Ioffe Workshop on GRBs and other transient sources: 25 Years of Konus-Wind Experiment
September 9–13, 2019, St. Petersburg, Russia

Central Engine from Early Multimessanger GRB observations

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GRB Energy

$E \sim 10^{51\text{-}53}$ erg

This energy is typical for collapse

$E \sim 0.1\ Mc^2$, $M \sim 1\text{-}100\ M_{solar}$

Firstly pointed out by Blinnikov et al., 1984; Pachinsky, 1986 (!), Astrophys. J. 308, L43-L46

SPECTRUM

- E_{peak} ~ 1 Mev
- Typical energy for relativistic collapse
- $E \sim m_e C^2$

DURATION

$$\Delta t_{obs} \sim 0.1-100s$$

Typical collapse time scale:

$$\Delta t \sim \frac{R_g}{c} \sim 10^{-5}s << \Delta t_{obs}$$

The MAIN Paradox

2 SOLUTIONs

1. **Back fall rotating envelope**
   Woosly et cetera

$$V_{env} = HR < (\frac{2GM}{R})^{\frac{1}{2}}$$

$$\Delta t \sim R^2/2D$$ *diffusion massive disk accretion*

2. **Magneto-rotational collapse(Spinar paradigma)**

$$\Delta t \sim I_{core}\Omega / K$$

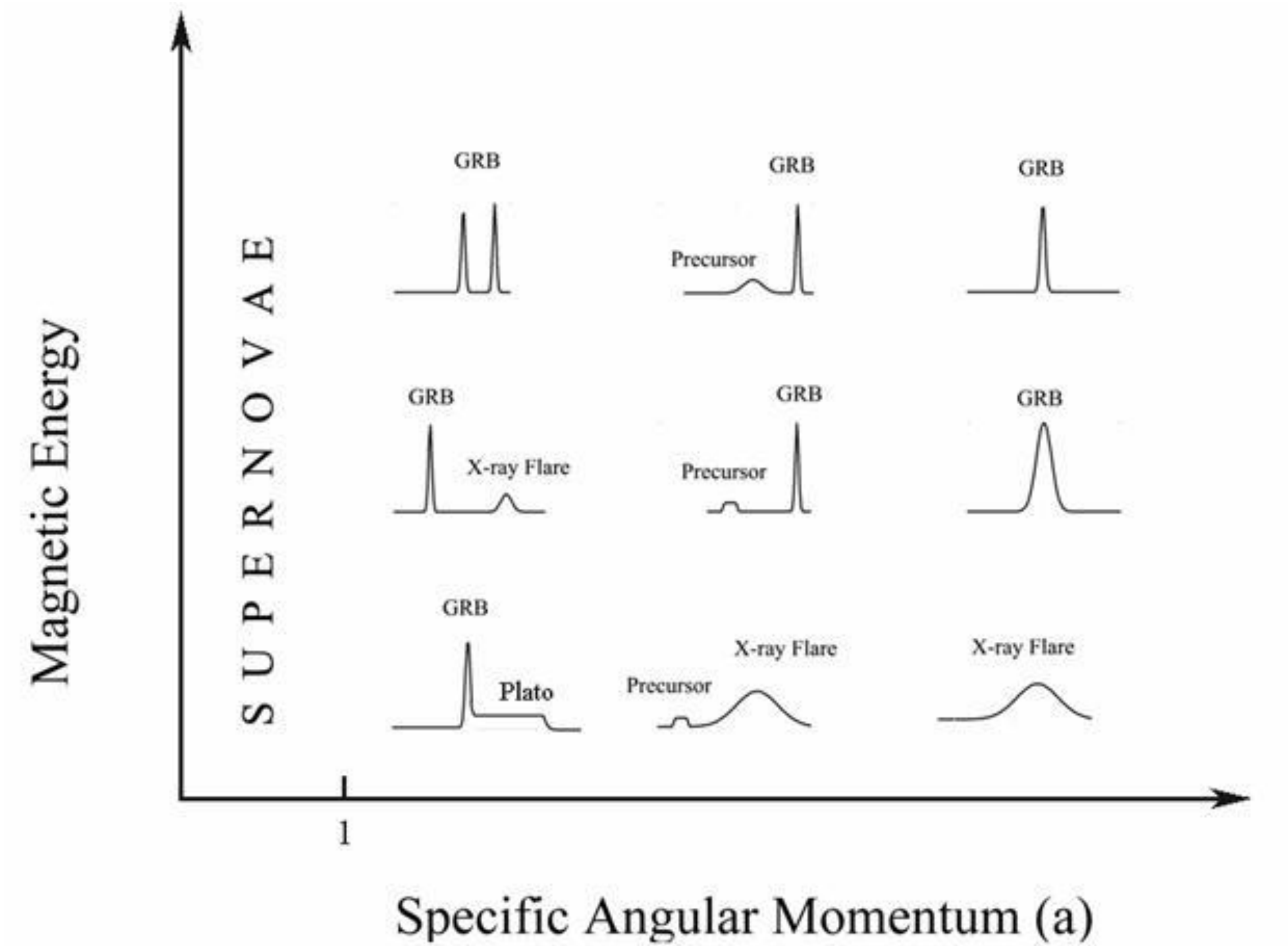
Where K – dissipation force moment

Of the Viscosity + Magnetic Field

- Usual Collapse   -   Super Novae
- Magneto-Rotational Collapse – GRB
- Rate (SN) / Rate (GRB) ~ 100

SN & GRB in Spinar Paradigma

Lipunov & Gorbovskoy, 2007,ApJ, 665, . L97



After 17 Aug 2017

Short GRB

NS+NS merging

And NS+BH …

Long GRB

core collapse rotating massive star

IS THERE THE NEW PHYSICS IN GRB?

- Kardashev limit

$$\frac{B^2}{8\pi R^3} = Mc^2, R = R_g = \frac{2GM}{c^2}$$

- $$Max.Energy = eER \sim eBR \sim (1/137)^{1/2} E_{pl}$$

$10^{27} eV$

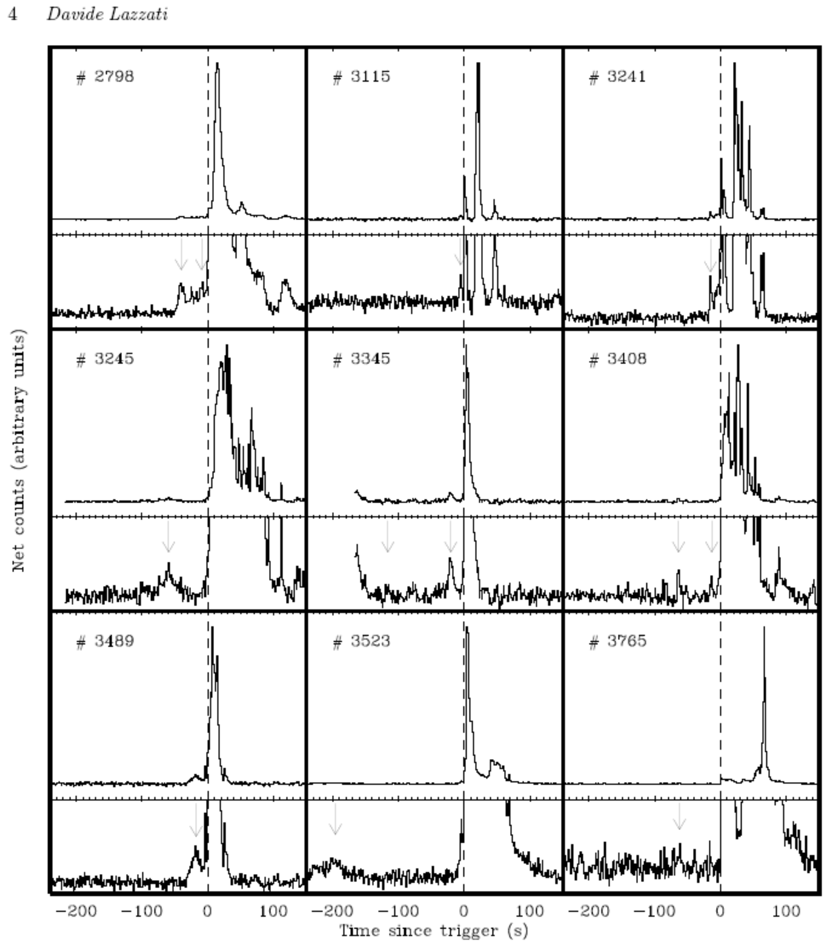
Prolongated GRB activity fetures

1. early Precursors (up to 200сек)

2. follow-up X-ray Flares (up to 10000s)

Precursors

Lazzati, D. Precursor activity in bright, long BATSE gamma-ray bursts. *MNRAS* **357**, 722-731 (2005).



Spinar history

The Importance of the magnetic rotational effect was pointed firstly with connecting to energetic and evolution of the quasars *(Hoyle & Fauler, 1963; Kardashev, 1964; Ozernoy, 1966; Morison, 1969; Ozernoy & Usov,1973*)

SN explosion (*Bisnovatiy-Kogan; 1971, LeBlance & Wilson 1970*).

The formation of the quasi eqvilibrium object was noted - Spinar. *(Lipunov (1983) proposed of the idea Spinar with stellar mass)*.

Spin-up and spin-down was considered by in the frame the magnetorotator *(Lipunov, 1987)* .

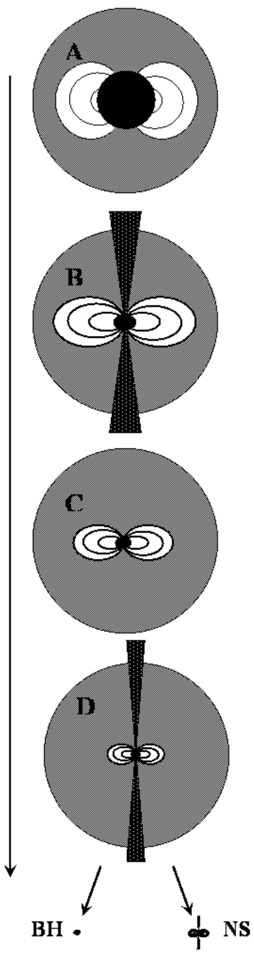
The relativistic Spinar was considered by, where was a first model GRB as the Spinar *(Lipunova G.V. , 1997)*.

Prolongated GRB activity was predicted

- Lipunova, G.V. **A burst of electromagnetic radiation from a collapsing magnetized star.** *Astronomy Letters* 23, 84-92 (1997).
- Lipunova, G.V. & Lipunov, V.M. **Formation of a gravitationally bound object after binary neutron star merging and GRB phenomena**. *Astron. Astrophys.* 329, L29-L32 (1998).

Spinar Paradigma

(Lipunov & Gorbovskoy, 2007, ApJLetters, v.665, 97L)



$$a_0 \equiv \frac{I\omega_0 c}{GM^2_{core}} \qquad \alpha_m \equiv \frac{U_m}{GM^2_{core}/R_A}$$

$$E_B \approx GM^2/2R_{spinar} = (1/2a_0^2)M_{core}c^2$$

$$\omega R_B^2 = GM^2_{core}/R_B$$

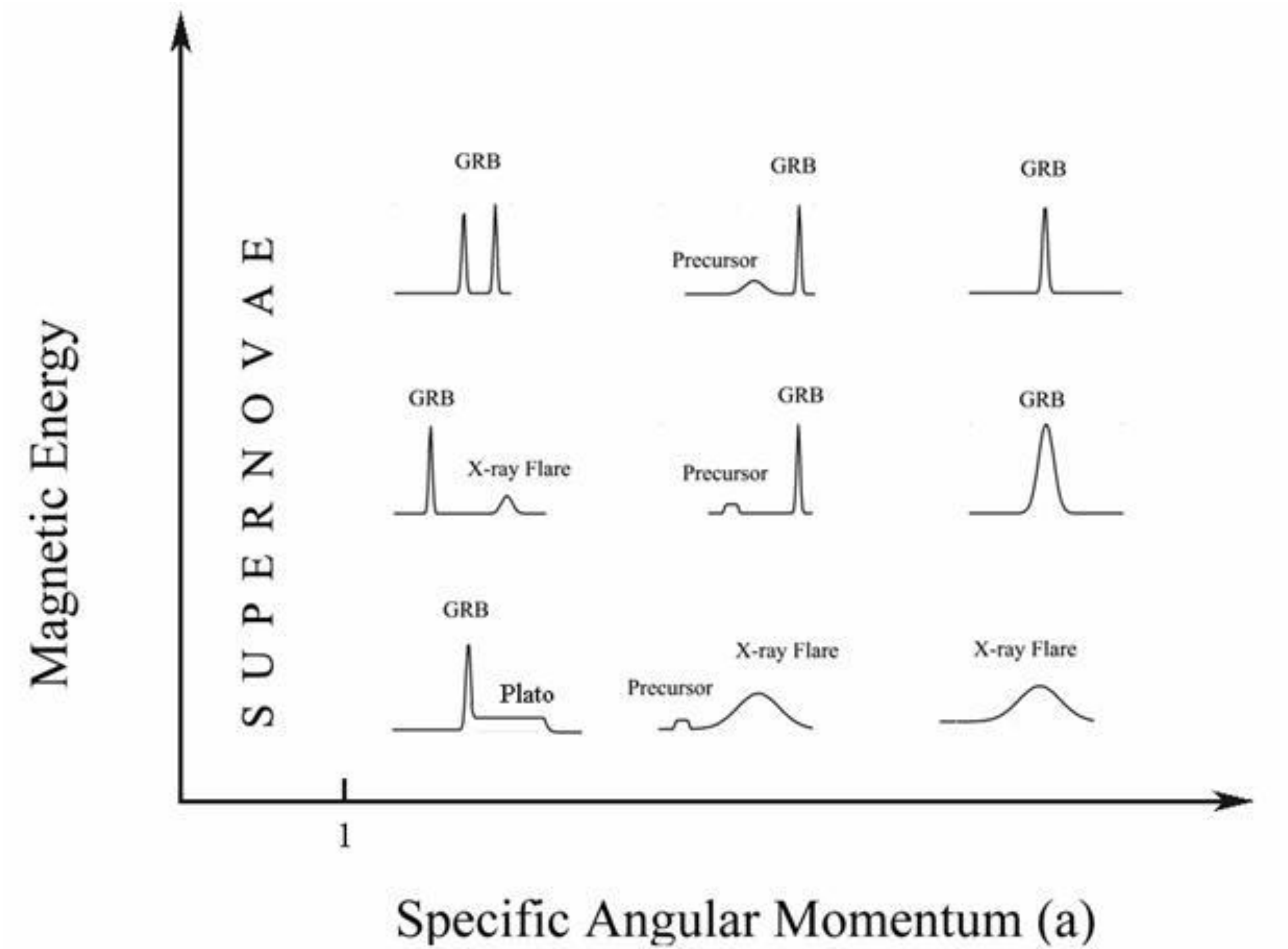
$$dI\omega/dt = -U_m$$

$$L = -\omega dI\omega/dt = U_m\omega \propto R^{-5/2}$$

$$L = \frac{\alpha_m}{a_0^5}\frac{c^5}{G}(1 - t/t_C)^{-3/5}$$

SN & GRB in Spinar Paradigma

Lipunov & Gorbovskoy, 2007, ApJLetters, v.665, 97L



Nonstationary Relativistic Pseudo-Newtonian Spinar Model

(Lipunov & Gorbovskoy, 2008, MNRAS , V383 p1397)

$$\frac{d^2R}{dt^2} = F_{gr} + F_c + F_{nuclear} + F_{diss}$$

$$F_{gr} = -\frac{GM}{x^3}\frac{(x^2-2ax+a^2)^2}{(\sqrt{x}(x-2)+a)^2} \qquad x = 2R/R_g$$

Mukhopadhyay, 2002

χ

$$F_{nuclear} = \frac{1}{\rho}\frac{dP}{dr} = \frac{P}{\rho R}$$

$$P = \rho(\sqrt{c^4 + b\rho^{2/3} + (Q/M)^2} - c^2) \qquad b = \left(\frac{4\pi}{3}\right)^{2/3} G^2 M_{Class}{}^{4/3}$$

$$F_{diss} = -\frac{1}{\tau}\frac{dR}{dt} \qquad \tau = 2\pi\chi/\omega$$

χ =0.04.

$$K = \int_{R_{\min}}^{\infty} \frac{B_z B_\varphi dS}{4\pi} = \frac{1}{2}\int_{R_{\min}}^{\infty} B_z B_\varphi R dR \qquad K = \kappa_t \frac{\mu^2}{R_t^3} \qquad R = Rc = \left(GM/\omega^2\right)^{1/3}$$

see Lipunov, 1987

$$\frac{dI\omega}{dt} = -\frac{\mu^2}{R_c^3} = -\frac{\kappa_t \mu^2}{GM\omega^2}$$

Magnetic Field Evolution and Central Engine Power

$$\mu \sim BR^3 \sim BR^2 R \sim R$$

$$\mu = \mu_0 \frac{R - R_{\min}/2}{R_0 - R_{\min}/2}$$

$$\mu \sim \mu_0 \left(\frac{R_0}{R}\right)^2 \frac{\xi(x_0)}{\xi(x)}$$

$$\xi(x) = \frac{1}{x} + \frac{1}{2x^2} + \ln(1 - 1/x)$$

Ginsburg & Ozernoy (1963):

$$L_0 = \frac{1}{\tau} kM \frac{dR}{dt}$$

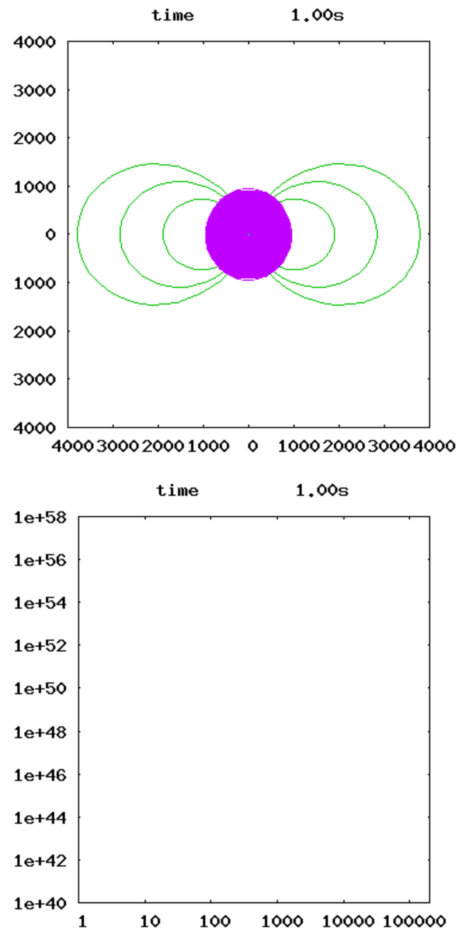
$$L_0 = \frac{\mu^2}{R_{\min}^3}\omega$$

$$L_\infty = \alpha^2 L_0$$

$$\alpha = \sqrt{\frac{x^2 + a^2 - 2x}{x^2 + a^2}}$$

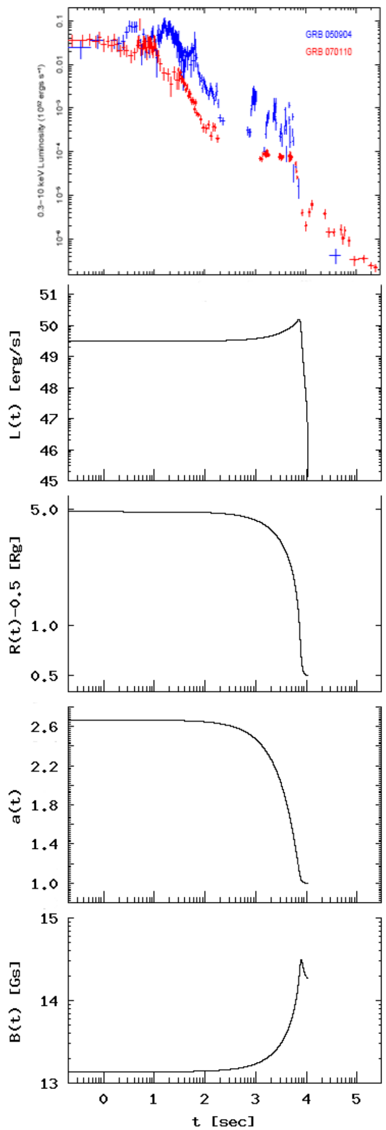
Thorne et al., 1986

Spinar Collapse Video



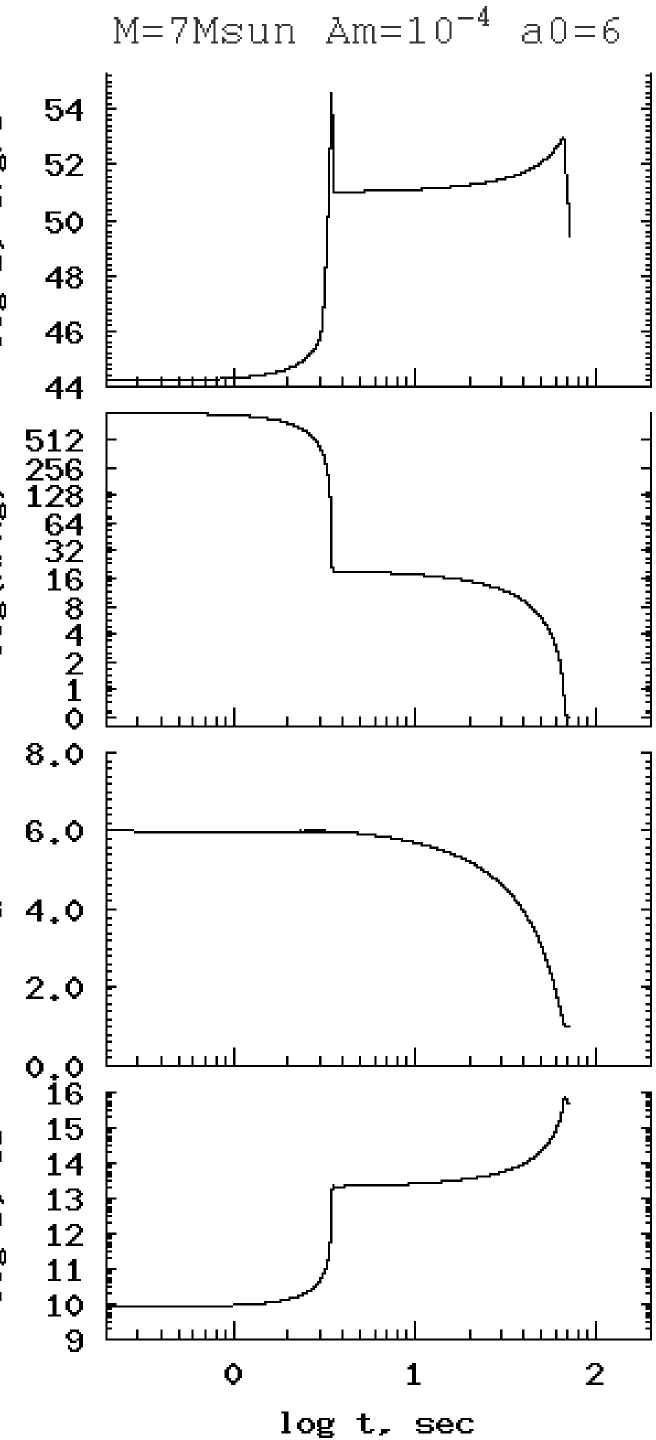
Vladimir Lipunov, Central Engine from Early Multimessanger GRB observations, KW25

Extralong X-ray Plato



*Lipunov & Gorbovskoy, 2007, ApJLetters, **665**, 97L*

Among several hundred gamma-ray bursts, two GRB070110 and GRB050904 do not fit into the usual picture of the formation of X-Ray afterglow. Both bursts revealed an extensive plateau lasting up to 6000-7000 seconds in their own frame of reference. Troja et al. (2007) suggested that such a long manifestation of activity was associated with the features of the central engine and specifically with the formation of a neutron star after the collapse of a small mass nucleus (less than the Oppenheimer-Volkov limit).

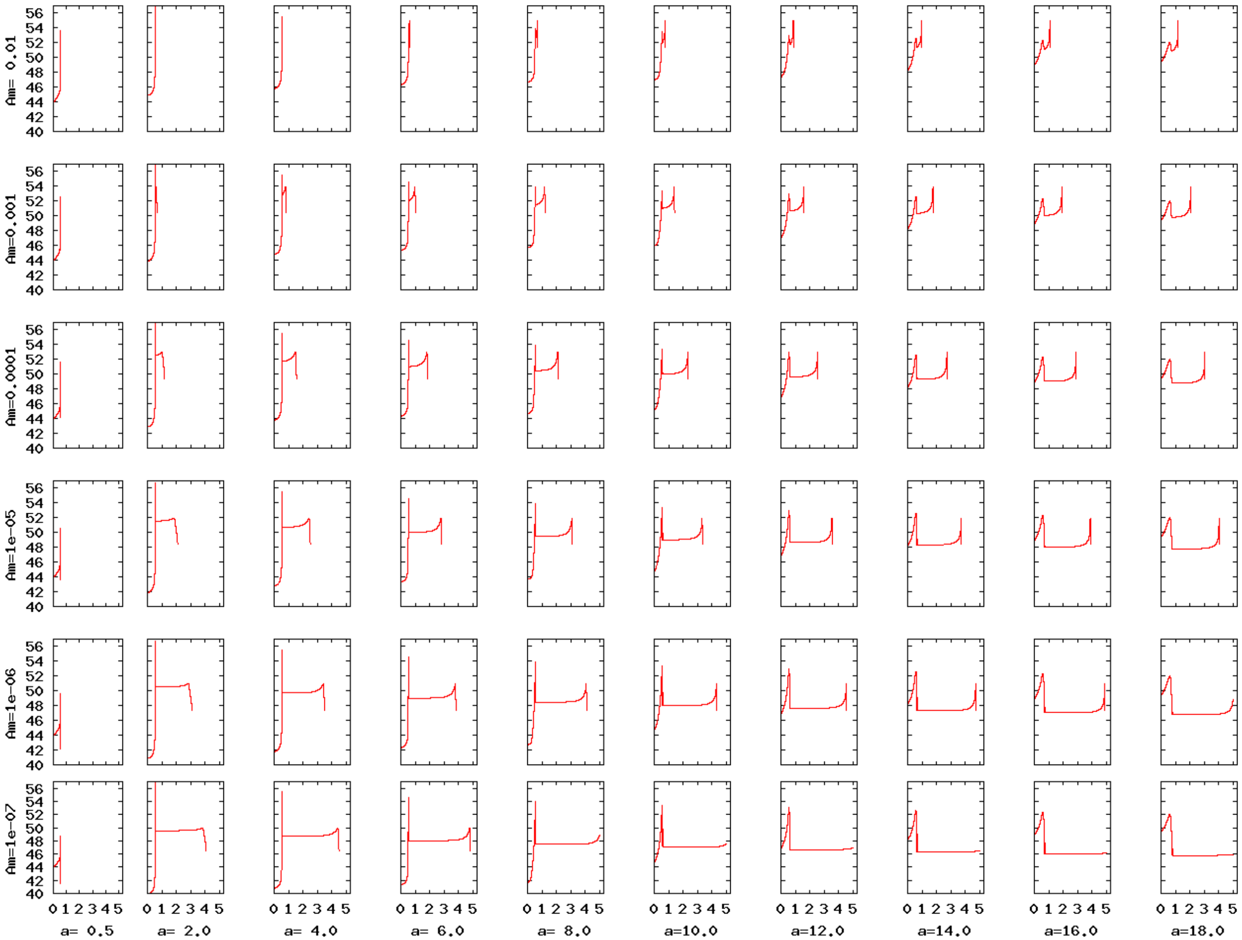


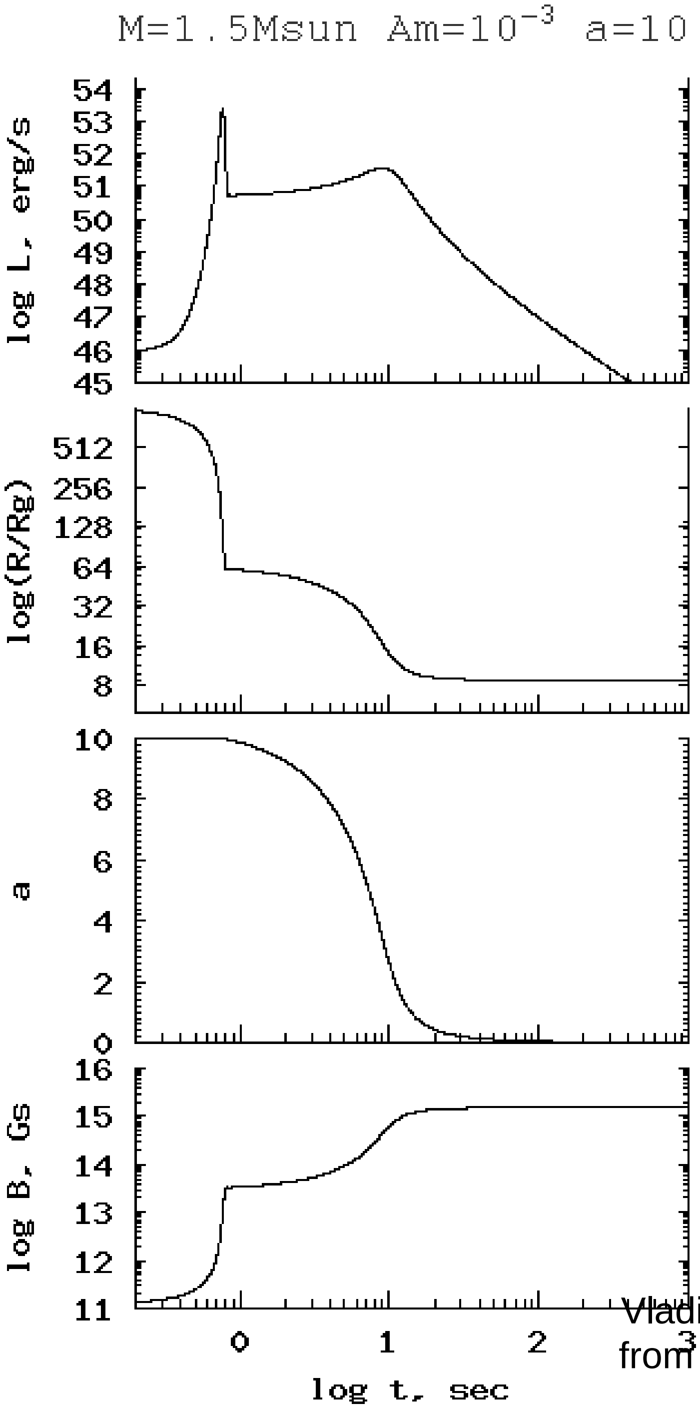
Massive Core Collapse (M > MOV).

7 Solar Mass Core Collapse

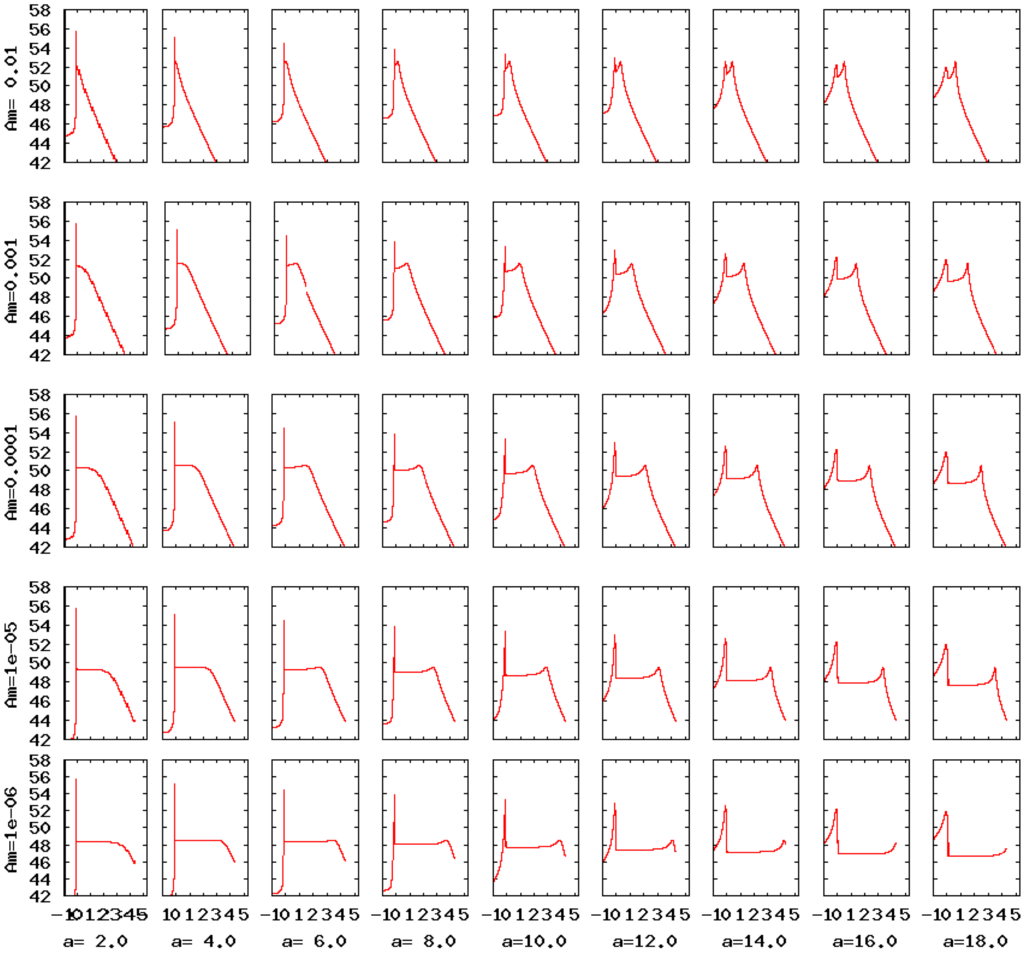
Up to down: energy release, Spinar radius, Kerr parameter and Magnetic Field for far observer frame

7 Solar Mass Core Collapse Luminosity for different Kerr parametyers





Low mass collapse $M<M_{OV}$



Low Mass Core Collapse .

(Neitron Stars Formated)

Vladimir Lipunov, Central Engine from Early Multimessanger GRB observations. KW25

5 UNSOLVED OBSERVATIONAL GRB PROBLEMS

I. **The discovery of the most distant objects in the Universe.** **+-**

II. **Prompt optical Short GRB emission detection.** **-**

III. **Optical emission Precursor detection.** **-**

IV. **Polarization measurement of the prompt optical, X-ray and Gamma GRB emission.** **+**

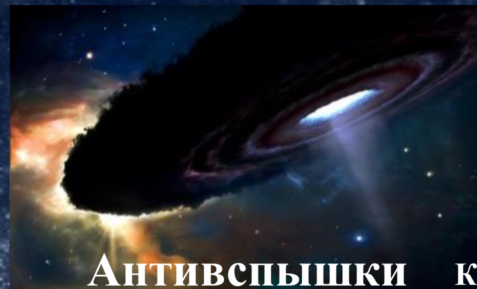
V. **High time resolution observations of the prompt optical/UV/IR emission.** **-+**

Global MASTER Robotic Net

Vladimir Lipunov, Central Engine from Early Multimessanger GRB observations, KW25, St.Petersburg, Russia, 12 sep 2019

MASTER Net Dteceted 10 types of the OTs from NEO to redshift z ~ 5.

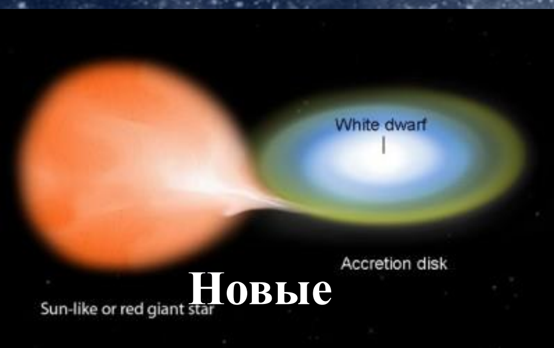
Сверхновые



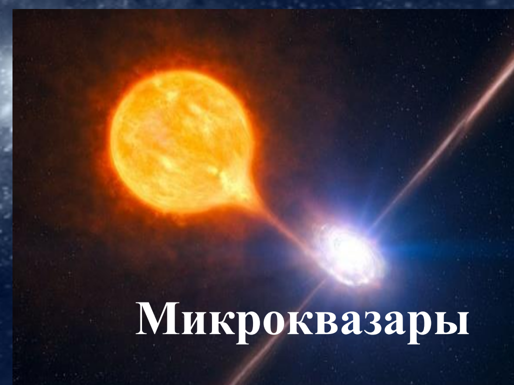
Антивспышки

Короткие гамма-всплески

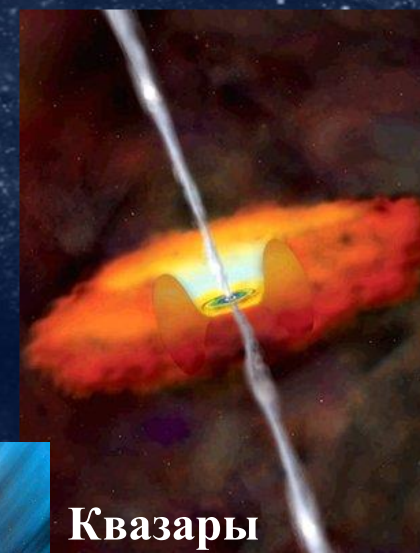
Длинные гамма-всплески



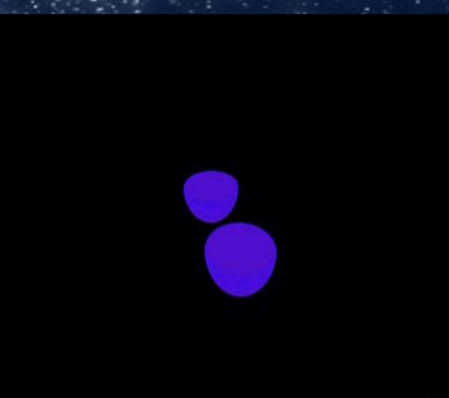
Новые



Микроквазары



Квазары



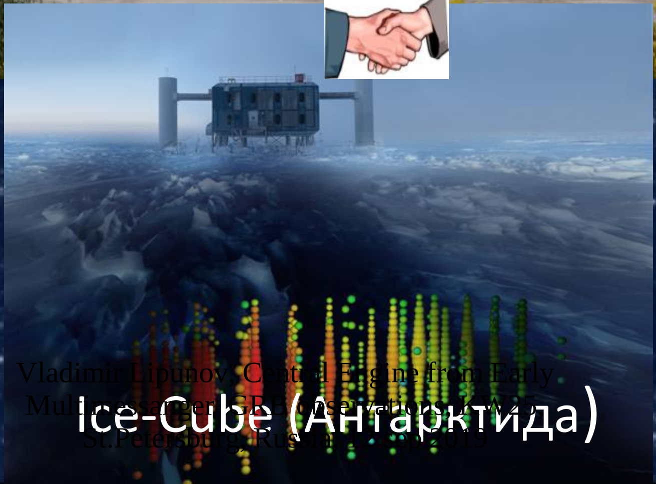
Красные Новые

Кометы

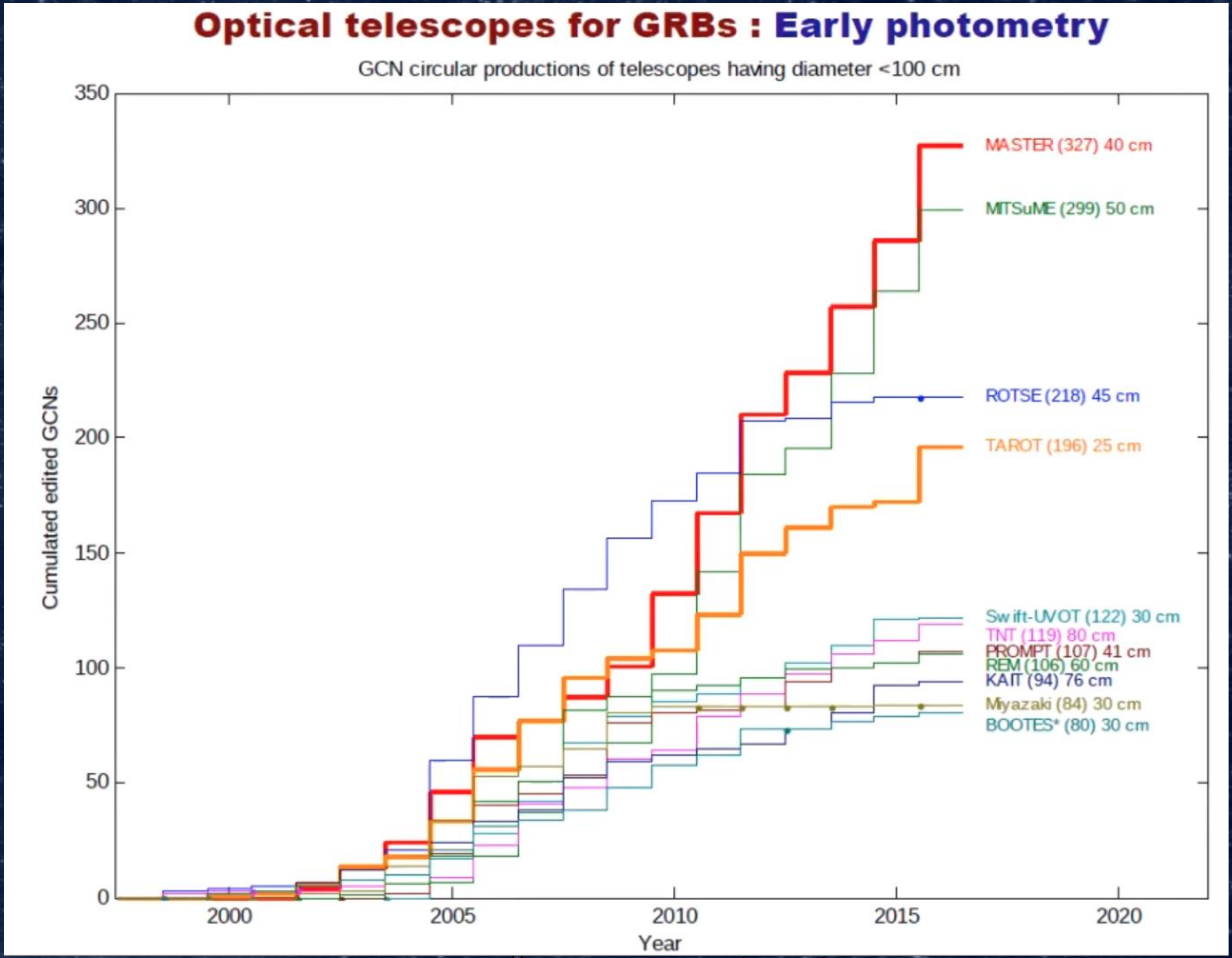
Опасные астероиды


Свифт
Интеграл
Ферми
Большой южноафриканский телескоп, Южная Африка 10 м
Большой Канарский Телескоп, 10.4 м
MASTER
ESO, 3.6 м
Телескоп В. Гершеля, Испания 4.2 м
Телескоп Хобби-Эберли, США 9.2 м
БТА, Россия 6 м
ММТ Обсерватория, США 6.5 м

MASTER and Huge Physical Experiment

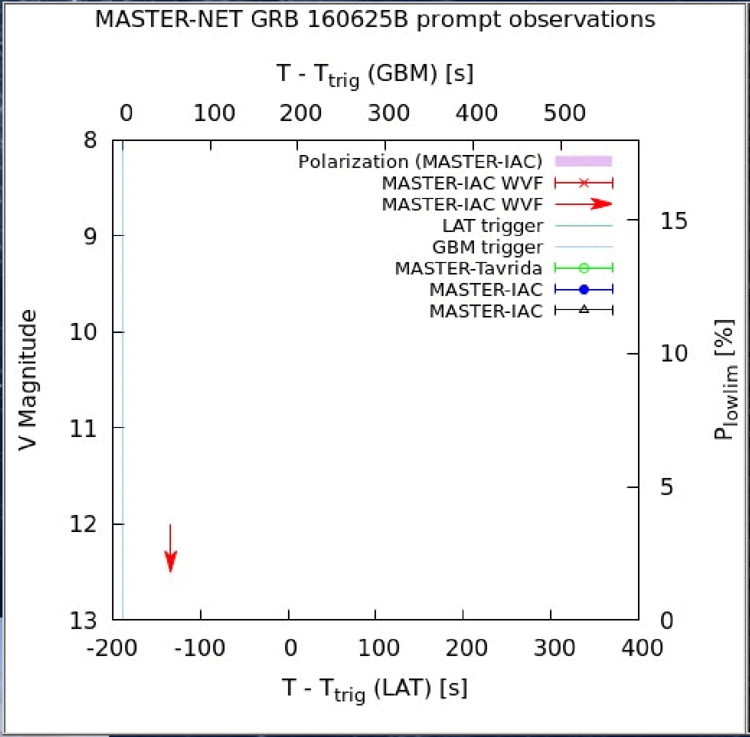


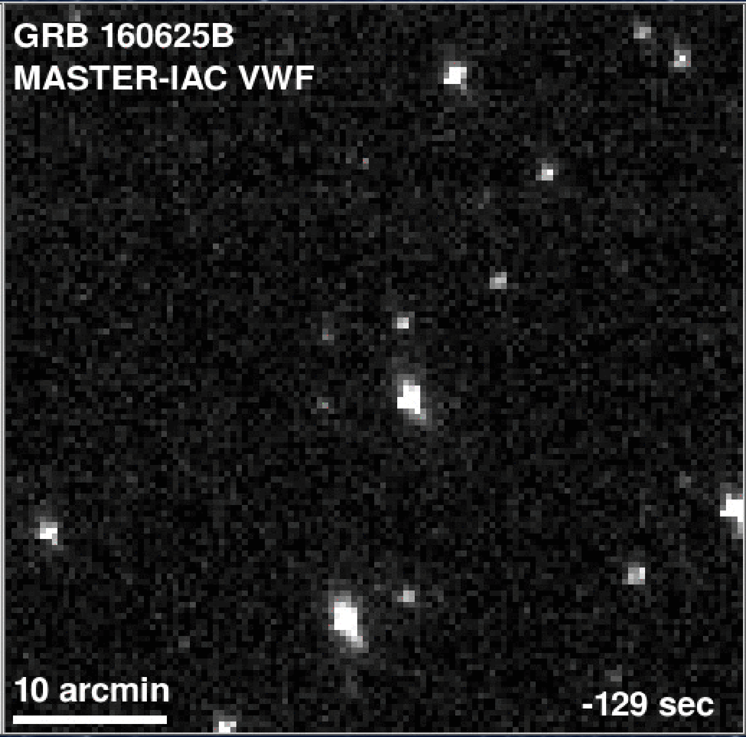
Alain Klotz^ Talk "TAROT: follow-up of LIGO, GRB, IceCube, ANTARES“
International Conference is devoted to the 15 th Anniversary MASTER project
"Bursting Universe by Robots Eyes" SAI MSU 14-18 Aug. 2017

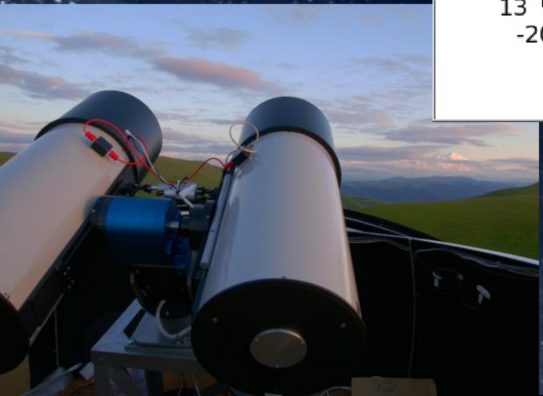


GRB 160725B
Troja et al.,
Nature,2017, 547, 425-427

MASTER-IAC







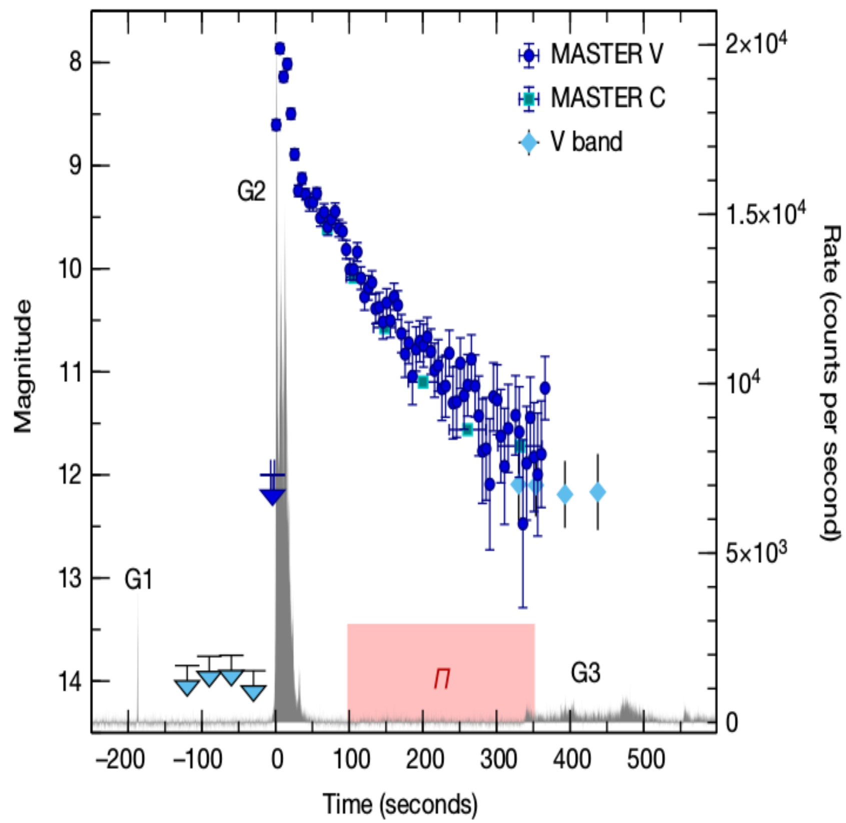
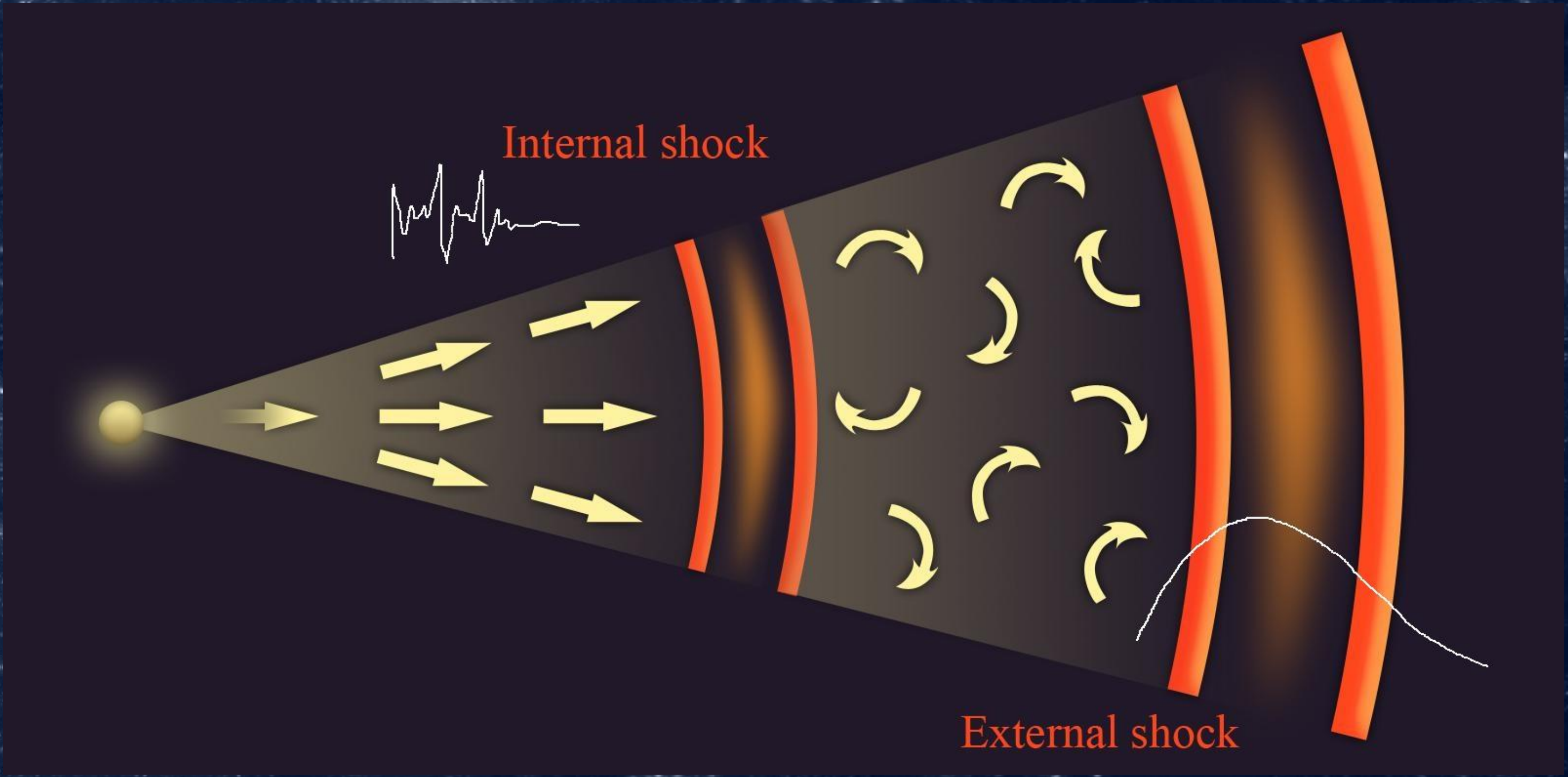


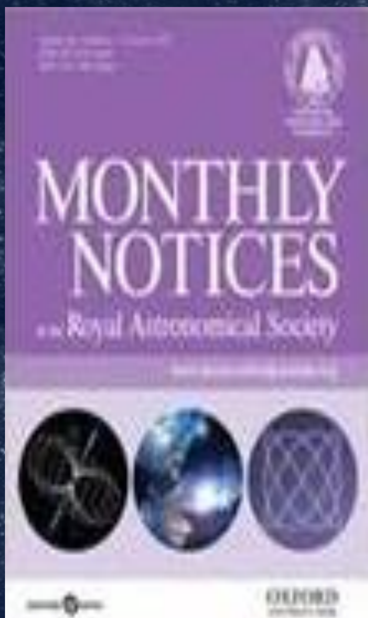
Figure 1 | Prompt γ-ray and optical light curves of GRB 160625B. The γ-ray light curve (black; 10–250 keV) consists of three main episodes: a short precursor (G1), a bright main burst (G2), and a fainter and longer-lasting tail (G3). Optical data from the MASTER Net telescopes and other ground-based facilities[19] are overlaid for comparison. Error bars represent 1σ; upper limits are 3σ. The red box marks the time interval over which polarimetric measurements were taken. Within the sample of nearly 2,000 bursts detected by the GBM, only six other events have a comparable duration (https://heasarc.gsfc.nasa.gov/W3Browse/fermi/fermigbrst.html). Most GRBs end before the start of polarimetric observations.

Jet structure



"The optical identification of events with poorly defined locations: the case of the Fermi GBM GRB 140801A

*Lipunov, Gorosabel, Pruzhinskaya et al., MNRAS, **455**, 712-724L. 2016*



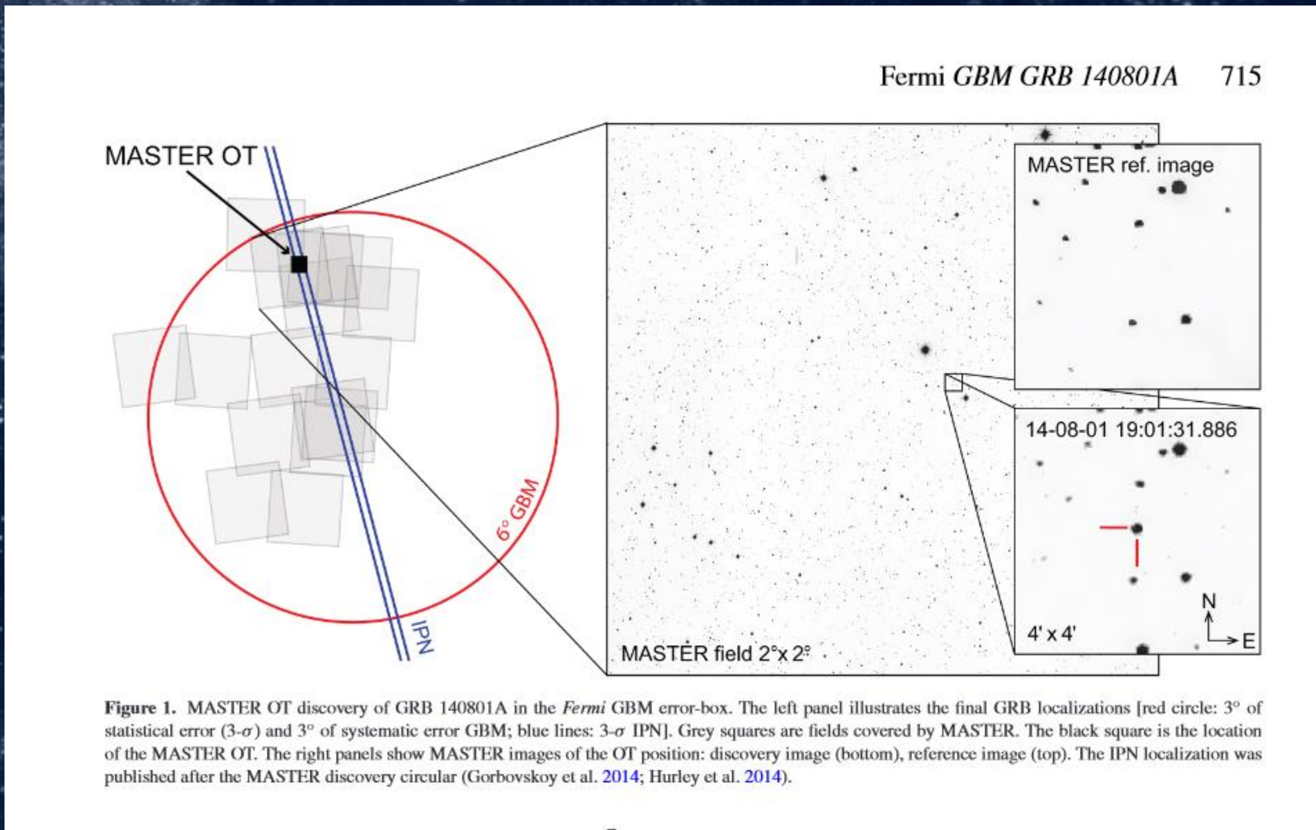
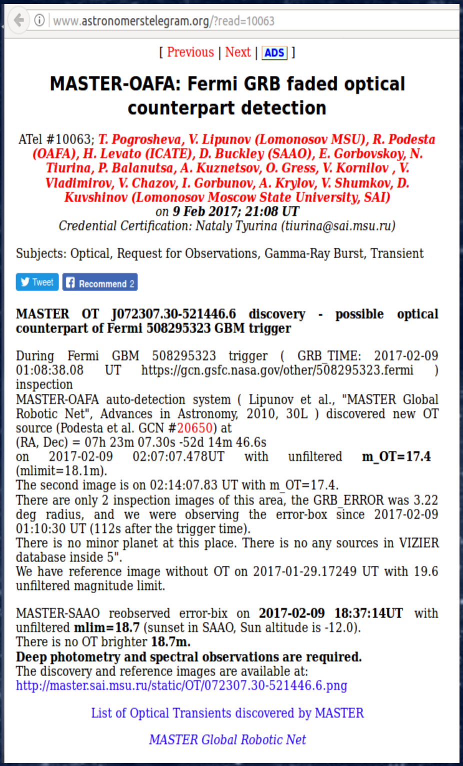

Fermi *GBM GRB 140801A* 715

Figure 1. MASTER OT discovery of GRB 140801A in the *Fermi* GBM error-box. The left panel illustrates the final GRB localizations [red circle: 3° of statistical error (3-σ) and 3° of systematic error GBM; blue lines: 3-σ IPN]. Grey squares are fields covered by MASTER. The black square is the location of the MASTER OT. The right panels show MASTER images of the OT position: discovery image (bottom), reference image (top). The IPN localization was published after the MASTER discovery circular (Gorbovskoy et al. 2014; Hurley et al. 2014).

One more FERMI GRB 170209A

OT detected inside 600 sq. Degree error box At MASTER-OAFA


www.astronomerstelegram.org/?read=10063

[Previous | Next | ADS]

MASTER-OAFA: Fermi GRB faded optical counterpart detection

ATel #10063; *T. Pogrosheva, V. Lipunov (Lomonosov MSU), R. Podesta (OAFA), H. Levato (ICATE), D. Buckley (SAAO), E. Gorbovskoy, N. Tiurina, P. Balanutsa, A. Kuznetsov, O. Gress, V. Kornilov , V. Vladimirov, V. Chazov, I. Gorbunov, A. Krylov, V. Shumkov, D. Kuvshinov (Lomonosov Moscow State University, SAI)*
*on **9 Feb 2017; 21:08 UT***
Credential Certification: Nataly Tyurina (tiurina@sai.msu.ru)

Subjects: Optical, Request for Observations, Gamma-Ray Burst, Transient

Tweet | Recommend 2

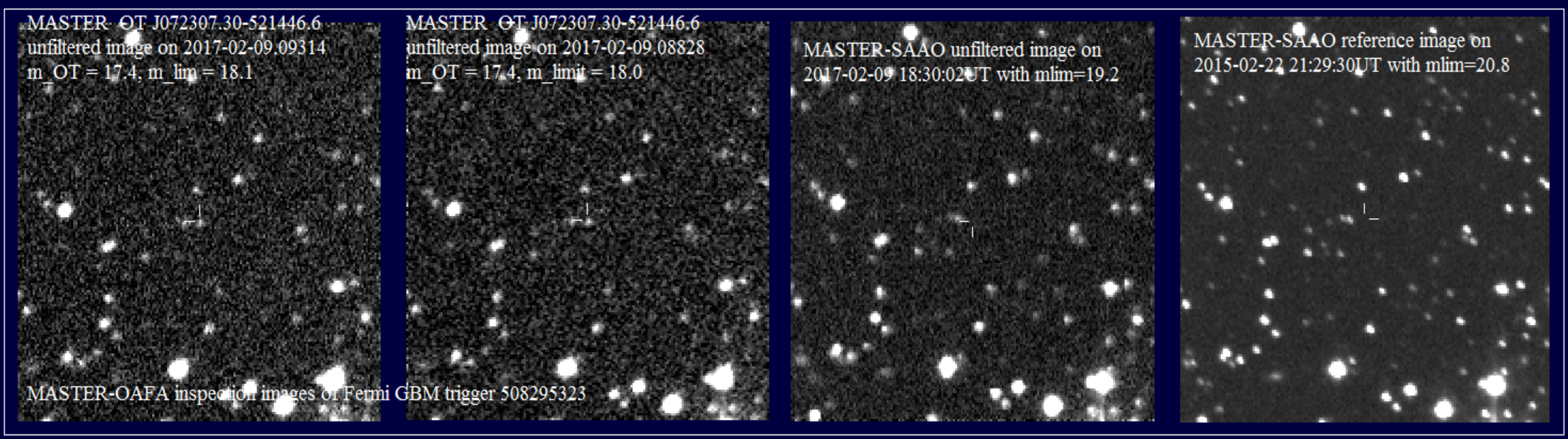
MASTER OT J072307.30-521446.6 discovery - possible optical counterpart of Fermi 508295323 GBM trigger

During Fermi GBM 508295323 trigger (GRB TIME: 2017-02-09 01:08:38.08 UT https://gcn.gsfc.nasa.gov/other/508295323.fermi) inspection
MASTER-OAFA auto-detection system (Lipunov et al., "MASTER Global Robotic Net", Advances in Astronomy, 2010, 30L) discovered new OT source (Podesta et al. GCN #20650) at
(RA, Dec) = 07h 23m 07.30s -52d 14m 46.6s
on 2017-02-09 02:07:07.478UT with unfiltered **m_OT=17.4** (mlimit=18.1m).
The second image is on 02:14:07.83 UT with m_OT=17.4.
There are only 2 inspection images of this area, the GRB_ERROR was 3.22 deg radius, and we were observing the error-box since 2017-02-09 01:10:30 UT (112s after the trigger time).
There is no minor planet at this place. There is no any sources in VIZIER database inside 5".
We have reference image without OT on 2017-01-29.17249 UT with 19.6 unfiltered magnitude limit.

MASTER-SAAO reobserved error-bix on **2017-02-09 18:37:14UT** with unfiltered **mlim=18.7** (sunset in SAAO, Sun altitude is -12.0).
There is no OT brighter **18.7m.**
Deep photometry and spectral observations are required.
The discovery and reference images are available at:
http://master.sai.msu.ru/static/OT/072307.30-521446.6.png

List of Optical Transients discovered by MASTER

MASTER Global Robotic Net



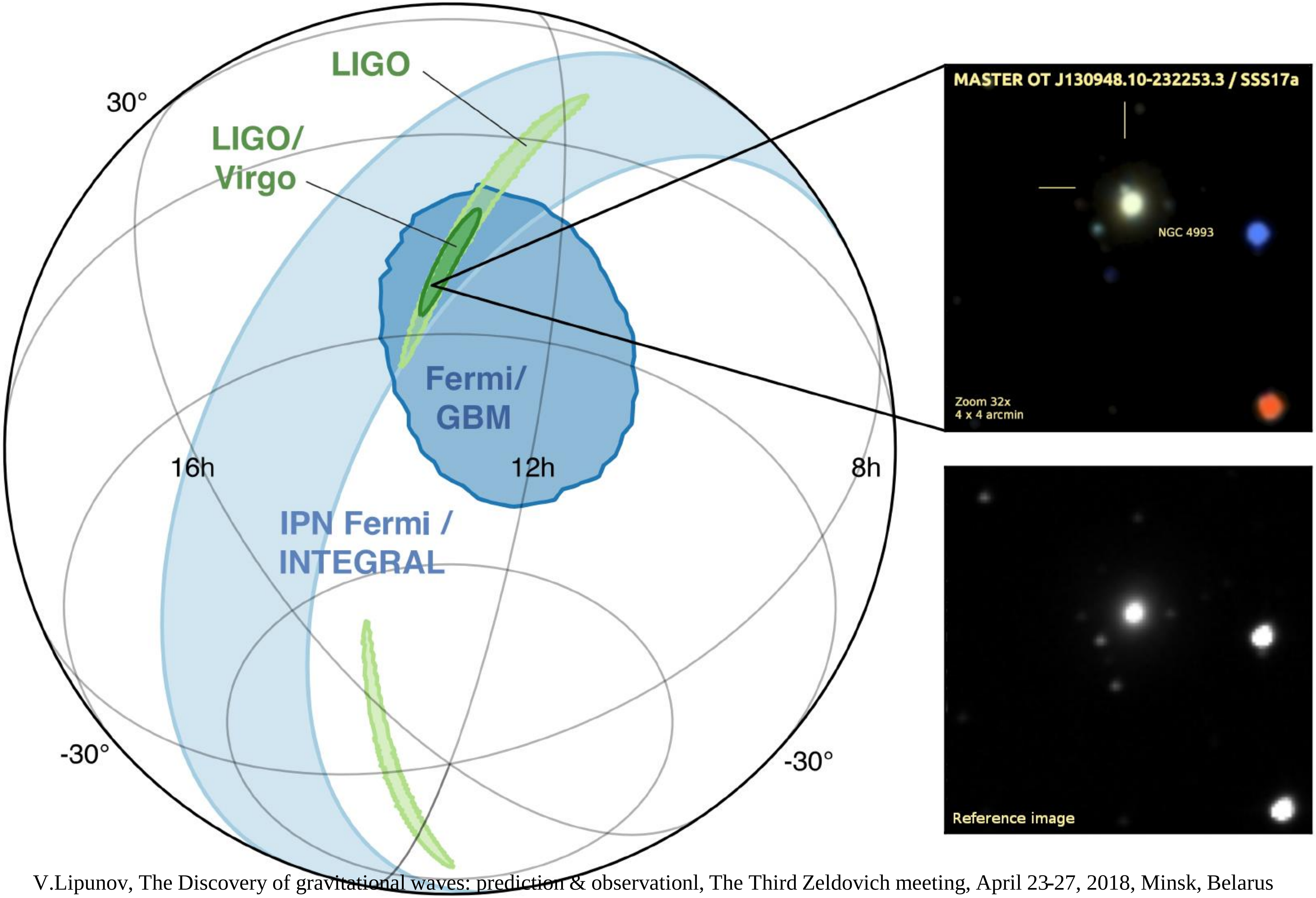
MASTER-OAFA May/2016.

Observatorio Astronomico Felix Aguilar (OAFA), San Juan University, Argentina

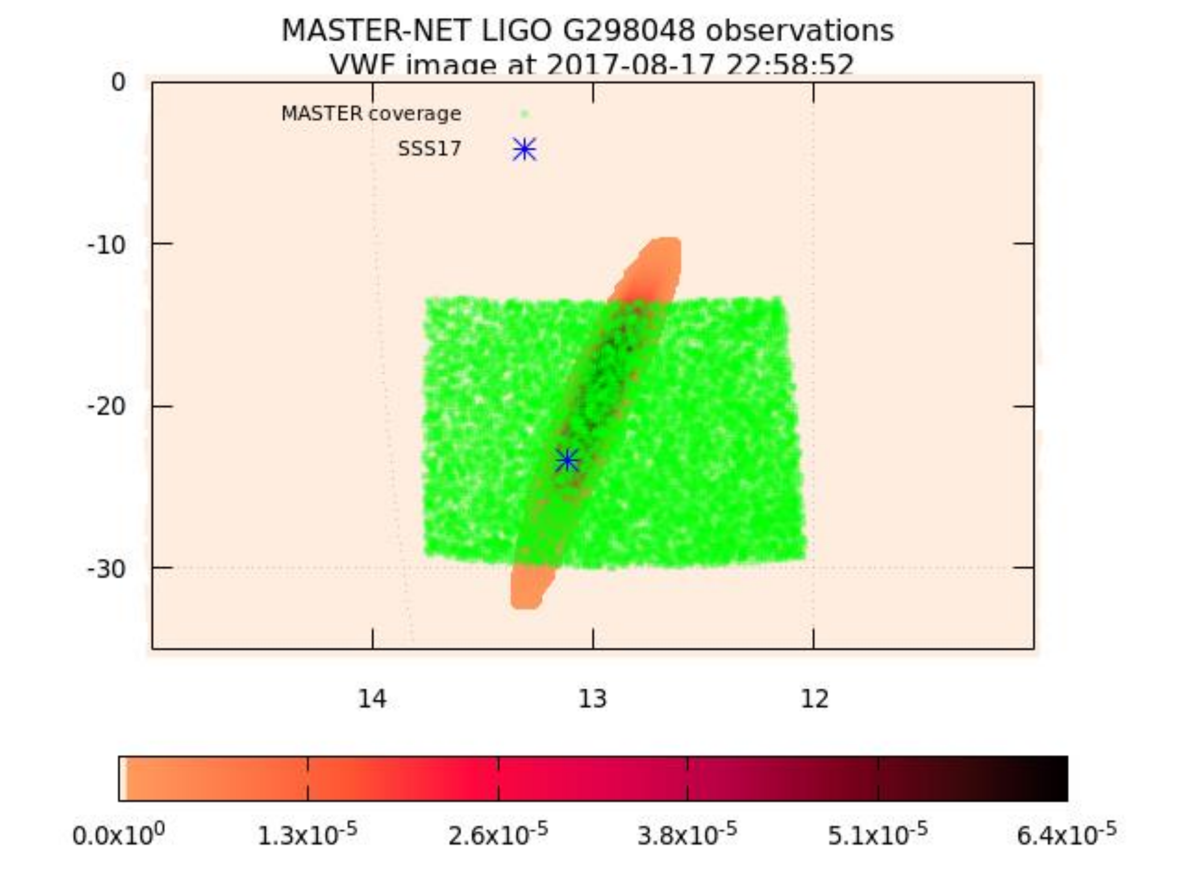
Left-rught: Federico Podest , Carlos Safe, Helpman, Ricardo Podesta, Vladimir Lipunov, Igor Gorbunov, Evgeniy Gorbovskoy

Первый снимок аргентинский МАСТЕР сделал в 22:54:18 UT то есть через 10.22 часа после столкновения и как выяснилось позже, телескопы МАСТЕРа прошли мимо галактики NGC 4993.

Independ optical Localization GW



First pointing in Argentina MASTER Wide field cameras started at 22:54:18 UT, 10.22 часа after merging in NGC 4993.



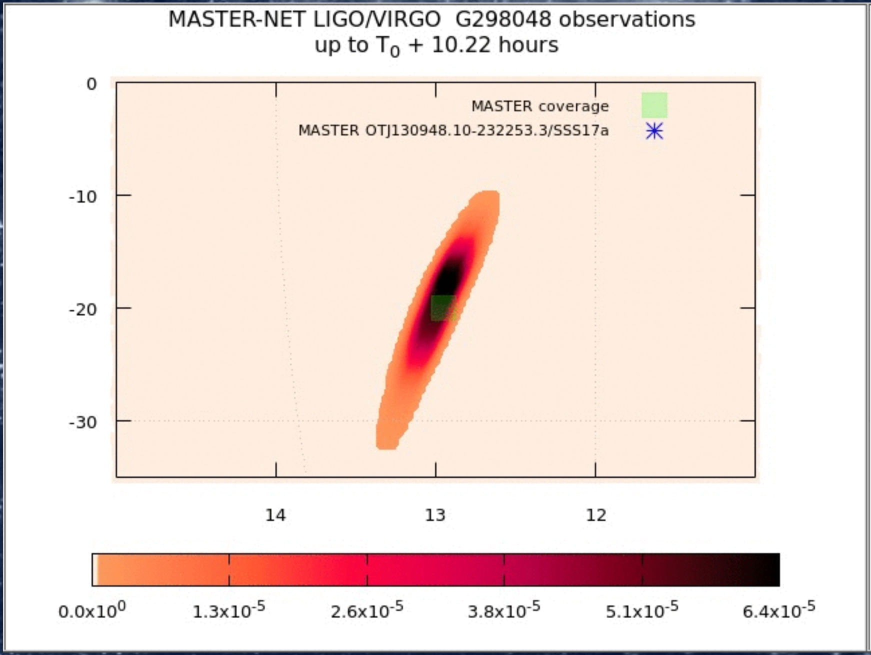
- The MASTER-OAFA with two MASTER-VWF cameras, began imaging the new BAYESTAR-HLV (Singer,Price 2016,Singer et al.2016) localization map of LIGO/Virgo G298048 (LIGO Scientific Collaboration and Virgo Collaboration 2017a,b,c) at 2017-08-17 22:54:18 UT, immediately after sunset. Observations started for the first field at RA, DEC = 12h 59m 00.00s -19d 59m 38.00s.

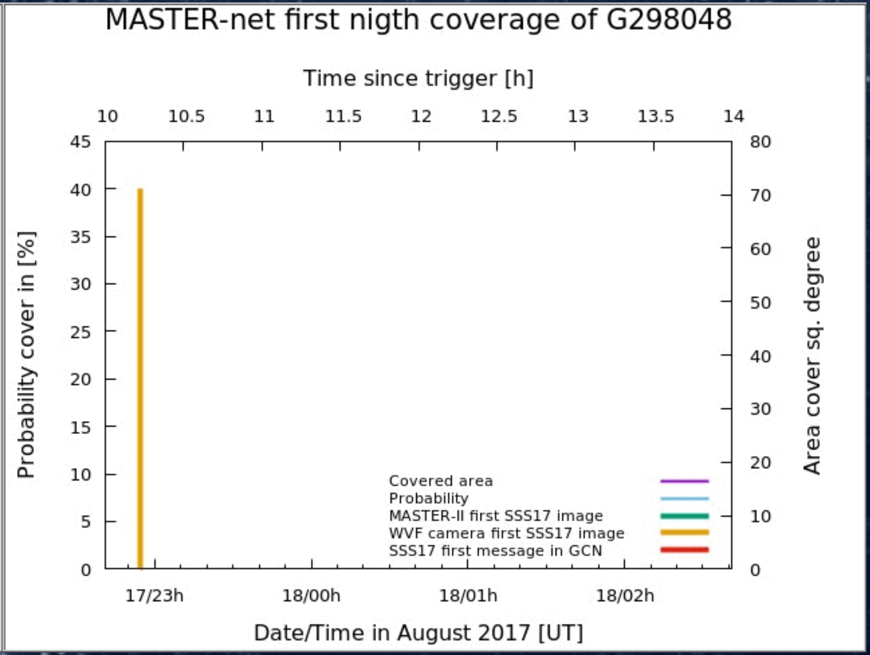
First image host galaxy NGC 4993 after NSs Merging at 10.22 hours UT 2017-08-17 . Upper OT limit 15.2 V.

MASTER-OAFA inspection.
Kilonova started imaging at 2017-Aug-17 11:59:56 UT (02:59:56 Moscow Time)

Lipunov, Kornilov, Gorbovskoy et al., ApJlett,

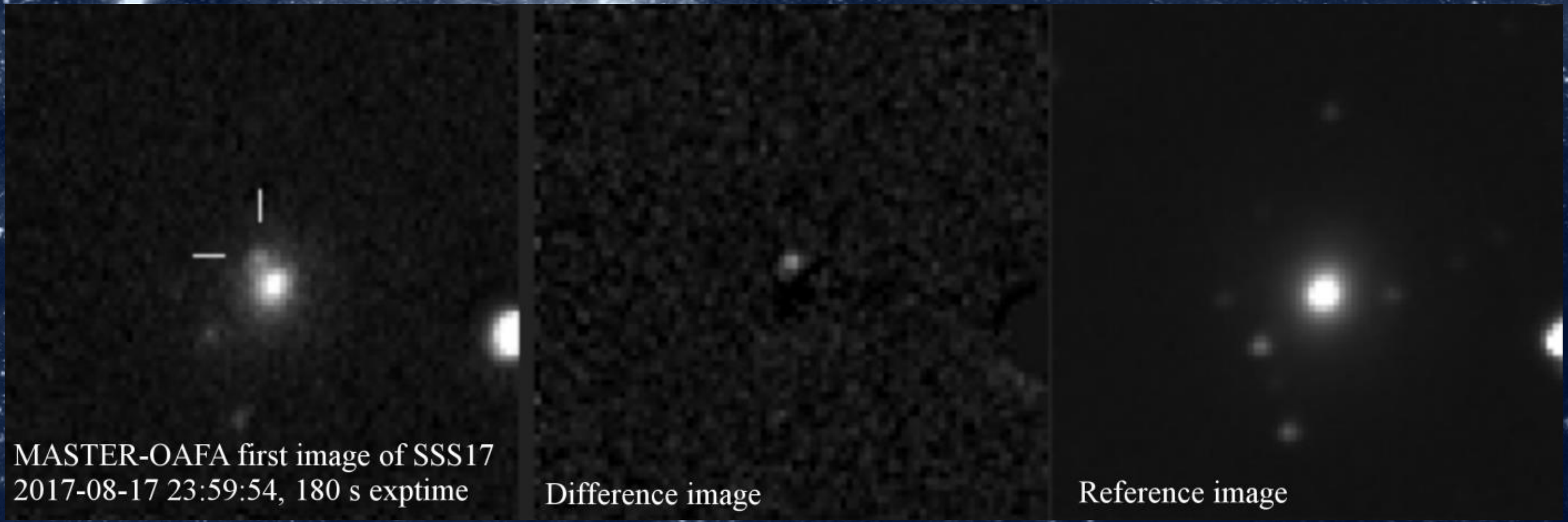
MASTER optical detection of the first LIGO/Virgo neutron stars merging GW170817.





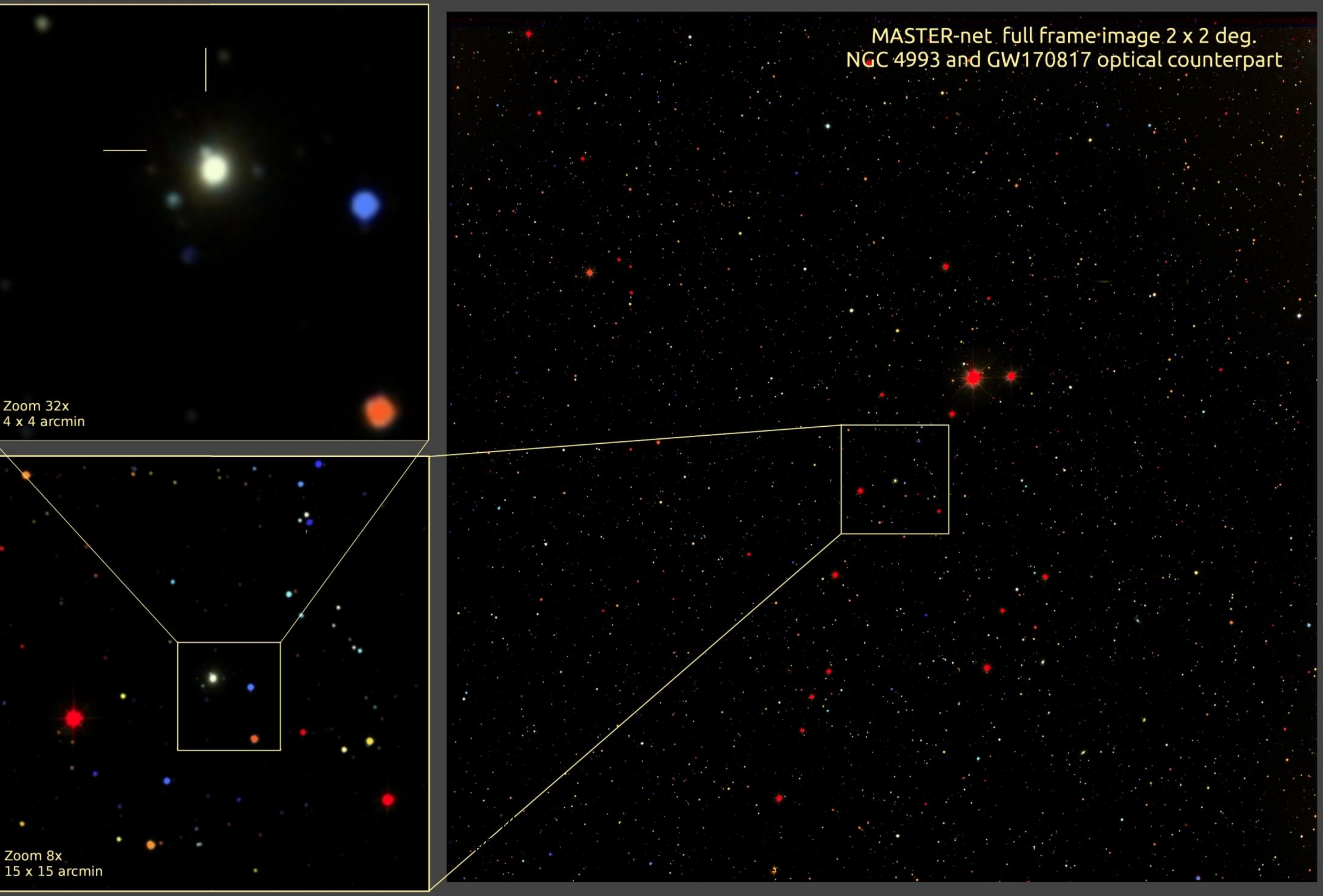
MASTER OT J OTJ130948.10-232253.3/SSS17a detection in NGC4993 by MASTER-OAFA

Lipunov, V., Gorbovskoy, E., Kornilov V., et al., 2017c, GCN, 21546, 1



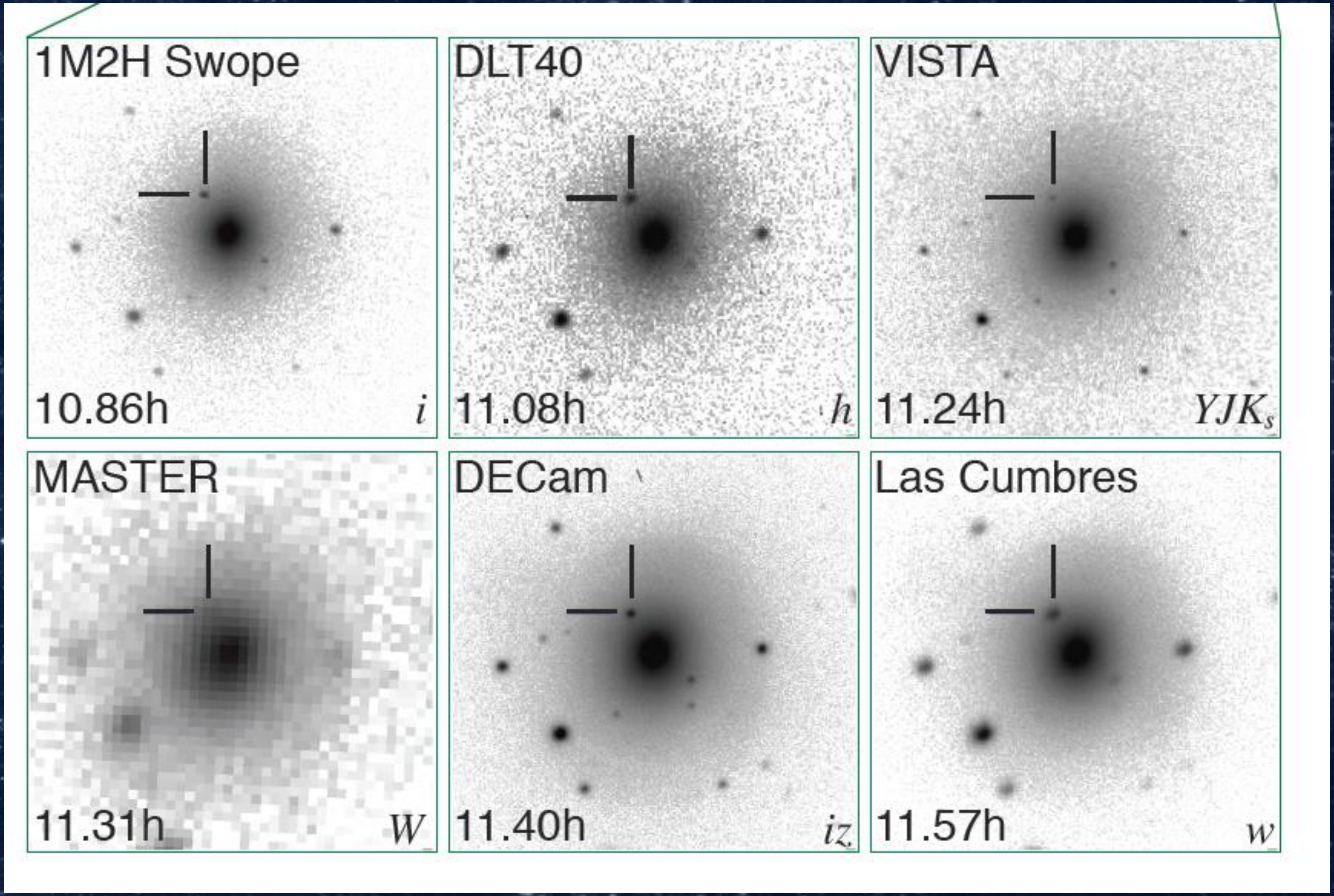
Color composed Kilonova image by W, B,V,R , I MASTER-SAAO+OAFA

Composed MASTER image

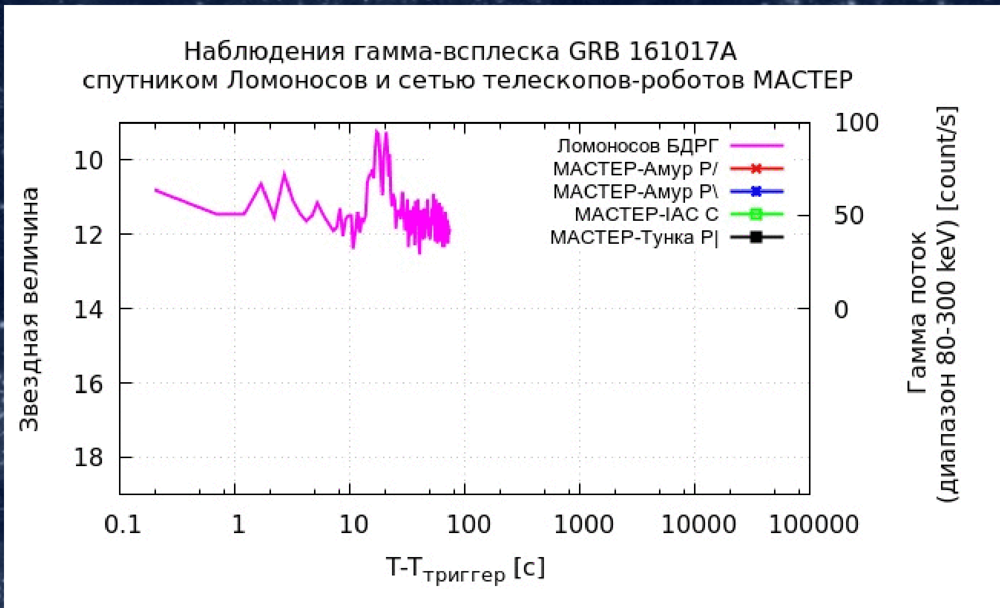


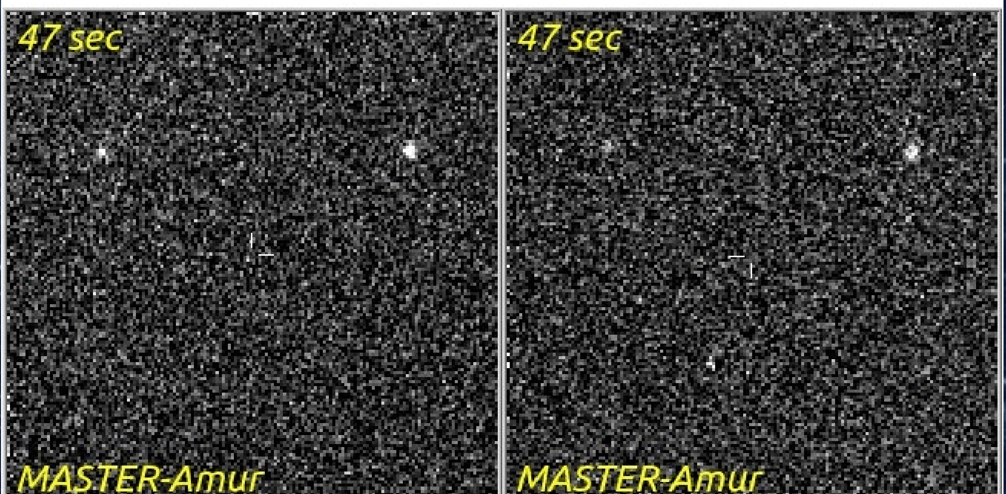
MASTER-OAFA
One year – one superdiscovery

Abott et al., 2017, *MULTI-MESSENGER OBSERVATIONS OF A BINARY NEUTRON STAR MERGER*, **ApJlett**,



Sadovnichy, et al The Astrophysical Journal, Volume 861, Issue 1, article id. 48, 12 pp. (2018).





At 17:52:17 UT on 17 Sep 2016, the Lomonosov BDRG Gamma-ray Burst Monitor triggered GRB 161017A (E. Troja et al.,, GCN 20064). GRB 161017A has several peaks LC, total duration ~100s,the energy range 70-300 keV.

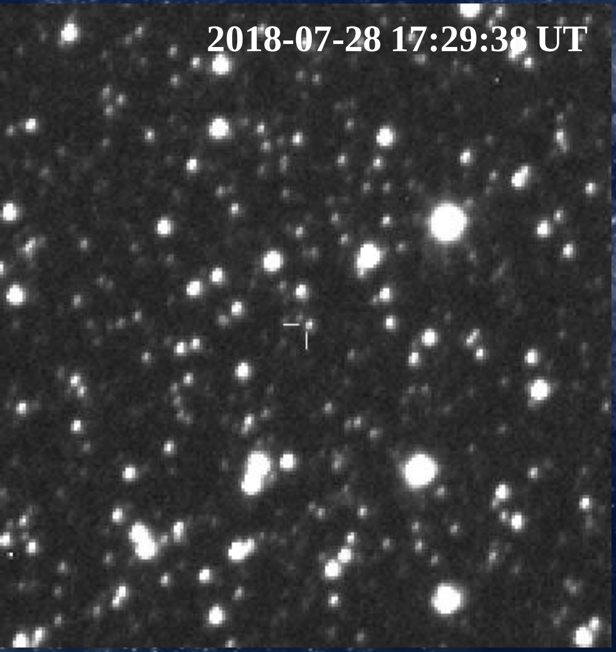
MASTER-Amur robotic telescope (MASTER-Net: http://observ.pereplet.ru) located in Blagoveschensk was pointed to the GRB161017A 21 sec after
notice time and 47 sec after Swift trigger time at 2016-10-17 17:52:38 UT in two polarizations. On our first (10s exposure) set we marginally found optical transient at Yurkov et al. (GCN 20063) and Troja et al. (GCN 20064) position. The 5-sigma upper limit has been about 14.5 mag .
The OT was became brighter up to maximum at 3-4 set .

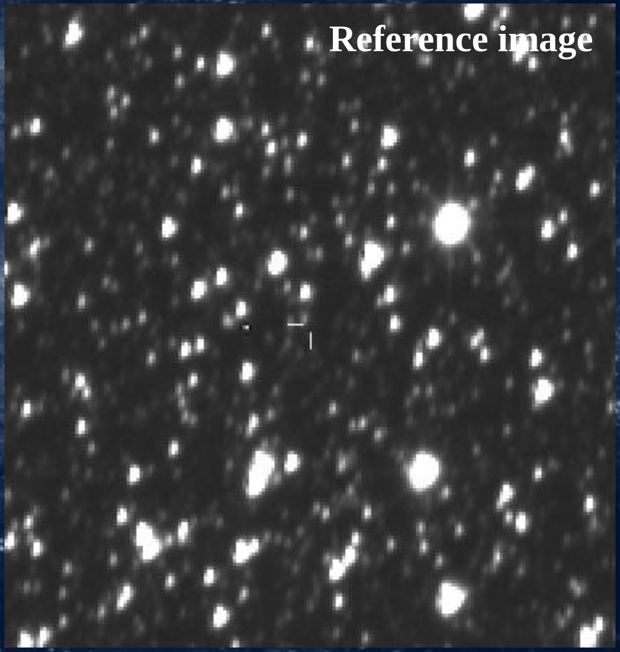
MASTER-Tunka robotic telescope (MASTER-Net: http://observ.pereplet.ru) located in Tunka (Baykal lake) was pointed to the GRB161017.74 75 sec after notice time and 103 sec after trigger time at 2016-10-17 17:53:34 UT.
We imaged OT late.
MASTER-IAC robotic telescope located at Teide jbservatory (Tenerife, Canary, Spain) was pointed to the GRB161017A 32942 sec after trigger time at 2016-10-18 03:00:53 UT. We found optical transient on coaded images

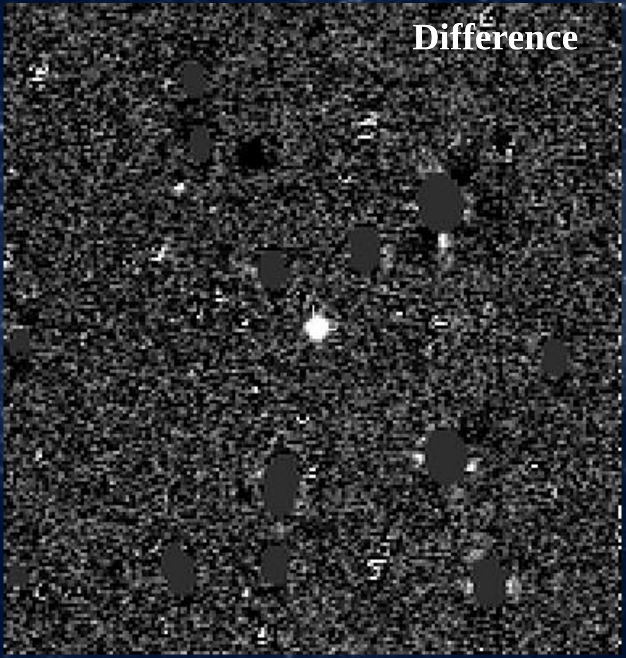
GRB 180728A: MASTER-SAAO observations:

Detected by SWIFT BAT Starling et al GCN 23046

OT discovered by MASTER Lipunov et al GCN 23048







V. Lipunov et. Al GCN 23048

MASTER-SAAO robotic telescope located in South Africa (South African Astronomical Observatory) was pointed to the GRB180728A

22 sec after notice time and 38 sec after trigger time at 2018-07-28 17:29:38 UT

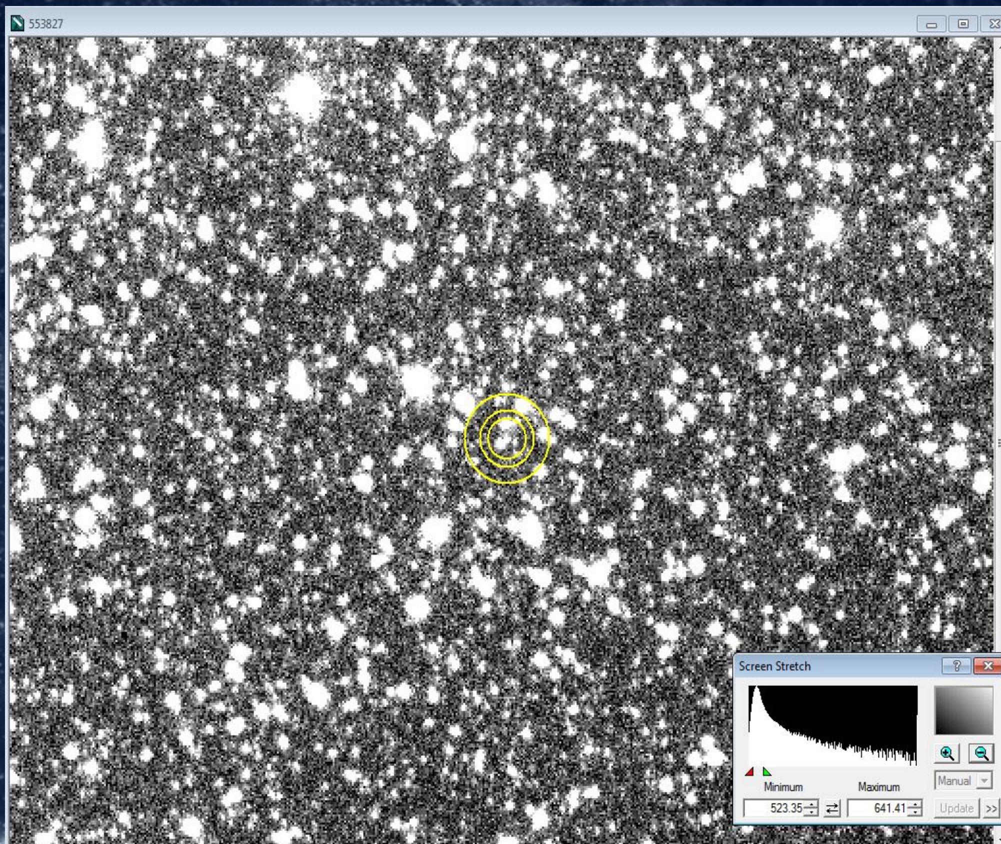
in two polarizations. On our first (10s exposure) set we found new optical object (transient) within SWIFT error-box

MASTER OT J165415.75 -540239.27 RA, DEC = 16h 54m 15.75s , -54d 02m 39.27s m ~ 14.5

GRB 180728A: MASTER-SAAO observations:

Detected by SWIFT BAT
Starling et al GCN 23046

Z = 0.117 ESO VLT
(Rossi et. al GCN 23055)

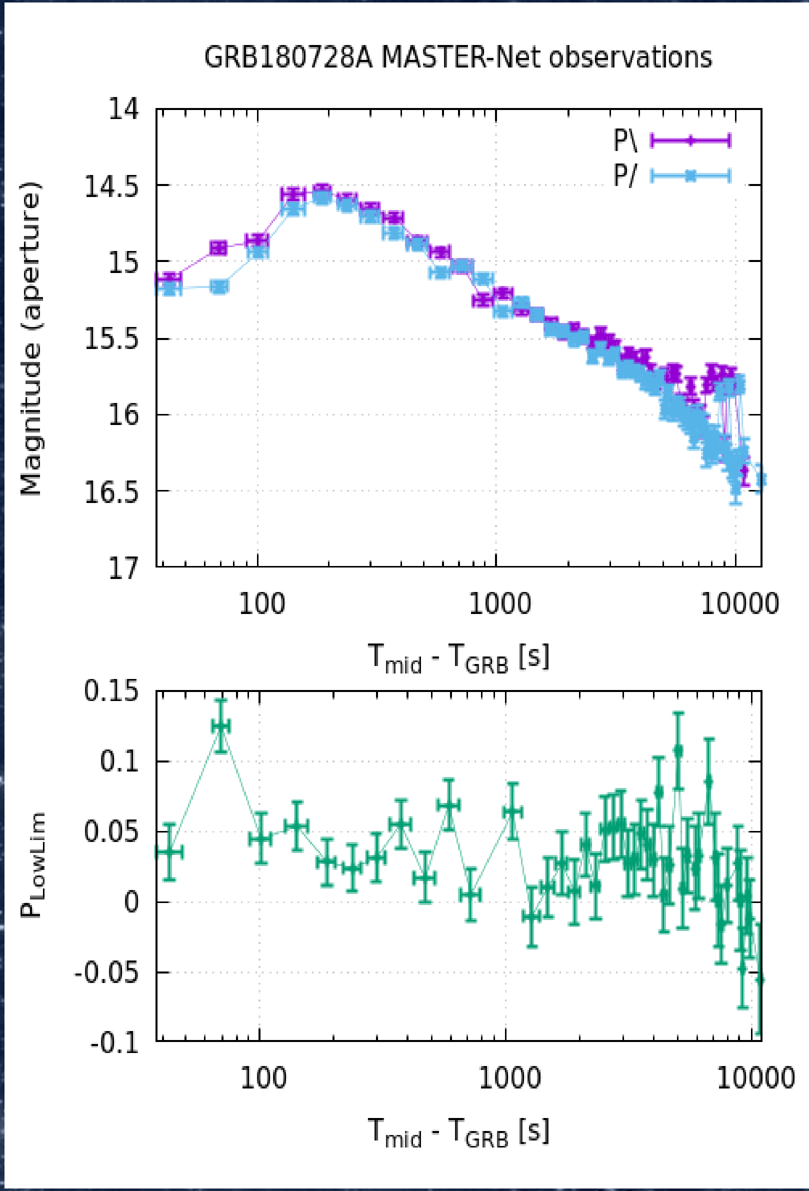


Very close GRB

Gal. latitude: -7.0 d
Gal. longitude: 334.2 d

Supernova SN 2018fip discovered 12 days after trigger by X-shooter instrument on the ESO/VLT (Izzo et al. GCN 23142)

GRB 180728A: MASTER-SAAO observations:



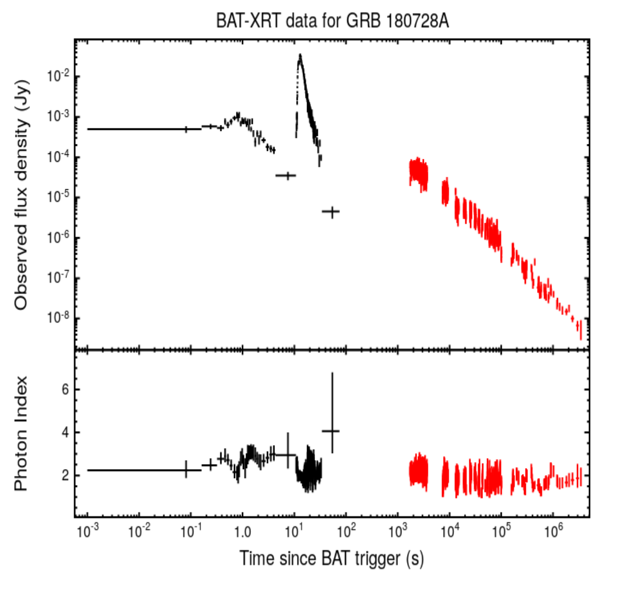
Detected by SWIFT BAT Starling et al GCN 23046

OT discovered by MASTER Lipunov et al GCN 23048

T_{90} = 8.68 +- 0.3 s

Second point polarization low limit

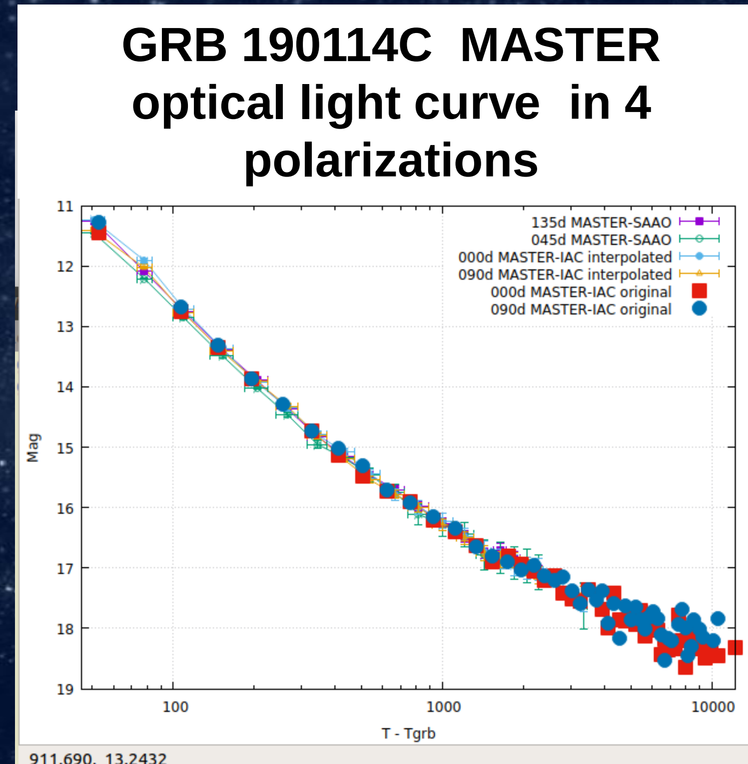
P > 12.5% +- 1.8%



GRB 190114C: MASTER-NET 4 tube observations

(Troja et al. in preparation):

Detected by Swift BAT Gropp et al GCN 23688



V. Tyurina et. Al GCN 23690

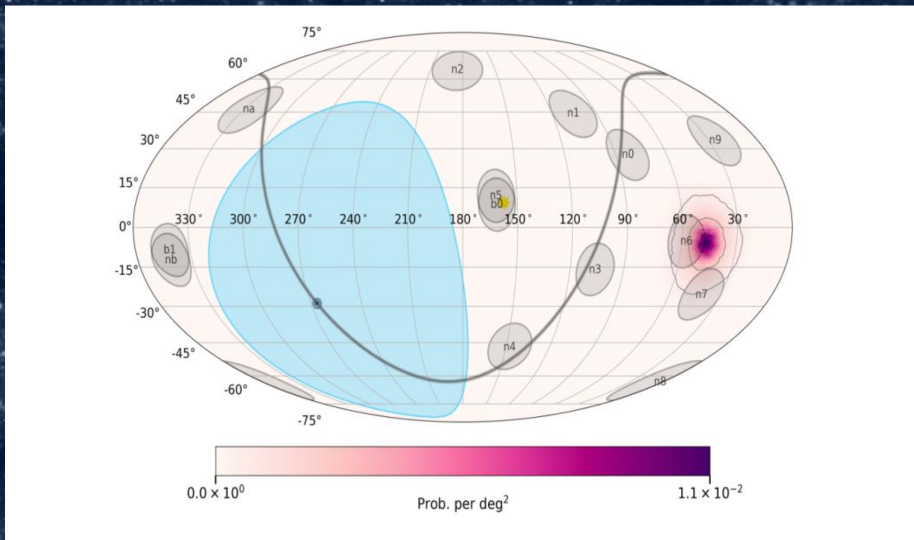
MASTER-IAC robotic telescope (Global MASTER-Net: http://observ.pereplet.ru, Lipunov et al., 2010, Advances in Astronomy, vol. 2010, 30L) located in Spain (IAC Teide Observatory) was pointed to the GRB190114.87 25 sec after notice time and 47 sec after trigger time at 2019-01-14 20:57:51 UT. On our first (10s exposure) set we found 1 optical transient within SWIFT error-box brighter than 16.54.

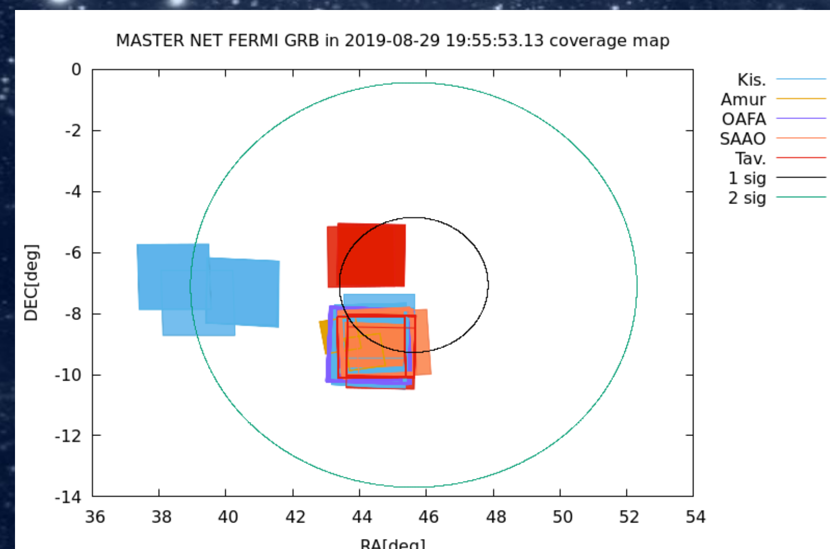
T-Tmid	Date Time	Expt.	Ra	Dec	Mag
52	2019-01-14 20:57:51	10	(3h 38m 01.17s ,	-26d 56m 46.73s)	11.21

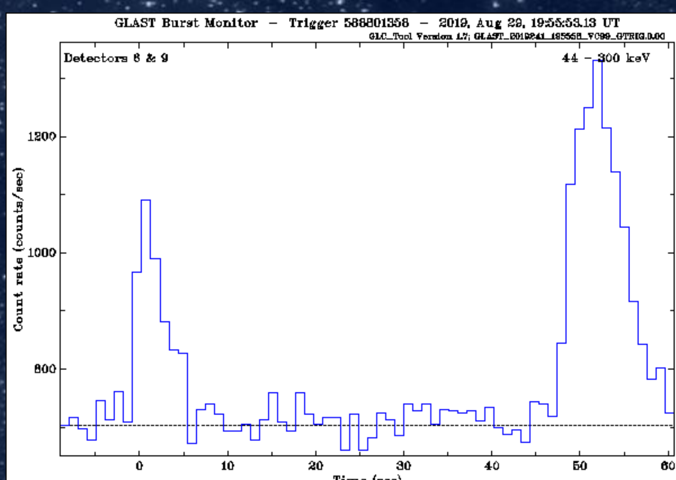
Fermi GRB190829A

MASTER

2019-08-29 19:55:53.13 GCN 25551





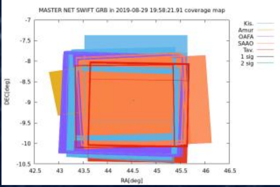


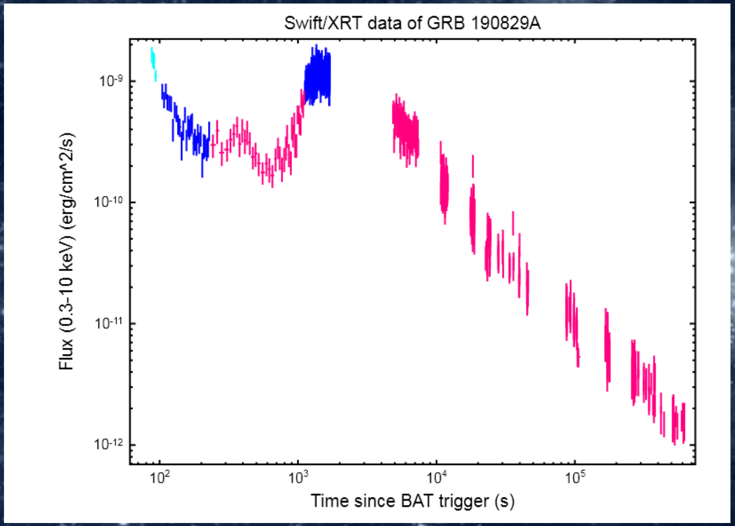
Vladimir Lipunov, Central Engine from Early Multimessanger GRB observations, KW25, St.Petersburg, Russia, 12 sep 2019

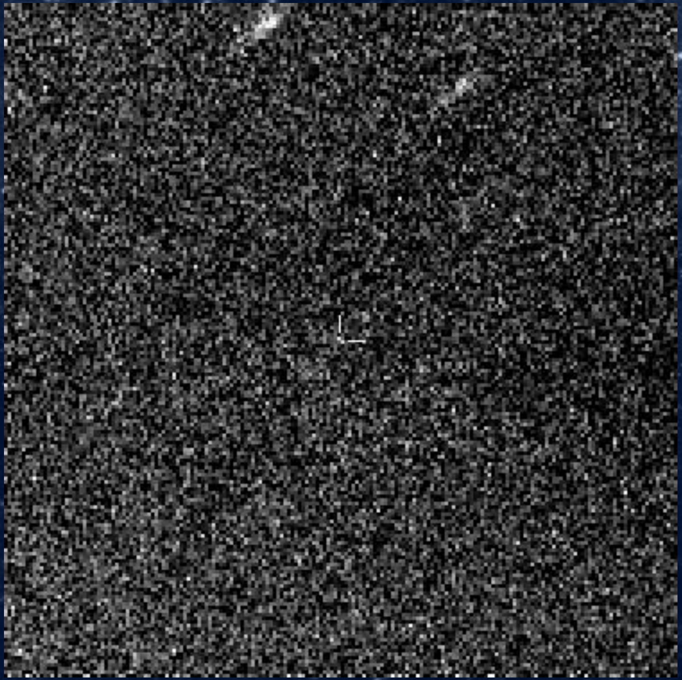
Swift, GRB190829A

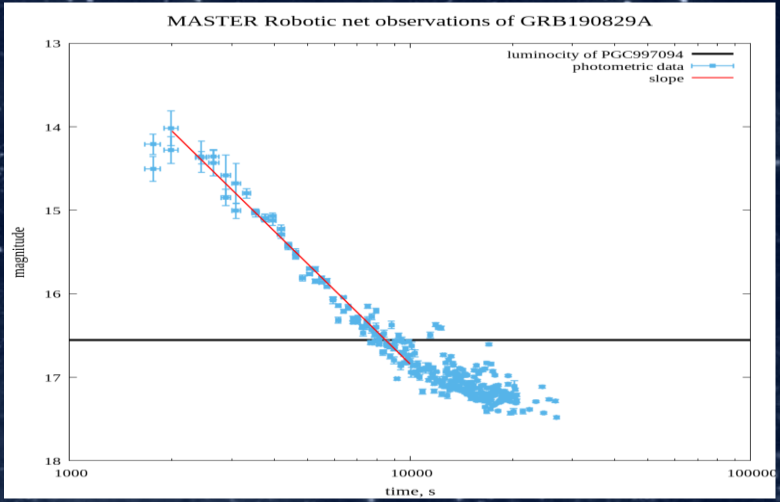
GCN 25552 (19/08/29 20:25:37)

Ttrig= 19:56:44.60 UT









Vladimir Lipunov, Central Engine from Early Multimessanger GRB observations, KW25, St.Petersburg, Russia, 12 sep 2019

Fermi / Swift GRB190829A

Fermi 588801358 GCN 25551 (19/08/29 20:06:10 UT)
Ttrig=2019-08-29 19:55:53.13

Swift BAT,XRT (UVOT-) GCN 25552 (19/08/29 20:25:37)
Ttrig= 19:56:44.60 UT

MASTER GCN 25553 (19/08/29 21:31:14)
MASTER-Kislovodsk 1259 sec after notice time (1290 from trigger)

Dabancheng-0.5m optical afterglow detection (GCN 25555 19/08/29 21:36:30,
started at 20:49:03 UT (52.3 min after the burst), x150s **OT**

MASTER bright and decay OT detection (GCN 25558 19/08/29 22:35:55

GROWTH India detection of afterglow GCN25560 19/08/29 22:55:45 g + r, starting 51 min after, 16.9

NOT optical afterglow detection and spectroscopy GCN 25563 19/08/30 03:42:22,
r-band 19/08/30 02:03:52 18.9

10.4m GTC GCN 25565 19/08/30 06:40:25 i = 18.42 19/08/30 3:00UT, z =0.0785

VHE gamma-ray emission with H.E.S.S. GCN 19/08/30 07:08:37 T0 + 4h20, >5sigma gamma-ray excess compatible with the direction of GRB190829A

Fermi / Swift GRB190829A

25651 GRB190829A: GROND detection of the accompanying SN

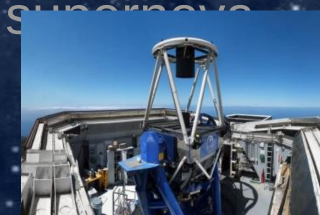
MPG/ESO 2.2-metre Gamma-ray Burst Optical/Near-infrared Detect

La Silla, Chile

25652 GRB 190829A: MASTER confirmation of G

25657 GRB 190829A: Liverpool Telescope observations of a slow s

rise



25660 Konus-Wind observation of GRB 19

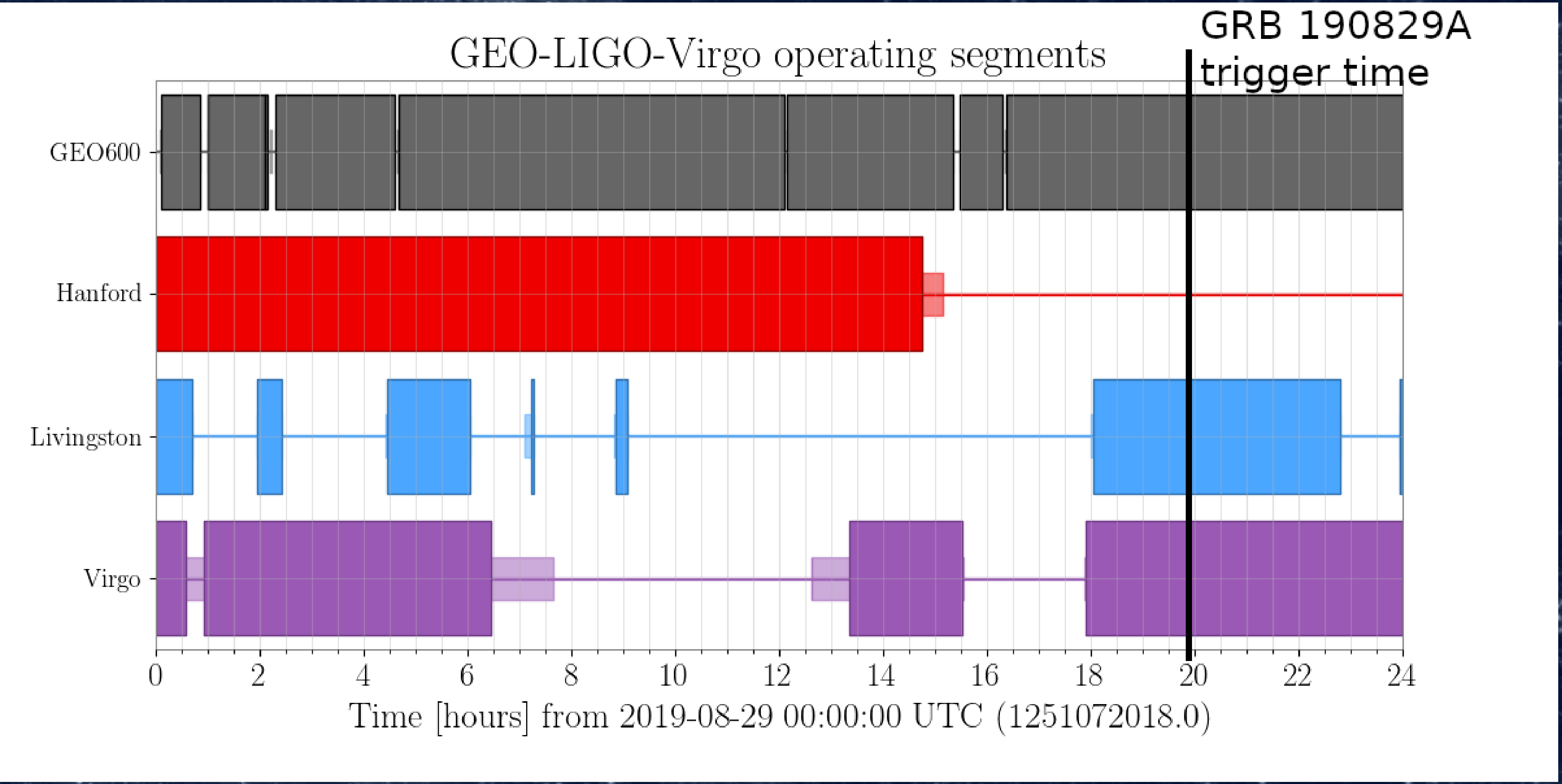
25664 GRB190829A: Keck LRIS spectroscopic confirmation of the accompanying supernova

Low Resolution Imaging Spectrograph (LI

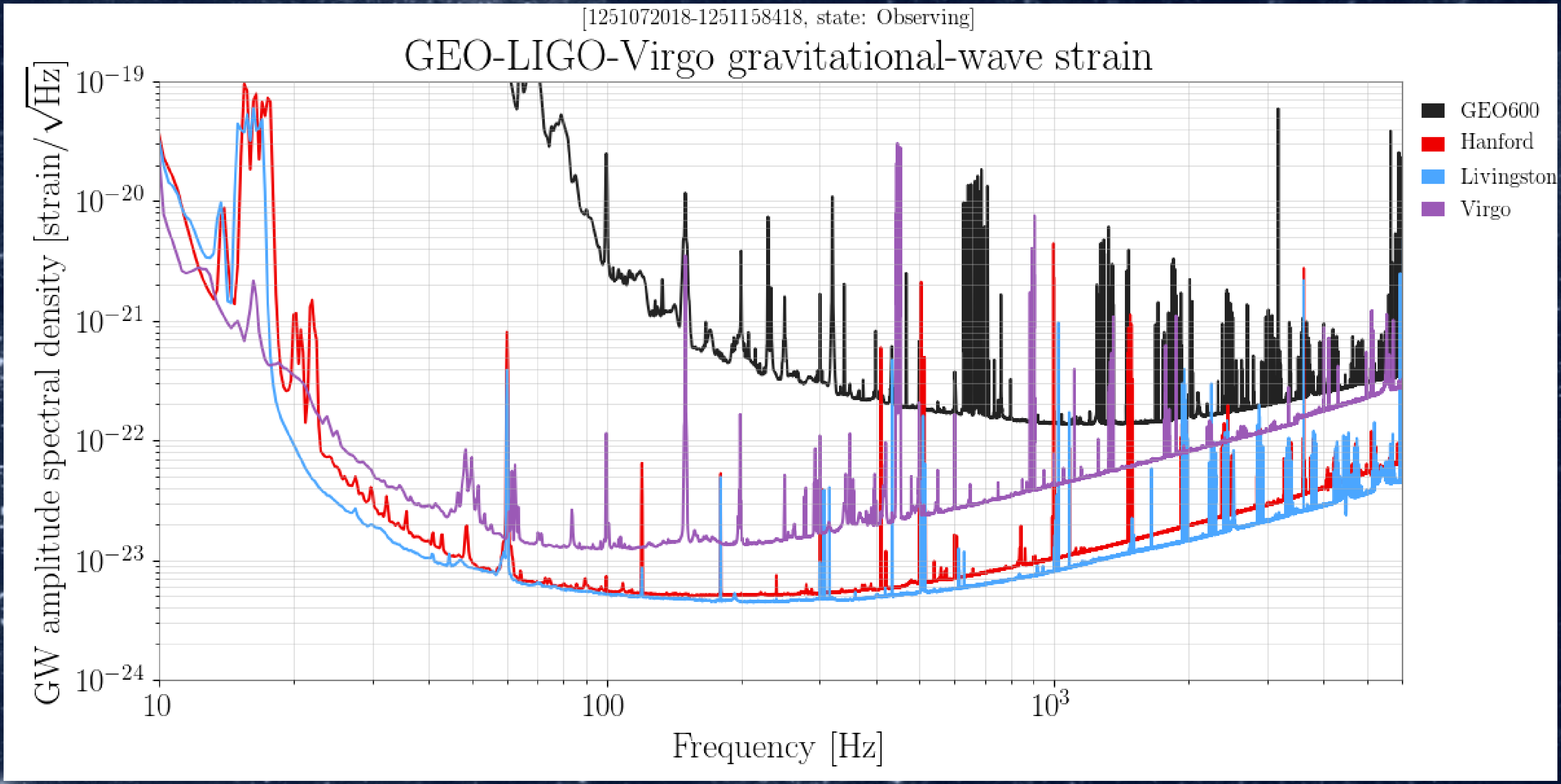
25667 GRB 190829A optical observation

РАБОТА LVC

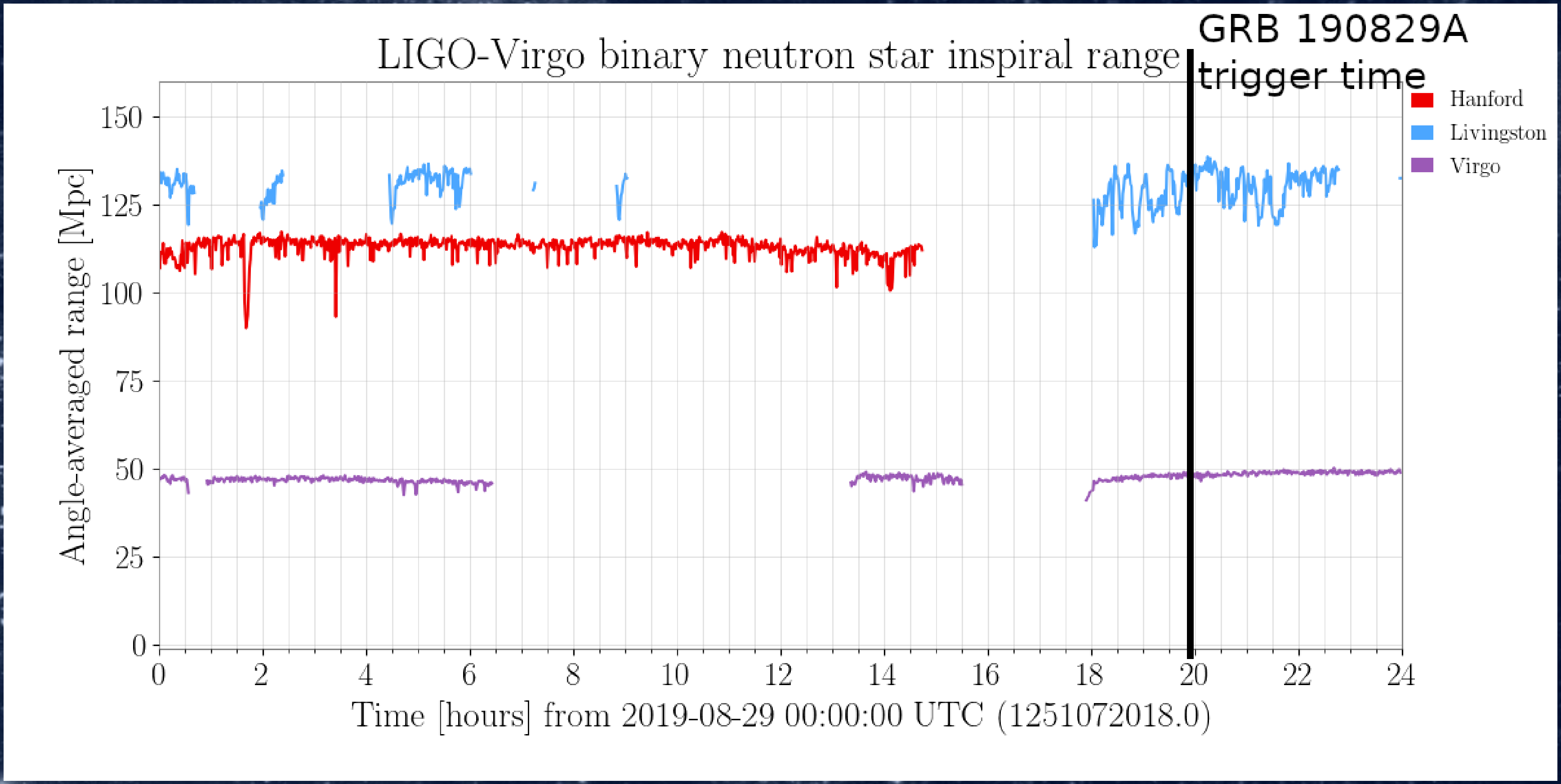
(Грав.Волновые детекторы)



Чувствительность LVC



Чувствительность LVC в момент гамма-всплеска по нейтронным звездам



MASTER Net MASTER Database: LIGO alert list

Please use the reference to MASTER DataBase as Lipunov et al., 2010, MASTER Robotic Net, Advances in Astronomy, vol. 2010, pp. 1-7

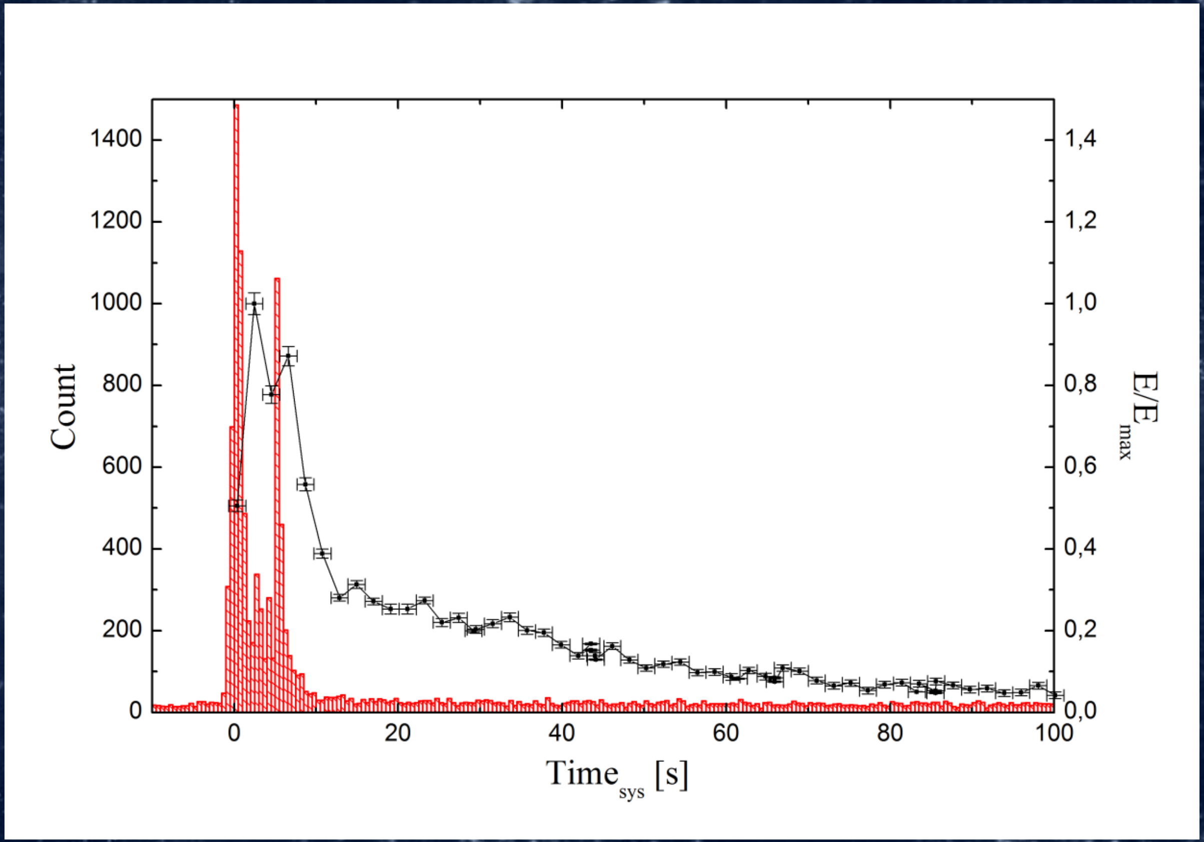
LVC EVENTS TABLE FROM GCN

Pages: [1] ... 2

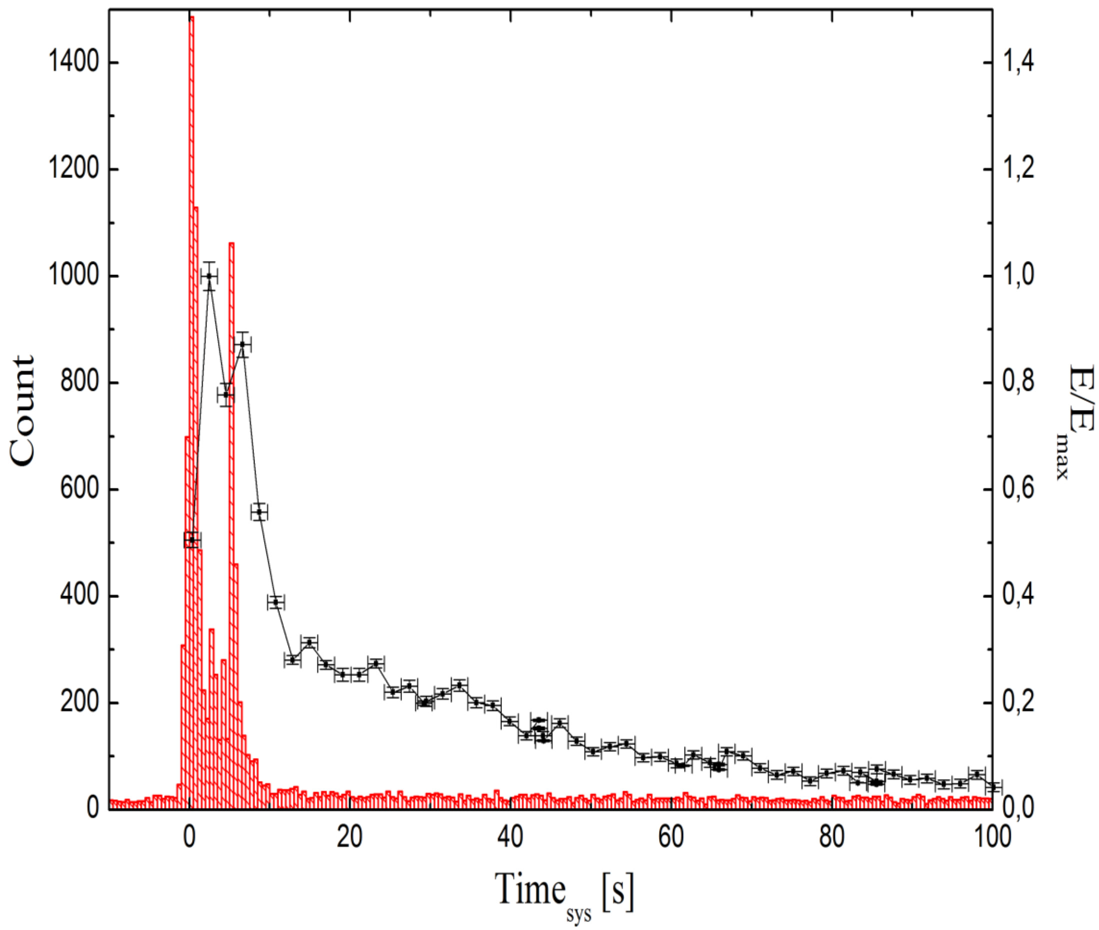
select set_sphere_output('HMS'); select set_sphere_output_precision(1); SELECT id , grbtime , noticetime , coord2000 , satel , errorbox , type , name as gname ,data_path , superalert , distance ,d_dist , bns , bbh , gap , terr , nsbh FROM ligo where satel='LVC' and id in (select max(id) AS id from ligo GROUP BY name) ORDER BY grbtime desc OFFSET 0 LIMIT 50

№	Name	Trigger	Notice	Detector	Path	Distance	BEST	links	
10778	**S190901ap**	2019-09-01 23:31:01	2019-09-02 12:26:41.280418	LVC	/master/data/ligo/db/S190901ap/152/3/	240.869 ± 78.6482	BNS	This =>	Best =>
10754	**S190829u**	2019-08-29 21:05:56	2019-08-29 21:13:18.446497	LVC	/master/data/ligo/db/S190829u/150/1/	157.208 ± 45.0109	3-5Msun	This =>	Best =>
10744	**S190828l**	2019-08-28 06:55:09	2019-08-28 07:41:09.870678	LVC	/master/data/ligo/db/S190828l/151/2/	1609.3 ± 426.351	BBH	This =>	Best =>
10749	**S190828j**	2019-08-28 06:34:05	2019-08-28 08:08:41.489804	LVC	/master/data/ligo/db/S190828j/152/3/	1802.53 ± 422.884	BBH	This =>	Best =>
10728	**GW190816_FERMI**	2019-08-24 21:53:45.784479	2019-08-24 21:53:45.784479	LVC	/master/data/ligo/db/GW190816_FERMI/152/	428.449 ± 142.625		This =>	Best =>
10722	**S190822c**	2019-08-22 01:29:59	2019-08-22 01:38:05.752008	LVC	/master/data/ligo/db/S190822c/150/1/	34.9392 ± 9.5232	BNS	This =>	Best =>
10714	**S190816i**	2019-08-16 13:04:31	2019-08-16 13:13:21.10371	LVC	/master/data/ligo/db/S190816i/150/1/	260.617 ± 100.392	NSBH	This =>	Best =>
10710	**S190814bv**	2019-08-14 21:10:39	2019-08-15 16:10:32.734442	LVC	/master/data/ligo/db/S190814bv/152/5/	267.402 ± 51.5854	NSBH	This =>	Best =>
10674	**S190808ae**	2019-08-08 22:21:21	2019-08-08 22:59:51.567759	LVC	/master/data/ligo/db/S190808ae/151/	208.014 ± 76.6051	Terr	This =>	Best =>
10643	**S190728q**	2019-07-28 06:45:10	2019-07-28 20:35:28.340329	LVC	/master/data/ligo/db/S190728q/152/	873.782 ± 170.813	BBH	This =>	Best =>
10650	**S190727h**	2019-07-27 06:03:33	2019-08-01 17:07:40.490847	LVC	/master/data/ligo/db/S190727h/152/	2838.58 ± 655.239	BBH	This =>	Best =>
10579	**S190720a**	2019-07-20 00:08:36	2019-07-24 15:05:19.020467	LVC	/master/data/ligo/db/S190720a/151/	1070.89 ± 323.335	BBH	This =>	Best =>
10580	**S190718y**	2019-07-18 14:35:12	2019-07-24 15:21:04.251101	LVC	/master/data/ligo/db/S190718y/150/	226.629 ± 164.934	Terr	This =>	Best =>
10471	**S190707q**	2019-07-07 09:33:26	2019-07-07 10:29:39.642918	LVC	/master/data/ligo/db/S190707q/151/	809.827 ± 233.565	BBH	This =>	Best =>
10578	**S190706ai**	2019-07-06 22:26:41	2019-07-24 15:04:50.81308	LVC	/master/data/ligo/db/S190706ai/150/	5725.06 ± 1445.52	BBH	This =>	Best =>
10449	**S190701ah**	2019-07-01 20:33:06	2019-07-01 21:06:35.566666	LVC	/master/data/ligo/db/S190701ah/151/	1044.74 ± 233.891	BBH	This =>	Best =>
10447	**S190630ag**	2019-06-30 18:52:05	2019-06-30 18:57:12.765088	LVC	/master/data/ligo/db/S190630ag/150/	1059.02 ± 307.214	BBH	This =>	Best =>
10445	**S190602aq**	2019-06-02 17:59:27	2019-06-02 18:36:09.496198	LVC	/master/data/ligo/db/S190602aq/151/	797.337 ± 238.488	BBH	This =>	Best =>
10440	**S190524q**	2019-05-24 04:52:06	2019-05-24 05:04:58.088204	LVC	/master/data/ligo/db/S190524q/150/	191.693 ± 101	Terr	This =>	Best =>
10408	**S190521r**	2019-05-21 07:43:59	2019-05-21 08:57:30.566673	LVC	/master/data/ligo/db/S190521r/151/	1136.13 ± 279.258	BBH	This =>	Best =>
10439	**S190521g**	2019-05-21 03:02:29	2019-05-21 15:43:38.646296	LVC	/master/data/ligo/db/S190521g/152/	3931.42 ± 953.035	BBH	This =>	Best =>
10404	**S190519bj**	2019-05-19 15:35:44	2019-05-19 17:05:40.170498	LVC	/master/data/ligo/db/S190519bj/151/	3153.54 ± 790.989	BBH	This =>	Best =>
10403	**S190518bb**	2019-05-18 19:19:21	2019-05-18 19:25:48	LVC	/master/data/ligo/db/S190518bb/150/	27.7601 ± 15.2671	BNS	This =>	Best =>
10402	**S190517h**	2019-05-17 05:51:01	2019-05-17 16:41:50.480126	LVC	/master/data/ligo/db/S190517h/150/	2950 ± 1037.85	BBH	This =>	Best =>
10366	**S190513bm**	2019-05-13 20:54:28	2019-05-13 21:34:08.234118	LVC	/master/data/ligo/db/S190513bm/151/	1987.05 ± 501.212	BBH	This =>	Best =>
10401	**S190512at**	2019-05-12 18:07:14	2019-05-17 16:20:31.761949	LVC	/master/data/ligo/db/S190512at/152/	1387.68 ± 322.114	BBH	This =>	Best =>
10363	**S190510g**	2019-05-10 02:59:39	2019-05-10 10:47:19.047701	LVC	/master/data/ligo/db/S190510g/152/	227.221 ± 92.413	BNS	This =>	Best =>
10644	**S190503bf**	2019-05-03 18:54:04	2019-07-30 15:03:36.592837	LVC	/master/data/ligo/db/S190503bf/150/	421.108 ± 104.533	BBH	This =>	Best =>
10201	**S190426c**	2019-04-26 15:21:55	2019-04-26 16:39:31.835087	LVC	/master/data/ligo/db/S190426c/152/	375.432 ± 108.174	BNS	This =>	Best =>
10198	**S190425z**	2019-04-25 08:18:05	2019-04-26 15:16:33.849222	LVC	/master/data/ligo/db/S190425z/152/	156.144 ± 41.3734	BNS	This =>	Best =>
10196	**S190421ar**	2019-04-21 21:38:56	2019-04-22 17:06:12.033586	LVC	/master/data/ligo/db/S190421ar/151/	2281.32 ± 696.623	Terr	This =>	Best =>
10185	**S190412m**	2019-04-12 05:30:44	2019-04-12 06:40:50.026518	LVC	/master/data/ligo/db/S190412m/150/	812.179 ± 194.141		This =>	Best =>
10183	**S190408an**	2019-04-08 18:18:02	2019-04-09 13:48:07.07137	LVC	/master/data/ligo/db/S190408an/151/	1472.9 ± 357.875		This =>	Best =>
10186	**S190405ar**	2019-04-05 16:01:30	2019-04-12 15:17:49.139004	LVC	/master/data/ligo/db/S190405ar/152/	268.106 ± 128.788		This =>	Best =>
10066	**G299232**	2017-08-25 13:13:37	2017-08-29 16:08:46.552308	LVC	/master/data/ligo/db/G299232/151/	254.502 ± 86.5358		This =>	Best =>
10070	**G298936**	2017-08-23 13:13:58	2017-08-29 17:21:36.838523	LVC	/master/data/ligo/db/G298936/152/	1541 ± 415.434		This =>	Best =>
10047	**G298389**	2017-08-19 15:50:46	2017-08-19 [illegible]	[illegible]	[illegible]/G298389/151/	±		This =>	Best =>
10174	**GW170818**	2017-08-18 02:25:09.1	2019-03-14 [illegible]	[illegible]	[illegible]/GW170818/150/	567.547 ± 112.025		This =>	Best =>
10071	**G298048**	2017-08-17 12:41:0[illegible]	[illegible]	[illegible]	[illegible]/ligo/db/G298048/152/	39.77 ± 8.30844		This =>	Best =>
10[illegible]	**[illegible]7595**	[illegible]7-08-[illegible] 10:30[illegible]	[illegible]	[illegible]	/master/data/ligo/db/G297595/152/	534.286 ± 131.305		This =>	Best =>

Very Bright GRB160625B

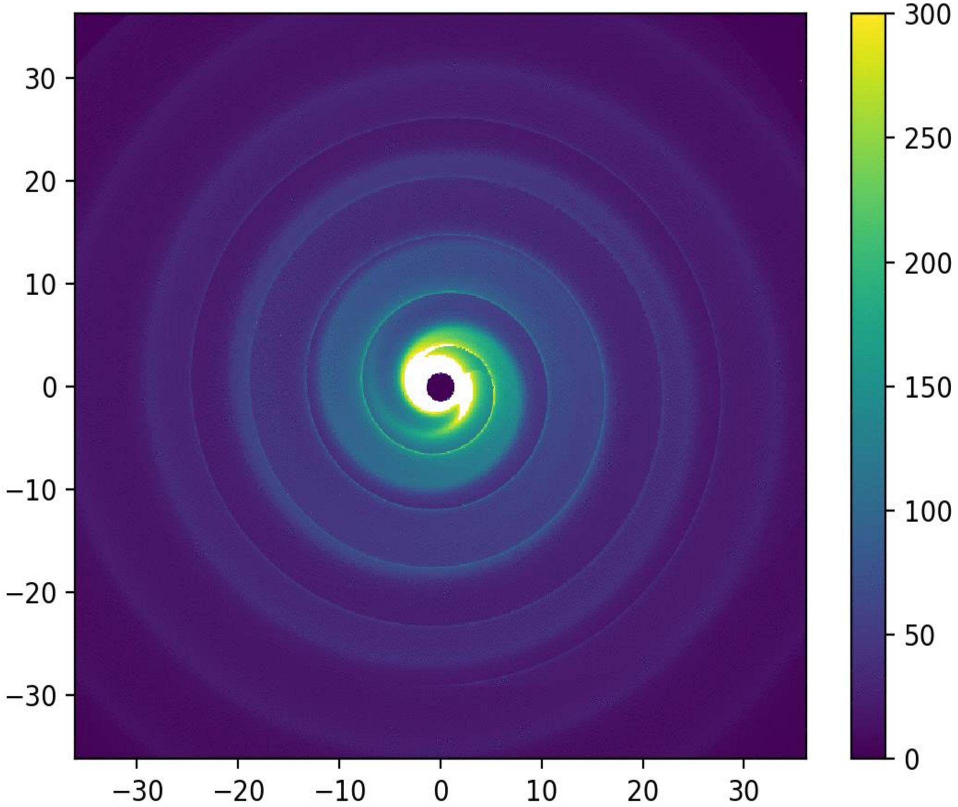


The black curve is the MASTER optical curve,
red - Fermi LAT observations (> 1 MeV)



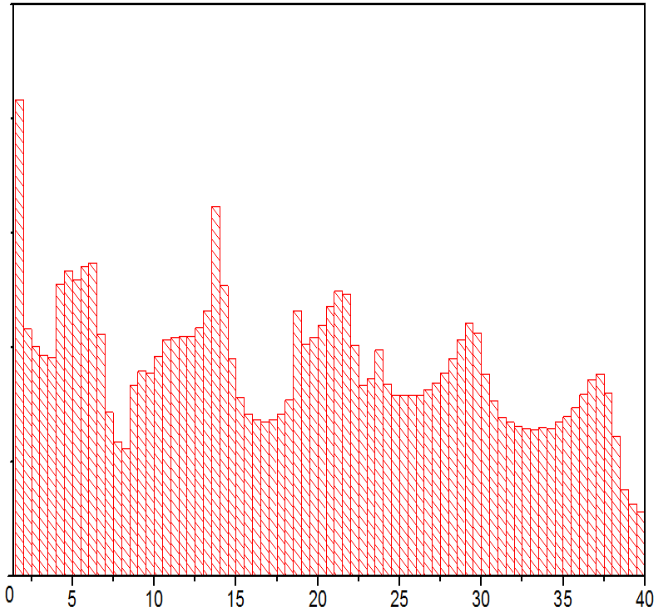
The black curve is the MASTER optical curve, red - Fermi LAT observations (> 1 MeV)

Model A: The gravitational impact of a companion star (NS) directly on the stellar wind. (Topolev et al.,2019)



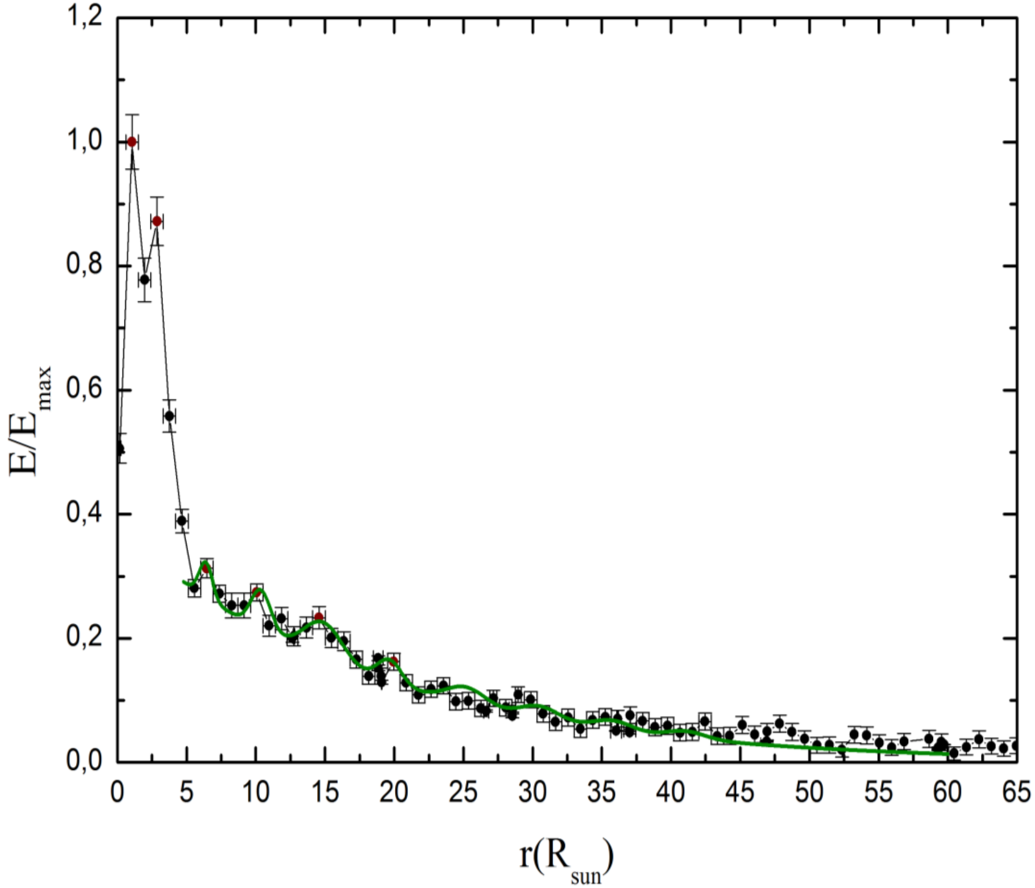
Параметры моделируемой системы:

1. $M_1 = 1.5M_\odot$
2. $M_2 = 20M_\odot$
3. $R_2 \approx 1.4R_\odot$
4. $v_\infty \approx 1300$ км/c
5. T ≈ 5800 c



The x, y axes show the distance in solar radii, the relative density of particles is shown in color (above)

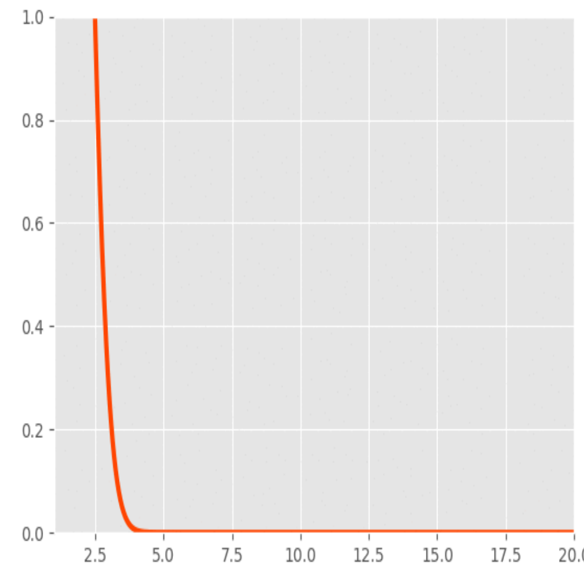
Density distribution on the line of sight, x - distance in the radii of the Sun, y - relative density (right)



Model B: a companion star (NS) is drawn in an ellipse relative to a collapsing star; passage through the pericenter of the orbit perturbs the main star. The stellar wind flux density increases, creating a density wave that is already accelerating according to the stellar wind acceleration law (Topolev et al.,2019):

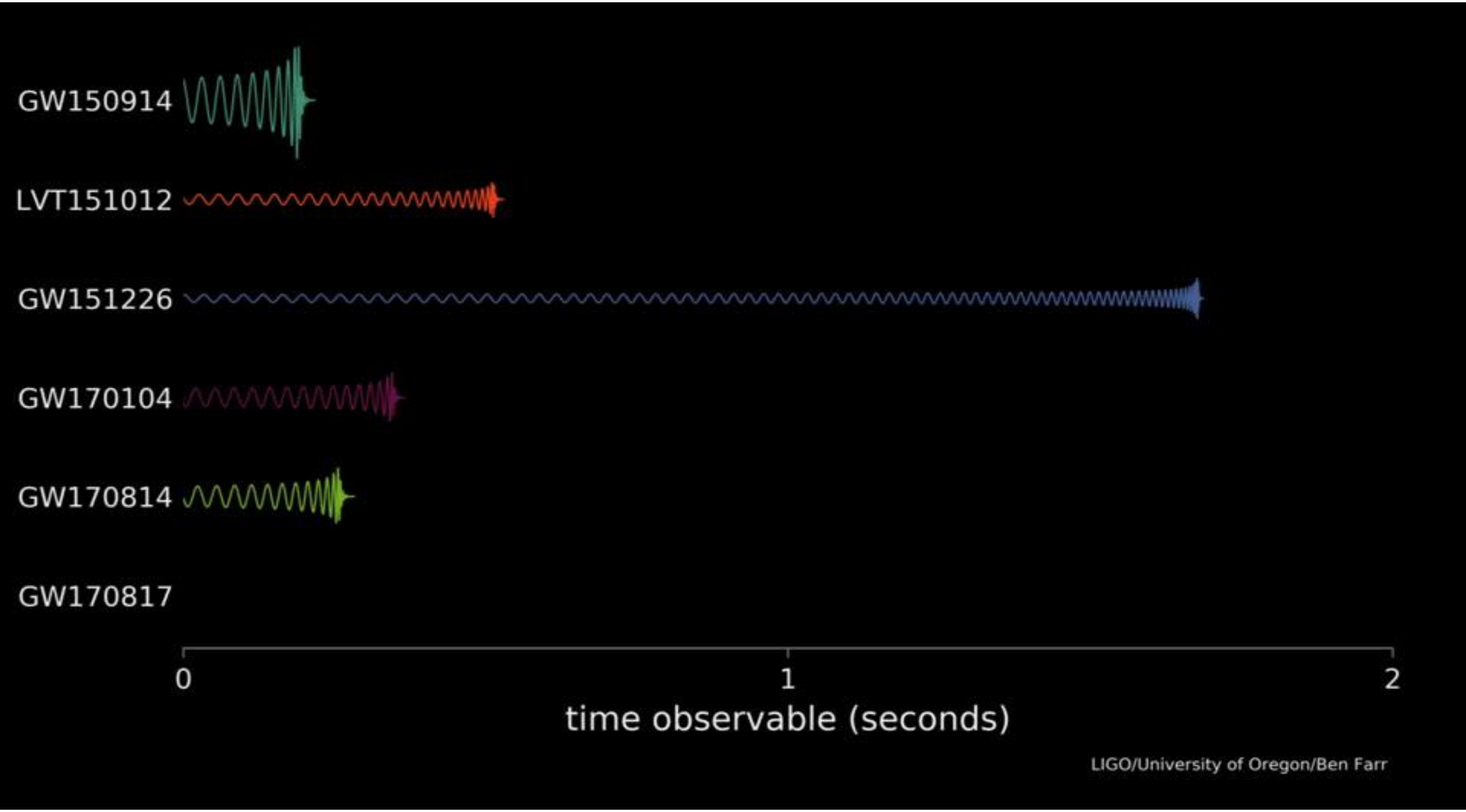
$$v = v_\infty \sqrt{1 - R_{surf}/r}^{\,\beta}$$

[Michalas, D. "Stellar atmospheres"]



Зеленый - модельная кривая для параметров: радиус поверхности испускания – 1,4 R⊙ ; Tsystem ≈ 7200 с; $v\infty$ ≈ 500км/с (Сверху)

Движение волн плотности в радиальном направлении (Справа)


GW150914
LVT151012
GW151226
GW170104
GW170814
GW170817
0
1
2
time observable (seconds)
LIGO/University of Oregon/Ben Farr

SPINAR COMEBACK!

- *Lunan Sun, Milton Ruiz, Stuart L. Shapiro, Phys. Rev. D 99, 064057 (2019)* - **Magnetic Braking and Damping of Differential Rotation in Massive Stars**

- *Milton Ruiz, Antonios Tsokaros, Vasileios Paschalidis, and Stuart L. Shapiro, Physical Review D, Volume 99, Issue 8* - **Effects of spin on magnetized binary neutron star mergers and jet launching**

- *Maurice H.P.M. van Putten and Massimo Della Valle, Mon. Not. R. Astron. Soc.000, 1–9, 4 September 2018* **Observational evidence for Extended Emission to GW170817**

MODERN CALCULATIONS and observations

- *Lunan Sun, Milton Ruiz, Stuart L. Shapiro, Phys. Rev. D 99, 064057 (2019)* - **Magnetic Braking and Damping of Differential Rotation in Massive Stars**

- *Milton Ruiz, Antonios Tsokaros, Vasileios Paschalidis, and Stuart L. Shapiro, Physical Review D, Volume 99, Issue 8* - **Effects of spin on magnetized binary neutron star mergers and jet launching**

- *Maurice H.P.M. van Putten and Massimo Della Valle, Mon. Not. R. Astron. Soc.000, 1–9, 4 September 2018* **Observational evidence for Extended Emission to GW170817**

New Spinar consideration

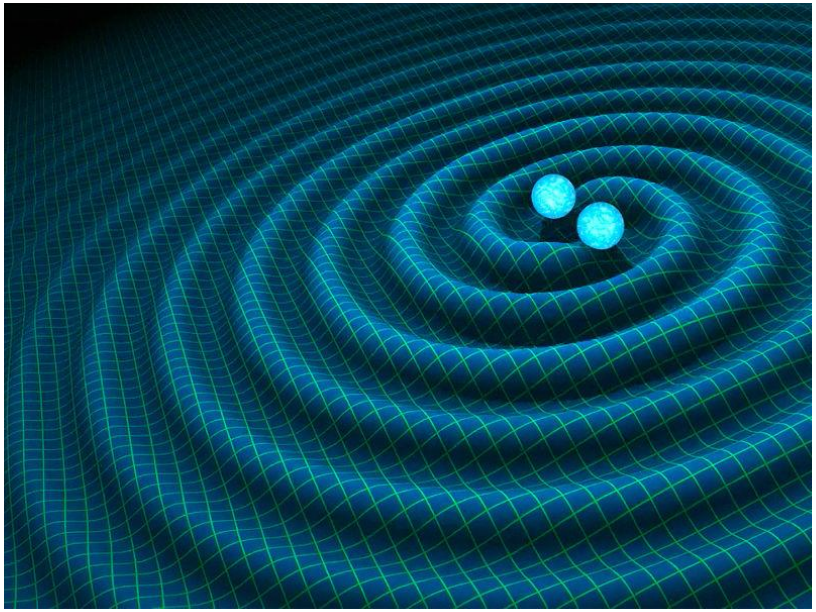
(Posdnyakov et al. 2019, in preparation):

- *Nuclear pressure*
- *Lense-Thirring effect*
- *Disappearance of the magnetic field during collapse*
- *Angular momentum losses*
- *New: Dynamo-mechanism*

Before merger:

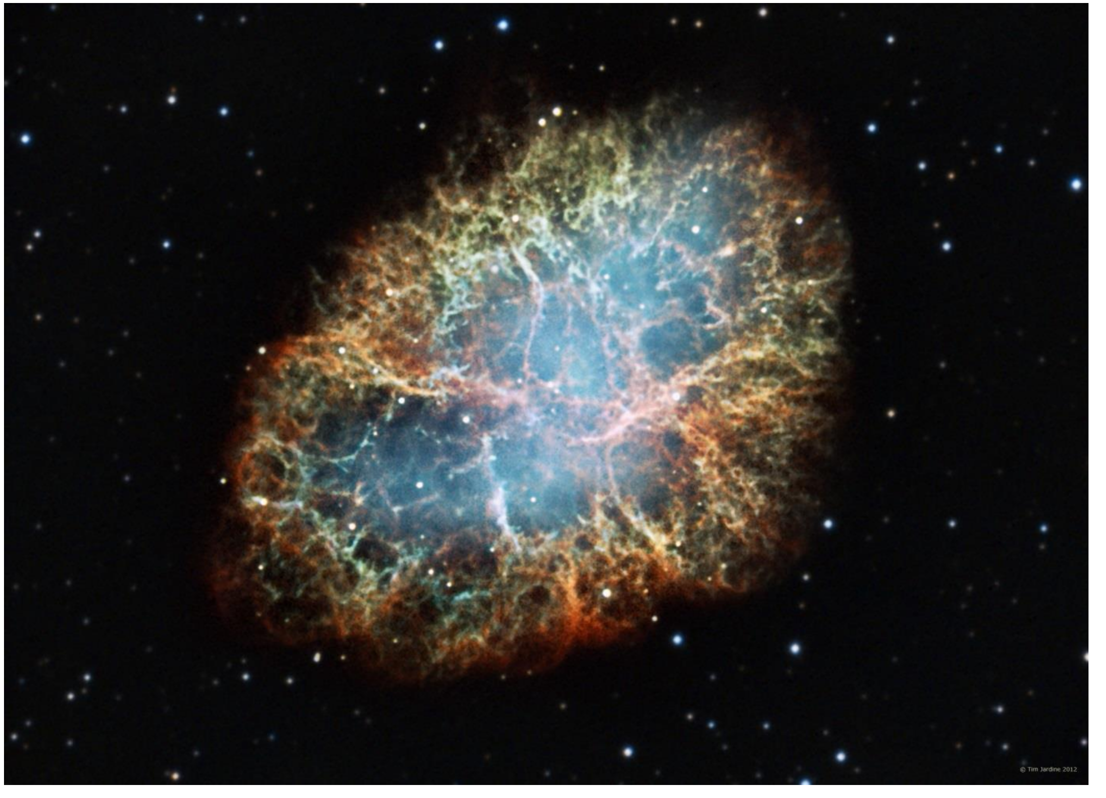
$$L_g = \frac{32G^4 M_1^2 M_2^2 (M_1 + M_2)}{5c^5 A^5}$$

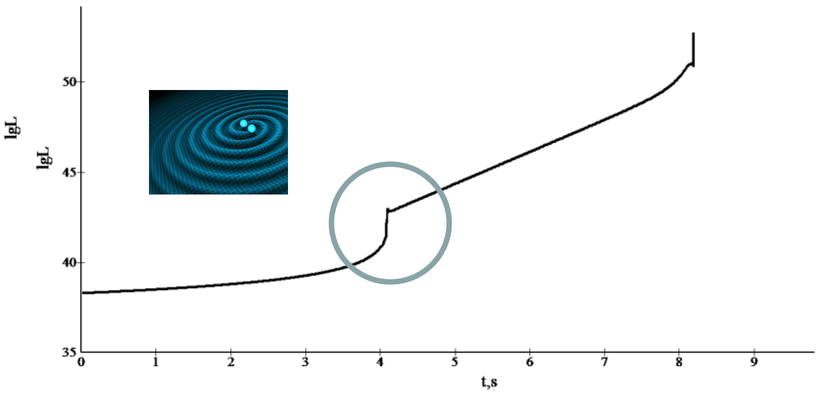
$$L = \frac{\dddot{D}^2}{180c^5}$$



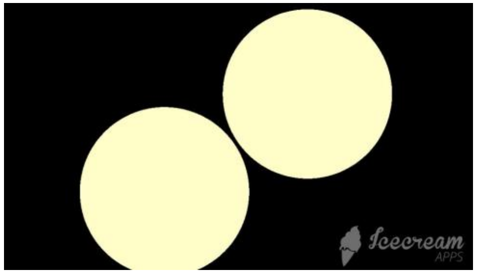
optical radiation

- We assume that the spinar spectrum corresponds to the Crab pulsar (B0531+21) spectrum.

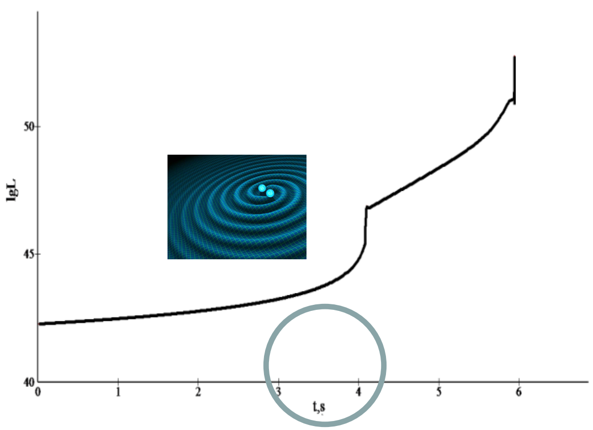


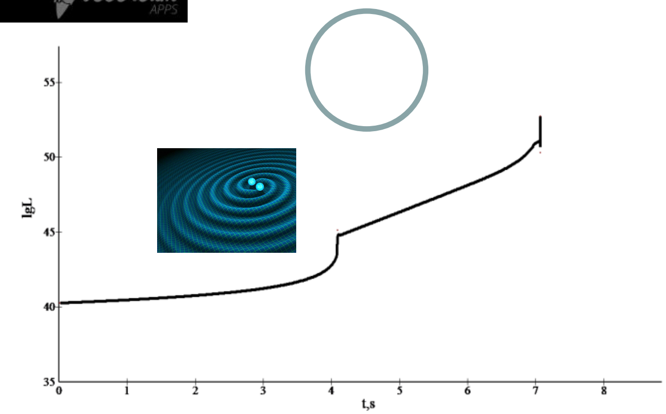


$$B = 10^{12} G$$

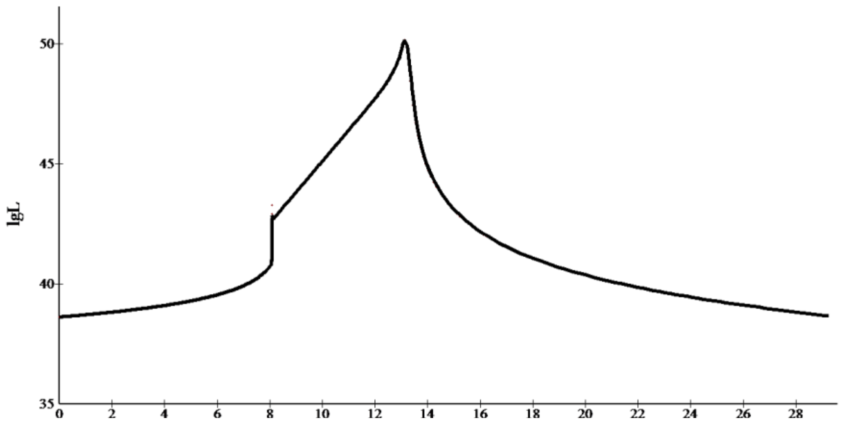


$$B = 10^{13} G$$





$$B = 10^{14} G$$


lgL
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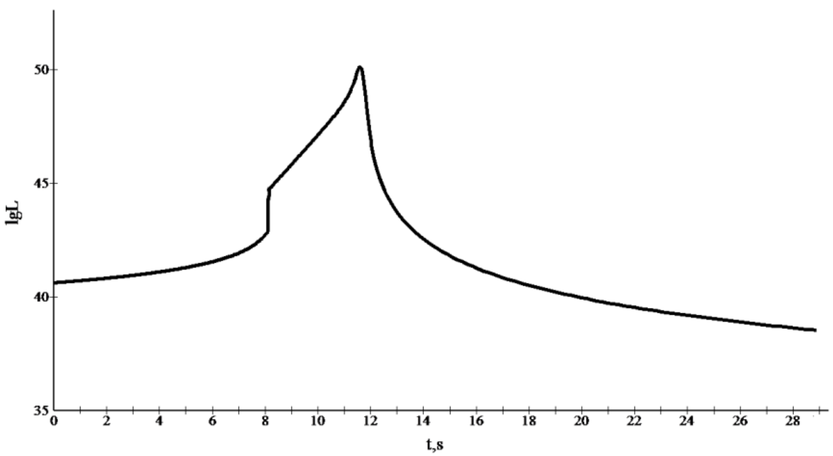
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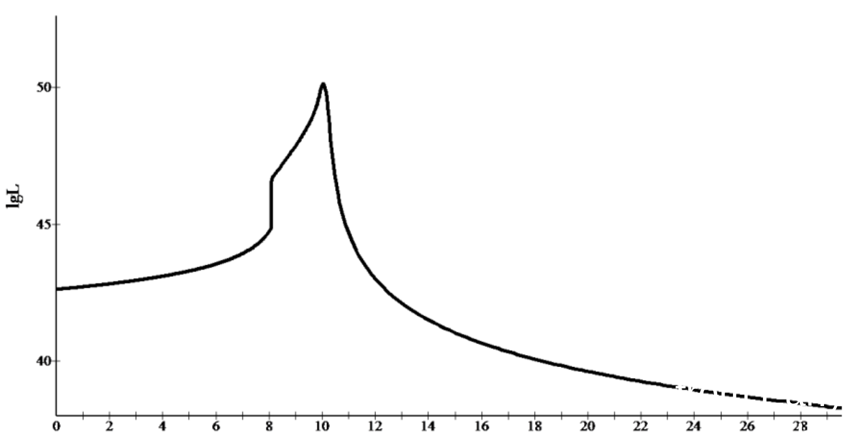
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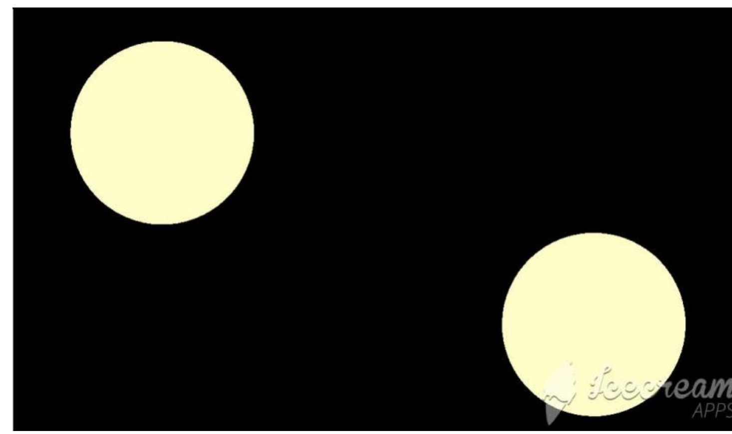
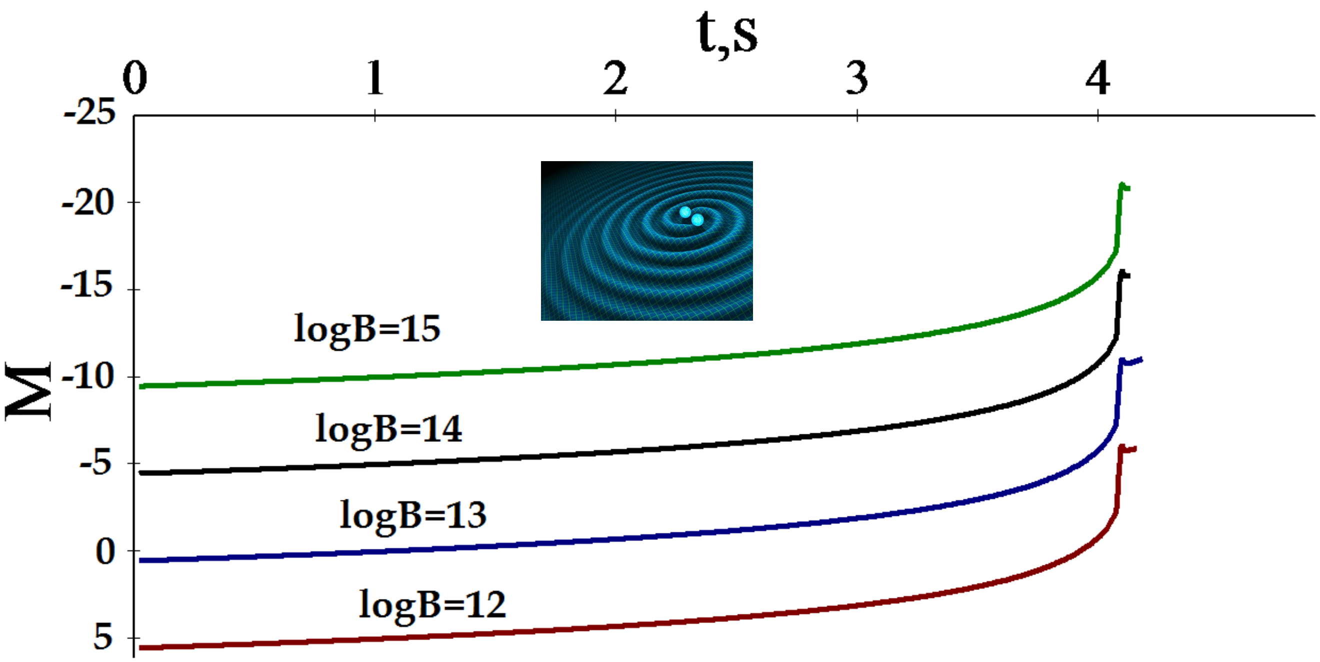
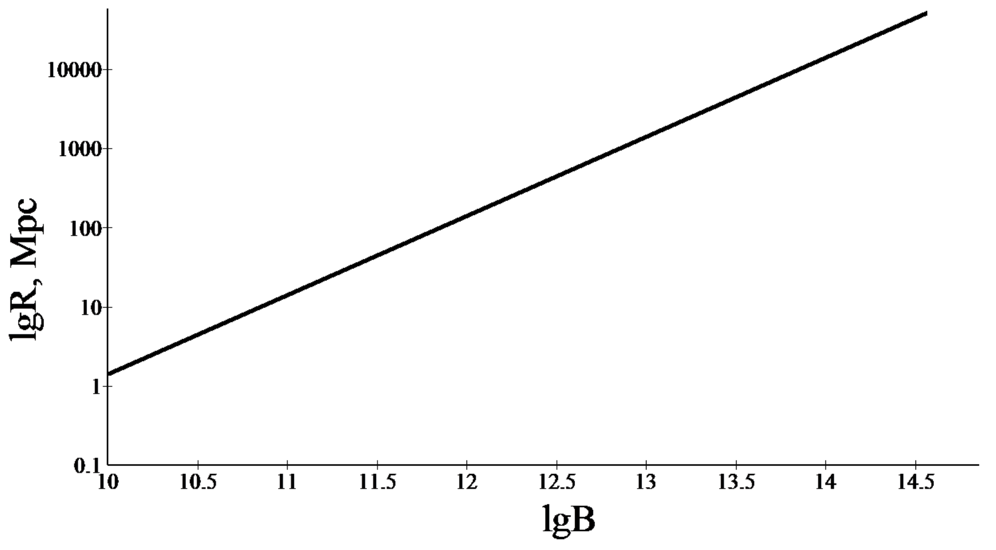


Pozdnyakov et al., in prep.
GW precursor



MASTER can see the optical transient:



Summary

- The magnetic field strongly affects the electromagnetic luminosity
- For usual electromagnetic fields we can see the optical transient at a distance about 200-300 Mpc
- At these distances in the radio band can radiate about 20 Ya at a frequency of 178 MHz

Perspectives

- More detailed account of differential rotation
- Accounting of statistical data on magnetic fields of neutron stars
- More detailed account of the jet

5 UNSOLVED OBSERVATIONAL GRB PROBLEMS

I. The discovery of the most distant objects in the Universe. **+-**

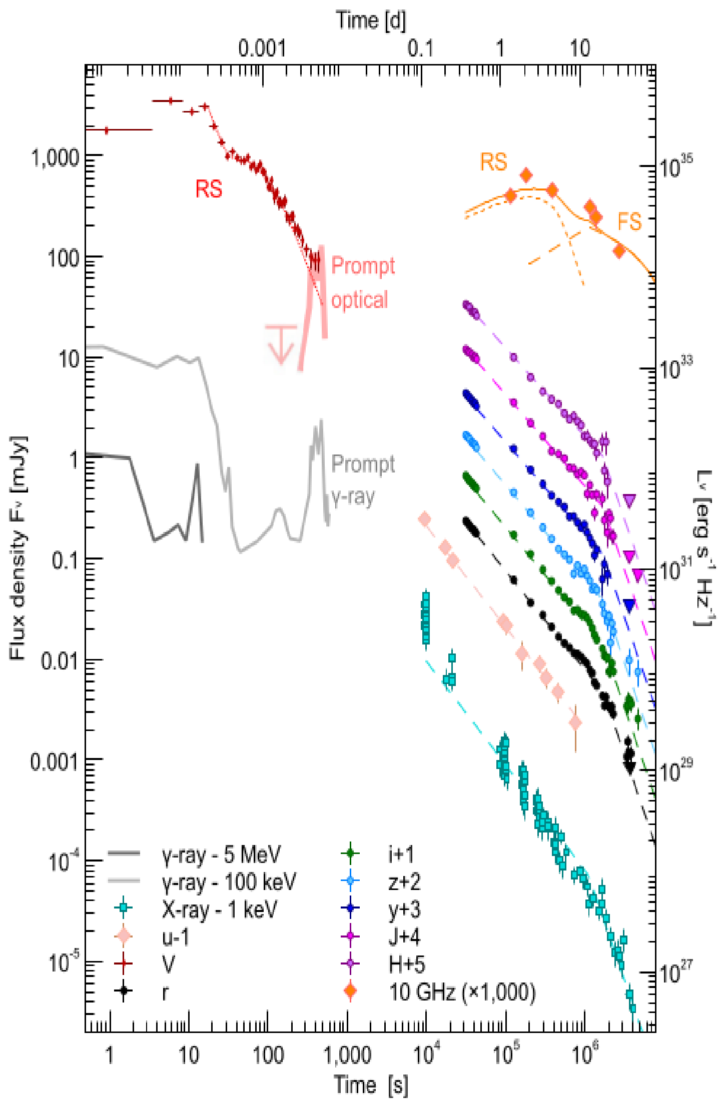
II. Prompt optical Short GRB emission detection. **-**

III. Optical emission Precursor detection for GRB. **-**

IV. High time resolution observations of the prompt optical/UV/IR emission. **-+**

V. NS+BH localization

Thank you for attention



Extended Data Figure 1 | Multiwavelength light curves for GRB 160625B and its afterglow. Different emission components shape the temporal evolution of GRB 160625B. On timescales of seconds to minutes after the explosion, we observe bright prompt (solid lines) and reverse-shock (dotted lines) components. On timescales of hours to weeks after the burst, emission from the forward shock (dashed lines) becomes the dominant component from X-rays down to radio energies. After about 14 days, the afterglow emission falls off at all wavelengths. This phenomenon, known as jet-break, is caused by the beamed geometry of the outflow. Error bars denote 1σ limits; upper limits are 3σ. Times are given with reference to the LAT trigger time T_0. FS, forward shock; RS, reverse shock; a subscript 'ν' refers to frequency; u, V, r, i, z, y, J and H denote specific optical filters.

Early Multimessanger