中国科学技术大学
University of Science and Technology of China
STCF

Injector and positron source of STCF in China

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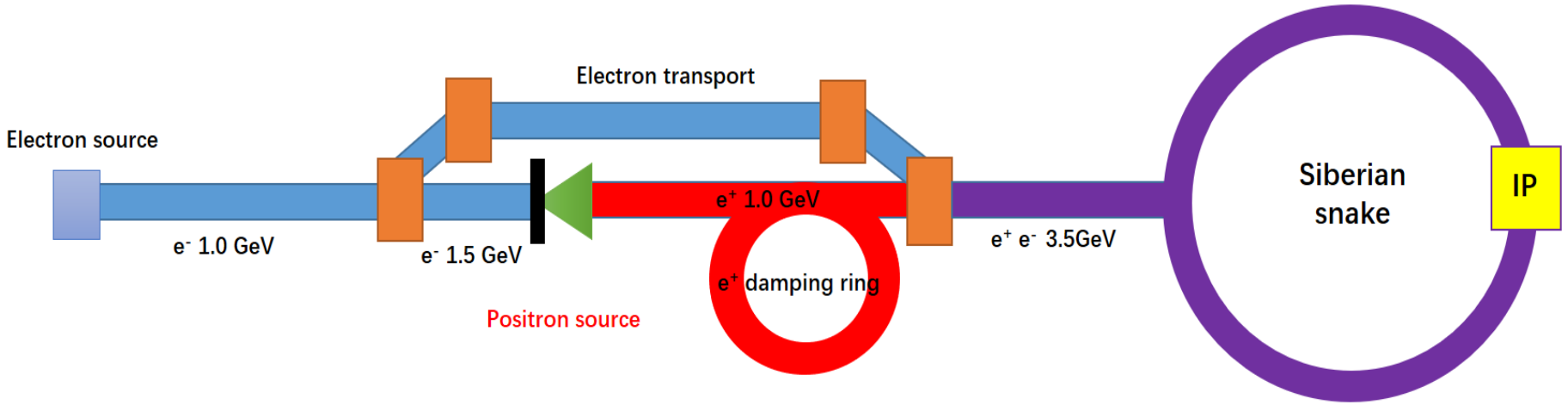
Workshop on future Super c-tau factories 2021

Contents

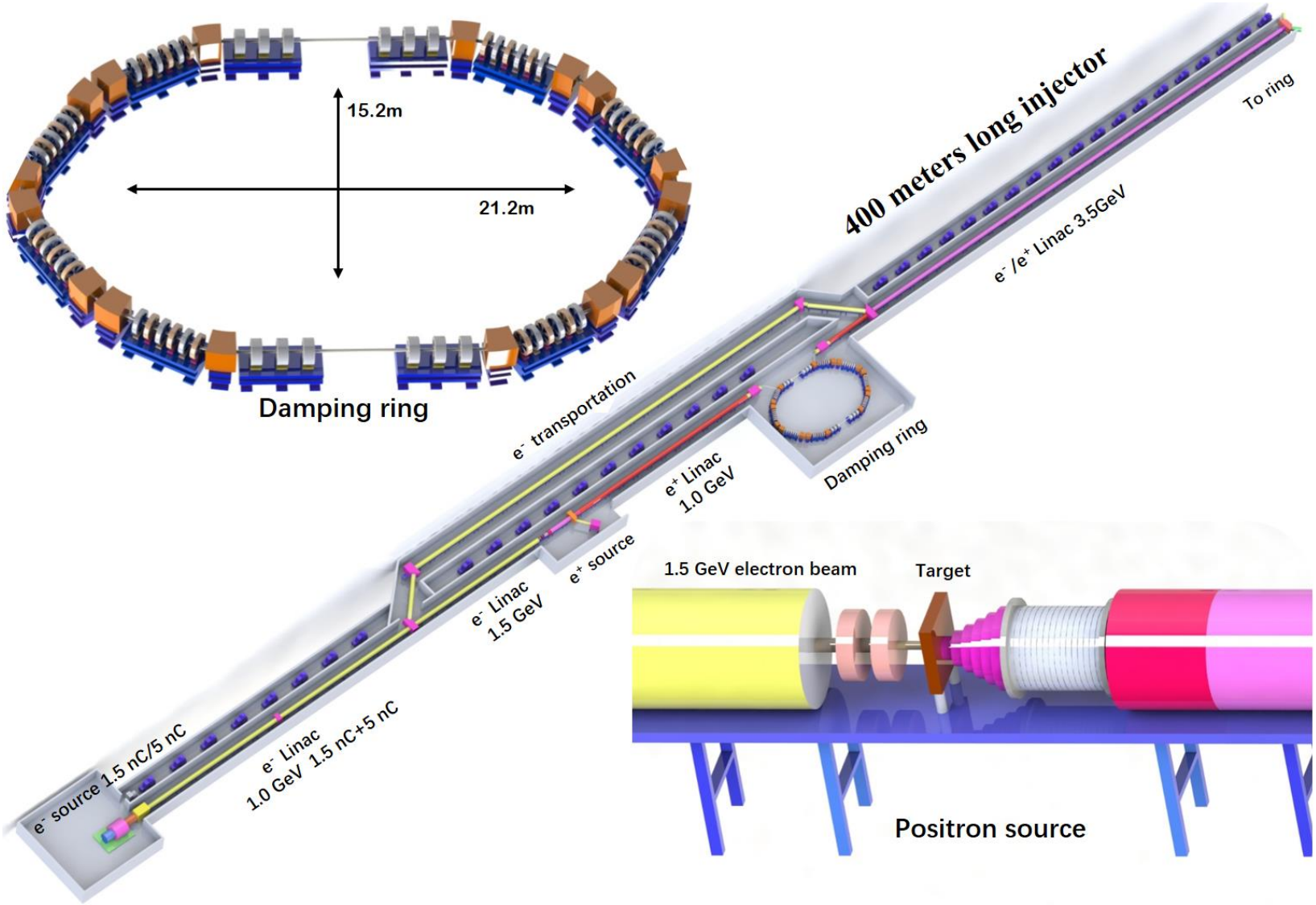
The Super Tau-Charm Facility in China

STCF

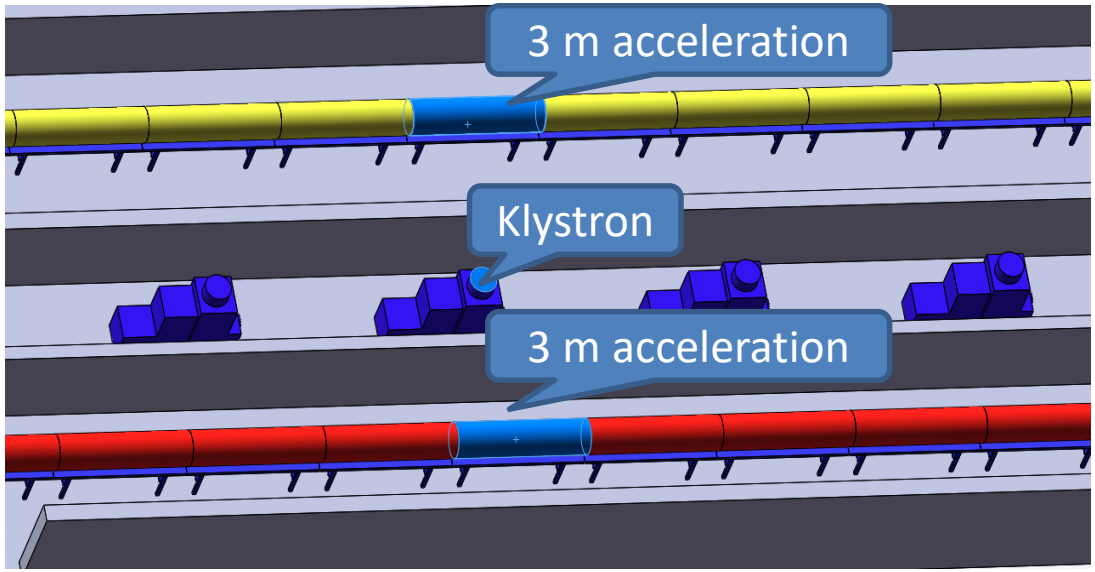


Parameter	Value
Perimeter/m	600~800
Optimized beam energy/GeV	2
Energy/GeV	1-3.5
Current/A	1.5
Emittance$(\varepsilon_x/\varepsilon_y)$/nm·rad	5/0.05
$\beta(\beta_x^*/\beta_y^*)$/mm	90/0.9
Crossing Angle 2θ/mrad	60
Frequency shift ξy	0.06
Hourglass	0.8
Luminosity/$\times 10^{35}$cm^{-2}s^{-1}	≥0.5

The injector of STCF

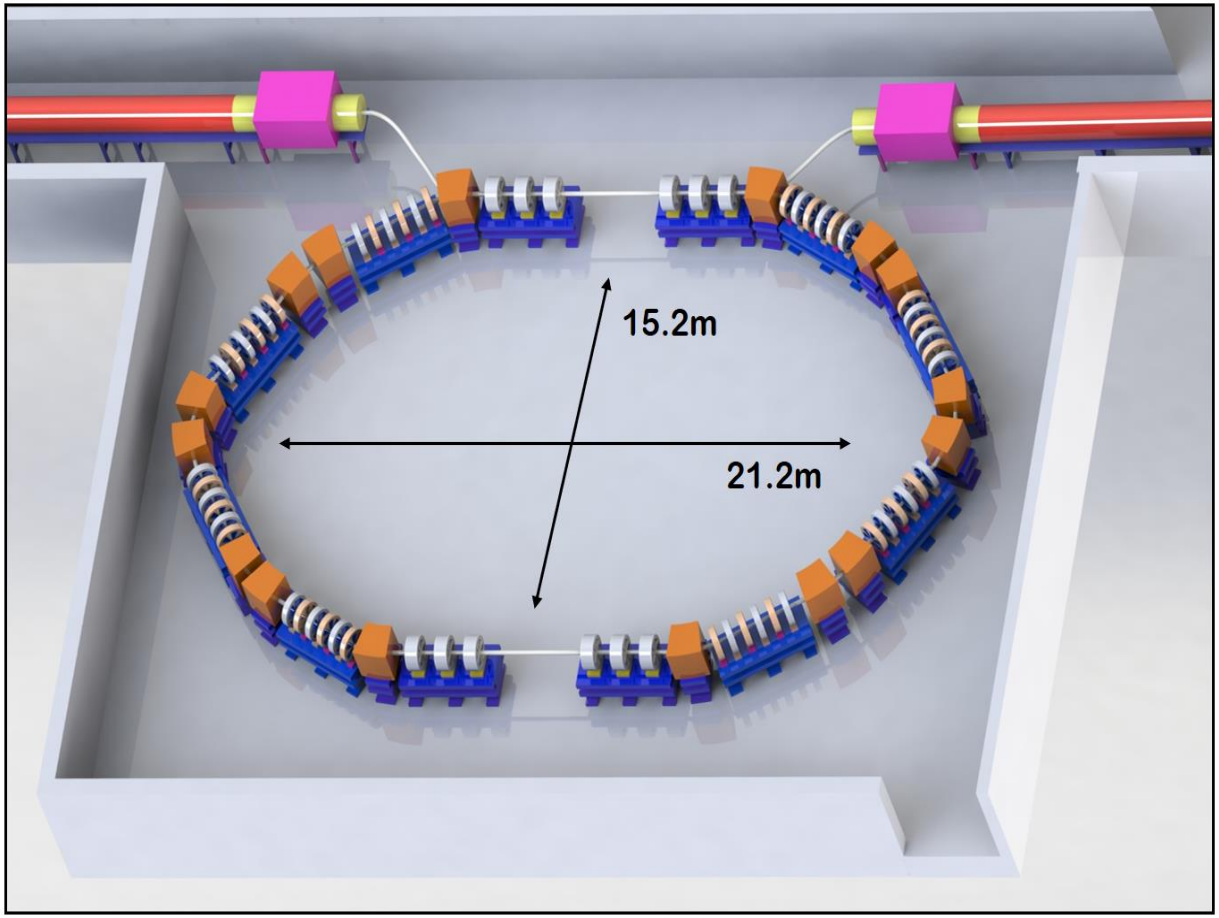


Acceleration structure



Parameter	Value
Klystron	1
Frequency， f_0	2856 MHz
Repetition frequency	0-50 Hz
Peak power	50 MW
Pulse width	3.5 μs
SLED	1
Amplification factor	5
output power	250 MW
Number of acceleration	2
Accelerating gradient	23MeV/m
Energy gain	134MeV

Damping ring



Parameter	Value
Energy	1.0 GeV
Perimeter	~58 mm
Repetition frequency	50 Hz
Bending radius	2.7 m
Dipole magnets, B_0	1.4 T
Momentum compression factor , α_c	0.076
U_0	35.8 keV
Damping time x/y/z	12/12/6 ms
δ_0	0.05%
ε_0	287.4 mm·mrad
Bunch length	7 mm
ε_{inj}	2500 mm·mrad
$\varepsilon_{ext\ x/y}$	704/471 mm·mrad
$\delta_{inj}/\delta_{ext}$	0.3/0.06
Divergence of energy	1%
f_{rf}	650 MHz
V_{rf}	1.8 Mv

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II. The thermal research of single-crystal tungsten target

III. The new target design for positron

Thermal conductivity of single crystal tungsten

The thermal conduction can be presented as

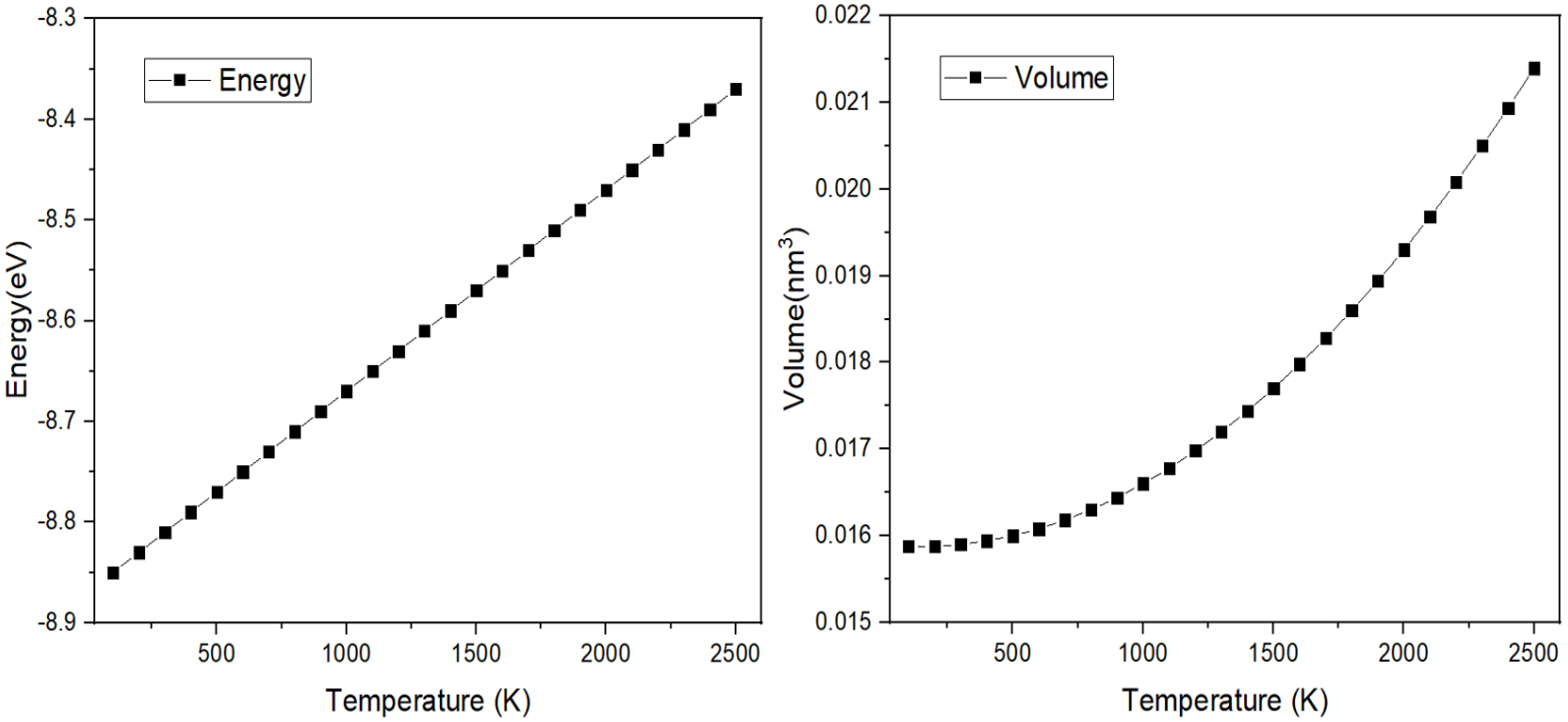
$$k = \frac{J}{\partial T / \partial x}$$

The empirical N-body potential was used for tungsten by Finnis and Sinclair. In the F–S potential, the total potential energy of system is expressed as

$$E = E_p + E_N$$

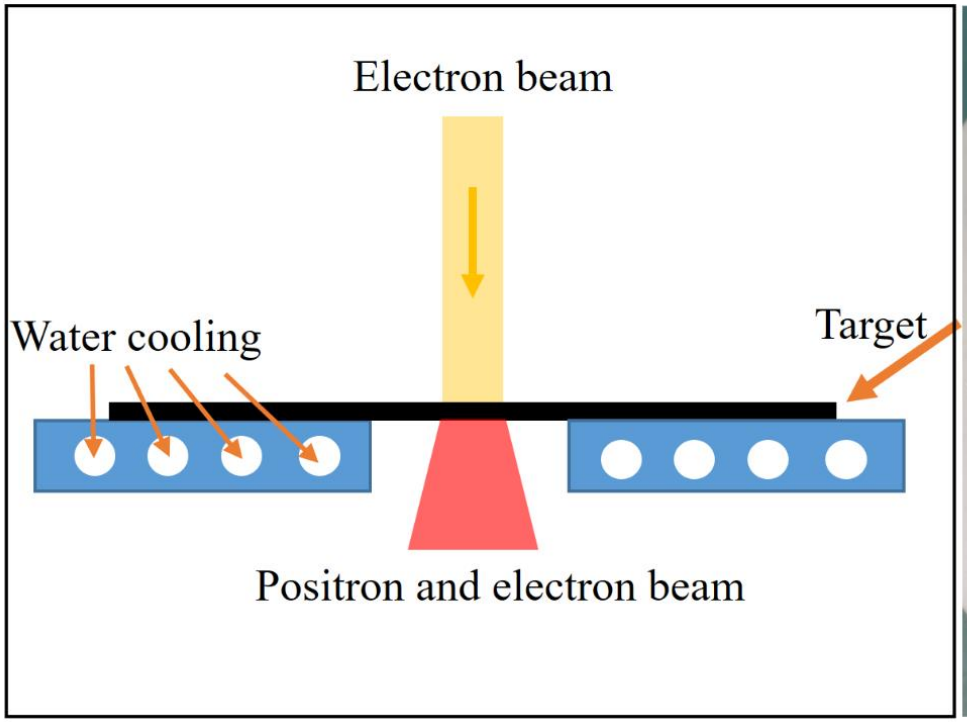
$$\varphi(r_{ij}) = \begin{cases} B & r_{ij} \leqslant r_{c1} \\ B_0 + B_1 r_{ij} + B_2 r_{ij}^2 & r_{c1} < r_{ij} < r_{c2} \\ (r_{ij} - d)^2 & r_{c2} \leqslant r_{ij} < d \\ 0 & r_{ij} \geqslant d \end{cases}$$

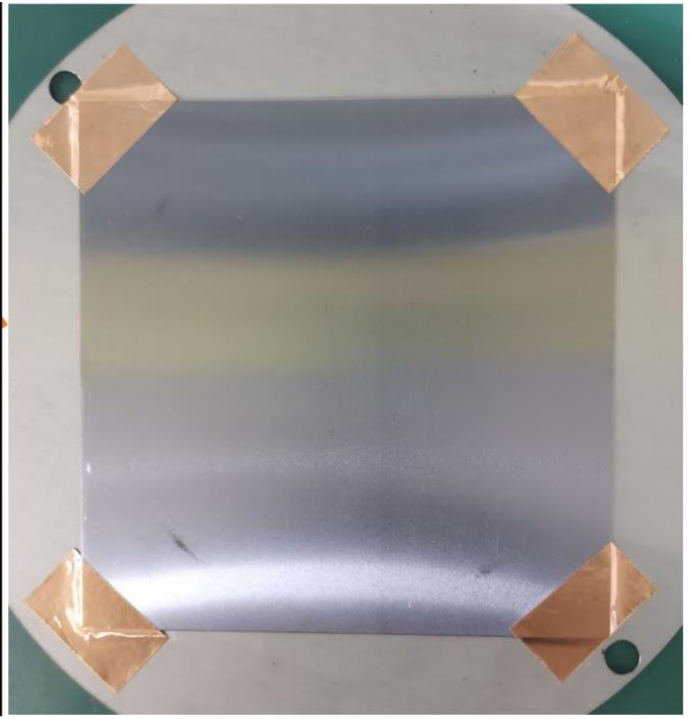
Positron source for STCF

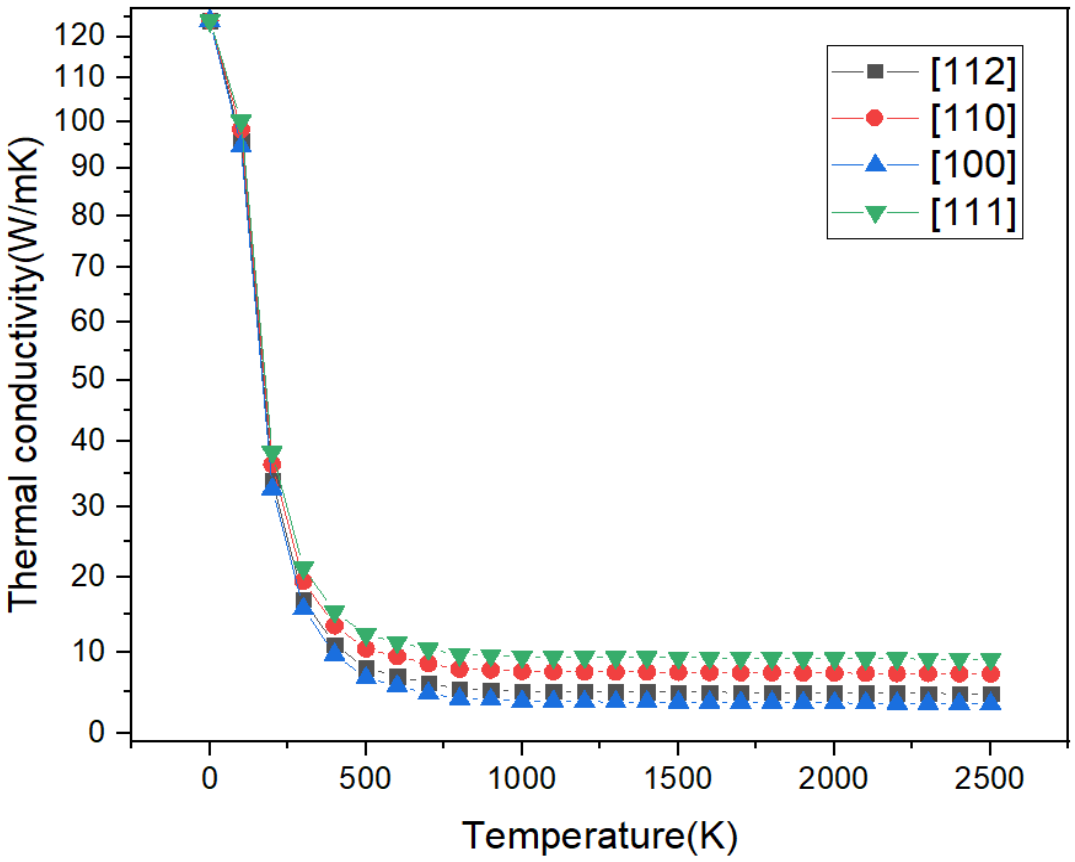


The time averaged total energy of one tungsten atom (left) and the time averaged volume (right) as functions of temperature.

Experimental results of thermal conductivity of single crystal tungsten

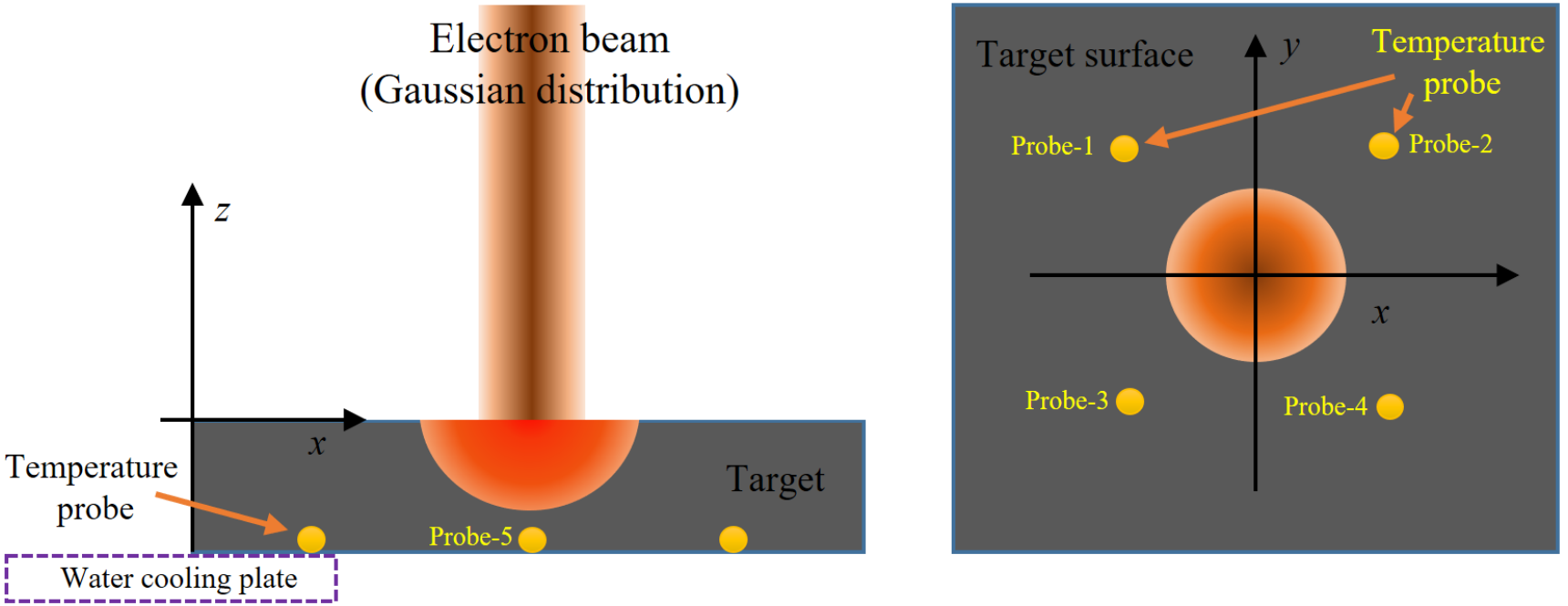






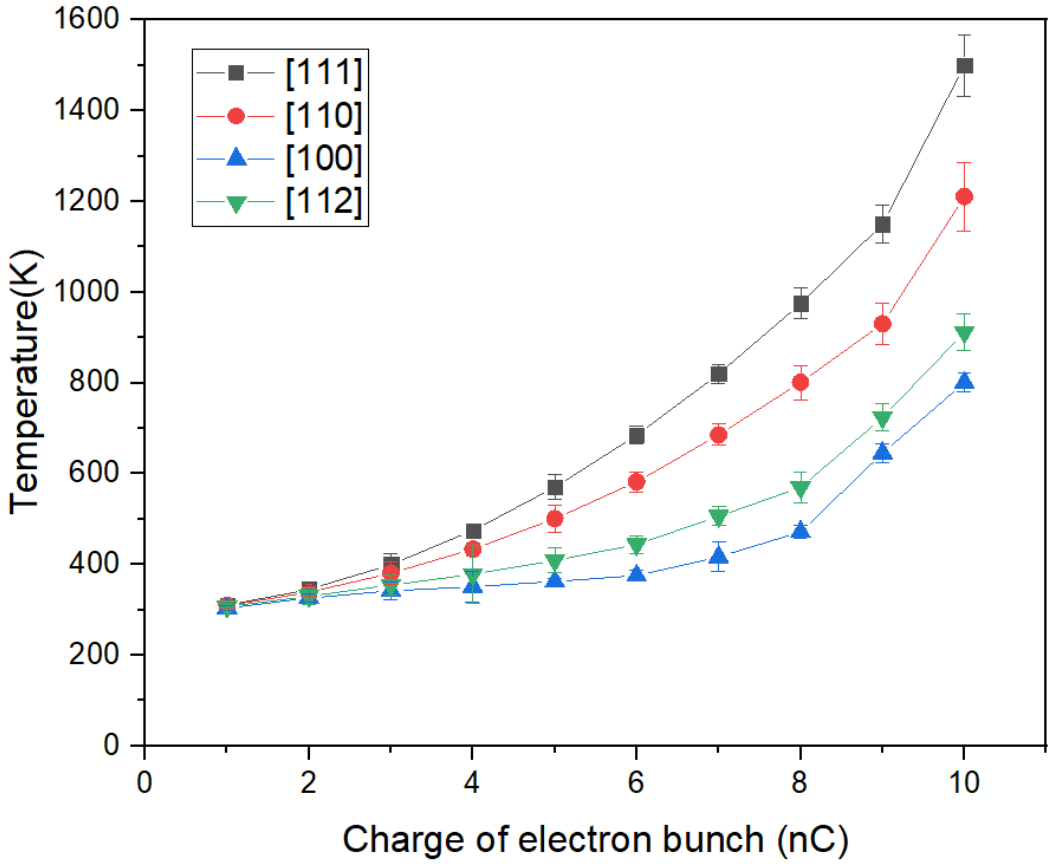
Simulation results of the thermal conductivity for different crystallographic orientation of various temperatures

Positron source for STCF



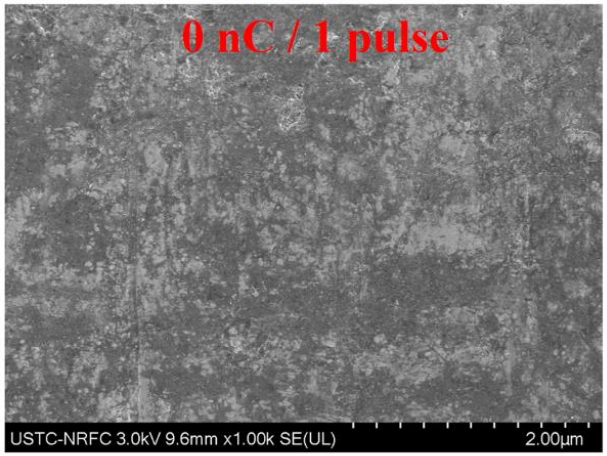
The experiment diagram of thermal conductivity measurement

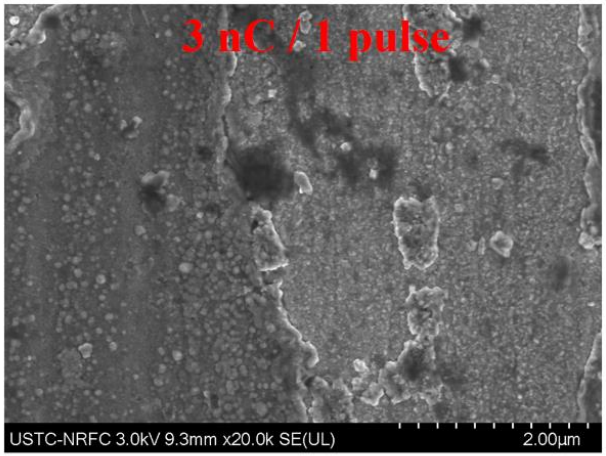
Positron source for STCF

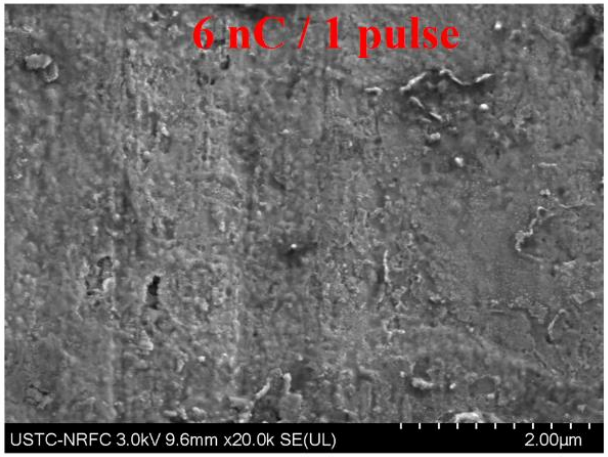


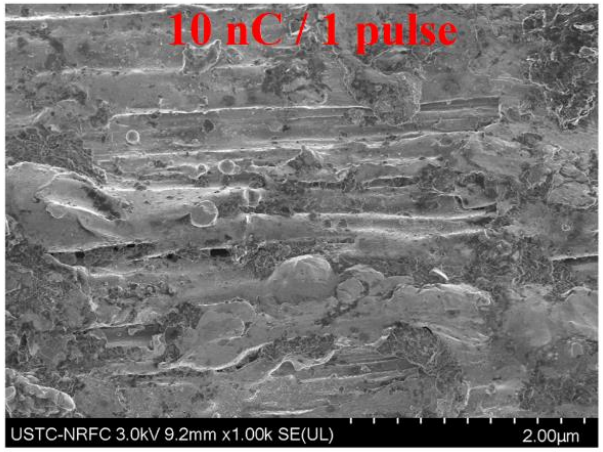
The experimental results of thermal conductivity with different crystallographic orientations

Positron source for STCF

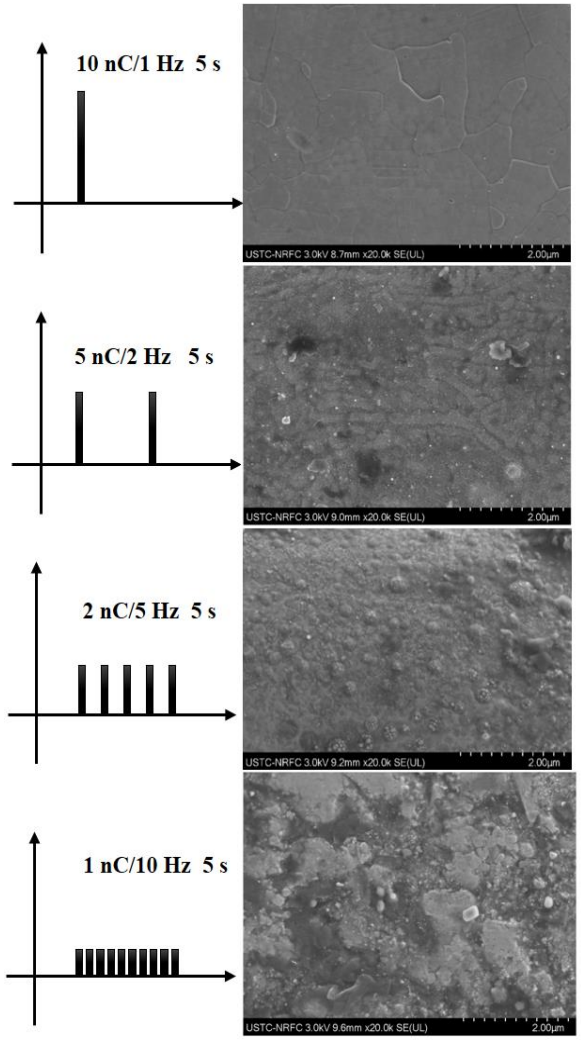








Positron source for STCF



A pulsed electron beam with different pulse structures but the same power was used to bombard the crystal tungsten target to study what conditions recrystallization occurred. Fig. 9 shows the results of 4 kinds of pulse structures. All structures had the same bombardment time of 5 seconds. It can be seen from the SEM results that there was obvious recrystallization at a time structure of 10 nC/1 Hz, slight recrystallization at 5 nc/2 Hz, and no recrystallization at 2 nc/5 Hz and 1 nC/10 Hz. This series of experiments shows that the main factor of recrystallization is not the average power of the bombardment electron beam but the relatively strong instantaneous power.

Positron source for STCF

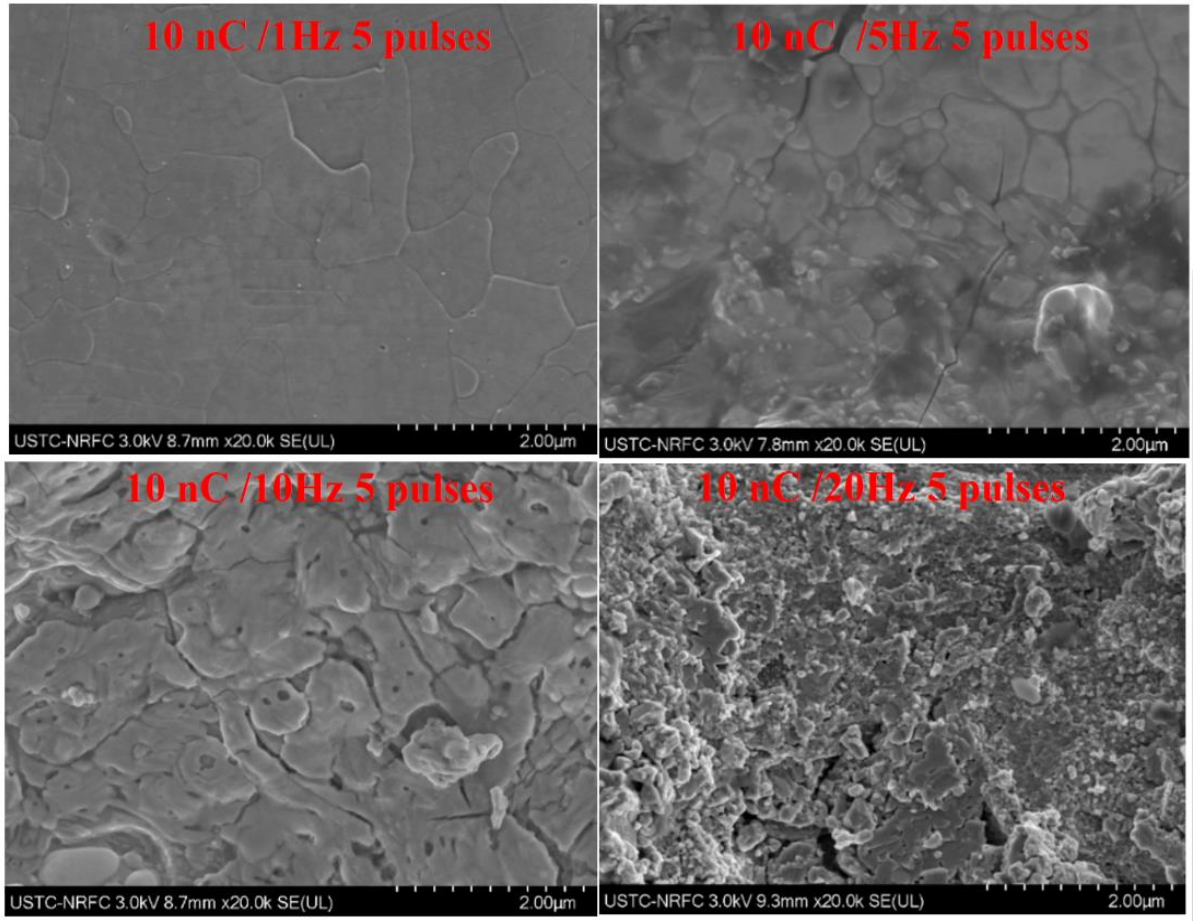


Table III Thermal conductivity changes in thermal conductivity after different electron beam bombardment

Electron beam	Thermal conductivity (relatively)
0	1
10 nC single pulse	1.18
10 nC/1 Hz 5 s	1.12
10 nC/5 Hz 5 s	1.24
10 nC/10 Hz 5 s	2.02
10 nC/20 Hz 5 s	4.12

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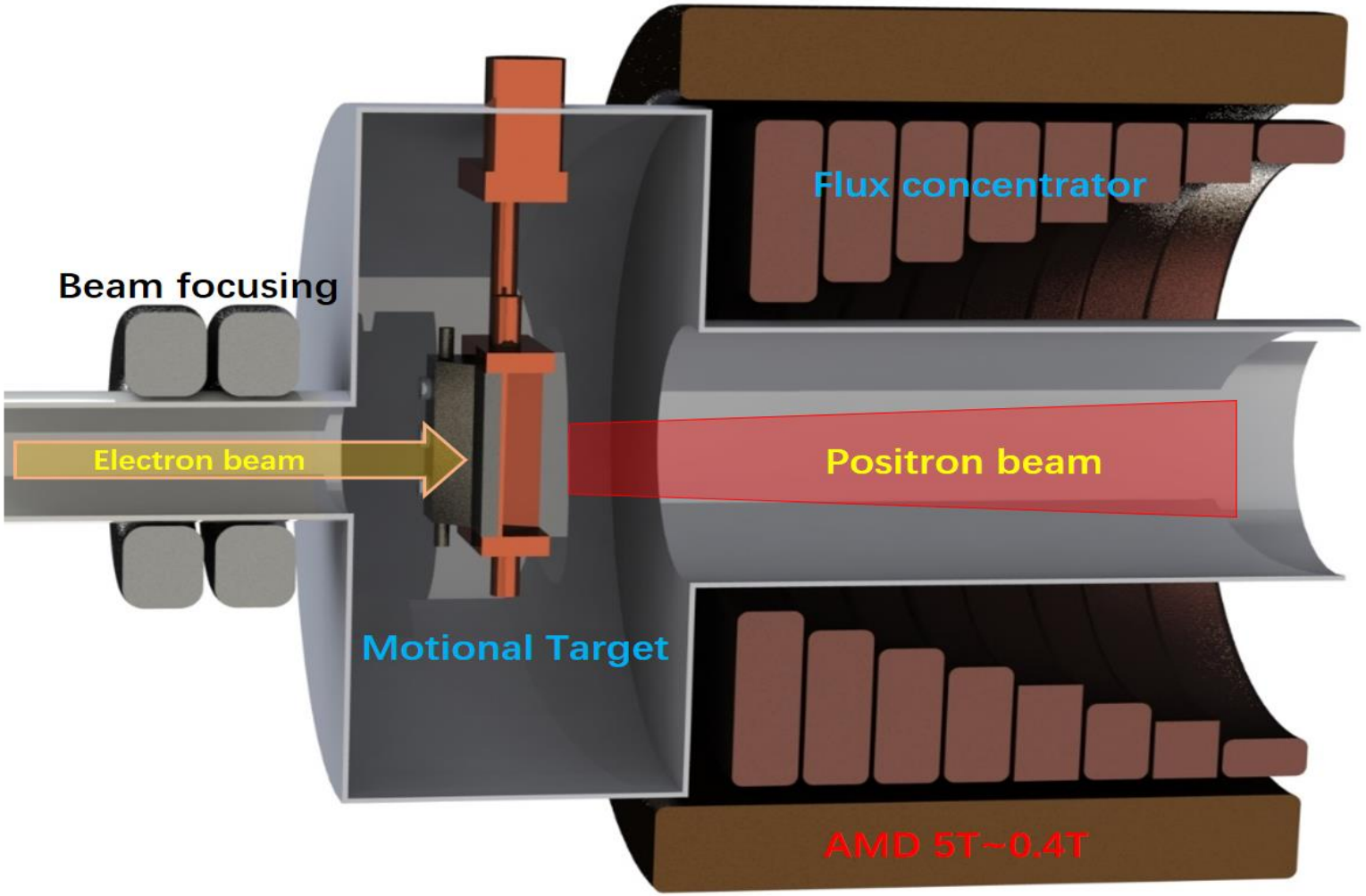
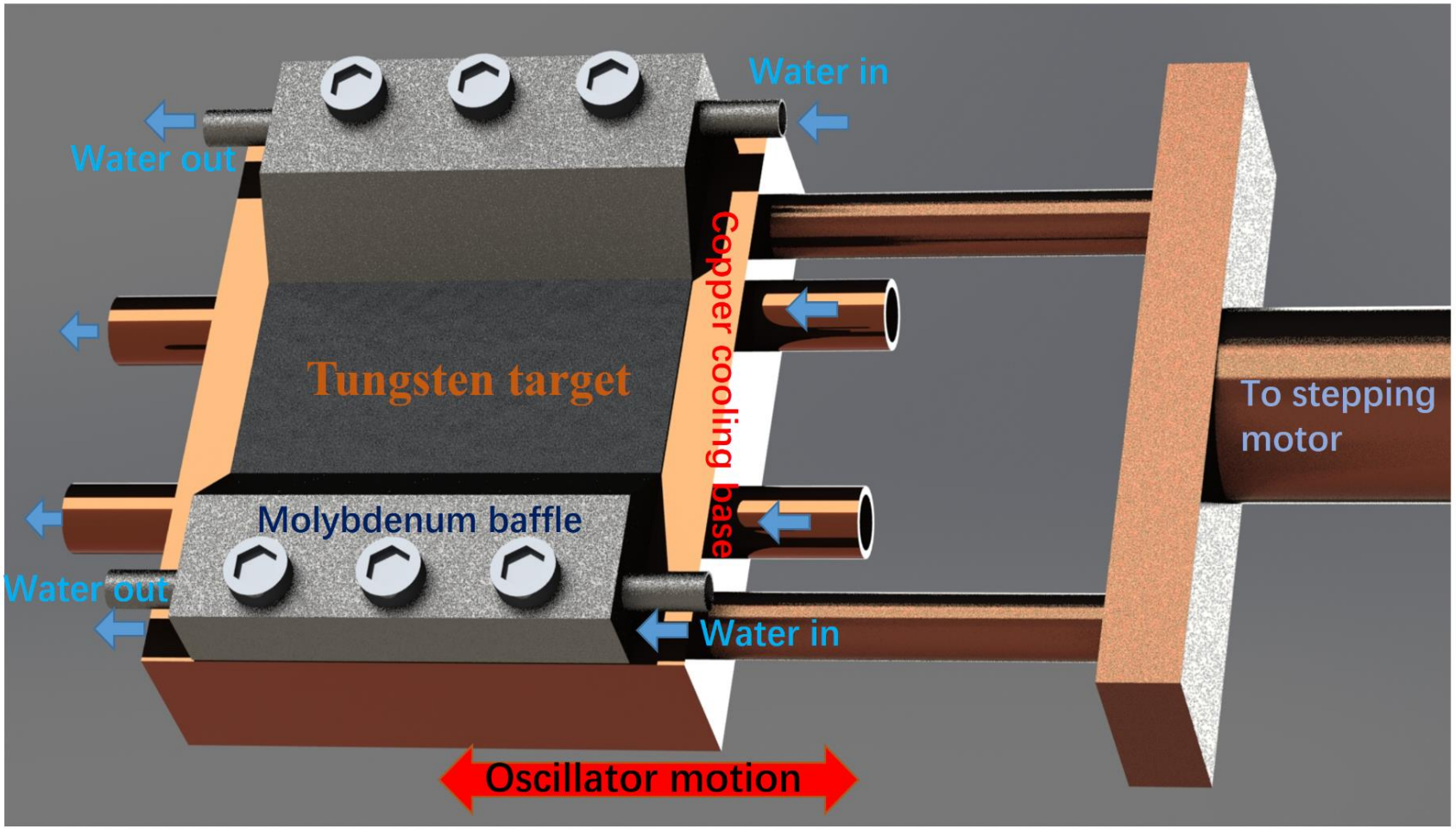
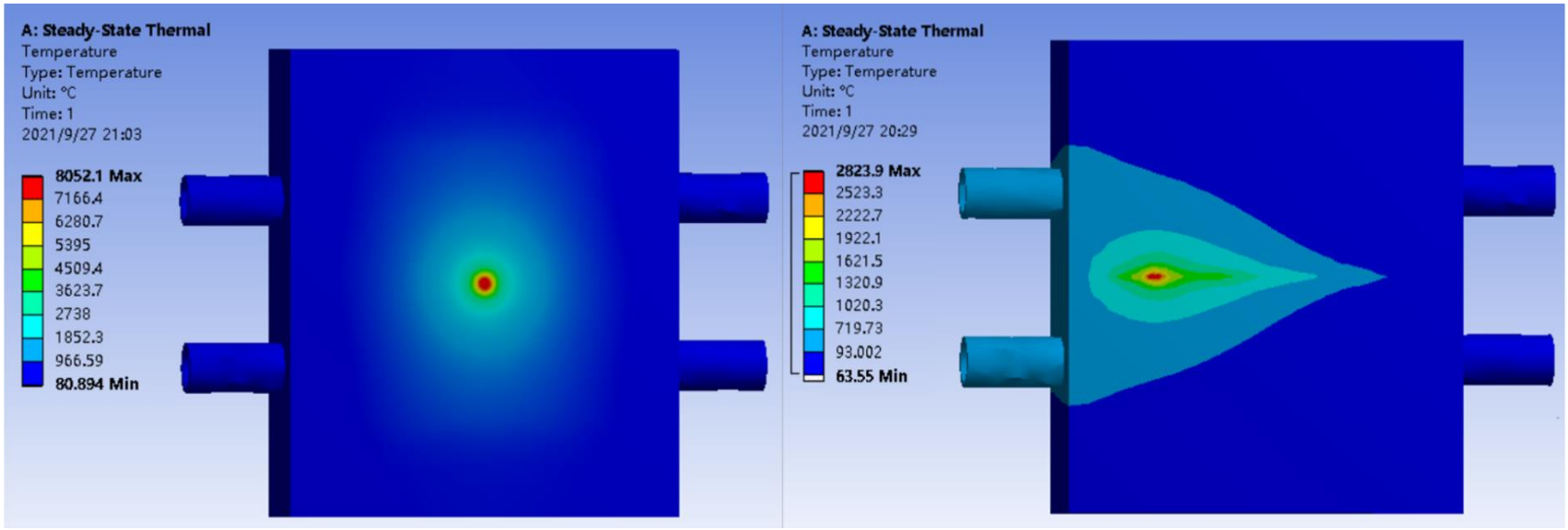
The positron production system



The motional target for positron production

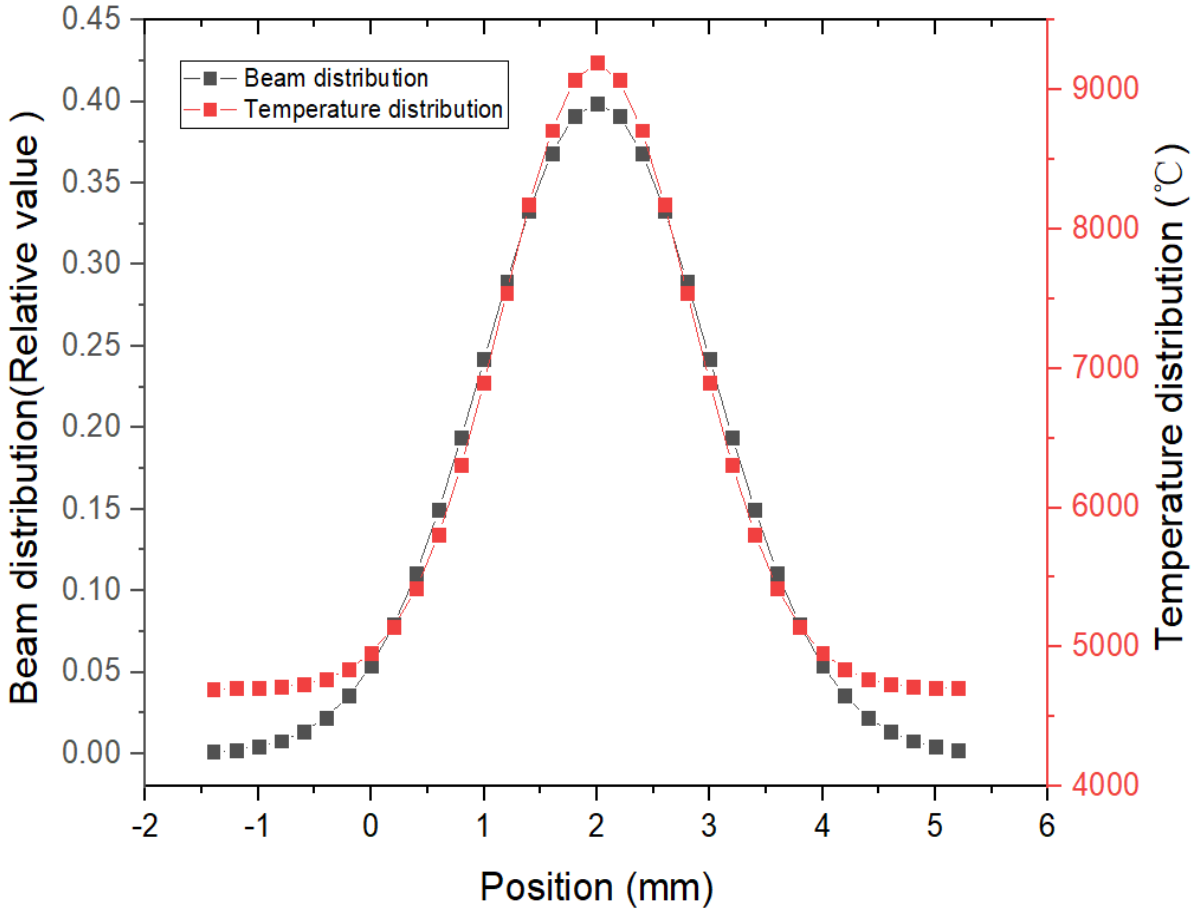


Thermal simulation for motional target



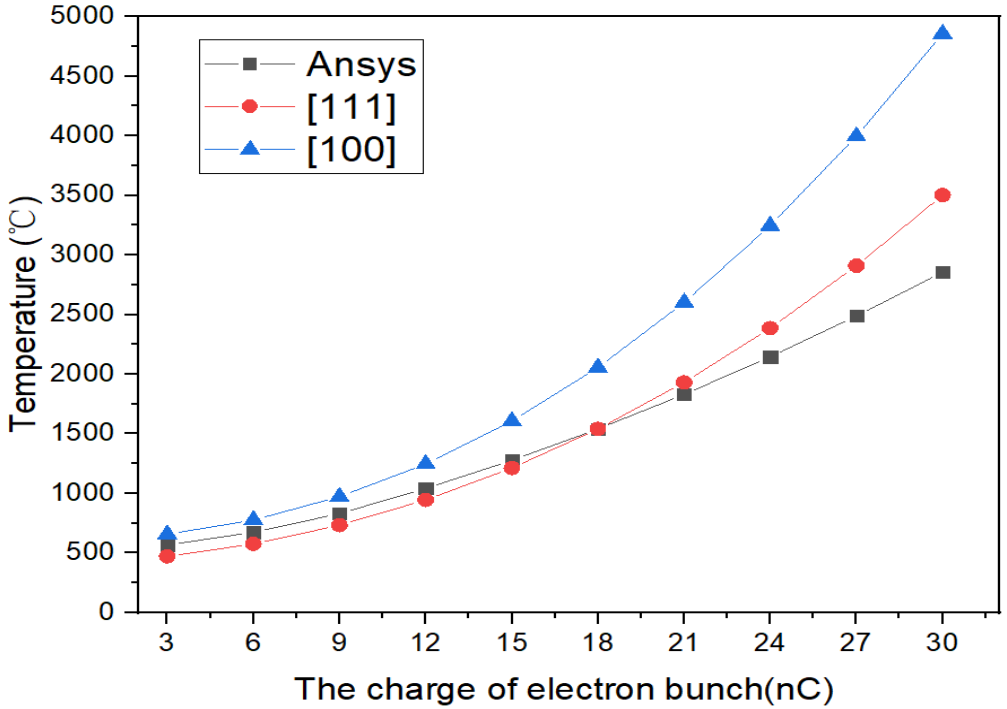
Simulation results of the static target (left) with strong water cooling and the motional target (right) with the same water cooling

Positron source for STCF



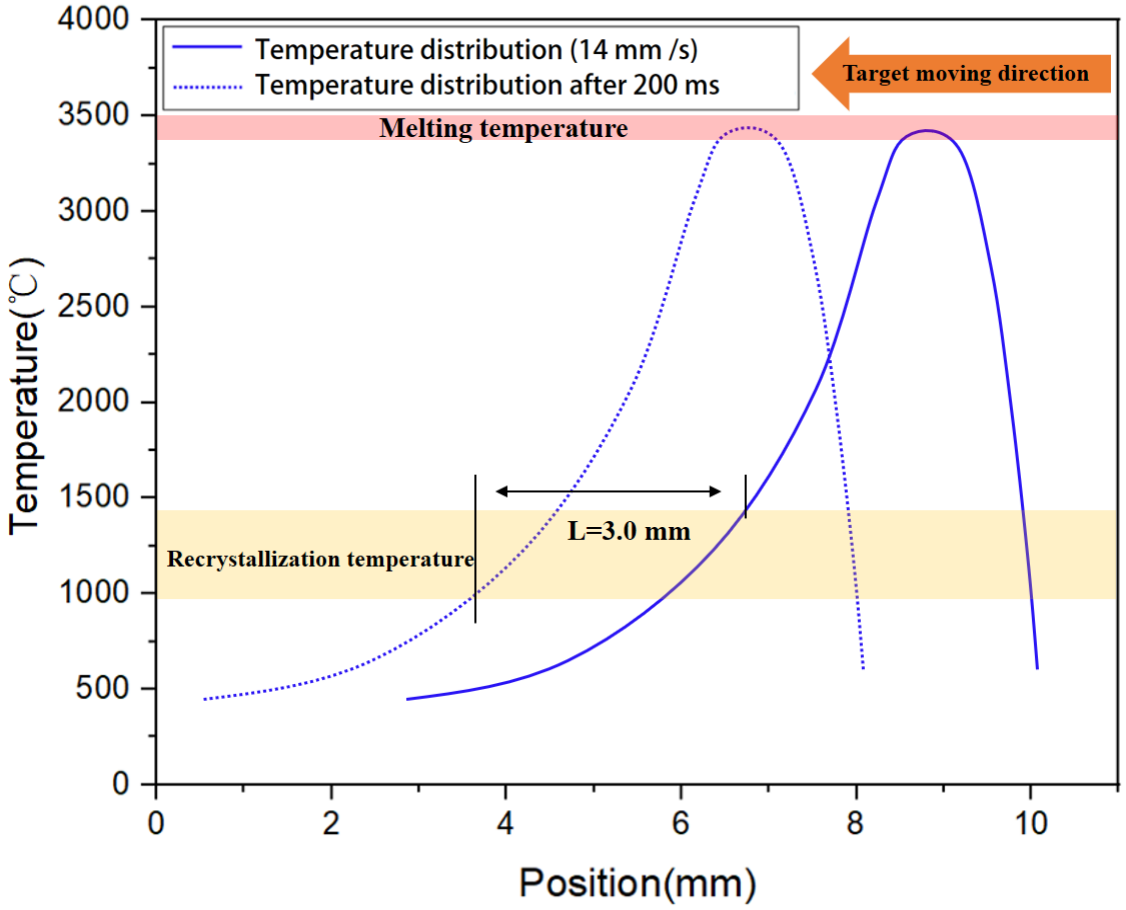
The electron beam distribution and temperature distribution when the target is stationary (30 nC/100 Hz 1.5 GeV)

Positron source for STCF



The difference between thermal simulation results considering and not considering the influence of the crystallographic orientation on thermal conductivity of various electron bunch charge. The repetition frequency is fixed at 100 Hz, electron energy is fixed at 1.5 GeV. Positive triangle - the thermal conductivity comes from the molecular dynamics simulation of [100] crystallographic orientation. Round - the thermal conductivity comes from the molecular dynamics simulation of [111] crystallographic orientation. Square –the thermal conductivity comes from the Ansys database for tungsten.

Positron source for STCF

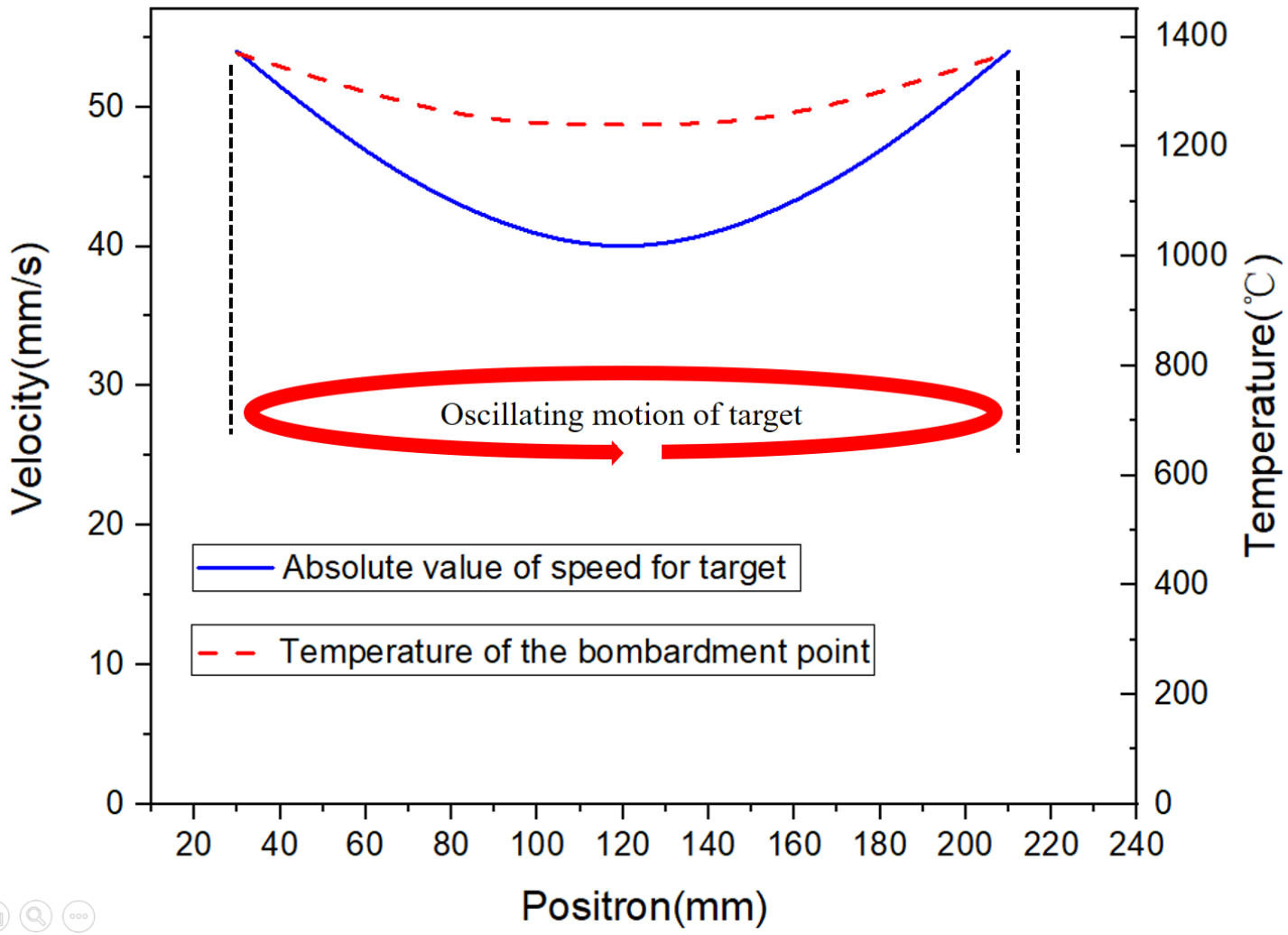


The temperature distribution when the target moves with the target speed of 14 mm/s (30 nC/100 Hz 1.5 GeV, 14 mm/s is melting point velocity)

Positron source for STCF

Speed of the target (mm/s)	Temperature (℃)	Thermal effect
＜14	＞3401	Melting point exists
14-38	1400 -3401	Disordered recrystallization
38	1400	High recrystallization temperature
38-54	1231 -1400	Gentle recrystallization
54	1231	Minimum recrystallization time
54-177	900-1231	Incomplete recrystallization
＞177	＜900	Non-recrystallization

Positron source for STCF



Thanks for your attention !