

GROWTH プロジェクト

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東京工業大学

2017-07-25@三鷹



Global Relay of Observatories Watching Transients Happen



✓ 全世界規模の観測ネットワーク
8国, 15機関, 2015年10月 ~

✓ Time-domain astronomy
重力波天体、超新星、近傍小惑星

GROWTH PIRE

@GrowthPire

The sun never rises on the GROWTH network of telescopes! An international project exploring transient cosmic events. Led by @caltech, funded by @NSF PIRE

📍 Earth

🔗 growth.caltech.edu

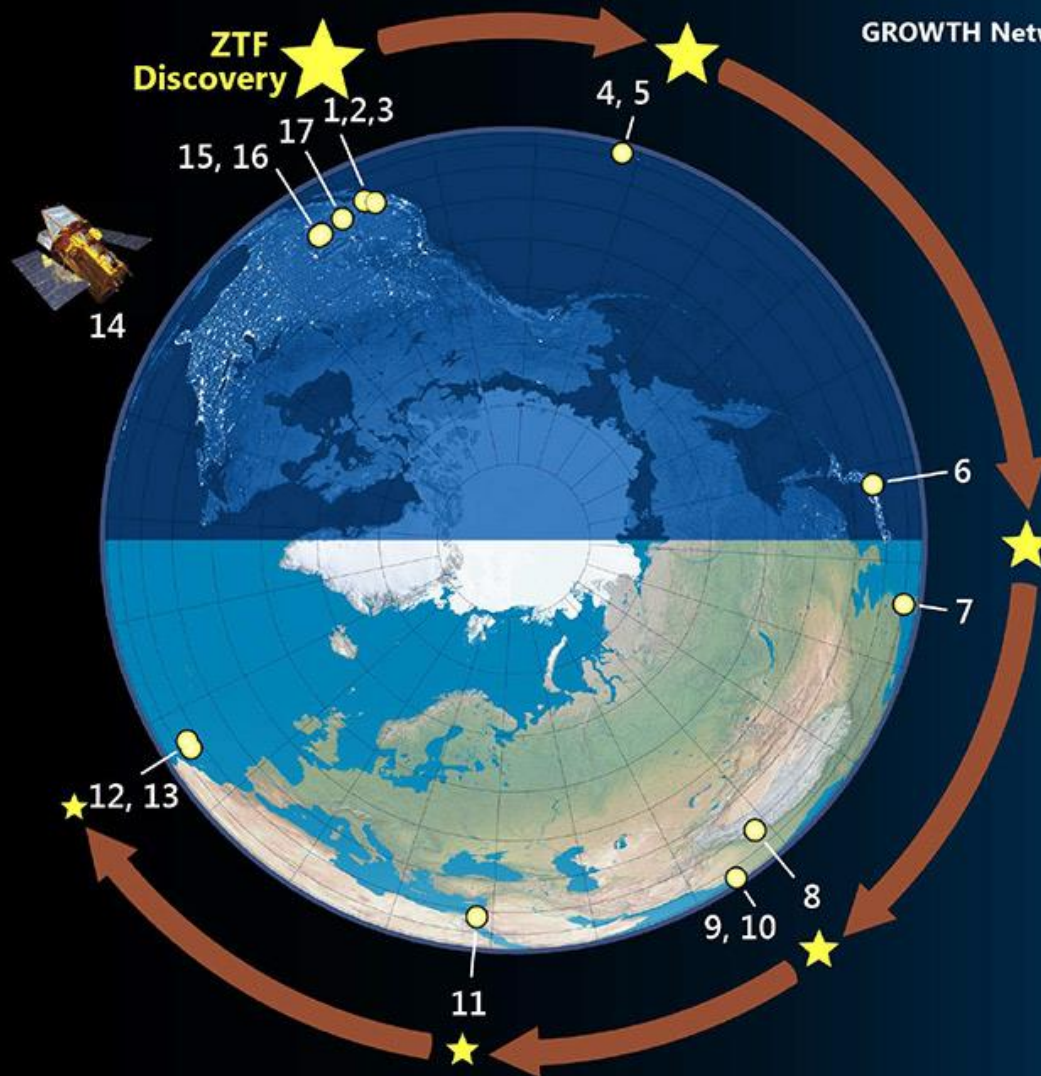
📅 2016年3月に登録

Collaboration meeting@Caltech, 2016



<https://sites.google.com/site/growthpire/>

<https://twitter.com/GrowthPire>



- GROWTH Network:**
1. **Palomar Observatory**
Caltech (USA)
 2. **Table Mountain Observatory**
Pomona College (USA)
 3. **Mount Laguna Observatory**
San Diego State University (USA)
 4. **Gemini North Observatory**
NOAO (USA) - Mauna Kea
 5. **W. M. Keck Observatory**
Caltech (USA)
 6. **Murikabushi Observatory**
Tokyo Tech University (Japan)
 7. **Lulin One-meter Telescope**
National Central University (Taiwan)
 8. **Himalayan Chandra Telescope**
Indian Institute of Astrophysics (India)
 9. **Giant Metrewave Radio Telescope**
NCRA (India)
 10. **IUCAA Girawali Observatory**
IUCAA (India)
 11. **WISE Observatory**
Weizmann Institute (Israel)
 12. **Stella Observatory**
Humboldt University (Germany)
 13. **Nordic Optical Telescope**
Oskar Klein Centre (Sweden)
 14. **Swift Satellite (Ultraviolet and X-ray)**
NASA (USA)
 15. **Expanded Very Large Array (Radio)**
NRAO (USA)
 16. **Fenton Hill Observatory**
Los Alamos National Laboratory (USA)
 17. **Discovery Channel Telescope**
University of Maryland/JSI (USA)
- + **University of Wisconsin-Milwaukee**

Credit: Image courtesy Mansi Kasliwal/Caltech

<http://www.ipac.caltech.edu/project/39>



Palomar / PTF, ZTF team

<https://www.gemini.edu/sciops/telescopes-and-sites>



<http://www.astro.caltech.edu/research/keck/>



Gemini-North
Keck



<http://www.panoramio.com/photo/70368755>

Nordic Optical telescope (NOT)/2.6m
Telescopio Nazionale Galileo (TNG)/3.6m

http://physastro.pomona.edu/wp-content/uploads/2012/08/TMO_Panorama.jpeg



Table Mt./1m

<http://bollrandchivens.com/?cat=5>



SRO/1.2m

<http://growth.caltech.edu/images/observatories/lulin.jpg>



Lulin/1m

https://upload.wikimedia.org/wikipedia/commons/c/c9/Himalayan_chandra_telescope.jpg



HCT/2m

https://en.wikipedia.org/wiki/Girawali_Observatory

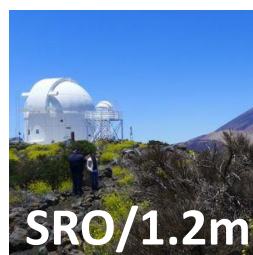


Girawali/2m



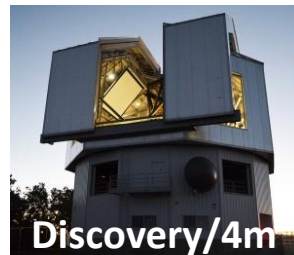
WISE/1m

https://physics.tau.ac.il/astrophysics/wise_observatory



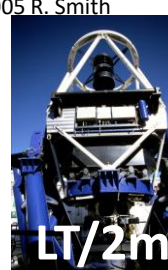
SRO/1.2m

<http://growth.caltech.edu/observatories.html>



Discovery/4m

<https://lowell.edu/research/research-facilities/4-5-meter-dct/>



LT/2m

© 2005 R. Smith

Expanded Very Large Array

Giant Metre-Wave Radio Telescope

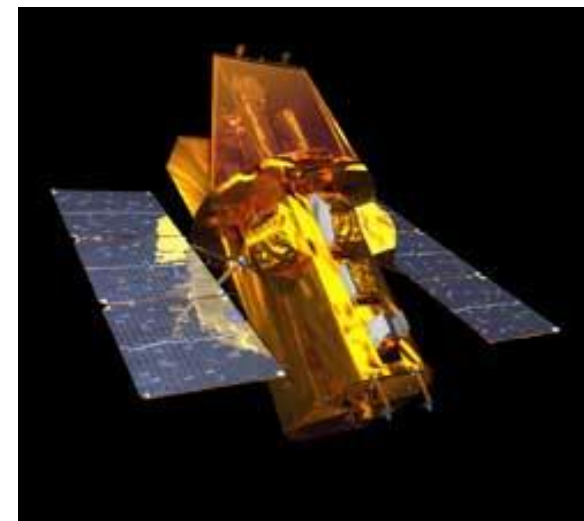


<http://www.ncra.tifr.res.in/ncra>

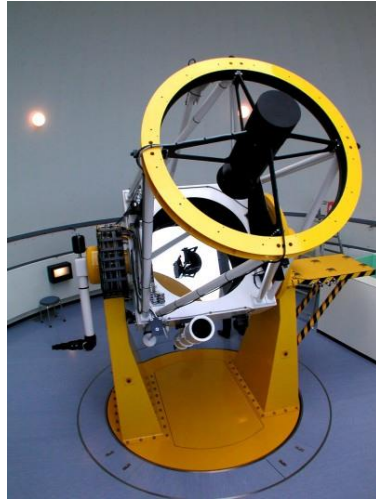


<http://growth.caltech.edu/observatories.html>

Swift

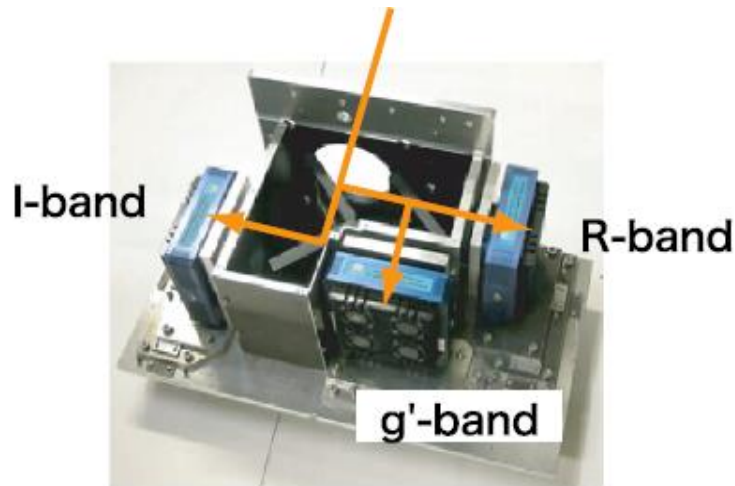


石垣島天文台
むりかぶし望遠鏡
 $d = 1.05 \text{ m}$

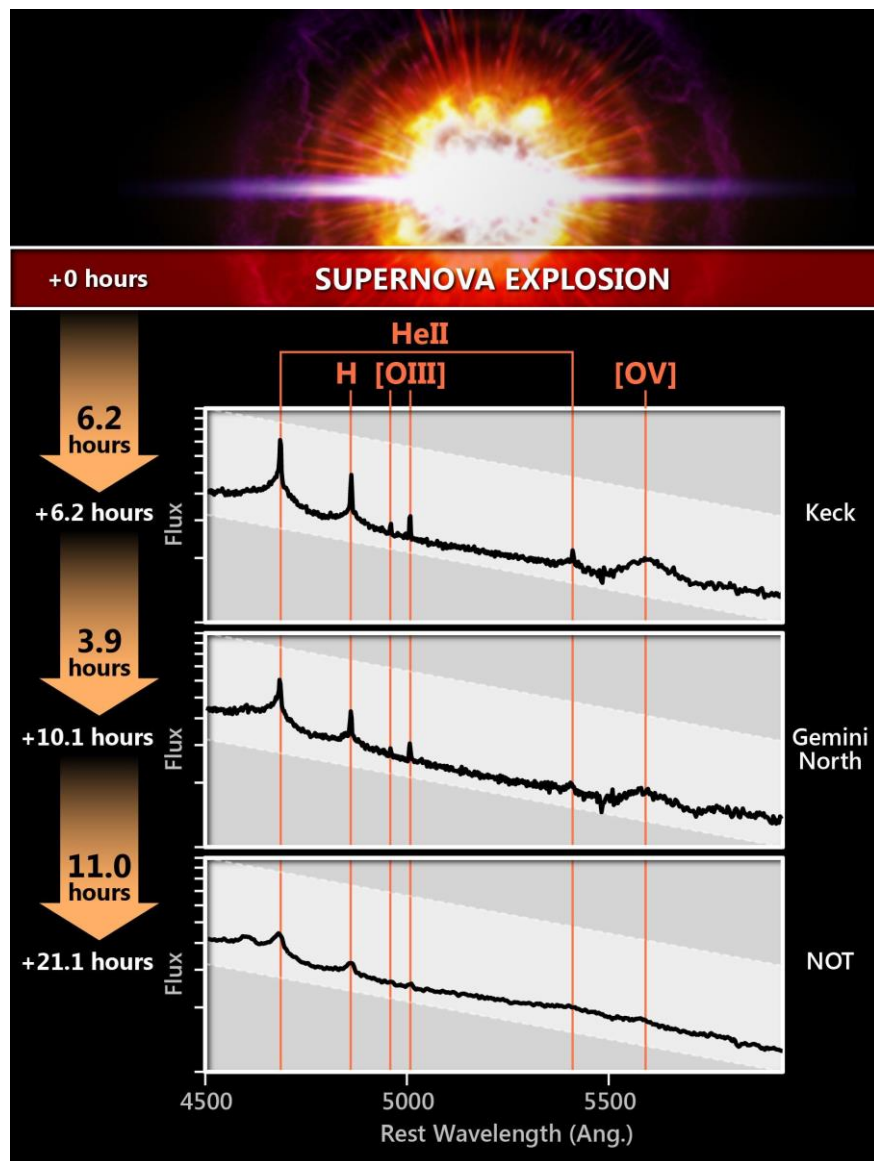


<http://www.nishimura-opt.co.jp/about/history/index.html>

東工大明野
50cm望遠鏡
 $d = 0.5 \text{ m}$

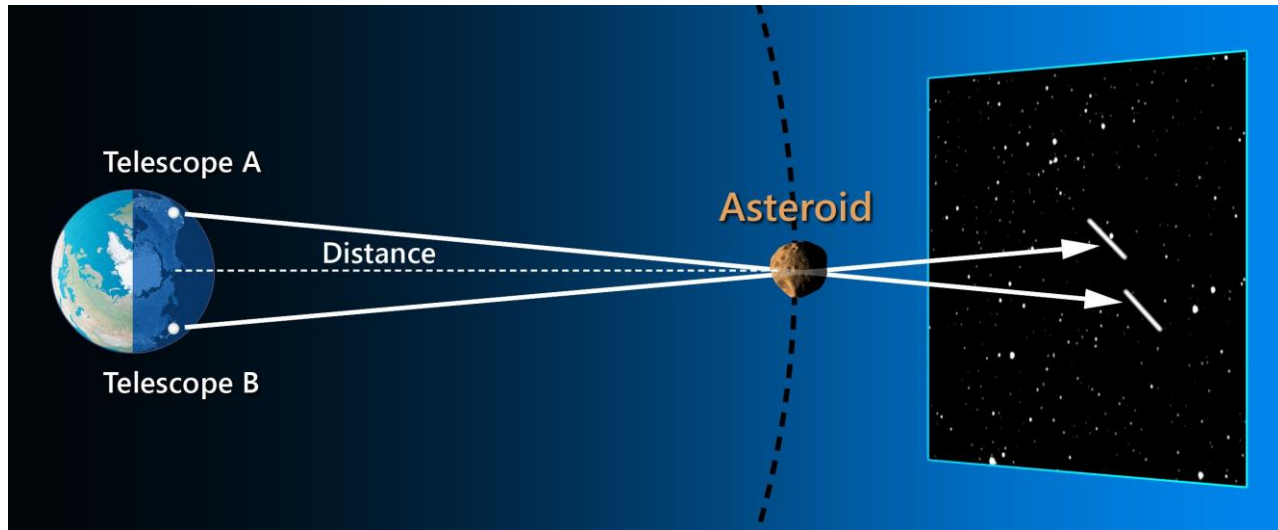


MITSuME による
可視3色同時撮像

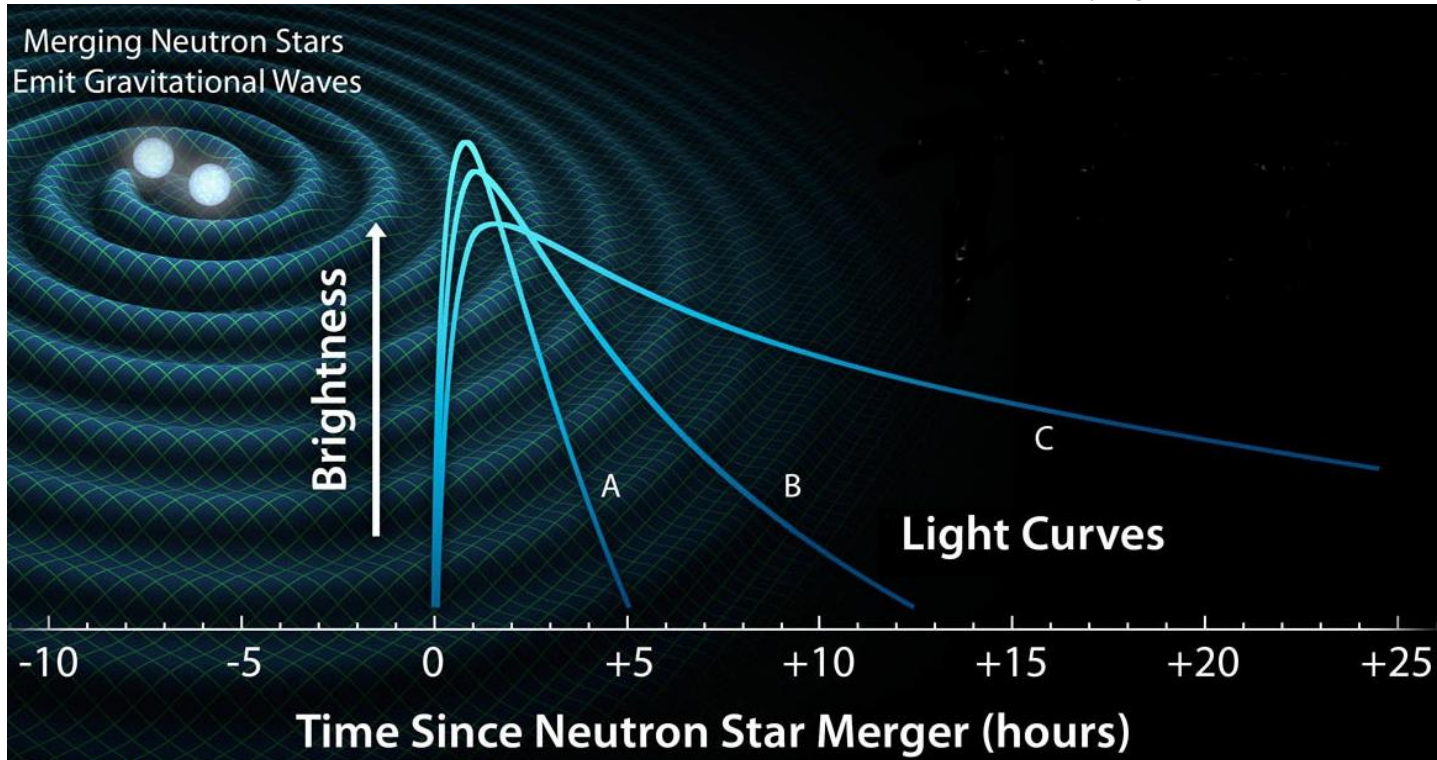


- ✓ Type II 超新星の早期分光 & 時間変動解析による重力崩壊型超新星の研究
- ✓ ZTF での探査+GROWTHによる追観測体制
- ✓ Type Ia の早期観測も実施
統計を増やして爆発機構解明を目指す

<http://growth.caltech.edu/science-questions.html>



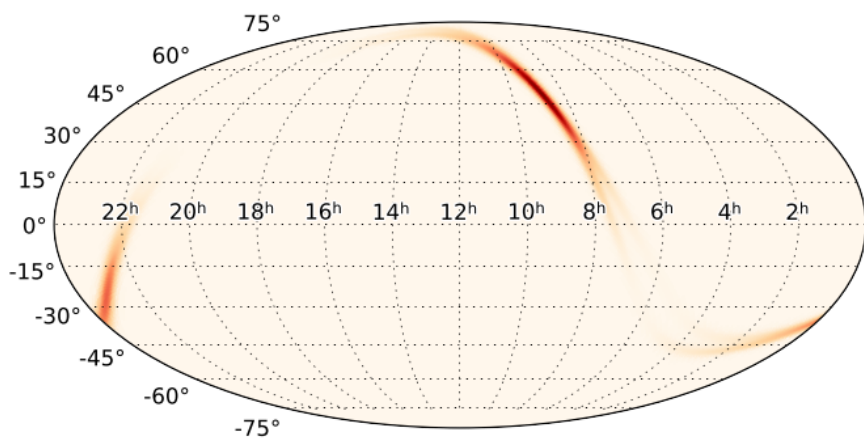
- ✓ Near-earth asteroids (NEAs) の多地点同時観測による軌道要素決定
- ✓ 分光、光度変動観測によるNEAの性質解明



- ✓ 中性子星衝突での電磁波対応天体探索
& GROWTHネットワークによるhour-scale
での追跡観測

GCN #20401, #20430

BH-BH merger

PTF survey $\sim 1069 \text{ deg}^2$ 
<https://losc.ligo.org/events/GW170104/>

iPTF17fs 162.900034 +69.833971 10:46 18.94
 iPTF17ha 230.580928 +80.725830 13:14 19.29
 iPTF17gf 272.970627 +68.486958 13:32 20.03
iPTF17ft 201.323053 +78.426314 11:09 19.95
iPTF17fu 192.417627 +80.149750 11:11 18.78
iPTF17fw 156.366148 +71.757620 10:46 18.24
iPTF17gr 193.895770 +79.226903 11:11 20.21
iPTF17gv 176.227516 +82.619152 11:04 19.77
iPTF17hc 165.400920 +68.097753 10:47 19.52
 iPTF17fe 330.745910 -03.303166 02:33 17.80 0.044
 iPTF17fg 339.797294 -17.341041 02:49 16.63 0.074
iPTF17gw 178.409537 +72.864968 10:58 19.41 0.176 photo-z
 iPTF17gj 257.427906 +70.158947 13:29 19.74 0.258 photo-z
 iPTF17he 214.716535 +79.793033 13:07 19.88
iPTF17ge 159.042893 +69.146836 10:47 19.87
iPTF17hf 195.818782 +80.173138 11:11 19.52
iPTF17hh 194.925476 +75.016124 11:08 20.34
iPTF17gu 194.101611 +78.204729 11:09 19.47
iPTF17gt 191.763759 +76.839773 11:09 19.70
iPTF17gs 199.058226 +76.521298 11:09 20.07
iPTF17hi 180.885869 +72.050360 10:58 20.30
iPTF17gn 232.045095 +74.611299 13:15 19.99
iPTF17gm 235.823172 +74.750334 13:15 19.69
 iPTF17hd 213.248302 +79.332924 13:07 19.44
 iPTF17gc 240.341194 +78.345723 13:17 19.54

ATLASで発見

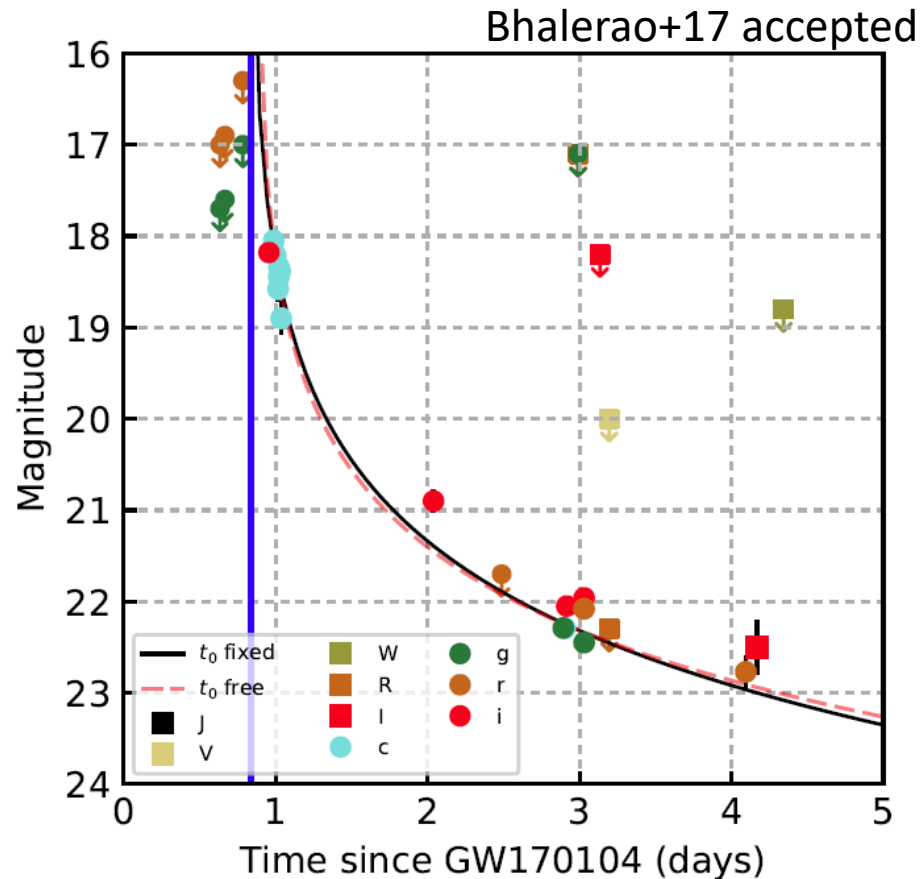
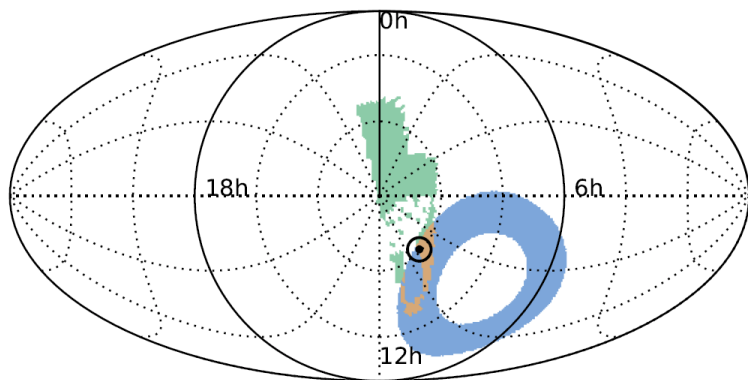
非常に速いdecay time (0.7mag/hour)

Estimated $T_0 = 57758.303 \pm 0.045$ [day]

GW170104Aの 21.1 +/- 1 時間後

AstroSat, POLAR で検出された GRB 170105A
と時間的・場所的に一致

GW eventとは無関係なGRB



東工大に設置した
web server上で観測
天体の情報を共有

Human/machine
readable output (html,
JSON, VOEvent)

全観測所でのvisibility,
instruments, 観測結
果のQL表示

GROWTH

Global Relay of Observatories Watching Transients Happen

[All targets](#) | [ToO Requested](#) | [ToO info log](#) | [Add new ToO](#) | [Update info](#) | [Upload Obs. result](#) | [Show Obs. result](#) | [Observatories](#) | [Link](#)

Detail information for CTA 102

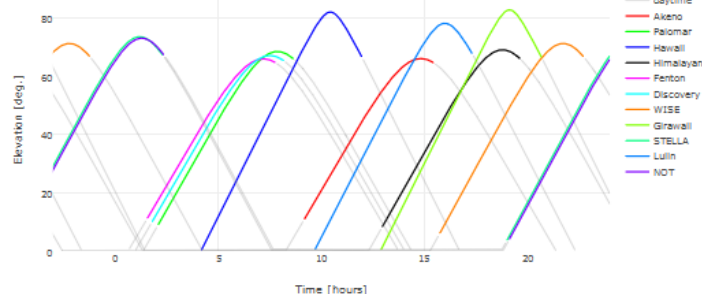
object	VOEvent
Priority	B
R.A.	338.151708333
Decl.	11.7308055556
Pos. err.	None
Imag. Obs.	Y
Cadence	None
Reference	None
Spec. Obs.	N
Cadence	None
Magnitude	16.0
Note	AGN
PI	Itoh
Insert	2017-03-09 03:31:46.6677779+00:00
Update	2017-06-06 04:11:04.044689+00:00

[Modify this information](#)

visibility

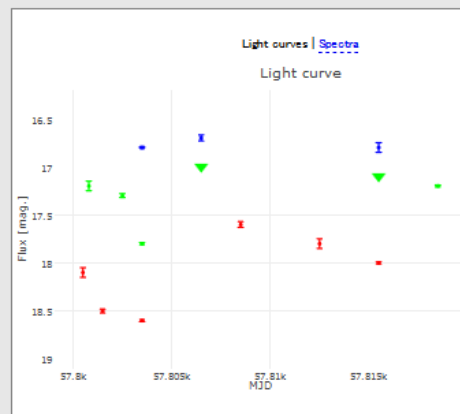
☐ Akeno ☐ Palomar ☐ Hawaii ☐ Himalayan
☐ Fenton ☐ Discovery ☐ WISE ☐ Grawall
☐ STELLA ☐ Lulin ☐ NOT

Visibility at 2017-07-21 02:30:01.919533 (UT)



Observation for CTA 102

[Upload new result](#)

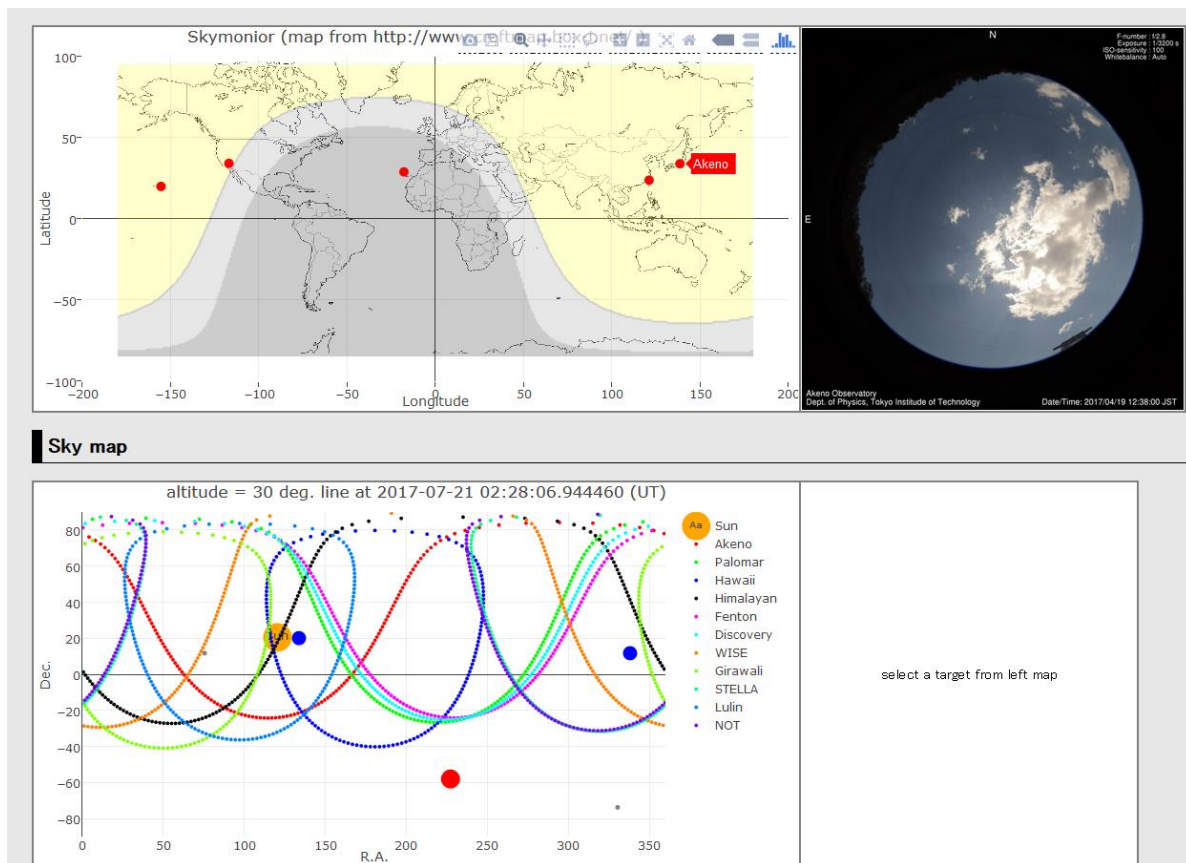


obsid	sender	updated	obs_MJD	state	mode	filter	magnitude	error	spectroscopy
Akeno	None	2017-04-13 07:46:14.100830+00:00	56800.0	Observed	spec	None	None	None	text
Akeno	None	2017-04-13 07:45:44.056116+00:00	None	Observed	spec	None	None	None	text
Akeno	None	2017-04-13 03:51:47.357803+00:00	57815.5	Observed	phot	I	16.8	0.05	none
Akeno	None	2017-04-13 03:51:47.302764+00:00	57806.5	Observed	phot	I	16.7	0.03	none
Akeno	None	2017-04-13 03:51:47.233155+00:00	57803.5	Observed	phot	I	16.8	0.01	none
Akeno	None	2017-04-13 03:51:47.136784+00:00	57818.5	Observed	phot	g	17.2	0.01	none
Akeno	None	2017-04-13 03:51:47.037371+00:00	57815.5	Observed	phot	g	>17.1	0.05	none
Akeno	None	2017-04-13 03:51:46.970837+00:00	57806.5	Observed	phot	g	>17.0	0.03	none
Akeno	None	2017-04-13 03:51:46.915779+00:00	57803.5	Observed	phot	g	17.8	0.01	none
Akeno	None	2017-04-13 03:51:46.847131+00:00	57802.5	Observed	phot	g	17.3	0.02	none
Akeno	None	2017-04-13 03:51:46.771799+00:00	57800.8	Observed	phot	g	17.2	0.05	none
Akeno	None	2017-04-13 03:51:46.656654+00:00	57815.5	Observed	phot	R	18.0	0.01	none
Akeno	None	2017-04-13 03:51:46.659617+00:00	57812.5	Observed	phot	R	17.8	0.05	none
Akeno	None	2017-04-13 03:51:46.599507+00:00	57808.5	Observed	phot	R	17.6	0.03	none
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Akeno	None	2017-04-13 03:51:46.492851+00:00	57801.5	Observed	phot	R	18.5	0.02	none
Akeno	None	2017-04-13 03:51:46.439686+00:00	57800.5	Observed	phot	R	18.1	0.05	none

各サイトのリアルタイム
の観測状況を共有

天体登録はメンバーな
ら誰でも可能

観測計画立案補助など
が今後の課題



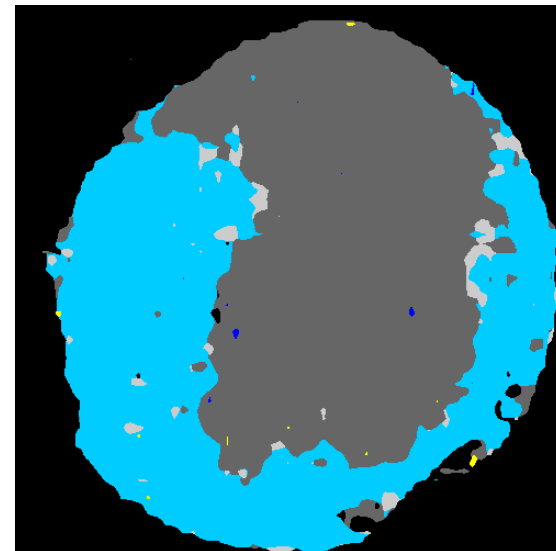
RAW Image



Recognized by Human

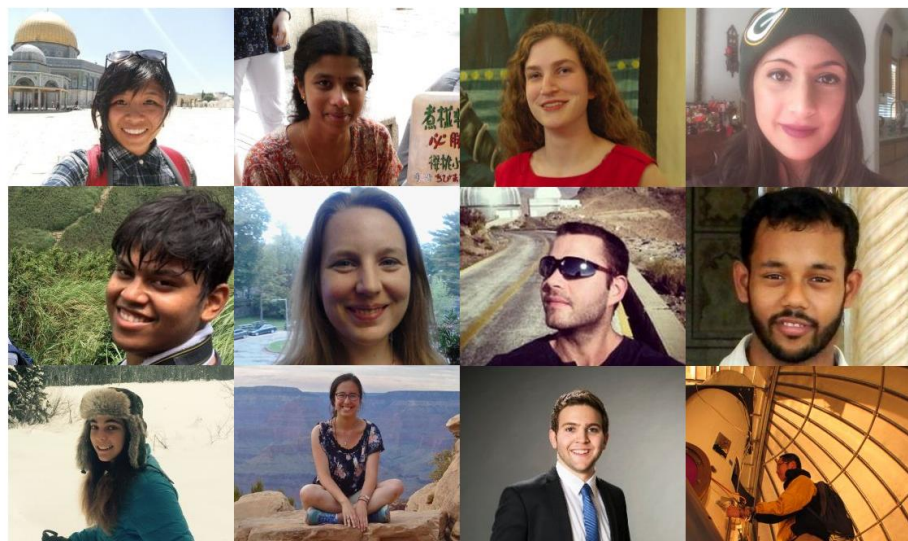


Predicted



- 民生品とDeep Learningを用いた安価で手軽な気象識別器を開発.
- プロトタイプの識別精度は
 - 晴天域 (82.7 %)
 - 濃い雲 (84.9 %)
 - 月 (20.1%)

スライド from 谷津さん



- Summer Research Program
- Graduate/Posdoc Exchange
参加機関の間でインターン
数週間~数か月の滞在

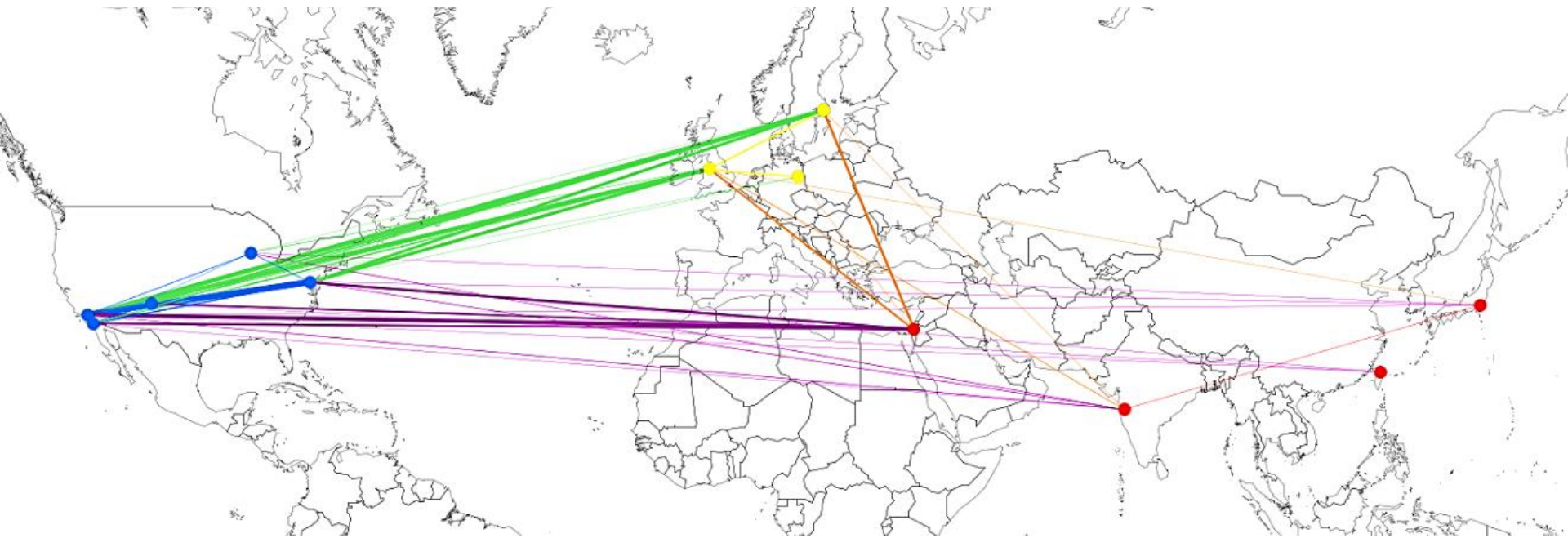
2016-2017年で12名の参加者

Caltech の大学生 1
2週間の東工大滞在
MAXI でのX線増光アラート
システムについて

Caltech の大学生 2
MISTuMEで撮ったX線連星
データの解析

東工大の博士課程学生
4月から半年ほど、
Caltech/ZTF に滞在中





- ✓ 8ヶ国、15機関での全世界観測ネットワーク
- ✓ 重力波電磁波天体観測、超新星、地球近傍小惑星が狙い
- ✓ 24時間継続での観測体制
- ✓ 観測 / システム構築で貢献
- ✓ インターンシップ等の教育プログラム

<http://growth.caltech.edu>

Twitter handle is: @GrowthPire

Facebook is: www.facebook.com/growthpire