REMARKS ON THE USE OF BUBBLE CHAMBERS IN VERY HIGH ENERGY EXPERIMENTS

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For the time being it is impossible to see which instrument could be better than the bubble chamber for the general study of very high energy phenomena. Special arrangements of spark chambers and counters can certainly be superior in particle identification and high precision momenta measurements, but just because they will be special arrangements they will probably be restricted to the study of simple events of particular interest (elastic scattering, low multiplicity production, etc.).

One should not expect that the bubble chamber gives the same detailed knowledge of an event for very high energy phenomena as it gives now for events from 0 to 4 GeV energy. Either the multiplicity of \( \pi_0 \) and other neutral particles will be too large or the accuracy of measurements will be too small to make a detailed and complete kinematic analysis. Therefore certain studies will remain of statistical nature (like in old cosmic rays study) or experiments will be concerned with a well defined class of events and particles, for instance one will study especially the particles emitted backward in the centre of mass system. Nevertheless, as mentioned above, one does not see which instrument could be better (unless there are new revolutionary developments as important as was the invention of the bubble chamber).

A certain number of points can be made:

I. There will always be a great interest in having free protons as targets. The argument that at very high energies the binding energy of nucleons does not count is not a good one. It should be true already for energies of some GeV and at these energies the fact that the target was a free proton has been found very useful. The most disturbing feature of complex nuclei is the fact that the secondaries of the primary interaction may react inside the nucleus.

II. There is a critical length of tracks, so that for tracks longer than this critical length the Coulomb scattering error will dominate the geometrical measurement error and therefore above the critical length the precision of momentum measurement will increase only with the square root of the track-length. This critical length depends on the Coulomb scattering constant, on the accuracy of geometrical measurements, on the energy of the particles, but not on the magnetic field. It is of the order of 4 m in PS/3613/ag
a hydrogen chamber for a particle of 100 GeV, and of 1 m for a particle of 10 GeV (for accuracies of geometrical measurements which are standard in existing chambers).

This fact has several consequences:

a) Weakness of magnetic fields cannot always be compensated by increase of size and the development of high magnetic fields is of primary importance.

b) For a given energy, a given length of tracks (superior to critical length) and a given field, a heavy liquid chamber (with a radiation length of 30 cm) will have a precision 5 times \((\equiv)\) less good than a hydrogen chamber. This would not be bad if the precision was too large, but that is not the case. For the tracks mentioned above, the precision is of 20 to 100 MeV in the hydrogen chamber, with a field of 100 KG. Therefore the conflict: detection of \(\gamma\) rays, precise angles and momenta measurements, will remain. Thus the solution of a small hydrogen chamber in a large propane chamber is not an ideal one. It seems that the large hydrogen chamber with heavy metal plates has at least as bright a future. Of course the large hydrogen chamber embedded in a freon chamber which will only do \(\gamma\) rays measurements will be even better, if feasible.

c) Large increase in the precision of geometrical reconstruction even in small chambers, if realisable, will not give answers to all the problems (because of the Coulomb scattering error) without mentioning all the other disadvantages of small chambers (no available path to particles for decay or interactions).

III. Since it is established that in high energy events the transverse momentum is small, the precision of measurements will not be severely limited if the length of tracks emitted at relatively large angles is small. Therefore an elongated (raso-tracks) chamber of 5 m length and about 60 cm to 1 m width will be the instrument best adapted for the job. For certain technical aspects (resistance of glass, temperature control, expansion) it will be also the most easy to extrapolate from existing chambers. For others (optics, mechanical resistance of the coils for very high fields) it will be much more difficult to construct than a 2 m diameter chamber proposed by Shutt and Rau, who might possibly

\((\equiv)\) for 1 m radiation length (pure propane) the ratio of precision will still be 3
be right in their conclusion in favour of this type of chamber. However the comparison should be made when much more technical knowledge is available.

One should not forget also another aspect of the technical problems. It might be that it remains always practically impossible to get 100 Kg in a chamber of 2 m diameter, because of the difficulties of the critical field in superconductors. Superconductivity will still remain useful to obtain more conventional fields in large volumes, with smaller expenses in power. If this was true, the hydrogen race-tracks chamber with plates of heavy metal will probably be the best instrument.

In all cases it must be clear from what precedes that there will not be a universal instrument. Therefore heavy liquid chambers, with or without small hydrogen chambers inside will continue to play an important part. Here the effort should be definitely in the direction of high fields.