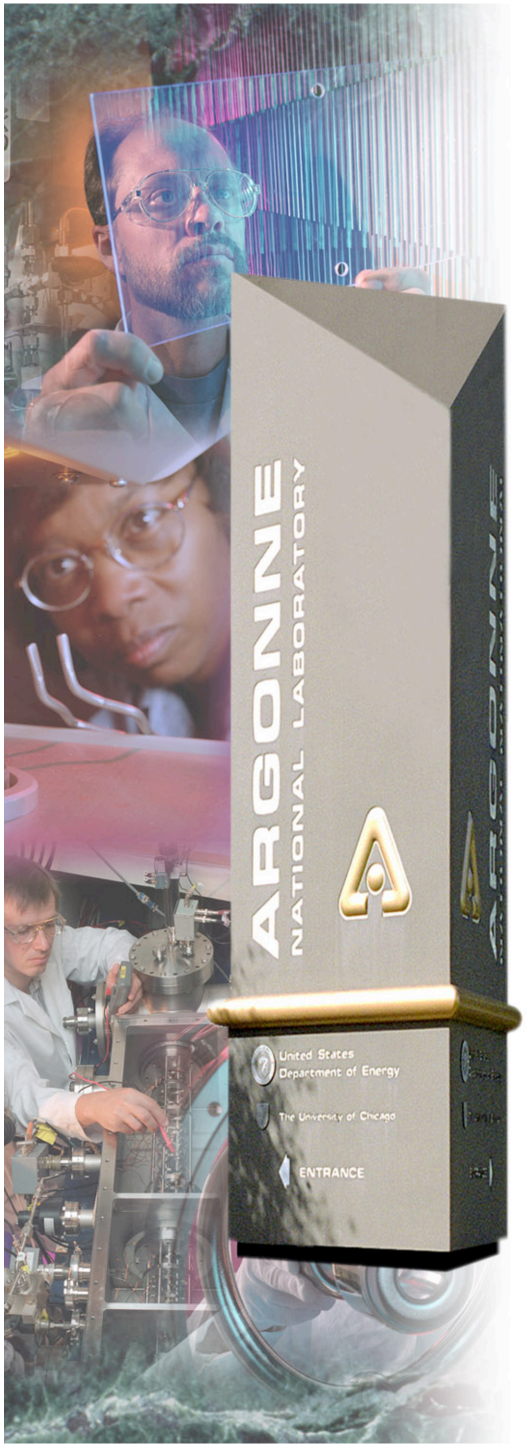


Insertion Device News

Liz Moog

APS User / Operations Meeting

Feb. 9, 2005

Argonne National Laboratory

Office of Science
U.S. Department of Energy

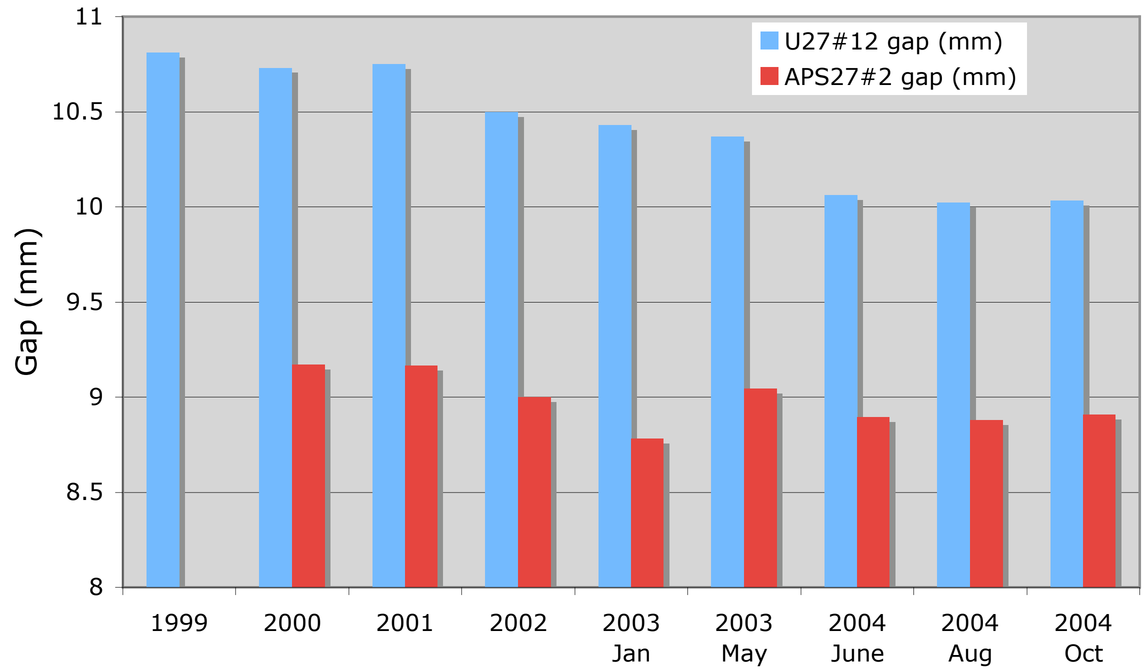
A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago

Outline

- **Radiation damage is continuing in Sectors 3 & 4, the two sectors with 5-mm aperture vacuum chambers**
  - Small aperture is the scraper for the ring
  - Users see significant changes in beam characteristics as the run progresses
- **What we are doing about it and what we have learned**
- **New undulators in production now**
- **Superconducting undulator progress**

Sector 3: Gap vs. time for 21.657 keV light

Year	U27#12 gap (mm)	APS27#2 gap (mm)	flux (arb.units)
1999	10.81		1.3
2000	10.73	9.173	1.3
2001	10.75	9.164	1.2
2002	10.5	9	1.1
2003 Jan	10.43	8.78	1
2003 May	10.37	9.045	1.3
2004 June	10.06	8.896	1.2
2004 Aug	10.025	8.88	1.2
2004 Oct	10.035	8.91	1.2

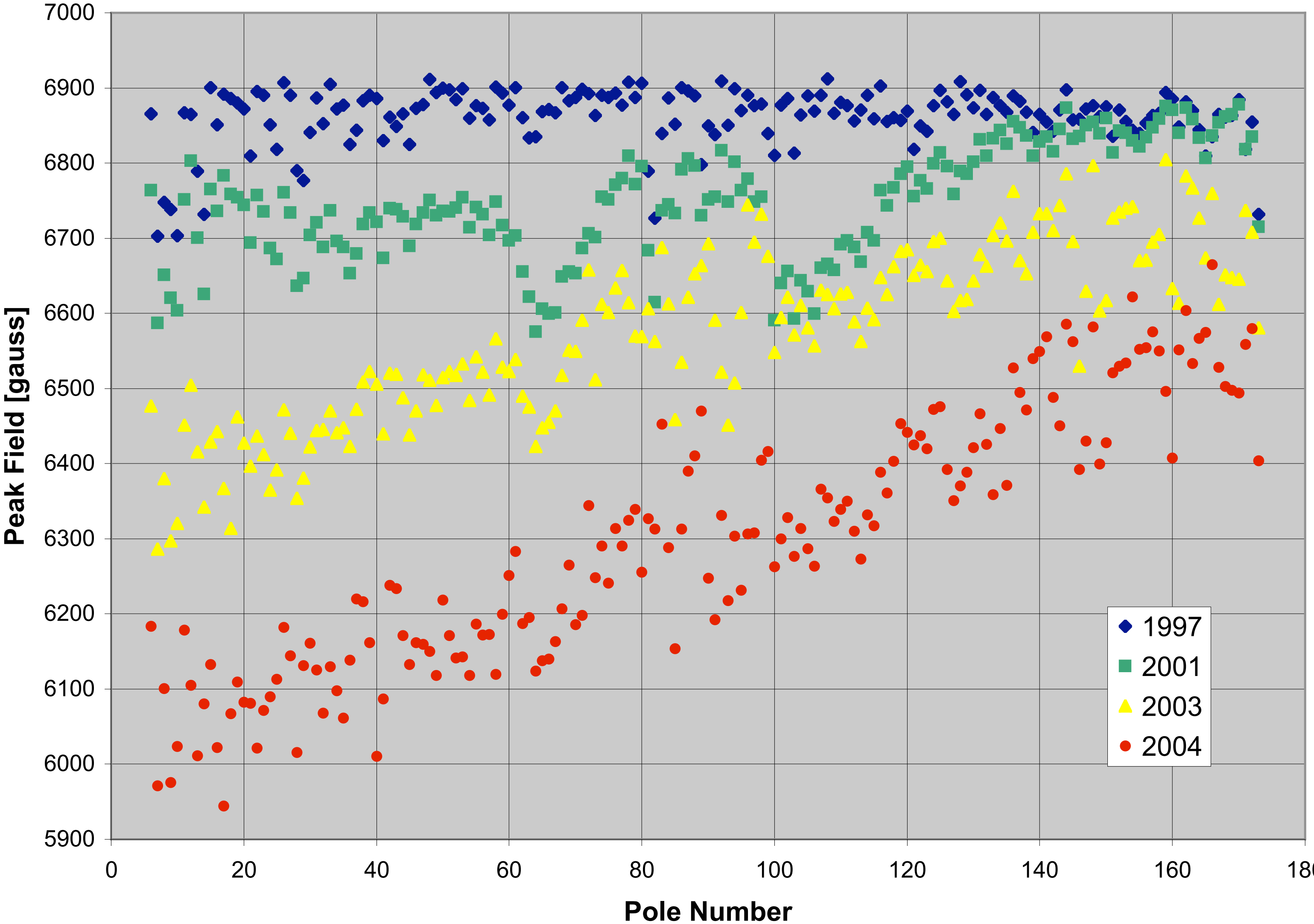


Sector 4: Taper that optimizes flux vs. time

Run	Date	Taper in mm
2003-3	10/01/03	0
	10/29/03	0
	12/04/03	0.1
	12/16/03	0.14
2004-1	01/29/04	0
	02/25/04	0
	03/10/04	0
	04/07/04	0.265
2004-2	05/25/04	0
2004-3	10/20/04	0.144
	11/03/04	0.144

The difference between the energy requested (i.e. the gap setting) and the monochromator energy is also monitored. It changes as damage sets in, by amounts that very with the harmonic and energy.

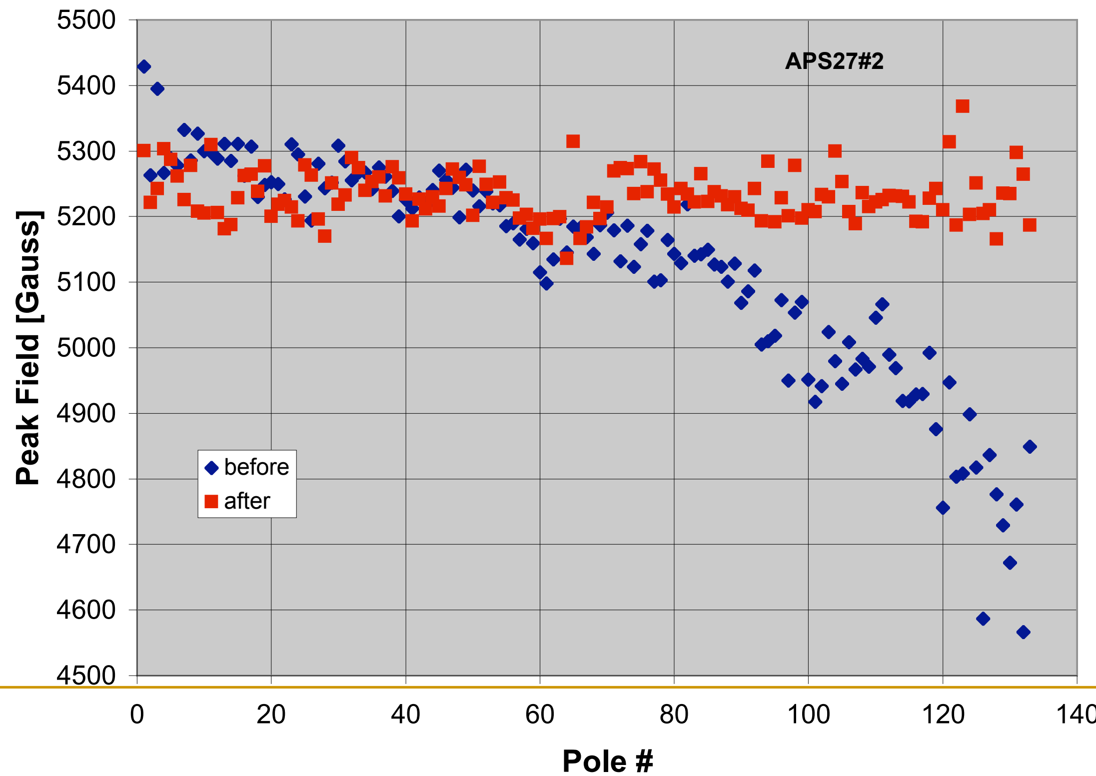
Damage sequence in downstream ID, Sector 3



First major repair to undulator

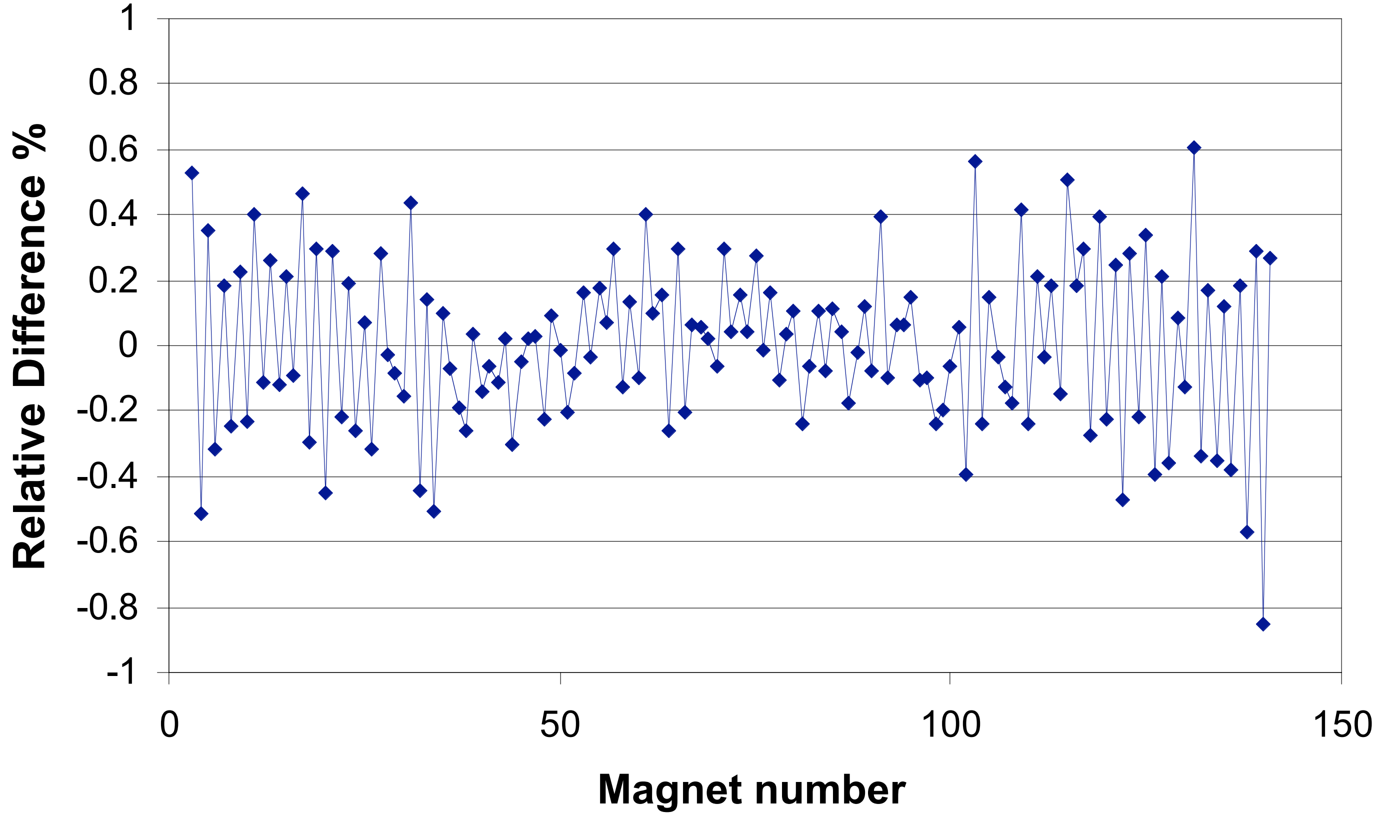
Damage to the upstream Sector 3 undulator reached the point where users could no longer close the gap enough to reach the desired photon energy. The undulator was restored to full operation by:

- Replacing some of the worst magnets with unused spares
- Rotating other magnets to turn the damaged side away from beam
- Standard tuning techniques

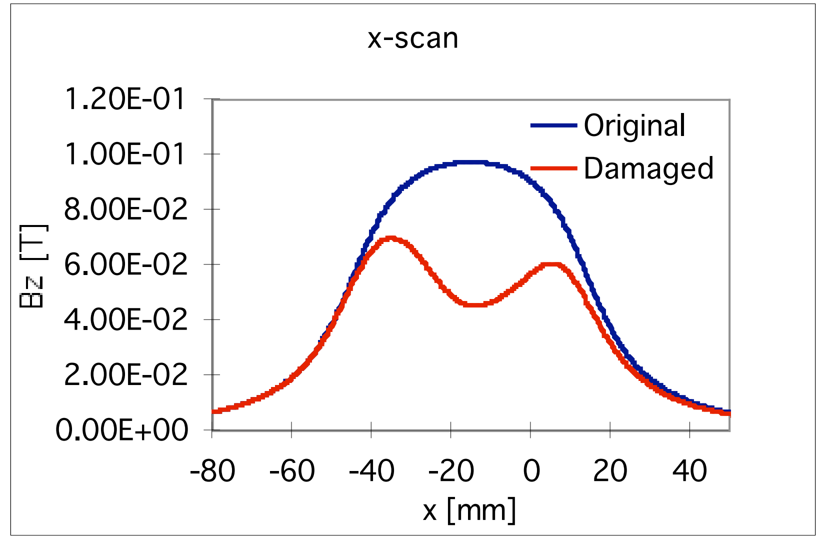


Uniformity of remagnetized magnets

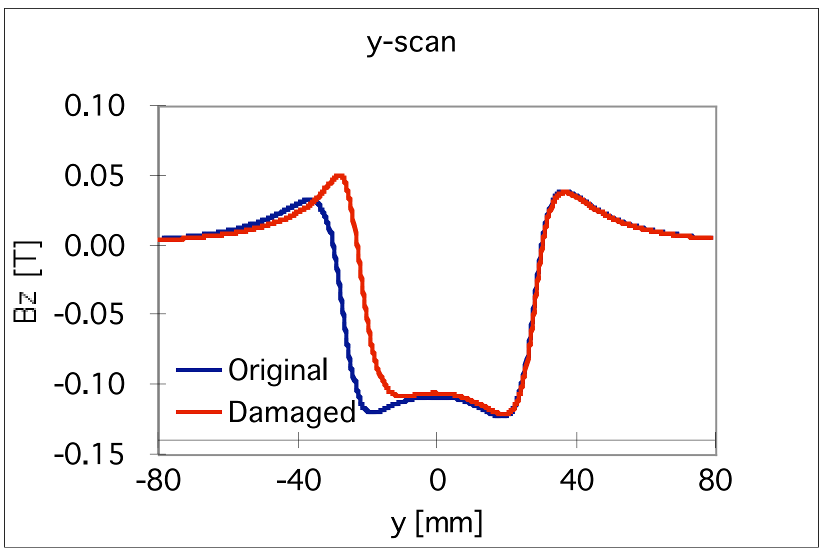
Magnets damaged in Sector 4 undulator were remagnetized. Uniformity of magnetic moment after remagnetization to saturation was very good

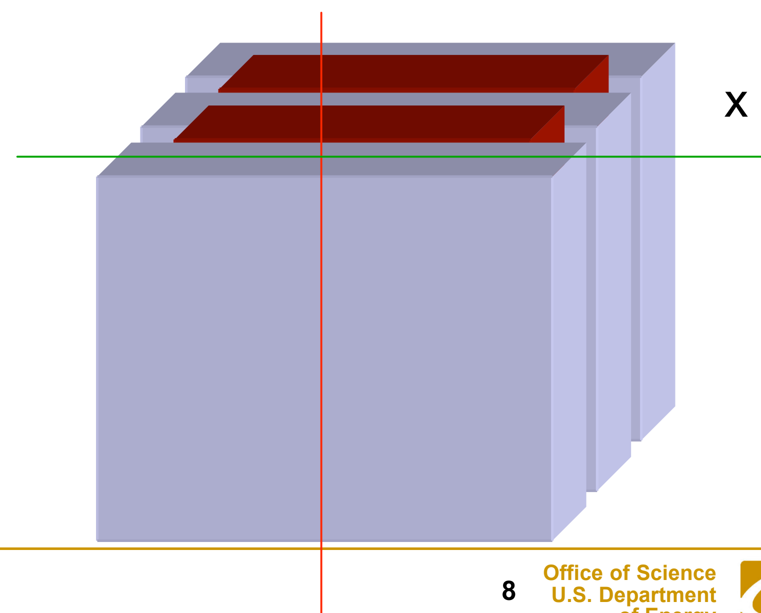


Damage distribution in magnet block

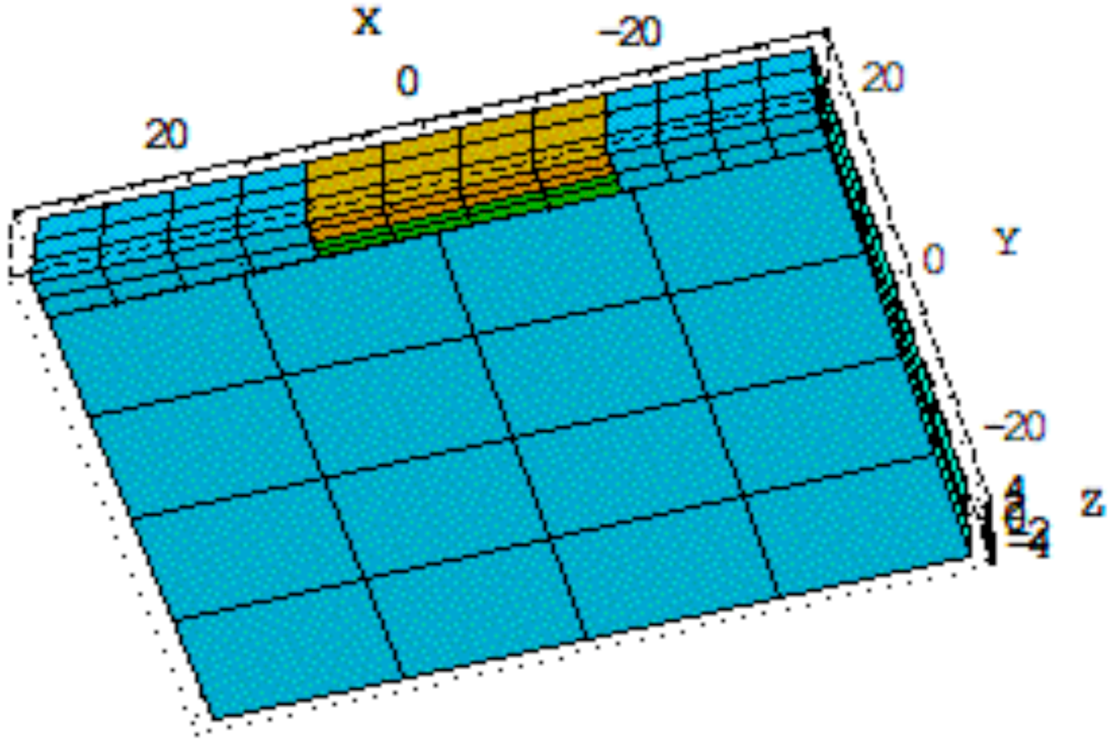


Magnet #6 from upstream end
of upstream Sector 3 undulator



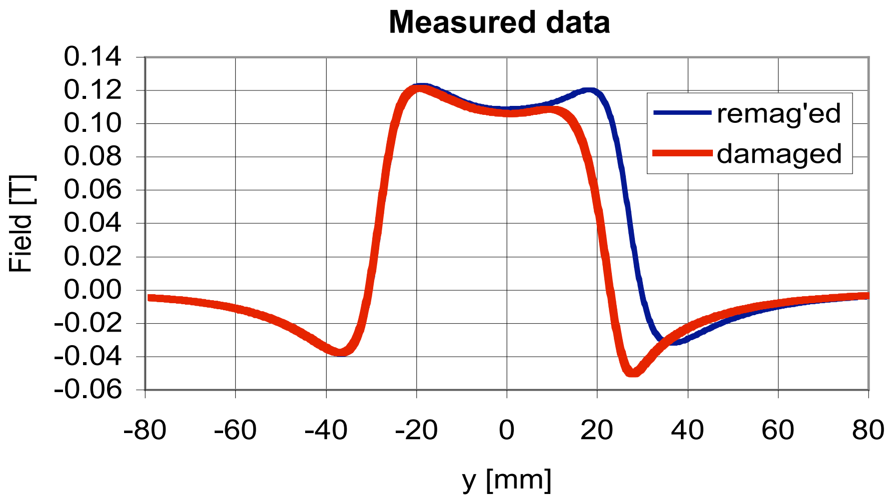


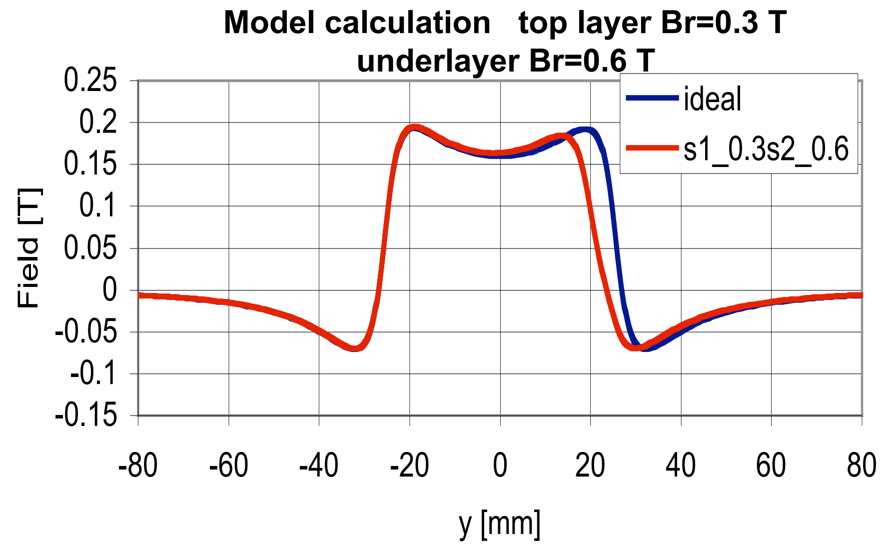
Model for magnet damage calculations

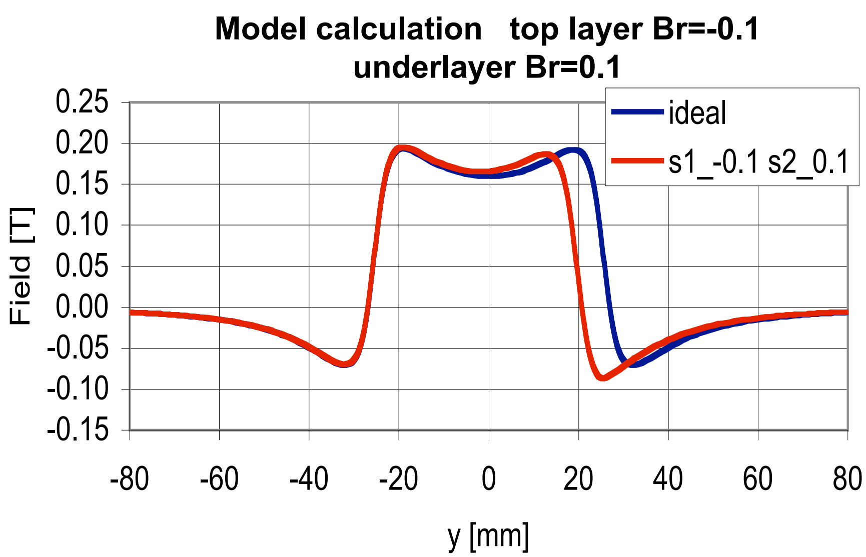


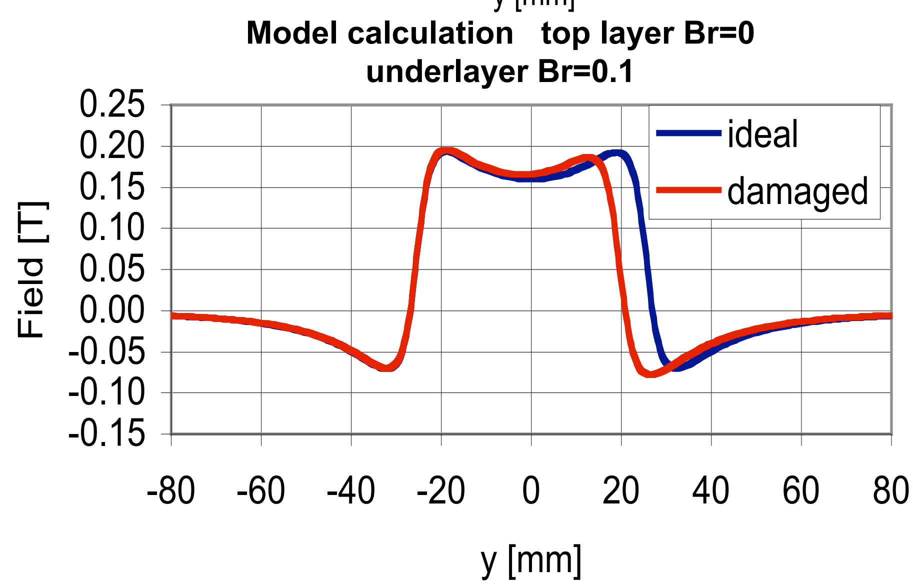
Two regions in the magnet can be set to have a magnetic field strength different than in the body of the magnet, to simulate damage profiles. Each region is 3 mm thick.

Models with different parameters





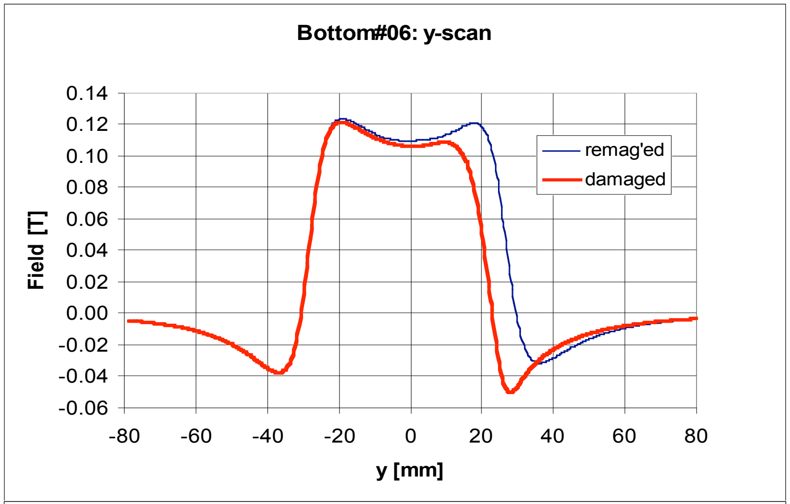


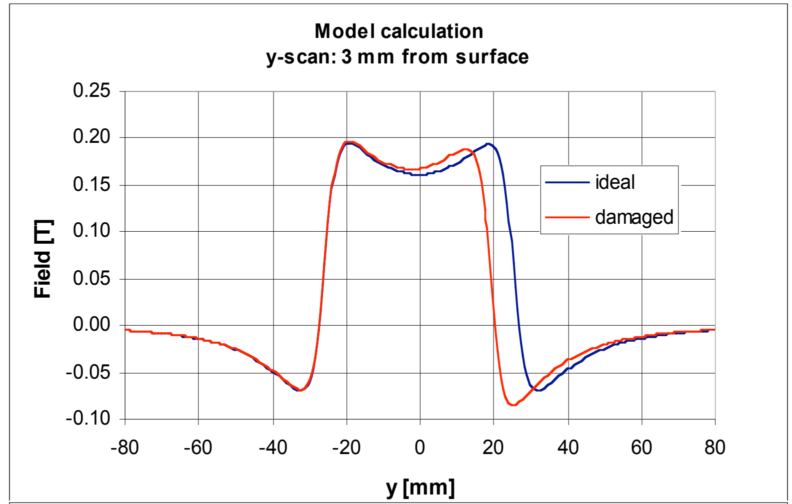


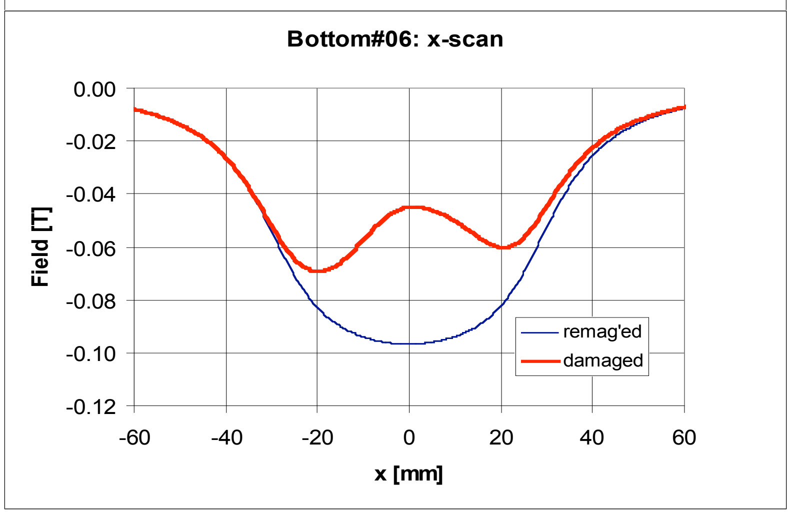
Measured and fitted profiles of one magnet

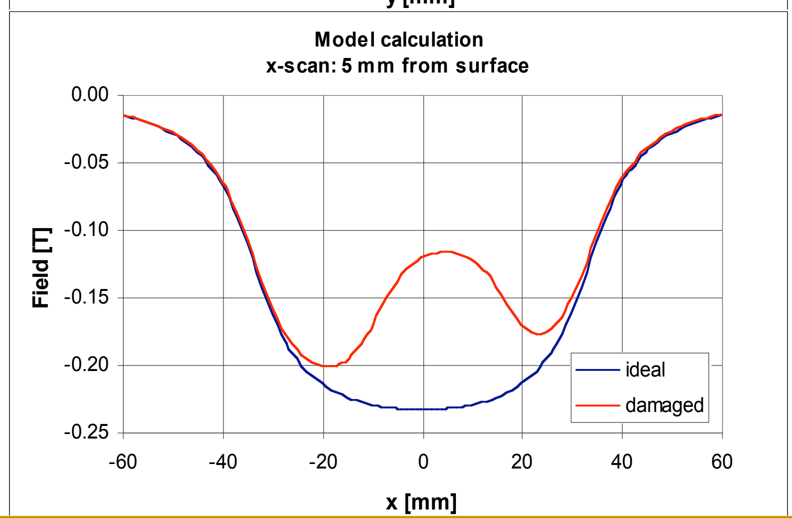
Measured

Model calculation. Surface Br=-0.1 T, underlayer Br=0.1 T

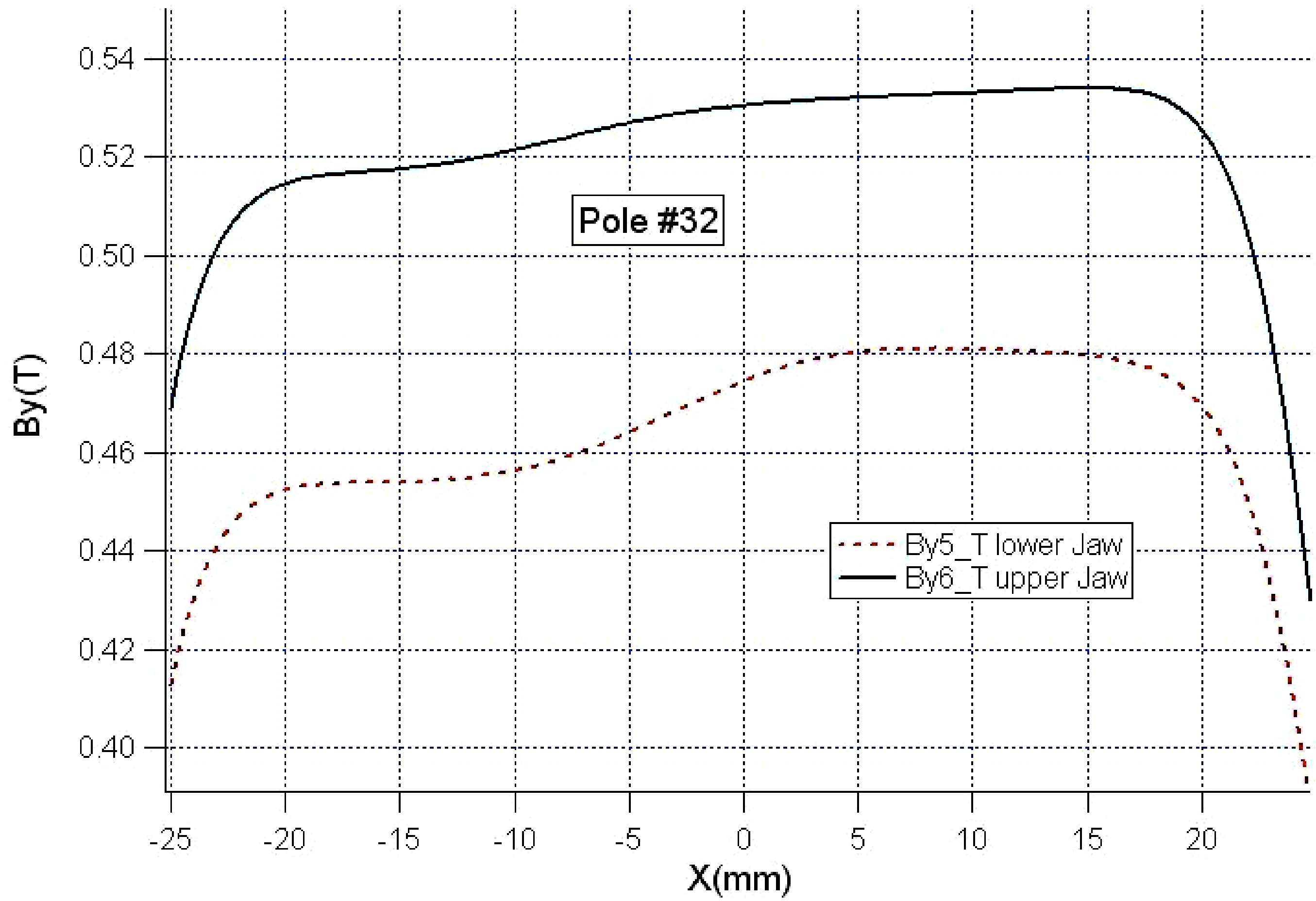








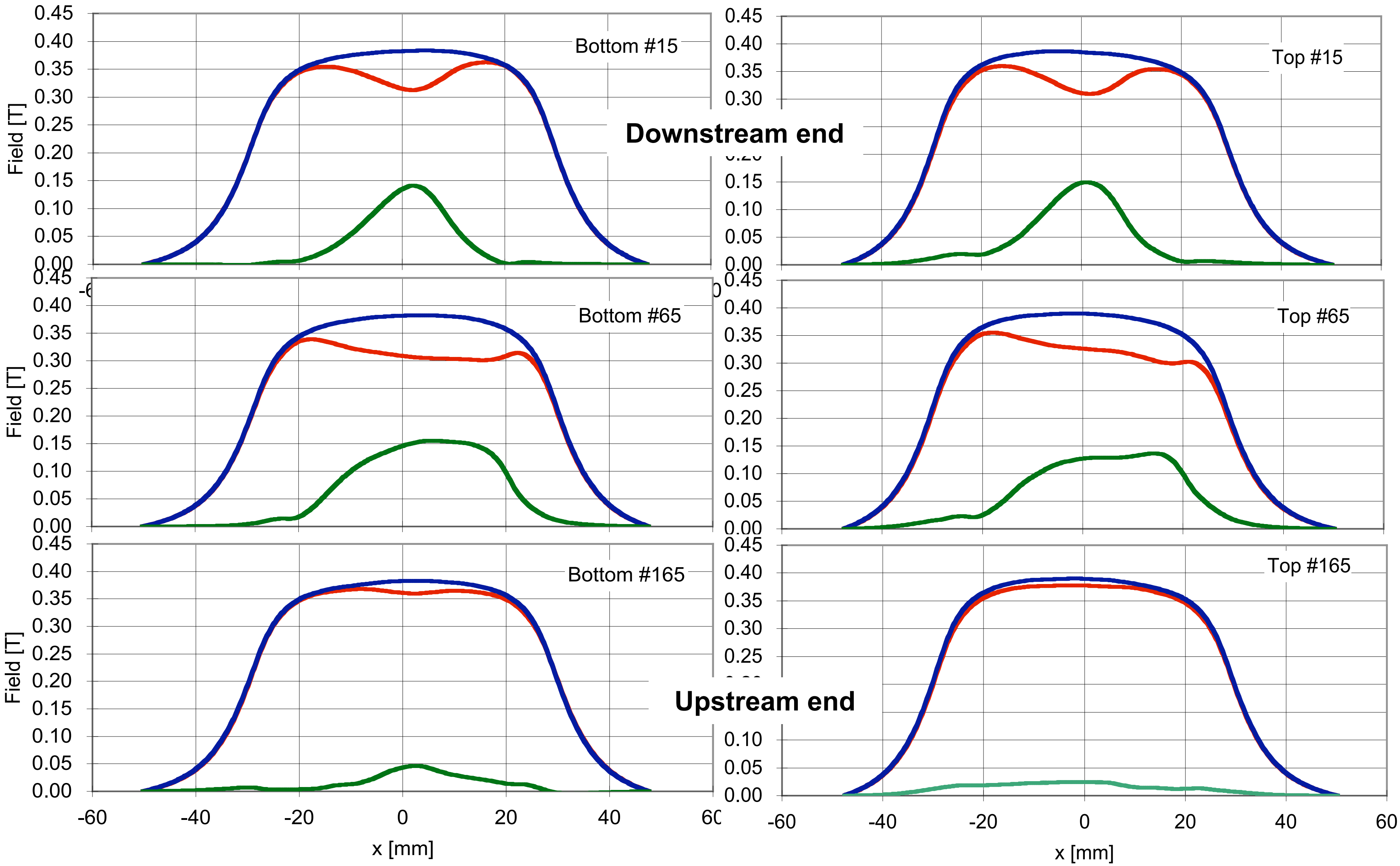
Sector 4 demagnetization vs. x



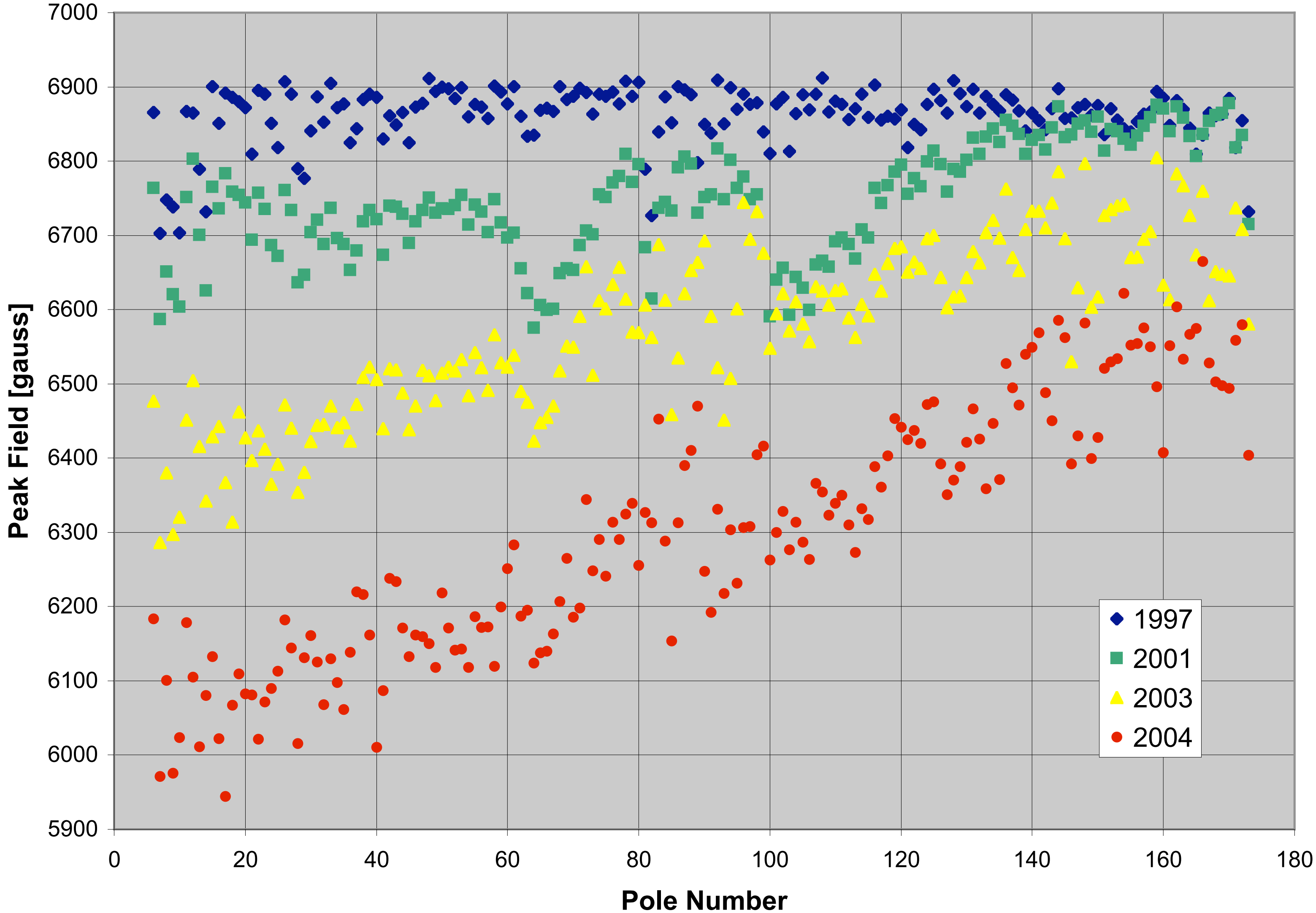
In Dec 2004 (above), demagnetization was worse on the inboard side.

However, in May 2004, the demagnetization was worse on the outboard side.

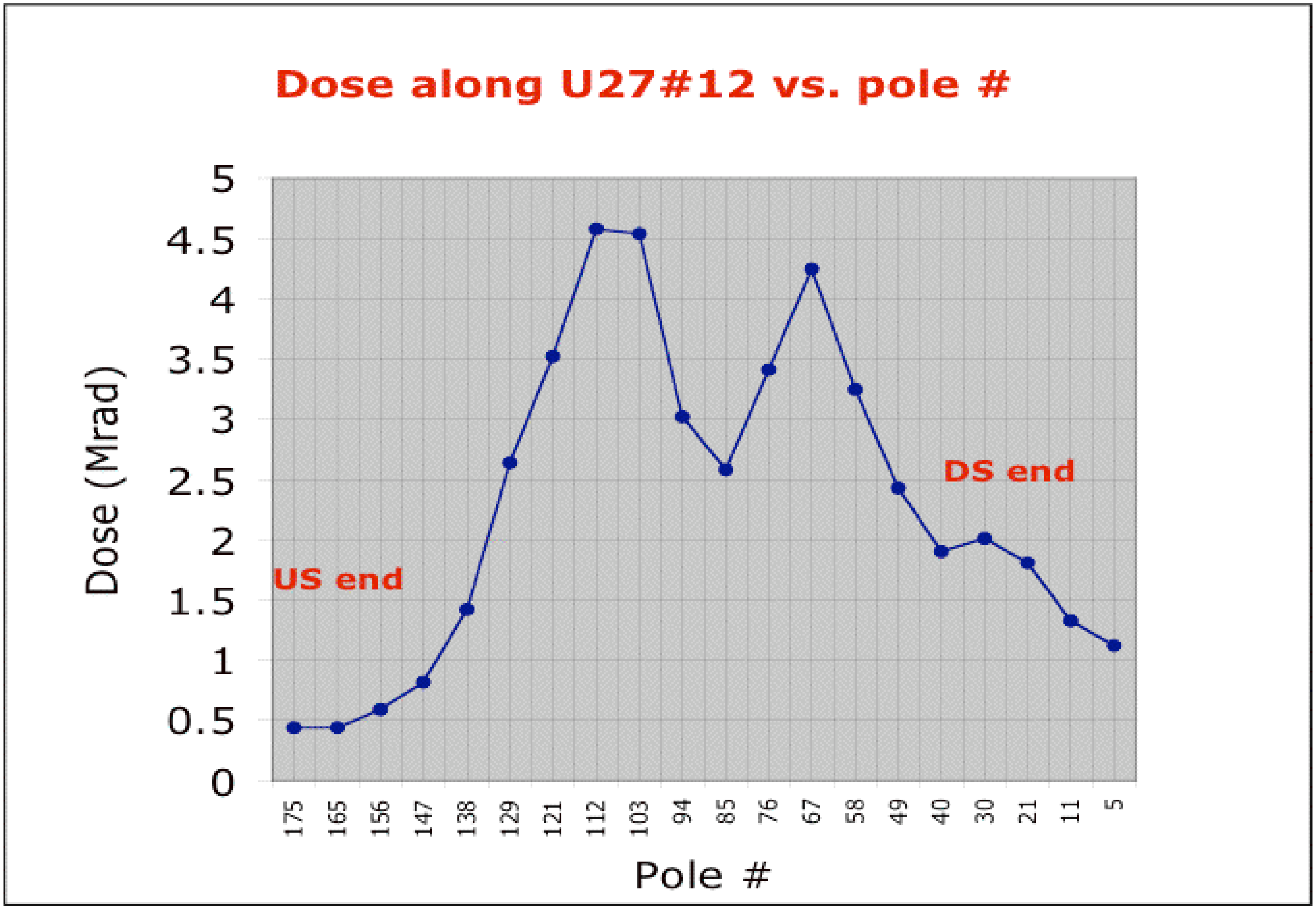
Demagnetization in Sector 3 downstream ID



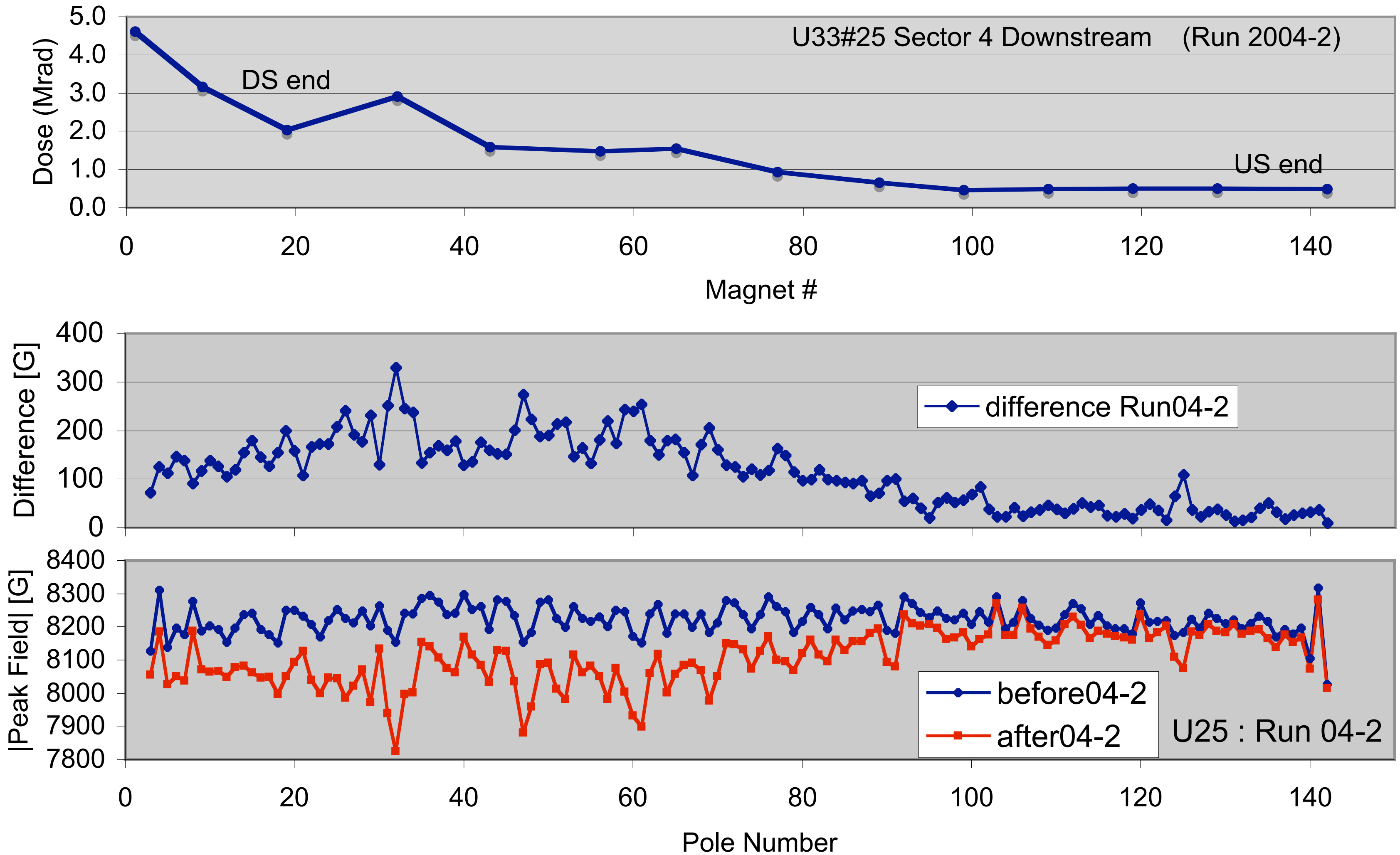
Damage sequence in downstream ID, Sector 3



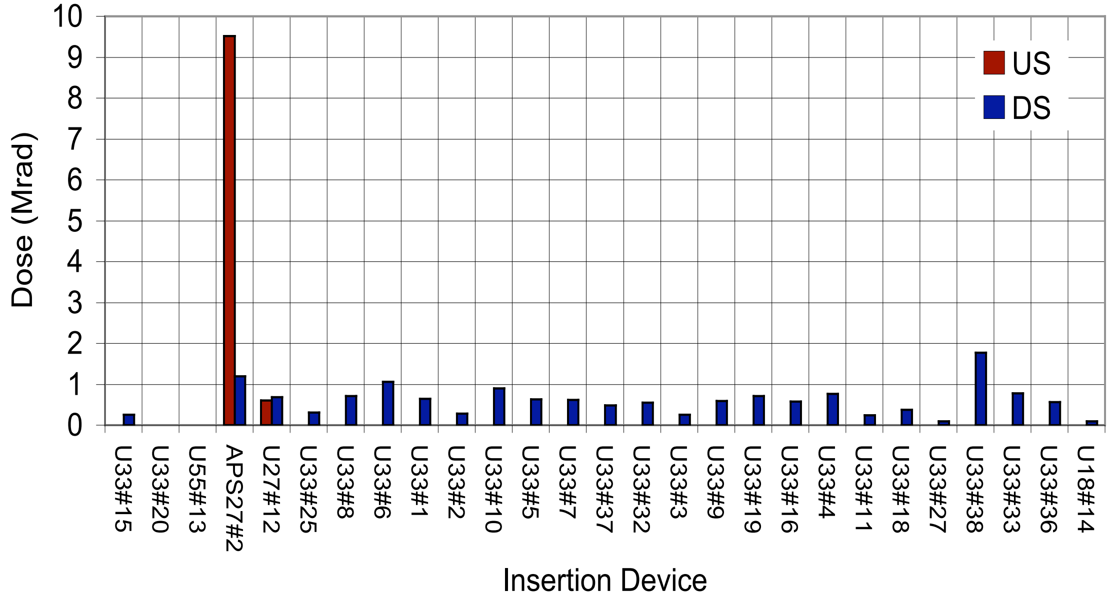
Dose profile along downstream Sector 3 ID



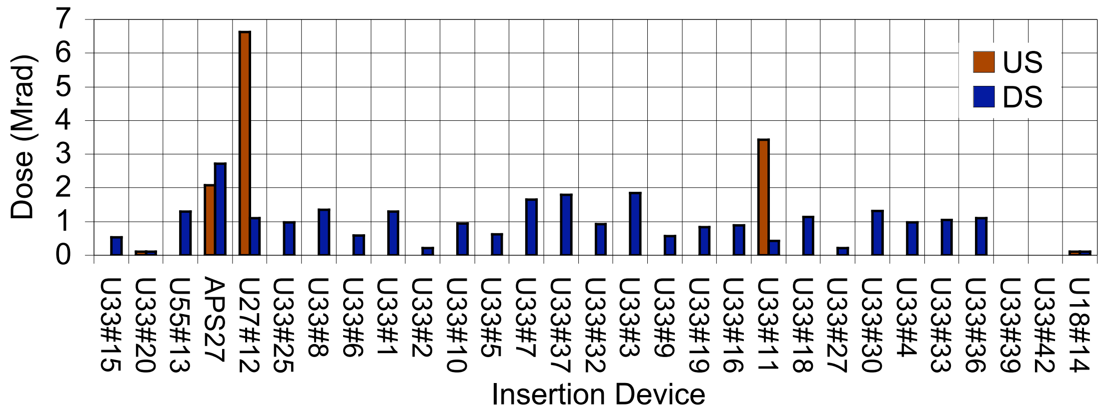
Comparison of dose and field loss



ID doses around the ring - alanine dosimetry

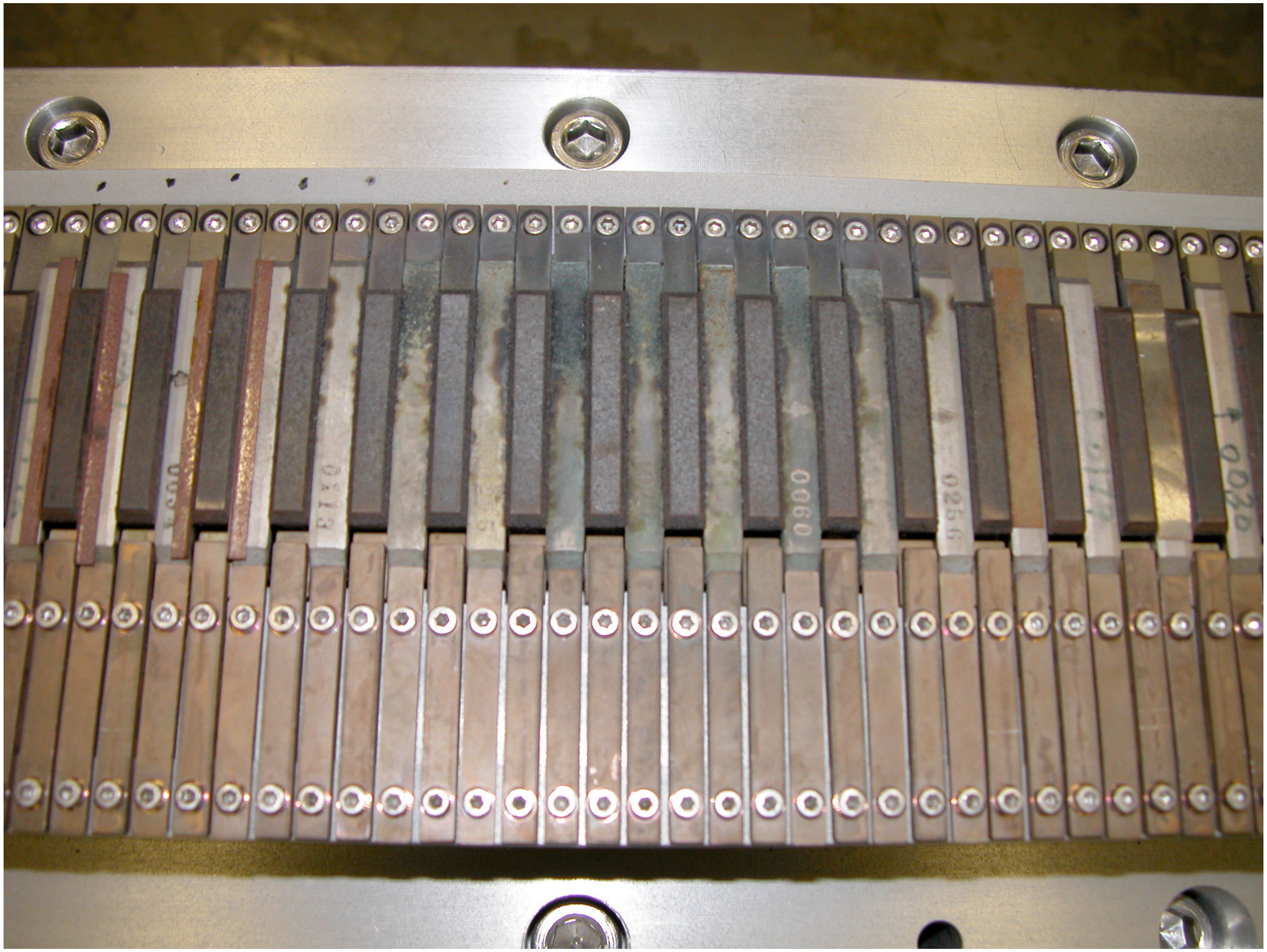


Run 2003-1



Run 2004-2

Corrosion is significant in Sector 3



IDs installed as of Feb 2005

Type	Number	Length (periods)	K_{eff}
33-mm undulator	24	72	2.75
33-mm undulator	5	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[†] $K_x \leq 1.4$
Circularly polarized undulator (12.8 cm)	1	16	$K_y \leq 2.86$ $K_x \leq 2.75$

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.

New planar undulators in production

- **27-mm undulator, 2.4-m long for Sector 3**
  - Will replace weaker field undulator so small gap ID vacuum chamber can be replaced by standard chamber
  - Scheduled installation April 2005
- **30-mm undulators**
  - Two, 2.4-m long for IXS-30. Scheduled for April 2005
  - One, 2.05-m long for GM/CA-23
  - One, 2.05-m long for LS-21
- **35-mm undulator with SmCo magnets for Sector 4**
  - SmCo magnets are more radiation resistant
  - Scheduled installation Sept 2005

Status of production

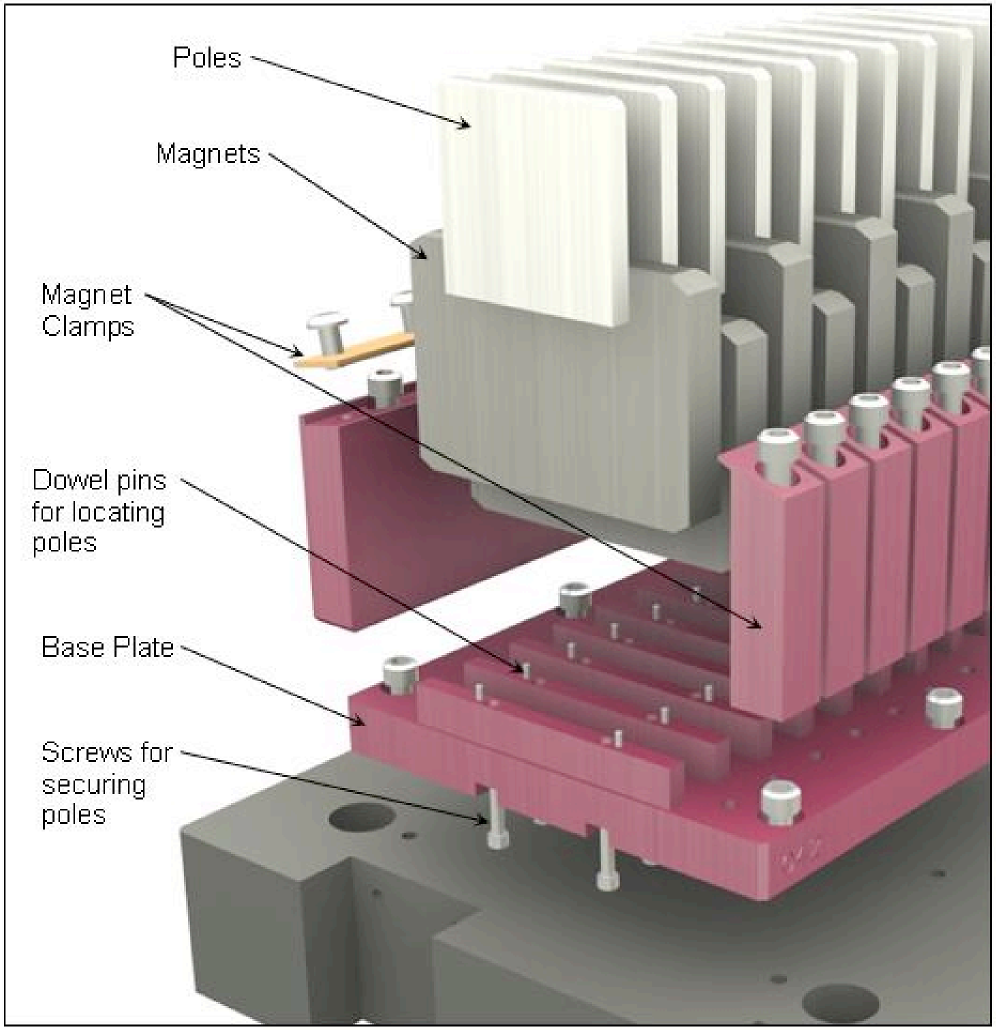
For 2.7-cm undulator:

- **Magnets: most arrived in December; last few came last week**
- **Poles: due 2/11**
- **Strongbacks: arrived**
- **Misc. parts: done**

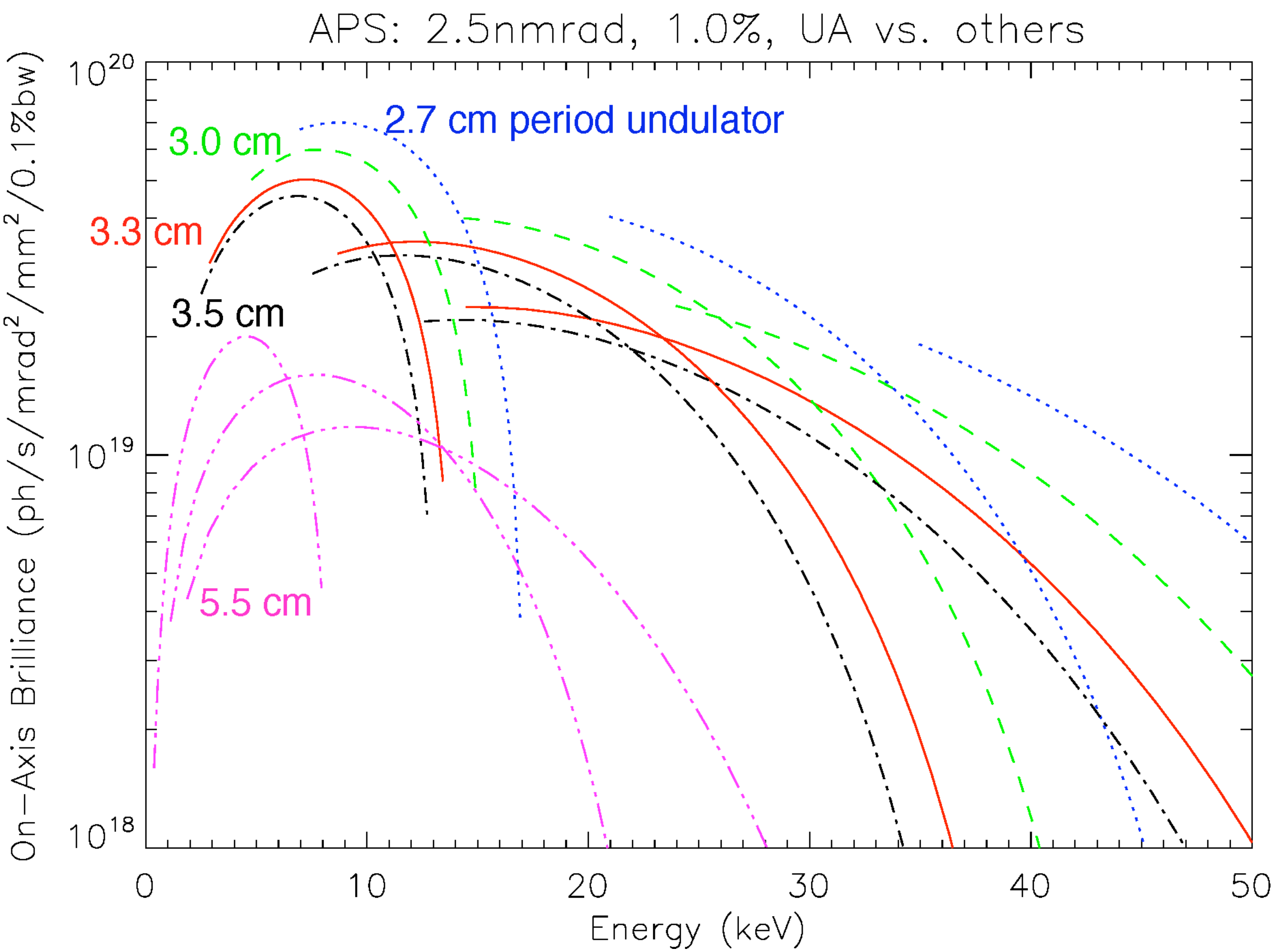
For 3.0-cm undulators (the first two):

- **Magnets: due by end of Feb.**
- **Poles: due 2/11**
- **Strongbacks: arrived**
- **Misc. parts: due on March 18**

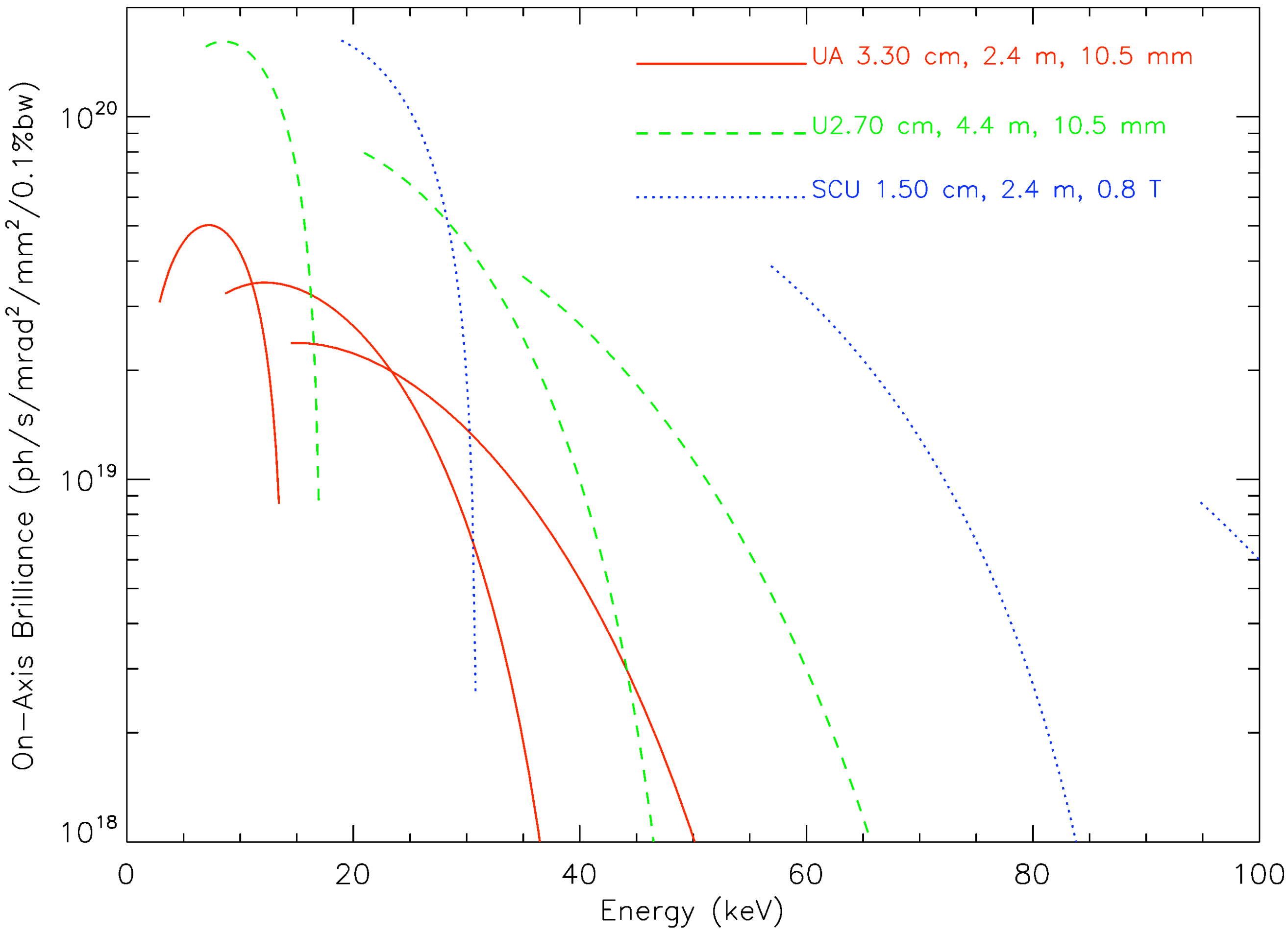
New undulator magnetic structure design



Tuning curves

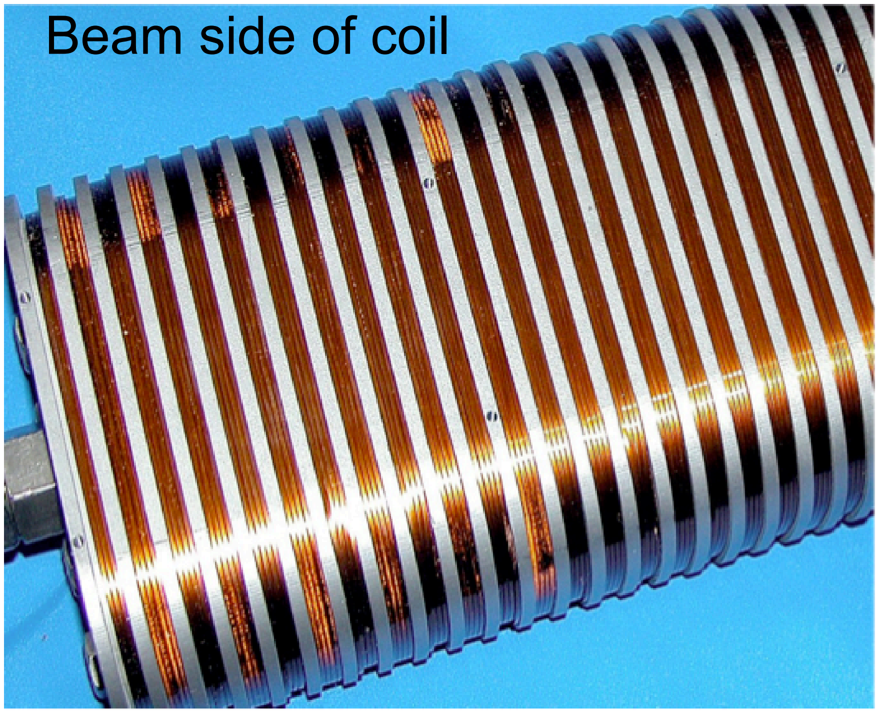


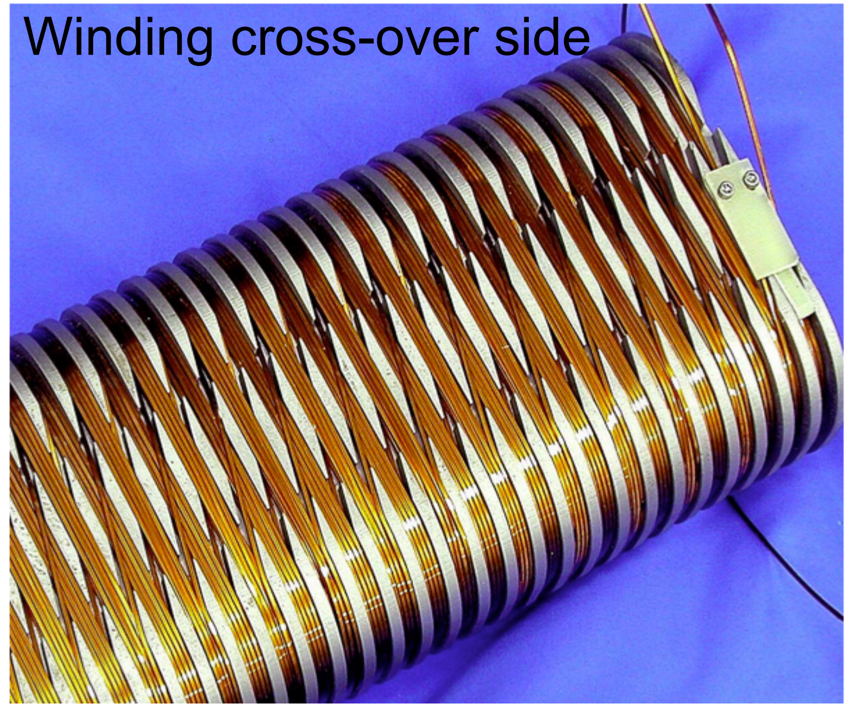
Superconducting undulator at 20-25 keV



- **Superconducting undulator surpasses Undulator A ~ 10 times at 25 keV (when magnetic field errors are taken into account)**

Test coil built at APS



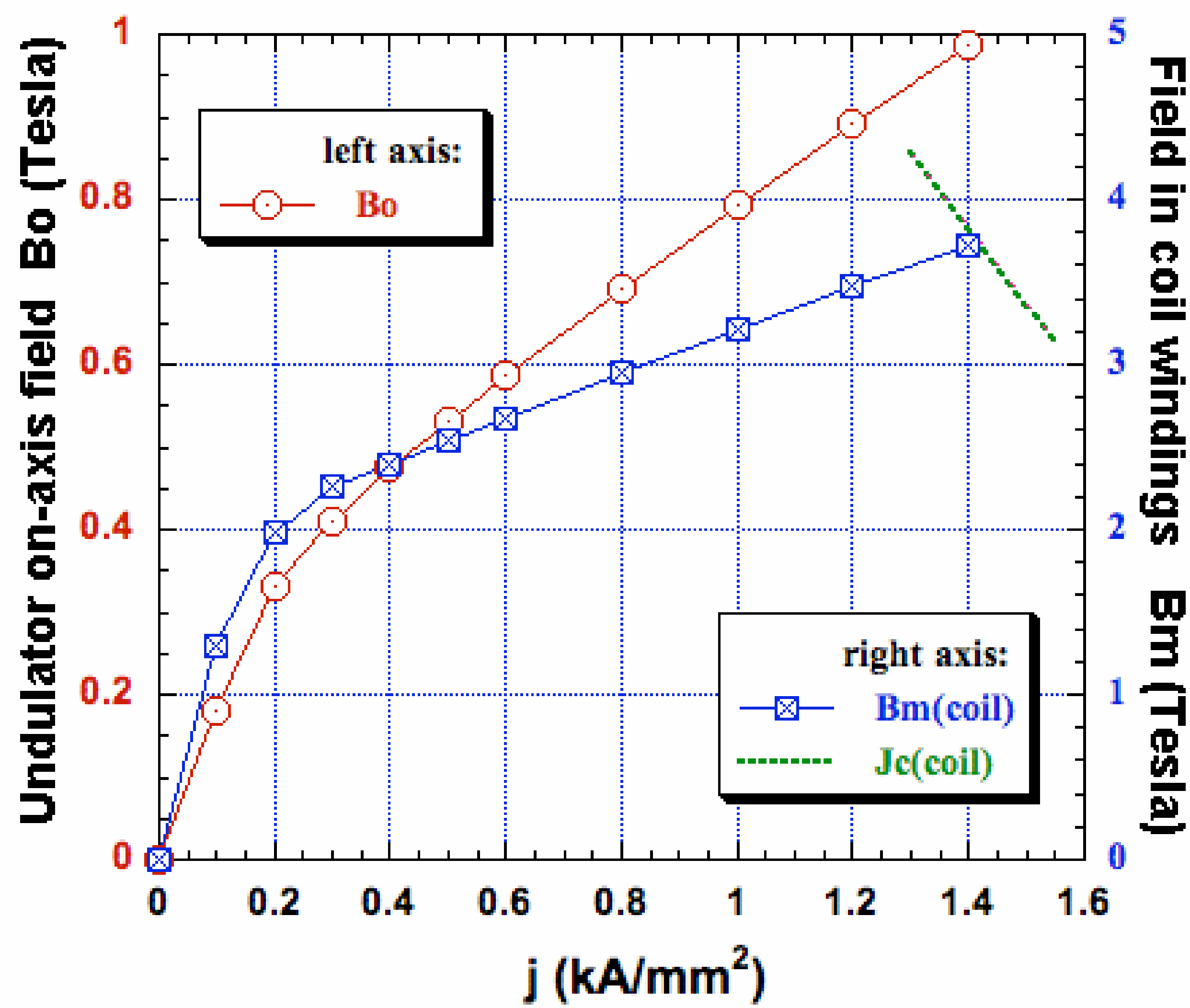


Goals for undulator:

- 15-mm period (or shorter)
- 0.8 T field (or higher)
- 1st harmonic tunable down to 20 keV
- Field quality adequate for strong 3rd harmonic

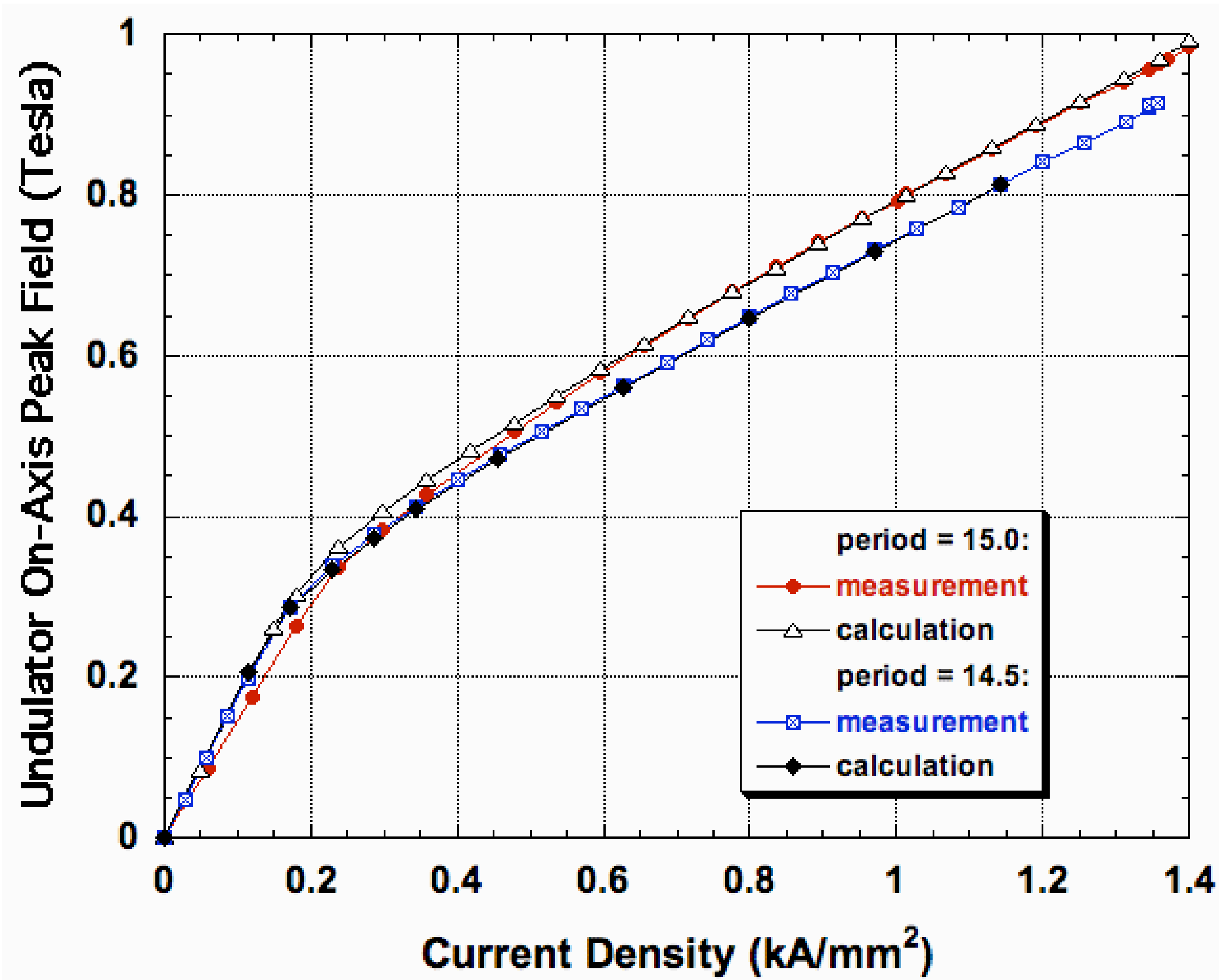
Magnetic model calculations

Advanced Photon Source



8 mm
pole
gap

High current density tests



Next steps for R&D

1. Build a second NbTi coil so a short section of a full undulator can be measured
    - Field measurement, field quality, and magnetic tuning issues can be studied
2. Test sections using Nb_3Sn wire
    - Higher critical current
    - Must be wound in its non-superconducting state, then fired
    - After processing, wire is brittle

Options for acquiring a superconducting und.

1) ACCEL:
   Design based on NbTi conductor
   Prototypes promising, approach looks feasible but not much margin
   Magnetic measurement & tuning not finalized

2) A collaboration with Nat'l High Magnetic Field Lab in Florida
   Design based on Nb_3Sn conductor (higher critical current)
   Proposed design has wider magnetic gap so beam chamber is at liq N_2 temp.
   No pressure bursts in ring even if superconductor quenches
   They know Nb_3Sn and know who can wind to their specs
   Collaborate on measurement & tuning
   Prototype first

3) Collaborating with Berkeley, who also are working on one