



BRAMS : the Belgian RAdio Meteor Stations

A new facility to detect and
characterize meteors

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Overview

- Radio meteor observations: forward scattering
- Description and status of BRAMS
- Scientific goals of BRAMS
- Future and perspectives



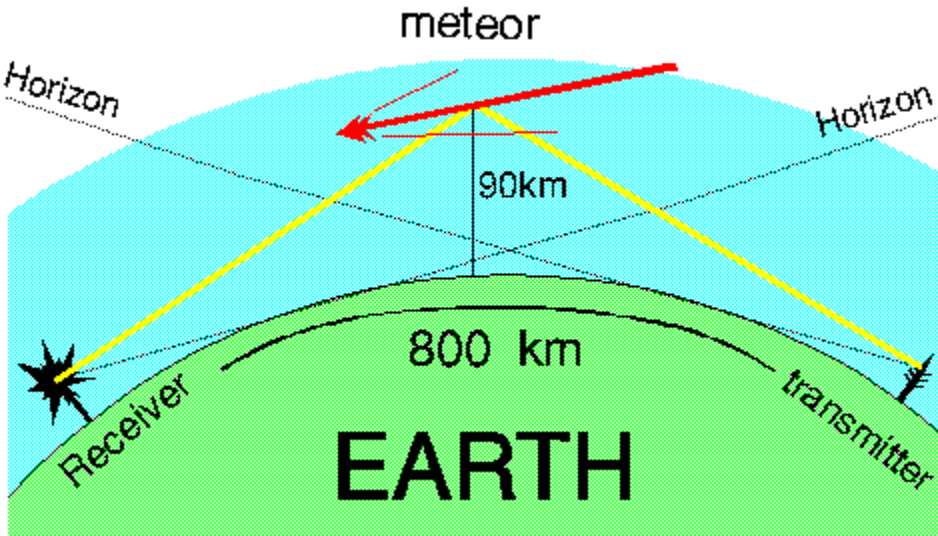
RADIO FORWARD SCATTERING OBSERVATIONS OF METEORS



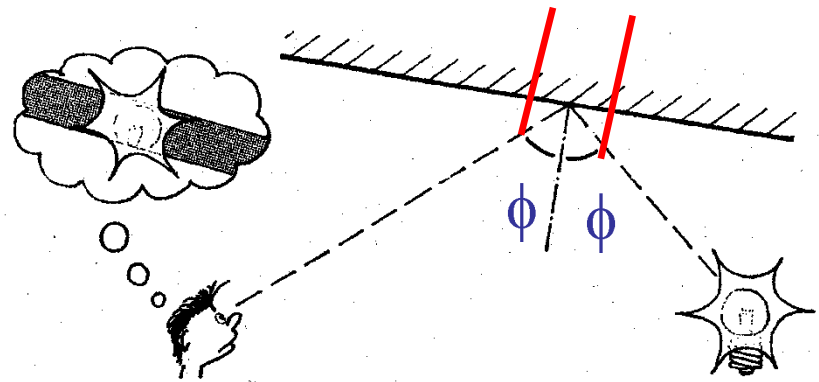
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Radio forward-scattering observations



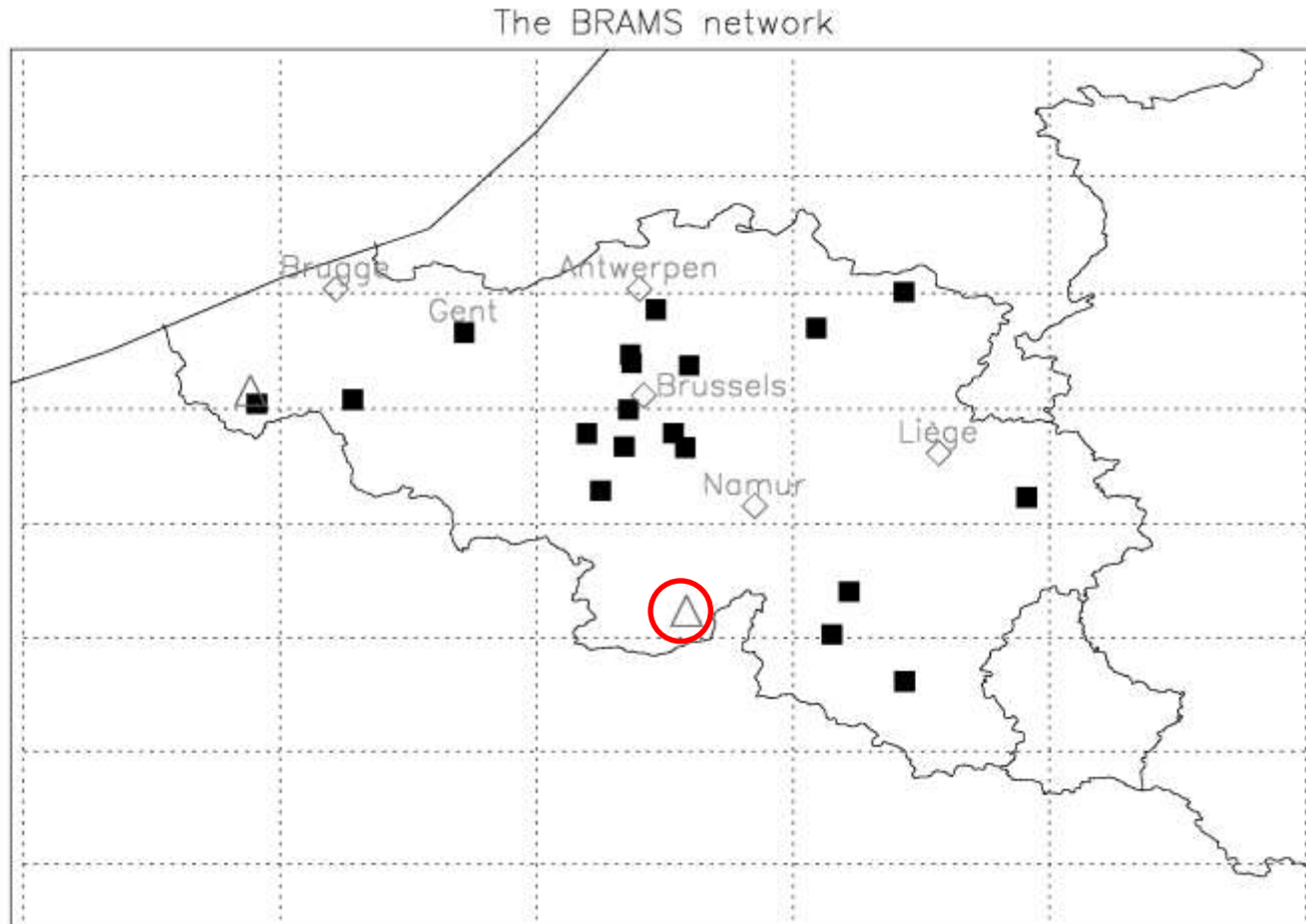
Duration of the « meteor echo » depends on the lifetime of the electron trail released in the wake of the meteoroid (from a fraction of a second up to a few minutes) and of the sensitivity of the receiver



BRAMS: the Belgian RAdio Meteor Stations



The BRAMS network



A dedicated beacon in Dourbes



- ✓ 49.97 MHz
- ✓ 150 W
- ✓ pure sine wave with circular polarization
- ✓ altitude \sim 230m



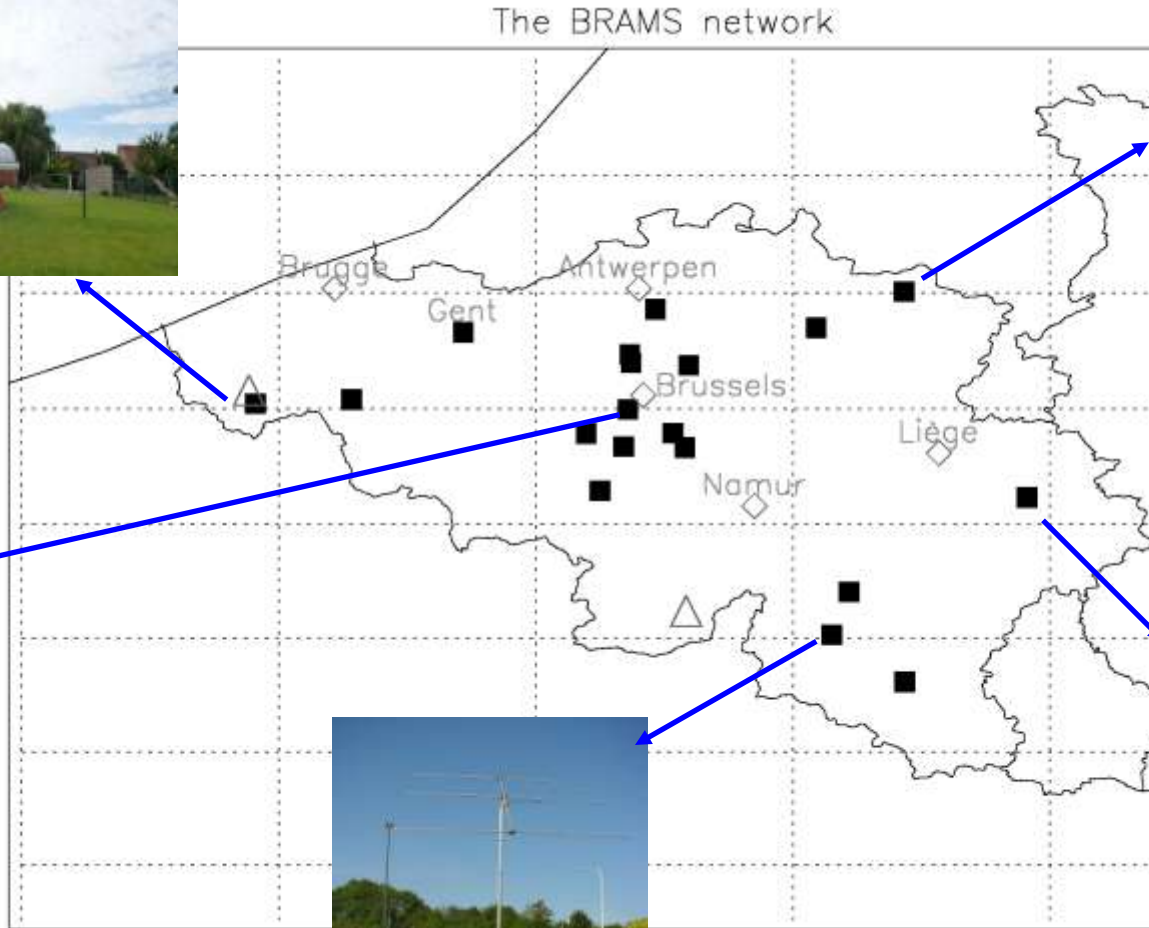
A typical receiving station



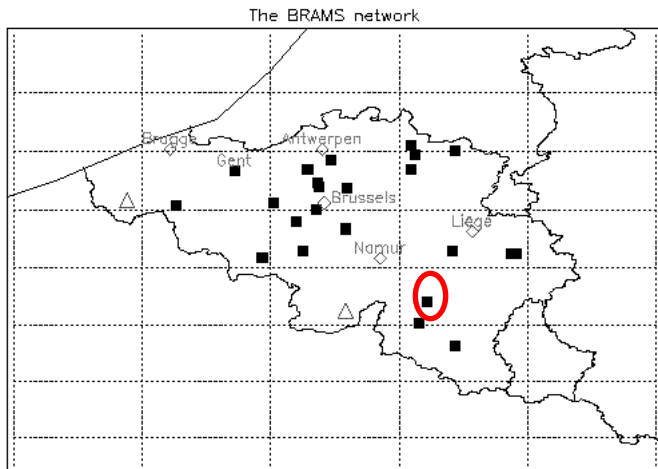
AGC switched off



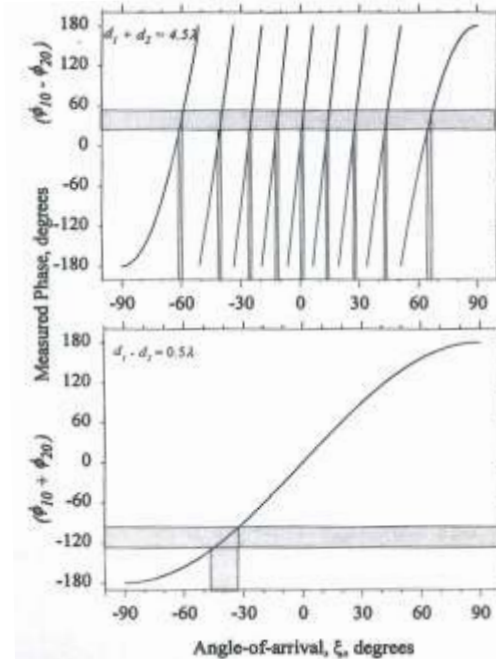
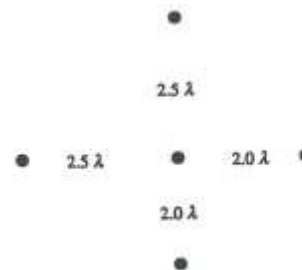
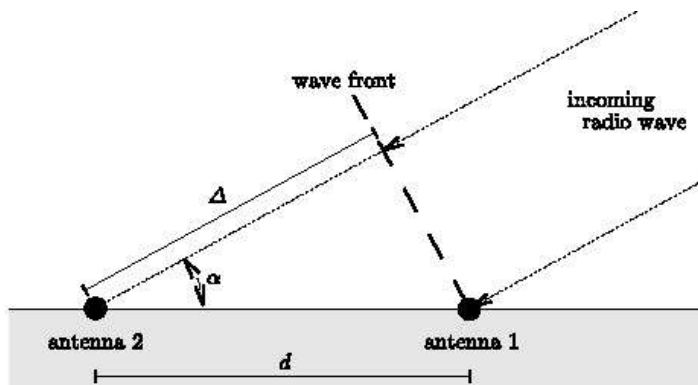
Current status of BRAMS



Interferometric station in Humain

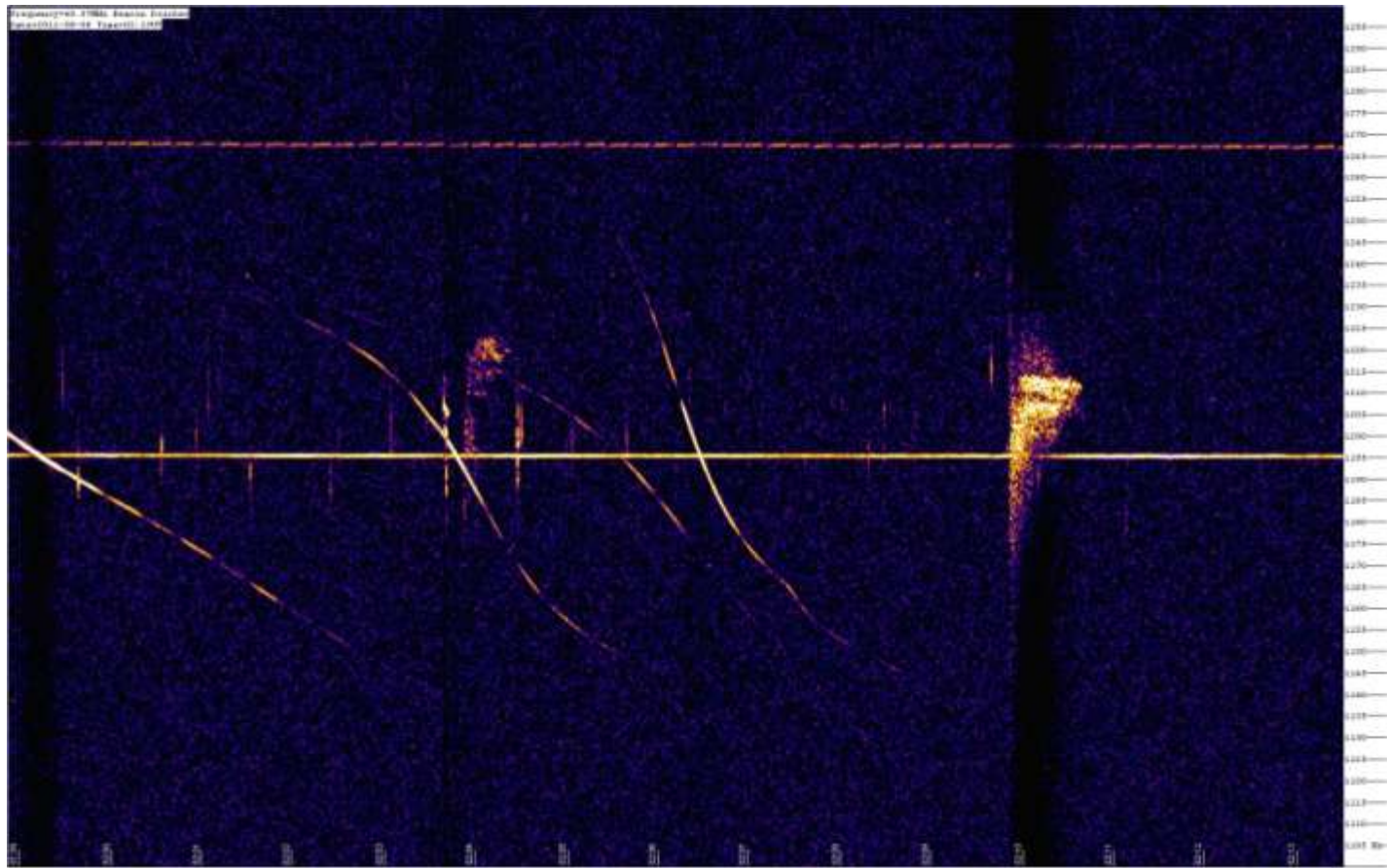


Based on the method proposed by Jones et al (1998)



Analysis of the signal

- We make a FT of the sampled signal to obtain spectrograms



Frequency
 $\Delta f = 200\text{Hz}$

06/08/2011 2h13 UT BEUCCL

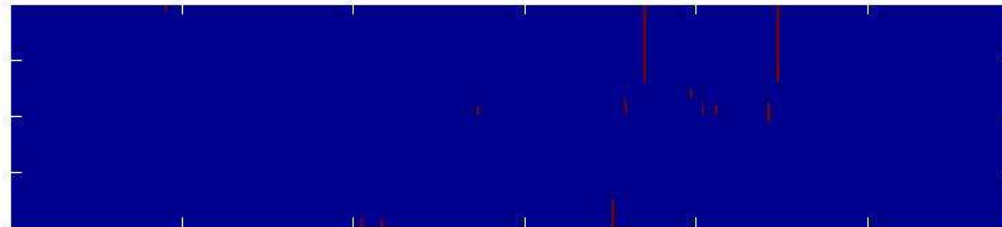
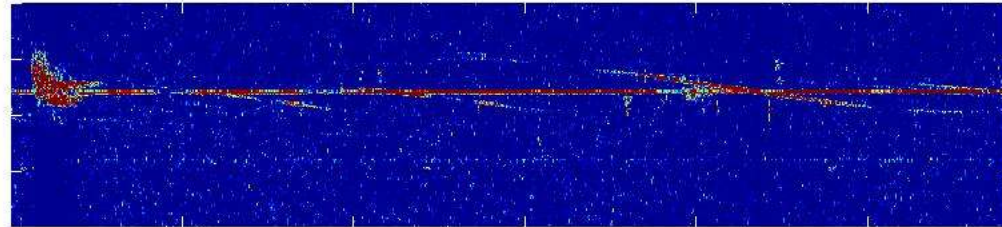
time

$\Delta t = 1\text{ min}$

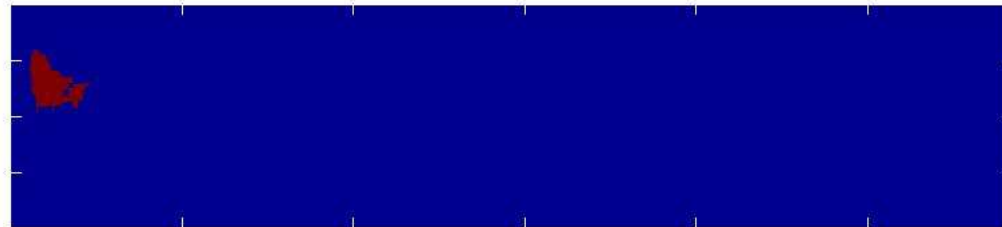
Automatic detection of meteor echoes



Mathieu Deltour (EPHEC)



underdense



overdense

Use of Matlab functions such as edge detection, labelisation, erosion and dilatation

Must be validated but looks promising

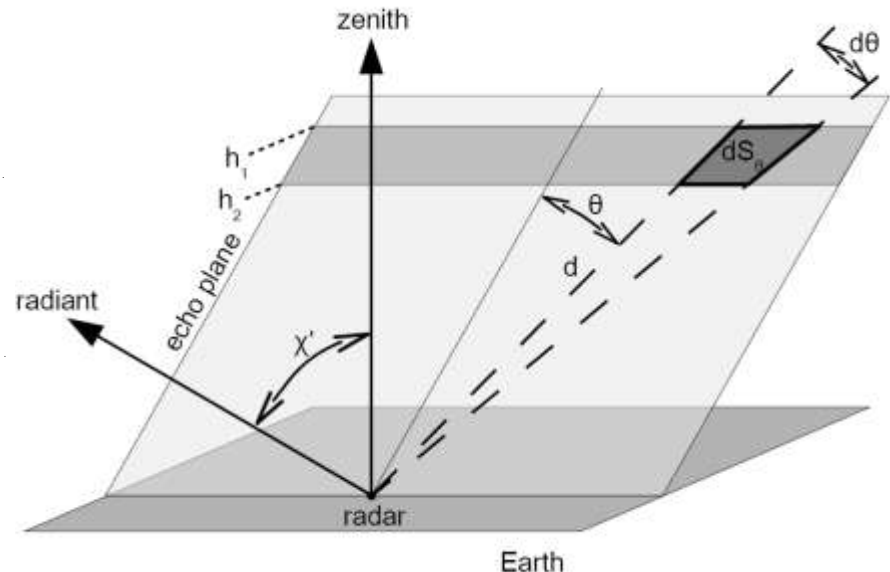
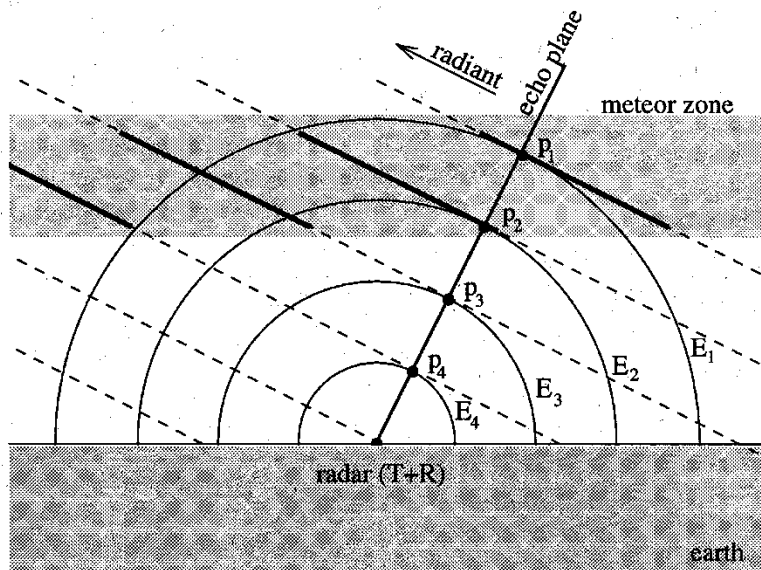


Scientific goals of BRAMS



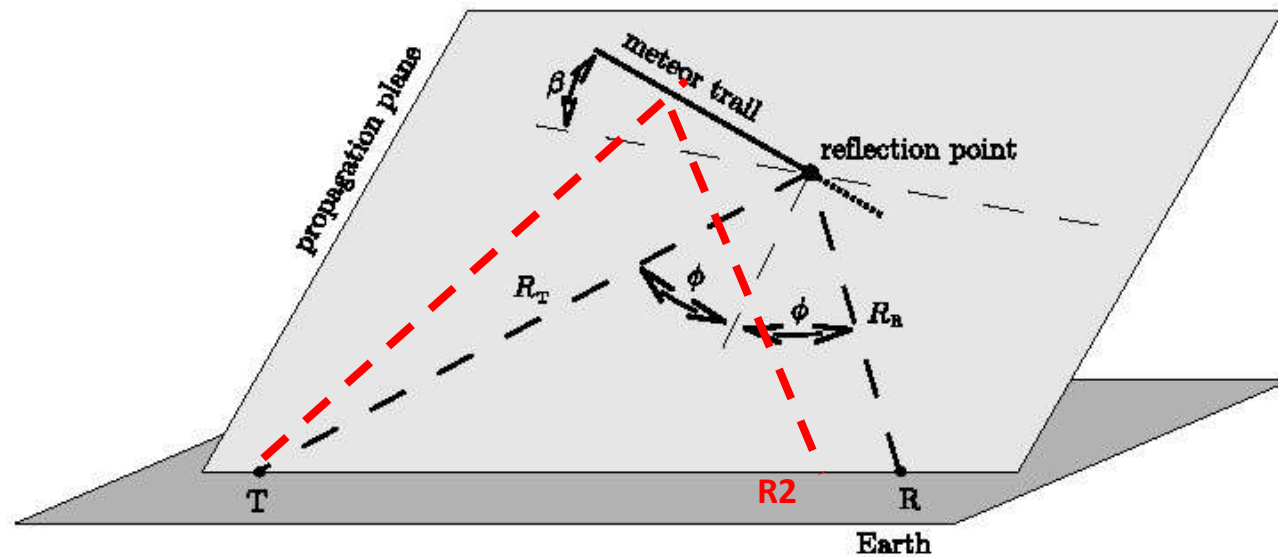
Meteoroid flux densities for meteor showers

- Meteoroid flux density $Q(m)$ = number of meteoroids having masses greater than m that intersect a unit area perpendicular to the meteoroid velocity vector (or radiant) per unit time
- Based on meteor echo countings and following the methods of Kaiser (1953) and Belkovich (1971, 2006) and extended to forward scatter systems by Ryabova (2006, 2007). Two different methods using all observed meteor showers and only overdense meteors



- The previous methods assume that we can estimate the mass index s of the shower (e.g. from the slope of the cumulative logarithmic amplitude distribution of meteor radar echoes)
- Belkovich (2006) proposed another method to fine-tune both meteoroid flux densities $Q(m)$ and mass index s of a meteor shower at the same time.

Retrieval of meteoroid trajectories



Retrieval of meteoroid trajectories (2)

- **Multi-stations observations of the same meteor** : the meteor trajectory must be tangential to a set of ellipsoids whose foci positions are the locations of the transmitter and receiver.
- **Multi-stations observations of the same meteor** : by accurately measuring the start of the echo (linked to the positions of the various specular points) at each station, it is in principle possible to retrieve the meteor trail path. This needs at least six stations (3 DoF for position and 3 for velocity) synchronized by GPS. Problem : this assumes no deceleration of the meteor unless we can measure it from another method (e.g. from Fresnel oscillations in underdense meteor echoes)



Retrieval of meteoroid trajectories (3)

- **Multi-stations observations of the same meteor including the interferometer** : from the interferometer data, the direction of one specular point can be accurately determined as well as a direction perpendicular to the meteor path. Three other stations are necessary since only the distance, path orientation and velocity still have to be determined.
- **Particular case of head echoes** : measurements of Doppler shifts and slope of the head echoes can be used to retrieve trajectory and speed of a meteor observed by at least 6 stations.



Future activities coordinated with BRAMS

- Development of a radar system located next to the beacon in Dourbes. Among others goals, to compare and calibrate meteoroid fluxes obtained with back scattering and forward scattering systems. In particular, test of the echo ceiling effect preventing backscattering systems to detect small and/or fast meteors at high altitude.
- Addition of an optical camera in Humain → simultaneous optical / radio detections of meteors → better accuracy on the trajectories.
- Meanwhile, coordinated observation campaign with a SPOSH (Smart Panoramic Optical Sensor Head) camera from ESA?



Conclusions

- BRAMS will be a unique tool to detect and characterize meteors. By end of 2011, BRAMS will have ~20-25 stations, one interferometer and a dedicated beacon.
- BRAMS will be challenging, both in terms of new methods to develop and test, but also in terms of data storage and analysis.
- BRAMS is currently a Belgian project but collaborations with neighbouring countries are already going-on with future stations in the south of Paris, in Lille, in the Netherlands, etc...



BRAMS : the website



BRAMS Listen to the meteors
Belgian Institute for Space Aeronomy

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What is BRAMS?

BRAMS (Belgian Radio Meteor Stations) is a set of radio receiving stations using forward scattering techniques to study the meteoroid population. The project is coordinated by the Belgian Institute for Space Aeronomy (BISA), in the frame of the Solar-terrestrial Centre of Excellence (STCE). Most stations will be run by Belgian radioamateurs or groups of amateur astronomers. Two dedicated beacons located in Jeger (Western Belgium) and Dourbes (Southern Belgium) act as transmitters.

The main goals of this project are:

- To collect and standardise the meteor observations of all the stations.
- To write codes for **automatic detection** of underdense/overdense meteor echoes.
- To compute **meteoroid flux densities** for meteor showers and **mass indexes** for meteor showers and sporadic meteors.
- To determine **individual meteor trajectories** from observations of the same meteor by multiple stations (both shower meteors and sporadic ones)
- To determine **orbital parameters** of multi-station meteoroids.
- To analyse meteor profiles in order to retrieve physical parameters such as **ionization, speed and mass** of the meteoroids
- To study **head echoes** and the so-called "**epsilon**" **echoes**
- To promote radio-observation of meteors.

Currently, most of the BRAMS receiving stations belong to the radioamateur network of the **VVOB** with about 15 receiving stations mainly spread over the Flemish region. They listen to the **beacon XCM44 4.130MHz** which emits a cw circularly polarized signal at a frequency of 49.99 MHz with a constant power of 50W.

In September 2010, we will add a second beacon in the **Demographic Office of Dourbes** which is part of the Royal Meteorological Institute of Belgium (MIB). It will emit a cw circularly polarized signal at a frequency of 49.97 MHz with a constant power of 150W.



By the end of 2010/begin of 2011, we would like to provide all existing stations with new hardware material to listen to this new beacon. The material will be identical for each station, allowing an easier comparison of the data. We also plan to extend the network by setting up new stations, first in the South of Belgium. The following groups of amateur astronomers have already expressed their interest to host a receiving station and to join our effort:

- the **GRAB** in Spa, the **S&L** in Raads
- the group "**Astronomie Centre Ardennes**" in Neufchâteau
- the **Sonopact Center** in Redu

If you are interested to join our effort and present radio-observation of meteors to your visitors, please contact us.

One of our receiving stations will be located in the **radioastronomical site of Louvain-la-Neuve** which belongs to the Royal Observatory of Belgium (ROB). This station will have interferometric capabilities using the 3-antenna design described in Jones & Jones, Radio Science, 33, 55-65, 1998.



<http://brams.aeronomy.be>



THANKS!



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