First Physics with the Super Separator Spectrometer S3



Overview

The S3 workshop took place from the 27th of March 2017 14h00 to the 30th 16h00 at CEA Saclay, Orme des Merisiers. 62 physicists were registered, from 19 different laboratories. It was financed by the ESNT (lunches for all participants), Ganil (part of workshop dinner), IRFU and DRF (invitations of 6 speakers).

WORKSHOP PROGRAM (updated 20th March) 🔑 S3WorkshopAgenda20March17.pdf

Monday 27 th	Tuesday 28 th	Wednesday 29 th	Thursday 30 th
	8h55-10h30 TALKS Heavy and superheavy elements	8h55-10h30 TALKS N = Z nuclei	8h55- 10h30 TALKS Masses
	10h30 Break	10h00 Break	10h30 Break
	11h-12h20 TALKS Heavy and superheavy elements	10h30-12h10 TALKS N = Z nuclei	11h- 12h45 TALKS Reaction Dynamics
	Lunch		
[Galilée room] [building 713]	[room 135] [bldg 703- SPhN]	[Galilée room]	[Galilée room]
13h30 Welcome 13h50 Introduction	14h Summary	13h30 Summary	14h Summary
14h-16h S3 Instrumentation 16h05 break	14h10-17h30 Heavy and superheavy elements Open Discussion	14h-16h N = Z nuclei Open Discussion	14h30-16h Open Discussion
16h35-17h50 S3 Instrumentation	Discussions	16h30-18h30 Discussion LEB instrumentation & synergies with DESIR	16h-18h Closed session Management board

Talks

28 talks were given in 4 different sessions. The first "Instrumentation" session (6 talks) was set as an introduction to the different detection setups of the S3 project, as well as an overview of the project.

In the 2 major sessions (superheavy nuclei and N=Z nuclei, 7 talks each), presentations were given in the morning, with significant time for questions. The afternoon was devoted to an open discussion (~3 hours) based on a few summary slides prepared by the chairman. In the 2 minor sessions (Masses of the nuclei and Reaction dynamics, 4+3 talks) the talks were followed by ~1hour discussion.

We emphasize that the large proportion of questions/discussion (~50% of the total time) was widely appreciated. Many debates occurred during the afternoon sessions, that raised important questions within the collaboration.

Monday 27 March- S3 Instrumentation

S3 Status update, H. Savajols 📙 S3_Status_Update_HSavajols.pdf SIRIUS Implantation Decay Station, B. Sulignano 📙 SIRIUS_BSulignano.pdf Perspectives with the S3 Low - Energy Branch, P. Van Duppen 📙 LowEnergyBranch_PvanDuppen.pdf Mass separation and mass measurement capabilities/opportunities with PILGRIM, P. Delahaye 📙 <u>PILGRIM_PDelahaye.pdf</u> DESIR: Timeline & Physics program, J-C. Thomas 🔑 DESIR_JCThomas.pdf FISIC, E. Lamour 🔑 <u>FISIC_ELamour.pdf</u>

Tuesday 28 March - Heavy and Superheavy Elements

Introduction, P. Greenlees Shapes and alpha-decay of superheavy nuclei, D. Vretenar SuperHeavy_DVretenar.pdf The structure of heavy and superheavy nuclei with an assessment of theoretical uncertainties, A. Afanasjev StructureSHE_AAfanasjev.pdf Description of properties of heavy and very heavy nuclei: mean field and beyond, M. Bender PropertiesSHE_MBender.pdf X-ray tagging for heavy and superheavy nuclei, D. Ackermann XraySHE_DAckermann.pdf Nuclear structure and decay spectroscopy of seaborgium and rutherfordium isotopes, S. Antalic SpectroRfSg_SAntalic.pdf High resolution resonance ionization spectroscopy of actinides with REGLIS3, R. Ferrer LaserIonizSHE_Rferrer.pdf In-trap spectroscopy with MLLtrap, A. Lopez-Martens Intrap_Spectro_ALopezMartens.pdf Wednesday 29 March - N = Z nuclei Introduction, P. Van Duppen Open problems at the N=Z line, P. Van Isacker 🔑 <u>N=Zline_PvanIsacker.pdf</u>

Review of shell model results in the 100Sn region, K. Sieja SHellModelN=Z_KSieja.pdf

Cluster radioactivity studies at S3, B. Blank

Eluster_BBlank.pdf The 100Sn factory, D. Seweryniak

100Sn_DSeweryniak.pdf

Single particle states and proton-neutron interaction in the 100Sn region, L. Caceres 100SnRegion LCaceres.pdf

Resonant ionization spectroscopy of 94Ag and neutron-deficient Sn isotopes, I. Moore

ResonantIon94Ag_IMoore.pdf Quadrupole moments of isomeric states @S3, G. Georgiev

<u>QMoments_GGeorgiev.pdf</u> Discussion session, Summary, P. Van Duppen

Discussions: LEB Instrumentation for the first S3 experiments & synergies with DESIR, Conveners: P. Van Duppen and B. Blank

Thursday 30 March - Masses

Introduction, P. Delahaye Modern nuclear mass models, S. Goriely Masses_SGoriely.pdf High-precision mass measurements at DESIR with S3 beams, P. Ascher NdeficientMasses_PAscher.pdf Future perspectives for mass measurements of the heaviest elements, M. Block SHEMAssesMeas MBlock.pdf Physics with the MLL trap at Alto and S3, E. Minaya Ramirez MLLTRAP_EMinaya.pdf

Thursday 30 March - Reaction dynamics

Introduction, C. Theisen Mean-field and beyond mean-field description of large amplitude motion: application to transfer and fission, D. Lacroix MicroReactionDynamics_DLacroix.pdf

Synthesis of super-heavy-elements: what can we predict?, D. Boilley SHEProduction_DBoilley.pdf

Can we produce new isotopes of Sg -> Cn with an uranium target ?, C. Stodel UTargetsFusion_ChStodel.pdf

Goals of the workshop

The goals of the project were:

1. to obtain an overall view of the physics goals and update the physics programs The presentations gave a wide range of interesting physics topics that could be performed at S^3 . They were put into perspective the S3 physics program, notably in comparison to other similar facilities (GSI, Dubna...). Some priorities of the S3 program were discussed. 2. to create new collaboration, re-enforcing the existent one;

Each session was focused on a more general physics topic and the talks involved people from different detector collaboration (SIRISU, LEB and DESIR). This allowed to pinpoint the synergies and peculiarities of each setup. The relative time schedule were discussed.

3. to gather together experimentalists and theoreticians in order to create strong collaboration between both fields;

Each session stared with 3 theoretical 25" talks presenting the important issues on each subject, followed by shorter (15") specific experimental talks connected to S³. This triggered direct discussions among the participants.

4. to encourage exchanges among the different groups focusing on different areas of the nuclear chart;

Talks subjects were coordinated to have the same experimental techniques applied to different region of nuclei: notable spectroscopy of fast alpha decays in the 100Sn region vs SHE region, or laser spectroscopy applied to neutron deficient light nuclei or very heavy nuclei.

5. to form working groups based on experimental synergies, in order to study the technical developments needed to accomplish the Letters of Intent;

Some clear subjects of interest were highlighted. An example is the study of nobellium isotopes, both with the SIRIUS setup to perform detailed gamma and electron spectroscopy, as well as with the low energy branch to perform laser spectroscopy and with the high-resolution mass measurements with the MR-ToF-MS. For the laser spectroscopy, it was emphasized that decay spectroscopy AFTER the low energy branch is also required to identify and study the ions of interest: a working group on that subject to study this setup has been organized, with $\ensuremath{\mathsf{M}}.$ Vandebrouck as its coordinator.

Commenté [PVD1]: I don't know what you mean by relative probably comparative with respect to the different set-ups.

6. to develop future proposals, defining the needs to accomplish the experiments in terms of theoretical and technical wise.

It has globally been estimated that the present letters of intent do not require updates, but should be transformed into proposals that could be proposed to the Ganil PAC when it will be open to S3 (next year at earliest).

The priority of the collaboration will be to work on the final construction stage of SIRIUS and the LEB and to organize their commissioning, first with sources (mid 2018 for SIRIUS, end 2017 for the LEB installed at LPC Caen with the laser system).

General recommendations from the Collaboration

- A superconducting ion source and a RFQ A/q=7 are definitely required for the fulfilment of several of the most interesting and unique programs at S3.
- The high mass resolution mode is important for several physics cases (²⁵⁰No, moscovium mass assignment, spectroscopy in the ¹⁰⁰Sn region, reaction mechanism studies...)
- Most wanted targets: rare earth (commissioning) Sn, Pb and ²⁰⁹Bi (compound forms), uranium targets. In a second stage: actinide targets (Am, Cm) required
- Most wanted beams: Ne, ⁴⁰Ar (commissioning), ⁴⁸Ca (>2pμA), ⁵⁰Ti, ⁵⁸Ni
- A realistic time plan should be made available as soon as possible. This is essential for the different 'detector projects' to organize their commissioning and to evaluate on a realistic basis the uniqueness of the S3 set up with respect to activities ongoing and planned elsewhere (→ before the end of 2017)
- Information about the S3 project should be communicated: a newsletter will be regularly (~ every each other month) published. A yearly workshop-type meeting will be organized by the Collaboration Board.
- MoU Sirius under signature
- MoU S3-LEB ready to be sent to the institutes (This MoU is very important as in the future, KU Leuven will be looking for funds through the Big Science program of the Flemish Research Fund (Belgium) to contribute to the SPIRAL2-GANIL operation cost

Superheavy nuclei

- The combination of SHE production and the low energy branch is a unique setup with interesting perspectives, since they will bring new observables in this region.
- It should be noted that dye lasers are mandatory for the study of e.g. nobelium and other heavy elements. The installation of these lasers should be ready for 2021.
- While ²⁵⁴No is a natural first experiment for qualifying both S³ and SIRIUS, groundbreaking results are not expected in the 1st days. Phase 1++ is required to extract new information on this already thoroughly studied nucleus (see general recommendations).
- Reactions using a uranium target are considered as very interesting candidates for 1st day experiments, all the more so as they make a good first step toward actinide targets.
- The commissioning process of SIRIUS must still be discussed within the collaboration, notably on the relevance of in-beam test without S3.

LEB

- Full off-line commissioning with a laser system will take place at LPC Caen.
- Commissioning experiment on erbium, then study of neutron-deficient actinium and thorium isotopes (physics around the N=126 shell closure).

- Manpower from Leuven will help during the first years of operation, but the should be a local, permanent support (laser physicist)
- The first campaign could cover both N=Z nuclei and heavier nuclei.
- For very heavy elements, the effective and efficient laser ionization schemes are generally not or poorly known. A priority list for elements to be studied in the first campaigns should be established.
- A very efficient identification setup is required after the gas cell and/or the MR-ToF-MS (beware of vacuum constraints). Two kind of detection systems could be foreseen:
 - For very/super heavy nuclei, identification by alpha/electron spectroscopy. A silicon box could be a possibility. Marine Vandebrouck, CEA/IRFU, investigates this solution. See existing box at CENBG
 - For beta-emitter nuclei, a tape station and beta/gamma-decay station could be used. The opportunity to install it in the multipurpose room (no 51) has to be investigated.
- LEB instrumentation for the S3 "day 1 experiments" before DESIR completion were discussed.
- The Desir collaboration is willing to propose experiment at S3-LEB as spokesperson and vice-versa when DESIR will be ready.
- We clearly state that according to the various timelines & the international competition, S3-DESIR synergy (DES³IR) is of the upmost importance if we want to maximize scientific output. We propose to move forward from the "aged" Lols to a common S3-DESIR roadmap for the coming years.

User Collaboration board

The last day of the workshop the Kick-off meeting of the S3 User Collaboration Council was held

Goals of the S3UCC: liven up the scientific life of S^3 & propose a Campaign configuration (CC) of S^3

The proposed process of the definition of this CC is:

- 1. The physicist community propose letters of intents that's are discussed by the User collaboration at collaboration meetings
- 2. The User Collaboration Council chooses a campaign setting, that is proposed to the GANIL management. A Campaign Convener is appointed.
- 3. The Physicist community submit pre-proposals for discussion during the collaboration workshop to the campaign convenor prior to the PAC meeting
- 4. Final proposals are submitted to the PAC
- 5. Beam time is allowed to the validated experiments.

Composition of the UCB

- Representatives of major contributing institutes to the construction of S3 project (ANL, CSNSM, GANIL, INSP, IPNO, IRFU, KU Leuven, LPC Caen)
- S3 management board members (ex-officio)
- Invited on demand of the UC board chair
- S3 SIRIUS Scientific and Technical coordinator

- S3 LEB Scientific and Technical coordinator
- S3 FISIC Scientific and Technical coordinator