

# UPDATE OF LHC COLLIMATORS IMPEDANCE : COMPARISON VOS / BUROV-LEBEDEV / ZOTTER

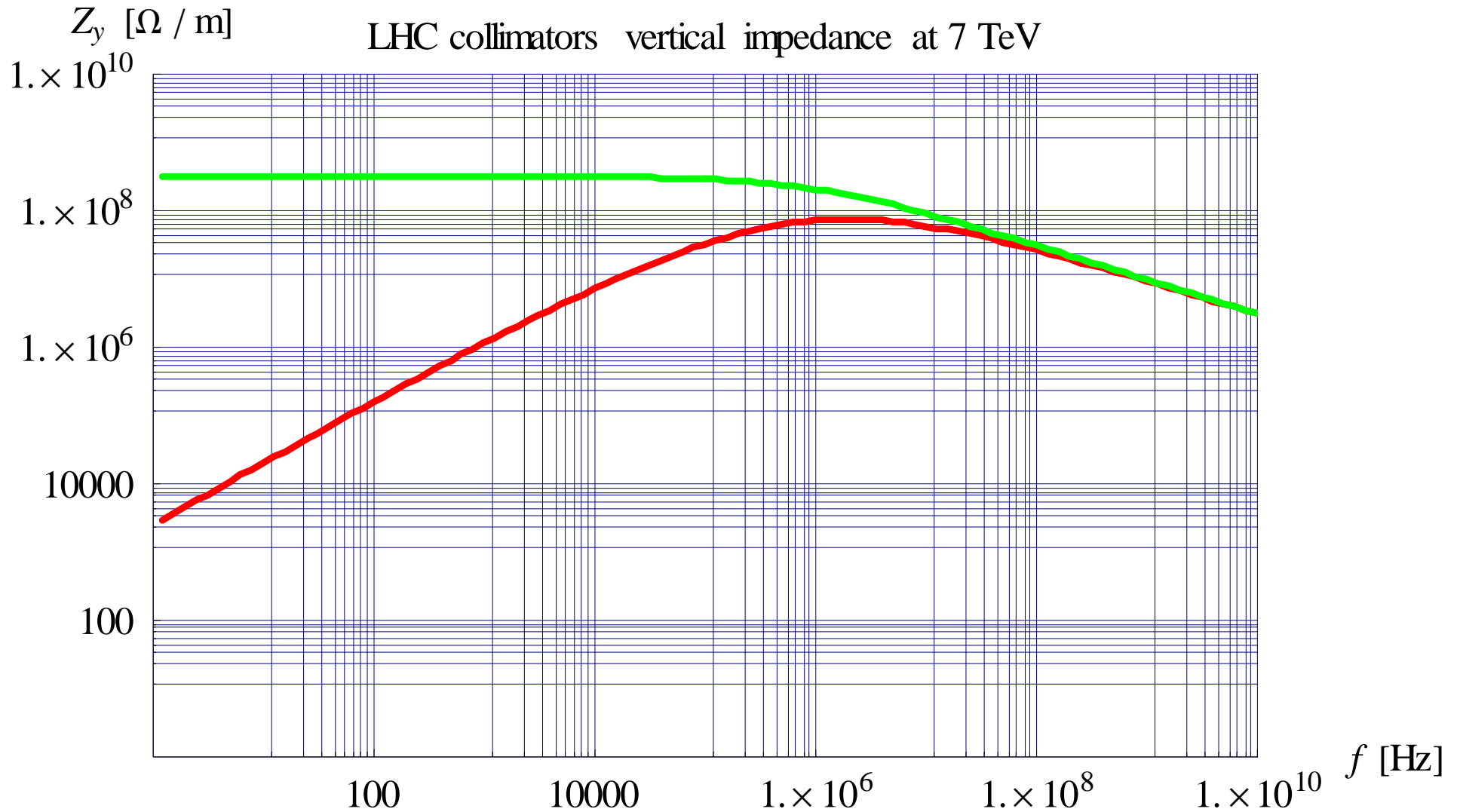
E. Métral

- ◆ **Comparison Vos/Burov-Lebedev/Zotter for the 19 collimators used until now (4 P + 15 S)**
- ◆ **Update with Zotter's formula for all the collimators (42, including the TCDQ, TDI, etc.) of PHASE 1 and new resistivity (10 instead of 14  $\mu\Omega\text{m}$ )**
- ◆ **Question from R. Assmann (11-05-05): Can we accept an increase in the P's length from 0.2 m to 0.6 m (better cleaning efficiency) ?**

## 19 collimators before

| #name        | angle[rad] | betax[m]   | betay[m]   | halfgap[m] | Resistivity [Ohm m] | Length[m] |
|--------------|------------|------------|------------|------------|---------------------|-----------|
| TCP.D6L7.B1  | 1.57E+00   | 1.55E+02   | 8.00E+01   | 1.20E-03   | 0.000014            | 0.2       |
| TCP.C6L7.B1  | 0.00E+00   | 1.51E+02   | 8.28E+01   | 1.65E-03   | 0.000014            | 0.2       |
| TCP.B6L7.B1  | 2.36E+00   | 1.46E+02   | 8.56E+01   | 1.45E-03   | 0.000014            | 0.2       |
| TCP.6L3.B1   | 0          | 132.552134 | 143.460162 | 0.00387    | 0.000014            | 0.2       |
| TCSG.A6L7.B1 | 2.47E+00   | 3.99E+01   | 2.27E+02   | 1.67E-03   | 0.000014            | 1         |
| TCSG.B5L7.B1 | 2.56E+00   | 1.60E+02   | 1.67E+02   | 2.00E-03   | 0.000014            | 1         |
| TCSG.A5L7.B1 | 7.06E-01   | 1.86E+02   | 1.46E+02   | 2.04E-03   | 0.000014            | 1         |
| TCSG.D4L7.B1 | 1.57E+00   | 3.33E+02   | 6.90E+01   | 1.30E-03   | 0.000014            | 1         |
| TCSG.B4L7.B1 | 0.00E+00   | 1.40E+02   | 1.31E+02   | 1.86E-03   | 0.000014            | 1         |
| TCSG.A4L7.B1 | 2.37E+00   | 1.29E+02   | 1.41E+02   | 1.82E-03   | 0.000014            | 1         |
| TCSG.A4R7.B1 | 7.72E-01   | 1.18E+02   | 1.52E+02   | 1.82E-03   | 0.000014            | 1         |
| TCSG.B5R7.B1 | 2.34E+00   | 1.22E+02   | 2.68E+02   | 2.20E-03   | 0.000014            | 1         |
| TCSG.D5R7.B1 | 1.01E+00   | 2.14E+02   | 1.59E+02   | 2.07E-03   | 0.000014            | 1         |
| TCSG.E5R7.B1 | 2.14E+00   | 2.42E+02   | 1.36E+02   | 2.03E-03   | 0.000014            | 1         |
| TCSG.6R7.B1  | 8.00E-03   | 3.36E+02   | 4.74E+01   | 2.88E-03   | 0.000014            | 1         |
| TCSG.5L3.B1  | 0          | 54.345351  | 299.318626 | 0.00294    | 0.000014            | 1         |
| TCSG.4R3.B1  | 0          | 26.33905   | 393.832179 | 0.00206    | 0.000014            | 1         |
| TCSG.A5R3.B1 | 2.97404    | 36.58475   | 341.340923 | 0.00272    | 0.000014            | 1         |
| TCSG.B5R3.B1 | 0.198968   | 46.499464  | 310.055013 | 0.00305    | 0.000014            | 1         |

# Total (Zotter) vertical impedance for the 19 collimators

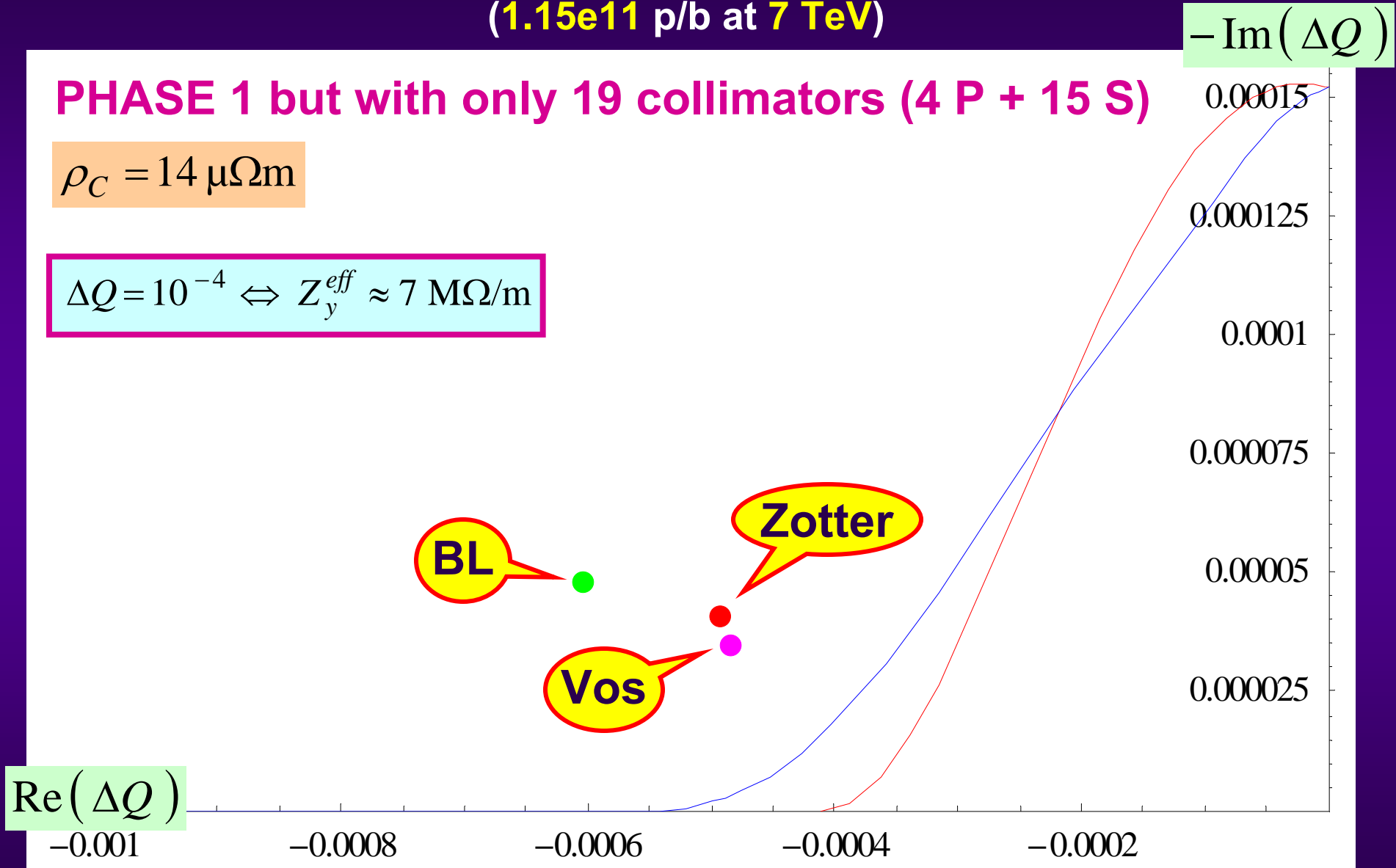


Stability diagram (maximum octupoles) and collective tune shift  
 for the most unstable coupled-bunch mode and head-tail mode 0  
 (1.15e11 p/b at 7 TeV)

PHASE 1 but with only 19 collimators (4 P + 15 S)

$\rho_C = 14 \mu\Omega\text{m}$

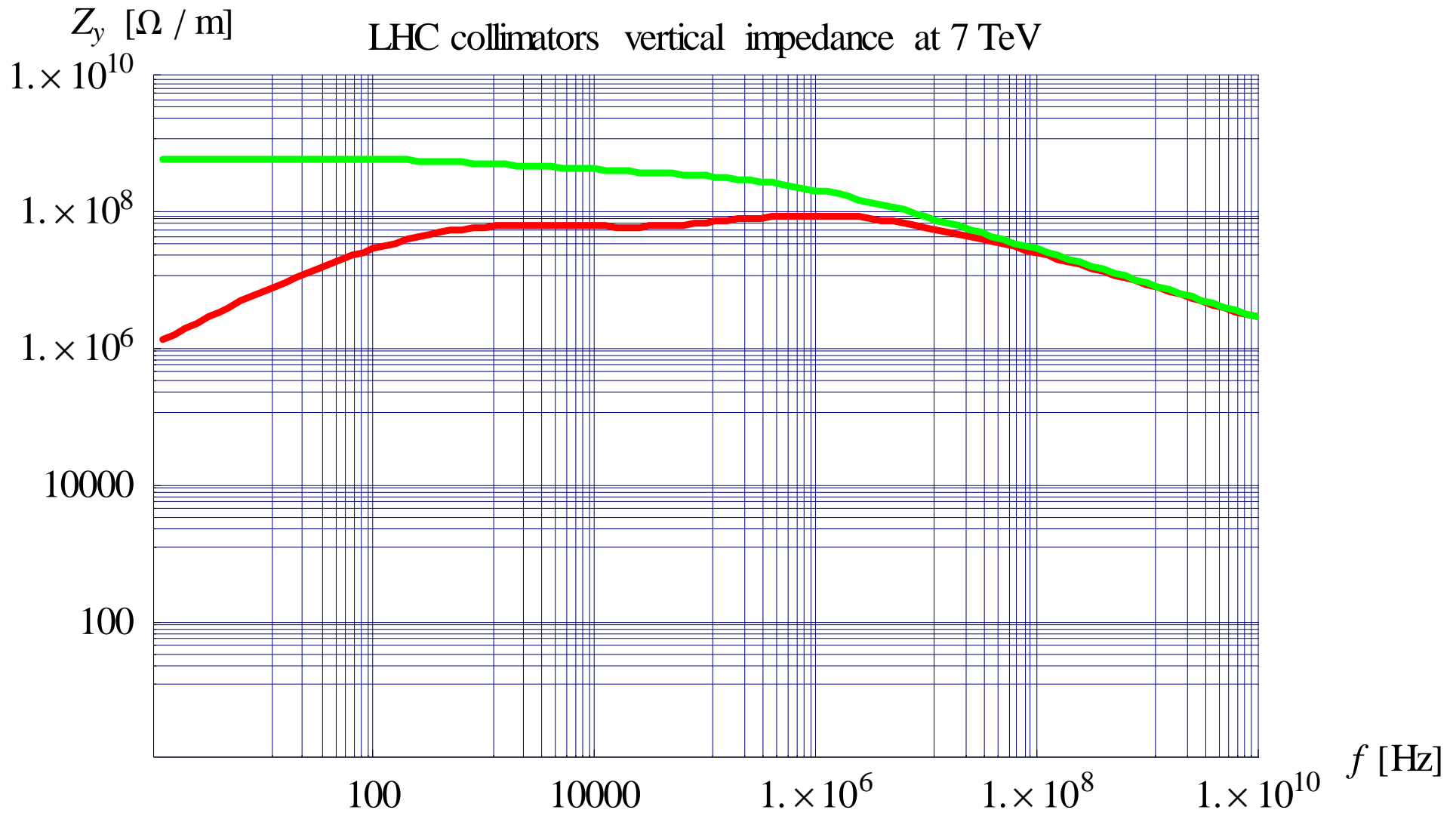
$\Delta Q = 10^{-4} \Leftrightarrow Z_y^{eff} \approx 7 \text{ M}\Omega/\text{m}$



# 42 collimators now

| #name       | angle[rad] | betax[m] | betay[m] | halfgap[m] | Resistivity [Ohm m] | Length[m] |
|-------------|------------|----------|----------|------------|---------------------|-----------|
| TCL.5R1.B1  | 0          | 131.93   | 925.95   | 0.0025752  | 0.000000017         | 1         |
| TCTH.L2.B1  | 0          | 50.891   | 49.763   | 0.0013275  | 0.000000005         | 1         |
| TDI.4L2     | 1.571      | 112.57   | 49.684   | 0.14223    | 0.000000017         | 4         |
| TCTV.4L2.B1 | 1.571      | 132.88   | 57.748   | 0.0014141  | 0.000000005         | 1         |
| TCLIA.4R2.B | 1.571      | 54.939   | 126.7    | 0.22712    | 0.00001             | 1         |
| TCLIB.6R2   | 1.571      | 271.59   | 30.888   | 0.11214    | 0.00001             | 1         |
| TCP.6L3.B1  | 0          | 131.79   | 144.07   | 0.0038606  | 0.00001             | 0.2       |
| TCSG.5L3.B1 | 0          | 54.598   | 297.51   | 0.0029819  | 0.00001             | 1         |
| TCSG.4R3.B1 | 0          | 26.253   | 396.73   | 0.0020677  | 0.00001             | 1         |
| TCSG.A5R3.B | 2.981      | 35.949   | 345.36   | 0.0026726  | 0.00001             | 1         |
| TCSG.B5R3.B | 0.1885     | 45.627   | 313.84   | 0.0029941  | 0.00001             | 1         |
| TCLA.A5R3.B | 1.571      | 142.59   | 176.74   | 0.0059612  | 0.000000017         | 1         |
| TCLA.B5R3.B | 0          | 151.67   | 169.39   | 0.0055222  | 0.000000017         | 1         |
| TCLA.6R3.B1 | 0          | 129.27   | 168.71   | 0.0050981  | 0.000000017         | 1         |
| TCLA.7R3.B1 | 0          | 62.901   | 100.24   | 0.0035562  | 0.000000017         | 1         |
| TCTH.L5.B1  | 0          | 1646.5   | 623.78   | 0.0075507  | 0.000000005         | 1         |
| TCTV.L5.B1  | 1.571      | 1651.6   | 657.58   | 0.0047718  | 0.000000005         | 1         |
| TCL.5R5.B1  | 0          | 128.6    | 907.77   | 0.0025425  | 0.000000017         | 1         |
| TCDQ.4R6.B1 | 0          | 485.26   | 160.88   | 0.0049388  | 0.00001             | 8         |
| TCS.TCDQ.B1 | 0          | 501.16   | 165.5    | 0.0045172  | 0.00001             | 1         |
| TCP.D6L7.B1 | 1.571      | 161.93   | 76.835   | 0.0011791  | 0.00001             | 0.2       |
| TCP.C6L7.B1 | 0          | 153.51   | 81.276   | 0.0016667  | 0.00001             | 0.2       |
| TCP.B6L7.B1 | 2.215      | 145.36   | 85.943   | 0.0013939  | 0.00001             | 0.2       |
| TCSG.A6L7.B | 2.463      | 40.93    | 224.39   | 0.0016699  | 0.00001             | 1         |
| TCSG.B5L7.B | 2.504      | 155.67   | 165.97   | 0.0019809  | 0.00001             | 1         |
| TCSG.A5L7.B | 0.71       | 180.91   | 145.59   | 0.0020214  | 0.00001             | 1         |
| TCSG.D4L7.B | 1.571      | 323.86   | 69.276   | 0.0013062  | 0.00001             | 1         |
| TCSG.B4L7.B | 0          | 136.69   | 132.92   | 0.0018349  | 0.00001             | 1         |
| TCSG.A4L7.B | 2.349      | 125.98   | 143.27   | 0.0018218  | 0.00001             | 1         |
| TCSG.A4R7.B | 0.808      | 115.95   | 154.24   | 0.0018299  | 0.00001             | 1         |
| TCSG.B5R7.B | 2.47       | 124.91   | 268.08   | 0.0021075  | 0.00001             | 1         |
| TCSG.D5R7.B | 0.897      | 218.64   | 158.38   | 0.0021163  | 0.00001             | 1         |
| TCSG.E5R7.B | 2.277      | 246.63   | 135.83   | 0.0021201  | 0.00001             | 1         |
| TCSG.6R7.B1 | 0.009      | 341.67   | 46.546   | 0.0029008  | 0.00001             | 1         |
| TCLA.A6R7.B | 1.571      | 296.69   | 47.528   | 0.0015456  | 0.000000017         | 1         |
| TCLA.C6R7.B | 0          | 157.1    | 77.269   | 0.0028101  | 0.000000017         | 1         |
| TCLA.E6R7.B | 1.571      | 65.302   | 156.52   | 0.0028049  | 0.000000017         | 1         |
| TCLA.F6R7.B | 0          | 60.053   | 166.17   | 0.0017374  | 0.000000017         | 1         |
| TCLA.A7R7.B | 0          | 63.26    | 147.05   | 0.0017832  | 0.000000017         | 1         |
| TCTV.4L8.B1 | 1.571      | 128.8    | 52.857   | 0.0013529  | 0.000000005         | 1         |
| TCTH.L1.B1  | 0          | 1648.7   | 624.84   | 0.0075558  | 0.000000005         | 1         |
| TCTV.L1.B1  | 1.571      | 1653.8   | 658.72   | 0.004776   | 0.000000005         | 1         |

# Total (Zotter) vertical impedance for the 42 collimators



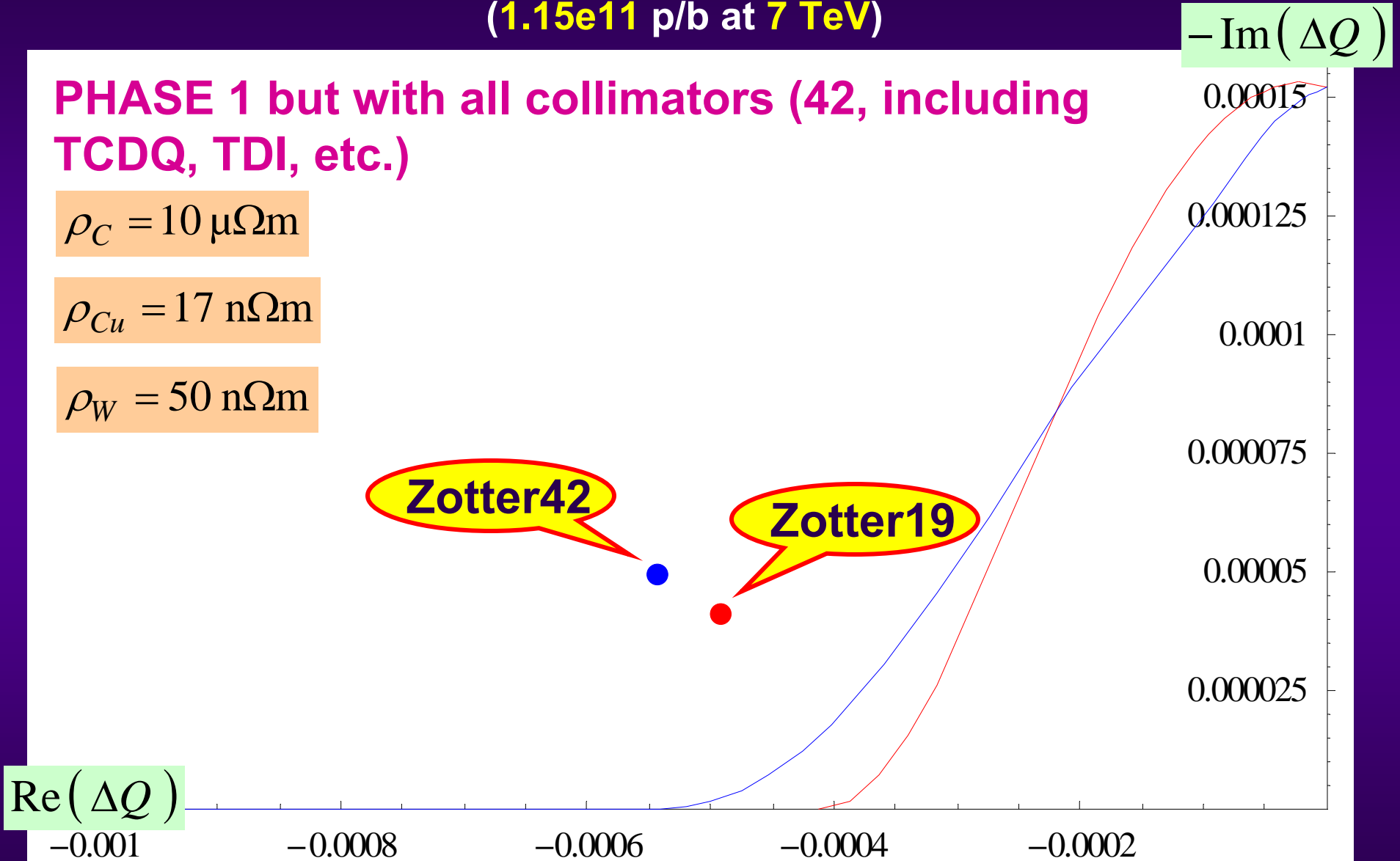
Stability diagram (maximum octupoles) and collective tune shift for the most unstable coupled-bunch mode and head-tail mode 0 (1.15e11 p/b at 7 TeV)

PHASE 1 but with all collimators (42, including TCDQ, TDI, etc.)

$$\rho_C = 10 \mu\Omega\text{m}$$

$$\rho_{Cu} = 17 \text{ n}\Omega\text{m}$$

$$\rho_W = 50 \text{ n}\Omega\text{m}$$

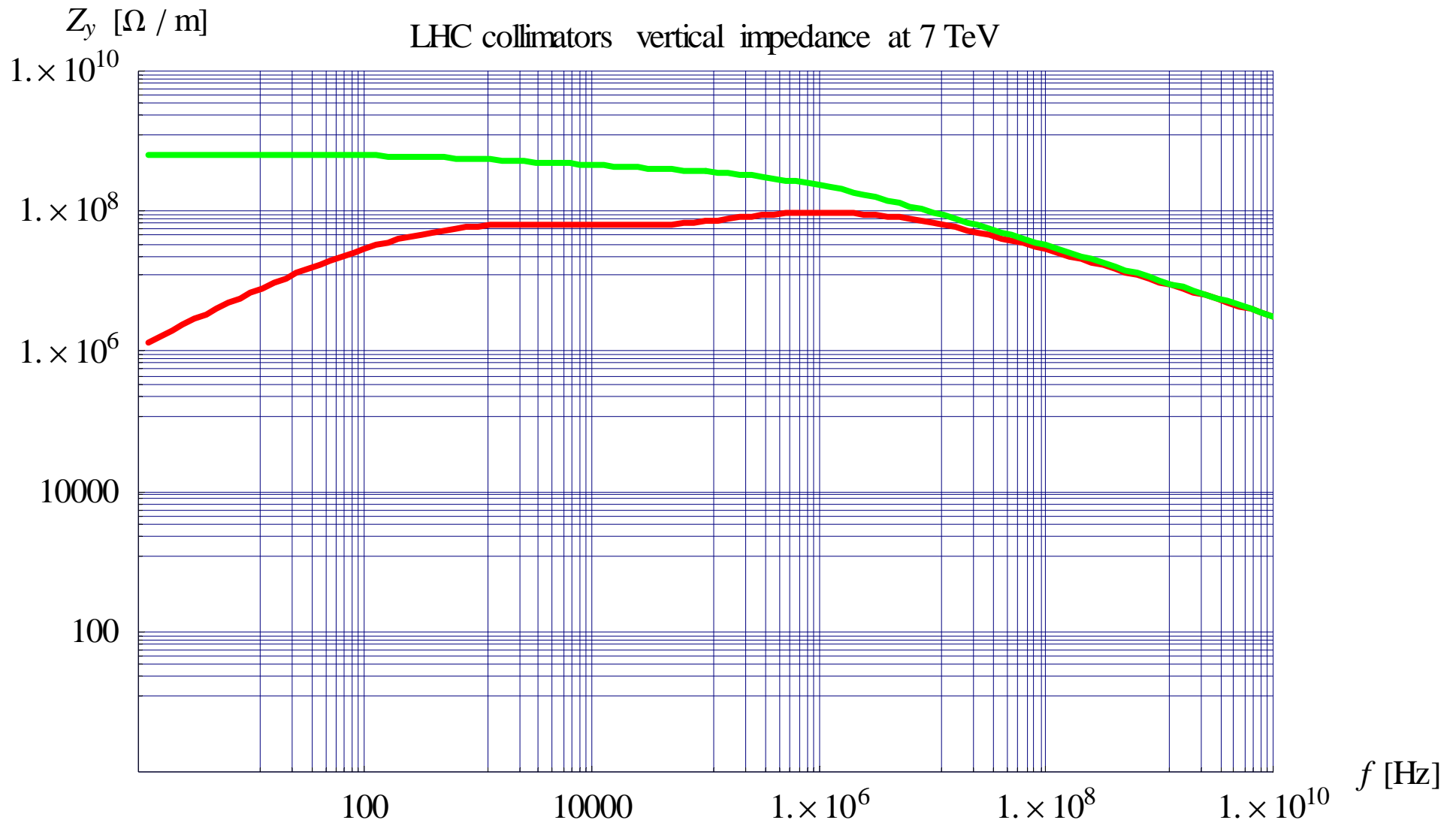


**42 collimators  
with 0.6 m  
instead of  
0.2m for the P**

| #name       | angle[rad] | betax[m] | betay[m] | halfgap[m] | Resistivity [Ohm m] | Length[m] |
|-------------|------------|----------|----------|------------|---------------------|-----------|
| TCL.5R1.B1  | 0          | 131.93   | 925.95   | 0.0025752  | 0.000000017         | 1         |
| TCTH.L2.B1  | 0          | 50.891   | 49.763   | 0.0013275  | 0.00000005          | 1         |
| TDI.4L2     | 1.571      | 112.57   | 49.684   | 0.14223    | 0.000000017         | 4         |
| TCTV.4L2.B1 | 1.571      | 132.88   | 57.748   | 0.0014141  | 0.00000005          | 1         |
| TCLIA.4R2.B | 1.571      | 54.939   | 126.7    | 0.22712    | 0.00001             | 1         |
| TCLIB.6R2   | 1.571      | 271.59   | 30.888   | 0.11214    | 0.00001             | 1         |
| TCP.6L3.B1  | 0          | 131.79   | 144.07   | 0.0038606  | 0.00001             | 0.6       |
| TCSG.5L3.B1 | 0          | 54.598   | 297.51   | 0.0029819  | 0.00001             | 1         |
| TCSG.4R3.B1 | 0          | 26.253   | 396.73   | 0.0020677  | 0.00001             | 1         |
| TCSG.A5R3.B | 2.981      | 35.949   | 345.36   | 0.0026726  | 0.00001             | 1         |
| TCSG.B5R3.B | 0.1885     | 45.627   | 313.84   | 0.0029941  | 0.00001             | 1         |
| TCLA.A5R3.B | 1.571      | 142.59   | 176.74   | 0.0059612  | 0.000000017         | 1         |
| TCLA.B5R3.B | 0          | 151.67   | 169.39   | 0.0055222  | 0.000000017         | 1         |
| TCLA.6R3.B1 | 0          | 129.27   | 168.71   | 0.0050981  | 0.000000017         | 1         |
| TCLA.7R3.B1 | 0          | 62.901   | 100.24   | 0.0035562  | 0.000000017         | 1         |
| TCTH.L5.B1  | 0          | 1646.5   | 623.78   | 0.0075507  | 0.00000005          | 1         |
| TCTV.L5.B1  | 1.571      | 1651.6   | 657.58   | 0.0047718  | 0.00000005          | 1         |
| TCL.5R5.B1  | 0          | 128.6    | 907.77   | 0.0025425  | 0.000000017         | 1         |
| TCDQ.4R6.B1 | 0          | 485.26   | 160.88   | 0.0049388  | 0.00001             | 8         |
| TCS.TCDQ.B1 | 0          | 501.16   | 165.5    | 0.0045172  | 0.00001             | 1         |
| TCP.D6L7.B1 | 1.571      | 161.93   | 76.835   | 0.0011791  | 0.00001             | 0.6       |
| TCP.C6L7.B1 | 0          | 153.51   | 81.276   | 0.0016667  | 0.00001             | 0.6       |
| TCP.B6L7.B1 | 2.215      | 145.36   | 85.943   | 0.0013939  | 0.00001             | 0.6       |
| TCSG.A6L7.B | 2.463      | 40.93    | 224.39   | 0.0016699  | 0.00001             | 1         |
| TCSG.B5L7.B | 2.504      | 155.67   | 165.97   | 0.0019809  | 0.00001             | 1         |
| TCSG.A5L7.B | 0.71       | 180.91   | 145.59   | 0.0020214  | 0.00001             | 1         |
| TCSG.D4L7.B | 1.571      | 323.86   | 69.276   | 0.0013062  | 0.00001             | 1         |
| TCSG.B4L7.B | 0          | 136.69   | 132.92   | 0.0018349  | 0.00001             | 1         |
| TCSG.A4L7.B | 2.349      | 125.98   | 143.27   | 0.0018218  | 0.00001             | 1         |
| TCSG.A4R7.B | 0.808      | 115.95   | 154.24   | 0.0018299  | 0.00001             | 1         |
| TCSG.B5R7.B | 2.47       | 124.91   | 268.08   | 0.0021075  | 0.00001             | 1         |
| TCSG.D5R7.B | 0.897      | 218.64   | 158.38   | 0.0021163  | 0.00001             | 1         |
| TCSG.E5R7.B | 2.277      | 246.63   | 135.83   | 0.0021201  | 0.00001             | 1         |
| TCSG.6R7.B1 | 0.009      | 341.67   | 46.546   | 0.0029008  | 0.00001             | 1         |
| TCLA.A6R7.B | 1.571      | 296.69   | 47.528   | 0.0015456  | 0.000000017         | 1         |
| TCLA.C6R7.B | 0          | 157.1    | 77.269   | 0.0028101  | 0.000000017         | 1         |
| TCLA.E6R7.B | 1.571      | 65.302   | 156.52   | 0.0028049  | 0.000000017         | 1         |
| TCLA.F6R7.B | 0          | 60.053   | 166.17   | 0.0017374  | 0.000000017         | 1         |
| TCLA.A7R7.B | 0          | 63.26    | 147.05   | 0.0017832  | 0.000000017         | 1         |
| TCTV.4L8.B1 | 1.571      | 128.8    | 52.857   | 0.0013529  | 0.00000005          | 1         |
| TCTH.L1.B1  | 0          | 1648.7   | 624.84   | 0.0075558  | 0.00000005          | 1         |
| TCTV.L1.B1  | 1.571      | 1653.8   | 658.72   | 0.004776   | 0.00000005          | 1         |



# Total (Zotter) vertical impedance for the 42 collimators with 0.6 m for the P



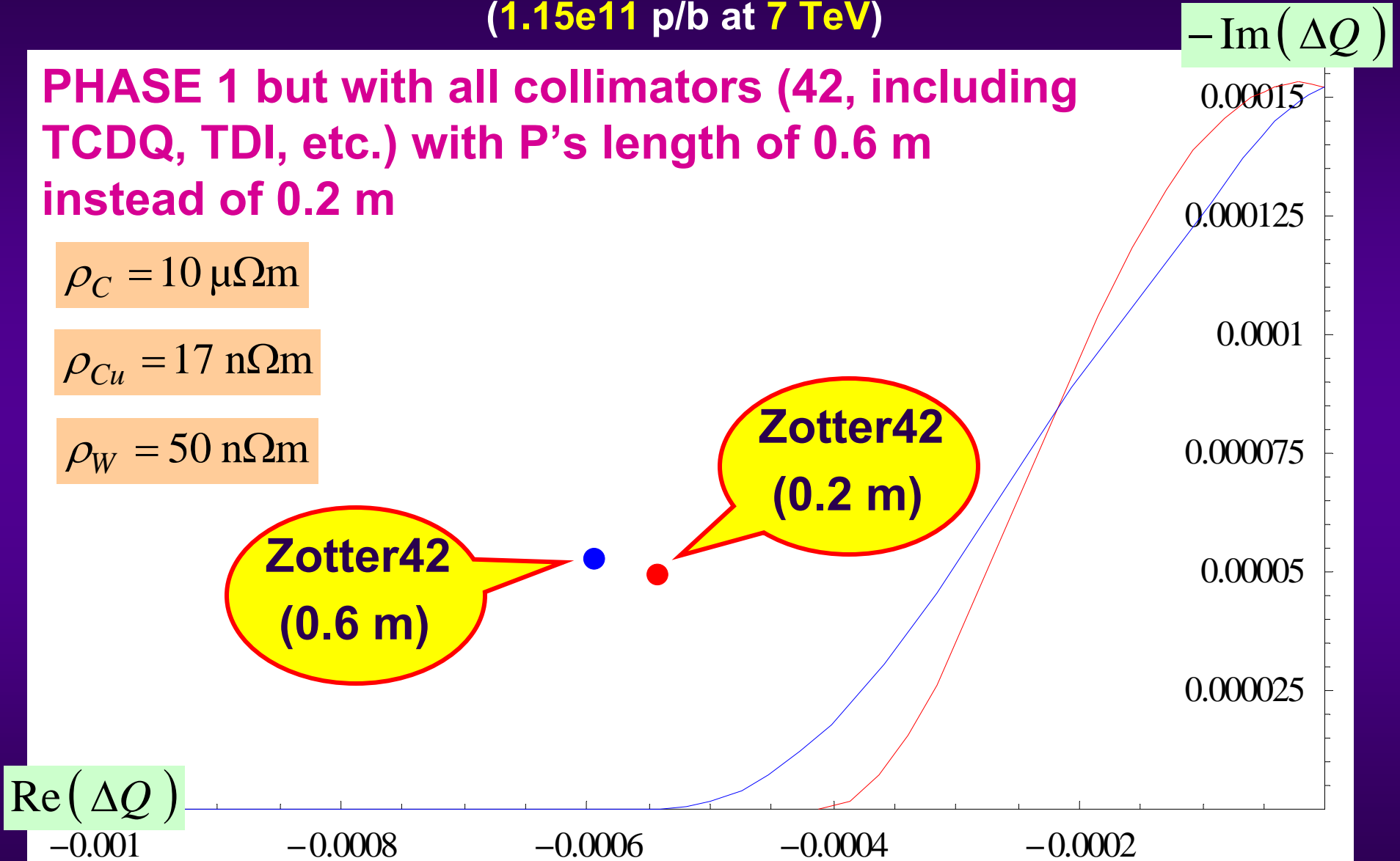
Stability diagram (maximum octupoles) and collective tune shift for the most unstable coupled-bunch mode and head-tail mode 0 (1.15e11 p/b at 7 TeV)

PHASE 1 but with all collimators (42, including TCDQ, TDI, etc.) with P's length of 0.6 m instead of 0.2 m

$$\rho_C = 10 \mu\Omega\text{m}$$

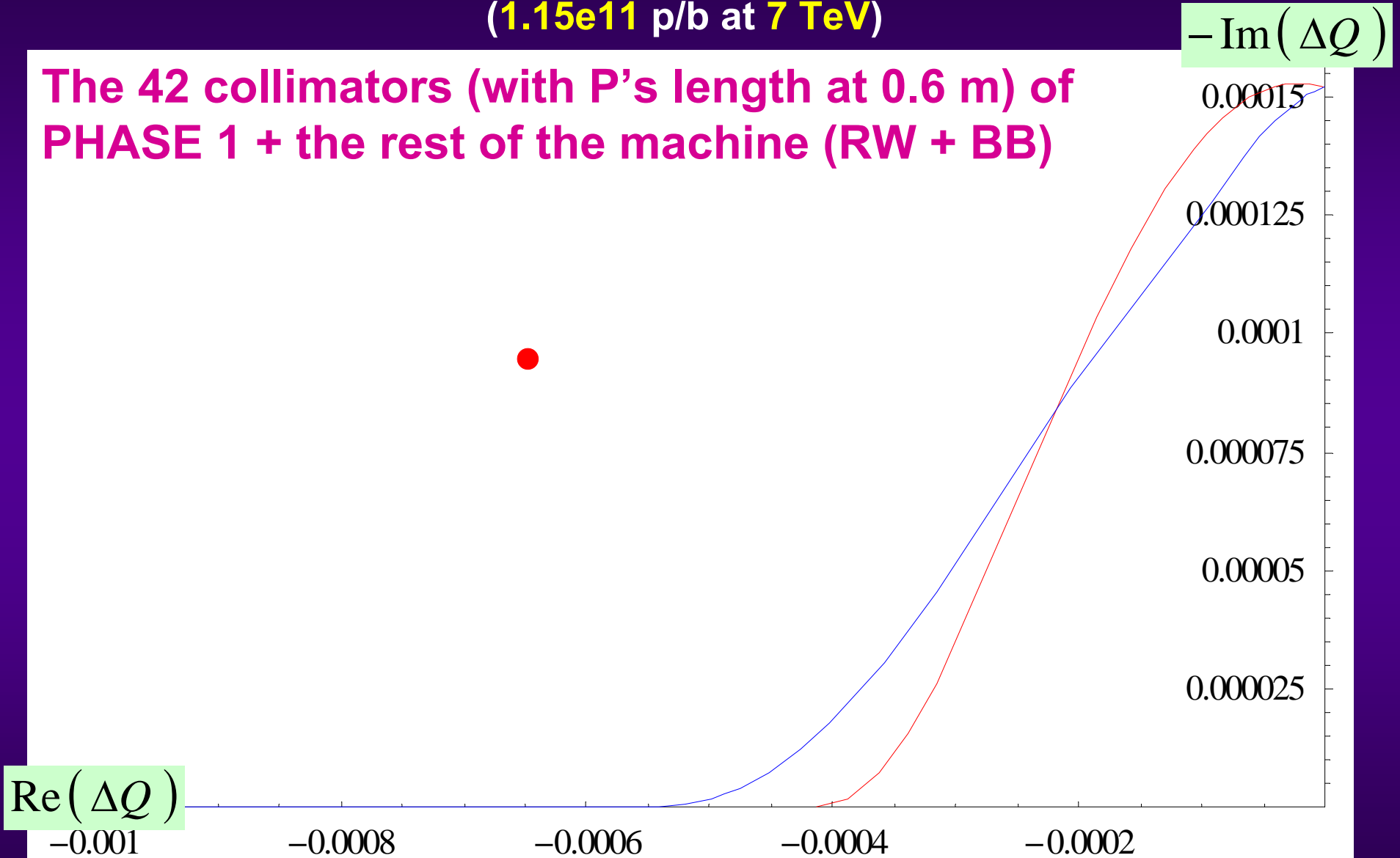
$$\rho_{Cu} = 17 \text{ n}\Omega\text{m}$$

$$\rho_W = 50 \text{ n}\Omega\text{m}$$



Stability diagram (maximum octupoles) and collective tune shift  
for the most unstable coupled-bunch mode and head-tail mode 0  
(1.15e11 p/b at 7 TeV)

The 42 collimators (with P's length at 0.6 m) of  
PHASE 1 + the rest of the machine (RW + BB)



Stability diagram (maximum octupoles) and collective tune shift for the most unstable coupled-bunch mode and head-tail mode 0

( $0.5 \times 1.15e11$  p/b at 7 TeV)

The 42 collimators (with P's length at 0.6 m) of PHASE 1 + the rest of the machine (RW + BB)

⇒ Beam stable from Landau damping at ~50% of the nominal intensity

