

La rete PRISMA

Stato e Prospettive

D. Barghini, S. Bertocco, A. Carbognani, M. Di Carlo, M. Di Martino, C. Falco, D. Gardiol, M. Morelli, G. Pratesi, W. Riva, G. M. Stirpe, C. Volpicelli, and the PRISMA team

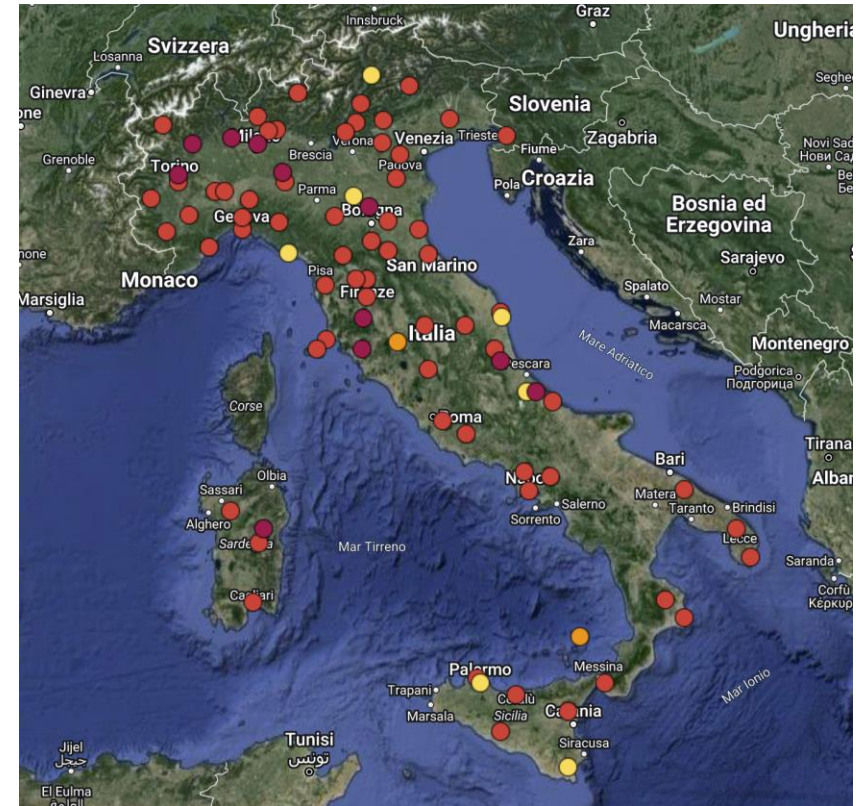
INAF
ISTITUTO NAZIONALE
DI ASTROFISICA



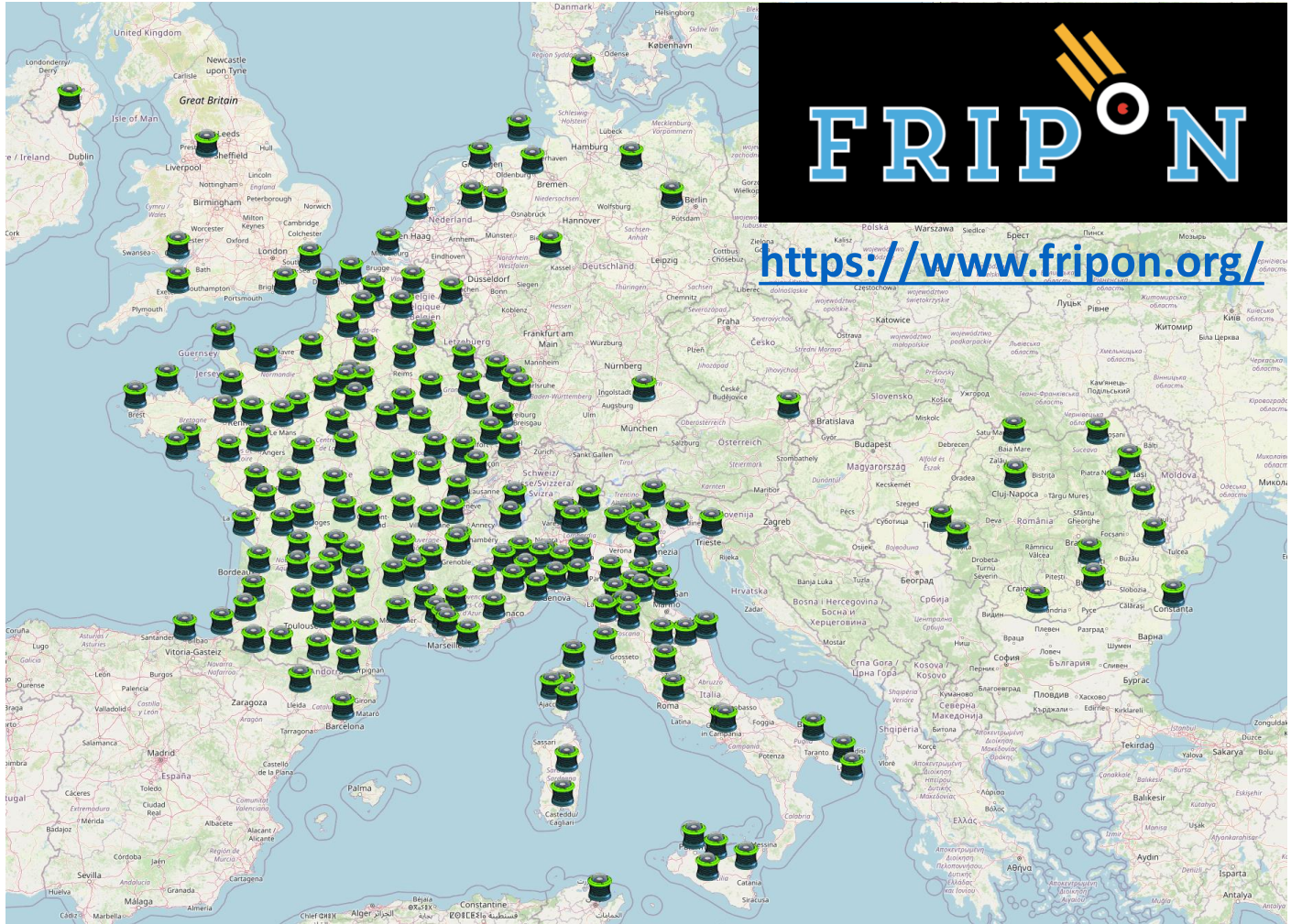
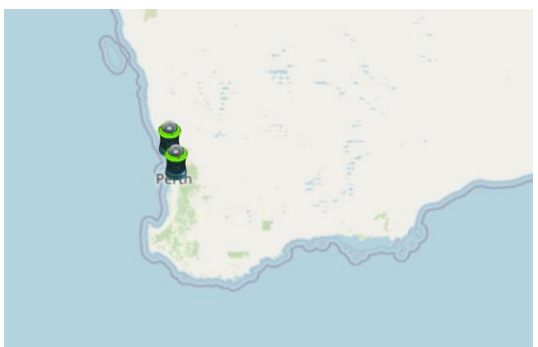
The PRISMA network

Prima **Rete Italiana** per la **Sorveglianza** sistematica di **Meteor**e e **Atmosfera***
i.e. First Italian Network for the Systematic Surveillance of Meteors and Atmosphere

- Deploy **70 stations** equipped with all-sky cameras for a continuous monitoring of the Italian skies
- Started in 2017 and currently **led by INAF** in collaboration with many Italian universities, professional/amateur observatories, schools, associations...
- Partnered with the European project **FRIPON** (<https://www.fripon.org/>)



PRISMA and FRIPON

The FRIPON logo, featuring the word "FRIPON" in large, blue, sans-serif capital letters. Above the letter "O" is a stylized graphic consisting of three horizontal lines of increasing length from left to right, with a small red dot at the end of the longest line. Below the logo is the website URL <https://www.fripon.org/> in blue text.

The PRISMA/FRIPON station

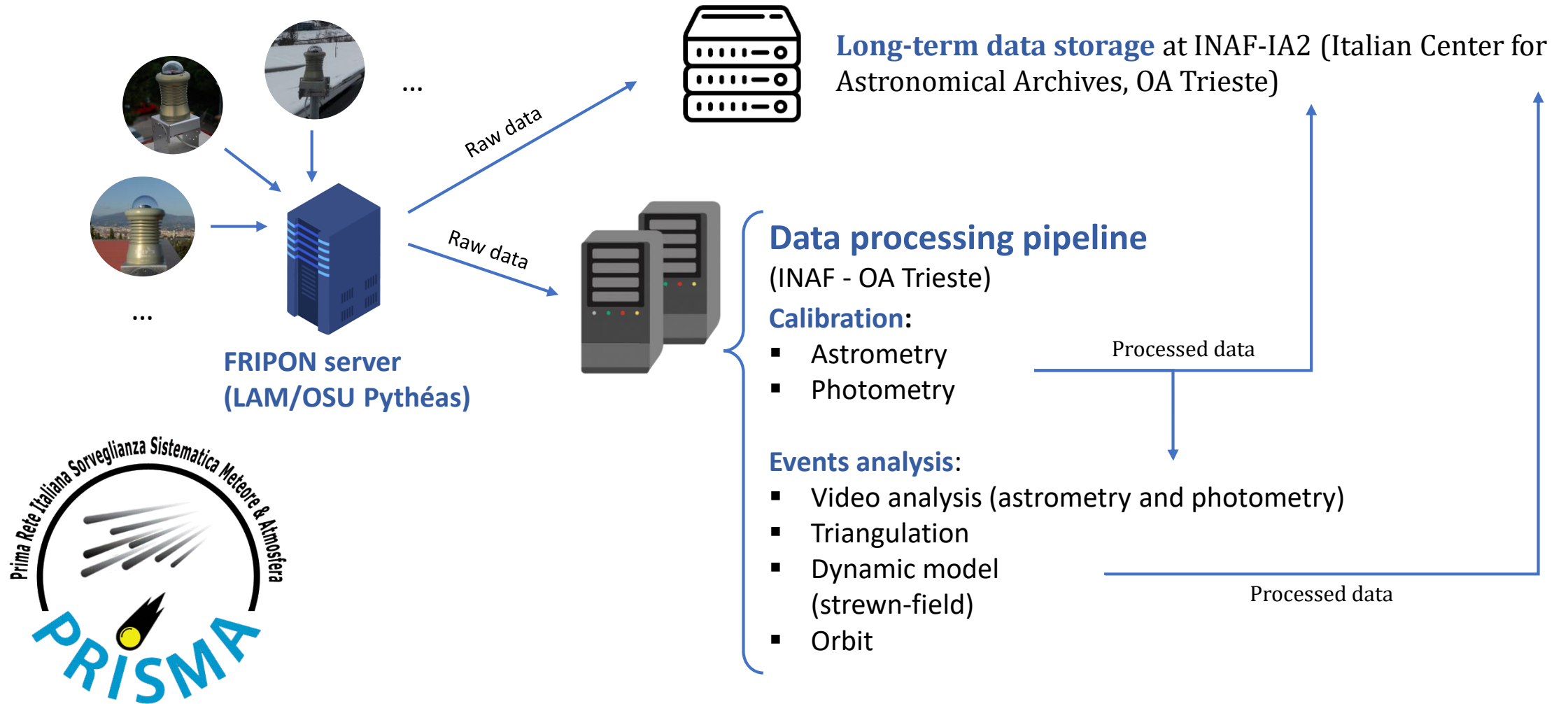


- All-sky camera **operated at 30 Hz** to capture meteors with a suitable sampling rate
- Meteor acquisition triggered by a dedicated software named **FreeTure** (<https://github.com/cmarmo/freeture>)
- A central server combine **detections of the same meteor** in events
- Every 10 minute the camera performs a 5 s exposure (**capture**) for calibration purposes

PRISMA dataset:

- **Captures:** ~140 / day (x 60 cameras, x 5 years)
- **Events:** ~2000 since 2016 (multiple events from ≥ 2 cameras)

PRISMA data flow



FRIPON data release

Multiple event search

fireball.fripon.org/list_multiple.php

FRIPON Fireball Recovery and InterPlanetary Observation Network Database web frontend

Guest mode • Sign in

CREDITS STATIONS SINGLE EVENTS MULTIPLE EVENTS CAPTURE MOSAIC MAPS DATA RELEASE FULL DATA ACCESS

FRIPON Multiple event search

[+ Data content details](#)
[+ How to use this table?](#)
[+ Legend](#)

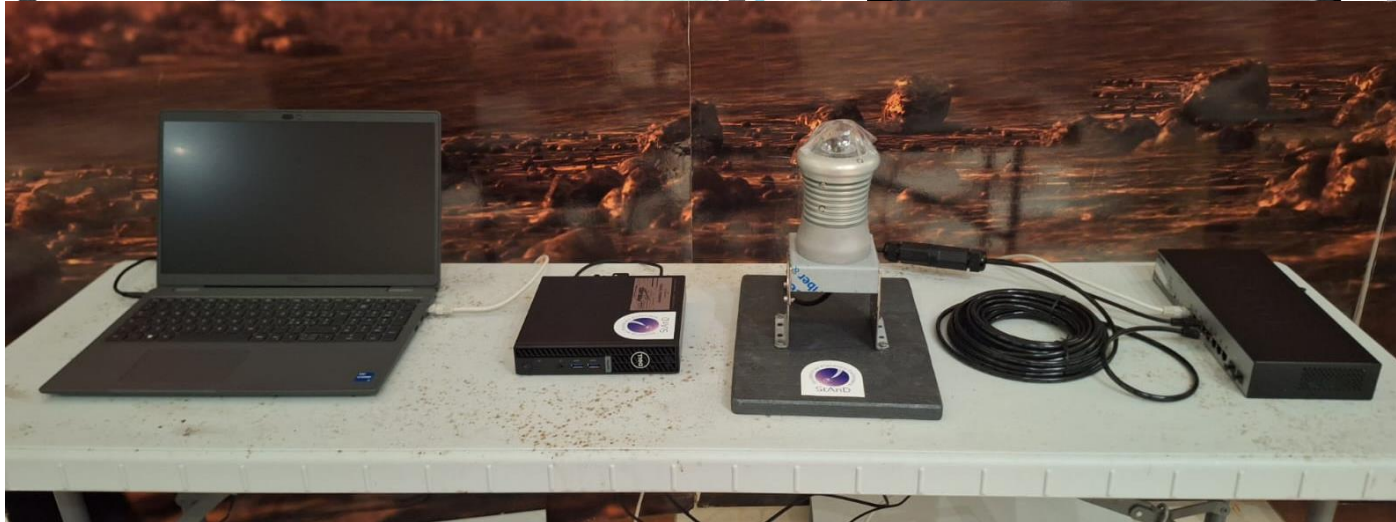
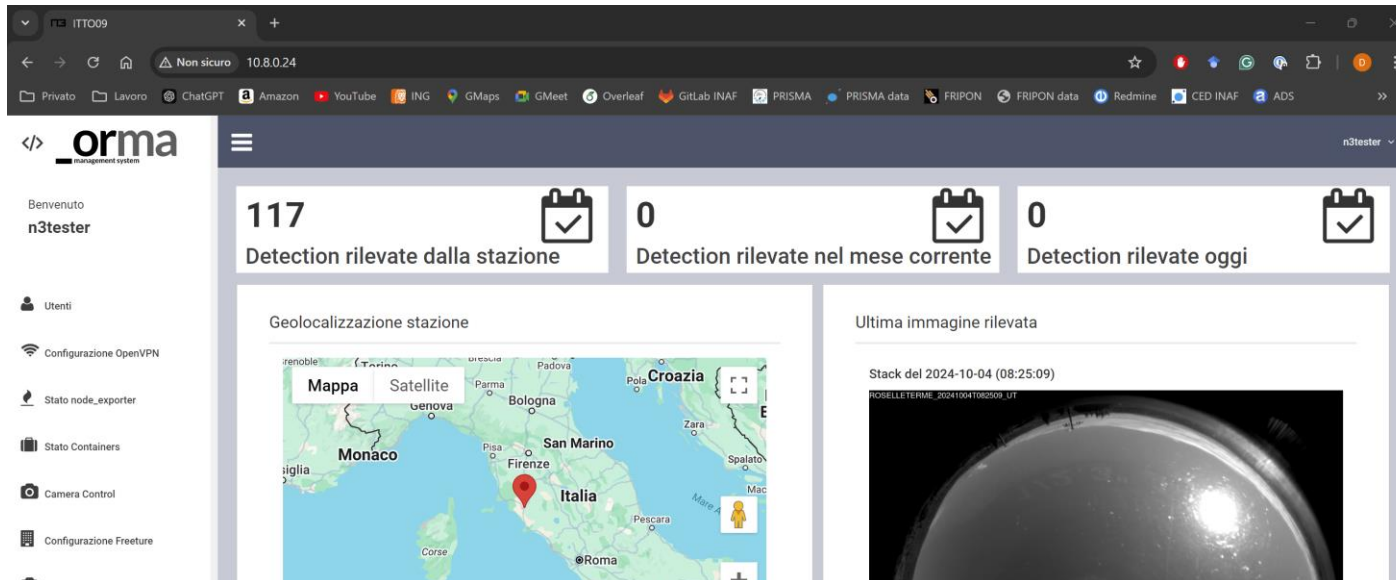
Excel Print Copy CSV PDF ID Event date Count Status Radio head echo Radio tail echo Station involved

Showing 1 to 50 of 10,160 entries

Previous 1 2 3 4 5 ... 204 Next

ID	Event date	Count	Status	Radio head echo	Radio tail echo	Station involved
23677	2024-10-04 01:56:42	2	Confirmed	Pending	Pending	CLRM01-SantiagoDeChile ARMZ01-Mendoza
23676	2024-10-04 00:33:42	6	Confirmed	Pending	Pending	FRPA03-OHP FRPA07-Lesangles FRPA01-Marseille FRPA05-Caussols FRPA06-Hyeres FRLR04-LeBleymard
23675	2024-10-04 00:30:15	2	Confirmed	Pending	Pending	ENSE03-Eastbourne ENSE05-Cowes
23674	2024-10-03 23:00:28	4	Confirmed	Pending	Pending	CAQC01-Montreal CAQC02-ValSaintFrancois

New version of the PRISMA station



New PRISMA station developed by N-3 s.r.l. in collaboration with INAF – OATo Upgraded chip (CMOS), optics, new mini-PC and network switch

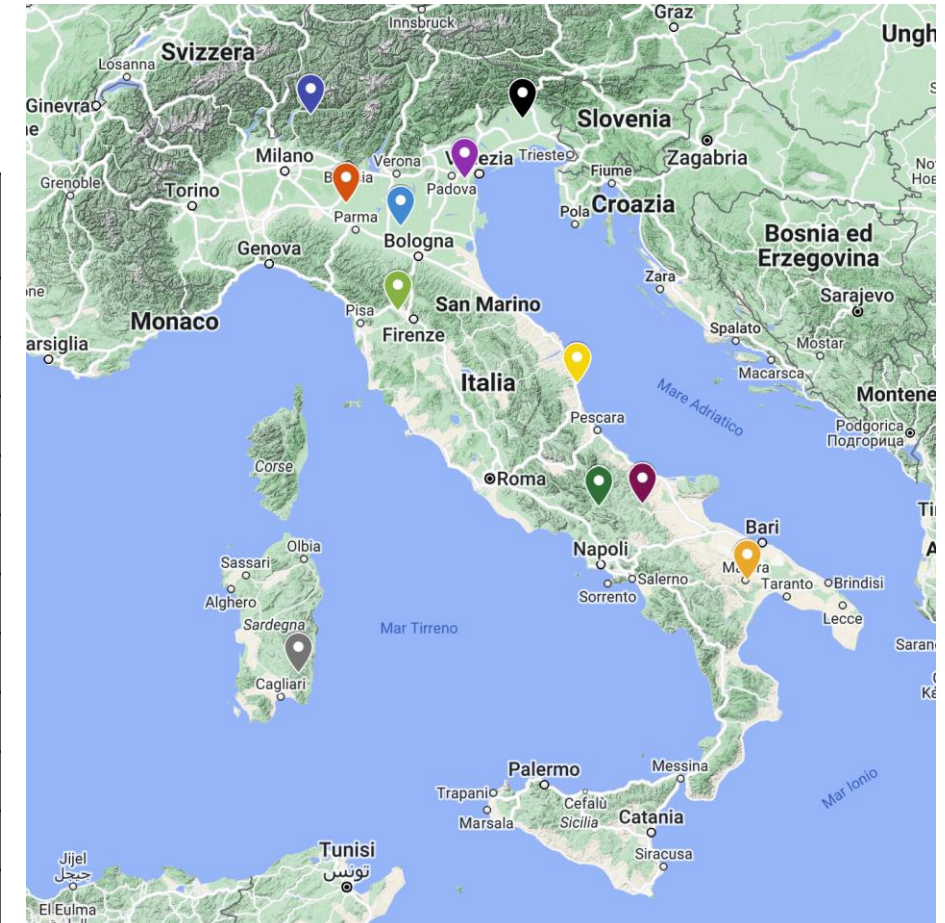
- User-friendly interface developed by N-3
- Migrating towards a fully Italian and independent network
- Already ~10 station deployed and linked to the PRISMA server in INAF – OATs, together with StAnD cameras in Europe



Potential meteorite fall recorded by PRISMA

- PRISMA has the potential to detect fireballs of **apparent magnitude $m < 0$**
- This corresponds to a meteoroid **size greater than 1 cm** and **mass above few grams**
- Estimated **1 meteorite dropping fireball per year over Italy**. So far, this estimation is more or less consistent

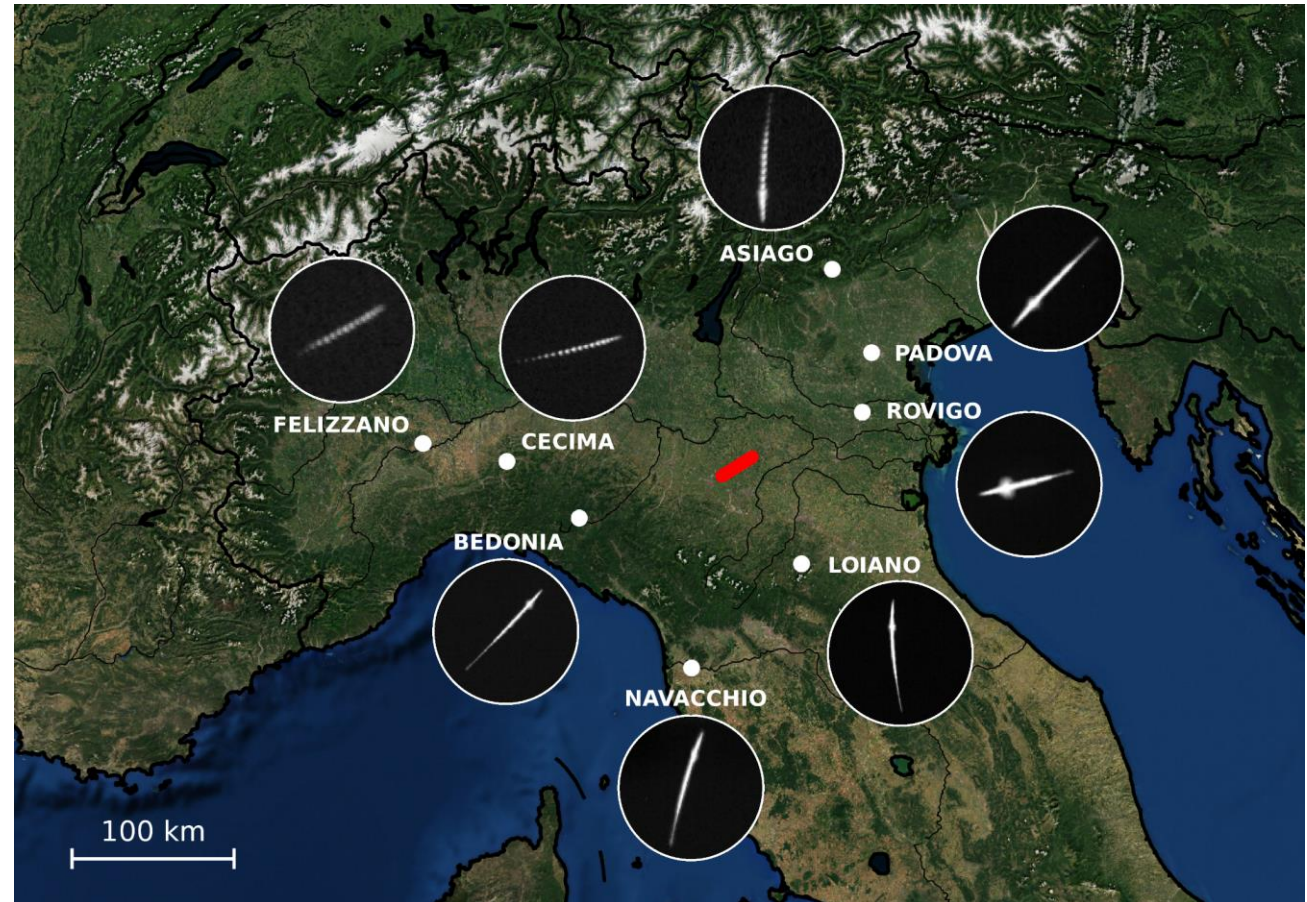
Date	Time UT	Region of fall	N° of cams	Speed [km/s]	Inclin. [deg]	Init. mass [kg]	Fin. mass [kg]
30/05/2017	21:09:26	Padova	2	15.5	29°	4 – 12	0.2 – 4
22/08/2018	21:37:28	Sondrio	6	17.9	72°	2 – 5	0.4 – 1.2
01/01/2020	18:26:54	Modena	8	12.2	68°	10 – 40	0.5 – 1.5
15/03/2021	19:57:32	Isernia	1	14.7	84°	~ 2	~ 1
01/10/2021	01:04:57	Pistoia	8	16.0	31°	3 – 8	0.01 – 0.1
05/03/2022	18:55:52	Ascoli P.	10	15.5	17°	10 – 90	0.3 – 1.5
14/02/2023	17:58:29	Matera	3	16.4	57°	6 – 22	0.1 – 0.5
23/05/2023	22:21:04	Cremona	10	15.4	35°	3 – 10	0.1 – 3
05/08/2023	20:21:26	Campobasso	2	13.8	63°	20 - 100	0.1 – 2.5
08/10/2023	21:53:30	Cagliari	2	16.5	78°	0.2 – 1	0.08 – 0.2
23/07/2024	19:31:03	Pordenone	3	14.1	29°	1.5 – 5	0.05 – 4



The 2020 New Year's Eve Bolide

- Captured by **eight PRISMA cameras** on 01/01/2020 at 18:26:52.9 – 58.5 UT (5.6 s)
- The meteoroid entered the atmosphere at **$12.8 \pm 0.2 \text{ km s}^{-1}$** with an inclination angle of about **68°** w.r.t. the ground
- The bolide shone from 76 km to 22 km altitude and reached **-9.5 abs. magnitude**

		Beginning	Terminal
Time (UT)	t	18:26:52.9	18:26:58.5
Height (km)	h	75.9 ± 0.2	21.5 ± 0.1
Latitude (N)	ϕ	$44^\circ 44' 03'' \pm 7''$	$44^\circ 50' 24'' \pm 7''$
Longitude (E)	λ	$10^\circ 43' 09'' \pm 7''$	$10^\circ 57' 25'' \pm 7''$
Velocity (km s^{-1})	v	12.2 ± 0.2	4.0 ± 0.2
Mass-section ratio (kg m^{-2})	D	280 ± 20	210 ± 20
Mass (kg)	m	3.5 ± 0.8	1.5 ± 0.4
Diameter (m)	d	0.13 ± 0.01	0.09 ± 0.01
Luminous path-length (km)	L		59
Duration (s)	T		5.6
Trajectory inclination ($^\circ$)	T_i		68.4 ± 0.3
Trajectory azimuth ($^\circ$)	az		238.1 ± 0.2
Min. absolute magnitude	M		$-9.5 \pm 0.5 @ 32.6 \text{ km}$
Pre-atmospheric velocity (km s^{-1})	v_∞		12.8 ± 0.2
Ablation coefficient ($\text{s}^2 \text{ km}^{-2}$)	σ		0.012 ± 0.003
Max. dynamic pressure (MPa)	P_{max}		$1.0 \pm 0.3 @ 28.2 \text{ km}$
Impact Energy (T TNT)	E		0.07 ± 0.02

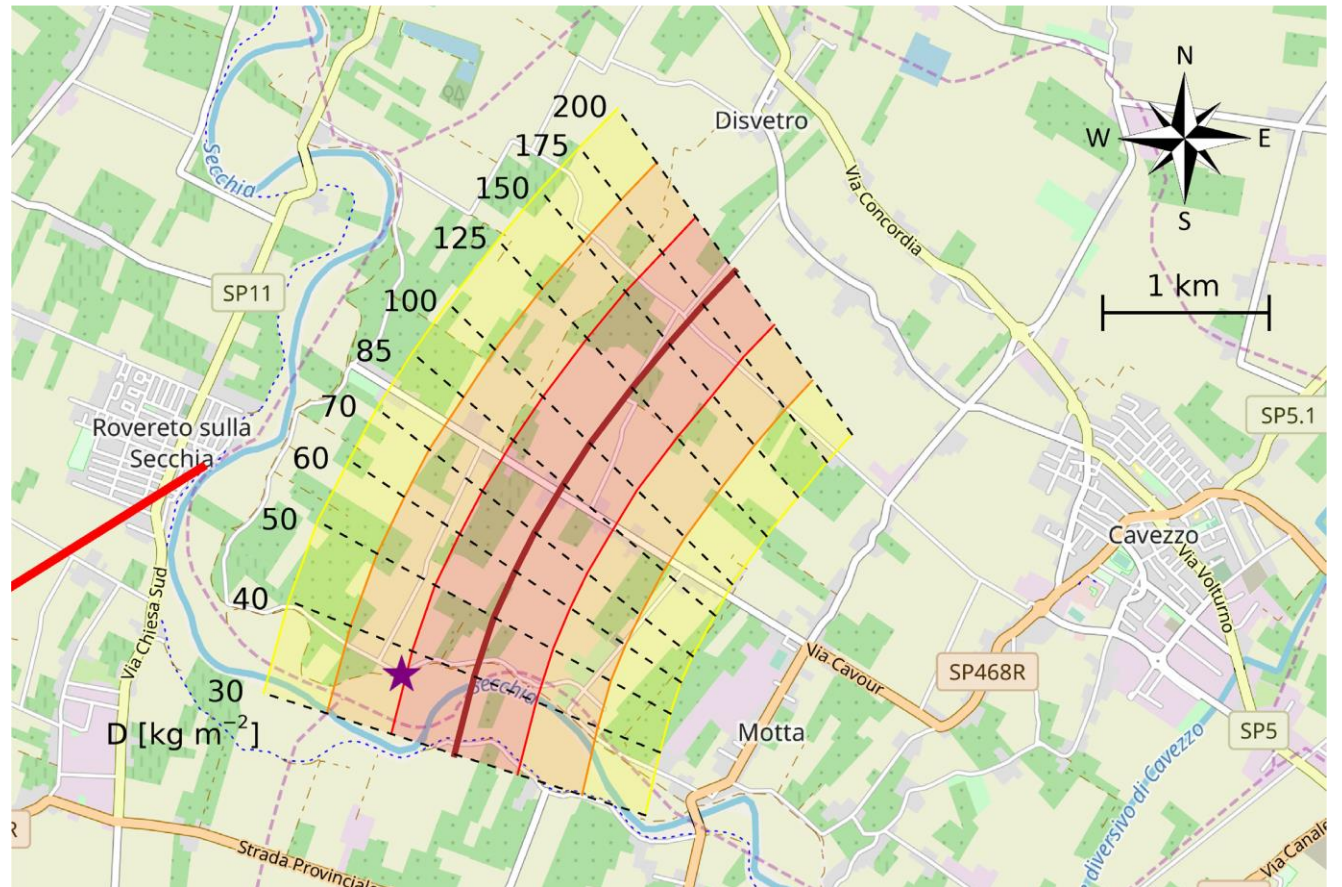
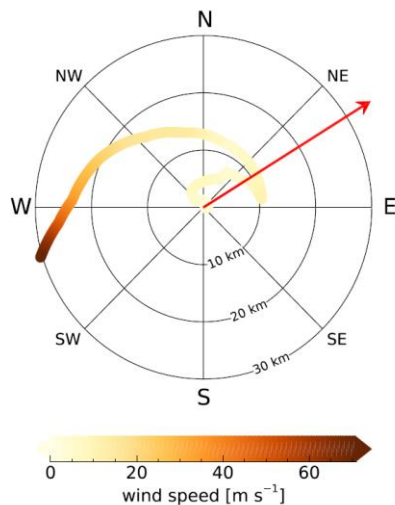


The Cavezzo meteorite finding – strewn field

- A **strewn field of about 2 km x 3 km** was identified from trajectory, dynamics and dark-flight computation from PRISMA observations
- Due to intense winds of that night, the area of probable fall was shifted to East with respect to ground trajectory
- PRISMA informed and reached the attention of the local population by press releases and local media coverage

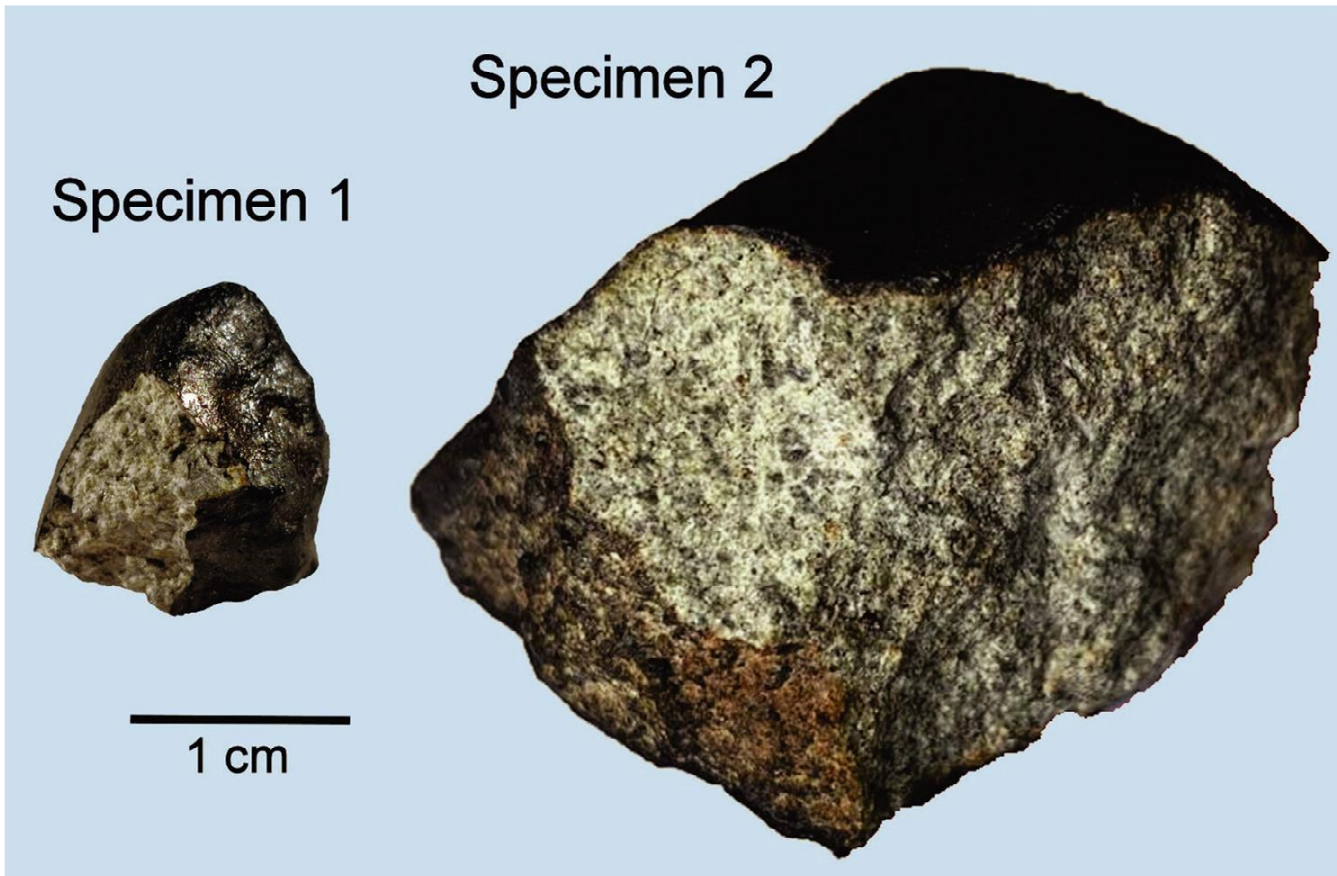
For details about the Cavezzo meteorite recovery:

Gardiol D., Barghini D. et al., "Cavezzo, the first Italian meteorite recovered by the PRISMA fireball network. Orbit, trajectory, and strewn-field", *Mon. Not. R. Astron. Soc.*, **2021**, 501, 1215–1227



The Cavezzo meteorite finding

- Two meteorite pieces were recovered by a local inhabitant, Mr. Davide Gaddi, **less than three days after the fall** on the afternoon of 04/01/2020 in the municipality of Cavezzo (MO)

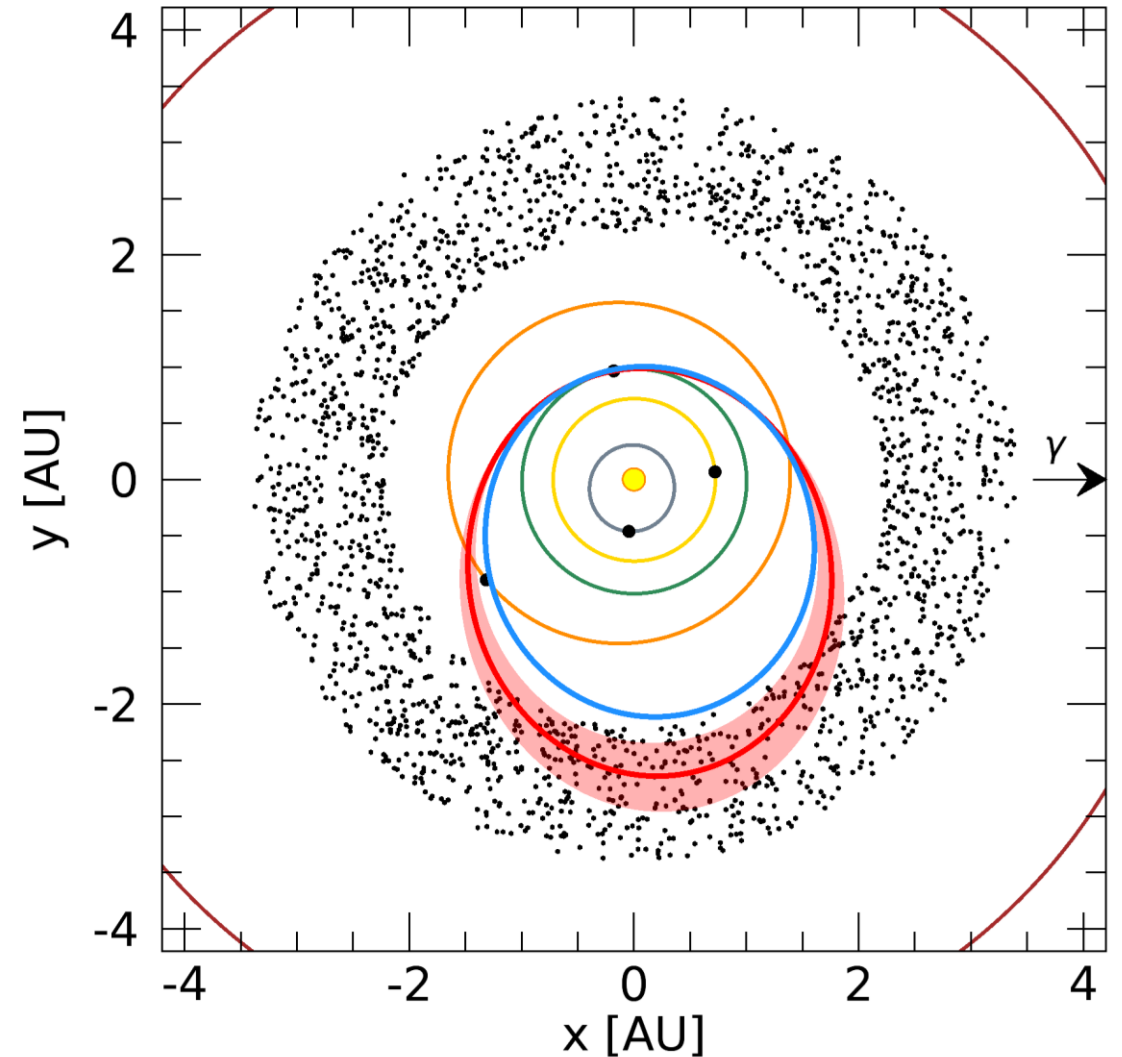


- The coordinates of the finding are $44^{\circ}49'43''.7$ N, $10^{\circ}58'19''.5$ E
- The two specimens weigh 3.12 g (**F1**) and 52.19 g (**F2**) respectively
- Due to the morphology of the two recovered pieces, other fragments should have been found on site, but further campaigns were unsuccessful up until now

The orbit of the Cavezzo meteoroid

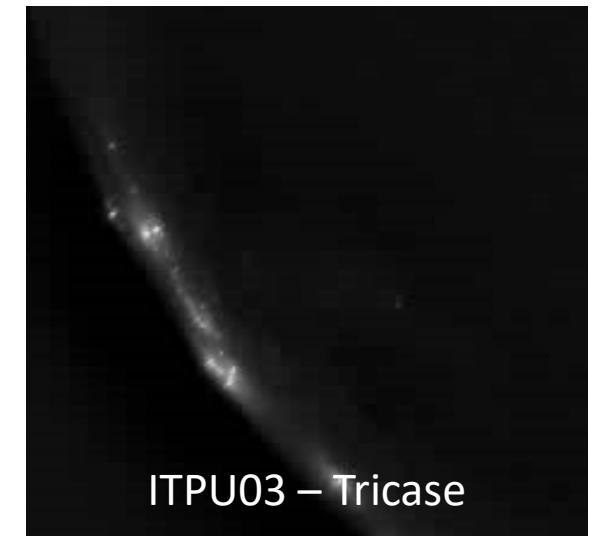
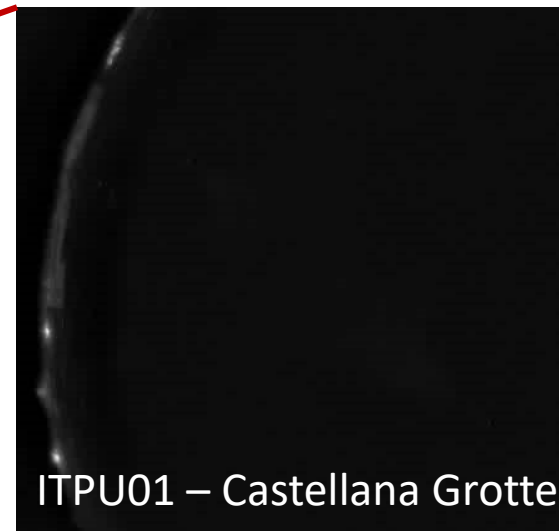
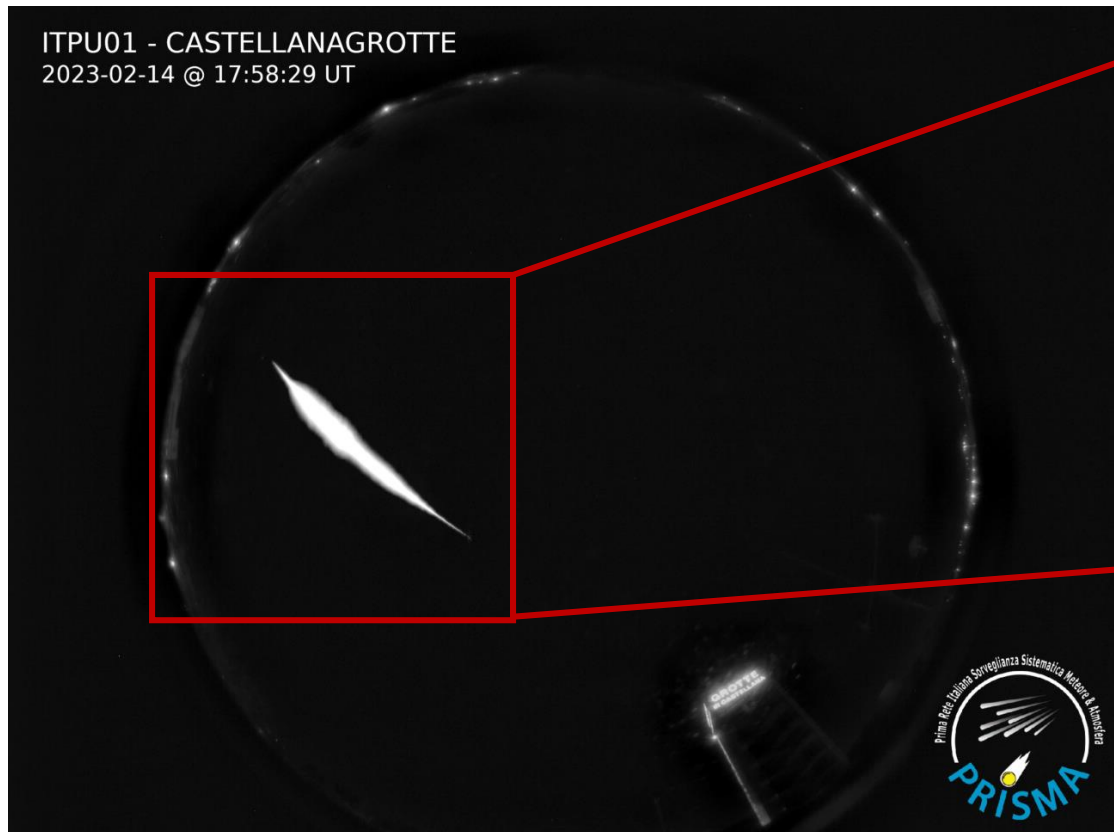
- From PRISMA observations, it was also possible to reconstruct the pre-atmospheric orbit of Cavezzo
- Compatible with the orbit of one object only among currently known NEOs: **2013 VC₁₀**
- It is an **Apollo type asteroid** observed only for 54 days in 2013 of +24.8^H abs. mag. (10-meters sized) and ~2 y orbital period

Quantity	Cavezzo	2013 VC ₁₀
Epoch	J2000	MJD59000
Semimajor axis (AU)	1.82 ± 0.22	1.56622
Eccentricity	0.460 ± 0.063	0.365295
Inclination (°)	4.0 ± 1.6	2.044
Long. of ascending node (°)	280.52311 ± 0.00001	224.068
Argument of Perihelion (°)	179.2 ± 4.8	240.264
Longitude of Perihelion (°)	99.7 ± 4.8	104.332
Perihelion passage (JD)	2458849.6 ± 0.5	2458808.1
Perihelion distance (AU)	0.983 ± 0.001	0.9941
Aphelion distance (AU)	2.66 ± 0.41	2.1383



2023 Valentine's Day bolide

An event similar to the Cavezzo bolide occurred on **Saint's Valentine Day of 2023** at 17:58:29 UT over the Puglia and Basilicata regions and was **recorded by three PRISMA cameras**



2023 Valentine's Day bolide – observation results

The bolide was detected from a **starting altitude of 85.5 ± 0.1 km** at an initial speed of 16.3 ± 0.1 km/s.

It traversed the atmosphere for about 5.3 s at an inclination angle of **$56.7 \pm 0.3^\circ$** , for a total trajectory length of 75.0 ± 0.1 km, **arriving from the NNE direction** and travelling towards SSW with an azimuth angle of $24.3 \pm 0.1^\circ$

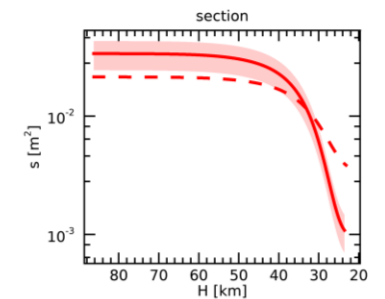
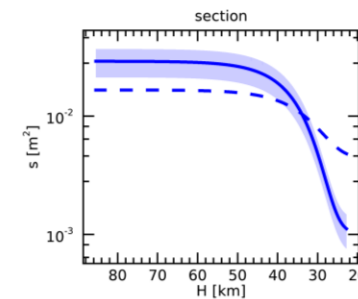
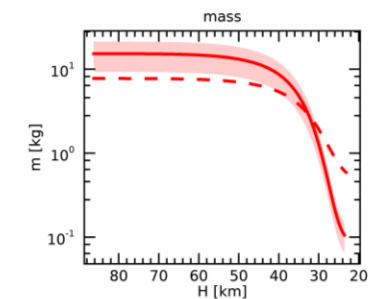
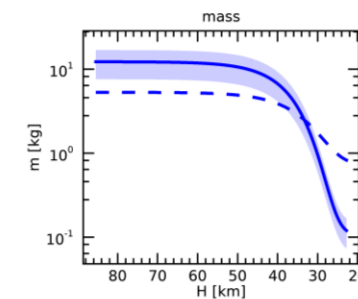
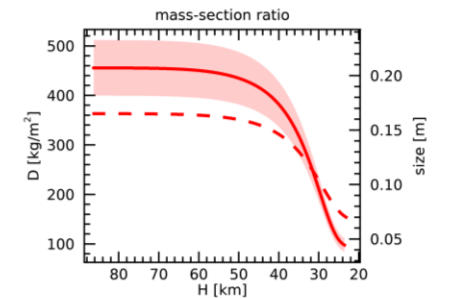
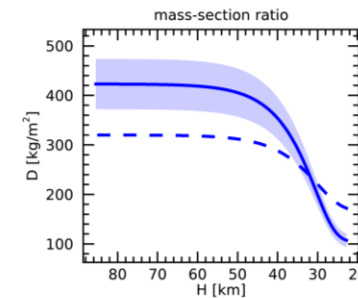
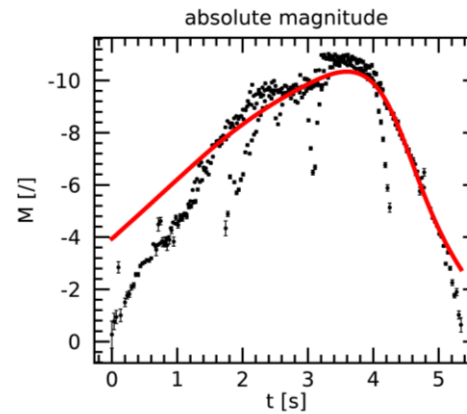
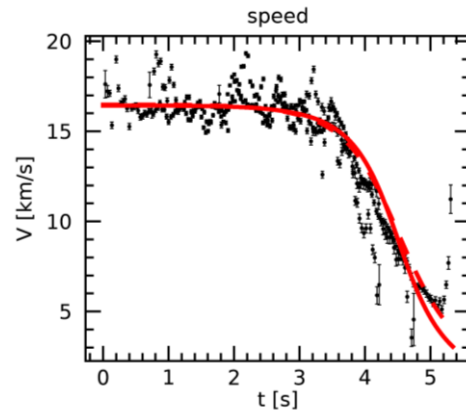
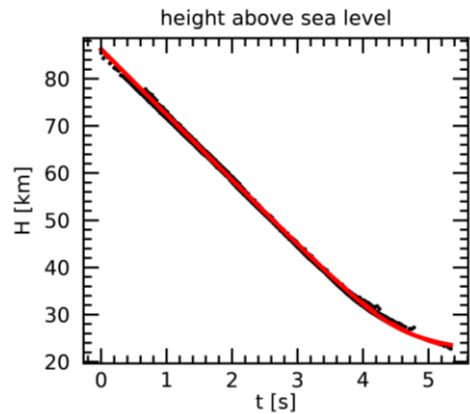
Projected on the ground, its trajectory began SW of Bari and ended NE of Matera, where the visible flight **terminated at an altitude of 22.8 ± 0.1 km**, while the meteoroid was travelling at a low speed of 3 ± 1 km/s.

Triangulation

			Beginning	Ending
Time	t	(UT)	17:58:29.54	17:58:34.89
Latitude	ϕ	[deg N]	41.0893 ± 0.0006	40.7496 ± 0.0006
Longitude	λ	[deg E]	16.8053 ± 0.0004	16.5996 ± 0.0004
Height	H	[km]	85.5 ± 0.1	22.8 ± 0.1
Speed	V	[km/s]	16.3 ± 0.1	3 ± 1
Time of Flight	ToF	[s]	5.34 ± 0.05	
Trajectory Length	L	[km]	75.0 ± 0.1	
Trajectory Inclination	γ	[deg]	56.7 ± 0.3	
Trajectory Azimuth	a	[deg]	24.3 ± 0.1	
Min. Abs. Magnitude	\mathcal{M}_{min}	[/]	-11.1 ± 0.1	



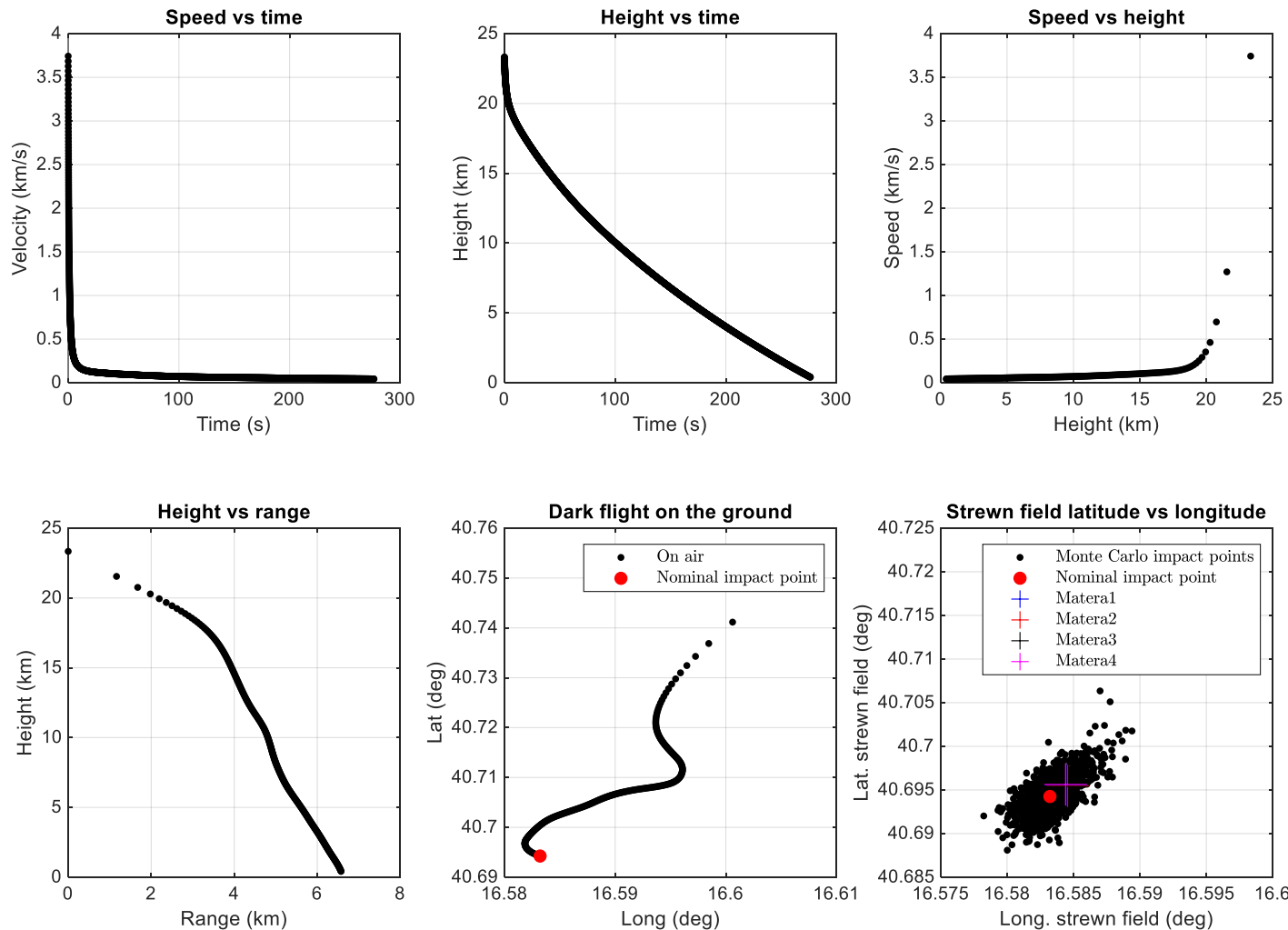
2023 Valentine's Day bolide – dynamic model



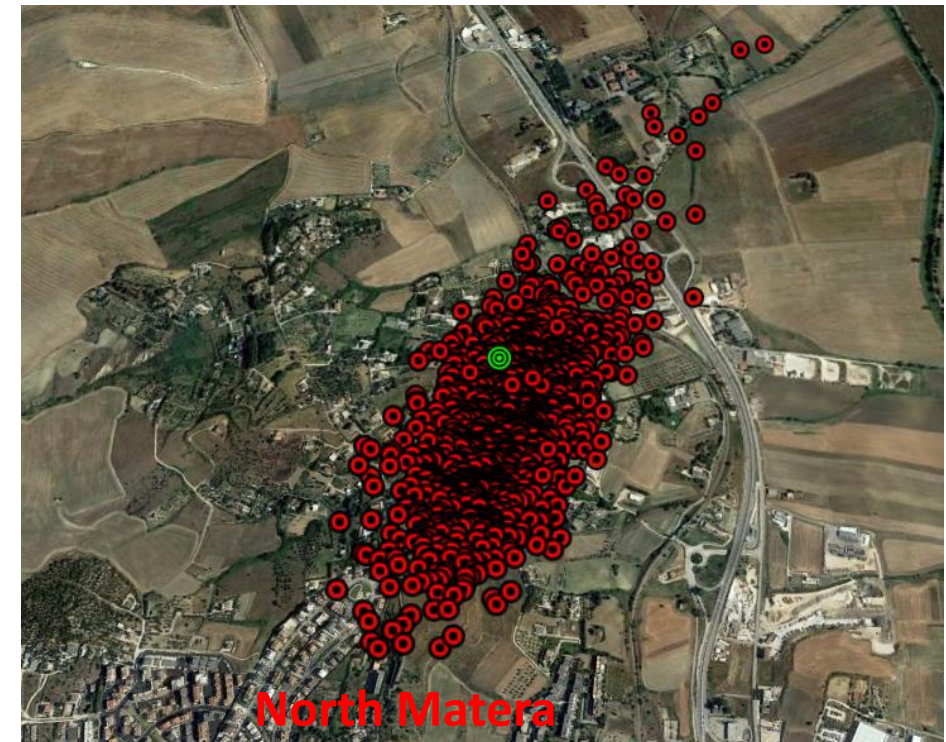
Dynamic model

			NUM_DYN	NUM_PHD
Preatm. speed	V_∞	[km/s]	16.4 ± 0.2	16.4 ± 0.2
Ablation coeff.	σ	[s ² /km ²]	0.020 ± 0.005	0.038 ± 0.002
Shape-change coeff.	μ	[/]	2/3	0.69 ± 0.03
Luminous efficiency	τ	[%]	–	1.5 ± 0.5
Preatm. MSR	D_∞	[kg/m ²]	360 ± 50	460 ± 50
Preatm. mass	M_∞	[kg]	8 ± 3	15 ± 6
Preatm. size	$2r_\infty$	[cm]	17 ± 2	21 ± 3
Final MSR	D_{fin}	[kg/m ²]	150 ± 30	100 ± 10
Final mass	M_{fin}	[kg]	0.6 ± 0.3	0.10 ± 0.04
Final size	$2r_{fin}$	[cm]	7 ± 1	4.4 ± 0.7

2023 Valentine's Day bolide – strewn field



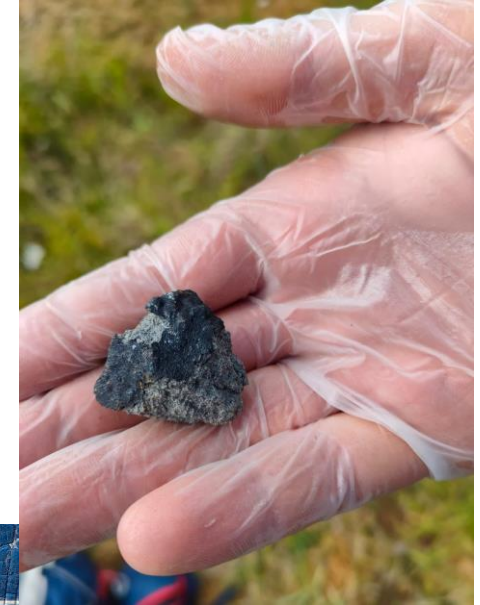
The first computed strewn-field was made **available to the public on 16/02/2024** and field search campaign began



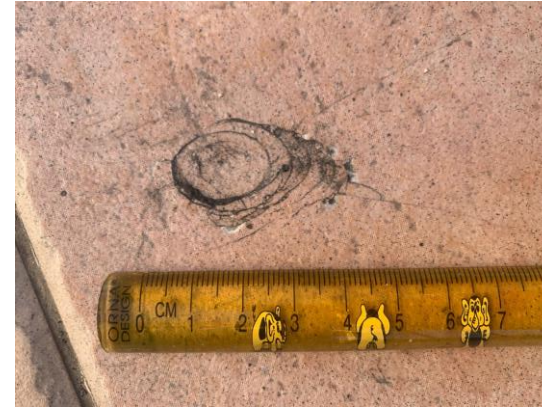
The recovery of the meteorite «Matera»

Many fragments were recovered just the next day on the property of **brothers Losignore in Matera** – Contrada Rondinelle.

Classified and approved as an **H5 ordinary chondrite** on 14 February 2024 (on Saint's Valentine Day!)



The recovery of the meteorite «Matera»

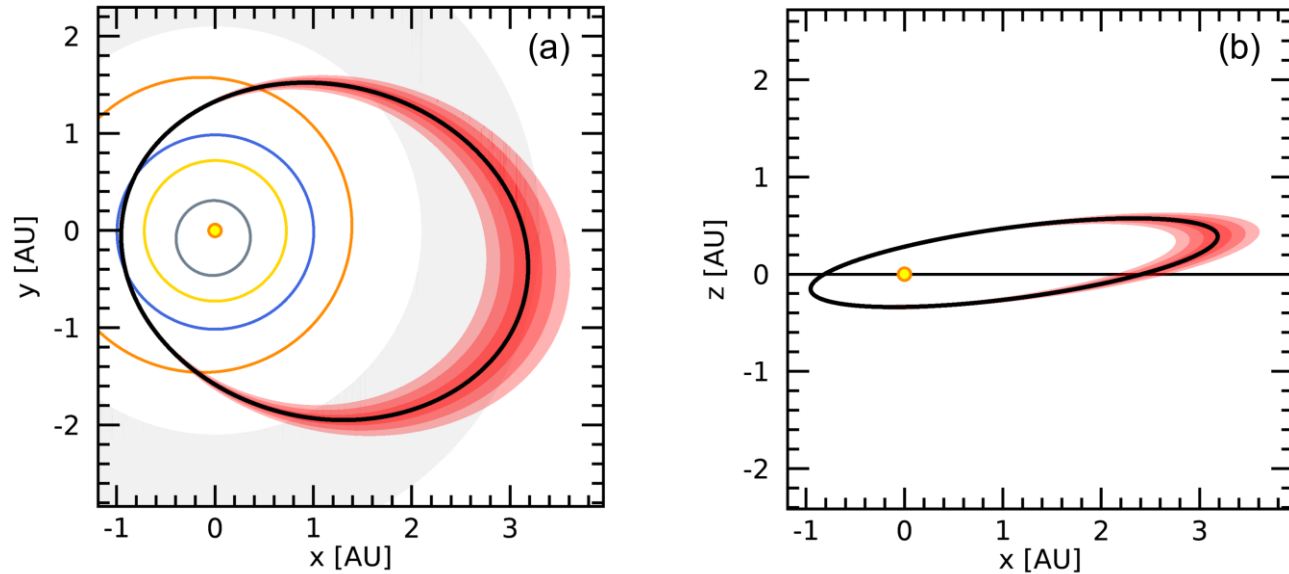


Specimen	Mass (g)	Characteristics	Finder	Fragment	Lat. (°)	Long. (°)
01	24.42	Single piece	Silvia Padilla & Pierluigi Cox	Matera 3	40.695418	16.584402
02	4.34	Single piece	Gianfranco e Pino Losignore	Matera 1	40.695507	16.584413
03	13.48	Single piece				
04	17.06	Single piece				
05	3.92	Many pieces				
06	2.12	Many pieces				
07	3.60	Many pieces				
08	2.26	Many pieces		Matera 2	40.695468	16.584554
09	0.09	Many pieces				
10	46.21	Main mass		—	Matera 4	40.695631
11	~ 0.1	Many pieces	Paola Manzari (ASI)	Matera 5	unknown	unknown

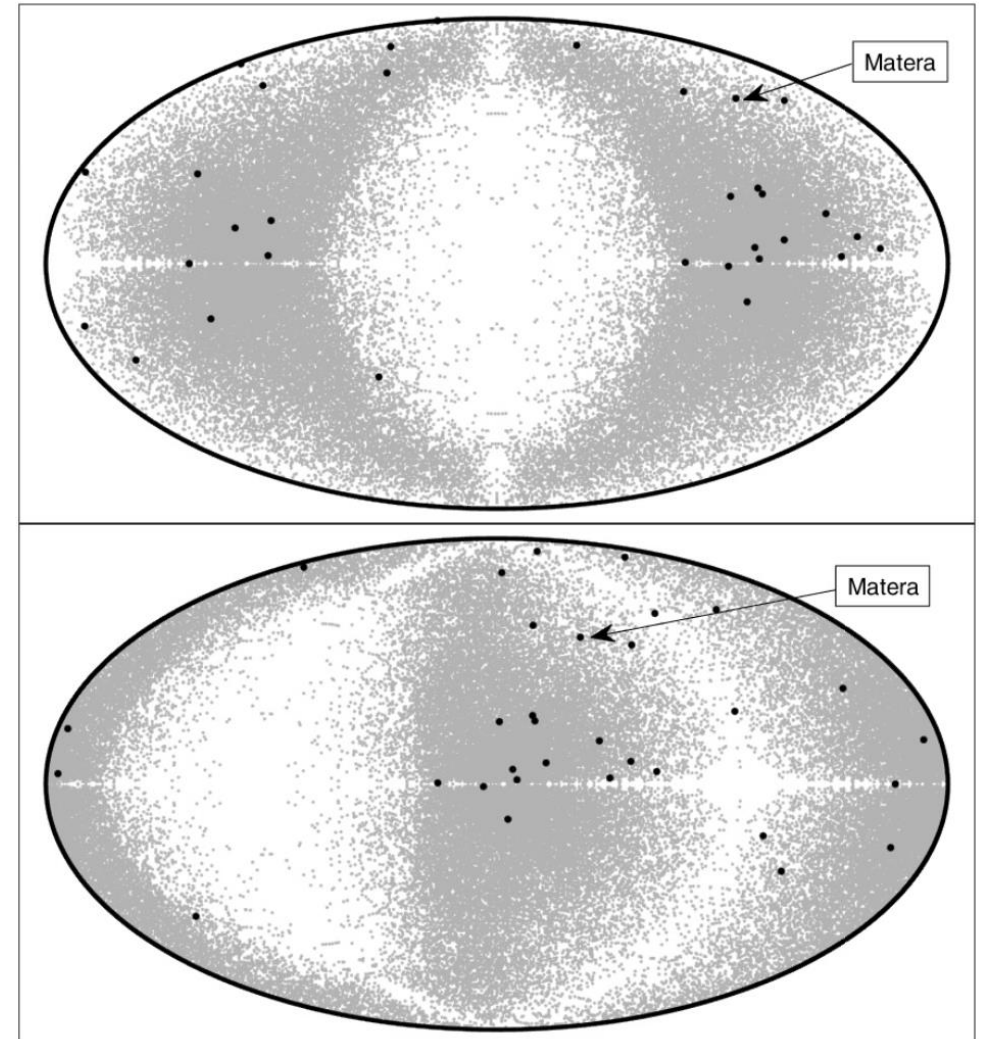
TKW = 117.5 g

4 main fragments, dozens of small specimens

Pre-atmospheric orbit of the «Matera» meteoroid



- Typically **asteroidal orbit** with aphelion at 3.17 ± 0.19 and Tisserand invariant with respect to Jupiter equal to 3.55 ± 0.11
- Search in the NEODys-2 database with $D_N < 0.06$ (Valsecchi et al., 1999; Carbognani & Fenucci 2023) **1999 LD₆** ($D_N = 0.045$) and **2014 TS₁₆** ($D_N = 0.047$)



PRISMA network: next steps

- Working towards a **first data release** of PRISMA data / results
 - Calibration of data from 2017 to 2022 now ongoing at INAF – OATo after a few patches
 - Data from 2023 onwards will be processed on the INAF – OATs servers
 - Hopefully fully working and automated ~ **2025 Q2-3**
- Deploying new Italian cameras and **transitioning towards a fully Italian network**
- Expand and bring **PRISMA in European schools with StAnD**
- Improve the technology, detection algorithm and software

D. Barghini et al., for the the PRISMA team

INAF – Osservatorio Astrofisico di Torino

Thank you for your attention!

