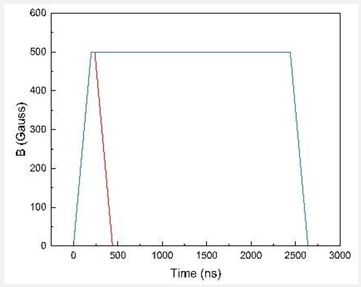
Progress in Coating on Inwall of the Ceramic Vacuum Chamber for the Collider Ring's Kicker of CEPC

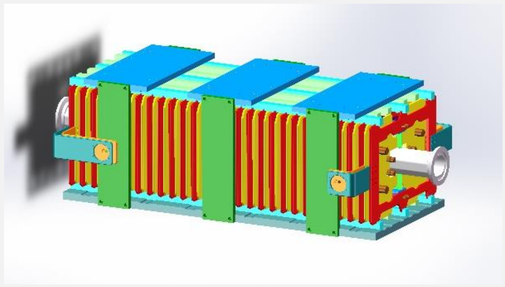
Zilin Chen[a,b], Guanjian Wu[a,b], Sen Yue[a,b], Pilong Tian[a], Jinhui Chen[a,b], Na Wang[a,b], Xiaohua Peng[a] , Ping He[a,b, ✶]

a Institute of High Energy Physics, CAS; **b** University of Chinese Academy of Sciences; ✶ heping@ihep.ac.cn

Introduction

The magnetic field waveform of the kicker of the collider ring of the CEPC is a trapezoidal wave with a rising edge (falling edge) of 200 ns and a flat top time of 0-1980 ns. Adapted to the kicker is a 1200 mm-long coated ceramic vacuum chamber.



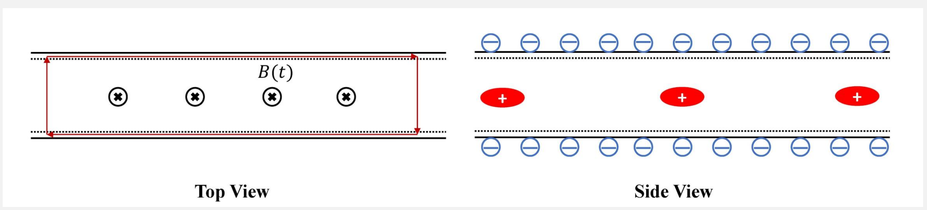


Why a ceramic vacuum chamber?

Due to the eddy-current shielding effect, the fast-pulse magnetic field cannot maintain the original waveform when it penetrates the metal vacuum chamber.

Why coating?

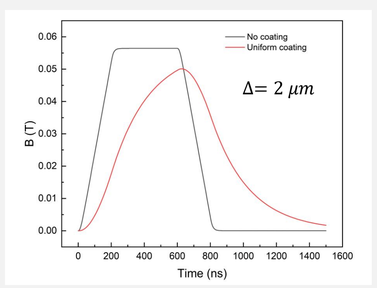
As an insulating material, ceramic cannot conduct the image charges induced by the beams, and the charges are stacked on the ceramic wall to produce a great impedance to the beams.



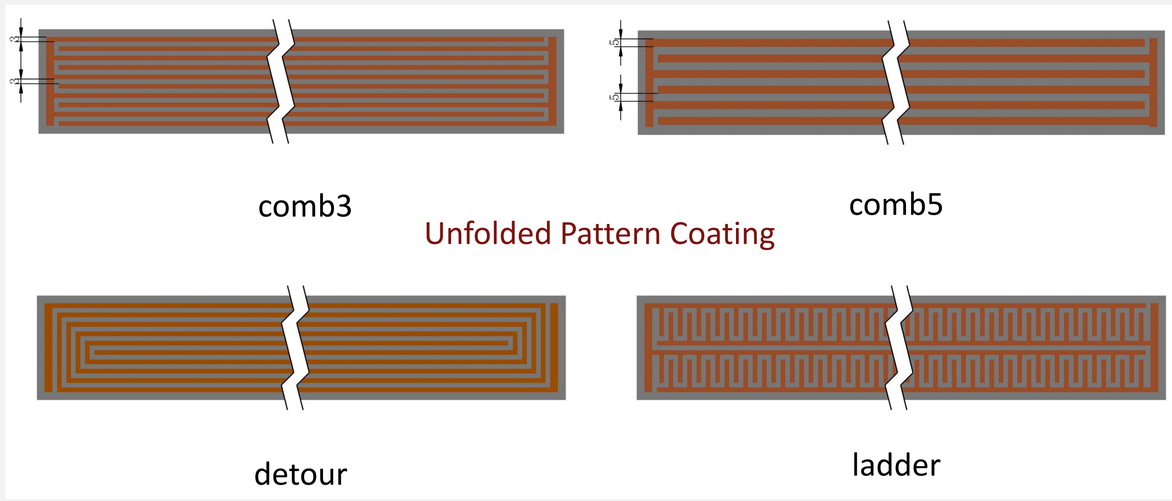
Coating Material: Titanium nitride (TiN), Δ is thickness

- Widely used in ceramic vacuum chamber coating
- Higher conductivity than pure titanium
- Lower secondary electron yield

Long loop, Fast pulse → Uniform coating is ineffective. → Pattern Coating



Effect of the Pattern Coating on the Magnetic Field



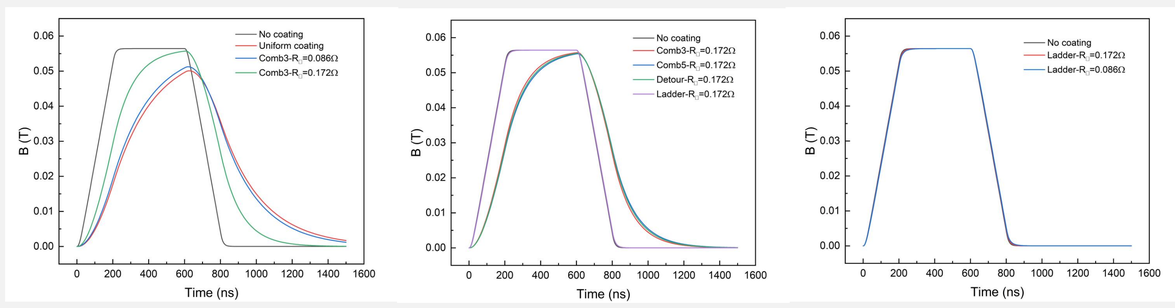
Simulation software: **COMSOL**

In order to simplify meshing, the coating in the model is equivalent according to the following principle of equal square resistance,

$$R_{\square} = \frac{1}{\sigma\Delta},\ \sigma \text{ is conductivity.}$$

Taking a magnetic field waveform with a flat top time of 400 ns as an example.

$$\Delta = 2\ \mu m, \sigma = 5.8 \times 10^6\ S/m^*\ \text{TiN coating}$$
$$\Leftrightarrow \Delta = 1\ mm,\ \sigma = 11600\ S/m\ \text{film}$$



Comb and detour-shaped pattern coatings are **incapable** of maintaining magnetic field waveform, even if the film's square resistance is increased.

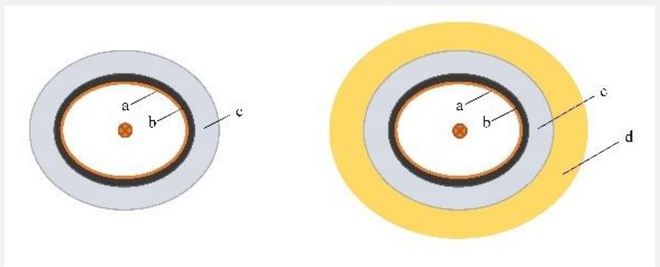
Ladder pattern coating has little effect on magnetic field and is not sensitive to conductivity. **Ladder will be the preferred coating pattern**.

*Y.H.Chin, S.Lee, K.Takata, T.Toyama, Impedance and radiation generated by a ceramic chamber with RF shields and TiN coating, 2006.

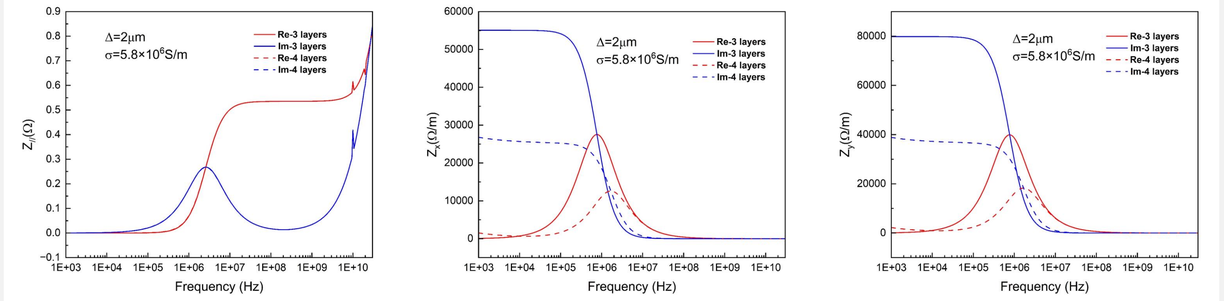
Estimation of the Impedance

Computational Idea:

- **IW2D** calculates the wall resistance of uniform coating as a reference.
- Select the suitable modeling method for uniform coating in **CST** to bring the results close to IW2D.
- Model pattern coatings in CST to calculate impedance.



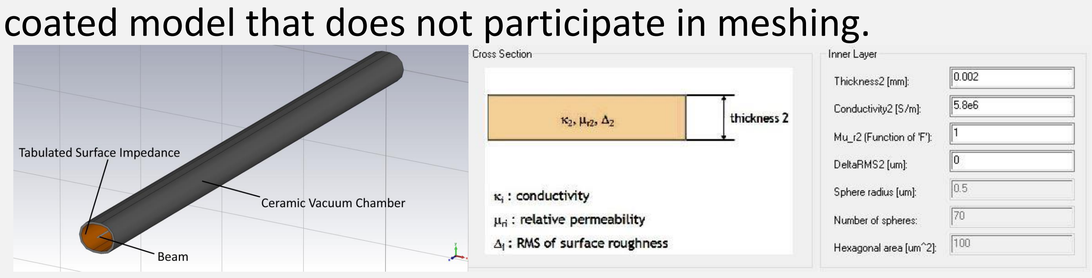
In IW2D a:2 μm TiN, b: 5 mm Ceramic chamber, c:5 mm Air, d:PEC



Micron-sized coatings make it difficult to mesh models in **CST**.

Tabulated Surface Impedance:

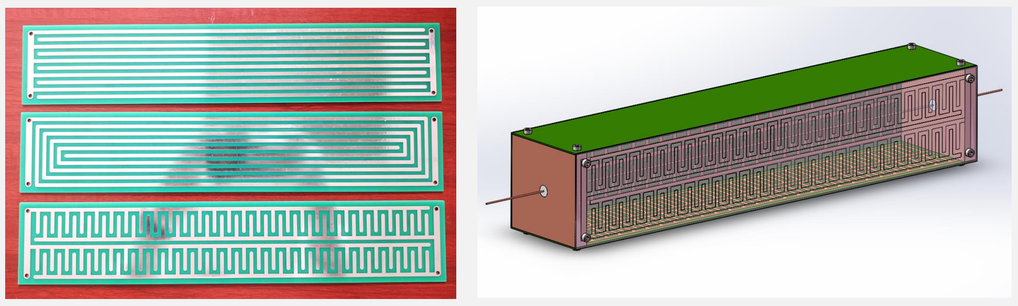
A coated model that does not participate in meshing.



The longitudinal impedance of the uniform coating is 1 Ω or less.

The transverse impedance converges at a wake length of about 50 m, and the results are similar to IW2D.

More results are being calculated……



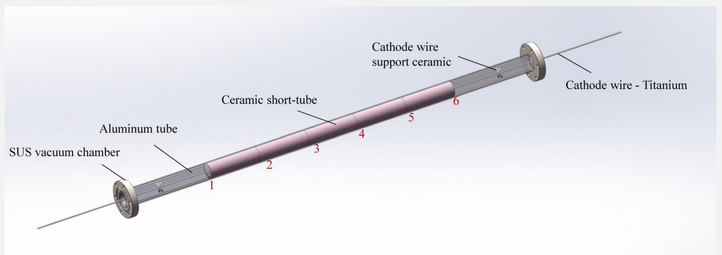
The coating patterns printed on PCBs and the concept design of testing transmission characteristics by **coaxial line** . (The Figure Above)

Coating Experiments

Based on the coating of the circular ceramic vacuum chamber, the coating process is explored.

Adjusting different parameters, the conductivity of pure TiN coating is always lower than expected.

Doping silver or copper in TiN to improve conductivity.



coating	conductivity	roughness
TiN	376000 S/m	smooth
TiN-Cu	1807000 S/m	rough
TiN-Ag	6230000 S/m	smooth