Current Capabilities at the Metrology Light Source

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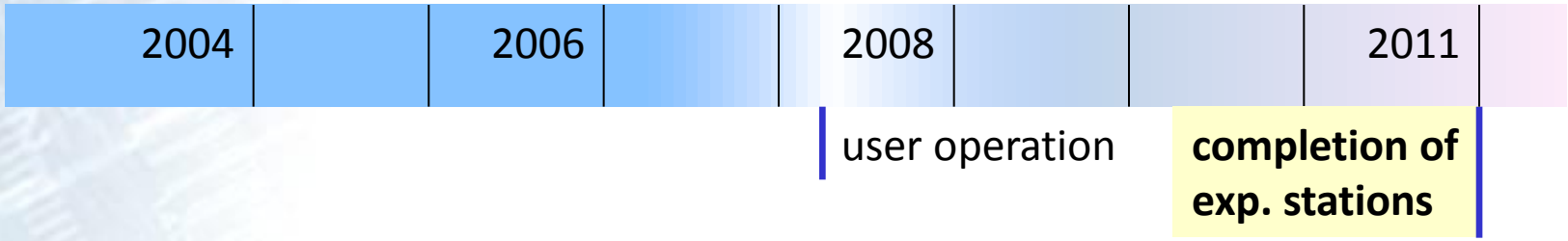
PTB's Metrology Light Source (MLS)

630 MeV electron storage ring

Synchrotron radiation from THz to EUV

PTB owned,
HZB* operated

**Helmholtz-Zentrum Berlin, formerly BESSY*



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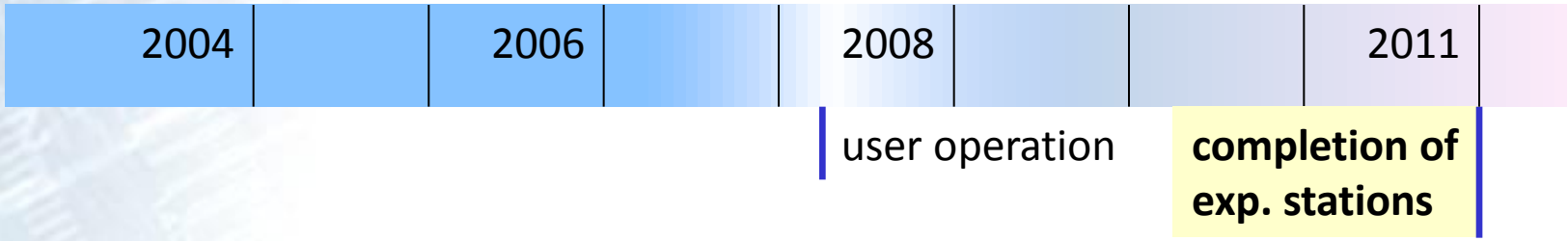
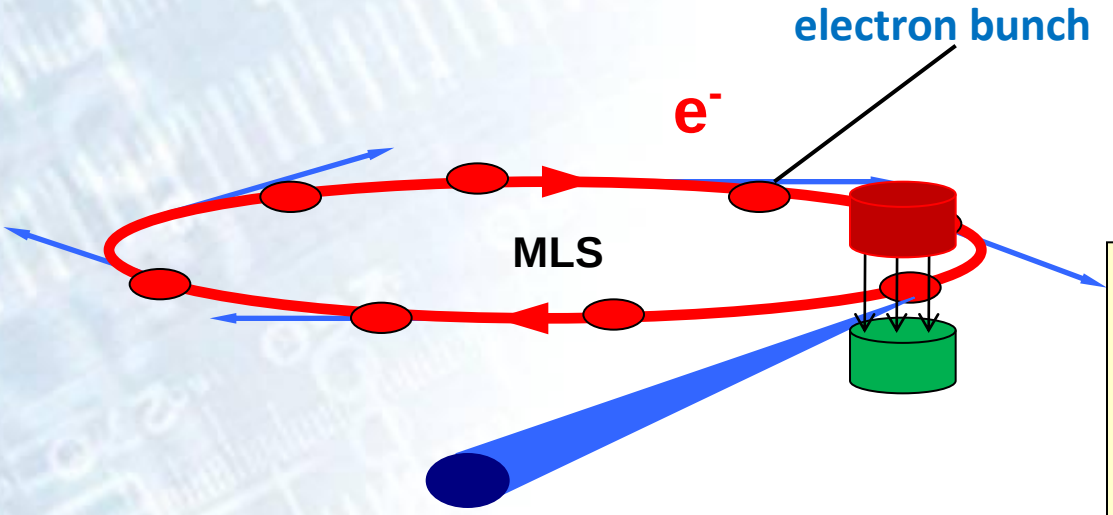


Outline

- Operation
  - *special operation modes*
  - *standard operation*
- Instrumentation
  - *experimental stations (“beamlines”)*
  - *single instruments*
- Applications

MLS design parameters



synchrotron radiation

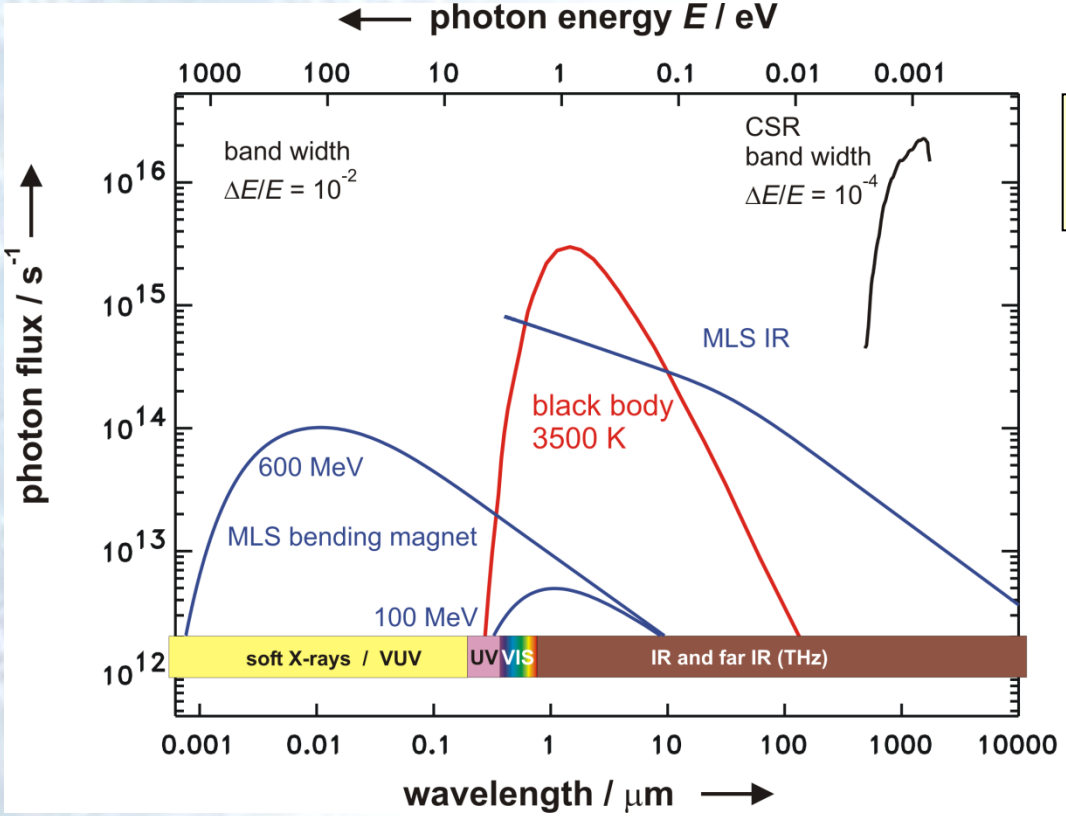
calculable by
Schwinger theory
$\Phi = \Phi\ (W, I, B, \sum_{\gamma}, \psi, d, r)$

(J. Schwinger, 1949)

- **electron energy**
  105 MeV to 630 MeV
- **electron beam current**
  1 pA (1 electron)
  to 200 mA ($2 \cdot 10^{11}$ electrons)

e.g. calibration of Single Photon Avalanche Diode, see talk of I. Müller

MLS as primary source standard



Calculable radiation source = primary source standard

special operation modes:
variable energy
variable ring current
variable electron bunch length

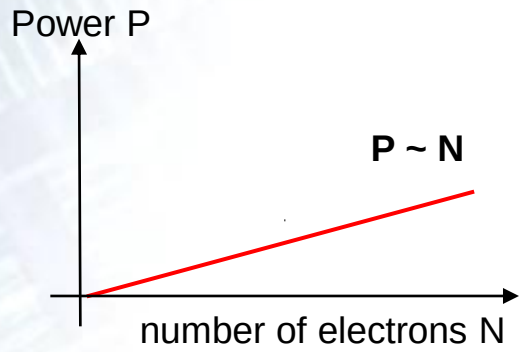
R. Klein et al., Phys. Rev. ST Accel. Beams **11**, 110701-1 (2008)

Bunch length variation

Special operation mode: Coherent synchrotron radiation (CSR) emission in the THz spectral range

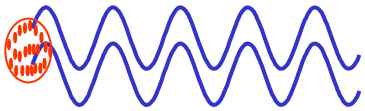
incoherent emission

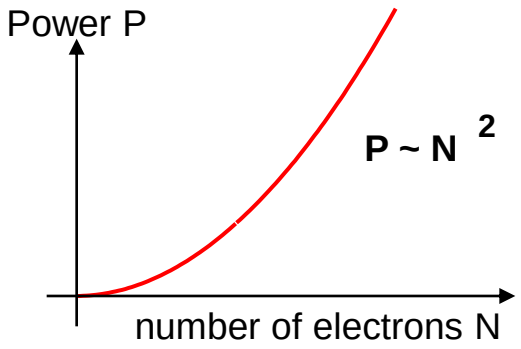
(bunch length s > 5 mm)



coherent emission

(bunch length s < 1 mm)

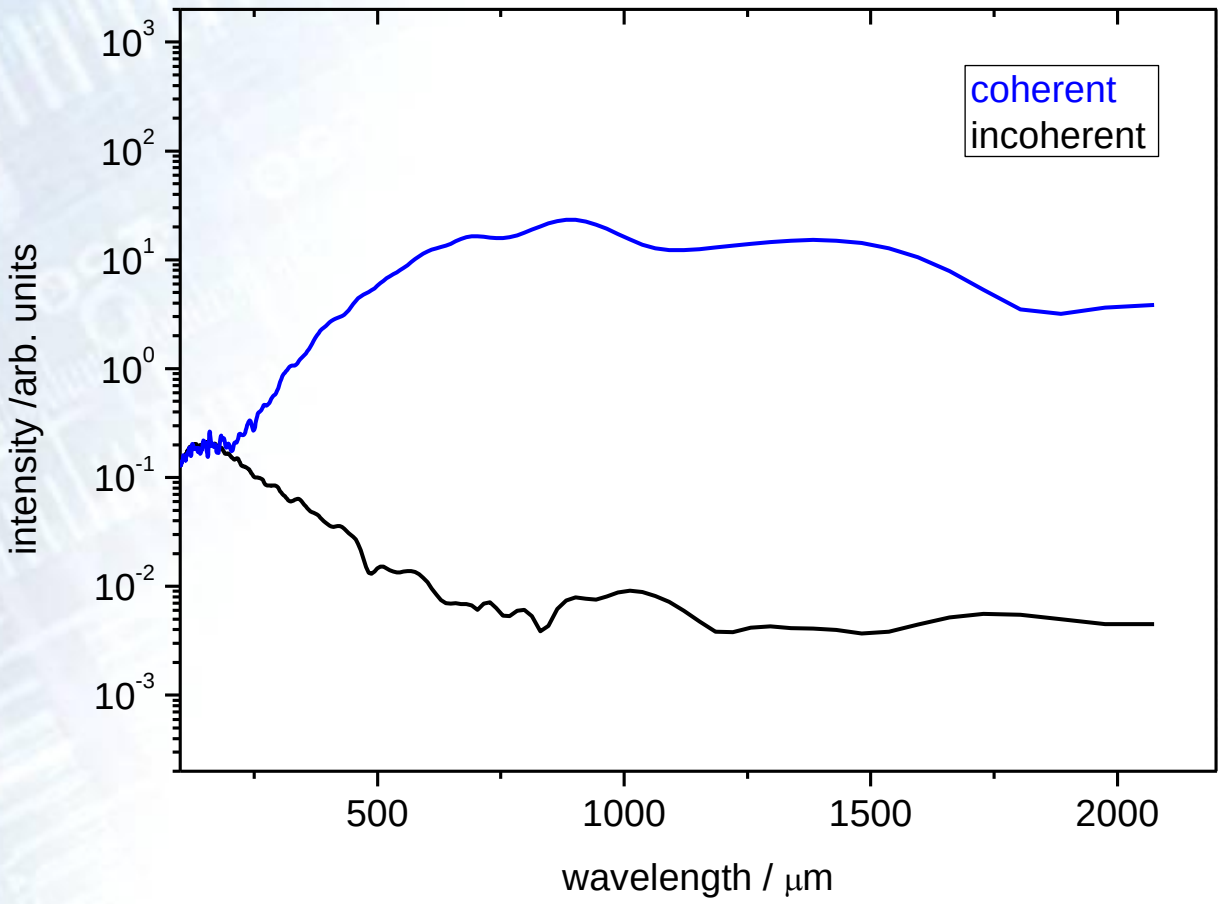




$N \approx 10^8$ electrons per bunch !

The MLS has a dedicated electron optics design for the CSR mode

Intensity gain in CSR mode



… by more than 3 orders of magnitude at λ = 1 mm (ν = 0.3 THz)

MLS operation modes

HZB team optimizes operation for:

Special operation
flexibility

- primary source standard
- spectral tuning
- radiant power tuning
- CSR mode for THz

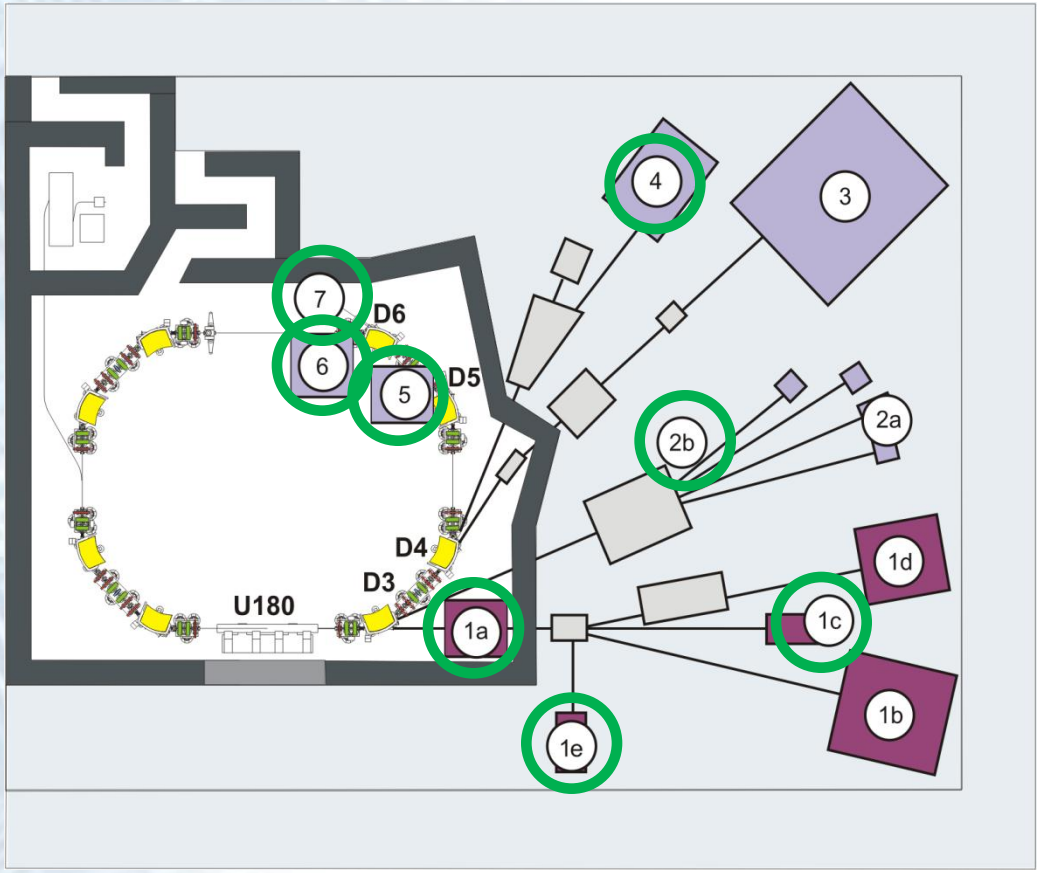
vs.

Normal operation
stability

- detector calibration
- reflectometry

At the MLS, easy switching of operation modes is possible!

Experimental stations at the MLS

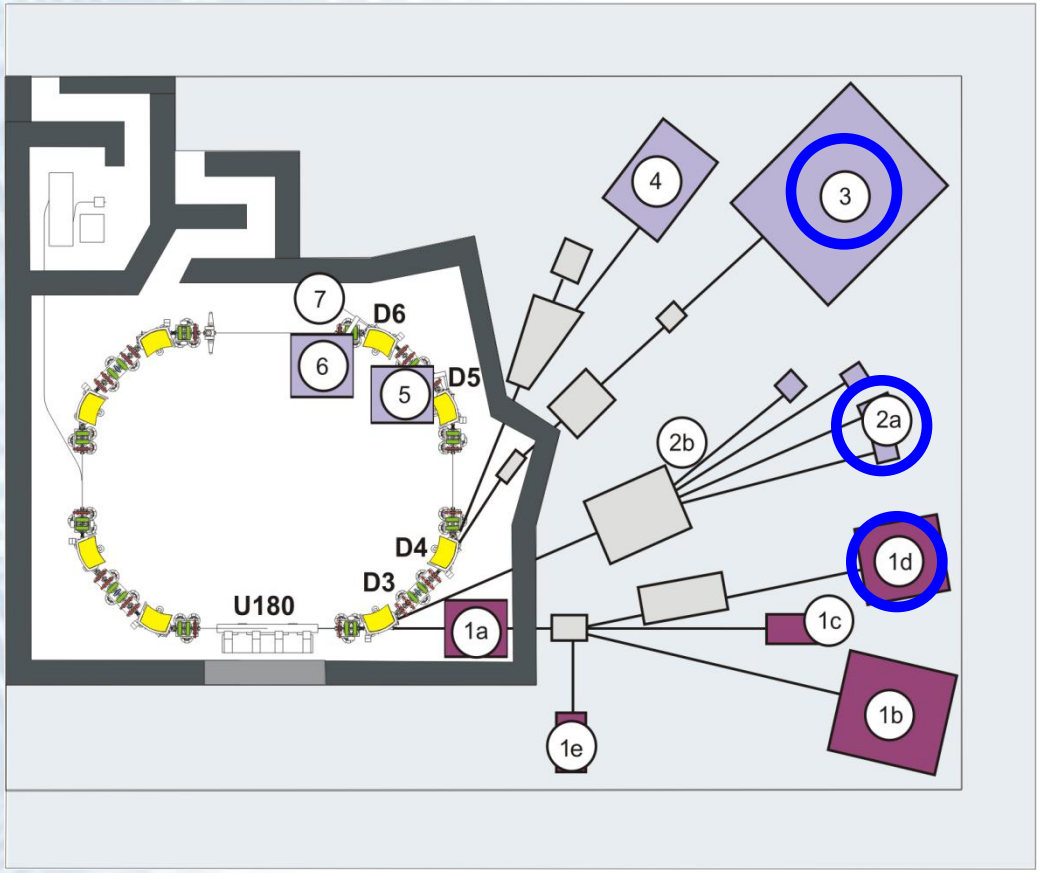


operational before 2011 :

1a IDIR, 1c IDWL, 1e
2b DWL direct beam
4 UV/VUV
5 IR
6 THz
#7 Diagnostics

Synchrotron radiation beamlines operating in the spectral range from the THz to the extreme ultraviolet (EUV) regime

Experimental stations at the MLS

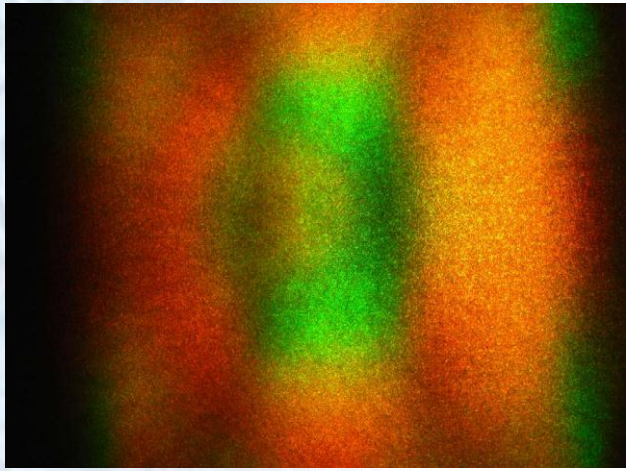


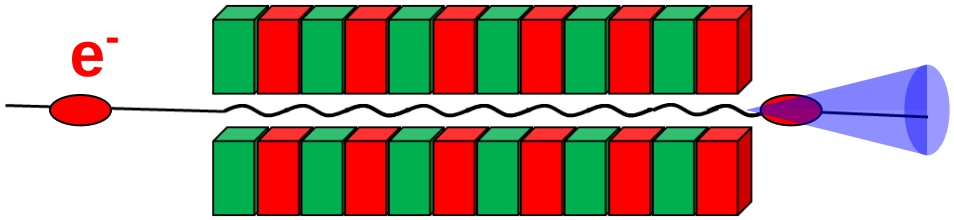
operational end of 2011 :

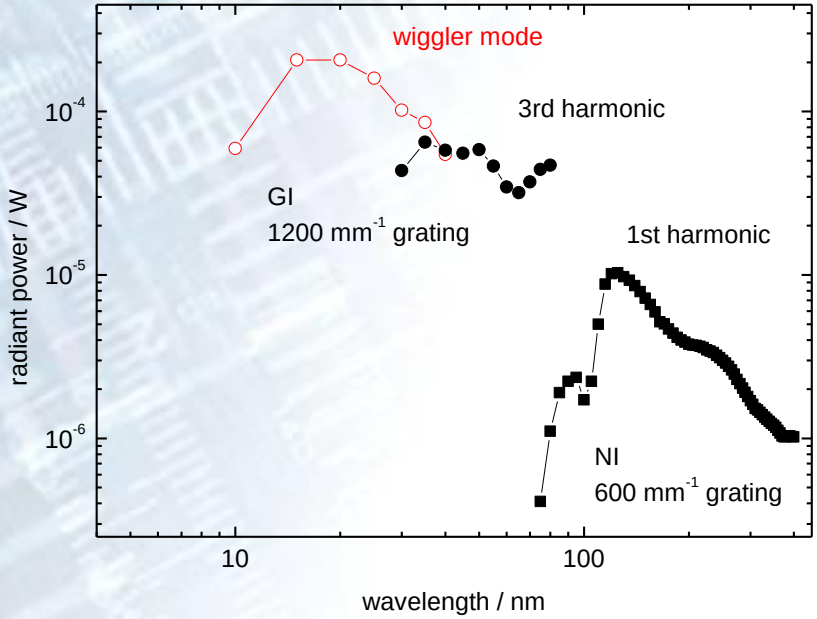
1d IDB
2a UV/VUV source cal.
3 EUV

Synchrotron radiation beamlines operating in the spectral range from the THz to the extreme ultraviolet (EUV) regime

Undulator radiation beamline







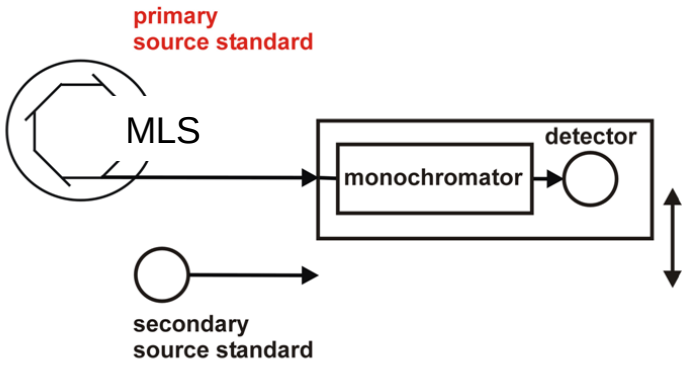
U180 :

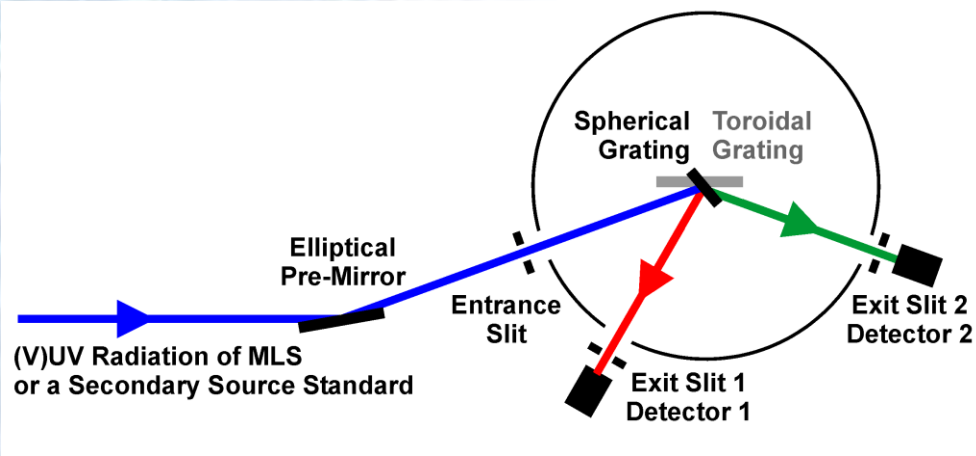
- tunable radiation from EUV to IR
- high intensity
- high linear polarization

Monochromator beamline:

- combined NI / GI geometry,
  wavelength range 4 nm to 400 nm
- **under commissioning**
- prospected applications:
  cryogenic radiometry
  EUV/VUV spectroscopy, ellipsometry

Source calibration beamline





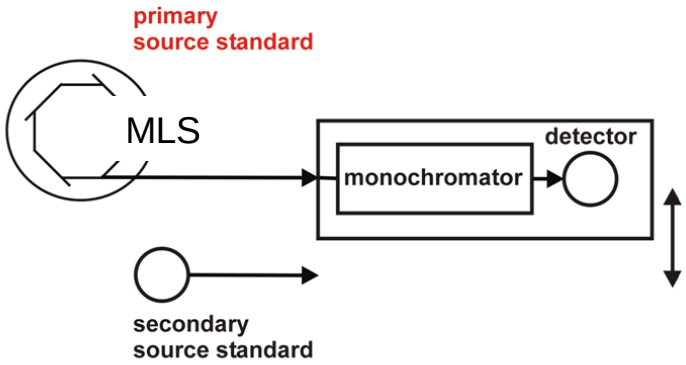
- **calibration of transfer source standards to MLS**

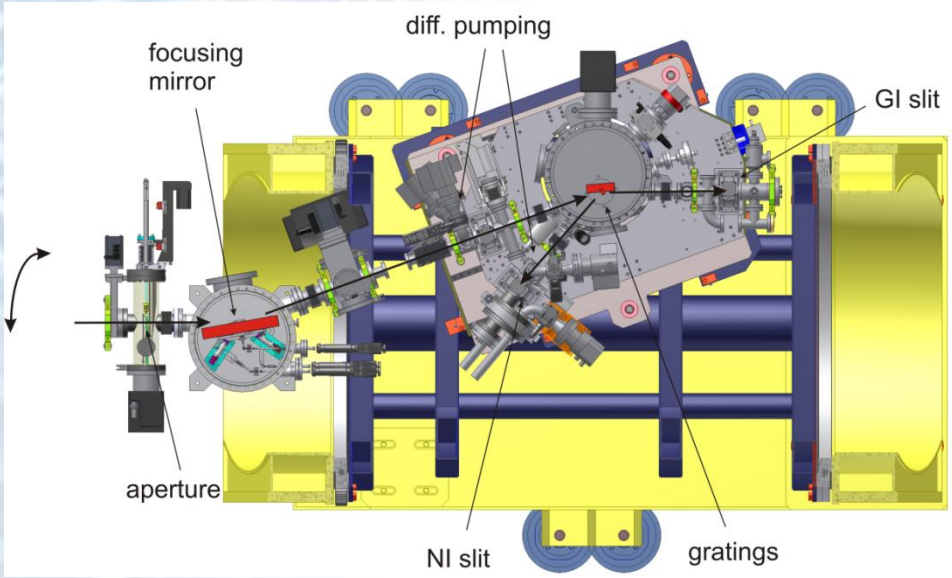
(spectral intensity, spectral radiance)

- **combined GI / NI geometry in rotatable set-up for extended wavelength range 7 nm to 400 nm**
  (BESSY II: 40 nm to 400 nm)
- 6 gratings in revolver mounting

- **in operation from end 2011 onwards**

Source calibration beamline





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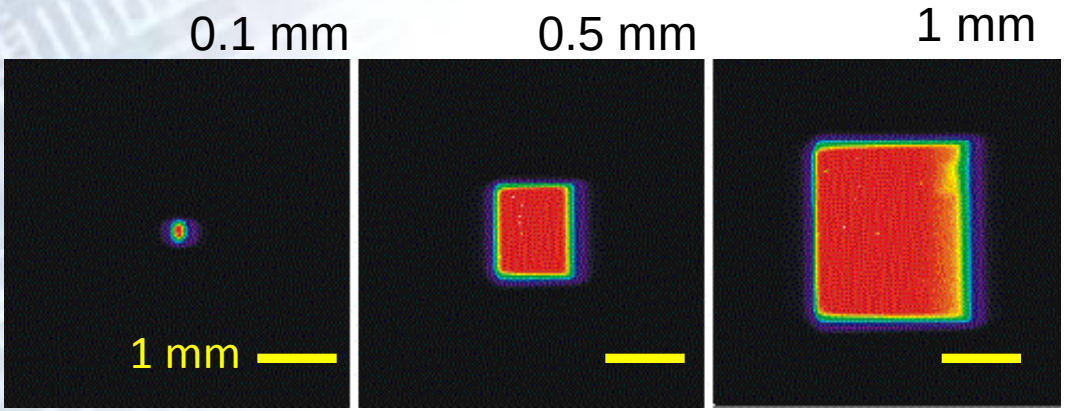
EUV beamline for reflectometry

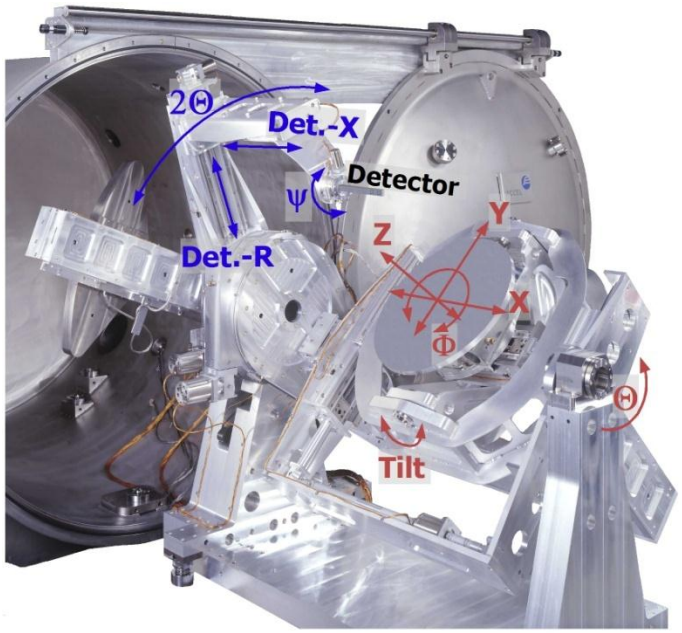
- **(extended) EUV reflectometry**
- **wavelength range 5 nm to 50 nm** (BESSY II: 0.7 nm to 35 nm)
- **higher flux for λ > 20 nm** than at BESSY II
- **adjustable spot size at sample position**
- **reflectometer: currently at BESSY II,**

  user operation at MLS from (end of) 2012 onwards

focal image at the beamline for different slit sizes



EUV reflectometer



Instrumentation at MLS

Basic tasks:

- **Spectral responsivity: 5 nm to 400 nm**
- **Spectral intensity, spectral radiance: 7 nm to 400 nm**
- **Reflectance/transmittance: 5 nm to 400 nm**

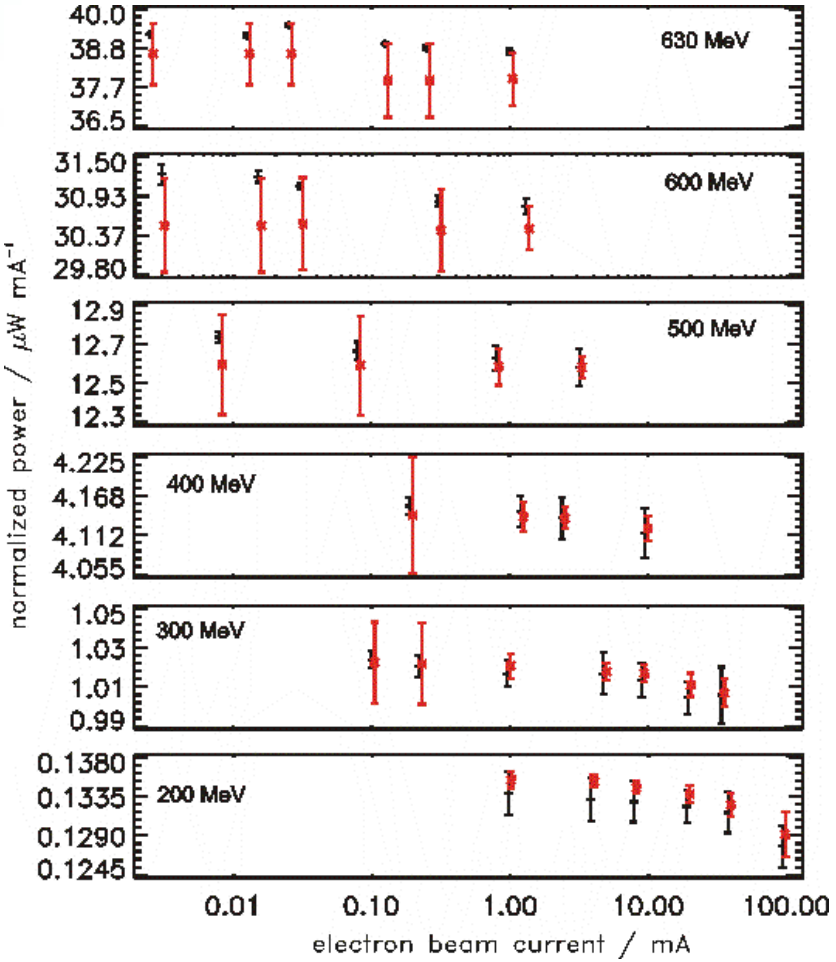
+ applications (spectrometry etc.)

Detector based radiometry

Electrical substitution cryogenic radiometer as detector standard

Optimized for VUV radiation
100 mK/µW sensitivity
120 s time constant

Comparison of MLS calculated radiant power with power measured by radiometer



*R. Klein et al., Metrologia **48**, 219 (2011)*

Conclusion

- **MLS user operation since 2008:**

  continuous improvement in normal operation & special operation

- **MLS experimental stations:**

  first set-up phase finished by end of 2011, 12 endstations in operation

- **Applications & new capabilities: still to come!**

Acknowledgement:
HZB MLS Team
PTB co-workers

Thank you