U. Weinrich, ESRF

Limitations on Minimum Gaps of Insertion Devices

"Radiation Problems will become dominant in the end"

ICFA Workshop on Furture Light Sources, Argonne, April 1999

Overview

- Vertical Acceptance
- Lifetime
- Injection Efficiency
- Radiation

Vertical Acceptance

Development of Beta Function

$$\beta(s) = \beta_0 + s^2/\beta_0$$

Acceptance

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

Optimum Acceptance

$$A_{opt} = A\left(\beta_{0,opt}\right) = \frac{1}{4} \cdot \frac{G^2}{L}$$

Maximum Beta Function

$$\beta_{max} = \beta(s = \pm L/2) = \beta_0 + L^2/4\beta_0$$

Optimum Beta Function

$$\beta_{0,opt} = L/2$$

L = Straight Section Length

β_0 = Vertical Beta Function in the middle (s=0)

G = Inner Vertical Gap

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"

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"

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 !!!

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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 !!!

Quit | Help

SR/D-CT/1

Hard Copy | Panel

Start

Signal Options...

Graph Options...

31/03/89 01:01:47

Period 1.00 s

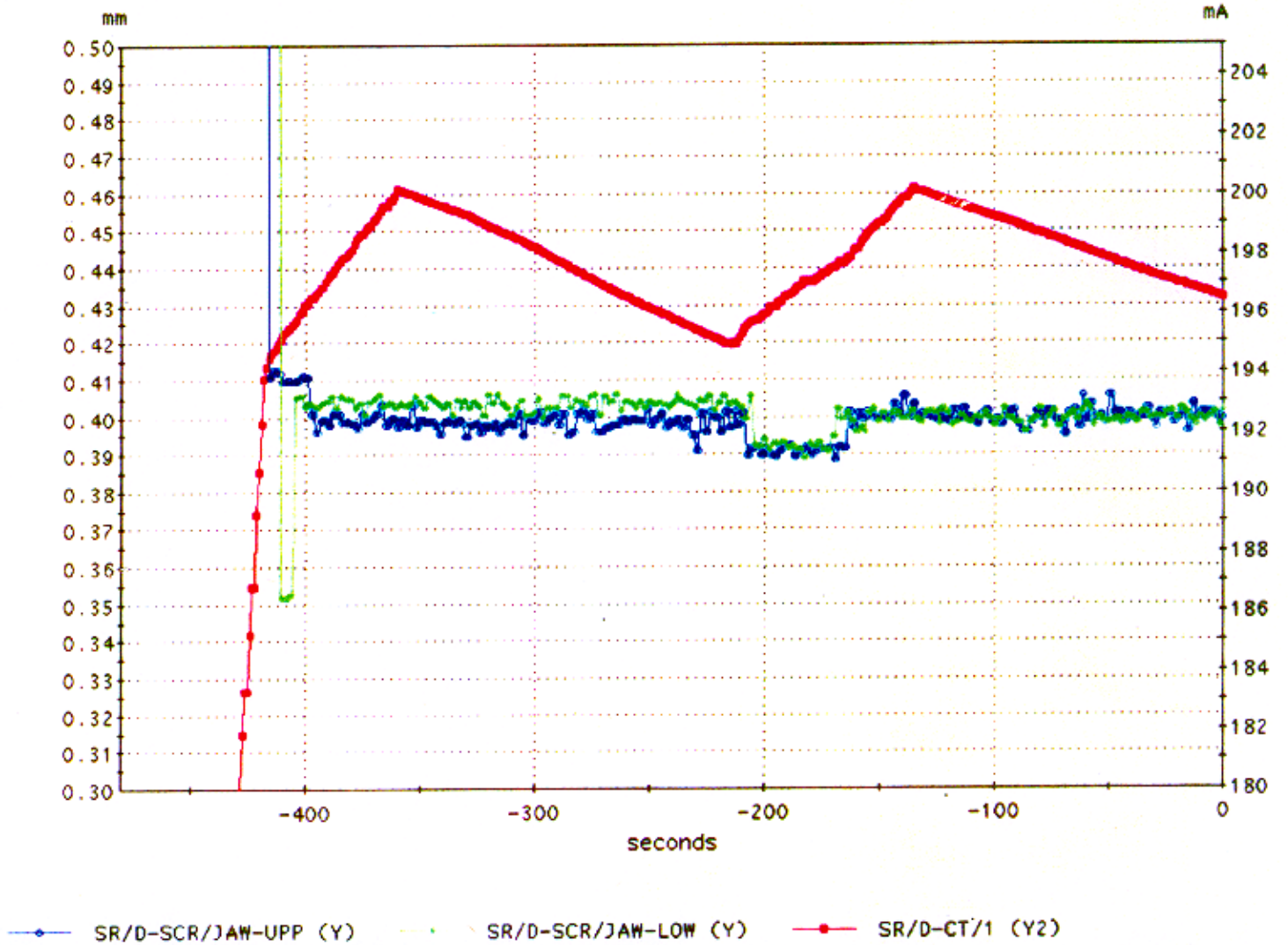
Ymin 0.3

Ymax 0.5

Y2min 180

Y2max 205.0000

SR/D-CT/1
196.486 mA
SR/D-SCR/JAW-UPP
0.400 mm
SR/D-SCR/JAW-LOW
0.401 mm



Quit | Help

SR/D-CT/1

Hard Copy | Panel

Stop

Signal Options...

Graph Options...

31/03/89 01:01:38

Period 1.00 s

Ymin 0

Ymax 3.1

Y2min 180

Y2max 205.0000

SR/D-CT/1
196.727 mA
SR/D-SCR/JAW-UPP
0.401 mm
SR/D-SCR/JAW-LOW
0.400 mm