Lifetime and apertures

Apertures measurements

longitudinal – cavity voltage scan
vertical – scraper and/or kick excitation
horizontal – scraper and/or kick excitation

Longitudinal aperture > 1.8% (1.8% SLS, 2.4% ESRF, 2.5% BESSY-II)
(but agreement with model is not excellent)
Transverse aperture also generally smaller than expected

Lifetime is limited by apertures (dynamic or physical depending on the machine)

The cases where simulations agree with measurements are rare !
(careful modelling is mandatory:
edge focussing, fringe in dipoles, octupoles in quads, …)

Identification of causes for lifetime reduction: the case of an inverted sextupole

Beam lifetime suddenly reduce by 30% after a shutdown; reduced momentum aperture through RF scans (a sextupole problem was suspected; one or more “bad” sextupoles)

Methodology: Physical quantities to target for comparison machine to simulations

- chromaticity sector by sector;
- Tune dependence on orbit bump through sextupoles
- Chromatic phase advance (phase advance for different dp/p from orbit response matrix at dp/p)
- Second order dispersion;
- Empirical search with harmonic sextupole knobs
- Guidance from tracking (sextupole scan with 6D tracking: discrepancy in optimised solutions)

The cause was identified successfully after 1 year

Lifetime issues at NSLS-II

Lifetime > 3h; required dp/p 2.5% (dp/p_RF = 3%)

Effect of multipolar errors (systematic and random) from 4D tracking with off – momentum and definition of tolerances

Momentum aperture impacted by Damping Wigglers, 5 mm in vac gaps;

Apertures at ESRF

Investigated dependence of lifetime on transverse apertures and momentum apertures

Longitudinal

Energy acceptance (lifetime vs RF voltage scan) dp/p 2.4 %
limited by transverse dynamic aperture; no effect from septum
Measurements agree with simulations only after a 0.75 reduction of the bunch volume

Horizontal

Dynamic aperture limitation in H (decrease H aperture decreases lifetime)
measured dip at -1% not fully understood
Increase in chromaticity decreases dynamic aperture reduce lifetime

Vertical

limited by the physical ID gap $\pm$4 mm

Detuned lattice for ESRF upgrade can be reoptimised to achieve the same lifetime

Apertures at BESSY

longitudinal – cavity voltage scan
- 2.5% no effect of 4 SCW

vertical – scraper and/or kick excitation experiments
- 2.1 mm from scraper due to low gap ID
- roughly confirmed with kickers

horizontal – scraper and/or kick excitation experiments
- scraper: no clear limitation visible
- 10 mm with kick excitation (septum at 12.1 mm)

Impact of intensity in the aperture measurements
- transverse wake quadrupole effect seen on the FM

Impact of non linear stray field from septum:

Enlargement of H aperture with tune point:
- FM helps identifying strong resonances and good WP
- Much more resonances are found in the real machine

Apertures at SLS

longitudinal – cavity voltage scan

- 1.8% (RF acceptance 3%)
- lifetime decreases with chromaticity
- Suspected nonlinear resonance

vertical – scraper

- well understood (1.5 -1.8 mm mrad measured - 2 mm mrad in FEMTO wig.)
- 1.55 corresponds to 3.5 mm from scraper due to low gap ID
- lifetime not limited by vertical acceptance:
- vertical aperture can be further reduced (lower gap 4 mm; round beams)

horizontal – kick excitation experiments

- smaller than theory (Ax = 30 mm mrad)
- but sufficient for 100% injection efficiency
- kicking up to Ax 11 mm mrad did not reach the horizontal aperture limit
- exp with stronger detuning also showed smaller H aperture

Touschek lifetime with coupling (low chromaticity and high chromaticity)

- good agreement with simulations for low chromaticity (0.4%)
- not for high chromaticity
- Beam lifetime 8 hrs in user operation is acceptable.