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STATUS OF LINK EXISTING FACILITY PROJECT FOR FAIR

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Abstract

The project *Link existing Facility*, or GaF (*GSI Anbindung an FAIR*), is an important sub-project of the overall FAIR facility [1]. In order to serve as injector for SIS100, the main accelerator of FAIR, the existing GSI synchrotron SIS18 [2] is undergoing an upgrade program leading to about 100 times higher beam intensities. Especially the foreseen operation with 4 GeV Protons with up to $5x10^{12}$ protons per cycle increases the radiation protection requirements to such an extent that the existing radiation protection measures are no longer sufficient. The project consists of 78 individual measures. The four most substantial activities are the construction of a table-like structure to carry additional shielding, the creation of an opening and a first part of transfer tunnel for the beamlines towards the future FAIR campus, the preparation for the building, beam dump and connection of the FAIR proton injector and the incorporation of state-of-the-art radiation- and fire-protection measures into the present facilities including the a new technical building to house technical infrastructure. We report on the project status which is foreseen to finish mid 2018.

INTRODUCTION

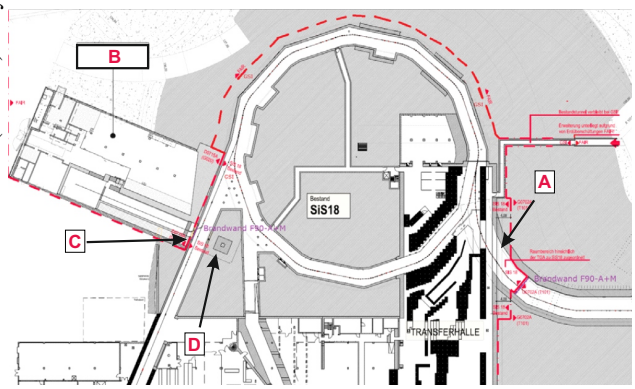

Figure 1: Layout of the present SIS18 building with GAF and WTK extension. The extraction towards FAIR is done into tunnel 101 at Point A. The pLINAC Building is shown at point B. The proton injection of from the new pLINAC is done into the transfer channel at C. The pLINAC beam dump has been cast at position D.

The GaF Project is a civil construction project with different goals. It has to connect the existing GSI accelerator facility to the FAIR site. To obtain a radiation protection permit to operate the existing facility with higher intensities the overall shielding has to be improved. Regulations for radiation protection and fire protection have changed since the original building permit has been obtained. The present regulations require various upgrades of the building and infrastructure. The planned pLINAC has to be connected to the existing building and needs a beam dump. This was taken out of the original GAF project because the proton linac (pLINAC) was to be delayed into a later upgrade module of FAIR. After a re-evaluation of the overall FAIR project it was put back in the already started GAF project as WTK (*Westwand Transferkanal*).

Figure 1 depicts the layout of the present SIS18 building with the GAF and WTK extensions. The tunnel 101 towards FAIR connects at point A. The pLINAC building B connects at C and the beam dump for the pLINAC has been cast at D. Note that the synchrotron tunnel is partly build by movable concrete blocks in the *Transfer Halle* (TR) which houses fragment separator FRS, storage Rings ESR and Cryring and experiment areas.

RADIATION PROTECTION

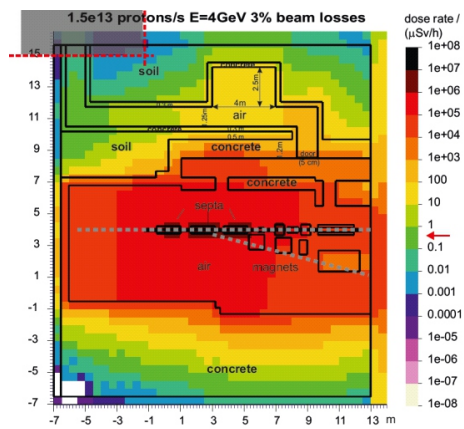

Figure 2: FLUKA [5] calculation of the extraction area (left of the letter A in Fig. 1). Assuming 2.7 Hz booster operation of SIS18 with 4 GeV protons towards SIS100 and 3 percent beam-loss. The red arrow on the right indicates the legal limit of radiation exposure.

The *Facility for Antiproton and Ion Research* (FAIR) will utilize the present GSI facility's linear accelerator UNILAC and synchrotron SIS18 as injectors for it's main synchrotron SIS100. SIS18 will inject four times into SIS100 with 2.7 Hz repetition rate during a FAIR standard cycle. Compared to about one cycle in 3 seconds during present operation this alone leads to about a factor of 10 increase in average intensity. Omitting one stripper stage leading to partially striped ions like the design ion U^{28+} will further increase intensity. The planned upgrade program of the existing synchrotron will be finished after the long shutdown from

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2016-2018 [3]. This and further upgrades will increase

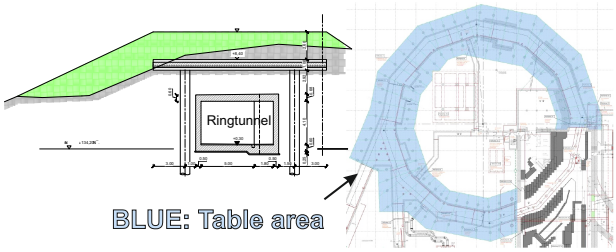

Figure 3: To increase the amount of shielding for the existing SIS18 tunnel a table construction has been constructed on top of the existing tunnel which will carry 1.5 m soil. An upgrade option for 2.5 m soil has been foreseen. The table covers the blue area on the right side. A cut is shown at the left.

the average heavy ion intensity by a factor of 100 or more compared to standard operation.

FAIR will use a dedicated proton linac (pLINAC) [4] as second injector for SIS18 leading to average proton intensities of up to $5x10^{12}$/cycle with an energy of 4 GeV. The later being the critical path for radiation protection (see. Fig. 2).

The existing building structure is not capable of carrying the weight of additional shielding. To allow the upgrade a concrete table has been constructed above the synchrotron's tunnel. A cut through the table and tunnel and the total area covered is depicted in Fig. 3.

The complete table is set on a pile foundation consisting of 89 pillars, each with a diameter of 0.9 m. Their average length is 27 m. The total volume of the pillarts is 1500 m^3. The table itself covers an area of 3200 m^2, has a volume of 1800 m^3 and a weight of about 5000 t. The amount of soil carried is 9000 t with 1.5 m coverage and up to 15000 t with the upgrade option of 2.5 m coverage.

The table itself is supported by reinforced concrete joists as shown in Fig. 4. End of April 2018 95% of the Table and 100% of the joists are build. The soil on top of the table is filled to about 50% and the landscaping around the tunnel is finished to the 90% level.

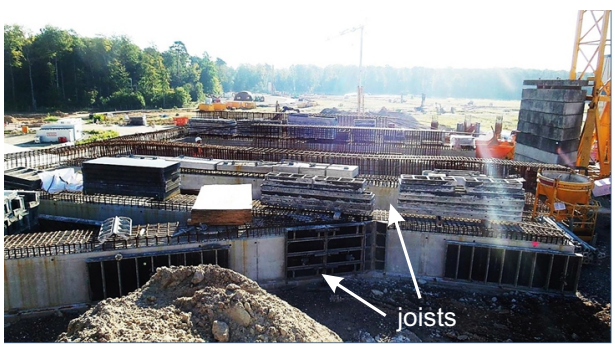

Figure 4: The complete table construction has a piled fondation consisting of 89 pillars. The table itself is supported by reinforced concrete joist as shown in the picture taken during construction.

This measures do cover the part of the tunnel which are outside the TR. To improve the shielding inside with movable concrete bars the existing building has been upgraded to support the additional weight of about 280 new shielding bars made of normal and heavy (haematite) concrete. The new bars will not be installed before 2022 but the reinforcement of the building's outer structure and foundations has been done as part of the GAF project (see Fig. 5).

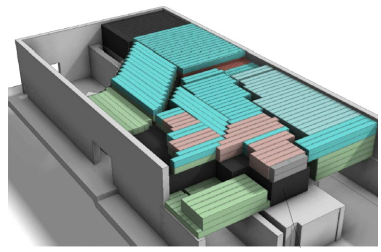

Figure 5: The shielding within the existing *Transfer Halle* (TR) will be improved by about 280 new shielding bars made of normal and heavy haematite concrete. The total shielding mass in this area will increase from 5400 t to 8050 t. The bars will be installed in 2022 but the upgrade of the existing building to support the additional load is part of the GAF project.

CONNECTIONS OF PLINAC AND TOWARDS FAIR

The opening for the future beamline towards FAIR in the existing building has been constructed. It has been temporally closed to allow SIS18 operation during the construction phase of FAIR. The first part of tunnel T101 behind this opening has been build and covered by soil to ensure further radiation protection. The existing escape tunnel from SIS18 towards the east has been reconstructed to exit at the FAIR side beyond the improved shielding. All this work allows to build the remaining part of tunnel T101 and later the connecting beamline towards FAIR without extended disturbance of SIS18 operation. A normal shutdown should be sufficient.

After the GAF project had already been started it was decided to prepare the western connection of the pLINAC in a similar way to allow the construction of it's building without major disturbance of SIS18 operation. The required measures are a sub-project called WTK. It consists of building a beam dump for the pLINAC, additional shielding at the west wall of the transfer channel (TK) and establishing the opening for the future beamline which will be closed temporally to allow operation of the existing facility. The sub-project included piled foundations made out of 16 pillars with 0.9 m diameter and an average length of 40 m. Total volume of the pillars is 400 m^3 concrete. In addition about 1500 m^3 of concrete has been poured including 100 m^3 of heavy magnetite concrete (see Fig. 6).

Additional movable shielding has been placed in the SIS18 tunnel to ensure radiation protection during pLINAC

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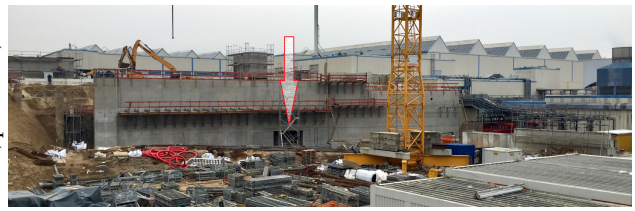

Figure 6: WTK construction works for enhanced transfer channel shielding and the interface of the pLINAC building. The arrow indicates the window for the later pLINAC beam line.

operation in adjacent areas. The overall shielding has been optimized and could be reduced compared to the original plans. The pLINAC building was foreseen to get power and other media supply from the FAIR site. This has been changed and the building will be connected to the existing GSI campus.

The overall WTK project allows the construction and commissioning of the pLINAC building and accelerator without disturbing SIS18 and UNILAC operation and independently of the rest of the FAIR project.

UPGRADE FIRE PROTECTION AND BUILDING INFRASTRUCTURE

The GAF project divides the existing synchrotron tunnel in three fire protection areas of roughly the same volume. Ten fire-protection walls have been erected. Three in the tunnel itself at chosen positions around main dipoles. The others in the various entrances/exits and the injection, extraction and re-injection beamline areas. The walls are fire-inhibiting (F90 standard) and airtight. The accelerator tunnel will get a complete overhauled ventilation system with the goal to have a directed air-flow towards the inside. The air exhaust will be radiation monitored and realized via GSI's chimney. After finishing the FAIR construction the exhaust can be transferred to the FAIR chimney with delayed air output via a decay line. To enable the directed flow four air-locks have been build and roughly 1000 m^2 of ceiling made of shielding bars has to be sealed air-tight. Furthermore about 1500 existing cables, 100 cable runs and 50 tubes have to be encased air-tight and fire-inhibiting. The ventilation system can transport 2 x 500 m^3/h of air.

The tunnel gets a nitrogen based fire extinguishing system coupled to a new fire warning and smoke handling system. The setup can extinguish fires within one of the three fire protection areas. The system is foreseen to serve the pLINAC building at a later time. The nitrogen flow is 1.37 m^3/s resulting in a reduction of oxygen concentration to 13.5% within 10 minutes. The system is fed by 60 steel bottles of 43.3 kg nitrogen each. The full amount of gas is released after roughly 30 minutes.

The building gets a new fire warning system. The existing ventilation system is upgraded in addition to the new one. The security lights are replaced by a modern system. The accelerator tunnel's communication infrastructure is upgraded.

The water cooling of the three magnetic extraction septa is realised with a new cooling circuit which is separated from the main circuit to contain possible activated water in a smaller volume.

All this measures lead to a complete refurbishment of the building automation system. Many of the new systems will be placed in a new service building (TG1) on top of the new tunnel building (see Fig.7).

SUMMARY AND PROJECT STATUS

The overall GAF project is mostly finished. The introduced WTK part resulted in about 3 month delay from the originally planed schedule. The building construction is practically finished. Missing is additional soil coverage and the "outer" infrastructure like pathways and lights.

The technical subsystems are close to be finished but lack final acceptance tests and test runs. GSI will apply for a permit to run the accelerator in 2018 without operating the new radiation and fire-protection systems. All the old systems are still operational and will be used for the upcoming beamtime which will start in June 2018. The technical installations in the new building TG1 are finished 75%. They can be continued during the operation phase of 2018.

The total cost of the project is about 16 Mio Euro with about 1.5 Mio Euro contingency. The project will stay within this frame.

The finished upgrade program of both the SIS18 and it's building is a major milestone for the successful erection of the FAIR accelerator complex [6, 7].

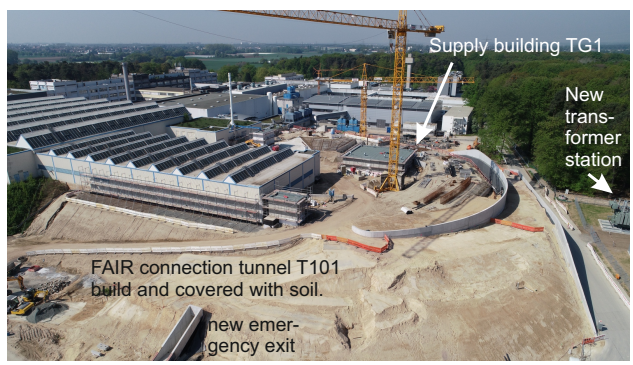

Figure 7: Photo of GAF construction site taken 22th April 2018 by M. Konradt. (GPS: N 49.932879 E 8.682875). The photo is taken from above the FAIR construction site. Clearly visible the new emergency exit. The opening in the existing building and the part of tunnel T101 which have been build are already covered with soil. Most of the table construction on top of the building is covered too. Visible to the right is part of one transformer of FAIR's power station north which is already used to supply GSI's pulsed power grid which feeds the upgraded main power supply of SIS18.

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