FP420 MEETING

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- **Experience with the LHC collimators**
  - **Resistive-wall effect**

    $\Rightarrow$ Numerical application for the FP420 detector (8m long pipe, 1-sided, copper, 3 mm half gap)
  - **Trapped modes**
  - **Broad-band impedance (constant inductive impedance)**

1) RESISTIVE-WALL EFFECT

THE CASE OF THE LHC GRAPHITE COLLIMATORS

- **First unstable betatron line** $f_\beta^1 \approx 8\ \mathrm{kHz}$
- **Skin depth for graphite (ρ = 10 μΩm)** $\delta\left(8\ \mathrm{kHz}\right) = 1.8\ \mathrm{cm}$
- **Collimator thickness** $d_{th} = 2.5\ \mathrm{cm}$

$$\Rightarrow \quad \delta\left(f_\beta\right) = \sqrt{\frac{\rho}{\pi\,\mu\,f_\beta}} < d_{th}$$

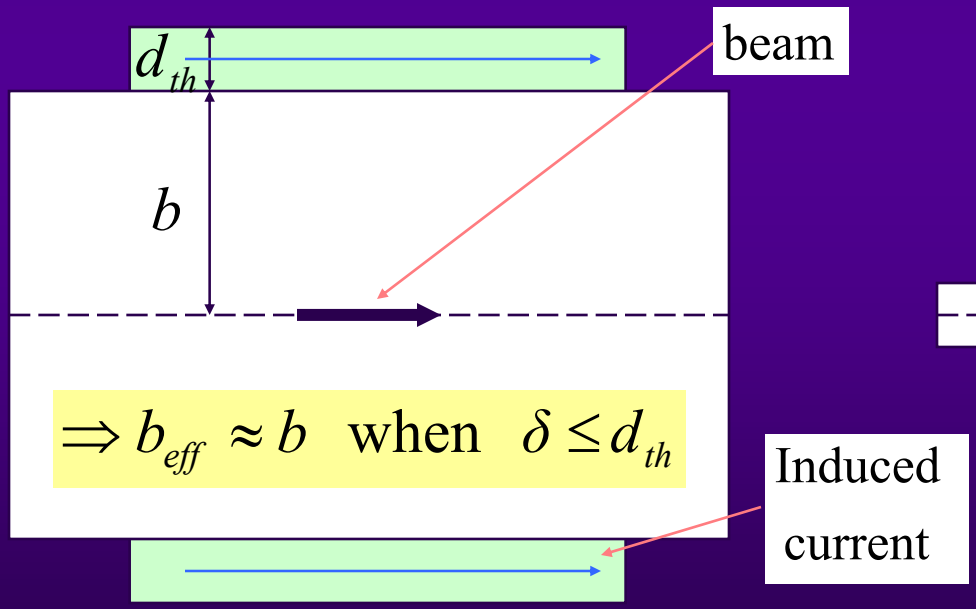
⇒ **One could think that the classical "thick-wall" formula would be about right**

$$Z_\perp^{\mathrm{thick-wall}}\left(f\right) \propto \frac{1}{b^3\sqrt{f}}$$

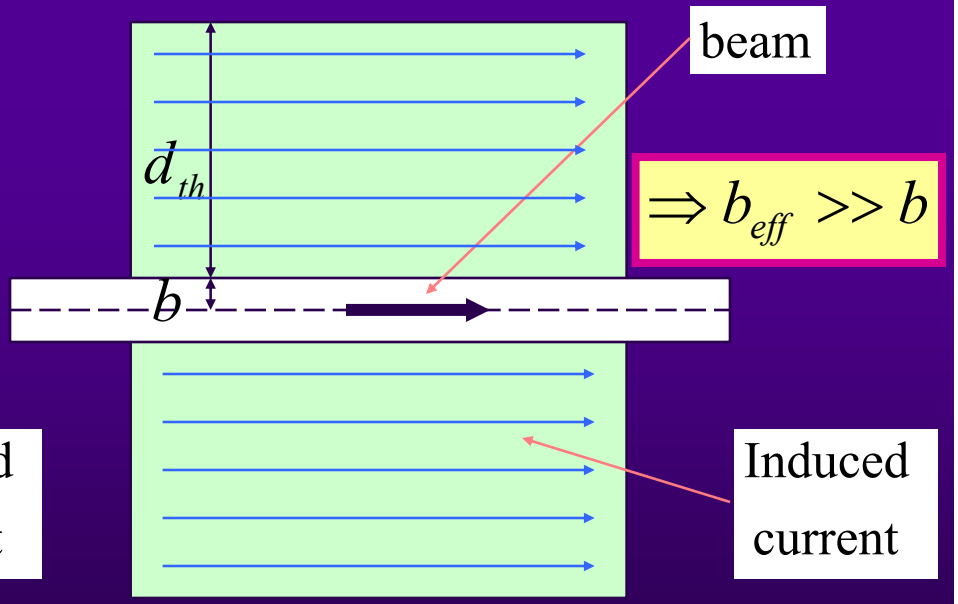
- **In fact it is not ⇒ The resistive impedance is ~ 2 orders of magnitude lower at ~ 8 kHz !**

⇒ A new physical regime was revealed by the LHC collimators

Usual regime : $d_{th}, \delta < b$

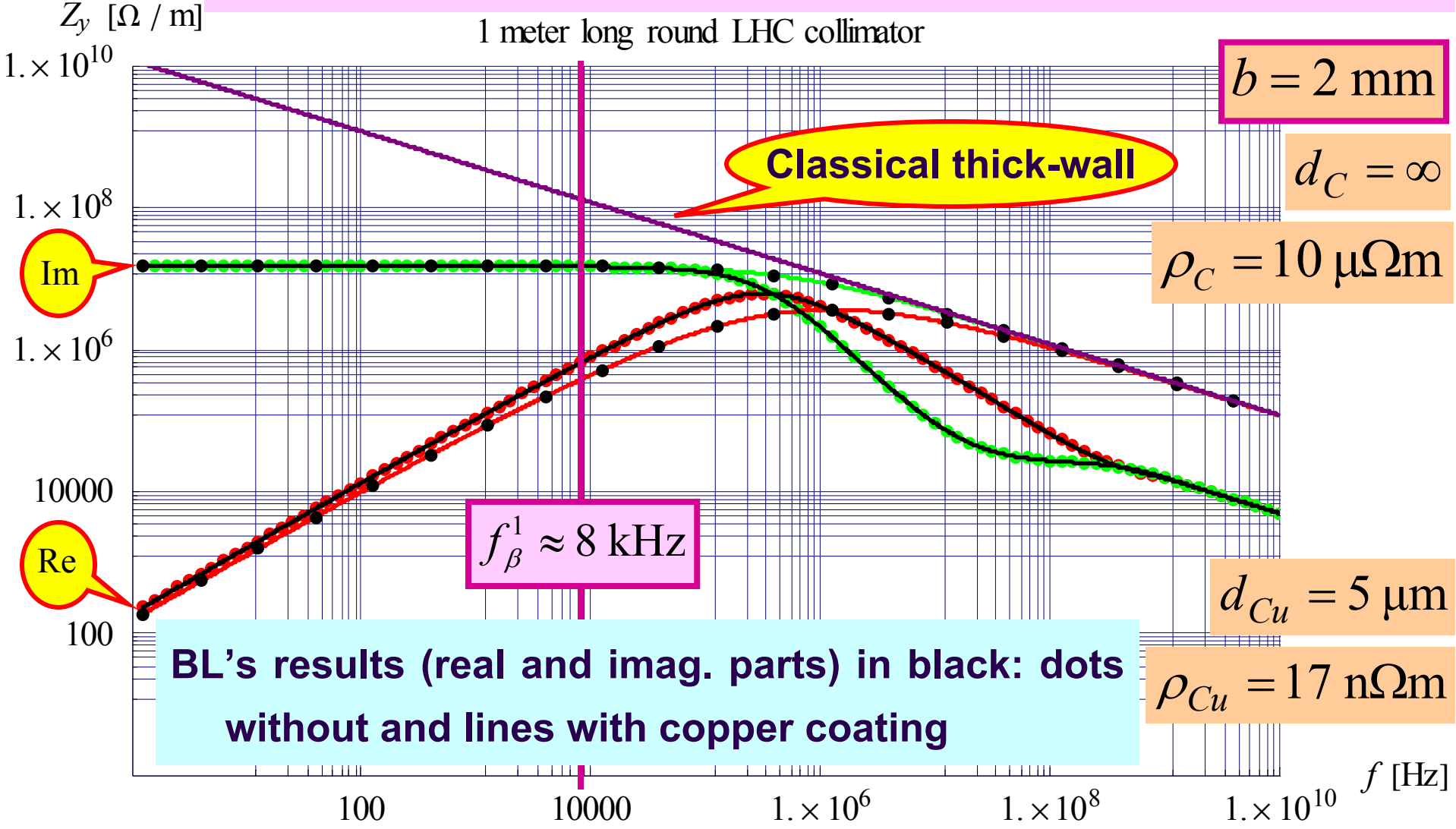


New regime : $d_{th} >> b$, $\delta \leq d_{th}$



TRANS. RW IMPEDANCE OF THE LHC COLLIMATORS

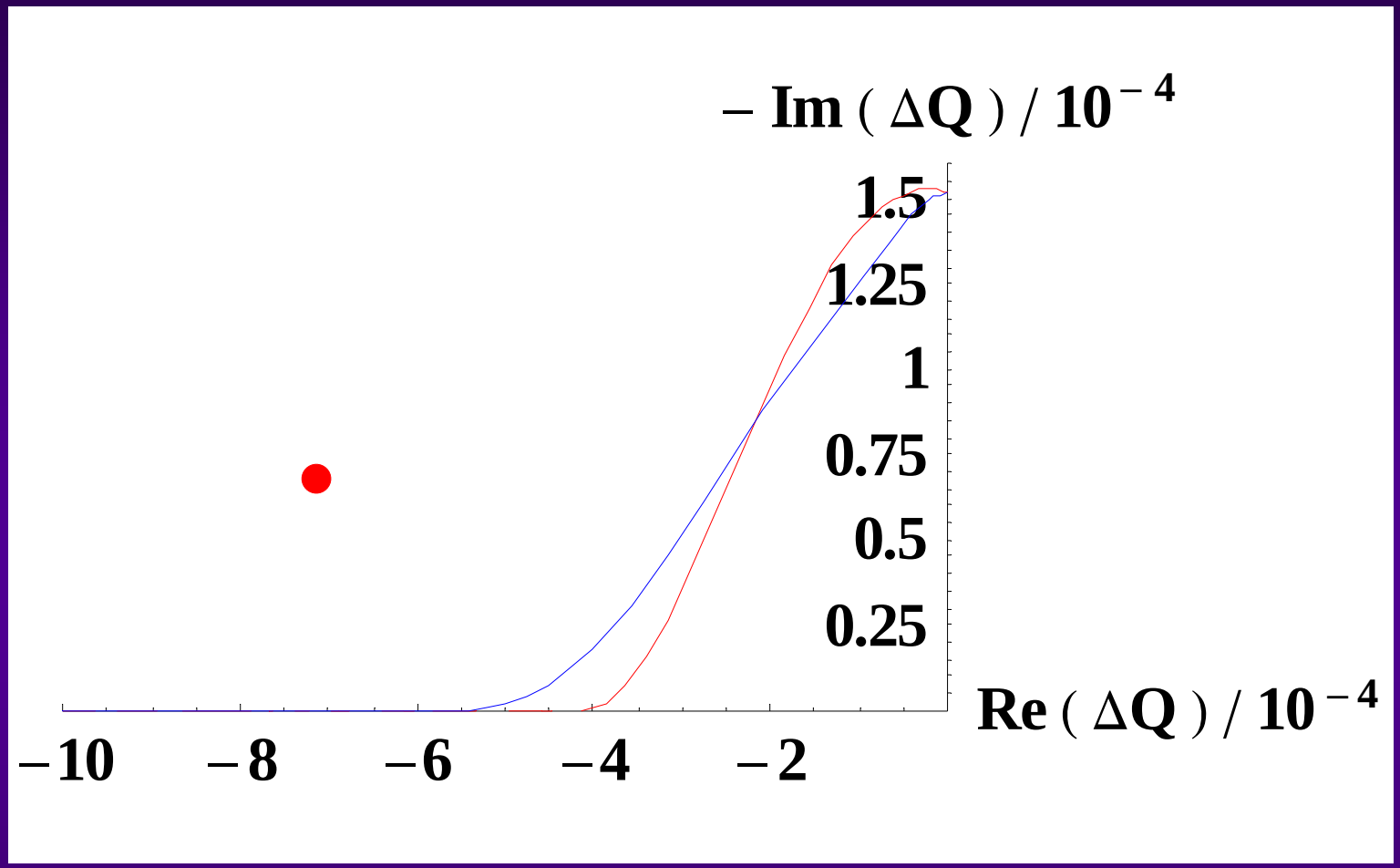
COMPARISON ZOTTER2005-BUROV&LEBEDEV2002



LHC collimator list (except TDI and TCDQ treated separately)

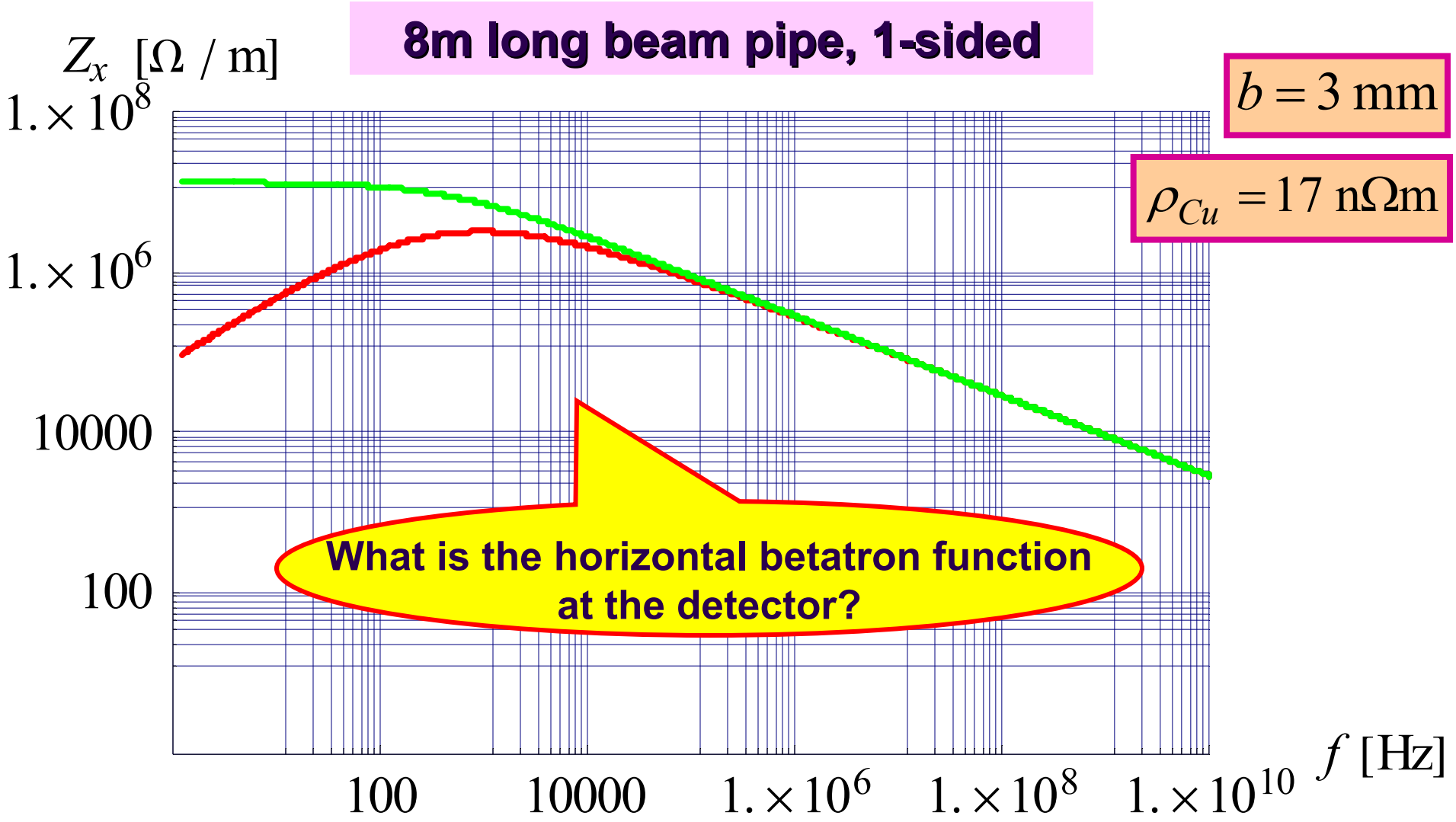
#name	angle[rad]	betax[m]	betay[m]	halfgap[m]	Resistivity [Ohm m]	Length[m]
TCL.5R1.B1	0	131.930046	925.939244	0.002575162	0.000000017	1
TCTH.L2.B1	0	50.8905324	49.7634705	0.001327484	0.00000005	1
TCTV.4L2.B1	1.571	132.878596	57.7485257	0.001414104	0.00000005	1
TCLIA.4R2.B1	1.571	54.9399025	126.695909	0.227120612	0.00001	1
TCLIB.6R2	1.571	271.5918	30.8891662	0.112144615	0.00001	1
TCP.6L3.B1	0	133.173819	142.421503	0.003880909	0.00001	0.6
TCSG.5L3.B1	0	55.2316125	295.084643	0.002999156	0.00001	1
TCSG.4R3.B1	0	26.2566047	402.556797	0.002067876	0.00001	1
TCSG.A5R3.B1	2.981	36.2555658	350.426671	0.002685595	0.00001	1
TCSG.B5R3.B1	0.1885	46.1122737	318.428996	0.003011138	0.00001	1
TCLA.A5R3.B1	1.571	144.265025	179.180893	0.006002174	0.00000005	1
TCLA.B5R3.B1	0	153.437469	171.707025	0.005554289	0.00000005	1
TCLA.6R3.B1	0	130.137774	167.358555	0.005115221	0.00000005	1
TCLA.7R3.B1	0	66.0337326	93.1616861	0.003643726	0.00000005	1
TCTH.L5.B1	0	1646.47497	623.773574	0.007550721	0.00000005	1
TCTV.L5.B1	1.571	1651.5656	657.575043	0.004771814	0.00000005	1
TCL.5R5.B1	0	128.604788	907.761503	0.002542502	0.000000017	1
TCS.TCDQ.B1	0	501.167596	165.505192	0.003764311	0.00001	1
TCP.D6L7.B1	1.571	168.879644	73.4174845	0.001152614	0.00001	0.6
TCP.C6L7.B1	0	160.233365	77.6735947	0.001702788	0.00001	0.6
TCP.B6L7.B1	2.215	151.86291	82.1555769	0.001393408	0.00001	0.6
TCSG.A6L7.B1	2.463	43.0720503	216.932384	0.001657723	0.00001	1
TCSG.B5L7.B1	2.504	147.345413	163.177444	0.001940944	0.00001	1
TCSG.A5L7.B1	0.71	171.206577	143.46244	0.001981527	0.00001	1
TCSG.D4L7.B1	1.571	306.612559	69.6322005	0.001309592	0.00001	1
TCSG.B4L7.B1	0	131.22721	138.531839	0.001797806	0.00001	1
TCSG.A4L7.B1	2.349	121.231917	149.143312	0.001826087	0.00001	1
TCSG.A4R7.B1	0.808	111.88628	160.369012	0.001838418	0.00001	1
TCSG.B5R7.B1	2.47	131.104839	272.505246	0.002139507	0.00001	1
TCSG.D5R7.B1	0.897	228.139661	159.916518	0.002143107	0.00001	1
TCSG.E5R7.B1	2.277	257.03478	136.813892	0.00214865	0.00001	1
TCSG.6R7.B1	0.009	353.17157	44.9237507	0.002949228	0.00001	1
TCLA.A6R7.B1	1.571	311.567299	45.2928573	0.001508856	0.00000005	1
TCLA.C6R7.B1	0	163.888957	73.0525544	0.00287017	0.00000005	1
TCLA.E6R7.B1	1.571	66.3427234	151.468451	0.002759268	0.00000005	1
TCLA.F6R7.B1	0	62.6000088	157.726835	0.001773862	0.00000005	1
TCLA.A7R7.B1	0	59.8259125	148.758902	0.001734113	0.00000005	1
TCTH.L8.B1	0	47.1043837	47.8950155	0.001277149	0.00000005	1
TCTV.4L8.B1	1.571	128.802029	52.8559028	0.001352875	0.00000005	1
TCTH.L1.B1	0	1648.69683	624.83177	0.007555814	0.00000005	1
TCTV.L1.B1	1.571	1653.81877	658.708163	0.004775924	0.00000005	1

HORIZONTAL STABILITY DIAGRAM AT TOP ENERGY



The beam is stable if the red dot is below the curves ⇒ The beam is unstable and only ~half of the nominal intensity is stable

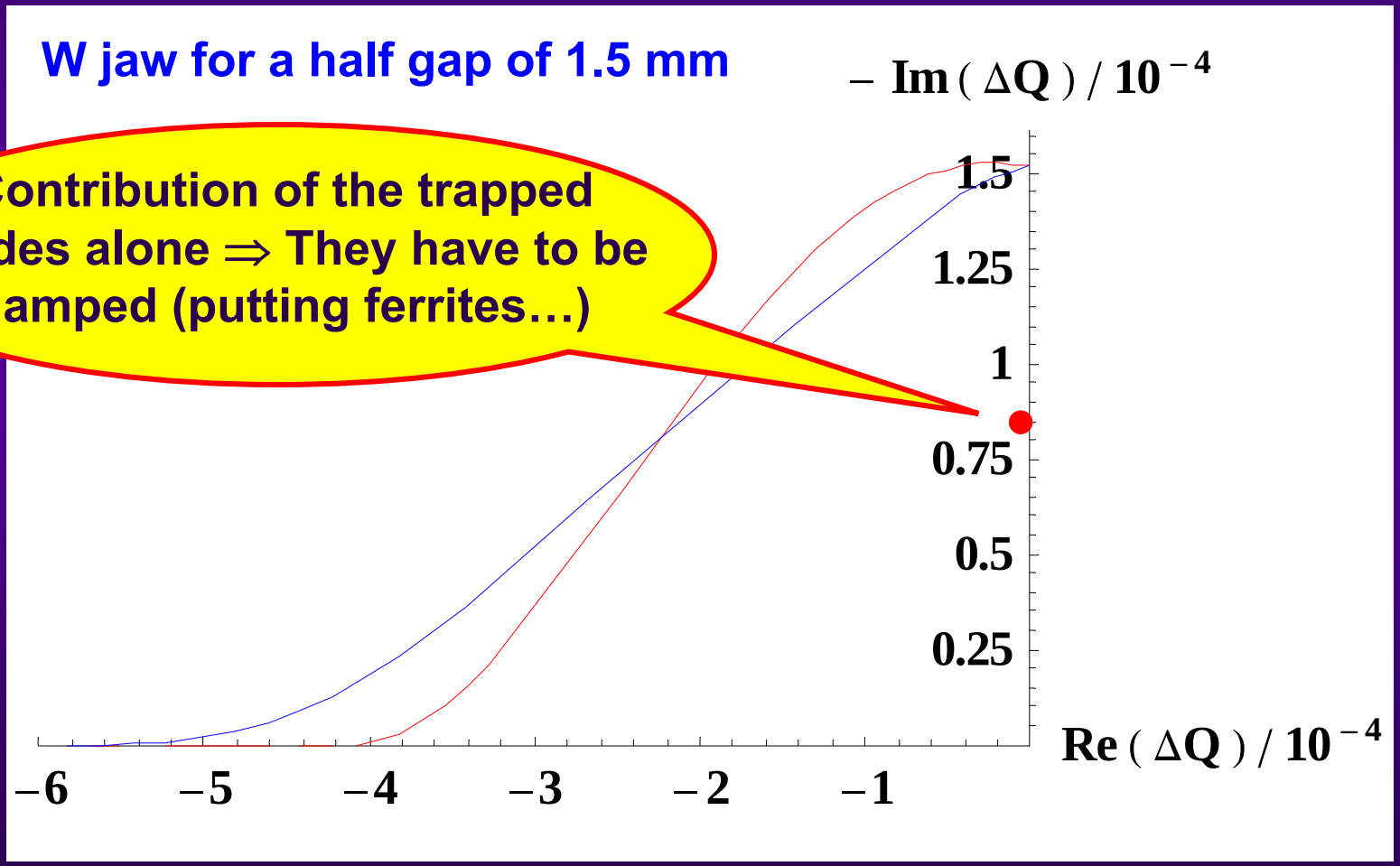
NUMERICAL APPLICATION FOR THE 1-SIDED FP420 DETECTOR



2) TRAPPED MODES

THE CASE OF THE TCTV.4L8.B1 ⇒ At D1 (the 2 beams are not separated, i.e. it is a 2-beam pipe) ⇒ Currently under design/simulations

W jaw for a half gap of 1.5 mm



3) BROAD-BAND IMPEDANCE

THE CASE OF THE TCTV.4L8.B1 $\Rightarrow$ At D1 (the 2 beams are not separated, i.e. it is a 2-beam pipe) $\Rightarrow$ Currently under design/simulations

Opening the RF fingers to damp the trapped modes using ferrite has a detrimental effect $\Rightarrow$ It increases the broad-band impedance because the trapped modes are shifted to lower frequencies. What would help is instead:

- Increase the gap
- Reduce the transverse dimensions of the elliptical vacuum chamber