Survey of Commissioning of Recent Storage Ring Light Sources

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Outline

- Motivation
- Survey questions and responses
- Conclusions

Motivation

- APS and other facilities are contemplating replacing operating rings
- Users and funding agencies insist that “dark time” is minimized
  - E.g., APS is targeting 12 months for removal, installation, and commissioning
  - 3 months set aside for commissioning
- We want to determine
  - How realistic is this?
  - What factors are most likely to prevent this?
  - What steps can be taken to ensure rapid commissioning?
- Toward this end, we surveyed recently-commissioned light sources to understand their experience
  - “Recently-commissioned” was defined as within the last 10-15 years
  - NSLS-II and TPS not included (not commissioned at the time)
- Survey questions created M. Borland, L. Emery, J. Kerby, and A. Zholents
  - Questions are paraphrased below in the interest of brevity

Question 1: Names of facilities and respondents

- ALBA: F. Perez
  Began operation in 2012
- BESSY-II: A. Jankowiak, P. Kuske, R. Müller
  Began operation in 1998
- CLS*: M. de Jong, L. Dallin
  Began operation in 2004
- DLS: R. Bartolini, I. Martin
  Began operation in 2007
- PLS-II: S. Shin
  Began operation in 2012
- SOLEIL: L. Nadolski
  Began operation in 2007
- SSRF: Z. Zhao
  Began operation in 2009
- SPEAR3: J. Safranek
  Began operation in 2004

7 out of the 8 of the machines for which responses were received were commissioned in the last 10 years

*Didn't address questionnaire directly but provided related Information.

Question 2: What does “commissioning” mean?

- It is hard to make a universal definition, but we tried
- Suggested definition:
  - Begins when beam is first injected into the ring
  - Ends when ring is capable of supporting meaningful beamline commissioning, which generally requires
    - Ring can routinely store a significant fraction of the planned initial operating current for periods of 8 hours or more
    - Lattice and emittance are essentially at initial design configuration/values
    - Lifetime is workable
    - Orbit and stability are workable
    - One or more ready-to-use insertion devices
- Respondents generally agreed on this definition
  - In some cases, beam delivery to friendly users was the endpoint

Q3: How was the commissioning schedule developed?

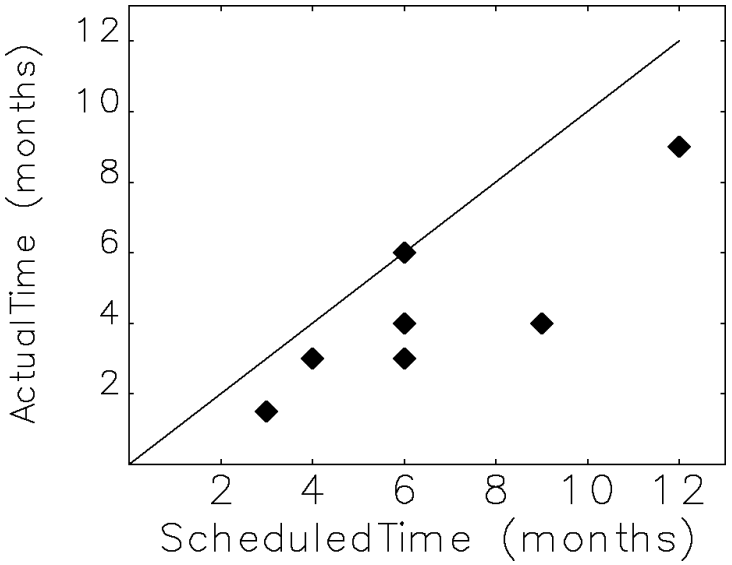
- Question was intended to ask about the process for developing the commissioning schedule, but wasn't very clear and was misunderstood by several respondents
- Common themes in answers:
  - Based on experience at other facilities
    - E.g., PLS-II followed the SPEAR3 example of 6 month replacement followed by 6 month commissioning
  - Based on requirements set by user community
  - Extensive discussions among commissioning team
  - Creation of a list of major milestones
  - Definition of a phased commissioning approach

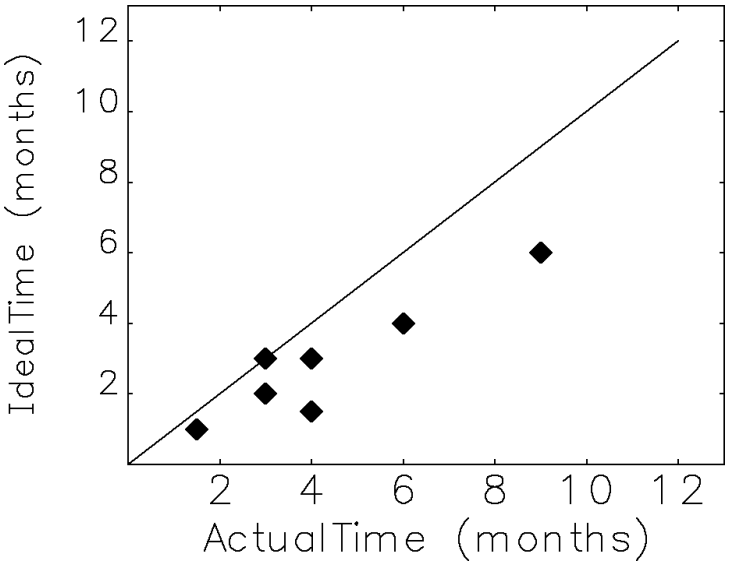
Q4a: What was the scheduled duration of commissioning and how was it structured?

- Scheduled duration ranged between 4 and 12 months
  - 1/7 gave 3 months
  - 4/7 gave 6 months
  - 1/7 gave 9 months
  - 1/7 gave 12 months
- In terms of planning, at least, a 3 month commissioning period is a factor of two shorter than typically contemplated

Q4b: How much time would ideally have been required and how much was actually required?

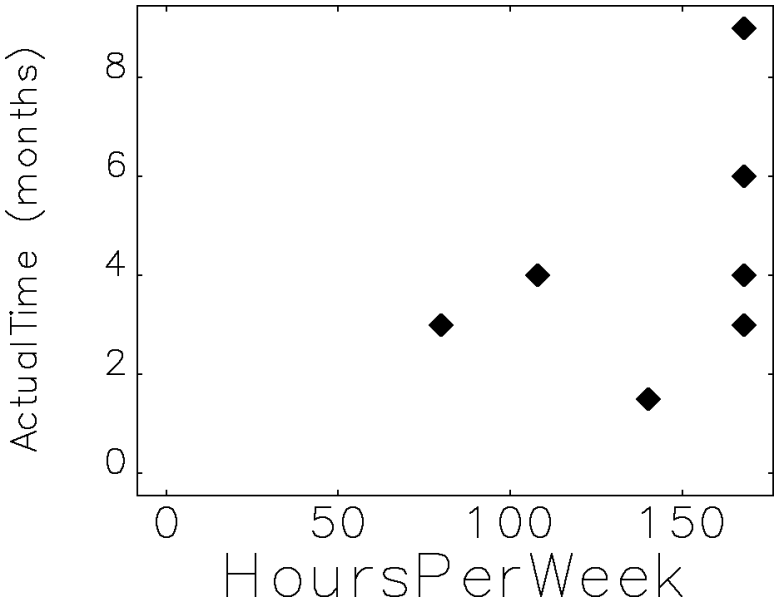
- Actual time
  - All but one facility completed commissioning in less than the scheduled time
  - **Five of the seven responding facilities reported commissioning in 4 months or less**
  - The median ratio of actual to scheduled time is 2/3
  - No correlation between year of start and actual time
- Ideal time
  - All but one facility reported that some delays occurred that increased the time above the ideal duration
  - The median increase over the ideal time is 50%
  - **Five of seven responding facilities thought commissioning could be done in 3 months or less**





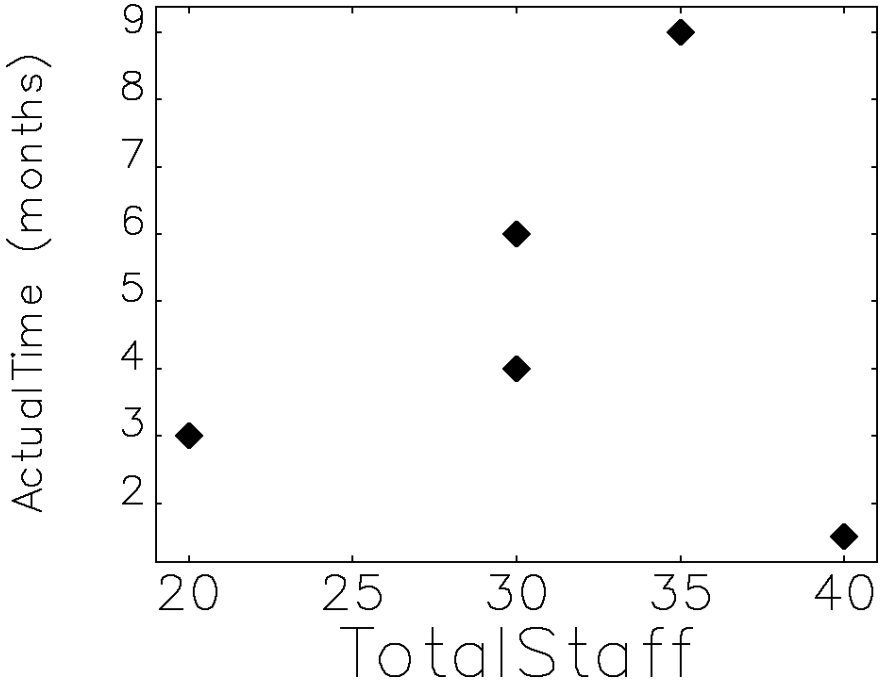
Q5: What was the shift schedule? If not 24/7, why not?

- Mostly 24/7, but with interruptions for repairs/installation in some cases
- No obvious relationship between hours of shift work per week and time required for commissioning
  - Probably swamped by other effects



Q6: Personnel involved in commissioning

- By type
  - Physicists: between 6 and 18, median of 7
  - Operators: between 5 and 7, median of 5
  - Total: between 15 and 50, median of 30
- Data weakly suggests that more people means slower commissioning
  - Responses are incomplete and hard to compare
  - Perhaps more people become involved when difficulties are encountered



Q7: Which factors introduced the largest delays?

- 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)
- Inadequate simulation of start-up method (1)

- Lessons:
  - Vacuum system problems are common, good to test components (e.g., bellows liners) on existing accelerator when possible
  - Commissioning interleaved with installation introduces delays

Q8: Which factors advanced commissioning most rapidly?

- Thorough subsystem commissioning (8)
- Control system ready and tested (5)
  - MML/AT (3)
  - Model-based tools (2)
- First-turn BPMs (2)
- Planning for failures and problems (1)
- Robust rf bellows (1)
- Sending staff to commission other rings, to gain experience (1)

- Lessons:
  - Test hardware carefully ahead of time before introducing beam
  - Use well-tested software

Q9: For new ring in next 5-10 years, what are essential factors for rapid progess?

- Working, well-understood diagnostics (5)
  - Turn-by-turn BPMs (3)
- Thorough subsystem commissioning (4)
- Control system applications ready (3)
  - MML (2)
  - LOCO (1)
  - Data logging (1)
- Well trained, experienced staff (2)
- Robust lattice design (1)
- Technical documentation (1)
- Reliable magnet measurements (1)

- Lessons
  - Some evidence of frustration with technical system readiness, BPMs in particular
  - Control system readiness is very important

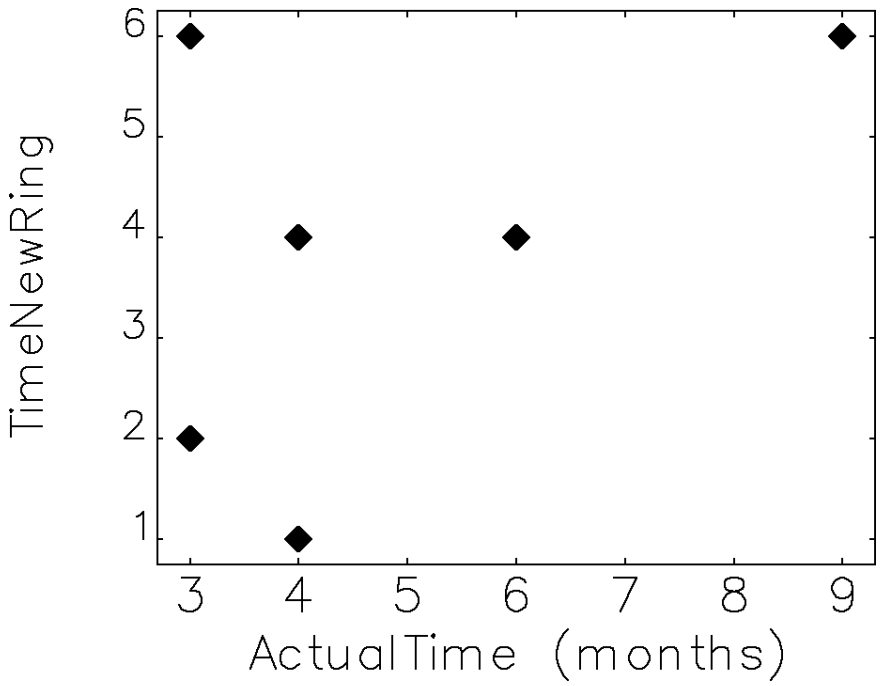
Q10: For new ring in next 5-10 years, what factors are most likely to introduce delays?

- Obtaining stored beam with small DA/PA (4)
- Obtaining sufficient stored beam to perform corrections (3)
- 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)
- Aged staff (1)

- Lessons:
  - Physicists worry about physics-related issues
  - Subsystem commissioning and vacuum issues are understandable worries

Q11: If commissioning a new ring in the next 5-10 years, what's your best estimate of the minimum time required?

- Median estimate: 4 months
  - Corresponds to the median time to commission rings in survey
- Weak correlation between estimate for new ring and time taken with existing rings



Summary of Key Lessons

- 7 facilities responded to survey with item-by-item responses
  - Information also provided by CLS
- Most recent rings commissioned in 4 months or less
  - Typically took only 2/3 of the scheduled time
- Most respondents estimated new ring would take the same
  - Existing rings could have commissioned in ~2/3 the time if problems had been avoided (i.e., less than 3 months)
- Keys to success include
  - Thorough subsystem commissioning without beam
  - Controls software tested ahead of time
- Delays commissioning new rings most likely to be
  - Difficulty of getting (sufficient) stored beam in new lattices
  - Lack of full subsystem commissioning
  - Vacuum system issues (heating, obstructions)
  - Delivery delays
- Commissioning an upgrade in 3 months seems within the realm of possibility