and disposed. Meanwhile, the hazardous waste transfer information was reported to the solid waste management information system of Gansu province.

The application form for the purchase of precursor chemicals submitted by various laboratories was summarized and the purchase record certificate was handled. Four purchases of precursor chemicals, totaling 385.5 liters, were completed in accordance with the regulations, and the purchase and use of precursor chemicals were reported to the National Management Information System for Precursor Chemicals.

7 - 30 Preliminary Shielding Design of Pre-separator at HFRS

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A new radioactive ion beam line named HFRS (HIAF FRagment Separator) will be built at HIAF, where the rare isotopes are produced\(^1\)\(^2\). It consists of a two-stage magnetic system, the pre-separator and the main-separator. The former is used to distinguish the unreacted primary beam from the secondary beam, and the unreacted will be stopped in the beam dumps located between two dipoles; while the latter is used to purify the secondary beams. For the radiological safety of HFRS, the preliminary shielding design of pre-separator at HFRS is given in this work. All the calculations are conducted by the Monte Carlo code FLUKA\(^3\).

Two aspects must be considered in the shielding design: the radiation sensitive devices like drive motors must be protected and at the same time the tunnel is accessible after a certain cooling time (in the work is 3 d) when the beam is off. Thus, the overall shielding (ordinary concrete) together with compact shielding (iron) are adopted for the shielding design. The entire beam line is located 12.0 m underground. The dose rate limit for the lateral and bottom of tunnel is 5.0 mSv/h, the top is 0.25 μSv/h, and for the working place is 2.5 μSv/h. Meanwhile, in the case of hands-on maintenance of accelerator components, the residual dose rate limit is 100 μSv/h. The annual dose is 5 mSv/a for the occupational workers in HIAF. The typical primary beam is uranium with 0.8 GeV/u in energy and 3.0×10\(^{11}\) ions/s in intensity. The production targets are graphite (2, 6, 10 and 16 mm) and tungsten (0.5, 1.5 and 2.5 mm). For the target area, the previous studies indicate that the strongest radiation is produced by the 16 mm graphite, about 47.5% beam loss on target and 52.5% on beam dump. While for the beam dump area, which is produced by the 0.5 mm tungsten, about 2.5% beam loss on target and 97.5% on beam dump. So the shielding assessment and subsequent activation analysis are based on the this result.

Fig. 1 (a) and (b) shows the prompt dose rate distribution in the target area and beam dump area, respectively. Both the results show that the maximum dose rate can reach the order of 10\(^{11}\) μSv/h, and outside the compact shielding (iron) can reach 10\(^6\) μSv/h. For the target area, the needed thickness of iron is 0.6, 1.0 and 0.7 m in backward, lateral and forward direction of the target chamber, respectively; for the lateral tunnels L1 and L2 is 0.9 and 4.2 m, respectively; for the top shielding is 1.2 m concrete+5.2 m backfill gravel; and the bottom is 3.5 m concrete. For the beam dump area, the iron is 1.3 m in lateral direction; for L1 and L2 is 1.2 and 4.5 m, respectively; and for the top shielding is 1.2 m concrete+5.5 m backfill gravel; and the bottom is 3.7 m concrete. A hot cell might be necessary outside of the L2, so the design goal is 2.5 μSv/h in this study.

![Fig. 1](color online) Prompt dose rate distributions in the pre-separator of HFRS. (a) Target area (b) Beam dump area.
7 - 31 Work Progress of Slow Control Group in 2018

Wang Yanyu

Routine work of the slow control group is the running and maintains of several control and monitoring system in HIRFL, such as the water leakage detection and alarm system, environmental temperature and humidity monitoring system, magnet cooling water temperature monitoring and alarm system, ECR control system, SFC extraction electrostatic deflection motion control, vacuum device control and monitor hardware, CSR kicker system control, device support in physical experiment, etc. In 2018, through the efforts of all the members in slow control group, we had got several good results in HIRFL-CSR control, monitor and alarm system maintains and upgrade.

1) Realization of motion control system based on EPICS architecture for DR and CSRe cluster internal target.

In order to solve the inconvenience such as the decline of control accuracy and running instability, a set of new motion control system is design and realized for DR(Dielectronic Recombination) and CSRe cluster internal target moving detectors in 2018. Beckhoff PLC has been used to build the hardware platform and the whole system structure is established based on EtherCAT(Ethernet for Control Automation Technology) technology and EPICS architecture.

2) Upgrade of the TR5 Experiment Terminal Control System.

In order to improve the stability of TR5 experimental terminal control system, a new control system was design and realized in 2018 both in hardware and software level. PLC (Programmable Logic Controller) is used in hardware instead of assembled PC based plug-in board. In software, several sets of control software with independent functions are integrated into one software developed by C++. After finishing reconstruction the of control system, two period of experiment in TR5 have been finished under the support of the upgraded control system, in each experiment, it runs smoothly without any major mistakes. The experiment beam utilization is improved from 70% to above 90%.

3) Upgrade of HIRFL cryopump temperature monitoring system based on EPICS.

The original HIRFL cryopump temperature monitoring system can fulfill the basic function of remote monitoring and alarming. But it has some unknown errors after running for a period of time. In order to solve this problem, a new software with different structure is presented. This software is designed based on Experimental Physics and Industrial Control System (EPICS). It is realized to collect temperature data from onsite devices, display the temperature and store historical data automatically. When receiving abnormal data it will alert immediately.

4) Design of state monitoring cabinet used for the newly built high energy single event effect terminal.

The new high-energy heavy ion beam transmission line on the HIRFL-CSR starts on site assembly in 2018. Based on the principle of centralized control of the controlled object, a monitoring system cabinet is designed. The cabinet has a high space utilization rate and centralized monitoring of water, vacuum, temperature and environment. It is planned to connect the devices to this control cabinet and proceed other debugging work in the next year according to progress of the whole project.

5) Design of Ar39 Ion Source Control Software.

The software of the Ar$^{39}$ ion source control system is based on EPICS (Experimental Physics and Industrial Control System) architecture. The basic operation of the controlled device of the Ar$^{39}$ ion source is realized in this software. Besides, waveform shows of some important parameters are also realized which allows the user to understand the changes in the field power supply more clearly and intuitively. Beam sweeping function is also realized.

6) Design of Water Leakage Monitoring System for LEAF.

The water leakage monitoring system for LEAF (Low Energy Accelerator Facility) was designed and implemented in 2018, which could detect the water leakage status of the cooling system in real time. The monitoring system adopted Experimental Physics and Industrial Control System (EPICS) and the Operator Interface (OPI) was