**Project: Electron Cyclotron Resonance (ECR) ion sources hands-on training.**

## I Introduction

Ion sources are one of the critical components of all particle accelerators. They create the initial beam that is accelerated by the rest of mashine. Electron Cyclotron Resonance (ECR) ion sources are used for production of highly charged ions for nuclear and particle physics research, for industrial and medical applications, material modifications, surface treatment and semiconductor doping. In Flerov Laboratory of Nuclear Reactions four cyclotrons equipped with ECR ion sources (http://flerovlab.jinr.ru/flnr/accelerators.html, http://flerovlab.jinr.ru/flnr/she_factory_no.html, http://flerovlab.jinr.ru/flnr/accel_virtual_tours.html), are in operation.

## II Description

The practice is aimed at training of particle accelerators service/maintenance staff and ion source physicists.
During the study the overview of FLNR accelerator complex will be presented to students with descriptions of main parameters.
Students will also learn the basics of ion sources physics and technology with emphasis on ECR sources and their subsystems.

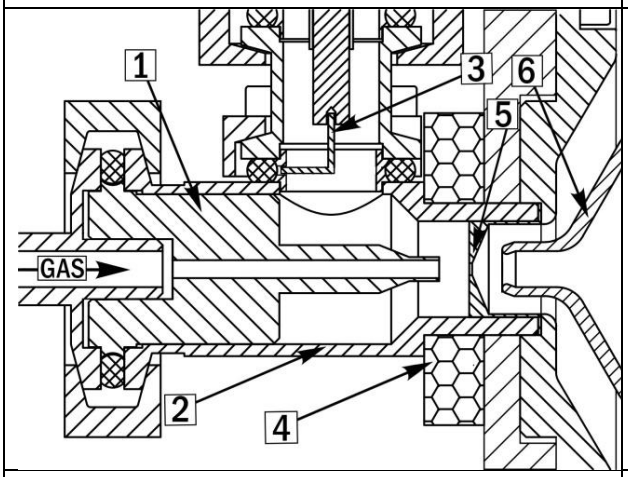
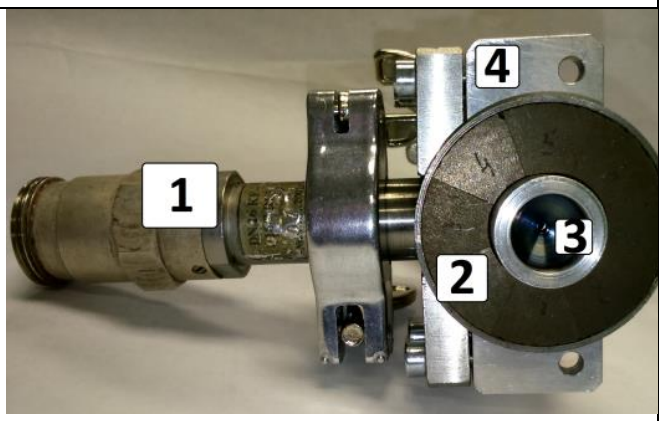
## III Practice structure

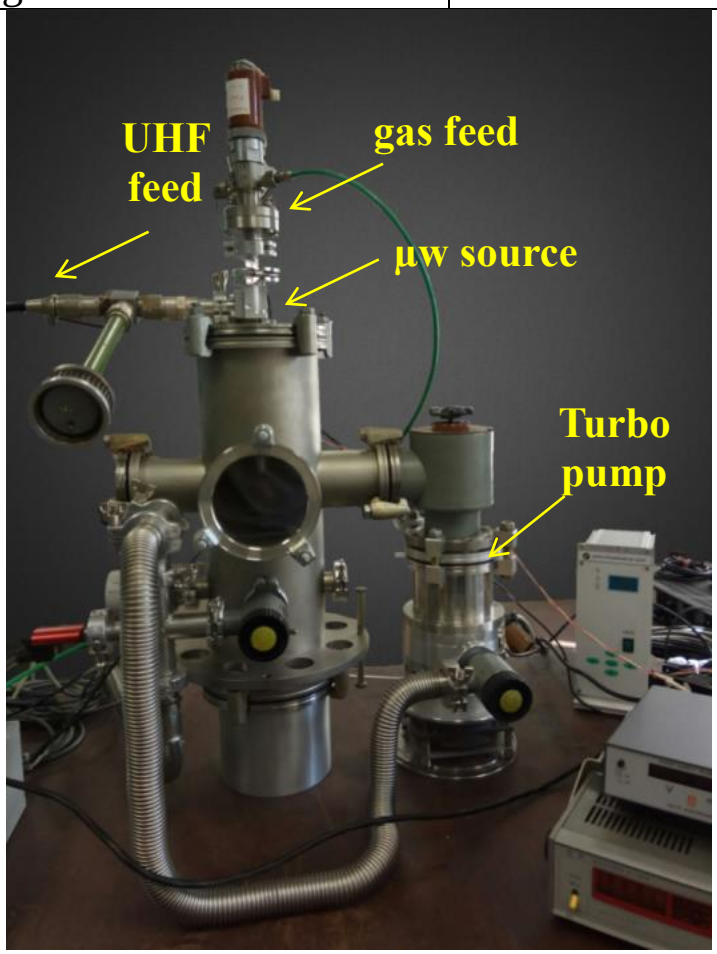
The practice is divided into theoretical and practical parts.
The theoretical part includes the study of main parts of ECR ion source:

- Magnetic system
- UHF system
- Vacuum system
- Working substances feed system
- Power supply and control system

The practical part includes the tuning of the ECR source, measuring of charge state distribution (depending on the availability of one of the ECR ion sources at FLNR cyclotrons).

The practical part also includes the study of compact ECR ion source, operating at the 2.45 GHz frequency (shown at the figures).

| Sketch view of compact ECR ion source | The view of compact ECR ion source |
|---|---|
|  |  |
| 1 - replaceable internal part of the resonator<br>2 – resonator casing<br>3 – coupling loop<br>4 – permanent magnet ring<br>5 - replaceable plasma electrode<br>6 - pulling electrode | 1 – coaxial feedtrough, 2 – permanent magnet ring,<br>3 – plasma electrode, 4 – resonator casing |




The view of experimental apparatus

During this part of practice the participants will acquaint with the design of the source and principle of operation. The characteristics of the source will be studied (measurements of extracted current as a function of UHF power, frequency and gas flow).

**IV Prerequisites**

Basics of physics, electricity, vacuum technics.
Basics of accelerators and plasma physics.

**V Recommended amount of participants**

Up to 2 persons

**VI Supervisor**

Sergey Bogomolov, head of ion sources group, JINR FLNR R&D Department of Accelerators.

VII Recommended literature


1. Ian G. Brown, The physics and Technology of Ion sources (Wiley-VCH, 2004)
2. Huashun Zhang, Ion Sources (Science Press, 1999)
3. Bernhard Wolf, Handbook of Ion Sources (CRC Press, 1995)
4. Richard Geller, Electron cyclotron resonance ion sources and ECR plasmas (IOP Publishing Ltd, 1996)
5. Materials of Accelerators Schools:

http://www-eng.lbl.gov/~dleitner/USPAS_2016_Fundamental_Of_Ion_Sources/

http://cas.web.cern.ch/schools/senec-2012