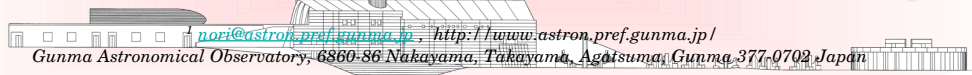


Follow-up Observations at Gunma Astronomical Observatory

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Gunma Astronomical Observatory

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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 as follows in addition to nominal observation programs; for example, follow-up observations of transient objects, cooperated observation with satellites including campaign, cooperation with other institutions, educational use for students or young astronomers from overseas. The observation object extends to many topics such as GRBs, SNe, Novae, AGB, Variable, Comet, WR, Tago event, and etc...

Gunma Astronomical Observatory (GAO)

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	150 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 μ 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 Instruments in GAO

▲ 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 μ m)
Detector	e2V CCD44-82 2048 x 4096 pixels (pixel size: 15 μ m x 15 μ m)
Read-out	16 bit / 2000 Hz (read-out noise: <2e)
Cooler	He circulating mechanical cooler
Type	Semi-Littrow
Collimator	Lens system
Camera optics	Lens system
Echelle grating	R = 2.8, 31.8 gr/mm, blaze angle 71 deg
Cross disperser	(red) 250 gr/mm, blaze 600 nm, 4.8deg (blue) 400 gr/mm, blaze 415 nm, 4.8deg
Limiting magnitude	10 mag (=600nm) S/N=50, 120min
Manufacturer	Geniesia corporation

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 ONEGATA 1024 x 1024 0.4" / pixel \rightarrow FOV: 6.8"
Imaging	10 filter positions Wide-band: J, H, K, Ks Narrow-band: (Fe II) (1.644 μ m), (H α) (1.081 μ m), (2.122 μ m), Br γ (2.165 μ m), K-cont. (2.144 μ m)
Spectroscopy	6 grism positions J (1.114 - 1.397 μ m) R ~ 1000 H (1.439 - 1.704 μ m) R ~ 900 K (1.959 - 2.397 μ m) R ~ 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 CCD55-30 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	600 - 900
Slit	40" (length) \rightarrow 1.8" (width)
Cooler	3 stage Pariter
Comparison	Fe, Ar, Ne in HGT
Manufacturer	Geniesia corporation

CCD camera and Gunma Compact Spectrograph (GCS) on 65cm Reflector

Some CCD cameras and spectrograph (GCS) are available on 65cm reflector for various observations.

Alta U6	Kodak KAF-1001E, 1024 x 1024 (FOV: 10")
AP-8	SiTe-SIA003A8, 1024 x 1024 (FOV: 10")
AP-7	SiTe-SIA002A8, 512 x 512 (FOV: 5")
Detector	Apogee AP-8 (SiTe 1K x 1K) 0.6" / pixel \rightarrow FDV: 10"
Coverage	380 - 760 nm
Disperser	Grating 300gr/mm, 1200gr/mm
Resolution	500 or 2000 (selectable)
Slit	10" (length) \times 2" (width)
Calibration	Hg, Ne
Manufacturer	Geniesia corporation

Various Observations at GAO

List of IAU Circulars / CBET

No.	Date	Object	Type	Instrument
IAUC 9332	2001-11-11	SN 2001bg in MCG608	SN Ia	150cm GSC
IAUC 9325	2001-11-15	SN 2001st in MCG044-42-22	SN Ia?	65cm GSC
IAUC 7811	2002-11-31	SN 2002ap in M74	Broad line	65cm GSC
IAUC 7815	2002-12-2	SN 2002aq in MCG209	SN Ia	65cm GSC
IAUC 7848	2002-12-4	SN 2002ay in MCG121	SN Ia	65cm GSC
IAUC 7848	2002-12-11	SN 2002ba in MCG130	SN Ia	65cm GSC
IAUC 8216	2004-1-12	SN 2004A in MCG207	SN Ia	150cm GSC
IAUC 8317	2004-4-8	SN 2004m in MCG798	SN Ia	65cm GSC
IAUC 8456	2004-12-18	SN 2004et	SN Ia?	150cm GLOWS
CBET 454	2006-4-1	SN 2006bb in MCG468	SN Ia?	150cm GLOWS
IAUC 8988	2006-4-5	V2162 Cyg	Novae	150cm GLOWS
CBET 475	2006-4-12	SN 2006ba in MCG8-33-20	SN Ia?	150cm GLOWS
CBET 1126	2007-11-19	CN in Pegasus	Novae	150cm GLOWS
CBET 1181	2007-12-26	V459 Vulpeculae 2007 No. 2	Novae	150cm GLOWS
IAUC 9003	2007-12-14	Variable in Serpens	Novae?	150cm GLOWS
CBET 1229	2008-1-28	SN in Cygnus	SN Ia	150cm GLOWS
IAUC 8951	2008-6-7	V2781 Ophiuchi 2008	Novae	150cm GLOWS
CBET 1254	2008-11-7	Variable in Pegasus	Novae	150cm GLOWS
CBET 1268	2009-2-8	SN 2009 in MCG372	SN Ia	150cm GLOWS
CBET 1376	2009-4-23	Variable in Cygnus	Novae?	150cm GLOWS
CBET 1398	2009-4-20	SN 2009a in MCG305	SN Ia	150cm GLOWS
IAUC 9041	2009-5-3	Novae Sagittarii 2009	Novae	150cm GLOWS
CBET 1408	2009-5-22	SN 2009ap in MCG329	SN Ia	150cm GLOWS
CBET 1516	2009-5-29	V2382 Sagittarii 2009 No. 2	Novae	150cm GLOWS

List of GCN (The Gamma-ray bursts Coordinates Network)

No.	Object	Mag.	Instrument
1216	031217	19.25	150cm GSC
1749	021211	-28.7	65cm CCD
2118	030329	11.32	150cm GSC
2598	040511	10.51	65cm GSC
2614	041004	19.17	150cm GSC
2832	041006	17.8	GCS
2834	041015	136.42	150cm GSC
4282	051015A	148.9	65cm GSC
4283	051015B	143.2	65cm GSC
4284	051015C	143.2	65cm GSC
4295	051016A	20.5	150cm GLOWS
4296	051016B	18.7	GCS
4297	051016C	18.8	GCS
4466	060202	19.8	GCS
4629	060204	151.9	GCS
5684	060927	-26.2	150cm GLOWS
5699	060205	16.5	GCS
7218	090205	12.5	150cm GLOWS
7487	090206	19.3	150cm GLOWS
7498	090207	19.15	150cm GLOWS
7413	090319	20.1	150cm GLOWS
7582	090328	20.7	150cm GLOWS
9183	090408	19.1	150cm GLOWS
9189	090410	19.6	150cm GLOWS
9282	090416	19.9	150cm GLOWS

GRB030329

GRB060927

Observation on 37 min. later after burst.
 $R - 20.3$ mag.
 $-Z = 5.47$ lit.

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.

Super Novae

SN2002ap

SN2006x

The overall features resemble that of the peculiar type-Ibc supernovae (SN 2002ap, 1997et, but SN 2002ap is much bluer (IAUC7811, Kinugasa et al. 2002).

Early spectral evolution of the rapidly expanding type Ia SN2006x. (Yamamoto et al. 2009)

01bg

04gt

02ap

04A

01bt

06bb

02ao

04ct

06gc

Spectral information provide us the classification of many types of SNe in addition to materials and physical conditions inside SNe.

Cooperation with Satellite and follow-up observation for Satellite

Suzaku

Campaign observation with X-ray satellite (ASCA, Suzaku, Chandra, etc.)

AKARI

Optical spectrum of FYC159-6-1 which was detected by AKARI All-Sky Survey. It suggests a low-mass Weak-line T-Tauri Star (WTTS). (Takihi et al. 2009)

Others

← C200104(NEAT)
 ▼ C2001A2(LINEAR)

Mars image which were derived by GIRCS. These images show the spatial distribution of H₂O ice.