OPERATION MODES OF THE METROLOGY LIGHT SOURCE
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OUTLINE

• RF incident

• Established User Modes

• Exotic Operation Modes
• operation since 2008
• purpose: metrology
• two operators sharing duty for BESSY II and MLS
• manned operation Mo – Fr / 7-23
• unmanned operation (user & machine) during nights and weekends
• highly automated operation (machine & users)
• 10 h of machine commissioning time per week (+ Sunday + commissioning weeks)
RF FAILURE – IOT POWER SUPPLY

- IOT power supply (the only RF cavity) faulted during user operation
- overheat protection
- reason: oil pump
- Time to recover was 3 days
- stock spares
- replace on time
ESTABLISHED USER MODES
• fully automated (push-button)
• change optics $\approx 10$ s
• reinject $\approx 15$ min
• homogeneous filling, 200 mA, no gap
$\rightarrow$ ions 😞
MOTIVATION: DESIGN USER

- $\xi_{\text{hor}} \approx 120 \text{ nrad m}$
- $I_T \approx 1000 \text{ mAh}$
- $>80\%$ of scheduled user time
- $\alpha = 0.03$
HOW TO GET THERE?

• Ions
  • clearing electrodes
  • sinusoidal excitation
  • white noise excitation applied to the vertical plane (minimized coupling)
• white noise feedforward as a function of current
• Tune feedforward (U125)
• active longitudinal multi bunch feedback
MOTIVATION: GENERATE COHERENT SYNCHROTRON RADIATION

• $\xi_{hor} \approx 200 \text{ nrad m}$
• $I\tau \approx 1600 \text{ mAh}$
• $\alpha = +1.3e^{-4}$
• Usually used in the bursting region... $I \approx 100 I_{th}$
HOW TO GET THERE?

- carefully set up 3D chromaticities on optic ramp (while squeezing the beam)
- octupole
- Introduce coupling to improve S/N ratio of spectra
- Masterclock frequency controller
MOTIVATION: NEAR FIELD MICROSCOPY

- $\xi_{\text{hor}} \approx 30 \text{ nrad m}$
- $I\tau \approx 400 \text{ mAh}$
- Increasing part of user time
- Dynamics heavily ion-dominated
- Outperforming similar experiments at other sources
HOW TO GET THERE?

- preserve usage of the existing energy ramp → allow fast optic changes
- cross multiple 3rd order resonances with full current
- sextupole settings adjusted on ramp and in user state
MOTIVATION: STUDY INTRABEAM SCATTERING ??

- lengthening vanishes on transverse blow up
- no bursting

- absolutely calibrated
- close to resolution limit 😃
EXOTIC OPERATION MODES
MOTIVATION: TICKLE & PROBE MEASUREMENTS

- based on alpha buckets / nonlinear longitudinal beam dynamics
- idea: make both buckets race each other
- alpha buckets need to be in the RF cavity at the same time (diff. energy loss negligible)
- breaking longitudinal symmetry of the ring
MOTIVATION: TICKLE & PROBE MEASUREMENTS

- low-α lattice (on average!)
- large partial momentum compaction of different signs in both halves of the ring (R56)
MOTIVATION: TICKLE & PROBE MEASUREMENTS
MOTIVATION: TICKLE & PROBE MEASUREMENTS

- Accessible bunch length range corresponds to low-alpha range (factor $\sqrt{2}$ due to $\alpha$-buckets)
- Delay is tunable
- Arbitrary current distribution
- Horizontal emittance suffers due to dispersion manipulation
- Only THz usage so far

Streak measurement in ID straight
MOTIVATION: BEAM SEPARATION

operation close to resonance
MOTIVATION: BEAM SEPARATION
HOW TO GET THERE?

- starting from DBA lattice
- setup optic ramp to cross coupling resonance, move working point near $\Delta Q_{\text{hor}} = \frac{1}{3}$
- correct transverse chromaticities
- use 3rd sextupole family to preserve lifetime while approaching the resonance
- carefully check diagnostics:
  - lifetime measurement or loss monitor
  - tune spectra
  - source point imaging system / emittance measurement
  - take care for strong IDs / machine protection

• only core populated
• only islands populated
• only “one island” populated
• core and islands equally
MOTIVATION: REVOLUTION DOWN CONVERSION

How to populate a single island?

→ Nonlinear kicking (stripline)

streak measurement
(aperture used to exclusively select photons from a single island)

- (a) equally populated islands
- (b) + (c) single island populated
MOTIVATION: USER OPERATION

Commissioning together with users to optimize beam separation (rotation in phase space)

two user runs in decay mode with more than 10 h each for ARTOF experiments
USER EXPERIENCE WITH ISLAND BUCKETS

- operational stability is surprisingly high → pushbutton implementation for the operator
- long term orbit stability is comparable to standard user operation
- beam lifetime is acceptable for decay operation
- scientific case is not very strong for the MLS as it is a very flexible machine anyway → apply to BESSY II or BESSY VSR
  see talk of P. Goslawski
- large emittance requires delicate tuning to minimize intra-bucket diffusion rates
  \[ \Delta Q_{\text{hor}} = \frac{1}{3}, \frac{1}{4} \] suitable resonances for operation
- dynamics were also investigated around
  \[ \Delta Q_{\text{hor}} = \frac{1}{2}, \frac{1}{5} \]
- also works in the vertical plane at \[ \Delta Q_{\text{ver}} = \frac{1}{3} \]
• user operation of the MLS is characterized by:
  • single standard user mode
  • many user-tailored modes making use of machine flexibility
  • close cooperation with users when developing new modes of operation
• CSR instability thresholds
• Ions dominating dynamics in several states
• MLS is a great machine to study nonlinear beam dynamics
  • Longitudinal plane → alpha buckets
  • Transverse plane → resonance island buckets
• experience gained is transferred between MLS and BESSY II
• realization of the Robinson wiggler project will be exciting
THANK YOU FOR YOUR ATTENTION
REFERENCES

• Nonlinear Momentum Compaction and Coherent Synchrotron Radiation at the Metrology Light Source
• Survey of Beam Optics for the MLS Lattice
• BESSY VSR Technical Design Study
• Transverse Resonance Island Buckets at the MLS and BESSY II
• Status of the Robinson Wiggler Project at the Metrology Light Source
BACKUP SLIDES
BEAM LOSSES

Accumulated lost electrons due to sudden beam loss over time.

- Total
- E-Ramp
- O-Ramp
- Static
- Beamshutter clearance = true
- Commissioning
- Intentional

Time scale: 02/05/14 to 02/05/15.
• $E = 50 \ldots 629$ MeV
  (105 MeV inject.)
• $C = 48$ m
• $R_{bend} = 1.528$ m
• $\delta_0 = 0.7e^{-4} \ldots 4.2e^{-4}$
• $f_{rf} = 500$ MHz
• $U_{rf} = 500$ MV
• $\tau = 20$ s ... 10 ms
• $\alpha = -3e^{-2} \ldots 7e^{-2}$
• $\sigma = 1$ ps ... 100 ps
• $Q_{hor} = 3.18$
• $Q_{ver} = 2.23$
Operation Modes of the MLS - Markus Ries et al. - ESLS AAm - Paul Scherrer Institut - Böggis - 25.11.2015
MOTIVATION: STUDY BURSTING THRESHOLDS
NEGATIVE ALPHA

MOTIVATION: STUDY CSR BURSTING DYNAMICS

- low-α operation without octupole
- study differences near the bursting threshold for ±α
MOTIVATION: LOW EMITTANCE – RAMPING DOWN

![Graph showing beam current over time](image-url)
MOTIVATION: REDISTRIBUTE DAMPING PARTITION

Principle of operation

Pole

\[ \Delta X \propto \eta_x \]

\[ \vec{B} \]

Operation Modes of the MLS - Markus Ries et al. - ESLS XXIII - Paul Scherrer Institut - Böttstein - 25.11.2015