CSS Experiment/ Research Racks

1. Inboard General Science Experiments Racks

A certain number of general science experiment racks in the pressurized modules of the Space Station will have been provided with free space for international partners to develop and equip their own payloads and experiment facilities.

The payloads and experiment facilities will be installed inside payload units to be developed by international partners. Each general experiment rack provides different kinds of interfaces for accommodating multiple payload units. Onboard astronauts could install payload units and replace them with new ones, allowing space experiments to be conducted in a rolling fashion.

The interfaces include mechanical interfaces, power supply interfaces, data interfaces and thermal interfaces, as well as nitrogen, vacuum and venting interfaces.

There are three types of specifications for payload units namely

(a) Standard Payload Unit (SPU)
(b) Standard Drawer Unit (SDU)
(c) Standard Payload Locker (SPL)

The internal thermal control units can provide liquid cooling for multiple payload units through cooling pipes connected in parallel or in a series. The nitrogen, vacuum and venting interfaces are available to some payload units in the general science experiment racks.

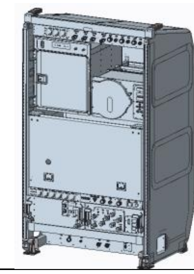
2. Inboard Domain Research Experiment Racks

A number of scientific experiment racks in the pressurized modules of the Space Station will have been equipped with experiment facilities for scientific and technological research in different fields. Each experiment rack functions as a small space lab that supports research on space science in one or more research domains. The overview, main functions and research topics of these research experiment racks are illustrated each below:

a. **Human System Research Rack**

Overview	The human system research rack supports the research of the physiological effects, psychological characteristics, and changes of human capacity under long-term space travel, as well as human experiments aiming at developing new protective technologies. Important research and/or application value are expected from these innovative experiments 
Main Functions	• Physiological function experiments on the human body's cardiovascular, muscles, bones, nervous systems, etc., as well as experimental data synchronization and acquisition. • Measurement of the human body's basic ability, biological rhythm, operating status and performance, and study of confrontation and intervention methods. • Cultivation facility suitable for a microgravity space environment to provide stable nutritional conditions for the cultivation and reproduction of medical cells, tissues and organs. The temperature, liquid displacement and gas components of the cultivation environment can be controlled, supporting the normal growth, proliferation and differentiation of biological samples. • On-orbit nutritional metabolomics study based on Raman spectroscopy; • Monitoring, precise observation and on-orbit analysis and detection are supported during the experiments. • The replacement of on-orbit test samples and modules is supported.
Research Topics	• Effects of long-term weightlessness on astronauts' health and on protective technology • Effects of space radiation on astronauts' health and on protective technology • Behaviors and abilities of astronauts • Advanced on-orbit monitoring and medical treatment • Application of Chinese traditional medicine to aerospace medicine

b. **Medical Sample Analysis Rack**

Overview	The medical sample analysis rack is designed to support real-time on-orbit detection and biochemical index analysis of the body fluids of astronauts, reflect the health status of the organism, and support the testing of medical biology samples and the study of astronaut metabolomics 
Main Functions	• Centrifugal separation of samples • Refrigeration of agents and samples at 4℃ • Multi-index on-orbit detection analysis including human body fluid sample and cell biological sample based on chip lab technology
Research Topics	• Effects of long-term weightlessness on astronauts' health and protective technology • Effects of space radiation on astronauts' health and protective technology • Behaviors and abilities of astronauts • Advanced on-orbit monitoring and medical treatment • Application of Chinese Traditional Medicine to aerospace medicine

c. **Ecological life Experiment Rack**

Overview	The ecological life experiment rack is used for studying the effect of microgravity on biological life, including plants, small mammals, insects, aquatic organisms, microbes, etc., tissues at the microscopic cellular level and the macroscopic holistic level, as well as basic research on ecological life support systems in space. 
Main Functions	• Environmental control and life support for multiple types of biological samples like biochemical molecules, tissues, microbes and plants. Featuring good biocompatibility. • Cultivation methods suitable for a microgravity space environment to achieve dynamic control of temperature, liquid displacement and gas components of the cultivation environment to provide stable nutritional supply conditions for the growth of biological samples, and to support the normal growth, proliferation and differentiation of biological samples • Monitoring of space experiment processes and the precise observation of biological samples • Component testing for gas in an experimental cultivation environment • Microbiological testing of the entrance and exit area of experimental cultivation • Real-time measurement of particle type and energy spectrum of the space radiation field in the experimental module. • Capability to replace and extend experiment samples and modules
Research Topics	• Gravity biology • Space radiation biology • Space biotechnology and its applications • Fundamental research on ecological life support systems in space

d. **Biotechnology Experiment Rack**

Overview	The biotechnology experiment rack is set up for space biotechnology research on biological cells and tissues, microbes, animals, etc., as well as basic biology research on cell and tissue samples 
Main Functions	• Suitable life support and environmental conditions for various categories of biological samples, such as molecules, cells, tissues, small animals and small mammals; Featuring good biocompatibility • Cultivation methods suitable for a microgravity space environment to achieve the control of temperature, liquid displacement, gas components and other elements of the cultivation environment, to provide stable nutritional supply conditions for the growth of biological samples, and to support the normal growth, proliferation and differentiation of biological samples • Dynamic monitoring of space experiment processes, observation of biological samples, in-situ detection of biological samples, monitoring of animal physiological parameters, and dynamic analysis of metabolites • Accurately measurable microgravity levels in the experimental area • Capability to replace and extend experiment samples and modules
Research Topics	• Space biotechnology and its applications • Space radiation biology • Forefront and cross study of space life science • Space-based biology

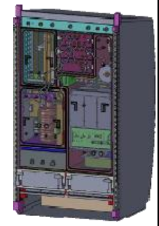
e. **Fluid Physics Experiment Rack**

Overview	The fluid physics experiment rack carries out research on basic laws of the macroscopic and microscopic movement of fluids, diffusion process, heat and mass transfer in a space environment as well as complex fluid research and experimental research for transparent space materials, space life sciences and biotechnology. 
Main Functions	• Real-time diagnostic methods for static and dynamic light scattering, spectroscopy, turbidity and other rheology parameters in the course of complex fluid experiments; Preprocessing of image data • Accurately measurable microgravity levels in the experimental area • Ability to replace and extend experiment modules
Research Topics	• Microgravity hydrodynamics and its applications • Complex fluid • Mechanisms for material preparation processes in a microgravity environment • Crystal growth kinetics and protein crystallization • Process of space biotechnology-related fluid transportation

f. **Two-Phase System Experiment Rack**

Overview	The two-phase system experiment rack is implemented for research on key scientific issues and technical applications, such as space evaporation and condensation transformation, boiling heat transfer, two-phase flow and loop systems, and space fluid control. 
Main Functions	• Observation methods for the morphology of gas-liquid interface (bubble and droplet) and phase transition of liquid layer and liquid film, two-phase fluid flow or spray atomization. The surface temperature field is measured. • Gas and liquid fluid required by the experiment in which the temperature, flow and pressure can be adjusted and controlled. The gas environment required by the experiment is effectively controlled. • Capability to replace and extend experiment samples and modules.
Research Topics	• Two-phase flow, phase transition, heat transfer and their applications

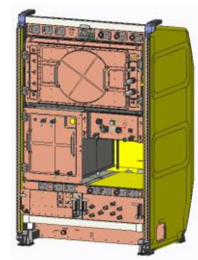
g. **High Temperature Materials Science Experiment Rack**

Overview	The high temperature materials science experiment rack is implemented for scientific experiments for melt growth and the solidification of multiple types of materials, such as metal alloys, semiconductor optoelectronic materials, nano and mesoporous materials and functional inorganic materials. 
Main Functions	• High-temperature heating of materials, sample movement and rapid cooling to find the solution for material thermal environment management such as heating temperature curve and temperature gradient control • Rotating magnetic field to achieve active control of the melt flow during the preparation of space materials. • Real-time on-line detection of resistance, conductance, diffusion coefficient, Seebeck coefficient and other parameters of material samples • X-ray fluoroscopy and real-time optical observations to obtain visual information and data on solid/liquid interface morphology and the effects of interface transport in the sample preparation process • Accurately measurable microgravity levels in the experimental area • Capability to replace and extend experiment samples and
Research Topics	• Mechanisms for the materials preparation process in a microgravity environment • Preparation and research on materials with an important application background

h. **Combustion Science Experiment Rack**

Overview	The combustion science experiment rack supports combustion research in a microgravity space environment, including fundamental combustion questions and techniques, rocket propulsion, and applications in manned space flight. 
Main Functions	• Providing an environment for combustion experiments under microgravity conditions and meeting combustion requirements for various solid, gas and liquids; • Having sufficient means of measurement and diagnosis. Measurable experimental parameters include the flame structure, temperature, pressure, velocity, product component concentration and spectral characteristics. • Capability to purify and dispose of exhaust gas
Research Topics	Fundamental combustion science and its applications in a microgravity environment.

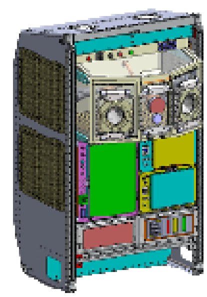
i. Container-Free Materials Science Experiment Rack

Overview	The container-free materials science experiment rack allows for container-free processing through electrostatic levitation technology and is used to carry out research on metal, non-metallic and other container-free processing as well as the deep super cooling of materials. 
Main Functions	• Container-free processing environment to avoid container wall effects on materials' properties and achieve a deep super cooling capacity of the material • Capability of direct in-orbit measurement to allow for accurate measurement of the starting point of material solidification and determine the relationship between super cooling characteristics and super cooling solidification of the material • Ability to obtain accurate data on melting, start of solidification, completion of solidification, cooling, and the completion of processing of materials during the container-free processing of materials • Accurately measure the thermos physical properties of high temperature materials such as density, surface tension, viscosity coefficient, specific heat, solidification latent heat and conductivity, providing basic data for material research • Capability of nucleation trigger of the material in microgravity • Capability to replace and expand experiment samples and modules.
Research Topics	• Mechanisms of material preparation processes in a microgravity environment • Preparation and research on materials with important applications background

3 Inboard General Supporting Racks and Facilities

To satisfy the common demands of space experiments utilizing domain experiment racks, general support racks and facilities are developed and deployed onboard the China Space Station. They include a scientific glovebox, freezers, a high microgravity rack, a variable gravity rack, an online maintenance and adjustment operation facility, and an independent payload support facility. Their functions are illustrated described below:

a. General Supporting Racks and Facilities

Rack/ Facility	Description of Main Functions
Scientific Glovebox & Freezer Facility	The scientific glovebox is mainly employed for the isolation, airtight and specific operation of various scientific experimental samples. Research on space medicine, space life science and biotechnology, space materials science, microgravity fluid physics, basic physics and other directions are supported. The freezer facility is equipped to store samples at low temperatures. 

Main functions of Scientific Glove-box	• Astronauts could transfer or replace experiment facilities, samples, diagnostic instruments and other items through the door of the glovebox; • Astronauts could install and debug experimental facilities and directly or remotely operate scientific experiments through the wrist (entrance) of the glovebox; • Astronauts could observe the items in the glovebox and the operation process directly through the internal instrument or by connecting to a laptop; • Astronauts could check the experimental results and screen the result by operating instruments equipped with the glovebox; • The environment (light, humidity, temperature, gas, etc.) within the glovebox is controllable and adjustable and can be disinfected; • Supporting precise or micro operations such as injection, extraction and separation; • Providing power, communication and installation conditions for the experimental facilities or scientific instruments inside the glovebox; • Providing interface capabilities for the laptop to inspect and manage the experiment facilities; • Supporting tele-science operations
Main functions of the Freezer Facility	• Three typical low temperatures are provided to meet the storage requirements of samples; • The samples in the three low temperature storage zones may be accessed independently; • Each low temperature storage zone features temperature detection, display and high temperature alarm; • Each low temperature storage zone is frost-free; • Liquid water generated in the process of refrigeration and operation may be collected; • When each low temperature storage zone is opened, auxiliary lighting comes on automatically; • Each low temperature storage zone is designed to prevent condensation; • The low temperature storage device may be tested and managed by the controller of the experiment racks

High Microgravity Science Experiment Rack	By using levitation technology, the rack could effectively provide microgravity experimental conditions at the microgram level for experimental payloads, thus supporting research on microgravity hydrodynamics and its applications, mechanisms for material preparation processes and relativistic and gravitational
	• Providing mechanical, power, measurement and control data and • thermal control interfaces; • Different experiments may be performed through the replacement of experiment payloads; • Interface is provided for laptops to examine, test and manage the rack; • Astronauts may participate in experiment management and sample recovery; • Supporting tele-science operation.
Variable Gravity Experiment Support Facility	It achieves the separation of microgravity from other space environmental effects by establishing a simulated experimental gravity environment through centrifugal technology and comparison with the experimental results in the microgravity environment. The rack is suitable for multidisciplinary research such as basic space biology, forefront and cross study of space life science, space ecological life support system and fluid science, two-phase flow, phase transition heat transfer and applications.
	• Supporting various standard experiment modules which may be combined for use; • Providing experiment modules with mechanical, power supply, command, data and thermal control interfaces. The experiment modules may be replaced conveniently in orbit; • Dynamically adjusting balance to adapt to the change in status due to the replacement of experiment modules; • Measuring acceleration of the variable gravity area to determine its gravity level; • Providing interface capabilities for a laptop to detect and manage the support facility; • Astronauts may participate in managing experiments and replacing and retrieving samples; • Supporting tele-science operation

In-orbit Maintenance/ Installation/ Commission-ing Support Platform	It supports specific mechanical operations of scientific and technical experiments, structural and electronic assembly, and other operations and testing validation, as well as research on space robotics and remote science technology.
	• Providing online diagnosis and test function • Supporting structural lubrication, structural assembly, electronic assembly, and other specific maintenance operations • Supporting in orbit precise operations, and capability to clean and sterilize internal payload modules • Providing independent experimental modules and scientific instruments with mechanical power and thermal interfaces • Providing spec welding mechanisms and processes for homogenous/ heterogeneous materials, the experimental study of the sue of functional space oriented materials, and experiments on new equipment's, components and p[arts; • Capability to replace and extend experiment modules • Dealing with exhausts affluent and waste residues • Astronauts may participate in experiment management and sample recovery • Providing interface capability for laptop to detect and manage support platform
Independent payload Support	These facilities are equipped to provide interfaces of heat, power and data for independent payloads inside the space station. It provides: • Interfaces for installation of standard payloads in different specifications. Support for installation for nonstandard payloads by a combination of multiple standard interfaces • Integrated payload management equipment to provide power supply, monitoring and data interfaces for independent payloads • Payload thermal control unit to provide interface for independent payload • Interfaces for high purity nitrogen, vacuum or exhaust gas

4. **Exposed Experiment Support Facility**

a. **Standard Experiment Support**

Exposed platforms are deployed on the exterior of the EM I and EM II of the Space Station on which standard interface support equipment, called payload adapters, are installed to provide standard mechanical, electrical, thermal and data interfaces for exposed payloads to support exposed experiments. International partners can use payload adapters to carry out exposed scientific experiments by developing exposed payloads.

A standard exposed payload is installed on a payload adapter. A large exposed payload could be installed through the combination of multiple payload adapters. A payload adapter includes an active end and a passive end. The passive end is set up on the exposed platform while the active end is attached to the exposed payload.

The cargo airlock module of the EM II provides access for payloads to Station modules. Astronauts inside the module operate the robotic arm for on-orbit mounting and replacement of exposed payloads. In order to achieve in-orbit mounting of standard exposed payloads, the robotic arm target adapters are required to be attached to exposed payloads.

When mounting exposed payloads on orbit, astronauts will attach them to the egress mechanism of the cargo airlock module of the EM II, then operate the robotic arm to grab the target adapter. After taking it off the egress mechanism and moving it to the desired position at the passive end of the exposed platform payload adapter, they will perform the docking, locking and electrical connection between the active and passive ends of the payload adapter. The strategy applies to dismounting exposed payloads from exposed platforms.

b. **Non-standard Experimental Support**

In order to support specific exposed payload experiments that require a long testing period and hold significant scientific and application value, mounting points for large payloads and an expanded experimental platform are also deployed on the exterior of the CM and EM I.

Large payloads will be delivered to the Space Station by cargo spaceship and will be mounted onto the payload mounting points by on-orbit astronauts using the robotic arm.