EC Contract ERBFMGECT980102

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

Minutes of the 1st Project Meeting, held at Sincrotrone Trieste on the 18th-19th May 1998.

Participants -

Sincrotrone Trieste:	B. Diviacco, M. Marsi, R.P. Walker
CEA:	M.E. Couprie, R. Roux
CLRC Daresbury:	N. Bliss, J.A. Clarke, M.W. Poole
Univ. Dortmund:	D. Nölle
ENEA Frascati:	F. Ciocci, G. Dattoli, L. Giannessi
MAX-lab :	M. Eriksson, S. Werin

1. OPENING OF THE MEETING

R.P. Walker welcomed all the participants to the first meeting of the project, which began on the 1st May. He thanked and congratulated everybody for the work done during the writing of the proposal, and for its successful outcome. After having everybody's approval for the draft agenda distributed at the beginning of the meeting, he officially started the meeting.

2. PROJECT MANAGEMENT

R.P. Walker went through the main points of the Contract received from the EEC in particular:
- it was agreed that R.P. Walker would be the designated person to manage and direct the project
- progress reports and cost statements are required every 12 months; reports will be drafted by R.P. Walker and approved by all partners before submission
- 40 % of the contract sum is expected within 2 months; each partner should provide their bank details for the transfer of their part of the money
- all communication to and from the EEC will be through the project Coordinator
- it was stressed that all participants should keep records of the hours devoted to working on the contract (except for fixed staff from partners on an Additional Cost basis), at least on a monthly basis, as well as records of all allowable costs including delivery dates of equipment; all documents must be available for audit by the European Commission

The following people were nominated as being in charge of the work and communications for each partner:

Sincrotrone Trieste - R.P. Walker, deputy M. Marsi
CLRC Daresbury - M.W. Poole
CEA - M.E. Couprie
DELTA - D. Nölle
ENEA, Frascati - G. Dattoli
MAX-lab - M. Eriksson, deputy S. Werin

It was agreed to use mainly electronic mail to exchange information, and to send to the Coordinator a copy of any (relevant!) message between participants.

M.W. Poole strongly suggested to set up a Web page for the project. Everybody agreed that it is a good idea, especially during the FEL commissioning, and that the details should be discussed at a later stage

Recruiting plans:

• M.E. Couprie explained there is a potential candidate for filling the post-doc position at CEA for this contract, and that this person should in July, taking charge for the mirror characterization, and in general for all mirror-related problems, including the interaction with the manufacturers. This should be done under M.E. Couprie's supervision and in tight collaboration with the other groups, especially DELTA, Trieste and CLRC.

• D. Nölle asked for a person to fill his Ph.D. student position. It was agreed that this person should be in charge of the mirror degradation tests to be performed under exposure to synchrotron radiation at the DELTA undulator, and should collaborate with CEA on mirror characterization and with CLRC for problems related to mirror holders and optical cavity design and construction.

• R.P. Walker communicated that Sincrotrone Trieste also plans to hire a person, tentatively for a period of three years, to work on various aspects of the project including system integration.

R.P. Walker explained about the mid-term review of TMR activities and was given the go-ahead for the proposed reply to the request for information about the present project. The project will also be reviewed at a hearing at Lund in October.

The proposed abstract of a paper to be submitted to the FEL '98 Conference was approved. It was agreed that it be put forward for oral presentation.

3. PARAMETER REVIEW

The main technical parameters of the ELETTRA FEL were discussed:

Photon energy range: R.P. Walker explained the basis of the presently proposed parameters - visible light at 1 GeV for initial commissioning; operation above 4 eV possible at 1.2-1.3 GeV; possible future operation above 4 eV at 1.5 GeV. B. Diviacco presented the tentative undulator parameters that meet these requirements based on a 10 cm period length.

M.W. Poole expressed some doubts about the effects of such a high K-value on the beam dynamics and L. Giannessi raised the question of the sensitivity of the emitted higher harmonics to emittance and alignment errors. It was agreed that these topics should be examined, but that there was in effect little scope for making dramatic changes to the parameters.

Optical klystron (OK) The question of the advantage of an optical klystron (OK) configuration was discussed. G. Dattoli pointed out that if the energy spread of the beam is not much in excess of the expected value (0.19 % at 20 mA/bunch), the OK is the best solution, otherwise a normal undulator is better. M.E. Couprie said that her calculations also indicated higher gain for the OK case, even taking into account the reduced total number of undulator periods. The question of gain vs. power optimization was discussed. D. Nölle pointed out that maximizing the gain also allows increased power, because one can extract more light from the cavity. In conclusion, it was agreed that the OK is the best solution because of its flexibility, since an adjustable modulator permits optimization of the gain or of the power, and that this possibility outweighed the loss of a few undulator periods. In addition, it also provides flexibility for possible experiments with harmonic generation and crossed-polarization.

Optical cavity parameters. The original idea of a 21.6 m cavity (corresponding to 6 bunches in the ring) presents the problem of leaving the back mirror inside the ELETTRA radiation wall. It was pointed out that this would be a severe restriction, in particular during FEL commissioning, in view of the limited access to the ring, and therefore it was important to consider avoiding this by adopting a 32.4 or 43.2 m cavity (4 or 3 bunches, respectively). It was agreed that the decision should be taken quickly (tentatively by June 1st), because it affects all the other technical choices; this requires knowing the performance of the ring in 3 and 4 bunch mode (which have never been tried), and checking if the longer cavities are actually compatible with the other beamlines at ELETTRA. The idea of storing more bunches than needed for the FEL was not considered feasible, because it would cause Compton scattering (unless possibly a non-symmetric bunch pattern could be used). The problem of

diffraction losses (see next point) could also be enhanced with a longer cavity and so this also needs to be considered. It was agreed that the longest wavelength that should be considered for efficient lasing is 400 nm.

Radiation slot. A technical point which raised much concern was the 10 mm radiation slot in the bending magnet chamber and the related diffraction losses. M.E. Couprie stressed that the slot can be a problem, not so much for diffraction losses when lasing in ideal conditions, but rather for the initial alignment, because sometimes the FEL "wants to lase" off axis. R.P. Walker asked for precise figures on losses, tolerances, alignment margins. M.E. Couprie and L. Giannessi said they would adapt/develop some codes to simulate the effects of the slot (also, the back slot should be considered in these simulations) and estimate these values. M.E. Couprie said that some tests can be performed at SuperACO by checking the effects of a vertical slit installed in the cavity; L. Giannessi pointed out a side effect of the FEL lasing off axis, namely the presence of higher harmonics on the optical axis (which at that point is not the undulator axis).

4. TASK A: OPTICAL CAVITY

M.W. Poole gave an overview on the problems related to the design and construction of the optical cavity. He asked for an opinion on the mechanical parameters and tolerances adopted for the first draft of the optical cavity vessel(s). In particular, he pointed out how a longer cavity would imply larger mirrors, which would be a problem for the multiple mirror holder (see next point): M.E. Couprie estimated that for a 43.2 m cavity, 35-40 mm diameter mirrors would be necessary. It was pointed out that with a longer cavity there would be less power density on the mirror surface.

N. Bliss presented the first draft of the optical cavity chamber (see Annex). The general consensus was that 3 mirrors in the chamber, with an efficient introduction system, should be sufficient for the operation of the FEL. Ranges, accuracies, tolerances should be checked by everybody. On the question of cooling, it was agreed that mirror cooling looked very difficult, but that a mask would be needed to shield everything except the active area of the mirrors, and that a cooling of the mirror supports would also be studied.

M.E. Couprie confirmed that a good vacuum ($\leq 2 \times 10^{-10}$ Torr) is essential to avoid carbon deposition on the mirrors. She also suggested leaving space for a Brewster plate in the downstream chamber as well as an etalon in the upstream chamber. The requirement to be able to see the back surface of the mirrors for alignment purposes was also mentioned. It was agreed that mirror feedback would only be implemented in a future phase, if required.

It was agreed that there was no advantage to testing the optical cavity at DELTA as originally foreseen, and that instead the DELTA activity would be centred around mirror degradation tests (see below). R.P. Walker said that the optical cavity should therefore be delivered to Trieste, ready for installation, by the end of July '99.

5. TASK B: MIRRORS

M.E. Couprie gave an overview of the various possible candidates for making the mirrors for the ELETTRA project. The main problem for achieving short wavelengths is the fact that, with respect to conventional lasers in comparable wavelength domains, the FEL mirrors will be exposed to a hostile environment (synchrotron radiation from the insertion device), which can cause degradation of optical elements prepared with traditional methods. For the same reason, also the sapphire substrates are likely to be present problems (which have already been noticed at SuperACO), so the option of using other substrates than sapphire should be considered for ELETTRA: their choice will be related to the thermal load from the undulator. This has to be looked into soon, because it can take several months to actually get new substrates. Everybody agreed that mirrors are a very critical component of the project. CEA will coordinate the effort in this direction, but a strong involvement of DELTA and ELETTRA is necessary. This strategy has been proposed:

• M.E. Couprie and the CEA post-doc will handle the interaction with the manufacturers, and are in charge of characterizing the mirrors (reflectivity, optical profile), using their instrumentation at SuperACO. A new laser, that will be bought on their budget, will allow

them to do this at least down to 238 nm, and various possibilities of finding other lasers and test equipment available for shorter wavelengths (possibly close to SuperACO) should be explored as soon as possible.
• Tests of mirror degradation due to exposure to synchrotron radiation should be performed instead at DELTA, which should make sure they can guarantee enough beamtime for this purpose. The Dortmund student should be in charge of preparing a system to permit an easy testing of the mirrors, and it was recommended (M.E. Couprie) that it should collaborate intensively with the CEA group also during the other steps of their characterization.
• The efforts should be made in parallel for various wavelengths, which should correspond to the progress of lasing at ELETTRA: 350 nm (to benefit of the experience developed at SuperACO), 300 nm (possibly), 250 nm (which is also the next target for DELTA) and 193 nm (which is the main goal).

6. TASK D: ELECTRON BEAM TESTS

R.P. Walker showed experimental data for bunch length vs. current at ELETTRA, measured in single bunch mode using both a streak camera (single shot) and also with a fast photodiode, on which the initial FEL performance calculations have been based (i.e. 25 ps at 10 mA/bunch, 30 ps at 20 mA/bunch). Tests in 6 bunch mode showed that above 10 mA/bunch the beam becomes unstable, but these tests were performed with a non-optimized beam, and that tests with other bunch configurations has shown that stable conditions could be achieved with an appropriate tuning of the r.f. cavity temperatures. He added that further bunch length measurements will be made with a new dual-sweep streak camera after its commissioning in October.

G. Dattoli and others recommended that experimental values for the energy spread also be determined and various ideas were proposed to do such a measurement. M.W. Poole said that measurements should also be made for energies in the range 1-1.5 GeV. M.E. Couprie pointed out that an effort should also be made to modify the beam in order to get 100% coupling. In view of the possibility of lengthening the optical cavity, tests with 3 and 4 bunches should also be made as soon as possible. R.P. Walker agreed to try to schedule in advance FEL related measurements at ELETTRA, to make it possible for other groups to participate.

7. TASK E: THEORY

R.P. Walker pointed out the most important and immediate contributions needed from theory:
- the slot problem (see above), should be clarified and quantified as soon as possible, taking into account the various possible cavity lengths (ENEA, CEA).
- optimization of optical cavity parameters for different cavity lengths
- problem of the higher harmonic power related to the undulator K value (ENEA and B. Diviacco).
- optimization of the optical klystron parameters for maximum gain and power, at 350 and 200 nm, to determine the required modulator characteristics (ENEA).

8. CONCLUSION

Several participants will be at EPAC ‘98, which will be a good occasion to discuss about the ELETTRA FEL, and exchange information. The next meeting was scheduled for July 22, 1998, at LURE.

R.P. Walker thanked everybody for their contribution to this first meeting, which served well its purpose of starting the project and evidencing the problems. The next meeting at LURE should mark the “end of the design phase”: *all of the main technical choices should be clear at that point.*.

M. Marsi, R.P. Walker
Trieste, 17th June, 1998