Example key parameters for a SCRF linear collider

Interaction Point	parameter				comment
	Centre of mass energy	Ecm	500	GeV	
	Beam energy at interaction point	$E_{final} = E_{CM} / 2$	250	GeV	
	normalized horizontal emittance	$\gamma\varepsilon_x$	10	mm.mr	
	normalized vertical emittance	$\gamma\varepsilon_y$	0.04	mm.mr	factor of 2 from DR to allow for emittance dilution
	horizontal focusing	β_x^*	20	mm	
	vertical focusing	β_y^*	0.4	mm	
	horizontal beam size	$\sigma_x^* = \sqrt{\beta_x^* \varepsilon_x}$	639	nm	
	vertical beam size	$\sigma_y^* = \sqrt{\beta_y^* \varepsilon_y}$	5.7	nm	
	vertical disruption	$D_y \approx \frac{2r_e N \sigma_z}{\gamma \sigma_y^* \sigma_x^*}$	19.4		
	beamstrahlung parameter	$\Upsilon_{avr} = \frac{5}{6} \frac{N r_e \lambda_e \gamma}{\sigma_z (\sigma_x^* + \sigma_y^*)}$	0.048		
	beamstrahlung energy loss	$\delta_{BS} \approx 0.86 \frac{e r_e^3}{2 m_0 c^2} \left(\frac{E_{cm}}{\sigma_z} \right) \frac{N^2}{(\sigma_x^* + \sigma_y^*)^2}$	2.4	%	valid for low beamstrahlung regime

	bunch length	σ_z	300	μm	
	Enhancement	$H_y = 1 + D_y^{1/4}\left(\frac{D_y^3}{1+D_y^3}\right)\left[\ln\left(\sqrt{D_y}+1\right)+2\ln\left(\frac{0.8\beta_y}{\sigma_z}\right)\right]$	1.7		
	bunch charge	N	2×10^{10}	e	
	# bunches per pulse	n_b	2625		
	repetition rate	f_{rep}	5	Hz	
	Luminosity	$L = \frac{n_b N^2 f_{rep} H_y}{2\pi\sigma_x^*\sigma_y^*}$	2×10^{34}	$cm^{-2}s^{-1}$	
Main Linac					
	bunch spacing	Δt_b	369	ns	480 RF wavelengths
	beam current	$i_{beam} = \frac{Ne}{\Delta t_b}$	8.7	mA	
	beam pulse length	$t_{beam} = n_b \Delta t_b$	969	μs	
	RF frequency	f_{RF}	1.3	GHz	
	RF wave number	$k_{RF} = \frac{2\pi f_{RF}}{c}$	27.2	m^{-1}	
	cavity accelerating voltage	V_{acc}	32	MV	assume on-crest operation
	cavity quality factor	Q_0	5×10^9		
	beam power per cavity (peak)	$P_{beam} = P_{for} = i_{beam} V_{acc}$	278	kW	
	cavity r/Q	(r/Q)	1	kΩ	
	cavity shunt impedance	$r_s = (r/Q)Q_0$	5×10^{12}	Ω	

	cavity wall (peak) power	$P_{cav} = \frac{V_{acc}^2}{r_s}$	205	W	
	coupler coefficient (matched)	$\beta = \frac{P_{for}}{P_{cav}} \approx \left(\frac{i_{beam}}{V_{acc}}\right)(r/Q)Q_0$	1360		
	loaded quality factor	$Q_L \approx \frac{Q_0}{\beta}$	3.7×10^6		also referred to a *external Q*, Q_{ext}
	cavity fill time constant	$\tau = \frac{Q_L}{\pi f_{RF}}$	900	μs	
	cavity fill time	$t_{fill} = \ln(2)\tau$	624	μs	
	RF pulse length	$t_{RF} = t_{fill} + t_{beam}$	1.6	ms	
	RF to beam power efficiency	$\eta = \frac{t_{beam}}{t_{fill}}$	0.61		
	# cavities per klystron	N_{ck}	26		
	Klystron power	$P_{klys} = N_{ck}P_{beam}$	7.2	MW	
	ΔE per klystron	$\Delta E_{klys} = N_{ck}V_{acc}$	832	MeV	
	# klystrons per linac	$N_k = \frac{E_{final} - E_{DR}}{\Delta E_{klys}}$	295		rounded up; no overhead. Ignores bunch compressor, and assumes on-crest operation
	# cavities per linac	$N_k N_{ck}$	7670		
DR					
	Energy	E_{DR}	5	GeV	
	circumference	$C_{DR} = 2\pi\rho_{DR}$	6.7	km	
	bunch spacing kicker rise time	$\Delta t_{DR} = \frac{C_{DR}}{n_b c}$	8.5	ns	

	current	$i_{DR} = \frac{Ne}{\Delta t_{DR}}$	376	mA	
	Damping time	τ_{DR}	26	ms	wiggler dominated
	Average power loss per electron	$\left\langle P_\gamma \right\rangle = \frac{2E_{DR}}{\tau_{DR}}$	385	$GeV.s^{-1}$	wiggler dominated
	RF power	$P_{DR,RF} \approx \left\langle P_\gamma \right\rangle n_b Ne$	3.2	MW	
	bunch length	$\sigma_{z,DR}$	9	mm	
	energy spread	$\delta_{DR} = \left(\frac{\Delta P}{P} \right)_{RMS}$	0.13	%	
bunch compressor					**single stage assumed**
	compression ratio	$F_c = \frac{\sigma_z}{\sigma_{z,DR}}$	30		
	Voltage	$V_{BC} = \frac{E_{DR}}{k_{RF}} \left(\frac{\delta_{DR}}{\sigma_{z,DR}} \right) F_c$	797	MV	
	longitudinal dispersion	$R_{56} = \frac{k_{RF} V_{RF}}{E_{DR}} \left(\frac{\sigma_{z,DR}}{\delta_{DR}} \right)^2 \frac{1}{F_c^2}$	23	cm	
	final energy spread	$\delta = F_c \delta_{DR}$	3.9	%	too high