



The ESRF is a multinational research institute, situated in Grenoble, France and financed by 19 countries mostly European. It operates a powerful synchrotron X-ray source with some 30 beamlines (instruments) covering a wide range of scientific research in fields such as biology and medicine, chemistry, earth and environmental sciences, materials and surface science, and physics. The ESRF employs about 600 staff and is organized as a French *société civile*.

Within the Accelerator and Source Division, the *Insertion Devices* group is now seeking to recruit a:

## PhD Thesis Student (m/f)

**Subject: Development of permanent magnet quadrupoles**

**Fixed-term contract**

### GENERAL FRAMEWORK

The ESRF is a third generation synchrotron light source. Hard X-rays are created by deflecting relativistic electrons with periodic magnetic structures called undulators. Electrons are accelerated up to 6 GeV and are injected in a storage ring; undulators are inserted along this ring. The production of high energy X-rays (50 – 150 keV) is an important research and development topic. Short period undulators must be used to generate efficiently these high energy photons. Their magnetic gap must be reduced to obtain a sufficiently strong magnetic field. The minimal gap of an undulator is set by the vertical extension of the electron beam in the vertical axis, which is determined by the so-called  $\beta$  function of the storage ring. Focusing elements can be inserted in the middle of a straight section to reduce the extension of the electron beam; this is achieved in mini- $\beta$  sections. The focalization of the electrons in the center of the straight section is usually done with a triplet of quadrupole magnets. Each quadrupole generate a magnetic field gradient.

The ESRF Insertion Devices Laboratory has developed an expertise in the fields of undulators and accelerator magnets. First mini- $\beta$  beta experiments will be performed in 2013 at the ESRF ID23 straight section. Quadrupole magnets have not been optimized yet to be installed on mini- $\beta$  straight section. Different topics must be investigated: the geometric aperture of the magnets must be reduced, especially in the vertical plane; higher field gradients can be obtained by using permanent magnets in spite of resistive magnets. In a more general context, the design of Permanent Magnet Multipoles (PMM) with combined function (i.e. dipole, quadrupole, sextupole) may allow to reduce the size of the electron beam (so-called emittance).

### DESCRIPTION OF THE THESIS WORK

The aim of this PhD project is to design and to test permanent magnet multipoles for synchrotron light sources. The arrangement of the magnetic materials around the vacuum chamber must be optimized: numerical optimization methods will be used. Variable gradient and combined function PMMs will be investigated also. The design will be validated with a prototype and magnetic measurements. A permanent magnet quadrupole and its insertion in a mini- $\beta$  section will be studied, relying on the ID23 mini- $\beta$  section experiments.

Modelization of the magnetic field is an important topic because it is the basis of beam dynamic calculation. The widely used harmonic analysis of the magnetic field is not well-suited with non circular apertures: other analysis methods will be studied and integrated to beam dynamic tools and to measurement benches.

**Place of Work:** ESRF in Grenoble  
**Supervisor:** J. Chavanne, [chavanne@esrf.fr](mailto:chavanne@esrf.fr), (+33) (0)4 76 88 20 94

### OUR OFFER

**The working language of the ESRF is English.** You should hold a degree in Applied Physics, Electrical Engineering or Physics allowing enrolment for a PhD, such as an MSc, Master 2 de Recherche, Laurea or equivalent. Further information on the post can be obtained from J. Chavanne (tel.: +33 (0)4 76 88 20 94, email: [chavanne@esrf.fr](mailto:chavanne@esrf.fr)). For further information on employment terms and conditions, please refer to <http://www.esrf.fr/Jobs/Conditions>. The ESRF is an equal opportunity employer and encourages applications from disabled persons.

**Contract of two years renewable (subject to satisfactory progress) for one year. Monthly gross remuneration: 2286 €.**

If you are interested in this position, please apply on-line at this address: <http://www.esrf.fr/Jobs>.

**Ref. CFR374 - Deadline for returning application forms: 11 June 2012**