MPP Meeting

# *FMCM Commissioning and first operational experience with new converters*

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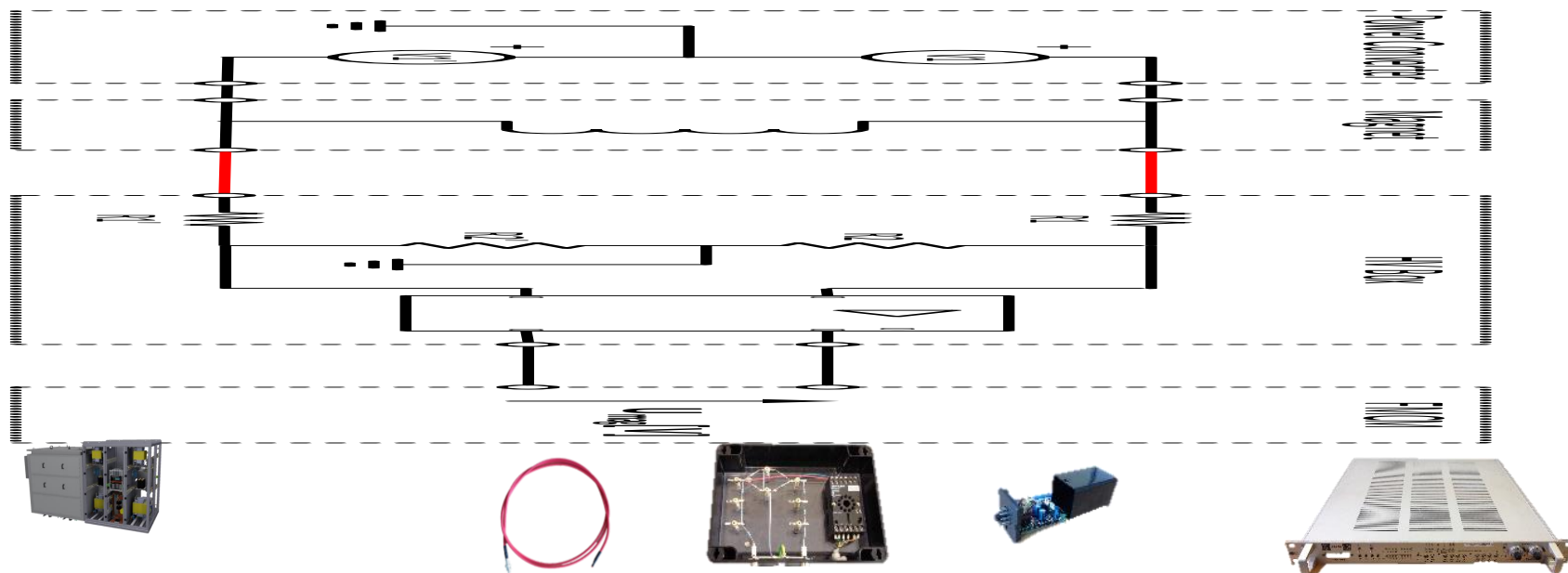# *Outline*

- Introduction

- EYETS 2017 Work

- RD34.LR3 Issue

- Lessons

- First operational experience

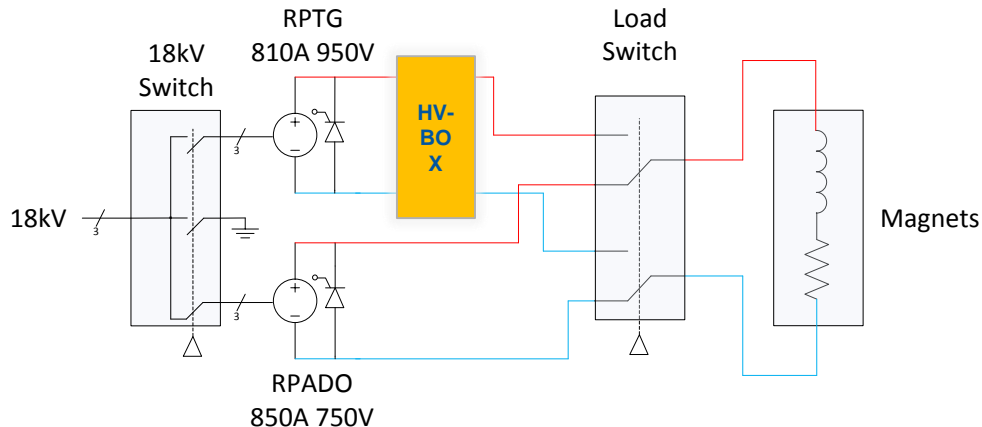- Conclusions

# *Introduction*

## *Measurement principle*



$$\begin{cases} V_1 = V_1{'} \\ R_2 = R_2{'} \\ R_2 = R_2{'} \end{cases}$$

$$U_{mag} = 2 \times V1 \times \frac{R2}{R1 + R2}$$
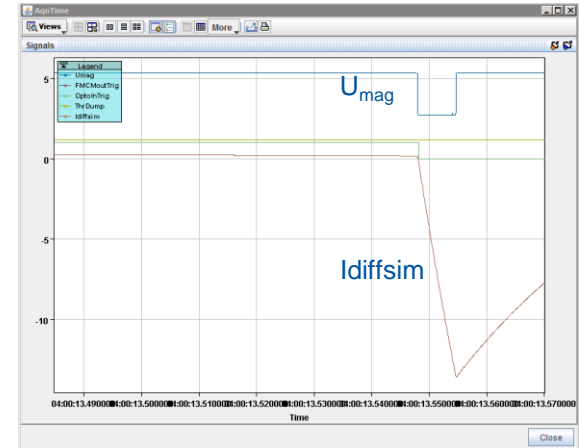
# EYETS 2017 Work
## Summary of changes

- In 2016, **22 beam dumps in stable beams provoked by electrical disturbances and followed by FMCM trips.**

  (40% could have been avoided with SATURN)

- **No changes** at the level of the FMCM firmware but two HV-box interfaces (RD34.LR3/7) relocated following PC replacement + related changes on the FMCM IPOC.

- RPTG power converters on **RD1.LR1/5 and RD34.LR3/7 replaced by new SATURN power converters** aiming at reducing the sensitivity of FMCMs against electrical network perturbations.
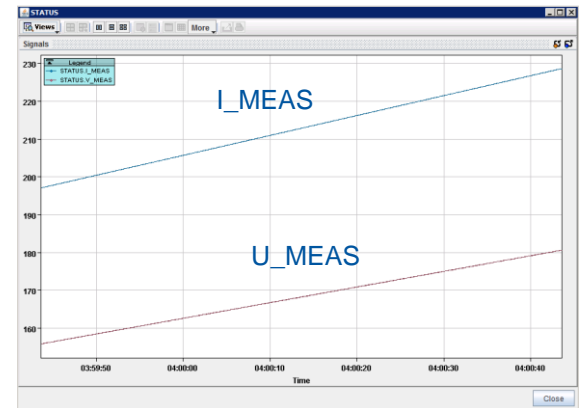
# RD34.LR3 Issue

## *Intervention*

- FMCM of RD34.LR3 **tripped 4 times** on 29/04/2017 after the successful commissioning (in appearance) of the FMCMs.

- FMCM was **masked** during the weekend.

- The intervention on 01/05/2017 pointed out a **badly crimped connector of one HV cable**.

- After exchange of the HV cable, the HV divider had to be **multiplied by 2** in order to remove the saturation of the isolation amplifier !



FMCM $U_{mag}$ & Idiffsim



Power converter U & I

# RD34.LR3 Issue
## Bad crimping



Bad crimping = cable core retracted
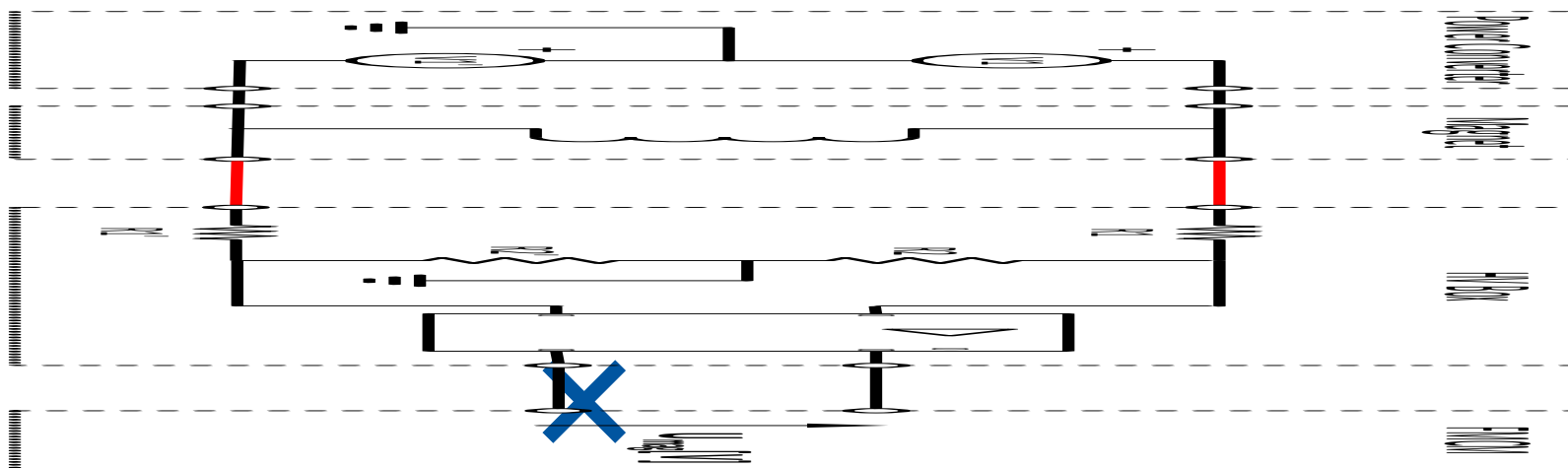
HV cable to connect the output of the Power converter to the FMCM HV box

# RD34.LR3 Issue

## Analysis of the divider value change



$$\begin{cases} V_1 = V_1' \\ R_2 = R_2' \\ R_2 = R_2' \end{cases}$$

$U_{mag}$ originally calculated as $U_{mag} = \cancel{2} \times V1 \times \dfrac{R2}{R1 + R2}$

# Lessons

## Analysis of all FMCM data's

- The RD34.LR3 experience triggered a deeper analysis of **all FMCM** data's.

| Nr | FMCM Device | Operationnal Measurements | | | | HV Divider Configuration | | | | | Meas. Vs. Calcul. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $U_{mag}$ [V] (FMCM) | $U_{nom}$ [V] (FGC) | $I_{nom}$[A] (FGC) | $U_{mag}/U_{nom}$ | R1 [Kohm] | R2 [Kohm] | R3 [Kohm] | R4 [Kohm] | Ratio | |
| 1 | CIF.SR3.RD34 | 7.7803 | 487.0872 | 593.5738 | 0.016 | 56 | 56 | 27 | 5 | 0.035 | **2.188** |
| 2 | CIF.SR3.RQ4 | 7.979 | 268.2587 | 518.3544 | 0.03 | 56 | 0 | 39 | 5 | 0.05 | **1.667** |
| 3 | CIF.SR3.RQ5 | 8.1124 | 288.0615 | 546.1754 | 0.028 | 56 | 56 | 39 | 5 | 0.032 | 1.143 |
| 4 | CIF.SR7.RD34 | 7.1814 | 295.0717 | 593.6323 | 0.024 | 27 | 56 | 0 | 5 | 0.057 | **2.375** |
| 5 | CIF.SR7.RQ4 | 8.4332 | 236.7124 | 552.9301 | 0.036 | 56 | 15 | 56 | 5 | 0.038 | 1.056 |
| 6 | CIF.SR7.RQ5 | 8.084 | 247.5349 | 562.5544 | 0.033 | 56 | 27 | 56 | 5 | 0.035 | 1.061 |
| 7 | CIF.UA27.RBXWTVL | 9.197 | 29.2283 | 578.9254 | 0.315 | 3.3 | 0 | 0 | 5 | 0.301 | 0.956 |
| 8 | CIF.UA27.RBXWTVR | 8.2611 | 22.5967 | 497.0412 | 0.366 | 2 | 0 | 0 | 5 | 0.357 | 0.975 |
| 9 | CIF.UA67.RMSDB1 | 7.9165 | 410.7927 | 753.7723 | 0.019 | 100 | 100 | 33 | 5 | 0.021 | 1.105 |
| 10 | CIF.UA67.RMSDB2 | 7.9676 | 415.091 | 753.7723 | 0.019 | 100 | 100 | 33 | 5 | 0.021 | 1.105 |
| 11 | CIF.US152.RD1 | 8.6091 | 490.0038 | 628.5567 | 0.018 | 110 | 100 | 51 | 5 | 0.019 | 1.056 |
| 12 | CIF.USC55.RD1 | 7.8257 | 499.24 | 628.2944 | 0.016 | 180 | 56 | 56 | 5 | 0.017 | 1.063 |

Caption above table: **23 October 2016**

# *Lessons*

## *RD34.LR7 Intervention*

- Triggered by the analysis.

- Nearly same issue as for RD34.LR3 with variant:

  - Bad **positive** HV cable.

  - **No** electrical contact **suddenly restored**

  - Much faster intervention. 

- Successful intervention done on 15/05/2017.

# *Lessons*

## *Analysis of all FMCM data's after HWC*

- RQ4 still identified as potentially having a measurement issue.

| | FMCM | 11/15 May 2017 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Operationnal Measurements | | | | HV Divider Configuration | | | | | |
| Nr | Device | $U_{mag}$ [V] (FMCM) | $U_{nom}$ [V] (FGC) | $I_{nom}$[A] (FGC) | $U_{mag}/U_{nom}$ | R1 [Kohm] | R2 [Kohm] | R3 [Kohm] | R4 [Kohm] | Ratio | Meas. Vs. Calcul. |
| 1 | CIF.SR3.RD34 | 8.2004 | 487.1878 | 593.574 | 0.017 | 110 | 110 | 56 | 5 | 0.018 | 1.059 |
| 2 | CIF.SR3.RQ4 | 7.9875 | 268.0284 | 518.3553 | 0.03 | 56 | 0 | 39 | 5 | 0.05 | **1.667** |
| 3 | CIF.SR3.RQ5 | 8.0982 | 287.8312 | 546.1752 | 0.028 | 56 | 56 | 39 | 5 | 0.032 | 1.143 |
| 4 | CIF.SR7.RD34 | 8.8674 | 292.4898 | 593.6322 | 0.03 | 56 | 47 | 47 | 5 | 0.032 | 1.067 |
| 5 | CIF.SR7.RQ4 | 8.4132 | 235.561 | 550.4762 | 0.036 | 56 | 15 | 56 | 5 | 0.038 | 1.056 |
| 6 | CIF.SR7.RQ5 | 8.0669 | 246.6137 | 560.5725 | 0.033 | 56 | 27 | 56 | 5 | 0.035 | 1.061 |
| 7 | CIF.UA27.RBXWTVL | -9.5911 | 29.2283 | 578.9249 | -0.328 | 3.3 | 0 | 0 | 5 | 0.301 | -0.918 |
| 8 | CIF.UA27.RBXWTVR | -8.9212 | 22.5148 | 497.0406 | -0.396 | 2 | 0 | 0 | 5 | 0.357 | -0.902 |
| 9 | CIF.UA67.RMSDB1 | 7.8824 | 411.2915 | 753.772 | 0.019 | 100 | 100 | 33 | 5 | 0.021 | 1.105 |
| 10 | CIF.UA67.RMSDB2 | 7.9506 | 414.4769 | 753.7714 | 0.019 | 100 | 100 | 33 | 5 | 0.021 | 1.105 |
| 11 | CIF.US152.RD1 | 8.6063 | 489.994 | 628.5571 | 0.018 | 110 | 100 | 51 | 5 | 0.019 | 1.056 |
| 12 | CIF.USC55.RD1 | 7.8144 | 505.3038 | 628.2942 | 0.015 | 180 | 56 | 56 | 5 | 0.017 | 1.133 |

# *First operational experience*
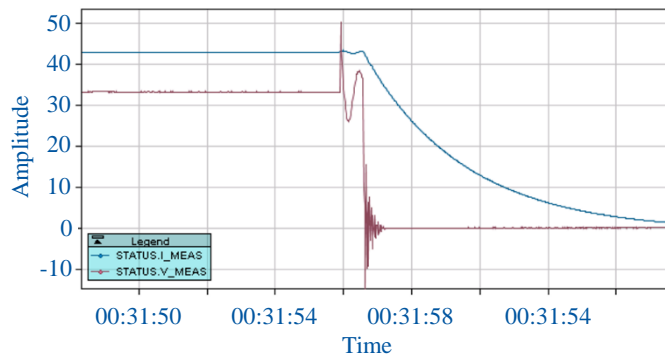
- 4 beam dump triggered by FMCMs

- All of them because of electrical perturbations affecting all facilities.

- The new 4 SATURN converters have never tripped the FMCMs !
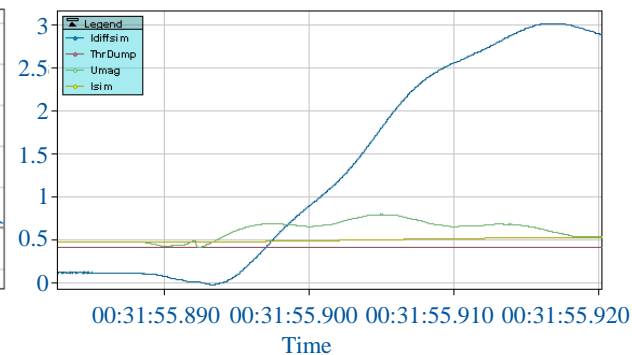
# First operational experience

## Exemple of RD1.LR5: 2016 Vs. 2017 (1)

- On 12th October 2016, RD1.LR5 triggered a beam dump because of an electrical perturbation of ~8.5 % with a duration of 100 ms.
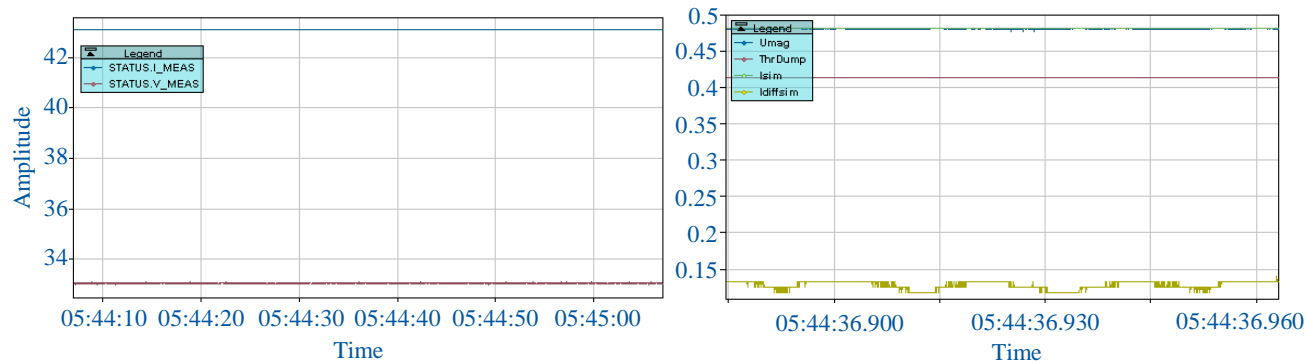


**Power Converter**
- V Meas.
- I Meas.

**FMCM**
- Umag
- Idiffsim
- Threshold
- BEAM_PERMIT

# First operational experience
## Exemple of RD1.LR5: 2016 Vs. 2017 (2)

- On 31th May 2017, a comparable perturbation of 2016 triggered a beam dump by the FMCM RMSDB1.
- RD1.LR5 converter rejected successfully the electrical perturbation.



**Power Converter**
- V Meas.
- I Meas.

**FMCM**
- Umag
- Idiffsim
- Threashold
- BEAM_PERMIT

# *Conclusions*

- Very successful RD1/RD34 power converters replacement by EPC as there was no interlock from FMCM on these power converters in 2017.

- Commissioning and initial operation revealed problem on the HV boxes of the FMCM
  - Bad crimping on HV connectors leading to missing half the measurement circuit and causes 4 beam dump.
  - Analysis of all circuits made.
  - Two circuits have been corrected (RD34.LR3 & RD34.LR7)
  - One remaining circuit foreseen to be corrected in TS1.

# *Thank you for your attention*

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