Research overview

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Complementary skills workshop, 15th – 19th March, Liverpool

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Outlines

Last results on Coherent Diffraction Radiation experiment at CTF3 (CERN).

• Upgrade of the Coherent Diffraction Radiation setup at CTF3 has been performed in February 2010

Study of Kramers-Kronig relation as a tool for longitudinal bunch profile reconstruction.

• Errors and applicability range estimation.
• Detectors coverage range and extrapolation procedures.
• Accuracy of bunch distribution reconstruction.

CDR Simulations.

• Classical theory of BDR is used.
• Development of a computer code for a two target configuration.

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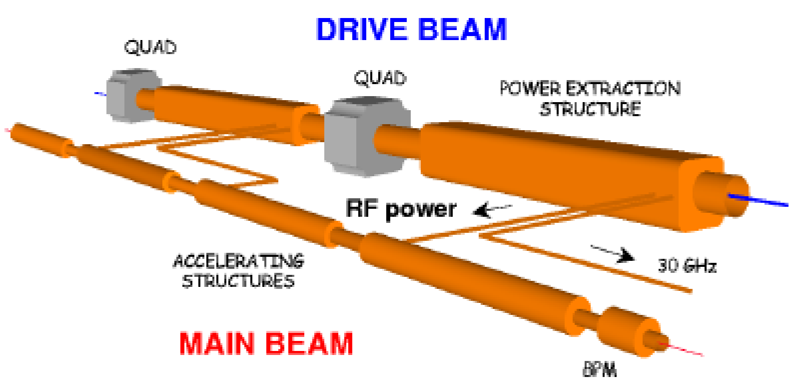
CLIC & CTF3

CLIC

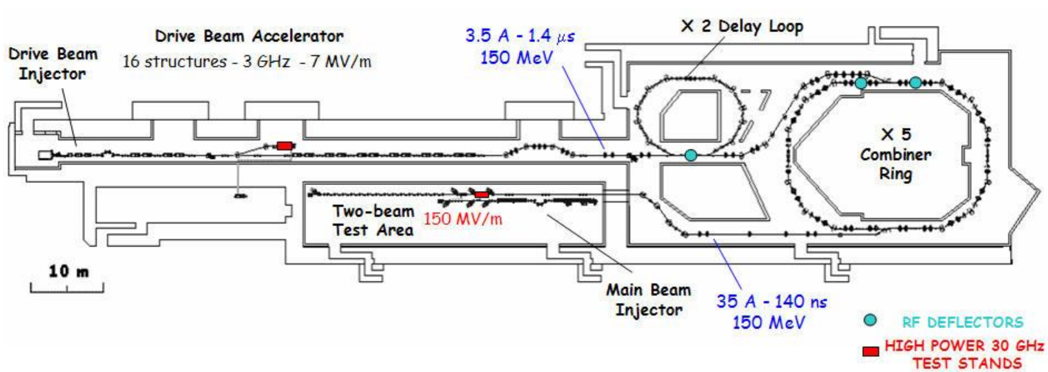


• Future electron-positron collider based on room temperature acceleration scheme.

• Coupled RF cavities transfer the power from a low energy, high current drive beam to a high energy, low current probe beam.

• Would potentially allow for higher accelerating gradient and proposed Centre-of-Mass energy 3-5 TeV.

CTF3



• Test accelerator at CERN to demonstrate the feasibility of CLIC concept.

• Generation of high charge, high frequency electron bunch trains by beam combination in a ring using transverse deflectors.

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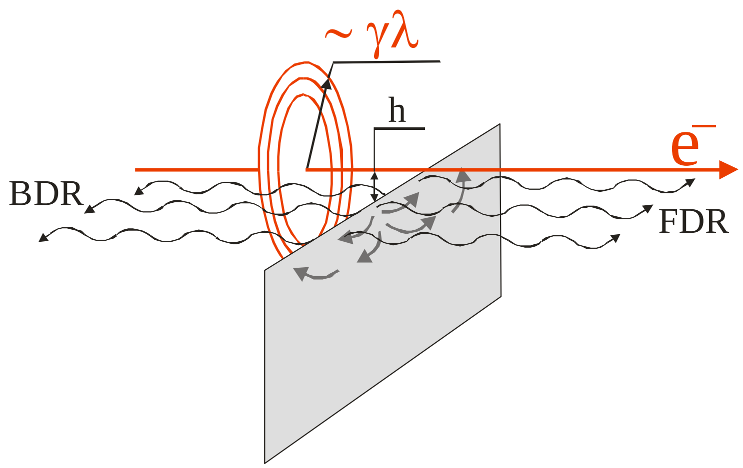
Diffraction radiation spectrum



$$h \le \gamma\lambda$$

Diffraction radiation appears when a charged particle moves in the vicinity of a medium.

Impact parameter h – the shortest distant between a particle and a target.

λ – observation wavelength,

$\gamma = \dfrac{E}{mc^2}$ – Lorentz factor.

$$\boxed{S(\omega) = S_e(\omega)\left[N + N(N-1)F(\omega)\right]}$$

$S(\omega)$ - radiation spectrum

$S_e(\omega)$ - single electron spectrum

N - number of electrons in a bunch

$F(\omega)$ - longitudinal bunch form factor

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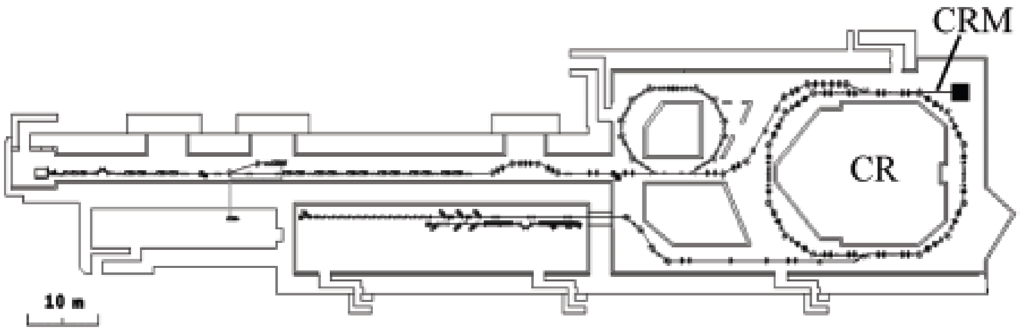
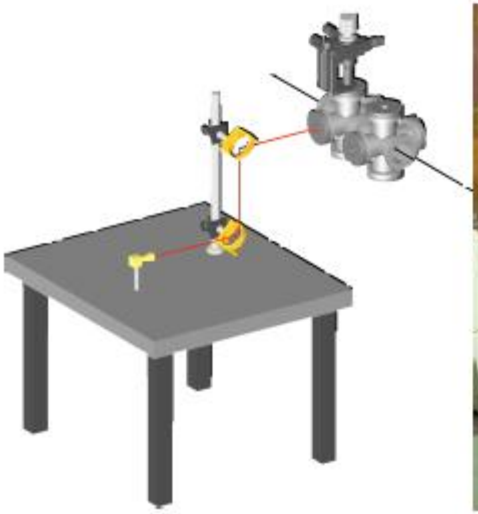
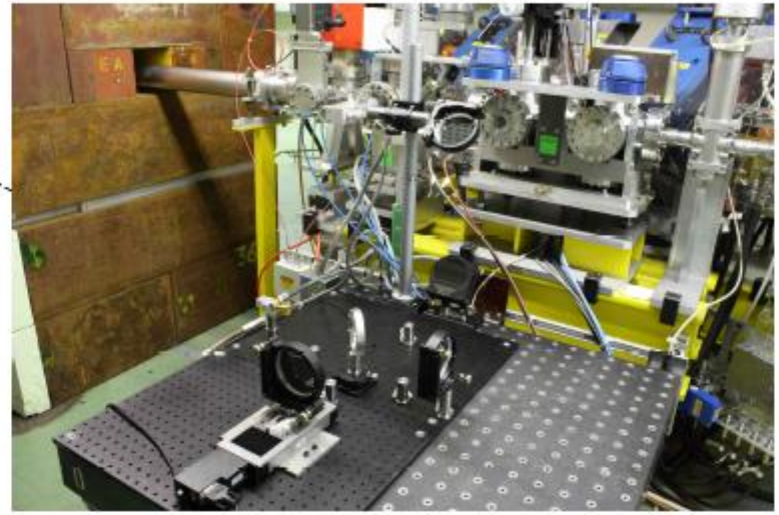
CDR setup



Located at CRM line of CTF3.
Location allows to measure CDR and CSR.





CDR running at:

Train length:

$100\, ns\ to\ 200\, ns$

Bunch sequence frequency:

$3GHz$

Nominal current:

3.5 A

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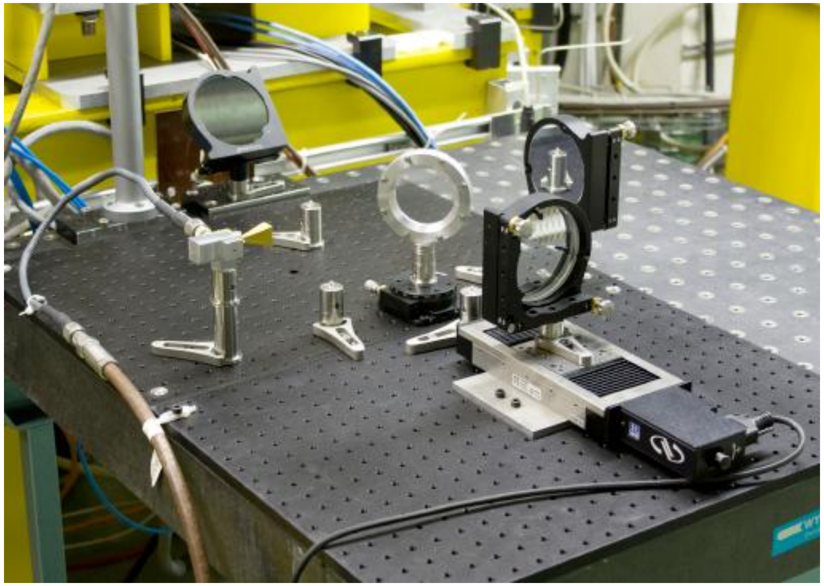
CDR UHV hardware & interferometer

• 2 six way crosses, containing the targets.
• 4D UHV manipulator for the first target.
• Diamond UHV window, with viewing diameter 40 mm, through which radiation is detected.

In February 2010, upgrade has been performed:
• installed second target.
• 1D UHV manipulator.
• Quartz fused silica UHV window, with viewing diameter 40 mm.

• Signal from the UHV window is translated to the Michelson interferometer.
• Using a Kapton film optical beam splitter at the moment.
• 4” aluminised broadband mirrors.
• High precision translation stage.
• Schottky Barrier Diode detector.



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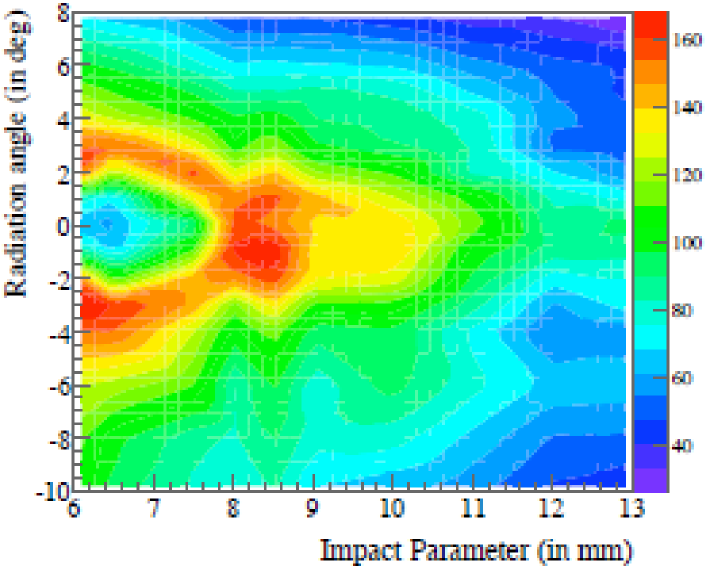
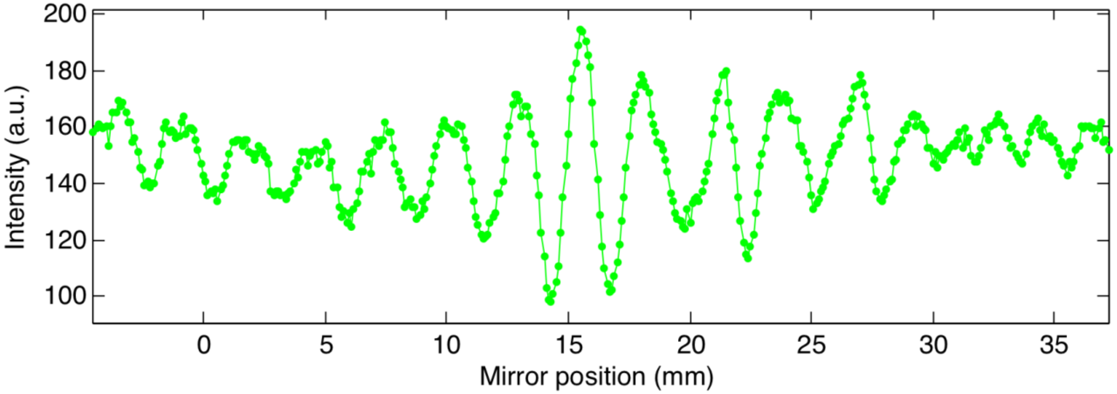
Experimental results

CDR 2D distribution (horizontal polarization):



Good agreement with expectations, But some distortion that can be explained by background caused upstream (CSR, wake-fields).

Interferometric CDR scan:



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Kramers-Kronig analysis

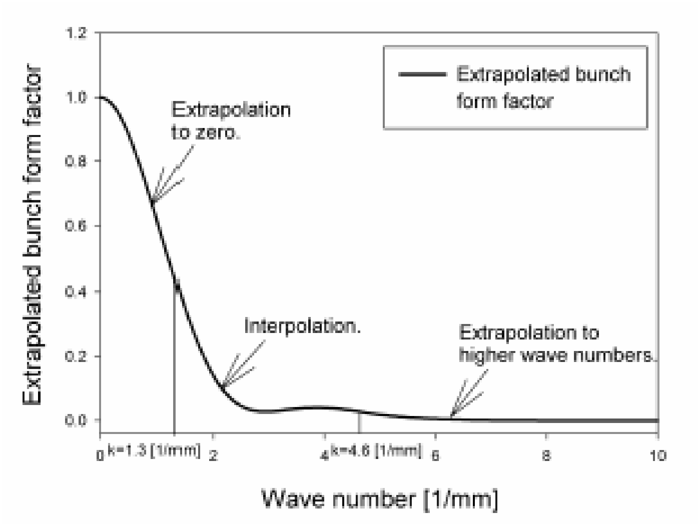
The normalized bunch distribution function can be determined as:

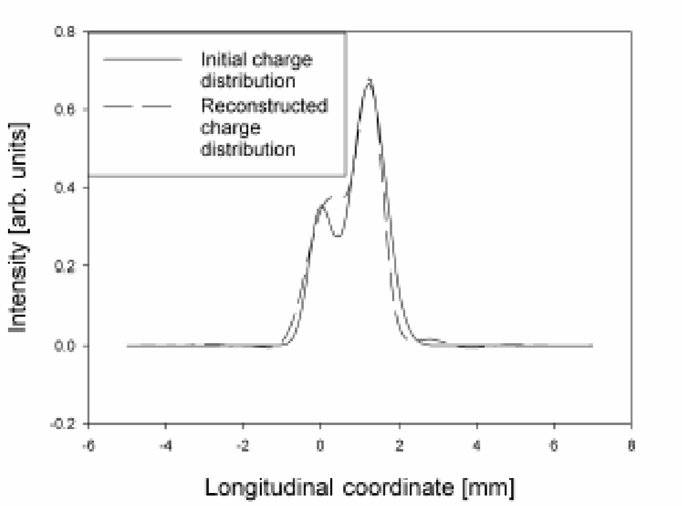
$$S(z) = \frac{1}{\pi c}\int_0^\infty d\omega \rho(\omega)\cos\left(\psi(\omega) - \frac{\omega z}{c}\right)$$

The phase factor can be obtained using Kramers-Kronig relation:

$$\psi(\omega) = -\frac{2\omega}{\pi}\int_0^\infty dx \frac{\ln\left(\rho(x)/\rho(\omega)\right)}{x^2-\omega^2}$$

where $\rho(\omega)$ is the form factor amplitude and $\psi(\omega)$ is the phase factor.





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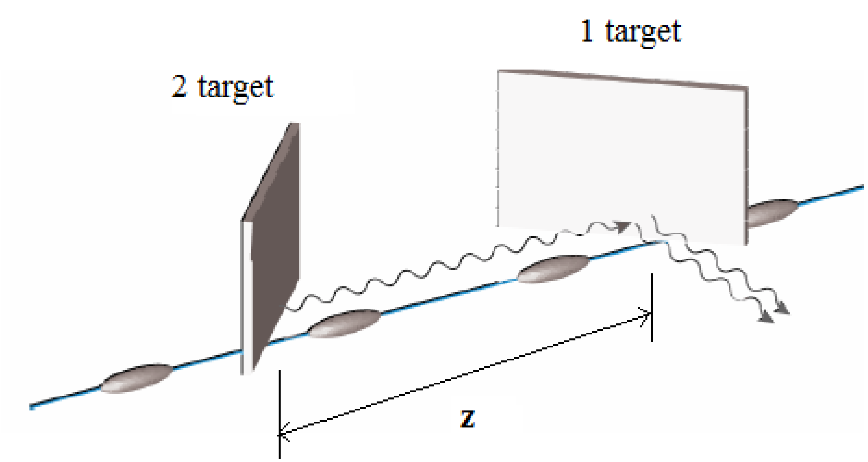
Simulation studies

Diffraction radiation spatial distribution from a system of two targets:

$$\frac{d^2W^{DR}}{d\omega d\Omega} = 4\pi^2 k^2 a^2 \left[\left| E_1^{BDR} - E_2^{FDR} \exp\left[-\frac{ikz}{\beta} \right] \right|^2 \right]$$

E_2^{FDR} - forward diffraction radiation from the second target. z - distance between targets.

E_1^{BDR} - backward diffraction radiation from the first target. $\beta = \frac{v}{c} \approx 1$



Parameters for the setup at CTF3:

- target dimension 40x60 mm
- beam energy $\gamma = 235$
- Distance from the first target to the detector $a \approx 2m$

Simulation studies is a part of an ongoing work.

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Conclusions & Outlook

Conclusions:

• Upgrade of the Coherent Diffraction Radiation setup at CTF3 has been performed in February 2010, which included installation of the second target, UHV window, and automation of a various components that made system nearly complete.
• Development of the computer code for simulation of CDR from two targets.
• Investigations on Kramers-Kronig bunch length reconstruction method.

Outlook:

• Finalize and apply the computer codes for longitudinal bunch profile reconstruction and for simulation of Coherent Diffraction Radiation spectra, to be used in data analysis.
• Take over the ongoing programme on development of the coherent diffraction radiation monitor at CTF3 and lead it to its ultimate goal.
• Participate in preparation of the cost-effective design for CLIC Conceptual Design Report towards the end of 2010.

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