# A SPACE ACCELERATOR STATION FOR PLANET SUBSTANCE ANALYSIS

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*Abstract*

The structure analysis of a planet surface can be performed by means of space station generating hydrogen beam. To obtain high density of hydrogen beam the method of space groping of accelerated ion is proposed. The accelerator produces ions with energy increasing during current pulse so that at the planet surface they com at one time moment. The paper discusses the requirements to the parameters of such accelerator.

One of modern directions of development accelerator technique is the development of methods and means of acceleration electronic and ion flows for an effective utilization of the charged particles in space research and decision problems of  the Earth ecological safety. In particular, the accelerators of the charged particles can be used with monitoring of an earthly atmosphere exposed to the increasing pollution, for definition of scales of ecological accidents. Simultaneously with it the search of ways of research of planets of Solar system from orbital stations containing accelerators does not stop. From the point of view of practical realization the most developed there was a military direction connected to the creation beam weapon. It is possible to mention the launch of station with the linear accelerator of negative ions of hydrogen carried out  in USA some years ago [1].

To the present time there is a plenty of results of ground and space supervision avroral  and solar proton come out in the upper atmosphere with energy of protons from units keV for avroral  up to hundreds MeV for solar ones. The significant interest represents direct experiment on injection of protons at heights of 200-300 km in high breadths, where the powers lines of a magnetic field of the Earth allow protons to enter the per atmosphere. The basic allocation of protons will occur at heights of 80-100 km. According to the form of distribution of a beam and spectrum of intensity of a luminescence it is possible to determine topology of a magnetic field of the Earth and to analyze processes in an atmosphere. The important applied application of this task is sounding of the top layers of an atmosphere to measurement halogen concentration, influencing the changes of ozone  layer of the Earth [2].

Not less perspective the American project of cooperation with Russia is in the way of sounding a surface of the Moon by beams of the accelerated protons and deuteron or recharged up to a neutral state of negative ions of hydrogen. The launching into an orbit of the Moon of space station with board acceleration complex (BAC), supplied with a detector of the secondary radiation formed with an irradiation of a surface by accelerated particles is supposed. The variant of removing with BAC to a lower orbit of the independent detector allowing essential to increase sensitivity of the detector and to reduce influence of background radiation from the very accelerator is considered. Height of an orbit BAC - (50-200) km, height of an orbit of the detector - (10-50) km, energy of ions - (5-15) MeV. The scheme  of one of the offered variants BAC is shown in Fig. 1.
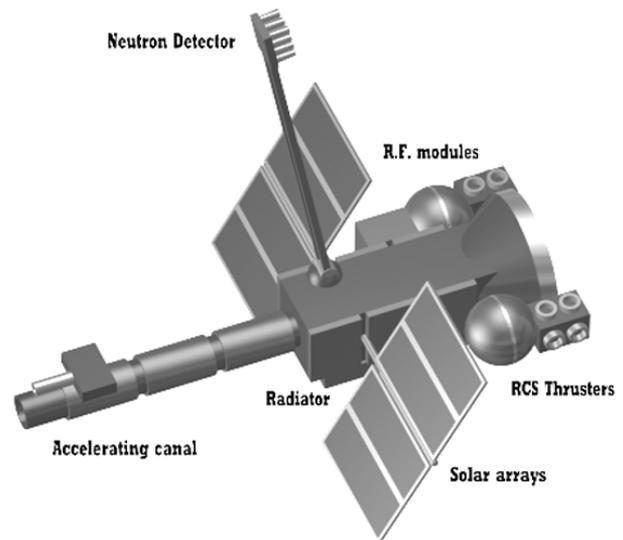


Figure 1: A configuration of BAC.

In all cases the basic difficulty to realize of the considered project is the small efficiency of registration back - reflect radiation caused by character of radiation with BAC, formed with precipitation of the accelerated particles of a beam on elements of a design (in accelerating structure, system of formation of a beam, deflection etc.). In of the authors opinion the problem concerned can be decided with the use of a known principle spatial - temporary modulations of a ions flow or neutral particles at the  expense of inside impulsive power modulation. Thus on irradiated object there comes a flow of particles compressed on time by 2-3 orders, but much time more intensive, that not only allows to exceed a background signal on amplitude, but also to use selectivity of the detector with time. In particular, the acceleration in general can carry continuous character, whereas a registered signal from a surface - frequency, with frequency of following of modulating pulses.

Naturally, thus there are additional requirements to stability of parameters of the accelerated beam, as the stochastic disorder on energy should not have an effect as the process of power modulation. Modulation itself can occur both on an output of accelerating complex with constant energy, and in an accelerating structure allowing its change in each of the elements, for example, in one-gap phasing resonators.

The results of research of an opportunity of using peak modulation of accelerating RF-fields to form a single bunch in the given point of space of drift, that is realization temporary compression of a pulse of a beam current of the accelerated particles are given below. A methodical basis of the carried out researches has become development and debugging of the integrated software package of account of longitudinal dynamics being the first stage of the works considered. The realization of the put task consisted in reception of numerical results allowing quantitatively to estimate an opportunity of peak modulation to realization temporary compression of a pulse of a current of a beam [3].

The program represents the integrated package ensuring the performance of the following functions:

- Calculation of the laws inside impulsive modulation of amplitude and phase of an accelerating field;

- Decision of the equations of a longitudinal movement for the given laws inside impulsive of modulation of amplitude and phase of an accelerating field;

- Definition of power and phase spectra of bunches of the accelerated beam according to the known solutions of the equations of a longitudinal movement;

- Calculation of the form of a pulse of a current of the accelerated beam in the given point of drift space;

- Representation of the calculated data of account in the graphic form.

As an object for research of opportunities using of peak modulation the accelerating structure as a consecutive chain of cylindrical resonators, each of which is supplying by the own RF-amplifier is considered. It is supposed, that all resonators are identical and are characterized by the following parameters: working frequency - 433 MHz; length of an accelerating backlash - 1.0 cm; a period of following of resonators - 10 cm; nominal voltage amplitude in resonator accelerating gap - 300 kV; total number of accelerating resonators - 200. Also it is supposed, that each RF-amplifier provides an opportunity of independent management of amplitude and phase of a voltage in resonator accelerating gap and the accelerating field strength in resonators gaps is constant along the length, and on an input into the accelerating system the injection of mono energy bunches of negative hydrogen ions of by extent of 50 degrees with constant density of a charge is carried out.

The value of injection energy is accepted to be equal to 10 MeV with the duration of a pulse of a current of the accelerated beam 1.0 ms. The synchronous phase is chosen to equal 30 degrees.

The direct purpose of research was the reception of quantitative estimations of opportunities of realization of temporary compression of a pulse of a current of the accelerated beam for two characteristic meanings of distances up to a target - 2000 km and 200 km. For a distance of 200 km the restriction to the maximal energy of the accelerated particles up to 30 MeV was involved, in this connection rating value of amplitude of a voltage on an accelerating gap was reduced to size 100 kV. Other parameters, except for phase extent injection of bunches, have remained constant. The extent phase of bunch was chosen to equal 30 degrees. Angular discrepance was assumed to be at a level of the order 0.1 milliradian with a negative hydrogen ions current up to 2.6 A in a pulse.

The basic results of calculations under the programs of a package for a distance of 2000 km and 200 km are given in Fig. 2-5. The laws of modulation of amplitude and phase of a voltage on gaps of accelerating resonators for the duration of a pulse of the RF-power appear to be practically linear functions with time.

The comparative analysis of the received results shows, that the reduction of distance up to the target (of the order) results in the following consequences:

- From 13 % up to 70 %, the necessary volume of depth of amplitude modulation of a voltage on accelerating gaps of resonators grows, that results accordingly in increase of depth of modulation of average energy accelerating of bunches from 15 % up to 50 %;

- The increase of depth of modulation of an accelerating field results in almost double reduction of a gradient distribution of a phase of a voltage on gaps of accelerating resonators during a pulse of RF-power;

- From 50-70 up to 100 the maximal volume factor compression of a pulse of the accelerated current on a target meaning increases the requirements to the quality of bunches being injected become more string.
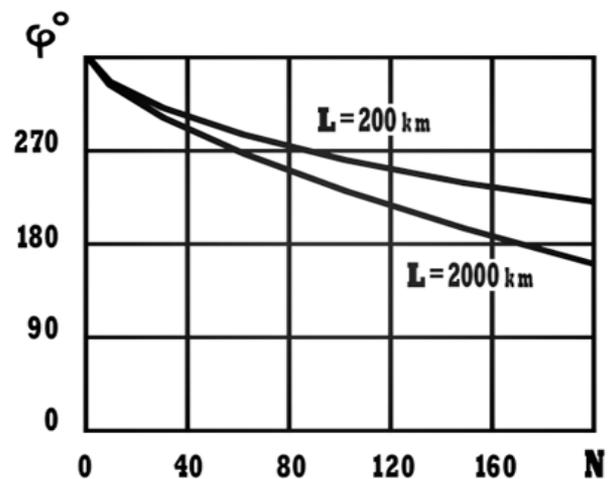


Figure 2: Distribution of a voltage phase on gaps of accelerating resonators (N - serial number of the resonator).
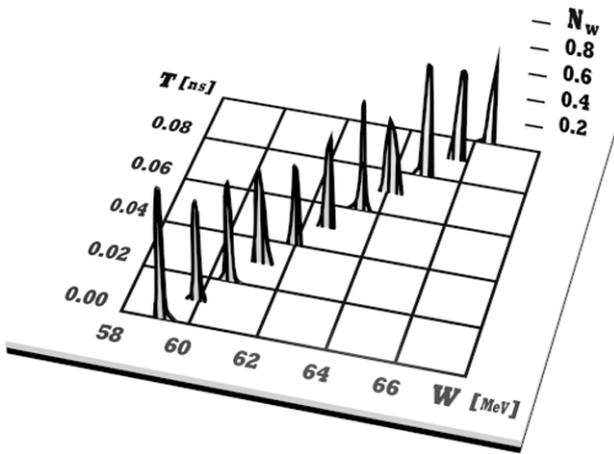
Figure 3: Power spectra of bunches of pulse of the accelerated current on a target array 2000 km.

Nowadays in MEPhI the installation allowing to carry out inside - pulse modulation energy of ions of hydrogen is created and tested. It includes an ion injector and some one-gap resonators, in each of which the independent adjustment of a phase and amplitude of a RF-field is possible. Axial extent of each resonator - 9 cm, working frequency - 150 MHz. On the installation the acceleration of protons with the change of energy from minimal, determined by energy of injection, up to maximal energy, appropriate to a gain, in each resonator of the order 60 keV is carried out at a level of introduced power no more than 40 kW.
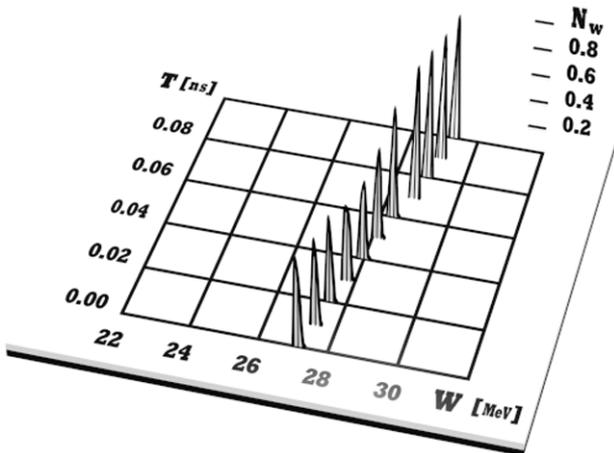


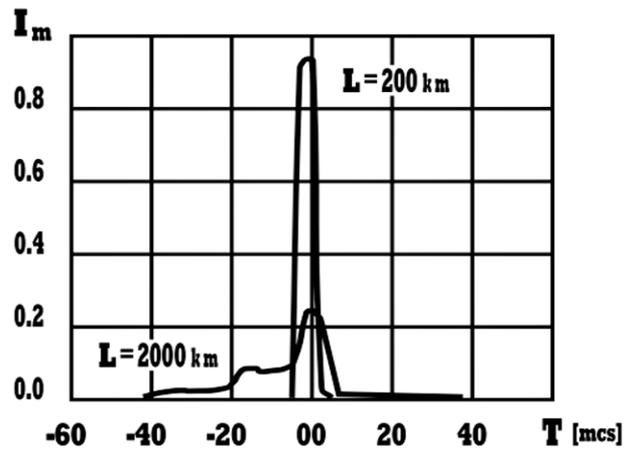Figure 4: Power spectra of bunches of pulse of the accelerated current on a target array 200 km.



Figure 5: The characteristic form of a pulse of a current of the accelerated beam on a target.

## REFERENCE

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