Review of paper by Hassenzahl et al.:

“An Assessment of the Effects of Radiation on Permanent-Magnet Material in the ALS Insertion Devices”

Two questions to answer:

A. Choose Sm-Co or Nd-Fe-B for PM material?
   - Nd-Fe-B more sensitive to radiation.
   - Sm-Co much more expensive.

B. What material (Al or Fe) to use for beam pipe?
   - Aluminum less expensive than stainless steel.
   - SS has higher Z... will it provide shielding?

- Thin-walls (0.3 cm) and PM close to beam (1 cm).
A. Effects of radiation on magnetized Nd-Fe-B:

**Neutrons**

![Graph showing loss of remanence in Nd-Fe-B due to neutron irradiation]

Fig. 1. Loss of remanence in Nd-Fe-B due to neutron irradiation.

**Ionizing Radiation**

![Graph showing effects of ionizing radiation on remanence of Nd-Fe-B magnetic material]

Fig. 2. Effects of ionizing radiation on the remanence of Nd-Fe-B magnetic material. Note the estimated dose of about $2 \times 10^4$ Gy for the ALS insertion devices.

- Several studies — some effect after $2 \times 10^6$ Gy (1 Gy = 100 rad).
- < 0.5% with $10^5$ Gy ($10^7$ rad).
B. Radiation doses expected in ALS ID’s:

- **Swanson (hand) calculation**
  - Uniform loss of electrons around ring.
  - Dose caused by *bremsstrahlung*.
  - 400 mA/fill of 1.5 GeV electrons.
  - 2 fills/day (about 700 fills/year).
  - $2 \times 10^6$ J (annual energy loss from decay/dumping)

- Result: $1.5 \times 10^3$ Gy/y ($3 \times 10^4$ Gy in 20 y).

(see figures... . . . . no problems)
B. Radiation doses expected in ALS ID's (continued):

(e- actually strike pipe at small θ)
B. Radiation doses expected in ALS ID’s (continued):

- **Al/Fe**
  - Depth, $z$ (cm)
  - $r=0.3$ cm
  - $10cm$
  - $0.022$

- **Fe/Fe**
  - Depth, $z$ (cm)
  - $r=0.3$ cm
  - $5cm$
  - $0.025$

See Fig. 8
B. Radiation doses expected in ALS ID’s (continued):

\[
D(Gy) = \left( \frac{dE}{dV} \right) \left( \frac{E_o}{\rho} \right) \times 1.6 \times 10^{-10}
\]

\[
D_{Al-BP} = (0.022) \left( \frac{1.5 \times 10^3}{7.85} \right) 1.6 \times 10^{-10}
\]
\[
\times \left( \frac{1}{2} \right) \left( \frac{1}{5} \right) \left( \frac{10\text{ cm}}{500\text{ cm}} \right)
\]
\[
\times 50\% \quad 1\ out\ of\ \ 5\ ID's
\]
\[
= 0.15 \times 10^4 \text{ Gy/y}
\]

\[
D_{Fe-BP} = (0.035) \quad \text{same...}
\]
\[
\quad \text{... same...} \quad \left( \frac{5\text{ cm}}{500\text{ cm}} \right)
\]
\[
= 0.13 \times 10^4 \text{ Gy/y}
\]
Conclusions

- Al or Fe beampiple give same results.
- 20 year dose will be about $3 \times 10^4$ Gy
- Can use Nd-Fe-B instead of Sm-Co.