

SNS Impedance Budget
(low frequency (below 10MHz) approximation)

	Z_ℓ / n	Z_T
Space charge	-j196	-j7,720¹
Extraction kicker, 50 W termination	35. + j42.	21.n+j200.
Extraction kicker, no term.	35. + j42.	9.n+j200.
Injection kicker³	»1, at Γ_0	30 (lowest tune 200 kHz)
RF cavity	supposed to be small²	supposed to be small
Injection foil assembly	hard to predict until measured	hard to predict until measured
Resistive wall	(j+1)0.69, at Γ_0	(j+1)6.23, at Γ_0
Resistive wall (collimator)	(j+1)0.14, at Γ_0?	(j+1)5, at Γ_0?
Broadband		
BPM	j4.0	j58.0
Bellows	j1.53	j13.8

**SNS Impedance Budget
(at 50MHz frequency)**

	Z_ℓ / n	Z_T
Space charge	-j196	-j7,720⁴
Extraction kicker, 50 W termination	11. + j0.	120. + j80.
Extraction kicker, no term.	11. + j0.	500. + j130.
RF cavity	supposed to be small⁵	supposed to be small
Injection foil assembly	hard to predict until measured	hard to predict until measured
BPM	1.9 + j3.3	27.+j48.
Broadband		
Bellows	j1.53	j13.8
Steps	j1.60	j14.4
Ports	j0.49	j4.42
Valves	j0.15	j1.35
Collimator	j0.22	j1.98
Total BB	j4.0	j36.0
Unit	W	kW/m

⁴ difference of coherent and incoherent part

⁵ assuming all parasitic modes removed and the active feedback operates successfully

SNS Ring Collective Effects (estimates)

Mechanism	Impedance value/type	Threshold	Comments
Transverse space charge	$Z_T = -j7.7 \text{ M}\Omega/\text{m}$	$\Delta v_{sc} \sim -0.2$	$\Delta v_{sc} = -0.15 \sim -0.2$ spread other impact under study
Longitudinal space charge	$Z_L/n = -j196 \Omega$		15 – 20 kV induced voltage comparing with 40 kV RF
Longitudinal microwave	$Z_L/n = 35 + j42 \Omega$ (extraction kicker)	$ Z_L/n = 32 \Omega$	Keil-Schnell-Boussaur criteria w/o space charge
Transverse microwave ($\mathbf{x} = \mathbf{0}$)	$Z_T = (j+1) 45 \text{ k}\Omega/\text{m} ??$ (resistive wall)	$ Z_T = 1.3 \text{ k}\Omega/\text{m};$ rise time 100 turns	For tunes (6.3, 5.8), at 200 kHz
Transverse microwave ($\mathbf{x} = -3$)	$Z_T = (j+1) 45 \text{ k}\Omega/\text{m}$ (resistive wall)	$ Z_T = 100 \text{ k}\Omega/\text{m}$	For tunes (6.3, 5.8), at 200 kHz
Transverse microwave ($\mathbf{x} = \mathbf{0} \sim -3$)	$Z_T = 500 + j130 \text{ k}\Omega/\text{m}$ (extraction kicker)	$ Z_T = 300 \sim 400$ $\text{k}\Omega/\text{m}$	At $\sim 50 \text{ MHz}$ Not considering space charge
Electron-cloud	$ \Delta v_{sc} = 0.15 \sim 0.2$	$ \Delta v_c \sim 0.2$	At 150 ~ 200 MHz

Instability type	Beam type	Impedance type	Comments	Limits	
Tr. Space Charge	μ bunch	-	$\Delta Q_{ix,y}$ -0.1		☺
	Mbunch (accum.)	-	-0.1		☺
	Mbunch (compress.)	-	-0.3		☺
Long. Space Charge	μ bunch	-	-j178 Ω 50 kV		☺
	Mbunch (accum.)	-	-j88 Ω 160 kV		☺
Tr. h-t single bunch	Mbunch	RW	m=2, $\rho = 10^{-6} \Omega m$	rise time ~ 100 ms	☺
Tr. coupled bunch	Mbunch	RW	n = 134, m = 1	~ 7 ms	☺
TMC	μ bunch	BB	m = -1, m = 0 stable	$N_b < 2 \cdot 10^{12}$	☺
	Mbunch (accum.)	BB	m = -1, m = 0 stable	$N_b < 5 \cdot 10^{13}$	☺
BBU single bunch	μ bunch	BB	stable	$Z_{\parallel}/n < 400 \Omega$	☺
	Mbunch (accum.)	BB	stable	$Z_{\parallel}/n < 10 \Omega$	☺
BBU multi bunch	μ bunch	BB	stable	$Z_{\parallel}/n < 2 \text{ k} \Omega$	☺
Long. coupl. bunch	Mbunch (accum.)	HOM's	68, 13, 6 ms stable		☺
Long. μ wave	Mbunch (accum.)	BB + Sp. Ch.	rise time ~ 0.5 ms	$Z_{\parallel}/n < 1 \Omega$	☹

RW = Resistive Wall

BB = Broad Band resonator, $f_c = 0.7 \text{ GHz}$, $Q = 1$