A MEANS OF *IN SITU* MEASUREMENTS OF NEUTRAL H AND HE ON AN OUT-OF-THE-ECLIPTIC MISSION

K. C. Hsieh

Department of Physics
University of Arizona
Tucson, Arizona 85721

ABSTRACT

On an out-of-the-ecliptic mission, *in situ* measurements of densities and temperature of interstellar neutral H and He in the heliosphere should complement observations based on backscattered Lyman-alpha intensities. A means of performing the *in situ* measurements is briefly described.

The experiments performed by the groups at the University of Paris (Bertaux and Blamont, 1971) and at the University of Colorado (Thomas and Krassa, 1971) have provided us the first glimpse of the presence and the distributions of interstellar neutral H and He in the heliosphere. Like all optical observations, the observations of neutral H and He by backscattered Lyman-alpha photons are indirect and integral in nature. Therefore, their results are constrained by the assumptions one must make about the properties of the solar wind and those of the solar H and He Lyman-alpha emissions as well as the temperature of the interstellar H and He. To complement the optical measurements, in situ direct determination of the densities and temperature of the H and He will be necessary. An out-of-the-ecliptic mission would provide the unique opportunity for such an effort since the relative velocity of the sun to the interstellar medium points out of the ecliptic.

The necessary in situ measurements can be performed with an instrument of low power (1 W), low mass (< 3 kg) and single-particle counting capability such as the field-ionization neutral detector (FIND) being developed at the University of Arizona (Curtis et al., 1975). Figure 1 illustrates the principal parts of FIND. The ionization tips, the grid and the surface-barrier Si detector are encased in a chamber with an entrance aperture. Neutral H and He enter the chamber and as they reach the vicinity of the tips, they are field-ionized to become H^+ and He^+, respectively. These +1 ions are immediately accelerated towards the detector and their electrical signals analyzed.

Although all the ions arrive at the detector with essentially identical kinetic energies acquired in acceleration, He^+, being more massive, will interact with the crystal lattice of the detector more and thus provide a smaller electrical signal than an H^+ of same energy. Figure 2 is a composite plot showing that the He^+ peak is shifted by 2.8 KeV from the H^+ peak which appears at 26 keV, corresponding to the accelerating potential of 26 kV. We note that each pulse-height distribution is gaussian and has well defined peak position and FWHM. Therefore, using only one detector and one pulse-height analyzer the two species can be separated.

Our laboratory results also indicate that with a bundle of 200 needles at +26 kV facing a 1 cm^2 detector at a distance of 1 cm, sensitivities of 3×10^{-7} counts sec^{-1} per unit flux (1 unit flux = 1 cm^{-2} sec^{-1}) for H and 4×10^{-8} for He in the same units can be attained. Assuming an H flux of 10^4 cm^{-2} sec^{-1}, e.g., $n = 0.01$ cm^{-3} and $v = 10$ km sec^{-1}, a detector background of 1.4×10^{-2} $E^{-1.2}$ sec^{-1} keV^{-1} (G. Gloeckler, private communication, 1974) and an FWHM of 3 keV, then H signals can be well separated from the background in one day's accumulation. (Actual background can be determined in flight by turning off the high voltage supply to the ionization tips.) Figure 3 is a computer simulation based on the above assumptions. In addition to H , He of three different relative abundances are also included. The varied n(He)/n(H) are due to the different values the parameter μ might take (see review by Axford, 1972). A least-square fit of two gaussian distributions of known peak positions and FWHM's to any of the three curves shown in Figure 3 will yield the corresponding n(H), n(He) and n(He)/n(H).

The above description of FIND leaves little doubt that in situ determination of neutral H and He concentrations can be performed. In addition, if the aperture of FIND scans the part of the sky surrounding the direction of maximum flux, the angular distribution of the neutral flux would then be a measure of the temperature of the neutral gas at the point of observation. With an instrument such as FIND complementing a Lyman-alpha spectrometer on a spacecraft that covers large heliocentric distances and latitudes, the local interstellar medium and its interactions with the solar wind can be examined fully.

ACKNOWLEDGEMENT: For the work on FIND I thank my colleagues C. C. Curtis, C. Y. Fan and also L. W. Swanson at the Oregon Graduate Center. The work on FIND is supported by NASA grant NGR 03-002-107 and my travel to this Symposium is made possible by the support of the University of Arizona.

REFERENCES

Bertaux, J. L., and J. E. Blamont, Evidence for a Source of an Extra-terrestrial Hydrogen Lyman-alpha Emission: the Interstellar Wind, Astron. & Astrophys., 17, 200-217, 1971.

Curtis, C. C., K. C. Hsieh, C. Y. Fan, and L. W. Swanson, A Field-Ionization Neutral Dectector: FIND, Proceedings of the 14th International Cosmic Ray Conference, T6-1, 1975.

Thomas, G. E., and R. F. Krassa, OGO5 Measurements of the Lyman Alpha Sky Background, Astron. & Astrophys. 17, 218-233, 1971.

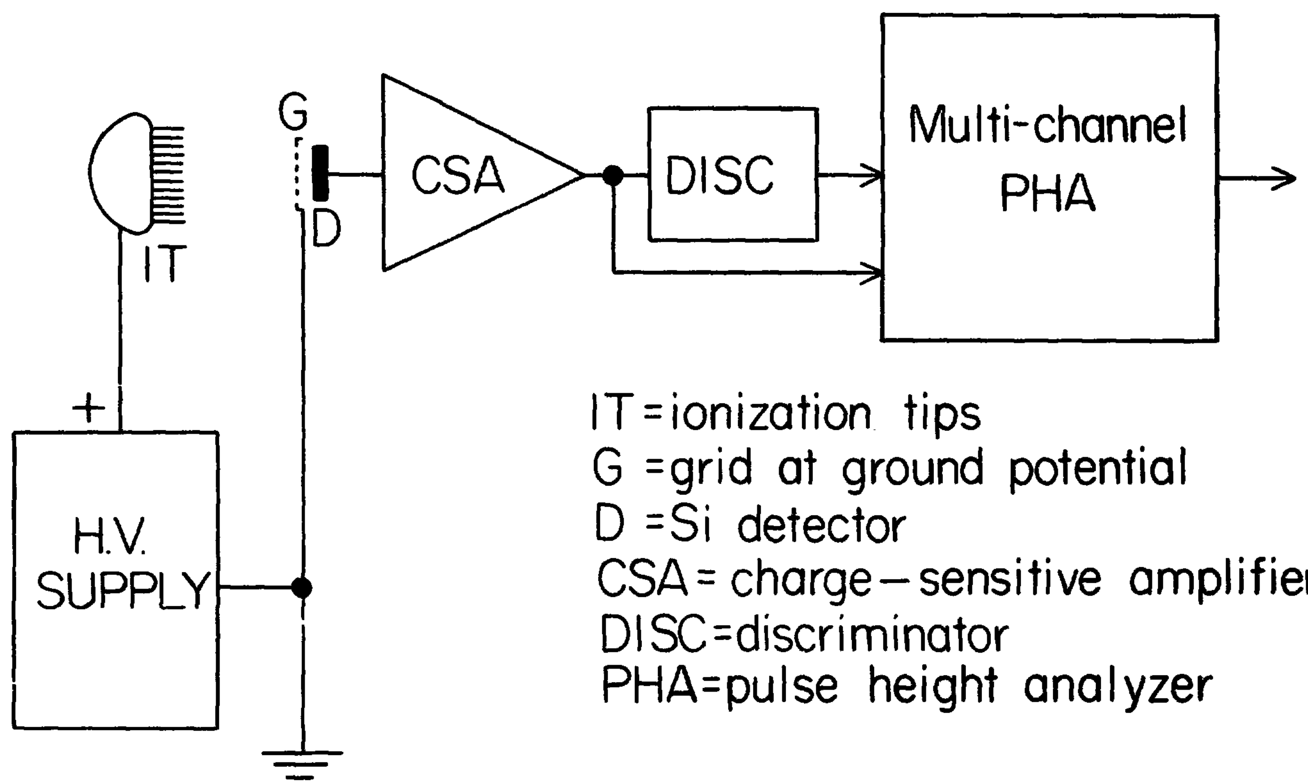
FIGURE CAPTIONS

Figure 1. An over-simplified diagram of FIND. For actual space missions, the ionization tips and the detector assembly should be protected from low energy charged particles by the use of repelling grids at the entrance aperture and from γ-rays and secondary particles by the use of an anti-coincidence guard counter immediately behind and surrounding the ion detector.

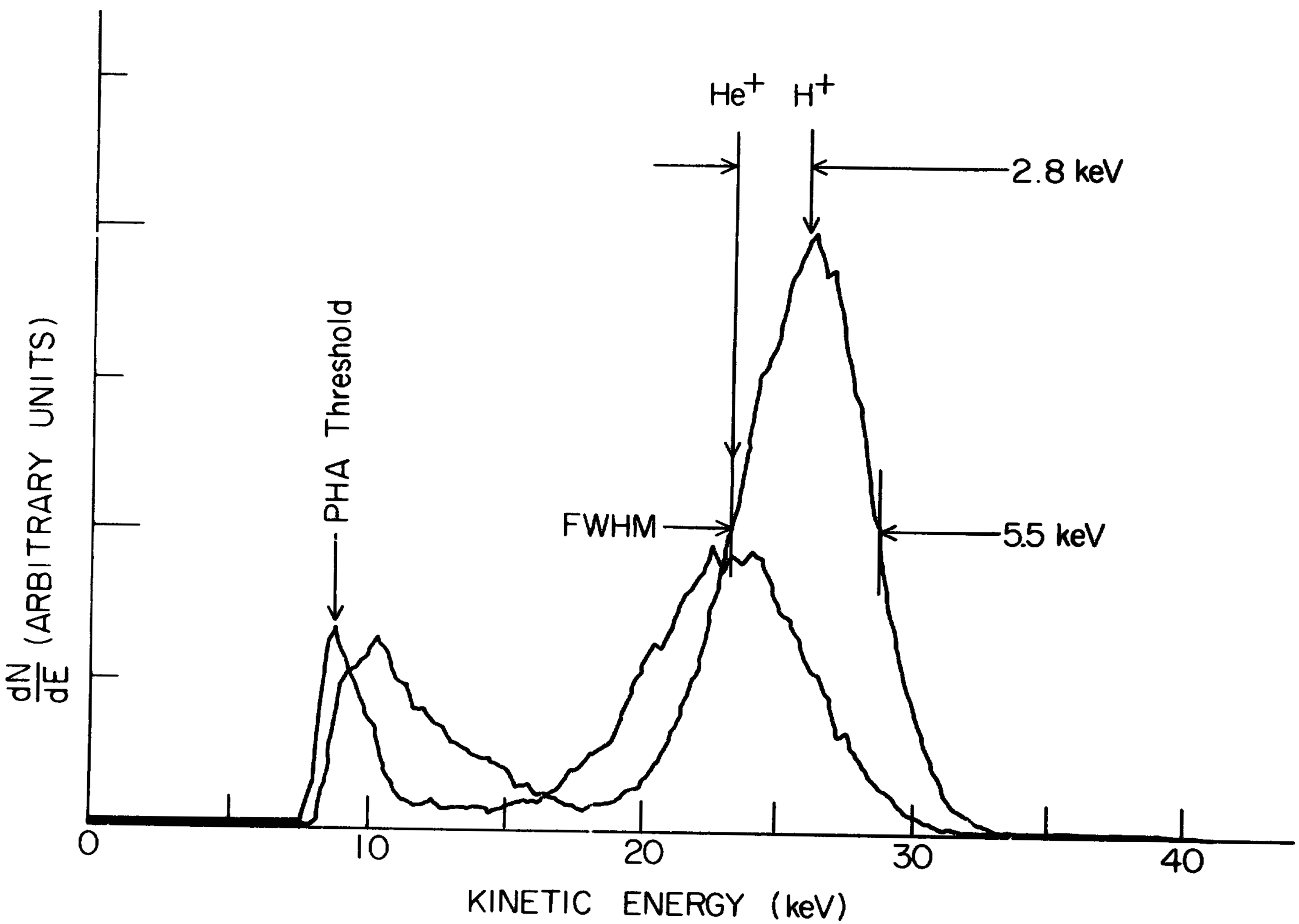
Figure 2. Laboratory results showing the difference in the pulse-height distributions of H^+ and He^+ signals by a 2.8 keV shift. Both ion species have an average kinetic energy of 26 keV. The noise of the detector is 5.5 keV (FWHM).

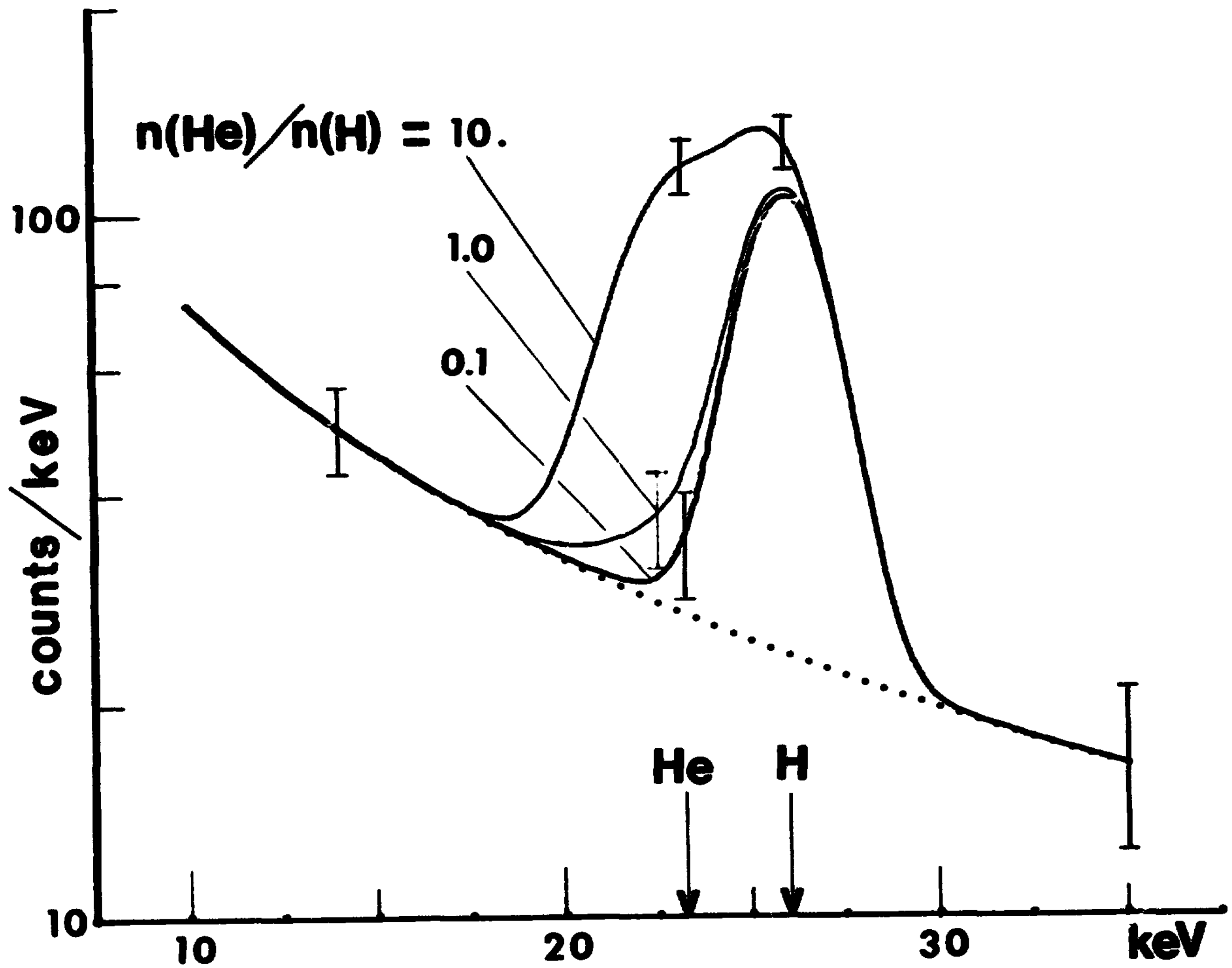
Figure 3. Predicted pulse-height distributions of an H flux of 1×10^4 cm^{-2} sec^{-1} and He fluxes of 10^3, 10^4 and 10^5 cm^{-2} sec^{-1} as seen in one day's accumulation by a FIND having an accelerating potential of 26 kV, a detector noise of 3 keV (FWHM) and a background following the distribution 1.4×10^{-2} $E^{-1.2}$ sec^{-1} keV^{-1}. The sensitivies to H and He used in this calculation are 3×10^{-7} counts sec^{-1} per unit flux and 4×10^{-8} counts sec^{-1} per unit flux, respectively.

SCHEMATIC DIAGRAM
FIND: Field-Ionization Neutral Detector



IT = ionization tips
G = grid at ground potential
D = Si detector
CSA = charge-sensitive amplifier
DISC = discriminator
PHA = pulse height analyzer


He+
H+
2.8 keV
PHA Threshold
FWHM
5.5 keV
dN/dE (ARBITRARY UNITS)
0
10
20
30
40
KINETIC ENERGY (keV)



n(He)/n(H) = 10.
1.0
0.1
100
10
counts/keV
He
H
10
20
30
keV