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ACOL DIPOLES

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Abstract

This paper describes the general design of ACOL dipoles, including the special injection area dipole. A list of mechanical, electrical and magnetic parameters and results of magnetic measurements are presented. Particular attention is paid to the proximity effects between quadrupoles and dipoles.

Introduction

In 1983 approval was given for the construction at CERN of the Antiproton Collector (ACOL) in order to gain at least a factor 10 in antiproton accumulation rate. The AC is a storage ring, concentric with the existing Antiproton Accumulator, but having a larger circumference and a considerably increased acceptance.

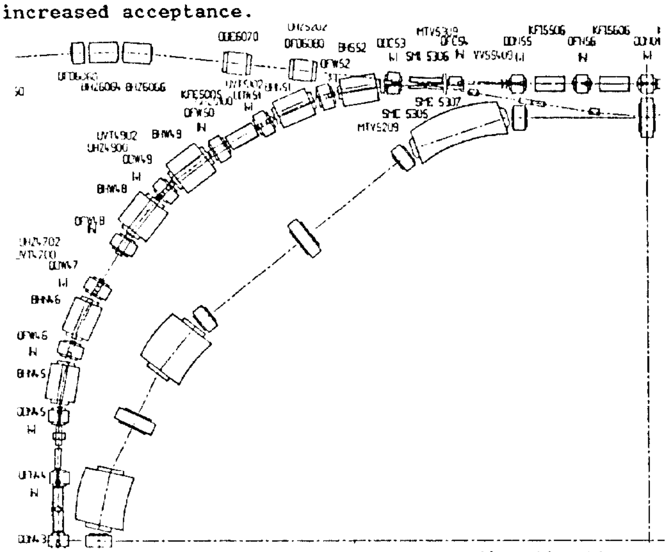


Figure 1 – A quadrant of the AC surrounding the AA.

The ACOL-lattice is of the "FODO" type and the bending magnets are distributed in such a way that the orbit dispersion is cancelled at each end of a quadrant. Due to the strong modulation of the horizontal beam size and also for economical reasons the bending magnets have been divided in two families : the 16 narrow dipoles (BHN) are located at the extremities of the arcs and the 8 wide bending magnets (BHW) are located near the centre of the arcs. One of the narrow dipoles (BHS) has been modified to accommodate the injected beam. Field calculations and the magnet design have been done during the first half of 1984. The order for the manufacture of the 24 magnets was placed in December 1984. The first magnet was delivered in November 1985, and the last one in November 1986. Installation started in January 1987 and is about completed by now (March 1987).

Design

All the bending magnets are of the symmetrical H-type and consist of 2 identical laminated half cores and 2 saddle-shaped coils. The half cores are assembled from precision-punched, insulated low carbon steel laminations, having a thickness of 1.5 mm. The laminations are stacked between thick end plates, and held together by angular plates welded on the outer surface of the stack.

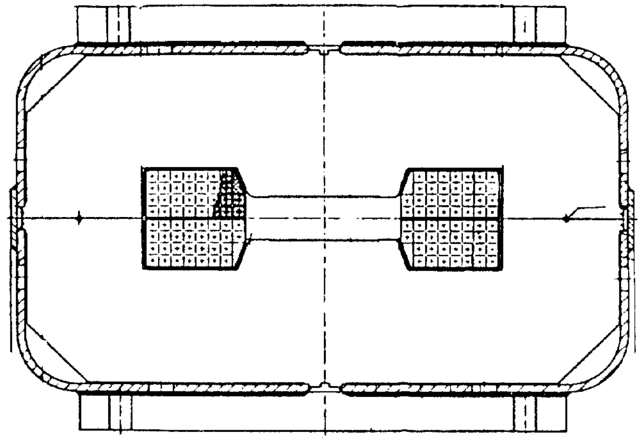


Figure 2a – ACOL N-Dipole cross-section.

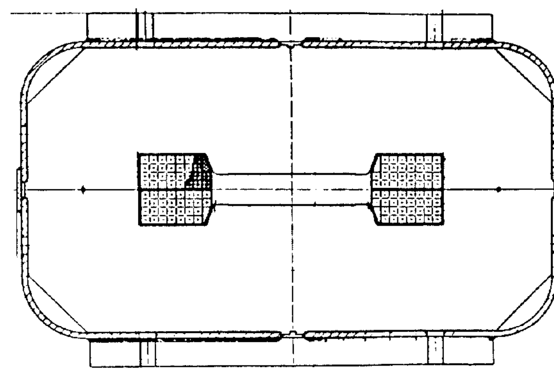


Figure 2b – ACOL W-Dipole cross-section

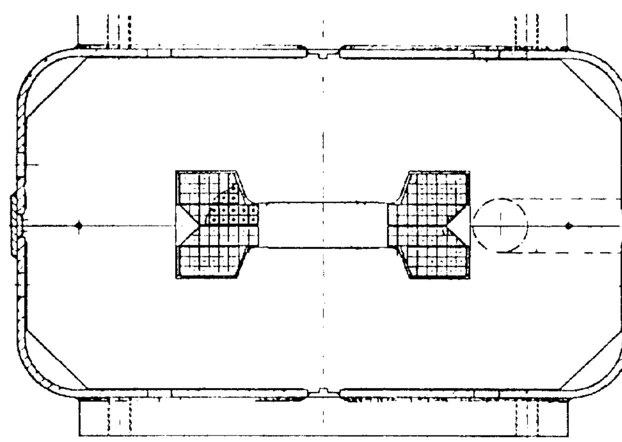


Figure 2c – ACOL S-Dipole cross-section.

The coils are made of hollow copper bars, shaped such as to from one turn and welded in series. Both interturn and ground insulation consist of glass-mica tapes impregnated with a thermosetting radiation resistant epoxy resin.

The N and W magnets are different in gap width and consequently in coil width and outer yoke dimensions. The S magnet is a modified N magnet to allow passage of the injected beam through a channel in the yoke and between the coil heads. In order to make the best use of the gap, the vacuum-chamber has been squeezed between the poles.

Parameters

	BHN	BHW	BHS	Unit
Number	15	8	1	
Nominal field	1.489	1.489	1.472	T
Integral field	2.924	2.924	2.924	Tm
Magnetic length	1.963	1.963	1.986	m
Iron length	1.794	1.794	1.814	m
Gap	114	114	116	mm
Good field region	± 105	± 135	± 105	mm
Magnetic flux	1.76	2.32	1.48	Wb
Nominal current	2280	2280	2280	A
Coil weight	2400	2540	1500	kg
Steel weight	19	25	19	tonnes
Total width	1546	1964	1546	mm
Total height	1253	1339	1140	mm
Total length	2200	2200	2210	mm
Magnet resistance (20°C)	9.3	11.0	15.2	mΩ
Power consumption (20°C)	48.4	57.2	79.0	kW
Inductance	46	61	39	mH
Stred energy	120	158	102	kWs
Pressure drop	10	10	10	bar
Cooling flow	54	52	69	l/min
Temperature rise of cooling water	13	16	17	°C

Results of measurements and shimming

The requirements concerning the magnetic field quality are the following :

- A variation of less than 1 Gauss per cm throughout the useful area.
- Spread of bending power over all 24 magnets : $\pm 1.10^{-4}$.
- Homogeneity of bending power within the useful area : $< \pm 2.10^{-4}$.

In order to meet these requirements it was proceeded as follows : the pole profiles of all 3 types of magnets were optimized for a pure dipole field using the two-dimensional programs MAGNET and POISSON. The magnet length was adjusted by adding on the end-plates 1.5 and 0.5 mm thin shims having the same shape as the pole profile. The homogeneity of the integrated field was adapted by adding steel washers of different shape and size on the magnet end plates. In this way a very homogene bending power distribution could be obtained. The perturbation of these distribution of bending power, introduced by the presence of the iron yoke of the lattice quads at a short distance was then corrected by adding again steel washers of different shape and thickness.

Achnowledgements

With pleasure we acknowledge the help of Mr. M. Zanolli for the mechanical design of BHW and BHN magnets and supervision of the manufacture, Mr. Battiaz for the computations of magnetic fields, supervision of manufacture and design of BHS magnets and Mr. Kreft who performed magnetic measurements and shimming. All the magnets were manufactured by ALSTHOM (France).

References

1. B. Autin, The CERN Antiproton Collector, CERN report, CERN 84-15.
2. Design Study of an Antiproton Collector for the Antiproton Accumulator (ACOL). (Ed. E.J.N. Wilson), CERN 83-10.
3. Technical Specifications PS/AC/Spec. 84-5, 84-6 and 85-10.

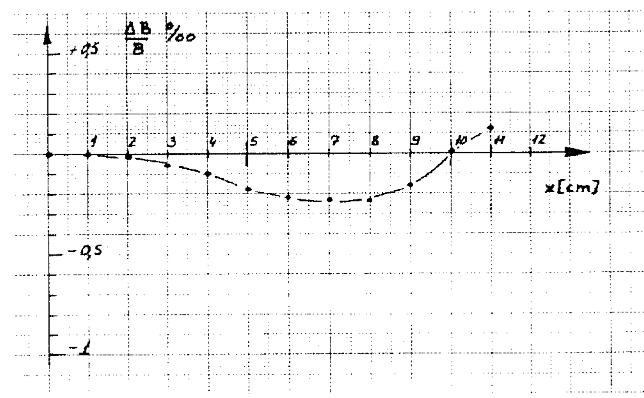


Figure 3a - BHN

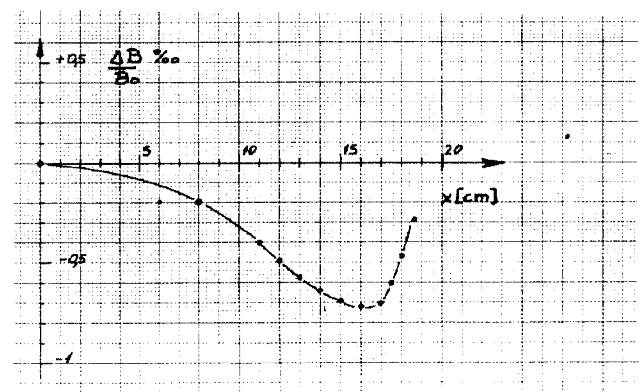


Figure 3b - BHW

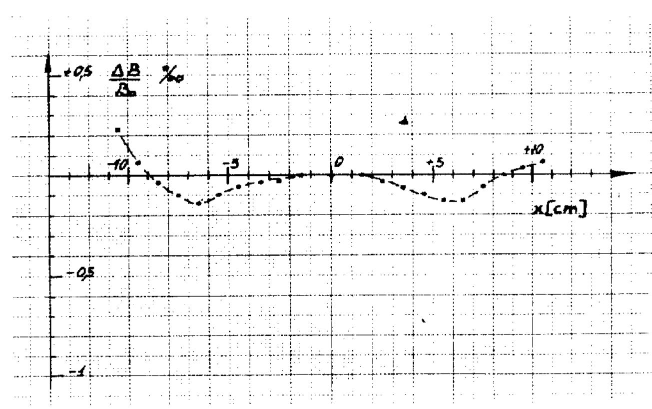
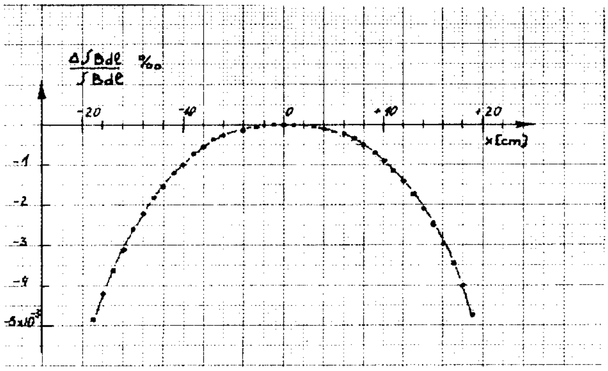
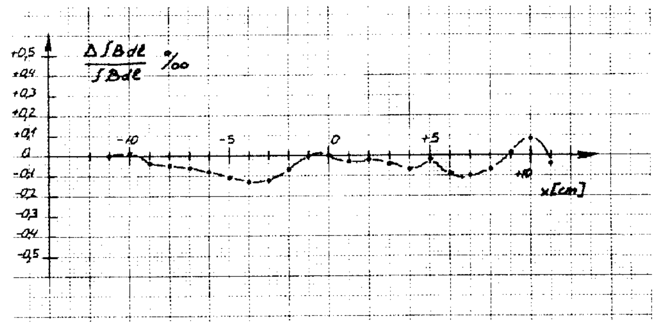


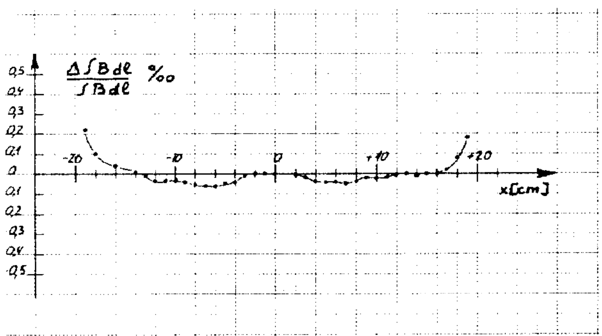
Figure 3c - BHS



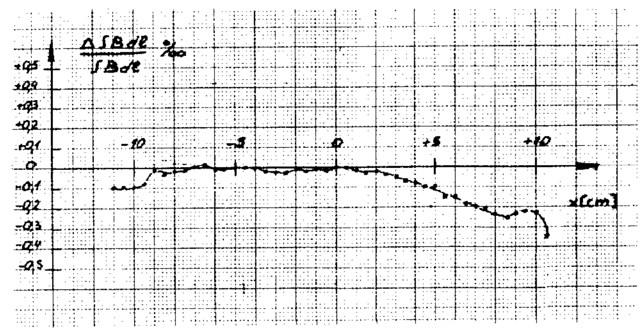
<u>Figure 4a</u> - BHW. No end shims



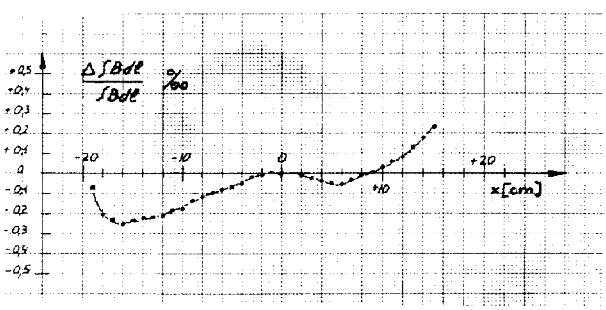
<u>Figure 5a</u> - BHN. With end shims, standing alone



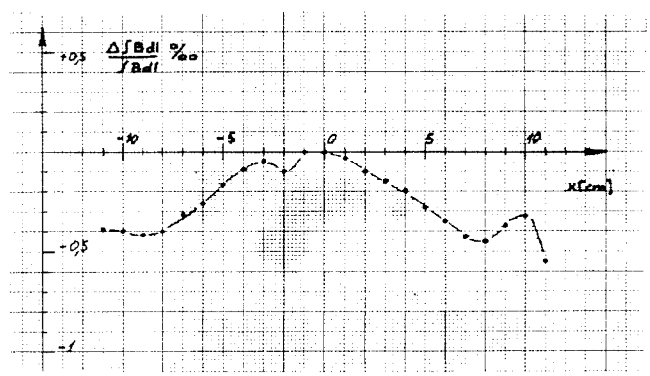
<u>Figure 4b</u> - BHW. With end shims, standing alone.



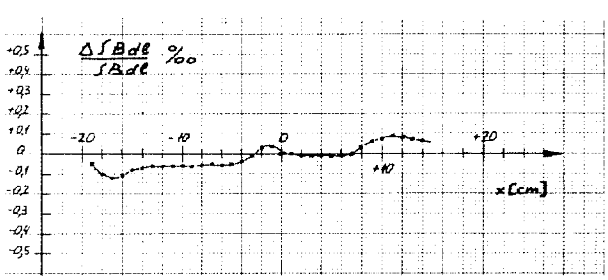
<u>Figure 5b</u> - BHN. Corrected for presence of lattice quadrupoles.



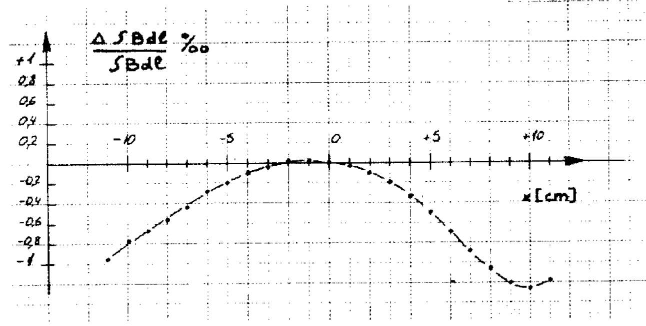
<u>Figure 4c</u> - BHW. Influence of proximoty of lattice quadrupoles



<u>Figure 6a</u> - BHS. No end shims.



<u>Figure 4d</u> - BHW. Corrected for presence of lattice quadrupoles



<u>Figure 6b</u> - BHS. With end shims, standing alone.