

## EC Contract ERBFMGECT980102

### "Development of a Combined Synchrotron Radiation and VUV Free-Electron Laser Facility"

**DRAFT** Minutes of the 8<sup>th</sup> Project Meeting, held at Sincrotrone Trieste, Italy  
on the 31<sup>st</sup> October 2000.

Participants -

Sincrotrone Trieste: M. Marsi (MM), M. Trovò (MT), R.P. Walker (RPW)  
+ E. Karantzoulis, L. Tosi (part time)  
CEA: M.E. Couprie (MEC)  
CLRC Daresbury: J.A. Clarke (JAC)  
ENEA Frascati: L. Giannessi (LG)  
MAX-lab: S. Werin (SW)

#### 1. PROJECT MANAGEMENT

The draft minutes of the 7<sup>th</sup> Project Meeting (Trieste, March '00) were approved after minor additional corrections from M.W. Poole, presented by JAC.

RPW confirmed that the 2<sup>nd</sup> Annual Report had finally been sent to Brussels on Nov. 16<sup>th</sup> after delays in obtaining the Cost Statements from various partners, in particular CLRC. He summarised the financial situation at the end of the second year of activity, as shown in the following table:

Partner	Original EC Contribution	Revised EC Contribution A)	Year 1 Accepted B)	Year 2 Requested C)	% of total	Remaining (kEUR) A-(B+C)
ST	423	440.5	305.6	297.9	137	-
CEA	200	200	110.6	94.0	102	-
CLRC	195	212.5	184.4	274.5	216	-
Dortmund	110	75	21.2	49.5	94	4.3
ENEA	50	50	25.8	10.8	73	13.7
MAX-lab	22	22	13.0	4.8	81	4.2

The table also shows the agreed revised EC contributions as a result of the reduction in the amount being requested by the University of Dortmund. RPW pointed out that the remaining sums were small but as usual still had to be justified to the EC.

RPW also summarised the manpower spent on the project up to the end of the 2<sup>nd</sup> year, as shown below (in man-months):

Partner	Year 1	Year 2	Total	% of Proposal
ST	28.5	54.2	82.7	100
CEA	18.2	18.0	36.2	65
CLRC	27.1	17.8	44.9	213
Dortmund	3.5	9.5	13	72
ENEA	6.0	1.6	7.6	84
MAX-lab	-	-	-	-
TOTAL	83.3	101.1	184.4	

The required minimum of 10 man-years of effort has thus already been well exceeded.

JAC presented data for CLRC showing a total capital expenditure of £ 218,676 (against a claim to the EC for £ 89,910); the effort spent in the first half of the 3<sup>rd</sup> year was 13.5 days. MEC said that at CEA only herself and D. Garzella were currently working on the

project, D. Nutarelli and E. Renault having now left; a total of 18 days had been recorded so far this year. LG said that at ENEA the main effort on the project was that of himself and G. Dattoli.

RPW summarised the status of publications relevant to the project:

- European Particle Accelerator Conference, Vienna, June 2000: invited oral presentation, contribution to the proceedings available on the web.
- International FEL Conference, Durham, NC, USA, August 2000: invited oral presentation, contribution to the refereed proceedings undergoing review.
- International Synchrotron Radiation Instrumentation (SRI) Conference, Berlin, August 2000: contributed oral presentation; contribution to the refereed proceedings accepted, but requiring shortening.

MEC pointed out that in addition there had been a general paper on SRFELs by D. Garzella et al. at the Xray Laser Conference (?), as well as a presentation and paper by A. Gatto et al. regarding the activities of the TMR SRFEL Network at the 45<sup>th</sup> Annual Symposium on Optical Science and Technology, San Diego CA, Jul./Aug., 2000.

## 2. FEL SYSTEMS

E. Karantzoulis summarised the present performance of ELETTRA in the 4-bunch FEL mode. The most dramatic change in the machine over the years has been the steady increase in vertical impedance due to the installation of lower gap ID vacuum chambers. It is felt that this is responsible for the varying injection efficiency, and the dependence of maximum current on closed orbit. A re-alignment of the machine later in 2001 may hopefully improve the situation. The impedance will however increase further when the remaining two ID vacuum chambers are installed (end 2001/early 2002), however high current should still be possible with higher chromaticity, which has yet to be explored in detail. The maximum current that has been able to be achieved recently is 60 mA, limited by an increase in pressure in the region of the low-gap BPMs, which may be an effect of r.f. heating. Further studies will be necessary to determine if the effect is real or not.

L. Tosi summarised the present situation regarding the operation of the FEL undulator. The same procedure described by F. Iazzourene at the previous meeting is still used for a local pre-compensation of the tunes before closing the undulator sections one at a time. A new program for performing various types of matching under dynamic conditions has been written and is in the testing phase. She also reported on dynamic aperture simulations for various matching conditions. Calculations treating only the linear effects of the device showed that both linear and non-linear effects are important for all matching schemes (global tune, local tune, alpha matching); for alpha-matching however the effect is mainly non-linear. In all cases the main overall effect is a significant reduction in the horizontal dynamic aperture. An attempt to reduce the horizontal beta function in the ID straight resulted in lower aperture even without the ID, probably because of the need to re-optimize the sextupoles.

M. Trovò presented a summary of experience with the mirror chambers. Various problems mentioned at the previous meeting have now been resolved: the leakage in the water cooling system of unit A has been repaired by DL technicians; the broken flowmeter of unit A has been replaced; the over-heating of the Y2 motors has been resolved by adjustment of the motor current – changing between mirrors can now be achieved in one step in about 3 minutes. The DL vacuum group has been contacted to help resolve the remaining problem of the ion pump connector, in the meanwhile a spare ST pump is being used. The vacuum interlock mentioned at the last meeting to protect the piezo units is now operational; a water flow indication will be implemented in the future.

A new problem is that the temperature controller of the front pitch stepper motor is not working properly; the interlock has been temporarily by-passed while awaiting a spare from DL. A potentially serious problem is the vibration of the front piezo unit that has been observed on various occasions. It is important to try to resolve the problem in case it starts

to affect the other unit, however the problem is difficult to diagnose since it has not been observed when reflecting the HeNe beam off the mirror. From the vacuum point of view the chambers are working well with a base pressure of  $7 \cdot 10^{-10}$  mbar in the front and  $1 \cdot 10^{-9}$  mbar in the back. During mirror change the pressure rises to  $2 \cdot 10^{-8}$  (front) and  $6 \cdot 10^{-8}$  (back), but the pressure recovers after a few minutes.

### 3. FEL COMMISSIONING

RPW summarised the progress to date with FEL commissioning, divided into 6 activities in roughly chronological order, based on the availability of mirrors (see below):

Activity	Substrate	Coating		Central Wavelength	Runs	Lasing Wavelength
1	Sapphire (MD, RSA) Silica (MD)	Mack.	Ta <sub>2</sub> O <sub>5</sub> /SiO <sub>2</sub> IBS	350	2,3,5, 8,12	351-356
2	Silicon (SESO)	DB (LZH)	HfO <sub>2</sub> /SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> /SiO <sub>2</sub> IBS	220/350	3,4	~ 350
3	Silica (DEL)	DB (IOF)	HfO <sub>2</sub> /SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> /SiO <sub>2</sub> PIAD	220/350	6	357 217.9-224.1
4	Sapphire (RSA)	F1 (IOF)	LaF <sub>3</sub> /MgF <sub>2</sub> EB	186	7,9,10	-
5	Sapphire (RSA)	O1 (IOF)	HfO <sub>2</sub> /SiO <sub>2</sub> PIAD	250	12,13, 14	235.5-264
6	Sapphire (RSA)	O2 (IOF)	HfO <sub>2</sub> /SiO <sub>2</sub> PIAD	245	14	?

- 1) initial and subsequent lasing at 350 nm with Mackowski mirrors; most investigations of FEL performance (detuning curve, spectral and temporal width, macropulse structure, gain measurements etc.) have so far been performed with these mirrors
  - 2) use of silicon mirrors with LZH dual-band coating; lasing was possible at 350 nm with one such mirror in combination with a Mackowski mirror, but because of difficulties in alignment lasing was not achieved with two such mirrors
  - 3) lasing at 220 nm and 350 nm using IOF dual-band semi-transparent mirrors
  - 4) unsuccessful attempts to lase at 190 nm using IOF fluoride coated mirrors
  - 5) wide tunability around 250 nm with IOF oxide (HfO<sub>2</sub>/SiO<sub>2</sub>) coated mirrors
  - 6) first attempts with IOF higher transmission mirrors, giving a power of about 100 mW
- A summary of the use of the FEL shifts was also presented (see table on following page).

A discussion took place about the stability of the laser. MEC said that her impression was that the 50 Hz noise was much stronger in ELETTRA than at SuperACO, and suggested that measurements should be made to evaluate the size and nature of the effect. LG suggested that a Q-switched mode of operation could give a more stable time structure since the laser would not be operating close to saturation where it is more sensitive to noise. MEC pointed out that such a mode would lose one of the main advantages of the SRFEL, namely the continuous MHz repetition rate. LG said that it could still be useful in an intermediate phase of operation, until noise sources are eliminated or corrected, and would also be a useful means of measuring laser rise-time.

FEL Run No.	Dates	No. of Shifts	Activity
1	Feb. 18-19	3	alignment
2	Feb. 28-29	1	<b>first lasing at 350 nm</b>
3	Mar. 11-12	4	lasing studies at 350 nm lasing with DB silicon front mirror with 0.8 mm hole
4	Mar. 25-26	3	lasing at 350 nm with DB silicon front mirror with/without hole
5	May 14-15	3	alignment; lasing studies at 350 nm
6	May 27-28	3	<b>lasing at 218-224 nm</b> with DB mirrors
7	Jun. 17-18	3	alignment; first lasing attempts < 200 nm with F1 mirrors
8	Jul. 1-2	3	studies of polarization of laser and sp. em. at 350 nm
9	Jul. 15-16	2	lasing attempts at < 200 nm with F1 mirrors
10	Jul. 29	1.5	lasing attempts at < 200 nm with F1 mirrors
11	Sep. 3	2	electron beam studies
12	Sep. 17-18	2.5	alignment studies and lasing at 350 nm lasing at 241-264 nm with O1 mirrors
13	Oct. 15-16	2	alignment; lasing at 235-240 nm with O1 mirrors study of sensitivity to laser axis
14	Oct. 30-31	3	lasing at 250 nm with O1 and O2 mirrors

#### 4. MIRRORS

MM summarised the status of available substrates. 10 CaF<sub>2</sub> substrates had been purchased from Layertec, but the achieved roughness was not very good (8 Å rms). An attempt will be made to coat 4 of them, while the remaining 6 have been sent back to Layertec for re-polishing. 10 sapphire substrates will arrive soon from SESO, with good transmission down to 220 nm. Given the difficulty with CaF<sub>2</sub>, there is a need therefore for further silica substrates for shorter wavelength. MM suggested re-using some of the 350 nm Mackowski mirrors which are no longer required, however MEC was not in agreement and pointed out that removing the coating would require the substrates to be re-polished. She also said that she had a personal agreement with Mackowski that his mirrors should not be sent to any other optics companies. MM pointed out that there were still 4 undelivered sapphire substrates from Maris-Delfour. MEC agreed to contact Maris-Delfour to obtain these substrates, as well as to request an offer for further silica substrates.

MEC said that it should be possible to achieve better performance in terms of absorption than is currently the case and suggested that a detailed discussion on this topic should be held within the TMR SRFEL Network.

#### 5. EXPERIMENTS

MM presented some details of the first experiments that will be carried out with the FEL radiation. The plan is to make use of the FEL as a tunable UV source to perform spectromicroscopy at the photothreshold, using the recently installed SPE-LEEM microscope. In practice this means covering the range 280-220 nm (or lower) in order to cross the work function of most materials. The first systems to be studied could be micro- and nano-structures of Co on W(110) and Pb on Si(111) or on Au/Si(111).

JAC mentioned a possible interest of DL users to carry out some atomic and molecular physics experiments using the FEL. RPW asked him to find out more about their requirements.

MEC pointed out that a user-related SRFEL Network meeting should be held before June 2001.

## 6. CONCLUSION

It was agreed that the next and final Project meeting should be held towards the end of the contract, in April 2001.

### SUMMARY OF MAIN ACTIONS:

- replace temperature controller (CLRC, ST)
- resolve the ion pump connector problem (CLRC, ST)
- investigate piezo vibration (CLRC, ST)
- commission tune/optics compensation program (ST)
- investigate 50 Hz noise source (ST)
- consider Q-switched mode of operation (ST)
- expedite delivery of remaining 4 Maris-Delfour sapphire substrates and request offer for new silica substrates (CEA)
- provide details of potential FEL users (CLRC)
  
- Action remaining from previous meeting: order mirror chamber spares (CLRC/ST)

R.P. Walker  
Trieste, 9<sup>th</sup> January 2001