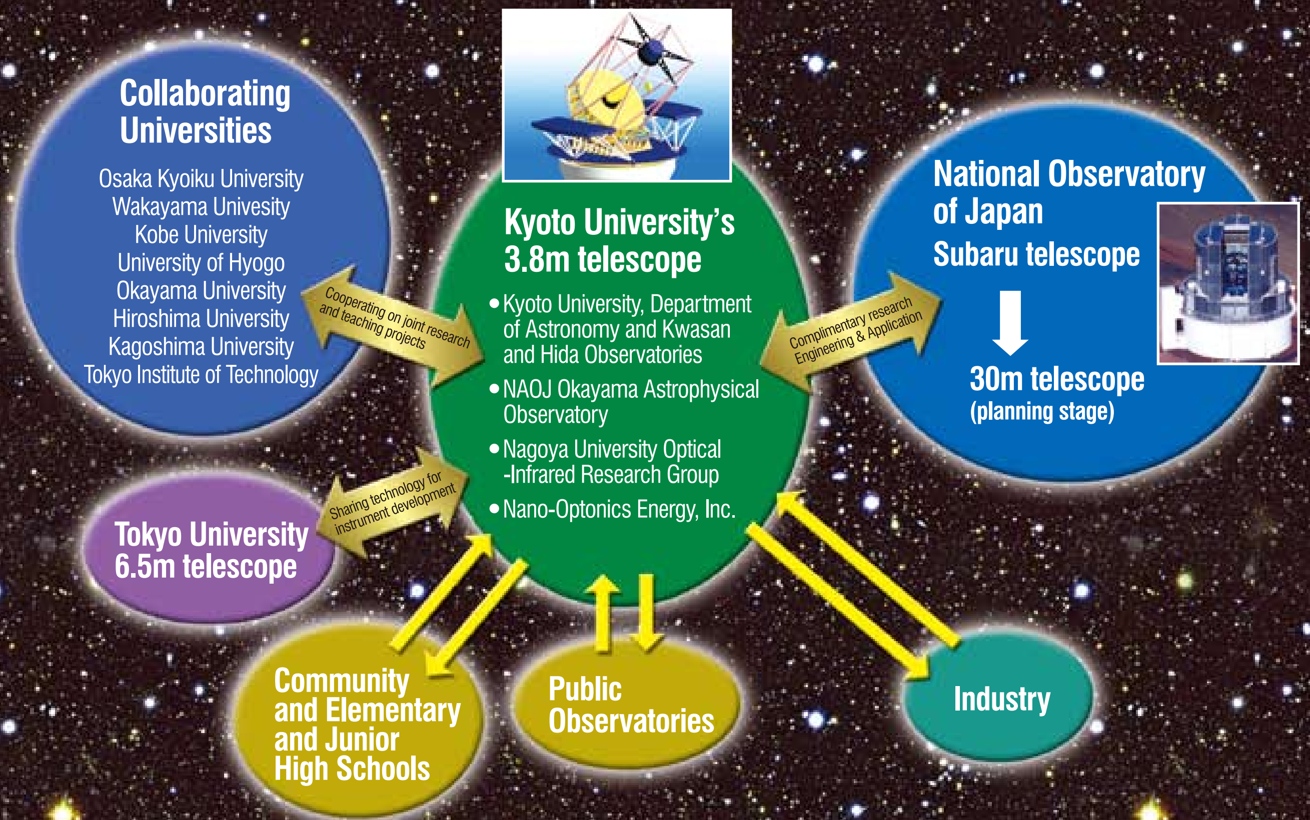
# Collaboration  Widening our cooperation network




**Site**

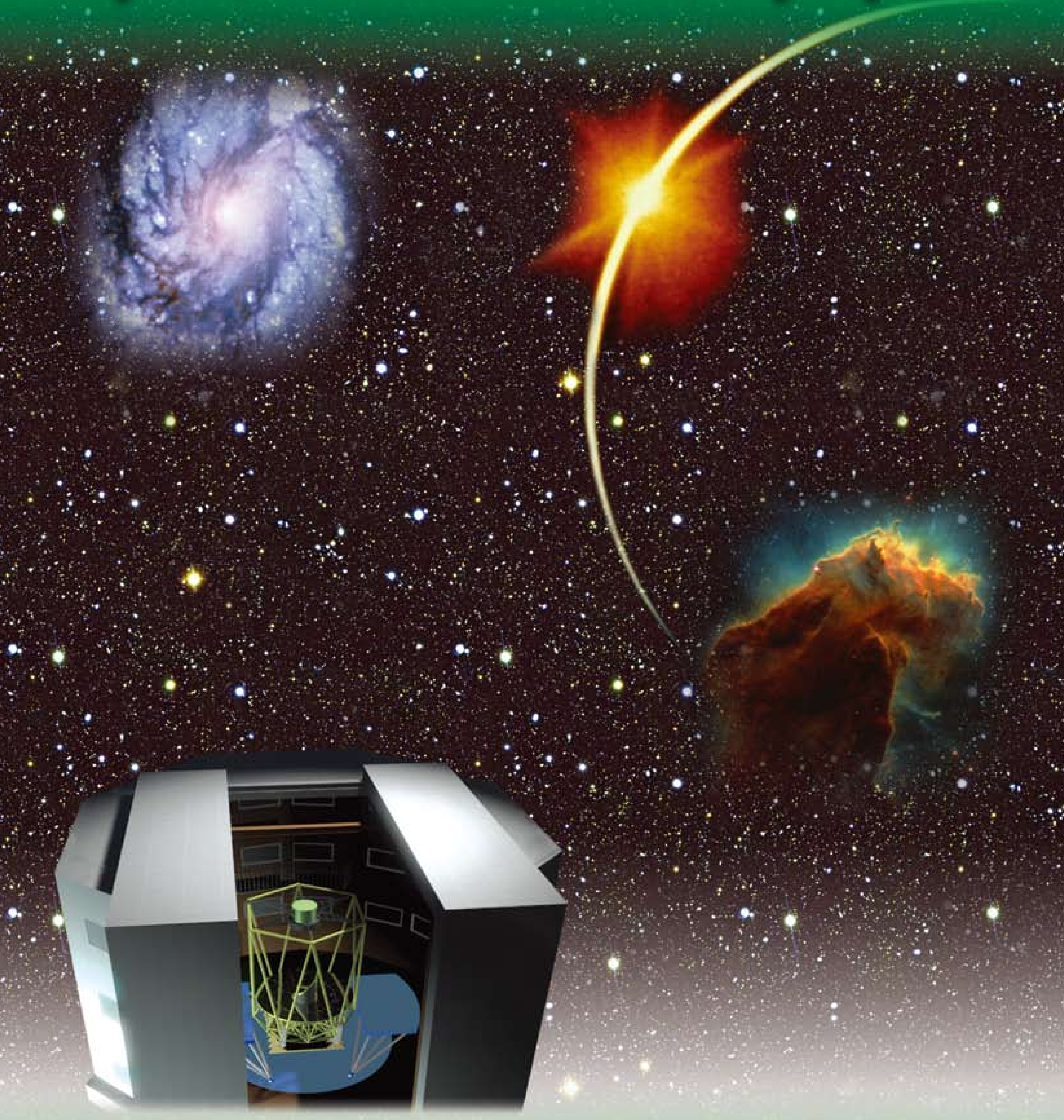
- Asaguchi City, Okayama Prefecture
- Highest level of clear sky in Japan
- Highest level of star visibility in Japan
- Easy access

Remote observations and data access from anywhere in the world via the internet

**Deapartment of Astronomy, Kyoto University**
Oiwake-cho Kita-shirakawa, Sakyo-ku, Kyoto City, Kyoto, 606-8502 JAPAN
phone: +81-75-753-3890 / fax +81-75-753-3897
http://www.kusastro.kyoto-u.ac.jp

**Kwasan and Hida Observatories**
17 Ohmine-cho Kita Kazan, Yamashina-ku, Kyoto City, Kyoto, 607-8471 JAPAN
phone: +81-75-581-1235 / fax: +81-75-593-9617
http://www.kwasan.kyoto-u.ac.jp/

# Okayama 3.8m new technology optical infrared telescope plan



**Kyoto University, Faculty of Science, Department of Astronomy and Kwasan and Hida Observatories**

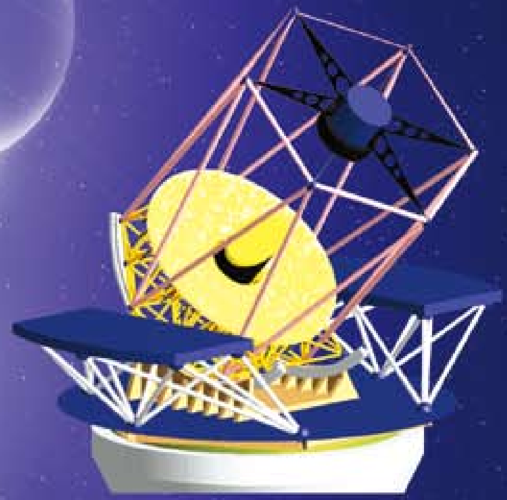
**March, 2010**

# New technology opening our eyes to the universe

## From dream to reality:
## The road towards 30m telescopes

## Technology

**Japan's first segmented mirror telescope**



## Science

**Black hole and star / planetary system research**


## Collaboration

**Leading cooperation between universities and industry**

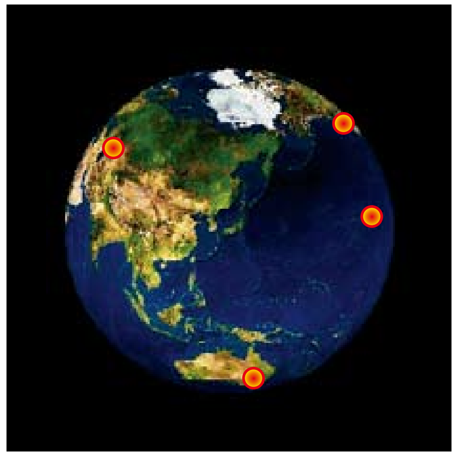
## Kyoto University's Okayama 3.8m telescope

### -Cooperation between Nano-Optonics Energy Inc, universities and industry-

From the apple falling from the tree to the moon floating in the sky, the same gravitational force is working. Building upon our discovery of this, we formed our view of the universe. Though the laws of physics hold universally, to complete our understanding of what is happening around us, we need to investigate processes that are occurring around the universe but cannot occur here on Earth. Right this instant, there are probably sudden bursts of energy being emitted from near black holes or around stars or there could be a planetary system being born. Observing these phenomena will provide valuable information about our universe.

Making a large primary mirror by fitting together 18 smaller mirrors and using new methods to gather both visible and infrared light, we are building a new telescope in Okayama. Making use of our country's high precision techniques in processing glass ceramics, we intend to create the world's first telescope mirror made by grinding.

**Region without large telescopes**



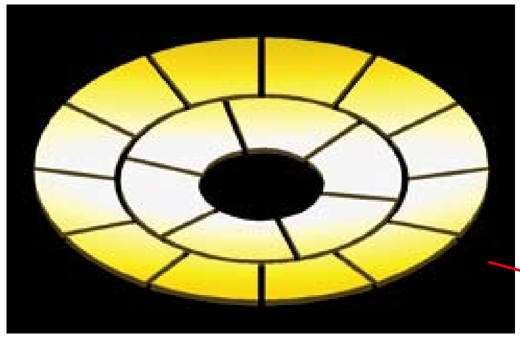
Picture showing the distribution of telescopes larger than 2.5m diameter
Through continuing international cooperation, we aim for continuous observations. In this respect, a medium diameter telescope in Japan is essential.

# Technology

## Building the largest optical telescope in Asia through industry-university collaboration

### Japan's first segmented mirror telescope
#### -Prototype for the next generation of super large telescopes-

The use of segmented mirrors will become the main method used to build super large telescopes.



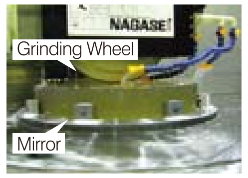
Segmented Primary Mirror
(gaps between mirrors have been exaggerated)

### Worlds first mirror made by grinding

Unlike the conventional polishing method, large mirrors can be made in relatively short periods of time.

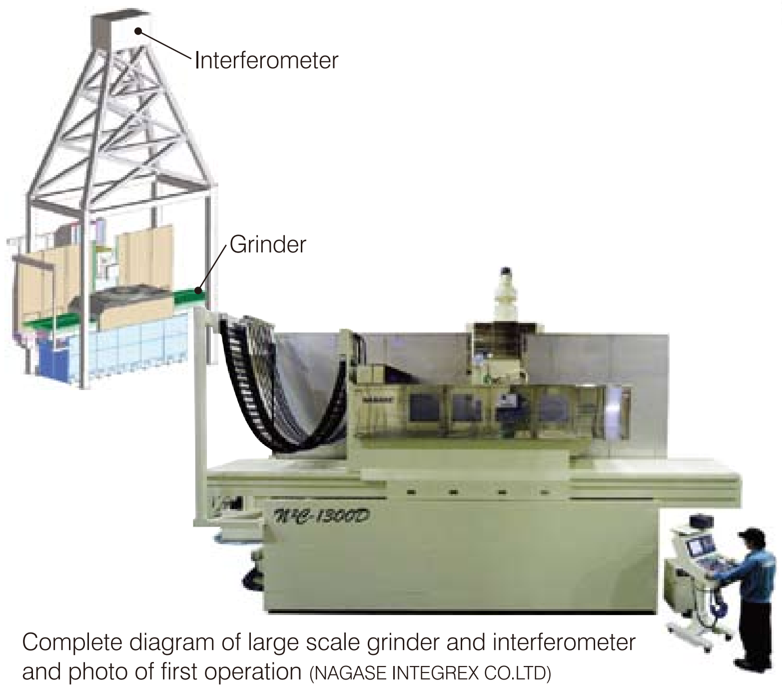
#### Conventional Method
**(Polishing)**

Making a mirror through uniform polishing of the surface.

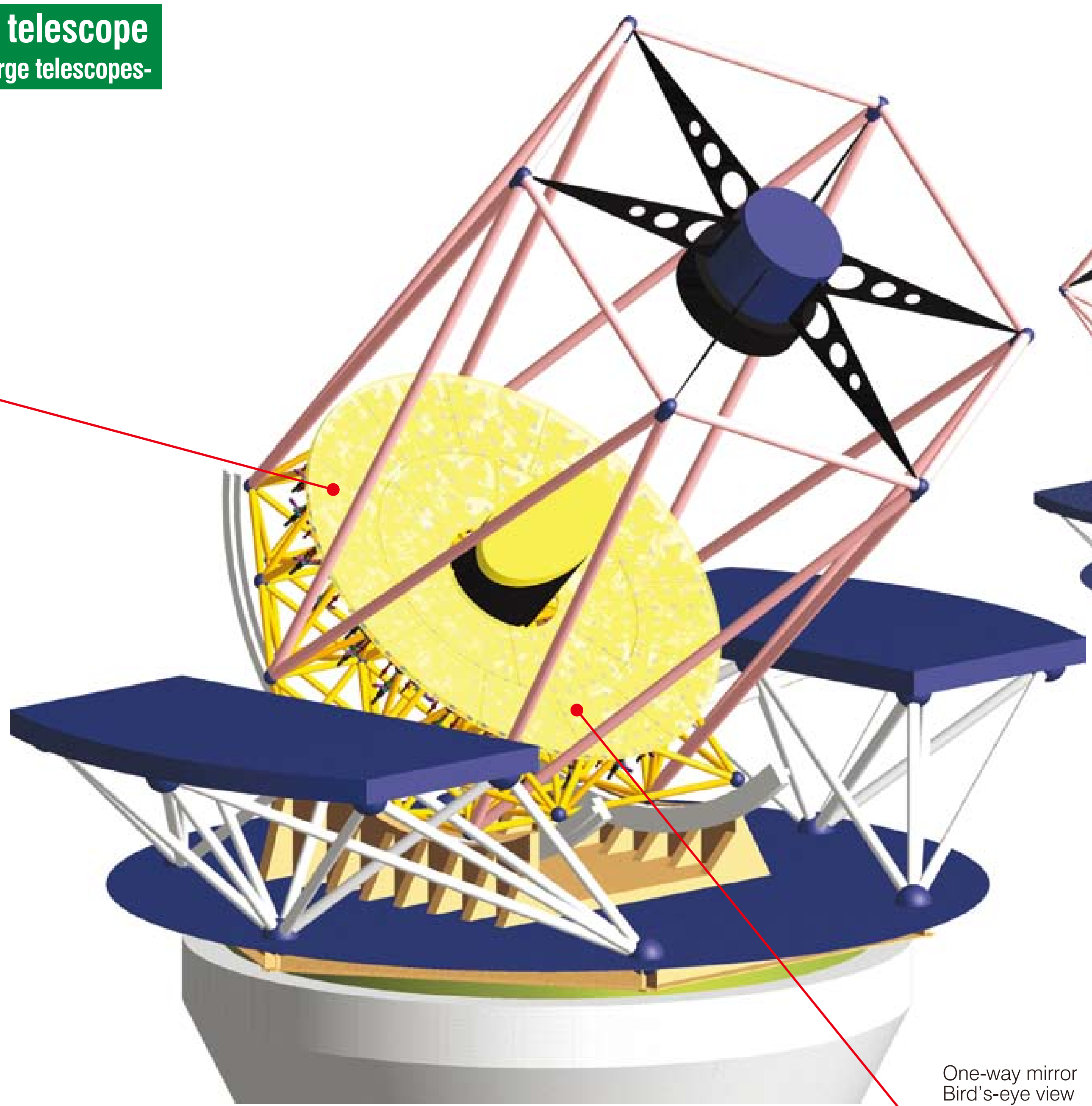


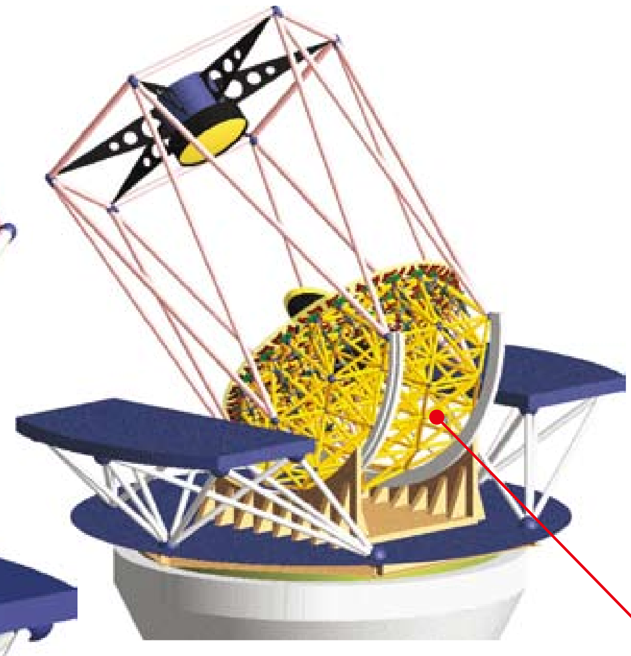

#### New Method
**(Grinding)**

Mirrors are made by grinding using a precisely controlled file.




Complete diagram of large scale grinder and interferometer and photo of first operation (NAGASE INTEGREX CO.LTD)

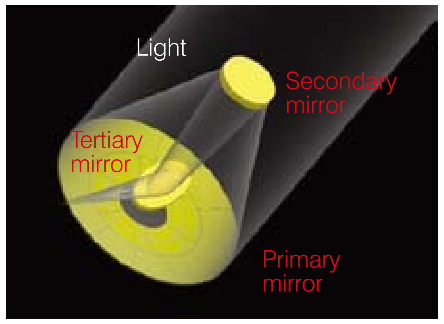




### Image of the telescope

- **Segmented Primary mirror** (concave)
- **Secondary mirror** (convex)
- **Tertiary mirror** (flat)

These mirrors form the telescope optics




### Telescope specifications

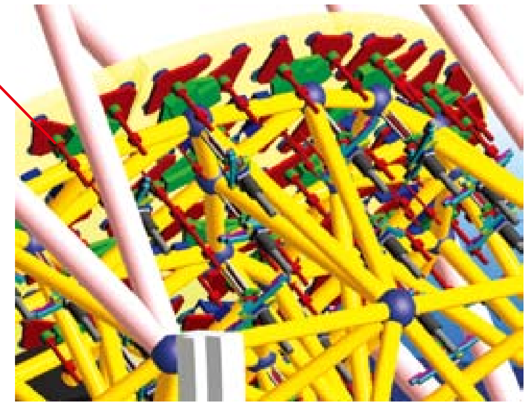
| | |
|---|---|
| diameter | 3.8m (Composed of 18 panel segments) |
| type | Ritchey-Chretien |
| focal point | Nasmyth focal point x2 |
| field of view | 1°$\phi$ (with correcting lens)<br>0.2°$\phi$ (without correcting lens) |
| image quality | 80% within an angle of 0.5 arc seconds |

### Development of segmented mirror control technology

Each mirror has its own control mechanism, so they can be aligned to nanometer precision.

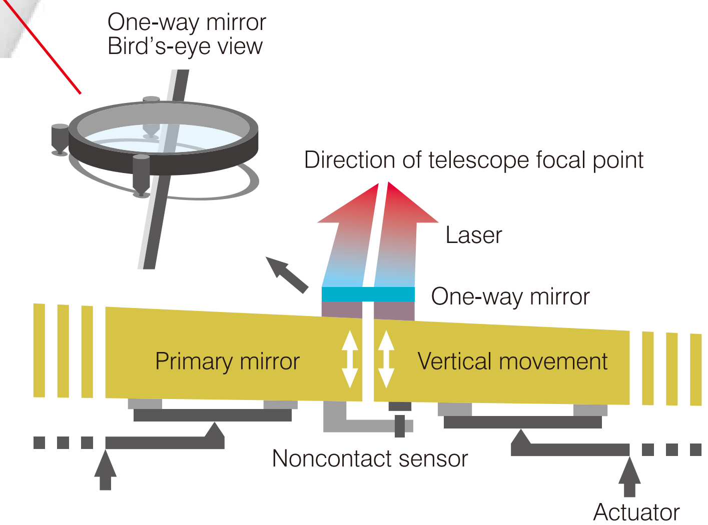
### Lightweight mount

The truss structure made it possible to build a light, sturdy telescope.



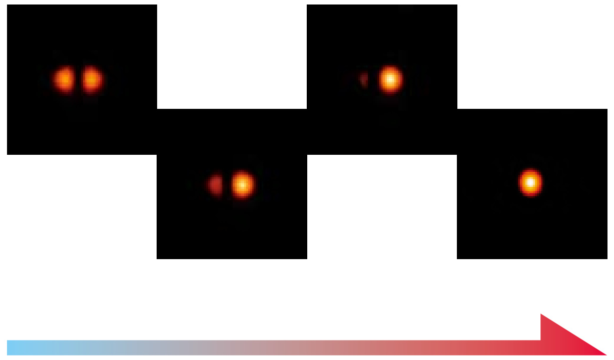
### Controlling the mirror position

With uniform support applied to each mirror, the position can be controlled by 3 precision jacks.




### Mirror position measurement

The mirror position is calculated using a sensor behind the mirror and a laser that shines from the focal plane between observations.

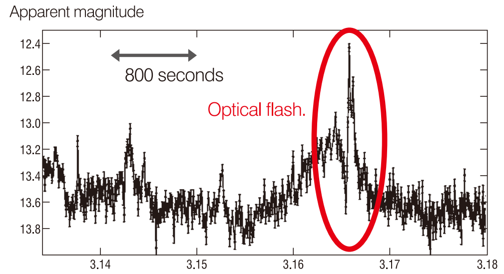


The laser light only forms 1 point when the mirrors are aligned, but when there is a discrepancy then the light is split into two.

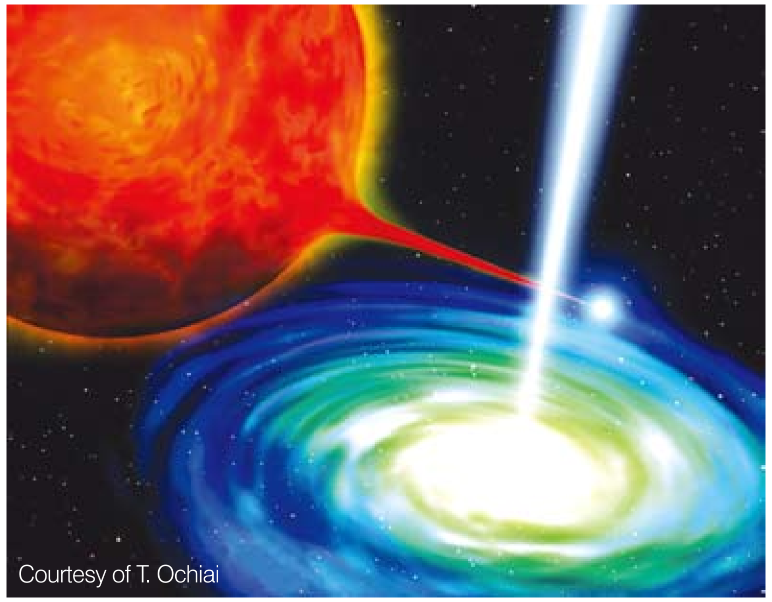
# Science Opening the frontiers of the universe through intermediate diameter telescopes

## High speed observations revealing the engine behind black holes

### Black hole x-ray binary



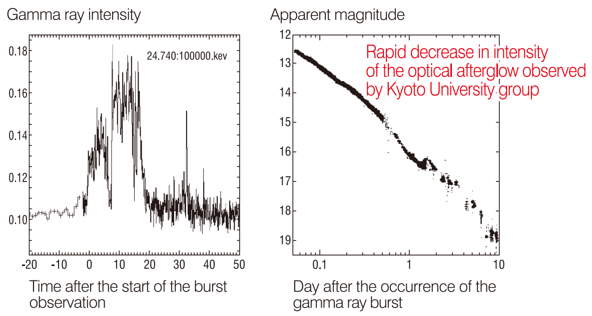

Observations by the Kyoto University group of the short time-scale fluctuations of visible light emission from a black hole binary. This is thought to show a flare occurring in close proximity to a black hole, and through this we can show that matter is accreting into the black hole. Using polarization measurement of jet eruptions, we can begin to understand the mechanisms involved.



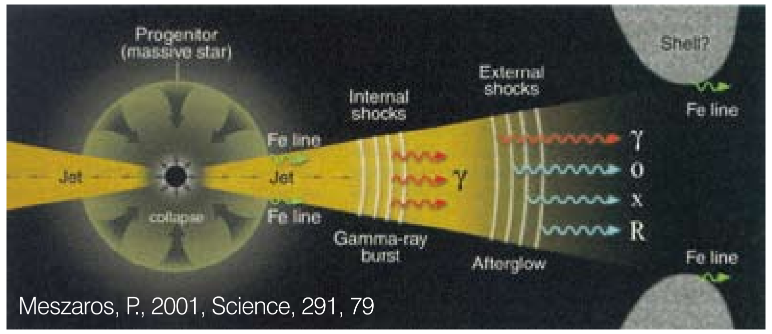
Courtesy of T. Ochiai

In the extreme conditions that surround black holes, violent activity occurs driving jets at near the speed of light

### Gamma Ray Bursts



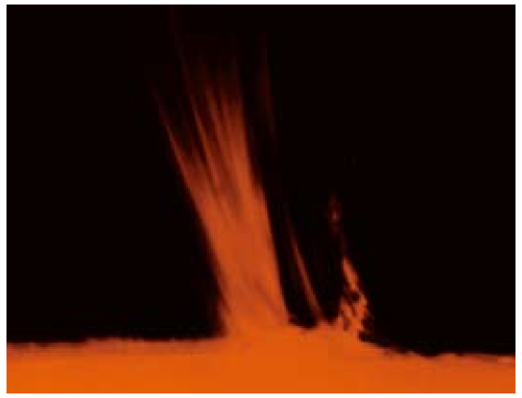

Using observations of short time scale variations and polarization measurements we are aiming to explain the mechanisms that drive these explosions.




Meszaros, P., 2001, Science, 291, 79

This is the largest explosion in the universe, occurring at the death of a massive star.

### Stellar Flares



Image, taken at Hida Observatory, of a jet erupting from the solar surface. This kind of violent activity is constantly occurring in stars. It is believed that similar plasma phenomena are occurring in the proximity of black holes and in gamma-ray bursts.

**With the new telescope's ability to perform high temporal resolution photometry and polarization measurements, we aim to explain a whole range of short time scale phenomena.**

Picture, taken in near infrared, of the star forming region M17 in our Galaxy
(Nagoya University & National Astronomical Observatory of Japan)

## Searching for star and planetary formation regions through ultra high-dispersion spectra observations

### With sufficient light concentration capacity and observation time, we will be able to detect the hydrogen molecules in interstellar space

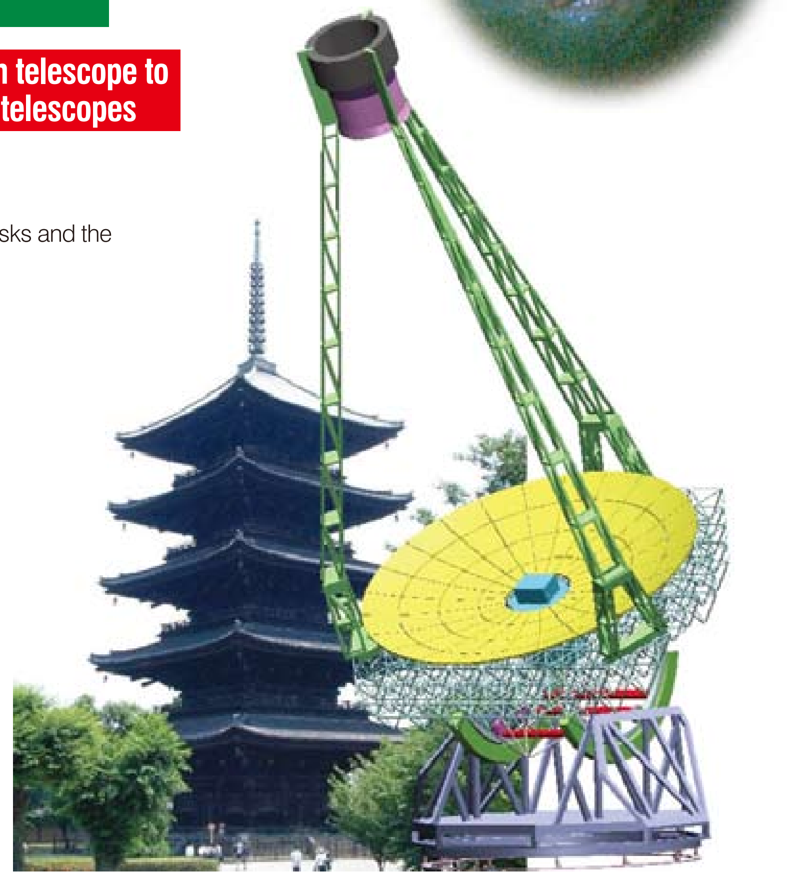
This ultra high spectral resolution will play a major role in understanding interstellar chemistry, revealing star and planet formation regions bringing new understanding to the physics of interstellar space.

## A great step toward the next generation 30m telescope

### Using the research developments of the 3.8m telescope to understand the science behind building 30m telescopes

- Searching for newly formed black holes
- Observations of the first formation of stars
- Determining the structure of the inner edge of accretion disks and the mechanisms behind jet formation
- Observing the shape of planets outside our solar system
- searching for the traces of extraterrestrial life

**Moving from understanding individual phenomena to a comprehensive understanding of the universe**



**The next generation 30m telescope (image)**

Conventional telescope mirrors are made as one piece, but the next generation of telescopes will have segmented mirrors.