Scientific Feasibility for Fusion Energy

For the past 40 years, the IFE fusion research community has adopted: achieving a fusion gain of \( \approx 1 \) as the demonstration of scientific feasibility, where gain was defined as fusion energy produced divided the external energy incident on the fusion reaction chamber. Typical fusion power plant design concepts require a fusion gain of 30 for MFE and 70 for IFE.

Fusion energy production using lasers to compress the fuel was first described by Nuckolls et al, Nature 239, 139, (1972) where fusion gain (fusion energy/Laser energy) was introduced as the measure of performance and usefulness. Brueckner and Jorna Rev. Mod Phys 46 No. 2 April 1974 pg. 325 ff.

“In order to rate target performance somewhat independent of the laser (or driver) efficiency, \textit{scientific breakeven was defined as fusion yield equal to incident laser (or driver) energy}.”

Other early ICF references are:

• The LLNL annual laser report in 1980 (first section), which is easily available at LLNL

• Roger Perkins at the US/IAEA Conf. Inertial Confinement Fusion, San Francisco CA February 1978 LA-UR 78-130 (attachment 1) This was also published later as:
  This is important as it shows Los Alamos and LLNL agreed on the definition.

• The LLNL definition of scientific breakeven was also published in:
  "Laser fusion experiments, facilities, and diagnostics at Lawrence Livermore National Laboratory", by H.G. Ahlstrom, Appl. Optics 20 No. 11 pp. 1902—1924, Note in particular Fig. 1 on page 1903 where target gain of 1 defines scientific breakeven. (This is therefore a Livermore definition!) (attachment 2).

• The NAS defined ignition as yield energy equal to laser energy incident on target (gain 1)--the same as scientific breakeven as defined by Perkins.

• This definition also occurs in \textit{Inertial Confinement Fusion} by James J. Duderstadt and Grgory A. Moses (Wiley & Sons New York 1982) , pg. 49 [ISBN 0-471-09050-6],or \textit{An Introduction to Inertial Confinement Fusion} by S. Pfalzner (Taylor and Francis, New York 2006) [ISBN 0-7503-0701-3]

The very recent redefinitions of scientific feasibility include statements like:

“More importantly, the self-generated energy of this target exceeded the input energy of the imploding DT fuel. This is called \textit{scientific break-even}.” or

"scientific break-even point," where the amount of energy that comes out of the fusion reaction is equal to that which was put in by the kinetic energy from the implosion. Physics of Plasmas, Edwards also


may appear to be similar to the traditional accepted definitions used in the scientific community for the past 40 years, but they are in fact quite different and can be achieved at fusion gains a factor of 125 lower than the traditional definition of scientific feasibility.