Synchrotron radiation photons reflections

Dominik Arominski
(Warsaw University of Technology/CERN)

Acknowledgements:
M. Ady, A. Sailer, A. Latina

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Overview

Motivation

Introduction

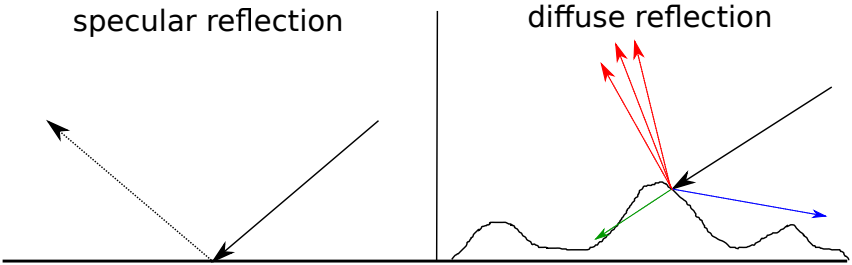
Synchrotron radiation photons in the IP region
- Fully absorbing walls
- Fully reflective walls
- Coppper walls
- Extended apertures

Summary and outlook

Motivation

- Synchrotron radiation photons reflections remain the last unchecked source of the beam-induced backgrounds
- It is an expected source of high fluxes of photons in the keV range, which may leave significant energy depositions in the innermost layers of the CLIC detector
- Detector safety, with the accepted aperture model, has to be checked

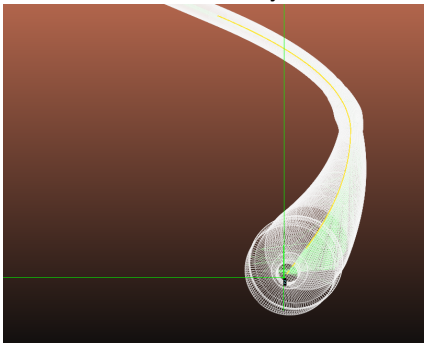
Photons reflections



- Upon collision a photon can be absorbed, reflected or transmitted, depending on the material properties and photon's energy
- Low energy photons, with $\lambda >> \sigma_{roughness}$, can go through specular reflection, where $\theta_{in} = \theta_{out}$
- When $\lambda \propto \sigma_{roughness}$, can go through diffuse reflection where the reflected angle is distributed over a range, and where backscattering and grazing are possible

Synrad+ software

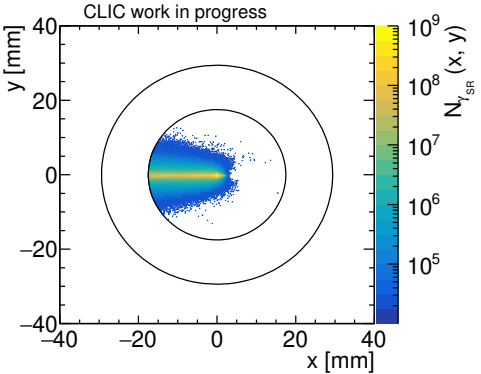
CLIC 380 GeV FFS in Synrad+

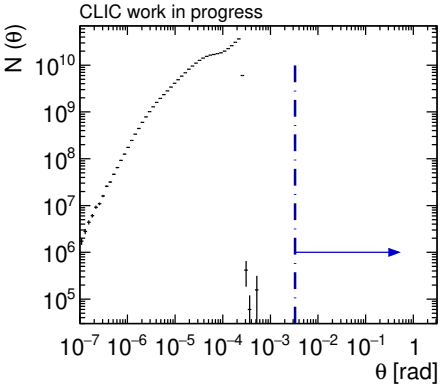


- Synrad+ is a Monte-Carlo program generating and tracing virtual synchrotron radiation photons in user-defined geometry, originally intended for SR-induced outgassing calculations
- Supported magnetic elements include bending magnets, quadrupoles, and analytic magnetic fields (e.g. sinusoidal or other periodic)
- The generation algorithm is used also in Geant4 and MADX
- Implemented are both specular and diffuse reflections

- Reflections depend on material parameters and are based on measured reflection tables
- Can import geometry from MAD-X output, including the apertures
- More information can be found in the Synrad+ documentation

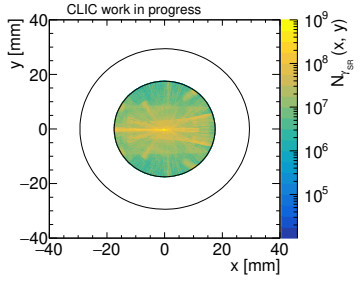
Fully absorbing walls

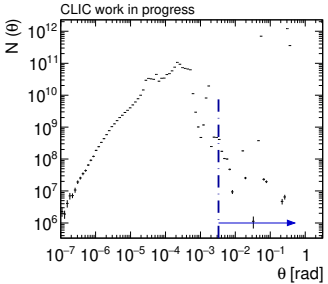


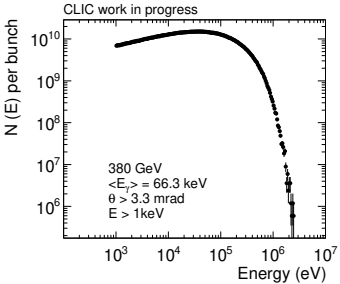


- All photons not-direct are absorbed; 4% of total SR power transported to the IP region
- Not a single photon in detector acceptance - agreement with previous PLACET results
- Best-case scenario - safety of the detector ensured and no need to intervene

Fully reflective walls

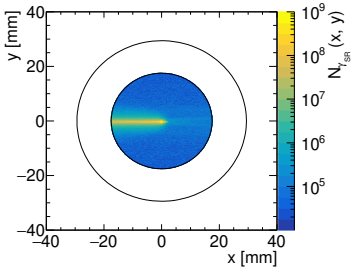


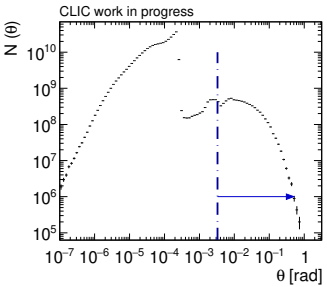


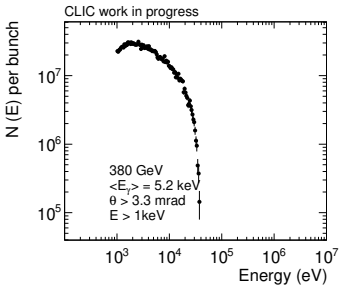


- Worst-case scenario - all produced SR photons are transported to the IP
- Numerous photons in the detector's acceptance with over 74% of total SR beam energy

Copper walls, 100 nm roughness

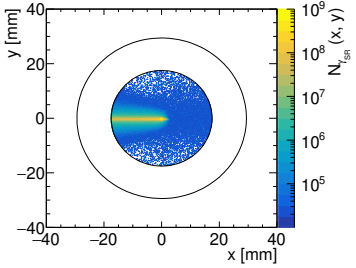


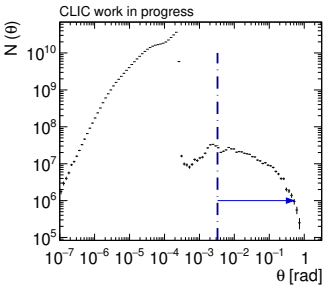


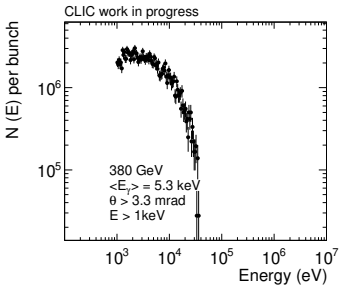


- Strongly absorbing: 95% of SR power is absorbed before reaching the IP
- 0.09% of the energy present in QD0 visible to the detector, with $\theta > 3.3$ mrad and E$>$ 1 keV
- Visible photons generally low energy $<$ 30 keV, are mostly absorbed in the beam pipe before reaching sensitive material

Copper walls, 1 μm roughness

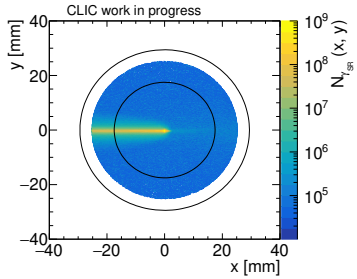


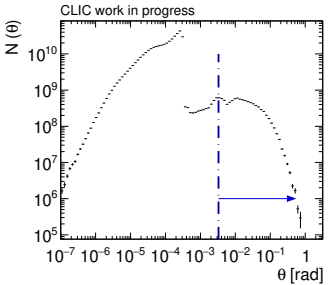


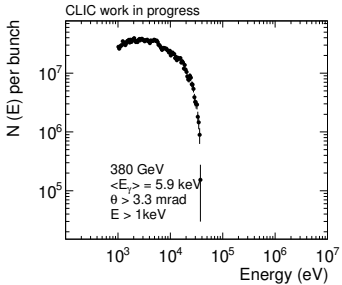


- Increased absorption of divergent photons $\rightarrow$ safer conditions for the detector
- $8{\cdot}10^{-3}$% of the energy present in QD0 visible to the detector, with $\theta > 3.3$ mrad and E$>$ 1 keV
- Most of the photons in the acceptance absorbed in the beam pipe

Copper walls, +44% radius, 100 nm roughness







- Larger apertures lead to higher flux of photons in the IP region, with 20% more of total SR power
- 0.11% of the energy present in QD0 visible to the detector, almost 50% more than in the nominal case
- Photon beam closer to the vertex detector, aperture change not desirable for the detector's safety

Summary and outlook

- An average of 11 W of synchrotron radiation power is expected to be created in CLIC FFS
- Only 5% of the total power is going to be transported to the detector region when using copper beam pipe,
- 0.1% of this energy can impact the detector material when $\sigma_{roughness} = 100$ nm
- Rougher surface is less reflective = desirable for detector safety; 1 μm average roughness lowers the SR power in the IP region by a factor of 10
- Extending beam pipe apertures decreases the margin of safety of the detector: more photons are reflected and there's more energy in the detector's acceptance

Future and ongoing works:

- Assess the full impact of reflected synchrotron radiation photons on the CLICdet
- Implement 3 TeV BDS in Synrad