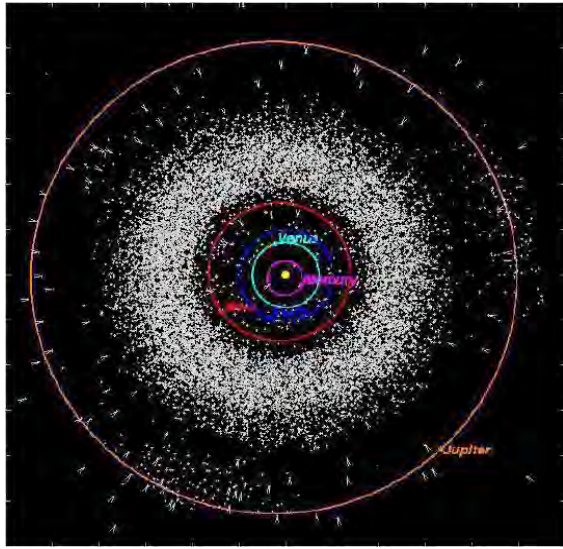




## The FRIPON network

(Fireball Recovery and Interplanetary Observation Network)



Solar System

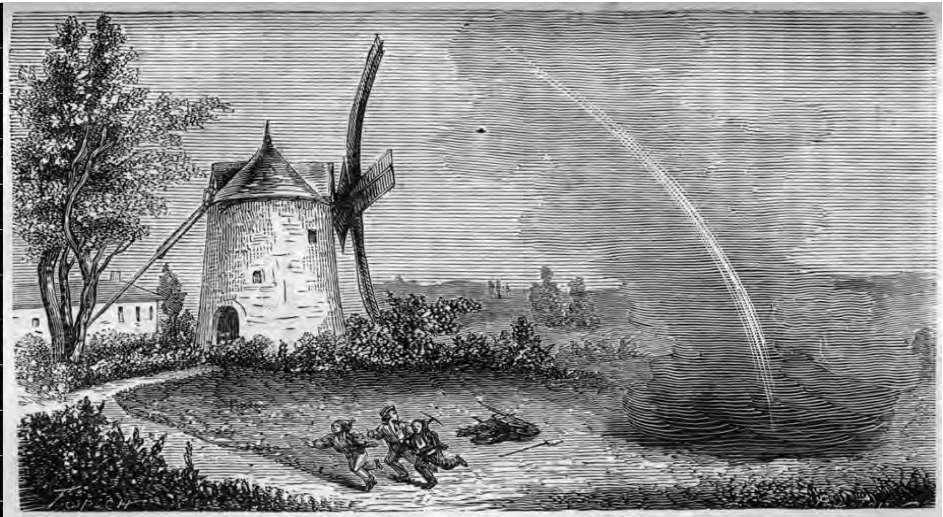


Fig. 3. Chute du bolide du 14 mai 1864.

Orgueil, 1864

- F. COLAS
- B. ZANDA
- S. BOULEY
- J. VAUBAILLON
- P. VERNAZZA
- J. GATTACCECA
- M. BIRLAN
- C. MARMO
- Y. AUDUREAU
- M.K. KWONG

And the FRIPON team



IMC - GIRON 2014

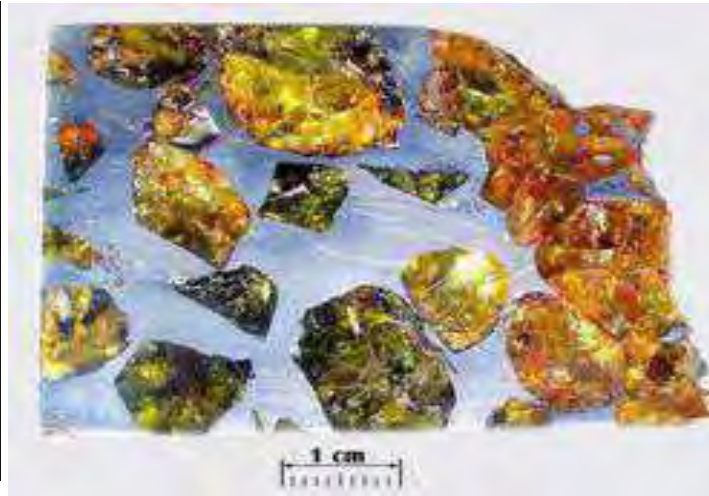


# Connexion asteroid / meteorites

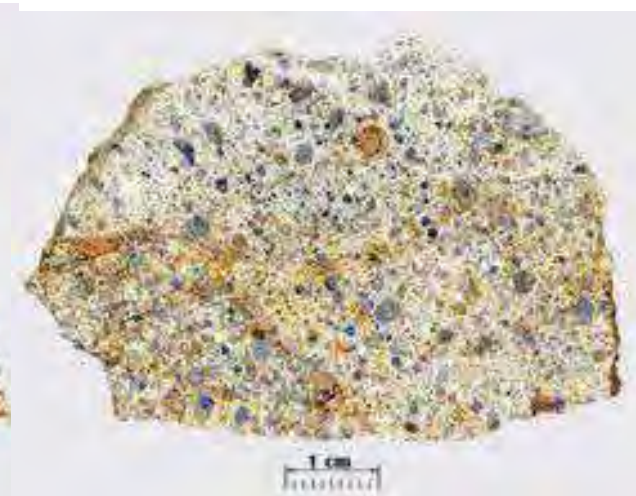
## Geology



Iron

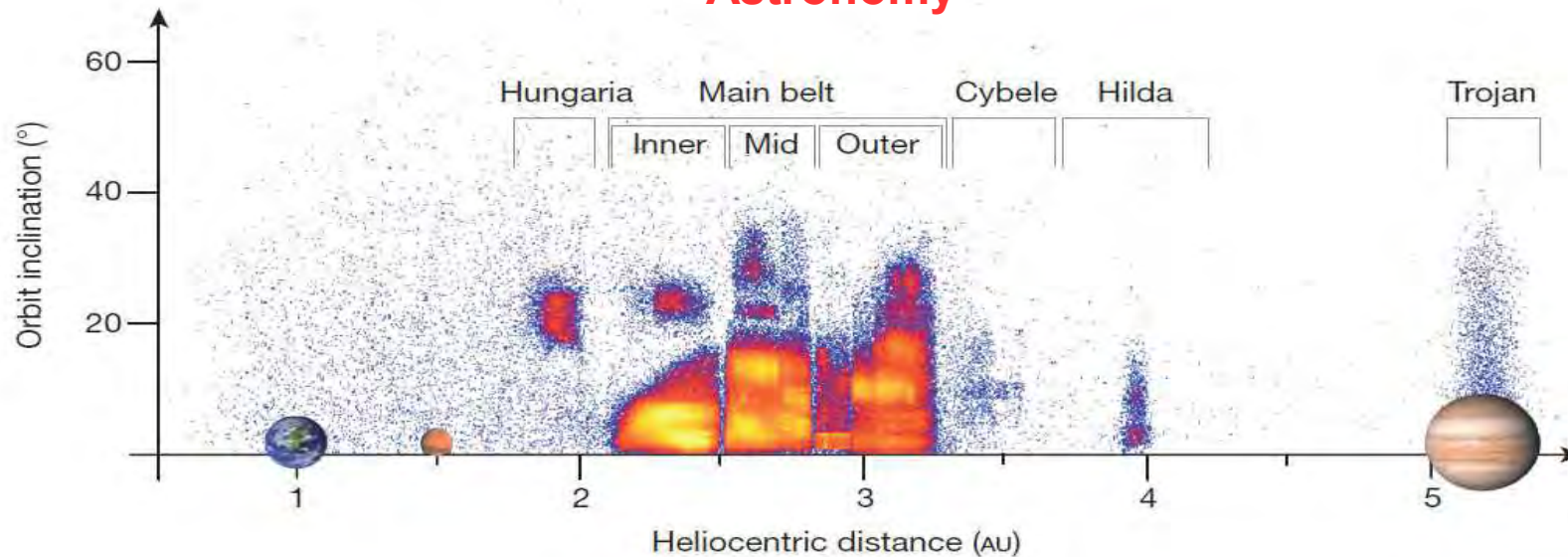


Pallasite



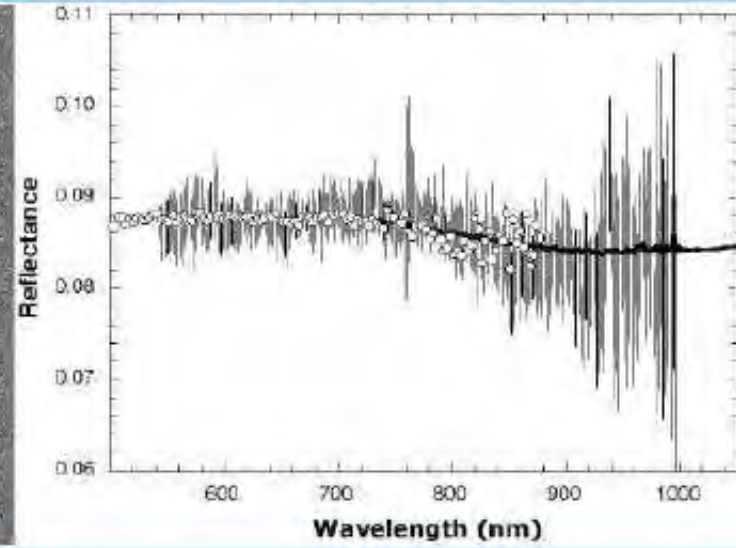
Achondrite

## Astronomy

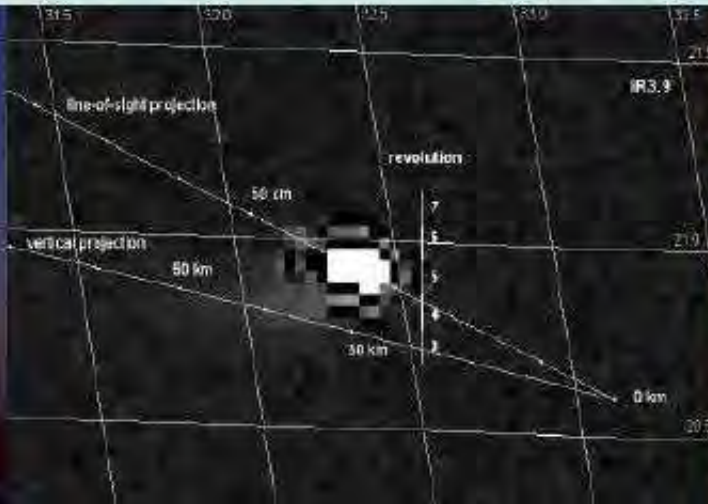


2008, FRIPON genesis

# 2008 TC3



## Almahata Sitta



**Good dynamic data for the first time**

# We know only a few meteorites orbits

Name	Date of fall (UT)	Meteorite type	Recovered mass (kg)	$V_{\infty}$ (km s <sup>-1</sup> )	$a$	$e$	$i$	$\omega$	$\Omega$
Příbram	1959/04/07	H5	5.8	20.89	2.4	0.67	10.5	241.8	17.8
Lost City	1970/01/04	H5	17	14.2	1.66	0.42	12.0	161.1	283.8
Innisfree	1977/02/06	L5	4.58	14.54	1.87	0.47	12.2	177.9	317.5
Peekskill	1992/10/09	H6	12.4	14.72	1.49	0.41	4.9	307.6	17.0
Tagish Lake	2000/01/18	C2	~10	15.8	1.98	0.55	2.0	224.4	297.9
Morávka	2000/05/06	H5	0.633	22.5	1.85	0.47	32.2	203.5	46.3
Neuschwanstein	2002/04/06	EL6	6.19	20.95	2.4	0.67	11.4	241.2	16.8
Park Forest	2003/03/27	L5	18	19.5	2.53	0.68	3.2	237.5	6.1
Villalbeto de la Peña	2004/01/04	L6	3.5	16.9	2.3	0.63	0.0	132.3	283.7
Bunburra Rockhole	2007/07/20	Euc	0.324	13.4	0.85	0.25	9.1	209.9	297.6
Almahata Sitta (2008 TC <sub>3</sub> )	2008/10/07	Ure-Anom	3.95	12.42	1.31	0.31	2.5	234.5	194.1
Buzzard Coulee	2008/11/21	H4	> 50	18.0	1.23	0.22	25.5	212.0	238.9
Jesenice	2009/04/09	L6	3.6	13.8	1.75	0.43	9.6	190.5	19.2

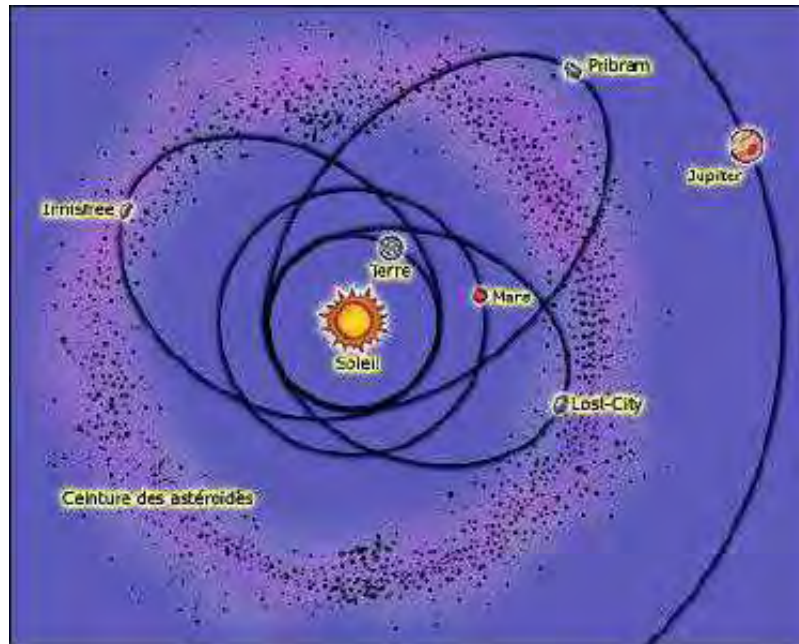


Table 4. Heliocentric orbit for the Grimsby meteorite.

$\alpha_r$	$248.93 \pm 0.22^\circ$
$\delta_r$	$55.87 \pm 0.11^\circ$
$V_{\infty}$	$20.91 \pm 0.19 \text{ km s}^{-1}$
$V_g$	$17.89 \pm 0.22 \text{ km s}^{-1}$
$\alpha_g$	$242.61 \pm 0.26^\circ$
$\delta_g$	$54.97 \pm 0.12^\circ$
$a$	$2.04 \pm 0.05 \text{ AU}$
$e$	$0.518 \pm 0.011$
$i$	$28.07 \pm 0.28^\circ$
$\omega$	$159.865 \pm 0.43^\circ$
$\Omega$	$182.9561^\circ$
$q$	$0.9817 \pm 0.0004 \text{ AU}$
$Q$	$3.09 \pm 0.10 \text{ AU}$

Dynamic studies need data ( **700 000 astéroïds !!** )

- Families are the result of impacts

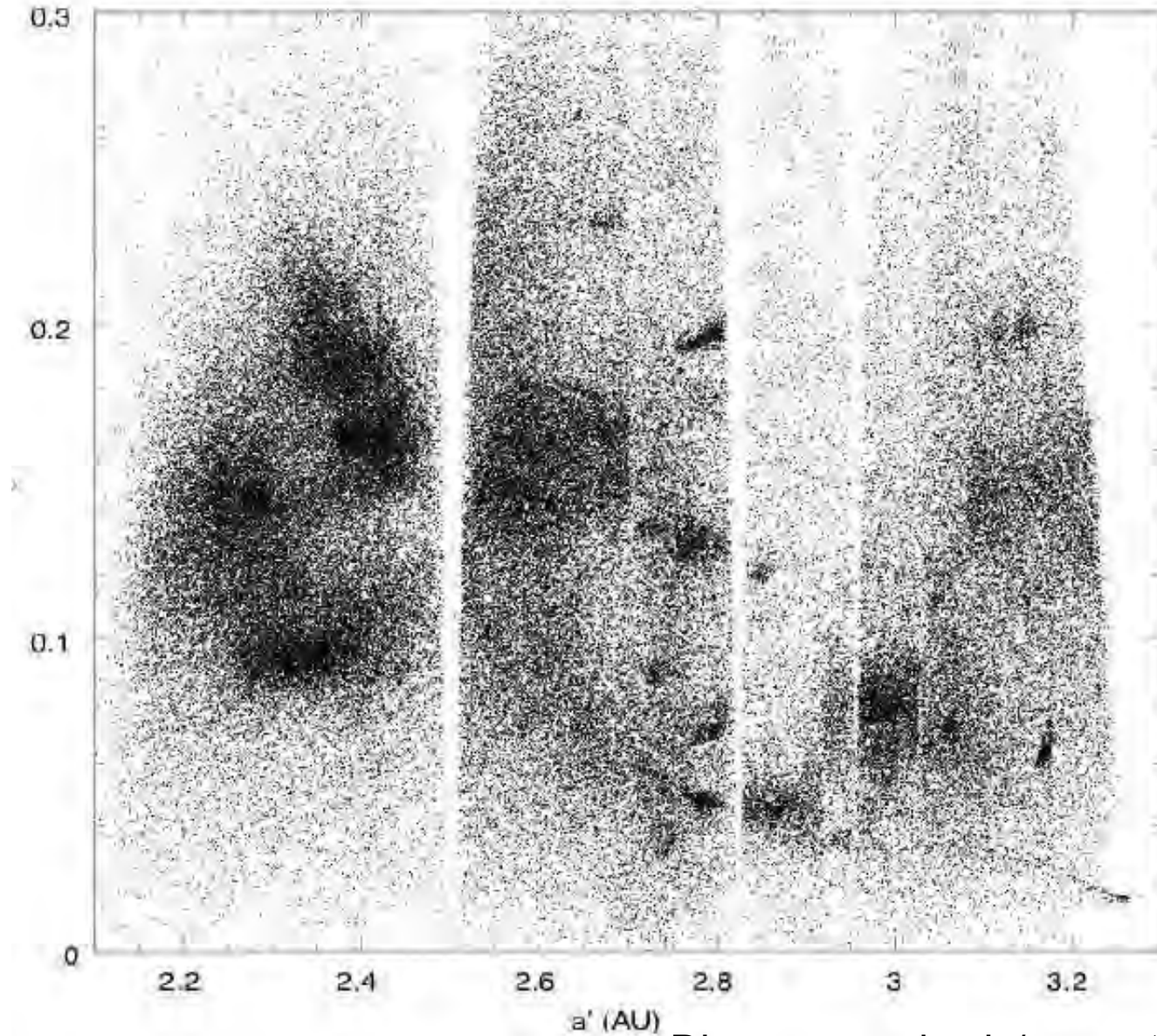
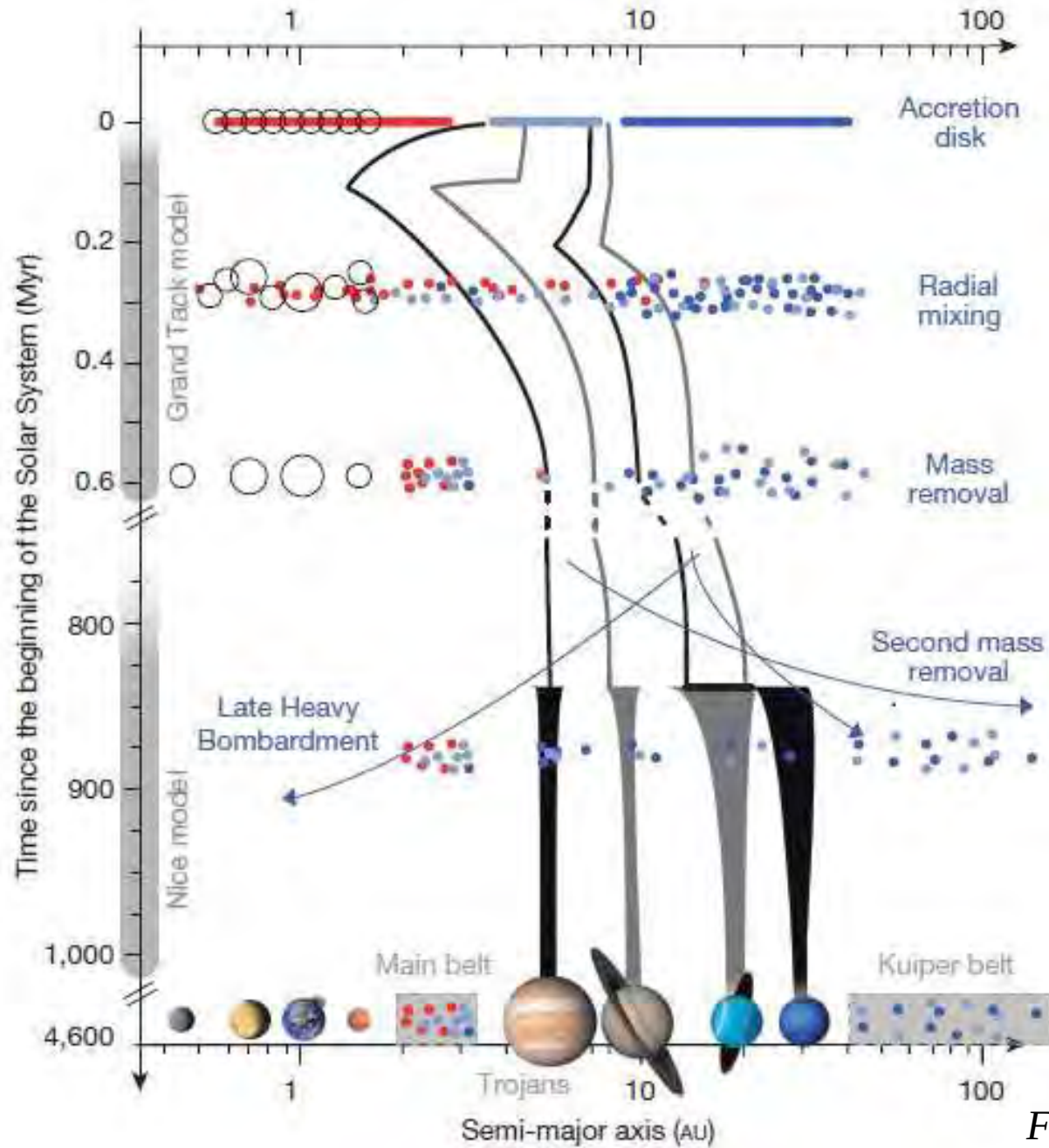
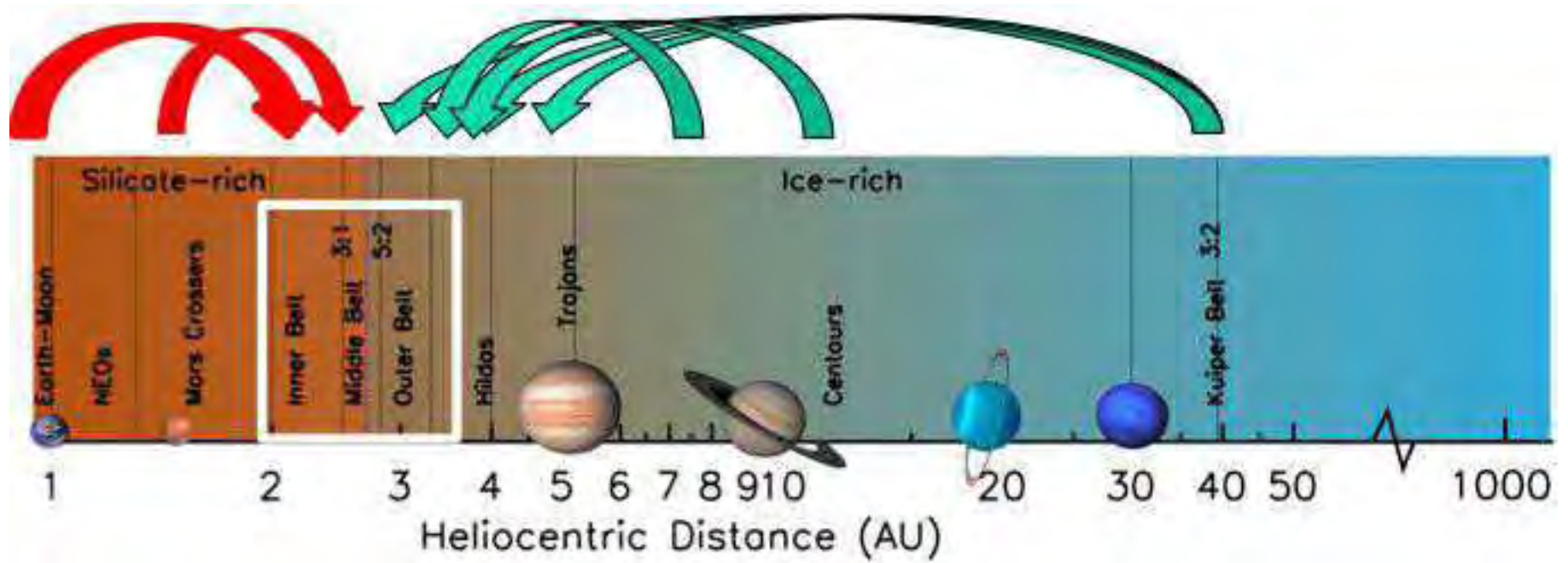


Diagram semi axis/ excentricity

# The discovery of exo planet change our view on The solar system formation

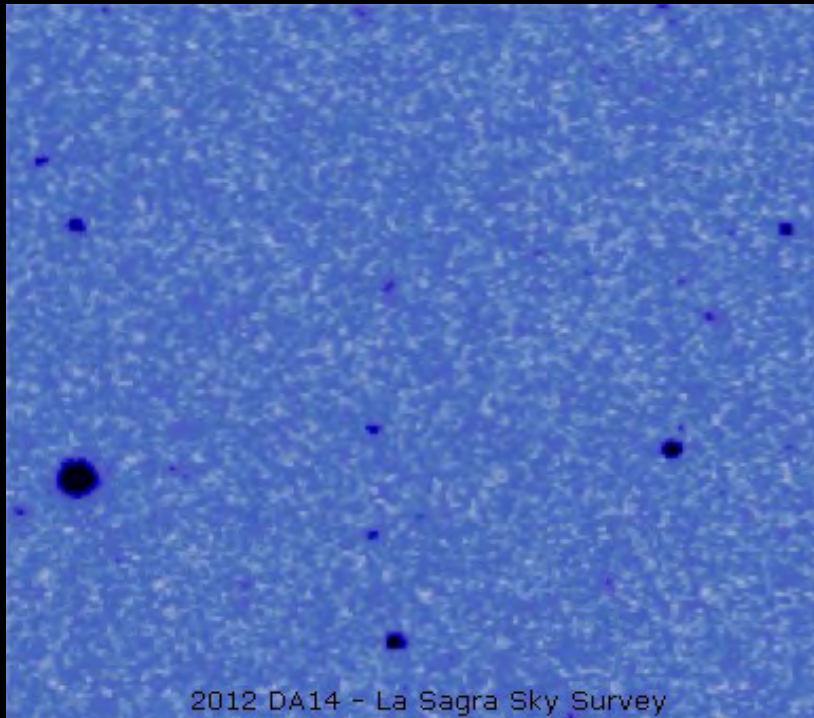


Study asteroids / meteorites = study all the solar system



F. DeMeo

## The same problem viewed from two different points!



2012 DA14 La Sagra  
(Spain) 15 feb 2013



Tchelyabinsk (Russia)  
15 feb 2013 ...

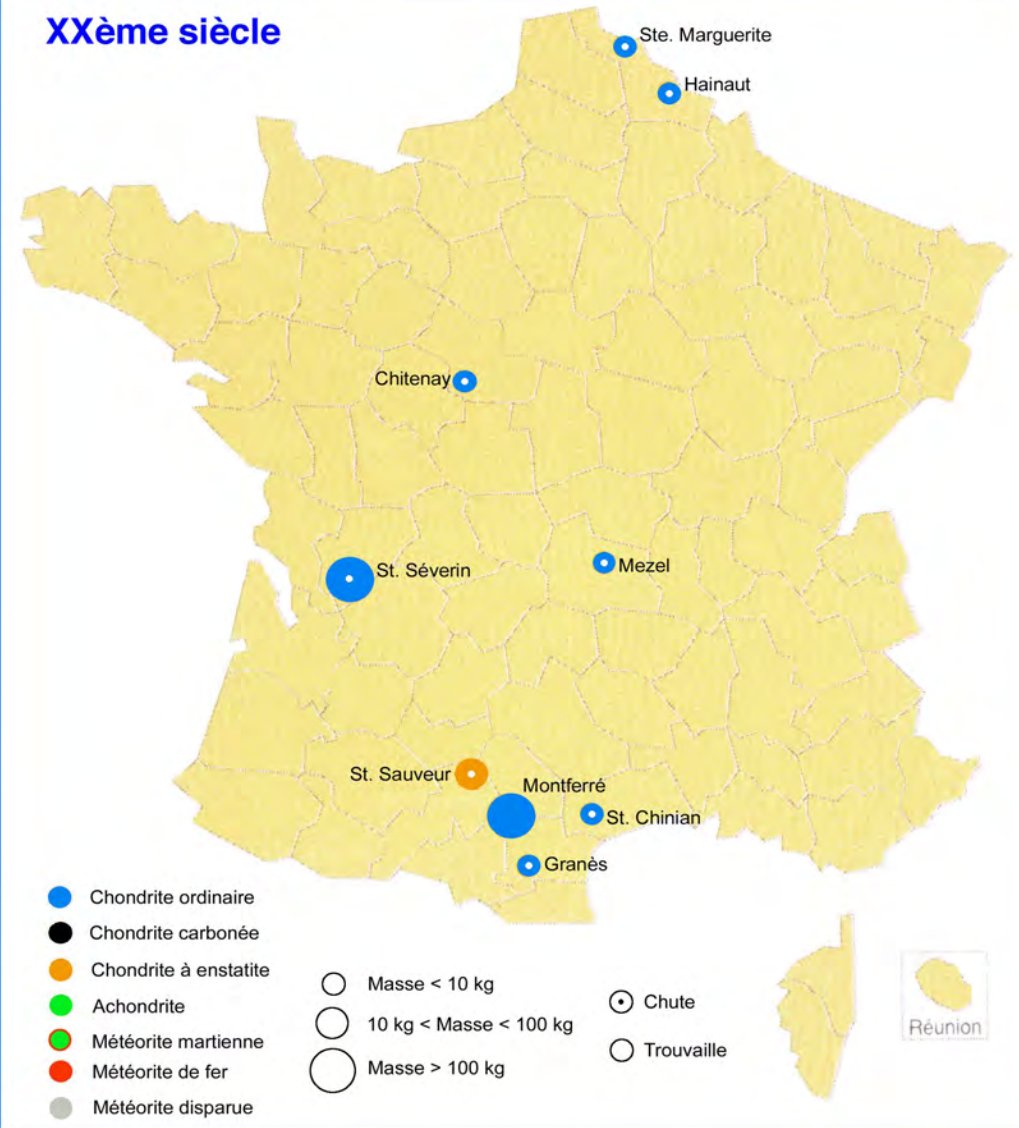


# Impacts seen over France

## XIXème siècle



## XXème siècle



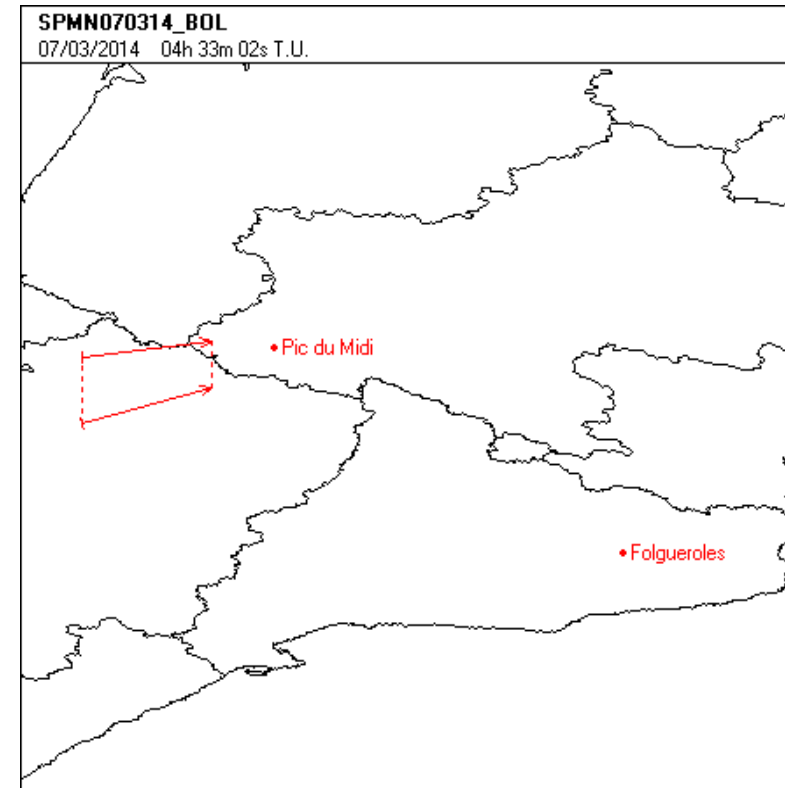
**XIX<sup>ème</sup> siècle : 45 météorites**  
**XX<sup>ème</sup> siècle : 9 météorites**

# Bolide detection



Fish eye detector, also to compute orbits

# Bolide march 7 2014 FRIPON – Pic du Midi



“J.M. Trigo (SPMN)

# GRAVES RADAR

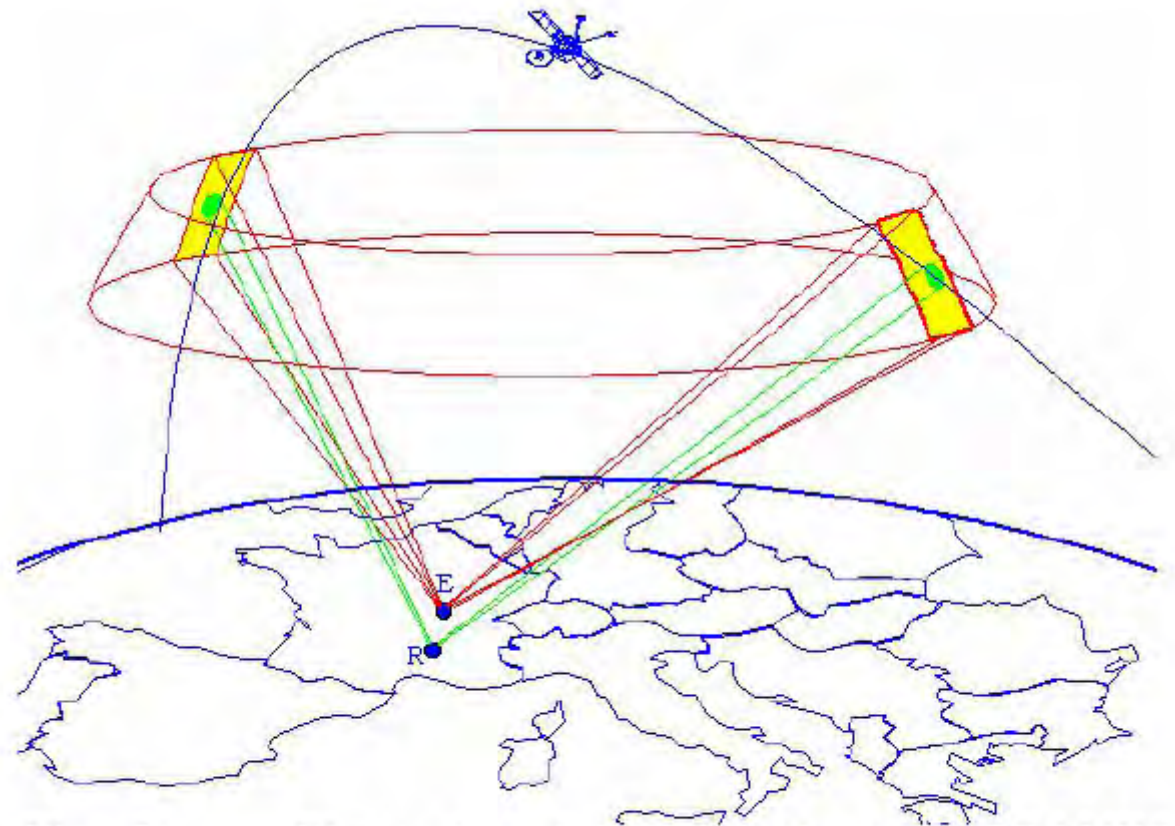
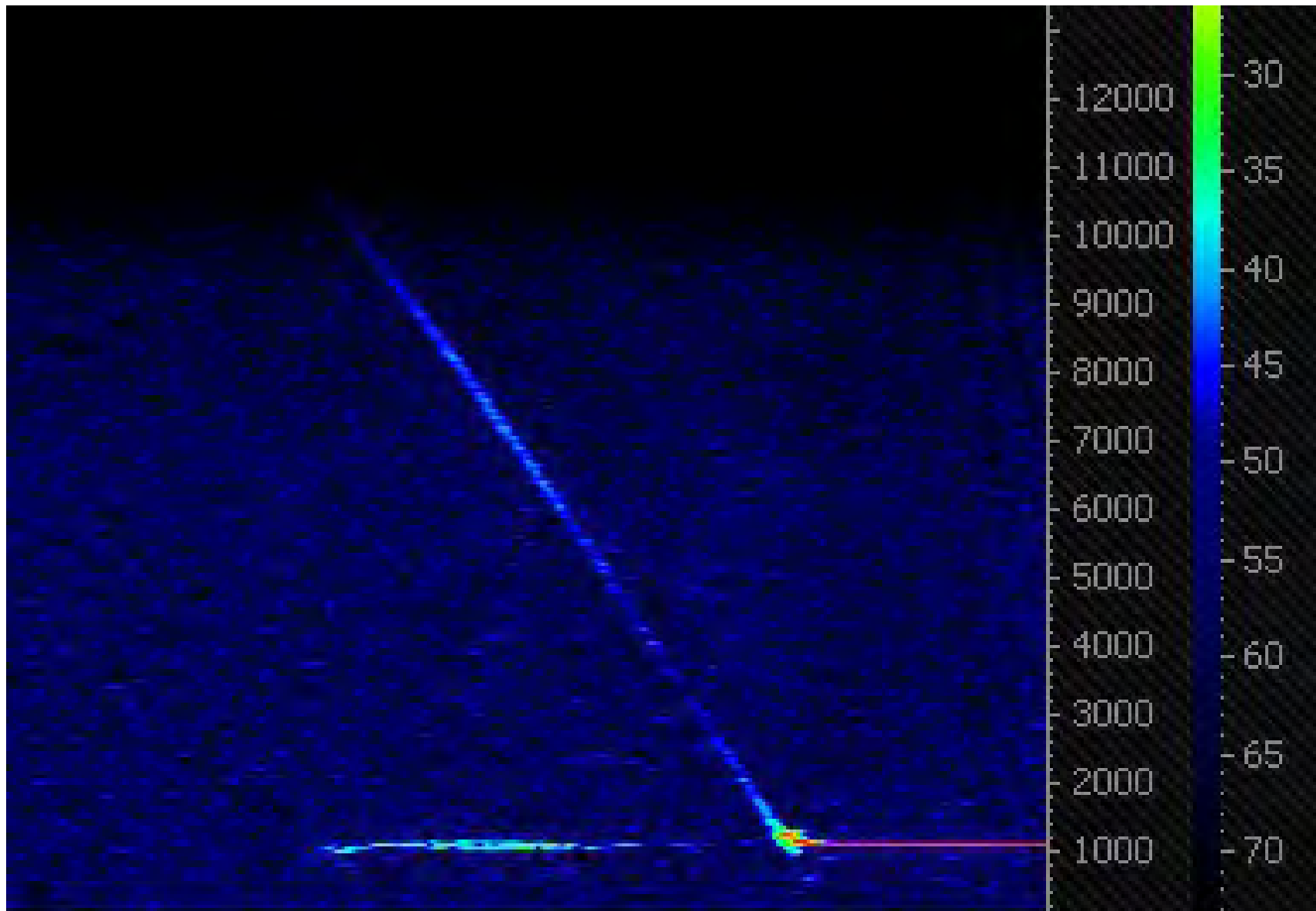


Fig : 3. Illustration of the principle of the GRAVES radar

143 MHz

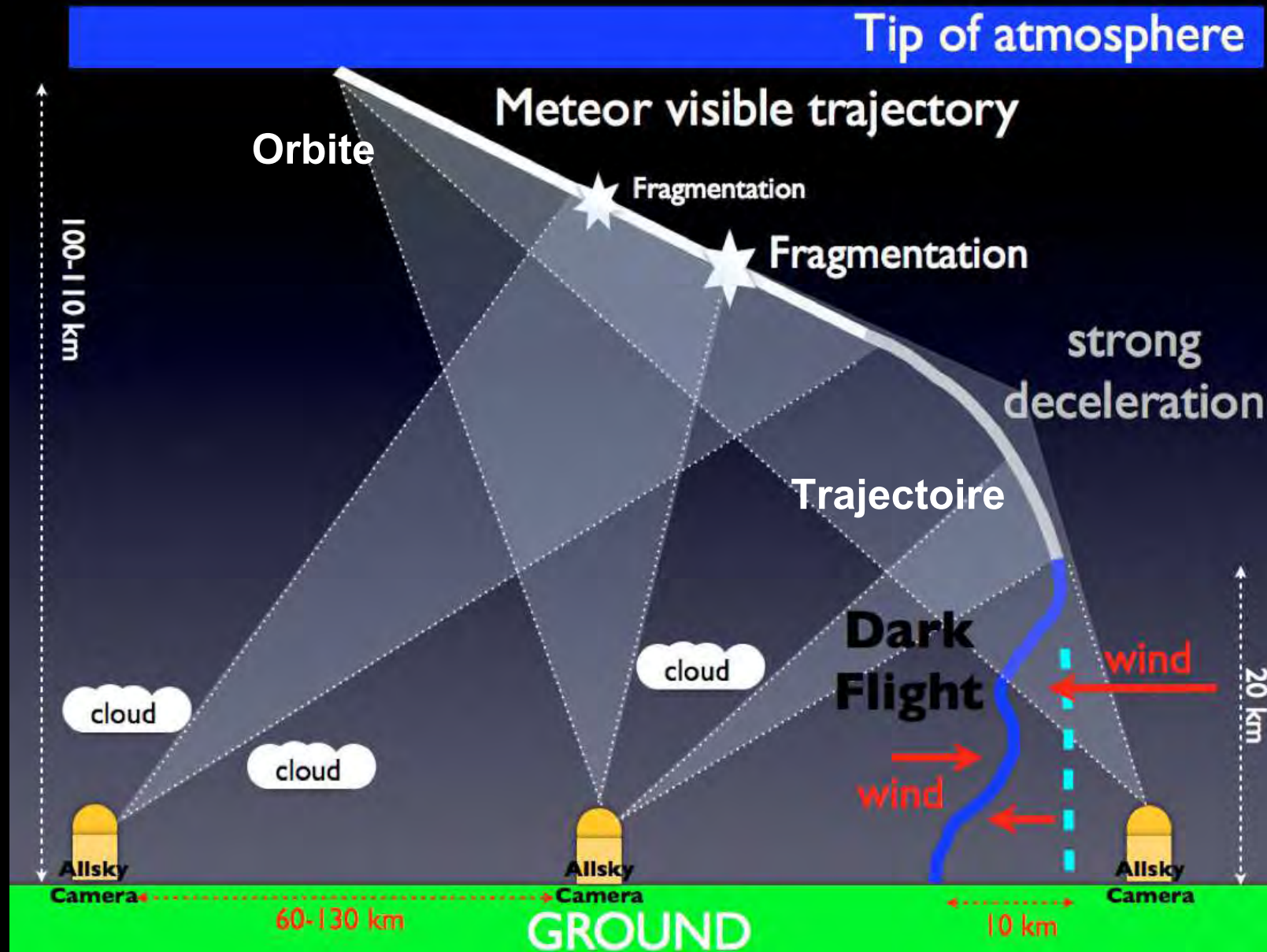
## Head echo as seen by GRAVES



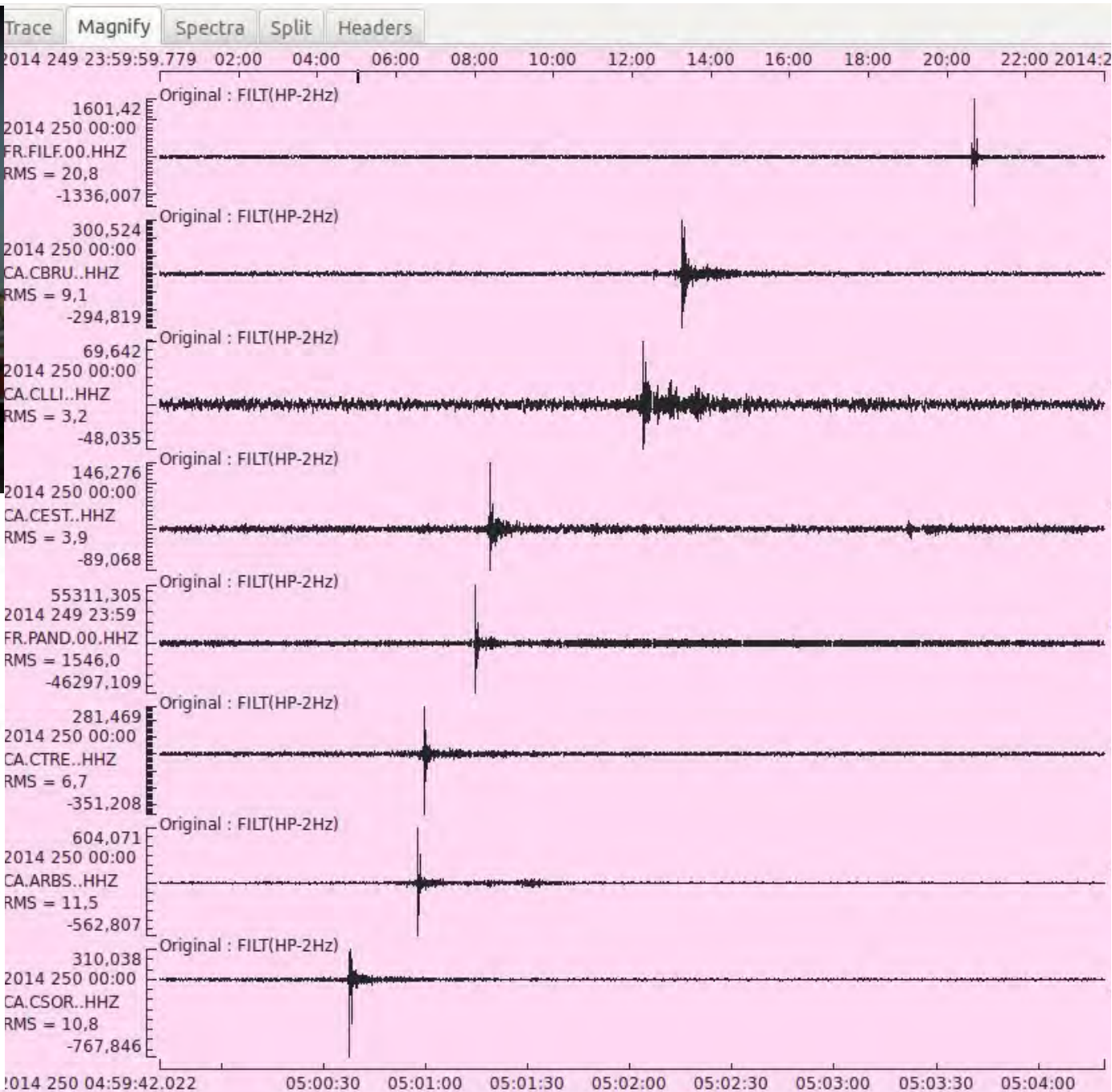
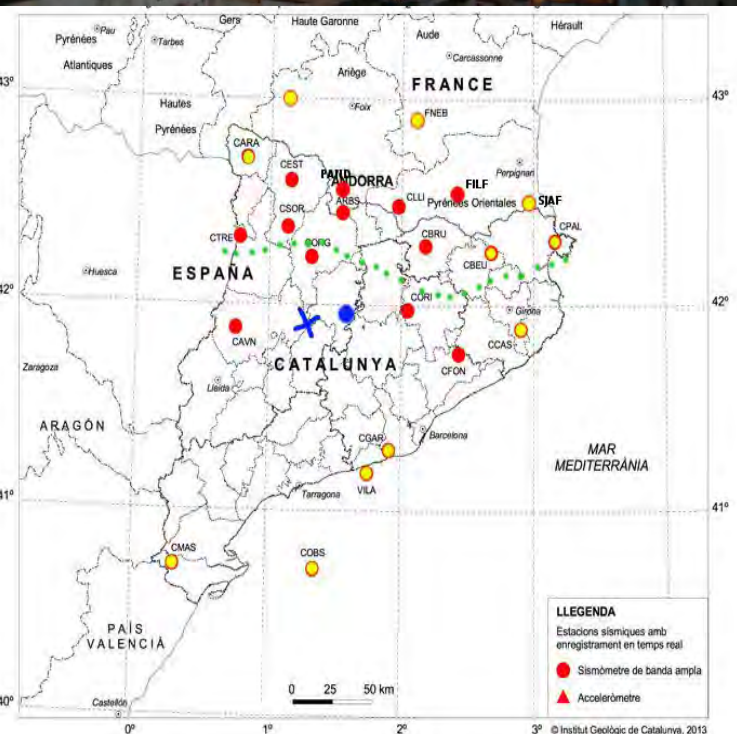
Moreover, object like Chelyabinsk of 2014 RC (Tonight!!!) can be observed

# Orbit and trajectory

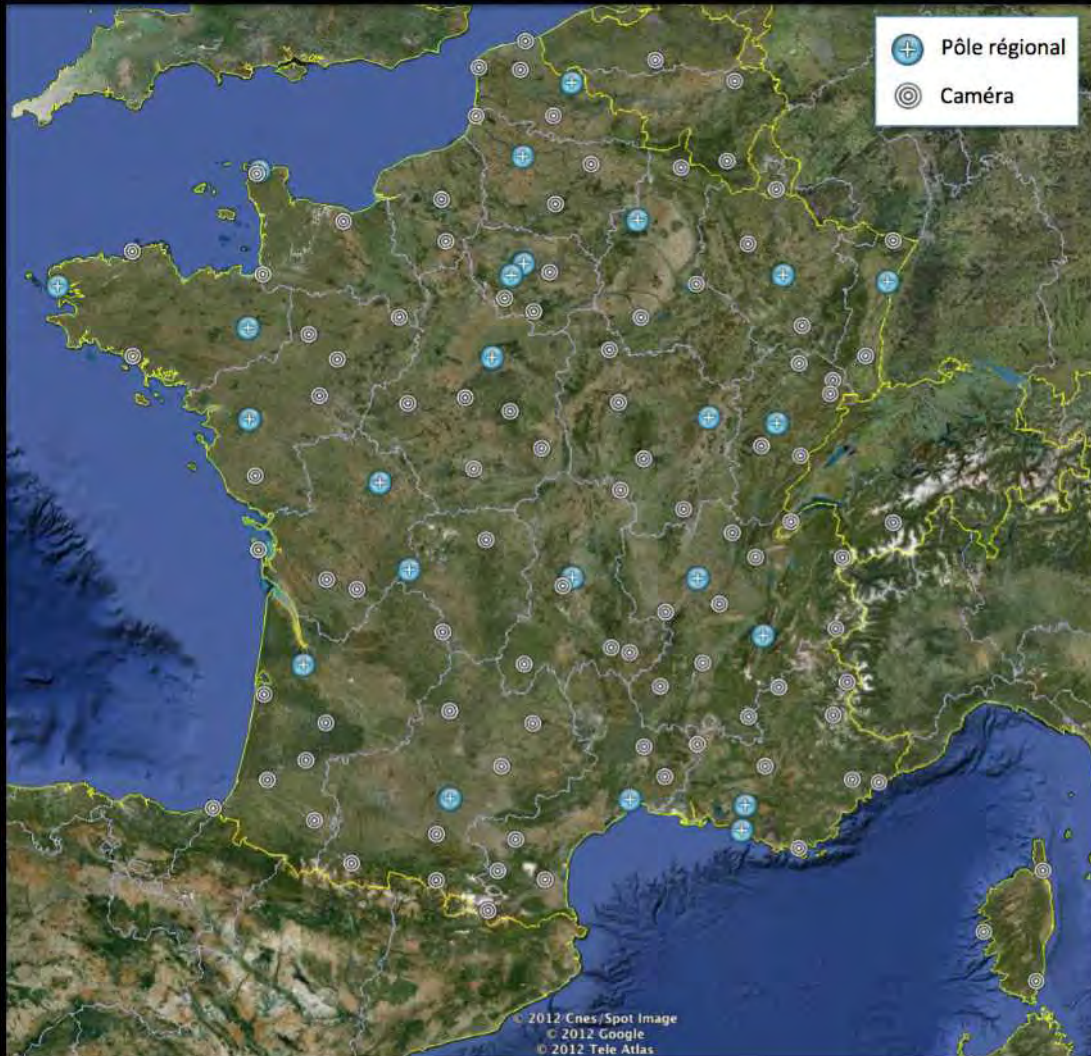
100 fish eye cameras and 25 radio receptors



# Fireball September 7th 4h56 UTC



# Le réseau FRIPON



IMCCE / Observatoire de Paris

→ Détermination des trajectoires/Expertise technique

LMCM / MNHN

→ Recherche des météorites/ Science participative

GEOPS / OSUPS:

→ Gestion des données et du réseau humain

CEREGE - LAM / OSU Pytheas

→ Caractérisation des météorites/ Régions source

100 stations avec caméras

24 pôles régionaux

→ Laboratoires Astro/Sciences de la Terre/Université)

75 pôles locaux

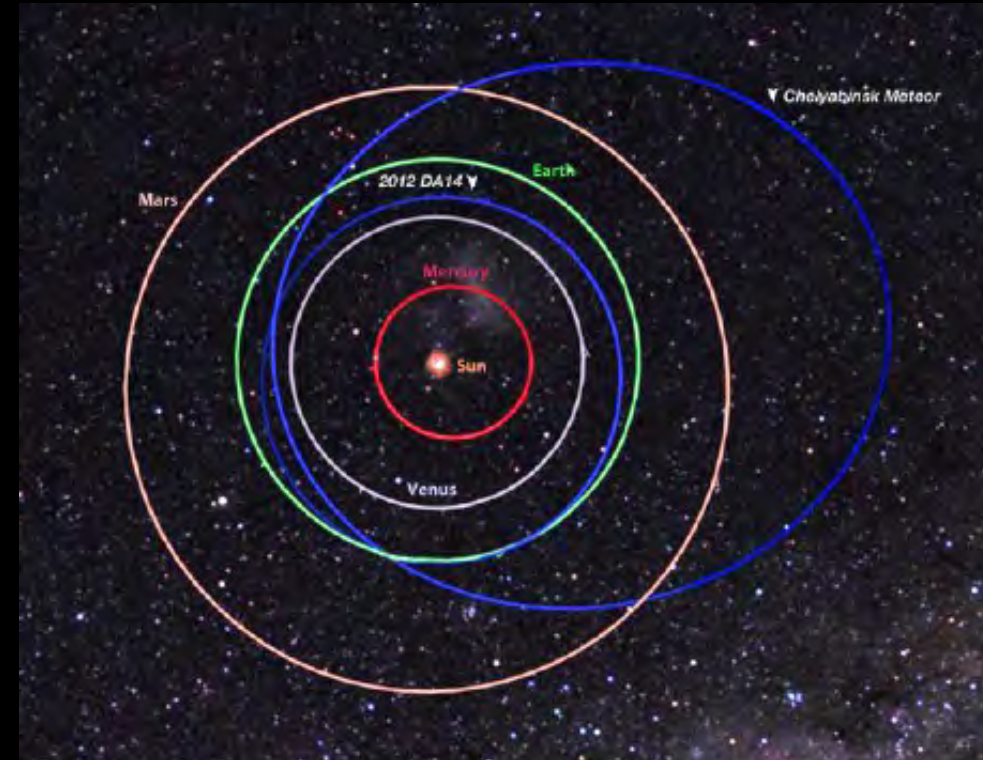
→ Observatoires amateurs, musées et sites naturels, CCSTI, Etablissements scolaires, Planétariums



# Science with FRIPON

## Orbits

- *Determination of hundreds of orbits (with or without meteorites on the ground) and source regions*
- *Determination of parent bodies (comets / asteroids)*
- *Spectral spectral type meteorite / asteroid-type connection*
- *Atmosphere Interaction / meteoroid - fragmentation*



## Meteorites

- *Characterization of the meteorite by the MNHN and providing samples to partner teams*
- *Determination of the transfer time to the Earth (Exposure to cosmic rays)*
- Study of Oxygen isotopes (parent bodies)*
- *Paleomagnetism of meteorites - primitive magnetic field in the solar system*
- Origin of rare meteorites (CO CM / Comets?)*

## Hardware

- *Digital camera (Mega pixel) 30fps*
- *Alimentation Power Over Ethernet (one cable, 50 m)*
- *0,015 ms exposure time  
=> daytime observation*
- *Passive cooling*
- *PC, fanless i3 / i5*

## Software

- *Open source*
- *Driver for many cameras (genicam, ...)*
- *Orbit computation*
- *Strewnfield determination*

## Network

- *Top - Down*
- *Density / area*
- *Amateurs at every level (soft, observations...)*
- *Number, variety and geographical distribution of participants*

