Report on the GRETINA Users Workshop on

"Future GRETINA Science Campaigns"

March 1st and 2nd 2013
Argonne National Laboratory

GRETINA Users Executive Committee
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Overview

The current round of GRETINA operations proposed and endorsed at a community workshop held at Richmond University in October 2007 is nearing completion and it is timely to plan for the next series of GRETINA experiments and siting. On March 1-2, 2013 a workshop on "Future GRETINA Science Campaigns" was organized by the GRETINA Users Executive Committee (GUEC) and hosted by the Physics Division at Argonne National Laboratory (ANL). The focus of the meeting was two-fold: To discuss and exchange information on the upcoming GRETINA science and operation at ANL, as well as the ongoing campaign at NSCL, and to discuss science opportunities and future siting of GRETINA beyond the ANL campaign. The purpose of this document is to provide a brief report on the workshop and its conclusions.

Construction of the gamma-ray tracking array GRETINA was completed at Lawrence Berkeley National Laboratory (LBNL) in March 2011 and operations began in April 2011 with a period of system integration, testing, and commissioning runs carried out at the LBNL 88-Inch Cyclotron. In April 2012, the array was moved to the National Superconducting Cyclotron Laboratory at Michigan State University (NSCL/MSU) and installed at the target location of the S800 spectrometer for a campaign of experiments using "fast rare-isotope beams". Experiments at NSCL began in June 2102 and will continue through June 2013. GRETINA is then scheduled to move to the ATLAS facility at ANL for a campaign of experiments – concluding the first round of operations proposed at the Richmond meeting.

The workshop on "Future GRETINA Science Campaigns" was attended by over 60 scientists from 21 institutions and was broadly announced and open to all current and prospective GRETINA users. The announcement, agenda, and list of participants are given in the appendices. Talks from the community were solicited in advance and were a major part of the program. The exchange of information served as important guidance to GRETINA users planning experiments at ATLAS, and to the GRETINA and ATLAS staff preparing for the upcoming campaign. Ample time was allocated for discussion and for input from participants. The workshop program and links to talks are available at "www.phy.anl.gov/atlas/GretinaWorkshop".

The meeting began with presentations on the current status and operating modes of GRETINA, the ATLAS facility, as well as potential auxiliary detectors, and provided technical and performance overviews. This was followed by a session of thirteen contributed presentations on a broad range of science opportunities utilizing the capabilities of GRETINA and ATLAS. On the second day we heard a number of talks on recent results from the ongoing GRETINA physics campaign at NSCL. This was followed by a presentation and discussion on a proposed second campaign at NSCL, and then talks on GRETINA upgrades and the path towards GRETA. The meeting concluded with a general discussion on the workshop conclusions and recommendations.

A brief summary of the major outcomes and conclusions relating to future GRETINA operations and siting is given below. Further details can be found in the main text.

A schedule for GRETINA operations covering the period July 2013 through 2015 was proposed and unanimously endorsed by the GRETINA user community.

GRETINA operations at ANL would continue through 2014 allowing time for experiments in both "standalone" mode and in combination with the FMA, using reaccelerated radioactive beams from CARIBU as well as high-intensity stable beams. This period would also be used to carry out source and in-beam tests to continue the ongoing performance measurements and enhancements.

GRETINA would then move to NSCL for a second campaign of experiments beginning in 2015 for approximately 12 months that builds on the very successful first campaign and uses fast beams of rare-isotopes in conjunction with the S800 spectrograph.

In parallel, **the GRETINA user community will begin preparing the plan for 2016+.** The scope of this task should involve a careful evaluation of options, which may include - along with siting at US facilities - campaigns overseas, and will require a realistic assessment of the science, feasibility, cost, and required resources.

GRETINA at ATLAS

ATLAS is a DOE National User Facility supporting a worldwide nuclear science community and operated by Argonne National Laboratory's Physics Division. It provides stable beams at high intensity and energies up to 10-20 MeV/u; in-flight radioactive beams of light ions; and low-intensity CARIBU beams of heavy neutron-rich fragments from Cf fission that can be re-accelerated to energies up to 15 MeV/u. State-of-the-art instrumentation is available for Coulomb barrier and low-energy experiments.

A campaign of GRETINA experiments at ATLAS was an important part of the proposal developed at the 2007 Richmond meeting to optimize the science for the first round of GRETINA operations. The superior Doppler reconstruction, high-energy efficiency, count rate capability, polarization sensitivity, and the ease of coupling auxiliary detectors to GRETINA were recognized as offering many physics opportunities that would match well with the availability of re-accelerated neutron-rich CARIBU beams and world-class instrumentation, such as the Fragment Mass Analyzer. The current round of GRETINA experiments at the National Superconducting Cyclotron Laboratory is scheduled to end in June 2013. GRETINA will then be moved to ANL and installed at the ATLAS Facility, and operations will begin soon after the second stage of the ARRA funded upgrade to ATLAS is completed in Fall 2013. At this time a new ^{252}Cf source will also be installed in CARIBU.

The workshop on "Future GRETINA Science Campaigns", held at ANL on March 1st and 2nd 2013, brought together members of the GRETINA and ATLAS user communities, the GRETINA project, and the ANL Physics Division to discuss the science and prepare for GRETINA experiments at ATLAS. It was agreed that GRETINA should stay at ATLAS until the end of 2014 in order to capitalize on the various running modes and allow flexibility to switch between configurations. Time between the completion of installation and start of experiments can also be used to carry out measurements (source and in-beam) to characterize and implement improvements.

Two locations for GRETINA are currently planned. One is a standalone mode on the "APEX" beam-line, well suited to the use of auxiliary detectors such as CHICO2, the Phoswich Wall, and the ORRUBA array. This is ideal for spectroscopic studies using Coulomb excitation and multi-nucleon transfer reactions with CARIBU beams or stable beams. The other location is at the FMA target position. Here, to maximize the efficiency for coincident recoil-gamma spectroscopy, the detectors will be mounted at backward angles so that a 30-cm distance can be realized between GRETINA and the FMA. The resulting improvement in the combined efficiency (relative to the Gammasphere-FMA combination) can extend the reach of experiments to study heavier N~Z nuclei in the vicinity of ^{100}Sn, for example, using fusion reactions with intense stable beams. Examples of the broad range of science opportunities utilizing the capabilities of GRETINA and ATLAS are described in the overview and contributed presentations given at the workshop and available online (see attached program Appendix C).

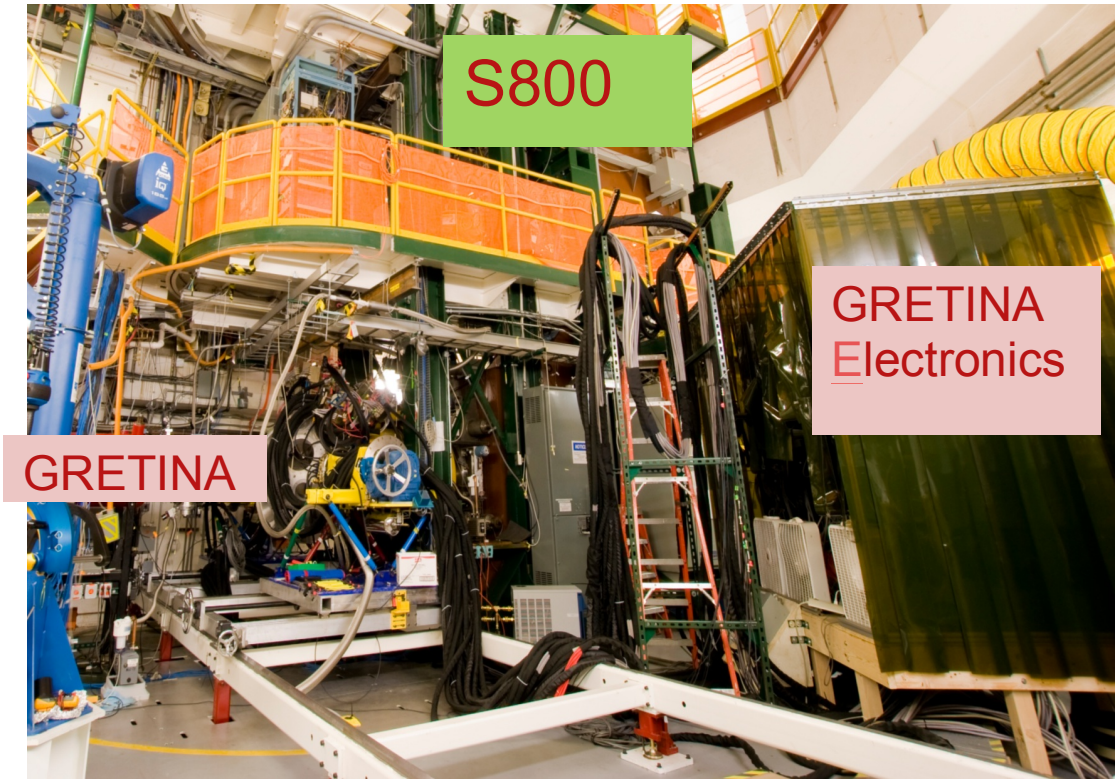
At ATLAS, the 8-person team that has been closely associated with the successful operation of the Gammasphere array over the last 10+ years is carrying out site preparation activities with funding through base experimental equipment funds. Thus, one member of the Physics Division's scientific staff has been put in charge of all site preparation activities for GRETINA. He has the full commitment of the Physics Division's technical and scientific personnel for the installation, maintenance and operation of GRETINA. At ATLAS, GRETINA will benefit of some of the facilities originally designed for Gammasphere such as the electronics shack, the liquid nitrogen delivery system and the computer networks, and of the considerable expertise developed over more than a decade in operating and maintaining a large gamma-ray detector array. In addition, the recent efforts toward implementing digital Gammasphere will benefit GRETINA directly and will also facilitate the interface with ancillary equipment. Finally, software suitable for on-line monitoring of experiments is being developed.

As a National User Facility, the ATLAS Program Advisory Committee reviews proposals and makes recommendations on the scientific program to the ATLAS Scientific Director who then allocates beam-time. Requests for beam-time for GRETINA experiments will follow this process and will be approved based on scientific merit and feasibility.

In-beam γ-ray spectroscopy with GRETINA at NSCL's S800 Spectrograph – Present and Future

GRETINA's fast-beam science campaign at NSCL using the S800 Spectrograph has been a great success. Thirteen experiments, approved by NSCL's program advisory committee (PAC), were successfully completed in 2012. Ten more PAC-approved measurements will have been conducted by the time GRETINA moves to ANL in June of 2013. Experiments at NSCL exploit the chemistry-independent, in-flight fragmentation production scheme of rare-isotope beams that enables a broad variety of nuclear structure and nuclear astrophysics measurements. Rare-isotope beams are provided for experiments at velocities typically exceeding 30% of the speed of light with the crucial Doppler reconstruction of γ-rays emitted in-flight greatly benefitting from the position resolution of GRETINA. Together with the capabilities of the S800 spectrograph, this allows for an event-by-event identification of nuclei in the entrance and all exit channels. Thick reaction targets can be employed that restore luminosities comparable to those run with stable-beam intensities and enable in-beam γ-ray spectroscopy with projectile ion rates of a few tens per second. The physics at the heart of the present campaign is broad and covers topics ranging from the complementary study of shell evolution (single-particle and collective degrees of freedom, the role of 3N forces) and the determination of excitation energies and spectroscopic factors of astrophysical relevance to benchmarking the treatment of weak interactions in modern shell-model Hamiltonians. A wide variety of experimental techniques is used, often based on direct reactions like nucleon knockout, nucleon-adding transfer reactions and inelastic scattering,

or employing novel approaches for precision excited-state lifetime measurements. Excited-state lifetime measurements specifically benefit from GRETINA's superior in-beam γ-ray energy resolution due to significantly increased sensitivity.



NSCL proposes the return of GRETINA to the S800 Spectrograph for a second science campaign starting in 2015, after the completion of GRETINA's run at ANL. NSCL offers to commit a similar amount of beam time[1] and infrastructure and manpower support as for the first campaign. For the 2012/2013 running period at NSCL, GRETINA – like the S800 spectrograph – operated as an NSCL-supported device with a service level description and a device physicist in charge and on call. The S800 and GRETINA data acquisition systems were combined to allow online-monitoring and NSCL's computer department provides local network and GRETINA Cluster support. The Facilities Department provides air-conditioning for GRETINA's NSCL-built electronics shack as well as for the computer farm. The Mechanical Design and Alignment Groups designed the cart and rail system for the GRETINA frame and provided the precision alignment of the hemispheres at the S800 target position. NSCL has in-house expertise and specialized infrastructure that allows for on-site maintenance of the GRETINA detectors. Local

[1] Approximately 2000 hours – assuming the NSCL will be funded for 4000 hours of operations per year – and with the understanding that experiments are subject to the Director's approval based on a recommendation from the PAC

faculty involved in experiments provided important postdoc support during the setup and commissioning phase of GRETINA.

The first fast-beam campaign at NSCL has attracted researchers from many institutions in the US and abroad with diverse, world-class science programs that capitalize on (i) GRETINA's superior position resolution, coincidence efficiency, and detection efficiency at high energy, (ii) NSCL's large variety of fast rare-isotope beams, and (iii) the world-unique reaction-residue detection and tracking opportunities provided by the S800 Spectrograph. The 2012/2013 campaign only started to exploit the vast opportunities available and NSCL anticipates the vibrant fast-beam program to continue in 2015.

Appendix A: Meeting Announcement 1

December 13, 2012

Dear Colleague:

The gamma-ray energy tracking array, GRETINA, is currently running a campaign of experiments at the National Superconducting Cyclotron Laboratory, MSU, which began in June 2012. In summer 2013, GRETINA is scheduled to move to the ATLAS facility at ANL. This would conclude the series of campaigns planned and endorsed by the user community in Richmond, 2007

It is time again for the user community to reconvene to discuss future science and siting of GRETINA. To that end, a workshop is being planned at Argonne National Laboratory on March 1-2, 2013, with a dual and distinct agenda for the two days.

Day 1) Discuss and exchange information between ATLAS staff and GRETINA users on the detailed science opportunities at ATLAS, serving as guidance for the call of proposals in late spring

Day 2) Discuss science opportunities and future siting for GRETINA beyond the ATLAS campaign

Please mark these date and pass this announcement on to any interested colleagues.
More details on the agenda and logistics will follow in the new year.

In the meantime, we would very much like to hear any thoughts, comments, or suggestions you may have regarding GRETINA operations; either currently at NSCL, the planned campaign at ATLAS, or on future GRETINA siting and science opportunities.

The GRETINA Users Executive Committee

Paul Fallon
Partha Chowdhury
Alexandra Gade
Ingo Wiedenhover
Shaofei Zhu

Appendix B: Meeting Announcement 2

January 17th 2013

Dear Colleague

Registration is now open for the upcoming workshop on future GRETINA science campaigns. The meeting will be held in the Physics Division building at Argonne National Laboratory, starting Friday March 1st at 8.30 am and continuing through Saturday afternoon March 2nd.

Please go to following link to register
https://www.phy.anl.gov/atlas/GretinaWorkshop/
The ATLAS facility at Argonne National Laboratory will host GRETINA, for a campaign of experiments starting Fall 2013. The goals of the workshop are (i) to discuss the science opportunities and provide technical information for these experiments, and (ii) to plan for the next round of GRETINA experiments following the stay at ATLAS.

Details on the program will be posted on the meeting website January 30th.

At this time we would like to invite people interested in presenting a short contribution on science topics or experiments using GRETINA at ATLAS to please contact Shaofei Zhu (zhu@anl.gov). Talks and input from the community are a main part of the program and are important to guide the planning and preparation for the upcoming campaign.

We look forward to seeing you in Argonne.

The Gretina Users Executive Committee
Partha Chowdhury
Alexandra Gade
Paul Fallon (chair)
Ingo Wiedenhover
Shaofei Zhu

Appendix C: Program

Workshop On Future GRETINA Science Campaigns – Agenda

Friday March 1st 2013

Session I (Chair: P. Fallon)

8:30 am	Welcome	R.V.F. Janssens
8:35 am	Introduction	D.C. Radford
8:55 am	Gretina at LBNL	A. O. Macchiavelli
9:15 am	Gretina at NSCL	D. Weisshaar
9:35 am	ATLAS/CARIBU status	G. Savard
9:55 am	Break	

Session II (Chair: P. Chowdhury)

10:20 am	Gretina at ATLAS technical overview	A.O. Macchiavelli
10:50 am	DAQ performance/overview	C. Campbell
11:05 am	Data analysis	M. Cromaz
11:20 am	Tracking	T. Lauritsen
11:35 am	Discussion	
12:05 am	Lunch	

Session III (Chair: C. Beausang)

1:30 pm	CHICO2	D. Cline
1:45 pm	FMA	D. Seweryniak
2:00 pm	Phoswich Wall	D.G. Sarantites
2:15 pm	ORRUBA	S. Pain
2:30 pm	Discussion	
3:00 pm	Break	

Session IV (Chair: M. Riley)

3:30 pm	Overview of the GRETINA at ATLAS science program	M.P. Carpenter
3:50 pm	Shape dynamics in the A=100 mass region: Coulomb excitation studies of CARIBU beams using GRETINA and CHICO2	M. Albers

4:00 pm	E2 strength distribution at the brink of deformation in ^{98}Zr	V. Werner
4:10 pm	COULEX of CARIBU beams	J. Rissanen
4:20 pm	Explore the nuclear structure of fission fragments using GRETINA/CHICO2	C-Y. Wu
4:30 pm	Direct Reactions with ORRUBA and GRETINA	S. Pain
4:40 pm	^{14}C transition rates and transfer reactions using Xe from CARIBU	A.O. Macchiavelli
4:50 pm	Spectroscopy of Light Nuclei with Gretina+FMA at ATLAS	C.R. Hoffman
5:00 pm	Inverse-kinematic studies with Gretina and Phoswich Wall	W. Reviol
5:10 pm	Discrete gamma-ray spectroscopy of neutron-rich nuclei with incomplete fusion reactions induced by radioactive beams on a ^{7}Li target	B. Fornal
5:20 pm	Core excited states in ^{101}Sn	D. Seweryniak
5:30 pm	Interplay between rotation and proton decay in highly-deformed proton emitters	D. Seweryniak
5:40 pm	Discussion on in-beam spectroscopy of heavy elements with GRETINA	T.L. Khoo
5:50 pm	N ~ Z studies with Gretina and neutron detectors	C. J. Chiara
6:00 pm	Discussion	

Saturday March 2nd 2013

Session V (Chair: I. Wiedenhover)

8:30 am	Introduction	P. Fallon
8:50 am	Agency perspective	C. Baktash
	Results from the first NSCL campaign	

9:15 am	Important excitation energies of 58Zn for the rp-process	C. Langer
9:30 am	Spectroscopy of Mirror Nuclei in the Upper fp Shell	T. Henry
9:45 am	Lifetime Measurements with the MSU plunger in the first GRETINA campaign at NSCL	H. Iwasaki
10:00 am	Single-particle structure of neutron-rich N=40 nuclei	K. Wimmer
10:15 am	Neutron Knockout to Probe the Role of 3N Forces in the Ca Isotopes	H. Crawford
10:30 am	Break	

Session VI (Chair: P. Fallon)

11:00 am	Proposed second science campaign at NSCL	A. Gade
11:30 am	Gretina project upgrades and path to GRETA	A.O.Macchiavelli/D.C. Radford
12:00 noon	Discussion on Gretina's future 2015 and beyond	
1:00 pm	Meeting Close	

Appendix D: Participants

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