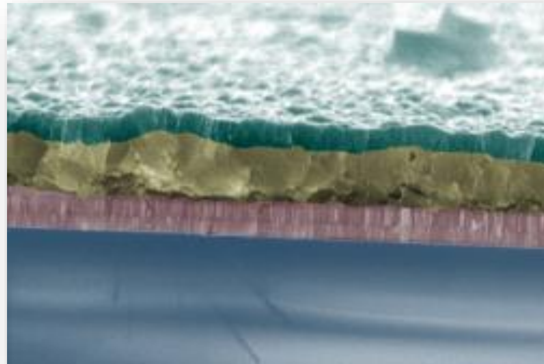
Welcome

and Accelerators & Accelerator Research @ HZB

Andreas Jankowiak
Head Institute for Accelerator Physics
Helmholtz-Zentrum Berlin

RULε (WP7) Topical Workshop
Injection & Injections Systems
28.08.2017

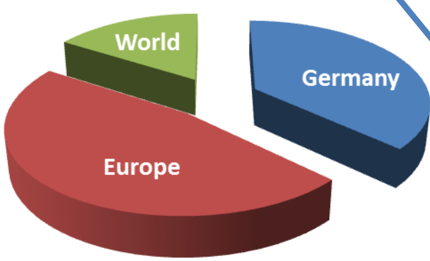
Helmholtz-Zentrum Berlin



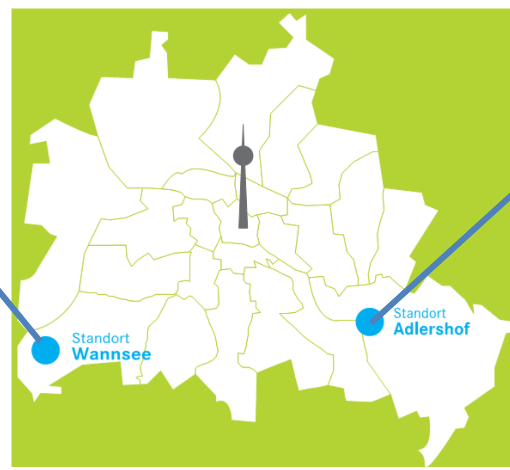
Neutron Source BER II
Berlin-Wannsee

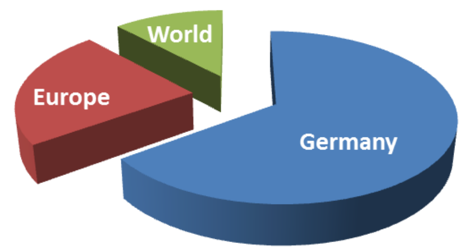
Materials & Energy Research

Photon Source BESSY II
Berlin-Adlershof



BER II: 400 user visits p.a.





BESSY II: 3000 user visits p.a.

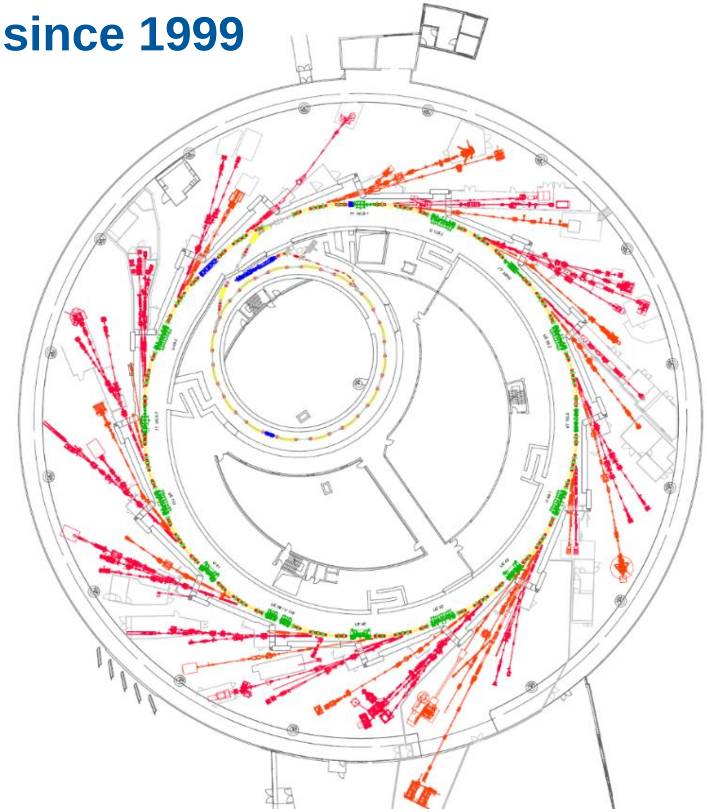
total staff about 1150 (400 scientists), 140 Mio€ annual budget

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

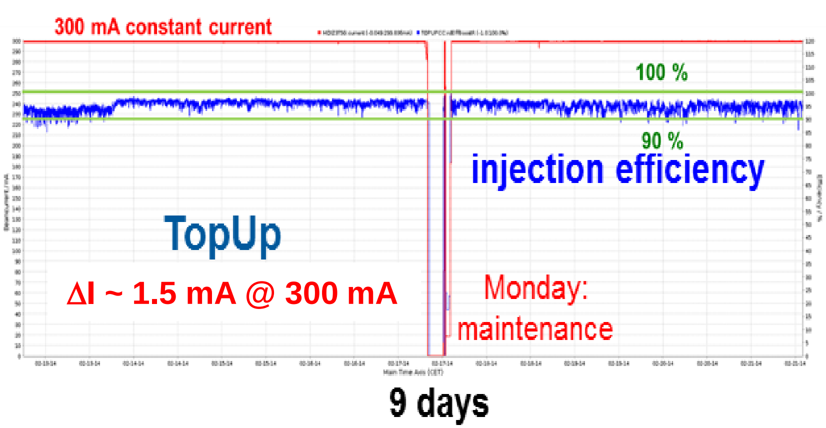


> 5000 h user operation, 3000 user visits / a

> 98% availibility

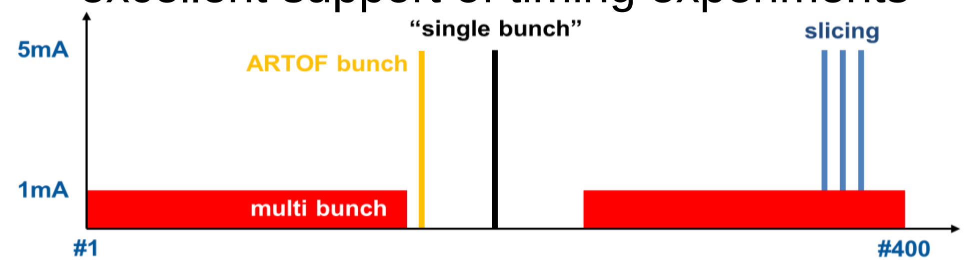
low-α operation, femto slicing

ps beams, CSR, THz, 100 fs, polarised x-rays



standard mode = 4 in 1

excellent support of timing experiments

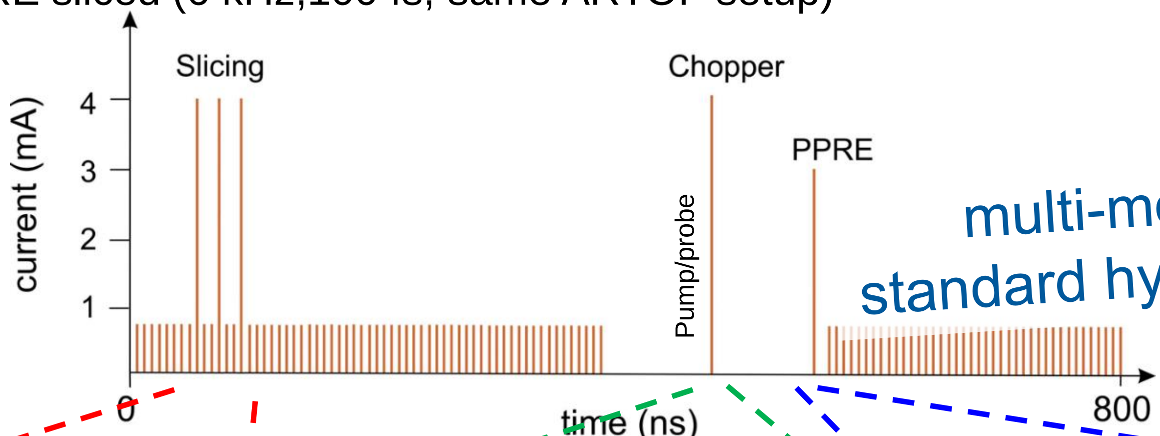


Timing Experiments well supported @ BESSY II

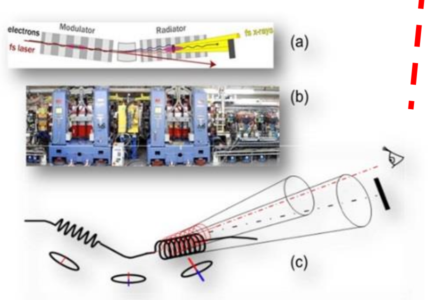
- ~2 weeks true SB (single bunch): 13.5 mA / Bunch, 27 ps
- ~2 weeks low α, MB (multi bunch) 0.025 mA or 0.33mA /Bunch, 5 ps (non-bursting/bursting)
- Camshaft bunch (1 Bunch) 4 mA, 17 ps, purity > 10^4 (pump, probe)
- fs-slicing (3 Bunches) 4 mA / Bunch, 17 ps → 100 fs light pulses, 10^6 photons/s,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

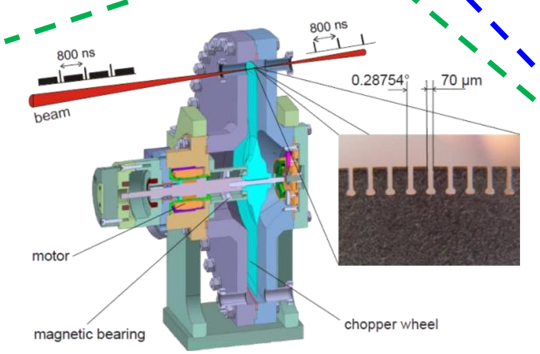
Pseudo Single Bunch:

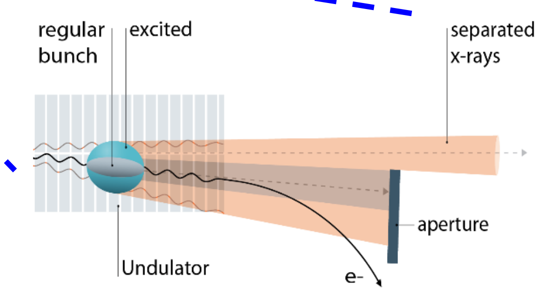
- MHz chopper, beamline PM4, within 180 ns dark gap
- PPRE excited (1.25 MHz, 17 ps, and low-α 4 ps, 10^7-10^9 photons/s 0.1%BW)
- PPRE sliced (6 kHz,100 fs, same ARTOF setup)



multi-mode fill pattern
standard hybrid fill since 2015





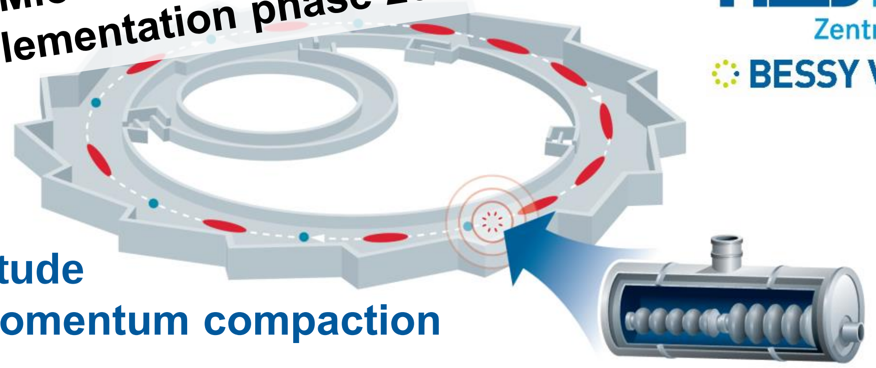


BESSY VSR – variable pulse length storage ring upgrade

$$\sigma \propto \delta_0 \sqrt{\frac{E_0}{f_0} \cdot \frac{\alpha}{\dot{V}_{rf}}} \qquad I \propto \alpha$$

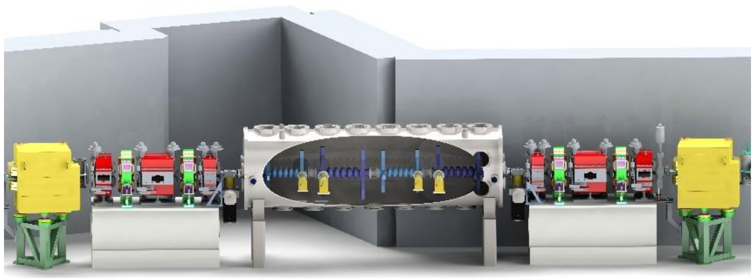
30 Mio€ investment, fully funded
implementation phase 2017 – 2022

HZB Helmholtz Zentrum Berlin
BESSY VSR

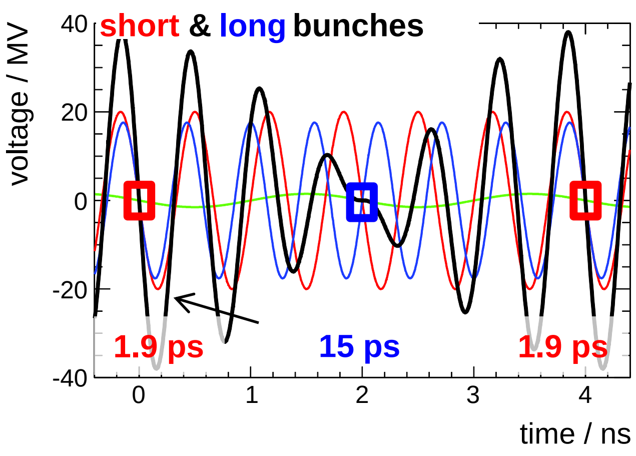


high voltage (20 MV/m) cw multi-cell SC cavities allow to increase the total voltage gradient by to orders of magnitude
→ ca. 1/10 bunch length @ constant momentum compaction

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.

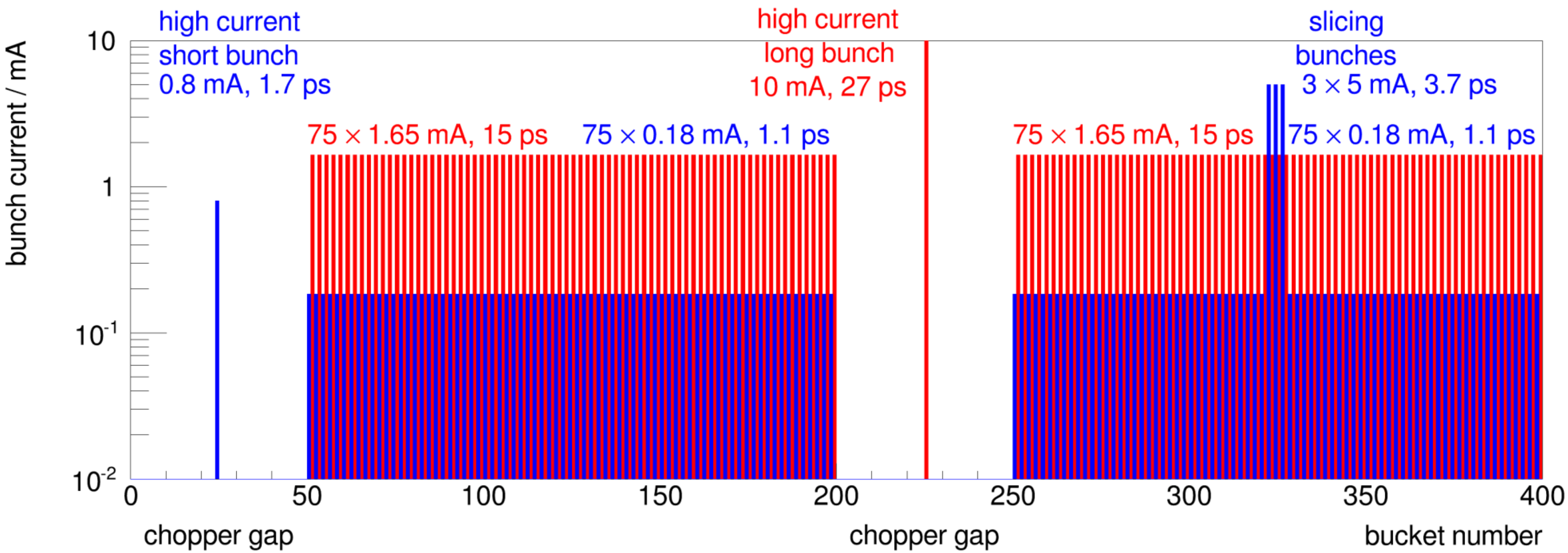


One cryo-module with:
2 x 4 cell @ 1.5 GHz & 2 x 4 cell @ 1.75 GHz
operating at **1.8 K LHe** temperature
active length: **1.50 m** with **20 MV/m**
total gradient: **2π 50 MV×GHz (x 60 increase)**



Installed voltage: 16 MV @ 1.5 GHz
14 MV @ 1.75 GHz

VSR – adding advanced timing capabilities to storage rings



- 300 mA average current
- camshaft single bunches (short and long) in gaps
- ion clearing provided through gaps

in low alpha mode
500 fs @ 0.04 mA / bunch

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

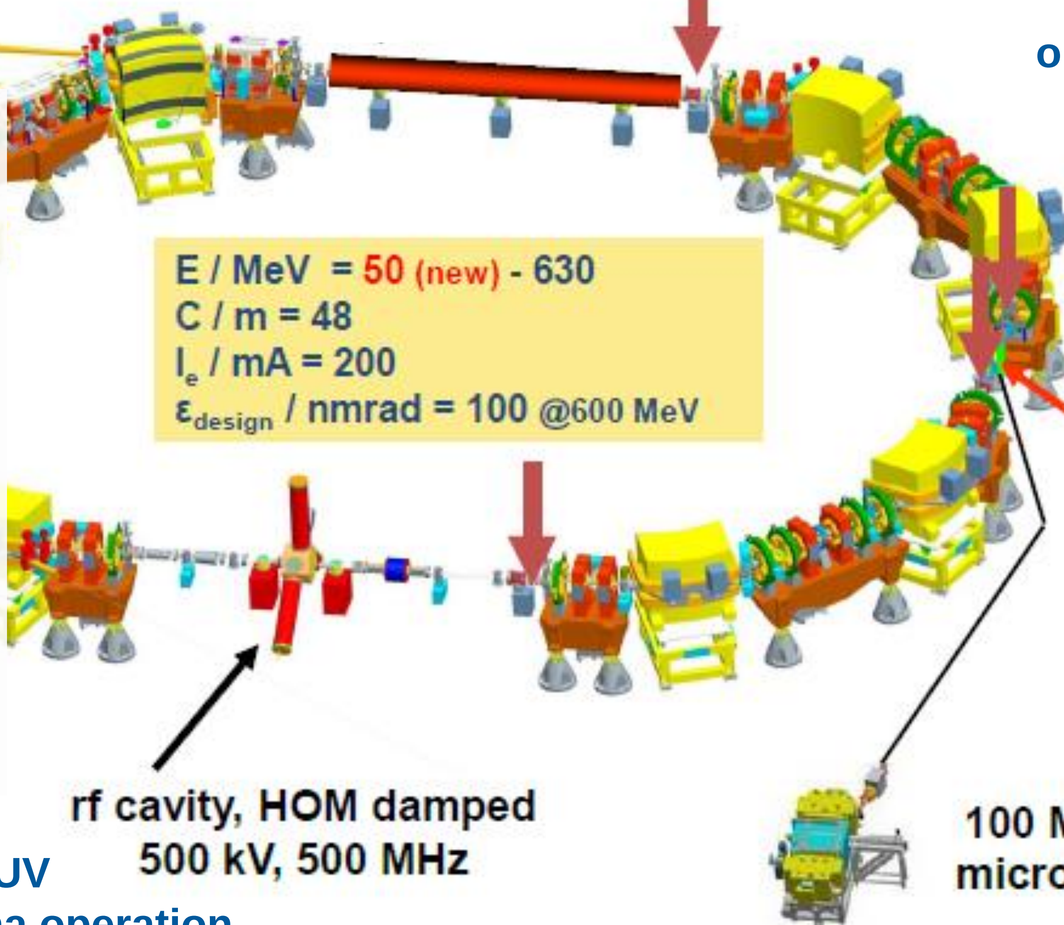
- **top up operation: injection from booster in short VSR bunches, lifetime**
  bunch length in booster 42 ps, injection efficiency > 90%
  → bunch "compression" in booster necessary

Metrology Light Source (MLS)

important test-bed for our accelerator R&D and education (Master, PhD Students)

owned by PTB

developed and operated by HZB



Robinson Wiggler from PS (CERN)

L. Nadolski, ESLS XIX, Horizontal Emittance Reduction using a Robinson Wiggler

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

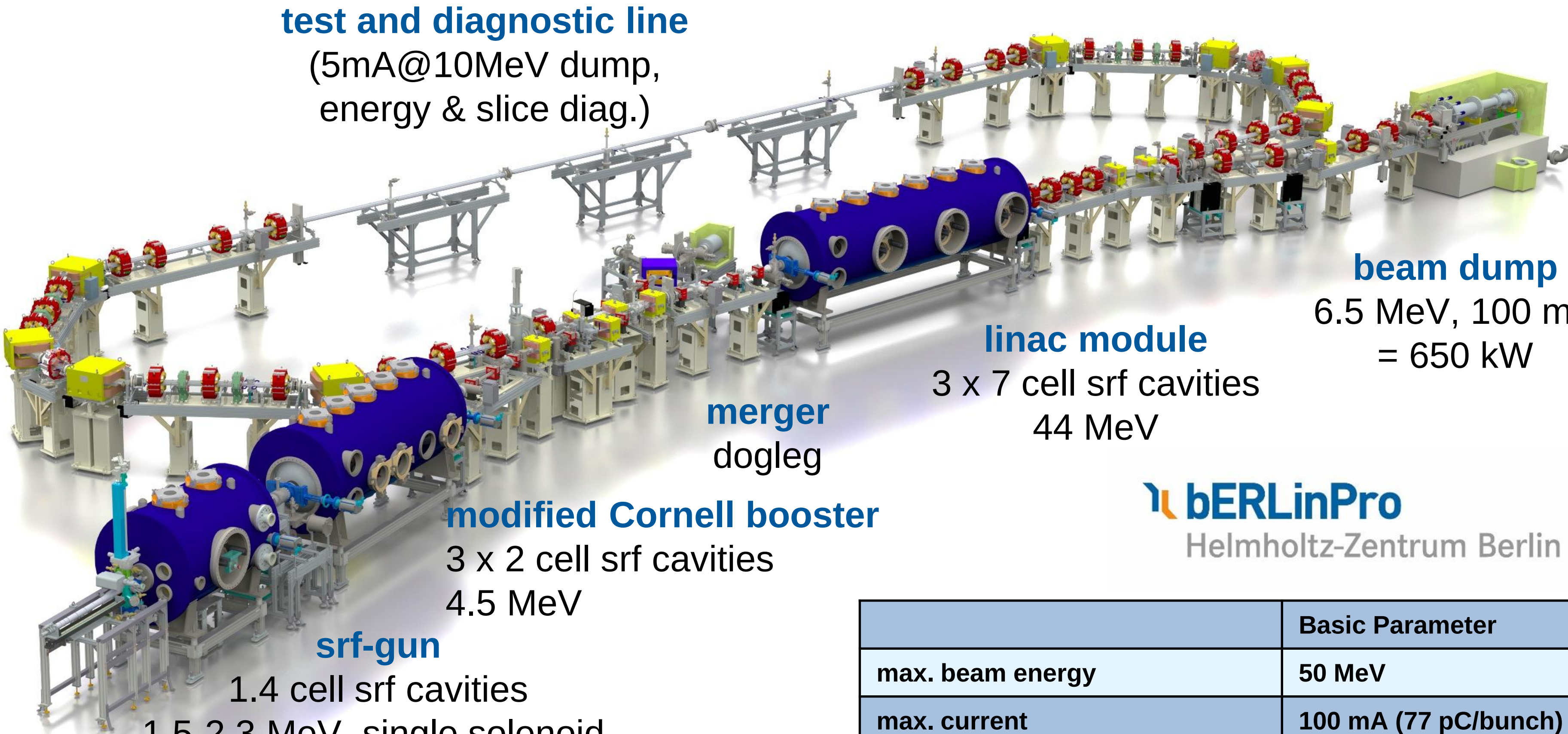
J. Feikes, J. Li, T. Tydecks, et al.

- **metrology in the UV-EUV**
- **optimised for low-alpha operation (IR / THz generation)**
- **EUV reflectometry (ZEISS)**

bERLinPro – Berlin Energy Recovery Linac Project

bERLinPro = Berlin Energy Recovery Linac Project

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



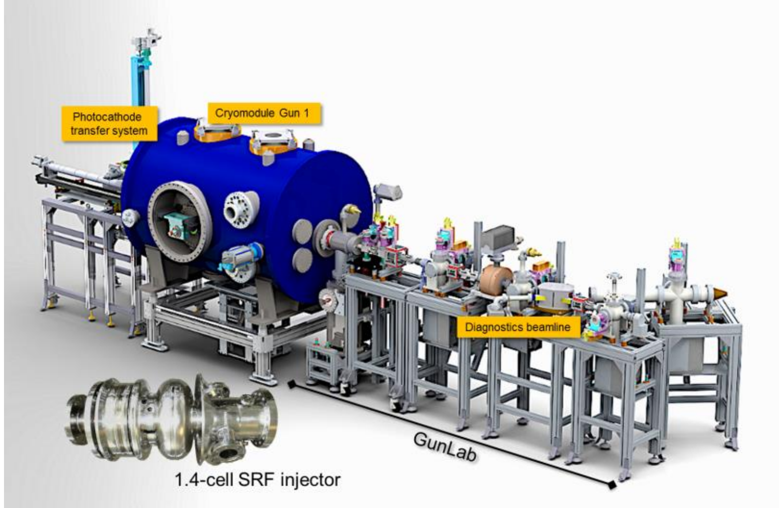
	Basic Parameter
max. beam energy	50 MeV
max. current	100 mA (77 pC/bunch)
normalized emittance	1 µm (0.5 µm)
bunch length (straight)	2 ps or smaller (100 fs)
rep. rate	1.3 GHz
losses	< 10^{-5}

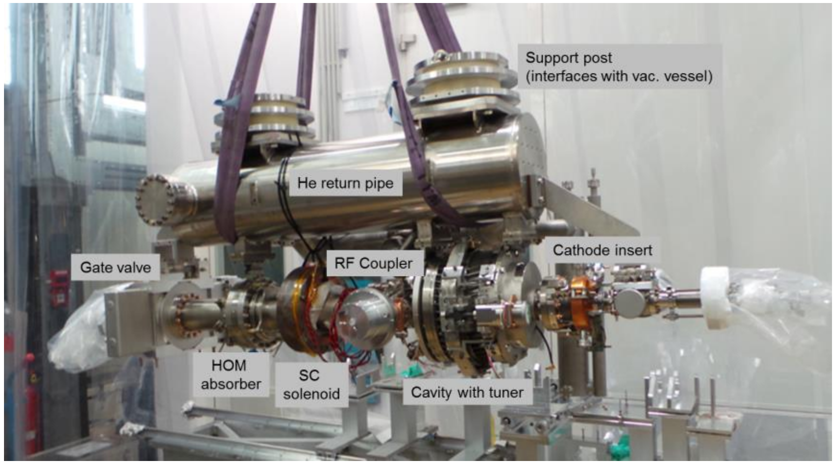
project started 2011, fully funded
building ready 2017
first electrons 2018
recirculation 2019/2020

bERLinPro – building 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