Newsletter Interview

ASIX, AN INNOVATIVE X-RAY DETECTOR FOR INDUSTRIAL RESEARCH

Interview with Luca Baldini, researcher at the University of Pisa and INFN, and Principal Investigator of the ASIX project

The Ministry of University and Research (MUR) recently awarded funding worth € 1,531,691.47 to the ASIX project to develop an innovative X-ray detector as part of the first edition of the MUR tender for FISA, the Italian Fund for Applied Sciences. The purpose of the fund is to promote the competitiveness of the national production system by enhancing industrial research and experimental development.

The ASIX project, which will last four years, will be carried out at the INFN Pisa Division and was funded within the Space macro area of FISA. We asked Luca Baldini, researcher at the Department of Physics of the University of Pisa and INFN, to tell us about the goals of the project that he is Principal Investigator of.

What are the goals of the ASIX project?

The goal of the project is to build a new X-ray detector that combines the state-of-the-art of current detectors in terms of spatial and energy resolution but, above all, that can process photons one at a time with a high global counting rate. This would be a great innovation because, by reading one photon at a time, we would be able to eliminate a series of problems. For example, we would no longer be faced with the problem of not being able to distinguish two photons that, arriving at the same point or at points very close in the detector, mix until they are practically indistinguishable. In our future detector, we'll be able to read a very small fraction of the detector matrix, thus managing to avoid the problem that I mentioned.

Our challenge is to do all this at a useful speed for the applications that we have in mind: the goal is to read the signal that reaches the detector in a few microseconds in a sufficiently parallelised architecture.

What led you to envisage this project?

The idea of developing this project came quite naturally. The reading strategy that I described is something that, in Pisa, we have worked on in the last twenty years. This, for example, is the architecture that the detectors of the IXPE focal plane operate with. IXPE is the NASA and Italian Space Agency mission launched in December 2021, dedicated to studying the polarisation of x-rays. After developing the IXPE detectors, which are gas detectors, we thought of using the same type of chip used in this mission for building solid-state detectors. In this case, we'd lose the ability to measure polarisation but, at the same time, we would greatly improve the detector's energy and position resolution and would manage to be much faster. That's how the idea behind ASIX was born.

Where might ASIX detectors be applied?

The fundamental idea of the project is to develop a detector for future space missions in the field of x-rays to do spectroscopy and imaging, or to measure the energy and direction of x-rays. This is an obvious development, since the project has received MUR funding in the area of developing technologies for space.

In any case, this is not the only possible application. At the end of ASIX, we'll have an x-ray detector able to measure energy, position, and arrival time of the photons with extreme precision. Thus, possible applications in material diagnostics or x-ray diffraction immediately come to mind. Diffraction is a technique used for characterising some types of materials, like solid crystallines.

I'm not ruling out medicine, in fact I've already started talking about possible applications in diagnostics with some colleagues here in Pisa. However, this isn't the first application that comes to mind because, in medicine, the speed is usually one of the most important factors and, for how our detector is devised, it is inherently difficult to be very fast with this approach. The biomedical applications, like, for example, micro-computed tomography might, in contrast, competitively exploit the accuracy and richness of information provided by the detector on energy, imaging, and arrival time.

ASIX recently received significant funding from the MUR, in the first edition of the tender related to the Italian Fund for Applied Sciences. In your opinion, why was the project deemed promising?

I believe that the project was funded because we're proposing a valid and innovative idea. Above all, it's because we demonstrated that, in the project's four years, we'll succeed in achieving the predetermined results, building, in the expected time frames, the detector that we have proposed.

Two factors will make this possible. The first is that, in Pisa, we have a small, very cohesive group of people that has demonstrated it's able to autonomously follow all the steps that lead to the implementation and operation of the detector: from the production of sensors, chips, acquisition electronics to the coupling of these elements and switching on the detector. The second element is the experience that we've accumulated in twenty years of work in this sector. Thanks to this, we've managed to document that we have all the expertise I mentioned, and that our project is not speculative and is low risk. Moreover, we're not starting from zero. We already have a chip (which we developed for IXPE) that has the same reading concept as the chip that we'll need for ASIX. Thus, we'll start from that to develop the new project.

It's important to underline that, in my opinion, the project was positively assessed precisely because in our proposal we highlighted the value of the group of people that would work on the project, and not just that of the Principal Investigator.

How will you use the funding obtained? And how will the project be structured?

ASIX is a hardware project, so fairly peculiar nowadays. As a result, the vast majority of funding will be used to design and produce all the elements necessary for the detector: from producing the new solid-state sensor to creating a new reading chip that is compatible with the new sensor, to coupling these two elements.

The project will be divided into two steps. In the first place, we'll develop the new silicon sensor and we'll couple it with a chip that we already have - the one we produced for IXPE. We'll see how it functions and based on the results that we obtain, we'll design the new chip that will be the core of the ASIX project. Clearly, a project of this breadth will also need people and we're thinking of adding one or two new staff to our team.

As Principal Investigator, what difficulties do you expect to have to face over the project's four years?

I'm certain that technical difficulties won't be missing. For example, we may encounter problems when we turn the various components on for the first time and couple them together. In any case, I'm sure that we'll be able to deal with them with a bit of inventiveness, as we always have done.

What results are you expecting to obtain at the end of these four years?

At the end of the project, we'd like to have a project that's of interest to the world of industry: a highly engineered detector, not just a prototype that operates in the laboratory and for the exclusive use of the scientific community. For this reason, right from drafting the proposal for this project, we've been in contact with INFN's Technology Transfer group with the goal of best exploiting the results that we achieve.

In your opinion, what is the recipe for creating successful technologies that can both advance research in fundamental physics and be useful in other areas?

In our case, the culture that we've developed working for years on space projects, with Fermi first and then IXPE, was an important factor. The space sector is highly structured and characterised by very careful formal documentation. Learning to work in this area has helped us to interact with industrial organisations too.

However, I think that one of INFN's strong points is at the base of our success above all – one that I'm very proud of. At INFN, we're still able to "build things". Here in Pisa, for example, we have everything we need to develop a detector: cleanroom, mechanical laboratory, high technology, staff with exceptional technical expertise. So we're able to build, in-house, a system that functions and this lets us significantly cut times and costs.

The development of a project like ASIX proceeds by trial and error. If every time we encountered an error in our system, we had to interact with an external supplier, we would significantly increase costs and times. Our trial and error cycle here lasts one day: today we made a mistake, tomorrow we correct it, and we rebuild a system that works.