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STATUS OF INERTIAL FUSION

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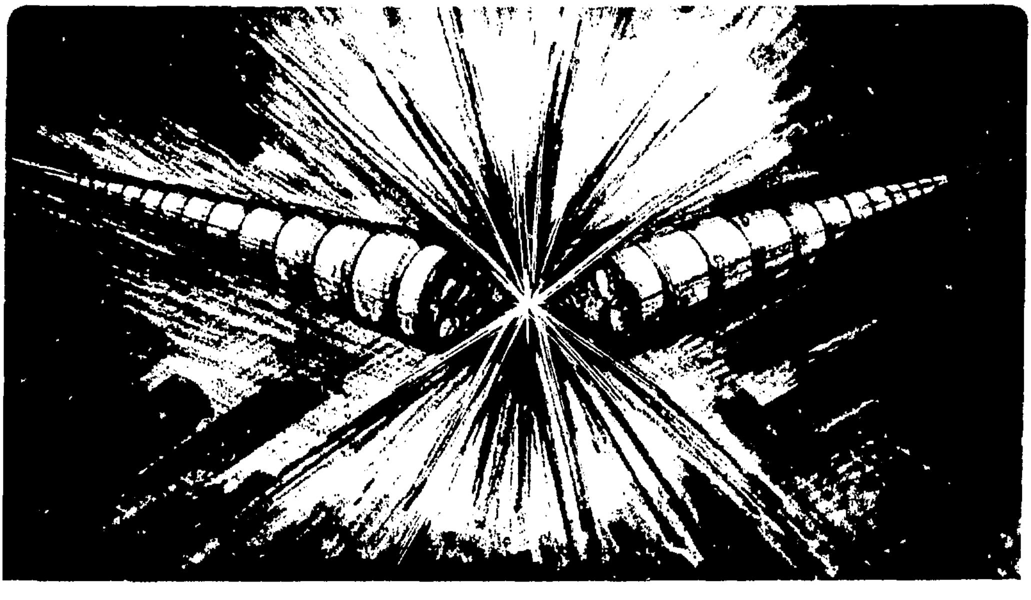

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First, let me offer some general comments on the application of particle beams since that is a major topic at this Symposium. High energy physicists are fond of showing the Livingston chart which exhibits the exponential growth of particle kinetic energy attained as a function of time (Fig. 1). This growth has been achieved and maintained by successive developments in new particle beam technology, allowing new types of accelerators to be built as tools for High Energy Physics.

When left behind by the advancing high energy physics "kinetic energy frontier," these tools have themselves proceeded to advance on a different frontier -- that of high current, high beam power, and electrical efficiency, and most have remained crucial to the development of other physics fields. For example, dc voltage generators in the 1 MV range (the first technology to succeed in "splitting the atom" nearly 60 years ago) are still the basis for neutral particle beam heaters for magnetic fusion -- they have other applications, too, such as ion implantation.

The march on this other frontier, namely to high-power beams, has also given birth to new technologies. That class of Free Electron Lasers that employs rf linacs, synchrotrons, and storage rings -- although they use the tools of HEP -- was developed well behind the kinetic energy frontier. The induction linac, however, is something of an exception; it was born directly from the needs of the magnetic fusion program, and was not motivated by a high-energy physics application (interestingly enough, high energy physics is now taking a keen look at this technology as of potential value in making efficient high-power rf sources for future "frontier" accelerators).

The heavy-ion approach to inertial fusion starts with picking from the rich menu of accelerator technologies those that have, ab initio, the essential ingredients needed for a power plant driver:

- Multigap acceleration -- which leads to reliability/lifetime
- Electrical efficiency
- Repetition rate
- Beams that can be reliably focussed over a suitably long distance.

Heavy ion beams at ~ 10 GeV have about the right range in matter for inertial fusion needs (0.1 gm/cm^2), and can be focussed on a small target across a 10-m reactor. While the beam intensities are very high, they are not nearly as high as needed for light ion beams.

One approach being pursued in Europe, USSR, and Japan is to use an rf linac to boost the kinetic energy of the heavy ions at constant current, followed by a sequence of storage rings to give current amplification.

Most recently, in the U.S., we have been pursuing, at a relatively low scale, the use of induction linacs with some novel features -- multiple beams inside the accelerating structure, and a method for current amplification that proceeds simultaneously with energy increase. The economics looks at least as attractive as for magnetic fusion.

A scaled experiment (MBE-4) is currently in progress at LBL as part of the Heavy Ion Fusion Accelerator Research (HIFAR) program under the DoE Office of Energy Research. The HIFAR goal is to establish a physics/technology data-base suitable for deciding in the future whether or not to proceed to a fusion program with heavy-ion drivers. MBE-4 uses a heavy ion (cesium) for which the current amplification process can be most readily demonstrated. When completed, we expect to have a five-fold increase in kinetic energy accompanied by a six-fold boost in current and a corresponding shortening in pulse length. (In a driver, which will be much longer, the current amplification needed will be ~ 200.) A crucial part of the experiment is to prove how well we can control the beam quality (i.e., emittance in six-dimensional phase-space). Any damage to the emittance must be contained in a driver if the beams are to be successfully focussed on a small pellet.

We are seeking to move forward next with a larger experiment, called ILSE, which will establish, on a proof of principle basis (in a scaled fashion, of course) essentially all the features to be encountered in a driver. We would like to have the apparatus fully assembled by 1992-3; this would take a doubling of the present modest HIFAR budget in the intervening years.

Finally, in thinking about how a civilian inertial fusion power program may come about (there is no such program office yet in DoE) we must note the following features: There is a strong overlap between the present DoE Defense Programs Inertial Fusion (IF) program and a potential civilian fusion power program:

(1) The target physics (i.e., high-gain) must be proved if inertial fusion is to be an energy source;

(2) The energy application is indeed a declared goal of DP-IF (but only a secondary one).

On the other side of the coin, there are contradictions:

(1) For the DP-I.F. program, it is desirable to "over-reach" in driver parameters to get high yield with a high degree of confidence. For I.F. Power, on the other hand, it may be more cost-effective to advance in stages from below, e.g., to build a 1 MJ driver first that can be expanded in steps to 2 MJ, 4 MJ, etc.

(2) Certain technologies can be acceptable for the single-shot I.F. prime goal, but not for a fusion power source, e.g., if they are not scalable in repetition rate, efficiency, focusability, or lifetime.

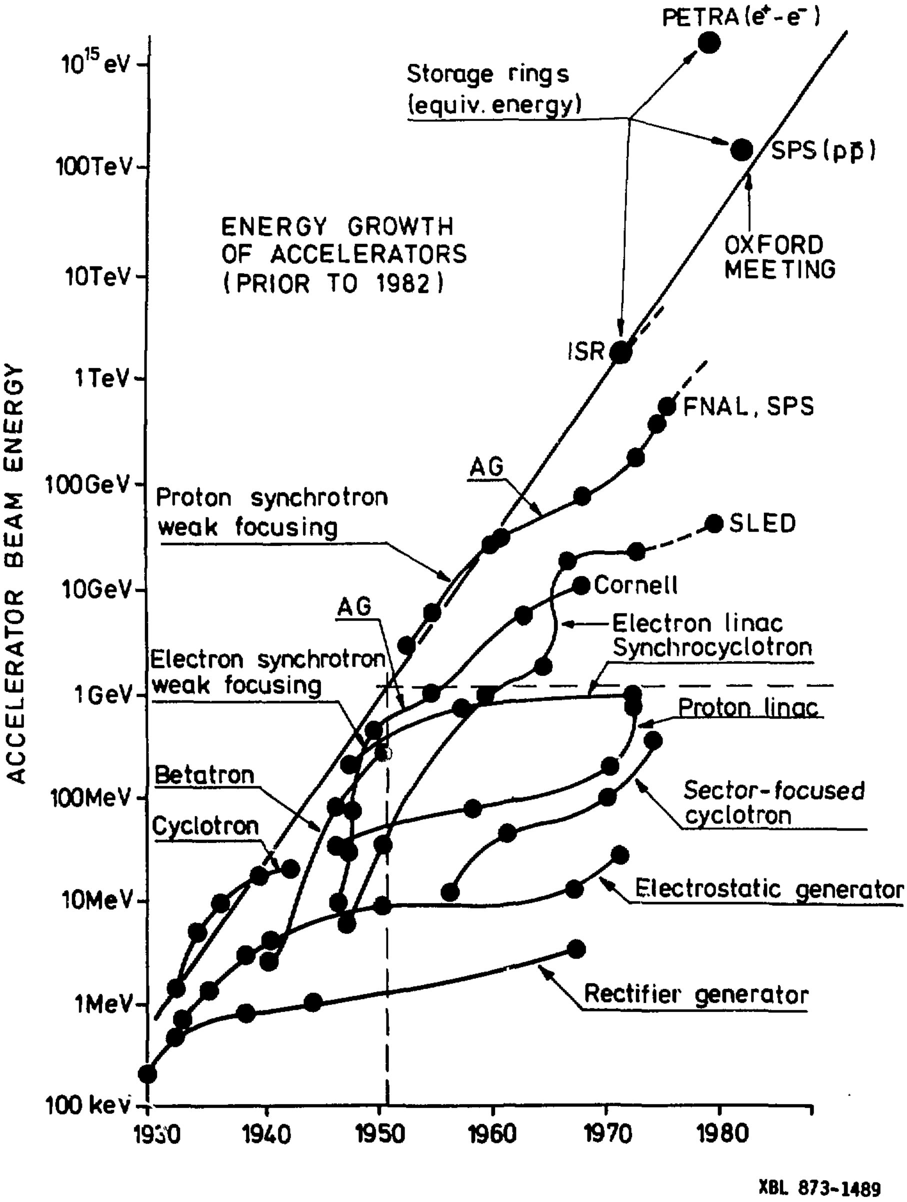

Figure 1: The Livingston Chart

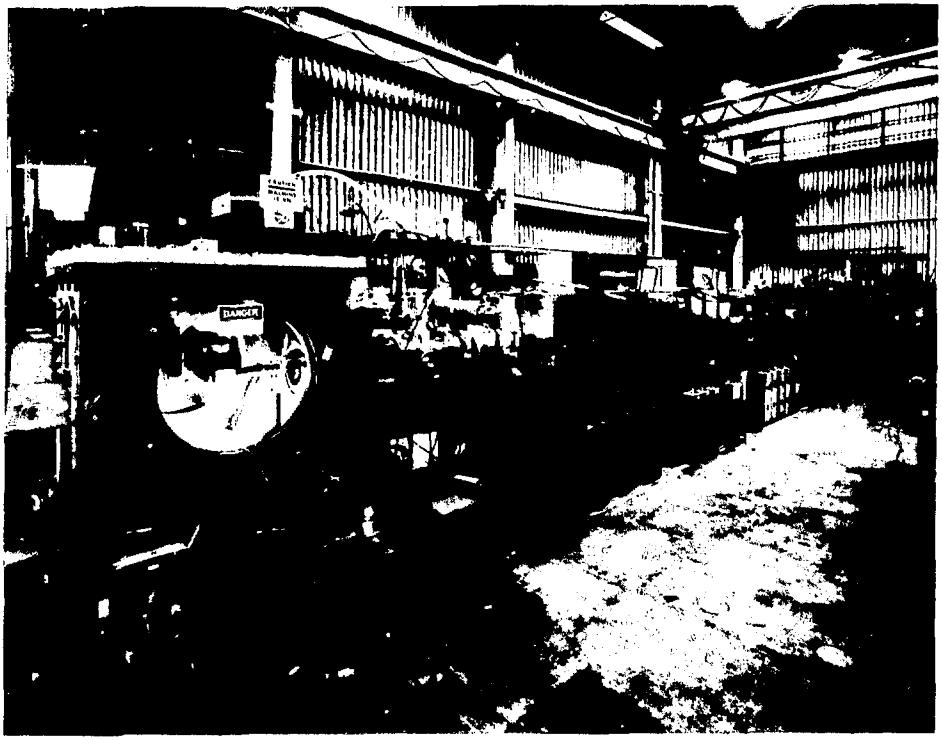

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Figure 2: The multiple beam apparatus now nearing completion at LBL. The four-beam injector is at the left; twenty induction acceleration units can be seen to the right.