Overview of the Russian-American Konus-Wind experiment

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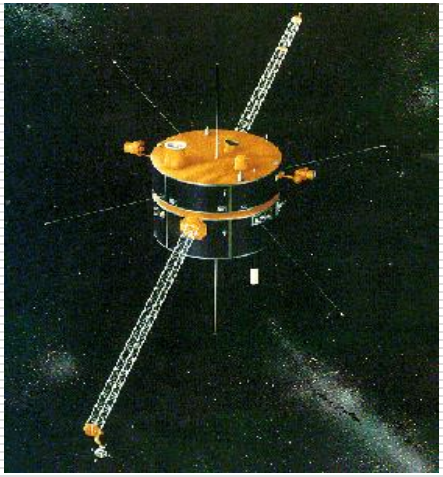
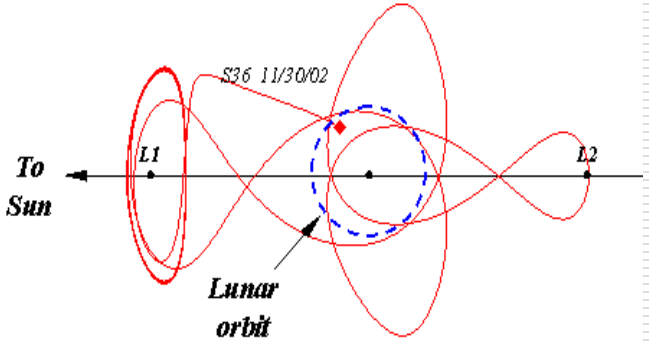
Joint Russian-US Konus-Wind experiment

- *Launched on November 1, 1994*
- *Two detectors S1 and S2:*
  NaI(Tl) 13 cm x 7.5 cm, Be entrance window.
  Located on opposite faces of spacecraft, observing correspondingly the southern and northern celestial hemispheres
- Continuous observations of all sky
- ~20 keV – 15 MeV energy range (present time)
- ~100-160 cm^2 effective area



- The orbit of s/c excepts an interferences from radiation belts and the Earth shadowing.
- Exceptionally stable background
- Duty cycle ~95%
- Detects virtually all rather bright bursts



- *Two detectors S1 and S2:*
  NaI(Tl) 13 cm diameter, 7.5 cm height, 12.5 cm Be entrance window.
  Located on opposite faces of spacecraft, observing correspondingly the southern and northern celestial hemispheres
- *Burst mode:*
  Time history analyzer: resolution 2ms – 256 ms, total duration 230s
  20 – 80 keV 4096 ch
  80 – 300 keV 4096 ch
  300 – 1200 keV 4096 ch
- *Pulse Height analyzer:* accumulation time 64ms – 8.192 s, duration 79 – 492 s
  PHA1 20 – 1100 keV 63 ch quasilog scale
  PHA2 350 keV – 15 MeV 63 ch quasilog scale
- *Background mode:* accumulation time 1.47 – 2.94 s
  Count rate:
  20 – 80 keV
  80 – 300 keV
  300 – 1200 keV
  > 15 MeV

Joint Russian-US Konus-Wind experiment

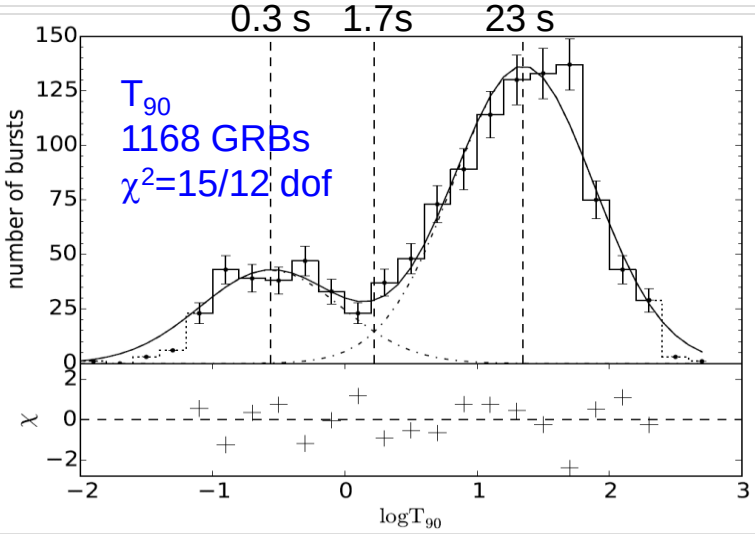
Summary (up to 2014, July; only triggered events):

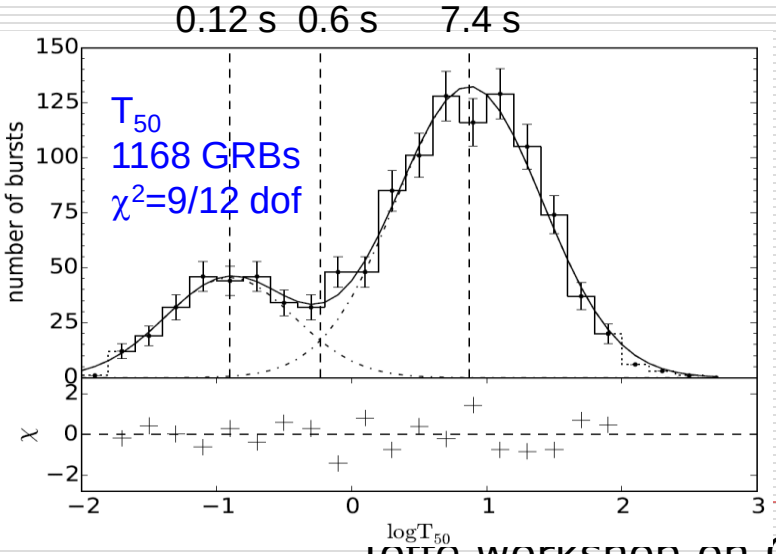
- 2465 GRBs: ~125 GRBs/year (2702 GRBs in the Current BATSE GRB catalog)
- 190 Swift/BAT GRBs – 21% of BAT GRBs
- 132 GRBs with measured redshift

Non-GRB science:

- 249 triggers caused by SGR bursts; two SGR giant flares, two burst clusters, four ultra-long bursts
- 940 solar flares
- several giant flares from Cygnus X-1
- Continuous observations of pulsating emission from accreting pulsars: Vela X-1, GX 301-2, A0535+262, GRO J1008-57 and others

KW GRB distributions and classification





- The subsample of 1168 bright GRBs is well described by two log-normal distributions.
- Boundary at T_{50} ~0.6 s
- 30% short-duration, 70% long-duration
- In the full sample ~400 short GRBs (~16%; the short weak GRBs are undersampled) (BATSE: 24%, BAT: 8%, GBM: 18%)
- ~9% of short GRBs have weak long tail (extended emission)

Determination of GRB spectral parameters and energetics

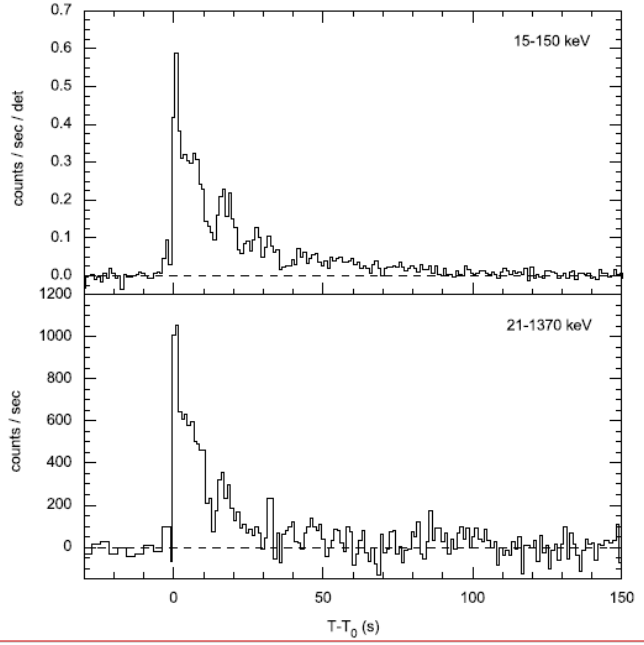
- Wide energy range let us to determine GRB spectral parameters: low energy PL index α, peak energy E_p, high energy PL index β (for Band model), and bolometric fluence and peak flux.
- For GRBs with z, E_{iso}, L_{iso}, and $E_{p,rest}$ can be determined

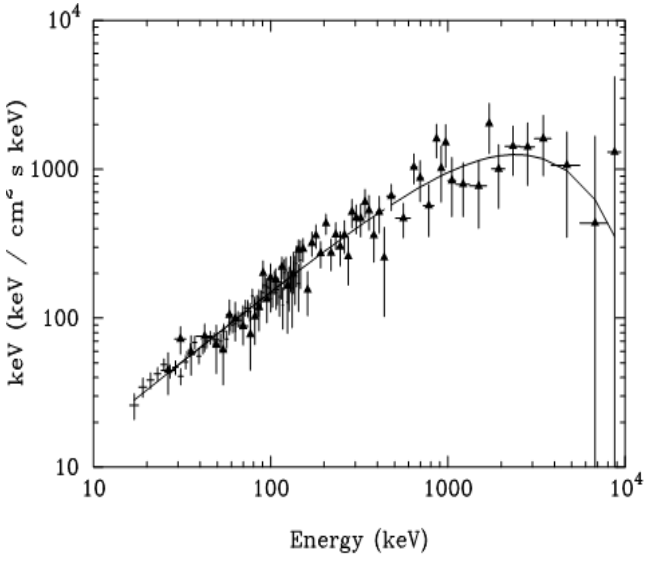
GRB 050717

(Cummings et al. 2005)

Swift-BAT + Konus-Wind

$E_p \approx 2.4$ MeV- one of the highest ever measured for long GRBs



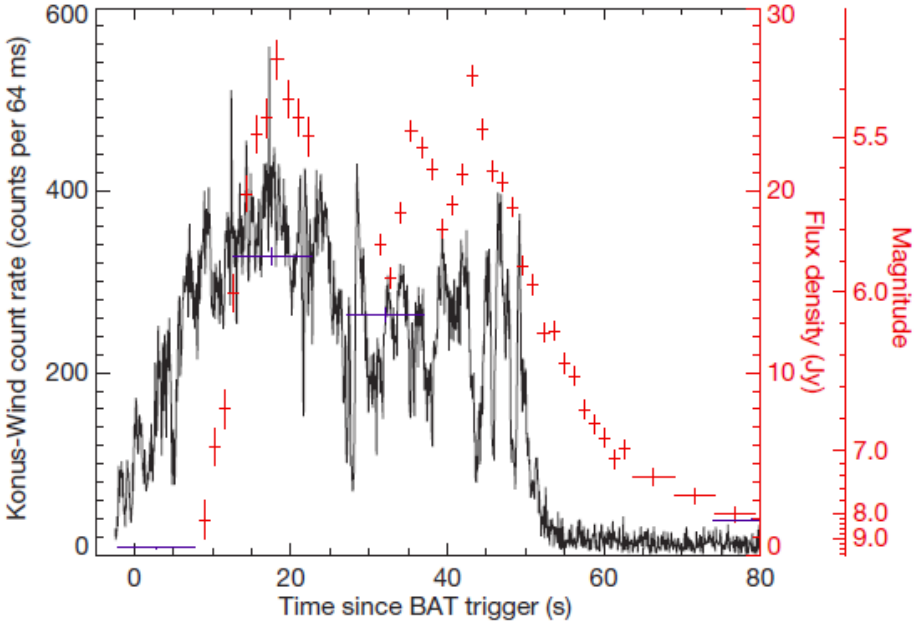


Konus-Wind observations of GRBs with prompt optical emission

Konus-Wind has observed all GRBs with bright prompt optical emission.

Among them the famous GRB 990123 (m ~9), GRB 041219A (m ~14), GRB 050820A (m ~14.5), GRB 080319B (m ~5.3)

Racusin et al. 2008



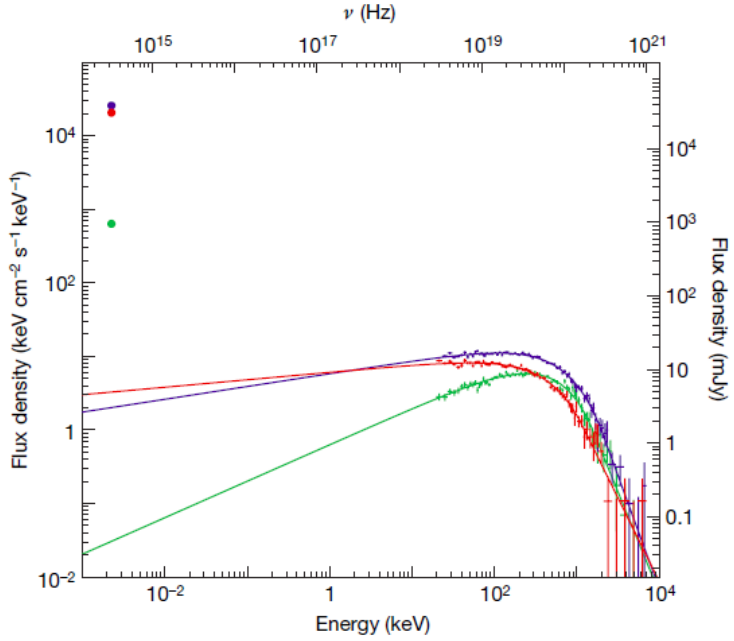
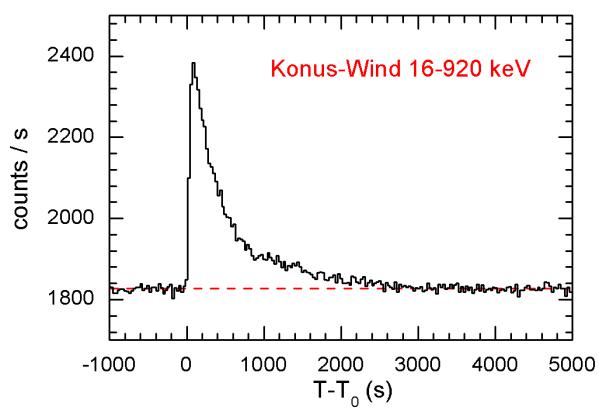


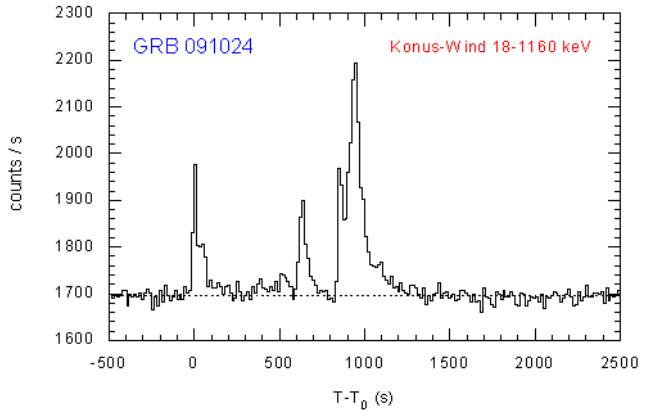
Figure 3 | Spectral energy distribution of the prompt emission. Konus-Wind spectra and 'Pi of the Sky' flux density in three 10-s time intervals

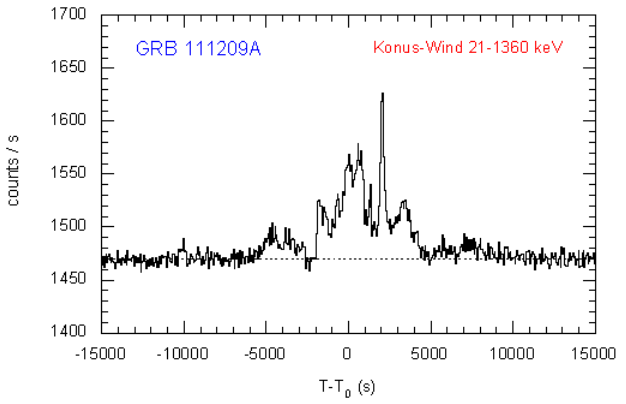
GRB 080319B: z=0.937, $L_{iso,peak} \approx 10^{53}$ erg s^{-1}, $E_{\gamma,iso} \approx 10^{54}$ erg, $E_{\gamma} \approx 4 \times 10^{50}$ erg ($\theta \approx 0.2^{o}$, 4^{o})

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 a few 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},

$E_{iso}\approx3\times10^{53}$ erg

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

S ≈5×10^{-4} erg cm^{-2},

$E_{iso}\approx6\times10^{53}$ erg

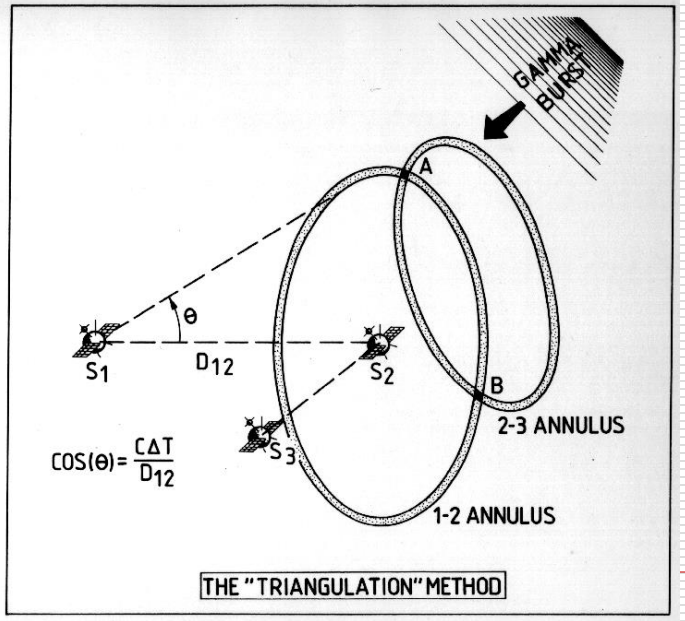
Konus-Wind is an important vertex of IPN

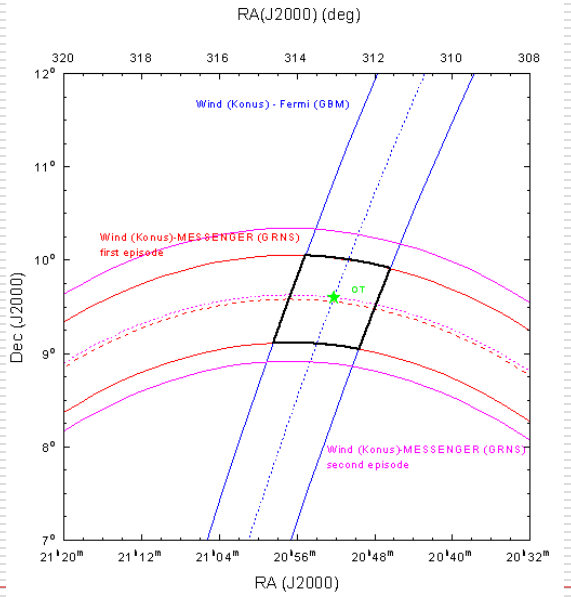
The 3rd interplanetary network (IPN), which has been in operation since 1990, presently consists of 9 spacecraft: AGILE, Fermi, RHESSI, Suzaku, and Swift, in low Earth orbit; INTEGRAL,in eccentric Earth orbit with apogee 0.5 light-seconds; Wind, up to ~7 light-seconds from Earth; MESSENGER, en route to Mercury; and Mars Odyssey, in orbit around Mars.

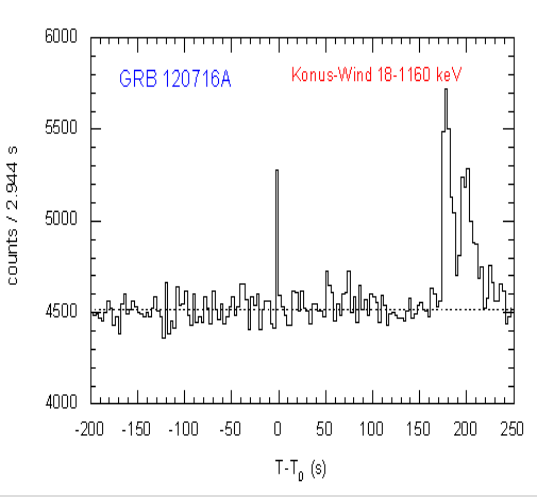
The IPN operates as a full-time, all-sky monitor for transients down to a threshold of about 6×10^{-7} erg/cm^2 or 1 photon/cm^2/s. It detects ~335 cosmic gamma-ray bursts per year.

IPN localizes many bright and interesting GRBs, improves Fermi GBM and LAT locations, help to find untriggered BAT bursts

Searches for: gravitational wave bursts, neutrino signals, UHE photons, giant SGR flares in nearby galaxies, bursts which occurred in conjunction with Type Ib/c supernovae

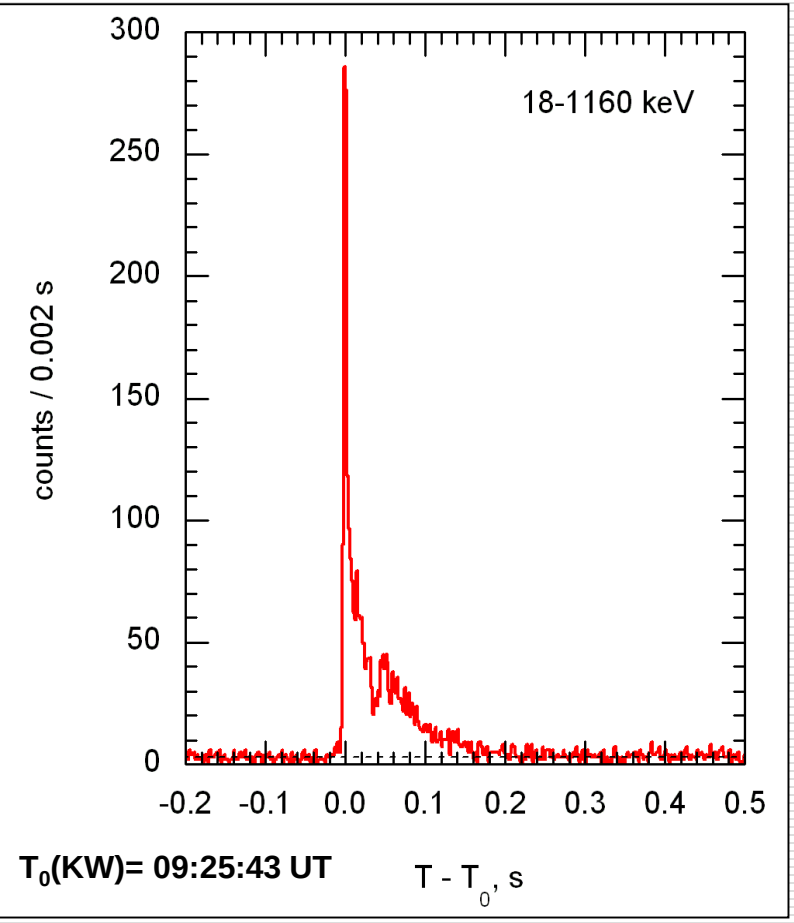




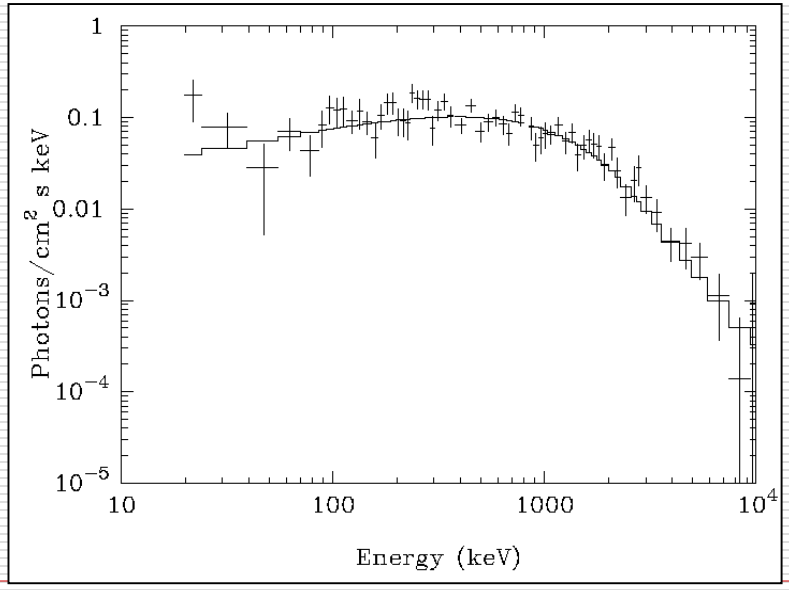


GRB 120716A. Localized by IPN. iPTF found an OT (~1.5 d after the trigger), z =2.38. A radio source has been found.

Short GRB 051103 – SGR giant flare in M81/M82?

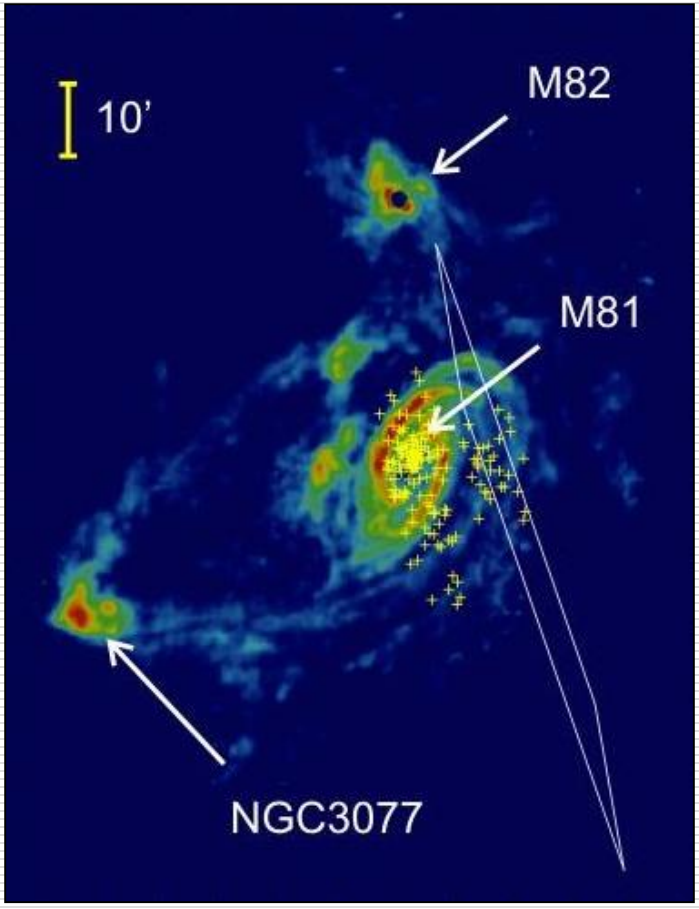


- Very bright, hard GRB
- Single pulse, very steep rise (~2 ms)
- Ep=2300±200 keV
- Total burst fluence [18 keV–14 MeV]: $S=(4.4\pm0.5)\times10^{-5}$ erg cm^{-2}
- 2-ms peak flux: $F=(2.8\pm0.3)\times10^{-3}$ erg cm^{-2} s^{-1}



Frederiks et al. 2007

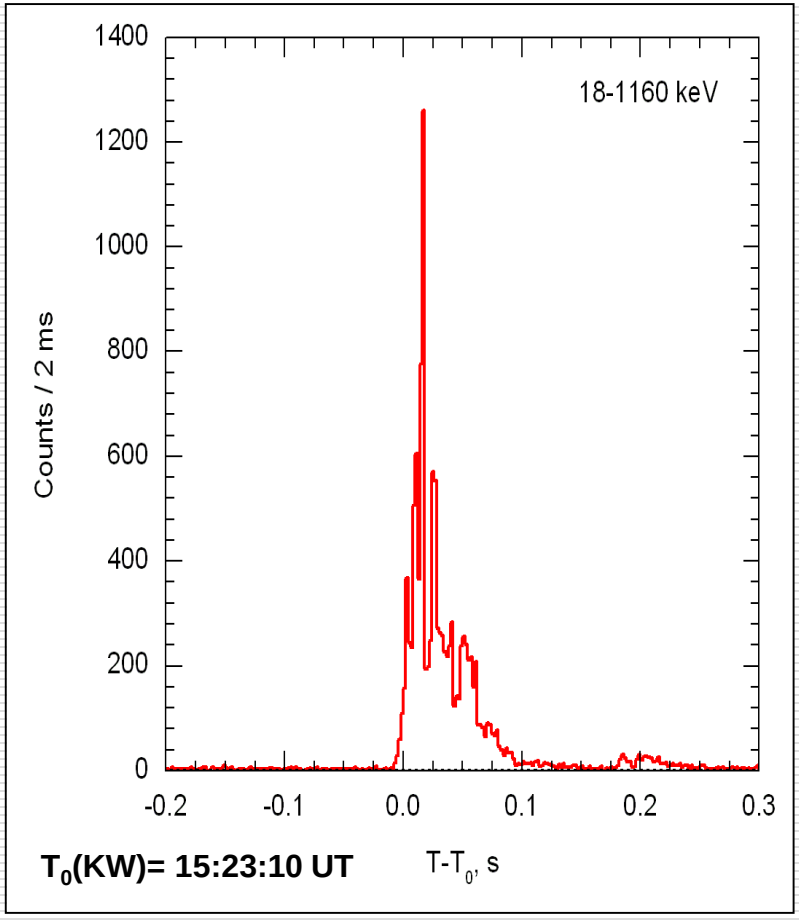
GRB 051103



VLA 21cm map

- The IPN error box overlaps with M81 group of galaxies
- For D_{M81}=3.6 Mpc
  Energy release: $Q_{iso}=7\times10^{46}$ erg
  Peak luminosity: $L_{max\ iso}=4\times10^{48}$ erg s^{-1}
  (for the 24th December 2004 Giant Flare from SGR 1806-20
  $Q_{iso}=2\times10^{46}$ erg
  $L_{iso,peak}=4\times10^{47}$ erg s^{-1})
- No detections from optical and radio followup observations
- Another possibility (Lipunov et al. 2005; Hurley et al. 2009): SGRB in a nearby (~100 Mpc) galaxy:
  $Q_{iso}=5\times10^{49}$ $(D/100Mpc)^2$ erg

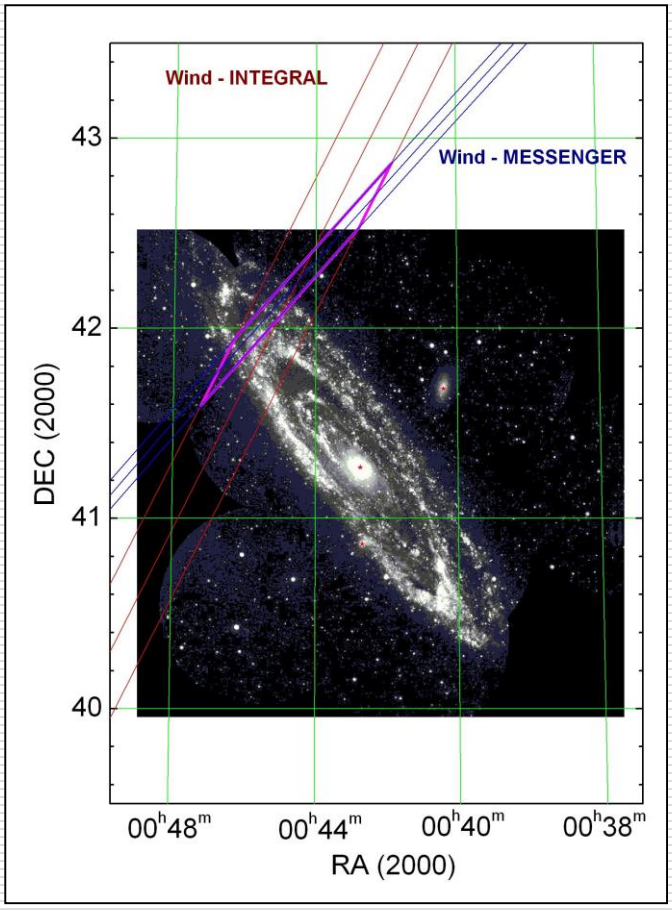
Short GRB 070201 – SGR giant flare in Andromeda galaxy



- Exceptionally bright
- Single pulse, steep rise
- Ep ~ 300 keV
- Fluence [18 keV–14 MeV]:
  $S=2.00(-0.26+0.10)\times10^{-5}$ erg cm^{-2}
- 2-ms peak flux:
  $F=1.64(-0.50+0.29)\times10^{-3}$ erg cm^{-2} s^{-1}

Mazets et al. 2008

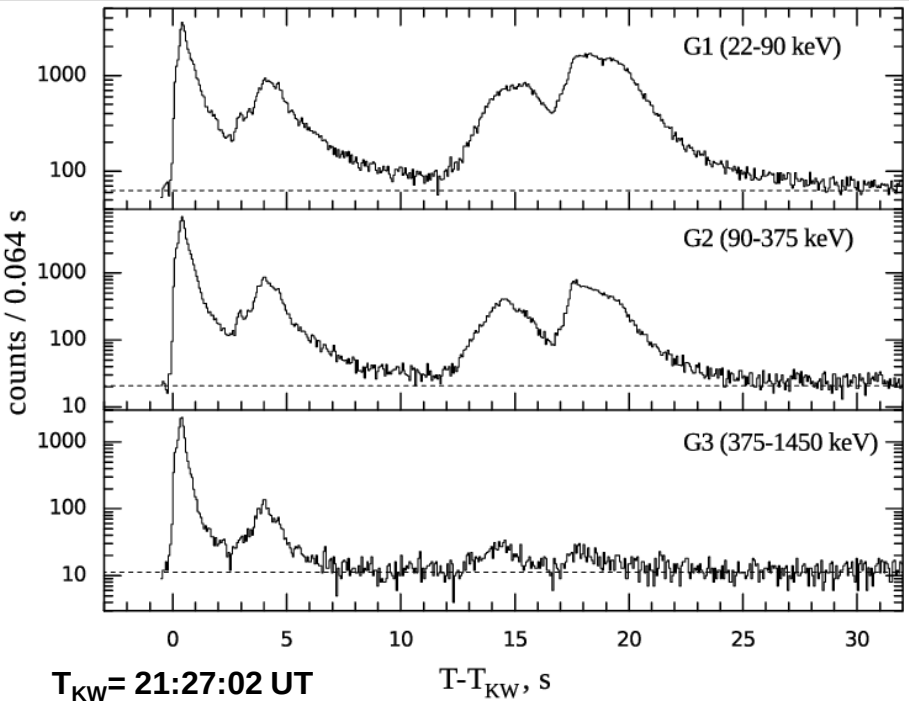
GRB 070201



GALEX synthesized M31 UV image

- The IPN error box overlaps with M31 (Andromeda) galaxy (with its prominent circular ring that considered to be the main SF region)
- For D_{M31}= 780 kpc
  Energy release: $Q_{iso}=1.5\times10^{45}$ erg
  Peak luminosity: $L_{max\ iso}=1.2\times10^{47}$ erg s^{-1} (for the 5th March 1979 Giant Flare from SGR 0526-66
  $Q_{iso}=7\times10^{44}$ erg
  $L_{max\ iso}\sim 10^{46}$ erg s^{-1})
- Both the temporal and energetic characteristics of the event on 2007 February 1 match the general pattern of a GF very closely.
- Beyond a doubt, we can conclude that this event is a GF which originated in SGR 0044+42 in M31

Ultra-luminous GRB 110918A

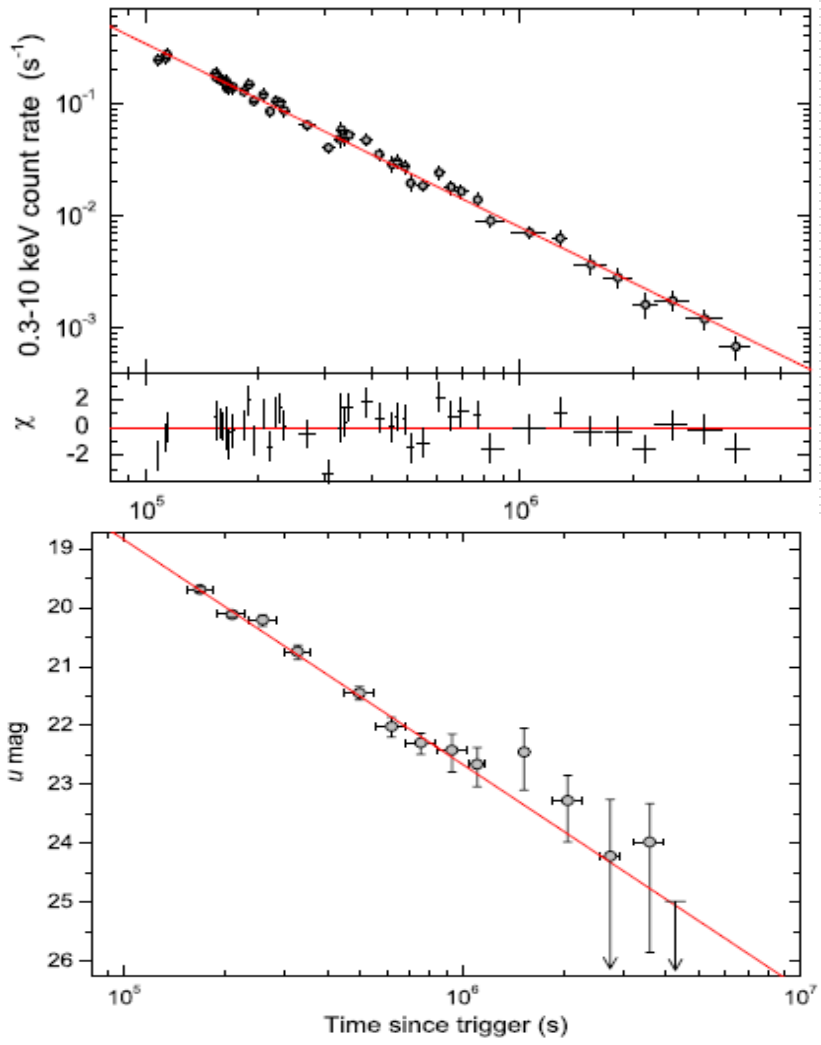


T_{KW}= 21:27:02 UT

- The brightest GRB detected by KW
- Localized by IPN
- Bright X-ray counterpart was found by Swift/XRT 1.2 days after the trigger
- The optical afterglow was discovered by Isaac Newton Telescope (z=0.982)
- $E_{iso}=(2.1+/-0.1)\times10^{54}$ erg
- $L_{iso,max}=(4.7+/-0.2)\times10^{54}$ erg s^{-1}
- $E_{p,max}$ ~2 MeV

Frederiks et al. 2013

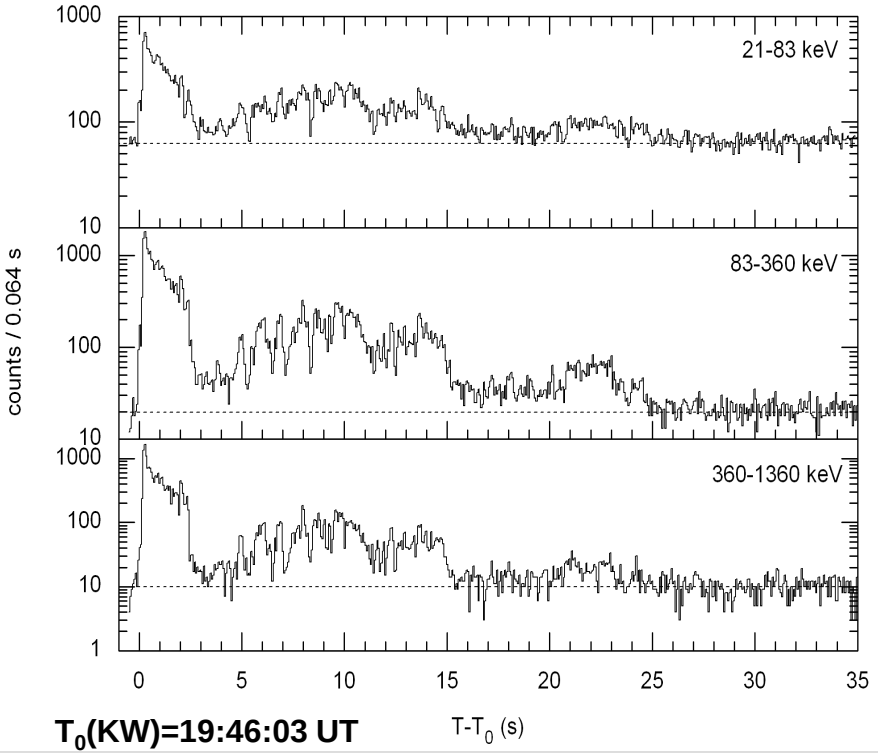
Ultra-luminous GRB 110918A



- More than 40-days long Swift/XRT and Swift/UVOT monitoring of the X-ray and optical afterglow shows a power-low temporal decay with index ~1.6
- Estimated jet break time ~0.2-1.2 days
- Implied jet collimation angle ~1.7-3.4 deg
  ($\theta^2/2 \sim (4\text{-}8)\times10^{-4}$)
- $E_\gamma \sim 10^{51}$ erg
- $L_{\gamma,max} \sim 2\times10^{51}$ erg s^{-1}

- Detection horizon:
  z~7.5 for Konus-Wind
  z~12 for Swift-BAT

Recent record holder GRB 140219A

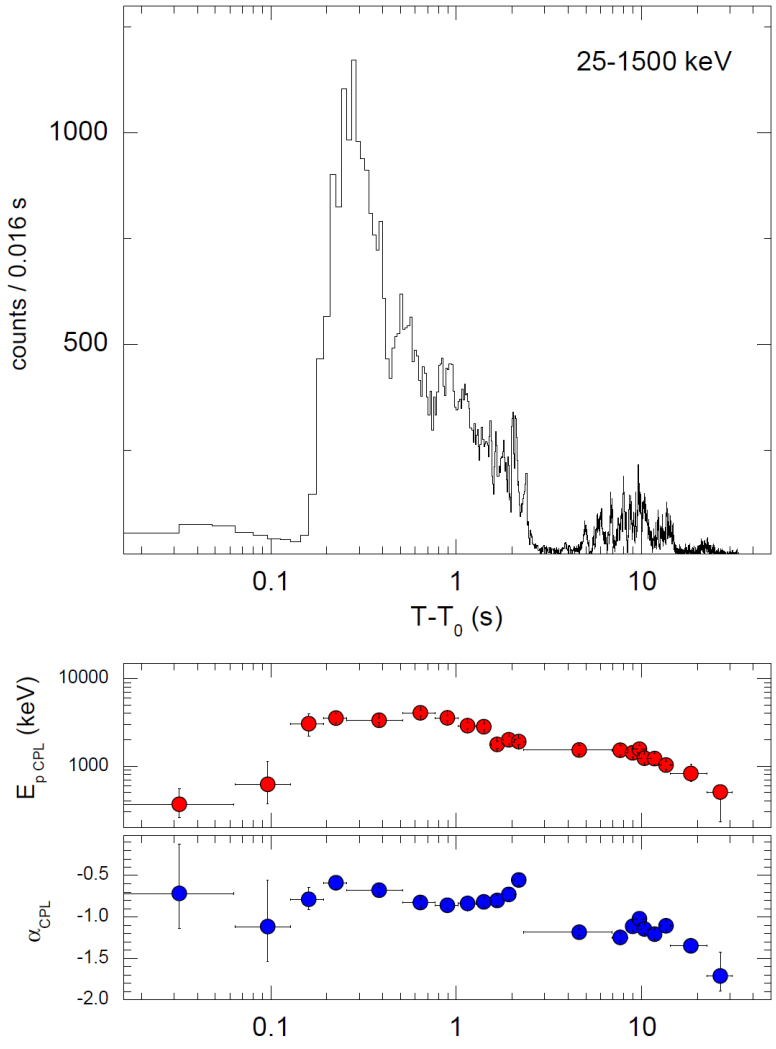


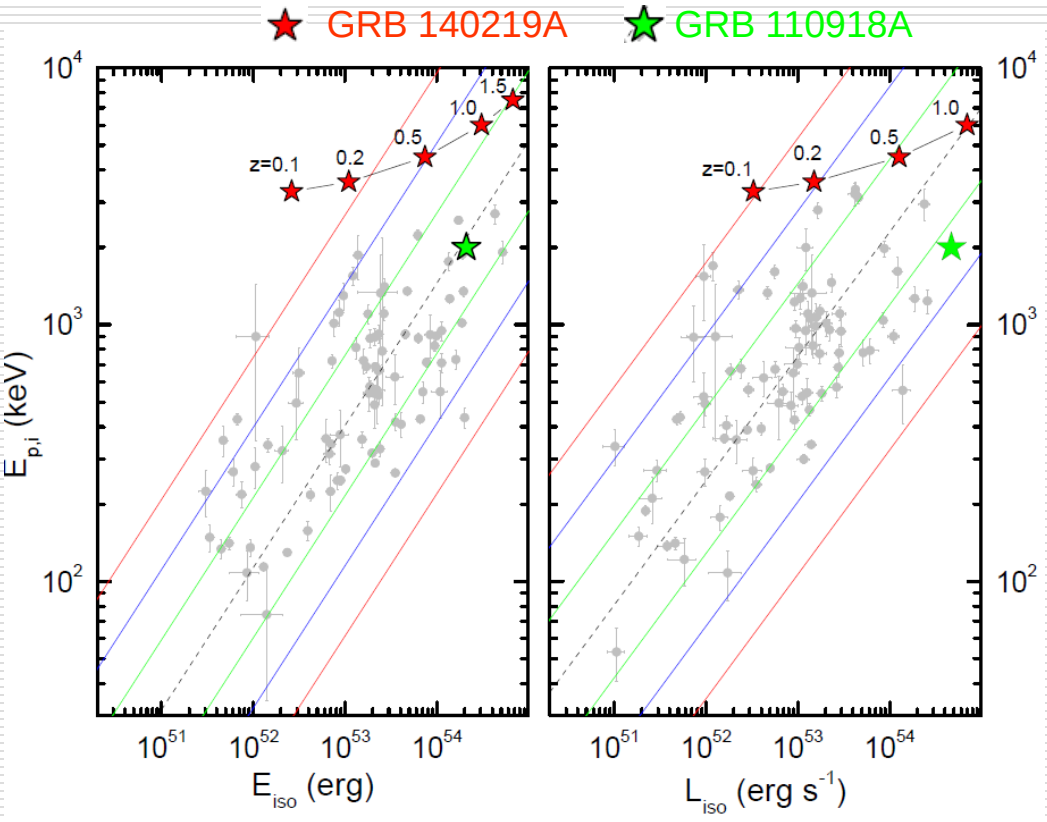
Golenetskii et al. GCN 15870

- Localized by IPN
- No credible afterglow was found despite the efforts (Swift/XRT, MASTER,iPTF,Mondy)
- Marginal LAT detection (from ~T_0+500 s to T_0+2300 s)
- The highest peak flux ever measured: 16-ms peak flux (20 keV–10MeV) $F=(1.44\pm0.12)\times10^{-3}$ erg cm^{-2} s^{-1} (~50% higher than the previous record holder, GRB 110918A, with the measured peak flux of ~0.9×10^{-3} erg cm^{-2} s^{-1})
- Fluence (20 keV–10MeV): $S=(1.14\pm0.02)\times10^{-3}$ erg cm^{-2} (the most fluent GRB 130427A had S ~2.7×10^{-3} erg cm^{-2})

GRB 140219A

- $E_{p,max}$ ~3.4 MeV
- $<E_p>$ ~2.8 MeV
- Ep,i=(1+z)Ep >~3 MeV!





Summary

Konus-Wind continues to provide important and often unique data on GRBs:

- Detects almost all bright GRBs and measures its spectral and energetic parameters. Almost no one important event has been missed!
- Routinely provides Ep, bolometric fluences and peak fluxes for bright Swift-BAT bursts (distributed via GCN)
- In the waiting mode observes ultra-long GRBs in their entirety, thereby providing estimations of burst spectral parameters and energetics
- KW is an important vertex of the IPN, that provides localization for many bright GRBs, thereby confirming/disproving their association with optical transients, SNe, high energy transients, nearby galaxies and so on, and enabling search os X-ray, optical, radio, VHE, neutrino and gravitational signals for the most interesting events