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AAC CONSOLIDATION PROJECT

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<u>Distribution</u>

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1. *INTRODUCTION*

The aim of phase I of the consolidation programme (years 1989/1990) is to bring the AAC performance to the design goal* of the ACOL-project and to attain a level of reliability and ease of operation compatible with the expected physics programme and decreasing support personnel.

This part of the programme is based on operational experience and performance achieved todate, as well as on extrapolations supported by machine experiments and theoretical work. The items are commented in chapter 2 and listed in the Table at the end of this paper.

Of the most urgent items in 1989/1990, some have already been anticipated of the project approval in 1988. The commitments in 1988 are expected to somewhat exceed 780 kSF.

2. *ITEMS FOR CONSOLIDATION: 1989/1990*

About 15 months after completion of the ACOL project, the deficiencies and weakness of the AAC (resulting in a missing factor of about 2.2 in accumulation rate and 1.5 in maximum $\bar{p}$ stack intensity) have been identified:

1) Incident proton beam intensity
2) Modifications for reasons of radiation safety
3) Antiproton production
4) Debunching in Antiproton Collector
5) Stochastic cooling
6) Antiproton Accumulator

Some of these items (1, 4, and 6) require qualified manpower and machine study time more than major capital investments.

2.1. Incident Proton Beam Intensity

2.1.1. RF-Feedback system in the PS

On top of the high-level rf feedback installed this year for efficient beam loading compensation, machine studies indicate that a one-turn delay low-level feedback similar to the system built for the travelling wave cavities in the SPS is needed to further reduce the strong revolution harmonics of the $\bar{p}$ production beam during the merging process.

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* Design goal: $5 * 10^7$ $\bar{p}$ accumulated per shot, every 2.4 s
i.e. $7.5 * 10^{10}$ $\bar{p}$/h with all PS cycles
about 10^{12} $\bar{p}$/day in realistic operation.

2.2. Modifications for Reasons of Radiation Safety

2.2.1. Target Area

2.2.1.1. Remote handling and spare service vehicle. Several items related to remote handling need consolidation. In particular, there is a need for a back-up service vehicle (used for remote lifting and handling of practically all components in the target area). A failure of the present development service vehicle could turn the AAC off for long periods. Making Mantis II operational is also essential for any major intervention in the zone.

2.2.1.2. Improvement of target area mechanisms. The reliability of the target area mechanisms is still a cause for concern. Remote handling of certain parts of the system is not possible or very difficult, and positioning tolerances are outside design goals. Thus the need for further improvements to those mechanisms. This consolidation is a compromise; a complete redesign (abandoned at present) would cost about 1 000 kSF.

2.2.1.3. Radiation-hard quadrupoles. A failure of one of the two radiation hard pulsed quadrupoles downstream of the collimator will at present result in very long downtime of the AAC since they can only be repaired by remote handling, if at all.

Construction of a spare quadrupole has been launched in 1988.

2.2.2. Off-Line Target

2.2.2.1. Mock-up. At present, alignment checks of new chariots can only be done in the target area, where the radiation levels are increasing steadily. The mock-up zone in building 232 must be finished to enable us to check the chariots prior to installation in the target area.

2.2.2.2. Universal strip-line. At present two different types of strip-lines are in use for the collector lens "chariot" (one for horn and 36 mm lens, another for the 20 mm lens), a third would be required for a test of a plasma lens, and a fourth would be required for pulsed target tests.

It is proposed to develop a "universal" strip-line which satisfies the voltage and current requirements of all these devices.

2.2.3. Radiation Level

2.2.3.1. Improvement of tunnel roof shielding. New concrete beams with different orientation are needed over sections 1 and 13 of the AA, to facilitate the handling of the roof shielding by overhead crane.

2.2.4. Access Control and Maintenance Aspects

2.2.4.1. Power supplies: polarity inversion and earthing. More polarity inverters will expedite changes between normal and reverse polarity modes. A motorized earthing system of the AA and AC ring supplies will expedite safe access to the ring enclosure during any time of the day and night and avoid numerous lock-out procedures.

2.2.4.2. Improvement of AA septum coils. Present operating temperatures are very close to the limit. The water connections are cumbersome to disconnect (required at each bakeout) with a fairly high level of induced radioactivity. A rebuilt coil for the two dc septa is proposed.

2.3. Antiproton Production

2.3.1. New 36 mm Lithium-Lens

This item was postponed during the ACOL project due to lack of funds. The yield is predicted to be about 50% higher than with the cheaper 20 mm Li-lens and 60 mm Al-horn used so far. Since the measured $\bar{p}$ injection yield into AC falls short of expectations by a factor of about 1.5, it became urgent to reactivate that project early in 1988, in order to test and install this equipment in February 1989.

The 1.3 MA radiation hard pulse transformer is being designed and built by INP, Novosibirsk. The reimbursement for their work is not included in this budget proposal.

2.3.2. Improvement of $\bar{p}$ Transfer Efficiency

2.3.2.1. Vacuum chamber in dogleg. For simplicity and savings about 40 m of the dogleg injection line were built without a vacuum chamber and the beam passes through air. This results in a 10% loss in $\bar{p}$ yield due to scattering and absorption, and a factor 2 loss in proton stacking efficiency. A 10% gain in yield for 100 kSF is very cost effective!

2.3.3. Research and Development

2.3.3.1. Target analysis (Ispra). Although no signs of target failure or fatigue have yet been observed at 10^{13} protons per pulse, calculations predict that target and/or window problems can occur above 1.5 * 10^{13}, an intensity which will be achieved soon.

A collaboration with IRC, Ispra has been started this year, while the consultancy in this field provided by Sheffield City Polytechnic continues.

2.3.3.2. Conducting target development. While beam experiments with conducting targets have been stopped since 1985, a reliable conducting target is essential to achieve a substantial yield increase. This work must go on with a low spending level in preparation for 1991's.

2.3.3.3. Large magnetic horn. The improvement of the large magnetic horn is to get more $\bar{p}$ than with the present 400 kA magnetic horn, but maybe less than 50% expected from the 36 mm Li-lens. The great advantage of the magnetic horn is the ease of exploitation relative to the Li-lens.

2.4. Debunching in Antiproton Collector

2.4.1. Improvement to AC rf System

The power supplies and interlocks, in particular the h=6 rf system, are still in a fairly experimental state. The specified voltage of 750 kV per gap has not yet been reached due to inadequate power of the driver (or inadequate matching between driver and final stage. Good performance of the h=6 $\bar{p}$ debunching system is urgently needed to relieve the need for doing the same momentum reduction by stochastic cooling (essential in improving the efficiency of the 2.4 s cycle).

2.5. Stochastic Cooling

2.5.1. Enhancement of Cooling Rate

2.5.1.1. Band III power amplifiers. The ordering of one third of the stochastic cooling power amplifiers was intentionally postponed during the ACOL project due to lack of funds.

The speed of the AC stochastic cooling is the major obstacle to operation at 2.4 s cycle time (design value, we presently operate more efficiently at 4.8 s cycle time). We therefore need all the microwave power which we can reasonably get, to improve the efficiency of 2.4 s operation.

The amplifiers have already been ordered and will be delivered and installed in the Jan/Feb 89 shutdown.

2.5.1.2. Power amplifier development (GaAs). Although the improvements to the AC cooling mentioned above will probably enable us to reach the design accumulation rate, further development is required to go substantially beyond that performance.

The rapid evolution in GaAs technology should result in cheaper broadband power amplifiers, and development of more sensitive pick-up and kicker structures must be pursued during the years 89/90 if a substantial increase in accumulation rate is to be achieved during 1991's.

2.5.1.3. Improvements of pick-ups and kickers. A new structure of the pick-ups and kickers is under study in order to increase the coupling with the beam.

2.5.2. Noise Reduction (Cooling of Combiner Boards)

The most cost-effective way to increase the gain of all 3 bands of the AC stochastic cooling system by a factor of about 1.2 (equivalent to 45% added power) is to lower further the temperature of the 12 moving beams with pick-up and combiner boards from the present 115°K to 30-50°K by additional cryogenic cooling. In fact, most of the microwave power is of thermal origin and the major contribution comes from the combiner boards.

This project has been launched in June and installation is planned for the beginning of 1989.

2.5.3. Spares

2.5.3.1. Spare parts for stochastic cooling system. Due to lack of funds during the ACOL project, several of the AAC stochastic cooling systems simply have no spare parts. There is a substantial risk of reduced availability.

2.6. Antiproton Accumulator

2.6.1. Vacuum Improvement to Below 5E-12 Torr

The recent achievements in record stack intensities in AA have resulted from repairs and improvements to the ion clearing system. However, there are good reasons to believe that the stack intensity is still mainly limited by ion induced resonances. To push further up the threshold of these instabilities, we must reduce the residual neutralization. This can be obtained both by a further improvement to the clearing system, and by a better vacuum. We therefore propose an upgrade of the AA vacuum system: additional pumping speed, new gauges and a consolidation of the bakeout system.

2.6.2. Beam Instrumentation

2.6.2.1. Scrapers, Schottky analysis, PU amplifiers. The AA scrapers in section 21 urgently need new mechanisms (reliability). A second dual channel FFT is needed for real time Schottky analysis of $\bar{p}$ momentum distributions. The head amplifiers for the AA orbit pick-up need to be replaced to enable us to measure the clearing currents without having to remove a large number of delicate head amplifiers.

2.6.3. RF System

2.6.3.1. Low-level rf and dampers. The h=1 low level rf systems for both AC and AA need both modules and improvements to the prototype modules presently used. A phase lock operating on the second harmonic of revolution frequency to be developed for the AA will improve $\bar{p}$ stacking and unstacking. Closed-loop feedback on the phases of the h=6 gaps in the AC is much needed to improve phase stability during $\bar{p}$ debunching.

The AA dampers need consolidation of electronics, spares, pick-ups with lower noise (to improve Schottky diagnostics), better common mode control, and facilities to measure BTF's for performance checks, using an FFT analyzer.

Recent observation of quadrupolar transverse instabilities excited by ions make development of a quadrupolar damper urgent. To keep such a damper operating during rf unstacking, new quadrupolar structures to be built. The h=160 (300 MHz) rf system for unstacking of low intensity $\bar{p}$ pilot beam for LEAR needs consolidation as well.

2.6.4. Spares

2.6.4.1. Spare quadrupoles for the AC/AA transfer line. At present no spare quadrupoles are available. A new system, using permanent magnet quadrupoles as a replacement, is proposed.

SUMMARY OF AAC CONSOLIDATION PROJECT

				Payments	
				1989	1990
1. INCIDENT PROTON BEAM INTENSITY			150		
1.1 RF-Feedback System in the PS		150			
1.1.1 9.5 MHz Feedback system	150			150	0
2. MODIFICATIONS FOR REASONS OF RADIATION SAFETY			1360		
2.1 Target Area		750			
2.1.1 Remote handling and spare service vehicle	450			220	230
2.1.2 Improvement of target area mechanisms	200			100	100
2.1.3 Radiation-hard quadrupoles downstream targ	100			100	0
2.2 Off-line Target/lens Test Stand		280			
2.2.1 Mock-up	200			100	100
2.2.2 Universal strip line	80			40	40
2.3 Radiation Level		50			
2.3.1 Improvement of tunnel roof shielding	50			20	30
2.4 Access Control and Maintenance Aspects		280			
2.4.1 Power supplies: polarity inversion and earthi	200			100	100
2.4.2 Improvement of AA septum coils	80			40	40
3. ANTIPROTON PRODUCTION			1100		
3.1. New 36 mm Lithium-lens		700			
3.1.1 Pulsed power supply (1.3 MA)	300			300	0
3.1.2 Mechanical engineering and lens construction	300			300	0
3.1.3 Cooling	100			100	0
3.2 Improvement of p-bar Transfer Efficiency		100			
3.2.1. Vacuum chamber in dogleg	100			50	50
3.3 Research and Development		300			
3.3.1 Target analysis (ISPRA)	50			50	0
3.3.2 Conducting target development	130			30	100
3.3.3 Large magnetic horn	120			50	70
4. DEBUNCHING IN ANTIPROTON COLLECTOR			300		
4.1 Improvement to AC RF system		300			0
4.1.1 RF (h=6 and h=1), interlocks, amplifier	300			100	200
5. STOCHASTIC COOLING			1160		
5.1 Enhancement of Cooling Rate		560			
5.1.1 Band III power amplifiers	410			410	0
5.1.2 Power amplifier development (GaAs)	100			0	100
5.1.3 Improvements of pickups and kickers	50			50	0
5.2 Noise Reduction (Cooling of Combiner Boards)		500			
5.2.1 Cryogenic systems (30 K)	250			250	0
5.2.2 Controls of cooling heads	100			50	50
5.2.3 New ceramic for cooling boards	150			0	150
5.3 Spares		100			
5.3.1 Spare parts for stochastic cooling systems	100			50	50
6. ANTIPROTON ACCUMULATOR			1190		
6.1 Vacuum Improvement to below 5E-12 Torr		340			
6.1.1 Pumping system	100			0	100
6.1.2 Bakeout system	240			0	240
6.2 Beam Instrumentation		400			
6.2.1 Scrapers, Schottky analysis, PU amplifiers	400			100	300
6.3 RF System		300			
6.3.1 Low-level RF and dampers	300			150	150
6.4 Spares		150			
6.4.1 Spare quadrupoles for the AC-AA transfer li	150			0	150
7. INDUSTRIAL SUPPORT			300		
7.1 Installation and Testing		300			
7.1.1 Stochastic cooling: noise reduction	160			160	0
7.1.2 Stochastic cooling: increase of cooling rate	140			70	70
TOTAL AAC CONSOLIDATION PROJECT			5560	3140	2420