DESIR status report
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for the DESIR collaboration

Over the past few years, the DESIR facility has been designed to a large degree of details. Presently the infrastructure is studied and evaluated by the four candidates for the construction of SPIRAL2 Phase 2 together with the production building. In September 2009, one company will be chosen for the construction of SPIRAL2 Phase 2 for which DESIR is one of the options. This means that with the results from this first round for the civil construction of SPIRAL2 Phase 2, we will have for the first time a complete cost estimate from an outside company.

In parallel, studies are ongoing for radioprotection around DESIR, the links between DESIR and the three different production sites for radioactive ISOL beams at GANIL, namely SPIRAL1, SPIRAL2, and S3. Work also continues on the general DESIR equipment like the RFQ cooler SHIRAC, the high-resolution separator HRS, the general purpose ion buncher GPIB, and the identification station.

In addition, the different groups in the DESIR collaboration continue to develop and to test their setups to be installed in the DESIR hall from 2013 onwards. Some of the progress made since the TDR for DESIR from end of 2008, we be laid out in some detail below. Before that we summarize a few other items.

The DESIR collaboration

As always mentioned the DESIR collaboration is open to everybody interested in the physics programme possible at DESIR. In this sense, contacts have been established with India via the planned LIA. It turned out that groups from Calcutta and Bombay are interested in joining the DESIR collaboration and maybe in contributing to the facility. These plans will be discussed in much more detail during a conference in Bombay in December 2009.

Civil construction programme for DESIR

The construction programme for DESIR was established over the last year or so in close collaboration with the SPIRAL2 team. This programme was submitted to the different candidates for the construction. We are now in the process of answering to specific questions from these candidates. The importance of this process will certainly increase significantly once the company for the construction is chosen and the detailed design study of this company starts. As the questions become increasingly technique, it is more and more important that the DESIR collaboration gets a quasi permanent technical support from GANIL. **Therefore, we ask that a technician and/or and engineer from GANIL be assigned to DESIR.**

Radioprotection

Discussions have been taken place with the radioprotection group at IRFU Saclay in order to see whether this group could be involved in radioprotection around DESIR. It turned out that due to the fact that nobody from IRFU is involved in DESIR, this would only work for DESIR, if they were paid for the work. For the moment, this is not pursued.

Beam lines

IPN Orsay was asked to do a cost estimate for electrostatic beam lines from the production sites to DESIR and within the DESIR hall. For the moment, only a cost estimate based on the beam lines at ALTO was established. A much more detailed study is, however, needed, including beam line simulations, to refine these estimates. New discussions are needed with IPN Orsay.

RFQ cooler SHIRAC

The SPIRAL2 high intensity radio frequency cooler SHIRAC will be coupled with the high resolution spectrometer HRS. Its purpose is to cool the radioactive beams to an emittance of about 1π.mm.mrad. With cooled beams the HRS should reach its design performance in mass resolution (~20000). The cooler is a radio frequency cooler with gas buffer. These coolers have been running successfully at RNB facilities for 10 years, most of them handle nA beam currents. For SPIRAL2, the goal is to reach 1 µA. At these currents, space charge effects are the main problems. In order to cool beams up to 1 µA, the RF voltage will be a few kV peak to peak at a variable frequency (~MHz) to handle a broad mass range (Fig. 1). The buffer gas is helium. Since 2007, a prototype has been tested and several points have been investigated (RF high voltage sparking, vacuum, electrode surface quality) and subsystems have been developed (RF voltage, slow control).

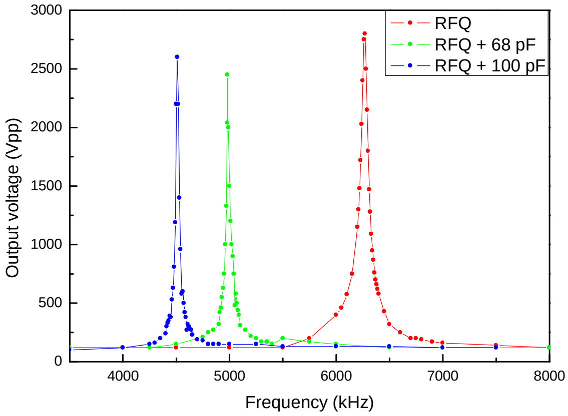

Figure 1: RF voltage

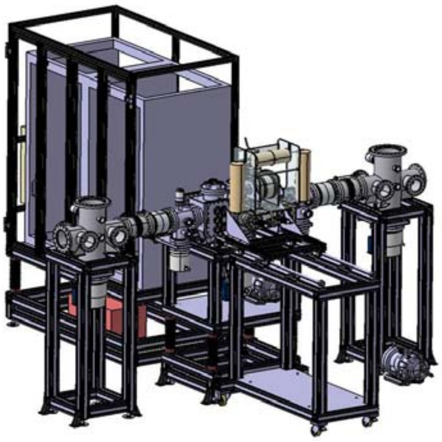

Figure 2: Overall view of SHIRAC

The new SPIRAL2 cooler has been simulated and designed (Fig. 2). This work is under completion and the first tests are foreseen in the beginning of 2010.

High-resolution separator HRS

The High Resolution Separator (HRS) for SPIRAL2/DESIR will purify beams of exotic nuclei produced by SPIRAL2. The HRS is being designed to achieve a high transmission (close to 100%) and a high resolving power (m/ΔM ~20000) within a compact configuration. This high resolving power will allow one to separate neighbouring isotopes for nuclei far from stability.

Initially a mirror symmetric “C-arrangement” was proposed with two bending magnets of 60° and 50 cm radii, obtaining a mass dispersion of 20cm/%, for which a resolving power of 20000 can be attained using 1π mm mrad beam emittance. The detailed ion-optical design is described on the DESIR Technical Design Report. However, a new “Alpha-arrangement” of 270° for the HRS has been proposed, in order to reduce the size of the production building. Two prototypes for this new arrangement are currently under study: one asymmetric at the dispersive plane, with a total mass dispersion of ~10cm/% and a magnification of ~0.5; and a second prototype, mirror symmetric with magnification equal to -1, and a mass dispersion of ~26cm/%.

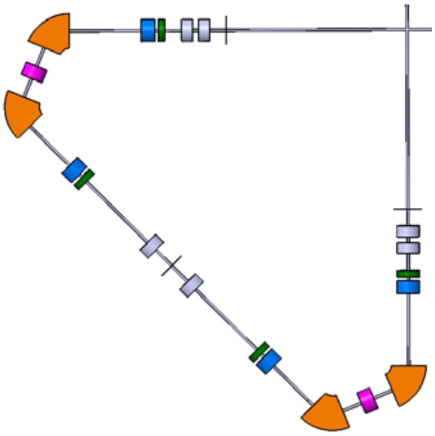

Figure 3: HRS-Alpha Asymmetric

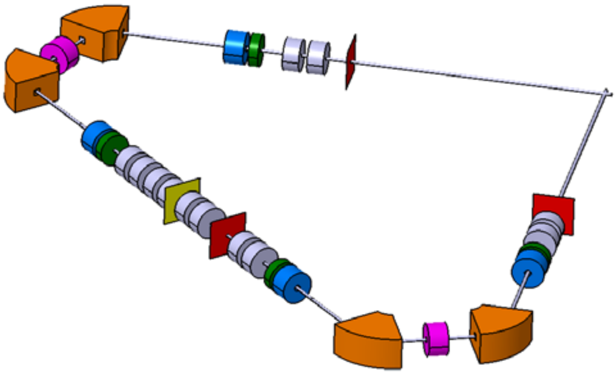

Figure 4: HRS-Alpha Mirror Symmetric

Both designs rely on a strong optical focussing in order to keep as low as possible the size of the separator. This optical condition makes the system more sensitive to the fringe field effects, and a correct simulation of such effects is important in order to perform a correct design of the separator. Different ion-optical codes have been used in order to analyse the different prototypes: COSY INFINITY, GICOSY, TRANSPORT and GALOP. However, due to the different approximations used by these codes to calculate the fringe field effects, different results are obtained. In the near future, we will use TOSCA map to overcome this problem.

Next actions:

1. Workshop to be held at CENBG for a closer discussion with experts on the HRS.
2. Simulations of field maps with other codes, such as TOSCA, in order to carefully evaluate the fringe field effects and later perform a more realistic study of possible misalignment effects on the resolution.

General purpose ion buncher GPIB

The GPIB is meant to bunch ions before they are sent to the different experiments which need bunched beams like the LUMIERE installation or the Double-Penning trap system for trap-assisted decay spectroscopy. The design of this setup is largely inspired by the ISCOOL device of ISOLDE. However, injection and extraction conditions will be different. Therefore, some technical studies are needed before its construction can be planned. This work is about to start and a first cost estimate has been established. Discussions also start about the financing of this device.

DESIR identification station

The identification station of DESIR is based on a tape transport system and different detection setups. A new tape transport system is presently developed in Strasburg within the framework of the French ANR VS3. This tape station will be the basis for the DESIR identification station.

The LUMIERE facility

Exploitation of the unique spectroscopic opportunities offered by DESIR places strict demands on the LUMIERE laser station. This station must out-perform the existing facilities in terms of sensitivity, speed and stability in order to access the most rare and exotic species provided by the development.

Great progress has been made on each requirement since our last submission to the SAC. The demonstrated sensitivity of the newly commissioned cooler-buncher at ISOLDE, a development by members of the LUMIERE collaboration, has permitted extensive studies of neutron-rich species in the chains of Cu (Z=29) and Ga (Z=31) and has proven our core design for DESIR. In the studies, continuous loading times of 50 ms and release times of 6 μs were achieved, the former and latter are both a factor of 2 shorter than obtained by members of our collaboration at JYFL. The same level of background rejection (ratio of release to bunch time) is thus achieved using only half the loading time. The effect for short-lived isotopes is dramatic and up to 28% of systems with 10 ms half-lives now survive the beam preparation.

The stability requirement of LUMIERE, essential for the study of low Z species, is being addressed by our twin, primary-secondary, cooler-buncher developments. The high velocities and small nuclear field perturbations encountered in low Z nuclei necessitate voltage stabilities and reproducibilities of better than 0.1 V in many tens of thousands of volts. A low pressure, low volume and an actively stabilised secondary cooler will provide the required stability, without compromising the release and transit times of the station, and is to be demonstrated at both JYFL and ISOLDE prior to inclusion in LUMIERE.

Recent developments at MLLTRAP

After the first successful offline commissioning of the double Penning trap system with rubidium ions, further work concentrated on the characterization of systematic effects on the mass accuracy. Influences of ambient properties like atmospheric pressure and room temperature on the magnetic field and thus on the frequency of the measured cyclotron resonance were systematically studied. In addition, tests of a Multi-Reflection Time-of-Flight mass spectrometer (MRTOF) developed by the Giessen group were performed at the Garching Tandem accelerator. The prototype spectrometer was transferred to Garching and coupled to the MLL Ion Catcher buffer gas cell.

A new quadrupole mass separator (QMS) and a diagnostic unit allowing alternatively to detect ions behind the QMS using a Si detector or ion transmission via a segmented RFQ was newly constructed and added to the beam line setup behind the gas cell.

A high mass resolving power of about $m/\delta m \sim 200000$ could be determined for the MRTOF device, clearly qualifying the MRTOF concept not only as applicable for isobaric purification outside the Penning trap system, but also for mass measurements of short-lived nuclear species due to the short measurement times of only a few ms.

Further work on the MLLTRAP facility will include the setup of a 'Multi-Passage Spectrometer', i.e. a dipole magnet with round pole tips allowing for pulsed operation in combination with an electrostatic lens and mirror system, which can serve as a 4-way beam bender as well as (q/A) separator when using a charge breeding device aiming at the use of highly charged ions in the trap. First experimental studies at MLLTRAP aim at investigating α recoil products of actinides (e.g. ^{240}U), which are produced in high charge states.

The double MOT

In the last year we have worked on a number of issues which are relevant for future options at SPIRAL2. Some of it was achieved using the funding of the FP7-SPIRAL2PP. One part concerns the production and optical properties of Ra ions and atoms for various isotopes. The mapping of the optical properties are of relevance in order to be able to develop cooling and trapping schemes and will be one of the major tasks ahead.

For the atom trapping system measuring beta-decay correlations, we are redesigning and calibrating aspects associated with the infrastructure of the dual trap system: A UV laser was installed that allows us to ionize the trapped cloud of stable atoms in front of the recoil-ion spectrometer. In this way we obtain triggered ion events such as occurs in beta decay. With this we can test the resolutions of the time-of-flight of the recoil and its position without the need of radioactive atoms. This work has led us to reconsider some details of the setup. A detailed design of the transfer line between the two atom traps was finished and will soon be installed.

Day-one experiments

Although no specific call for day-one experiments for DESIR has been launched, the collaboration was asked to propose their “preferred” experiment with a short description of the physics case and why this experiment has to be performed at DESIR. A short list of the experiments is given below. Besides these physics topics the first experiments to be carried out will certainly be rather straightforward experiments employing well-known techniques and equipment. Therefore, decay-type experiments with β and γ detectors will most likely be the very first choice.

A list of possible more advanced day-one experiments follows.

- high accuracy mass, half-life and branching-ratio measurements of the superallowed β emitters ^{66}As and ^{70}Br
- precision mass measurements of heavy transfermium elements (e.g. Z=104-107)
- in-trap coincident conversion electron + α spectroscopy in heavy nuclei (Z>=82), allowing to extract lifetimes (excited 0^+,2^+ states) and Q values
- study of the shell evolution in the Ca, Sc, Ti region beyond N=28
- magic number at N=32 in the Ca, Sc, Ti isotopes via isotope shift measurements. Possible cases: $^{51\text{-}53}$Ca, $^{52\text{-}54}$Ti. From the hyperfine structure, direct access to their spins and magnetic moments, maybe also quadrupole moment
- evolution of the proton sd-orbits when filling the higher neutron pf-orbitals: measurement of the hyperfine structure out to ^{51}K (N=32) and beyond to see whether there is a new magic number N=32
- measurements on hyperfine anomaly: probing the magnetic and the charge distribution, getting nuclear spin assignments
- precise measurement of the β-ν angular correlation parameter of ^{8}He to search for physics beyond the standard model

In general, the connection to S3 will provide beams which are not and will not be available in the same quantities and qualities at any other installation in the foreseeable future. Therefore, experiments which will use beams from S3 will certainly be the most interesting ones.