MEMORANDUM

S21

NP/Memo/332

11 July, 1962

To : Professor V.W. Weisskopf,
Director-General,
B.D. Hyams

From : G. von Dardel

Re : Neutrino Experiment Programme for Period III

In answer to your memo, the neutrino groups would like to make the following request for machine time and other facilities during Period III, and rough predictions for the programme.

During Period III, the neutrino experiment will be in an intense state of preparation for the experiment next year. We are putting every effort into avoiding that these preparations interfere with the other experiments on the machine. We are planning the following programme (see the attached plan).

a) Shielding installation - The plan shows the shielding present at different stages. About 2500 tons of iron shielding and a somewhat smaller quantity of concrete will have to be installed between the detectors and the machine, and the shielding will be arranged to provide a long decay tunnel through the shielding wall. This decay tunnel will be opened up during the autumn shut-down, but will again be temporarily plugged, at the machine end, so as to allow the installation work to go on without interference with the machine operation. For the same reason it is intended to build a provisional shielding wall also towards the experimental area in the South Hall. Without detailed information on the thickness of this wall necessary to reduce the radiation level behind it to a tolerable level, and on the detailed layout of the experimental programme, in particular on the c_4 beam, we cannot guarantee that the c_4 beam can be kept, but as is seen from the layout, it is not improbable. We suggest that these questions should be discussed in more detail with the experimental teams concerned and the beam layout group. Extensive installation work will also go on in the area around the blockhouse, but will, we feel, not interfere appreciably with other experiments.

It is intended to recruit extra auxiliary labour for the installation of the neutrino shielding and from this point of view there should be little interference with other installations for the research programme.

5122/p

There may be occasional collisions of interest in the use of fork trucks and other installation equipment, and sometimes urgent transports of materials needed for the neutrino installation may necessitate short interruptions of the run, perhaps for as much as one hour per day.

b) Spark Chamber Tests - By Period III, the spark chambers which have recently undergone extensive tests in the m_2 beam will be in an advanced state of construction with a fair fraction of the final set-up being ready. It is essential that these chambers can be made to undergo realistic tests in a particle beam. For this, we will require a sufficient area, 4 x 8 m^2 for the chamber and camera, and 10 m along the beam for counters, in a beam with particles in the range 500 MeV/c - 2 GeV/c. We would require an estimated 30 shifts during November-December, if possible distributed with 5-10 shifts per week over the period, running in parallel with other experiments, counters or bubble chambers, around target 1. The q_1 beam would be suitable for these tests.

We feel that it will, in addition, be important to extend the recent tests to higher energies when a large fraction of the final set-up is available, so that particles of several GeV will be slowed down or absorbed by interactions. The reason for this is that after the Brookhaven neutrino experiment the emphasis of the CERN experiment will have to be shifted to the search for, and study of the intermediate boson, produced mainly by high-energy neutrinos from K decay, whose spectrum extends to 6 GeV and above. The m_2 beam would be suitable for these tests. We would require about 10-20 shifts for these measurements, probably towards the end of the Period.

Details for these tests are given in the attached memo of the spark chamber team.

c) Bubble Chamber Tests - The CERN heavy liquid bubble chamber is at present undergoing modifications and improvements. The operating staff is being increased and the experimental team is strengthened by more physicists. By September, this new staff will undergo a training programme with one or several short runs with cosmic rays, in the present position of the chamber. Although not essential for these test runs, we would like to discuss with you the possibilities for a simple calibration beam for these test runs, similar to the beam which was previously derived from the d_8 beam.

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A more thorough run, before the actual experiment, with particles of the general type expected in the neutrino experiment would certainly be very desirable. As you know, several alternatives have been considered for such a run, as for example, the X2 experiment in the North Hall, an 18 GeV pion exposure (T16-Fretter) and a high-energy K exposure (T11) in the m_2 beam. Such a run would have to take place in December-January if the chamber is to go into the neutrino blockhouse in time for the neutrino run.

Of these experiments we have chosen the experiment T11 in the m_2 beam, since this would be a natural continuation of the experiment in which the group is at present engaged (T8), and therefore should not present many new problems which might detract from the neutrino experiment. At the same time the methods of analysis and the computer programme perfectioned in this experiment will be useful in the neutrino experiment. We will not be able to offer much assistance in the setting up of the m_2 beam, and we assume that this beam is set up for other experiments before Period III. 100.000 pictures will be taken in this beam. We shall prefer to use a magnetic field of 26.5 kG supplied by three generators, and run the machine on a 3 cycles period at 24 GeV.

We want to emphasize that this experiment, while interesting in itself, and also of importance as a means of studying the performance of the bubble chamber in view of the neutrino experiment, is considered as secondary compared to the neutrino run early next year. In case this experiment could not be performed in the requested time period between December and January, or if the efforts of the bubble chamber group are taken too completely by the preparations for the neutrino experiment to run the experiment, we may be led to cancel it or replace it by a shorter, simpler run, entirely directed to study the performance of the chamber in the conditions of the neutrino experiment and not towards an actual experiment. Such a run would involve 50.000 pictures in a negative beam of 5-10 GeV/c in the present chamber position. We believe that these two alternatives constitute an upper and lower limit to the programme for the bubble chamber during Period III.

d) Background Tests - Towards the end of Period III, the shielding around the neutrino experiment and the blockhouse should be almost complete. Previous measurements have shown that the shielding was nearly adequate and some of the shortcomings of the old shielding should be remedied by the new installation. It will not be known with certainty if this installation will prove completely adequate before the actual neutrino experiment is well under way.

However, a relatively short background run in January, with targets in straight sections 5 and 10 could detect if drastic mistakes in the shielding were made and allow this to be remedied during the February shut-down. We would need about 50.000 short burst pulses on target 5 with a machine energy of 22 GeV or above, on a pulse shared or full time basis. For the study of the background from target 9 or 10 we would also need about 50.000 pulses of short duration, and could parasite on a bubble chamber run with this target.

Approximate programme for 1963.

For the first actual neutrino run, we consider a major run of 100 shifts. In principle we agree to run as uninterrupted as the functioning of the ejected beam and the detection equipment will permit, so that the experiment may be finished as quickly as possible. Whether the equipment is reliable enough is not yet known, and it is probably necessary to foresee at least two reserve weeks which can be inserted in the neutrino run and used by stand-by experiments if the ejected beam or detectors should break down and needed repairs.

The major part of the main run would use the machine at 24 GeV, 3 sec period in order to accumulate sufficient statistics on the intermediate boson production in the bubble chamber. The last third of the run would be used for a number of exploratory shorter runs, to investigate the effects of variation of parameters, such as machine energy, the current and polarity of the neutrino horn, and the length of the decay path. These runs can only be planned in detail on the basis of the first part of the run.

The main run would be preceded by a test period, both for the ejected beam and the detectors. The ejected beam will require a test period of at least 6 weeks after the installation shut-down. During the first two weeks these tests would be merely electrical and mechanical tests, which in principle should not interfere with the operation of the machine. During the next two weeks attempts would be made to eject the beam and guide it down the beam transport. 4-6 shifts per week of machine time would be needed during this period, possibly on a pulse sharing basis with other users. The last two weeks would be used to trim up the beam and achieve the simultaneous operation of all the constituents with high efficiency. This programme is of course very tentative, and could only be considered as a rough average. It is very unlikely that the tests of the beam will take less than 4 weeks and if they take more than 8 weeks, it may be best to dismantle part of the equipment and repair or modify it.

The testing of the detectors will already be partly done during Period III. For the bubble chamber, very little additional tests need to be done. The muon channel used in the first neutrino run will allow sufficient muon flux into the chamber for the setting up procedure. The spark chamber will be more tricky to adjust and 10 shifts will be necessary with the ejected beam to check the timing, and performance of the circuitry before the actual experiment can start. If the testing of the ejected beam proceeds well, this setting up time may be done in conjunction with the final tests. For part of these tests a machine energy of 28 GeV will be used to allow muons to penetrate into the chamber. Parallel users would be tolerated on a 1:1 pulse sharing basis.

Possibilities of Parasiting

Parasiting or parallel running during the neutrino experiment is desirable from a general point of view if this leads to more gain for the parasite than the neutrino experiment loses in the process. Parasiting on a pulse sharing basis is obviously uneconomic, except if the parasite user only needs infrequent pulses, as for cloud chamber experiments, or for some types of beam setting up.

Sharing the intensity in the same pulse with a parasite is useful if the parasite only needs a small fraction of the intensity. The possibility to parasite depends on the solutions to a number of technical problems. The following possibilities are at present being studied:

1) Interception of a small fraction of the beam before ejection by a bubble chamber target. The RF K.O. could be used to increase the beam size until the beam hits the target and then reduces it again for ejection. Tests need to be done on the deterioration of the beam size during this process.

2) Interception of part of the ejected beam by a target at a convenient point after the ejector, probably in magnet unit 2. The size of the target and the multiple scattering in the target are not well known and may well render this method unsuitable.

3) Ejection of 19 bunches, leaving the last in the machine for other users. This requires an ejection pulse with faster rise and fall time than is foreseen at present. This solution will certainly require an effort on the ejection, especially devoted to this problem, and is unlikely to be ready for the first run.

4) The ejection kicker first kicks a single bunch onto a bubble chamber target in the machine and then ejects the rest of the beam. The target efficiency of the bubble chamber may be very low, because of the drastic limitation in space for betatron oscillations by the kicker magnet.

All these possibilities must be actively investigated before it can be shown that parasiting is profitable. It should be emphasized that the neutrino groups cannot take the responsibility to develop the facilities for parasiting. This must be done by the teams who would like to parasite. Some co-operation in this direction has already been initiated.

It has been assumed that only cloud and bubble chambers can profitably parasite. In the case of counter experiments, it will be necessary to provide a flat top, with a corresponding decrease in repetition rate in addition to the reduction in intensity.

The competition for magnet power between the bubble chamber of the neutrino experiment and parasites raises further problems. The heavy liquid chamber will be run at a current of 7500 A from three generators, with a magnetic field at the centre of 26.5 kG as against 20.5 kG with 5000 amp from two generators. The parasite would have to be satisfied with the remaining generator or provide power from other sources.

Stand-by Experiments

Although we intend to run the neutrino experiment with only short interruptions, there are several uncertain factors which may make it necessary to interrupt the experiment for some time. The ejected beam may break down and need a few weeks or months for repair, it may turn out necessary to make major improvements to the shielding, or the result of the first part of the run may suggest a more promising new line for the experiment.

For these alternatives, it is necessary to have a number of stand-by experiments ready which may take over the machine at short notice.

Beam c_4 will be solidly blocked by the neutrino shielding at this time, but there is no obvious reason now why other beams should not be able to take over immediately or after removal of some concrete shielding.

Copies :-

N.P.R.C.

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<u>ANNEX</u>

M E M O R A N D U M

To : Nuclear Physics Research Committee

From : Neutrino Spark Chamber Group

Re : PS Machine Time and Facilities During Period III, 1962

There are two major lines of activity during Period III:

A. Test runs of special spark chamber assemblies in a high-quality beam.

B. The setting up of a test area for routine tests of counters and spark chambers as a permanent installation, during Period III, in a beam of low quality.

The purpose of A is

1) to find an optimal combination of our Al- and brass chambers for the analysis of complicated events (say the production and decay of an intermediate boson),

2) to try to operate the chamber as "proportional chambers" i.e. to try to use the number of sparks per cm in a given track as a measure for the particle's ionization.

The NPRC has allocated 20 shifts to this purpose. It must be emphasized that the beam must be of high quality in order to be able to produce complicated events under well controlled conditions.

Our <u>specifications</u> are:

$0.25 \lesssim p \lesssim 8$ GeV/c.

<u>Intensity</u> $\lesssim 10^4$ particles long burst in order to avoid accidental tracks in the spark chamber.

<u>Particle Separation</u> by electrostatic separators would be appreciated, but is not essential.

$\Delta p/p \lesssim 2\%$.

According to discussions with the PS Experimental Planning Group, beam m_2 would fulfil all our requirements. An area of 10×10 m^2 would be needed. The tests should be finished by the end of the year.

B. The routine test facility will be needed through practically all of Period III for $\approx$ 2 days (30 shifts) per week (average value; some weeks without beam are acceptable).

Beam requirements: > 1 particle per cm^2 and burst.

Space requirements: $\approx$ 10 x 8 m^2 and some setting up space ($\approx$ 100 m^2 which can be somewhat remote).

According to the PS Experimental Planning Group, q_2 is most suitable. Our set-up would go in behind the equipment of the groups scheduled for q_2. We would be a permanent parasite. Main experiments would not be disturbed by us. Some re-arrangements of the old partition walls in our present test area would be necessary and, of course, some restacking of shielding.