STATUS BESSY II

P. Kuske
Introduction: Some Facts about BESSY II

On-going Projects:
  new 50 MeV LINAC
  Fast Orbit Feedback
  Top-Up Operation
  EMIL
  Modernization

Future Projects:
  BESSY_VSR

Other Projects @ HZB:
  BERLinPro

Outlook

slides „borrowed“ from A. Jankowiak, D. Schüler, R. Müller, K. Bürkmann, ....
BESSY II – The Storage Ring

- Energy/current: 1.7GeV / 300mA
- Emittance: 6 nm rad 4 nm rad
- Straight sections: 16
- Undulators / MPW+WLS: 10 / 1+3
- ID / dipole beam lines: 32 / 20
- End stations (fixed+var): 52

~ 5000 h/a user service
~ 2400 users / a
~ 1000 h/a beam test + commiss. used for accelerator research

Running up-grades:
- New injector linac for 30x higher charge in single bunch injection (under commissioning right now)
- Fast Orbit Feedback, up to 100Hz
- Top-Up (will start 2012)

R+D project: Development and tests of a new non-linear injection kicker (NO field on axis)
Experimental Verification of Emittance Reduction

\[ \tau_a \approx \tau_x \cdot \sigma^2 / A^2 \cdot e^{(A^2/2\sigma^2)} \]

Measurement of the aperture dependent quantum lifetime with scrapers

30 % emittance reduction in agreement with theoretical expectations

without 7T sc IDs

I < 1 mA

Thanks to
R. Thornagel (PTB)
>> from THz to keV <<

- spectroscopy & scattering
- imaging & lithography
- dynamic studies

pioneered low $\alpha$ ps beams (3ps), CSR, THz

femto slicing
100fs, polarized x-rays
6kHz and variable pump probe laser

flexible fill patterns
single bunch, hybrid, ...
Integration of the Linac in the Synchrotron-Tunnel
(Dirk Schüler)
Limited space and radiation from booster
During injection with the Microtron into the Booster we observed approx 20 mSv/h in Linac area. This radiation induces problems in the Gun Cabinet and in the 500 MHz-Prebuncher.
The picture shows the radiation survey after shielding and orbit correction.
Cathode Driver Board

The Driver Board is designed and made by Thales. During commissioning HV sparks in the Gun cabinet destroyed the very fast and over-sensitive output transistor.
Water leak

In November 2010 after one month of commissioning a water leak between the structure cooling water tube and the vacuum occurred. Thales and PMB needed 4 months to find a solution and complete repair. The cooling tube was repaired in the BESSY Synchrotron tunnel.

BESSY got a 12 Year warranty for the Linac Structure. This warranty includes a newly designed structure.
All specified Beam parameters were achieved

<table>
<thead>
<tr>
<th>SAT results</th>
<th>spec. SB</th>
<th>measured</th>
<th>spec. MB</th>
<th>measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (MeV)</td>
<td>50</td>
<td>50.9</td>
<td>50</td>
<td>50.6</td>
</tr>
<tr>
<td>Transmission (%)</td>
<td>61</td>
<td>64</td>
<td>68</td>
<td>88</td>
</tr>
<tr>
<td>Charge (nC)</td>
<td>0.35</td>
<td>0.34</td>
<td>2.00</td>
<td>2.15</td>
</tr>
<tr>
<td>Energy Spread (% rms)</td>
<td>0.40</td>
<td>0.24</td>
<td>0.40</td>
<td>0.39</td>
</tr>
<tr>
<td>norm. Emittance h/v (π mm mrad)</td>
<td>50/50</td>
<td>38.6/32.7</td>
<td>50/50</td>
<td>12.2/10.7</td>
</tr>
</tbody>
</table>

**Today's Booster current for MB 1.7 mA and for SB 0.1 mA**

this is already comparable to the Microtron

**First injection in the storage ring with SB on 29/09/2011**

**It is possible to use the existing injection line optic with both injectors**

**Charge restrictions in place due to radiation protection**
Orbit Quality and Fast Orbit Feedback (Roland Müller)

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Status by Components

Fast BPM Data Acquisition: Existent (100%)
- 2.4 kHz Sampling Rate
- FFT Diagnostic Use: 0.5 – 200Hz

New Fast Powersupplies: 8/112 Installed
- Transfer function: up to 200Hz
- Control flexibility
- Comparable Specs @ +/- 8A, 40V

Fast Set Point Distribution: Operational (100%)
- Digital I/O board modified
- Reflective Memory: BPM DAQ, PS IOCs
- Known Time Budget: < 8ms/cycle

Optimized Algorithms: currently tuned (20%)
- Rapid Prototyping: Matlab Middle Layer (MML)
- Verification: Slow FOFB == proven SOFB
- Closed Loop Tests (Beam Time Needed)

Open questions

Interplay of SOFB/FOFB
- Removal of FOFB DC component
- Inference of golden Orbit
- Role of RF

Control system integration
- Performance monitoring, supervision, control
- Detection of faults, misreadings
- Countermeasures

Phase II = New BPMs
improved position precision, fast diagnostics
- New, innovative solutions available (NSLS-II)?

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Beam current limitation $I < 300$ mA (7 T Wiggler)
Lifetime requirement $\tau > 5$ h (radiation shielding), $\tau > 10$ h in routine operation
Booster current $I_{\text{syn}} > \sim 1$ mA (efficiency determination with <1 % accuracy)
$\Rightarrow \Delta T \sim 20$-40 s and $\Delta I_{SR} \sim 0.4$ mA, also for top-up of intense single bunches
standard optics with strong negative impact of IDs in the doublet straights:
reduce impact of IDs in the doublet straights by smaller horizontal $\beta$-function:

horizontal $\beta$-function 20 m/rad in the injection straight and 10 m/rad elsewhere;
should make oscillation of injected beam smaller at IDs.
“4 wire“-design
In-vacuum stripline-type design

4 wires with 200A each
Kicker Magnet Design for BESSY II

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Real Injection Studies

4-kicker injection bump optimized for small orbit perturbation

injection efficiency $\sim 80\%$

single, non-linear injection kicker – not fully optimized:
horizontal $< 60\,\mu$  
vertical $< 15\,\mu$

injection efficiency $\sim 80\%$ up to 300 mA
After the tests the kicker had to be removed

Thermal and Vacuum Problems: Temperature at the outside of the kicker tank increased within 20-30 min to 60° C with \( I_{mb} = 300 \) mA or \( I_{sb} = 15 \) mA, along with severe vacuum degradation

Beam Dynamics Issues: Except for vacuum related beam blow-up no coupled bunch instability was observed

Injection Efficiency: was as good as with the 4 kicker injection bump, stored beam was far more stable
Details of the Kickermagnet

5 μ thick Ti-coated ceramic holds the wires and allows image currents to flow
Figure 3: Sectional view of kicker magnet structure, second magnet design.
New experimental capabilities @ BESSY II: EMIL / SISSY

At first it was

SISSY - Solar Energy Material In-Situ Laboratory at the Synchrotron

Than it became

EMIL - Energy Material In-Situ Laboratory Berlin

SISSY – Catalysis – 60to6

And all this is part of

DOMINO

restructuring the user floor

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Targets given by EMIL:
- spectral range (60 eV – 10 keV)
- small focal spots
- high brilliance over large spectral range in „one“ beamline

Solution - 2 insertion devices in one straight section:
1. 60eV ... 2000eV covered by conventional out-of-vacuum APPLE II undulator
2. 2 … 8 keV in the 1st to 7th harmonic covered by planar hybrid in-vacuum cryogenic undulator (to be developped by G-A3, Undulators. J. Bahrdt)

Challenges for EMIL / SISSY

Optical functions

Optics development and beam tests:
G. Wüstefeld, P. Schmid, P. Kuske
Preservation and Modernization

Running annual Budget ~ 1 M€ / a
maintenance, licenses, small replacement, small R&D, consumables, travelling

800 k€ / a
operation, app. progs., control system, electronic, power supplies, diagnostic, vacuum

200 k€ / a
rf, cryo

Projects: preservation, modernisation, up-grade:

| projects    | up to 2010 | 2011 | 2012 | 2013 ...
|-------------|------------|------|------|----------
| Linac       | 2654       | 1015 | 90   |          |
| Top-Up      | 751        | 175  | 324  |          |
| HOM cavities| 370        | 380  |      |          |
| 7T MPW      | 175        | 175  |      |          |
| Sum         | 3485       | 2360 | 1244 |          |

From 2012 on:

2000 k€ / a is available for photon projects (machine + user floor)

On average per year: 1000 k€ for the machine!
(projects needs to be negotiated within BESSY II steering com.)
pioneered short pulse operation in low-$\alpha$ mode (IR, THz, coherent THz) (special mode, not compatible with most other users)

provides $\ll \text{ps}$ pulses from femto-slicing facility (limited flux, only one ID)

→ provide short pulses (ps and shorter) at all end stations simultaneously with high flux, high brilliance
BERLinPro – Project definition (Andreas Jankowiak)

BERLinPro = Berlin Energy Recovery Linac Project

100mA / low emittance ERL demonstrator, including all the key aspects of large scale ERL
An accelerator science and technology experiment

3 x 2 cell cavities, 4.5MeV
3 x 7 cell cavities, 44MeV

1.5-2MeV SRF-Gun

<table>
<thead>
<tr>
<th>Basic Parameter</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>max. beam energy</td>
<td>50MeV</td>
</tr>
<tr>
<td>max. current</td>
<td>100mA</td>
</tr>
<tr>
<td>nominal bunch charge</td>
<td>77pc</td>
</tr>
<tr>
<td>pulse length</td>
<td>~ 2 ps</td>
</tr>
<tr>
<td>Rel. energy spread</td>
<td>~10^{-4} range</td>
</tr>
<tr>
<td>rep. rate</td>
<td>1.3GHz</td>
</tr>
<tr>
<td>normalized emittance</td>
<td>&lt; 1mm mrad</td>
</tr>
</tbody>
</table>

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Up-Grade = Providing new and unique capabilities
Bridging the gap to the future

To allow BESSY II to reach the future:

Preservation (continuous replacement of worn out and out dated components, e.g. standard power supplies, control hardware, ...)

Modernisation (better than only preservation)
(e.g. new solid state rf-transmitters replacing old klystron systems  → higher reliability, lower phase noise = higher beam quality)