Gamma-Ray Bursts and "V"s of the big data

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Gamma-Ray Bursts

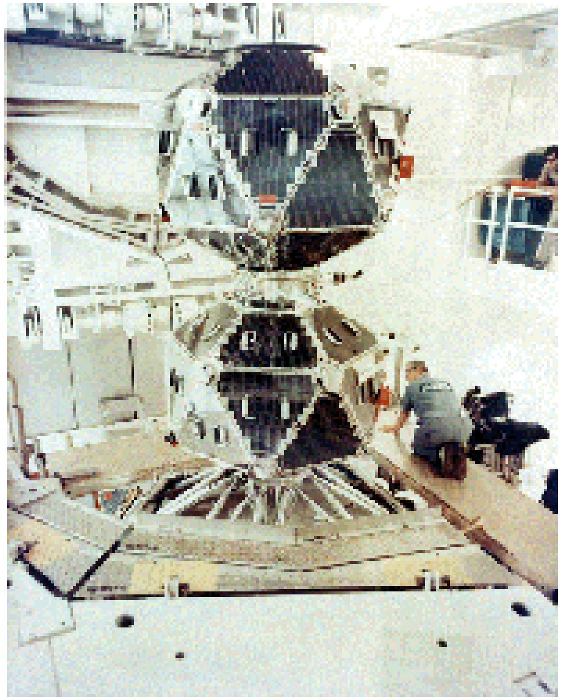
Outline

- GRB overview
- Observations
- Possible cooperation
- “V”s of the GRBs

Records of GRB astrophysical profile

- The brightest event on the sky in gamma-rays during short time (down to a few ms.)
- One of most distant observed sources (current maximal redshift $z=9.4$)
- EM energy release (if isotropic)   <~10^{54} ergs per a few seconds
- Energy emission range: from radio up to ~100 GeV (more than 15 orders!)
- Unsolved puzzle since discovery in 1967

Vela satellites (1967-1975): monitoring from space for ground based ***nuclear tests***



Открытие гамма-всплесков: первая публикация и первый всплеск

THE ASTROPHYSICAL JOURNAL, **182**:L85–L88, 1973 June 1

OBSERVATIONS OF GAMMA-RAY BURSTS OF COSMIC ORIGIN

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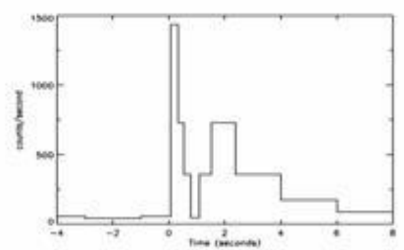
ABSTRACT

Sixteen short bursts of photons in the energy range 0.2–1.5 MeV have been observed between 1969 July and 1972 July using widely separated spacecraft. Burst durations ranged from less than 0.1 s to ~30 s, and time-integrated flux densities from $\sim 10^{-5}$ ergs cm^{-2} to $\sim 2 \times 10^{-4}$ ergs cm^{-2} in the energy range given. Significant time structure within bursts was observed. Directional information eliminates the Earth and Sun as sources.



1967 07 02 (UT) 14:19
Vela 3, Vela 4

GRB

- A few facts from GRB life

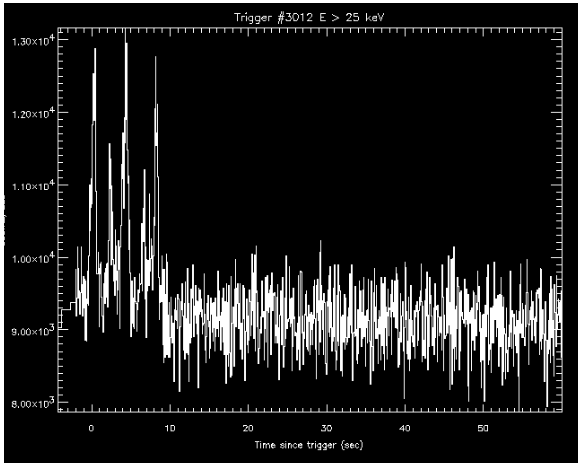
Time profile of prompt emission

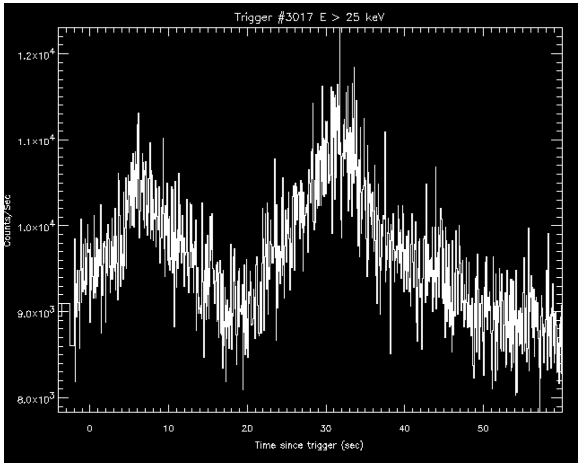
Short and Long GRB

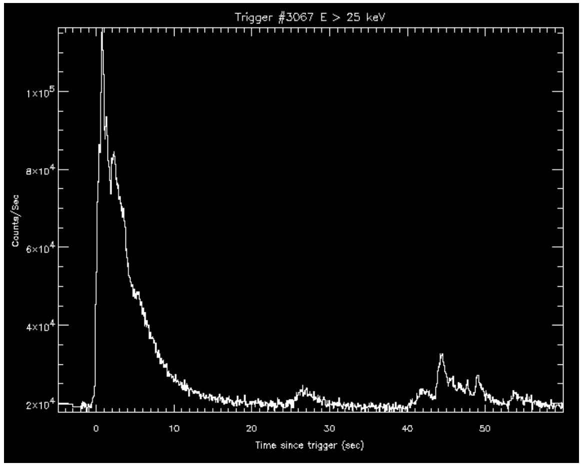
Afterglow

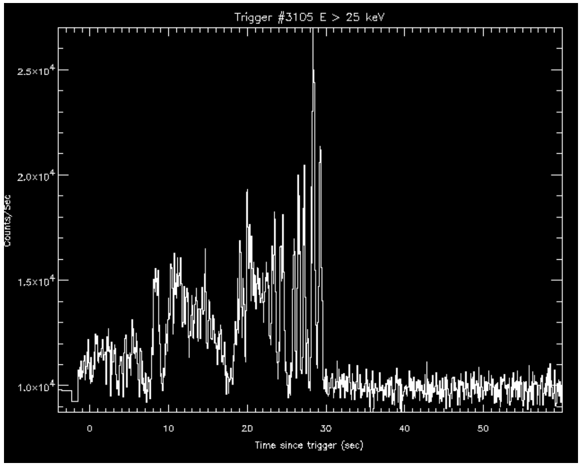
- EE
- Periodicity, QPO or nothing
- Aperiodic properties
- Spectral variability, spectral lag

GRB time profile (light curve of prompt = *active phase*)
A wide diversity of duration, shape and variability
There is no two identical time profiles

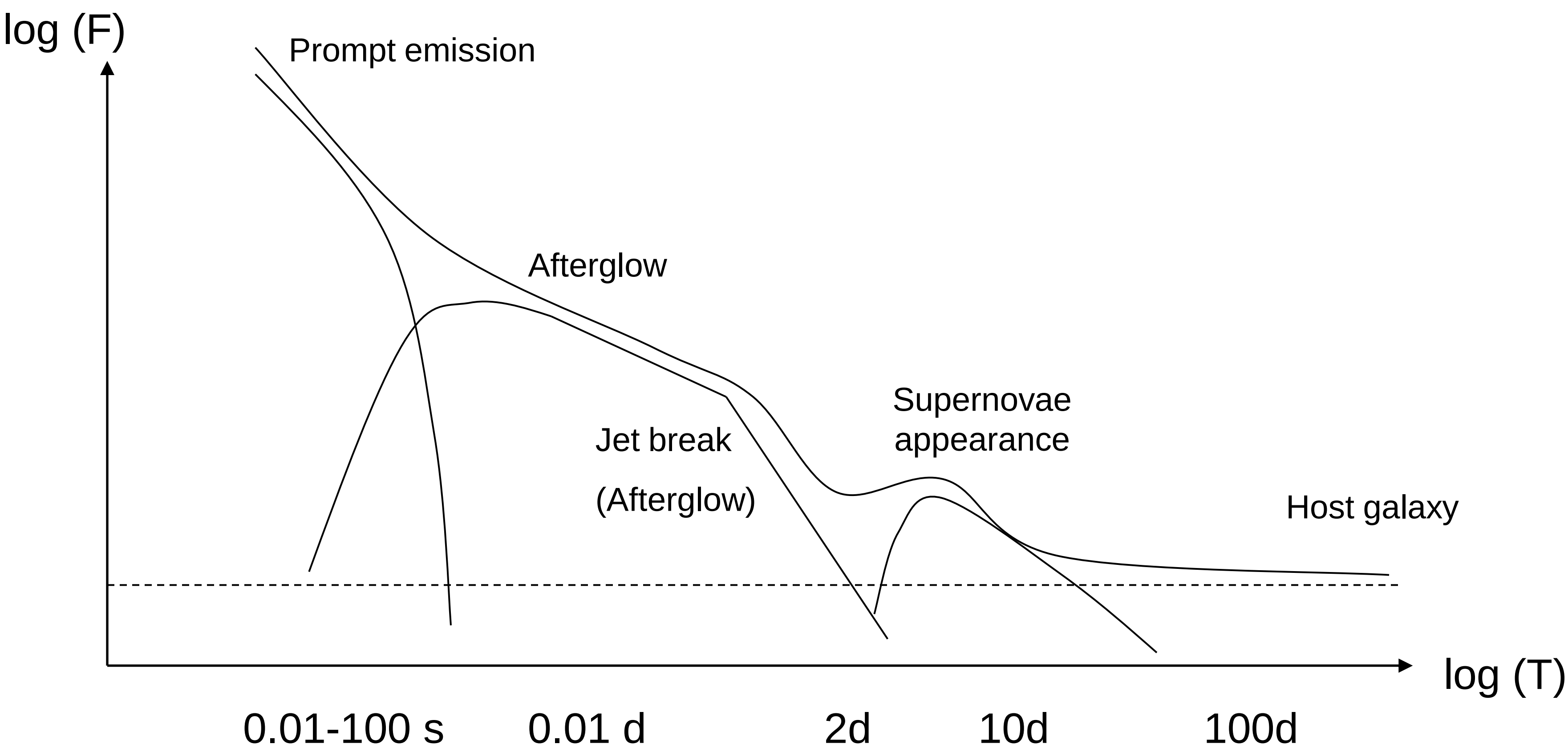








GRB light curve in optic



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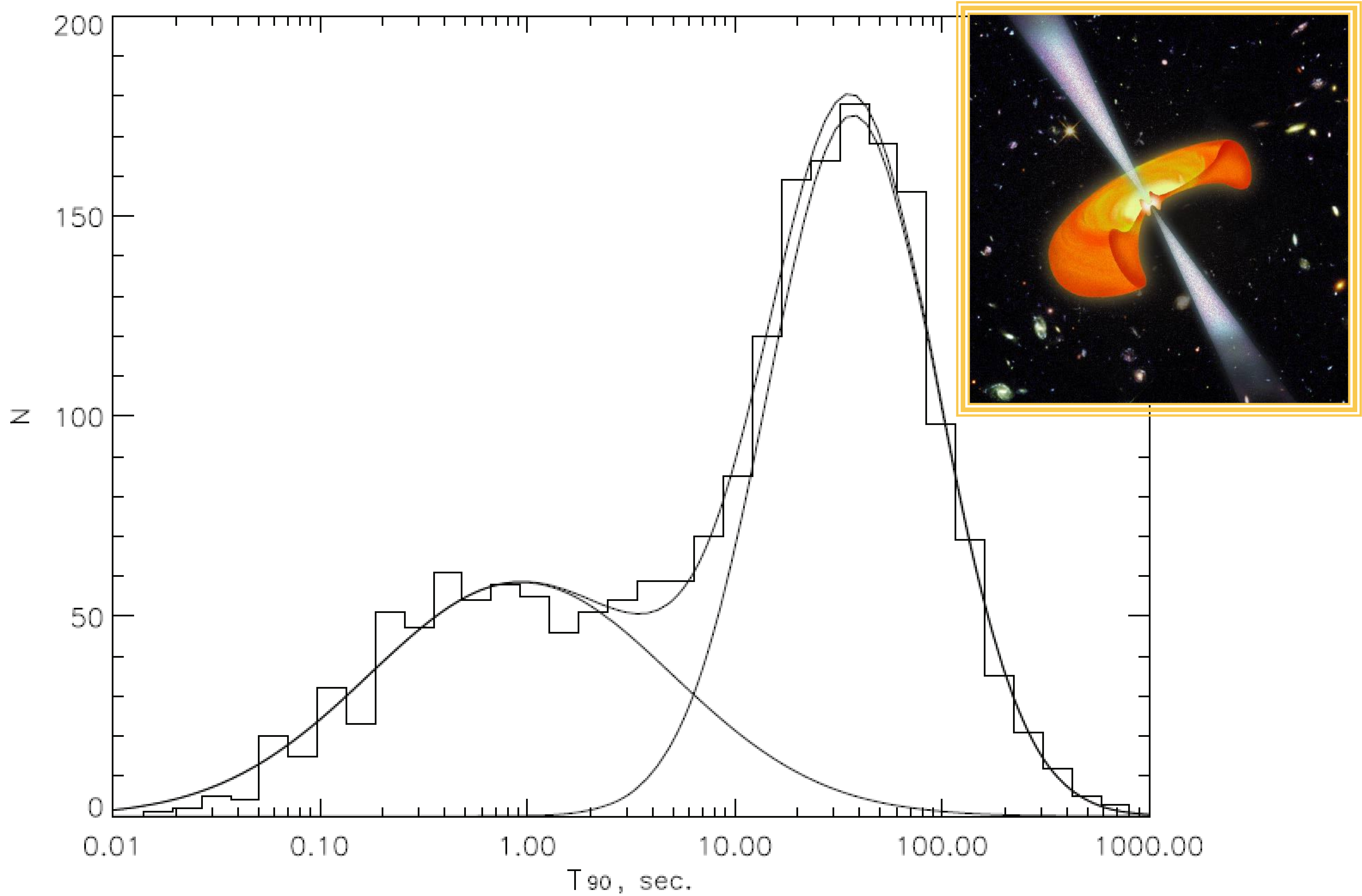
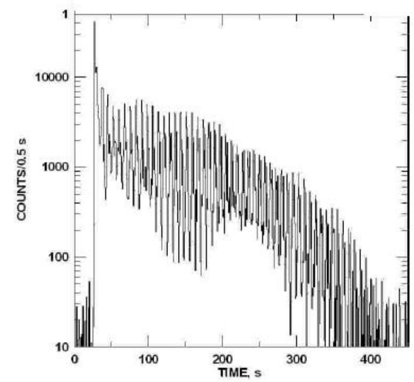
BATSE GRB T_90

(Duration of the prompt emission in gamma-rays)



Zoo of rapid celestial γ-ray transients

Tidal disruption



Long duration (classical) GRB

Soft Gamma-ray Repeaters, d=10-30 kpc

Больше, к сож. ничего сказать не можем,

Short GRB with EE

?

?

GRB, z< 9.4

Dark GRB

GRB Orphans

Short GRB, z~0.5

X?

?

?

SN Type Ib/c
Core collapsed

z < 15, POPIII ?

NS-NS/BH merging

(very short) Primordial BH
evaporation?

GRB

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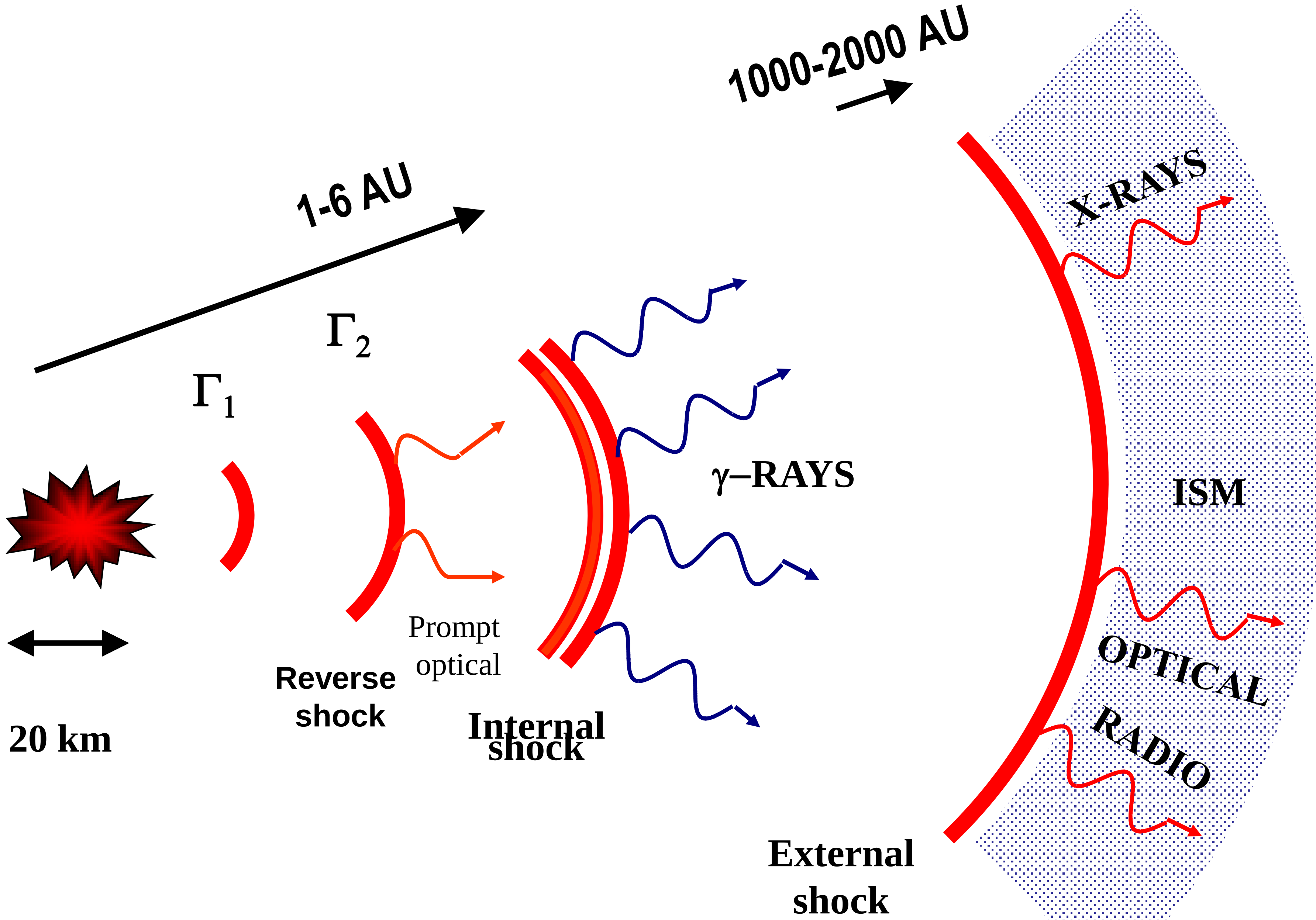
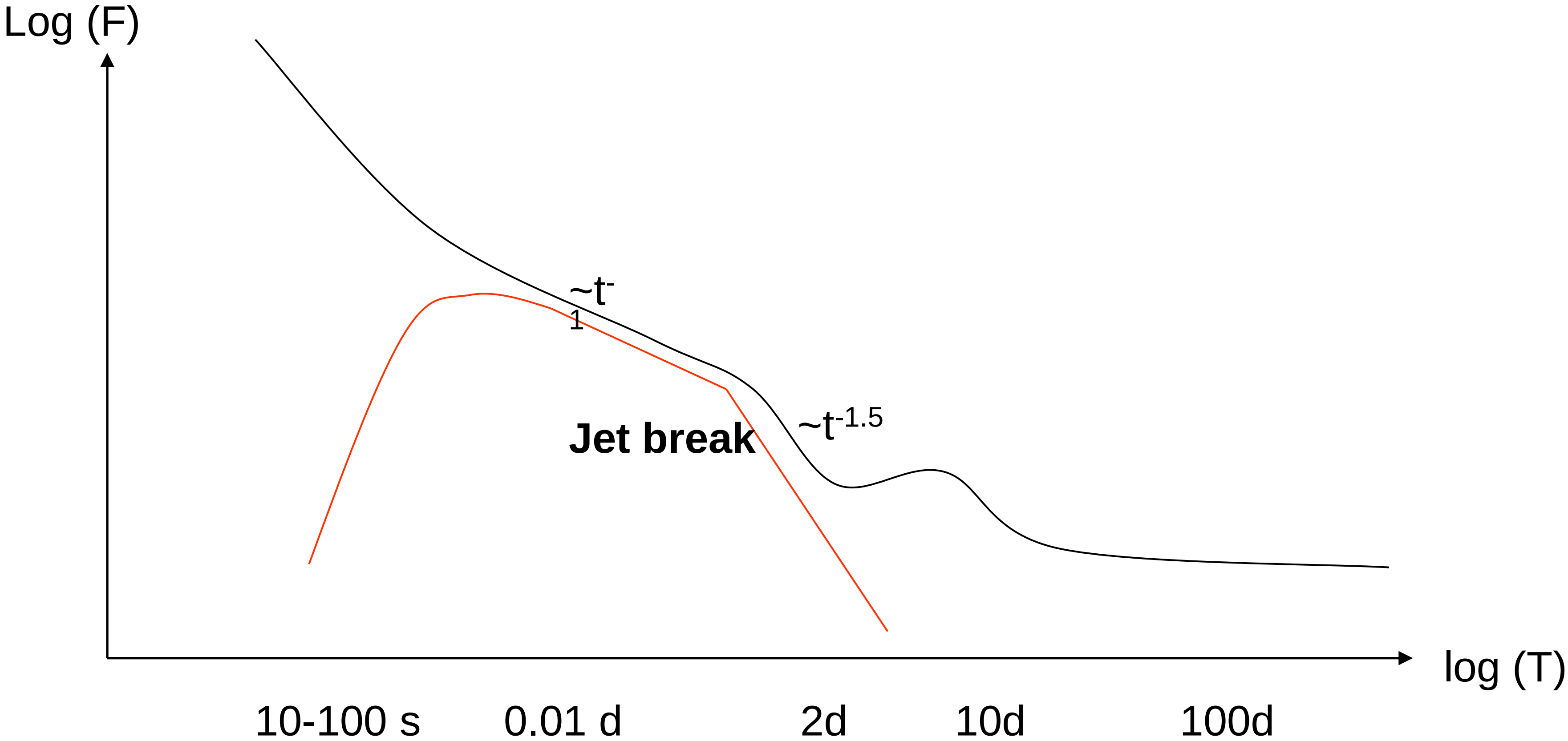
FIREBALL MODEL



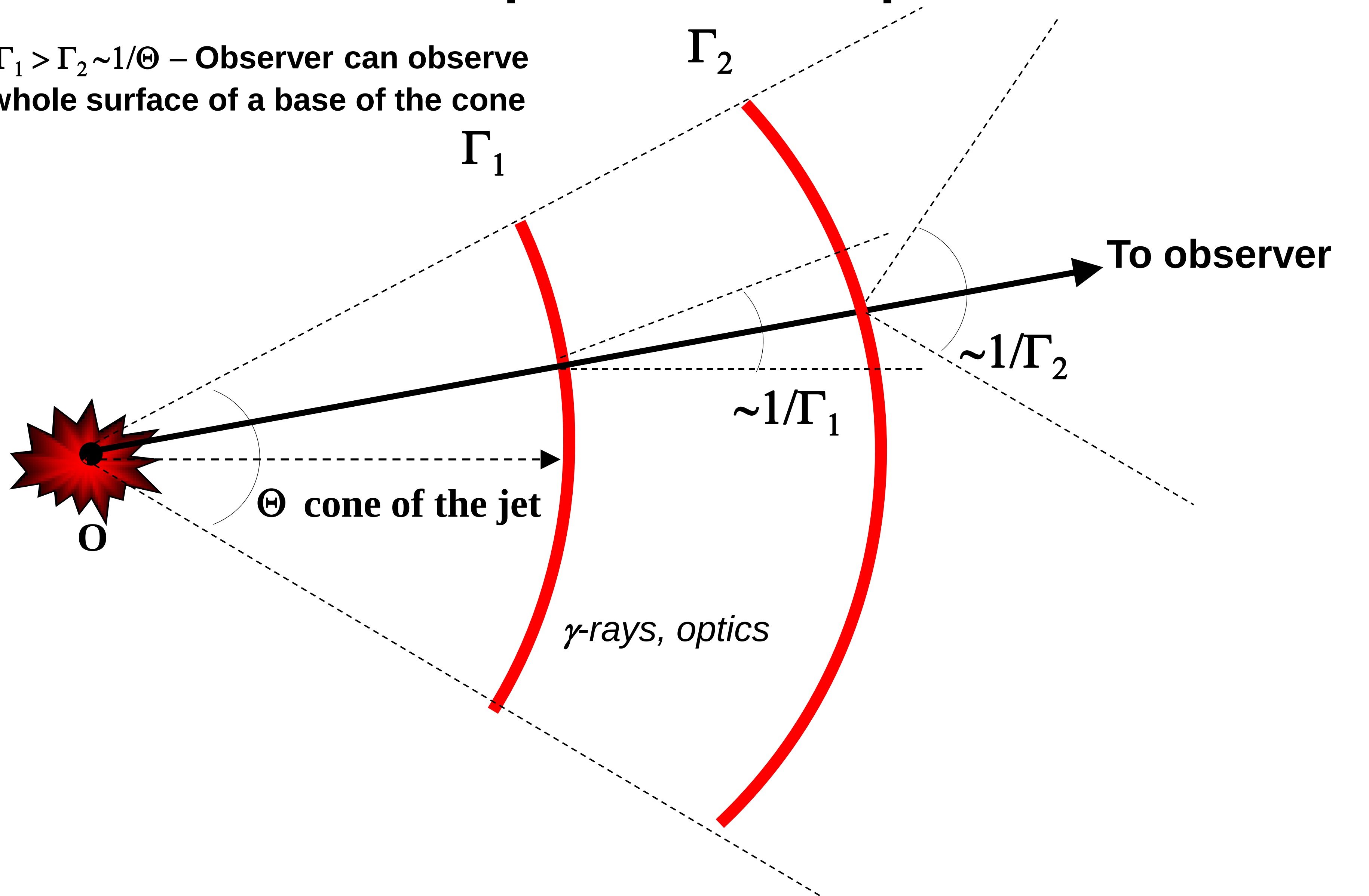
Afterglow: to be … (1)

“Standard” afterglow

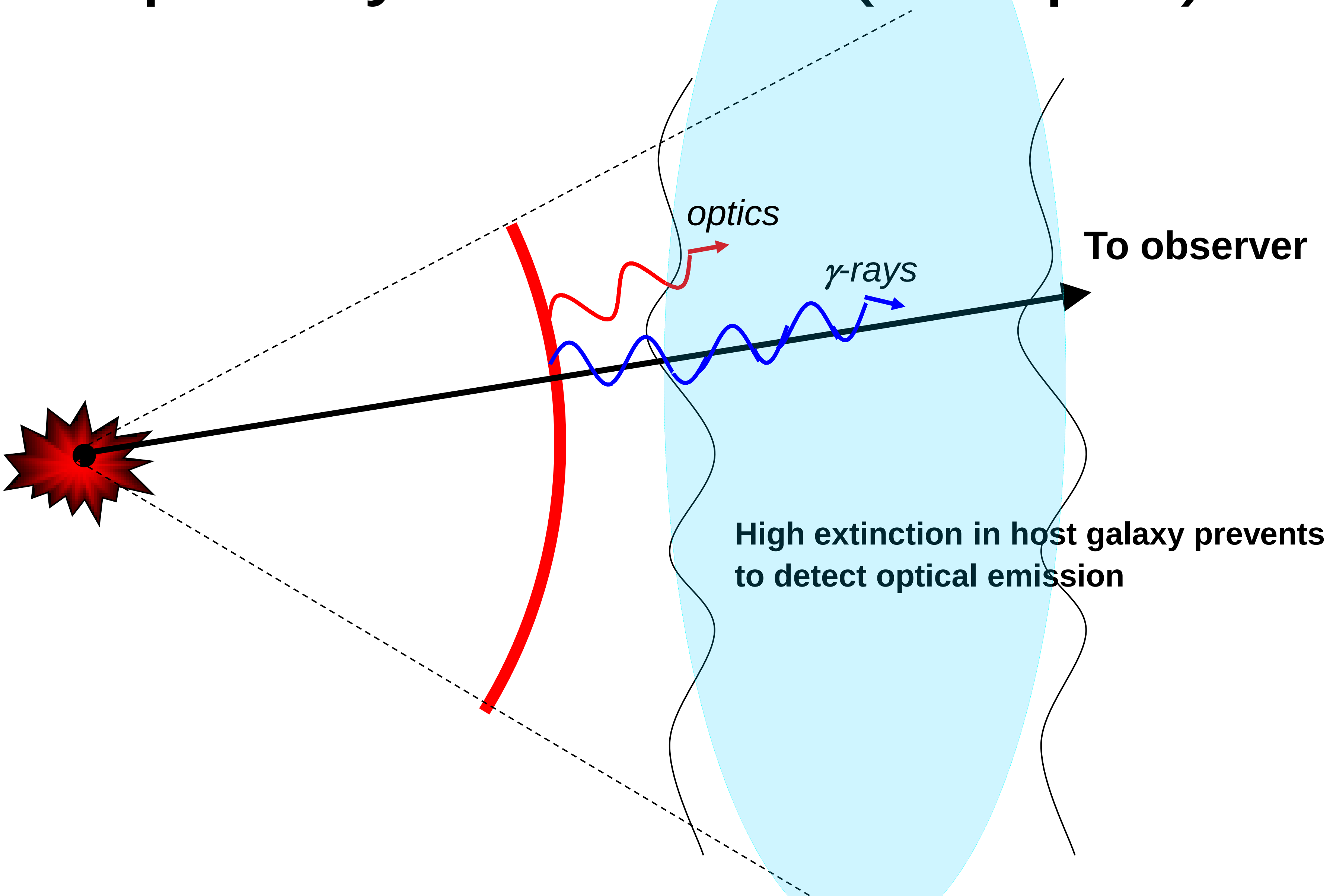


Jet break episode explanation

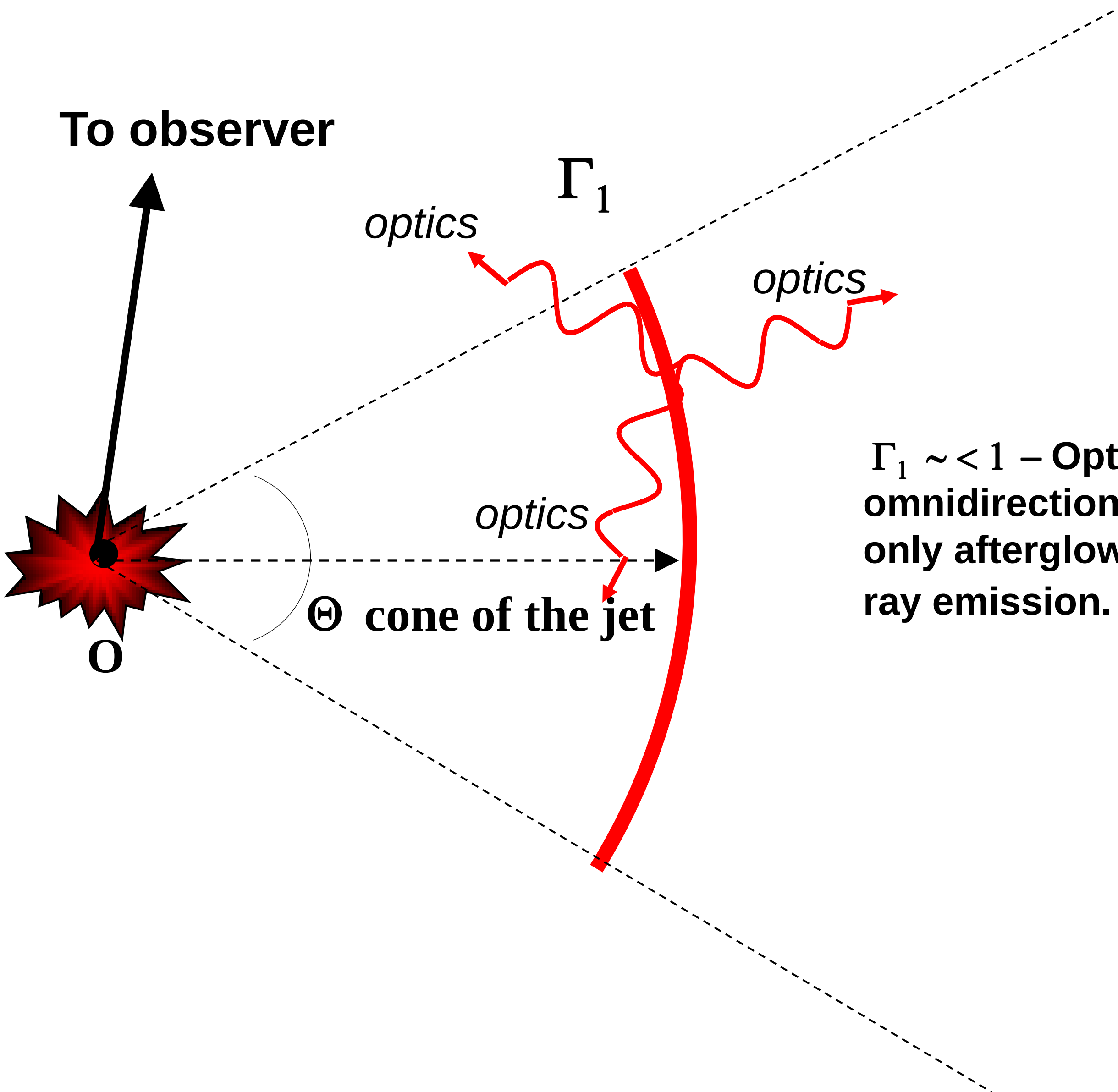
$\Gamma_1 > \Gamma_2 \sim 1/\Theta$ – **Observer can observe whole surface of a base of the cone**



Optically dark burst (no optic)

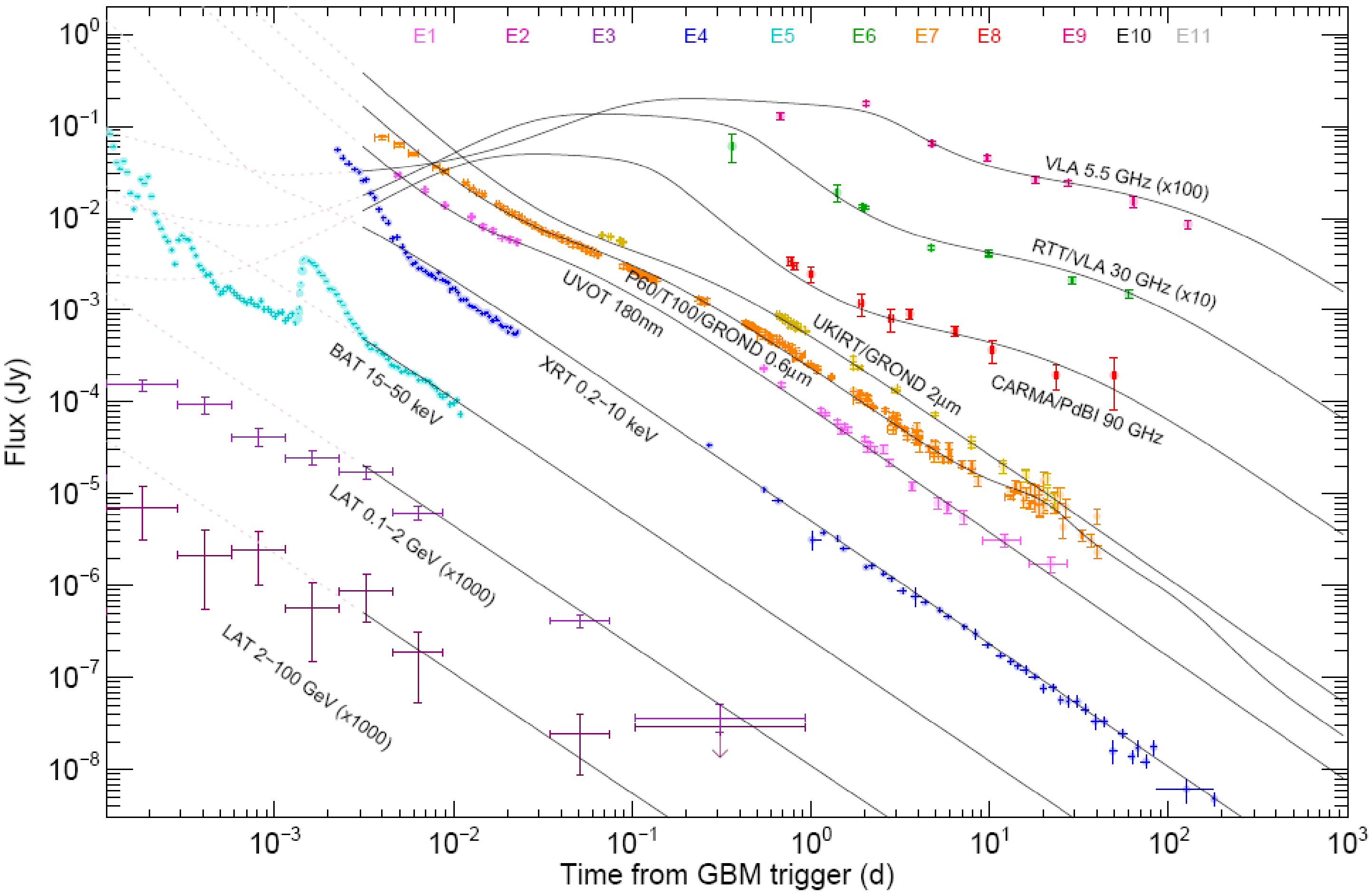


Orphan burst (no γ-ray emission)

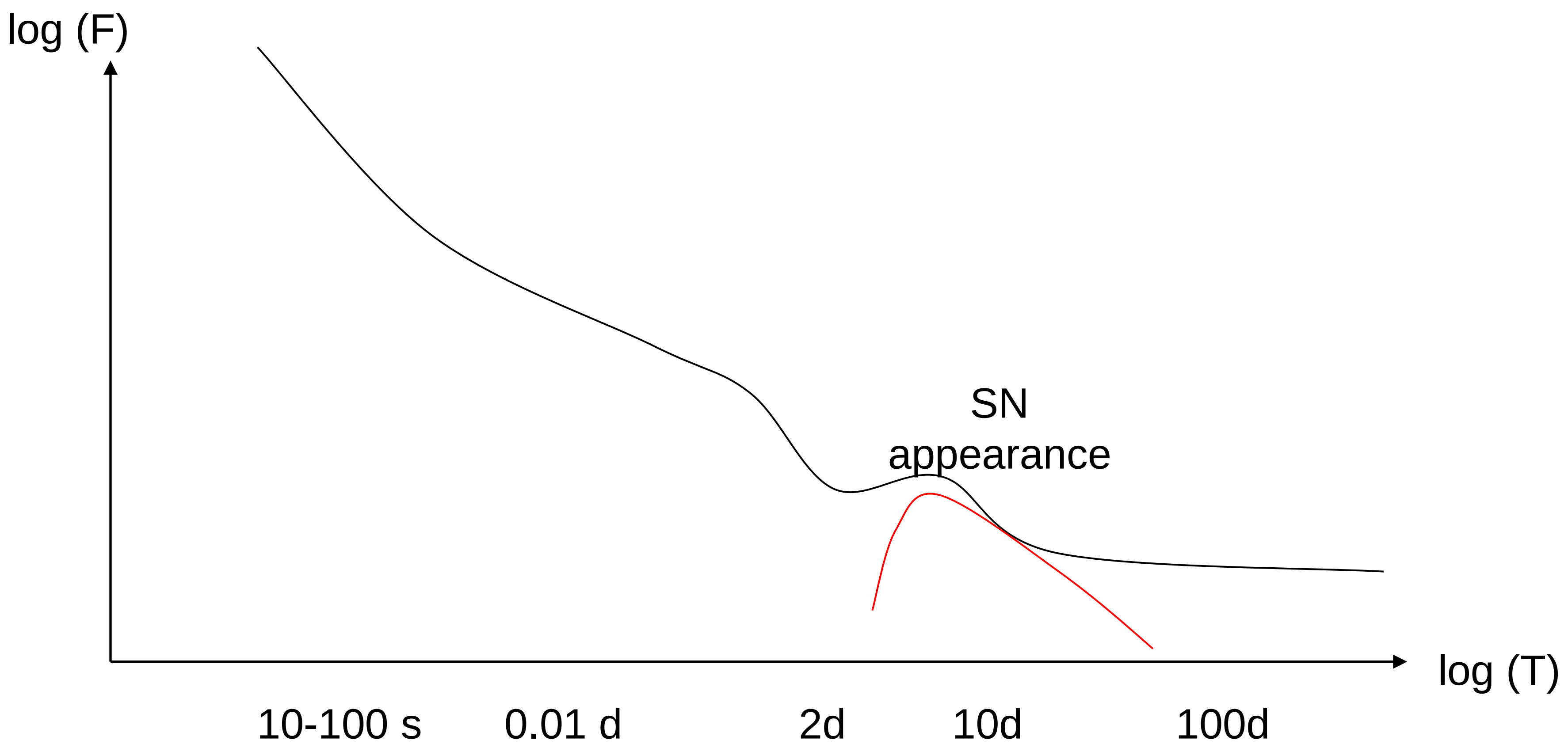


$\Gamma_1 \sim < 1$ – **Optical emission is nearly omnidirectional. Observer can observe only afterglow, not a collimated gamma-ray emission.**

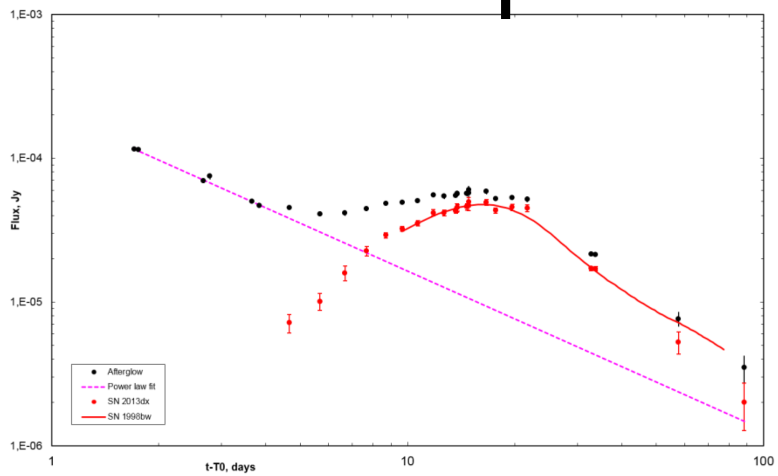
Afterglow (=*passive phase*) of GRB 130427A (Perley+ 2014) from radio to GeV



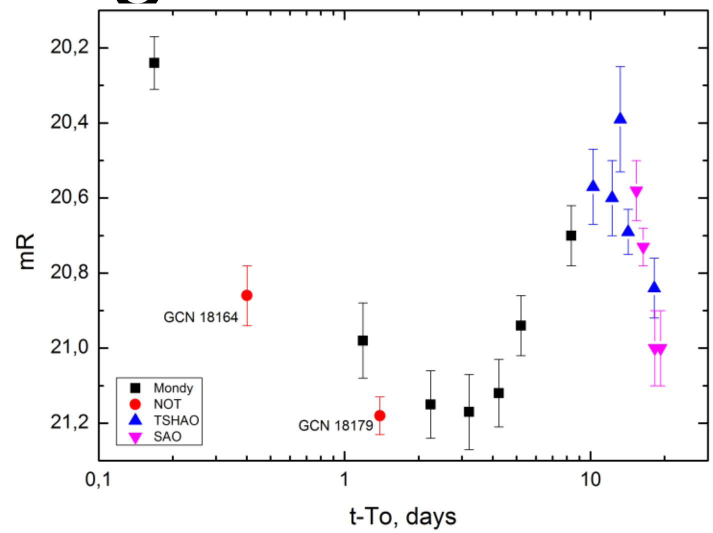
GRB/SN connections: bump in the light curve



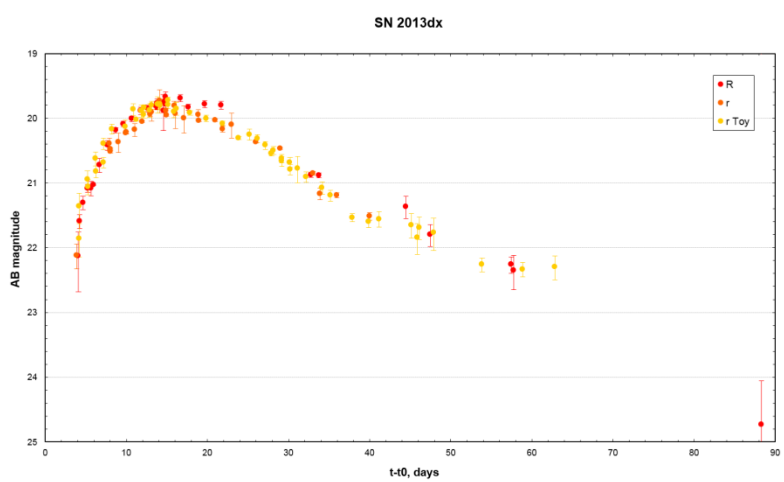
GRB/SN connections: bump in the light curve



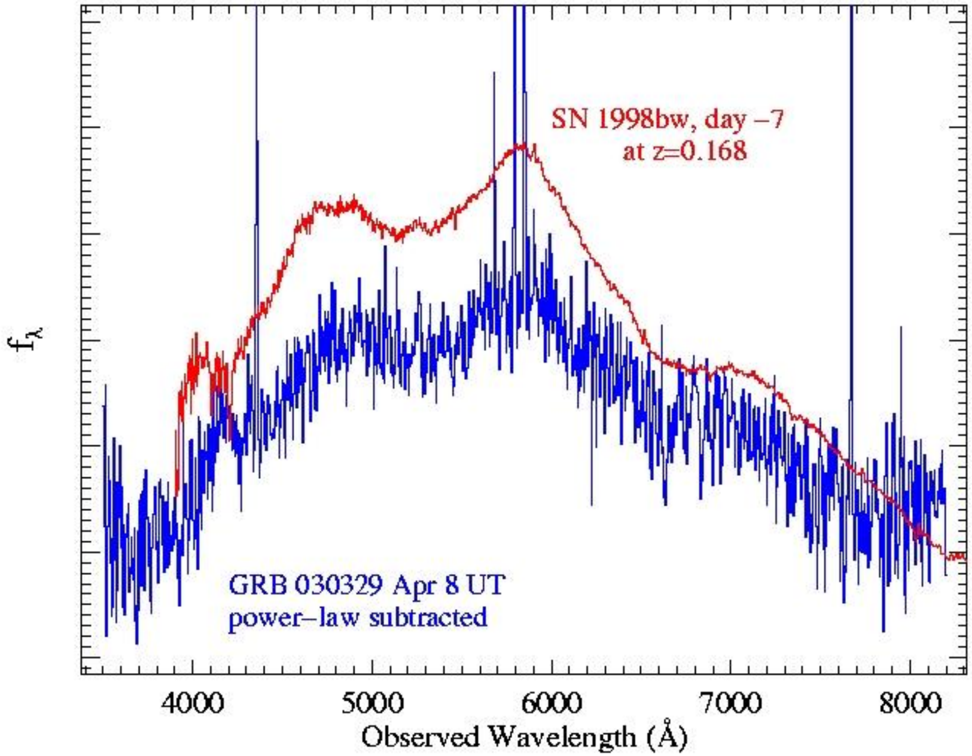
GRB 130702 / SN 2013dx



GRB 150818A / SN name?



GRB/SN connections: GRB 030329 spectroscopy similarity of SN spectrum



Observations in FSU

IKI/ISON follow up network is one of the two networks in Russia

raphy of GRB in FSU

Zeiss-2000

Ussuriisk, Far East (Russia)

43.69917° N, 132.16583° E, 200 m

Zeiss-400

Beta-Ori (D=22cm)

Mondy, East Siberia

51° 37' 18.10'' N, 100° 55' 07.65'' E, 2000 м

AZT-33IK *(D= 1.6 m)*

Mt. Terskol, North Caucasus

43.27631° N, 42.49939° E, 3126 m

Zeiss -2000 (2.0 m)

Tien Shan, Kazakhstan

43°03'29" N 76°58'17" E

Zeiss-1000 (1.0 m), TSHAO

AZT-20 (1.5 m), Assy-Turgen

CrAO, Crimea

44.72785° N, 34.01567° E, 595 m

Shajn (2.6 m)

AZT-11 (1.25 m)

ISON and IKI follow up network

Telescopes of the network

Site	Telescope	Aperture, m	~ Num. of clear night hours/year
Mil’kovo	ORI-22	0.22 (f/2.45)	n/a
Siding Spring	AstroPhysics V2	0.4 (f/2.4)	n/a
Ussuriysk	ORI-65	0.65 (f/2)	900
Blagoveshchensk	ORI-22	0.22 (f/2.45)	1600
Hureltogot	ORI-40	0.4 (f/2.3)	1400
Mondy	AZT-33IK	1.6 (f/18.75)	1570
Tian Shan	Zeiss-1000 East	1.0 (f/6.7)	n/a
Maidanak	AZT-22	1.5 (f/7.7)	2200
Kitab	ORI-40	0.4 (f/2.3)	1650
Abastumani	AS-32	0.7 (f/3)	1400
Kislovodsk	SANTEL-400A	0.4 (f/3)	1343
Terskol	Zeiss-2000	2.0 (f/3.15)	1200
Terskol	K-800	0.8 (f/2.9)	1200
Krasnodar	Astrosib RC-508	0.51 (f/6.3)	1200
Crimea	ZTSh	2.6 (f/3.8)	1400
New Mexico	Centurion-18	0.45 (f/2.8)	1800

Cooperation within BRICS initiatives?

What we can provide

- Follow up photometric observations of dedicated transient targets (TOO) with 1.0 - 2.6 m telescopes
- Secondary photometric standards in the FOV
- Data reduction and photometry
- Multicolor calibration of photometry of different observatories

What we would like cooperate

- Follow up photometric observations with available telescopes of GRB afterglow and transient targets (TOO)
- NIR photometry
- Spectroscopy observations of transients and host galaxies

Four “V”s of the GRBs

- **Volume**
- **Variety**
- **Veracity**
- **Velocity**

Volume I

- Before GW detection

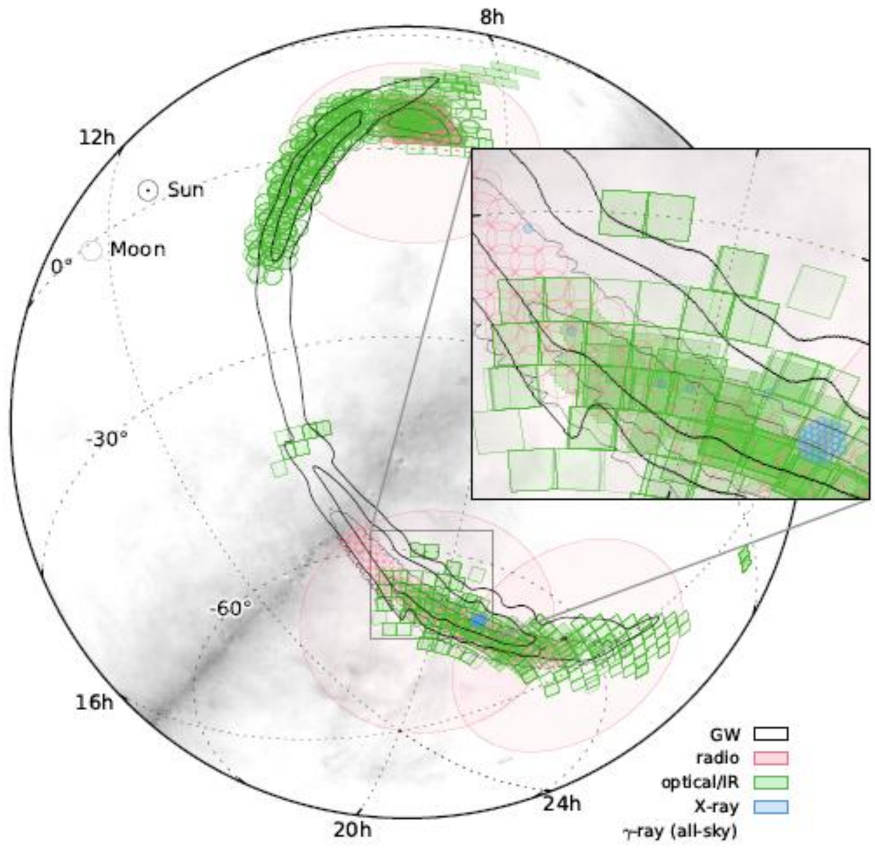
- Optical follow up GRB localization (3 arcmin, radius) and 3 – 30 days of observations ~ tens Gbytes

Volume II

- After GW detection

- Optical follow up GW localization (600 deg^2) and 3 – 30 days of observations ~ tens Tbytes

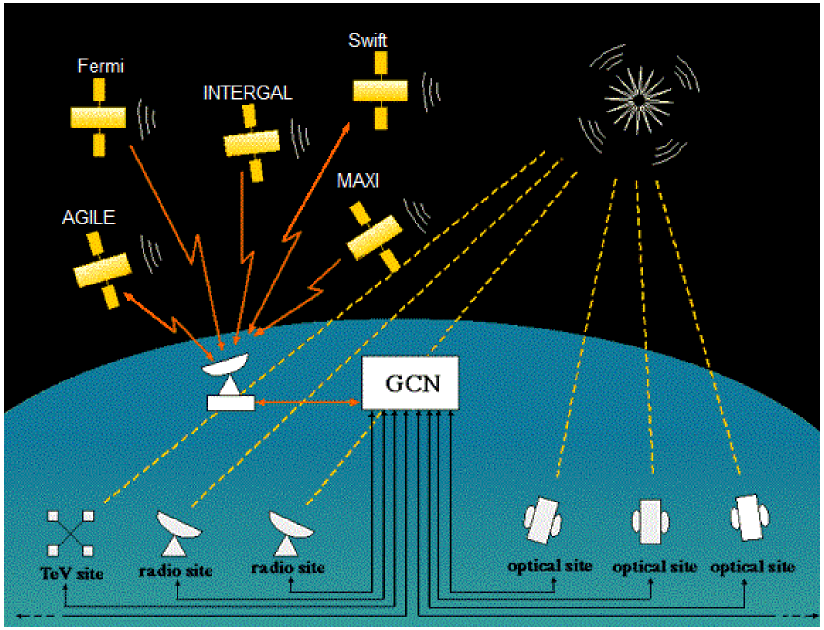
LIGO GW150914 localization and coverage (Abbott+, 2016)



Variety

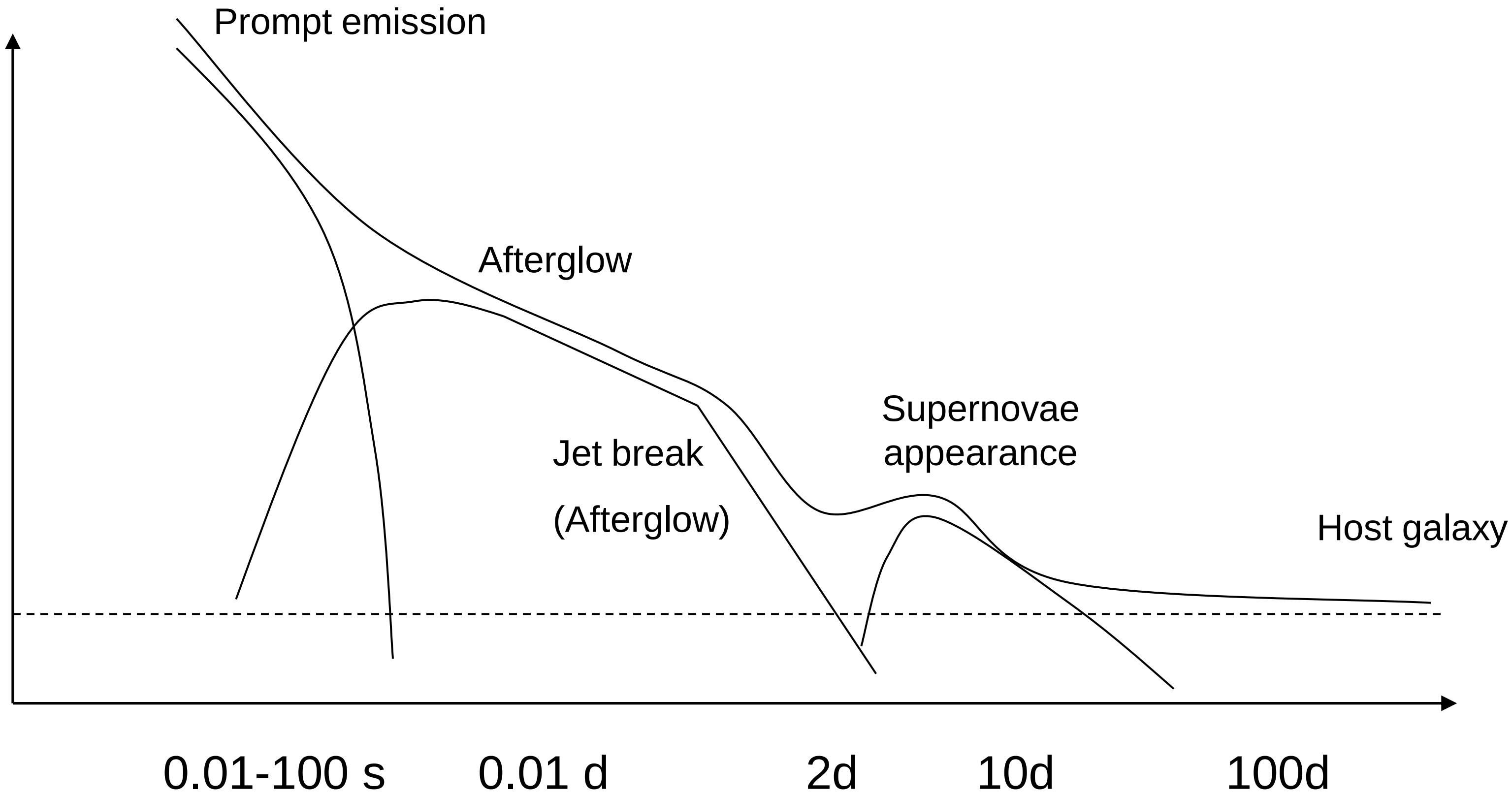
- Gamma-ray, X-ray, GeV, optic, radio, gravitational wave, neutrino
- Even optic data is not homogenous
- Not homogenous by nature: time series (gamma, X-ray, GW), time tagged events (GeV, neutrino), images (optic, x-ray, gamma) etc

Velocity I



Information about Gamma-Ray Burst is distributed in real-time worldwide via GCN. Short messages are received in several seconds after the event trigger and contain preliminary position of the event with an accuracy of 3’ – 10° . This allows to provide quick search and follow-up of GRB optical and radio counterparts with ground-based telescopes.

Velocity II



Prompt emission
Afterglow
Jet break
(Afterglow)
Supernovae
appearance
Host galaxy
0.01-100 s
0.01 d
2d
10d
100d

Velocity III

(near) Real time large volume data should be analyzed

Veracity

- Cross identification of sources (gamma, radio, optic, GW)
- Cross calibration
- SN, host - observations

Thank you

Questions are welcome!