Limitations on Minimum Gaps of Insertion Devices

"Radiation Problems will become dominant in the end"

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Overview

- Vertical Acceptance
- Lifetime
- Injection Efficiency
- Radiation
Vertical Acceptance

Development of Beta Function

\[ \beta(s) = \beta_0 + \frac{s^2}{\beta_0} \]

Acceptance

\[ A = \frac{(G/2)^2}{\beta_{\text{max}}} = \left( \frac{G}{2} \right)^2 \cdot \frac{\beta_0}{\beta_0^2 + (L/2)^2} \]

Optimum Acceptance

\[ A_{\text{opt}} = A(\beta_{0,\text{opt}}) = \frac{1}{4} \cdot \frac{G^2}{L} \]

Maximum Beta Function

\[ \beta_{\text{max}} = \beta(s = \pm L/2) = \beta_0 + \frac{L^2}{4\beta_0} \]

Optimum Beta Function

\[ \beta_{0,\text{opt}} = \frac{L}{2} \]

\[ L = \text{Straight Section Length} \]

\[ \beta_{0,\text{opt}} = \text{Vertical Beta Function in the middle (s=0)} \]

\[ G = \text{Inner Vertical Gap} \]

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Lifetime

The Vertical Elastic Gas Scattering Lifetime is proportional to the Vertical Acceptance

Coupling at large amplitudes leads to a Horizontal Aperture Limitation for a Vertical Aperture much smaller than the Horizontal Aperture

"Lifetime will be no issue of future light sources since storage rings will run in topping up mode"

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Injection Efficiency

A Small Vertical Acceptance will reduce the Injection Efficiency

Small Injection Efficiencies can be improved with small emittance injectors with small coupling and well controlled orbit

"Injection Efficiency is no issue if the Injection Rate is still sufficient"

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Radiation

High Beam Intensities can be maintained with very small Lifetimes and very small Injection Efficiencies

Permanent Topping up with very small Lifetimes and very small Injection Efficiencies will create a lot of Electron Losses

Actual ESRF Injector use:

\[
\frac{1 \text{ min at } 1 \text{ Hz}}{12 \text{ hours at } 10 \text{ Hz}} = 1.4 \cdot 10^{-4}
\]

....and the ESRF is already at its Radiation Limit !!!
Radiation

Collimation Solution: Scraper everywhere
Problem: Secondary scattering

Shielding Solution: Separation of Bremsstrahlung and Synchrotron Radiation

Neutron Shielding: Very heavy

A lot can be done on Beam Loss Collimation and Shielding but the Radiation will still dominate in the End !!!

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