

Alternative Solution of RF Region Beam Separating System in CEPC

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Abstract

This paper proposes kicker magnet scheme as an alternative solution of RF region beam separating system in CEPC. Two types of kicker magnet systems—resonant kicker and square wave kicker have been designed and developed. Magnetic, electrical, and thermal performance have been validated through multiphysics simulation and experiments. The vacuum and mechanical structures have been designed to ensure reliable system operation.

Introduction

In the Technical Design Report of CEPC, RF region beam separating system adopts static-electrical separator scheme, which will face challenges such as DC high voltage and beam impedance issues. In Higgs mode, e-/e+ beams only fill half ring respectively. So, it is possible to separate beams by kickers. Compared with static-electrical separator, kicker magnet is stronger and contributes lower beam impedance. Four sets of kicker locate at both sides of RF region, K1 and k4 applied for e+ beam, K2 and K3 applied for e- beam.

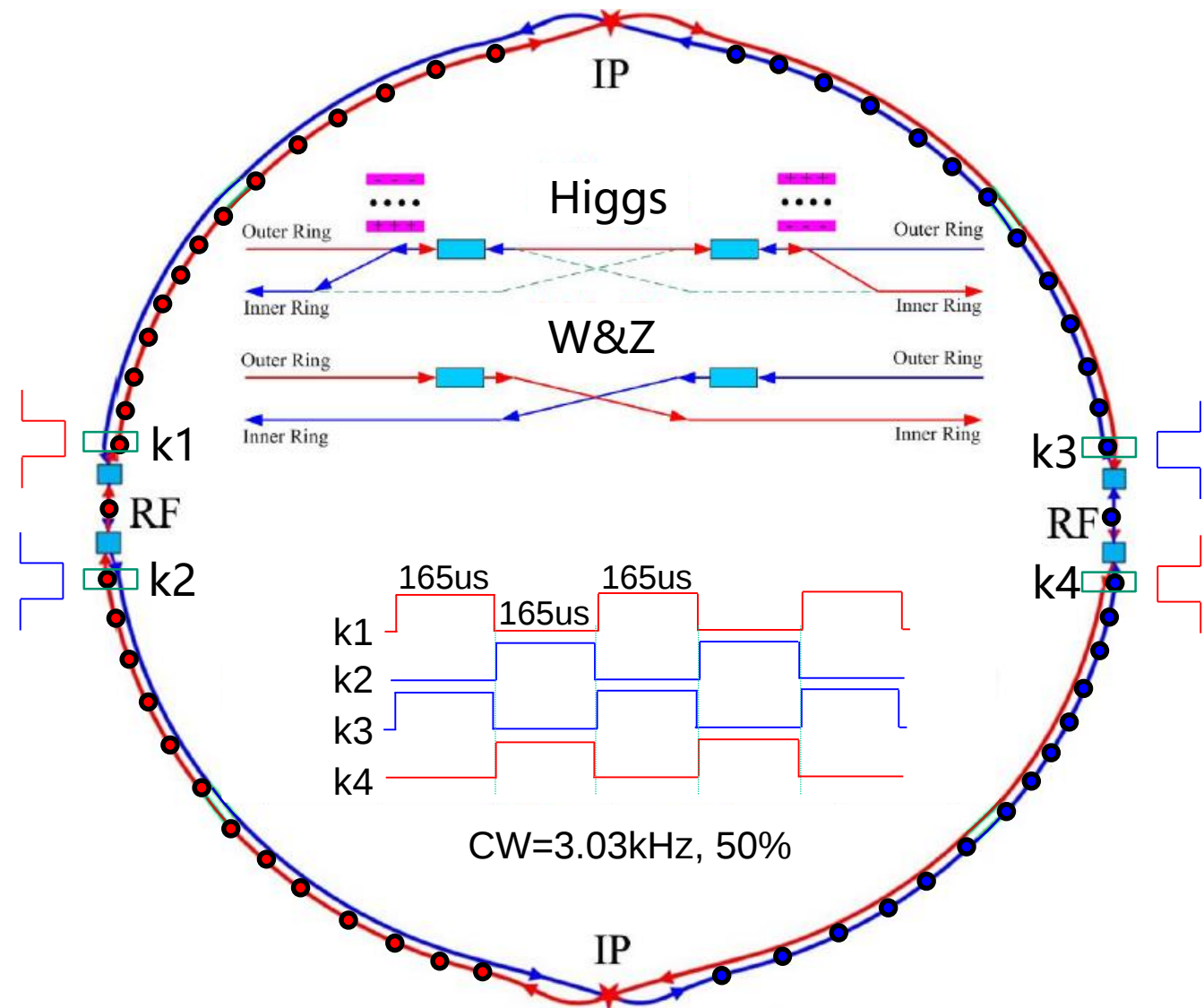


Figure1 Layout of Beam Separating System

Purpose

The waveform of kicker pulse is square wave with duty cycle of 50%, pulse width of 165 μs and frequency of 3.03kHz. When resonant discharge circuit with higher efficiency and recoverable energy is adopted, the repetition frequency is 1.5MHz.

Table1 Requirements of Kicker Magnet System

Item	Value	Unit
Name	Kicker	-
Integrated strength BL	0.1624	T·m
Magnetic strength	203	Gauss
Effective magnetic length	8	m
Repetition frequency	3030	Hz
Beam clear region H×V	20.2×7.6	mm
Good field region H×V	19.2×7.2	mm

Resonant Kicker System

Two circuit modes have been designed for the resonant kicker magnet system. The fully resonant kicker magnet system is powered by two resonant power supplies. The single resonant kicker magnet system is powered by a DC power supply and generates resonant pulses through rapid switching. In resonant mode, the structural design outside vacuum will generate extremely high eddy current losses on vacuum chamber. Therefore, the structural design in the vacuum is adopted. Figures 4 and 5 show the magnetic field models of two types of kicker magnets in vacuum. Figures 6 and 7 show the circuit model designs of the kicker magnet system for two types of resonant discharge circuits.

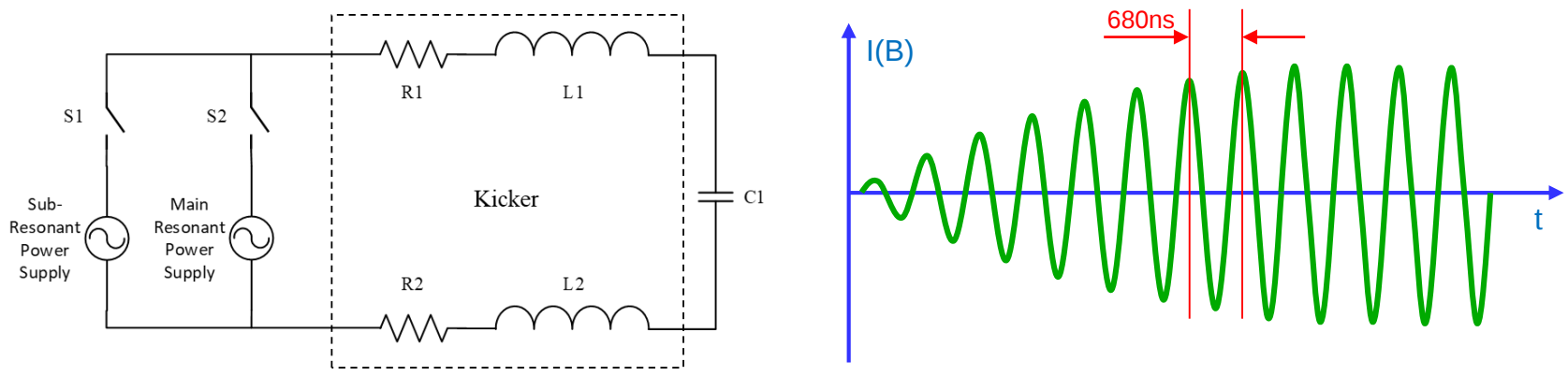


Figure2 Fully Resonant Kicker Magnet System

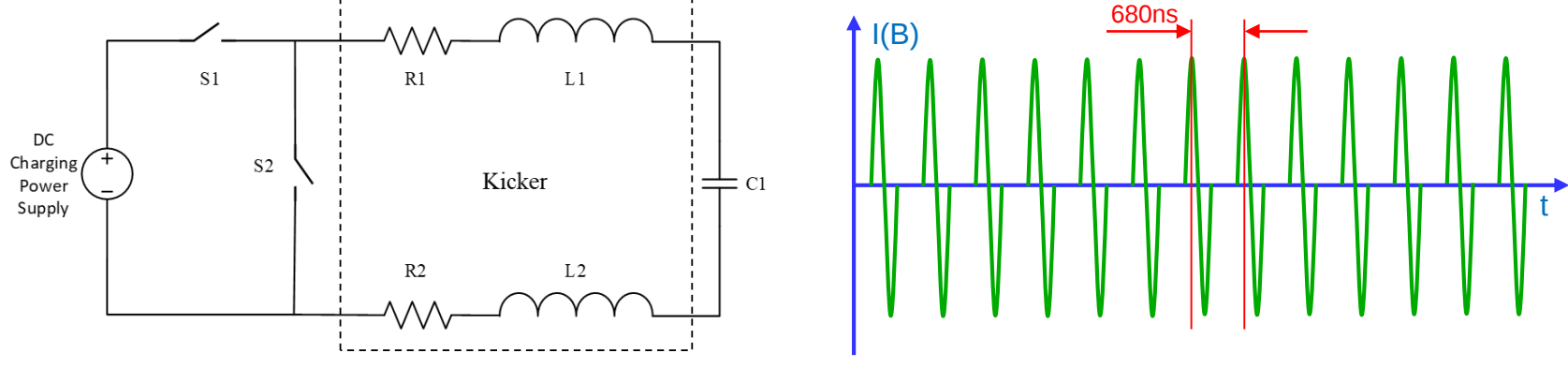


Figure3 Single Resonant Kicker Magnet System

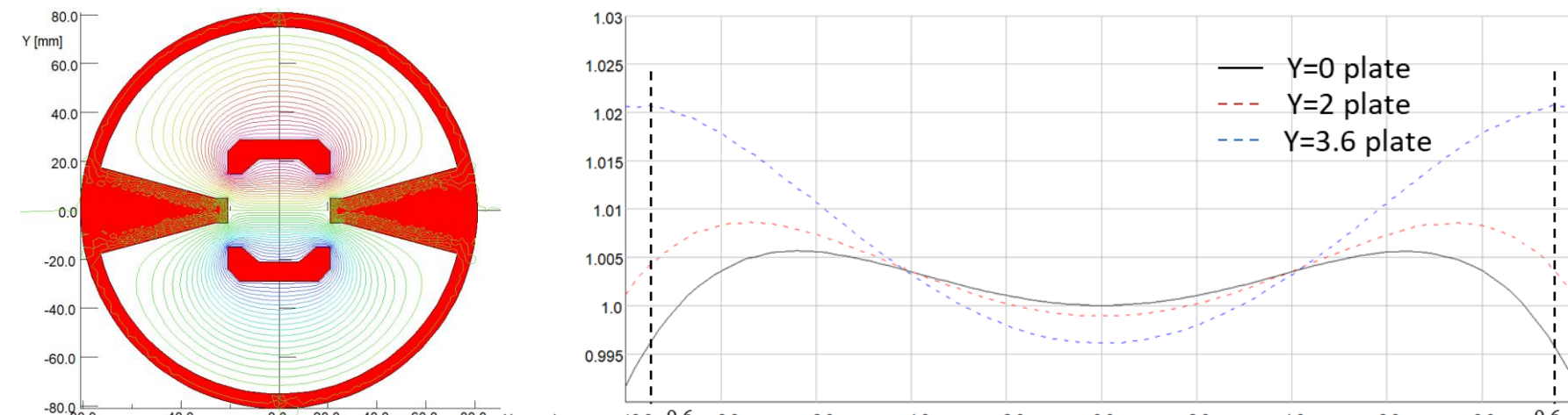


Figure4 Air-core Coil Type Kicker Magnetic Model

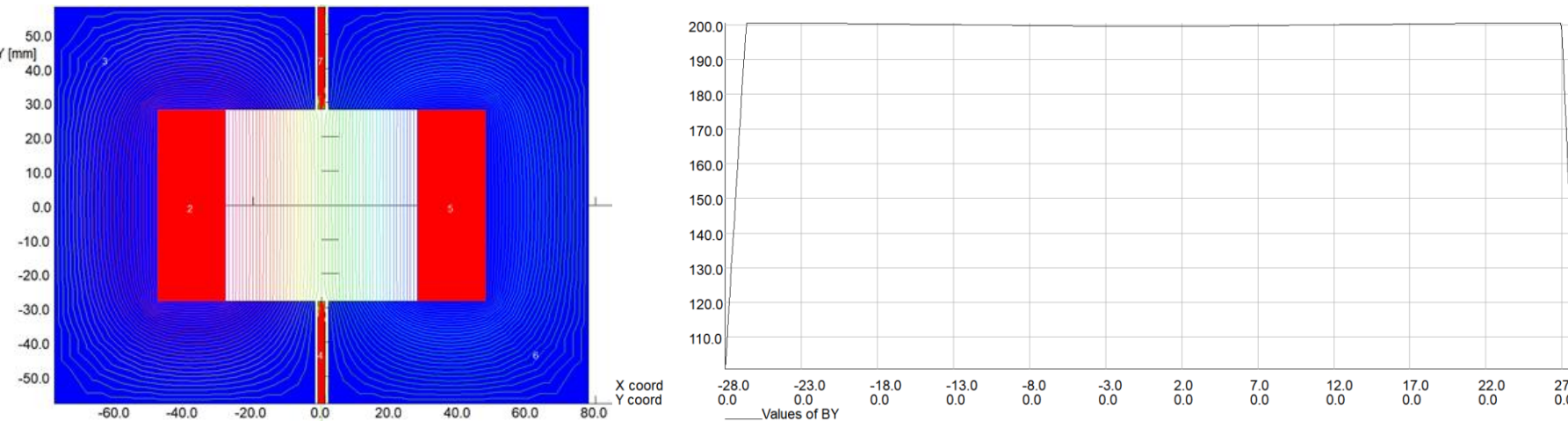


Figure5 Ferrite Type Kicker Magnetic Model

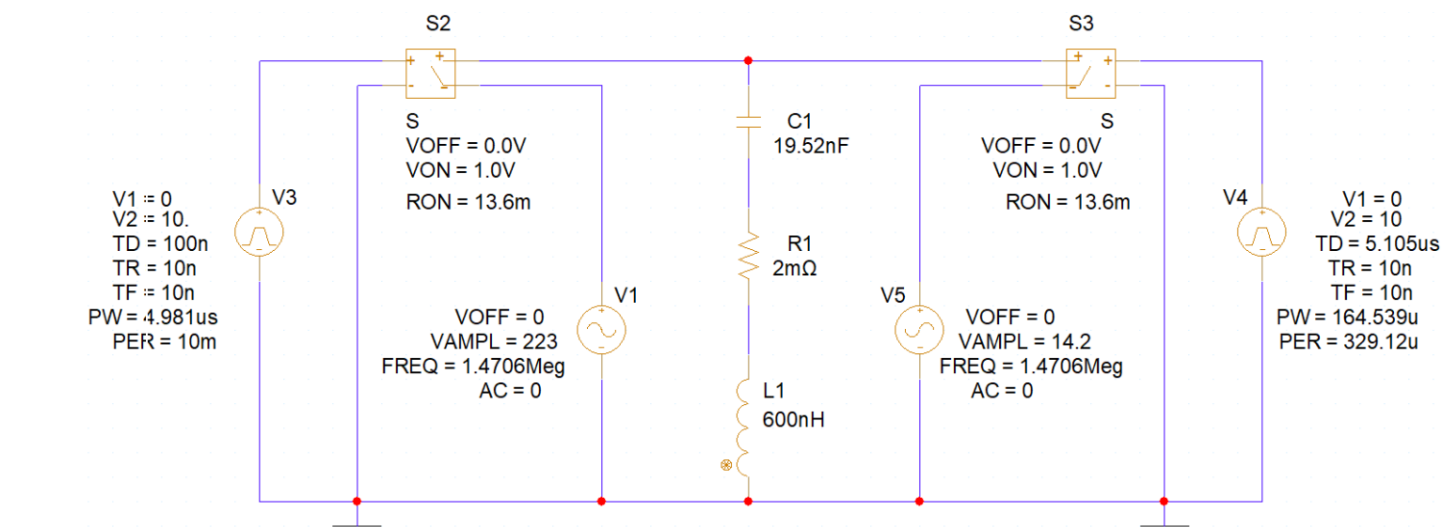


Figure6 Circuit Model of Fully Resonant Kicker System

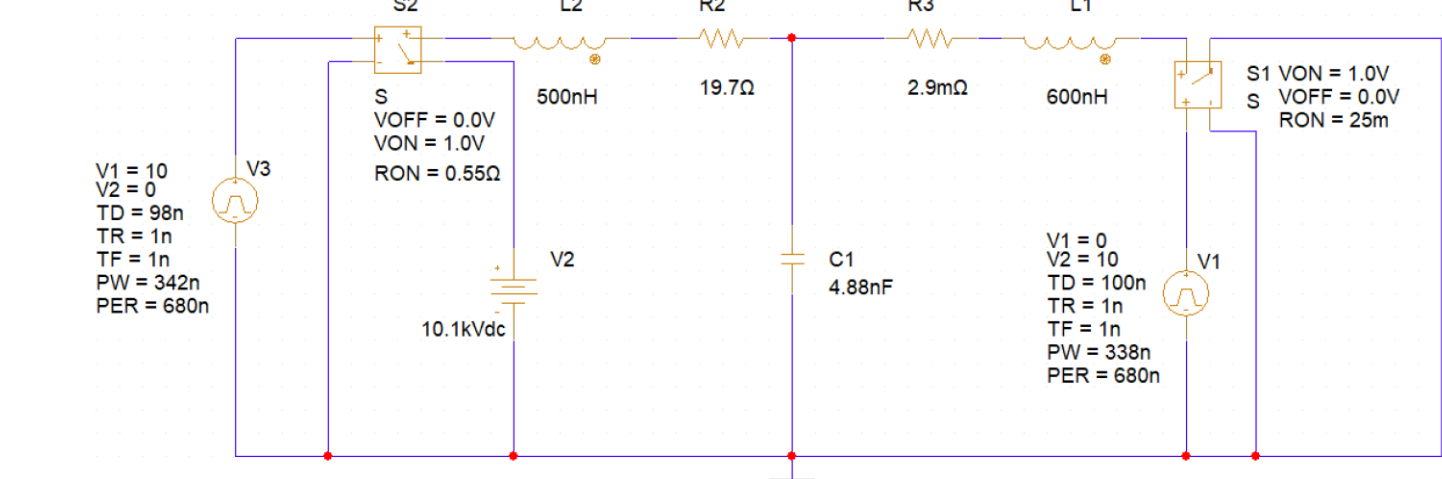


Figure7 Circuit Model of Single Resonant Kicker System

Square Wave Kicker System

Two circuit modes of square wave kicker magnet systems have been designed. One scheme is to directly generate square wave by a square wave pulse generator, which has relatively high requirements for the power supply. Another scheme is to use a DC power supply and generate square wave by switching the switches on the two branches. Figure 9 shows the circuit model of the second square wave kicker system mode.

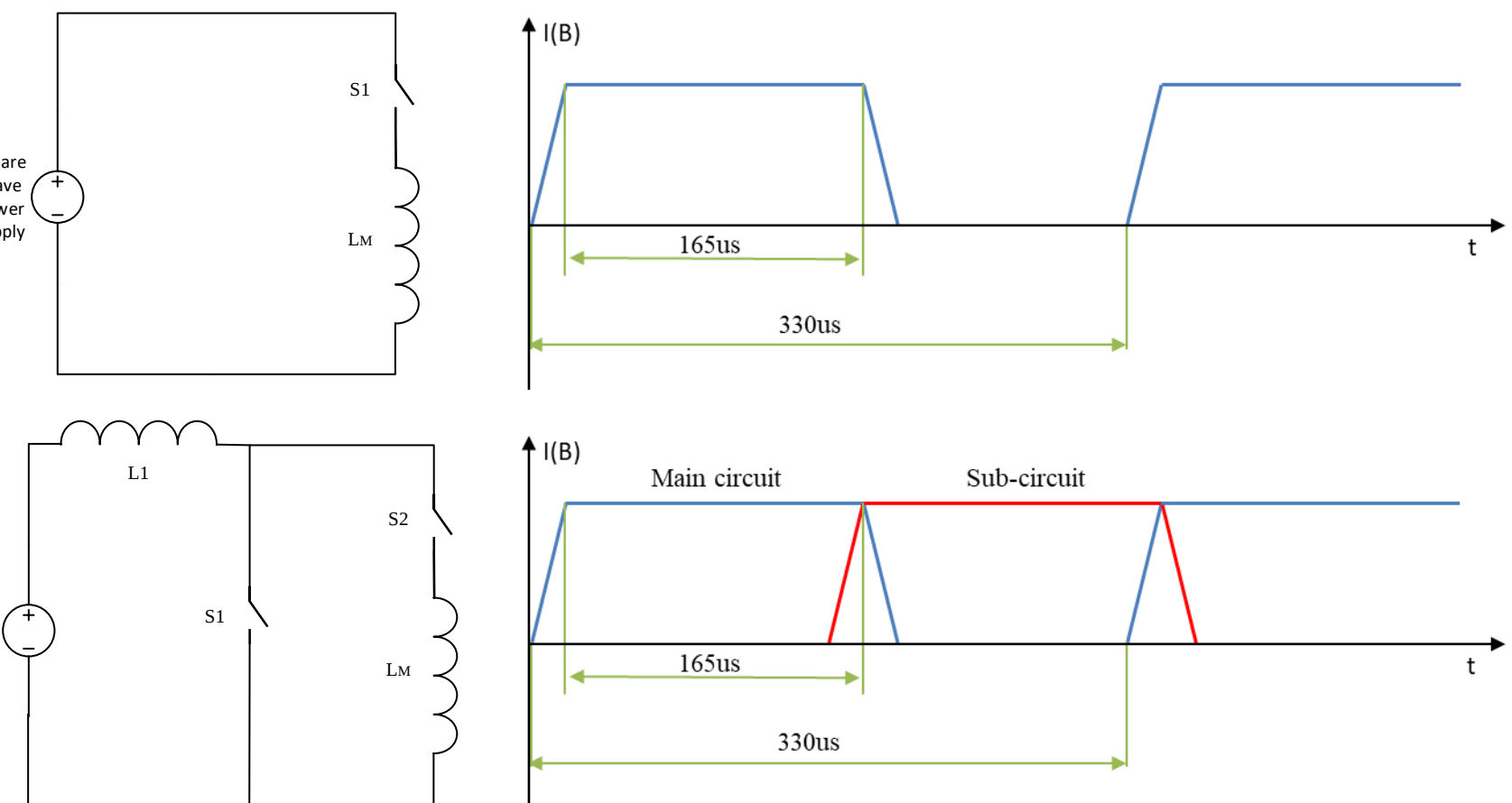


Figure8 Square Wave Kicker Magnet System

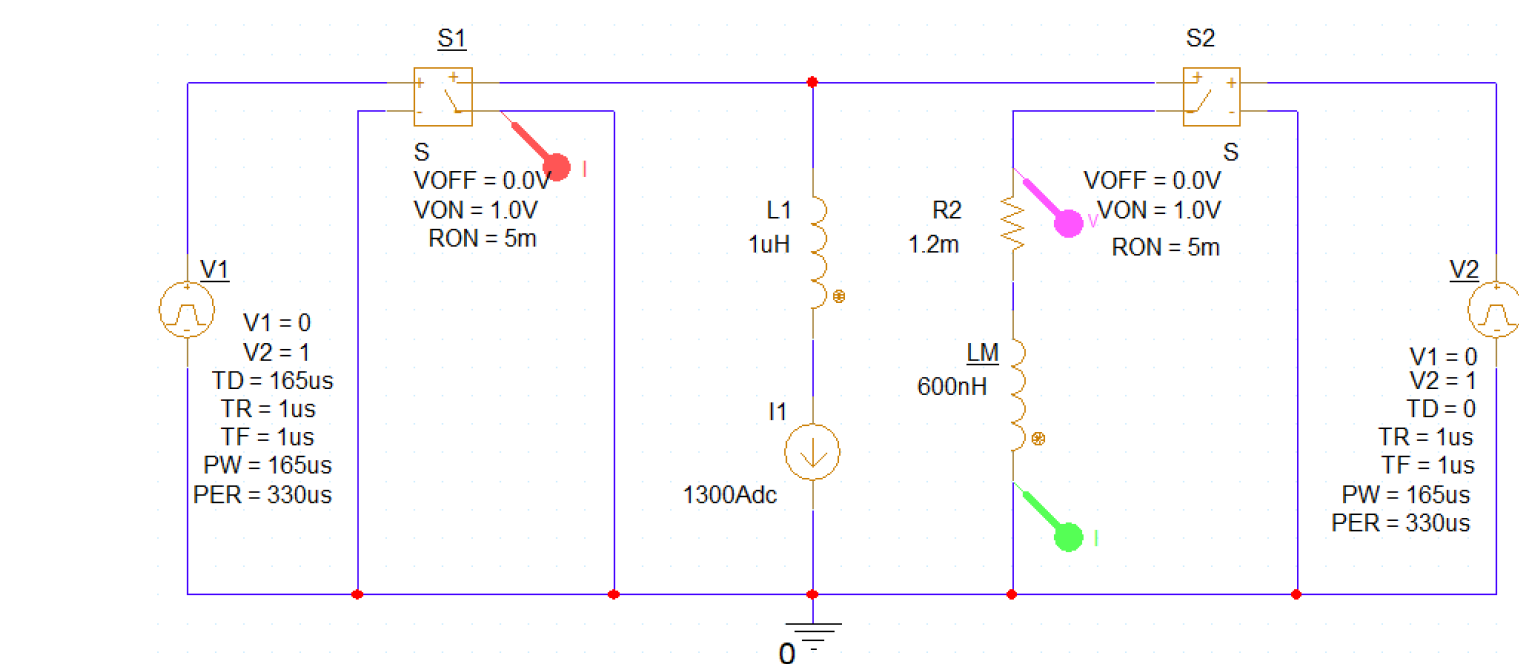


Figure9 Circuit Model of Square Wave Kicker System

The feasibility of generating square waves by switching branches of a DC power supply was experimentally validated. The kicker magnet adopts outside vacuum structure design. Vacuum chambers with metal and ceramic coating are designed and calculated. Simulation of magnetic field, eddy current loss and beam loss calculation, temperature rise calculation, and mechanical structure design were conducted in sequence.

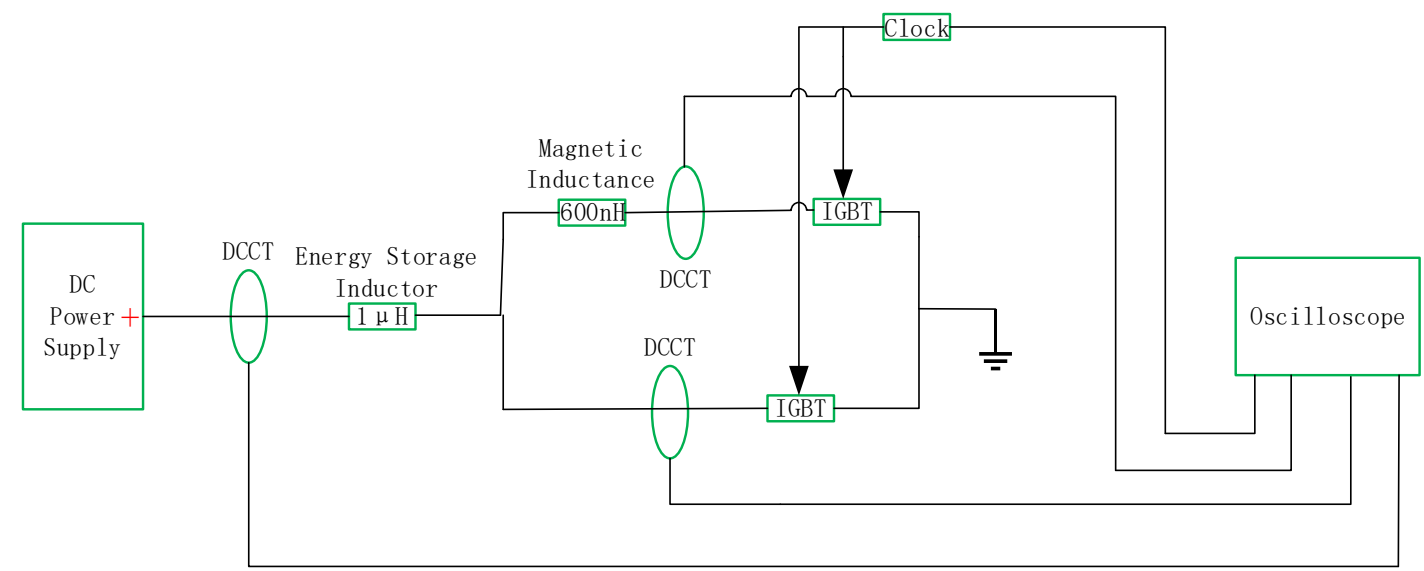


Figure10 Principle of Square Wave Circuit Test

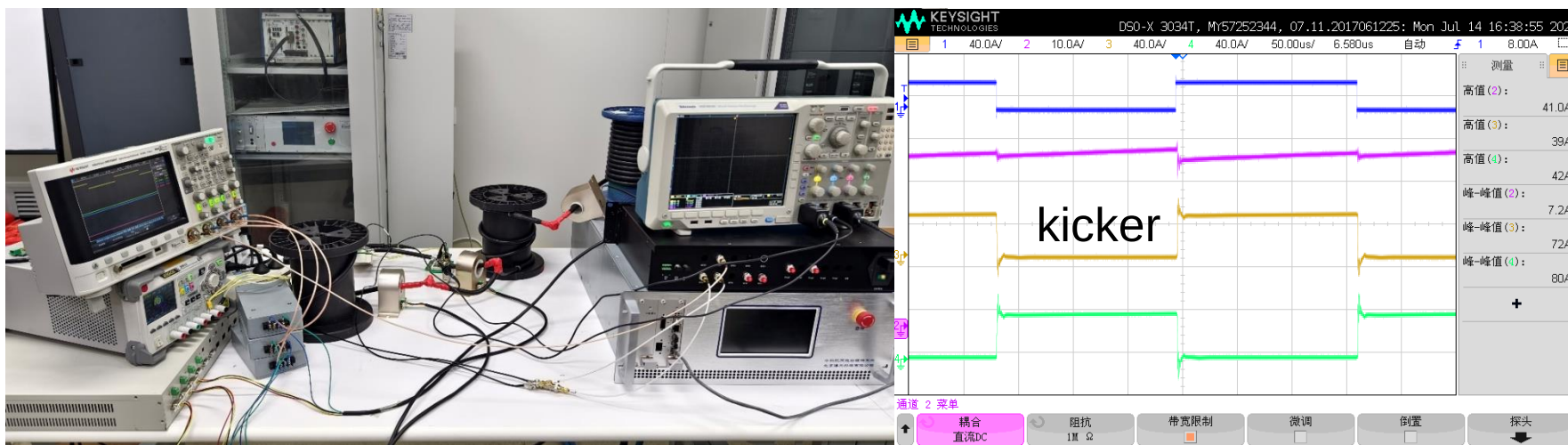


Figure11 Circuit Experiment Platform and Result

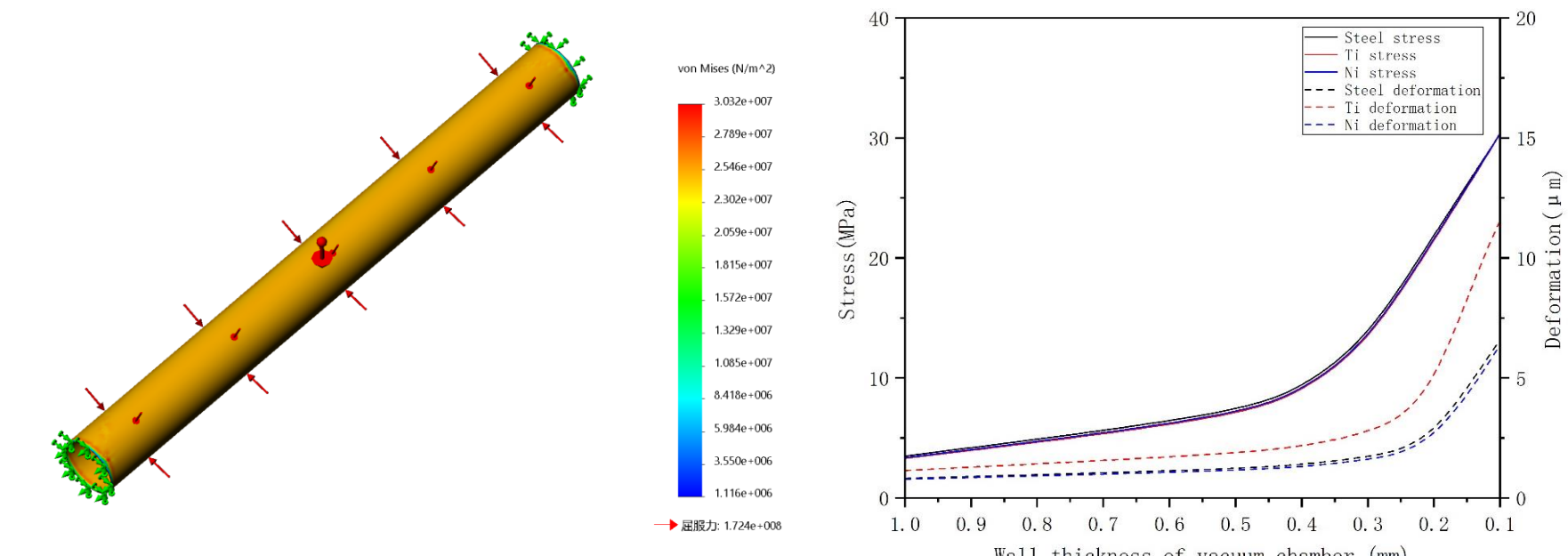


Figure12 Design of Vacuum Chamber

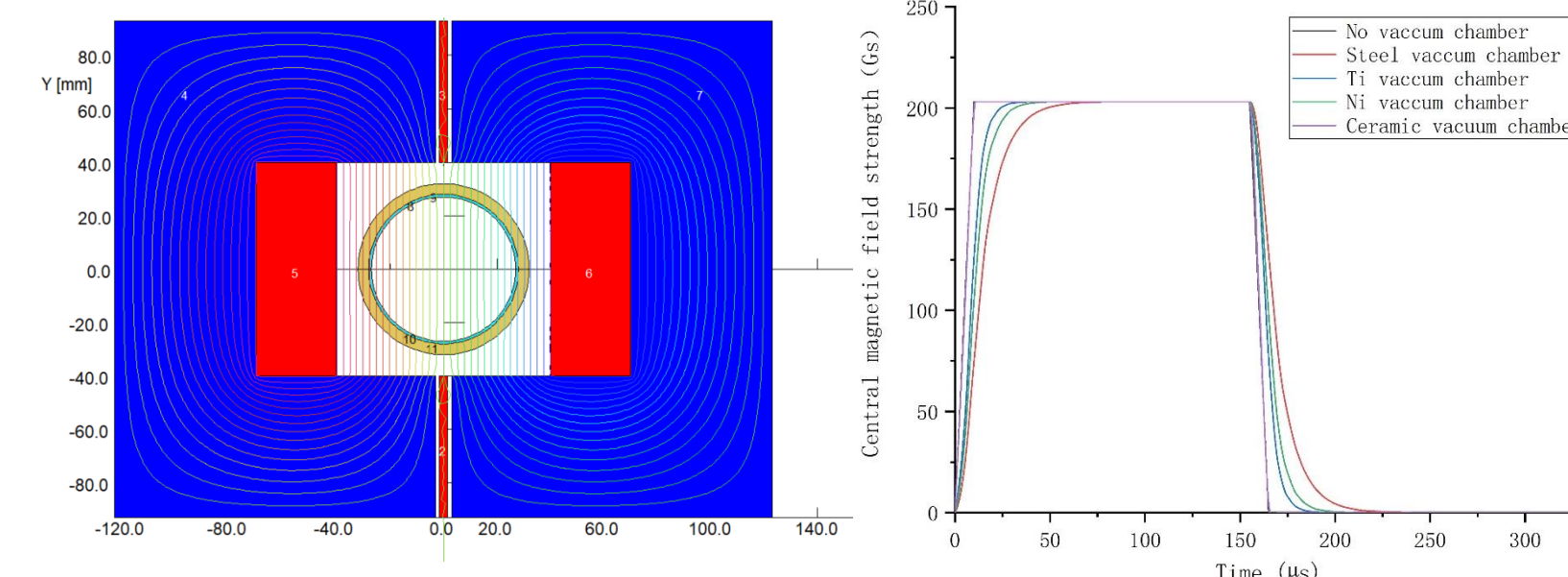


Figure13 Central Magnetic Field Distribution

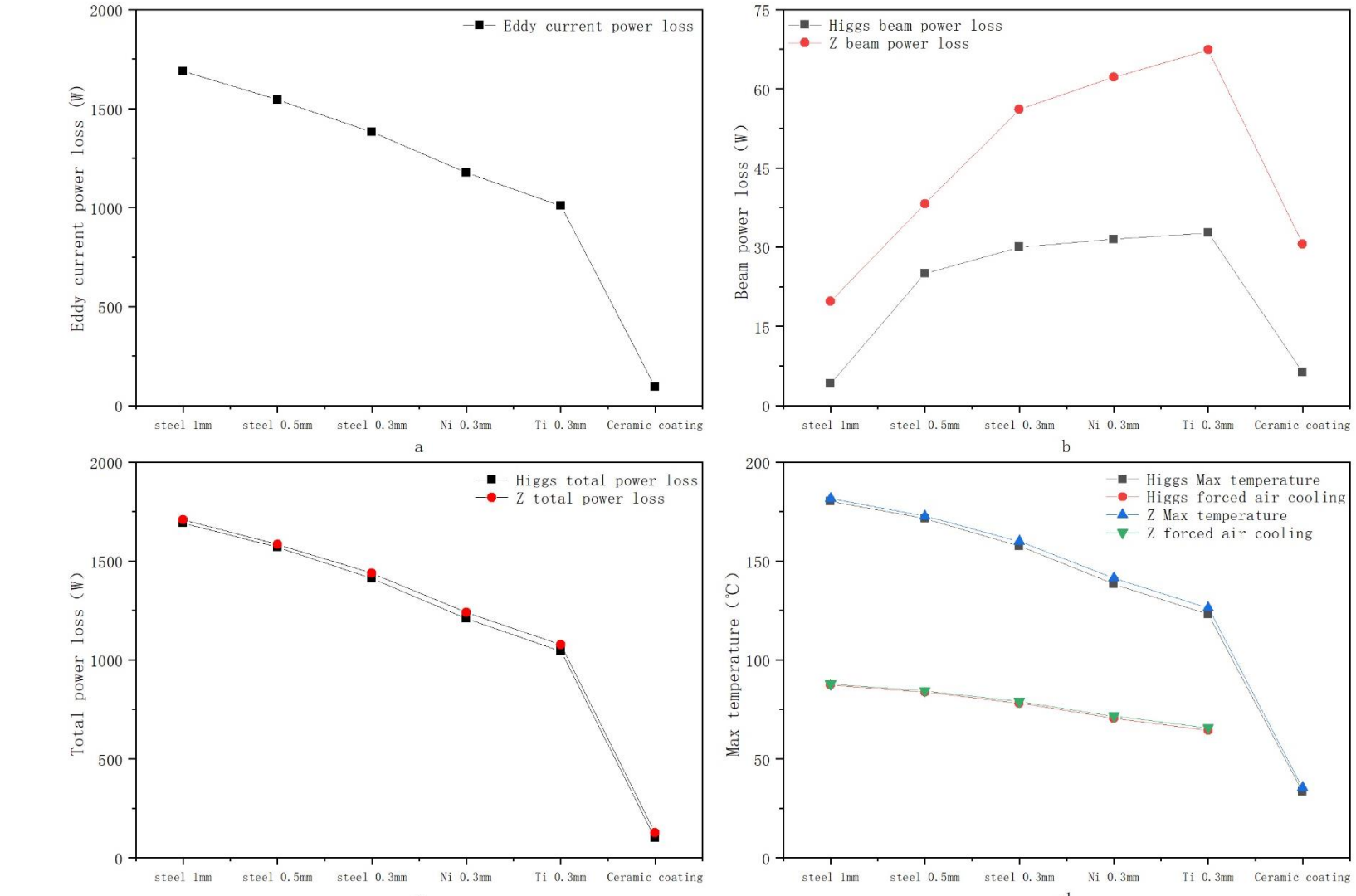


Figure14 Calculation of Power Loss and Temperature

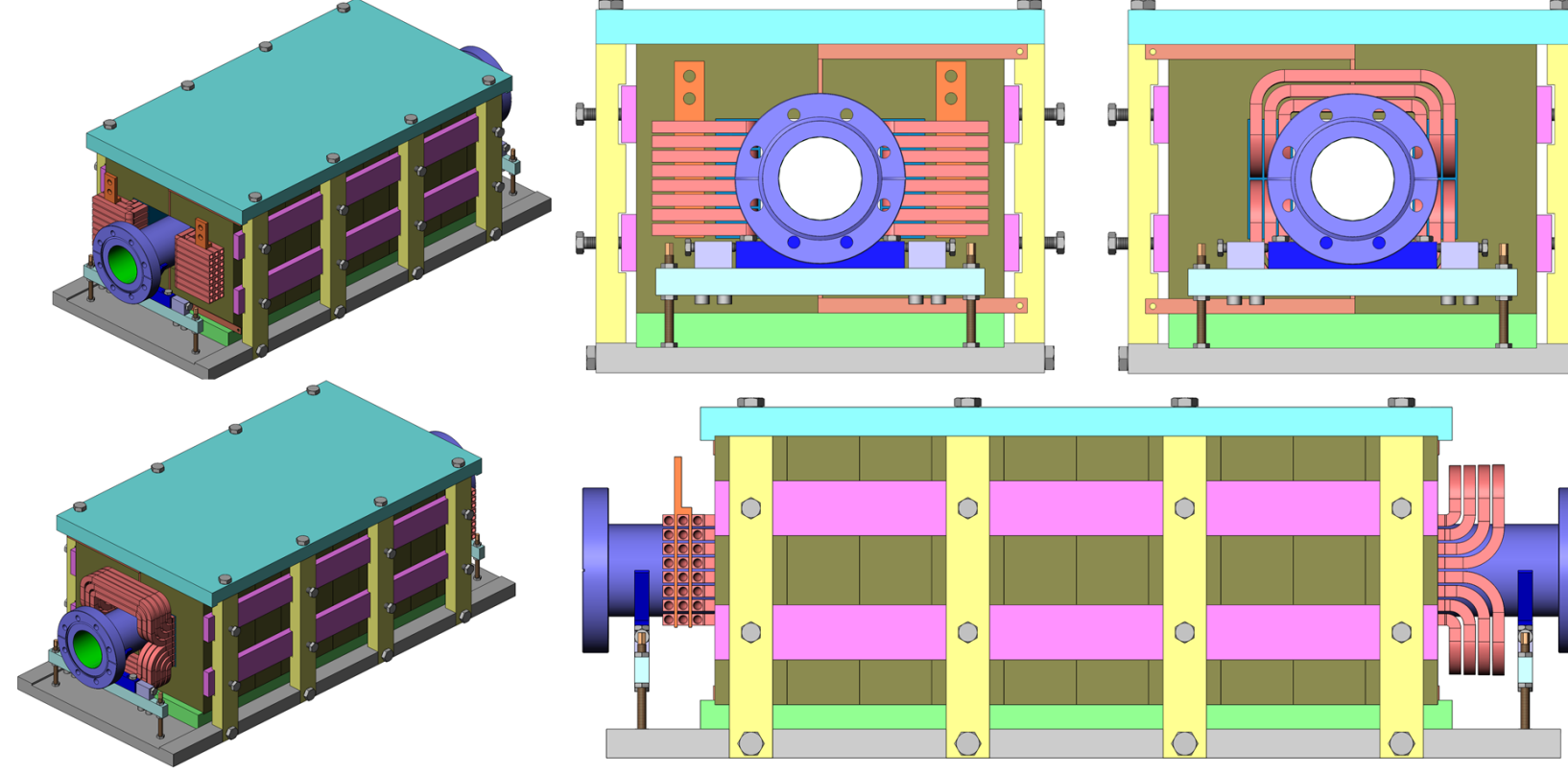


Figure15 Mechanical Design of Square Wave Kicker

Summary

This paper has completed the system design of resonant kicker and square wave kicker. The detailed circuit, magnetic field, vacuum and mechanical design of the square wave kicker have all been completed and presented. The processing and assembly of the prototype will be carried out next.