gravitational synchrotron radiation

$$W_{GSR}=\frac{5\pi}{16}\frac{m^2}{M_P^2}\frac{\hbar c^2\gamma^4}{\rho^2}n_b^2N_b^2$$

assuming coherence over all n_b bunches

P. Chen, SLAC-PUB-6666 (1994)

$$W_{SR}=\frac{2}{3}\alpha\frac{\hbar c^2\gamma^4}{\rho^2}n_b\ N_b$$

$$\frac{W_{GSR}}{W_{SR}}=\frac{15\pi}{32}\frac{m^2}{\alpha M_P^2}n_b\ N_b\ \sim 3.5\times 10^{-21}$$

for LHC

gravitational beamstrahlung

$$W_{GB} = \frac{\pi}{4}\frac{1}{\alpha}\frac{m^2}{M_P^2}\left(\frac{\sigma_z}{\lambda_c}\frac{B}{B_c}\right)^2 N_b n_b W_{EM}$$

P. Chen, SLAC-PUB-6666 (1994)
P. Chen, Modern Phys. Lett. 6 (1991) 1069

with a cut off at $\omega \geq c/\sigma_z$

for FCC-ee-Z:

$\sigma_z \approx 12$ mm
$M_P \approx 1.2\times 10^{19}\,\frac{\mathrm{GeV}}{c^2}$ (Planck mass)
$B_c \approx 4.4 \times 10^9$ T (Schwinger critical field)
$\lambda_c \approx 2.4 \times 10^{-12}$ m (electron Compton wavelength
$\langle B \rangle \approx \left(2^{3/2}/\pi\right) N_b\, r_e/(\gamma \sigma_x^* \sigma_z)\, p/e \approx 10$ T

$$\frac{\pi}{4}\frac{1}{\alpha}\frac{m^2}{M_P^2}\left(\frac{\sigma_z}{\lambda_c}\frac{B}{B_c}\right)^2 N_b n_b^2 \approx 10^{-21}$$

$W_{EM} \sim 0.5$ MW
$\rightarrow W_{GB} \sim 0.5$ fW

assuming coherence over all n_b bunches