Welcome
and Accelerators & Accelerator Research @ HZB

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Head Institute for Accelerator Physics
Helmholtz-Zentrum Berlin
total staff about 1150 (400 scientists), 140 Mio€ annual budget
Member of the Helmholtz- Association (Germanys 18 large scale research facilities)
BESSY II – 3rd generation light source (UV/XUV/Soft-X-Ray)

Construction 1992 – 1998, in user operation since 1999

Energy/current 1.7GeV / 300mA
Emittance 4/6 nm rad
Pulse length 15 ps (rms)
Circumference 240 m
Straight sections 16
Undulators / MPW+WLS 12 / 1+2
Beamlines 46

> 5000 h user operation, 3000 user visits / a
> 98% availability

low-\(\alpha\) operation, femto slicing
ps beams, CSR, THz, 100 fs, polarised x-rays

300 mA constant current

TopUp
\(\Delta I \sim 1.5 \text{ mA} @ 300 \text{ mA}\)

injection efficiency

Monday: maintenance

9 days

standard mode = 4 in 1
excellent support of timing experiments
A. Jankowiak, Welcome & Accelerators@HZB, ARIES – WP7 RUL: Topical Workshop, HZB, Berlin 28.08.2017

Timing Experiments well supported @ BESSY II

- ~2 weeks true SB (single bunch): 13.5 mA / Bunch, 27 ps
- ~2 weeks low α, MB (multi bunch) 0.025 mA or 0.33 mA /Bunch, 5 ps (non-bursting/bursting)
- Camshaft bunch (1 Bunch) 4 mA, 17 ps, purity > 10^4 (pump, probe)
- fs-slicing (3 Bunches) 4 mA / Bunch, 17 ps → 100 fs light pulses, 10^6 photons/s, 0.1%BW

Pseudo Single Bunch:
- MHz chopper, beamline PM4, within 180 ns dark gap
- PPRE excited (1.25 MHz, 17 ps, and low-α 4 ps, 10^7-10^9 photons/s 0.1%BW)
- PPRE sliced (6 kHz, 100 fs, same ARTOF setup)

Multi-mode fill pattern standard hybrid fill since 2015
BESSY VSR – variable pulse length storage ring upgrade

\[ \sigma \propto \delta_0 \sqrt{\frac{E_0}{f_0} \cdot \frac{\alpha}{V_{rf}}} \quad l \propto \alpha \]

30 Mio€ investment, fully funded implementation phase 2017 – 2022

high voltage (20 MV/m) cw multi-cell SC cavities allow to increase the total voltage gradient by to orders of magnitude → ca. 1/10 bunch length @ constant momentum compaction

Combining two RF systems with different frequencies (1.5 GHz & 1.75 GHz) generates long and short buckets, which can be filled individually to generate optimized fill pattern.

One cryo-module with:
2 x 4 cell @ 1.5 GHz & 2 x 4 cell @ 1.75 GHz
operating at 1.8 K LHe temperature
active length: 1.50 m with 20 MV/m
total gradient: \(2\pi \times 50 \text{ MV} \times \text{GHz} \) (x 60 increase)

Installed voltage: 16 MV @ 1.5 GHz
14 MV @ 1.75 GHz
• 300 mA average current
• camshaft single bunches (short and long) in gaps
• ion clearing provided through gaps

**multi functional hybrid mode**

ps short single bunch, high current single bunch, slicing bunches, high average brilliance, background of intense CSR/THz radiation

**preserving BESSY II emittance and TopUp capabilities**

(> 90% inj. efficiency on average, > 60% single shot)
BESSY-VSR – Main challenges

• verification of the scaling behaviour bunch-length versus current

• development and operation of high gradient superconducting cavities
  1.5 GHz and 1.75 GHz @ 20 MV/m gradient cw
  → 130W @ 1.8 K cooling plant
  → particulate free (clean) vacuum around cavity straight, 10^-10 mbar

• control of coupled bunch instabilities
  induced by higher order modes of sc cavities
  → proper HOM damping design of sc cavities
  → sufficiently strong bunch by bunch feedback

• operation with large (transient) beam loading and
in regime of possible Robinson instability
  lifetime reduction, phase shift over bunch train, losses
  → careful set up and control of RF-parameters
  → appropriate low-level RF-control
  → control of vertical phase space

• top up operation: injection from booster in short VSR bunches, lifetime
  bunch length in booster 42 ps, injection efficiency > 90%
  → bunch “compression” in booster necessary
important test-bed for our accelerator R&D and education (Master, PhD Students)

Robinson Wiggler Study concluded within the dissertation Tobias Tydecks:
- manipulation of damping partition numbers, e.g.
  - increase bunch length
  - increase lifetime
- more flexible user operation
- project started
  J. Feikes, J. Li, T. Tydecks, et al.

- metrology in the UV-EUV
- optimised for low-alpha operation
  (IR / THz generation)
- EUV reflectometry (ZEISS)
bERLinPro = Berlin Energy Recovery Linac Project

100 mA / low emittance technology demonstrator (covering key aspects of large scale ERL)

Test and diagnostic line
(5mA@10MeV dump, energy & slice diag.)

Modified Cornell booster
3 x 2 cell srf cavities
4.5 MeV

Srf-gun
1.4 cell srf cavities
1.5-2.3 MeV, single solenoid,

Linac module
3 x 7 cell srf cavities
44 MeV

Beam dump
6.5 MeV, 100 mA
= 650 kW

Bunch length (straight)
2 ps or smaller (100 fs)

Rep. rate
1.3 GHz

Losses
< 10^{-5}

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<thead>
<tr>
<th>Basic Parameter</th>
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<tbody>
<tr>
<td>max. beam energy</td>
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<tr>
<td>50 MeV</td>
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<tr>
<td>max. current</td>
</tr>
<tr>
<td>100 mA (77 pC/bunch)</td>
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<tr>
<td>Normalized emittance</td>
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<tr>
<td>1 μm (0.5 μm)</td>
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Project started 2011, fully funded
Building ready 2017
First electrons 2018
Recirculation 2019/2020
bERLinPro – building near to completion

August 2017 – building & technical infrastructure near to completion

BESSY II
High bay building
Technical Infrastructure building
LN₂ storage
Helium gas storage
Underground bunker

8. March 2017, underground accelerator hall
Installation of magnets and girder

August 2017 – building & technical infrastructure near to completion
GunLab – SRF photo electron gun test stand

1.4 cell SRF gun cavity, high QE photo cathode, up to 3.5 MeV, first beam just now
Thank you for joining us!

Enjoy the workshop, HZB, and Berlin