HSE
Occupational Health & Safety
and Environmental Protection unit

NIR sources at CERN

NIR Seminar

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CERN's low frequency NIR sources

Magnets

warm

superconducting

permanent

Electricity supply

Electricity conversion

substations

cables

UPS

SVC

power converters

Transient fields from kickers and high-power modulators

Welding/brazing

General spectrum of NIR sources

Electromagnetic Spectrum	Induced voltage in a 20cm Ø loop (size of the head) at 1µT flux density
0 Hz (static and quasi-static magn. field)	0 (except you move through field lines)
50 Hz mains frequency	69.7 nV
1 kHz audio frequency	1.39 µV
1 MHz broadcast medium wave	1.39 mV (theoretical value, body starts to screen)
28 MHz short wave	body (water) screens, no field inside body
100 MHz broadcast FM		
900 MHz portable telephone		For all induced voltages the limit
1.8 GHz portable telephone		is 100µV, which can be reached
2.45 GHz WLAN and microwave oven		either by increasing the field or by
1 THz human body radiation		increasing the frequency, or both.
6 THz infrared heat radiation		
385 THz visible light red		
789 THz visible light blue		
1 PHz UV radiation		
300 Phz Röntgen ("X-ray")		
300 Ehz Gamma-rays	

Magnetic NIR sources (alternating, unipolar and transient fields)

Summary table of sources	Characteristic values
a) Magnet flux densities up to 10 Tesla	Static field. Technical consequences only.
a) Radio frequency power up to 5 MW	Closed circuit installation. Small leakage in vicinity.
b) Modulated power in the MW range	idem
c) Powerful power factor compensators	Dynamic magnetic fields up to 1 kHz. No access.
d) Special power supplies in bulks	Bulk operation creates NIR "cloud" up to 200MHz.
e) Kickers (i.e. transient magnets)	Strong transients. Technical consequences only.
f) UPS	8 kHz + harmonics, 50Hz + harm., no pacemaker
g) Power supplies with smoothing coils	Altern. magnetic fields up to 50 kHz. Hazardous.
h) Brazing and welding	Altern. magnetic fields around 5 kHz. Hazardous
i) Power transformers	Altern. magnetic fields. Hazardous.
j) Power lines	Altern. magnetic fields depend on load, degree symmetry, conductor configuration, THD. Permanent close vicinity exposure is not recommended.

NIR out of warm magnets

High Energy Physics runs magnets with currents up to 10 kA, fed by thyristor rectifiers.

The static magnetic fields cannot change fast enough to induce anything.

The ripple of the current pushes the corresponding alternating fields (usually at 600Hz fundamental on 12-pulse rectifiers) into the air gaps. Small induction may occur.

NIR exposure is limited to dynamic magnetic near-fields close to the power transformer and rectifier, where there is no access for persons.

Static magnetic fields were limited to very low values by the EC. No study has proven any danger below 1, or even 2 Tesla.

The present limits are 10 mT for the public, 0.5 mt for pacemaker wearers and 2000mT for a 8 hour full body occupational exposure.

The real danger is malfunctioning equipment, such as electric motors or electromagnetic valves, and projectiles accelerated by the magnetic field.

NIR out of cold magnets

CERN runs superconducting magnets with currents up to 24 kA, fed by switch mode power supplies.

The static magnetic fields cannot change fast enough to induce some voltage nearby.

However, these magnets need extensive thermal screening, massive mechanical supports to hold the conductors in place and in most cases a vacuum vessel for further insulation.

The fastest field collapse, the quench, induces voltages in the vessels but eddy currents do limit the gradient.

Backquench protection

The effects of a quench can be lowered by eddy currents driven by the induced emf. Part of the magnet field energy is converted to heat and damps all field changes towards the outside.

No noticeable effects are known with respect to exposure of personnel to static, quasi-static or dynamic magnetic near-fields.

There are no known physiological hazards for persons resulting from these fields.

Measurements were taken in SM18.

No exposure occurred.

NIR due to RF Generation

Today's sources of high power RF are large klystrons for CW or pulsed operation, and large semiconductor packs.

Stringent checks and carefully engineered flanges keep the installation's leakage radiation to a minimum.

Hazards appear when

Equipment malfunctions
Corrosion or overheating occurs
Mechanical deformation is inflicted
Bad operation destroys components
AND the collective protection fails

What are the real values?

A 5 MW klystron feeding a rectangular waveguide at 353 MHz (e.g. LINAV IV) exhibits a near field of less than 1 V/m on any frequency.
No bigger field levels are measured along the waveguide, provided the flanges are done as prescribed by the manufacturer.

Accelerator operators need to respect CISPR11 (EN55011) OUTSIDE the research premises. Interlock receivers will react on higher than allowed leakage radiation (Collective protection). Interlocks against technical parameters, e.g. SWR, complete the protection.

Power Factor Compensators

Large accelerator centres need hundreds of Megawatts of pulsed power. Part of this power is reactive power that needs to be compensated in order to keep the mains voltage sinusoïdal.

CERN runs compensators with power levels up to 150 MVAr (about 3000 Amps@18kV).

Powerful dynamic magnetic near fields force CERN to establish exclusion zones for personnel.

Results of simulations and measurements:

Up to 1.6mT@50Hz on the footpaths between the compensators, lower values for 5th, 7th, 11th and 13th harmonic. During operation this zone is a no go, even for professionals.

The field levels, however, do not say very much. Only together with the frequency they give an indication how much is induced in the human body and, more specifically, into the surface of the head (law of induction).
Short term exposure to ELF magnetic near-fields causes headache and fatigue.

ELF dyn. magn. near fields increase the likelihood of illnesses, in part. leucemia.
Their reach is limited.
In general the dimension of the equipment suggests the safety distance.

Special Power Supplies

Special equipment may hide some bad surprises.	CE-marking has improved the way equipment is made and used
High current busbars Unacceptably high NIR values were found next to certain busbars where people can access installations. Ageing of components accelerated by radiation (cables, capacitors) Lack of time and opportunity for testing all safety aspects under close-to-reality conditions Short operating times considered "not dangerous"	CERN had a NIR-case in the past A power supply smoothing coil was not properly shielded. The coil had no iron core. No permanent damage was inflicted to our personnel Other cases were treated on the grounds of prevention. All cases were ELF except two: a) Physicists modified a microwave oven and ran it "open" b) Testing of a 2MW amplifier was done without covers, causing not only exposure of personnel but also triggering of alarm systems and disturbance of the radio spectrum. The testing was stopped by HSE because of imminent danger.

NIR of high power transient magnets

Kickers (and magnetic horns)

Kickers are used to deviate particle beams into a new direction, either when entering or exiting a particle orbit.

As high as possible transient magnetic fields are required for a few microseconds. Kickers are fed by capacitor banks being discharged when action is needed.

Currents reach 180 kA at CERN (stronger than most lightning). Transient fields occur around power feeders and the kickers themselves.

In contrary to (quasi)static magnets that precisely define particle orbits the kicker magnets are higly laminated to allow for best transient behaviour.

Core material is specially selected for best performance.

In consequence kickers issue strong transient fields that are dangerous in immediate proximity.

Personnel may be exposed during tests and is kept at safe distance by a procedural approach.

Once installed this equipment also issues ionising radiation which prevents people from coming close.

Conclusions

CERN's static and low frequency NIR sources are well governed.

Where field levels require access restrictions instructions or barriers are decreed.

The zone of influence is the close vicinity, often anyway a restricted access zone because of other reasons, such as ionising radiation, electrical safety or underground general safety.

The size of the equipment suggests the magnetic fringe field volume, and as such the zones directly concerned.

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