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ON THE ORIENTATION OF BUBBLE CHAMBERS

1. INTRODUCTION.

In the early stages of design of experimental apparatus it is necessary to consider its orientation. This is particularly important with large bubble chambers where the whole construction is strongly influenced by the orientation of the window plane.

2. BEAM TRANSPORT WITH MOMENTUM ANALYSIS ONLY.

With weak focusing accelerators experimental beams generally emerge through the stray field with deflection and some momentum separation. Either to enhance these effects, or to compensate for them further bending magnets are arranged with their magnetic field parallel to that of the accelerator itself.

To simplify trajectory analysis it is usual to place the target in the median plane of the accelerator and to accept particles in a cone, symmetrical with respect to the median plane. All cyclic accelerators have horizontal median planes which leads to a convenient layout of beams in the median plane of the machine.

For strong focusing accelerators the situation is different. The diminished radial width of the vacuum chamber and the existence of many field free sections often permits beams which are practically unaffected by the stray field. There is thus no fundamental reason from beam optics for momentum analysis in the horizontal plane, and there is no strong reason for the centre of any particle detector to be in the median plane of the accelerator. However practically all apparatus will be located within a few metres of the median plane. It is interesting nevertheless to investigate the possibilities associated with this extra degree of freedom in beam layout.

3. ELECTROSTATIC MASS SEPARATION.

A parallel plate electrostatic separator gives mass separation in the direction of the electric field. In order to make the separation independent of momentum dispersion and positional fluctuations introduced by the bending magnets it is preferable to choose the direction of mass separation perpendicular

to the plane of momentum analysis. Under these circumstances it could for instance be arranged that the images of particles with different masses are parts of coaxial Thomson parabolas, but otherlayouts may be more useful. Since the angular deflection in the magnetic momentum analysis is usually larger than that caused by the electric field, it is convenient to have momentum analysis in the horizontal plane and mass separation in the vertical plane.

For efficient mass separation the dimension of the image of the target and thus also that of the target itself, should be small in the plane of separation. For bubble chambers the beam pulse should be less than 200 microseconds (100 revolutions of the beam in the CERN-PS). In this time the yield from a thin multiple traversal target will be small so that it is probable that for bubble chambers targets with a thickness in the beam direction of 5 to 10 cm and a few millimeters high will be used. This situation also demands vertical mass separation.

The present results of our experimental studies show that high voltage bushings work best in a region free from magnetic field. One simple consequence of this situation would be to use parallel electric plates without a superimposed magnetic field and to arrange the separator tank to fit an appropriate curve in the vertical plane. The mean curvature of the system could be adjusted by a levelling arrangement.

Under these circumstances the separated beams will leave the system deflected and displaced in the vertical plane. Experimental apparatus intended for use with such separated beams must either by suitable orientation or by the installation of extra bending facilities be able to accept beams not confined to the horizontal plane.

4. THE ORIENTATION OF BUBBLE CHAMBERS.

It is clear from the above considerations that for use with separated particles a bubble chamber can be used conveniently if it can accept particles in directions inclined to the vertical over some range which is dependent on the separator characteristics, i.e. that the window should be in the vertical sense.

As an illustration we shall discuss the 2.5 GeV/c antiproton separator which is under construction for the South Experimental area of the CERN-PS. Its layout is shown in CERN PS/Int. EA 58-2, but it is now assumed that the electric field is vertical and that the three separator tanks are arranged on a suitable curve in a vertical plane, as shown in Fig. 1. The magnetic field which compensates for the chromatic dispersion of the spectrometer electric field is concentrated in the bending magnet M1.

Antiprotons pass through the slit I2, whereas the pions hit the wall of the slit. The descending beam is bent upwards into the bubble chamber by the magnet M2 some distance from I2. The bubble chamber field is in a sense to bend the particles downwards again. In the situation shown in Fig. 1, where M2 produces a deflection of 7° the beam passes about 8 cm below the centre of the propane chamber. Since the latter has a diameter of 1 m this is not important. If the total angle of deflection in M2 is increased to 15° the beam will pass through the centre of the chamber. These figures were arrived at with the assumption that the entrance window is at the same height as the centre of the chamber. For a circular chamber this is actually en unnecessary restriction, since it can easily be tilted.

After I2 the beam has a horizontal profile, i.e. its vertical extent is much smaller than its horizontal extent. For the observation of the beam in the bubble chamber a vertical profile may be preferable. The transformation can be made easily by a quadrupole magnet Q1 of rather modest strength between I2 and M2.

It may appear that the magnet M2 could be eliminated by somewhat changing the angle of deflection of M1. It appears quite likely however that additional bending between I2 and the bubble chamber will be necessary in order to reduce background, produced at the slit.

In the layout shown in Fig. 1 the height of the bubble chamber centre above the floor is unimportant from the point of view of beam optics. This suggests that a very large bubble chamber could easily be built with its centre well above the median plane of the PS, if this would lead to a more convenient construction. It is obviously possible to arrange for particles to enter a chamber with a horizontal window but the bending action of the horizontal magnetic field in a chamber with vertical window makes it easier to use beams not confined in the horizontal median plane of the accelerator.

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