EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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TECHNICAL SPECIFICATION

FOR MAGNETIC PROPERTIES OF FERRITES FOR KICKER MAGNETS

1. Magnetic Induction	B at 7 Oe	(Gauss)	> 3000
2. Coercive force	H_c at B_7	(Oe)	< 0,3
3. Initial permeability	μ_i	(at 50 Hz)	> 600
4. Loss factor	$\tan \delta/\mu_i$	(at 10 MHz)	< 10^{-4}
5. Specific resistivity	ρ	(Ohm cm)	> 10^6

air to avoid connections to a water system.

5. Electrical connections to the lens would be outside the cell, the current to the lens would be carried to the lens by a line rigidly connected to it.

6. Should it be necessary to change a lens, the target was to be ejected into a shielded container and the external connections to the feed-line disconnected,before opening the concrete curtain to remove the lens.

It is not expected that these requiments can be fully maintained for the new target station but it useful to describe how they were implemented in the present station.

1.1 Target module.

The target consists of a 11 cm long copper wire of diameter 3 mm. It is fitted inside a graphite cylinder to give good thermal contact and protected from the air by end windows. The heat deposited by the primary proton beam is about 4kJ per pulse or about 2 kW. This heat is dissipated by blowing air over the finned suface of the graphite cylinder. The target module is shown in Dwg. No. CERN-A60-3201-2

1.2 Collecting lens.

This lens, mounted downstream of the target, is a magnetic horn consisting of two coaxial conductors. The inner conductor is 1 mm thick with varying radius, while the outer is cylindrical. Antiprotons coming from the target penetrate the inner conductor and are focussed in the azimuthal magnetic field created by a pulsed axial current flowing along the inner conductor and returning via the outer cylinder.

1.3 Lens power-supply.

The current is generated by discharging a 225 microfarad capacitor bank and has a half sine-wave waveform with a peak current of 160 kA. The rise-time is 8 microseconds. The capacitor bank is divided into twelve sections each with its own ignitron switch and crow-bar circuit. The cubicles containing the power supply are located in the target area, while the ignitron trigger units are in the Antiproton Accumulator hall to reduce the exposure to radiation of the semiconductor components. Connection to the lens is via twelve parallel coaxial cables (3 to 4 m long) to a junction box located in a trench below the concrete shielding curtain. This box is connected to the lens by a parallel plate sandwich-line that is rigidly attached to the downstream end of lens. Expoxy bonded mica sheets are used as insulation in the sandwich-line, otherwise the combined line and lens structure is made from aluminium.

1.4 Alignment.

Both target and lens are mounted on vee-blocks that have been prealigned on a marble block which has three feet which enable it to fit on sockets fixed on the floor under the beam line. Once the block is in place, target or lens can be removed or installed in a reproducible way. The block itself may also be removed and replaced using a fork-lift without losing the alignment accuracy of the target station.

1.5 Handling of target and lens.

If it is becomes necessary to replace either target or lens after exposure to the proton beam, care has to be taken because of the induced radioactivity. The target can be ejected into a bin which remains behind the curtain. This is done with a simple hand operated lever. A new target may then be introduced through a hole in the curtain using a special rake and rail to roll it into position on its vee-block. Provided it is not too radioactive, a target may be recovered for remounting with the rake.

To replace the lens-line combination, the target is first removed and the cables disconnected from the box at the base of the curtain which is then opened to allow the assembly to be lifted off the vee-block and removed.

3. PROPOSED NEW TARGET STATION.

The yield of antiprotons can be increased by providing an even shorter focal length lens to replace the magnetic horn. The lens to be used is known as a "lithium lens". It is so named because it consists of a cylinder of metallic lithium also placed after the target and coaxial with it. Lithium is chosen as the lens material because of its relatively low absorption of the traversing antiprotons. The focussing is performed by the azimuthal magnetic field created by a coaxial current in the lithium, with a return path in a surrounding cylindrical conductor. the current pulse must last a sufficiently long time to allow a nearly constant current density to be established in the lithium.

It is also known that a better distribution of antiprotons can be obtained, and the yield increased further, by passing a coaxial current along the target wire itself. Once again the pulse length must be suffient for the field to penetrate the copper wire.

However, such a field in the target will defocus the incident proton beam causing some of the primary protons to be deflected radially out of the target and preventing them from creating antiprotons. It is therefore planned to increase the focussing of the incoming beam to compensate for the field inside the target. The strength of lens required is such that once again a lithium lens is required.

A target station consisting of a conducting target with pre-focussing and collecting lithium lenses has been described in the document entitled "AA Long Term Note No.26, Antiproton Collector Study", December 13-14, 1982 (CERN/PS/AA/EJW/afm). It was pointed out in this study that the improvement in yield that could be provided would be limited by the technological problems in both producing the necessary high currents and the ability of the lenses and target to support the mechanical and thermal stresses imposed by the current pulses and the primary proton beam. It is therefore necessary to propose parameters for the power supplies that will enable the technological limits to be explored but which at the same time do not pose too severe problems for the construction of the power supplies or in the connections between supplies and loads.

Since it is apparent that there will not be sufficient space in the existing target area for the additional supplies, it is planned to construct a new building at ground level to house the three pulse power supplies. The proposed new building is also shown, overdrawn, on Dwg No. CERN-SB-ES-1.193.25.K. The end is aligned with the beam line and will be about 8 m above the target tunnel. Tentative dimensions for this building are: width 12 m, length 20 m and height 6 m. Access to the tunnel via a vertical shaft is being considered. This shaft will be normally filled with blocks of shielding material.

4. SCOPE OF THE DESIGN STUDY.

A design study is required for the construction of three pulsed power-supplies for the new Antiproton Accumulator target area. These supplies will be housed in a new buiding to be constructed at ground level. The study will include the design and siting of the supplies as well the method of connecting them to their loads which will be located on the beam line in the underground target area. It is anticipated that the study will involve consideration of the size and the services needed for the new building. Because of the technical problems relating to the connections at the loads, the overall problems of operating the target station and the relatively unknown properties of the various loads, it is expected that a close liason with CERN staff will be imperative. The time taken for the study should be between two and three months from the date on which the study is authorized.

The result of the study will be an technical report which will become the property of CERN and may be used as the basis of a call-for-tender document for the procurement of the power-supplies. It should show the feasibility of the supplies and the connections to their loads or otherwise propose modifications to the specifications that would permit a feasible system. The study should be sufficient to establish equipment layout and enable a complete cost estimate. Where unusual technical problems are identified, solutions should be proposed. It is not required that the study produces the detailed mechanical and electrical designs that would normally be made by a construction contractor.

5. PRINCIPAL ELECTRICAL PARAMETERS.

It is assumed that all current pulses result from switching capacitor banks. Estimates of the inductances of the loads are given but the additional inductances due to feed-lines,transformers and connections are to be determined by the study. In each case the current waveform is expected to be a slightly damped half sine-wave. Should it be considered desirable to have a longer waveform, problems likely to result from the increased heat load will have to be discussed with CERN staff. Risetimes are between zero and peak current.

1. Prefocussing lithium lens.

Radius of lithium cylinder	10 mm.
Load inductance	40 nanoH
Load resistance	120 microohm
Peak current	500 kA.
Rise-time	165 microsec

2. Collecting lithium lens.

Radius of lithium cylinder	20 mm.
Load inductance	40 nanoH
Load resistance	50 microohm
Peak current	1000 kA.
Rise-time	1.2 millisec

3. Conducting target.

Radius of copper wire	1.5 mm.
Load inductance	30 nanoH
Load resistance	500 microohm
Peak current	225 kA.
Rise-time	6 microsec.

4. Failure rate.

Power supplies	30E6 pulses
Connecting transformers	10E6 pulses

The supplies are required to operate continuously at a repetition rate of one pulse every 2.4 seconds. Under normal operation of the Antiproton Accumulator complex, runs last for up to three weeks during which periods access to the supply is only possible at the sacrifice of several days accumulation of antiprotons. In the new proposal for the target area, the supplies are housed in the new surface building and access will permitted for minor repairs to equipment. However, when there is beam on target, the building will be under controlled access because of the radiation levels present. Routine maintenance and monitoring at the supplies must therefore be minimized. Any current step-up transformers will most likely be placed in the target area. They must be resistant to radiation. The dose rate will depend on the degree of shielding possible, but in any case only inorganic materials should be used in their construction.

Remote control and aquisition of supply parameters via the Antiproton Accumulator control computer is required. However, detailed design for this feature need not be prepared.

6. OPERATING EXPERIENCE WITH PULSED TARGETS AND LITHIUM LENS.

6.1 Pulsed targets.

Some experiments have been performed in which antiprotons have been produced while currents up to 160 kA were passing along the target. These tests were made at reduced repetion rates and were only intended as feasibility studies. The maximum current that can be used at the full repetion rate with a fully operational target assembly is not known. Further testing of conducting targets may occur in mid-september,1983.

6.2 Lithium lenses.

Lithium lenses, with parameters similiar to those given above for the prefocussing lens, have been operated at the Institute of Nuclear Physics at Novosibirsk in the U.S.S.R. There is little information available as to the life-time of these lenses, particularly at the current levels required at CERN.

Following a collaboration between the Novosibirsk Institute and the Fermilaboratory in the U.S.A., a lithium lens with the parameters given above for the pre-focussing lens has been designed and built at the Fermilaboratory (Dwg. No. FERILAB-8000-ME-169541). It is planned to transport this lens to the CERN site and install it in the Antiproton Accumulator target station for tests in mid-september, 1983.

The lens assembly is mounted along the axis of a surrounding coaxial transformer and together with the transformer core casing, completes a single turn secondary circuit as shown in Dwg. No. FERMILAB-8000-ME-169033. The primary circuit has 24 turns. The lens has already been tested with a 440 kA secondary current, but in the absence of a high-energy proton beam. It will be mounted in the beam line as showmn in Dwg. No. CERN-A60-4020-0.

Although this circuit design leads to a low inductance load, minimizing the amount of stored energy in the capacitor bank, it has the disavantage that it exposes the transformer to large radiation doses. In the event of a failure of the transformer or lens, they must be jettisoned as it is expected that they will have become highly radioactive. It is thefore appropiate, within the study, to explore the possibilty of physically seperating the lens and transformer so as to be able to introduce some radiation shielding for the latter. Apart from the problem of the increased inductance due to the connecting line, there may be an additional one if the current in the lens does not have cylindrical symmetry. This may be solved by using multiple feeds to the lens.