OBSERVATORY SCIENCES News

Autumn 2023 ✦ Software for telescopes and accelerators

FUSION FACILITY WILL HAVE EPICS CONTROL

A fusion equipment testing facility, known as CHIMERA, being built by the UKAEA (United Kingdom Atomic Energy Authority) in Rotherham, Yorkshire will use EPICS control software developed by Observatory Sciences Ltd (OSL).

Credit: UKAEA

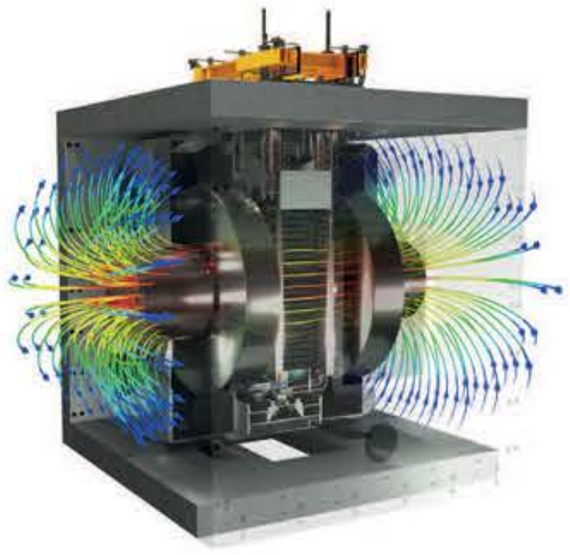
Construction of the testing facility is being undertaken by global technical services company Jacobs, which has selected Observatory Sciences to produce the SCADA software for the CHIMERA control system.

The UKAEA's Fusion Technology Facility is at the forefront of global efforts to develop nuclear fusion as a major source of low-carbon electricity. At the heart of the testing facility is CHIMERA (Combined Heating and Magnetic Research Apparatus), a system designed to address the specific engineering challenges associated with nuclear fusion. It is the only device in the world able to test critical fusion component prototypes, such as blankets, divertors and diagnostic modules, in an environment representative of a fusion power plant.

CHIMERA is designed to simulate combinations of high heat flux with static and pulsed magnetic fields within a vacuum or inert atmosphere, as could be found in an operational fusion power plant. This includes heating to 0.5 megawatts/m^2; up to 4 Tesla magnetic fields with high spatial horizontal gradients and rapidly pulsed vertical fields to simulate a plasma disruption; vacuum pressure to 10^{-5} bar, and water cooling to PWR (pressurised water reactor) conditions, 155 bar and 330°C.

Optical digital image correlation and laser metrology will be used to map 3D surface deformations and other damage of the test pieces due to the harsh testing environment. Digital twins, predictive models and simulations, will be used alongside the real tests to help perfect designs for future fusion power components. This 'virtual qualification' is a key strand of CHIMERA's capability, enabling double-checking and ensuring steady progress of the test programmes.

The CHIMERA control system will consist of a distributed set of programmable logic controllers, each controlling a hardware subsystem of the overall facility. A separate LabVIEW-based data acquisition system will acquire high-speed data at the time of each magnetic pulse. This process is time critical, and a large amount of data has to be made available for further analysis.



Credit: UKAEA

With recognised EPICS software expertise, Observatory Sciences has developed many large-scale plant and machine control systems based on the EPICS framework, which is a set of Open Source software tools, libraries and applications developed collaboratively and used worldwide to create distributed soft real-time control systems for scientific instruments such as accelerators, telescopes and other large scientific experiments. The CHIMERA SCADA software is OSL's first major contract in the field of nuclear fusion.

OBSERVATORY SCIENCES SETS UP THIRD BASE AT HARWELL CAMPUS

A third operations office has been opened by Observatory Sciences Ltd (OSL), on the UK's Harwell Science and Technology Campus near Oxford, one of the world's premier locations for cutting edge science and research. The company already has offices in St Ives near Cambridge and Dunfermline near Edinburgh.

Harwell is already home to over 6000 scientists and 300 scientific organisations such as the Diamond Light Source synchrotron, the ISIS pulsed neutron and muon source, the National Quantum Computing Centre, the Central Laser Facility, the European Space Agency, many innovative private sector organisations, plus teams from over 30 UK universities. It is expanding rapidly, with plans to add many more laboratories and offices, alongside accommodation, sports, health and welfare facilities over the next five years.

"This concentration of both talent and enterprise coupled with world-class facilities makes Harwell an ideal environment for science and technology development, while also ensuring that the results can be realised, developed and commercialised to the benefit of everyone," says Andy Foster, the OSL Director who currently works at Diamond Light Source.

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LASER FOCUS ON NOBEL PRIZE PHYSICS

Laser technology will take a big step forward when the Extreme Photonics Applications Centre (EPAC), being built by the Science and Technology Facilities Council (STFC) Central Laser Facility (CLF) at the Rutherford Appleton Laboratory, comes on-stream in a few years' time. Observatory Sciences is already involved with this project, which is still in its early stages.

EPAC will be a groundbreaking international facility that will apply laser-driven plasma accelerators to a multitude of areas. It will expand the pioneering work of 2018 Physics Nobel Prize-winners Donna Strickland and Gérard Mourou, whose work in developing high-intensity, ultrashort pulses of light beams has already transformed several sectors.

The vision behind the centre at Harwell is to create an ecosystem that brings academia, defence & security, industry and manufacturing together, providing new capabilities for fundamental science and applications from across a wide spectrum of sciences and industry.

Credit: Courtesy of STFC

At the heart of EPAC is a laser producing 10,000 times more power than the whole of the UK national grid, albeit for a hundred-trillionth of a second. Focusing this to a spot that is smaller than the width of a human hair on a target will create temperatures hotter than the sun's core.

Observatory Sciences' involvement with EPAC has started with the Data Acquisition Systems - helping to review current designs and software architecture as well as IT infrastructure to support experiments. This consultancy work enables the sharing of knowledge and experience on these topics from other large scientific facilities like Diamond Light Source and the Square Kilometre Array.

OSL is also developing a demonstration pulsed laser tomography experiment data acquisition system using EPICS software and the BlueSky data collection framework, plus an EPICS training course for STFC Central Laser Facility staff.

THIRD BASE AT HARWELL CAMPUS

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The office, in building R104 of the Rutherford Appleton Laboratory, is home to two new OSL employees, including Ulrik Pedersen, who has 17 years experience working with synchrotron beamlines.

Credit: STFC Business Incubation Support Team
L-R: Ulrik Pedersen, Bryn Roberts, Andy Foster

His technical speciality is designing, developing and providing operational support for SCADA systems, primarily based on EPICS distributed control systems. This is coupled with long experience of managing and leading beamline control teams on major experimental projects.

He is joined by new recruit Bryn Roberts, who joined OSL in 2023 after obtaining a doctorate in experimental particle physics from the University of Warwick.

His main work studied the decay of particles detected by the ATLAS detector at the Large Hadron Collider. He also worked on automating a calibration workflow for ATLAS.

Credit: STFC

"Harwell is focused on science and technology research," says Bryn. "With frequent new developments, the campus is an exciting place to work"

OBSERVATORY SCIENCES GROWS ITS SKA SOFTWARE TEAM

As construction of the SKA telescopes gathers pace, Observatory Sciences Ltd (OSL) has been instrumental in creating a new software development team (Team Wombat), within the SKA Observatory. Product Owner Ulrik Pedersen (OSL) explains:

"We are a small but growing team that supports the rest of the SKA software organisation with expertise on the Tango distributed control system as well as contributing effort to the wider Tango collaboration, maintaining and developing the core Tango projects. We are tasked with developing software to integrate instrumentation hardware using Tango into the wider SKA software environment known as the MCCS (Monitor, Control and Calibration Subsystem). Our initial project is to implement the software integration of Power and Signal Distribution (PaSD) instrumentation for antenna stations via a Modbus protocol".

L-R: Thomas Juerges (SKAO), Emma Arandjelović (OSL), Alex Morrison (scrum master of Team Wombat) & Ulrik Pedersen (OSL)
SKAO Council Chamber, Jodrell Bank, 2023. Credit: Nick Rees

The team currently consists of experienced engineers and OSL is helping with the hiring process for additional qualified personnel with a view to becoming a training resource for the SKAO.

Most of the work that OSL does for the SKAO is on the SKA-Low telescope now being built in Western Australia. This is a "mathematical" telescope that works by filtering out what is not desired from the observable sky. Its antennas see the whole sky, and through data processing astronomers can "point" in different directions even though the antennas have no moving parts.

It will combine the signals received from thousands of small antennas spread over a wide area to create a single giant radio telescope capable of extremely high sensitivity and angular resolution. It will search for earth-like planets and potential life elsewhere in the universe, test fundamental scientific positions such as the theory of gravity, and probe the dark energy of the early universe.

The SKA-Low telescope will see back to a time before the first stars lit up.

Observatory Sciences provides full project management and support services for public and private sector clients. This can reduce the learning curve at project implementation and achieve crucial savings in time and manpower.

- Design and development of instrument and equipment control software
- Technical reviews and studies of software solutions
- Training and skills transfer
- Systems maintenance and upgrade management
- Procurement and integration
- Facilities management and operation
- Software commissioning and support
- Project reviews

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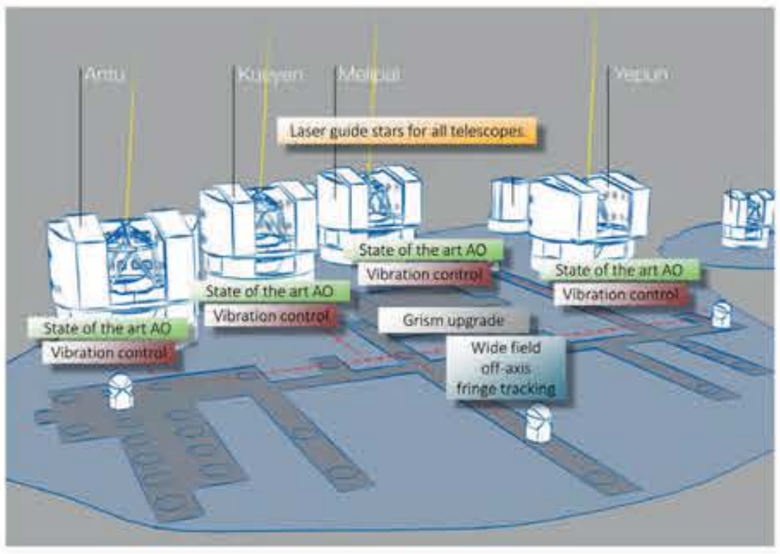
GOOD VIBRATIONS AT GRAVITY+

In January 2023, after an international open tendering procedure, the European Southern Observatory (ESO) awarded Observatory Sciences Ltd (OSL) another contract to work on software support for ESO's Very Large Telescope (VLT) and ESO's VLT Interferometer (VLTI). OSL has already been successfully working on supporting this software infrastructure since 2017. The new contract involves an increased level of effort and OSL's team, based at our Dunfermline office, has been enlarged to progress the new contract.

OSL has also become involved with new ESO VLT instrumentation software working with KU Leuven in Belgium and the Australian National University in Canberra. OSL engineers worked with KU Leuven to improve vibration control for the GRAVITY+ project, which is opening up the extragalactic sky for milliarcsecond-resolution interferometric imaging.



Credit: MPE / F.Eisenhauer

This picture shows the upgrade of GRAVITY and the VLTI to GRAVITY+ for faint-science, all-sky, high-contrast, milliarcsecond interferometric imaging. The key elements are improved instrument throughput and vibration control, wide-field off-axis fringe tracking, state-of-the-art adaptive optics, and laser guide stars for all telescopes. GRAVITY+ is led by the Max Planck Institute for extraterrestrial physics in collaboration with INSU/CNRS, University of Cologne, MPIA, CENTRA, University of Southampton, and KU Leuven.

With the Australian National University, OSL is working on the design phase of software for Heimdallr instrument, which is the core enabling fringe-tracking technology for the entire Asgard suite which is a diverse set of back-end beam combiners for the VLTI. In addition, OSL is now sharing its ESO software expertise with other institutions developing new VLT facilities.

BIG SCIENCE CONFERENCE ARRIVES IN AFRICA

With the worldwide scientific community getting back up to speed after the Covid pandemic Observatory Sciences Ltd (OSL) is sending five delegates to a major conference.

The ICALEPCS 2023 conference (International Conference on Accelerator and Large Experimental Physics Control Systems), is being held in Cape Town, South Africa in October 2023.

All five OSL delegates have submitted papers to the conference as well as helping to manage the Company's stand in the conference exhibition area.

ICALEPCS has had 19 previous meetings but this is the first time in its history that Africa has hosted the event. South Africa also hosts the international Square Kilometre Array project.

The SKA-Mid telescope has now started construction in the Karoo region, which will eventually see 133 SKA-Mid dishes added to the existing 64 of the SKA-precursor telescope MeerKAT to form a mid-frequency instrument.

Philip Taylor, a founding director of OSL says:

"The ICALEPCS events allow us to meet and exchange ideas with many people working in Big Science. These meetings are always stimulating with new ideas and enthusiasm and you come away having had a rare opportunity to meet up with existing clients from all over the world as well as making new contacts".

CANARIES TAKE FLIGHT WITH NEW TELESCOPES

Two new telescopes being constructed on La Palma, Canary Islands, will help push our understanding of the universe to new levels.

The Cherenkov Telescope Array (CTA) is a next generation ground-based observatory for gamma-ray astronomy at very-high energies. The European Solar Telescope (EST) will be an advanced large-aperture solar telescope with a 4.2m primary mirror optimised for studies of the magnetic coupling of the solar atmosphere.

The CTA will consist of more than 100 telescopes located around the world, to research the origin and role of relativistic cosmic particles, probe extreme environments and explore physics frontiers.

EST will provide the increase in observing capability needed to understand the fundamental processes that control plasma physics in the Sun's outer atmosphere.

In November 2023, to celebrate Observatory Sciences' 25th birthday, the Company is taking staff to visit the Observatories on La Palma.

NEW SOFTWARE WILL TAKE HYDRA TO NEXT LEVEL

The Hydra multi-fibre spectrograph instrument on the WIYN telescope in Arizona has recently undergone a hardware upgrade, and Observatory Sciences Ltd (OSL) has been contracted to develop an upgraded software control system for the instrument.

The WIYN Observatory is a 3.5m optical telescope atop Kitt Peak, second-highest peak on the Tohono O'odham Nation Reservation in the desert state. It is operated by a consortium of universities from Indiana, Wisconsin-Madison, Pennsylvania State and Purdue plus the NSF's NOIRLab. The telescope incorporates an actively controlled mirror and is renowned for its excellent image quality.

Hydra is a multi-fibre positioner that places optical fibres at the telescope focal plane corresponding to precise object positions on the sky. The light from each fibre is then transmitted to a bench spectrograph.

"Hydra's original hardware was built about 30 years ago and its software is now over 20 years old," says Philip Taylor of OSL. "The upgrade we are working on will modernise its capabilities to a new level to serve a new generation of astronomers and astrophysicists."

Credit: Kitt Peak National Observatory/NOIRLab/NSF/AURA/R. Sparks

DIAMOND LIGHT TO SHINE 70 TIMES BRIGHTER

The UK's Diamond Light Source synchrotron is to undergo a co-ordinated programme of development over the next few years. In June 2022 Diamond Light Source received confirmation that UKRI has allocated £81.5M for the first phase of Diamond-II until April 2025. The development project will combine a new machine and new beamlines with a comprehensive series of upgrades to optics, detectors, sample environments, sample delivery capabilities and computing power. This will improve brightness and coherence by a factor of up to 70, across existing beamlines. This, plus three new flagship beamlines, will open up a new era of scientific opportunities.

To facilitate this step change, Observatory Sciences Ltd (OSL) is helping to develop a web-based EPICS control system User Interface (UI). This UI is already displaying real-time beam status information in the Diamond Light Source control room and around the building.

OSL has also been involved in the development of a back-end application to serve the EPICS Process Variable data to the web UI. Progress continues towards producing a comprehensive web-UI.

Credit: Diamond Light Source 2023