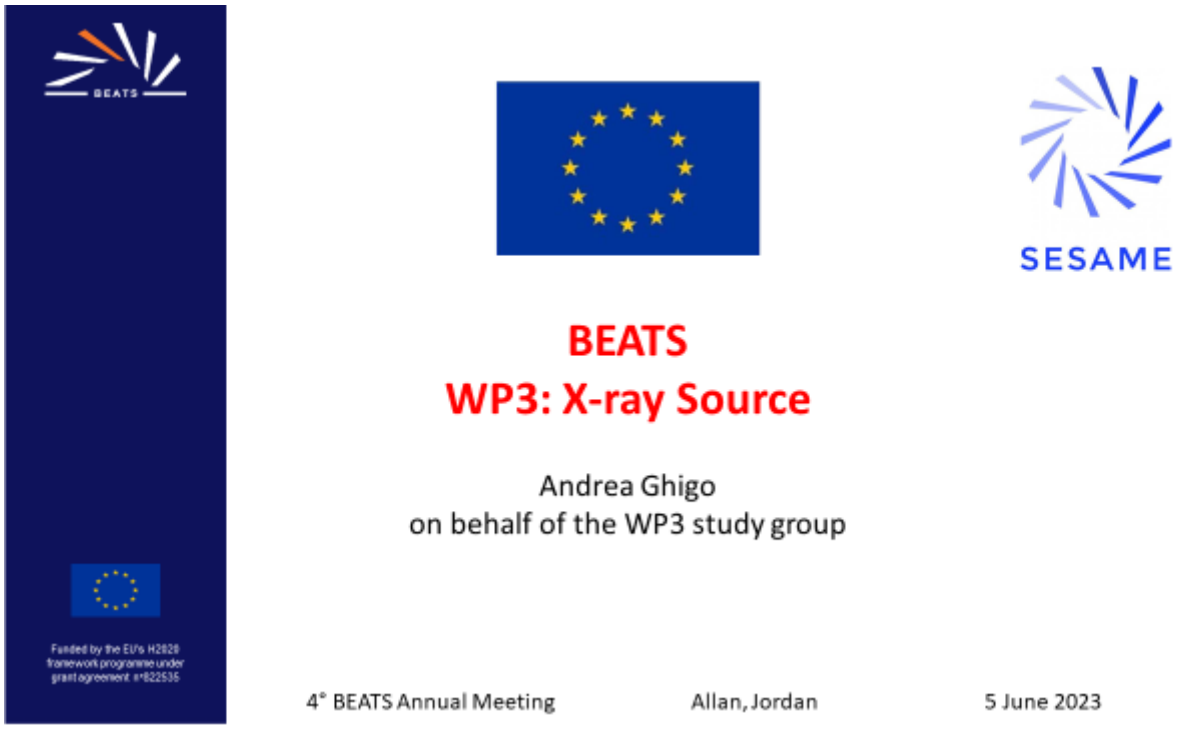
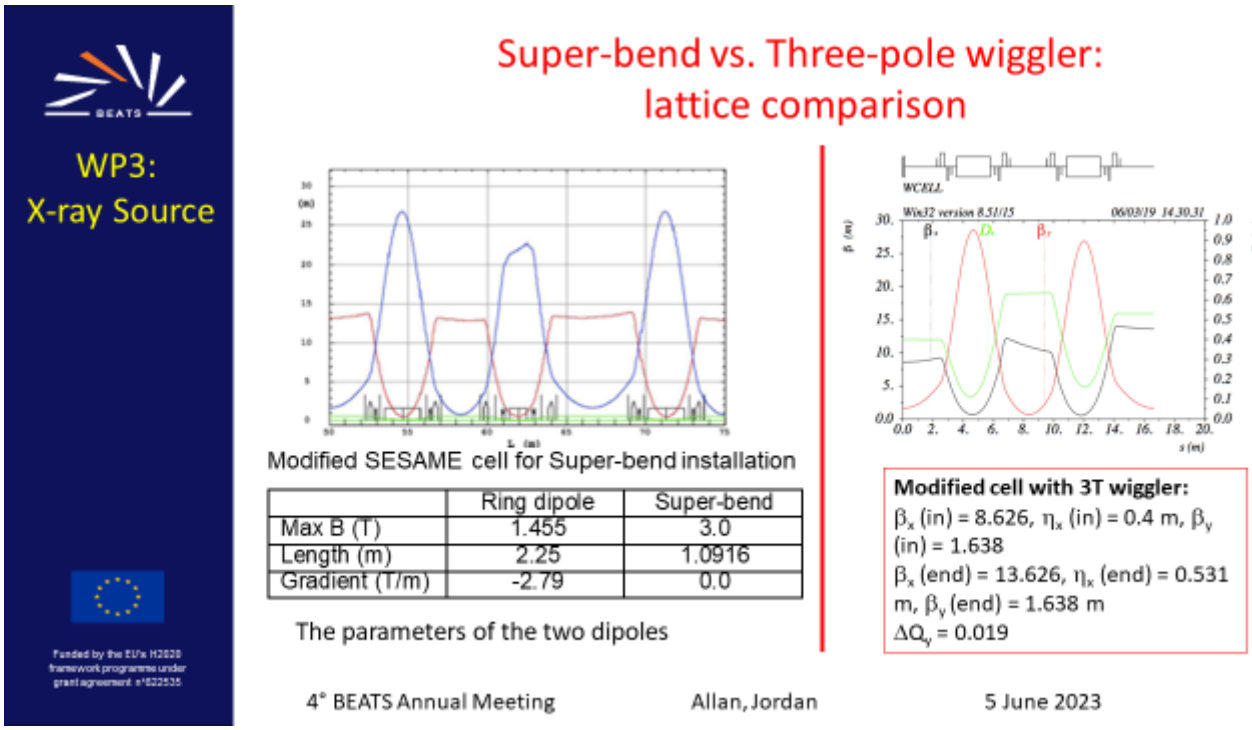
Last but not least…



Presentation WP3, Andrea Ghigo





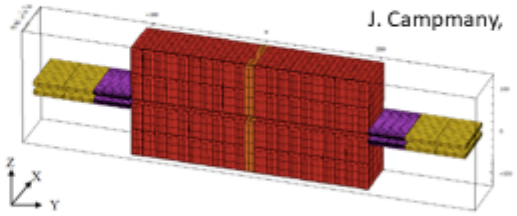
WP3:
X-ray Source

Funded by the EU's H2020 framework programme under grant agreement n°822535

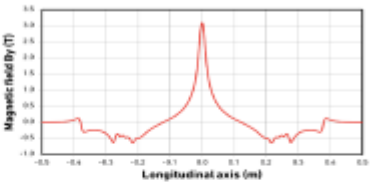
Three-pole wiggler electromagnetic design

A model of a three-pole wiggler out-vacuum, with 3 T peak field, and 11 mm gap, including kick-maps and emission spectrum through 1mrad aperture, is described in a report with technical specifications on magnets and poles.

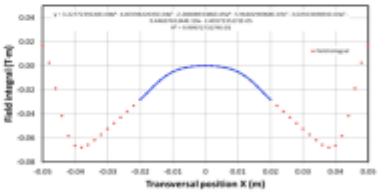
J. Campmany,



Magnetic model generated by RADIA. Red, yellow and orange parts are NdFeB magnets, and pink parts are iron poles. Overall length is 0.755 m.



Magnetic field on axis



Field integral along the horizontal axis

WP3:
X-ray Source

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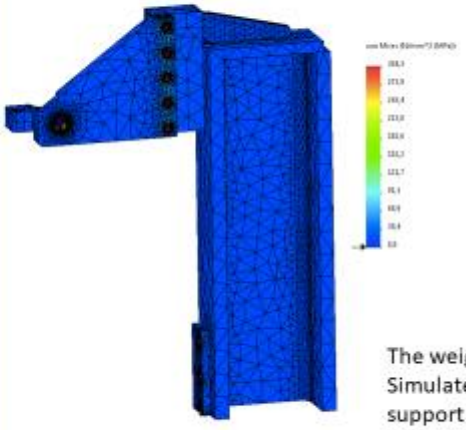
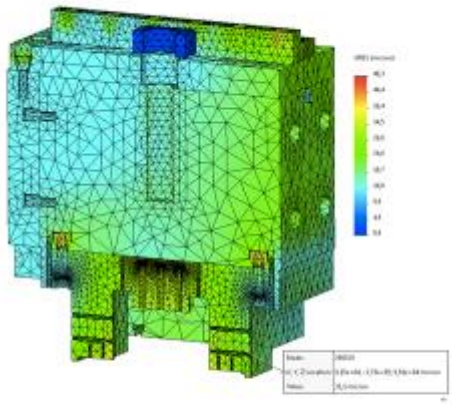
Mechanical design (KYMA)





The weight of 1881 kg was increased by 30% for simulation. Simulated weight was 2445 kg (24450 N) acting on the central support 155.2 mm away from support surface in the transversal direction (in the mass center).

WP3:
X-ray Source

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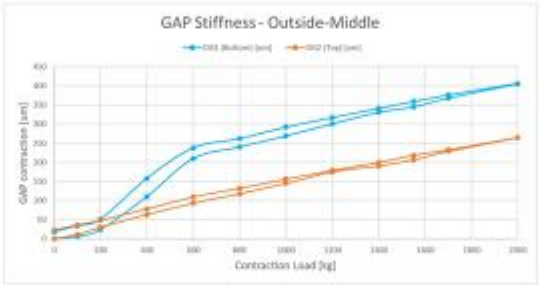
Mechanical test: load test measurements

Deformation with passive control system : outside -middle position



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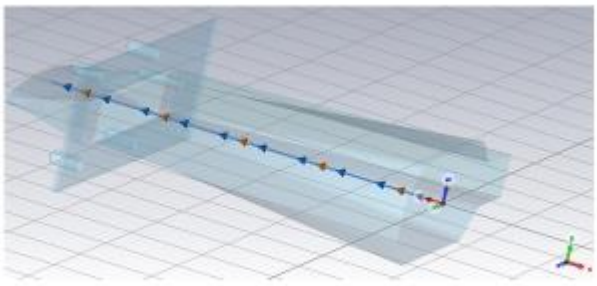
WP3:
X-ray Source

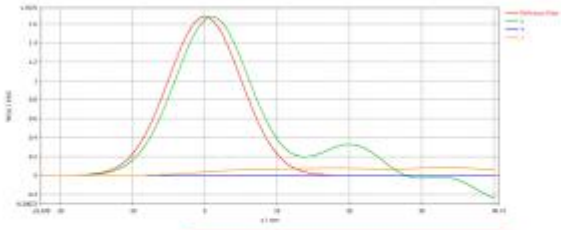
Funded by the EU's H2020 framework programme under grant agreement n°822535

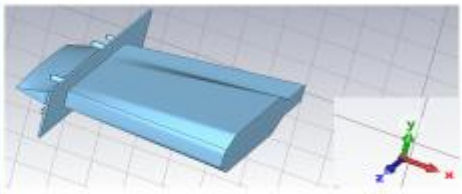
WP3: X-ray Source
Vacuum chamber

Beam Parameter	Value
Charge	888 pC
Length, sigma z	5 mm (16.6 ps)
Energy and beta	800 MeV, 0.9999



On-axis Wake Potentials





Wake-loss Factor = -1.18 V/pC

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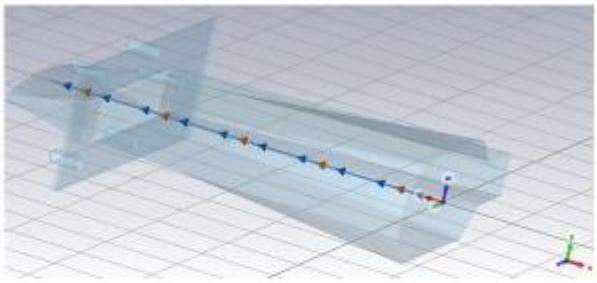
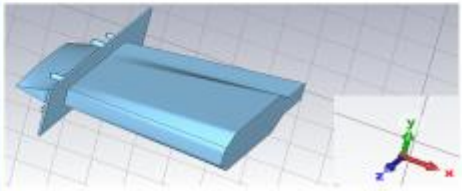
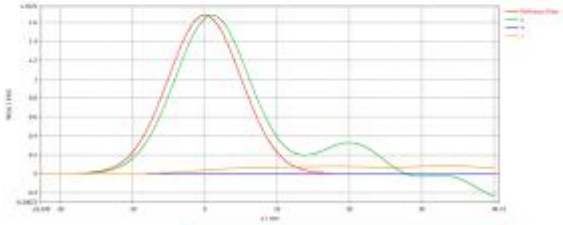
WP3: X-ray Source
Vacuum chamber

Beam Parameter	Value
Charge	888 pC
Length, sigma z	5 mm (16.6 ps)
Energy and beta	800 MeV, 0.9999



On-axis Wake Potentials





Wake-loss Factor = -1.18 V/pC

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WP3:
X-ray Source

Magnetic Measurements

The mechanical and magnetic measurements of the three-pole wiggler were carried out by the manufacturer KYMA during the pandemic period.

The steering committee decided not to transfer the magnet to ALBA for magnetic checks, as planned, but to involve experts from ALBA and INFN in the measurements in the company.

In this way it was possible to complete the test of the magnet within the time established for the installation

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WP3:
X-ray Source

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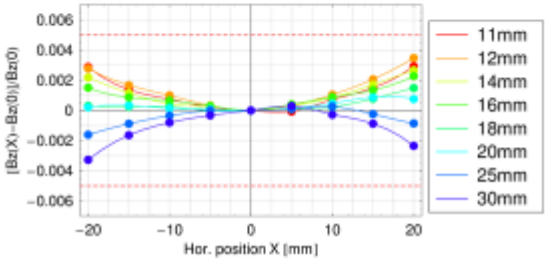
Magnetic measurements

1. **2D Field scans with Hall probe:** The goal of these measurements was to define the peak field dependence vs gap and the magnetic field roll-off. In particular, they shall allow verifying that a central field larger than 2.9T is obtained at minimum gap (11mm).
2. **Vertical dependence of the magnetic field at the central pole** to verify the location of the device's midplane.
3. **Field integral Measurements** with flipping coil system to validate the on-axis field integrals (first and second) and the integrated multipoles.
4. **Characterization of correction coils:** to determine a table of correction coil current settings (look-up table) at different gaps.

Roll-off of the magnetic field at the central pole for different gap openings.



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Allan, Jordan, 5 June 2023

WP3:
X-ray Source

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Three-pole Wiggler installation

In AUGUST-SEPTEMBER 2022 shutdown
Three pole wiggler and front-end have been installed

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WP3:
X-ray Source

Funded by the EU's H2020 framework programme under grant agreement n°822535

Commissioning of the BEATS Three-Pole Wiggler

S. Kasaei, M. Attal (October 2022)

- Due to the residual magnetic field errors, first and second field integrals of the 3PW are not zero.
- These errors cause an angular perturbation and displacement error in the closed orbit respectively.
- 3PW is provided with four correction trim coils designed to compensate for the two field integrals thus to eliminate the residual distortions generated in the orbit.

Effect of the 3PW on chromaticity

The initial horizontal and vertical chromaticities in the storage ring are 7.939 and 7.318 respectively.
When the 3PW has been closed to the minimum gap, they changed to 8.077 and 7.594 respectively, i.e. by less than 4% which is small.

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WP3:
X-ray Source

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Electron beam orbit correction

Using the feed forward table, the closed orbit at minimum gap has been corrected to within

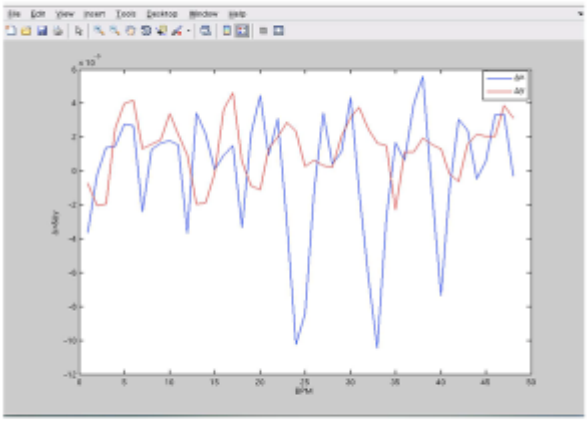
10µm horizontally

and

4µm vertically

with respect to the orbit at fully opened gap.

Part of the horizontal drift in corrected orbit is thought to be due to thermal effect.



The residual error in horizontal (blue) and vertical (red) closed orbit after correction using the feed forward table.

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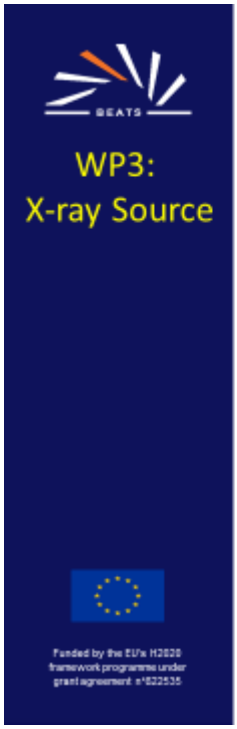


Conclusion

The 3PW showed so low effect on SESAME storage ring optics that didn't need to be corrected.

The major effect was on the closed orbit which has been compensated using the 3PW trim coils.

The SESAME Council greatly appreciated the results of the BEATS project

4° BEATS Annual Meeting Allan, Jordan 5 June 2023

Presentation WP4,5,6 Gianluca Iori

BEATS annual meeting #4

05.06.2023

WP4: Beamline Technical Design and Instrumentation Procurement
WP5: Procurement and construction of beamline infrastructure
WP6: Beamline Assembly and Commissioning

Gianluca Iori
BEATS beamline scientist

BEATS_eu
@BEATSeu1

WP4: Beamline Technical Design and Instrumentation Procurement

Task 4 Procurement of beamline instrumentation
Task 5 Assembly of individual beamline components

WP5: Procurement and construction of beamline infrastructure

Task 4 Construction of the technical infrastructure

WP6: Beamline Assembly and Commissioning

Task 1 Installation and commissioning of the optical components
Task 2 Installation and commissioning of Experimental Hutch components

BEATS

BEAmline for Tomography at SESAME

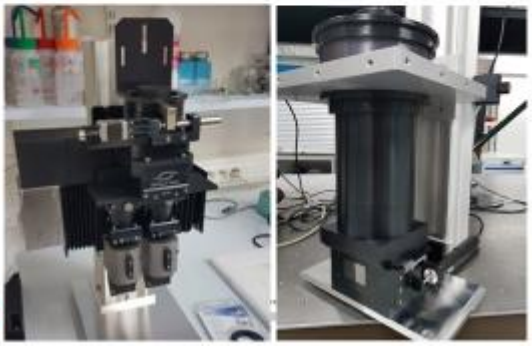
Funded by the EU's H2020 framework programme under grant agreement n°822535

WP4: Procurement situation at last GA

GA meeting December 2022

	CFT out	contract signed	kickoff	FDR	fabrication	installation	commissioning
X-ray source							
Front End							
Monochromator							
Hutches							
Computing							
Detector #1							
Detector #2							
Endstation #2							

- Detector #1
  - In operation
- Detector #2
  - Under commissioning
- Sample endstation #1 (PSI TOMCAT)
  - In operation
- Sample endstation #2
  - Final design

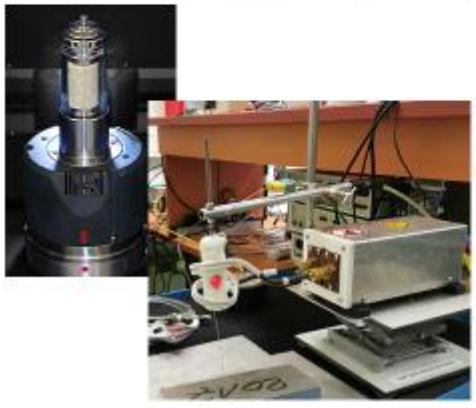


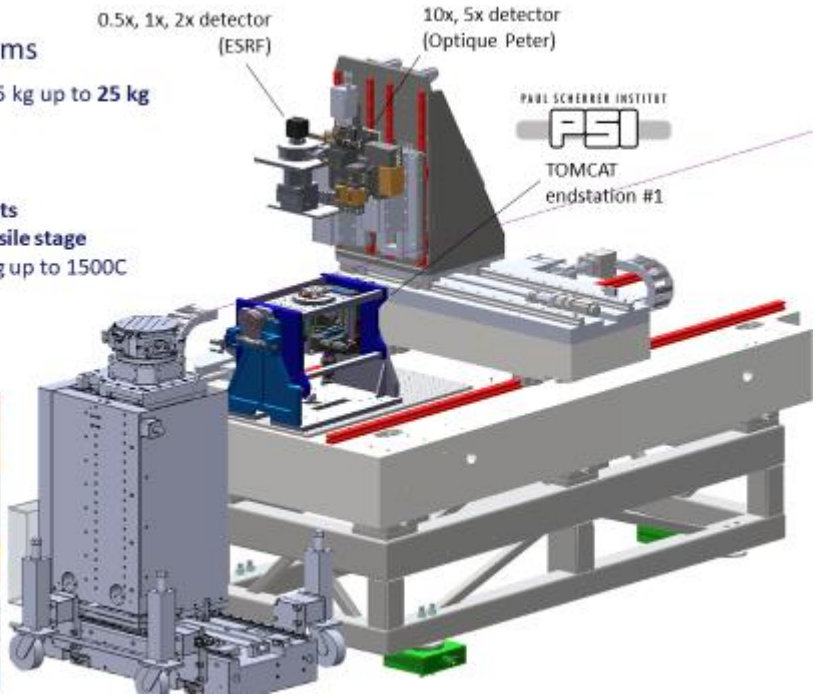
BEATS experimental station

Endstation #2 – LAB Motion Systems

- Air-bearing stage for large samples: from 5 kg up to **25 kg**
- Include slip ring and ROT control systems
- Final Design Review

- Electrical slip ring for **sample environments**
  - 1000N mechanical **compression/tensile stage**
  - **Induction furnace** for sample heating up to 1500C





Double Multilayer Monochromator

Installation @ SESAME

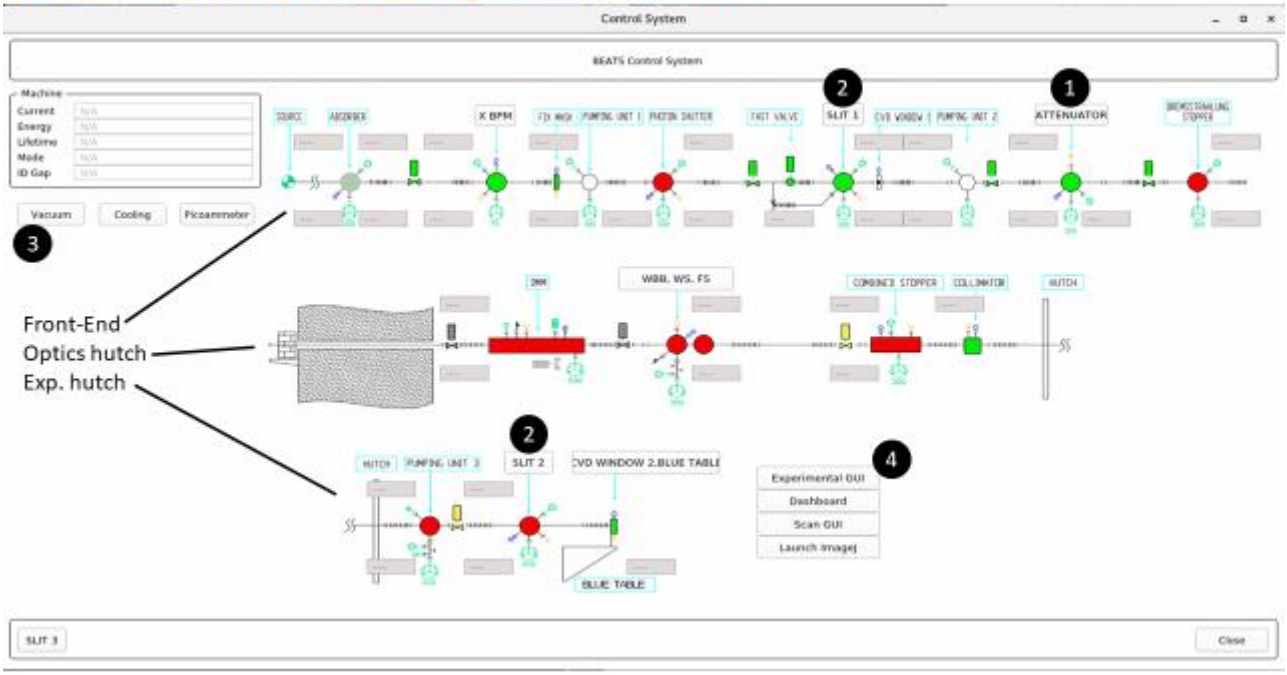
- ✓ Preliminary alignment
- ✓ Cabling + Motion SAT

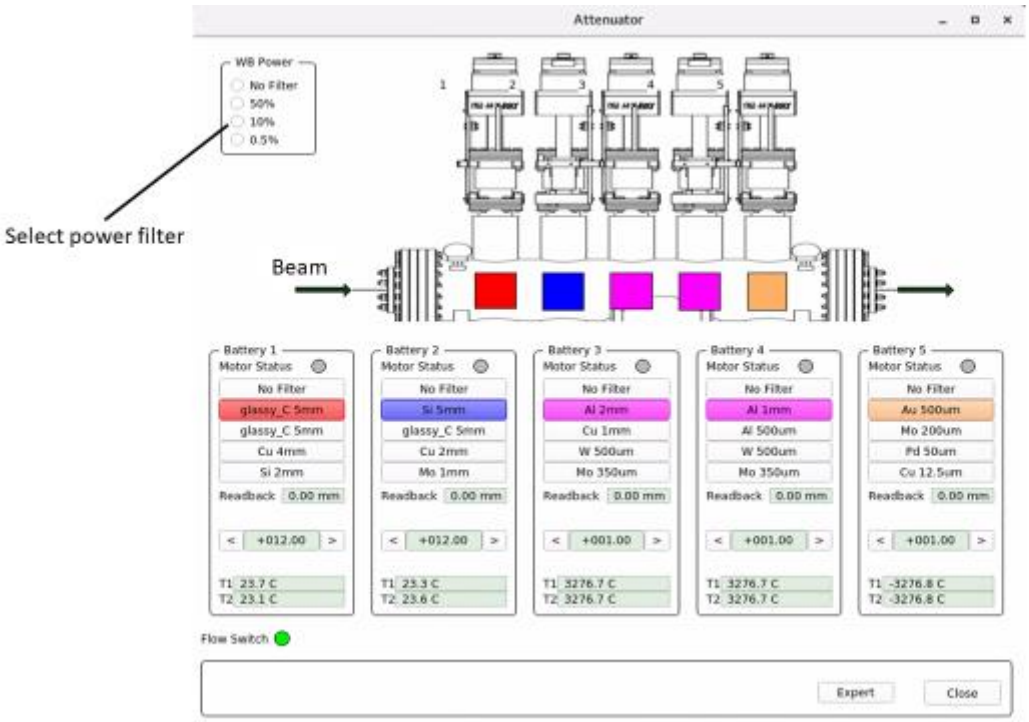
Double Multilayer Monochromator

Installation @ SESAME

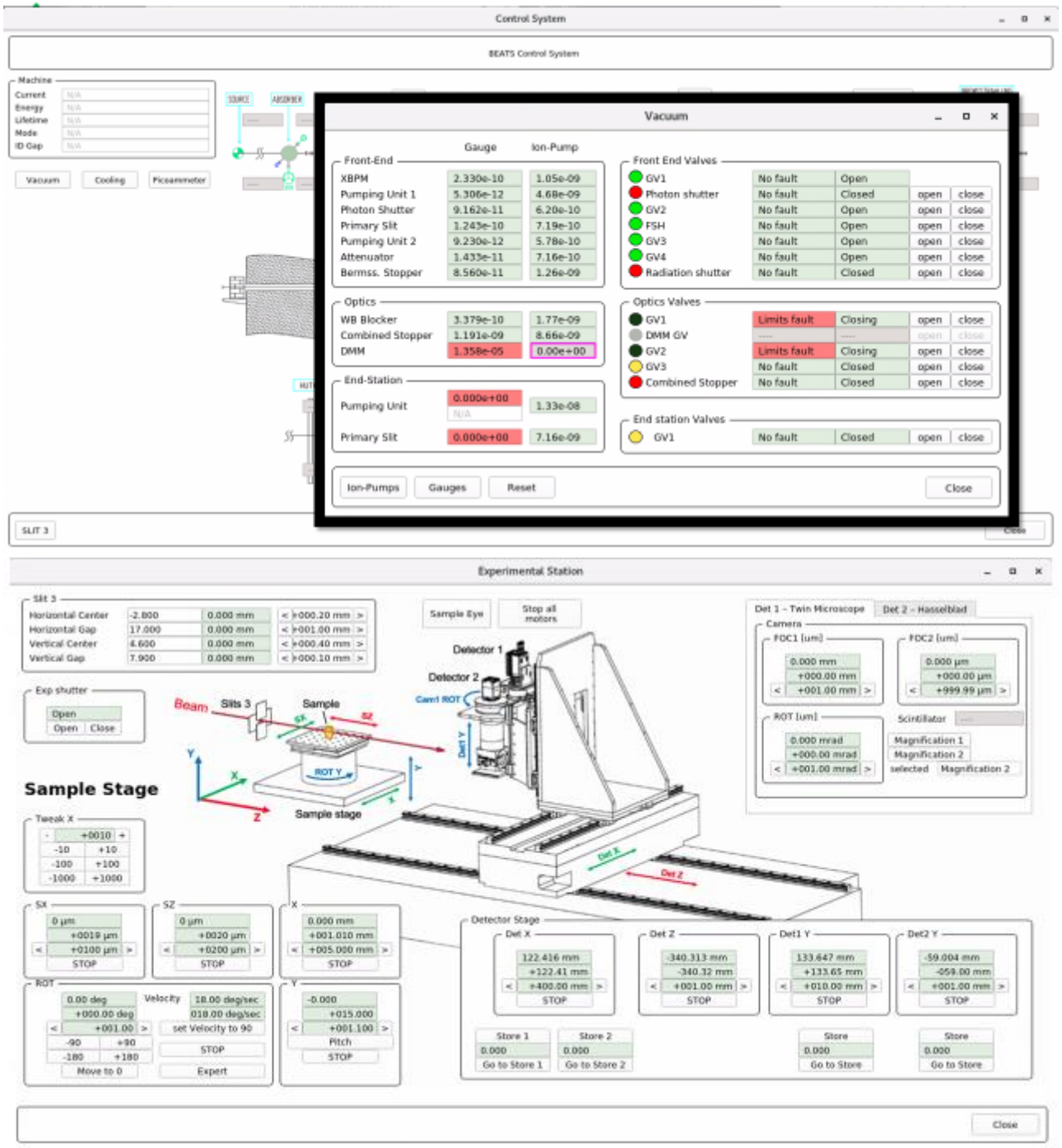
- ✓ Preliminary alignment
- ✓ Cabling + Motion SAT

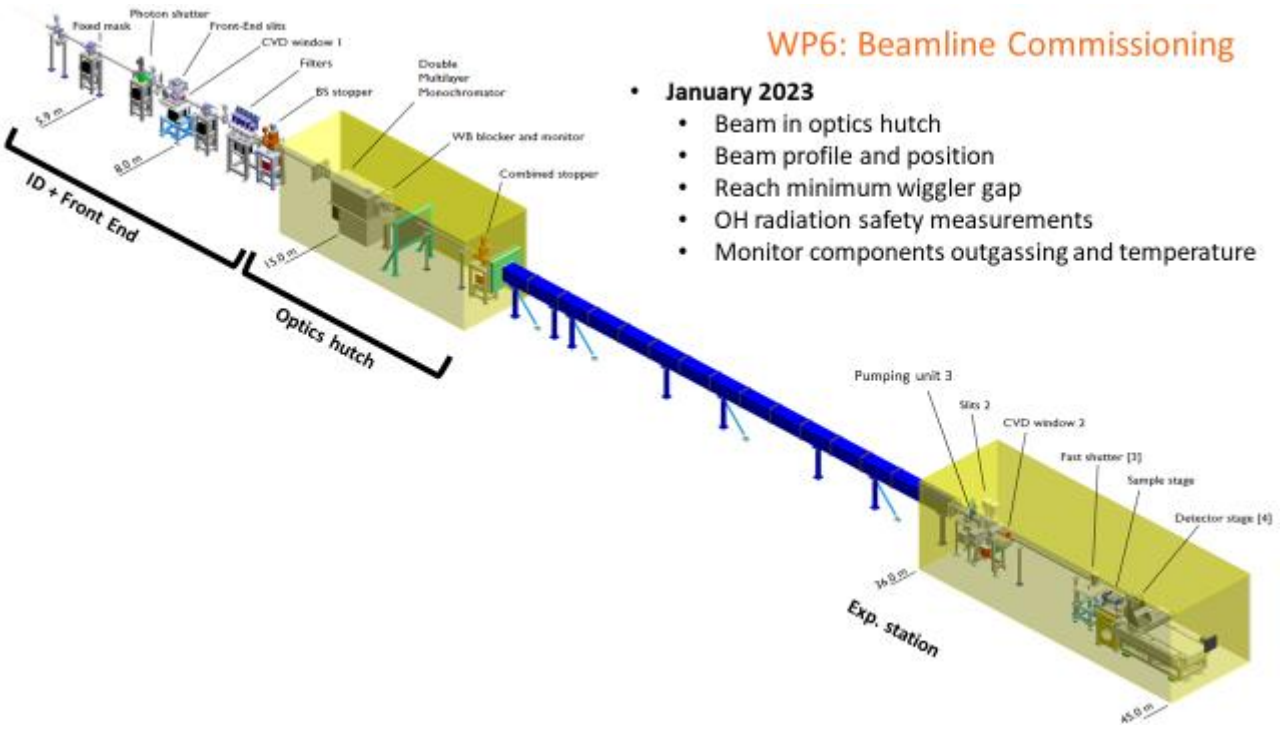
WP5: Development and testing of beamline GUIs





WP5: Development and testing of beamline GUIs

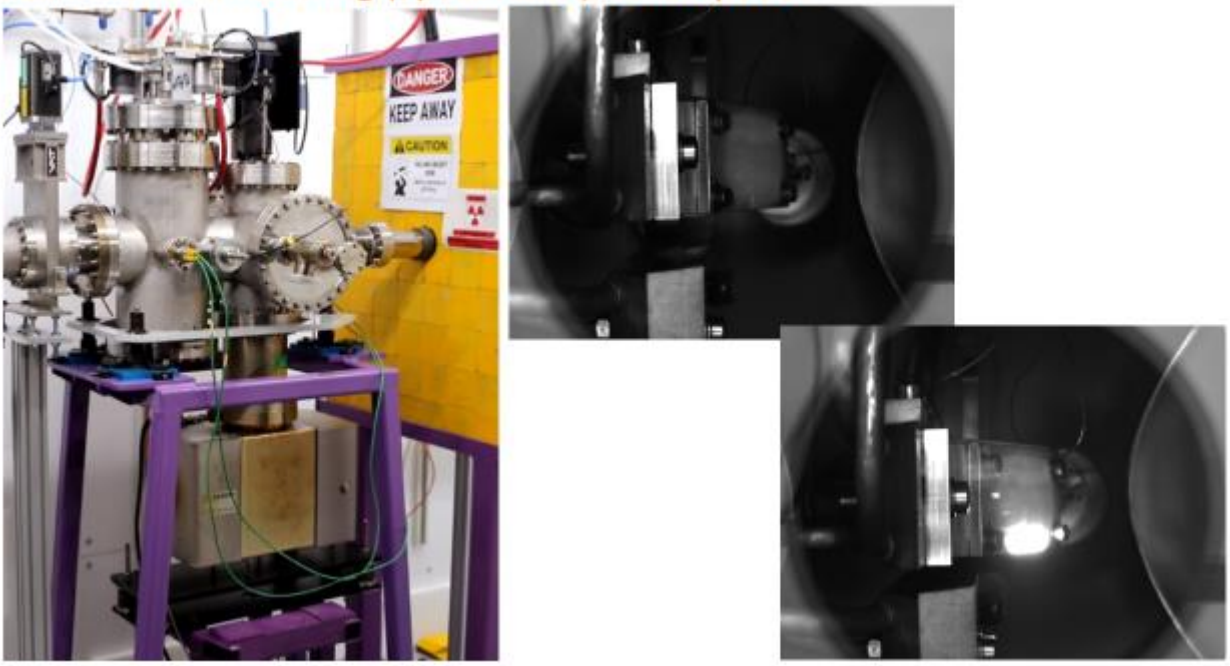




WP6: Beamline Commissioning

- **January 2023**
  - Beam in optics hutch
  - Beam profile and position
  - Reach minimum wiggler gap
  - OH radiation safety measurements
  - Monitor components outgassing and temperature

Beamline commissioning (optics hutch): January 2023



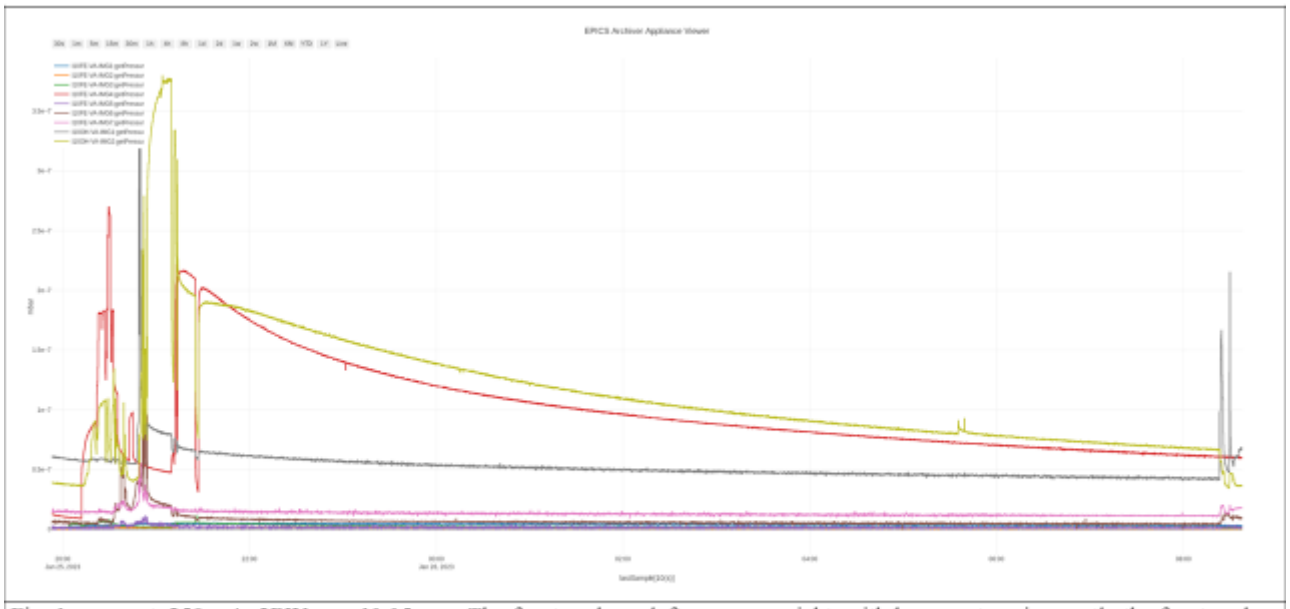


Fig. 1 - current: 250 mA; 3PW gap: 11.15 mm. The front-end was left open overnight, with beam outgassing partly the front-end slits and partly the combined stopper (in the optics hutch). The max vacuum reading was ~3E-7 mbar. The same was repeated, the following night and over the weekend, illuminating with the full beam at min. gap the combined stopper (with slits completely open this time.

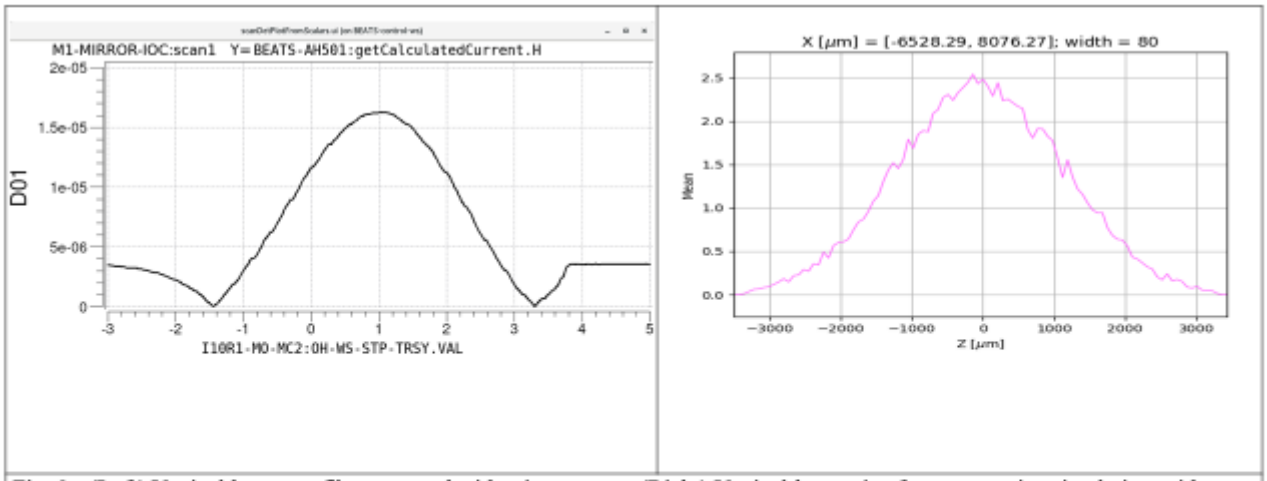
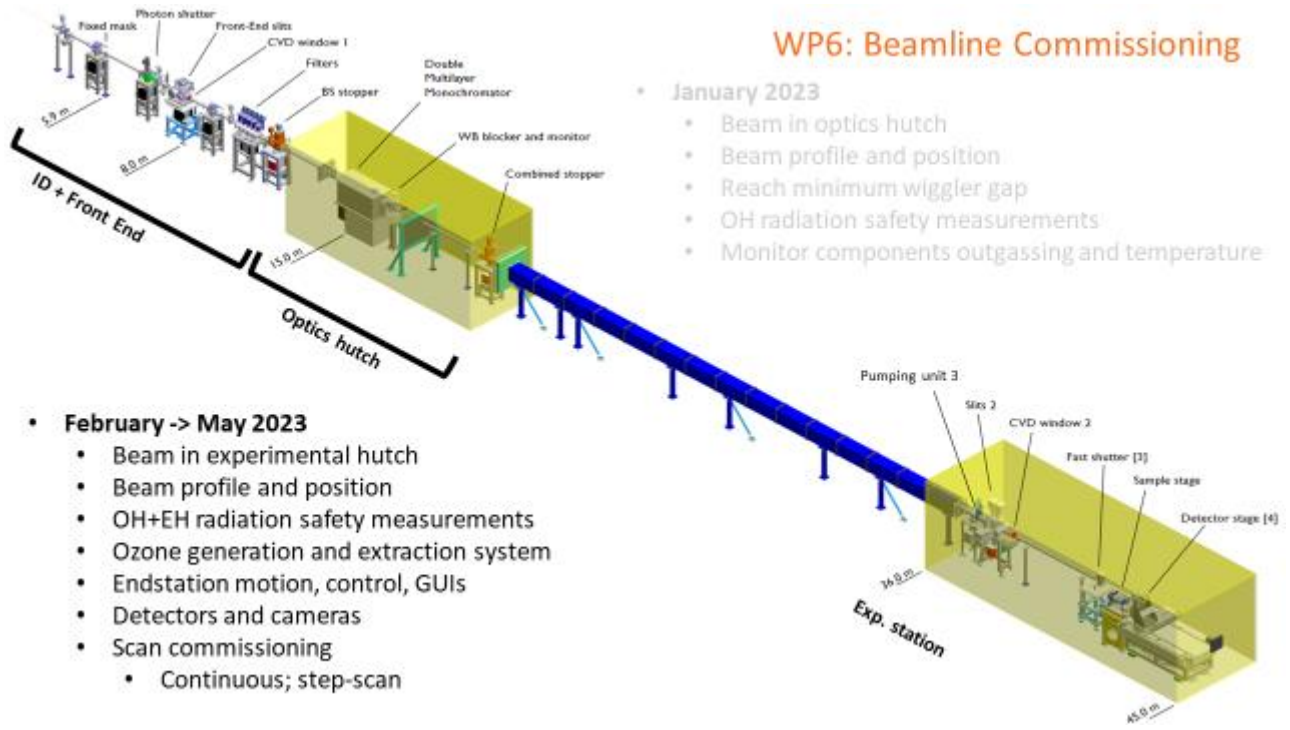


Fig. 2 - (Left) Vertical beam profile measured with wire scanner. (Right) Vertical beam size from raytracing simulation with SHADOWOUI.



Beamline commissioning (experimental station): February 2023

Beamline commissioning (experimental station): February 2023

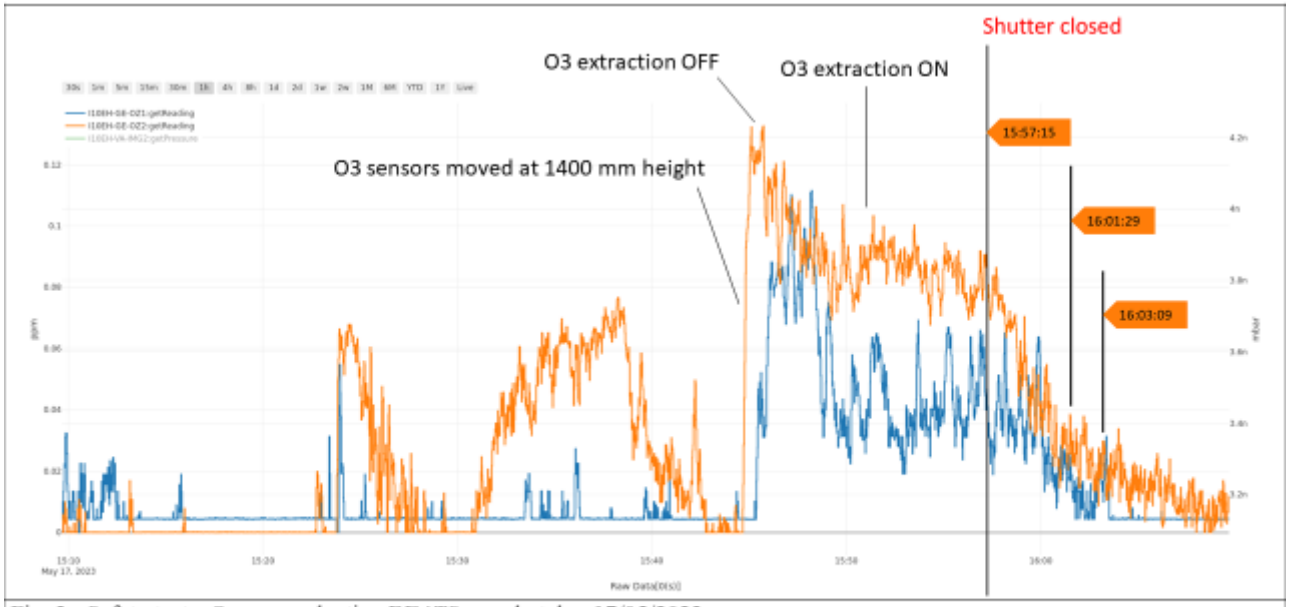
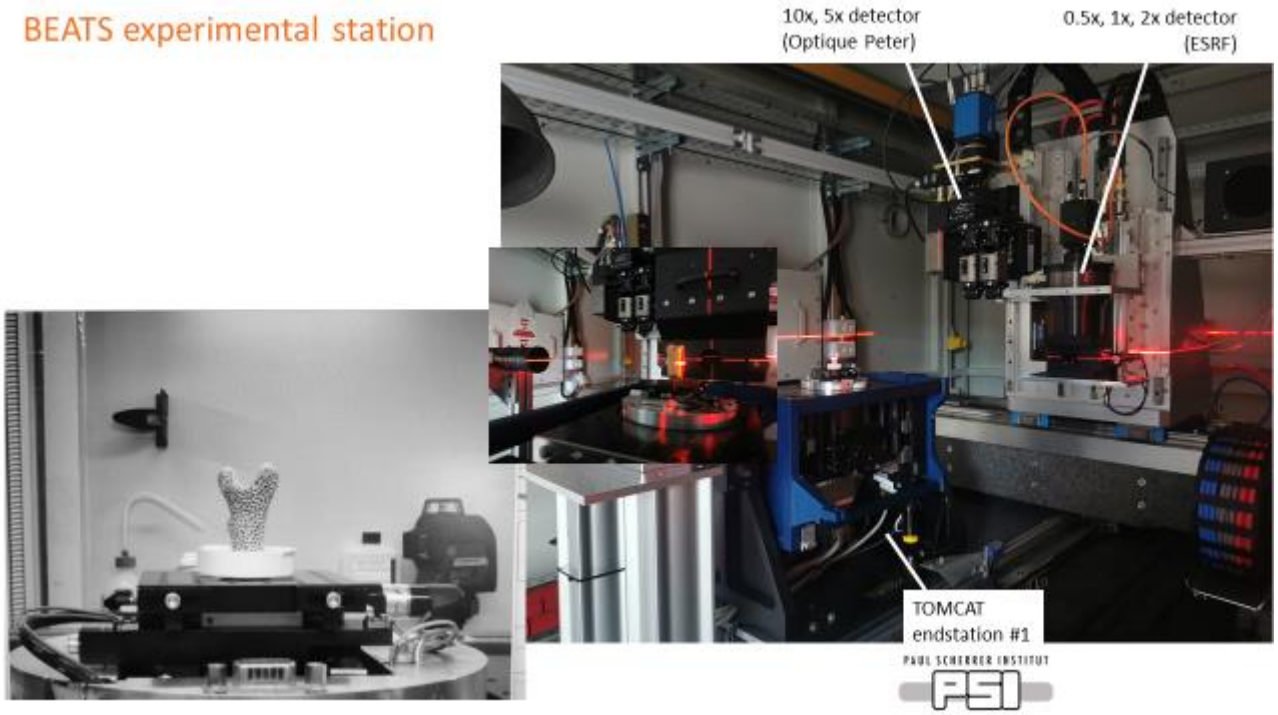


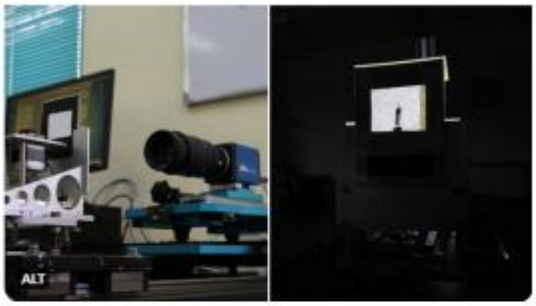
Fig. 3 - Safety tests: Ozone production BEATS exp. hutch – 17/05/2023:
a. Test Ozone sensors BEATS EH
b. Test Ozone saturation BEATS EH under different ventilation conditions

BEATS experimental station



BEATS KBLT (Kitchen-based Light Tomography)

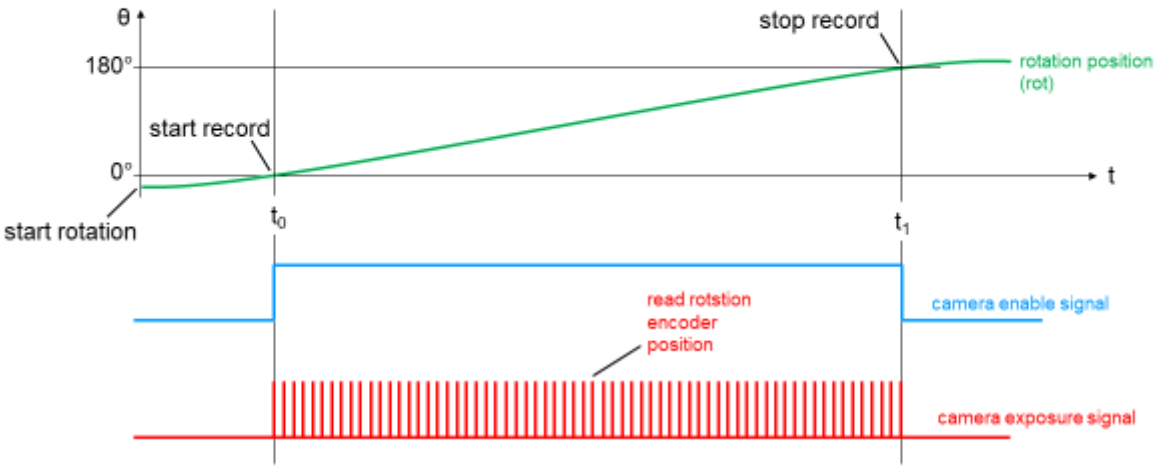
- TOMOSCAN DAQ commissioned with visible light
  - EPICS driver adapted for MICOS R160 AIR
  - Both BEATS cameras (PCO edge and ORYX FLIR)
  - Step scan and continuous scan + encoder readout
  - Reconstructions with Tomopy + ASTRA (CPU, GPU)
  - 3D rendering (2x RTX5000 GPUs + dragonfly)



Day 1 scanning modes:

Continuous scan

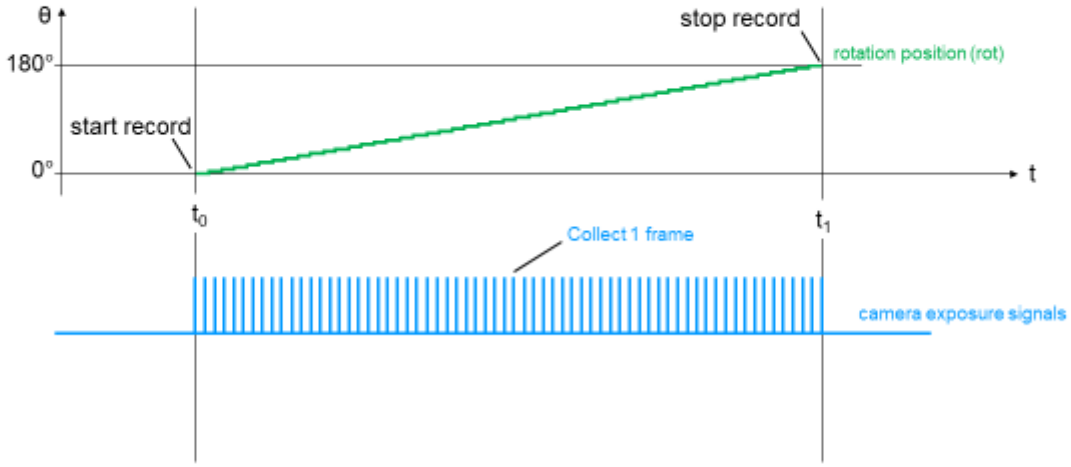
1. set rotation to constant speed; start rotation
2. wait until rotation speed is stable
3. start record of n projections; read rotation encoder readout
4. stop record; stop rotation

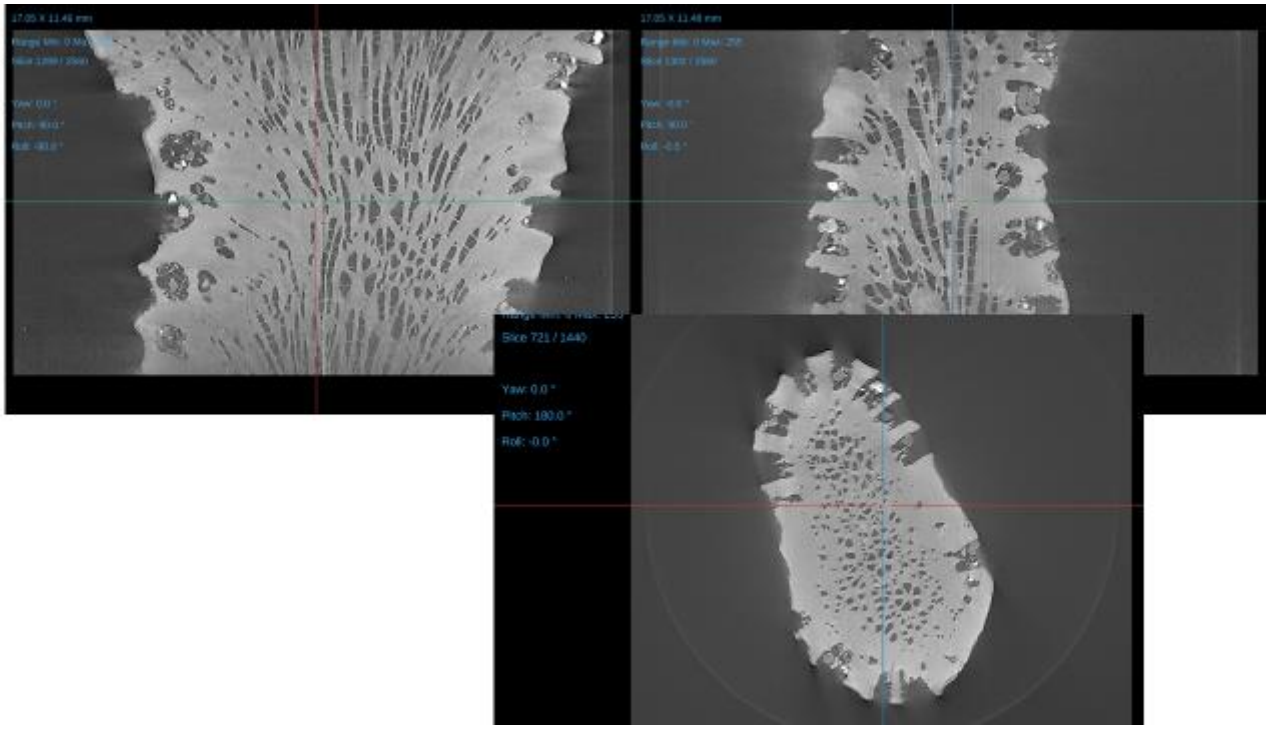


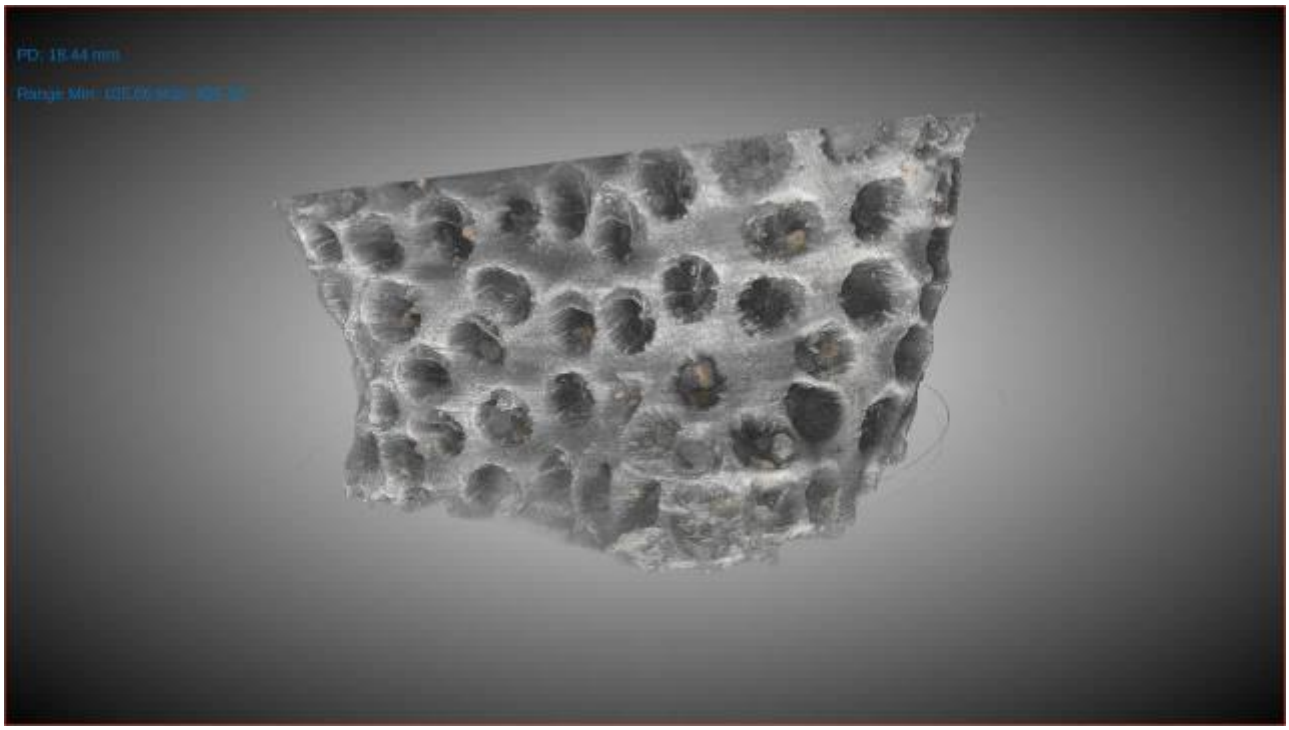
Day 1 scanning modes:

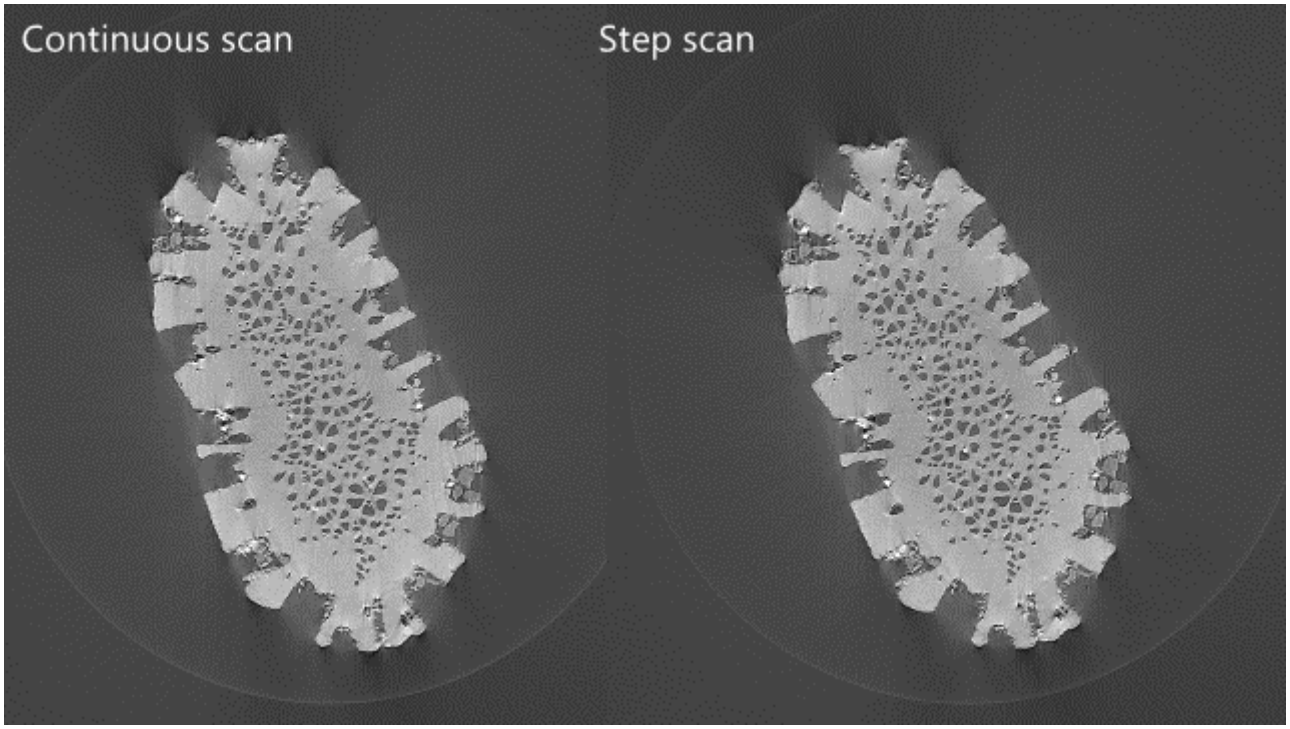
Step scan

1. move rotation stage to step angle position
2. wait until rotation position is reached
3. collect 1 projection; read rotation encoder readout
4. repeat for all angles



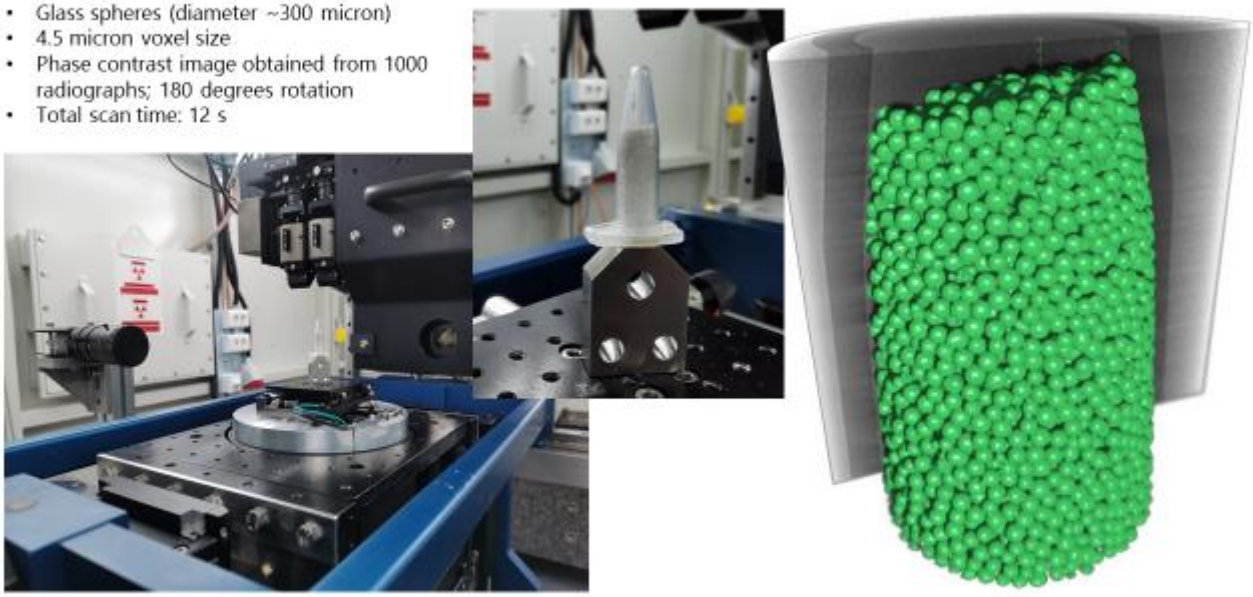

Slice 721 / 1440
Yaw: 0.0 °
Pitch: 180.0 °
Roll: -0.0 °



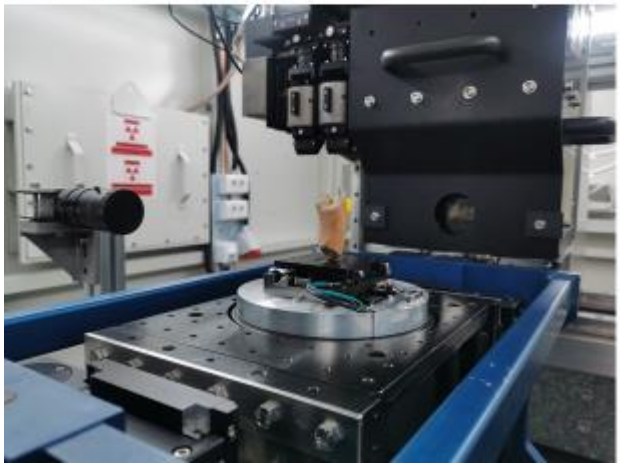


11 May 2023 – First BEATS scan

- Glass spheres (diameter ~300 micron)
- 4.5 micron voxel size
- Phase contrast image obtained from 1000 radiographs; 180 degrees rotation
- Total scan time: 12 s



- Sample: Terracotta specimen; diameter ~ 20 mm
- Detector: Hasselblad lenses (1x magnification) with ORYX FLIR camera; 4.5 micron voxel size
- Scan settings:
  - filtered white beam
  - Phase contrast reconstruction
  - 1800 projections; 360 degree scan
  - 600 ms exposure time
  - Scan time: ~20 mins



Installation and Commissioning - next steps

- **June -> December 2023**
  - Multilayers ready in July 2023
  - Sep 2023: install DMM multilayers

- **06 July 2023**
  - Multilayers coating (ESRF)
  - Metrology; Shipping
- **September 2023**
  - DMM multilayers installation
- **November 2023**
  - DMM beam commissioning
- **December 2023**
  - Delivery endstation2

BEATS

BEAmline for Tomography at SESAME

Funded by the EU's H2020 framework programme under grant agreement n°822535

Thank you for your attention

Acknowledgements

SESAME control, motion, data collection
computing, power supplies, procurement, alignment, and vacuum groups
PSI TOMCAT
ESRF mechanics group, ID19
SOLARIS mechanics group

BEATS_eu
@BEATSeu1

Presentation WP7, Mustafa Ali Alzubi

The Data Acquisition of BEATS

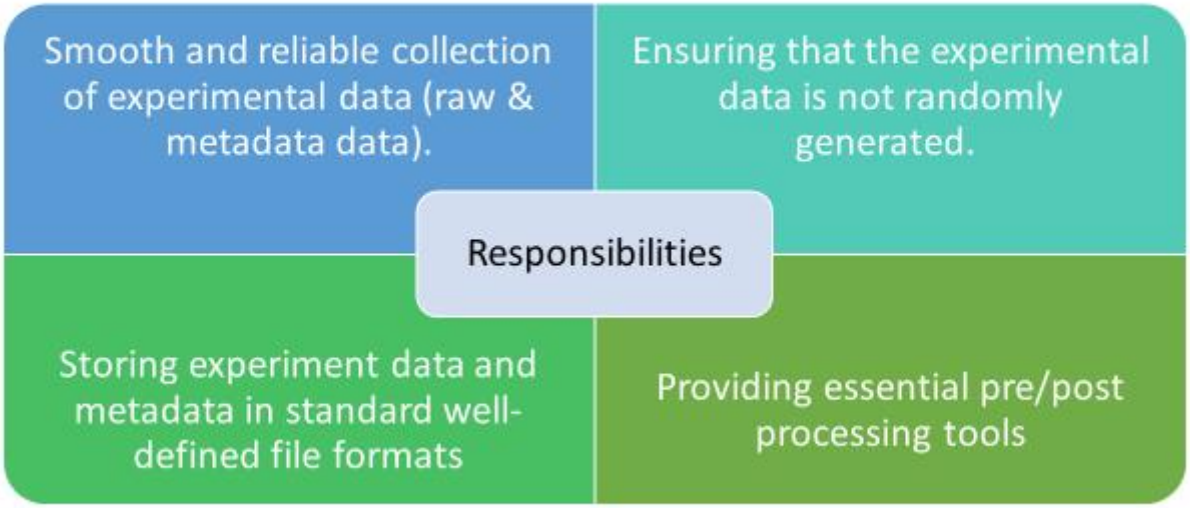
A. Abbadi, A. Al-Dalleh, A. Lausi, A. Mohammad, A. Aljadaa, C. Chrysostomou, G. Iori, H. Mohammad, **M. Alzubi***, R. khrais, S. Matalgah, Y. Momani

June 5, 2023

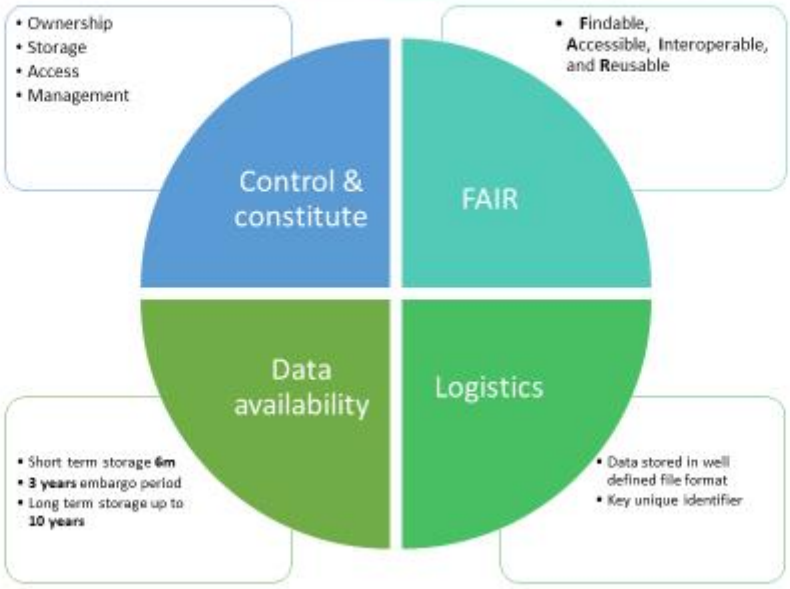
Mustafa Ali Alzubi
Team Leader
Data collection and analysis
SESAME Synchrotron

Provided with the financial support of the European Union
بدعم مالي من الاتحاد الأوروبي

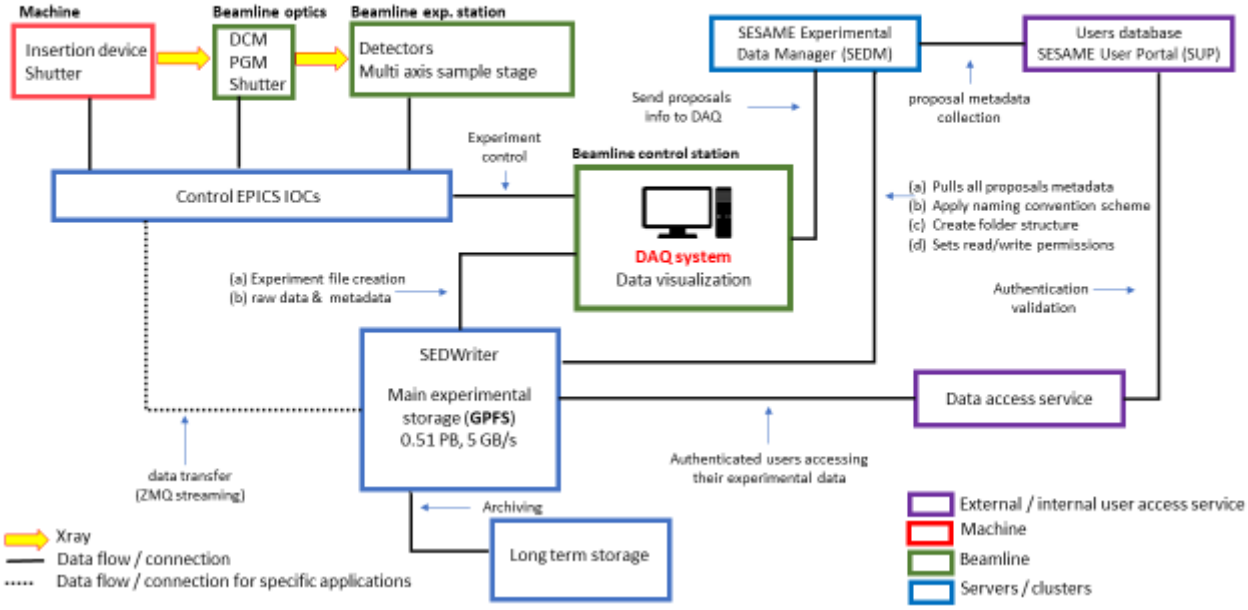
Data Collection and Analysis (DCA) Team



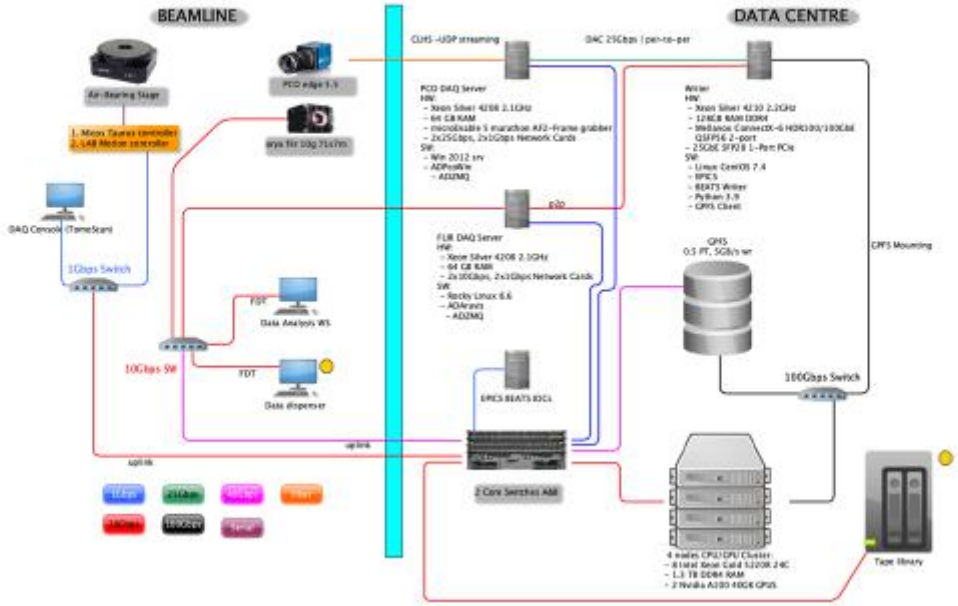
SESAME Experimental Data Management Policy vs standardization



DAQ General Pipeline

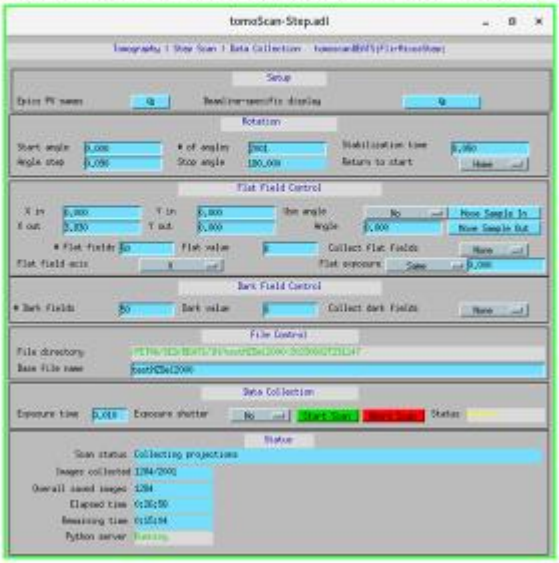


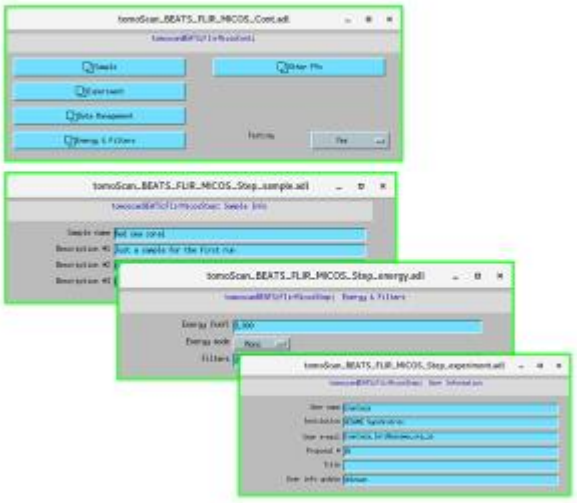
BEATS | DAQ | Pipeline | Current Setup



BEATS | DAQ | TomoScan

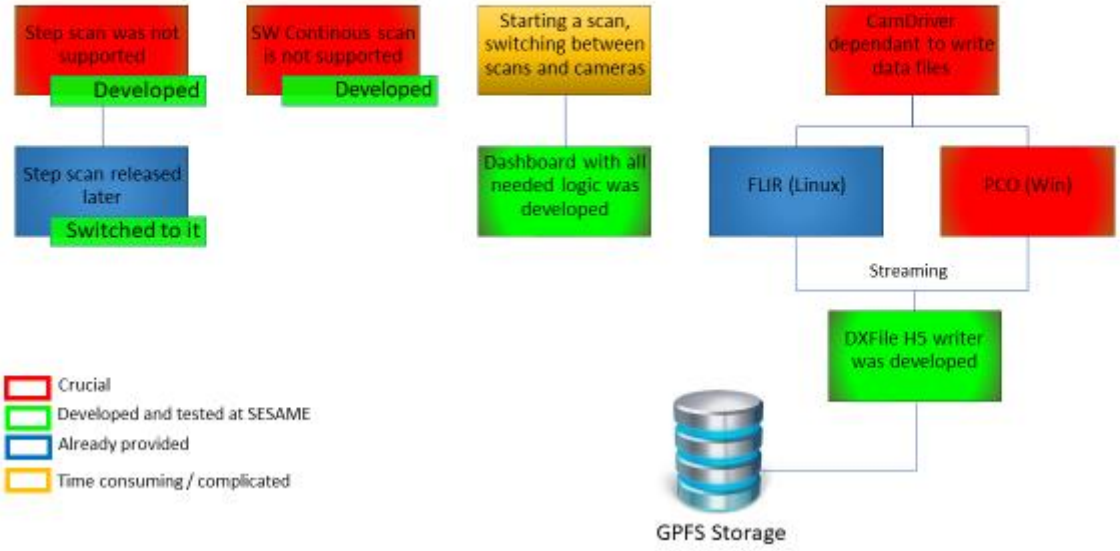
- TomoScan: It is a Python OOP software for collecting computed tomography data
- Developed by: Mark Rivers (University of Chicago) & De Carlo Francesco (Advanced Photon Source)





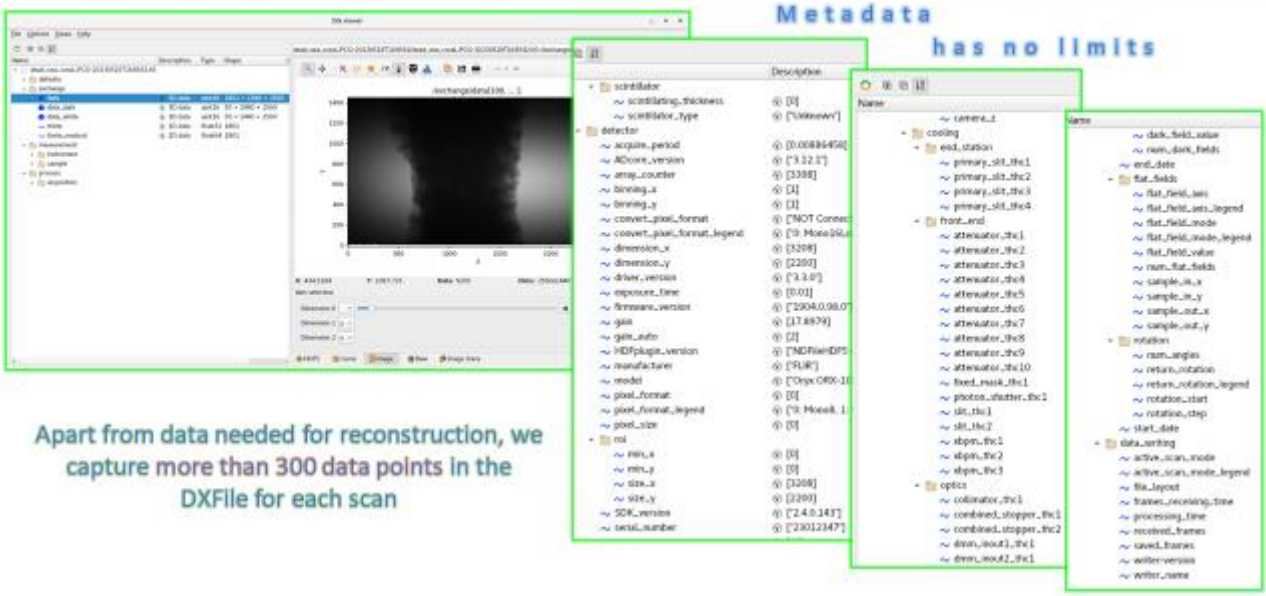
Integrated with exposure shutter and combined stopper

BEATS | DAQ | TomoScan | Issues



BEATS | DAQ | TomoScan | Dashboard

BEATS | DAQ| ZMQWriter | DXFile



BEATS | DAQ | Detector issues

PCO Camera – Step Scan (Performance issue)

External software trigger is not supported in the camera
Step scan → Image mode: Single, trigger source: Auto

External TTL trigger is supported in the camera
Step scan → Image mode: Multi, trigger source: External

RPTrigServ: PCO edge 5.5 Simple triggering system for step scan
Eliminates arming time between Frames

FLIR Oryx 71S7M (Crucial issue)

Issue: Frame timeout while scanning
When: unexpected
Scan type: both step and continous
Debugging time: 6 days
People involded: control, YM, GI and DCA

→ Detailed report sent to Mark Rivers

PROBLEM SOLVED!

BEATS | DAQ| Results and validation

- Experimental data obtained from the very first scan
- ZMQWriter is capable to capture frames at the maximum throughput of the detectors

Results

- DXFile generated by ZMQWriter has been validated by De Carlo Francesco (main founder)
- Stress tests on testing bench (benchmarking)

Validation

BEATS | DAQ| What is next?

What is next?

- Finalize DXFile layout – Some amendments are needed
- Data management (set the right permissions on the experimental files)
- More runs in the next period (collect feedbacks … add enhancements)
- Integrate Tomoscan with SUP (Needed after having BEATS in CfP)
- Implement Fast Data Transfer (FDT) for data transmission between GPFS and analysis and data dispenser workstations
- Exposure shutter tunning

Thanks

A. Abbadi, A. Al-Dalleh, A. Lausi, A. Mohammad, A. Aljadaa, C. Chrysostomou, G. Iori, H. Mohammad, **M. Alzubi**∗, R. khrais, S. Matalgah, Y. Momani

Mustafa Alzubi
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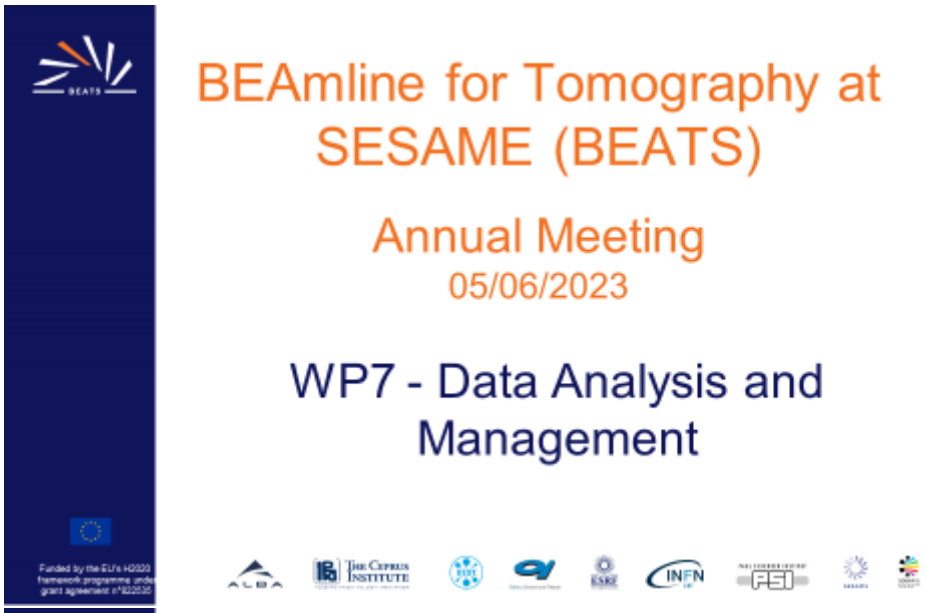
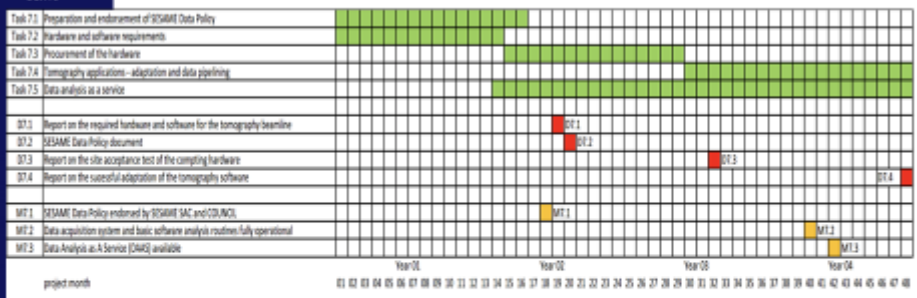
Presentation WP7, Ch. Chrysostomou



WP7-Data analysis and management

- **Task 1:** Preparation and endorsement of SESAME data policy (SESAME, ESRF, Cyl, PSI); Months 1 – 16
- **Task 2:** Hardware and software requirements definition. (SESAME, Cyl, ESRF, PSI); Months 1 – 14
- **Task 3:** Procurement of the hardware (SESAME, Cyl); Months 15 – 29
- **Task 4:** Tomography applications - adaptation and data pipelining (ESRF, Cyl, PSI, SESAME); Months 30 – 48
- **Task 5:** Data analysis as a service (Cyl, SESAME). Months: 14 - 48

WP7 Gantt Chart



Task 7.1: Completed
Task 7.2: Completed
Task 7.3: Completed
D7.1-D7.3: Completed
D7.4: End of the project

Task 7.3 Procurement of Hardware

BEATS tests computing infrastructure for big data processing

NEWS 28 APR 2022

Computing infrastructure updates

- ICAT to handle the STS and LTS file access
- Long Term Storage will be located and archived on a Tape library + management Backup/Archiving server
- RAM upgrade due to the need of recon (under procurement process) each GPU node will be 512 GB RAM (instead of 192)
- Dragonfly VizServer available for remote data analysis after beamtime (2 seats) (under procurement process)

IBM TS4300 Long Term Storage
- IBM TS4300 base Unit with one expansion with LTO 9 Data Cartridges QTY60 (1PB Capacity)

Data analysis, management and curation

- Software for data reconstruction and data processing:

#	name	URL	features	open source	license type
CT reconstruction					
	TomoCuPy	https://github.com/tomography/tomocupy	GPU	yes	
	ASTRA	https://www.astra-toolbox.com/	high-performance GPU primitives	yes	
	TomoPy	https://tomopy.readthedocs.io/en/latest/	parallelization, distributed	Yes	
3D data processing and visualization					
	ImageJ	https://fiji.sc/		Yes	
	Paraview	https://www.paraview.org/		Yes	
	Dragonfly	https://www.theobjects.com/dragonfly/index.html	GPU ready; ML ready	No	Academic; single user
	3D Slicer	https://www.slicer.org/		Yes	
	PALABOS	https://palabos.unige.ch/	fluid dynamics simulations; permeability	Yes	
	Quanfima	https://github.com/rshkarin/quanfima	quantitative analysis of fibrous materials	yes	
	Calculix	http://www.calculix.de/	FE solver	yes	
	iMorph	http://imorph.sourceforge.net/index.html	characterization of cellular materials	no	free

[Chrysostomou et al. 2020 - Report on the required hardware and software for the BEATS beamline]

Task 7.4 Tomography applications - adaptation and data pipelining

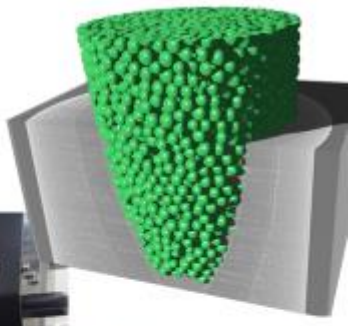
Reconstruction Tests

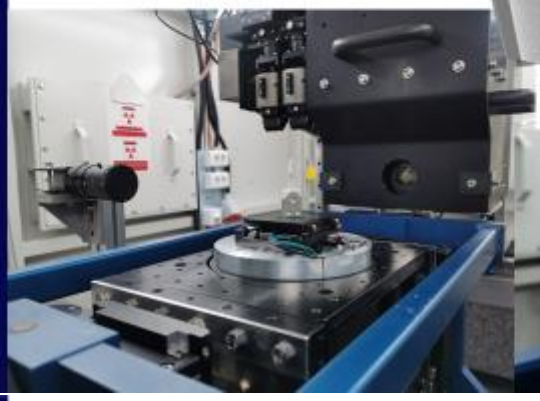
- Tomopy reconstruction of a full X-ray dataset collected at BEATS tested on both CPU and GPU nodes
- Several algorithms for CPU and GPU recon tested
- Main reconstruction pipeline utilizes the fastest algorithm (gridrec on CPU)
- Recon time for gridrec (full dataset) on 96 threads are as low as 60 seconds
- Extended field-of-view scan exceeds the available memory (~250 GB) on one node
- Solution: Completed this recon on the data analysis workstation, where we have 512GB RAM (recon shape: 4129 x 4129 x 2160) (tomopy gridrec; ncore=36; 172sec; 303G/503G)
- Memory was purchased to expand one of the rum nodes to 512GB RAM
- Slurm scheduling is up and running

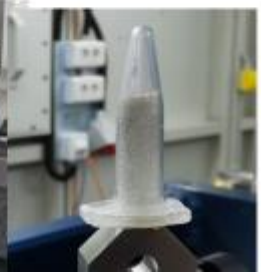
BEATS Pipeline

- All needed steps (I/O, normalization, Center Of Rotation detection, artefact correction, phase retrieval, recon, extended FOV reshape, 8bit conversion) are present in the pipeline, tested and available to users
- The pipeline is accessible via a Jupyter Notebook
- A script has been prepared to enhance productivity. Most functionalities are already available in the script.
- Examples of first reconstruction tests are available (**courtesy of Gianluca Lori**):
  - **Glass beads** - contains the first example of absorption VS phase-contrast recon
  - **Dana Terracotta** - contains the reconstruction of an extended FOV scan (6316 x 6316 pixels slice)
  - **Red Sea Coral** - comparison between reconstructions of the same sample scanned with step scan or with continuous scan mode. Both scan modalities work perfectly.

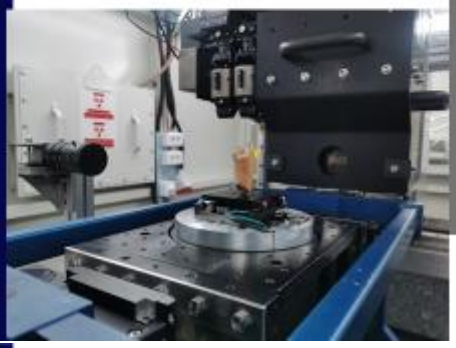
- Sample: Glass spheres diameter 300 – 400 micron
- Detector: Hasselblad lenses (1x magnification) with ORYX FLIR camera; 4.5 micron voxel size
- Scan settings:
  - filtered white beam
  - Phase contrast reconstruction
  - 1000 projections
  - 12 ms exposure time
  - Scan time: 12 s



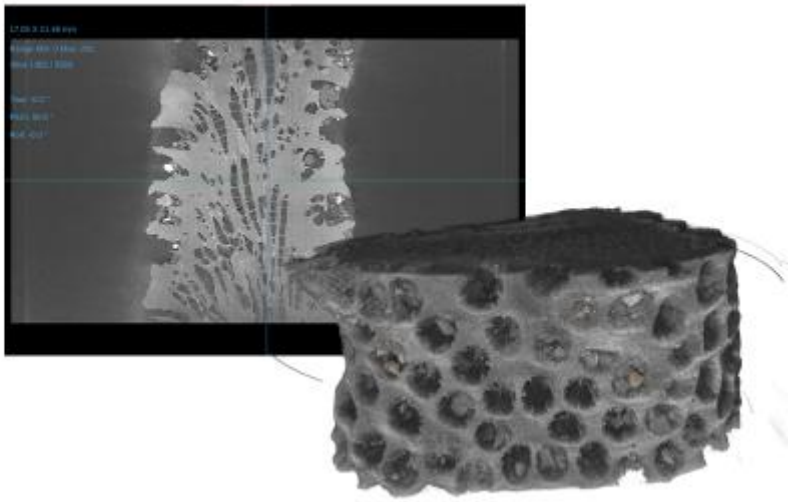




- Sample: Terracotta specimen; diameter ~ 20 mm
- Detector: Hasselblad lenses (1x magnification) with ORYX FLIR camera; 4.5 micron voxel size
- Scan settings:
  - filtered white beam
  - Phase contrast reconstruction
  - 1800 projections; 360 degree scan
  - 600 ms exposure time
  - Scan time: ~20 mins



- Sample: Red Sea Coral



Task 7.5 Data Analysis as a Service

Data analysis as a service. Between CYI and SESAME

Network

- Successful exchange of data between SESAME and The Cyprus Institute were performed by utilising Arab States R&E Network (ASREN) and GÉANT networks.

Hardware

- SESAME HPC Computing Infrastructure (HPC and Workstation)
- Cyclone with 33 compute nodes
- Dragonfly Vizserver with 2 seats for 100% smooth remote data analysis after the beamtime (32-core CPU, 512 GB RAM 2x NVidia RTX A6000 GPUs, RAID5 SSD 2 TB (usable))
- Dedicated Workstation for Visualisation at CyI with Paraview remote server (32-core CPU, 128 GB RAM, NVidia RTX 4900 GPU, SSD 2 TB)

Software

- Successful adaptation of the reconstruction pipeline to work on multiple HPC through the usage of Apptainer

BEAmline for Tomography at SESAME (BEATS)

Thank you for your attention.

Presentation WP1, Axel Kaprolat

BEATS

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BEATS, WP 1, The Global Status

Axel Kaprolat, ESRF – ISDD
BEATS Project Coordinator
4th Annual Meeting of the BEATS project 05.16.2023

Content:

- WP 1: Where do we stand?
- WP 1: What will happen next?
- Overall situation of the project

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From 3rd Annual Meeting: The (then) next steps

January 2023:
- Installation components OH, TL, first elements EH
- Qualification of the white beam

done

February 2023:
- Arrival of sample station I
- Radiation test

done

March 2023:
- Delivery DMM
- Start commissioning

done

The project is running smoothly.

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Ongoing: commissioning

April 2023

- First tests found the DMM not vacuum tight (CINEL).

May 2023

- Vacuum leak DMM repaired, SAT (CINEL, SESAME)
- SAT completed, vacuum being characterized
- Experimental station commissioning

Last lap

To come: multilayer coating and installation

To come: Outstanding deliverables

D 5.6 EMRC license obtained, report, CO
D 6.1 Commissioning optical components, report, PU
D 6.2 Commissioning experimental components, report, PU

D 1.n: notes AM04, SC meetings, published articles
D 2.3 stewardship models, funding
D 6.3 Beamline operation manual
D 7.4 Adaptation of tomography software

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To come: 3rd periodic report, technical review

30/06/2023 end of project
+ 60 days: 3rd periodic report due!

25./26./27. September 2023: 3rd technical review (on site?)

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