



## Australian Synchrotron Development Plan Project Submission Form

### Section A: Summary and Proponent Details

#### Project Title

Top-Up Mode Injection

#### Spokesperson

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#### Executive Summary (approx. 100 words)

Top-up is a mode of operation that aims to maintain a steady current in the storage ring by periodically injecting small amounts of current. It produces a more stable beam by keeping the heat loads and signal strengths constant over long time periods in both the storage ring and on the beamlines. Most of the third-generation light sources, including the Australian Synchrotron, are designed to run in top-up mode. Presently the APS, SLS, SSRL, ALS, SSRF, SOLEIL, Diamond, Spring8 and TLS operate in top-up mode. ESRF, BESSY, ALBA, and NSLS-II plan to move to top-up operation in the future. The talks from a recent top-up workshop can be found on the website:

<http://www.synchrotron.org.au/index.php/news/events/international-events/event/4-accelerator-physics-top-up-workshop>

#### Other proponents (add more rows if necessary)

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## **Section B: Detailed Description**

The accelerator equipment was designed to accommodate top-up operation and it has been demonstrated in principle during machine studies shifts. There are still many developments that will be necessary before top-up can be run reliably during user beam time. One of the first things that will need to be done is to study the injection process with a view to ensure that the injection into the storage ring with photon shutters opened to the beamlines can be done safely. Depending on the results of this study it may be necessary to install clearing magnets to prevent stray electrons from going down the beamlines. Other developments may include, but are not limited to expanded diagnostic capabilities, primarily in the booster to storage ring transfer line, an energy limiting aperture in the transfer line, and increased local shielding. The fact that the injection system runs constantly makes it worthwhile to try to reduce the energy of the injection into the booster to the point where the linac can be run on a single klystron by modifying the existing RF distribution system possibly including SLED cavities. This would also free up a klystron that could be used for other development projects.

### **B1: Description of Proposed Beamline/Development Project**

The main stages of the top-up program are:

- Tracking studies to determine if the phase space of an injected beam can overlap with the beamline apertures.

- Injections with shutters open during machine studies with controlled access to the technical floor to perform radiation surveys.

- Installation of additional radiation monitoring equipment and integration into the personnel safety system.

- Testing of injection bumping with shutters open to determine beamline sensitivities.

- Installation of additional waveguide components in the linac tunnel.

- Re-commissioning of the booster ramp to accept lower energy electrons.

- Installation of additional diagnostics in the booster to storage ring transfer line.

Concurrent with these developments, a detailed program of optimization of all parts of the injection process will be performed.

### **B2: Applications and Potential Outcomes to Australian Scientific Community**

Top-up results in an increase in the number of photons on sample at the beamlines by maintaining the 200 mA stored beam current for long periods of time. This, combined with the increased stability from the constant heat load on optical elements is the motivation behind the majority of third generation light sources implementing top-up operations. The constant current also provides a constant signal level in the storage ring beam position monitor electronics and eliminates the current dependence of the orbit feedback system. The reduced dependence on electron beam lifetime will allow the storage ring to be run with a much reduced emittance coupling which reduces the vertical source size. Top-up also eliminates the need to normalize data to the current and allows long scan times with no interruptions.

### **B3: Match to Selection Criteria**

- Meet the demands of an identified group of researchers for new techniques

The XFM beamline team and their users are the most vocal advocates of top-up injection. Evidence from the light sources that are running in this mode suggests that the vast majority of users see the advantages of top-up regardless of whether they were for, against or indifferent to the idea before implementation.

- Take advantage of the existing third generation light source

The accelerator systems were designed to be compatible with top-up operations.

- Will position Australasian scientists at the leading edge of their field

Top-up demands a level of understanding and control of the injection process that requires the accelerator personnel to be at the leading edge of the field.

- Can be demonstrated to be feasibly constructed within a 3 year timeframe

An implementation plan is being developed based on a two year time frame.

### **B4: Potential Users**

All users stand to benefit from the increased photon flux and stability that comes with top-up operations.