

DESIGN AND CALCULATION OF THE VACUUM SYSTEM FOR HIGH-ENERGY LINEAR ACCELERATOR AND TEST BENCH

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Project one

The project involves a high-current electron linear accelerator with a maximum energy of 40 MeV. For the high-power long-pulse mode, the normal operating condition is single-pulse mode, with a beam current of 100 mA, a pulse duration of 0.1 s, and a bunch repetition frequency of 100 Hz, with a maximum average repetition rate of 10 Hz. The total length of the linear accelerator is approximately 6.3 meters, and the vacuum system is divided into four sections. Specific vacuum requirements are listed in Table 1.

Table 1: Parameters of the vacuum(unit:Pa)		
Name	Static pressure ¹	Dynamic pressure ²
Electron gun section	<1×10 ⁻⁷	<2×10 ⁻⁶
Focusing Segment	<5×10 ⁻⁶	<1×10 ⁻⁵
DUMP Section	<5×10 ⁻⁶	<1×10 ⁻⁵
Quick-adjust tube	<5×10 ⁻⁶	<1×10 ⁻⁵

- Explanation:
1. Represents the pressure value when there is no microwave power or high voltage;
 2. 2. Represents the pressure value under normal operating conditions.

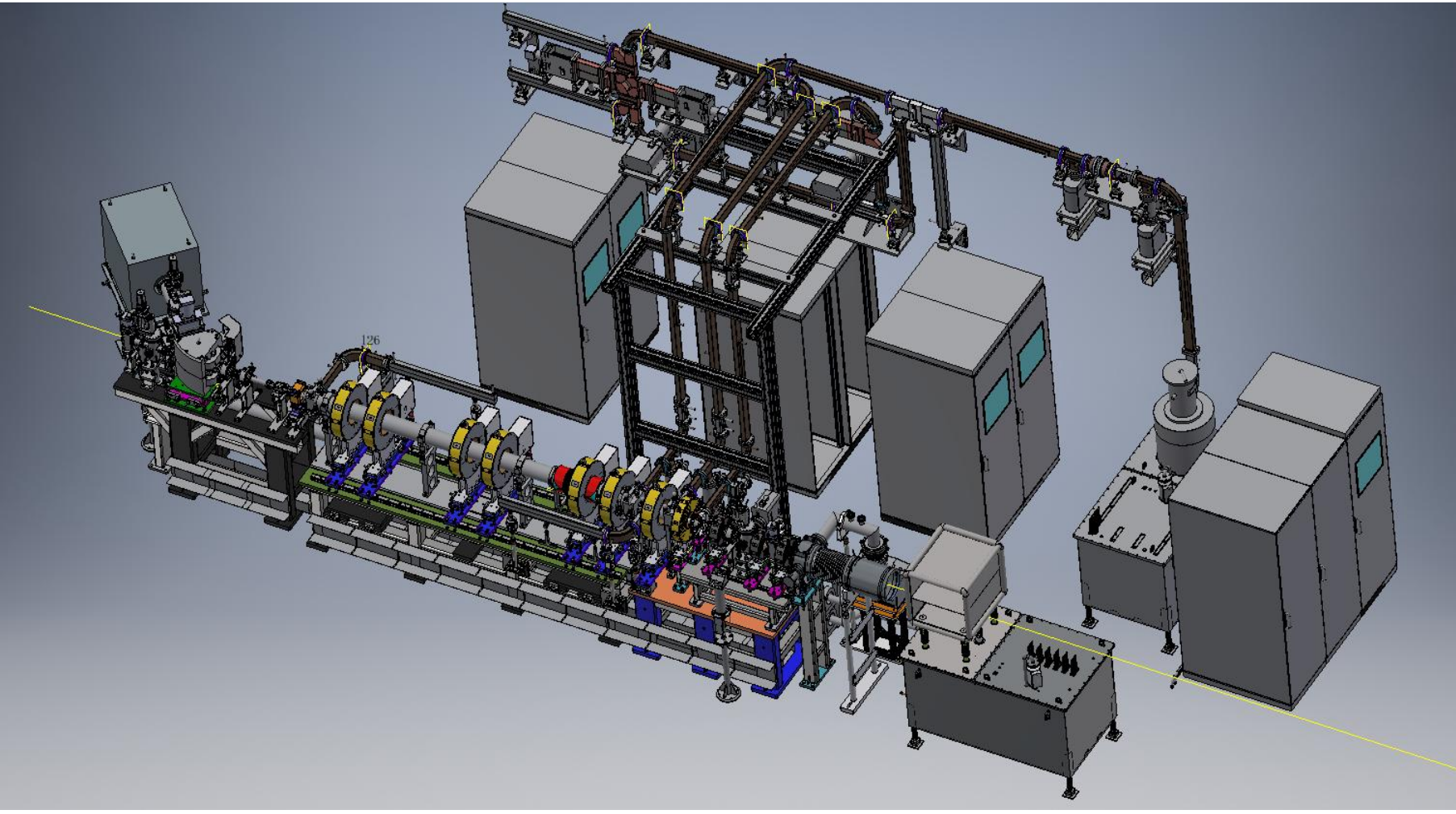


Fig. 1: Assembly drawing

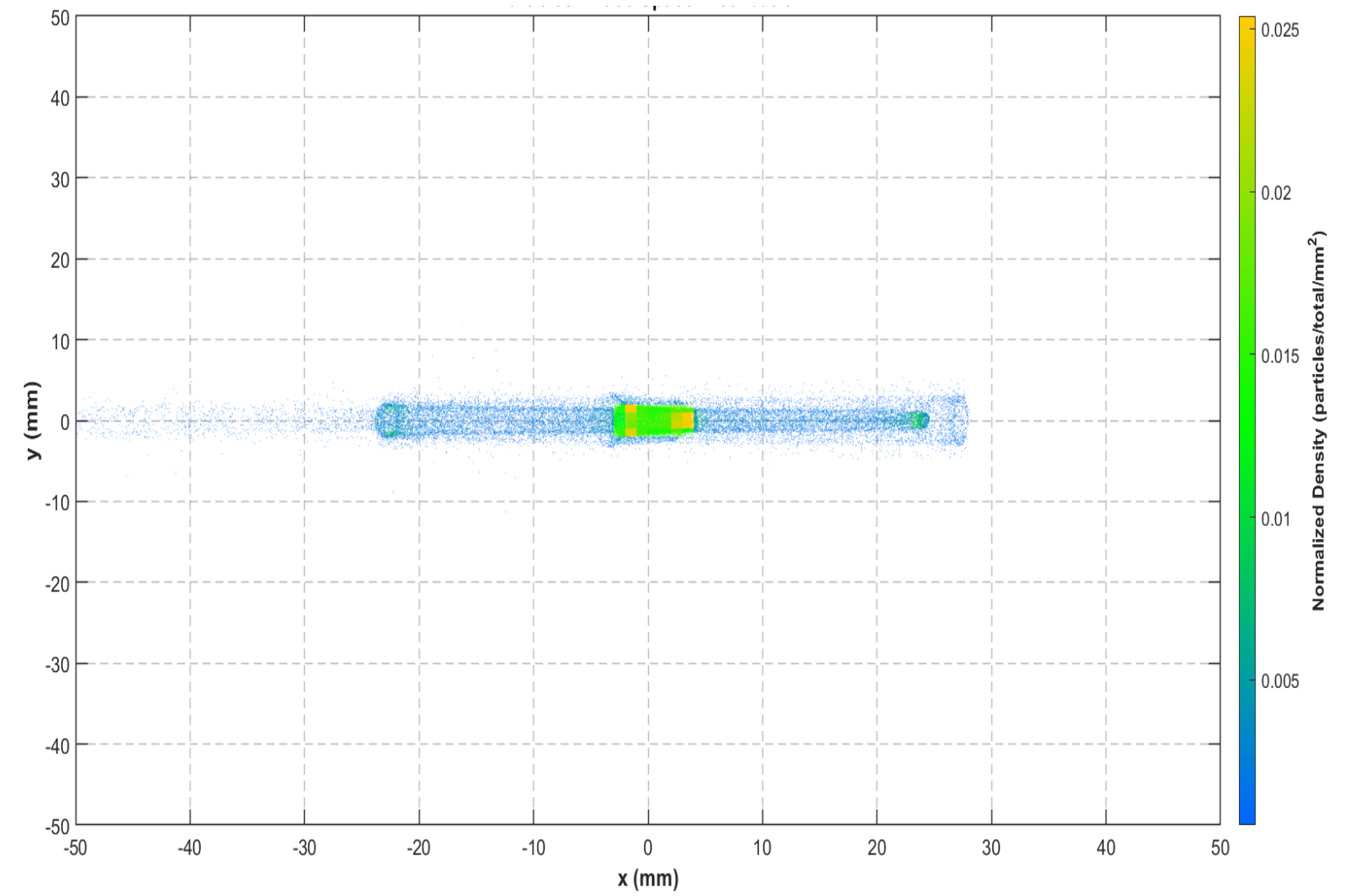


Fig. 2: In 4μs mode, particle density distribution (43.5 MeV, 111 mA)

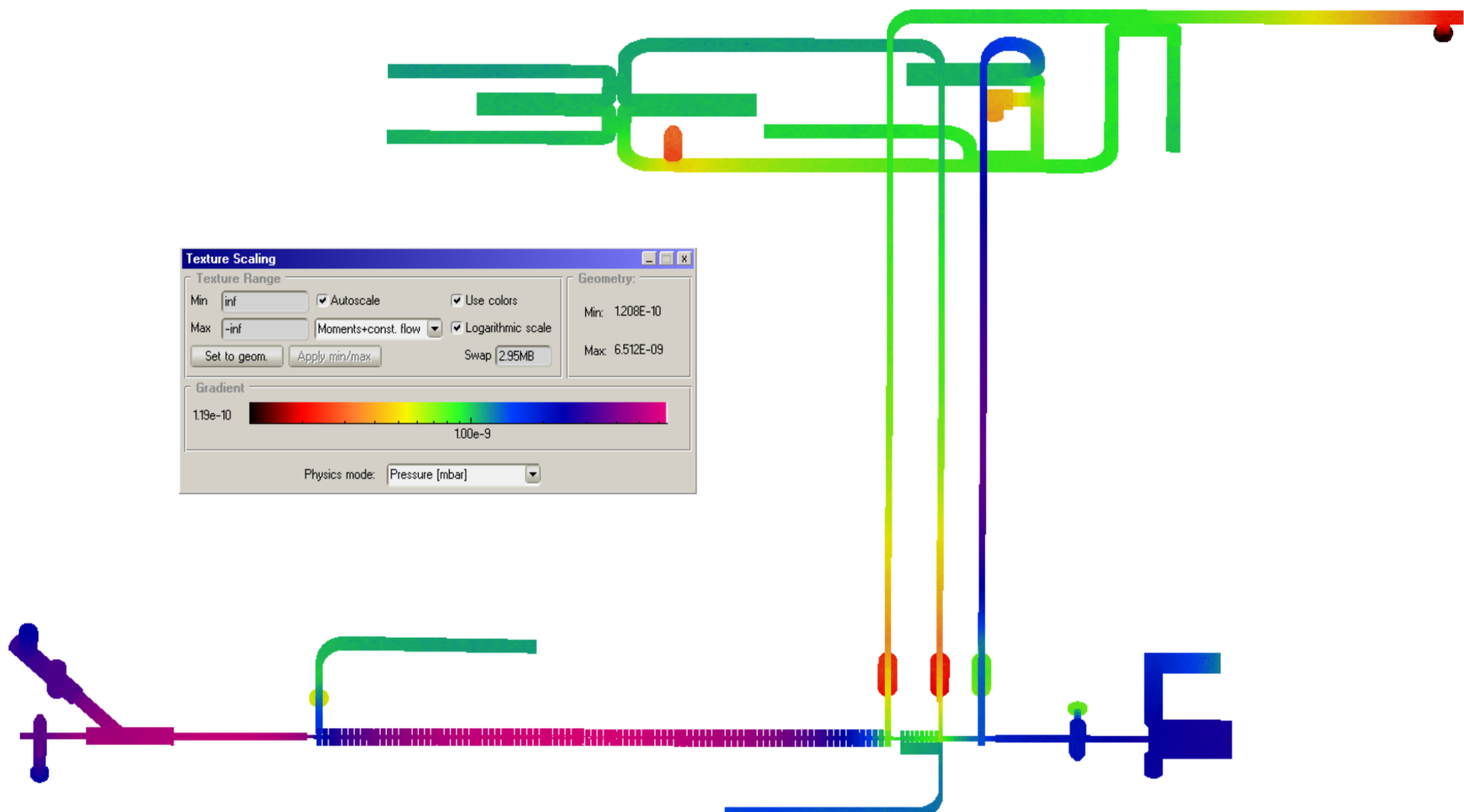


Fig. 3: Vacuum Distribution Calculation Diagram

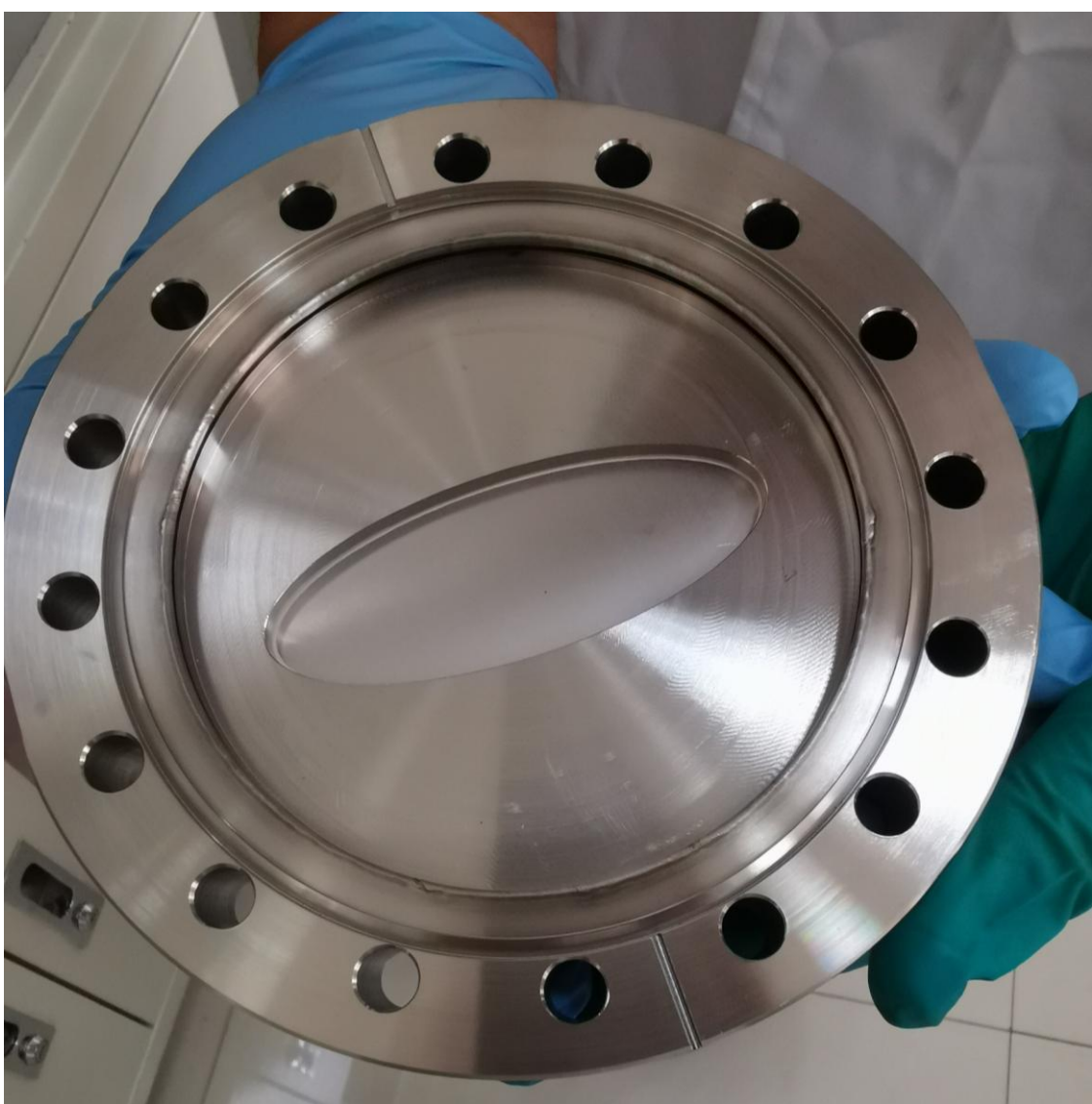


Fig. 4: Titanium window

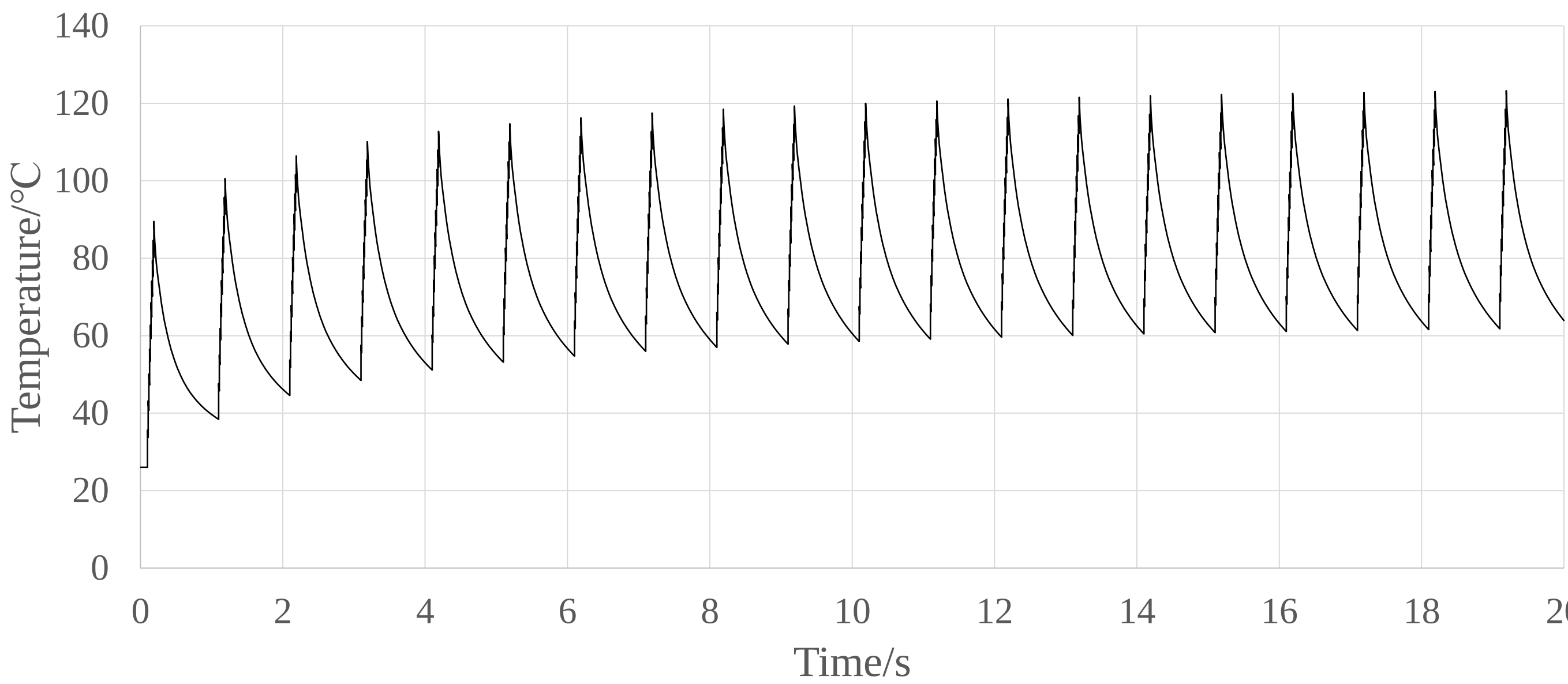


Fig. 5: Change in the central temperature of titanium windows

Project two

The project involves setting up a linear high-power test bench for accelerating tubes, spherical energy storage cavity energy multipliers, and the like. It requires a vacuum level better than 1.0e-5 Pa when increasing power.

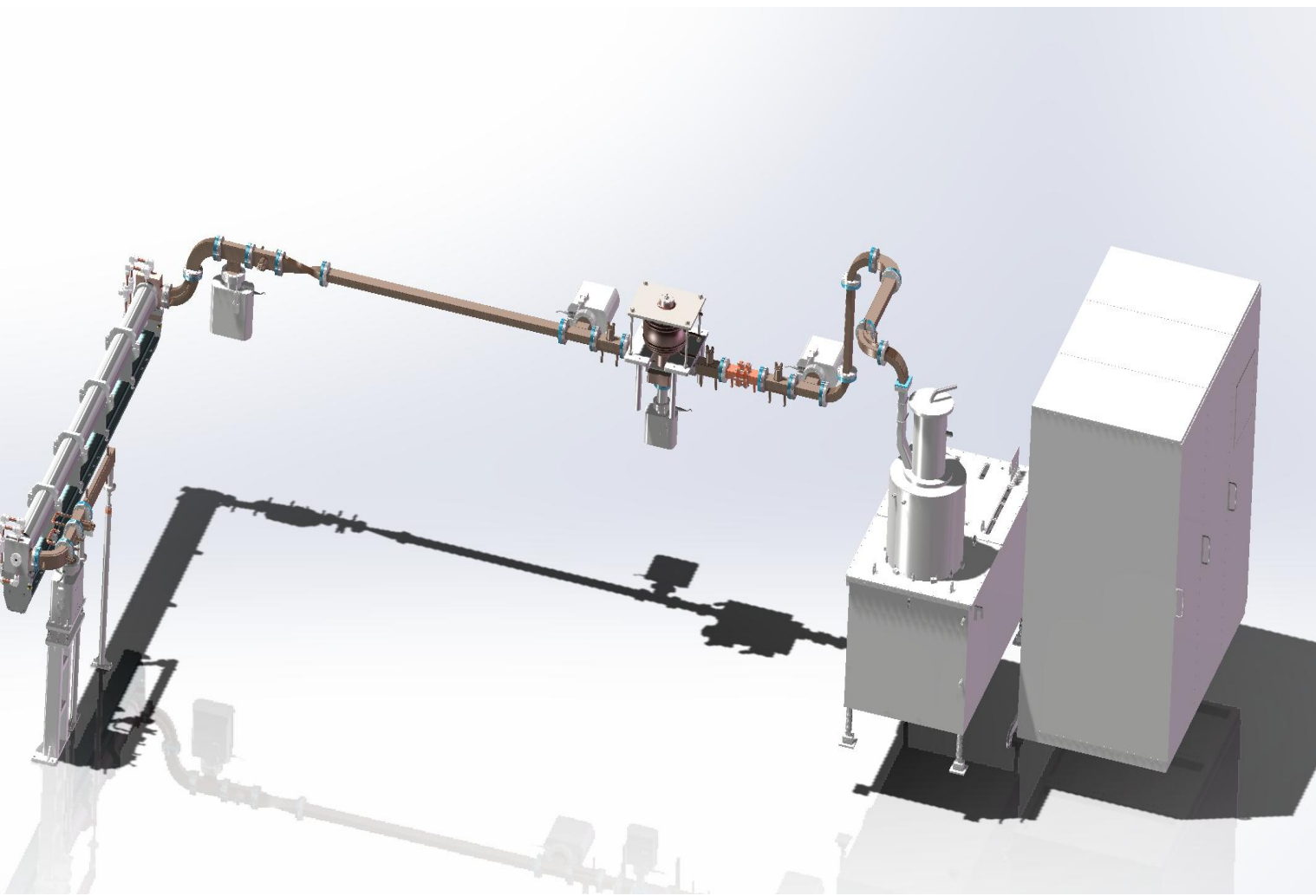


Fig. 6: Assembly drawing

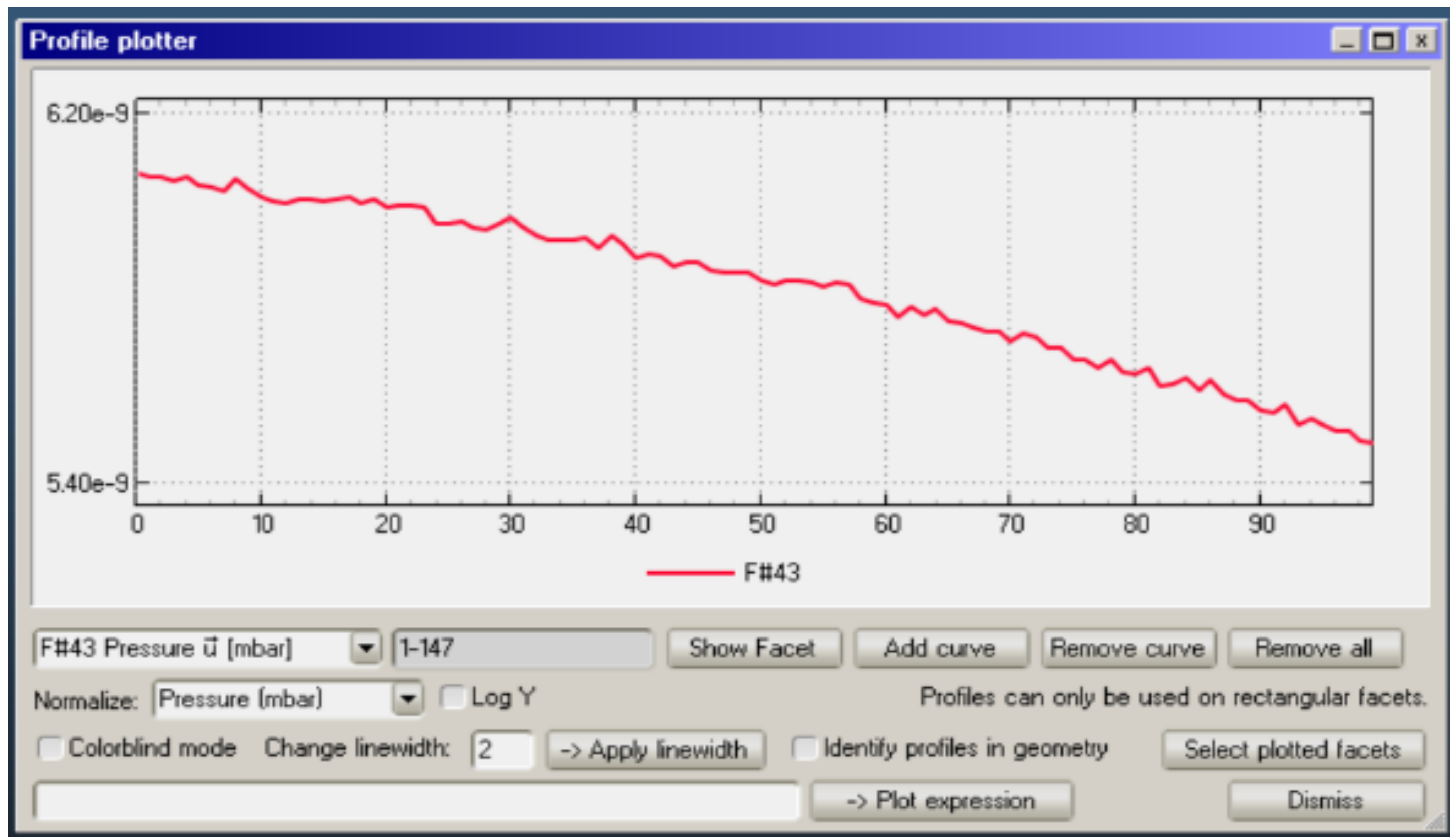


Fig. 7: Pressure curve



Fig. 8: Actual product image



Project three

The project, based on the actual design layout of HEPS's high-energy transport line, has built an offline vacuum system test bench to simulate the actual vacuum distribution.

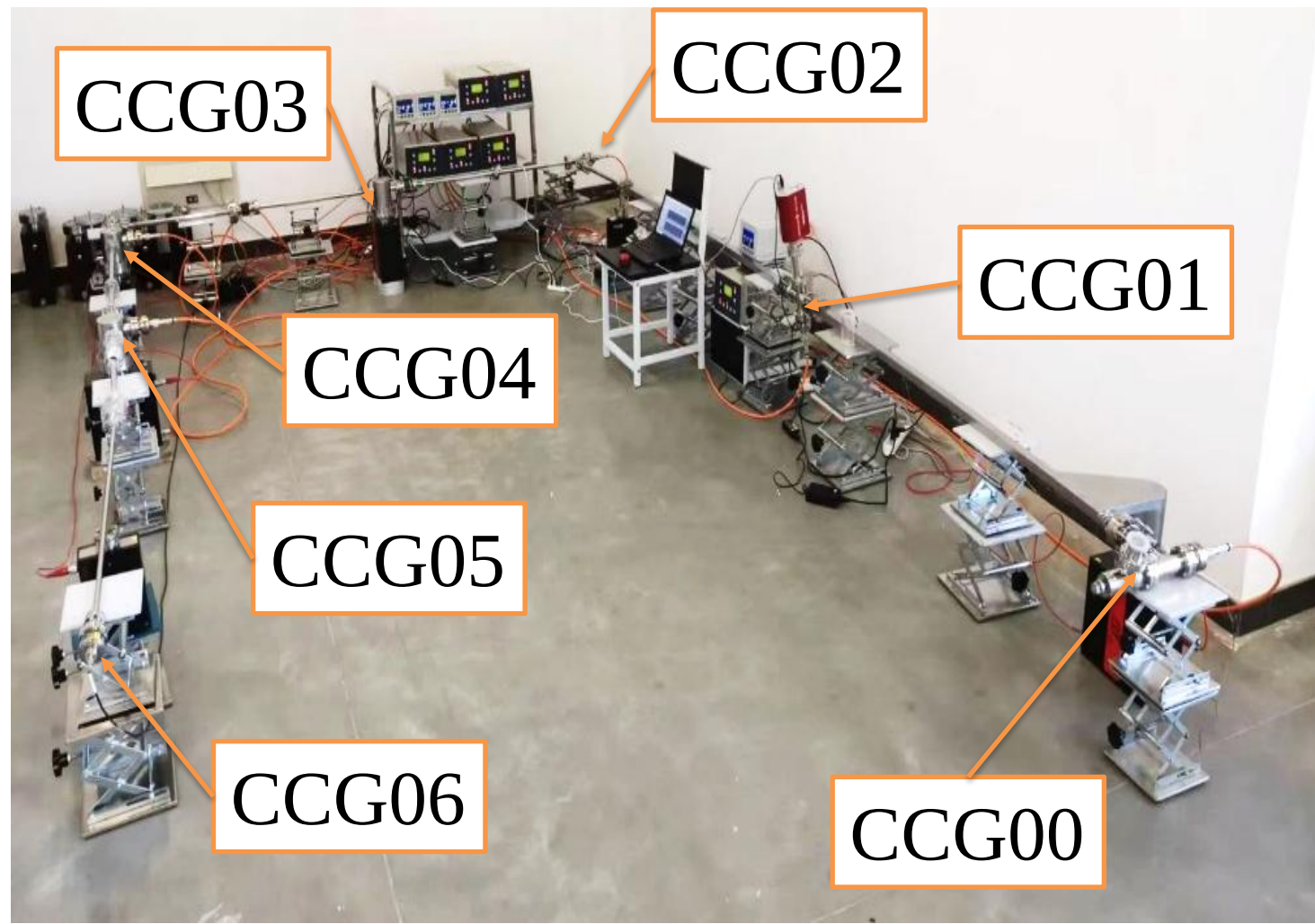


Fig. 9: Actual product image

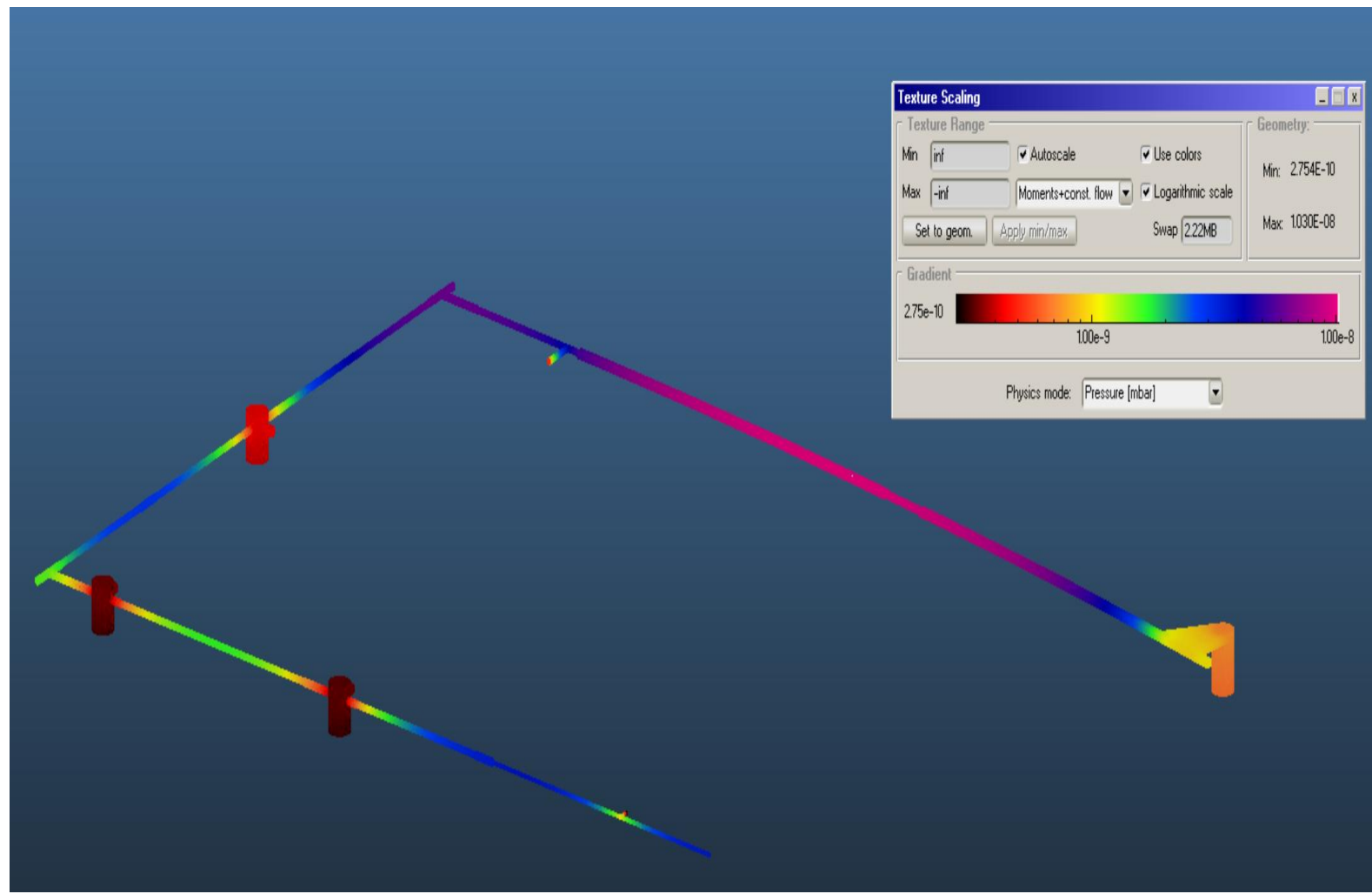


Fig. 10: Pressure distribution map

Table 2: Comparison between simulated and measured values

Name	Calculated value/Pa	Measurement value/Pa
CCG00	1.02e-7	2.8e-7
CCG01	9.7e-6	8.5e-7
CCG02	6.16e-7	5.3e-7
CCG03	4.29e-8	7.4e-8
CCG04	3.41e-8	6.8e-8
CCG05	3.32e-8	7.2e-8
CCG06	3.46e-7	2.2e-6

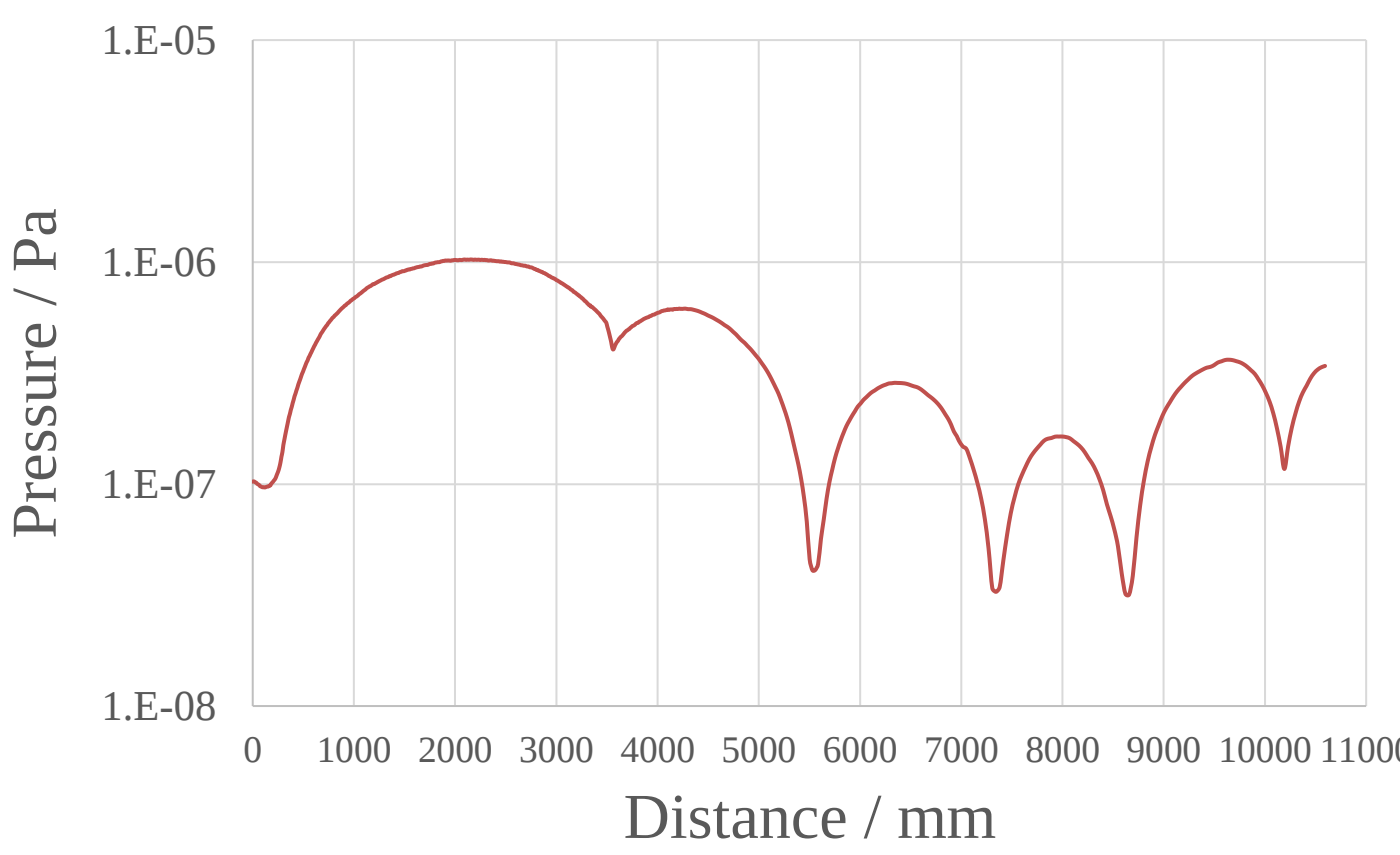


Fig. 11: Calculation curve of vacuum state at the middle section