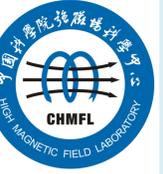


# Assembly and Commissioning of the helium cryogenic system for the hybrid superconducting outsert at CHMFL



**Junjie LI, Zhengrong OUYANG, Hongqiang LI, Qiumin MENG, Lei SHI, Xin AI, Ming FANG, Xuheng CHEN and Dazhi KUANG**

High Magnetic Field Laboratory, Chinese Academy of Sciences. Hefei, 230031, China.

## background

The hybrid magnet which consists of a 34 T resistive insert and an 11 T superconducting outsert has been put into operation early this year at the High Magnetic Field Laboratory of the Chinese Academy of Sciences (CHMFL). The superconducting outsert made of Nb<sub>3</sub>Sn cable-in-conduit conductor (CICC) technology can provide 11 T field in 800 mm room temperature bore. The superconducting coils whose total cold mass is 11 tonnes are cooled with forced flow supercritical helium at 4.5 K.

## summary

At CHMFL, construction of the helium cryogenic system which have the functions of liquid helium production and hybrid superconducting outsert cooling is finished; At 4.5 K, the field of the hybrid superconducting outsert is increased to 10 T. Combined with the water-cooled magnet, 40 T magnetic field in a 32 mm clear bore is obtained; The field will be increased to 45 T in the second half of this year.

## About the CHMFL

The main missions of the Lab:

- 1) Develop series of high field magnets (hybrid magnets, superconducting magnets and water-cooled magnets)
- 2) Research on physics, functional material, chemistry, life sciences and pharmacology in the extreme high magnetic field

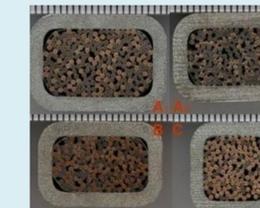
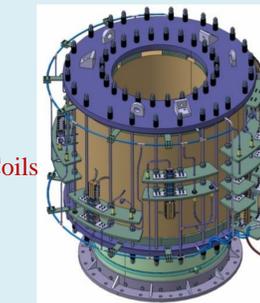
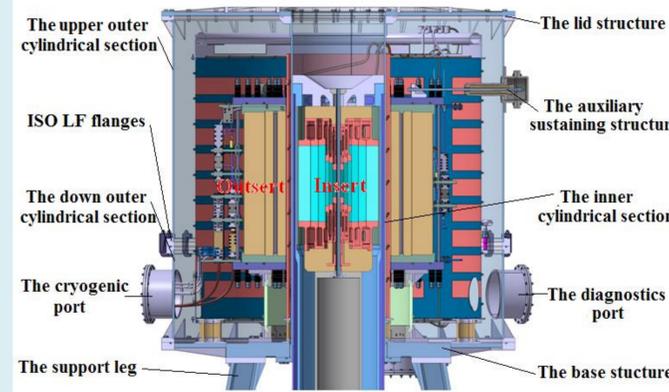


Magnets we have:

	Water-cooled magnets	Superconducting magnets	Hybrid magnets
WM1	38.5T@32mm	SM1	8T@100mm
WM2	25T@50mm	SM2	20T@50mm
WM3	20T@200mm	SM3	18.8T@54mm
WM4	27.5T@32mm	SM4	9.4T@400mm
WM5	35T@50mm		
		HM1	45T@32mm

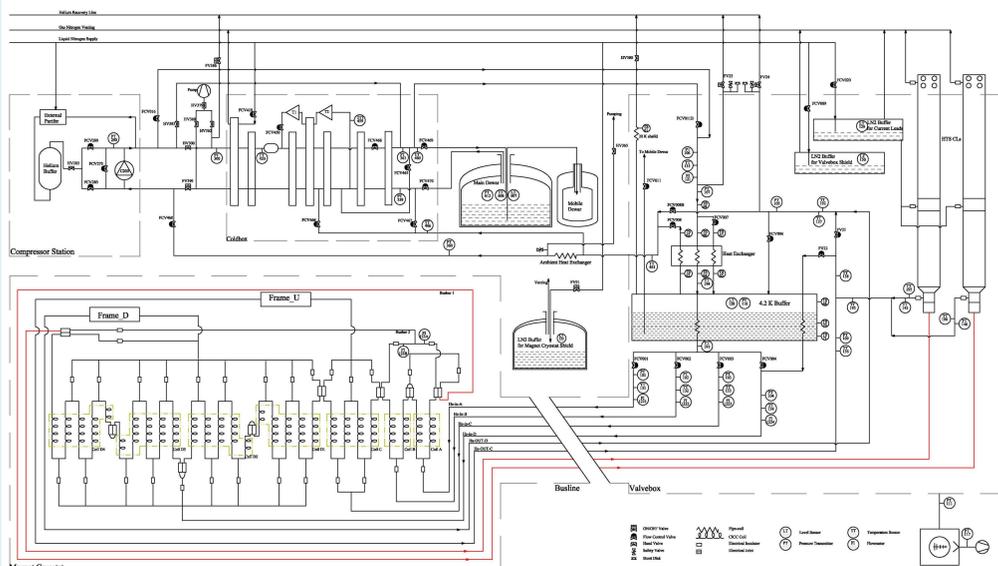
## The hybrid magnet and its superconducting outsert

Combined system	Field contribution	Operating temperature	Coil /conductors	Clear bore
SM	11T	4.5 K	CICC	800mm
WM	34T	RT	Florida Bitter	32mm



description	coil A	coil B	coil C	coil D
jacket Dimensions (mm)	22×15	20.2×13.4	20.2×13.4	15×14.4
number of strands(Cu/Sc)	160/80	105/75	60/120	36/108

## Assembly and the first commissioning of the helium cryogenic system



Circuit of the helium cryogenic system

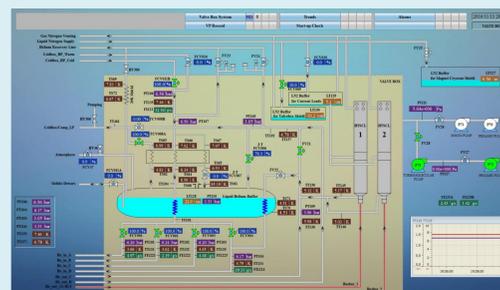
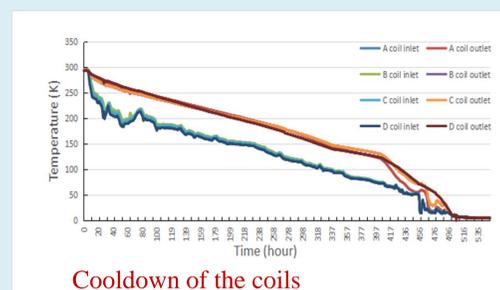
The main helium cryogenic system includes a helium refrigerator and a helium distribution system for the cooling of superconducting coils, structures, transfer lines and current leads.

The helium refrigerator was successfully commissioned at early 2012 and has been operated at liquefaction mode for 5 years.

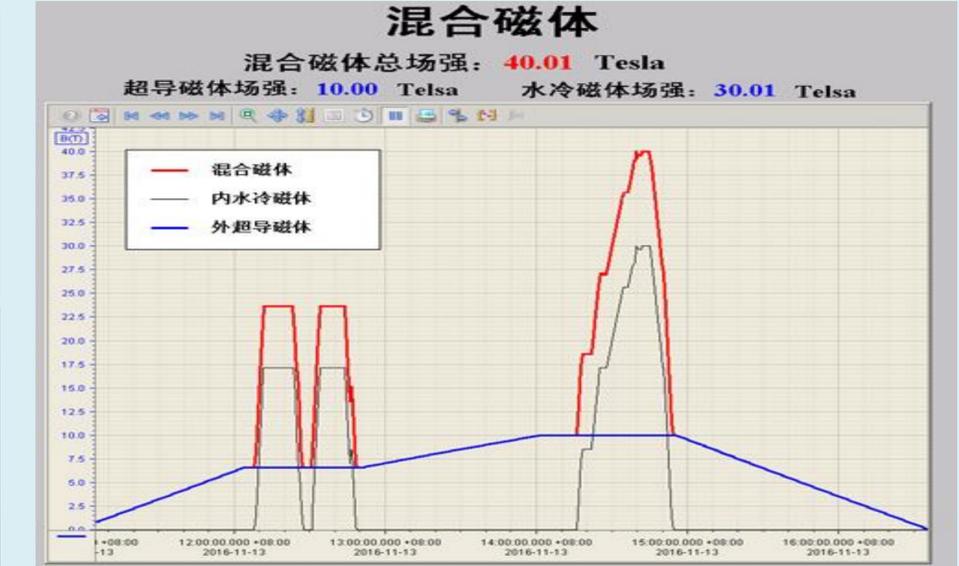
The helium distribution system assembly was finished at September, 2016. Then it takes more than 20 days to cool-down the superconducting magnet (The coils are totally divided into 26 cooling-channels which are hydrodynamically connected in parallel) to 4.5 K.

When the hybrid magnet is operating at 40 T field, the 4.5 K supercritical helium supply parameters are:

- Mass flow rate: >30g/s
- Max temperature of the coils: 5.3 K



Control of the helium cryogenic system



The first commissioning of the hybrid magnet