CEPC Cost Model Study and Circumference Optimization

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Introduction

The CEPC is a proposed high luminosity Higgs/Z factory, with the potential to be upgraded to top factory at center-of-mass energy of 360GeV. We perform an optimization study on the circumference of CEPC because we are still not quite clear now whether 100 km is the optimum. We calculate the instant luminosity, the construction and operation cost for different circumferences. With respect to the total cost and average cost per particle, we conclude that the optimal circumference for the CEPC Higgs operation is 80 km. Taking into account of the Z pole operation, the potential high-energy upgrade of CEPC (top factory), the optimal circumference increased to 100 km. The long future proton-proton upgrade of CEPC (SPPC) also favors a larger circumference, and we conclude that 100 km is the global optimized circumference for this facility.

CEPC cost model introduction

The total Higgs number can be expressed as:

$$N_{Higgs} = N_{IP} \cdot L_{design} \times 0.8 \times \sigma \times T_{physics}$$

$$T_{physics} = N_{year} \times month_{physics} \times 30(\text{days/month}) \times 24(\text{hours/day}) \times 3600(\text{seconds/hour})$$

The total cost of the Higgs factory is composed of five parts which is expressed as follows:

$$\text{Cost}_{total} = \text{Cost}_{machine} + \text{Cost}_{detector} + \text{Cost}_{elect} + \text{Cost}_{maintian} + \text{Cost}_{staff}$$

$$\text{Cost}_{detector} = 2(billion) \times N_{IP}$$

$$\text{Cost}_{maintain} = \text{Cost}_{machine} \times 3\% \times N_{year}$$

$$\text{Cost}_{machine} = \frac{C}{100} 24(billion) + 6(billion)$$

$$\text{Cost}_{staff} = \left(\text{Cost}_{machine} \times 1\% + 0.1(billion)\right) \times N_{year}$$

$$\text{Cost}_{elect} = P_{SR} \times F_{AC} \times \left(N_{year} \times month_{operation} \times 30(\text{days/month}) \times 24(\text{hours/day})\right) \times C_{power}$$

CEPC cost for the Higgs factory configuration

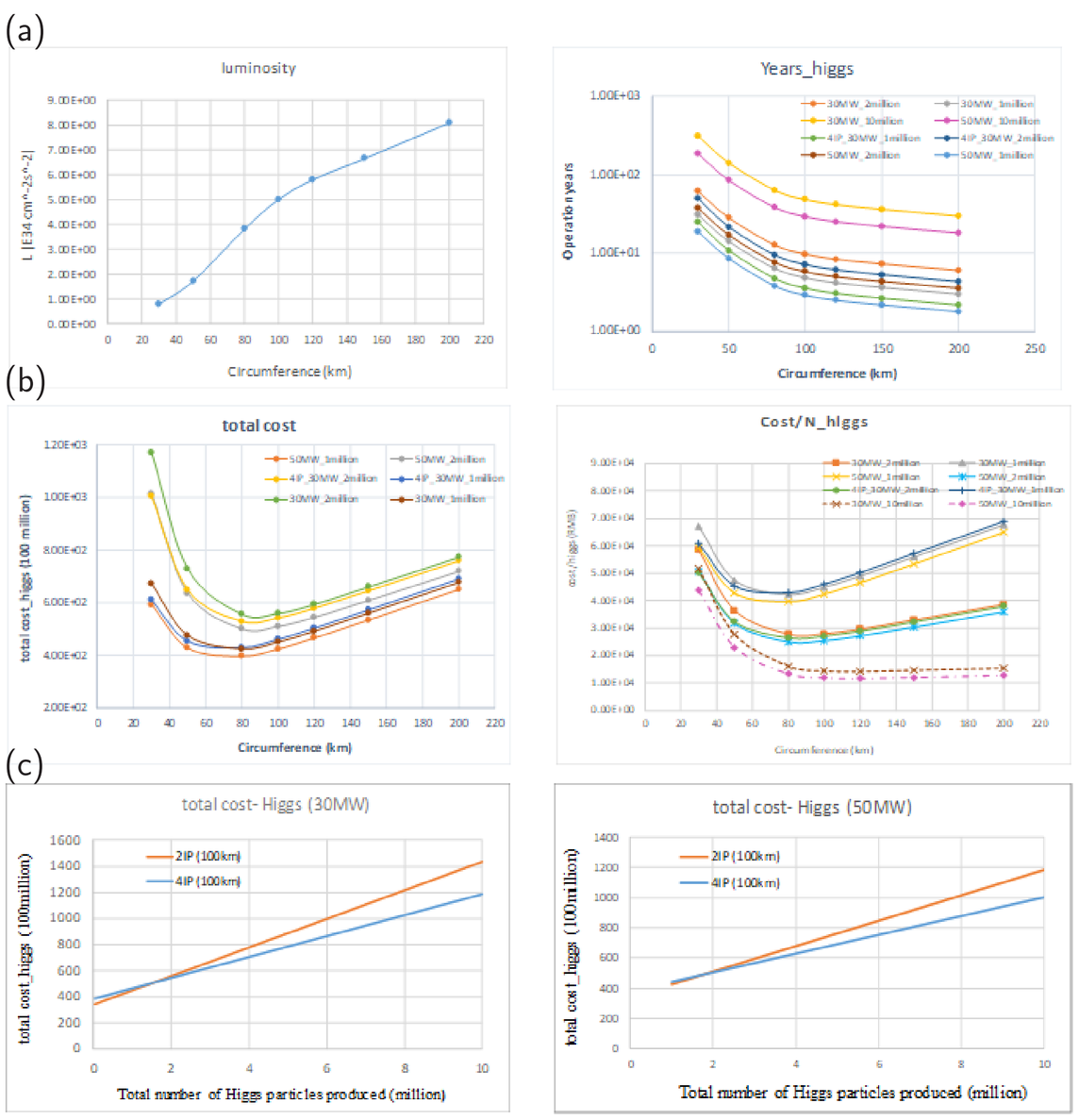

FIG.1. (a); Results of the luminosity optimization and the required operation years for the CEPC collider at the beam energy of 120 GeV(b); Total cost for Higgs factory and cost per Higgs particle (c); The total cost comparison of a Higgs factory between 2IP and 4IP scheme with different SR power.

CEPC cost combing Z factory

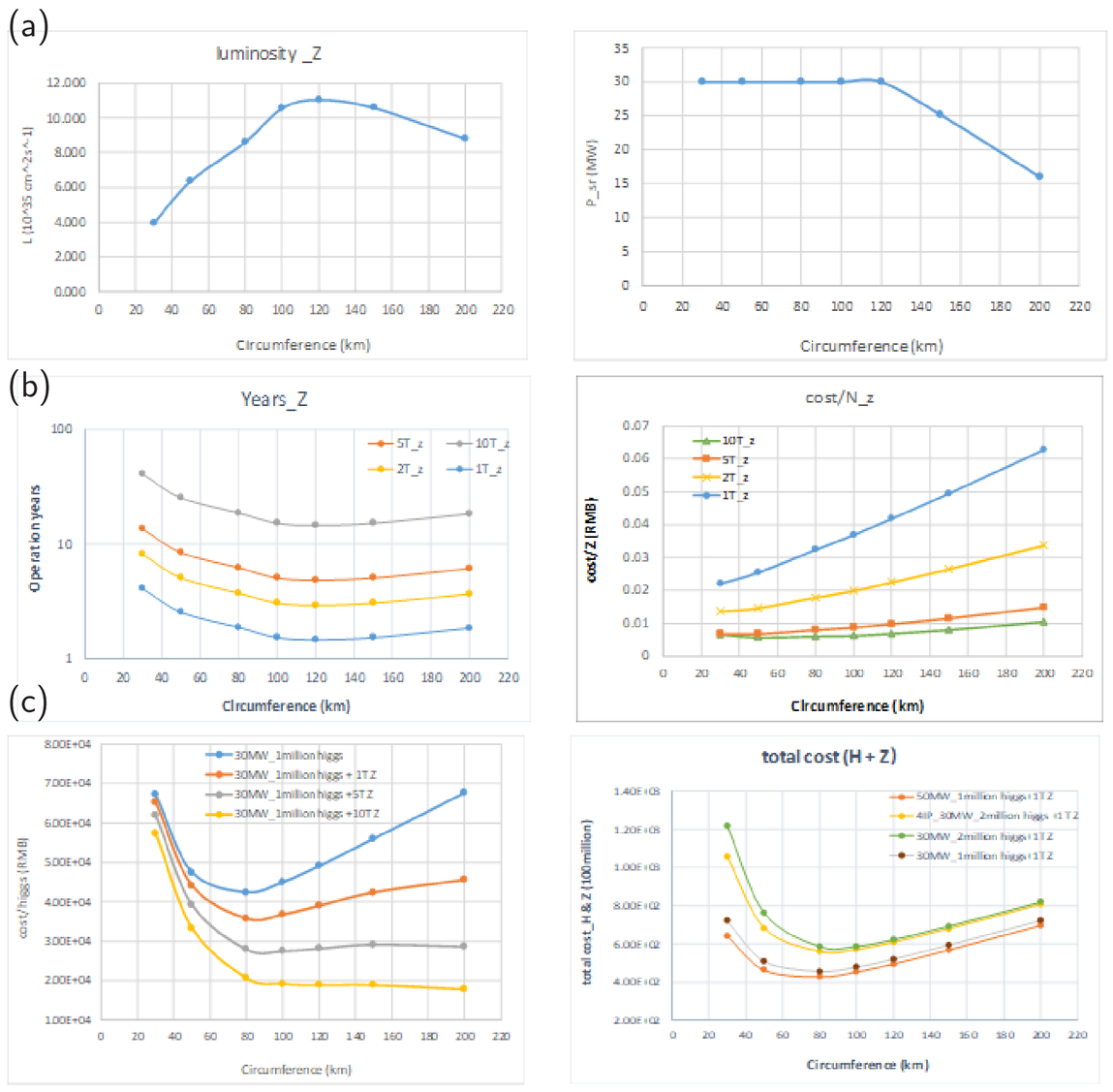

FIG.2. (a); Results of the luminosity optimization and the SR power per beam for the CEPC collider at the beam energy of 45.4 GeV (b); Required years of operation and cost per Z boson (c); Cost per Higgs particle combining Higgs and Z and total cost combining Higgs and Z.

CEPC cost combing tt physics

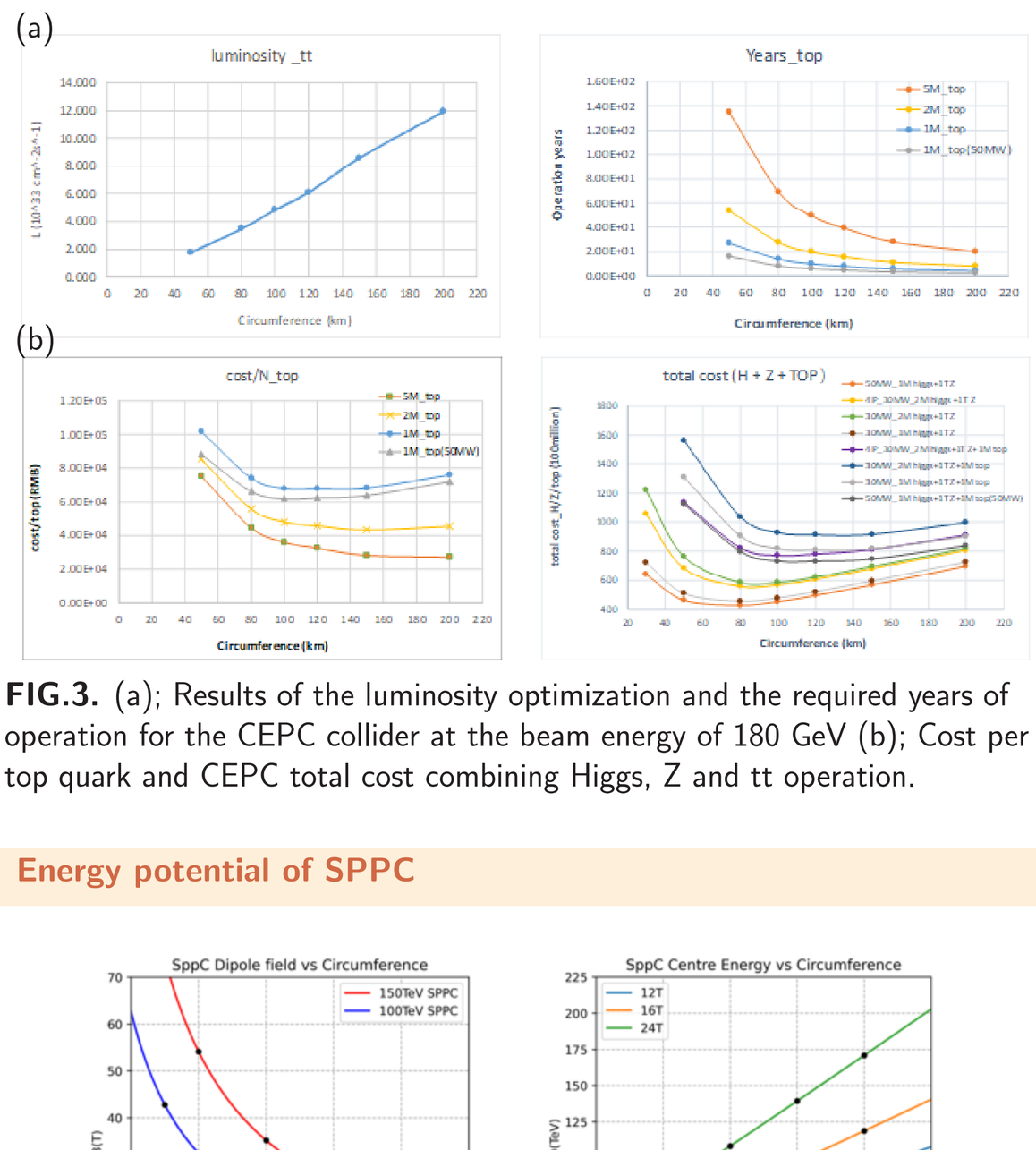

FIG.3. (a); Results of the luminosity optimization and the required years of operation for the CEPC collider at the beam energy of 180 GeV (b); Cost per top quark and CEPC total cost combining Higgs, Z and tt operation.

Energy potential of SPPC

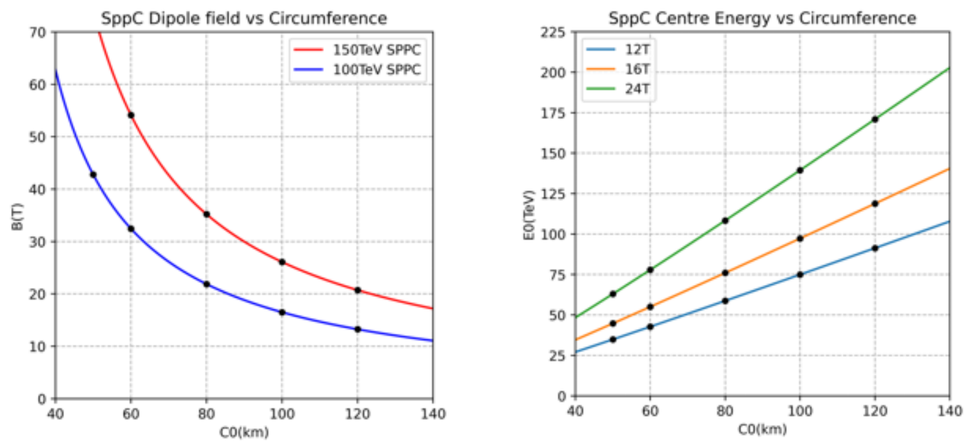

FIG.4. The dipole strength and C. M. energy of SPPC vs machine circumference.

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