Proposal and conceptual design of a new HHD dump line

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M. Sapinski, C. Hessler, C. Muehle, S. Ratschow, S. Reimann

1 Introduction

The current GSI beam dump line (HHD) forks from FRS beam line inside the first of the big FRS dipoles: GTS3MU1. This dipole is a slowly ramping magnet, therefore switching between FRS and HHD is not possible. The beam dump is used often during setup times for experiments, and in all these times the FRS cannot be operated and vice versa: when FRS is running, SIS18-beam development is impossible, what significantly affects operation efficiency of the GSI complex, Therefore, it is proposed to decouple FRS and HHD beam lines by constructing a new beam dump line (new HHD). It will be an effective doubling of beam time when FRS experiments can run and in a 1:1 sharing mode beam development and beam tuning (for highest intensities) can run in parallel.

In order to minimize the cost of the new HHD beam line it is proposed to reuse the old GTS1MU1 switching dipole magnet. This magnet will be exchanged with the new GTS1MU1, which can switch the beam in one of the three directions: FRS, HEST and FAIR. The current magnet can switch in two directions only.

The main challenges of this proposal are: an additional dipole to bend the beam further in the direction of the dump and major changes in the layout of the shielding blocks in this densely filled area.

2 Layout overview

The layout of the new beam line is presented in Figures 1 and 2. The new beam line requires three additional quadrupoles to control the beam size and a 15^{o}- dipole which provides the additional deflection allowing to direct the beam to the dump.
Figure 2 shows that the considered area is densely filled with magnets, FRS target station and shielding walls. Building of a new beam dump line requires a careful redesign of the area.
The new beam line will arrive at the dump block at a new angle, and the dump block, shown in Figure 3, must be rotate accordingly, by 7.5^{o}, to keep the dump face perpendicular to the beam direction.

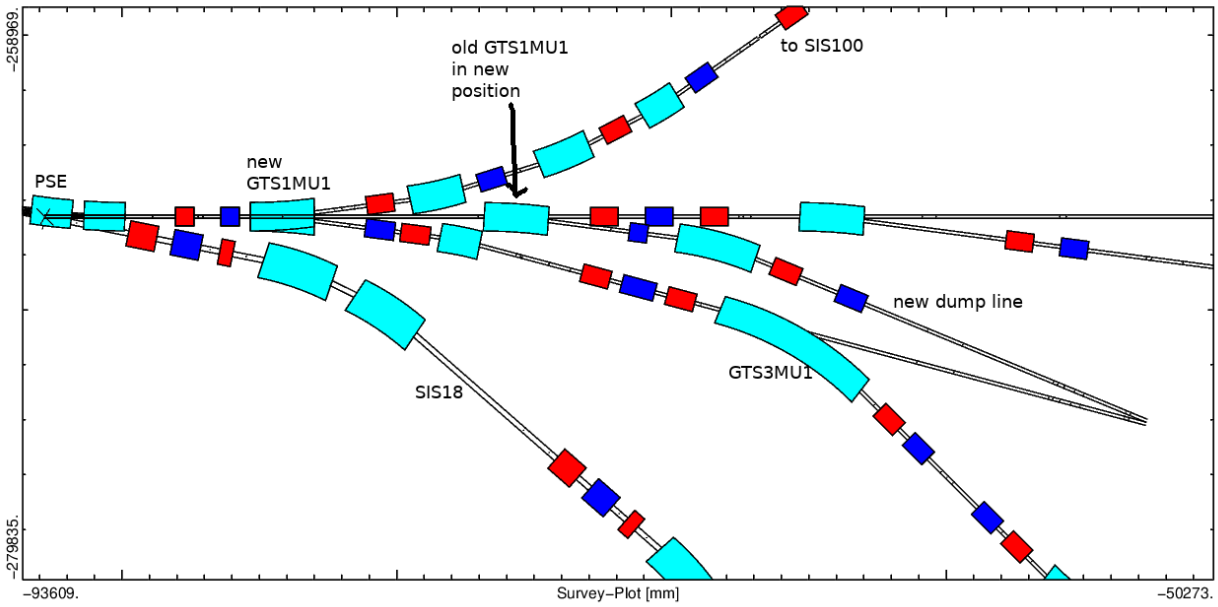

Figure 1. Footprint of the beam lines around the HHD beam dump and tentative footprint of the new HHD beam line.

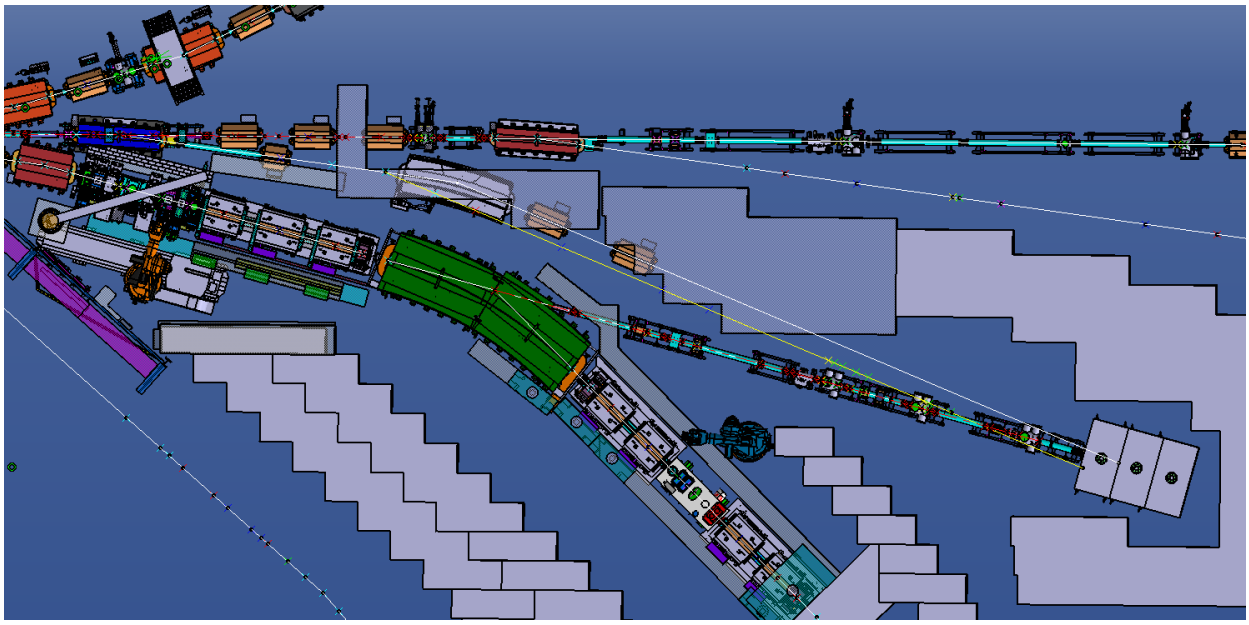

Figure 2. Layout of the beam line elements overlapped with magnets of the new HHD. Courtesy E. Nickchen.

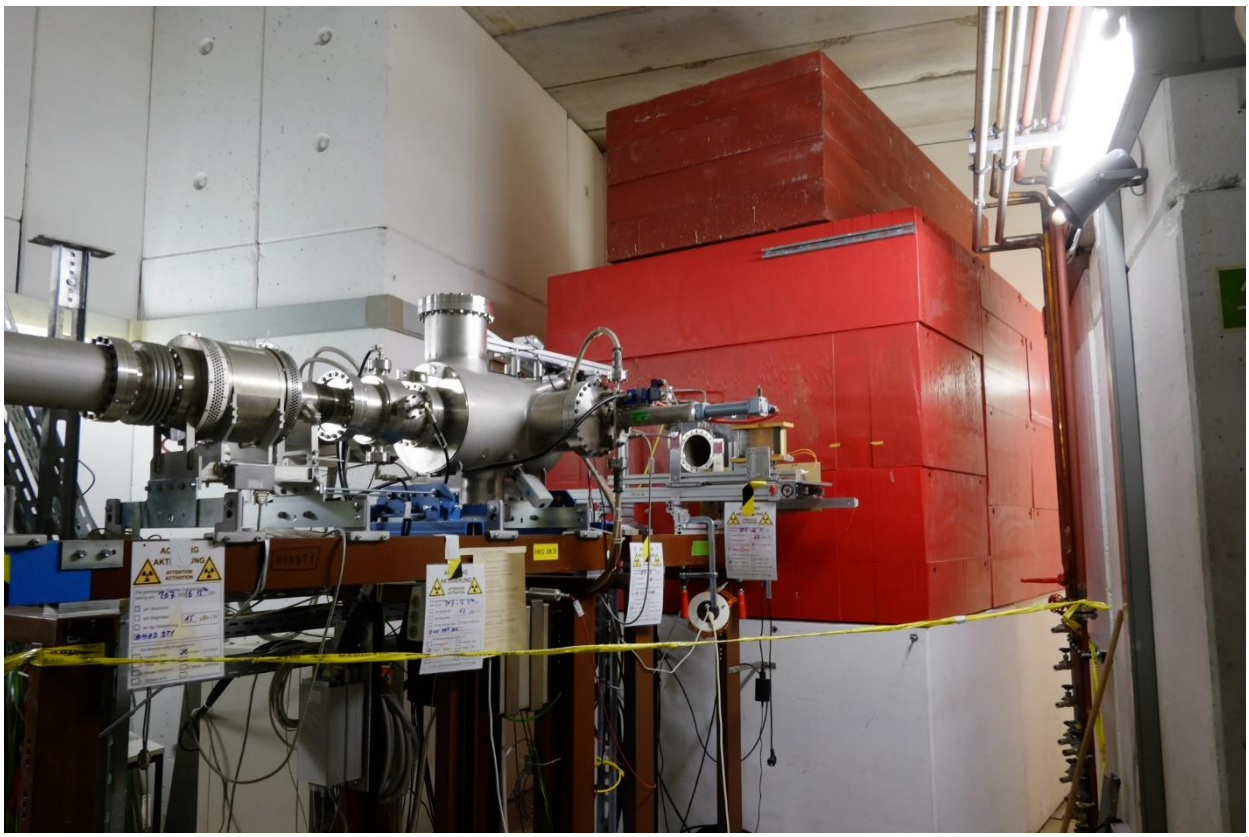

Figure 3. The beam dump block.

3 Ion optics

The proposed ion optics for the new HHD beamline is shown in Figure 4. The new GTS1MU1 (not visible because it is not active) is situated behind the first two quadrupoles. The optics of the beams going straight to HEST will be only slightly affected, because position of the quadrupole triplet must be changed.

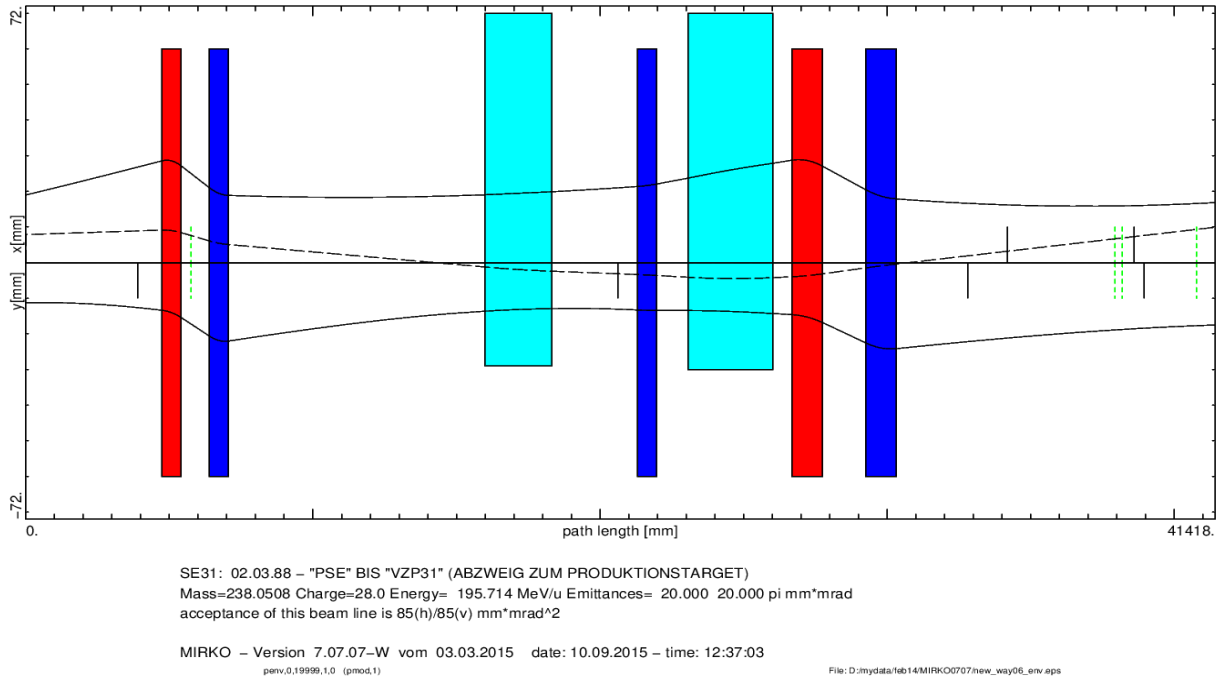

Figure 4. Beam envelope for the proposed ion optics for the new HHD beam line.

4 Magnets

This proposal assumes reuse of the old GTS1MU1 magnet, use of three standard HEST quadrupoles (one short GHEBTQPK and two long GHEBTQPL) which are in storage and acquisition of a new, 15^{o} FAIR dipole. This magnet is proposed because it provides the required deflection angle, it can be fit to the current layout and because the design and tooling are already available therefore the magnet can be produced fast. Four additional steerer magnets from the current line will be reused.

The main characteristics of the magnets:

- Old GTS1MU1, mass about 7 tons, deflection 7.5^{o}, new name GHHDMU1.
- New GTS1MU1, mass about 17 tons (this magnet does not belong to new HHD project, is mentioned here for comparison).
- New 15° FAIR dipole, mass about 20 tons, name GHHDMU2.
- GHEBTQPL quadrupoles need to be refurbished, new names: GHHDQD21 and GHHDQD22.
- GHEBTQPK quadrupole needs to be refurbished, new name: GHHDQS1.

The acquisition of the 15^{o}- dipole is critical for this project. It should be negotiated with Budker Institute which produces the original dipole. The estimated price includes grider and alignment feet, material, production and magnetic measurements. The design, tools and documentation already exist because one magnet like that is being produced for FAIR HEBT.

The demand for cooling water for magnets and all other auxiliary media can be covered by the existing plants in the target hall.

5 Power converters

All magnets, except the GHHDMU1 (old GTS1MU1) will be operated in DC mode. The power converter for 15 °-FAIR dipole costs about 100,000 €. For other magnets the existing power converters will be reused. Cost of recabling is about 50,000 €.

6 Beam instrumentation

The existing beam instrumentation will be reused on the new beam line. Due to short distance between existing and new layout of the beam line it is expected that recabling will not be necessary.

7 Vacuum

Most of the vacuum chambers will be reused, eg. the vacuum chamber from the old GTS1MU1 and the large piece of chamber right before the dump. Additional standard chambers of about 10 meters length have to be purchased. The vacuum chamber for the FAIR dipole must be ordered. Also, due to increased length of the beam line, additional ion getter pump is needed.

8 Cost estimate

The preliminary cost estimate is presented in Table 1. This cost does not include the cost of the work to move the shielding walls and reconstruct the zone.

Table 1: Cost estimate for the new beam dump line.

15° FAIR dipole	180.000 €
FAIR dipole vacuum chamber	15.000 €
Refurbishment of 3 quadrupoles	3.000 €
New power converter	100.000 €
Recabling of the powering system	50.000 €
Vacuum pump	10.000 €
Vacuum chambers (5 k€/m: FAIR-cost book 2005, projected to 2014)	50.000 €
Alignment	5.000 €
Assembly material (500 €/m)	5.000 €
Technical infrastructure (cable routes, cooling water, compressed air)	20.000 €
Total costs	448.000 €

9 Schedule

The proposed, optimistic schedule is visualised in Table. 2. It assumes that the decision is taken in September 2019. During the installation no SIS18 beam operation is possible, so the installation period must be carefully chosen. There are other tasks which require the opening of the SIS18 extraction area, namely: installation of the new GTS1MU1 which is foreseen for shutdown 2020 and reconfiguration of the shielding walls for connection to FAIR and enhancement of shielding, which will take place after 2020. New HHD beam line should be installed in one of these periods when opening of the extraction area is necessary anyway.

Table 2. Schedule for the new beam dump line - optimistic case.

	2019		2020		2021		2022		2023		2024	
Acquisition of 15° FAIR dipole			⟷	⟷								
Refurbishment of quadrupoles			⟷	⟷								
Installation				⟷	⟷							
Commissioning						⟷						