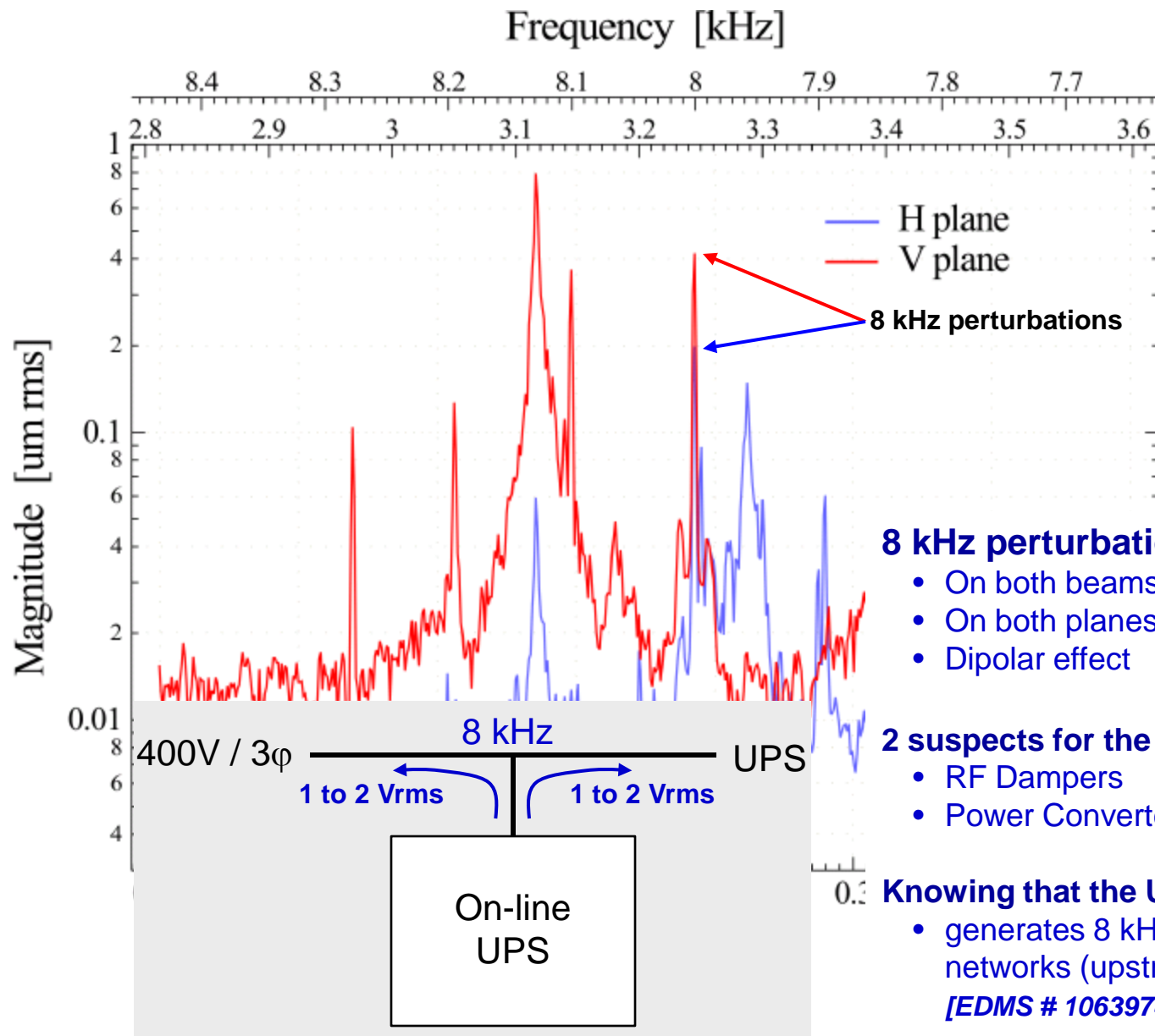


8 kHz Measurements on the LHC power converters

TE-EPC

V. Barbet, L. Charnay, H. Thiesen

8 kHz beam perturbations



8 kHz perturbations:

- On both beams
- On both planes
- Dipolar effect

2 suspects for the 8kHz perturbations:

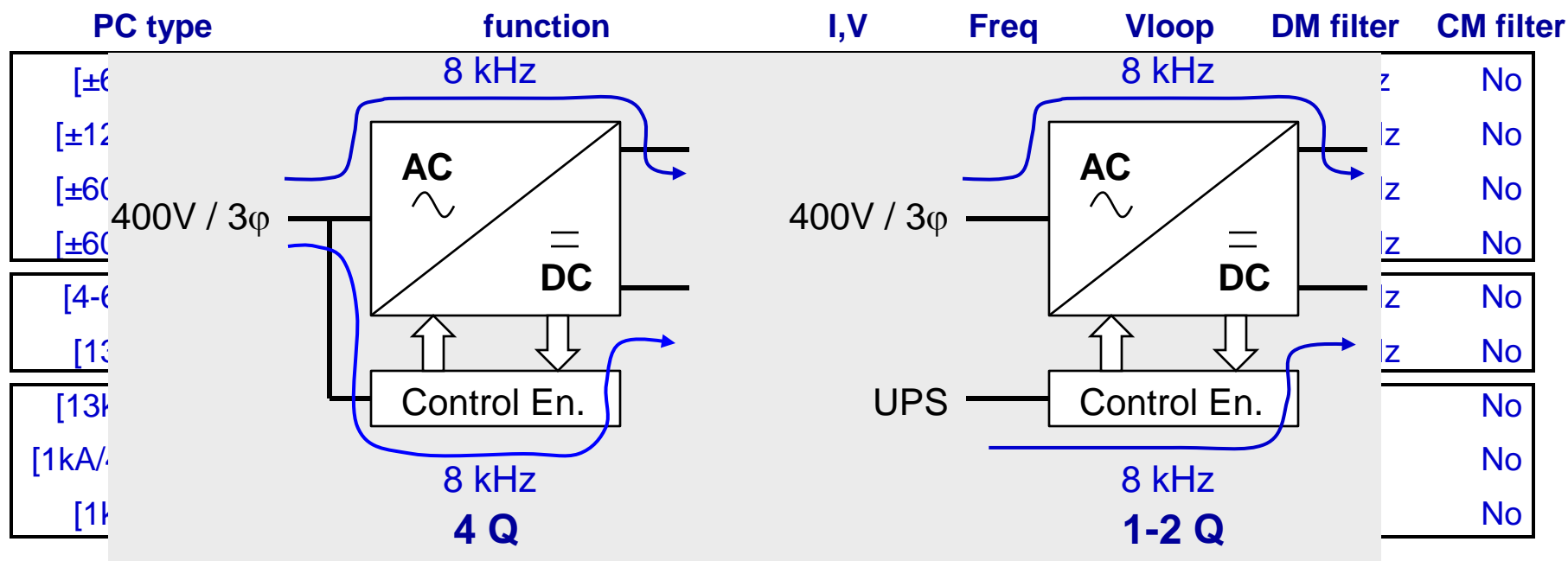
- RF Dampers
- Power Converters

Knowing that the UPS (APC):

- generates 8 kHz perturbations on both networks (upstream and downstream)
[EDMS # 1063974 - V. Chareyre]

LHC power converters

- 1752 power converters and 9 different types:

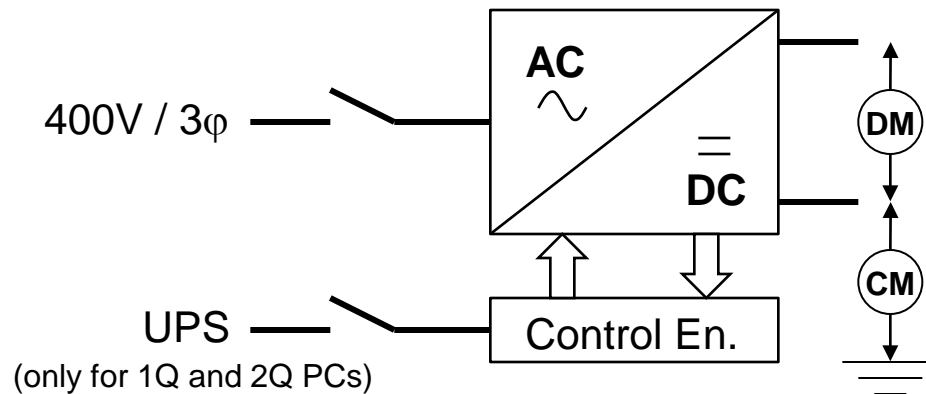


• How can the PCs generate the 8 kHz?

- By EMC coupling, the PCs can transmit 8 kHz perturbations coming from:
 - The 400V network for the 4Q power converters
 - The 400V and UPS networks for the 1Q and 2Q power converters

PC measurements

- **Measurements by PC types:**
 - DC side
 - At injection current
 - PC disconnected from the AC networks (400V and UPS)
 - AC side
 - 400 V
 - UPS (1Q and 2Q PCs)
 - In Differential Mode (DM) and Common Mode (CM)



PC measurements

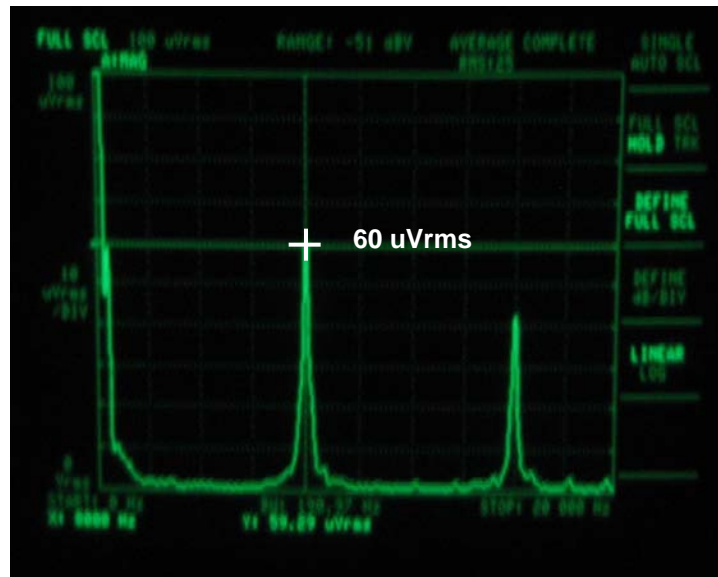
- Results:

- AC side

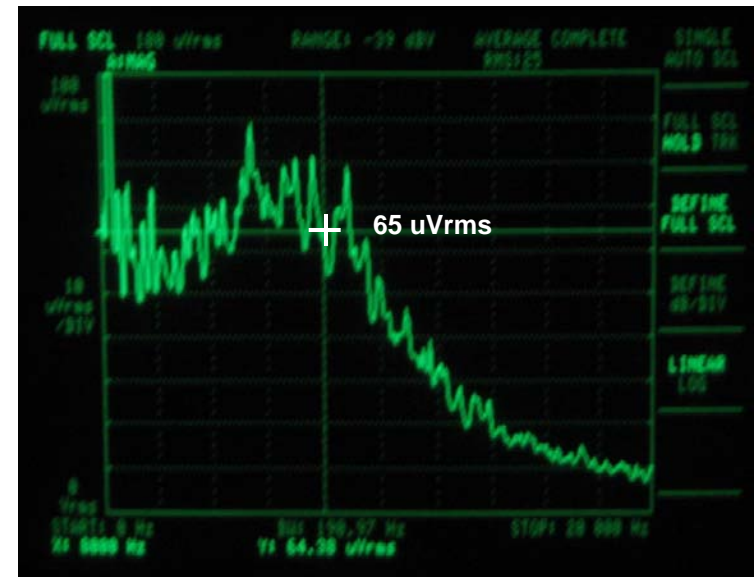
- Same order of magnitude in DM and CM
 - No 8kHz on the 400 V except for the **60A PCs** (between 1 to **2 Vrms**)
 - Between 1 and **2 Vrms** on **UPS** (electronics high current PCs)

- DC side (4Q power converters)

- Same order of magnitude in DM and CM
 - < 60 uVrms PC disconnected (**disappears when UPS are off**)
 - < 90 uVrms at injection (7 mVrms specified in DM)



PC disconnected



PC at I_{injection}

RQT12.R8B2 (DM)

PC measurements

- Results:

- DC side (1Q power converters)

- IPQ and IPD PCs (4-6-8 kA)

- Same order of magnitude in DM and CM

- < 20 μVrms PC disconnected

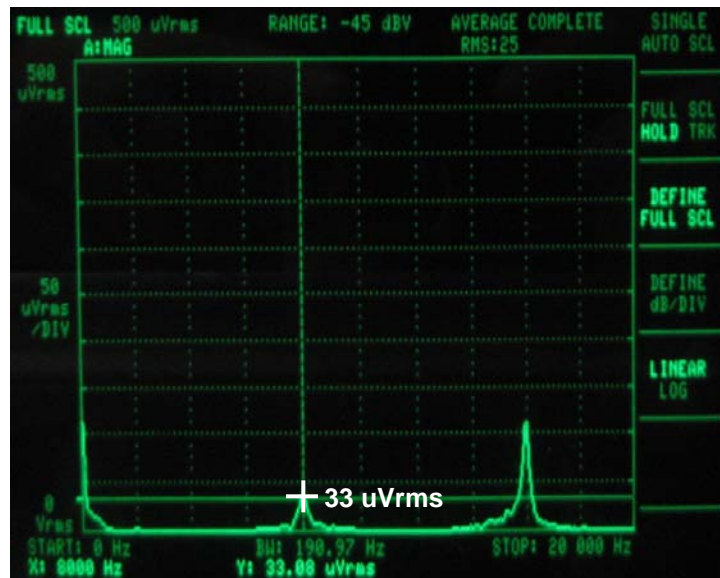
- < **350 μVrms** at injection (3.5 mVrms specified in DM) # 350 nA for 20 mH

- MQ

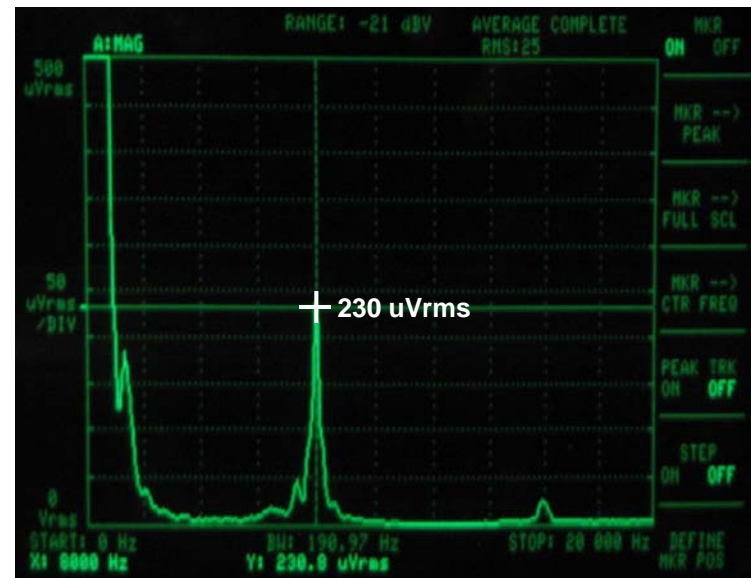
- Same order of magnitude PC disconnected or at I_{inj}

- < 40 μVrms in DM (3.5 mVrms specified in MD)

- < **250 μVrms** in **CM**



MD



CM

RQF.A81

PC measurements

- Results:

- DC side (SCR power converters)

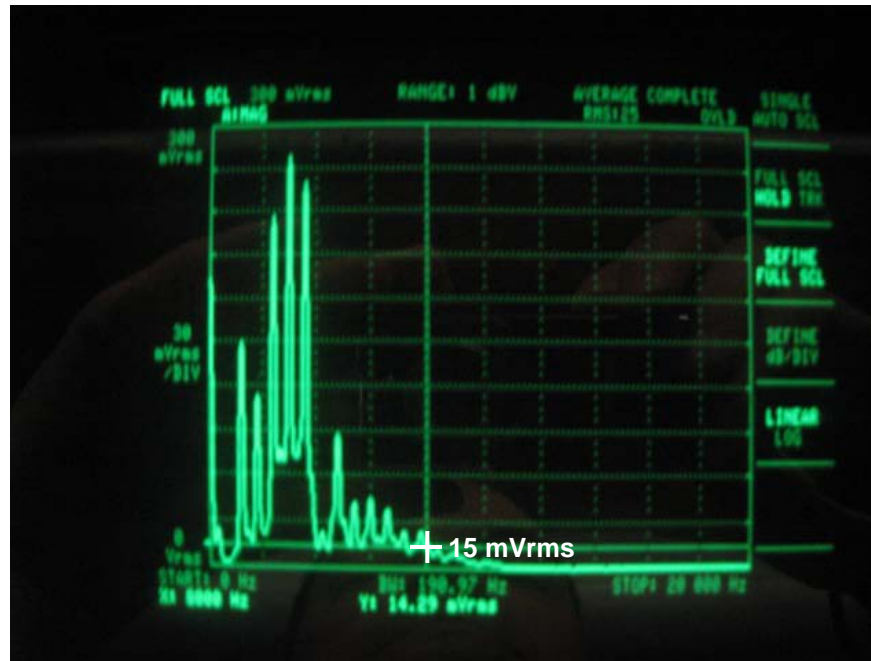
- MB

- PC disconnected: DM = 10 μ Vrms and CM = 20 μ Vrms

- PC at injection current: DM = **15 mVrms** and CM = 7 mVrms

- WM (2Q)

- Measures need to be confirmed but not high levels (> 10 mVrms) have been observed



RB.A81 at injection (DM)

Conclusion (1)

- **Conclusion:**

- The PCs do not generate high level of perturbation at 8 kHz ($< 350 \text{ uVrms}$)
 - Could 60A PCs transmit enough 8 kHz to perturb the beams by number effect ? (752 PCs).
- The 8 kHz is present with PCs disconnected from the AC network
 - Part of the 8 kHz is injected by the DC part of the circuits
 - Through the SC magnet instrumentation?
- EMC problem (DM and CM)
 - The 8 kHz can be injected by the parasitic capacitor of the circuits
 - Difficult to translate the voltage ripple to current ripple and finally to magnetic field ripple
- More investigations are needed
 - To confirm that the 8 kHz perturbations are generated by the UPS (APC)
 - To identify how the beams are perturbed by the UPS (APC): 60A PCs, SC magnet instrumentation
 - To find and validate a solution

Conclusion (2)

- **Investigations**

- Operate the LHC at 450 GeV with beams and without some UPS
 - Measure the tune without F3/RE (Arc SC magnet instrumentation)
 - Measure the tune without F3/RE and F4/RE (idem + 60A + nQPS)
- Test the EMC immunity at 8 kHz of
 - SC magnet instrumentation
 - 60A PCs
- Reproduce the 8 kHz perturbations in SM-18
 - Install UPS (APC) in SM-18 and measure the magnetic field for different type of magnets
 - Inject 8 kHz perturbations and measure the magnetic field for different type of magnets

Possible solutions

If the 8 kHz perturbation is generated by the UPS (APC)

- Change the setting point of the LHC to avoid the 8 kHz region
 - Can solve temporarily the problem before to implement another solution
- Change the switching frequency of the UPS (APC)
 - Reject by the supplier (APC)
 - Do not solve definitively the problem. Only move it.
- Install EMC filter at the input and the output of each critical UPS
 - Not easy to implement
 - Need to be validated
 - Can be more efficient and less expensive to replace the UPS
- Replace the most critical UPS (APC) by MGE type (double conversion, 5kHz switching frequency)
 - UPS need to be qualified
 - Interfaces need to be modified (PIC, supervision, etc...)
 - UPS Need to be re-commissioned
 - EN/EL will propose a plan