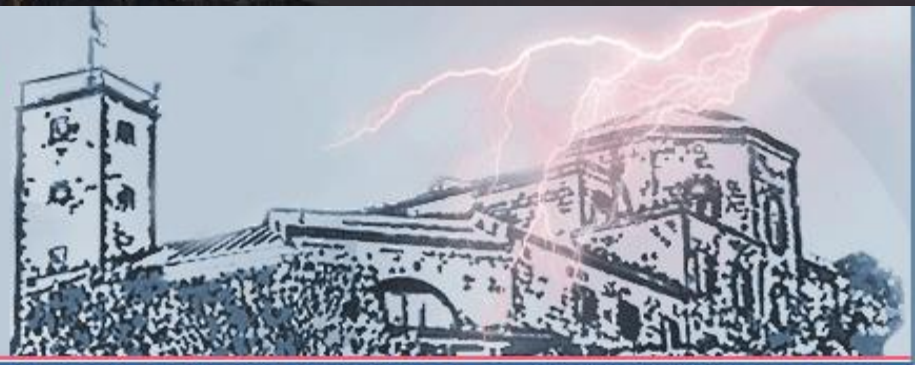
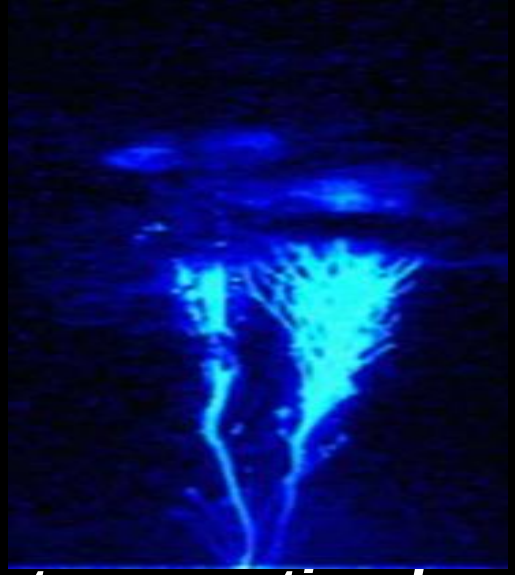
Overview of MSU orbital observation of TLE's and future prospects

M.Panasyuk, Moscow State University

TEPA 2013
September 9-13
Nor Amberd International Conference Center, Village Byurakan, Aragatsotn Province, Armenia



INTERNATIONAL SYMPOSIUM AT THE YEREVAN PHYSICS INSTITUTE



Transient energetic phenomena
in the upper atmosphere are observed
within the wide range
of electromagnetic emisions:
UV , red, X-ray;
in gamma – rays (1-10 MeV);
Infrasound;
in neutrons (?)
in relativistic electrons, positrons(?)

Sometimes with a huge energy/impulse
(for TLE) - up to several 10*9 J !

Transient energetic phenomena in the upper atmosphere

Some experimental facts

- TEP are observed in the upper atmosphere between the clouds altitudes and the ionosphere (~ 10-70 km)
- TEP – exteremely short-time events (duration from one up to hundreds of milliseconds)
- Dimensions of area where TLEs appears are about dozens and even hundreds kilometers.
- **Do TLEs are genetically connected with other TEPs???**

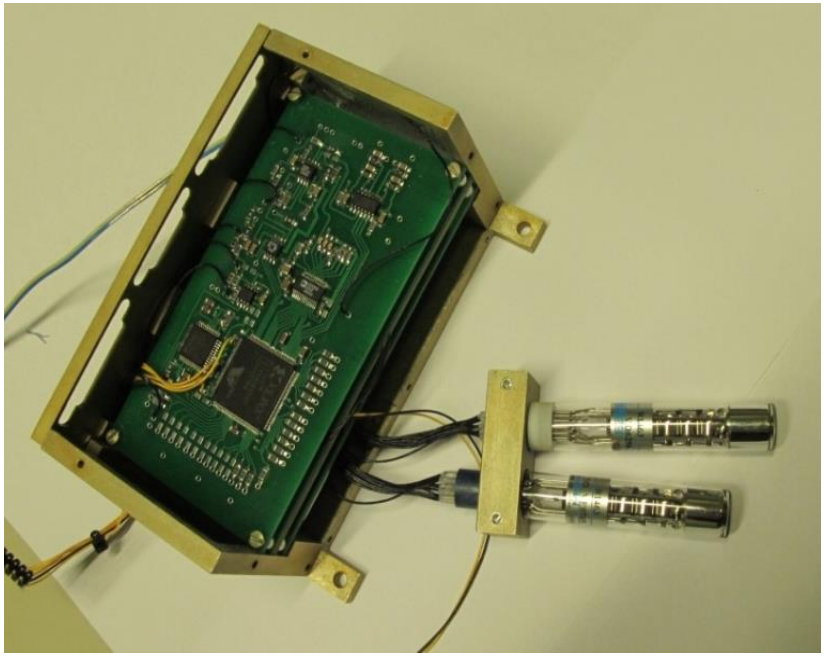
MSU satellite projects

SINP/MSU space experiments directed for TLE's study

1. TATIANA -1 2005 -2007
2. TATIANA -2 2009
3. CHIBIS 2012

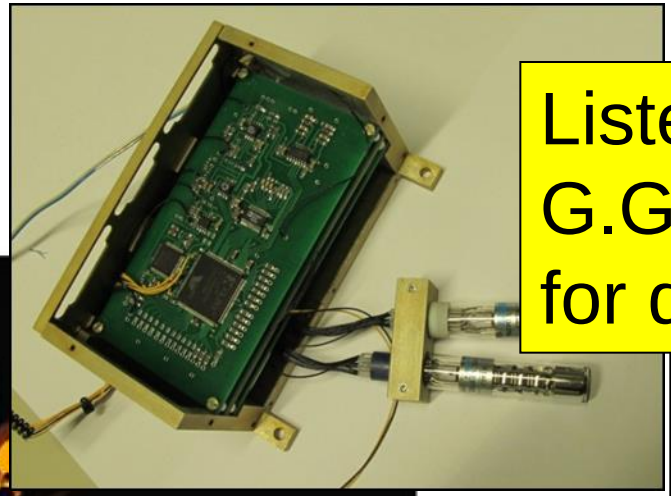
4. RELEC 2014
5. LOMONOSOV 2014

“Tatiana-1” → “Tatiana-2”

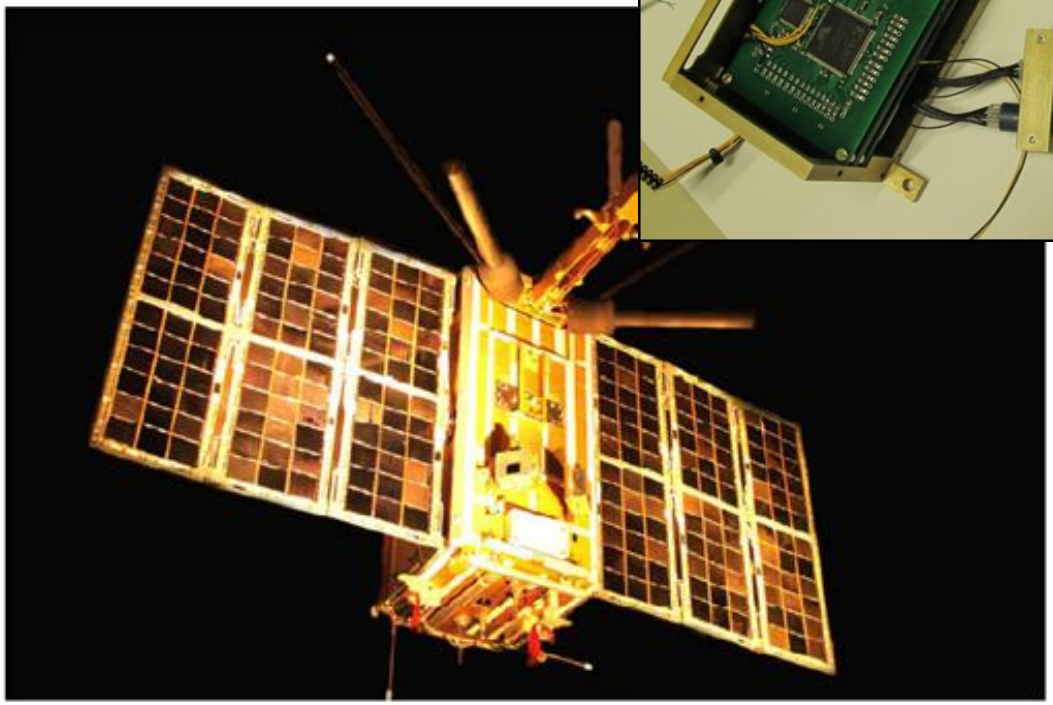


	«Tatiana-1»	«Tatiana-2»
Temporal resolution	16 us 64 us	1 ms
Oscillogram length	4 ms 64 ms	128 ms
Wavelength range	240 - 400 nm	240 - 400 nm 600 - 800 nm
TRIGGER	One event per orbit cycle	One event per minute

CHIBIS

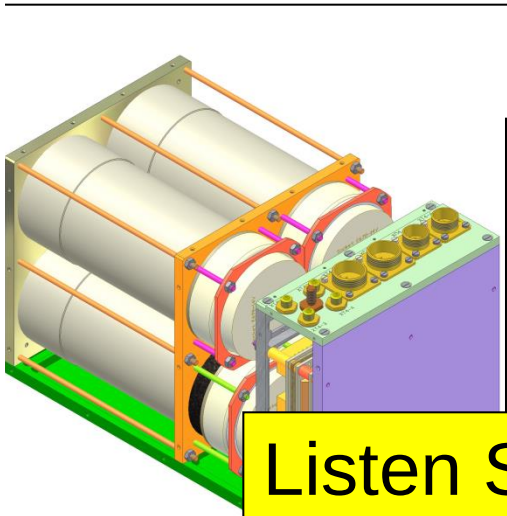


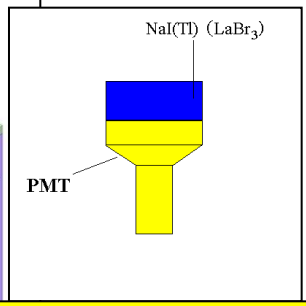
Listen G.Garipov for detailes



UF

	240-400nm
	610-800nm
Sensitive area ~	0.5cm2
Field of view ~	150
Mass ~	0.65kG
Power <	2.5Wt



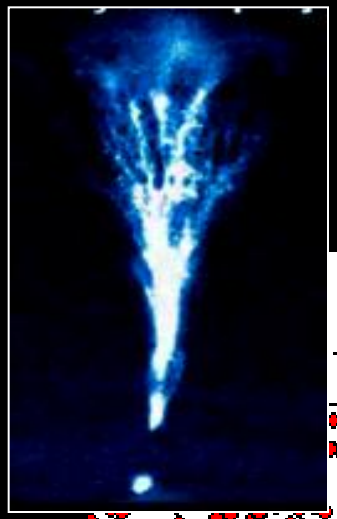


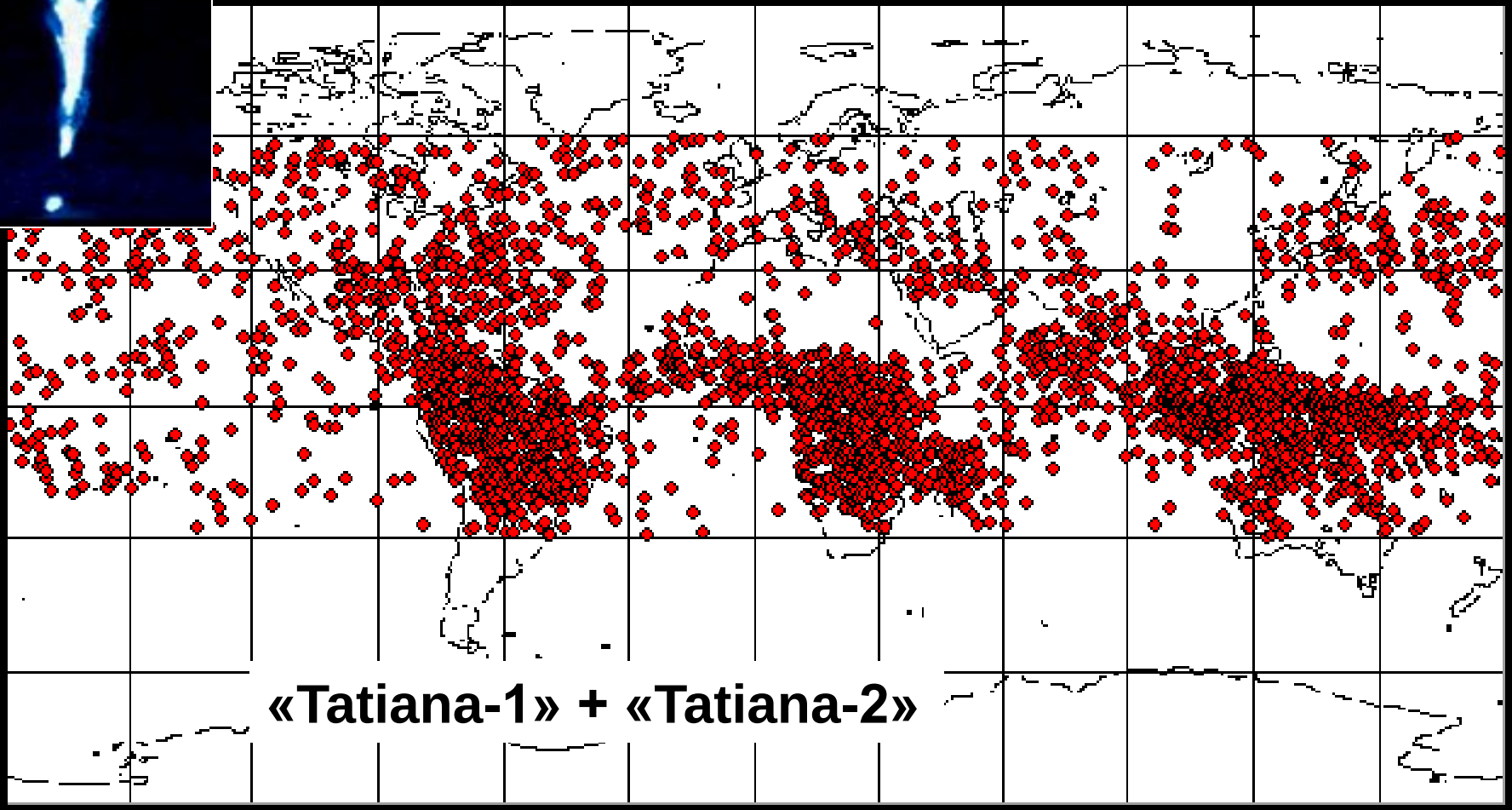
Listen S.Svertilov for detailes

RGD

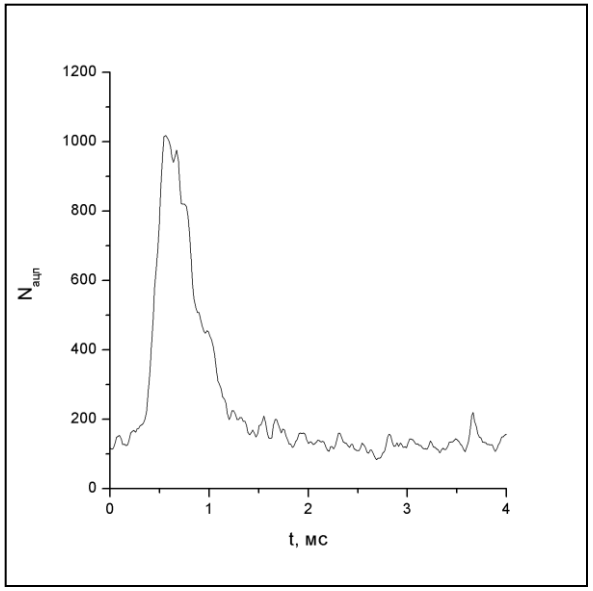
(Reontgen – Gamma Detector) instrument is intended for detection of sporadic X-ray and gamma-ray flashes (0.02 – 1.0 MeV) from high-altitude atmospheric discharges.

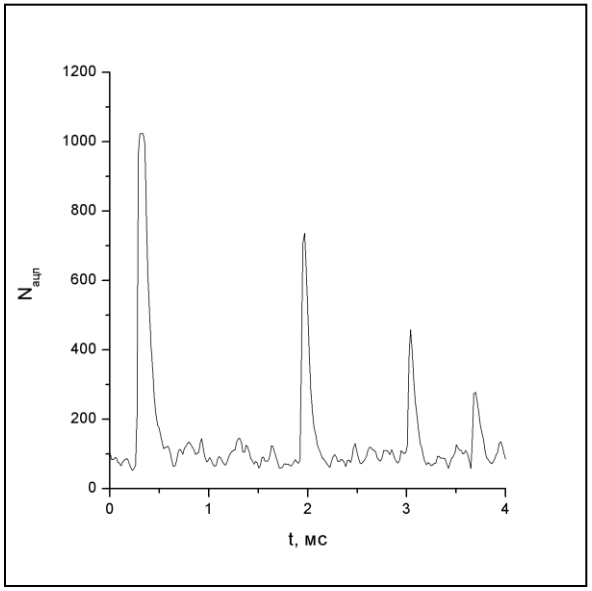
«Transient » illumination of the Earth's upper atmosphere





Different temporal- spatial distributions of UV flashes





Listen V. Morosenko for detailes

Serial distributions of TLEs

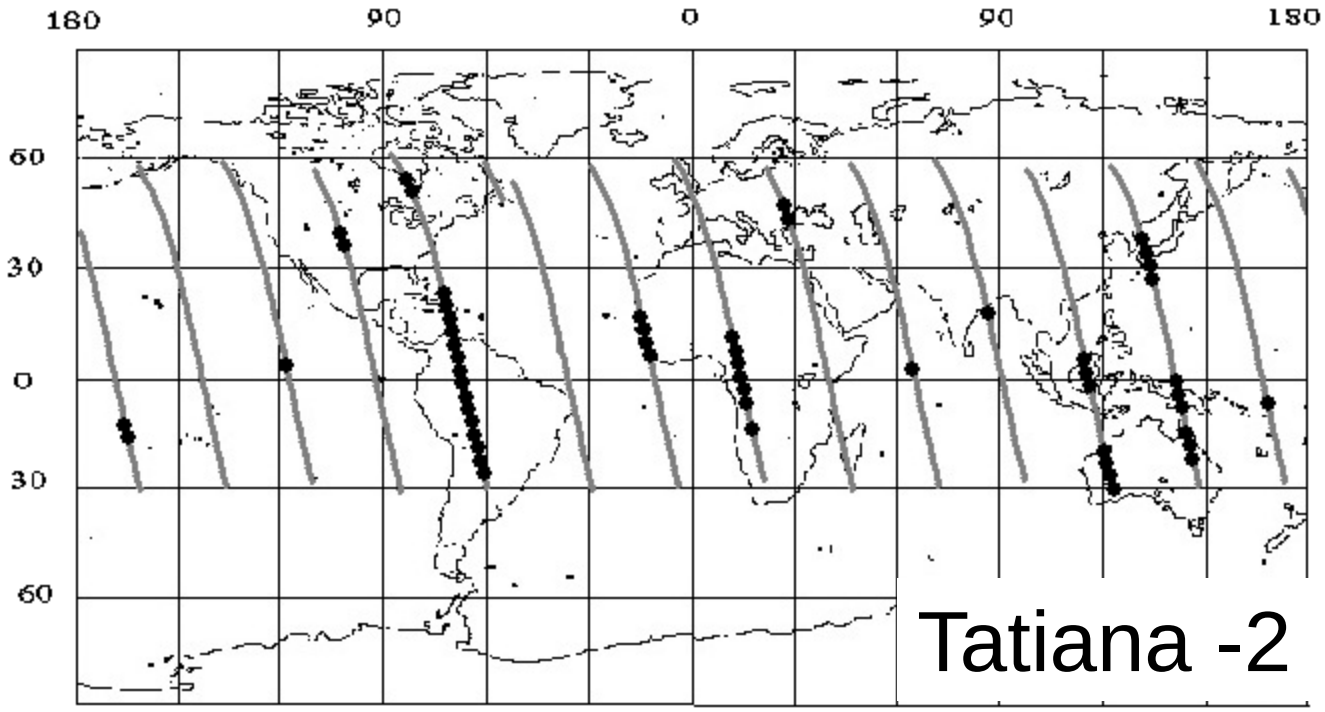
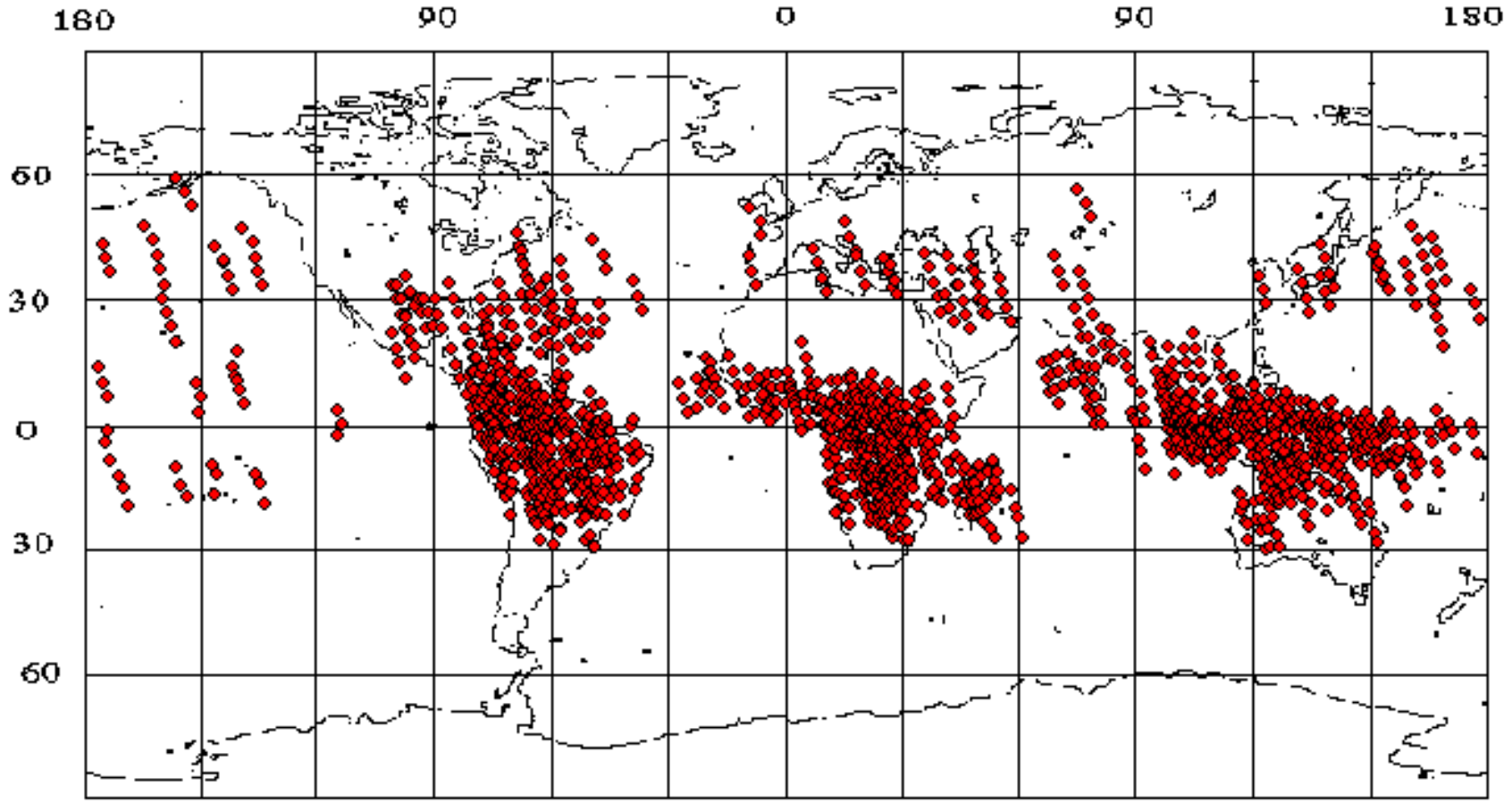
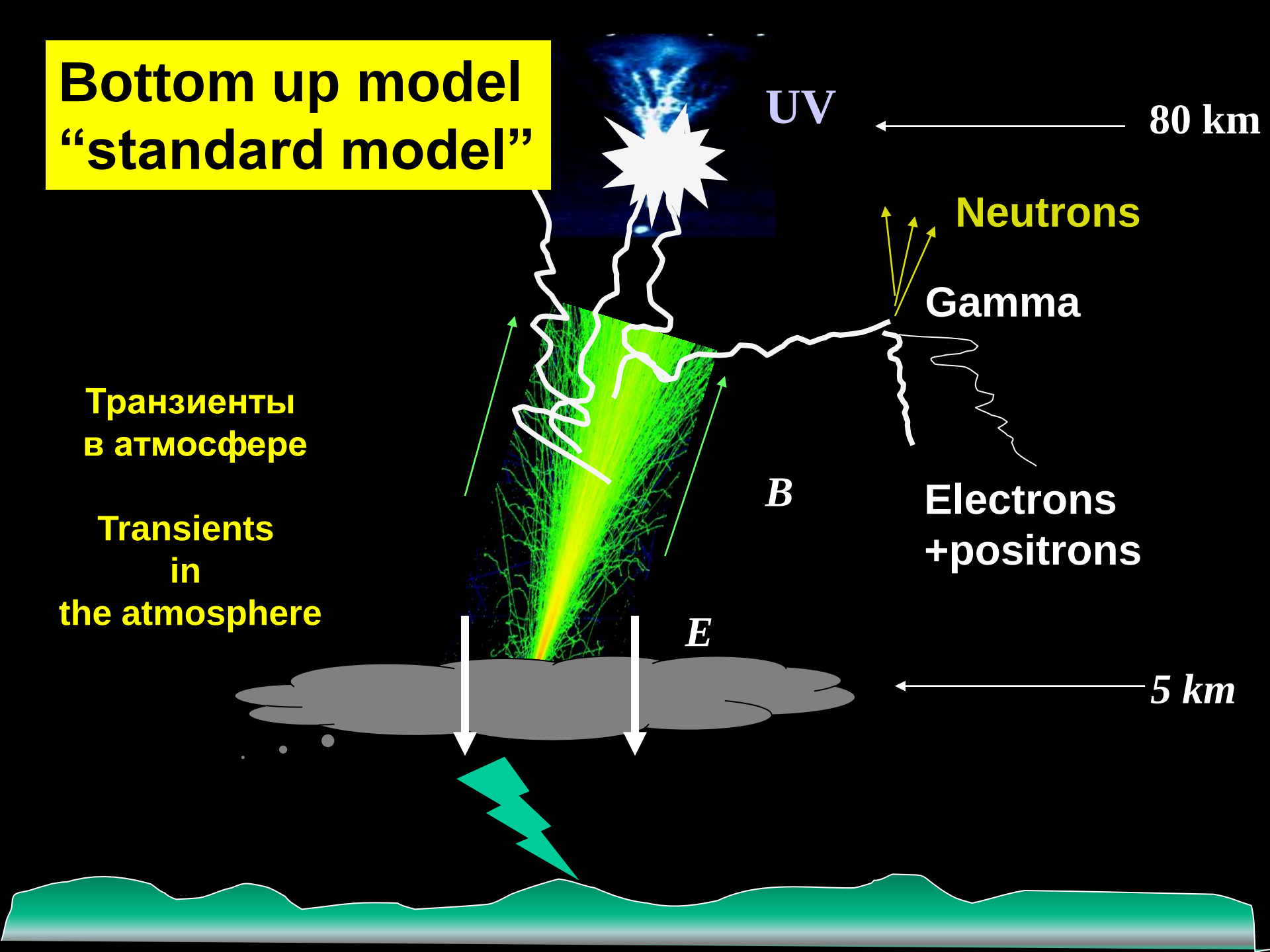


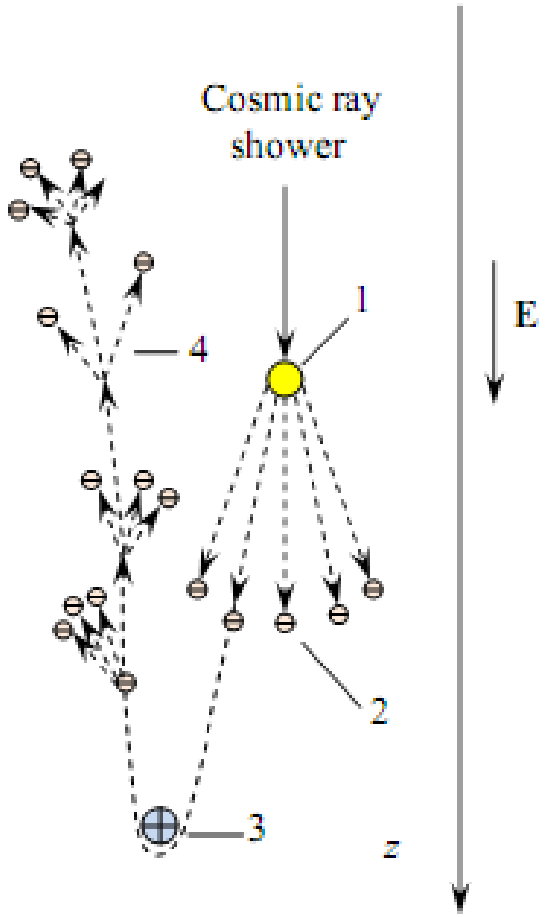
Рис. 3.17. Пример пролётов «Татьяна -2»
с зарегистрированными сериями вспышек (чёрные точки).

Spatial distributions of serial TLEs



Basics of modeling


Bottom up model
“standard model”
UV
80 km
Neutrons
Gamma
Транзиенты
в атмосфере
Transients
in
the atmosphere
B
Electrons
+positrons
E
5 km



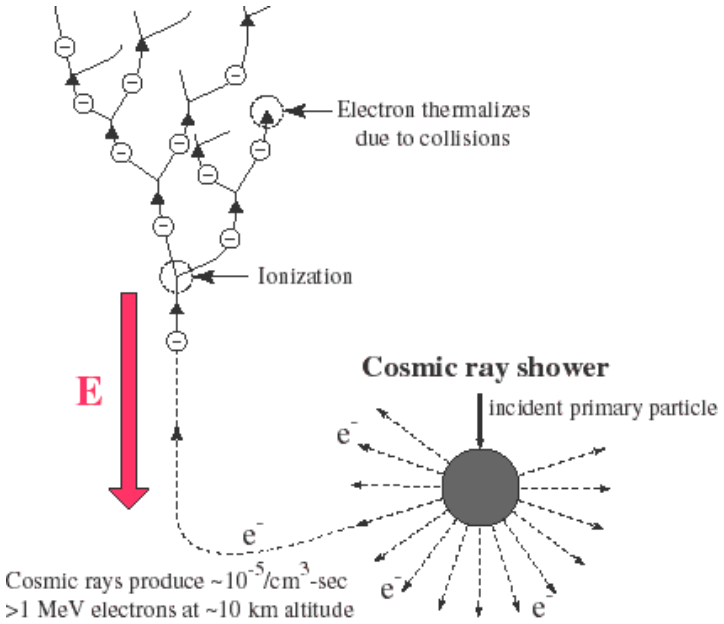


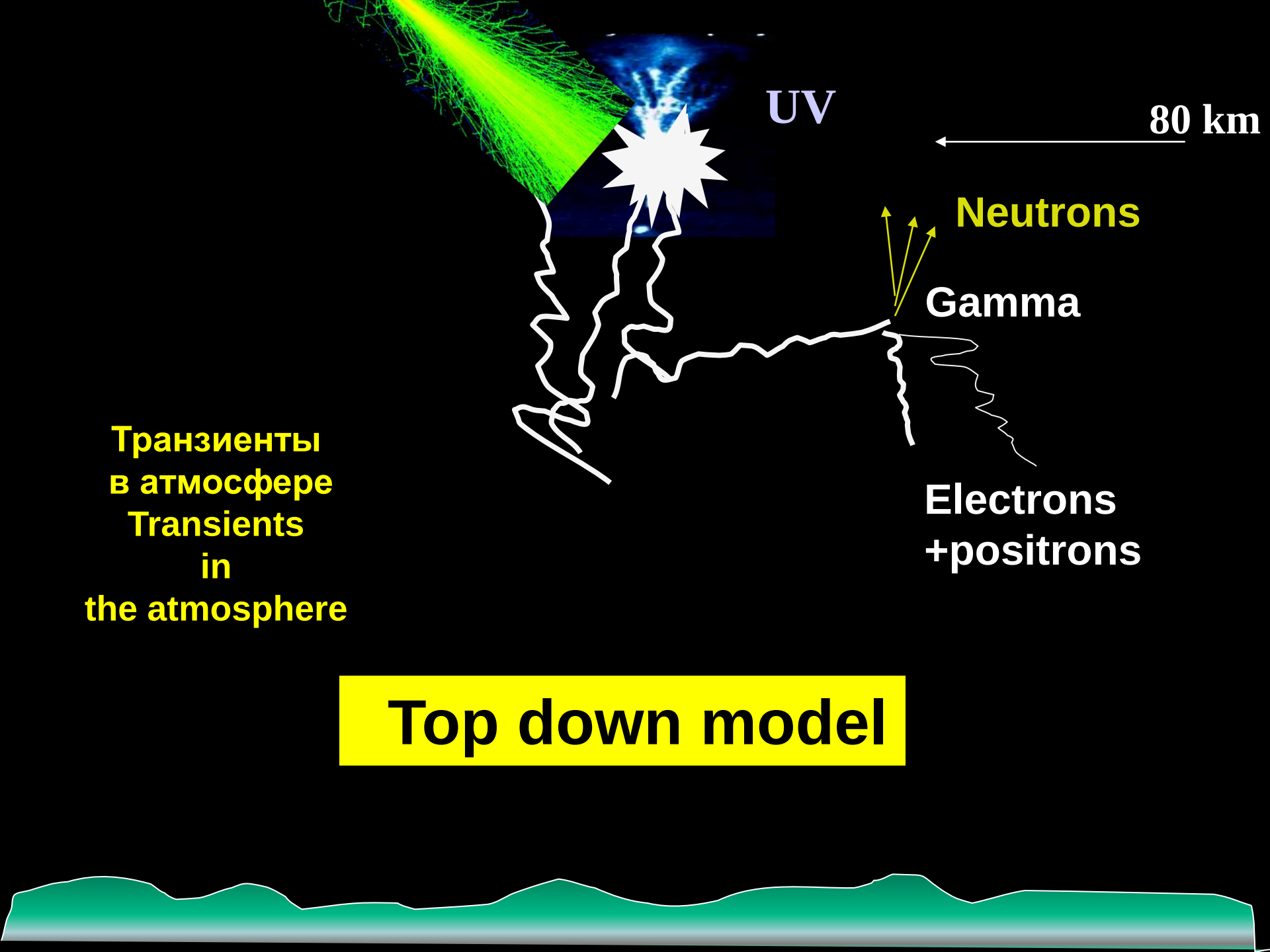
Fig. 4. A schematic illustration of upward avalanche of fast seed electrons resulting from a cosmic ray shower in the presence of the downward-directed ambient electric field E. Trajectory of the secondary downward-directed electrons can be distorted due to the scattering by nuclei. 1 – incident primary particle, 2 – secondary fast seed electrons, 3 – nucleus, 4 – upward avalanche of electrons.

small. The air breakdown followed by the production of free electrons results in enhancement of the electron contribution to the air conductivity. It is customary to assume that the free electrons can play a crucial role in the ionization of neutrals in the ambient electric field, because their mobility is much greater than that of ions.

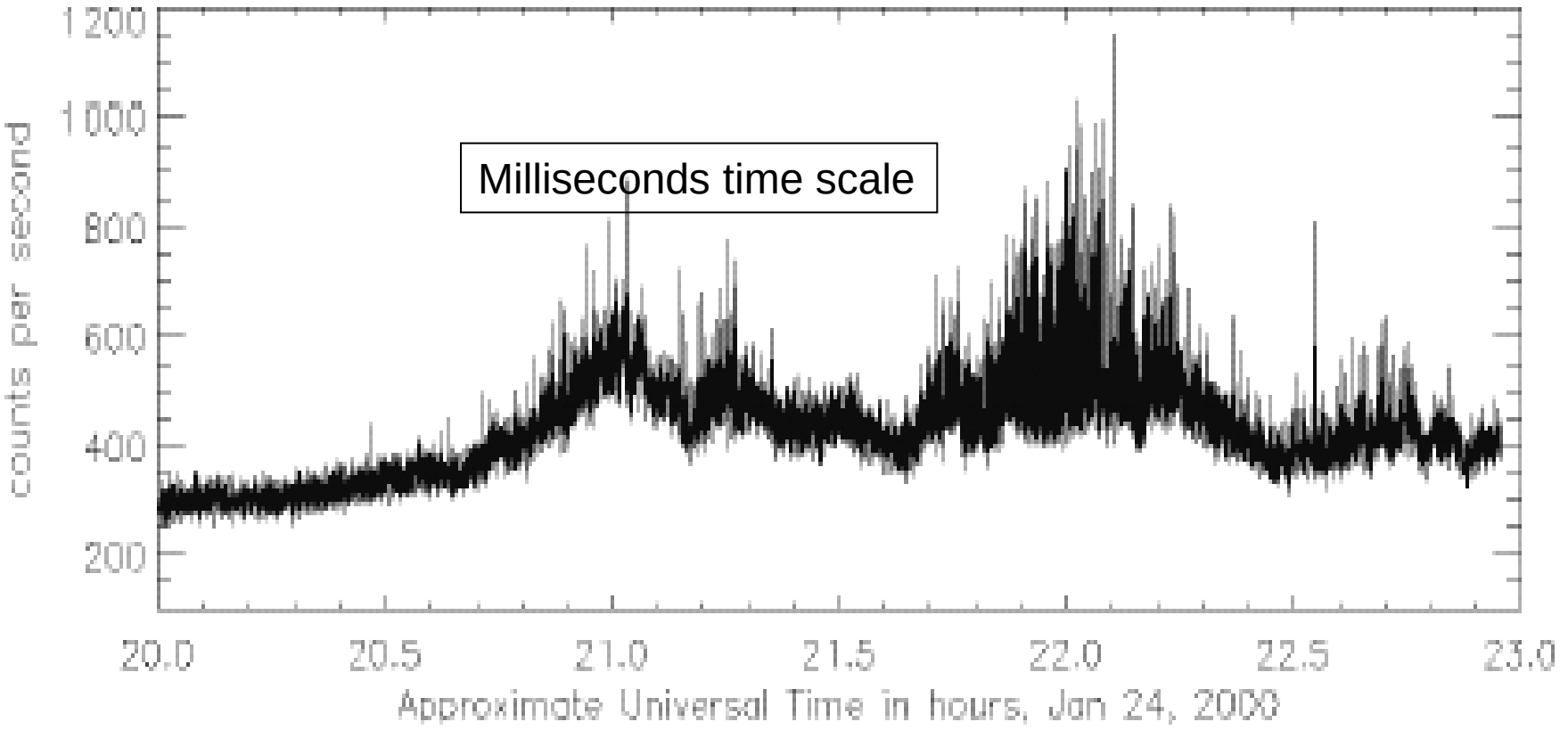
Underlying mechanisms of transient luminous events: a review

V. V. Surkov[1] and M. Hayakawa[2]

Ann. Geophys., 30, 1185–1212, 2012
www.ann-geophys.net/30/1185/2012/
doi:10.5194/angeo-30-1185-2012

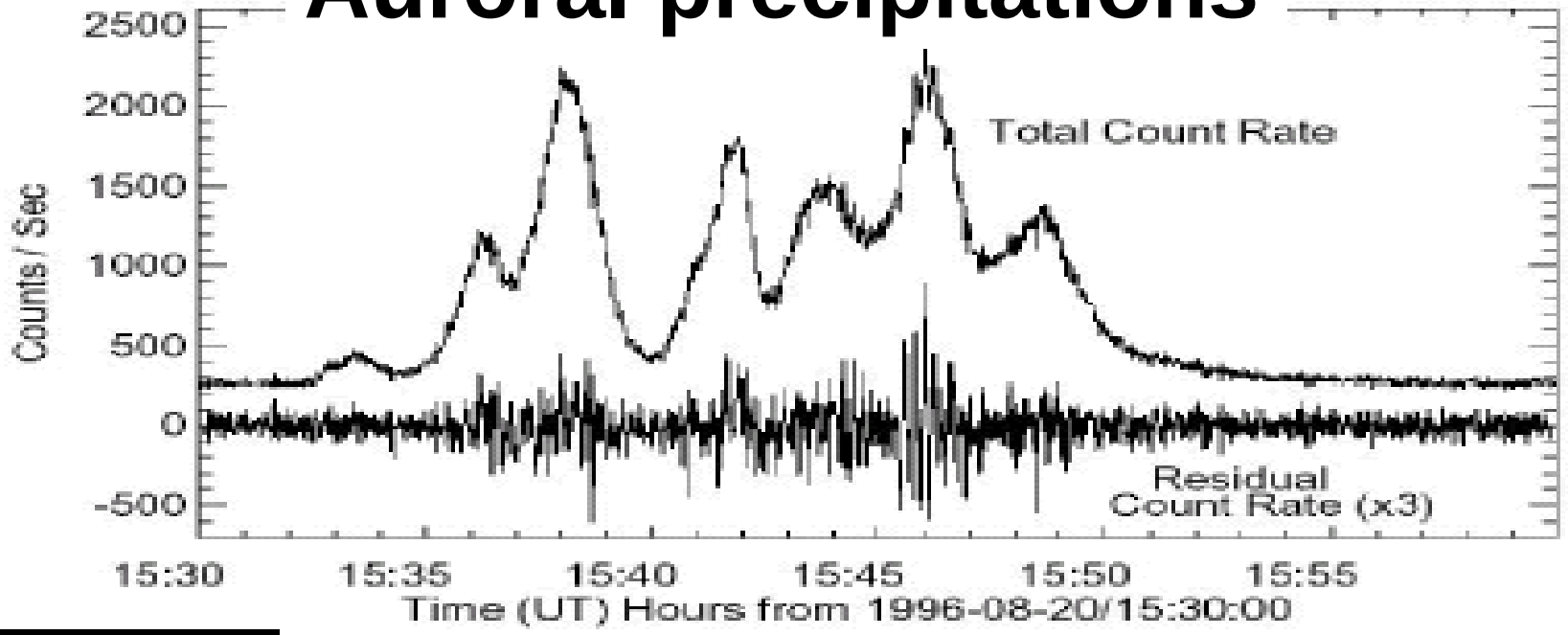

UV
80 km
Neutrons
Gamma
Electrons
+positrons
Транзиенты
в атмосфере
Transients
in
the atmosphere
Top down model

Examples of natural relativistic electrons precipitations



Precipitation of ~100 keV electrons from radiation belts measured in SAMPEX experiment.

Auroral precipitations



X-ray count rate for 1996 Kiruna MeV Precipitation Event [Foat et al., 1998].

The X-rays (produced from ~1.7 MeV electrons) measurements showed that there are two main types of precipitation – long-term (~100 s) and short enhancements (~10 s) modulating the count rate. MAXIS measurements.

Monoenergetic relitivistic electrons precipitations

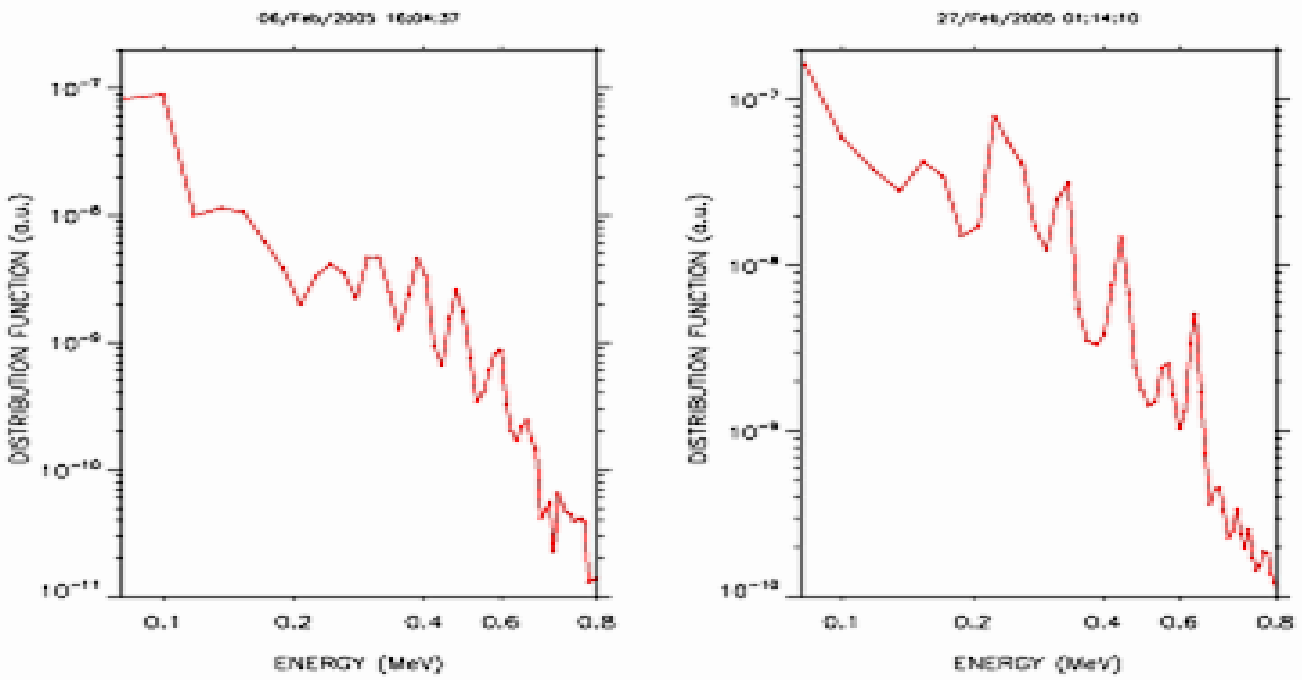
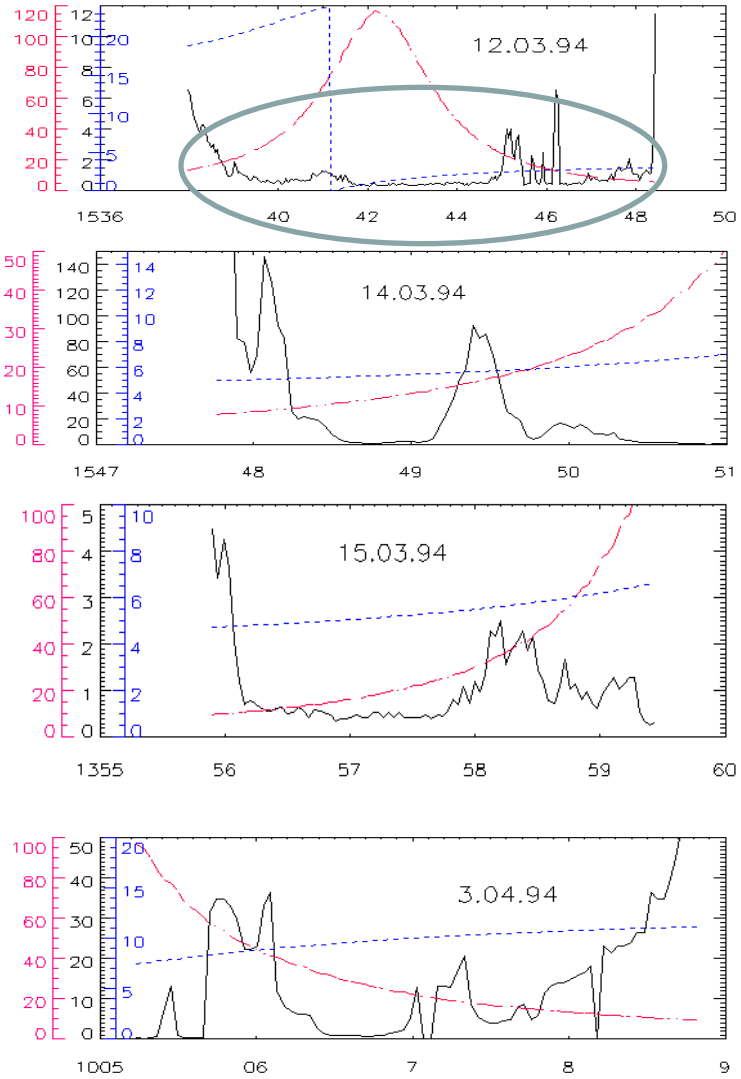
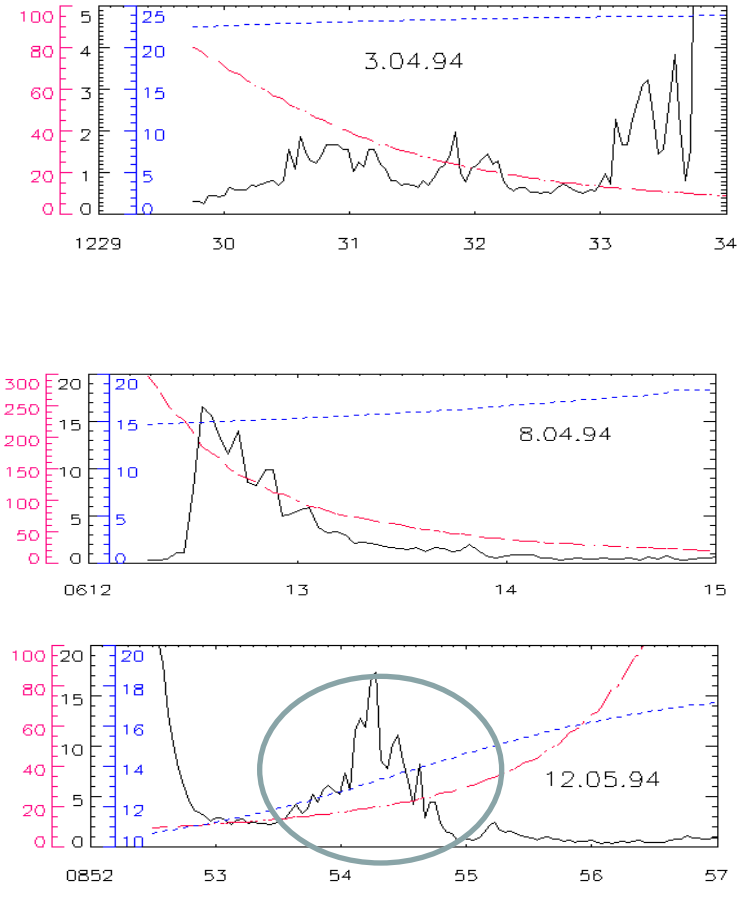


Figure 3: Example of electron perpendicular distribution functions in the inner belt for the cases presented in Figures 1 and 2.

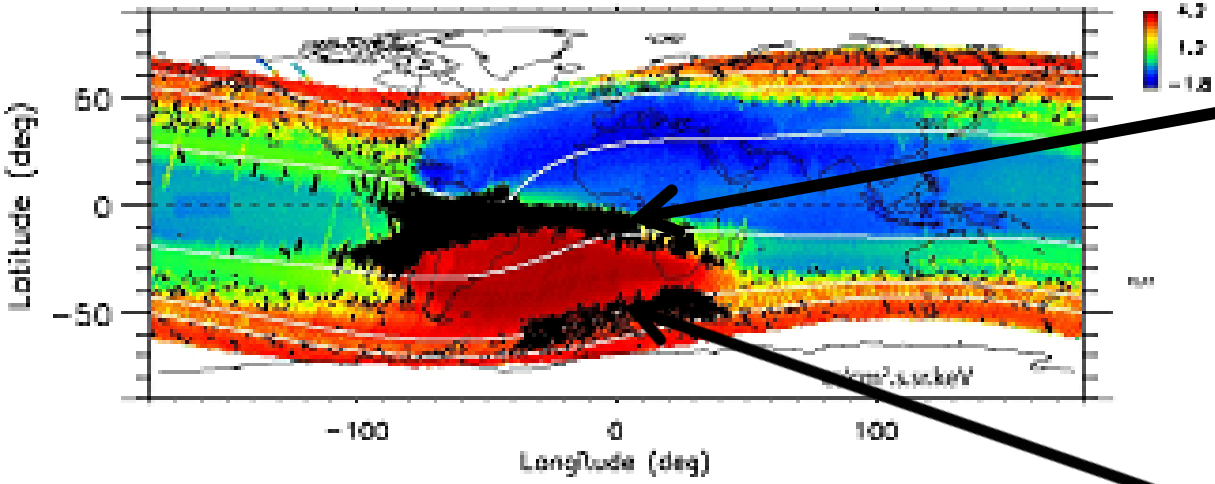
Near-equatorial relativistic electrons





Examples of RE precipitation measured in CORONAS-I mission: lines - 0.5-1.3 MeV RE intensity time profiles, dots – L values, dashed limes – local time.

DEMETER electron data

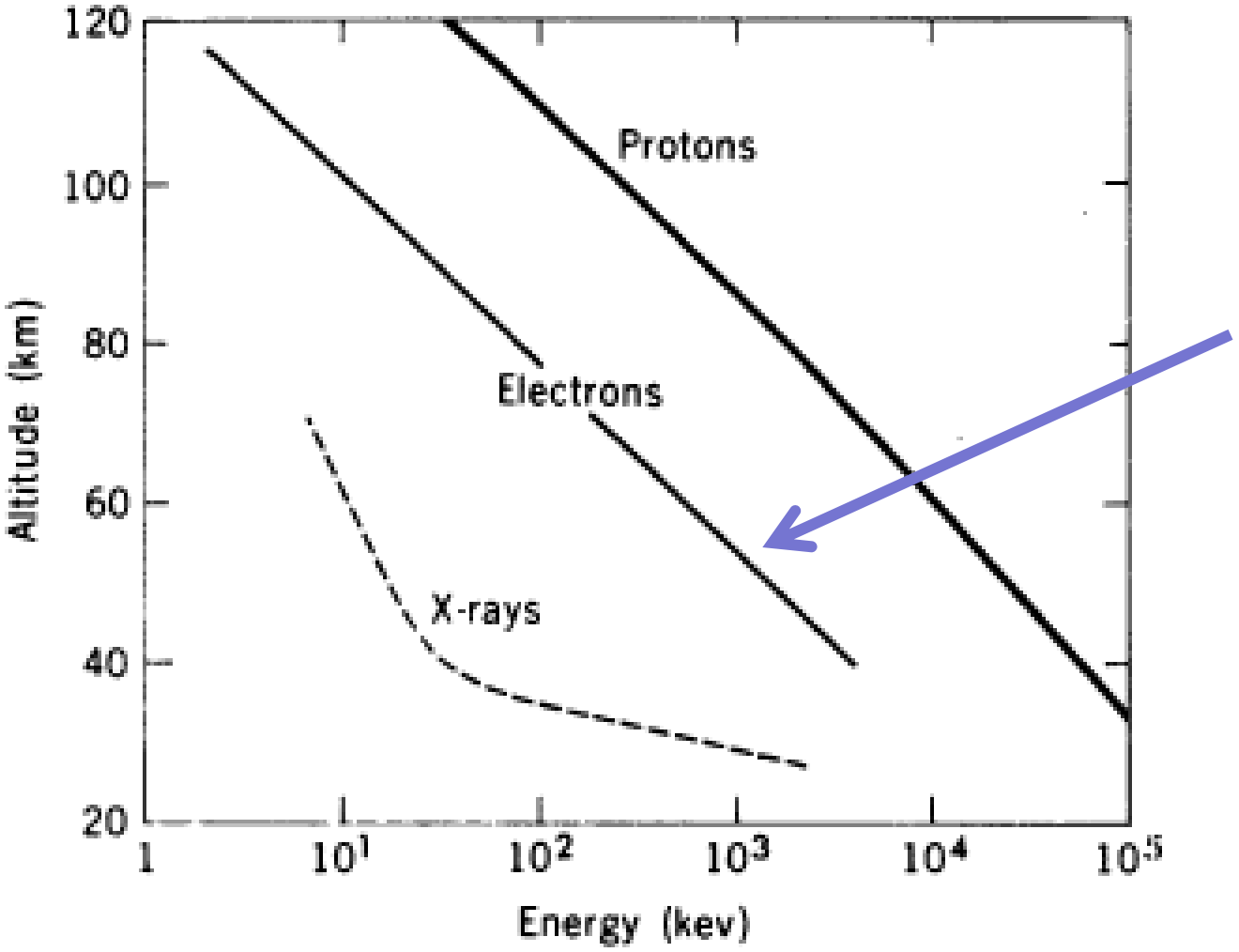


North from SAA

South from SAA

Figure 10 : Geographical distribution of energetic particle spectra during the year 2005 (black symbols) : proton spectra with at least two maxima in the 1-2 MeV energy range are mainly located south of SAA, and electron spectra with maxima between 150 and 450 keV north of SAA. The white lines close to +/-50° latitudes indicate the footprint of 2.5 and 3.5 L-values while the L=1.7 white lines are located at lower latitudes. The color code shows the differential fluxes of electrons with 200 keV energy.

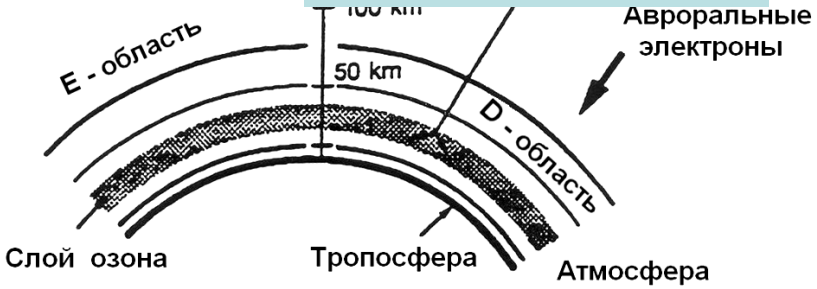
Lenthpasses in the atmosphere



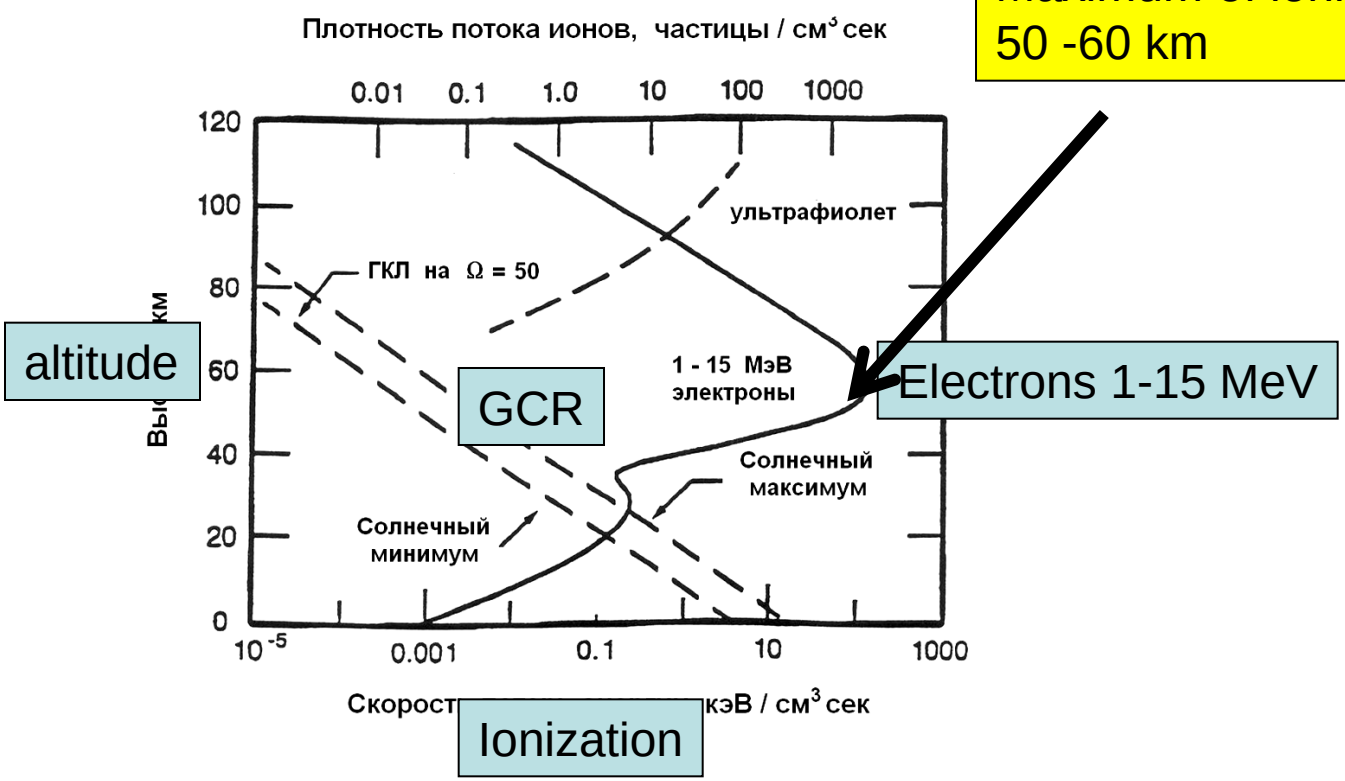
Thorne, R., Science,(1977)**195**, 288-289

Ionization in the atmosphere caused by electrons

Electrons 1-15 MeV



Maximum of ionization at 50 -60 km



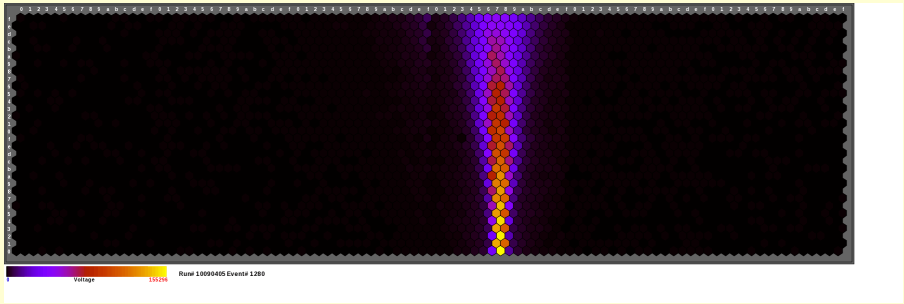
altitude

GCR

Electrons 1-15 MeV

Ionization

Electron accelerator ELS in Utah

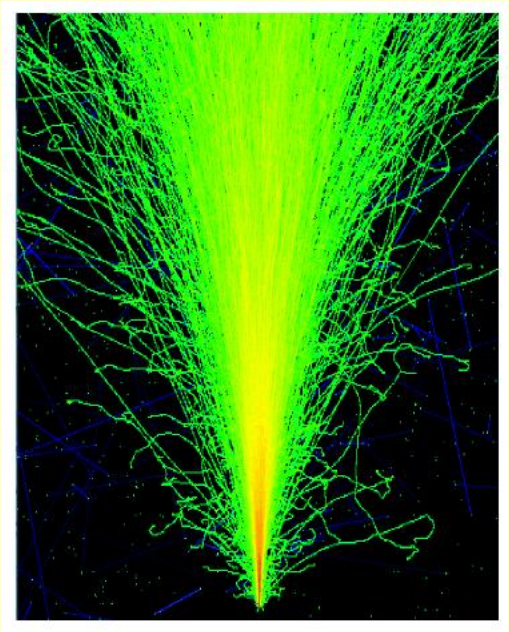


ELS Calibration

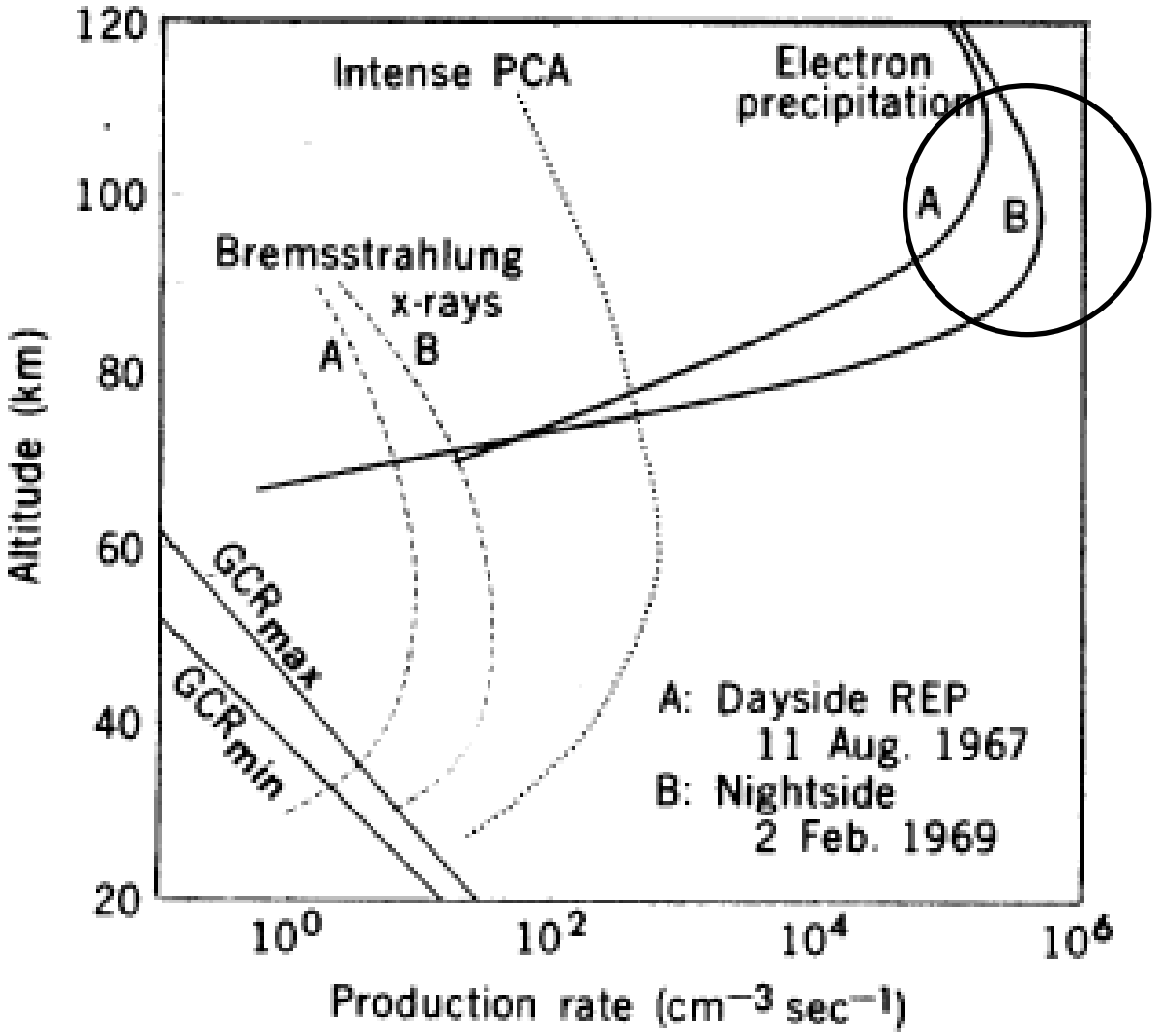
- ELS = 40 MeV electron accelerator in front of BR FD station.
- Equivalent to a 10^{18} eV shower at shower max.
- End-to-end calibration of TA fluorescence energy scale.

- Man-made shower to use for R&D purposes:
  - TA-EUSO prototype test.
  - Osaka, KIT/Chicago groups search for molecular bremsstrahlung radiation.
  - TARA, ICRR groups search for radar reflections.

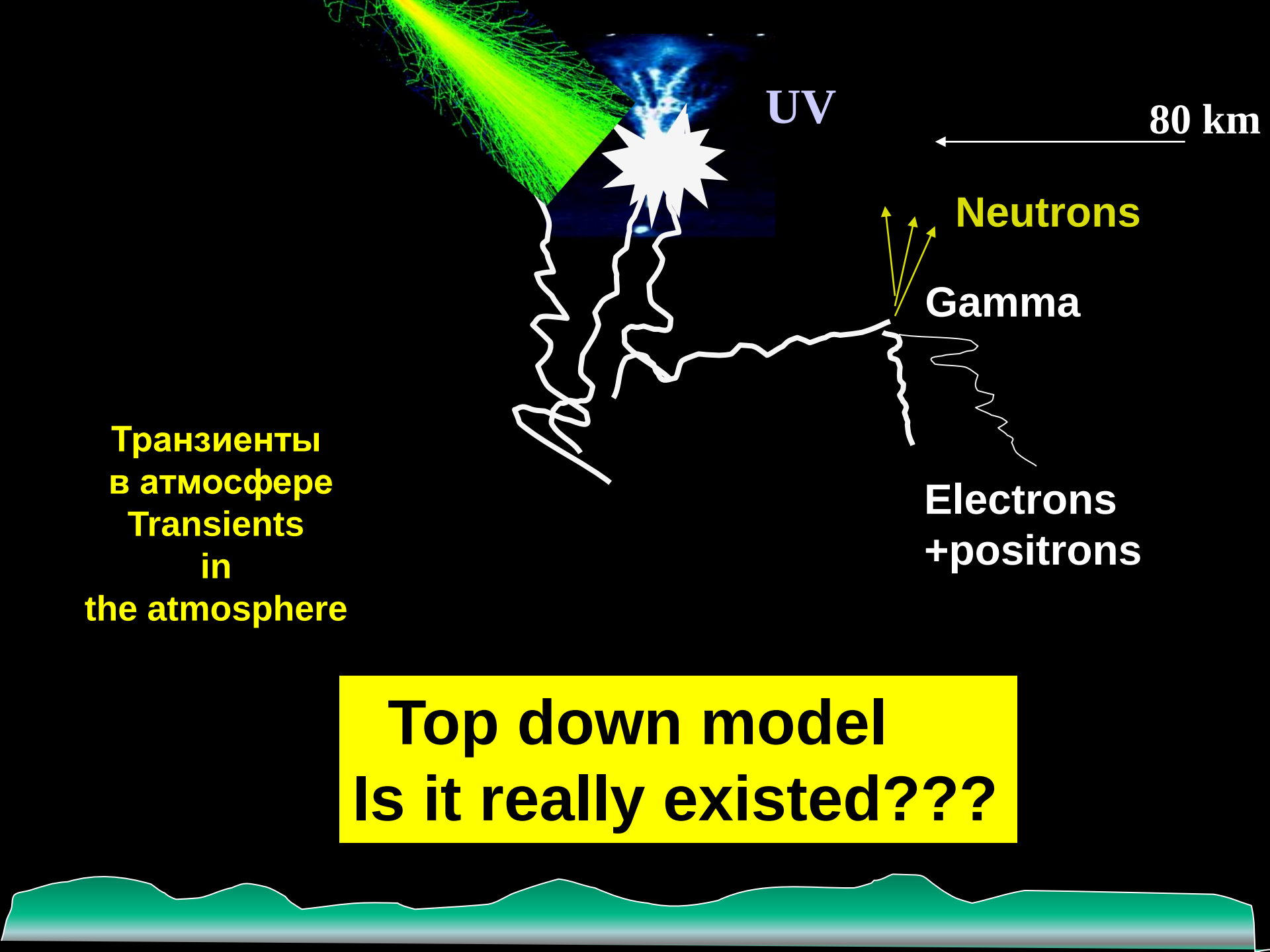
UV – light, Ionization, impact



Another estimation, by Thorne



Thorne, R., Science,(1977)**195**, 288-289



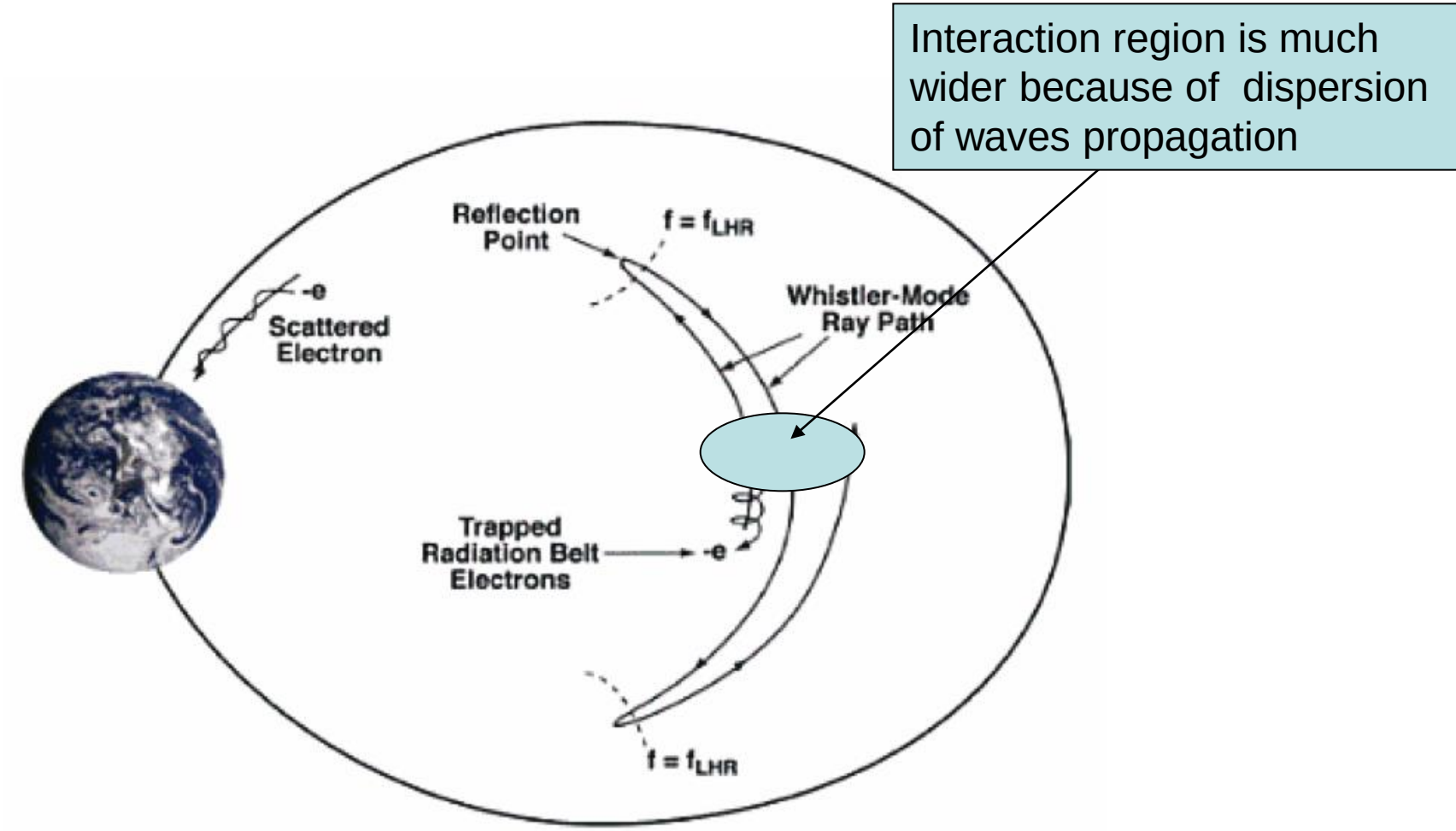
Транзиенты
в атмосфере
Transients
in
the atmosphere

Top down model
Is it really existed???

Where to get drivers
for electron precipitation from the space?

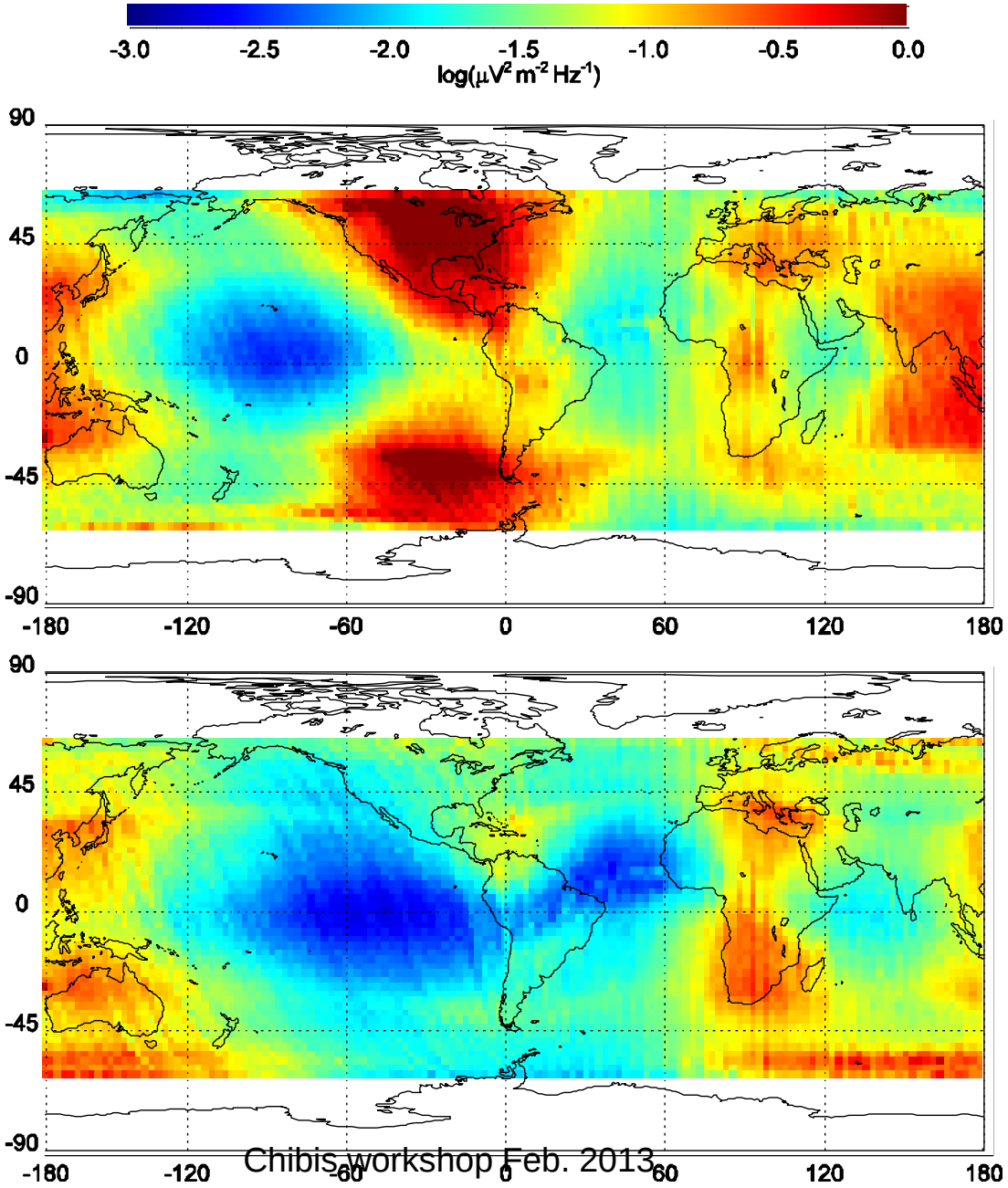
WAVE PARTICLE INTERACTIONS

1. Cyclotron resonance



Nature of waves: natural & anthropogenic

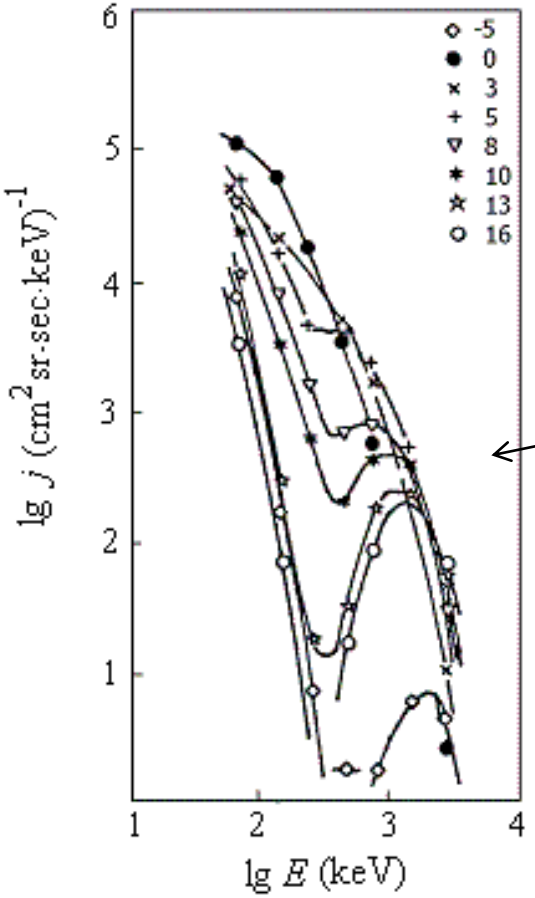
Nemec et al., JGR, 2010



1-10 kHz
Night time

Индуцированное ОНЧ передатчиками высыпание электронов

Electron precipitations induced by on ground VLF transmitters



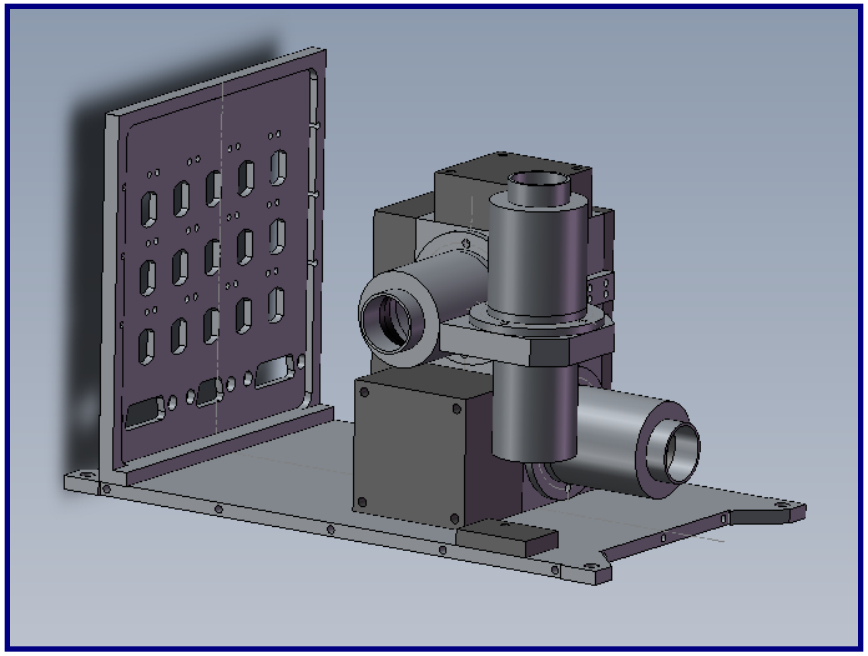
1971!
(Imhov, Smith, JGR)

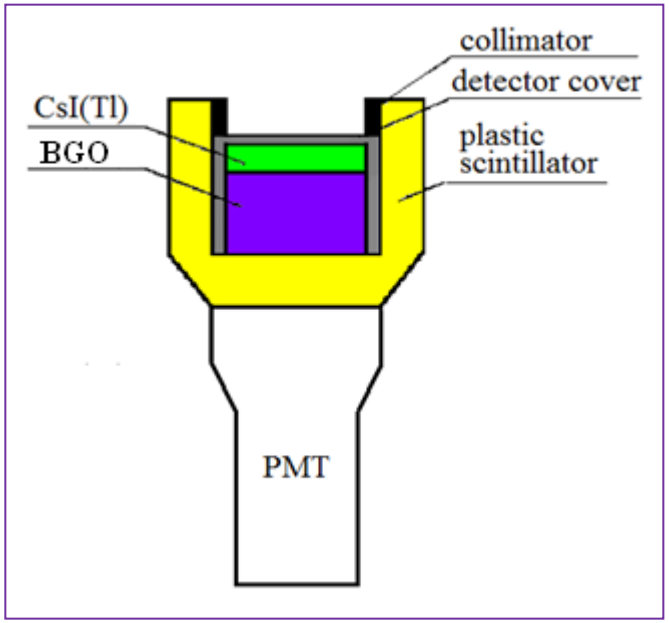
MSU future space experiments directed for TLE&TGF study

Scintillation detectors of DRGE

Three identical BGO/CsI(Tl)/plastic scintillator phosvich detectors are directed along three axe mutually normal (as Cartesian coordinate system)

To the sky





Detector consists of optically coupled thin (3mm) CsI(Tl) and considerably thick (17mm) BGO crystals with ∅20mm. Surrounding plastic scintillator is 5mm thick. FOV is formed by cylindrical collimator made of 1mm Cu.

Along the geomagnetic field line

DUF instrument

Two photomultiplier tubes with different input window filters

Physical parameters:

Spectral band:
PMT1 - 300-400 nm
PMT2 (red) - 630-800 nm
Angle of view: $\pm 7.5^{o}$.
Time resolution: 100 μs.
Amplitude range: 10^{6}.

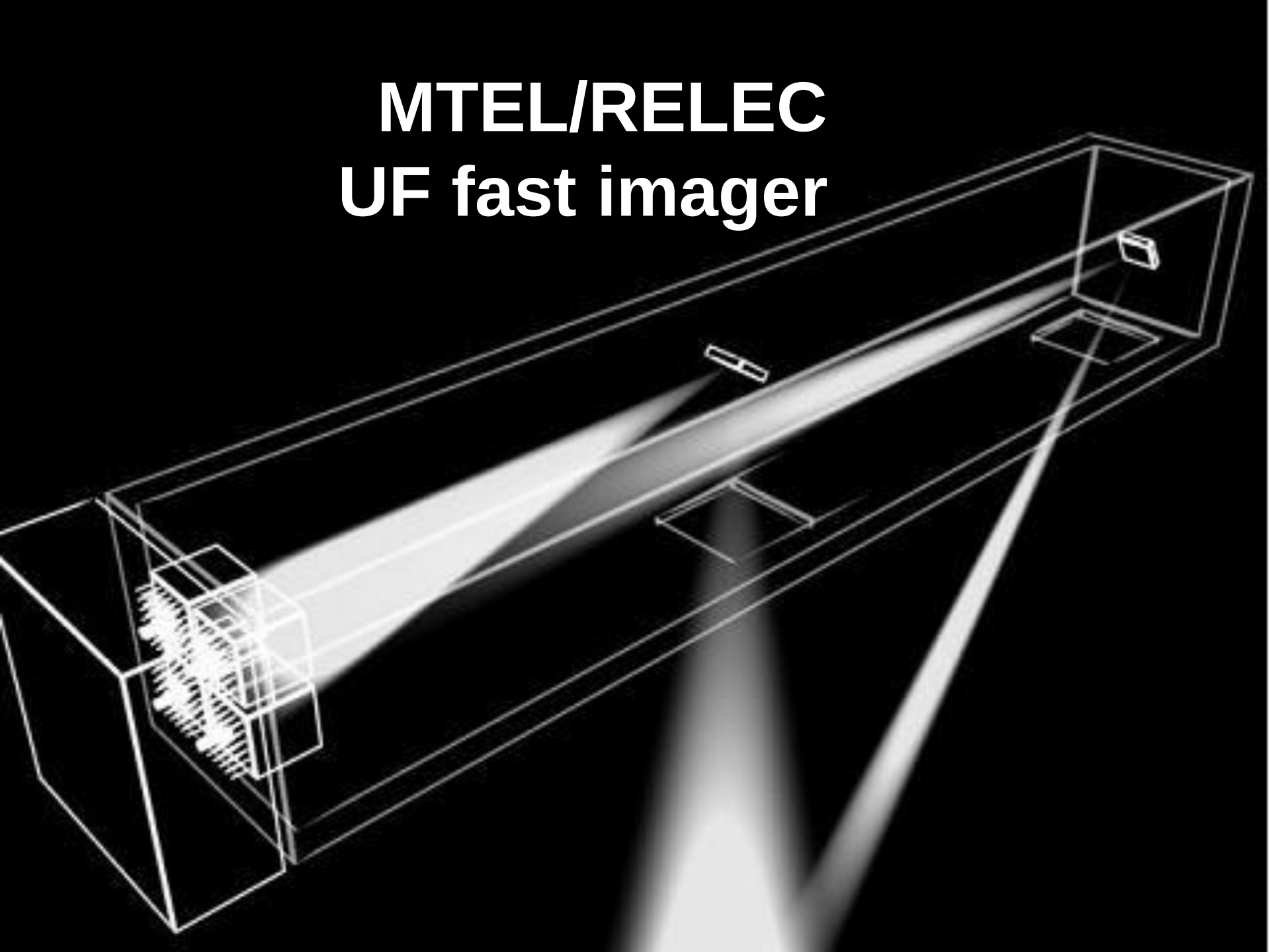
Technical parameters

Mass - < 1 kg;

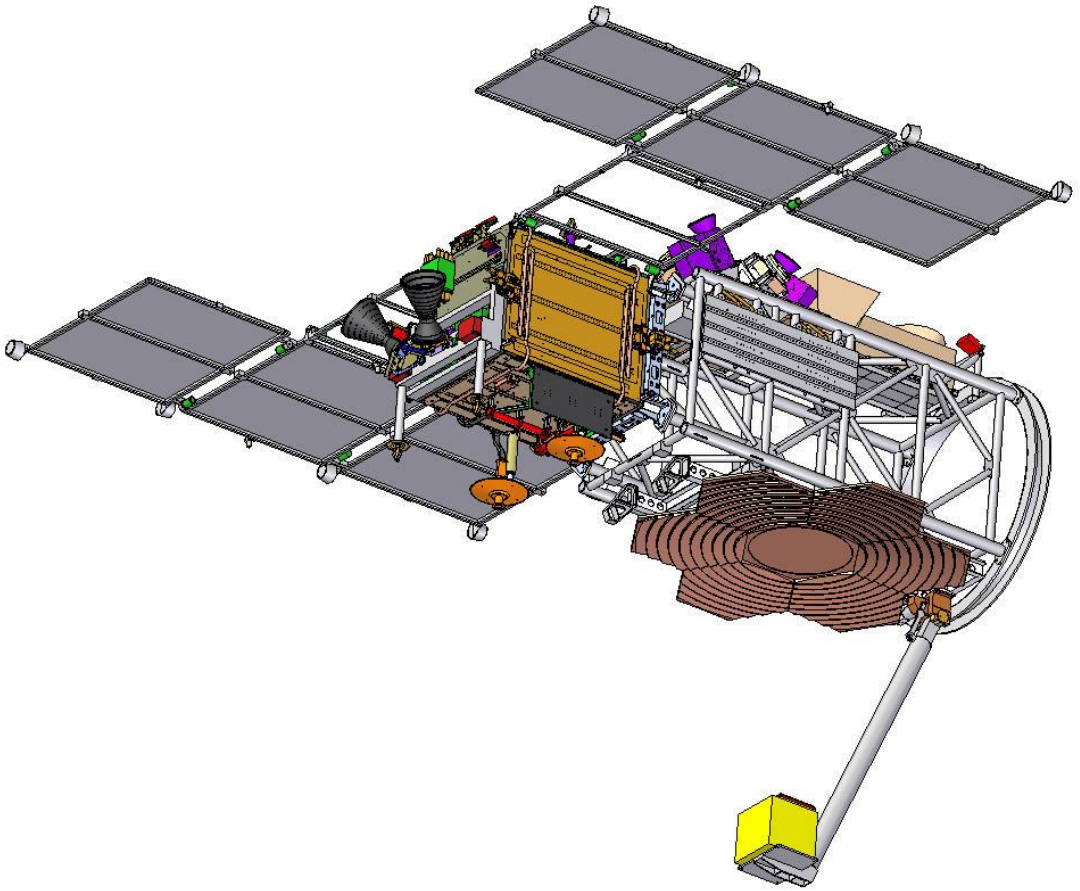
sizes 140×140×80 mm;

power expenditure at 28 V no more 1 W.

MTEL/RELEC
UF fast imager



«LOMONOSOV»



ТУС

Задачи ТУС:

- Регистрация космических лучей сверхвысоких энергий по их трекам в ночной атмосфере Земли;
- Мониторинговое наблюдение других оптических эффектов в атмосф

Параметры эксперимента:

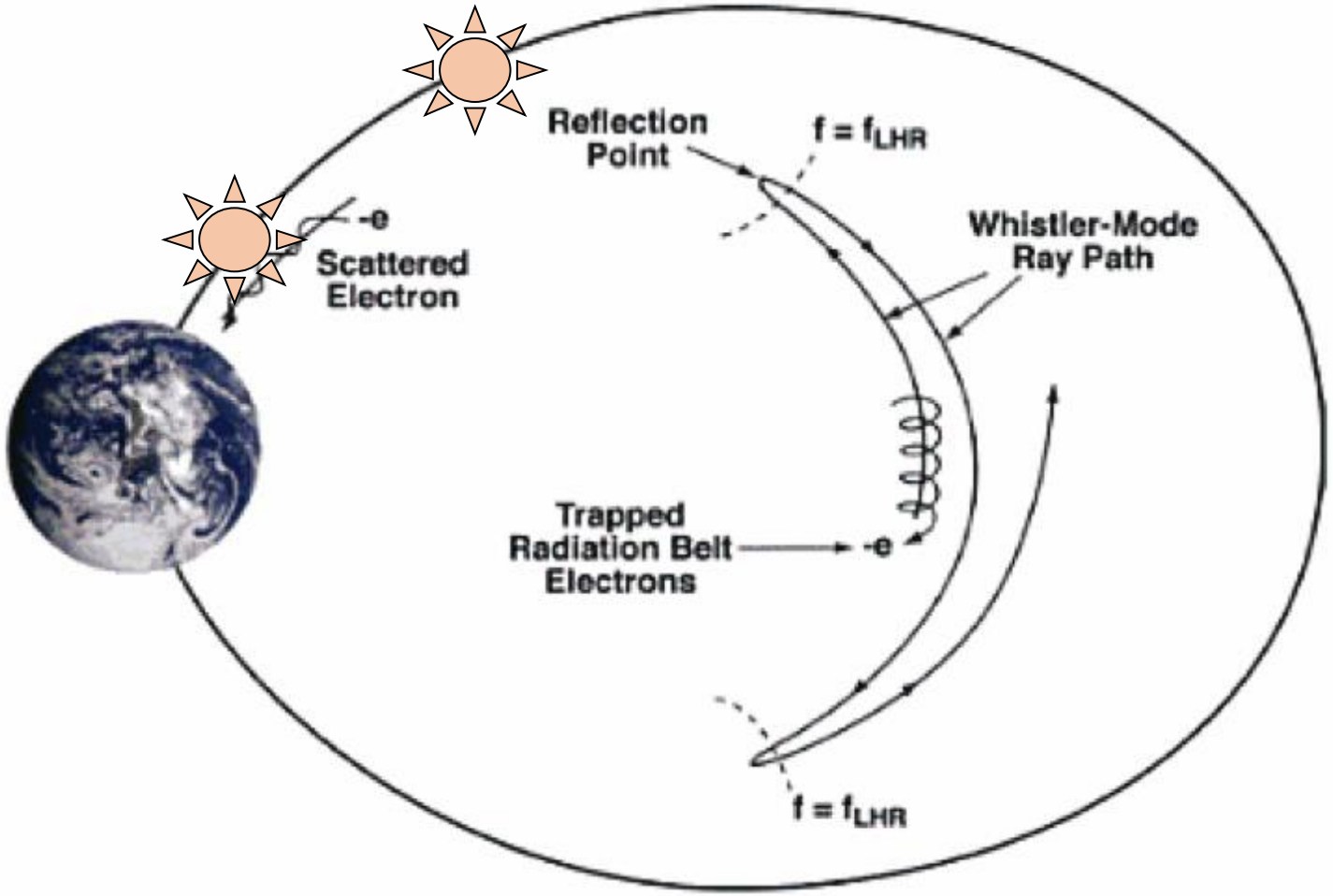
Размер: ∅1850 мм, h=1900 мм – рабочее; h=400 – транспортное;

Масса: 60±5 кг;

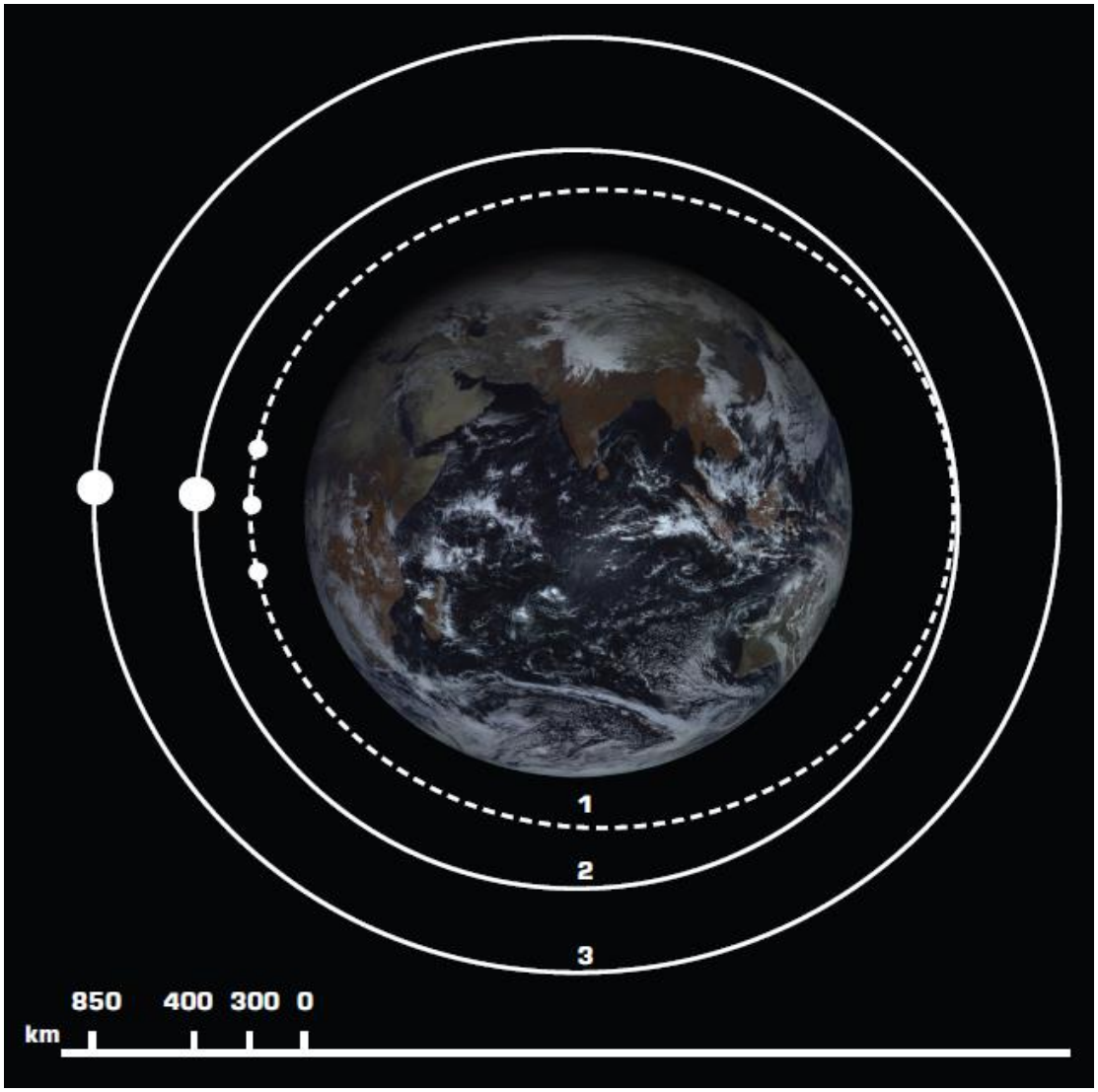
Информативность: 200 Мб/сут

Участники эксперимента: **МГУ (НИИЯФ), Космическая Регата**

Plans for future: «Soyuzsat»



Plans for future: «Soyuzsat»



Thank you

TePa 2013

September 9-13

Nor Amberd International Conference Center, Village Byurakan, Aragatsotn Province, Armenia

INTERNATIONAL SYMPOSIUM AT THE YEREVAN PHYSICS INSTITUTE