

LHC EMC workshop

EMC is not only a science but

a) a legal requirement

b) a safety requirement

c) a risk management tool

d) a money saver

LHC EMC workshop

In March 2004 an LHC EMC workshop was organised for experiments and machine but the machine community missed the bus.

The March workshop had presentations of FNAL, ESA, all four LHC experiments, AEMC Grenoble (an EMC consultant) and AB/PO.

What did we learn?

How can we apply this to the LHC machine?

LHC EMC workshop

Experiments are threatened by common mode, synchronous 40 MHz operation and transients. They hesitate to make use of the inherent equipotentiality and jeopardise screen continuity. Only one experiment has an EMC-expert.

AEMC Grenoble reported on solved EMC cases and on its internal possibilities. Mr. Charoy, the owner, is France's top EMC expert.

LHC EMC workshop

The European Space Agency has put EMC at the level of the Directorate. They have a full-fledged EMC laboratory with 5 FTE. NOBODY passes a project without the EMC-Director's signature.

Where is CERN? Why did we never go for the science of EMC in an organised way?

EMC @ CERN

- Although CERN always had people interested in the subject there never was a broad, organised EMC-effort. Today STI says that the EMC-community is 28 strong.
- Nowhere at CERN EMC shows up in the hierarchical structure (except individuals). The EST part of TS should do that.
- Physicists in the domain of High Energy Physics do not happen to know the subject at all.

EMC @ CERN

- In contrary to physicists some of our engineers take advantage of established EMC knowhow (contracts, standards).
- Presently there are only few units with a born-bred EMC plan. There is no systematic check on the feasibility of such plans.

EMC @ CERN

- **Bad EMC examples at CERN:**
- Alarm systems - NDE's, false alarms, alarm avalanches, wrong alarms
- Multiple grounding & shielding sessions without consulting the technicians/engineers concerned
- Entire project failures in physics (e.g. a Microvertex detector cancelled due to severe lack of EMC)



EMC @ CERN

- **Bad EMC examples at CERN:**
- Large computing effort on signal analysis for patching up noise ridden measurements (postprocessing)
- Too fragile designs asking for “quiet environments” (e.g. chips optimised for low power with no ripple or overvoltage margin)
- Mutual accusations for making “noise”.



EMC @ CERN

- EMC related accidents/incidents at CERN:
- Destruction of 600 kW cryogenic compressor because hardwired safety loop was subject to cable tray induction
- Fire in experiment NA48 - isolation transformer fed electronics caught fire
- Recent beam loss and consequent magnet destruction in TT40



EMC @ CERN

- EMC related accidents/incidents at CERN:
- BA3 fire - the cause was not EMC but the alarm system showed a fire elsewhere. This effect was again found in an exercise in building 40, when the alarm system said building 179.
- Accumulation of NDE'S in buildings with power equipment (EHN1, SR4, BA80 etc.)



EMC @ CERN

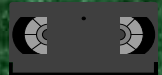
- Good EMC examples at CERN:
- DC stray currents of railway influencing accelerator found after long investigation
- EMC laboratory in the safety commission, mainly for functional safety
- Large EMC effort for limiting emissions in the forthcoming LHC machine.

EMC @ CERN

- Good EMC examples at CERN:
- EMC position in one of the large physics experiments at LHC
- EMC professionals directly involved in problem solving (see later talks)
- CE requirements slowly find their way into CERN specifications, including EMC.

Why is EMC important now ?

- Switch Mode Power Supplies in very high density and numbers (~10000 in one pit).
- Higher dynamic ranges than ever before (experiments require 10^5 range in 10^6 channels)
- Silicon detectors at very large scale, at very high density, in a very hostile environment



Why is EMC important now ?

- Quarter micron technology asks for very low supply voltages (+/- 1.25 Volts) but the supply currents do not change much. Huge EMC problem on ripple, common mode, transients. ELV DC needs to be brought into 4 Tesla field without possibility of conversion in situ.
- Accelerator uses very high current SMPS distributed over the entire ring. EMC problem due to cabling in parallel with instrumentation and general services. Safety Commission is not aware of systematic EMC assessments in this domain.

Why is EMC important now ?

- Accelerator needs 10^{-6} current precision for its main circuits. EMC is one of the threats to the required precision.
- Accelerator puts the first batch of equipment in the tunnel - we are acquiring a first experience on real cabling soon.
- Experiments build prototypes on the surface for behavioural studies - EMC personnel will be there to torture their setups.

Some aspects of EMC: Ground

- **CERN has a TN-S ground system, and it is believed to well meshed. Care is taken to having low contact resistance and limited effect upon electrical faults, such as a possible 50 kA short circuit in our low voltage bus bars. The final check on this is part of my section's work on "controle electrique".**
- **Physicists have doubts about our ground system BECAUSE THERE IS LITTLE UNDERSTANDING ON COMMON MODE and its consequences.**

Some aspects of EMC: Power Quality

- **CERN specifies the power quality on AC for LHC operations. There should be a systematic EMC check between the specification of the source(s) and the specifications of all client equipment. This should include the foreseen cable neighbourhoods.**
- **For fear of transients and magnetic stray fields from the magnets one experiment intends to use a very large 400 Hz power system (over 1 MVA) running on motor-generators. No scientific justification exists.**

Dealing with EMC: Collaborations

- **CERN experiments are collaborations between large groups of institutes. The perception of EMC varies from “First we build, then let’s see” to false experts (“EMC trouble comes only from transmitters”) to very good institutes like NIKHEF where EMC is integral part of their procedures, and failures due to that simply do not exist once the electronics is installed here at CERN.**
- **Recognition of scientific work in the EMC domain is extremely rare. It’s the classic physicist<-->engineer communication problem.**

EMC and Safety

- Due to lack of EMC knowledge there are noise cancellation religions in physics:
 - “Floating” the power supplies
 - “Floating entire metallic structures”
 - “Separate dirty ground, RF-ground, etc.”
-
- Safety requires a certain earth configuration. If researchers claim certain connections to carry noise this noise must be measurable.

EMC and Safety

- **The Safety Commission is not able to circumvent electric regulations because of the installed believe that the earth is the mother of all noise and all ground loops.**
- **CE label, environmental questions: The Safety Commission encourages scientists to ask for proof on CE-labelling, in particular for DC-DC converters and switch-mode power supplies.**
- **CE-Conformity is mandatory at CERN.**

EMC and Cost

- A major part of EMC can be had for free - it's cabling discipline, earth interconnections, good equipment choice.
- **EMC integrates well into early phases of project planning. Just imagine if we needed to ask AB-PO to deal with EMC starting today - the cost would be astronomical. Because EMC IS part of their approach the entire system is better adapted to the needs today, and it is more reliable too.**

EMC and Safety

- **Faites circuler les courants!** (quoted from a professional French magazine)
- **Make use of unoffending ground loops where it does not hurt.**

Conclusion and link to the workshop

- **The Safety Commission sees two major problems:**
- **Physics experiments want to install many insulated circuits and even metallic structures for ground loop cancellation, which is a severe safety concern.**
- **The immunity of electronics in accelerator and physics experiments physics must fulfill basic requirements. For the accelerator this is more or less also a safety issue. For the experiments it is a performance and equipment protection issue.**