2017 ISR Summer School
Incoherent Scatter Radar Experiment Request
Arecibo Observatory

To design your experiment, choose the desired options from each category.

Transmitting modes:

There are many data-taking modes at Arecibo. All modes are optimized to take full advantage of the sensitivity. The ones below guarantee fast processing. Note: Coded Long Pulse (CLP) is designed for altitudes as high as 600 km. Topside is used for higher altitudes. (Check one or both)

☐ Coded Long Pulse (CLP)

☐ Topside

ISR Receivers

Note: If you choose two feeds ("Double Beam") the power is split between the beams and the sensitivity is reduced but an extra set of data is collected.

☐ Gregorian

☐ Line feed

Ponting direction

An example: Use the Gregorian at vertical (range = height) and Line Feed at 15 degrees from zenith (to sample a different volume than the Gregorian) and azimuth at magnetic north (guarantees that the line feed is looking to the magnetic line). The values for this configuration are (348, 0, 15).
Provide three values:

1. _____________: Azimuth direction (If rotating, leave blank and specify azimuth rotation below)
2. _____________: Gregorian inclination (degrees from zenith)
3. _____________: Line Feed inclination (degrees from zenith)

Azimuth rotation

Azimuth rotation entails moving the platform. To rotate the azimuth, select the initial and final position of the rotation in degrees. The range of values are 0 to 720 degrees.. The platform will rotate between these values and then return to the starting value with a velocity equivalent to 360 degrees/15 min. One common example is to leave the Gregorian vertical and rotate the Line Feed from 0 to 360 degrees. This configuration is used to estimate vertical winds with the Gregorian and then estimate the other two components with the scanning Line Feed.

☐ Yes _________________: Initial position _________________: Final position

☐ No

Appendix: Data taking modes description

Text taken from: "Isham B., C.A. Tepley, M.P.Sulzer, and Q.H. Zhou, Upper atmospheric observations at the Arecibo Observatory: Examples obtained using new capabilities, J. Geophys. Res., 105, 18,609-18,637, 2000." With some updates by M. Sulzer.

Topside

The topside mode uses the ion line to measure properties of the ionospheric plasma up to 4000 km in altitude. In the standard configuration, a 500 μs pulse is transmitted every 20 ms, and parameters are measured between the F peak and 2600 km. There is also a version with half the IPP for a more height restricted experiment. Although range gates are computed every 38 km, the true range resolution, 75 km, is determined by the 500 μs pulse length. At altitudes near 255 km, accurate parameters often cannot be measured as the pulse is too long to resolve the short scale heights found at those altitudes and below. However, inversion of the lag profiles gives reasonable results down to the peak. At higher altitudes where scale heights are long, range resolution can be sacrificed to improve the signal-to-noise ratio, and the data can be averaged over height to improve the accuracy of the calculated parameters.

The data are sampled at 2 μs in quadrature, providing a 500-kHz bandwidth from which two parts of 125 kHz. This is because the transmitter center frequency alternates between plus and minus 62.5 kHz from band center during alternate pulse repetition periods, in effect making two receiver channels each having twice the nominal 20-ms pulse repetition period. The signal data come from the channel in which the transmitter is pulsed, while the noise data come from samples taken near 40 ms (6000 km) gate delay in the unpulsed channel. In this way, the need to take long-gate-delay noise samples in the data channel is avoided, and the transmitter duty cycle can be kept at the reasonably high level of 2.5%. The 125-kHz bandwidth is enough to span even the widest spectrum due to H+.
In order to limit the errors in the parameter calculations to reasonable values the topside data are typically averaged for 10 min and often 30 min at the higher heights where the signal-to-noise ratio is poor. On occasion, when the electron and ion temperatures are especially low, the spectra will be narrow, resulting in more power in each frequency bin, which increases the signal-to-noise ratio and allows shorter integration times. Typical electron, O+, and H+ temperature errors in the lower topside are around 30 K; the longer time and altitude averages commonly used at the higher altitudes can give error bars of about 100 K at 2000 km. Electron density and O+, He+, and H+ composition errors of a few percent are common. Topside data are normally taken with the radar pointing vertically, and the vertical velocities of O+ and H+ can be measured separately at altitudes up to 1000 km wherever sufficient concentrations of the respective ions are present.

The typical error in the lower topside is 10 m/s. Temperature and velocity for He+ are not compute due to generally low He+ concentrations and the difficulty of separating its spectral component from those due to H+ and O+.

Coded long pulse.

Coded long pulse is a technique developed at Arecibo to obtain high-resolution ion and plasma line spectra [Sulzer, 1986b]. The code is used to randomize unwanted spectra from neighboring gates, thus allowing range resolution limited only by the bandwidth of the radar. The setup is easily configurable based on experimental requirements and baud lengths as short as 1μs, corresponding to 150 m range resolution, are often used.

For ion line measurements, a pulse of length 440 μs with 2 μs bauds is typically transmitted every 10 ms, yielding a 4.4% duty cycle. The frequency resolution of the directly digitized data is then 2.3 kHz, height resolution is 300 m, and the time resolution for usable processed data can be as low as 10 s. Ion line spectra can be measured beginning at 90 km or below, where they may be used to estimate the ion-neutral collision frequency [*Dougherty and Farley, 1963; Hagfors and Brockelman, 1971; Zhou et al., 1997c*]. Electron temperatures and oxygen ion temperatures and velocities are routinely obtained with this technique up to >200 km. In between these limits a 1-min integration can yield results accurate to 20 K for the temperatures.

For plasma line, observations with the same CLP - ion line pulses are used. The frequency resolution of the directly digitized data is then 1 kHz, height resolution is 150 m, and time resolution is 2 s. Useful plasma line data may be taken throughout the bulk of the E and F regions, limited by low plasma densities at ~120 km and below and by $1/r^2$ losses at ranges beyond 400 km.