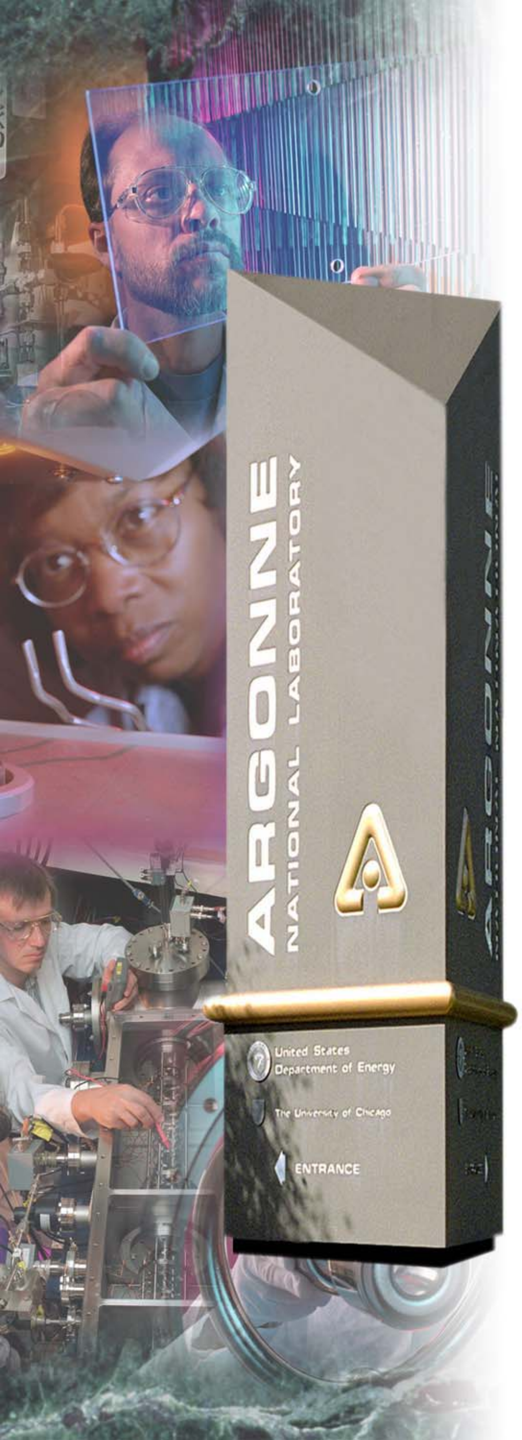

Insertion Device Research and Development

Liz Moog

The University of Chicago Review
for the Advanced Photon Source
at Argonne National Laboratory

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U.S. Department of Energy

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Office of Science Laboratory
Operated by The University of Chicago

Introduction

The properties of a user's insertion device determine characteristics of the x-ray beam, such as:

- **Range of x-ray wavelengths produced**
- **Brilliance**
- **Power (heat load)**
- **Harmonic content**
- **Polarization**

An appropriately-chosen insertion device that is working as designed is critical to the effectiveness of a beamline!

Outline

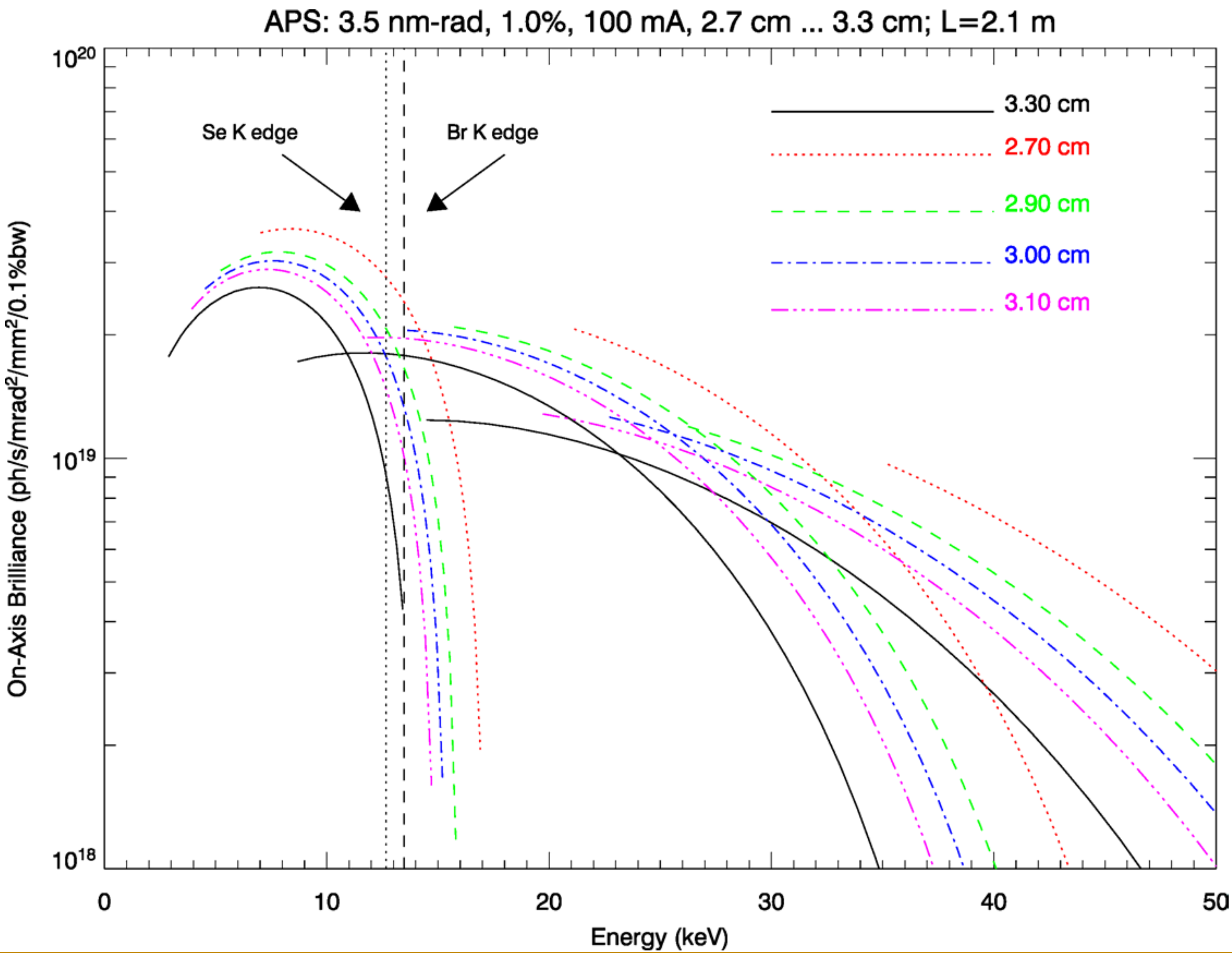
- **Planar Insertion Devices**
  - New period lengths
  - Superconducting undulator
  - Variable Period undulator
- **Circular and variable polarizing undulators**
- **Other sector and front-end improvements**
- **Radiation damage to ID magnets**

IDs Installed as of June 2003

Type	Number	Length (periods)	K_{eff}
33-mm undulator	23	72	2.75
33-mm undulator	2	62	2.75
55-mm undulator	1	43	6.57
27-mm undulator	1	88	1.70; 2.18¥
27-mm undulator	1	72.5	1.36; 1.80¥
18-mm undulator	1	198	0.455
Elliptical wiggler (16 cm)	1	18	K_y=14.7† K_xŠ1.4
Circularly polarized undulator (12.8 cm)	1	16**	K_yŠ2.86 K_xŠ2.75

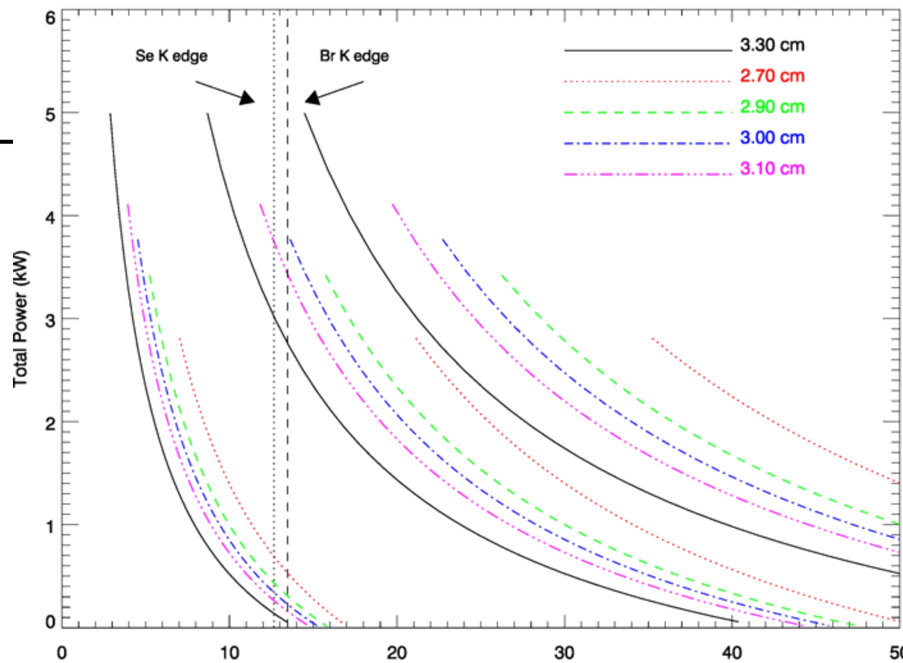
Device length includes the ends - approx. one period at each end is less than full field strength.
K value is at 10.5 mm gap unless stated otherwise. (CPU and horizontal elliptical wiggler field are electromagnetic, with different fixed gaps.)
† at 24 mm gap (the device minimum). Values are for peak K, not K_{eff}
¥ at 8.5 mm gap.
** In addition to this, there are separate correctors at both ends.

Tuning Curves for Different Period Lengths

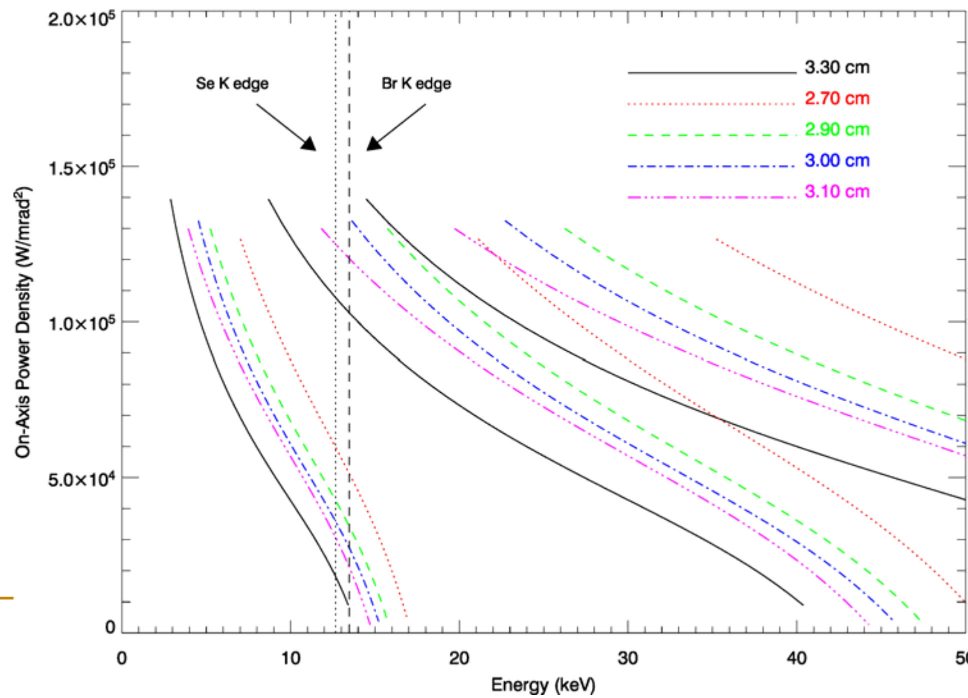


Power vs. Photon Energy for Different Period Lengths

Total Power

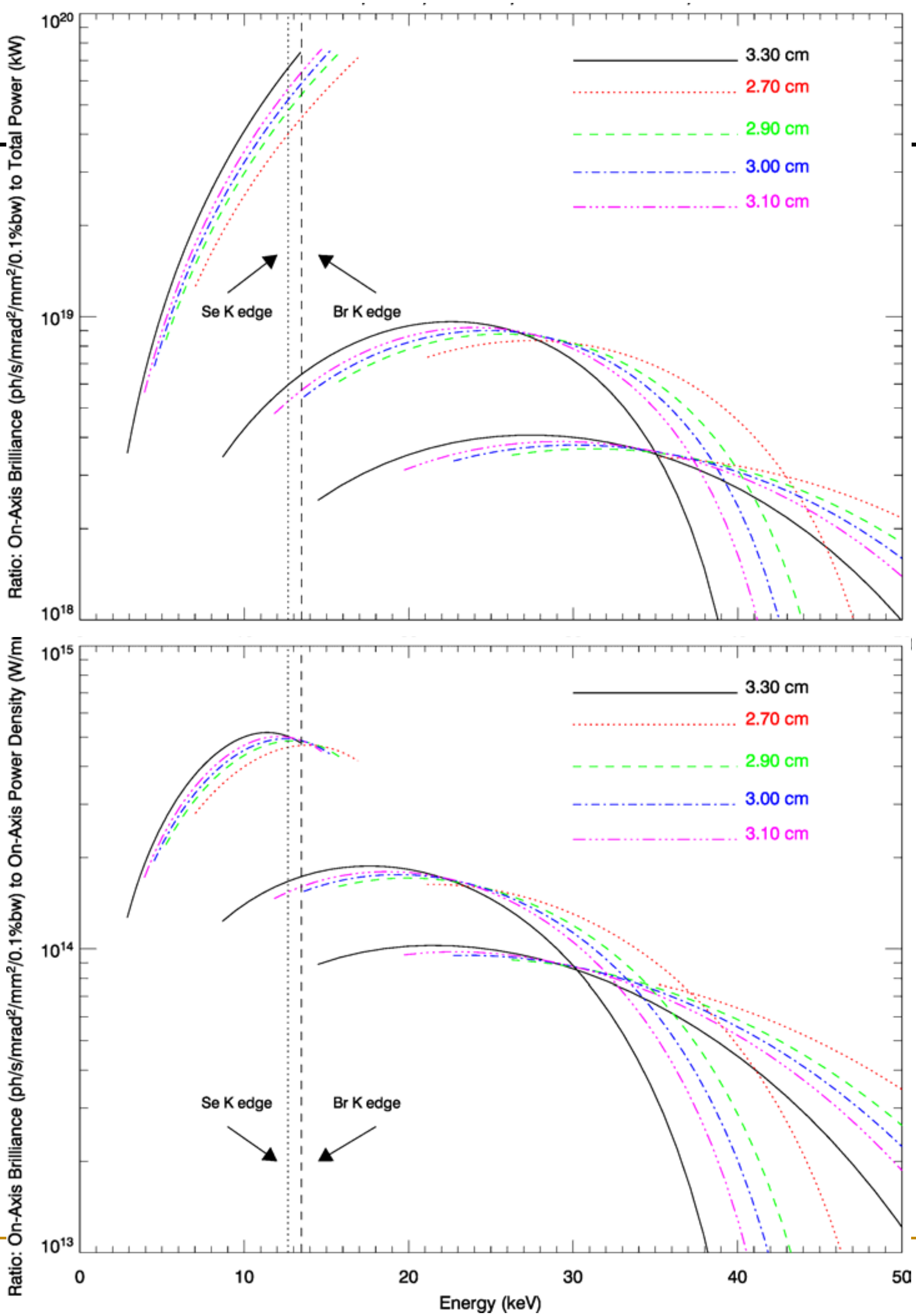


On-axis Power Density



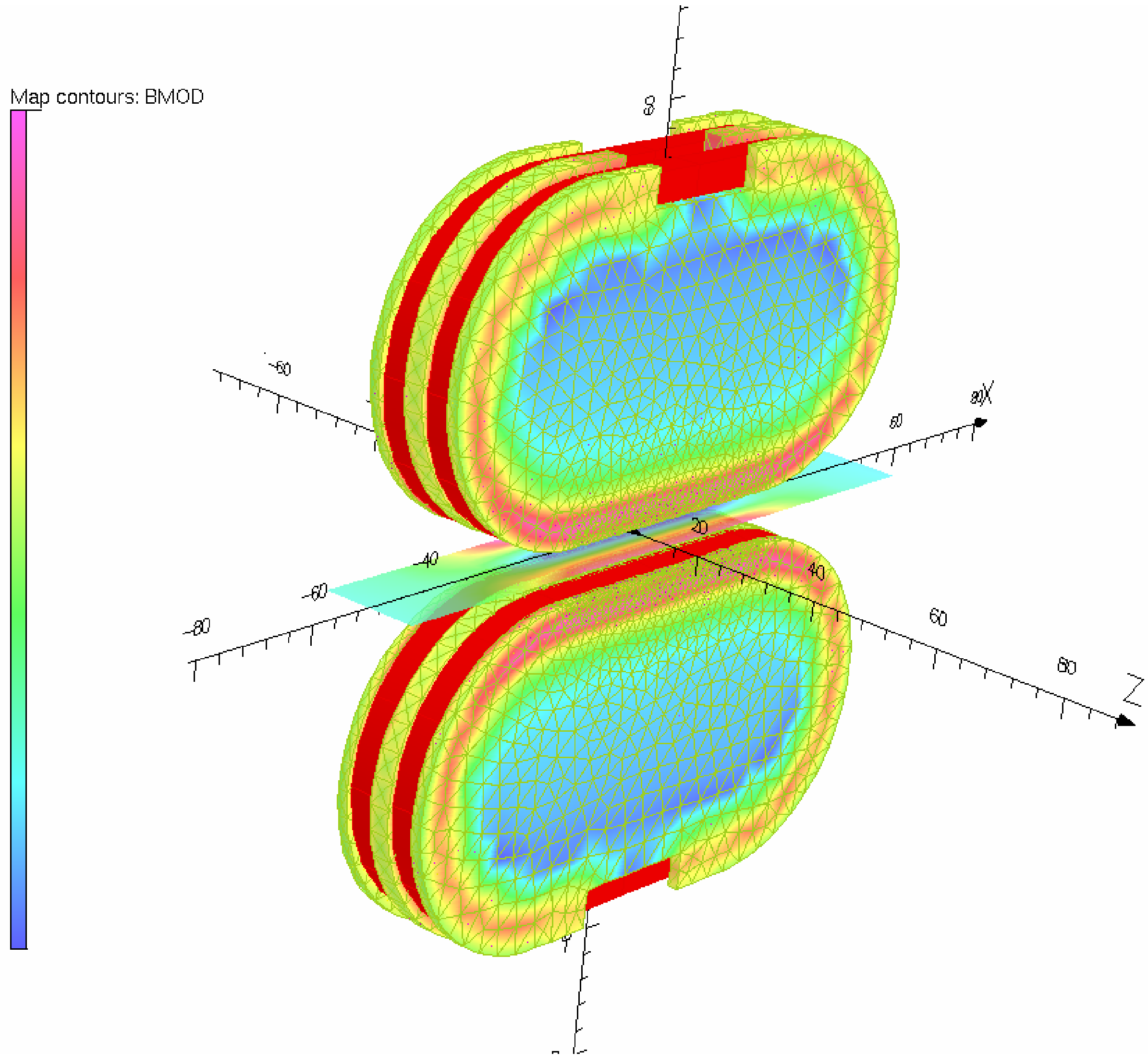
<u>Brilliance</u>
Total Power

<u>Brilliance</u>
Power Density

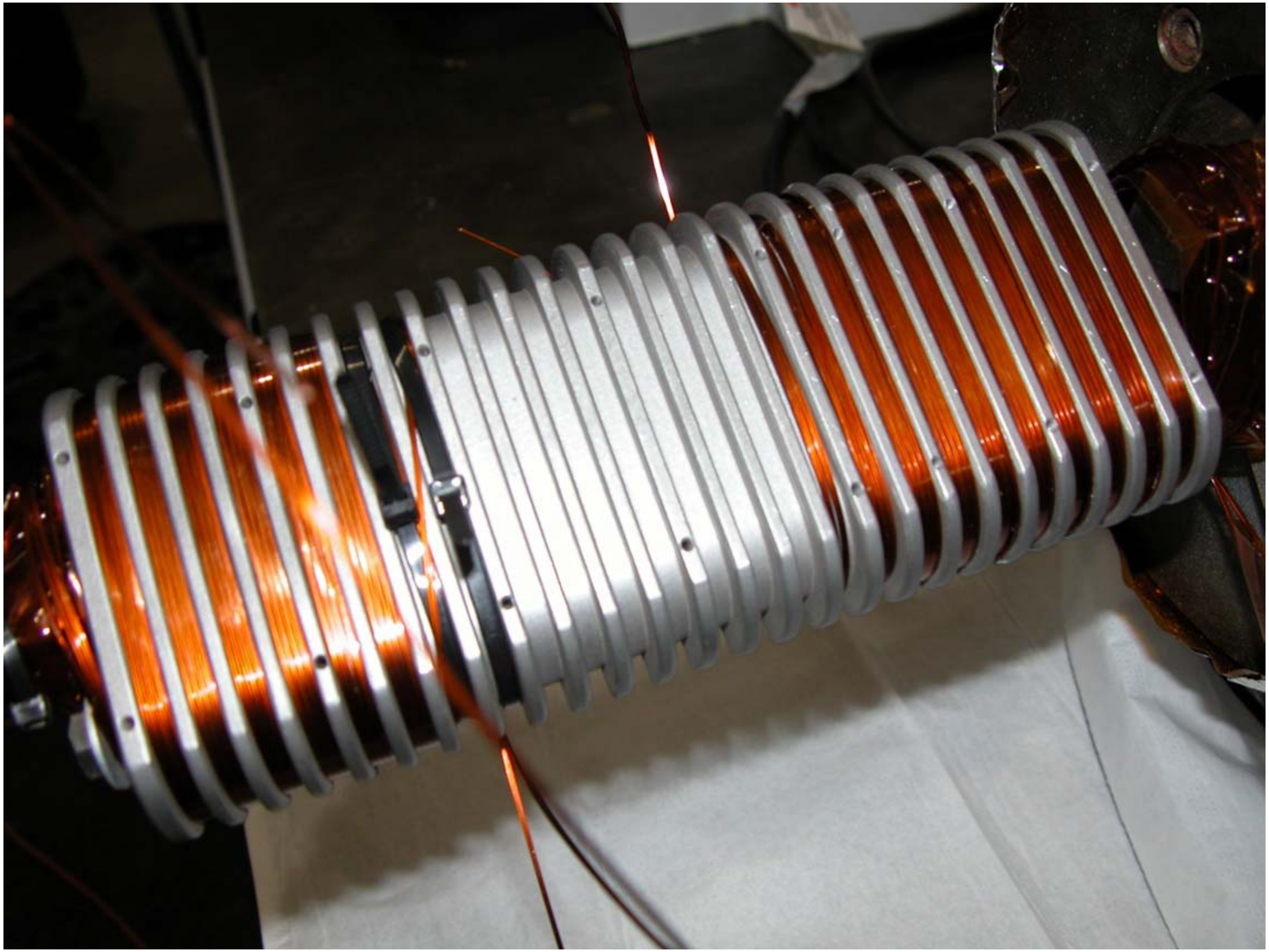


Ratio of Brilliance to Power for Different Period Lengths

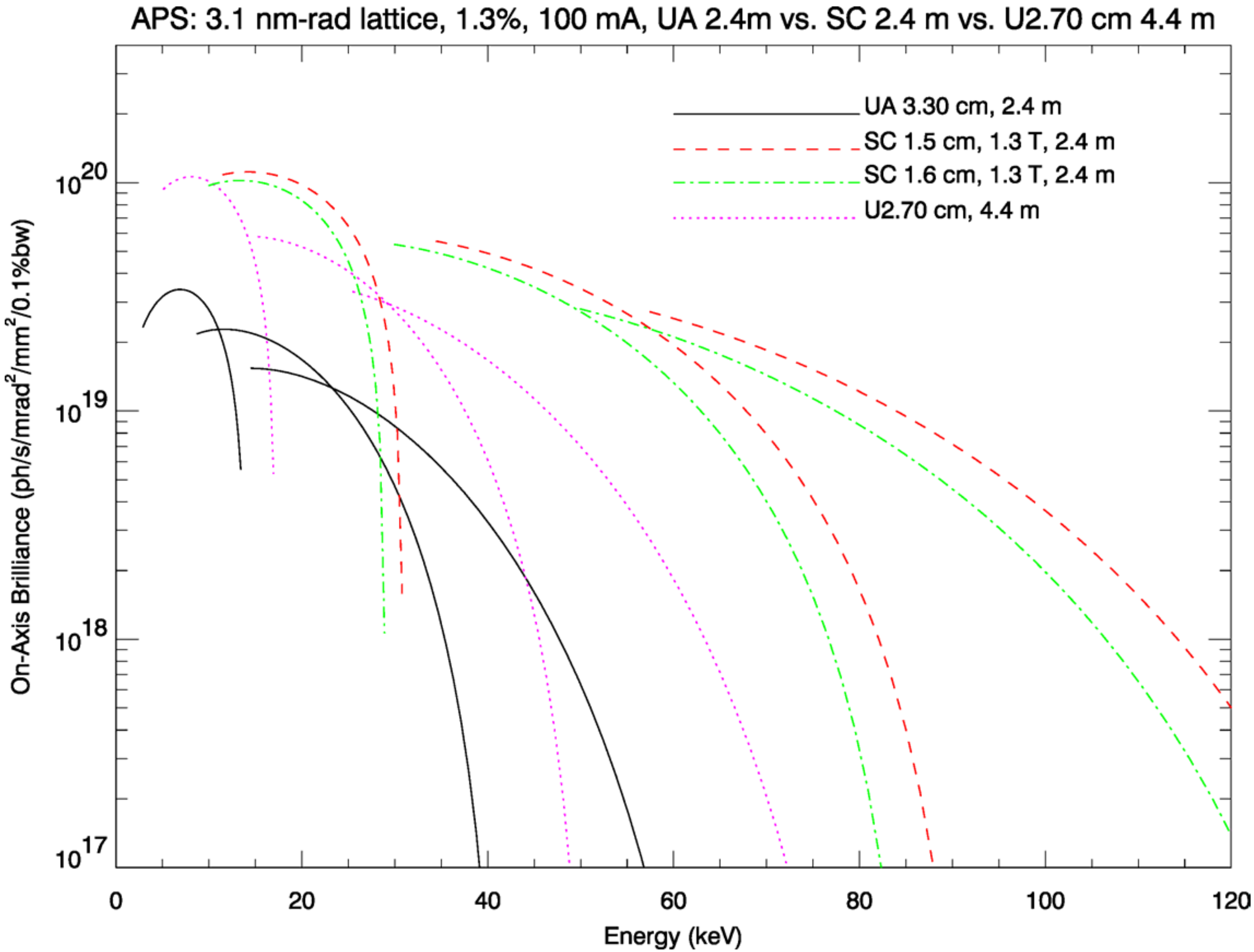
Model for Superconducting Undulator



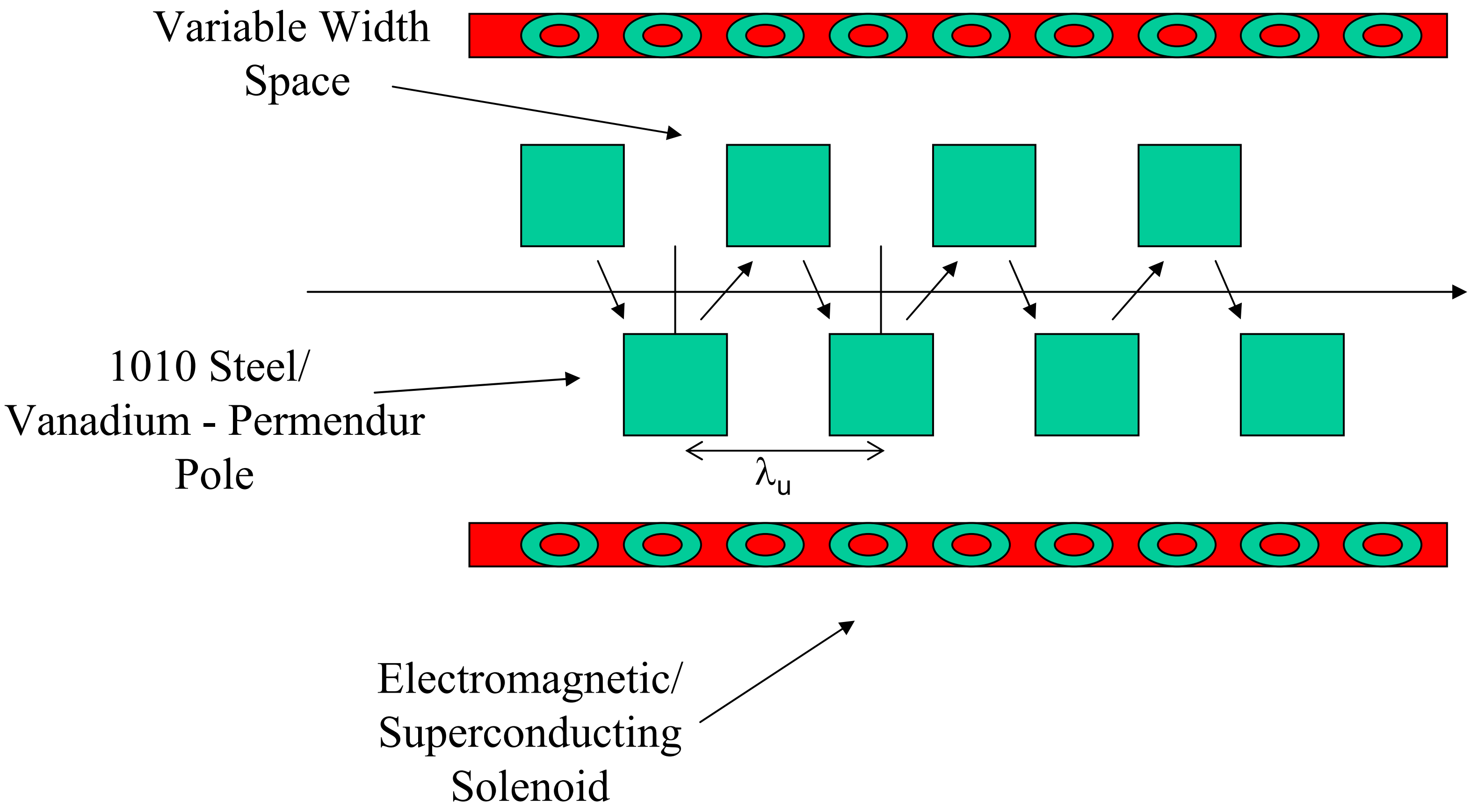
Test Piece for Superconducting Undulator



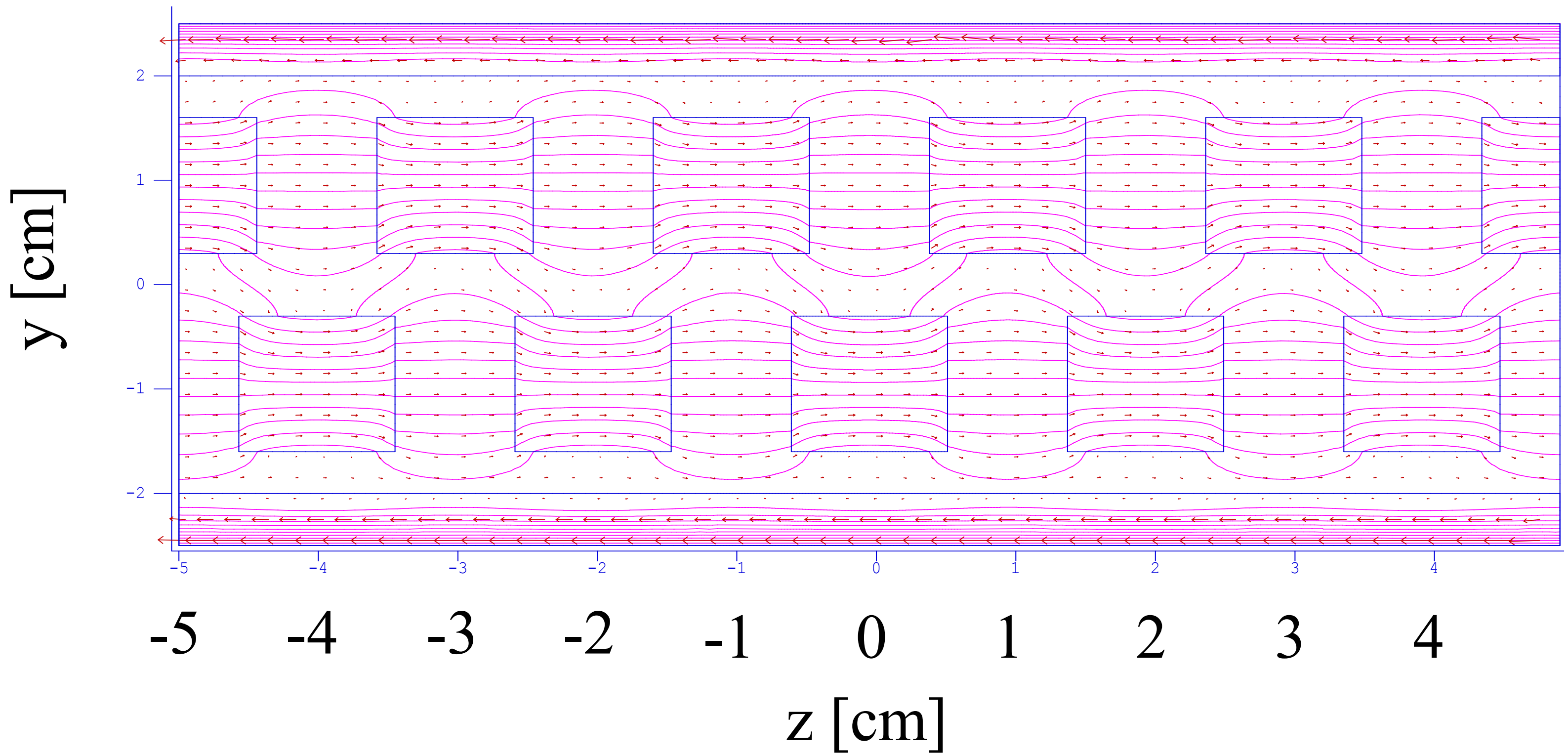
Tuning Curves Show Benefit of Superconducting Undulator for 20-25 keV



Schematic of Poles and Solenoid for Variable Period Undulator

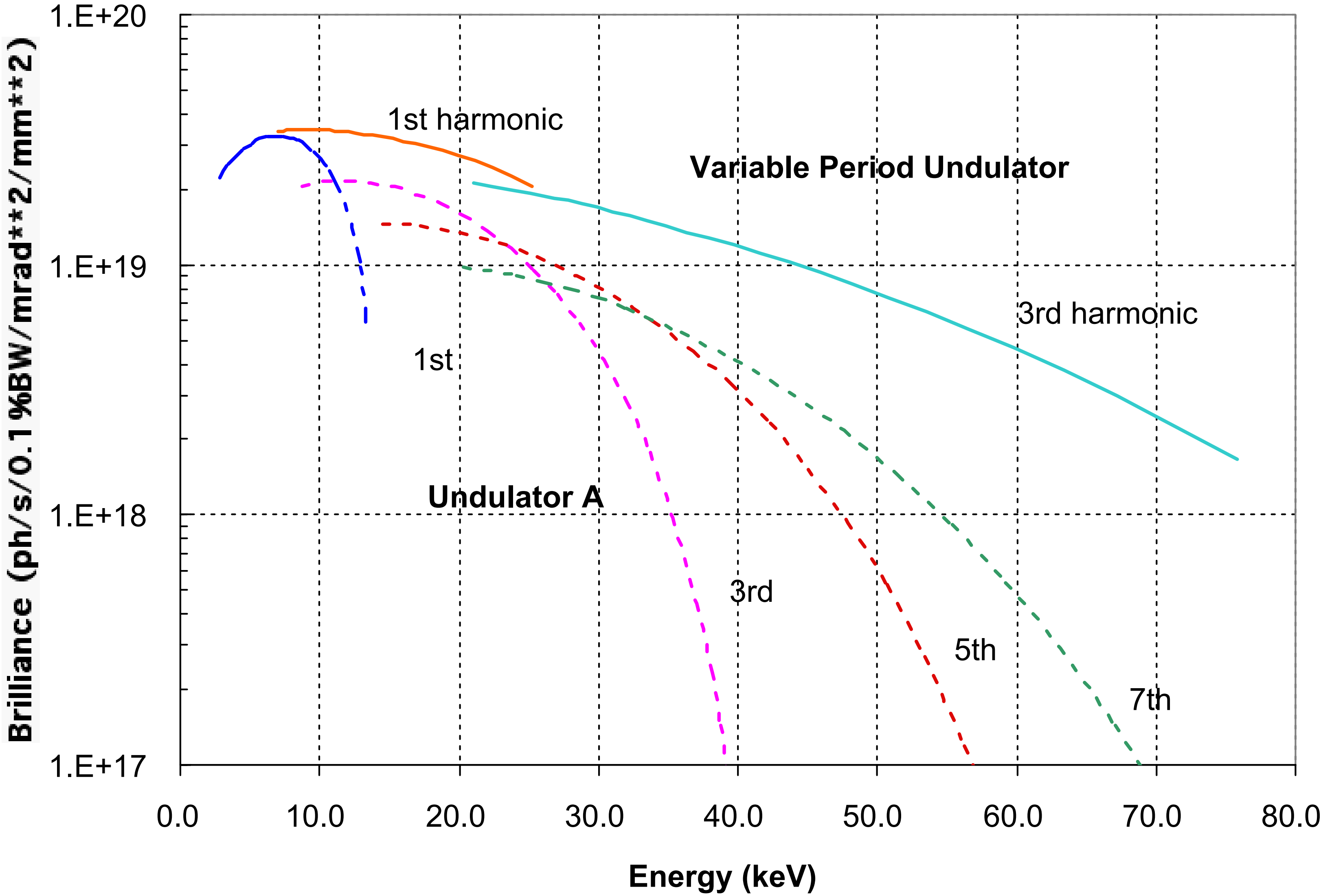


Magnetic Field Map Calculation

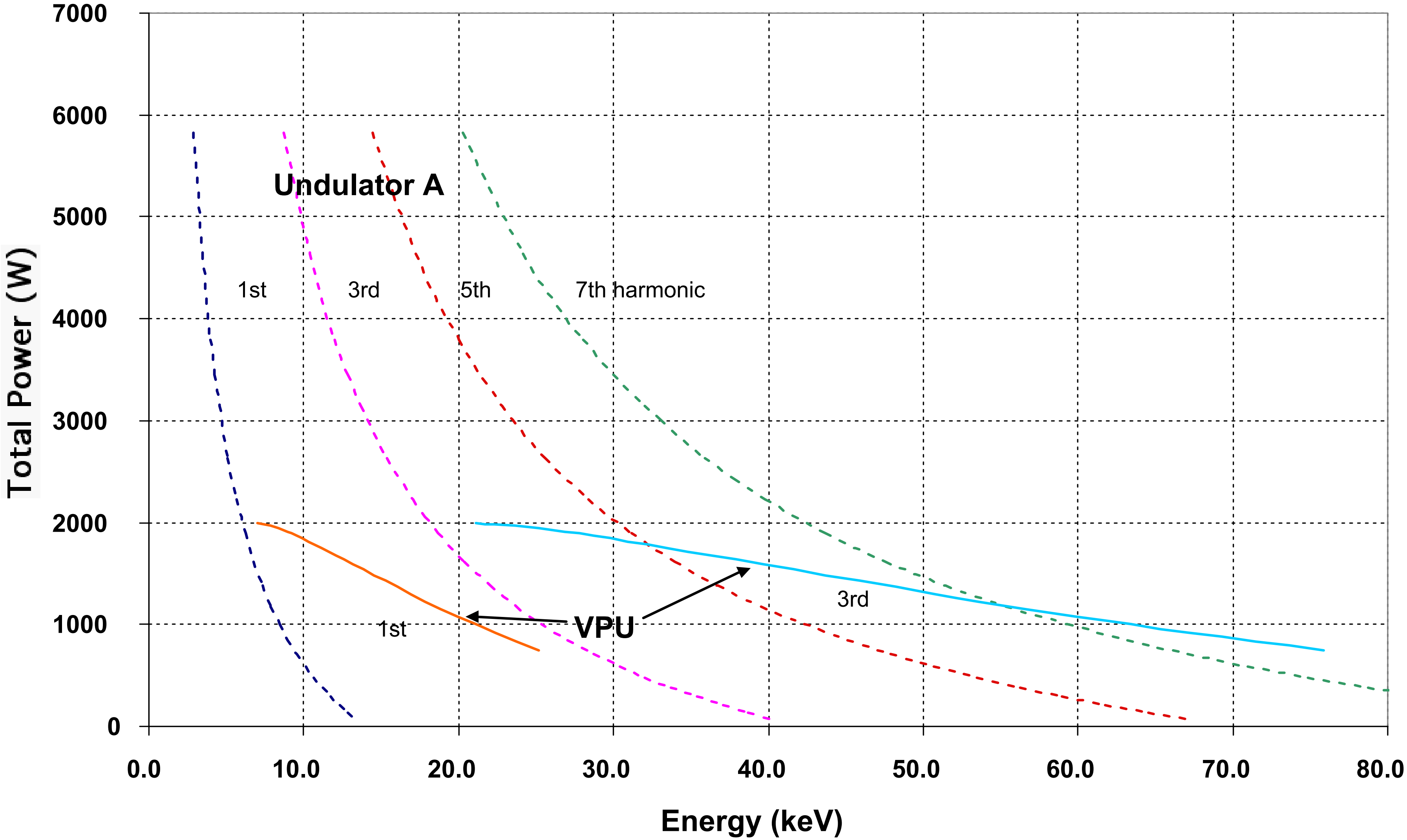


period=2cm, pole width=1.13cm, gap=0.6cm

Tuning Curve Compared to Standard Undulator



Variable Period Undulator - Power



Circularly Polarized Undulator

Shown in cross-section.

•12.8 cm period

•500-3000 eV output

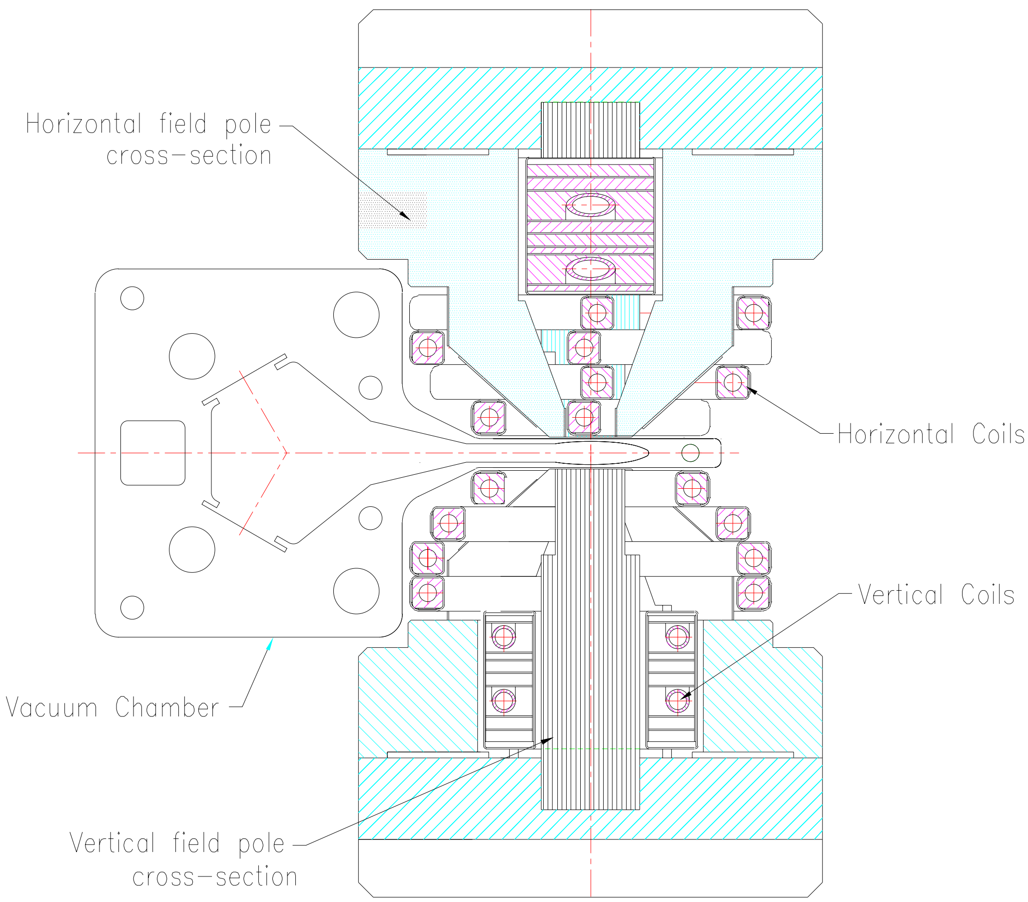
•circular polarization, both left and right

•linear polarization, both vertical and horizontal

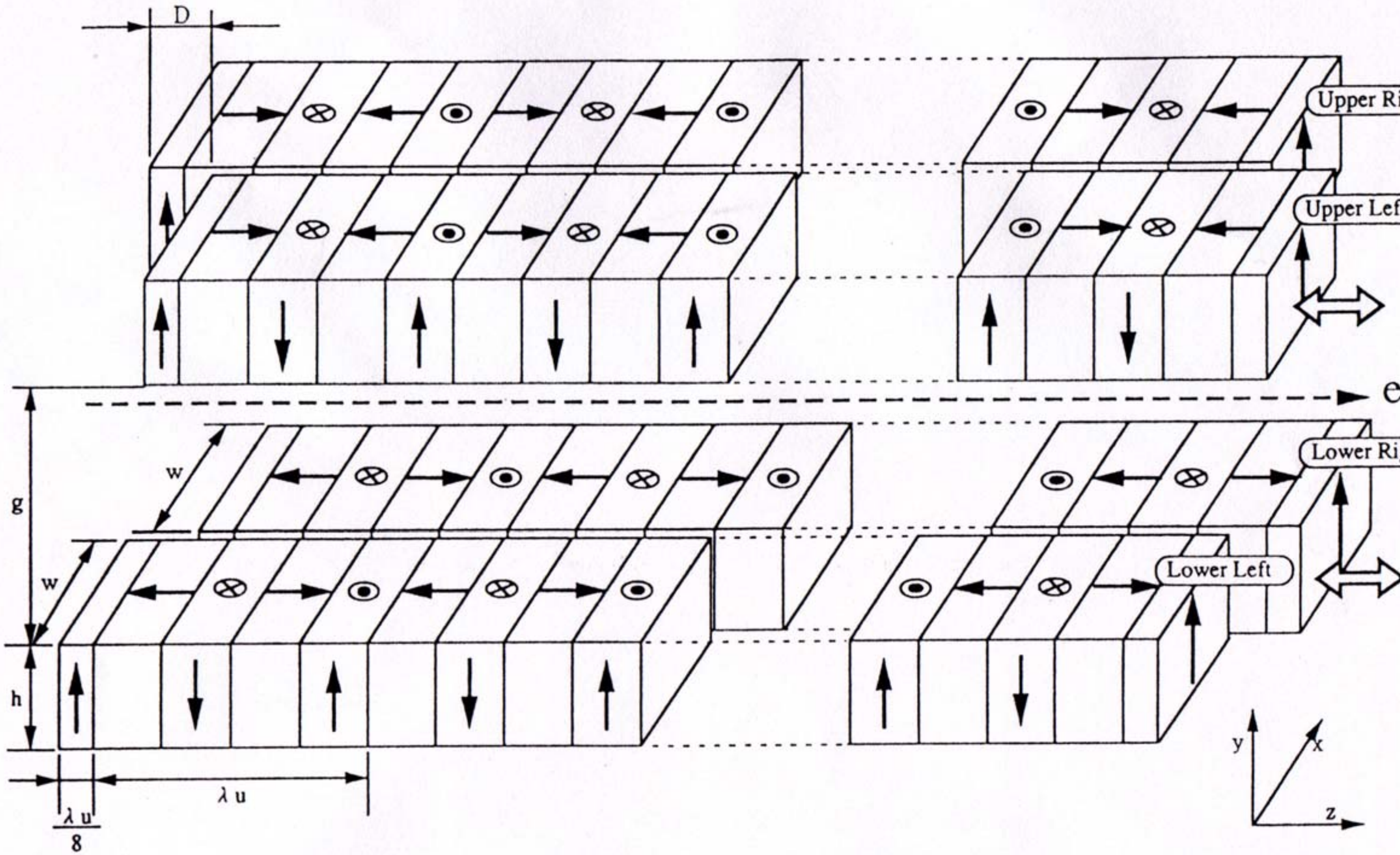
•switchable polarization

•compatible with standard ID vacuum chamber, so it can share a straight section

•open along one side for access by magnetic measurement probes



Advanced Planar Polarized Light Emitter II
Undulators



Schematic view of the magnetic structure for generating variably polarized undulator radiation. $D=\lambda_u/4$.

APPLE-Style Undulator Issues

Many APPLE-style undulators installed at rings around the world

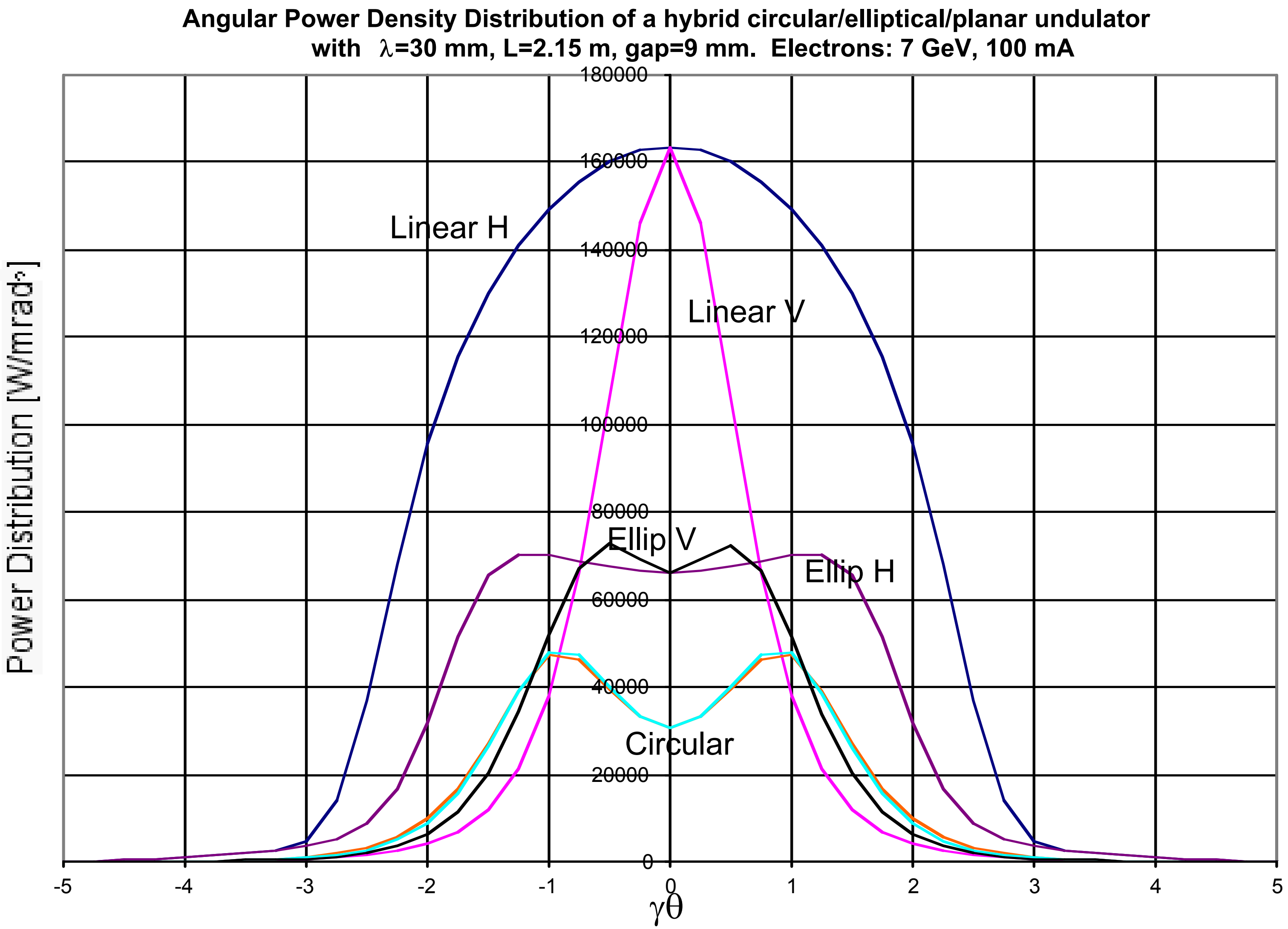
Challenges accompanying APPLE-II undulator:

- Field varies with transverse position => beam focusing

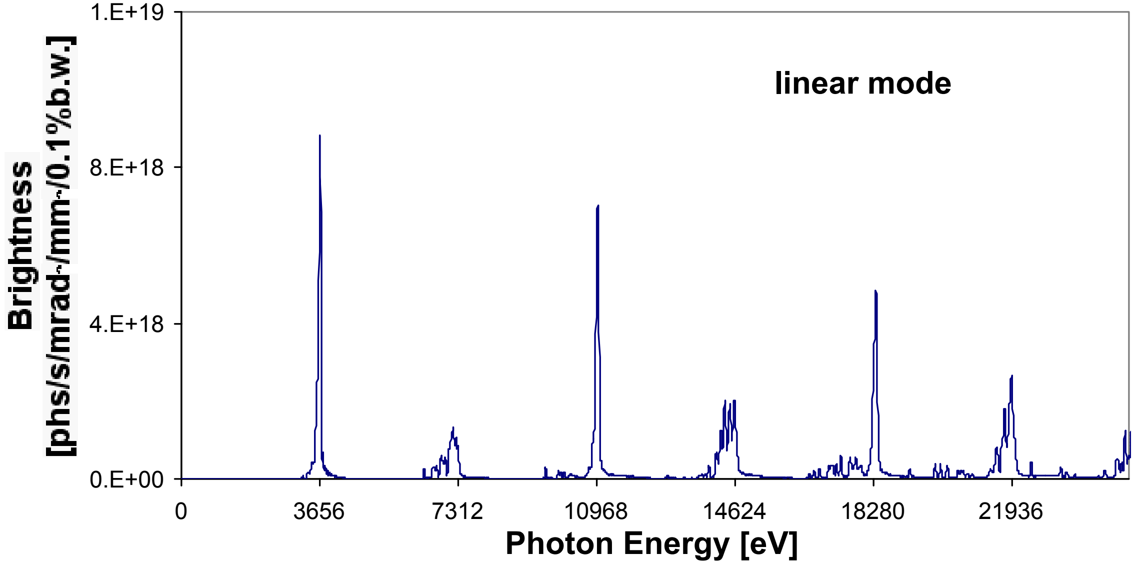
Advantages of APPLE-II undulator:

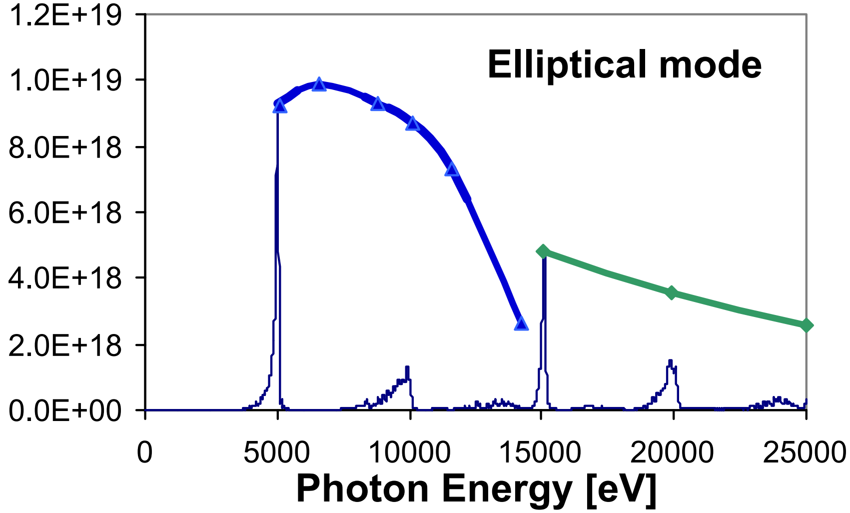
- Flexibility
- Linear or elliptical polarization
  - Higher harmonics also produced
- Circular polarization
  - Low power on axis
  - Only first harmonic produced

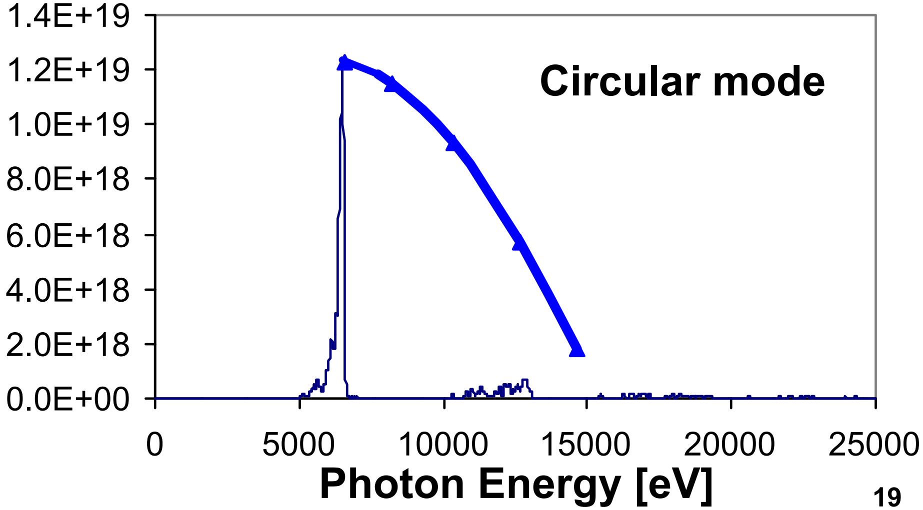
Power Distribution from APPLE Undulator



Circular Mode: Lower Power But Still Bright

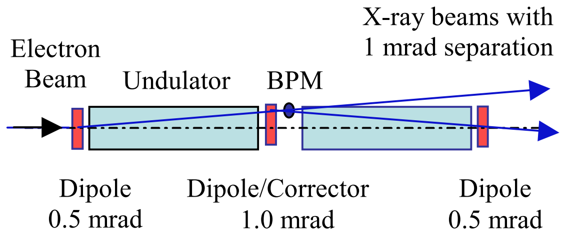


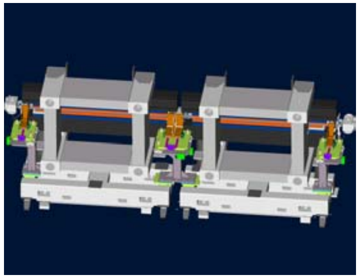


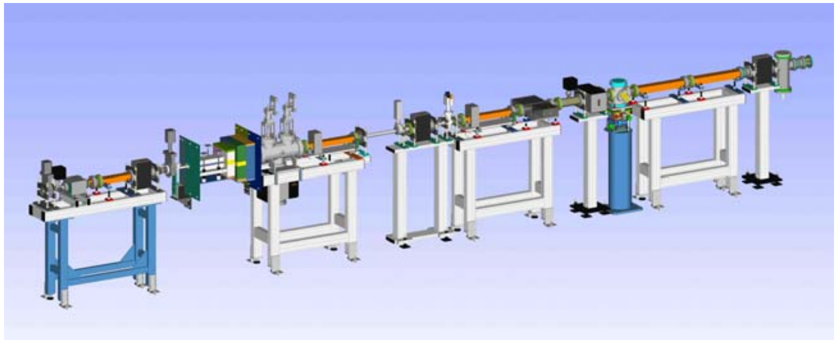


Dual Canted Undulators

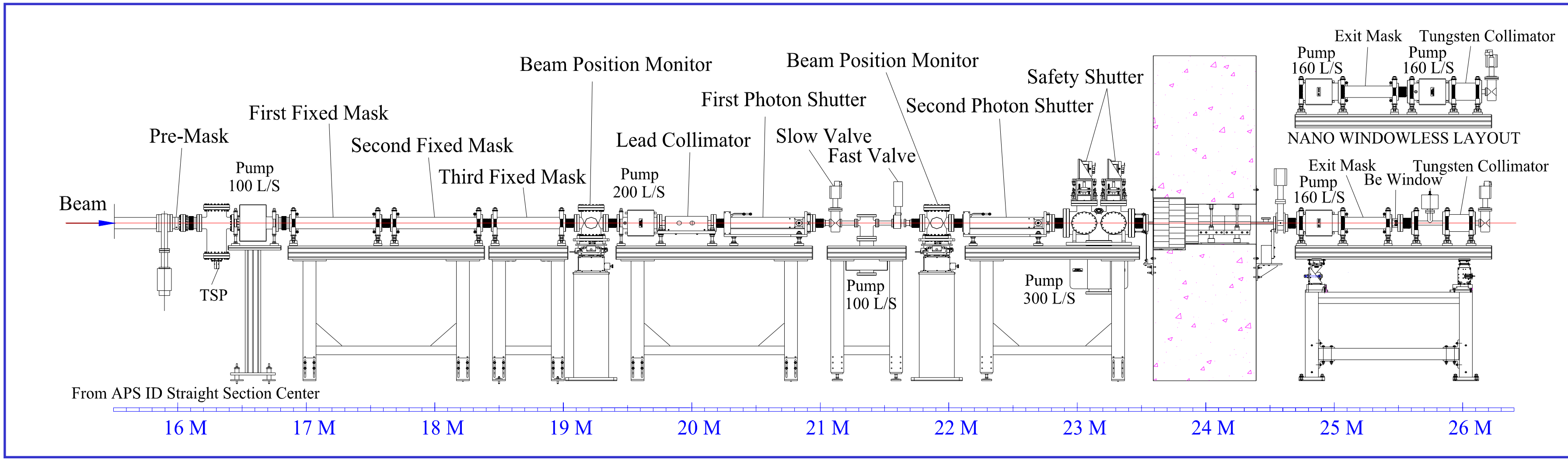
- **Three new sectors**
- **Two ID beamlines from single straight section**
  - 3 dipoles create chicane with 1 mrad offset
- **Shared FE transports two beams**
  - Designed for operation at 200 mA, 20.4 kW total power







New High-Heat-Load Front End for In-line Undulators



Maximum power load: 21 kW

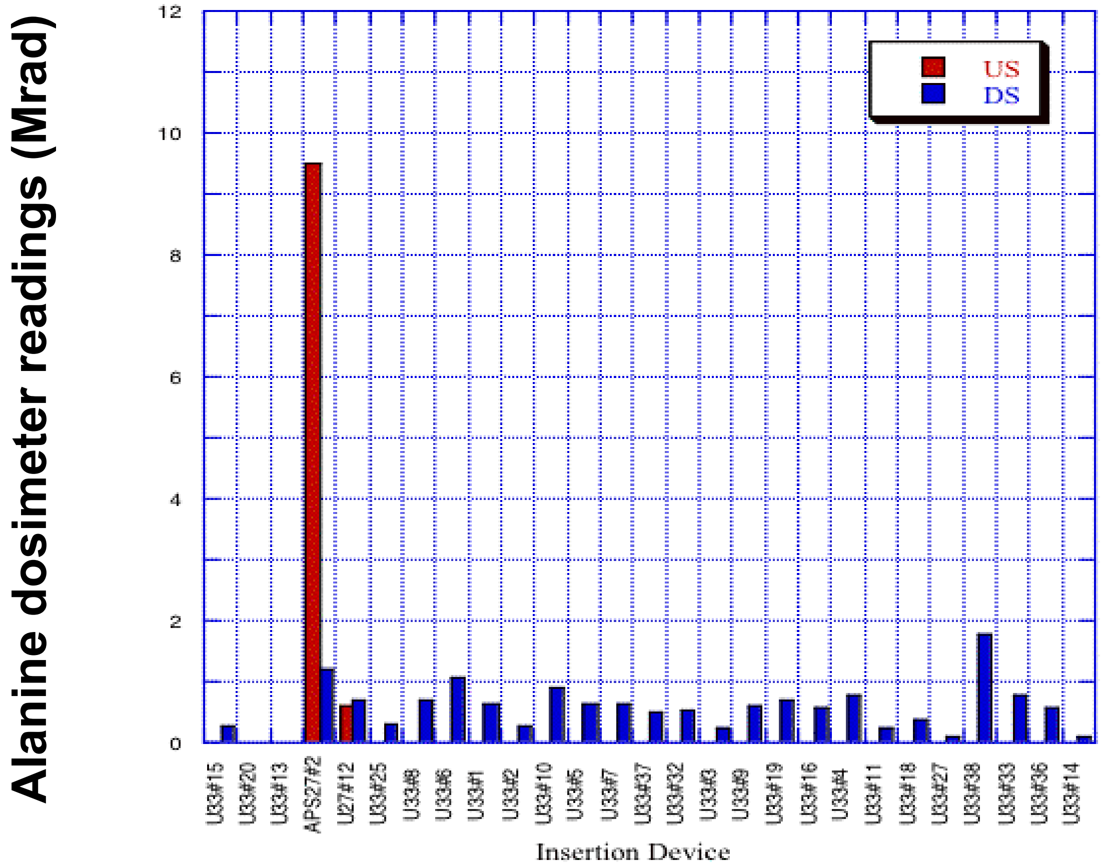
Maximum power density: 590 kW/mrad^2

Can accommodate:

- Two in-line Undulators A at 3 keV (10.5 mm gap), 180 mA (Nano-CAT)
- Three in-line Undulators A at 5 keV (14 mm gap), 150 mA (IXS-CAT)

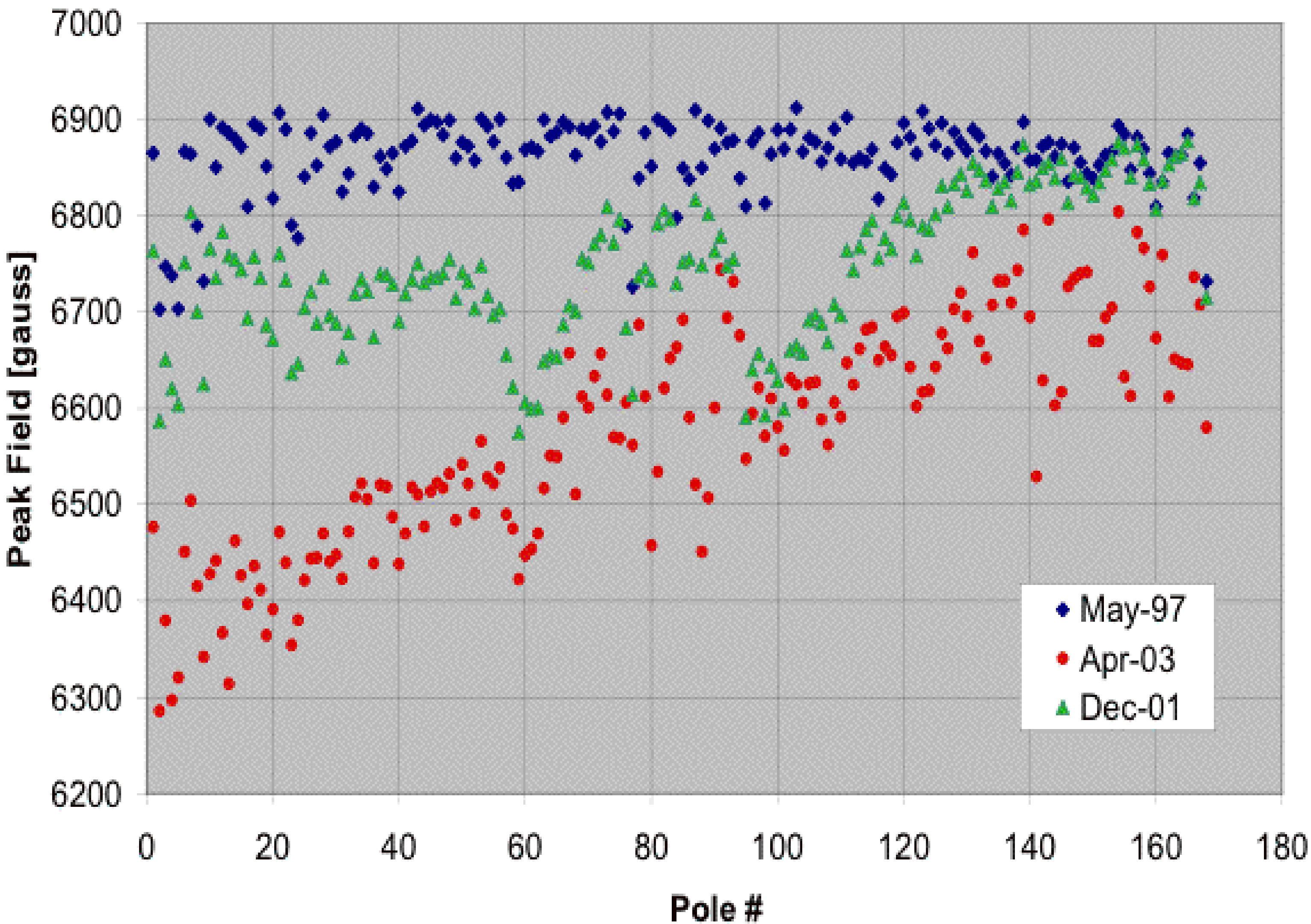
To be installed Sept. 2004 for IXS-CAT and Jan. 2005 for Nano-CAT

Run 2003-1   ID dose in Megarads

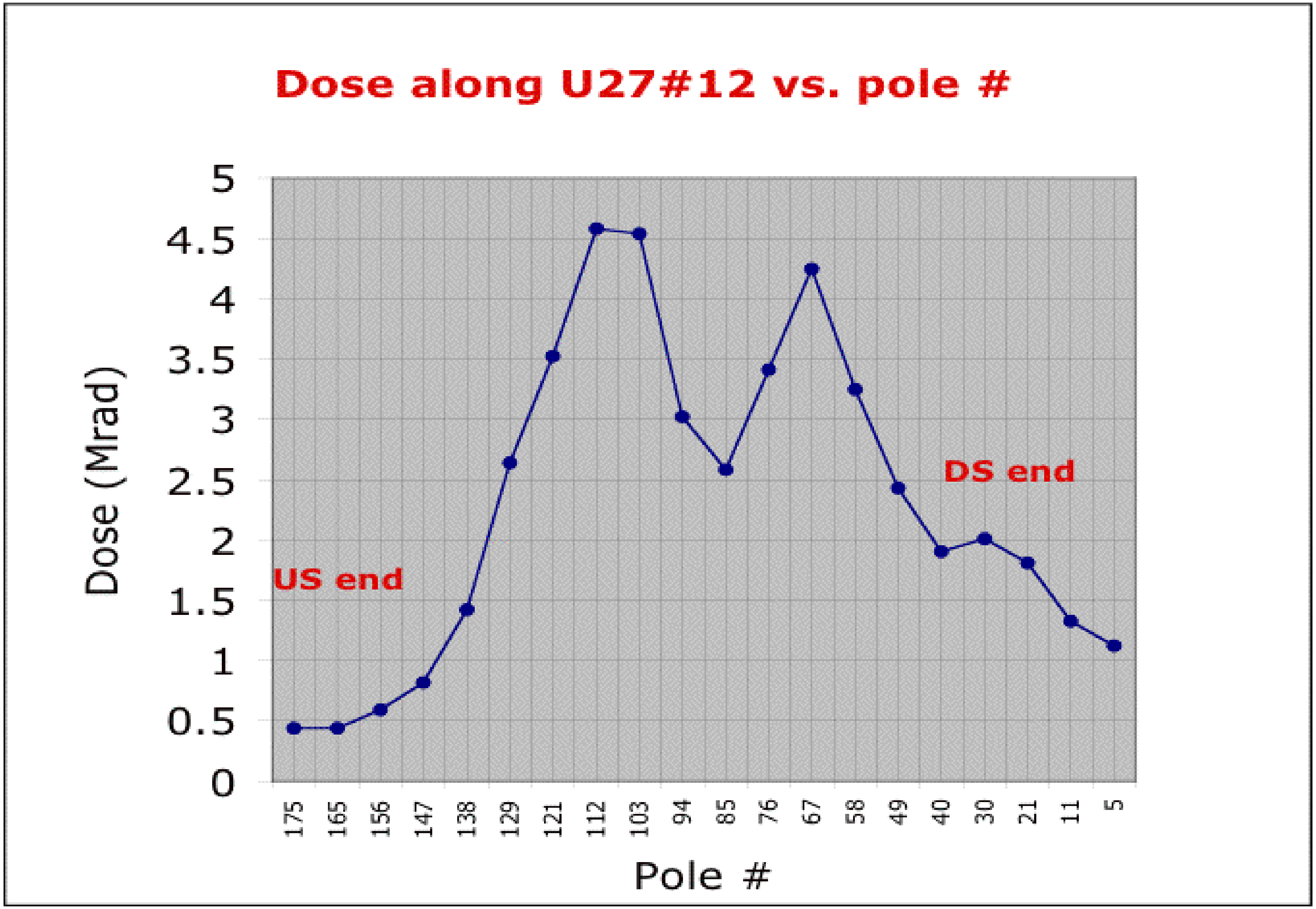


Dose in Sector 3 is very high at nearly 10 Mrad!

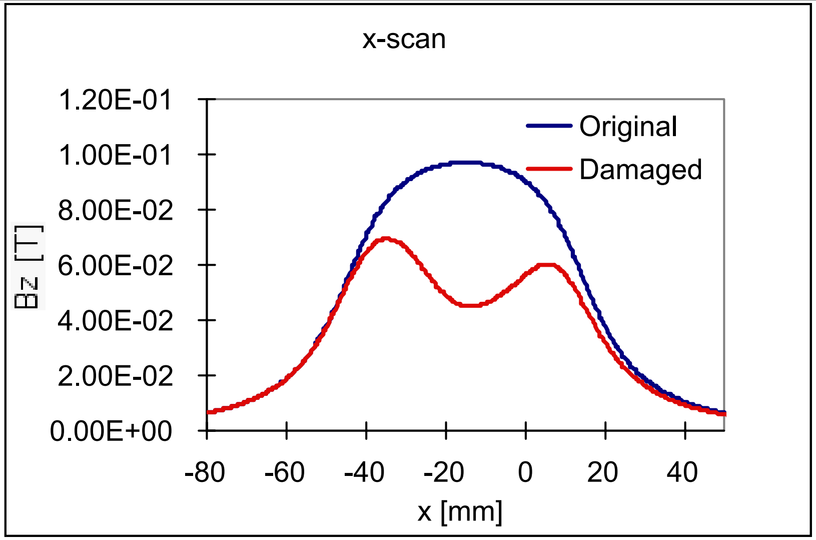
U27#12 Damage Sequence



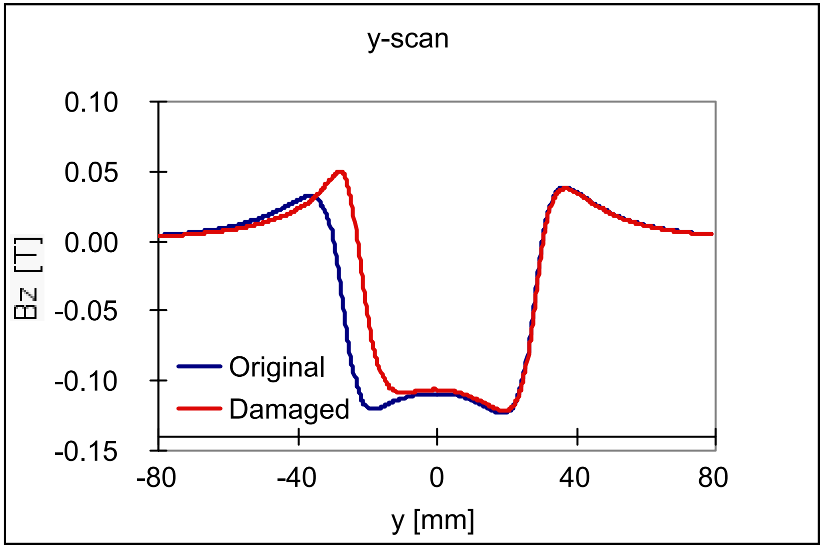
Dose Profiles

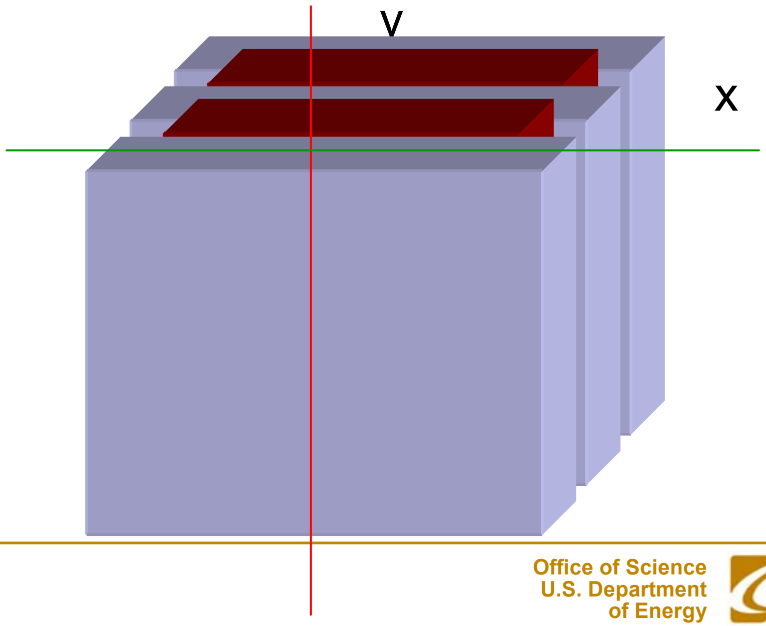


Damage Distribution in Magnet Block



Magnet #6 from U/S end of APS#2 Undulator

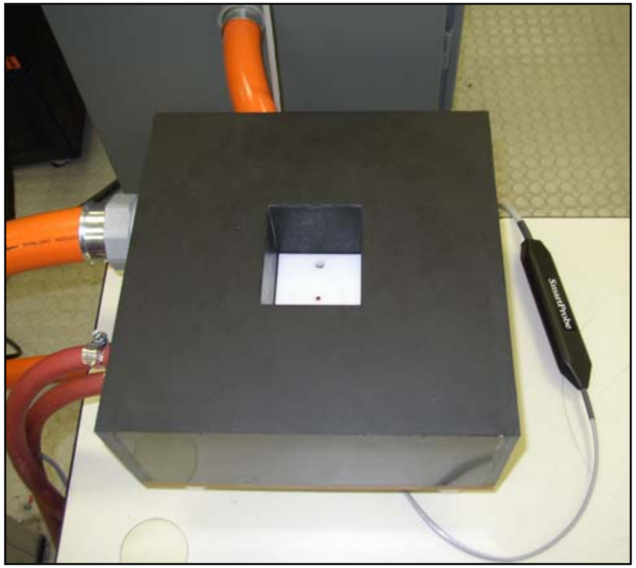




Computer-Controlled Pulsed Magnetizer

- Automated reverse-field treating, guided by Hall probe
- Nominal maximum field: 35 kOe
- Pulse width: 9.4 ms
- Max magnet size: 90 x 58 x 27 mm
- Capacitor cycle time: <15 s

Power supply and control system



Magnetizing Fixture

Summary

We are working to design shorter period undulators:

- Permanent magnet
- Superconducting
- Variable period

APPLE-style undulators

New higher power front ends

Radiation damage:

Retuning has kept undulators working

Now more extensive repairs are possible

But the frequent repairs and retuning in Sector 3 are a burden