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ISOLDE AND NEUTRON TIME-OF-FLIGHT EXPERIMENTS COMMITTEE

Minutes of the 35th meeting of the INTC
Held on Monday 16 and Tuesday 17 November 2009

OPEN SESSION

Monday 16 November 2009 at 14:00 h, Council Chamber

The Chairman of the INTC, Peter Butler, opened the meeting and announced the agenda. He informed the Committee on the approval of the HIE-ISOLDE project by CERN management and welcomed the new members of the Committee Prof. Hanns-Ulrich Habermeier and Dr. Danas Ridikas.

ISOLDE Technical Report

The EN-representative for the INTC, Richard Catherall, summarized the main issues from ISOLDE operation in 2009. For the whole running period 23 target units were produced including 12 uranium-carbide targets. Several target/ion-source developments have been pursued: The new VADIS arc-discharge ion source, which has been tested successfully in 2008 and has meanwhile drawn the interest of other facilities, was combined with different target units and gave again higher ionization efficiencies. Another target test concentrated on the production of intense ^{6}He beams using a BeO target material and a neutron converter. In addition to the successful production, the spectrum of neutrons from the converter was investigated in more detail. Finally, a low work-function cavity for the suppression of surface ionized contamination was tested in order to be applied in future runs.

The REX-ISOLDE system was operated for 9 different beams. In case of neutron-rich Kr isotopes, the failure of a vacuum seal of the last acceleration stage led to the cancellation of the run. It was rescheduled and was running nicely, but was then stopped due to sequential power cuts which fully cut the ISOLDE vacuum system for one week. For another run on ^{11}Be isotopes the cathode of the EBIS broke just before the setup time and the run was very much delayed and could only take a few shifts for tests. Otherwise the REX-ISOLDE campaign was very successful including post-accelerated iron isotopes after in-trap decay and transfer reactions with ^{66}Ni at MINIBALL. The REX-ISOLDE low-energy part is looking forward to a new control system upgrade. It is foreseen for the shutdown period 2010-2011. In addition a new Pico-Ampere meter has been designed and tested and will be implemented during the upgrade. The installation of a shielding close to the REX-EBIS charge breeder to reduce the effect of the magnetic field of WITCH was not sufficient. The A/q scaling from the stable beam to a weak radioactive beam was not working with the WITCH field being operated. The REX-LINAC consolidation has progressed. The cooling and ventilation of the RF amplifier room was

improved to give a better temperature stability which will allow longer RF tube lifetimes. Furthermore, the REX-LINAC concrete shielding tunnel has been put in place and will be closed in the upcoming shutdown. This will make future interventions much easier and the X-ray background at the MINIBALL experiment will be greatly reduced. The beam instrumentation controls have been brought to CERN standard to allow better support and much easier extension and/or modification. Finally, a new tuner mechanics for the 7-gap resonators have been designed which will improve the reliability and stability for operation. Technical development concentrated on new setups for tilted-foil polarization and the recently recuperated beta-NMR system. First tests are planned at the end of the 2009 running period.

Many radioactive beams made use of the selective RILIS laser ionization. In 2009, the new solid state Nd:YAG lasers have been used to pump the dye lasers for all RILIS runs. The schemes comprised the following elements: Be, Ge, Ag, Nd, Po, Mn, Mg, Sn, Zn, and Ni. Especially in the case of manganese a new scheme has been applied which was found in the off-line LARIS laboratory. More than 2100 hours of RILIS operation was distributed on 14 different radioactive ion beam runs.

The main incidents for ISOLDE operation include the failure of the robots. In the case of the GPS a wrong shelf position was programmed which could have led to a collision with an already stored unit. A re-programming of the robots and shelf positions is planned for the upcoming shutdown. The failure of the HRS robot was related to a wrong pick-up which caused the robot to be jammed at the front-end. The intervention resulted in a high collective and individual dose for the participating engineers. Other incidents hampering ISOLDE operation and the Physics program include the proton steering from the PS Booster to ISOLDE, general problems with the controls, vacuum equipment, sparking of the high-voltage of the targets, and failure of diagnostic tools like Faraday cups and beam scanners. Despite all these problems the physics program was very successful and all support groups involved are thanked for their help and contributions.

The robot incidents mentioned above and an internal Safety Audit held this Summer led to a new approach to safety at ISOLDE. The Safety Audit was regarded as an exercise to review safety standards and to define recommendations in order to improve procedures and documentation. Concerning the robot incidents it was decided to implement a new procedure for the PS complex with respect to interventions: Depending on the level of radiation, different procedures will be applied, with a special ALARA Committee being in place for the highest risk level. For the latter, a DIMR (Dossier d'Intervention en Milieu Radioactif) has to be initiated.

The 2009/2010 shutdown planning is governed by two major tasks: The replacement of the HRS front-end FE#3 with the new front-end FE#6, and the renovation of the ISOLDE vacuum system. An overview of the front-end exchange planning was given and key dates for the start up of ISOLDE in 2010 defined. It is expected to have both major interventions finished on April 5, 2010 in order to take protons from the PS Booster on April 26, after a two-week cold check out period.

The report was concluded with an overview on the HIE-ISOLDE project plan. It is expected to start the project January 1, 2010 and to have the cryogenics building ready end of 2011. All installation infrastructure is planned to be in place end of 2012. With the cryogenics installed and commissioned in June 2013, the high-energy beam line up to 5.5 MeV/u is planned to be installed in March 2013 and the full energy upgrade to 10 MeV/u by January 2014. One cavity prototype is completed and will soon be tested at TRIUMF. The cryomodule concept design has been finished and work will start as soon as manpower is available. The complete cavity-configuration test is planned by the end of 2010. A resource-loaded project plan will be prepared for CERN management in order to release required resources as early as possible.

ISOLDE Physics Report

The ISOLDE Physics Coordinator, Alexander Herlert, gave an overview on the final experimental schedule for the 2009 campaign, summarized the main problems and failures, and presented some of the highlights of the 2009 ISOLDE experimental program. In the last two INTC meetings 11 new ISOLDE experiments were recommended for approval by the Research Board (IS484-IS494) with in total 384 RIB shifts. From all 84 ISOLDE experiments 11 experiments declared their scientific program as completed and 51 experiments out of the 73 remaining active experiments requested beam time for the 2009 period. Out of the 627 requested RIB shifts, 437 RIB shifts were scheduled (about 70%) with beam to 39 experiments. Furthermore, additional target and ion-source development runs were scheduled. For REX-ISOLDE 9 experiments were scheduled (in 8 REX-ISOLDE runs) with in total 140 scheduled RIB shifts.

The main problems affecting the physics program include power cuts, problems with the vacuum system, problems with the control system, low performance of some targets, and failures of the injector chain, i.e. problems with LINAC2 or the PS Booster operation. While in many cases only slight delays occurred and experiments were able to take data, three experiments did not get beam at all: In the case of IS478 the target was not ready and in addition a series of power cuts stopped ISOLDE operation for several days. The second experiment was IS480 which was not able to run as the LINAC2 was stopped due to a severe vacuum leak, which took several days for the repair until protons were delivered to the PS Booster and ISOLDE. The third experiment was IS413, which was cancelled because of severe high-voltage sparking in the target due to a wrongly set extraction electrode.

Some of the highlights of the physics results obtained in 2009 comprise data from precision mass measurements with ISOLTRAP, laser spectroscopy with COLLAPS, as well as in-source laser spectroscopy. Furthermore, neutron-rich manganese isotopes were studied with MINIBALL and with a background-free detector setup for decay experiments. With MINIBALL and a dedicated detector chamber T-REX a successful one-neutron transfer reaction with ^{66}Ni was performed. Many results of the 2009 campaign will be presented at the ISOLDE Users Workshop 2009 right after the INTC meeting.

Finally, an outlook for the 2010 measurement campaign was given. It is expected to start with the physics program on April 29 and the last protons will be delivered on November 22. This will give about 30 weeks for ISOLDE experiments, which is similar to the 2009 period.

n_TOF Facility Status Report

The representative of the n_TOF Collaboration, Enrico Chiaveri, summarized the status of the n_TOF facility and gave an overview of the 2009 experimental program as well as an outlook of the campaign in 2010. The new target design was reviewed including the new target cooling station and the ventilation station. During May 2009 the new cooling station was installed, which comprises several mechanical filters, ion-exchanger cartridges, a degassing device, and two physically separated circuits, one for the cooling and one for the moderator. The cooling station and its parameters can be monitored on-line during operation. The ventilation station continuously flushes the target area and releases the air into the atmosphere as requested by Radiation Protection. The operation of n_TOF started on May 26 and is expected to end on November 23 as scheduled and the planned number of 7.2×10^{18} protons on target in 2009 will be reached.

The plans to modify the experimental area into a Work Sector of Type A was then presented. Several safety issues have to be addressed like fire proof installations, improved ventilation,

special access procedures, and the availability of a decontamination area. A new layout of the n_TOF facility was presented including the plans for a changing room and a new experimental area.

An update was given on the use of borated water. The circuit is in the engineering phase and it should be possible to run with and without boric acid in the water and to change within reasonable time. It is planned to have either 0% boron content or fully saturated borated water. First tests for the photon-energy distribution showed an additional 470 keV line for borated water due to neutron capture of ^{10}B. However, a prominent 2.2 MeV line due to neutron capture of ^{1}H was reduced at the same time. Furthermore, the neutron fluence is not changed above 10 eV and the effect of ^{10}B is visible as a suppression of the 'thermal' peak below 10 eV.

Finally, the experimental program of the n_TOF phase II was reviewed. The measurements can be grouped into neutron capture, neutron fission, and other applications. The main focus in 2009 was put on the neutron capture measurements with ^{56}Fe and ^{62}Ni. These experimental runs were preceded by the commissioning of the new target which was finished on August 15, 2009. The performance of the new target is as expected and new and multiple detectors were used to evaluate the beam characteristics. For 2010 it is planned to look into angular distributions of fission fragments (nTOF14), capture measurements with C_6D_6 detectors (nTOF13), capture measurements on actinides (nTOF15) and to finish the commissioning program with tests of borated water moderator (nTOF12).

n_TOF Commissioning

The result from the commissioning of the new n_TOF target were summarized by Vasilis Vlachoudis. The proposed measurements included the determination of the neutron fluence, the beam profile, the neutron energy resolution function, and the relation between neutron energy and the time-of-flight. All these tests require the measurement of cross sections. In addition, further measurements are required to obtain information on systematic uncertainties: The scattered in-beam γ-ray background or the scattered neutron background need to be determined as well as the off-beam background.

The requested beam time added up to a total of 2.45×10^{18} protons on target. For the measurements several experimental setups were proposed, including a fission chamber from PTB or Medipix detectors. The start of the commissioning run was delayed due to problems with the PS accelerator. Some of the tests measurements were hampered, e.g., due to alignment problems and part of the program was pushed to the end of the running period, e.g., the determination of the scattered neutron background.

The results from the commissioning run were reviewed, showing data on the beam profile, the resolution function, and the neutron fluence. The beam profile is in good agreement to the simulated result and only a small deviation is present which can be explained with a tilted second collimator. The neutron fluence is about 20-25% lower than expected which can be attributed to the collimator misalignment. For the resolution function no significant change to the previous target was found. The analysis is sill in progress and additional measurements are planned for the remainder of the 2009 period as well as the 2010 campaign., especially taking data with the borated water circuit.

The following proposals were then presented:

1. **CERN-INTC-2009-024 and INTC-P-268,** *Study of the effect of shell stabilization of the collective isovector valence-shell excitations along the N=80 isotonic chain*, Norbert Pietralla

2. **CERN-INTC-2009-034 and INTC-P-270**, *Study of the onset of deformation and shape coexistence in ^{46}Ar via the inverse kinematics (t,p) reaction*, Kathrin Wimmer

3. **CERN-INTC-2009-036 and INTC-P-271**, *Laser Spectroscopy of Cadmium Isotopes: Probing the Nuclear Structure Between the Neutron 50 and 82 Shell Closures*, Deyan Yordanov

4. **CERN-INTC-2009-037 and INTC-P-272**, *Study of single particle properties of neutron-rich Na isotopes on the "shore of the island of inversion" by means of neutron-transfer reactions***,** Thorsten Kröll

5. **CERN-INTC-2009-038 and INTC-P-214-ADD-2,** *High Precision Laser Spectroscopy on ^{12}Be*, Christopher Geppert

6. **CERN-INTC-2009-039 and INTC-P-273**, *High-Precision Mass Measurements in the Rare-Earth Region to Investigate the Proton-Neutron Interaction*, R. Burcu Cakirli

CLOSED SESSION

Tuesday 17 November 2009 at 8:30 h, room 60-6-002

Present: S. Bertolucci, J. Billowes, Y. Blumenfeld, H. Breuker, P. Butler (Chairman), R. Catherall, E. Chiaveri, M. Doser, H.-U. Habermeier, P.-H. Heenen, A. Herlert (Secretary), R. Julin, Y. Kadi (for point 6), H. Leeb, N. Orr, D. Ridikas, E. Rondio, P. Roussel Chomaz, Ch. Scheidenberger, V. Vlachoudis, U. Wahl

Apologies: -

1. INTRODUCTORY REMARKS

The Chairman welcomed Dr. Danas Ridikas and Prof. Hanns-Ulrich Habermeier as two new Committee members. He also thanked four members, Jonathan Billowes, Paul-Henri Heenen, Rauno Julin and Christoph Scheidenberger, who agreed to continue their membership in the INTC, and introduced Enrico Chiaveri as the new Chair person and deputy spokesperson for the n_TOF collaboration.

2. MINUTES OF THE LAST INTC MEETING

The minutes of the 34th INTC meeting held on 18 and 19 May 2009 were approved without amendments.

3. STATUS OF ISOLDE

The Committee regarded the 2009 running period as a success despite some incidents including robot failures and power cuts. There is some concern that with the new safety procedures in place certain emergency repairs will be delayed by several days which might even cause cancellation of ISOLDE experiments. Nevertheless, with the installation of the new HRS frontend and the consolidation of the vacuum system, it is expected to have a much smoother operation and fewer failures. Furthermore, it was mentioned that a new laser physicist will be hired and additional funds from the ISOLDE Collaboration will be provided to improve the operation of the RILIS laser system. Furthermore, collaboration with SPES has been established. Concerning REX-ISOLDE operation a three-day setup period is required and cannot be condensed much further. With additional training of all ISOLDE operators the setup of the post-accelerator should improve as well.

4. STATUS OF N_TOF

The Committee congratulated the n_TOF Collaboration and all people involved for the successful 2009 running period. The commissioning of the new target went very well and deadlines were kept. All progress points in the right direction and on-line monitoring is in place for better operation. Although part of the envisaged experimental program on Fe and Ni isotopes was accomplished in 2009, experiments with actinide targets were postponed until the classification of the experimental area as a Work Sector Type A is achieved. As European funding for these experiments will end in 2010, priorities for the future measurements campaigns have to be defined. With the Work Sector Type A environment any open target with unlimited activity may be used and thus it should be possible to apply unsealed actinide targets in the upcoming running period. It is also looked into the possibility to extend the European funding until 2011. In general, there is a long list of measurements to be done and it is most likely that in 2010 a similar amount of protons will be assigned to n_TOF as it was the case in 2009. The Committee acknowledged the idea to use and test the application of borated water as part of the approved commissioning program. However, these tests and additional calibration

measurements require a non-negligible amount of protons which will not be available for the approved experiments. Thus the Committee **requested** for the upcoming INTC meeting a priority list for all n_TOF experiments and tests planned in 2010 as well as the number of required protons for each of these runs. This should also take into account the installation and operation of a Work Sector Type A laboratory and application of actinide targets.

5. DISCUSSION ON THE OPEN SESSION AND OTHER DOCUMENTS

The proposals presented during the open session as well as a letter of clarification were then discussed:

CERN-INTC-2009-024/P-268, *Study of the effect of shell stabilization of the collective isovector valence-shell excitations along the N=80 isotonic chain*

It is planned to employ the MINIBALL experimental setup for the investigation of mixed-symmetry states in rare-earth nuclei along the N=80 isotonic chain. The signature of these states is a strong M1 transition, which can be excited in a single step by Coulomb excitation. Up to date mixed-symmetry states have not been observed in unstable nuclei and for the stable nuclides ^{136}Ba and ^{138}Ce a fragmentation of the transition strength has been seen. Recently large-scale shell model calculations have been done and comparisons to the IBA model are feasible. However, the question remains how reliable the calculations are and what information the measurements will give. It is not clear if and how much the transition strength will be fragmented and thus it is of interest to determine the evolution along the N=80 isotonic chain. The experimental challenge is the identification of such a state and with beam energies as planned for HIE-ISOLDE the proposed experiment will be feasible. As a precursor experiment it is proposed to measure the B(E2) values of ^{140}Nd and ^{142}Sm for the normalization of future measurements. The Committee decided to **recommend** for approval by the Research Board **18 shifts** and asked the Physics Coordinator to schedule the ^{142}Sm beam after initial target and RILIS tests.

CERN-INTC-2009-034/P-270, *Study of the onset of deformation and shape coexistence in ^{46}Ar via the inverse kinematics (t,p) reaction*

This proposal aims to investigate the N=28 nucleus ^{46}Ar using two-neutron transfer. Only the ground and lowest lying 2^+ state have firm spin-parity assignments and the principal motivation of the proposal is to confirm the identification of the second 0^+ state (suspected to lie at 2.7 MeV) and establish its 2p-2h character. The collaboration has successfully undertaken a two-neutron transfer measurement on ^{30}Mg using a tritium target and has recently tested and successfully used the new target and detector system T-REX. It was noted that two-neutron transfer on ^{44}Ar to populate states in ^{46}Ar should be easier than for the ^{30}Mg experiment. It was pointed out that ^{44}Ar beams are available at GANIL, however, the use of a tritium target is, at the moment, only possible at ISOLDE. The Committee considered the general physics case – evolution of structure around N=28 – of high interest and one that will open up a new region for physics at ISOLDE. However, the Committee felt that the specific physics case was not well developed. In particular, it is not clear precisely what physics can be derived from the measurements. The proposal aims to explore shape coexistence, yet little information is provided as to how this will be done from the measurements themselves. For example, what will be learnt (and how) beyond confirming the identification of the 2.7 MeV state as the second 0^+ ? The Committee therefore decided to **request a letter of clarification** in which the proponents should address the physics case in more detail and justify the large number of requested shifts.

CERN-INTC-2009-035/CLL-006, *Letter of Clarification for the proposal CERN-INTC-2009-009/P-257: Study of oblate nuclear shapes and shape coexistence in neutron-deficient rare earth isotopes*

This letter of clarification gives additional information on the technical feasibility of the planned experiment on rare-earth isotopes. Results from recent target/ion-source tests are reported on which show a sufficiently high suppression of surface ionized contamination by use of a GdB_6 cavity. Since the physics case was endorsed in a previous meeting and the open technical questions have been addressed with this letter of clarification, the Committee decided to **recommend** for approval by the Research Board **15 shifts** for the investigation of ^{140}Sm. As in the case of P-268, the scheduling of the experiment is subject to successful RILIS tests planned in 2010. The Committee suggested to submit a new proposal for the case of ^{142}Gd which should be handed in after successful developments and tests on Gd beams.

CERN-INTC-2009-036/P-271, *Laser Spectroscopy of Cadmium Isotopes: Probing the Nuclear Structure Between the Neutron 50 and 82 Shell Closures*

The proposed experiment wants to employ laser spectroscopy to determine nuclear spins, moments and root-mean-square charge radii of Cd isotopes between the N=50 and 82 closed neutron shells. The Committee found the proposal well written and the physics case well motivated. The COLLAPS experiment has produced many data in the past and it is expected that also with the presented measurement program valuable data will be retrieved. However, the neutron-rich isotopes, especially up to the r-process waiting point ^{130}Cd, are regarded as of higher interest and the Committee therefore decided to **recommend** for approval by the Research Board **17 shifts** for the neutron-rich isotopes $^{106-120}$Cd (8 shifts) and for one experiment on $^{121-130}$Cd (9 shifts). The committee noted that off-line work would be necessary to assess the suitability of the transitions being considered for the measurement. The scheduling and availability of off-line shifts for tests shall be discussed with the Physics Coordinator.

CERN-INTC-2009-037/P-272, *Study of single particle properties of neutron-rich Na isotopes on the "shore of the island of inversion" by means of neutron-transfer reactions*

The proposal is directed towards the investigation of the shores of the 'island of inversion'. Intruder states in ^{28}Na are proposed to be probed by the (d,p) single-neutron-transfer reaction using the MINIBALL coupled to the T-REX system. This is a very challenging experiment as an odd-odd nucleus will be populated and as such one must rely on the gamma-rays depopulating the excited states to separate them and allow the proton angular distributions to be constructed for each state. The Committee found the physics case of high interest. However, the use of a ^{27}Na beam from ISOLDE at present would render the measurements impossible owing to the very strong ^{27}Al contamination. The Committee thus decided to **not recommend the proposal** to be accepted and requested the proponents to discuss target ion-source development issues and the possible suppression of ^{27}Al with the ISOLDE technical group before considering resubmission.

CERN-INTC-2009-038/P-214-ADD-2, *High Precision Laser Spectroscopy on ^{12}Be*

This second addendum to the proposal P-214 asks for additional shifts in order to measure the charge radius of ^{12}Be. The Committee found the physics case well motivated and noted that with the COLLAPS experiment magnificent results were obtained for ^{11}Be. The main interest for ^{12}Be is governed by (i) the conflict between data from GSI and the data obtained by Tanihata et al., (ii) the importance of ^{12}Be as a first step towards ^{14}Be, and (iii) the importance of the charge

radius of the Be isotopes for nuclear structure. The number of shifts is well justified and thus the Committee decided to **recommend** for approval by the Research Board **18 shifts** for the continuation of the measurement program. The scheduling of off-line shifts shall be discussed with the Physics Coordinator. The Committee asked the proponents to submit a new proposal if further shifts are required.

CERN-INTC-2009-039/P-273, *High-Precision Mass Measurements in the Rare-Earth Region to Investigate the Proton-Neutron Interaction*

With this proposal systematic mass studies as well as differential mass studies are planned with the ISOLTRAP mass spectrometer. The ISOLTRAP experiment is a well established system and has provided several hundred mass values up to date. The proposed program is feasible and should be straight forward to accomplish. However, the Committee found part of the physics case not well motivated. While with the two-neutron separation energies S_{2n} the evolution of the mass surface can be studied and thus may reveal its explorative character and could give first data on so far unknown nuclei, the study of the proton-neutron interactions by examining double mass differences δV_{pn} is somewhat questionable. Especially in the case of deformed nuclei it is not clear if the δV_{pn} values will reflect the true nature of the p-n interaction in that mass region. The Committee suggested to also look into other mass differences or mass filters to provide alternative approaches to the interpretation of the data. The Committee decided to **recommend** for approval by the Research Board **8 shifts** for the study of the mass surface for the Dy, Er, and Yb isotopes.

Out of the **146** radioactive beam shifts requested to the INTC a total of **76** have been recommended for approval by the Research Board.

6. HIE-ISOLDE

The Chairman and the Director for Research and Computing summarized the status of funding for this project at the time of the "New Opportunities" workshop in May, the adverse situation that had developed by the time of the Research Board meeting in September, and the considerations taken by CERN management afterwards. The decision was taken to approve the HIE-ISOLDE project, as it was very important to start immediately with the work, otherwise the whole project would have been jeopardized. As resources become available, CERN will take responsibility for the necessary infrastructure, while the ISOLDE Collaboration is urged to find additional matching funds from outside CERN. The Committee decided to set up a steering group which will follow the progress of the project and shall report to the INTC on a regular basis. The Committee also decided that Letters of Intent related to experiments at HIE-ISOLDE should be discussed at the INTC meeting in June 2010, and a call for LoIs will be published in January. These should address, in addition to the proposed physics programme, the required beam properties and layouts of proposed experimental setups.

7. A.O.B.

7.1 The dates of the next INTC meetings were announced: February 4-5, June 23-24, and November 4-5, 2010.

7.2 The following inactive experiments were requested to give a status report at the next INTC meeting: IS410, IS420, IS431, IS438, IS461, and IS470. All these experiments did not request beam in the last three years or have no shifts left. The Committee suggested to close these experiments and asked the users to submit new proposals rather than addenda.

8. DATES OF NEXT MEETING

The next INTC meeting will take place on **Thursday 4 and Friday 5 February 2010**. The deadline for submission of proposals is **Friday 8 January 2010**.

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