PRISMA
Italian network for meteors and atmospheric studies

Daniele Gardiol, Alberto Cellino and Mario Di Martino

INAF – Osservatorio Astrofisico di Torino, Pino Torinese, Italia
gardiol@oato.inaf.it

The aim of the PRISMA project is to develop the Italian participation in a network of European observing facilities whose primary targets are bright meteors (the so-called bolides and fireballs) and the recovery of meteorites. Several all-sky cameras have been recently installed in France (FRIPON project), and we propose to do the same in Italy, interconnecting the Italian network with the French one. Such a network is of great interest for the studies of interplanetary bodies and the dynamical and physical evolution of the population of small bodies of the Solar System and for the studies of collected meteorites. Those eventually recovered will be classified and investigated from the petrologic, genetic and evolutionary points of view, analyzed for their spectral characteristics and compared with known asteroids. The possibility to measure the radioactivity of samples shortly after the fall using gamma-ray spectrometers available in the Osservatorio Astrofisico di Torino laboratories, will allow us to reveal the presence of short-lived cosmogenic radioisotopes. PRISMA is also very suitable for the purposes of atmospheric studies. This includes the statistics of cloud coverage and lightning frequencies, as well as the comparison of the optical depth measured using satellites and PRISMA cameras.

1 Scientific motivations

PRISMA for meteor studies

Meteorites represent samples of Solar System bodies naturally brought to our labs from a variety of different locations. Dynamical studies suggest that most meteorites come from the asteroid main belt, rather than from the closer population of so-called near-Earth asteroids, as commonly believed (Burbine, 2002). However, it is difficult to conclusively identifying possible links between some individual asteroids and some meteorite classes. It is therefore important to develop ground-based observations of meteor phenomena to improve our capability of deriving accurate orbits of the small bodies impacting our planet, to monitor a statistically sufficient number of events to study their origin and possibly to recover "fresh" meteorites. The currently open scientific problems for which we can expect to get some important answers from an extensive work of detection of fireballs and recovery of freshly fallen meteorites include the following questions:

- Where do meteorites come from?
- How many parent bodies of known meteorites can we surely identify?
- Can we better understand the mechanisms of delivery from the asteroid main belt?
- What is the abundance of water possibly delivered to the Earth by different classes of asteroids?
- Are there new classes of meteorites that we have not yet discovered?

The latter question is not academic. Actually, many meteorites presently in our collections are "finds" (as opposed to "falls"), *i.e.* meteorites found a significant amount of time after their fall, often weathered having been exposed to terrestrial alteration, which makes them scientifically less valuable. A way to reliably determining the source regions of meteorites is to witness the falls when they occur. For this purpose, the same event should be detected simultaneously from different directions, in order to be able to derive at the same time the original heliocentric orbit of the impactor and the site of fall of possible meteorites produced by the event. This has been the goal inspiring many observation networks, such as the European Fireball Network in middle-Europe, the NASA All-sky Fireball Network[1] in the USA, and a similar one in Australia[2]. In this context a new generation of detectors optimized for the studies of bright meteors and the establishment of a much wider network of automatic observing stations, with a grid spacing of 60–100 km, operating 24 hours per day, can allow us to obtain a major improvement. The French community (Colas, 2012; Colas 2014) has recently accomplished the first steps forward to start this enterprise (FRIPON, Fireball Recovery and Inter Planetary matter Observation Network)[3]. Doing the same in Italy would give a decisive contribution to a full European network.

PRISMA for atmospheric studies

The inherently multi-disciplinary nature of the project makes it appealing to a wide scientific community. In the field of atmospheric science, cloudiness forecasting is a challenge for numerical models. To validate current numerical models of cloud cover it is essential to compare simulations with large amounts of measurements. Data detected by all-sky cameras are useful for this and other branches of atmospheric physics (Arbizu-Barrena, 2015). In this respect PRISMA is

[1] http://fireballs.ndc.nasa.gov
[2] http://fireballsinthesky.com.au
[3] http://www.fripon.org

complementary to traditional weather ground networks, such as the ones operated by Agenzia Regionale Per l'Ambiente (ARPA), Local Governments and other Institutions. The continuous sky monitoring by PRISMA can provide much additional information on the status of the atmosphere, including also statistics of lightning. Finally, the sky's polarization is sensitive to the aerosol properties in the sky and it is an ideal complementary measurement device in combination with aerosol optical depth measurements.

Figure 1 – Meteorite falls and finds on italian soil since the beginning of times.

2 Project description

Project description

The project consists of the installation of a network of fireball detectors. We plan to use the same typology of detectors adopted in France in the framework of the FRIPON project, which started operations in early 2016. These detectors are cutting edge technology. The goal of PRISMA is to develop a full Italian network, suitably covering the national territory. The planned camera grid distribution will make it possible to derive the orbital paths of the impactors with an accuracy of the order of 200 meters. The first nodes of the grid will be hosted in North-Western Italy, to be easily interconnected with the FRIPON network. The fireball detectors have a 100% duty cycle, as bright fireballs can be detected even in daytime. The cameras operate at the wavelengths of visible light, with an estimated visual magnitude limit as faint as m_v = 2-3. Each camera is connected to the internet, and will acquire data at a maximum frequency of 30 frames per second, with recording starting in case of detection of a bright moving source, according to triggering conditions defined by the automatic software of data processing. Every 10 minutes the camera takes a longer single exposure for astrometric calibration and other purposes, including public outreach and further scientific processing, such as for atmosphere studies. Detections and long exposures are automatically transmitted to the data processing center where they are saved and stored.

Table 1 – Meteorite falls and finds on Italian soil.

Name	Region	Year	
Albareto	Emilia-Romagna	1766	Fall
Alessandria	Piemonte	1860	Fall
Alfianello	Lombardia	1883	Fall
Assisi	Umbria	1886	Fall
Bagnone	Toscana	1904	Find
Barbianello	Lombardia	1960	Find
Barcis	Friuli V.G.	1950	Find
Borgo S.Donino	Emilia-Romagna	1808	Fall
Castel Berardenga	Toscana	1791	Fall
Castenaso	Emilia-Romagna	2003	Find
Castiglione d. Lago	Umbria	1970	Find
Castrovillari	Calabria	1583	Fall
Cereseto	Piemonte	1840	Fall
Collescipoli	Umbria	1890	Fall
Fermo	Marche	1996	Fall
Girgenti	Sicilia	1853	Fall
Lago Valscura	Piemonte	1995	Find
Masua	Sardegna	1967	Find
Messina	Sicilia	1955	Fall
Mineo	Sicilia	1826	Fall
Monte Milone	Marche	1846	Fall
Motta dei Conti	Piemonte	1868	Fall
Narni	Umbria	921	Fall
Noventa Vicentina	Veneto	1971	Fall
Orvinio	Lazio	1872	Fall
Patti	Sicilia	1922	Fall
Piancaldoli	Toscana	1968	Fall
Renazzo	Emilia-Romagna	1824	Fall
Rivolta de' Bassi	Lombardia	1491	Fall
San Michele	Marche	2002	Fall
Siena	Toscana	1794	Fall
Sinnai	Sardegna	1956	Fall
Tessera	Veneto	2000	Fall
Torino	Piemonte	1988	Fall
Trenzano	Lombardia	1856	Fall
Vago	Veneto	1668	Fall
Valdinizza	Lombardia	1903	Fall
Valdinoce	Emilia-Romagna	1496	Fall
Vigarano	Emilia-Romagna	1910	Fall

Expected rates

Over Italy we can expect to have about 1 bright meteor every 48 hours. Among these events, according to current estimates (Halliday, 1996), we can expect, in a country as extended as Italy, the recovery rate of meteorites to be somewhere between 2 and 10 per year, these numbers depending critically on whether the corresponding fireball is seen or not. The actual recovery fraction has been very low in the past (see *Table 1* for a complete list of confirmed Italian meteorites, including the very recent confirmation of Castiglione del Lago, and *Figure 1* for a geographical distribution), only less than 40 meteorites have been recovered (and among them only 32 are falls) since the beginning of times. The proposed fireball network is expected to produce a significant improvement.

Sites choice

The choice of the sites hosting the network nodes will be done taking into account the strong community of Italian amateur astronomers that operate several small observing stations located in very convenient locations, and our intention to deeply involve secondary schools. This is an excellent opportunity for several amateur teams and schools to work and collaborate with professional researchers following the citizen science and audience engagement philosophies. *Figure 2* shows a preliminary assessment of possible candidate sites in Northern Italy.

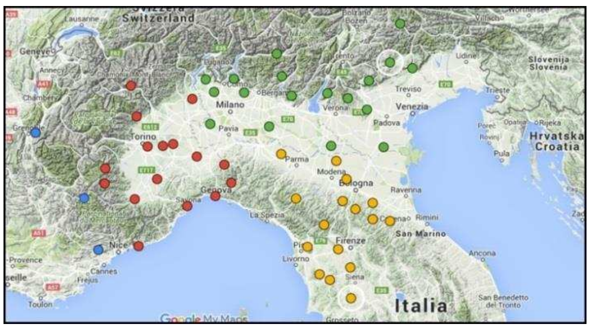

Figure 2 – Candidate sites for node deployment in Northern Italy. On the left the three FRIPON cameras already operating in France.

Participating institutes

PRISMA is a project of the Italian National Institute for Astrophysics (INAF), led by INAF-Osservatorio Astrofisico di Torino. Other INAF participating structures are: INAF-Osservatorio Astrofisico di Catania, INAF-Osservatorio Astronomico di Trieste, INAF-Osservatorio Astronomico di Bologna, INAF-Istituto di Radio Astronomia (with the Medicina and Noto sites), INAF-Osservatorio Astronomico di Padova and INAF-IAPS in Rome. Collaborations include regional observatories such as Osservatorio Regionale della Valle d'Aosta[4] (OAVdA) and Osservatorio Polifunzionale del Chianti (OPC, Florence)[5], as well as several amateur astronomer groups, some of which are already part of small meteor tracking networks. For the atmospheric studies we rely on the Italian Meteorological Society[6] and on the Agenzia Regionale per l'Ambiente[7], the former being in particular interested in improving the meteorological data on five historical monitoring stations for which long time historical data record exist. Strong collaboration is also under development with universities, in particular Università di Torino, Università di Firenze and Università di Padova, and with the Consiglio Nazionale delle Ricerche (CNR)[8]. We are developing our outreach activities in contact with Infini.to (Museum of Astronomy and Space – Planetarium of Torino)[9] and with Museo Regionale di Scienze Naturali[10] and Museo Craveri[11], located in Piedmont, and with Parco Astronomico delle Madonie (Sicily), that soon will begin the activities. *Figure 3* shows the geographical distribution of the currently involved institutes.

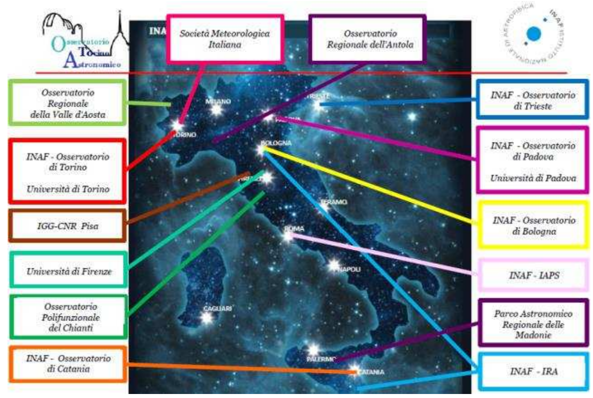

Figure 3 – Geographical distribution of the PRISMA participating institutes.

Strategy for network funding and deployment

We are currently looking for funds to realize the project. The natural funder for a scientific project is the Italian Ministry for Education, University and Research (MIUR)[12], that operates in several ways. The PRIN (Progetti di Ricerca di Interesse Nazionale) is a call that is issued usually once a year, for which we already submit a proposal. Another interesting call is PLS (Piano Lauree Scientifiche)[13], an educational program which aim is to increase the number of undergraduate students choosing scientific studies in Universities, such as Mathematics or Physics, that should be issued in late summer. A second channel is represented by private bank foundations, as most of them are interested to support scientific research (although mainly in the medical area) and, more interesting for us, educational activities in schools. The bigger bank foundations operate at regional or super-regional level, the smaller ones instead focus their activities in a small territory such as the neighborhood of a single city. Therefore, following this second channel, it is very unlikely to get the entire network funded. We are currently proposing to bank foundations to support regional sub-networks or even single nodes, following a modular approach for the network implementation, so that the smaller sub-networks can be later on integrated to form a whole Italian network.

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[4] http://www.oavda.it
[5] http://www.osservatoriodelchianti.it
[6] http://www.nimbus.it
[7] http://www.arpa.piemonte.gov.it
[8] http://www.cnr.it
[9] http://www.planetarioditorino.it
[10] http://www.mrsntorino.it
[11] http://www.museocraveri.it
[12] http://www.istruzione.it
[13] https://laureescientifiche.miur.it

Meteorites analysis facilities

At INAF- Osservatorio Astrofisico di Torino Monte dei Cappuccini laboratory we perform gamma spectrum analysis of meteorite samples (Colombetti, 2013). The HyperPure Germanium detector (see *Figure 4*) allows determining very low emission rates of cosmogenic radioisotopes. A second detector, a NaI scintillator, is used to work in coincidence in order to suppress unwanted signal and noise. Analysis of very recently fallen meteorites (few days) is able to determine the activity of short-lived cosmogenic isotopes, as it was done for the Torino meteorite (Bhandari, 1988). The University of Firenze runs a laboratory for Electronic Microscopy and Micro Analysis (MEMA)[14] where meteorite samples are normally classified after chemical analysis with a Scanning Electron Microscope (SEM) using the Energy Distribution Spectrometry (EDS) technique.

Figure 4 – A detail of the detector of the Monte dei Cappuccini laboratories in Torino.

3 Conclusion

We are just at the beginning of the project, we have already installed a FRIPON camera on the rooftop of our Observatory in Pino Torinese and started acquisition. Currently this camera is connected to the French network, but if we succeed in getting the required funds we will start deploying the Italian network. A web site[15] dedicated to the project is under construction but already accessible.

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[14] http://www.mema.unifi.it
[15] http://prissma.oato.inaf.it