Radiation protection for SIS 100 – Shielding in the extraction area

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One of the central buildings of the FAIR-facility [1] is the tunnel for the SIS100 synchrotron. The basic layout and the shielding requirements of the tunnel have been submitted to the radiation protection authorities (HMUELV, now HMUKLV) in 2011 [2] together with the construction permit proposal for other FAIR-buildings. One of the three major concerns for the radiation protection of FAIR is the release of radioactivity through washout of the soil surrounding the beam tunnel by groundwater, the other two are direct radiation and release via airborne activation.

Due to proceeding physical and technical development a series of revisions in geometry took place. To achieve an almost perfect combination of the radiation protection requirements and the needs of the experiments all conditions have to be managed carefully. The new layout is checked with the Monte-Carlo simulation program FLUKA [3] to comply with the regulations of the German Radiation Protection Ordinance (Strahlenschutzverordnung).

The shielding of the maintenance tunnel adjacent to the SIS100 tunnel is designed for the maximum possible beam loss parameters, i.e. a $^{238}\text{U}$ beam at loss rate of 3E10 particles/s and energy of 2.7 GeV/u, occurring in the extraction section of the SIS100. Here during the slow extraction procedure beam losses up to 10% of the primary intensity are expected between two quadrupoles in front of the Lambertson septum [4]. The calculations with the mentioned parameters showed high radiation levels in the soil shielding, therefore the groundwater could be activated. The former geometry (2011) of the extraction section had 2 m concrete walls plus 1 m mobile concrete and 2 m for the basement and ceiling (see Fig. 1).

After all calculations it was decided to increase the ceiling and the basement shielding up to 2.5 m (see Fig. 2), which will reduce the groundwater activity much below the allowed limits. For the wall on the outer side of the SIS100 ring a concrete thickness of 2.5 m is found to be sufficient, which will save the construction costs and the wall facing inward the ring tunnel is kept the same (see Fig. 3).

Figure 1: Layout (2011) of extraction section of SIS100 tunnel with beam tunnel (below) and maintenance tunnel (above).

Figure 2: Calculations of the equivalent dose rate in the extraction part of the SIS100 tunnel (Side view). The shielding thickness of basement and ceiling is 2.5 m of concrete.

Figure 3: Equivalent dose rate in the extraction part of the SIS100 beam and maintenance tunnel nearby the loss point which is situated in between 2 quadrupoles (Top view).

References