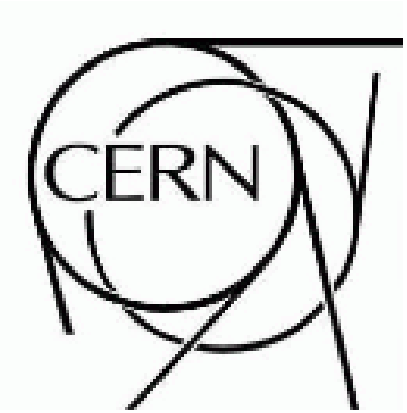
UV/X-ray Diffraction Radiation for Non-Intercepting Beam Size Diagnostics

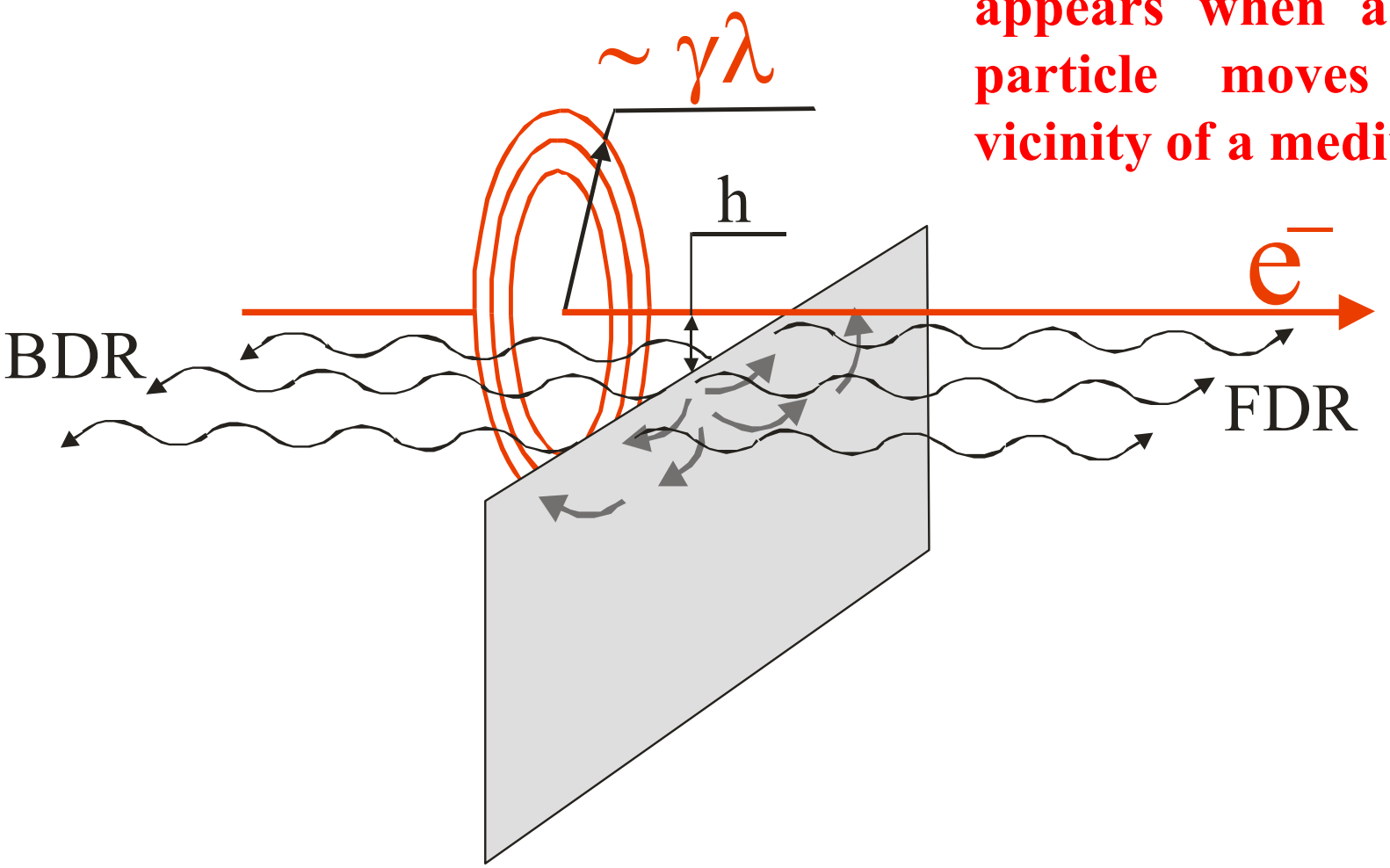


Pavel Karataev

Thibaut Lefevre

What is diffraction radiation?

Diffraction radiation (DR) appears when a charged particle moves in the vicinity of a medium



Impact parameter, h, – the shortest distance between the target and the particle trajectory

$$h \leq \gamma\lambda$$

λ - observation wavelength

$\gamma = E/mc^2$ – Lorentz - factor

Advantages of the ODR technique

- **Non-invasive method**

  (no beam perturbation or target destruction)

- **Instantaneous emission**

  (quick measurements)

- **Single shot measurements**

  (no additional error from shot-by-shot instabilities)

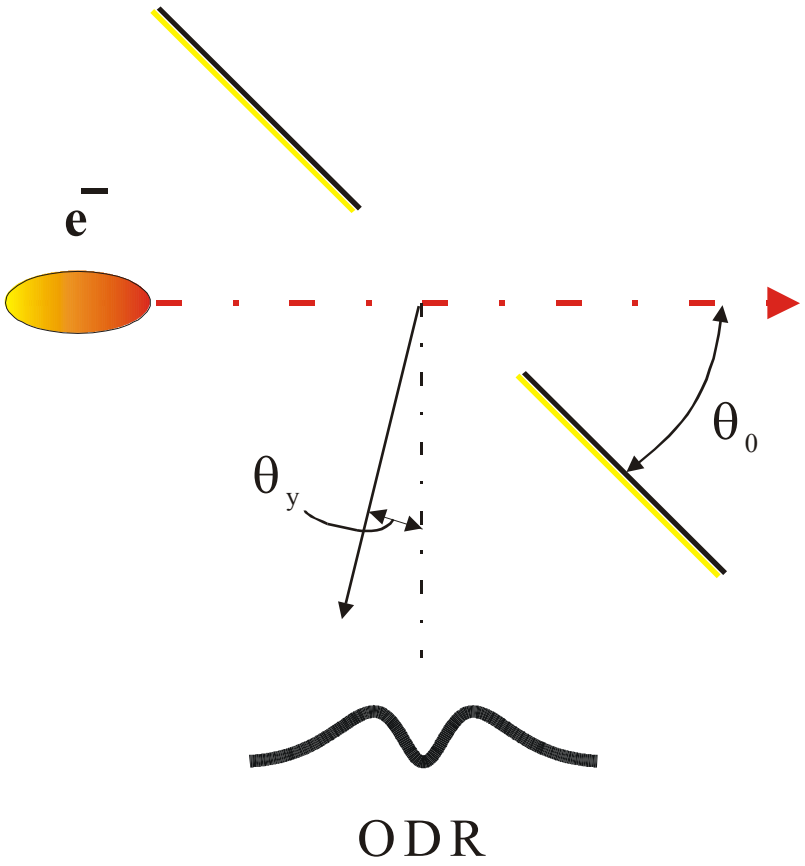
- **Large emission angles ($0 \sim 180^0$)**

  (good background conditions)

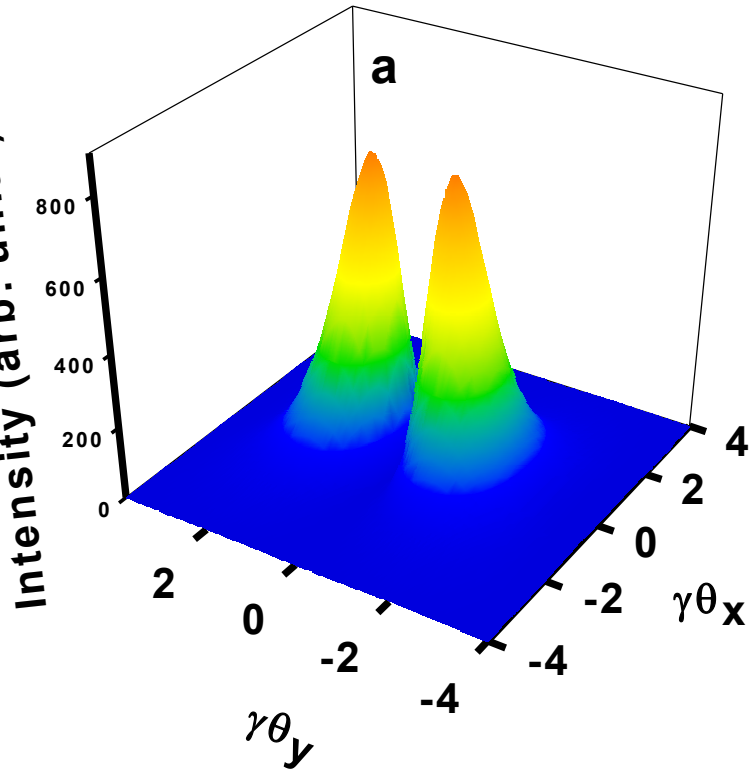
UV/X-ray Diffraction Radiation for Transverse Electron Beam Size Measurements

- The state-of-the-art in Optical Diffraction Radiation was developed at KEK
- Sensitivity to the beam size as small as 14 μm was achieved
- The resolution was limited by
  - Diffraction limit
  - Residual synchrotron radiation background
  - Non-optimal measurement system

Basic Principle

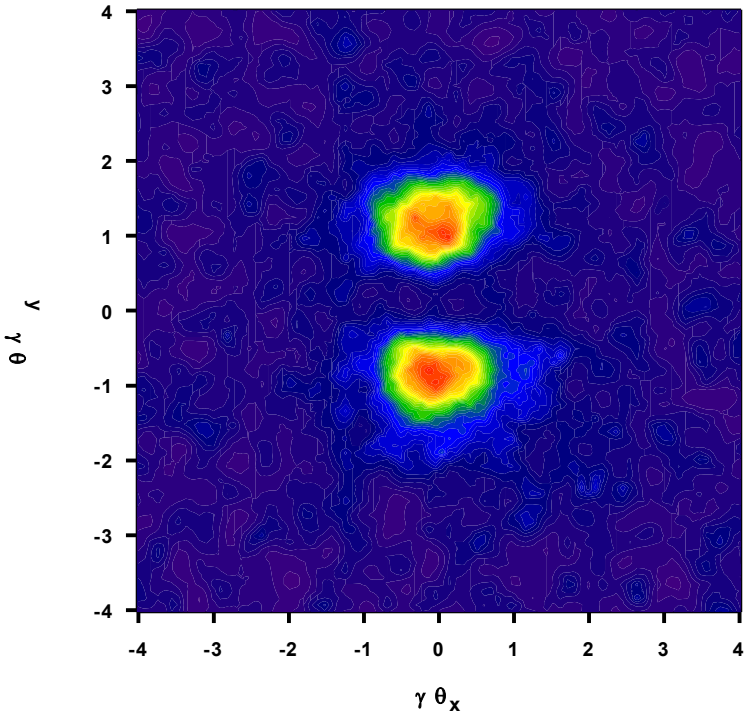


Vertical Polarization component

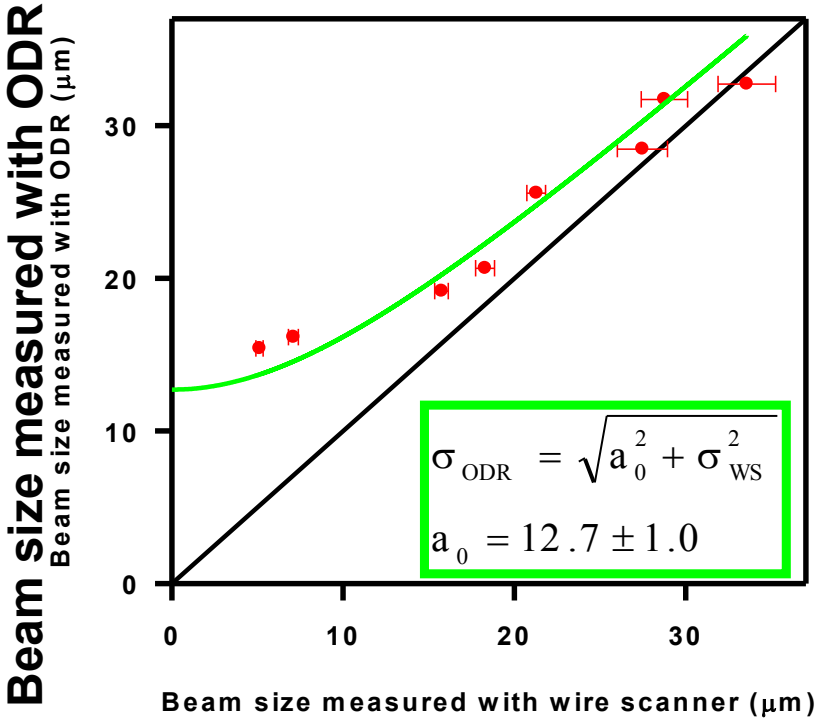


Basic Principle

Typical CCD image measured in the back focal plane of the lens



Visibility of the ODR vertical Polarization component depends on the electron beam size



Summary: Limitations and Sensitivity

Photon yield: $$Z = \frac{\omega}{\omega_c} = \frac{2\pi a}{\gamma\lambda} < 1$$

CesrTA: $\gamma = 4000 \quad and \quad \lambda = 0.5\,\mu m$

$a < 320\ \mu m$

Optimal Sensitivity: $$\sigma > 0.05\,\frac{\gamma\lambda}{2\pi}$$

CesrTA $\sigma > 16\,\mu m$

For λ = 0.5 μm:

Optimal Sensitivity: $$\sigma > 0.05\,\frac{\gamma\lambda}{2\pi}$$

CesrTA $\sigma > 3\,\mu m$

For λ = 0.1 μm :

Work plan

- DR simulations and evaluation of its sensitivity to beam size measurement

- Hardware development for the beam test in CESR-TA
  - Design by Summer 2011
  - Construction of the Vacuum system and detection system in UV range
  - Installation in 2012
  - Design of a X-ray detection system 2012
  - Installation of the X-ray detection system in 2013

- Beam test and validation of UV/X-ray DR monitoring
  - Beam test in the UV domain in 2012
  - Beam test in the X-ray domain in 2013

Deliverables

1. **Design report of CESR-TA UV-DR beam size monitor (2011)**
2. **Design report of CESR-TA X-ray-DR beam size monitor (2012)**
3. **Report on beam test and Performance (2013)**

4. ***Design report on CLIC (MB & DB) DR beam size monitor (2014)***
5. ***Full engineering report and cost estimate on CLIC DR beam size monitor (2015)***

Manpower

1. P. Karataev (10%)

2. PDRA (funded within CLIC – UK collaboration)

3. PhD student funded by CERN (Lorraine Bobb)