TSR@ISOLDE Workshop

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CERN

Book of Abstracts

Contents

0

Welcome and introduction

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1

HIE-ISOLDE: present status of the project and the physics program

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The ISOLDE Facility at CERN produces radioactive beams through fission, spallation and fragmentation reactions induced by 1.4 GeV protons from the PS booster. By a clever combination of target and ion source unit intense and pure beams of 700 different nuclei of 75 elements are produced and delivered to experiments where the properties of the nuclei are determined. Since more than a decade it offers the largest variety of post-accelerated radioactive beams in the world today. The combination of the Mini-ball gamma-ray array and T-REX charged particle detection system has been successfully used to study nuclear shapes through Coulomb excitation and transfer reactions up in different region of the nuclear chart. Elastic scattering and transfer in light system has allowed for the study of the interplay between halo structure and reaction mechanism as well to reveal the composition of the few excite states of halo and unbound nuclei.

In order to broaden the scientific opportunities beyond the reach of the present facility, the HIE-ISOLDE (High Intensity & Energy) project will provide major improvements in energy range, beam intensity and beam quality. A major element of the project will be an increase of the final energy of the post-accelerated beams to 10A MeV throughout the periodic table. The first stage will boost the energy of the current REX LINAC to 5 MeV/u where the Coulomb excitation cross sections are strongly increased with respect to the previous 3 MeV/u and many transfer reaction channels will be opened.

The first phase of HIE-ISOLDE will start for Physics in the autumn of 2015. The physics program is very attractive. After a submission of thirty-four letters of intend in 2009, twenty-seven experiments have been approved for day-one physics with more than six hundred shift allocated. The physics cases approved expand over the wide range of post-accelerated beams available at ISOLDE. A large variety of instrumentation will be implemented. In this presentation the HIE-ISOLDE project will be described together with a panorama of the physics cases addressed.

2

Status of the TSR project

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The TSR will be the first low-energy storage ring at an ISOL-type radioactive beam facility [1]. Specifically, we intend to setup the heavy-ion, low-energy ring TSR at the ISOLDE facility in CERN, Geneva. Such a facility will provide a capability for experiments with stored secondary beams that is unique in the world. The envisaged physics programme is rich and varied, spanning from investigations of nuclear ground-state properties and reaction studies of astrophysical relevance, to investigations with highly-charged ions and pure isomeric beams. The TSR might also be employed for

removal of isobaric contaminants from stored ion beams and for systematic studies within the neutrino beam programme. In addition to experiments performed using beams recirculating within the ring, cooled beams can also be extracted and exploited by external spectrometers for high-precision measurements. The existing TSR, which was until end of 2012 in operation at the Max Planck Institute for Nuclear Physics in Heidelberg, is well suited and can be employed for this purpose. An overview on the status of the project will be given.
[1]M. Grieser et al., Eur. Phys. J. ST 207, 1 (2012)

3

Report on technical study of TSR@ISOLDE

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A number of machine related aspects of the TSR@ISOLDE initiative at its present stage will be presented, for instance the interfacing of the ring with the HIE-ISOLDE linac and a tentative layout of experimental areas will be introduced. The results from the recently concluded extensive integration study covering the technical aspects of the move and integration into the CERN accelerator environment will be summarized. Finally, some results from the on-going study of an upgraded charge breeder, which could be highly beneficial for TSR@ISOLDE, will be given.

4

Considerations for the implementation of experiments

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In the talk the feasibility of TSR@Isolde experiments will be represented. It will be discussed how -many ions are necessary to conduct in ring decay experiments to determine the half-life of 7Be. In connection with this experiments the detection limit of Schotty noise analyses will be discussed. Based on the Schottky noise detection limit long-lived isomeric states experiments are investigated. In addition mass measurements at TSR@ISOLDE are discussed and the viability of proton pick-up reactions will be investigated. In-ring laser spectroscopy experiments needs ion beams with momentum spreads as small as possible. Lastly a method to generate ion beams with momentum spreads below 10-5 will be treated.

5

In-ring decay experiments and plans for TSR & FAIR

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Heavy-ion storage rings coupled to radioactive-ion beam facilities allow for a wide range of physics experiments.

One of such experiments is the investigation of radioactive decays of highly-charged ions.
The latter offer the unique possibility to study, e.g., weak decays of clean well-defined quantum systems, exotic decay modes that are disabled in neutral atoms, or investigate the decay probabilities versus the number of bound electrons.
Since storage rings are, as a rule, operated under ultra-high vacuum conditions, radioactive ions in high-atomic charge states can be stored for extended periods of time sufficient to investigate their decays.
At present, the ESR at GSI is the only storage ring where such experiments are pursued. However, due to high kinetic energies employed, several exciting experiments on light nuclei are not feasible.This will be overcome with the TSR@ISOLDE.
In this contribution, the experimental program on decay studies of highly-charged ions will be presented with an emphasis on the uniqueness of the TSR@ISOLDE in comparison to the present ESR as well as the future CRYRING, CR and HESR rings of FAIR.

6

Nuclear Astrophysics in-ring and TSR plans

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The talk will explore how heavy ion storage rings are just starting to be used for studies of nuclear astrophysical reactions. In particular, heavy ion storage rings offer the prospect of measurements relevant for explosive astrophysical scenarios. The new TSR@ISOLDE has the potential to open up an exciting new era for such reaction measurements using a range of radioactive ion beams injected from the HIE-ISOLDE facility.

7

Plans for in-ring Nuclear Structure studies using TSR

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Plans for in-ring nuclear structure studies using TSR The peculiar characteristics of ion beams orbiting in a storage ring offer interesting opportunities for nuclear structure studies. Nuclear reactions would exploit the superior energy resolution which could be achieved by the combination of a cooled beam and the use of a gas jet target. This would allow detailed measurements on nuclei where the density of states is high. Possibly, the use of the ring bend as a separator may help identifying transfer reactions to unbound states, which occur in light nuclei close to the drip lines. Beta-delayed light-ion emission has also been used to characterise those systems. In this case the main experimental limit is normally represented by the small relative momentum of the fragments. In the storage ring the problem would be overcome as the decay takes place in flight, within a narrow cone around the circulating ion beams. We will present possible flagship experiments for the different techniques.

8

Plans for Nuclear Structure studies using extracted TSR beam

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The push to study the properties of nuclei far from stability has led to a renewed interest in the use of direct reactions motivated by both nuclear structure and astrophysics. This talk will discuss some of the the experimental requirements for performing direct reaction studies using extracted beams from the TRS. The potential of a solenoidal spectrometer system will be assessed by comparison with other experimental techniques. Options and upgrade paths for a solenoid for the TRS will be discussed.

9

Status of collaboration and agreements

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Collaboration issues and agreements as well as the funding situation will be discussed.