

## GRAAL ON BM7: GAMMA-RAY BEAM

*GRAAL does not exploit synchrotron radiation but utilizes gamma-rays produced by Compton backscattering of photons from the circulating electrons, for studies in nuclear and particle physics.*

*As such, it is not a typical CRG beamline, for example no beam time is made available to general ESRF users.*

**A**toms, molecules and more complex structures are studied almost uniquely by the long-range electromagnetic interactions, while the much smaller nuclei and elementary particles have been investigated mostly by the short-range strong and weak interactions. In fact, if the strong, hadronic interaction yields the largest cross-sections and therefore the highest event rate, photon-induced reactions have several advantages, and high-energy gamma beams can be good probes of nuclei.

The first polarised and tagged gamma-ray beam was obtained by the backward Compton scattering of laser light against high-energy electrons circulating in a storage ring (Adone, in Frascati). After this successful start, other similar beams entered into operation at Novosibirsk and Brookhaven. When the ESRF was originally proposed, it was evident that its high energy and low emittance would make it the best machine to produce such a beam and therefore a proposal was immediately submitted and included in all ESRF presentations. It was named Graal.

The Graal experiment is now in full operation. It produces a gamma-ray beam with a maximum energy of 1470 MeV and an intensity of about  $10^6$  photons per second. It has a 98% linear polarisation at the maximum energy and a resolution of 16 MeV fwhm. The main parts devoted to the production and monitoring of the beam are:

- a laser electron interaction region situated in one of the short straight sections of the storage ring;
- a tagging system, to measure the position and therefore the energy of the electrons which have interacted with the laser

photons. It is located at the exit of the storage ring dipole which follows the interaction region;

- a vacuum system to connect the machine vacuum pipe to the cabin where the laser is located;
- a laser cabin with the optical bench which supports the laser and its optics;
- an adjustable lead collimator, a clearing magnet and a second, fixed, lead collimator to collimate the gamma-ray beam and clear it of the background of undesired photons and electrons;
- a liquid hydrogen (or deuterium) target;
- three intensity, energy and position monitors for the gamma-ray beam.

The detector consists of:

- a BGO crystal ball made of 480 BGO crystals for the detection of high-energy gamma-rays and medium-energy protons; it covers a polar angle between  $25^\circ$  and  $155^\circ$ ;
- two cylindrical wire chambers located around the target, inside the crystal ball, followed by a barrel made of 32 plastic scintillators. The wire chambers and the

barrel are used to measure the angles and the ionization of the charged particles entering the BGO;

- two plane wire chambers and three walls of plastic scintillators to detect particles emitted in the forward direction, at  $\theta < 25^\circ$ .

This very complicated apparatus requires various expertises: storage ring physics, laser optics, gamma-ray beam handling, cryogenic targets, organic and inorganic scintillator detectors and wire chambers, plus fast electronic, data acquisition electronics, data handling, etc. This expertise is provided by a large international collaboration which includes about 50 scientists from Italy, France, Russia and the USA.

The beam polarization asymmetries have been measured for the photo-production of  $\pi^0$ ,  $\pi^+$ ,  $2\pi^0$  and  $\eta$ . A more detailed report on these measurements will be given in a future issue of the ESRF Newsletter. ■

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*The BGO crystal ball surrounding the cryogenic target on Graal.*

