Precise measurement of the velocity of muon capture on the proton in hydrogen gas. "The muCap Experiment. Gas system."

The precise measurement of the muon capture on the proton required high purity protium (with less than 1.0 ppm deuterium and N_2, O_2, and $H_2O<10^{-8}$) to avoid muon capturing by contaminant nucleus. Hence, it was very important to obtain and use the gas of appropriate quality. The procedure included:

- preparation of high purity protium,
- analysis of the gas on D_2, N_2, O_2, and H_2O content,
- filling the experimental chamber with protium and its periodical sampling,
- cyclic purification of protium from contaminating compounds during the experiment.

Preparation.

Naturally occurring hydrogen compounds, including water, beside major protium isotope contain approximately 100-150 ppm of deuterium. The muCap experiment required purification of hydrogen gas from deuterium contamination to the levels less than 1 ppm. Our group suggested a method of enriched protium gas preparation by electrolysis of deuterium depleted water. Such water containing less than 1 ppm deuterium was purchased from Ontario Power Generation Company (Canada). The electrolysis was conducted on Whatman 72-30 Hydrogen Generator which produced gas at 150 ml/min rate.

Purification.

Purification of the obtained gas from N_2, O_2, and H_2O contaminants was achieved in two ways: by the adsorption of impurities to NaX and NaA zeolites at the temperature of liquid nitrogen (77^oK) and by filtration through "Mr.Hydrogen" apparatus (Pd-filter). During experiment the purified gas in TPC chamber was constantly contaminated by other gases and moisture penetrating through micro-leaks. Therefore the cyclic purification of protium in functioning chamber was provided. The method of cyclic purification is based on ability of zeolites and carbons quantitatively and reversibly bind hydrogen at low temperatures and release it upon temperature increase. The use of two or more adsorbing materials in a row allowed uninterrupted flow of contaminated gas out and purified gas into the chamber. Manual procedure for cyclic purification was originally developed and tested by our group. Later an automated device CHUPS utilizing our procedure was created by KCT laboratory and successfully used in the latest steps of the muCap experiment at PSI, Switzerland.

The basic scheme of protium gas preparation, feeding it to the chamber and cyclic purification is outlined in Figure 1.

Analysis.

The hydrogen purity had to be analyzed on each and every step of the muCap experiment. The presence of N_2 and O_2 micro-contaminants was determined by the improved gas-chromatography method on ЛХМ-8МД and ЛХМ-80-1 instruments. Concentrating the contaminants prior to analysis on empirically chosen CaA zeolite allowed detection of less than 10^{-6} % N_2 and O_2 in protium gas. All experiments conducted at PSI were accompanied by this analysis.

The content of H_2O in protium was measured on specially ordered gas humidity meter ИВГ-1 with sensitivity improved to 0.017 ppm.

The important role in the final steps of the experiment was played by the cryogenic rectification column which was designed and manufactured to purify protium from D2. This work was done by the Laboratory of Cryogenic and Super-conductive Techniques and Hydrogen Isotope Separation Laboratory with participation of the ARC group.

Constant analysis of hydrogen ortho-para isotopes content provided by our group during optimization process allowed to achieve very high degree of protium purity (< 10E-7 of D2).

The work on gas system of the muCap experiment conducted by the ARC group helped its successful completion in 2007.

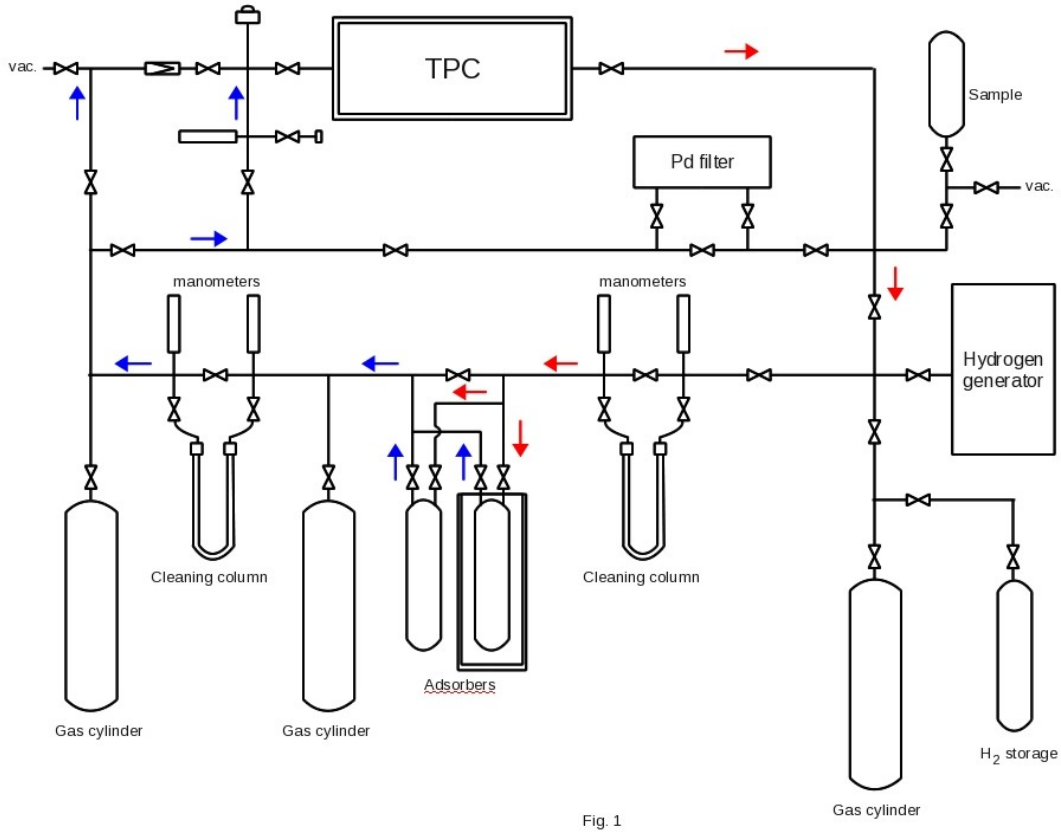

Fig. 1

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