2014/Nov./21
先端放射光源に関する研究会@分子科学研究所

極短周期アンジュレータ開発の現状
Present status of R&D for very short period undulators

1. Target & Circumstances
2. Formation of a "very short period" undulator field
3. Field measurement & characterization
4. Recent achievements on magnet elongation
5. Summary

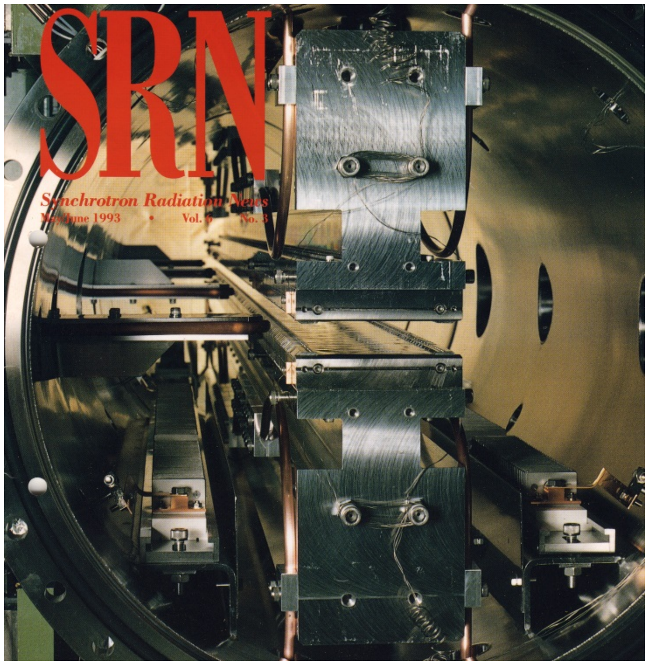
Photon Factory, KEK

Shigeru YAMAMOTO
山本　樹

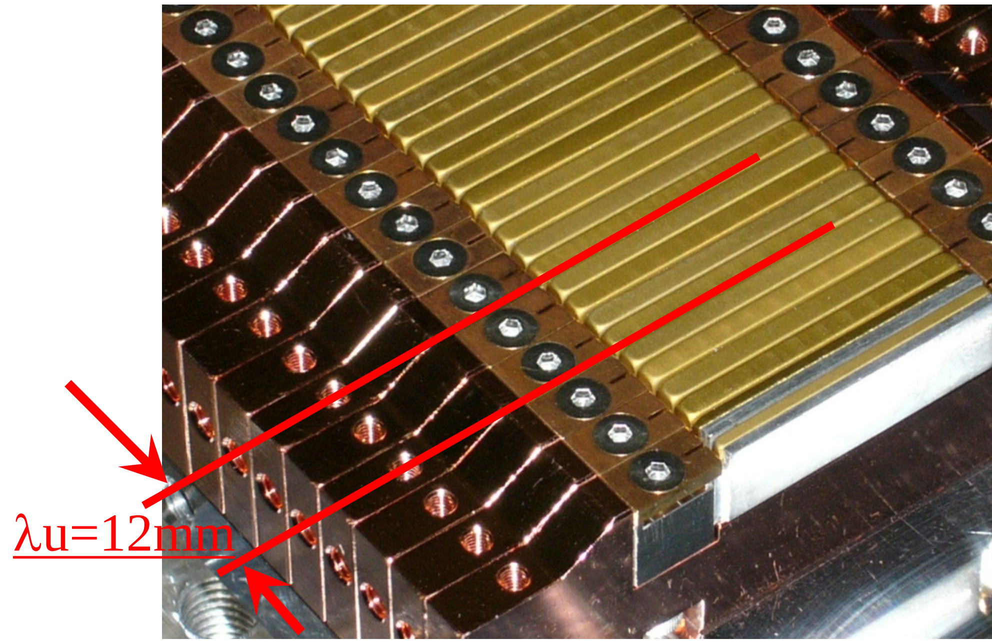
1. Target & Circumstances

Hard x rays by shorter λu & lower (1st) harmonics @ lower energy LS

In KEK we constructed the In-Vac Us to reduce the period length:



In-vac Us (λu=4cm)
@ 6.5GeV PF-AR (since 1989)
Gap=10mm



In-vac Short Gap Us (λu=1-2cm)
@ 2.5GeV PF (2003-08)
Gap=4mm

Other institutes: 3G LS (ESRF, APS, SPring-8): In-vac Us (λu~several cm)
Compact 3G LS: In-vac Us (λu~2 cm)

Short Gap Undulators @ PF

Name	***Make***	***iH_c****	***λ_u***	***N***	***12-keV photon***	***K_{max}*****
SGU#17	2003	25kOe	16mm	29	5^{th}	1.374
SGU#03	2005	30kOe	18mm	26	5^{th}	1.684
SGU#01	2008	28kOe	12mm	39	3^{rd}	0.781

* Magnet: NEOMAX TiN coated

** @ Gap_{min}=4.0mm

What is the shortest λ_u?

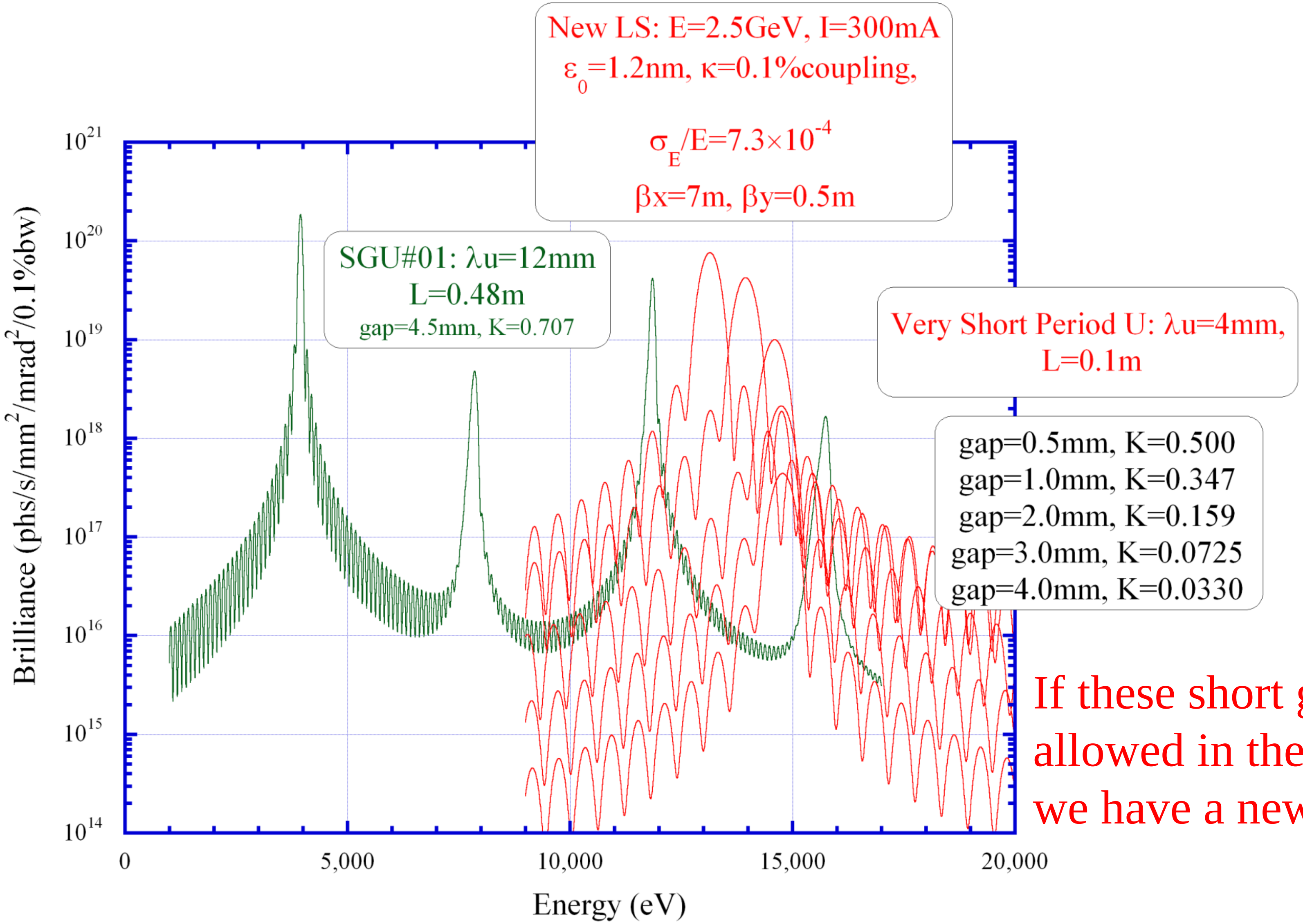
Target:

Very short λ_u = several cm (ordinary type) x 1/10

= several mm (4mm)

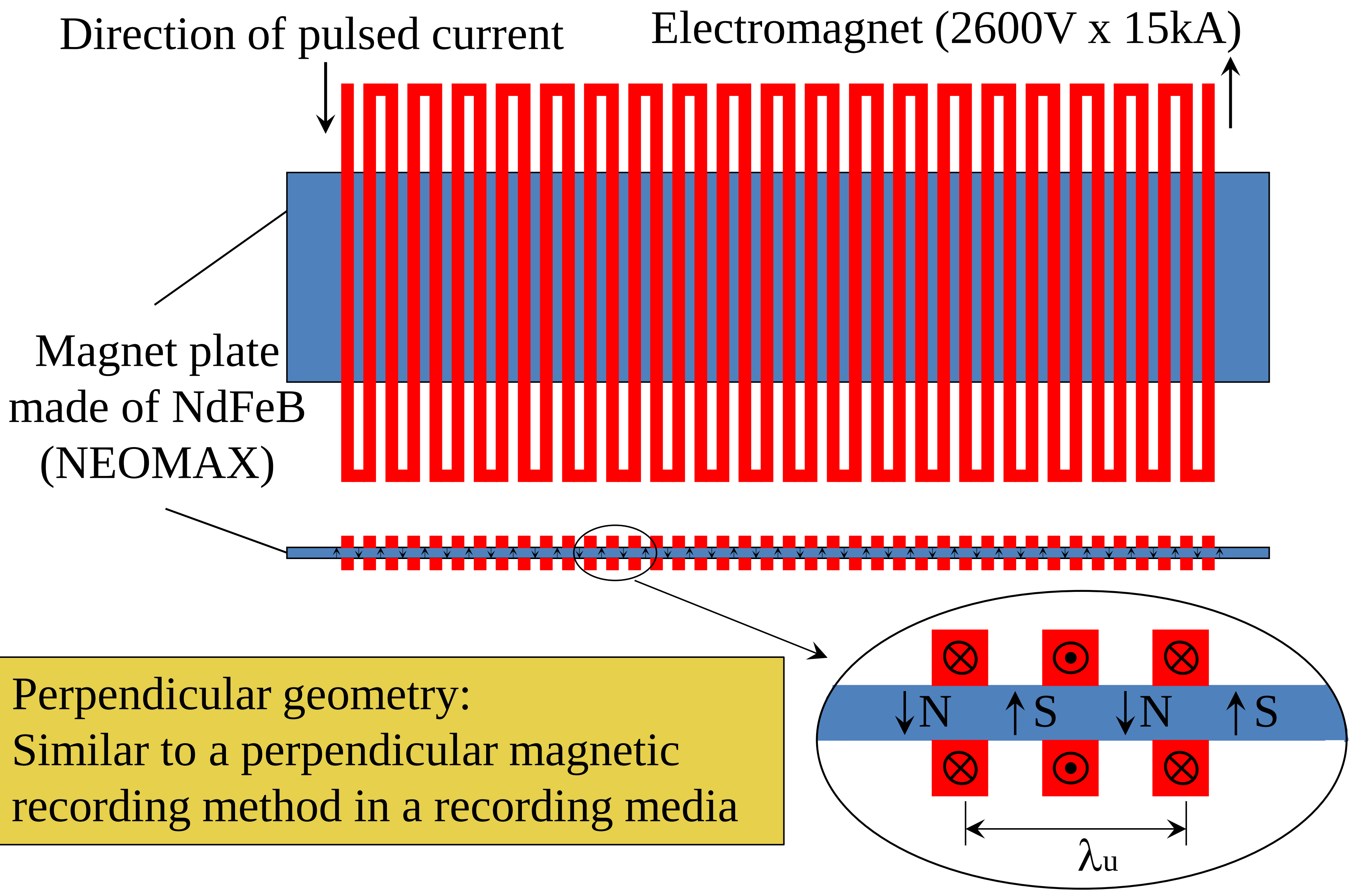
1. Target & Circumstances

Very short period Uundulators @ 2.5GeV LS



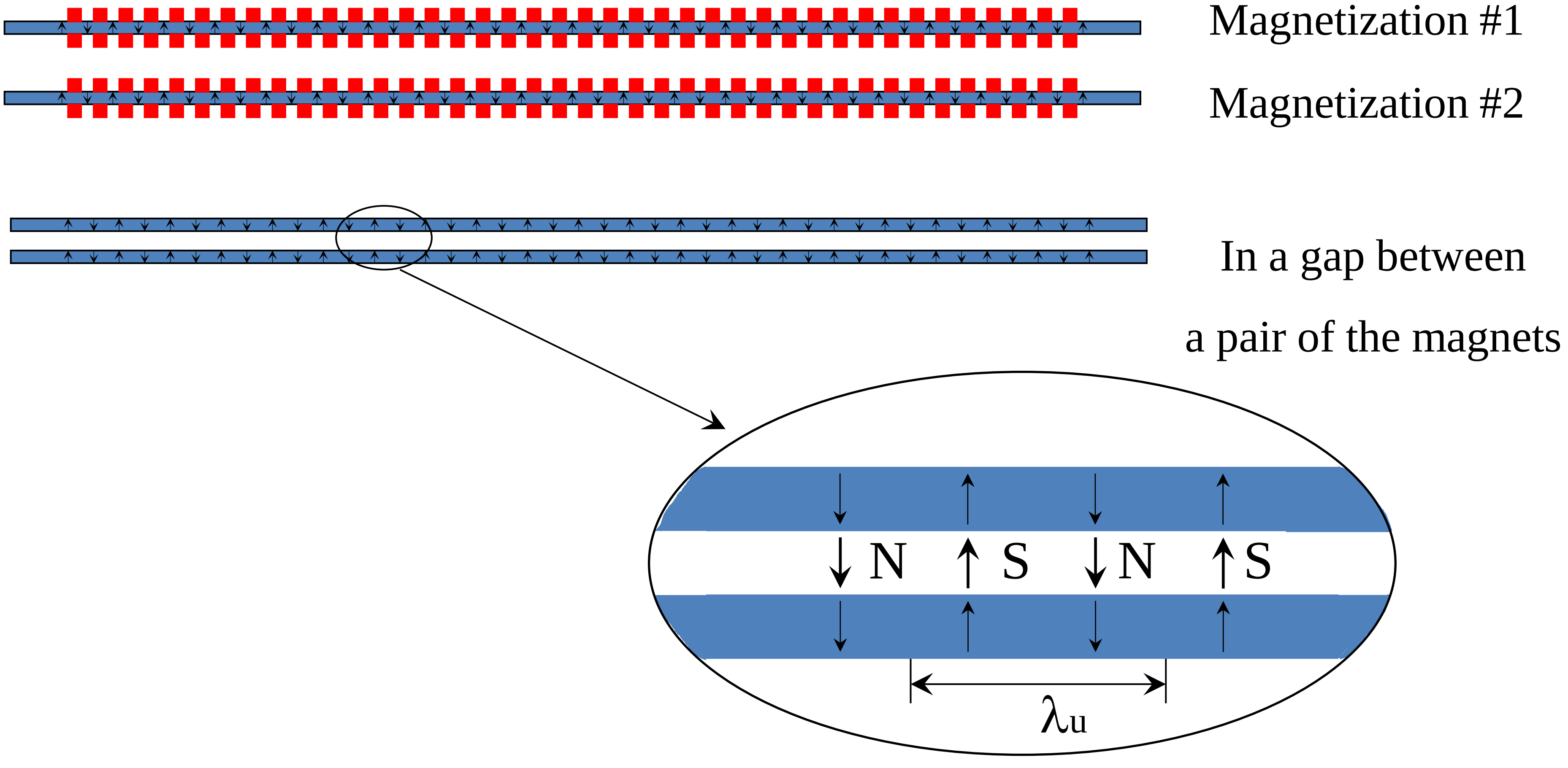
If these short gaps are allowed in the accelerator, we have a new possibility.

2. Formation of a "very short period" undulator field: perpendicular geometry

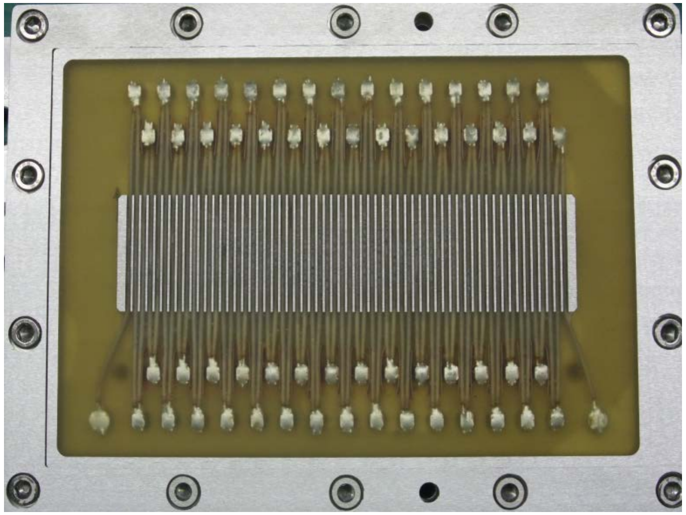


Perpendicular geometry:
Similar to a perpendicular magnetic recording method in a recording media

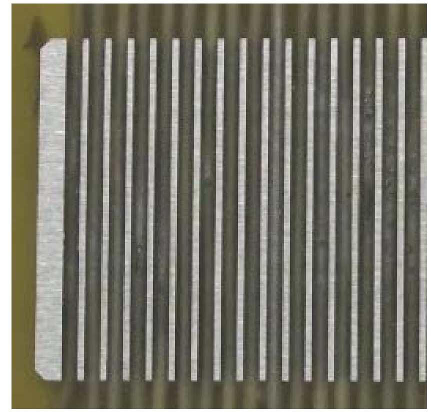
2. Formation of a "very short period" undulator field: perpendicular geometry



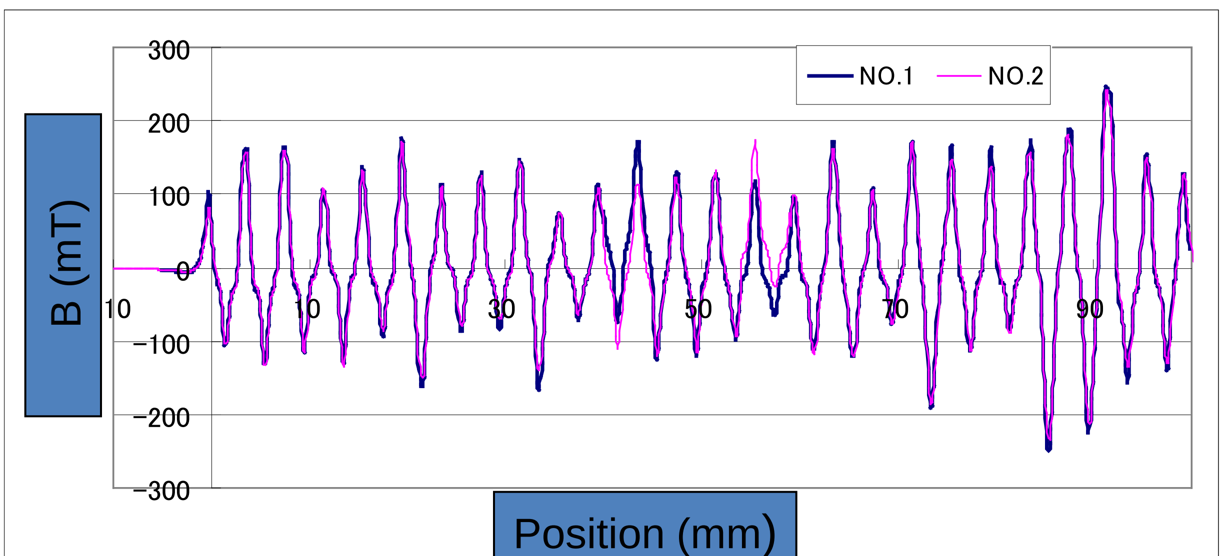
2. Formation of a "very short period" undulator field: A result of early stage attempts



Magnetizing head



Pole piece (expanded)



Magnetization test with NEOMAX-48BH plate

Magnet size:

100mm x 20mm x 2mm

λu = 4mm

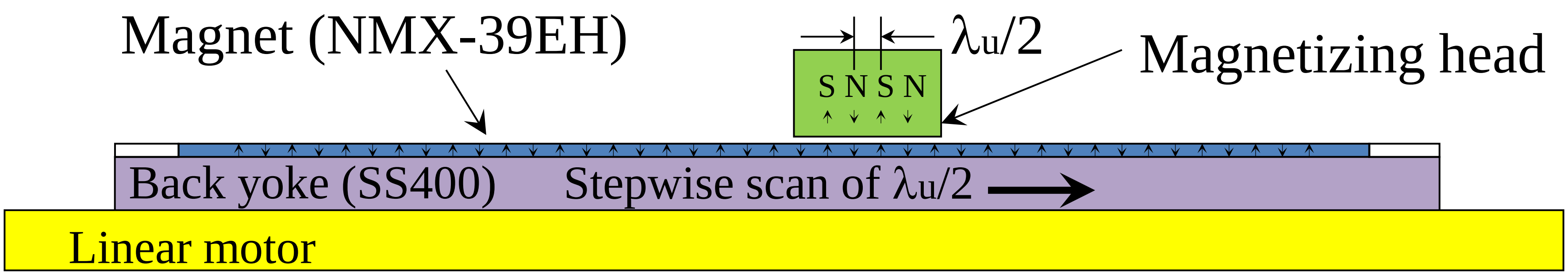
Unsatisfactory !

B ~ 150mT +/- 50mT

$\lambda u/2$ ~ 2mm +/- 0.6mm

2. Formation of a “very short period” undulator field: fabrication of undulator magnets

Magnetizing a magnet plate driven stepwise in the perpendicular geometry



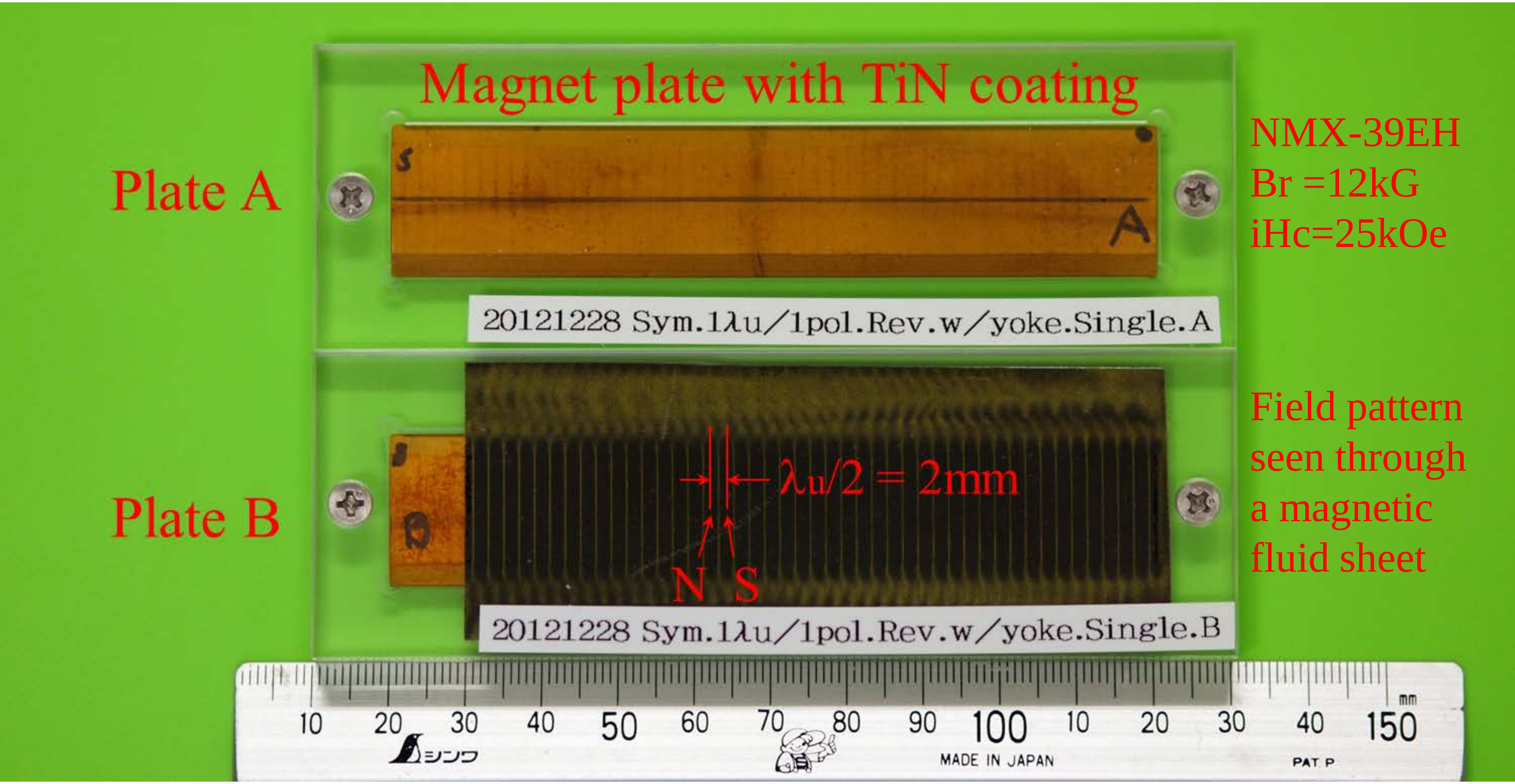
λ_u scan = 1st step of $\lambda_u/2$ (S N S N) + 2nd step of $\lambda_u/2$ (N S N S)

Accuracy in λ_u: Wire spacing & step width

Accuracy in B-field: λ_u & e^- charge to the head

Linear motion is cntl’d by a closed loop scheme (+/- 3μm)

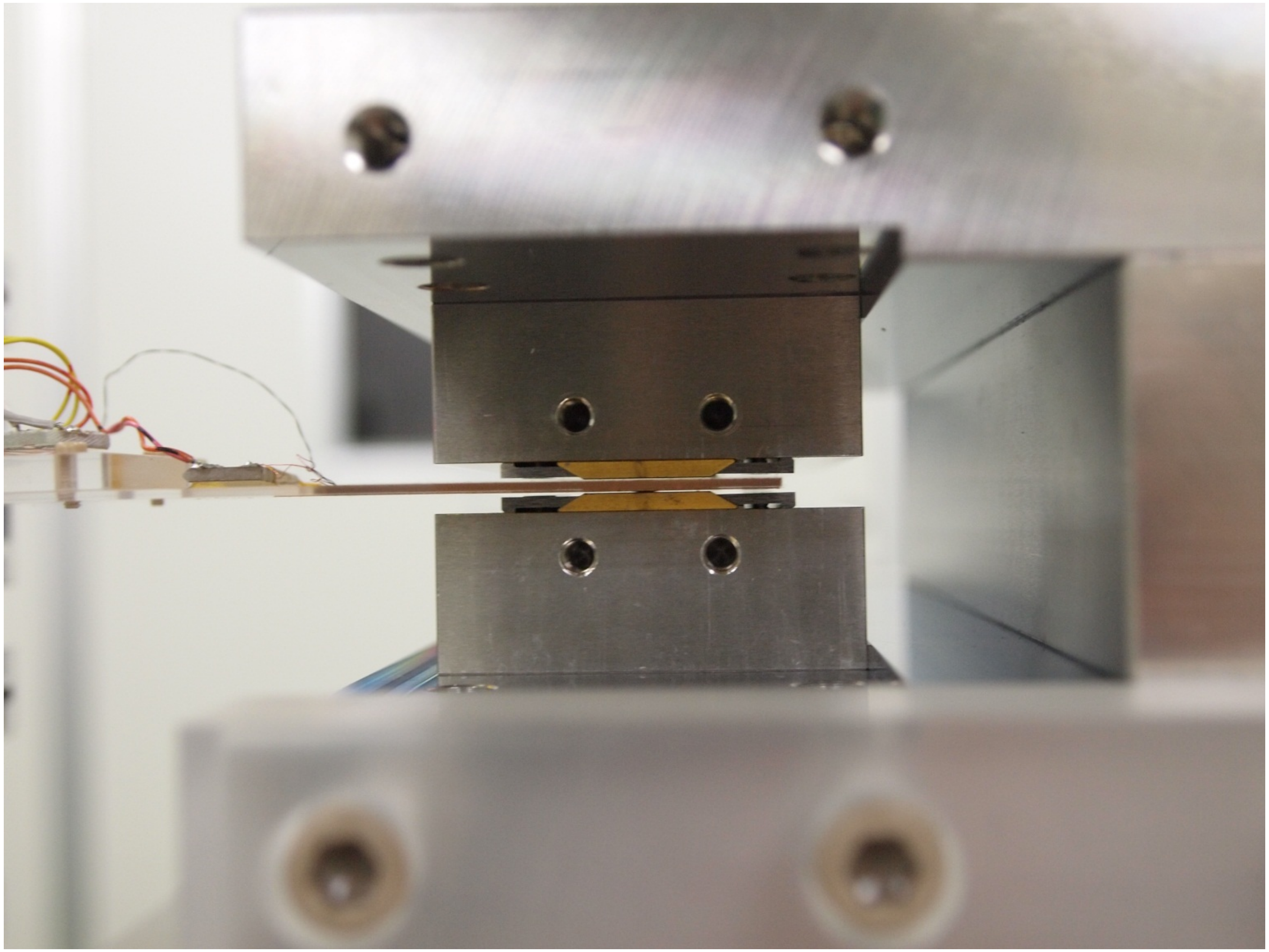
2. Formation of a “very short period” undulator field: fabrication of undulator magnets



A pair of Nd-Fe-B magnets (TiN coated):

100mm long, 20mm wide, 2mm thick

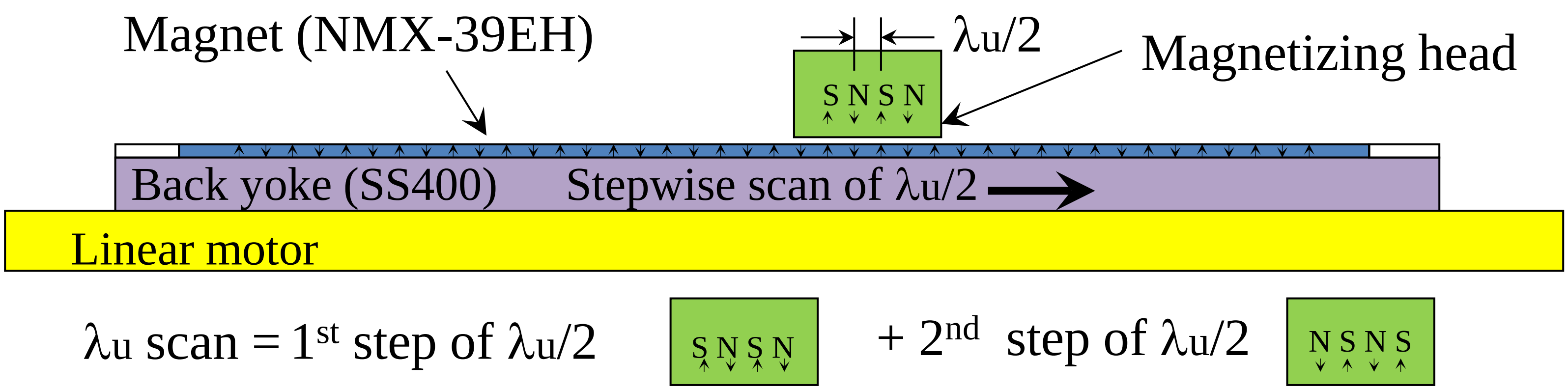
Measurement @ fixed gap=1.6mm



Hall probe ~1.3mm thick with 0.05 x 0.05 mm^2 resolution

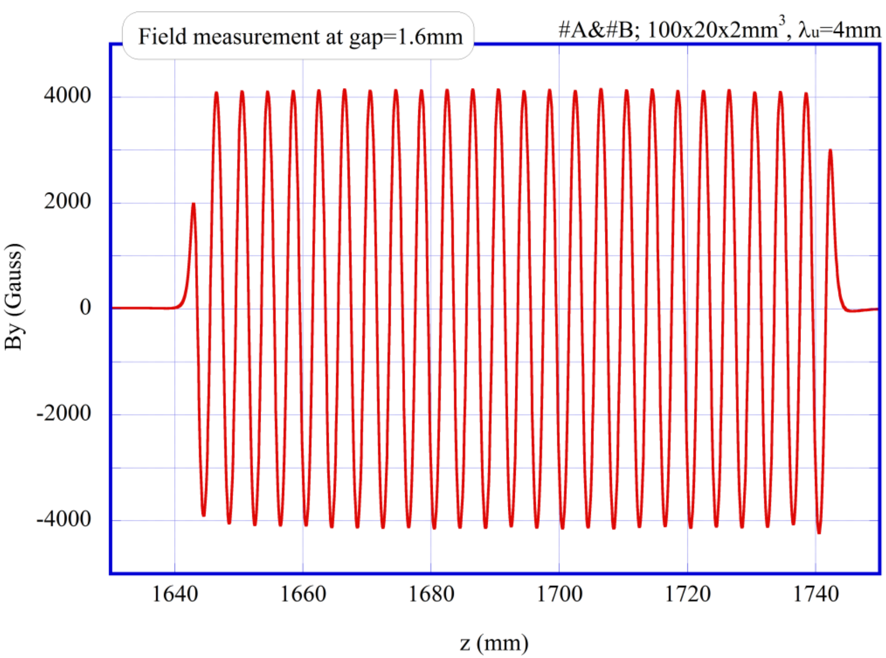
Gap > 1.6mm

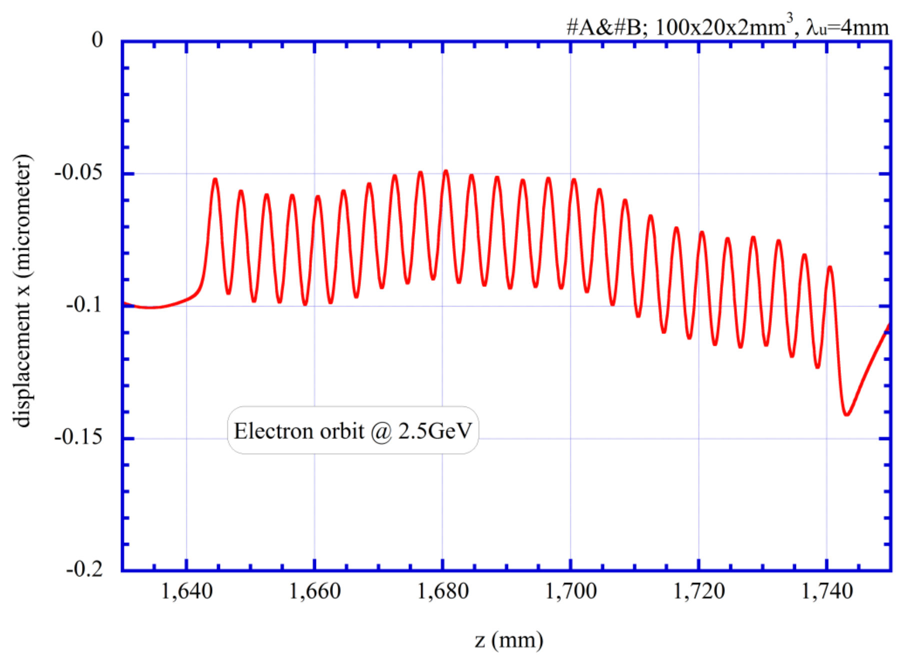
3. Field measurement & characterization: continued



Measured undulator field (λ_u=4mm) @ gap =1.6mm

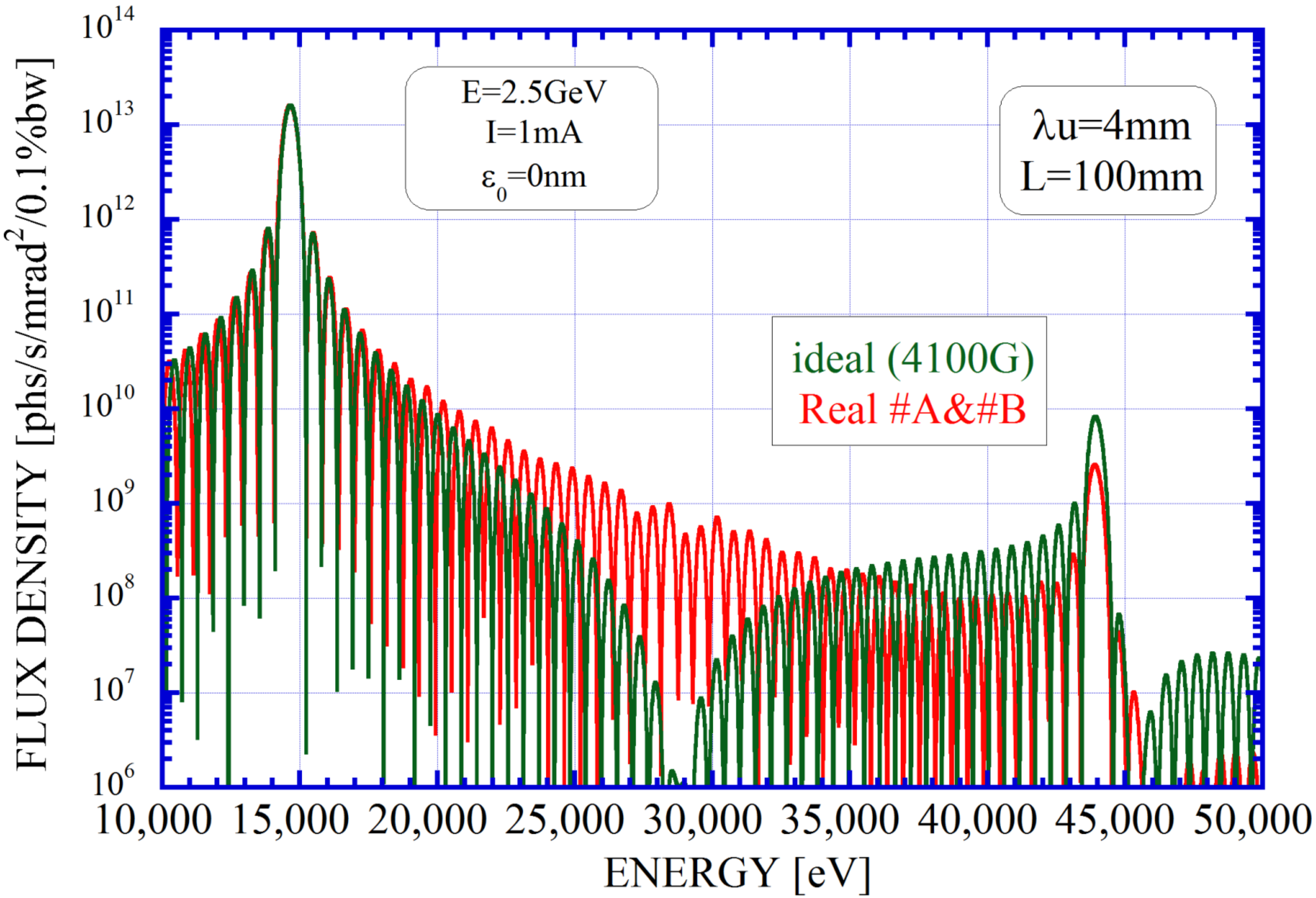
Electron orbit @ 2.5GeV: end correction not made





3. Field measurement & characterization: continued

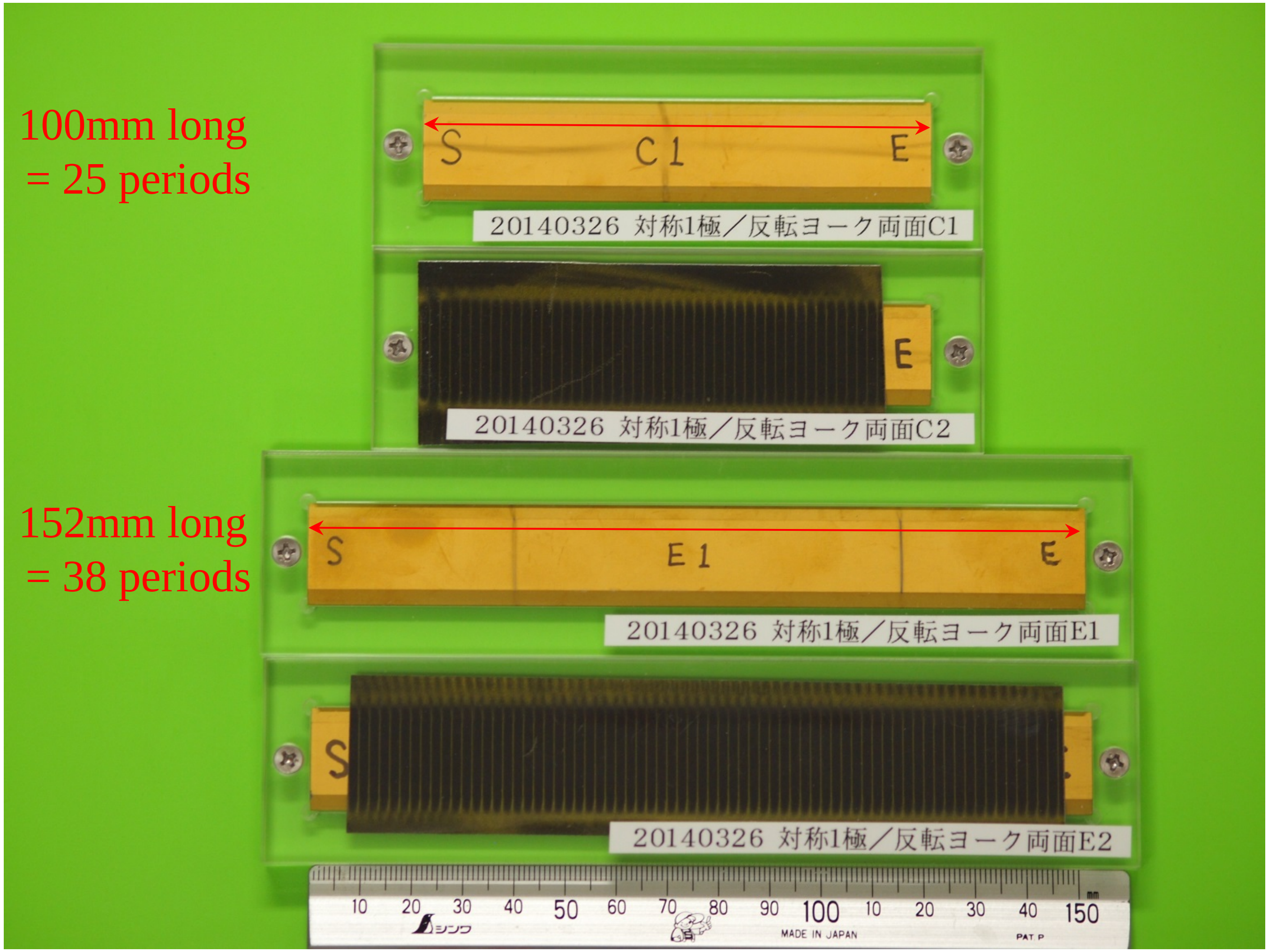
Undulator field (λ_u = 4mm) of 4100G @ gap=1.6mm



Measured field is compared to ideal field with the same strength

4. Recent achievements

1. Magnet elongation by material improvement



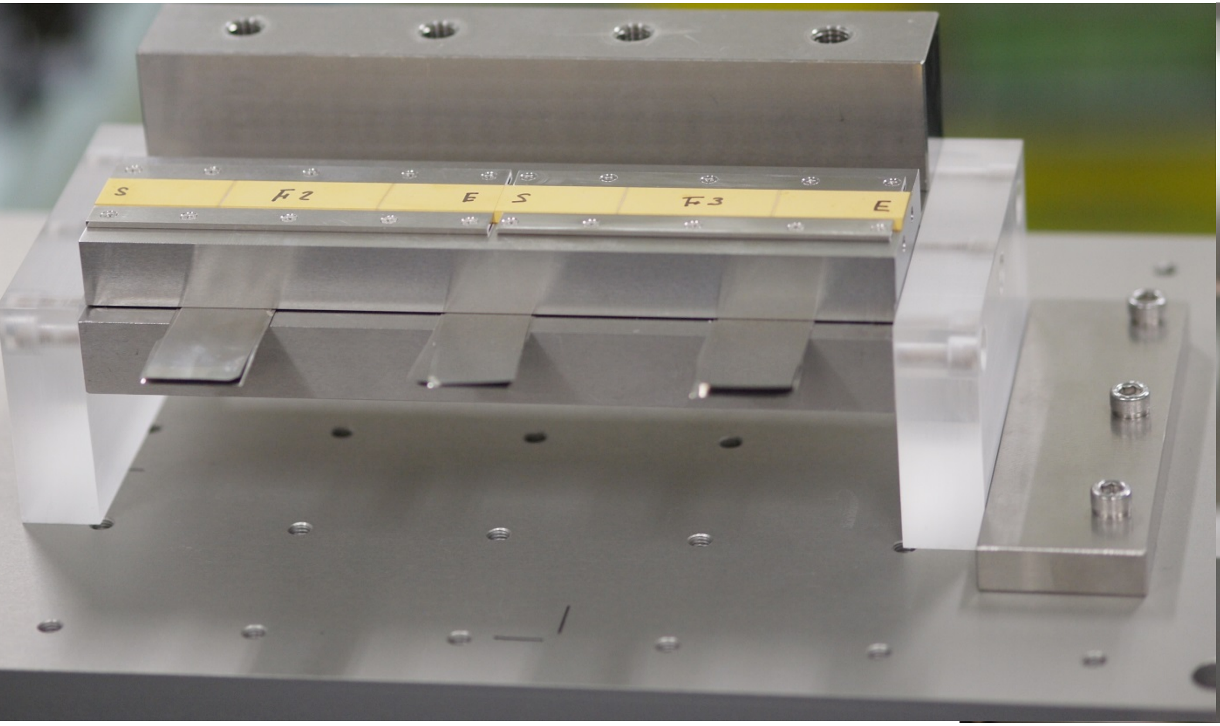
Field pattern seen through a magnetic fluid sheet

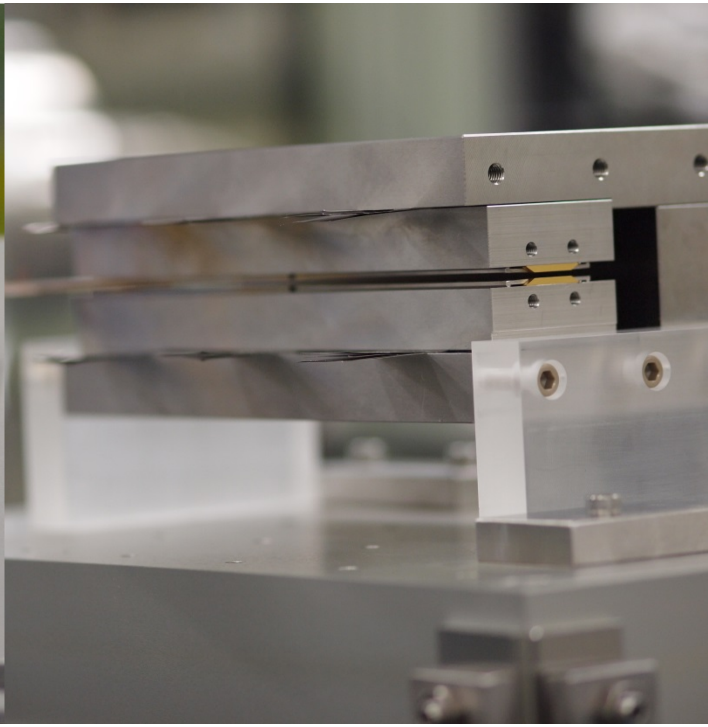
NMX-39EH TiN coated (Br =12kG, iHc=25kOe)
20mm wide, 2mm thick

4. Recent achievements

2. Magnet elongation by connecting magnet plates.

Two plates are connected longitudinally.
Measurement is made at fixed gap of 1.6mm.





NMX-39EH TiN coated (Br =12kG, iHc=25kOe)
100 long, 20mm wide, 2mm thick

5. Summary

We have been resolving major subjects and taking the right direction to develop the very short period undulaotrs.

We can start preliminary tests to elongate magnet length.

Still we need further improvements in the magnetization especially for both ends of the magnets, and

precise field measurement methods at a very short gap, *etc*.

However, we believe that evaluation experiments of the very short period undulator based on the real electron beams will take place in the near future.

I am happy if this technology is useful to construct next generation light sources.

JSPS Kakenhi
KEK-IMSS Intramural