ERLP COMMISSIONING

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Abstract

ERLP (Energy Recovery Linac Prototype) is a 35 MeV ERL and FEL test facility located at Daresbury Laboratory. Electrons are produced using a laser-driven photoinjector. This part of the machine is complete and first electrons were produced in August last year. Work is still being carried out to optimise the photoinjector. It is physically separate from the rest of the machine at the moment so that the construction of the remainder of the machine could continue in parallel with photoinjector commissioning, as well as the commissioning of the cryogenic and RF systems. Naturally, some conflicts have arisen as a result of trying to do these activities in parallel.

The gun has its own set of diagnostics and once commissioning is complete some of these will be removed and the photoinjector will be connected to the rest of the machine so that commissioning of the beam transport, ERL and FEL sections can proceed. This paper also discusses the training of the staff that run this machine, the method of production of the documentation, how documentation is stored and the way in which the people involved in the project communicate with each other.

OVERVIEW

As part of the UK's R&D programme to develop an advanced energy recovery linac-based light source (called 4GLS), a 35 MeV technology demonstrator called the Energy Recovery Linac Prototype (ERLP) has been constructed. It is based on a combination of a DC photocathode electron gun, a superconducting injector linac and superconducting main linac operating in energy recovery mode, driving an IR-FEL. The priorities for this machine are to gain experience of operating a photoinjector gun and superconducting linacs; to produce and maintain high-brightness electron beams; to achieve energy recovery from an FEL-disrupted beam and to study challenging synchronisation issues.

The significant milestones achieved on this machine so far are:

- First electrons obtained from the gun;
- Operation of the cryogenic system to cool both superconducting linac modules to 2K;
- Demonstration of RF-photoinjector drive laser synchronisation;
- High power RF tests of the linac module;
- Commissioning of a terawatt laser to drive a Compton-backscattering x-ray source and electro-optic longitudinal beam diagnostic.

In addition, this progress has been made in parallel with an extensive construction programme to complete the installation of the whole machine (barring a few diagnostic devices currently being used with the gun) in preparation for commissioning of the completed machine at a later date. Details of the status of the commissioning of ERLP can be found in [1].

PLANNING THE COMMISSIONING

In order to make as much progress as possible with the commissioning of ERLP in the shortest possible time, it was decided to commission the electron gun, using a dedicated diagnostic beamline, while the rest of the electron Beam Transport System (BTS) was still being constructed. This rationale was based on the fact that the lead time for the delivery of the superconducting linac modules was significantly longer than any other major component. In addition, an existing building was available to house ERLP, minimising the civil engineering required before accelerator components could be placed on the floor.

Unfortunately, problems in achieving a XHV-standard braze between the 14 inch diameter gun ceramic and its metal flanges led to serious delays in the gun construction programme. This in turn led to the gun commissioning starting late and coinciding with the most intense period of BTS construction. In addition, various problems with the operation of the electron gun have also delayed gun commissioning. This has now led to the gun commissioning being on the critical path rather than having a comfortable degree of slack. Thus the gun and the overall commissioning plan have been subject to frequent significant rewriting.

COMMISSIONING AND CONSTRUCTION CONFLICTS

In order to undertake construction and gun commissioning in parallel it has been necessary not only to separate these activities in time (in general construction work has taken place during "office hours" and commissioning overnight and at the weekends) but to pioneer a new method of control and authorisation of work. Almost all work on the accelerators and associated systems at Daresbury takes place under a Permit To Work (PTW) system. A permit will be taken out for a specific piece of work, which may last several days and will include a risk assessment and a written system of work if the work is not routine. While the permit is in force the accelerator will usually be disabled in some way. However, it would not be practical to cancel every permit on ERLP

every evening to allow commissioning to take place and then take out new permits every morning. To overcome this, a "Handover Procedure" has been developed (see below) to allow accelerator beaming while there are still outstanding permits to work.

In addition, most of the staff who work on ERLP do not work on this machine full time. The commissioning team are mainly accelerator physicists and technologists who are working on other projects, which means that particular emphasis has to be placed on keeping them up-to-date with the status of the machine and its commissioning. The construction team are also involved in other accelerator projects at Daresbury Laboratory, particularly the Synchrotron Radiation Source (SRS). The SRS has a user and shutdown schedule written many months in advance; planned maintenance and emergency repair work take priority over any ERLP activities, leading to periods when progress on ERLP construction is limited by conflicts with the SRS programme.

SCHEDULING AND SHIFTS

In the periods when commissioning is taking place a three shift system is used to divide up the day as follows:

- Shift 1 00:00-08:00
- Shift 2 08:00-16:00
- Shift 3 16:00-00:00

On weekdays commissioning normally only takes place during shifts 1 and 3 and the machine is opened up for construction work during shift 2. At weekends the machine is usually operated for commissioning on all three shifts. In addition, construction work is often allowed to overrun beyond 16:00 when it makes sense for the job to be completed or a particularly important piece of work must be finished.

The staff who man the commissioning shifts are rostered on shifts on a casual basis (i.e. they do not work shifts every day; on average doing one ERLP shift a week). This is done by first asking staff to complete an Excel spreadsheet recording their availability for shift working one month in advance. Commissioning team members are expected be available a reasonable amount of the time (including outside normal working hours) but they are not expected to be available for every shift. A roster is then drawn up based on staff availability. A macro within Excel has been developed which uses Microsoft Outlook to automatically send invitations to those people on shift so that the ERLP work appears in their calendar. Because there is a large pool of people to choose from, rostering shifts in this way has never yet been a problem. If the pool of people were smaller it may become necessary to make people work fixed shifts.

HANDOVER PROCEDURE

In order to operate ERLP without cancelling all existing PTWs, it was necessary to develop a robust method to manage the transition from construction to commissioning and vice versa, in order to assure personnel and machine safety.

ERLP has a Site Manager assigned every day who is in charge of issuing PTWs and who will have an oversight of what construction work is going on that day and which permits are outstanding. A second person, the Handover Manager, is responsible for the handover procedure being followed correctly. A number of steps must be followed and recorded and signatures obtained on a sheet each handover, Fig 1.

ERLP Gun Commissioning - Handover Check Sheet - WITH BLOCK WALL			
Date:		Permit No:	
Handover Manager:			
Site Manager:			
Key Commissioning Person:	See attached shift roster		
Other Commissioning Team:			
Must Be Carried Out On Handover to Commissioning			
	Task		**Signature**
1	Review current PTWs to confirm that commissioning is feasible		
2	Shift roster sent to SRS MCR and Security		
3	Carry out pre-search inspection:		
3.1	Ensure platform acoustic covers are padlocked.		
3.2	Floor ducts cleared and panels down.		
3.3	Door in yellow mesh fence locked and Castell key in PS rack.		
4	Copy of PTW and original of this check sheet put in "Permit to Work" folder.		
Search Procedures Required			
Roof Search			
Pumping Platform Search			
Accelerator Room Search			
Potential Hazards and Obstructions			
All laminar flow units, temporary scaffolding, etc. should be included here.			
Must Be Carried Out On Handover to Construction:			
1.1	Turn off laser and HV systems as detailed in manual. Open and then lock laser room door.		
1.2	Remove PSS run key and accelerator room shielding key and place in lock-out box in control room.		
1.3	Perform radiation survey and record maximum level seen in shift log and on whiteboard at entrance to accelerator from control room.		
1.4	Turn HV power supply contactor off and lock.		
1.5	Remove two Castell keys from external labyrinth doors and place in lock-out box in control room.		
1.6	Place all laser-related keys in lock-out box in control room.		
1.7	Lock lock-out box in control room.		
Confirmation that I have read this AND the PTW:			**Signature**
Key Commissioning Person 1st Shift			
Key Commissioning Person 2nd Shift			

Figure 1. Handover Checksheet

- The Site Manager checks that there are no outstanding PTWs that prevent commissioning;
- Jointly the Machine and Handover Managers tour the accelerator to ensure that there are no personnel left inside, including looking in confined spaces and under floor panels. In addition a record is made of any safety hazards or obstructions

that may affect the subsequent commissioning.
- The Site Manager then generates the PTW for the commissioning work and issues it to the commissioning team, simultaneously releasing the keys for machine operation.
- The Key Commissioning team member (see below) reads and signs the handover sheet.

A copy of the handover sheet is kept with the permit on display as it must be read by subsequent Key Commissioning team members. The handover sheet also specifies what must be done to return from commissioning to construction mode.

All that remains is for the commissioning team to search the accelerator prior to commencing commissioning. After the handover, the commissioning team, and particularly the Key Commissioning team members, are responsible for personnel and machine safety in all areas of ERLP.

COMMISSIONING TEAM

Every beam commissioning shift requires two people, one of whom must be a "Key Commissioning Team Member", who is not only responsible for leading the technical work undertaken on the shift, but is responsible for personnel and machine safety in all areas of ERLP. During periods of ERLP commissioning the key team members will be devoting 30% of their working time to ERLP commissioning-related work, and will have undertaken extra training. The second member of the team will not be making such a large commitment to ERLP, but they are expected to keep up-to-date with progress of the project and be interested and enthusiastic to take part.

TRAINING

All personnel who wish to enter the ERLP accelerator areas must have undertaken basic radiation safety training (or be accompanied at all times by someone who has). This is enforced by a controlled access system that uses the person's identification badge to operate electronic locks on the doors.

The commissioning team have additional training on the operation of the Personnel Safety System (PSS) and how to carry out a search of the ERLP accelerator controlled area. If there was a radiation-related incident during a commissioning shift, the SRS duty crew (the SRS control room is manned 24 hrs a day during normal user operations) can be called and are responsible for implementing any action required.

The Key Commissioning team members have additionally had further training in the management of health and safety, including a new four-day course being rolled out at Daresbury to all those people with management or project responsibilities.

Running in parallel, there is a separate system in place for the control and authorisation of laser system work. All the Key Commissioning team members, if they do not already have the required laser training, are trained and authorised to turn the ERLP photoinjector laser system on and off.

COMMISSIONING TASKS

At present, as the construction of ERLP is not complete, commissioning has been undertaken in the following areas:

- Photoinjector laser system. This was installed and commissioned prior to the ERLP gun being ready to beam. Following the first phase of gun commissioning further enhancements to the system were implemented. If the full-power laser beam is exposed in the ERLP accelerator area, the handover system and the PSS is used to create a temporary "Laser Designated Area" to exclude personnel not authorised to be present.
- The electron gun is currently beaming into a dedicated gun diagnostic beamline, while the rest of the construction continues around it. This requires the implementation of all the systems required to control the radiation levels inside and outside the accelerator.
- The cryogenic system, designed to produce liquid helium at or below 2K to cool the two accelerating modules, has undergone a long period of commissioning. This has usually been possible in parallel with the construction work and therefore has not been done exclusively in the commissioning shifts.
- RF system – the buncher cavity, transverse deflecting cavity and main superconducting accelerating modules are all now commissioned in readiness for beaming.

DOCUMENTATION

ERLP has a safety handbook which is issued to all the key commissioning team members and certain other staff who work on the machine. It covers how safety is organised, lists the people who have defined safety responsibilities (and what those responsibilities are) and details procedures for carrying out all types of work on the machine. The content of this handbook is presented during the basic safety training which all staff must attend. This handbook is also available on the internal web so that staff have access to the most up-to-date version at all times.

Associated with all systems that can potentially produce ionising radiation are a set of local rules. All

commissioning team members must be familiar with these.

An item of shareware, “ELOG” has been modified to provide three electronic document systems: a log for recording the work undertaken during the commissioning shifts, a fault reporting system which automatically e-mails selected technical specialists with details of the fault recorded, and an ERLP manual. The manual includes the procedures which staff who are involved in commissioning shifts should be familiar with. This manual is slowly being replaced by a Wiki-style ERLP manual, which can be edited by anyone but automatically keeps a record of all previous versions. This is also easier to navigate within and search for particular terms. All of these documents are web-based and therefore can be read by our international collaborators from outside the site.

There is a live project plan which is updated regularly so that everyone involved in the project can see where it is up to and when the next commissioning period will begin. When commissioning is taking place there is also a much more detailed shift by shift plan of the work to be done. The fine detail is only added to this plan near the time when the work is to be done.

Reports detailing the outcome of significant work during the commissioning shifts are written after the work has been discussed at a weekly meeting.

COMMUNICATION

Due to the fractured nature of the team working on the project, a number of meetings are held on a regular basis to facilitate communication between team members. While construction is taking place a meeting is held at 09:00 every weekday to discuss the work that is going to happen that day and resolve any conflicts within construction work and with commissioning. In addition a weekly planning meeting is held to look at construction issues over a longer timeframe.

During commissioning periods a meeting is held to discuss what will happen in the next 16 hours of commissioning shifts at 16:00 every weekday. All the commissioning team members who have been on shift in the previous 24 hours or who will be on shift in the next 24 hours are expected to attend (with the exception of those on night shifts). This meeting also keeps the commissioning team up-to-date with any recent changes to the hardware or any safety issues that need to be brought to their attention.

A weekly commissioning shift review meeting takes place which is attended by all key commissioning team members and as many other commissioning team members as possible. This meeting is held to discuss the previous week’s work and to plan the coming week’s work. It also identifies what reports are required to record the commissioning work undertaken in the previous week.

CONCLUSION

We have developed a successful method of simultaneously constructing and commissioning a particle accelerator which satisfies all health and safety requirements without imposing an impractical level of administration. This has allowed significant progress on ERLP to be achieved despite some technical difficulties and provides the flexibility to accommodate a construction and commissioning team, the majority of whom are not dedicated to the project.

REFERENCES

[1] S.L. Smith et al, ‘The Status of the Daresbury Energy Recovery Linac Prototype’, Proc. PAC 2007.