17TH ADVANCED BEAM DYNAMICS WORKSHOP ON

FUTURE LIGHT SOURCES

Advanced Insertion Device Practices and Concepts

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Advanced Insertion Device Practices and Concepts

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Harima RIKEN, SPring-8

1. Motivation to develop insertion devices?

2. In-vacuum undulators

3. Examples of in-vacuum undulators

4. Advanced in-vacuum undulators

5. A new concept of SR facility

Motivation to develop insertion devices?

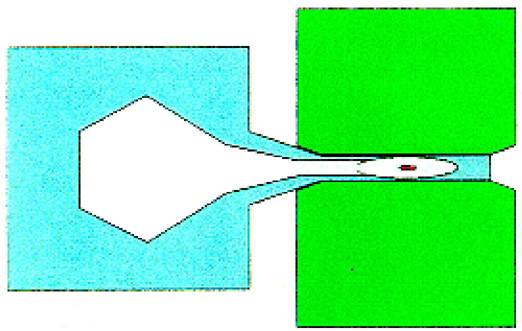
1. Various polarization characteristics

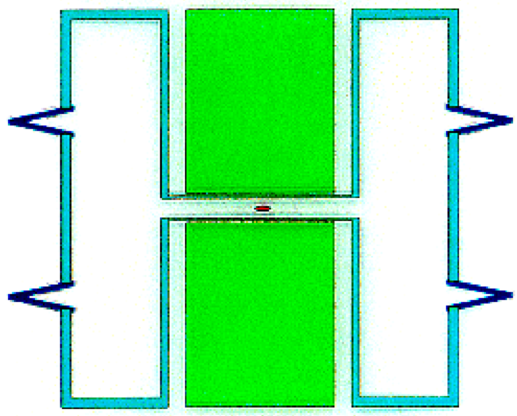
helical, elliptical, vertical, Figure-8

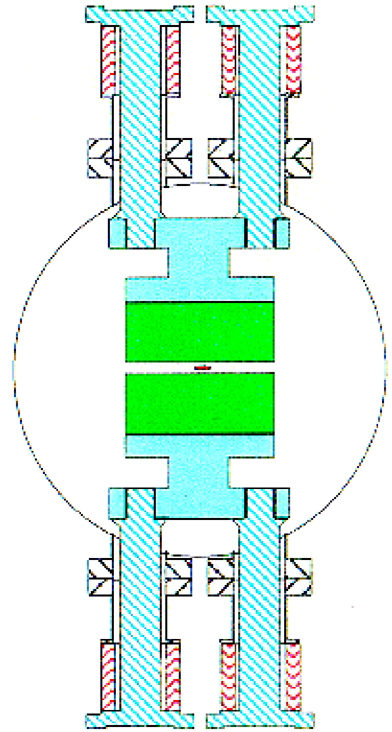
2. Higher-energy radiation

superconducting wiggler

short-period undulator→ short magnetic gap







Out-of-Vacuum

x Thickness of the chamber wall

x Conservative gap-height margin for injection or unordinary operation of the ring

Flexible

o Flexibility against any operation of the ring

x Thickness of the chamber wall

x Long devices?

In-Vacuum

o Flexibility against any operation of the ring

o Vacuum gap = magnet gap

o Long devices

x Difficulty in making devices
UHV?
demagnetization

Development of In-Vacuum Undulators

Delicate undulator magnet system

should be compatible with Ultrahigh Vacuum (UHV).

○ Outgassing from permanent magnets ?

TiN coating

○ Demagnetization due to UHV bakeout?

Permanent magnets with very high coercivity at high temperature (140℃)

○ clamping?

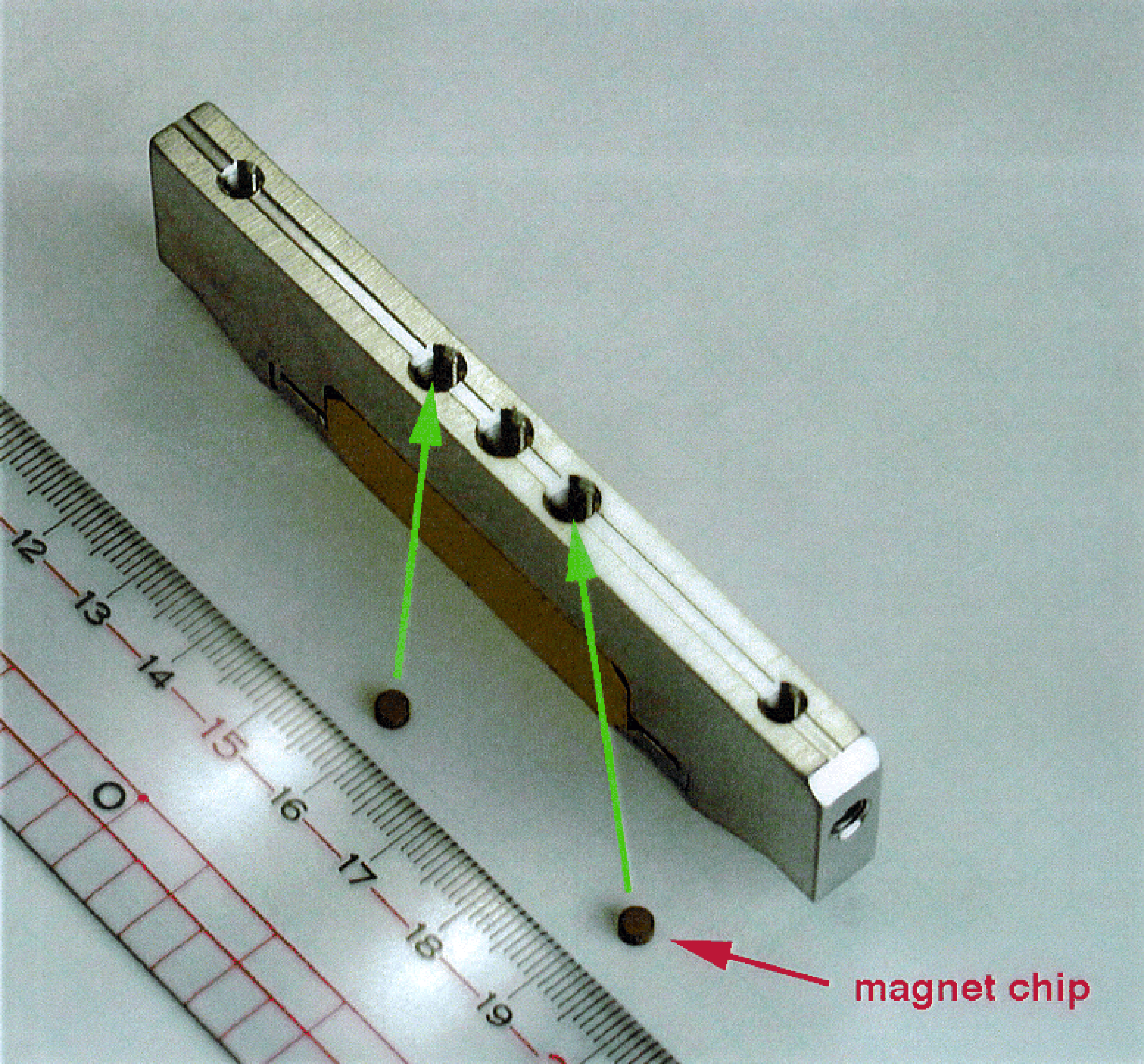
○ Shimming?

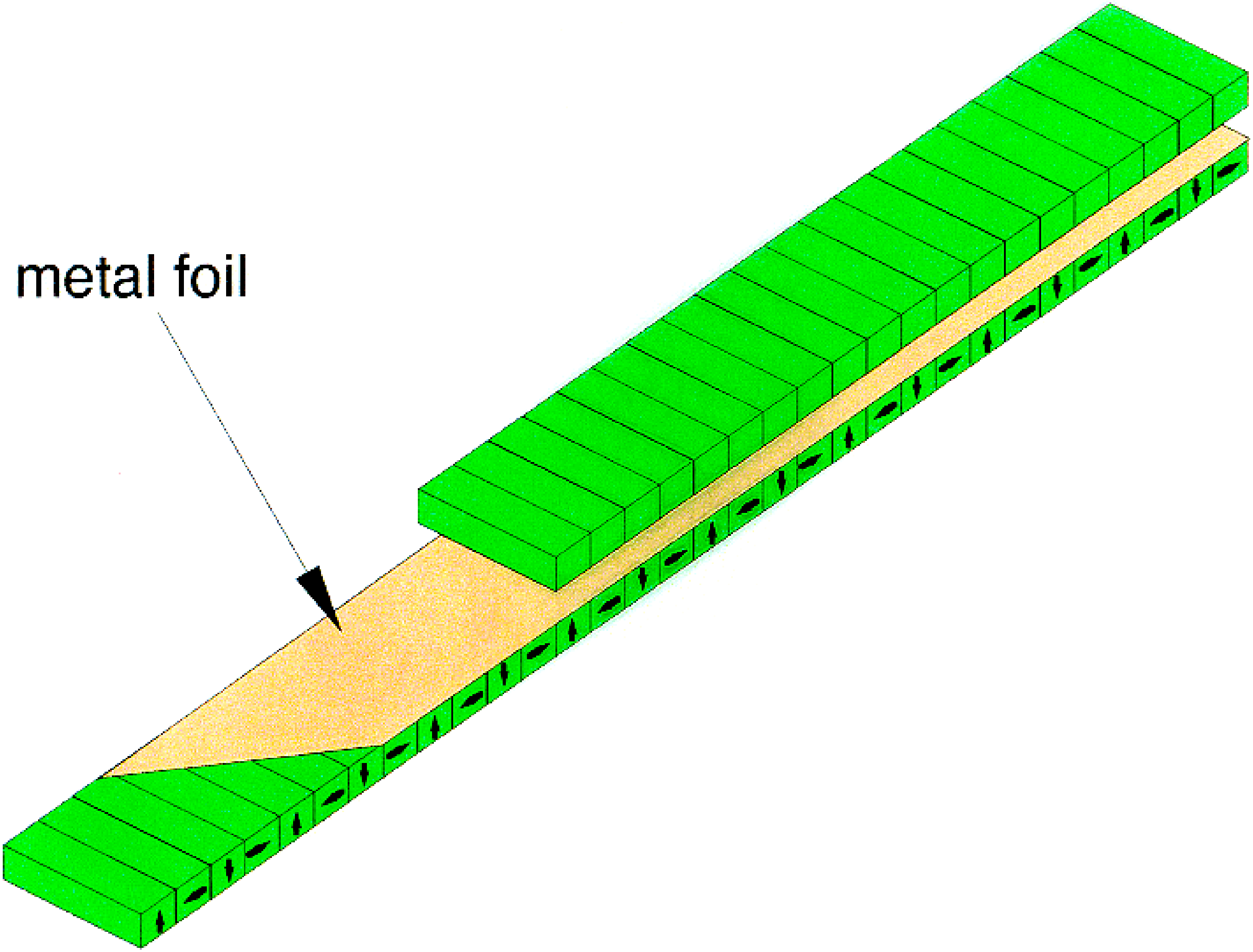
small magnet chips

Heating problem by image beam current

Solution;

Cu-plated Ni foils for magnet cover
Water-cooled rf-finger

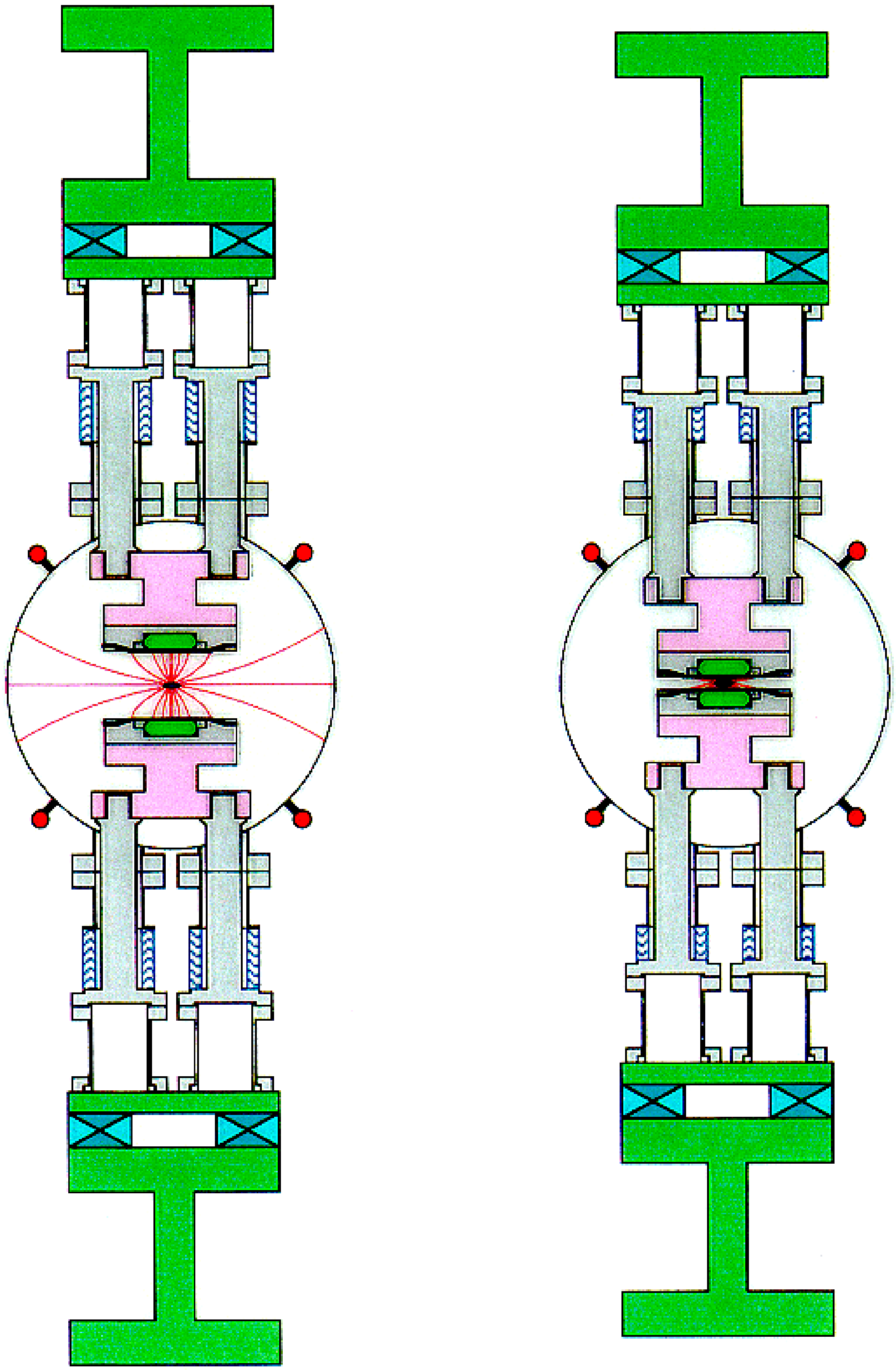

magnet chip



Magnet Cover

Image current heating

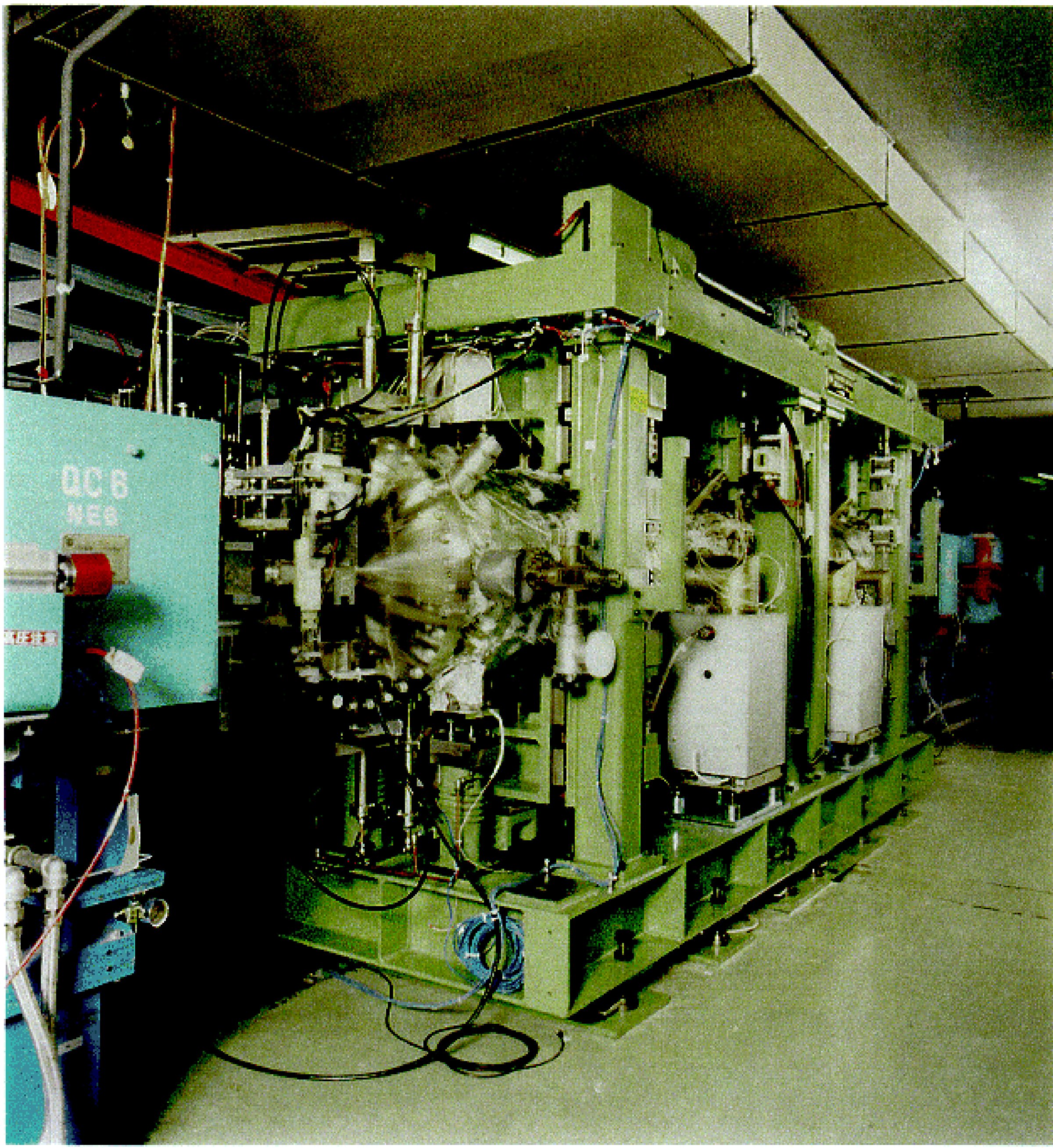
$$P \propto \frac{1}{Gap}$$

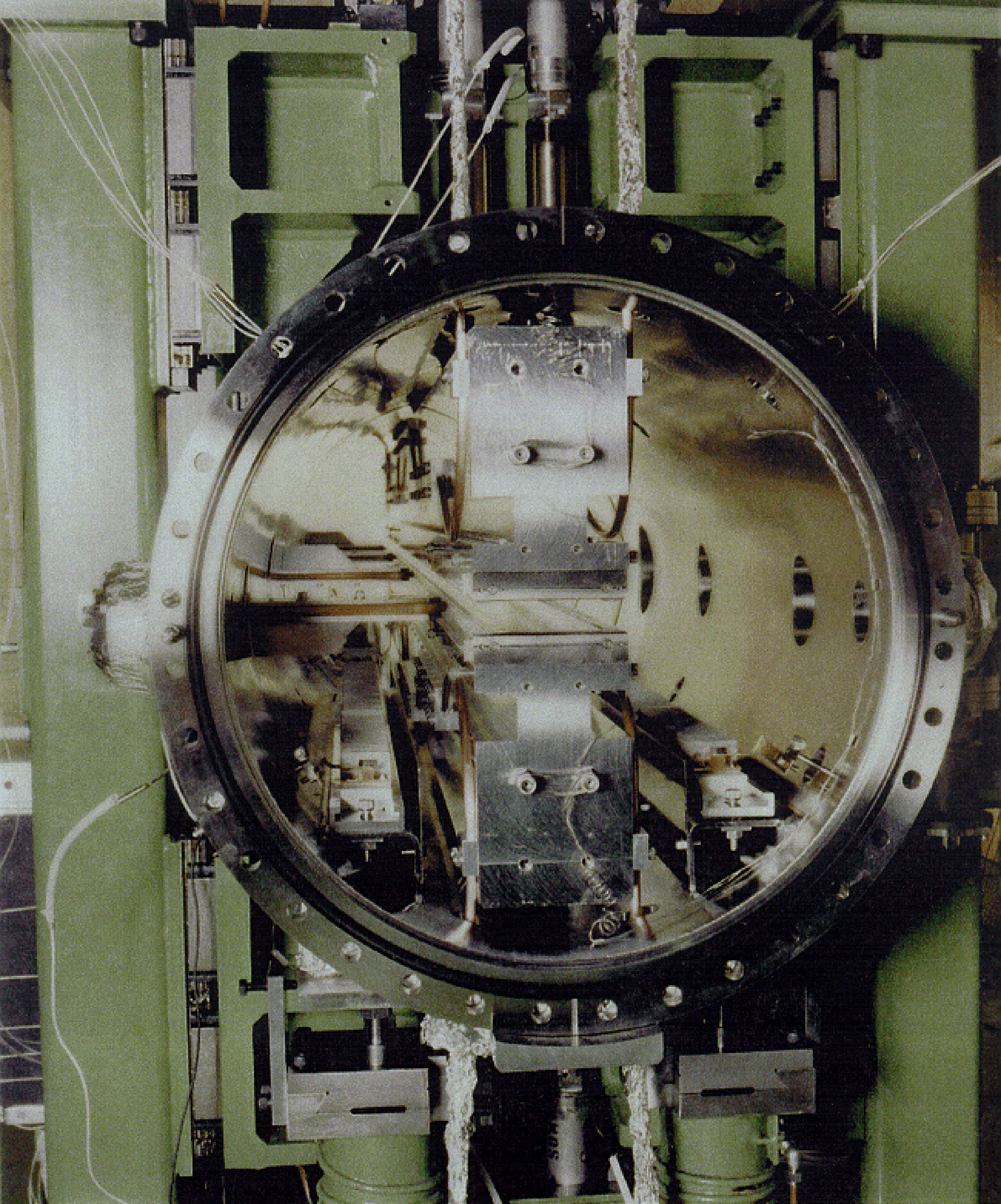


G=50mm G=10mm

KEK (1990)

$\lambda_u = 4\,cm$, $N = 90$, $G_{min} = 10\,mm$





In-vacuum undulators installed at SPring-8

Standard type

λ_u(mm)	N	G_{min}(mm)	B_{max}(T)	K_{max}	total #
32	140	8	0.84	2.5	8
40	112	13	0.59	2.2	1

Hybrid type(+permendur)

λ_u(mm)	N	G_{min}(mm)	B_{max}(T)	K_{max}	total #
24	187	5	0.9	2.2	1

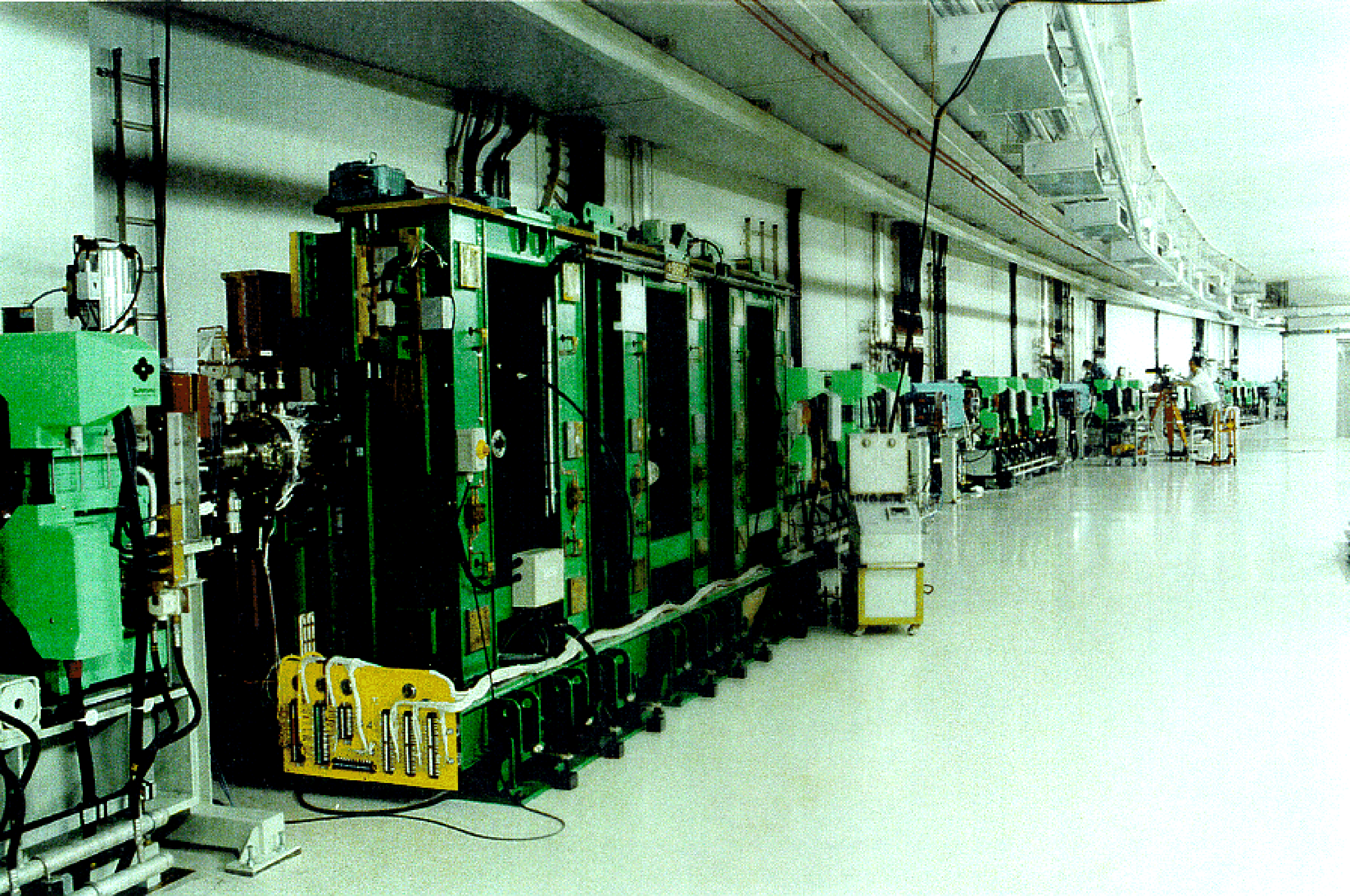
Vertical undulator

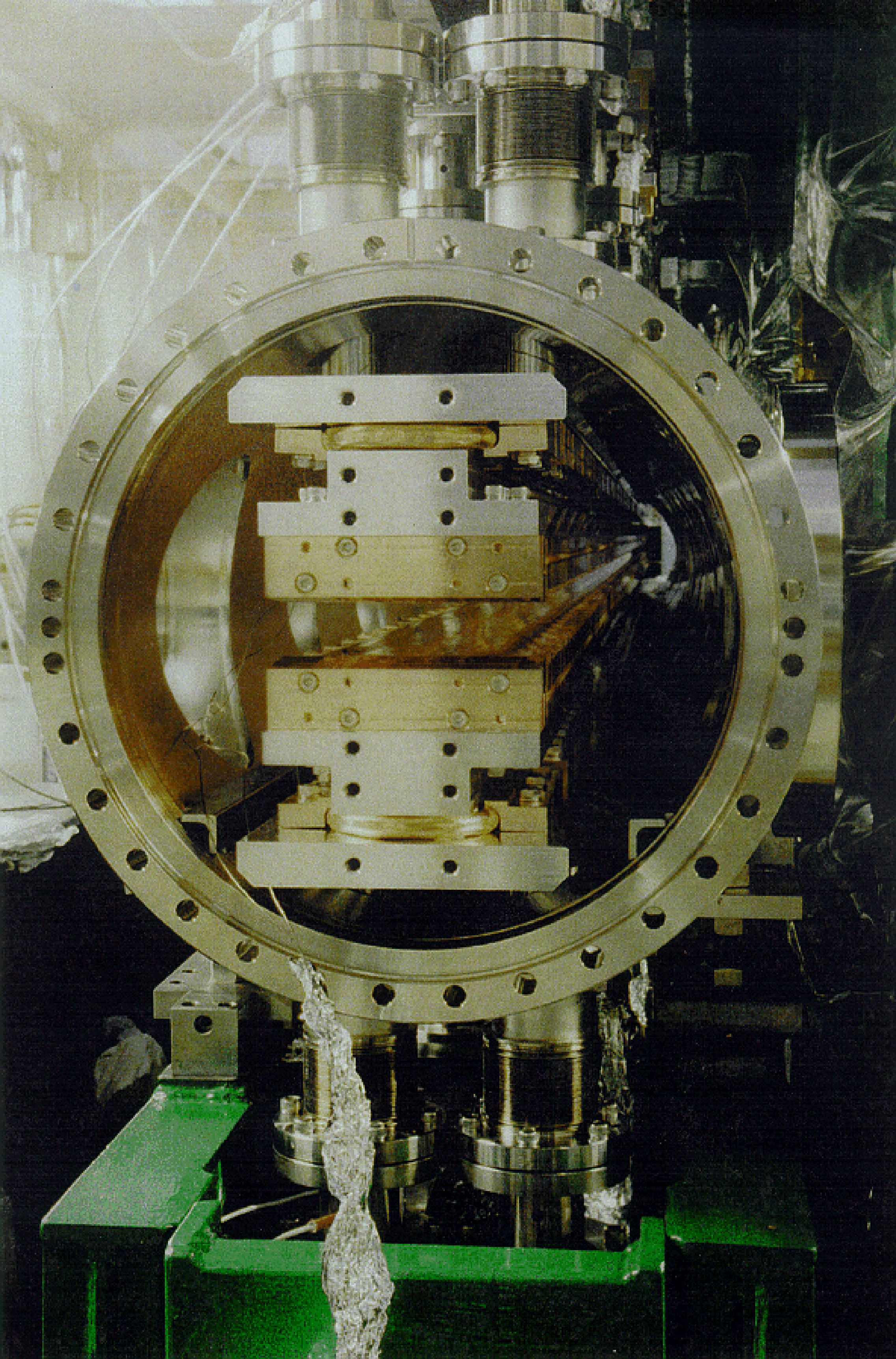
λ_u(mm)	N	G_{min}(mm)	B_{max}(T)	K_{max}	total #
37	2x37	8	0.5	1.7	1

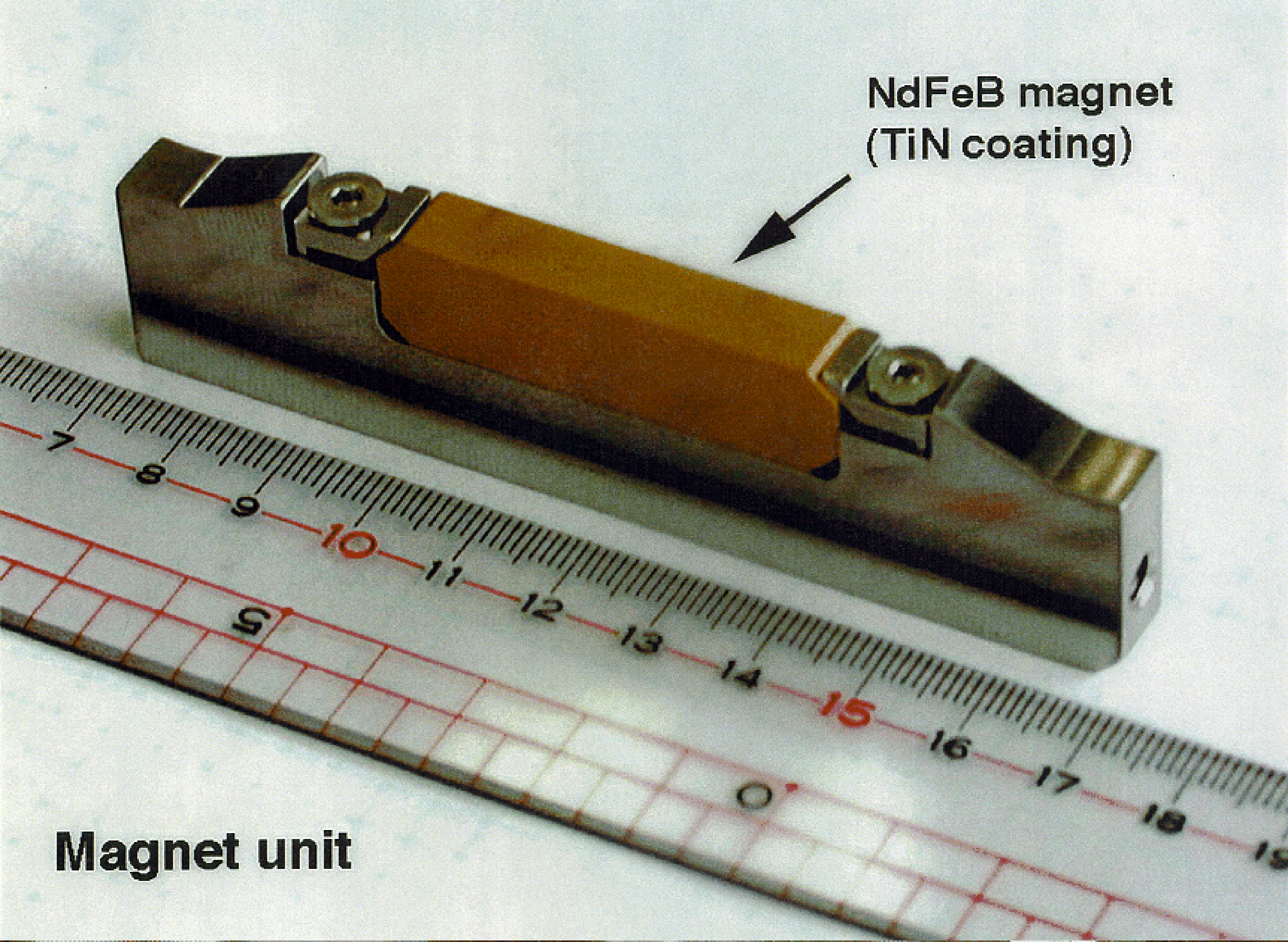
Figure-8 undulator

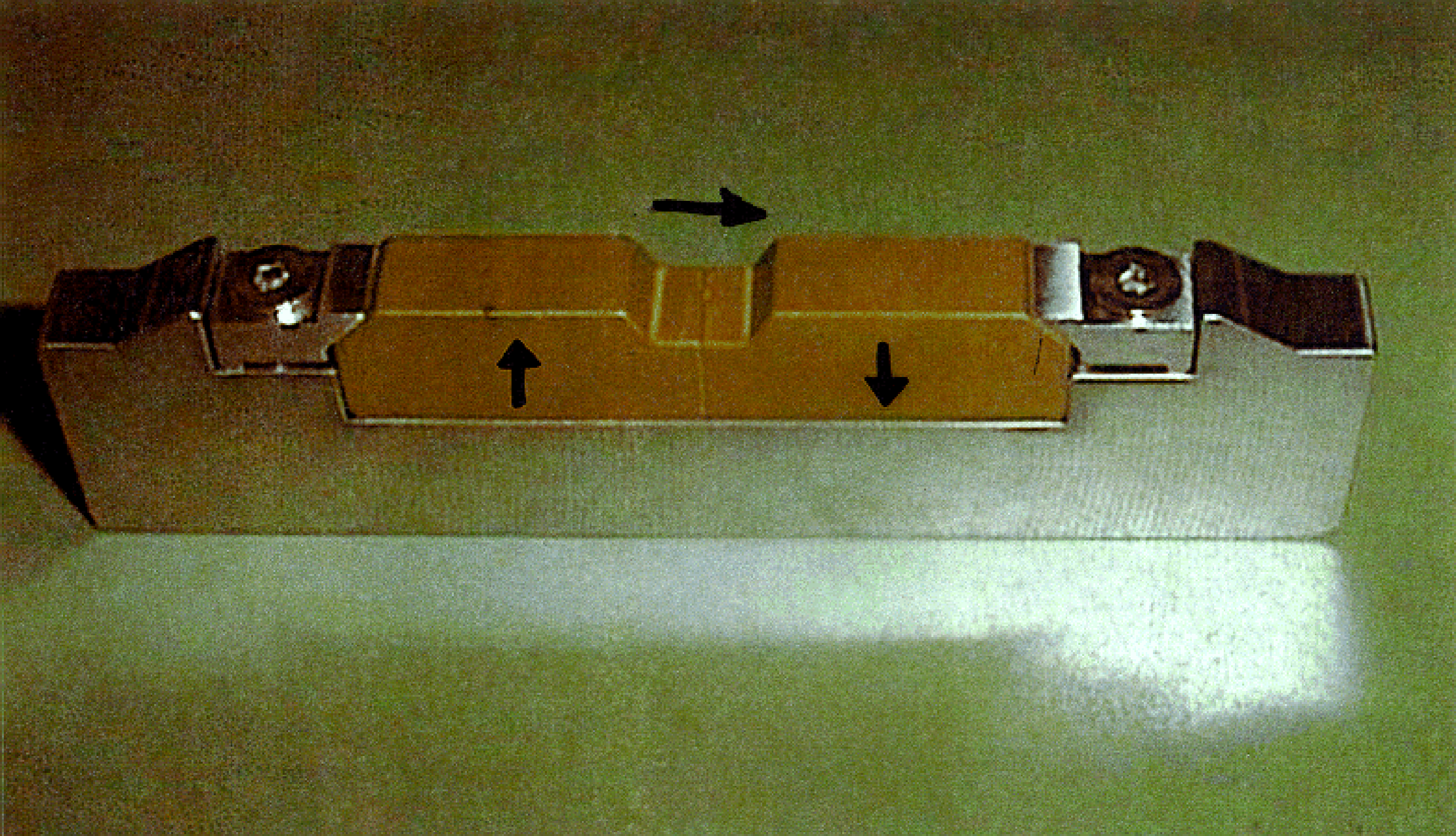
λ_u(mm)	N	G_{min}(mm)	B_{max}(T)	K_{max}	total #
26	172	5	1.05 0.34	2.6 1.7	1

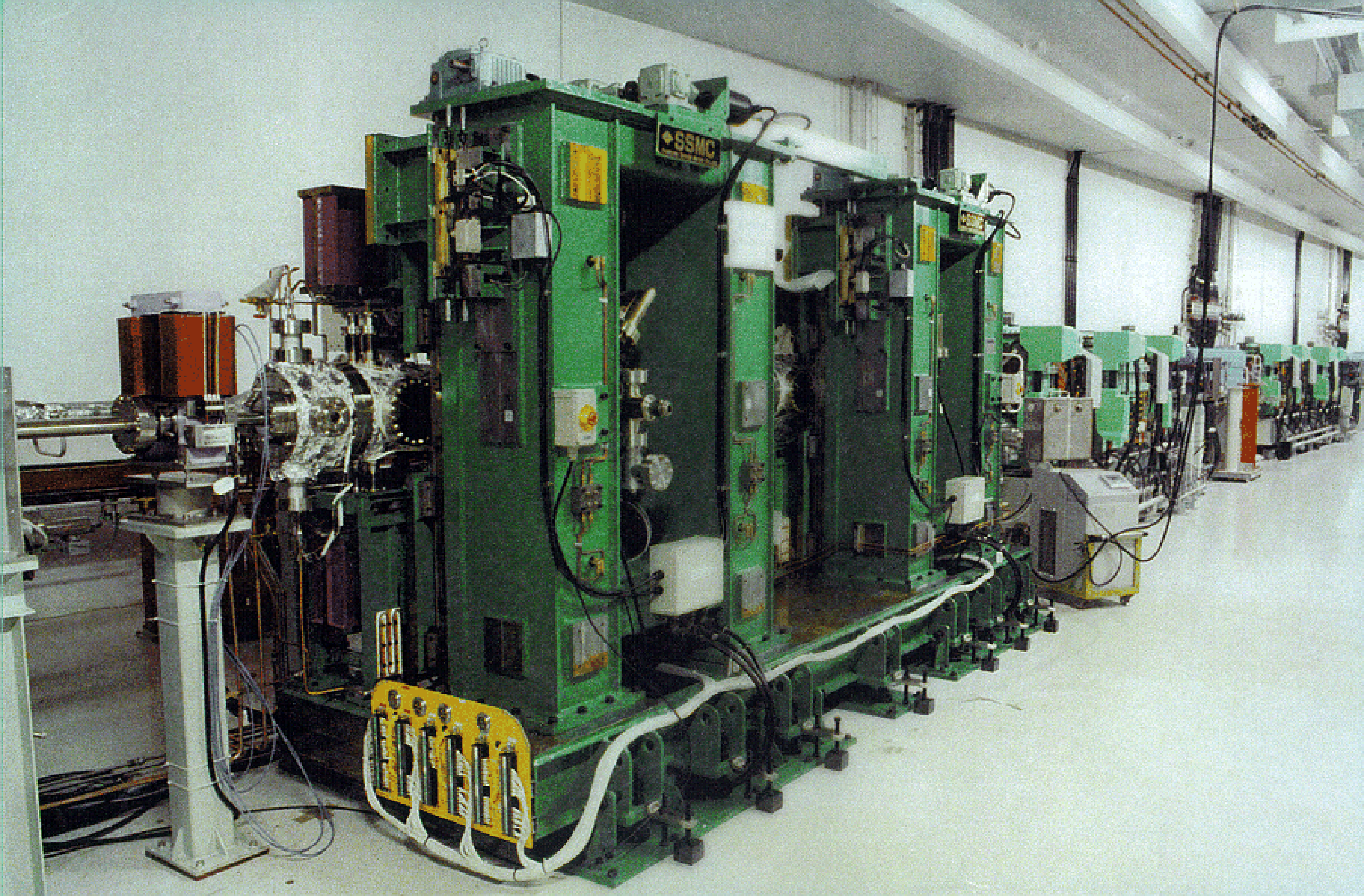
Out-of-vacuum type: 4 devices

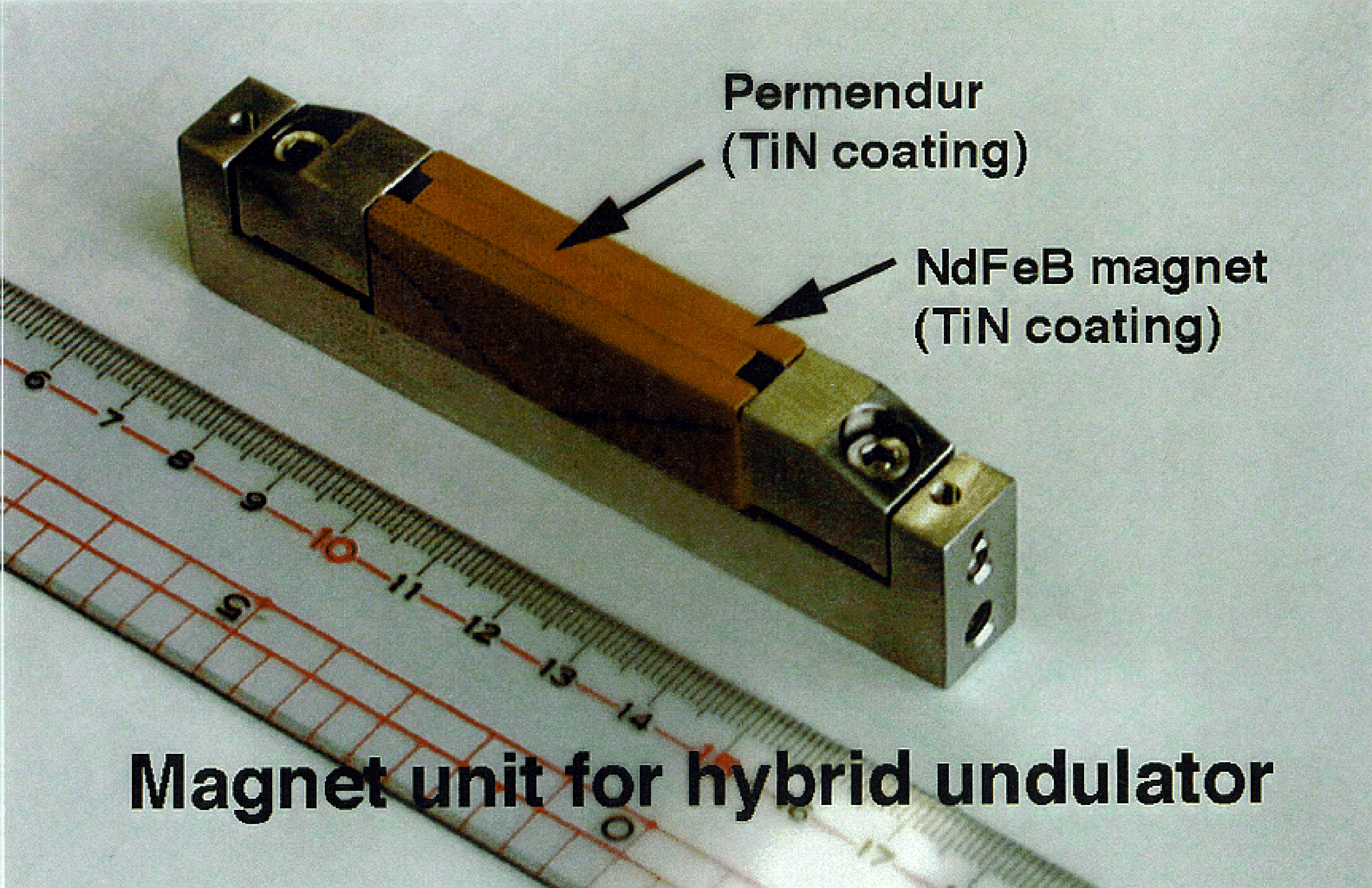





NdFeB magnet
(TiN coating)
Magnet unit

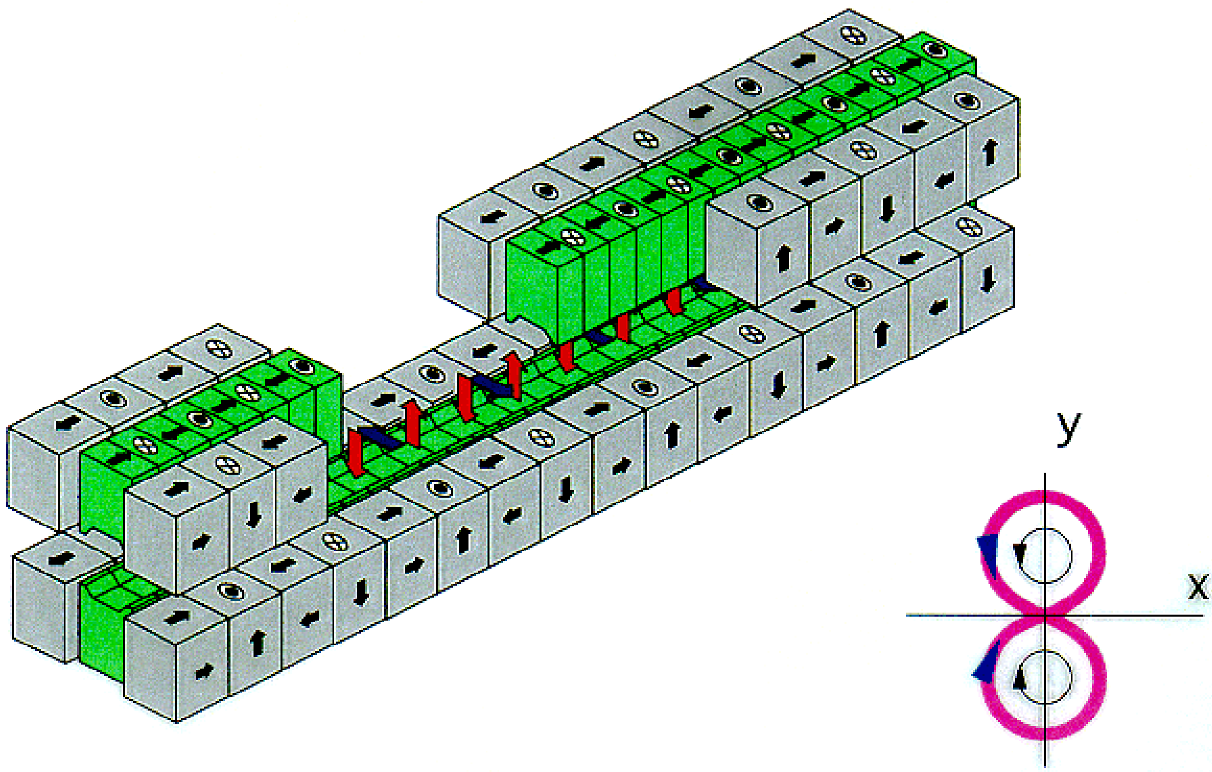



SSMC



Magnet unit for hybrid undulator

Figure-8 Undulator



For soft x-ray region

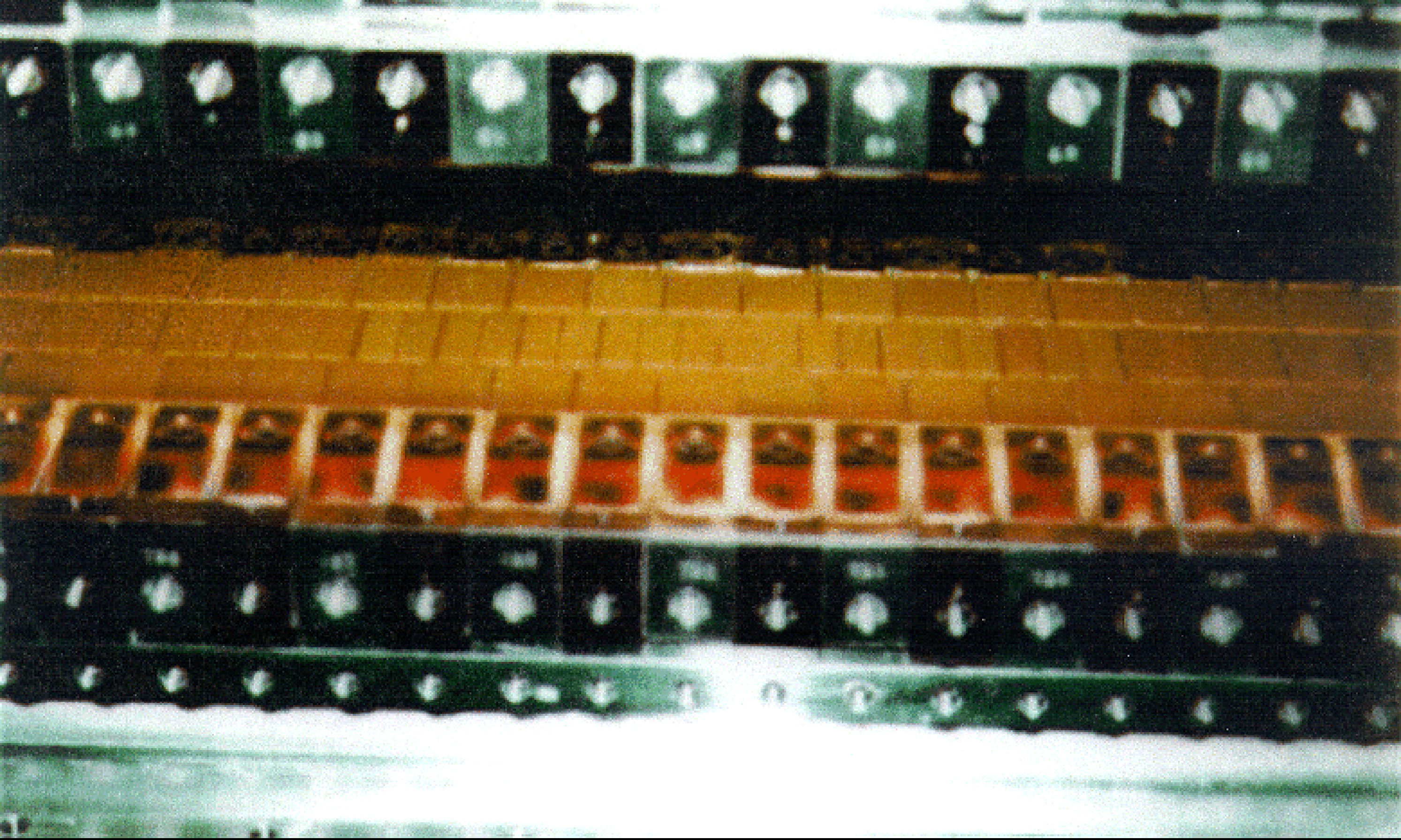
$\lambda_u = 100mm$, $N = 45$, $G_{min} = 30mm$

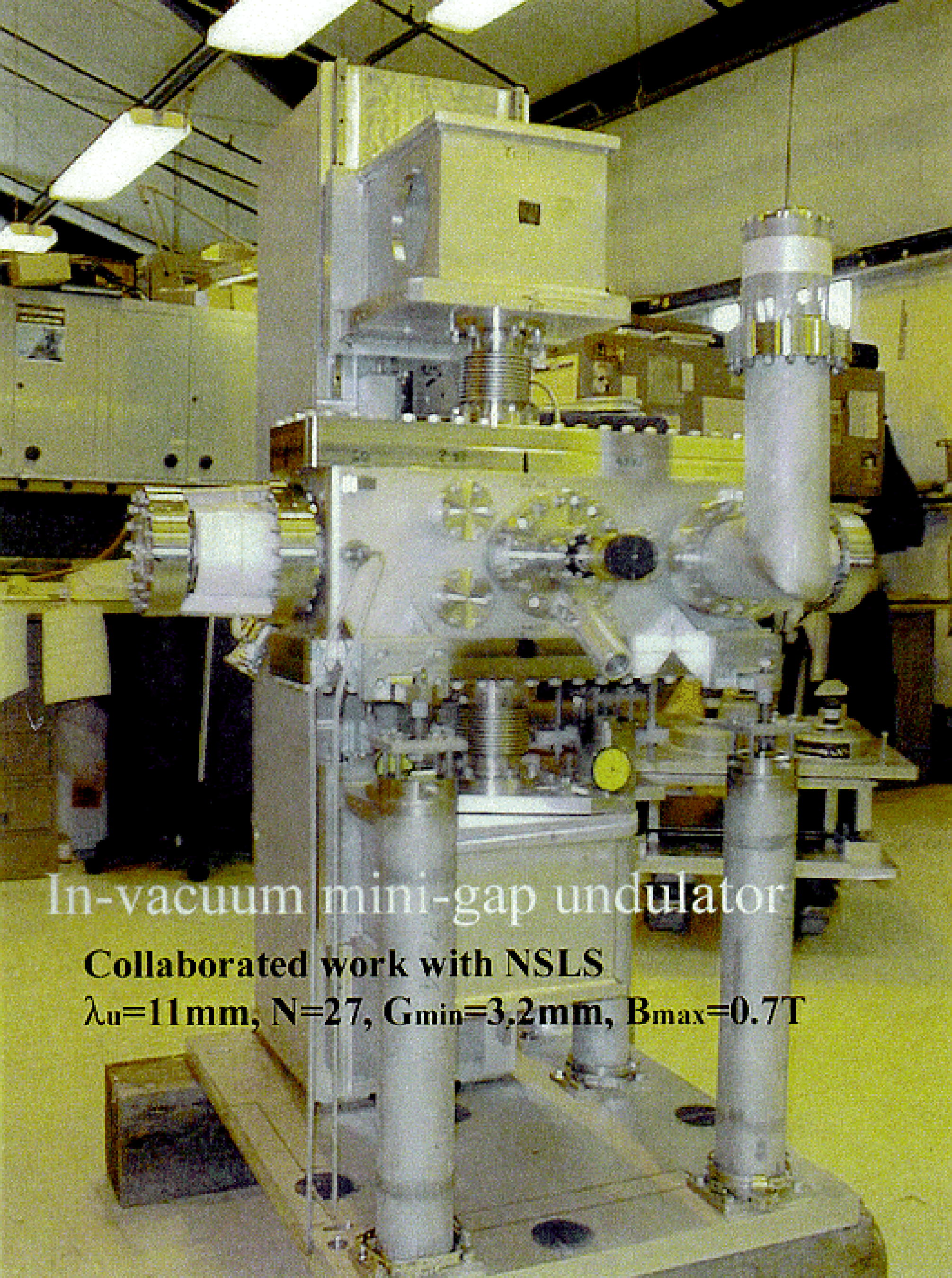
$Bv_{max} = 0.73T$, $Bh_{max} = 0.23T$

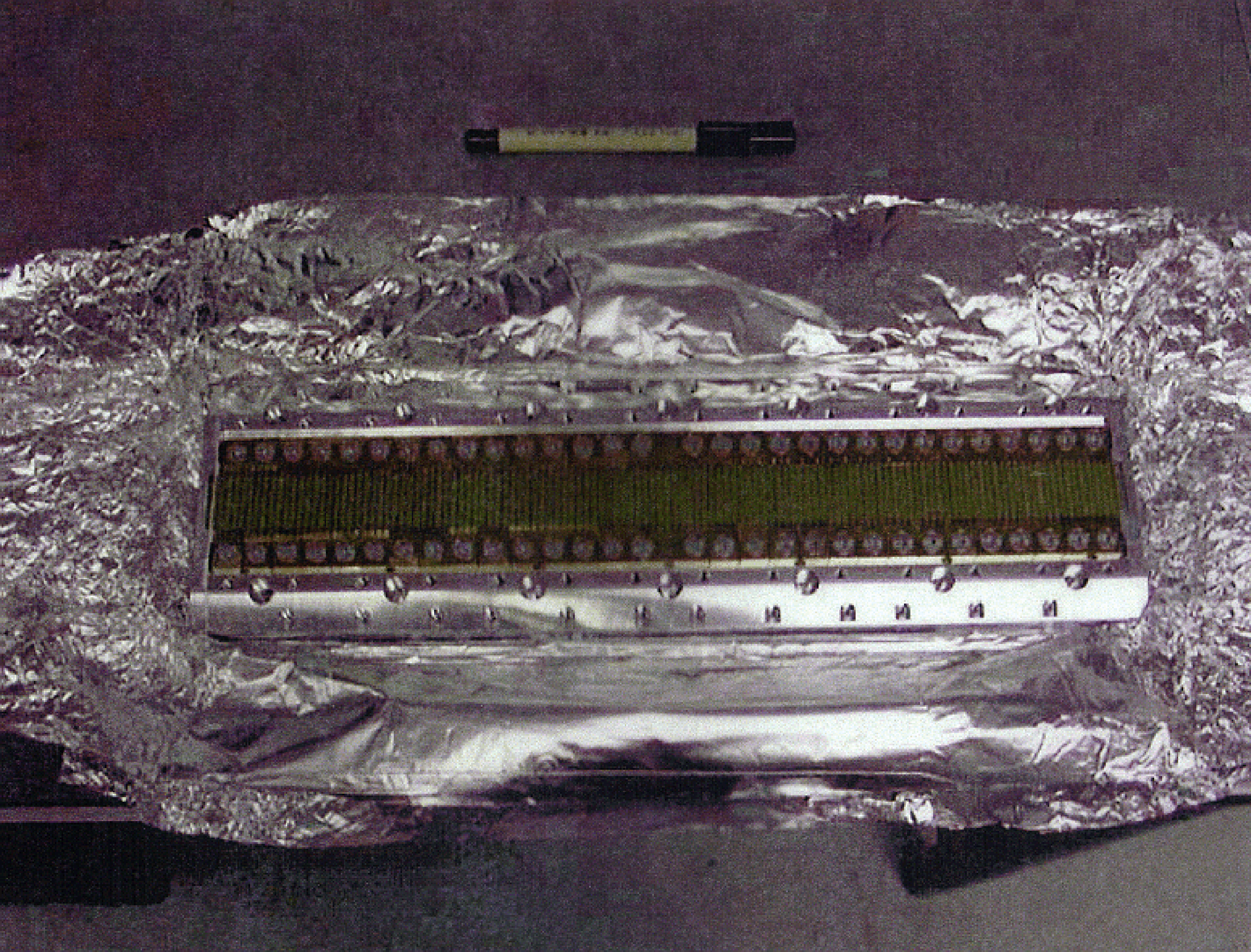
For x-ray region (in-vacuum)

$\lambda_u = 26mm$, $N = 171$, $G_{min} = 5mm$

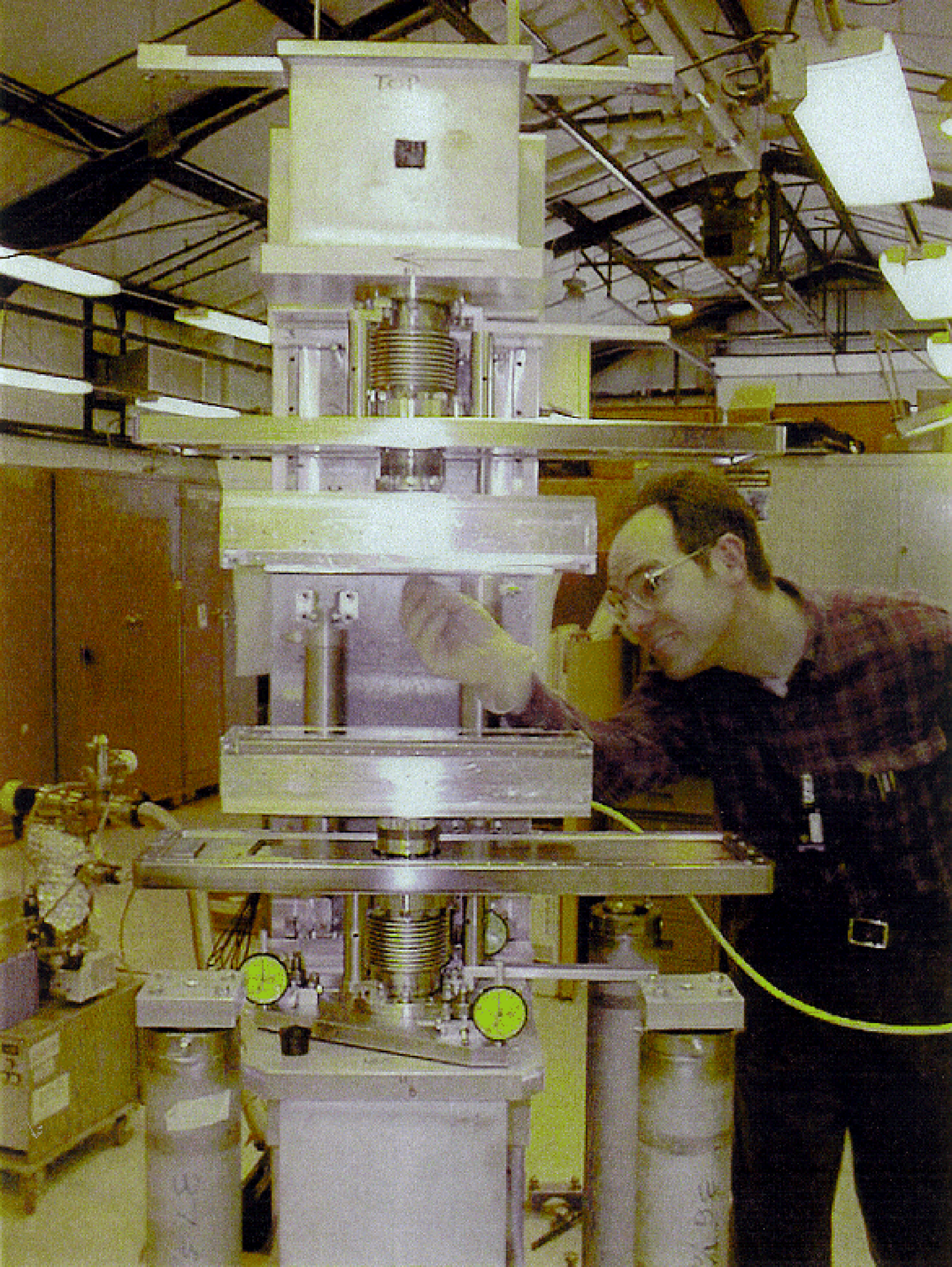
$Bv_{max} = 0.99T$, $Bh_{max} = 0.30T$



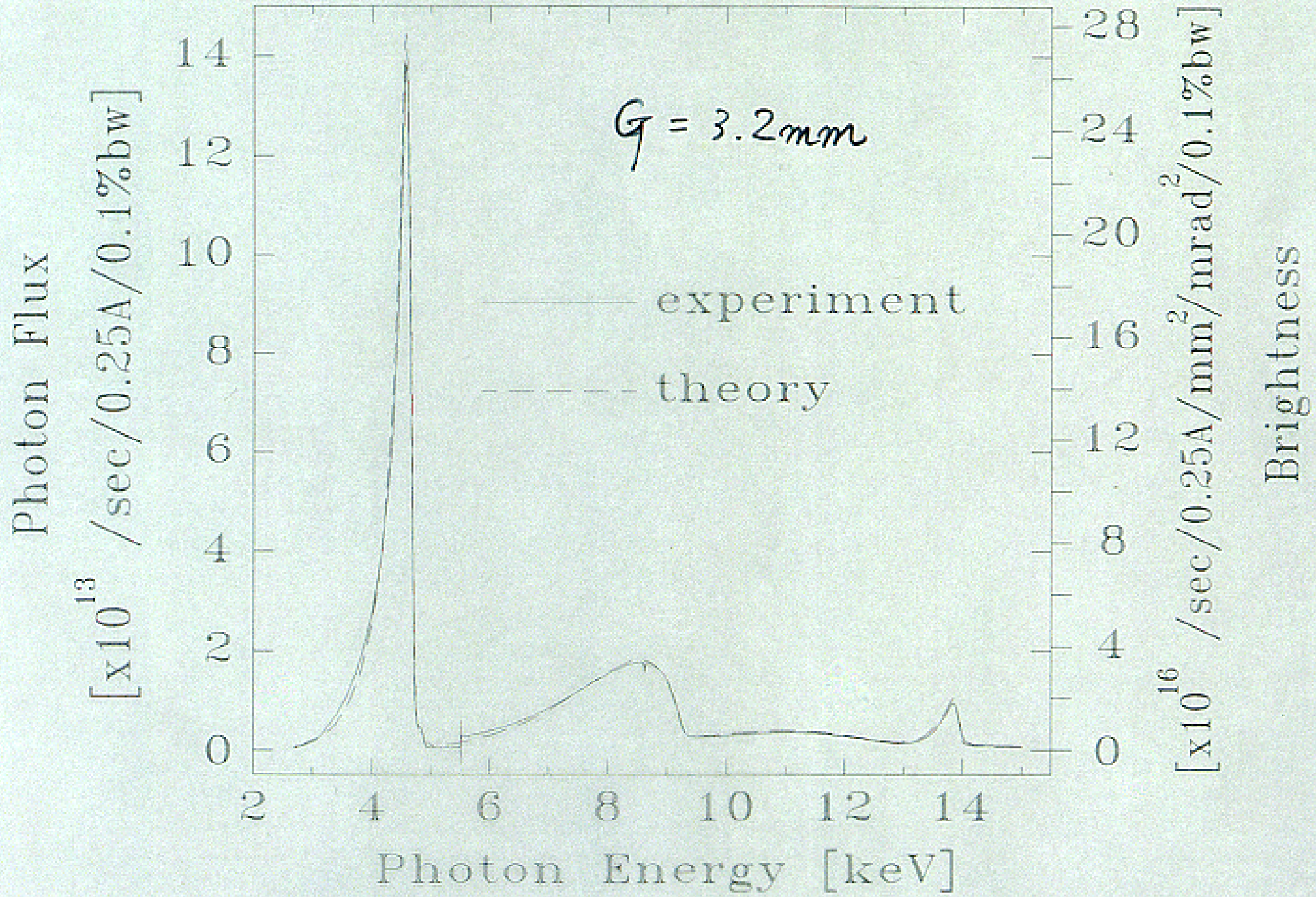

In-vacuum mini-gap undulator
Collaborated work with NSLS
λu=11mm, N=27, Gmin=3.2mm, Bmax=0.7T




後 B
A
gap =
Y



Spectrum from the In Vacuum Undulator IVUN at 2.584 GeV



Special in-vacuum devices under construction

In-vacuum helical undulator

$L = 4.5m$, $G_{min} = 7mm$
$\lambda_u = 36mm$ $(N = 125)$
$B_{max} = 0.33T$

In-vacuum revolver undulator of mini-gap type

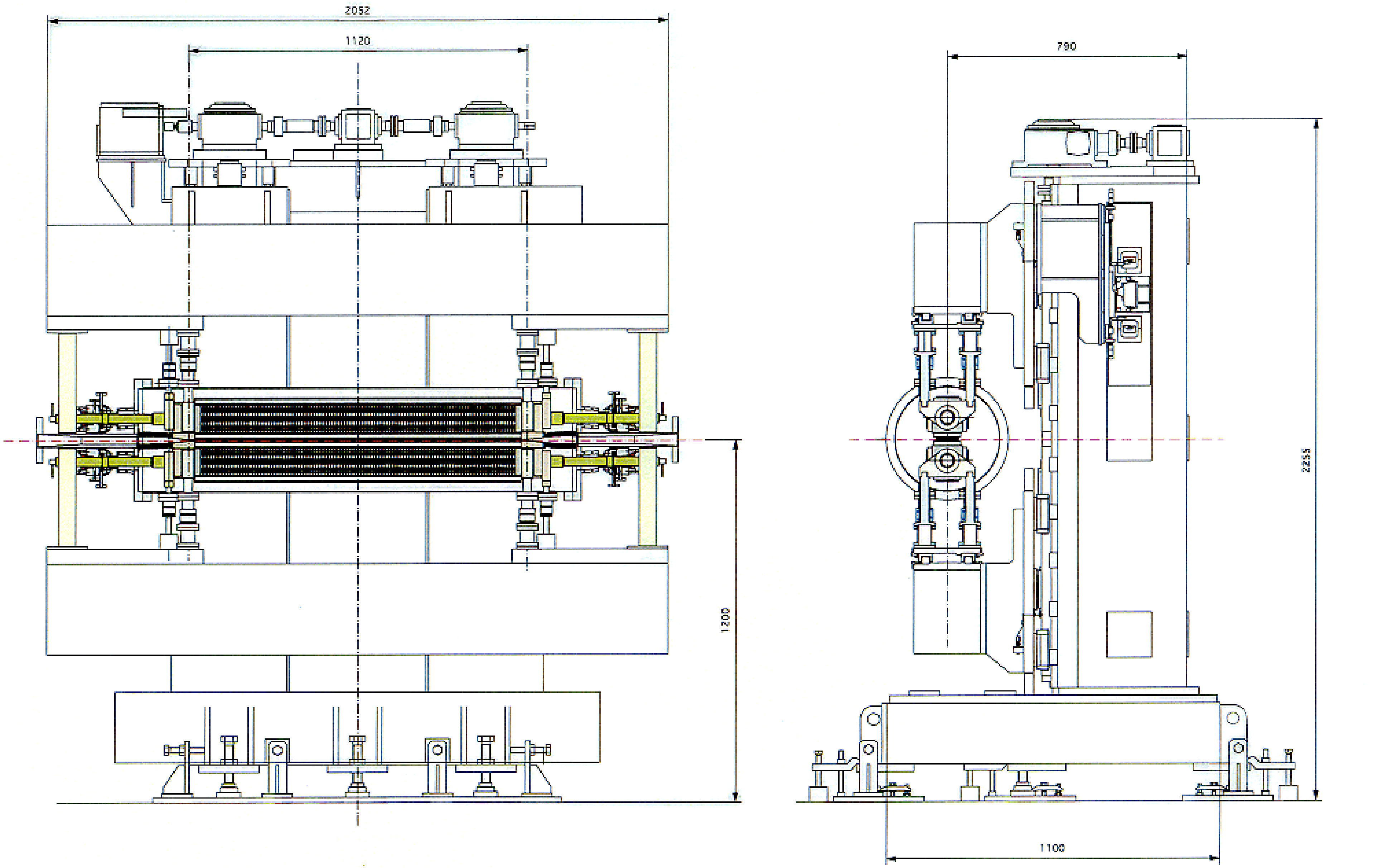
$L = 1m$, $G_{min} = 2mm$
4-undulator system
$\lambda_u = 6mm(N = 173)$, $10mm(N = 104)$,
$15mm(N = 69)$, $20mm(N = 51)$
additional magnet arrays to reduce magnetic load

In-vacuum high-field wiggler

$L = 4.5m$, $G_{min} = 7mm$
$\lambda_u = 100mm$ $(N = 45)$
$B_{max} = 2T$

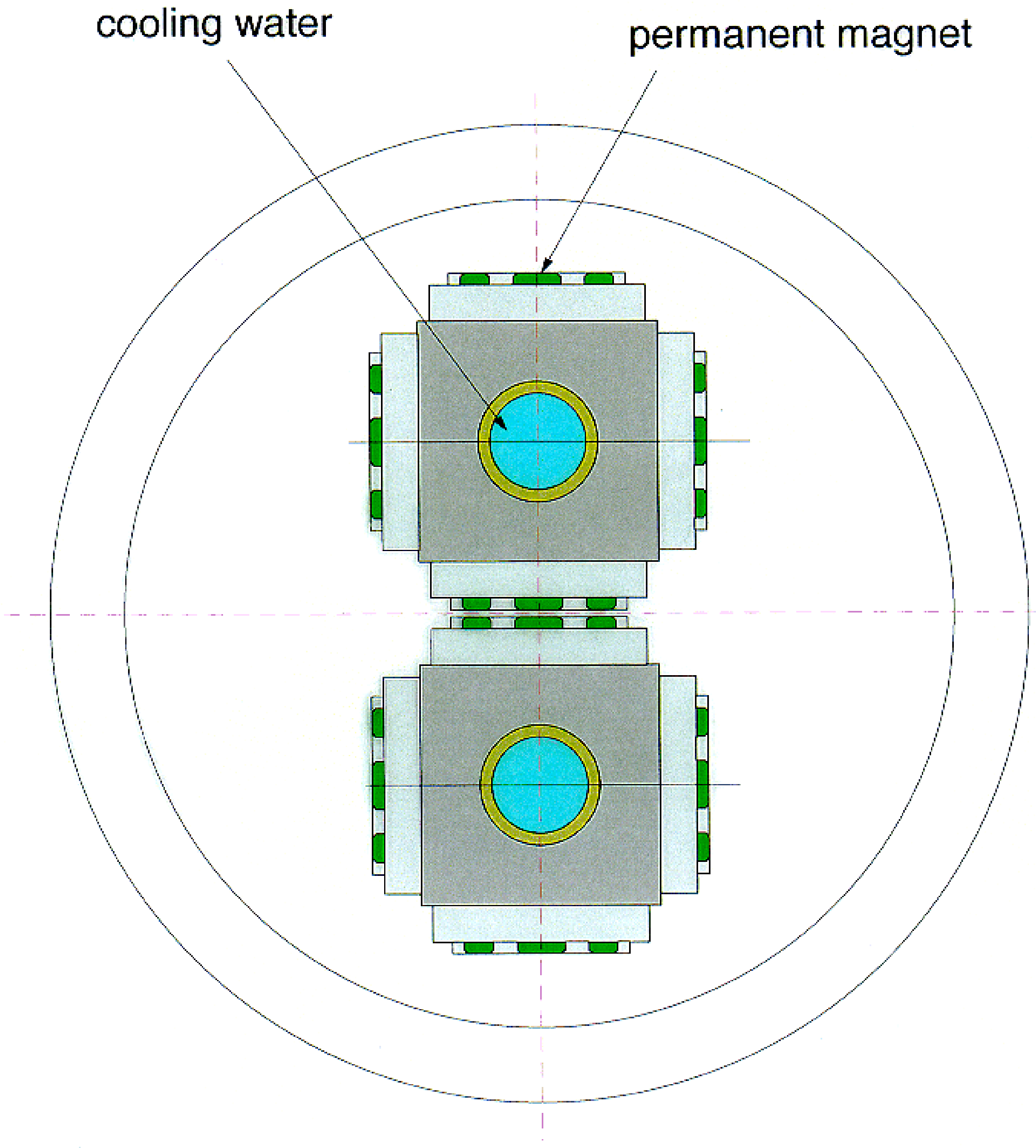
Very long in-vacuum undulator

$L = 25m$, $G_{min} = 12mm$
$\lambda_u = 32mm$ $(N = 781)$
$B_{max} = 0.57T$

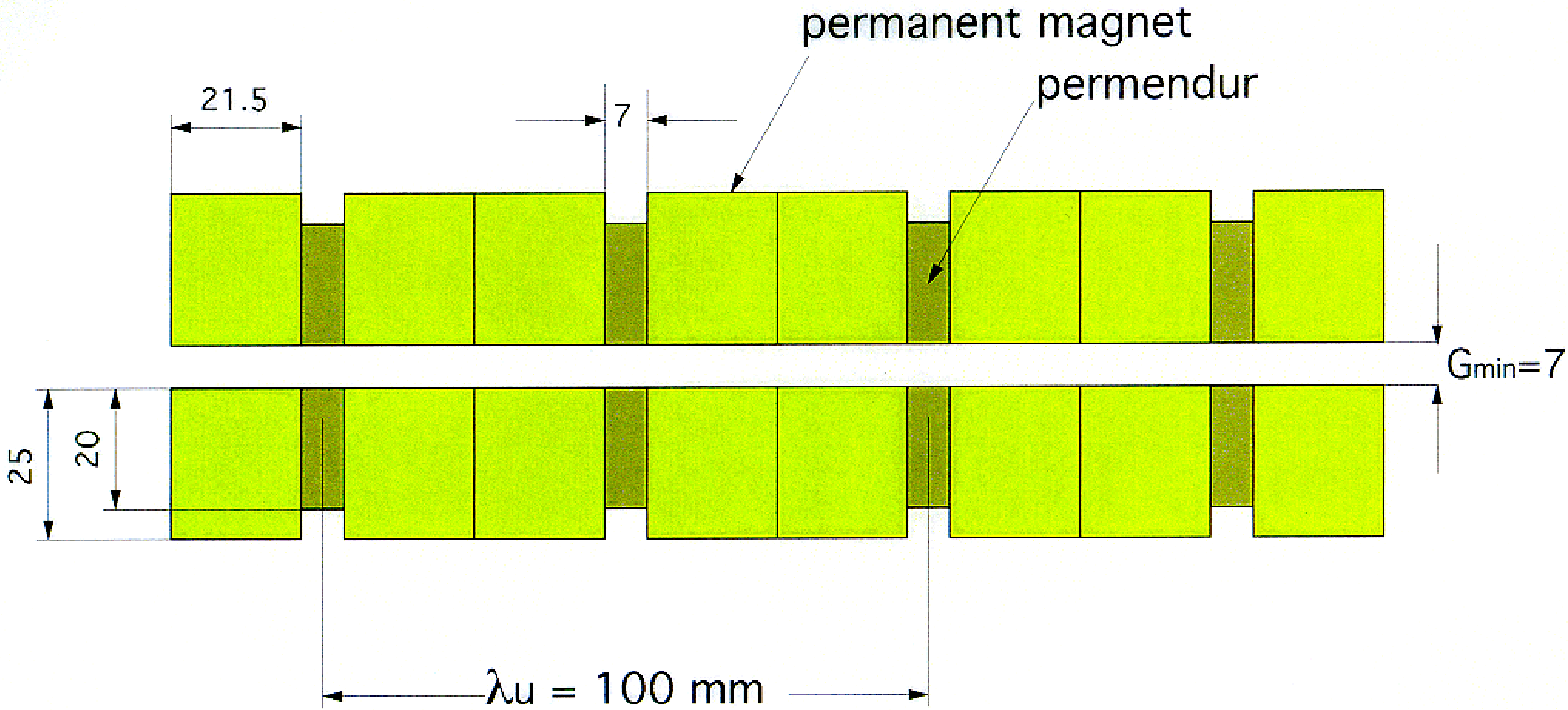


In-vacuum Revolver Undulator

図4-1-1　挿入光源開発装置



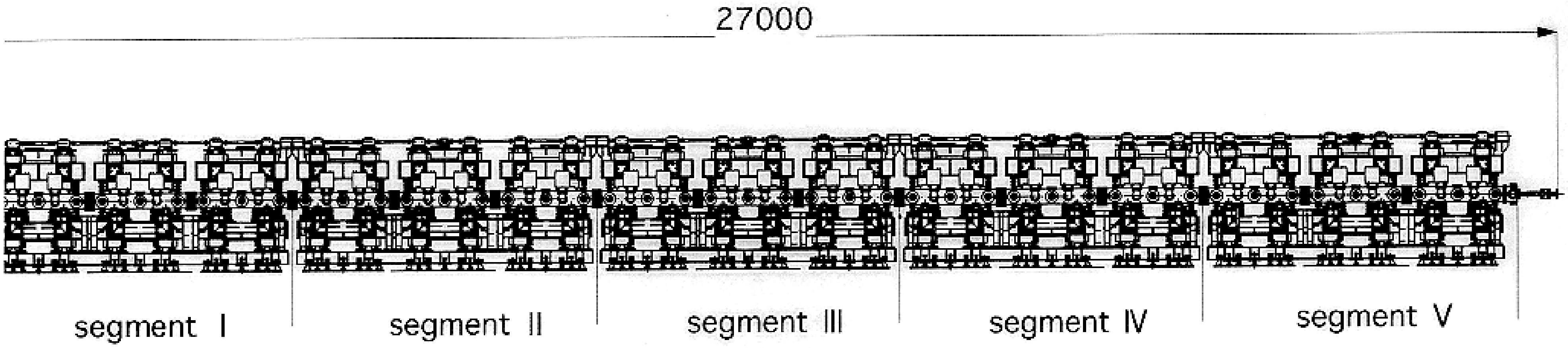
In-vacuum Revolver Undulator



In-vacuum high field wiggler

λ_u=100mm, N=45, B_{max}=2 T

ε_c = 85 keV



Very long in-vacuum undulator
$L=25m$, $\lambda_u=32mm$, $N=781$
$G_{min}=12mm$, $B_{max}=0.57T$

In-vacuum mini-gap undulators

↓

New concept of SR facility

Moderate-cost and medium-sized facility with a combination of a low emittance ring and very short gap undulators.

Performance:

comparable to that of APS, ESRF or SPring-8

Examples

Swiss Light Source

E = 2.5GeV, I = 400 mA, ε = 3 nm·rad
Totally 12 straight sections
6 straight sections for (in-vacuum) mini-gap devices

Australian Light Source