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Discovering EM counterparts with ZTF, DECam, and GROWTH facilities

Igor Andreoni

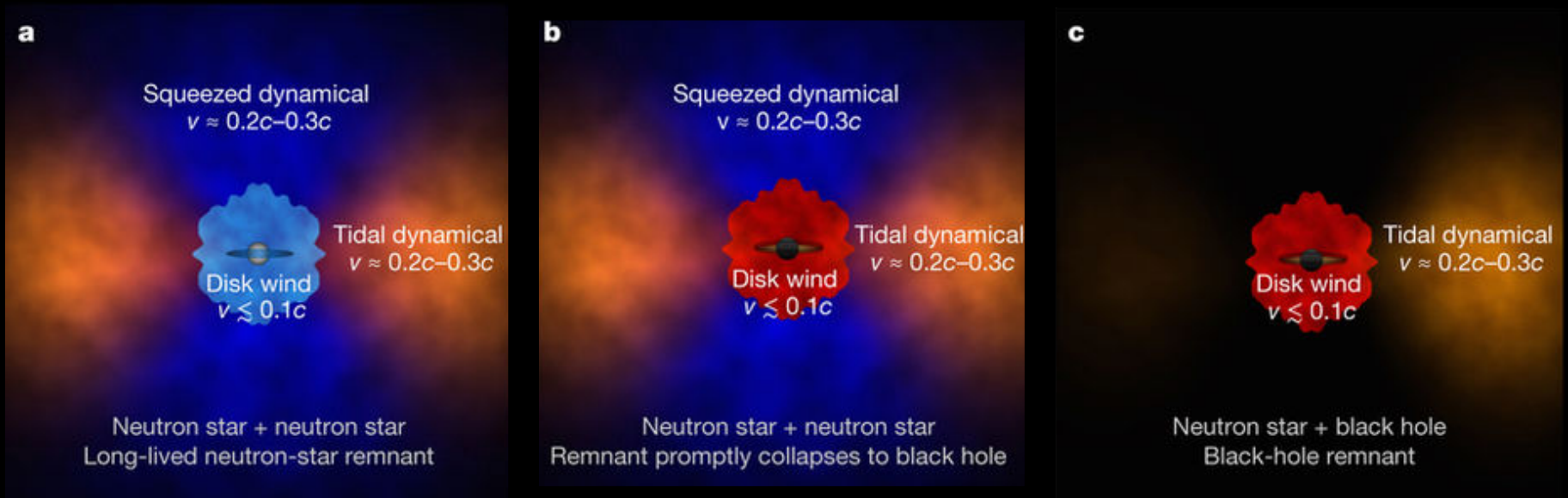


Global Relay of Observatories Watching Transients Happen

Groningen, March 28th, 2019

Kilonovae

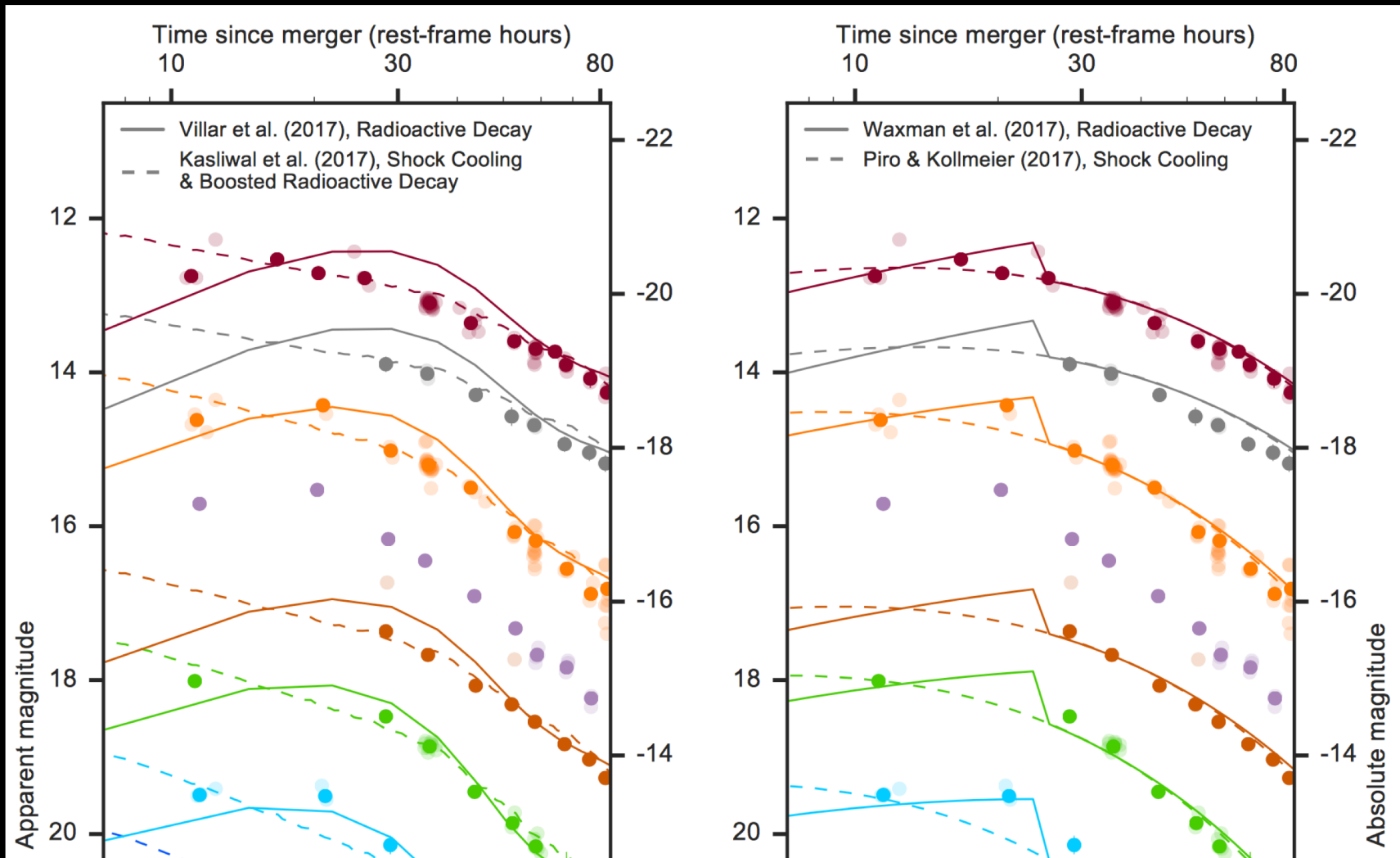
Optical/IR signatures of neutron star mergers



Kasen+17

Dominant sites of
heavy element nucleosynthesis
in the Universe?

Why is rapid detection important?



Modified from Arcavi+18

Kilonova discovery wishlist

Optical/IR discovery facilities

Wide field of view

Deep imaging

Both Northern and Southern hemisphere

Automatic scheduling, optimized observing strategy

Automatic data processing pipelines

Photometric & spectroscopic follow-up

Image credit: NASA

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Image credit: NASA

GROWTH

Global Relay of Observatories Watching Transients Happen



PI Mansi Kasliwal
(Caltech)

March 28th, 2019



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Image credit: NASA

Imagers for discovery

DECam $g < 24$

ZTF $g < 20.5$



ZTF

Samuel Oschin 48-inch Schmidt telescope @Palomar, CA, USA



Baseline strategy: g+r+g



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DECam

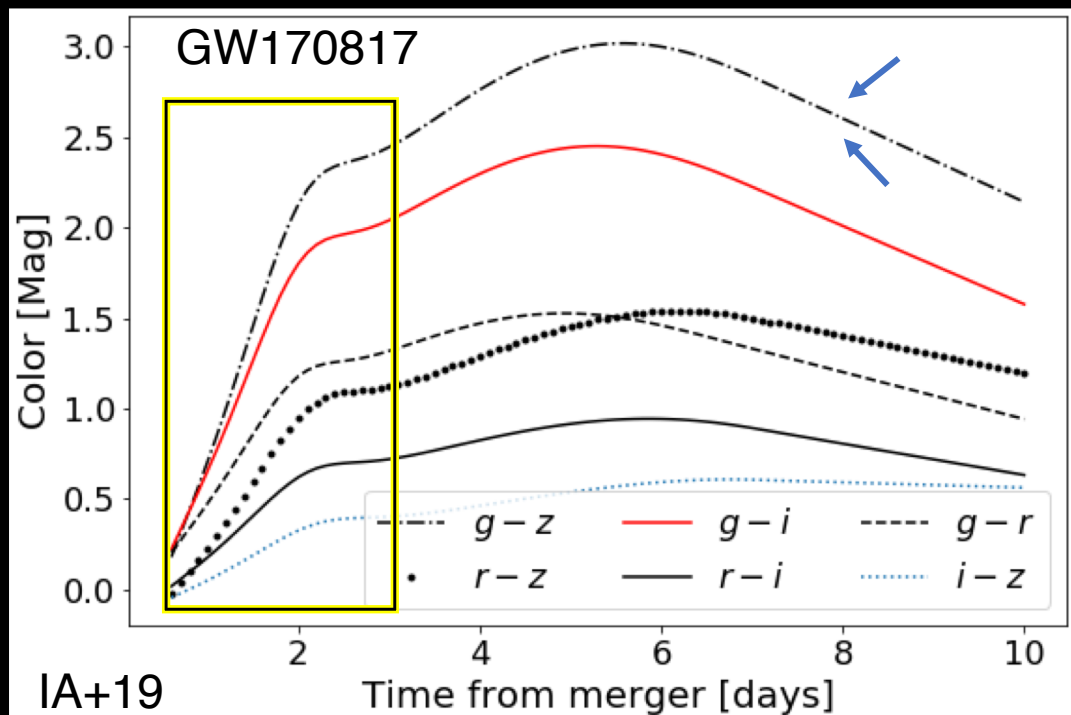
4m Blanco telescope @CTIO, Chile



PI Andreoni & Goldstein

“Public DECam Follow-Up of Neutron Star Mergers during O3” – NOAO proposal 2019A-0205

Approved – 2 triggers



Baseline strategy:

Night 1 $g+z+g$

Night 2 $g+z$

GROWTH kilonova discovery facilities

Gattini IR

Aperture: 0.3m
FoV: 25 deg²
Palomar, USA
Synoptic

ZTF

Aperture: 1.2 m
FoV: 47 deg²
Palomar, USA
Synoptic

KPED

Aperture: 2.1m
Kitt Peak, USA
Targeted

GROWTH-India telescope

Aperture: 0.7m
FoV: 1 deg²
IAO, India
Targeted

DECam

Aperture: 4m
FoV: 2.5 deg²
CTIO, Chile
Synoptic



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Image credit: NASA

GROWTH ToO Marshal



Leo Singer
(NASA)



Michael Coughlin
(Caltech)

IA
(Caltech)



Tomas Ahumada
(UMD)

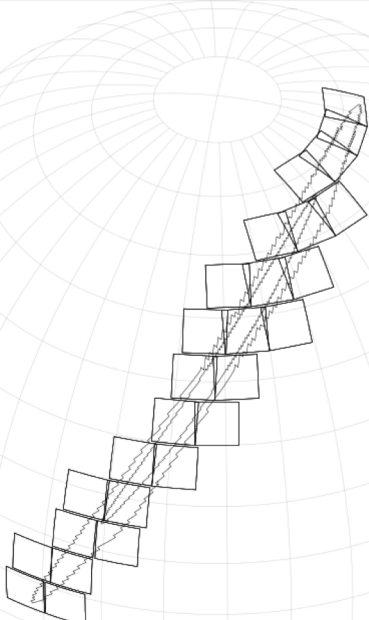


Shreya Anand
(Caltech)


GROWTH ToO Marshal







190327-07:30:38 (an hour ago) LVC GW BNS MDC retracted

Overview Planning Objects



+ New... Delete Go!

Name	Status	Start	End
DECam			
 gz_greedy_1_1_integrated_50_90	READY	2019-03-27 07:37:55.410137	2019-03-28 07:37:55.410137

Name	Status	Start	End
DECam			
 gz_greedy_1_1_integrated_50_90	READY	2019-03-27 07:37:55.410137	2019-03-28 07:37:55.410137
 schedule_greedy_P50_gfilter	WORKING	2019-03-27 09:10:34.721493	2019-03-28 09:10:34.721493
Gattini			
 J_greedy_0_0_block_300_90	READY	2019-03-27 07:37:55.410297	2019-03-28 07:37:55.410297
GROWTH-India			
 r_greedy_0_0_integrated_300_90	READY	2019-03-27 07:38:16.508942	2019-03-28 07:38:16.508942
KPED			
 r_greedy_0_0_integrated_300_90	READY	2019-03-27 07:37:55.416555	2019-03-28 07:37:55.416555
ZTF			
 grg_greedy_0_1_block_300_90	READY	2019-03-27 07:37:55.407433	2019-03-28 07:37:55.407433

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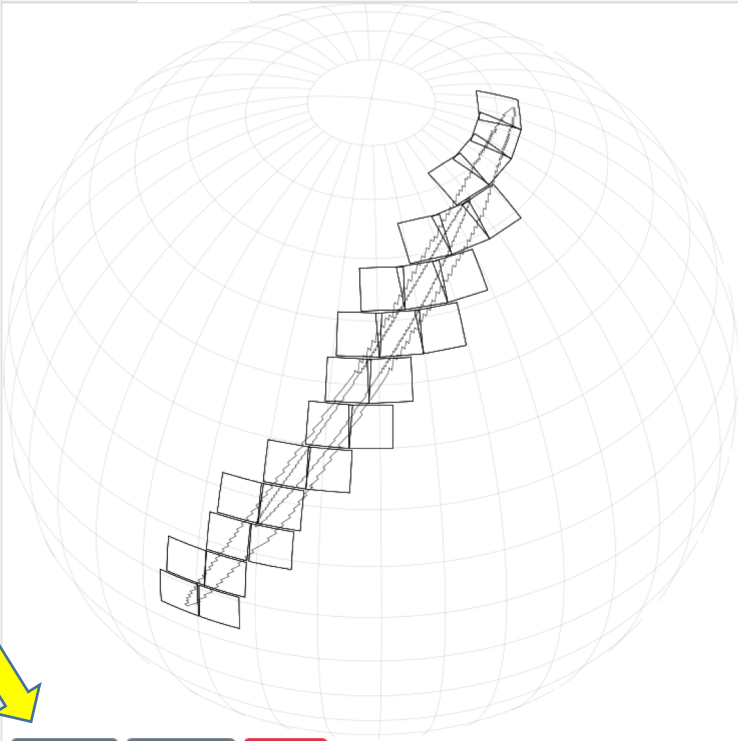
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GROWTH ToO Marshal

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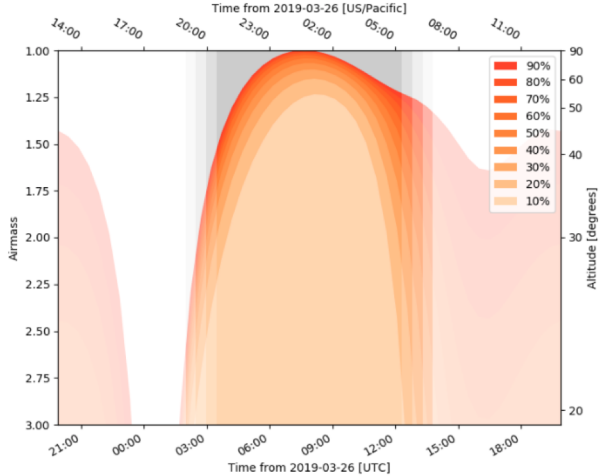
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Create Observation Plan



Telescope: ZTF Localization: bayestar.fits.gz

Start time: 2019-03-27 09:09:00 End time: 2019-03-28 09:09:00

Exposure time (s): 300 Filters: g,i Options: ☐ Dither ☒ Require references

Available filters: g, r, i

Algorithm: greedy sear airmass_weigh block integrated Scheduling: integrated Integrated probability: 90

Plan name: REPLACE ME

Create

March 28th, 2019



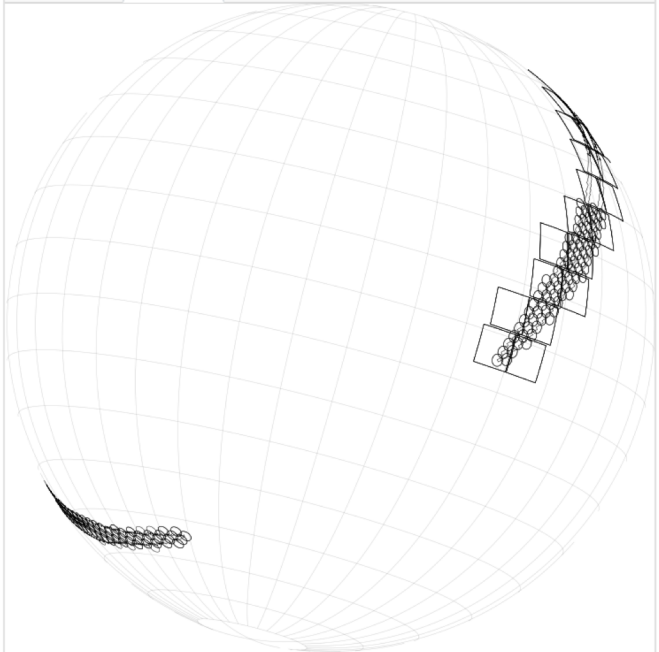
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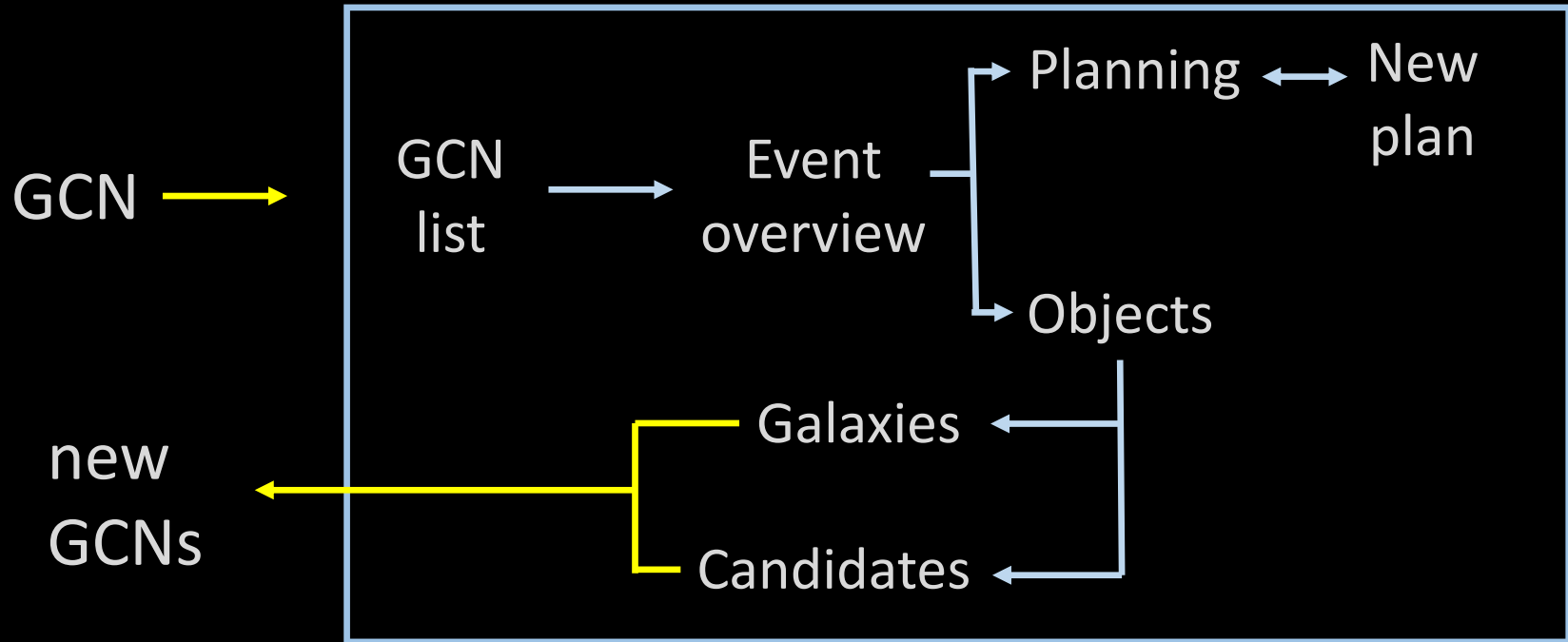
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GRB	Area covered	% Probability covered	r-band limiting magnitude	Objects followed-up	GCN ID
GRB180523 B	2900 deg^2	60%	$r > 20.3$	14	22739
GRB180626C	275 deg^2	87%	$r > 20.9$	1	22871
GRB180715B	254 deg^2	37%	$r > 21.4$	14	22969
GRB180728B	334 deg^2	76%	$r > 18.7$	7	23379
GRB180913A	546 deg^2	53%	$r > 22.2$	12	23324
GRB181126B	1400 deg^2	66%	$r > 20.5$	11	23515

Table by Tomas Ahumada

GROWTH ToO Marshal



<https://github.com/growth-astro/growth-too-marshal>

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ZTF: Masci+19
DECam: IA & Goldstein

Image credit: NASA

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GROWTH Marshal

Kasliwal+19

Developed and maintained
by Ashot Bagdasaryan (Caltech)

Follow-up facilities

P48/ZTF

Gemini

Keck

GROWTH-India

AAT

Mount Laguna telescope

Ishigakijima Astronomical Observatory

Himalayan Chandra Telescope

Lulin Observatory

Stella Robotic Observatory

Giant Metre-Wave Radio Telescope

Total Number of SNe: 1420 | Ia: 921 | II: 325 | Ib: 26 | Ic: 35 | Ibc: 5 | Ic-BL: 16 | SLSNe: 40

GROWTH Followup Marshal

 view source

 cone search

 view report

 view spectra

 at an observing run

 scan for candidates

Welcome, Igor

Currently Displaying For

 newsfeed

Transient Advocate: n/a

 **Richard Walters** commented on [ZTF19aanoawn](#):
"pysedm_report" [[view attachment](#)]
4 minutes ago

 **Richard Walters** uploaded a P60 (SED)
spectrum to [ZTF19aanoawn](#) from 2019-03-27
4 minutes ago

 **Steve Schulze** set the redshift of [ZTF19aannbj](#)
to 0.0871
1 hour ago

 **Kishalay De** classified [ZTF19aanesxt](#) and
[ZTF19aanbojt](#) as "SN Ia"
2 hours ago

 **Kishalay De** set the redshift of [ZTF19aanesxt](#)
and [ZTF19aanbojt](#) to 0.048
2 hours ago

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 next runs

2019-03-27 APO+DIS
2019-03-27 DCT+Deveny+LMI
2019-03-29 APO+DIS
2019-03-31 APO+DIS
2019-04-02 Keck1+LRIS
2019-04-05 P200+DBSP
2019-04-05 Keck1+LRIS
2019-04-06 P200+DBSP
2019-04-06 Keck1+LRIS
2019-04-06 P200+DBSP
2019-04-06 APO+DIS

 Today's toO runs

Liverpool telescope

Palomar P60 & P200

Spitzer

LCOGT

Expanded Very Large Array

Neil Gehrels Swift Observatory

Nordic Optical Telescope

Fenton Hill Observatory

WISE Observatory

Girawali Observatory

Discovery Channel Telescope

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Summary

The GROWTH collaboration is ready to discover and study kilonovae during O3

Discovery facilities of the GROWTH network include ZTF, DECam, Gattini, KPED, and GROWTH-India. More than 18 observatories are lined up for follow-up.

The ToO marshal will help making discoveries. Most of the code is already public.

**Thank you
for your attention!**

Contact
andreoni@caltech.edu
igorandreoni.com