Operation Experience of Insertion Devices at SPring-8

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on behalf of SPring-8 Accelerator Group

Contents

3rd Generation Light Source SPring-8

8GeV Electron Storage Ring

C=1436m

I=100mA

DBA with four 30m-LSSs

e=6.6nmrad (achromat)

3.4nmrad (non-achromat)

1GeV Linac

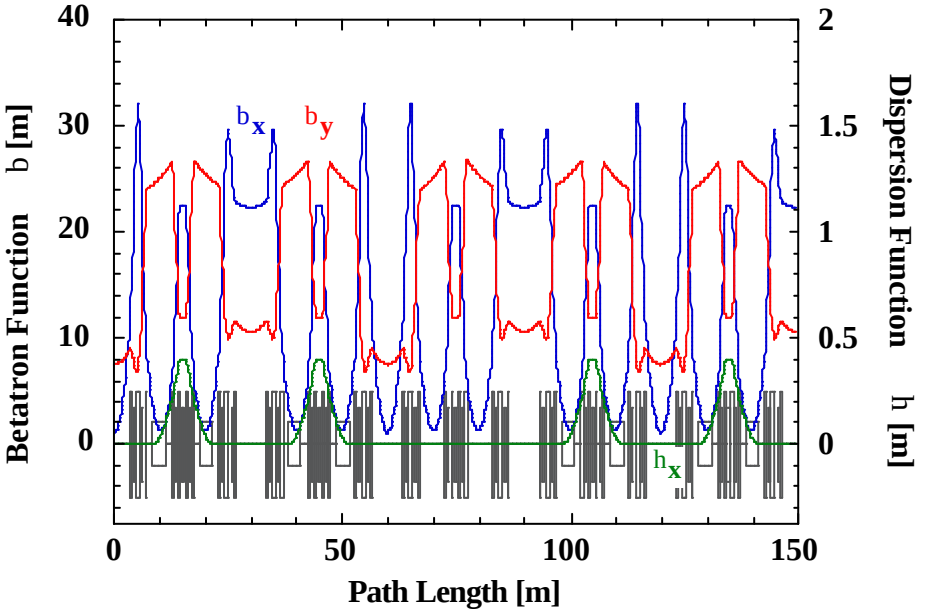
8GeV Booster Synchrotron

Typical Optics without LSS

Hybrid Optics

6.9nmrad

1997/3-1999/7

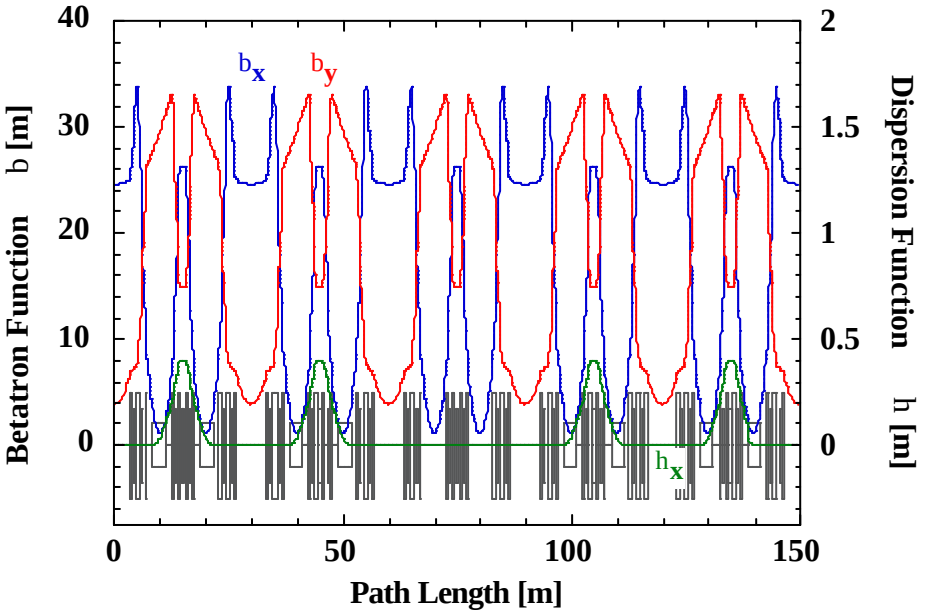


HHLV Optics

6.3nmrad

1999/9-2000/7

HHLV: High Horizontal and Low Vertical Beta



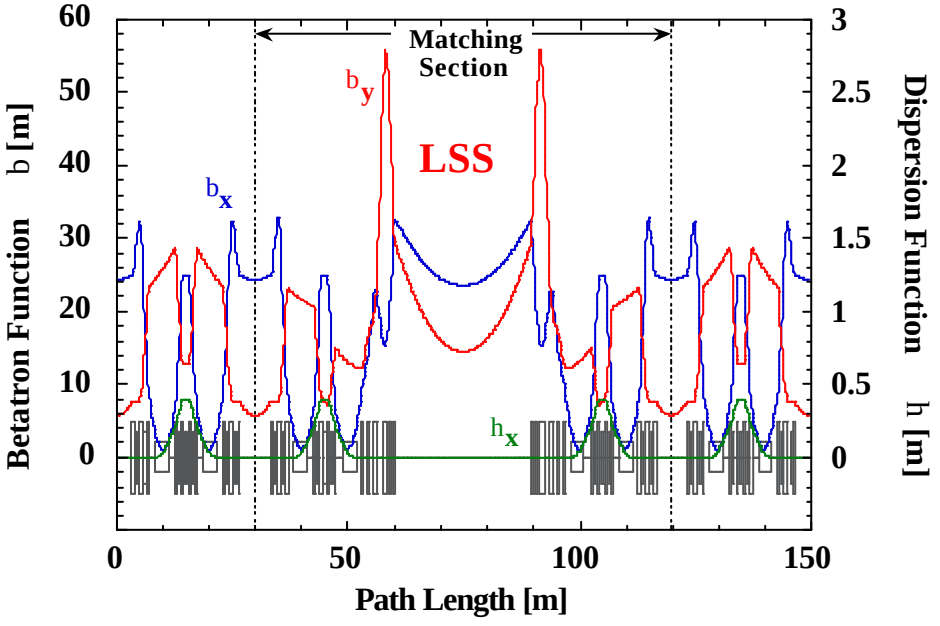
Typical Optics with LSS

Achromat Optics

6.6nmrad

2000/8-2002/11

2003/10-

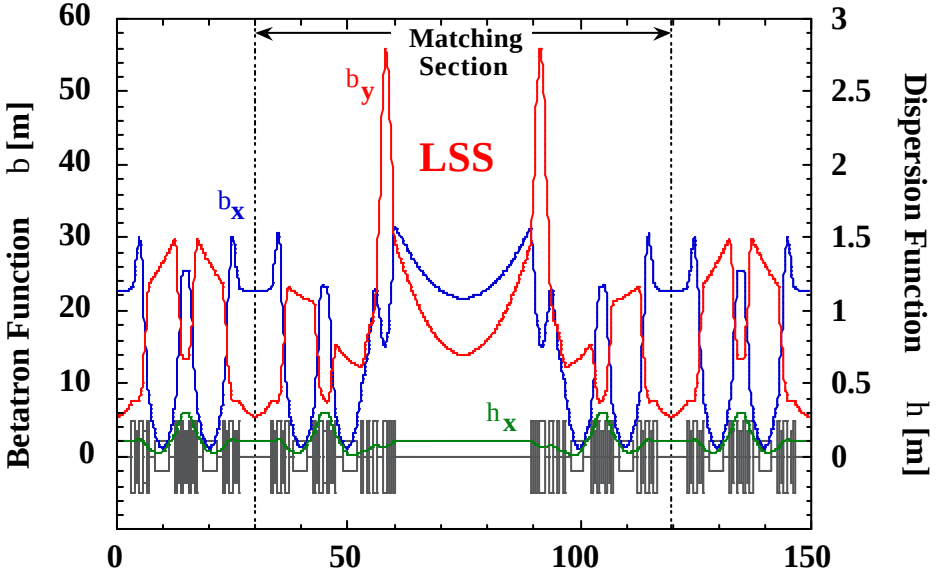


Non-Achromat Optics

(Low-Emittance Optics)

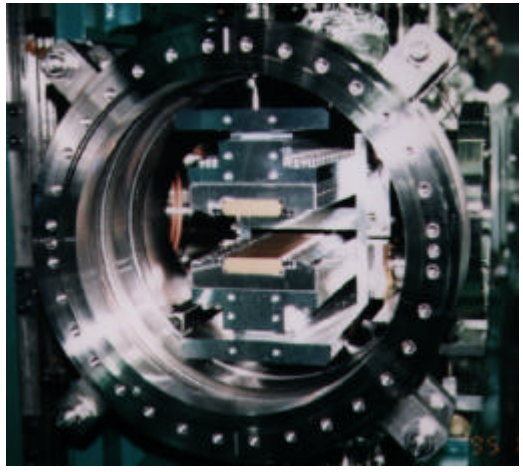
3.4nmrad

2002/11-2003/10



Insertion Devices

Up to now 26 insertion devices are installed.



In-Vacuum ... Total 20

Standard Type ... Total 12

(l = 32mm, N=140, Min.Gap=8mm, K_{max}=2.5)

ID24: Figure-8

ID19: 25m-Long Planner (l = 32mm, N=780)

*** Minimum gap value (full) is 7mm for ID20.**

Out-Vacuum ... Total 6

ID08: Elliptical Wiggler (l = 120mm, N=37, K^{y}_{max}=10)

ID15: Revolver (Planner/Helical)

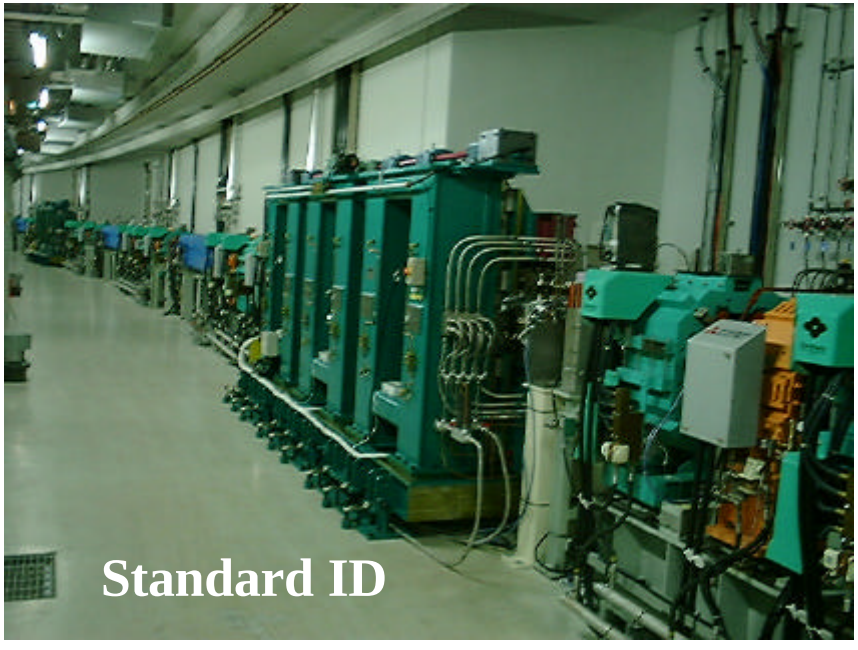
ID17: Combination of Permanent Magnets and Electromagnets with Iron-Poles
Fast Switching of Helicity, Figure-8 (Symmetric/Asymmetric)... under tuning

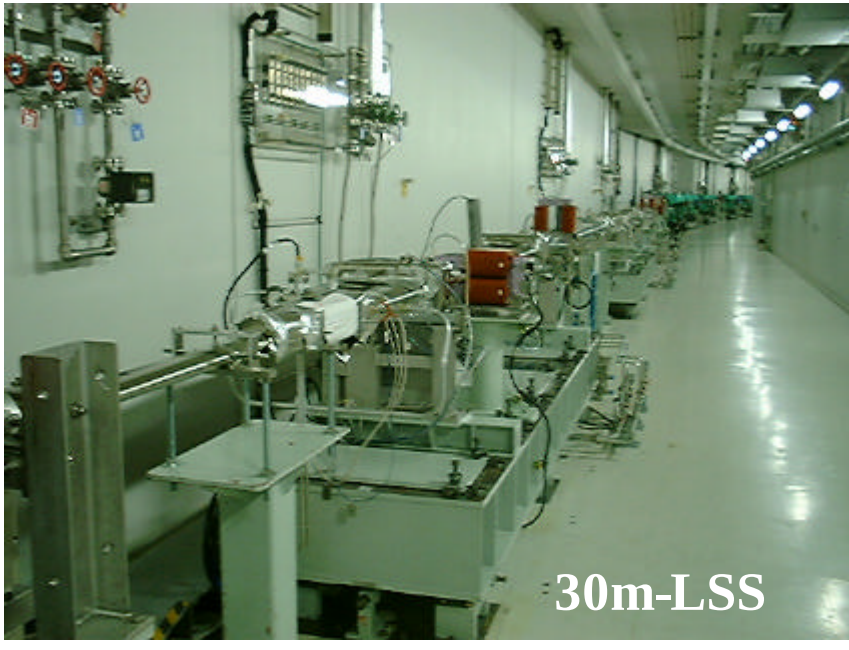
ID23: APPLE-II (Planner/Helical/Vertical)

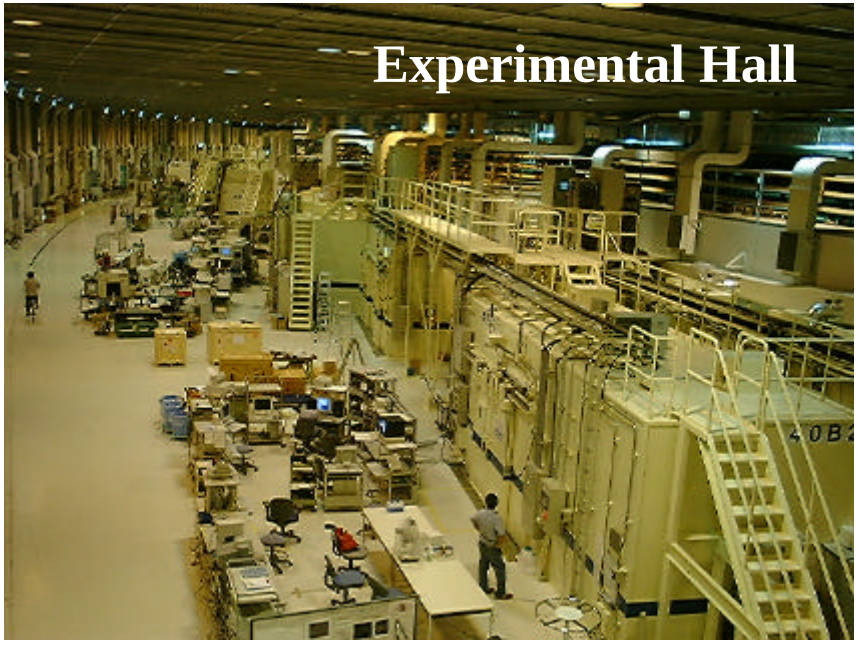
ID25: Helical Tandem, Fast Switching with Bump Orbit (1-10Hz)

ID27: Figure-8

*** Vertical aperture (full) is 15mm.**


Standard ID


30m-LSS


Experimental Hall


Long Undulator

Beam Size (Emittance) Measurement

Two-Dimensional Visible Light Interferometer : H, V

M.Masaki and S.Takano, J.Synchrotron Rad. 10 (2003) 295

Phase Zone Plate with 8keV X-ray : V

S.Takano, et.al, in Proc. DIPAC2001, ESRF, p.145.

X-ray Intensity Interferometry : V

M.Yabashi, et.al, PRL 87 (2001) 140801, PRL 88 (2002) 244801, PR A69 (2004) 023813.

From Beam Parameters such as Touschek Lifetime : V

M.Takao, et.al, in Proc. PAC1999, New York, p.2349.

H.Tanaka, et.al, NIM A486 (2002) 521.

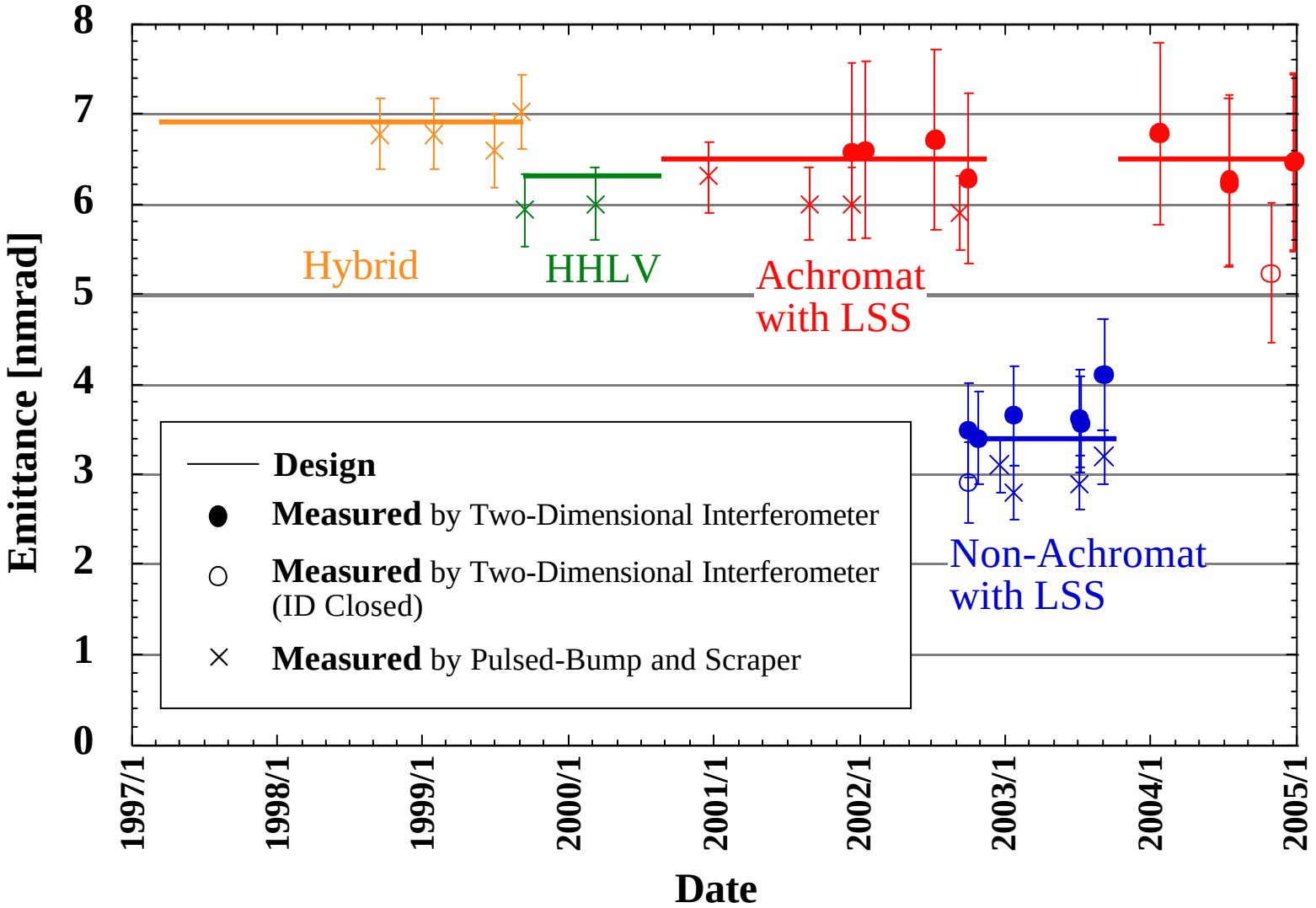
Vertical Dispersion as a Probe : V

H.Tanaka, et.al, in Proc. EPAC2000, Vienna, p.1575.

Pulsed-Bump & Scraper : H

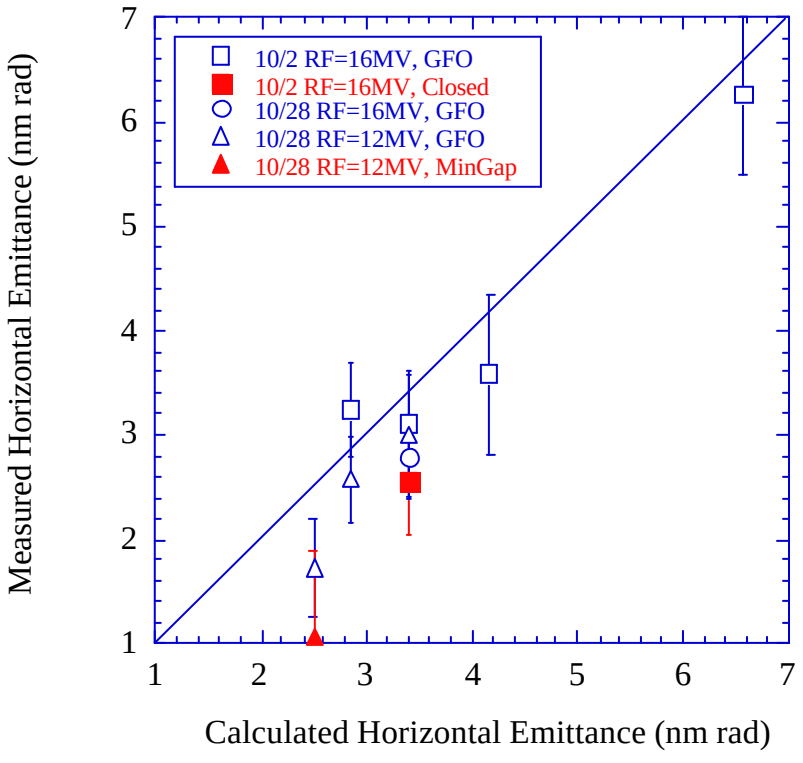
K.Soutome, et.al, SPring-8 Ann. Rep. 1999, p.136.
http://www.spring8.or.jp/e/publication/ann_rep/AR99PDF/p136-138.pdf

Horizontal Emittance of Typical Optics

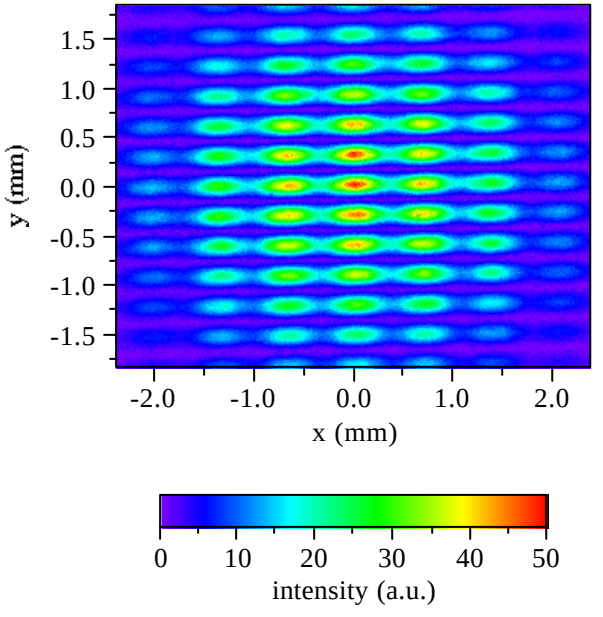


Horizontal Emittance and ID

Measured with Two-Dimensional Visible Light Interferoemter

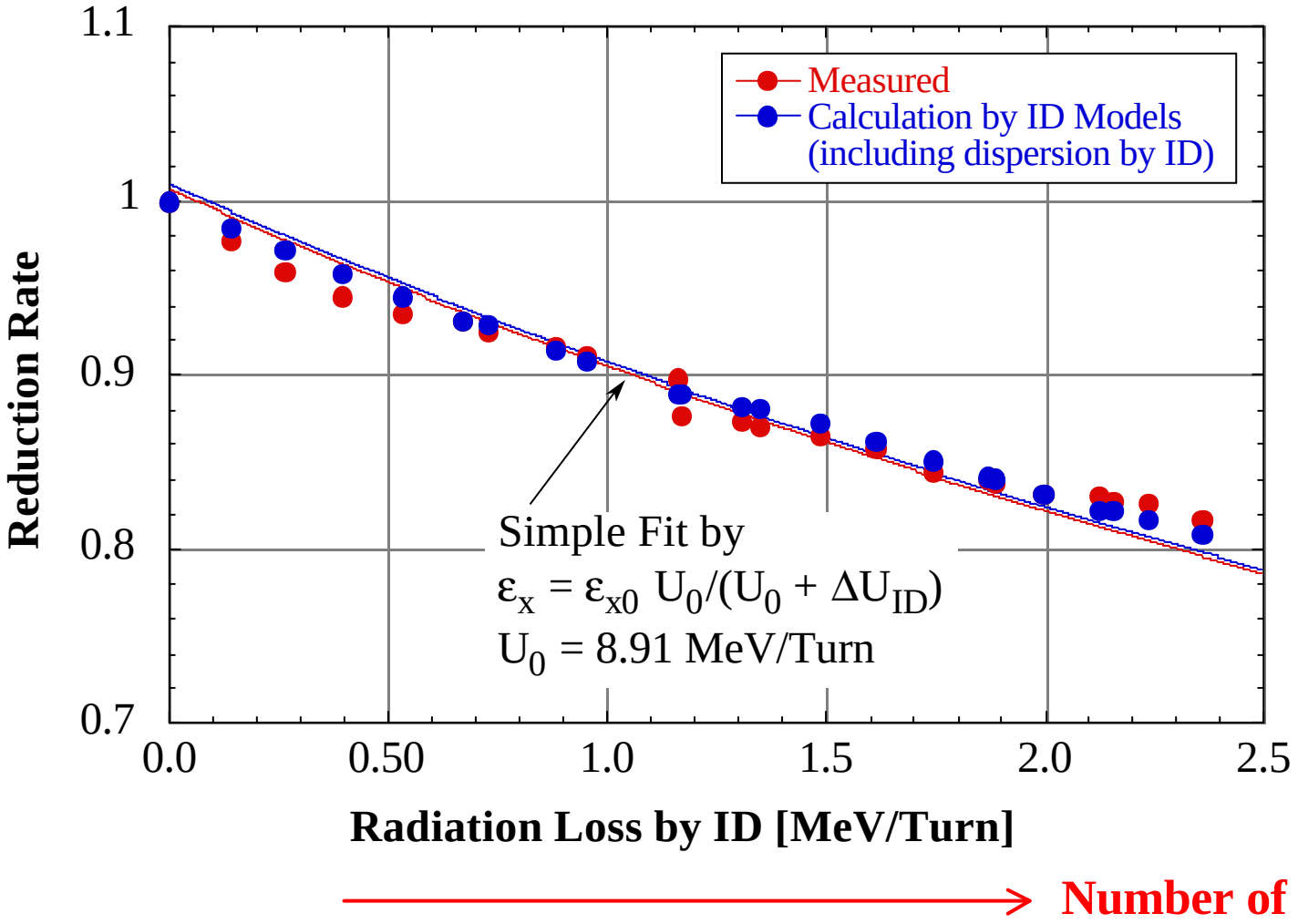


M.Masaki and S.Takano,
J.Synchrotron Rad. 10 (2003) 295



As ID Gaps are closed, the emittance is reduced by about 20% due to radiation damping in both achromat and non-achromat optics.

Horizontal Emittance and ID (cont.)

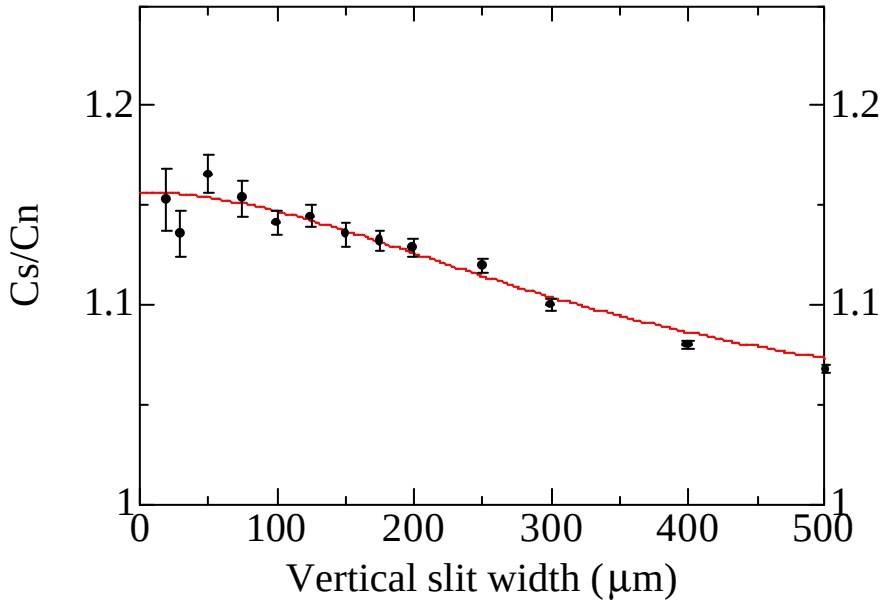


by M.Takao

As the number of ID increases, the emittance is reduced.

Vertical Emittance

Measured by X-ray Intensity Interferometry (14.41keV)



Large Correlation

Small Area

M.Yabashi, et.al., Phys.Rev. A69 (2004) 023813.

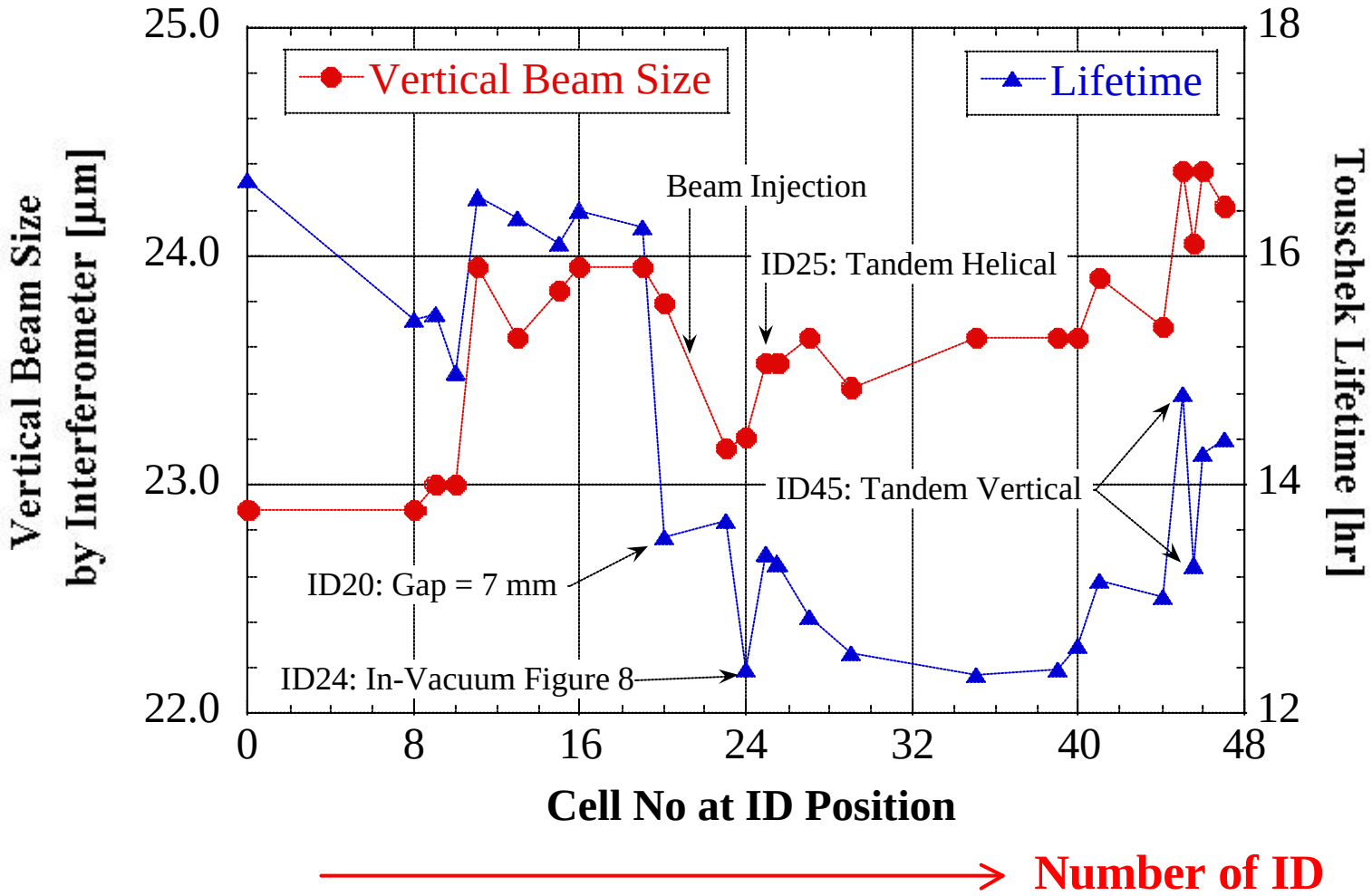
Non-Achromat (Low-Emittance) Optics

Electron Beam Size: $\sigma_y = 4.6 \pm 0.14$ mm

Vertical Emittance: $\varepsilon_y = 3.6 \pm 0.2$ pm.rad

Coupling Constant: $\kappa = 0.12$ %

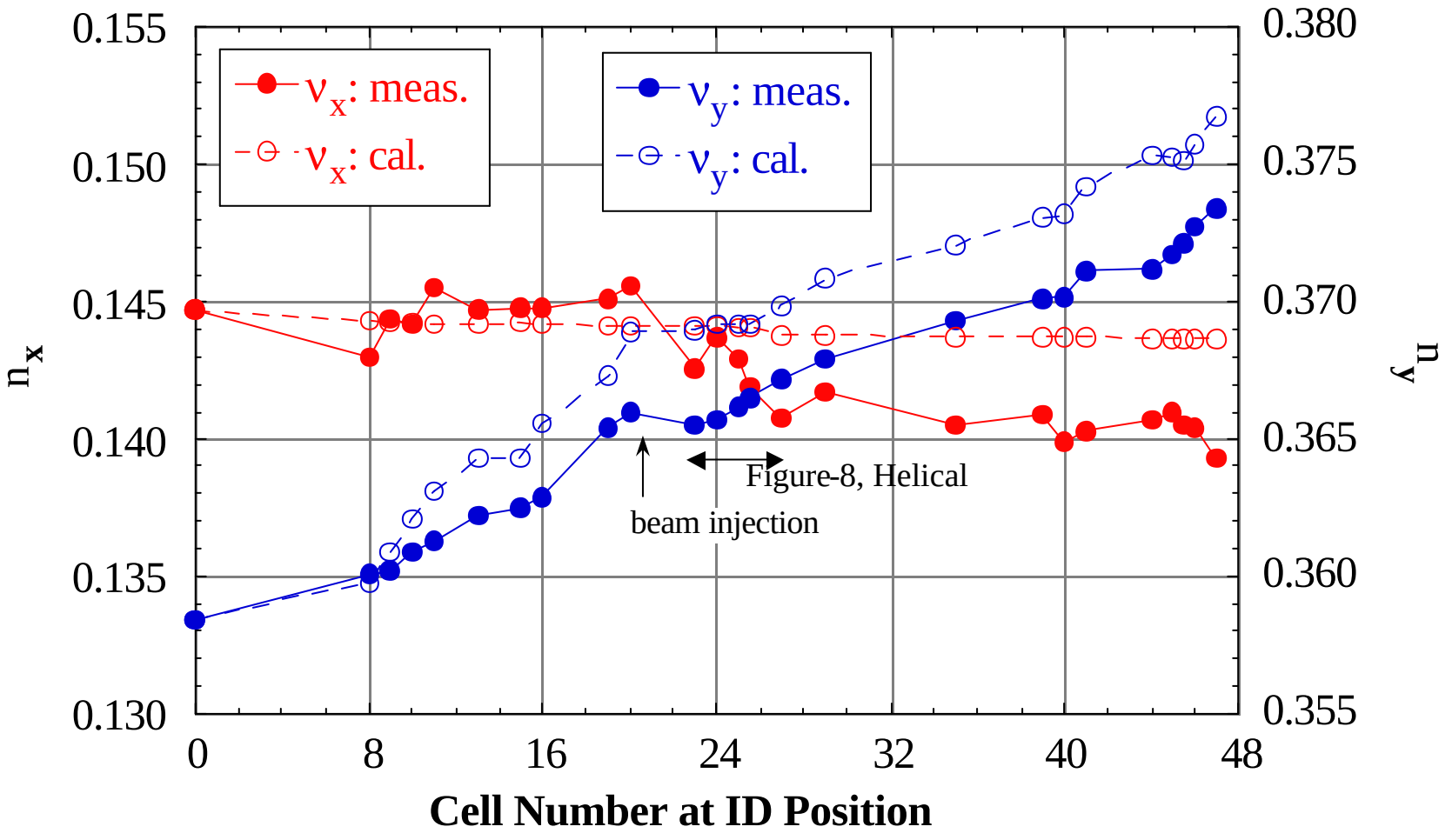
Vertical Emittance and ID



Number of ID

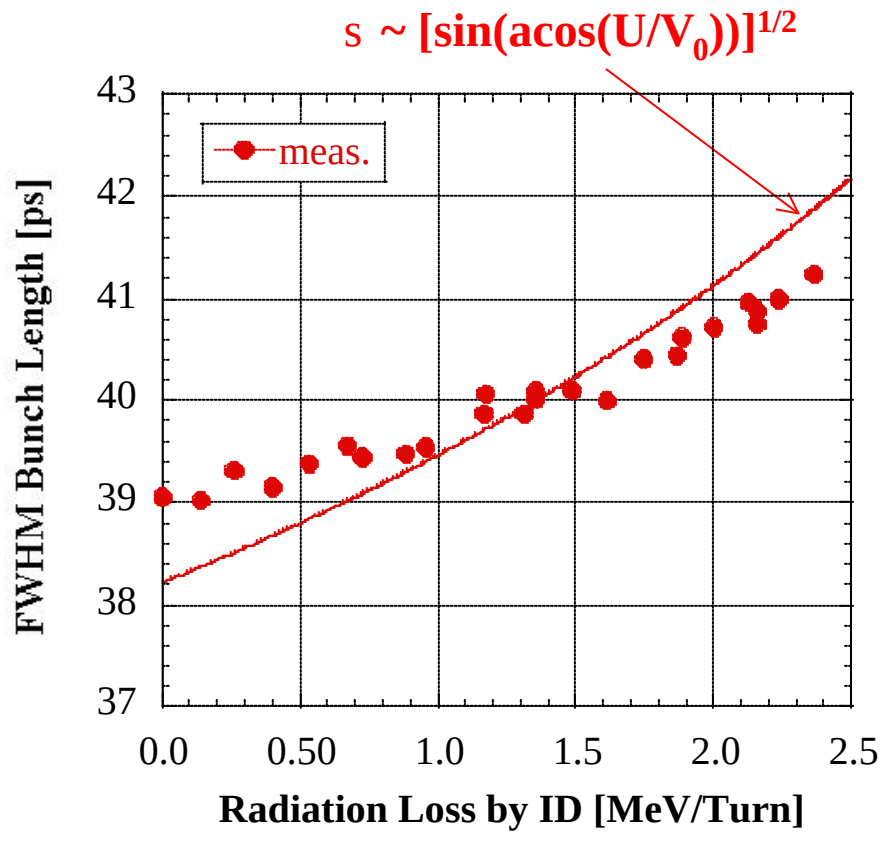
We observed no drastic change of vertical beam size (emittance).

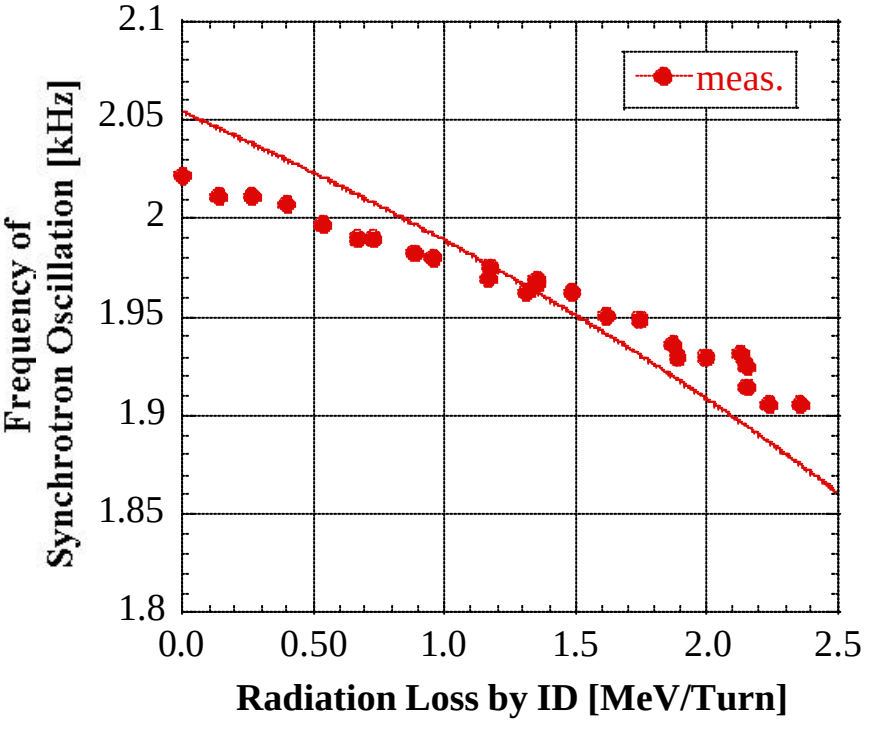
Tune Shift and ID



The discrepancy will be due to impedance effects, etc.

Bunch Length and ID



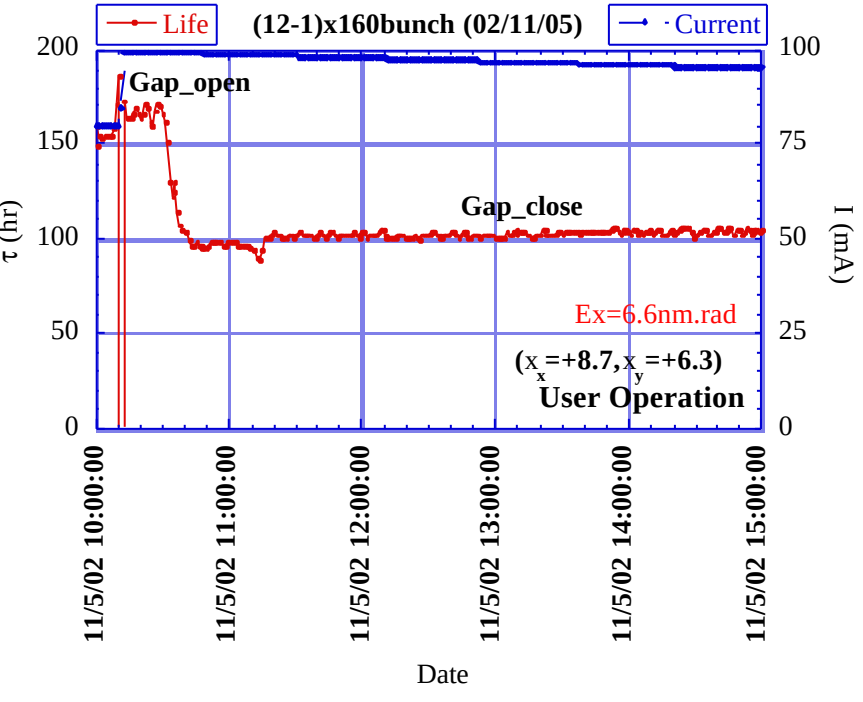


The amount of bunch lengthening is smaller than expectation.

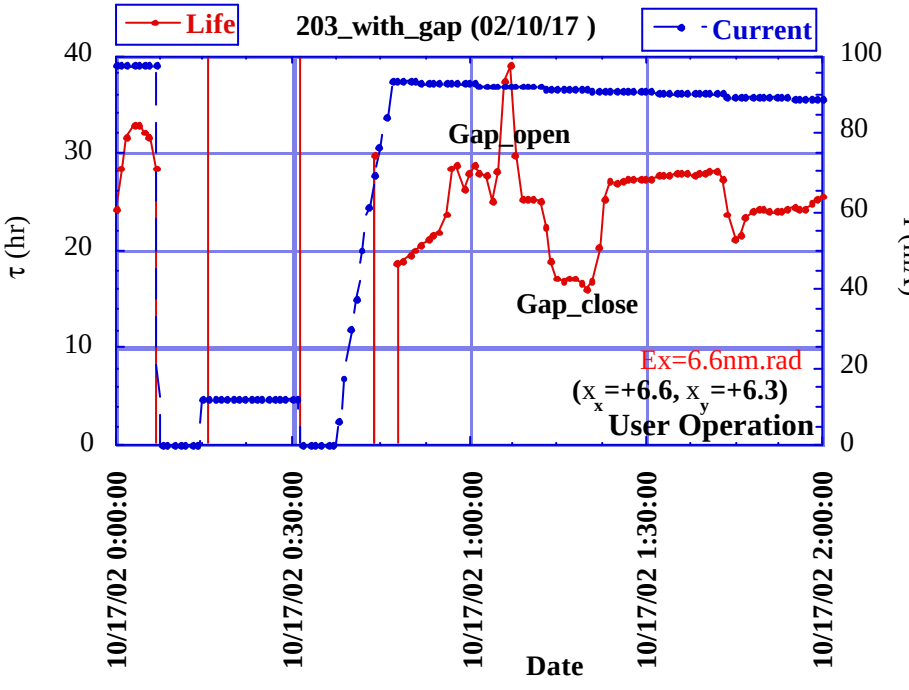
=> Impedance effect is a possible reason.

Beam Lifetime and ID

Achromat Optics



Multi-Bunch Mode



Several-Bunch Mode

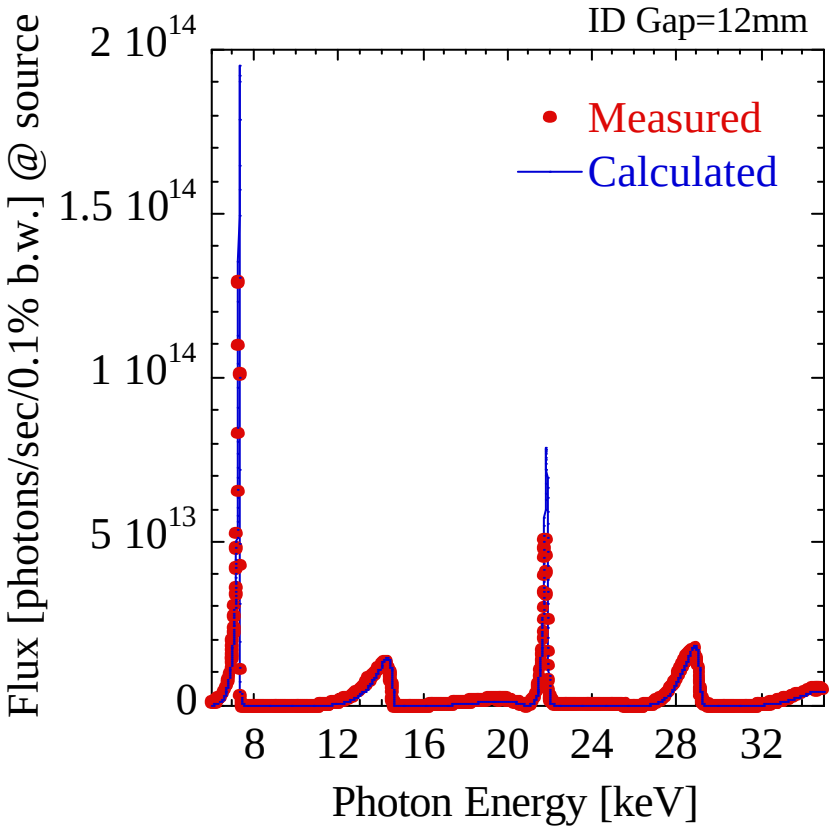
In the non-achromat optics the beam lifetime is shorter.

=> Top-up injection started in user operation since 2003/9.

Now $\Delta I/I < 0.1\%$.

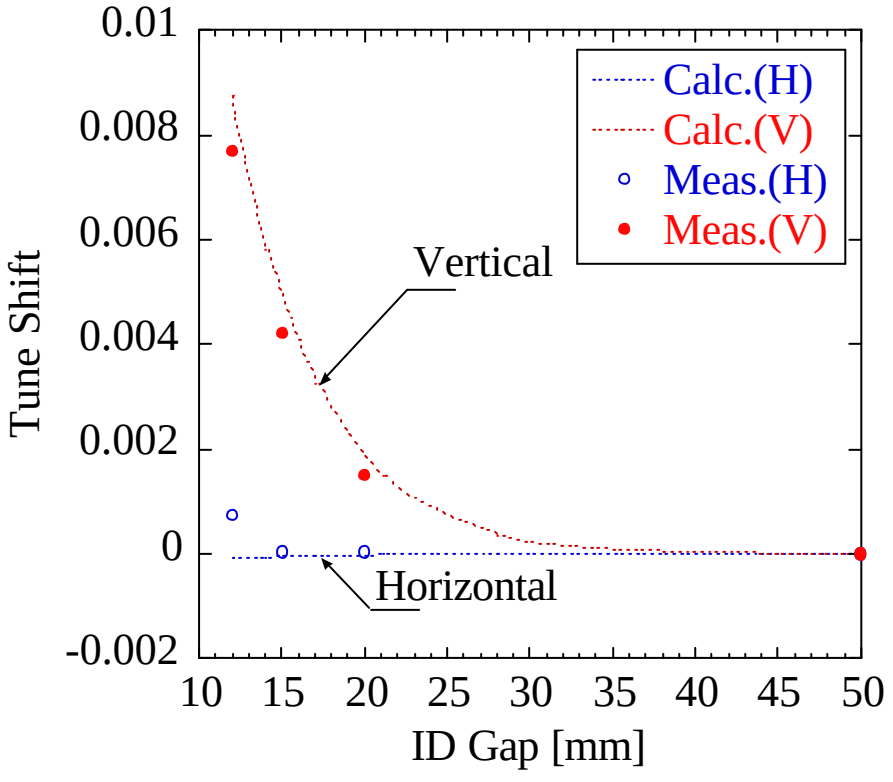
ID19: 25m-Long Planner Undulator

Photon Flux



by T.Hara

Betatron Tune Shift

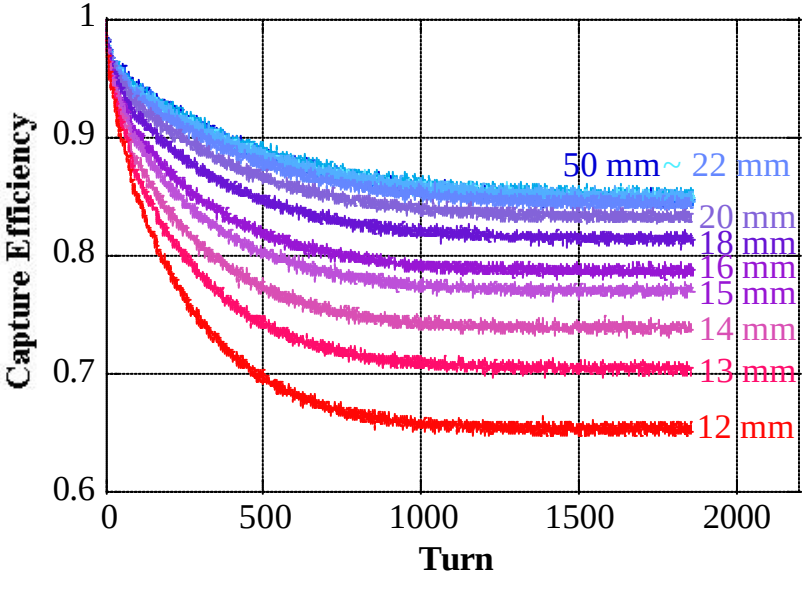


by H.Tanaka

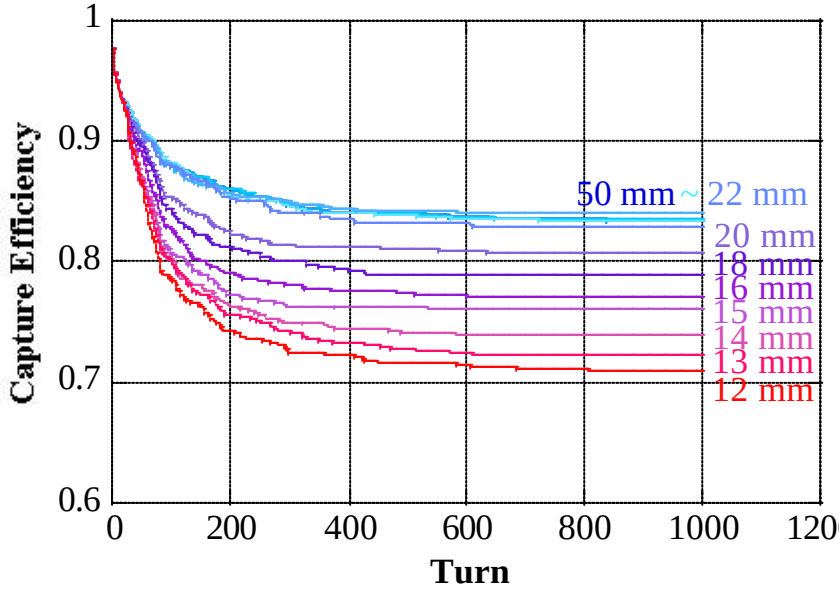
Experimental data agrees well with calculations.

ID19: 25m-Long Planner Undulator (cont.)

Injection Efficiency as a Function of Gap Height

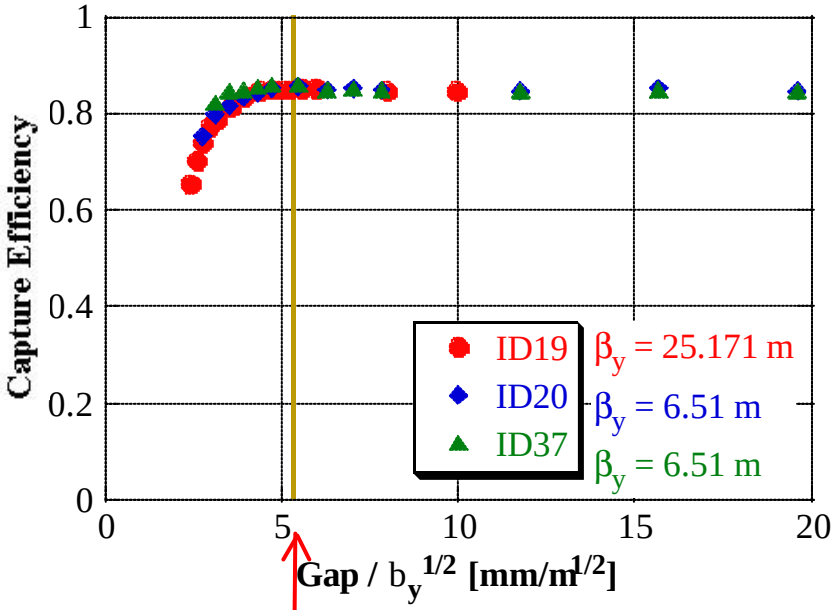


Experiment

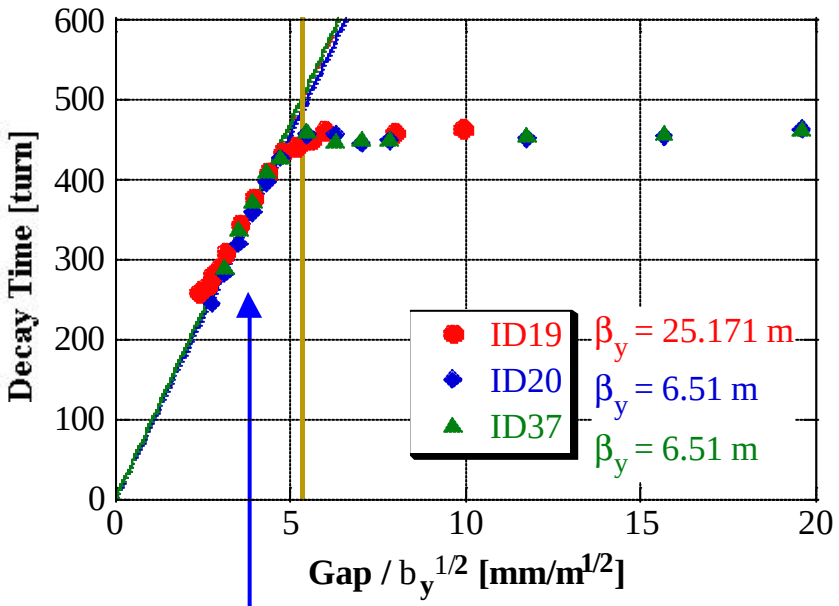


Simulation

ID19: 25m-Long Planner Undulator (cont.)



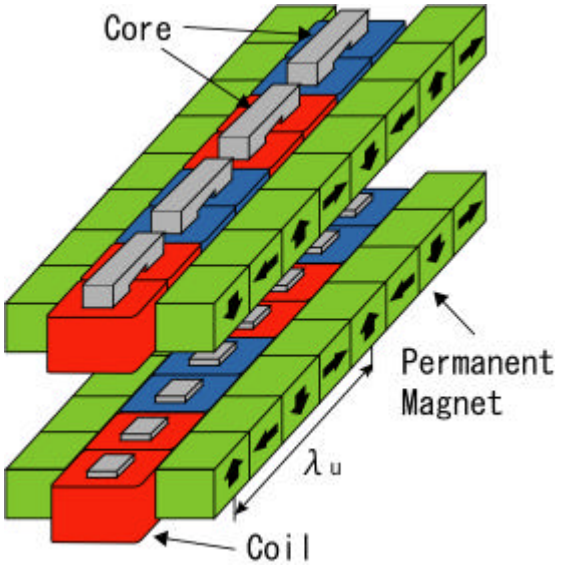
Effective Height of Vacuum Vessel at the Largest Vertical Betatron Function

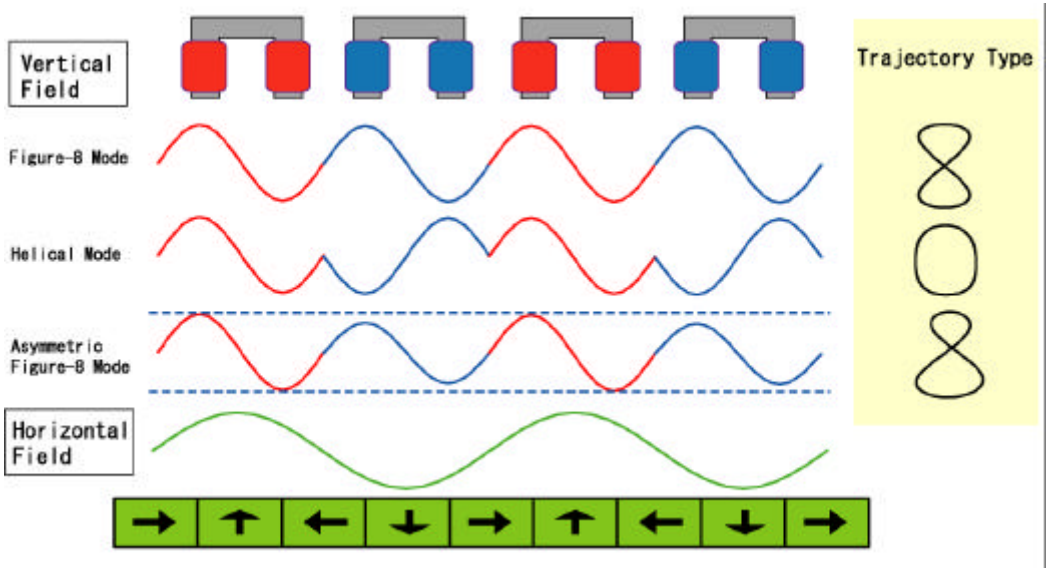


Tail of the particle desity seems to have a dependence of y^{-2} during the damping process.

M.Takao, et.al., in Proc. EPAC2004 (Lucerne) p.417.

ID17: Multi-Operation Mode Undulator





by K.Shirasawa

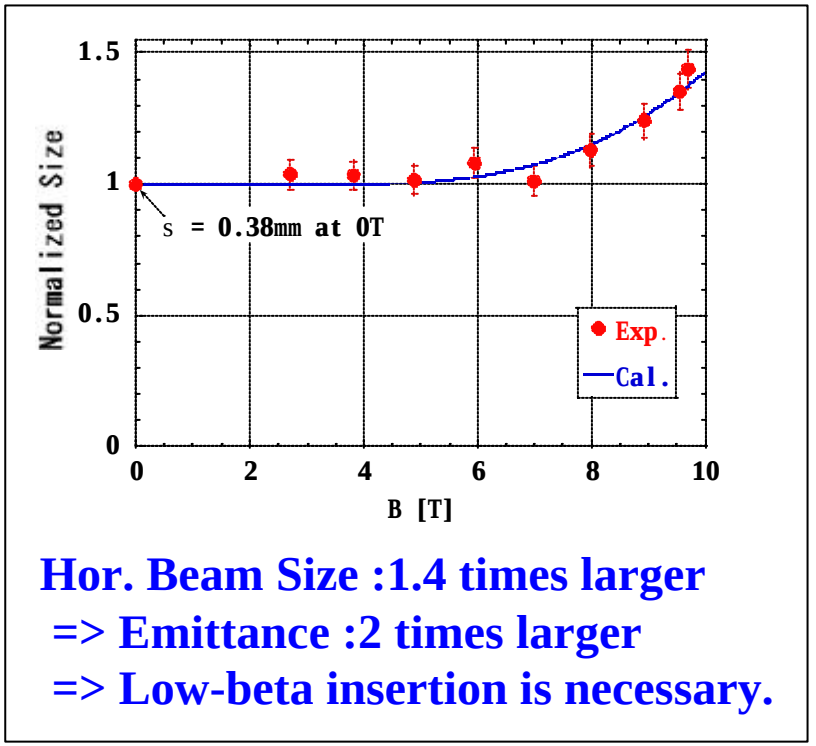
Effects on the stored beam is large and tuning is in progress.

=> Improvement of the ID model including nonlinear kicks

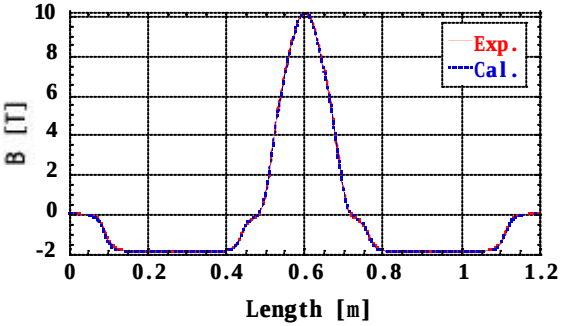
... to be discussed tomorrow

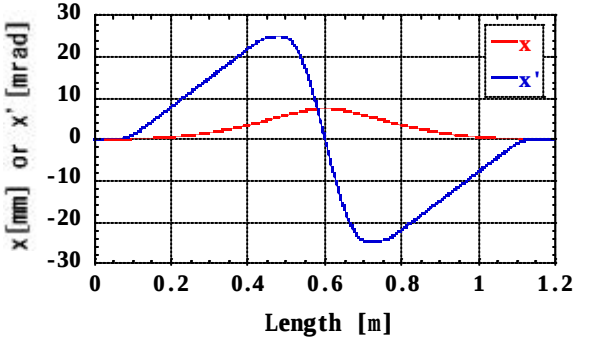
10T Superconducting Wiggler

10T SCW by Budker INP was tentatively installed in August 2002 in the normal straight section (b_x = 24m), and beam tests were carried out with a low current.



Hor. Beam Size :1.4 times larger
=> Emittance :2 times larger
=> Low-beta insertion is necessary.





K.Soutome, et.al., in Proc. PAC2003 (Portland) p.250.

Summary

- Achromat (6.6nmrad) and non-achromat(3.4nmrad) optics

=> Non-achromat optics was optimized so as to minimize the effective emittance (dispersion effects included).

- ID gap closed => About 20% reduction of the horizontal emittance
- No drastic worsening of vertical emittance.
- Vertical tune and bunch length seem to be affected by impedance.
- Injection efficiency and beam lifetime => Top-up injection
- Improvement of the model

=> ID combined with iron yoke is difficult to manage (ID17).

=> Correction with quad. and sext. will be carried out in the future.

- Generation of high-energy gamma rays

=> 10T SCW project is in progress.

Possible application: nuclear astrophysics, slow-positron beam