PAUL SCHERRER INSTITUT

PSI

Top-up injection

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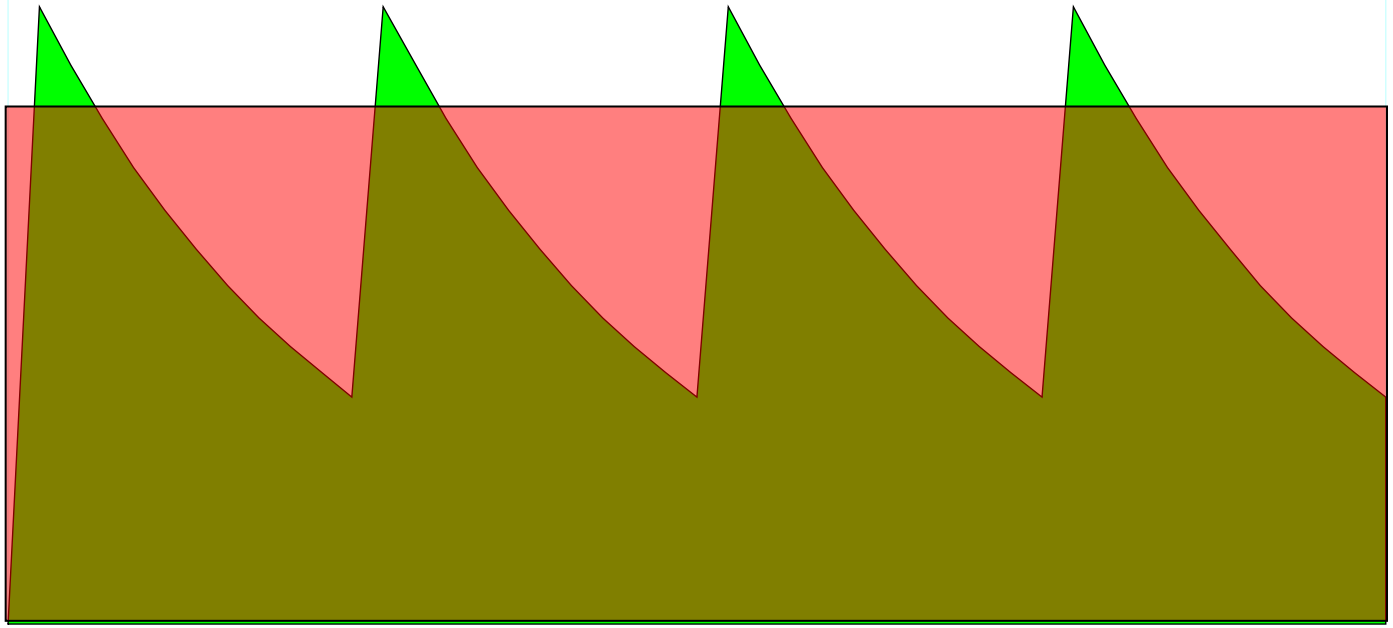
(on behalf of M. Böge, C. Gough, A. Lüdeke, V. Schlott, A. Streun and other members of the SLS team)

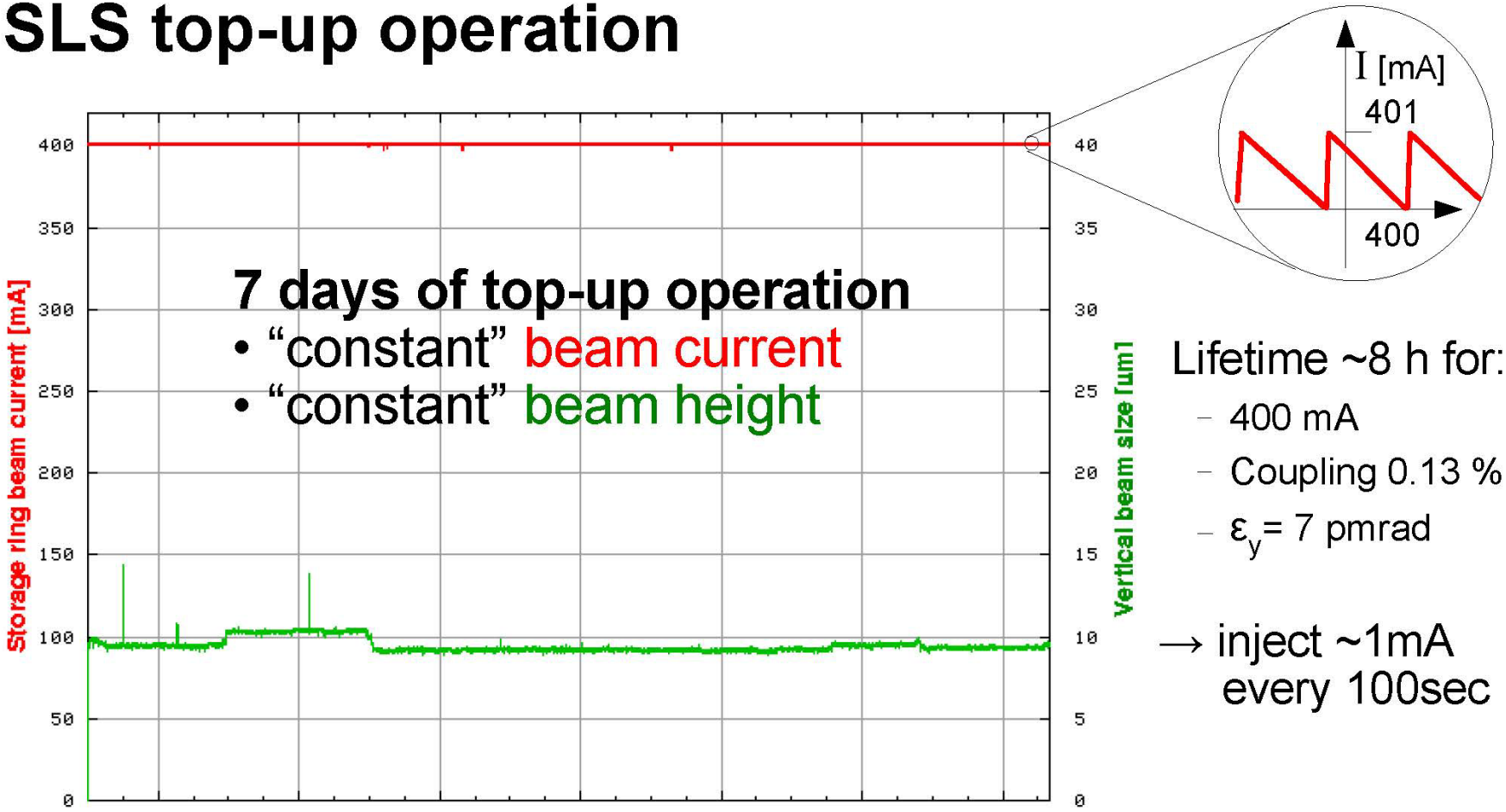
Experience at Swiss Light Source

SLS has been operating with top-up since 2001

- Beam current maintained constant to about 0.5%
- Need a full energy injector
- Injected beam with small emittance; minimize losses
- Injection gating signals provided (very rarely used)



SLS top-up operation



Lifetime ~8 h for:

- 400 mA
- Coupling 0.13 %
- ε_y = 7 pmrad

→ inject ~1mA every 100sec

- Sub-micron stability of the beam on the sample
  - higher order effects become visible!
- Performant feedbacks decoupling the beamlines

Top-up injection is used at many sources

Advantages:

- constant heat load on optical components (no refill interruptions): thermal equilibrium, but also
- constant heat load on the machine vacuum chamber
- increased stability of all systems
- diagnostics: small dynamic range

Threats

- radiation and safety issues
- injection disturbances
- injector availability
- injector running costs

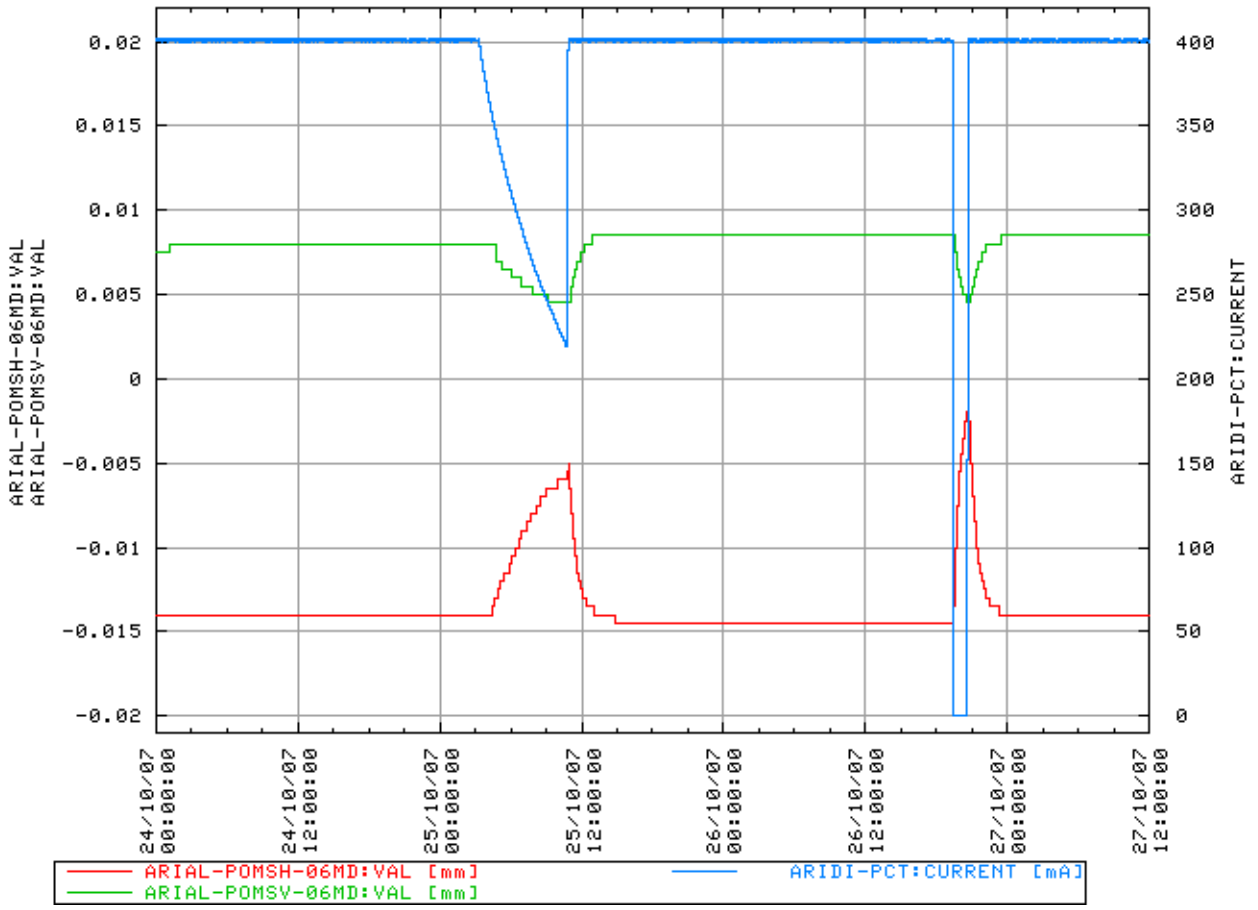
SLS: thermal equilibrium

BPMs move vs. magnet

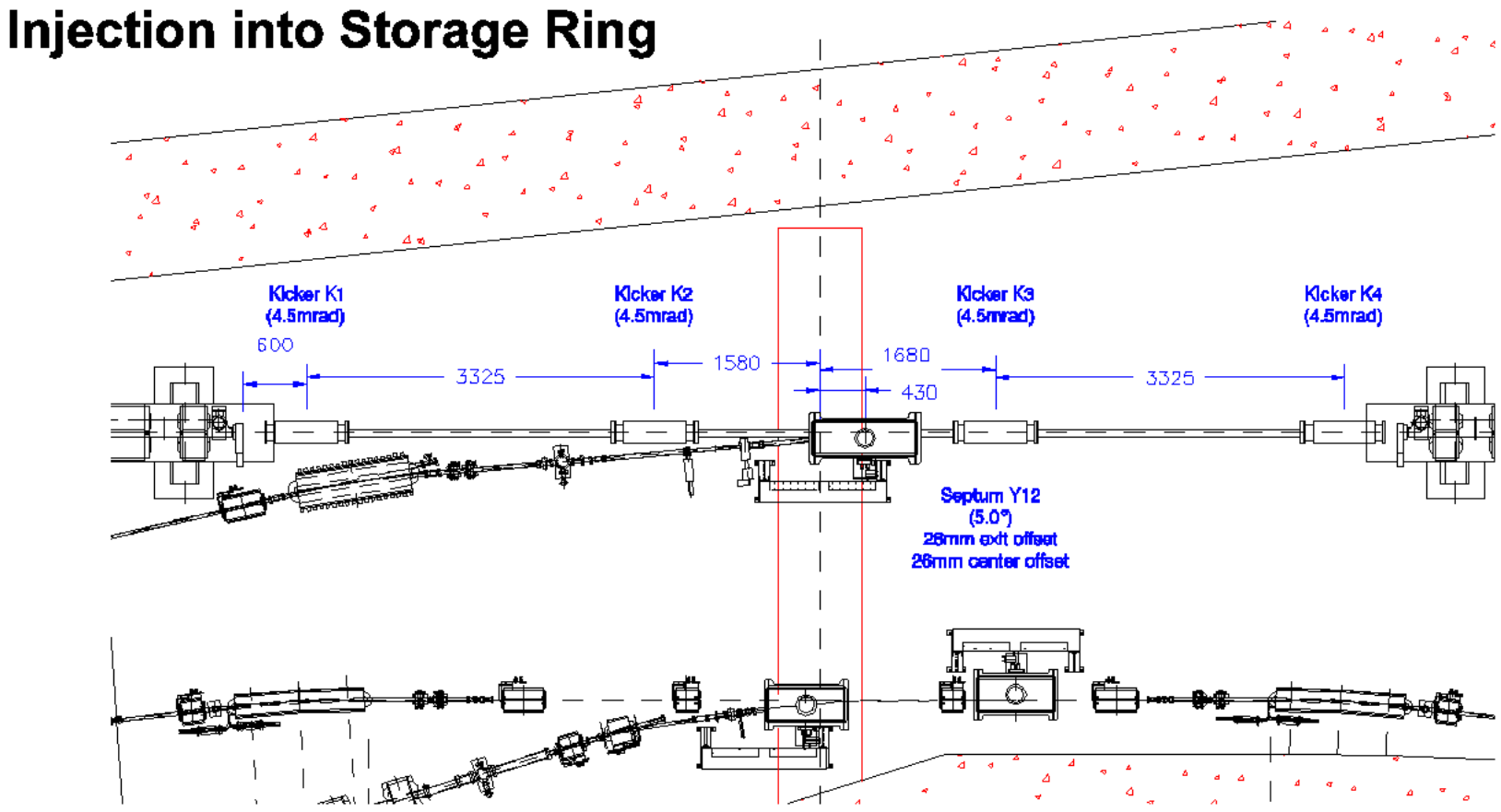
- Top-up
  < 1 μm
- Decaying beam
  5 – 10 μm

Reproducibility

- after beam loss < 1 μm
- time constant about 30 min

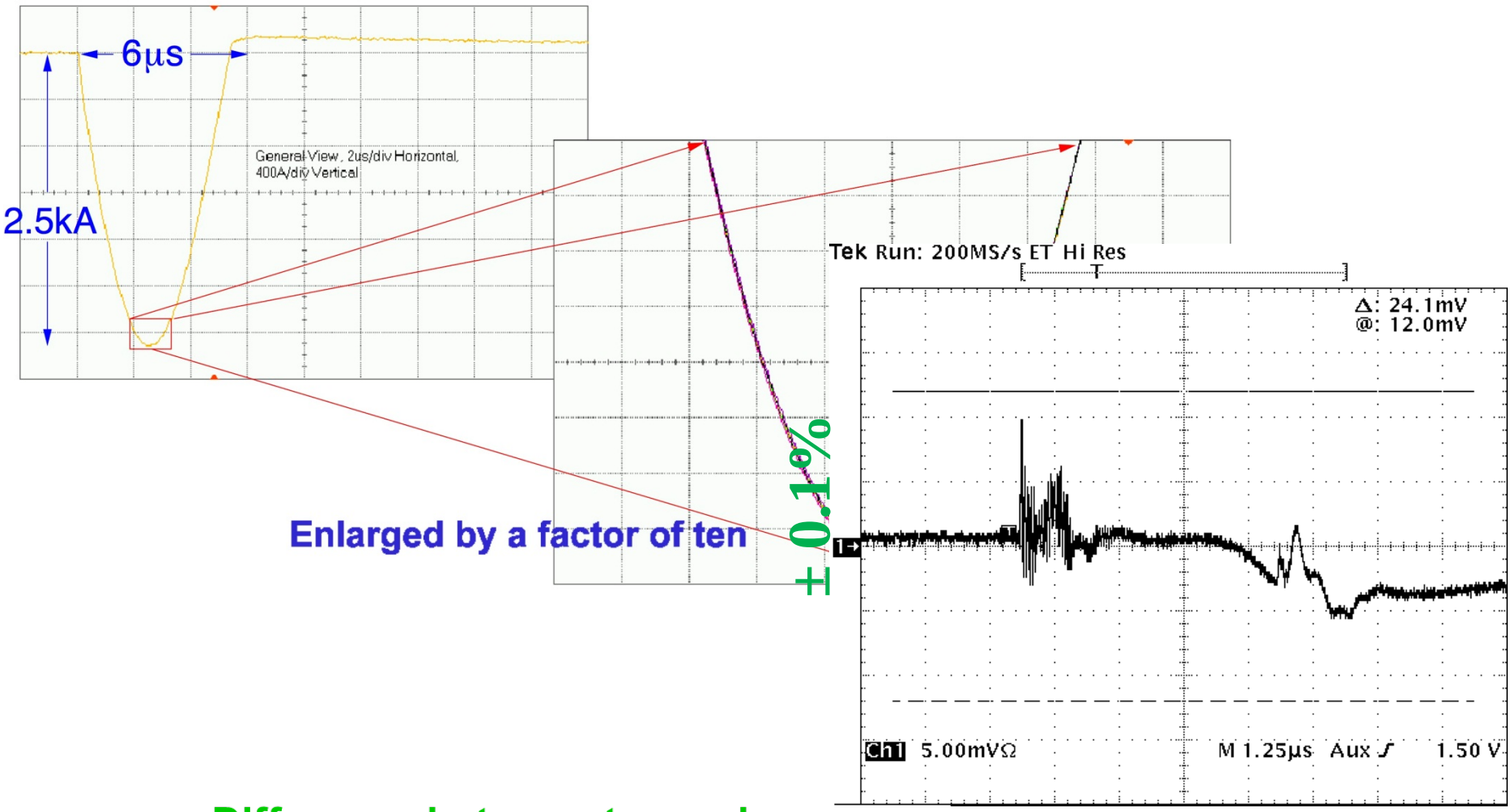


SLS Injection: transverse phase space



Symmetric bump on 11m long straight
No intervening multipoles

Kicker waveforms can be made ~ identical



Difference between two pulsers with identical inductive loads

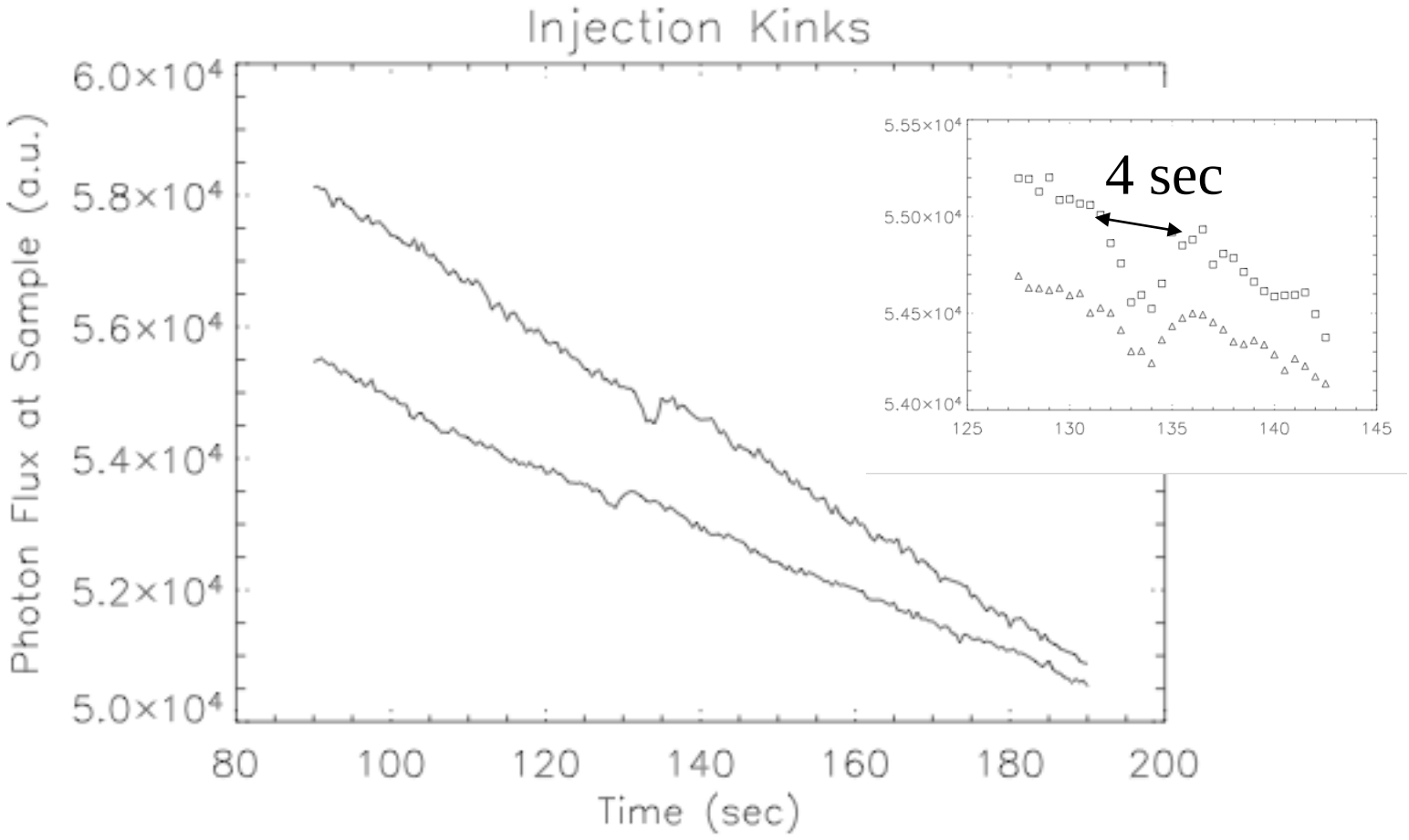
Chris Gough

SLS: closure of the injection kicker bump

Residual kick of injection bump

- The residual kick is about 50 μm in both planes
- Smeared out after 100 turns by Landau damping
- Beamlines see drop in intensity
  (beam vertical blow-up,
  from 10 μm to 40 μm
  within 1 ms)
- Vertical beam size is damped down in 2 – 3 damping times, 20 ms

SLS: top-up seen at a beamline



- Photon flux at sample taken at a rate of 2 Hz (LUCIA)
- Data taken with scanning energy → slope of data.

SLS: radiation and safety issues

Injector has to be designed for top-up

- high injection efficiency is important
- keep the losses down
- total losses independent of top-up frequency (lifetime)

Stored beam is the best guarantee for top-up safety

SLS: radiation and safety issues

Top-up permission from authorities without constraints

- No special top-up interlocks
- Open photon shutters allowed even during machine development
- No significant top-up related radiation has ever been measured

Vertical aperture limit is wiggler vacuum chamber

- Beamline with highest radiation level
- Wiggler was replaced with in-vacuum cryo-undulator
- Impedance optimized vertical scraper for injection straight installed

  Protects in-vacuum undulators for gaps ≤ 4 mm

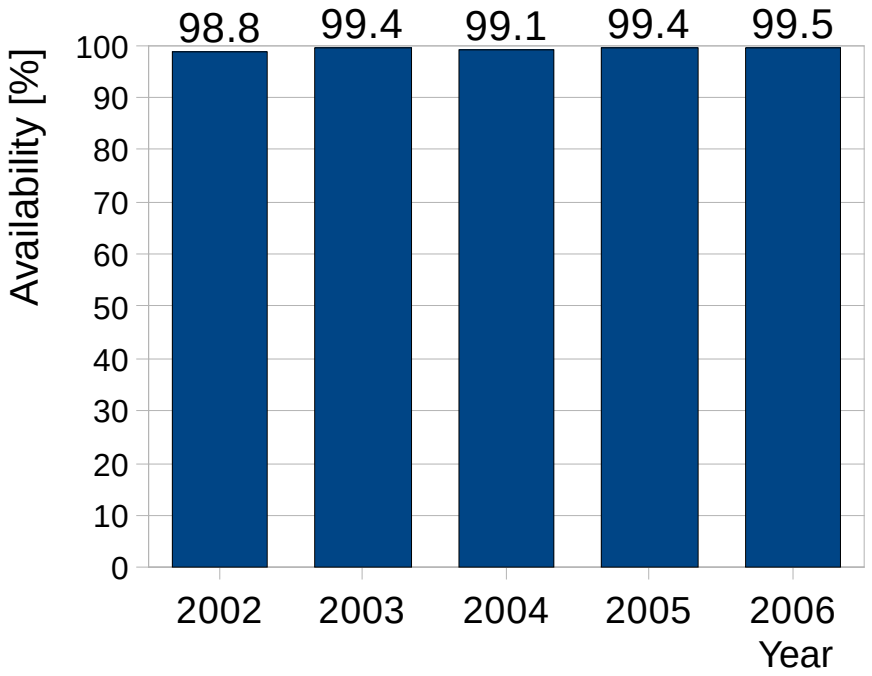
  Localize particle losses in best shielded area

SLS injector availability

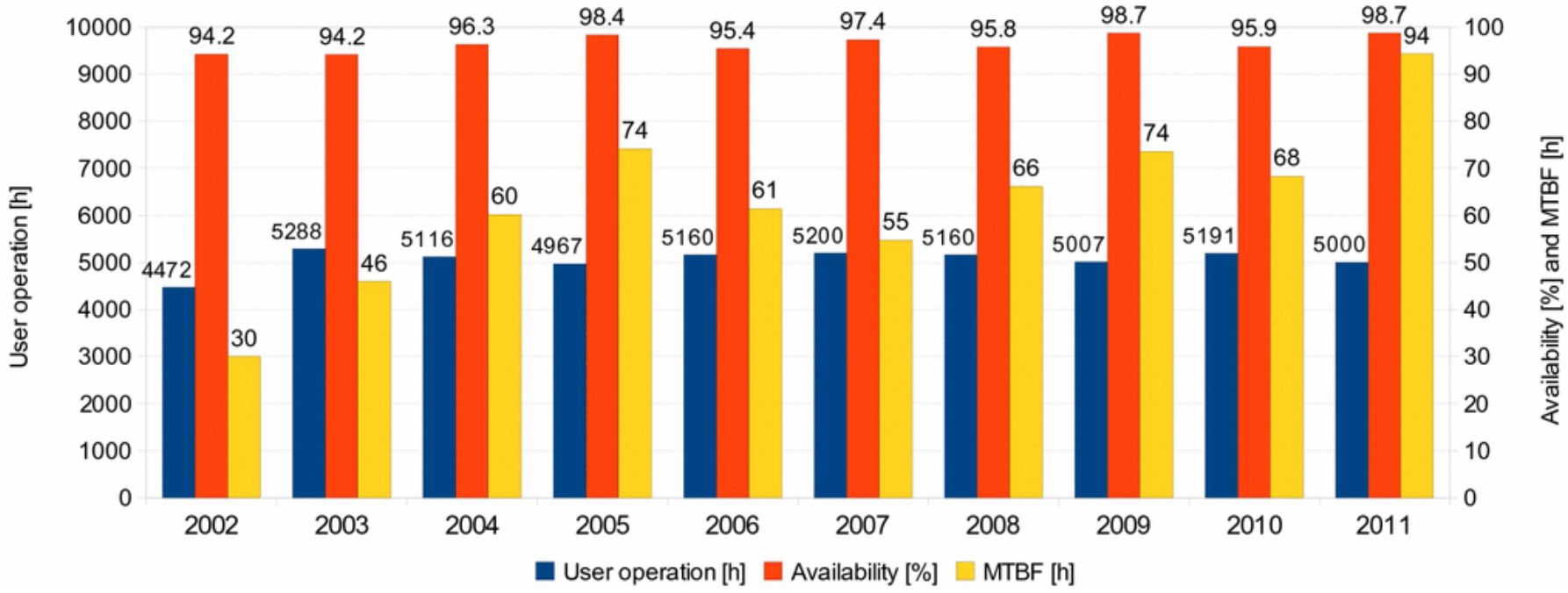
Short outages of less then 2 min. can be ignored

- Recovery from Linac and Booster RF system arcs is often shorter

Average injector availability > 99 %



Top-up is key to high stability & availability



Ultimate Storage Ring issues, questions

Top-up is a pre-requisite for sub-micron stability

Diagnostics: higher resolution over small dynamic range:

- BPM 1 mA → 400 mA ~ 100 μm absolute errors
- but 400 mA → 401 mA ~ 100 nm absolute errors

Different injection schemes, including on-axis, long. ?

Diffraction limited source:

- tolerance to injection disturbances: transverse, energy
- possibility of longitudinal injection?
- gating signals to the beamlines: they may be used!

Thank you