

SINGLE-BUNCH AND COUPLED-BUNCH INSTABILITY AT LHC TOP ENERGY VS. CHROMATICITY

E. Métral

- ◆ **All the collimators of PHASE 1, with the TDI and TCDQ treated separately, beam screen, BB impedance (including collimators), warm pipe, MQW (2 mm Cu), MBW (2 mm Cu)**
- ◆ **Computations for both injection and top energy, both horizontal and vertical planes, and both with and without collimators**

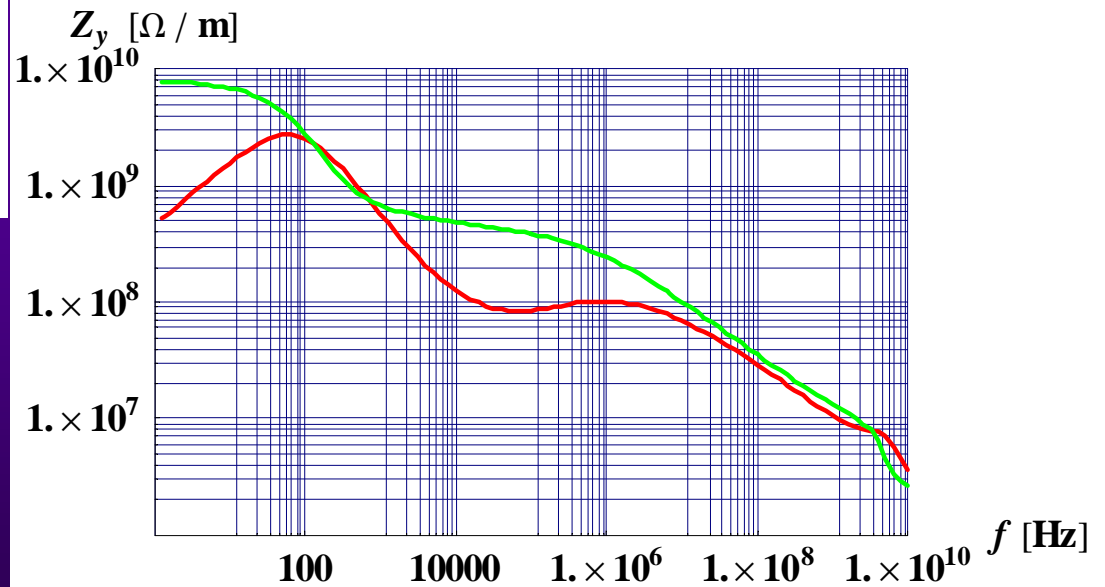
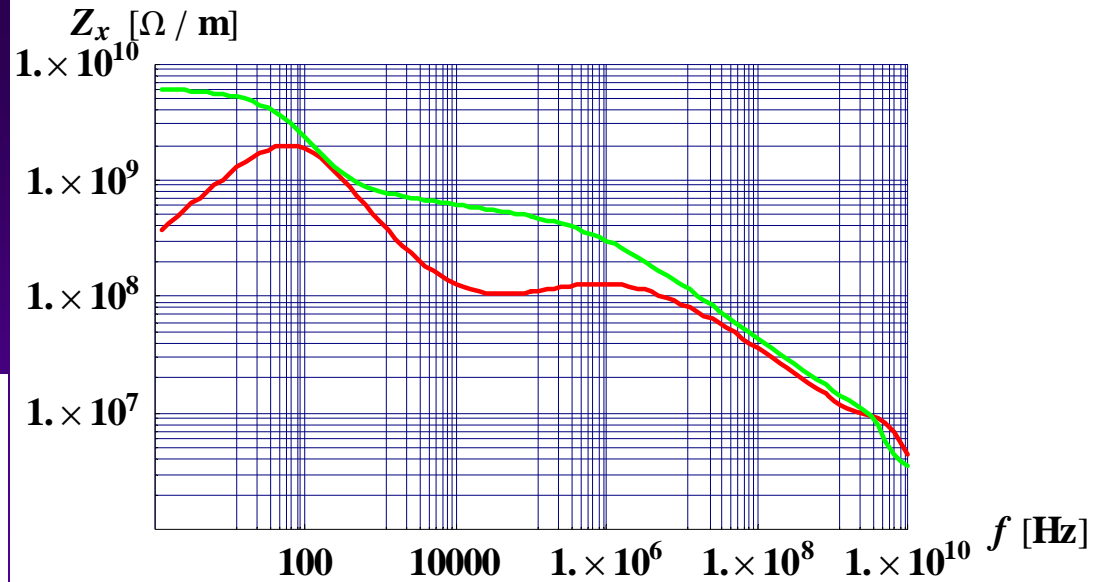
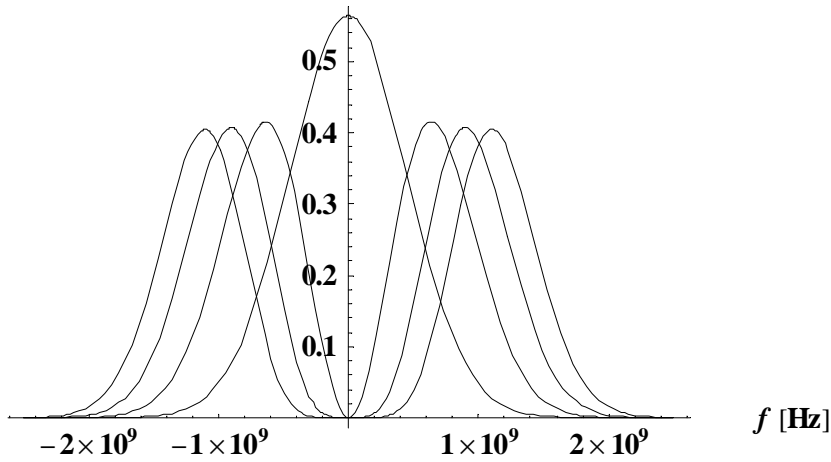
TOP ENERGY

Latest collimator list sent by
G. Robert-Demolaize on 11/10/05

#name	angle [rad]	betax [m]	betay [m]	half gap [mm]	Material	Length [m]
TCL.5R1.B1	0	132	926	2.6	CU	1
TCTH.L2.B1	0	51	50	1.3	W	1
TDI.4L2	1.57	113	50	142.2	CU	4
TCTV.4L2.B1	1.57	133	58	1.4	W	1
TCLIA.4R2.B1	1.57	55	127	227.1	C	1
TCLIB.6R2	1.57	272	31	112.1	C	1
TCP.6L3.B1	0	133	142	3.9	C	0.6
TCSG.5L3.B1	0	55	295	3.0	C	1
TCSG.4R3.B1	0	26	403	2.1	C	1
TCSG.A5R3.B1	2.98	36	350	2.7	C	1
TCSG.B5R3.B1	0.19	46	318	3.0	C	1
TCLA.A5R3.B1	1.57	144	179	6.0	W	1
TCLA.B5R3.B1	0	153	172	5.6	W	1
TCLA.6R3.B1	0	130	167	5.1	W	1
TCLA.7R3.B1	0	66	93	3.6	W	1
TCTH.L5.B1	0	1646	624	7.6	W	1
TCTV.L5.B1	1.57	1652	658	4.8	W	1
TCL.5R5.B1	0	129	908	2.5	CU	1
TCDQ.4R6.B1	0	485	161	4.0	C	8
TCS.TCDQ.B1	0	501	166	3.8	C	1
TCP.D6L7.B1	1.57	169	73	1.2	C	0.6
TCP.C6L7.B1	0	160	78	1.7	C	0.6
TCP.B6L7.B1	2.22	152	82	1.4	C	0.6
TCSG.A6L7.B1	2.46	43	217	1.7	C	1
TCSG.B5L7.B1	2.50	147	163	1.9	C	1
TCSG.A5L7.B1	0.71	171	143	2.0	C	1
TCSG.D4L7.B1	1.57	307	70	1.3	C	1
TCSG.B4L7.B1	0	131	139	1.8	C	1
TCSG.A4L7.B1	2.35	121	149	1.8	C	1
TCSG.A4R7.B1	0.81	112	160	1.8	C	1
TCSG.B5R7.B1	2.47	131	273	2.1	C	1
TCSG.D5R7.B1	0.90	228	160	2.1	C	1
TCSG.E5R7.B1	2.28	257	137	2.1	C	1
TCSG.6R7.B1	0.01	353	45	2.9	C	1
TCLA.A6R7.B1	1.57	312	45	1.5	W	1
TCLA.C6R7.B1	0	164	73	2.9	W	1
TCLA.E6R7.B1	1.57	66	151	2.8	W	1
TCLA.F6R7.B1	0	63	158	1.8	W	1
TCLA.A7R7.B1	0	60	149	1.7	W	1
TCTH.L8.B1	0	47	48	1.3	W	1
TCTV.4L8.B1	1.57	129	53	1.4	W	1
TCTH.L1.B1	0	1649	625	7.6	W	1
TCTV.L1.B1	1.57	1654	659	4.8	W	1

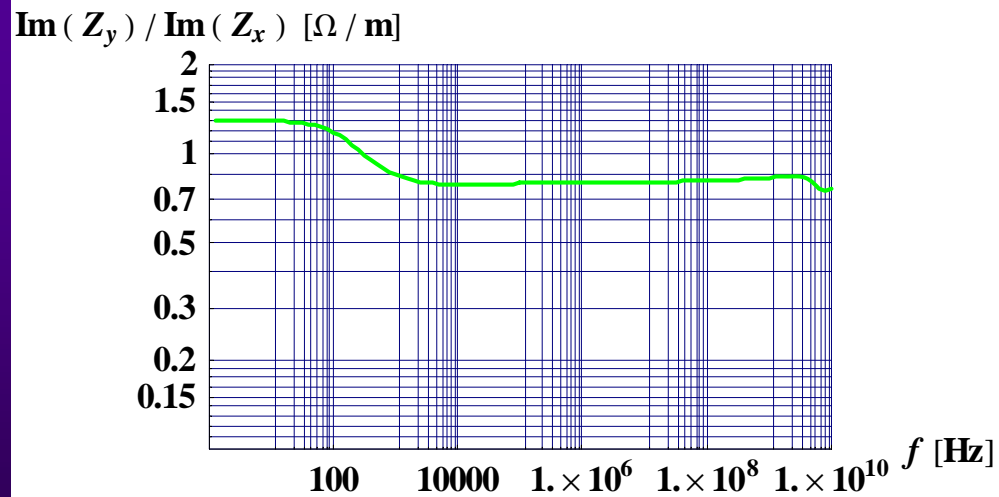
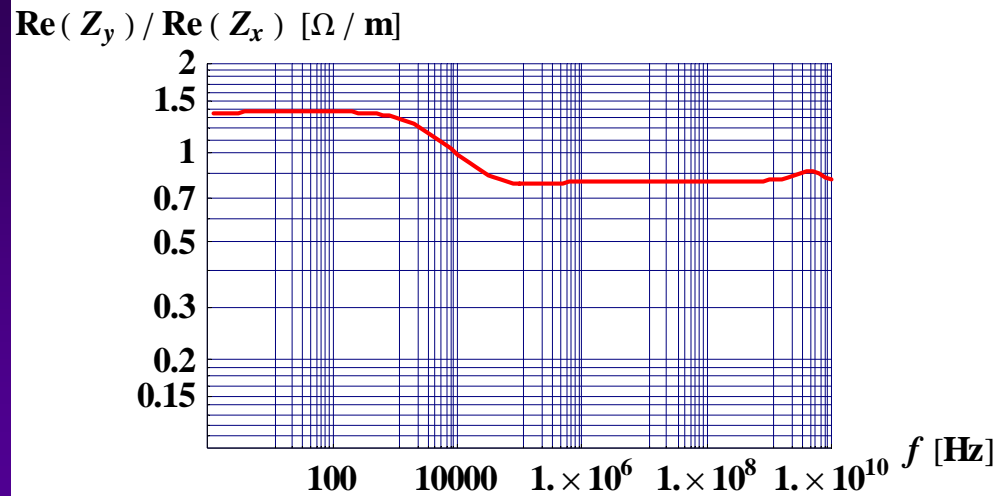
Bunch spectrum and total impedances

Bunch spectrum



$$Q'_{x,y} = 1 \Rightarrow f_{\xi_{x,y}} \sim 40 \text{ MHz}$$

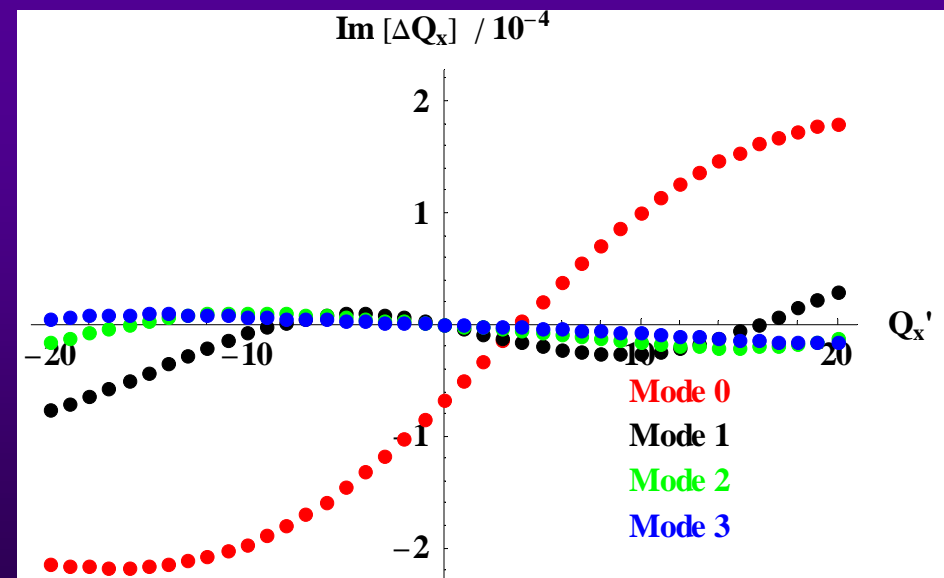
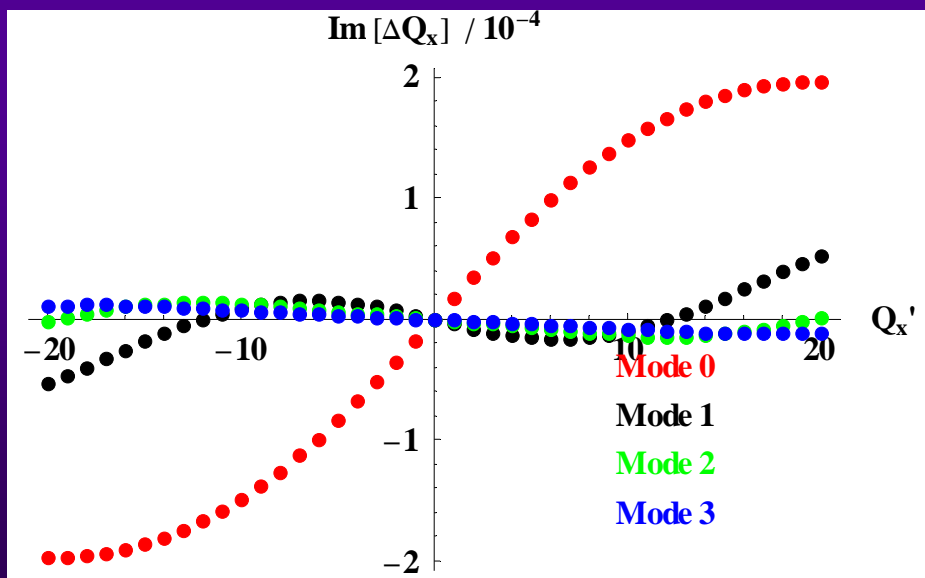
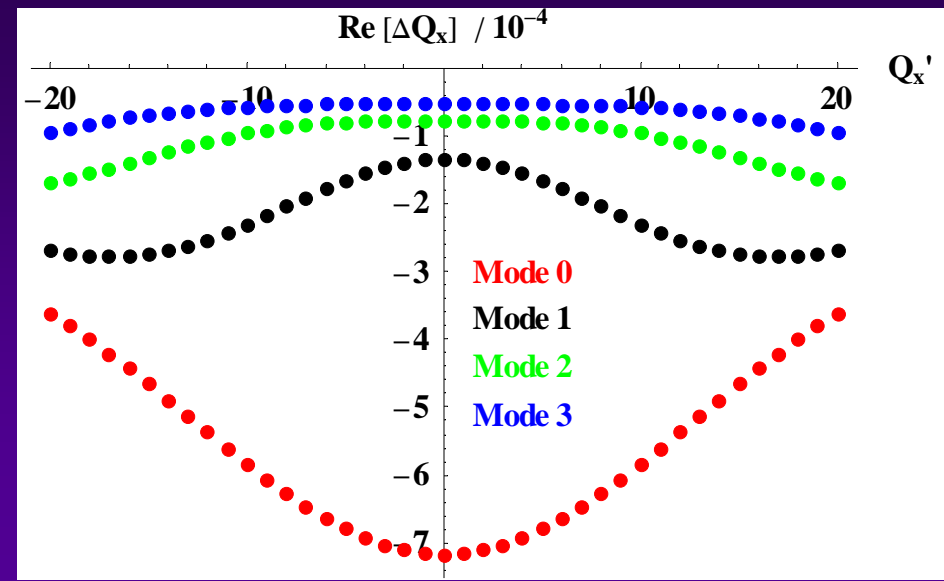
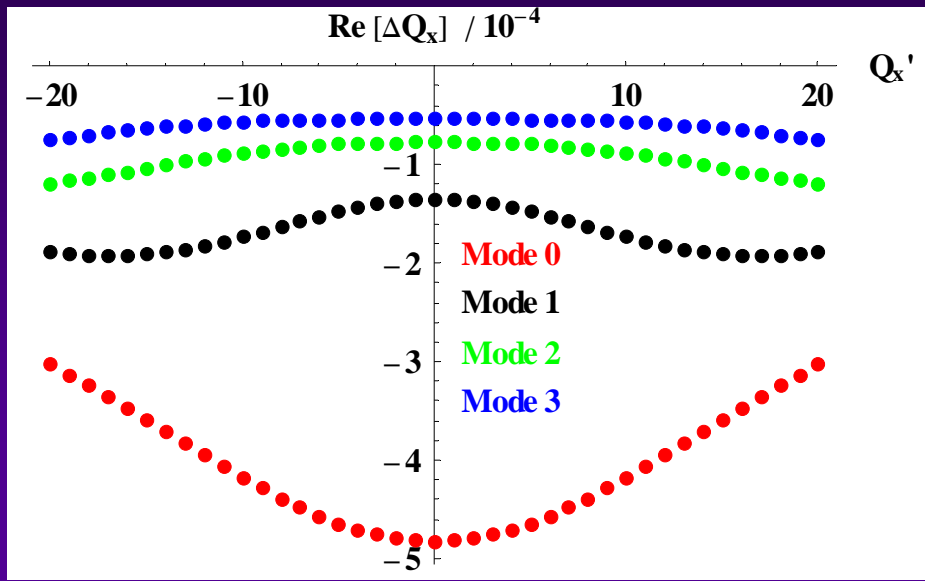
Comparison between the two transverse impedances



Single-bunch

X-plane

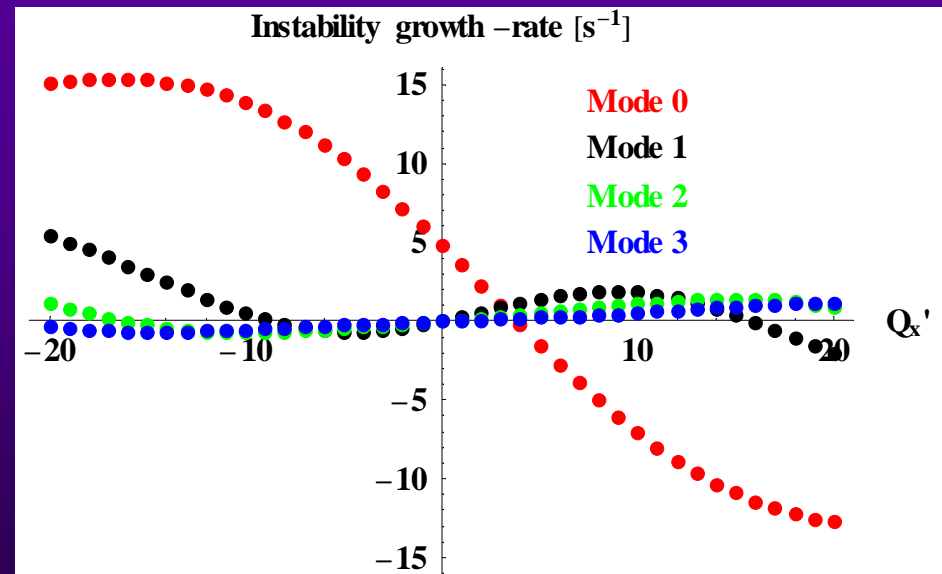
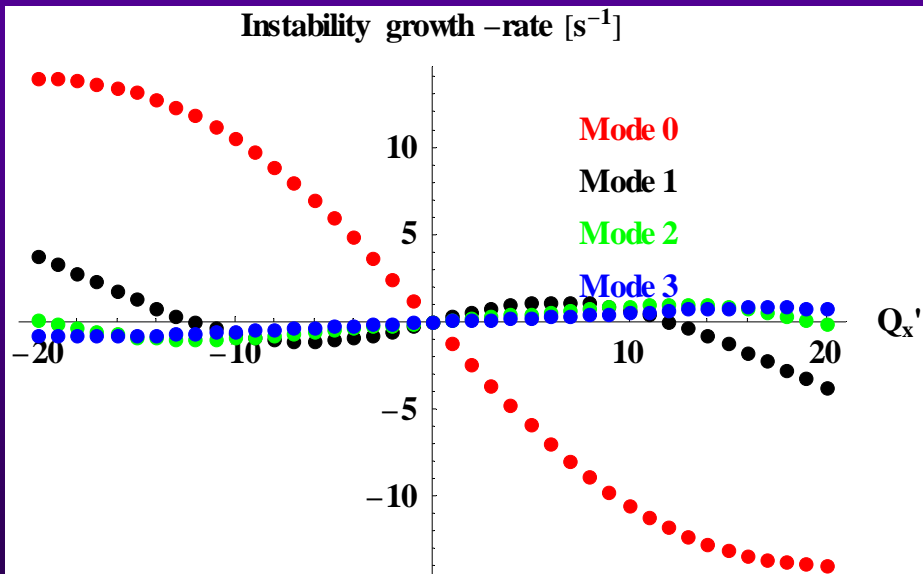
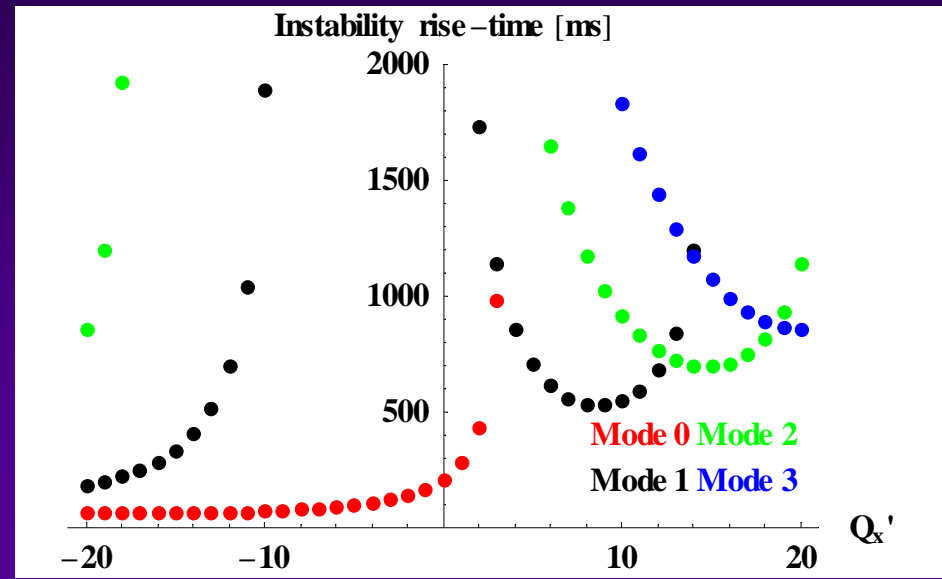
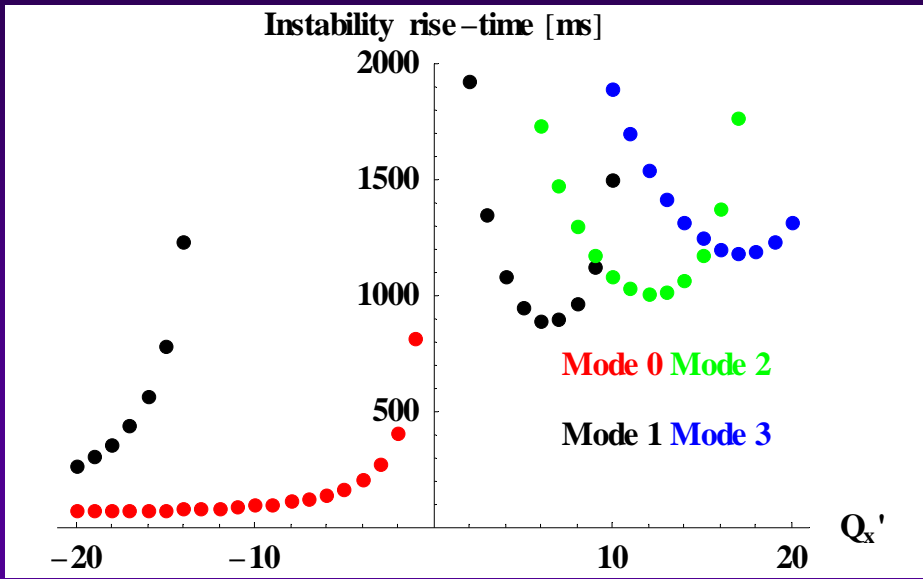
Coupled-bunch



Single-bunch

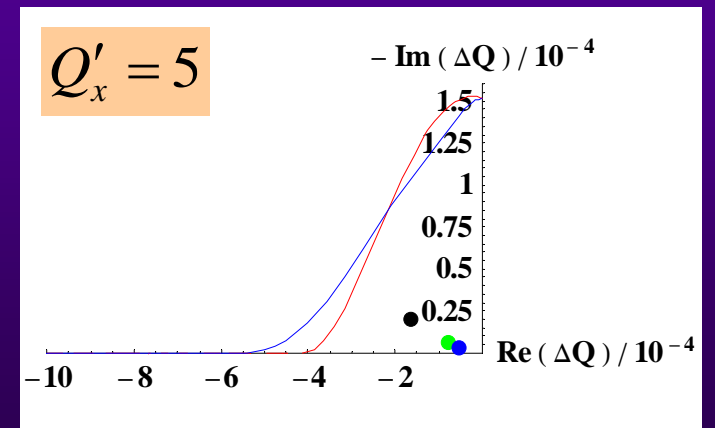
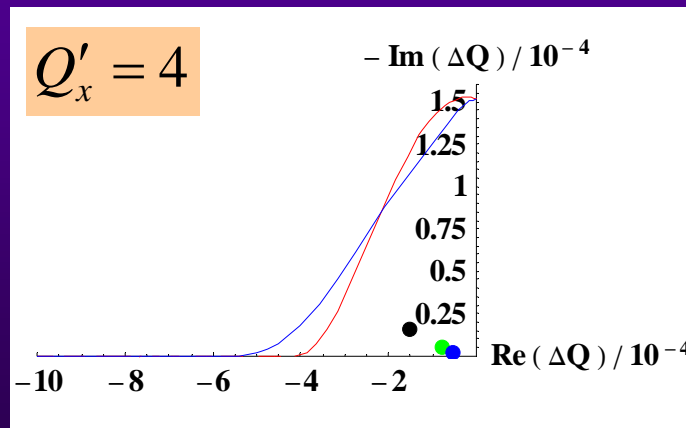
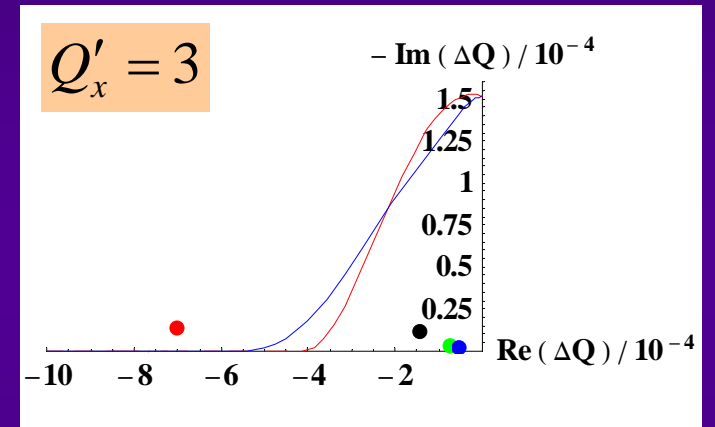
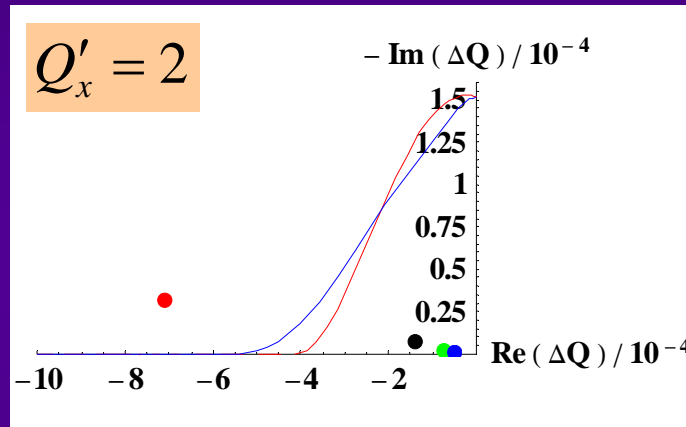
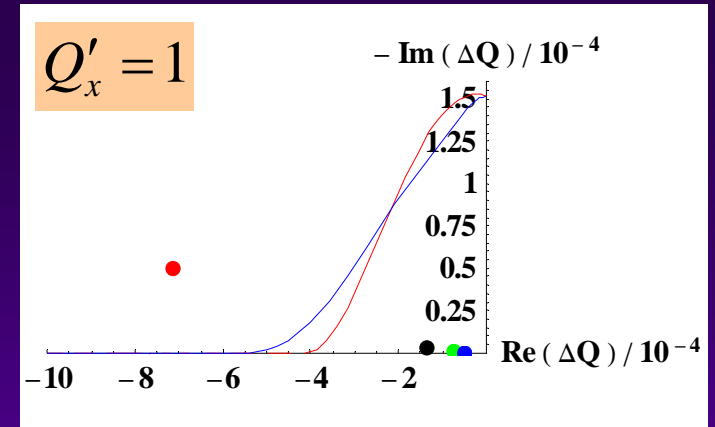
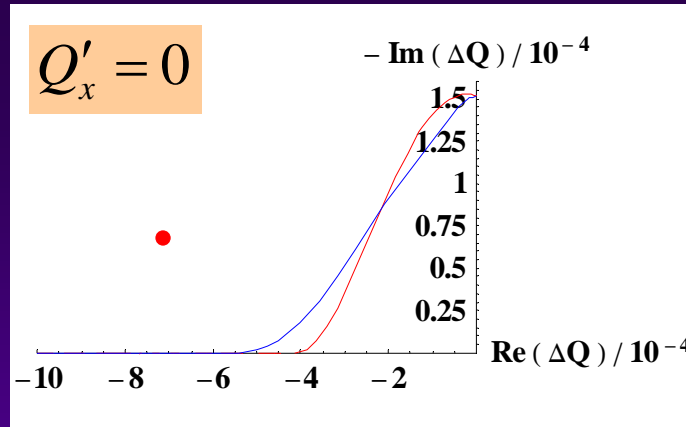
X-plane

Coupled-bunch



Stability diagrams (X-plane)

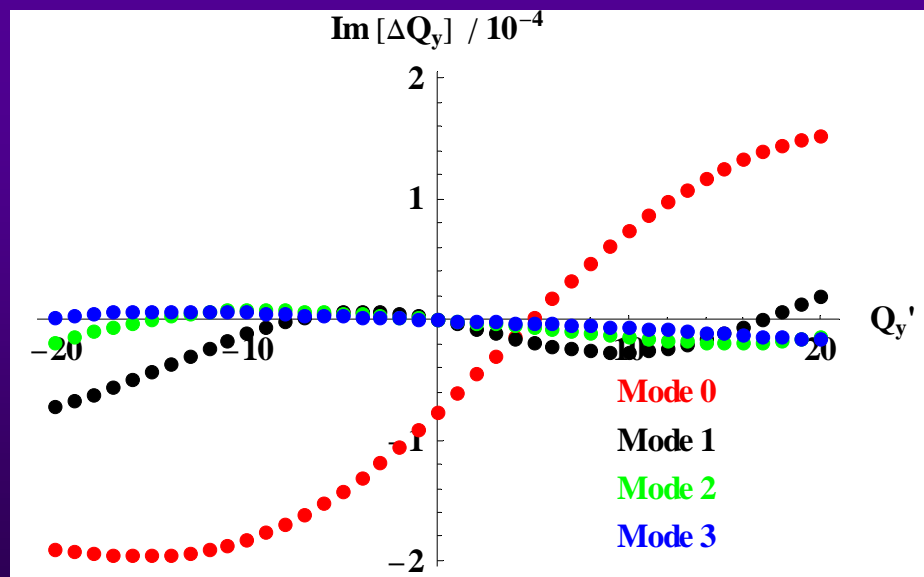
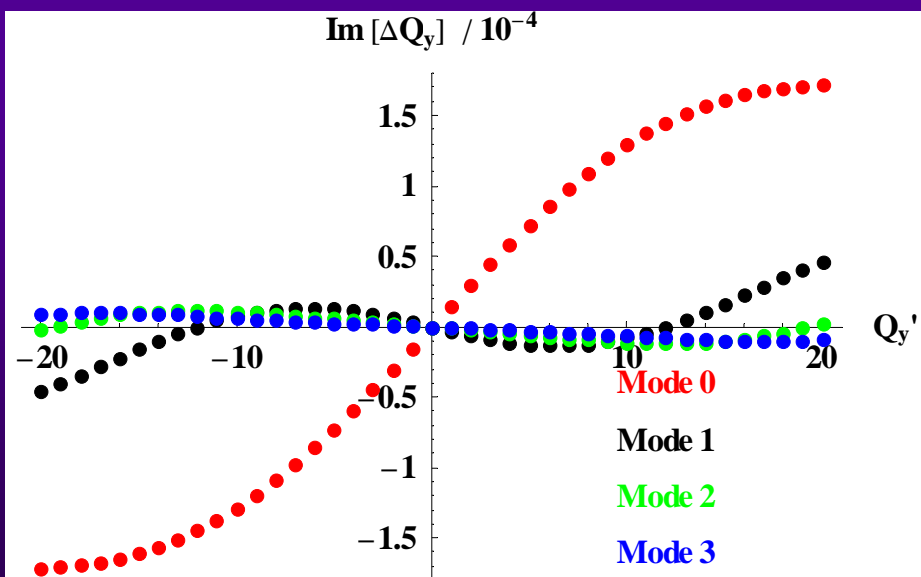
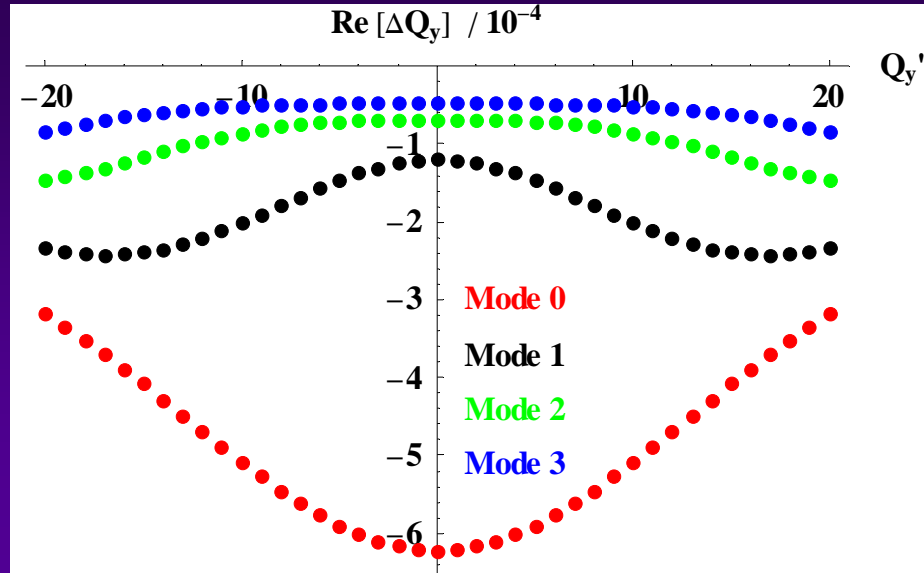
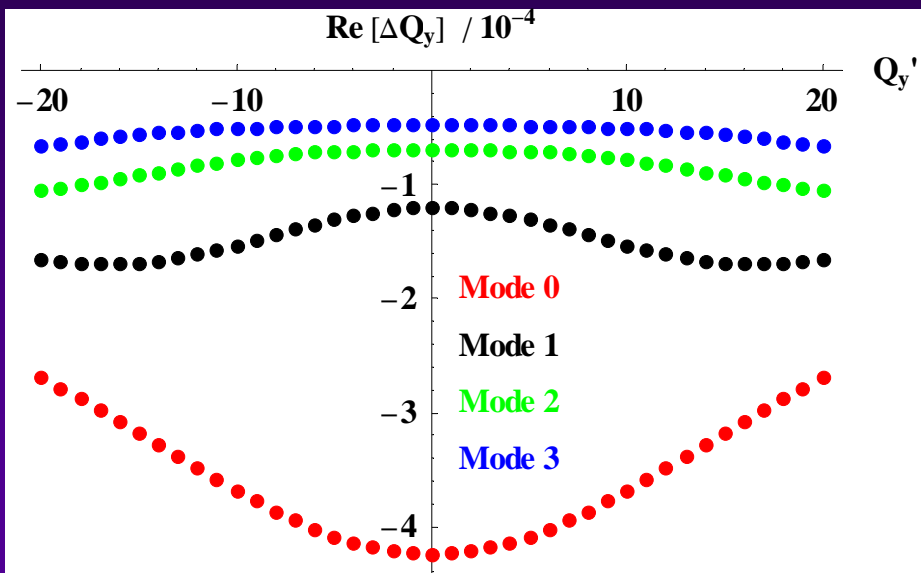
- Mode 0
- Mode 1
- Mode 2
- Mode 3



Single-bunch

Y-plane

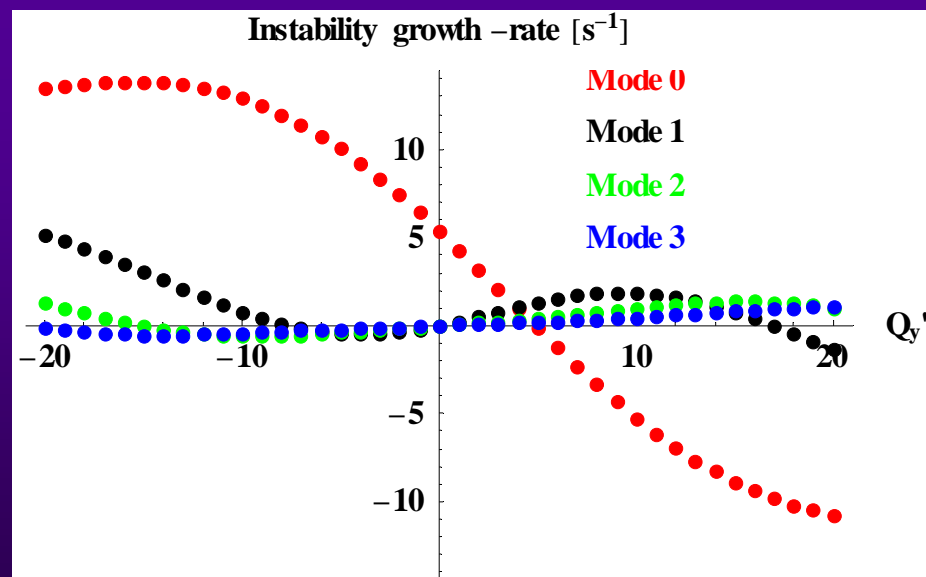
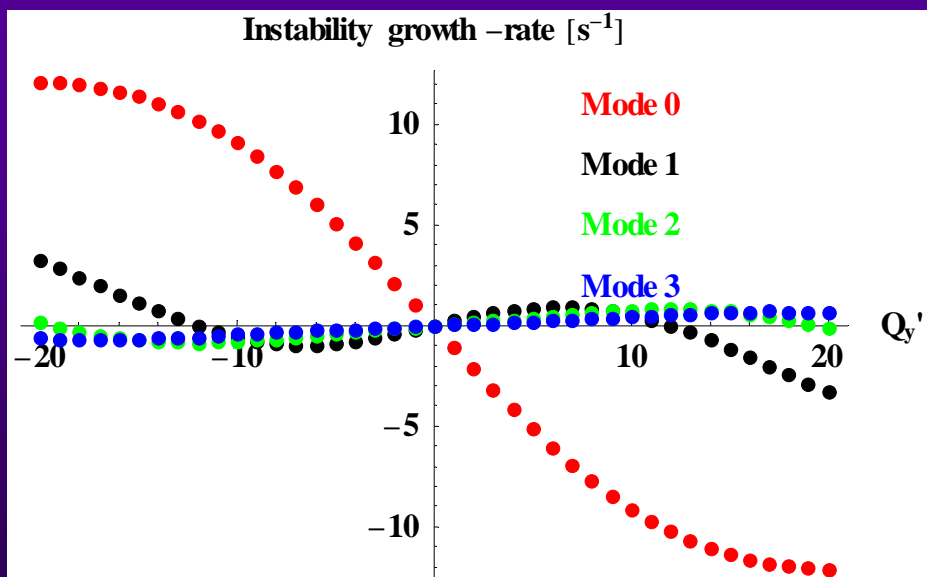
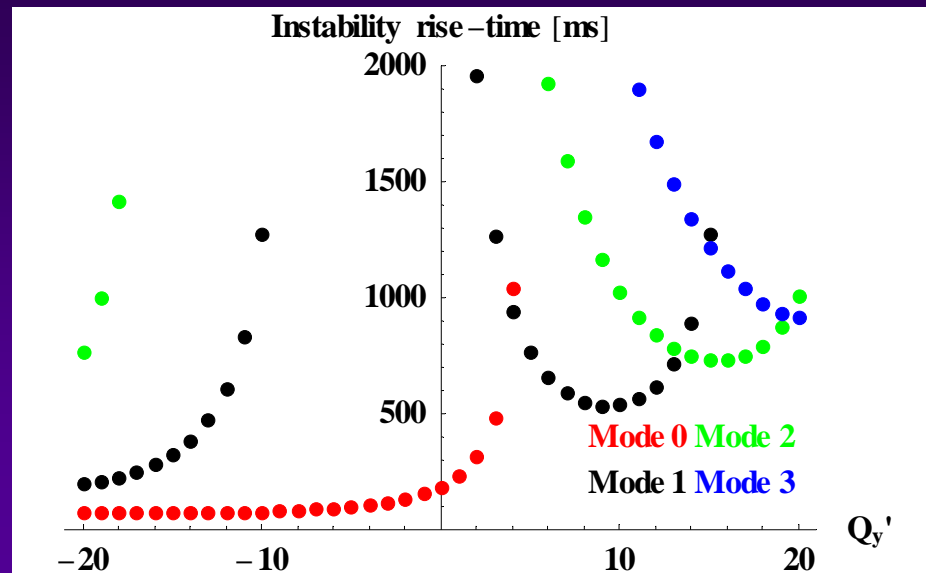
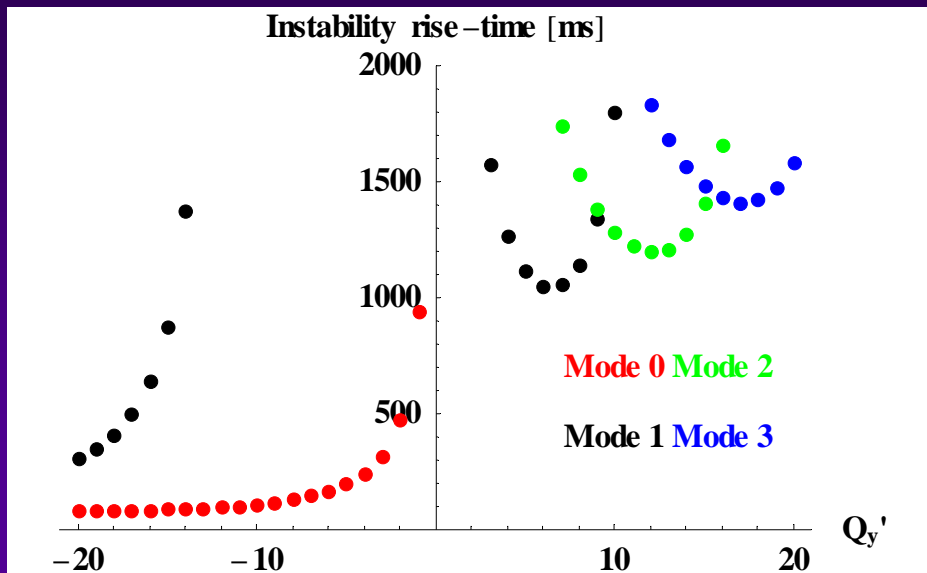
Coupled-bunch



Single-bunch

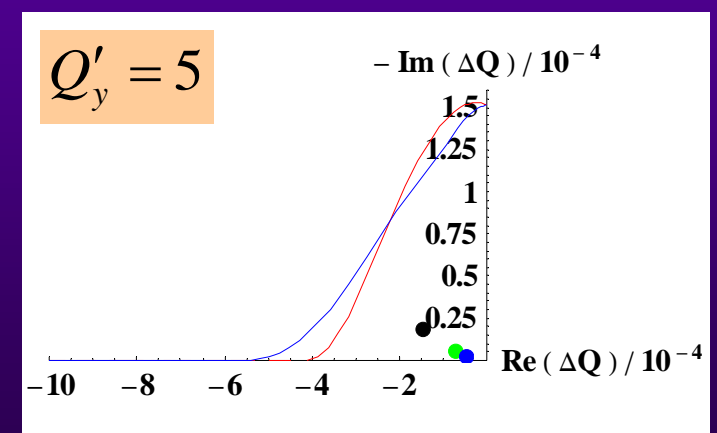
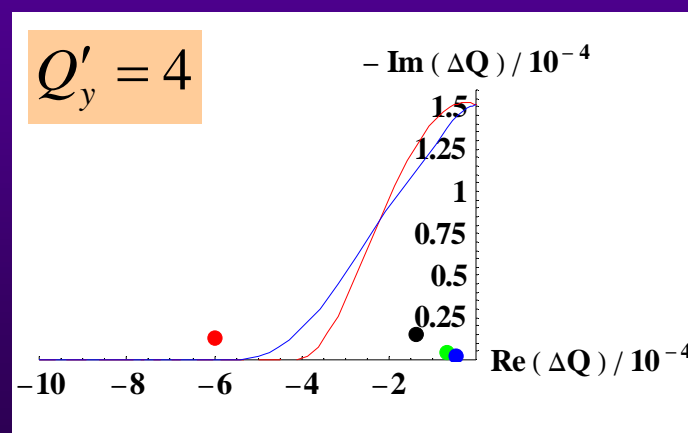
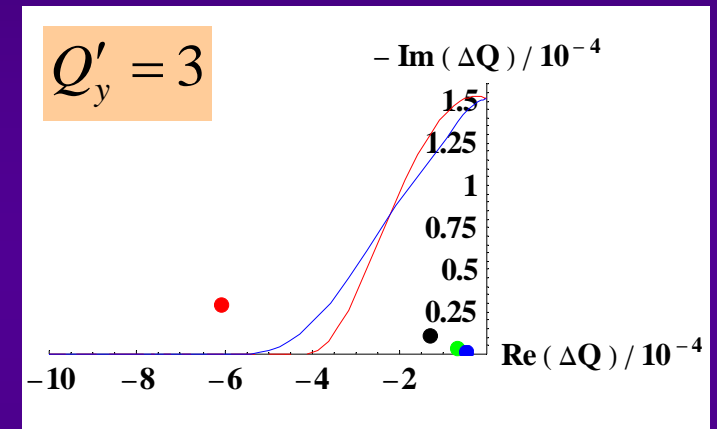
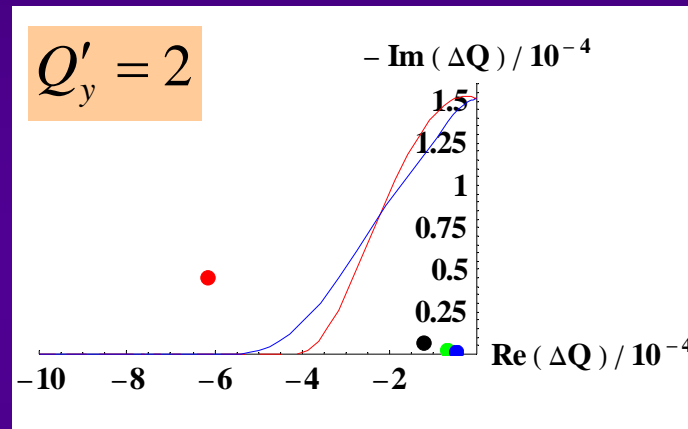
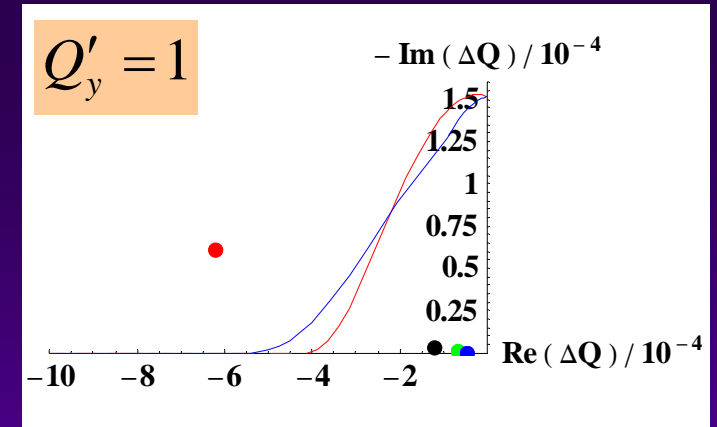
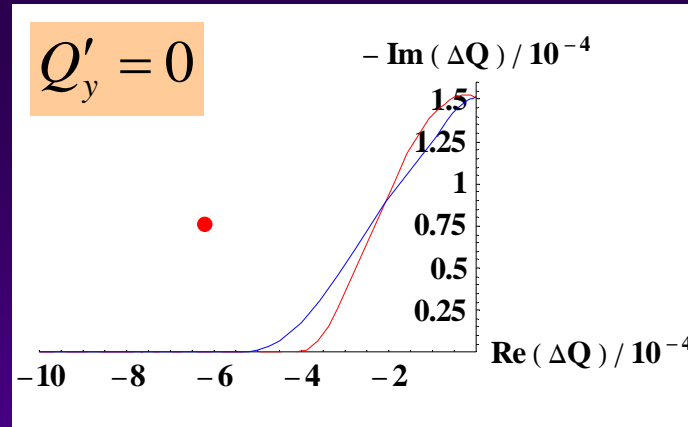
Y-plane

Coupled-bunch



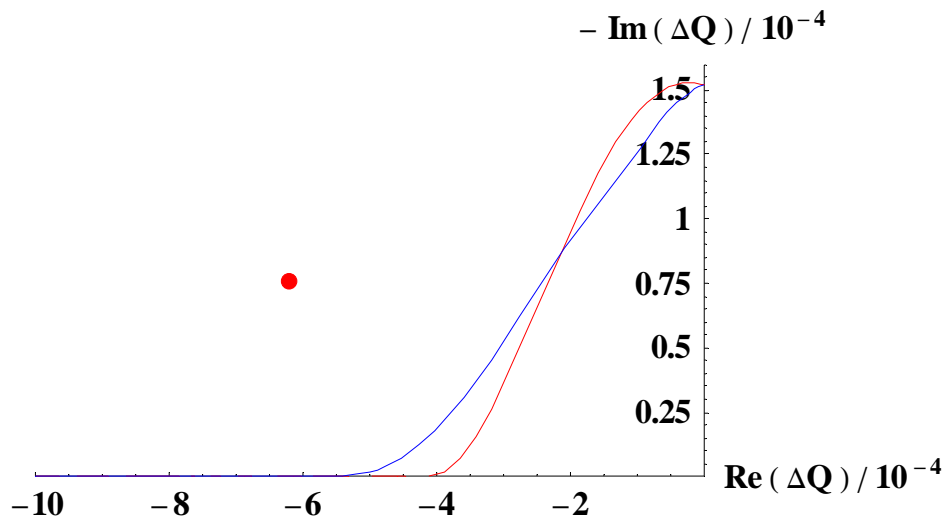
Stability diagrams (Y-plane)

- Mode 0
- Mode 1
- Mode 2
- Mode 3

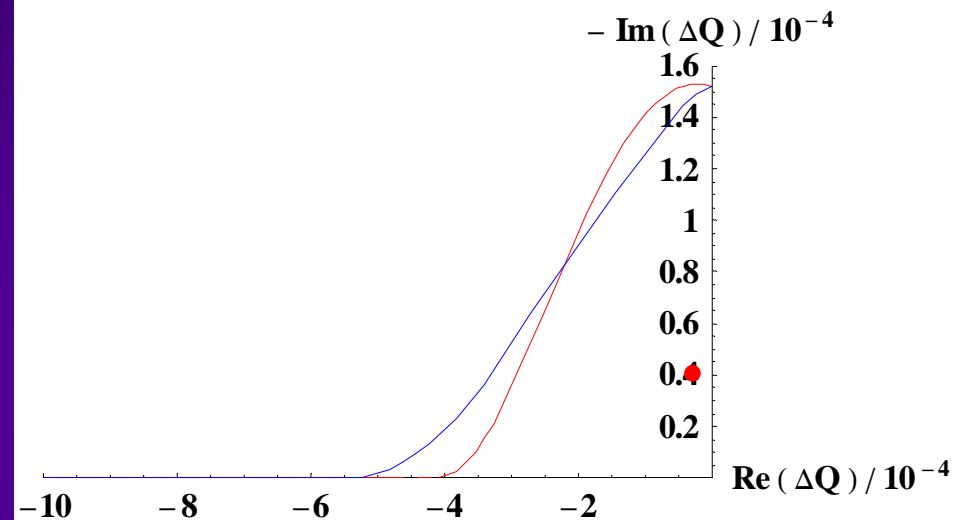


Stability diagrams (Y-plane)

With collimators



Without collimators
(RW + BB* effects)



* **BB (transverse) impedance for all the collimators estimated in the LHC Design Report at $j 1.5 \text{ M}\Omega/\text{m}$. The total BB is $2.67 \text{ M}\Omega/\text{m}$**

Updated estimates (with betatron functions...) are very close

◆ **Reminder: Tune shift for a BB impedance of $j 1 \text{ M}\Omega/\text{m} = - 0.15 \times 10^{-4}$**

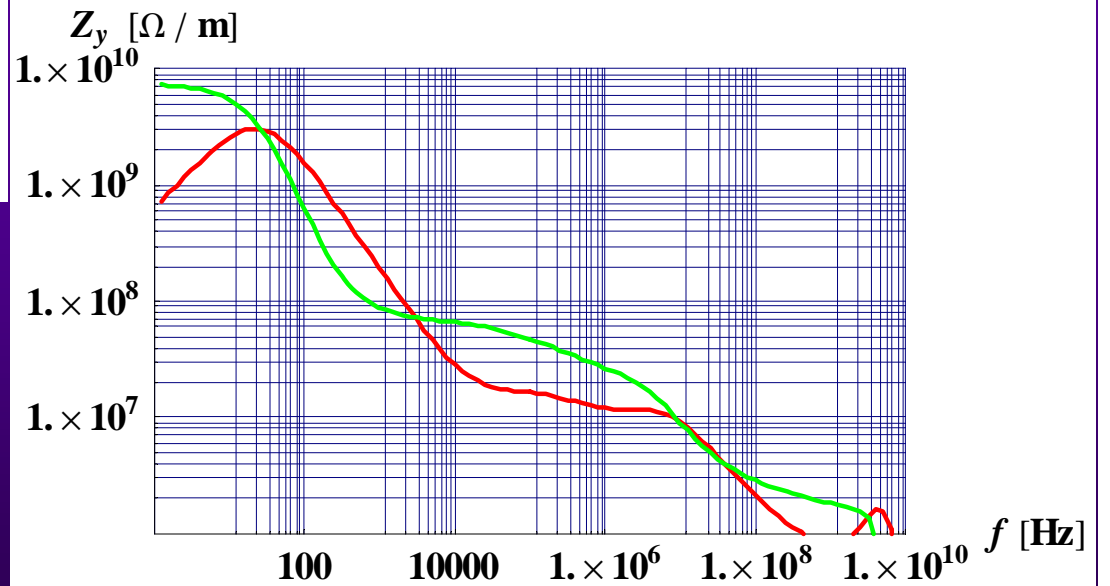
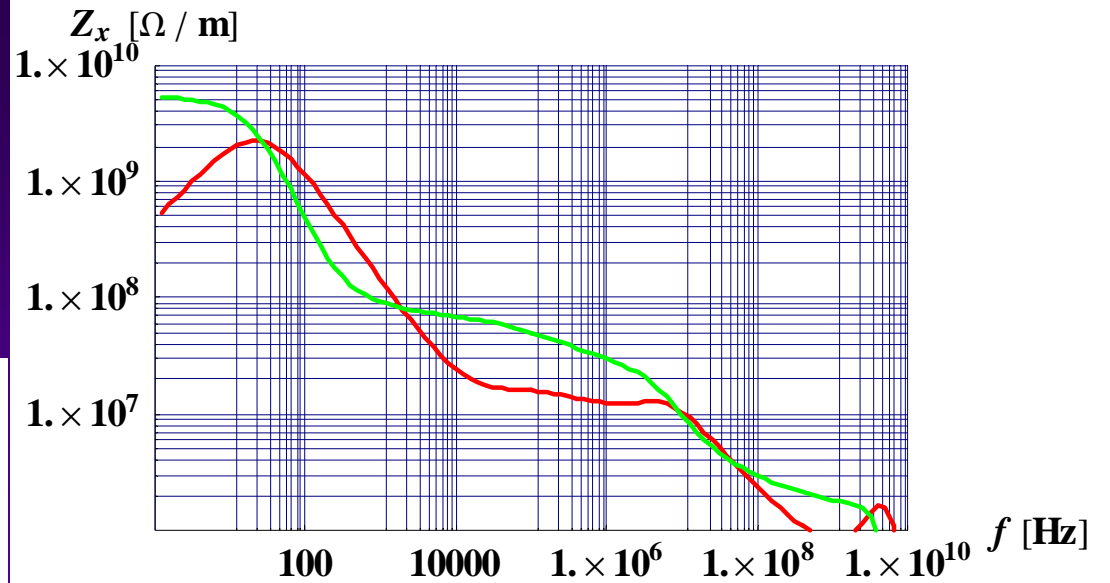
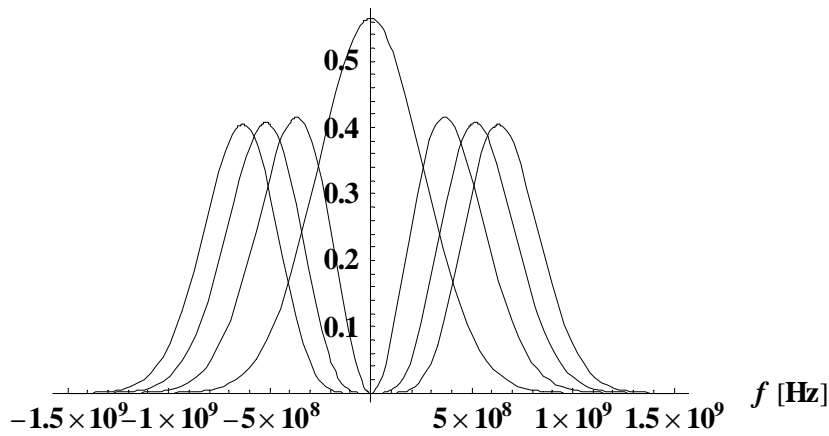
INJECTION ENERGY

Latest collimator list sent by
G. Robert-Demolaize on 11/10/05

#name	angle [rad]	betax [m]	betay [m]	half gap [mm]	Material	Length [m]
TCL.5R1.B1	0	261	134	1242.0	CU	1
TCTH.L2.B1	0	51	50	547.7	W	1
TDI.4L2	1.57	113	50	4.1	CU	4
TCTV.4L2.B1	1.57	133	58	583.7	W	1
TCLIA.4R2.B1	1.57	55	126	6.5	C	1
TCLIB.6R2	1.57	271	31	3.2	C	1
TCP.6L3.B1	0	133	143	7.9	C	0.6
TCSG.5L3.B1	0	55	296	5.9	C	1
TCSG.4R3.B1	0	26	402	4.1	C	1
TCSG.A5R3.B1	2.98	36	350	5.3	C	1
TCSG.B5R3.B1	0.19	46	318	5.9	C	1
TCLA.A5R3.B1	1.57	145	179	11.4	W	1
TCLA.B5R3.B1	0	154	171	10.6	W	1
TCLA.6R3.B1	0	131	167	9.8	W	1
TCLA.7R3.B1	0	66	93	6.9	W	1
TCTH.L5.B1	0	170	95	1001.1	W	1
TCTV.L5.B1	1.57	166	94	744.0	W	1
TCL.5R5.B1	0	266	132	1254.3	CU	1
TCDQ.4R6.B1	0	486	161	15.1	C	8
TCS.TCDQ.B1	0	502	165	13.4	C	1
TCP.D6L7.B1	1.57	169	73	4.2	C	0.6
TCP.C6L7.B1	0	160	78	6.2	C	0.6
TCP.B6L7.B1	2.22	152	82	5.0	C	0.6
TCSG.A6L7.B1	2.46	43	217	6.0	C	1
TCSG.B5L7.B1	2.50	147	163	7.1	C	1
TCSG.A5L7.B1	0.71	171	144	7.2	C	1
TCSG.D4L7.B1	1.57	307	70	4.8	C	1
TCSG.B4L7.B1	0	132	139	6.6	C	1
TCSG.A4L7.B1	2.35	122	149	6.7	C	1
TCSG.A4R7.B1	0.81	112	160	6.7	C	1
TCSG.B5R7.B1	2.47	131	272	7.8	C	1
TCSG.D5R7.B1	0.90	228	160	7.8	C	1
TCSG.E5R7.B1	2.28	256	137	7.8	C	1
TCSG.6R7.B1	0.01	352	45	10.7	C	1
TCLA.A6R7.B1	1.57	311	45	5.7	W	1
TCLA.C6R7.B1	0	163	73	10.9	W	1
TCLA.E6R7.B1	1.57	66	152	10.5	W	1
TCLA.F6R7.B1	0	62	158	6.8	W	1
TCLA.A7R7.B1	0	60	149	6.6	W	1
TCTH.L8.B1	0	47	48	528.2	W	1
TCTV.4L8.B1	1.57	129	53	558.5	W	1
TCTH.L1.B1	0	170	95	1001.1	W	1
TCTV.L1.B1	1.57	166	94	744.2	W	1

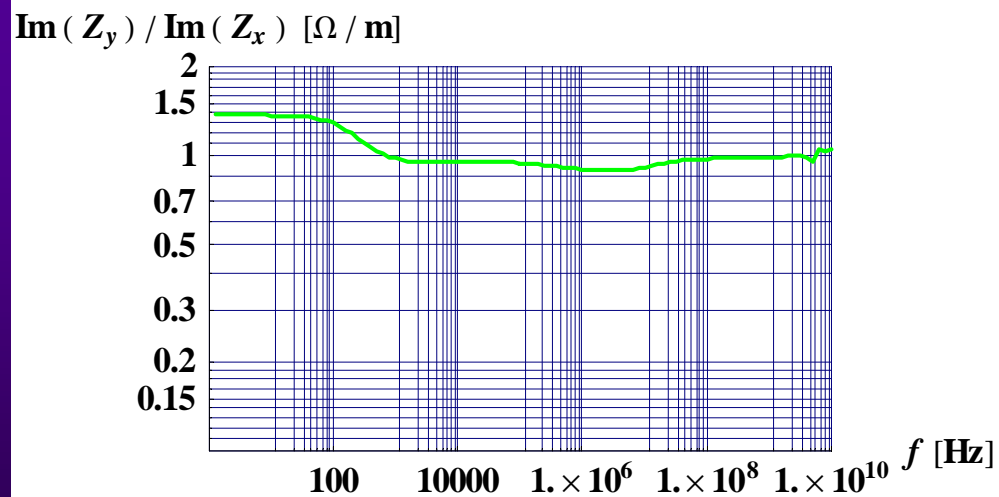
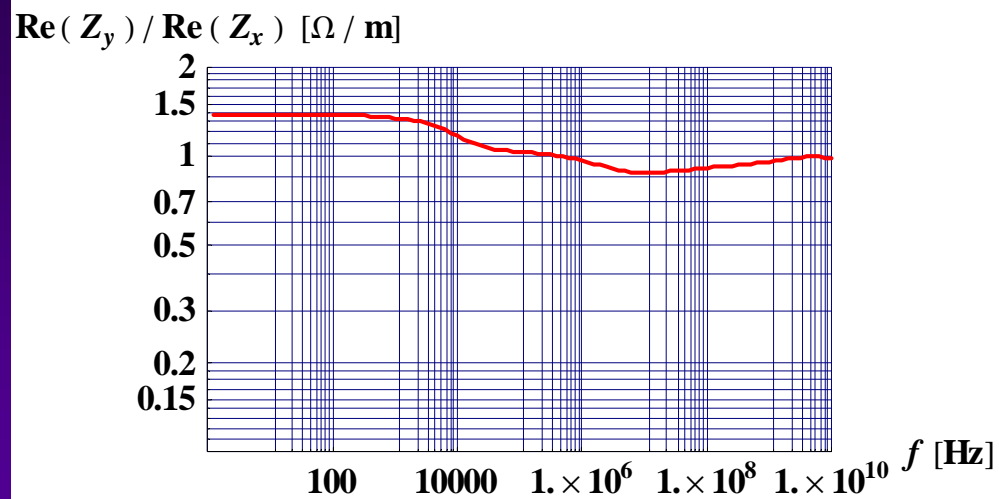
Bunch spectrum and total impedances

Bunch spectrum



$$Q'_{x,y} = 1 \Rightarrow f_{\xi_{x,y}} \sim 40 \text{ MHz}$$

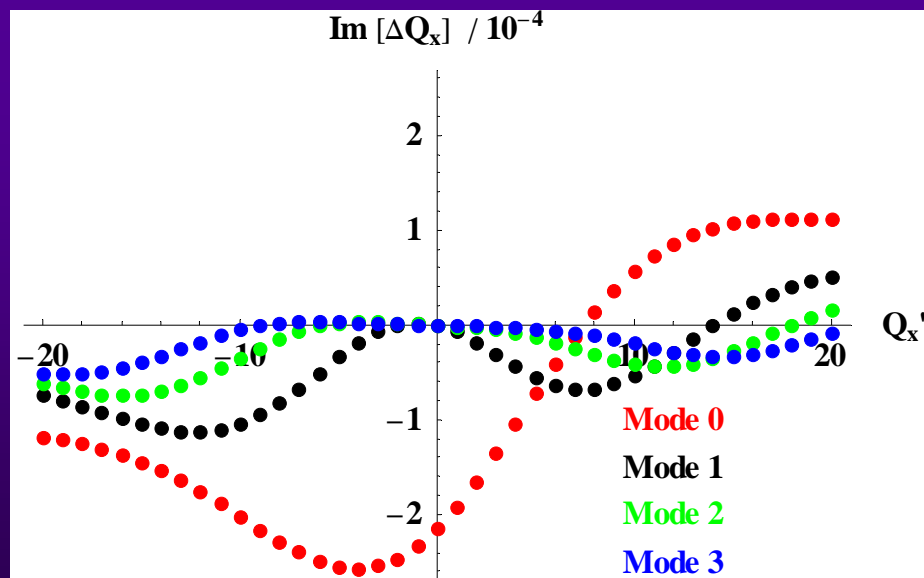
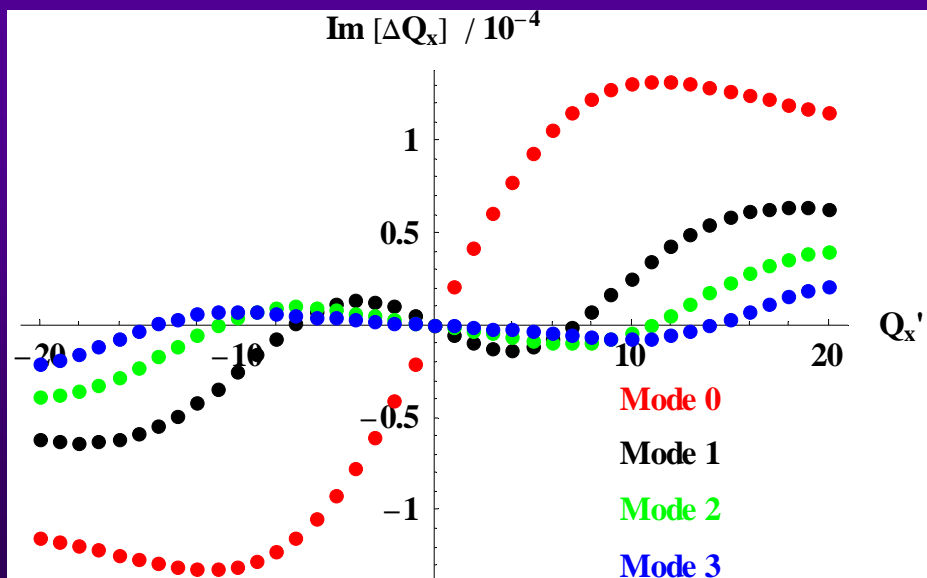
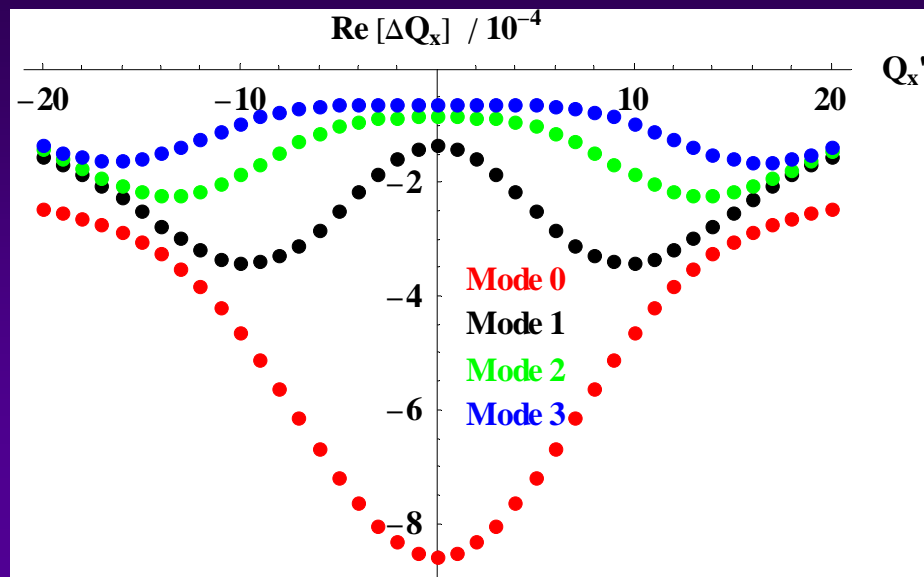
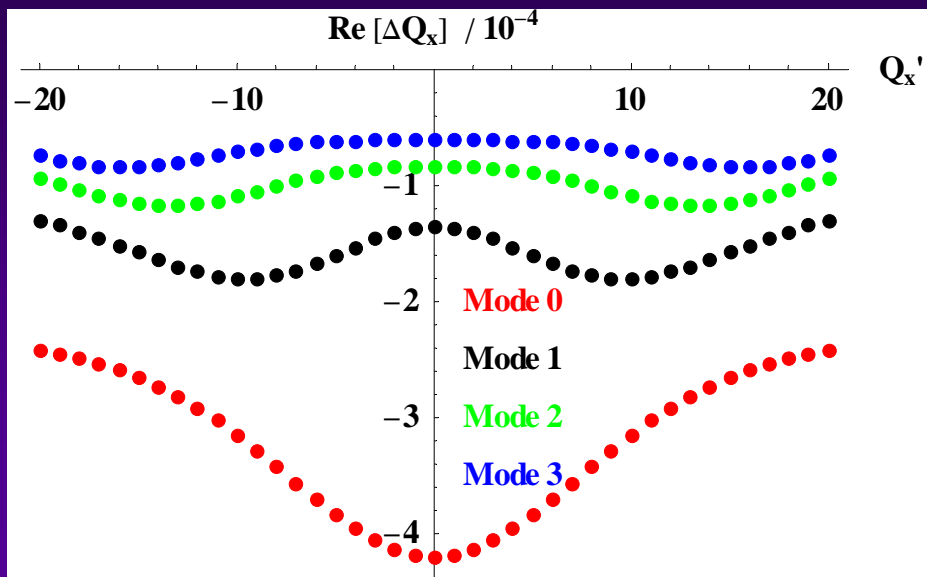
Comparison between the two transverse impedances



Single-bunch

X-plane

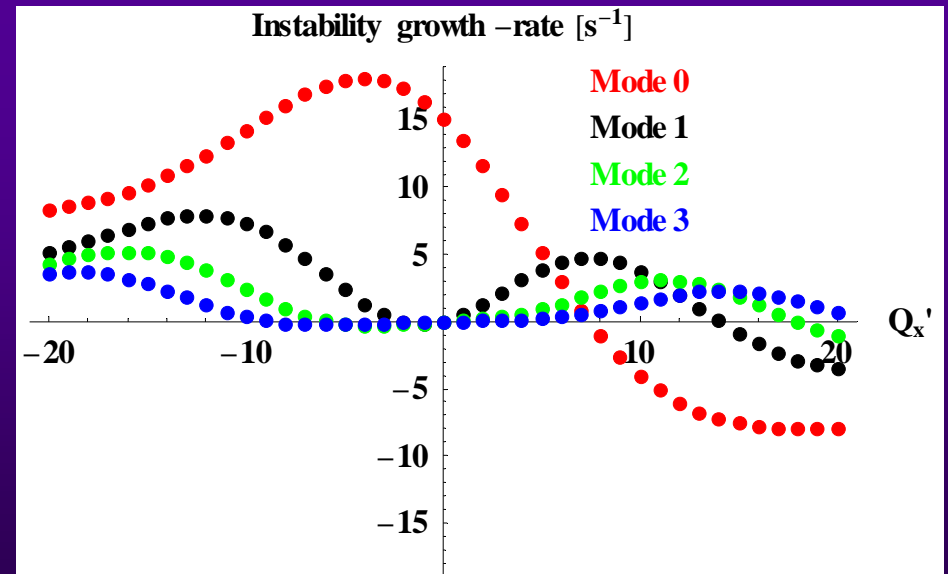
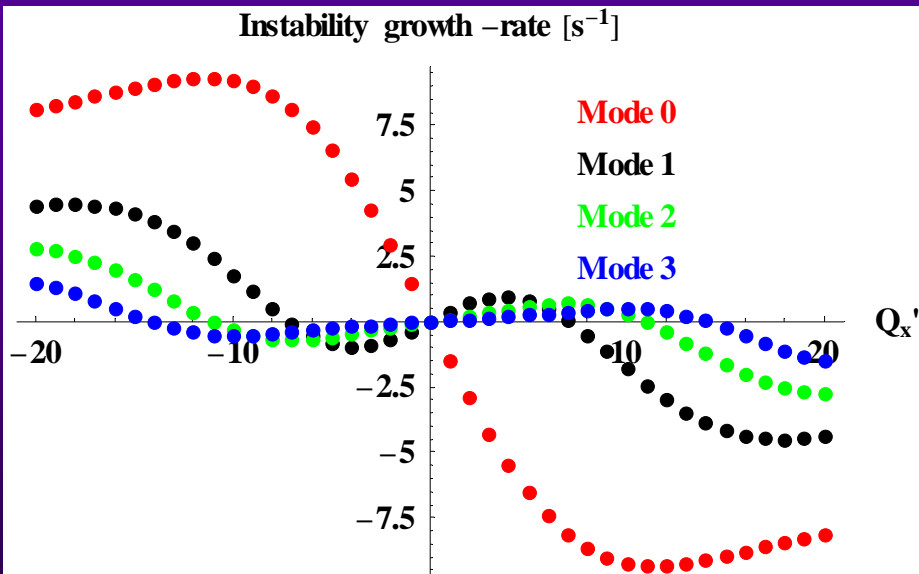
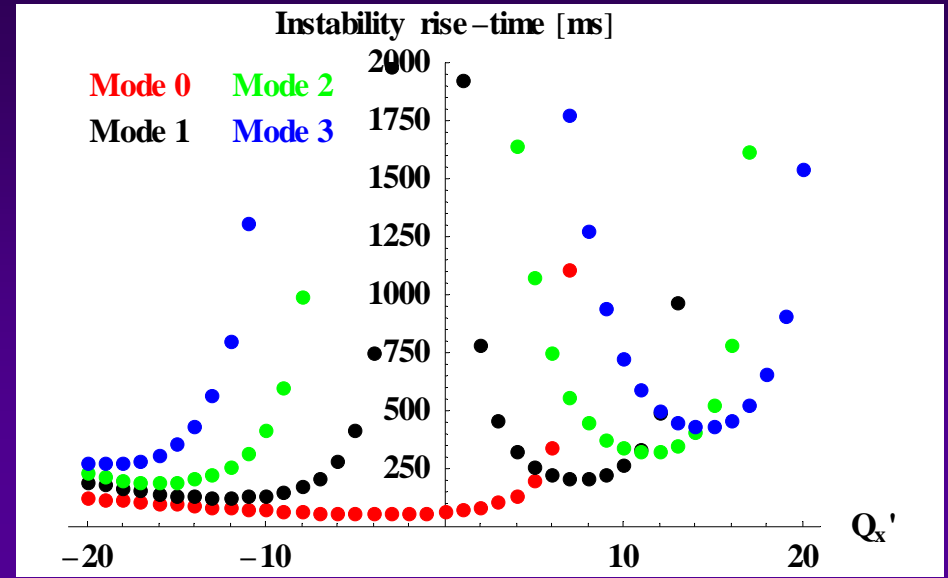
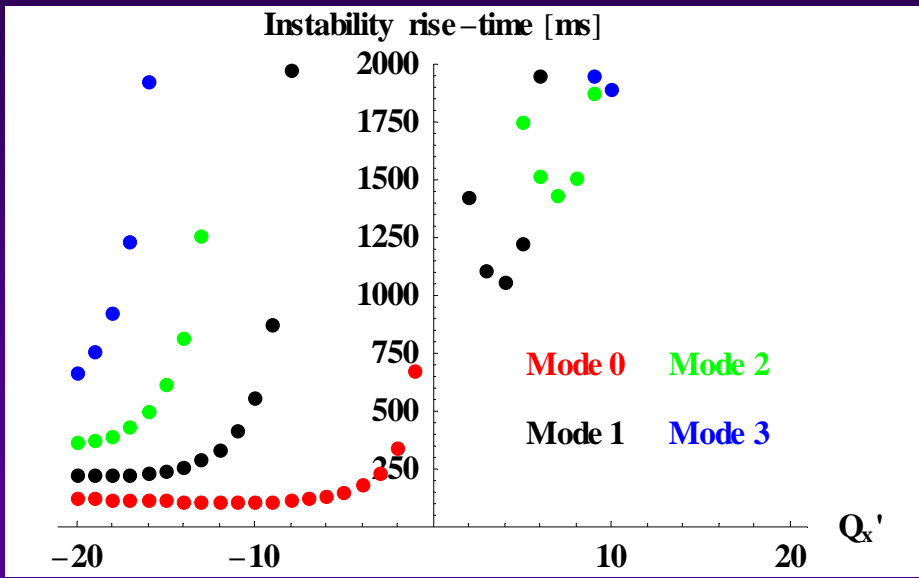
Coupled-bunch



Single-bunch

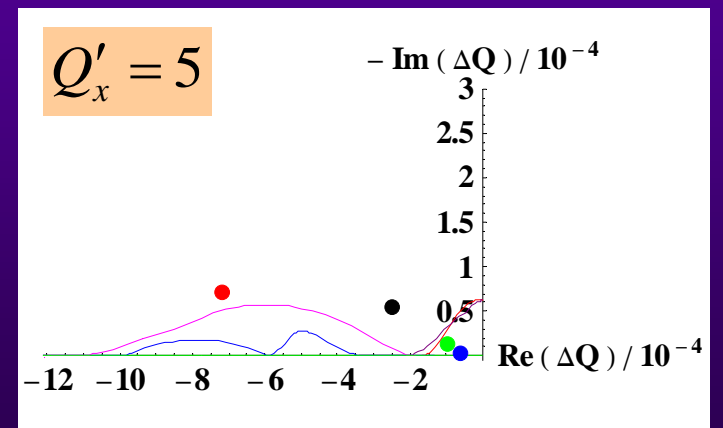
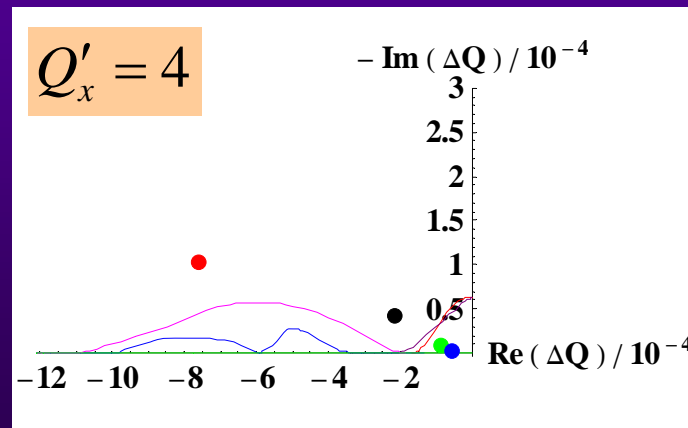
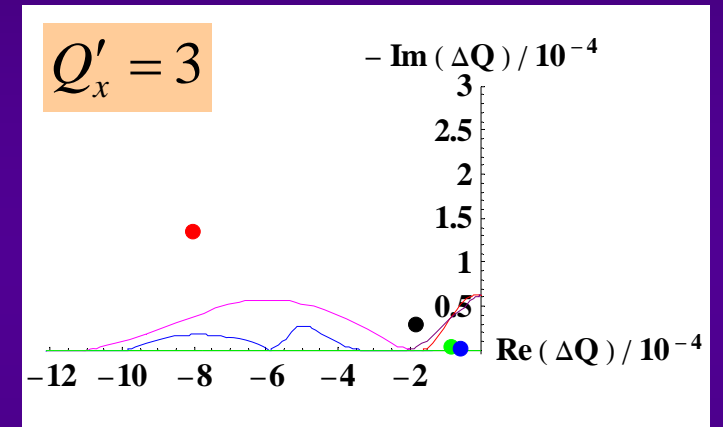
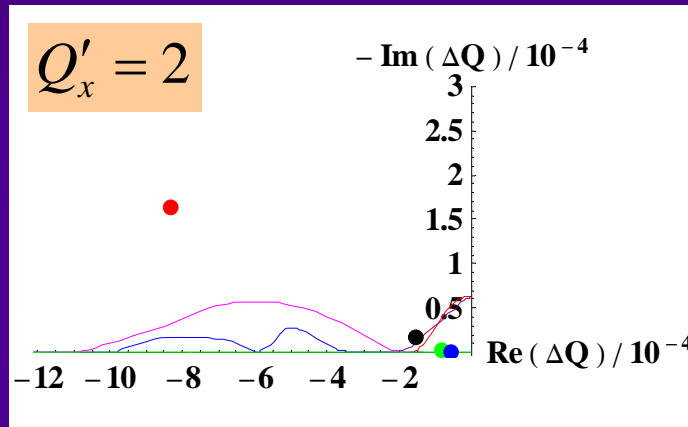
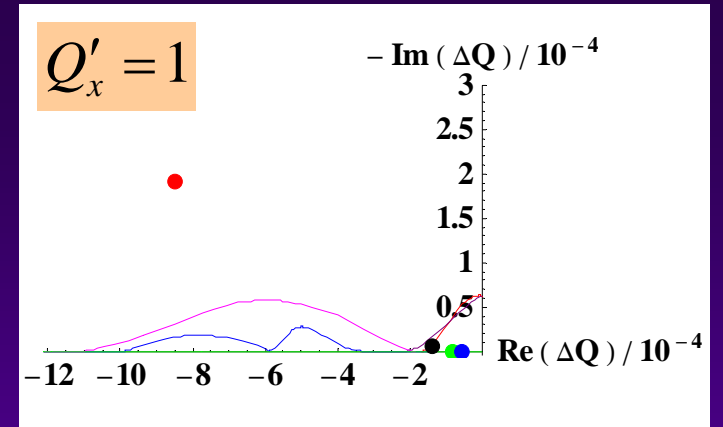
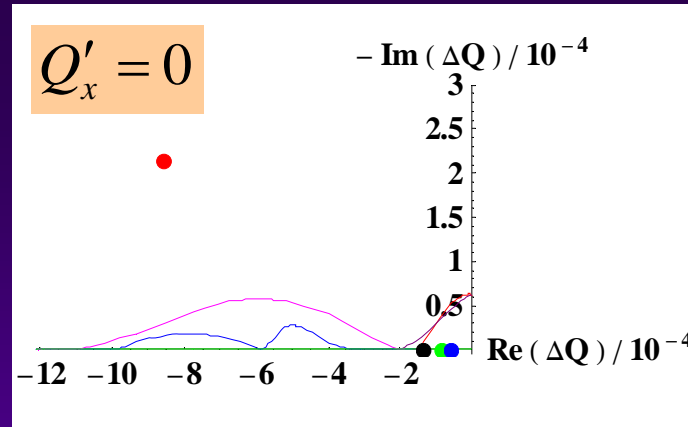
X-plane

Coupled-bunch



Stability diagrams (X-plane)

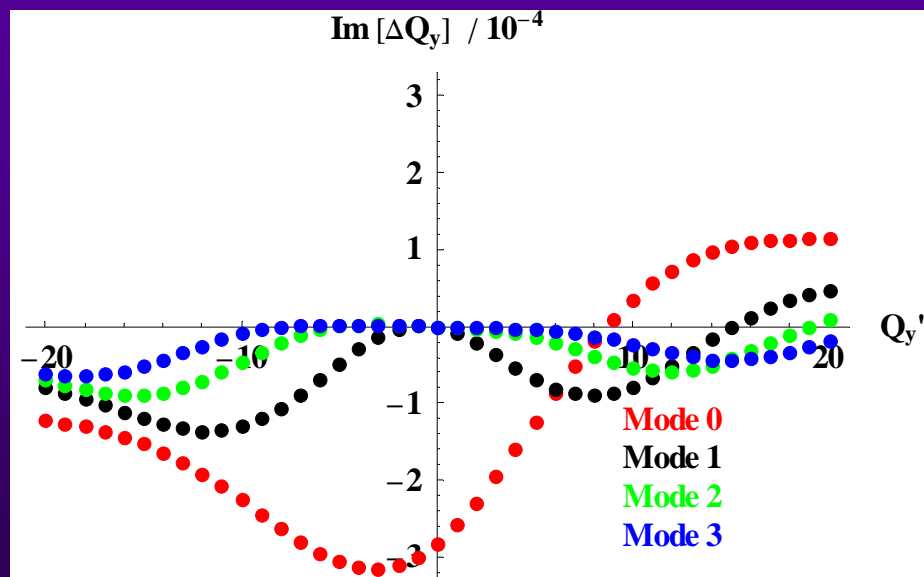
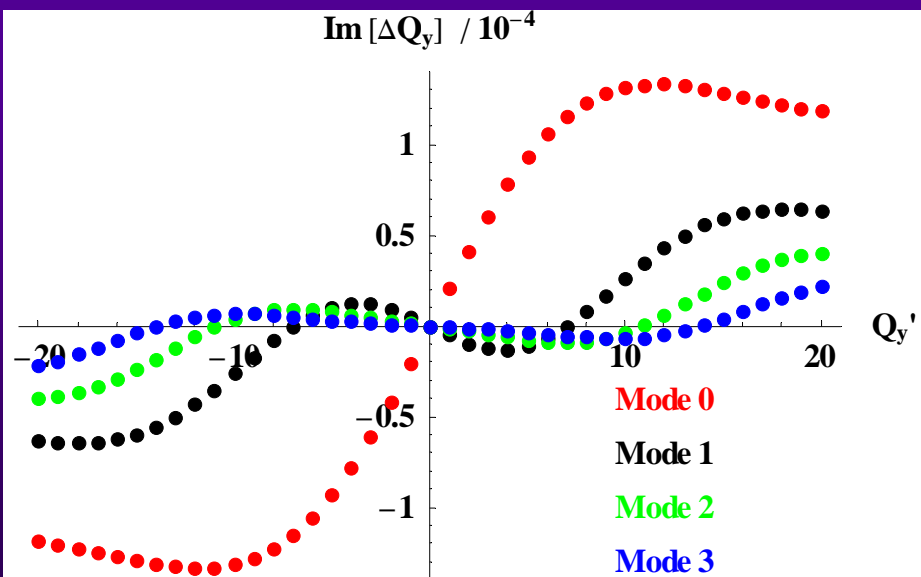
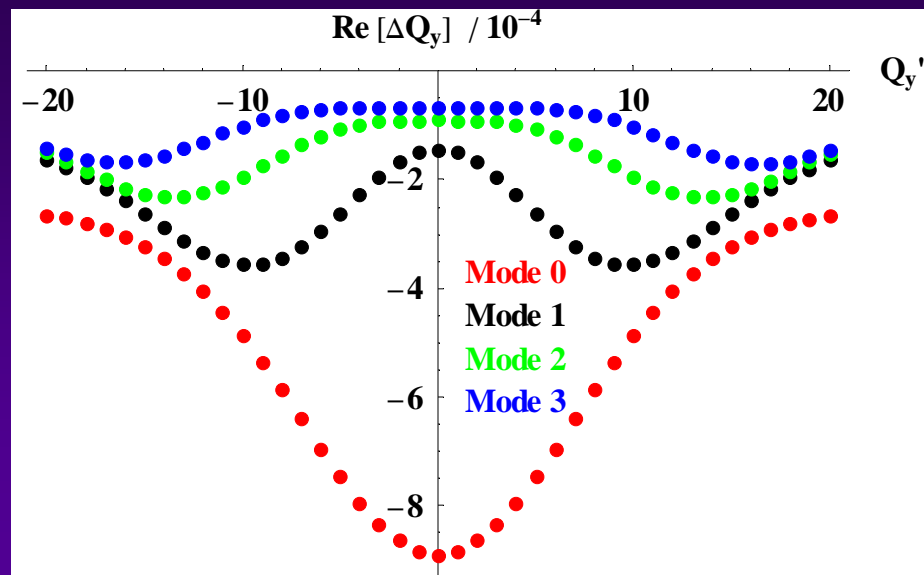
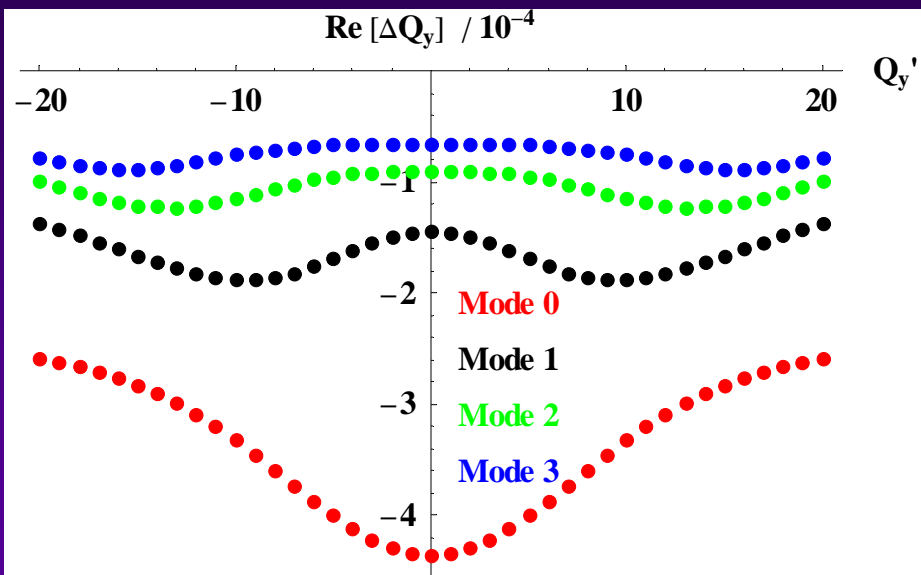
- Mode 0
- Mode 1
- Mode 2
- Mode 3



Single-bunch

Y-plane

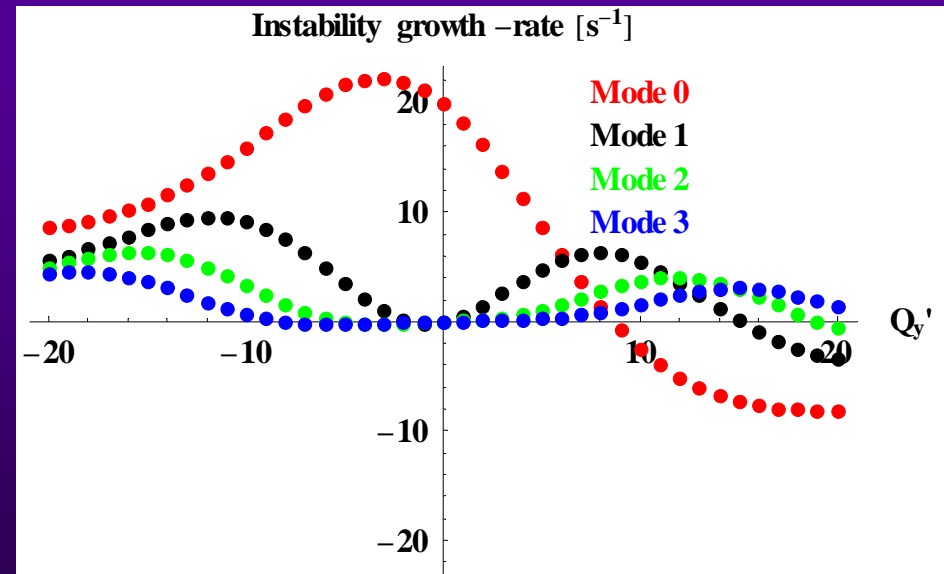
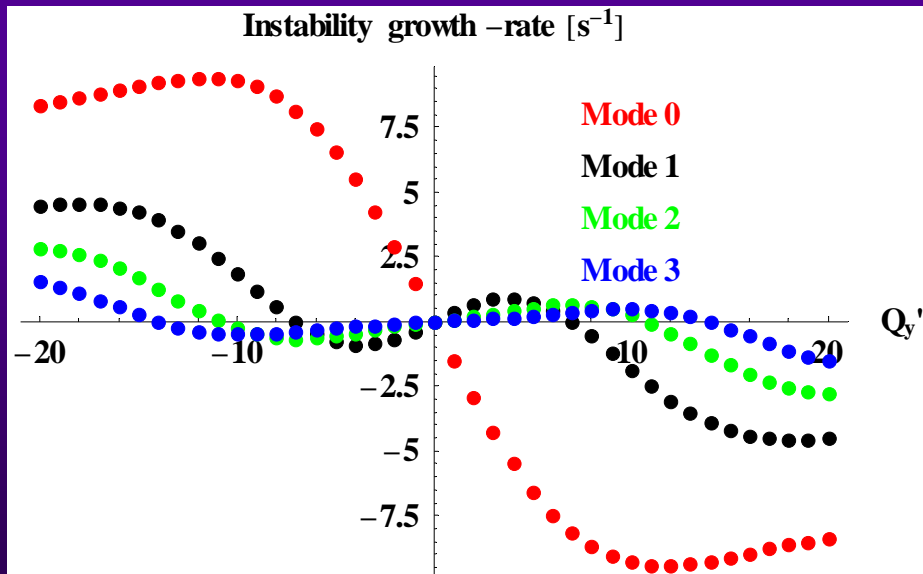
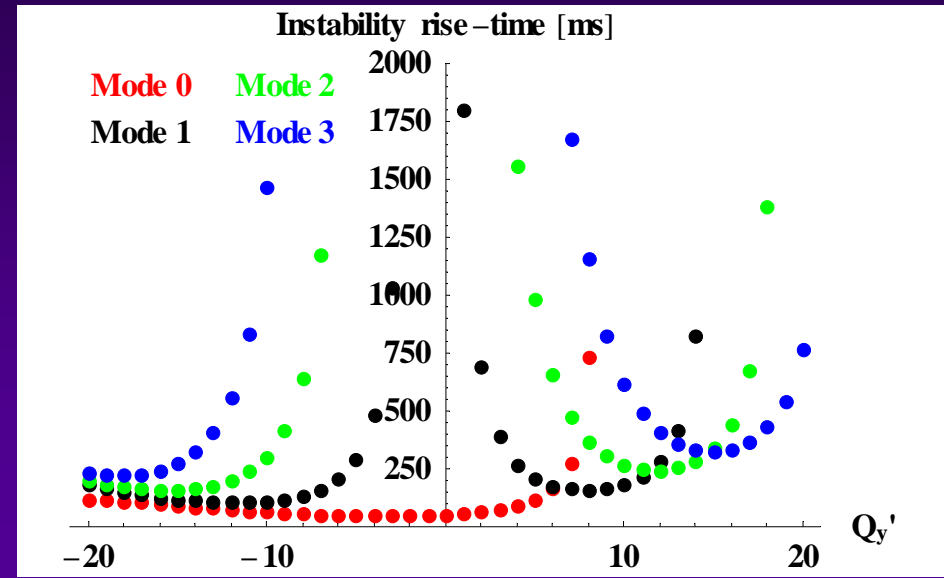
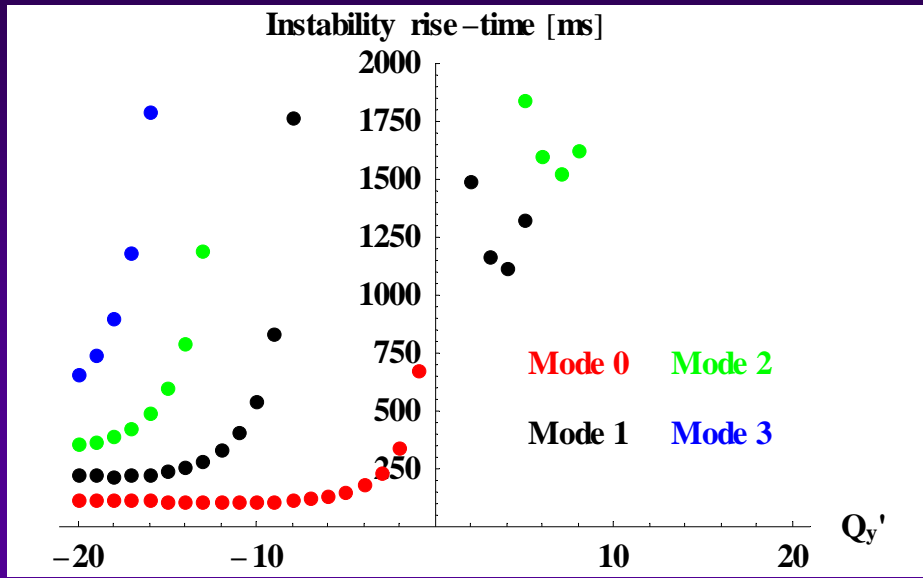
Coupled-bunch



Single-bunch

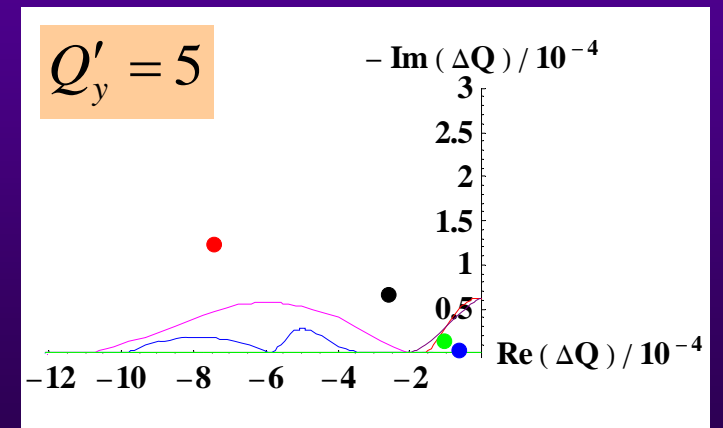
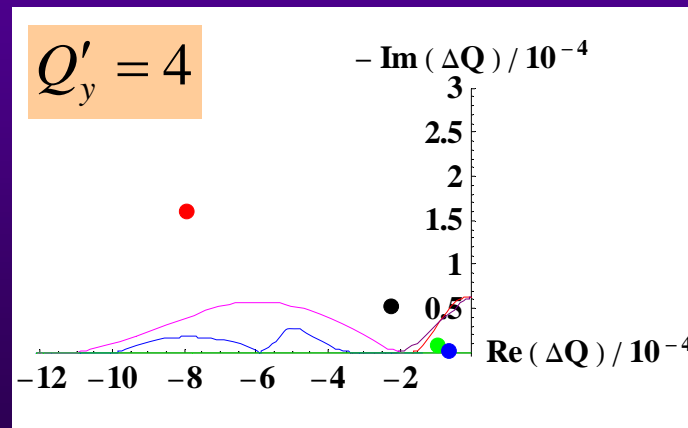
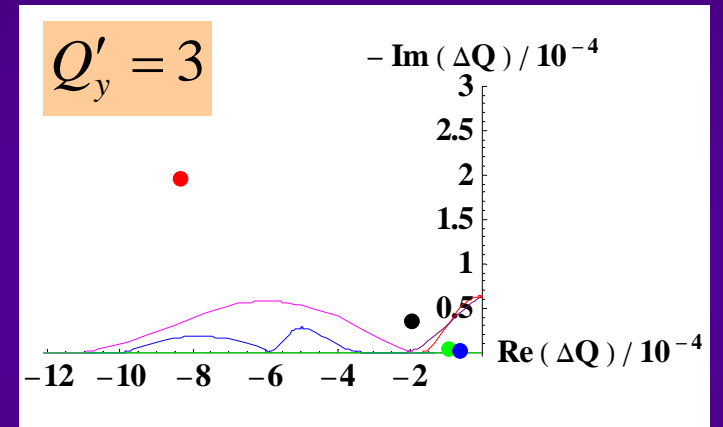
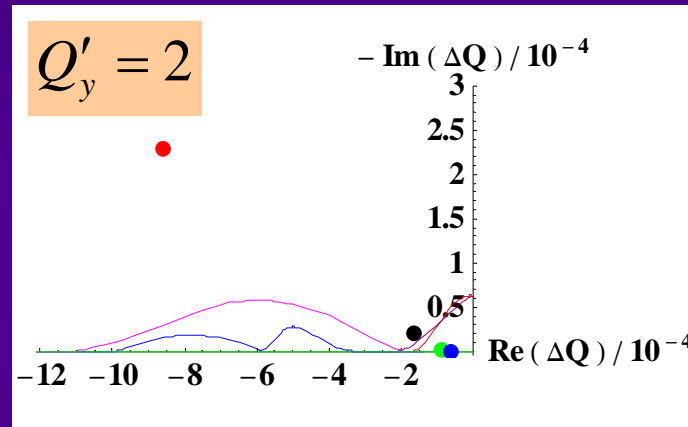
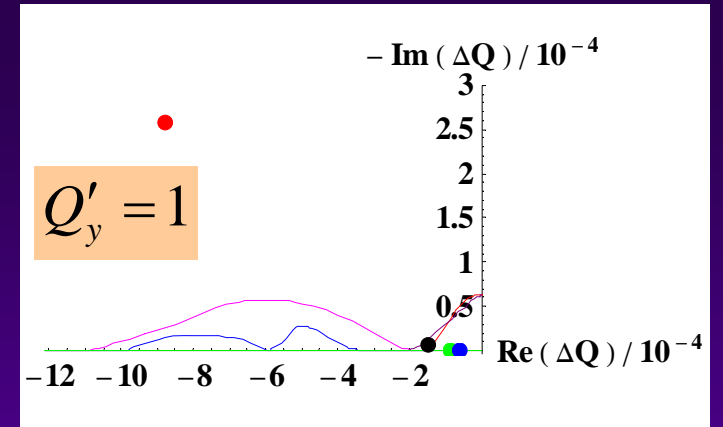
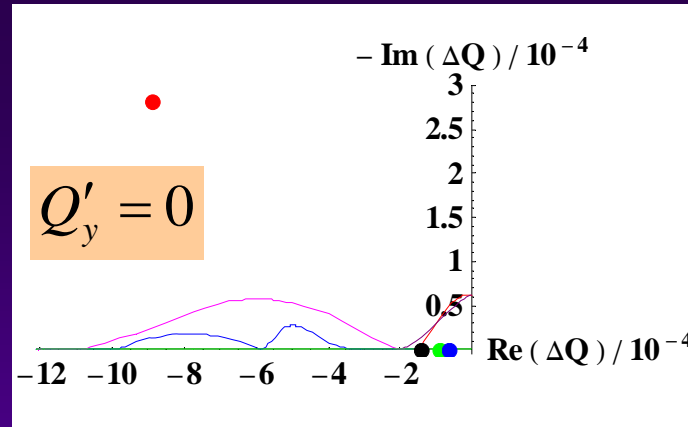
Y-plane

Coupled-bunch



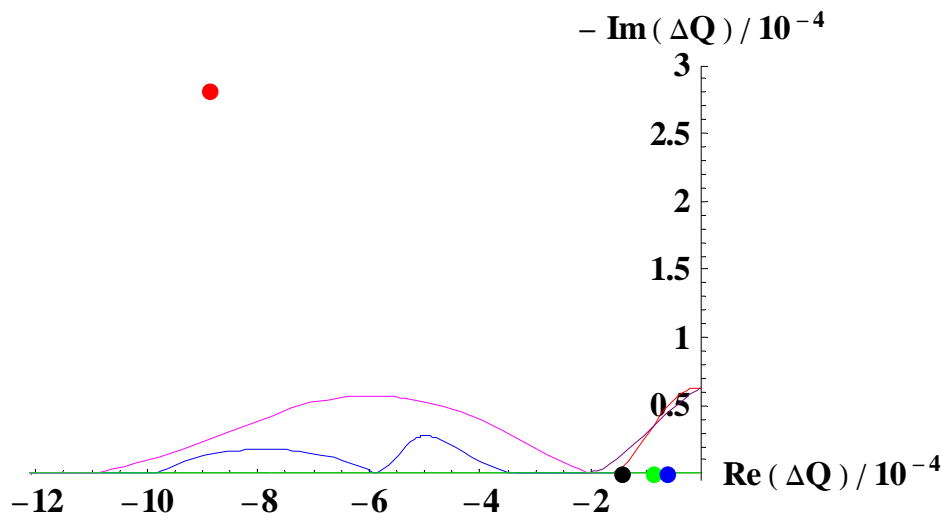
Stability diagrams (Y-plane)

- Mode 0
- Mode 1
- Mode 2
- Mode 3

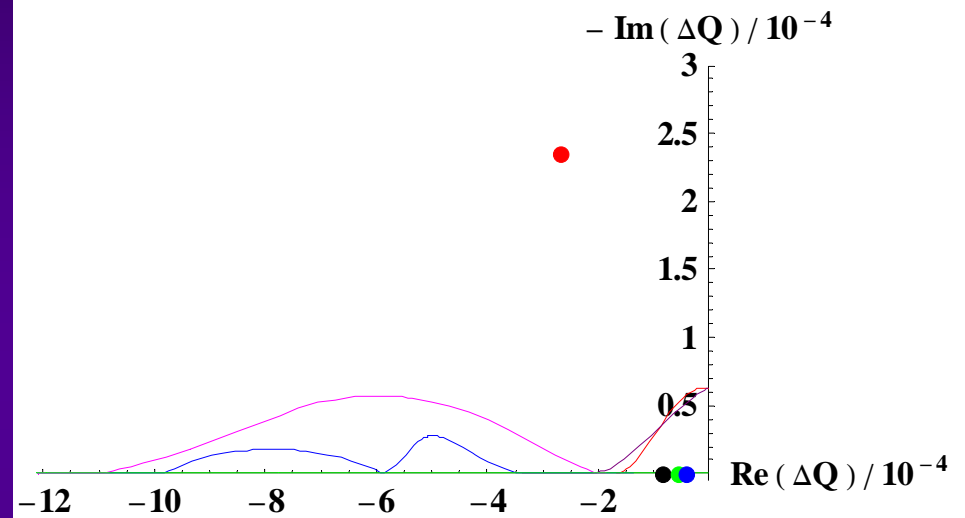


Stability diagrams (Y-plane)

With collimators



Without collimators
(RW + BB* effects)



* BB (transverse) impedance for all the collimators estimated in the LHC Design Report at $j 0.15 \text{ M}\Omega/\text{m}$. The total BB is $1.34 \text{ M}\Omega/\text{m}$

Updated estimates (with betatron functions...) are very close

◆ Reminder: Tune shift for a BB impedance of $j 0.1 \text{ M}\Omega/\text{m} = -0.13 \times 10^{-4}$