Lawrence Berkeley National Laboratory

Title

DEUTERIUM BEAM SPECIES MEASURED BY FUSION REACTIONS IN THE NEUTRALIZER

Author

Smith, R.R.

Publication Date

1981-11-01

Peer reviewed

LBL--13312

DE82 004846

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Accelerator & Fusion Research Division

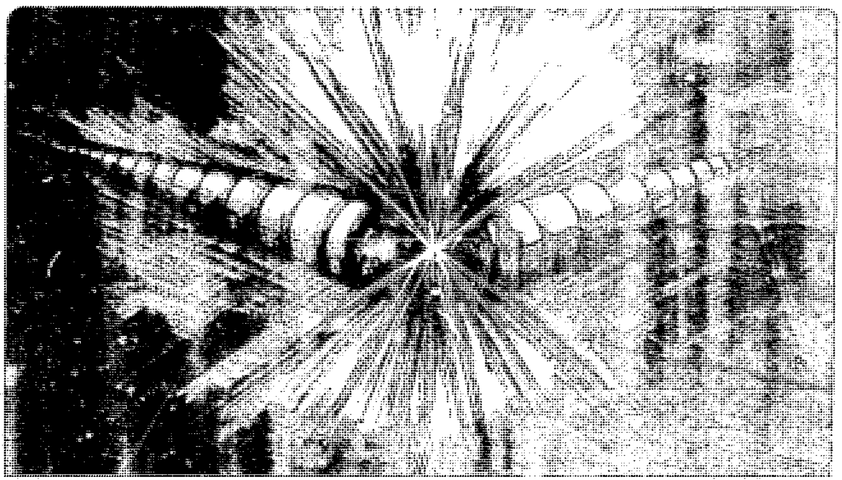
Presented at the American Vacuum Society Conference, Anaheim, CA, November 3, 1981

DEUTERIUM-BEAM SPECIES MEASURED BY FUSION REACTIONS IN THE NEUTRALIZER

R.R. Smith and M.D. Strathman

November 1981

MASTER



Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48

DEUTERIUM-BEAM SPECIES MEASURED BY FUSION REACTIONS IN THE NEUTRALIZER

R. R. Smith and M. D. Strathman
Lawrence Berkeley Laboratory, University of California,
Berkeley, CA 94720

Using a surface barrier detector and standard nuclear instrumentation, the energetic charged products of fusion reactions between deuterium neutralizer gas and accelerated deuterium ions are sorted in energy to yield a measurement of the species from a neutral beam source, i.e., the proportions of accelerated D^+, D_2^+, and D_3^+. Such sources have been designed at LBL for the TFTR project at Princeton University to accelerate currents of 6[illegible] amps to 120 kilovolts,[1] and the species distribution affects the power deposition within the target plasma. The species mixture has been measured by various techniques which sample downstream from the source, but this is complicated by the differing divergences of the ionic species. Furthermore, to compare with source physics models, one must project the measurements back through the neutralizer gas of uncertain density distribution. An integral measurement over the entire area of the beam can be performed with Doppler shift spectroscopy, but it involves a large number of cross sections, of which not all are known, and it is also dependent upon the neutralizer gas distribution. The present species measurement complements other measurements because it is integrated over the entire beam, is independent of the neutralizer gas distribution, and only requires one well known cross section.

This work was supported by the Director, Office of Energy Research, Office of Fusion Energy, Development & Technology Division of the U.S. Department of Energy under Contract No. W-7405-ENG-48.

The diagnostic is "on-line", small, and relatively cheap. The D-D reaction has two branches with almost equal probability and with products:

T (1.01) + H (3.02); ^{3}He (0.820) + n (2.45); where the C. M. energies in MeV are given in parentheses. The velocities per nucleon of the three accelerated species are in the ratio $1 : 1/\sqrt{2} : 1/\sqrt{3}$, and this fact allows the separation of the reaction products from each species. We observe at 135^0 to the beam, a compromise between mounting ease and maximizing the projection of the incident particles' velocity along the detector's line of sight. Detecting T seems preferable, because the higher velocity of P masks the differences in incident D velocities, and ^{3}He loses far more energy passing through the necesssary light - blocking foil and the detector dead layer due to its charge of 2.

An important advantage of a gas target over the Sc D_2 target used in Reference 2 is the absence of spectrum broadening due to deceleration of D before it reacts. We do have other sources of broadening: electronics noise of the amplifier, angular acceptance of the collimator, beam divergence, accelerator power supply ripple (which can be countered with synchronous gating of the PHA), straggling in the foil and dead layer, and stray light or electrons.

We estimate a target density of 5×10^{13} cm^{-3} and a detected volume of 370 cm^3. In order to maximize the count rate, we used a collimator made of a stack of rectangular channels 1.27 cm wide, 5.08 cm long, and 0.0127 cm high in the plane defining the reaction. With a 1 cm^2 detector at 70 cm from the center of the viewed volume, we take the average solid angle to be 1.0×10^{-4} sr.

In Fig. 1, the x's show the triton spectrum accumulated for 11.2 seconds at 112 keV with an accelerated current of 6.9 amperes from a 7 x 10 cm^2 source. A straight line background has already been subtracted. The solid curves show a seven parameter fit (three Gaussians with a common width) and the individual peaks. The fitted areas are 1788, 889, and 250 counts. The relative areas imply a species mix of 47: 35: 18, which compares well with a measurement of 54: 36: 10 using Doppler shift spectroscopy. For this measurement, we fed 2.8 Torr liters sec^{-1} into the source and 4.5 into the neutralizer. The additional gas feed was intended to raise the count rate and presumably caused an atypically low full energy species fraction. A fit to the less well resolved proton data gave a species mix of 49: 36: 15 and a total count rate of roughly 500 sec^{-1}. For the experimental conditions we would predict rates of 262, 128, and 30 for a total of 420 counts sec^{-1}.

A double set of 250μ gm cm^{-2} Cu foils was used to block light from the neutralizer plasma. A multi-channel collimator consisting of a stack of stainless steel meshes separated by 1.27 mm resulted in an acceptance angle of $\pm1.40^{0}$. This collimator seems to produce a much smaller tail on the low energy side of the proton peak than was observed with a collimator made from smooth plates. The FWHM of a pulser signal collected along with the data was roughly 21 keV and the FWHM's of the triton and proton peaks were 25 and 28 respectively. This implied that the broadening due to the effects mentioned above was roughly 13 to 19 keV.

In the future, we plan to use a light - tight detector and a thermoelectrically cooled preamplifer in order to improve the resolution. Higher resolution would allow useful spectra to be taken with less beam time and at lower beam voltages.

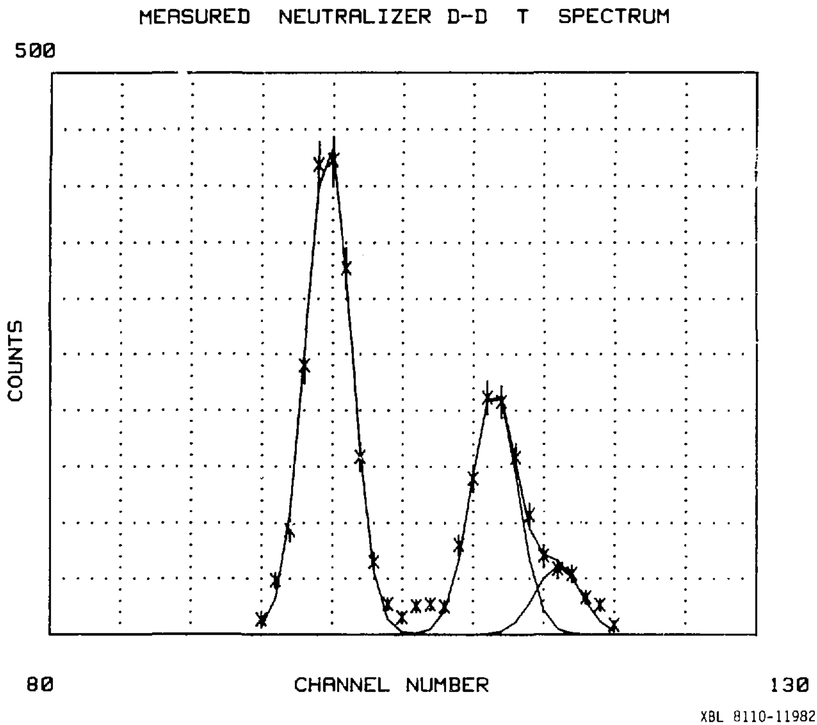
This work was supported by the Director, Office of Energy Research, Office of Fusion Energy, Development & Technology Division, of the U. S. Department of Energy under Contract No. W-7405-ENG-48.

REFERENCES

1. K. H. Berkner, "Advanced Neutral-Beam Injection," LBL-11432 and 2nd Joint Grenoble-Varenna International Symposium on Heating in Toroidal Plasmas, Como, Italy, September 1980.

2. Frank M. Bacon, et al., "D-T Neutron Generator Development for Cancer Therapy: 1980 Annual Progress Report, "SAND80-1033, May 1980, and references therein.

3. C. F. Burrell, private communication.


MEASURED NEUTRALIZER D-D T SPECTRUM
500
COUNTS
80
CHANNEL NUMBER
130
XBL 8110-11982