

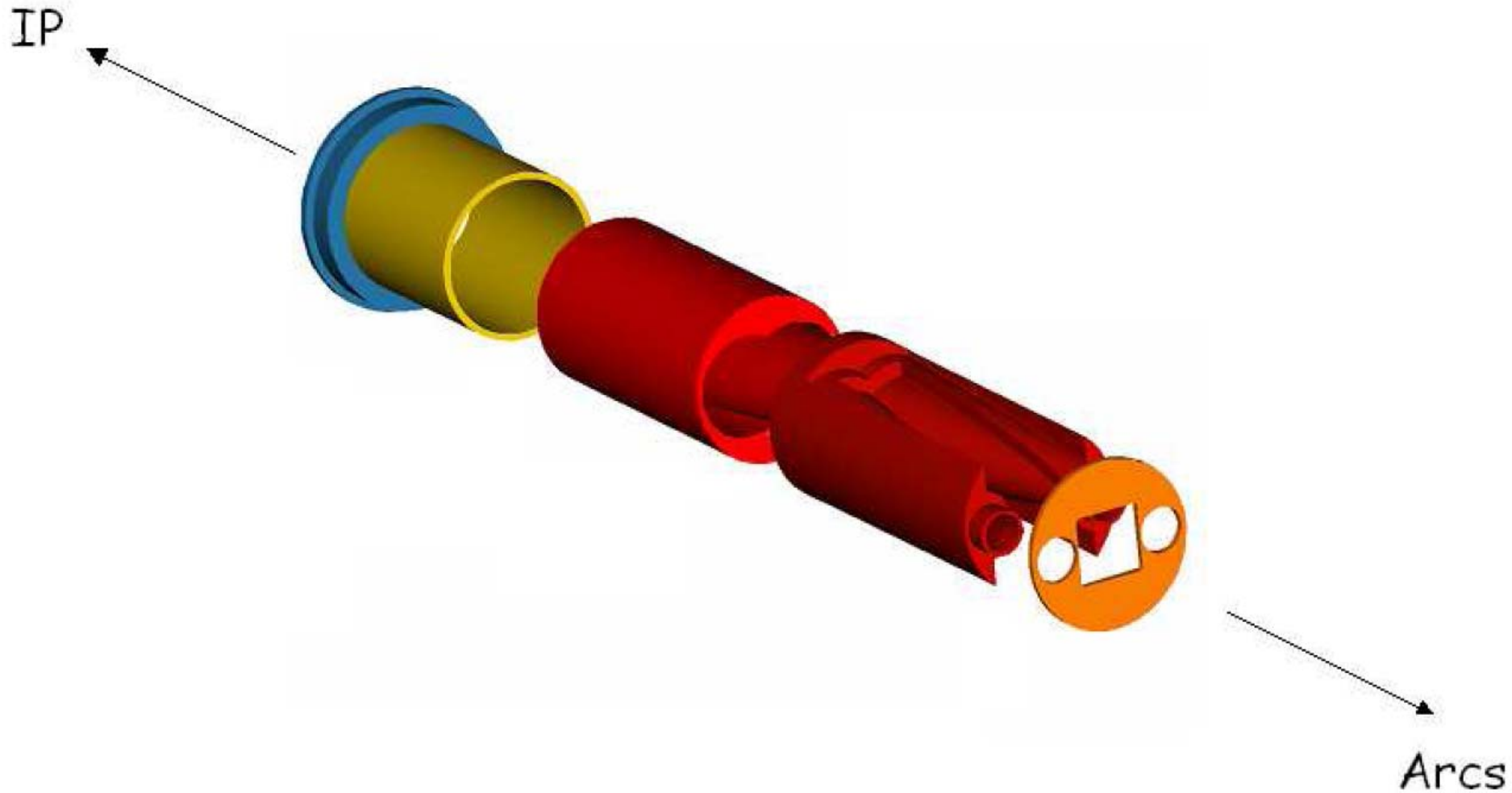
# Y CHAMBERS IN THE LHC

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- ◆ **The recombination chamber in LHC allows the separated proton beams to merge into a common vacuum chamber surrounding the interaction points**
- ◆ ***“Numerical and experimental results show that in the smooth transitions between pipes of different diameters a trapped mode may exist. The mode results to be not harmful for the LHC operation, both for the beam stability and power loss”*** (<http://doc.cern.ch/archive/electronic/cern/preprints/lhc/lhc-project-report-604.pdf>)
- ◆ **Update of the longitudinal and transverse impedances for the Y chambers in IR2L and IR8R (i.e. 2 in total) after the modification proposed by J.B. Jeanneret (see RLC meeting 07/11/06) ⇒ Computation done by B. Spataro and sent to me on 23/11/06**

## Summary of the previous results (1/3)

[\[http://doc.cern.ch/archive/electronic/cern/preprints/lhc/lhc-project-report-604.pdf\]](http://doc.cern.ch/archive/electronic/cern/preprints/lhc/lhc-project-report-604.pdf)



## Summary of the previous results (2/3)

[<http://doc.cern.ch/archive/electronic/cern/preprints/lhc/lhc-project-report-604.pdf>]

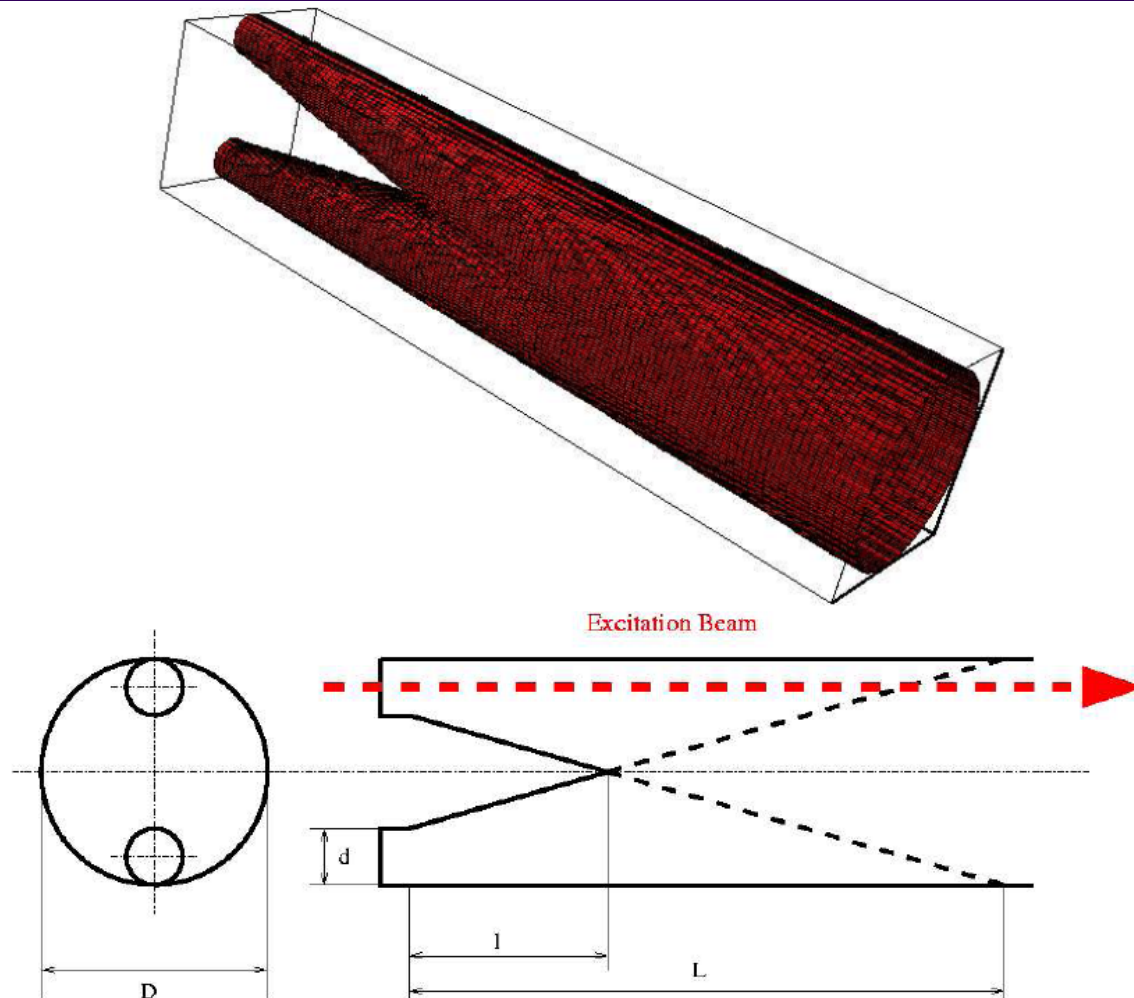
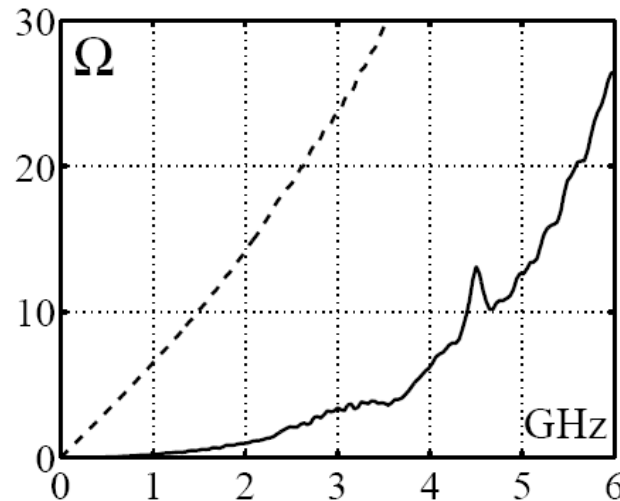


Figure 2: Relevant geometry for the Y-junction. The upper picture shows the model used in the MAFIA simulations (circular geometry). The cross sections are shown in the lower picture ( $L = 852 \text{ mm}$ ,  $l = 260 \text{ mm}$ ,  $d = 54 \text{ mm}$ ,  $D = 180 \text{ mm}$ ) where the arrow indicates the path of the exciting beam.

## Summary of the previous results (3/3)

[<http://doc.cern.ch/archive/electronic/cern/preprints/lhc/lhc-project-report-604.pdf>]



**~ 100  $\mu\Omega$   
were found with  
(simplified) rectangular  
geometry**

Figure 8: Real part (solid line) and imaginary part (dashed line) of the impedance for the Y-chamber (actual structure, circular shape).

The existence of a weak trapped resonance around at 4.5 GHz is clearly shown; the cut-off frequencies for TM modes of the combined chamber are 1.06 GHz and 4.42 GHz for the smaller tubes. It also confirmed that the smoother transition introduced by the metal sheet with parabolic edge, allows the mode to propagate in the wider common chamber. The residual mode should not be a concern to the beam dynamics; in fact it is characterised by a small  $R/Q$  value, its frequency is high compared to the LHC bunch spectrum (nominal r.m.s bunch length of 7.5 cm) and therefore the excitation of this mode is weak. The broad band impedance [5] of this mode is also very small, namely  $Z/n$

$\approx j 75 \mu\Omega$

# In the LHC Design Report

- ◆ **“The inductance of each of the 8 recombination chambers (Y-chambers) is 1.5 nH. Total length of the unshielded bellows is 2.6m (0.36m in Alice, 0.6m in CMS, 0.75m in ATLAS, and 0.9m in LHCb) giving an inductance of 65 nH”**

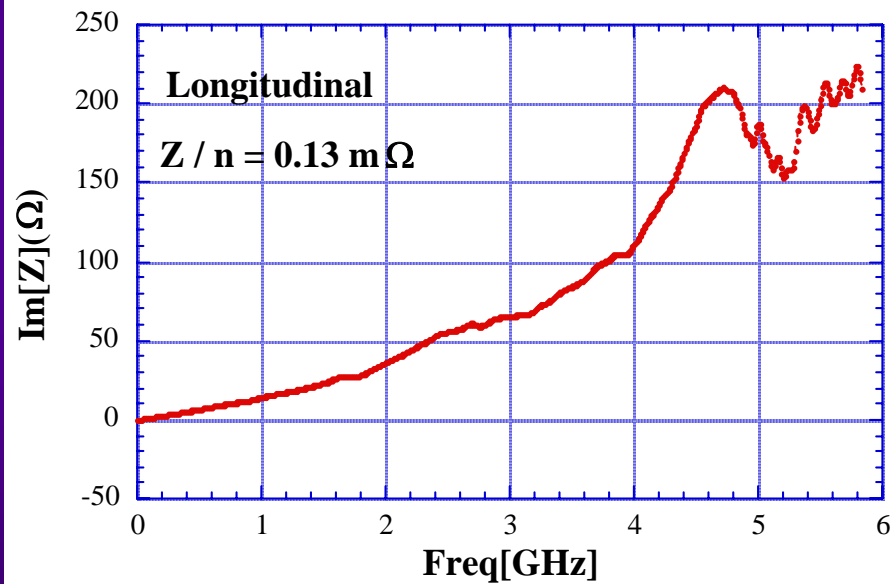
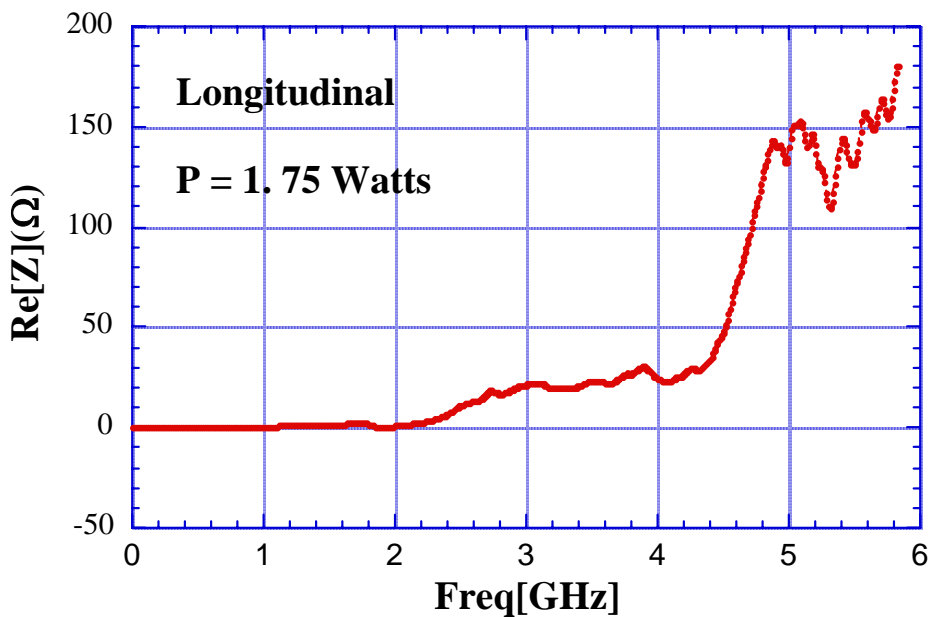
Table 5.4: LHC broad-band impedance budget. The first three columns report element name, latest relevant reference, and inner vertical aperture  $b$  in mm. The last two columns give the effective longitudinal and transverse impedance in the vertical plane, the latter being multiplied by  $\beta/\langle\beta\rangle$ , where  $\langle\beta\rangle = 70$  m.

element	Ref.	$b$	$\text{Im}(Z/n)$	$\text{Im}(Z_{\perp})$
		mm	$\Omega$	$\text{M}\Omega/\text{m}$
Pumping slots	[23]	18	0.017	0.5
BPM's	[24]	25	0.0021	0.3
Unshielded bellows		25	0.0046	0.06
Shielded bellows		20	0.010	0.265
Vacuum valves		40	0.005	0.035
Experimental chambers		-	0.010	-
RF Cavities (400 MHz)		150	0.010	(0.011)
RF Cavities (200 MHz)		50	0.015	(0.155)
Y-chambers (8)	[25]	-	0.001	-
BI (non-BPM instruments)		40	0.001	0.012
space charge @injection	[2]	18	-0.006	0.02
Collimators @injection optics		4.4 ÷ 8	0.0005	0.15
Collimators @squeezed optics		1.3 ÷ 3.8	0.0005	1.5
TOTAL broad-band @injection optics			0.070	1.34
TOTAL broad-band @squeezed optics			0.076	2.67

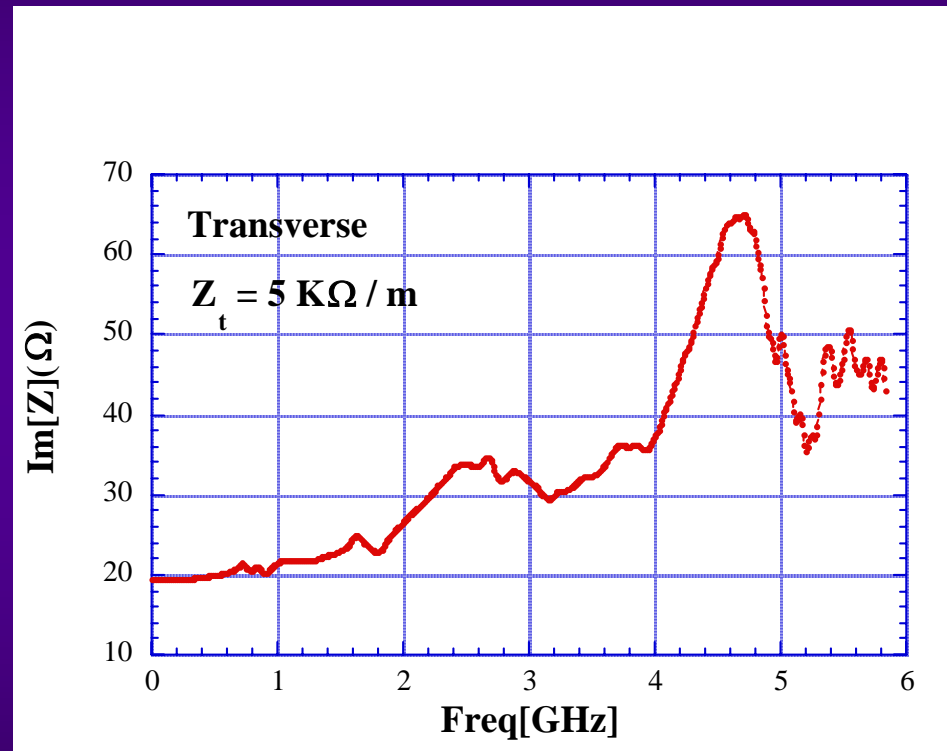
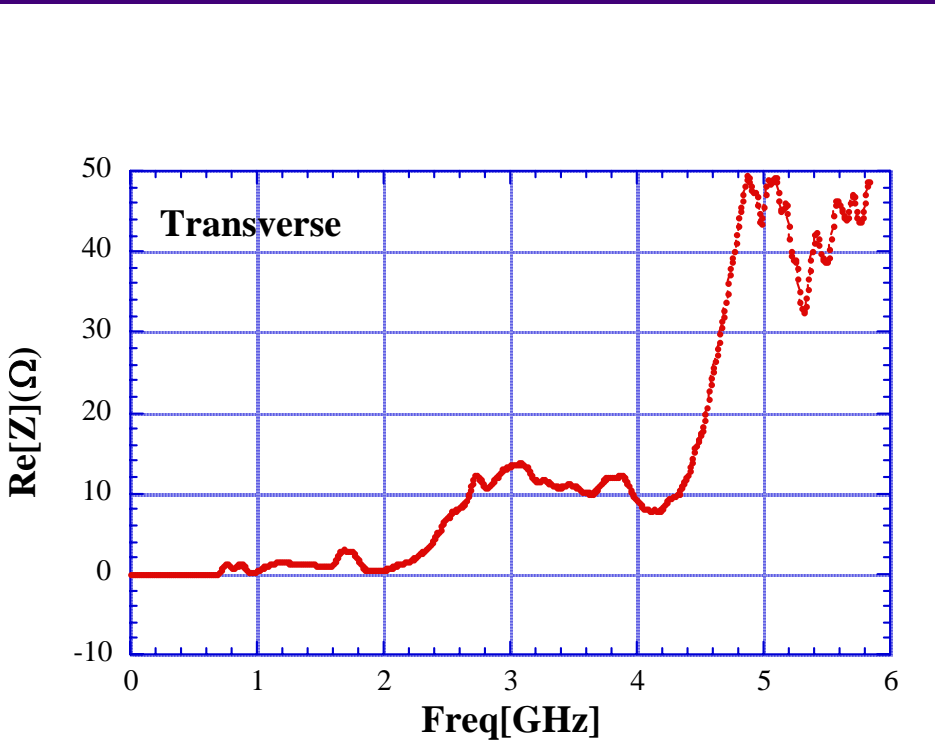
**= 8 × ~ 0.1 mΩ  
 ≈ 0.8 mΩ ≈ 1 mΩ  
 in total**

# New results from B. Spataro with the new geometry (1/2)

⇒ Results with rectangular cross-section (no significant difference expected with round one, which will be simulated later)



# New results from B. Spataro with the new geometry (2/2)



# Conclusion

- ◆ Before:  $\text{Im} ( Z_l / n ) = 8 \times \sim 0.1 \text{ m}\Omega \approx 0.8 \text{ m}\Omega \approx 1 \text{ m}\Omega$  in total for the 8 Y chambers (i.e. 1.4% of the total BB impedance at low frequency and injection)
  - ◆ Now:  $\text{Im} ( Z_l / n ) = 6 \times \sim 0.1 \text{ m}\Omega + 2 \times \sim 0.13 \text{ m}\Omega \approx 0.86 \text{ m}\Omega \approx 1 \text{ m}\Omega$  in total for the 8 Y chambers
- ⇒ Same estimate as in the LHC Design Report can be kept
- ◆ I gave a preliminary green light to J.B. Jeanneret (asking him to wait for the official one after this meeting)