DEVELOPMENT OF THE MILLIMETER WAVELENGTH ACCELERATING STRUCTURE

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Introduction

We began to develop accelerator facility with short electron beams at Budker Institute of Nuclear Physics. It will be based on the RF photocathode gun. Substantial feature of such a gun is production of low emittance beams compared to conventional thermionic cathode guns. At the same time, charge of the beam from this gun can be high enough. Thus, such beams are suitable to serve a driver for the excitation of the W-band accelerating structure. There are several motivation to develop this course:

1. From the point of view of high gradient due to the higher frequency. Length of the W-band accelerator may be significantly reduced compared to length of the conventional S-band one.
2. Plasma excitation with subsequent wakefield acceleration where bunch required length is determined by the Langmuir wavelength and equals about 1-3 mm
3. Excited W-band structure may serve as bunching system for a “long” beam with a spatial period of about 3 mm

Excitation of the structure by the electron beam

Geometry of the structure was chosen as a result of CST simulations

Parameter	Value
Exciting beam charge	2 nC
Exciting beam RMS duration	2 ps
Frequency of the mode E_{010}	96.2 GHz
Electric field amplitude	50 MV/m
Damping time	60 ns

Table 1: Exciting beam parameters and simulation results

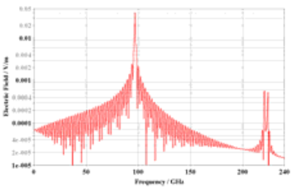

Figure 1: Spectrum of excited electric field in one of the cavities

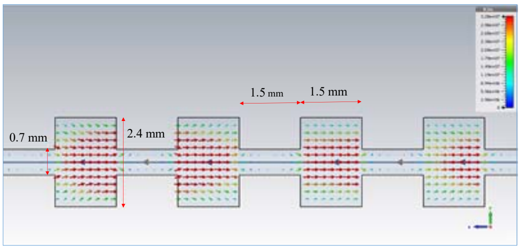

Figure 2: Excited W-band cavity structure

Focusing system on permanent magnets

From the envelope equation for the beam with Kapchinsky-Vladimirsky distribution one can estimate required magnetic field for given beam parameters:

$$B_z = \frac{2\beta\gamma mc}{q}\sqrt{\frac{K}{a^2}+\frac{\varepsilon_n^2}{\beta^2\gamma^2 a^4}}$$

$B_z \approx 2$ T

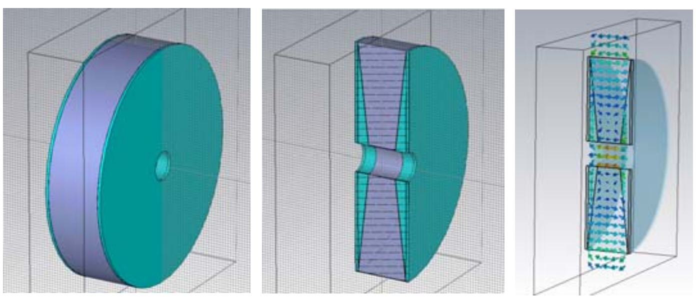

Figure 3: View of a single axisymmetric magnet element with longitudinal magnetization

Beam dynamics simulations, Q = 2 nC

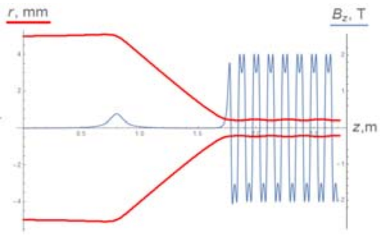

Figure 4: Beam envelope in the field of permanent magnets and matching solenoid (obtained the use of ASTRA [ref])

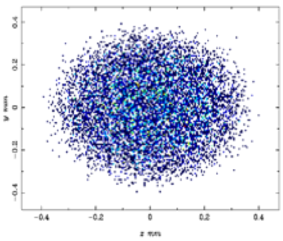

Figure 5: Transverse profile of the exciting beam (almost constant along the structure)

In the properly chosen focusing system beam radius stays almost constant of about 0.27 mm along all the structure with focusing elements

Fabrication of the structure

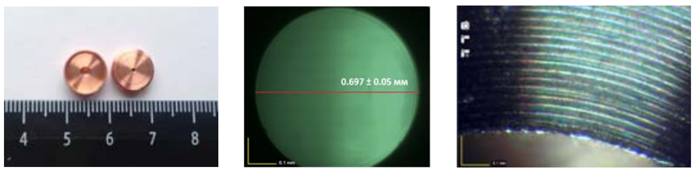

Figure 6: Fabricated cavities examined under the microscope

Figure 7: 50 cavities were brazed into the structure

The structure was checked for tightness; measurements from the outside revealed misalignment of cavities from the structure axis less than 0.02 mm

Conclusion and Future Works

1. We began to develop W-band accelerating structures at BINP. To excite the structure, we plan to use electron beam from the photocathode RF gun.
2. We performed simulations of the structure excitation and defined optimal exciting beam parameters, i.e. in terms of E_{010} mode excitation.
3. To focus the exciting beam in the structure, it was proposed to use permanent magnets. Two cases were considered corresponding to the exciting beam charge of 2 nC and 0.1 pC. In both cases beam dynamics simulations showed successful beam passage through the structure aperture in the permanent magnet solenoidal field. Magnets are designed.
4. The structure was successfully fabricated, preliminary measurements showed satisfactory results for tightness and coaxiality of cavities.
5. The next step is to manufacture magnets and the prototype which will be suitable for the experiments on the structure excitation by the beam.

References

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