High-efficiency narrow-band 30-GHz Bragg FEM-oscillator was elaborated during the last few years in JINR-IAP collaboration based on 0.8 MeV / 200 A / 250 ns LINAC LIU-3000 (JINR). An attractive solution to prospect FEM into short wave-lengths keeping beam energy and geometry of electron-optical system is operation at harmonics of bounce-frequency. Two FEM schemes exploiting this idea are under development at LIU-3000.

To achieve stable single-mode operation regime in short wavelength FEM-oscillator with strongly oversized interaction space we propose to use advanced Bragg structures based on coupling of propagating and quasi-cutoff waves. Simulations demonstrate that Bragg structures of such type are able to provide selectivity up to transverse size \(~ 10\) wavelengths and encourage development of sub-mm wavelength FEM of multi-MW power level driven by intense quasi-continuous electron beams formed by LINACs. Prove-of-principle experiment of novel FEM scheme was performed at 30 GHz at the fundamental harmonic of bounce-frequency based on LIU-3000. Under designed parameters in the cavity with diameter \(~ 2\) wavelengths stable single-mode 15 MW / 150 ns operation was observed with the spectrum width of \(~ 8\) MHz, close to the theoretical limit. Experimental study of 60-GHz FEM operating at second harmonic of bounce-oscillations is in progress currently. In this project the advanced Bragg structure provides stable selective single-mode excitation in the cavity with diameter of about 4 wavelengths.

Another scheme is an FEM-multiplier, which simultaneously generates several modes at different harmonics of the bounce-frequency. Namely, operating mode self-exciting at the fundamental resonance produces RF current, the higher harmonic of which radiates the high modes at the second (third, etc.) harmonic of the bounce oscillations at multiplied frequencies. In the FEM-multiplier driven by LIU-3000 the two-mode generation regimes were realized with excitation of the fundamental harmonic at 24 GHz and simultaneous excitation at the second harmonic of the bounce oscillation at 48 GHz and 72 GHz corresponding to double and triple frequency multiplication. The output power was measured to be about 2 MW at 48 GHz and 0.5 MW at 72 GHz. Project of sub-mm FEM-multiplier is designed.