Status report on the DESIR facility to the SPIRAL2 Scientific Advisory Committee

SPIRAL2 Week, January 28, 2010

Since the last report to the SAC (September 2009) the DESIR Collaboration has progressed on two main fronts: detailed simulations and design for the High Resolution Separator (HRS) and prototyping of the HRS beam preparation stage (SHIRAC). The experimental and design studies for SHIRAC have been summarized in a recent doctorial thesis (F. Duval, LPC Caen). Therefore, in this report we will concentrate primarily on the design of the HRS. In order to have the HRS available on schedule, a large funding request to pay for magnets and associated equipment will be necessary in 2010.

The SPIRAL2 high-resolution mass separator for DESIR and CIME

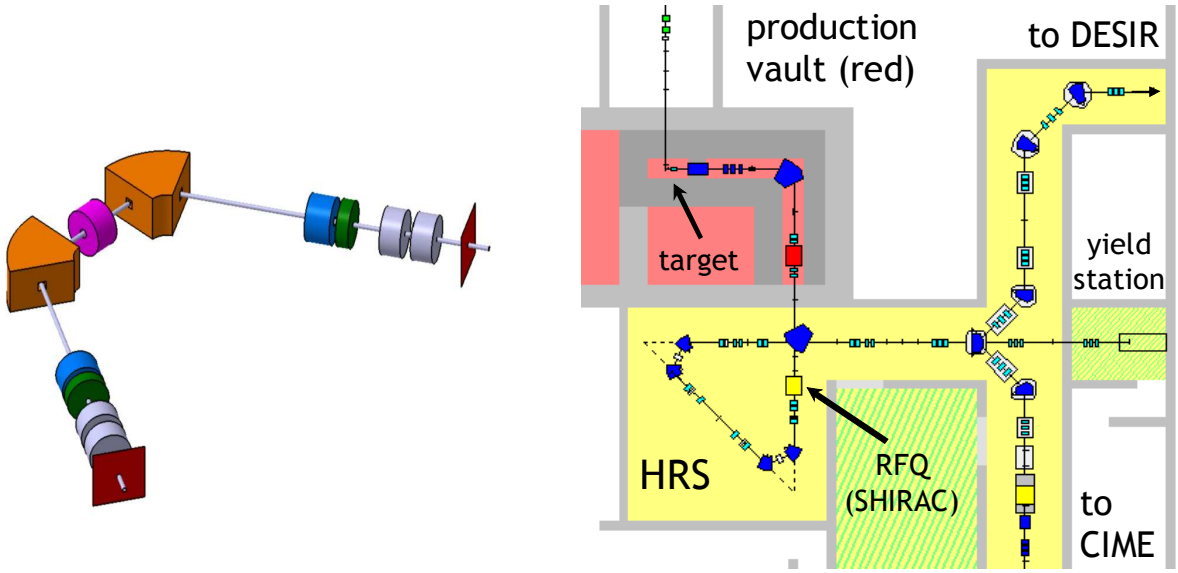
A high-resolution mass separator (HRS) is a crucial step for DESIR as well as for the post-acceleration of the radioactive beams by CIME. SPIRAL2 aims at increasing the production of radioactive species by 2-3 orders of magnitude. If isobaric contamination is not suppressed then background and even radioprotection problems are likely to compromise operation of the facility.

Two preliminary HRS designs were considered in the early stages of the SPIRAL2 project. One of those, based on the CARIBU project now being built at Argonne National Laboratory, was retained for detailed study (see the design document by T. Kurtukian-Nieto, which was appended to the last report to the SAC) with a targeted mass resolving power of $m/\Delta m = 20\,000$.

During a two-day workshop, held November 12-13, 2009 at CENBG (Bordeaux), several beam optics experts critically examined the SPIRAL2 HRS design and suggested improvements. The workshop was a great success since the various experts were unanimous in the proposed solutions (a summary of the workshop is appended to the present report). These are briefly discussed here.

The initial design involved a C-shaped, symmetric configuration using two 67.5-degree dipoles. In consultation with F. Varenne of the production-building design team, this layout was extended by adding a second C-shaped, symmetric configuration to form an alpha-shaped overall layout (see figure below). This solution, in addition to offering increased mass resolving power, had the very desirable feature of saving floor space in the production building.

The main recommendation of the Bordeaux workshop (apart from the invaluable transfer of technical know-how-not) was that while the alpha layout was a clear advantage in terms of space, the attempt of including an additional (double) mass-separator stage would critically complicate operation of the facility. The use of electrostatic beam transport for the second bending stage would alleviate this problem. This opinion was shared by all the experts attending the meeting.



(left) Initial optical design of the SPIRAL2 HRS, based on the symmetric, double-dipole design of Davids and Peterson for the CARIBOU project at ANL; (right) the implantation of the double-C solution in the SPIRAL2 production cave (also shown are the transport lines).

The experience of operating magnetic mass separators at TRIUMF and ISOLDE has shown that high resolving power requires considerable investment in money and manpower. The Bordeaux workshop was particularly helpful in pointing out the pitfalls to avoid at future facilities. In addition to not overcomplicating the separator, including sufficient space and beam diagnostics is also extremely important.

A new design based on the recommendations is underway and the first results will be presented at the SPIRAL2 week. The initial separator will not change very much. The footprint will also remain essentially unchanged with the latter two dipole magnets being replaced by two pairs of electrostatic kicker-bender chambers.

The magnets that were ordered for the CARIBU HRS took two years to be delivered. This means that in order to have the HRS ready in time, the magnets must be ordered in 2011. Therefore, the DESIR Collaboration intends to make a large funding request in 2010. While the details are not completely finalised, the request will be of the order of 500 k€ for 2010.

The RFQ cooler and the HRS

Achieving high mass resolving power requires three main ingredients: in addition to high magnetic dispersion and large angular beam acceptance, a small beam emittance is necessary. There are now several instruments operating a many of the world's radioactive beam installations capable of reducing beam emittances with good efficiency. All are based on gas-filled quadrupole sections that use radiofrequency confining fields. While the input currents of these instruments have been limited, recent R&D has now produced a prototype capable of increasing their capacity up to the microampere range (see O. Gianfrancesco et al., NIMB 266 (2008) 4483). Excellent progress has been made on the high-intensity RFQ cooler specifically designed for SPIRAL2 (doctoral thesis of F. Duval, LPC-Caen). The performance of the prototype device was characterised in detail, a detailed numerical model including space charge has been validated and a design for an on-line

version has been performed with the main elements already fabricated by the LPC mechanical engineering staff (see photos).

Photographs of the new SPIRAL2 High Intensity RFQ Cooler (SHIRAC2) prototype; (left) the insulated housing, high voltage cage and differential pumping stages; (right) the segmented quadrupole electrode and RF backbone structure, mounted as a module.

DESIR beam transport

During the Bordeaux HRS workshop, the subject of beam transport from the HRS to DESIR was also discussed. From the point of view of cost (in addition to ease of operation) most low-energy facilities use electrostatic beam transport. Since the requirements for beam transport will be the same as for existing facilities, different options exist e.g. at TRIUMF-ISAC and at CERN-ISOLDE. Machine drawings are available for elements with which a low-energy beamline may be constructed.

Within the budding collaboration between SPIRAL2 and the Bhabha Atomic Research Center (Mumbai), there has been interest in the production of such an electrostatic beam transport system. Hopefully this will be pursued in future discussions.

DESIR web pages

The DESIR web pages www.cenbg.in2p3.fr/desir contain information on the physics at DESIR, the facility layout, the experimental equipment which will be installed at DESIR, the DESIR collaboration, meetings, etc.

Conclusion and planning

The HRS, and much of the associated diagnostic and beam transport system, will be realised in consultation with the international partners TRIUMF, Argonne, and ISOLDE. It is hoped that at least part of the construction can be performed in collaboration with BARC (Mumbai) and perhaps with IMP (Lanzhou).

Given the constraints of the production building and hence, HRS calendar, the DESIR Collaboration has concluded that in order to safely send beams to DESIR and perform first experiments, **the first funding application – of roughly 500 k€ for the HRS magnets and associated equipment – must be made in 2010**.