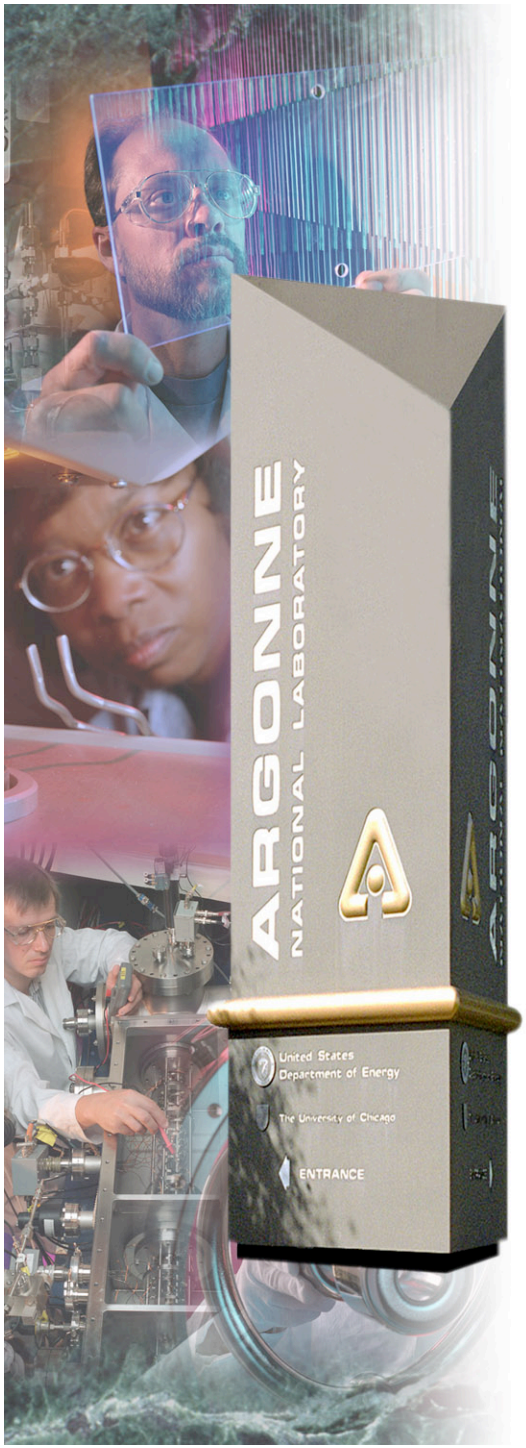


Magnet Material Choice

Liz Moog

LCLS Undulator System
Final LLP Pre-production Review
15-16 Nov 2004

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

Potential vendors

Prequalified:

- **Shin-Etsu**
- **Neomax (formerly Sumitomo Special Metals)**

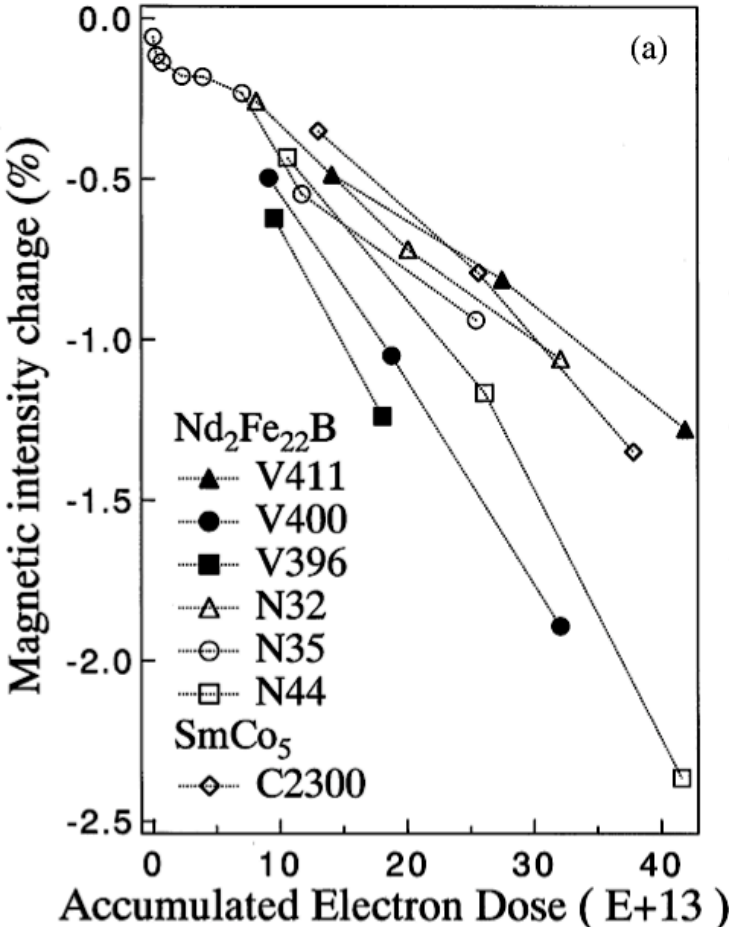
Others:

- **Outokumpu**
- **Vacuumschmelze**
- **Ugimag**
- **Dexter (representing Chinese manufacturer)**

Radiation resistance

- A significant issue for LCLS magnet choice is radiation resistance.
- Radiation resistance has been found to vary with the vendor
- Within a particular vendor's line, higher coercivity is correlated to better radiation resistance.

Some published radiation results

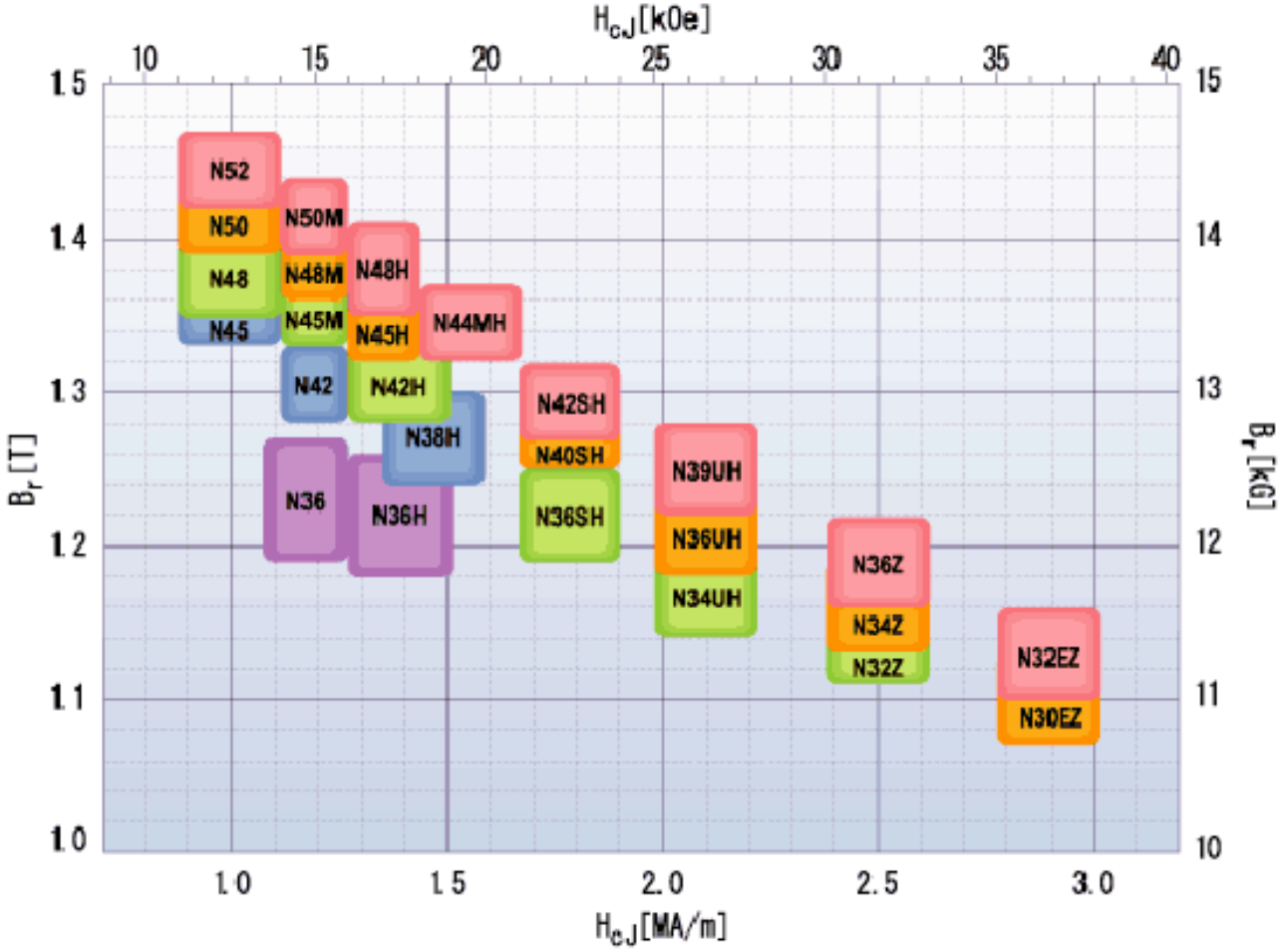


Label	Material	Br (T)	Hcj (kA/m)
V411	VACODYM411	1.00	3260
V400	VACODYM400	1.10	2470
V396	VACODYM396	1.15	2150
N32	NEOMAX-32EH	1.11	2387
N35	NEOMAX-35EH	1.17	1989
N44	NEOMAX-44H	1.36	1273
C2300	CORMAX2300	0.93	796

Reprinted from Nucl. Instrum. Meth. Phys. Res. A, Vol. 467-468, T. Bizen et al., "Demagnetization of undulator magnets irradiated by high energy electrons", pp. 185-189 (2001), with permission from Elsevier.

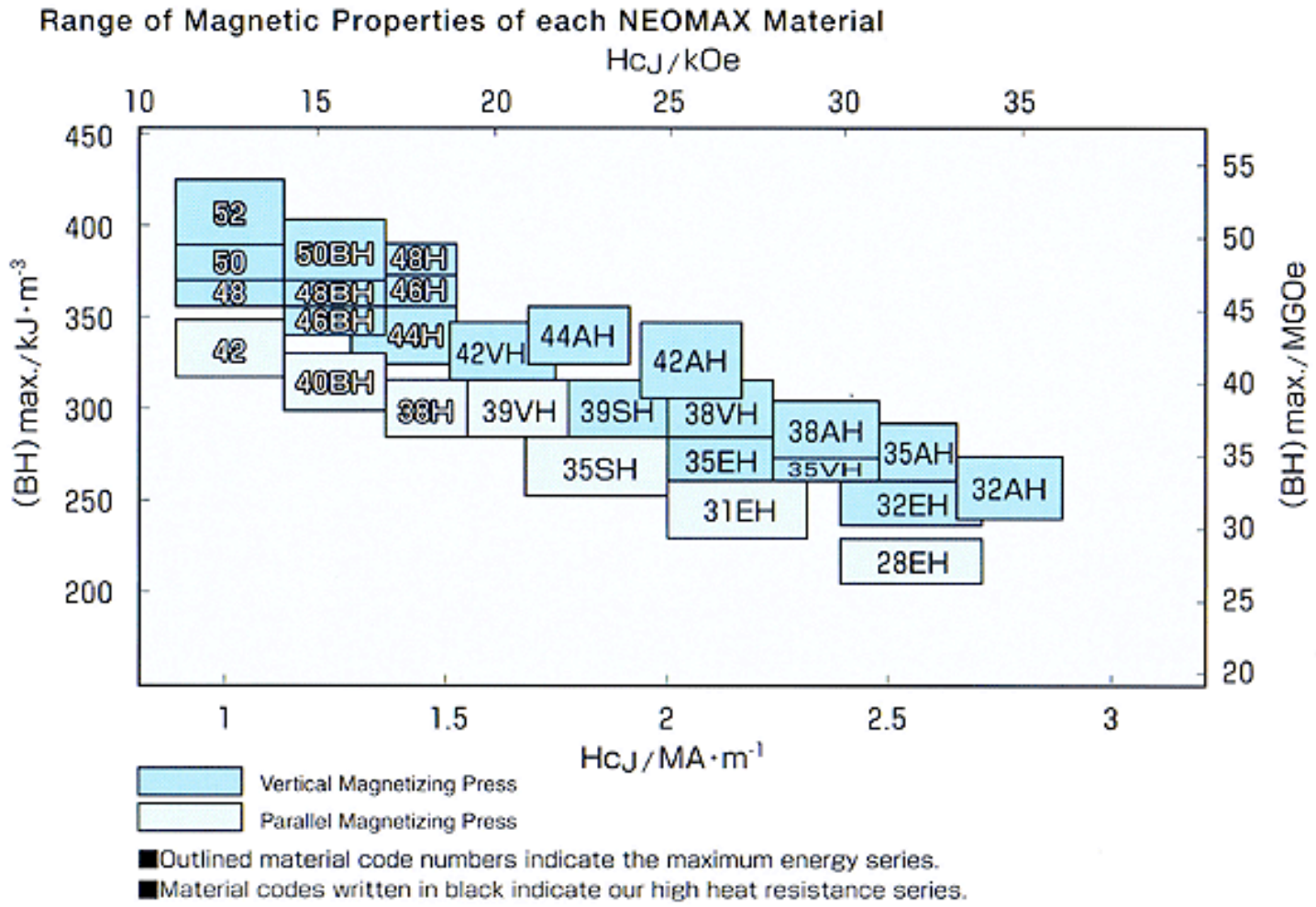
Shin-Etsu magnet grades

N39SH from Shin-Etsu was used for the prototype undulator, but newer and better magnet grades are now available



Neomax magnet grades

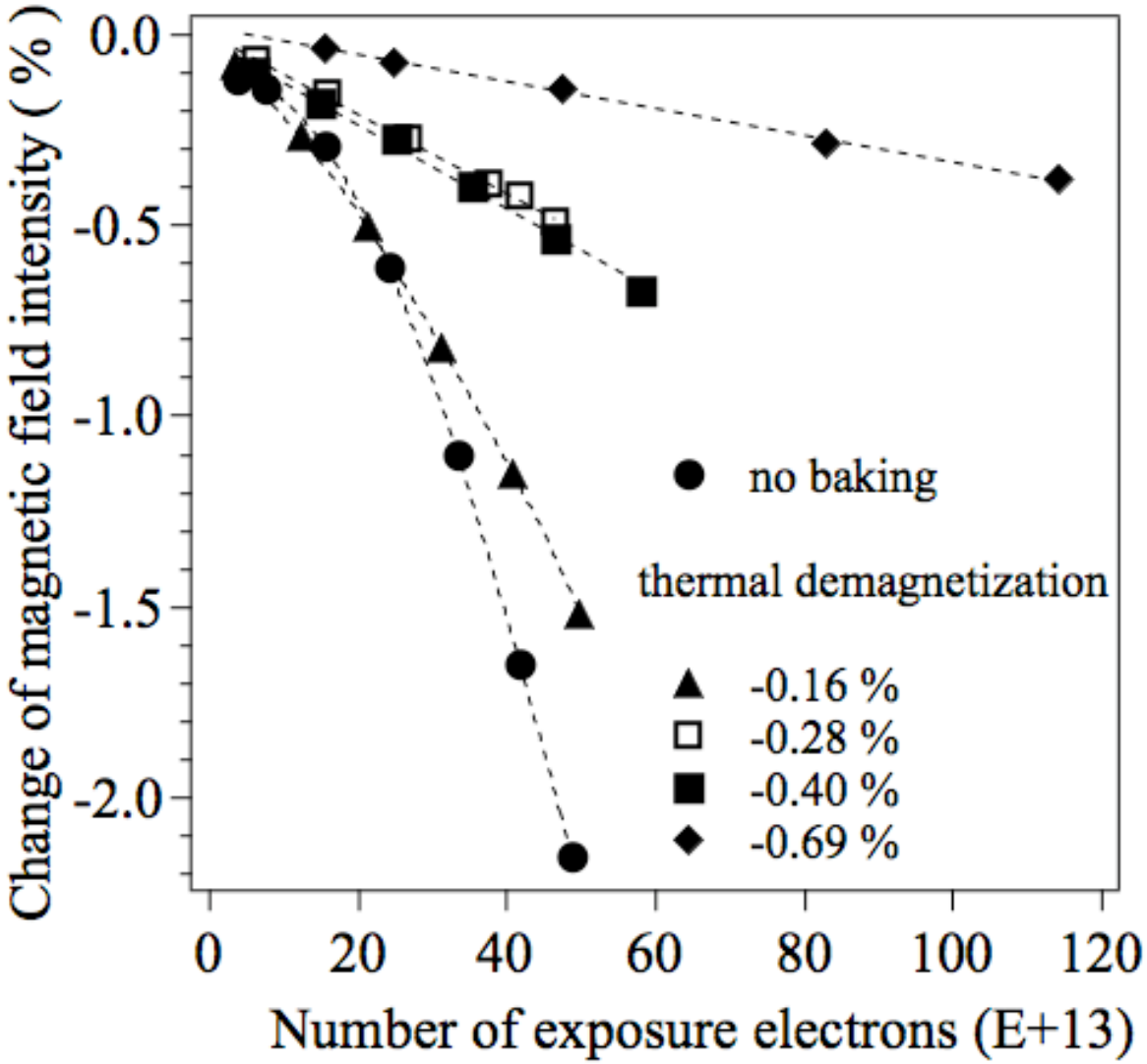
Neomax 38VH is equivalent to Shin-Etsu N39UH



Newest grade availability / cost

- Neomax gave us quotes for 42AH and 44AH on a recent (summer 2004) magnet procurement.
- Cost was ~25% higher than for 38VH.
- Delivery schedule was 90 days longer (240 days vs 150 days).
- These grades require an ingredient that presents availability challenges.
- Neomax is presently challenged to meet customer demand; they are expanding production capability

Heat treatment can improve NdFeB resistance

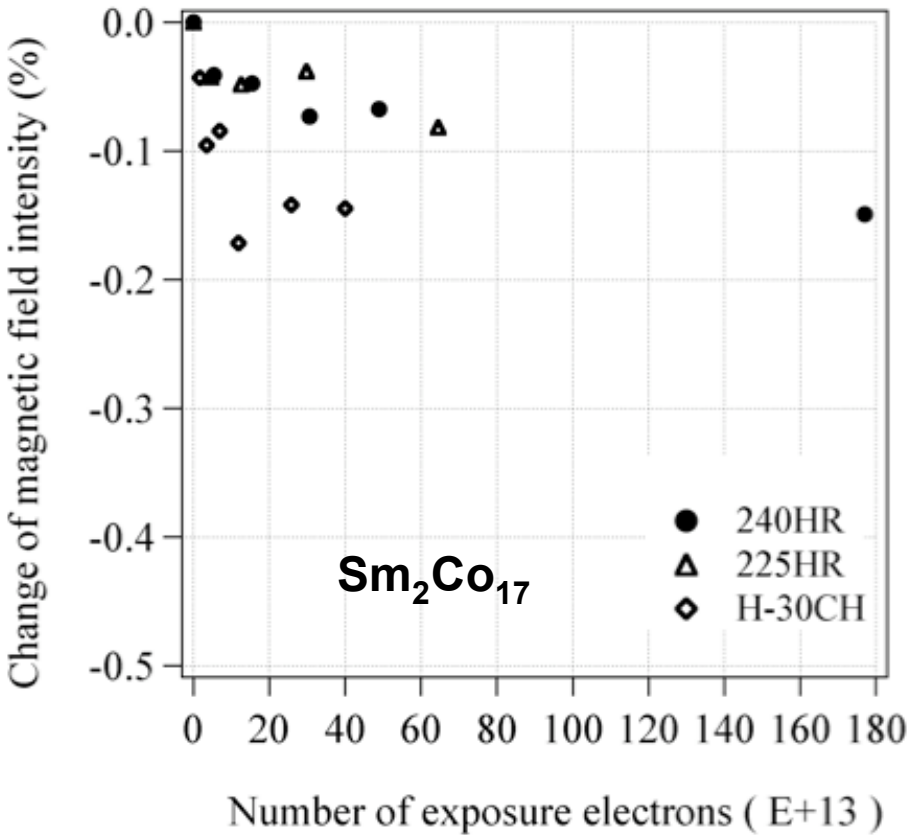


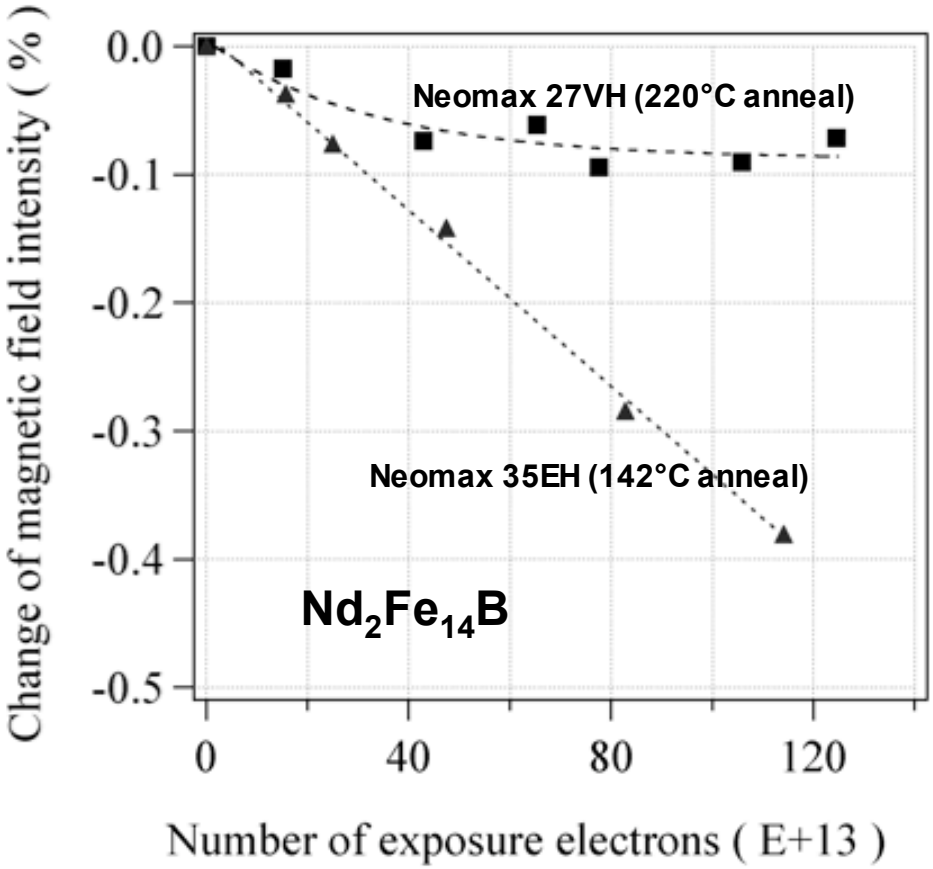
Radiation effect on 35EH magnets after different bake times at 142°C.

Longest bake is 24 hrs.

(Reprinted from Nucl. Instrum. Meth. Phys. Res. A, Vol. 515, T. Bizen et al., "Baking effect for NdFeB magnets against demagnetization induced by high energy electrons", pp. 850-2 (2003), with permission from Elsevier.)

Compare Sm_2Co_{17} and $Nd_2Fe_{14}B$





(T. Bizen, et al., Proceedings of 8th Int'l. Conf. on Synchrotron Radiation Instrum., 25-29Aug 2003, San Francisco, CA (2004, Amer. Inst. of Physics) p. 167)

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Br comparison:

27VH: 1.02 - 1.10 T

35EH: 1.17 - 1.25 T

240HR, 225HR: 1.11 T

SmCo magnets

- SmCo magnets were considered for the LCLS undulator
- More resistance to radiation
- But weaker magnetically
- More brittle to handle
- Long-lived activation
- We have no experience with it (yet)

The decision was made to opt for the known material, NdFeB.