VACUUM ULTRAVIOLET LUMINESCENCE SPECTROSCOPY SETUP AT MAX IV LABORATORY

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INTRODUCTION

The tuneability of synchrotron radiation and its inherent well-defined time structure makes it particularly well suited for time-resolved luminescence studies. It is proven that time-resolved vacuum ultraviolet (VUV) luminescence excitation spectroscopy under synchrotron radiation is a powerful tool for the study of electronic structure of many classes of wide band gap luminescent and scintillating materials.

The FinEstBeaMS beamline has been constructed at the 1.5 GeV storage ring of the MAX IV facility in the autumn of 2016. It has two branch lines and three permanent end stations. With a circumference of 96 m and an electron energy of 1.5 GeV, the new storage ring at MAX IV Laboratory is a perfect synchrotron source for VUV and soft x-ray (XUV) photon generation. Time-resolved luminescence experiments will be performed on the photoluminescence endstation installed in one of the branches of the FinEstBeaMS beamline. The photoluminescence setup named as *FINESTLUMI*. The possibility to use high-resolution excitation in scanning mode and the option of tuneable polarization of the incident light make the *FINESTLUMI* setup very attractive for the field of luminescence and scintillating studies under VUV and XUV excitations.

STORAGE RING, BEAMLINE PROPERTIES, OPTICAL LAYOUT AND RAYTRACING RESULTS

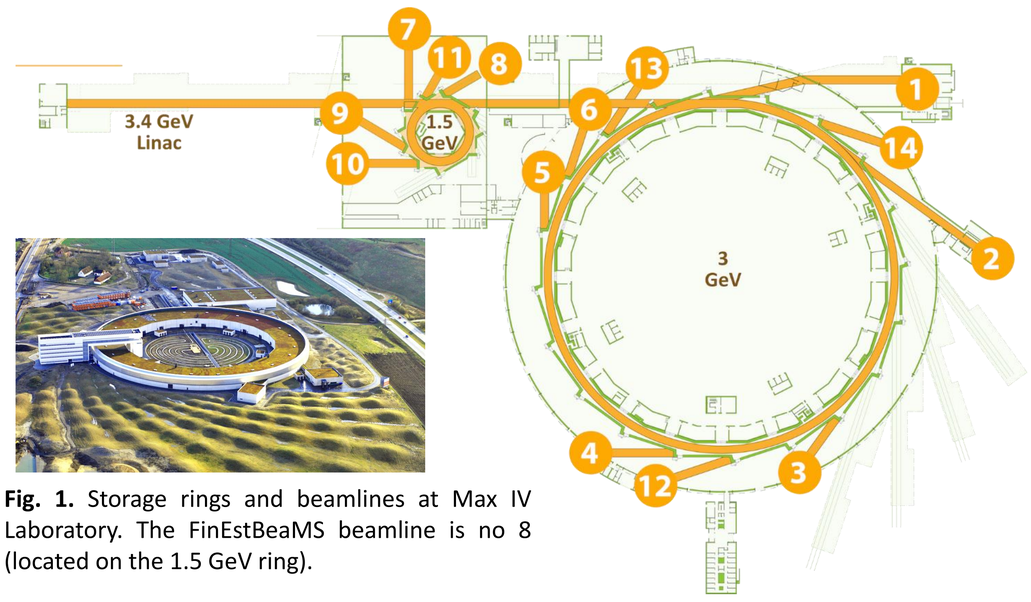

Fig. 1. Storage rings and beamlines at Max IV Laboratory. The FinEstBeaMS beamline is no 8 (located on the 1.5 GeV ring).

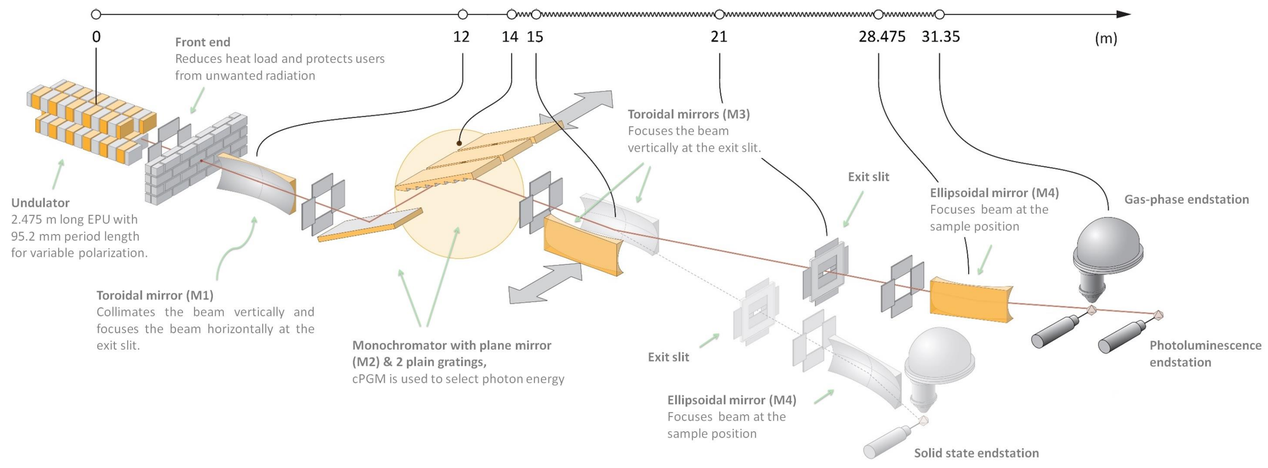

Fig. 2. The optical layout of the FinEstBeaMS beamline is based on the plane grating monochromator illuminated with collimated light.

X-ray source (EPU)	Elliptically polarizing undulator, 95.2 mm period, 26 periods, 14 mm minimum gap, 2.475 m magnetic length
Energy (wavelength) range	4.3 - 1000 eV (288 - 1.24 nm), up to 1500 eV in the wiggler mode
Monochromator (cPGM)	Plane grating monochromator using collimated light, two plane gratings (92 and 600 mm/l), internally cooled planar premirror
Resolving power	$R=E/\Delta E \approx 1 \times 10^4$
Focusing optics	Ellipsoidal mirror
Beam size at sample	100 x 100 µm² (horizontal x vertical), 30 x 20 µm² when limiting exit slit and baffles. The beam size can be increased by moving the gas-phase end station out of focus
Flux at sample (focused)	8×10^{13} - 10^{11} ph/s (4.3 – 800 eV)
Experiment set-ups	X-ray Photoelectron Spectroscopy, Time-of-Flight Mass Spectroscopy, Photoelectron-Photon Coincidence Spectroscopy, **Photoluminescence spectroscopy**, X-ray Absorption Spectroscopy

Table 1. Summary of parameters of the FinnEstBeaMS beamline.

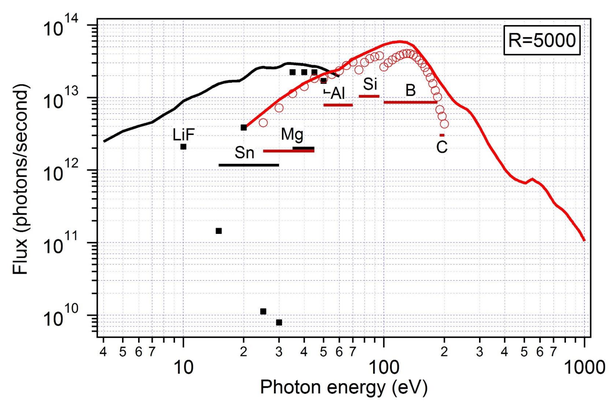

Fig. 3. Estimated photon flux at experiment for low energy grating (curve at left) and the wide energy range grating (curve at right) with the resolving power of 5000. Symbols depict fluxes when 200 nm thick filters are used.

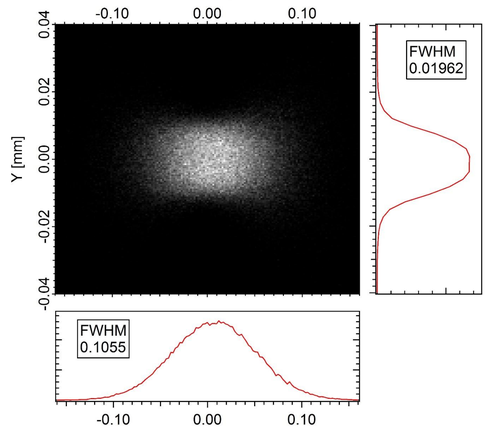

Fig. 4. Spot pattern and beam intensity profiles at the sample plane at 17 eV (600 l/mm grating used, c=2.25).

PHOTOLUMINESCENCE ENDSTATION – *FINESTLUMI* SETUP

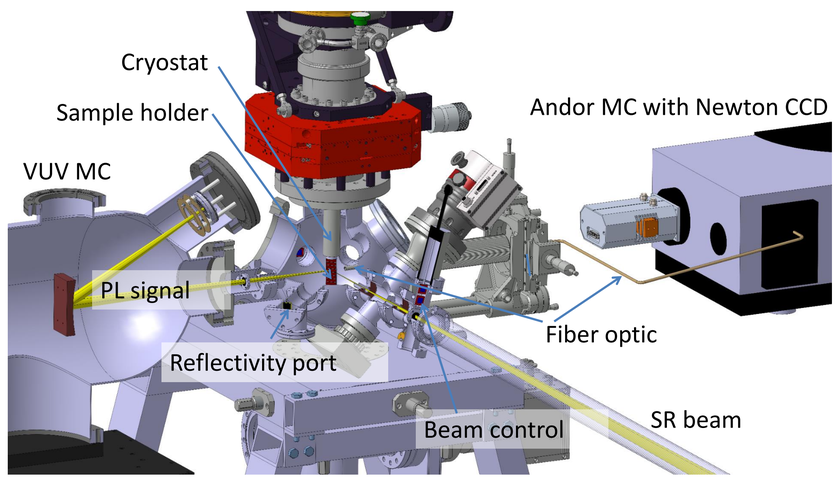

Fig. 5. Schematic view of FINESTLUMI

Key components of *FINESTLUMI* in short:

- UHV vacuum chamber (estimated base pressure ~10^{-9} mbar)
- Close-cycle helium cryosystem (Advanced Research Systems). Temperature adjustable between 7 and 400 K
- Sample holder with space for up to 50 samples
- Fiber optics connection to external Andor Shamrock (330i) 0.3 m UV/visible spectrometer. Detection with Newton Andor CCD or PMTs on second exit port. Covers 200-1500 nm range, max resolution 0.1 nm.
- Secondary VUV mono (0.4 m, 1650 l/mm, 0.6 nm resolution) covers 50-300 nm.
- The set of photo diodes for the control the flux of the beam.
- The set of the filters for suppressing higher order excitations.

Experimental possibilities of *FINESTLUMI*:

Luminescence endstation is intended for the study of the optical and luminescence properties of any type of inorganic solids: single crystals, nanocrystals, ceramics, glasses, films, composite materials and etc.

- Emission spectra from VUV to NIR spectral range **(50 – 1500 nm)**
- Excitation, absorption and reflection spectra with high resolution in **4.3 -1000 eV** spectral range
- Time-resolved luminescence spectroscopy experiments (sub nanoseconds time resolution) can be implemented in single bunch mode (**320 ns** time window) of storage ring and/or utilize a chopper (up to milliseconds range). Synchrotron pulse is **130 ps**. Time window in standard 10 bunch regime is **10 ns**
- Optical (reflection, transmission) and luminescence spectroscopy under tuneable polarization (**vertical/horizontal/elliptic**)
- Temperature dependence of optical and luminescence properties down to liquid helium temperature (**7 K**)
- Pump-probe or photo-stimulated experiments utilizing external light sources
- Mounting of multiple samples of both sides of the sample holder i.e. high productivity of the setup

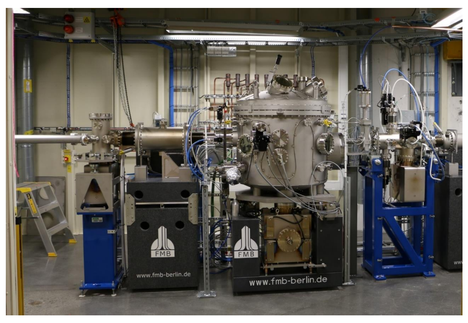

Fig. 6. FinEstBeaMS monochromator and switching mirror chamber.

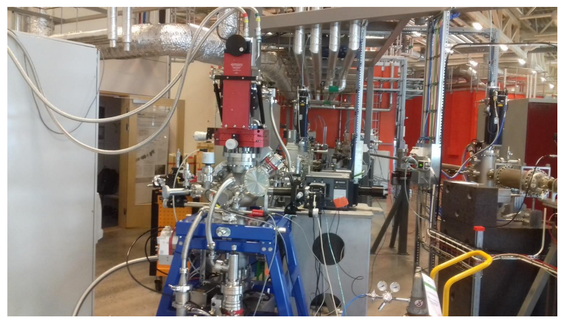

Fig. 7. FINESTLUMI setup installed on one of the branches of FinEstBeaMS beamline.

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https://www.maxiv.lu.se/accelerators-beamlines/beamlines/finestbeams/

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