Synchrotron radiation and photoemission from the 11T-dipoles

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Synchrotron radiation power

Old configuration: 1 MB bending magnet L_{MB} = 14.3 m ρ_{MB} = 2.8 km

New configuration: 2 MBH high field magnets L_{MBH} = 2 x 5.3 m ρ_{MBH} = 2.1 km

The **total bending angle is kept constant**, therefore:

$$\frac{L_{\mathrm{MB}}}{L_{\mathrm{MBH}}} = \frac{\rho_{\mathrm{MB}}}{\rho_{\mathrm{MBH}}} = 1.3$$

The **energy radiated by a proton** in a single turn, in a dipole of length L and bending radius ρ, is given by:

$$U_{1\mathrm{T}} = \frac{e^2\gamma^4}{6\pi\varepsilon_0}\frac{L}{\rho^2} \qquad (1)$$

The **average power radiated by a beam** of N_p protons in the considered bend is given by:

$$P = \frac{N_p}{T_{\mathrm{rev}}} U_{1\mathrm{T}} \qquad (2)$$

For a **single MB magnet** and the two HL-LHC beams at 7TeV:

$$P_{1\mathrm{MB}} = 12.4\ W$$

We can use (1) and (2) to to **scale to the MBH**:

$$P_{2\mathrm{MBH}} = P_{1\mathrm{MB}}\frac{\rho_{\mathrm{MB}}}{\rho_{\mathrm{MBH}}} = 16.1\ W$$

The increase of about 4 W is completely negligible w.r.t. the cooling capacity of 8 kW/arc

For details: A. Hofman, "The physics of synchrotron radiation"

The **photon energy (frequency) spectrum** is given by:

$$\frac{\mathrm{d}P}{\mathrm{d}\omega} = \frac{P_s}{\omega_c} S_s\left(\frac{\omega}{\omega_c}\right)$$

Where:

$$P_s = \frac{e^2}{4\pi\epsilon_0}\frac{2c\gamma_{\mathrm{rel}}^4}{3\rho^2}$$

Instantaneous power

$$\omega_c = \frac{E_c}{\hbar} = \frac{3c\gamma_{\mathrm{rel}}^3}{2\rho}$$

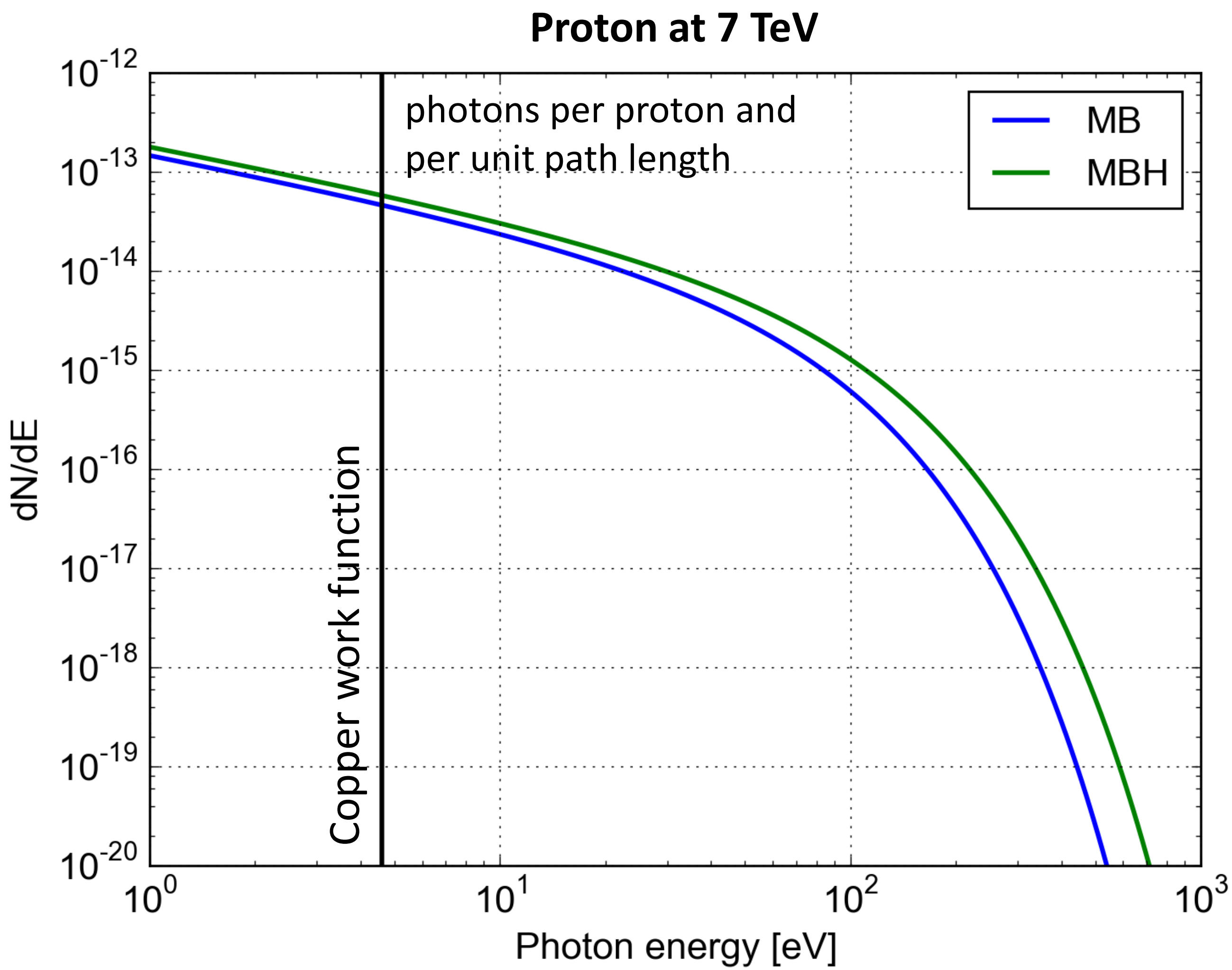
Critical frequency

$$S_s(x) = \frac{9\sqrt{3}}{8\pi} x \int_x^{\infty} K_{5/3}(z)\mathrm{d}z$$

Special function

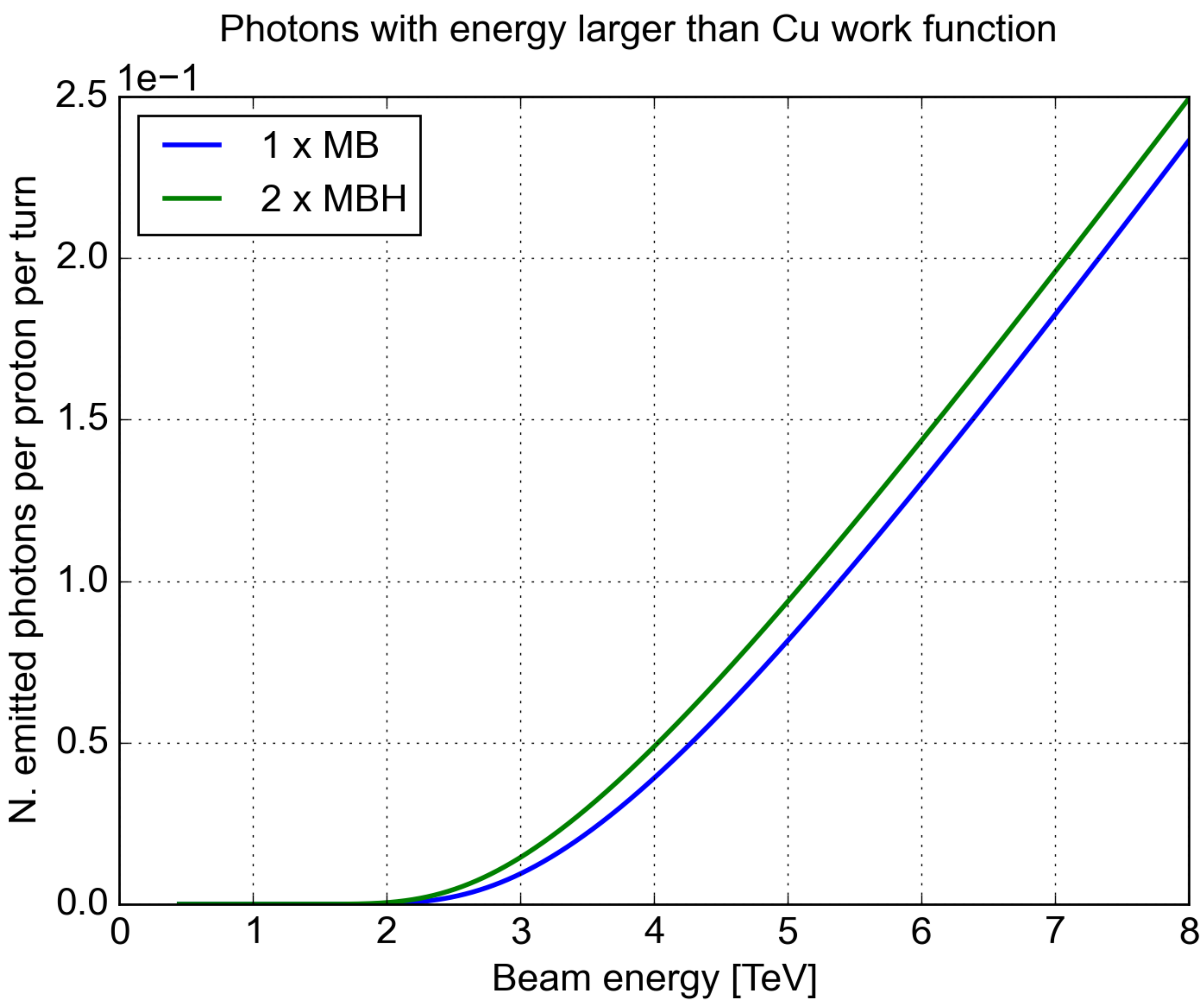
Calculation described in detail in P. Dijkstal et al., “Simulation studies on the electron cloud build-up in the elements of the LHC Arcs at 6.5 TeV” and implemented in python tool at https://github.com/PyCOMPLETE/CellStudyInputPyECLOUD

The **photon spectrum** changes as a function of the bending radius:

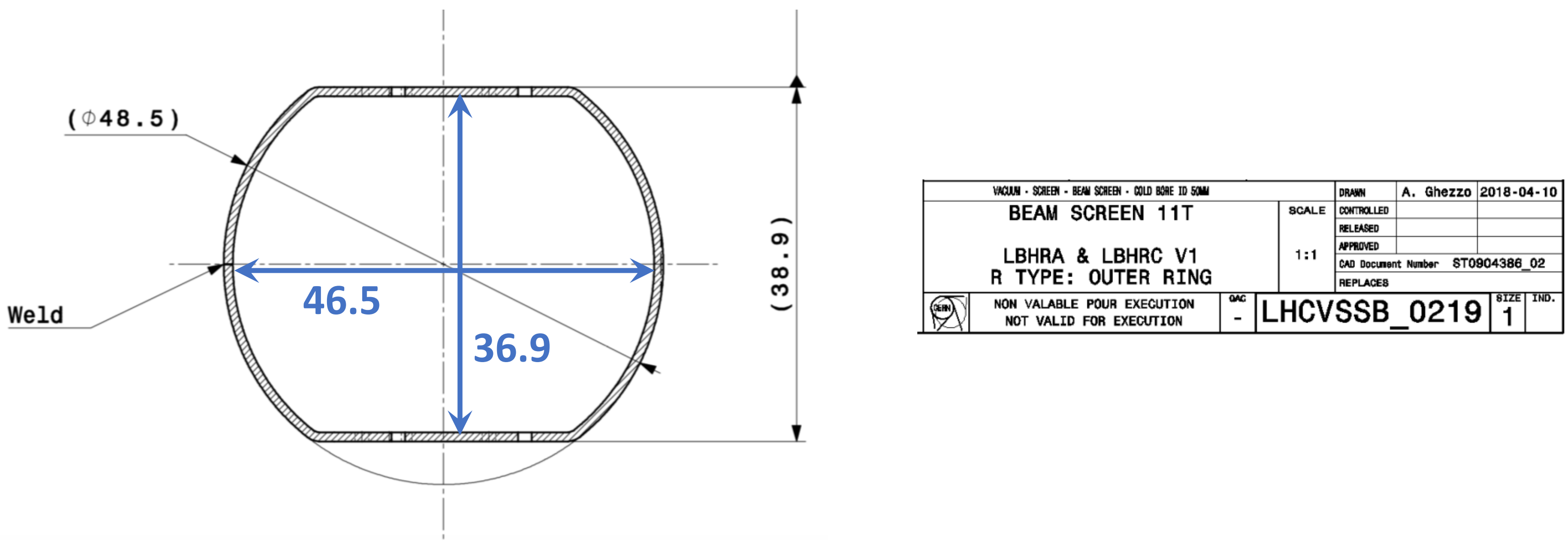


The **number of photoelectrons is proportional to the number of photons above the work function**, it can be obtained integrating the spectrum…

The **increase in the number of photoelectrons is marginal**



The **geometry is very similar** to the one of the LHC MB beam screens
→ **no significant changes expected on the e-cloud buildup**



Drawing provided by P. Andreu Munoz and D. Shoerling

Summary

- The increase of the magnetic field from 8.33T to 11T results in an increase of the **synchrotron radiation power** and number of **generated photoelectrons**
  → Both effects have been evaluated and are **expected to be very small** (hardly detectable)

- As the beam screen geometry is extremely similar to the one installed in the standard MBs, **no change is expected on the e-cloud buildup w.r.t. the LHC standard bending magnets**

Thanks for your attention