Update on ALS Upgrades

March 2, 2004

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Outline

— What is the ALS Upgrade
  - Top-off

—General Description of Top-Off Operation

— Near and Far-term Goals for Top-Off
  - Activities for this year

—Future Plans

What is the ALS Upgrade

Reason for Upgrade

- Need to continue to improve the performance of the ALS and to keep it at the forefront of synchrotron radiation sources

History

- February 2003 → Presentation was made at the BESAC 20 year roadmap subcommittee. An evolutionary, cost effective approach to upgrade the brightness and performance of the facility.

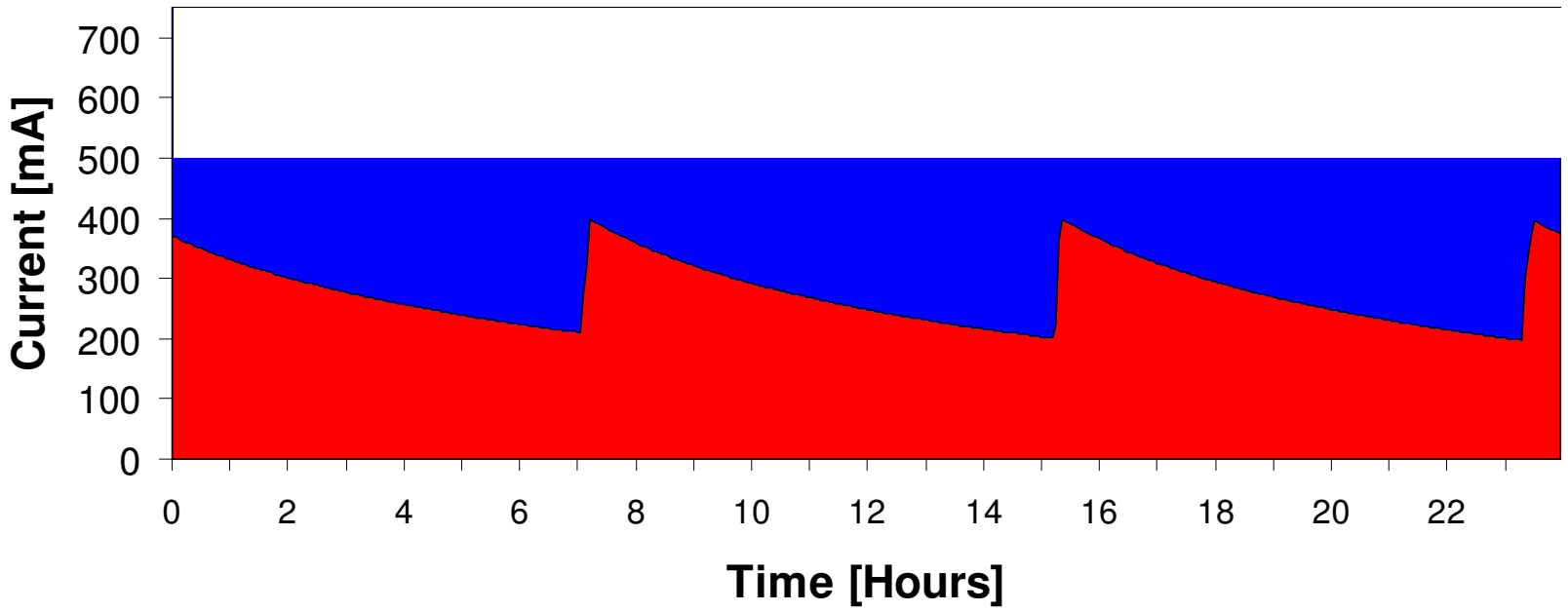
Three Phased Approach

Phase 1. Top-Off injection at 500 mA
Phase 2. Increase the average current
Phase 3. Upgrade the beamlines and insertion devices

- Plan was well received

Phase 1: Top-off

Top-off : Quasicontinuous filling of the ring

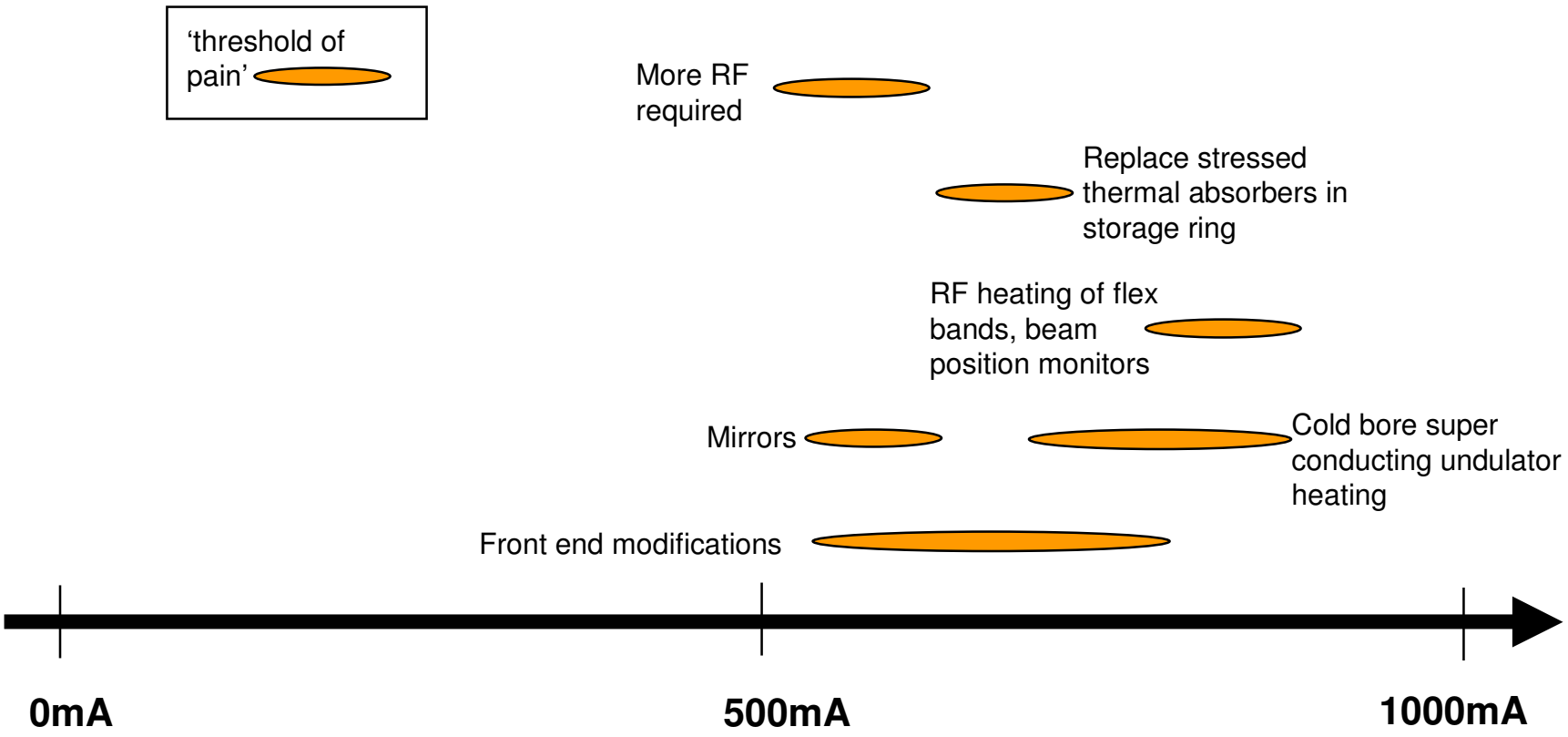


Benefits

- Increase in time averaged current by a factor of 2 (assuming a peak current of 500 mA)
- Improved thermal stability

- Phase 1 considered a “no brainer” and initial funding (500 K this year and at least 500 K next year) has been provided this year to begin feasibility studies
  - —Plan is to complete Phase 1 in FY07
    - Top-off kickoff meeting on October 7, 2004
    - Goal for FY04 ➔Complete a scope, cost, and schedule for the Top-Off Upgrade
- Phase 2 and 3 need to be more carefully developed
  - —Not clear if and when to do Phase 2
  - —SAC (12/2003) recommended reversing Phase 2 and Phase 3

Technical issues above 500mA



Activities for this year

- Defining the Scope for the Top-off project
  - —Determine Operational Modes
  - —Investigate Radiation Safety Issues
    - Will need to inject with the shutters open
  - —Look at Engineering Issues

What is required to go to Top-off injection

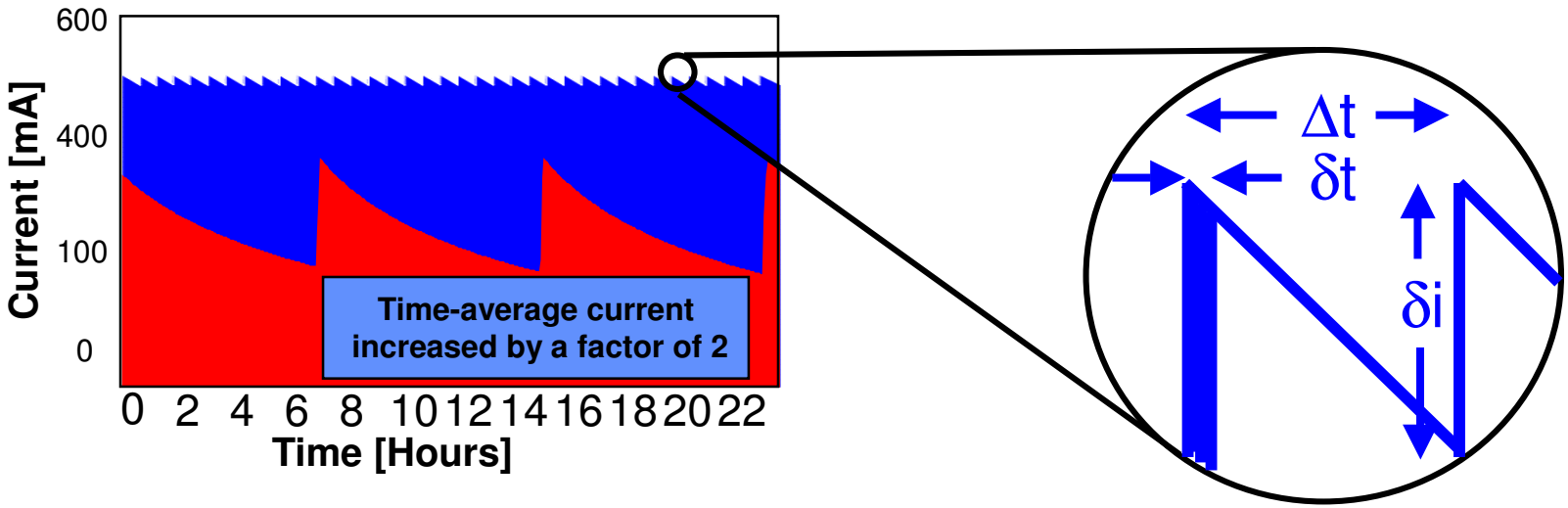
1. **Upgrade to a full energy injector**

2. **Inject quasicontinuously with shutters open**

The exact scope of the project will depend upon user requirements. There is flexibility in many parameters (even on a week-by-week basis). However some choices need to be made now.

- **Allowable change in current when topping up**
- **Allowable orbit disturbance during injection**
  - **Amount and duration**
  - **Is gating an option?**
- **Inject equally spaced in time or current drop**
  - **Inject one pulse or several pulses (burst mode)**
- **Two bunch mode and camshaft beam cleaning**

How frequently should we fill?



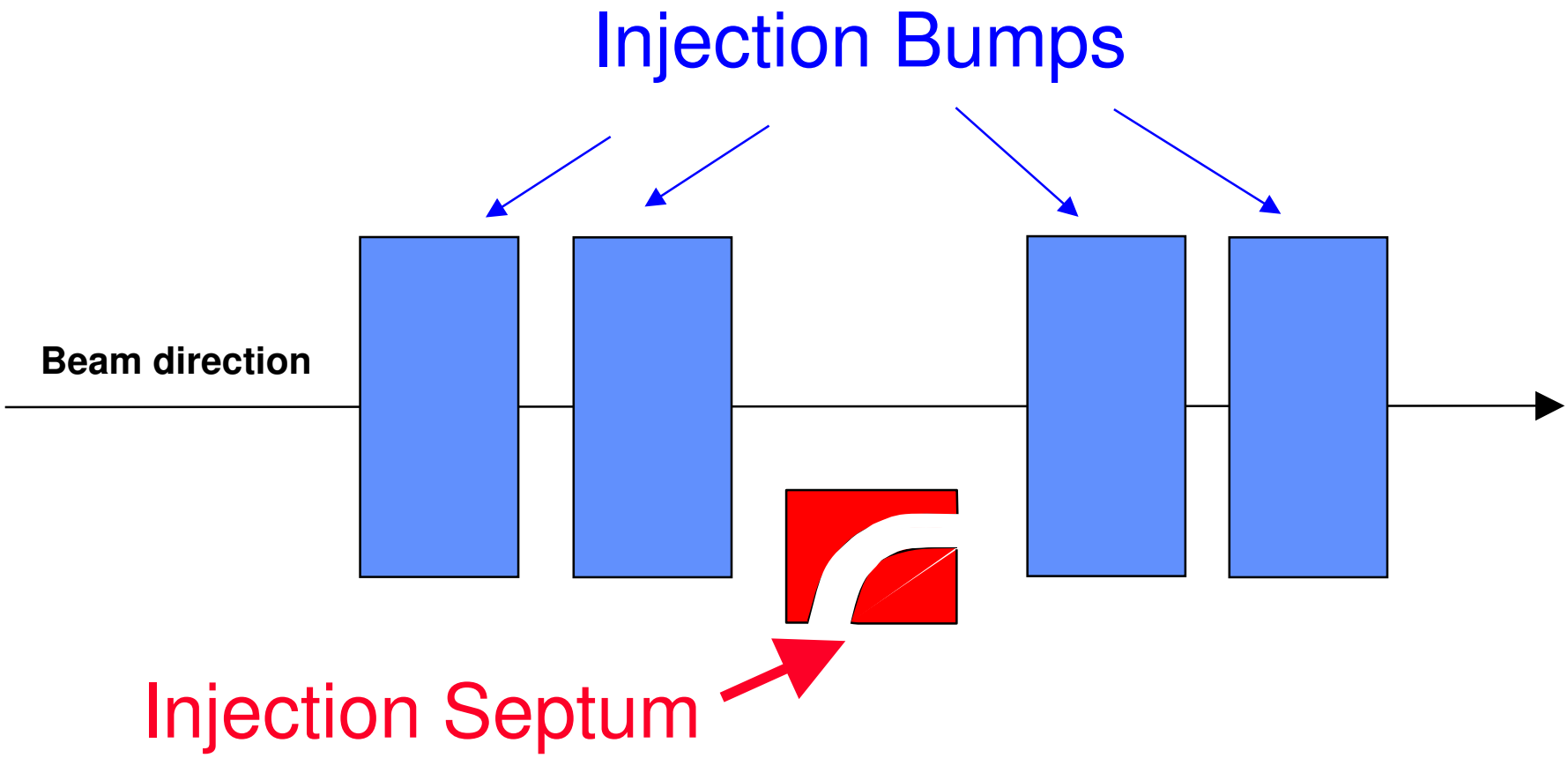
Present plan is to upgrade injector to 1.9 GeV with a maximum repetition rate of 0.5 Hz

Frequency of injection depends upon

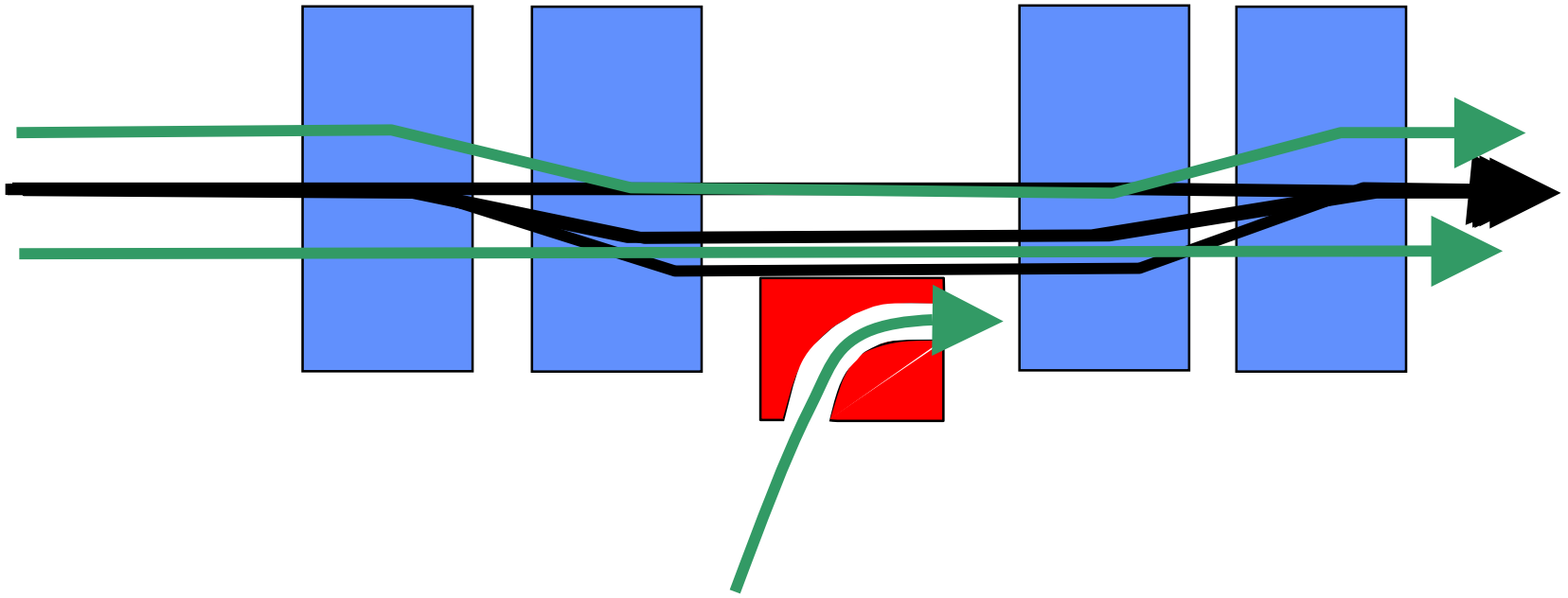
- **Beam lifetime**
- **Acceptable current drop between fills**
- **Maximum output charge of the injector**
- **Inject in one shot or several shots (burst)**
- **Perturbation of user experiments due to the injection scheme**

Injection Elements

Injection Elements in Straight 1



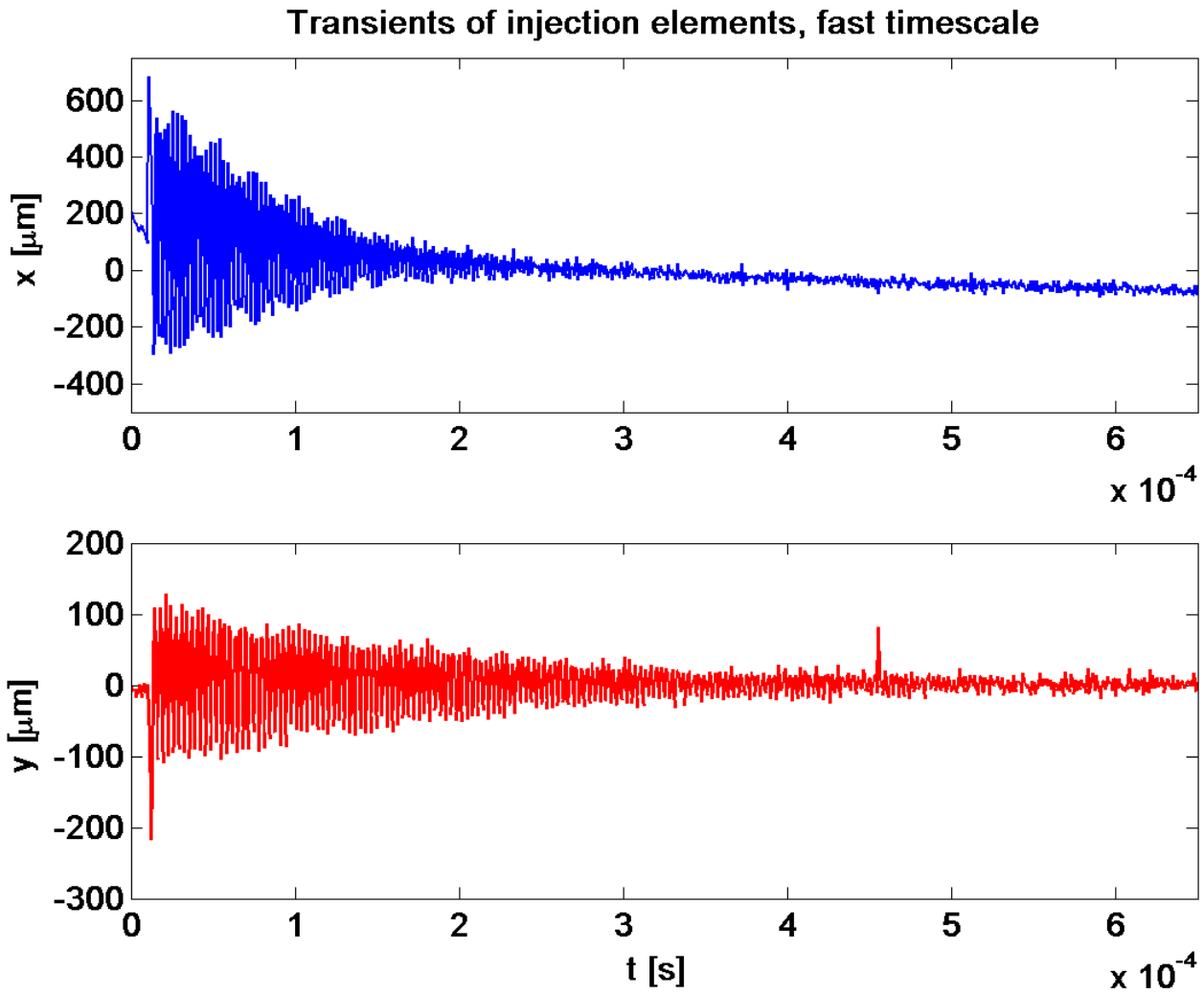
Injection process



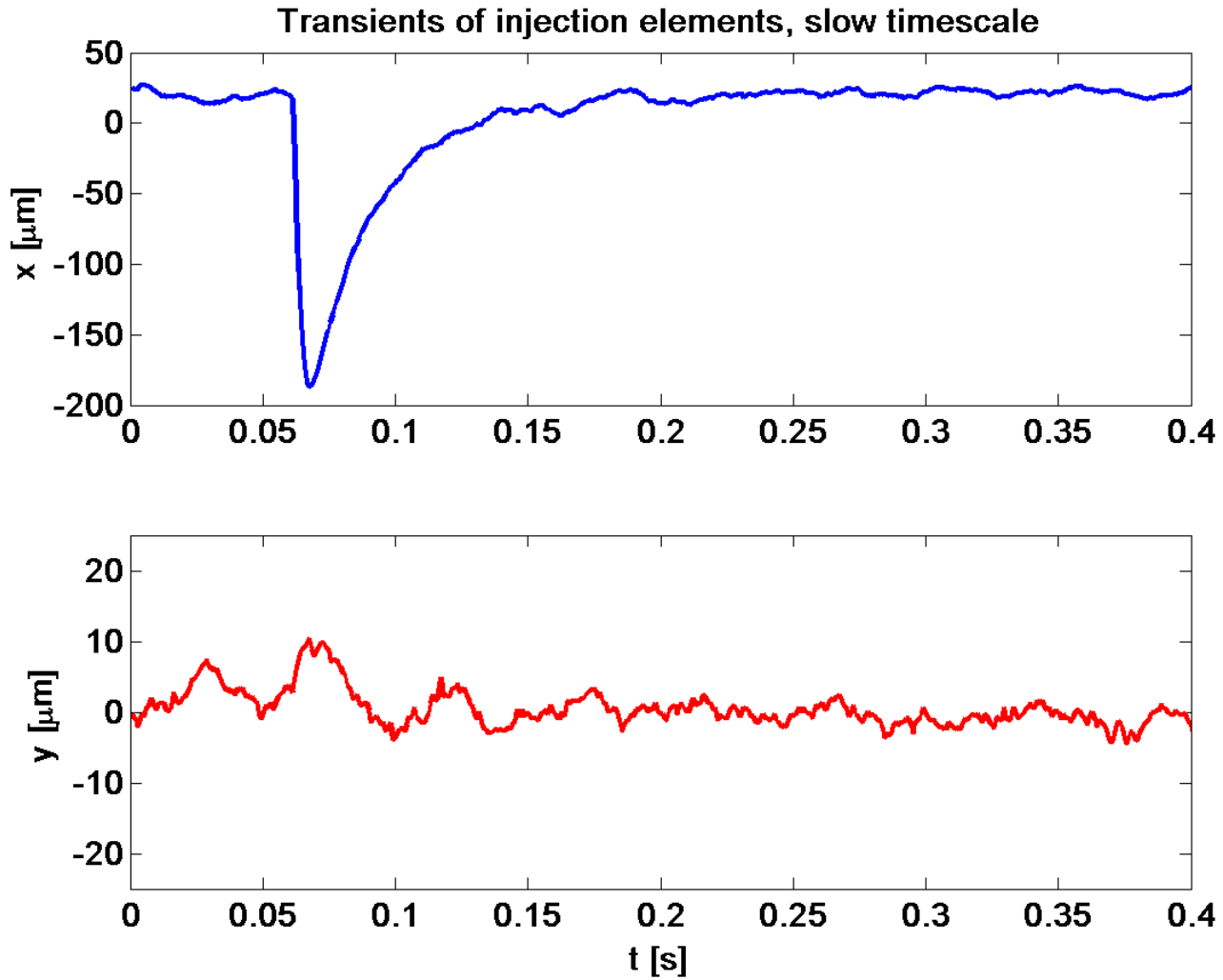
Injection transients

- Injection Process is not completely transparent
  - — Bumps are not completely closed
    - Leaves a small oscillation of stored beam
  - — Eddy currents in the Septum
    - Leaves a slow (10s ms) drift in the orbit

Effect of the Bumps



Effect of the Septum



Initial experimental results with users

On December 7, 2003 and January 26, 2004 we conducted several experiments with some users on beamlines

1.4, 4.0, 5.3.2, 7.0, 7.3 (PEEM), 8.3.1, 10.3, 11.0

Goal: See which type of experiments are effected by the perturbation of the stored beam by the injection elements.

— Look for effects when we turn on and off the bump and septum magnets.

Meeting on February 13 to discuss the results.

Preliminary results: Injection process was transparent to most users however some (particular STXM) where effected and will require a gating signal.

Time between fills

Beam lifetime (dI/dt) is proportional to total current and inversely proportional to the beamsize

$$\frac{\Delta I}{\Delta T} \alpha \frac{I^2}{\sigma_y}$$

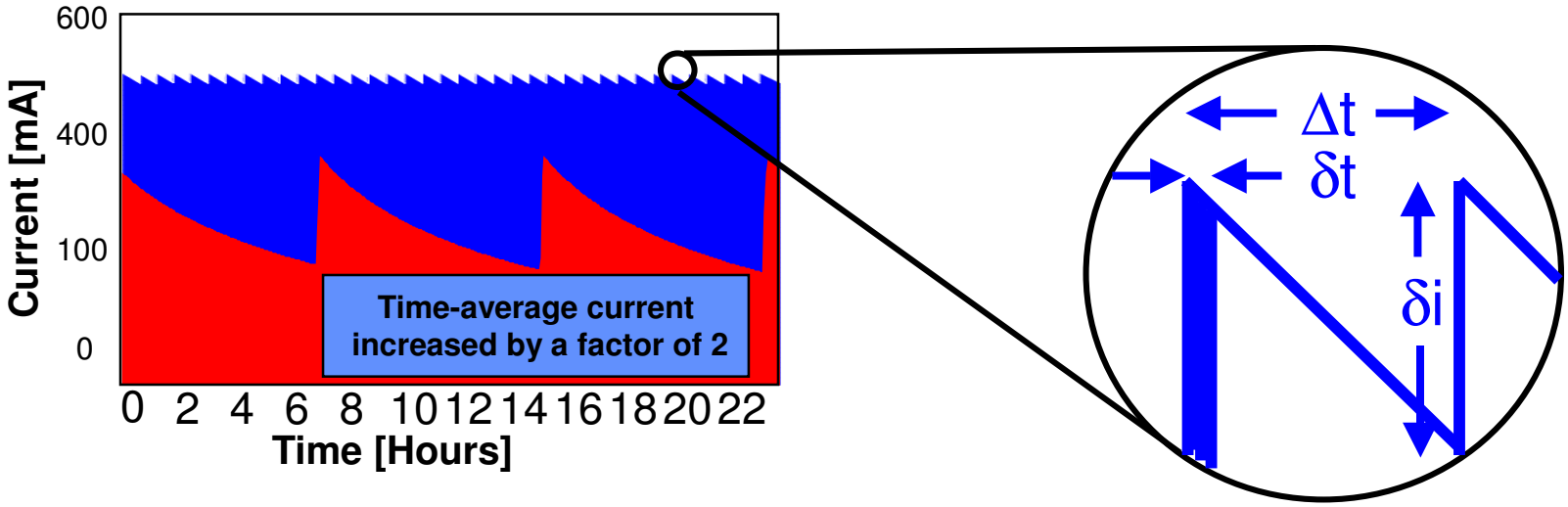
So in the case of a maximum acceptable ΔI

$$\Delta T \alpha \frac{\sigma_y}{I^2} \Delta I$$

So in the case of maximum acceptable ΔI/I

$$\Delta T \alpha \frac{\sigma_y}{I} \frac{\Delta I}{I}$$

Top-off injection with reduced vertical emittance



coupling	δi	Δt	δt	ε_v	σ_h	σ_y	$\sigma`_h$	$\sigma`_v$
Operational 03	1.5mA	72.0s	≤50ms	150×10^{-12}	298μm	23μm	22μrad	6μrad
Intermediate	1.5mA	32.0s	≤50ms	30×10^{-12}	298μm	10μm	22μrad	3μrad
Smallest Ever	1.5mA	14.4s	≤50ms	5×10^{-12}	298μm	4μm	22μrad	1μrad

Questions about the injection process

- What is an acceptable time between fills?
- Should we inject evenly spaced in time?
- Should we inject one shot or a burst of shots?
  - If a burst then is 0.5 Hz fast enough?
- What is an acceptable bunch to bunch current variation
- What is best trade off of emittance and time between injection?
- Which experiments need gating?
- Are there problems with gating?

Bunch Purity

- Two Bunch Mode requires small parasitic bunch contamination (~10^{-5})
- Presently we actively clean the fill pattern in the storage ring before giving the beam to users
- This is not compatible with Top-off
- Several light sources (Spring 8, ESRF) have successfully demonstrated bunch cleaning in the booster prior to transferring into the storage ring.
- This would be an extension of the scope but would be possible to implement at the ALS
- May be advantageous for Camshaft operation
- Is this something we should explore?

Summary

- Trying to identify user issues early-on
- We are defining the scope of Top-off
  - —We will have another set of experiments
  - —Will improve the performance of the septum
  - —Need to provide a suitable gating signal
  - —Look at the feasibility of bunch cleaning in the booster
- We would like your feedback

BES Stretched Goals

1. **Demonstrate the operation of top-off mode for two of more hours at a time at an energy of 1.5 GeV**

2. **Demonstrate the delivery of x-rays to user end stations while operating in top-off mode at 1.5 GeV for two or more shifts**

3. **Demonstrate the operation of top-off mode for two or more hours at a time at an energy of 1.9 GeV**

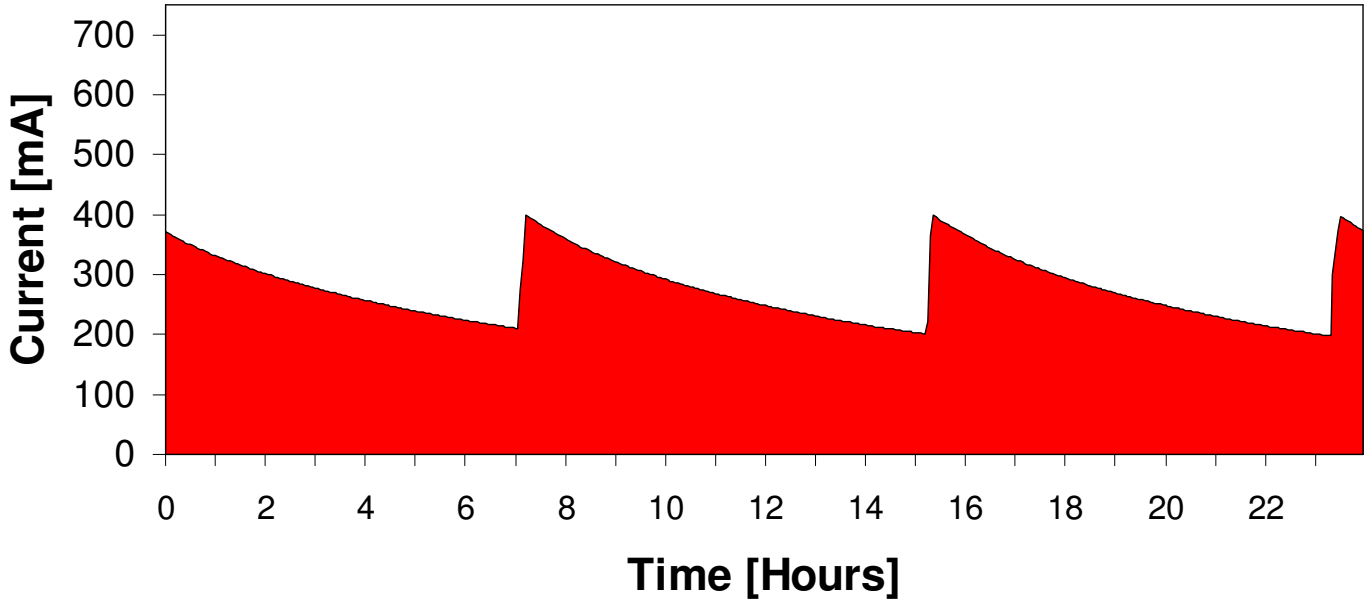
4. **Demonstrate the delivery of x-rays to user end stations while operating in top-off mode at 1.9 GeV for two or more shifts**

Present brightness limitation – beam lifetime

Brightness increases are possible by :

- **Increasing the time averaged beam current**
- **Reducing the beam size**
- **Reducing the insertion device gap**

These changes would result in unacceptably small beam lifetimes



Beam loss is caused by intrabeam scattering

- **Currently the fill the ring 3 times daily to 400mA and decays down to 200mA in 8 hours (with time averaged current of 250mA)**

Thermal Changes Impact Stability

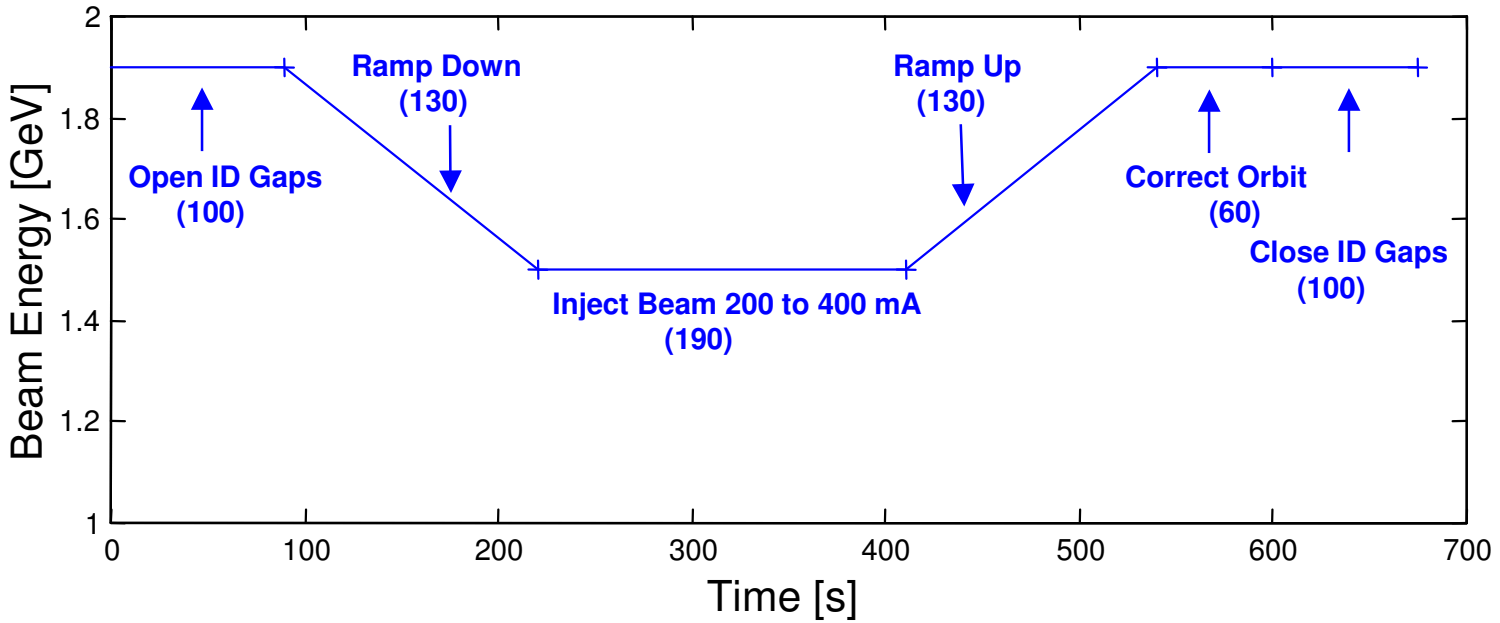
CHANGES IN THE HEAT LOAD

During a user run

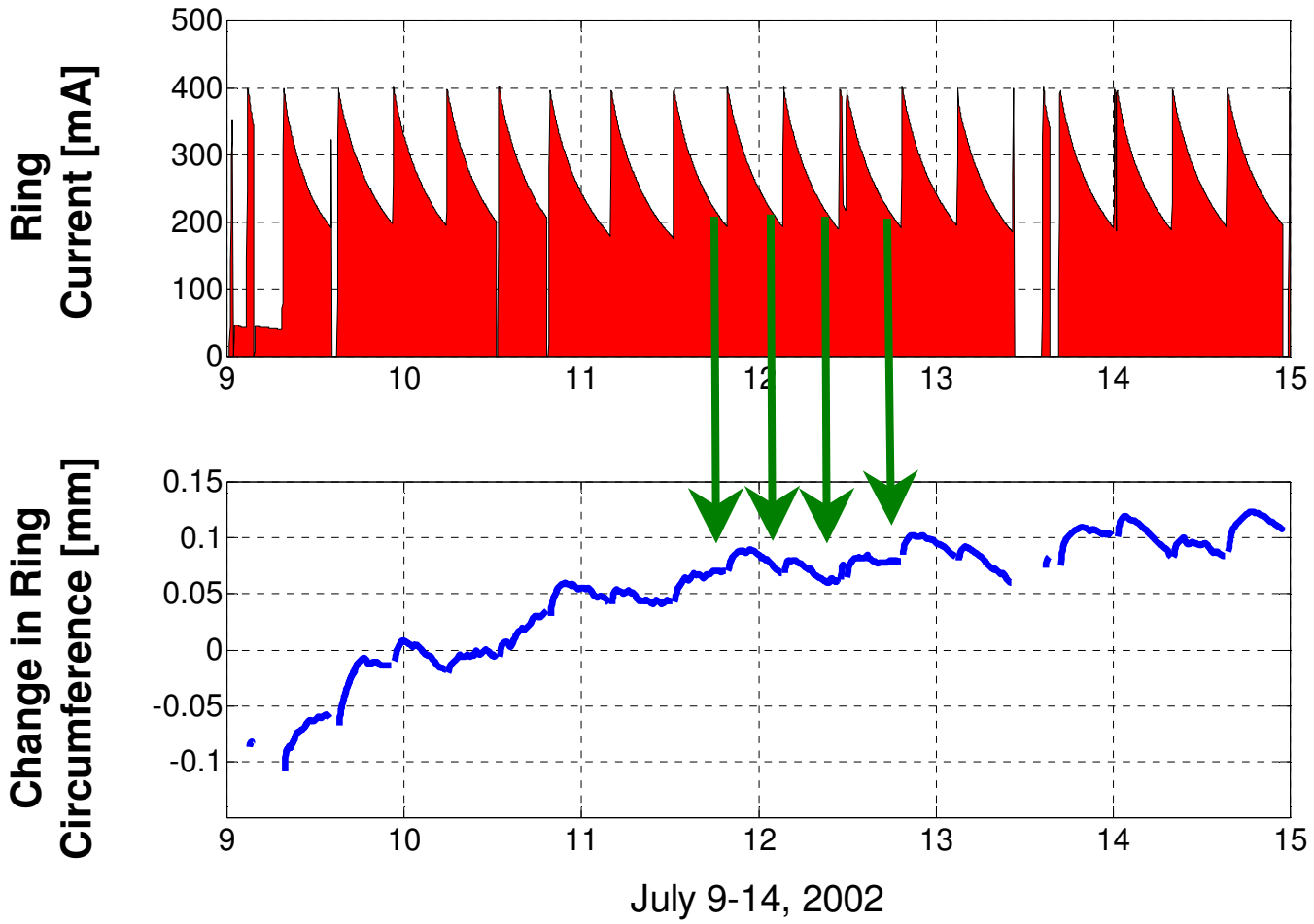
- Slow decay in the stored beam current

During the injection cycle

- Close the beamline shutters
- Ramp the storage ring magnets



Weekly variations in circumference



February 13, 2004

- David Attwood, John Bozek, Erik Gullikson, James Holton, Zahid Hussain, David Kilcoyne, Mark Le Gros Dennis Lindle, Alastair MacDowell, Mathew Marcus, Howard Padmore, Andreas Scholl, Christoph Steier, Tony Warwick, Tony Young

- Absent Mike Martin, Eli Rotenberg