SUBARU Telescope
Damages and Recovery from the Earthquake

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(SUBARU Telescope)

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1. Brief Overview of the Earthquake

- **Date, Time, Magnitude:**

  1st: October 15 (Sun) 7:07AM **M6.7**

  2nd: October 15 (Sun) 7:14AM M6.0

  - Observation had finished at 6:50 and operators had left summit for HP at 7:00.
  - After the 1st earthquake, the power supply had been failed. The power was recovered after 3 PM.

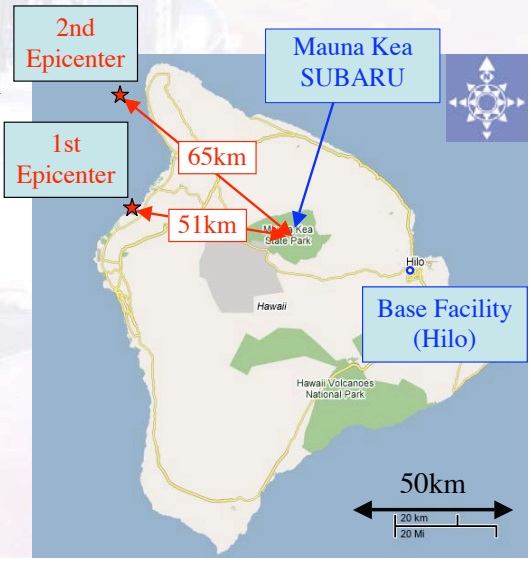
- **Epicenter: North-West of Big-Island**

  1st: Distance from the Mauna Kea summit is ~51km / 2nd is ~65km.

- **Modified Mercalli Intensity (Shindo in Japanese)**

  Mauna Kea summit (estimated): **VII (shindo=4~5)**

  Hilo: V (3~4) / Honolulu: IV (3)



1. Brief Overview of the Earthquake

- Previous Earthquakes:
  - It is the biggest last 200 years at the summit of Mauna Kea.
- Design Specification (in 1992) of SUBARU for an earthquake.
  - The conditions not to be awfully destroyed are as follow:

    Horizontal and Vertical Acceleration = 0.3 and 0.2 G
- Estimated Acceleration due to the M6.7 earthquake:
  - According to the reports from US Geological Survey (USGS), the peak ground acceleration (PGA) was estimated to be **0.2~0.3G** at the summit.

Fortunately, there were no significant damages on SUBARU.

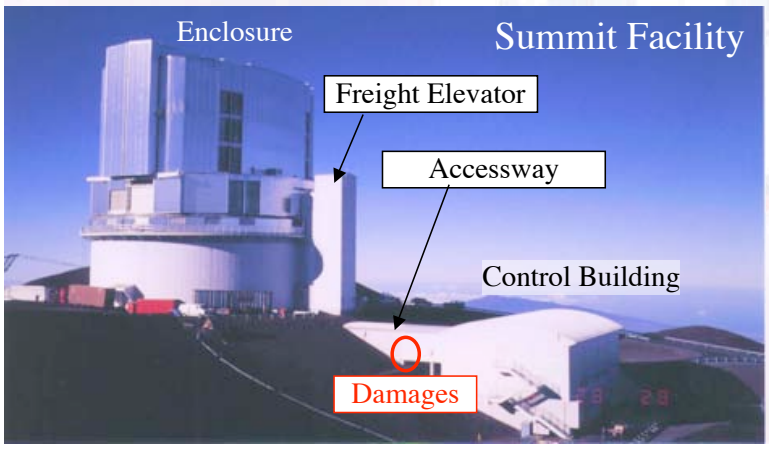
It was necessary to carry out detailed analyses of the impact of the earthquakes and careful repair work. Science observations and public tours of the telescope will be halted until the end of October.

Tomonori Usuda

1. Brief Overview of the Earthquake

2. Damages at the summit facility

- One of the four slide guide was broken on the freight elevator.
  → 10/17 (temporally repair), 11/6 (Repair done)
- Ceiling boards, computers, displays, etc. were fallen at the 3rd floor of the control building.
- Several cracks on the walls of the control building.
- Some cracks in the foundation of the access way between the enclosure and the control building.



3. Damages on the Telescope

Center hub of the Az axis was moved.

- **About 1.2mm shifted toward South-West direction**

  → The tracking accuracy was worse, since the separation between Az incremental encoder tape and its detector was changed (normally 0.25mm).
- Shift the hub back to the original position → Difficult & Give up
- **Shift the position of the Az encoder tape**
- Non-shrink mortar around the hub was broken.

  → Difficult to refill and spread mortar between the center hub and the pier, thus the **mechanical steel ring structure** is designed and will be installed around the hub in order to support it in May.

IR-M2

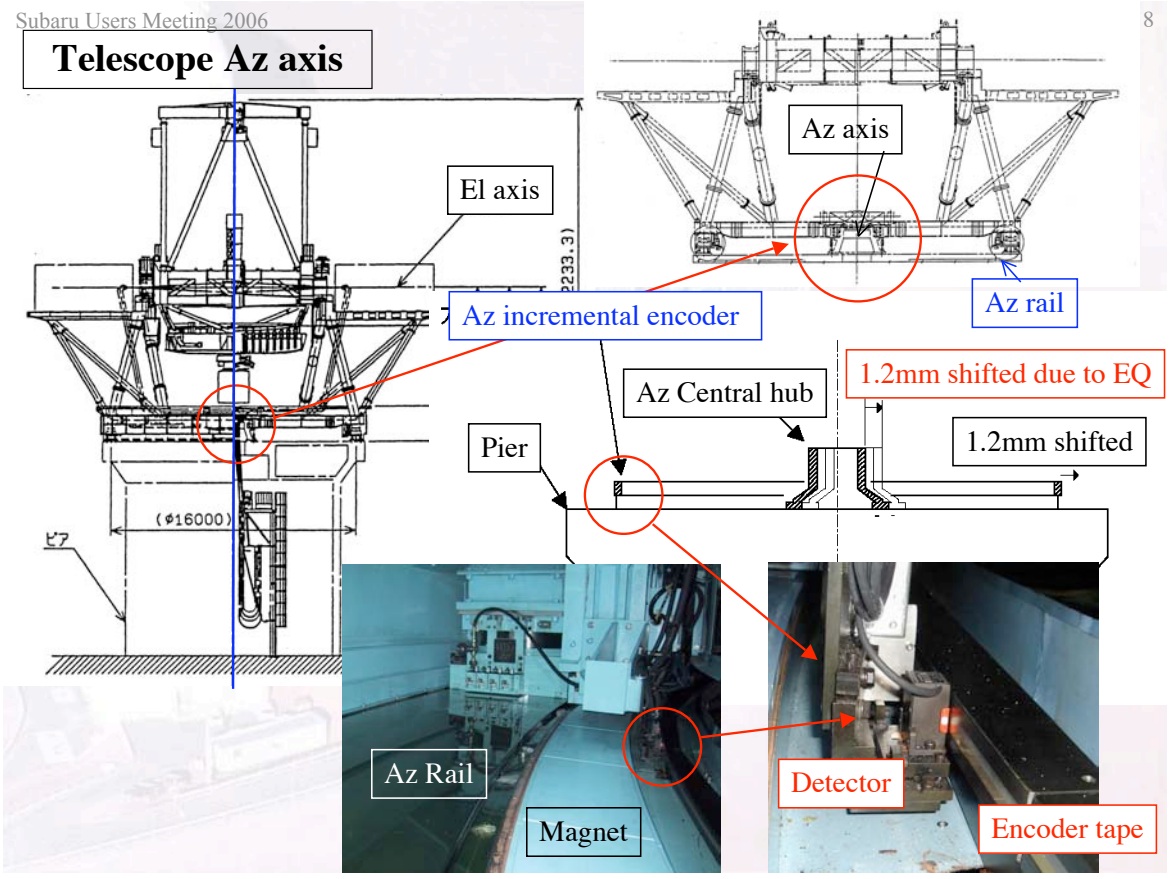
- The mechanical fuses were broken which have been installed between the M2 glass and the electromagnetic actuator to protect glass.

  → Disassemble the M2 unit to replace fuses.

Poorer Image Quality

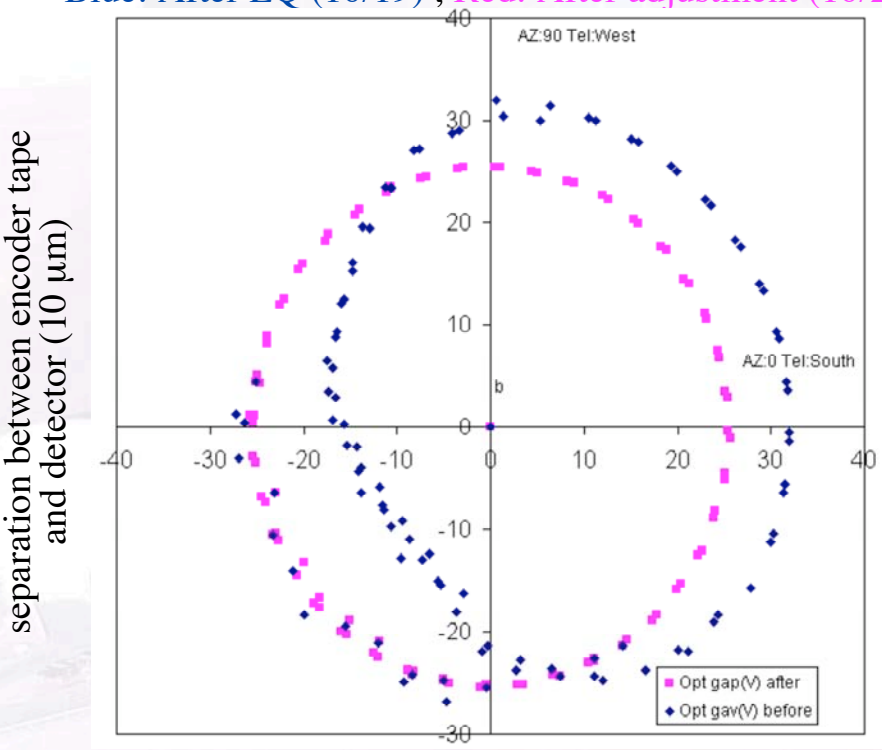
- Images taken by FOCAS
  - Astigmatism (aberration) was seen.
  - Focal plane was tilted → Best focus position was different in the FOV.

→ Primary mirror was shifted. Mirror analysis works for all foci are on going.

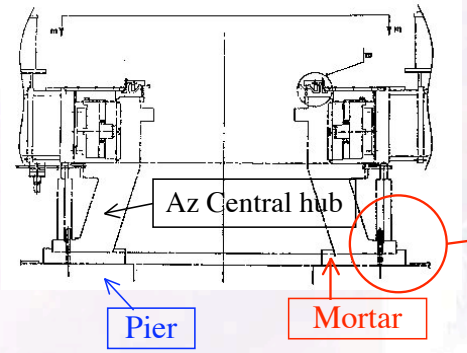


Comparison between before/after adjustment

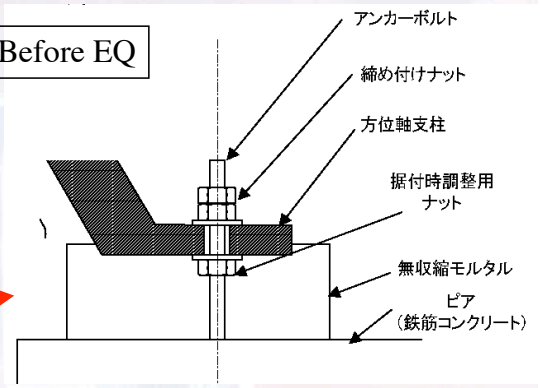
Blue: After EQ (10/19) , Red: After adjustment (10/24)

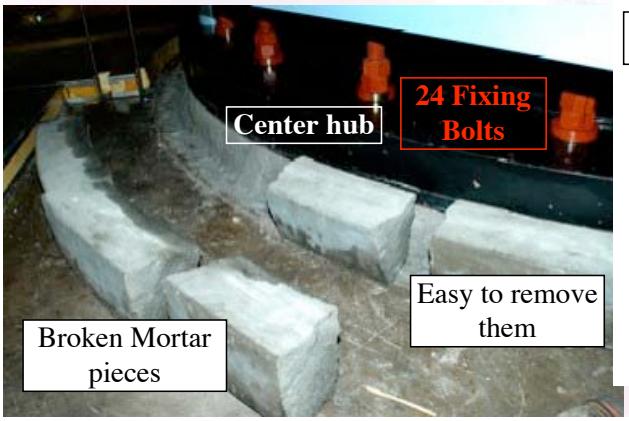


Center hub shifted

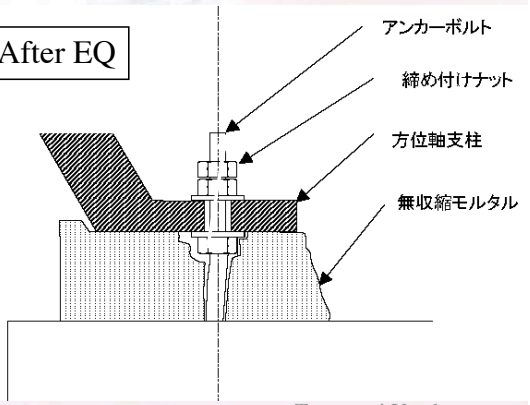


Before EQ

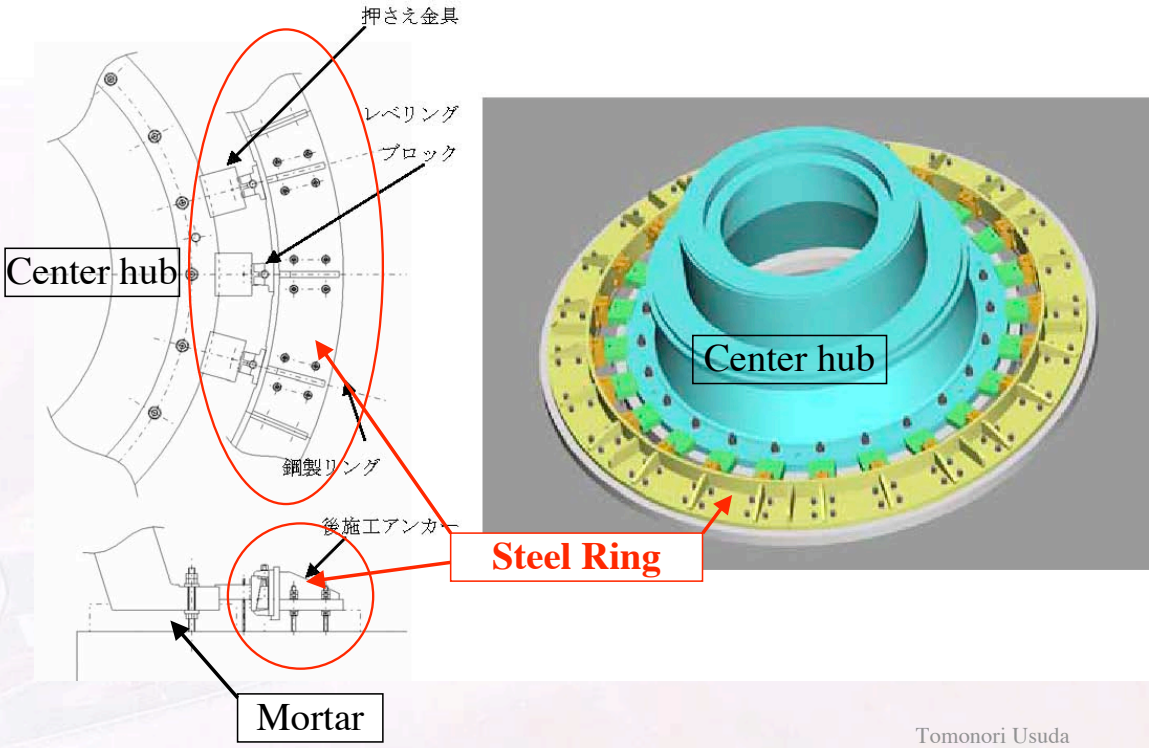




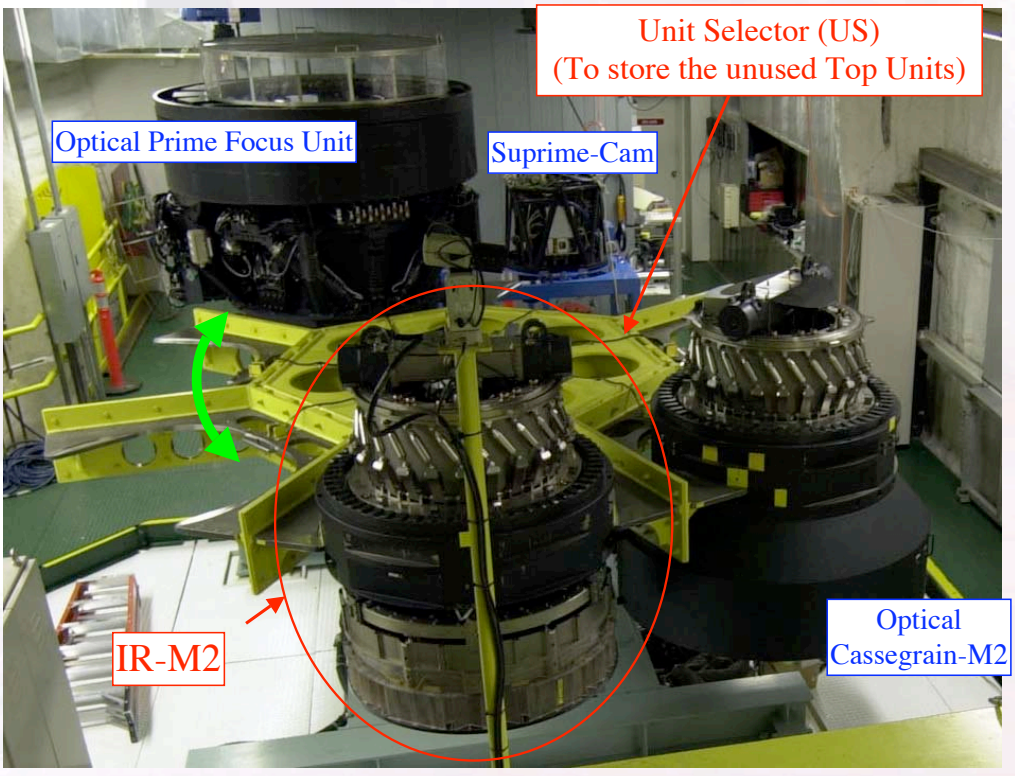
After EQ



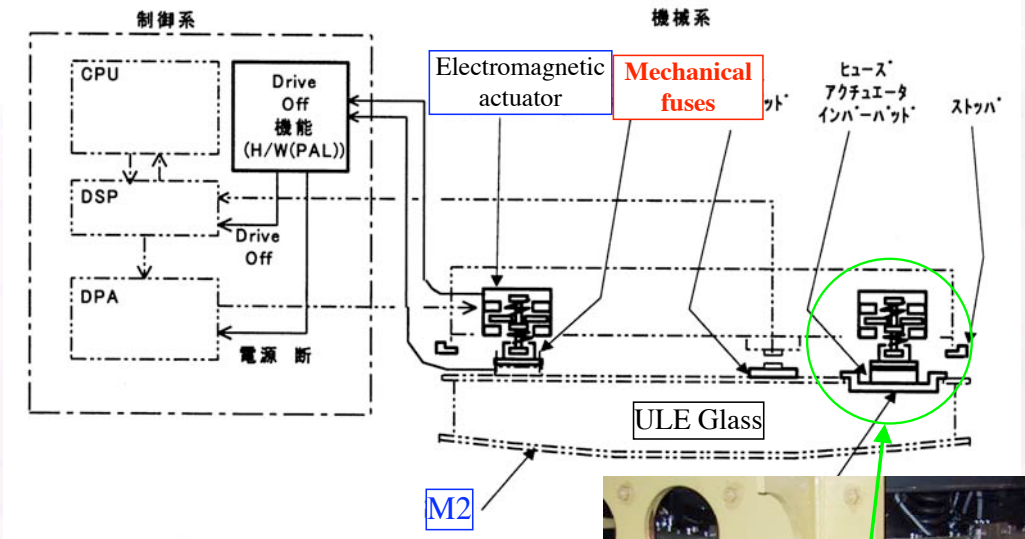
Mechanical steel ring structure

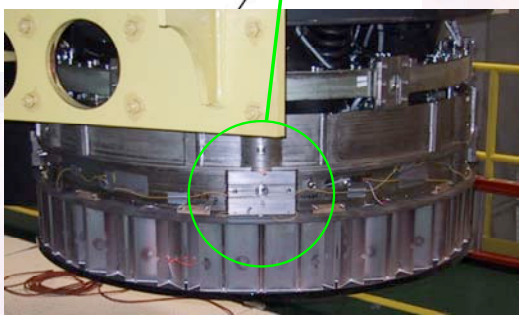


IR-secondary mirror (IR-M2) @Dome TUE floor (4F)



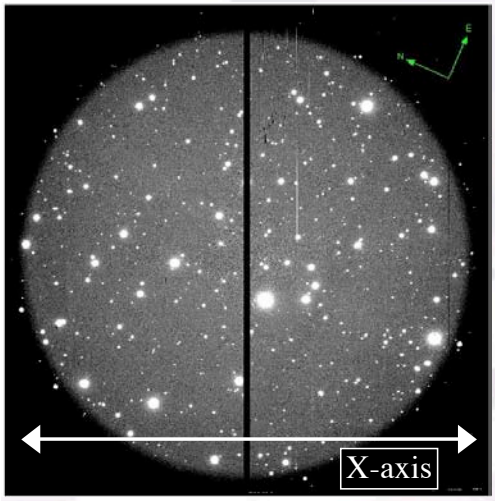
IR-M2 Unit: Mechanical Fuse

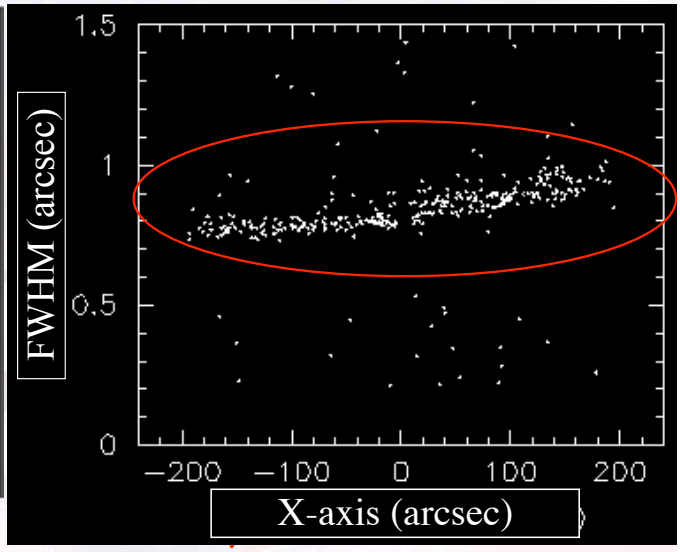




The mechanical fuses are working, in order to protect glass due to impacts, over-loads, etc.

Tilted Focal plane: Results from FOCAS @Cs focus





→ **Adjust M2 positions**

1. Instruments (e.g., MOIRCS, IRCS, S-Cam) were used to check image quality.
2. Cs-IR (Dec.26) / Cs-Opt focus (Dec.22) / PF-Opt (Nov.16) / NsIR (Nov.06) / NsOpt (Dec.07 & Jan.24)
3. There are **29 modes**! Moreover, some software bugs are found.

Current status of PA/MA

29 modes!

	PA	MA	Off-axis SH	X(mm)	Y(mm)	tX(')	tY(')	U(mm)	V(mm)
PIR									
POpt	EngObs061116	EngObs061116	EngObs061116	0	0	1.5	0	-	-
Cs(?CsOpt)	EngObs061027	EngObs061027		0	0	0	0	0	0
Cs(?CsOpt)+ADC*1	EngObs061222	EngObs061222	EngObs061124	2.5314	0.2912	0.2364	-2.7859	0	0 or -0.5*2
?NsOpt(CsOPt)	EngObs061028	EngObs061027		0	0	0	0	0	0
?NsOpt(CsOPt)+ADC	EngObs061028	EngObs061027		0	0	0	0	0	0
?NsOpt(?CsOpt)+ImR(B)	EngObs061028 1PA			0	0	0	0	0	0
?NsOpt(?CsOpt)+ImR(B)+ADC									
?NsOpt(?CsOpt)+ImR(R)+ADC									
?NsOpt(?CsOpt)+ImR(R)	EngObs061028 1PA			0	0	0	0	0	0
NsIR(?CsOpt)+ImR	EngObs061028 5PA	EngObs061028		0	0	0	0	0	0
NsIR(?CsOpt)									
?NsOpt(?NsOpt)	EngObs061207	EngObs061207	eye	-0.8	-0.4	0	0	0	0
?NsOpt(?NsOpt)+ADC	EngObs070124	EngObs070124	eye	-1.2	-0.8	0	0	0	0
?NsOpt(?NsOpt)+ImR(B)									
?NsOpt(?NsOpt)+ImR(B)+ADC									
?NsOpt(?NsOpt)+ImR(R)+ADC									
?NsOpt(?NsOpt)+ImR(R)									
NsIR(?NsOpt)+ImR									
NsIR(?NsOpt)									
Cs(IR)	EngObs061226	EngObs061226	EngObs061226	2.791055	1.367355	1.62892	-4.46040	0	0
?NsOpt(IR)									
?NsOpt(IR)+ADC									
?NsOpt(IR)+ImR(B)									
?NsOpt(IR)+ImR(B)+ADC									
?NsOpt(IR)+ImR(R)+ADC									
?NsOpt(IR)+ImR(R)									
NsIR(IR)+ImR	EngObs061226 1PA	EngObs061114	EngObs061106	-1.188121	0.001820	0.90612	2.08125	0	0
NsIR(IR)	EngObs061226 1PA		EngObs061226	2.791055	1.367355	1.62892	-4.46040	0	-0.5

4. Damages on the instruments

No damages

- Suprime-Cam, COMICS, MOIRCS, CISCO(*) , AO36, CIAO, Kyoto3DII(*), FMOS(*)

Damaged instruments

- Nasmyth-IR focus: **IRCS**, **AO188**(*), **Laser Guide Star system (LGS)**
- Nasmyth-Opt focus: **HDS**

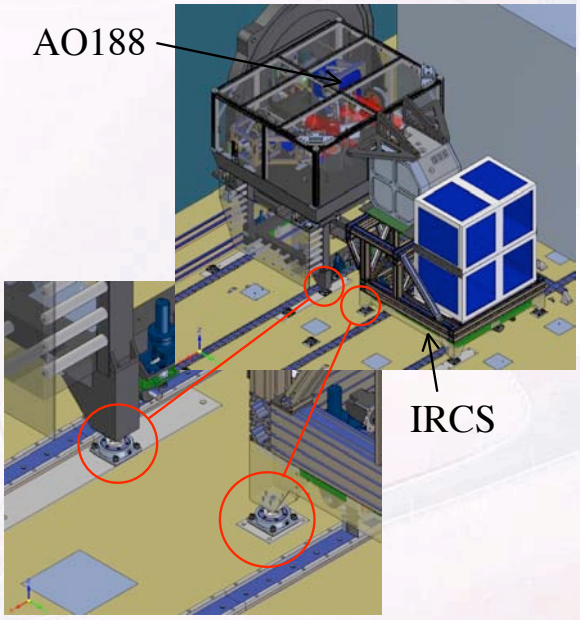
(*): The final tests have not been done yet when they are mounted on the focus position.

4. Damages on the instruments: IRCS & AO188

Both AO188 and IRCS were fallen off from the fixed bases.

Normal

AO188

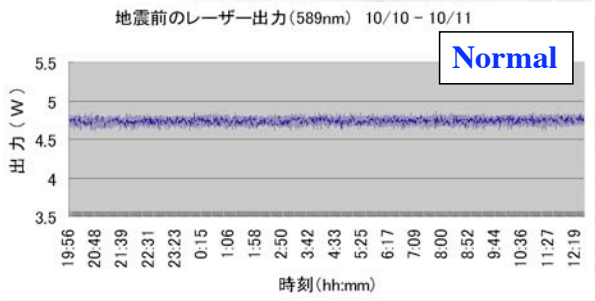


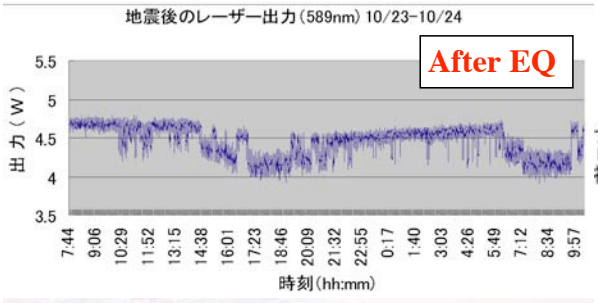
IRCS

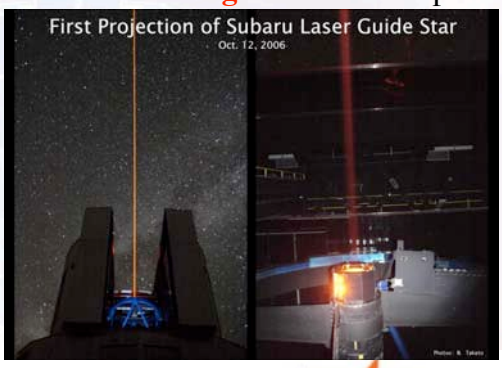
After the Earthquake

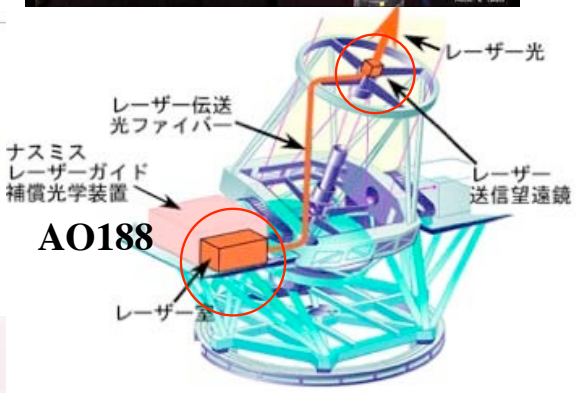
4. Damages on the instruments: LGS

The output is **unstable** after the earthquake due to the **misalignment** of the optical and laser parts (~0.01 mm).









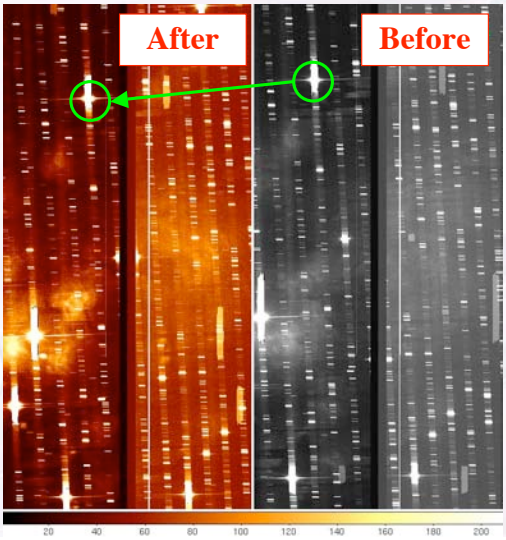
4. Damages on the instruments: HDS

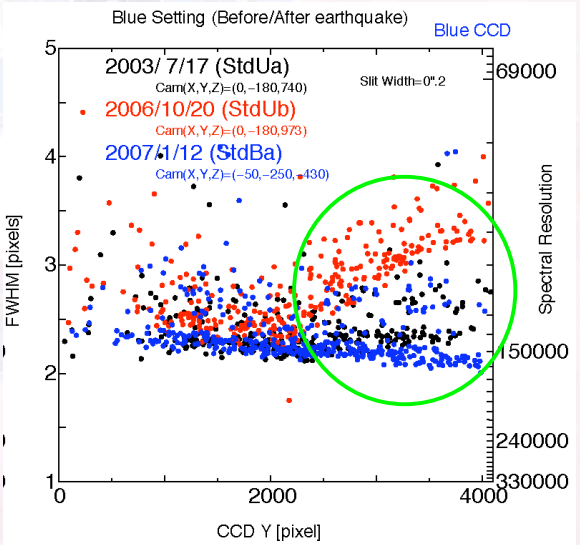
Misalignment of the optics and CCD camera unit.

→ Worse spectral resolution and tilted focal plane

- Installation accuracy was ~0.1mm.
- Non-uniform spectral resolution on the CCD with 0.2”

→ Re-adjustment works had been successfully done on Jan.17.





Summary

- It was necessary to carry out detailed analyses of the impact of the earthquakes and careful repair work. Science observations(*) and public tours of the telescope will be halted until the end of October.

(*)10/15-16: FOCAS (UH: Bresolin) 10/17-19: K3DII (Saito)
10/20-21: S-Cam (UH: Sheppard) 10/22-24: S-Cam (Ouchi)
10/25: IRCS (Miyata) 10/26-27: IRCS (Leigh)

- Fortunately, there were no significant damages on SUBARU.
- From Oct.26, SUBARU could start engineering observations.
- From Nov.3, SUBARU **resumed open-use observations.**
- From Nov.8, SUBARU **resumed public tours at the summit.**
- The performance test works are still on going. It takes more engineering time to check all functions on SUBARU.

We appreciate your expressions of concern and encouragement.

今回の地震に際して多くの方からご心配をいただき、
どうもありがとうございました。

Tomonori Usuda