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COSY Vacuum, Beam Lifetime and Quality Studies in Presence of the PANDA Cluster-Jet Target Beam*

B. Hetz†, P. Brand, H. Eick, D. Klostermann and A. Khoukaz, the PANDA collaboration
Institute of Nuclear Physics, WWU Münster, Germany

INTRODUCTION

The upcoming PANDA experiment at the antiproton storage ring HESR at FAIR will investigate proton-antiproton annihilations using a cluster-jet target and accelerator beam momenta of up to 15 GeV/c. It will be one of the most precise experiments for the understanding of the theory of QCD, e.g., by analysing exotic hadron states like glue balls or multiple quark states [1].

The internal cluster-jet target build up at the University of Münster will be the phase-1 target for the PANDA experiment. The target was successfully set into operation in the Münster laboratories and is now installed at the proton and deuteron accelerator COSY at FZ Jülich, Germany. It was shown that the desired hydrogen target thicknesses for PANDA of more than 2×10^{15} atoms/cm^2 are achievable on a stable and regular basis having real accelerator and beam conditions. Furthermore, crucial vacuum studies, accelerator beam lifetime and quality studies in presence of the PANDA cluster-jet target have been performed during two beam times in the year 2019. Additionally, intensive work was done in simulation of new techniques to optimize the later HESR vacuum at the PANDA experiment location.

VACUUM STUDIES AND SIMULATION

During the PANDA cluster-jet target beam times at COSY in 2019 a proton beam with a momentum of 3.0 GeV/c was used to study beam-target interactions. These studies included systematic scans of the cluster-jet beam with different cluster sizes and target thicknesses by sweeping the COSY proton beam over the jet beam. At low target thicknesses and small cluster diameters, energy losses of the proton beam caused by the target beam were directly observable as a vacuum pressure increase at the interaction point (cf. fig. 1). This shows the need for further investigation with larger cluster sizes and highest thicknesses at upcoming COSY beam times to study the effect on the later HESR vacuum at PANDA conditions.

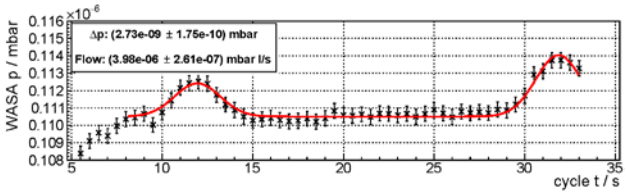

Figure 1: Pressure increase at the interaction point due to beam target interaction. The proton beam is parallel sweeping from left to right and back over the target beam.

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† b.hetz@wwu.de

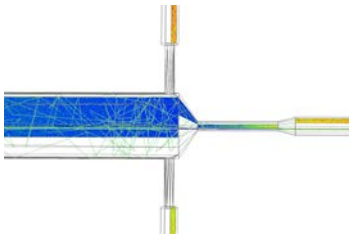

Figure 2: Gas flow simulation for a design study for the PANDA IP cross.

Further optimizations of the HESR vacuum conditions are under investigation not only by means of direct measurements at COSY but also by Monte Carlo particle vacuum simulation using Molflow+ [2]. Depicted in figure 2 is such a simulation for a design study on the interaction point geometry at PANDA using, e.g., a 140 mm tube instead of the original 20 mm interaction point cross.

Also started was the development of a special cryogenic pump for PANDA which should be installed inside of the upstream beamline. Simulations show that this new pump, in combination with an optimized interaction point design, yields a significantly improved vacuum situation.

ACCELERATOR BEAM LIFETIME AND QUALITY STUDIES

Long antiproton beam lifetimes for PANDA at HESR are desired for highest integrated luminosity. Thus, measurements of COSY beam lifetimes in presence of the PANDA cluster-jet target were performed using different scenarios using COSY HF cavity, RF barrier bucket, stochastic cooling, and different target settings.

With a test installation of the later HESR stochastic cooling system available at COSY, it was shown that long proton beam lifetimes and particle losses of less than 10% in >30 minutes cycle times with high target thicknesses are possible. Further measurements will be done to show the excellent performance of the PANDA cluster-jet target and the HESR stochastic cooling at COSY with even higher target thicknesses and optimized cooling parameters.

Beam quality studies using the COSY Schottky pickup with the given target and cooling conditions at COSY also showed that momentum spreads of $<\Delta p/p < 2 \times 10^{-4}$ are achievable and will be improved in future.

REFERENCES

[1] PANDA Collaboration et al, Strong Interaction Studies with Antiprotons, arxiv: 0903.3905, 2009

[2] Molflow+, A Monte-Carlo Simulator package developed at CERN, https://molflow.web.cern.ch/