

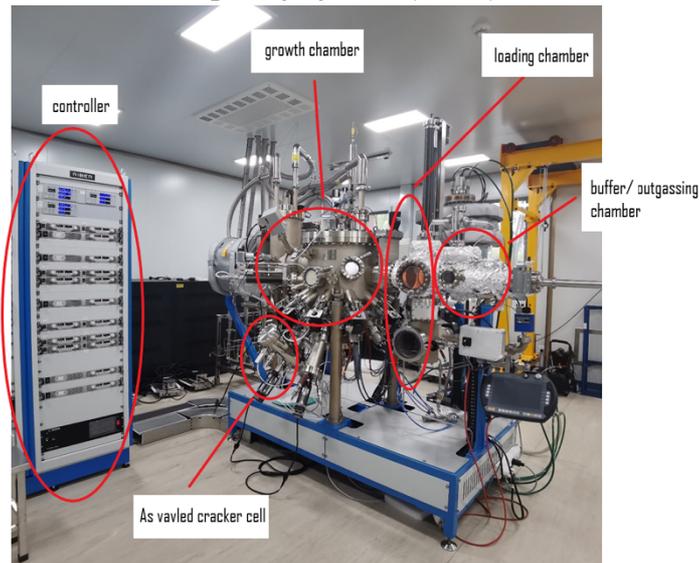
## Sample preselection and characterization station

The sample preselection and characterization station is mainly to provide sample synthesizing and processing for each experimental station in the Synergetic Extreme Condition User Facility (SECUF), and through preliminary morphology, structure and property characterization, high-quality samples are preselected to make preparation for the next research under extreme conditions. In order to accomplish these tasks, the station has set up 11 sub-units to complete various functions.

System	Name	Administrator	E-mail
Sub running system 1	Molecular beam epitaxy system	Dr. Su	sski@iphy.ac.cn
Sub running system 2	Multifunctional annealing furnace	Dr. Zhang	szhang@iphy.ac.cn
Sub running system 3	Scanning electron microscope	Ms. Cui	cuiminjie@iphy.ac.cn
Sub running system 4	Single crystal X-ray diffractometer	Mr. Sun	suntao@iphy.ac.cn
Sub running system 5	X-ray diffractometer	Mr. Sun	suntao@iphy.ac.cn
Sub running system 6	16 T multifunctional ultra-low temperature physical property measurement system (PPMS-16 T)	Ms. Ren	renhui fen@iphy.ac.cn
Sub running system 7	Ultra-low temperature magnetic measurement system (MPMS3)	Ms. Ren	renhui fen@iphy.ac.cn
Sub running system 8	Triton cryogen-free He3-He4 dilution refrigerator	Dr. Zhang	szhang@iphy.ac.cn
Sub running system 9	Fourier transform infrared spectrometer system	Ms. Cui	cuiminjie@iphy.ac.cn
Sub running system 10	LabRAM HR evolution	Ms. Cui	cuiminjie@iphy.ac.cn
Sub running system 11	9 T nuclear magnetic resonance spectrometer system	Dr. Luo	junluo@iphy.ac.cn

Next, introduce one by one.

## Run unit 1: Molecular Beam Epitaxy system (MBE)



This MBE system is made by RIBER, model COMPCT21 DZ, wafer up to 3 inches, ultimate pressure  $3.8 \times 10^{-11}$  Torr. MBE source: Arsenic, antimony valved cracker cell, Gallium, Indium high capacity effusion cell, Aluminium double filament effusion cell; Silicon, Beryllium, GaTe dopant cell. Appendix including: Beam flux gauge, Residual gas analyser and 12 KeV RHEED system. This MBE is applicable to grow AlGaAs and InGaAs film, and Si, Be and Te for doping.

Parameters or configuration	Values or Model
Ultimate pressure	$3.8 \times 10^{-11}$ Torr
Arsenic valved cracker cell	VAC 500
Antimony valved cracker cell	VCOR 300
Gallium effusion cell	ABI 85
Indium effusion cell	ABI 85
Aluminium double filament effusion cell	ABN60D
Silicon, Beryllium, GaTe dopant cell	ABN135DC8
Beam flux gauge	Bayard-Alpert ion gauge; range $10^{-3}$ to $10^{-10}$ Torr
Residual gas analyzer	From Hide; model HALO 201 RC
RHEED	Form STAIB, model STAIB RHEED12

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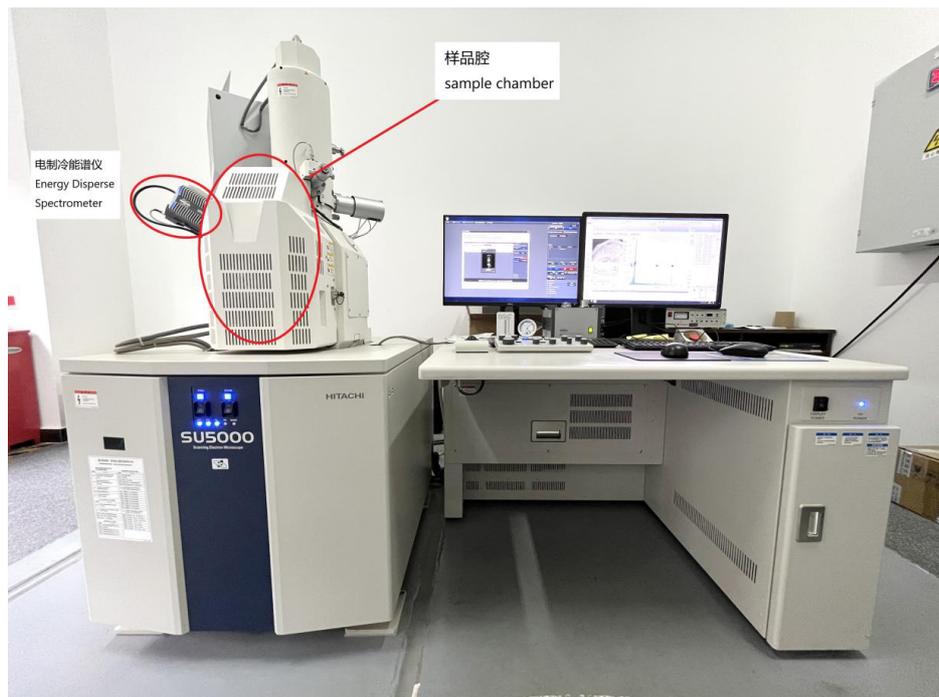
## Run unit 2: Multifunctional annealing furnaces

More than 20 high-temperature furnaces provide rich experimental conditions to meet different experimental requirements such as sample sintering, melting and annealing. It can be mainly divided into general Muffle furnaces, two-zone tube furnaces, induction furnaces and bridgeman furnaces, which have corresponding vacuum and atmosphere environments.

Parameters	Values
Muffle furnace	1700 °C, Temperature precision $\sim \pm 1\%$
Two-zone tube furnace	1200 °C, Temperature precision $\sim \pm 1\%$ , Vacuum pressure $\sim 1$ Pa
Bridgeman furnaces	1200 °C, Temperature precision $\sim \pm 1\%$ , Vacuum pressure $\sim 1$ Pa, Speed range: 30 $\mu\text{m/hr}$ $\sim$ 30000 $\mu\text{m/hr}$
Induction furnace	2000 °C, temperature controlled by an infrared thermometer

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## Run unit 3: Scanning electron microscope (SEM)



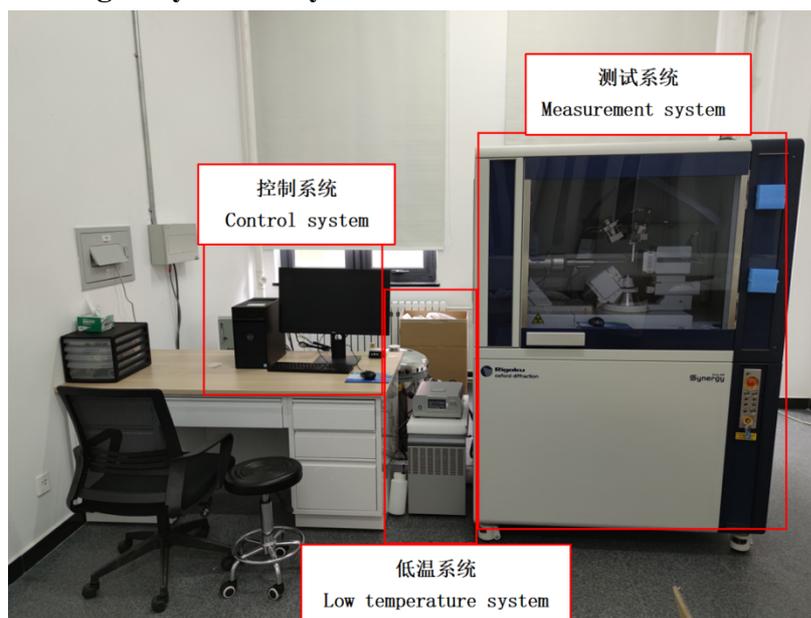
Parameters	Values
Acceleration voltage	0.5-30 kV , (0.1 kV step)
Magnification	140 ~ 600,000 x
Specimen stage	5-Axis motorized stage X : 0~100 mm Y : 0~50 mm Z : 3~65 mm T : -20~90° R : 360°
Energy resolution	Better than 129 eV
Energy detection range	BE (4)-Cf (98)
Area of detection	60 mm <sup>2</sup>

The thermal field emission scanning electron microscope (SEM) of SU5000 model is equipped with high vacuum secondary electron detector, high sensitivity BSE detector (optional) and Brooke XFlash®6/60 electric refrigeration energy spectrometer. The high-resolution observation of the surface morphology, composition, crystal orientation, concave-convex and other information of a variety of samples and the analysis of the composition information of the micro-region of the material surface can be realized comprehensively.

XFlash®6/60 electric refrigeration energy spectrometer can realize the effective detection chip detection area of 60 mm<sup>2</sup>. The energy spectrum resolution is better than 129 eV; Element detection range: BE (4)-Cf (98), and through the processor hardware and software double automatic deduction peak, automatic selection of the best processing time.

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## Run unit 4: Single crystal X-ray diffractometer



The XtaLAB Synergy is a full-featured single crystal X-ray diffractometer. It has two independent X-ray sources that can be switched between Cu and Mo wavelengths and greatly expanded the experimental flexibility available for analyzing single crystal samples. It is the perfect diffractometer for protein crystallography and small molecule crystallography.

Parameters	Values
Brand, Model	RIGAKU, XtaLAB Synergy
X-ray generator	1200 W high brilliant X-ray generator Rotating anode target (Cu/Mo) Tube Voltage: 20 kV~60 kV, Tube Current 10 mA~30 mA
Goniometer	high-precision 4-circle kappa goniometer
Detector	Super speed detector HyPix-6000
Options	Low temperature system-Liquid nitrogen refrigeration (80 K-400 K) Temp Accuracy: $\pm 0.1$ K
Measurement content	Biomacromolecule or small molecule single crystal Indexing, Determination lattice constant, Data collection, Structural analysis

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## Run unit 5: X-ray diffractometer (XRD)

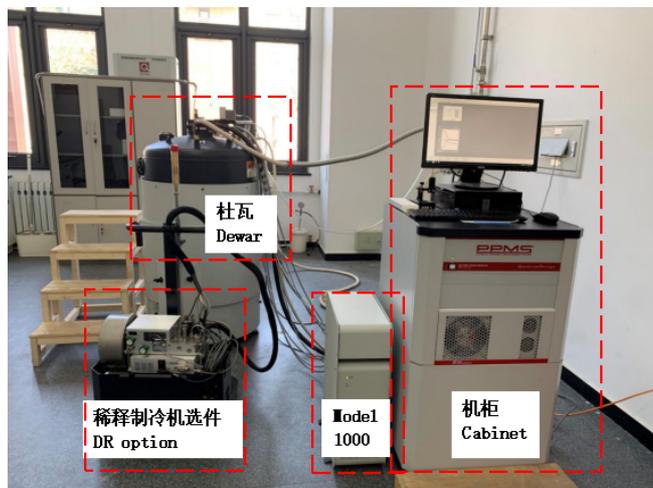


Rigaku SmartLab is a full-featured high-resolution X-ray diffractometer (XRD). The equipment accepts powder, bulk, films samples, and measurements can be performed with the new Rigaku SmartLab Studio II software suite, which is an integrated software platform incorporating all functions from measurement to analysis.

Parameters	Values
Brand, Model	RIGAKU、 SmartLab 9 kW
X-ray generator	9 kW High-frequency X-ray generator Rotating anode target (Cu) Tube Voltage $\leq 45$ kV, Tube Current $\leq 200$ mA
Goniometer	Wide angle goniometer $\theta$ - $\theta$ ( $-10^{\circ}$ ~ $160^{\circ}$ )
Detector	2D High speed detector HyPix-3000 Supports 0D, 1D and 2D measure modes
Base unit	Standard $\chi$ cradle, Slit system, CBO Cross beam optics
Options	Micro area measurement optics, Ge(400)crystal, High precision film RxRy tilt stage, In-plane geometry, Mapping stage
Measurement content	XRD, Glancing Incidence (GI), X- Ray Reflectivity (XRR), Rocking Curve, Reciprocal space mappings (RSM), In-plane, Micro area, Mapping

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**Run unit 6: 16 T multifunctional ultra-low temperature physical property measurement system (PPMS-16 T)**

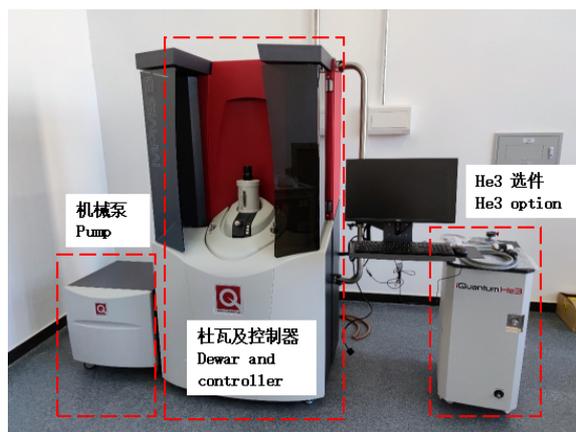


16 T multifunctional ultra-low temperature physical property measurement system is mainly a 16 T-PPMS. The system provides a controlled low temperature and high magnetic field environment. It is equipped with the resistivity option, electrical transport option (ETO), heat capacity option (HC), Vibrating Sample Magnetometer option (VSM), AC Measurement System option (ACMS II), Horizontal Rotator Option, Dilution Refrigerator option (DR, is capable of measure resistivity and heat capacity). Users can choose the desired measurement options for electrical, thermal and magnetic measurement, and can build their own measurement system with the PPMS' measurement environment as well.

Parameters	Values
Temperature range	1.8-400 K 0.05-4 K Dilution Refrigerator
Sweep rate of temperature	0.01-8 K/min
Stability of temperature	$\pm 0.2\%$ T < 10 K $\pm 0.02\%$ T > 10 K
Magnetic field range	$\pm 16$ T
Sweep rate of magnetic field	0.1-100 Oe/s
Stability of magnetic field	1 ppm/h
Remnant magnetic field	5 Oe (falling magnetic field from 9 T to 0 in oscillation mode)

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## Run unit 7: Ultra-low temperature magnetic measurement system (MPMS3)

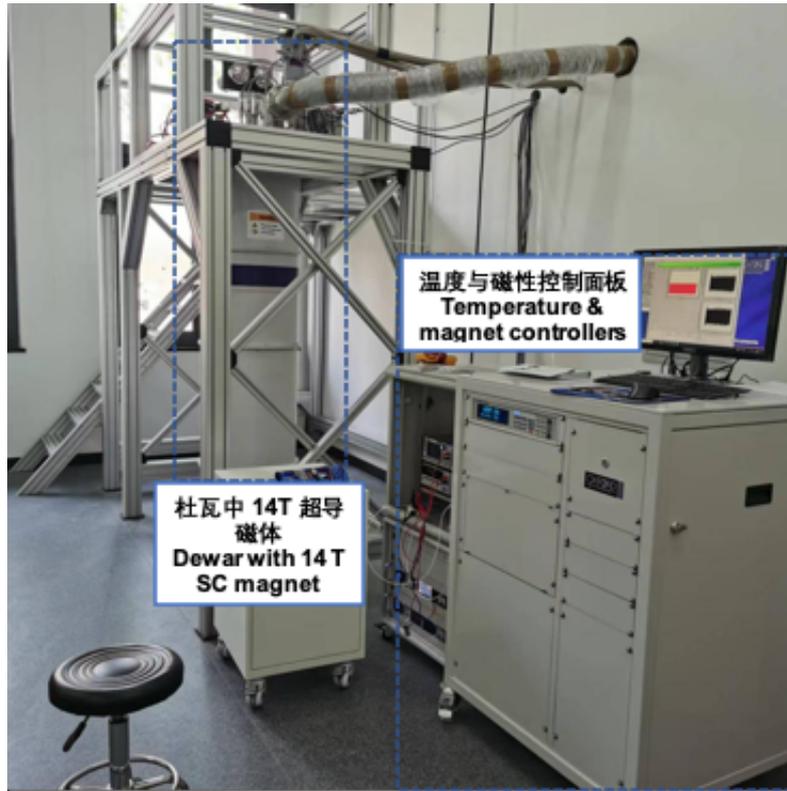


Ultra-low temperature magnetic measurement system is mainly a MPMS3 system. The system provides a controlled low temperature and high magnetic field environment. It provides the SQUID-VSM and DC mode to make the magnetic measurement. In addition, the extended functional options include the AC magnetic susceptibility measurement system options (the frequency is 0.1-1 KHz, the sensitivity is  $10^{-8}$  emu), ultra-low magnetic field option (to obtain the ultra-low remnant magnetic field up to 0.005 G), He3 option (for temperature expansion of 0.42-1.8 K).

Parameters	Values
Temperature range	1.8-400 K 0.42-1.8 K He3 option
Sweep rate of temperature	10 K/min T<10 K 30 K/min T>10 K
Stability of temperature	$\pm 0.2\%$ T<10 K $\pm 0.02\%$ T>10 K
Magnetic field range	$\pm 7$ T
Sweep rate of magnetic field	2-700 Oe/s
Stray field	0.01 @4 cm
Remnant magnetic field	5 Oe (ling magnetic field from 9 T to 0 in oscillation mode)
Vibrating range	0.1-8 mm
Measuring sensitivity	$<1 \times 10^{-8}$ emu H = 0 T (10 seconds measurement time); $<8 \times 10^{-8}$ emu H = 7 T (10 seconds measurement time)
Maximum moment	10 emu
Sample space	9 mm

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## Run unit 8: Triton cryogen-free He3-He4 dilution refrigerator

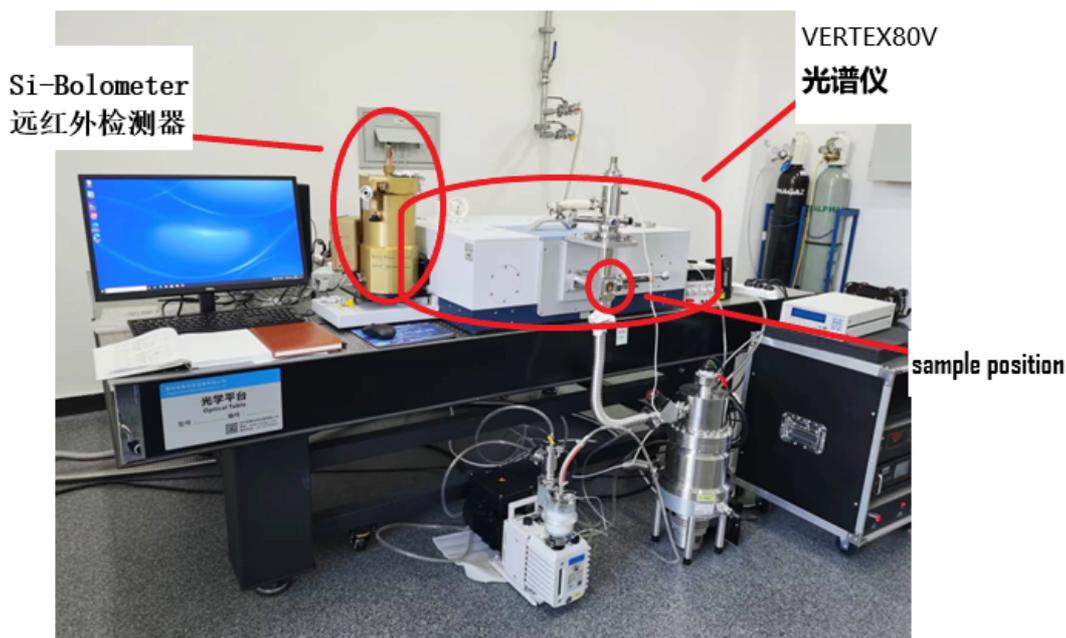


The triton cryogen-free system consists of He3-He4 dilution Refrigerator and superconducting magnet, offering a unique experimental condition of ultra-low temperature (10 mK) and high magnetic field (14 T). Sample puck is exchanged using the top-loading method. Measurements techniques including general AC/DC electrical resistivity and heat capacity are available at the present system, while more measuring options such as capacitive dilatometer and sound velocity are in progress.

Parameters	Values
Base temperature	> 10 mK
Magnetic field	< 14 T, < 0.3 T/min
Cooling power	12 $\mu$ W @ 20 mK 450 $\mu$ W @ 20 mK
Sample space	< $\Phi$ 30 mm

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## Run unit 9: Fourier transform infrared spectrometer system (FT-IR)



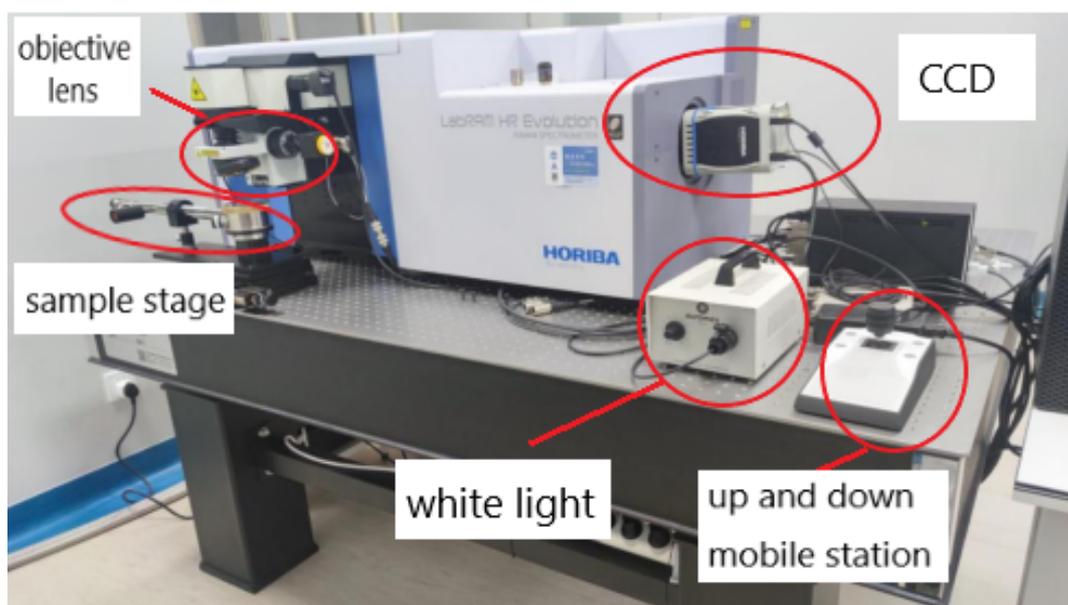
This system is made by Bruker, model VERTEX80V.

Parameters	Values
Spectral range	25,000-10 $\text{cm}^{-1}$
Resolution	Better than 0.2 $\text{cm}^{-1}$
Si-Bolometer, liquid He cooled	Range 8-650 $\text{cm}^{-1}$
FIR DLATGS detector	Range 15-700 $\text{cm}^{-1}$
MIR DLATGS detector	Range 350-12000 $\text{cm}^{-1}$
High sensitivity MCT detector, liquid N2 cooled	Range 420-12000 $\text{cm}^{-1}$
InGaAs diode detector	Range 4000-12800 $\text{cm}^{-1}$
Si diode detector	Range 9000-25000 $\text{cm}^{-1}$
Temperature range	5 K~350 K

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## Run unit 10: LabRAM HR evolution

Parameters	Values
<b>Confocal microscope</b>	A high stability open space confocal research grade microscope, 10x (0.25, 10.6mm), 100x (0.9,0.21mm), LWDD50x (0.5, 10.6mm)
<b>Laser and corresponding filters</b>	Laser 532 nm, 100 mW Interference Filter and Edge filter for 532 nm for measurement above 50 $\text{cm}^{-1}$
	Laser 632.8 nm, 17 mW Interference Filter and Edge filter for 632.8 nm for measurement above 50 $\text{cm}^{-1}$
<b>Spectrometer</b>	Raman shift range: 50-9000 $\text{cm}^{-1}$ with 532 nm excitation, 50-6000 $\text{cm}^{-1}$ with 632.8 nm excitation,
<b>CCD detector</b>	Spectral range 200-1050 nm
	MPP selected, 1024x256 pixels - Open electrode chip
	Quantum efficiency (QE) > 30 % between 500 and 850 nm
	TE cooled to (-70 °C)
	Chip size: 26.6x6.7 mm
	Pixel size: 26x26 $\mu\text{m}$
<b>High resolution helium cooler</b>	Temperature range 5 K~450 K

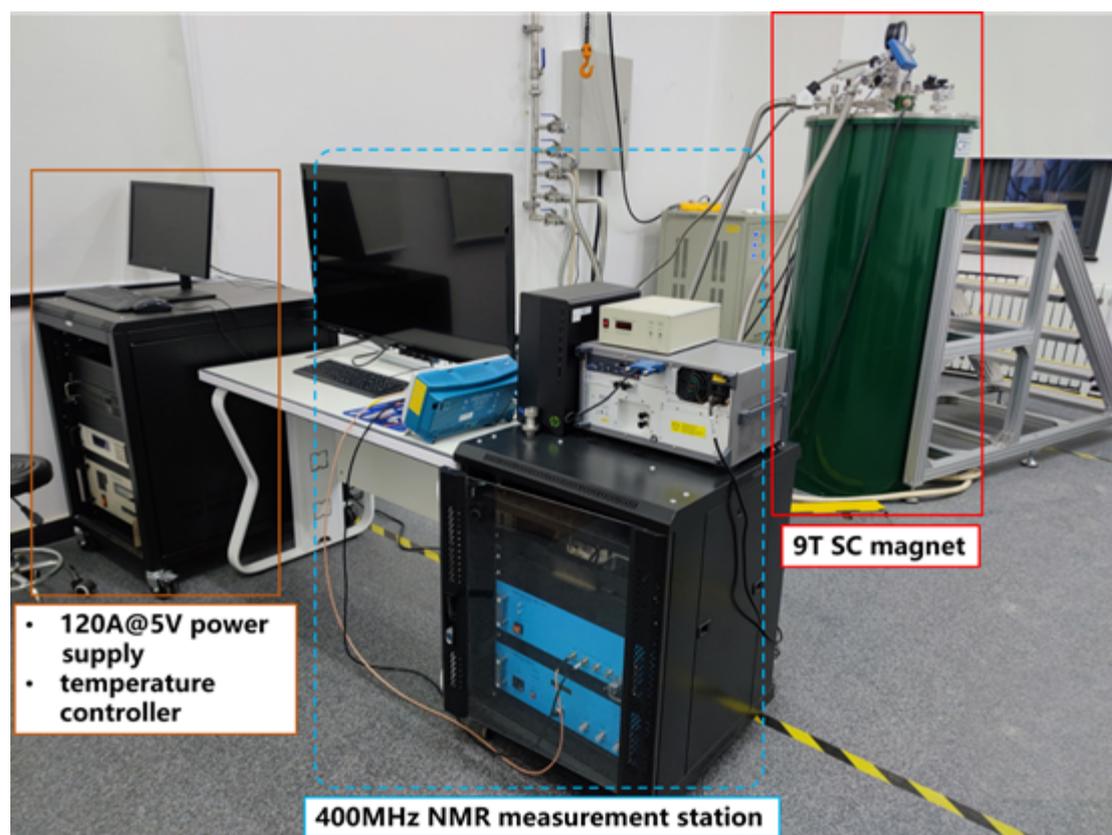


LabRAM HR Evolution UV-Visible-NIR (220–2200 nm) is a fully integrated confocal Raman system with open space microscope, offering a large free space under the objective turret for large sample holders like cryostats, high temperature cells, high pressure cells, or just large samples. The open space microscope is hard coupled to the LabRAM HR Evolution in order to get high stability. Focusing is achieved by adjusting the height of the microscope objectives instead of the sample stage.

Integrated laser Raman instrument for confocal and punctual analysis including a confocal microscope, transfer and filtering optics, an achromatic spectrograph equipped with two gratings, a multichannel detector and a computerization package.

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### Run unit 11: 9 T nuclear magnetic resonance (NMR) spectrometer system



9 T nuclear magnetic resonance (NMR) spectrometer system consists of the 9 T superconducting magnet, the variable temperature insert, and the NMR spectrometer, which is mainly used to study solid materials. The  $^4\text{He}$  variable temperature insert can control the temperature from room temperature to 1.9 K, with 40 mm sample space.

The NMR probe is homemade with two cryogenic coaxial cables. The operating frequency range of the NMR spectrometer is 1 MHz~400 MHz.

<b>Parameters</b>	<b>Values</b>
<b>Magnetic field</b>	9 T
<b>Homogeneity</b>	$<3*10^{-6}$ @10 mm
<b>Maximum energization rate</b>	0.0088 T/s
<b>Stary field</b>	4.7 Gauss @ 1.7 m
<b>Temperature range</b>	1.9 K~300 K
<b>Sample space</b>	40 mm
<b>Frequency</b>	1 MHz~400 MHz

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