EMI conform planning's for XFEL

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DESY

Main aspects for plant engineering

★ **Keeping the GND system free of currents.**
but still a fraction of the currents will appear in all metal parts
Requirements to commercial instrument selection and custom designs with electronics

★ **Making the construction independent of currents in the GND system**,
but sensitivity will never be zero.
All work packages with metal parts have to contribute.

★ **Providing a good current guide for user-currents and induced currents**
for keeping current loops small and well understood
That minimized transformer like couplings and also currents away from foreign systems.
Influenced by electronic designs, cables and their infrastructure

- **Providing signals in cables as differential signal** with
stable common modes for voltage and current
Tasks of the electronic designs

- **Direct RF-field** coupling is minor issue for plant engineering, if the designs are OK.
Dipole near field decreases with d/r^3

Nothing will get perfect for EMI:

- Not all techniques might be applicable to all stages.
- Not optimizing a step requests higher effort at other stages.
- Later optimizing is often hard to do or impossible.

⇒ **Where possible plan it in the beginning**

I will try to cover items relevant to plant engineering and leave out the specific electronic design issues.

Keeping GND free of current

Three functions of GND:

- Safety GND: No point of discussion, that has to be provided, to be done conform to EMI

- GND as reference: Needed, but the electronic design can reduce the sensitivity.
  - Needed mainly close to the active sensors
  - Downstream electronics can be designed differentially,…. RF need other techniques but not always commercially available in older styles
  - To be done by electronic design, may be in cooperation with detector development.

- Avoid/minimize GND as current return: If reference is used for it, it will be disturbing.
  …. Current will use any provided metal path ⇒ Every work-package involved using metal
  Think about:
  …. Implementing dedicated isolations in paths to be blocked for return currents
  …. Implementing continues connected low impedance paths for foreseen return paths and also for supporting metal structures, since induced currents are generated. "short direct connections"
  Needs cooperative work:
  - All work packages as far as metal is involved
  - Concepts for electronic system and the electrical infrastructure
  - Instrument selections: e.g. floating supplies, closed current loops….. and not only for the sensitive once, also the robust infrastructure.
  - In custom designs low sensitivity/low disturbances to be aimed.

Keeping GND free of current
Concept from Siemens, A.Kohling, Siemens

Construction of the building cable channels

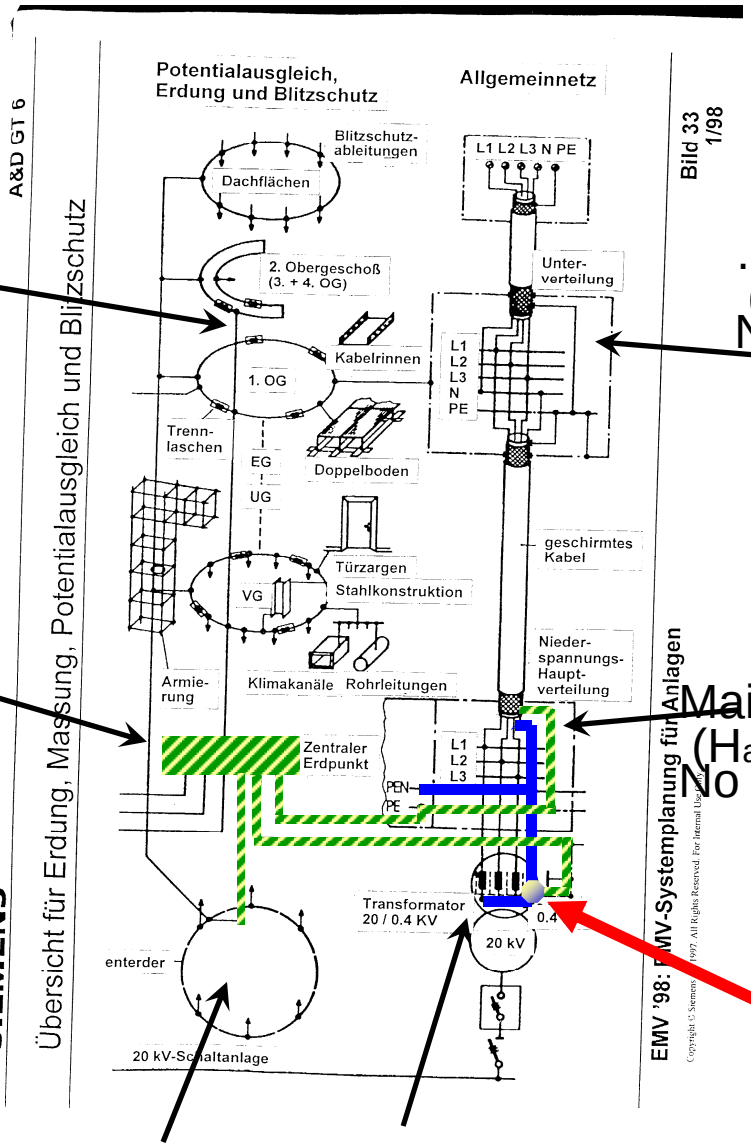
… distributor (UnterVerteiler) No connection N-PE

Main grounding point

Main distributor (HauptVerteiler) No connection N-PE

Only ONE connection Is allowed and needed Between GND-current-return and GND-reference.

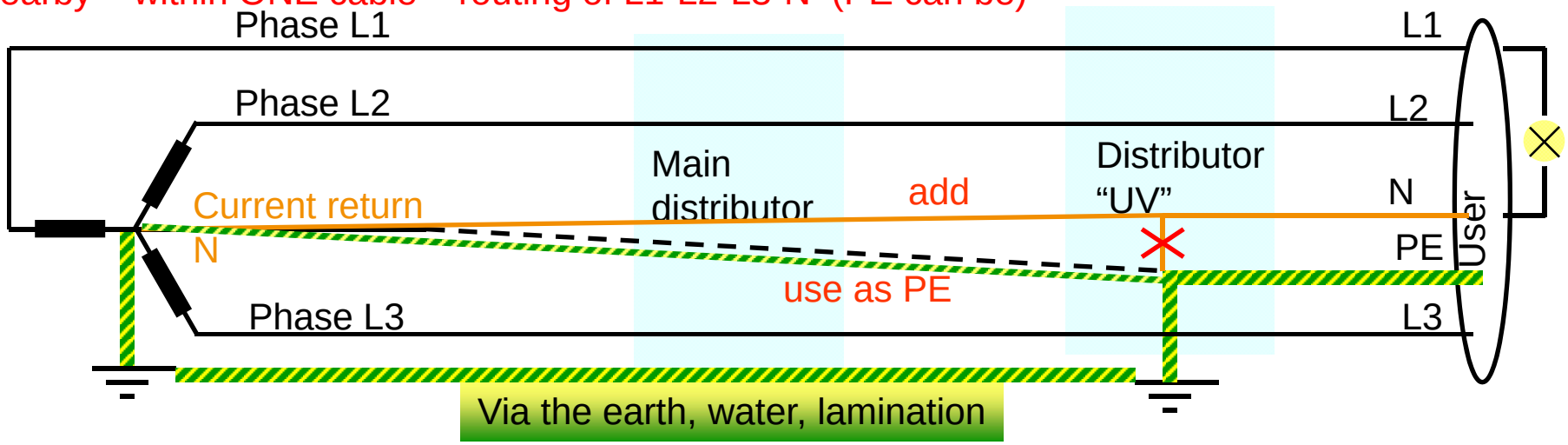
Only connection from PE to N



TN-S net is required:
Bad experience at FLASH and OLYMPUS

Only ONE connection of current return and reference/PE – NO PEN (common PE and N)

Nearby – within ONE cable – routing of L1-L2-L3-N (PE can be)



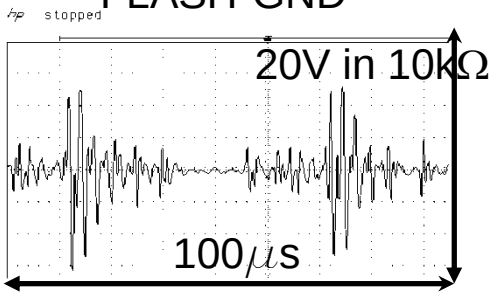
Via the earth, water, lamination

Transformer at DESY

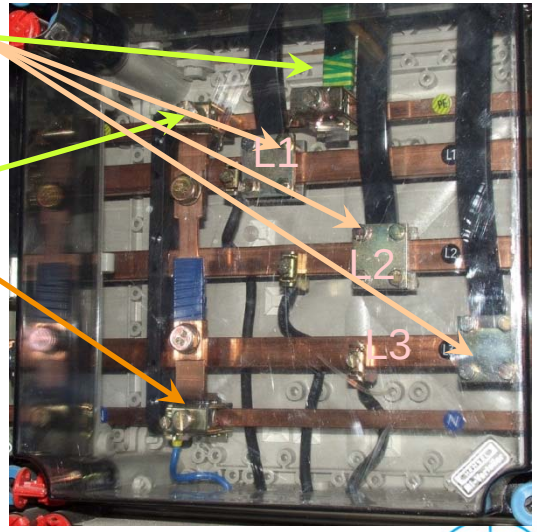
4 visible inputs

4. Contact:
N Neutral
and
PE Ground

Measurement on FLASH-GND

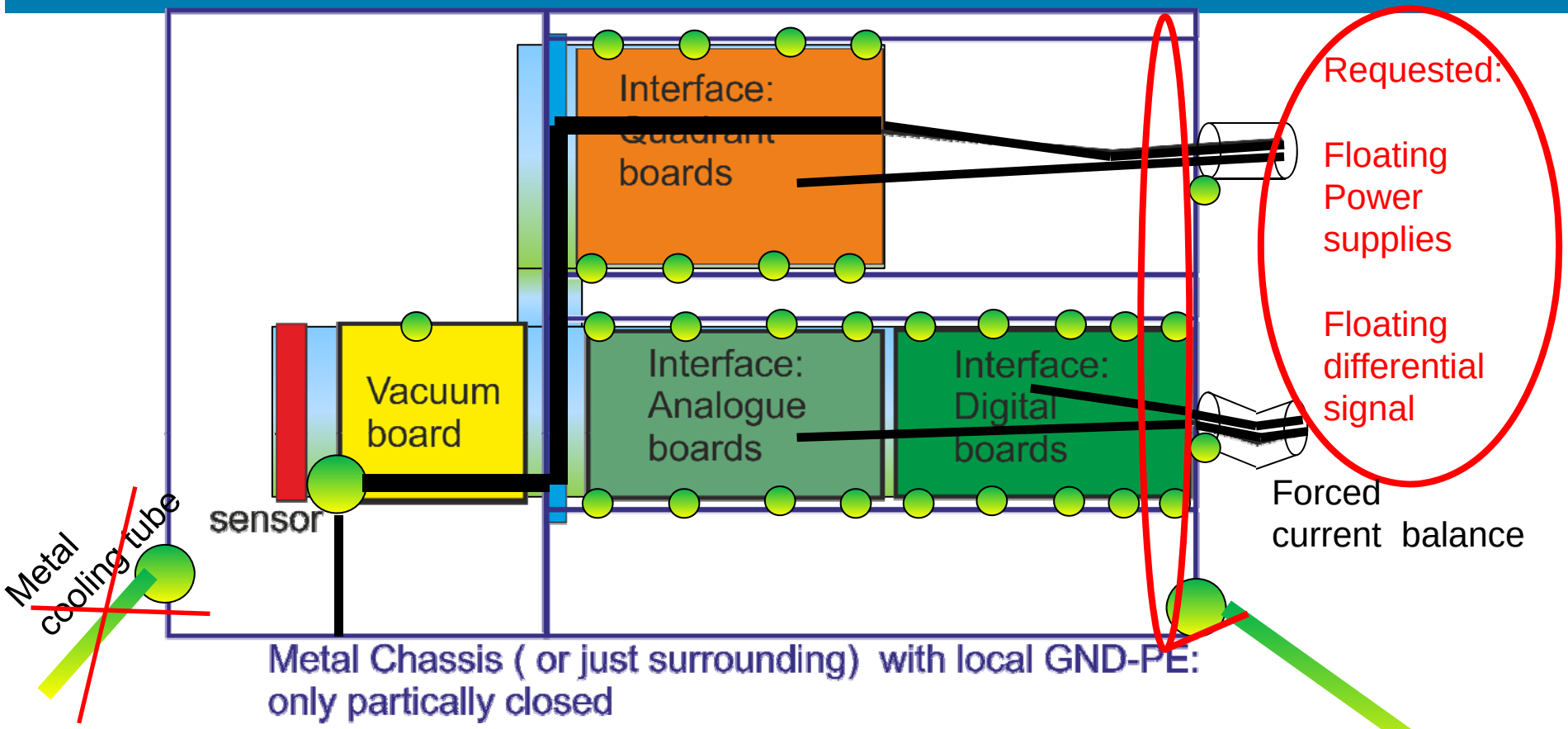


Bridge from PE to N



Distributor (UV) at DESY

Keeping GND free of currents: AGIPD-plans



Using floating power supplies forces the currents to go to the power supply
Without using the general metal structures on PE.

Voltage drops on the metal of the detector are generated only by
the fraction of none controlled currents. They will be there!
⇒ They don't generate currents within the external metal PE system,
if only a small area provides the metal contacts to the outer world.

Keeping GND free of currents: Never zero, but the generated voltage can be kept small

U = R *I + L dI/dt

Often the impact to a foreign system is the voltage on the GND.

“Cheap” by using all anyway available metal … R gets small
and do short loop interconnects….. L gets small

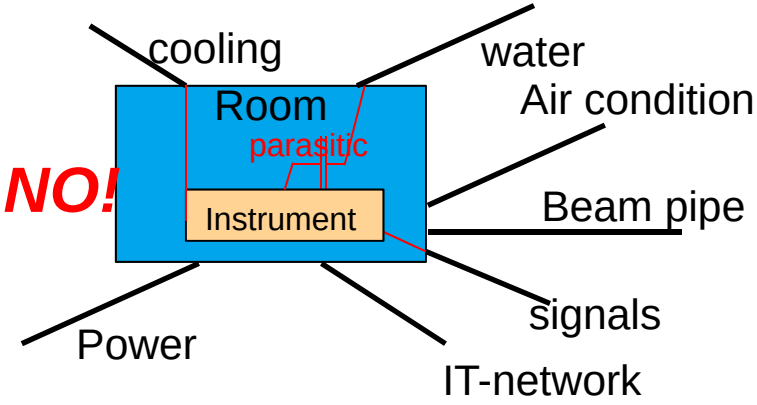
Making the construction independent of currents in the GND system
EMI-zoning Main conceptional system issue!!!!

Goal: minimize the coupling between different areas, functions

- Minimize Z_K
- Maximize Z_E

Minimize Z_K (room planning)

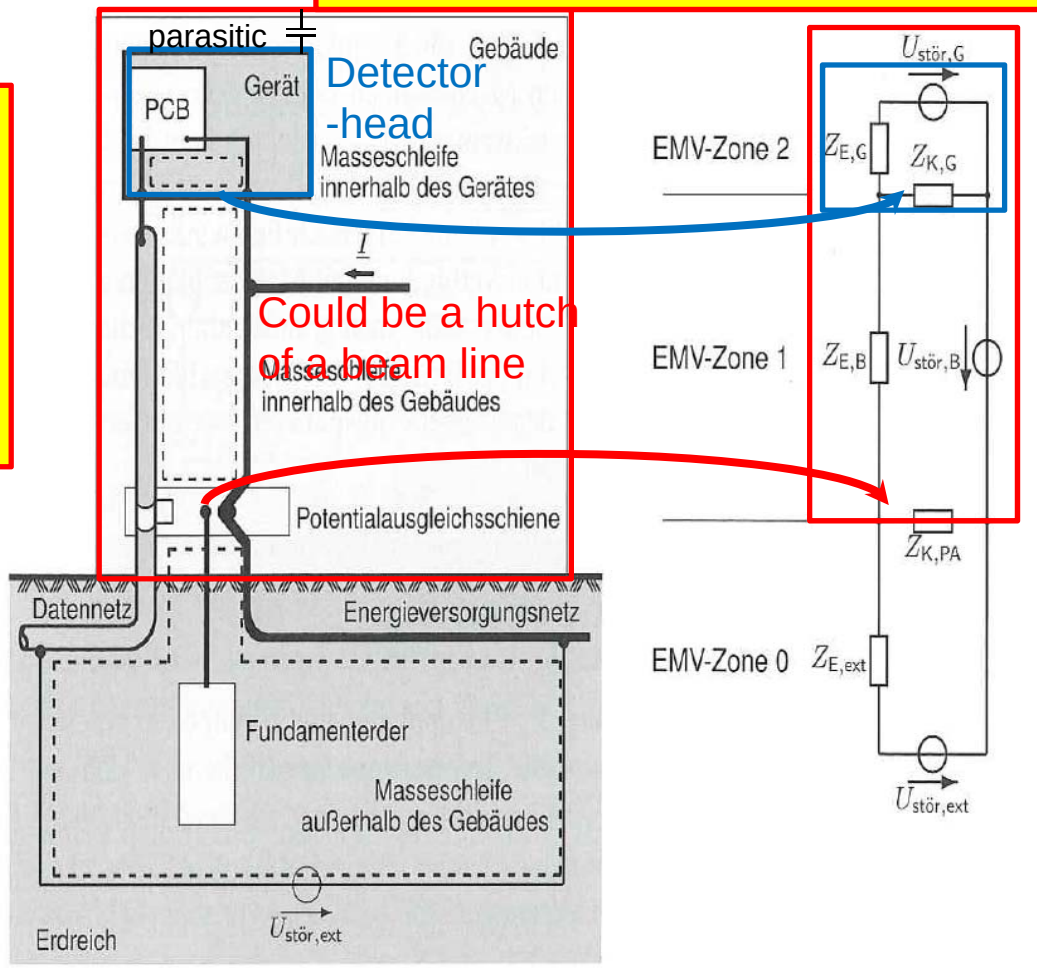
- All conductive connections at ONE point to instrument, to room, to building Afterwards/before distances to limit crosstalk
- Hard to get, than apply filters



Why not?

- Isolations for cooling, water, air, IT
- Short distance power, signals at ENTRANCE, not full length

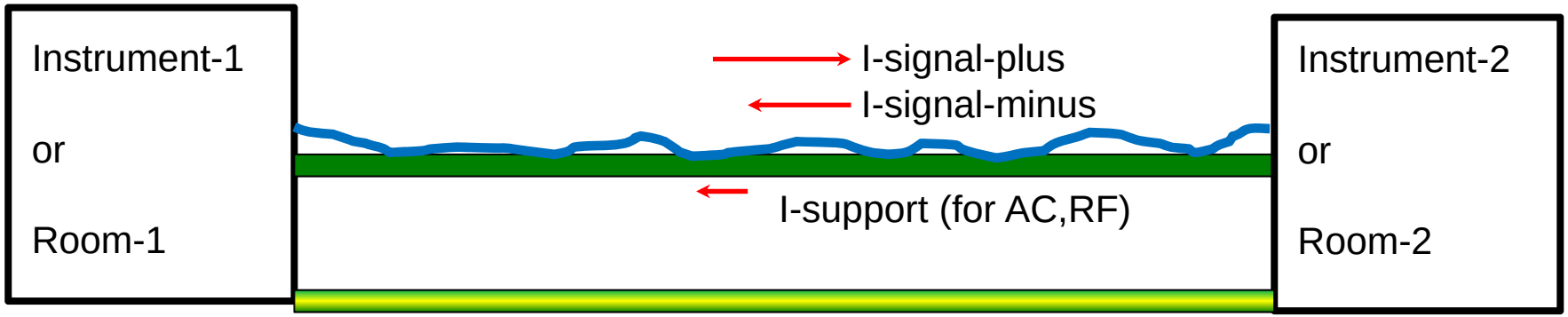
Multiple zoning: "parasitic coupling" The hutch can already be a good shielding, if free of current



J. Franz, EMV, ISBN 978-3-8348-0893-6

Bild 7.32: Masseschleifen in einer Anlage und ESB

Providing a good current guide for user-currents and induced currents

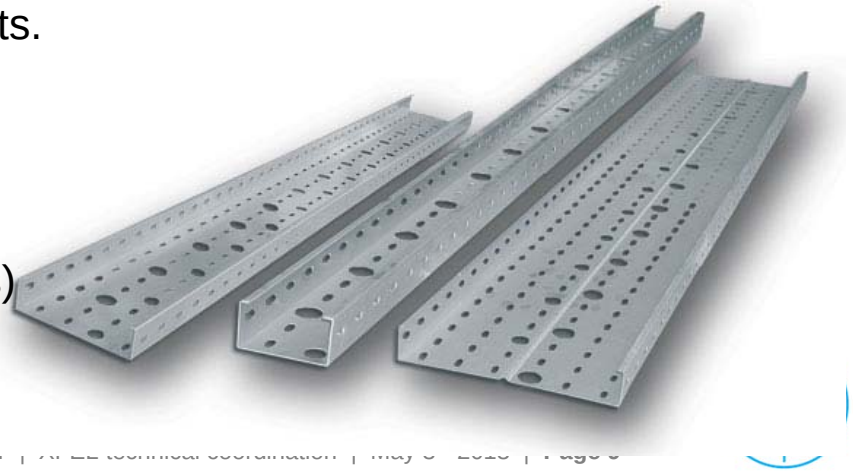


Basics:
Cables and electronics should be designed to get current and return into one cable or as a minimum to get the wires onto the same cable support
"small loops and transformer like couplings"

Even differential signals build up currents in the supporting metal structure

It is better to get the current into the metal structure than into the neighbouring cable.
- Metal structure is needed to guide these currents.
- Metal plates are better than just ladders

Grouping cables to different supports by a few classes from
- Disturbers (e.g. single ended coax, step-motors)
- Sensitives



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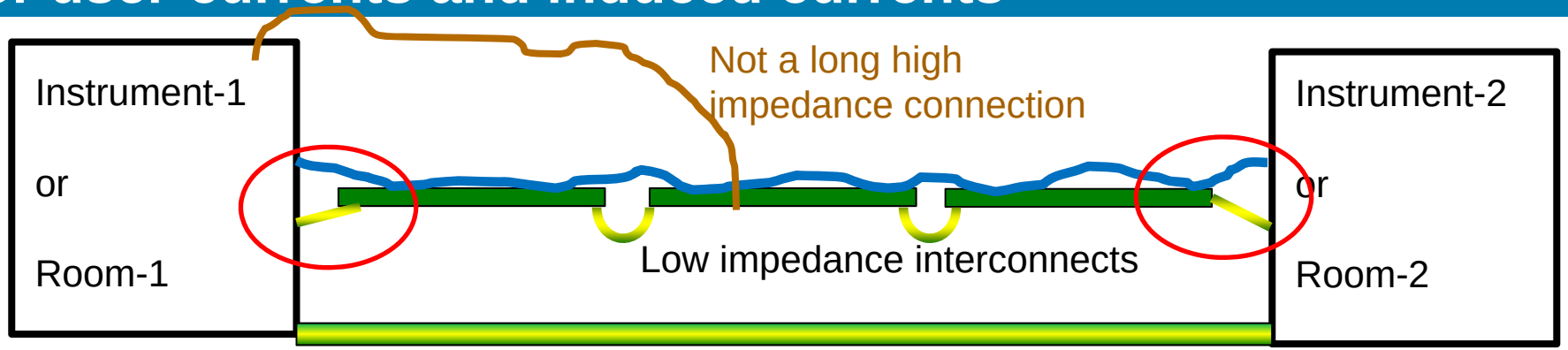


Connect the shields and the cable support at the instruments?

- Industrial advice: YES
  This closes the EMI zones, best if also the cables are shielded and also connected.
- If shield is not connected, the cable or metal part should not run long distance into the room. That would be an antenna in the room. Filter at zone-entrance needed!
- Large scale detectors: CMS connects the shields, ATLAS connects via capacitors.

Difference is, what is the disturbance at low frequencies, because some component introduce its current into the protection-earth. It gets relevant, if a second PE connection is present.
In either decision, it can be prepared for the cable trays to change connections with reasonable amount of work.

Connection of other metals to the rooms:
At the point, where everything else connects and not random position or random contact.
They might help to get low R, but might also introduce currents…. Isolation ?

Providing a good current guide: Currents on cable shields

Cable shields should be connected at the entrance of the EMI zone.

Otherwise they are antennas inside

Alternative filter at that point

Low impedance connection, because AC/RF has build up on the cables.

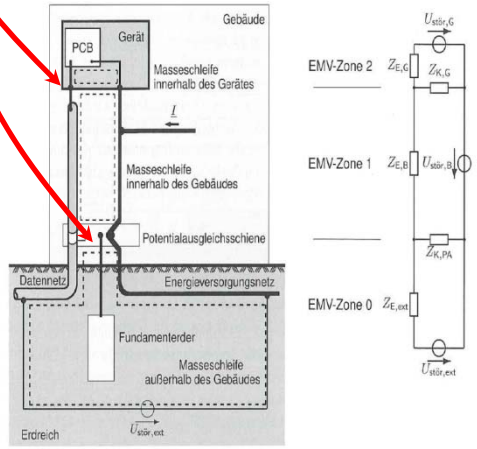
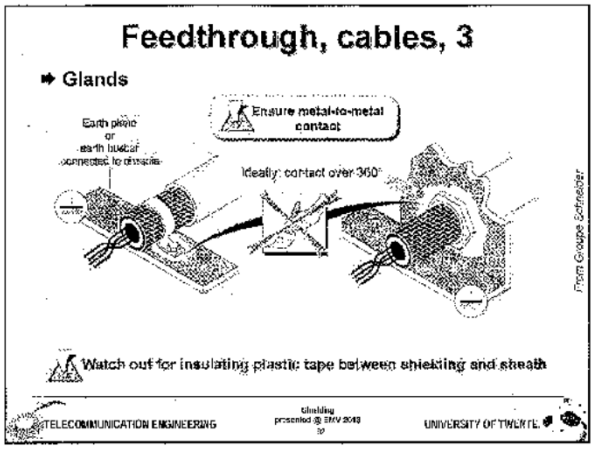
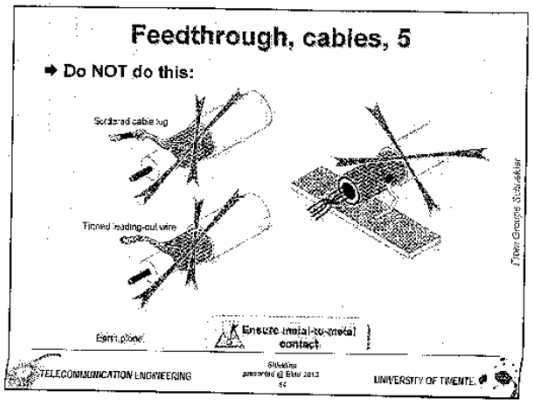


Bild 7.32: Masseschleifen in einer Anlage und ESB

Ideal



Bad, but not Useless



What is Practicable?
Try to minimize length.

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Summary

- For plant engineering the current in the GND-system is the most important issue
- Zoning with shields protects the areas against each another
  Outer area can tolerate worse EMI that the sensitive inner areas, if a good protection is achieved.
  - metal cages with low impedance interconnects as shields
  - current on the shield has to be minimized
- All metal connections are points of introducing currents: “Single” connection point/area
- Low impedance (R and L) connections for guiding currents.
- Classifying cables and instruments and group according to EMI-behaviour
- Instrument selection, e.g. low ripple supplies, differential signalling, avoids the source.
- Fields shouldn’t be forgotten, but are localized in reasonable designs.

EMI might need compromises
- Is the hutch an outer but already good EMI-zone?.... What would be the effort to do it?
- Is only the detector a good EMI-zone?
- Depends: Where is digitized? Are sensitive connections from long distances?

It is correlated: Optimised low sensitive system
normally generates only small disturbances to others