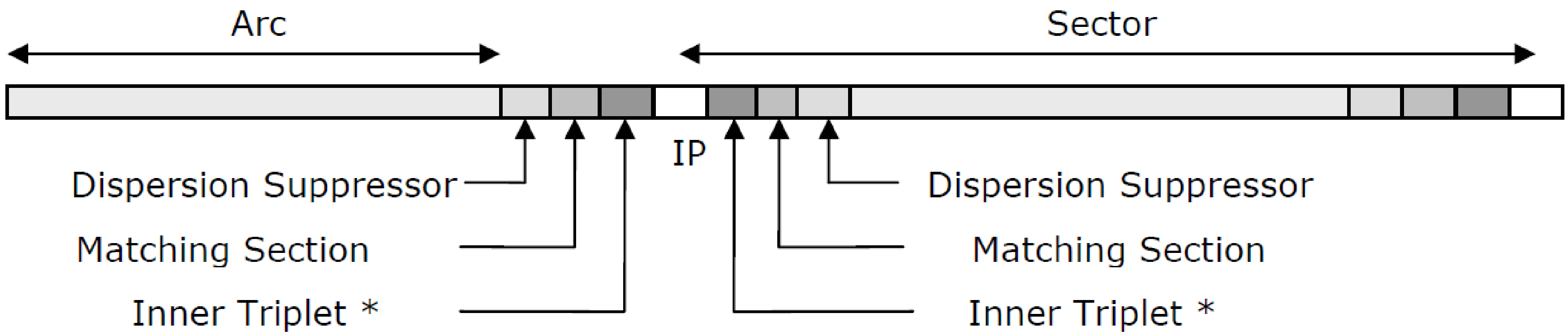
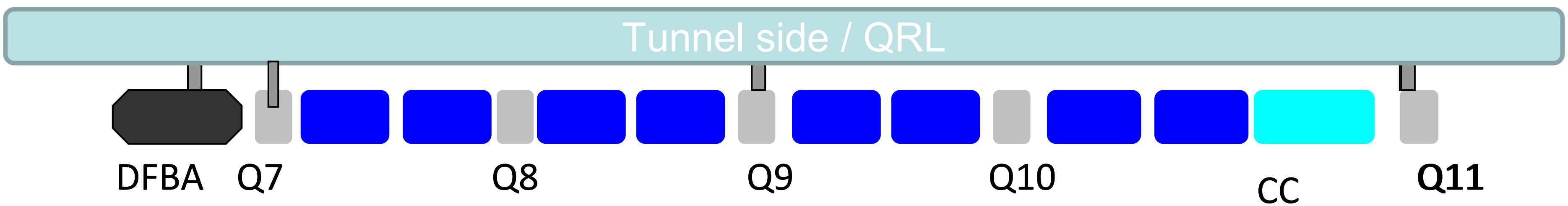
Magnets
Materials
Effects of radiations
Conclusion

Magnets





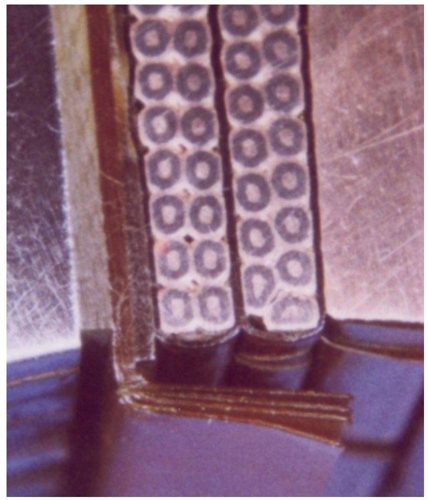
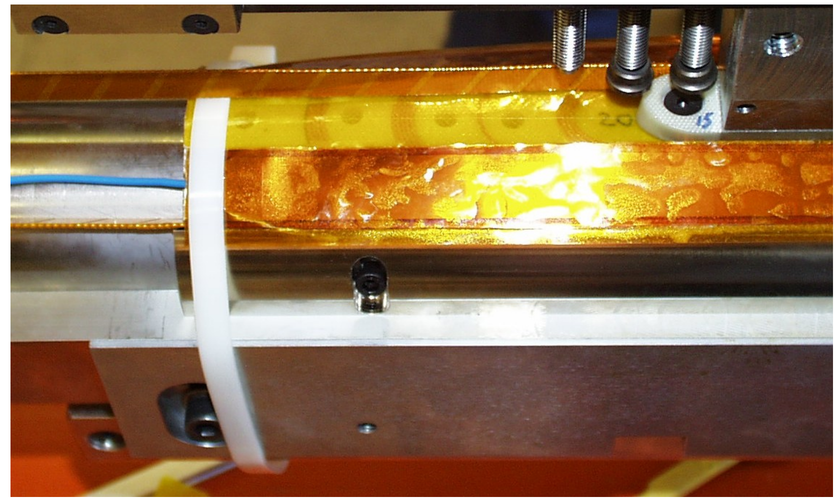
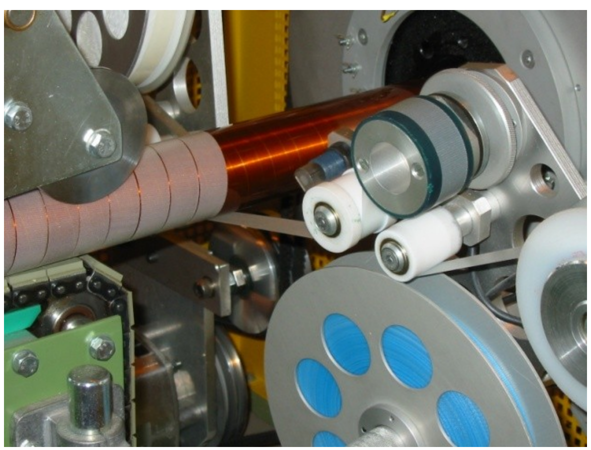
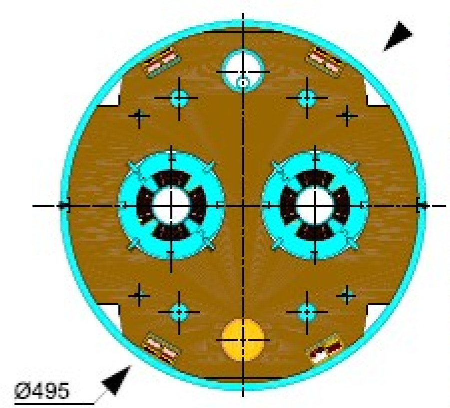
	Sectors 1-2-4-5-6-8	Sectors 3-7
Q8	MQML+MCBC	MQ+MQTL+MCBC
Q9	MQMC+MQM+MCBC	MQ+2xMQTL+MCBC
Q10	MQML+MCBC	MQ+MQTL+MCBC
Q11	MQ+MQTL+MSCB	

Q8-Q10-Q11 are 6620 mm long, Q9 is 8020 mm long, all magnets @ 1.9 K

Plastic Materials

polyimide (bare and adhesive)
epoxy (Bisphenol A) - fiberglass (E-type) composites
other filled (glass or alumina) epoxy resins or polyetherimide (Ultem)



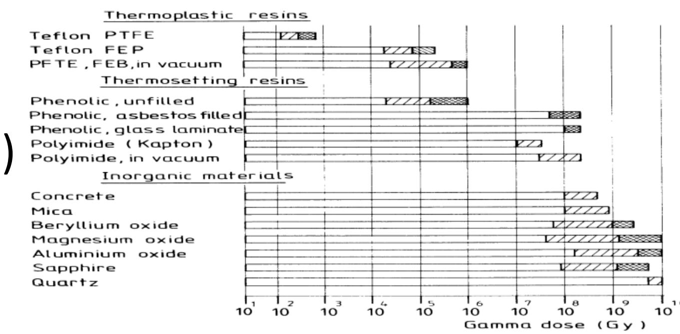
Effects of radiations on plastics: generalities

They depend on:

- the material
- the environment (for example presence/absence of oxygen)
- the radiation characteristics
- the absorbed energy (1 Gray = 1 J/kg)*

They can produce:

- increase of cross-linking, strengthening- embrittlement –breaking
- creation of free radicals by breakage of molecular bonds
- formation of gas producing delamination in composite materials



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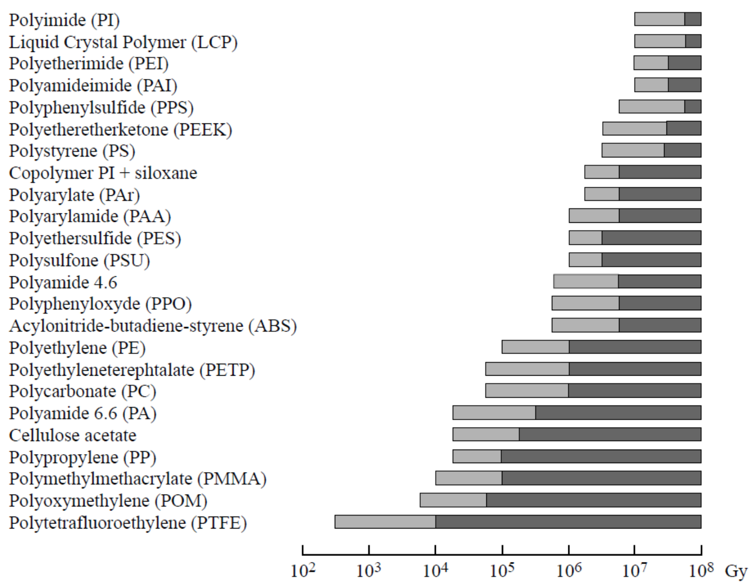

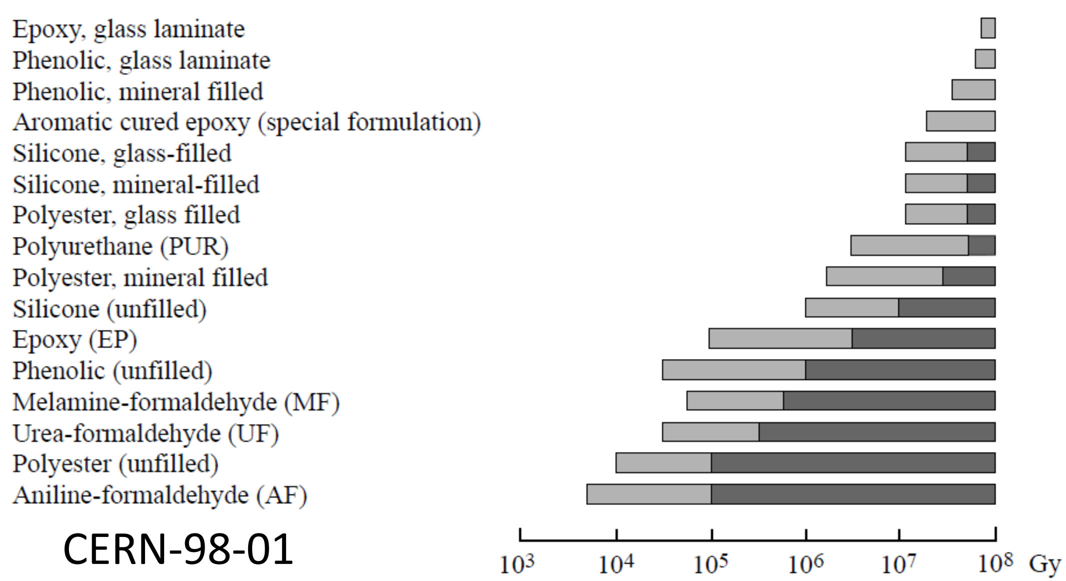

CERN-98-01

*please note that its estimate from fluence maps is very complicated and only approximate

Effects of radiations on plastics: data

EFFECTS OF RADIATION AT 5 K ON ORGANIC INSULATORS FOR SUPERCONDUCTING MAGNETS*

R. R. Coltman, Jr., C. E. Klabunde, R. H. Kernohan, and C. J. Long

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Oak Ridge, Tennessee 37830

1979

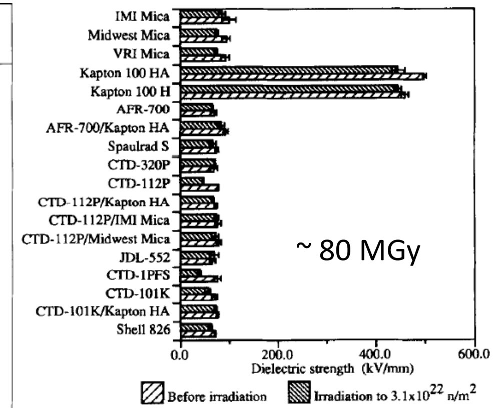
1. Stycast 2850 FT (Blue) — Epoxy, with 7% 24 LV hardener; Emerson and Cuming, Inc.; an inorganically filled room-temperature-curing epoxy.
2. EPON 828 — Epoxy, with 20-pph-Z curing agent, 0.5% Z6020 Silane couplant; Shell Chemical Company; filled with 40 wt% 400-mesh SiO_2 (80°C cure, followed by 150°C post-cure).
3. G-10 CR — National Electrical Manufacturers Association (NEMA), a heat-activated amine-catalyzed bisphenol solid type epoxy resin laminate reinforced with continuous filament E Glass fabric, silane finished; designated for cryogenic use; Spaulding Fibre Company.
4. G-10 CR (BF) — Same as No. 3, except made with boron-free E Glass.
5. G-11 CR — Same as No. 3, except that an aromatic amine-hardened bisphenol liquid-type epoxy resin is used in its fabrication.
6. Nomex 410 — Paper, type 410; E. I. Du Pont de Nemours & Company; aromatic polyamide (aramid) sheet.
7. Kapton H — Film; E. I. Du Pont de Nemours & Company; polyimide film frequently used in magnets.

γ-irradiation @ 5K
"low" = 24 MGy
"high"=100 MGy

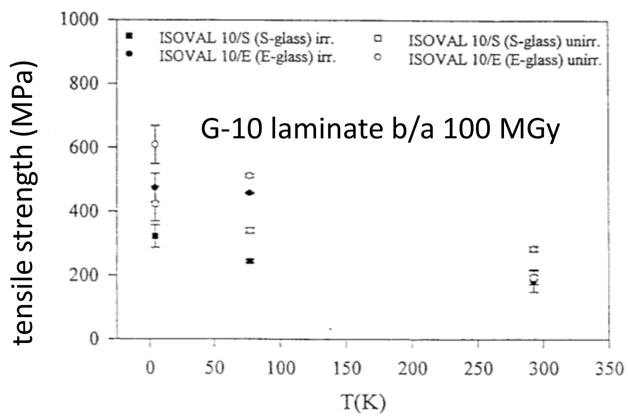
no effects at "low"
some effects at "high" for Stycast, G10 and G11

Material	Description	Supplier	Fabrication	Cure cycle	Specimen thickness (mm)
CTD-101K	Flex. DGEBA	CTD	RTM	1.5 h at 135°C	0.53
Shell 826	DGEBA	Shell	RTM	4 h at 150°C	0.53
CTD-112P	TGDM	CTD	Prepreg	2 h at 177°C + 7 h at 200°C	0.56
JDL-552	TGDM/DGEBA blend	J.D. Lincoln	Prepreg	1 h at 177°C + 2 h at 150°C + 2 h at 200°C	0.59
CTD-1PFS	One part DGEBA	CTD	Prepreg	2 h at 150°C + 1 h at 175°C	0.60
CTD-320P	Polyimide	CTD	Laminate	1 h at 300°C	0.68
AFR-700	Polyimide	Hexcel	Laminate	1 h at 300°C + 1 h at 600°C	0.51
Spaulrad S	Polyimide, S-2 glass fabric	Spaulding Composites	Laminate	Fabricated by supplier	0.50
Kapton H	Polyimide film	duPont			0.025
Kapton HA	Amorphous PI	duPont			0.025
VRI 366.63	Mica paper	VRI		2 h at 177°C	0.21
MM #553	Mica paper	MM		2 h at 177°C	0.44
IMI 498-37B	Mica paper	IMI		2 h at 177°C	0.24
CTD-1010K/Kapton HA	Hybrid			(Hybrids fabricated like primary insulation)	0.57
CTD-112P/MM#553	Hybrid				0.60
CTD-112P/IMI 498-37B	Hybrid				0.66
CTD-112P/Kapton HA	Hybrid				0.58
AFT-700/Kapton HA	Hybrid				0.52

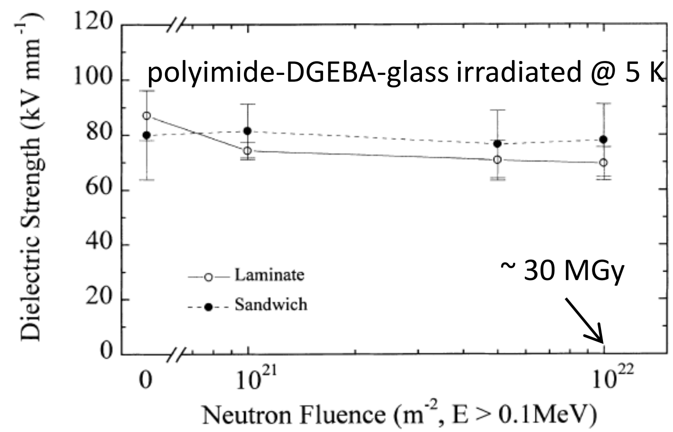
VRI—Von Roll Isola; MM—Midwest Mica; IMI—Insulating Materials Inc.; All mica papers are calcined



irradiation @ 4K in Garching. Source: J.B. Schutz *et al.*, *Cryogenics* **35** (1995), p. 759.



source: workshop on advanced materials for high precision detectors, CERN, 1994
Tests done according to IEC 544 with γ



source: H.Kumer et al, Cryogenics 40, 2000

Journal of Nuclear Materials 115 (1983) 11–15
North-Holland Publishing Company

11

LOW TEMPERATURE NEUTRON AND GAMMA IRRADIATION OF GLASS FIBER REINFORCED EPOXIES

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Measurements of the fracture strength of epoxies, which are reinforced with different types of fiber glass and used commercially for magnet insulation are described. The samples were exposed to reactor irradiation at 77 K, and measurements of tensile strength in the direction of the fibers were taken at the same temperature without warm up. The results show moderate degradation of the fracture strength up to a total dose of 7.4×10^7 Gy, a linear swelling by about 5% at the same dose and a total destruction of the composite after a dose of $\sim 1.5 \times 10^8$ Gy.

Effects of radiations on plastics: heavy ions

Proceedings of HB2010, Morschach, Switzerland THO2C04

RADIATION HARDNESS OF INSULATING COMPONENTS FOR THE NEW HEAVY-ION ACCELERATOR FACILITY

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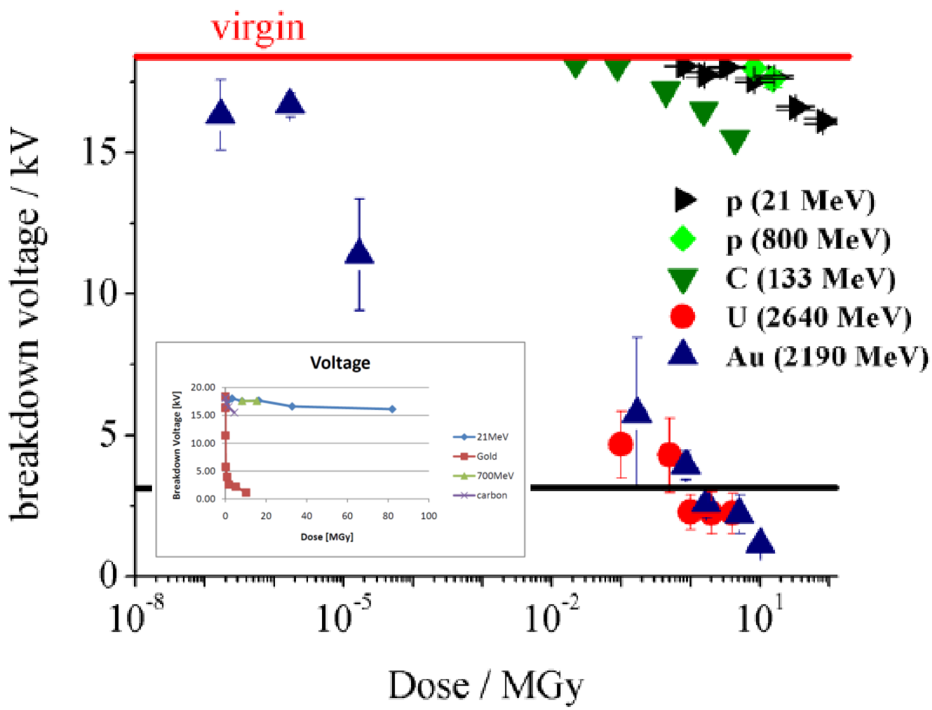
Type of Ion	Max. Dose (MGy)	$-dE/dx_{el}$ (keV/nm)	Kinetic Energy (MeV)	Facility
Protons (H)	82	0.003	21	ITEP
Protons (H)	3	0.0003	800	ITEP
Carbon (C)	4.4	0.21	132	GSI
Nickel (Ni)	50	4	638	GSI
Gold (Au)	10.1	15	2200	GSI
Uranium (U)	4	17	2840	GSI

all tests on polyimide foils, 50 μm thick

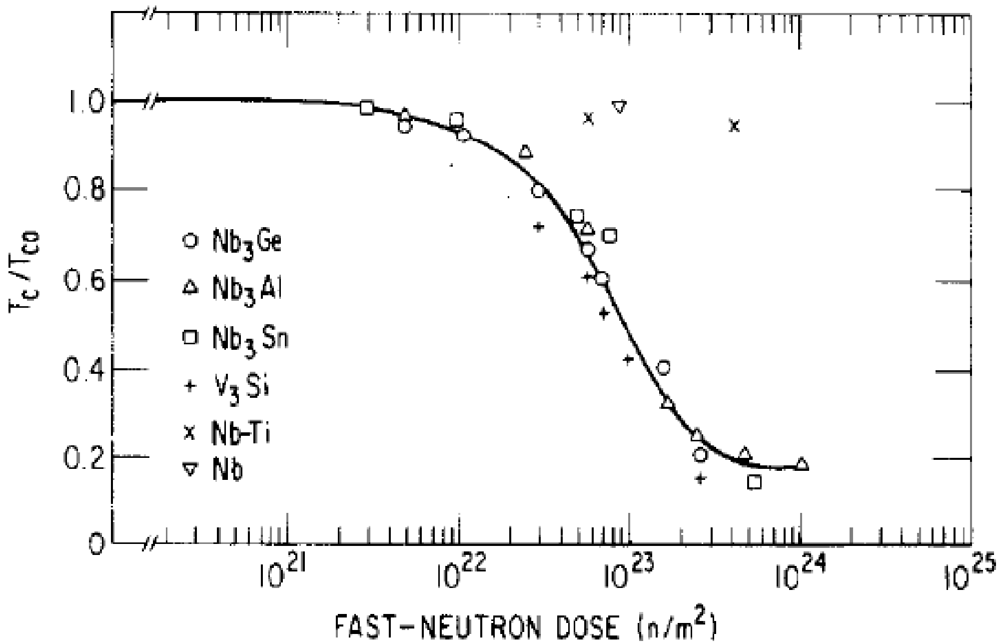


not really much information, heavy ions may trigger specific processes at low doses

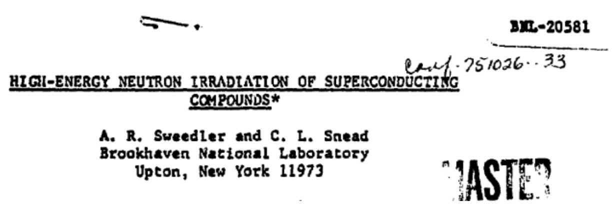
Effects of radiations on superconductors

Radiation may affect:

- the superconductor, with effect on T_c (disorder) and on J_c (pinning)
- the copper matrix, with effect on resistivity **BUT** no experience with irradiation at low T



A.R. Sweedler et al, , J. Nucl. Mater. 72 (1978) 50



BNL-20581

Conf-751026--33

HIGH-ENERGY NEUTRON IRRADIATION OF SUPERCONDUCTING COMPOUNDS*

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MASTER

Conclusion

- the materials used in the DS magnets are very robust to radiation
- up to 10 MGy we do not expect problems, except if structural loads act as accelerators
- between 10 MGy and 100 MGy the magnet “may” survive
- above 100 MGy the structural plastic components will certainly fail
- heavy ions may be a concern already below 1MGy : this needs further studies

bombardment by heavy ions may merit some further thoughts and experiments

estimate of “absorbed doses” in the plastic parts of these magnets