20 December 2005

MEMORANDUM

To: Prof. Dr. W. Henning, Prof. Dr. H. Gutbrod, Prof. Dr. H. Wenninger, Dr. I. Augustin

From: R. Bertini and A. Martin on behalf of the ASSIA Collaboration

Subject: Proposal for a symmetric proton-antiproton collider using HESR

The importance of energy and luminosity in antiproton-proton spin physics has been spoken out very clearly by R. Bertini since the open meeting of August 2004, and stated firmly by the STI in March 2005.

This is the case for all the physics channels which have been proposed, and particularly so for the measurement of transversity in the production of Drell-Yan lepton pairs and for the measurement of ΔG (the gluon polarization in a polarized nucleon) from the cross-section asymmetry of Λ_c [1].

The ASSIA Collaboration has repeatedly manifested its interest for this physics and stated the importance of the energy. Over the past year, the Collaboration has devoted some effort to promote and get indeed started a machine study to transform HESR in a symmetric polarized proton-antiproton collider, capable of attaining 30 GeV center-of-mass energy.

As you know the conceptual study for this collider was indeed started in the first half of 2005 by F. Bradamante in collaboration with Yu. Shatunov and his Novosibirsk colleagues. This study was recently completed and the results published [2].

It is a pleasure to stress that the results of this work are very encouraging:

- assuming an antiproton storage rate of $2 \cdot 10^6\ s^{-1}$, the luminosity is $5 \cdot 10^{31}\ cm^{-2}s^{-1}$;
- one can accumulate both polarized proton and polarized antiproton beams;
- a single electron gun is used to cool both beams;
- two beam intersection points are foreseen thus PANDA and a future Spin Experiment with AntiProtons (SEAP) can co-exist in the same experimental hall;
- the extra-cost to convert HESR in a collider is modest (order of magnitude 10 M€ and anyhow equal to that of the asymmetric collider presently being under consideration).

Moreover the solution we propose also provides the possibility to have, at the interaction point, spin orientations for the colliding particles oriented along any of the three possible Cartesian axes with an appropriate tuning of the devices inserted to preserve the spin orientation all along the acceleration.

For all these reasons we believe that this option represents a unique opportunity for FAIR, opening up exciting possibilities to the already rich physics program. We ask the Laboratory to evaluate this proposal and undertake now the necessary actions in the design of the experimental facilities so that the collider option might become a reality in the future.

A schematic scenario of the polarized beam complex is shown in Figure 1, taken from Ref.2. The polarized protons from the source are accelerated in the linac and synchrotron SIS-18 up to an energy of 3.5 GeV and injected into HESR. A special AP ring, which is supplied by antiprotons from the complex of CR-RESR storage rings, is foreseen for polarizing the antiprotons. The antiprotons are then injected into a COSY-type ring, equipped by e-cooler and full Siberian snake, and delivered to the collider at an energy of 3.5 GeV.

Figure 2 shows a schematic view of the HESR after modification into a symmetric collider. Both the proton and antiproton beams are circulating in a common vacuum chamber. Two parallel long straight sections accommodate (alternatively) two interaction regions. One houses the PANDA experiment and the other will house the SEAP.

In the long straight section, opposite to the interaction region, proton and antiproton beams are electrostatically separated and directed through the two different long solenoids of the electron cooler. Being a part of the Siberian snake, these solenoids simultaneously serve also for the spin control. The cooler's electron beam is accelerated to 8 MeV, and will be used for cooling of both protons and antiprotons beams sequentially. To that purpose, the electron beam passes first through the cooler solenoid, which is dedicated say for cooling the antiproton beam, and then it is bent by 180^0 and directed into another solenoid for the cooling of the second beam. After passing through the second solenoid the electron beam returns back to the acceleration column for deceleration and energy recovery.

The basic parameters of the proton-antiproton collider are listed in Table 1 [2].

For what concerns a possible experimental apparatus we are still going on making Monte Carlo simulations for the various physics channels [3]. Of course we will be able to attack the design of the apparatus and write the Technical Proposal only if the symmetric collider project is well taken and we are encouraged to go on. For this reason we kindly ask you to evaluate this proposal as soon as possible. Our Collaboration is strongly supporting this project and is ready to discuss its implementation with the accelerator physicists who are in charge of HESR, with the authors of Ref. 2, and with the GSI Management.

[1] R. Bertini et al. (ASSIA), Letter of Intent for "A study of Spin-Dependent Interactions with Antiprotons", http://www.gsi.de/documents/DOC-2004-Jan-152-1.ps

[2] F. Bradamante et al., "Conceptual design for a polarized proton-antiproton collider facility at GSI", INFN/TC-05/14, November 29, 2005 and arXiv/physics/0511252.

[3] A. Bianconi and M. Radici, Phys. Rev. D72 (2005) 074013; A. Bianconi and M. Radici, Phys. Rev. D71 (2005) 074014; A. Bianconi and M. Radici, J. Phys. G31 (2005) 645.

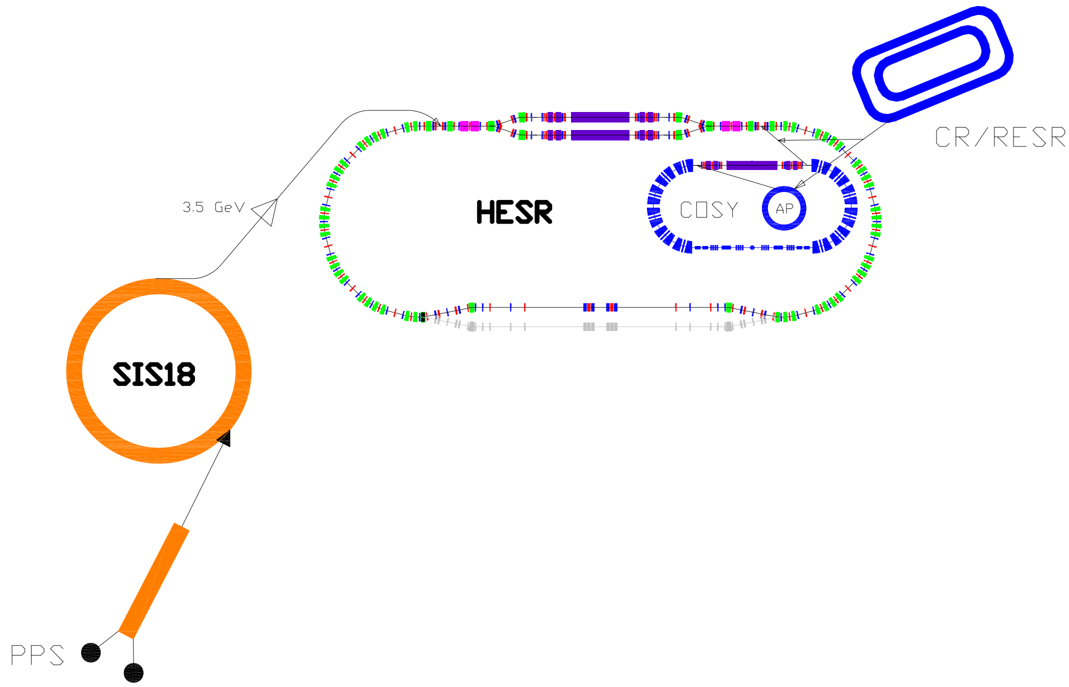

Figure 1. Schematic layout of polarization facility

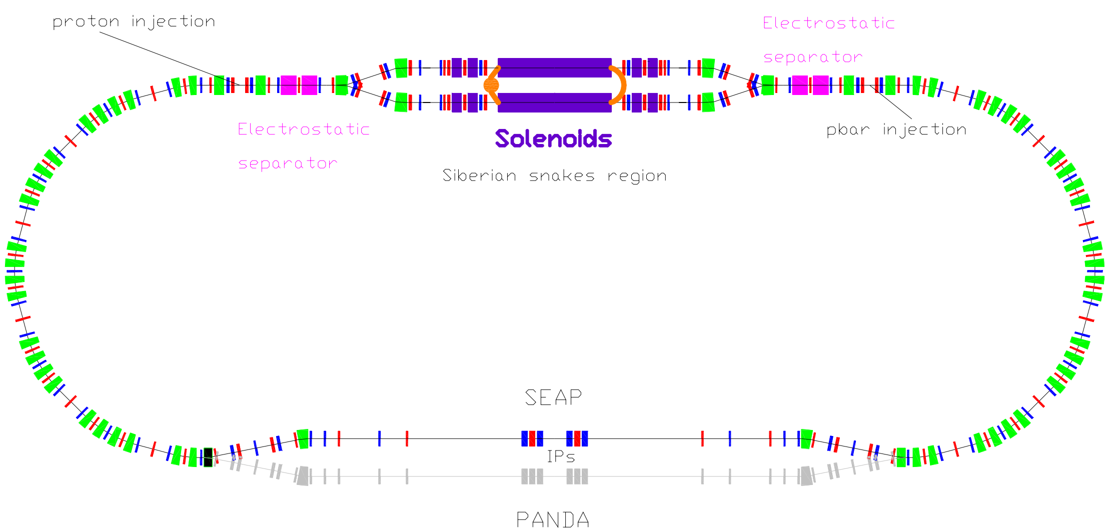

Figure 2. Layout of the proton-antiproton symmetric collider

Table 1. List of the proton-antiproton collider parameters

Collider circumference, C	681.58	m
Revolution frequency, f_0	0.445	MHz
Total number of antiprotons, $N_{\bar{p}}$	$1\cdot 10^{12}$	
Total number of protons, N_p	$1\cdot 10^{12}$	
Number of bunches per beam, n_b	12	
Distance to first parasitic crossing, L_p	28.4	m
Proton beam emittance, ε_p	$1.55\cdot 10^{-6}$	$cm\cdot rad$
Antiproton beam emittance, $\varepsilon_{\bar{p}}$	$0.465\cdot 10^{-6}$	$cm\cdot rad$
Space charge tune shift, $\Delta\nu_p = \Delta\nu_{\bar{p}}$	0.1	
Beam-beam parameter, $\varsigma_{x,z}$	0.022	
Electron cooling and IBS time constants, $\tau_e \approx \tau_{IBS}$	10	s
Luminosity, L	5×10^{31}	$cm^{-2}s^{-1}$