ANNEX 3.5 **Memorandum of Understanding**

ILIMA Collaboration
Isomeric beams, Lifetimes and Masses

Content of Annex 3.5

3.5.1 Introduction

Nuclear masses and lifetimes of exotic nuclei in ground and isomeric states are basic quantities which are essential for the understanding of nuclear structure and the creation of the elements in stars. The ILIMA collaboration proposes an experimental setup to measure the masses and lifetimes of exotic nuclei up to the limits of nuclear existence which will be first available at FAIR facility.

Systematic precision measurements with the variation of proton (neutron) number along isotopic (isotonic) chains will provide important information, like the location of the drip-lines, the development of shell closures, the changes in shapes and pairing. Proposed new experimental developments involving storage rings yield access to measurements of bare and few-electron ions in the laboratory, thus under conditions that prevail in hot stellar environments. A great research potential is that not only ground state properties can be studied but also those of isomeric states, which are populated in projectile fragmentation and fission at relativistic energies. The experimental possibilities will expand with the availability of pure isomeric beams that can be used for secondary nuclear reactions, which will open novel ways to explore the nuclear structure.

The physics case and the technical realisation are described in detail in the Technical Proposal that has been evaluated and approved. The estimates given in this annex for the ILIMA construction costs are those evaluated and recommended by the CORE review committee.

3.5.2 Purpose of Annex 3.5

The purpose of this Annex to the NuSTAR MoU is to define the ILIMA collaboration and its organisational structure as well as the distribution of tasks and responsibilities among the groups participating in the ILIMA collaboration. It also defines the financial contribution towards the investment cost for the construction of the experimental setup for each group as agreed upon by the different institutes or funding agencies.

3.5.3 Institutions and scientists presently participating in ILIMA collaboration

Institut d'Astrophysique, CP-226 Université Libre de Bruxelles, B-1050, Belgium
K. Takahashi

GSI Darmstadt, D-64291 Darmstadt, Germany
E. Badura, K. Beckert, F. Bosch, C. Dimopoulou, A. Dolinski, P.Egelhof, B. Franczak, B. Franzke, H. Geissel, F. Herfurth, J. Hoffmann, H.-J. Kluge, R.K. Knöbel, C. Kozhuharov, N. Kurz, S.A. Litvinov, Yu.A. Litvinov, G. Münzenberg, F. Montes, I. Nesmiyan, F. Nickel, F. Nolden, C. Nociforo, W. Ott, W. Quint, C. Scheidenberger, H. Simon, M. Steck, Th. Stöhlker, K. Sümmerer, B. Sun, S. Typel, G.K. Vorobjev, H. Weick, N. Winckler, M. Winkler

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M. Hausmann, M. Matoš, H. Schatz

Technische Universität München, D-85748 Garching, Germany
T. Faestermann, P. Kienle, L. Maier, P. Ring, D. Vretenar

St. Petersburg Nuclear Physics Institute, 188350 Gatchina, Russia and
St. Petersburg State University, 198904 St. Petersburg, Russia
Yu.N. Novikov, D.M. Seliverstov, Yu. Gusev

Justus-Liebig Universität Gießen, D-35390 Gießen, Germany
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D. Cullen

Frankfurt Institute for Advanced Studies, J.W.Goete-Universität Frankfurt, D-60438 Frankfurt, Germany
Th. Bürvenich

Institute of Modern Physics, Lanzhou, Gansu 730000, China
Ruishi Mao, Zhiyu Sun, Guoqing Xiao

Los Alamos National Laboratory, Los Alamos, NM 87545, USA
D. Madland, P. Moeller, D. Vieira

Johannes Gutenberg Universität Mainz, D-55099 Mainz, Germany
K. Blaum, K.-L. Kratz, B. Pfeiffer

CSNSM-IN2P3-CNRS, F-91405 Orsay, France
G. Audi, D. Lunney

Niigata University, 950-2181 Niigata, Japan
T. Ohtsubo
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T. Suzuki, T. Yamaguchi
Tsukuba University, 305-8577 Tsukuba, Japan
A. Ozawa

Aristotle University, GR-54124 Thessaloniki, Greece
G.A. Lalazissis

Warsaw University, 00681 Warsaw, Poland
Z. Janas, M. Pfützner

Soltan Institute for Nuclear Studies, 00681 Warsaw, Poland
Z. Patyk

3.5.4 Organisational structure of the ILIMA collaboration

The ILIMA collaboration has a Spokesperson (Chair of the Collaboration Board), a Deputy Spokesperson, a Project Manager (Chair of the Technical Board), a Collaboration Board, and a Technical Board.

The **Collaboration Board** is the highest authority of the ILIMA collaboration. The Collaboration Board consists of the representatives of those institutions in the ILIMA collaboration, or the associated funding agencies, which have signed the present MoU. The board membership and voting rights in the board are linked to the contributions of the particular institution and the board shall decide on a case-to-case basis. The ILIMA Collaboration Board elects the **spokesperson** and the **deputy spokesperson** for a period of two years. Re-election for further periods of office is possible.

The spokesperson shall represent and coordinate the collaboration, shall organize the budget of the collaboration. The spokesperson chairs the ILIMA Collaboration Board and represents the collaboration in the NuSTAR steering committee. The deputy-spokesperson assists the spokesperson and shall replace the spokesperson if the spokesperson is absent. The spokesperson and deputy-spokesperson are members of the Collaboration Board and have full voting rights.

The ILIMA Collaboration Board elects a **Project Manager**, who reports to the Collaboration Board. The Project Manager is responsible for the technical coordination of the ILIMA project in general and coordination of the working groups on the day-to-day basis. The project manager is a member of the Collaboration Board with full voting rights.

The **ILIMA Technical Board** consists of the coordinators of the working groups responsible for the sub-systems of ILIMA, as described below. It is chaired by the **Project Manager**.

Persons currently holding Management Positions

Spokesperson	Philip Walker (Uni. Surrey, UK)
Deputy Spokesperson	Yuri Litvinov (GSI, Germany)
Project Manager	Helmut Weick (GSI, Germany)
GSI contact person	----

Present members of the ILIMA Collaboration Board

The members of the collaboration board are representatives from institutes having signed this MoU. The current members of the collaboration board are listed in the table below.

ILIMA Collaboration Board			
Representative		**Institute**	**Country**
G	AUDI	CSNSM, ORSAY	FRANCE
Th	BÜRVENICH	UNIVERSITY OF FRANKFURT	GERMANY
Th	FAESTERMANN	TECHNICAL UNIVERSITY OF MUNICH	GERMANY

H	GEISSEL	GSI (KPII)	GERMANY
Ch	KOZHUHAROV	GSI (AP)	GERMANY
K-L	KRATZ	UNIVERSITY OF MAINZ	GERMANY
G	LALAZISSIS	ARISTOTLE UNIVERSITY THESSALONIKI	GREECE
Yu	LITVINOV	GSI (DEPUTY SPOKESPERSON)	GERMANY
Yu	NOVIKOV	PNPI GATCHINA	RUSSIA
Z	PATYK	INS WARSAW	POLAND
W	PLASS	UNIVERSITY OF GIESSEN	GERMANY
M	STECK	GSI (ACCELERATORS)	GERMANY
K	TAKAHASHI	UNIVERSITE LIBRE DE BRUXELLES	BELGIUM
P	WALKER	UNIVERSITY OF SURREY	UK
H	WEICK	GSI (PROJECT MANAGER)	GERMANY
T	YAMAGUCHI	SAITAMA UNIVERSITY	JAPAN

ILIMA Technical Board

Sub-Project	Group Leader		Institute
Project Manager, Chair	**H**	**Weick**	GSI, Darmstadt
Simulation and Beam Handling	H	Weick	GSI, Darmstadt
Evaluation Software	Yu	Litvinov	GSI, Darmstadt
Physics and Theory Programs	Th	Bürvenich	JWGU Frankfurt
ToF Detectors	W	Plass	JLU Giessen
Schottky Detectors	C	Kozhuharov	GSI, Darmstadt
Other Detectors	Th	Faestermann	TU Munich
Spokesperson	P	Walker	Uni. Surrey
Deputy-spokesperson	Yu	Litvinov	GSI, Darmstadt

Relation to NuSTAR management structure

The relationship between **ILIMA** and the NuSTAR structure is spelled out in the NuSTAR MoU to which this is an annex.

3.5.5 Subsystems of ILIMA and involvement of the participating institutes

Working packages / Institutes	Physics Programs					Evaluation software	Simulations, beam handling			Detectors				
	Key experiments: mass measurements	Key experiments: life-time measurements	Key experiments: isomeric beams	Theory: new predictions	Theory: improvement of theoretical models	Mass evaluation	Stochastic cooling in the CR	Electron cooling in the NESR	Coupling of the Super-FRS with the CR and NESR	Time-of-Flight detectors	DAQ systems for IMS and data storage	Schottky detectors	DAQ systems for SMS and data storage	Decay detectors
Uni. Bruxelles				X	X									
MSU, East Lansing	X			X	X									
TU München	X	X		X	X						X	X	X	X
PNPI, St. Petersburg	X	X	X							X				X
JLU Giessen	X	X	X			X			X	X	X	X	X	
Uni. of Surrey, Guildford	X	X	X									X	X	X
JWGU, Frankfurt	X	X	X	X	X									
IMP, Lanzhou	X	X										X	X	
LANL, Los Alamos	X	X		X	X									
JGU Mainz	X	X		X	X						X		X	
Uni. of Manchester			X											
Uni. of Edinburgh	X	X											X	X
Uni. Niigata	X	X										X	X	
CSNSM-IN2P3 -CNRS, Orsay	X	X				X					X		X	
Uni. Saitama	X	X		X						X	X	X	X	
Uni. Thessaloniki	X			X	X									
Uni. Tsukuba	X	X								X	X	X	X	
Uni. Warsaw	X	X	X								X		X	
SINS Warsaw	X	X		X	X	X								
GSI, Darmstadt	X	X	X	X	X	X	X	X	X	X	X	X	X	X

3.5.6 Investment cost estimates for ILIMA construction

Summary of investment costs of the project (k€) – see Technical Proposal for details

Item		costs per item / k€	number	costs / k€
Schottky detectors	Schottky pick-ups in the CR	25	4	100
	Schottky pick-ups in the NESR	25	8	200
	Cavity coupling	10	12	120
	Cavity closings (mechanical)	15	12	180
	Low-noise, broad-band amplifiers	25	12	300
Time-Of-Fight detectors	Vacuum chamber, baking	60	1	60
	Partially reused vacuum chamber	20	1	20
	Magnets	5	2	10
	Vacuum pumps, valves controllers	90	1	90
	Detector, MCP	25	2	50
	Electronics, power supplies	25	2	50
	Slow control of HV and step motor	2	2	4
	Scaffolding with adjustment	2	2	4
	Cables for signals and control	2	1	2
Other detectors	Vacuum pockets with step motor	20	4	80
	Si detectors with indiv. readout	54	2	108
DAQ Schottky detectors	Amplifiers	1	12	12
	Remotely controlled tunable mixers	10	12	120
	Remotely controlled frequency generators	10	12	120
	Data acquisition, VME crate	10	2	20
	ADCs	1	72	72
	Cables, connectors, and such	5	2	10
	Data storage	15	1	15
DAQ ToF detectors	Data acquisition (Digital Oscilloscopes)	60	2	120
	Data storage	15	1	15
DAQ Other detectors	Data acquisition (VME crate, electronics)	20	1	20
			total	1902

3.5.7 ILIMA Working Groups and responsibilities (**Coordinators)**

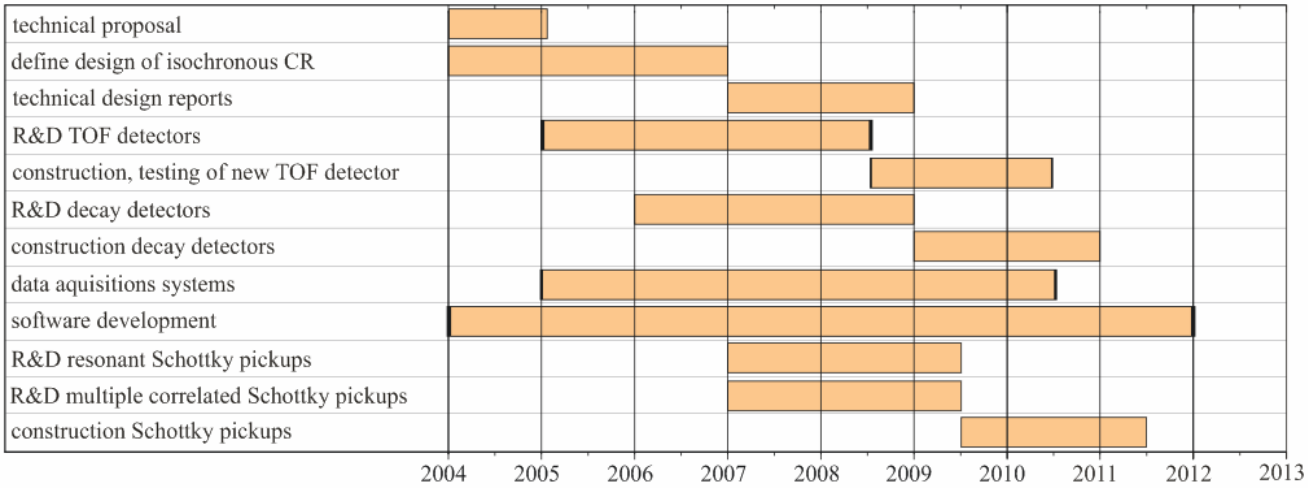
Project	**Members**
Physics and Theory Group	**Th. Bürvenich**
TOF detectors Group	**W. Plass**

Schottky detectors Group	**C. Kozhuharov**
Other Detectors Group	**Th. Faestermann**
Evaluation Software Group	**Yu. Litvinov**
Simulations and Beam Handling Group	**H. Weick**

The working group leaders marked in bold are members of the Technical Board. They are responsible for coordination of the work performed towards the development, design and construction or completion of the respective sub-system of ILIMA. A time schedule with milestones and deliverables is given below. The working group leaders are responsible for the deliverables. They will report any technical difficulty or delay of the project to the Project Manager and the Technical Board.

3.5.8 ILIMA Schedule and milestones

The time schedule for the individual tasks is given below



3.5.9 Deliverables

Deliverables are to be completed by Technical Design Reports for the individual sub-systems.

Sub-Project	**Deliverable**	**Time due**	**Institute and person being in charge**
Physics and theory Programs	Comprehensive program for first measurements and their scientific impact	Prior the first operation of the Super-FRS, CR, RESR, and NESR	Th. Bürvenich (JWGU Frankfurt)
ToF detectors	ToF detectors installed in the CR	Prior the commissioning of the	W. Plass (JLU Giessen)

	and commissioned. The corresponding DAQ installed and tested	CR ring	
Schottky detectors	Schottky probes installed in the CR and NESR and commissioned. The corresponding DAQ installed and tested	Prior the commissioning of the CR and NESR rings	C. Kozhuharov (GSI, Darmstadt)
Other detectors	Set of particle identification detectors as described in TP tested offline	Prior the first operation of the Super-FRS, CR, RESR, and NESR	Th. Faestermann (TU Munich)
Evaluation Software	Software packages for the analysis of the measured data. Fully correlated mass evaluation as described in the TP	2009-2012	Yu. Litvinov (GSI, Darmstadt)
Simulations and Beam Handling	Ion optical design of the Isochronous mode of the CR. Matching of the Super-FRS and CR-NESR rings	2006-2007	H.Weick (GSI, Darmstadt)

3.5.10 Sharing of investment costs

Institute	ToF detectors	Other detectors	Schottky detectors	DAQ and data storage	Sum (k€)	Country
CSNSM Orsay				15	15	France
Warsaw				10	10	Poland
PNPI Gatchina	25	25			50	Russia
Edinburgh/ Manchester/Surrey		78		75	153	U.K.
Tsukuba/RIKEN/ Niigata/Saitama	15			15	30	Japan
GSI, Darmstadt	45	25	865	204	1139	Germany
JLU Giessen	205		35	135	375	Germany
JGU Mainz				50	50	Germany
TU Munich		60		20	80	Germany
total	**290**	**188**	**900**	**524**	**1902**	

3.5.12 Common Projects

Common projects are defined within the NUSTAR collaboration.
ILIMA is ready to take part/contribute in projects concerning: decay detectors and Schottky pick-ups in the CR and NESR; fast sampling, high memory depth oscilloscopes; high-sampling rate, high accuracy ADCs; very high quality, high frequency cables, splitters etc; data storage.