PAUL SCHERRER INSTITUT

Photonics Spring Workshop

SwissFEL ATHOS and SLS-2

10 – 12 April 2017

Information for workshop participants

1. Motivation

The Paul Scherrer Institute (PSI) is planning two large projects in the field of photonics (Fig. 1) – the soft x-ray branch of the SwissFEL, called ATHOS (240-1930 eV; Fig. 2), and an upgrade of the Swiss Light Source to a diffraction-limited storage ring (SLS-2), promising a fortyfold improvement in the horizontal emittance (Fig. 5a). ATHOS is expected to come online in 2020, while first light for SLS-2 is forecast to be in 2023.

The input of potential users of both of these two complementary facilities with regards to future scientific directions and associated instrumentation is essential in making them a success. Accordingly, the PSI announces a combined "Photonics Spring Workshop" to address these aspects, on 10th – 12th April 2017.

All present and future users of either facility are strongly encouraged to attend.

Fig. 1: Image with SwissFEL and SLS locations at PSI.

2. Goals of the Workshop

The primary aim of the workshop is to highlight the science that will be enabled with ATHOS and SLS-2, including any complementarity. We want to assess the interests of the potential ATHOS and SLS-2 users, and to identify their requirements for the x-ray beamlines and experimental infrastructure. The workshop's discussion will be on the specific needs of the experimental groups and on the necessary pieces of equipment. The focus will be on the identification of grand challenges in condensed-matter research, magnetism, chemistry, chemical spectroscopy, imaging, and macromolecular crystallography. Each of these research areas will be the focus of a breakout session during the workshop.

3. ATHOS

The ATHOS soft X-ray beamline at SwissFEL (Fig. 2) will complement the existing hard x-ray beamline ARAMIS, which goes into operation in 2017. The building and accelerator construction makes provision for the ATHOS machine, the soft x-ray beamlines and the ATHOS experimental stations. The last of these will be flexibly located in a single large hall. The installation of the first ATHOS accelerator components has already begun.

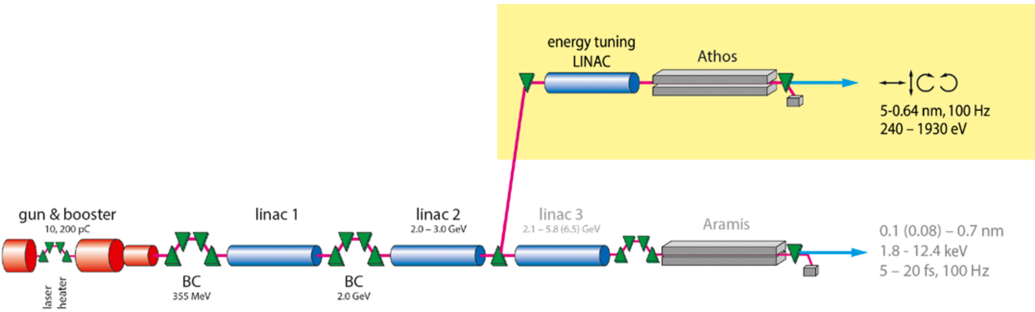

Fig. 2: A schematic overview of the SwissFEL facility, showing the ARAMIS hard x-ray branch, scheduled for operation in 2017, and the ATHOS soft x-ray branch.

The ATHOS beamline will extend the capabilities of the SwissFEL x-ray free electron laser to include time-resolved, soft x-ray spectroscopy, providing a powerful tool for the study of the dynamics of valence electrons in matter (see Fig. 3).

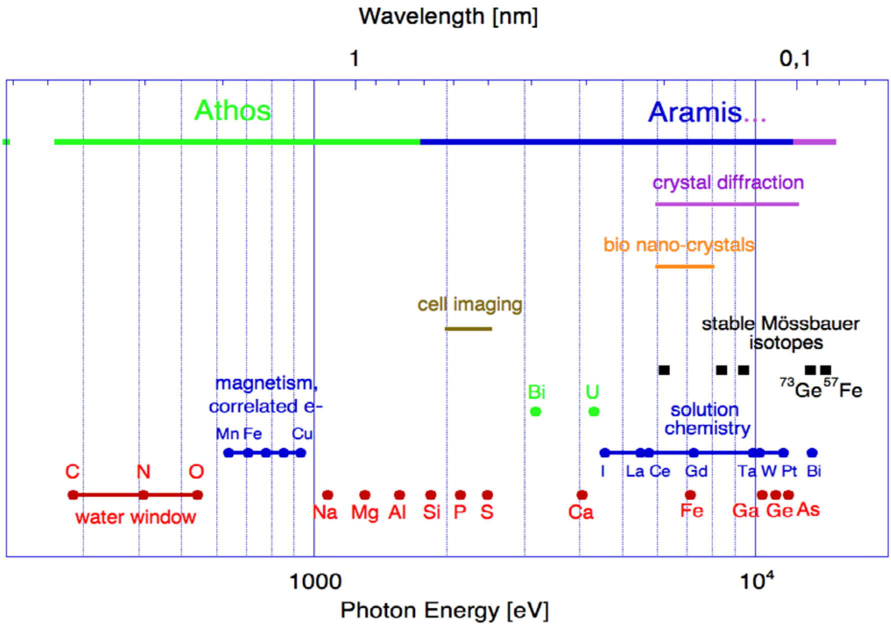

Fig. 3: The spectrum of photon energies and wavelengths provided by SwissFEL, in the hard x-ray regime by ARAMIS and in the soft x-ray regime by ATHOS. In the "water window", there is a high contrast between absorbing imaging biological material and water, which remains transparent. Magnetism and correlated electron phenomena are particularly accessible with soft x-ray spectroscopy at the L-edges of the 3d transition-metal ions (600 – 1000 eV). ATHOS will also cover the resonances of many adsorbates and substrates in important catalytic systems.

ATHOS has a strong scientific case, which can be downloaded at https://www.psi.ch/swissfel/ the topics in the scientific case include: ultrafast magnetization dynamics, catalysis & biochemistry, time-resolved spectroscopy of correlated electron materials, and non-linear x-ray techniques. During the workshop the beamline parameters (see Fig. 4) and the main features of the endstations required for the experiments at ATHOS should be established. The ATHOS x-ray beam parameters are depicted in Table 1.

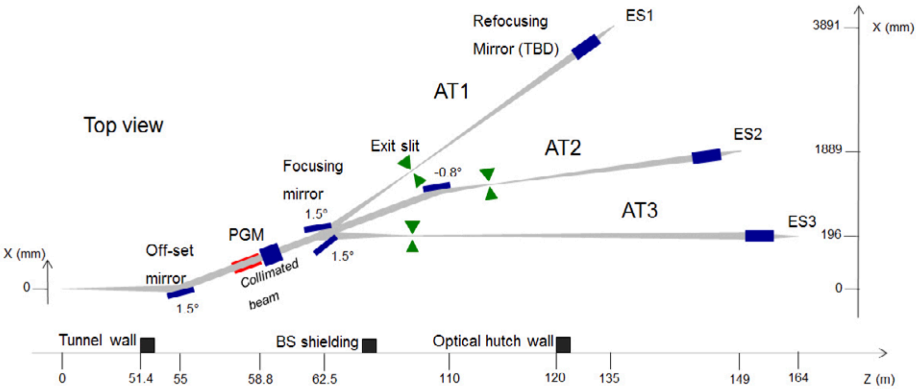

Fig. 4: Schematic layout of ATHOS beamlines.

Mode	Pulse Energy	#Photons @ 1 nm	Pulse Length (RMS)	Bandwidth	Comment
SASE (200pC)	>1mJ	$5 \cdot 10^{12}$	30 fs	0.1-0.4%	
Optical Klystron	As SASE	$5 \cdot 10^{12}$	As SASE	Broader than SASE	More length for taper
Harmonic Lasing	As SASE	$5 \cdot 10^{12}$	As SASE	Narrower than SASE	More length for taper
TW Pulse	> 1mJ	$5 \cdot 10^{12}$	~1 fs	1% FWHM	200 pC bunch
Two Colors	2 x >50 µJ	$2 \times 2.5 \cdot 10^{11}$	2 x 2-10 fs	0.2%, tuning range: factor 5	Based on 200 pC bunch
HB-SASE	As SASE	$5 \cdot 10^{12}$	As SASE	0.02-0.04%	
Large Bandwidth	>0.5 mJ	$2.5 \cdot 10^{12}$	30 fs	>10% FW	200 pC only
Self-Seeding	>1mJ	$5 \cdot 10^{12}$	30 fs	< 1e-4	Above 1nm, 200 pC only
HHG-Seed	1 µJ (every 3 fs)	$5 \cdot 10^{9}$	< fs per pulse	0.1-0.4 %	Sub-fs locking
Slicing	1 µJ (every 3 fs)	$5 \cdot 10^{9}$	< fs per pulse	0.1-0.4 %	Sub-fs locking
Mode Locking	Less than SASE	10^{11}	As SASE	2% FWHM	Locked to laser

Table 1: ATHOS x-ray beam parameters corresponding to the different operation modes available with the “CHIC” scheme. The modes depicted in blue are possible extended modes and not part of the base line design.

4. SLS-2

Synchrotrons are entering their fourth generation, defined by a much improved horizontal emittance. The first of these so-called diffraction-limited storage rings (DLSRs), MAX-IV, produced first light in the Summer of 2016. A second green-field facility, SIRIUS (Brazil), is expected to come online in 2019. In addition, several third-generation facilities are planning or already undergoing upgrades to DLSR-status (see Fig. 5). The SLS, long a benchmark regarding performance in the world of synchrotrons, also needs to upgrade in order to remain at the forefront of x-ray science. This would also provide an opportunity to implement other timely innovations not directly associated with the promised lower emittance.

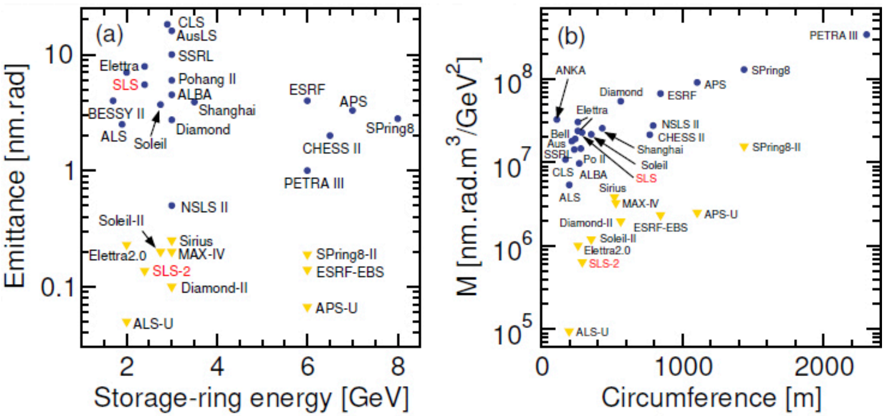

Fig. 5: (a) Overview of the horizontal emittance at third-generation (blue circles) and DLSR (yellow triangles) synchrotron facilities. (b) Figure of merit M of the same facilities as a function of storage-ring radius.

The three central scientific thrusts of the PSI are human health, energy and the environment, and matter and materials. It is expected that SLS-2 will have an enormous impact on all these themes. The case for SLS-2 is summarized in the flow diagram in Figure 6.

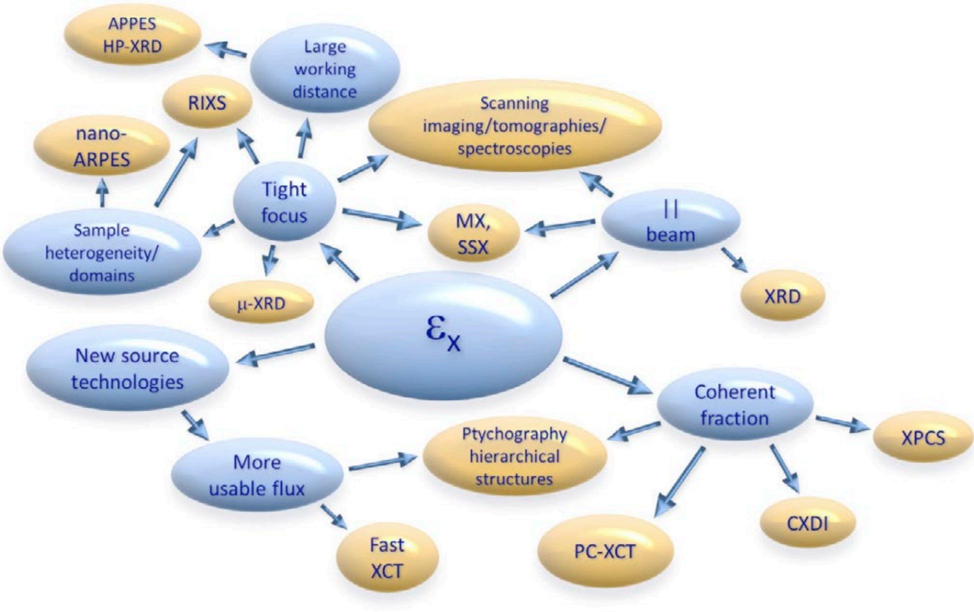

Fig. 6: Flow diagram showing the impact of DLSR technology on enabling new scientific opportunities at SLS-2.

5. Expected input from the workshop participants

Besides a general description of the envisaged science to be performed at ATHOS and SLS-2, we strongly encourage the workshop participants to provide us with input regarding the desired performance parameters of ATHOS and the impact of the improved emittance at SLS-2.

In addition to keynote lectures from internationally renowned researchers and presentations from PSI staff, there will be seven breakout sessions in which lively discussions and input from all participants are encouraged. Your input should be based on preferably one, or maximum two slides that will assist us in answering the following questions of fundamental importance:

ATHOS @ SwissFEL:

a. Which advantages do you expect for your experiments from the novel unique "CHIC" operation mode of ATHOS?
b. What experiments do you want to do with ATHOS?
c. What are the beamline and experimental station requirements for these experiments?
d. Do you have a pre-existing instrument you would like to use at ATHOS and what would you need to operate it at ATHOS?
e. What requirements do your experiments have, e.g. in terms of pump lasers, sample environment or detector capabilities?

SLS-2:

a. How can the improved emittance be best exploited for your experiment?
b. Is the increased coherent fraction of the x-rays beneficial to your experiment?
c. What new and/or improved instrumental infrastructure (including, among others, optics, sample manipulators, and detectors) would help you to perform your experiment?
d. Will the approximate threefold increase in the pulse length of x-rays from 60 ps to 200 ps adversely impact your experiment?
e. What other novel developments not directly associated with the machine upgrade could be implemented in parallel?

6. Organization of the workshop

The workshop will be held at the University of Applied Sciences and Arts Northwestern Switzerland FHNW in Brugg-Windisch. The workshop spans three days and is based on keynote talks from international experts on the seven breakout-session topics. Furthermore, there will be ATHOS and SLS-2 specific talks by PSI scientists.

The parallel breakout sessions, where the input of "you" as workshop participant is needed, will be summarized in wrap-up sessions for all workshop participants. Afterwards the results of the breakout sessions will be documented in a workshop booklet that will be distributed among the participants after the workshop and will also be available on the workshop website. Your one-to-two slide contribution(s) to the breakout session(s) should be submitted to the breakout-session chairs (see list below) before 03/04/2017.

Breakouts session leaders:

1. Simon Gerber – Condensed matter @ ATHOS
   (simon.gerber@psi.ch)

2. Chris Milne – Ultrafast chemistry and biology @ ATHOS
   (chris.milne@psi.ch)

3. Nick Plumb – Correlated electron systems
   (nicholas.plumb@psi.ch)

4. Ana Diaz – Imaging
   (ana.diaz@psi.ch)

5. Vincent Olieric – Macromolecular crystallography
   (vincent.olieric@psi.ch)

6. Olga Safonova – Chemical spectroscopy
   (olga.safonova@psi.ch)

7. Armin Kleibert – Magnetism
   (armin.kleibert@psi.ch)

University of Applied Sciences and Arts Northwestern Switzerland FHNW
Campus Brugg-Windisch
Bahnhofstrasse 6
5210 Windisch
Switzerland

The meeting rooms will be signposted.

Plenary room: 5.0H06
Parallel sessions: 5.0H02 and 5.0B15/16

Registration at: http://indico.psi.ch/internalPage.py?pageId=0&confId=5401

Contact:

Anja Minikus, anja.minikus@psi.ch
Martina Füglister, martina.fueglister@psi.ch

Local Organizing Committee (LOC):

Luc Patthey, Paul Scherrer Institut (Workshop Chair)
Phill Willmott, Paul Scherrer Institut (Workshop Chair)
Mirjam van Daalen, Paul Scherrer Institut (LOC Chair)
Anja Minikus, Paul Scherrer Institut
Martina Füglister, Paul Scherrer Institut
Simon Gerber, Paul Scherrer Institut
Chris Milne, Paul Scherrer Institut
Nick Plumb, Paul Scherrer Institut
Ana Diaz, Paul Scherrer Institut
Vincent Olieric, Paul Scherrer Institut
Olga Safonova, Paul Scherrer Institut
Armin Kleibert, Paul Scherrer Institut

Paul Scherrer Institut :: 5232 Villigen PSI :: Switzerland
Tel. +41 56 310 21 00 :: www.psi.ch