The history of cosmic gamma-ray burst observations at Ioffe Institute

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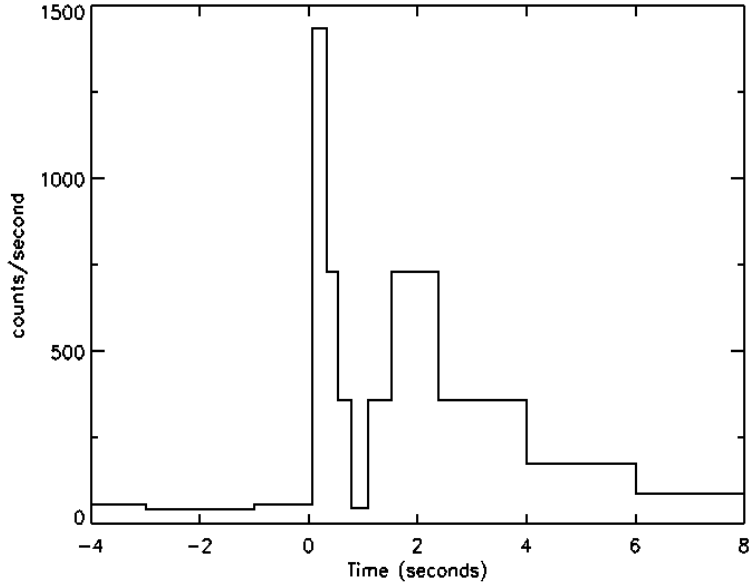
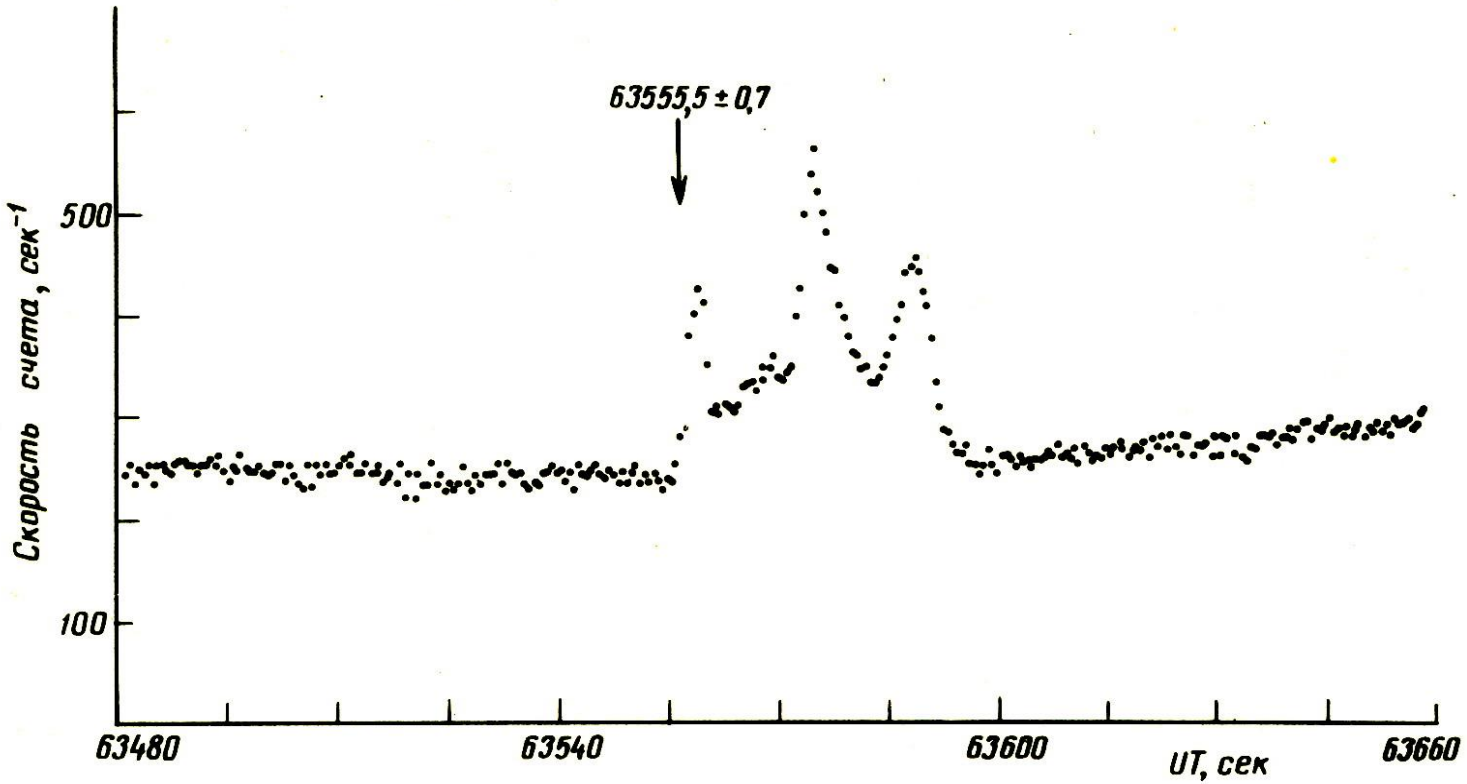
Gamma-ray burs discovery

- Gamma-ray bursts (GRBs) were discovered in the end of 1967-x by detectors onboard Vela 4 spacecraft (0.1-1 MeV energy band).
- Further detections onboard Vela 5, 6 (Klebesadel et al., 1973).

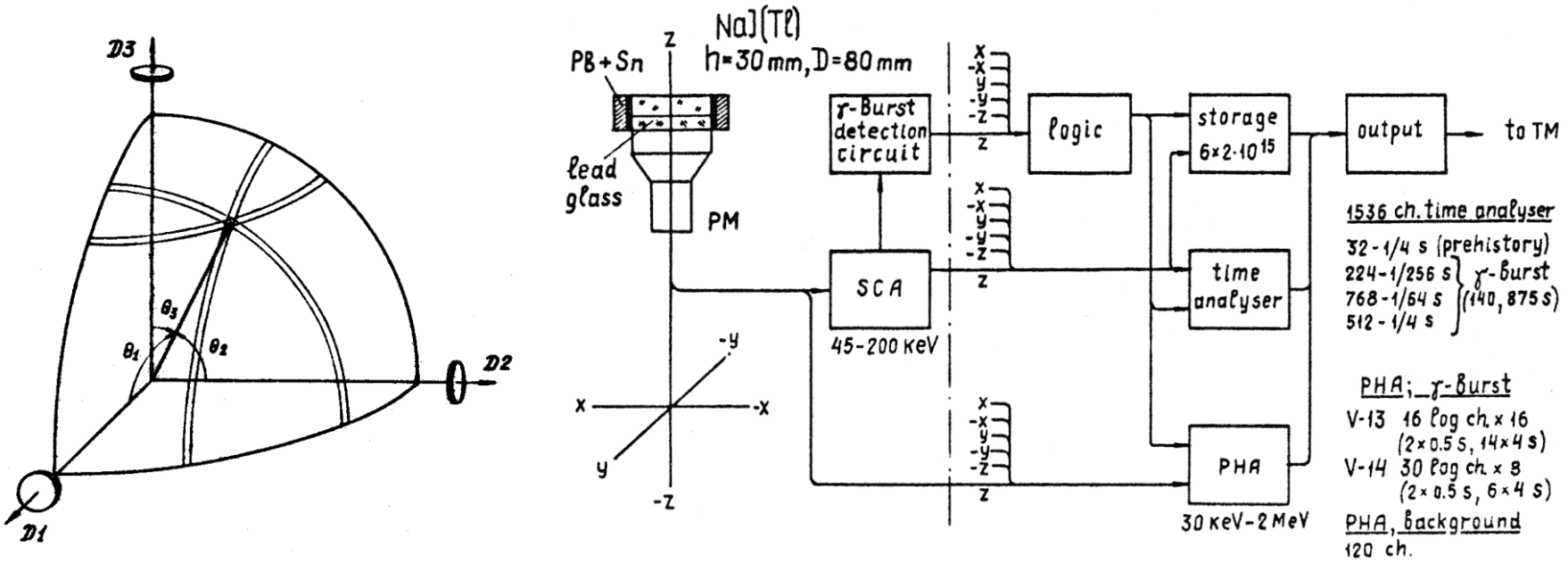


History of GRB observations at Ioffe Institute

- One of the first independent confirmation of the GRB discovery.
  A gamma-ray detector on Kosmos-461 s/c detected GRB 720117 from the Vela catalog (Mazets et.al., JETP Letters 19, 126, 1974)



The Konus experiments on board the Venera 11 to 14 deep space missions in 1979 to 1983

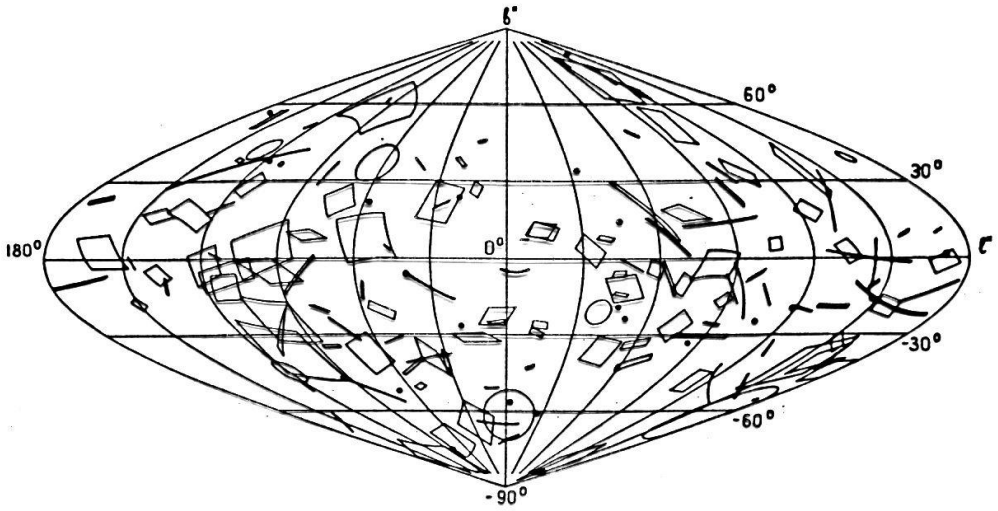


Left: determination of the source direction of a gamma burst with a system of gamma detectors with anisotropic angular sensitivity;

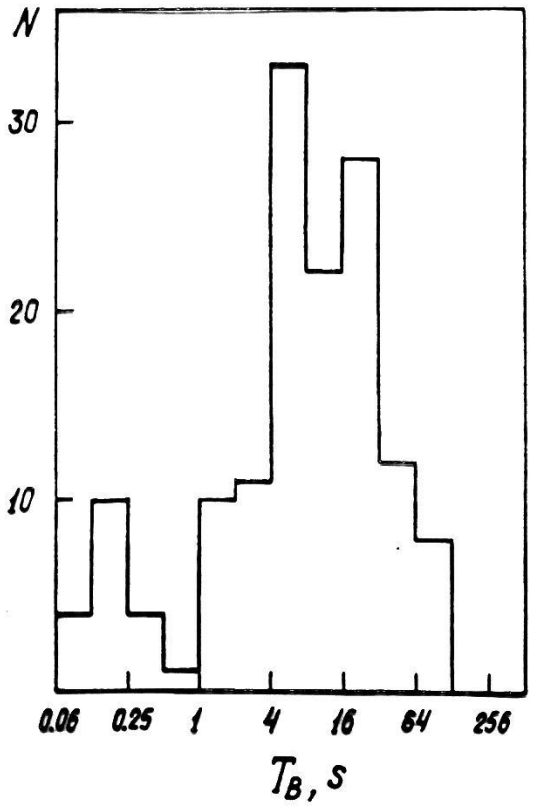
Right: Block diagram of the Konus instrumentation. A sensor system of six scintillation detectors with a close to cosine angular sensitivity pattern arranged along six axes of the spacecraft.

History of GRB observations at Ioffe Institute

- ~150 GRBs were detected in the KONUS experiments on board Venera 11-14 missions in 1979-1983.
- Discovery of a bimodality in the GRB duration distribution and an isotropy of spatial distribution of their sources.



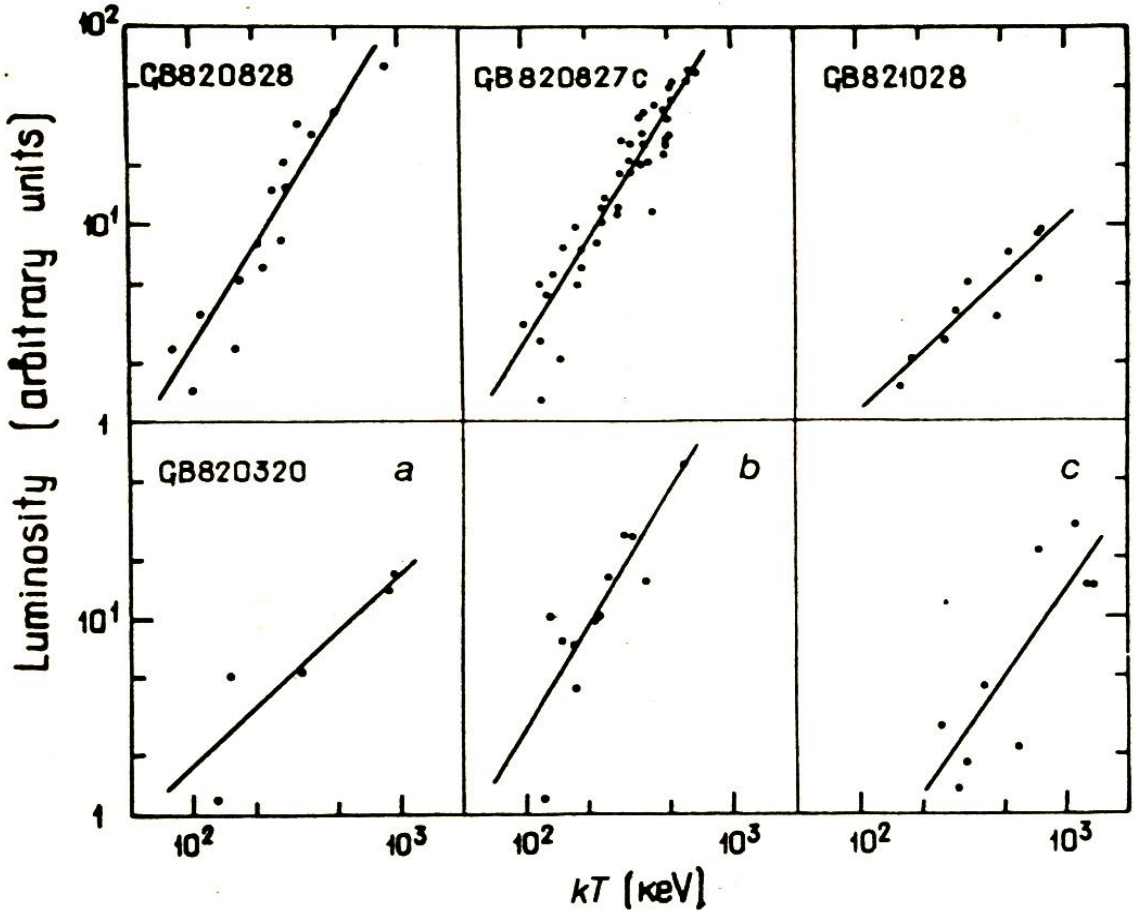
Mazets & Golenetskii, Sov. Sci. Rev., Sect. E 6, 3, 281 (1981)



Mazets et al., Ap&SS 80, 3 (1981)

History of GRB observations at Ioffe Institute

- The first evidence of hardness-intensity correlations in GRBs (Venera 13-14 missions; Golenetskii et al., Nature, 1983)



"Golenetskii" Relation

History of GRB observations at Ioffe Institute

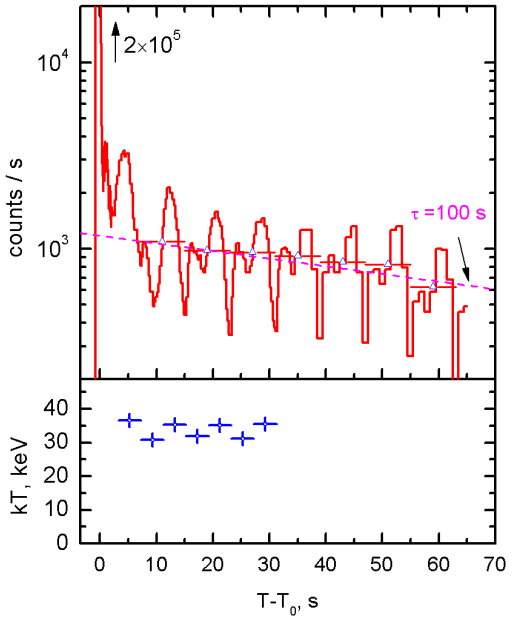
- **The pioneer studies of Soft Gamma-ray repeaters** (Venera 11-12, Venera 13-14)

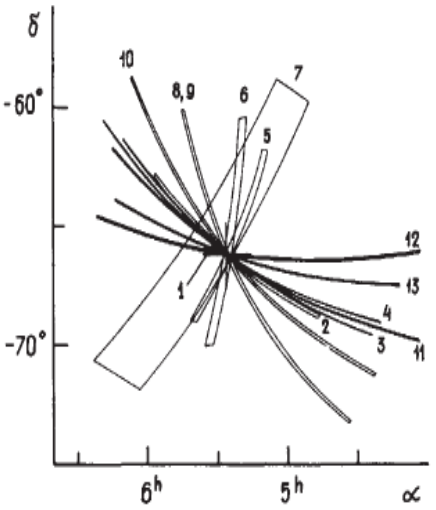
- **Giant Flare on March 5, 1979** (top, Mazets et al., Nature, 1979) followed by 16 short bursts from the same source in the next few years (**bottom**, Golenetskii, Il'inskii & Mazets 1984, consistent with Evans et al., IAU Circ., 1979) FXP 0526-66 = SGR 0526-66
  (N49, LMC, 55 kpc; Cline et al., ApJ, 1982)

- B1900+14 = SGR 1900+14 (3 bursts in March 1979, Mazets, Golenetskij, & Guryan, Ast. Lett., 1979)

- First two sources of short recurrent bursts with soft spectra were discovered and localized, a distinct class of sources different from other GRBs suggested (Golenetskii, Il'inskii & Mazets, Nature, 1984)

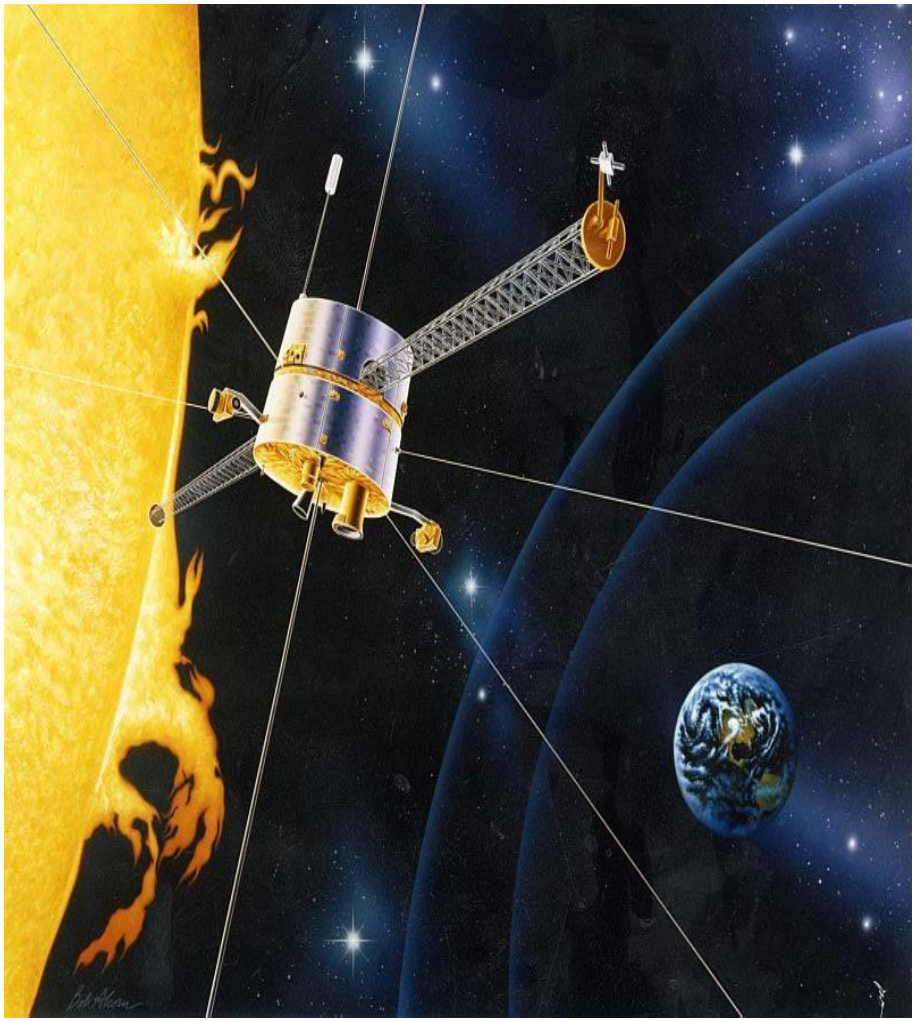
- SGR 1806-20 (Prognoz 9, ICE, SMM) Atteia et al. ApJ, 1987, Laros et al., ApJ, 1987, Kouveliotou et al., ApJ, 1987
  1st Konus burst on Jan 7, 1979!





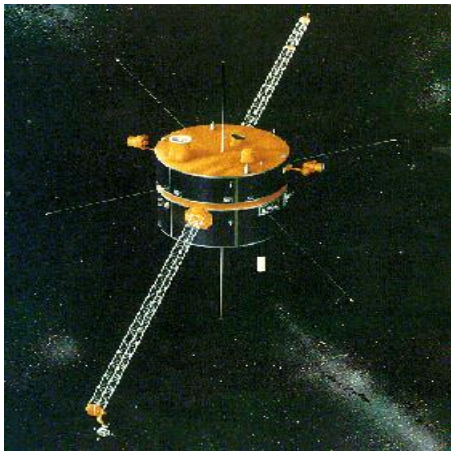
Joint Russian-US Konus-Wind experiment

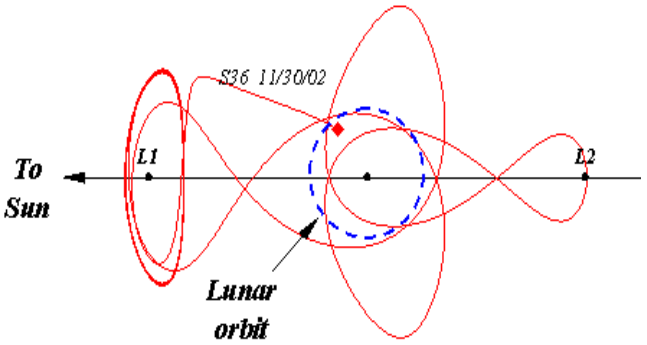
The Global Geospace Science (GGS) *Wind* satellite is a NASA scientific s/c launched on November 1, 1994.
24+ years of continuous operation (!)
Mission is operated from GSFC.
Now the satellite is on orbit near L1, up to 2.1 million km (~7 light s) from Earth.
The Konus-Wind (KW) is a joint Russian-American experiment aimed primarily at GRB and SGR studies.
The KW gamma-ray spectrometer is designed and manufactured at Ioffe Institute (Saint-Petersburg, Russia)
The first Russian scientific instrument onboard an American satellite.



Joint Russian-US Konus-Wind experiment

- *The instrument contains two detectors with NaI (Tl)* cristals with the diameter by 13 cm and height by 7.5 cm with the beryllium entrance windows. The detectors are located on the opposite sites of the spacecraft stabilized by rotation in such way that constantly observed the northern and southern ecliptic hemisphere in all sky monitoring mode
- The photon registration range now is from 20 keV up to 15 MeV and
- The burst detection sensitivity is ~ 10^{-7} erg cm^{-2}
- Detectors operate without influence of radiation belts and shielding by the Earth
- The Wind orbit provides very stable radiation background
- The pure time of observation is approximately 95%;
- Detectors registered practically all occurred GRBs.





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Joint Russian-US Konus-Wind experiment

- *The BURST mode*
- *The time history* has time resolution from 2 мs up to 256 мs with total duration up to 230 s with the following distribution over the energy:

  20 – 80 keV 4096 time channels

  80 – 300 keV 4096 time channels

  300 – 1200 keV 4096 time channals

- *The amplitude analysis:* accumulation time has time intervals from 64 ms up to 8.192 s and regulates by special system which provides an accumulation time from 79 s up to 492 s.

  The instruments has two following diapasons:

  20 – 1100 keV with 63 quasilogariphmic channels;

  350 keV – 15 MeV with 63 quasilogariphmic channels;

  There is a special system named “time nonius” aimed for detailed analyses with time resolution 2 ms any part of the burst with sharp changes of the burst count rate.

- *BACKGROUND MODE:* the accumulation time of the information is 1.47s or 2.94 s

  The count rate detects in the following channels:

  20 – 80 keV, 80 – 300 keV, 300 – 1200 keV and more than 15 MeV (it is a charged particle channel)

- The Konus instrument is designed and manufactured at Ioffe Institute with using Russian radiated protected IC.

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Joint Russian-US Konus-Wind experiment

The total number of GRBs detected up to september 1, 2019

3023 GRBs: ~125 GRBs per year;

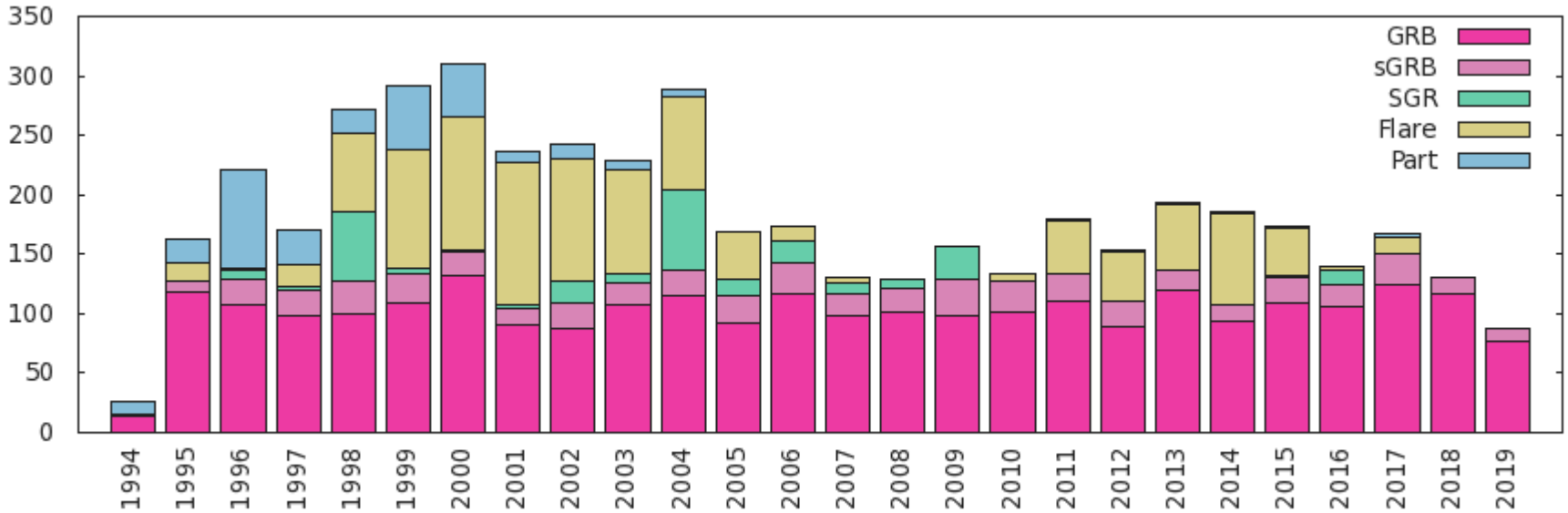
- 150 GRBs with known redshifts;
- 13 ultra-long GRBs with the duration ~1000 – 2500 sec;

Other bursts events:

- 249 bursts from soft gamma repeaters including 2 giant flare и series repeating bursts before giant flare;
- 1040 solar flare;
- Several giant flare from Cygnus X-1;
- The regular observations of pulsed radiation from X-ray pulsar such as : Vela X-1, GX 301-2, A0535+262, GRO J1008-57 and some others

Joint Russian-US Konus-Wind experiment

- Observation statistics (triggers):
  3000 – GRBs (Fermi ~1500, BATSE ~2700, Swift ~1000),
  250 – SGRs, 1000 – Solar flares
- ~ 1000 GCN circulars



Annual Konus-Wind trigger statistics in 1994-2019

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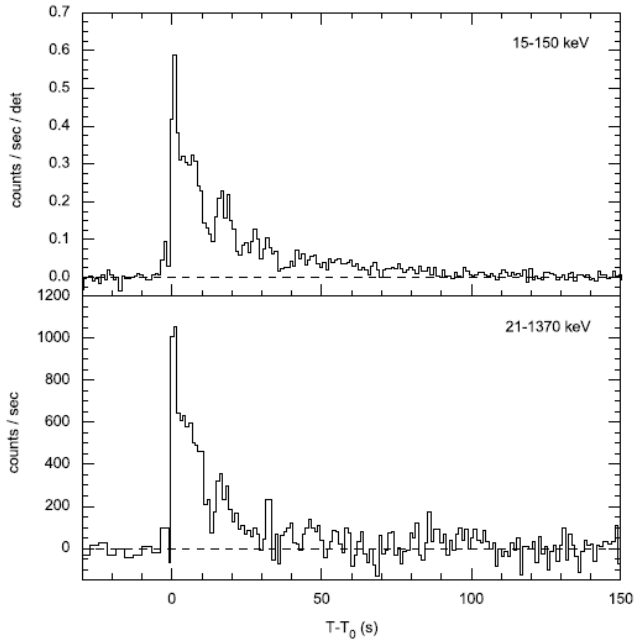
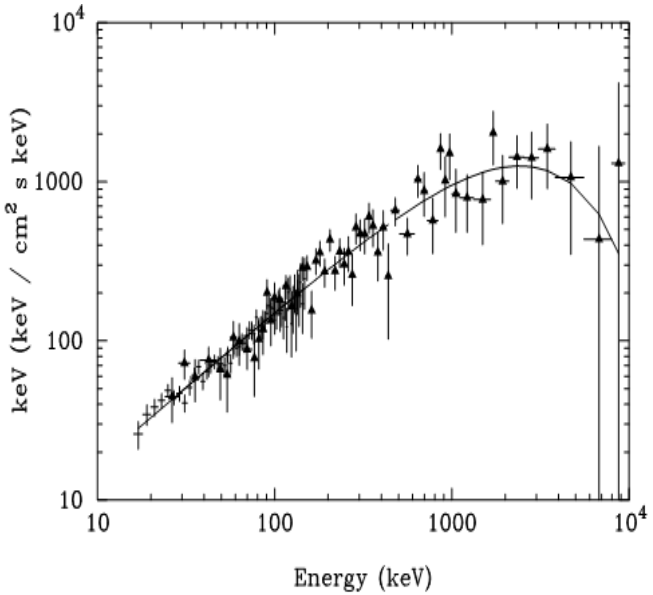
Joint Russian-US Konus-Wind experiment

- The measurements of GRB spectral parameters is important for understanding how the radiation generates in the sources. After the Swift mission was launched the cross-calibration was made
- The results of comparison BAT/Swift and Konus-Wind spectral data showed that they coincided with accuracy with accuracy about 20%.
- The left picture is the time profile of GRB050717 from BAT/Swift an Konus-Wind. The right picture is the result of joint fit of spectral data from both experiments.





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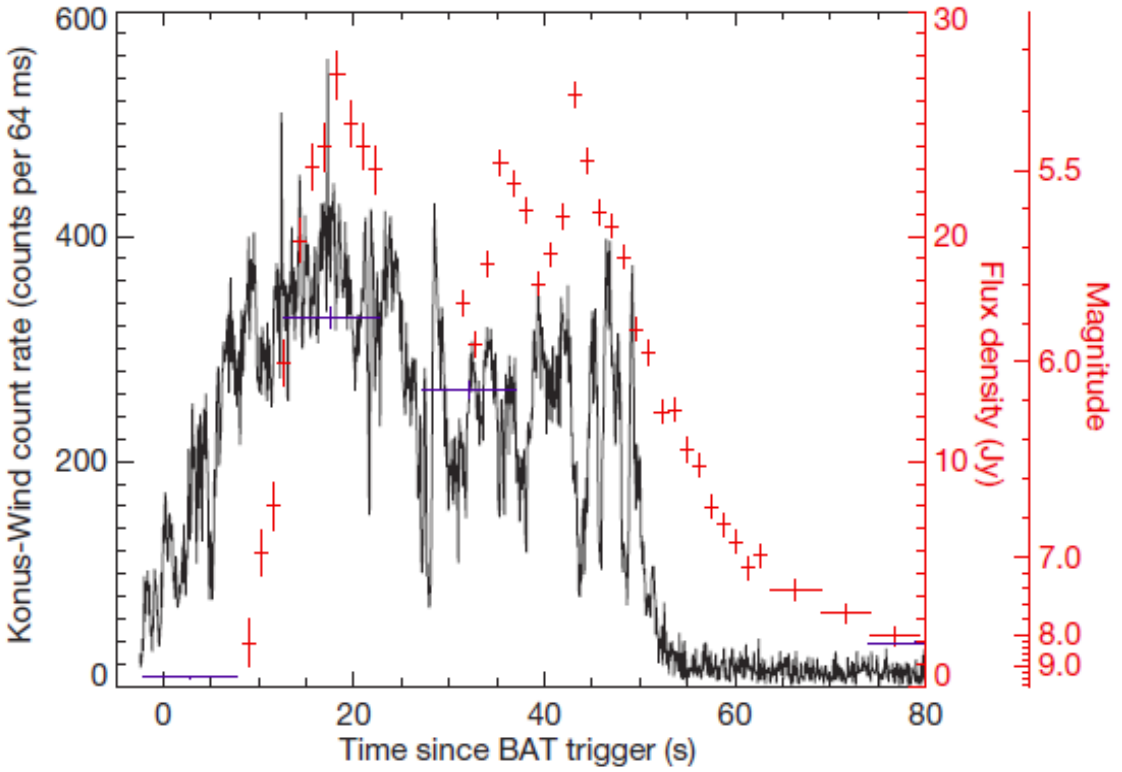
Konus-Wind GRBs with known redshifts



Black: Konus-Wind, Blue: 'Pi of the Sky',
Red: TORTORA (Racusin et al., Nature, 2008)

GRB 080319B: z=0.937, Liso,peak≈1053 erg s-1, Eγ,iso≈1054 erg, Eγ≈4×1050 erg (θ≈0.2o, 4o)

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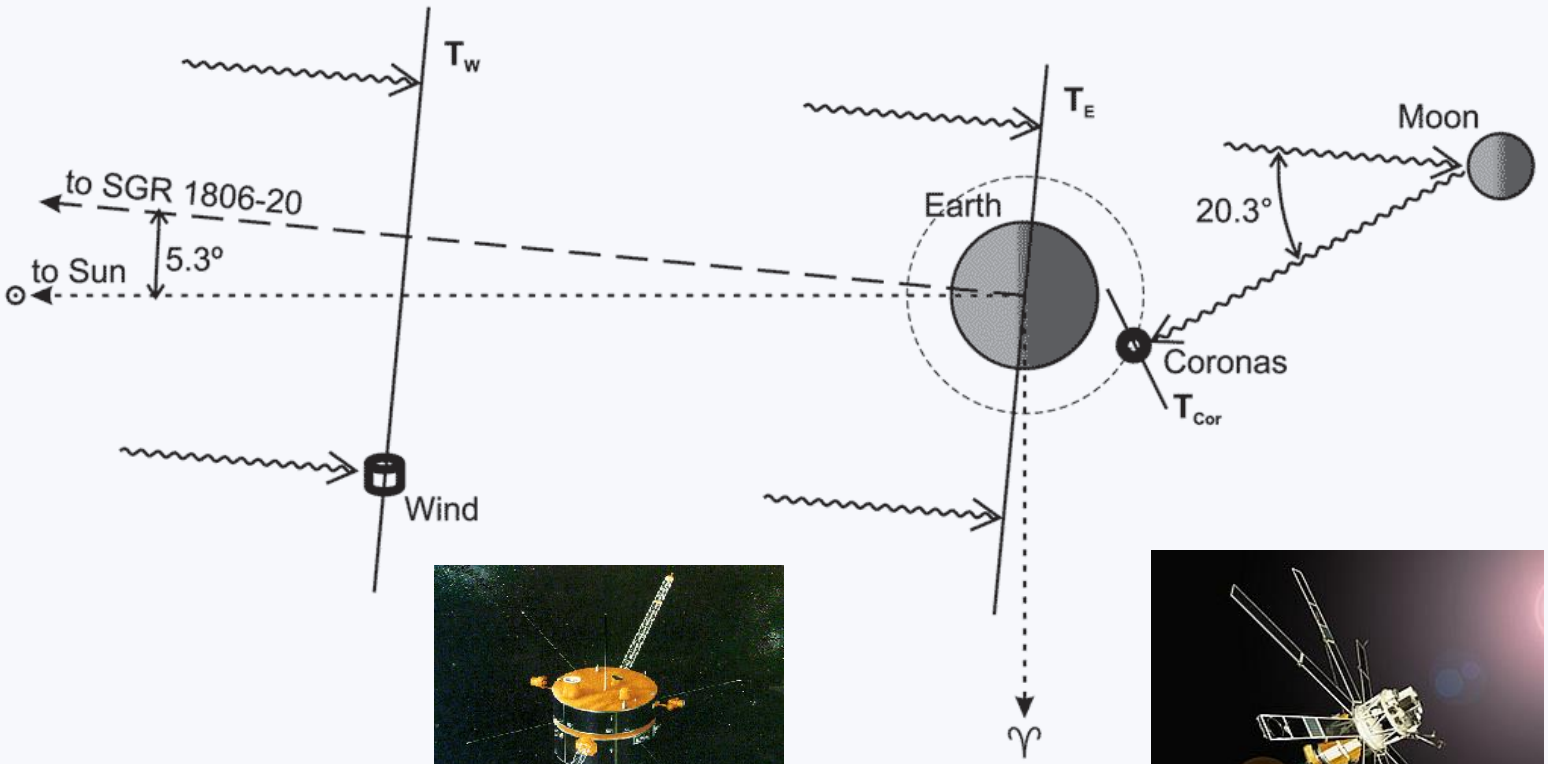
Konus-Wind and Gelikon-Coronas observations of giant flare of SGR 1806-20



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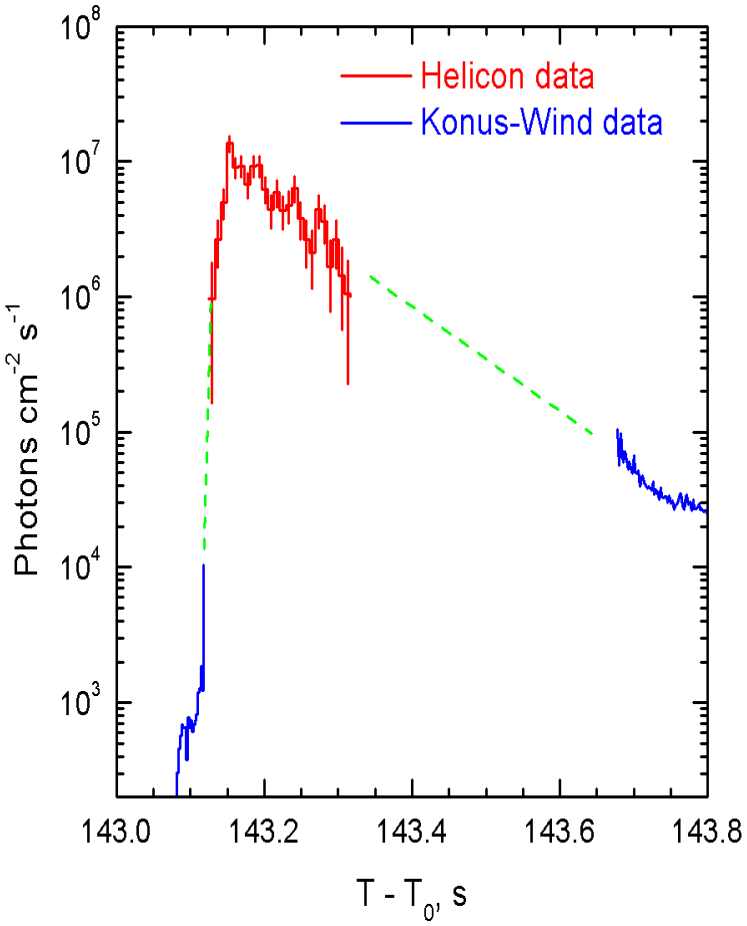
Konus-Wind and Gelikon-Coronas observations of giant flare of SGR 1806-20



Reconstructed light curve of the initial pulse

S=0.6 erg cm-2, Fmax = 9 erg cm-2 s-1

The full isotropic energy release Q=2.3×1046 erg and
the peak luminosity L=3.5×1047 erg s-1

The giant flare is ~100 times brighter
than of SGR 1900+14 GF!

The pulsating tail energetics was similar to that of the two previous GFs.

Due to the enormous luminosity of the initial pulse, GFs can be detected from SGRs in nearby galaxies

Frederiks et al., Ast. Lett. (2007)

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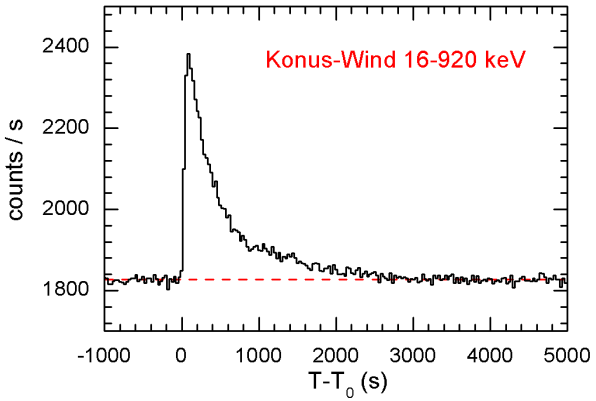
Konus-Wind observations of ultra-long GRBs

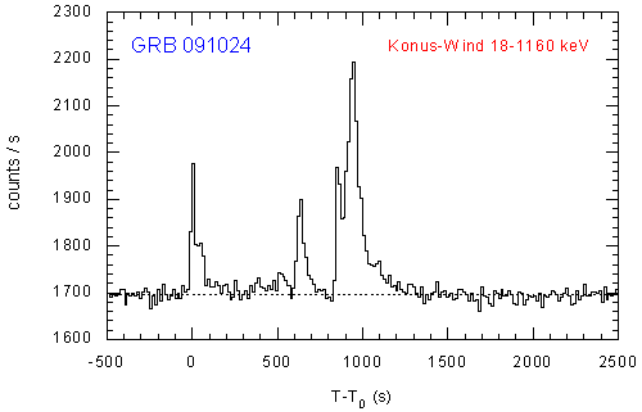
- Wind orbit is far from the Earth magnetosphere (at distance of 1-7 light seconds) that enables nearly uninterrupted observations of all sky under very stable background.
- Only restricted number of ultra-long GRBs (with durations > 1000 s) have been reported to date.



GRB 971208.

dT ~2500 s

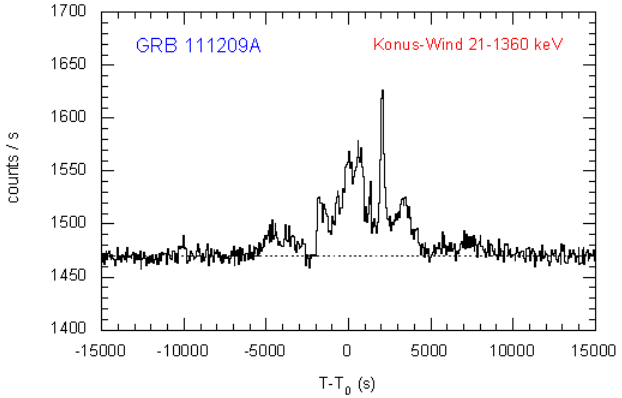
S ≈3×10^{-4} erg cm^{-2}



GRB 091024. dT ~1200 s, z=1.092,

S ≈1×10^{-4} erg cm^{-2},

E_{iso}≈3×10^{53} erg

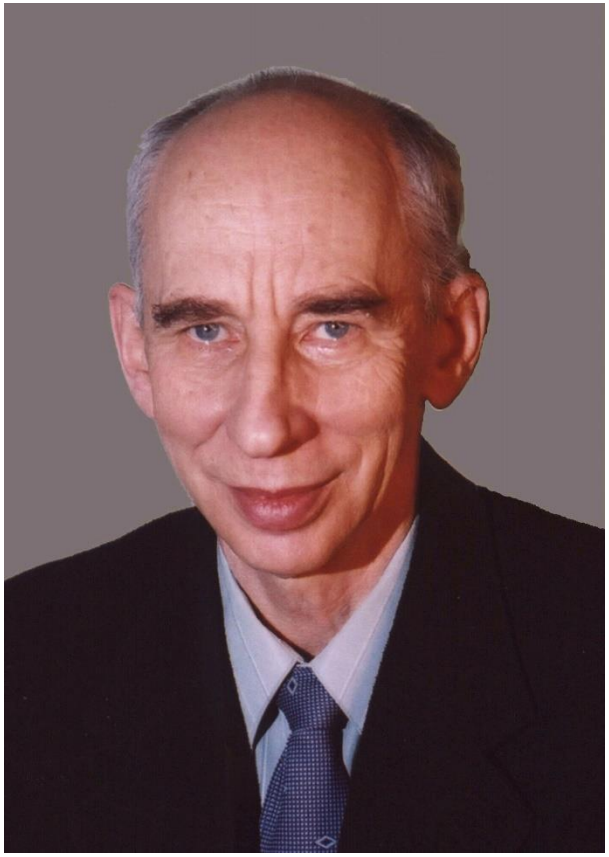


GRB 111209A. dT>7000 s (!!!) z=0.677,

S ≈5×10^{-4} erg cm^{-2},

E_{iso}≈6×10^{53} erg

Professor Evgeny Mazets (1929 – 2013)



Physics – Uspekhi, 56, 1150 (2013)

- One of the first independent confirmation of the GRB discovery: Kosmos 461 observation of GRB 720117 from Vela catalogue (Mazets et al. JETP Lett., 1974)
- Suggested and implemented a principle of autonomous burst localization using a system of detectors with anisotropic angular sensitivity
(Konus on Venera 11,12: Mazets & Golenetskii, Ap&SS, 1981)
- The first catalog of GRBs – 143 bursts (Venera 11,12 missions) and the discovery of a separate class of short GRBs (Mazets et al., Ap&SS, 1981)
- Hardness-intensity correlation in GRBs (Golenetskii, Mazets et al., Nature, 1983)
- Discovery of SGRs (March 5, 1979 Giant Flare from SGR 0526-66: Mazets et al. Nature 1979; repeated bursts from SGR 0526-66 and SGR 1900+14 : Golenetskii, Mazets, et al. 1979; Mazets et al., PAZh 1979)

PI of 24 space-based experiments in 1960s - 2010s

- **Konus-Wind – the first Russian instrument onboard a US s/c**

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Thank you!