RECENT RESULTS OF THE ENEA FRASCATI FEL EXPERIMENT

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Abstract

The spectral analysis of the spontaneous emission has been performed at the fundamental wavelength in the range 25÷35 μm and up to the 5th harmonic (5÷7 μm). Amplification of the spontaneous emission has been also observed.

The ENEA-Frascati FEL in the IR [1-3] has been designed in order to produce coherent radiation in the medium infrared (20÷40 μm). The device (fig. 1), driven by a 20 MeV circular microtron, utilizes a variable gap permanent magnet (SmCo) undulator.

The main parameters of the microtron, the undulator and the optical resonator are summarized in Tab. I. The large tunability range is achieved both by exploiting the variation of the electron beam energy and the variation of the undulator gap.

The apparatus is now in operation. In particular, a set of experimental measurements have been devoted to the characterization of the electron beam quality (emittance measurement) and to the proper matching of the electron beam into the undulator structure. To this aim the measurement of the linewidth of the spontaneous emission has been used as direct diagnostic tool. A strong dependence of the spectral width of the emission on the alignment of both electron beam and optical axis with respect to the undulator has been observed. The spectra of the radiation emitted in a cone $\Delta\Theta = 1.5$ mrad measured for poor and optimum e-beam alignment are shown in figs. 2a,b respectively.

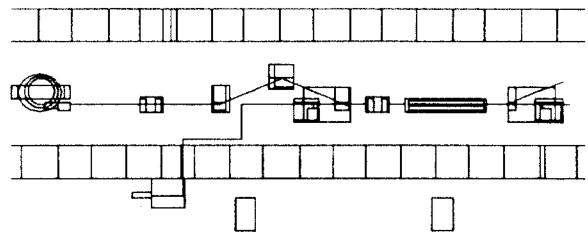

Fig.1 - Layout of the ENEA FEL in the medium infrared.

Table I - FEL Device Characteristics

MICROTRON		
Parameter	Achieved	Design Goal
Electron beam energy (MeV)	15÷20	15÷20
Electron bunch duration (ps)	20	20
Macropulse duration (μs)	10	12
Current macropulse (mA)	160	200
Peak current (A)	3.2	4
Normalized horizontal emittance (m·rad)	5×10^{-4}	7.5×10^{-4}
Normalized vertical emittance (m·rad)	2.5×10^{-4}	2.5×10^{-4}
Energy spread	0.12%	0.12%
PURE $SmCO_5$ CONSTANT PARAMETERS		
Period (cm)	5	
Number of periods	45	
Gap (cm)	0.9÷7	
k parameter at 1.3 cm gap	2	
k parameter at 2.4 cm gap	1	
OPTICAL RESONATOR AND FEL CHARACTERISTICS		
Parameter	Achieved	Design Goal
Resonator length (m)	6.37	6.37
Reflectivity of the end mirror (copper)	99%	99%
Reflectivity of output coupler (coated Si)	97%	97%
Total losses	~ 4%	~ 4%
Laser wavelength (μm)		20÷40
Gain per pass at λ=32 μm, I=200 mA		10%
Average laser power at λ=32 μm and at 150 Hz repetition frequency (W)		5
Peak power (micropulse) (MW)		1
Peak power (macropulse) (kW)		40

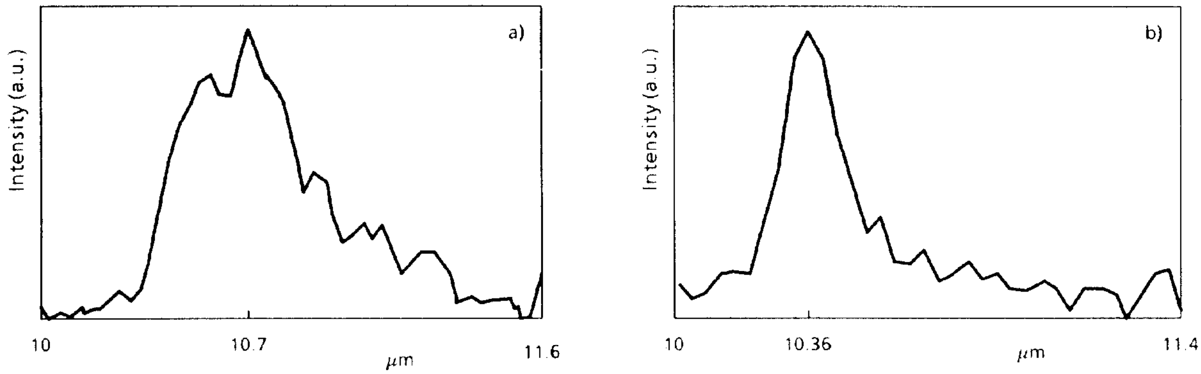

Fig. 2 - Spontaneous emission spectrum in 3rd harmonic with poor a) and optimum b) alignment of the electron beam.

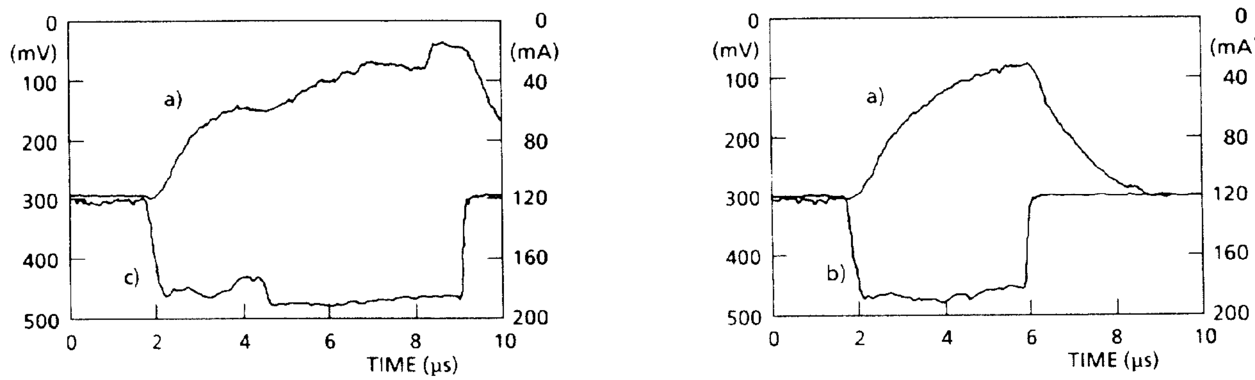

Fig. 3 -Ligth pulse (a) at electron beam macro pulse duration of 4 μs (b) and 8 μs (c).

Spontaneous emission spectra taken at different values of the undulator gap have confirmed the good potential tunability of the ENEA FEL in the medium infrared. The spectral analysis of the spontaneous emission has been performed at the fundamental wavelength in the range 25÷35 μm and up to the 5th harmonic (5÷7 μm).

In late December 1989 the optical cavity has been installed. Due to the large mirror spacing (~ 6 m) this cavity includes an interferometric system for the control of both angular and longitudinal alignment [4]. Variations of the mirror spacing as small as 0.1 μm and up to several millimeters can be actively controlled, while the resonator is kept aligned within 2.5 μrad.

Stimulated emission measurements have been performed at the third harmonic (10 μm), with the optical cavity installed, as a function of the electron beam current and of the macro pulse duration (fig. 3). An analysis of the rise-time and decay-time of the optical pulse has indicated a net gain of about 0.5% at the third harmonic.

Gain measurement will be performed in summer 1990 at the fundamental wavelength, with an improved light collection and detection system.

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