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THE CERN PROPANE BUBBLE CHAMBER PROJECT

1. Origin of the Project.

Studies with propane bubble chambers will be one of the major branches of experimental nuclear physics research around the P.S. Of the common track devices bubble chambers which can be filled with propane and other liquids, offer the special advantage of having radiation and interaction lengths intermediate between the much longer values of liquid hydrogen bubble chambers, and the much shorter values of emulsions. This feature, coupled with a strong magnetic field to permit accurate momentum determinations, makes a propane chamber particularly valuable for the detection of antinucleons and gamma rays.

Apart from these important scientific demands there is the practical consideration that neither the two metre hydrogen bubble chamber, nor the east site will be finished at the same time as the P.S. Therefore a propane chamber project has been considered essential in order to have available, as early as possible, an adequate bubble chamber suitable for experiments in the South Hall.

2. Aim of the Project.

As a compromise between experimental utility, safety and convenience of design it has been decided to construct a cylindrical bubble chamber, 1 metre in diameter and 50 cm deep, which will be operated first with propane but which will also be suitable for other liquids, which have similar operating conditions but different radiation and interaction lengths.

Experimental work planned for the chamber may be divided into two categories:

a) An exploration of the proton and π meson beams for bubble chambers which will be set up at the P.S. This will include the study and adjustment of the auxiliary apparatus such as targets, ejectors, beam transport channels and particle separators.

b) A programme of research which will depend strongly on the results of (a) and which is based on the fact that to experiment with the purest possible beams of elementary particles will be a very fruitful activity.

The exploration of beam possibilities with the P.S. is of course a fundamental duty, to which all experimental teams will make willing contributions in the early phases of operation of the machine. The bubble chambers have their part to play in this work since they have the advantage that visual observation of tracks is easy, and if necessary a large number of photographs may be obtained in few hours.

Obviously, as with many other experimental groups the first observations will be made on the highest energy protons and π-meson beams available from the P.S. Subsequently more carefully purified beams will be arranged and the following examples of experiments with such beams are seen as being particularly suited to study with the propane chamber.

a) Interactions involving antiprotons.

With a beam of antiprotons with momentum up to 2.5 GeV/c it is planned to study cross-sections for the following processes.

i) Annihilation
ii) Charge exchange scattering
iii) Strange particle production (e.g. $\bar{p} + p \rightarrow \Sigma^+ + \bar{\Sigma}^+$ and $\bar{p} + p \rightarrow \Sigma^- + \bar{\Sigma}^-$)

We hope as a result of further developments to be able to extend the useful maximum momentum possibilities of our particle separators as far as possible.

b) Interactions involving strange particles.

Preliminary experiments will include:

i) The production of hyperon antihyperon pairs can be very well studied at P.S. energies and apart from the interest in information about these interactions work is also envisaged on the lines suggested by d'Espagnat and Prentki for the test of symmetry hypotheses.

ii) The measurement of the cross-section for the production of hyperon-K meson pair in nucleon nucleon interactions above 3 GeV.

iii) The observation of the neutral decay of strange particles, since a large propane chamber offers the advantage of a useful radiation length together with the long tracks necessary for pecise momentum measurements.

It is felt at this stage however that further discussion of specific experiments would not be useful. The bubble chamber and much auxiliary apparatus must first be constructed.

3. Extent of the Project.

For serious experimental work on secondary beams at the P.S. with a propane chamber it is essential to obtain an adequate wanted particle flux in the chamber and sufficient freedom from background. Without suitable beam transport systems this is impossible. Thus apart from the design and construction of the propane chamber this project has also become concerned with the design and construction of some ejection, beam transport and particle separation devices for the P.S. Much of this work is obviously of common value to all experimental groups, and some is already well advanced. In the case of the beam transport equipment tenders for some 500 tons of bending and focusing magnets are now under consideration. This first contract will involve 44 magnets.

4. Proposed First Beam Layout.

In order to give a picture of the possibilities for operation of the propane chamber it may be useful to describe the equipment which will be installed in the south experimental area next year. Figure 1 shows that part of the first beam layout in the south experimental hall which will be especially useful for bubble chambers. The beams are briefly as follows:

Beam 1.

The channel for this beam will accept particles which leave the target at 5^{o} to the incident direction. At energies very close to the full energy of the protons in the machine the selection of positively charged particles in the channel may give almost a pure beam of elastically scattered protons. At lower energies there will be an important admixture of mesons, which will be extremely difficult to distinguish from the protons. When set for negatively charged particles at the very highest energies, the channel may yield an almost pure beam of π-mesons. At lower energies the admixture of other negative particles will increase.

Beam 2.

This beam will contain forward directed neutral particles from the target: the charged particles will be swept away by the bending magnets so that neutrons and anti-neutrons and gamma rays remain.

Beam 3.

This beam represents our first study on particle separation and it may well be modified as a result of the model studies which are now in progress. The position has been chosen to give the greatest possible path length in the South Hall. Basically the system consists of a magnetic analysing and focusing channel, followed by a parallel plate type velocity spectrometer, with crossed electric and magnetic fields. Preliminary studies indicate that for a momentum of 2.5 GeV/c it may be possible to separate anti-protons from π-mesons spatially by about 14 cm at the bubble chamber.

Many other interesting possibilities for use of the velocity spectrometer tanks can be envisaged but until our experimental work is more advanced we would prefer to refrain from their discussion.

Beam 4.

This channel represents a proposal for obtaining a K-beam with a final momentum of about 500 Mev/c. Its final form and position will depend so greatly on the results of experimental work that it will not be considered further here.

It is encouraging to observe, in support of our desire to experiment with beams of the highest possible purity that Berkeley is actively pursuing such a programme. It was recently reported that very satisfactory results were being obtained from their coaxial and parallel plate spectrometers. Our problems are however more severe on account of the higher energy of the P.S.

5. The Propane Chamber.

It would not be useful here to enter into a discussion about the "best" design for a large bubble chamber. The highest possible magnetic field is required if momentum measurements are to be attempted, and of course the forward axis of the chamber is predominantly important in high energy events. From a constructional aspect it is well known that extreme cleanliness and smoothness of the walls, a very fast expansion and recompression cycle and an accurate temperature control are required.

Our chamber will consist of a cylindrical stainless steel vessel containing the propane, bounded at one end by an expansion membrane supported by a hole plate against the magnetic pole piece, and at the other end by one face of thick glass window. The other face of the window will be supported statically by compressed nitrogen in a safety tank. From the end of the safety tank three cameras will view the tracks in the decompressed propane as shown in the general arrangement of Fig.2.

Preliminary experiments with a light source which we are developing are very encouraging. It is intended to use eight of these sources distributed around the inside of the highly polished stainless steel cylinder, to give a light flux almost normal to the viewing direction of the cameras. The angle of emission from the light sources is restricted to the extent that complete reflection occurs from each polished surface which the light may strike in the chamber. From the walls of the chamber specular reflection is obtained. The light emission is arranged so that total reflection of the light flux is obtained at the window surfaces, except for light scattered by the bubbles. When the light sources operate, the cameras will see the bubbles as bright points against a dark background. As distinct from liquid hydrogen the refractive index of propane is sufficiently great to give an adequate intensity of illumination for bubbles for light scattered through 90°.

The active volume of the chamber will be immersed in a magnetic field of maximum value of about 20 kG produced by a set of circular watercooled coils.

It is anticipated that the nitrogen compressors for the expansion mechanism can be installed in the same buildings as the power supply for the magnet, but the gas ballast tanks and other essential equipment must be installed on the magnet structure, to get sufficiently fast expansion and compression. An impression of the floor layout during operation is given in Fi. 1.

A method of transporting the whole assembly has not yet been chosen, but experiments concerning these problems have been undertaken by the mechanical engineering section of the P.S.

6. Utilisation.

It is too early to discuss in detail proposed operating procedures for the chamber, but for incident particles of sufficiently high energy the whole of the chamber wall exposed to the beam may be considered as a window. The cylindrical chamber is particularly attractive from this point of view since the wall thickness for the same safety factor is obviously less than for any other form.

For experiments demanding a thinner window a small portion of the chamber wall can be reduced in thickness.

Mounting of chamber operation and preliminary studies of experimental results will of course be made on reprojection tables, but systematic series of data track measurements and data reduction will be arranged by cooperation with the I.E.P. group in the S.T.S. Division.

7. Cooperation with other Propane Chamber Groups.

Recently an informal meeting was arranged by CERN so that propane bubble chamber groups in Europe might meet and discuss matters of common interest. Our own project has benefited greatly from this, in fact as an outcome of the discussion we are at present reconsidering our original plans for the expansion mechanism and we will have an improved design finished shortly. It is hoped that other members also may have derived some benefit from the meeting. The document PS/Int. EA 59-1 was issued to explain the scope of this meeting. We would like to acknowledge help in our designs from other propane chamber groups, particularly to the group at the Ecole Polytechnique Paris who have given us so very freely of their knowledge, both in the construction and utilisation of their excellent chambers.

Full utilisation of a large bubble chamber must of course involve experimental teams from many places, but the choice of suitable experiments and the realisation of the best experimental conditions cannot be made independently of actual experience in the setting up and operation of the chamber, and of the continuous monitoring of tracks during each experiment.

/jdw C.A.Ramm

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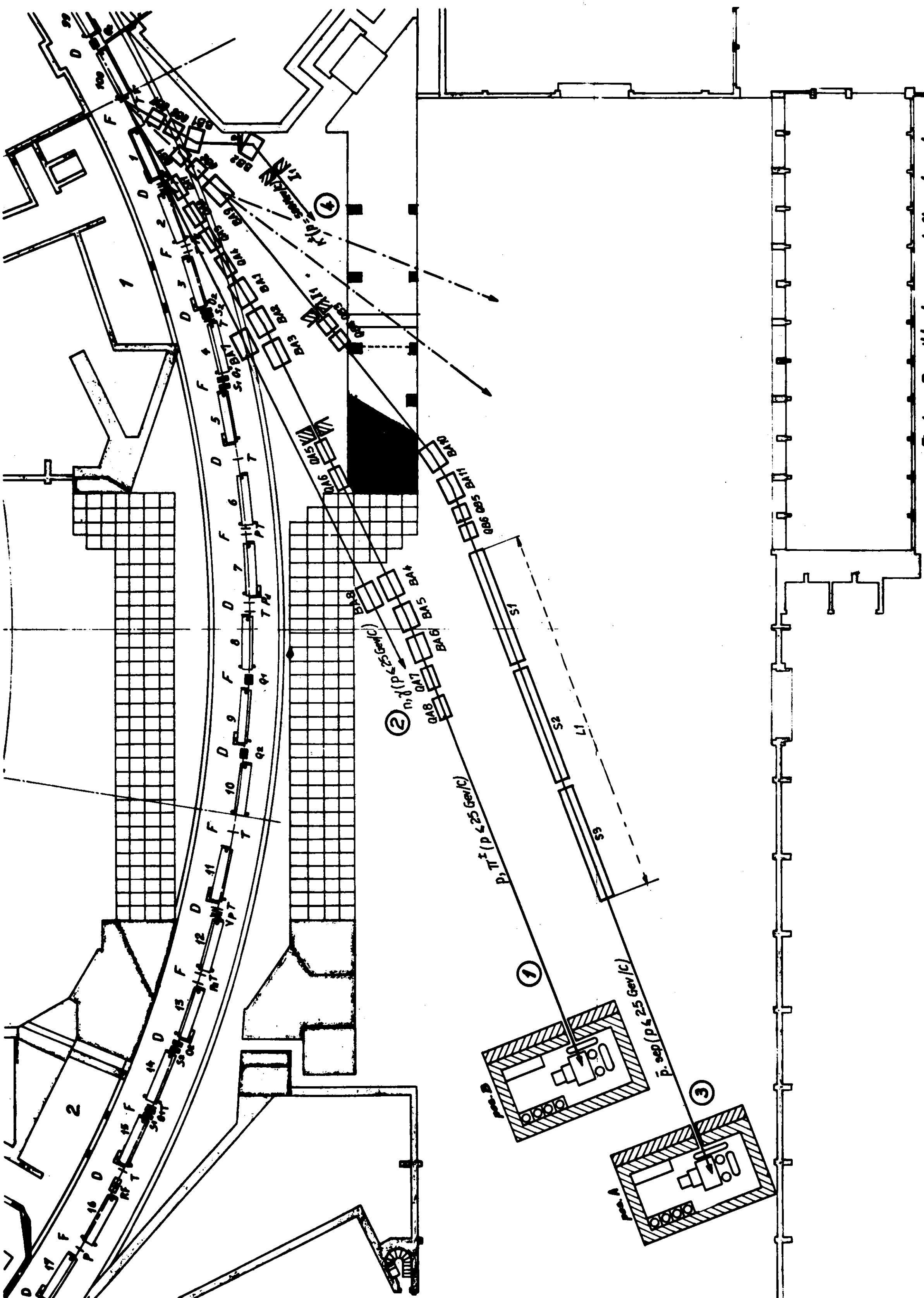

Fig.1 - Possible beam and floor layout for bubble chamber in the South Hall