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The purpose of this report is to describe the preliminary proposals of the Gargamelle Beam Study Group regarding beams for Gargamelle in the South-East area of the PS. We have considered physics and beam optics aspects, and make a tentative proposal for the over-all layout of the area. Members of the PS Division are in the process of making a detailed evaluation of the technical problems involved.

The aim of the study has been to provide around the ν installation, which is central to the whole area, conventional beams (K, π, p) delivering particles over a wide range of momenta, and also to consider in the same context some non-standard beams (μ, K^o).

1. CHOICE OF BEAMS

The full list of beams in the area has been taken to be:

- the ν beam (essentially already existing);
- three separated beams for the approximate momentum ranges 1.2 to 2.4 GeV/c (ES separation), 2.4 to 4.2 GeV/c (ES), and 5 to 14 GeV/c (RF - 2 cavities with variable separation);
- a muon beam;
- a K^o beam;
- a non-separated beam (test-beam).

The code numbers of these beams are shown in Table 1.

Some omissions from this list should be explained. For the present, no low-energy K^- beam (below 1.2 GeV/c) is envisaged, as it is not yet evident that such a beam could be successfully injected into Gargamelle through its fringe field. If this were eventually possible, we would propose a suitably modified version of the K11 beam. No high momentum, electrostatically separated, kaon beam is proposed, so that there would be a gap in kaon momentum from about 4 to 5 GeV/c, which could be larger if the RF beam were unsatisfactory at low momenta. For this reason it is proposed that in the event that this momentum gap is a serious one, it should be possible to construct an electrostatically separated beam (momentum about 5 GeV/c) along the line of the RF beam. A further qualification to the list of beams is that the non-separated beam is proposed in spite of the fact that most of its functions could be fulfilled by the RF beam. The reason is the difference in time scales. A high-momentum beam of hadrons will probably be required as a test beam long before an RF beam could be available.

2. LAYOUT OF AREA

A number of siting problems were considered, some general and some specific to certain beams. Since the area was conceived basically for ν experiments, Gargamelle is in a fixed position behind the ν shielding (although it can be rotated through an angle of $\pm 20^{\circ}$). Also the present ejected proton beam (EPB) is directly aligned towards the chamber in a narrow tunnel under a large mound of earth shielding. It has been assumed that the main bulk of the ν shielding is not to be moved, and that there will continue to be an axial hole through the fixed shielding. It would in any case be necessary to leave some shielding on the EPB axis in order to shield the low-momentum beam target (G1). It is possible either to take a beam out of the ν tunnel and round the shielding, or to keep it in the tunnel and to pass it through the shielding. Each possibility presents problems, but it is thought that these problems are surmountable, without deflecting the EPB, for all the standard beams with the exception of the RF beam. For the RF beam, a deflection of the EPB is necessary before the ν tunnel in order to obtain suitable high-energy beam optics in the given length, and to maintain compatibility with the ν beam. Care will be necessary in the design of the downstream end of the ν shielding if it is extended close to Gargamelle in order to maintain flexibility among the different beams.

From the beam optics point of view, the South-East area is, of course, symmetric about the present EPB line. The positions of the various beams will therefore be governed by other factors. These other factors have been considered in a non-detailed way, starting from the assumption that the greatest problems arise for the RF beam and that its position should therefore be fixed first. The question is then whether the RF beam should be placed on the left or on the right (looking downstream) of the present EPB. The considerations taken into account were: i) excavation near the PS ring; ii) effects on present buildings and plant; iii) effects on present access ways; iv) radiation hazards; v) ease of deflection of the present EPB to a new line. With all these things considered, it would seem preferable to have the RF beam on the right rather than on the left of the present EPB line. These two possibilities are being considered in much more detail by members of the PS Division. In the event of the choice of deflection to the right being made, then it would be logical for reasons of compatibility to place the two other separated beams (G1 and G2) on the left. On this side, the higher momentum beam of the two (G2) could make use of the already existing branch tunnel. The high-momentum unseparated beam (G4) does not enter into the discussion of left/right factors, as it is envisaged that this will be mostly within the ν tunnel and will emerge through the central hole of the shielding.

3. BEAM CHARACTERISTICS

Some of the characteristics of the beams G1 to G4 are shown in Table 2. The common assumptions made for the fluxes given are as follows: i) one bunch is 3.5×10^{10} protons; ii) the target is always copper of dimensions 2mm × 2mm × 100mm; iii) the target efficiency is 25%; iv) the beam-line transmission is 50%. For G1 and G2 it is assumed that the limiting value of the separation ratio (including chromatic aberrations) is 1.0.

G5 has not been considered, as it is expected to be essentially similar to the present ν beam. G6 and G7 do not appear in Table 2, as their study is not so far advanced as the other beams. They are, however, discussed at the end of this section. Appended to this report is a drawing showing the lines of the beams G1 to G5 as they are envisaged at present. It should be emphasized that the information on the drawing and in Table 2 is provisional only.

There follow some comments about the individual beams. The studies for the beams G1 and G2 were made by D. Simon and D. Leroy (NPA Int. 68-4).

G1: This is a single-separation-stage beam with momentum definition before and redefinition after the separation. The momentum dispersion is almost compensated through the separation stage.

The flux figures were obtained from the curves given by Jordan (CERN 65-14), and by Sanford and Wang (AGS Internal Report JRS/CLW-2).

G2: This is again a three-stage beam with a single-separation stage, definition of momentum bite before and after separation, and approximate correction of dispersion through the separator. The fluxes were obtained from the papers of Jordan, and Sanford and Wang.

Some modification of the ν branch tunnel will probably be necessary for G2 but this should involve only a small addition to the programme of work which will be necessary for the RF beam in that area.

G3: G3 is a two-cavity RF separated beam from which a continuous momentum band of particles will be available through the use of one mobile cavity. The maximum length available is about 150m, which causes some problems of beam design. The optics are not yet sufficiently fixed to allow solid angles and fluxes to be quoted. In order to obtain an idea of the fluxes expected, a rough comparison with the U3 beam is made (CERN/TC/BEAM 66-7). The solid angles accepted in the two beams should be similar but we can tolerate a larger momentum bite, which in turn leads to a larger target width. However, the chromatic aberrations will probably be worse in G3. It can thus be expected that the fluxes should be about the same in the two beams.

G4: This is an unseparated beam which, in its π^- version, has a target at the beginning of the ν tunnel. A momentum selection and recombination is made in the tunnel, using pulsed magnets, and the π^- beam then passes through the central hole of the ν shielding before being shaped by standard quadrupoles for entry into Gargamelle. The fluxes were calculated from curves given by Sanford and Wang (AGS Internal Report JRS/CLW-1) and are uncertain at high momenta.

The proton version of G4 is still being studied. The principal problem is the reduction of the flux to about 10 protons, given one whole bunch ejected. Use of an internal target would be very difficult because of the pulsed nature of the septum, EPB, and G4 magnets. The momentum of the G4 proton beam would be equal to the momentum at ejection, and the lower limit is uncertain.

G5: The details of the ν beam have not yet been considered except in recognizing the problems of compatibility that will exist. As already stated, it is not expected that there will be any radical changes in the ν beam when it is reconstructed for Gargamelle.

G6: The muon beams that are being considered are of two basic types, large and small momentum bite. The large momentum bite beam (about ±10% or more) is being studied in two forms, both of which use the ν target but which use the ν horn or a quadrupole doublet for focusing the pions. The ν-horn version has already been used in a pilot experiment, and with proper choice of shielding can provide muons in the approximate momentum range of 8-16 GeV/c. The version with quadrupole focusing provides a smaller momentum spread and a smaller muon flux. Each version requires two or three magnets between the shielding and Gargamelle to shape the beam for entry.

The low-momentum-bite version attempts to trap the muons which are produced when a pion beam decays over a long drift length in which it is parallel in both planes. Such muons can be spatially separated from the pions in the plane of a subsequent pion image. A large absorber placed at the pion image may then absorb the pions while allowing a useful fraction of the muons to pass. It is expected that the loss factor for the muons will be large and calculations are being made to determine its magnitude. Even if it proves possible to produce a useful muon flux in this way, this version of the muon beam would suffer from the disadvantage that it would require a large number of magnets, probably about the same number as in a conventional high-energy separated beam. Because of this, the possibilities are being considered of using lines in the region of G3 or G4 for this beam.

G7: There are a number of possible ways of producing K^0's for study in Gargamelle and there is no universally optimum beam. If a repeat of the X4 experiment (B11 beam) were desired (K^0_2 produced by protons; tube through chamber), it would probably be possible by using a target in the ν tunnel and passing the K^0_2 beam through the hole in the ν shielding. Other possible solutions are being studied in which K^0's are produced by the interactions of π^- or K^+, both with or without tubes in the chamber and with or without knowledge of the K^0 momentum. These solutions are expected to suffer in general from low fluxes when compared with an X4 type experiment.

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Table 1

Beam Number	Particles	Momentum (GeV/c)		Type of separation
		Lowest	Highest	
G1	$K^{\pm}$, $\pi^{\pm}$, p, $\bar{p}$	1.2	2.4	ES
G2	"	2.4	4.2	"
G3	$K^{\pm}$	5	14	RF
	$\pi^{\pm}$		22	
G4	π^{-}	2	22	None
	p	-	25	
G5	ν, $\bar{\nu}$	-	-	-
G6	μ	-	-	-
G7	K^{0}	-	-	-

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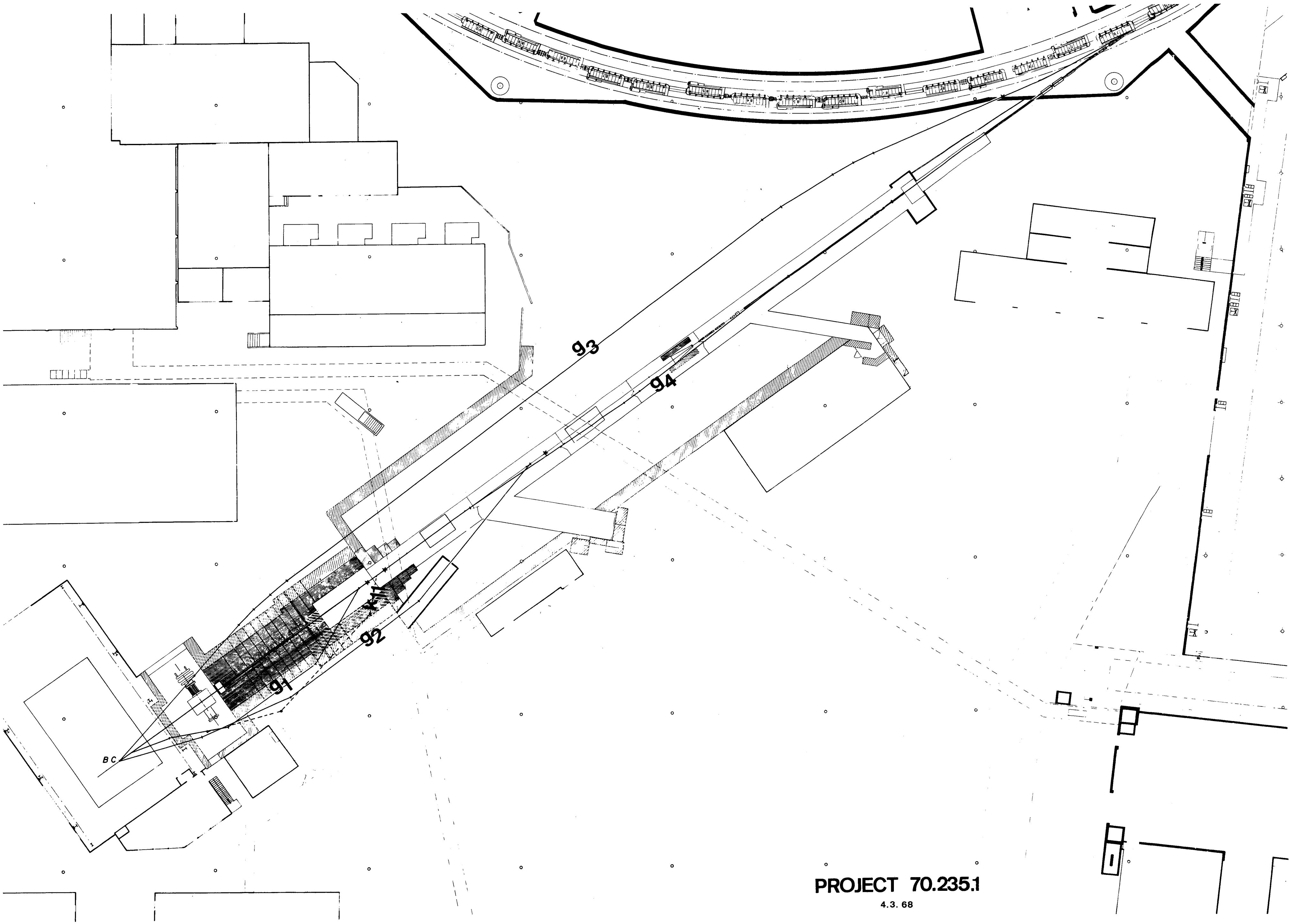
Table 2

Beam	Length (m)	Δp/p (%)	Ω (msr)	Particle	Flux/Bunch
G1	40	±½	0.58 at 1.2 Gev/c, 0.11 at 2.4 Gev/c	K^-	15 at 1.2, 105 at 2.4
				K^+	30 at 1.2, 150 at 2.4
				$\bar{p}$	180 at 1.2, 90 at 2.4
G2	75	±¾	0.2 at 2.4, 0.05 at 4.2	K^-	36 at 2.4, 75 at 4.2
				K^+	50 at 2.4, 150 at 4.2
				p^-	230 at 2.4, 110 at 4.2
G3	146	±½	-	-	-
G4	122	±0.4	0.03	π^-	600 at 2, 4000 at 6, 100 at 22



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