Milestones

The Bremsstrahlung total cross section over the whole solid angle 4π is

$$\sigma_{\rm Bre}(4\pi) = 353 \text{ mb}\,,$$

meanwhile, in each brick of the ZDD it is reduced to

$$\sigma_{\rm Bre}(\text{ZDD}/4) = \mathbf{2.5\ mb}\,.$$

The maximum luminosity achievable by BEPCII is

$$\mathcal{L}_{\rm max} = 8\times 10^{32}\,\text{cm}^{-2}\text{s}^{-1} = 8\times 10^{5}\,\text{mb}^{-1}\,\text{s}^{-1}\,,$$

which corresponds to a Bremsstrahlung event frequency over each ZDD brick

$$F_{\rm Bre}(\text{ZDD}/4) = \mathcal{L}_{\rm max}\cdot\sigma_{\rm Bre}(\text{ZDD}/4) = \mathbf{2\ MHz}\,.$$

Assuming for these events an energy distribution $f(E)\propto 1/E$, and considering the energy interval $[20\,\text{MeV}, 1890\,\text{MeV}]$ we get the mean energy as

$$E_{\rm av} = \frac{\displaystyle\int_{20\,\text{MeV}}^{1890\,\text{MeV}} E\,f(E)\,dE}{\displaystyle\int_{20\,\text{MeV}}^{1890\,\text{MeV}} f(E)\,dE} = \frac{1870\,\text{MeV}}{\ln(1890/20)} = \mathbf{411\ MeV}\,.$$

The corresponding current in the ZDD brick will be

$$I_{\rm Bre}(\text{ZDD}/4) = E_{\rm av}\cdot n_{\rm pe}\cdot A_{\rm PM}\cdot F_{\rm Bre}(\text{ZDD}/4)\cdot c_{\rm e}\,,$$

where:

- $n_{\rm pe} = 1-5\ \text{MeV}^{-1}$: is the number of photoelectrons per MeV;
- $A_{\rm PM} = 10^5$: is the photomultiplier gain;
- and $c_{\rm e} = 1.6\times 10^{-19}$ C: is the electron charge.

It follows

$$I_{\rm Bre}(\text{ZDD}/4) = 411\cdot(1-5)\cdot 10^5\cdot 2\times 10^6\cdot 1.6\times 10^{-19}\,\text{A} = \mathbf{(13\text{-}65)\ \boldsymbol{\mu}A}\,, \qquad (1)$$

where the two numbers refer to $n_{\rm pe} = 1\ \text{MeV}^{-1}$ and $n_{\rm pe} = 5\ \text{MeV}^{-1}$ respectively.
If we account for the fact that the shower should be read by more than one photomultiplier, this number can be considered as a strong upper limit.

Calibration

The ZDD calibration has been done at the DAΦNE-Beam Test Facility at Frascati using an electron beam with $E_{\rm av} = 450$ MeV. With a photomultiplier gain was: $A_{\rm PM} = 1.16\times 10^6$ a total charge $Q_{\rm tot}$=296 pC has been collected. This corresponds to a number of photoelectrons per MeV

$$n_{\rm pe} = \frac{Q_{\rm tot}}{E_{\rm av}\cdot A_{\rm PM}\cdot c_{\rm e}} = \frac{2.96\times 10^{-10}}{4.5\times 10^2\cdot 1.16\times 10^6\cdot 1.6\times 10^{-19}} = 3.54\,.$$

The expected current, using eq. (1), is

$$I_{\rm Bre}(\text{ZDD}/4) = 411\cdot 3.54\cdot 10^5\cdot 2\times 10^6\cdot 1.6\times 10^{-19}\,\text{A} = \mathbf{46.6\ \boldsymbol{\mu}A}\,.$$