# DESIGN OF A DELTA-TYPE SUPERCONDUCTING UNDULATOR AT THE IHEP

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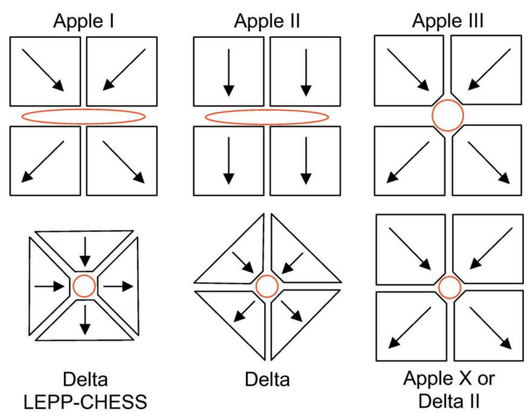
## ABSTRACT

Undulators play an important role in the 4th generation radiation light source. In order to satisfy different requirements of the experiments, various undulator structures have been proposed. The Delta-type undulator can provide circular polarized radiation. Conventional undulators are usually made of permanent magnets, but the application of the superconducting technology in the undulator is developing quickly. Compared to the permanent magnet undulators, superconducting undulators can provide higher photon flux with the same magnetic pole gap and period length, especially when the period length is longer than 20 mm. An R&D project is underway to produce a prototype of a Delta-type superconducting undulator with 28 mm long period and 12 mm gap at the IHEP. The structure design and the simulation results of the magnetic field are presented in this paper.

## Introduction

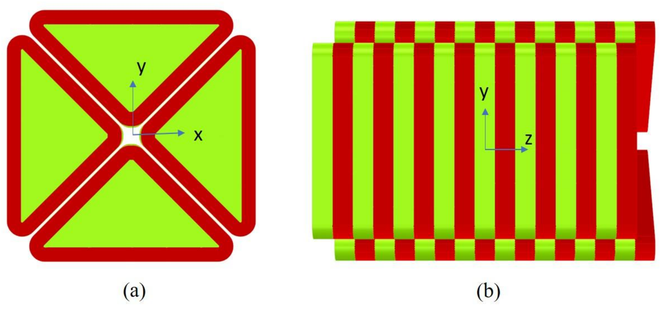
At the Institute of the High Energy Physics (IHEP) in China, a research group have been formed to study the SCUs. The SC magnets are arranged periodically and the coils are operated with alternating current pattern to create an undulatory magnetic field on axis. The field strength can be controlled by the current density.

Refer to the Delta-type permanent magnet undulator, IHEP insertion device group plans to build a prototype of a 0.5 m long Delta-type SCU device. The initial phase of the R&D project includes the intensive magnetic modeling performed with the OPERA-3D and the RADIA software packages. The simulation focuses on the magnetic design of the SCU including calculation of the peak field on the axis and the maximum field in the coils, superconductor load line optimization and the undulator correction coils.



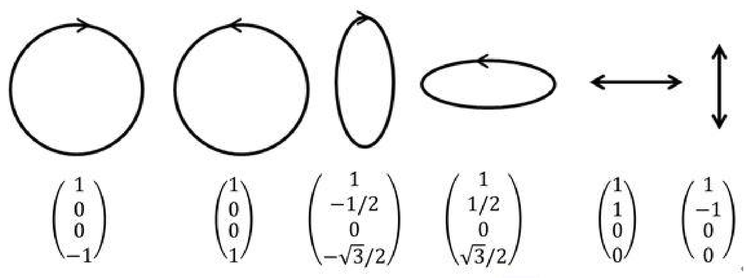

Different cross sections of Apple-type and Delta-type undulators.

## Delta-type SCU




Delta SCU cross-section and side view.

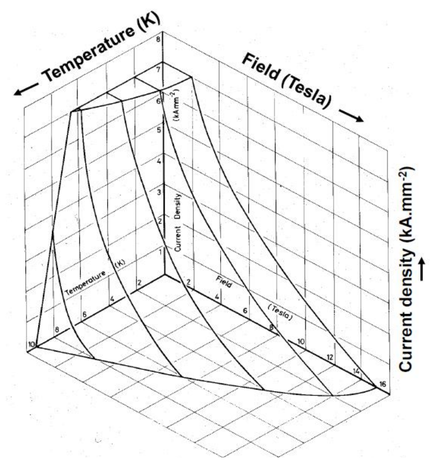
| Parameters | Values |
|---|---|
| Undulator length | ~0.5 m |
| Gap | 12 mm |
| Period | 28 mm |
| Groove deep | 6 mm |
| Peak field | ≥1T |

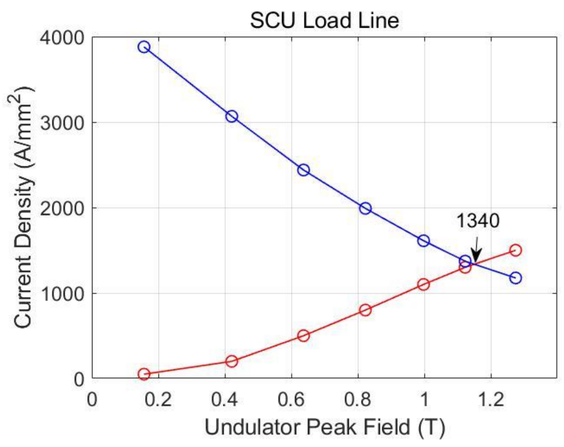



Typical polarization types with the corresponding Stokes parameters that can be provided by Delta-type SCU.

## Magnetic Field Characterizations

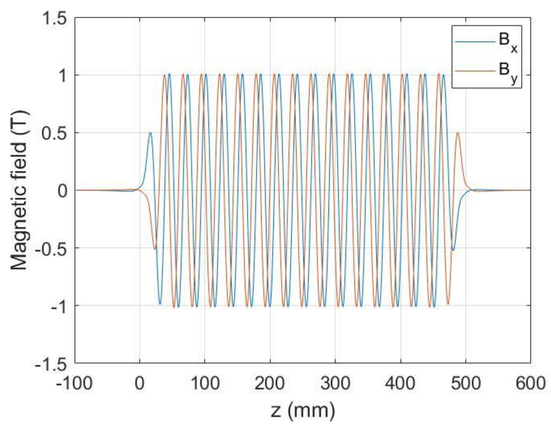
### *Load Line*



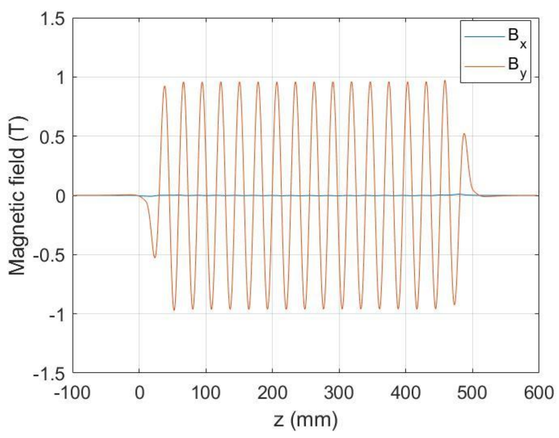




Critical current density 1340 A/mm$^2$, Operation current density 1100 A/mm$^2$

### *Field distribution*



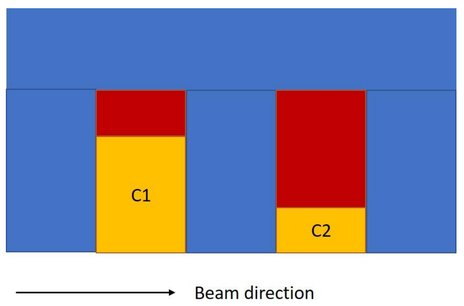

Circular mode



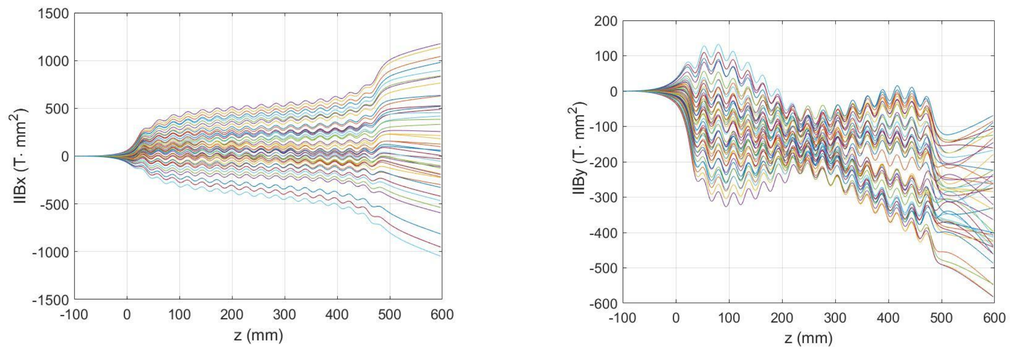

Linear mode

The vertical coils can contribute the horizontal magnetic field component on the axis and the horizontal coils can contribute the vertical magnetic field component.

### *Correction Coils*




Correction coils are wound on the two end grooves of both ends of the iron cores along with the main coils to provide the required end fields.




Second integral of the horizontal (left) and vertical (right) magnetic field component with different current density.

## SUMMARY

An R&D project is undergoing at the IHEP aiming to build a prototype of a Delta-type SCU. In this paper, we introduce the primary design of the Delta-type SCU containing the magnetic field calculation by using OPERA-3D and RADIA software packages. The Delta-type SCU can generate circular and linear polarization photon beams. In order to reach the designed magnetic peak field (1 T) on axis, at least a current density of 1100 A/mm$^2$ is required. Correction coils are applied on both ends of each core to adjust the end fields. The second integral of the magnetic fields with different correction current are also calculated. Further studies for the Delta-type SCU are required to optimize the physical parameters.