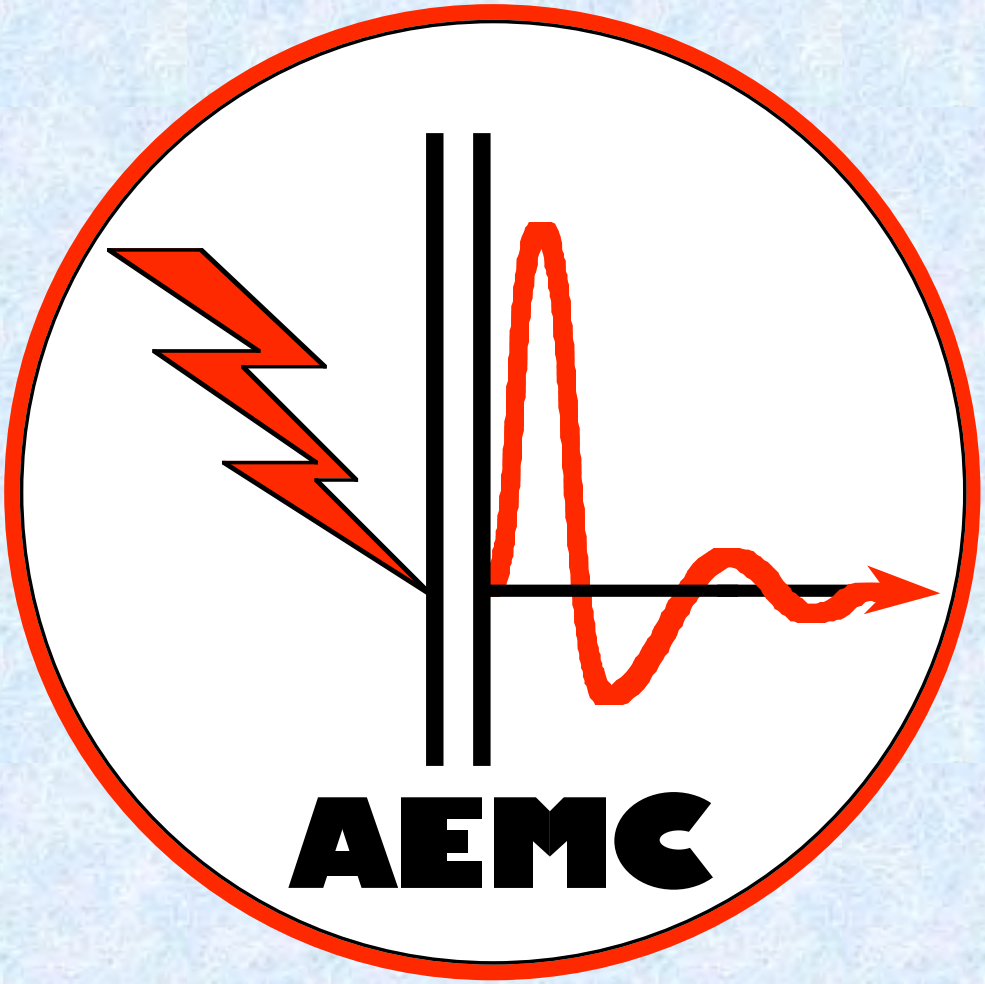
ElectroMagnetic Interference



Recurrent EMI mistakes - Good & poor practical fixes

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Electromagnetism is electricity

- **Conducted disturbances**
  - Current — i (in amps) — 10 mA (permanent) to > 10 amps (peak)
  - Voltage — u (in volts) — 1 V (permanent) to > 1 kV (peak)
  - Impedance — Z = u / i (in ohms) — typically 40 to 400 Ω (in HF)
  - Power — $P = u_x i$ (in watts) — mW (permanent) to > MW (transient)
  - Delay of propagation — ≈ 5 ns/m (in any cable)

- **Radiated disturbances**
  - Magnetic field — H (in A/m) — B may exceed 100 mT in DC
  - Electric field — E (in V/m) — 1 V/m (CW) to kV/m (impulse)
  - Impedance — (Z = E / H, in Ω) — 377 Ω for “far field” in air or vacuum
  - Power density — ($P = E_x H$, in W/m^2) — 1 W/m^2 (CW) to MW/m^2 (transient)
  - Propagation speed — ≈ 300 000 km/s — in air or in vacuum

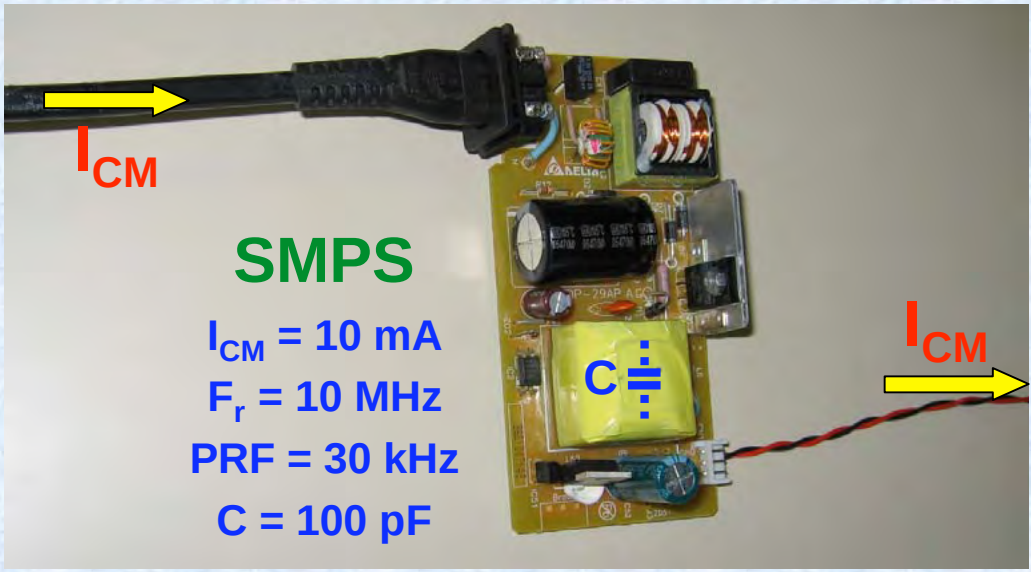
Some usual EMI Sources

Talkie-walkie

E = 10 V/m @ 1 m

Cell-phone

E = 3 V/m @ 1 m



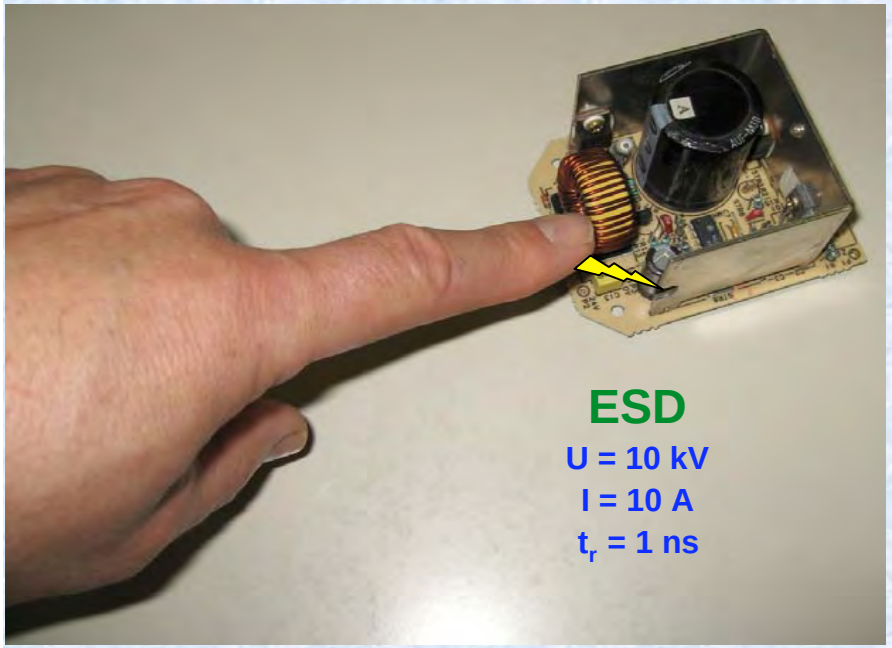
SMPS

I_{CM} = 10 mA

F_r = 10 MHz

PRF = 30 kHz

C = 100 pF



ESD

U = 10 kV

I = 10 A

t_r = 1 ns

Lightning

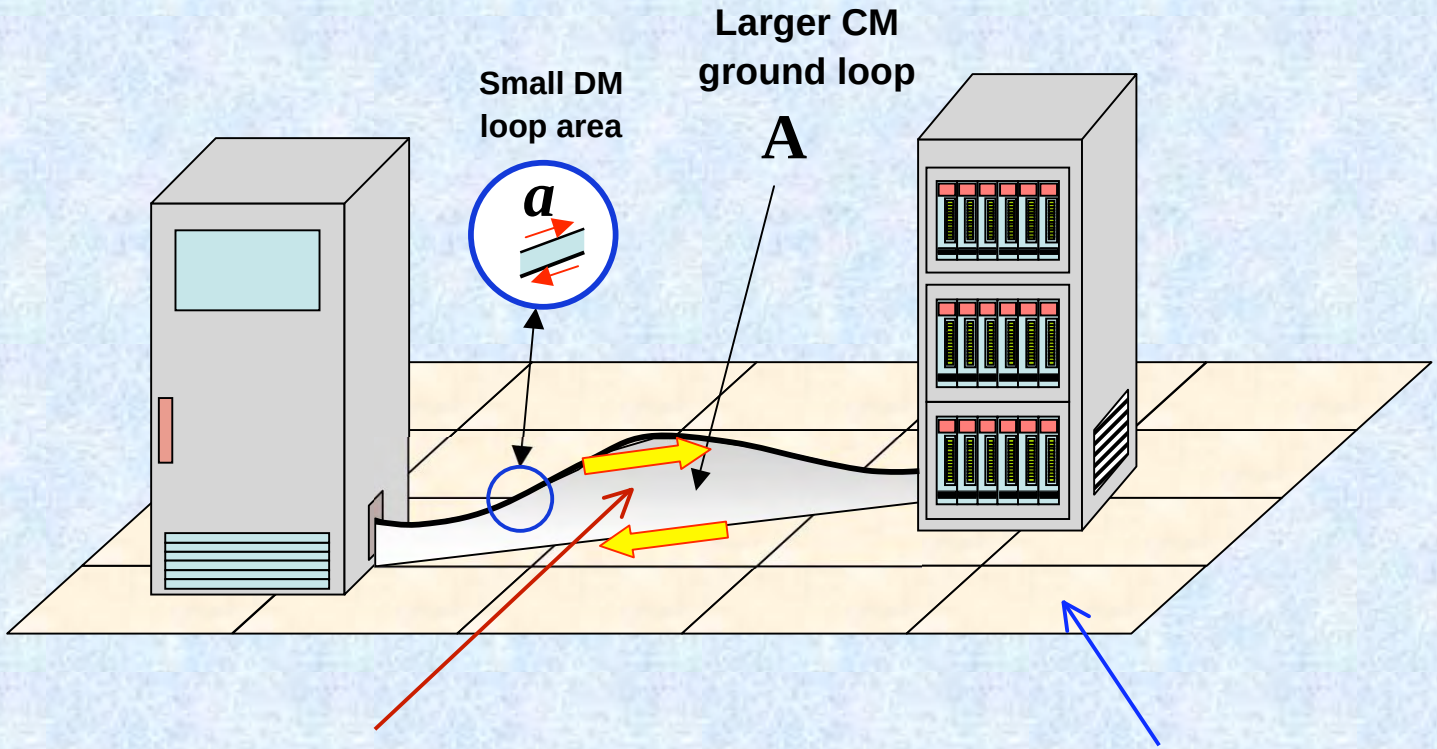
I = 30 kA

t_r = 1 µs

t_d = 50 µs

The Ground Loop problem

A variable magnetic field (difficult to shield at LF) induces voltage across loops



This ground loop area is unavoidable

It should be reduced by:

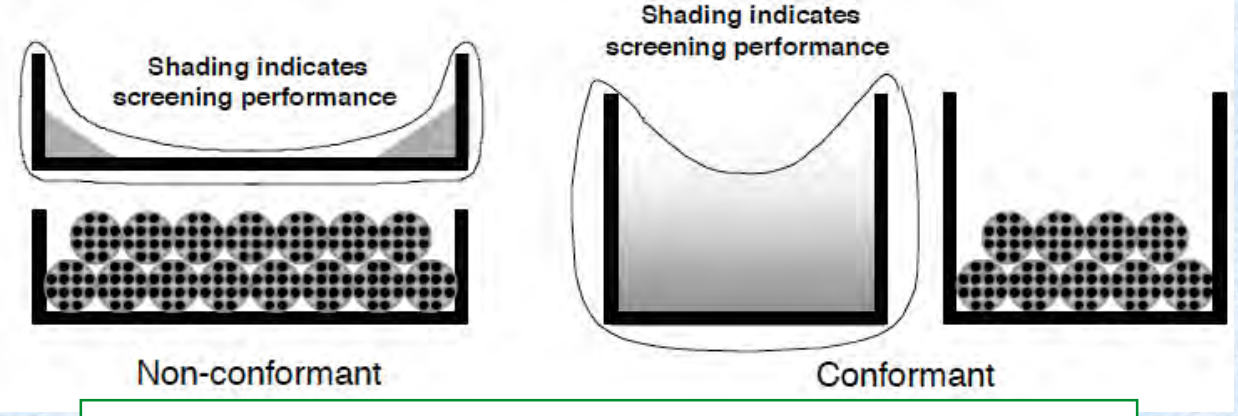
- Laying the cables down over the (metallic) ground plane
- Using cable trays (in contact from one end to the other)
- Using shielded cables with connection at both ends

A raised floor loop is not a ground loop

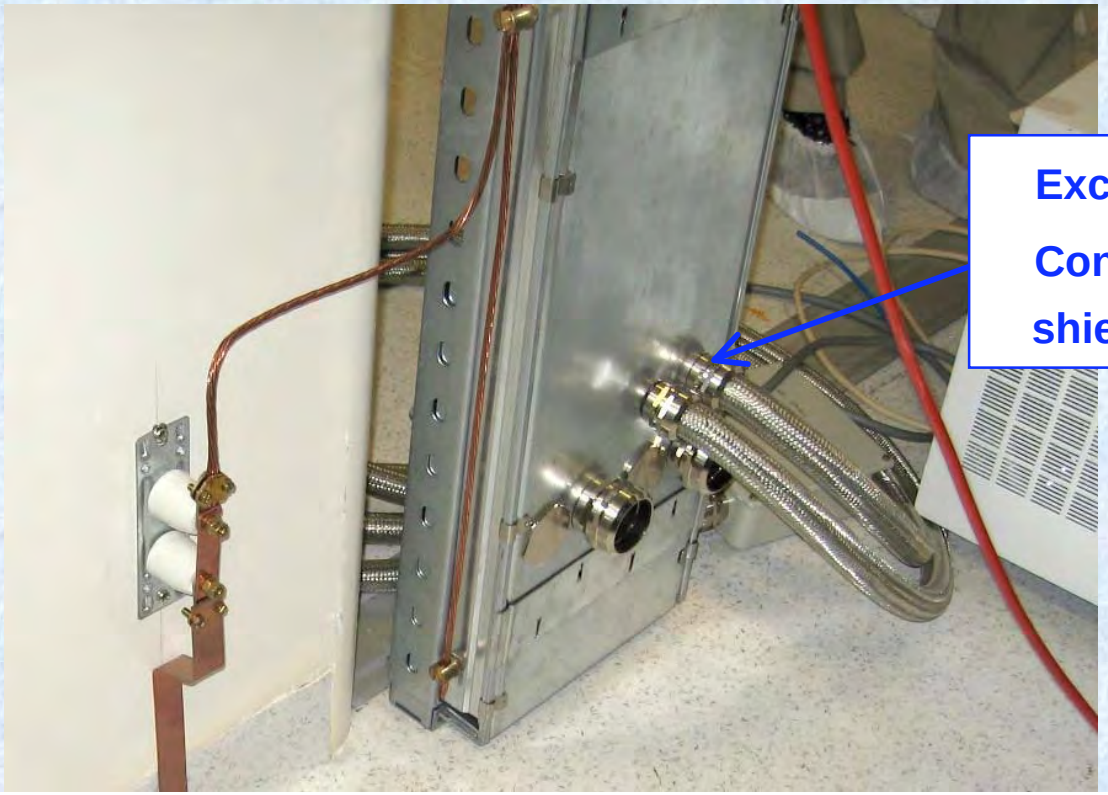
It is a favourable loop:

- It lowers the common mode impedance
- It divides the common mode currents
- It reduces the external EM fields

Cable tray shielding effectiveness



Cable arrangement in a metallic section



Excellent solution:

Continuous cables shielding with nuts

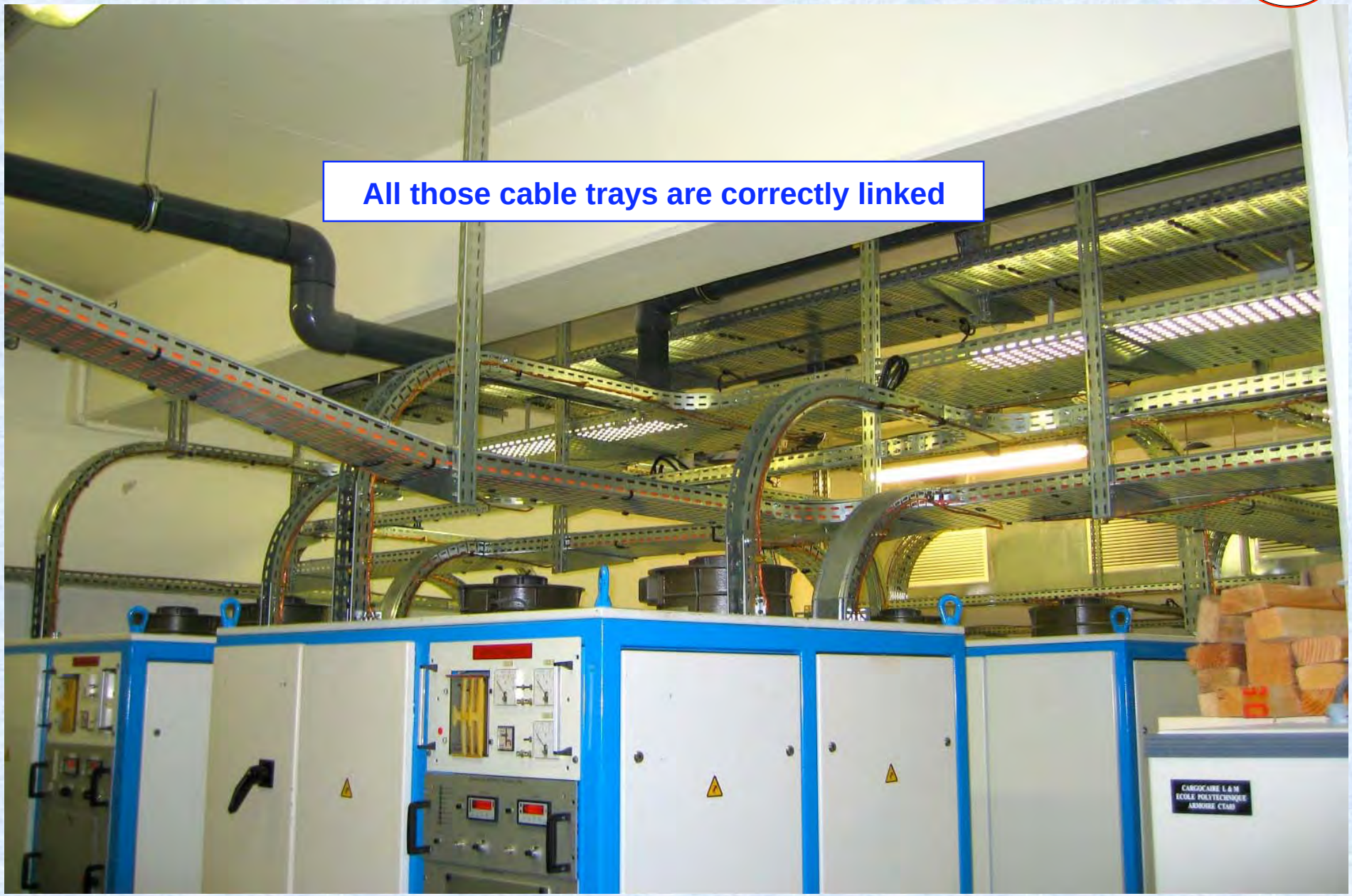
Properly shielded cable trays

Excellent solution:

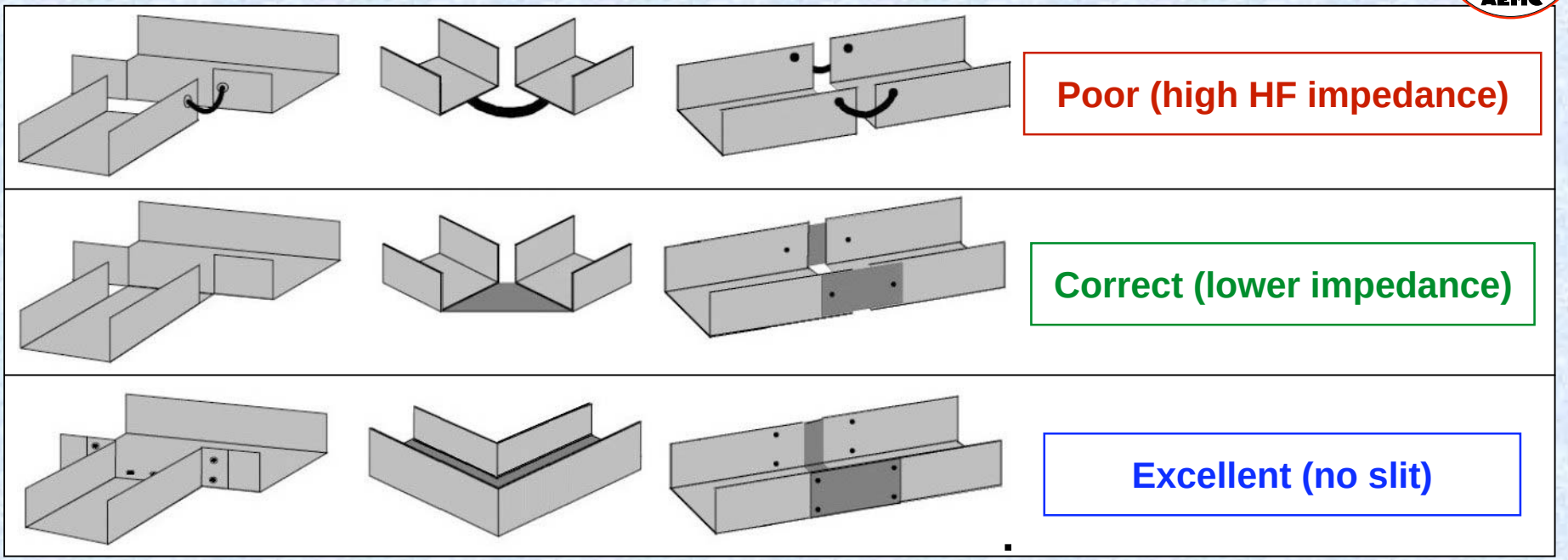
Shielded cable trays

Cable tray to cabinet transition

Correctly used cable trays



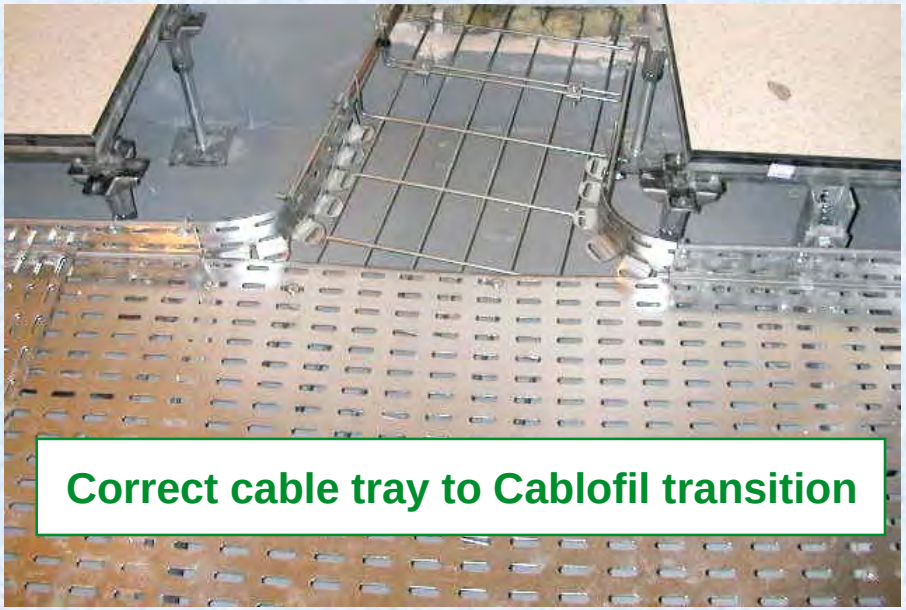
Some EMC alternatives - 1



Poor (high HF impedance)

Correct (lower impedance)

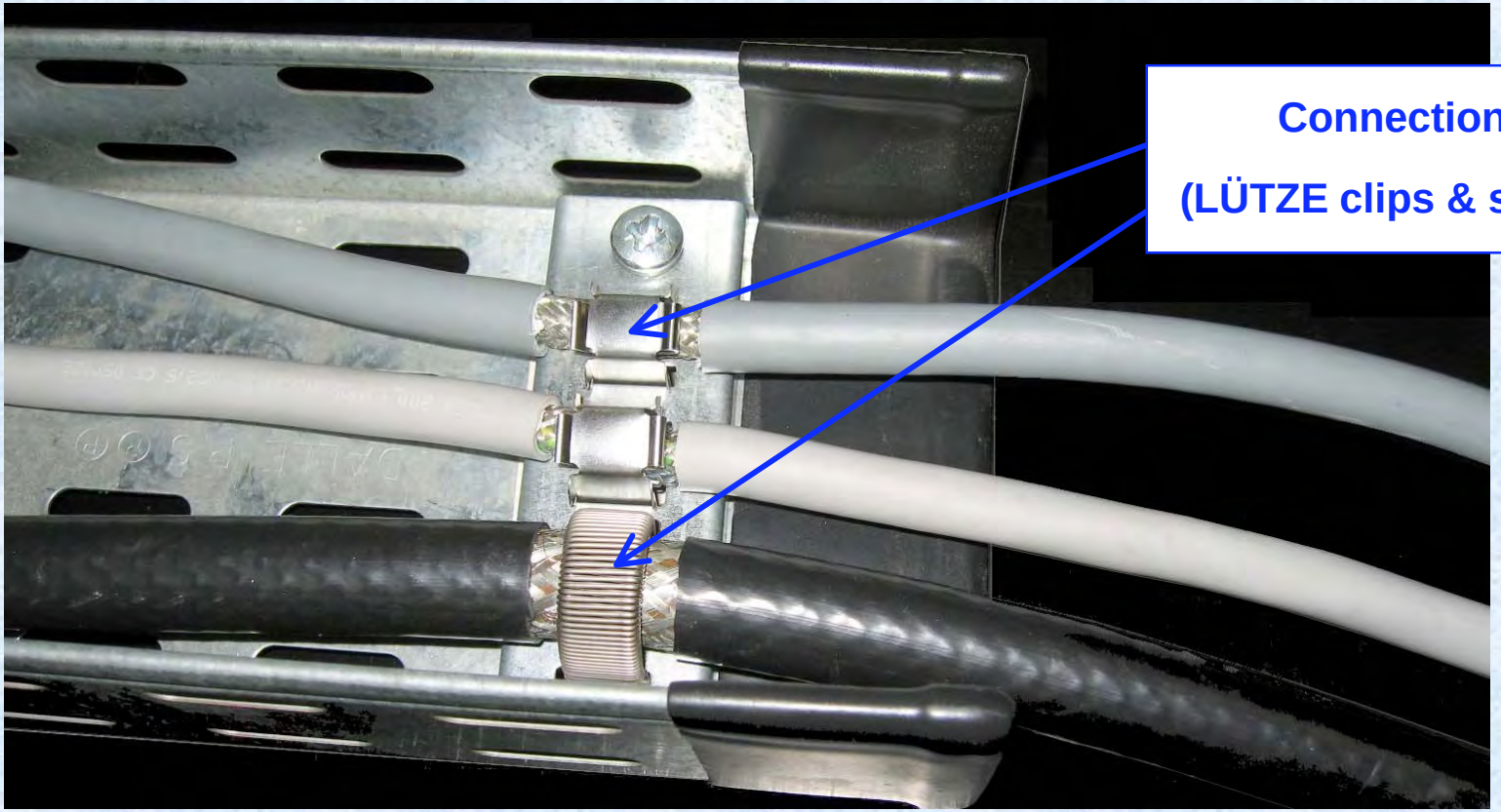
Excellent (no slit)

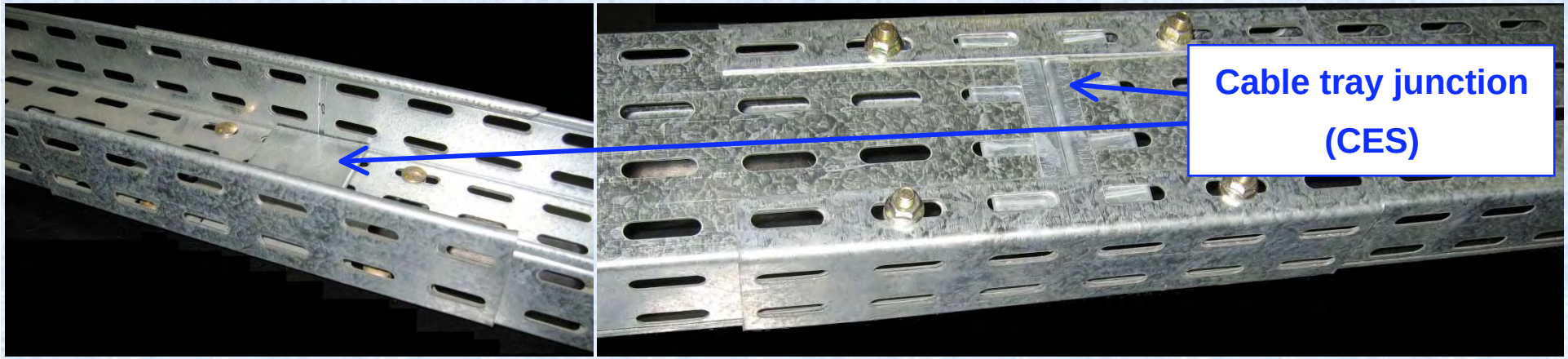


Correct cable tray to Cablofil transition

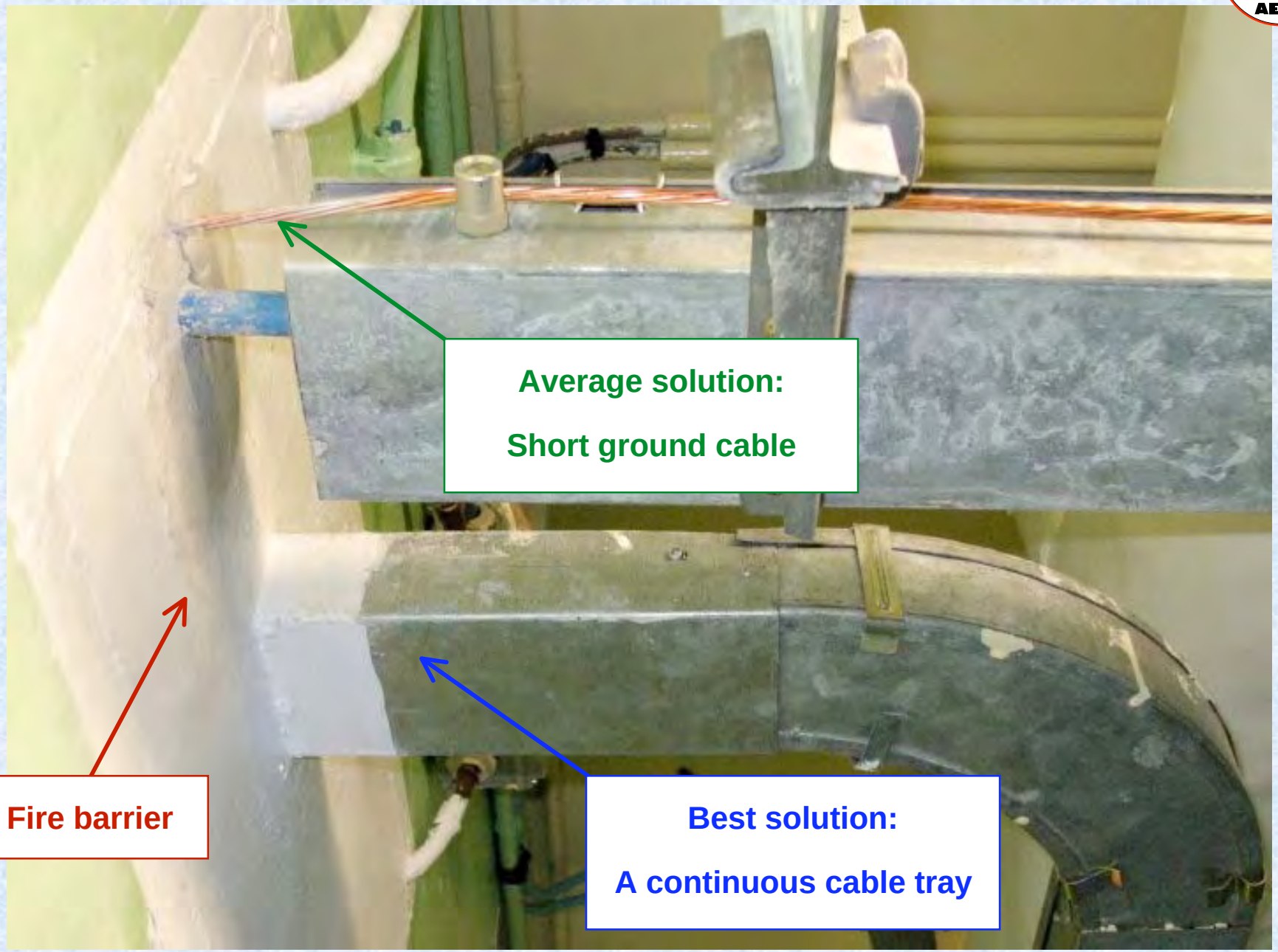
Poor HF cable tray continuity

Some EMC alternatives - 2

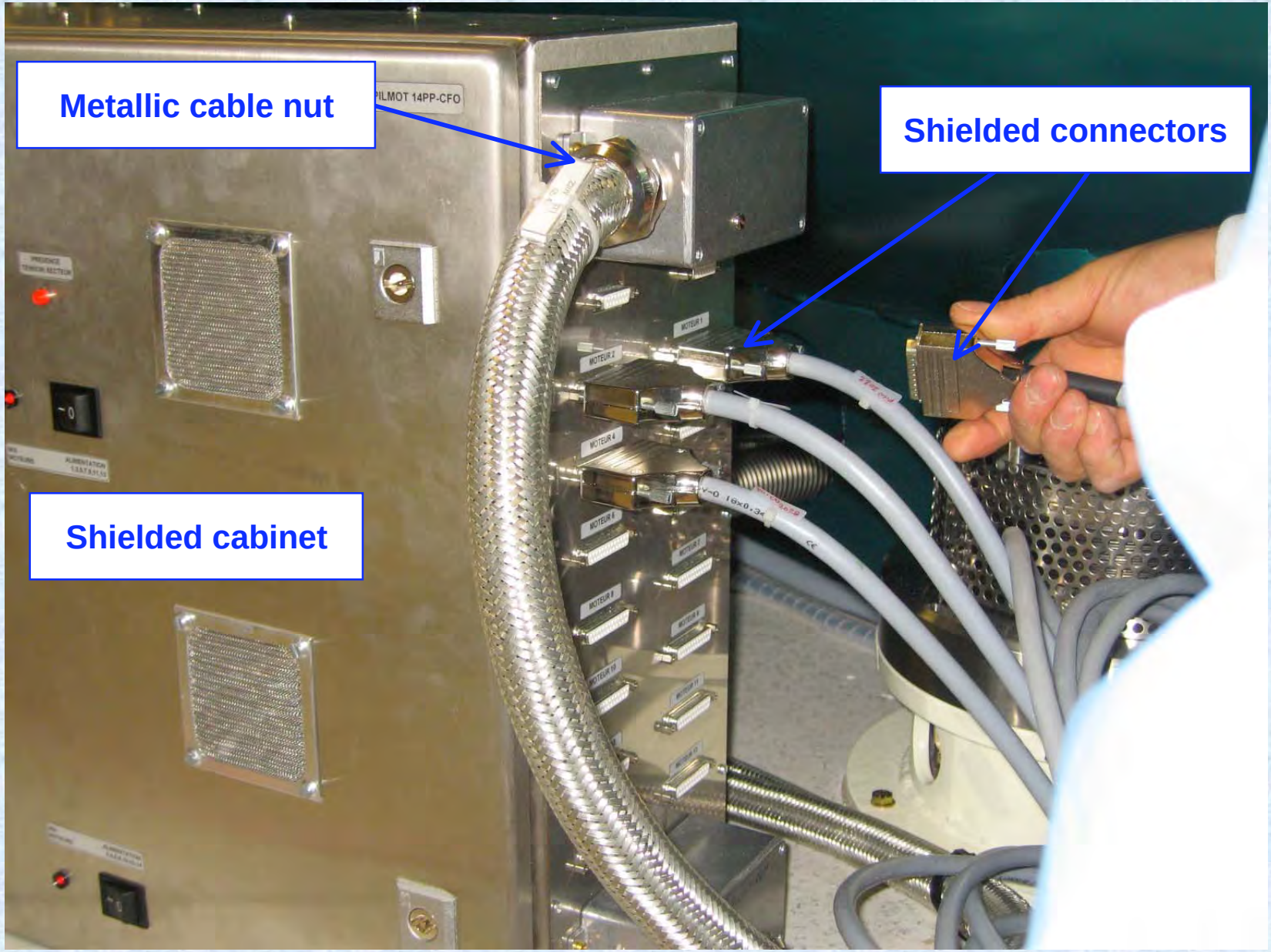




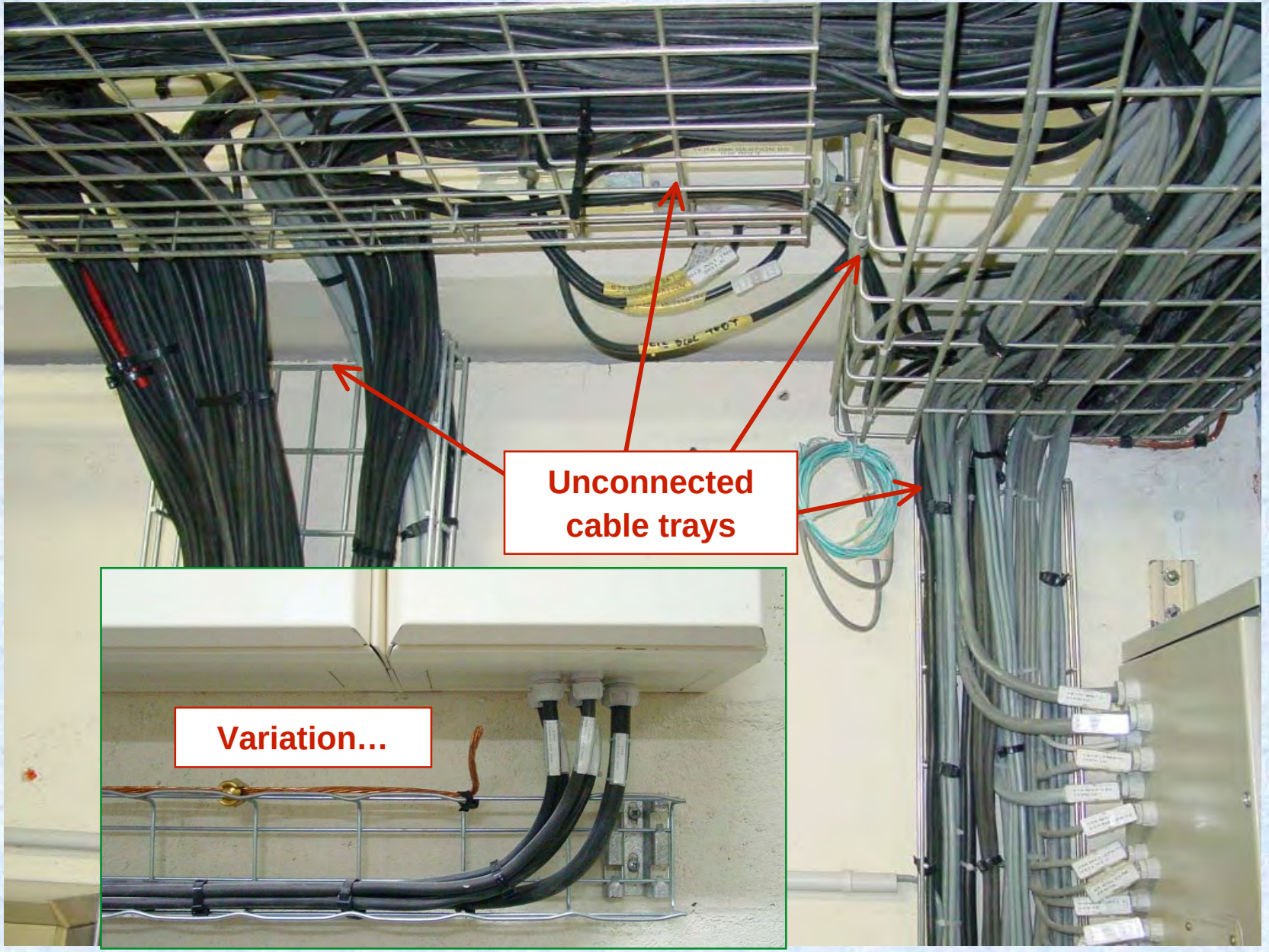
Some EMC alternatives - 3



Some EMC alternatives - 4

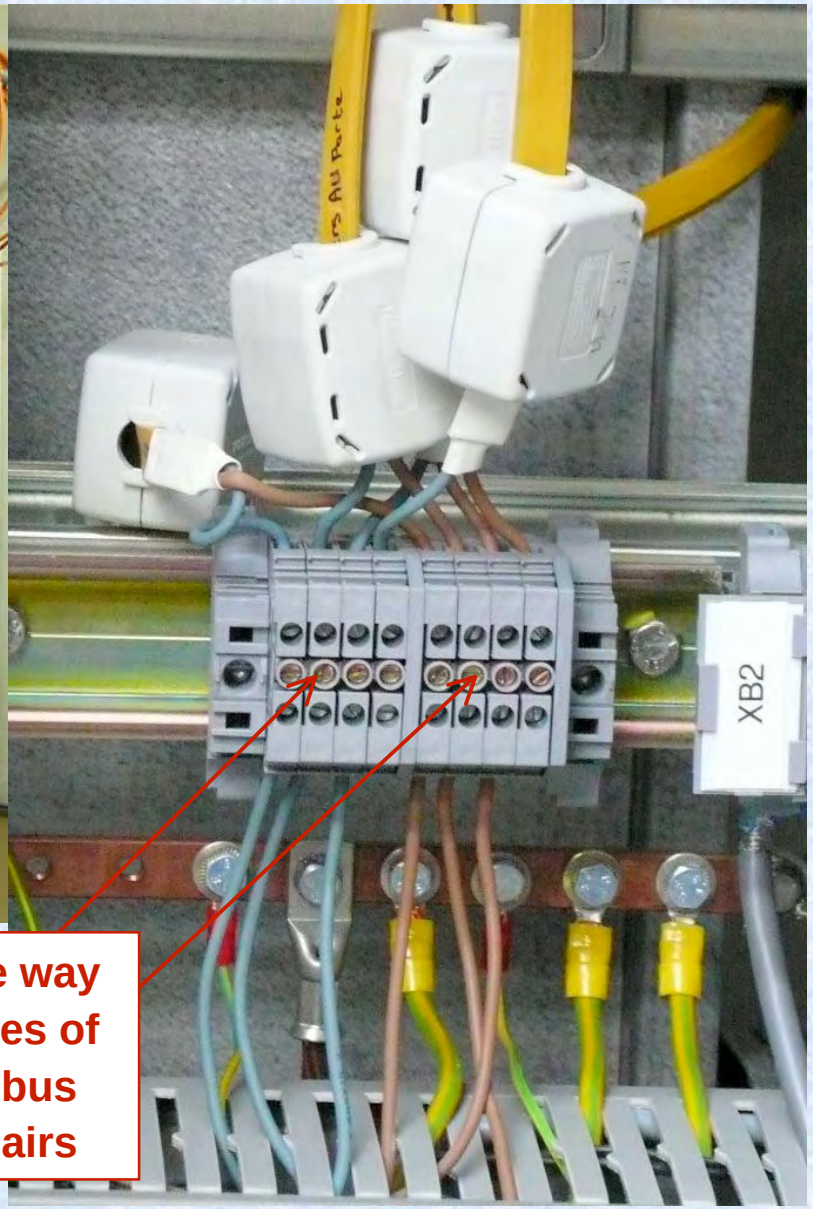


Usual EMC mistakes - 1



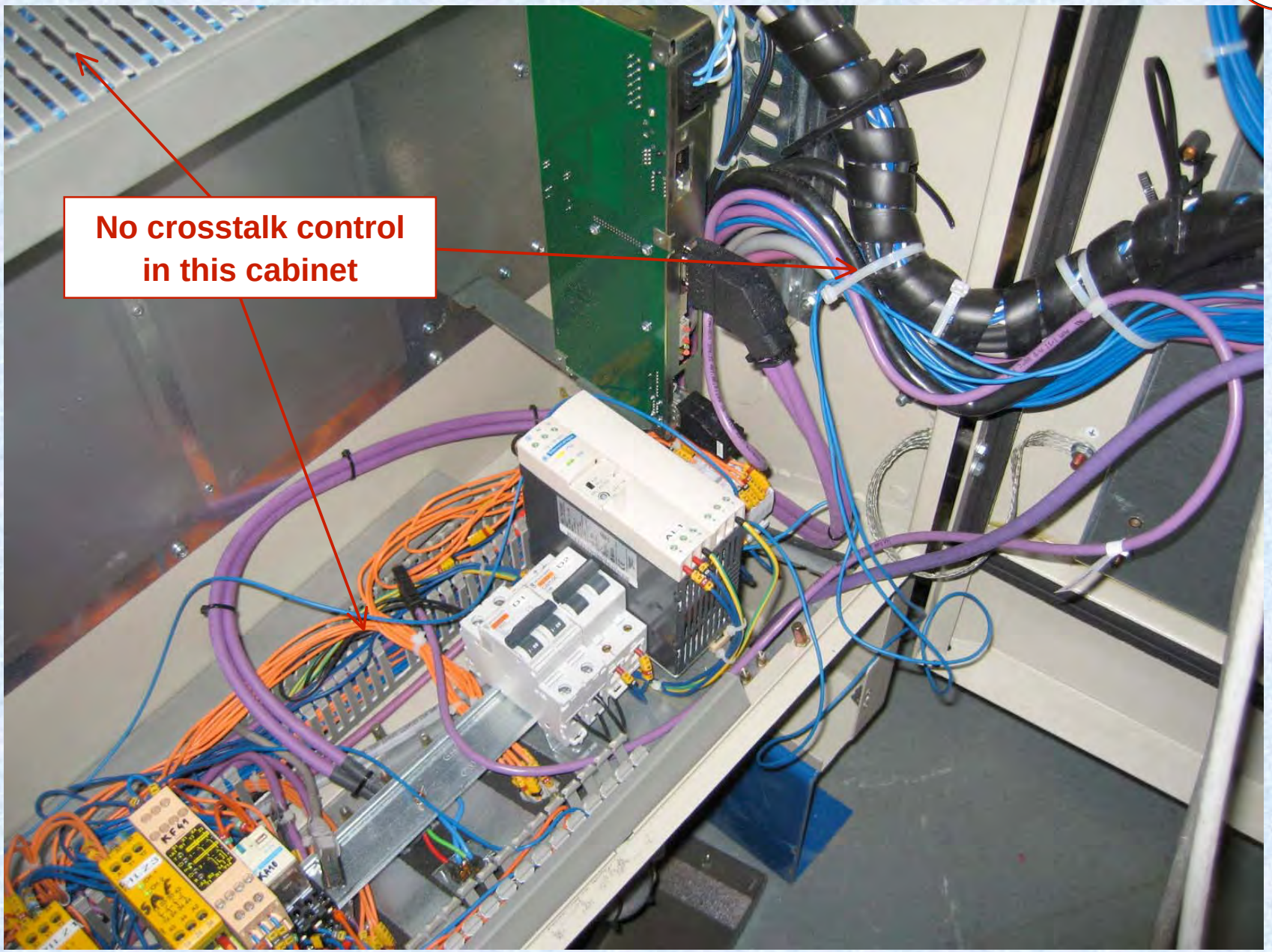
Usual EMC mistakes - 2

m^2 of radiating loops (with kAmps pulses)

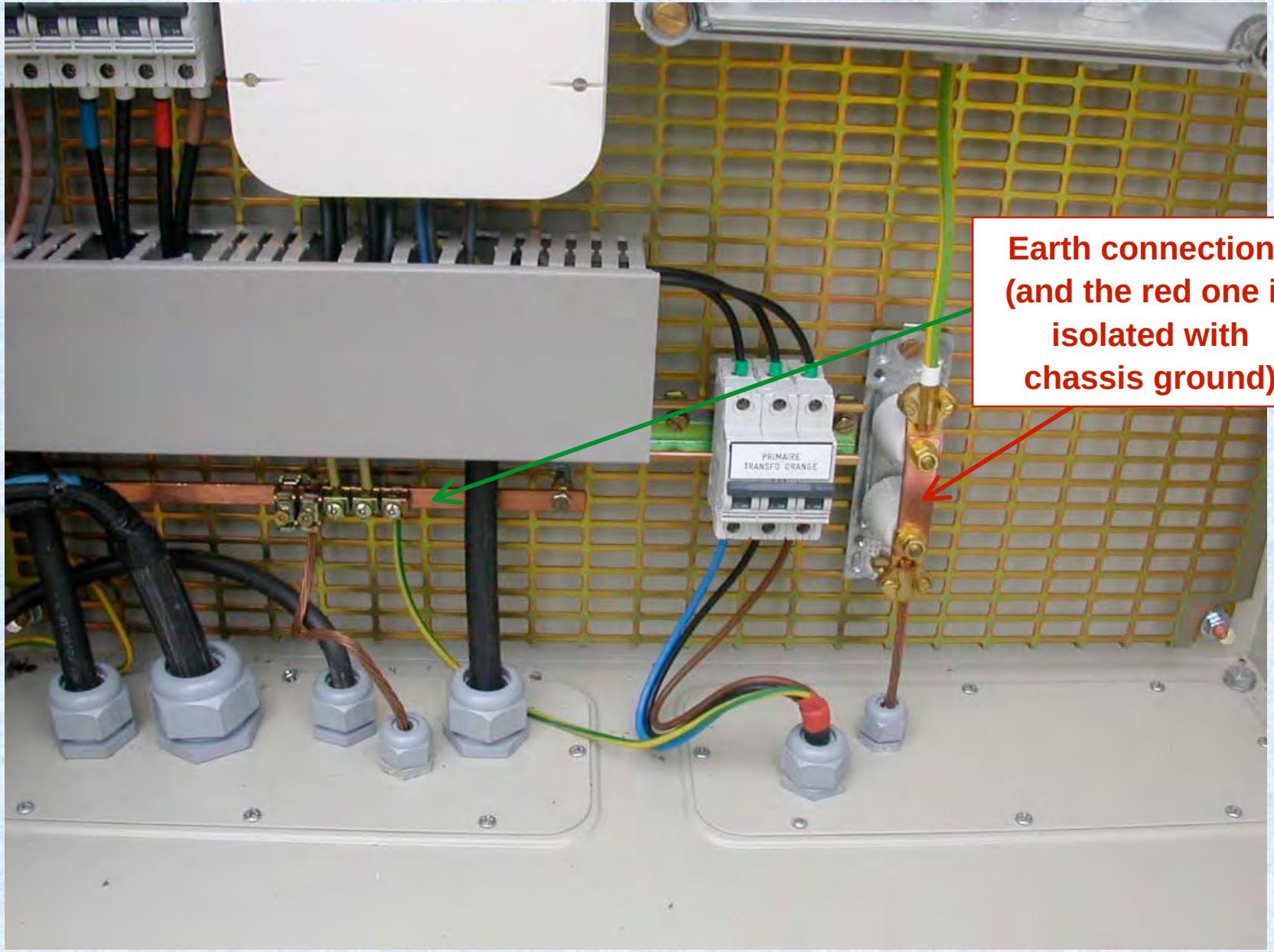


Separated one way and return wires of those 4 field-bus unshielded pairs

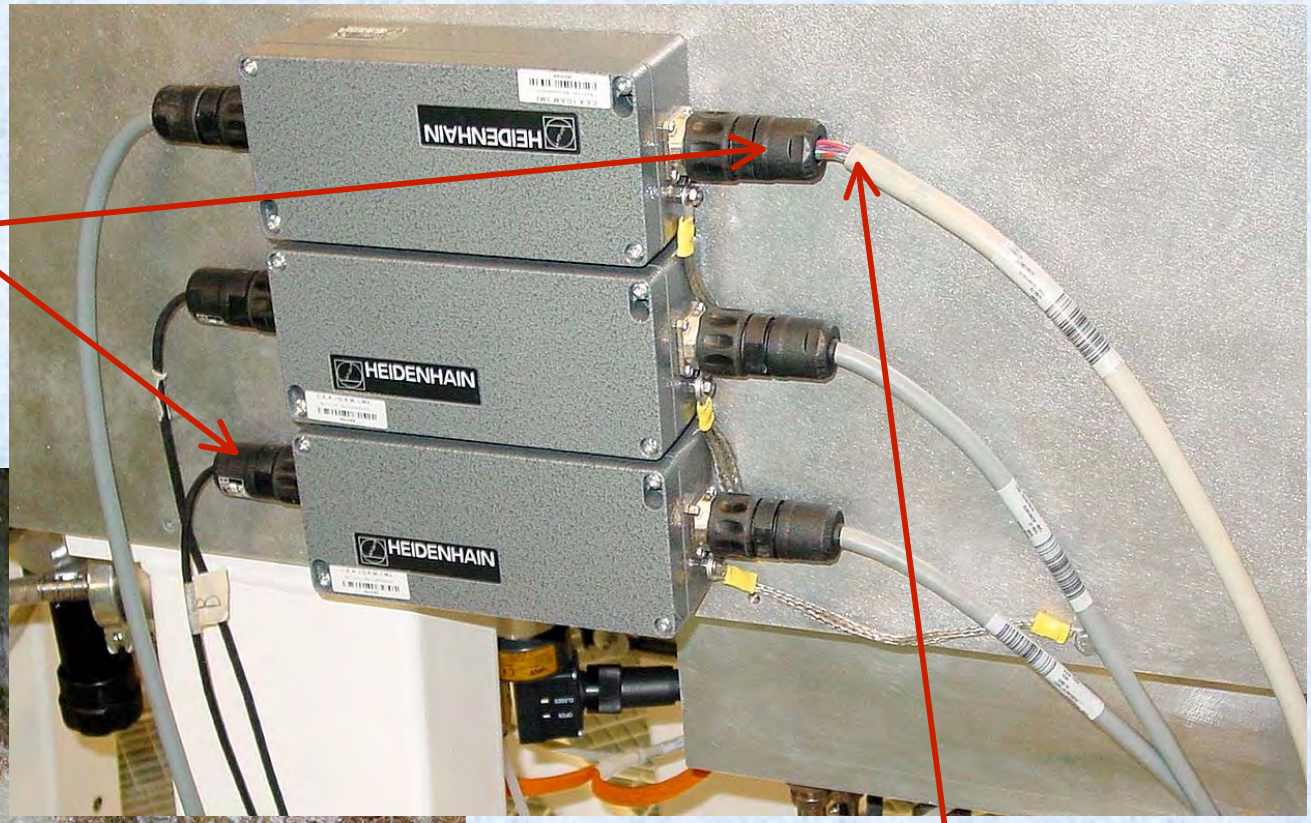
Usual EMC mistakes - 3



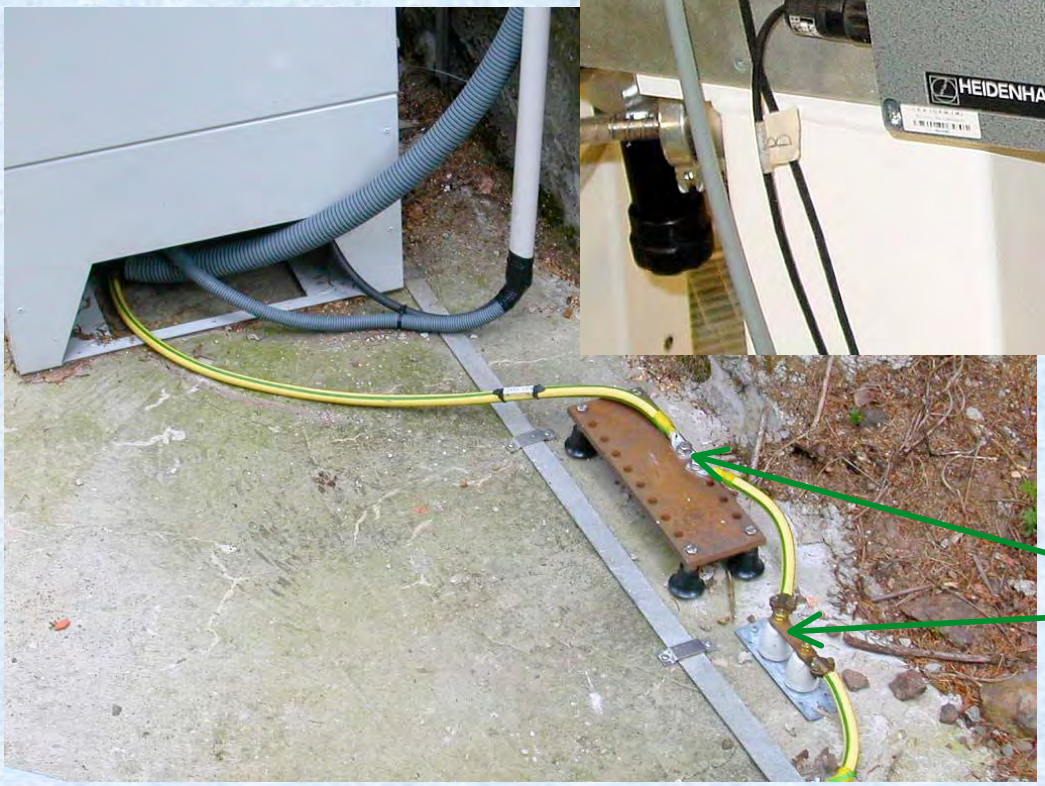
Usual EMC mistakes - 4



Usual EMC mistakes - 5



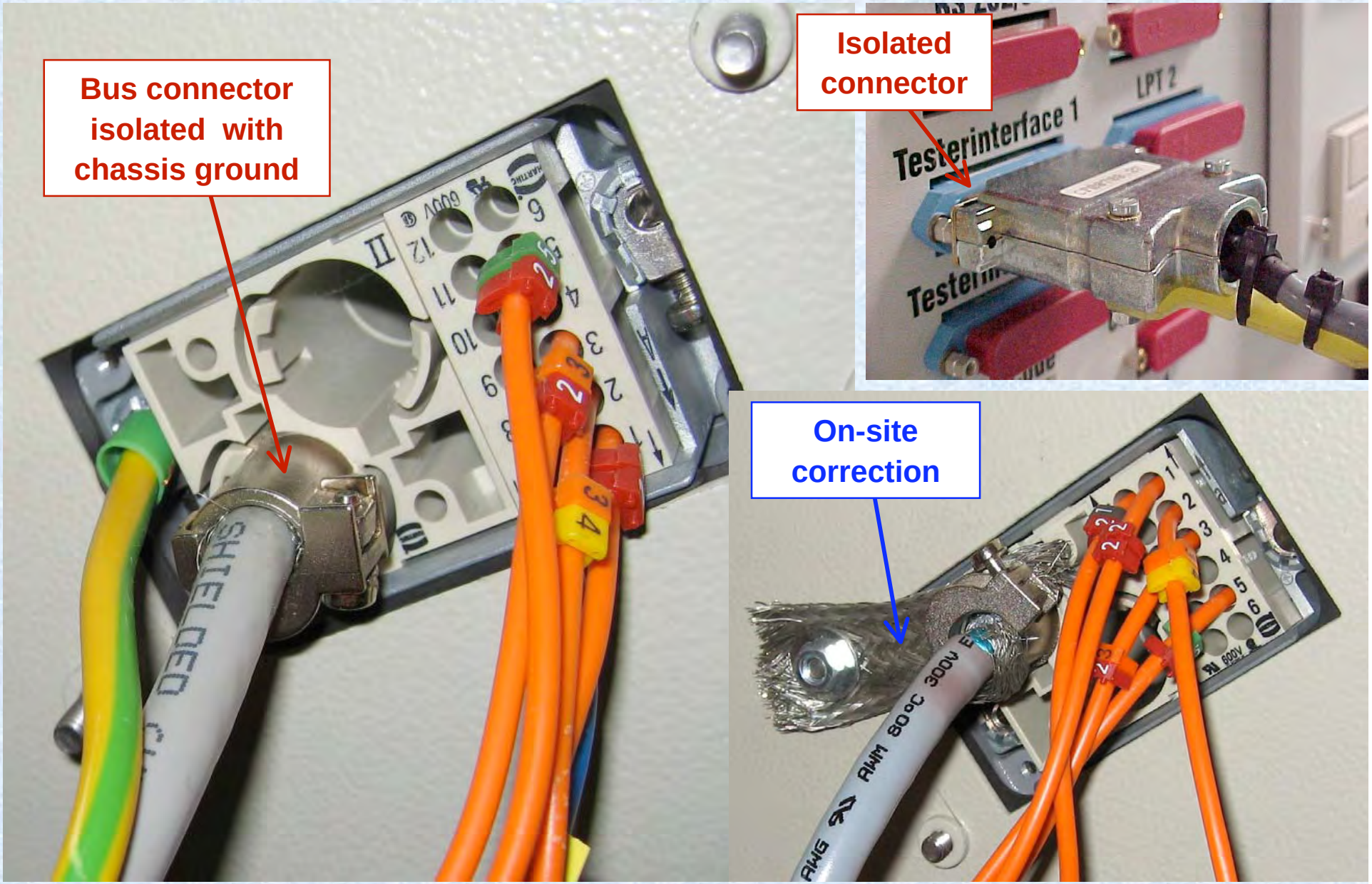
Plastic connectors



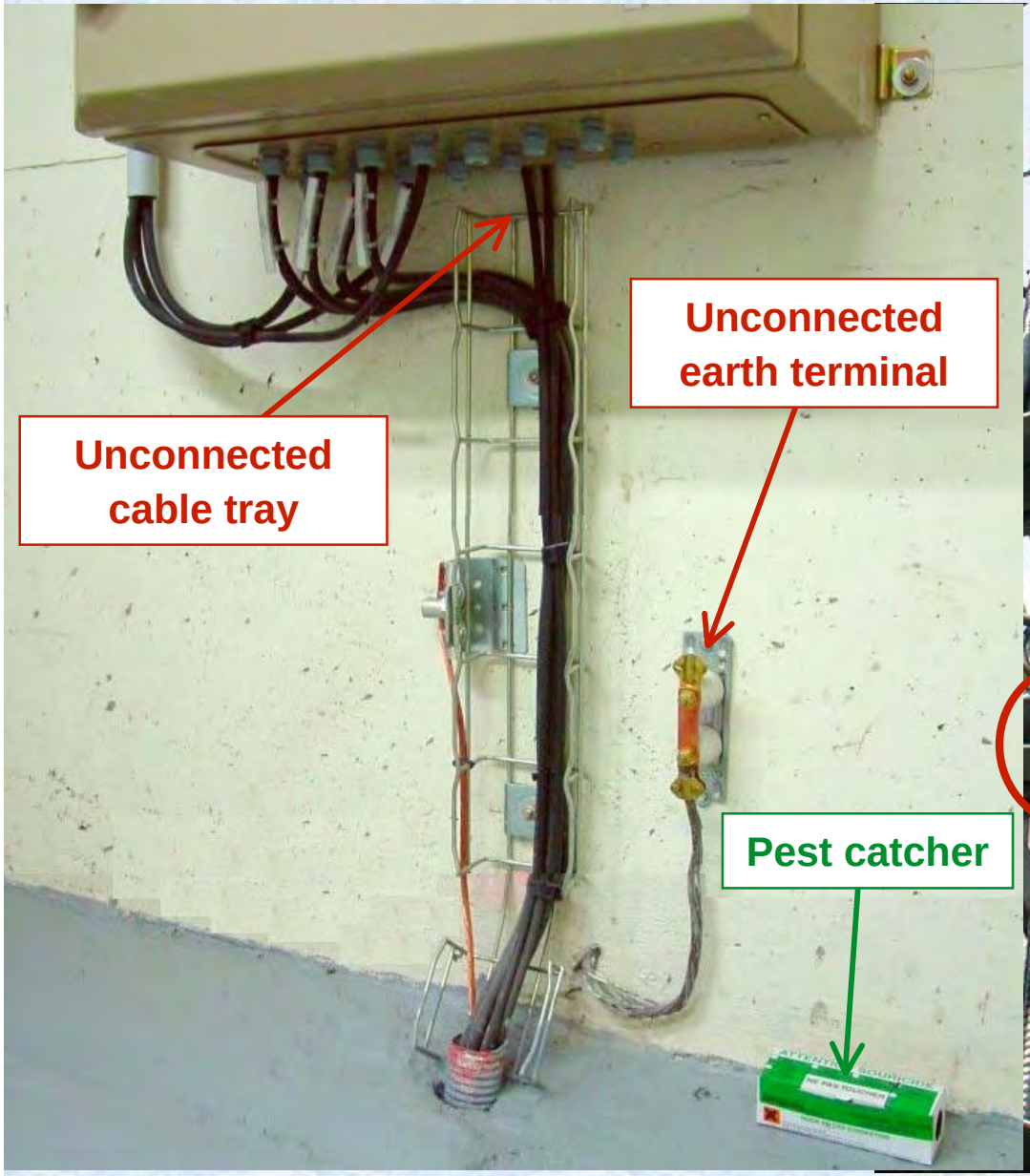
Unshielded signal cable

Useless terminals in series

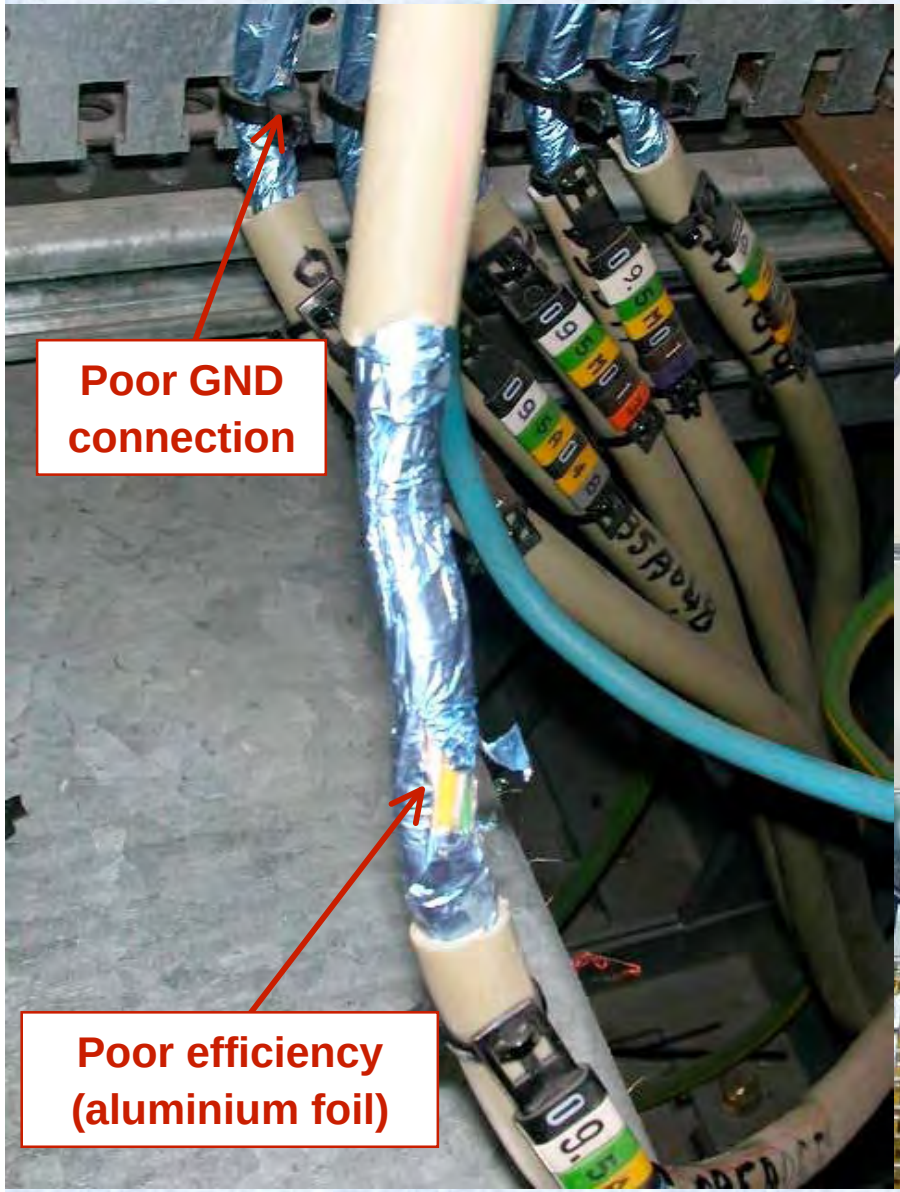
Usual EMC mistakes - 6

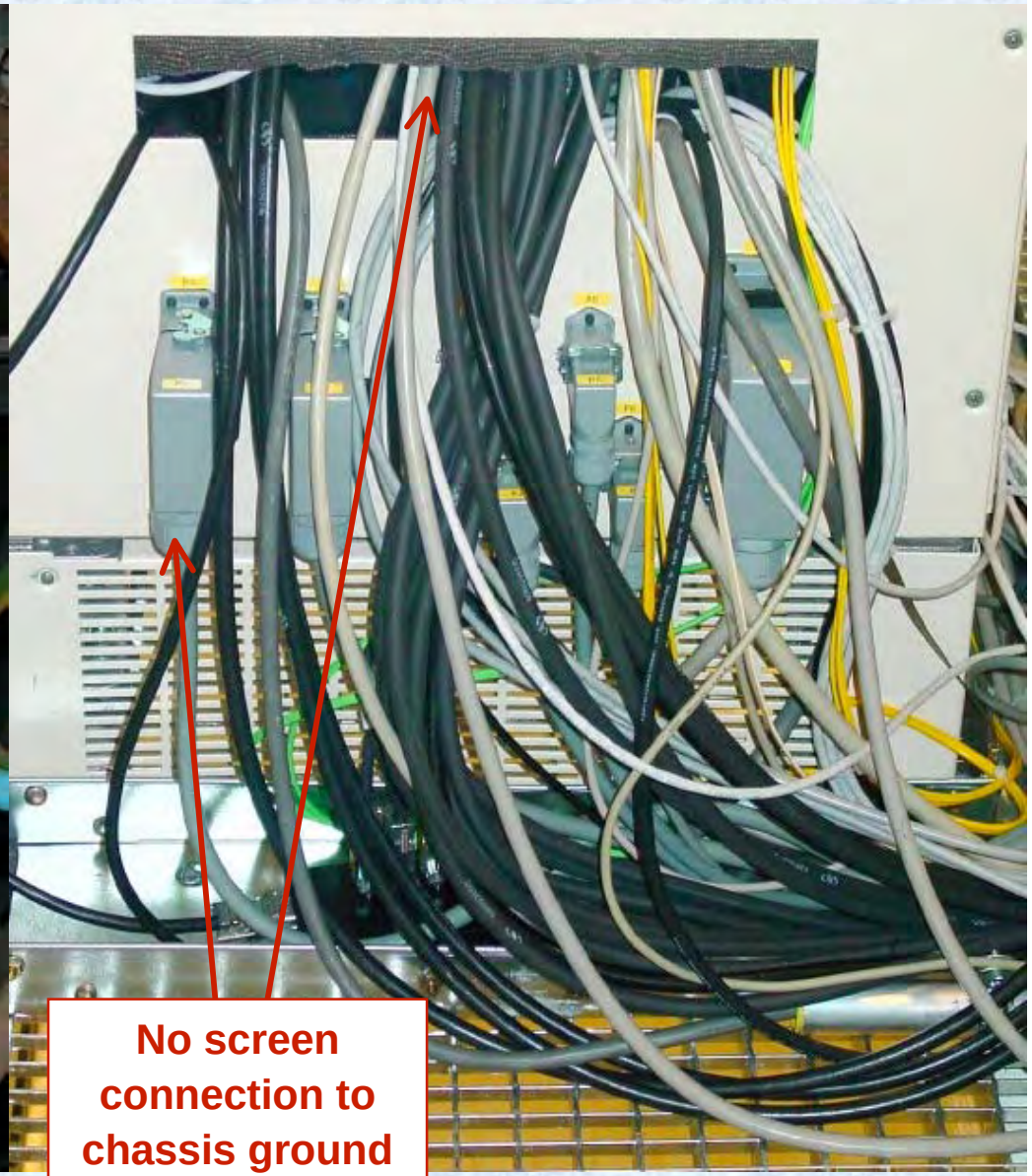


Usual EMC mistakes - 7

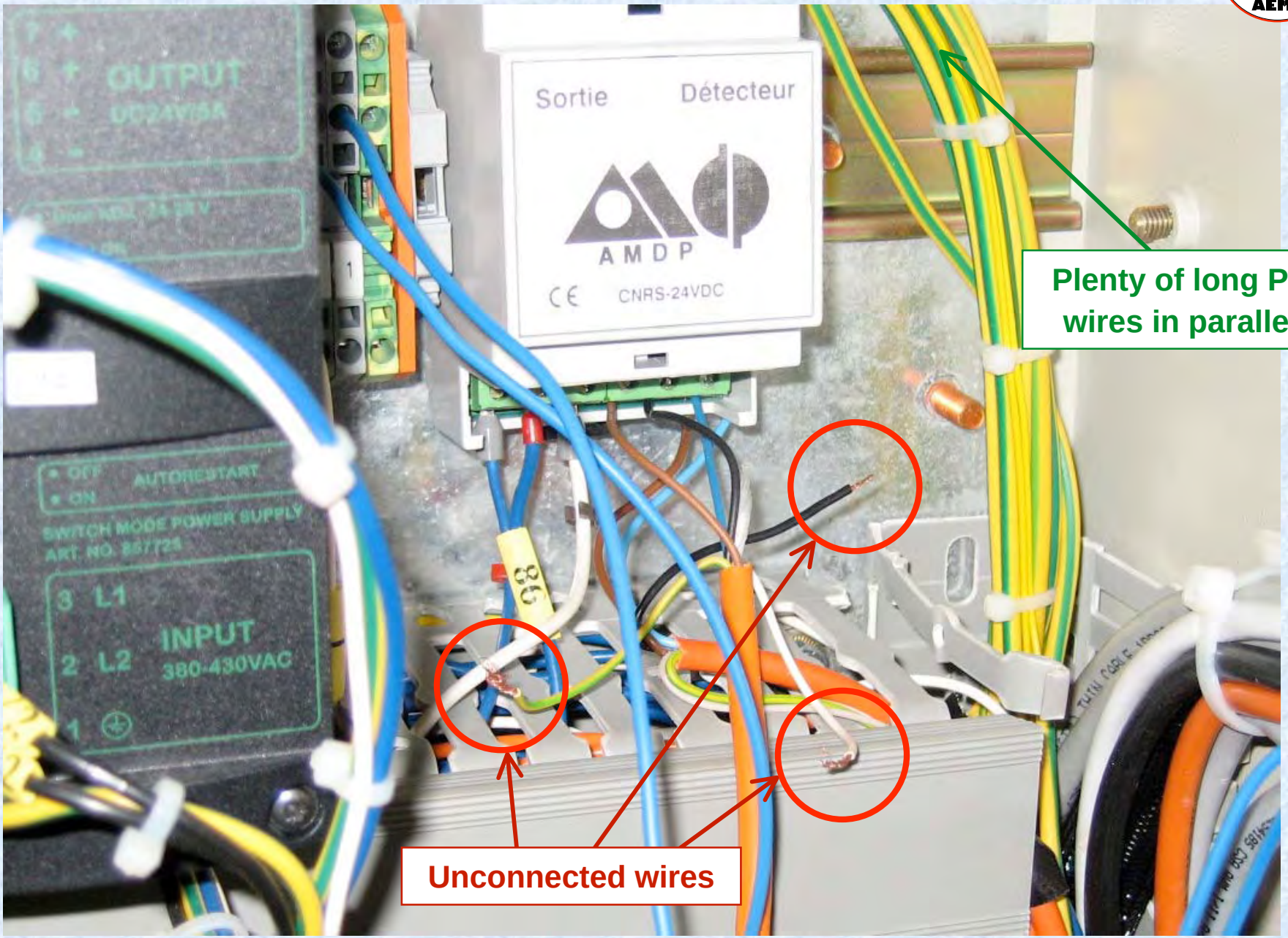


Usual EMC mistakes - 8



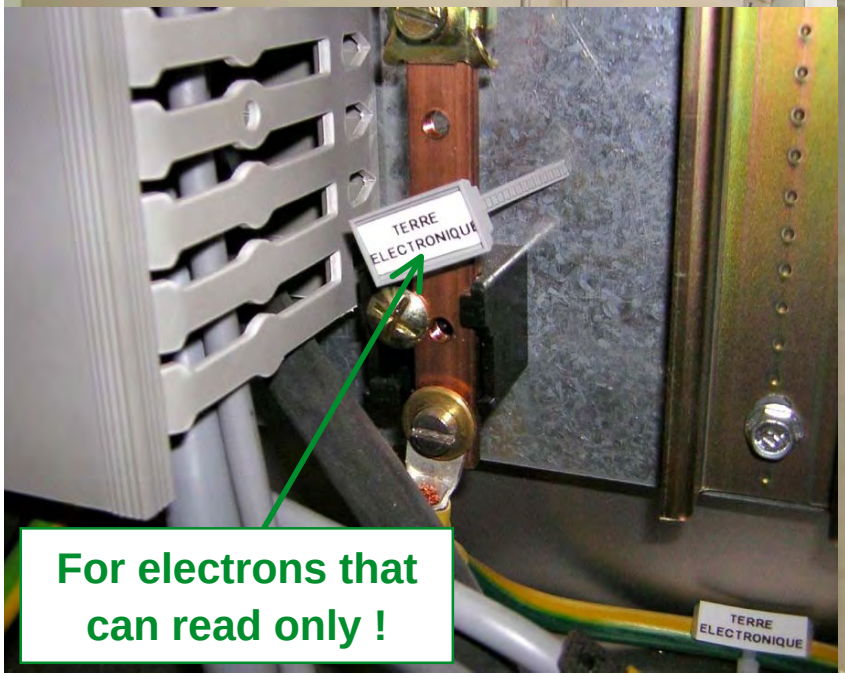


Usual EMC mistakes - 9

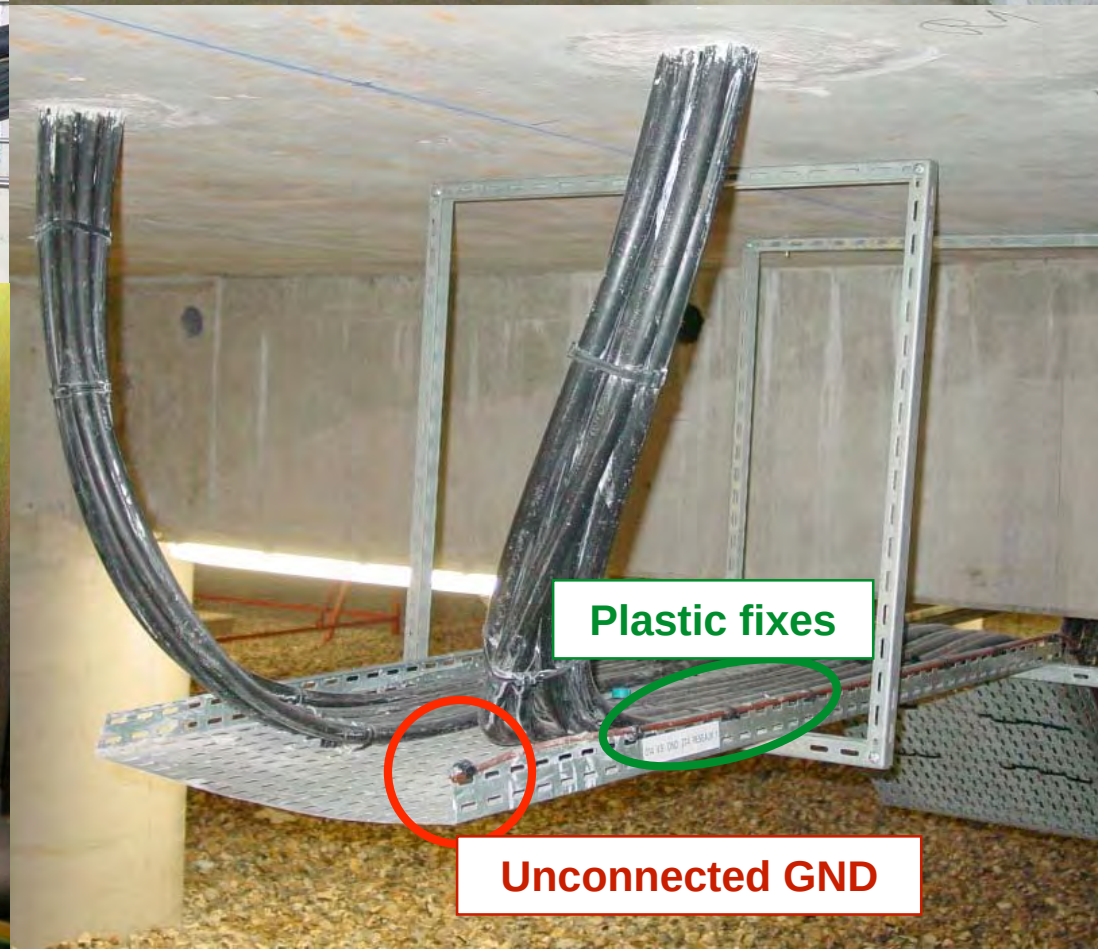


Usual EMC mistakes - 10

No comment !



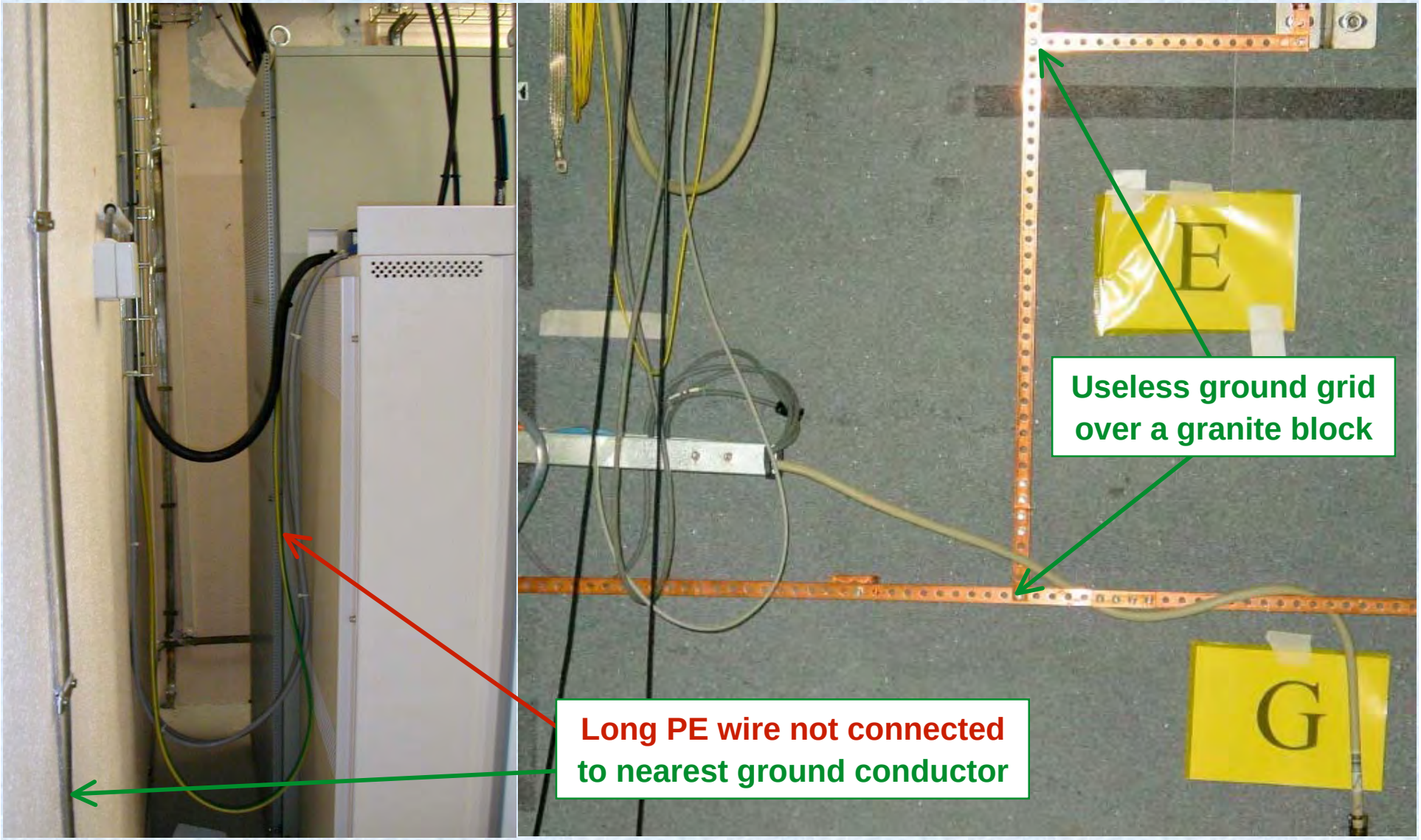
For electrons that can read only !



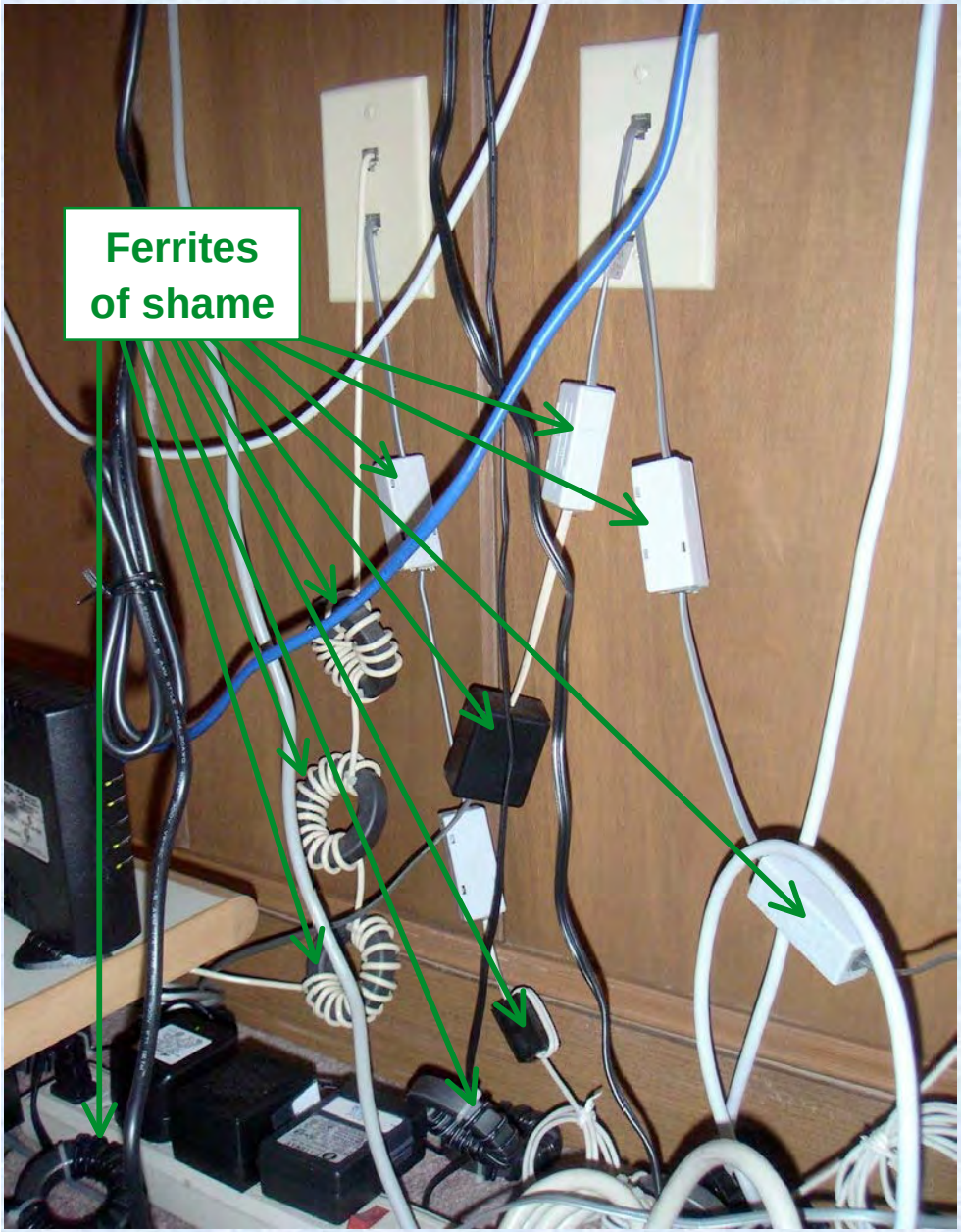
Plastic fixes

Unconnected GND

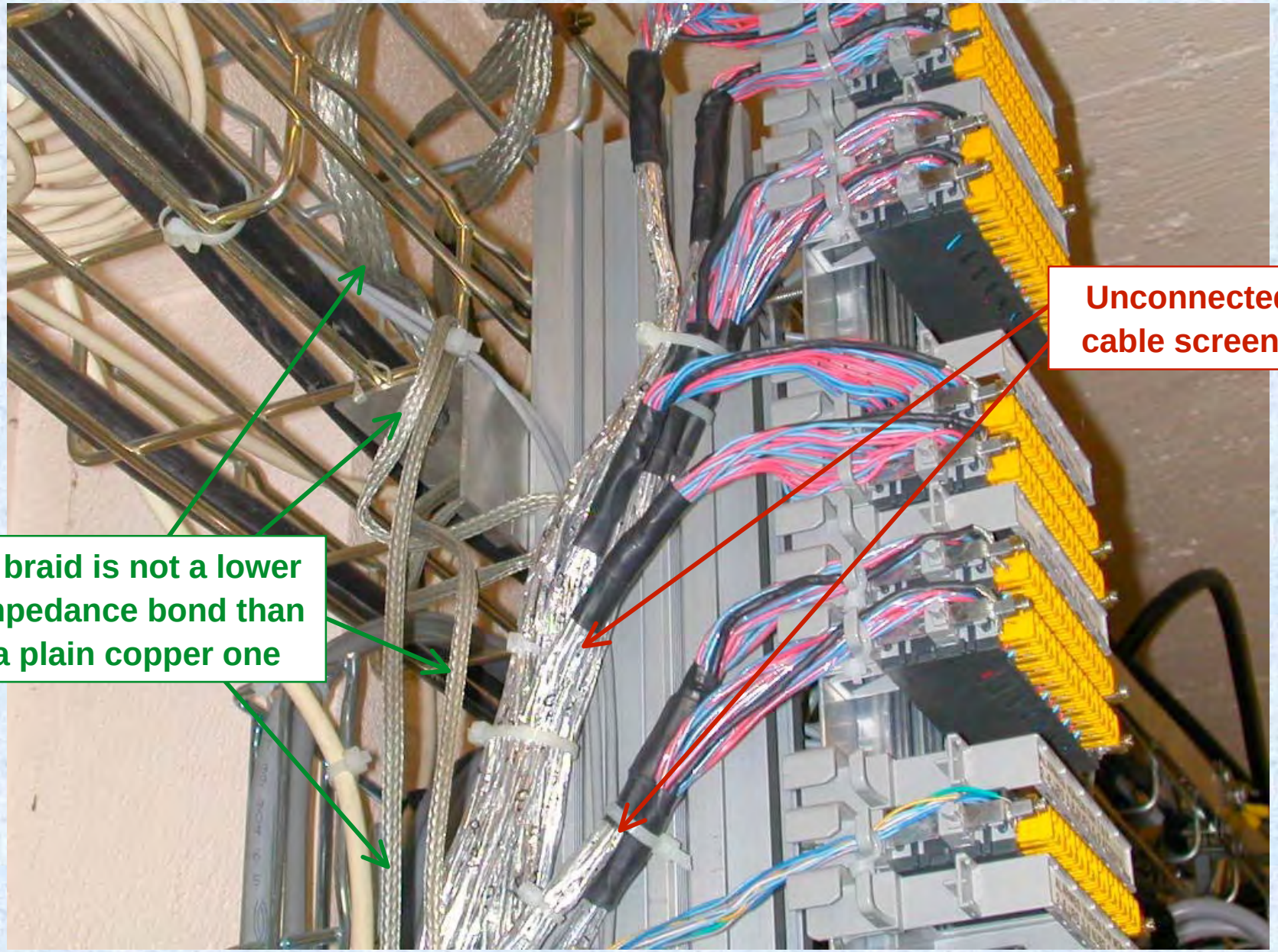
Usual poor EMC fixes - 1



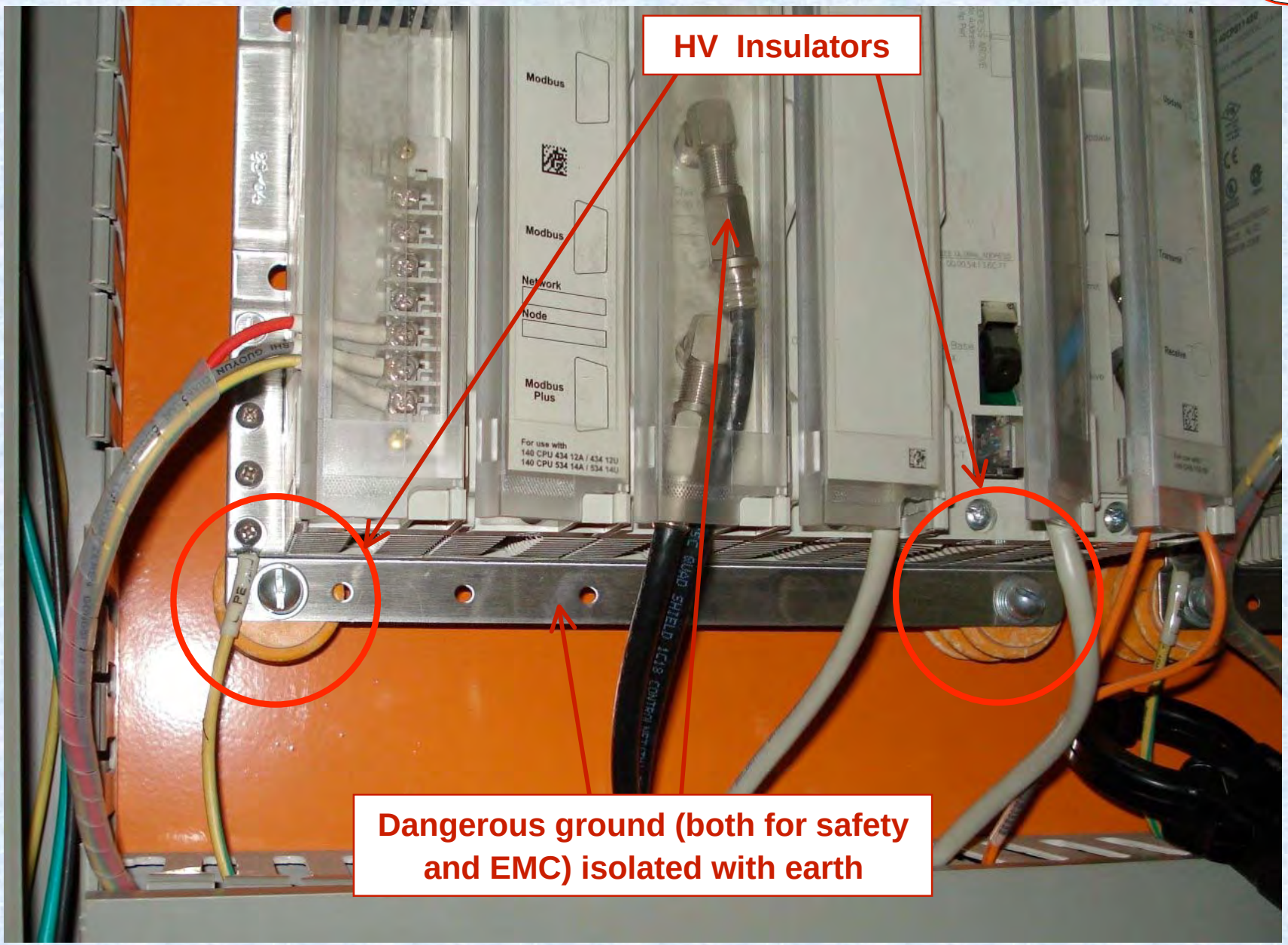
Usual poor EMC fixes - 2



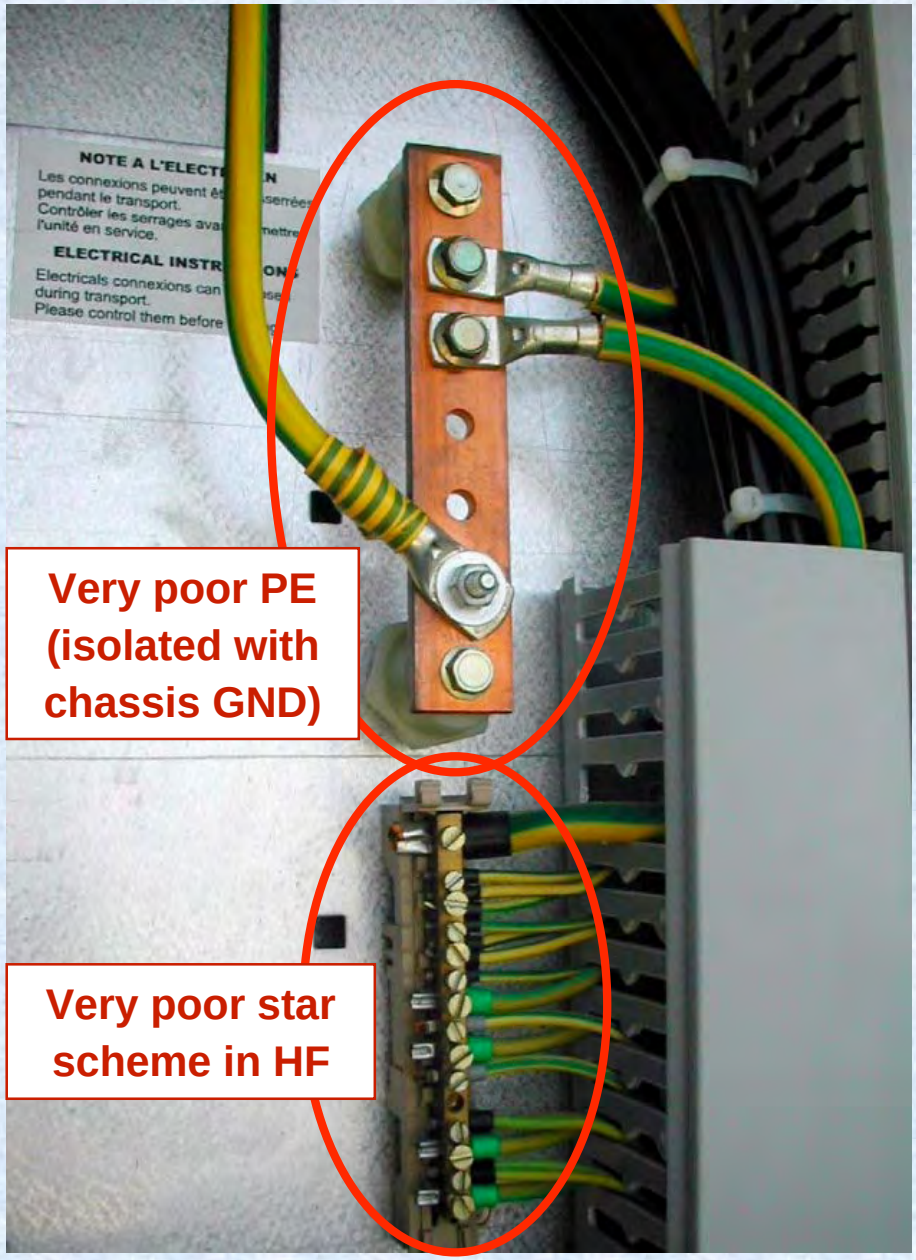
Usual poor EMC fixes - 3

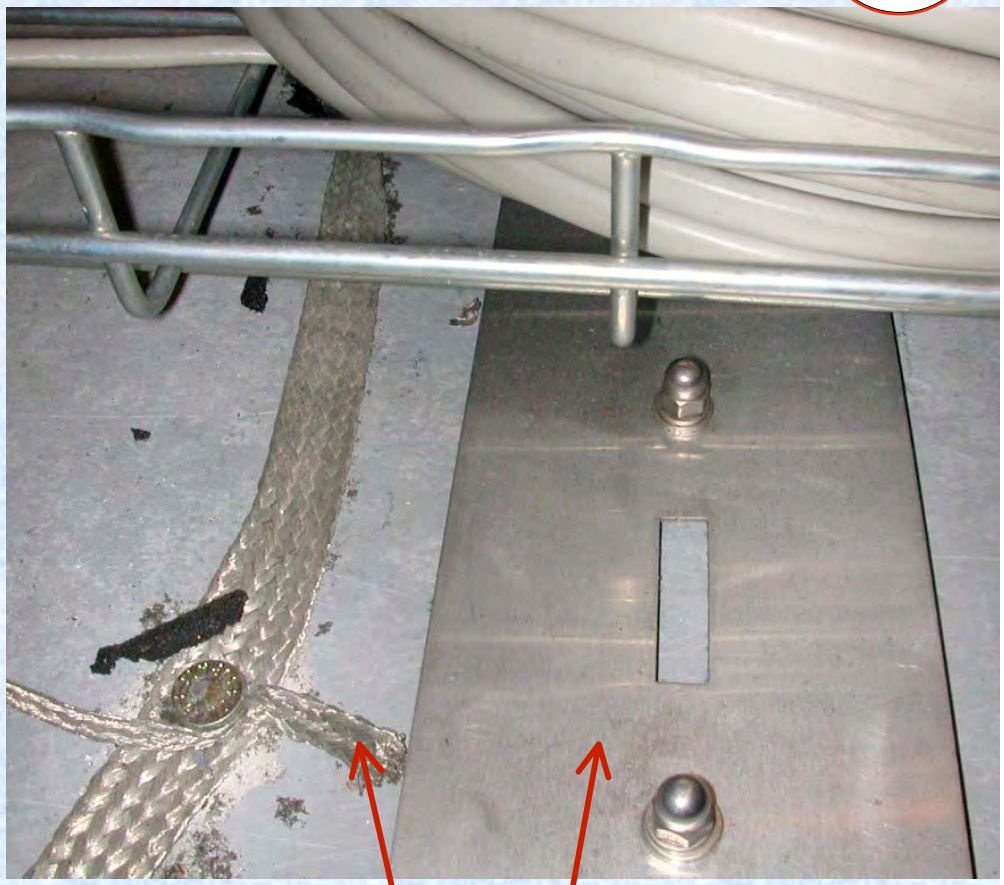


Usual poor EMC fixes - 4

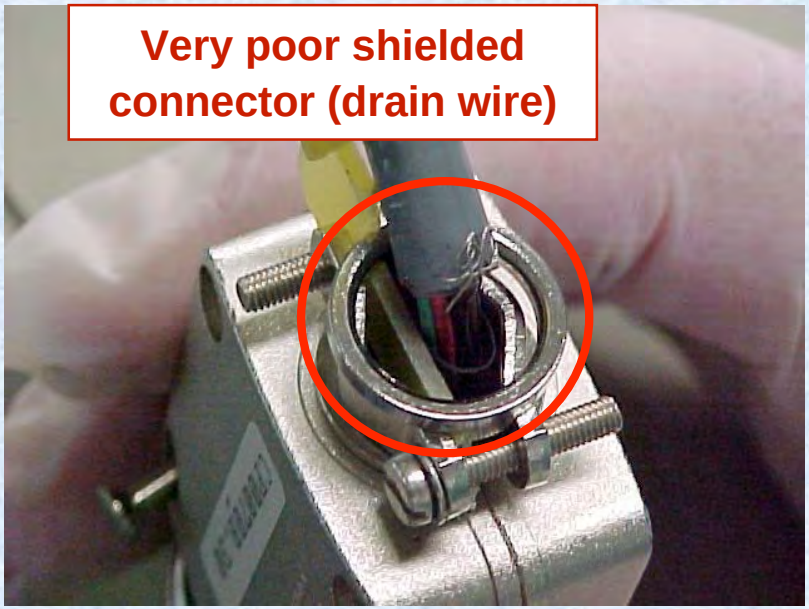


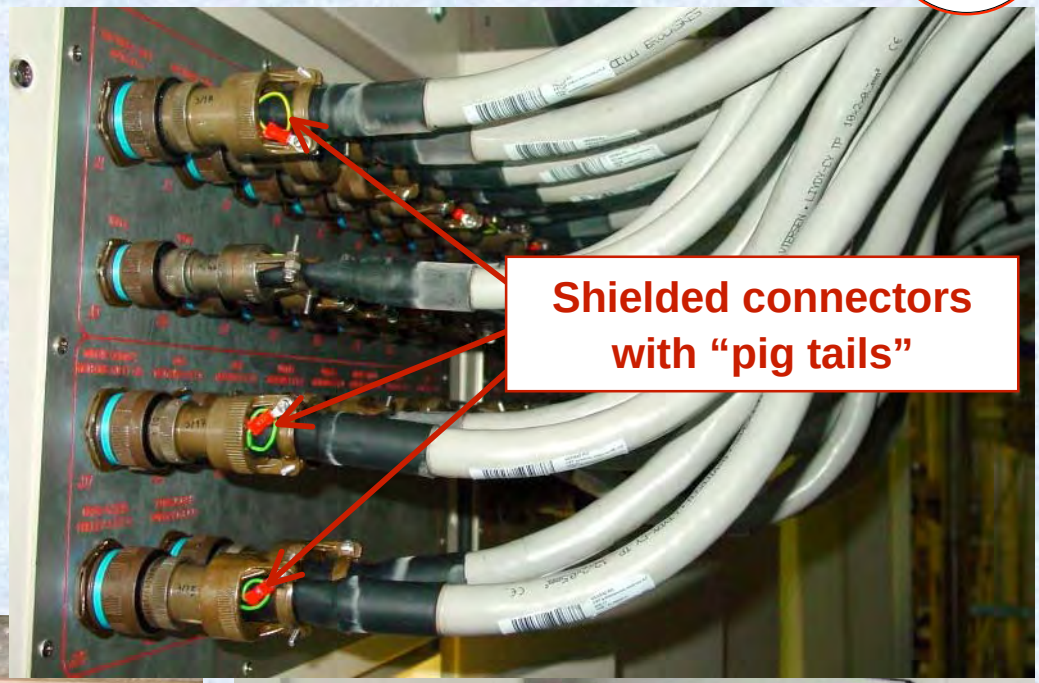
Usual poor EMC fixes - 5

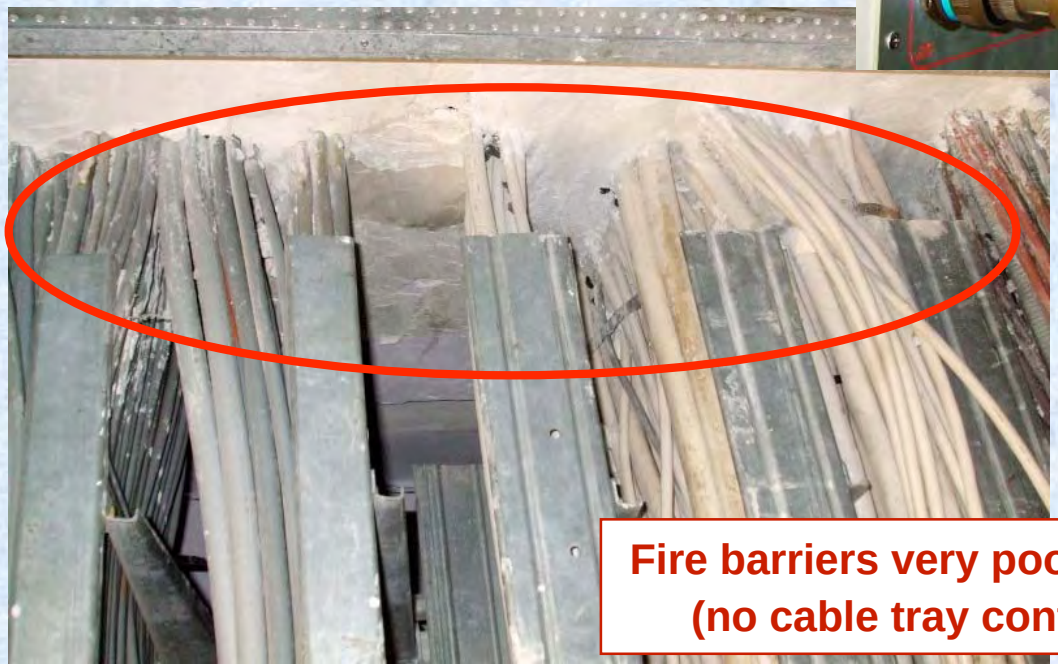


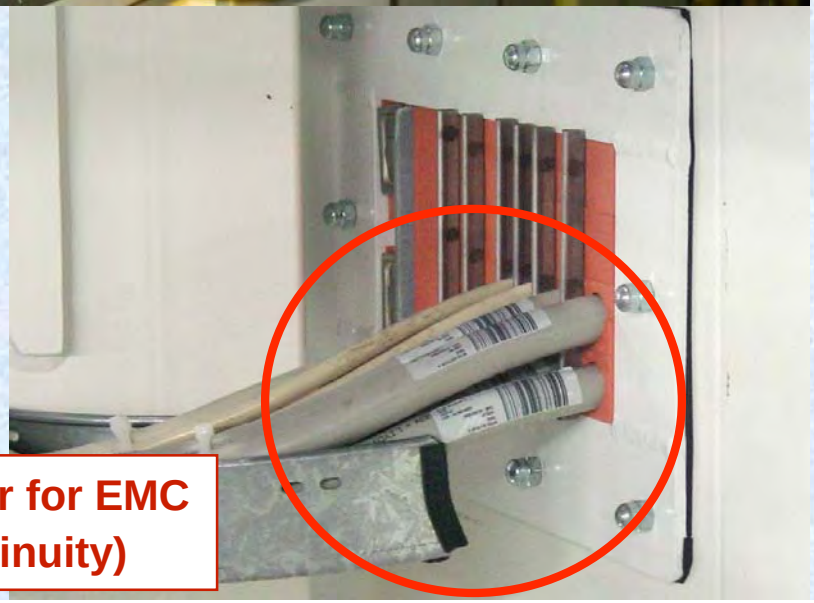


Usual poor EMC fixes - 6

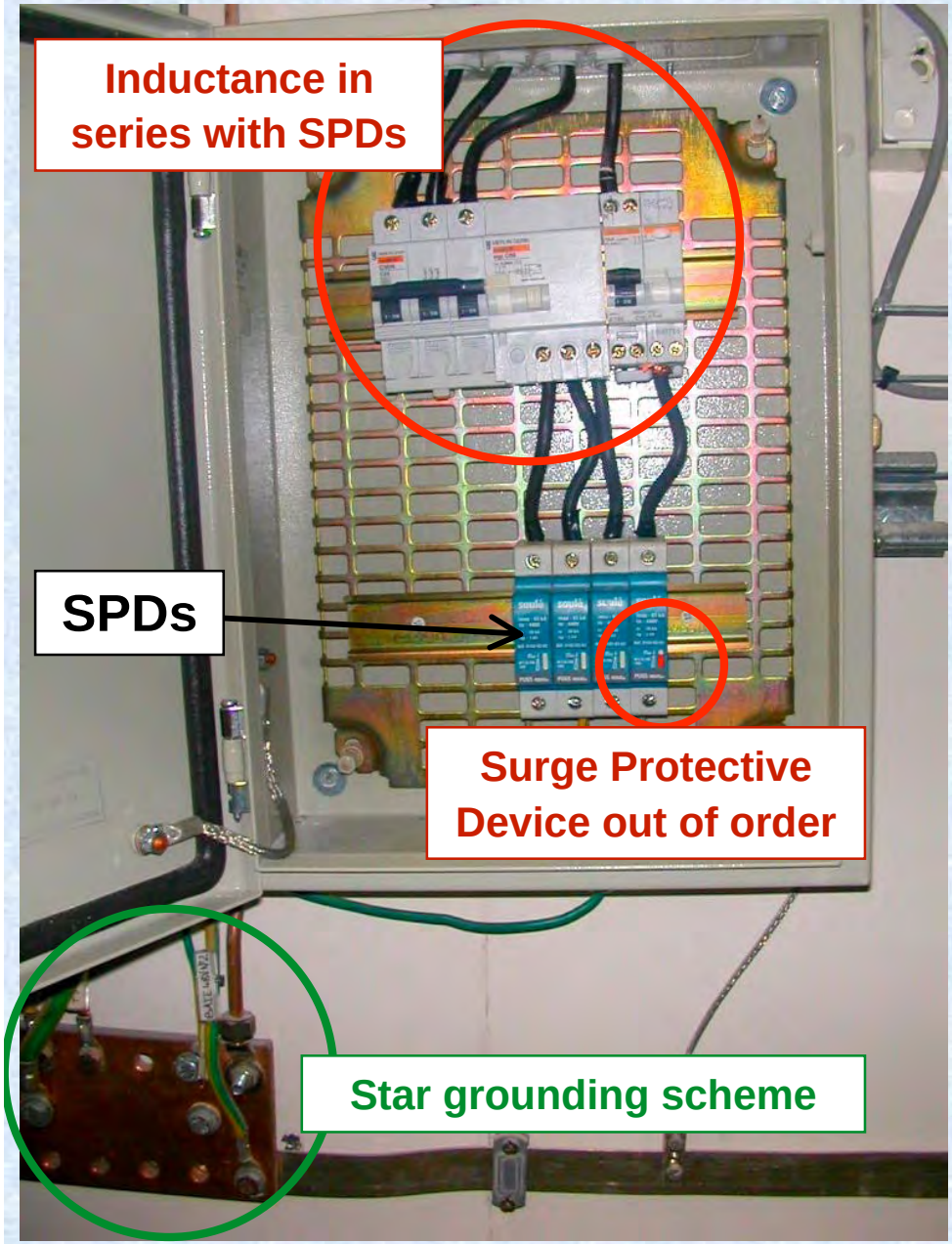




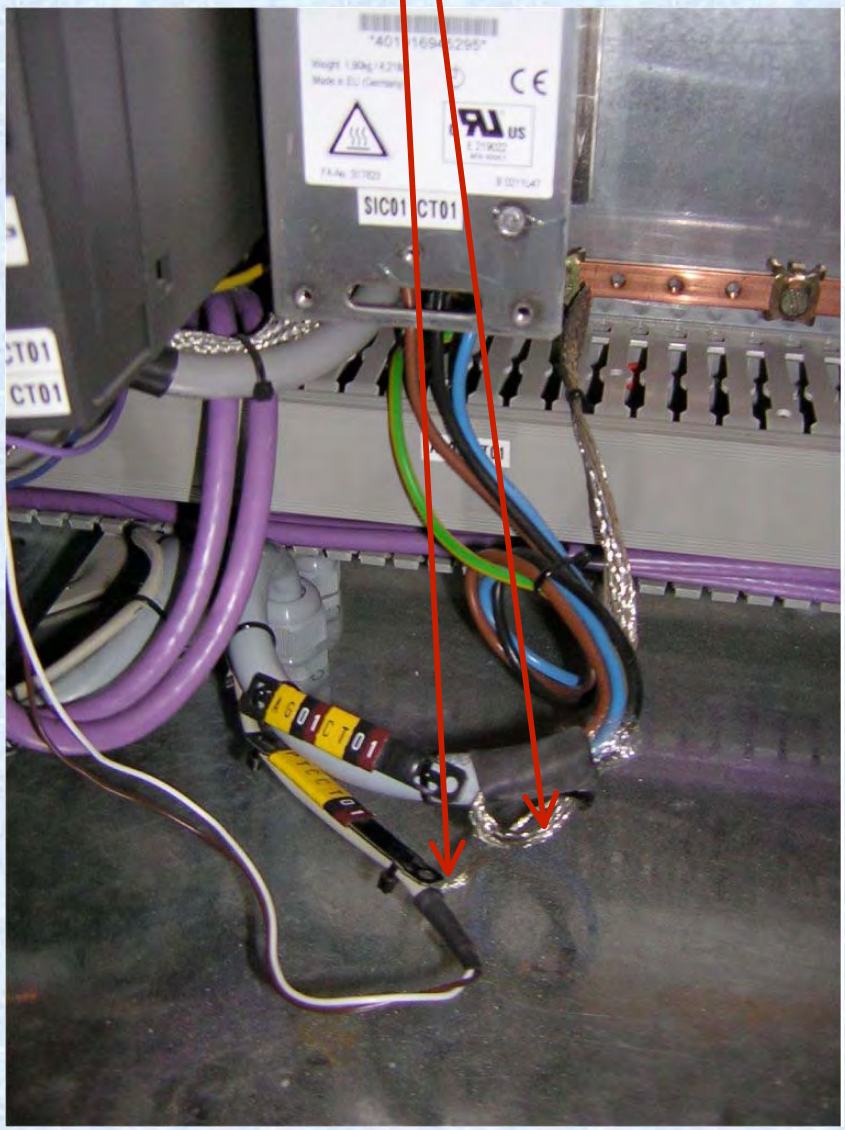


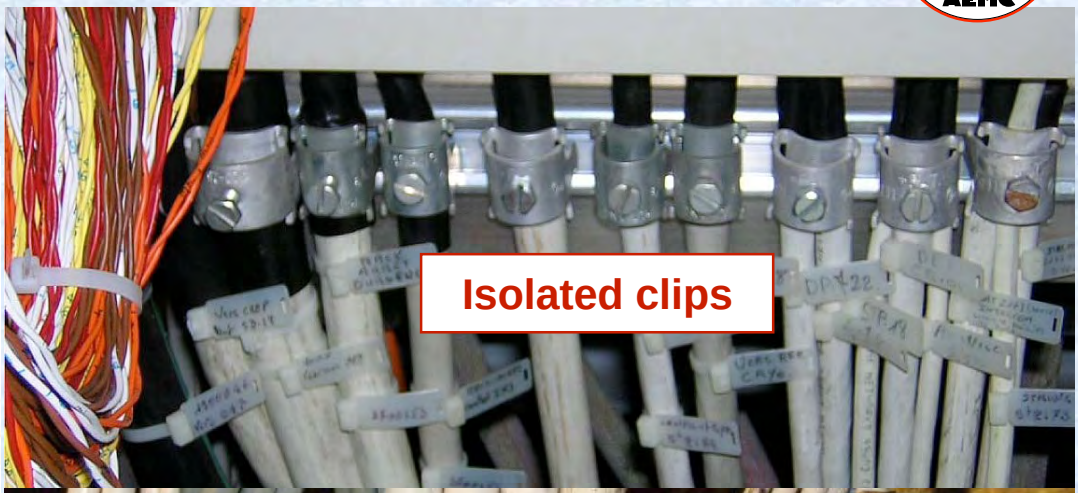


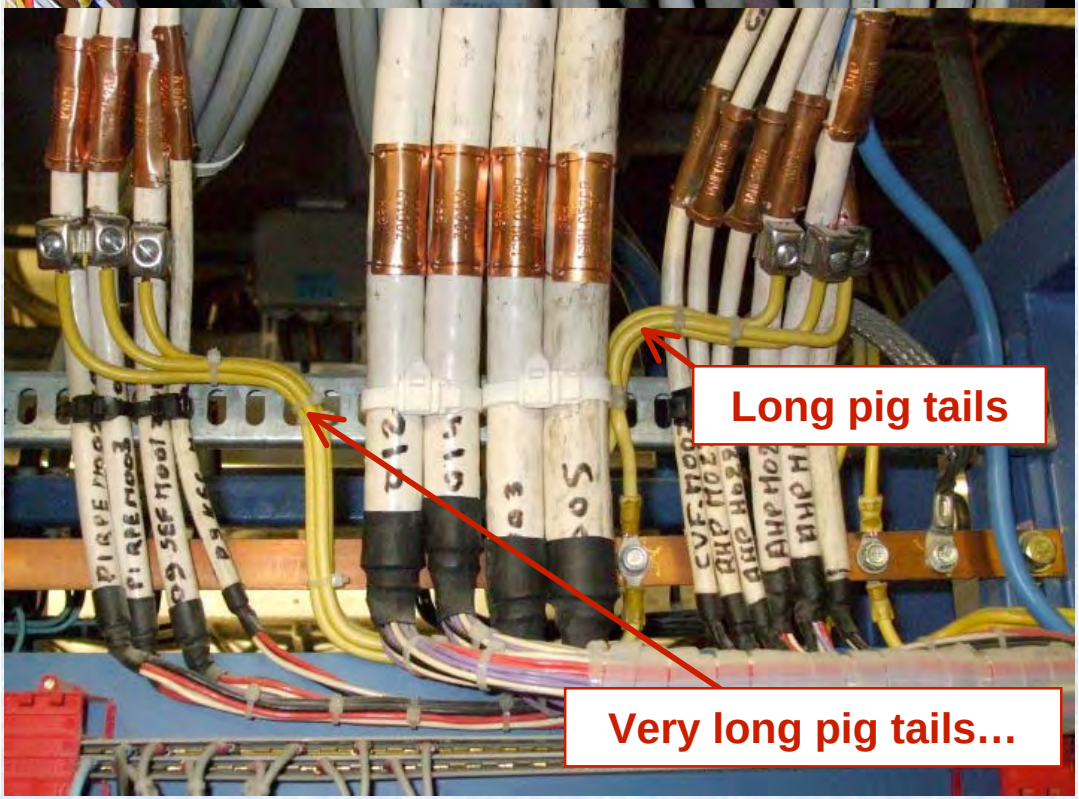
Usual poor EMC fixes - 7



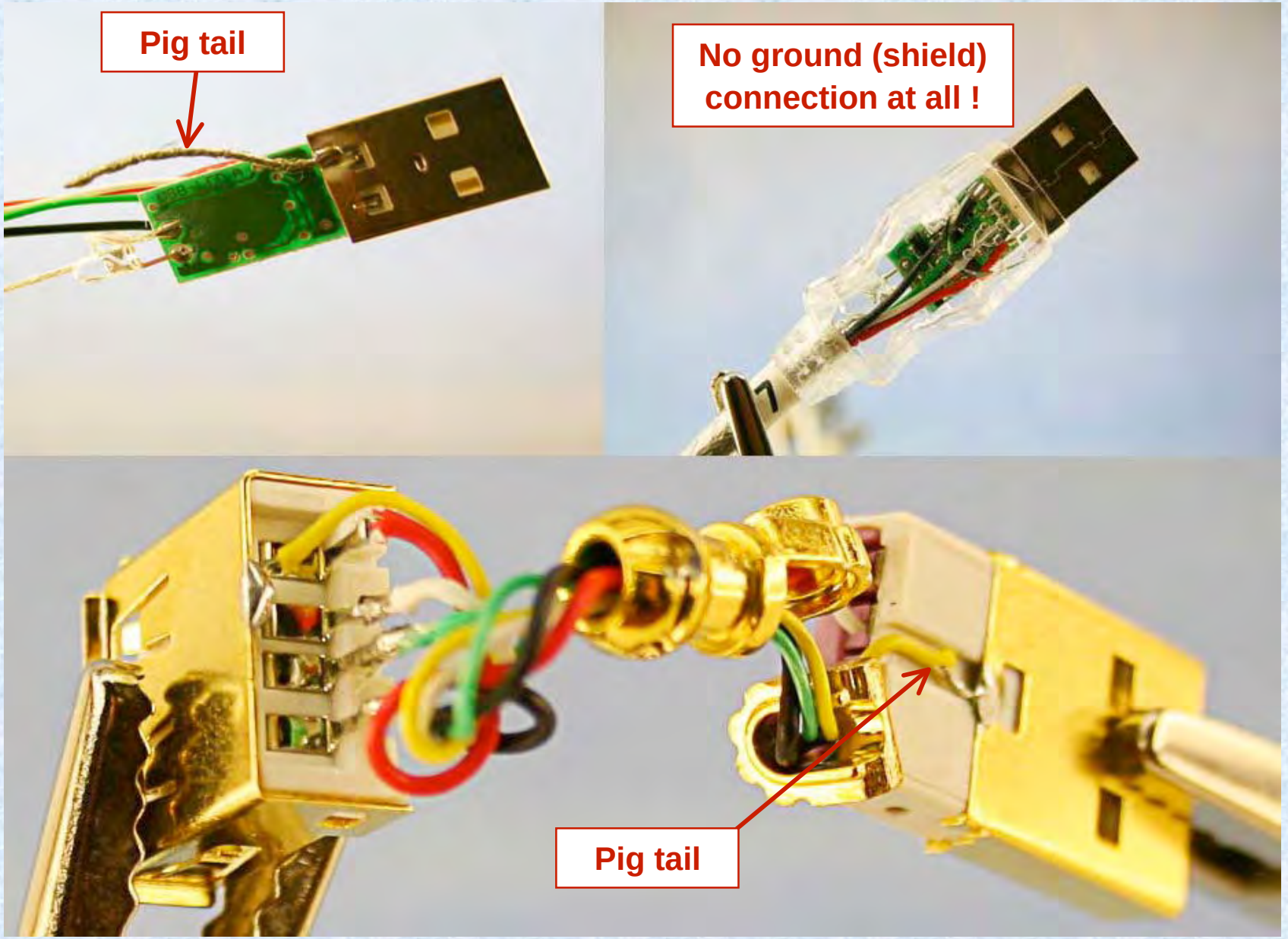
Usual poor EMC fixes - 8



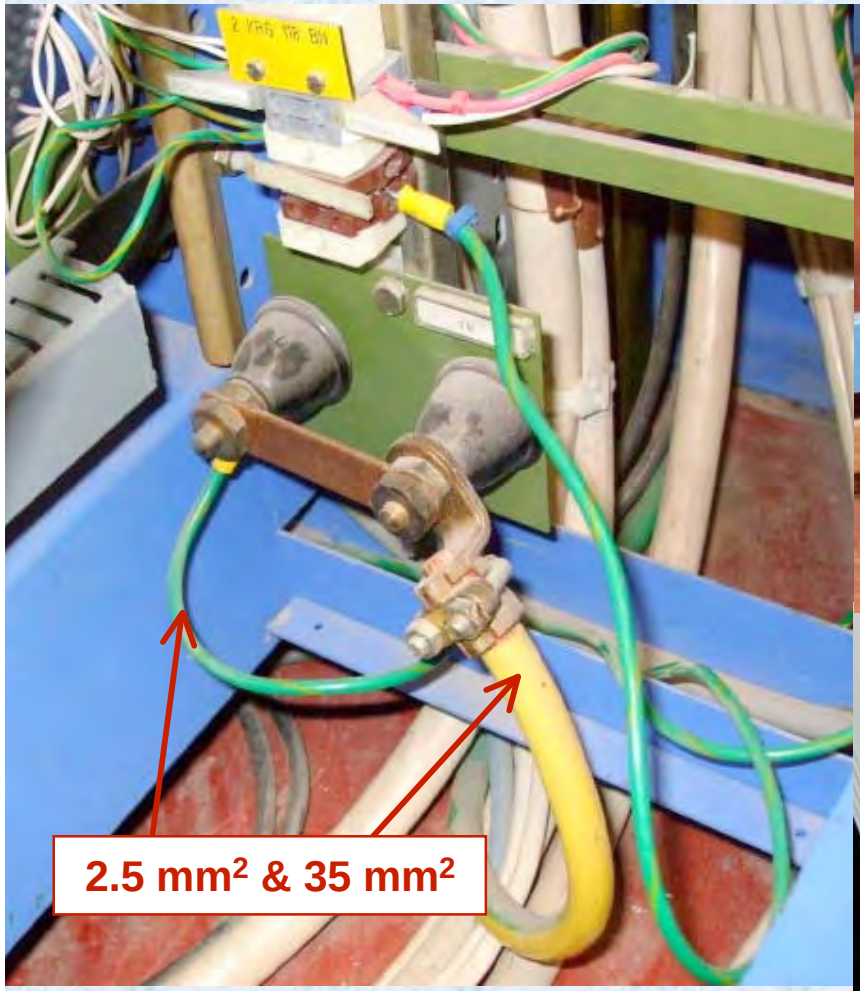


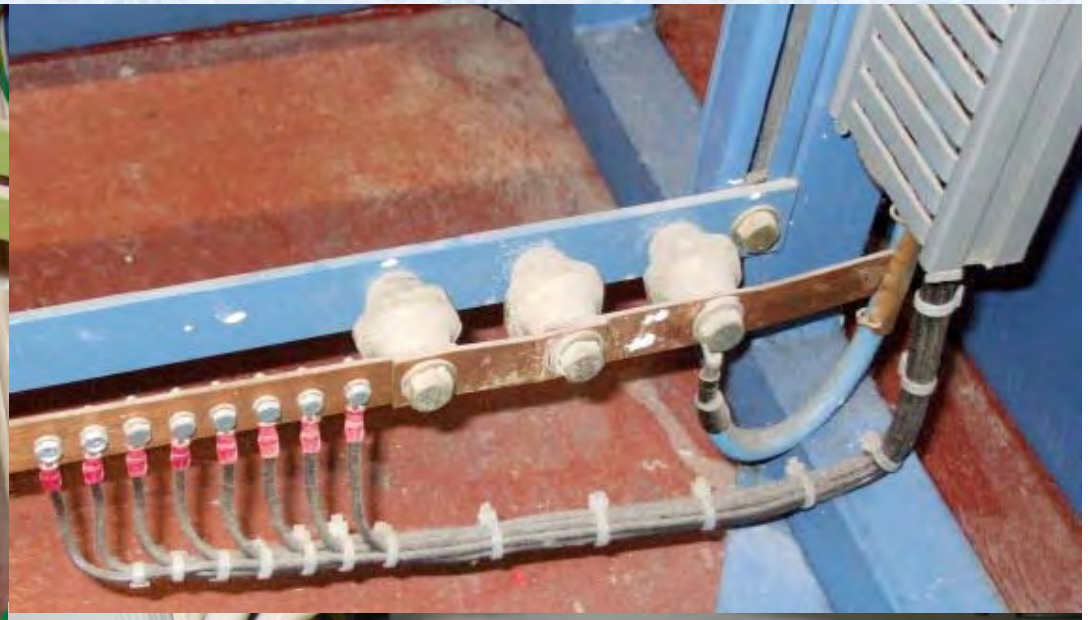


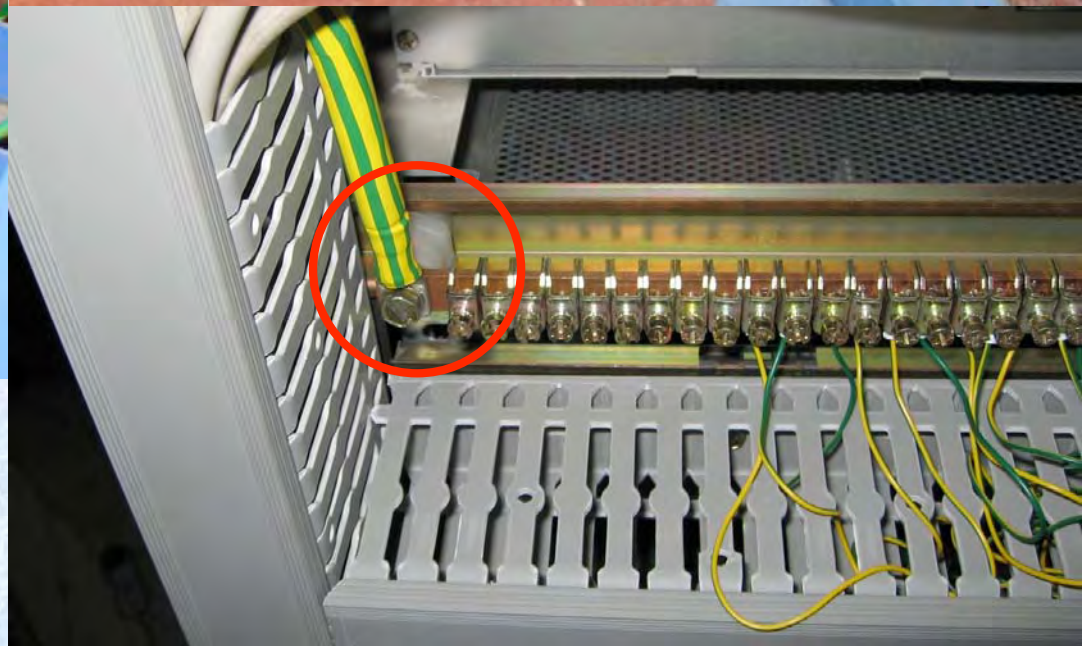
Usual poor EMC fixes - 9



Usual poor EMC fixes - 10







Separate grounds…
and star grounding

An ultimate EMC fix - 11