**Motivation**

The He(1s) 1s 1S and 2s 1S to 2p 1P 3P transitions at low energies are relevant in pure and applied physics. These reactions take place in the first minutes during the Big Bang nucleosynthesis and occur in the early phases of stellar burning. Active discussion [1] is being made to encourage scientists in research in this field.

The low-energy regime (tens to hundreds of keV) typical for nucleosynthesis and fusion plasmas is challenging to probe because of exponentially decreasing in the reactions cross section and low elastic scattering cross sections. However, due to low-energy effects of electrons and polarizing reactions [2] fusion reaction rates can be increased significantly.

The DD fusion is the reliable source of thermonuclear HYDROGEN and helium for fusion reactors [3] without an external tritium source. Handling of programmed production and the by-product emission direction can be achieved by polarizing deuterium in specific ways [2].

The experiment aims to study fusion reactions of He(1s) 1s 1S and 2s 1S to 2p 1P 3P with the beam energy at 10-100 keV and various spin combinations. Fusion byproducts are detected by using the 4 δ detector system with 1% filling based on 500 silicon piddies to measure its energy.

We plan to measure different spin-compilation parameters such as asymmetry, vector and tensor analyzing powers, spin-compilation coefficients, polarizations matter coefficients, and also differential and total cross sections of the reactions at given energy range.

The world’s first colliding-beam experiment with both polarized beams POLIS [4] has been started in PNPI, Gatchina, in collaboration with Forschungszentrum Jülich and PNPI University of Ferme.

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**Polarized atomic beam source**

Polarized deuterium atoms of the Fermi ABS beam collide with polarized deuterons of the POLIS in the center of the 4 δ detector system. It delivers a beam of deuterium atoms of requested nuclear vector or tensor polarizations and energies of about 0.1 keV. The intensity of the beams of 4.10⁸ atoms, achieved by a laser, is measured with a measurement of the fusion reaction with low cross-section.

**Polarized ion source (POLIS)**

The POLIS is capable of producing an ion beam of 10 μA with energy up to 500 keV. The variety of polarization states can be achieved using a combination of one weak-field (WF) and two strong field (SFI, SFII) radio-frequency transition unites. The gas jet formation system consists of a nozzle, skimmer, collimator, cooling and transporting system, including heat interception, thermal bridge, cryo-generator, heater, and a temperature sensor.

The beam profile is measured at the center of the detector system.

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**Lamb shift polarimeter**

The Lamb-Shift Polarimeter measures directly the spin-substitution distributions of deuterium ions from which the polarization can be obtained with an absolute precision better than 1% within a few seconds [5].

Two test runs were carried out with the test system including the 4 δ detector system and the POLIS in 2015 and 2019 on different targets.

The amplitude spectra obtained show three distinct peaks of the deuteron fusion products, namely 0.8 MeV 1H + 1H, 1 MeV triton, and 3 MeV protons (neutrons are not detected in this experiment). Typical x-ray rates do not exceed 120 events per hour for 1 MeV tritons. Therefore, background and noise should be minimized to distinguish these rare events.

In the summer of 2015 the foil of deuterated polystyrene-phenolic was used as a target. The reaction produced energy was measured by eight silicon detectors that surrounded the collision area.

The target was exposed to the ion beam of 10 μA with 15 keV energy.

The results of the test run in 2018 with heavy water target (D₂O) as a target (~10₂D³O₀) [1]. POLIS provided the ion beam of 10 μA with 10 keV energy. The 4 δ detector system had 22 silicon detectors on front, bottom, and top planes.

**References**