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Memo to: R. Bacher

From: D. K. Froman

Subject: Experimental Program of the Physics Division

The purpose of this memorandum is to review, in part, the experimental program of the Physics Division on the premise that the criterion for judging if an experiment should be done is that such an experiment makes the most efficient use of time, personnel, and available equipment and materials for the fulfillment of our primary object. In particular, it is assumed that those experiments which are expected to result in definite and specific information aiding in the design and construction of the gadget take precedence over all others; in fact, that this criterion is so strong that other types of experiment should not be attempted unless it is evident that there are no directly pertinent experiments left unstarted which could be done by the personnel or with the equipment involved. A working basis as outlined above does not minimize the value gained from general experimentation, but merely emphasizes the fact that the probability of obtaining useful results is greater if the specific use of the results can be seen a priori.

For the purpose of illustration, a number of experiments have been divided into two categories, viz: (A) Those which, in the opinion of the writer, deserve increased effort, and (B) those which, in his opinion, should be dropped or curtailed in order to put more effort on those in class (A). It must be pointed out that all of the reasons why certain experiments are in progress while others are not, probably are not known to the writer. Also, that the details of experiments in progress are easier to see and their results easier to evaluate than those of prospective experiments, so that a few items in group (A) mentioned in general terms may require many man-months of experimentation and may be divided into many sub-experiments, whereas many small experiments are mentioned explicitly in part (B).

The great majority of experiments in progress have unquestioned value and are not mentioned here. However, results in many cases might be speeded by additional personnel or equipment which could be transferred from experiments of lesser [illegible] (possibly mentioned in group B). That is, the criterion for not doing an experiment should not necessarily be that [illegible] other new, more significant experi-

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ment is at hand.

As a general criticism, there are too many experiments whose details are not thought out carefully, sufficiently in advance to guarantee good procedures and equipment. This is evident from the fact that a third of the job orders coming to the electronics shop call for the job completion in less than ten days in spite of the well-publicized opinion of the shop personnel that this is a minimum period for the production of sound, well-tested equipment. This state of affairs indicates the prevalence of either procrastination or "flash-in-the-pan" experiments.

A more important criticism than the preceding one is the very natural tendency of our well-trained staff to (i) push the precision above that required for the immediate purpose, (ii) to go off on a tangent either because of the intrinsic interest or in the hope of finding a general law and (iii) to do a second related experiment of little value for the project, merely because a suitable apparatus has been set up or a new material has come along. These things require continued vigilance and, even then, the stopping point is usually a matter of opinion. Such points should have the benefit of the combined judgement of many minds. In this category we must include also, certain measurements made at the request of the Theoretical Division. Decision whether or not to make these measurements should be made on the basis of our fundamental criterion. It should be kept in mind too that, had Fermi waited for the measurements of all the cross-sections involved and the theoretical calculations, it is probable that we would not yet have had a reacting pile.

The lists of experiments given below are taken entirely from Physics Division work and are not exhaustive for this division. The intention is to illustrate the general principles. The writer feels that much longer lists could easily be made if the work of some other Divisions were considered. It is probably true that in the majority of cases listed, the comments are of no value because it is too late.

In spite of being a group leader and a member of the coordinating council, the writer has practically no knowledge of experiments contemplated or being instrumented or even being performed until a report on the progress or results appears. He gets some information through the back door of job orders. It seems that "coordinating" is a misnomer if the council does not coordinate the work of the whole project, i.e. consider and pass on the methods and relative desirability of all proposed experiments and suggest experiments to fill out gaps. At present, the planning of an

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experiment is confined almost entirely within a group, certainly within a Division and persons suggesting experiments appear to do so from the group viewpoint rather than the project viewpoint. Need is felt for a detailed plan of what we are attempting to do including well defined intermediate objectives. Such a plan would give rise to suggestions on pertinent experiments and would help confine the work to the essentials. In particular, it would help us in the Experimental Physics Division, to keep in mind that our work should be in the nature of nuclear engineering rather than academic. Let Chicago have all the fun of doing the general information and academic experiments. We are here to build a gadget. Every proposed experiment should be written up in sufficient detail for members of the staff to be able to grasp the essential points and evaluate the worth of the experiment. The results of calculations on how well the expected experimental results will meet the precision etc., required by the purpose of the experiment, should be given. If there are too many such experiments or the coordinating council is too unwieldy to consider them all, at least the existance and title of each write-up could be announced and in special cases, committees could be appointed to look into the desirability of the proposals. Such a procedure should reduce any tendency toward unknowing duplication, should produce many valuable suggestions as to experimental details and generally keep us on the ball.

The writer feels that the time has come for a real beginning of a shift in emphasis in the Physics Division from differential type toward integral type experiments. It is thought that this should be accomplished by assignment of these experiments to groups or individuals already here and conversant with the whole problem rather than by keeping them on the less useful differential experiments and bringing new men to the project for the new work.

GROUP A

1. Experiments dealing with auxiliary mechanisms of the gadget.

a. Ignition mechanism in the gun method. Although the necessity for such a mechanism has been known for many months and much general talk about it has been heard, it is only today that the details of measurement of the neutron emission from such ignitors have been considered in the Experimental Physics Division. No thought yet has been given to the measurement of neutron emission during the period of assembly, but only after complete seating. Even now, the problem [illegible] to members of the Division by the Ordnance Di[illegible] will be ready to assemble parts containing igni[illegible] two or three days. Thus, these measurements will be delayed for lack of equipment and no doubt will be attempted with hurriedly-

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assembled measuring gadgets.

b. Nuclear ignition in implosion. Possibly step-by-step experiments with "tracer" materials could be done. In any case, detecting equipment needs careful consideration and experimentation.

c. Preliminary experiments on the effects of the assembly of segments of a tamper, etc, so that techniques and equipment will be ready for critical size determinations. In particular, an augmented program of instrumentation for time scale measurements, both the modulated and unmodulated types. Instrumentation, technique development, and especially thought should be pushed on measurements on super critical masses rendered sub-critical by absorbers or by other means.

2. Experimental development of small volume neutron detectors and measurement of the perturbations produced by them under various geometries. Some work being done on this, but it seems that the efforts in this direction should be greatly increased in order to measure neutron distributions throughout tampers, mixtures, etc.,

3. Experiments on measurements of neutron distributions in both homogeneous and heterogeneous mixtures. We need to know how and have equipment ready for determining critical masses by Feynman's method by the time the material is at hand. How nearly homogeneous is it necessary to make the mixture, how is it to be done?

4. a. Physical experimentation in the medical group. Although there is a large group of Physicists in this type of work associated with the Chicago project, there are some specific problems at this project with which they will have no occasion to deal. For examples, the problem of personnel protection in handling large quantities of 49 in dry, powdered or other forms, and protection during and after explosions in which sizeable quantities of radioactive material are used. We are faced with both of these problems now without suitable detection equipment.

b. Consideration should be given to the question as to whether or not there are useful experiments which could be performed to aid in estimating the radioactive biological effects of an explosion. The wide range and great fluctuation of opinion as illustrated in reports LAMS44 and 49 indicate that an occasional committee meeting plus some calculations by the Theoretical

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Division based on inadequate data, are unsufficient for clear-cut conclusions.

On the whole, it appears that the medical group is being neglected from the Physics angle. For example, there is not even one Physicist on the committee formed for the purpose of deciding how to measure dangerous contamination in the air and elsewhere, and how to minimize the danger.

5. An experimental program leading to the preparation of apparatus and development of techniques for measuring the many quantities we will want to know if a full-sized trial explosion is made. Among other measurements, there are physical damage estimates, resulting meteorological effects, biological effects and spreading of radioactive products.

6. Increased emphasis on the development of ingeneous detectors. There are two main limitations on counting: noise and background. Although work on the improvement of amplifiers should be continued, it does not seem likely that the noise level will be appreciably reduced or that the speed will be much increased for many months. It seems more hopeful to develope really good detectors such as the C.P. counter and the fish counter which internally cancels Alpha pulses.

7. A program of measurements of the Albedo type on tamper materials. We are interested essentially in the numbers and energy distribution of the neutrons returned from the tamper block rather than in the scattering and capture cross sections.

GROUP B

1. The water-boiler

The original specific purpose of the water-boiler was to provide a high-intensity source of neutrons. (See report LA4), p. 23). The intention to operate at high power has now been dropped and even if it had not been, it is questionable if this particular geometry is appreciably better suited for experiments than existing sources such as a reacting pile or a cyclotron.

The reasons for continuing the project appear to be essentially the following:

(i) To make some use of material before the critical mass has arrived.

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(ii) To gain experience in handling a critical set-up.

(iii) To check the calculations of the Theoretical Division.

(iv) To provide a place for the assembly of nearly critical masses in more-or-less final form.

Obviously, item (i) does not even remotely conform with our basic criterion. Instead, it might be argued that this material should be used in semi-integral experiments. Although item (ii) sounds good, the action of the water-boiler is much more akin to that of a carbon pile than to a gadget so that the value of the experience is questionable. The conclusion that this type of experience is not valued highly is evident from the fact that although the action is so nearly akin to that of the carbon pile, it was not deemed necessary to put anyone with pile experience on the water-boiler group. As for item (iii), the bases and methods of calculation for water-boiler and gadget differ widely. For the purposes of constructing a gadget, no significance can be seen in such a check. Item (iv) is surely more efficiently done by providing a place for the specific purpose rather than adapting a place built for something else.

There is no question in the writer's mind but that much useful information will come from the water-boiler experiment or that it is one of the most attractive problems in modern physics, but it seems unlikely that the useful results for our purpose will be commensurate with the enormous amount of work going into the job. There is no evident, specific reason why dropping the project would in any way delay the production of a gadget. The prompt-chain-period and neutron distribution measurements do not seem to be relavent to the gadget. First, the time scale differs so much, and second, we already have people in the laboratory with experience in the measurement of decay times with slow neutrons.

2. Spontaneous fission in Thorium, Ionium and Protoactimium. Since none of these materials are under consideration for use in the gadget, it is not obvious that these measurements will directly contribute toward its construction.

It appears that the reason for measuring spontaneous fission is to aid in determining the acceptable minimum speed of assembly and to set a limit upon the chemical purification from light elements. Thus, there is some, not very hi[illegible] precision required for such measurements. Since [illegible] will be present in a 25 gadget and since th[illegible] assembly

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will be calculated on an arbitrary admissable probability of predetonation, it is surely unnecessary to carry the precision for 28 to ± 2 or 3%. In the case of 49 rather rough results would seem sufficient in view of the enormous chemical purification problem and the precision with which contaminants can be measured.

3. Stopping power of various elements for fission fragments. It is not evident that these experiments conform with our criterion.

4. Proposed measurements of energy distribution of fragments of 49. It is perfectly evident that the values of ν, σ, and the neutron distribution are of immediate use in calculations leading to proper design. The total energy release per fission is interesting, but is probably already known or calculable sufficiently accurately and a knowledge of the division of energy between the fragments seems irrelevant.

5. Measurements of σ_c with particular, but not-too-well known neutron spectra from natural sources for such elements as Cu, Na, Sb, As, Br, Mn, Ag, V, Al, etc. Connection with the gadget not evident.

6. Measurements of σ_c thermal for a number of elements. It is not clear why any thermal experiments should be done except those in the nature of auxiliary experiments such as those for calibration. Gold seems to fall in this category, but it seems to have had much more attention than one would have thought necessary for establishing a kind of secondary measuring rod. Reasons for work on many other elements is not clear.

7. Capture, scattering, and/or fission cross sections of heavy elements such as Thorium, not under consideration for either active materials or tampers. Such measurements do not meet our criterion.

8. Energy degradation by brass and cadmium. If such measurements are necessary in order to correct or interpret results of measurements on other materials they should not appear in Group (B). Otherwise, it is not evident that they qualify as suitable experiments.

9. Diffusion lengths in lead and in iron and lead. The purpose is not clear, especially in the [illegible] case unless the whole experiment with iron [illegible] of technique development for use with pos[illegible] tampers instead of

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iron. If the experiment is related to the gun, it is surely much better to do an integral experiment with the hydrogenous propellant present rather than trust to measurement of elementary quantities and calculations with the difficult gun geometry.

10. The development and construction of a precision frequency divider. It is obvious that this does not meet the criterion but still the work continues in the writer's own group.

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