Preliminary Results of the Artificial Periodic Irregularities Excited by the HAARP HF Heater

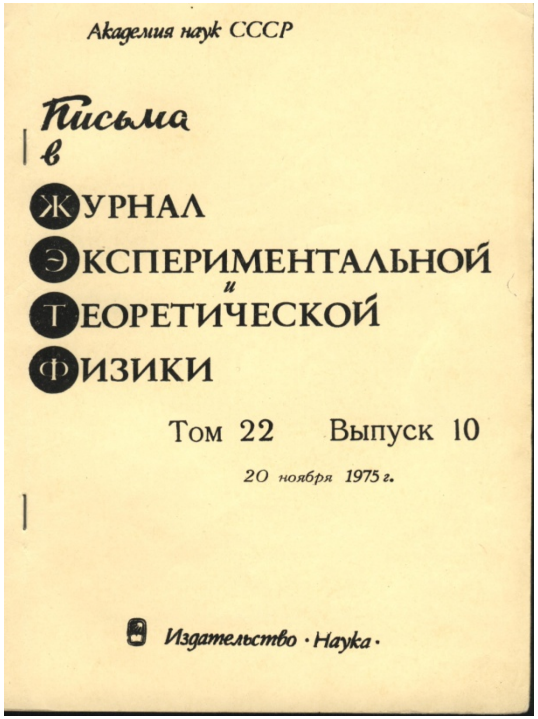
S.M.Grach (1,2), E.N.Sergeev (1,2), N.V.Bakhmetieva (2), G.Milikh (3), A.V.Shindin (1,2)

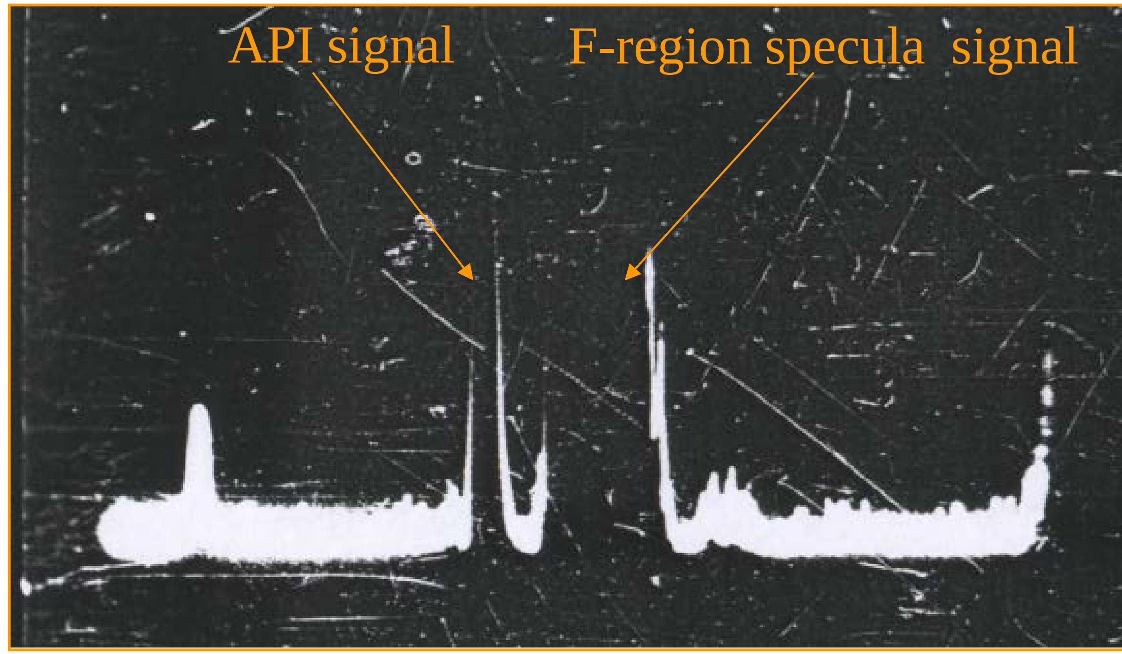
(1) Lobachevsky State University of Nizhni Novgorod, 23 Gagarin Avenue,
Nizhni Novgorod, 603950, Russia

(2) Radiophysical Research institute, 25/12a, Bolshaya Pecherskaya Str.,
Nizhni Novgorod, 603950, Russia

(3) University of Maryland, College Park, MD, 20742-2421, USA

The first observation of the Artificial Periodic Irregularities (API) scattering phenomena

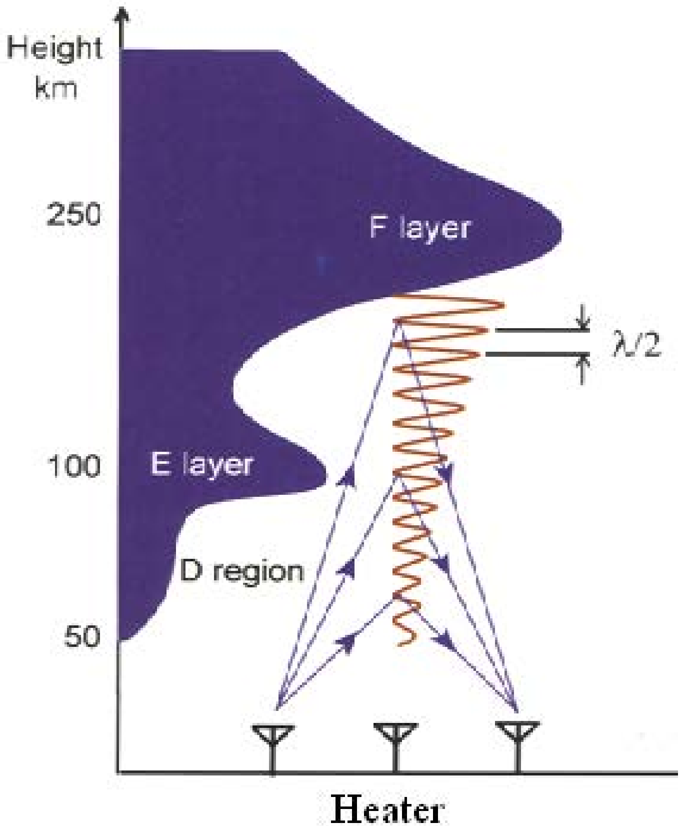




The experimental frame of the height-time-amplitude plot on a oscilloscope screen, where API signal have been firstly observed.

V.V. Belikovich,
E.A. Benediktov,
G.G. Getmantsev,
Yu.A. Ignat'ev,
G.P. Komrakov.
JETP Letters,Vol.22, No 10 (1975).

Formation of the Artificial Periodic Irregularities of the ionospheric plasma and the ionosphere diagnostics



- API are formed in antinodes of a standing electromagnetic wave radiated by power facility;
- API generation:

in the lower ionosphere API is caused by thermal effects, in the F-region they caused by the ponder motive force;

- $\lambda_1=\lambda_2$ is a condition of a resonance scattering of radio waves on API; λ_1 is a power wave length in plasma, λ_2 is a wave length of a radio locator.

The API technique bases upon an observation of Bragg scattered signals (probe waves) from the artificial periodic structure of the ionospheric plasma during the API relaxation stage.

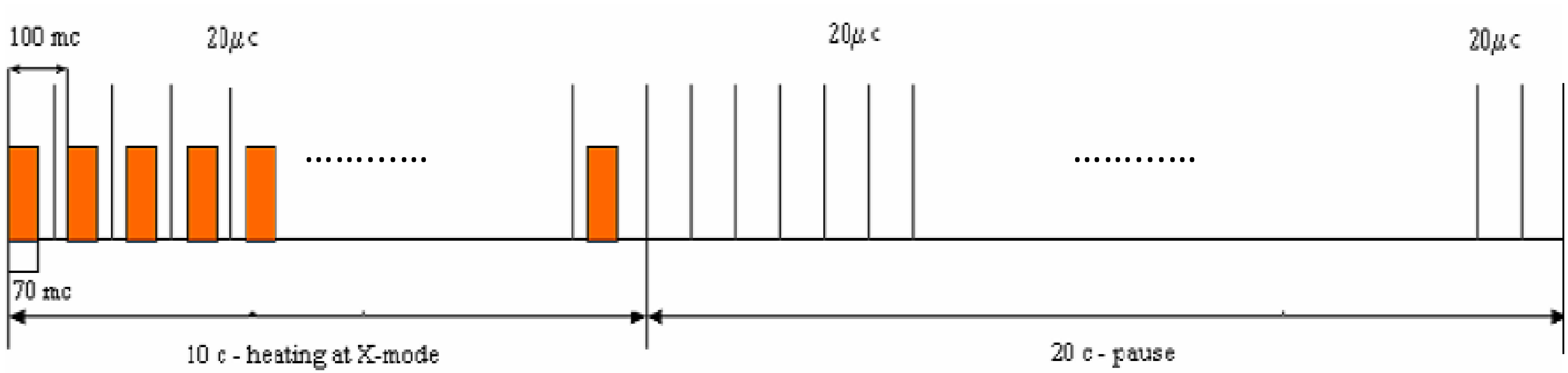
The phenomena in the lower ionosphere studied by the API technique

- Sporadic- E layer and its irregular structure
- Ion staff of the Sporadic- E layer
- Internal gravity waves
- Turbulence of neutral atmosphere
- Irregular structure of the lower ionosphere, including stratification of the regular E-region
- Stratifications of the electron density profile from the lower D-region till F-region maximum
- Sunset-sunrise phenomena in the lower ionosphere, terminator effect
- API and in the lower ionosphere during a solar eclipse

Ionosphere parameters determined by API technique

- Velocity of vertical plasma motions in the D- and E-regions of the ionosphere (60-120 km)
- Turbulent velocity and turbopause height (95-110 km)
- Temperature and density of the neutral atmosphere at the E-region heights (90-120 km)
- N(h) profiles of the electron density at the E-region heights, including the interlayer valley (90-150 km)
- Molecular masses and densities of prevailing metal ions in the sporadic-E layer
- Relative concentration of negative ions of oxygen, concentration of atomic oxygen and raised molecular oxygen $1\Delta g$ in the D-region
- Electron and ion temperatures in the F-region (200-250 km)

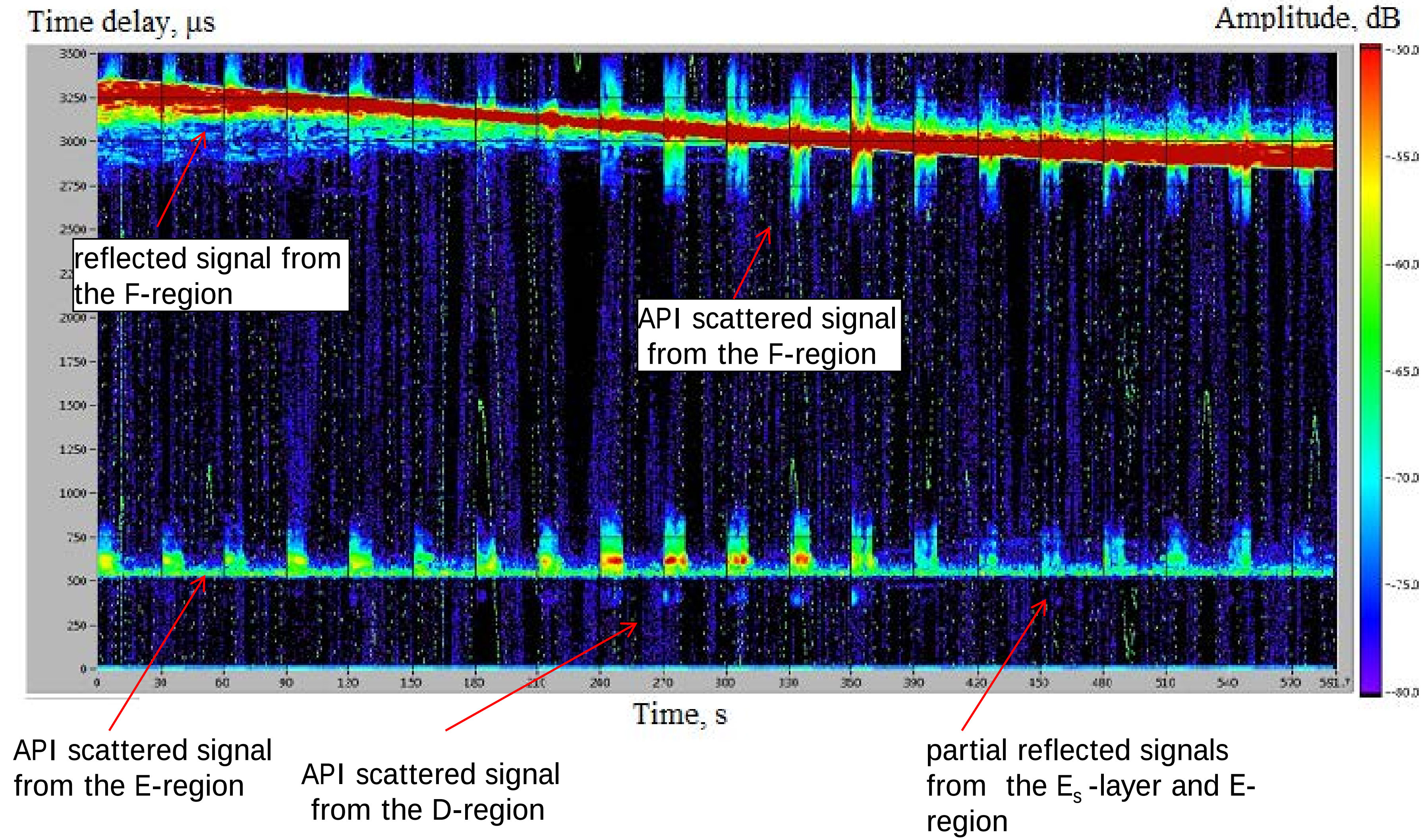
The diagram of the timing of API diagnostics during the pumping and relaxation phases of the plasma striations



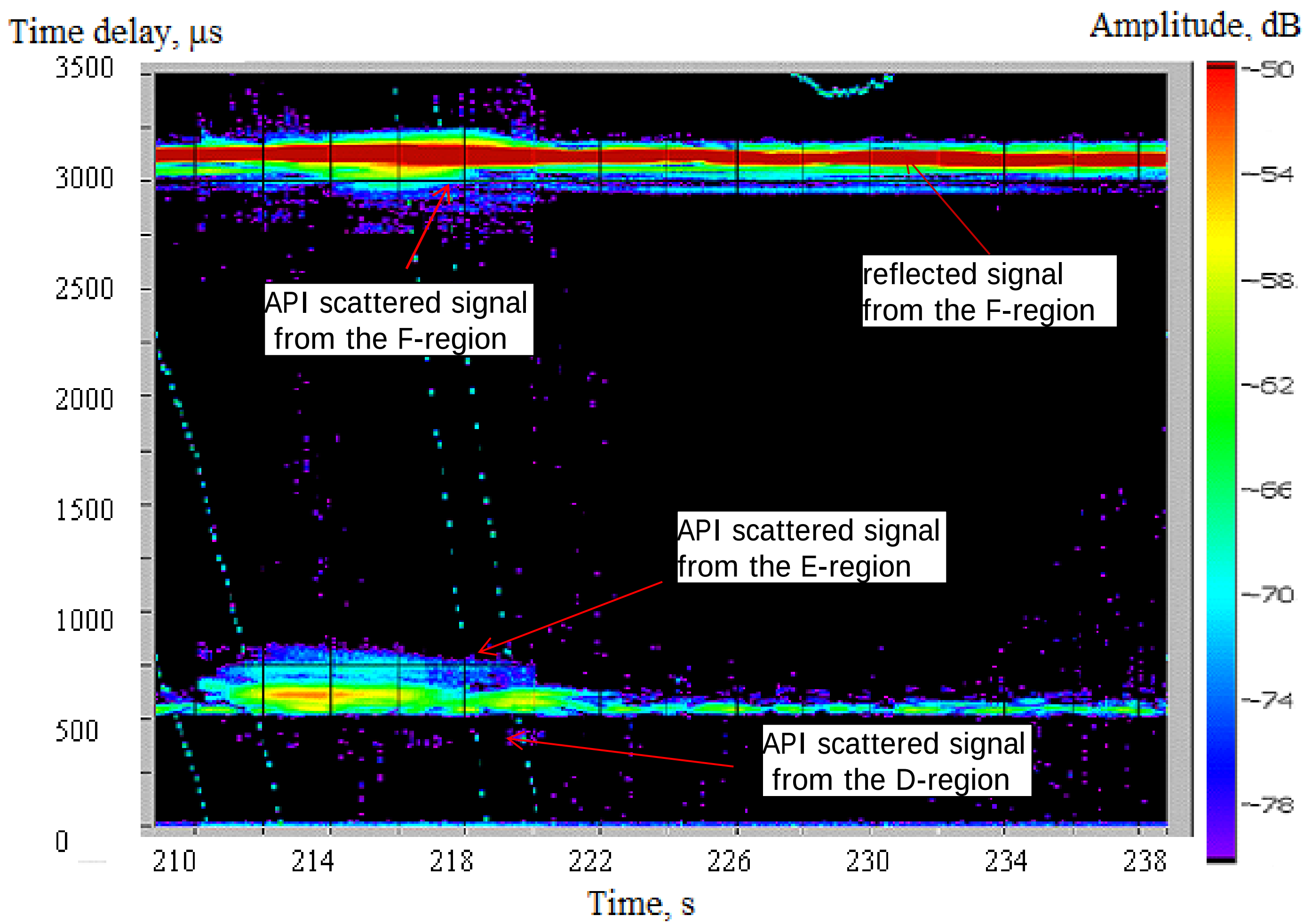
API formation stage API relaxation stage

The HAARP facility operated with period 15(30) s. This period consisted of (i) 70 ms pulses separated by 30-ms pauses and short (20 µs) sounding pulsed during first 3 (10) s, and (ii) 20 µs sounding pulses with IPP 20 ms during the following 12 (20) s. The pulse train (i) used for study of the API development and stationary states, while the train (ii) used for the relaxation stage. The X-polarization of the heating and sounding modes was applied.

An example of signals reflected from the ionosphere and API scattered signals. Signals reflected from F-region (the red thick line), E-region and sporadic-E layer (the thin green-blue line) as well API scattered signals in the D-, E- and F-regions are seen. June 5, 2014.

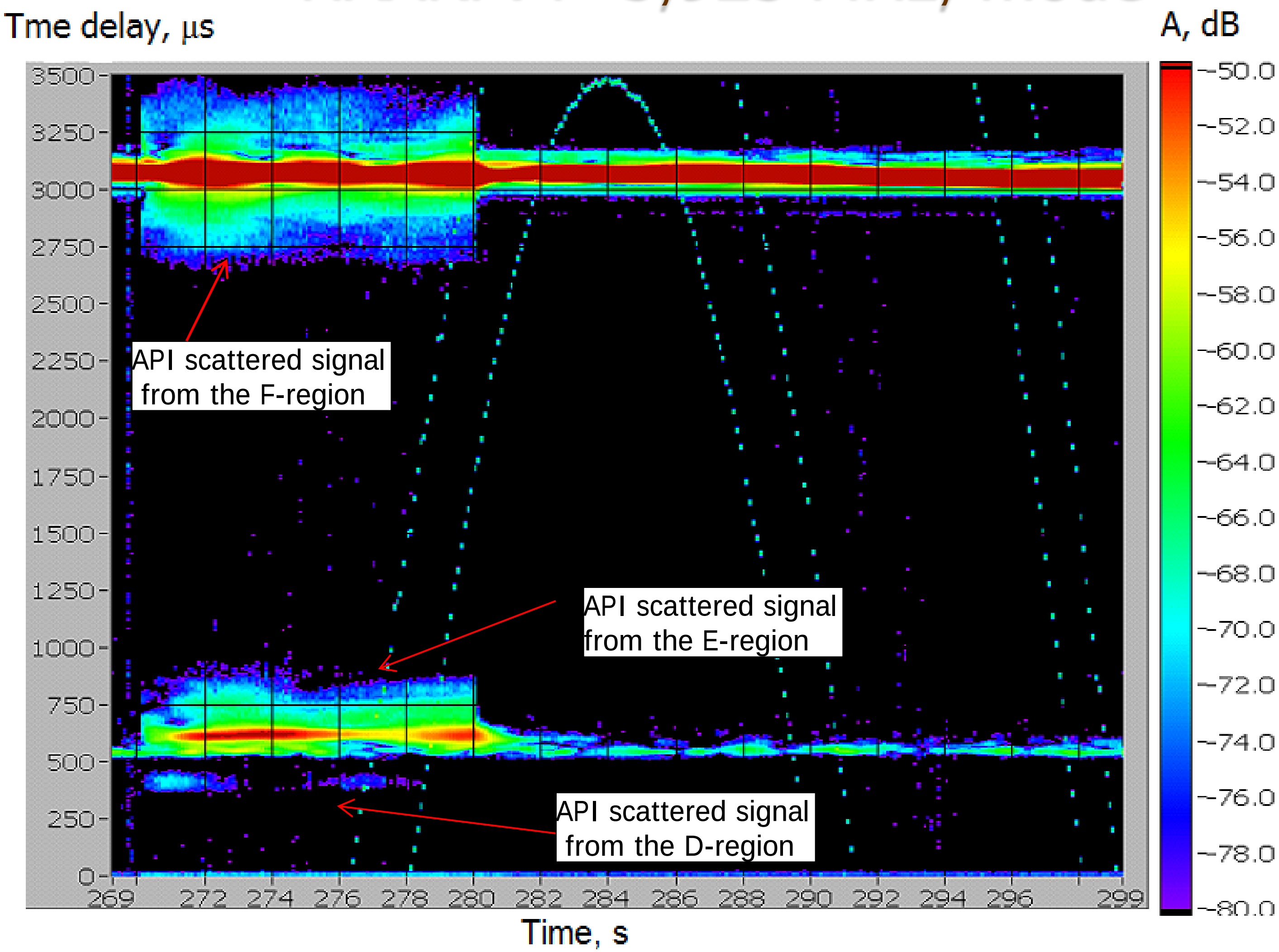


API June 5, 2014
HAARP: f=5,925 MHz, X-mode

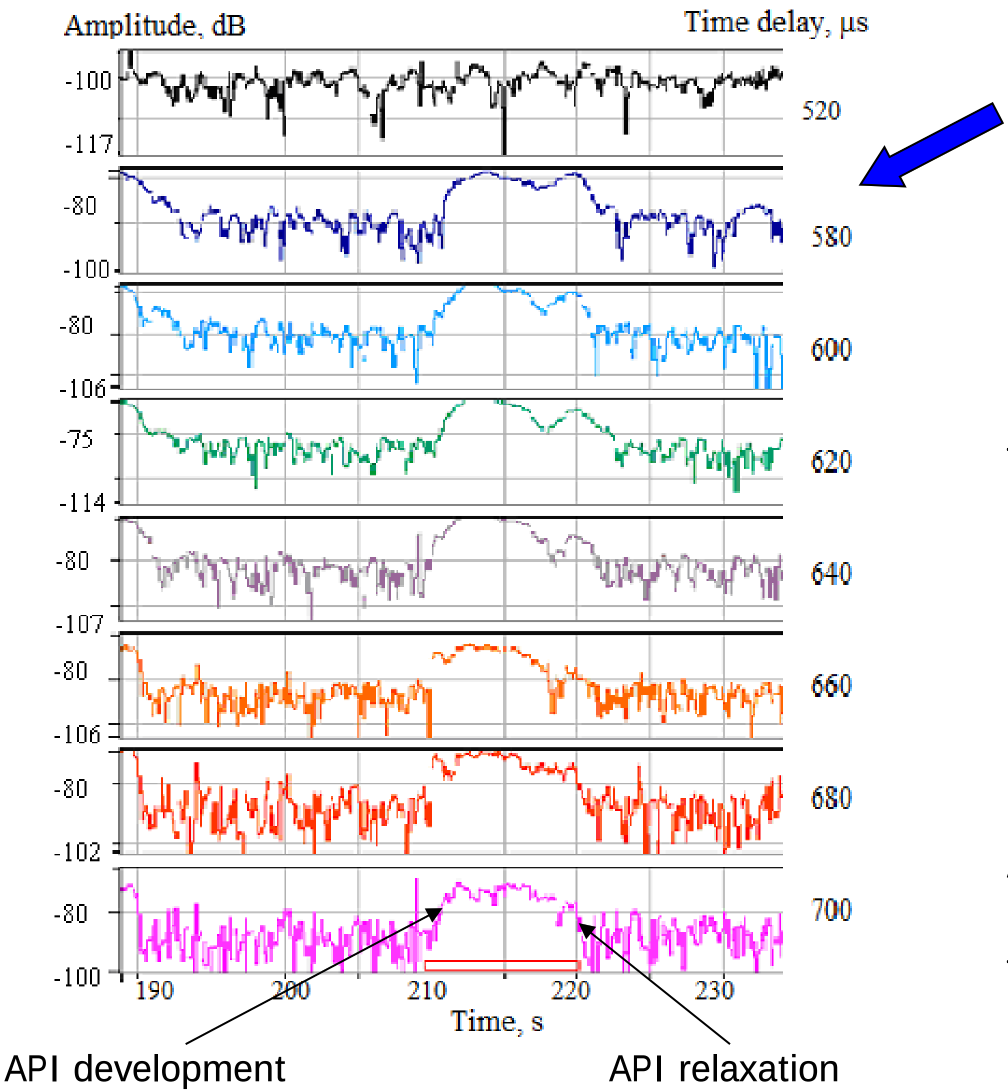


API scattered signals formation and decay and in the E- and F-regions and very small API scattered signals in the D-region

API June 5, 2014
HAARP: f=5,925 MHz, mode



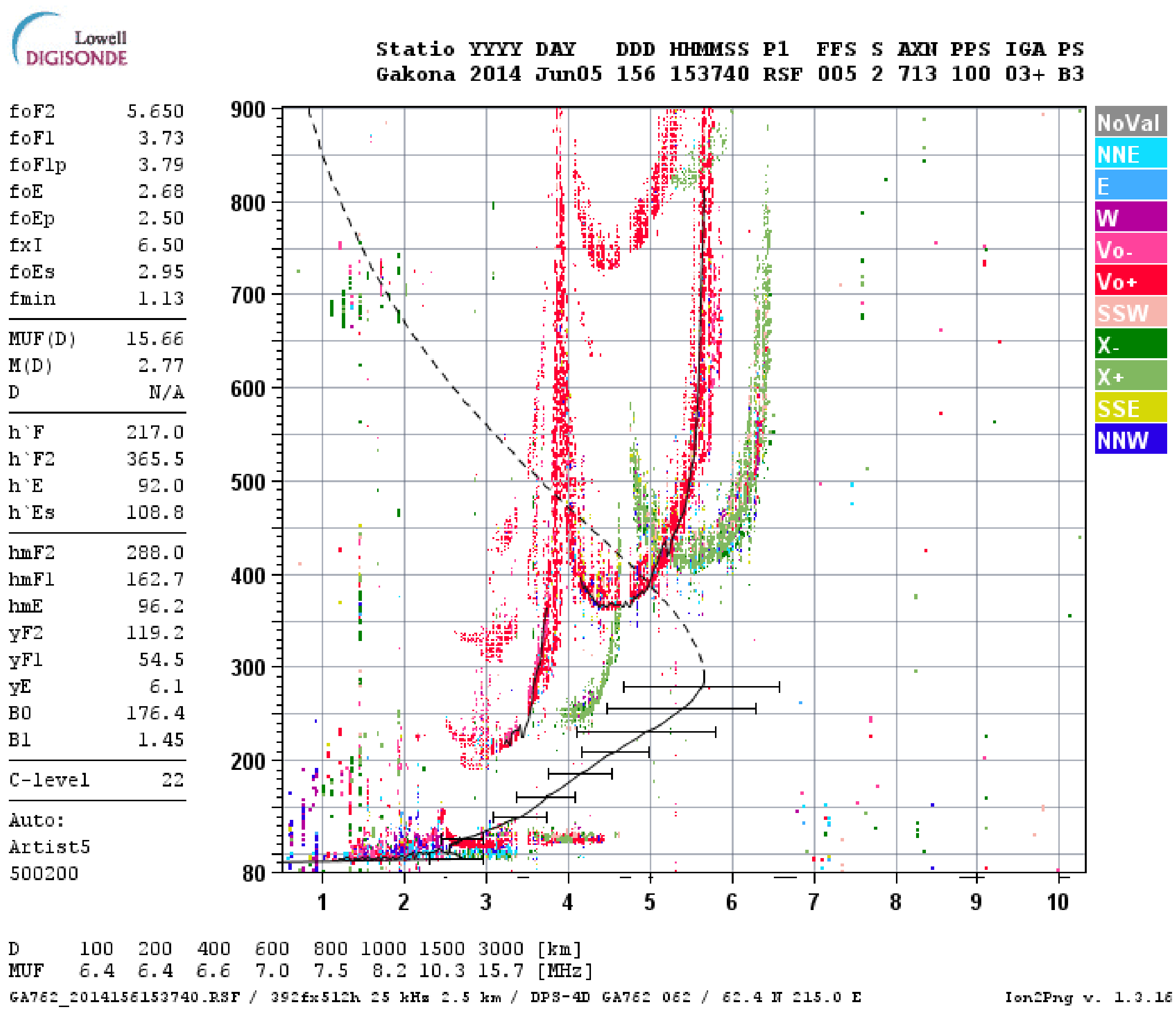
API development and relaxation processes in the E-region



Amplitude of the scattered signal versus altitude for 8 virtual height (time delay)

Characteristic times of the API rise and relaxation in the E-region amounted 1-1.5 s, which corresponds to the API theory. Examples of one of the records of the API scattered signal and amplitude for 8 time delays corresponding to the different heights of the E-region are shown. It is apparent that the API characteristic relaxation time decreases with the altitude. It is due to the nature of the API diffusion relaxation in the E-region. One can see significant fluctuations of the scattered signal.

Ionosphere condition



The ionogram for a minute before heating

Conclusions

1. During the experiment with the heating frequencies 4.1, 5.1 and 5.925 MHz, the APIs were observed in the D-region (occasionally), E- and F-regions. A weak scattering on the API in the sporadic-E layer were also detected.
2. In the E and F-regions API scattered signals at the HAARP heater were similar to those at the SURA facility.
3. Characteristic times of the API rise and relaxation in the E-region amounted 1-1.5 s, which corresponds to the API theory.
4. API characteristic relaxation time decreases with the altitude. It is due to the nature of the API diffusional relaxation in the E-region.
5. One can see significant fluctuations of the API scattered signal.

References

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