Coherent Diffraction and Cherenkov Radiation in fibers

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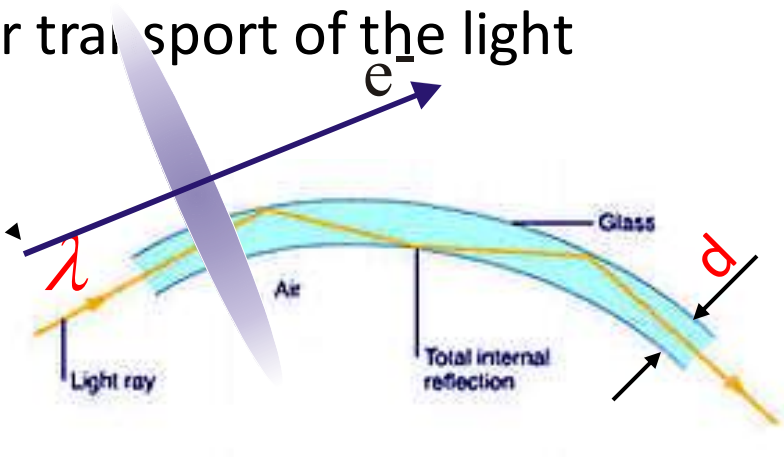
Optical fibers

Well known technique for transport of the light



based on the full internal reflection in fiber.

If λ is comparable to d, radiation propagates in several modes.

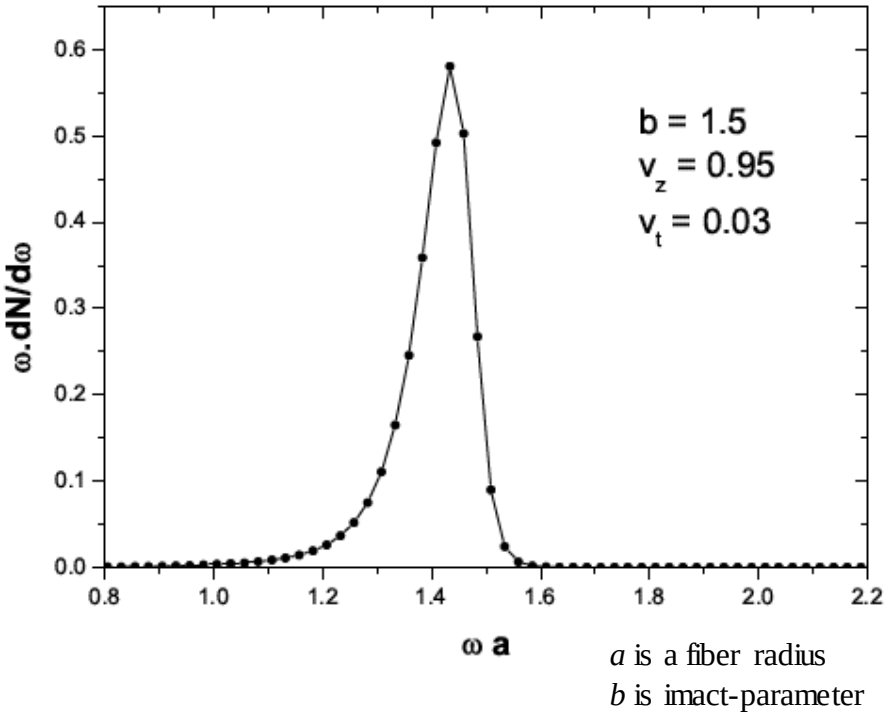
However, radiation in dielectric fibers may be generated by a Coulomb field of relativistic particles.

This may be useful in beam diagnostics.

Theoretical background

X Artru, C Ray. Radiation induced by charged particles in optical fibers. hal.archives-ouvertes.fr, 2012

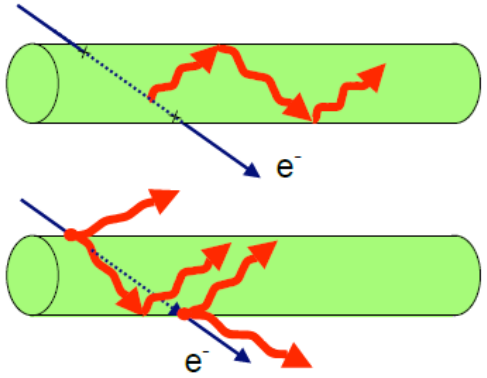
Spectra



a is a fiber radius

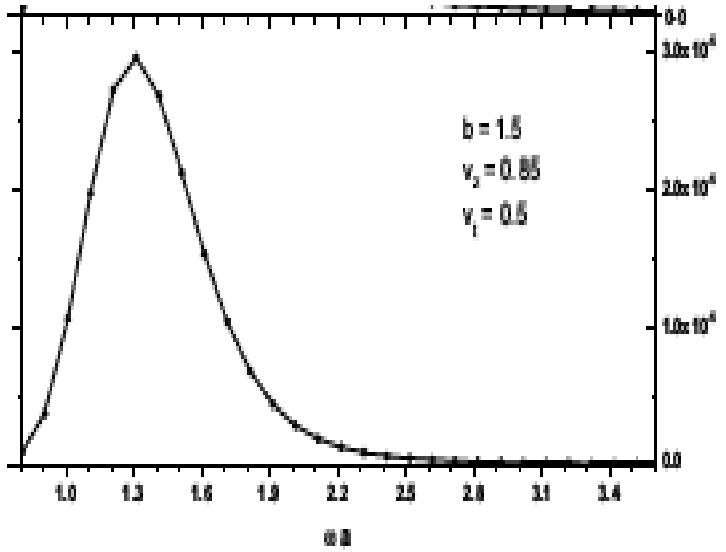
b is imact-parameter

Figure 5: Photon yields in the HE_{11} mode with $M = +1$ for a small crossing angle : $(v_L, v_T) = (0.95, 0.03)$; $b = 1.5a$.



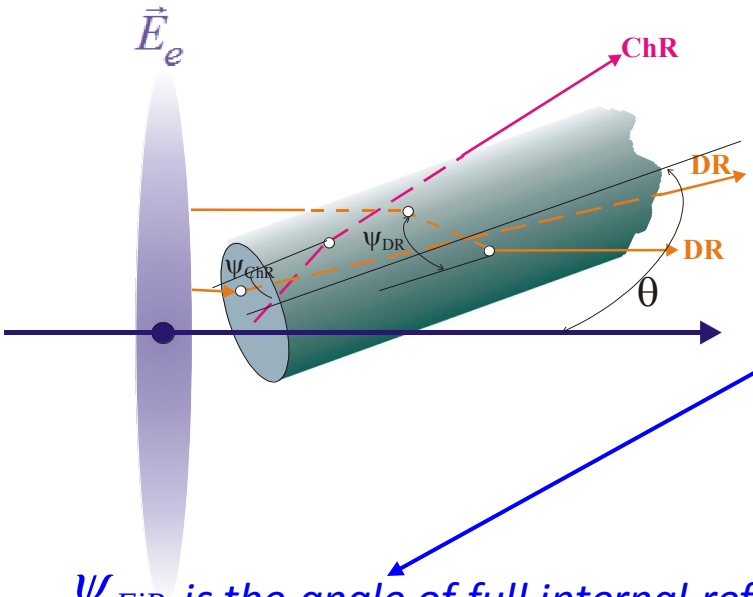
VChR

TR



Here *a* is fiber radius

Possible geometries of radiation generation in fibers



$\psi_{DR} > \psi_{FiR}$

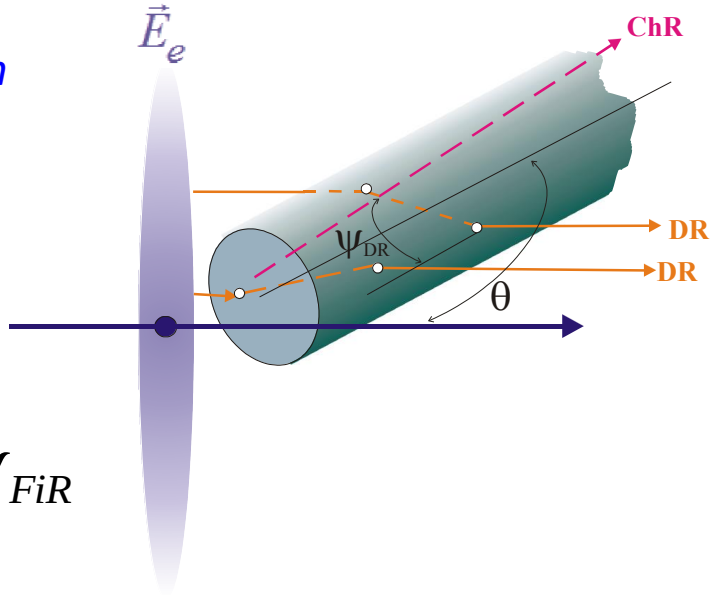
$\psi_{ChR} > \psi_{FiR}$

$\theta < 45^0$

Mainly the DR propagate along the fiber

ψ_{FiR} *is the angle of full internal reflection*

For Teflon fiber $\psi_{FiR} \approx 45^0$

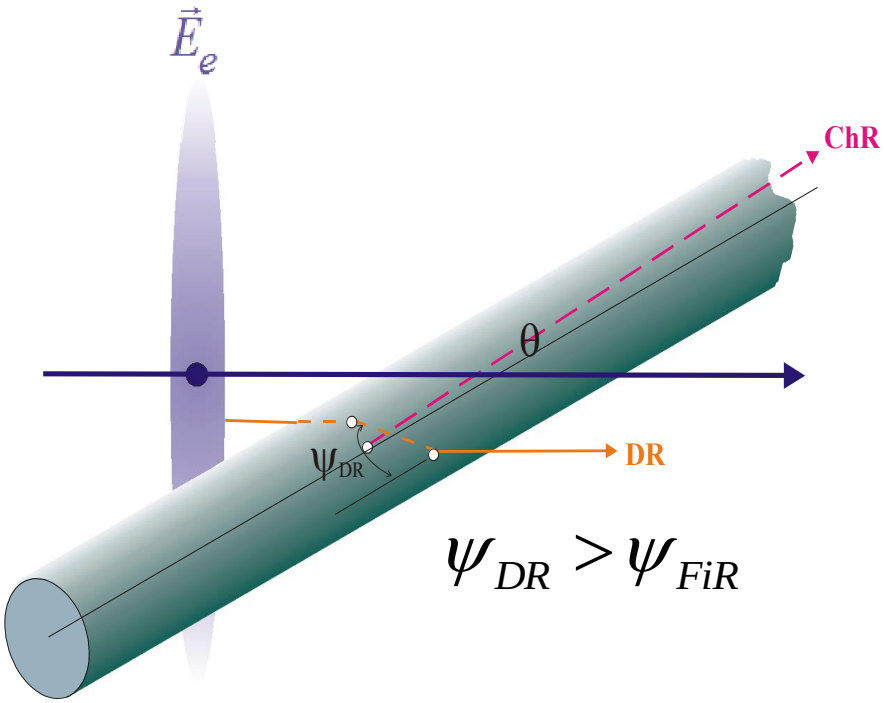


$\theta \geq 45^0$

$\psi_{DR} > \psi_{FiR}$

Mainly the ChR propagate along the fiber

Case of a fiber under the electron beam



$$\psi_{DR} > \psi_{FiR}$$

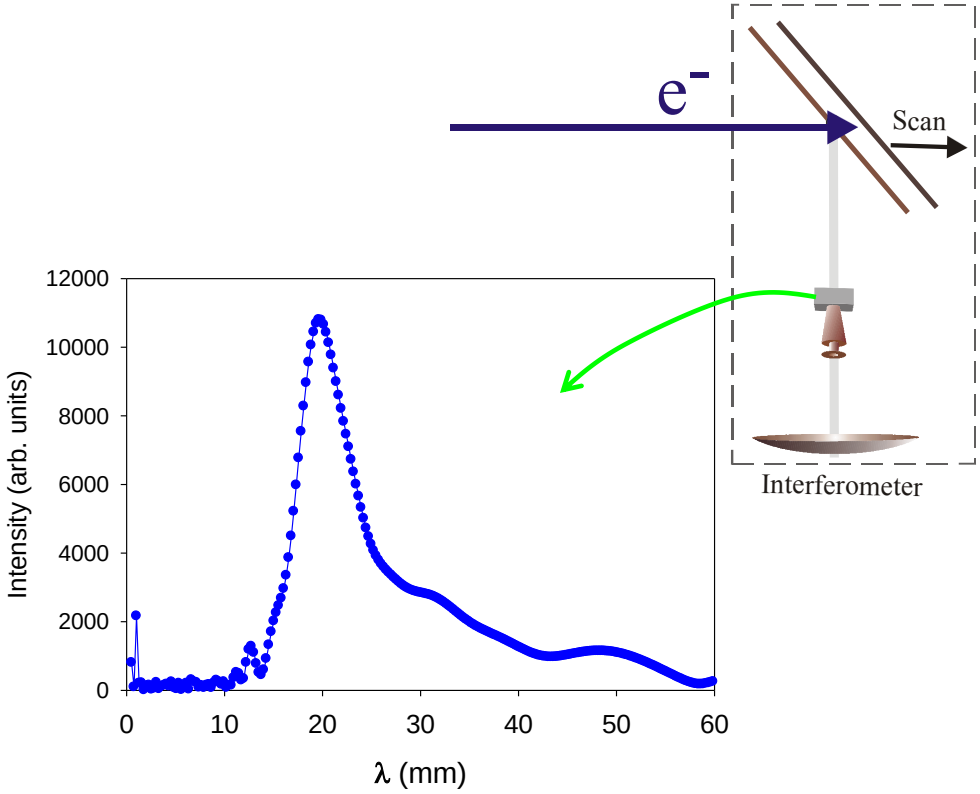
Only the ChR propagate along the fiber

Experiment

Beam parameters

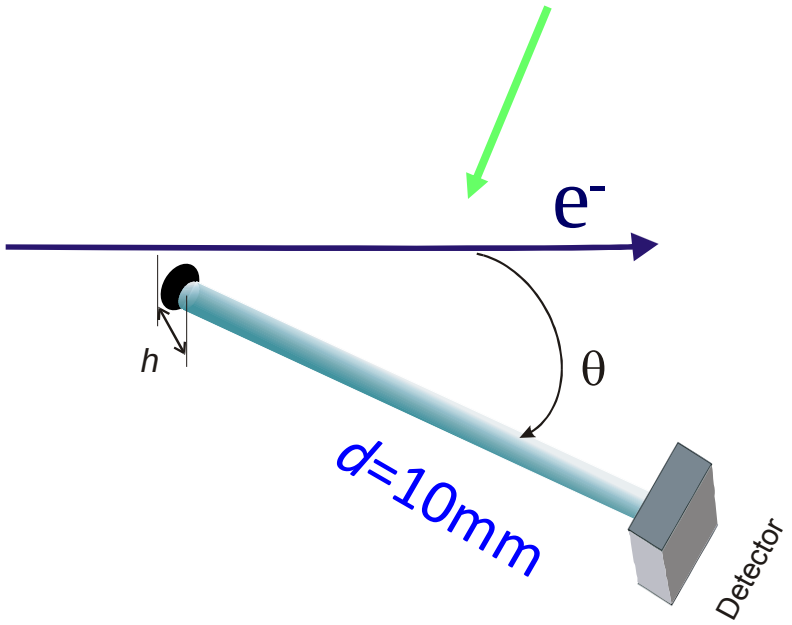
Electron energy	6.1 MeV	$\gamma = 12$
Macro-pulse duration	2~6 ms	
Pulse repetition rate	1~8 Hz	
Micro-pulse length	≈ 6 mm	
Electrons number per micro-pulse	≈ 10^8	
Micro-pulses number per macro-pulse	≈ 10^4	
Beam size at the output	4×2 mm^2	
Emittance: horizontal	$3 \cdot 10^{-2}$ mm ×rad	
vertical	$1.5 \cdot 10^{-2}$ mm ×rad	

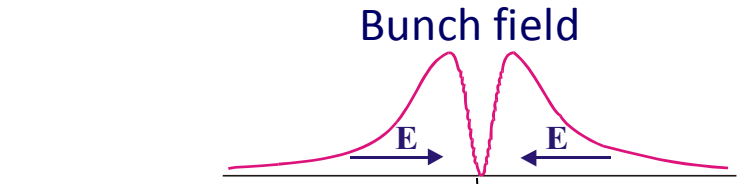
Spectrum of electron bunch field

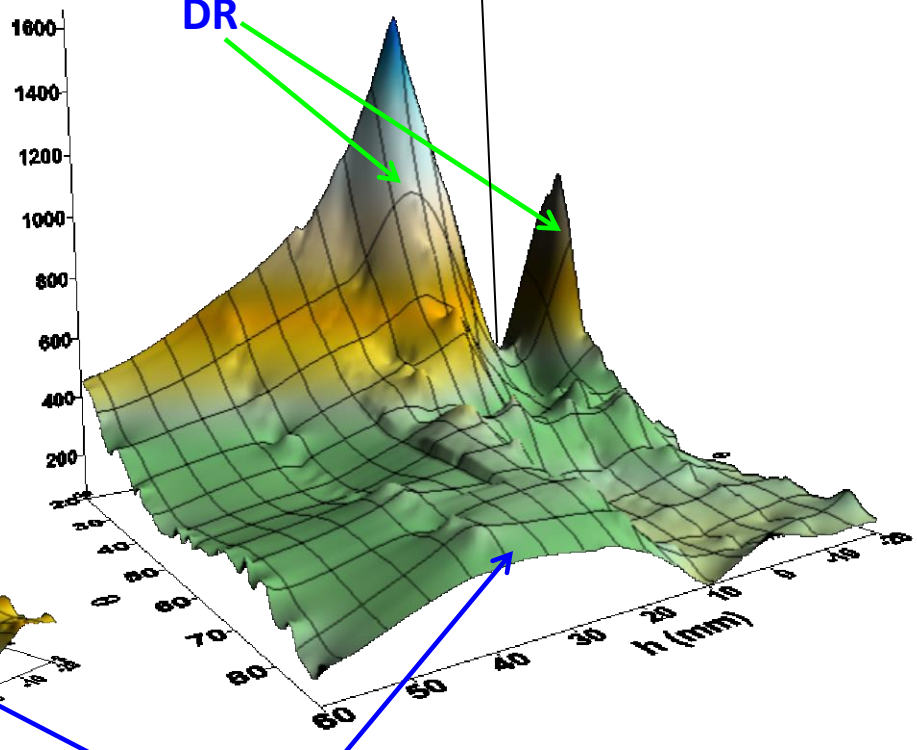


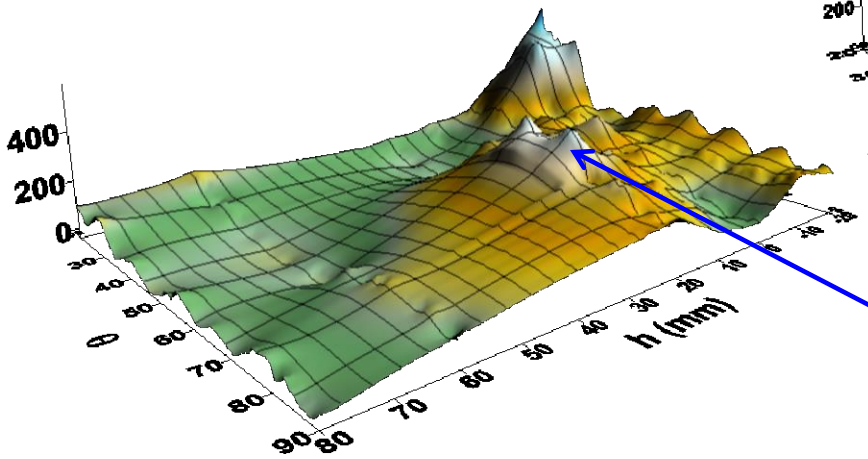
Dependence on the angle θ and impact-parameter h

Scheme *a*





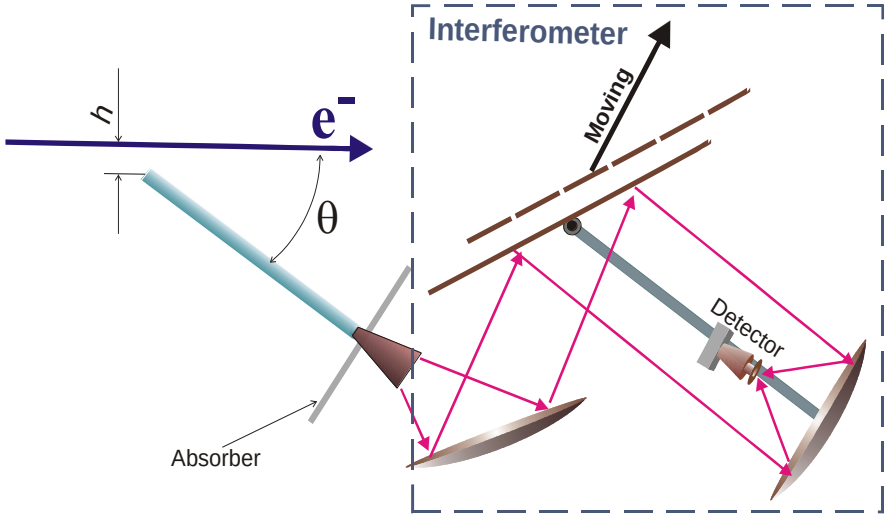




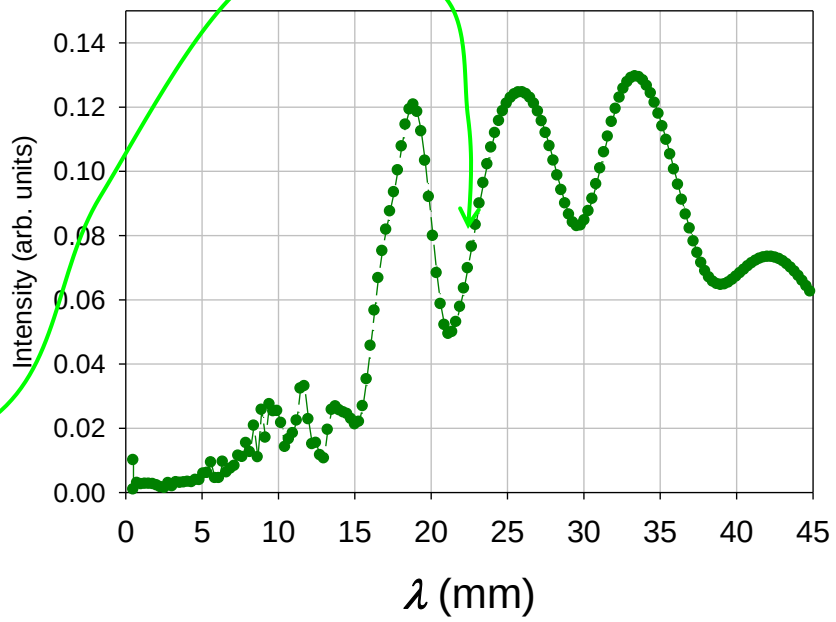
ChR

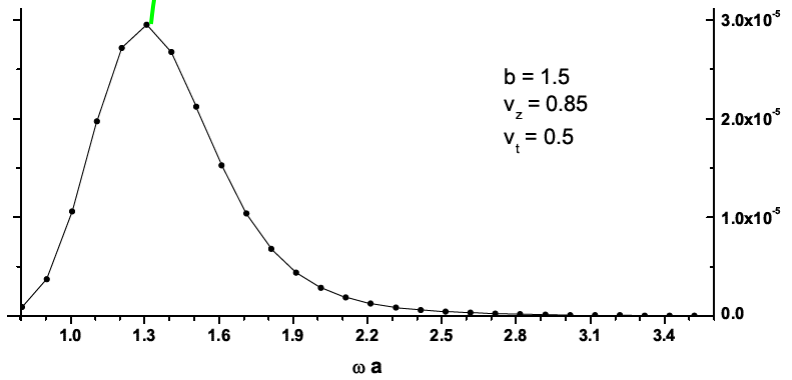
Spectrum from fiber

Scheme of spectra measurement

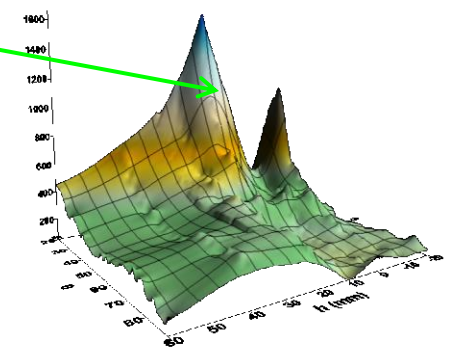


Spectrum





$$\theta = 30^0$$
$$h = 15\ mm$$



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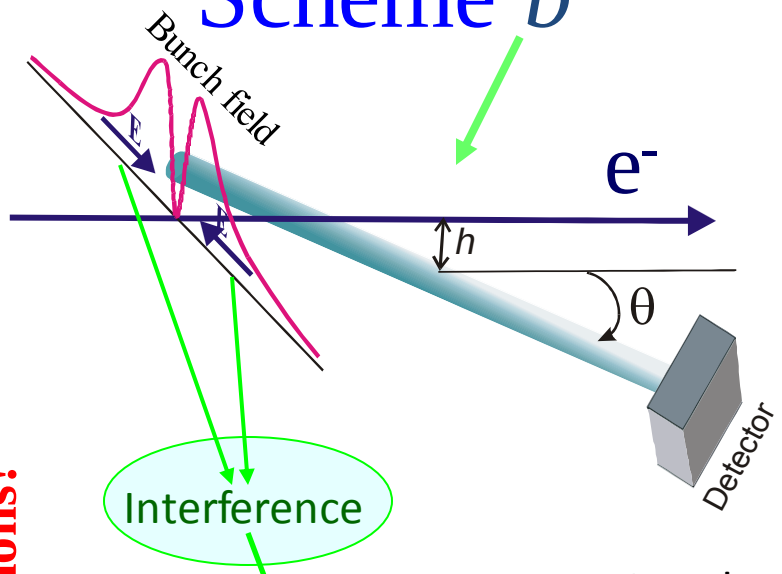
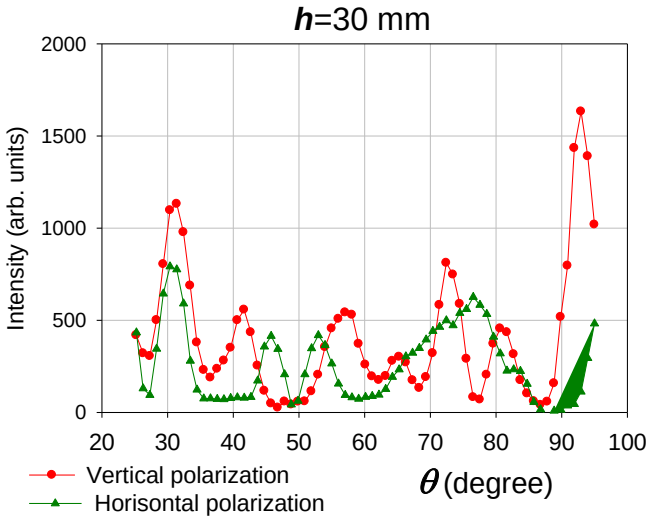
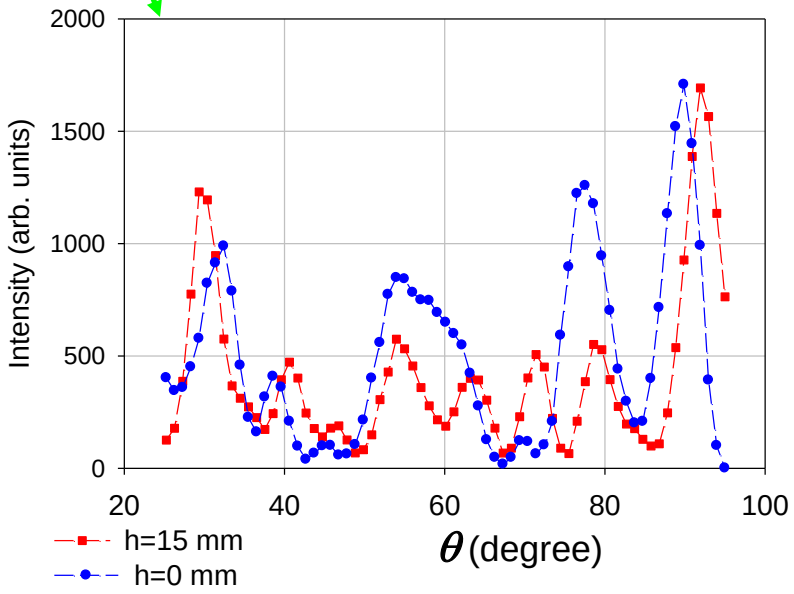
Scheme *b*

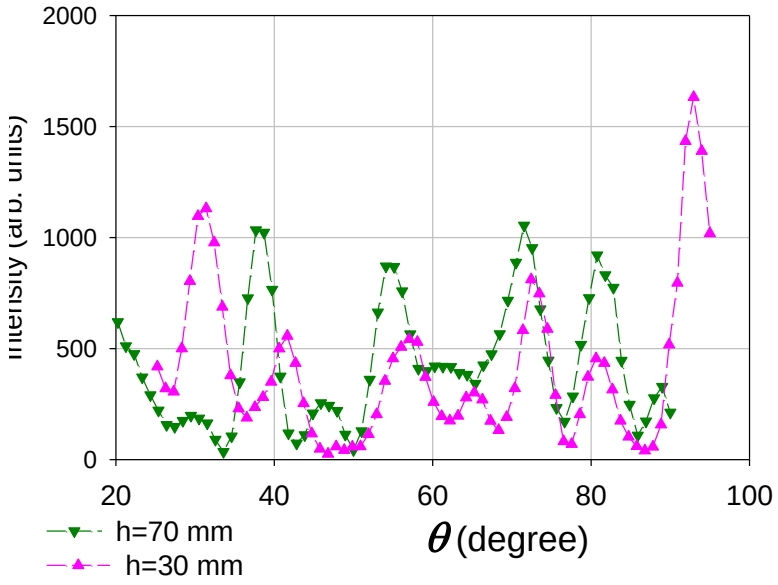


Polarization influence



Angular dependence

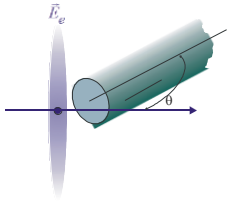




What is cause of the oscillations?

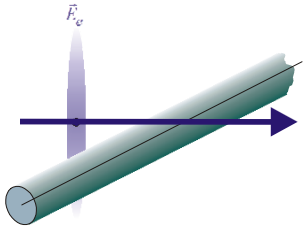
Summary

Geometry



Both ChR and DR may be generated and propagate along fibers depending on the angle of fiber in respect to the electron beam.

The dependence on the angle of fiber in respect to the electron beam is unimodal.



Probably only ChR propagates along fibers.

The dependence on the angle of fiber in respect to the electron beam is multimodal.

If $\lambda \approx 2d$, the spectrum of propagated radiation is of several modes.

Thank you for attention