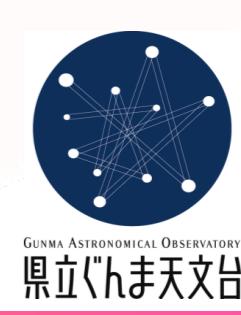
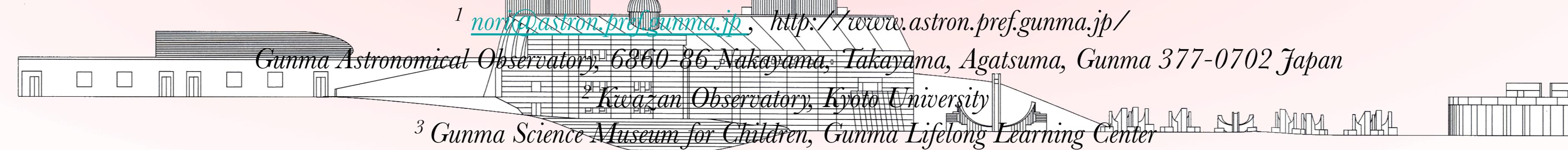


# Instruments of 150cm Reflector at Gunma Astronomical Observatory and Its Observational Results

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Gunma Astronomical Observatory

<http://www.astron.pref.gunma.jp/>

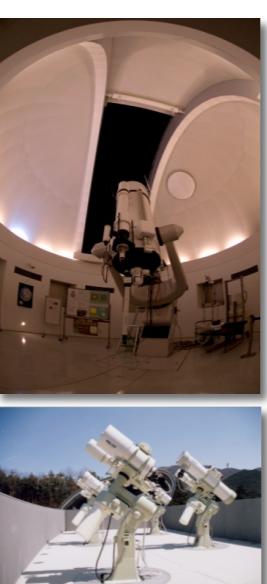
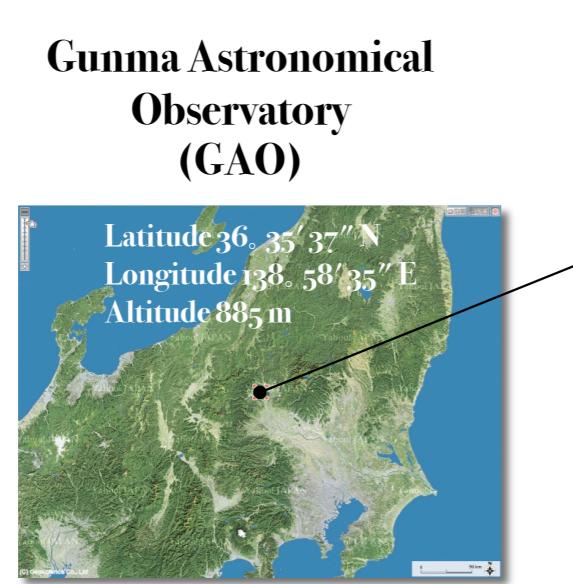
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Gunma Astronomical Observatory (GAO), which is located about 120km northwest of Tokyo, is not operated only for public education of general people but also for astronomical observation. We have some advantages for scientific research; (1) multiple telescopes; 150cm reflector, 65cm telescope, 25-30cm size small telescopes, and customized telescope unit for gamma-ray burst object (GETS), (2) multiple instruments of 150cm reflector; optical high dispersion echelle spectrograph (GAOES), near infrared camera and spectrograph (GIRCS), and low resolution spectrograph and imager for optical wavelength (GLOWS), and (3) having time flexibility of urgent or long term observations. Making use of above advantages, we make various observations not only nominal observation programs but also follow-up and campaign observations.

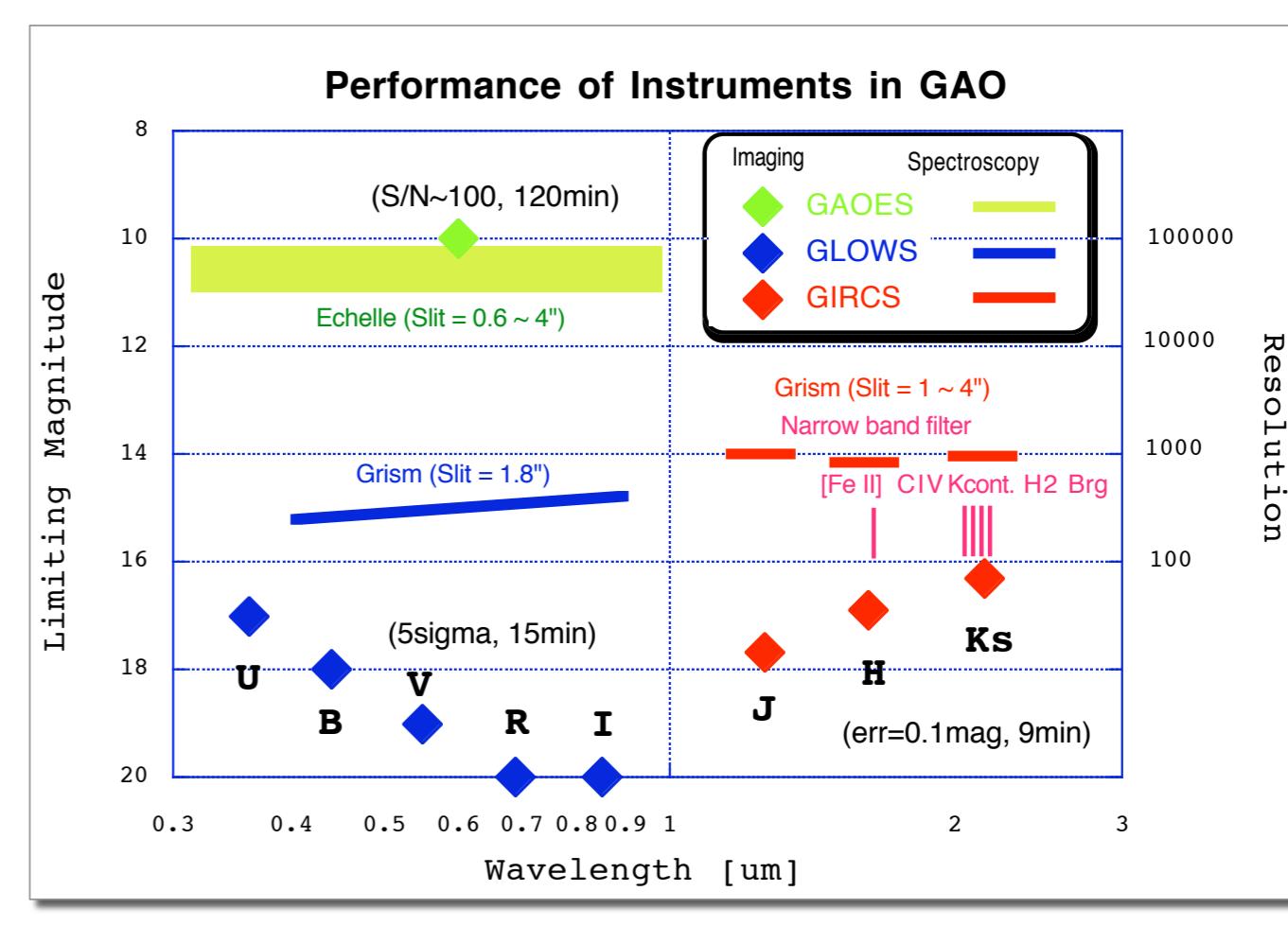
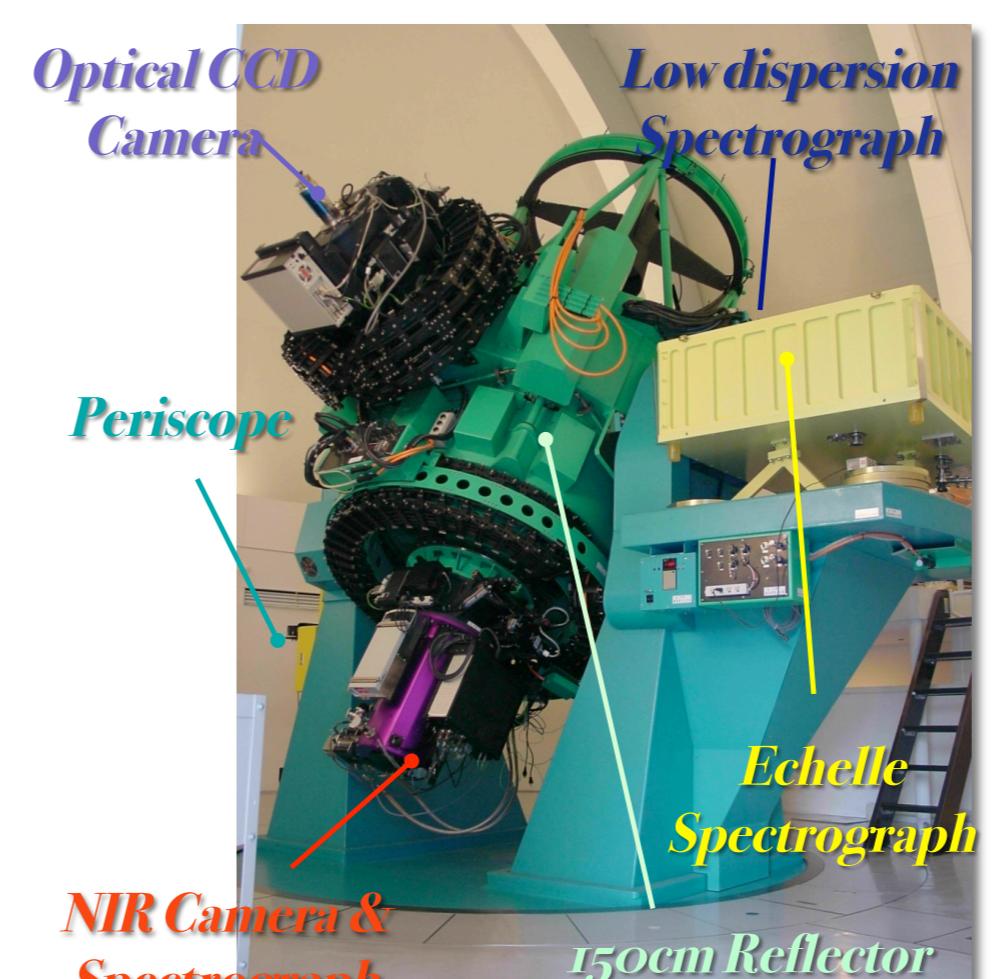


- Established in April 1999 by Gunma prefecture local government
- Designed for both **astronomical research** and **public use**
- With devices and facilities for full scale observational research, such as 150cm reflector and GAOES
- There are some other telescopes which is prepared for both researchers and public visitors; a 65cm reflector on an equatorial mounting, and six 25-30cm small telescopes in sliding roof.

## Gunma Astronomical Observatory & 150cm Reflector

Optics	Ritchey-Chretien
Diameter of primary mirror	160 cm
Effective diameter	150 cm
Focal length	1830 cm (F/12.2)
Haltman constant	0.3 arcsec
Mounting	Altazimuth
Pointing accuracy	3.0 arcsec (rms)
Tracking accuracy	0.7 arcsec (rms) (15 min)
Diameter of dome	11 m
Establish	March 1999
Manufacturer	Mitsubishi Electronics
Coverage	Optical~NIR (0.38 - 2.35 $\mu$ m)
Nasmyth 1	Echelle spectrograph
Nasmyth 2	Periscope
Bent-cassegrain 1	LN2 cooled CCD Camera
Bent-cassegrain 2	Low dispersion spectrograph & Imager
Cassegrain	NIR camera & spectrograph

▲ Specifications of 150cm Reflector



▲ Performance of 150cm Instruments

## Gunma Astronomical Observatory Echelle Spectrograph (GAOES)

GAOES is a high resolution spectrograph on a Nasmyth focus of the 150cm reflector. It provides an optical spectrum of a spectral resolution up to 100,000.

Coverage	360 – 1000 nm
Spectral resolution	75,000 (Slit 1.0"), 100,000 (Slit 0.6")
Slit length	8.0" (720 $\mu$ m)
Detector	e2V CCD44-82 2048 $\times$ 4096 pixels (pixel size: 15 $\mu$ m $\times$ 15 $\mu$ m)
Read-out	MFront2 + Messia-V (read-out noise: <3e <sup>-</sup> )
Cooler	He circulating mechanical cooler
Type	Semi-Littrow
Collimator	Lens system
Camera optics	Lens system
Echelle grating	R = 2.8, 31.6 gr/mm, blaze angle 71deg
Cross disperser	(red) 250 gr/mm, blaze 600 nm, 4.5deg (blue) 400 gr/mm, blaze 415 nm, 4.8deg
Limiting magnitude	10 mag (~600nm) S/N~50, 120min
Manufacturer	Genesia corporation

## Scientific Instruments at GAO

### Gunma Infrared Camera and Spectrograph (GIRCS)

GIRCS is an infrared camera at Cassegrain focus for wavelength from 1.0-2.4 micron, covering a field of 6.8 square arcminutes. It has also spectroscopic capability using grism.

Detector	HAWAII (HgCdTe 1024X 1024) 0.4" / pixel $\rightarrow$ FOV: 6.8"
Imaging	10 filter positions Wide-band: J, H, K, Ks Narrow-band: [Fe II] (1.644 $\mu$ m) CIV (2.07 $\mu$ m) H2 1-0 S(1) (2.122 $\mu$ m) Br $\gamma$ (2.166 $\mu$ m) K-cont. (2.144 $\mu$ m)
Spectroscopy	6 grism positions J (1.114 - 1.397 $\mu$ m) R $\sim$ 1000 H (1.439 - 1.794 $\mu$ m) R $\sim$ 900 K (1.989 - 2.397 $\mu$ m) R $\sim$ 1000 Slit : 1", 2", 4"
Manufacturer	Infrared Laboratories Inc.

### Gunma LOW resolution Spectrograph and imager (GLOWS)

There is low resolution spectrograph GLOWS at a bent-Cassegrain focus. It is often used for the identification of newly discovered targets such as SNe.

Detector	Andor DW432 (e2v CCD53-30 Back-Illumination 1250 X 1152) 0.6" / pixel $\rightarrow$ FOV: 10"
Coverage	400 – 780 nm
Imaging	4 filter positions (+ hole) : B, V, R, I
Disperser	Grism
Resolution	400 – 500
Slit	40" (length) $\times$ 1.8" (width)
Cooler	3 stage Peltier
Comparison	Fe, Ar, Ne in HCT
Manufacturer	Genisia corporation

## Project Observations and Collaborations

### GAOES

- Evolution of carbon stars in AGB
- Stellar Metallicity in globular clusters
- High dispersion spectroscopy of eclipsing binaries
- Mass loss of cool giants

### GIRCS

- IMF of HII regions
- Search for WR stars in massive starforming regions
- Monitoring of SNe in starburst galaxies
- Spectral library of Mira variable

### GLOWS

- Transient observation of GRBs
- Early phase spectroscopy of SNe and Novae
- Spectroscopy of dwarf Novas
- Spectroscopy of planets and dwarf planets
- Spectral library of Cepheids

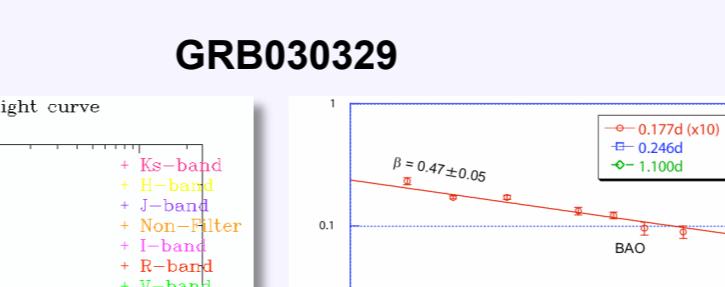
### Campaign

- ASCA
- SUZAK
- Akari
- MAXI
- VETI

### GRB

#### GRB030329

GRB030329



GRB060927

Observation on 37 min. later after burst.  
R  $\sim$  20.3 mag.  
Z  $\sim$  5.47 !!

As for the observation of GRB, the promptness is very important. In GAO, the flexibility of the observation is made use of, and a lot of observation of GRB are done.

## Observational Reports of Transient objects

### IAU Circulars / CBET

Ref ID	Date	Object	Type	Notes
TAC-7622	2001.5.11	SN 2001ef	SN	GCN 608
TAC-7625	2001.5.15	SN 2001ef	SN	GCN 608
TAC-7811	2002.1.31	SN 2002a	SN	W4
TAC-7812	2002.1.31	SN 2002a	SN	W4
TAC-7844	2002.3.5	SN 2002a	SN	GCN 629
TAC-7848	2002.3.11	SN 2002a	SN	GCN 190
TAC-8261	2004.1.12	SN 2004a	SN	GCN 207
TAC-8262	2004.1.12	SN 2004a	SN	GCN 207
TAC-8454	2004.12.18	SN 2004qt	SN	GCN 2048
TAC-8460	2005.4.1	SN 2005eb	SN	GCN 2048
TAC-8475	2005.4.12	CV 2005	CV	GCN 2048
TAC-8475	2005.4.12	CV 2005	CV	GCN 2048
TAC-8477	2007.11.25	CV 18 Piscis	CV	GCN 2048
TAC-8481	2007.12.26	V459 Velpeculae	SN	GCN 2048
TAC-8483	2008.1.1	SN 2008-1	SN	GCN 2048
TAC-8488	2008.1.28	SN 2008-1	SN	GCN 2048
TAC-8591	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8592	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8593	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8594	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8595	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8596	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8597	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8598	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8599	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8600	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8601	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8602	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8603	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8604	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8605	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8606	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8607	2008.4.7	V2671 Ophiuchi	SN	GCN 2048
TAC-8608	2008.4.7	V2671		