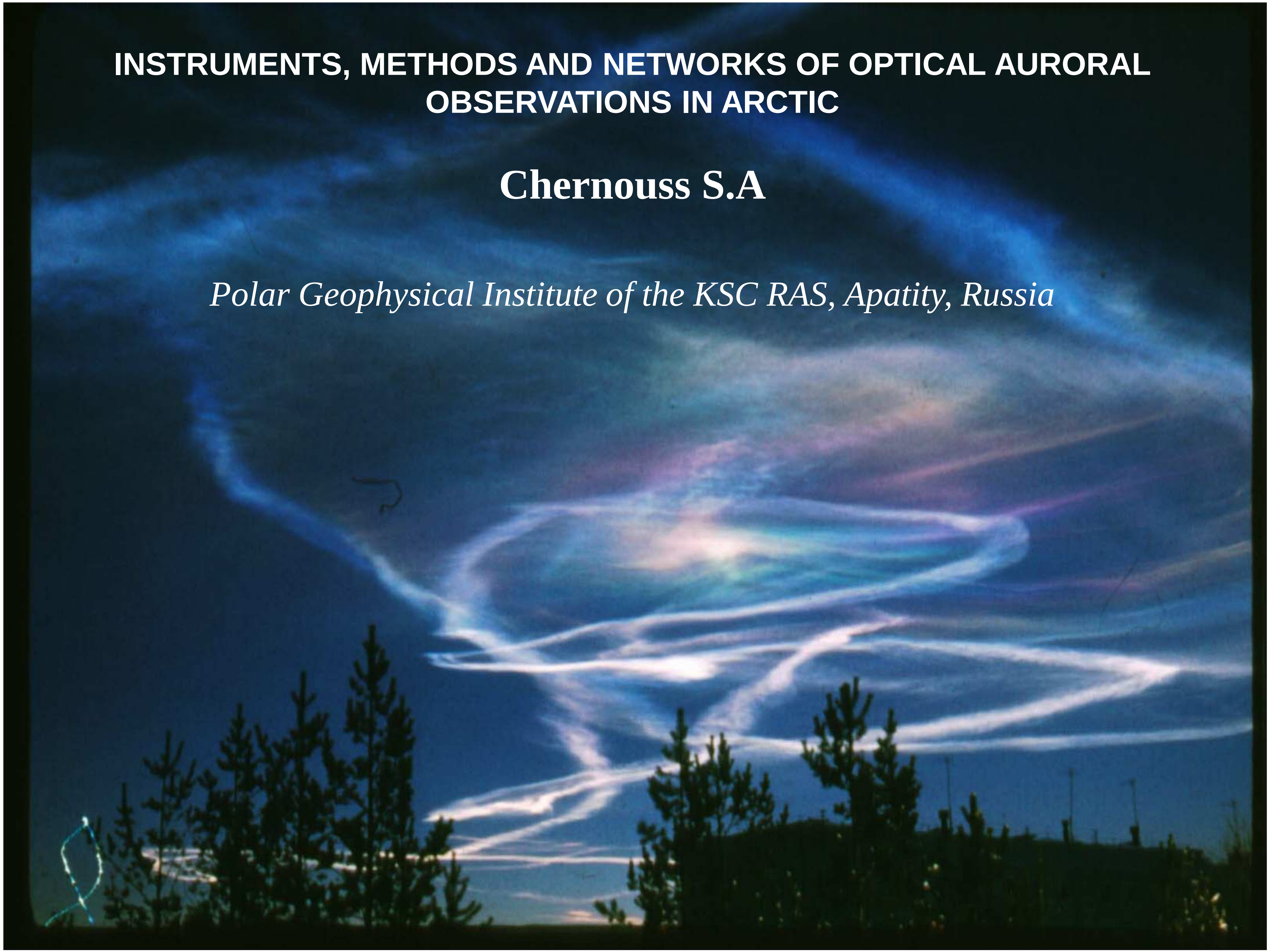
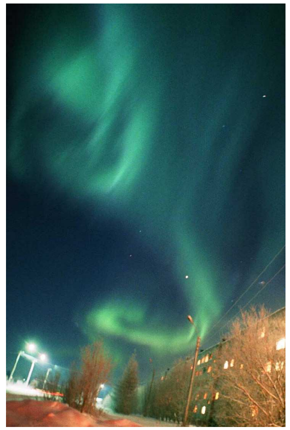


INSTRUMENTS, METHODS AND NETWORKS OF OPTICAL AURORAL OBSERVATIONS IN ARCTIC

Chernouss S.A

Polar Geophysical Institute of the KSC RAS, Apatity, Russia

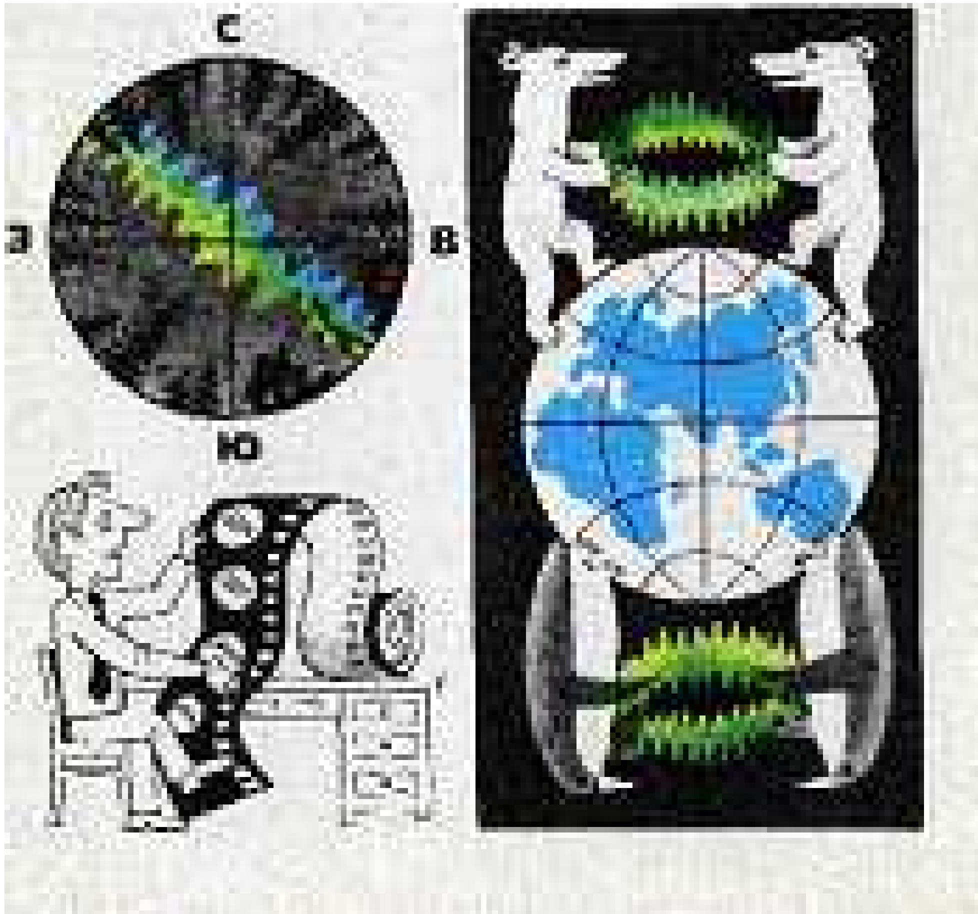

АПАТИТЫ

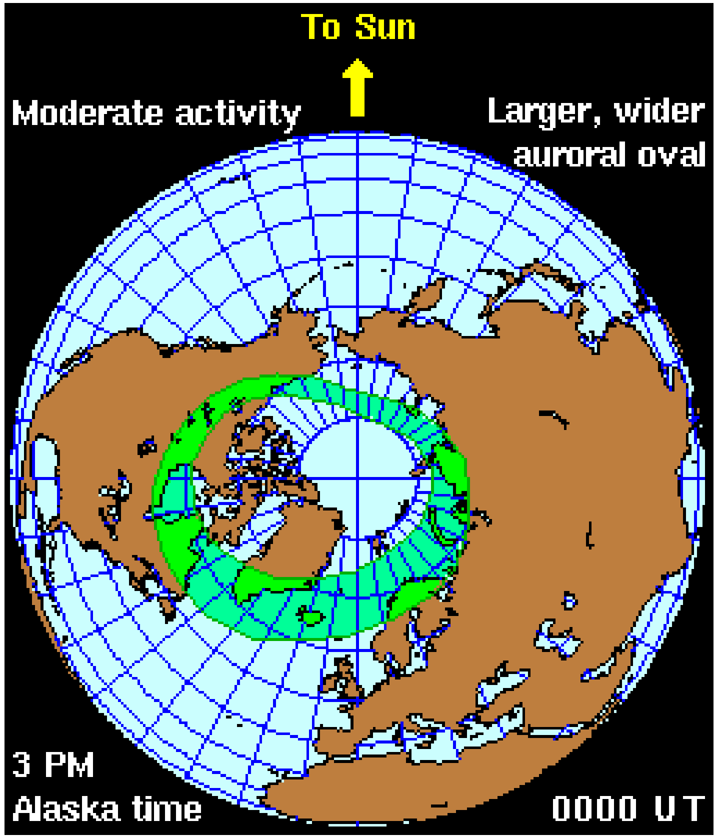


Soviet stamp in honor of the Iternational Geophysical Year (IGY 1957 -1958)

All-sky camera for auroral observations in Arctic

All-Sky camera C-180 and spectral all-sky camera at Mirny station





One of the main result of IGY is **Auroral Oval**

Map of Russian Arctic and launch of solid propellant rocket on the map. More than 20 automatic all-sky camera were installed during IGY

Altitude of phenomenon - 250 km.

NOVEMBER 04, 1983

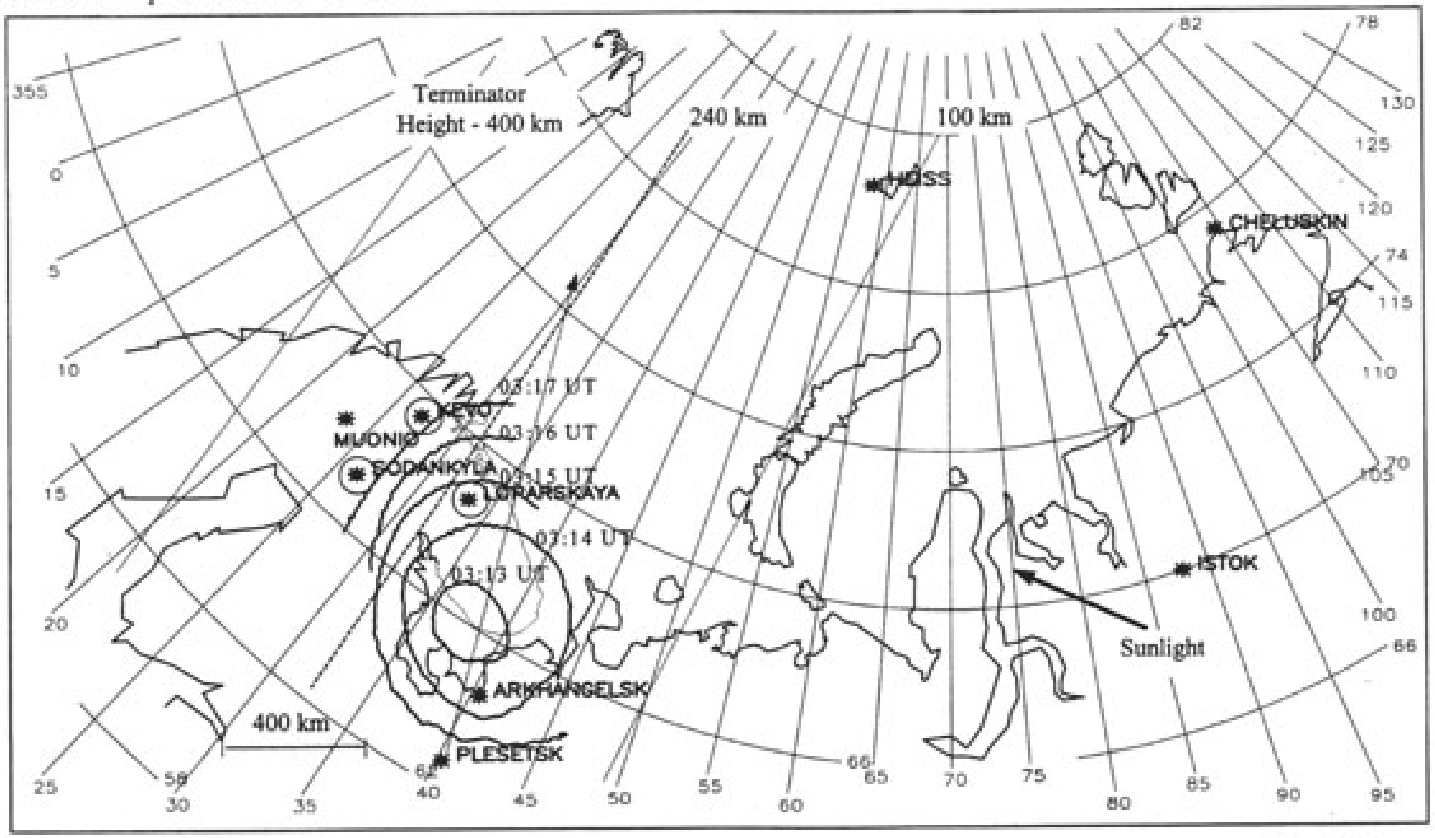
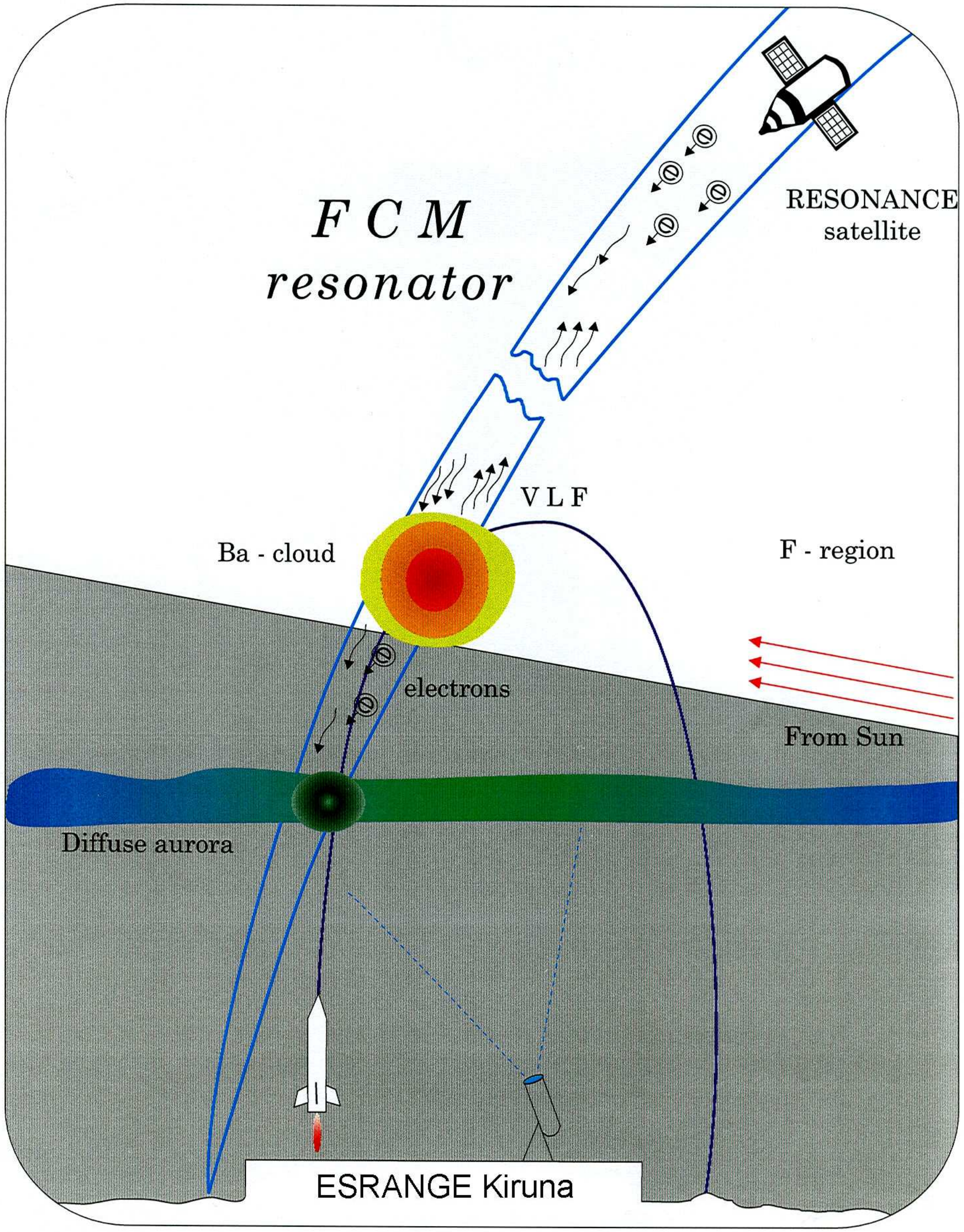


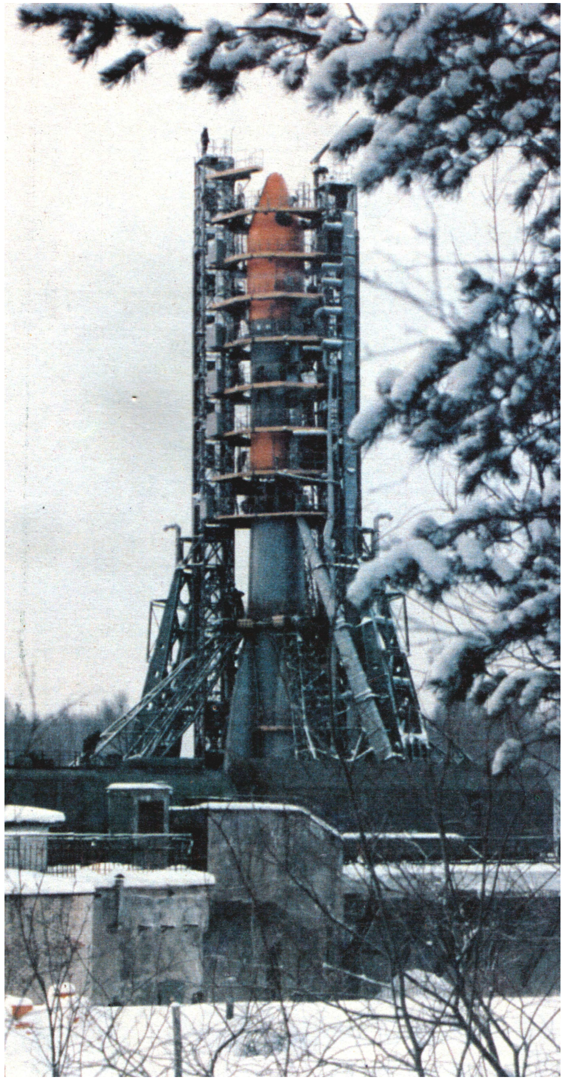
Fig. 9 Results of triangulation mapped on coastline of northwestern Russia and Scandinavia for case study on 4 Nov. 1983.


F C M
resonator
RESONANCE
satellite
V L F
Ba - cloud
F - region
electrons
From Sun
Diffuse aurora
ESRANGE Kiruna

North-West Arctic (Barents region) is the zone of experimental works of the Polar Geophysical Instute (PGI)

Location Map (Source: CIA World Factbook) Click to Enlarge.

International Centre of All-sky network auroral data is in PGI department in Apatity (ICD B2)



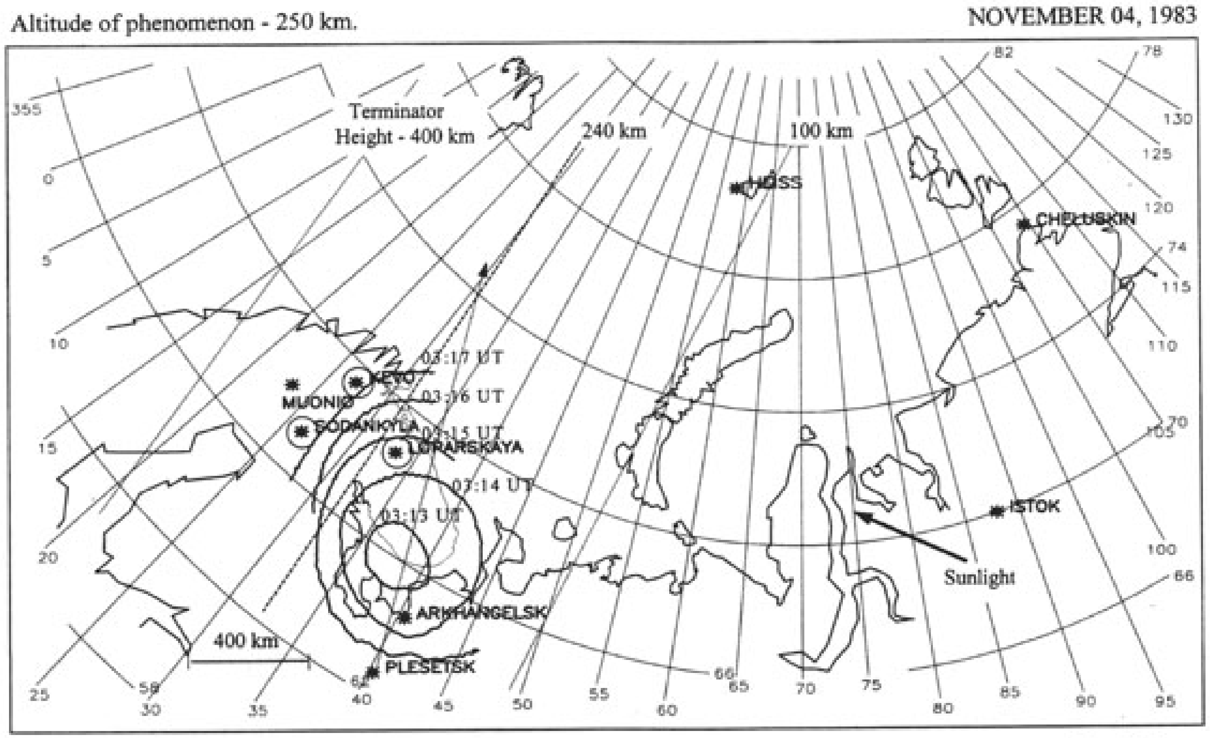
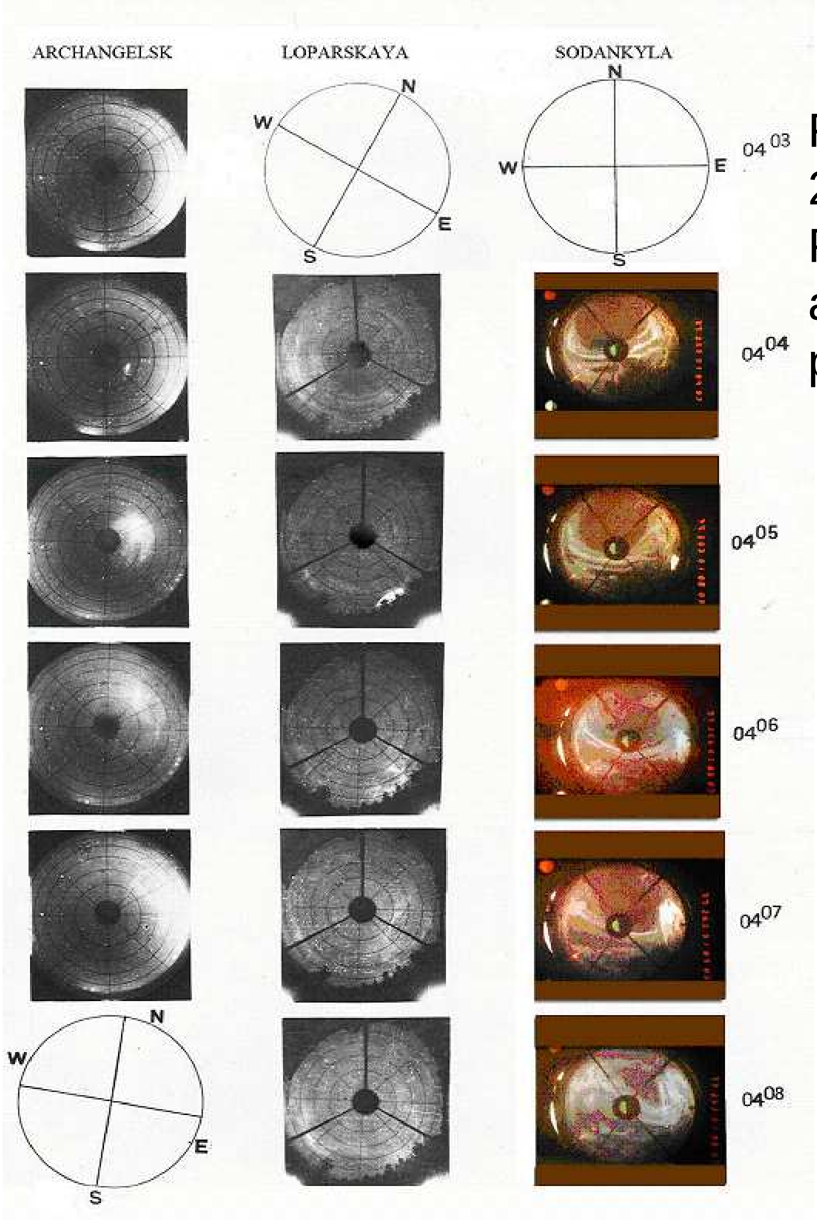


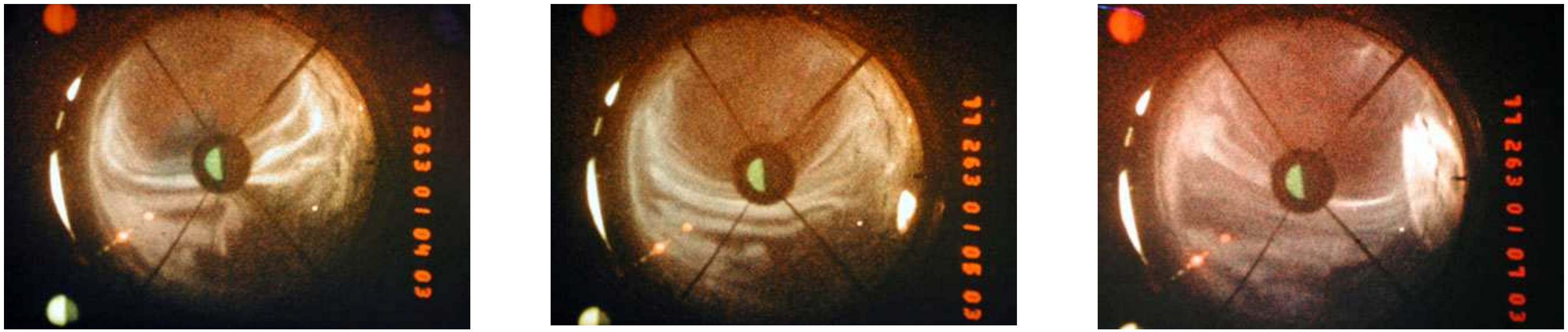
Fig. 9 Results of triangulation mapped on coastline of northwestern Russia and Scandinavia for case study on 4 Nov. 1983.

Launch from the Plesetsk range.
Reconstruction of spreading cloud by the triangulation method

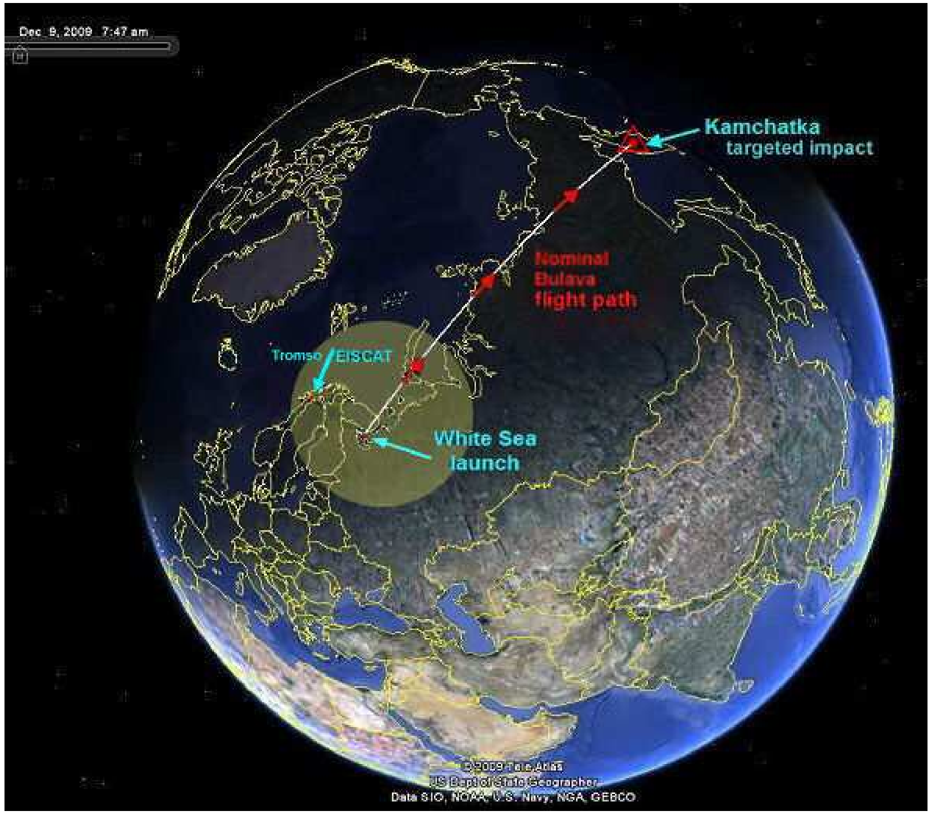


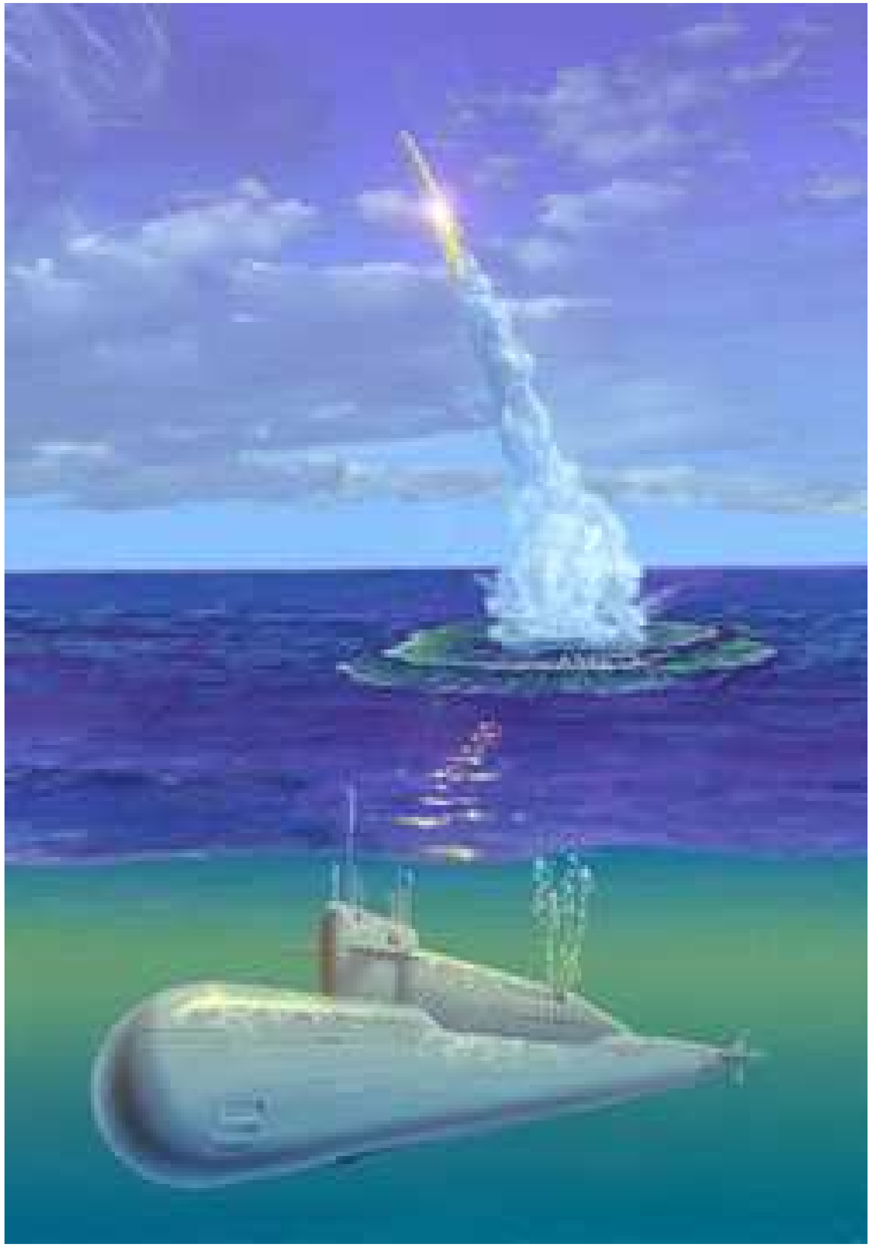
Famous Russian UFO of September 20. 1977 (Petrozavodsk Phenomenon). Photos were done by all-sky cameras from 3 observation points

Satellite “Meridian”, Soyuz 2-1A Fregat ¨2205,2009, launched frm the Pleseck Range. Photo Alexander Smirnov , Vologda.

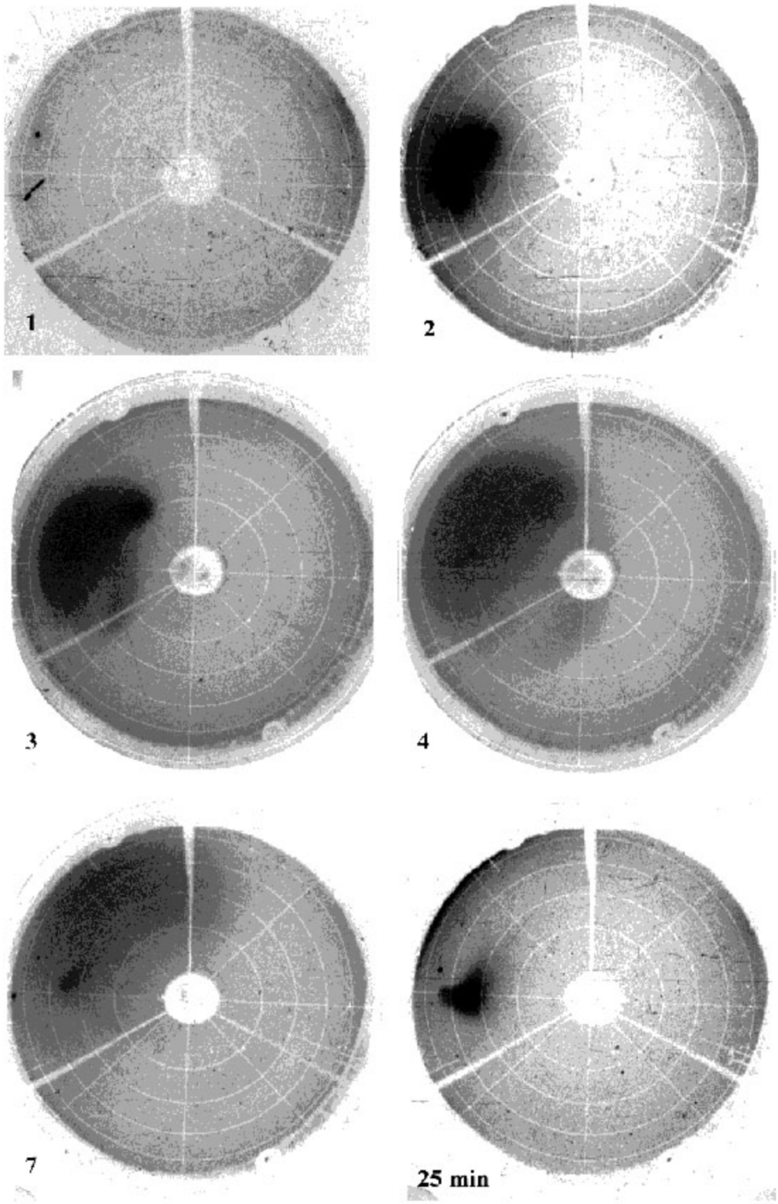


Cosmos 955 launch 20.09.1977, Sodankyla observatory (Finland) during aurora.



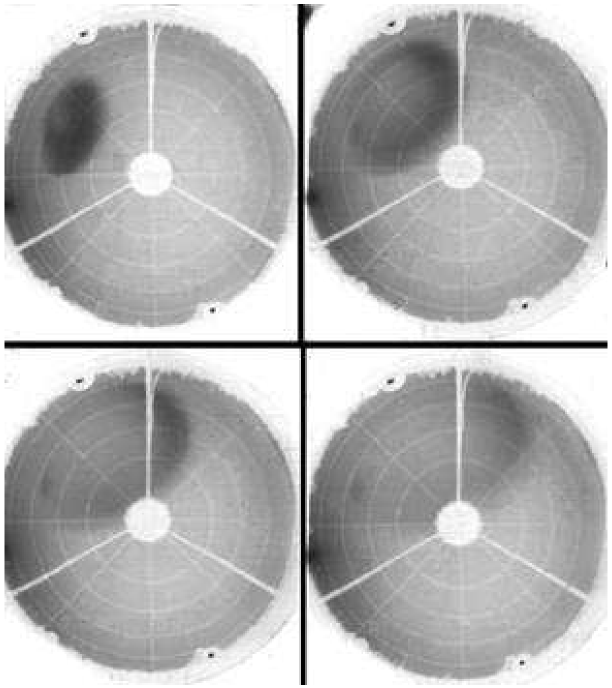


A typical rocket`s trajectory from the White Sea range to Kamchatka *(Tele Atlas, 2009)*

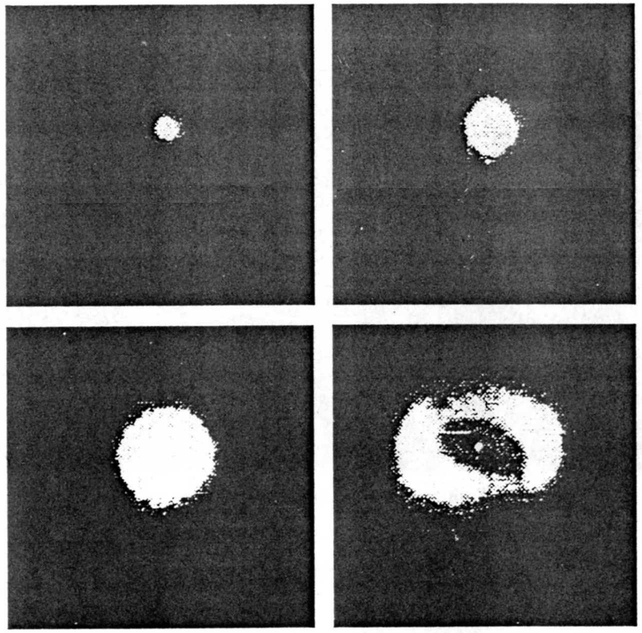


Negative all-sky images of the development of the gas and dust clouds formed during shutoff a solid-fuel rocket engine. The solar zenith angle is ~ 16 deg at the first frame and ~11 deg at the last one

Geometry and Scales



The development of gas-dust cloud formed in the separation stages of solid-fuel rocket, the photo is obtained by all-sky camera;



The evolution of clouds monomethyl hydrazine injected at an altitude of 250 km. The sequence of images corresponds to 1, 5, 20 and 60 seconds after injection. Each frame ~ 6x6 km.

Geometry and Scales

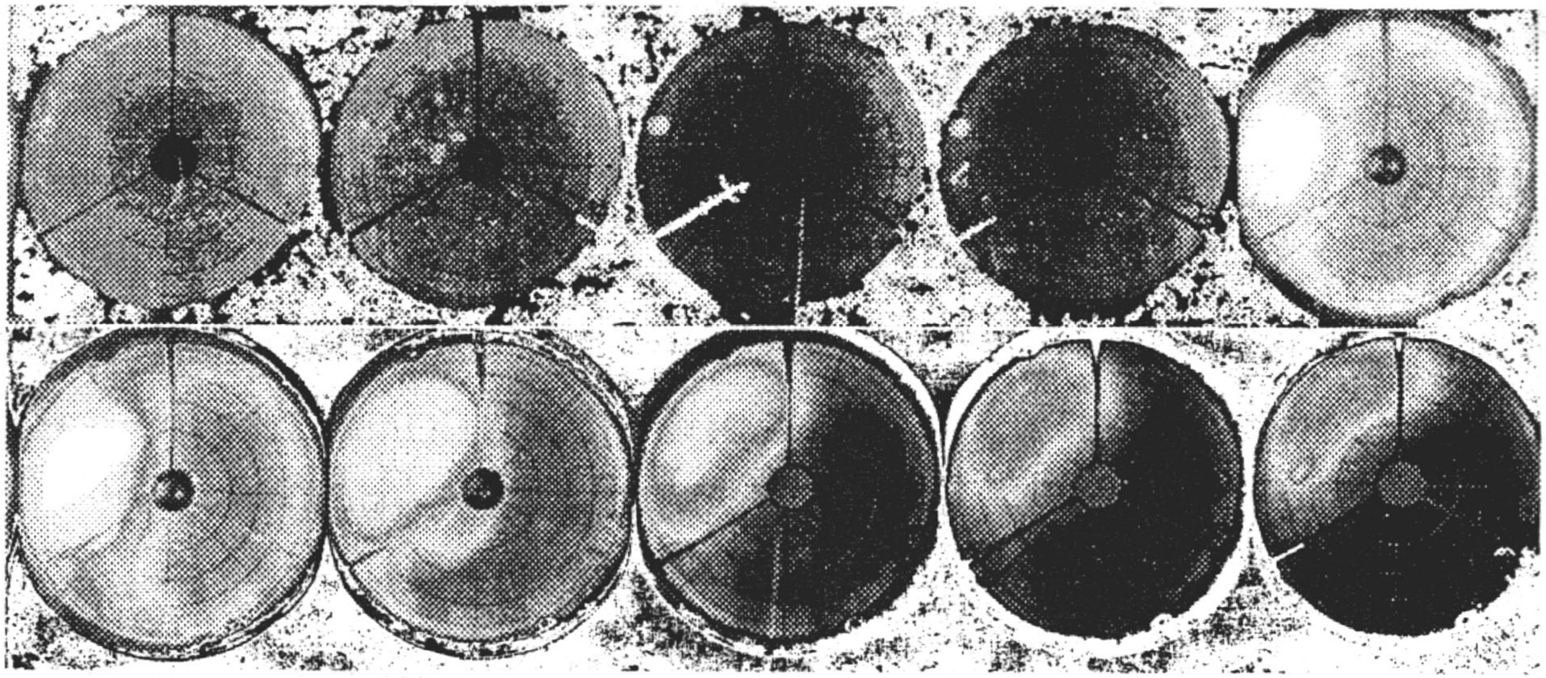


Fig. 2. Development of a gas-dust cloud associated with a solid-fuel rocket launch (every al-sky image is a one minute integration; a white-gray patch at the top left of the images is the appearance of a rocket launch cloud)

All-sky spectral camera images of solid fuel rocket exhaust products.

One can see Al and Li lines and AlO bands near horison

Al (396.1 nm)

Li (670.7 nm)

AlO (533.7 nm, 535.7 nm, 537.7 nm,

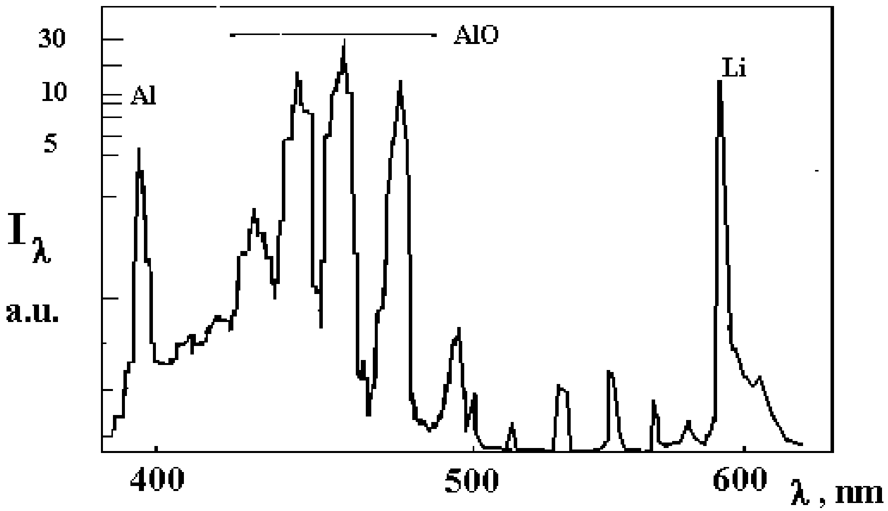
539.4 nm, 541.0 nm)

TEMPERATURE AND CHEMISTRY

Spectrum of solid propellant engine exhaust products

AlO emission– Resonance Scattering of the solar radiation

$AlO+h\nu \rightarrow AlO^* \rightarrow AlO+h\nu$ (4374 A – 5424 A)



Typical components of composition of rocket solid fuel :

NH_4ClO_4 $NOClO_4$ $C_6H_7O_2(OH)_3$

Al Mg Be

$(BeH_2)_x$

LiH $LiClO_4$

$(AlH_3)_x$

Electronic excitation of AlO in the atmosphere

Processes of AlO appearance in the upper atmosphere are very similar ones that connected with artificial releases of threemethylaluminium (TMA) by the rocket (Harang,1967; Uppsala report,1971), which caused the production of aluminium oxide in the chemical processes:

TMA +O $\rightarrow$ AlO + radicals.

At sunlit condition in the upper atmosphere responsible mechanism for AlO emissions could be resonance scattering of solar radiation on AlO molecules:

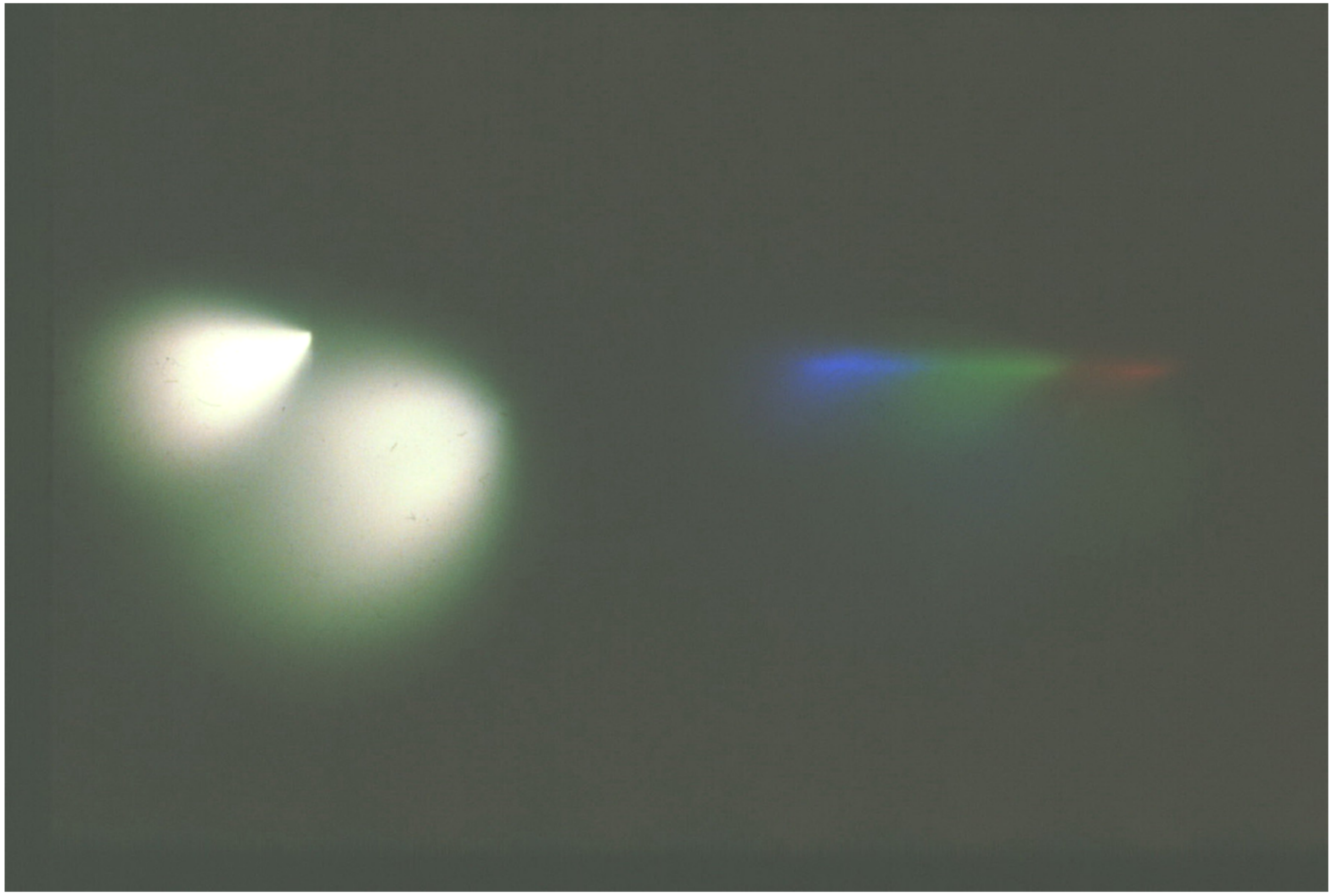
AlO + hν $\leftrightarrow$ AlO* $\leftrightarrow$ AlO + hν (AlO $\leftrightarrow$ AlO* + hν).

Al atoms react with different oxidants: N_2O, O_2, O_3, CO_2, NO_2, NO etc. Usually the inelastic interactions lead to the production of electronically excited AlO (Dagdigian et al., 1975; Rosenwaks et al.,1975) and ultraviolet, visible and infrared emissions have been observed after the reactions with the oxidants.

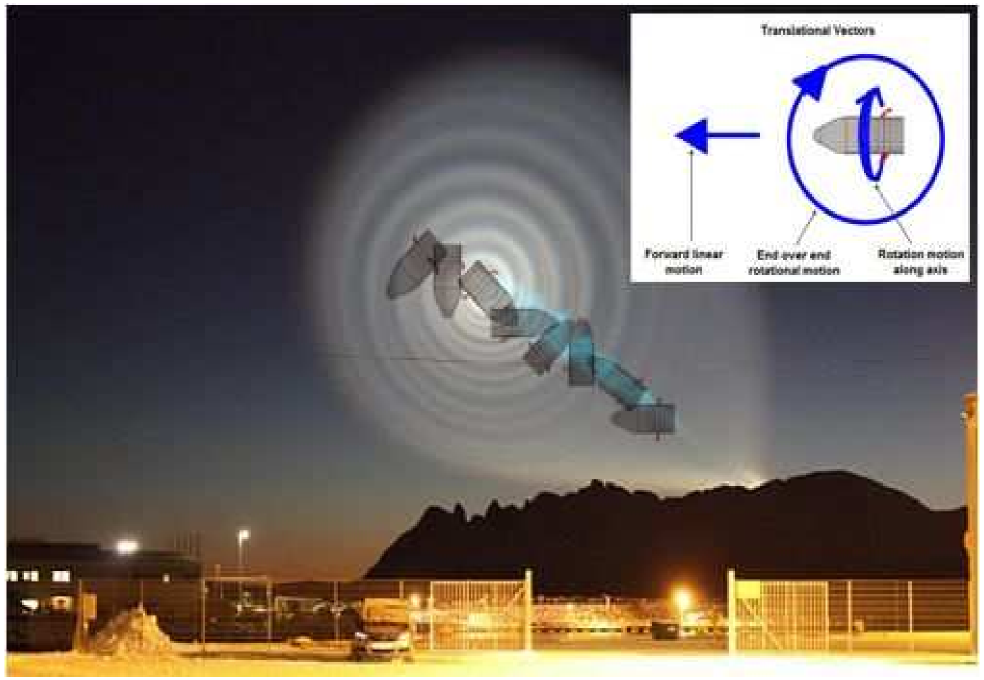
It could be possible that some continuum radiation during rocket releases is related with the reaction:

AlO + O $\rightarrow$ AlO_2* $\rightarrow$ AlO_2 + hν (continuum).

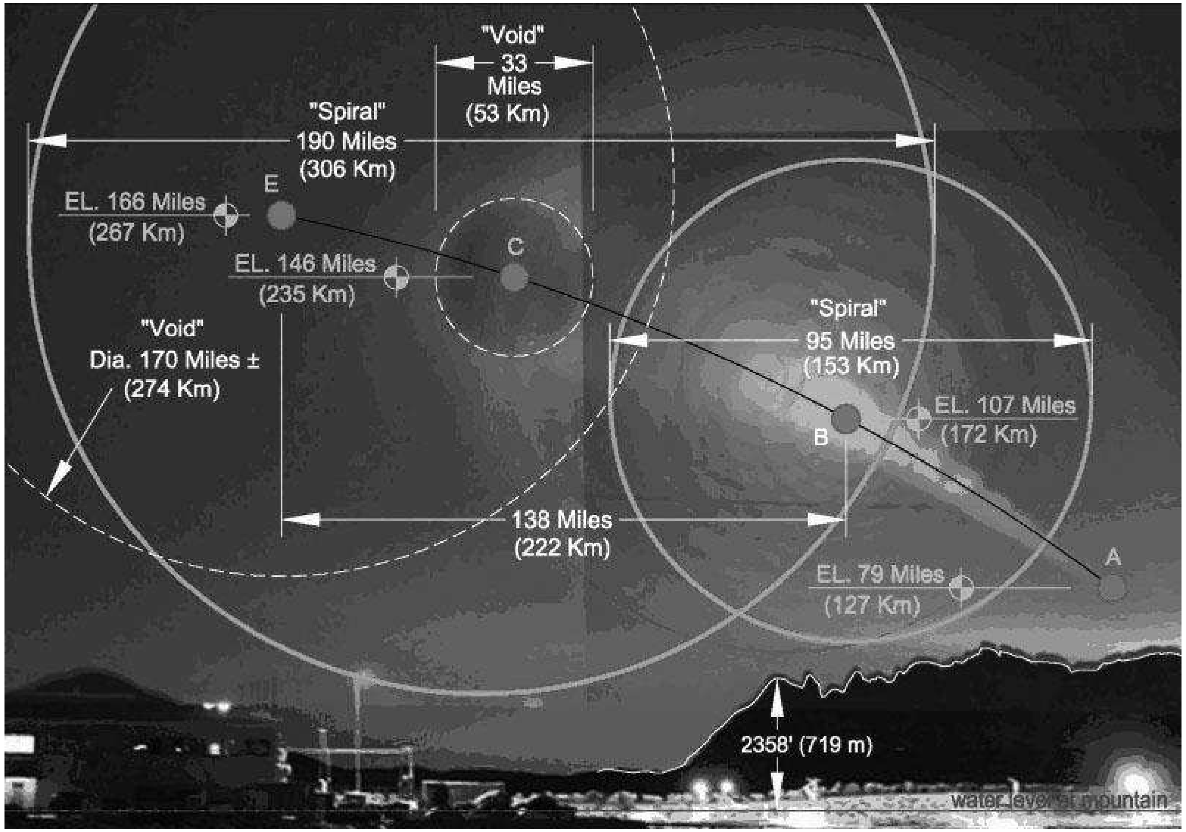
Photo of rocket exhaust products obtained by photocamera with objective grating installed before input lense



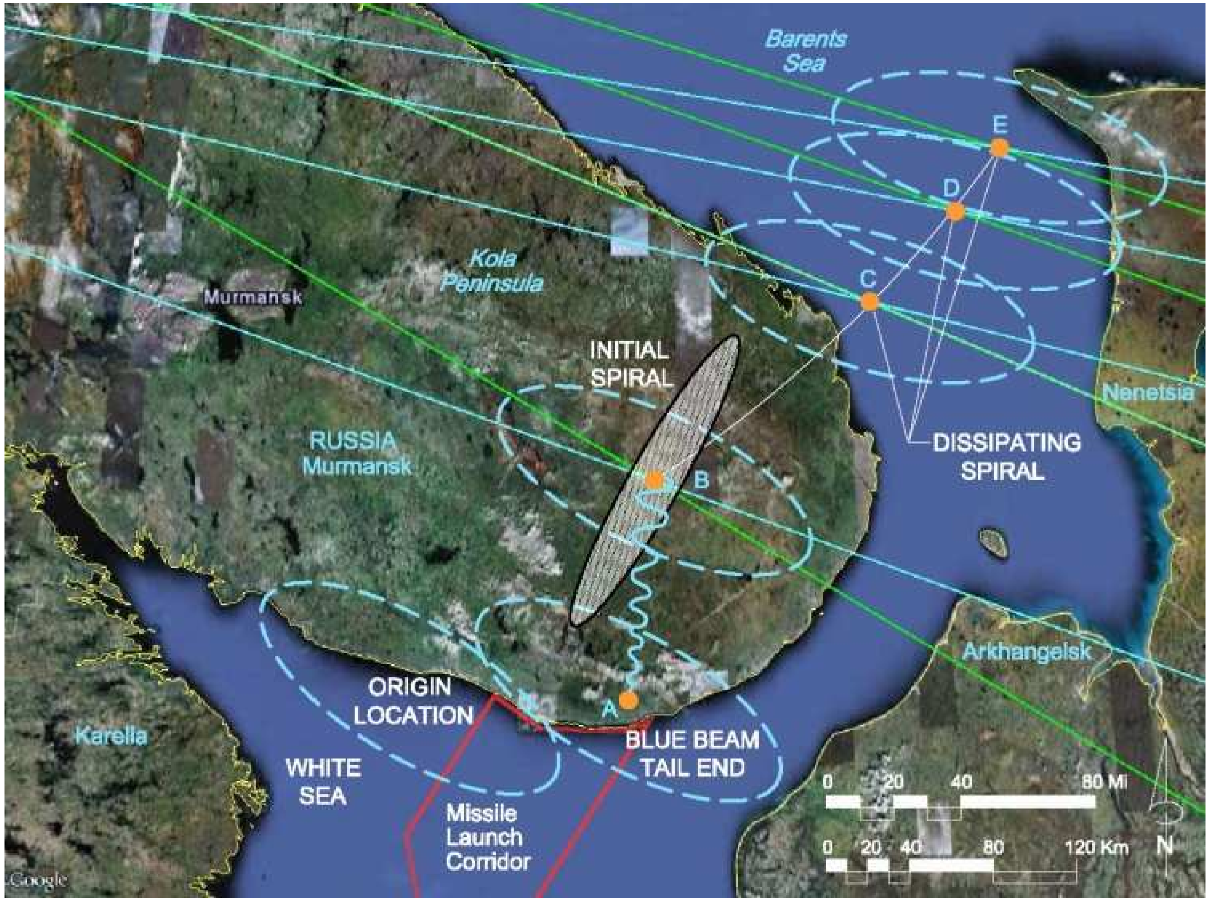
Norwegian Phenomenon. Launch of the “Bulava” missile rocket December 9, 2009.



Big spiral appears owing to failure in the third stage of rocket separation



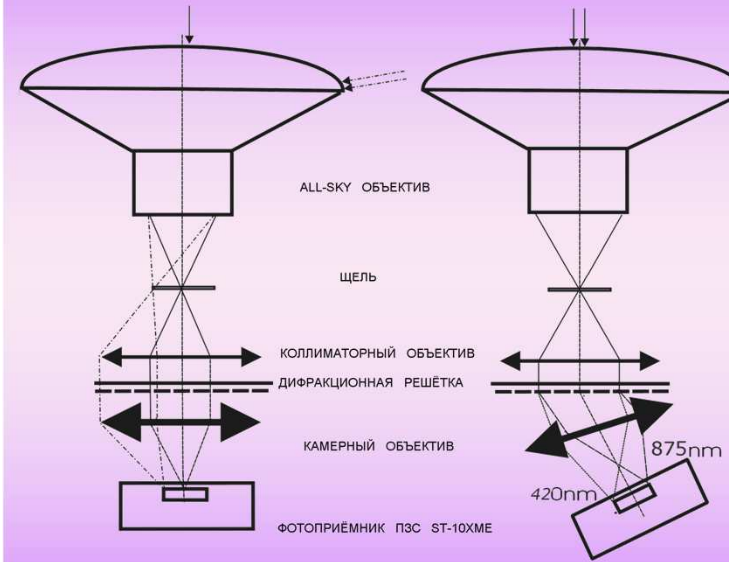
Results of Bulava trajectory calculations on basis of amateurs photo and GPS data (Tony Spell, 2009)



Calculation of trajectory by Google Earth (Tony Spell. 2009)


Solid propellant
“Bulava” launch
9.12,2009

Spectrograph S180

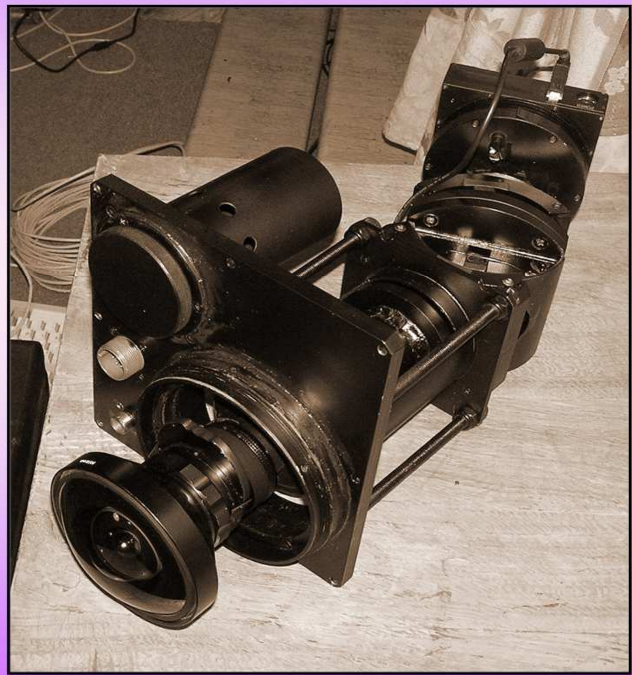


Optical Scheme of the Spectrograph S180

CCD parameters

Параметр	Значение	Примечания
формат матрицы, пикс.	2184 × 1472	
размер пиксела, мм	0.0068	
размер матрицы, мм	14.85 × 10.01	
квантовая эффективность, %	53÷86	в рабочем диапазоне λ
темновой ток, эл./пикс./сек.	0.05	при -30°C
шум считывания, эл	8.8	
динамический диапазон, ед	55 000	разрядность АЦП – 16 бит
скорость чтения матрицы, пикс./сек	425 000	возможно суммирование 1xN, 2xN, 3xN, пикс

Spectrograph S180

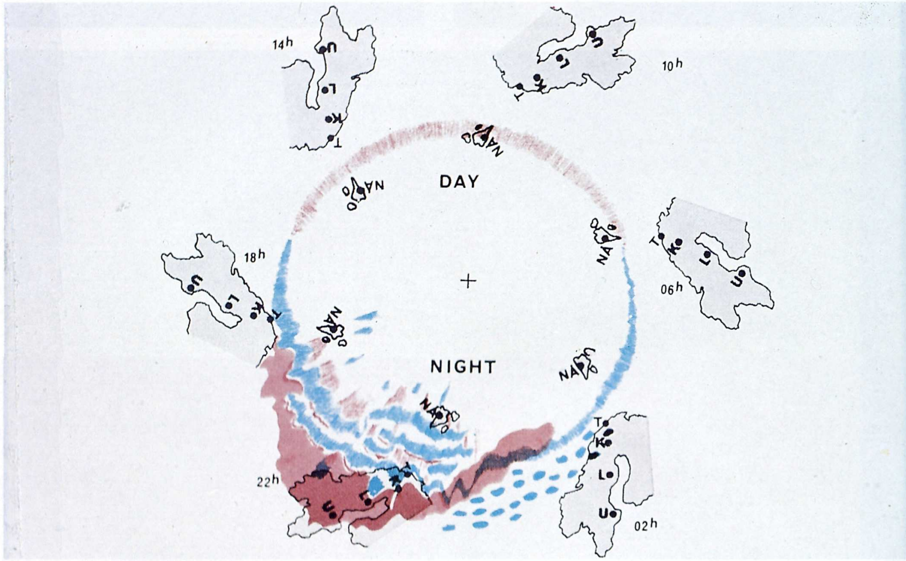


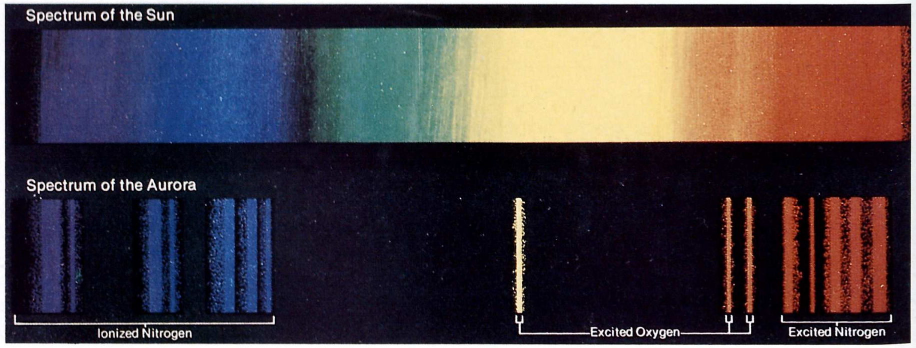
TEMPERATURE AND CHEMISTRY (Blue-green ALO emissions)

Diffuse trail, with a turquoise glow that remains after the passage of solid-fuel rockets (Apatity, 2000);

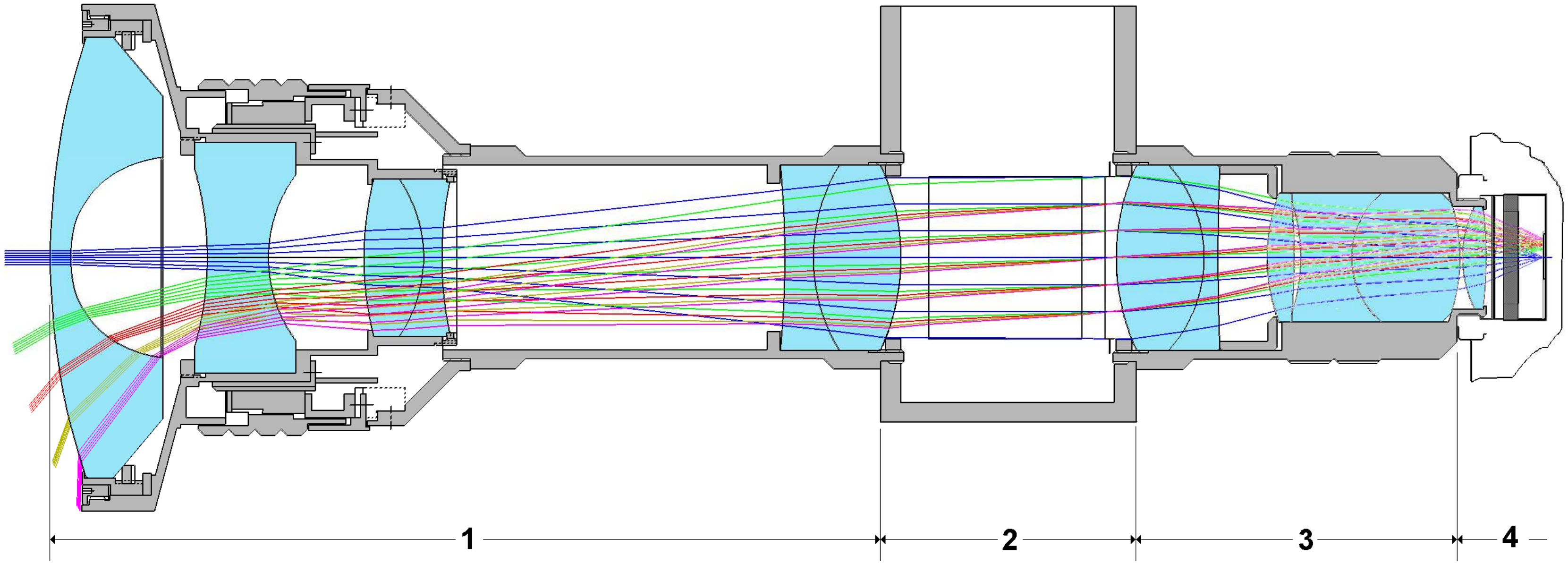
Turquoise cloud along the trajectory of "Bulava" observed December 9, 2009 in Norway.

SOLID PROPELLANT CLOUDS COLOURS


DAY
NIGHT
14h
10h
18h
06h
22h
02h


Spectrum of the Sun
Spectrum of the Aurora
Ionized Nitrogen
Excited Oxygen
Excited Nitrogen

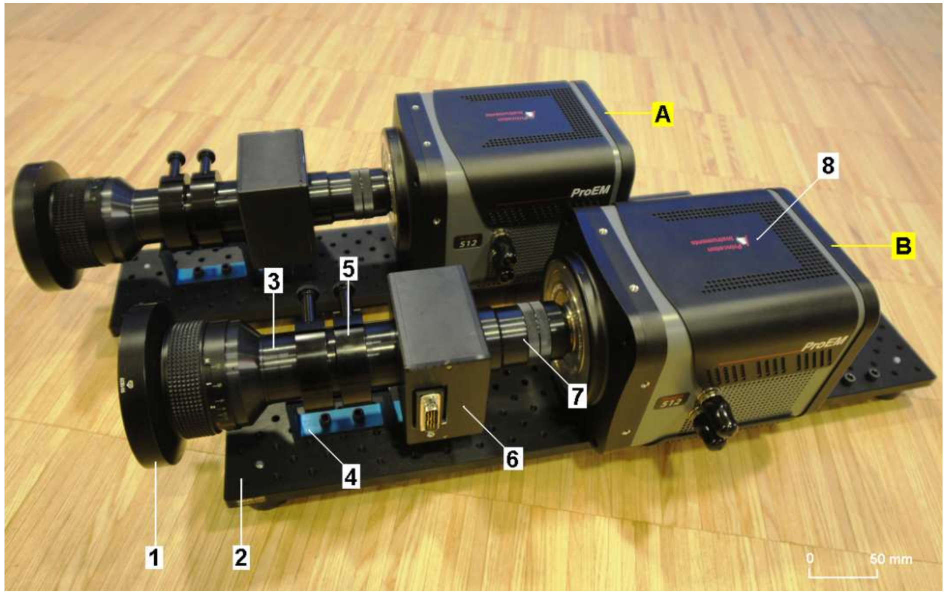
Optical layout and design of the NORUSCA II lens



Lens mechanics and optical diagram of the NORUSCA II all-sky lens:
(1) focusing mechanism and collimator lenses, (2) filter box - chamber,
(2) (3) camera lens, and (4) camera head.

UNIS

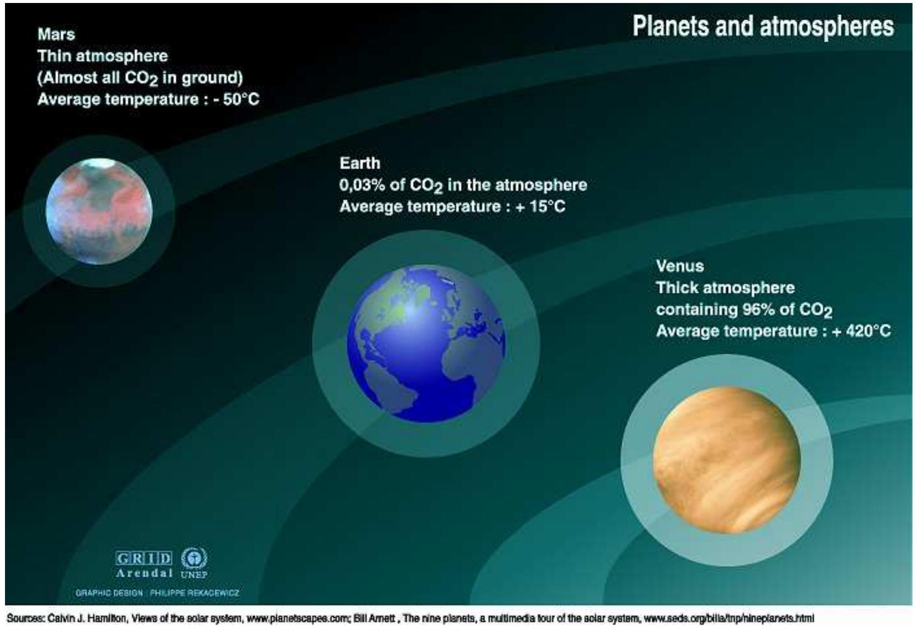
The NORUSCA All-sky cameras

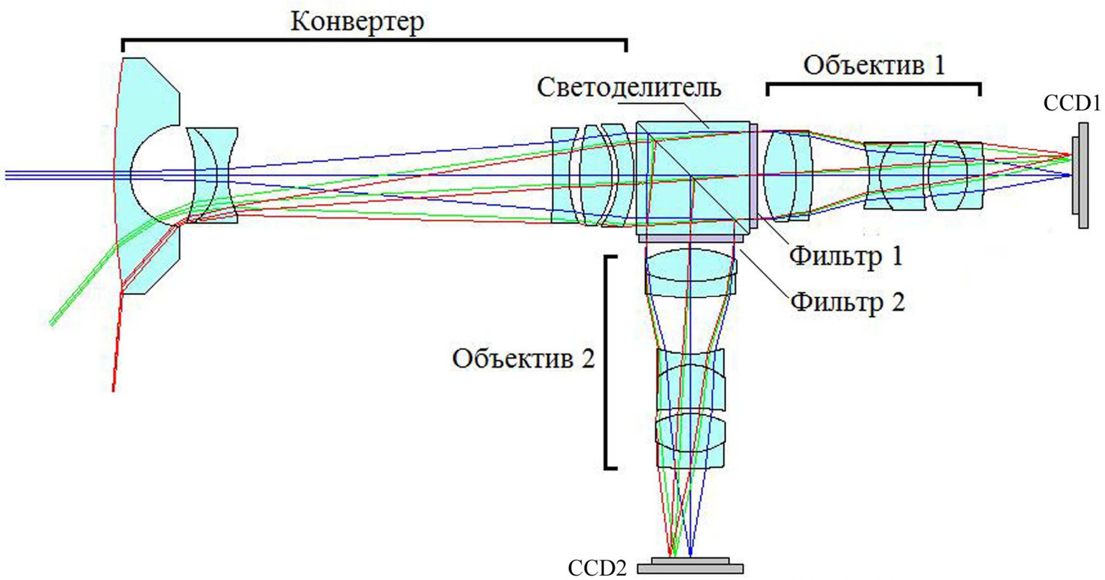


NORUSCA II-E fish-eye lens specifications	
Spectral range	430 – 750 *nm*
Paraxial focal length	3.5 *mm*
F-number	f/1.1
Number of lens elements	12
Field of view	180 º (circular)
Filter diameter	35 *mm*
Angle of incident on filter	< ±7 º
Dimensions	Ø110 320 *mm*
Camera lens mount	C-mount

Two NORUSCA II 1st Generation all-sky cameras (A) and (B). (1) Front element of all-sky lens, (2) 24 x 4 inch2 mount plate, (3) collimator lens tube, (4) lens mount, (5) ring holders, (6) filter box, (7) camera lens, and (8) EMCCD detector. Instrumental volume is ~ 65 x 18 x 16 *cm3*. Total mass is 8.9 *kg*.

EMCCD detector:
- PI ProEM 512B
- 8.2 x 8.2 mm^2
-70 deg. air cooled
- Back-illuminated; 90% QE

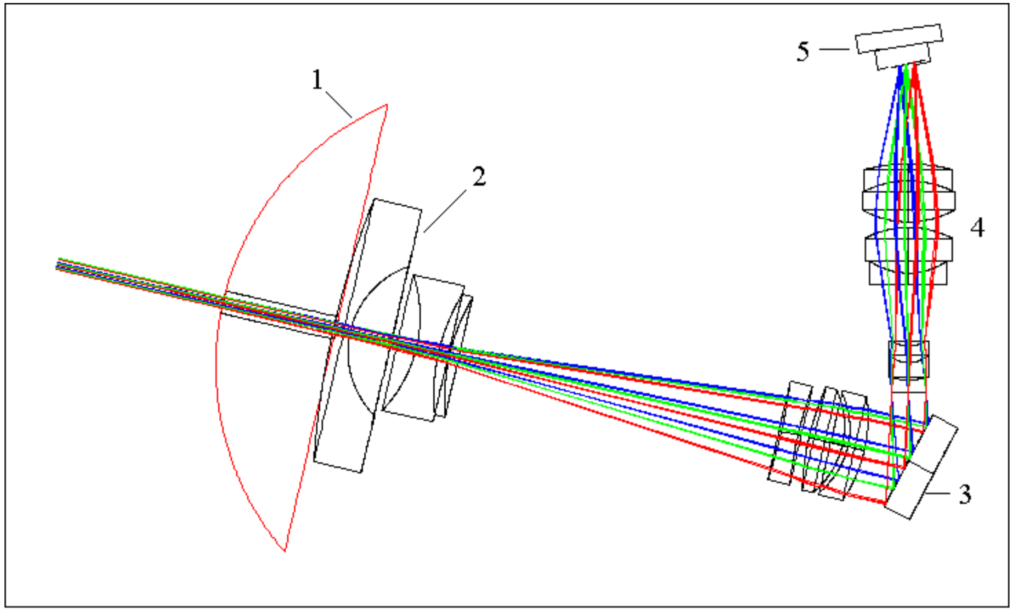


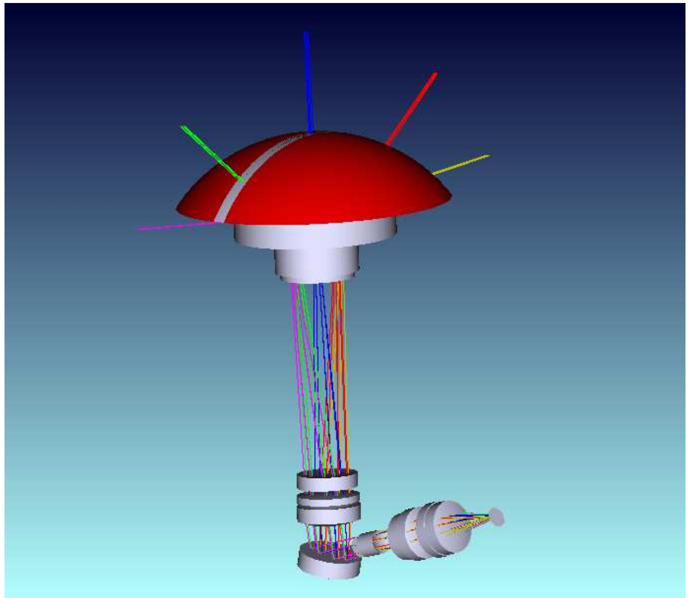


ExoMars 2018

2. All-Sky SPECTROGRAPH

field-of-view – 1800 x 50 - spectral resolution ~ 0.5 - 2 nm in UV range 200-230 nm- number of elements in image 32x32- detector - EM CCD 8x8 mm or position-sensitive photoelectron converter or UV region.



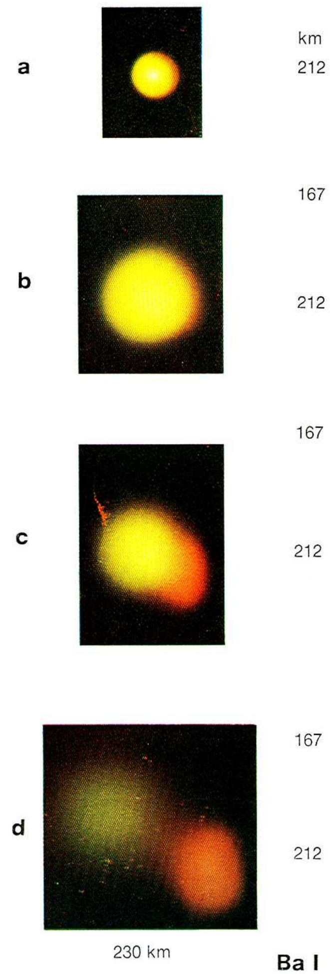


Scheme of spectrograph

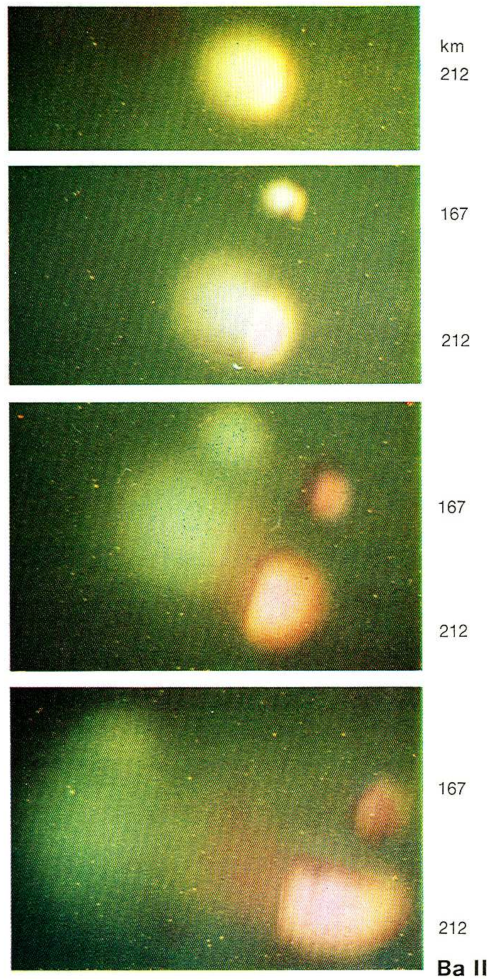
1- slit; 2– fish-eye lens; 3 – diffraction grid ;
4 – camera lens;
5 – EM CCD 8x8 mm2 or position-sensitive UV photoelectron converter
(working diameter 18 mm).

Optical layout of all-sky spectrograph

SEPARATION INTO NEUTRAL AND IONIZED BARIUM CLOUDS



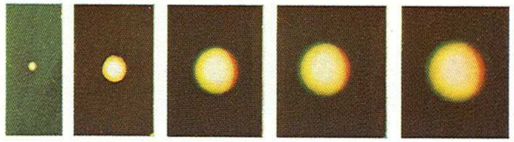
Ba-RELEASE
after
2-25-65-150 sec
Fig 5.2.3 (page 28)



TWO CLOUD Ba-RELEASE
after
1-2-5-9 min
Fig 5.2.4 (page 28)

Ba clouds experiment in ESRANGE

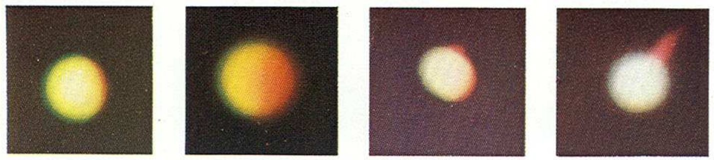
BARIUM RELEASE
INITIAL PHASE



0 5 10 15 20 sec

Fig 4.2.1 (page 18)

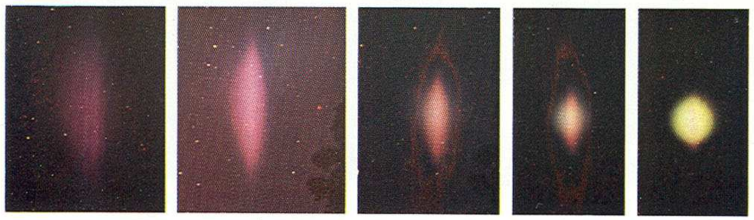
EFFECT OF OPTICAL DENSITY **EARLY ISSUE OF ION CLOUD**



a b c d

Fig 5.2.2 (pages 18 and 28)

ELONGATION OF ION-CLOUD ALONG GEOMAGNETIC FIELD LINES (Lycksele)



← e d c b a

Fig 8.2.2 (page 49)