EC Contract ERBFMGECT980102

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

Minutes of the 3rd Project Meeting, held at Daresbury Laboratory, England on the 23rd November 1998.

Participants -

Sincrotrone Trieste:	B. Diviacco (BD), M. Marsi (MM), R.P. Walker (RPW)
CEA:	E. Renault (ER)
CLRC Daresbury:	N. Bliss (NB), A. Chesworth (AC), J.A. Clarke, M.W. Poole (MWP) + (item 4 only) B. Fell, N. Harris, I. Mullacrane, R. Reid
Univ. Dortmund:	H. Quick (HQ)
ENEA Frascati:	G. Dattoli (GD), L. Giannessi (LG)
MAX-lab:	M. Eriksson (ME), S. Werin

1. PROJECT MANAGEMENT

The minutes of the previous Project Meeting (LURE, July '98) and Technical Meetings (Williamsburg, Aug. '98 and LURE, Oct. '98) were approved.

RPW asked for details of manpower and expenditure during the first 6 months of the contract. For ST, partial figures indicated at least 7.5 man-months had been recorded, while approximately 500 kECU had been committed. ER presented data for CEA which showed 4.3 man-months plus an additional 4 man-months for himself (post-Doc) who started on July 1st. Expenditures had been 80.3 kECU for the argon laser and 8.7 kECU on consumables (mirrors and substrates). MWP reported that about 9.5 man-months had been recorded for CLRC, more than anticipated since design work was not yet complete; no expenditures have yet been made. For ENEA, GD said that work on the project was certified monthly and that details of the first 6 months would be forwarded to RPW in the next few weeks. HQ said that the only additional costs at Dortmund are for himself, who is working half-time on the project from October '98 until March '99.

On the topic of recruitment, RPW reported that adverts had been placed to try to find an extra person for ST, and that it was hoped to hire someone from the beginning of January. ER said that he will work on the project for 1 year at CEA. HQ said that Dortmund is trying to hire a PhD student to continue on the project after he leaves.

Circulation of documents by e-mail appears to be working well and is preferred to fax, however some problems were experienced with the large files sent by CLRC. The possibility of setting up an ftp or web site was suggested as a way to overcome this.

RPW reported that the paper submitted to the International FEL Conference had been accepted as a 4-page Journal article and that a presentation had been made to the TMR review panel in October.

2. PROJECT STATUS

RPW summarised the main decisions and actions arising from the previous meetings. Actions not yet completed are reported at the end of the present minutes.

On the question of the Rayleigh length, MWP raised the point that with the nominal radii the cavity was quite close to the stability limit and the effect of small changes (or errors) in radii could be significant. LG presented some figures showing that at long wavelength the gain was anyway sufficient and so a smaller Rayleigh length was not needed, but at short

wavelength a useful gain increase could be obtained at the expense of a less stable cavity and hence more critical alignment. It was concluded that at least for initial lasing attempts the nominal mirror radii of 19 and 16 m gave sufficient margin for errors in radius of curvature. In any case, it was agreed that any future change of mirror radii would have to adapt to the present beamline apertures and mirror sizes, since these are now fixed.

3. TASK C: UNDULATOR AND FRONT-END

BD presented the final parameters of the undulator, as proposed in the note circulated on Oct. 13th. Regarding the modulator, various designs had been considered and finally a 'wiggler' type had been chosen with magnetically isolated upper and lower yokes rather than a C-shape design, since this proved to be more efficient and gave less saturation than the alternatives. ME asked about the effect of the earth's field on the open structure. BD replied that this had not been studied, but that any residual field could be compensated with the correction coils. With the proposed design the nominal maximum Nd=80 can be achieved with about 250 A at 1 GeV, 350 nm, compared to the maximum foreseen current of 300 A. The field of the modulator at the fixed end of the undulator is sufficiently small (10-30 G) even without shielding plates that interaction effects should be negligible.

RPW presented the situation regarding the front- and back-ends. For the front-end, a slightly smaller aperture mask of 28.2 mm diameter was foreseen at 9.15 m from the source, corresponding to an angular acceptance of 3.08 mrad, in order to shield the downstream vacuum chambers from the synchrotron radiation emitted by the downstream undulator. This aperture will also be circular, rather than rectangular as previously stated. For radiation safety reasons the rear mirror must be located in a radiation shielded area, which also implies the need for a radiation stopper in the back-end beamline, and the fact that there will be no access to the mirror chamber with the stopper open while the ring is operational. MWP reminded about the need to leave space for additional chambers. NB pointed out the need to leave sufficient space around the mirror chambers to permit access for mirror changing.

4. TASK A: OPTICAL CAVITY

MWP reported that the design of the optical cavity has been much more complex than foreseen therefore causing some inevitable delays to the programme, but was now nearing completion. The main outstanding issues are the cooling and integration of the chambers at Trieste (controls, interlocks, software etc.) as well as requirements for commissioning at Daresbury. The date of Oct. 1st for delivery to Trieste includes a 1 month contingency, but is otherwise very tight. Tendering is due to begin straight away in order to place the first orders for the longest delivery items (chambers, motion systems etc.) by Dec. 18th. The key dates are as follows :

complete design	13th Nov.
place first contracts	18th Dec.
delivery to DL	25th May
assembled, cleaned and baked	6th July
tested, ready for shipment	24th Aug.
delivery to Trieste	1st Oct.

AC presented the results of an assessment of mirror position sensitivity, concluding that tolerances on position and angle of 500 µm and 2 µrad were adequate. RPW however expressed some doubt about the method used to calculate these figures.

B. Fell presented the results of his calculations of thermal distortion of the mirrors. Essentially these show that under the spontaneous power (1 GeV, 100 mA, 200 nm) the

mirror temperature would be unacceptable without any cooling, even if apertured to 30 mm diameter. Effective cooling with a constrained mirror introduces significant distortions, although no definite specification has yet been made for the required accuracy. The best solution would be therefore to allow free expansion while still providing good thermal contact between the mirror and holder. Achieving sufficient heat transfer by mechanical clamping, without introducing thermal distortion, seems to be impossible and so the proposed solution is to use a UHV compatible liquid medium with good thermal properties, while holding the mirror in place with light spring fingers. The heat transfer between holder and cooled base-plate has been modelled and seems acceptable. Practical measurements of contact resistance are planned in the near future for a different project, which could give some confidence in the assumptions made in the present calculations. The effect of the power loading due to the laser has also been simulated. An absorption of 10 W (1 W) into a FWHM of 1.5 mm would lead to a maximum temperature of about 177 ^{o}C (55 ^{o}C), and maximum slope error of about 500 µrad (50 µrad). This distortion, which cannot be avoided by better cooling, may thus set a practical limit on the laser power.

GD doubted that the absorbed power could reach 1 W since his calculations indicate a maximum extracted power of only 1 W, with optimized 10 % output coupling i.e. 10 W intra-cavity power. Thus, even assuming 2-3% absorption, the absorbed power would be 0.2-0.3 W.

On the topic of the mirror holder, ER reported that a modified holder (model 'C', referring to the minutes of the last Technical Meeting) had been tested at LURE with liquid Gallium interface, but that no improvement had been measured. A new holder is presently being built (model 'D') with reduced space between mirror and holder (0.1 mm) which could be filled with InGa sheet. It was agreed that some practical experiments need to be carried out to learn how best to apply InGa. It was agreed that this will be done at Trieste, using a sapphire substrate from LURE.

NB presented the final mechanical design of the mirror chambers. Cooling of the base-plate has now been included, avoiding any water-vacuum joints. A fixed shield of 35 mm diameter is proposed to shield the edge of the mirror and holding springs from radiation. Ports have been added for looking at the back of the mirrors. Two adjustable survey monuments have also been added. A different type of transfer arm, which is shorter, has been chosen. MM requested that space is left for the installation of some bellows to permit the arm to be 'wobbled' if it proves necessary. In-vacuum limit switches are available, but only in the normally-open configuration whereas for interlock systems normally-closed is usually preferred; a decision will have to be made in the next few weeks on how to proceed. Regarding the vacuum performance, R. Reid requested information on the total number of photons of energy greater than 10 eV going into the chamber in order to check the gas load due to photo-desorption. The vacuum equipment has been specified following as closely as possible the ST preferred items. The positioning of the control and vacuum racks must now be defined, also who supplies the long cables.

5. TASK B: MIRRORS

ER presented details of the Argon laser recently commissioned at LURE. The measured power of the lines at 238, 244, 248, 257 and 264 nm agrees or exceeds the specification. ER also presented the results of the request for quotation for sapphire substrates with 16 m and 19 m radius of curvature, edge thickness 4.0 ± 0.1 mm, diameter 40 ± 0.1mm. It was proposed to purchase 10 of each radius from RSA. After delivery, the radius of curvature and roughness will be measured before sending to Mackowski (INPL, Lyon) for coating for 350 nm operation with SiO_2/Ta_2O_5.

HQ said that there had been some delay in the delivery of the samples from IOF to Dortmund. Samples for 200, 225 and 257 nm are being prepared, with quartz (3) and

sapphire (1) substrates of each type. The 257 nm mirrors will be tested at LURE using the new Argon laser in Jan./Feb. '99. ER confirmed that the system will be ready for then.

6. TASK E: THEORY

GD discussed the discrepancies between his calculation of the power and that of the CEA group. His results indicate a maximum efficiency (χ) of 8.5 10^{-4}, corresponding to a power of 1.3 W. This is confirmed by the work of Elleaume and Krinsky who both give approximate expressions for the maximum efficiency at most a factor of two larger than this. Neglecting any increase in bunch length would at most give a factor of 2.5 more (3.4 W), contrary to the statement in the minutes of the previous Project Meeting.

7. TASK D: ELECTRON-BEAM TESTS

RPW summarised the 8.5 shifts that had been dedicated to electron beam tests in the FEL mode since the beginning of the project. Attempts had been made to measure the bunch length using a fast photodiode in time for the FEL Conference, but without success. Other measurements had included tests of different r.f. cavity operating conditions, and attempts to increase the lifetime by approaching the coupling resonance.
LG presented the first results of measurements with the new streak camera taken during its installation tests on the 18-19th Nov. Preliminary data, averaged over 100 shots, indicated a bunch length of 35 ps at 20 mA in single bunch mode, compared with 30 ps from the measurements of some years ago. RPW said that measurements in the FEL mode will be made after assuring that the streak camera has been fully commissioned. All partners indicated interest in participating in these measurements. RPW agreed to keep everyone informed of progress. The need to measure also the energy spread was stressed again.

8. TASK F: FEL COMMISIONING

A first discussion was held on the diagnostic equipment needed for FEL commissioning. MM reported that M.E. Couprie had strongly recommended purchasing a dissector which could be useful for making a longitudinal stabilisation system as at LURE. After discussion it was agreed that the cost and effort involved did not warrant considering this a priority. It was agreed that a spectrometer with a CCD line would be very useful for alignment and calibration etc. HQ said that the DELTA project had such a device and that this could be made available to Trieste on loan. The need for a set of optical elements and interference filters was mentioned, as well as the usefulness of different colour lasers for alignment. The requirements for laser safety have also to be considered.

9. CONCLUSION

It was agreed that the next meeting should be held in about 3 month's time, and possibly at Trieste in order to coincide with measurement shifts on ELETTRA. Possible dates are the 12th Feb. or 12th March.

SUMMARY OF MAIN DECISIONS:

- confirmed optical cavity parameters: radii R1 = 19 m, R2 = 16 m, Rayleigh length ~ 4m,
- 3.08 mrad front-end acceptance defined by circular fixed mask
- final design of mirror chambers approved

• shield in front of the mirrors with 35 mm diameter
• undulator parameters and modulator magnet design approved

SUMMARY OF MAIN ACTIONS:

• design of new vacuum chambers with increased slot height (ST)
• outline of diagnostic hutches including safety aspects (ST)
• investigate availability and suitability of excimer lasers for mirror measurement (CEA)
• further tests of mirror holders (CEA) and of applying InGa (ST)
• calculate photo-desorption in mirror chambers (CLRC, ST)
• interface requirements for mirror chamber installation at Trieste (CLRC, ST)
• study mirror slope error requirements (ALL)
• arrange measurement shift(s) on ELETTRA (ST)
• investigate setting up web site (ST)

R.P. Walker
Trieste, 11th March, 1999