SURVEY OF COMMISSIONING OF RECENT STORAGE RING LIGHT SOURCES*

M. Borland, ANL, Argonne, IL 60439, USA
Riccardo Bartolini, Ian Martin DLS, Oxfordshire, UK
Les Dallin, Canadian Light Source, Saskatchewan, Canada
Francis Perez, CELLS-ALBA Synchrotron, Cerdanyola del Valles, Spain
Peter Kuske, Roland Mueller, HZB, Berlin, Germany
Laurent Stanislas Nadolski, SOLEIL, Gif-sur-Yvette, France
James A. Safranek, SLAC, Menlo Park, California, USA
Seunghwan Shin, PAL, Pohang, South Korea
Zhao Zhentang, SINAP, Shanghai, China

Abstract

The Advanced Photon Source and other existing storage ring light sources are contemplating replacing an operating storage ring with a multi-bend achromat lattice [1–6]. Existing light sources have large user communities who are greatly inconvenienced by extended shutdowns. Hence, there will be a premium placed on rapid commissioning of the new lattice. To better understand the possibilities, we undertook a survey of recent commissioning experiences at third-generation light sources. We present a summary of that survey here.

INTRODUCTION

APS, ESRF, and other existing synchrotron light source facilities are contemplating replacing their operating storage rings. Users and funding agencies insist that "dark time" is minimized. APS, for example, is targeting 12 months for removal, installation, and commissioning of a new multi-bend achromat replacement ring. Of this 12 month period, only three months are set aside for commissioning. Other facilities are facing similarly demanding constraints.

As a result, we need to determine how realistic such short commissioning intervals are. We also need to determine what factors are most likely to prevent successful commissioning in such a short time, and what steps can be taken to ensure rapid commissioning. Toward this end, we surveyed recently-commissioned light sources to understand their experience, where "recently-commissioned" was defined as within the last 10-15 years.

The survey questions were created at APS by M. Borland, L. Emery, J. Kerby, and A. Zholents. In the interest of brevity, the questions are paraphrased below. Responses directed at the survey questions were received from seven facilities, namely, ALBA, BESSY-II, DLS, PLS-II, SOLEIL, SSRF, and SPEAR3. Information was also provided by CLS. The co-authors of this paper responded to the survey for their respective facilities.

* Work supported in part by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

A potential source of confusion is that commissioning may mean different things to different people. As part of the survey, we suggested the following definition: commissioning begins when beam is first injected into the ring. It ends when the ring is capable of supporting meaningful beamline commissioning, which generally requires several conditions

1. The ring can routinely store a significant fraction of the planned initial operating current for periods of 8 hours or more.
2. The lattice and emittance are essentially at the initial design configuration and values.
3. The lifetime is workable.
4. The orbit and beam stability are workable.
5. One or more ready-to-use insertion devices are installed and available.

Respondents to the survey generally agreed with this definition. In some cases, delivery of beam to "friendly users" was considered the endpoint.

QUESTIONS AND ANSWERS

Question: How was the commissioning schedule developed? This question was intended to ask about the process for developing the commissioning schedule, but wasn't very clear and was misunderstood by several respondents. Common themes in answers included: Basing the schedule on experience at other facilities; e.g., PLS-II followed the SPEAR3 example of 6 month replacement followed by 6 month commissioning. In some cases, requirements were driven by the user community. Also mentioned were: extensive discussions among commissioning team, creation of a list of major milestones, and definition of a phased commissioning approach.

What was the scheduled duration of commissioning and how was it structured? Scheduled duration ranged between 4 and 12 months, with 6 months being the most common response (five). Other responses (one each) included 3 months, 9 months, and 12 months. Hence, in terms of planning, the 3 month commissioning period contemplated by APS is a factor of two shorter than typically contemplated.

How much time would ideally have been required and how much was actually required? This question was intended to determine how much safety margin was built into the schedule. Five of seven facilities stated that if nothing had gone wrong, commissioning would have taken 3 months or less (see Fig. 1). Commissioning typically took much less time than scheduled (see Fig. 2). All but one facility completed commissioning in less than the scheduled time, with five of seven reporting commissioning in less than 4 months. The median ratio of actual to scheduled time was 2/3 and no correlation was seen between year of start and time required to commission (see Fig. 3).

What was the shift schedule? If not 24/7, why not? Most respondents reported using a 24/7 commissioning schedule, but with interruptions for repairs and installation in several cases. There was no obvious relationship between the number of hours of shift work per week and the time required for commissioning, as shown in Fig. 4.

How many personnel were involved in commissioning? The reporting in this case was more varied. Between 6 and 18 physicists were involved, with a median of 7. Between 5 and 7 operators were involved, with a median of 5. In total, between 15 and 50 personnel were invovled, with a median of 30.

Amusingly enough, the data appear to (weakly) suggest that having more people is associated with slower commissioning, see Fig. 5. However, the responses are hard to compare and are incomplete. It may well be that more people became involved when difficulties (and hence delays) were encountered.

Which factors introduced the largest delays? Various factors were cited in the responses, including vacuum obstruction (4), delivery delays (2), vacuum chamber heating (2), need to understand detailed behavior of hardware (2), vacuum leak (1), machine protection system delayed (1), magnet wiring error (1), operating procedure error (1), catastrophic failure of a unique component (1), and inadequate simulation of start-up method (1). One of the lessons to be drawn from the responses is that vacuum system problems are common and that it is advisable to test components (e.g., bellows liners) on an existing accelerator when possible In addition, commissioning interleaved with installation introduces delays.

Which factors advanced commissioning most rapidly? The most-cited factor was thorough subsystem commissioning (7), followed by control system ready and tested (5). Under the latter heading, MATLAB Middle Layer (MML, 3) and model-based tools (2) were emphasized. Other factors included first-turn BPMs (2), anticipating failures and problems (1), robust rf bellows (1), and sending staff to commission other rings to gain experience (1).

Lessons here are to test hardware carefully ahead of time before introducing beam, and use well-tested software.

For new ring in next 5-10 years, what factors are most likely to introduce delays? With this question, the responses shifted toward more physics-related concerns, with obtaining stored beam with small dynamic and physical aperture (4) and obtaining sufficient stored beam to perform corrections (3) being the most-cited concerns. Other issues are familiar, including lack of full subsystem commissioning (2), vacuum components (2), rf bellows (1), impedance (1), late delivery of components (1), control system not ready or not tested (1), unforeseen major failures (1), and aged staff (1).

For new ring in next 5-10 years, what are essential factors for rapid progess? Responses here shifted somewhat compared to the responses to the previous question, the working, well-understood diagnostics (5) and in particular turn-by-turn BPMs (3) being commonly cited. Thorough subsystem commissioning (4) and having control system applications ready (3) was again emphasized. Under the latter heading, MML (2), LOCO (1), and data logging (1) where all mentioned. Other factors included well trained, experienced staff (2); robust lattice design (1); technical documentation (1); and reliable magnet measurements (1).

The responses evinced some frustation with technical system readiness, particularly with respect to BPMs.

If commissioning a new ring in the next 5-10 years, what's your best estimate of the <u>minimum</u> time required? The median estimate was 4 months, which corresponds to the median time to actually commission the rings surveyed. However, there was only a weak correlation between the estimated time and the actual time for the ring surveyed (see Fig. 6).

CONCLUSIONS

Our survey of recently-commissioned rings garnered detailed responses from 7 facilities. Most recent rings commissioned in 4 months or less, typically taking only 2/3 of the scheduled time. Most respondents estimated that a new ring would take the same amount of time, although respondents from facilities that commissioned quickly did not necessarily feel a new ring would also be commissioned quickly. Existing rings could have commissioned in about 2/3 the time if problems had been avoided.

Keys to success include thorough subsystem commissioning without beam and having controls software tested ahead of time. Delays in the commissioning of new rings are most likely to be caused by the difficulty of getting (sufficient) stored beam in new lattices, the lack of full subsystem commissioning, vacuum system issues (heating, obstructions), and delivery delays.

Commissioning an upgrade in 3 months seems within the realm of possibility with sufficient care and advance preparation.

ISBN 978-3-95450-168-7

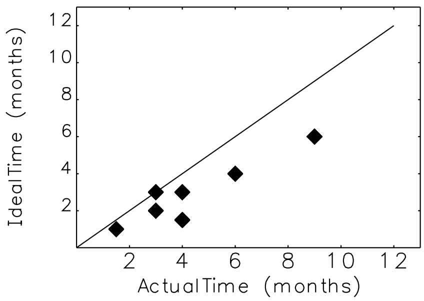

Figure 1: Relationship between ideal and actual commissioning time.

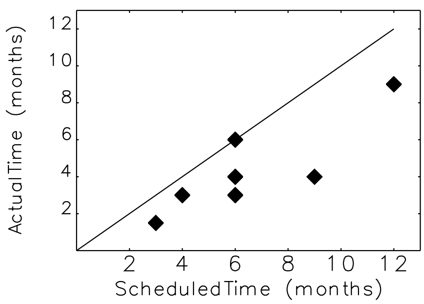

Figure 2: Relationship between actual and scheduled commissioning time.

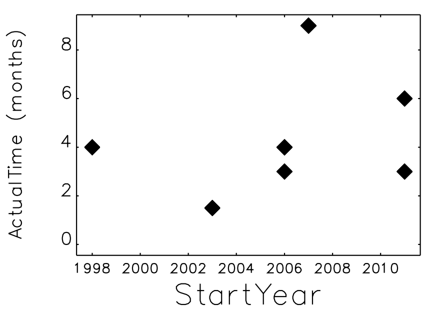

Figure 3: Relationship between actual commissioning time and year when commissioning started.

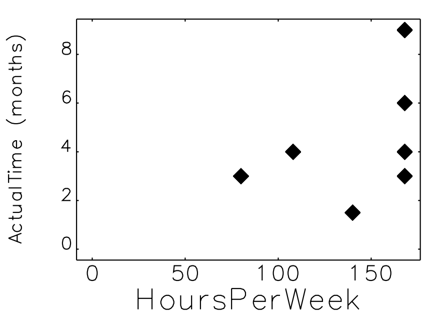

Figure 4: Relationship between actual commissioning time and commissioning hours per week.

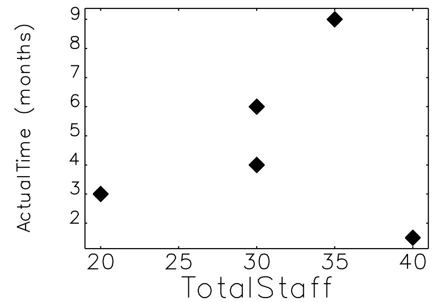

Figure 5: Relationship between actual commissioning time and total staff.

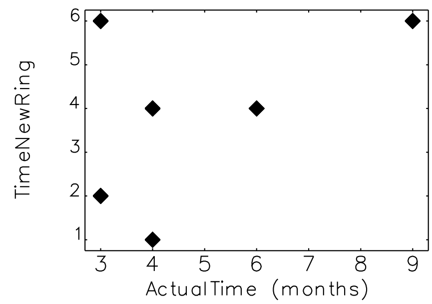

Figure 6: Relationship between actual commissioning time and estimated minimum time for a new ring.

REFERENCES

[1] R. Bartolini and others. *Proc. of PAC2013*, 24–26 (2013).

[2] J. C. Biasci et al. *Synchrotron Radiation News*, 8–12 (2014).

[3] G. Decker. *Synchrotron Radiation News*, 13–17 (2014).

[4] C. Steier. *Synchrotron Radiation News*, 18–22 (2014).

[5] H. Tanaka. *Synchrotron Radiation News*, 23–26 (2014).

[6] L. S. Nadolski and others. *Proc. of IPAC2014*, 203–205