

# High current proton beam operation at GSI UNILAC

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A significant part of the experimental program at FAIR is dedicated to pbar physics requiring a high number of cooled pbars per hour [1]. The primary proton beam has to be provided by a 70 MeV proton linac followed by two synchrotrons. The new FAIR proton linac [2] will deliver a 35 mA beam of 36  $\mu$ s pulse duration. The recent GSI heavy ion linac (UNILAC) is able to deliver world record uranium beam [3] intensities for injection into the synchrotrons, but it was not dedicated to high intensity proton beam operation relevant for FAIR. In an advanced machine investigation program it could be shown, that the UNILAC is able to provide for sufficient  $\text{CH}_3$ -beam intensities, cracked (and stripped) in a supersonic nitrogen gas jet into protons and carbon ions [4]. This advanced operational approach results in up to 2 mA of proton intensity at a maximum beam energy of 20 MeV, 100  $\mu$ s pulse duration and a sufficient rep. rate to fill the SIS18 (max. 2.7 Hz). It could be shown, that the UNILAC is able to serve as a proton FAIR injector for the first time, while the performance is limited to 17% of the FAIR requirements.

## MACHINE DEVELOPMENT

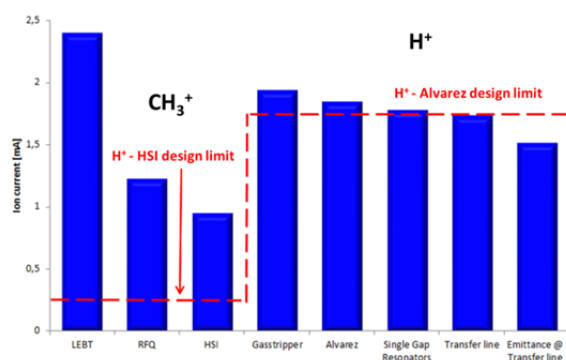


Figure 1: Measured beam current along UNILAC and transfer line to the SIS18; the proton design limit (to fill the SIS18 up to the space charge limit) was reached in the post stripper section.

The MUCIS source [5] was operated with methane ( $\text{CH}_4$ ) gas while a high-current  $\text{CH}_3^+$ -beam (2.3 e mA) is delivered to the HSI. Due to the huge emittance in the LEBT only 50% of the  $\text{CH}_3$ -beam could be accepted by the HSI-RFQ, minor additional particle losses in the matching section to the HSI-IH-DTL limits the overall HSI-transmission to 40%. Anyway, due to the increased HSI design limitations for the  $\text{CH}_3^+$ -beam, the improved beam transmission compared to a pure proton beam is evident. Furthermore a triple particle output (for protons)

from each  $\text{CH}_3^+$  molecule behind the stripping section allows for proton beam operation at the design limit of the poststripper linac (Fig. 1). Strong efforts were launched to push the high current proton beam transmission through the entire poststripper and transfer line to a value of up to 80%.

## 20 MeV proton beam

The single-gap resonators (SGR) provide intermediate energies between 3.6 and 13.0 MeV/u for all ion species. During the high current experiment protons were pre-accelerated in the UNILAC to a beam energy of 11.4 MeV/u. Inside the following eight single gap resonators, each providing for an energy increase of more than 1 MV, a final energy of 20 MeV could be reached (Fig. 2). This final energy corresponds to 28.5% of the required beam energy of the FAIR p-linac. Besides optimizing the high current proton beam performance for the ongoing GSI experiment program, the UNILAC is able to serve as a high performance proton injector for FAIR-commissioning and for first pbar experiments as a redundant option for the FAIR proton linac injector.

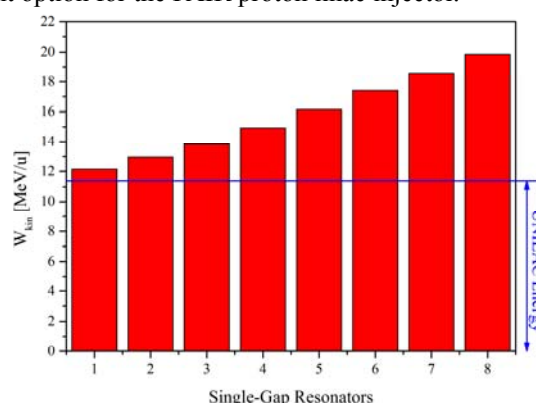


Figure 2: UNILAC operation with eight SGR for maximum proton beam energy of 20 MeV

## References

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