Undulator Development for SPring-8-II and Related Issues

Takashi Tanaka for SPring-8 ID Group
RIKEN SPring-8 Center

Outline

- Overview of SPring-8-II
- Undulator R&D Activities
  - Structural Reform of IVUs
  - Helical-8 Undulator for Polarization Control
  - New Scheme for Quick Helicity Switching
- Demagnetization Issues
- Summary

Outline

- **Overview of SPring-8-II**
- Undulator R&D Activities
  - Structural Reform of IVUs
  - Helical-8 Undulator for Polarization Control
  - New Scheme for Quick Helicity Switching
- Demagnetization Issues
- Summary

SR and XFEL Facilities in SPring-8

From SPring-8 to SPring-8-II

SPring-8-II: major upgrade of the SPring-8 storage ring planned in the early 2020s (not yet funded)

✓ DBA to 5BA & Energy Reduction

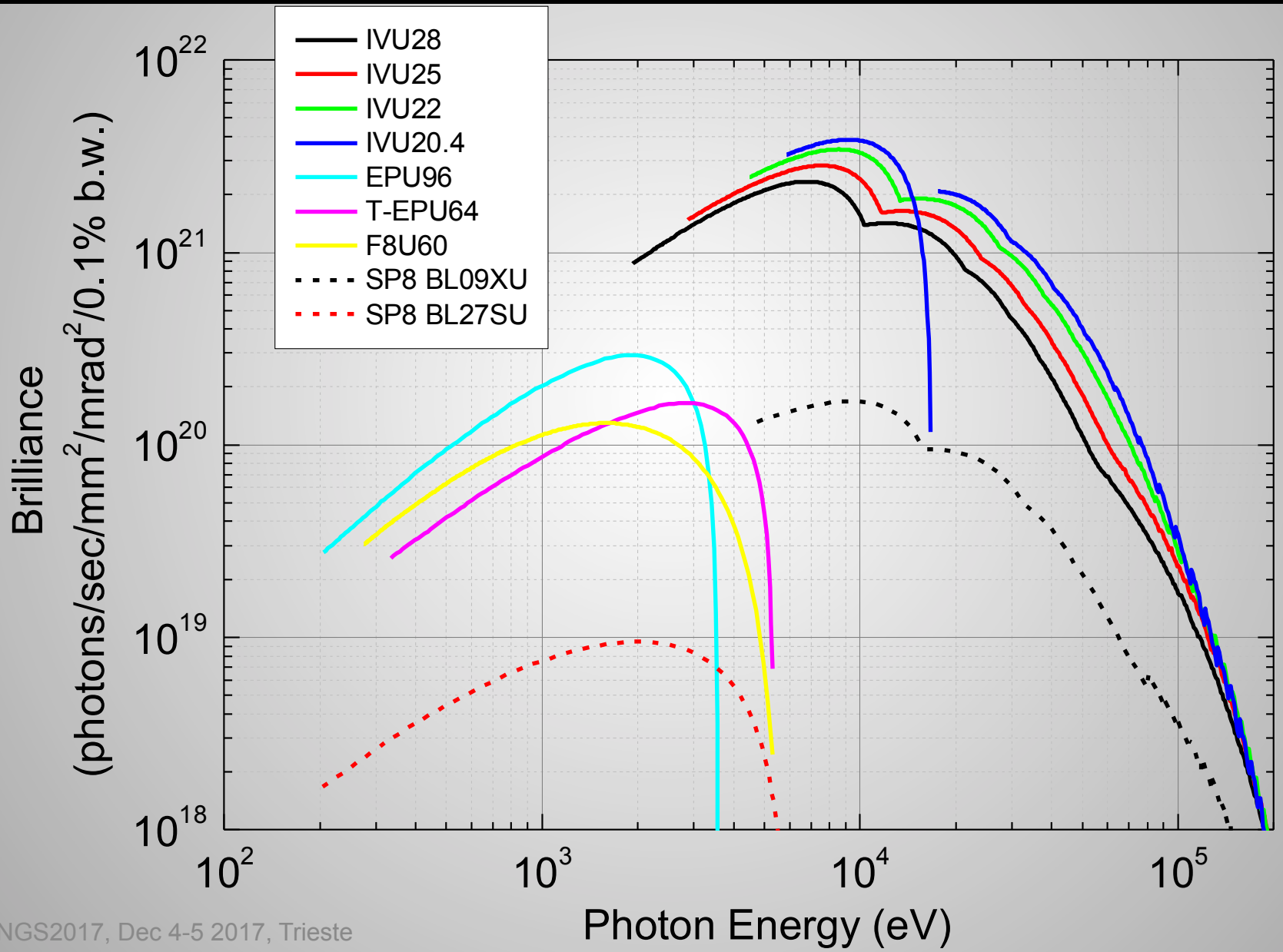
Parameters	SPring-8	SPring-8-II*
Electron Energy	8 GeV	6 GeV
Natural Emittance	2.4 nm.rad	0.14 nm.rad
Coupling	0.2 %	10%
Average Current	100 mA	<200 mA
Energy Spread	1.1×10^{-3}	9.3×10^{-4}
$\beta_{x,y}$@ID	31.2m/5.0 m	5.5m/3.0 m
Dispersion@ID	0.146 m	0
Length of Straight	5.7 m	4.2 m
ID Minimum Gap	8 mm	5 mm

*all values are subject to change except energy

Key Issues Besides Parameters

- Reuse the existing building
- Permanent magnet dipoles to reduce running cost (electricity)
- Injection
  - SACLA linac is used for a new injector
  - Existing injectors (1GeV linac & 8GeV booster) will be decommissioned
- 30-m straight sections are to be left for future applications (FELs?)
- One-year shutdown supposed

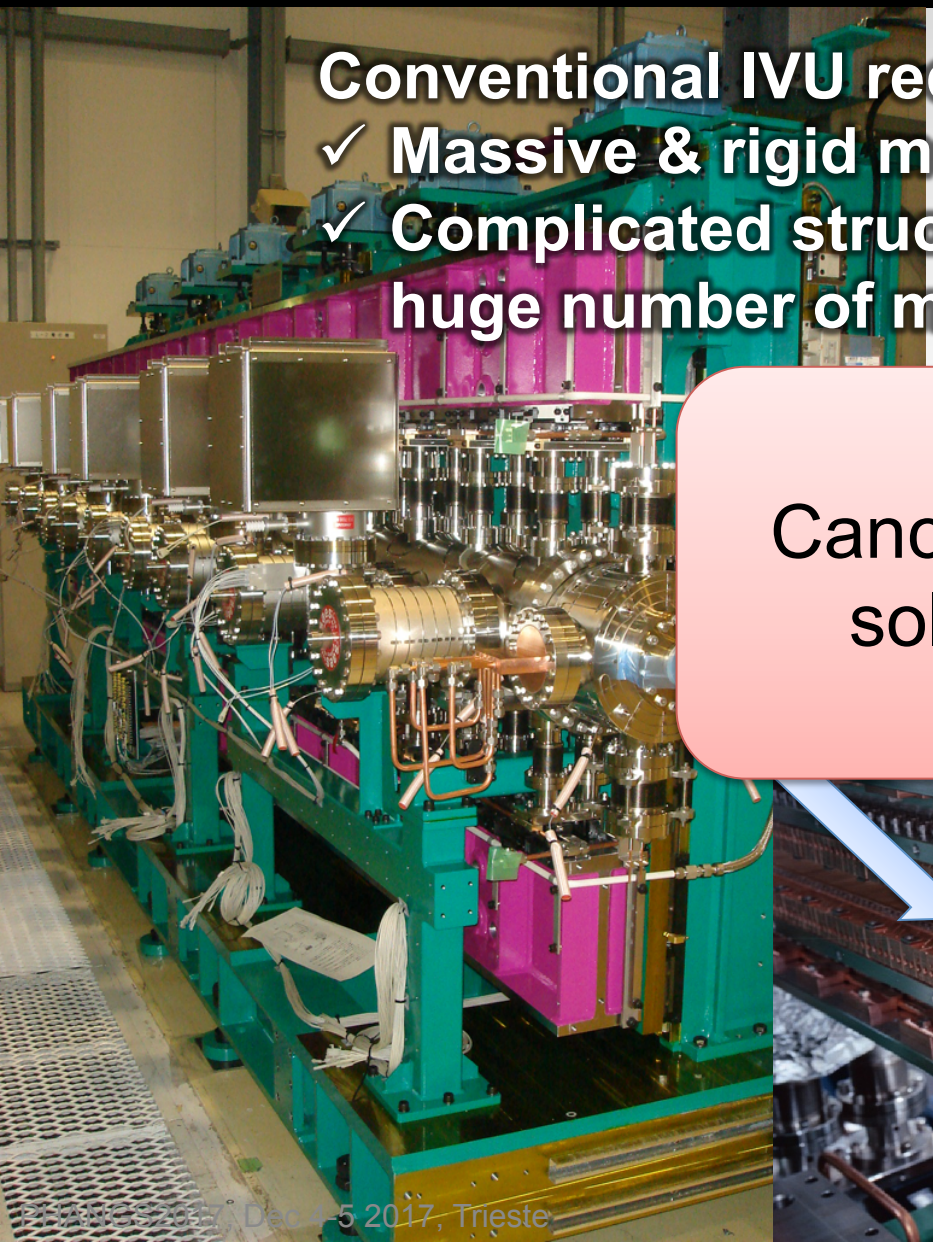
Expected Performances



Outline

- Overview of SPring-8-II
- **Undulator R&D Activities**
  - **Structural Reform of IVUs**
  - Helical-8 Undulator for Polarization Control
  - New Scheme for Quick Helicity Switching
- Demagnetization Issues
- Summary

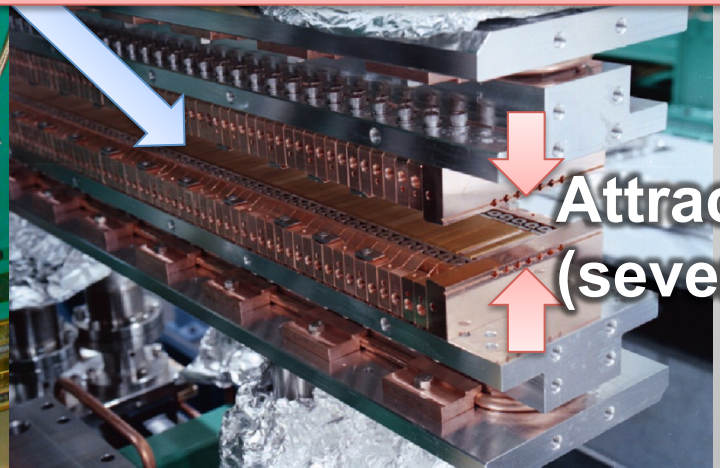
Background & Motivation



Conventional IVU requires:

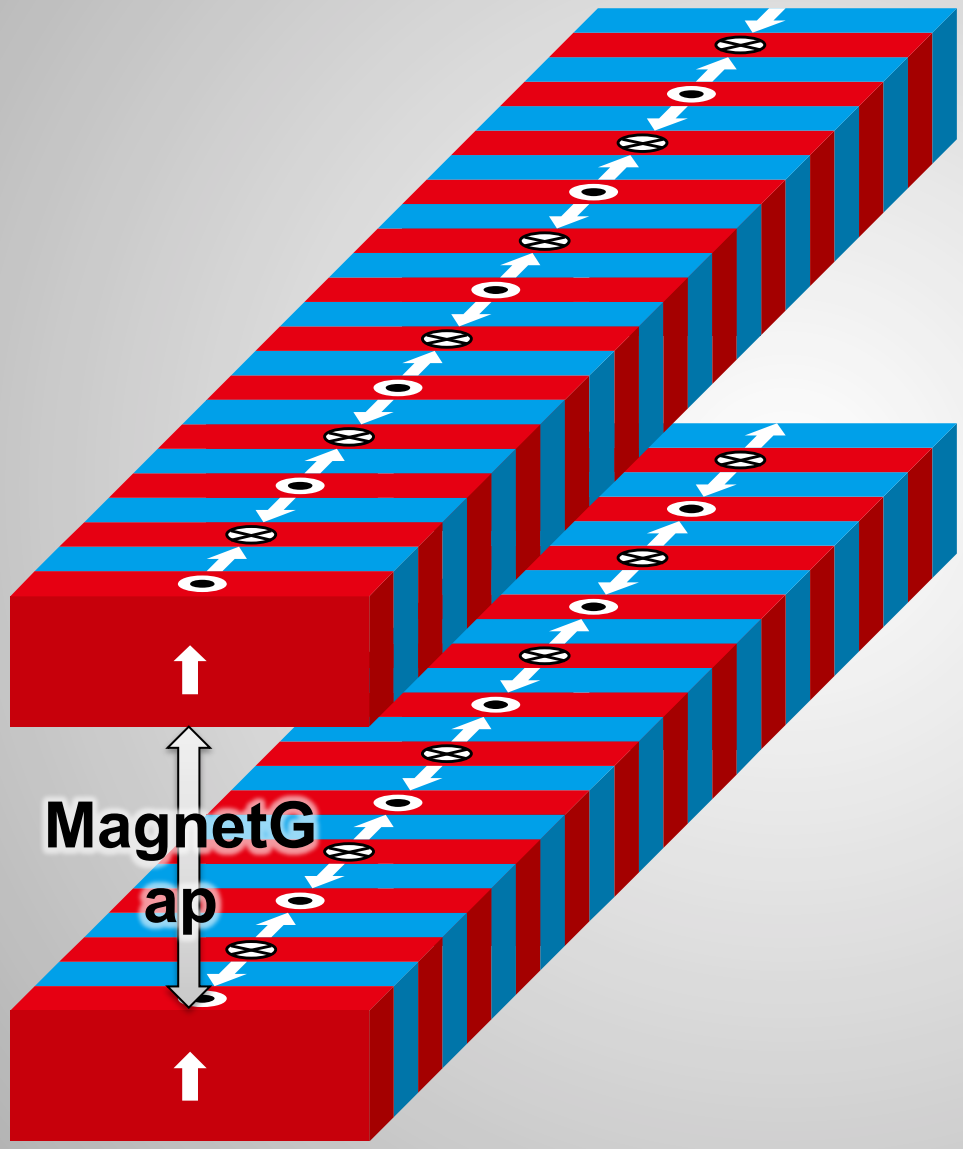
- ✓ **Massive & rigid mechanical frame**
- ✓ **Complicated structure composed of a huge number of mechanical elements**

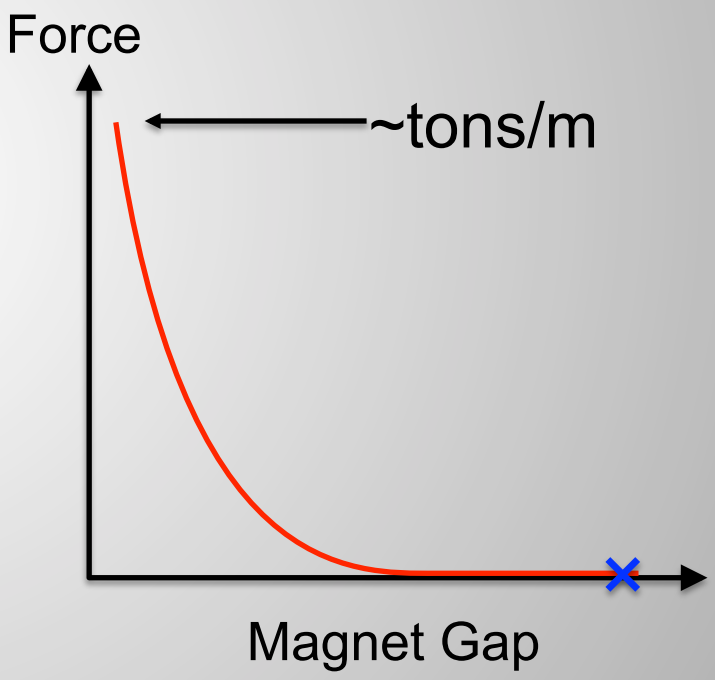
Cancellation of magnetic forces solves the problems, but…



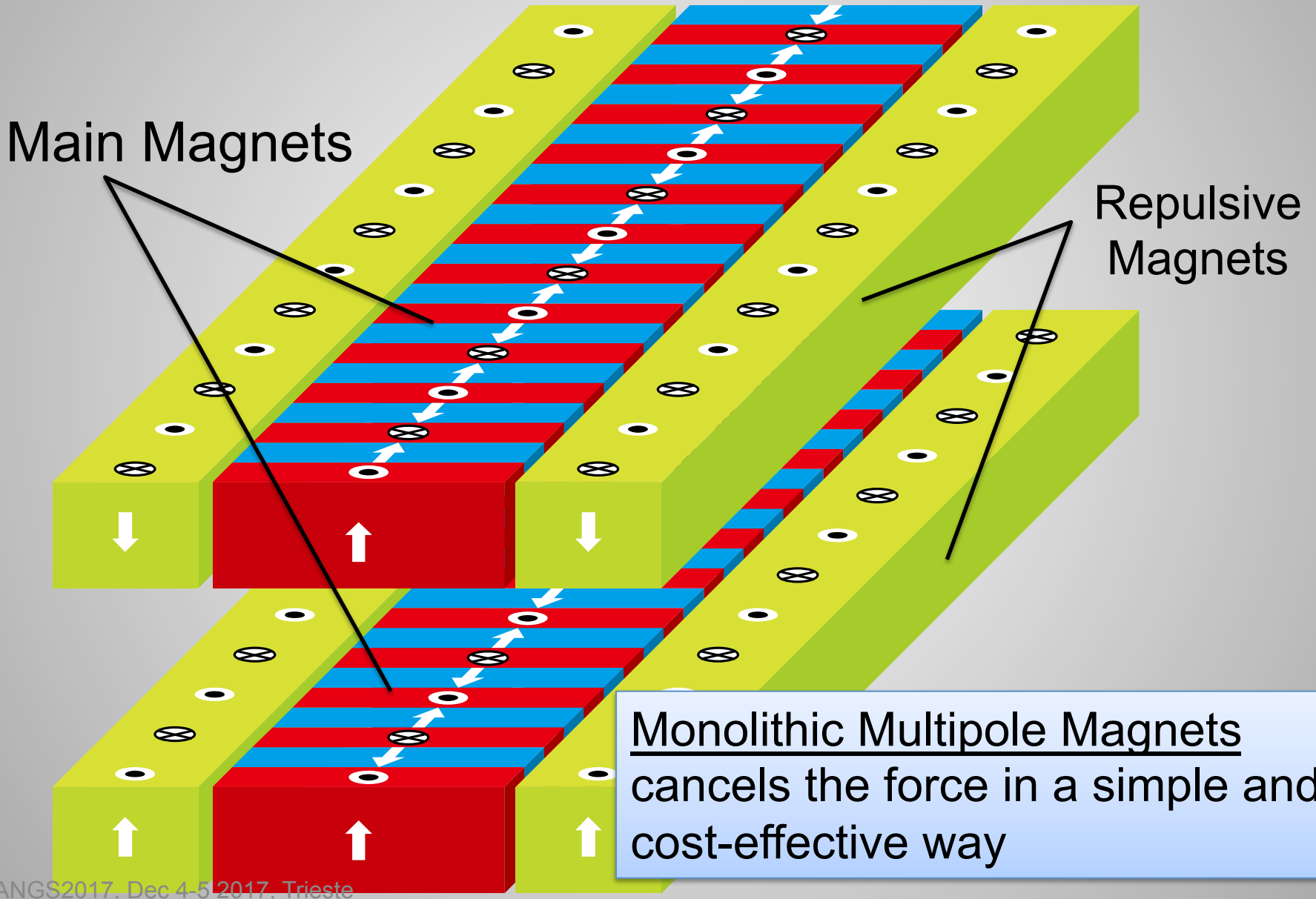
Attractive Force (several tons/m)

Exponential Reaction Makes Things Difficult



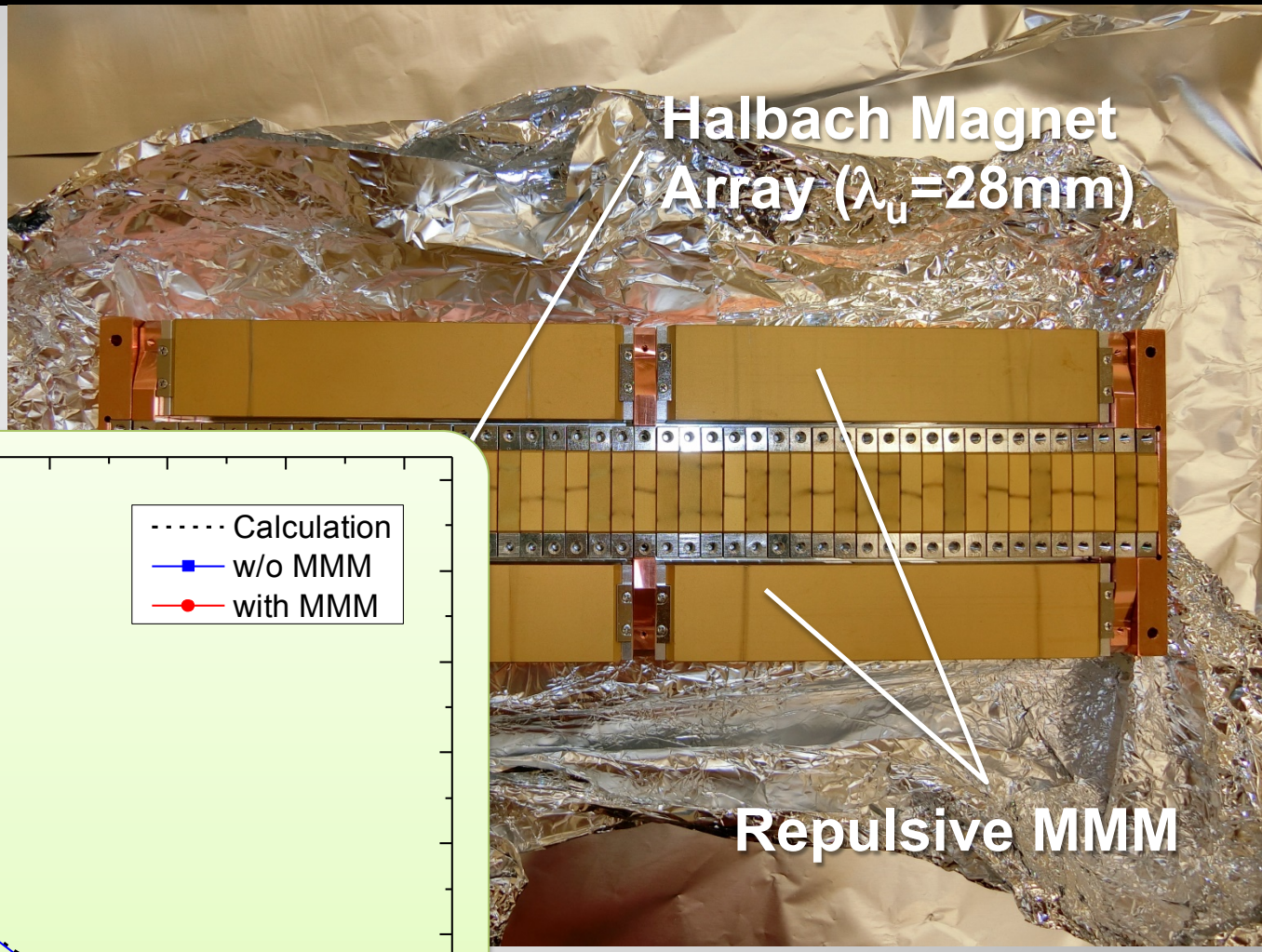


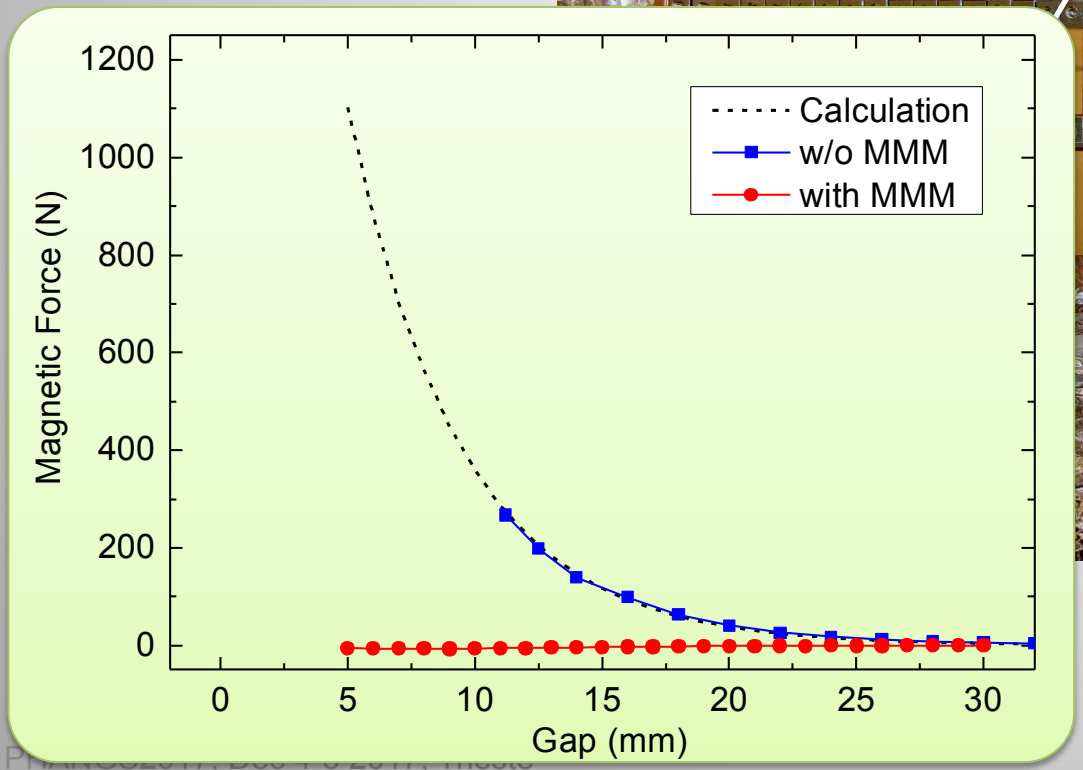
Force Cancellation by MMM



Monolithic Multipole Magnets cancels the force in a simple and cost-effective way

Construction in Progress…

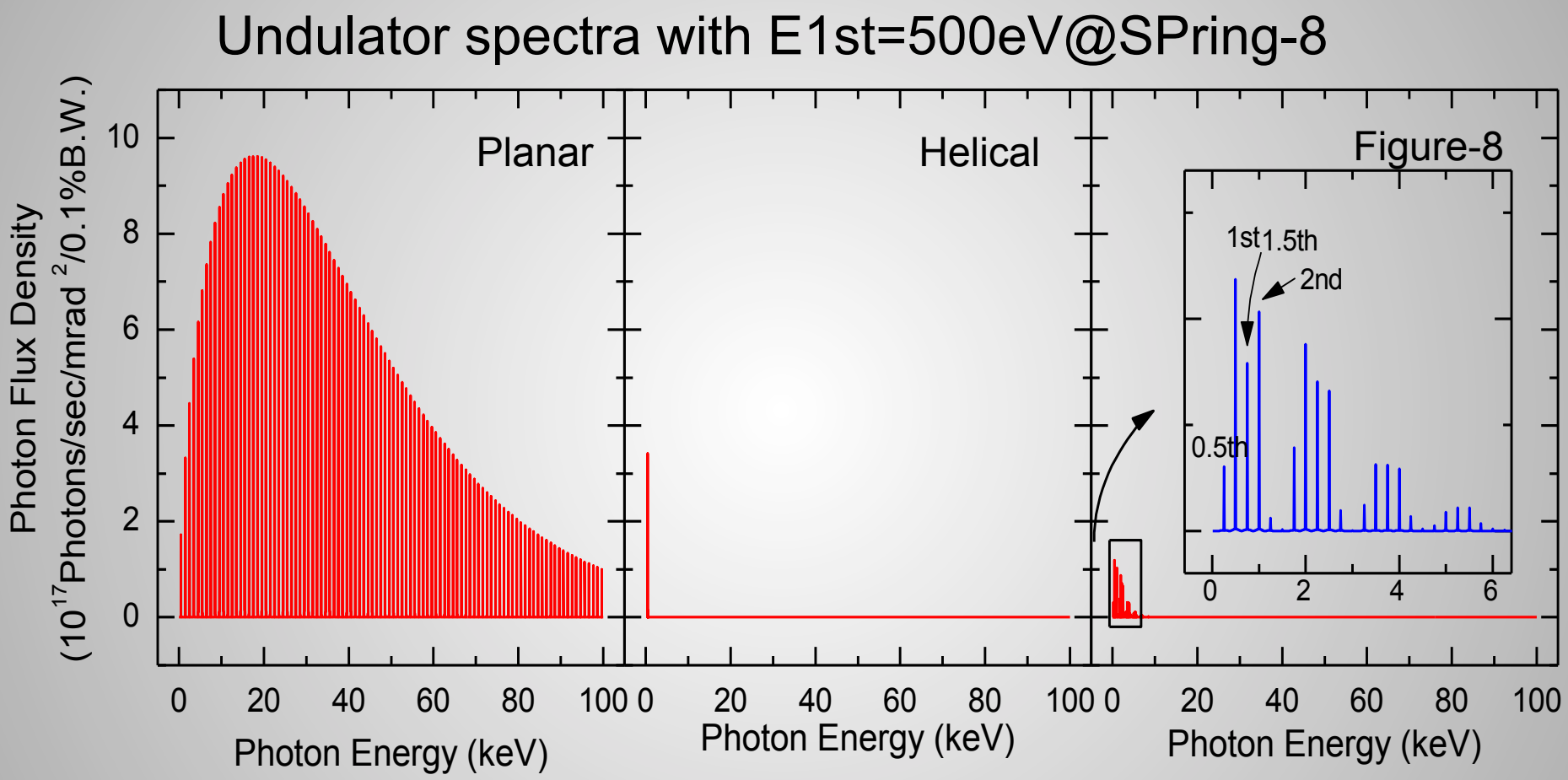




Outline

- Overview of SPring-8-II
- **Undulator R&D Activities**
  - Structural Reform of IVUs
  - **Helical-8 Undulator for Polarization Control**
  - New Scheme for Quick Helicity Switching
- Demagnetization Issues
- Summary

Motivation: SX Undulators in SPring-8



- ✓ High K brings severe heat load by high harmonics
- ✓ F8 undulators exclude the possibility of CPR

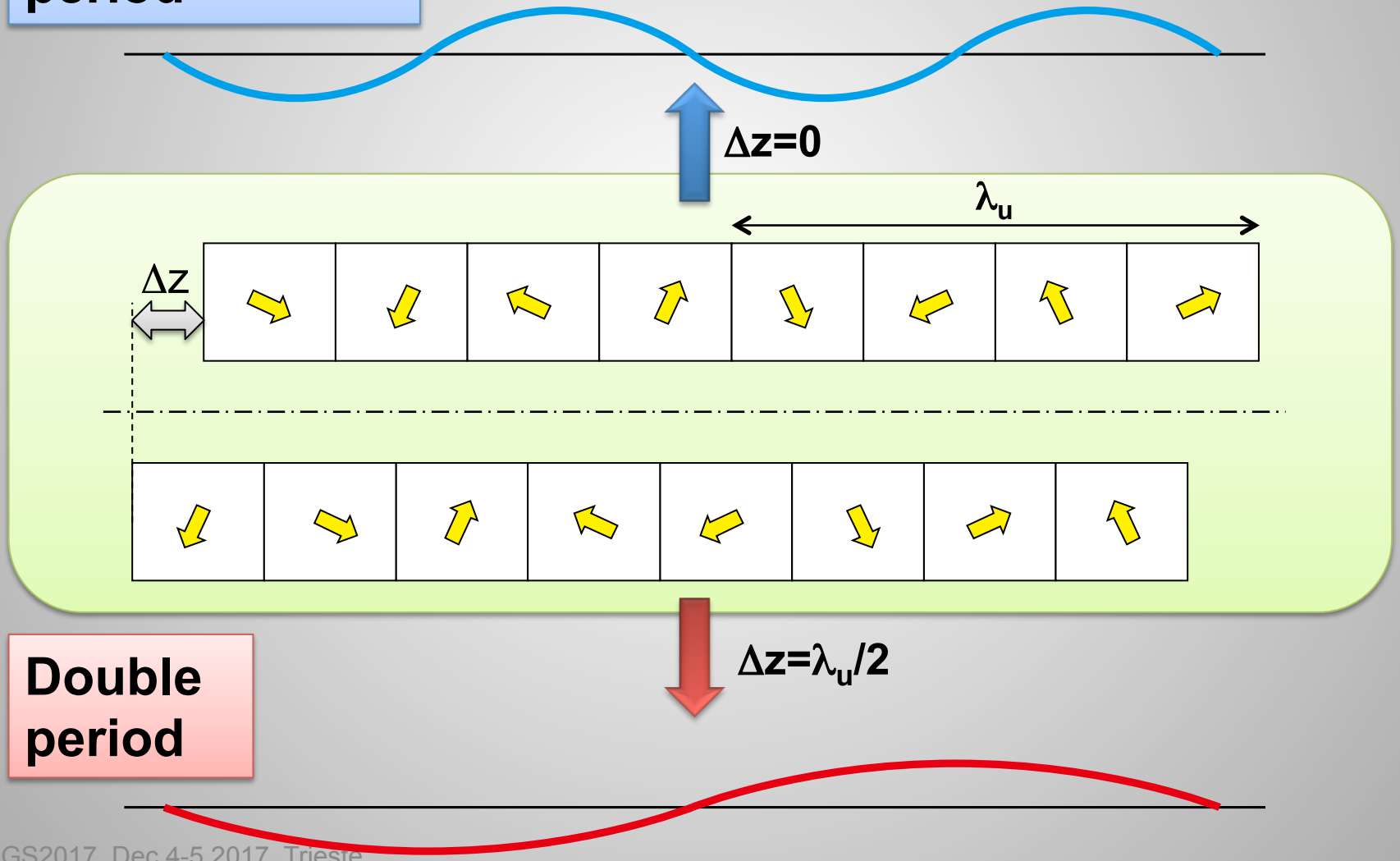
Solution: Helical-8 Undulator

- Based on a Composite-Period Undulator (CPU) concept
- Can be operated in two modes:
  - Helical mode for CPR (L&R)
  - Figure-8 mode for LPR (H&V)
- The mode can be switched by a simple mechanical motion (phasing)

CPU: Composite Period Undulator*

*T. Tanaka and H. Kitamura,
Phys. Rev. ST-AB, 14 (2011) 050701

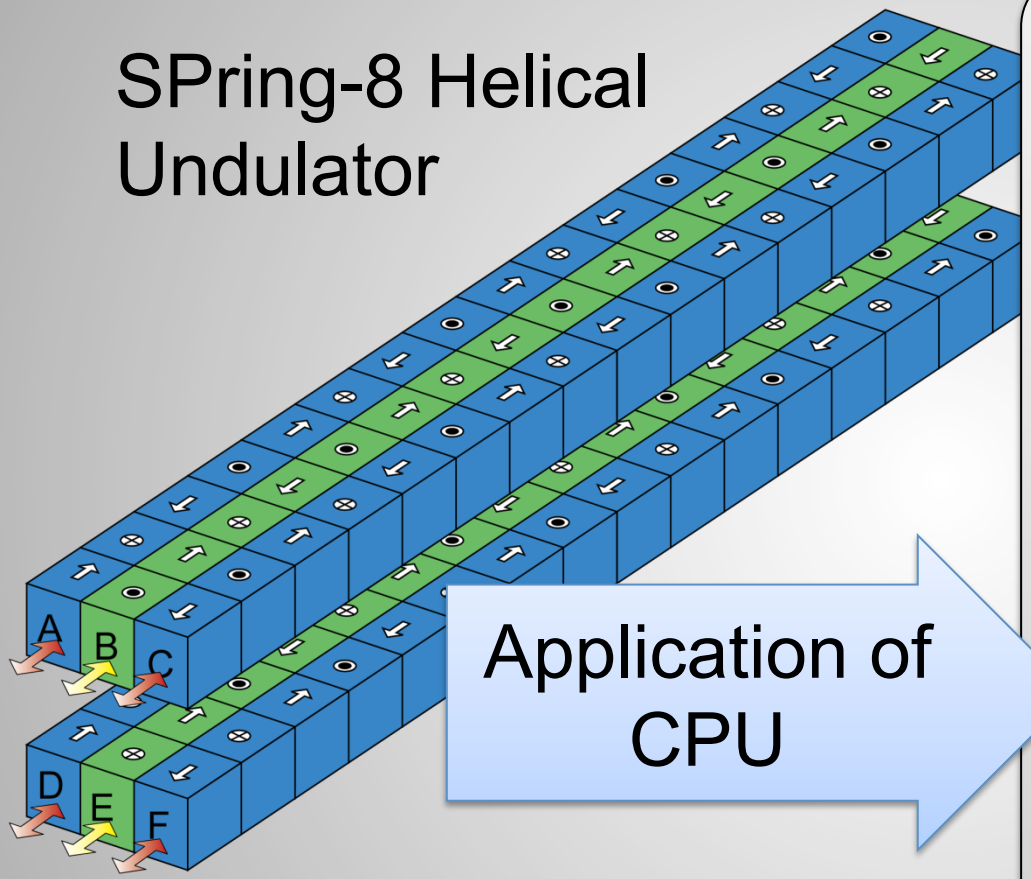
Fundamental period



Double period

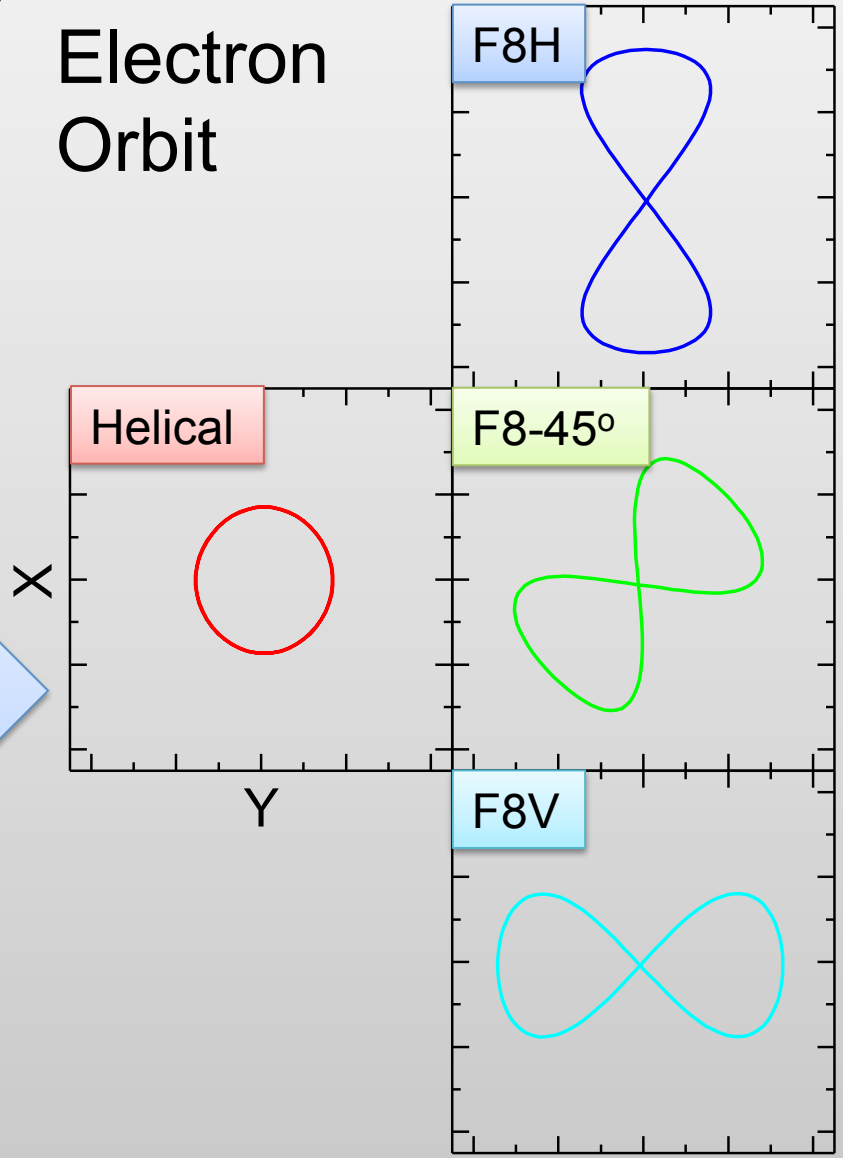
Application to Polarization Control

SPring-8 Helical Undulator



Application of CPU

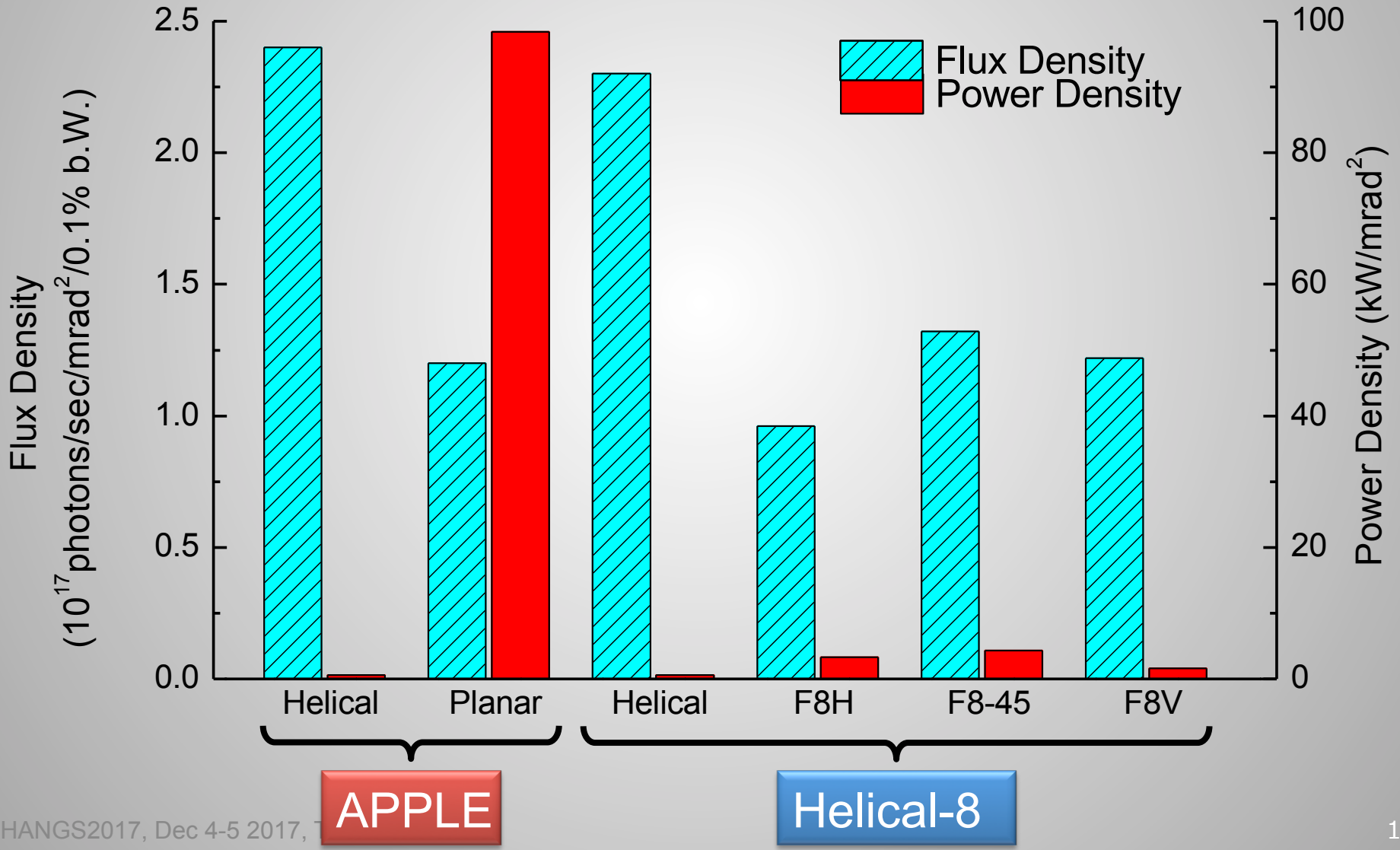
Electron Orbit



*T. Tanaka and H. Kitamura, Nucl. Instrum. Meth., A659 (2011) 537

Comparison with APPLE

Performance Comparison at E1st=500eV@SP8

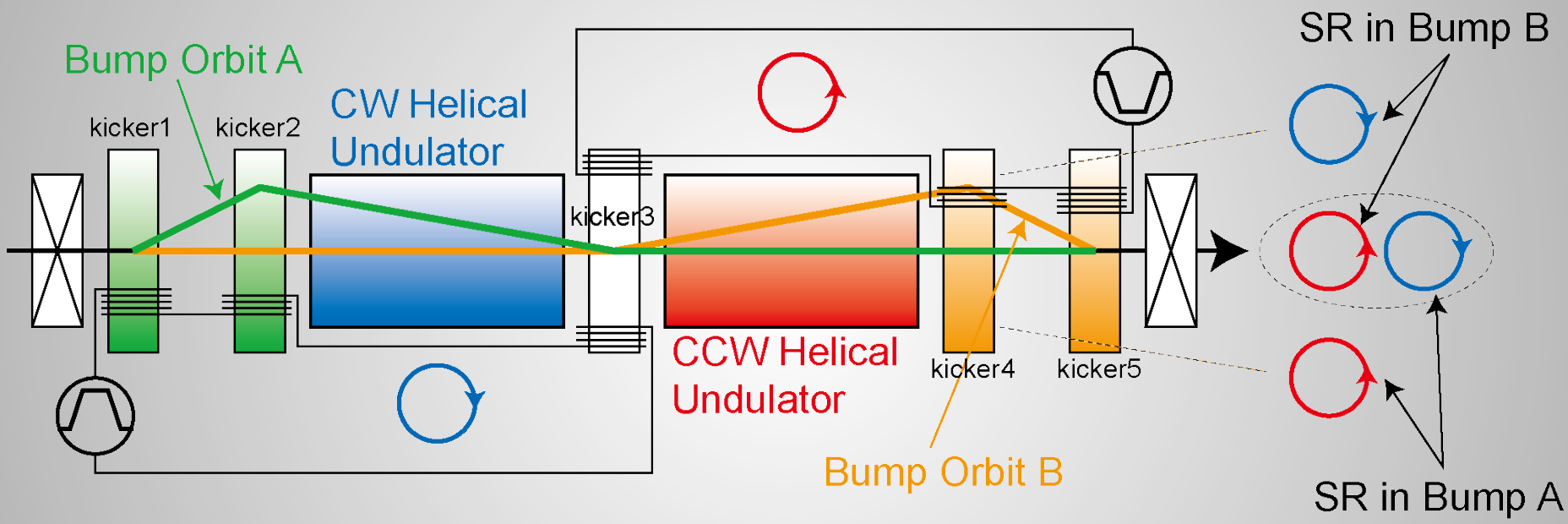


Outline

- Overview of SPring-8-II
- Undulator R&D Activities
  - Structural Reform of IVUs
  - Helical-8 Undulator for Polarization Control
  - **New Scheme for Quick Helicity Switching**
- Demagnetization Issues
- Summary

Background & Motivation

Present System Based on Kicker Magnets in BL23 & 25



The large kick angle (0.1~0.3mrad)

- ✓ limits the switching speed (<10Hz)
- ✓ imposes frequent update of a feedforward correction table

Proposal to Use Spectrum Splitting

CrossMark

research papers

JOURNAL OF SYNCHROTRON RADIATION

ISSN 1600-5775

Spectrum splitting for fast polarization switching of undulator radiation

Ryota Kinjo* and Takashi Tanaka

RIKEN SPring-8 Center, 1-1-1 Kouto, Sayo-cho, Sayo-gun, Hyogo, Japan. *Correspondence e-mail

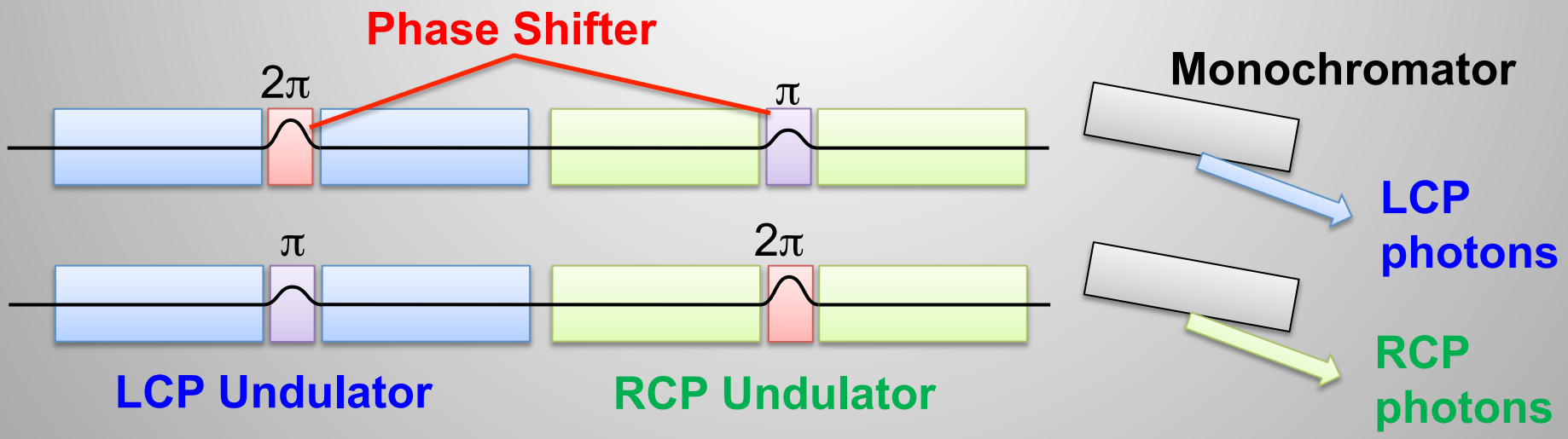
Received 16 February 2016
Accepted 16 March 2016

Edited by J. F. van der Veen

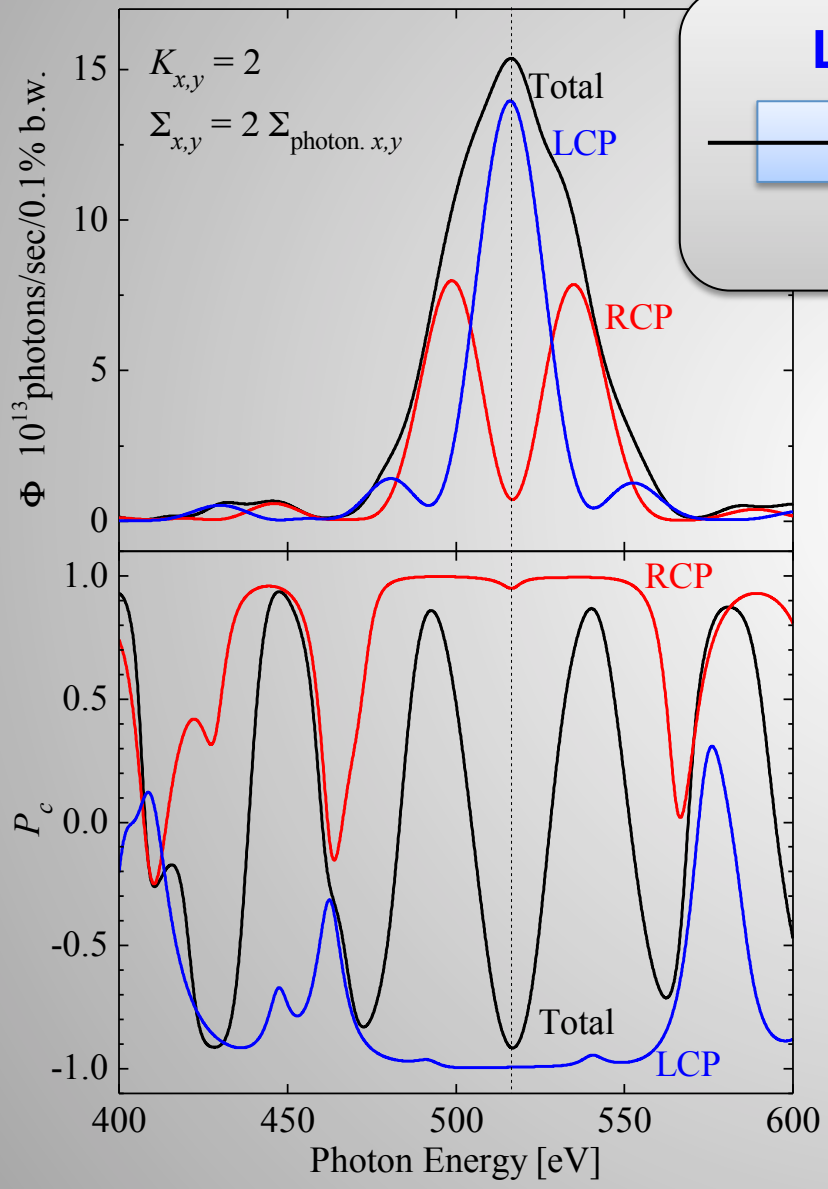
Keywords: undulator radiation; fast polarization switching; spectrum-splitting scheme.

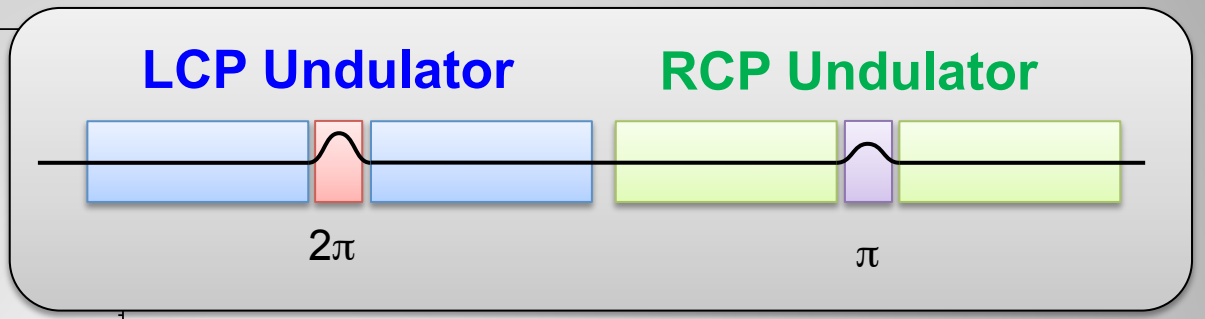
A simple scheme to quickly switch the polarity of circular radiation is pr
which is based on spectrum splitting of undulator radiation. In this sche
helical undulators with opposite helicities are placed tandem in one
section, both of which are divided into several segments. The optical
between segments are tuned so that light waves from one of the two und
are out of phase, while those from the other are in phase. Then the ra
spectrum of the former is split and the intensity at the fundamental
energy vanishes. As a consequence, the monochromated photon bean
fundamental energy is circularly polarized with the helicity specified
in-phase undulator, which can be quickly flipped by tuning the optica
Numerical calculations carried out to demonstrate the feasibility
proposed scheme show that a relatively high degree of circular polarization is
expected if the angular acceptance of the beamline is not too large.

Spectral separation of LCP & RCP photons instead of spatial separation



Numerical Examples





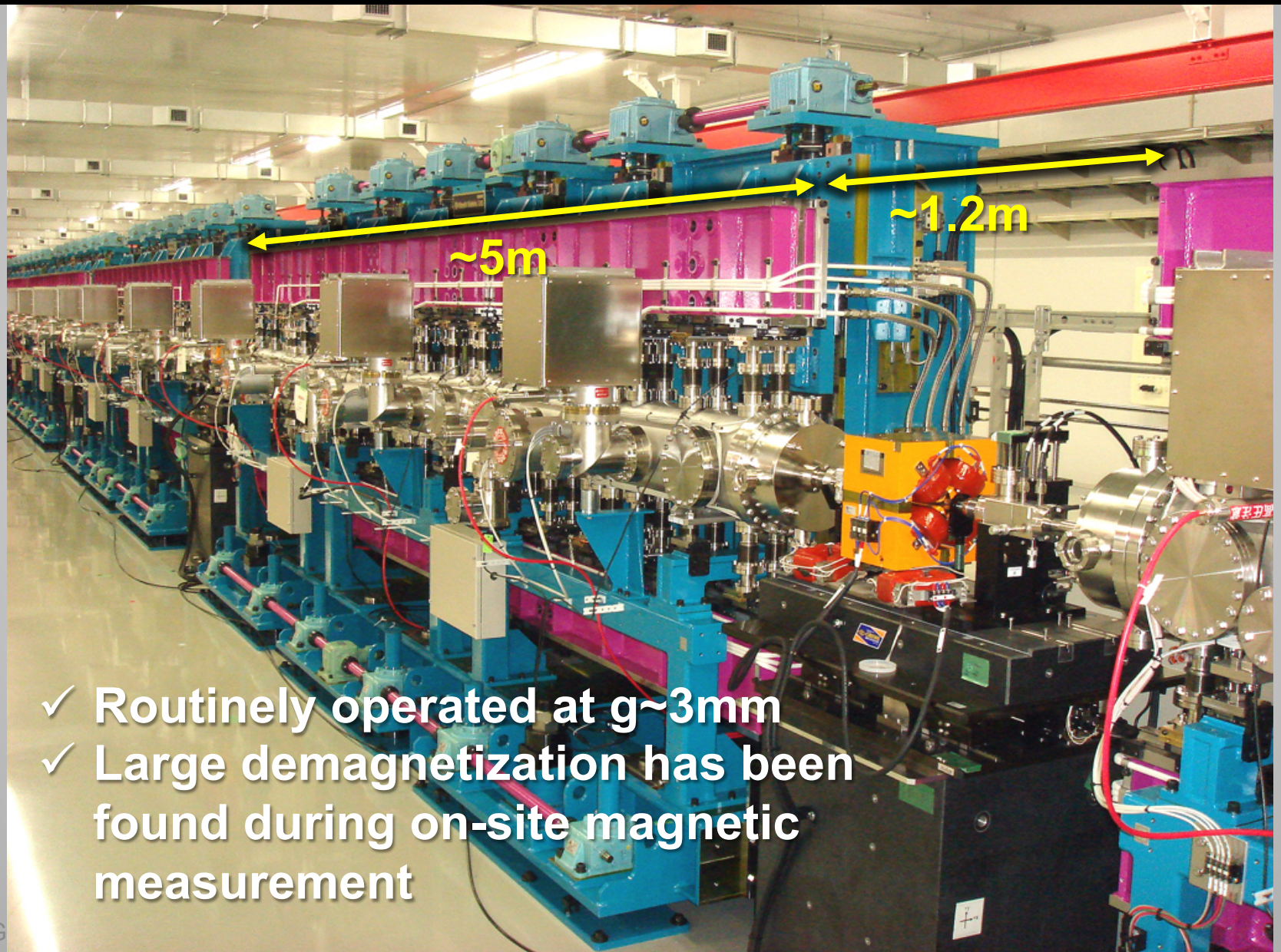
Advantages Against the Kicker System

- ✓Much smaller bump orbit: much less COD & much faster speed
- ✓Can be more compact

Outline

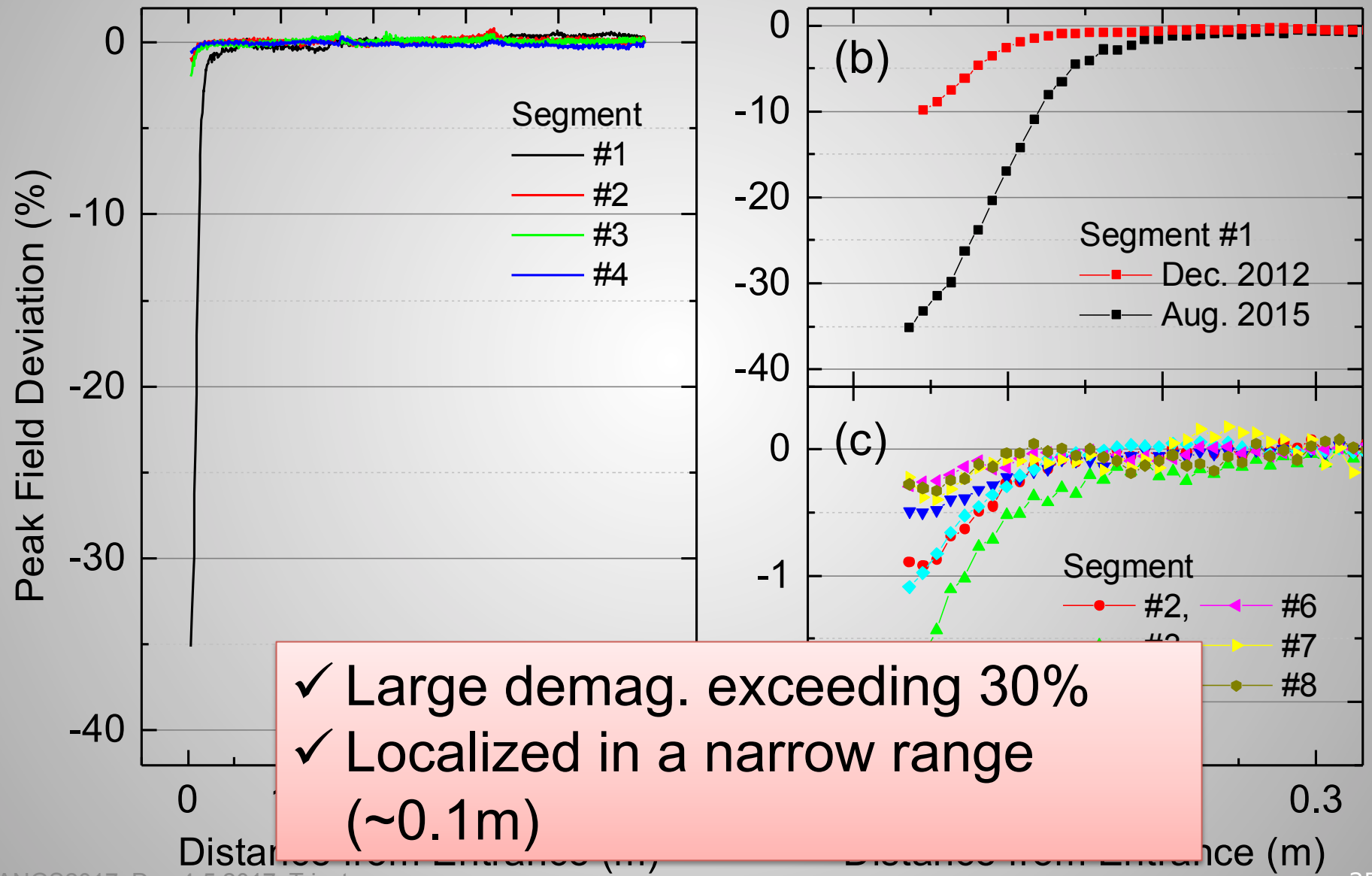
- Overview of SPring-8-II
- Undulator R&D Activities
  - Structural Reform of IVUs
  - Helical-8 Undulator for Polarization Control
  - New Scheme for Quick Helicity Switching
- **Demagnetization Issues**
- Summary

SACLA IVUs



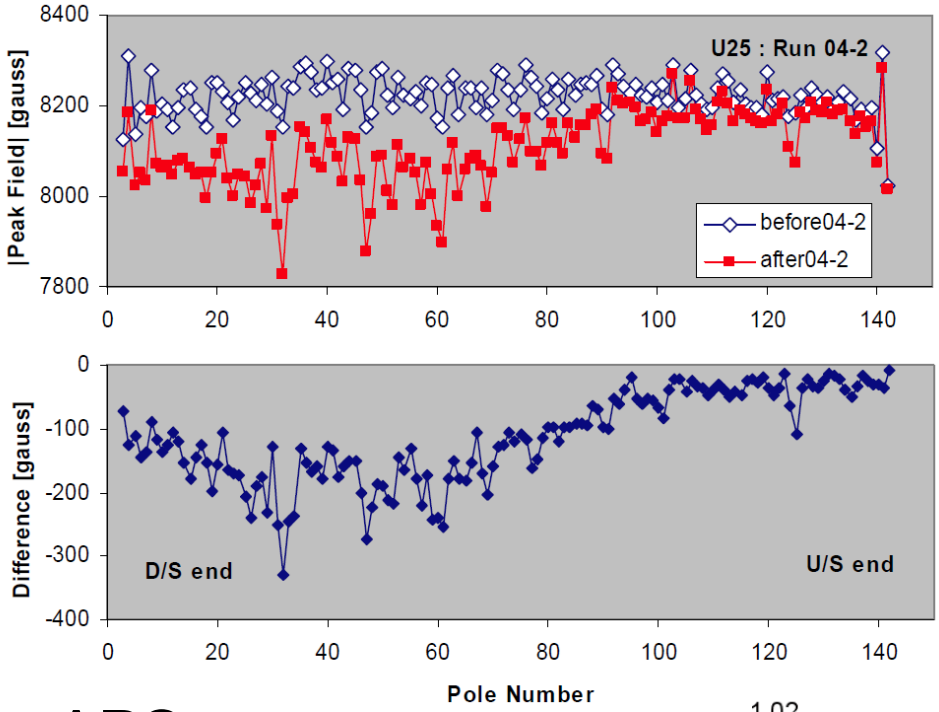
- ✓ Routinely operated at g~3mm
- ✓ Large demagnetization has been found during on-site magnetic measurement

Demagnetization Profiles

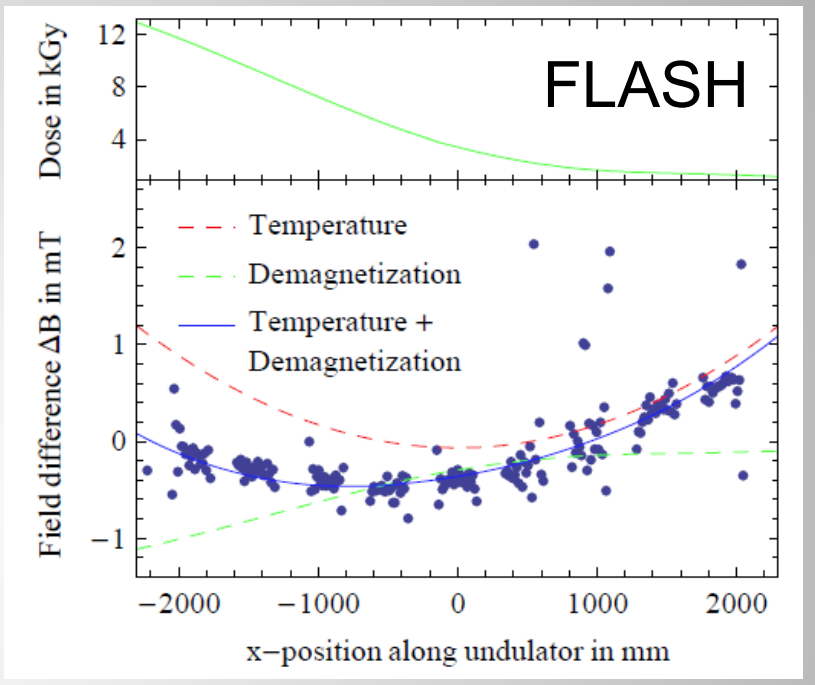


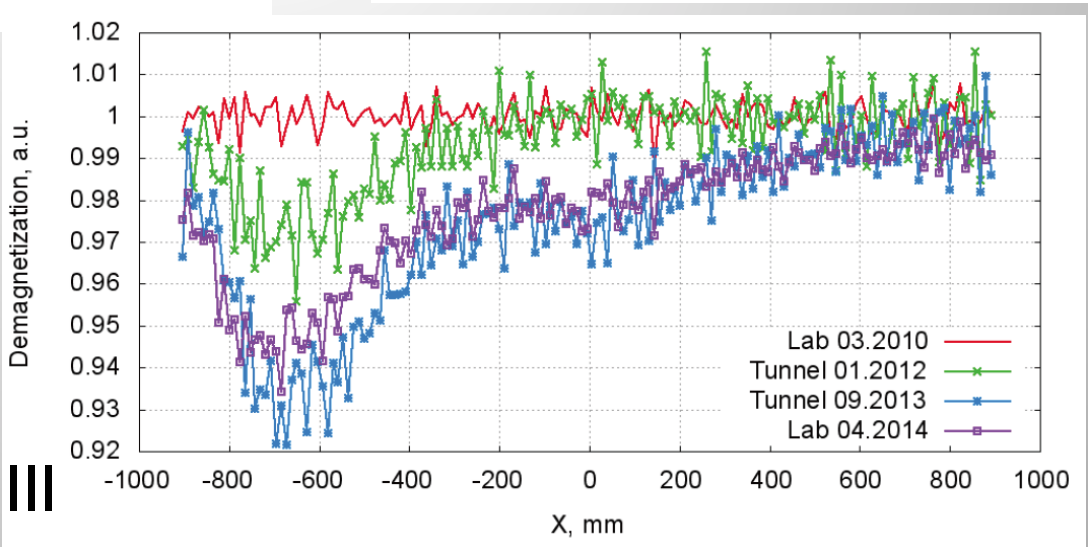
- ✓ Large demag. exceeding 30%
- ✓ Localized in a narrow range (~0.1m)

Results from Other Facilities



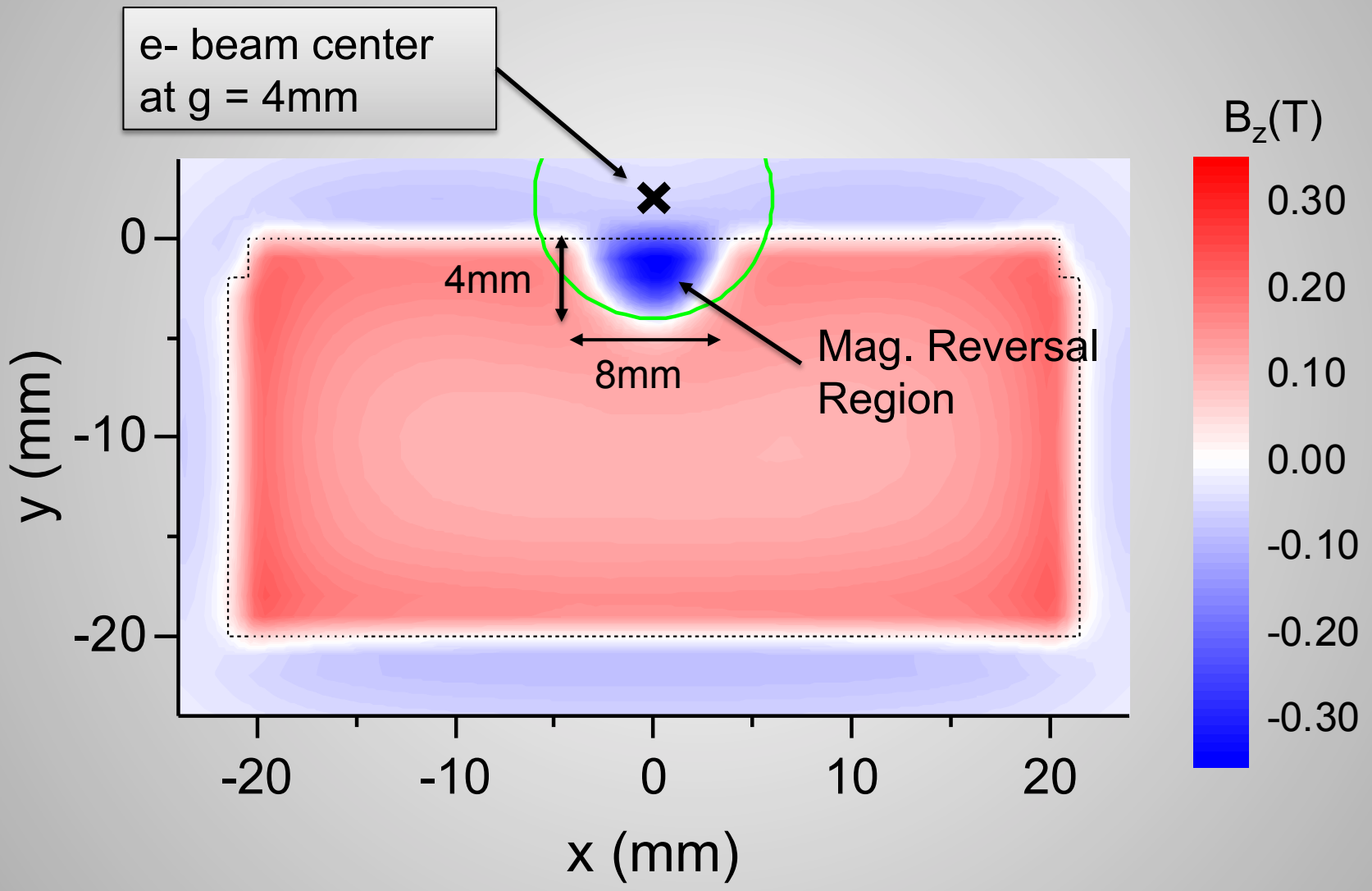
APS



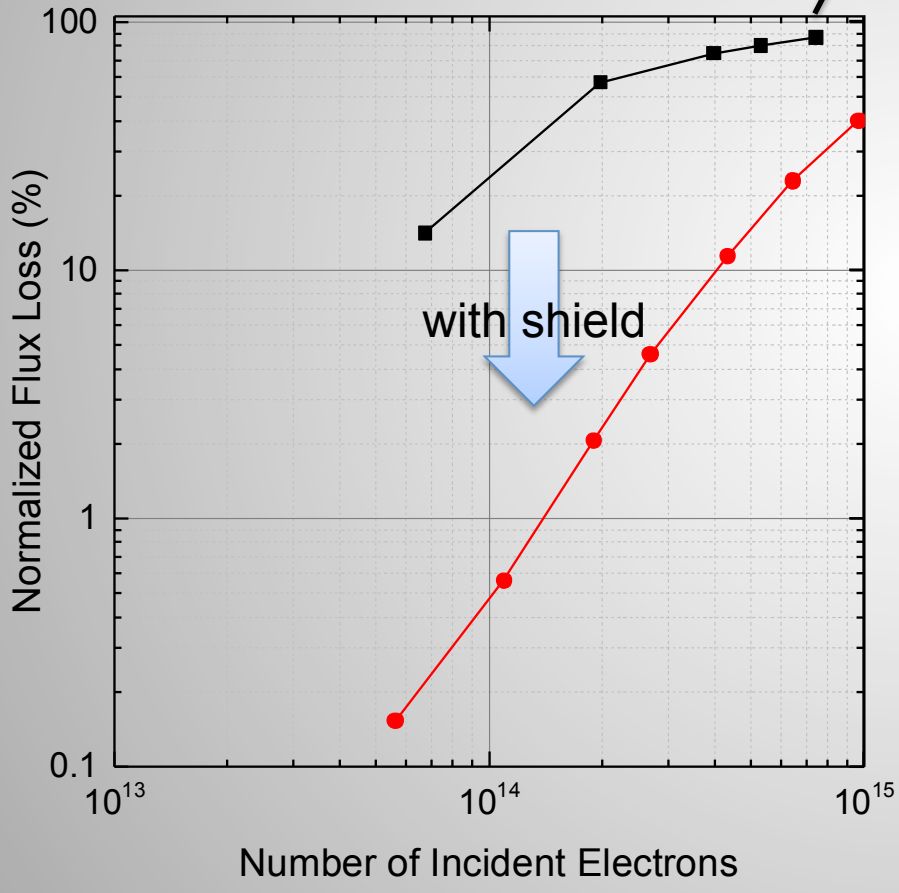


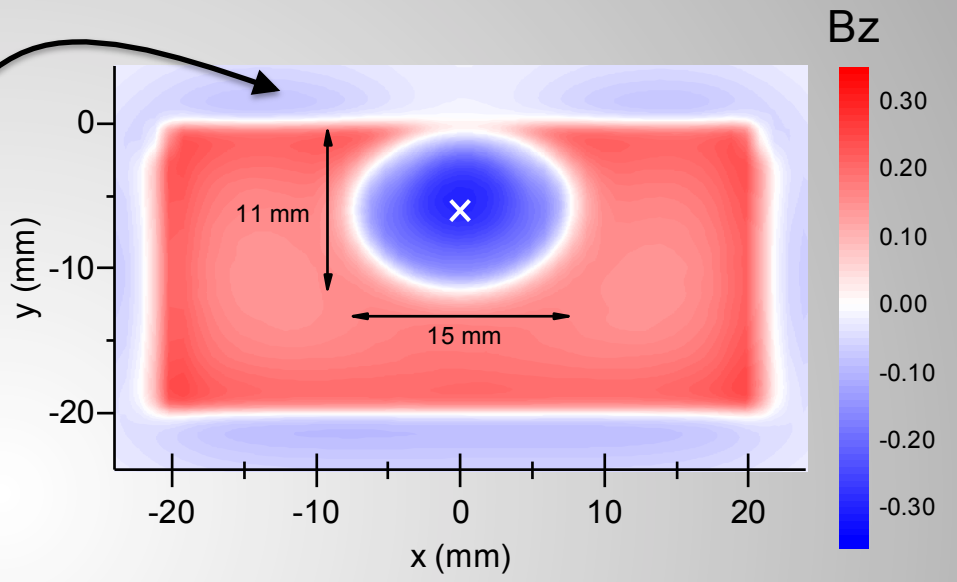
PETRA III

Surface Mapping of Demag. PM



Experiment in SP-8 Booster Sy.





- ✓ Mag. array with the same specs. but 1.5-period long, irradiated in the booster
- ✓ SUS shield (L=0.1m) can effectively protect PMs

Discussions

- Demag. rate found in SACLA-IVUs is much larger (~2 orders) than the former experiences
  - "Radiation-induced magnetization reversal" occurred in a macroscopic range
- Localized near entrance
  - Performance reduction is negligibly small
- Simple SUS shield works fine
  - Already installed in SACLA IVU (BL3#1)
  - More effective collimator to be installed

Summary

- R&D activities toward SPring-8-II in progress
  - Development of new IVU, polarization control system etc.…
  - Demagnetization due to (ultra) narrow gap operation of IVUs

Thank you for attention