PAUL SCHERRER INSTITUT	Projekt/*Project* SwissFEL
Titel/*Title* **Laser heater kickoff meeting** **Minutes of the meeting**	Dokument Nummer/*Document Identification* **FEL-PM16-063-03**
Autor/Author Marco Pedrozzi Mitautor(en) *Co-Author(s)*	Externe Referenz/*External reference*

Zusammmenfassung/*Summary*

- April 26, 2013 PSI and external contributors to the Laser Heater (LH) system meet at PSI for a kickoff meeting.
- The required functionalities and general layout of the LH were presented and discussed.
- The meeting program and related documents can be downloaded from the indico page:

  http://indico.psi.ch/conferenceDisplay.py?confId=2407
- The LH project documentation is available in Alresco:

  Projects> SwissFEL> Facility> TP Injector> SwissFEL 6 GeV> **2-Laser heater**
- Requirement specifications: FEL-PM16-031-05 (maintained in Alfresco)
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H. Braun	PL SwissFEL Accelerator	

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Revision	**Datum** *Date*	**Autor** *Author*	**Änderung** *Modification*
3	13.05.2013	H. Braun, P. Ming, M. Pedrozzi	Minor corrections, added new points for concept/review meeting (§3)
2	08.04.2013	C. Vicario, M Pedrozzi	Minor corrections
1	30.04.2013	M. Pedrozzi	Created

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1 Introduction

1.1 Goal of the meeting

The Laser Heater system seen as global system is complex. An optimal interfacing between components and the respective groups responsible for the design is essential to fulfill the SwissFEL requirements.

The following aspects were discussed:

- Project boundaries and management aspects
- Update all the contributors about specifications, functionality requirements and layout.
- Verify and agree on the requirements: what is essential, what is nice to have, did we forget something?
- Update about the status of the project: schedule, existing designs and concepts, pending items, who is doing what – introduction of the external contributors
- Identify and distribute tasks, if not yet done.
- Verify resource requirements
- Define the next step ⇒ concept evaluation review
    - Focusing on system and interfacing where existing hardware/procedure can't be applied: overlap monitors, vacuum chamber + laser coupling, movable parts, U50, …

1.2 AGENDA of the meeting

08:30 Welcome and General Introduction - presentation 30 min (M. Pedrozzi)
- Parameter summary (beam and laser)
- Layout Building situation and environment parameters
- Layout machine lattice at the LH (overview of all components + 2D model)
- Integration of Laser transfer in the building.
- Illustration of possible girder concept
- Interfacing aspects (task distribution overview)
- scheduling and commissioning aspects

09:00 LH specifications & beam dynamics - presentation (S. Reiche)
- Beam heating requirements
- Operation range (max-min charge, max-min energy)
- Undulator requirements
- Optics and chicane specifications (dipoles, axis separation, R56)

09:30 "Standard" Electron diagnostics - presentation (R. Ischebeck)
- Screen monitors specifications & options (interfacing with photon diagnostics)
- BPM (alignment survey along the undulator and feed back)
- BAM (synchronization survey and feed back)

10:00 coffee break

10:30 Undulator design - presentation + discussion
- Presentation of design status - presentation (Neil Thompson, Barry Fell)
- Discussion/verification interfacing with beam (magnetic design)
- Discussion interfacing with mechanics (positioning, supports and alignment)
- Discussion interfacing with controls (motors and encoders)

12:00 Lunch break (business lunch)

13:30 Laser system and transfer line - presentation (C. Vicario)
- Presentation laser system and transfer line specifications/concept
- Presentation laser optics and diagnostics & concept for the coupling (geometry & chamber constraints)

14:00 Laser diagnostic requirements

(this part requires a close collaboration between laser and electron diagnostics).

Suggestion:
- one presentation from PSI (C. Vicario here above)
- one presentation from UU, concepts and design based on previous experience
- discussion:

To be covered here:
- *Standard laser diagnostics*
  - Energy
  - Alignment/pointing survey (virtual waist image)
  - Virtual waist
- *Overlap diagnostics*
  - Transverse overlap: Day 1 adjustment (screens) followed by monitoring and feed back (pointing survey with 4 quadrant diodes or camera?)
  - Longitudinal: Day 1 overlap rough and fine adjustment followed by monitoring and feedback (options: BAM+LAM, EOM for survey?)).
- Support system laser optics and diagnostics (optical tables, protection box, ...)
- Discussion about task distribution & Role of Uppsala University.

16:00 Vacuum system - presentation (L. Schulz)
- Vacuum standards.
- Chamber basic concept (motorization requirements, laser coupling, chamber size,...)

16:30 Summary of:
- Decisions - Task distribution - Open points
- Next steps => define date and deliverable for the concept evaluation review focusing on system and interfacing where existing hardware/procedure can't be applied: overlap monitors, vacuum chamber + laser coupling, movable parts, U50, …

1.3 Participants

Neil Thompson	Undulator magnetic design & coordination	STFC
Barry Fell	Mechanical engineering	STFC
Volker Ziemann	Laser system, collaboration coordination	Uppsala University
Mathias Hamberg	Laser system and diagnostics	Uppsala University
Hans Braun	Head SwissFEL accelerator	PSI
Marco Pedrozzi	SwissFEL injector, PSI LH coordination,	PSI
Thomas Schmidt	Head Insertion devices	PSI
Marco Calvi	Insertion devices	PSI
Rasmus Ischebeck	Electron diagnostics coordination	PSI
Gian Luca Orlandi	Electron diagnostics (syncr. Radiation)	PSI
Pavle Juranic	Photon diagnostics	PSI
Carlo Vicario	Laser systems (Transfer line & gun)	PSI
Marta Divall	Laser systems (Stability and jitter)	PSI
Alexandre Trisorio	Laser systems (Gun)	PSI
Schulz Lothar	Head vacuum section	PSI
Elke Zimoch	Control system coordination	PSI
Edwin Divall	Control systems injector coordination	PSI
Haimo Jöhri	Mechanical engineering coordination	PSI
Karsten Dreyer	Head alignment group	PSI

2 Minutes of the meeting

2.1 Introduction

Introductory presentation of M. Pedrozzi

Management aspects

The LH heater system sits in the injector section of the accelerator. For this reason, the SwissFEL Injector sub-project leader (M. Pedrozzi) is presently the coordinator of the LH project.

The “requirement specifications” (FEL-PM16-031-05) summarize the basic specification and functionalities of the Laser Heater system as well as the boundary of this project. The Injector sub-project leader is responsible for writing and maintaining this document.

The coordinator distributes the required tasks to the Fachgruppen via a specific mandate form. Bilateral MOU agreements specify the tasks distributed to the external contributors. The project coordinator organizes the review procedures for checking the interfaces between systems and groups.

Documentation

Alfresco hosts the document relevant for the project. The coordinator and P. Ming are the administrators of the LH repository. The link to the documentation is:

http://ecm.psi.ch/alfresco/webdav/Projects/SwissFEL/Facility/TP%20Injector/SwissFEL%206%20GeV/2-Laser%20heater

Contributors can become write permissions on request.

To keep an overview on the mail exchange, meeting organization and history of the project, a team-mailbox for the LH project has been activated. The project coordinator and P. Ming administrate the account and deliver the read/write permissions. The team-mailbox contains three folders:

- eMail_IN: from extern contributors or suppliers to PSI
- eMail_OUT: from PSI to extern contributors or suppliers and a task list.
- eMail_Intern: for mail exchange within PSI employees.

and a task list.

The instruction how configure outlook are available in Alfresco: link

M. Pedrozzi will clarify if the extern contributors are eligible for a PSI mail account.

Scheduling

The assembly plan of SwissFEL defines the main boundary conditions concerning the scheduling of the Laser Heater project. The present plan concept, presented at the meeting, will be extensively discussed during a dedicated retreat beginning of June 2013.

All the parts of the laser heater being new component, not in operation at the Injector test facility, an early pre-assembly and test of the movable parts (undulator & chamber) in 2014 is possible. Required are test of the movable parts (undulator gap + translation and vacuum chamber) before assembly in the SwissFEL tunnel. A specification of the tests must be presented at the next concept/review meeting.

Layout

The basic layout of the LH system has been presented according to the description summarized in the requirement specifications version 5. M. Pedrozzi will distribute the update lattice presently finalized by the beam dynamic group, within a new version of the specification requirements.

Collaboration with Uppsala University

The contribution of U.U. depends on the acceptance of the proposal for founding submitted to the Swedish research council. The proposals will be discussed during the summer and the final decision should be in October-November 2012. U.U. experienced so far difficulties in collecting information about the status of the proposal. With this perspective the collaboration with U.U. becomes critical. To understand the status of the founding procedure and perspectives PSI will contact directly the representative at the research following this proposal[1].

2.2 LH concept and sub-systems

Presentations and discussion on LH sub-systems

Beam dynamic (slides S. Reiche)

The slides remind the requirements for the laser heater base on the actual lattice of the machine and BD optimization. The SwissFEL requirements are comparable to the LCLS LH system [1].

To be noted the relative insensitivity of the FEL performances to the energy of the laser at the laser heater. The experimental verification at LCLS shows that the FEL performances are insensitive to laser energy fluctuations of ±1.5 uJ for a central energy of 3 uJ [1], i.e ±50%.

For SwissFEL simulations shows that increasing the uncorrelated energy spread above 7 keV the starts affecting the FEL performances.

With the present design of the undulator modulator laser wave length in the range 820-1040nm are feasible.

Since LH and the photocathode will share the same laser source, the final decision about the laser wave length is still in the optimization phase. A decision is expected by mid May[2].

SwissFEL Electron diagnostics (slides R. Ischebeck)

R. Ischebeck summarized the standard electron diagnostics foreseen for the LH section.

The transverse monitors installed on both sides of the undulator are one ingredient for the setting of the transverse electron-laser overlap. For those monitors it is foreseen to use the new standard SwissFEL screen holder and chamber [2]. Briefly discussed the scintillating screen options for electron and Infrared visualization, in particular for 1040 nm where standard scintillators are less efficient.

M. Hamberg (U.U.) suggested verifying the Chromox option (Chromium doped alumina) – he will provide specifications of screens used for IR detection[3]. U.U. can provide few screen to PSI for test purposes.

Camera so far used at PSI are

BASLER Gigabit (overview, 10 Hz)

PCO edge (measurement, 100Hz)

Undulator modulator (slides N. Thompson & B. Fell: STFC)

N. Thompson summarized the magnetic design of the undulator modulator while B. Fell presented the engineered design of the system.

STFC take over the magnetic measurements during the assembly phase. N. Thompson will send to PSI a description of the measurement setup at Daresbury[4].

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[1] Action, H. Braun

[2] Action PSI

[3] Action M. Hamberg (U.U.)

Within the undulator the electron have a slight tilted orbit on the horizontal plane of approximately 50 μrad. V. Ziemann (U.U.) addressed the question about emittance dilutions due to a tilted modulation. This question will be answered by S. Reiche in the following days[5].

The minimum undulator gap and limit switches can be adjusted to the vacuum chamber size which for SwissFEL is: 16 mm inner diameter and 18 mm outer diameter.

The residual field on the beam axis for the "extracted" undulator (90 mm from beam axis) is smaller than the earth field.

M. Pedrozzi addressed the question about reproducibility of the vertical position of the magnet array after moving the undulator transversally from the park position to the operating position. This parameter must be measured. No encoder is foreseen so far. Suggestion expected from STFC[6].

The 5 phase motors proposed by STFC are not acceptable for PSI. E. Zimoch will provide an alternative based on the PSI motor recommendations[7].

In case of a failure of the electrical power, the position of the gap must be preserved according to the tolerance specifications. For this purpose a lead screw has been suggested[8].

A mechanism for fixing the magnet bridges in case of maintenance or transport must be added[9].

The deformation of the mounting frame requires a calibration of the axis position to be performed via magnetic measurements[10]. The option of minimizing the deformation of the frame by inserting a stiffening top plate is retained (reduction by ~ a factor of two).

The proposed encoders are acceptable. Precision end switch are foreseen for the absolute calibration of the position.

It has been suggested to control the motor systems via a Beckhoff system similarly to the U15 undulators. The Insertion Device group evaluates the option of taking over the responsibility for this task[11].

H. Jöhri underlined that for a short undulator it is not necessary to manufacture the magnet keepers in one single piece. This was a necessity for the 4 m long undulators but the concept could be modified for the U50. STFC will explore the advantages of this approach.

V. Ziemann (U.U.) suggest increasing the number of fiducials. He will submit a proposal base on the experience cumulated so far with similar installations[12].

For the fabrication of the Undulator Psi and STFC must agree on the practical procedure for ordering an billing. M. Pedrozzi will discuss with P. Fischer, responsible for the purchasing of SwissFEL and feed-back to STFC[13].

SwissFEL Laser systems (slides C. Vicario)

Two presentations by C. Vicario:

- Laser systems, source parameters and transfer line
- Requirements and concepts for the LH laser system and diagnostics

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[4] Action, N. Thompson

[5] Action, M. Pedrozzi

[6] Action, B. Fell (STFC)

[7] Action, E. Zimoch

[8] Action, B. fell (STFC)

[9] Action, B. Fell (STFC)

[10] Action, B. Fell (STFC)

[11] Action, T. Schmidt

[12] Action, V. Ziemann (U.U.)

[13] Action. M. Pedrozzi

At the moment it is not foreseen to motorize the in-vacuum laser mirrors of the Transfer Line (TL). The first alignment will be done with open vacuum chamber. It is foreseen to use CF components for UHV allowing the use of ion pumps (vibration reduction)

V. Ziemann suggested using photo diodes behind the TL mirrors to verify when hit by the laser.

Suggested after the TL a 2-3 lens telescope to adjust the waist at the undulator. The waist can be characterized by a camera mounted on a translation stage similar to the EU-XFEL.

The optics will be of two inches or more.

The operation of the laser heater with the Jaguar laser (1060 nm) is not an option for SwissFEL.

V. Ziemann asked if the laser waist was matched to the electron beam size to avoid a two spike transverse distribution of the electron after the undulator (see for example [1]). The question together with the definition of waist used for the simulations will be addressed by M. Pedrozzi to S. Reiche[14].

De-phasing in case of strong focusing could in extreme case affect the resonant condition along the undulator. This shouldn't be a problem with the relaxed laser and electron beam focusing foreseen at the SwissFEL LH.

For the pointing survey it has been suggested to use a four quadrant diodes. This diagnostic will be used as photon orbit survey and feedback to maintain the transverse overlap of electron and laser. The Electron BPM delivers the corresponding information for the electron trajectory. A pointing stability of few μm seems feasible but requires more detailed simulations)

The most critical aspect is the longitudinal overlap of electron (3 to 10 ps FW) and laser pulse (50ps FWHM), and in particular the day one diagnostics to identify the overlap conditions. A relatively simple detection using a fast oscilloscope and photo-sensors can be used for a rough adjustment in the range of 100 ps. To be evaluated the option of using the undulator spontaneous emission as signal for the rough overlap[15].

For the fine overlap few options requiring a deeper investigation have been mentioned:

- Measurement of the uncorrelated energy spread at the injector-Linac1 energy spectrometer (required a resolution of the order of 10 keV or below)
- Electro optical spectral decoding using as sampling laser the LH laser (could provide a signal for the survey)
- Measurement of the coherent radiation at the third dipole of the LH chicane before smearing out the transient longitudinal bunching at the laser wavelength of the electron bunch.

The necessity of monitoring longitudinal drifts must be clarified. Within "reasonable" environmental condition the longitudinal laser drift should be a minor effect. It has been decided to contact LCLS and FERMI to check requirements and operational experience for the longitudinal overlap at these two facilities[16].

Laser systems experience at Uppsala University (slides V. Ziemann and M. Hamberg)

Two presentations:

- Transverse and longitudinal overlap in the Optical replica synthesizer
- X-FEL laser Heater system

U.U. is responsible for the complete Laser heater system of the EU- XFEL starting from the transfer line and including laser diagnostics and optics, undulator and vacuum chamber.

The vacuum chamber elements supporting the transfer line mirror allow accessing the mirror in situ via a large flange. B. Fell suggested an ameliorating the mirror support to avoid modification of the optic orientation due to atmosphere pressure (when pumping). The mirror support should be fixed on the support plate of the vacuum chamber instead on one flange as proposed so far.

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[14] Action, M. Pedrozzi

[15] Action, M. Pedrozzi

[16] Action, C. Vicario, A. Trisorio

The LH is designed for beam energy between 120 and 160 MeV. The chamber is fixed and the dipoles are always ON.

A three lens telescope with independently motorized screen allows the adjustment and monitoring of the laser waist.

Two laser attenuators control respectively the laser energy on the main laser path trough the undulator and in the diagnostic line.

Vacuum systems

Lothar Schulz briefly introduced the basic concept of the vacuum chamber and the typical vacuum components used at PSI.

3 Conclusions

The lattice layout of the laser heater system is quite advanced; the last official release is expected within a few weeks. The electron diagnostics are defined, but the interfacing with photon diagnostic still require to be clarified. STFC presented a full engineered undulator requiring only minor modification before starting the production.

The laser diagnostic system and in particular the longitudinal overlap diagnostics are the most critical aspects of the project. The uncertain founding of U.U. for an in Kind contribution generate the following strategy

1. PSI collects information directly from the Swedish research council
2. PSI starts the design of the girder and support systems – eventually to be handled as sub-contractor with founded proposal (option to be verified by U.U.[17]).
3. PSI starts the design of the vacuum chamber and mover system - eventually to be handled as sub-contractor with founded proposal.
4. PSI prepares a first proposal for the LH laser system and diagnostic to be iterated with U.U. in order to converge rapidly to a concept and focalize on solutions[18]. The components and systems requiring development efforts and/or long delivery time must be identified.

The next step will be a concept/design review to be held in beginning of October at PSI[19]. The main purposes of the meeting are:

- Update contributors with last developments of the project
- Presentation of the design concept of:
  - Laser optics (simulated performances) and diagnostics (expected resolutions)
  - Laser-electrons overlap monitors (transverse and longitudinal)
  - Laser coupling design
  - Support system and girder system (included optical tables)
  - Vacuum chamber design and mover system
  - Concept on LH Controls?
  - Identification of long lead items > 8 weeks
  - Identify mandatory simulations for the review
- Status undulator
  - Design modifications
  - Production progress
  - Draft of FAT / SAT specifications
- Preassembly strategy
  - Pre-assembly procedure and timing
  - Test specification for the movable parts after pre-assembly

[17] Action, V. Ziemann (U.U.)

[18] Action, C. Vicario, R. Ischebeck & M. Pedrozzi

[19] Action, M. Pedrozzi

4 Summary action list

Action #	Description	In charge
1	Get in touch with the contact person at the research council for the U.U proposal	H. Braun
2	Define laser wavelength	PSI (Pedrozzii)
3	Send to PSI the specification of the scintillating screen compatible with IR and electron detection and few sample screens for test purposes.	M. Hamberg (U.U.)
4	Provide to Psi a description of the infrastructure for magnetic measurements at Daresbury	N. Thompson (STFC)
5	Effect of tilted orbit within the undulator on electron emittance	M. Pedrozzi
6	Reproducibility of the vertical position of the magnet array after moving the undulator transversally. Proposal for calibration and/or monitoring.	B. Fell (STFC)
7	Provide to STFC alternative motors	E. Zimoch
8	Solution preserving the position of the undulator gap in case of failure of the electrical power	B. Fell (STFC)
9	Add system for fixing the magnet bridges	B. Fell (STFC)
10	Calibration/measure procedure for the position of the undulator axis with deformed support frame	B. Fell, N. Thompson (STFC)
11	Verify the option of taking over the controls of the undulator and vacuum chamber movers via a Beckhoff system	T. Schmidt
12	Provide suggestions for additional fiducials on the undulator modulator	V. Ziemann (U.U.)
13	Clarify procedure for ordering and billing with P. Fischer and STFC	M. Pedrozzi
14	Clarify the definition of the laser Waist used for the simulations and reported in the specification requirements	M. Pedrozzi
15	Evaluate expected power spontaneous emission of U50 as signal for rough longitudinal overlap	M. Pedrozzi
16	Collect information about the longitudinal overlap diagnostics at FERMI and SLAC (visit to Fermi?) and in particular the experimental longitudinal drifts. Necessity of a EOS monitor?	C. Vicario
17	Verify option of using PSI as sub-contractor for specific mandate: support systems, vacuum chamber and laser coupling	V. Ziemann
18	First proposal of laser system and diagnostics	C. Vicario, R. Ischebeck and M. Pedrozzi
19	Organize a concept review meeting beginning of October 2013	M. Pedrozzi

[1] Z. Huang et al, SLAC-PUB-13854

[2] R. Ischebeck and al, proceeding IBIC12