TechS News- An Electronic Newsletter

No. 4, January 21

Editorial

Welcome to the 4th issue of TechS, an electronic newsletter reporting the information and updates on the activities of the Technology Platform (TP) of PlanetS. In the current issue we have selected and invited the company Officina Stellare to present some of their products and show their technological capabilities.

To make the newsletter a success, we will be relying on you, the subscribers to the newsletter, to send us news and update about something you think can be important to share within our community in terms of ***Seed funding, Networking, Training, Participating, Infrastructures*** and ***Competences***. If you want to share information with the other subscribers to the newsletter and facilitate the exchange of information, just let us just contact the TP here.

Best wishes,

The Technology Platform (TP)

General information about TP

General information about the TP activities and news from the us can be found here:

- Webpage of the TP: link.
- To subscribe or unsubscribe TechS: link.

In this edition

Update of the TP web page

People in PlanetS listed for technology skills

Have you ever wondered if someone in PlanetS could help you in your project or for the development of a product? PlanetS is a large interdisciplinary research programme and it can be tricky to find the right person with specific competences in the NCCR. We created the PlanetS' list of contacts for competences (🪪) which has the main gaol to answer to this need.

Figure 1 below shows how the web page looks like.

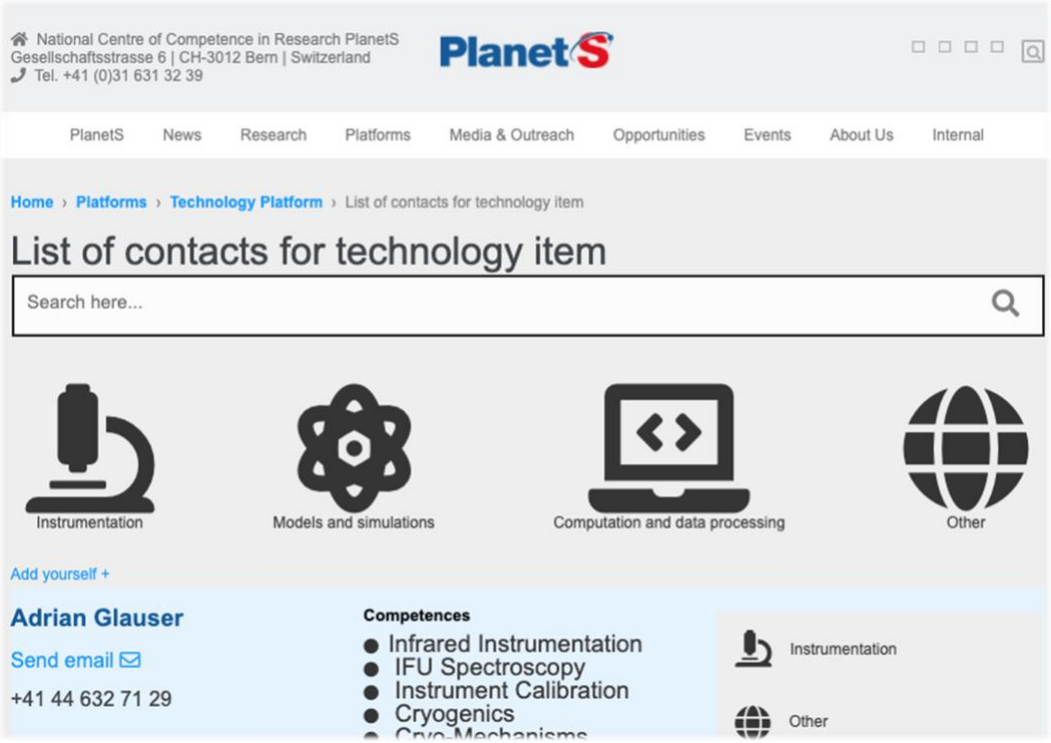

Figure 1. List of contact for technology item in PlanetS

For each contact, you find the following information:

- Name, email and phone number
- His/her competences

You can select a specific domain and find contacts in PlanetS based on macro areas, for example, '*Models and simulations'*, see the red box (#1.) in the Figure 2 below. To remove the filter, just click again on one of the icons of the selected domain (#2., green boxes in the Figure 2).

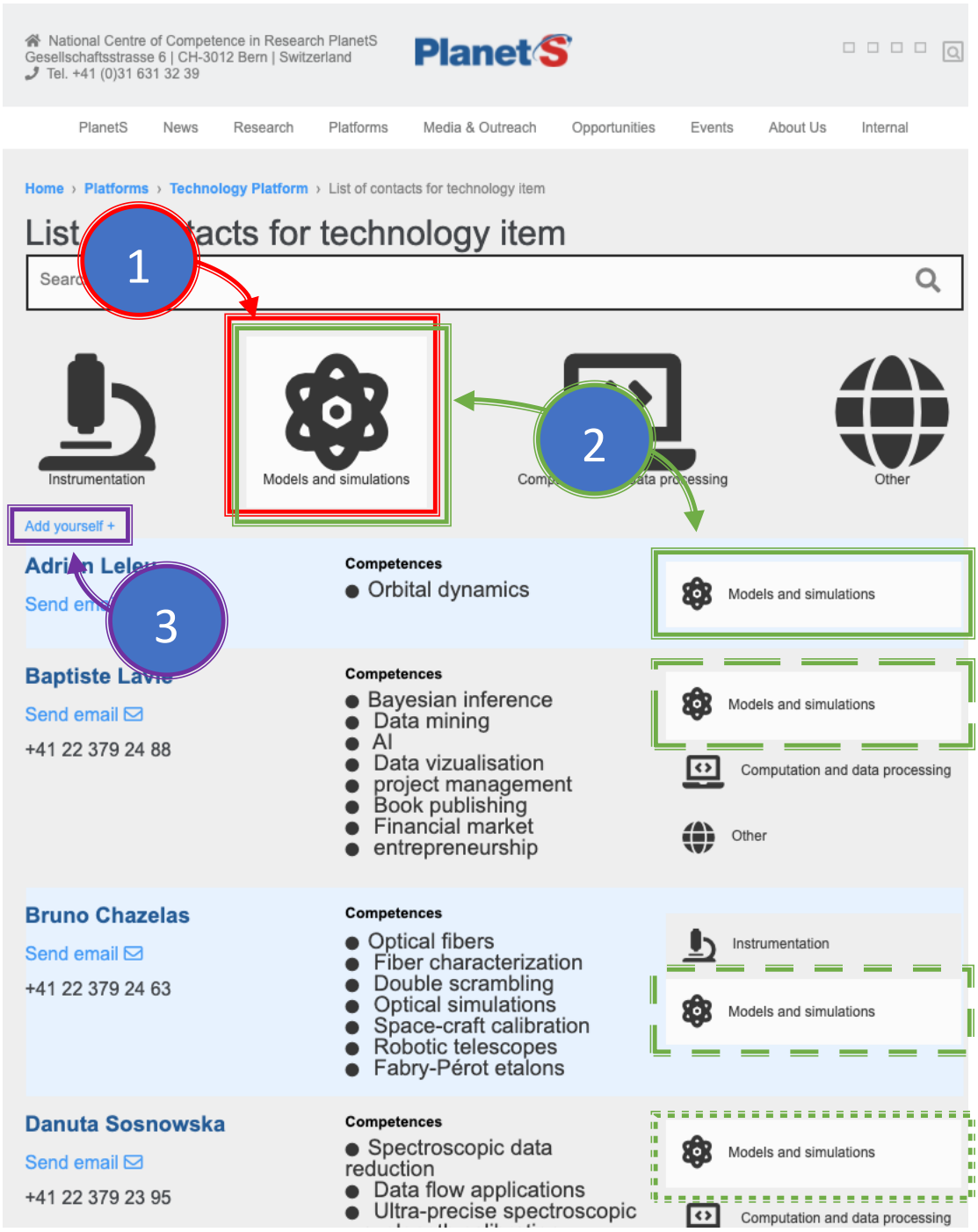

Figure 2. List of contact for technology item: add and remove filter, and 'Add yourself +' option

If you are a PlanetS Member or Associate and you are not in the list yet, click on the link *'Add yourself +'* and enter your competences with this form: see purple box in Figure 2 (#3.).

Link: *http://nccr-planets.ch/platforms/technology-transfer/list-of-contacts-for-technology-item/*

Spotlight on a project of the TP

Estimating the potential of thermal ionization cavity sources for PlanetS

The analysis of isotope ratios of trace elements in extra-terrestrial and terrestrial material is a key tool in cosmochemistry, and it is used to understand the processes involved in the formation of solar systems and the timing thereof. After chemical separation of the trace elements from the sample matrix, the actual measurement of an isotope ratio is performed with a mass spectrometer. Simply speaking, the analysis in the mass spectrometer can be split into three steps: ionization of the sample atoms and extraction of the resulting ions to form a beam, separation of the ions according to their masses in the so-called mass analyser, and detection of the relevant ions to be able to calculate isotope ratios. In each of these steps ions can be lost and the overall efficiency decreased, i.e. the number of ions detected per sample atom presented to the ion source. In particular, the ionization efficiency in the ion source is often a limiting factor in the analysis. Usually, the more ions that can be detected, the more precise the analytical result will be.

Thermal ionization cavity (TIC) sources are a type of ion source known to provide higher ionization efficiencies for some elements compared to any other ion source type (see Maden et al. 2018 for a review of TIC sources). While mainly used at radioactive beam facilities, these types of ion sources have not yet been employed for routine isotope ratio analysis in the fields of geo- and cosmochemistry. At ETH Zurich, an effort is being made to develop such a TIC source, also with the benefits in mind that it could bring to research applications within the framework of PlanetS. If successful, then commercialization of TIC sources should be explored. With this project, seed funding was provided to perform experiments aimed at convincing mass spectrometer manufacturers of the potential of TIC sources and arouse their interest in potential commercialisation thereof.

Principles of thermal ionization mass spectrometry

Among the mass spectrometric techniques used in geo- and cosmochemistry, thermal ionization mass spectrometry (TIMS) is a state-of-the-art technique for high-precision analysis of isotope ratios. After chemical separation from the sample matrix, the trace element of interest is loaded on a refractory metal filament and ionized under vacuum by passing an electric current through the filament. At temperatures between 1100 and 1900°C, depending on the element and the loading technique, the sample undergoes evaporation and thermal ionization on a filament surface.

The ratio of atoms ionised to those that aren't, in one contact with a hot surface, is governed by the Saha-Langmuir relation, which mainly depends on the surface temperature, its work function, and the ionization potential of the sample atom. For elements with high ionization potentials (>6 eV) the degree of ionization is around 1% at best, typically lower, even at temperatures above 1800°C and using ionising surfaces with the highest available work functions. The rest of the sample is evaporated as neutral atoms, and, because of the open geometry of the filament, is lost in the vacuum chamber of the ion source.

Thermal ionization cavity (TIC) sources offer the advantage that the samples are loaded into a cavity, which is open to the mass spectrometer through a small aperture (~1 mm diameter). Upon heating the cavity the sample will evaporate and surface ionise on the inner cavity walls just like with the filament, but the evaporated neutral atoms are less likely to be lost to the vacuum chamber of the ion source, because of the confinement of the sample in the cavity.

Hence, on average, neutral atoms can experience several inner wall contacts inside the hot cavity, and at each of them the probability of ionization is determined by the Saha-Langmuir equation (Figure 3). Generally, the overall ionization efficiency of a TIC source is governed by the probabilities with which ions can be extracted (using electric fields) and neutral atoms escape from the cavity, respectively.

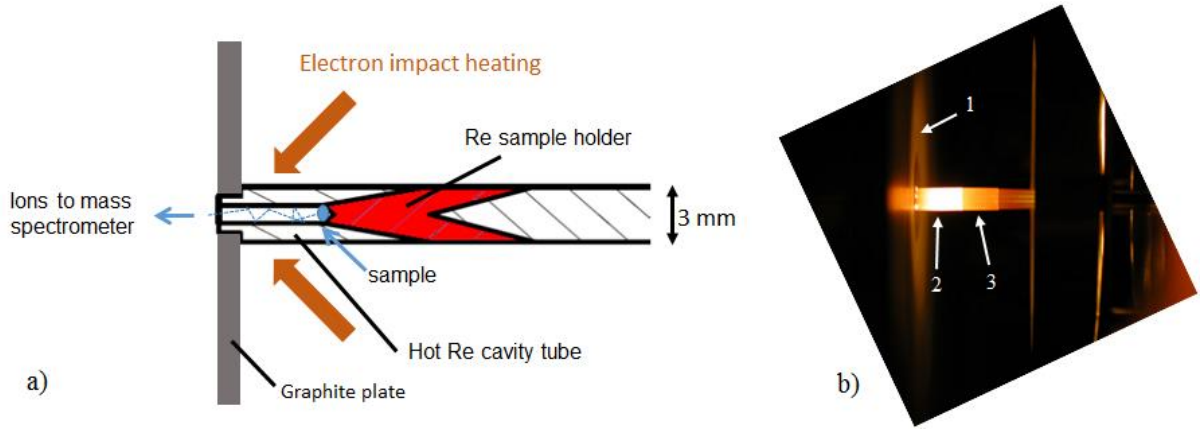

Figure 3. a) Illustration of the principles of a thermal ionization cavity source. b) Photograph of the ETH prototype TIC source in operation showing the hot cavity tube (2) and cooler sample holder (3) pushed against the graphite plate (1).

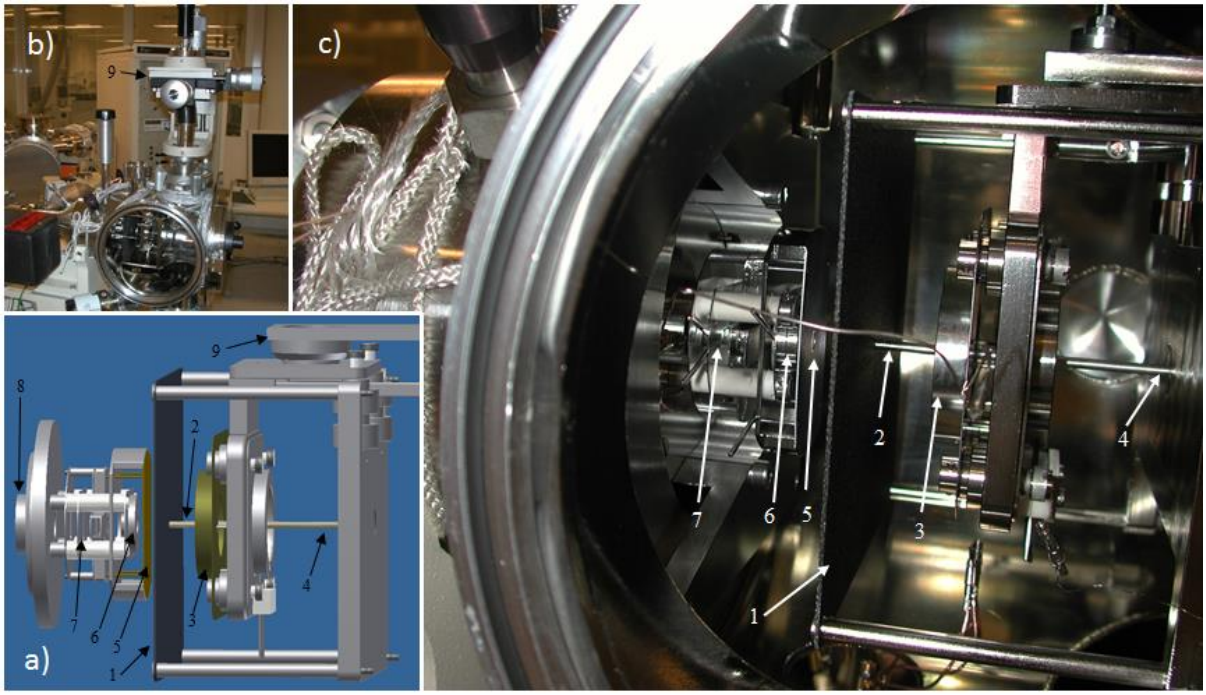

Figure 4. Illustration of the design of the prototype TIC source. a) CAD design of the TIC and extraction lens stack. b) and c) Photographs of the TIC source installed in the source head of the MAT262. The numbered elements are 1: graphite plate, 2: cavity tube

At ETH Zurich, a prototype TIC source has been developed in a collaboration with the Commissariat à l'Energie Atomique in France (Figure 4). This included simulation of the physical processes involved inside the cavity (Maden et al. 2016) and of the ion optics of the new TIC source mounted on a MAT262 TIMS mass spectrometer, in order to achieve best possible transmission of the produced ions through the mass analyser of the instrument (Maden et al. 2018).

Results

The first analyses of 1 – 3 µm diameter uranium oxide particles (containing ~4 – 100 pg U) yielded very encouraging results. The samples yielded U ion beam currents well above the cavity background and meaningful isotope ratios could be measured. However, the overall efficiency (ions detected per atoms loaded), one of the important figures of merit of the new ion source, could only be determined to lie within the range of 3 – 19% due to the large possible mass range of the samples.

In order to provide a better estimate for the overall efficiency, the analysis of uranium adsorbed to single ion-exchange resin beads was pursued and compared to the analysis of the same samples by conventional TIMS (a Thermo Fisher Scientific Triton TIMS instrument).

A few dozen resin beads, which are commonly used in cation or anion exchange column chemistry, were hand-picked in class 10 (ISO 4) clean room conditions under a binocular and added to U solutions of ca 20 ppb concentration. The average amount of U on each single bead is then estimated by observation of the drop in U concentration in the solution. Typically, U amounts per resin bead were 140 pg ±15% (2RSD).

Final preparation steps for analysis in the mass spectrometers involved transferring resin beads individually either to the bottom of a previously outgassed cavity or onto a degassed conventional TIMS filament under a binocular.

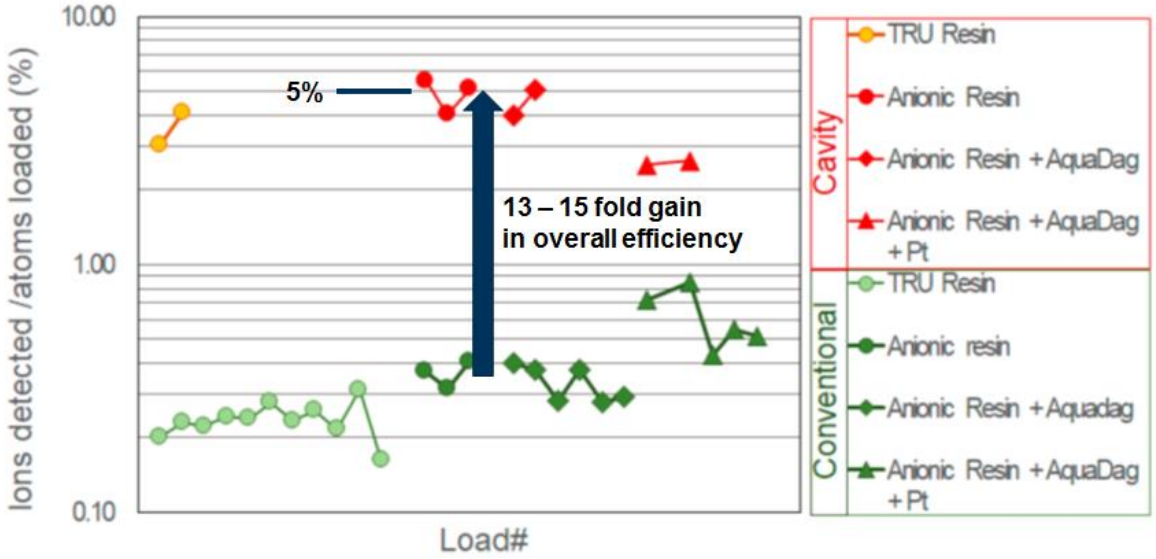

Figure 5. Comparison of the overall efficiency for 140 pg U loads on individual resin beads, between conventional source and cavity source TIMS. The enhancement in overall efficiency is more than ten-fold except for the sample loading protocol including addition of Pt powder.

In order to quantify the efficiency enhancement using the TIC source, the same types of samples using the same loading methods were analysed on a state-of-the-art Triton TIMS instrument and with our prototype TIC source. Different resins (transuranic Triskem™ TRU™ resin and Bio-Rad AG 1-X8) and different loading techniques (with or without addition of a solution of colloidal graphite (AguaDAG™) and platinum powder) generally demonstrated an order of magnitude overall efficiency enhancement between conventional TIMS and the TIC source (Figure 5). For the anionic resin (Bio-Rad AG 1-X8) loaded with and without AquaDAG™ the average overall efficiency for U analysis with the TIC source was 5%, which is among the best overall efficiencies reported so far and should awake interest in the TIMS community.

The summary of the results presented here have been published in greater detail by Trinquier et al. 2019.

Technology transfer / Industrial partners

These project results were presented to two of the three manufacturers of multi-collector TIMS instruments. The unique features of our TIC source and first preliminary results were discussed and possibilities for future developments and the possible market potential of such a source were explored. Generally, the manufacturers showed much interest in thermal ionization cavity sources. One of them provided confidential information about the designs and ion optics of their mass spectrometers, in order to evaluate if one of their existing mass analysers would be suitable for a TIC source to be interfaced to the front of it. Currently, this appears be the easiest way to commercialise a TIC source design. However, the manufacturers would also like to see the results of more fundamental research about the physics and operation of the source before they would be willing to commit financial support to the commercialisation of a thermal ionization cavity source.

References

Maden et al., 2016, International Journal of Mass Spectrometry 405, 39–49, https://www.doi.org/10.1016/j.ijms.2016.05.013

Maden et al., 2018, International Journal of Mass Spectrometry, 434, p70-80, https://www.doi.org/10.1016/j.ijms.2018.09.006

Trinquier et al., 2019, Analytical Chemistry, 91, p 6190 – 6199, https://www.doi.org/10.1021/acs.analchem.9b00849

More details about the project: http://nccr-planets.ch/platforms/technology-transfer/estimating-the-potential-of-thermal-ionisation-cavity-sources-for-planets/

More details about the programme: http://nccr-planets.ch/platforms/technology-transfer/call-for-ideas/

Focus on a company

As every month, this section wants to present an overview on a selected company which is active in domains related to the PlanetS' activities. This month, we are glad to present the company "Officina Stellare", which is headquartered in Sarcedo (Italy), not far from Venice, in the North East of Italy.

Officina Stellare SpA

Are you using commercial Earth Observation data products? There is a high chance that your data were imaged through an Officina Stellare system.

At Officina Stellare SpA we develop Ground and Space optical systems for, Research, Aerospace & Defense related applications. We deliver turn-key solutions for Astronomy, Space Situational Awareness, Optical Telecommunication, and Ranging&Tracking. Officina Stellare holds the capabilities to manage the full manufacturing and development cycle for optical systems, from small to large apertures (up to 1.6 m in diameter) completely in-house.

Figure 6 – one of Officina Stellare's Optical Ground Station composing the Space Situation Awareness network KASI.

The Company is a SME listed on the Alternative Investment Market (AIM) of Borsa Italiana (Italian public stock market). and it stands out on the international panorama for its bouquet of in-house engineering know-how, optical manufacturing capabilities, facilities and assets that cover all phases of product development and production through its full life cycle. The in-house optical design capabilities and manufacturing facilities allow to execute the full development cycle for space and ground-based optical systems up to 1.6 m diameter.

Our technical offering has been recently complemented through the acquisition of an Adaptive Optics manufacturer, Dynamic Optics Srl.

Since 2009, we've been serving a large variety of international network of research institutes and universities, space agencies, corporate and government players in the aerospace and defence market through commercial and custom products meeting customer requirements and needs.

Figure 7 – Customers of Officina Stellar are welcome not only to see our products, but also to test them in-field.

Our manufacturing and testing capabilities

Officina Stellare is equipped with state-of-the-art manufacturing and integration facilities to best serve customers on a wide range of services, from optical components manufacturing to systems integration. We can manufacture spheric, aspheric, freeform and planar optical components in-house (Optotech MPC-501 and MPC1501 CNC centers) as well as performing in-house light-weighting, grinding and shaping of optical components (DMG Mori 125 CNC center).

Our optics manufacturing and integration capability is completed by state-of-the-art metrology equipment for the verification of our components and assembly production, as well as environmental testing facilities for the verification of defense, aerospace and space products.

Figure 8 – Officina Stellare cleanroom area for integration of space hardware.

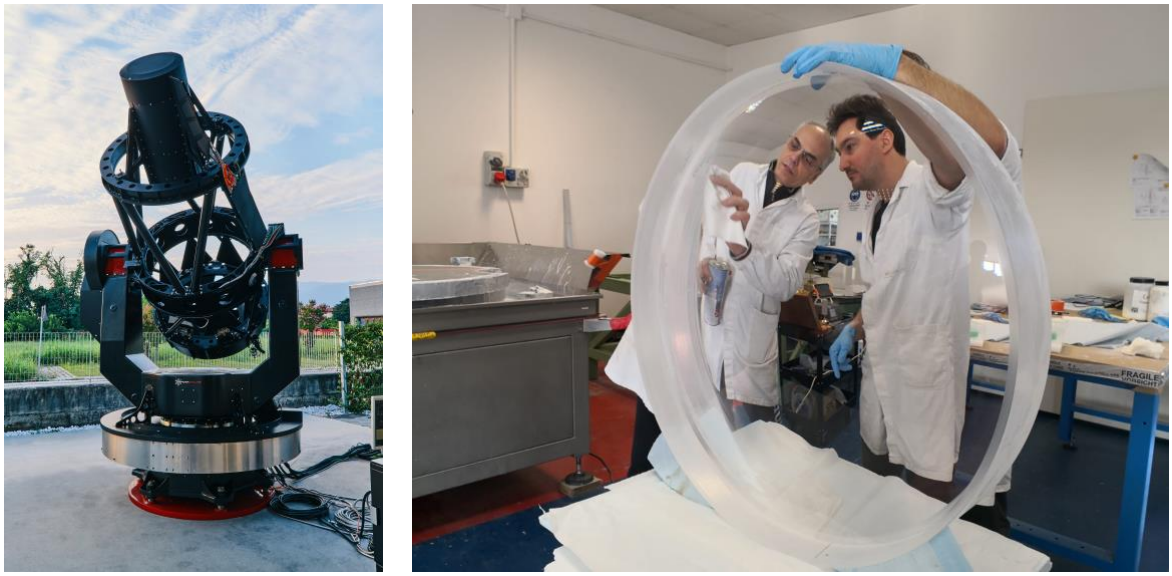

Figure 9 – Landmark products of Officina Stellare are the 1 m prime focus telescope for astronomy installed in Isnello (IT) in 2020 for the Gal Hassin foundation (left) and the 1 m Field Corrector lenses for the ESO VLT MOONS.

Focus on Optical and Quantum Telecommunications

At Officina Stellare we are convinced that ground-to-satellite optical telecommunication will promote access to, and protection of, information, accelerating global digitalization. Why is this important for us? Digitalization and access to information are sustainability enablers. Digital access – see the findings of a 2018 joint report of GESI and AccentureStrategy "Enabling the Global Goals" – has unsuspected positive impacts, by helping decreasing neonatal death or by decreasing gender gap in education.

Officina Stellare is investing to become one of the leading global players in optical and quantum ground-to-satellite telecommunications. The recent acquisition of Dynamic Optics Srl, a well recognized Adaptive Optics manufacturer is only one of the steps undertaken to position itself as a one-stop solution for the establishment of optical telecommunication ground stations.

Figure 10 – 70cm Optical Ground Station Prototype.

Still, the path for economically viable satellite-to-ground optical telecommunication networks at global level requires a joint effort. For this reason, Officina Stellare is already partnering with R&D institutions and industry to develop our joint future, and we are open to discuss further development partnerships.

Young researchers, what about you?

Would you be interested in getting to know Officina Stellare? We have submitted one research topic for a Planet-S NCCR externship related to our development roadmap (see "Knowledge transfer with a short-term project" paragraph). But if think you might have smart ideas or technologies that could help reaching our common goals, contact us!

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Breaking news

Course of Project Management (PM) for PlanetS

The PM course successfully took place in 2020. Initially proposed to PlanetS collaborators as a mixed online-onsite course but, due to the extraordinary Covid-19 situation, it was re-shapes to a 100% online.

The main objective of the course was to give the basic PM methods to participants that can be applied in their current and future research projects. The course followed the format created by Dr Carine Galli Marxer (CUBISMA) based on the Project Management-Cube© (PM-Cube). PM-Cube is a tool empowering users to not only complete their projects but also to find a path to solve problems in PM and specifically developed by the author for researchers in academia. This course was mainly targeted at Postdocs and PhD students, regardless of their field but it was also opened to professors.

The contents of the course were: basics in PM, system analysis, stakeholder analysis, project objectives and deliverables, work breakdown structure, milestones, scheduling (Gantt chart), resource planning, budget, risk analysis, project organization and roles, communication plan, project handbook, controlling and problem-solving, basic people skills, research proposals, success factors in PM.

Quotes from participants:

"It helped me to work on future project and avoid basic mistake in its construction. It also helped me think in more details and have wider vision on the implications of my project."

"I liked the very basic examples on the book. In my previous courses I always struggled to translate the theory to the practice, since the examples were always dealing with very large projects and required a different approach. In this case, I got the grasp on what I was supposed to do from the beginning."

"I liked the different tools presented during the workshop to build up a project and then follow it. A lot of tools are visual and help in the different tasks that can sometimes be difficult to handle without them. I really liked the first part that looks to a project from different view angles, and really allows us to see it globally."

The certificate of attendance at the course was proposed to the participants and provided by Cubisma.


CUBISMA

May 2020

Certificate of attendance

Dr. Firstname Name

has successfully completed the course:

Project management for successful researchers

This online workshop (corresponding to an intensive 3-day course) provided methods and tools in project management to structure, plan, control and successfully lead research projects.

Dr. Carine Galli Marxer

Funded by the Technology and Academic Platforms of PlanetS

Post: https://nccr-planets.ch/blog/2020/06/16/course-of-project-management-pm-for-planets/

Funding programmes of the TP

Permanent call for seed funding

The TP proposes a permanent call for seed funding called “Call for Ideas”. The call promotes activities and strategies that aim at strengthen the knowledge and technology transfer between PlanetS Members, industry, technical universities and other research laboratories.

The call is open to every company, institute or research laboratory, and the rules have been kept as simple and flexible as possible. Would you like to know more about the call? Have a look here.

Knowledge transfer with a short-term project

The TP proposes a programme for PlanetS Members or Associates (PhD-student, postdoc or engineer) who have developed competences or ideas that could be applied to areas outside their specific research activities. The PlanetS TP provides with up to 3 months of financial support (like a salary compensation) in order to pursue your project. Would you like to know more about the opportunity? Have a look here.

The following 3-month projects is available for PlanetS Member or Associate with the company “Officina Stellare”:

- *Title*: Concept of a Lasercom ground station under strong atmospheric turbulence.
- *Description of the activity*: in low latency Lasercom, an aspect currently uncovered is the impact of the atmospheric turbulence. The maximization of the link-time requires to establish a highly reliable link from very low elevation angles (~5° - strong turbulence regime) and to maintain it during the satellite orbit. We want to establish a knowledge base on perturbation from the atmosphere on Lasercom, and on the means to overcome it.
- *Necessary skills needed for the project*: Optical system view and multidisciplinary. Asset is knowledge on any of the followings: Adaptive Optics, Optical fibers, high power laser, rangefinders, atmospheric turbulence.

If you are the company or the research laboratory which would like to propose a project, let us know about your interest and fill out the following: proposal of a short-term project with for the external partner.