



Requirements for Top-up at the CLS

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1.0 INTRODUCTION

Top-up mode is a mode of operation in which the photon shutters and the safety shutters in the beamline front-ends remain open during injection into the Storage Ring. The purpose of top-up is to allow frequent injection into the Storage Ring while experiments are running on the beamlines, in order to keep the Storage Ring current nearly constant. An alternative mode of operation is injecting every 8 or 12 hours *with shutters open*. This mode maintains some heat load on the primary beamline optics and vacuum chamber.

This document is a summary of an initial survey on the potential performance and resource impact of top-up on beamlines and operation.

2.0 BEAM STABILITY

2.1 E-BEAM AND INJECTION

Injection into the storage ring is performed by locally displacing the orbit of the stored e-beam and injecting 0.5mA-1mA of current (depending on injection efficiency). A mismatch in the injection kickers or stray magnetic flux will act to perturb the closed orbit around the ring. The perturbation to the stored beam has a magnitude of ~ 2 mm and decays in less than 10 ms due to the natural damping time constant of the storage ring. Figure 1 shows turn-by-turn measurements of the stored e-beam displacement during injection.

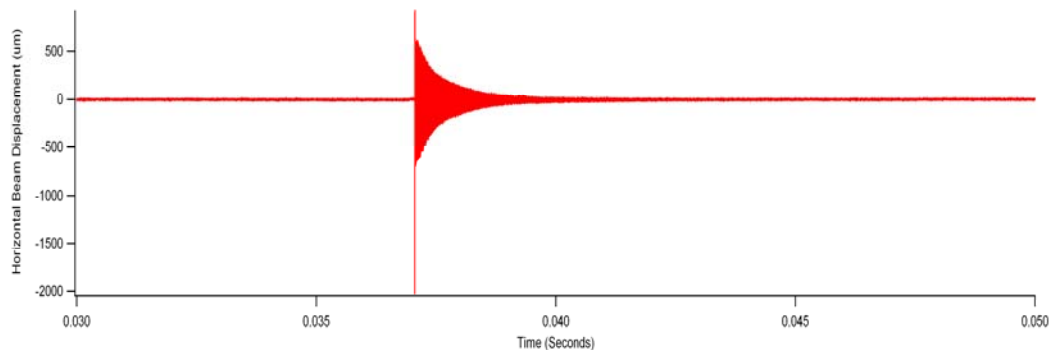
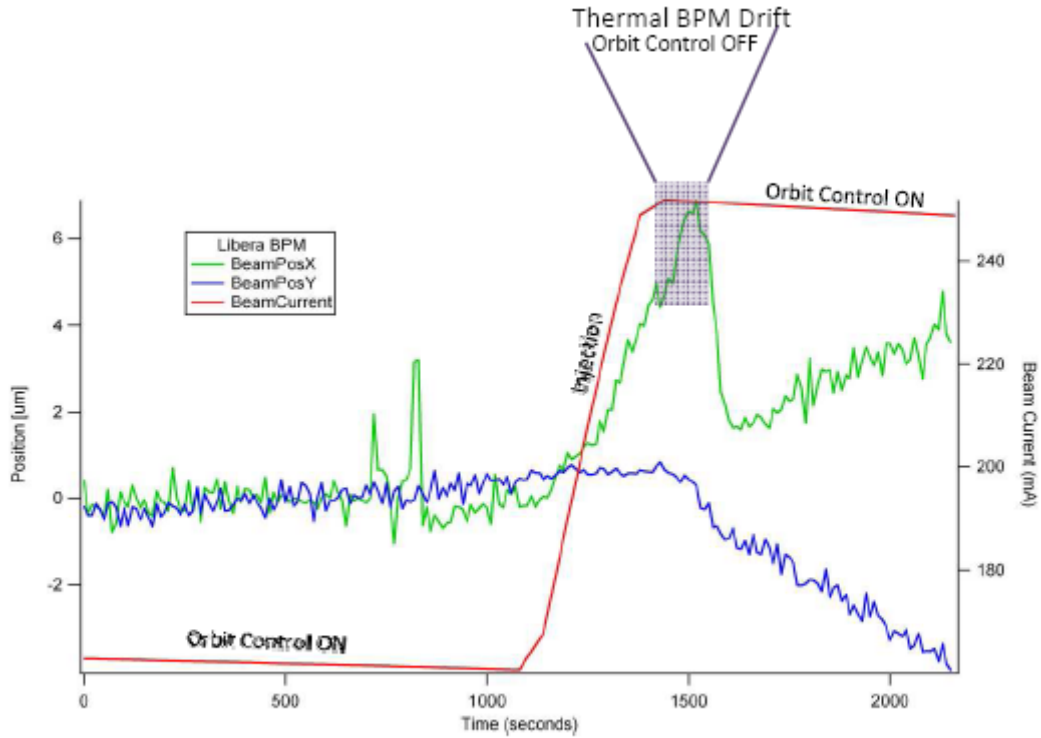


Figure 1: Turn-by-turn measurement of stored e-beam displacement during injection

2.2 E-BEAM ORBIT STABILITY

The displacement of the stored e-beam is measured by capacitive buttons welded to the storage ring vacuum chamber. Asymmetric changes of the vacuum chamber due to the changing thermal load from synchrotron radiation may cause an apparent shift in the e-beam position. This apparent change in beam position, as seen by the orbit correction system, is not distinguishable from an actual displacement of the e-beam relative to the buttons. A constant heat load on the vacuum chamber will minimize the effect.

Figure 2 shows the e-beam displacement during an injection cycle. At the end of the injection cycle the beam position undergoes slow drifts due to thermal change in the vacuum chamber. Also, the affect of the e-beam current dependence of the Bergoz BPM electronics is on the same order as the thermal drifts.



Courtesy S. Hu

Figure 2: Injection cycle

2.3 THERMAL STABILITY & OPTICS

A change in e-beam current will cause a proportional change of heat load on beamline optics affecting their thermal mechanical stability. A stable beam current will minimize the effects of changing heat load. This can ultimately improve photon position and energy stability for a beamline. Figure 3 shows the effect of current decay and injection on the stability on the CLS HXMA liquid nitrogen cooled double crystal monochromator.

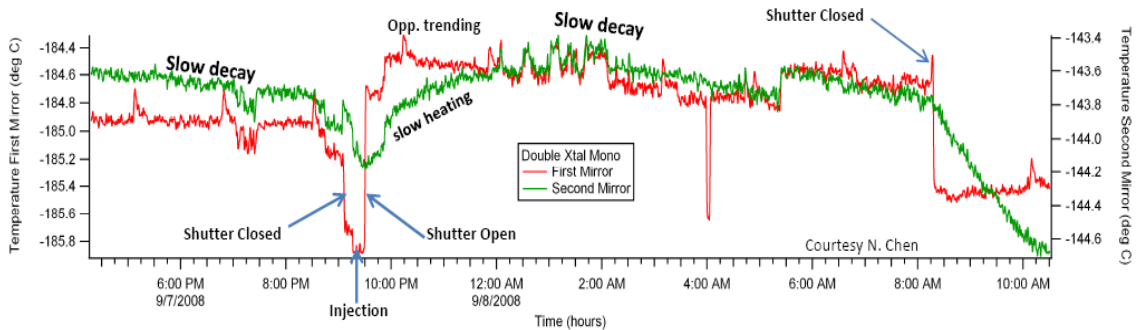


Figure 3: Temperature behavior of HXMA double crystal monochromator over 24 hrs

3.0 SURVEY OF IMPACT

The CLS first/second phase beamline scientists were surveyed to establish their initial concerns for top-up and its impact on the beamline operation. Accelerator Physics and Health&Safety were surveyed to establish, at a high level, the resources needed to implement top-up at the CLS. A set of questions was posed to each beamline group and are shown below.

- 1) Will top-up improve the performance of your beamline?
- 2) Which fill pattern would your users prefer?
- 3) How frequent would you like injections or how stable would you like the photon flux?
- 4) Are you affected by the kicker firing? What are your tolerances on the stability of your source?
- 5) What is the impact of frequent injections on your data acquisition? Level of transparency required in the data acquisition (i.e. automated data masking, manual editing of data, etc...)

The majority of the questions were addressed. The results are summarized in this section.

3.1 IMPACT ON BEAMLINES

3.1.1 Far & Mid-IR

In-favor of Top-up: No

Both the Far & Mid-IR use an interferometer type end-station as a spectroscope/microscope. The broadband spectroscopic information is collected on-the-fly with scans lasting from minutes to hours. The information is sampled at rates up to 40 kHz making the injection spikes apparent in the collected interferograms. Modification of the endstation data acquisition is difficult as the design is proprietary. Figure 4 shows a typical interferogram with an injection spike.

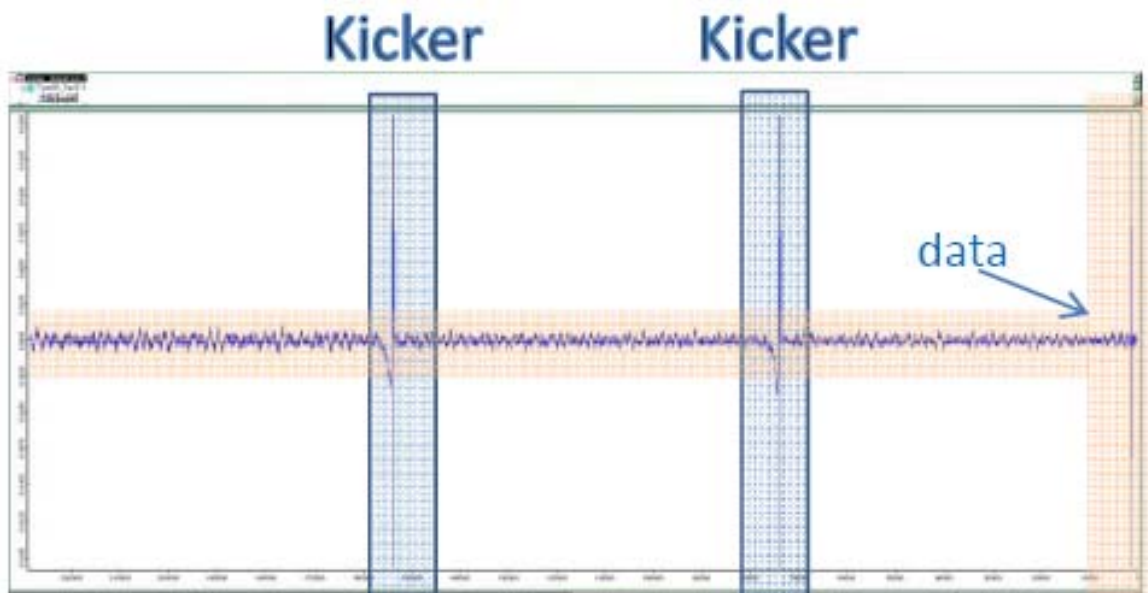


Figure 4: Example interferogram collected on Far-IR beamline

3.1.2 SGM

In-favor of Top-up: Yes

SGM (Spherical Grating Monochromator) beamline are not sensitive to the heat load on their optics owing to their large beam spot size but would benefit from the higher average flux. They are concerned about normalizing their measurements and possible brightness dilution due to high frequency e-beam motion.

3.1.3 PGM

In-favor of Top-up: No opinion

PGM (Plane Grating Monochromator) beamline does not presently have an opinion on top-up.

3.1.4 SM

In-favor of Top-up: No

SM (Spectromicroscopy) is concerned about possible brightness dilution and e-beam drift causing a respective decrease in coherence, energy shift, and changing flux all of which negatively affect spectroscopic and microscopic measurements. If top-up were to be implemented at CLS, SM would prefer injections every 8 hours or up to a tolerable injection frequency of 30 mins.

3.1.5 REIXS

In-favor of Top-up: Yes

REIXS (Resonant Elastic and Inelastic X-ray Scattering) would benefit from higher average flux and constant heat load on optics. They would prefer an injection frequency of 2 min.

3.1.6 CMCF I & II

In-favor of Top-up: Yes

CMCF (Canadian Macromolecular Crystallography Facility) would benefit from higher average flux and heat load stability. Their preference is for photon flux to be held constant to within 5-10% and an injection frequency of 2-3 min. Their only concern is potential e-beam scraping on the in-vacuum undulator for frequent closed gap injections which may result in partial demagnetization of the undulator magnets.

3.1.7 BMIT

In-favor of Top-up: Yes

BMIT (Biomedical Imaging and Therapy) would benefit from high average flux and heat load stability of their monochromator. They are concerned that injections may affect imaging for source size dependent experiments (brightness dilution), and wish to have the right to delay injection for live patients.

3.1.8 VESPERS, BIOXAS, SXRMB

In-favor of Top-up: Yes

VESPERS (Very Sensitive Elemental and Structural Probe Employing Radiation from a Synchrotron), BIOXAS, and SXRMB (Soft X-ray Microcharacterization Beamline) would benefit

from higher average flux and constant head load on optics but are concerned about beam stability during μ -probe experiments where the measurement time constant is on the same order as the injection time constant.

3.1.9 HXMA

In-favor of Top-up: Yes

HXMA (Hard X-ray Microanalysis) would benefit from higher average flux and constant head load on their double crystal monochromator. Figure 3 is an example of changing e-beam current over a 24-hour period and its impact on optics heat load. After e-beam injection HXMA must wait 30 minutes or more for temperature stabilization of their monochromator otherwise they have a non-negligible changing beam position and photon energy at their end station. The diffractometer end station is considerably more sensitive and may have to wait for an hour or more.

3.1.10 SyLMAND

In-favor of Top-up: Yes

SyLMAND (Synchrotron laboratory for Micro and Nano Devices) would benefit from constant flux for their lithography work. They have not expressed any concerns.

3.2 SUMMARY OF RESULTS

Table 1 outlines the 3 out of the 5 questions posed. (1) Is the beamline in favor of Top-up? (2) Is there a requirement for software/hardware gating? (3) What is the desired time interval between injections?

Beamline	In Favour of Top-up	Controls Res. Req.	Injection Interval
Far-IR	No	?	8 hrs
Mid-IR	No	?	8 hrs
SGM	Yes	Gate	Any
PGM	?	?	?
SM	No	?	8 hrs
REIXS	Yes	Gate	2 min
CMCF-I & II	Yes	Gate	2-3 min
BMIT	Yes	Gate	?
VESPERS	Yes	Gate	< 12 min
BioXAS	Yes	Gate	2 min
SXRMB	Yes	Gate	< 12 min
HXMA	Yes	?	< 8 hrs
SyLMAND	Yes	Gate	?

Table 1: Basic Summary of Survey

4.0 ACCELERATOR PHYSICS REQUIREMENTS

In order to provide Top-up as a regular mode of storage ring operations the following requirements must be fulfilled:

- Development of single shot filling (no additional shots)
- Reconfigure septum power supplies to reach their set point from cold start
- SR kicker reliability needs to be improved
- Implement cabling & reliability tests of 4 button current switch (personnel protection)
- Study feasibility of forward/reverse power measurement of RF cavity (personnel protection)
- Linac reliability – Reduce VSWRs and/or implement an automatic reset

5.0 HEALTH & SAFETY REQUIREMENTS

- Shielding calculations
- Modify ACSIS system for each beamline for operation with shutters open
- Update documentation, V&V, procedures for top-up
- Send technical and safety changes for top-up to the CNSC

6.0 MANPOWER AND COST REQUIREMENTS

Table two is a summary of the manpower and cost requirements in order to implement top-up. The question mark represents unknown values.

Task	Manpower (man-weeks)	Cost (k\$)
Current Switch	2	3
Cavity Feed Fwd/Rev	4	2
Shielding Calc	?	-
Energy Mismatch interlock	?	?
Radiation Measurements	?	-
Hazard Analysis	?	-
ACIS System Update	4	5
ACIS System Design Note	2	-
Project Plan	2	-
ACIS V&V Test Proc.	4	-
Total	18 + ?	10 + ?

Table 2: Summary of manpower and cost requirements