LRFF (LHC RF FINGERS) TASK FORCE: Kick-off meeting!

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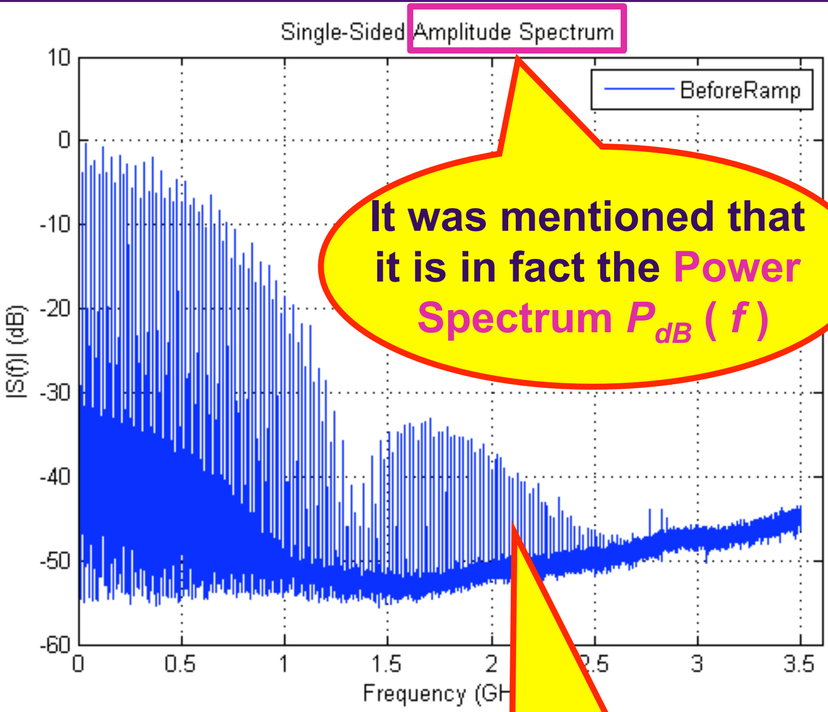
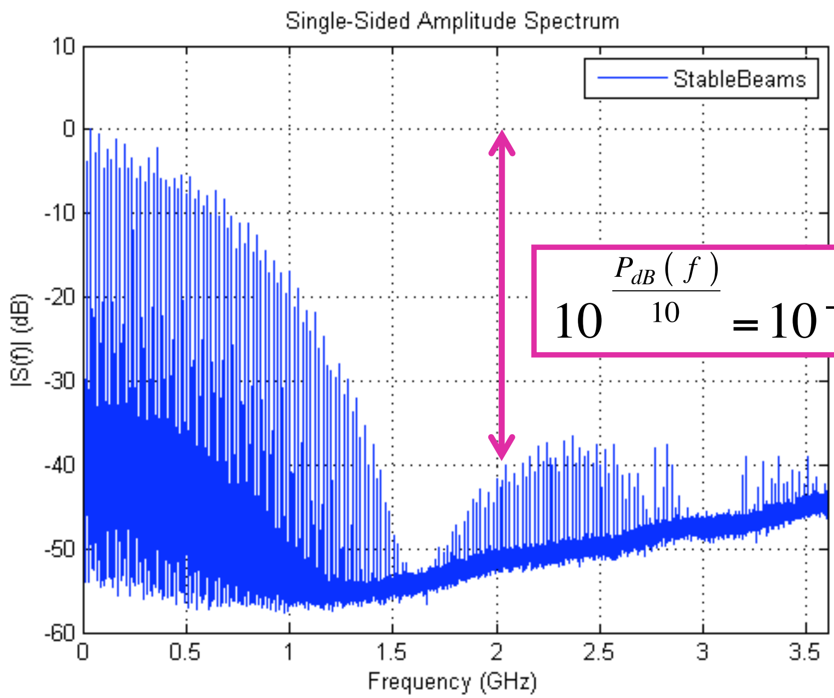
- **Web site: mandate, members, proposed modus operandi, useful documentation and presentations, meetings**
- **Reminder on RF heating => See for instance Beam-induced heating / bunch length / RF and lessons for 2012 (Chamonix2012) for more details**
- **Case of the VMTSA (double-bellow) modules in 2011 => New modules have been installed in 2012**
- **Conclusion and next steps**

REMINDER ON RF HEATING (1/3)

- **Measurements on B1 by ThemisM and PhilippeB on fill # 2261**



It was mentioned that it is in fact the Power Spectrum $P_{dB}(f)$

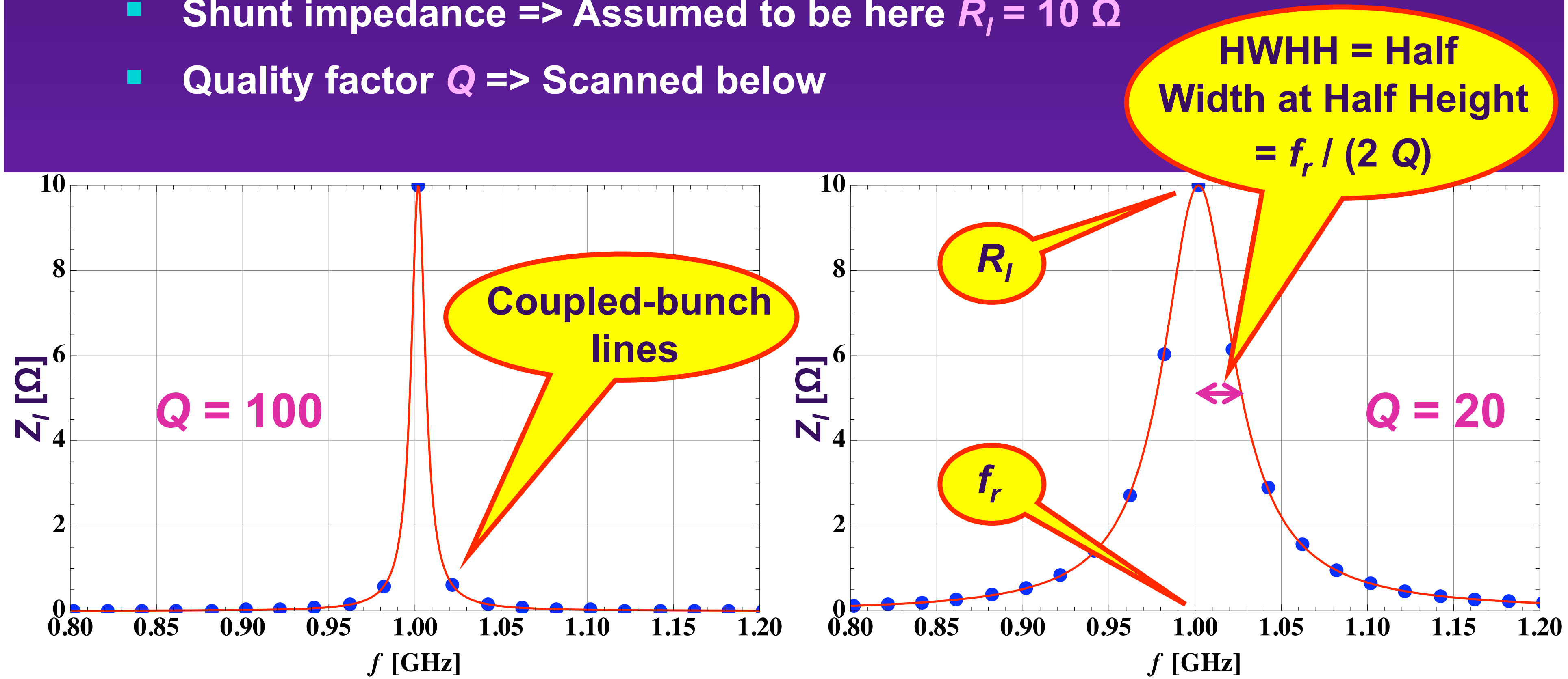


$$10^{\frac{P_{dB}(f)}{10}} = 10^{-4}$$

Coupled-bunch lines spaced by $M f_0 \sim 20$ MHz (for 50 ns bunch spacing) => It would be ~ 40 MHz for 25 ns

REMINDER ON RF HEATING (2/3)

- **Consider now the case of a narrow resonance (trapped mode due to the geometry) => 3 parameters:**
  - **Resonance frequency => Assumed to be here f_r = 1 GHz**
  - **Shunt impedance => Assumed to be here R_l = 10 Ω**
  - **Quality factor Q => Scanned below**



REMINDER ON RF HEATING (3/3)

- **Power loss formula for the case of a (sharp) resonance (i.e. with only 1 line, assumed to be on top of a coupled-bunch line => Worst case)**

$$P_{loss} = \left(M \, I_b \right)^2 \times R_l \times 10^{\frac{P_{dB}(f_r)}{10}}$$

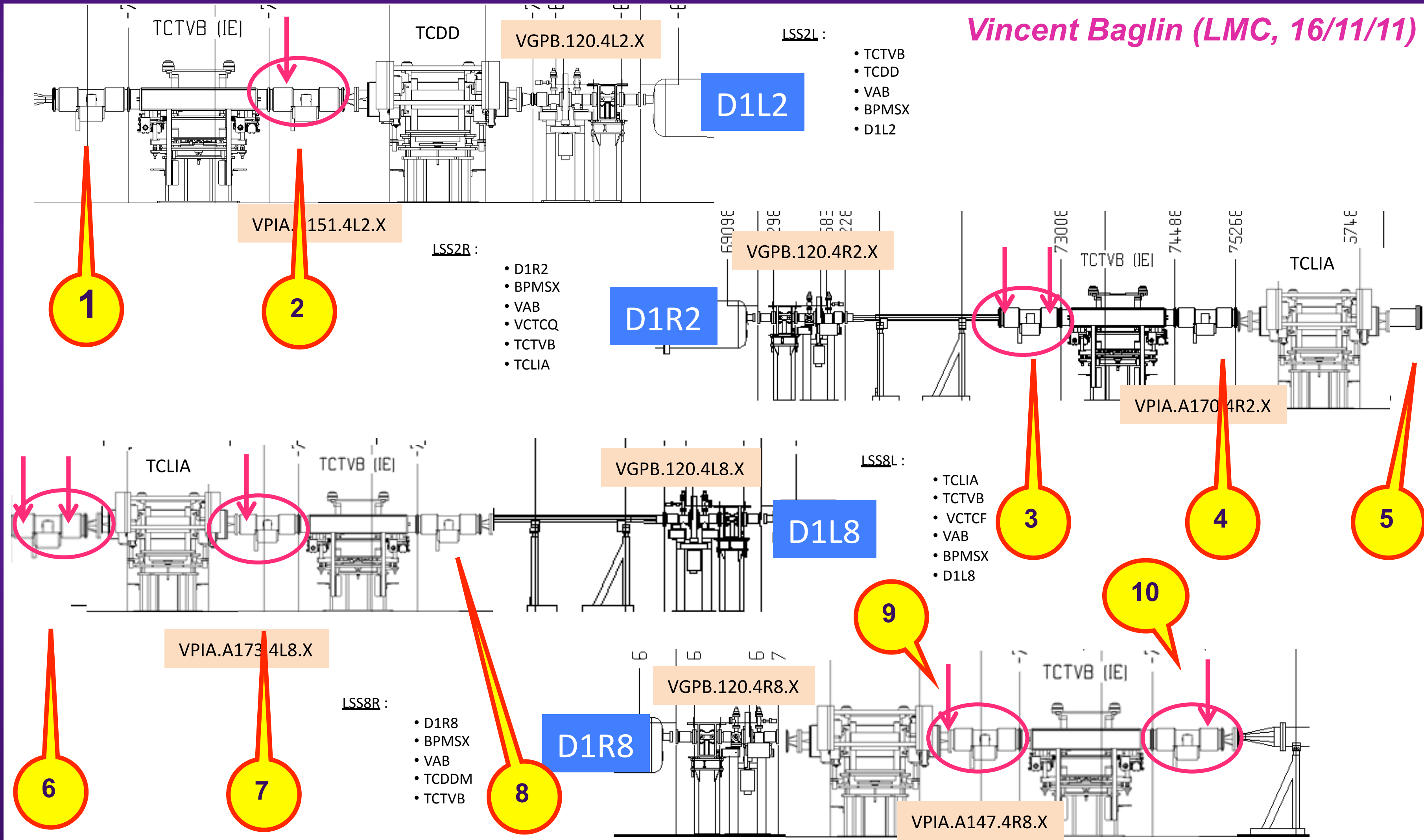
Total beam current

$P_{dB}(f_r)$ is the power in dB read from the power spectrum at the frequency f_r

  - **N.A.: M = 1380, N_b = 1.45E11 p/b => $M \times I_b = I_{total} \approx$ 0.36 A, R_l = 10 Ohm and f_r = 1 GHz => P_{dB} (1 GHz) ≈ - 17 dB => $P_{loss} \approx$ 26 mW**

VMTSA (1/8)

- **10 modules (each of 2 bellows) in total in 2011. 8 bellows were found with defaults (see arrows below). 2 modules removed for 2012**



VMTSA (2/8)

Typical default, DCUM 3259.3524

Vincent Baglin (LMC, 16/11/11)

Left side

Side view (xray from corridor to QRL)

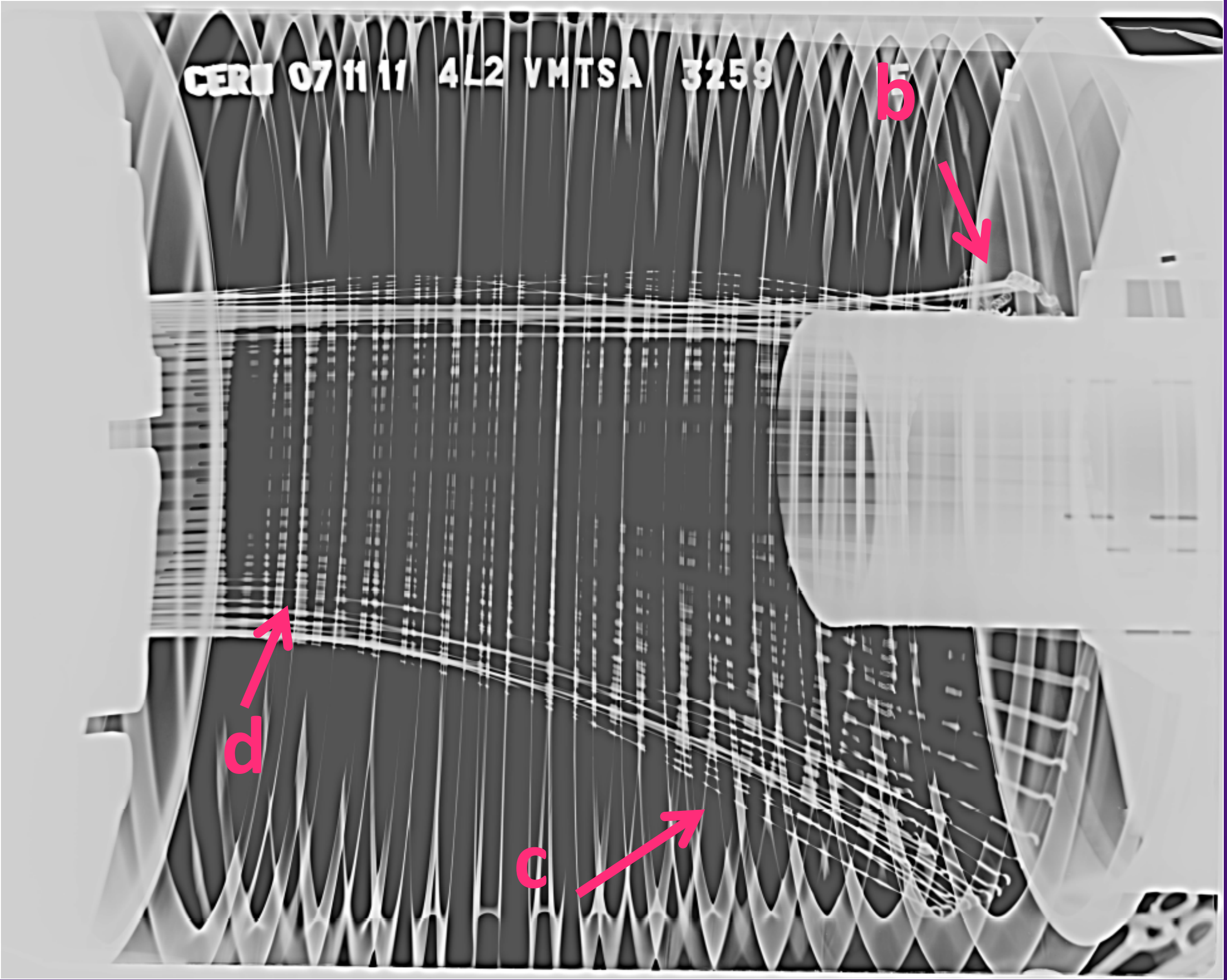
b) Metallic noise due to loose spring when hitting vacuum chamber

c) RF fingers falling due to broken spring

d) aperture reduced ?

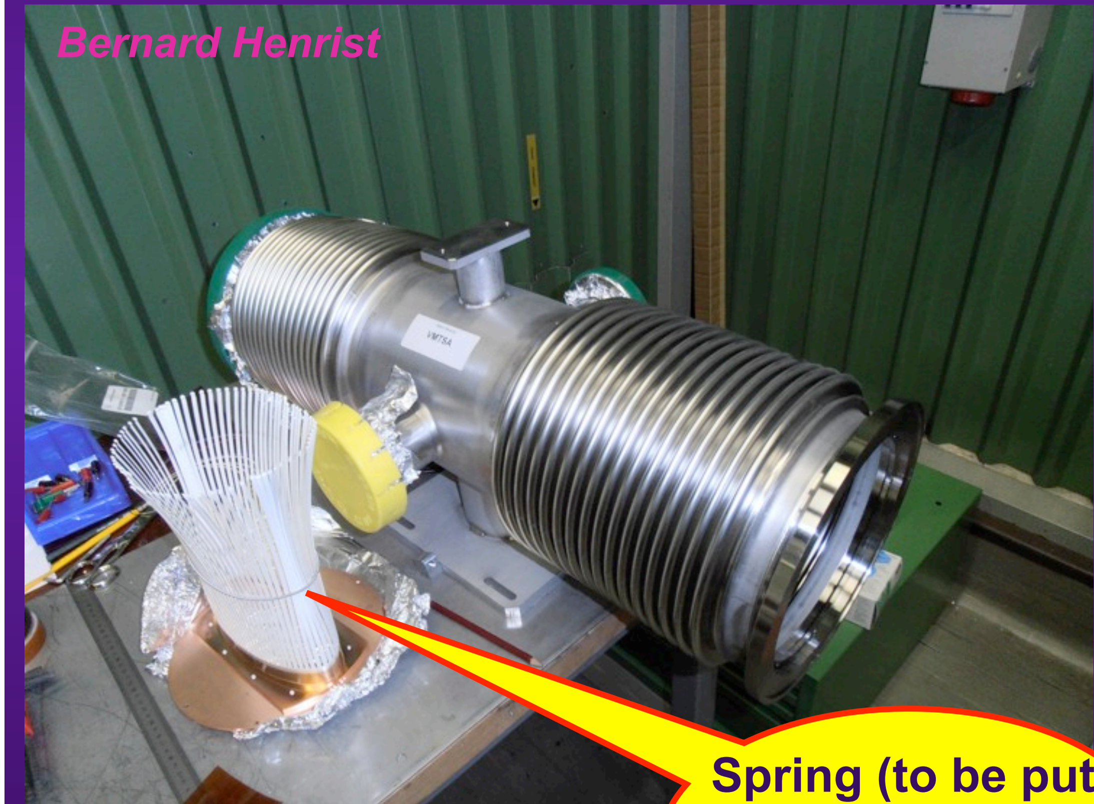
Non Conform

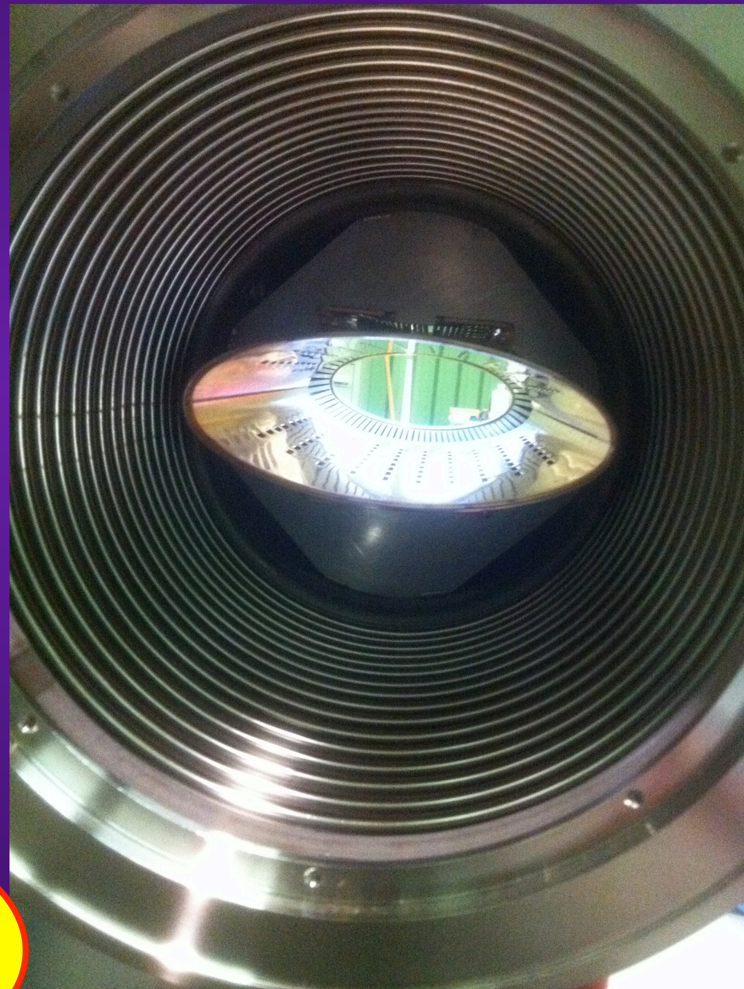
Spring was broken between May and November 2011



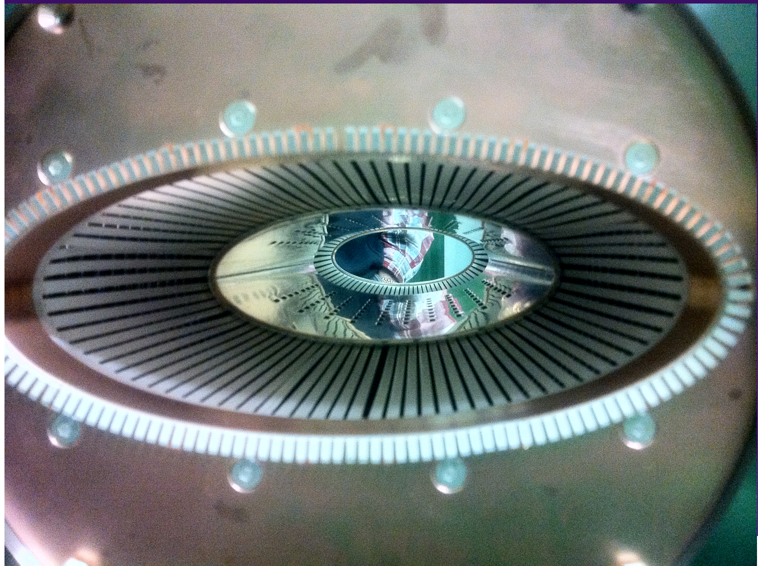
VMTSA (3/8)

- **Why? Is it an impedance problem? => Bench impedance measurements with 1 wire (and simulations ongoing)**

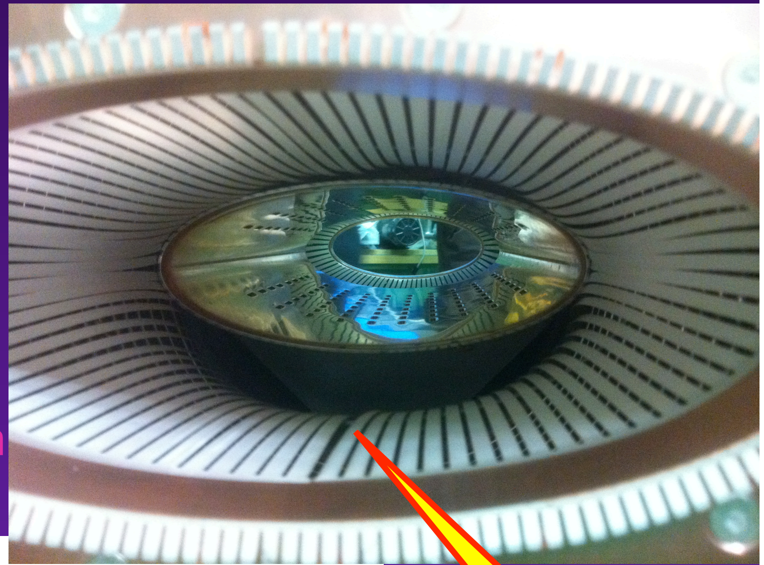




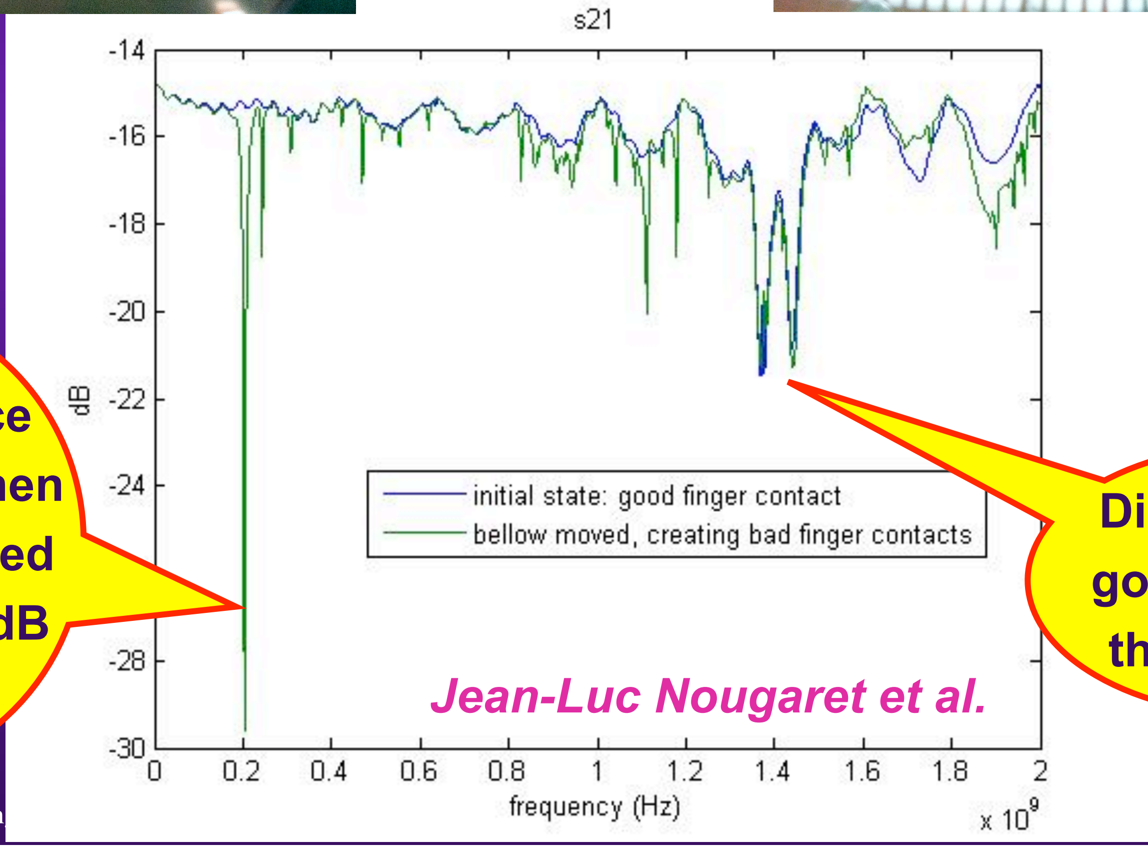
VMTSA (4/8)



Spring jumped back by moving laterally the bellow by few mm



Spring



Huge resonance at ~ 200 MHz when the spring jumped back! => ~ - 15 dB in S_{21}

Disappear with good contact at the end plates

Jean-Luc Nougaret et al.

VMTSA (5/8)

- Longitudinal impedance can be deduced from S_{21}

$$Z_l = -2\, Z_{ch} \ln\left(\frac{S_{21}}{S_{REF}}\right) \qquad S_{REF} = e^{-j\omega \frac{L}{c}}$$

=> Numerical application for the real part of the impedance

  - Z_{ch} was measured and found to be ~ 270 Ω
  - We use $S_{REF} = 1$

=> $$Z_l = -2\, Z_{ch} \ln\left(\frac{S_{21}}{S_{REF}}\right) = -2\, Z_{ch} \ln\left(10^{\frac{S_{21}[\,\mathrm{dB}\,]}{20}}\right) \approx 2 \times 270 \times \ln\left(10^{\frac{15}{20}}\right) \approx 930\ \Omega$$

- Power loss: P_{loss} ~ $0.36^2 \times 930 \times 0.7$ ~ 85 W for 1 beam and ~ 4 × 85 = 340 W for 2 beams (worst case)
- Conclusion: No impedance problem foreseen when the RF contacts are OK => 1st recommendation: Improve the RF contacts! And add ferrite to damp some possible resonances in case of problems…

VMTSA (6/8)

Available ferrite from FritzC:

1) Dimensions: ~ 12 cm × 3 cm × 1 cm

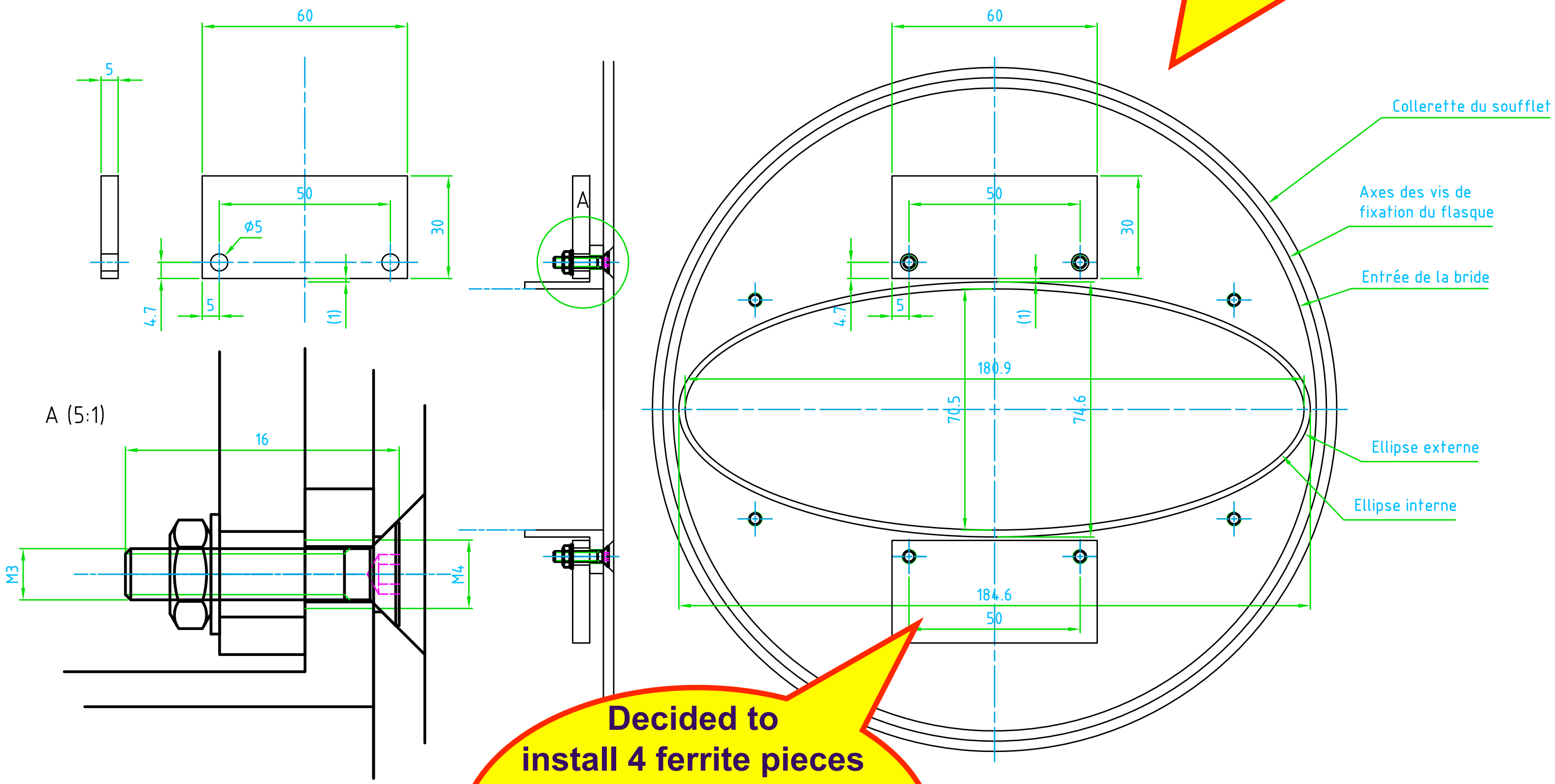
2) Should be excellent vacuum-wise as they were used in the past in the AA

3) Total: 79 (+ 6 broken)

VMTSA (7/8)

Bernard Henrist

2 recommendations from FritzC: 1) Water jet cutter to cut the ferrite; 2) Flexible clamping washer

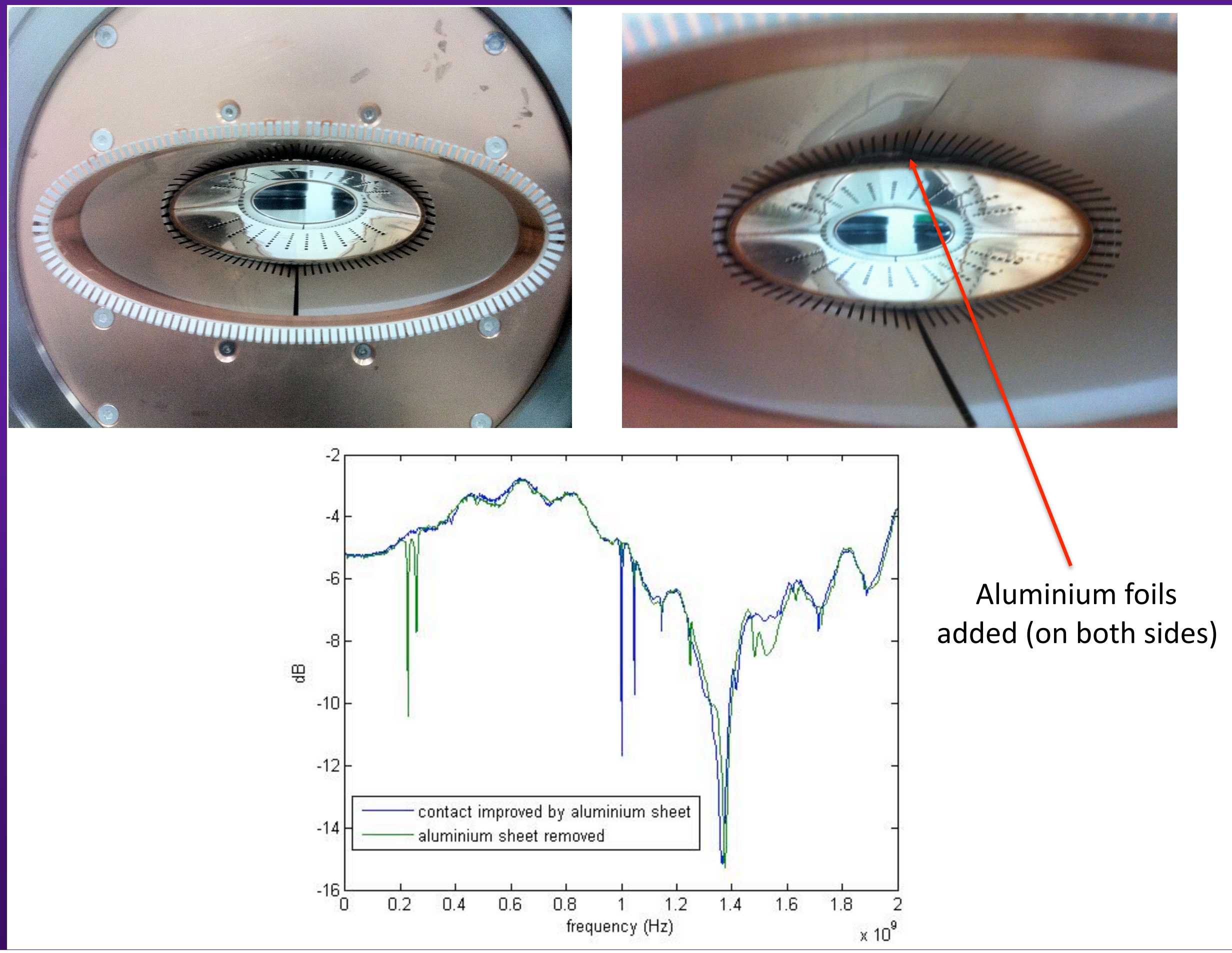


Decided to install 4 ferrite pieces per module (i.e. 2 per bellow: up and down => On the inside of the entry and exit plates)

=> 8 × 4 = 32 ferrite pieces needed

VMTSA (8/8)

- 1st observations with a 1st version of the new VMTSA (with shorter RF fingers and ferrite plates):
  - Close the gap otherwise the resonance at ~ 200 MHz is still there!
  - Exact mechanism still to be fully understood and reproduced



CONCLUSION AND NEXT STEPS

- **VMTSA**
  - **No impedance problem foreseen if "good" RF contacts**
  - **New VMTSA (with shorter RF fingers, ferrite plates and hopefully good contacts) have been installed in the LHC => Let's wait and see…**
  - **Meanwhile we will try and fully understand the resonance at ~ 200 MHz**
  - **What about smaller bunch lengths (probing higher frequencies)?**
  - **What about the transverse impedances? => Requires other (longer) bench measurements and other simulations…**
- **Next steps:**
  - **Start to review the design of all the components of the LHC equipped with RF fingers…**
  - **Summarize the past work and task force on the PIMs (and on other equipments)**
  - **…**