The Bolide

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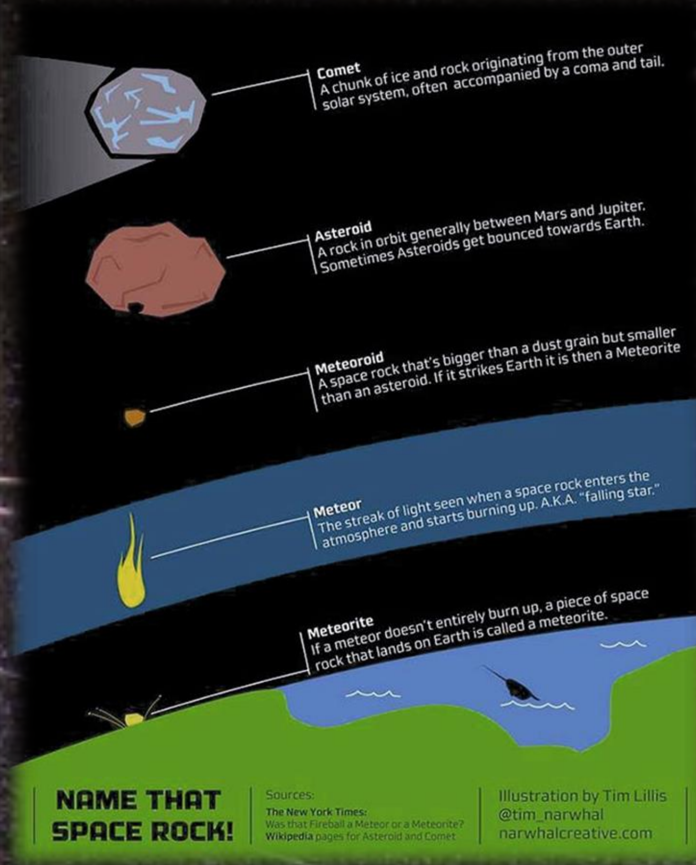
2016

ХАСКОВО

What is a Meteor?

A meteor is a meteoroid or a particle broken off an asteroid or a comet orbiting the Sun. It burns up as it enters the Earth's atmosphere and creates the effect of a "shooting star". Meteoroids that reach the Earth's surface without disintegrating are called meteorites.

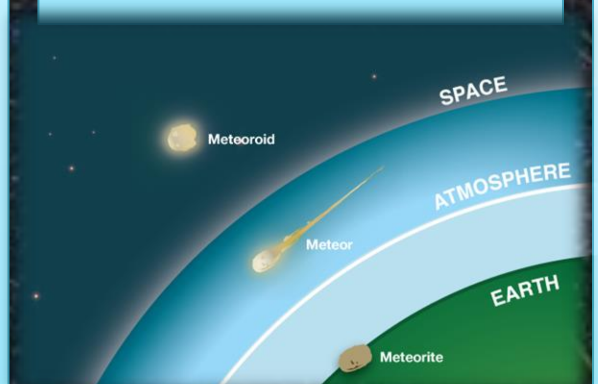


Why Can We See Them?

When Meteors enter the Earth's atmosphere from outer space, the friction caused by air particles heats them up so that they glow. After that they leave behind them a trail of gas and melted particles. Usually they disintegrate 48 to 97 kilometers from the ground. Most glow for about a second, but others leave a trail that lasts for several minutes.

Why Do They Come in Showers?

Millions of particles enter the Earth's atmosphere daily but at certain times each year the Earth passes through a comet's leftover particles creating a "meteor shower".



Where Do They Come From?

Most meteors are pieces of comet dust no larger than a grain of rice. In principle, meteors are rocks broken off asteroids in the asteroid belt, which is located between Mars and Jupiter. They can weigh as much as 60 tones.

Major Meteor Showers in 2016				
Shower	Radiant and direction	Morning of maximum	Best hourly rate	Parent
Quadrantid	Draco (NE)	Jan. 4	60-100	2003 EH_1
Lyrid	Lyra (E)	April 22	10-20	Thatcher (1861 I)
Eta Aquariid	Aquarius (E)	May 5	20-60	1P/Halley
Delta Aquariid	Aquarius (S)	July 28	20	96P/Machholz
Perseid	Perseus (NE)	Aug. 12	90	109P/Swift-Tuttle
Orionid	Orion (SE)	Oct. 21	10-20	1P/Halley
Southern Taurid	Taurus (S)	Nov. 5	10-20	2P/Encke
Leonid	Leo (E)	Nov. 17	10-20	55P/Tempel-Tuttle
Geminid	Gemini (S)	Dec. 14	100-120	3200 Phaethon

Perseids

The Perseids is a heavy meteor shower, whose maximum activity is around 12 August. Its origin is the comet Swift-Tuttle. Swift-Tuttle's orbital period is 133 years, which means that most of the leftover particles are around a thousand years old. Just like every other meteor shower, it got its name from the constellation in which the radiant lies. The Perseids radiant is in Perseus.

Usually the Perseids are fast, white and leave traces. Their ZHR* is 95-100.

**ZHR – the number of meteors an observer could see in case of a clear sky for an hour when the radiant is in zenith.*

How the Meteor Was Captured

For a third consecutive year we were at the annual astronomy summer school at The National Astronomy Observatory-Rozhen (NAO-Rozhen), organized by our amazing astronomy teachers. There we go to lectures taught by incredible and talented astronomers, learn a lot and take pictures of nature, constellations, stars, asterisms and of course - the Perseids. Usually we stay there for 9 to 11 days, sleeping in cozy rooms and cooking ourselves. Each time, we go back home with new interesting knowledge and many wonderful memories.

These are photos, shot in different years, during our astronomy summer school at NAO-Rozhen. The backgrounds on all of the pages are also ours.

Visual Observations of Meteor Showers

There are many ways to observe meteor showers. Visual observing and the resulting “hourly rate” is still the basis of meteor astronomy. Even though the photography is evolving fast, many people still use the “old-fashioned ways” – watching the sky and writing down the features of the meteor that they have just seen. Others use a recorder when observing. Some just photograph the sky in hope of catching meteors.

When we are at the summer school we usually “divide” the sky between all of us so we can observe the whole sky at the same time. We all take pictures and some of us observe, writing down or recording.

What you have to look for when observing a meteor shower?

1. The shower association.
2. Magnitude
3. The speed of the meteor (fast, slow etc.)
4. The colour of the meteor shows what they are made of (white-Barium, yellow-Calcium or Natrium, red-Strontium, green-Copper, purple- Cesium or Rubidium)
5. The length of its tail (long, medium, short, 1^{o}, etc.)
6. Finding the radiant by drawing an imaginary line that follows the meteor’s path backwards.
7. If it leaves a track and for how long is it visible.

The Capturing of the Bolide

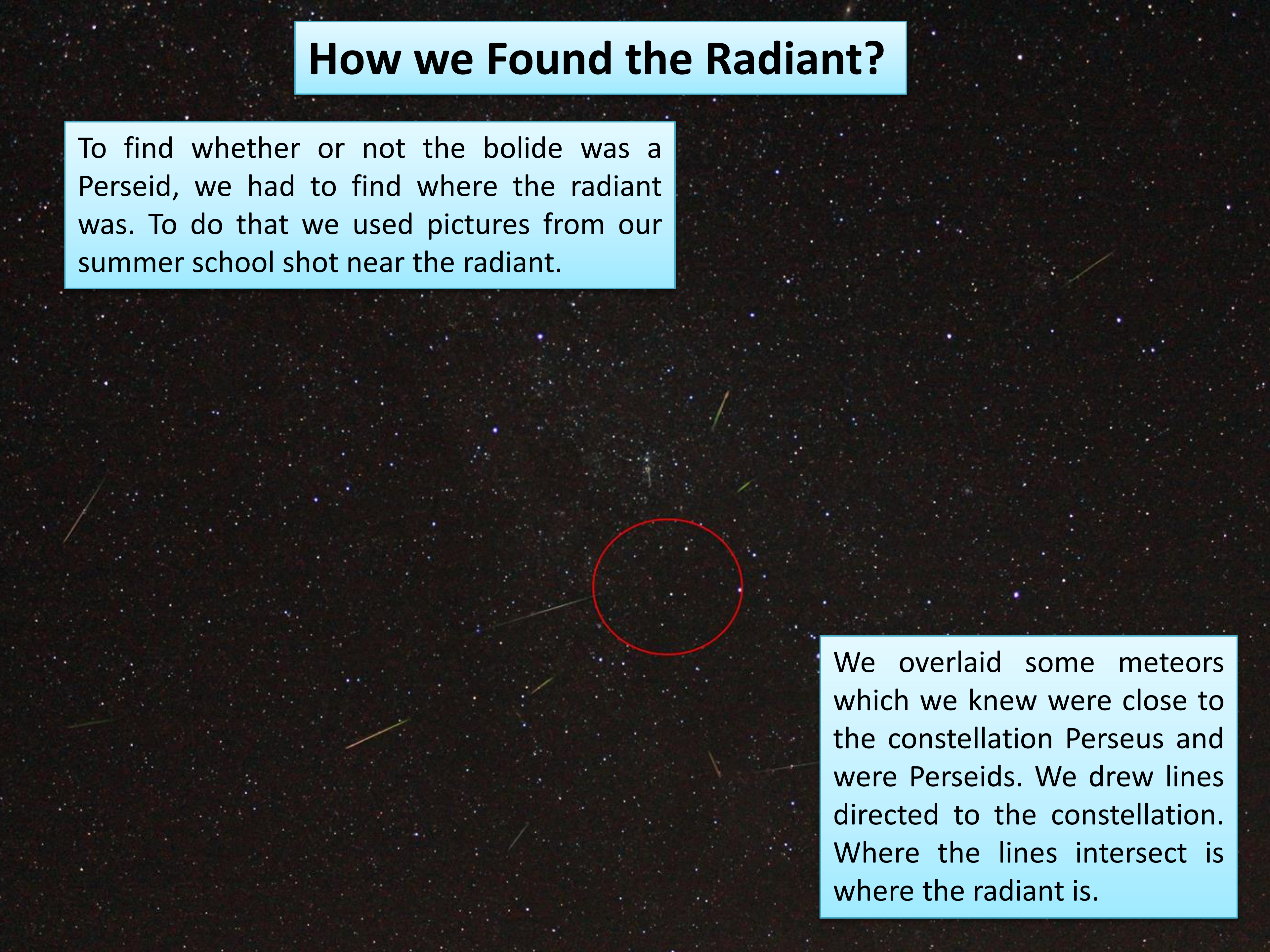
This year we were fortunate enough to witness an explosion of a bolide on 09/10 at 00:06 UT. Our friend – Victoria Mircheva – was successful in capturing it. To see it on a picture was amazing, but to witness it with our own eyes was beyond incredible. When the bright light flashed we were looking at another part of the sky.

We looked as quickly as possible to see what can cause a light so vivid and we saw the bolide. We were stunned and amazed. It left a trail for around 10 second then it vanished, leaving us with an astonishing memory of that picturesque moment.

The picture was taken with Canon EOS 750D, ISO 6400, F5.6, Exp 30s, Focal length 18mm

How we Found the Radiant?

To find whether or not the bolide was a Perseid, we had to find where the radiant was. To do that we used pictures from our summer school shot near the radiant.



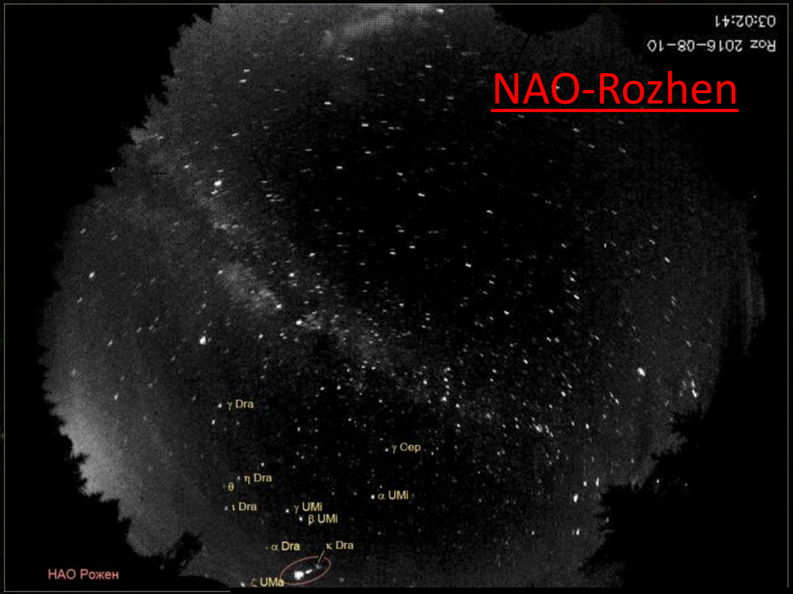
We overlaid some meteors which we knew were close to the constellation Perseus and were Perseids. We drew lines directed to the constellation. Where the lines intersect is where the radiant is.

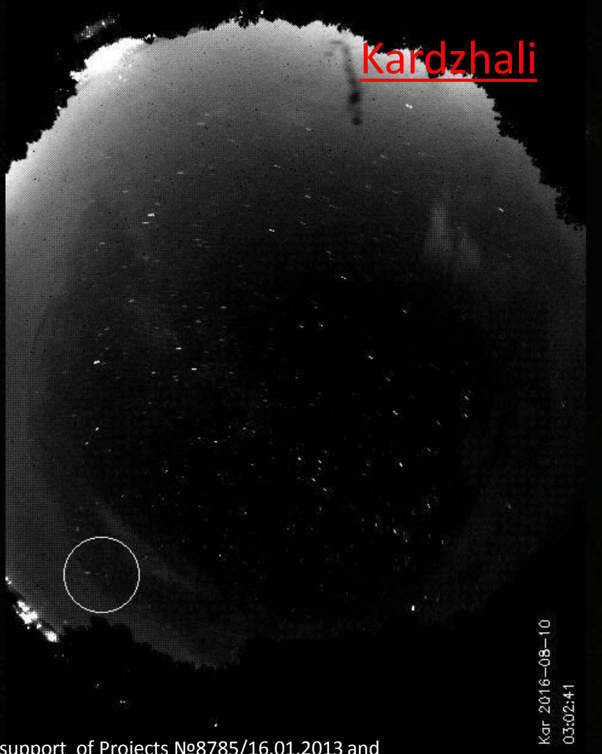
Is it a Perseid?

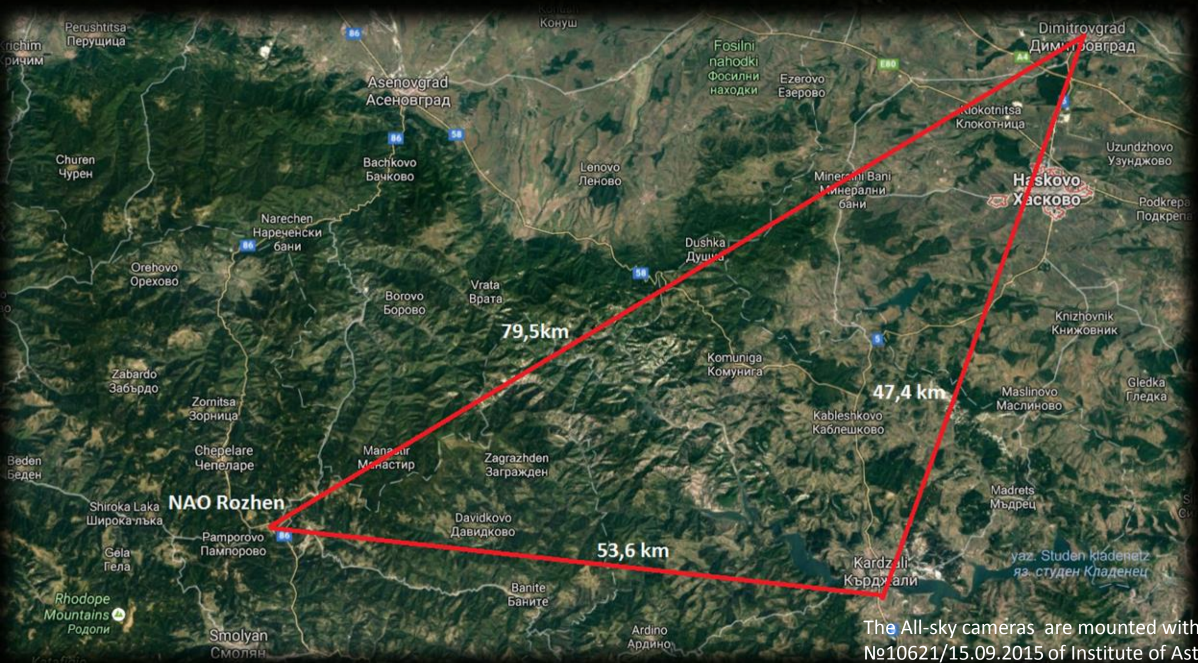
We decided to find out if the bolide is really a Perseid. First we placed the approximate trajectory of the bolide on a gnomonic projection map. Unfortunately, the exact place of the explosion and the radiant were not on one map. Furthermore the scales of both maps were not the same. Because of that the placement is not exact. As we expected the bolide turned out to be a Perseid, because the continuation of the bolide’s tale passes through the radiant.

All-Sky Cameras

Not long ago, 3 All-sky cameras have been installed – in Astronomical observatory and Planetarium "Giordano Bruno" - Dimitrovgrad, Astronomical observatory "S. Zlatev" - Kardzali and NAO-Rozhen. Unfortunately only 2 were working that night, but they were able to capture the bolide. The All-sky cameras take pictures of the whole sky all night at regular intervals of time.





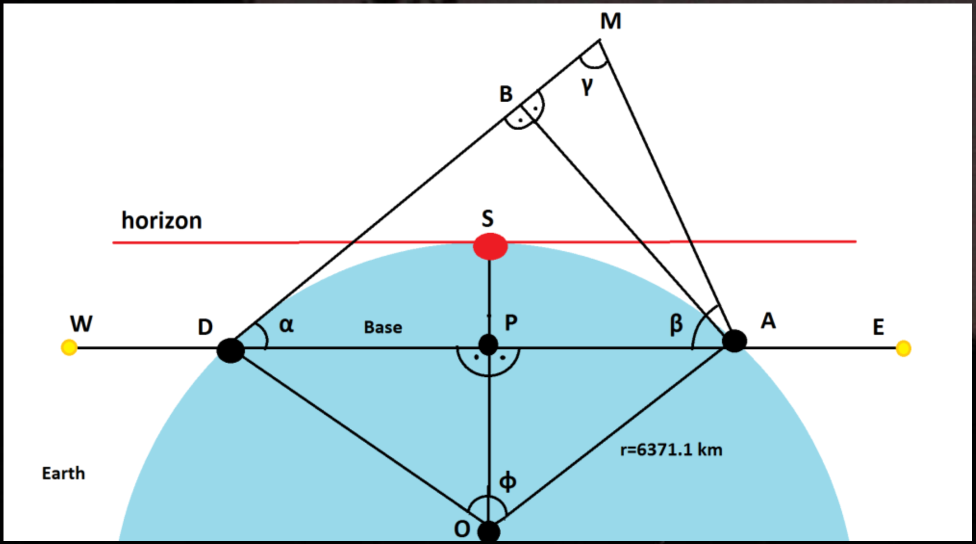


The All-sky cameras are mounted with the financial support of Projects №8785/16.01.2013 and №10621/15.09.2015 of Institute of Astronomy with NAO.

Altitude of the Meteor

The bolide was so intriguing that professional astronomers from the Institute of Astronomy like prof. Tanyu Bonev and Pencho Markishki decided to study it. We tried to do some calculations too and here we will present some of the results.

With the help of this drawing and after the identification of the stars on the pictures taken by Victoria and the all-sky cameras, the distance between NAO-Rozhen and the explosion of the bolide can be calculated.



- Φ – angular distance of the two points (A and D)
- S – a person standing between A and D
- Horizon – the horizon visible to person S
- M – bolide
- A – Kardzhali
- D – NAO Rozhen
- O – Earth's centre
- W and E – stars visible only to respectively D and A
- α and β – angles between the observatories and the bolide

Where the Bolide Exploded

The results of the calculations show that the bolide has fallen on Bulgarian land somewhere between the villages Rakita and Sadovets (near Cherven Bryag). The explosion had happened at an altitude of 60 km from those two places and 188 km for an observer watching it from NAO-Rozhen.

Velocity of the Bolide

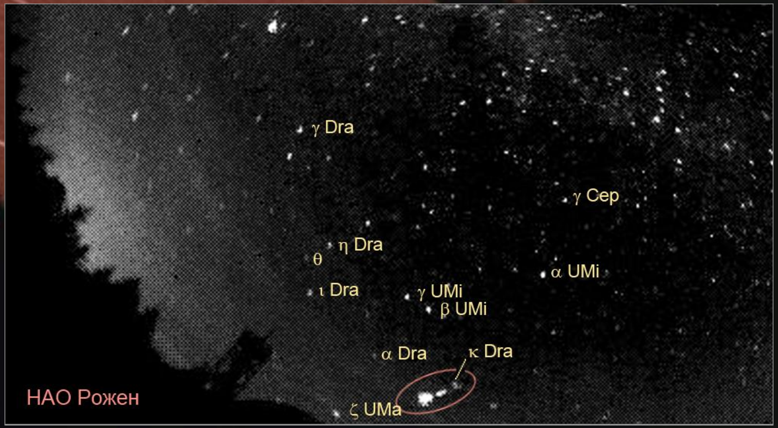
The all-sky cameras have a rotating shutter which works at a frequency of 10 Hz. The rotation speed is designed to give several interruptions during the time of a meteor's appearance which will produce a dashed line dividing the meteor's trail in segments. They alternate between light and darkness that lasts 0,3 sec. in the picture from Rozhen, there can be seen 3 such sections. Using the coordinates of the surrounding devices the angular velocity of the bolide at the end of its trajectory for an observer from NAO-Rozhen turns out to be 24,17^{o}. If the real direction of the bolide is perpendicular of another line of sight from NAO-Rozhen, then the real velocity of the bolide would be approximately 84 km/s. But probably it's just a projection which means that the real velocity is even higher.

$V_{meteor} = V_{meteoroid} \pm V_{earth}$

We know that the velocity of a meteoroid near the Earth's orbit is approximately 42 km/s and the velocity of Earth is around 30 km/s.

That means that the velocity of a meteor varies between 12 and 72 km/s.

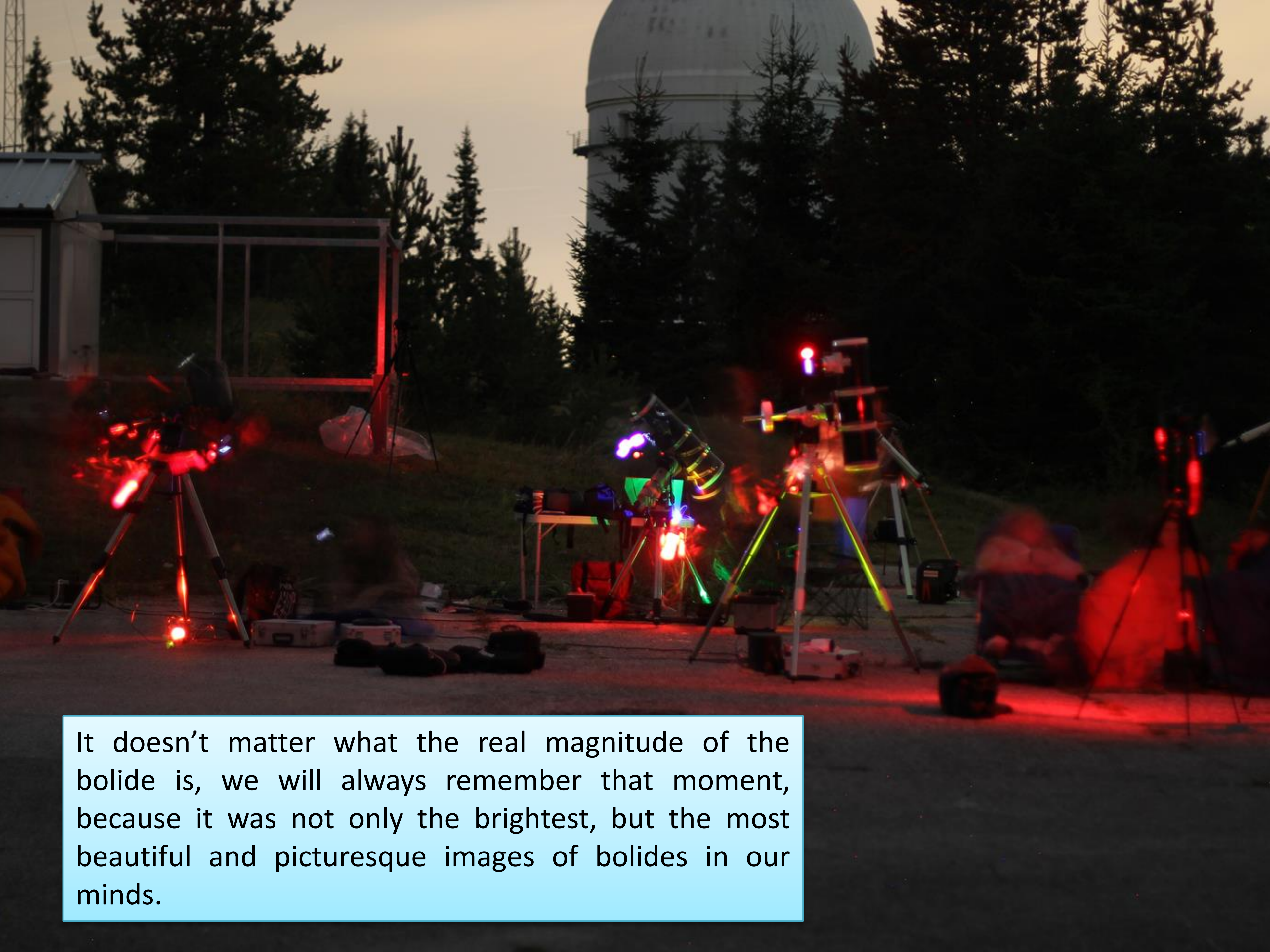
Probably the meteor is either not a Perseid or there is an uncertainty in the calculations due to the low resolution of the picture.



Apparent Magnitude of the Bolide

The photometric measurements, made by professor Tanyu Bonev lead to a high value of the apparent magnitude – more than -12^{m}.

It was in fact so bright that it coloured the clouds near which it happened to fall. The glow created a halo similar to the ones that the Sun and the Moon can create. It’s also called a corona.



It doesn't matter what the real magnitude of the bolide is, we will always remember that moment, because it was not only the brightest, but the most beautiful and picturesque images of bolides in our minds.

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