SOURCE OF POLARIZED DEUTERONS POLARIS. OPERATION AND IMPROVEMENT.

V.P.ERSHOV, V.V.FIMUSHKIN, L.V.KUTUZOVA,
Yu.K.PILIPENKO, A.I.VALEVICH
Joint Institute for Nuclear Research, Dubna 141980, Moscow region, Russia

The 200 μA cryogenic polarized deuteron source POLARIS is working at the JINR 10 Gev accelerator since 1981. There is a plan to use this apparatus at the new superconducting ring NUCLOTRON now. To increase the intensity of the polarized deuteron beam a pulsed charge exchange hydrogen plasma ionizer was developed. At the same time an improvement of an existing electron Penning ionizer was going.

The source is based on the Stern-Gerlach atomic beam method but has some features:
- superconducting magnets,
- cryopumping of the residual gas,
- cryocooling of the dissociator, nozzle and skimmer,
- compact design and a small power consumption,
- installation on a 700 kV terminal.

The polarization of the high energy deuteron beam is the following: $P_z^+ = 0.54\pm\ 0.01$, $P_z^- =-0.57\pm0.01$, $P_{zz}^+ = 0.76\pm\ 0.02$, $P_{zz}^- =-0.79\pm\ 0.02$. More detail see [1,2,3,4,5,6] To increase the intensity of the polarized deuteron beam from POLARIS two ways were chosen :
- a development of the short pulse charge exchange ionizer,(Fig.2) [7], - an increasing of the efficiency of the existing Penning ionizer.

The fabrication of the charge exchange ionizer was finished and first test bench experiments were produced. Polarized deuterons are produced by change exchange between polarized deuterium atoms and ions of hydrogen plasma $D_\uparrow^0 + H^+ = D_\uparrow^+ + H^0$ and ionization of $D_\uparrow^0$ by plasma electrons. The energy of the deuteron beam is 10 - 15 keV. The efficiency of the ionizer is estimated as: $\varepsilon{=}N_D^+\ /N_D^0$ where, $N_D^+{=}\ 6.25{*}10^{18} * I_D * \Delta t-$ is the number of D^+ ions after deflecting magnet, $N_D^0{=}n_0 * l * s-$ is the number of atoms in an ionization volume. The efficiency of the ionizer at the target thickness $n_0 l$=0.4-1$*10^{14}$ atoms/cm^2 is $3-5\%$. Under using POLARIS atomic beam stage the 0.5 mA polarized D^+ beam has been obtained at the output of the deflecting magnet of the ionizer.

To use advantages of the cryogenic source the charge exchange ionizer has to be cryogenic too. For this a cryoversion of the charge exchange ionizer was developed and some preliminary tests were produced. This is a combination of the POLARIS liquid helium cryostat with a 60 mm cold bore superconducting solenoid and a H^+ plasma source of the warm charge exchange ionizer.

The 1.2 A H^+ plasma current was observed after extracting grids. A pressure

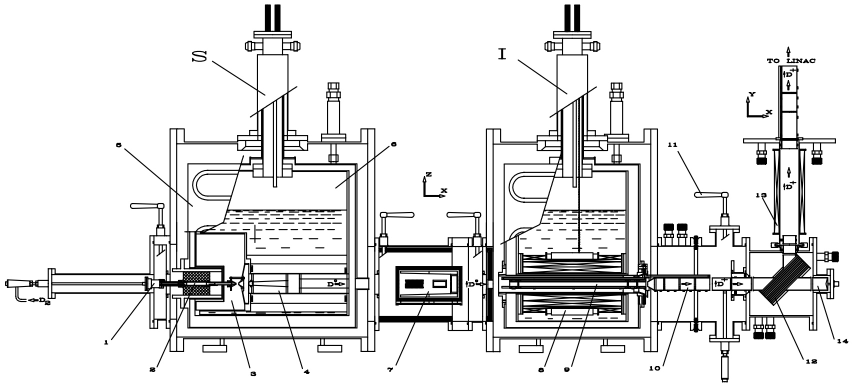

Figure 1: Schematic view of the polarized deuteron source POLARIS. S - polarized atomic source, I - Penning ionizer. 1- electromagnetic gas valve, 2- dissociator, 3- nozzle chamber, 4- SC sextupole magnets, 5- nitrogen shield, 6- helium cryostat, 7- RF cell, 8- SC solenoid, 9- electron optics, 10- ion optics, 11- vacuum gate, 12- electrostatic mirror, 13- solenoid of the spin-precessor, 14- Faraday cup.

in the cryostat due to cryopumping of hydrogen just before a plasma pulse is $2 - 4 * 10^{-6}$ mbar. To improve the vacuum a cryopumping of hydrogen at 2.6 K will be realized. Preliminary cryopumping tests give a good prognosis. It is planned to improve also an extraction system and a beam transportation through a spherical electrostatic mirror. A new deflecting magnet with a compact vacuum chamber is fabricated. Then a study of the charge exchange ionizer will be continued.

As to existing Penning ionizer some interesting results have been obtained recently. The diminishing of the diameter of the electron optics from 25 mm to 15 mm has increased the source current by factor 2-3. A new optics configuration is more preferable for an ionizer tuning in initial time of the source operation and increases its stability. An emittance of the beam is better then in the case of 25mm optics. The study of these results will be continued in the nearest future. This is a more simple way to increase the beam intensity of the polarized beam.

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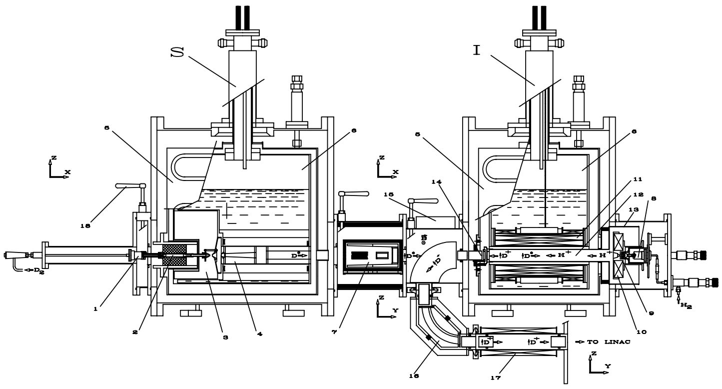

Figure 2: Schematic view of a new POLARIS version. S - cryogenic polarized atomic source, I - cryogenic charge exchange ionizer. 1- electromagnetic gas valve, 2- dissociator, 3- nozzle chamber, 4- SC sextupole magnets, 5- nitrogen shield, 6- helium cryostat, 7- RF cell, 8- electromagnetic hydrogen gas valve, 9- hydrogen plasma source, 10- magnet, 11- SC solenoid, 12- ionization volume, 13- 15 kV shield, 14- extracting grids and electrodes, 15- deflecting magnet, 16- spherical mirror, 17- solenoid of the spin-precessor, 18- vacuum gate.

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