

◆ Introduction

- To mainly increase the luminosity at the Higgs and Z energy, a high luminosity scheme of the CEPC has been proposed in TDR.

	<i>tt</i>	<i>Higgs</i>	<i>W</i>	<i>Z</i>
Bunch Number in collider	37	240	1230	11520
Bunch Separation	4.2μs	0.64μs	0.27μs	25ns
Bunch Number in booster	37	240	1230	3840
Lifetime (hour)	0.59	0.33	1.4	1.4
Interval for top up* (s)	65	38	155	153

* Beam current in collider decays by 3%.

- To achieve the designed luminosity, both the top-up injection and full injection from empty for the collider ring need to meet the design requirement. In addition, the hardware of injection and extraction for each subsystem should be compatible with different energy modes requirements in the Collider
- Z-mode is the most challenging operation in terms of charge flux delivered by the injectors.

- The RF frequency choice in CDR cannot meet the injection requirements for the bunch number at Z pole.

f (MHz)	SHB1	SHB2	Linac	DR	booster	collider
CEPC	143	572	2860	650	1300	650

- For CEPC, the common frequency is 13MHz, so the minimum time step= 76.92ns.
- For high luminosity Z top-up injection, the time separation required is only 20~28 ns.
- It cannot meet the requirements for bunch number and results in 40% luminosity drop.
- Max bunch number is limited by the common frequency of collider, booster and Linac.

➤ $2 \cdot 11 \cdot n = N \cdot m_2 \cdot m_1 \cdot k$

- $m_1 = 11$
- $m_2 = 3 \sim 5, 4$
- $N = 4 \sim 6, 5$

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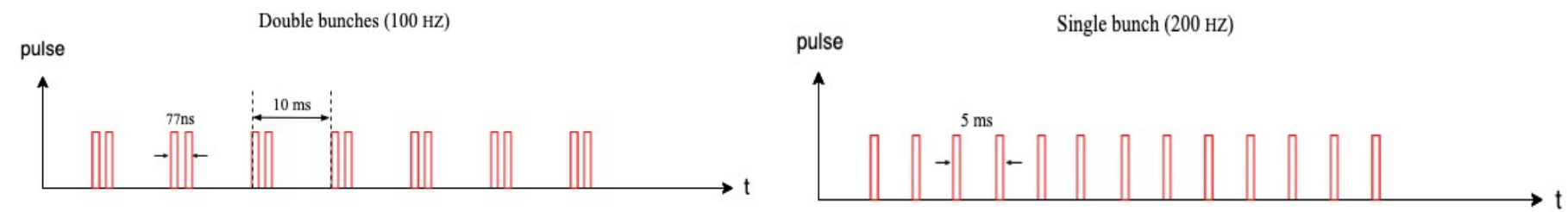
➤ $T_{\text{beam}} = 1/f_{\text{bm}} = N \cdot m_2 \cdot m_1 \cdot 0.34965\text{ns}$

	frequency	Multiple	Period	
Common frequency	13 MHz	1	76.9231	ns
Two bunch	13 MHz	1	76.9231	ns
SHB1	143 MHz	11	6.9930	ns
SHB2	572 MHz	44	1.7483	ns
LINAC	2860 MHz	220	0.3497	ns
Booster	1300 MHz	100	0.7692	ns
Ring	650 MHz	50	1.5385	ns

- We consider replacing the subharmonic bunchers and the thermionic gun with RF gun, the common frequency=130 MHz, and the minimum time step=7.692ns, bunch separation@Z=23.08ns.

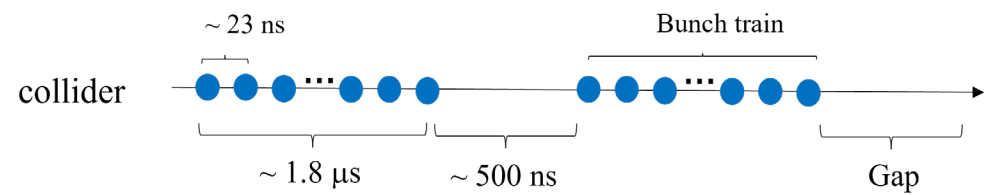
➤ For High-Lum Z, it becomes more complicated due to the large bunch number needed in the collider and the separation between bunches are only 20~30 ns.

a. The Linac can be upgraded to double bunch(100Hz) or 200Hz.

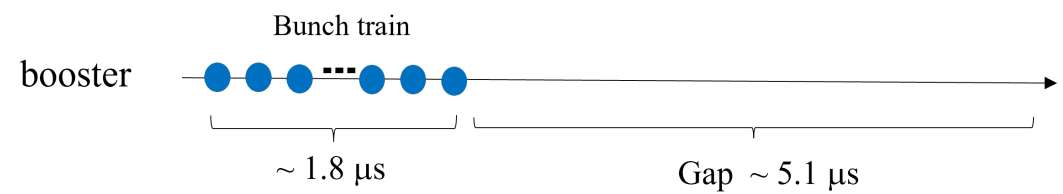


b. Considering the rise time of the kickers, bunches are arranged **train by train** in the collider.

c. Due to the current limit in the booster, The bunch number in the booster is only **1/3** of that in the collider.

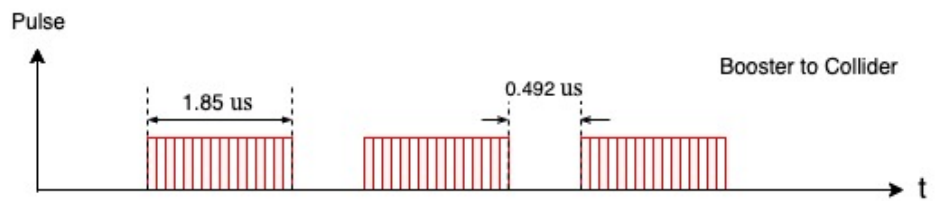
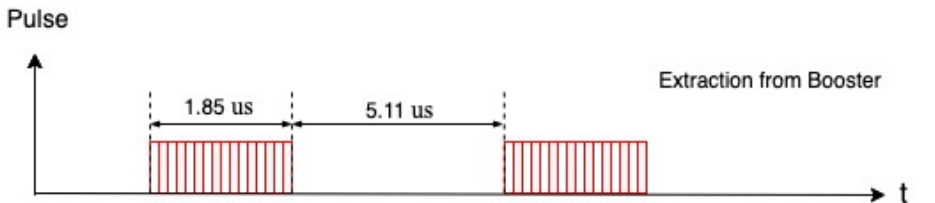
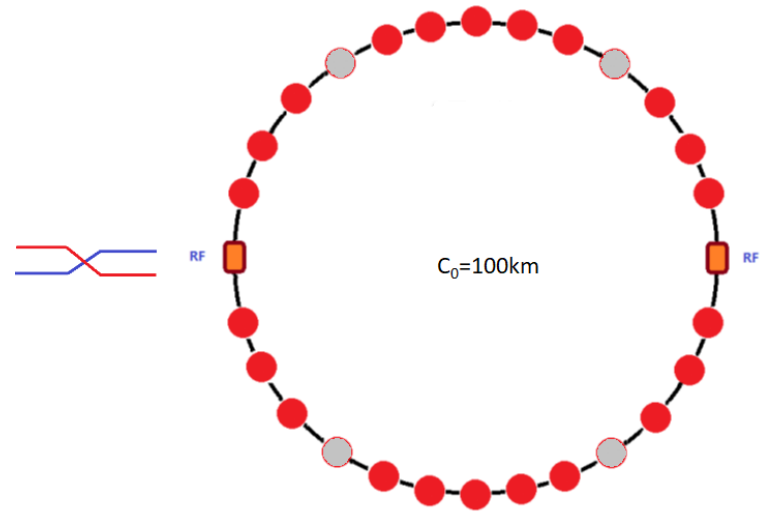
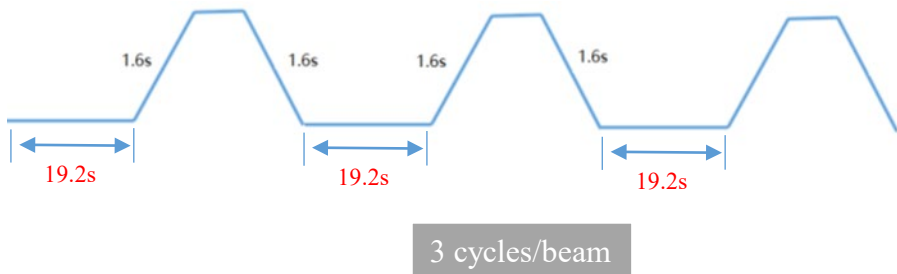
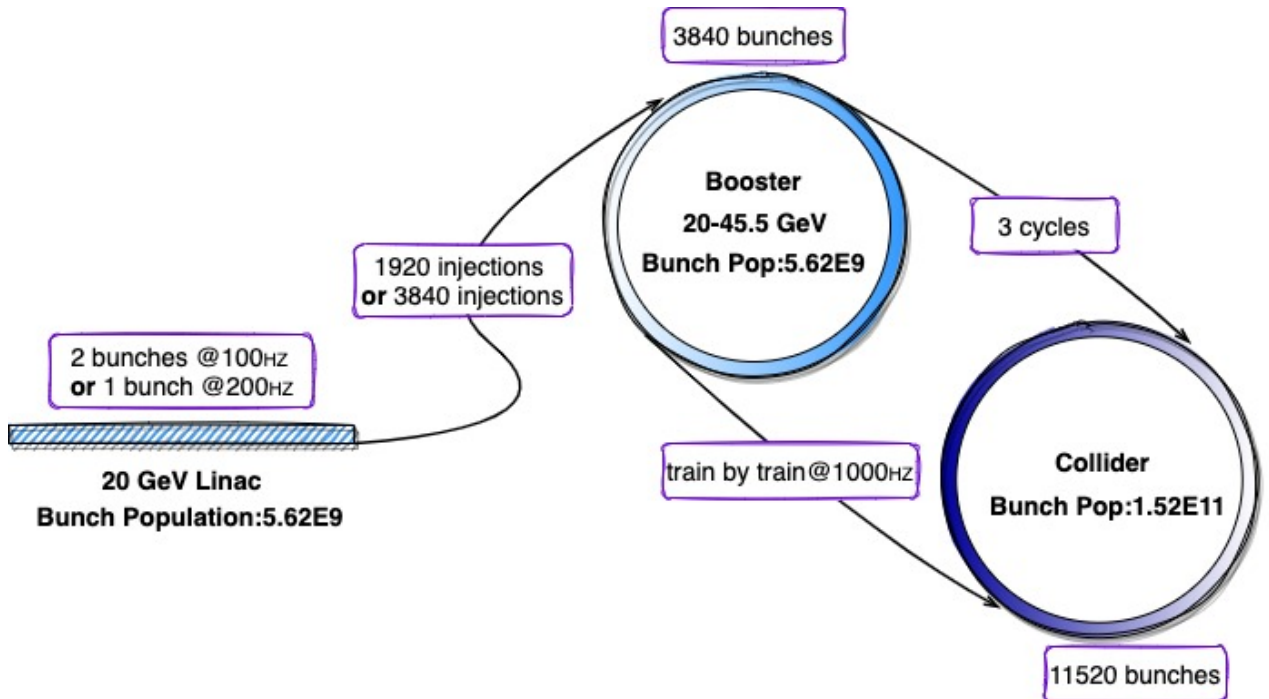


The bunches in the collider are arranged in bunch trains about **1.8 μs** and with gaps about **500 ns**. The kickers in the collider can rise and fall down in the gaps.

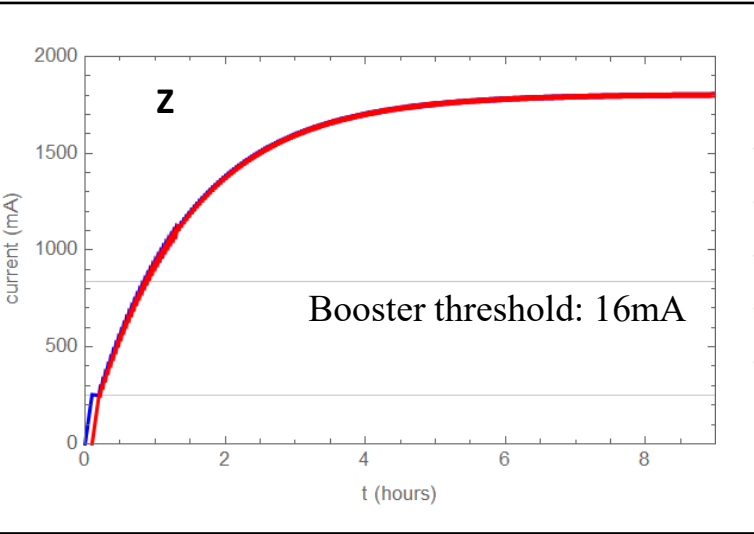
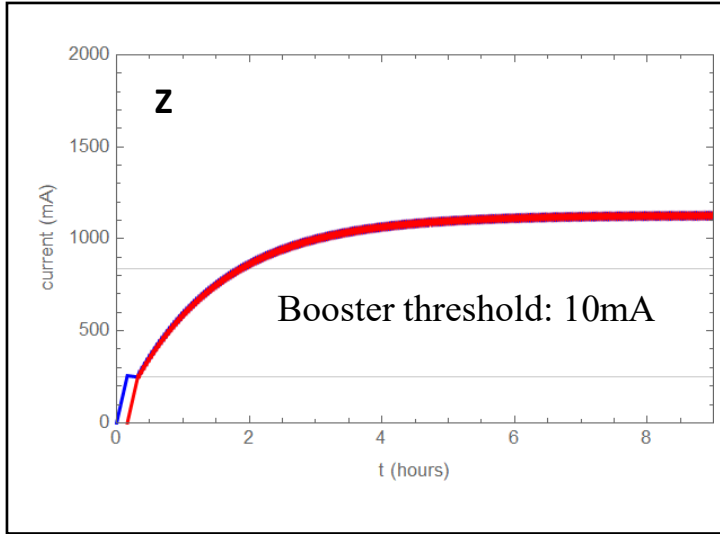
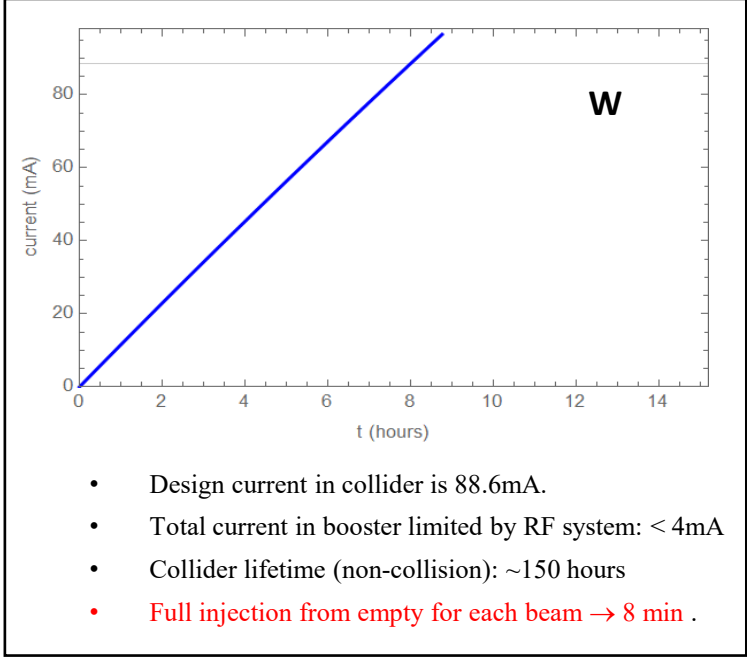
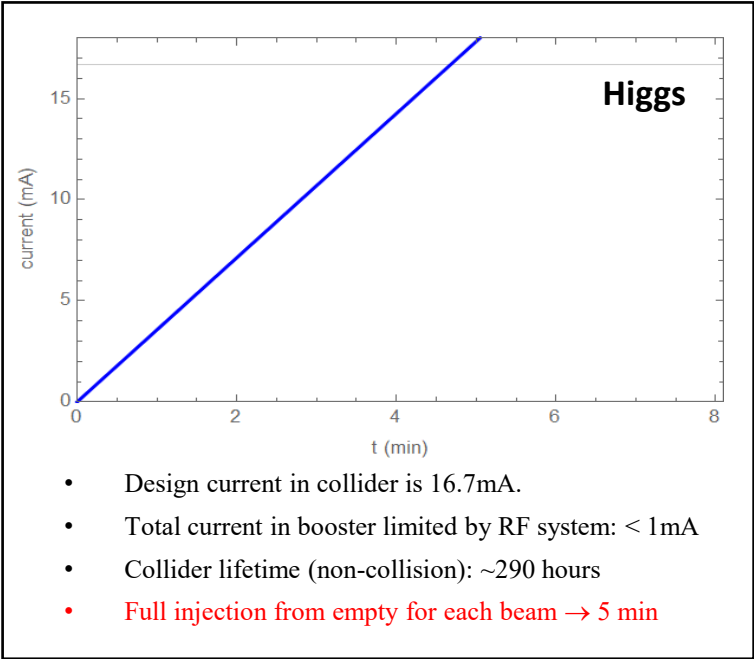
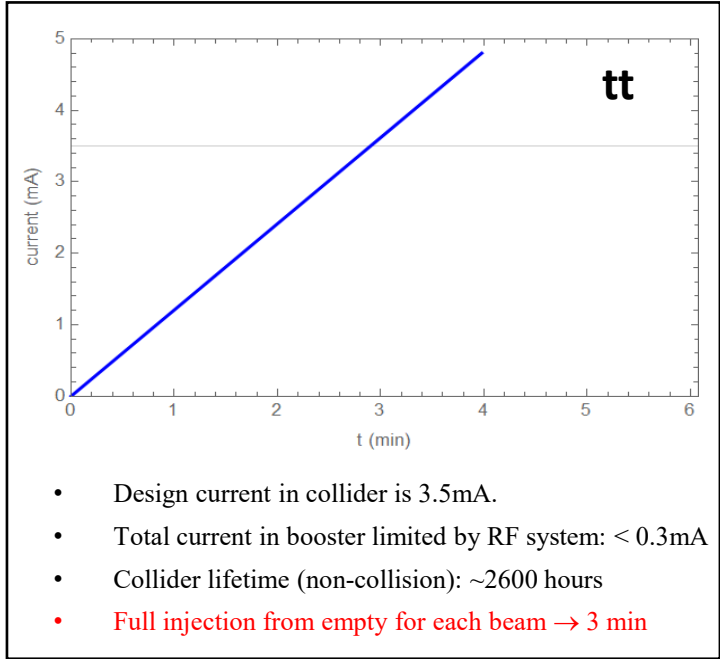


The bunches in the booster are arranged in the same bunch train structure. But the train number is **1/3**, so the gap is much longer.

◆ Top-up injection (Z pole)



◆ Full injection from empty



- Design current in collider is 840mA.
- Total current in booster limited by RF system: < 10 mA (16mA)
- Collider lifetime: 5.5 hours (non-collision), 1.4 hours (w. collision)
- Full injection from empty for both beam → 2 hours (50min)
- Bootstrapping from 250mA.