CURRICULUM VITAE

Luigi Giuseppe Celona

PERSONAL SUMMARY

L.G. Celona received the degree in Electronic Engineering at the University of Catania, in 1995 and he joined the Istituto Nazionale di Fisica Nucleare in 1996, at the Laboratori Nazionali del Sud (INFN-LNS), becoming Technological Engineer ("Tecnologo") in 1998 and Principal Technological Engineer (Primo Tecnologo) in 2006.
His main field of activity covers all the aspects of the production of singly and highly charged beams together with their acceleration to increase the performances of Particles Accelerators for Nuclear and Applied Physics.
Experienced in all the design stages of an ion source: from mechanical design and manufacturing through the installation and final commissioning, he is also active in research and development, proposing different innovative concepts concerning the role of microwaves in the development of ECR and microwave ion sources. He is actively working on the construction and development of many different ion sources, carrying out various experiments at the major facilities worldwide (GSI, CEA, MSU, LPSC, JYFL, LBNL, IMP, etc), interacting also on several technical issues with their relative experts and sometime getting involved in finding a solution.
He is a member of the INFN Machine Advisory Committee as ion source expert. He was member of the steering committee of the SPES project and, in the European framework, he was a referee committee member of ARES and EMILIE projects to coordinate the R&D activities on ECR ion sources of the major European physics labs.
He is the technical and scientific responsible of a joint-venture between INFN-LNS and some SMEs to design, realize and test a new hybrid ion source for Hadrontherapy named AISHa; two ion sources have been manufactured and successfully commissioned (one for INFN-LNS and one for CNAO Hadrontheraphy center), others are under discussion. He worked also for the actual CNAO ECR sources with technical innovations to reach the requests set by the facility.
He is the Leader of the design, manufacturing and commissioning of the high intensity proton sources along with the low energy beam transfer line for the European Spallation Source (ESS). A deep effort has been needed to cope the stringent requests in terms of high beam reliability, low emittance, fast beam pulse rise/fall times and the wide current tuning range. The outstanding commissioning results fully comply the requirements given. The first source has been successfully installed in its final position at ESS site at the beginning of 2018 as a first part of ESS linac.
He is the chair of the next International Workshop on ECR ion sources to be held in Catania in September 2018.
He has also designed and built other types of ion and plasma sources, as the microwave discharge ion sources named MIDAS, TRIPS and VIS, for high efficiency ionization of the reaction products originating from an ISOL target and for intense monocharged production of light ions.
During the period 2004-2007 he focused his efforts on the EXCYT radioactive beam facility, coordinating the installation, the commissioning and permitting to deliver the ^{8}Li beam for the first experiments. He also worked on the development of the K-800 Superconducting Cyclotron bunching system contributing to the optimization of the cyclotron in the years 1995-1998 and to the axial injection beamline.
During the years, he has been involved in different experiments of the 5th National Commission as National or Local Responsible, actually he is participating to the DEMETRA experiment which aims to explore new acceleration techniques. In particular, the efforts are now focused on the modeling, development and test of high gradient compact RF structures devoted to particle acceleration through metallic and dielectric devices.
The great continuity and quality of the results obtained on several fronts at the same time is evidenced by the number of oral and invited talks presented by me or my co-workers to international conferences with dedicated session on ion sources. Recently two contributions on ECR and MDIS sources have been published on Beam dynamic newsletter (No.73, April 2018) of the International Committee for future Accelerators (ICFA) evidencing the interest of the scientific community for such activities carried out in years of work.
Possessing a good team spirit, he developed a team leadership style based on result oriented and effective approach.

Spoken languages *Italiano*: Mother Tongue, *English*: Fluent writing&speaking, *French*: Good writing &speaking

Research Topics

Microwave-plasma interaction; Plasma Based Ion sources; Electron Cyclotron Resonance Ion Sources; Plasma and ion beams diagnostics methods; Multidisciplinary applications of plasmas. RF based plasma diagnostics methods, plasma immersed probes (Langmuir Probe) and plasma-emitted radiation diagnostics (OES, X ray detectors, interferometers). Simulation and modelling of plasma dynamics (heating, confinement).

Professional record

Jan. 2006 - today	**Permanent staff at INFN Laboratori Nazionali del Sud, Catania.** ***II level Principal MSc. Technological Engineer*** ("Primo Tecnologo" winner of competitive examination 10668/2004).
Feb 2001-Dec. 2005	**Permanent staff at INFN Laboratori Nazionali del Sud, Catania.** ***III level MSc. Technological Engineer*** ("Tecnologo" winner of competitive examination 7708/99).
Oct. 1999-Oct. 2001	**Temporary staff at INFN Laboratori Nazionali del Sud, Catania.** ***III level MSc. Technological Engineer*** ("Tecnologo")
Oct. 1998-Oct. 1999	**Temporary staff at INFN Laboratori Nazionali del Sud, Catania.** ***III level MSc. Technological Engineer*** ("Tecnologo")
Oct. 1996-Oct. 1998	**Fellowship at INFN Laboratori Nazionali del Sud, Catania.** Project: " Study of the coupling between microwave generators (2.45-30 GHz range) and ion sources".
Oct. 1995-Feb. 1996	**ANTECH S.p.A. - Catania** Professional agreement for the study, realization and installation of the transmission filters and waveguide branching to be installed at satellite TV station "AB Television" (France)

Education

April 1995	**University of Catania, Italy** **Master degree in Electronic Engineering.** *(5 yrs.)* Design and implementation of a Low Energy buncher for the K-800 superconducting cyclotron *(carried out in the INFN-LNS Accelerator Division).*

Qualifications

March 2018- March 2024	**National Scientific Qualification to function as Associate Professor** in Italian Universities (Italian Ministry of Education, universities and research – MIUR) **-** Sector 09/F1– "Campi elettromagnetici"
June 1995	Officially recognized by the Italian government as **Professional Engineer** after successfully completing the State examination.

Coordination and Management

June 2017	**Member of the INFN Machine Advisory committee**. *Evaluation of the existing and new proposals to develop innovative technologies in the accelerator physics; address the participation to European projects devoted to the realization of new big research infrastructure and the relative impact on financial and human resources needed.*
2016- today	**DEMETRA experiment** Topic: Study and development of high gradient dielectric and metallic RF accelerating structures. Supported by the 5th National Commission of INFN (Budget: 303 k€).
Jan. 2013-today	**AISHa project team leader.** Topic: Design, construction and commissioning of a high performace ECR ion source for Hadrontherapy. Supported by the Regional Government of Sicily and funded within the framework of the Sicilian Government program named PO FESR 2007-2013 (Budget: ~5 M€).
Jan. 2011-today	**Leader** of the Work Unit regarding the high intensity **ESS proton sources and its LEBT.** Topic: Design, construction and commissioning of two high intensity proton sources for the European Spallation Source along with their Low Energy Beam Transfer Line. Supported by the MIUR (Budget: ~5.1 M€).
2013- 2016	**Leader of the Work Package 8 inside the RDH experiment** Topic: Design and development of new components of accelerators for Hadrontheraphy. Supported by the 5th National Commission of INFN (Budget: 83 k€).
2012-2013	**National responsible of the UTOPIA experiment** Topic: Electromagnetic wave interaction with plasma and generation of plasma waves in compact size machines. (merged into WP8 of RDH a year after its opening). Supported by the 5th National Commission of INFN (Budget: 66 k€).
2012-2014	**Referee committee member of the ARES European collaboration** *Coordination of the R&D activities on ECR ion sources (Task1:Plasma heating, Wave-plasma interaction) of the major European physics labs (GSI, INFN, KVI, JYFL, ATOMKI, IFIN-HH, IKF) participating to the European programme. Final meeting: http://indico.gsi.de/event/3261/*
2012-2016	**Referee committee member of the EMILIE European collaboration** *Coordination of the R&D activities on ECR-based charge breeders of the major European physics labs (GANIL, INFN, LPSC, HIL, JYFL, CERN) to enhance the production of short lived isotopes.*

2010-2013 **Member of the SPES referee committee**
Address the technical and financial issues related to the construction of the SPES radioactive nuclear beam facility at INFN-LNL.

2009-2011 **Responsible for INFN-LNS of the HELIOS experiment**
Topic: Generation of hot electron layers in high density plasmas of ECR Ion Sources under different values of power and frequencies of the pumping electromagnetic wave for INFN-LNS**.**
Supported by the 5th National Commission of INFN (Budget: 210 k€).

2005-2008 **Responsible for INFN-LNS of the INES experiment**
Topic: Innovative methods of electromagnetic waves coupling to plasmas of ECR Ion Sources
Supported by the 5th National Commission of INFN (Budget: 160k€).

2004-2007 **Technological and scientific coordination of the EXCYT facility**
Topic: Coordination of the final assembling, the commissioning and the first experiments of the EXCYT facility at INFN-LNS.

2002-2008 **Representative of the LNS Technological Research personnel for two terms**

Committee Memberships

2017 **Chairman** of the **23rd International Workshop on ECR Ion Sources,** to be held in Catania (Italy), September 10th – 14th 2018 http://ecris18.lns.infn.it/

2011 **Co-chairman** and **Member of the Scientific Advisory Committee** of the **14th International Conference on Ion Sources,**
Giardini Naxos (Italy), September 12th – 16th 2011
Proceedings published on Rev. of Scientific Instruments,Vol. 83 (2012).
Preface Rev. Sci. Instr. 83,02A101 (2012); doi: 10.1063/1.3678669

Staff Training and Career Supervision

- **Member of XXXIII doctorate college** in Engineer, “Università Mediterranea” of Reggio Calabria

- Tutor of n. **3 PhD students in Telecommunication Engineer**
  Fabio Maimone, University of Catania, now at GSI – Darmstadt;
  Giuseppe Torrisi, University of Reggio Calabria, now at INFN-LNS Winner of prize 2016 (technological area);
  Giorgio Mauro, in progress at University of Reggio Calabria and INFN-LNL;

- Tutor of n. **1 PhD students in Physics**
  Alessio Galatà, University of Ferrara, Winner of 2015 Resmini prize and of 2016 Geller prize, now at INFN – LNL;

- Opponent n. **1 PhD students in Physics**
  Oystein Midttun, University of Oslo (17/12/2015) , now at University of Bergen;

- Co-tutor of n. **13 (Bachelor-10/Master-3) degree Thesis in Engineer**
  Telecommunications (7), Mechanics (2), Electronics (4): Catania University, Faculty of Engineer, AY (since) 2003/2004(to) 2016/2017.

- Co-tutor of **n. 9 Master degree Thesis in Physics**:
  Catania University, Faculty of Natural, Mathematical and Physical Sciences, Department of Physics and Astronomy, AY (since) 2003/2004 (to) 2016/2017.

- Tutor **of N. 2 students of the Catania University for the 240 hours stages** (from TLC Eng.)

Teaching

June 2012 — **CERN Accelerator School, Senec, Slovakia.**
Lectures: “Fundamental of Microwave engineering and RF coupling issues”; “Microwave discharge ion sources”; “Alternative heating methods”.Programme:
http://cas.web.cern.ch/sites/cas.web.cern.ch/files/programmes/senec-2012-programme.pdf
Entire book:DOI: 10.5170/CERN-2013-007 ISBN 9789290833956
https://cds.cern.ch/record/1445287/files/CERN-2013-007.pdf

Dec. 2010 — **Master Surface Treatment, INFN-LNL, Italy.**
Lectures: “Fundamental of microwave engineerings I & II” within the 9th Master in surface treatments for industrial applications, Academic Year 2010-11 (University of Padua, INFN, Confindustria Veneto).

May 2007 **INFN Laboratori Nazionali del Sud, Catania, Italy.**
Lecture: “Ion sources for particle accelerators” within the course “Physics aspects and radiation protection issues of high intensity accelerators for medical and research purposes”.

Jan- March 2003 **Higher Technical Training Education (IFTS) course, INFN-LNS.**
“Measurements of electromagnetic wave radiation” (28 hrs) within the "Data transmission and remote control” IFTS course. Member of the final examination commission of the IFTS course.

Jan. -June 1996 **AID S.p.A. - Catania**
Antennas and electromagnetic wave propagation course (64 hrs) within the "Data transmission and remote control” course (FSE N° 952139/CT/324/449/5).

Track record of the Technological Activities

The 10 selected papers are cited as [S1], [S2], … Invited and Orals are cited as [1],[2], …

Overview

The technological and management activity over the years has been focused in the **design, construction and commissioning** of more **reliable and effective** Electron Cyclotron Resonance and Microwave Discharge Ion Sources to **increase** the Particles Accelerator performances.
High-performance plasma based ion sources will play a role of increasing importance in the next future, for feeding particle accelerators devoted to Nuclear Physics and Applied Research.

The basic idea of the entire activity has been to **increase the knowledge** about the **plasma physics** underlying the ion beam generation mechanism and consequently **improving all technological aspects** related, in order to make a significant step forward in terms of overall performances.

Such goal has been achieved over the years working around all the components of an ion source: from microwave injection to beam formation, transport and its relative diagnostics.
Outstanding results have been obtained with this systematic approach especially pursuing the **investigations about a better coupling between electromagnetic waves and plasmas** generated [S1, S6, S7]. The experiments started since my fellowship at LNS from the strong belief that an electromagnetic structure is still present in the source plasma chamber even in presence of plasma [S6, S7]. This approach allowed to **discover several interplays between the microscopical plasma parameters** – especially the electron energy distribution function and the structural distribution of the plasma density – **and the beam quality**, namely the current, the average charge state, and the emittance [S6, S8].

The quality of the obtained results is testified by **several oral and invited talks** given in different conferences on such subject and **this knowledge is now allowing to optimize the performances of the existing sources** and in the **design and construction of the future generation ECRIS.** [2, 4, 5, 6, 7, 9, 11, 12, 13]

The innovative tests carried out over the years have constantly supported the activities of INFN-LNS ion sources group, which plays also a **worldwide leading role** in the **design, construction and characterization of ion injectors** for particles accelerators as demonstrated by the leaderships role covered in the ENSAR-ARES international collaboration [18] (in the frame of the FP7/2007–2013) and in the European Spallation Source (ESS) project. [15, 20, 24, 25]

The technological research activity carried out and the experience gained has been recognized with the **leadership of the design, production and commissioning** of the high intense proton source and of the relative low energy transfer line (up to the RFQ) **for the ESS project**. [S9, 15, 20, 24, 25] A long phase of study and testing was necessary to define the design of the source because of the high-profile requirements in terms of reliability, current and emittance of the proton beam and times of rising and falling of the beam pulse.

The source resume the experience gained in more than 20 years of work in this field and **represents the state of art of this kind of sources worldwide**, the **outstanding results of the commissioning** carried out at the LNS have been recently presented at the last International Conference on Ion Sources (Geneva, Oct. 2017) [S9].
The **successful installation** in the ESS accelerator tunnel has been completed at the beginning of February with a team of 5 people that I supervised in the different working phases and some detail have been reported in last IPAC conference (Vancouver, May 2018).

I have also made an important contribution to the development **of ECR sources for the CNAO therapy center**, in particular, the variations suggested by me allowed to satisfy the **requirements of reliability and intensity** of the beam produced which are **fundamental for such kind of application**. The need, in this specific field, to have a more performing source led to the definition of a new innovative and high performance source called AISHa designed to operate in a hospital environment with all the constraints related.[S10]
The realization of this source was financed in the line of intervention 4.1.1.1 of the **POR FESR Sicilia 2007-2013**, supporting the activities of experimental development, industrial research and, to a marginal extent, also of fundamental research with high degree of integration between SMEs and Research Institutions.

Currently I am the **Technical-Scientific Responsible of the Temporary Association of Companies** between INFN and the 3 participating SMEs. There are two AISHa sources that have been built: one within the aforementioned POR and another for CNAO, funded under the IRPT project.
The achieved results have raised up a lot of interest by the scientific community in the last International Conference of Ion Sources (Geneva, October 2017) because it represents a **turnkey solution to get a compact and performant source even for nuclear physics labs** [S10]. It represents also the ideal source for the **Cyclotron upgrade at LNS**, in terms of intense ion beam production for the expected challenging experimental activities (e.g. the NUMEN project), and discussion are in progress with GSI for its adoption in the FAIR project.

Furthermore, the activities have given rise to several completely innovative projects, such as: **MIDAS2, TRIPS, VIS**, in which I independently carried out the conceptual design, defining all the characteristic parameters and coordinating the different operating phases: the design of the equipment, the construction, the installation, tests and finally data acquisition, analysis and results synthesis.

In particular, the **MIDAS2** source was found to be very suitable for the **ionization of the reaction products produced from ISOL targets** and this solution was subsequently **adopted by several laboratories** (TRIUMF, GANIL, CERN), while the **TRIPS** source [S4, 3], after having been conceived, realized and characterized to LNS , was transferred to the LNL in November 2005.

It should be pointed out that this project was **financed by the Ministry of University and Scientific Research, according to the law 95/95 for the technology transfer** and our work was carried out in collaboration with a consortium of companies (HITEC-SISTEC), demonstrating the possibility of an effective transfer of know-how.

The **VIS** source, born as an evolution of TRIPS, is extremely **versatile for high intensity production of light ions** (H, H2, D, He, O). From 2013 to the end of 2014, it was operating at the BEST company (Vancouver, Canada) as intense H_2^+ beam injector in a cyclotron used to study the central region of the accelerators to be implemented for the ISODAR and DAEδALUS projects. [17, 21]

I also contributed significantly in the **realization of the EXCYT radioactive beam facility** during the years 2004-2007 (until the facility took part of the LNS accelerator division). During such years, I focused my daily efforts ***coordinating*** the installation, the commissioning of the entire facility and permitting to deliver the ^{8}Li beam to the first experiments. [S5, 8, 10, 14].
In this activity I continuously interacted with the staff of the technical division and the accelerator division of the LNS, supervising the work of the external companies employed, and organizing them in order to ***allow the smooth running of the scientific program*** of the LNS.
More specifically, the main activities I have dealt with since 1994, grouped by argument, are listed below:

- ***Study of relevant aspects of the physics & technology of ECR ion sources***
    - Study of the coupling with microwave generators in the 2.45-28 GHz range and related mathematical formalization; [S1, S3]
    - Plasma heating study in a wide range of frequencies through the use of Traveling Wave Tube Amplifier; [4, 5]
    - Development and validation of the concept of frequency tuning and related effects on the beam emittance; [S6, S8, 11,12,13]
    - Study of the optics of extraction of intense beams;
    - Improvement of ion beam currents and average charge states extracted from plasma based, highly performing ECRIS; [9, 13]
    - Improvement of beam quality (emittance, brightness) and reduction of beam ripple and halos; improvement of the ion sources reliability;
    - Propagation of electromagnetic waves in the microwave range inside non-isotropic nonhomogeneous media (strongly magnetized plasmas);
    - Study of microwave-based devices (cavities, generators, amplifiers) of interest in the field of R&D on plasma based Ion Sources;
    - Plasma diagnostics: electrostatic, electromagnetic (interferometry), X-rays spectroscopy; [S7, S8, 22]
    - Non-linear interaction of electromagnetic waves with high density plasmas;
    - Study, design and implementation of an ECR source operating at 28-37 GHz (RTD project "Innovative ECRIS" within FP5, MS-ECRIS project within FP6 EURONS-ISIBHI).[1,2]
    - Study, design and implementation of AISHa source for Hadrontheraphy [S10]

- ***Study, design, construction, installation and tests of high intensity proton sources***
    - SILHI for CEA-SACLAY (tests and modifications); [S2]
    - TRIPS for LNS-LNL (TRASCO-TRAsmutazione SCOrie project); [S4, 3]
    - PM-TRIPS, VIS for LNS [17, 21].
    - High intensity proton sources for the European Spallation Source [S9, 15, 20, 24, 25]

- ***Production and acceleration of exotic beams (EXCYT)***
    - Coordination of the installation and commissioning of the EXCYT facility with the 8Li beam
    - MIDAS and MIDAS2 sources;
    - ISOLDE-NIS, PIS, HPIS ion sources; [S5, 8, 10 ,14]
    - Extraction optics and minimization of the emittance of the radioactive beams;
    - Electrostatic calculations for high voltage platforms.

- ***Activities concerning the Superconducting Cyclotron (CS)***
    - 450 kV pre-injector; Bunching of the beam;
    - Commissioning of the Tandem - CS beam injection line, commissioning of the CS and of the lines that carry the beam to the experimental rooms.

Study of relevant aspects of the physics & technology of ECR ion sources

I started working on these sources during my fellowship in mid 90s' at INFN-LNS focusing the work on some open issues namely the *coupling* between the plasma and microwave generators in the 2.45÷30 GHz range and on the *beam extraction*.
The electromagnetic simulators and the calculation resources still not permit the simulation of so high-frequency structures so complicated and large compared to the wavelength and therefore an analytical approach to the problem with some assumption was needed. [S1]

After the SERSE installation and commissioning at 14 GHz, my contribution has been decisive for the ***upgrading of SERSE at 18 GHz and 28 GHz*** [S3]. I introduced several innovations permitting a ***more effective heating*** of the plasma and the ***source provides performances far superior to those of the second generation ECR sources existing today***.

I studied and developed for SERSE a microwave injection system able to heat the plasma at the same time with **several frequencies**. This allowed to have more ECR resonance zones in the plasma chamber with a significant **increase in performance** in terms of **intensity** of the extracted beam and of **average charge state**. [4, 5, 9, 13]
The results showed a significant increase in the extracted current (up to a factor of 5 for the highest charge states) and in these years, in the Fifth National Commission, I carried out a series of systematic study under several experiments with the aim to reveal the underlying physics, to optimize the related technologies and to analytically formalize the problem. In particular I was the ***local responsible at LNS of INES and HELIOS*** experiments and I was the ***national responsible of the UTOPIA*** experiment (merged into ***WP8 of RDH*** a year after its opening).
The experimental activity proceeded constantly side by side with the modelling through an analytical approach and with state of art electromagnetic simulators (HFSS, CST). Such tools, adequately supported by calculation resources permitted at the beginning to have the first ***qualitative feedbacks*** on the wave-plasma interaction and on the ionization processes inside the plasma chamber, but only since a couple of years the ***plasma "medium" has been successfully*** taken into account implementing also the ***self-consistency*** procedures.
The results of this approach have shown a behavior of the source ***strongly dependent also on small variations in frequency*** (what I called "***frequency tuning effect***"), in contrast with the international community's support. [S6, S7, S8]

These forecasts have been ***confirmed by a series of measurements*** made on the GSI testbench in November '06 and March '07, where we also investigated the distribution of the output beam from these sources, a topic of considerable importance for the correct preparation of the beam produced by the subsequent coupling with the accelerator. In particular, by making frequency ***variations of the order of MHz around the 14 GHz central frequency***, we found ***variations in the emittance of the extracted beam***, accompanied also by a ***variation in the intensity of the produced current***. [S6, S8] Similar observations have been repeated in various laboratories confirming the ***validity of the phenomenon*** described above and this has drawn the attention of the international community on the ***importance of the coupling*** between microwaves and ion sources, as I have supported since my fellowship.

The verification of the ***scaling laws up to 28 GHz*** at INFN-LNS on the SERSE ion source has been certainly another important ***breakthrough activity*** of my career and took place within the framework of a CERN-CEA-ISN-GSI-INFN collaboration, which aimed to produce medium-high and high-intensity ions for LHC [S3, 1, 2]. During these tests an ***extremely dense plasma was generated***, which in different operating modes produced high ion currents at a medium-high charge (over 500 eμA of Xe^{20+} , less than a factor two below the target for LHC) or currents of the order of μA of ions at a very high state of charge (Xe^{42+}).
This last result was extremely interesting for the LNS cyclotron because it confirmed the validity of the project of the third generation source ***GyroSERSE***, leading to a further increase in current and energy of the beams obtainable with the superconducting cyclotron.
I presented the results of this experiment for the first time at the Workshop on the Production of Intense Beams of Highly Charged Ions proposing also a new generation ion souce called GyroSERSE. [1]

In these experiments, assisted by the colleagues of the CEA-Grenoble, I studied and realized the ***coupling of the gyrotron of 28GHz-10 kW*** with the SERSE source. It was the **first time** that a generator operating at such a **high frequency was coupled with an ECR source and the technological problems were brilliantly overcome** allowing to operate with a very low percentage of reflected power (in the order of a few%) obtaining current values and of charge status never obtained previously. [S3]
Currently the existing 3rd generation sources such as VENUS (LBNL), SECRAL (IMP), SC-ECRIS (Riken), use the same coupling scheme that I developed and tested for the first time on SERSE.
The results achieved have been a **milestone** and permitted to **start the design of last generation ECRIS**, for these reason I have been invited to several conferences to illustrate the results with particular reference to the coupling problems. [2,7,16]

Following the excellent results of this experiment, the new source project ("GyroSERSE") was funded under the 6th EURONS-ISIBHI European Framework Program.
This source, slightly modified with respect to the initial project for budget constraints and named ***MS-ECRIS***, has been realized in the various components within FP6 at GSI, however the superconducting magnets, made at an external company, have not been able to reach the project specifications.
In this project I was mainly involved in the ***optimization of the extraction system*** for high currents through the use of finite element codes in three dimensions and the ***definition of the source coupling with the gyrotron of 28GHz-10 kW***, preparing it for a future upgrading at ***37 GHz***.

I also dealt with the choice of high power microwave source by writing the technical specifications, carrying out the evaluation of the offers received, and finally checking the acceptance tests of the system.
The results of these experiments are very important in the context of my career, due to the difficulties overcome and for the achievements in terms of production of high-charge and high-intensity ion beams, but above all because they represented ***an important step towards the construction of third generation ECR sources****.*

In September 2016 I was invited in Lanzhou at HCI ECRIS Symposium to discuss about the challenges for the coupling of 4th generation ECRIS [23]. In fact, IMP is interested in building the first source at 45 GHz and a new approach in the design is needed in this frequency domain.
In particular, if ***optical approximation*** is valid other mechanism enter into the game and the power deposition can be highly controlled.
Actually, the single-pass RF energy absorption efficiency at the Electron Cyclotron Resonance Layer is rather poor, and it is still difficult to drive energy deposition to specific parts of electron population. A "***microwave absorption optimization oriented***" design, based on the control of the electromagnetic radiation by a dedicated RF launcher, will permit a precise control of the **power deposition location** of the radiated signal. One of these launchers has been designed by a coworker for the first time in a compact ECR ion source (G. Torrisi et al. accepted for publication on Microwave Optical Letters) and extensive test are needed to draw any conclusion.

The importance of the results obtained is demonstrated by the fact that in almost every conference, concerning ion sources and particle accelerators with dedicated sessions, the status reports of the different projects/experiments above mentioned have been presented, by the large number of references to the works published and by several awards (Resmini and Geller prizes) given to doctorates working such topics and that I followed as tutor.
For this reasons I'm also serving since 20 years as referee for several international journals for articles related to ion sources.

Such activity has also an immediate feedback on the INFN-LNS ECR sources "***SERSE***" and "***CAESAR***". The different improvements took in place in the years allowed to ***satisfy the Accelerators Division*** of INFN-LNS, with an increase in both energies and ion currents accelerated by the Superconducting Cyclotron. The reliable operations achieved had a beneficial effects on the smooth running of the LNS scientific program and played a fundamental role for the CATANA facility where a reliable and stable proton beam is used for the uveal melanoma treatment
The knowledge and experience gained played a ***fundamental role to optimize the performance*** of ***CNAO ECR sources*** used to create the carbon and proton beams for the patient treatments.
The sources initially did not fulfill the CNAO requirements especially in terms of current produced and for the continuous beam trips. The origins of such failures have been identified in an ***injection system of old conception*** and by the ***inadequate design of beam extraction***. Both troubles have been overcome with an appropriate redesign of the parts therefore allowing reliable long term operations with the beam currents level required.
These are ***mandatory prerequisites*** for such kind of facility.

The need, in this specific field, to have a more performing source led to the definition of a new ***innovative*** and ***high performance source called AISHa*** designed to operate in a hospital environment with all the constraints related [S10].
The heart of the system is certainly the cryofree superconducting magnetic system, to avoid the cost of a cryogenic infrastructure, which produces the axial confining field, while the radial confinement is assured by a permanent magnet hexapole. I deeply studied the entire system in order ***to avoid any demagnetization*** induced by the high fields produced by superconducting coils.
The setup was also designed to ***minimize maintenance operations*** and to provide ***reliable*** and repeatable performance over time.
As previously mentioned, the realization of this source was financed in the line of intervention 4.1.1.1 of the ***POR FESR Sicilia 2007-2013***, supporting the activities of experimental development, industrial research and, to a marginal extent, also of fundamental research that experiment high degree of integration between SMEs and research institutions.
Currently I am the ***Technical-Scientific Responsible of the Temporary Association of Companies between INFN and the 3 participating SMEs***. There are two AISHa sources that have been built: one within the aforementioned POR and another for CNAO, funded under the IRPT project.

Study, design, construction, installation and tests of high intensity proton sources

I started this activity in 1998, when, within the scope of the TRASCO project (whose goal was the construction of a 1 GeV-30 mA proton accelerator for the transmutation of radioactive waste by the ADS method), the LNS source group was commissioned to build the ***TRIPS*** high intensity ion source.
The aim was to create a source of high-intensity protons, capable of working at a voltage of 80 kV, with currents extracted above 30 mA and normalized emittance of less than 0.2π mm.mrad. This source also had to satisfy the requirement of ***maximum stability, reproducibility and reliability***.
Similar projects were under way at the CEA-Saclay (SILHI source) and at Los Alamos (LEDA injector) with similar voltage and higher currents, but their performances in terms of beam emittance, stability and reliability ***were very far from a source for an ADS plant***.
In 1998, on the basis of an INFN-CEA MoU, a very fruitful collaboration was established for both groups.

In particular, after a few months of my arrival at Saclay I managed to obtain emittance values lower than the specifications of the TRASCO and IPHI projects following an original idea, based on the fact that a ***higher degree of space charge compensation, and therefore a decrease in the emittance, can be obtained by injecting gas into the transport line***. *[S2, 3]*
The tests were performed by injecting different types of gas (H2, N2, Ar and 84Kr) into the transport line through a calibrated leak valve and comparing the emittance measurements at different pressures.
In all the cases considered a ***decrease in the emittance has been obtained*** by slightly increasing the beam line pressure; in particular, by injecting 84Kr into the transport line, the emittance decreased by **a factor of 3** (from 0.33π to 0.11π mm mrad), losing only 5% of the beam.

The ***effectiveness of this approach*** has been confirmed in July 1999 with systematic measurements of the ***space charge compensation factor*** with a tool developed at Los Alamos National Laboratory.
These measurements confirmed my hypothesis, providing compensation values in the order of 75% while in the presence ***of gas this compensation increased to 98%*** [S2].
Such meaurements have provided over the years a reference point for all those involved in the design of the transport of intense beams. Such system, for its simplicity and effectiveness, has been adopted worldwide for the compensation of intense monocharged beams.
The search for ***maximum reliability***, was undoubtedly a longer path in which it was needed to ***redesign the extraction optics***. I carried out the simulations needed and, with this new extraction system, the number of failures fell by more than one order of magnitude, allowing reliable source operations with 140 mA of protons, never achieved before on SILHI.
The modifications I proposed therefore ***allowed to meet the initial specifications of SILHI***, drastically reducing both the emittance of the extracted beam and the source failures and allowing also a further increase in the beam current.

This know-how has been very useful for the construction of the ***TRIPS*** source, where the current values and operating voltages are lower compared to those of the SILHI source. For this reason it was possible to design a more compact source. For this source ***I coordinated all the operational phases***: from the site preparation (paying great attention to the electromagnetic compatibility problems), to the design, construction, testing, etc ..

The construction was completed in 2001 and the tests started in late spring 2001; in August 2001 ***the beam current requirement was reached and exceeded*** (over 60 mA at 80 kV were extracted). Throughout the second half of 2002, a set of systematic measurements of the influence of the various parameters (magnetic field profile, extraction voltages, power, gas injection in the line , etc ...) allowed to obtain the ***outstanding emittance value of 0.09 π*** mm.mrad (the project request was <0.2 π mm.mrad) at a beam current slightly higher than the required one. [S4]
In June 2003 an operating test was carried out continuously for 142 h at the nominal voltage and current and the source reached 99.8% reliability. [S4]

It should be emphasized that ***this project was financed by the Ministry of University and Scientific Research, according to the law 95/95 for the technology transfer and our work was carried out in collaboration with a consortium of companies (HITEC-SISTEC), demonstrating the possibility of an effective transfer of know-how***.

Taking into account the experience gained by LNS in the field, I have proposed and implemented a further ***optimized version of the TRIPS source called VIS***. The aim was to reduce the tuning parameters by the operator and to modify the hardware in order to ***reduce maintenance***, without affecting the characteristics of the source and maintaining the stability and high reproducibility of TRIPS.
Such compact source (coils were substituted with permanent magnets, extraction column simplified and reduced in dimensions, bulk HV platform disappeared) has proved to be very ***versatile in the ionization of light elements*** such as H2, D, He, O showing reliability and consistency over time even higher than the TRIPS source.

The VIS source represents the ***cutting-edge technology*** of the high intensity proton sources with permanent magnets and for its compactness and ease of use has been used ***as intense H_2^+ beam injector*** in a cyclotron used to study the central region of the accelerators to be implemented for the ISODAR and DAEδALUS projects. [17, 21]
In this case a ***project management*** efforts has been fundamental to organize the dismounting, the successive packaging and the safe transportation by ship to Vancouver. The LNS staff carried out the unpacking and reassembly in 14 working days. The same time was needed for dismounting in Vancouver, packaging and shipment back to LNS.

The technological research activity carried out and the experience gained has been recognized with the ***leadership of the design, production and commissioning of the high intense proton source and of the relative low energy transfer line (up to the RFQ) of the ESS project***. A long phase of study and testing was necessary to define the design of the source because of the high-profile requirements in terms of reliability, current and emittance of the proton beam and times of rising and falling of the beam pulse [15, 20, 21, 25].

Even in this case ***I coordinated all the operational phases***: from the site preparation (paying great attention to the electromagnetic compatibility problems), to the design, construction, testing, etc ..The source resume the experience gained in more than 20 years of work in this field and ***represents the state of art of this kind of sources worldwide***, the ***outstanding results of the commissioning*** carried out at the LNS have been recently presented at the last International Conference on Ion Sources (Geneva, Oct. 2017) [S9]. The ***successful installation int the ESS accelerator tunnel has been completed*** at the beginning of February with a team of 5 people that I supervised in the different working phases and some detail have been reported in last IPAC conference (Vancouver, May 2018).
An ***accurate effort of project management*** has been needed to coordinate all the actors involved during the source design, construction and commissioning. Moreover, due to the logistic issues, a precise schedule of the source removal to Lund was needed to ensure a safe transportation and an appropriate allocation and use of the human resources.

Production and acceleration of exotic beams (EXCYT)

Since the beginning of my research activity, I contributed to the **construction, assembly, testing and commissioning of the EXCYT facility** for the production and acceleration of exotic beams.
The EXCYT Special Project was based on the use of the two accelerators (Tandem and Superconducting Cyclotron) existing at the LNS. Intense beams of light ions accelerated by the cyclotron up to 50 ÷ 80 AMeV hit a thick target. The radioactive atoms produced diffuse in the target and then later effuse towards the source, where they are ionized. The ions are then separated from the contaminants with a high-resolution magnetic separator (M/ΔM = 20000) and injected into the Tandem, which permits to continuously vary the energy from 0.2 to 8 AMeV with stability in the order of 10^{-4} and beam emittance of 0.5 ÷ 1 π mm.mrad.

For this project I ***coordinated the final activities*** of installation and testing of high voltage platforms and mass isobaric separator, giving a contribution to many of the operating subsystems (safety system, depression system, remote manipulation, etc ...).

I also ***coordinated the commissioning of the entire facility and the first experiments with the 8Li beam allowing the smooth running of the scientific program of the INFN-LNS***.[S5, 8, 10, 14]
The most significant contributions to the different components are listed below:

a) the ***optimization of the primary ion sources*** for the CS, so as to provide maximum currents of 1 ÷ 7 pμA for the beams of interest (C, O, Ne, Ca). – See paragraph on ECR ion sources
b) the design, construction and related tests of a source prototype for secondary ionization with high efficiency (MIDAS 2) as described hereinafter;
c) the development and tests of the three "**ISOLDE**" sources: the positive surface ionization source (PIS), the negative surface ionization source (NIS) and the source Hot Plasma (HPIS);
e) the electrostatic design of the high voltage platforms and of the high voltage pipe connecting them;
d) the design of the ***extraction geometry*** of the sources for the radioactive beams in order to minimize the emittance at the entrance of the mass isobaric separator. From the calculations I made with the 3D code KOBRA3-INP it is clear that this result can not be obtained unless intercepting part of the beam extracted from the source. These losses are considerable if maximum separation is required, while they are much more limited when this demand is more relaxed.

MIDAS2

Within the EXCYT project my most ***innovative contribution*** was the design and implementation of the MIDAS2 source (MIcrowave DischArge Source), to ionize the reaction products coming from the target with high efficiency.
The source is based on the off-resonance discharge principle. According to this principle, the heating in the plasma occurs not by resonance ECR (electron cyclotron resonance) but for "UHR" (upper hybrid resonance) in the presence of a non-resonant field for the electronic component. In this case the plasma is not subject to density cutoff, but the electronic temperature is much lower than that of the ECR source (only a few tens of eV). This makes ***this source the ideal instrument for ionizing the radioactive beams***, as it ionizes with 1+ charge status more effectively than an ECR source can, and the extracted beam has a low energy spread (thanks to the low ionic temperature). Moreover, compared to other sources used for RIB, this type of source has the enormous advantage of the ***absence of parts subject to wear*** and of having a short ionization time (10-50 ms) which minimizes product losses with low average life.
After the encouraging results of the First version, I personally conceived and followed the second version in all phases (design, construction, test and collection and analysis of results) allowing a qualitative jump of one order of magnitude in the ionization efficiencies.

The ***efficiencies measured*** under different operating conditions (base pressure and gas load) range from a few% to 50%, depending on the operating pressure, but do not vary considerably with the ionic species.

For the results highlighted, **the MIDAS2 source is particularly suitable for ionization of radioactive beams; this solution was subsequently chosen by several laboratories** with RIB facility: in fact, a source based on this principle was created at TRIUMF (Canada), at GANIL (France), and at the ISOLDE facility at CERN.

Activities concerning the Superconducting Cyclotron (CS)

I started working at INFN-LNS as student on the coupling between the Tandem and the Superconducting Cyclotron doing the thesis ("Experimental-Theoretical study of a radiofrequency system for the pulsing of ion beams accelerated by the Superconducting Cyclotron of the LNS").
I proposed important changes to the original ***pulsation system***, which included a "double drift" buncher at a frequency of 15 ÷ 48 MHz and a rebuncher in IV harmonic, lowering the operating frequency of the Low Energy Buncher (to work also in the second subharmonic), in order to increase the distance in time between successive bunches, as required by nuclear physics experiments, without decreasing the pulsation efficiency significantly.
In 1996 I contributed to the ***design of the high energy chopper*** to further increase the temporal separation between two bunches.
I also participated in the beam line tests for the coupling between Tandem and CS.

Finally, over the years, I always supported the RF group activities of INFN-LNS on the design of several specific devices such as: the high energy chopper for the LNS superconducting cyclotron, the low energy chopper for the European Spallation Source and the buncher for the LNS superconducting cyclotron. I have been also working for the training of some engineers for the Accelerator Division.

Overview of the most significant activities per year

2018

- *Chair of ECRIS 2018 conference (http://ecris18.lns.infn.it/).*
- *ESS: Unpacking and installation at Lund of the first source.*
- *ESS: Procurement of the second source. Data Analysis.*
- *AISHa: Restart of the source. Commissioning with Ar, O, Xe, He.*
- *AISHa: Simulation of new extraction scheme and design of the relative upgrading.*
- *AISHa: Modification of diagnostics to implement the emittance measurement unit*
- *DEMETRA: Construction of Photonic Crystal (woodpile structure) at 18GHz and at 90 GHz. Construction of the final W band metallic structure at 90 GHz. RF characterization.*

2017

- *ESS: Successful completion of all commissioning phases: detailed mapping of operating conditions with EMU at source exit.*
- *ESS: Installation of the entire LEBT together with diagnostics and controls. Debugging of computer control and optimization of diagnostics. Emittance measurements at the RFQ entrance point.*
- *ESS: Assembly of the second platform with all component and services at UMAS Technology.*
- *ESS: Dismounting and packaging of the entire setup for the shipment to Lund. Preparation for installation at beginning of 2018.*
- *AISHa: Commissioning of the source with CH_4 and O.*
- *AISHa: Arrival of the second set of superconducting coils (IRPT) together with relative diagnostics.*
- *DEMETRA: Design of a Photonic crystal waveguide for particle acceleration-Construction of a metallic open Gaussian horn at 110 GHz and relative measurements*

2016

- *ESS: Procurement phase of source and LEBT components.*
- *ESS: Site preparation with particular care to the electromagnetic compatibility problematics.*
- *ESS: Assembly of High voltage platform and cross after the first element of the LEBT. ESS First plasma*
- *AISHa: Assembly of the different parts of ion source and beamline together with diagnostics and focusing elements. Assembly of vacuum system. Assembly of the platform*
- *AISHa: Arrival of the first set of superconducting coils (POR) together with hexapole and integration in the testbench. AISHa First Plasma*
- *DEMETRA: Design of W band open accelerating structure and design of a W-band Open Gaussian Horn Antenna*

2015

- *ESS Procurement phase, Tenders. Site preparation.*
- *AISHa Procurement phase. Site preparation.*
- *Microwave interferometer measurements.*
- *Conceivement and design of a photonic crystal based DC-BREAK for ECRIS.*

2014

- *Technical design of the high intense proton source for the ESS linac. Procurements and tenders.*
- *Technical design of the AISHa ECR ion source for Hadrontheraphy. Procurements and tenders.*
- *VIS adaptation to intense H_2^+ production in the framework of Daedalus collaboration: conceivement and manufacturing of three different source bodies for enhanced H_2^+ fraction generation; commissioning and tests at BEST site (Vancouver).*
- *Preliminary study of a compact microwave interferometer for plasma density measurement in ECR ion sources.*

2013

- *Conceptual design of the high intense proton source for the ESS linac: redesign of beam extraction and beam line optics due to new ESS requirements; space charge compensation tests at CEA IRFU to validate the chopper design.*
- *Conceptual design of the AISHa ECR ion source for Hadrontheraphy.*
- *VIS adaptation to intense H_2^+ production in the framework of Daedalus collaboration: VIS removal, installation at BEST site (Vancouver), re-commissioning and first tests.*

2012

- *Conceptual design of the high intense proton source for the ESS linac and the low energy transport beam line.*
- *Definition of a compact test bench named FPT for fundamental plasma physics studies in the framework of UTOPIA experiment.*
- *Modelling of ECR plasma (modification of the classical non-uniform cold tensor taking into account ion source peculiarities) and full wave computations of electromagnetic wave propagation in ECRIS.*

2011

- *Co-chair of ICIS 2011 conference (http://icis11.lns.infn.it/).*
- *Bernstein wave generation in a compact plasma reactor at INFN-LNS: observations of the non-linear broadening of the pumping EM wave spectrum and X-ray spectroscopy of the electron components).*
- *TFH and frequency tuning tests in the CAPRICE ECR ion source at EIS testbench (GSI).*
- *X-ray spectroscopy of warm and hot electron components in the CAPRICE ECR ion source at EIS testbench (GSI).*
- *Commissioning of the VIS source with light ions (He, O).*

2010

- *Emittance measurements of proton beams produced by the VIS source in the framework of the NTA- HPPA strategic project.*
- *Advanced conceptual design of the MISHA ion source for Handrontherapy.*
- *Frequency tuning investigations in the CAESAR ion source at INFN-LNS cross-checking the emittance of the extracted beams and the Bremsstrahlung measurements.*

2009

- *Definition of the MISHA ion source magnetic system through detailed VECTOR FIELDS magnetostatic simulations.*
- *Commissioning of the VIS source in the framework of the NTA- HPPA strategic project.*
- *Systematics of frequency tuning tests with relative emittance measurements at the AECR ion source at Jyvaskyla university and the SUPERNANOGAN sources at CNAO Hadrontherapy facility.*
- *Systematics of SUSI ion source performance (Michigan State University-NSCL) with different confinement conditions: emittance and Bremsstrahlung measurement.*

2008

- *EXCYT: coordination of the beam production activities and of the facility maintenance procedures.*
- *Test and development of the CNAO ion sources.*
- *Installation and first tests of the high intense PM-TRIPS ion source*
- *Commissioning of the 28 GHz-10 kW microwave source and of the coupling line with the chamber of MS-ECRIS ion source (GSI).*

2007

- *EXCYT: coordination of the beam production activities and of the facility maintenance procedures.*
- *EXCYT: definition of a common test-bench (INFN- LNS and INFN-LNL) for beam development.*
- *Electromagnetic characterization of the CAPRICE ion source (GSI) with and without plasma to validate the frequency tuning effect.*
- *Definition of the MS-ECRIS ion source coupling with the 28 GHz-10 kW microwave source.*

2006

- *EXCYT: coordination of the entire facility commisioning and first experiments (BIGBANG, RCS).*
- *First experimental evidence of the frequency tuning effect in ECR ion sources: beam produced at CAPRICE ion source (GSI) changes in intensity and shape with a frequency variation of ±2%.*
- *Simulations and definition of the MS-ECRIS beam extraction system in collaboration with GSI colleagues.*

2005

- *EXCYT: coordination of the isobaric separator commissioning with stable (^{7}Li) and radioactive(^{8}Li) ion beams.*
- *EXCYT: first post-acceleration of* $^{8}Li^{+}$.
- *Electromagnetic characterization of the microwave sources feeding the SERSE and CAESAR ion sources at INFN-LNS.*
- *Development of a code to investigate different coupling schemes between SERSE ion source and the microwave generators.*

2004

- *EXCYT: coordination of the activities for the completion of the facility.*
- *Investigation with INFN-LNS ion sources (SERSE, CAESAR) on the ECR heating phenomenon through the use of wide band microwave amplifier.*
- *Final optimization of the TRIPS source (delivery to INFN-LNL in 2005)*

2003

- *TRIPS source: beam extraction optimization and maximization of beam availability (up to 99.8%) in long run tests (142h).*
- *Optimization of SERSE microwave coupling with the microwave amplifiers: first experimental evidence of standing wave formation in ECR plasma chamber.*
- *GyroSERSE: Study of the magnetic system with VECTOR FIELDS codes and study of beam extraction with KOBRA-3D code.*

2002

- *Study of beam extraction and transport for third generation ion sources*
- *Minimization of the high intensity proton beam emittance produced by the TRIPS source.*
- *Commissioning of the hybrid source LIS+SERSE (ECLISSE experiment)*
- *Installation and tests of wide band power amplifier for the INFN-LNS ion sources: first experimental evidence of microwave coupling consequences in ECRIS.*

2001

- *TRIPS source completion, installation and first beam.*
- *Design study for the third generation ECR ion source "GyroSERSE".*
- *EXCYT: tests on ISOLDE-type RIB sources.*

2000

- *SERSE 28 GHz experiment: coupling of the SERSE ion source with a 28 GHz-10kW gyrotron (first time that a ECR ion source was coupled with a so powerful generator). CW and afterglow operations: scaling law studies.*
- *ECLISSE experiment: study of a hybrid source Laser + ECR.*
- *EXYCT: test and development of the MIDAS2 source; ionization efficiency tests.*

1999

- *Test and development of the SILHI ion source (CEA-Saclay).*
- *Design of the intense proton source named TRIPS for the TRASCO project.*
- *18 GHz upgrading of the SERSE ion source: scaling law studies.*
- *Study of the coupling between the SERSE ion source and a 28GHz-10kW gyrotron.*
- *Manufacturing of the MIDAS2 ion source and installation on a testbench.*

1998

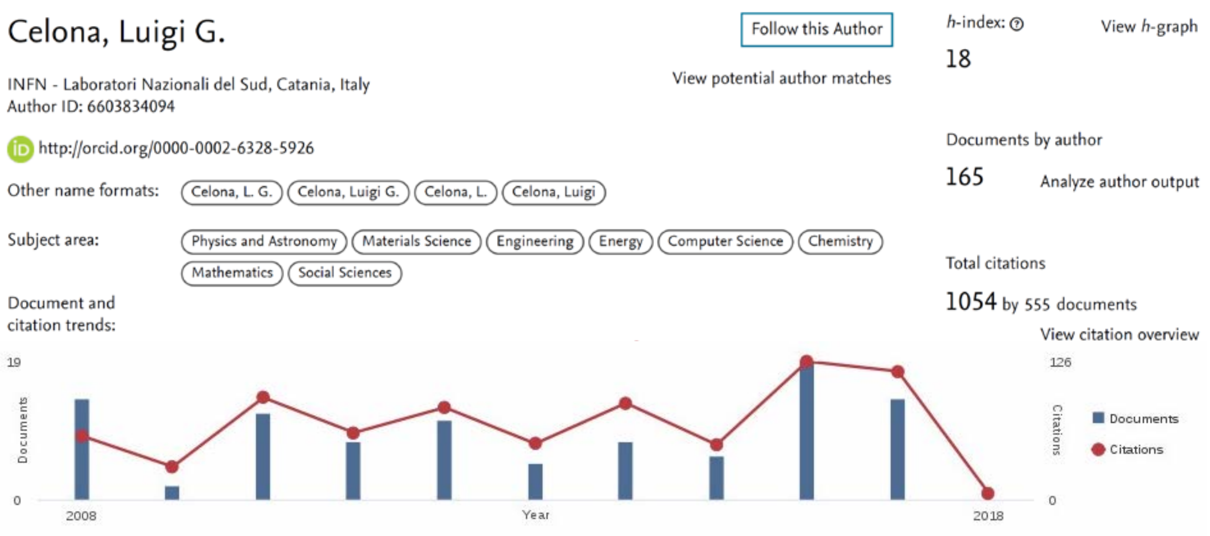
- *Design of MIDAS2 source for the high efficiency positive ionization of the recoils to be produced in the target of the EXCYT facility.*
- *Study and design of the extraction system for the EXCYT ion sources*
- *Electrostatic calculations for the EXCYT high voltage platforms system.*

1997

- *Test and development of MIDAS source.*
- *Design of the INFN-LNS high energy chopper.*
- *Member of ICIS'97 Local Organizing Committee.*
- *Study of the coupling between microwave generators and ion sources.*

Publications

- **137 Papers indexed by ISI Web of Science (165 indexed by SCOPUS)**
- **H-index 16 according to ISI Web of Science (18 by SCOPUS, 25 by Scholar)**
- **Citations: 949 according to ISI Web of Science (1054 SCOPUS, 1984 by Scholar)**



Oral and invited talks to international conferences

[1] L. Celona, S. Gammino, G. Ciavola, ***The GyroSERSE project,*** Int. Workshop on "Production of Intense Beams of Highly charged ions", Catania (20-24 September 2000) (Oral talk)

[2] L.Celona, G. Ciavola, S. Gammino, ***Third generation ECR ion sources***, 5th Int. workshop on Strong Microwave in Plasmas, (5-9 August 2002) Nizhny Novgorod, Russia (Invited)

[3] L. Celona, G. Ciavola, S. Gammino, F. Chines, M. Presti, L. Andò, X.H. Guo, R. Gobin, R. Ferdinand, ***Status of the TRASCO intense proton source and emittance measurements***, 10th International Conference on Ion Sources, (8-13 September 2003) Dubna, Russia (Oral talk)

[4] L.Celona, S. Gammino, G. Ciavola, F. Consoli, A. Galatà, ***Analysis of the SERSE ion output by using klystron –based or TWT-based microwave generators***, 16th Int. Conference on ECR Ion Sources, (26-30 September 2004) Berkeley, USA(Oral talk)

[5] L. Celona, F. Consoli, G. Ciavola, S. Gammino, S. Barbarino, G. Sorbello, A. Galatà, D. Mascali, ***Application of Traveling Wave Tubes (TWT) to ECRIS plasma***, 32nd Int. Conf on Plasma Science, Monterey, USA, 18-23 June 2005 (Oral talk)

[6] L. Celona, G. Ciavola, F. Consoli, S. Gammino, F. Maimone, ***Design and optimisation of ECR and microwave ion sources for high efficiency ionisation and high intensity applications***, 33rd Int. Conf. on Plasma Science, Traverse City, USA, 4-8, June 2006 (Oral talk)

[7] L. Celona, S. Gammino, G. Ciavola, ***Optimization of ECR ion sources for high charge state beam generation,*** 19th International Conference on the Application of Accelerators in Research and Industry, Fort Worth, Texas, 20-25 August 2006 (Invited)

[8] L. Celona on behalf the EXCYT collaboration, ***EXCYT: the RIB Project at INFN-LNS***, 19th International Conference on the Application of Accelerators in Research and Industry, Fort Worth, Texas, 2006 20-25 August (Invited)

[9] L. Celona, F. Consoli, S. Barbarino, G. Ciavola, S. Gammino, F. Maimone, D. Mascali, L. Tumino, ***Impact Of Microwave Technology On ECRIS Performances***, 17th Int. Workshop on ECR ion Sources, Lanzhou, Cina, 17-21 September 2006 (Oral talk)

[10] L. Celona on behalf the EXCYT collaboration: ***EXCYT (EXotics with CYclotron and Tandem): the RIB facility at INFN-LNS***, ISOLDE User Meeting Workshop, CERN, 12-14 Feb. 2007 (Invited)

[11] L. Celona, G. Ciavola, S. Gammino, N. Gambino, F. Maimone, D. Mascali, R. Miracoli, ***On the observation of standing waves in cylindrical cavities filled by microwave discharge plasmas***, 18th Int. Workshop on ECR ion Sources, Chicago, USA, 15-18 September 2008 (Oral talk) http://accelconf.web.cern.ch/AccelConf/ecris08/html/author.htm

[12] L. Celona, S. Gammino, G. Ciavola, F. Maimone, D. Mascali, ***Microwave to plasma coupling in ECR and Microwave ion sources***, 13rd International Conference on Ion sources, Gatlinburg, USA, 20-25 September 2009 (Invited)

[13] L. Celona, S. Gammino, G. Ciavola, D. Mascali, ***New tools for the improvement of beam brightness in ECR ion sources***, 19th International Conference on Cyclotrons and their Applications, Lanzhou, China, 6-10 September 2010 (Invited)

[14] L. Celona, ***Radioactive beams at LNS***, EURISOL meeting, CERN, Ginevra, 27-28 June 2011 (Invited) https://indico.cern.ch/event/138670/contributions/150731/

[15] L. Celona, ***The ESS Proton Source and LEBT,*** ESS Warm Linac meeting, Catania, Italia, 6 July 2011, (Invited) https://agenda.infn.it/conferenceDisplay.py?confId=3904

[16] L. Celona, G.Castro, S. Gammino, D. Mascali, G. Ciavola, ***ECRIS latest developments,*** 12th Heavy Ion Accelerator Tecnology, Chicago, USA, June 18-21 2012, (Invited) http://accelconf.web.cern.ch/AccelConf/HIAT2012/html/author.htm

[17] L. Celona, S. Gammino, G. Ciavola, D. Mascali, ***Optimization of VIS ion source for the DAEδALUS project***, ***DAEδALUS*** Workshop, Erice, Italia, 31 Oct. -3 Nov. 2012 (Invited)

[18] L. Celona, ***Plasma heating, Wave-plasma interaction,*** ENSAR-ARES meeting, Jyvaskyla, Finland, 5-6 June 2013, (Invited)

[19] L. Celona et al., **ECR ion source developments at INFN-LNS**, 21rd International Workshop on ECR Ion Sources, Niznhy Novgorod, Russia, 24-28 August 2014 (Oral talk) http://accelconf.web.cern.ch/AccelConf/ECRIS2014/html/author.htm

[20] L. Celona, **Source commissioning experiences at INFN-LNS and plans related to ESS source**, EUCARD2 (Enhanced European Coordination for Accelerator Research & Development) Workshop on Beam Commissioning of Proton Linacs, Lund, Svezia, 8-9 April 2014 (Invited) https://indico.esss.lu.se/event/164/timetable/#20140408.detailed

[21] L. Celona, S. Gammino, G. Castro, D. Mascali, L. Neri, G. Torrisi, ***H_2^+ intense beam production with the VIS (Versatile Ion Source) in the DAEδALUS/ISODAR framework***, DAEδALUS/IsoDAR meeting, Erice, Italia, 22-25 October 2014 (Invited)

[22] L. Celona, S. Gammino, D. Mascali, ***High density plasmas and new diagnostics: An overview (invited)***, 16th International Conference on Ion Sources, New York, USA, 23-28 August 2015 (Invited) http://www.c-ad.bnl.gov/icis2015/Program.htm

[23] L. Celona et al., ***Plasma heating and microwave injection efforts at INFN-LNS***, Symposium on Intense Beam production for HCIs with ECRISs, Lanzhou, China, 2016 (Invited)

[24] L. Celona et al., ***The proton source for the European Spallation Source (PS-ESS): installation and commissioning at INFN-LNS***, 22rd International Workshop on ECR Ion Sources, Busan, South Korea, 28 August – 1 September 2016 (Oral talk) http://accelconf.web.cern.ch/AccelConf/ecris2016/html/author.htm

[25] L. Celona et al., ***High intensity proton source and LEBT for the European Spallation Source***, 17th International Conference on Ion Sources, Ginevra, Svizzera, 15-20 October 2017 (Oral talk) https://indico.cern.ch/event/628126/program

Editorial Activity

During these years, I have serving as referee for several international journals:

• Physical Review Letters;
• Physical Review - Special Topics on Accelerators and Beams;
• Plasma Sources Science and Technology;
• Nuclear Instruments and Methods in Physics Research;
• Review of Scientific Instruments;
• Heliyon – Elsevier;
• Indian Journal of Physics

International Cooperation

The prominent role played by INFN-LNS in the field of Accelerator/Ion Sources physics and technology has permitted to activate a number of international collaborations worldwide. The ones in which I played a major role are:

Heavy ion sources with a high state of charge:
The most important collaborations in this field were those with the CEA of Grenoble (France) and with the GSI (Germany). Both have been very continuous and fruitful (since 1996) and focused on the most varied theoretical and experimental aspects of ion sources. In particular, the first focused on SERSE and the 28 GHz experiments, while the second on the study of the process of extraction of intense ion beams, on its modeling through finite element codes and recently on the MS-ECRIS source and on the effects of frequency tuning . In this field I have collaborated with: LBNL (Berkeley, USA), MSU-NSCL (East Lansing, USA), RIKEN (Japan), IMP-Lanzhou (China), Univerity of Jyvaskyla (Finland), KVI (Holland), IAP (Nizhny Novgorod, Russia), ISN (Grenoble, France) today LPSC.

High-intensity sources of light ions:
In this case, the most fruitful collaborations were those with the CEA of Saclay and with LANL (Los Alamos, USA). The collaboration with the CEA began in 1998 with tests on their SILHI source producing interesting results with considerable appreciation from the management of the CEA, which actively supported the continuation of this collaboration by participating in the commissioning of our TRIPS source, as described previously. As evidence of their interest, the CEA group has brought to the LNS the diagnostic developed for SILHI for the measurement of emittance of intense beams. The collaboration with the LANLs was instead focused on space charge compensation measures on SILHI and TRIPS using non-interceptive diagnostics made available by these laboratories. This collaboration has also been extended to the calculations for the definition of the new SILHI extraction geometry. In this field I also had a fruitful collaboration with the CRNL (Chalk River, Canada).

Ion sources for radioactive beams:
In this field the most important collaborations were with CERN, with the colleagues of the ORNL (Oak Ridge, USA) and with the laboratories of GANIL (Caen, France). In particular, the colleagues at CERN shared the drawings related to the ISOLDE-type sources and the decades of experience gained in the sector, receiving in turn the drawings of the MIDAS2 microwave discharge source, the ORNL colleagues made their knowledge available. on the charged exchange cell, while GANIL colleagues have allowed more than a month of EXCYT TIS testing on their SYRA testbench.

Hybrid and LIS sources:
I collaborated with colleagues JINR, Dubna (Russia) for calculations related to the ECLISSE experiment and then with colleagues from IPPLM (Warsaw, Poland) and CAS, (Prague, Czech Republic).

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Luigi G. Celona