AD AND LEIR CONSOLIDATION

T.Eriksson, M.-E. Angoletta, L.Arnaudon, J.Baillie, M.Calviani, F.Caspers, M.Cattin, A.Fowler, L.Joergensen, G.Le Godec, R.Louwerse, M.Ludwig, D.Manglunki, A.Newborough, C.Oliveira, S.Pasinelli, A.Sinturel, G.Tranquille, CERN, Geneva, Switzerland

Abstract

As the AD programme now faces a renewed lease of life following the start of the ELENA project, it is essential to ensure best possible reliability and performance for the next 20 years or so. The AD machine, which was started in 1999, is based on the Antiproton Collector (AC) ring of the Antiproton Accumulator Complex (AAC) which in turn was constructed in the mid-80:ies. Since most of the major AD components were retained from the AC, we now have a significant amount of 30-year old equipment to deal with.

LEIR is in a similar situation having started life in the 80s, supplying antiproton beams at various energies for the PS physics programme. After having been transformed into a heavy ion accumulator in 2004 and subsequently used in operation, some consolidation needs have become apparent. LEIR is expected to keep delivering heavy ions to the North Area and to the LHC until 2035, and possibly light ions to a new biology research facility in the South Hall.

A consolidation programme is underway for both machines and here we will discuss the main aspects of ongoing and planned activities from an operational point of view.

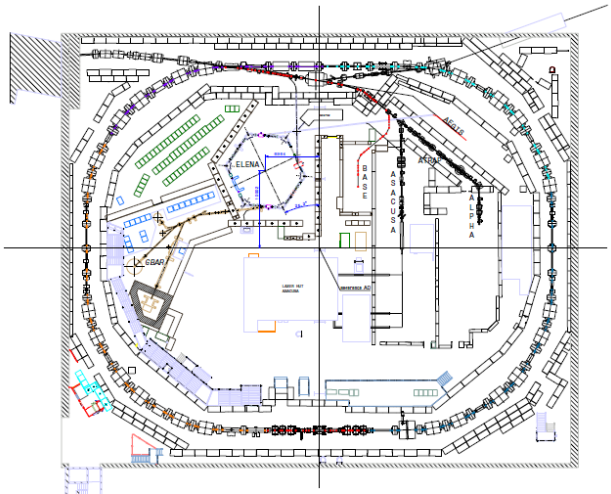

Figure 1: Layout of AD, ELENA and experimental areas.

INTRODUCTION

During more than ten years of regular operation, CERN's Antiproton Decelerator (AD) has supplied the successful physics program with low-energy antiproton beams at 5.3 MeV kinetic energy. The approved Extra Low Energy Antiprotons (ELENA) project will greatly increase the ejected beam density and intensity thereby increasing the number of trapped antiprotons at the experiments by up to two orders of magnitude. ELENA will deliver antiprotons at 100 keV to the experiments as of 2017. For the AD machine itself, an extensive consolidation program has been worked out. To reliably produce antiprotons and deliver them to ELENA for the next 10–20 years, all AD sub-systems have to be renovated or renewed. In total, a budget of some 23.8 MCHF has been allocated for AD consolidation during the period 2014 to 2020.

Layout of AD, ELENA and the experimental areas can be seen in Fig.1.

LEIR (Low Energy Ion Ring) is based on LEAR which was used for antiprotons starting in 1983. No general consolidation plan has yet been defined but a number of consolidation requests have been issued.

AD PRODUCTION TARGET AREA

The AD target area (see Figure 2) is undergoing important consolidation activities which will continue in the next years during the "ELENA era" of the AD machine exploitation. An initial and limited program took place during LS1 treating the most urgent items. A serious breakdown of the Magnetic Horn assembly was discovered in LS1 and repaired just in time for the start-up. This indicates the need for urgent and in-depth consolidation of the whole target area and associated systems. In case of further failures between LS2 and LS3, a significant impact on the AD physics program can be expected as well as increased contamination levels and radiological risks.

The main activities about to start are:

- Studies for a new target design with modified cooling.
- Production of spare Targets and Horns including stripline and junction box.
- Renewal of Target and Horn chariots
- Renovation of cooling and ventilation systems.
- Renovation of surface buildings.
- Additional monitors for beam intensity and position.

A budget totalling some 5.5 MCHF has been requested for the work packages which are spread over various groups/departments. Activities need to start as soon as possible in order to be ready for installation during LS2.

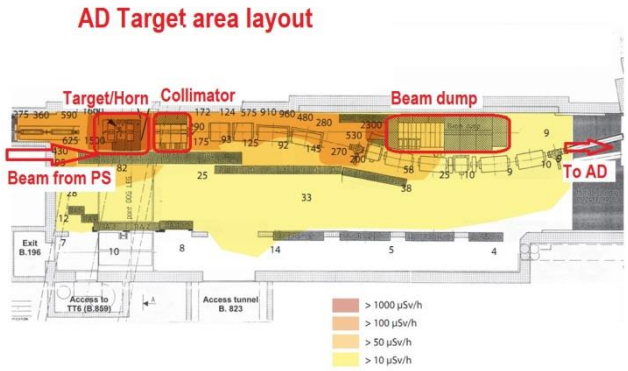

Figure 2: Layout of the production target area

AD MAGNETS

Degradation of the coil shimming has been observed in several of the 24 AD ring bending magnets as movement of the coils in relation to the yokes has gradually increased over the last few years. Renovation of the first unit (DR.BHN06) during LS1 showed that the coil shimming was severely degraded. The coils themselves were in good state and thus re-installed. Regular measurements of the coil movement of the dipoles will determine the order of renovation of the remaining units during the years to come. Procurement of some types of spare coils is about to be completed in order to have a complete set available.

For the ring quadrupoles, no specific needs have been identified as these 57 units underwent a re-shimming campaign a few years ago.

A general consolidation of the target area magnets is also planned. Apart from renovation of spare units, which can be difficult due to high activation levels, a re-design of the two quadrupoles immediately upstream of the target is under study. This was prompted by lack of knowledge about state, manipulation and connections.

As part of the ELENA project, all ejection line magnets will be replaced by electrostatic elements in a few years effectively eliminating consolidation needs here.

A total of 1.67 MCHF has been foreseen for magnet consolidation.

AD POWER CONVERTERS

A general consolidation program with the aim of standardizing the magnet power converters has been launched for the period 2015 – 2020 at a cost of 2.2 MCHF. The aim is to reduce the number of converter types. Included is upgrade of main ring converters, renewal of orbit corrector converters with standard Cancun units, replace the pulsed injection line converters with Megadiscap units and also replace thyristor converters with commercially available units.

AD VACUUM SYSTEM

A general consolidation of the vacuum system is underway since 2013 with the aim of completion by 2018. Cost is estimated at 2.2 MCHF. Completed or near-completion: Renewal of control system, Cryo-system, Sublimation pump filaments, 6000-line primary pumps, turbo-pump groups, previdage valves and Pirani/Penning gauges. Ongoing: renewal of bakeout equipment and Ion pumps, installation of Ion pump HV-feedthrough heaters and also integration of the BASE beamline vacuum equipment. To be started in 2015 is: Fabrication of spare vacuum chambers, Standardization of straight sections, procurement of spare Cryo compressors and renewal of the gas injection system as well as the fast valve electronics.

AD BEAM TRANSFER EQUIPMENT

A total budget of 950 kCHF is planned for beam transfer consolidation.

Prompted by the ELENA installation, the injection and ejection kicker pulse generators will have to be re-located into the new building B393. At the same time a renewal of the sub-systems will take place including controls and electronics renewal and consolidation of dump and main switches. This is to be operational for the 2015 start-up.

Other equipment that will be addressed includes:

- Renewal of septa electronics and controls
- Replacement of the Horn pulser HV supply
- Phase-out of the mercury switches for the Horn pulser ignitrons
- Installation of a test bench in B195 for testing Magnetic Horns

AD STOCHASTIC COOLING

A significant part of the consolidation was finished in time for the 2014 start-up.

Modern switch mode power supplies along with a modern PLC system for control, acquisition and interlock handling has replaced the old power supplies for the 48 RF power amplifiers.

Dynamic and static delay and attenuator control ("Platform Fritz") have been upgraded with PLC control. The notch filter delay line of the longitudinal system has been re-located to make space for ELENA. To further gain space in the AD hall, investigations will be done for the possible use of optical delay lines instead of the present coaxial cable. Both delay lines could initially be operational simultaneously in order to compare performance and reliability.

The pick-up and kicker tanks motor control has been modernized with up-to-date HW.

The 48 RF power amplifiers are equipped with obsolete semiconductors. Replacement using a new design or upgrade of the present design are under consideration. Estimated cost for a new design is 1 MCHF. Some prototype work will be done as a first step while carefully monitoring the failure rate of the operational amplifiers.

Life expectancy and mechanical integrity of the pickup and kicker tanks and their associated equipment is not very well known. A consolidation strategy has not yet been defined at this stage.

AD ELECTRON COOLING

The current electron cooler at the AD was recycled from the previous ICE and LEAR machines at CERN and is now close to 40 years old. No spares for the magnetic system exist. It has been decided to build a new electron cooler for the AD incorporating all the advances in electron cooling from the intervening period such as e.g. adiabatic expansion, variable density electron beam and electrostatic deflector plates for efficient collection of the electron beam. The preliminary design studies for the new electron cooler are being launched with an aim to install it at the AD during LS2 scheduled for 2018. Estimated cost is around 2.5 MCHF.

AD RF SYSTEMS

After replacement and relocation of the C02 (2 MHz) cavity tuning and HV power supplies with modern and more compact devices, next step is to migrate the low-level system to the Digital LLLRF (DLLRF) family [1] currently under development for all circular machines in CERN's Meyrin site. This is expected to take place between 2016 and 2018.

This new DLLRF family is an evolution of the system successfully operational in LEIR since 2006 [2]. The main benefits of the DLLRF approach are its remote controllability, built-in diagnostics and extensive signal observation capabilities. Its digital nature grants an excellent repeatability as well as the implementation of extensive archiving capabilities; this will allow recalling previously-validated sets of control parameters.

Regarding the 2 C10 (10 MHz) systems used for bunch rotation at injection, a solution has to be found for renewal of the final power stages where obsolete TH116 triode tubes are used. Only a few spares are available at this moment and a complete re-design of the system at a cost of some 4 MCHF might be necessary to ensure continued operation.

AD INSTRUMENTATION

In order to measure tunes during the deceleration ramps, a "BBQ" system, already used elsewhere in the LHC injector chain [3], and connected to the 5.7 MHz Schottky pickup has been installed and is ready to be commissioned for operation.

A new orbit system using individual ADC:s for each pickup is being developed with installation planned for 2015. This will allow orbit measurements also during the ramps.

To measure the low intensity of the circulating beam, a new technique will be tried at AD, also in view of possible use in ELENA. A ccc (cryogenic current comparator) will be installed in 2014-2015 and subsequently evaluated. A precise and continuous read-out during the AD cycle is expected, this will greatly improve and simplify monitoring of machine performance.

The ionisation profile monitors, which non-destructively measure the circulating beam profile throughout the deceleration cycle, will be upgraded to a strip read-out system similar to what has been implemented on LEIR [4]. The two monitors will be installed in vacuum sector 42 and will share a common gas injection system.

Further Instrumentation consolidation includes renewal of 2 BCT:s, addition of 1 BCT and 1 BPM in the target area and integration of the Schottky based DSP system into the new RF Low-level system.

Total consolidation cost for instrumentation during the period is around 900 kCHF.

AD CONTROL SYSTEM

A major upgrade was performed during LS1 with upgrades of the timing and cycle generation systems. Furthermore, the front-end computer upgrade and FESA/JAVA/InCA migration is nearly completed. No further consolidation needs are foreseen for the moment.

AD INFRASTRUCTURE

Requests have been made for a complete cooling/ventilation upgrade in B193 and B195 during LS2 at a cost of 5.9 MCHF. Upgrade of the overhead cranes in B193 is also requested for LS2 at a cost of 750 kCHF.

An upgrade of the present system for distribution of liquid Cryo-gases is planned for 2015/16 at a cost of 750 kCHF.

LEIR CONSOLIDATION

LEIR was transformed into a heavy Ion accumulator ten years ago. No general consolidation plan has been worked out as of now and only a few consolidation requests have been made.

LEIR MAGNETS

Main bending spare coils (190 kCHF): Production is in progress at SigmaPhi (FR) and prototypes are currently being validated.

Main quadrupoles spare coils and spare magnet (110 kCHF): produced and currently undergoing geometrical inspection at Danfysik (DK)

Ring extraction bumper & corrector, transfer line magnets: Spare magnets and coil sets are needed but this has a lower priority.

LEIR POWER CONVERTERS

Transfer line Danfysik converters: There are some reliability issues with the twenty operational units. A study is needed since these are not compatible with standard CERN converters. Estimated replacement cost is 600 kCHF.

Septum ER.SMH11 converter: Old non-standard unit with reliability issues. To be replaced with commercial unit at a price of 100 kCHF.

Furthermore a study is needed to investigate compatibility with 10Hz operation.

LEIR INSTRUMENTATION

The present Schottky analysis system is based on Agilent spectrum analyzers. Practical remote operation from CCC is not possible and the Windows operating system is no longer supported by CERN's IT Department. A new system needs to be developed in–house.

A system based on the ELENA orbit measurement system will be used at LEIR. It is proposed to implement this in the second half of 2016 at the same time as the upgrade of the digital RF system.

LEIR CONSOLIDATION, OTHER

Low-level RF: It is planned to upgrade to the same hardware and software as recently deployed and commissioned in PSB. This will probably happen in 2015, depending on the manpower available in BE/RF. After 2015 some parts of the existing system will no longer be supported by BE/CO. Also, some issues related to the real-time part of the FESA class have started to appear this year. This is not yet understood.

Electron cooler: renewal or spare part procurement for the collector.

REFERENCES

[1] M.E. Angoletta et al., "CERN's LEIR Digital LLRF: System Overview and Operational Experience", IPAC '10, Kyoto, Japan, May 2010, p. 1464.

[2] M. E. Angoletta et al. "CERN's PS Booster LLRF Renovation: Plans and Initial Beam Tests", IPAC '10, Kyoto, Japan, May 2010, p. 1461.

[3] M. Gasior, R. Jones: "The principle and first results of betatron tune measurements by direct diode detection", LHC-project report 853, CERN.

[4] First Results from the LEIR Ionization Profile Monitors, C. Bal, V. Prieto, R. Sautier, G. Tranquille, DIPAC'07, 20-23 May 2007, Venice.