TRAPPED MODES FOR SPS & LHC COLLIMATOR

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- **Tune shift for the SPS prototype of the LHC collimator (update from the last meeting after discussion with A. Grudiev)**
- **Multi-bunch tune shifts for the LHC at top energy**

TABLE OF TRANSVERSE MODES FOR FULL GAP = 5 MM (FROM A. GRUDIEV, RLC meeting, 28/01/05)

f [GHz]	Q	r_1/Q [Ohm/mm^2]	r_1 [Ohm/mm^2]	k_1 [V/nC/mm^2]	r_t/Q [Ohm/mm]	r_t [Ohm/mm]	k_t [V/nC/mm]	k_t (Py) [V/nC/mm]
0.605	139	6.105e-004	8.486e-002	5.802e-004	4.815e-	6.693e+000	4.576e-002	4.507e-002
0.769	612	1.467e-006	8.976e-004	1.772e-006	9.1 005	5.570e-002	1.099e-004	1.078e-004
0.799	639	8.823e-007	5.638e-004	1.107e-006	e-005	3.367e-002	6.613e-005	6.769e-005
0.848	687	1.135e-005	7.799e-		87e-004	4.388e-001	8.508e-004	8.432e-004
0.909	751	1.449e-005			-004	5.710e-001	1.086e-003	1.074e-003
1.226	934	4.174e-00			1	1.517e+002	3.128e-001	3.154e-001
1.228	961	9.441e-			4	3.525e+002	7.076e-001	7.040e-001
1.255	1070	1.473e-0			4	5.993e-001	1.104e-003	1.072e-003
1.295	808	6.198e-003			001	1.845e+002	4.645e-001	4.513e-001
1.306	570	9.626e-005	5.48		3.517e-003	2.005e+000	7.214e-003	6.707e-003
1.312	560	1.452e-005	8.134e-003	2.9 -005	5.282e-004	2.958e-001	1.089e-003	1.178e-003
1.315	530	1.910e-005	1.012e-002	-005	6.929e-004	3.672e-001	1.431e-003	1.255e-003
1.565	1294	1.143e-007	1.480e-004	-007	3.486e-006	4.511e-003	8.570e-006	9.109e-006
1.595	172	1.158e-002		002	3.463e-001	5.957e+001	8.677e-001	8.508e-001
1.611	171	1.288e-00			3.817e-004	6.526e-002	9.656e-004	1.628e-003
1.636	170	8.031e			842e+000	3.982e+002	6.019e+000	5.867e+000
1.659	925	1.58			e-009	4.216e-006	1.188e-008	1.182e-008
1.672	169	5.2			e+000	2.541e+002	3.949e+000	3.924e+000
1.673	940	9.2			-006	2.478e-003	6.927e-006	6.866e-006
1.674	1356	2.8			-006	1.085e-002	2.103e-005	2.075e-005
1.696	945	2.06			e-008	5.481e-005	1.545e-007	1.470e-007
1.717	168	2.603			4e-001	1.215e+002	1.951e+000	1.872e+000
1.727	958	6.217e-			.718e-008	1.646e-005	4.660e-008	6.611e-008
1.767	981	5.264e-011			1.421e-009	1.394e-006	3.945e-009	4.446e-009
1.772	167	1.948e-001	3.25	-001	5.245e+000	8.759e+002	1.460e+001	1.429e+001
1.785	1430	9.523e-010	1.362e-006	2.670e-009	2.546e-008	3.640e-005	7.138e-008	1.497e-007
1.815	1012	3.334e-008	3.374e-005	9.506e-008	8.765e-007	8.870e-004	2.499e-006	2.525e-006
1.835	165	1.318e-001	2.175e+001	3.800e-001	3.428e+000	5.656e+002	9.881e+000	9.742e+000
1.868	1028	4.096e-007	4.210e-004	1.202e-006	1.046e-005	1.075e-002	3.070e-005	3.003e-005
1.898	1494	3.463e-008	5.173e-005	1.032e-007	8.705e-007	1.300e-003	2.595e-006	2.913e-006
1.906	164	2.506e-003	4.109e-001	7.502e-003	6.272e-002	1.029e+001	1.878e-001	1.866e-001
1.930	1067	3.838e-007	4.095e-004	1.164e-006	9.489e-006	1.012e-002	2.877e-005	2.992e-005
1.983	164	7.304e-002	1.198e+001	2.275e-001	1.757e+000	2.882e+002	5.474e+000	5.509e+000
1.995	1000	8.990e-006	8.990e-003	2.817e-005	2.150e-004	2.150e-001	6.738e-004	7.114e-004

Linac's convention
$\Longrightarrow$ Divide by 2 for rings

Can be obtained from the loss factor :

$$R_t = \frac{Q\, k_t}{\pi f}\left(= \frac{r_t}{2} \right)$$

$\Longrightarrow$ The results of last week should be divided by 2

SPS HORIZONTAL SINGLE-BUNCH TUNE SHIFT FOR THE HEAD-TAIL MODE M = 0

TM1 : -2.03983×10^{-9}

TM2 : -5.81091×10^{-9}

TM3 : -1.3119×10^{-8}

TM4 : -8.08981×10^{-9}

TM5 : -1.24454×10^{-10}

TM6 : -1.1967×10^{-8}

TM7 : -8.07584×10^{-8}

TM8 : -5.1747×10^{-8}

TM9 : -2.484×10^{-8}

TM10 : -1.79741×10^{-7}

TM11 : -1.17202×10^{-7}

TM12 : -2.14036×10^{-9}

TM13 : -5.98159×10^{-8}

With the experimental parameters (E = 270 GeV…) $\Longrightarrow$ See FZ's talk at LCE meeting (22/10/04)

$\Longrightarrow$

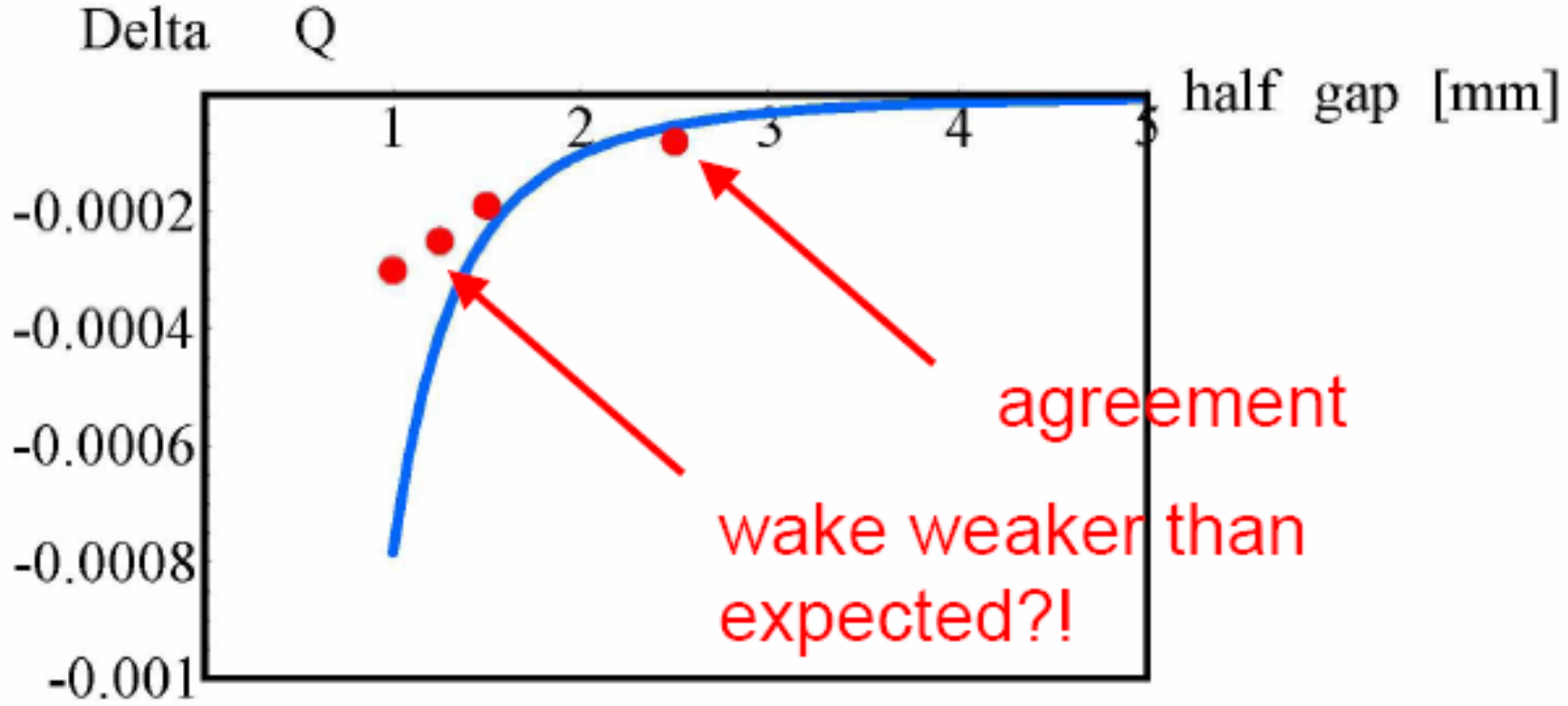
$$\mathrm{Im}[Z_{x,m=0}^{eff,\mathrm{All\,TMs}}] \approx 4.6\ \mathrm{k\Omega/m}$$

$$\Delta Q_{x,m=0}^{\mathrm{SB,\,All\,TMs}} \approx -5.6\times10^{-7}$$

$\Longrightarrow$ **Seems negligible compared to the measured tune shift of ~ 10^{-4}**

FZ'S RESULT

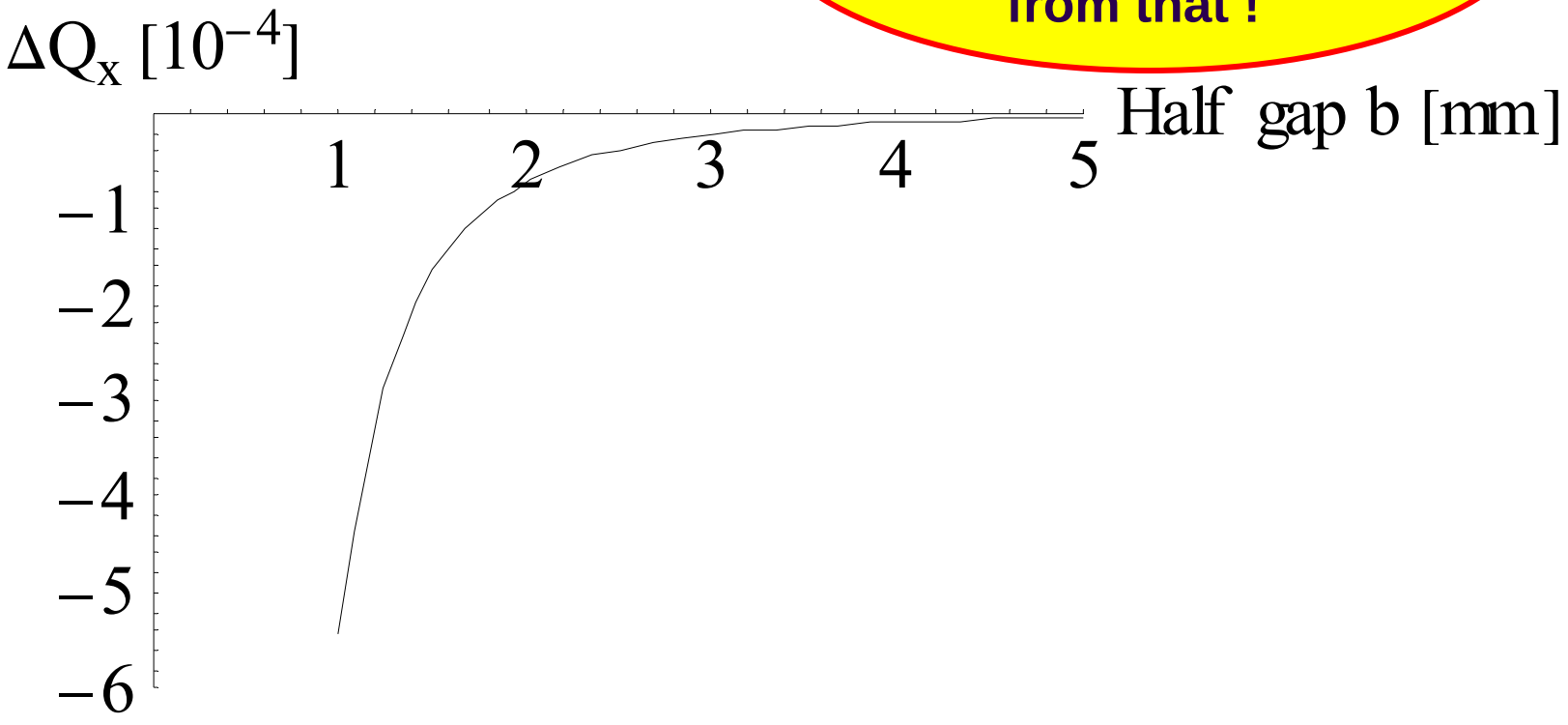
comparison of measured & predicted ΔQ



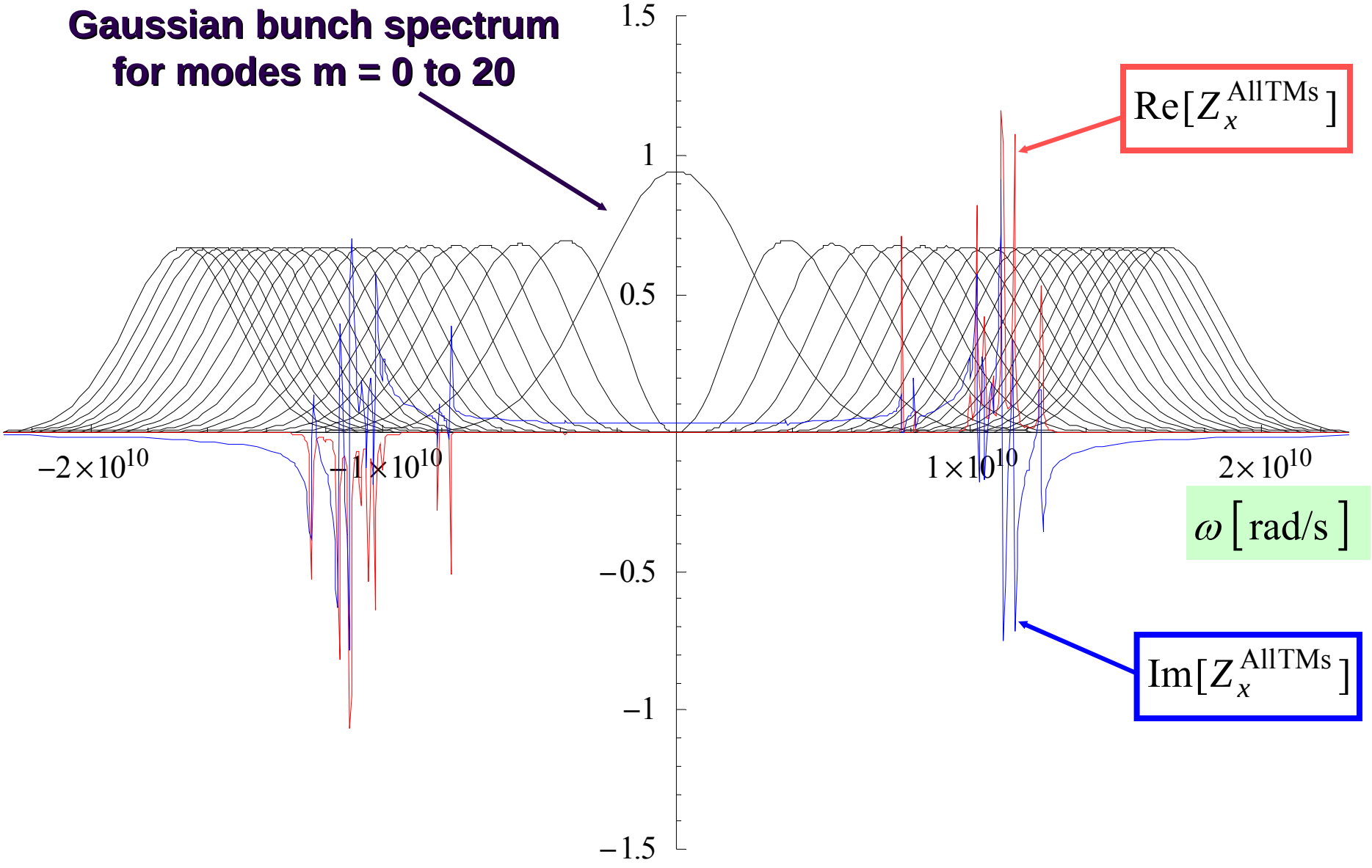
Expected tune shift of a pencil beam of constant intensity of 8.5×10^{10} protons, on which the measured data (from Marek Glasior's APC talk) are superimposed.

THE RESULT I OBTAINED
(USING THE SAME PARAMETERS … BUT THE MEASUREMENT PARAMETERS HAVE TO BE CONFIRMED FOR EACH GAP !)

May be part of the difference between theory and measurements come from that !



MULTI-BUNCH TUNE SHIFTS FOR THE LHC AT TOP ENERGY (1/5)



MULTI-BUNCH TUNE SHIFTS FOR THE LHC AT TOP ENERGY (2/5)

For 1 collimator with most critical betatron function (~ 400 m)

$-7.35496\times10^{-7} - 8.30054\times10^{-9}\,i$	
$-4.52494\times10^{-7} - 3.55758\times10^{-8}\,i$	$9.40848\times10^{-8} - 1.5836\times10^{-8}\,i$
$-3.866\times10^{-7} - 6.81186\times10^{-8}\,i$	$1.00594\times10^{-7} - 1.03212\times10^{-8}\,i$
$-3.64841\times10^{-7} - 8.94599\times10^{-8}\,i$	$9.67417\times10^{-8} - 6.50222\times10^{-9}\,i$
$-3.42943\times10^{-7} - 9.19787\times10^{-8}\,i$	$8.69313\times10^{-8} - 3.98337\times10^{-9}\,i$
$-3.03872\times10^{-7} - 7.97902\times10^{-8}\,i$	$7.47613\times10^{-8} - 2.37543\times10^{-9}\,i$
$-2.43904\times10^{-7} - 6.15077\times10^{-8}\,i$	$6.26328\times10^{-8} - 1.37523\times10^{-9}\,i$
$-1.68694\times10^{-7} - 4.73627\times10^{-8}\,i$	$5.18309\times10^{-8} - 7.69482\times10^{-10}\,i$
$-8.96369\times10^{-8} - 4.09279\times10^{-8}\,i$	$4.28261\times10^{-8} - 4.14216\times10^{-10}\,i$
$3.51564\times10^{-8} - 3.20641\times10^{-8}\,i$	$3.56027\times10^{-8} - 2.13771\times10^{-10}\,i$
$7.30457\times10^{-8} - 2.32251\times10^{-8}\,i$	$2.99192\times10^{-8} - 1.05562\times10^{-10}\,i$

MULTI-BUNCH TUNE SHIFTS FOR THE LHC AT TOP ENERGY (3/5)

$\Longrightarrow$ **Instability rise-time for the most critical mode (m = 4) :** ~ 155 s

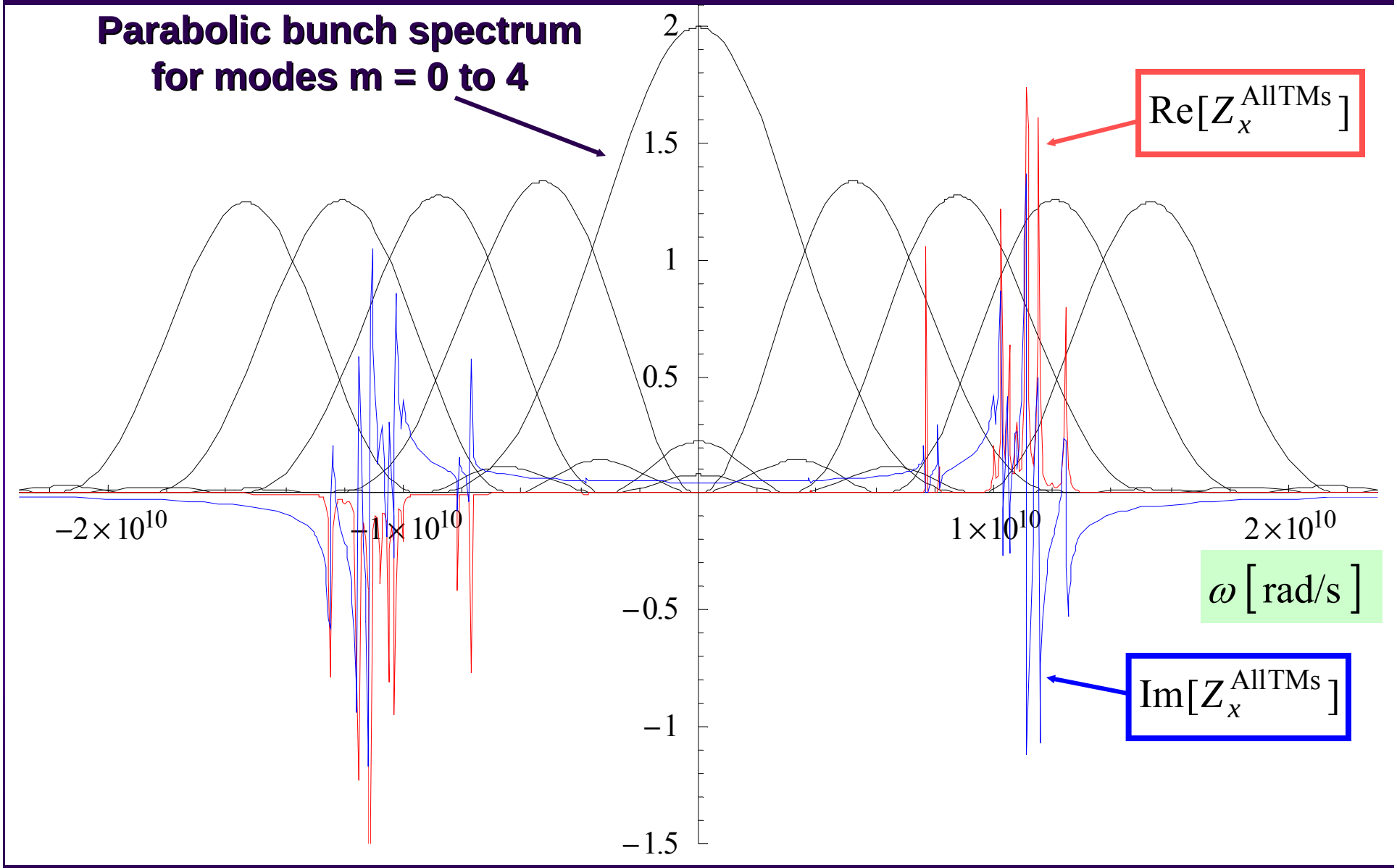
REMINDER

Present baseline for Phase 1

- **IR7 : 3 P + 11 S = 14 collimators**
- **IR3 : 1 P + 4 S = 5 collimators**

$\Rightarrow$ **19 collimators in total = 4 P + 15 S**

MULTI-BUNCH TUNE SHIFTS FOR THE LHC AT TOP ENERGY (4/5)



MULTI-BUNCH TUNE SHIFTS FOR THE LHC AT TOP ENERGY (5/5)

For 1 collimator with most critical betatron function (~ 400 m)

$$-7.39047\times10^{-7} - 1.08558\times10^{-8}\,i$$

$$-5.91127\times10^{-7} - 1.07342\times10^{-7}\,i$$

$$-4.9059\times10^{-7} - 1.28585\times10^{-7}\,i$$

$$1.47576\times10^{-7} - 5.53814\times10^{-8}\,i$$

$$1.75721\times10^{-7} - 4.18932\times10^{-9}\,i$$

$\Longrightarrow$ **Instability rise-time for the most critical mode (m = 2) :** $\sim 110\ \mathrm{s}$