The LEAR Experimental Areas

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Abstract

The Low Energy Antiproton Ring (LEAR) at CERN is a unique machine which delivers pure antiproton beams over a wide range of kinetic energy (between 2 and 1270MeV) to a large community of physicists.

In this paper, we describe the new layout of the experimental areas, designed to fulfil the requirements of the experiments of the "second generation".

1 THE 1991/1992 LAYOUT

1.1 Beam characteristics

They are given in reference [1]. Three extraction modes are presently used at LEAR. The beam emittances considered for the optics and tracking computations [2] are given below in Table 1. The momentum range covered is from 2GeV/c down to 61.3MeV/c (ratio of 33).

Table 1: extracted beam parameters at 2σ

ejection mode	E_h $\pi[mm.mrad]$	E_v $\pi[mm.mrad]$	$2\sigma_p/p$ [%]
ultra-slow	5	20	.1
semi-slow	5	15	.1
fast	10	10	.3

1.2 General layout

Figure 1 shows the LEAR experimental hall on the right hand side of the LEAR machine. The area covers about 1900m^2, of which 400m^2 are used to house the electronics of the experiments.

The sum of all the deflection bending angles amounts to 480 degrees, of which 110 degrees are in the vertical plane. Those two numbers characterize the complexity and the tightness of the transfer line network (total length of 250m) in a relatively small volume. Furthermore, for low momentum beams, all sorts of parasitic effects are to be localized and compensated whenever possible (i.e. magnetic shielding). The position of the mobile crane (20 tons of lifting capacity) perturbs the beam trajectory, and its rest position must be fixed to ensure that the perturbation remains constant.

Eight experimental areas have been created. They are classified following the momentum range which can be transmitted by the beam line considered:

- Very low energy : below 100MeV/c (5MeV), areas S3, S4, S5
- Low energy : between 100 and 200MeV/c (21MeV) , area S1
- All energies: between 100 and 2000MeV/c (1.27GeV), areas M1, M2, C1, C2

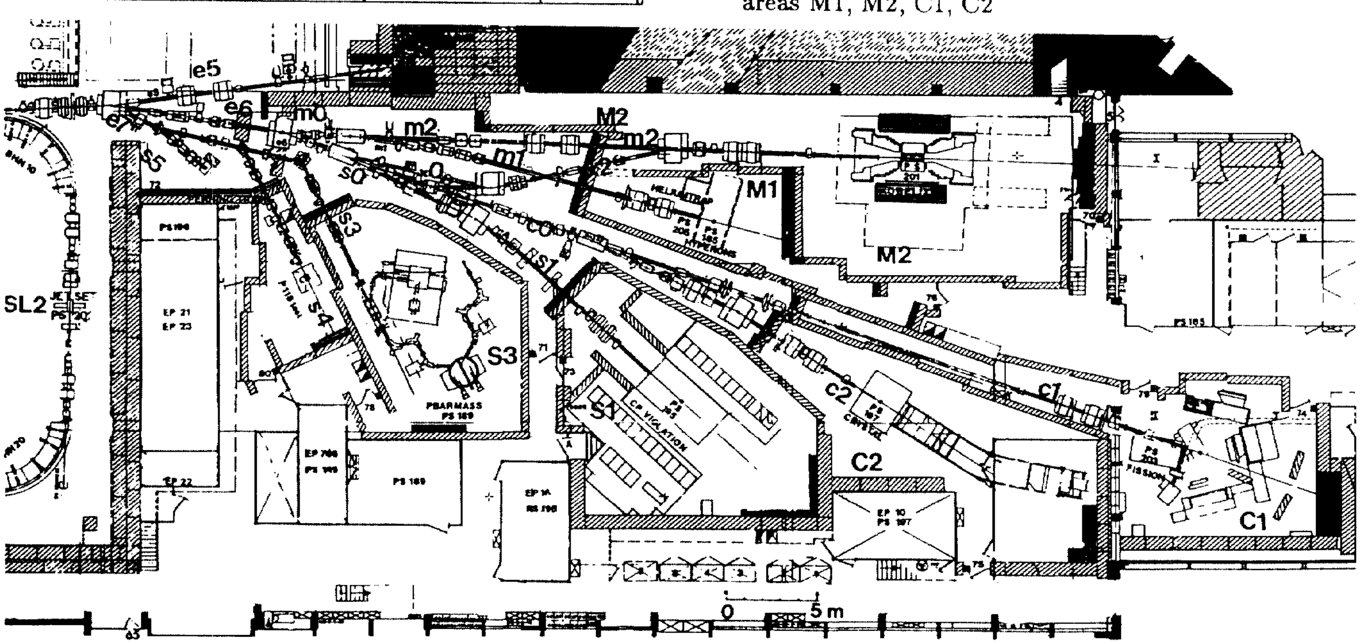

Figure 1: Experimental hall

The $e5_a$ transfer line is matched to the LEAR extracted beam optics. The beam is transported via the switchyard lines, and then focused into the physics detectors following the requests of the experiments.

Three "splitter magnets" (see figure 2) are used in the beam switchyard. Each of them gives the possibility of feeding two experiments simultaneously with tunable beam sharing ratios. The use of two splitters in series (i.e. splitters 2 and 3) permits to feed three experiments in parallel.

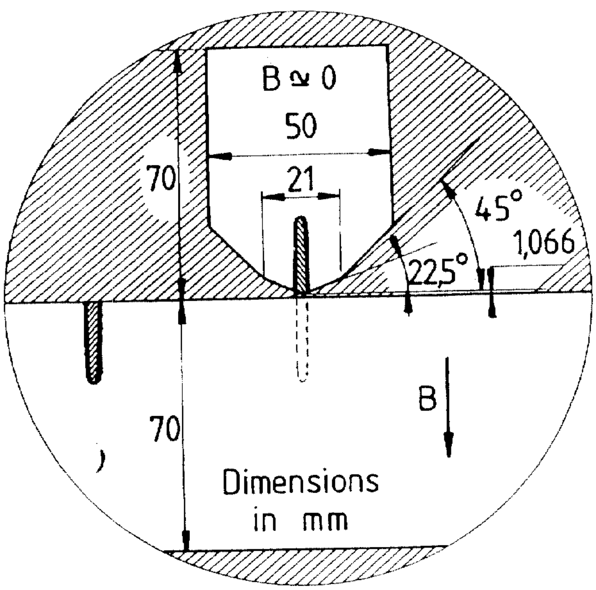

Figure 2: Schematic splitter magnet cross section

Beam losses arising from splitting are kept small because of the large vertical beam size and the small horizontal waist at each splitter magnet position [3]. Figure 3 shows the great flexibility, which is the result of the simultaneous use of two of these splitter magnets.

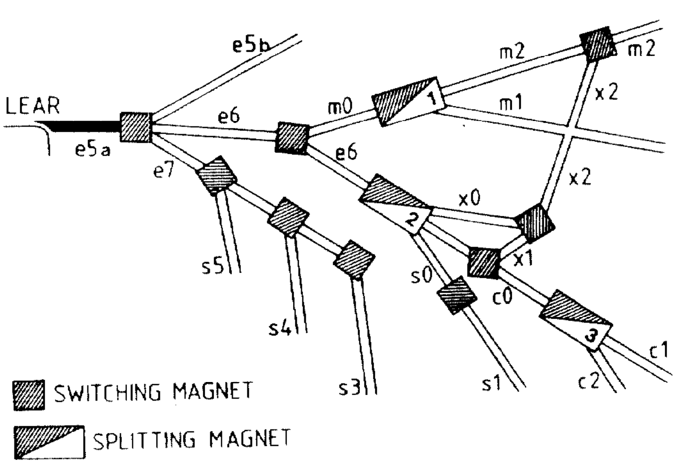

Figure 3: Transfer line network synoptic

LEAR is operating more than 4200 hours per year for the CERN antiproton programme and nine experiments are taking data [4] at present.

More details concerning the layout, the optics and the experiments on the floor can be found in [4]. In the following chapter, we give some information on special features of a few lines.

2 SPECIAL LOW ENERGY LINES

The 'S_i' lines were the most difficult ones to design and are the most critical to set-up : very short length, large angles requiring the correction of the chromatic dispersion, as well as matching to a target placed inside a solenoidal magnetic field (S1 and S5 lines) or into a Radio-Frequency-Quadrupole (S3 line).

In addition, unusual beam diagnostic monitors have to be used below 100MeV/c : the standard multi-wire chambers become blind and other more sophisticated devices are necessary [5].

2.1 S1 Line (PS195/CP VIOLATION)

This line ends up inside a 2.4m half-length solenoid of 0.5 Tesla used in normal and reverse polarity. The last two quadrupoles (upstream the detector) have to be tuned to compensate for the transverse phase space rotation in the solenoid. In addition, the beam direction can be adjusted up to 0.02 mrad to minimize the beam position shift when the solenoid polarity is reversed [6]. The beam spot size obtained at the target focus is about 2.5 mm (FWHM) in both planes.

2.2 S3 Line (PS189/PBAR MASS)

This line transports and matches the 2MeV antiproton beam of $500\mu s$ to a buncher, and then to an RFQ of 46 cells which decelerates the beam from 2 MeV (61.3MeV/c) down to 200keV (19.6MeV/c). The 200keV particles are afterwards injected into a Radio-Frequency Mass Spectrometer [7]. The first tests of proton deceleration have been successfully performed in 1991. Data taking with antiprotons should take place this year.

2.3 S5 Line (PS196/PENNING TRAP)

The experiment requires a short vertical beam line, in order to fill a Penning trap placed inside a 6 Tesla solenoidal magnetic field. In order to minimize the blow-up due to degradation in a foil in front of the trap, the beam spot size has to be small despite a large bending angle in the horizontal plane (see figure 1) and a 90 degree angle in the vertical plane (see figure 4). The parameters necessary to fulfil all optical conditions such as focus and correction of the chromatic dispersion in both horizontal and vertical planes have been obtained by designing two dedicated 45 degree magnets, each of them with rotated pole faces for the vertical bending.

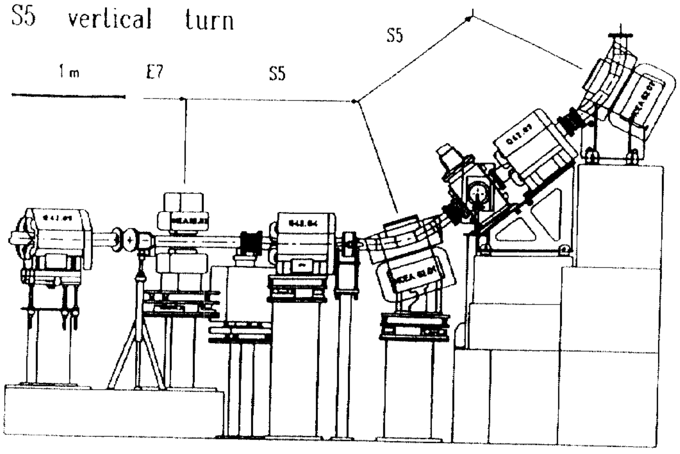

Figure 4: S5 line drawing

The resulting optics can be seen on figure 5. Measurements have shown that the beam spot size is less than 3mm in diameter (FWHM).

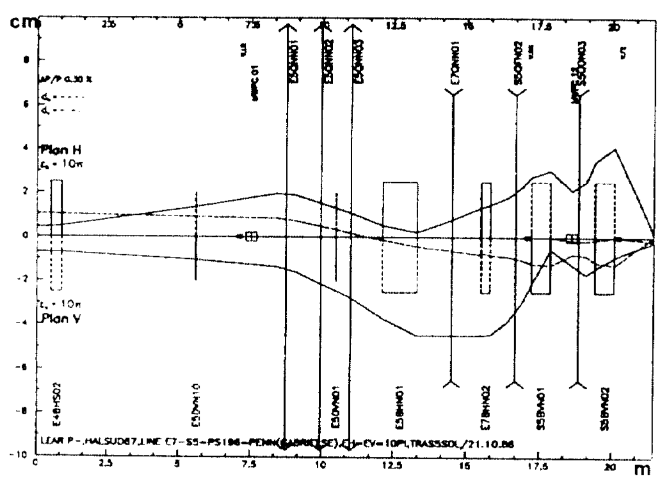

Figure 5: S5 line beam optics

3 ACKNOWLEDGEMENTS

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L. Danloy and his team are solving all problems of installation on the floor.

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