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AAC CONSOLIDATION

S. MAURY

ABSTRACT

The AAC consolidation study has been carried out in case the AAC is prolonged for a further 10 years and, in particular, with SuperLEAR. This study is also valid for the short term of the $\bar{p}$ physics programme. Thus, in order to keep the desired high reliability of the machines, the consolidation of a certain number of elements and of the target area is presented.

In the event that the life of the AAC is prolonged for a further 10 years, a certain number of elements will need to be changed and consolidated, and a buffer stock of spares should be made available for both the machines and the target area in order to obtain the desired high reliability. However, should the $\bar{p}$ programme continue for 3 years, some of these same elements will still require improvement to ensure the approved $\bar{p}$ physics programme.

In particular, I would like to draw attention to some key elements such as the target area robots and some missing spare parts in the machine which are absolutely crucial for the $\bar{p}$ physics. Operating these robots requires high skills and concentration from their operators. This implies continuity of trained and experienced personnel, properly established, who should work on robotics as a first priority in order to maintain and improve the equipment.

The consolidation of the elements and the establishment of the team must start as soon as possible and missing elements in the buffer stock must be purchased immediately in order to be fully confident of $\bar{p}$ production and to ensure the on-going $\bar{p}$ programme.

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INTRODUCTION

To run with a luminosity of 10^{32} $cm^{-2}s^{-1}$ in internal target mode SuperLear needs "topping-up" with batches of typically 3×10^{11} $\bar{p}$ every 8 h corresponding to a rate of 1×10^7/s.

With slow extraction a similar rate is desired.

The longitudinal acceptance of SuperLear is at least 1 eVs. At present 40% of the $\bar{p}$ stack can be ejected from the AA in one shot within this longitudinal emittance. Therefore, to transfer 3×10^{11} $\bar{p}$, a stack of 8×10^{11} $\bar{p}$ will be needed. This is well within the present capabilities of the AA and similar to the performance which was required for Sp$\bar{p}$S.

Obviously, the stacking rate is strongly dependent on the number of production cycles and for maximum performance every other PS cycle would be used. This mode of operation looks compatible with the anticipated future programme (Table 1), except for periods where several of these clients work simultaneously.

Table 1

Supercycle length(s)	19.2		14.4	
Number of cycles/supercycle	8		6	
Lead ion physics	working		not working	
LEP physics	working		not working	
Number of cycles for SuperLear	2 or 3		2 or 3	
Stacking rate (10^{10} $\bar{p}$/h)	2.6	4.0	3.5	5.0
Time to add 3×10^{11} $\bar{p}$ into the stack (h)	11.5	7.5	8.6	5.8

The production rate for SuperLear of 10^7 $\bar{p}$/s is based on the AAC $\bar{p}$ operation with a yield of 55×10^{-7} $\bar{p}$/p, a production beam of 1.5×10^{13} p on the target and a stacking efficiency of 80%. This yield has been achieved in the past with the 20 mm lithium lens and a careful setting of cooling is necessary to get such a stacking efficiency. The performance of the 400 kA magnetic horns is 15% lower. In the case of SuperLear, we have studied the possibility of producing antiprotons with more performant magnetic horns because magnetic horns have many advantages compared to the other collectors:

- simplicity (no dangerous chemical material),
- efficiency (used at top current),
- small weight,
- cheapness (the cost of the removable part is about 20 kSF),
- low-induced radioactivity (aluminium).

In 1988, a 400 kA magnetic horn was used for $\bar{p}$ collection for a few months. It had never been tested in laboratory. Then, a big 34 mm lithium lens was developed and used for the SPS collider runs. Later the same horn was re-installed and worked for about 12 months until it broke in December 1991. During the last Sp$\bar{p}$S collider run we reached 2.4×10^{10} $\bar{p}$/h with 2 cycles in a supercycle of 14.4 s. This performance of the 400 kA magnetic horn is not fully sufficient for SuperLear. Other 400 kA horns broke during laboratory tests or after relatively short operation in the target area. We are now working to get a reliable collector. Once we get a 400 kA magnetic horn, we should work on a higher current horn to be safe for SuperLear.

The present performance of the AAC with the 20 mm Li-lens, when all systems are well adjusted, looks adequate to supply $\bar{p}$ to SuperLear at a rate of 3×10^{11} every 8 h. In very busy periods, where the PS has to serve several other clients simultaneously, about 2.6×10^{10} $\bar{p}$/h would still be available. Some upgrading looks possible but does not seem essential to satisfy the programme as defined at present, but the consolidation of some elements is necessary for the machines and the target area as well to obtain the desired high reliability.

AAC MACHINE CONSOLIDATION

1. STOCHASTIC COOLING

To guarantee the high stacking rates and long stack-life times (>500 h) as achieved in the years 89-91, various improvements are suggested.

- Upgrade the low level circuitry of the precooling and stack-tail systems by replacement of components with mediocre phase amplitude characteristics (low level amplifiers, splitters, etc.).
- Purchase a modern facility for a quick design and manufacture of microwave amplitude and phase correctors, as currently used at Fermilab. The correctors would not only improve the direct feedback action of the cooling systems but also the filter characteristics (deeper notches, more correct notch frequencies).
- Improve procedures (and possibly add hardware) to avoid longitudinal blowup during bunching in the AC, transfer to the AA and debunching in the AA.

~300 kSF

2. AAC KICKERS

The AAC kicker consolidation which we propose concerns mainly the drift stabilisers, the trigger amplifiers, the circuit breakers and the high-pulse current connections. The price estimate is about 10 kSF/generator.

~160 kSF

3. AAC WATER COOLING

3.1 Magnet Cooling Circuit

The proposed AAC water cooling consolidation concerns mainly the ventilator reducers for the cooling tower, pumps and motors for the primary and secondary circuit. A 400 kW pump and motor should also be changed. To facilitate the operation of this cooling system, automatic temperature controls have to be added.

~ 250 kSF

3.2 Water Supply for the Air Conditioning System in Bldg. 193

Due to the 5 water leakages inside the Hall, which have been repaired by welding during the 91-92 shutdown, and to the generally bad condition of the water supply pipes, it is now necessary to replace them in order to avoid more serious problems in the future.

Two estimates have been made by ST Division, a) Argon-welded stainless-steel pipes with PIR heat-insulation, and b) GF galvanized-steel pipes with PIR heat-insulation.

This important work can only be carried out during a long shutdown. It necessitates a good organisation and, eventually, a tender action.

~ 80 kSF

4. POWER SUPPLIES

The consolidation of the power converters concerns mainly the AA ring power transformers.

A spare is needed for the quadrupole magnet power transformers, both QF and QD, and a revision of the bending BHZ transformer is desirable.

~110 kSF

5. RF POWER EQUIPMENT

To ensure further operation of the rf power equipment in the AAC for SuperLEAR, the following consolidation work is envisaged:

- revision of cascade and feedback amplifiers,
- modernisation of interlock systems,
- revision and modification of filament heating supplies, in particular for the bunch rotation cavities
- upgrading the electronic spares.

~80 kSF

6. VACUUM

6.1 Valves (VVS)

All four AA machine valves need to be changed and one spare must be available.

~114 kSF

6.2 Vacuum Gauge

The 50 AA vacuum gauges (BAG type with CSF modulators) have been recuperated from the ISR and the characteristics like sensitivity and pressure limit ($\sim 5 \times 10^{-11}$ mb) are poor. The consolidation consists in the replacement of these vacuum gauges by SVT 305 BAG type (similar to the LEAR ones) with better pressure limit (10^{-12} mb).

Power supplies and cablings should also be changed.

All these improvements should be made only if the AAC runs for more than 3 years or if it is decided to change the controls system before 1995.

~ 65 kSF

6.3 Compressors for PU Cooling

To run the AAC machine with a good reliability for a further 3 or 4 years, a stock of spares must be made available. For 1993, it is proposed to find money from the exploitation budget, and 100 kSF will be required for the years 1994 and 1995. AT Division is also going to ask for money to implement these needs.

In the event of the machine running for another 10 years, 400 kSF will have to be invested.

~ 400 kSF

7. VACUUM CONTROLS

At present, the AAC control system uses a NORD 100 computer with dedicated ex-SPS type of Touch Terminal consoles. It is planned to convert this control system to the new standard PS controls system with VME front-end processors and ULTRIX workstations as consoles by 1995/1996. Most of the budget is already included in the PS/CO project D067, but due to the necessity to change also the vacuum control, we should add 130 kSF for this work.

~ 130 kSF

This consolidation should be added in the D067 project.

8. CONTROL ROOM INSTRUMENTATION

Some specialised instrumentation (like frequency meter, spectrum analysers dating from 1978-79) need to be replaced by new versions because they are no longer maintained by the manufacturer.

~ 400 kSF

9. AA BAKEOUT

The old AA bakeout system, recuperated and re-used from ISR, should be consolidated and brought up-to-date. The consolidation and upgrade to reach conformity with electric security standards is estimated at

370 kSF

A completely new system with a PC control is evaluated at

400 kSF

If we continue the antiproton program for a further 10 years, the second solution is preferable.

10. PULSED QUADRUPOLES IN THE AC/AA TRANSFER LINE

There are no spares available for the two pulsed quadrupoles in the AC/AA transfer line. To ensure the $\bar{p}$-physics programme it would be advisable to build spares.

The investment for these pulsed quadrupoles is of

~ 150 kSF

TARGET AREA CONSOLIDATION

In the event that the life span of the AAC is prolonged, a number of elements of the target area may require changing, consolidating and reserve elements.

The reliability should be the main characteristics of all the collectors and all the elements put into this radioactive zone.

We are examining the possibility of producing antiprotons with magnetic horns. We are now working to get a reliable magnetic horn, and once we get a 400 kA magnetic horn, we should work on a higher current horn to be safe for SuperLear.

Is it possible to use a 20 mm lithium lens?

In the past, a collaboration between CERN and Karlsruhe was established to fill lenses with lithium at KfK where specialised equipment exists.

In principle it is possible to build and maintain such a lens at CERN but the expertise and the experience gained during the 12 years on lithium lenses is scattered.

The possibility to work on lithium lenses in a CERN workshop could be studied, although most of the experts are no longer available.

The budget to establish a filling station, with all its accessories would be about **200 kSF**. In addition, **120 kSF** are necessary to build a lens with its transformer, and finally **150 kSF** for a chariot as used to move the lens into and out of the beam.

The advantage of the lithium lens is the potentially higher (10-20%) yield. We could even slightly increase the performance by optimising the mechanical structure and putting the target closer.

A few words on the reliability of the Target Area

The target station includes of two sets of parallel precision aligned rails on which are mounted a target chariot and a collector lens chariot which both move in a high radiation level. Any manipulation either placing or removing the chariot, is and has proved to be an extremely high risk manoeuvre.

Up to now, the experience showed that the removal of the $\bar{p}$ collector was the most frequent manipulation. To permit the reliable continuity of antiproton physics, to reduce the number of human interventions in this highly radioactive zone, we propose to drill a hole of sufficient diameter above the collectors and to change them from the top (like at Fermilab) and not through the existing tunnel under Building 195. Due to the light weight of the magnetic horn, we can envisage the removal of the horns with a simple manipulator without moving the chariot.

Solutions should be carefully investigated. The other interventions (e.g. to change a magnet, ...) will be done with a remote handling system which could be a consolidated version of the present or a new device. This could also be investigated in collaboration with industry.

1. ROBOTICS

In order that the ACOL Target Zone and Dog-leg be able to function for the next ten years, consolidation of the handling system *and availability of sufficient staff to operate it MUST be foreseen.*

The Target Zone elements were specifically engineered to be compatible with an overall handling system based on the Service Vehicle, the Access Gallery and Shaft, the B232 Hot Shop and the remote manipulator Mantis. Up to now, this system has allowed to maintain the zone and to handle unplanned circumstances and incidents.

These operations are not automatic. They require proficient management and intense concentration and awareness of the operator. This implies a continuity of trained and experienced personnel, and properly established and maintained equipment.

1.1 Service Vehicle

Built by the ACOL team, on a very low budget, the service vehicle has been frequently stretched to new limits to suit new demands (e.g. 34 mm Li-lens).

Before being committed to a further 10 year's of operation, the service vehicle should be completely disassembled and overhauled.

1.2 Private Eye Mobile TV

All fully-remote operations, whether in the Target Zone, the Access Gallery or the Hot Shop involve the use of Prive Eye TV systems. One unit is mounted permanently on the service vehicle and another on MANTIS. Further units on trolleys are used independently for remote observation, e.g. searching for leaks, burn marks or debris. These units require specialised operation and maintenance. Availability of these units for the next 10 years implies complete revision and measures to ensure future maintenance support and continuity of personnel.

1.3 Radio-Controlled Device

Commercially obtained, the radio-controlled device WHEELBARROW has a fairly powerful radio system which works quite well in the limited ranges of the Target Zone and gallery. WHEELBARROW itself has limited use because it is restricted to short reach observation.

PRIVATE EYE 3 has a much better performance, but its radio communications are still in a prototype form and unreliable.

1.4 MANTIS

MANTIS 1 has been resident exclusively in the B232 Hot Shop for some years, except for a mission in the Neutrino Tunnel in January of this year. Its 22-year old servo-manipulator still functions but requires more and more attention in order to keep it going. It is used in planned or unplanned maintenance operations where hands-on work is restricted by gamma levels.

MANTIS 1 either requires substantial maintenance or it must be superseded by Mantis 2. This very large in-house project (MT Division) is at an advanced stage, with a newly developed control system just being commissioned.

Operation of Mantis is a job for skilled specialists. This implies team continuity.

The cost of this robotic hardware consolidation would be around

~ 200 kSF

A complete new service vehicle is of the order of

~ 250 kSF

2. BHZ6024 and BHZ6025

These two "C"-type dipoles were built radiation-hard but, one of these magnets failed in November 1991, and the coil needed to be replaced. It is considered that these coils have a design weakness and it would be advisable to replace them with new, modified ones.

A new magnet and a spare coil have recently been manufactured by PINK Engineering Ltd. It is proposed to manufacture two extra spare coils. The coils of the present two dipoles should be changed during an extended shutdown. The new spare magnet would serve as a complete emergency standby. The expected cost of two extra coils is approximately

~ 56 kSF

3. RADIATION CURTAIN AND COMMUNICATIONS

The curtain requires regular maintenance, and before starting on another long project, it would be advisable to change the electric drive motor and clutch.

The telephone and the intercom system at the entrance of the zone should be transferred to the other side of the tunnel to improve their shielding because they have often been out of order due to radiation damage.

All this work would cost of the order of

~ 15 kSF

4. WATER COOLING SYSTEMS

The cooling system of the injection line is part of the AAC main magnet cooling circuit, but the target and collector cooling systems are closed loop circuits fed from pumping stations in building 195. There is enough redundancy in the small pumping groups to cover an eventual failure, but the large pump has no spare. It is believed that this pump could be replaced by the smaller version in the event of its failure, and that is the reason why no large spare has been purchased.

A small spare pump is approximately

~ 20 kSF

This responsibility could be taken over by ST Division.

5. COMPRESSED AIR COOLING

The original reason to install the air compressors in TT6 was to operate under closed loop conditions and not to pressurise the target zone, thus avoiding radioactive air leaking out in an uncontrolled way. This idea was abandoned almost immediately after the AAC start-up, the air now being extracted directly from TT6. It is therefore of no further interest to continue to house these compressors in the TT6 tunnel, except for the reason that there is no building in the immediate area which could accommodate them. The location in TT6 has, on a number of occasions, been of great inconvenience requiring special access to investigate failures, and the repair not being possible until a later machine shutdown period.

Installation of the compressors on the surface should be studied and a second dry oil-free compressor should be purchased as a back-up. The present oily compressors could then be removed from the system. This would allow access and maintenance without interruption of the stacking.

The cost of a second compressor is about

~ 45 kSF

6. VENTILATION OF TARGET GALLERY AND TT6

Both systems have proved to be adequate and only require routine maintenance. The refrigeration compressors have failed on two occasions in the past four years. It is already known that during excessively hot weather the TT6 heat exchanger system on the roof of

Building 196 suffers from direct heating. This could be solved by the construction of a roof over the heat exchanger to provide shade.

The TT6 system would have to be modified, if the air compressors were reinstalled in a building on the surface. This modification would be around

~ 30 kSF

7. TARGET CHARIOT

In the event that the AAC is prolonged for a further 10 years, another target chariot should be built.

The cost of target chariot is about

~ 40 kSF

8. QDE6030 AND QFO 6040

These two identical, non-radiative, hard quadrupoles may be considered as reliable. We have no spare magnet but only 4 coils. Considering the disastrous consequences should they fail, it would be advisable to have one complete magnet as stand.

To manufacture the four quadrants would be of the order of

~ 100 kSF

9. MOVEMENTS AND INTERLOCKS

The target station was conceived and built in such a way that it was decided not to operate the station remotely because an intimate knowledge has been required in order to avoid damage to it or its chariot.

An improvement of the present movement and interlocks should be studied.

~ 70 kSF

10. SUMMARY

A summary of the AAC consolidation is given in Table 2 and of the target area consolidation in Table 3.

The column "3 years" concerns the consolidation necessary should the $\bar{p}$ programme stop within that time.

The column "more than 3 years" concerns the consolidation should the $\bar{p}$ programme run more than that time.

11. CONCLUSIONS

In the event that the life of the AAC is prolonged for a further 10 years, a certain number of elements will need to be changed and consolidated, and a buffer stock of spares should be made available for both the machines and the target area in order to obtain the desired high reliability. However, should the $\bar{p}$ programme continue for 3 years, some of these same elements will still require improvement to ensure the approved $\bar{p}$ physics programme.

In particular, I would like to draw attention to some key elements such as the target area robots and some missing spare parts in the machine which are absolutely crucial for the $\bar{p}$ physics. Operating these robots requires high skills and concentration from their operators. This implies continuity of trained and experienced personnel, properly established, who should work on robotics as a first priority in order to maintain and improve the equipment.

The consolidation of the elements and the establishment of the team must start as soon as possible and missing elements in the buffer stock must be purchased immediately in order to be fully confident of $\bar{p}$ production and to ensure the on-going $\bar{p}$ programme.

Table 2

AAC CONSOLIDATION

CONSOLIDATION	COST kSF	3 YEARS	MORE THAN THREE YEARS
AA stochastic cooling	300		+
Kicker	160		+
Magnet cooling circuit	250		+
Power supplies	110		+
RF power equipment	80	+ (interlocks only)	+
Vacuum valves/Gauges *	180		+
Vacuum controls **	130		+
Bake out *	400		(TIS decision)
Compressors for PU cooling *	400	+	
Instrumentation (control room)	400		+
AC/AA transf. line (pulse Q spare)	150	+	
Water cooling pipe (Bldg. 193)	80	+	
TOTAL	**2640**	**630**	**2010**

* This consolidation should be discussed with AT Division

** This consolidation should be put in the PS/CO project D067

Table 3

TARGET AREA CONSOLIDATION

CONSOLIDATION	COST kSF	3 YEARS	MORE THAN THREE YEARS
BHZ6024/6025	56		+
Quadrupole QDE6030	100		+
Water cooling	20		+
Air compressor	45		+
Robotics *	200	+(93)	
Communication	15	+	
Movement and interlocks	70	+	
Ventilation	30		+
Target chariot	40		+
TOTAL	576	285	291

NB: It would be very logical and elegant to remove collectors from the top and the compressors from TT6 tunnel (described in the text).

* This consolidation should be discussed with MT Division