drift tube we measured, from the interferograms, a plasma velocity of ~ 1 cm/μs. Surface discharges usually produce a few electron volt plasmas. The velocity we measured corresponds to an $\sim$2-eV hydrogen plasma and so we conclude that most of our plasma consists of hydrogen ions. This conclusion is further supported by an indirect measurement: when a relativistic electron beam is fired into the drift tube at early times after the plasma shot ($< 40\ \mu$s) there is no additional ionization—no new fringes on the interferograms. This indicates an almost full ionized plasma and the absence of heavy ions which can be further ionized by the beam. A new set of fringes appears when the beam is fired into the same plasma mixed with a few millitorr of neutral gas or when the beam is fired later in the plasma and neutrals were formed by recombination.

In an earlier version of this plasma gun we used parallel, straight, alternate plates of graphite and TiH_2 mixture. The discharge on its surface was much less homogeneous, only a small part of the gun produced plasma, and the plasma was lower in density than the plasma produced by the same current in the coaxial device.

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[1] K. G. Kato, G. Benford, and D. Tzach, Phys. Fluids 26, 3636 (1983).
[2] G. Benford, A. Ben-Amar Baranga, W. Main, and K. G. Kato, Bull. Am. Phys. Soc. 29, 1340 (1984); A. Ben-Amor Baranga, G. Benford, D. Tzach, and K. Kato, Phys. Rev. Lett. 54, 1377 (1985).

Construction of a periodic electrode array

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A design for an electrode array for use in nonlinear optics experiments is presented. The array applies a spatially periodic transverse electric field (amplitude $\sim$ 3 kV/mm and period 4 mm) to a gas sample through which a laser beam is focused.

The apparatus described here is designed for use in an electric-field-induced second-harmonic-generation (ESHG) experiment in which a frequency-doubled beam is produced by passing a laser beam through a gas sample subjected to a transverse dc electric field.[1] If the dc field reverses sign N times, with a spatial periodicity which matches the coherence length of the gas sample, then the second-harmonic signal is enhanced by a factor of about N^2. The design considerations for maximizing the signal enhancement factor have been discussed elsewhere.[1] Briefly, these considerations lead to an array of cylindrical electrodes on a square grid, with the electrode diameter about half the center-to-center spacing of the electrodes, and with the length of the array about twice the confocal parameter of the focused laser beam. The transverse dc field of such an array varies approximately sinusoidally in amplitude along the array axis. The diffraction limit for the laser beam in effect sets the limit on the maximum attainable enhancement factor at about 10^4, which is typically obtained with $N = 100$ repeats in the electrode structure.

The method of construction of the electrode array is illustrated in Fig. 1 for the case of an array with 100 full periods of the electric field in a length of 400 mm. The basic idea is that the longitudinal spacing of the electrodes is defined by grooves milled into the surface of four steel bars, while the transverse interelectrode spacing is defined by thin steel spacers. The parts are stacked into a pair of sandwiches consisting of a top grooved bar, a layer of electrode wires, a spacer sheet, another layer of electrode wires, and finally the bottom grooved bar, as shown in Fig. 1(d). The grooves in the top and bottom bars of each stack are offset by half the groove spacing so that the electrodes protruding from the

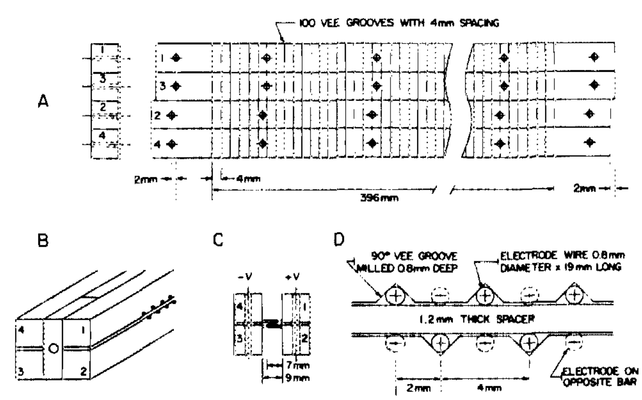

FIG. 1. Construction of the electrode array. The layout of the grooves and bolt holes on the face of the four grooved bars is shown in (a). A view of the end of the assembled array is shown in (b), while a cross section of the assembled array is shown in (c). The electrode wires interlace to form two long rows between which a laser beam passes. The magnified side view of the array in (d) shows that the electrodes of the right subassembly alternately form the upper and then the lower electrode of the successive electrode pairs of the array, thereby generating a field which periodically reverses sign.

side of the sandwich zig zag back and forth. Bolt holes are drilled offset with respect to the grooves in such a way as to ensure the correct alignment of the two bars [Fig. 1(a)]. The two subassemblies are assembled facing each other, separated at each end, and held in register by an insulating spacer block as shown in Fig. 1(b). The laser beam passes through the holes in these insulating spacers and propagates down the long axis of the array between two rows of interdigitating electrodes. The electrodes in the top row are alternately connected to the right or left subassembly and vice versa for the bottom row. Thus, connecting the + / − terminals of the voltage source to the right/left subassemblies results in a field which is alternately up or down for successive electrode pairs straddling the laser beam [Figs. 1(c) and 1(d).

The electrodes are cut from piano wire and have their ends rounded or beveled. The bolts holding together the sandwich prevent some of the electrode wires from being clamped by the full width of the bars. Piano wire is convenient because it is cheap, strong, and smooth but other materials may be used (1-m-long straight pieces of piano wire may be obtained from hobby shops). If ground stock is used for the bars then one need only mill grooves and drill holes in their preparation. To ensure that electrical contact is made with all the wires it may be necessary to coat their clamped ends with a thin layer of solder, or better still, to fill the entire space between the grooved bars, electrodes, and spacer of each subassembly with a suitable solder (ordinary soft solder flows poorly into the narrow spaces). Electrode arrays with periods from 2 to 10 mm have been constructed along the plan given above. The maximum attainable field strength on the axis of the array is essentially the same as the uniform-field breakdown electric field for the gas sample (several kV/mm, varying with gas pressure and composition), provided the electrodes are kept free of metal whiskers or filings.

[1]D. P. Shelton and A. D. Buckingham, Phys. Rev. A 26, 2787 (1982).

Integrated noise measurement of a silicon avalanche diode detector using a CAMAC module

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This paper describes a detailed experimental study of the integrating noise of a silicon avalanche diode detector using a current integrating ADC CAMAC module. The dark current noise and shot noise measurements are discussed in relation to a previously described theoretical model. The results confirm that the model can be used to optimize the detector parameters in order to maximize the signal-to-noise ratio of the detection system.

A detailed experimental study of the integrated noise of an avalanche photodetector was made using an analog-to-digital converter (ADC). The results are compared to theoretical values computed by using a previously described model developed by Waksberg.[1] The motivation to prove the validity of the theory comes from the fact that the model was proposed to be used to optimize the receiver system for the Thomson scattering diagnostic of the Varennes Tokamak. More generally, this model could be helpful in optimizing the signal-to-noise ratio for similar types of systems which require the detection of a small single-pulse signal integrated over a brief period of time (in the ns range) using an avalanche photodetector. This paper presents results for two different noise sources—no signal on the detector, the noise being only contributed by the dark current—shot noise resulting from incident radiation on the detector.

The characteristics of the silicon avalanche diode detector used in these experiments are given in Table I. Some of these parameters have been determined experimentally. The others have been supplied by the manufacturer. For the dark current measurements, the noise signal obtained at the de-

TABLE I. Silicon avalanche diode detector parameters (RCA No. C30919E).

Parameters values supplied by the manufacturer	
Nonmultiplied portion of the detector dark current: I_{ds}	300 nA
Multiplied portion of the dark current: I_{db}	0.4 nA
Effective gate leakage current of the preamp transistor: I_t	3 μA
Detector capacitance: C_d	10 pF
Effective transistor input capacitance: C_t	2 pF
Multiplication gain: M	60
Equivalent transistor noise voltage: e_n	2 nV/Hz$^{1/2}$
Experimentally measured parameters	
Bandwidth:	9.6 MHz
Time response:	11 ns
Voltage noise density:	47 nV/Hz$^{1/2}$
Diode load resistance:	27 kΩ
Responsivity:	7.1×10^5 V/W at 6328 Å max of 1.8×10^6 V/W at 9200 Å