Study of Reflectivity and Photo Yield on FCC-hh proposed beam screen surfaces

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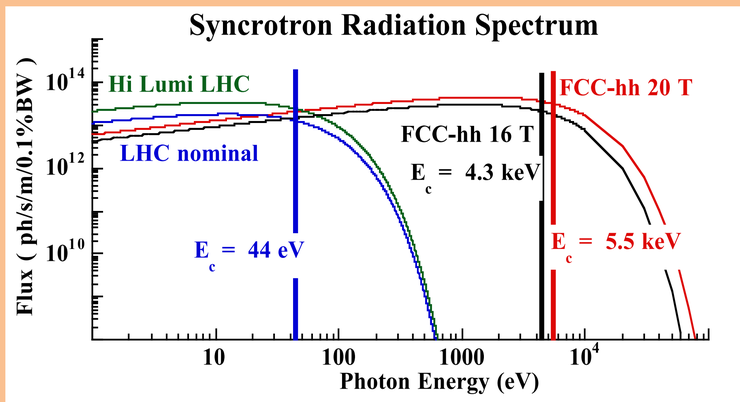
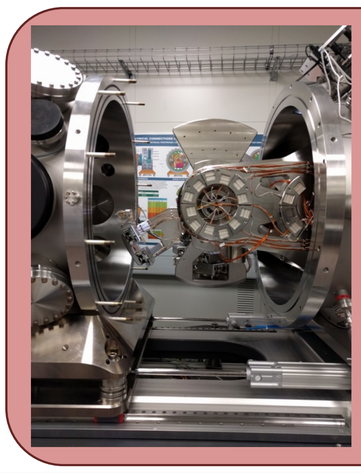
Introduction

In FCC-hh, large production of Synchrotron Radiation (SR) is expected. SR can cause: heat load on the accelerator walls, photo- electrons triggering e⁻cloud effects and/or single bunch instabilities, photon stimulated desorption etc. Simulation programs need realistic input parameters to trace where all photons (direct or reflected) interacts within the vacuum vessel, how many electrons are than produced etc. etc. Therefore, an experimental characterization of optical properties of technical surfaces, in particular reflectivity (R) and photo yield (PY), becomes mandatory at as close as possible to realistic conditions[1]. In FCC-hh, SR Light will impinge on the accelerator walls at 0.077° with energies going from few eV to more than 4 KeV.

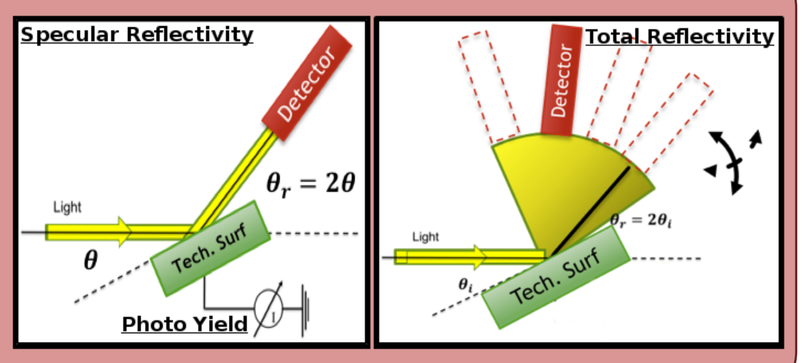


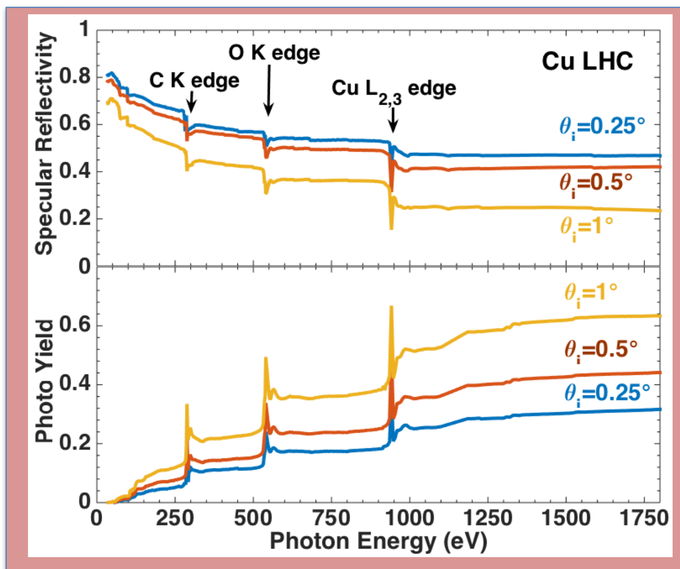
Experimental



R and **PY** were studied at the optical beamline "at wavelength Reflectometry" at Bessy II [2]. With this set-up we can reach incidence angles as low as **0.25 °** scanning the photon energy between **35-1800 eV**.

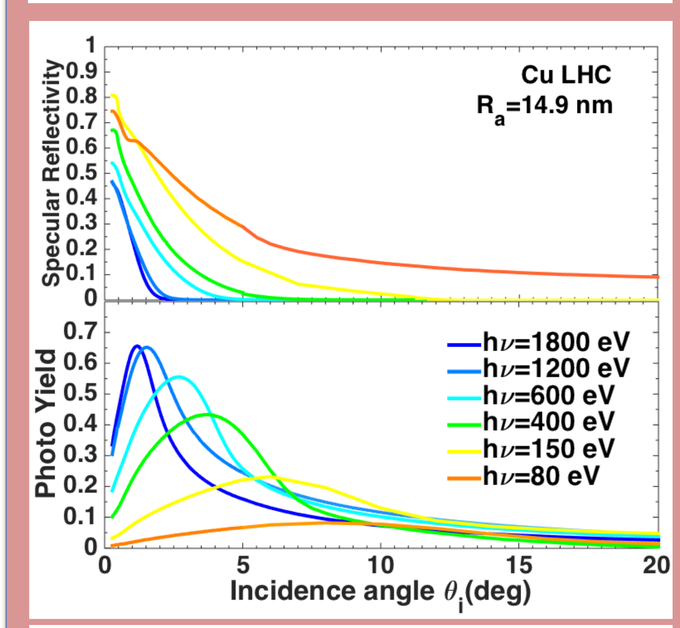
- **Specular Reflectivity** is measured when the detector (accepting ±0.35°) is at the geometrical θ/2θ position.
- **Total Reflectivity** is measured by integrating all signals, specular and off-specular, in plane and off-plane, at a given incidence angle and photon energy.
- In all cases we contemporarily measure the **Photo Yield (PY).**





Specular R(E) and PY(E) at fixed angles

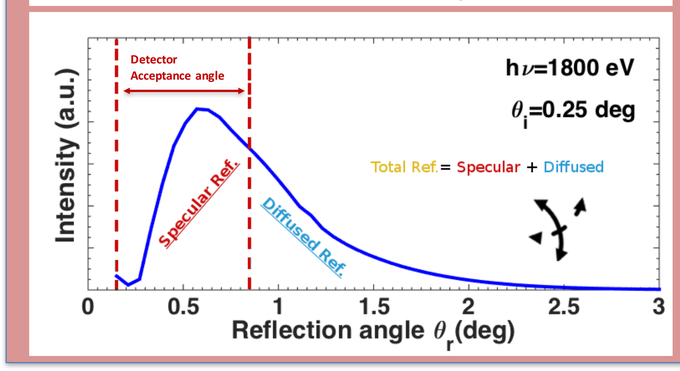
- **R** and **PY** at different energies with fixed incident angles can be measured. Such values do strongly depends on **roughness** [3].
- At such low incidence angles **R and PY** are also affected by light contaminants (C, O, etc).
- Scrubbing, ice formation on cold surfaces and "aging" may affect **R** and **PY.**



Specular R(θ) and PY(θ) at fixed energy

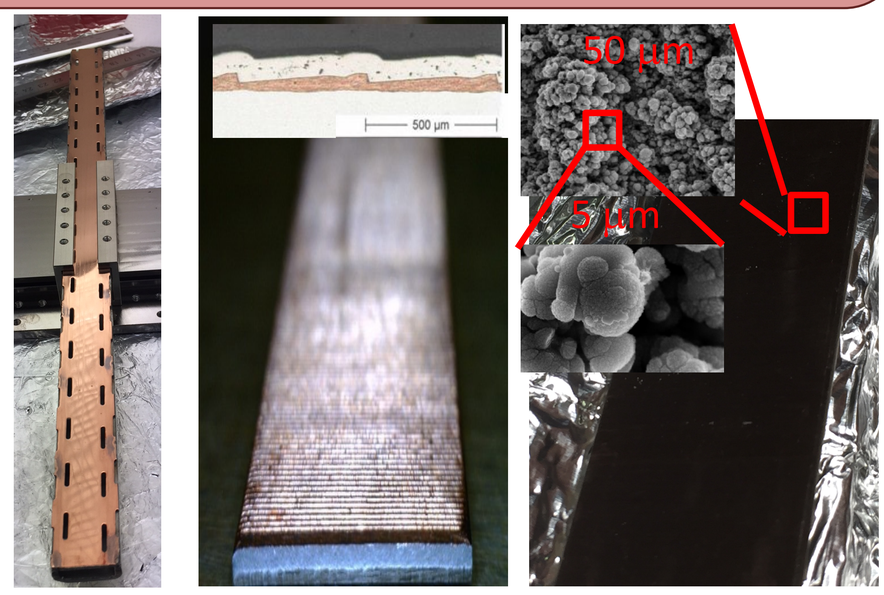
Analysis of **R(θ)** and **PY(θ)** highlights the importance of measuring at as close as possible operating conditions.

- **R(θ)** for flat surfaces is higher for smaller incidence angles and for lower energies.
- **PY(θ)** results from two competing effects:
- It increases with θ_i due to an enhanced photo absorption (reduced R).
- It decreases with θ_i due to a deeper radiation penetration and low electron mean free path.



Total Reflectivity (θ)

In rough samples and in geometrically modified surfaces, it is essential to consider Total reflectivity and not just the specular one.



LHC Cu | LHC Saw Tooth | LASE Cu [4]

Sample	hν (eV)	θ_i (deg)	Specular Reflect. (± 1E-5)	Total Reflect. (±10%)	PY (±2%)
LHC-Flat	1800	0.25	0.468	0.722	0.32
		0.5	0.421	0.627	0.44
		1	0.235	0.378	0.63
LHC-ST	1800	0.25	0.0040	0.054	0.07
		0.5	0.0017	0.006	0.06
		1	0.0003	0.001	0.05
LASE	1800	0.25	0.0015	0.007	0.08
		0.5	2.50E-05	0.0003	0.07
		1	8.10E-06	0.0003	0.07
LHC-Flat	400	0.25	0.586	0.790	0.11
		0.5	0.560	0.791	0.15
		1	0.435	0.720	0.22
LHC-ST	400	0.25	0.0038	0.094	0.04
		0.5	0.0030	0.026	0.05
		1	0.0014	0.013	0.04
LASE	400	0.25	0.001	0.009	0.05
		0.5	0.0005	0.003	0.04
		1	0.0002	0.001	0.04

Conclusions

- **Ultimate Synchrotron Radiation metrology has developed experimental tools to be used to extract parameters of interest for FCC-hh R&D.**
- **Morphologically modified structures, need to be experimentally studied: their simulated optical properties need experimental validation.**

References

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[4] R. Valizadeh, et al, Appl. Phys. Lett. 105, (2014)

Acknowledgements

This work was supported by LNF, MICA gr V. We thank the European Union's Horizon 2020 research and innovation programme under grant agreement No 730872 for support and EuroCirCol collaboration for the LASE sample. We thank also I. Bellafont and L.A. Gonzalez for their help.