

MRI and DSA from Layout Design to Installation

Zhangyi Shao¹, Chenjian Ye¹, Yang Li¹, Chunchun Ye², Sunzhong Lin^{1,*}

¹ Department of Medical Engineering and Equipment, Second Affiliated Hospital and Yuying Children's Hospital of Wenzhou Medical University, Wenzhou, China

² ICU, Yongjia County People's Hospital, Wenzhou, China

* Corresponding author: Sunzhong Lin (Email: 178723491@qq.com)

Abstract: MRI (Magnetic Resonance Imaging System) and DSA (Digital Subtraction Angiography System), as important equipment in the field of modern medical imaging, have gradually entered major hospitals. As large precision medical equipment, the preparation and installation of MRI and DSA are of great significance to the safety and long-term operation quality of the equipment itself. This paper takes the introduction of MRI and DSA in our new hospital as an example, combining the modern medical service concept of “patient-centered”, and introduces in detail the key links such as machine room design, construction cooperation, equipment arrival and installation, providing reference for the construction of medical equipment machine room.

Keywords: MRI, DSA, Large Medical Equipment, Layout Design.

1. Introduction

The construction project of Longwan Courtyard of our Institute was designed in 2014, commenced in March 2015, and completed and put into use in September 2020; The building area is 180,000 m² and 1200 beds are designed.

Longwan Hospital of our hospital is equipped with 2 MRI, 2 CT, 2 DR, 1 digital gastrointestinal machine, 1 breast X-ray machine, 1 digital bone density instrument, 2 DSA, and 1 hybrid operating room. MRI, CT, DR, digital gastrointestinal machine, breast X-ray machine and digital bone density instrument are all located in the radiology department on the first floor of the medical technology building, DSA is located in the DSA center on the fifth floor of the medical technology building, and the hybrid operating room is located in the operating room on the fourth floor of the medical technology building. This paper introduces the whole process of MRI and DSA from layout design to installation.

2. Layout Design Stage

In August 2020, the bidding for two MRIs in Longwan Hospital was completed, and the winning model was United Imaging uMR586, which features a magnetic field strength of 1.435T. The radiology department of Longwan Hospital has planned 4 MRI rooms. After thorough discussions involving clinical departments, equipment manufacturers, and the medical engineering and equipment department, considerations were given to both the convenience of patient visits and the need for humanistic care. It was ultimately decided to install United Imaging MRI systems in two of the rooms, designated as MRI (I) and MRI (II) as shown in Figure 1, while the remaining two rooms are reserved for future use.

The specific analysis is as follows:

MRI (I) Machine room: There is an elevator hall on the left side of the machine room. The elevator will affect the uniformity of the magnetic field. In addition, the elevator will also produce vibration, which will affect the stability and imaging quality of the MRI equipment. Especially for 3.0T MRI equipment, due to its higher magnetic field intensity, the requirements for environmental vibration and magnetic field uniformity are higher [1, 2], and the interference of elevators

may be more significant. Therefore, it is recommended that the MRI of 1.5T and below to be installed this time be installed in the MRI (I) machine room.

MRI (II) machine room: This machine room is positioned on the same side as MRI (I) machine room, forming a centralized equipment layout. This configuration significantly enhances patient accessibility and effectively implements the modern healthcare services concept of “patient-centered”. At the same time, due to the small space in the equipment room of the MRI (II) machine room, it is difficult to install 3.0T MRI equipment [3]. Therefore, it is recommended that the MRI of 1.5T and below to be installed this time be installed in the MRI (II) machine room.

To sum up, the equipment to be installed this time is MRI below 1.5T, so it is recommended to be installed in MRI (I) room and MRI (II) room; as for the remaining two rooms, it is recommended to reserve 3.0T MRI for future development.

In 2022, to meet the needs of precise diagnosis of neurological diseases, high-resolution imaging of the abdomen and pelvis, as well as vascular imaging and blood flow analysis, our hospital introduced a 3.0T magnetic resonance system, Philips Elition X model. Considering the convenience of patient visits, the Philips MRI was installed in the MRI (III) room, as shown in Figure 1.

In August 2020, one DSA in Longwan Hospital completed the bidding, and the winning model was Philips UNIQ FD20C. The other DSA is GE Innova 2100 IQ, which is transferred from the DSA Center of Nanpu Hospital of our hospital. The locations of the two DSA rooms (OR43 and OR44) are shown in Figure 2.

The two rooms (OR43 and OR44) are positioned closer to the patient entrance on the right side, significantly facilitating patient access. Furthermore, the two DSA rooms share a common control room [4], which streamlines operational efficiency for clinical departments. As for the remaining two rooms, it is recommended to reserve them for the DSA required for future development.

Between 2021 and 2023, to meet the growing clinical demands of the department of cardiovascular medicine, interventional medicine, vascular surgery, and neurosurgery, our hospital acquired two digital subtraction angiography systems. The models specified were Siemens Artis Pheno and

Philips Azurion 7 M12. To ensure convenience for patients, the Siemens DSA was installed in the OR45 room, while the Philips DSA was installed in the OR46 room. Additionally, anticipating sustained growth in DSA procedural volume in the coming years, four new DSA rooms (OR47-OR50) have been designated for future expansion, as illustrated in Figure 2.

After confirming the machine room of MRI and DSA,

contact the construction management department, equipment manufacturer and clinical department to survey the site. After the survey, the equipment manufacturer will issue the layout and discuss the layout with the clinic again. If there are details to be adjusted, the equipment manufacturer will adjust them again. After the clinical department determines the layout, the medical engineering department shall contact the equipment manufacturer to provide specific construction drawings.

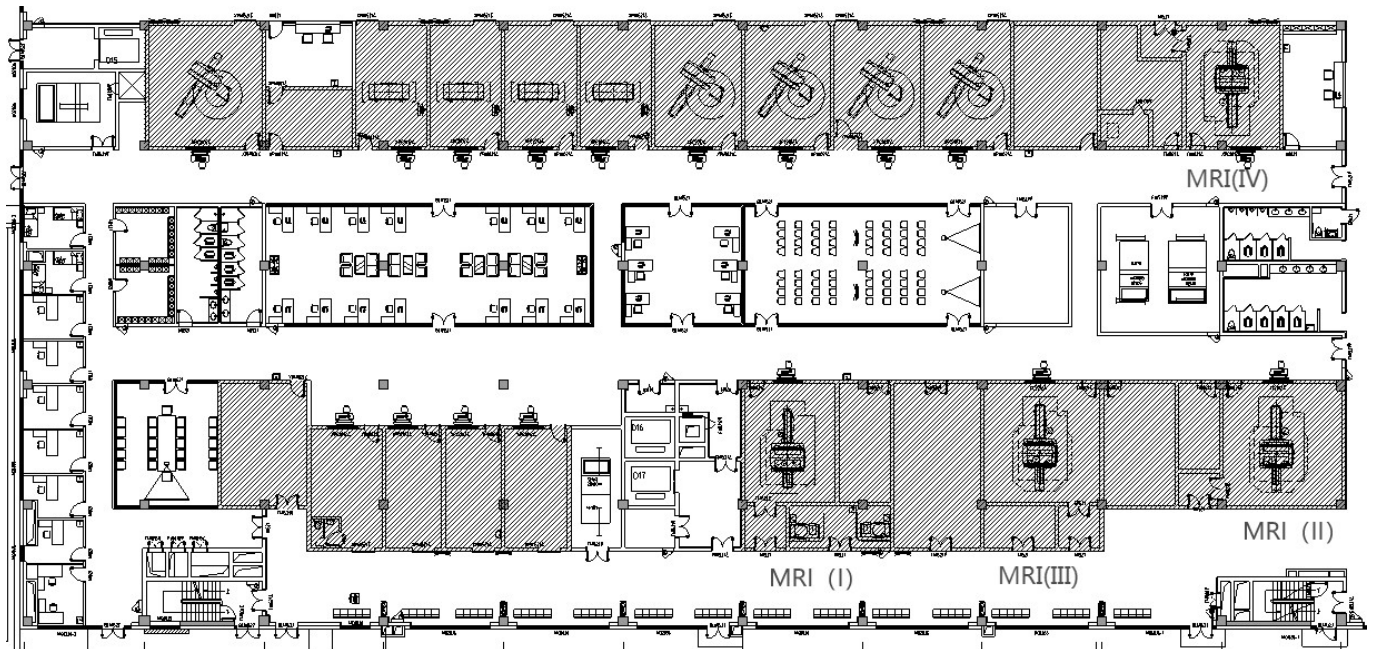


Figure 1. Location Plan of MRI Machine Room

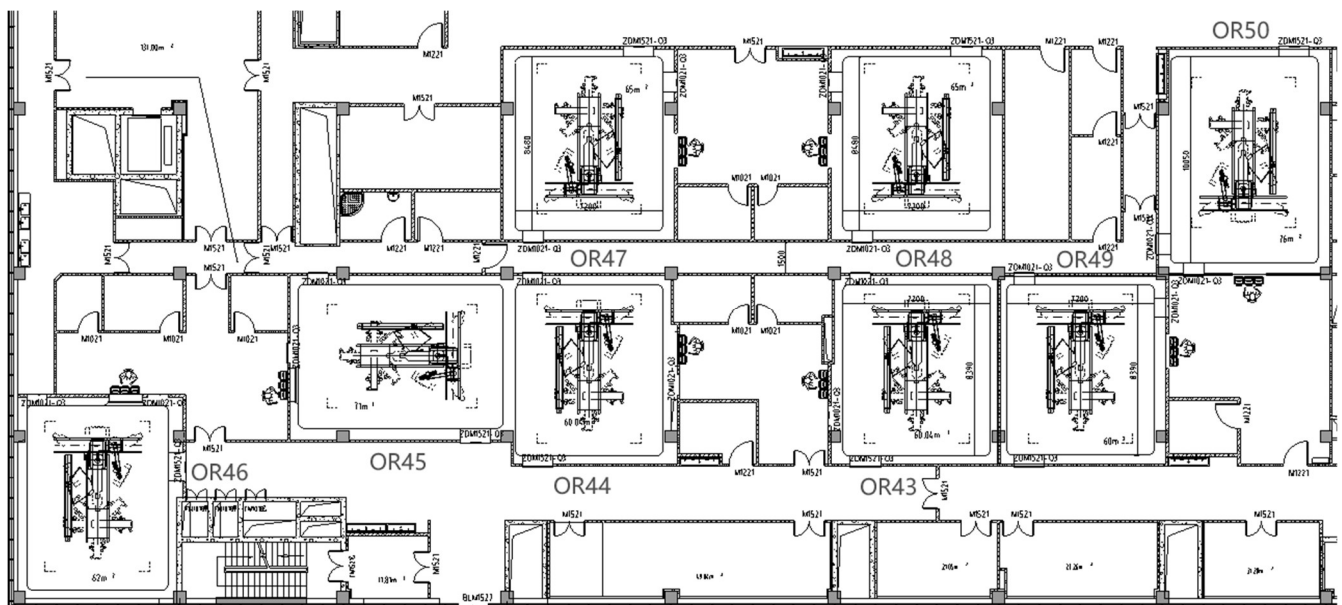


Figure 2. Location Plan of DSA Machine Room

In addition, we need to summarize the installation site requirements for third-party equipment. MRI needs to consider precision air conditioner, water chiller, ferromagnetic detector, high-pressure injector and other

ancillary equipment; DSA needs to consider monitor, high-pressure injector, multi-conductive physiology instrument, intravascular ultrasound, anesthesia machine, injection pump and other ancillary equipment [5]. See Table 1 for details.

Table 1. List of common third-party equipment for MRI and DSA

MRI Third Party Equipment:		DSA Third Party Equipment:	
Precision air conditioner	Power supply, location of indoor and outdoor units, water supply and drainage, and copper pipe wiring shall be considered	Monitor	Consider the power supply, the module extension cable of the monitor, and the split-screen cable routing
Water chiller	Power supply, location of indoor and outdoor units, water supply and drainage, and copper pipe wiring shall be considered	High-pressure injector	Consider the wiring of power supply, control panel and host cable
Ferromagnetic detector	Consider location, power	Multi-conductive physiology instrument	Consider power, split-screen wiring
High-pressure injector	Consider the wiring of power supply, control panel and host cable	Intravascular ultrasound	Consider the wiring of power supply, control panel and host cable
		Anesthesia machine, injection pump	Consider the power supply

When the MRI or DSA equipment manufacturer draws the construction drawing, the medical engineering department shall intervene in time, collect and summarize the site requirements of the third party equipment, and provide them to the MRI or DSA equipment manufacturer. The MRI or DSA equipment manufacturer shall check whether the original construction drawing can meet the installation requirements of the third party equipment. If not, the installation requirements of the third-party equipment should be separately marked in the construction drawing.

For the MRI (I) machine room, the corresponding drawings

of the third-party equipment are shown in Figure 3. For OR43 and OR44 rooms, the corresponding drawings of the third-party equipment are shown in Figures 4 and 5 respectively.

After the construction drawings are issued, the clinical department, the medical engineering department and the third party equipment manufacturer shall check the drawings again, feed back in time if there is any problem or omission, and determine the final construction drawings. The medical engineering department shall submit the final construction drawings to the construction management department.

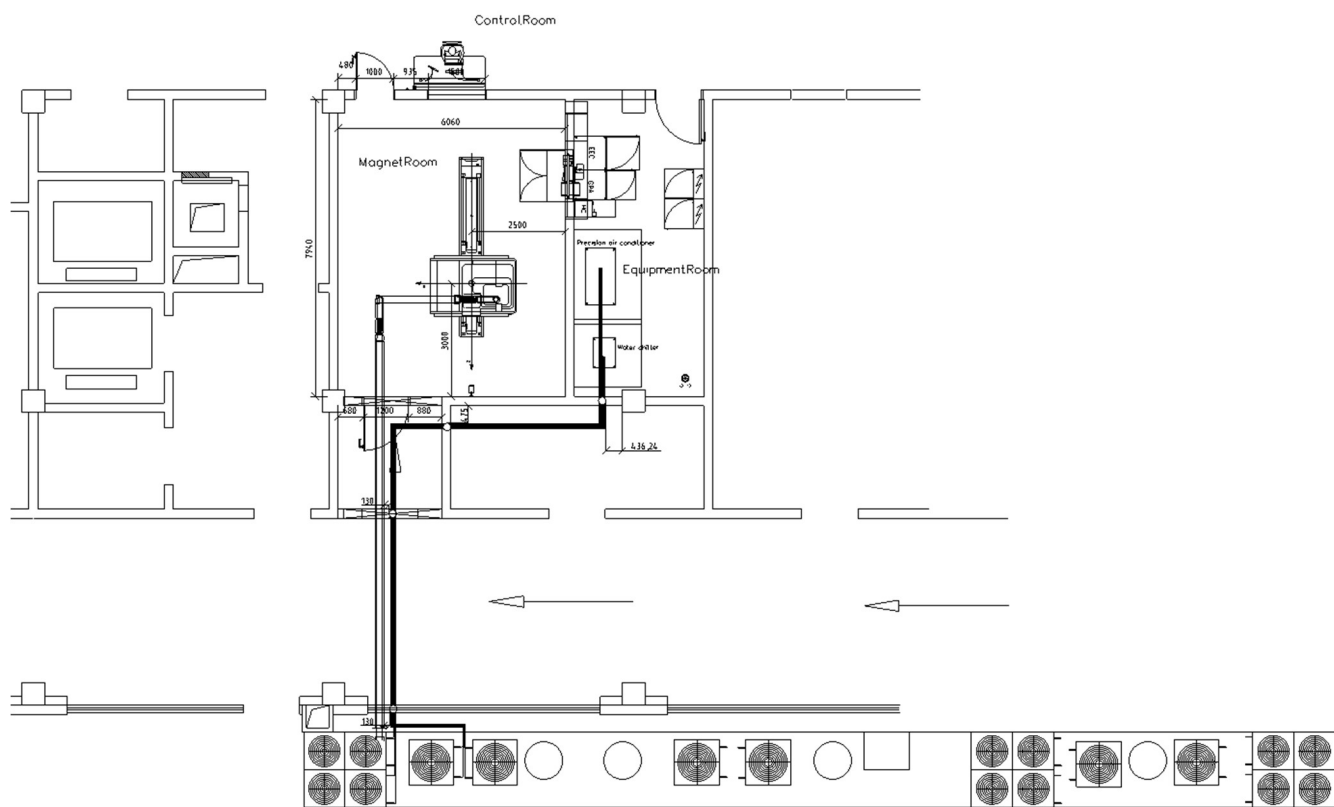


Figure 3. Layout and Wiring Diagram of MRI Air Conditioner and Water Chiller

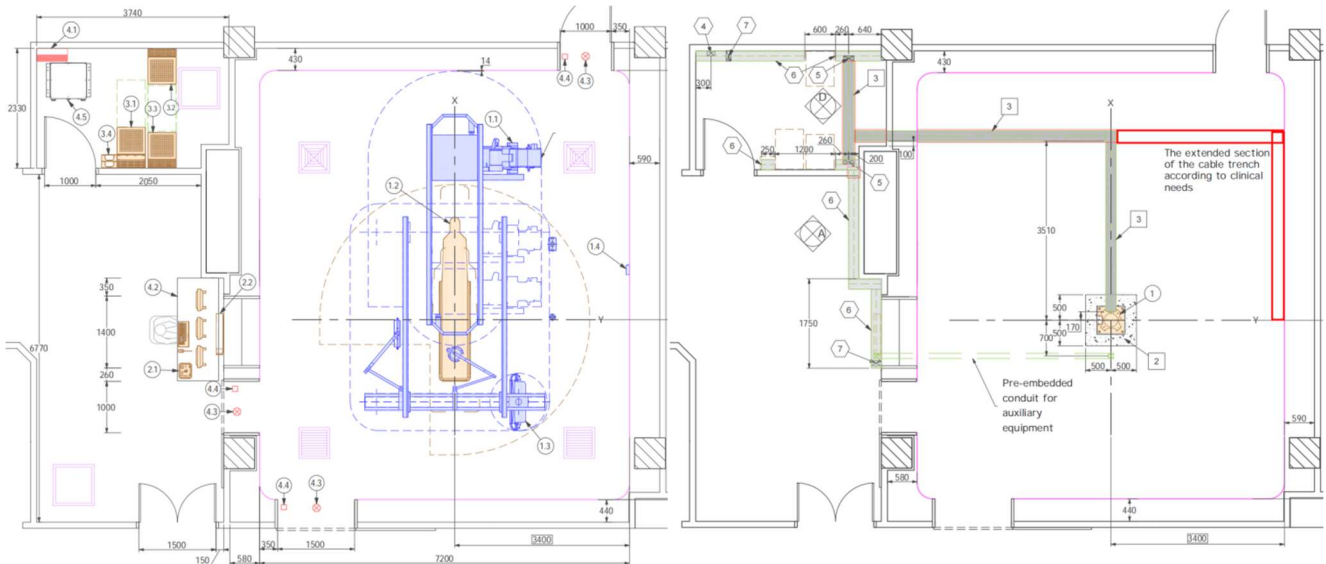


Figure 4. Cable Trench Diagram for Third-Party Equipment in OR43

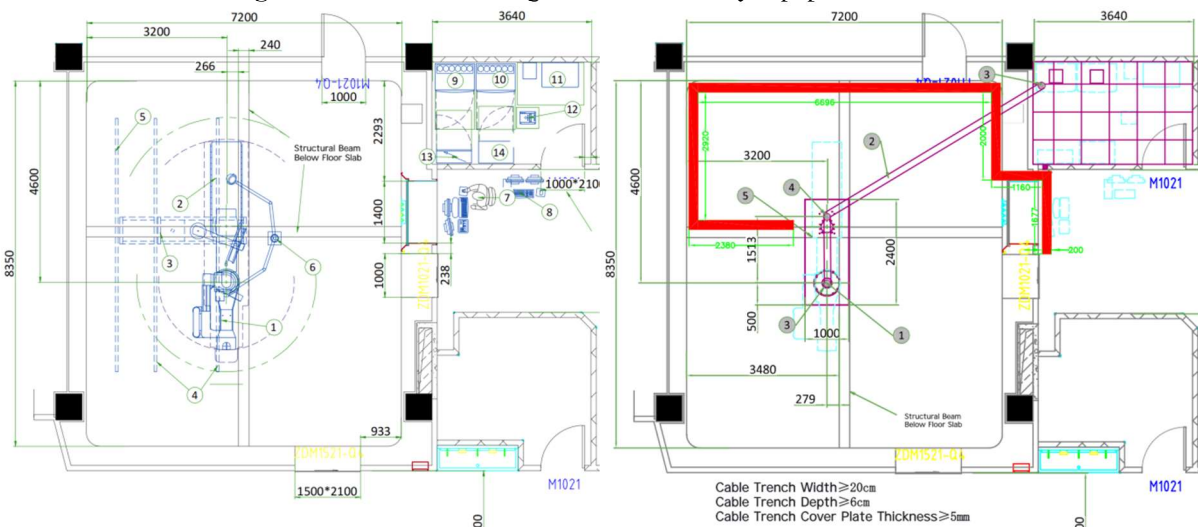


Figure 5. Cable Trench Diagram of Third-Party Equipment in OR44

3. Construction Stage

After the construction party is determined, the construction management department, the medical engineering department, the equipment manufacturer and the construction party shall hold a construction drawing disclosure meeting. The equipment manufacturer shall introduce the requirements of the equipment in detail according to the construction drawings, and the participants shall discuss and communicate with each other. After the meeting, the participants went to the machine room to survey the site.

The construction part shall be completed by the construction party under the guidance of the construction management department.

As the medical engineering department, it should regularly survey the site to understand the progress and ensure that the construction is carried out according to the design drawings. If the construction cannot be carried out according to the drawings due to objective factors, it should communicate with the equipment manufacturers in time, actively coordinate and solve the problems and continue to follow up, promote the effective communication among the user departments, the

equipment manufacturers, the construction management department and the construction party, and ensure that the site conditions meet the requirements of equipment installation.

The original layout of MRI (II) machine room is shown in Figure 6. During the investigation, the construction management department found that there was a fire hose [6] on the right side of the MRI magnet room, which was very difficult to remove or displace. After consultation with the clinical department and the equipment manufacturer, a small room was separated on the right side of the magnet room, as shown in Figure 7, so that the fire hose would not affect the MRI equipment. In addition, there is a cross beam on the side of the magnet room, which is required to be removed in the original drawing design, as shown in Figure 8. The construction management department fed back that it was difficult and affected the construction progress. After re-survey by the equipment manufacturer, it agreed to adjust. The diagram of reserved hole after adjustment of MRI (I) is shown in Figure 9.

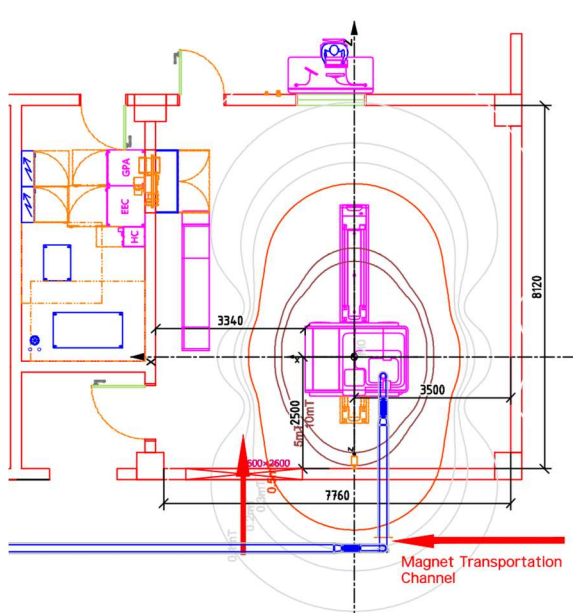


Figure 6. Original layout of MRI (II)

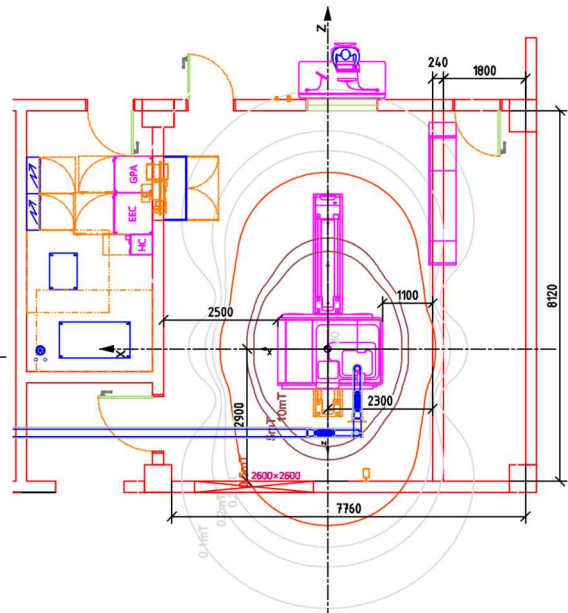


Figure 7. Modified layout of MRI (II)

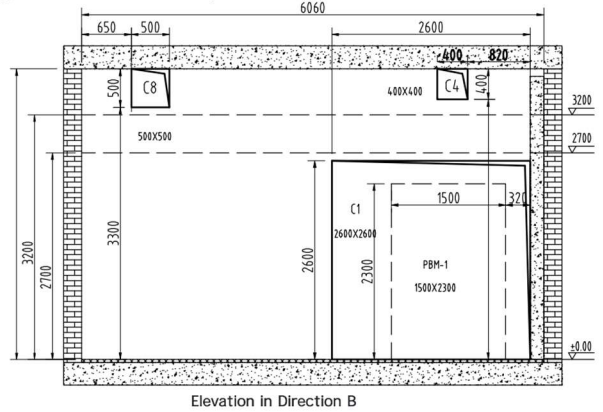
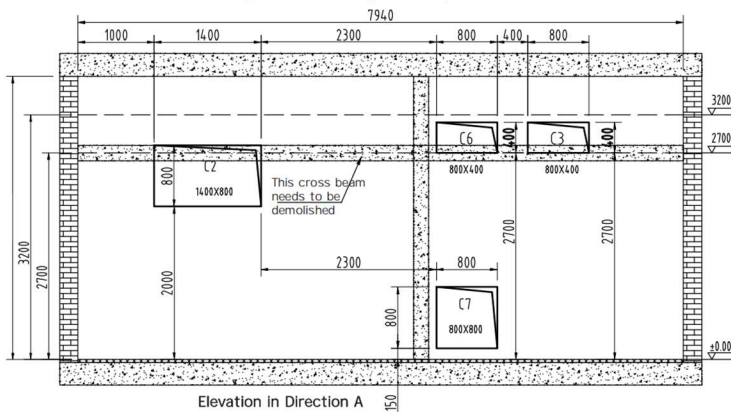


Figure 8. Diagram of Original Reserved Hole of MRI (I)

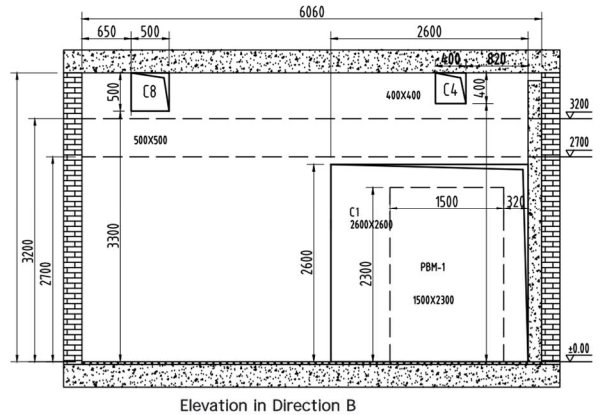
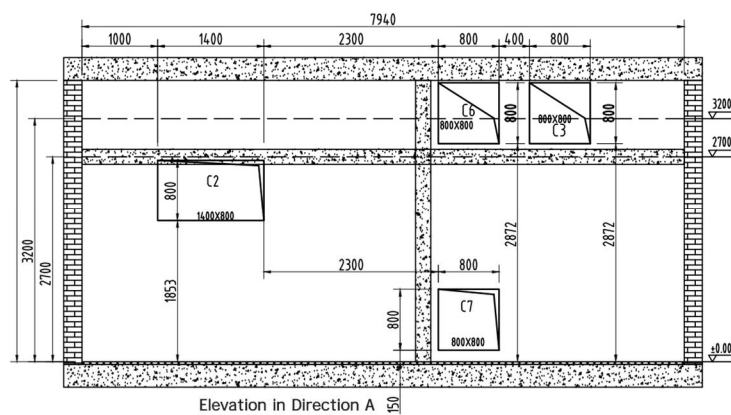


Figure 9. Diagram of reserved hole after adjustment of MRI (I)

During the construction of DSA, due to the high requirements for the operation and positioning accuracy of DSA [7], it is necessary to pay attention to the construction deviation of the steel structure center and the foundation center. See Figure 10 and Figure 11 for the two centers respectively. Taking Philips DSA in our hospital as an example, the C-arm is a suspension structure, which requires a steel structure for suspension, while the catheter bed requires a ground foundation. Ideally, the two centers are

completely coincident, and the construction can be positioned according to the drawings. However, errors are unavoidable in the construction process. Therefore, during the actual construction, the steel structure shall be constructed according to the drawings first, and then the foundation construction shall be carried out according to the actual center of the completed steel structure (not the steel structure or foundation center on the drawings) as the center of the foundation, which can effectively avoid the superposition of construction errors.

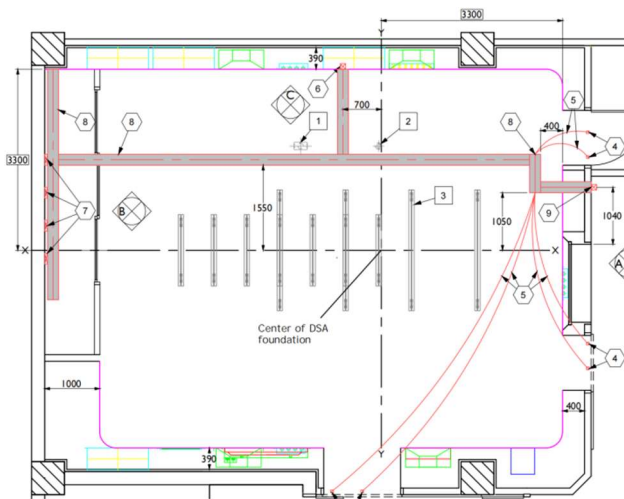


Figure 10. Center of DSA steel structure

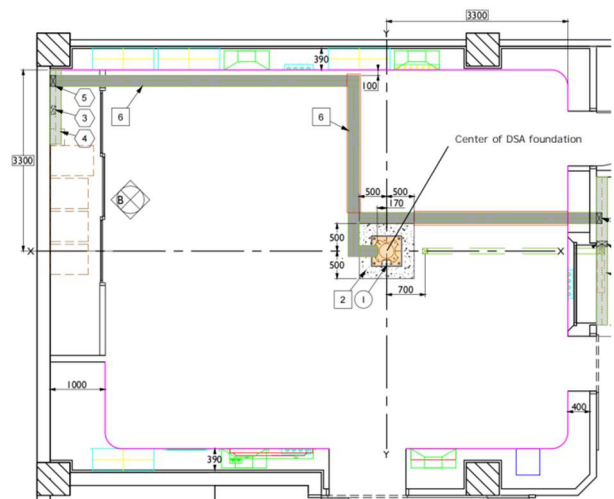


Figure 11. Center of DSA foundation

4. Arrival and Installation

In the installation and commissioning of MRI equipment, many details need to be considered, including shielding construction [8] (including RF shielding and ferromagnetic shielding, the ferromagnetic shielding may not be required, depending on the size of the machine room and the range of 5 Gauss line), the laying of air conditioning and water chiller pipes and quench pipe [9], the installation of MRI, the repair of shielding at the entrance of the magnet, the construction of outdoor platforms, etc., all of which need to be coordinated with the construction schedule of the site. The specific schedule of machine room construction and equipment installation is shown in Table 2. The blue font in the table shall be completed by the construction party, and the red font shall be completed by the equipment supplier and the equipment manufacturer. Especially important, after the confirmation of the schedule of machine room construction and equipment installation, timely survey and feedback are needed to ensure

the completion of the schedule with quality and quantity guaranteed. In addition, as the shielding materials and copper pipes are relatively expensive, temporary storage shall be considered for storage.

Compared with the installation of MRI, the installation of DSA is relatively simple. After the construction is completed, the equipment manufacturer will check and accept the site. If there is any problem, it will be immediately fed back and rectified. If it is qualified, it will be notified to deliver the equipment. After the arrival of the equipment, it can be installed on the site. It should be noted that since the newly purchased DSA equipment is imported equipment, the packaging box of the equipment needs to be kept for customs inspection. In addition, because some third-party equipment needs to be connected to the DSA machine (such as high-pressure injector), when the installation of the DSA is nearing the end, the medical engineering department will contact the third-party equipment manufacturer to install the equipment in time to facilitate joint debugging.

Table 2. Schedule of MRI Machine Room Construction and Equipment Installation

		Schedule for MRI Room Construction and Equipment Installation																																																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41										
Magnet Room	Magnet Room Decoration																																																			
	Shielding Materials Delivery and Construction																																																			
Equipment Room	MRI Arrival and Installation																																																			
	Repair the Entrance to the MRI Magnet																																																			
Control Room	MRI Liquid Nitrogen Filling and Commissioning																																																			
	Arrival and Installation of Air Conditioning Water Cooling Unit																																																			
Other Areas	Equipment Room Decoration (including Water and Electricity Construction)																																																			
	Arrival, Installation, and Commissioning of MRI Cabinet																																																			
Other Areas	Control Room Cabling Tray Construction																																																			
	Assembly of MRI Control Console and Commissioning of the Entire Machine																																																			
Other Areas	Outdoor Platform Construction																																																			
	Dismantling of Ceilings and Glass Curtain Walls																																																			
Other Areas	Laying of Air Conditioning Water Cooling Pipes and Quench Pipes																																																			
	Repair of Ceilings and Glass Curtain Walls																																																			
Other Areas	Quench Pipe Discharge Outlet Construction																																																			
	Outdoor Platform Handrail Construction																																																			

5. Conclusion

In the construction of the new hospital, MRI, DSA and

other large-scale equipment are particularly critical, and these equipment have more complex requirements for the installation site. As the medical engineering and equipment department, we should get involved early and finish the

equipment layout design, summary of equipment installation requirements, and confirmation of construction drawings before the decoration construction. In the construction stage, follow up in time, and feed back and solve in time when it is found to be inconsistent with the drawings. During the construction stage, the construction of the machine room and the schedule of equipment installation can be negotiated with the equipment manufacturer and the construction management department to ensure that the construction, installation and commissioning are not delayed and that the installation is completed smoothly.

Acknowledgments

This work was supported by the Wenzhou Municipal Science and Technology Bureau (Y20240826).

References

- [1] Chen Xiong. Magnetic interference and shielding design of 3.0T magnetic resonance room [J]. Medical Equipment, 2023, 36 (21): 30-32.
- [2] Shao Xiaoning, Liu Liang, Wu Kai, et al. Precautions for site preparation of medical 3.0 T magnetic resonance equipment [J]. Biomedical Engineering and Clinical, 2024, 28 (04): 568-572.
- [3] Huang Yekai, Feng Zhaohui, Song Qingjiang, et al. Implementation process management of 3.0T medical magnetic resonance project [J]. China Hospital Construction and Equipment, 2023, 24 (11): 66-70.
- [4] You Ning, Cui Wei. Construction of DSA Operating Room in Affiliated Hospital of Qingdao University [J]. China Hospital Architecture and Equipment, 2019, 20 (08): 77-78.
- [5] Gao Wanhe, Zhao Yanqiong, Pan Wenzhe. Radiation protection detection analysis of digital subtraction angiography equipment room construction and installation [J]. China Medical Equipment, 2018, 15 (10): 118-121.
- [6] Tian Weiliang, Xu Kaixi, Zhu Boguang. Discussion on installation scheme of 3.0T high-field medical magnetic resonance equipment [J]. China Medical Equipment, 2017, 14 (04): 149-151.
- [7] Fan Kaizhou, Xu Chang, Liu Qian, et al. DSA Computer Room Construction Project Management in Large Hospital -- Taking Cardiology Ward Renovation Project in a Hospital as an Example [J]. China Hospital Architecture and Equipment, 2022, 23 (07): 77-80.
- [8] Wu Ziyang, Cai Mingjin. Magnetic interference and shielding analysis of superconducting magnetic resonance room [J]. China Medical Equipment, 2018, 15 (05): 117-120.
- [9] Yang Yongyan, Hong Ming, Tang Hui, et al. Layout and design of MRI equipment room with AE special function [J]. China Medical Equipment, 2018, 15 (05): 121-123.
- [10] Zhang Pu, Lv Shunchao. Example of combination of large medical equipment installation and infrastructure construction in new hospital [J]. China Hospital Construction and Equipment, 2020, 21 (08): 120-123.