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BEAM DIAGNOSTICS AND INSTRUMENTATION FOR THE ANTIPROTON DECELERATOR (AD)

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Beam Diagnostics and Instrumentation for the Antiproton Decelerator (AD)

The AD will use existing Beam Diagnostics Devices and Measurement Systems already installed and running for the Antiproton Collector Ring and its Injection and Ejection lines, including the Antiproton Production Area. For some of the devices and their systems, a significant renovation effort has to be carried out because of age. This is because these particular systems were originally conceived and built for the AA Project in 1978 and merely extended to cover the AC Ring addition in 1986. In addition to renovation, a major part of the work involving all devices & systems is to migrate these CAMAC- Norskdata computer based equipment to the standard PS Controls environment of VME-based front-ends and workstation-based applications for acquisition and control. Certain interfaces may be reusable and even kept in CAMAC, controlled through VME front-ends to minimize costs. However, on the software side, all existing Norskdata computer-based low-level software has to be re-written in the front-end VME environment providing the same or similar functionality as the existing low-level Equipment Modules. The higher-level applications could use these from the yet to be developed programs running in the control room new workstation environment. The new application programs would use the concepts and ideas from the current high level application programs so as to minimize effort.

Injection Line Before Target and Injection into AD

Scintillation screens and TV cameras will continue to be used to help steer the beam onto the target. The existing stations , four before the target and four after the target are suitable both for 26 GeV/c high intensity production beam ($1 \cdot 10^{13}$ ppp) and the 3.5 GeV/c low intensity test beam ($1 \cdot 10^{10}$ ppp). One of the four stations before the target is in fact the screen on target used for focusing the production beam on target.

Four beam current transformers are routinely used in the existing production and injection area. These will continue to be used with exactly the same requirements and conditions as at present but with major adaptation to the new acquisition system implying substantial modifications to electronics and interfaces to the new control system.

AD Ring

A Scintillation Screen and TV Camera measure the beam position at the entrance to the injection septum and kicker of the current AC Ring. This will remain unchanged. Similarly, a screen which acts as a beam stopper after nearly one turn will continue to fulfil the same function. For beams ejected to experiments, a screen is also available at the exit of the septum magnet and just at the entrance of the ejection transfer line. This screen permits the observation of cooled antiproton beams ejected as well as proton test beams.

The current AC Ring closed orbit system of 32 horizontal and 28 vertical pickups measures orbits at 3.5 GeV/c with test proton beams of few times $1 \cdot 10^9$ particles. These pickup stations will not be changed; however, for the AD, it is foreseen to measure the closed orbit over the complete momentum range of the ring (3.5 GeV/c down to 100 MeV/c) for beam intensities down to $1 \cdot 10^7$ antiprotons . At each energy, the measurements will require a bunched beam, kept at a constant energy whilst the sum and difference signals are scanned by a 2 x 60 multiplexer and the Difference to Sum ratios determined by a Network Analyzer. The time required to scan the 60 pick-ups will be not more than 6 seconds for $1 \cdot 10^7$ particles and less for higher intensities. Most likely, new pick-up amplifiers and reception amplifiers will be required to optimize the signal to noise ratio.

The existing or upgraded Schottky pickup will be used to measure the antiproton yield, intensity and emittance. It will also be used to monitor the performance of the various processes of RF bunch rotation/debunching, and cooling through different stages of deceleration from 3.5 GeV/c to 100 MeV/c. The Schottky pickup will also be used for tune measurements with test proton beams. For tune measurements during deceleration, a system used in the present LEAR ring will be adapted for use in the AD. Similarly, a beam ionization profile monitor of the type used in LEAR will be installed in AD to measure beam profiles.

The existing DC beam current transformer TRA4105 is adequate to make measurements with test proton beams. However for low intensity antiproton beams, it has certain limitations. The transformer has a resolution of 2 to 3 μA while the routine antiproton injected intensities of $5 \cdot 10^7$ particles at 3.5 GeV/c correspond to about 13 μA or, 1.4 μA after deceleration in the AD to 100 MeV/c. Hence for accurate low intensity antiproton measurements a Schottky pickup will be used for antiproton intensity measurements, calibrated using the TRA4105 with proton beams of sufficient intensity.

The existing transverse scrapers in the zero-dispersion region of the AC ring will continue to be used in AD for machine aperture and acceptance studies using test proton beams. These 4 blades, a pair per plane permit the exploration of betatron phase space. The scrapers would also be used for antiproton emittance measurements, as carried out currently; the latter involves fast scintillation counters to monitor the secondary radiation while a scraper blade in a given plane is moved into the beam at constant speed. The acquisition and control of the horizontal and vertical scrapers will be upgraded to the new controls standard.

For measuring and correcting the injection coherent oscillations for test proton beams, the existing system of 100 MHz sample-rate digitizers will be used in conjunction with difference signals from transverse pickups at injection. To evaluate and correct the energy mismatch between PS and AD, the synchronising RF phase will also be digitzed using another low sample-rate ADC. For measurement and correction of coherent oscillations of injected antiprotons, special low-frequency resonant pickups will be used as in AC, coupled with the fast digitizer system and a digital oscilloscope. All these systems will be upgraded to function under the VME based front-end systems.

Ejection from AD to Experiments

Scintillation screens with TV cameras will be used to adjust the line using test proton beams since part of this line will also be used to inject the test proton beams from the PS via the transfer line TTL2. These stations, currently existing in the AC to AA line will also serve the purpose of steering the ejected beams to the last bending magnet before physics experiments. The beam current transformer in this line works adequately for the test proton beam intensities but is very close to the resolution limits for antiproton intensities. Possible methods of measuring very low intensities ($1{\cdot}10^7$ particles) and profiles are being studied but are very difficult to achieve and implement for non-destructive measurements; however, it is hoped that a device using a destructive technique to measure beam profiles and intensity will be implemented in front of the last switching magnet prior to the experimental area.

Proton Test Beams from TTL2

The existing TTL2 line which injects currently into the AA Ring will be modified to inject directly into the AD ring, using part of the AD-to-experiments line. The existing scintillation screens and TV cameras will be used to adjust the line to inject into the AD together with minor relocation if necessary. The beam current transformers TRA8084 in TTL2 and TRA7012 just before AD injection will be used to measure the test beam intensities. The close proximity of TRA8084 to another transformer TRA8086 which already functions under the new control system means that one of these two could be made redundant for the TTL2 to AD test beam operation.