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THE GSI FUTURE PROJECT: AN INTERNATIONAL ACCELERATOR FACILITY FOR BEAMS OF IONS AND ANTIPROTONS

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1. INTRODUCTION

The GSI Laboratory (Gesellschaft für Schwerionenforschung) at Darmstadt / Germany already has an excellent, and in many aspects unique, accelerator facility for heavy ion beams. Based on the experiences and technological developments attained here, a new facility that will boost the intensity of the beam by a factor of 100 to 10000 and increase the beam energy 15-fold is proposed.
The planned future facility is based on two superconducting synchrotrons and a system of associated storage rings. It will use the present accelerators, the universal linear accelerator (UNILAC) and the synchrotron ring accelerator (SIS18) as injector. The new large dual ring accelerator SIS 100/200 – with about 1100 meters five times the circumference of the current SIS - will be installed in a tunnel system 24 meters below ground, while the other buildings and facilities will be arranged above ground.
Approximately eight years have been planned for the realization of the project that is a challenge not only for the physicists but also for the survey and alignment group.

Figure 1:
Location of the projected new international facility

2. EXISTING ACCELERATOR FACILITY

The existing accelerator facility of GSI consists of the universal linear accelerator UNILAC (energy of 2-20 MeV/u), commissioned in 1975 and upgraded several times, the heavy ion synchrotron SIS18 (1-2 GeV/u) and the experimental cooler/storage ring ESR (0.5-1 GeV/u), both constructed between 1985 and 1990.

The facility is a user facility, open to national and international research groups. More than 1000 scientists from over 25 countries are involved in the ongoing research activities pursued at GSI. The program includes fundamental research in nuclear, atomic and biophysics as well as research in applied fields such as material sciences, plasma physics, cancer therapy, and accelerator development.

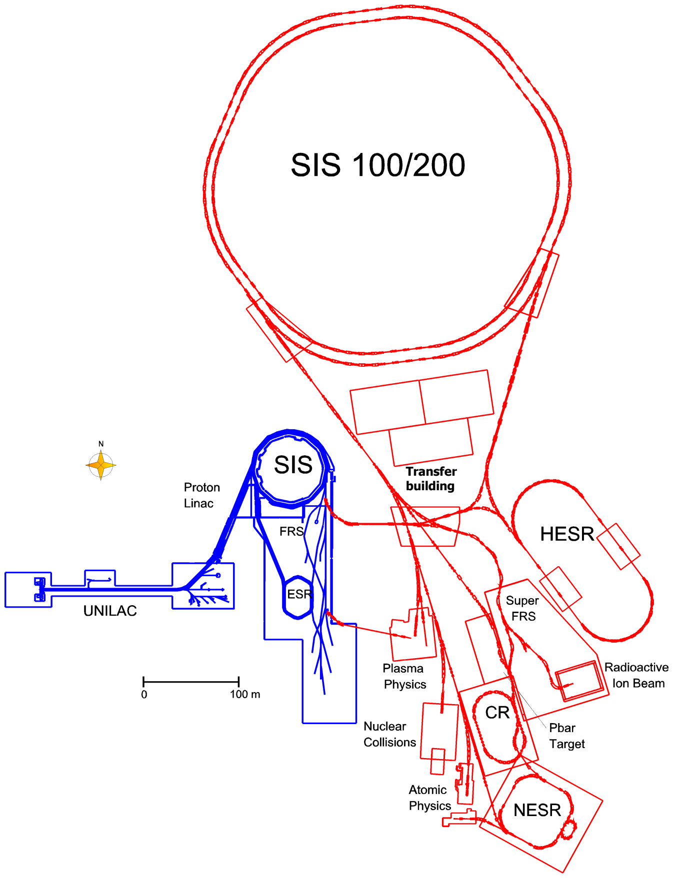

Figure 2:
Layout of the existing GSI facility (blue) together with the proposed upgrade (red). The UNILAC / SIS18 complex serves as the injector for the new double ring synchrotron.

3. PLANNED NEW ACCELERATOR FACILITY

The principal part of the planned new accelerator facility is a synchrotron complex, consisting of two separate synchrotron accelerator rings with 100 and 200 Tm maximum magnetic rigidity. They will be installed in the same tunnel and equipped with new, rapidly cycling superconducting magnets.

The facility will be complemented by three additional cooler/storage rings – the collector ring (CR), the new experimental storage ring (NESR) and the high energy storage ring (HESR) –, and will also contain the new fragment separator Super-FRS as well as several experimental areas.

Table 1 Key parameters of the proposed synchrotrons and cooler/storage rings

Ring	Circumference [m]	Bending Power [Tm]	Beam Energy
SIS100	1080	100	2.7 GeV/u $U28^+$ 29 GeV protons
SIS200	1080	200	22.3 GeV/u $U92^+$
CR	187	13	740 MeV/u, A/q=2.7 3 GeV antiprotons
NESR	208	13	740 MeV/u, A/q=2.7 3 GeV antiprotons
HESR	430	50	14 GeV antiprotons

4. CIVIL CONSTRUCTION

Due to the fact that the existing accelerator will be used as an injector, the new complex will be constructed east of the existing GSI facility. Environmental and safety aspects as well as anticipated costs led to the decision to install the large double ring SIS100/200 in one tunnel at a depth of -24 meters. For economic reasons all other buildings will be arranged above ground, south of the large new tunnel.

The tunnel should be built in shield driving technique while the injection / extraction ramps should be constructed by cut-and-cover technique. Radiation protection requirements will result in an effective inner tunnel diameter of 5m, compared to the exterior diameter of 8m.

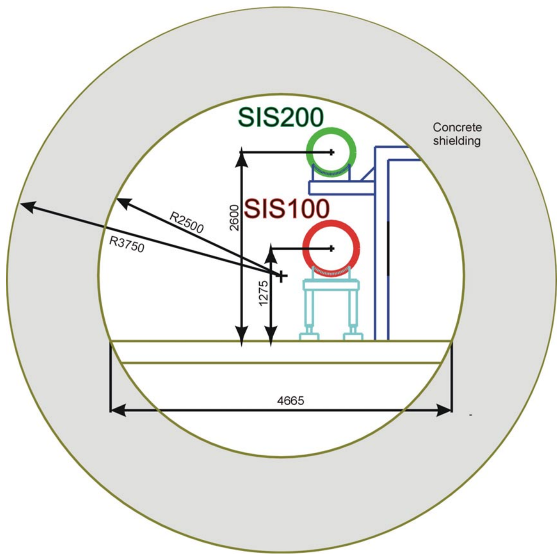

Figure 3: Tunnel cross-section for the two-ring synchrotron facility

Halls above ground will be constructed as framed structures and made of reinforced concrete. High activation, that is expected at some experimental areas and other parts of the accelerator, will result in extensive shielding measures implemented by concrete walls with a thickness up to 9m (Super-FRS).

5. SURVEY AND ALIGNMENT

Exact positioning of all elements with respect to neighboring components within the new facility, is essential for high beam quality, low losses and easy commissioning of the machine.

At this early stage of planning it is not possible to present a detailed concept for survey and alignment of the new facility, particularly because the final lattice is not yet known and alignment tolerances (global, relative) have not been definitively defined yet. At this stage tolerances are assumed to be in the range of a few tenths of millimeter (relative), depending on the machine.

5.1 Basic Alignment Concept

The basic principles of survey and alignment in order to achieve a successful start up of the new machines can be summarized as:

Figure 4:
One of the existing monument pillars used for SIS18 surface-to-tunnel transfer of coordinates

- Installation of a 3D reference network at the surface to ensure the correct location and orientation of the existing and the new accelerator facility with respect to each other
- Installation of 3D reference network(s) in the tunnel, in the rings above ground, transfer lines, …
- Network densification to allow the connection of networks between the surface and tunnel network as well as between all sections of the accelerator facility (e.g. horizontal and vertical sight pipes)
- Component fiducialisation
- Pre-alignment of supports and components
- Relative alignment of components and a quality control measurement

5.2 Particular geometrical characteristics of the GSI facility

A matter of special importance is the design and layout of the reference network for the machine because of the multiple bifurcations of the beamlines (see transfer building). Furthermore, the variation of beam level – not only the difference between the synchrotron at a

depth of -24m and the rings above ground, but also within the transfer area – should be considered. The ability to operate the accelerator subsystems in parallel up to four different scientific programs, involving different kinds of ions, is to guarantee. Therefore it is probably necessary to arrange the different beamlines one above and below the other within the transfer section.
Shielding for radiation protection can lead to concrete walls with a thickness of up to 9m. Hence, direct linkage of the machine reference systems using sight pipes will not be possible.

5.3 Fiducialisation of superconducting magnets

Both synchrotrons SIS100 / SIS200 will use superconducting magnets operating at temperatures of 4K to guide the circulating particles. Appropriate procedures for relating the effective magnetic axis of a non-accessible component to reference marks outside the cryostat have to be developed in close collaboration with the magnetic measurements group. The “classical” magnets can be fiducialised with laser trackers as it is accomplished at GSI already for several years.

Figure 5:
A Nuclotron-type short model dipole of 1.4 m length that is used for SIS100 – the 4K version in its cryostat.

5.4 Remote Systems

After initial installation, including all adjustment procedures, and beginning of operation, some areas of the new facility will not (or only with great effort) be accessible due to an expected high level of neutron production and activation. This will be true even in later shutdown periods. The basic necessity for using automated, remote systems for position control and realignment within this zone is therefore obvious.

5.5 Special tasks

Besides questions regarding the predefinition of reference frames (taking into consideration the earth's curvature and deflection of the vertical), the design of networks, the specification of measurement procedures and much more, it is rather essential at this early stage of planning to exert influence on decisions which have great impact on alignment – for example:

Civil engineering:

- Stability of the floor
- Climatic requirements
- Sight pipes and other stay-clears in space for alignment tasks
- Easy access to the machines

Mechanical engineering / magnet design:

- Component supports
- Adjustment systems
- Alignment fiducials on the magnets / cryostats

6. CONCLUSION

The survey and alignment of the new facility presents many challenges to a survey and alignment group, which still has to be set up, to work on these tasks.

7. REFERENCES

[1] Conceptual Design Report "An International Accelerator Facility for Beams of Ions and Antiprotons", GSI, 2001