Introduction of Continuous H-alpha Imaging Network (CHAIN) Project & Possibility of Observation at the Antarctica

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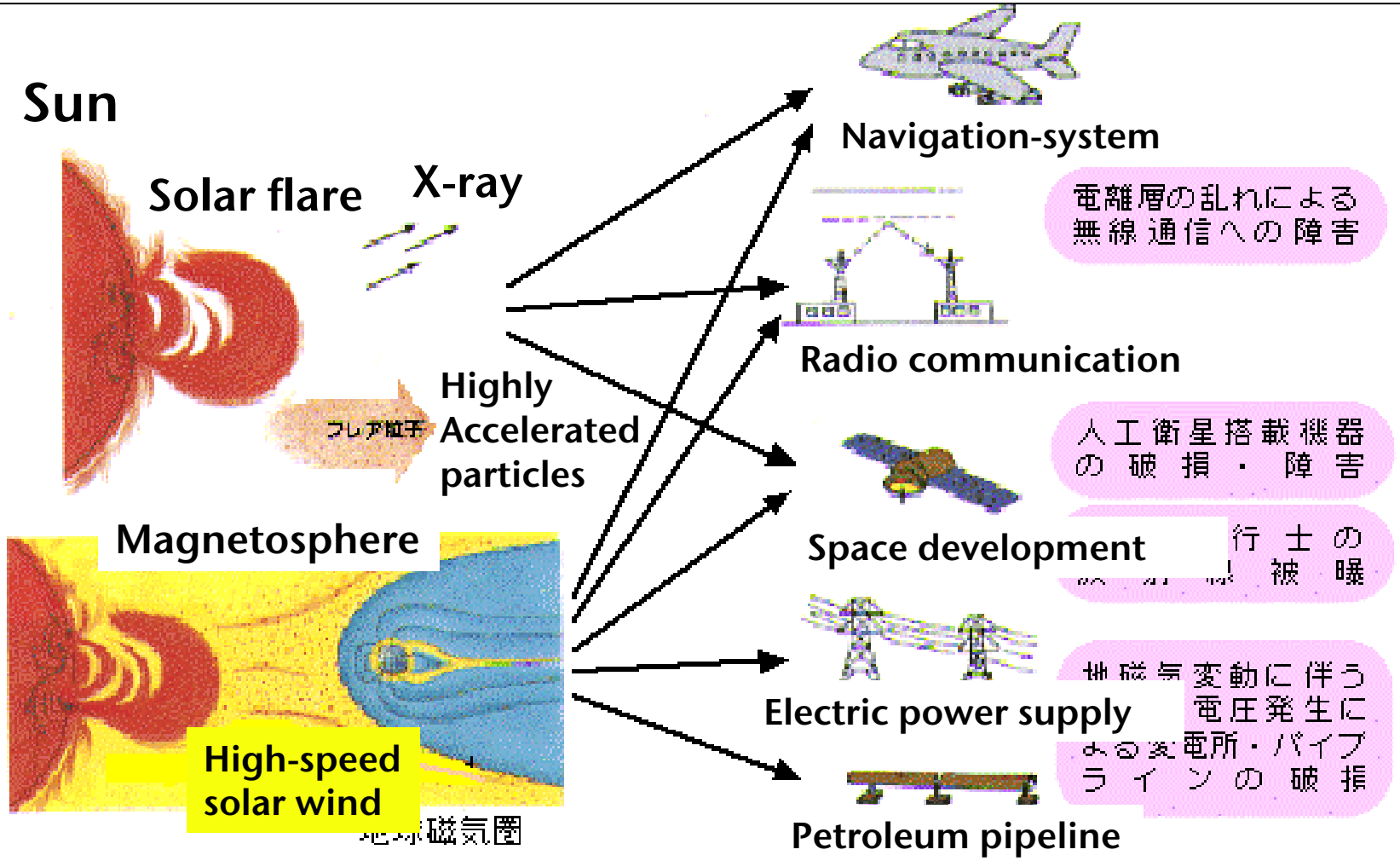
Two Themes of CHAIN Project

(Continuous H-alpha Imaging Network Project)

Observational investigation of the correlation between "the velocity strength and direction of the explosive phenomena" and "geoeffectivity of the corresponding Coronal Mass Ejections (CME)",
by monitoring full-disk Sun (chromosphere) continuously & obtaining 3-D velocity field of all large-scale active phenomena, that are initial and boundary conditions of space-weather.

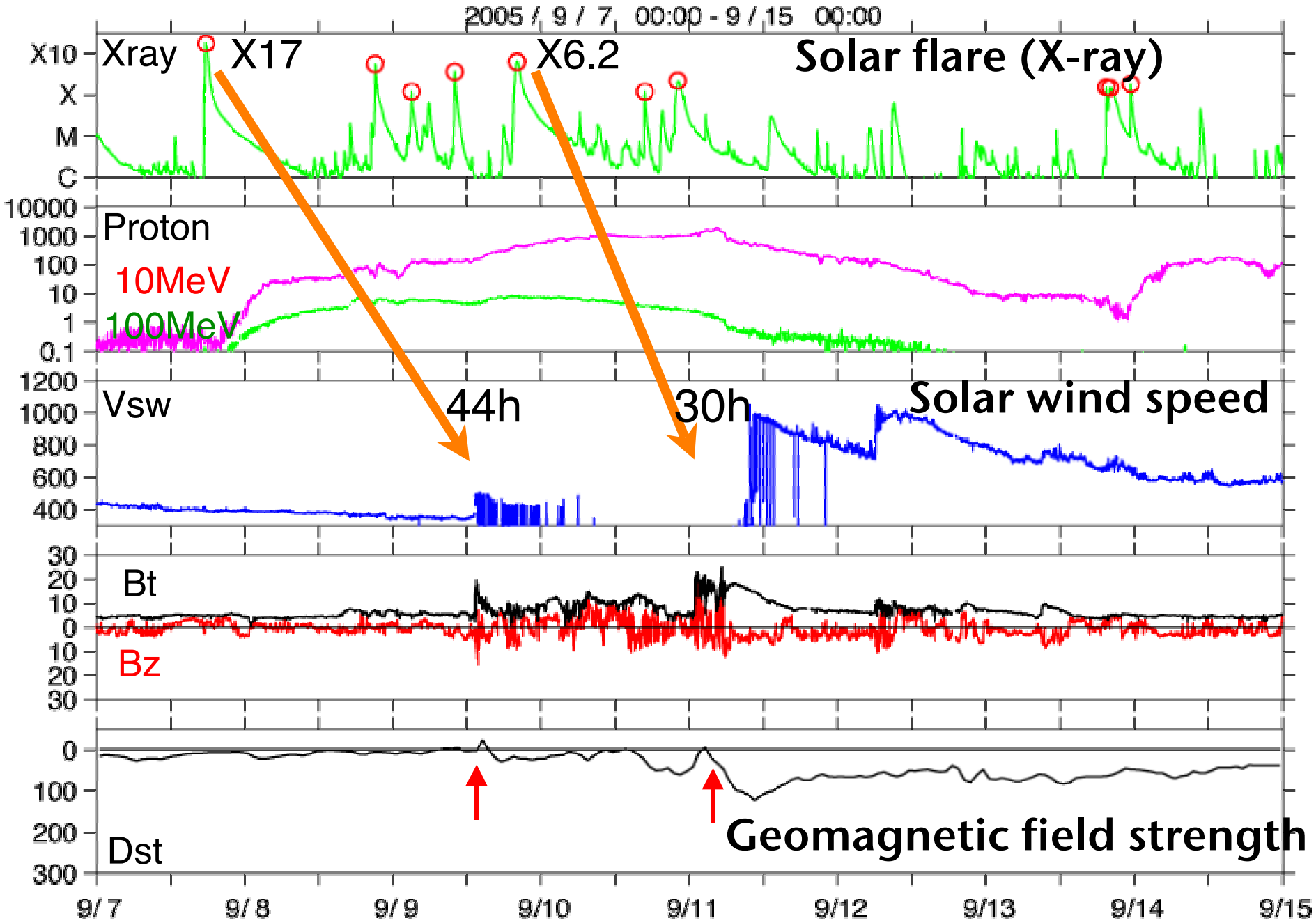
International exchange, the spread, and the development of the space weather, the solar physics, and the space science research by forming the international cooperative observational network with foreign countries including developing countries.

Influence of Solar Activity on the Earth and Our life



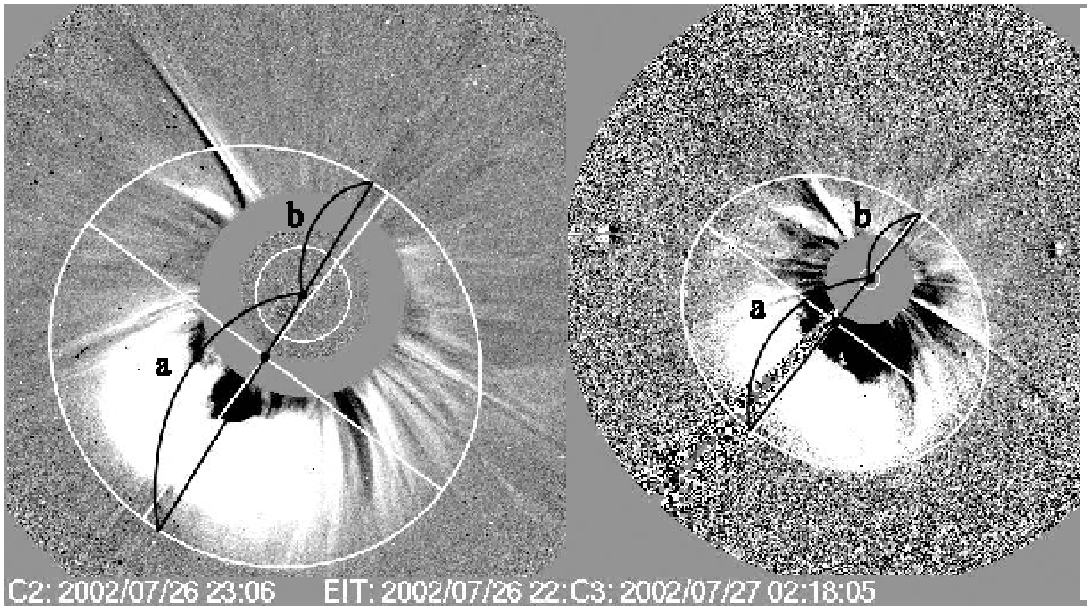
Space weather prediction is an urgent issue for human beings

During CAWSES campaign observations (by Shinohara)

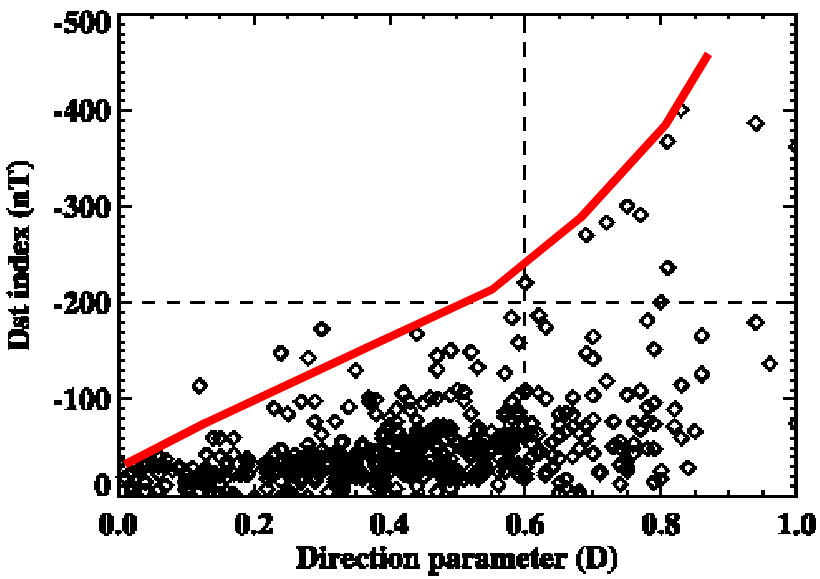


As for the correlation between
"the velocity strength and direction of the eruption" and
"the strength of geoeffectiveness"

R.S. Kim et al. ApJ, 677, 1378 (2008 Apr.20)
"CME Earthward Direction as an Important Geoeffectiveness Indicator"

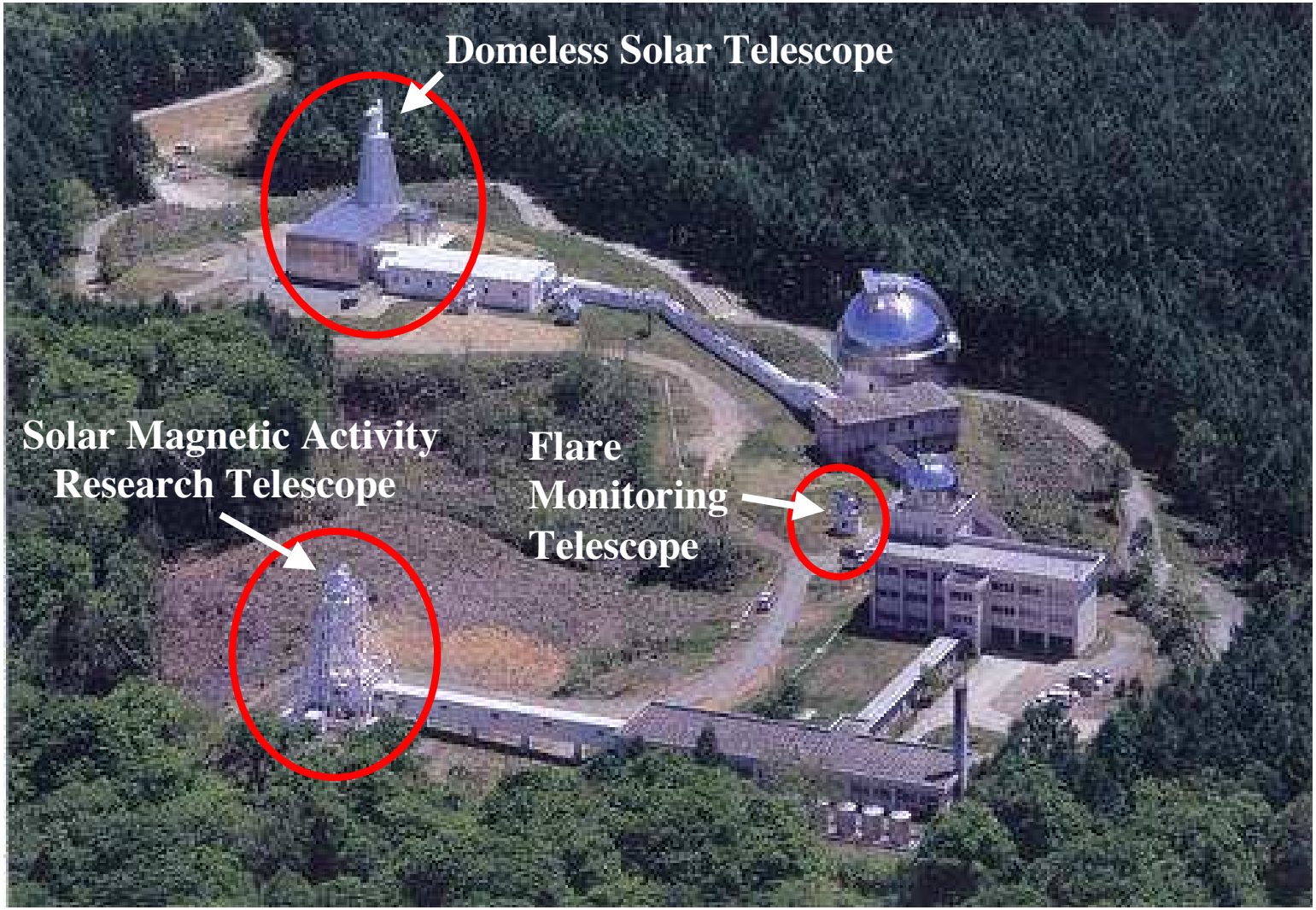


LASCOC2 (left) and C3 (ri ht) images to illustrate how to estimate the direction parameter. The ratio of the shorter (b) to longer (a) distance of the CMEfront measured from the solar center along the line (b/a) is defined as the direction parameter, D. Note that the line passes both through the centers of the ellipse and the Sun.



Direction parameter vs. Dst index for 486 frontside halo CMEs. The horizontal dashed line represents Dst = -200 nT, and the vertical dashed line indicates D=0.6.

*Solar Telescopes at Hida Observatory



Hida observatory

In our observatory, space weather researches have been done in two complementary ways with the three solar telescopes.

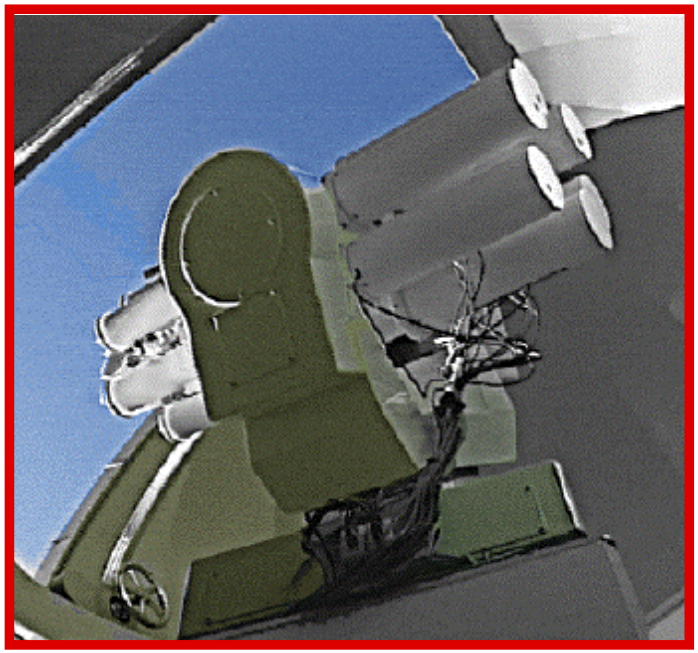
- Detailed observations of solar events with high-resolution imaging and spectrum-measurement

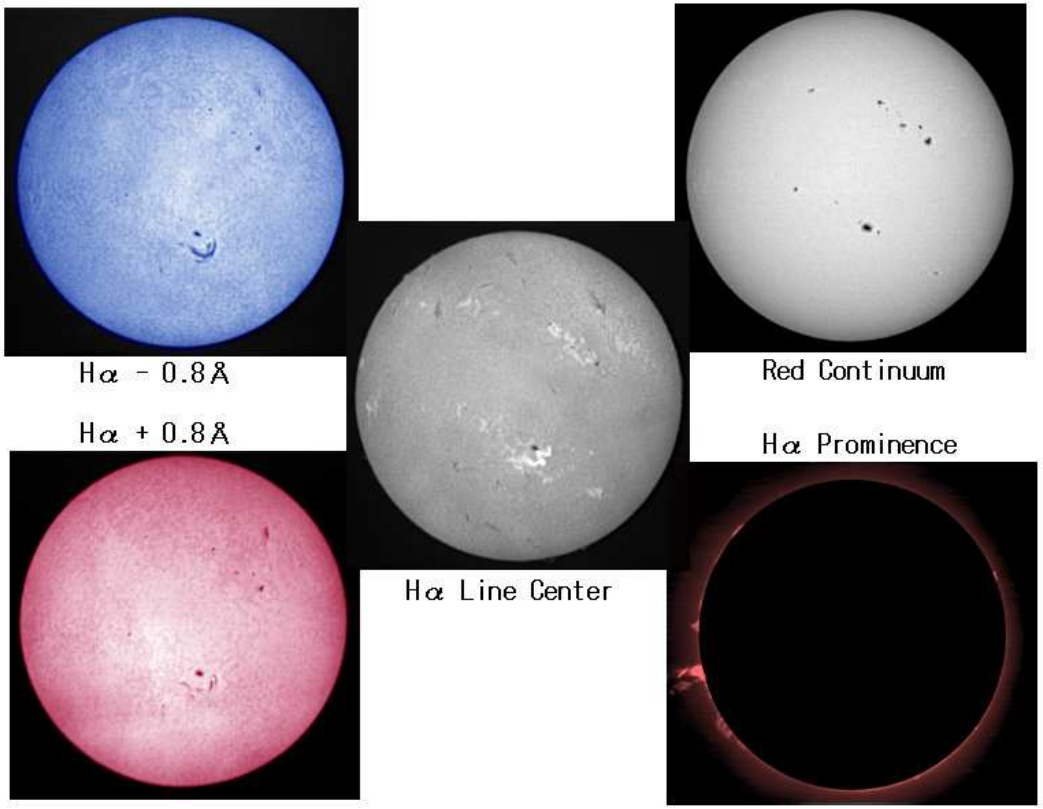
  => Domeless Solar Telescope (DST)

- The solar full-disk observations

  => Solar Magnetic Activity Research Telescope (SMART)
  => Flare Monitoring Telescope (FMT)

The Flare Monitoring Telescope (FMT)





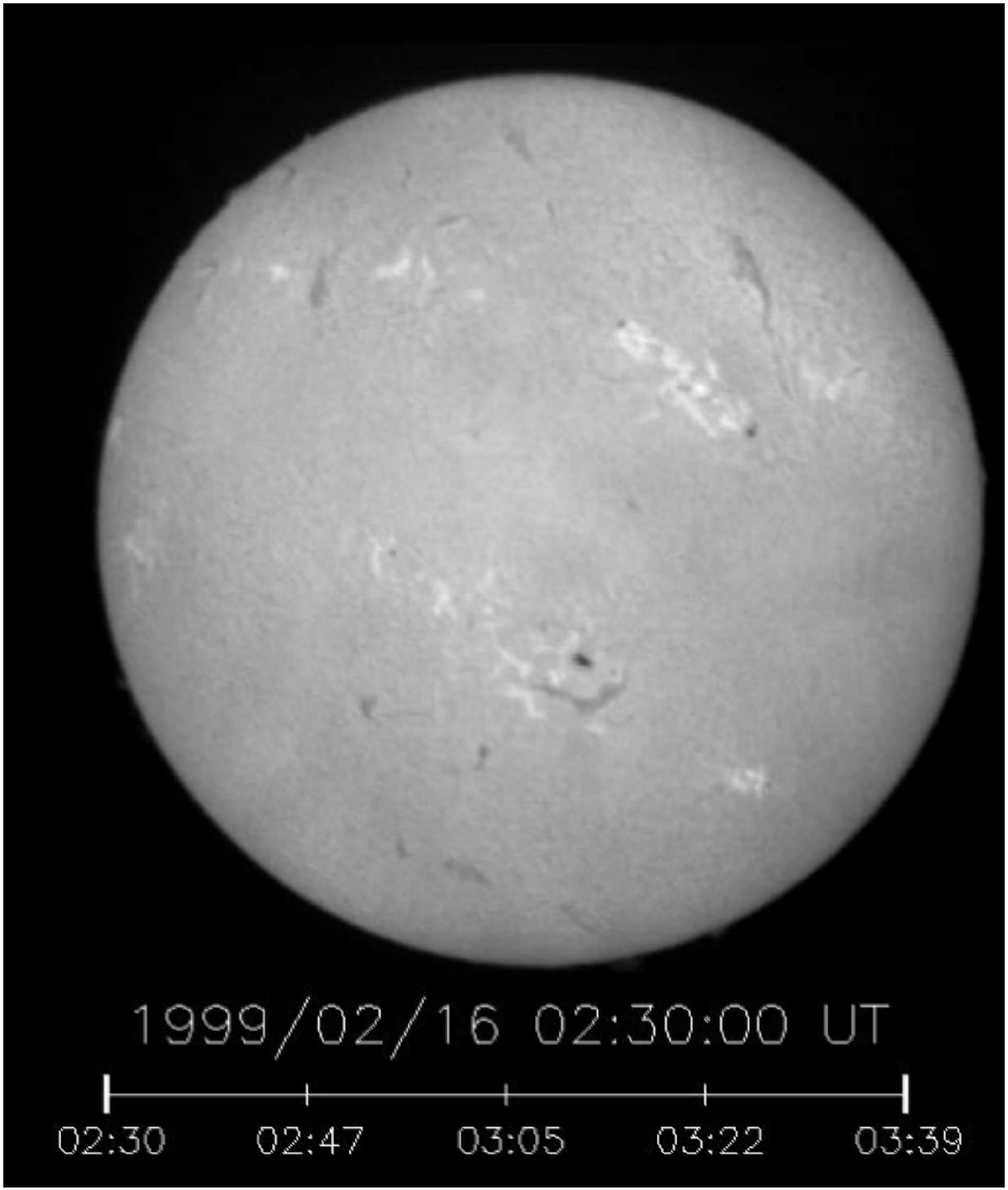
-The FMT was constructed in 1992 at Hida Obs. to investigate the long-term variation of solar activity and explosive events.

- The FMT consists of 6 small telescopes.
  The diameter of each telescope is only 64mm.
  However, the five telescopes simultaneously observe the full-disk Sun at different wavelengths or in different modes without time lag.

- Therefore, the FMT can measure the 3D velocity field of moving structures on the full solar disk with very small errors by the effect of the seeing.

Example of the flare

At H-alpha line center



Example of the prominence eruption

with the prominence mode

Examples of Data Analysis with the Flare Monitoring Telescope (FMT)

(1) 3D velocity field analysis of the eruptive phenomena

(2) Shock-wave analysis (Moreton wave)

(1) 3D velocity field analysis of the eruptive phenomena

Cloud Model Fitting

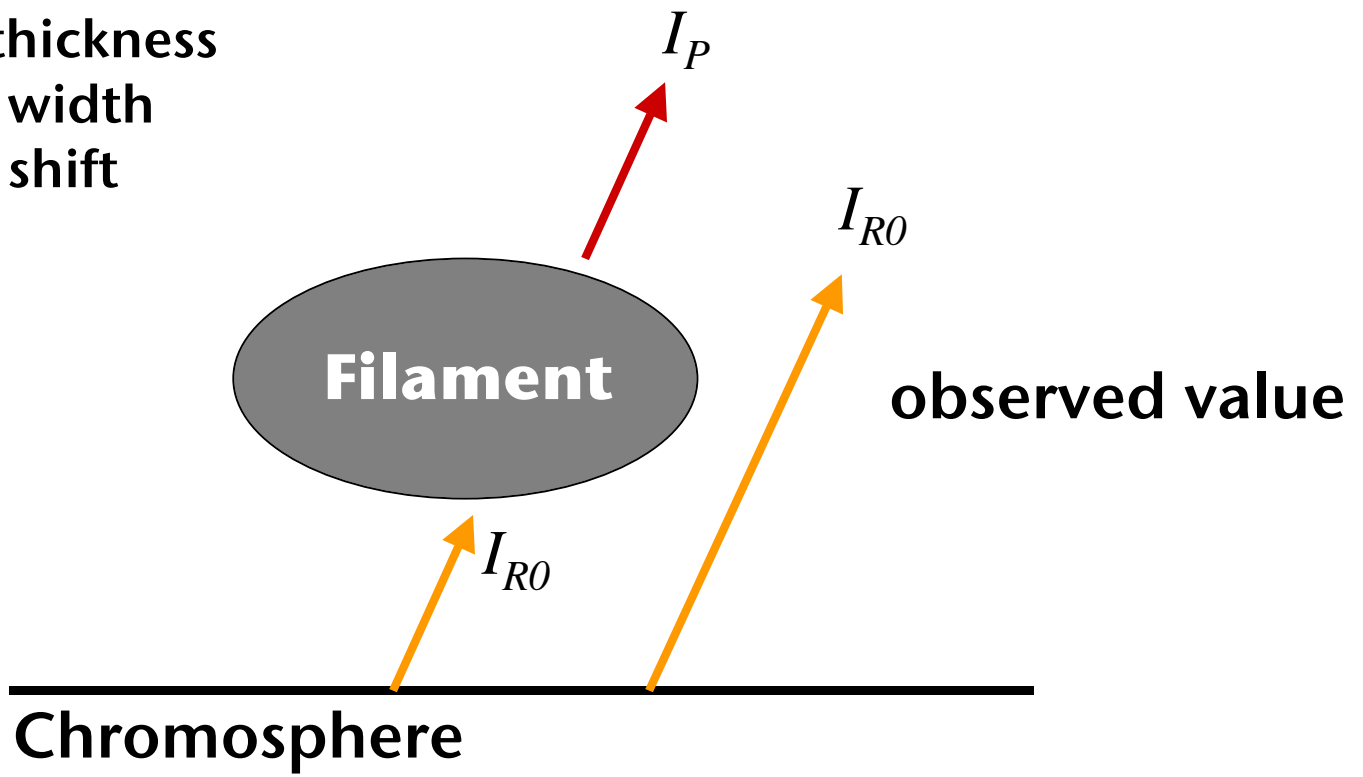
Observed contrast: $C(x,\Delta\lambda) = [I_P(x,\Delta\lambda) - I_{R0}(\Delta\lambda)]/I_{R0}(\Delta\lambda)$

$$C(\Delta\lambda) = \left[\frac{S}{I_{R0}(\Delta\lambda)} - 1\right]\{1 - \exp[-\tau(\Delta\lambda)]\}$$

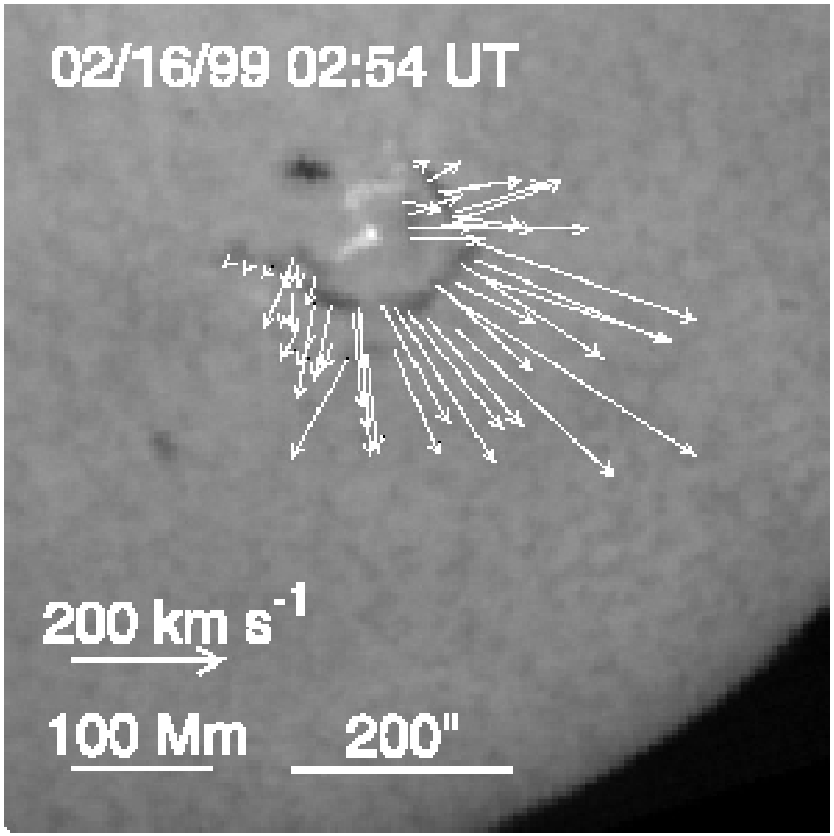
$$\tau(\Delta\lambda) = \tau_0 \exp\{-[(\Delta\lambda - \Delta\lambda_S)/\Delta\lambda_D]^2\}$$

parameters

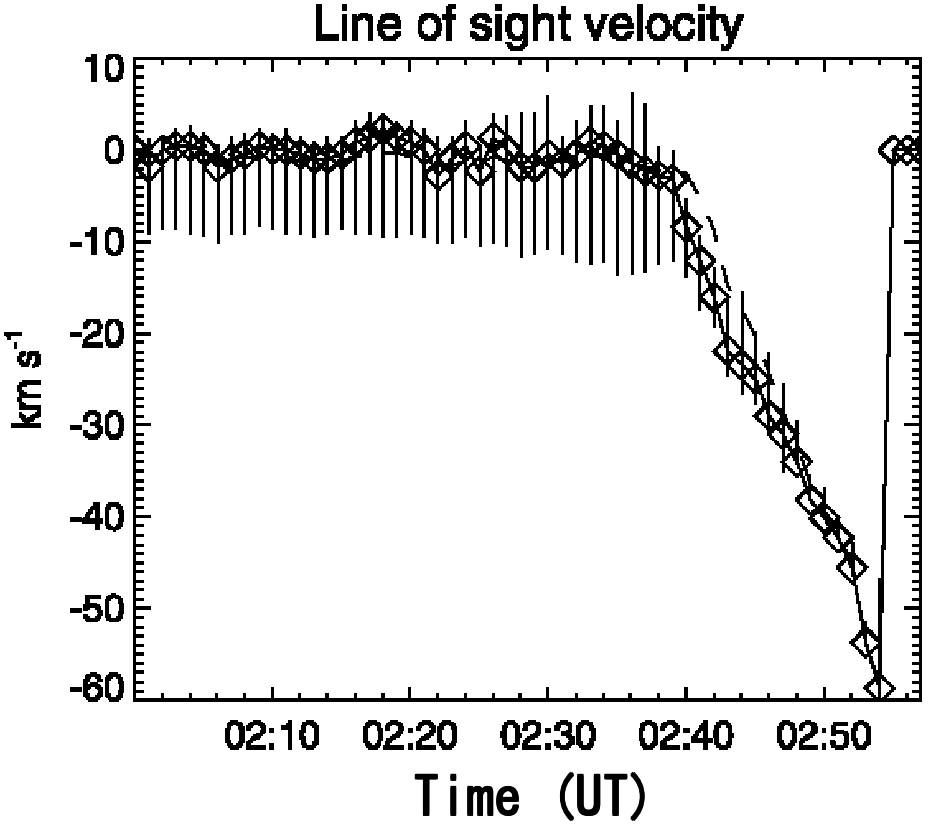
S : Source Function
$\tau(\Delta\lambda)$: Optical thickness
$\Delta\lambda_D$: Doppler width
$\Delta\lambda_S$: Doppler shift



Transversal Velocity Field

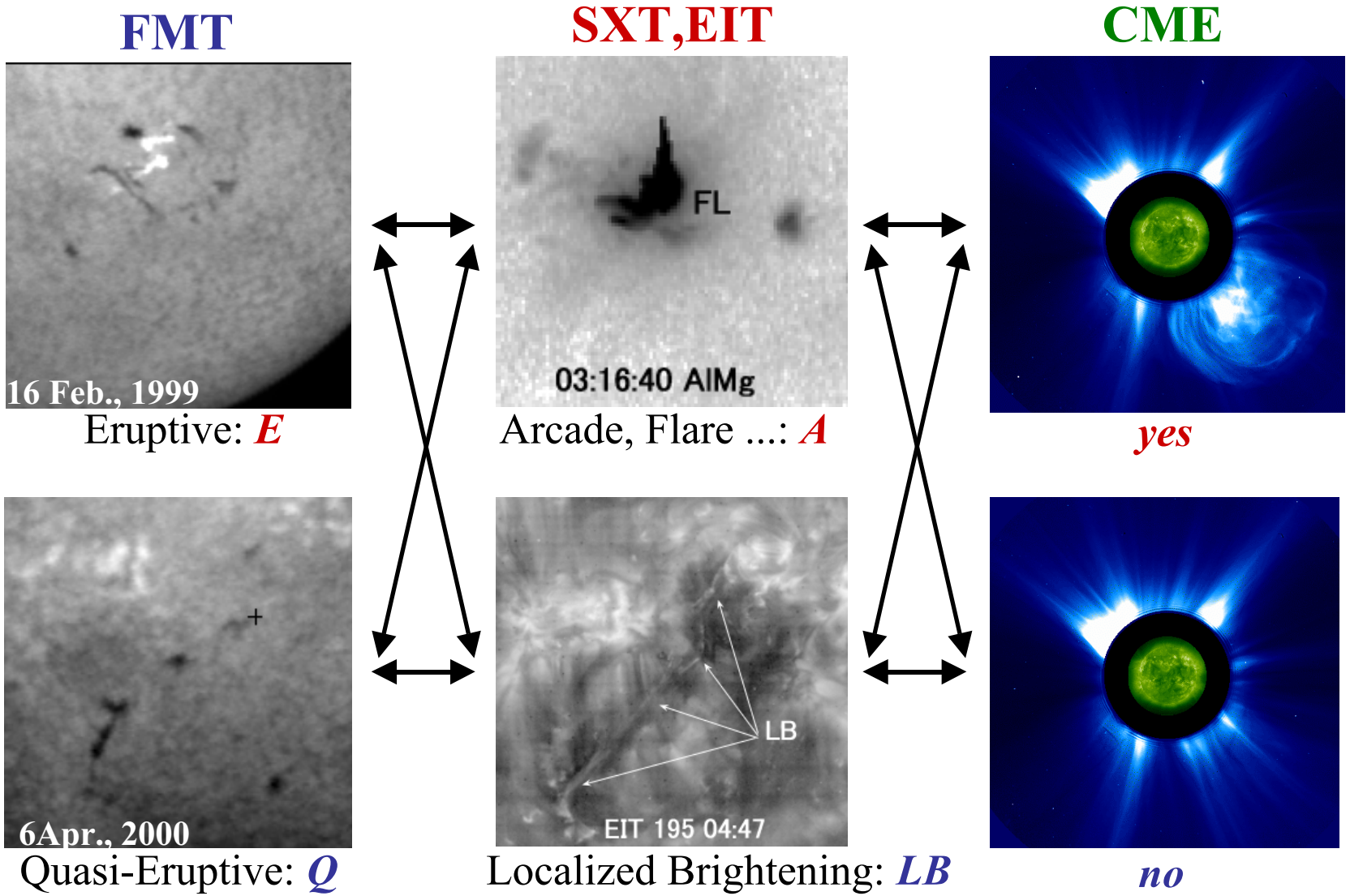


Time Evolution of the Doppler Velocity at the top of the filament



Morimoto & Kurokawa(2003 PASJ)

They distinguished whether each active filament really erupted or not by analyzing its time-variation of the radial upward velocity, and investigated the relation with coronal structure and CME.



As the result, all really erupting filaments correspond to appearances of "coronal arcade structures" and "CMEs".

No.	Time	Location/NOAA	Type (γ)	SXT	EIT	GOES(min)	CME
1	11/05/92 00:15-02:15	S20W17/	E (43)	A		-	
	.....	.....	...				
26	10/27/98 23:34-36:39	N18E40/8369	Q (0)	-	LB	C1.6	no
27	01/30/99 00:00-01:50	S34E20	E (84)	A		B3.3	
28	02/09/99 03:07-05:22	S27W39/8453	E (13)	A	A/EW/D†	C2.3	yes
29	02/16/99 01:42-04:15	S27W18/8458	E (53)	A		M3.2	
30	06/01/99 06:29-07:08	S23E17/8557	Q (0)	LB		C6.2	no
31	01/19/00 00:28-01:47	N08W18/8829	E (36)	A	A/D	C1.4	yes
32	01/28/00 05:35-06:20	S28W20/8841	Q (0)	LB	LB	B4.4	no
33	04/06/00 03:48-05:48	S27W02/	Q (0)		LB	C1.4	no
34	04/25/00 01:05-01:47	N23W27/8972	E (51)	A	A/FE	C1.1	yes
35	05/08/00 04:19-07:40	S21W03	E (45)	A	A/FE/D	B6.8	yes

DB Type vs. Coronal Signature

DB type	A	LB	Total
Eruptive	22 (71%)	0 (0%)	22
Quasi-eruptive	1 (3%)	8 (26%)	9
	23	8	31

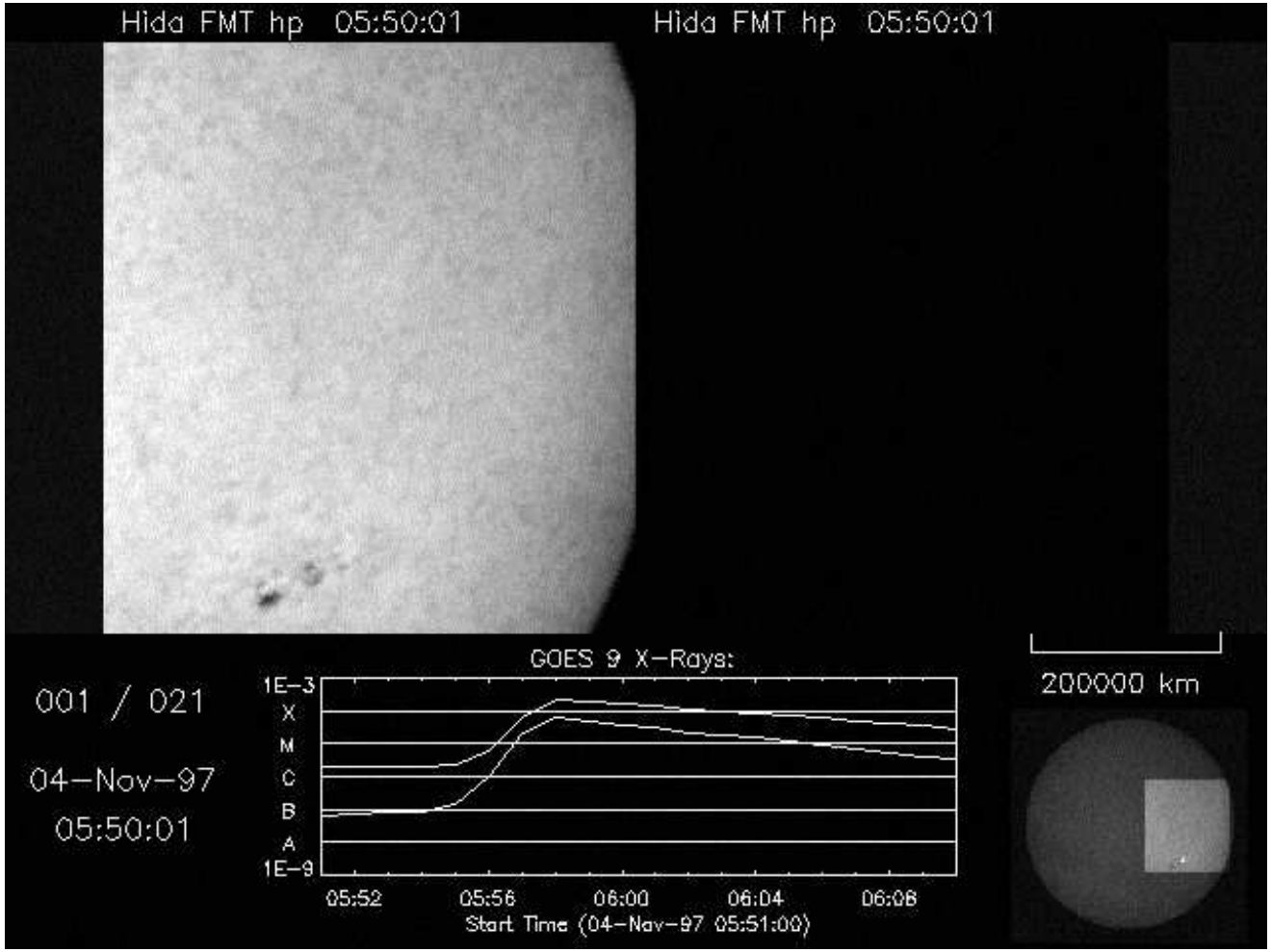
DB Type vs. CME Association

DB type (SXT & EIT)	yes	no	Total
Eruptive(A)	8 (53%)	0 (0%)	8
Quasi-eruptive(LB)	0 (0%)	7 (47%)	7
	8	7	15

Morimoto & Kurokawa (2003: PASJ)

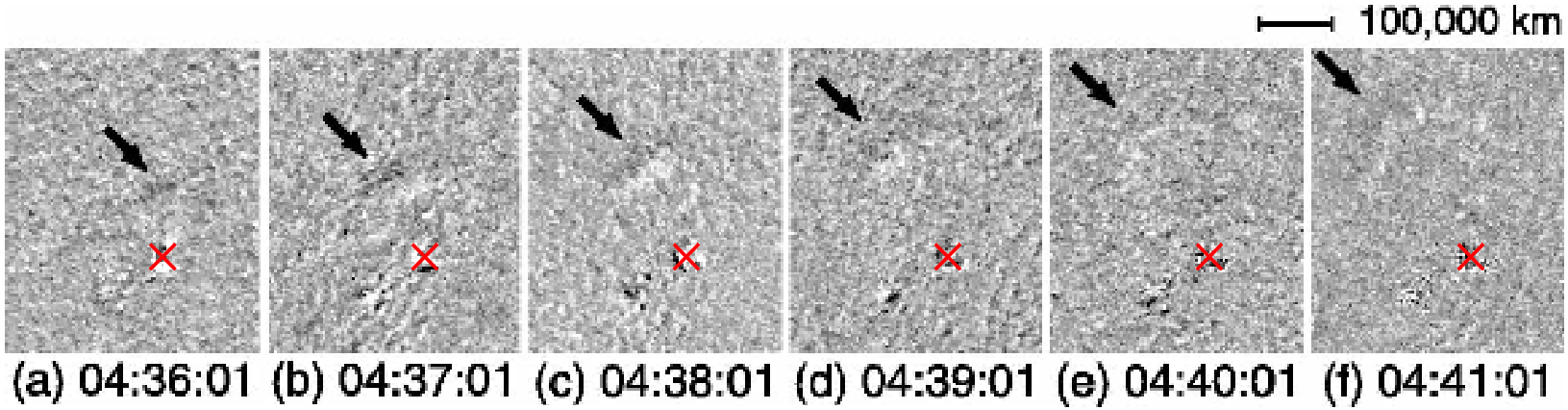
(2) Shock-wave analysis
(Moreton wave)

Moreton Wave: the cross section in the chromosphere of a shockwave generated by a strong solar flare



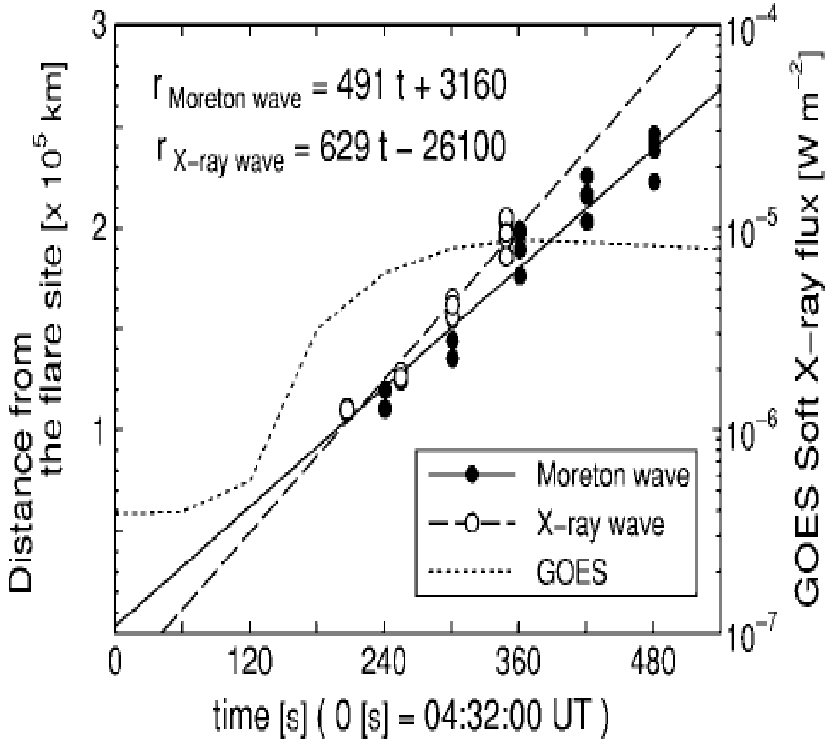
Study of Shockwave Structure observed on the Chromosphere

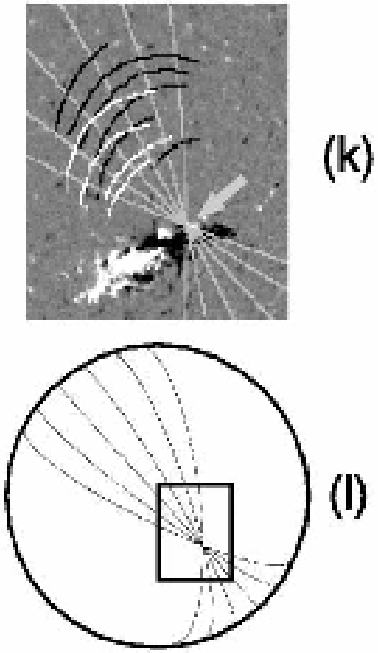
N. Narukage et al. (2002)



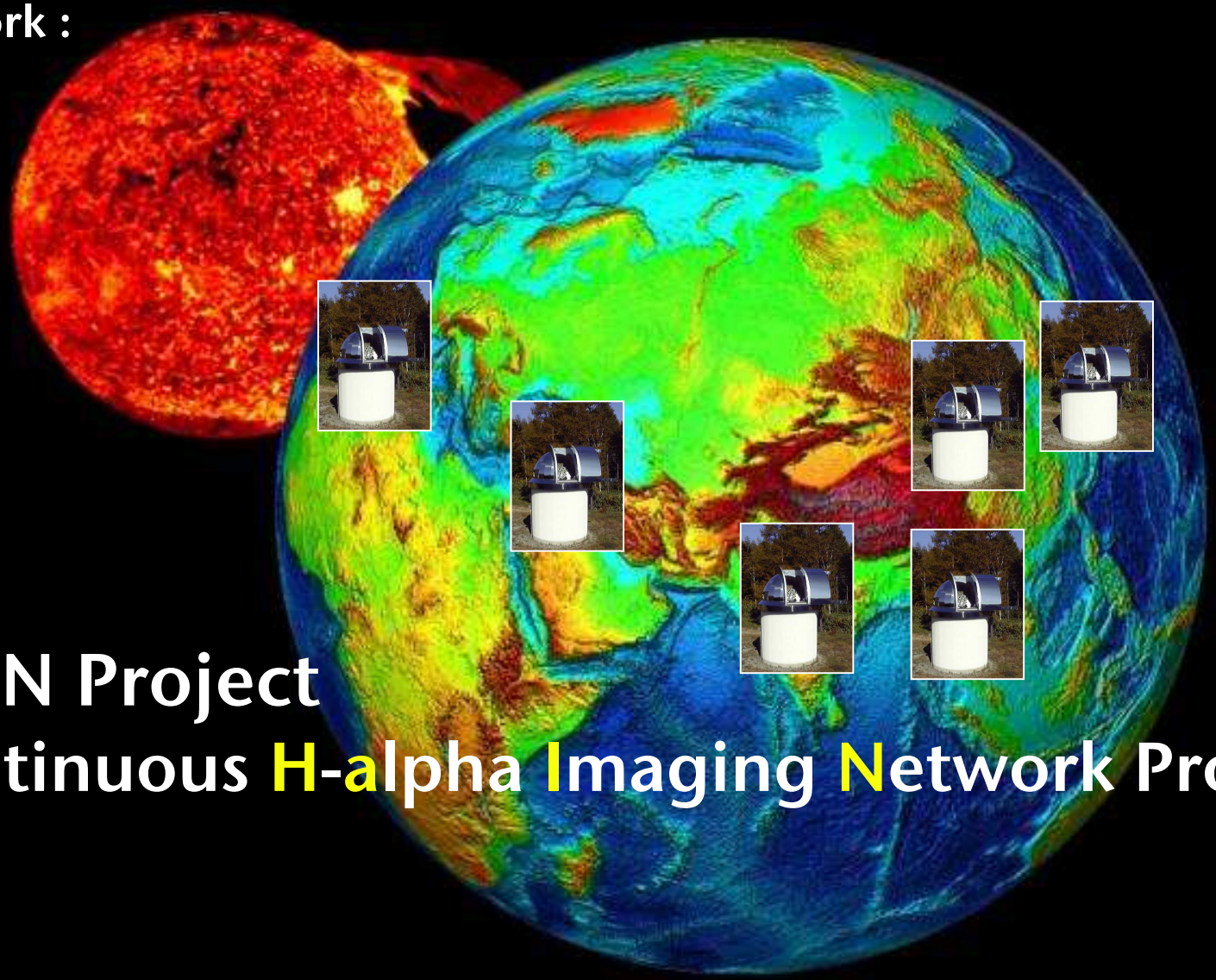
The FMT has detected many Moreton waves. More than half the number of Moreton waves that were found over the world in the past have been discovered with the FMT.

As result of comparison of Moreton waves on the chromosphere with X-ray waves in the corona, they are very similar in the speed, timing and direction, and their speed correspond to expected MHD shockwave.





We want to monitor more solar flares and erupting filaments continuously by using plural such characteristic telescopes.
Then, we are beginning to execute ground-based solar observation network :



CHAIN Project
(Continuous H-alpha Imaging Network Project)

Telescopes that are planned to be used in the CHAIN

1) Newly installed Flare Monitoring Telescopes (FMT)

We are examinig the possibility of the installation of the telescopes at appropriate foreign sites, especially in developing countries.

This should make not only the effect that the number of flare-monitoring station will be increased, but also the effect that the education and study of the solar-terrestrial physics in the developing countries will be encouraged.

2) Exsisting foreign similar H-alpha telescopes

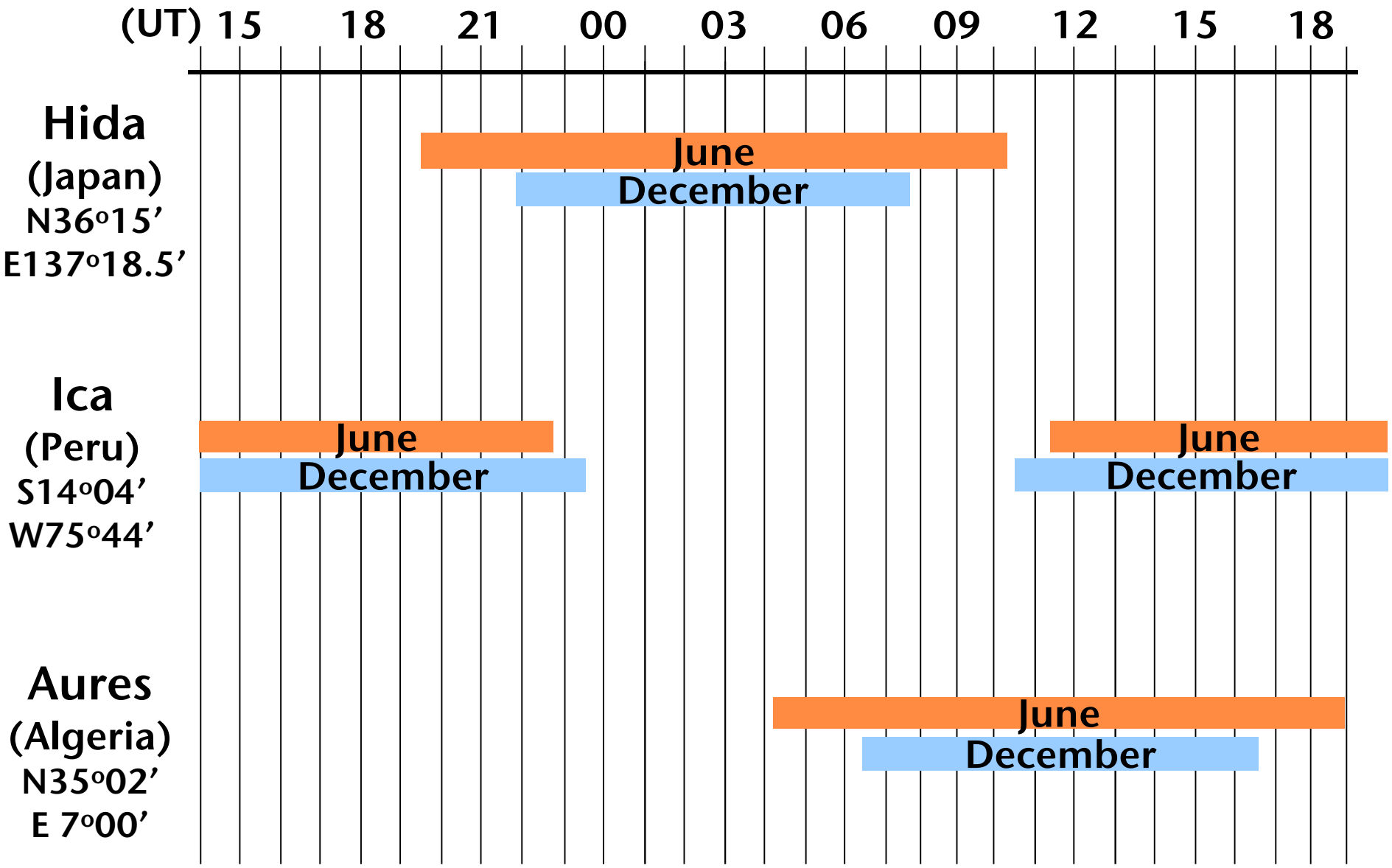
We have begun to contact with foreign observatories.
China, France, ...
It is not so easy, because they have to improve present telescopes to be able to multi-wavelength observation.

Continuous H-alpha Imaging Network (CHAIN)

Algeria — **Japan (Hida Obs.)** — **Peru (Ica Univ.)**

Daytime Period at Each Site

(between sunrise & sunset)



The 1st oversea FMT of CHAIN project ～ PERU · Ica ～

We decided that the FMT at Hida Obs. will be remodeled and be installed at Peru/Ica Univ. during 2009～2011 as the 1st oversea FMT under CHAIN-project.

National Ica University

Latitude	:	- 15°
Altitude	:	400 m
Rain	:	0 mm/year
Temperature	:	10 - 27 ℃
Avrg. Humidity	:	20 %

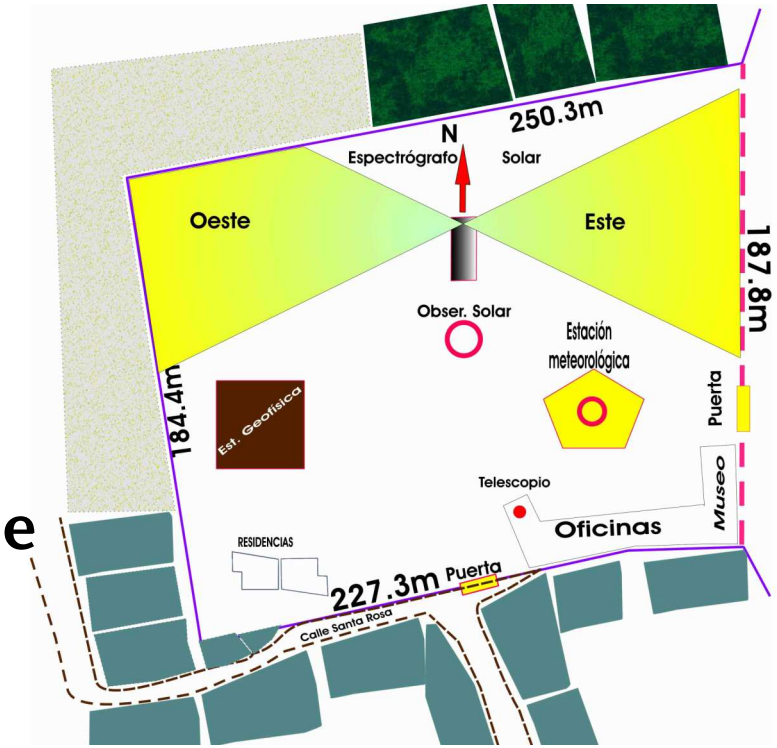
The view of the site in National Ica Univ.

Ica Univ. started to build "Solar Station" in the campus in 2008 by their special budget. It will be completed in the first half of 2009.

On 30th June of 2008, the ground-breaking ceremony was held at the campus.

The building for the FMT will also be started to be built soon.

Sketch Map of the "Solar Station" in National Ica Univ.



Air-flow Investigation with the Smoke

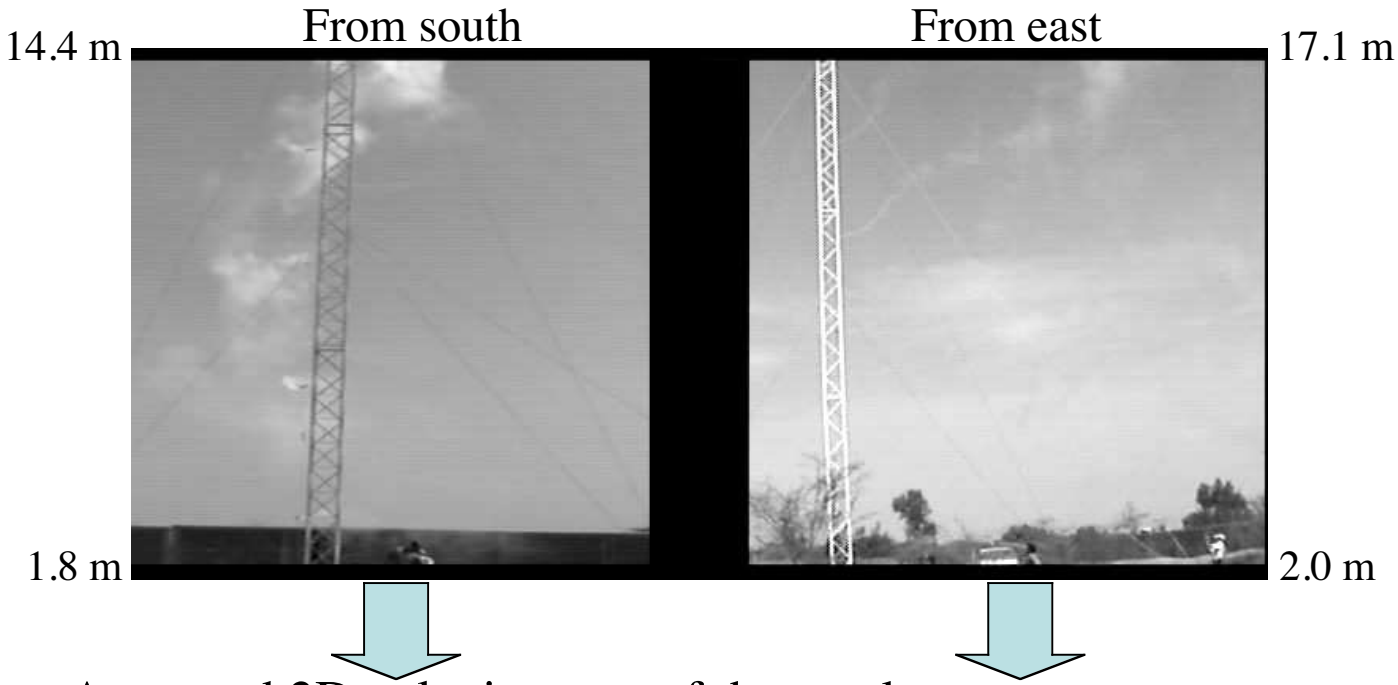
A smoke candle

Smoke candles attached to the pylon

A video camera with which smoke-flows were observed.

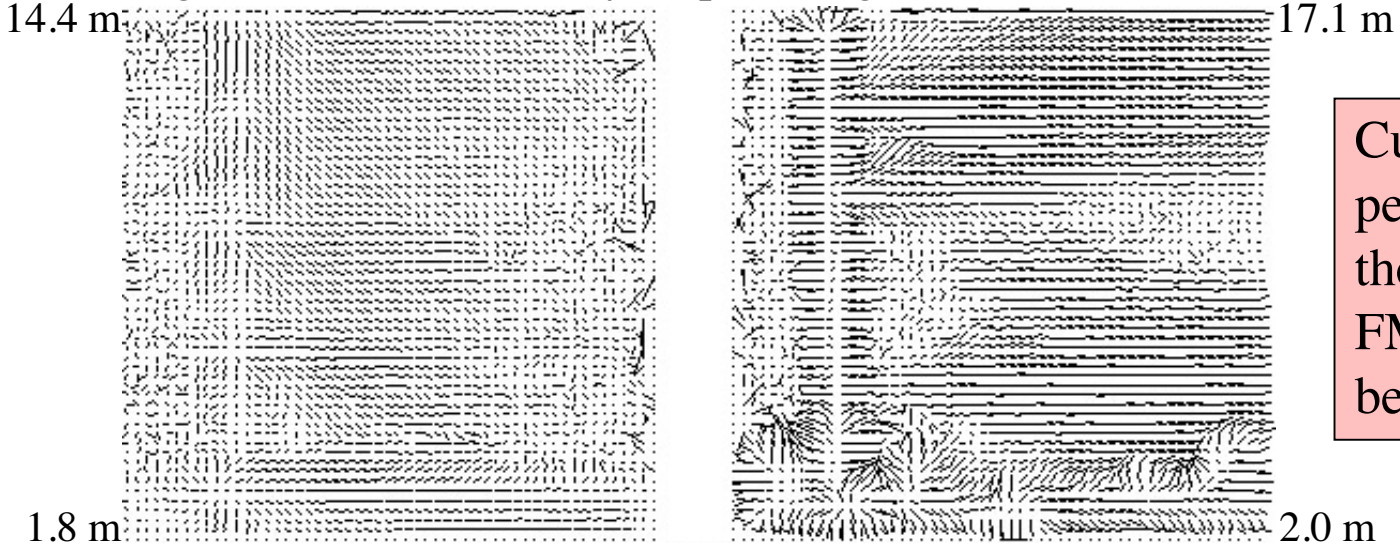
Smoke-flows from the smoke candles

*Analysis of the data at 9 o'clock on Oct. 6th



Averaged 2D velocity map of the smoke

(Average of 3896 2D velocity maps during 130 s)



Currently Peru people suggest that the height of the FMT-building will be 9 m.

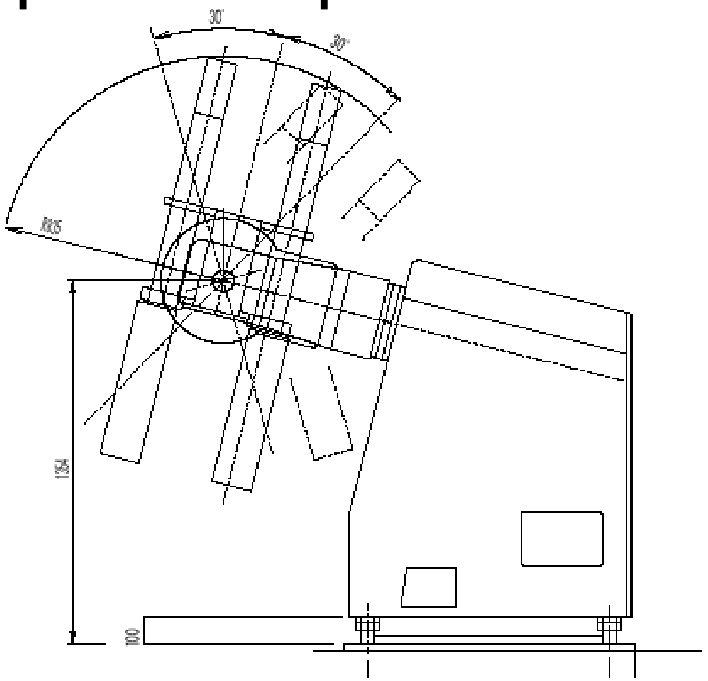
Plan of Kyoto Univ.

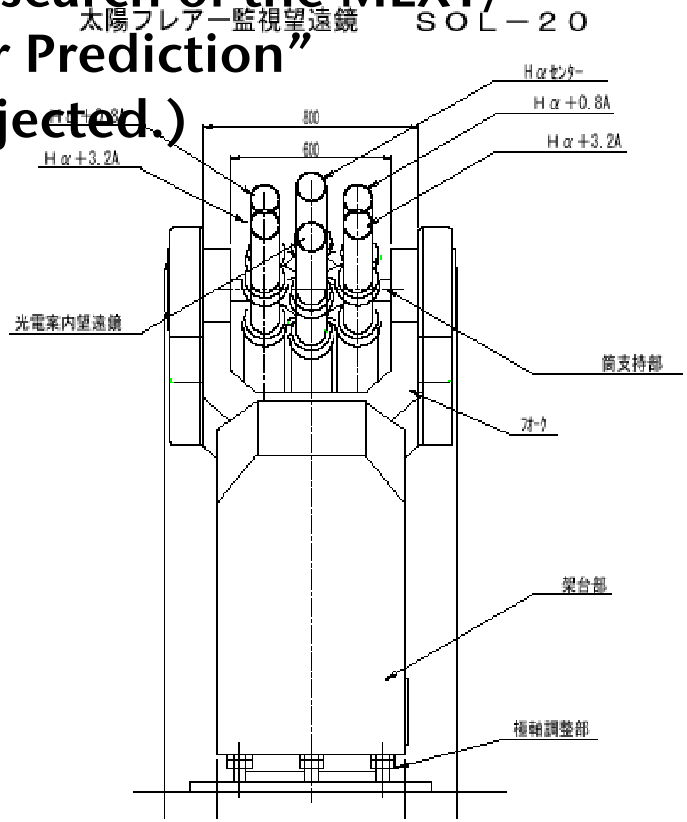
***Our observatory will remodel the present FMT at Hida and will send it to Peru by our budget.**

1）Three year plan of 2009～2011: under applying the Grant-in-Aid (B) for oversea academic investigations of the MEXT/Japan

or 2）One year plan in 2009 by our existing budget: Grant-in-Aid for Creative Scientific Research of the MEXT/ JAPAN “Basic Study of Space Weather Prediction” (If the application of plan-1 will be rejected.)

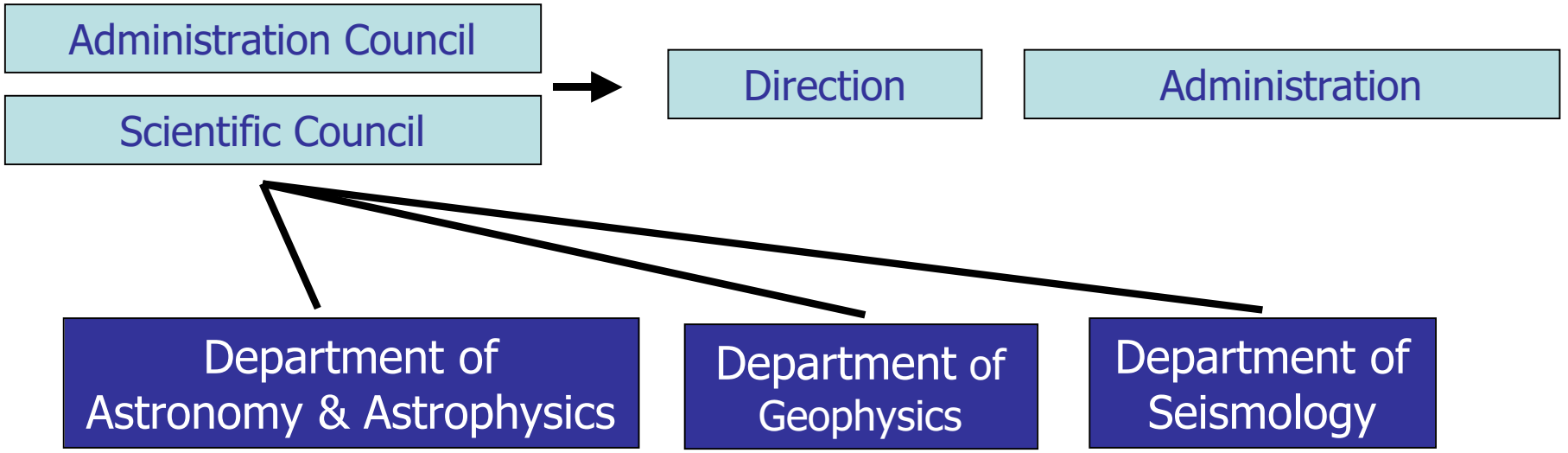
Drawing of the expected structure





Plan of constructing a new astronomical observatory by Algeria/CRAAG

(Centre de Recherche Astronomie Astrophysique et Géophysique)

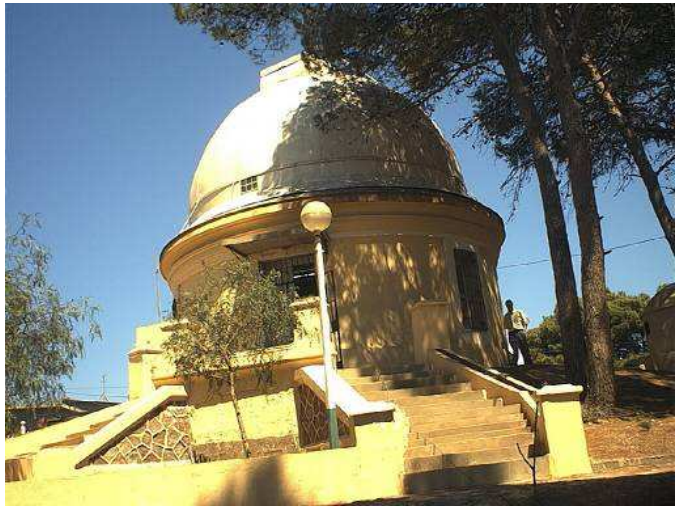


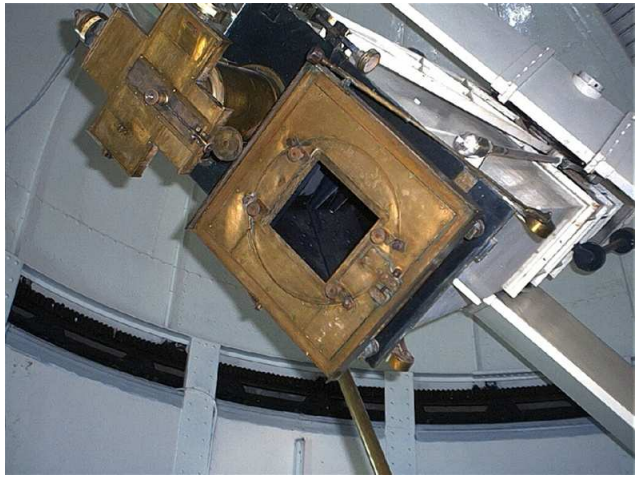
Chief: Dr. N.Seghouani

Tamanrasset Observatory
(Director: Prof. Nouredine AKACEM)

Alger Observatory since 1890

- Degrading of the old observatory,
- Light pollution in the night-time in Alger city,
- Atmospheric pollution, - The International Year of Astronomy 2009





Lat : 36°45’ N
Long: 03°02’ E

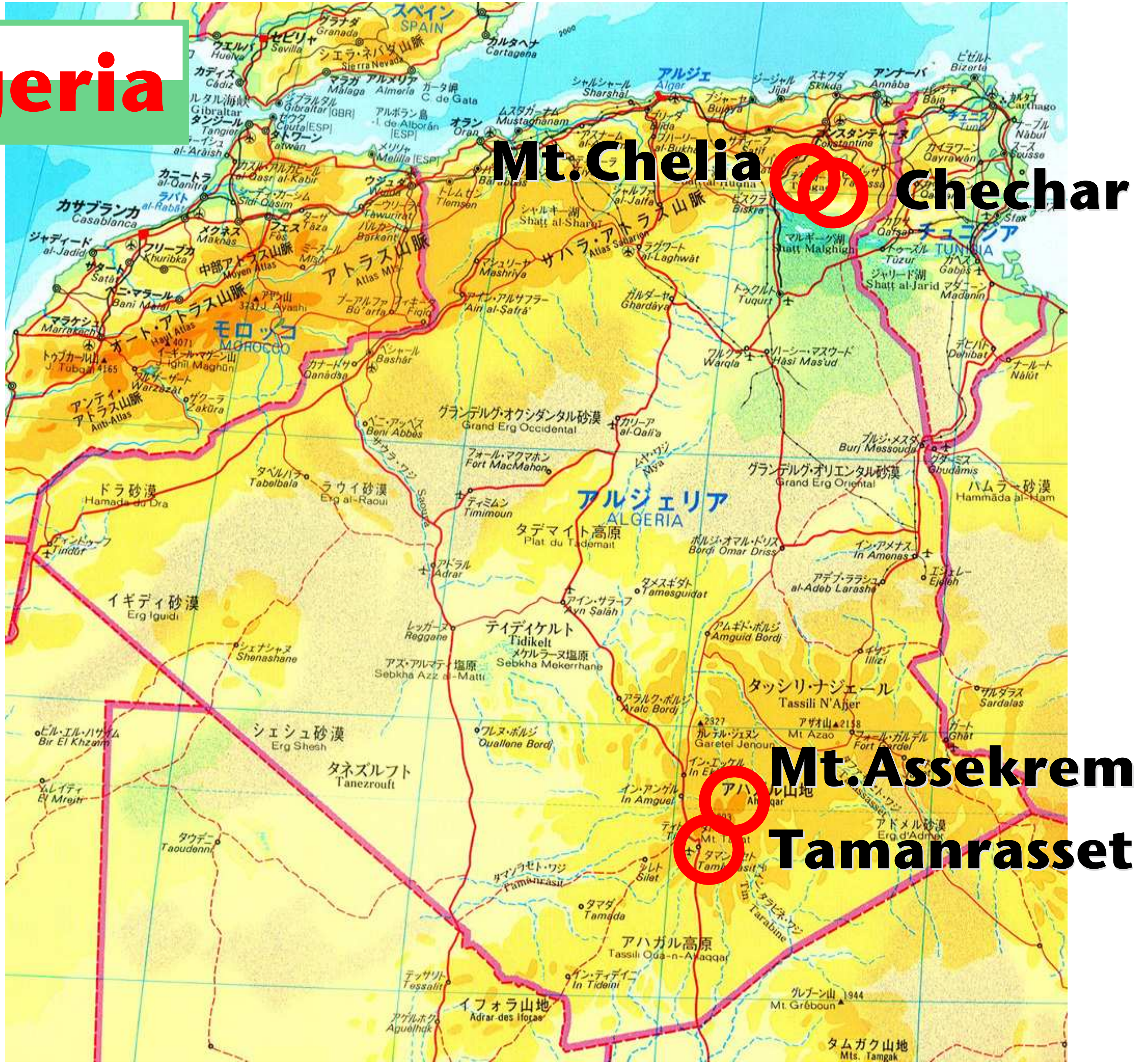
There is a 80 cm reflector for night-astronomy.

New Astronomical Observatory Requires Solar Observation Telescope, too

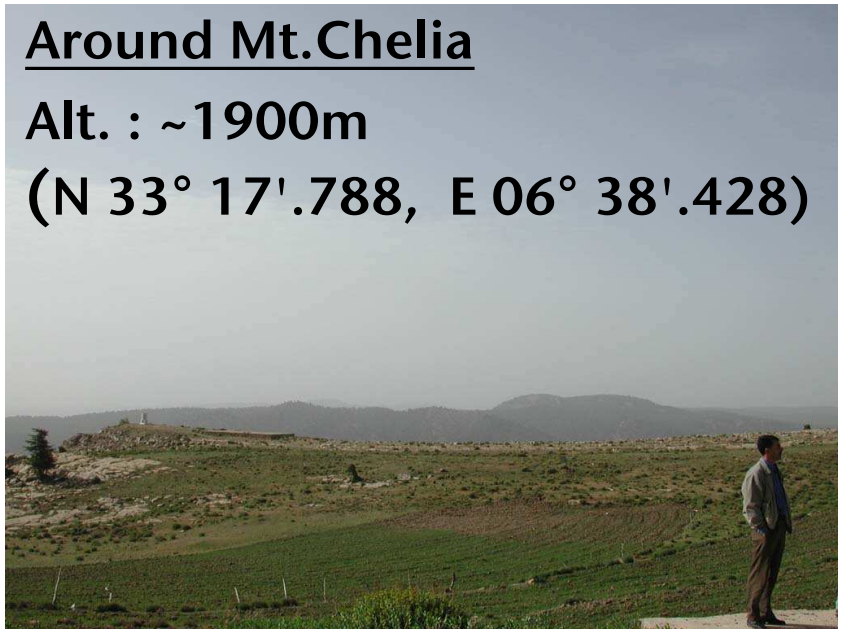
For Example,

- SOLIS-type Vector Magnetograph
  Very expensive and difficult techniques.
- Coronagraph
  At present, still just only armchair proposition.
  Needs very low scatter-light.
- FMT under the CHAIN-project
  Not so expensive, easy operation.
  The scientific theme fits to CRAAG (connection between astrophysics and geophysics).

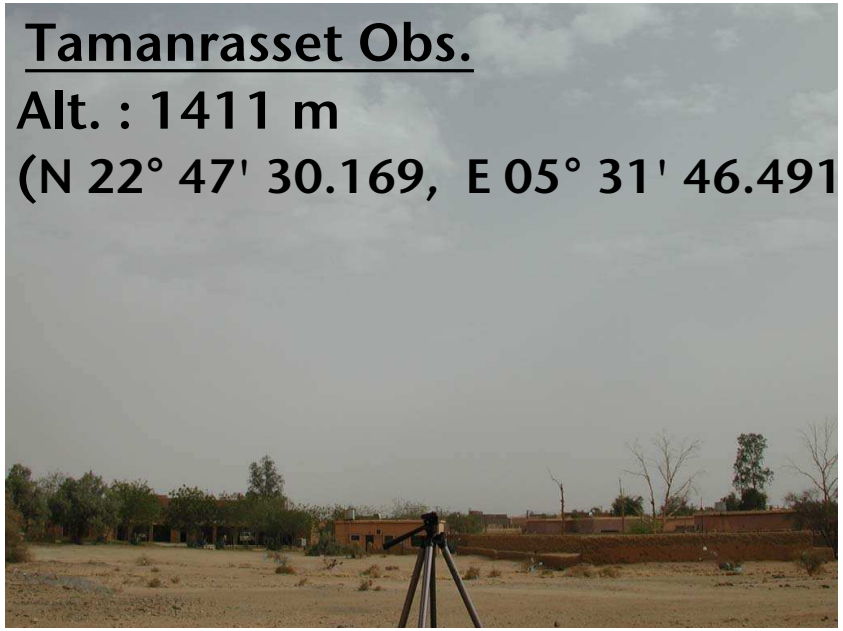
Algeria



Mt.Chelia
Chechar
Mt.Assekrem
Tamanrasset
アルジェリア
ALGERIA
モロッコ
MOROCCO
スペイン
SPAIN


Around Mt.Chelia
Alt. : ~1900m
(N 33° 17'.788, E 06° 38'.428)


Chechar
Alt. : ~2000m


Tamanrasset Obs.
Alt. : 1411 m
(N 22° 47' 30.169, E 05° 31' 46.491)


Mt. Assekrem
Alt. : 2700 m
(N 23° 15'.619, E 05° 38'.075)

Plan of Kyoto Univ.

◆ Our observatory is gathering the following informations with being supported by Algeria/CRAAG:

* General climate

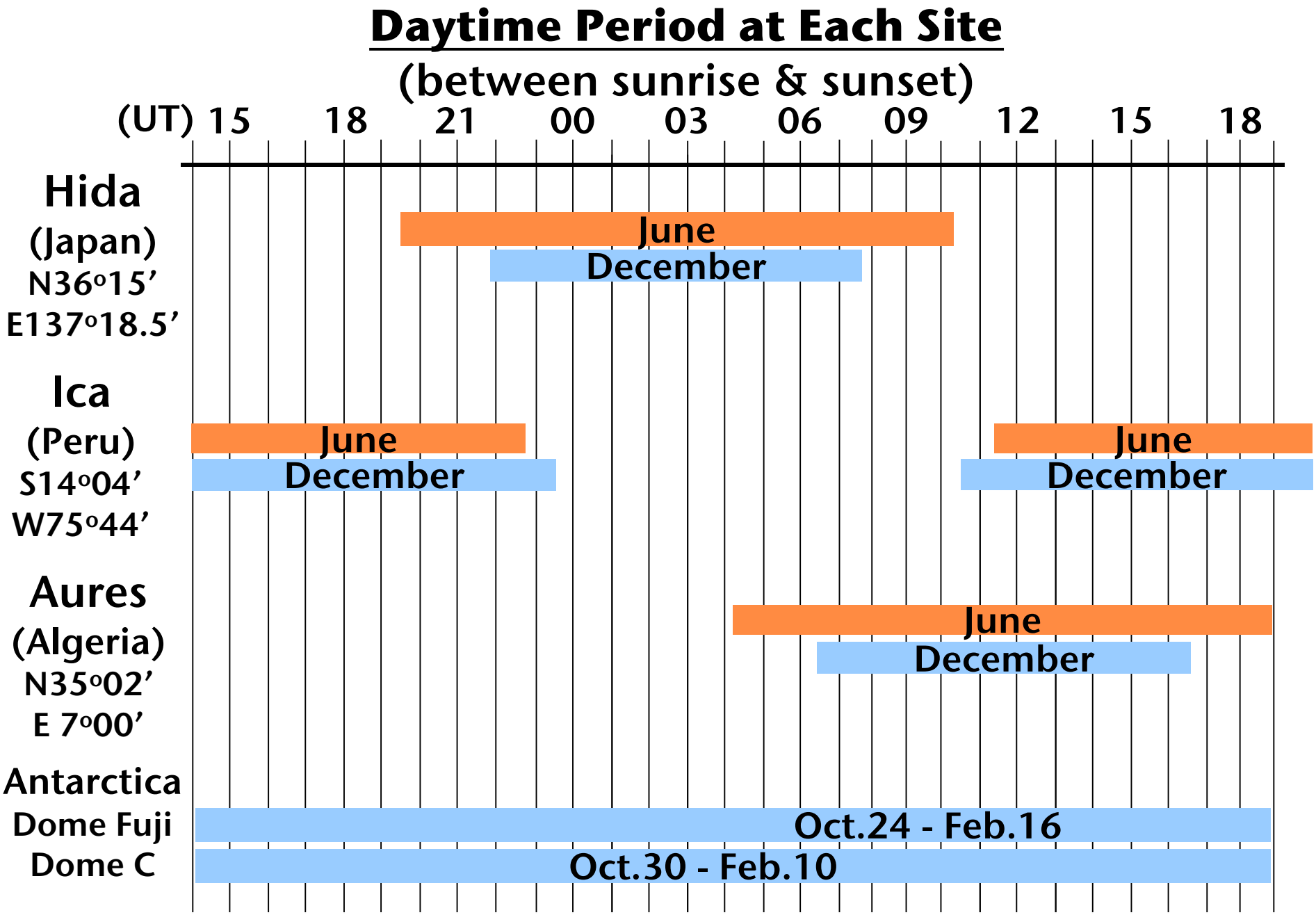
* Manpower

* Infrastructure

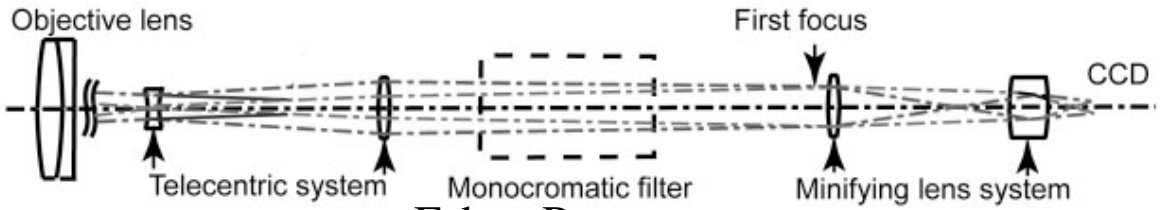
* Atmospheric turbulence

◆ Budget for the telescope itself is under being applied to the Grant-in-Aid (A) for oversea academic investigations of the MEXT/Japan as a three year plan of 2009～2011.

Possibility of Observation at the Antarctica


Daytime Period at Each Site
(between sunrise & sunset)
(UT) 15 18 21 00 03 06 09 12 15 18
Hida
(Japan)
N36°15'
E137°18.5'
June
December
Ica
(Peru)
S14°04'
W75°44'
June
December
June
December
Aures
(Algeria)
N35°02'
E 7°00'
June
December
Antarctica
Dome Fuji
Oct.24 - Feb.16
Dome C
Oct.30 - Feb.10

Hida Flare Monitoring Telescope (FMT)



Fabry-Perot type

If Seeing < ~2 arcsec, then OK.

Optics	
Diameter	64 mm
F-ratio	30
Focal length	1920 mm
Spatial resolution	**1.8 arcsec**

Filters	
Telescope name	Central / Passband
Ha center	6562.8 / 0.42 A
Ha +0.8 A	6563.6 / 0.5 A
Ha -0.8 A	6562.0 / 0.5 A
Continuum	6100 / 60 A
Prominence	6562.8 / 3 A

Telescope was manufactured by Nishimura Co. Ltd.
Lens system was manufactured by Minolta Co. Ltd. (Now:Konica-Minolta)
Filters were manufactures by Daystar Co.Ltd.

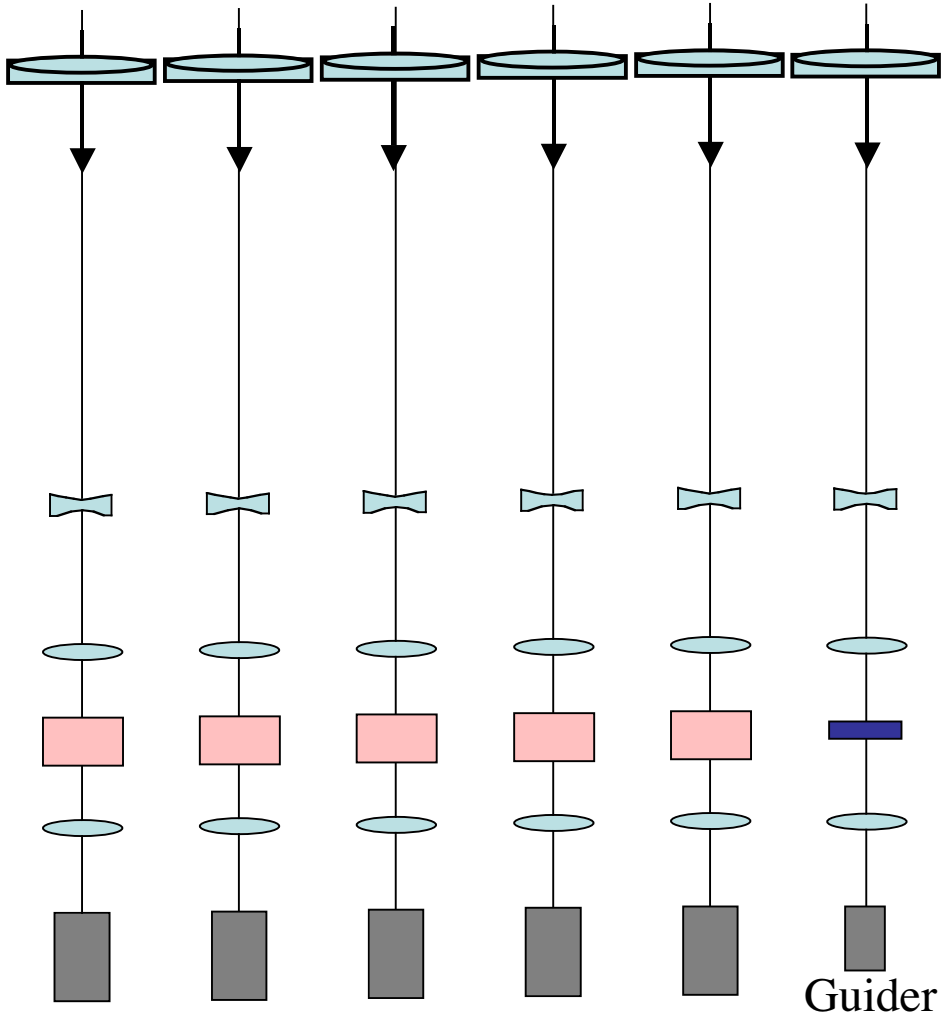
CCD system. [After 2006 May]

CCD	Takenaka System Co.LTD/ Digital Full Frame Shutter Camera FC1500CL (CamLink)
Time cadence	every 20 seconds in the routine observation (changeable)
Bit Depth	10 bits
Pixel Number	1392x1040 => **2.1 arcsec/pix** , **2.9 MB/frame**
Typical exposure time	4 ms, Simultaneousness **64 ns** << seeing timescale
Photon noise	2.0 % (corresponds to 2 km/s of the Doppler velocity)

In the case of Antarctica Observation .....

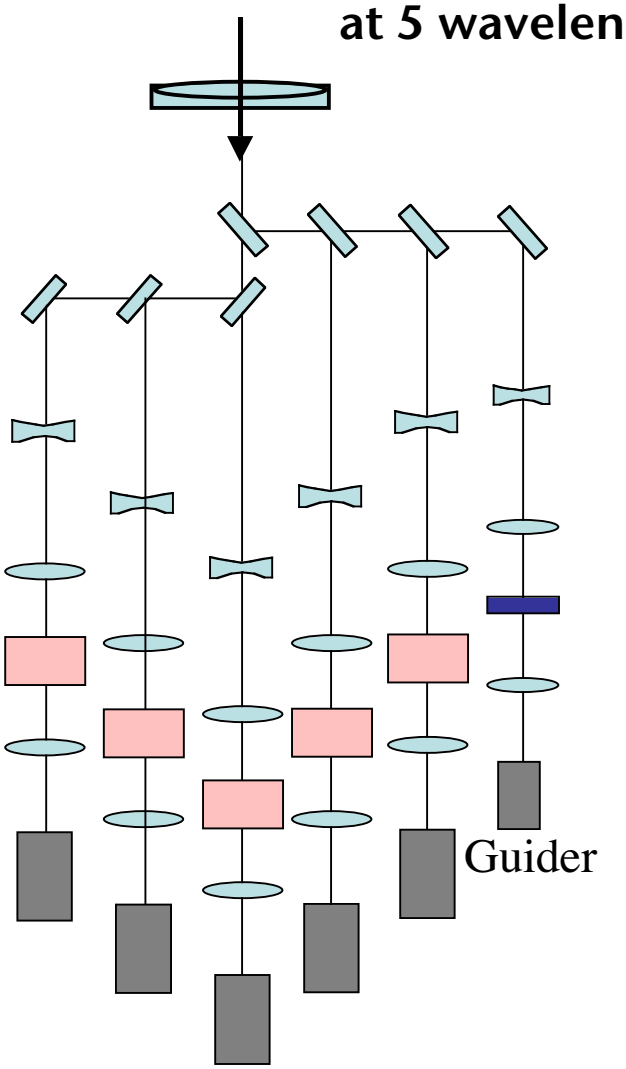
Case A

The original type (for medium seeing):
Six aperture &
Simultaneous observation
at 5 wavelengths



Case B

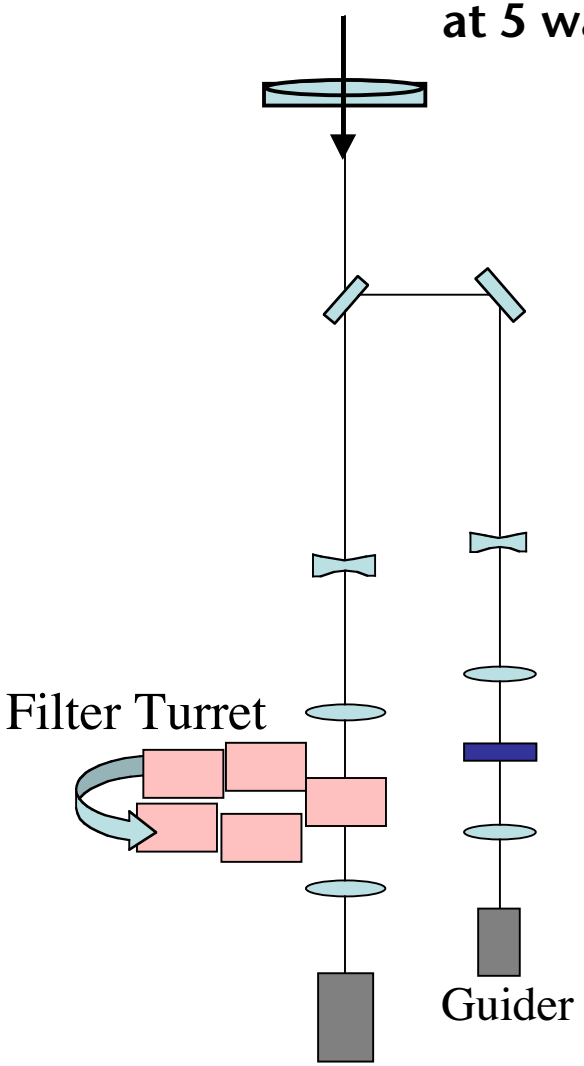
The most ideal type (for bad seeing):
One aperture &
Simultaneous observation
at 5 wavelengths



In the case of Antarctica Observation .....

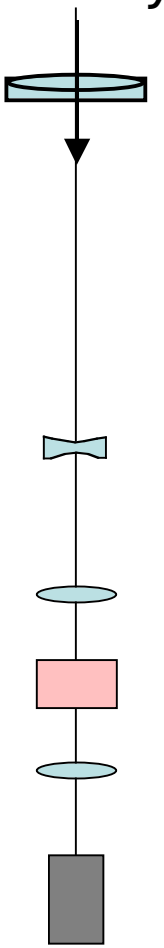
Case C

The most compact type (for good seeing):
One aperture &
Non-simultaneous observation
at 5 wavelengths



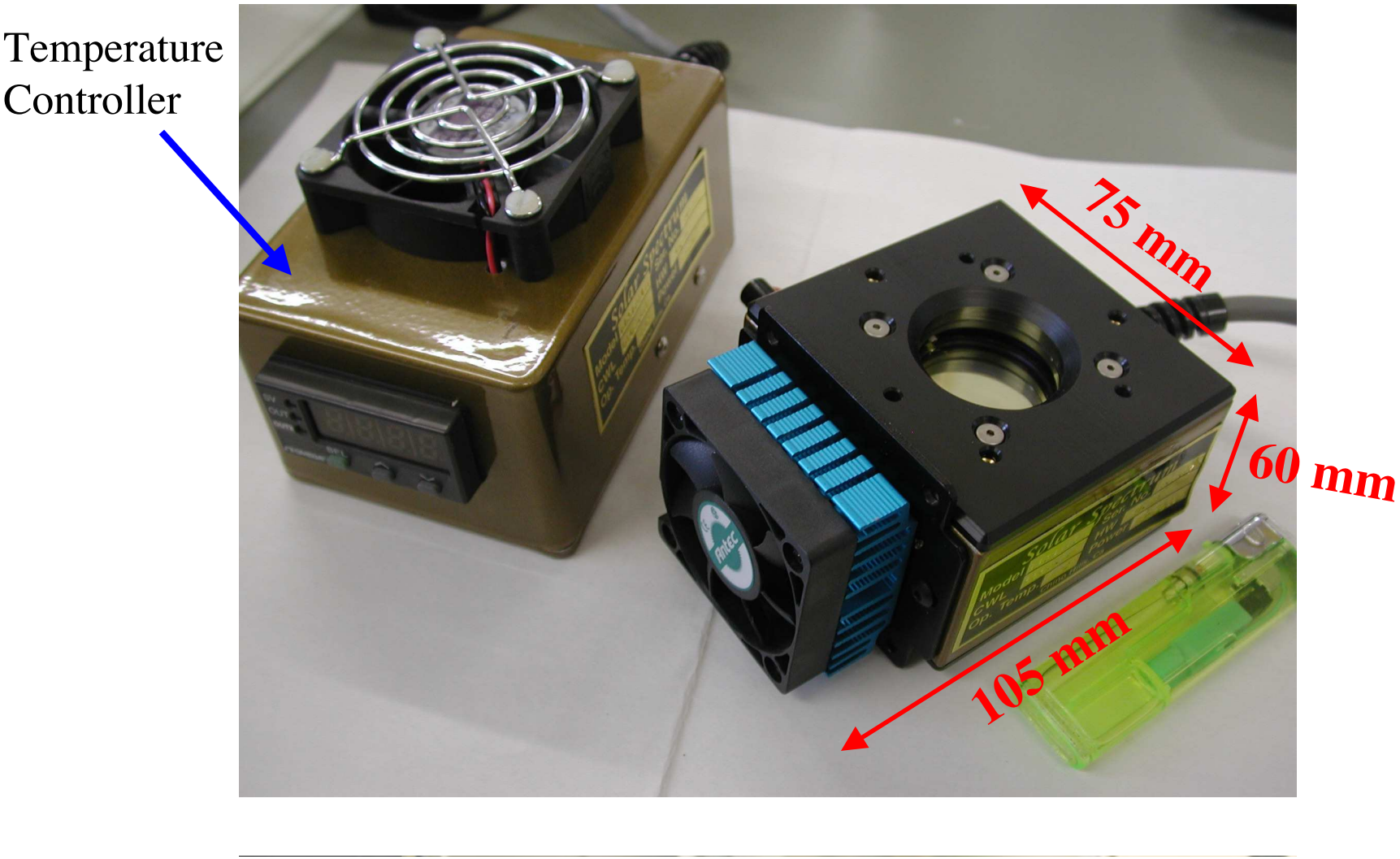
Case D

Test Observation Mode :
One aperture & One filter
(in order to monitor the weather condition, image quality by seeing and filter stability)

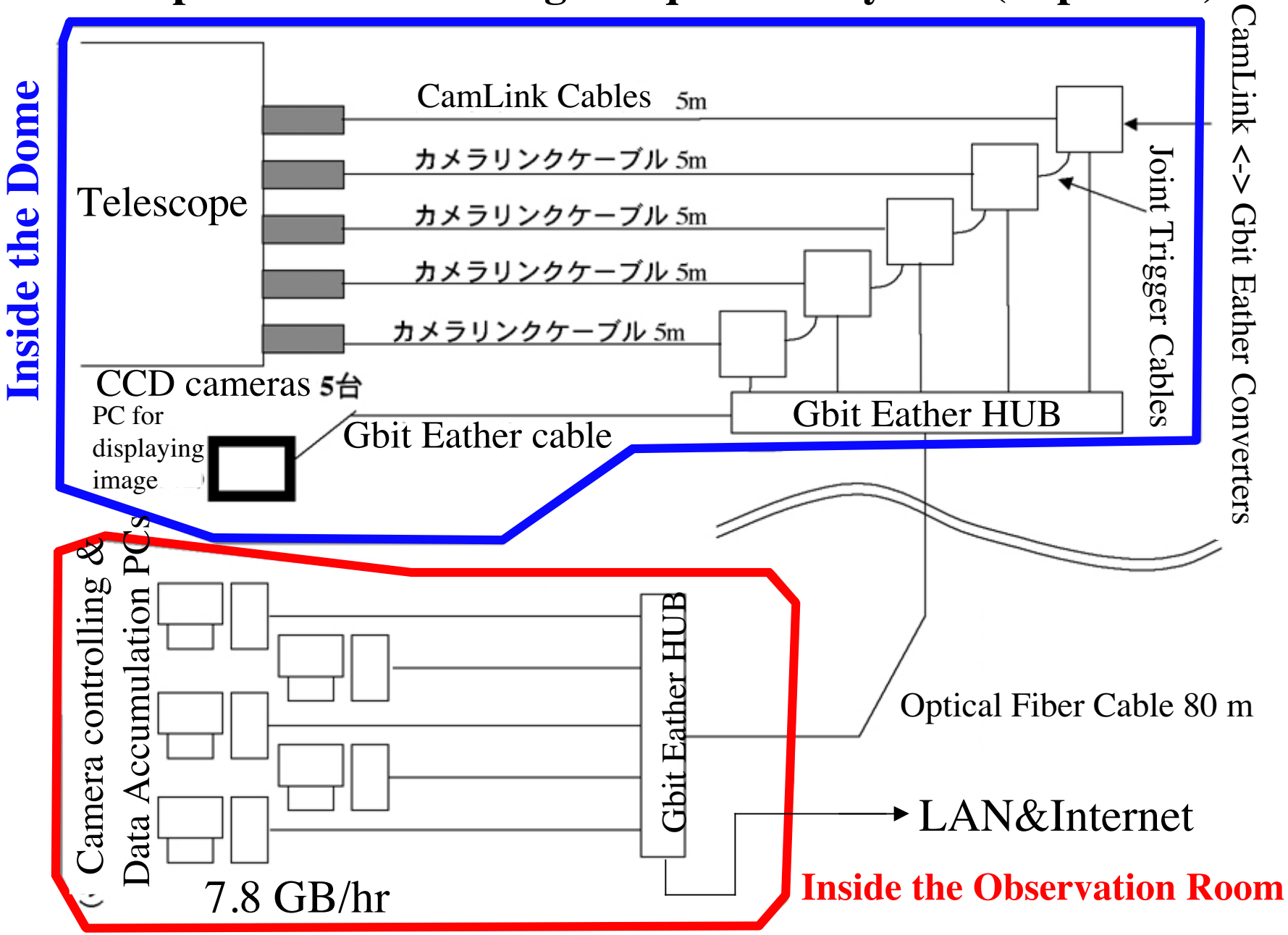


Filter by Solar Spectrum Co.Ltd.

Operating temperature: -10 to 50 °C
Operating humidity: Less than 90 % RH(non-condensing)
Storage temperature: -20 to 60 °C



Composition of the Image Acquisition System (at present)



Summary

◆ The observational purpose of the CHAIN-project is acquisition of 3-D velocity-field information of all geoeffective active phenomena on the full-disk Sun, by continuously monitoring solar chromosphere in five wavelengths around H-alpha absorption line.

◆ Kyoto Univ. decided that the installation-sites of the 1st & 2nd oversea FMT would be Peru (Ica Univ.) & Algeria (new astronomical observatory), and we are preparing so that 24 hr observation from the ground will be possible in principle for 2009～2011.

◆ If the weather would not be fine at some of these three sites, 24 hr continuous observation will be interrupted. Especially the probability of fine weather at Hida area in winter season is not so high. So, the supporting observation from the Antarctica (especially at Dome-C) is very attractive for our project.

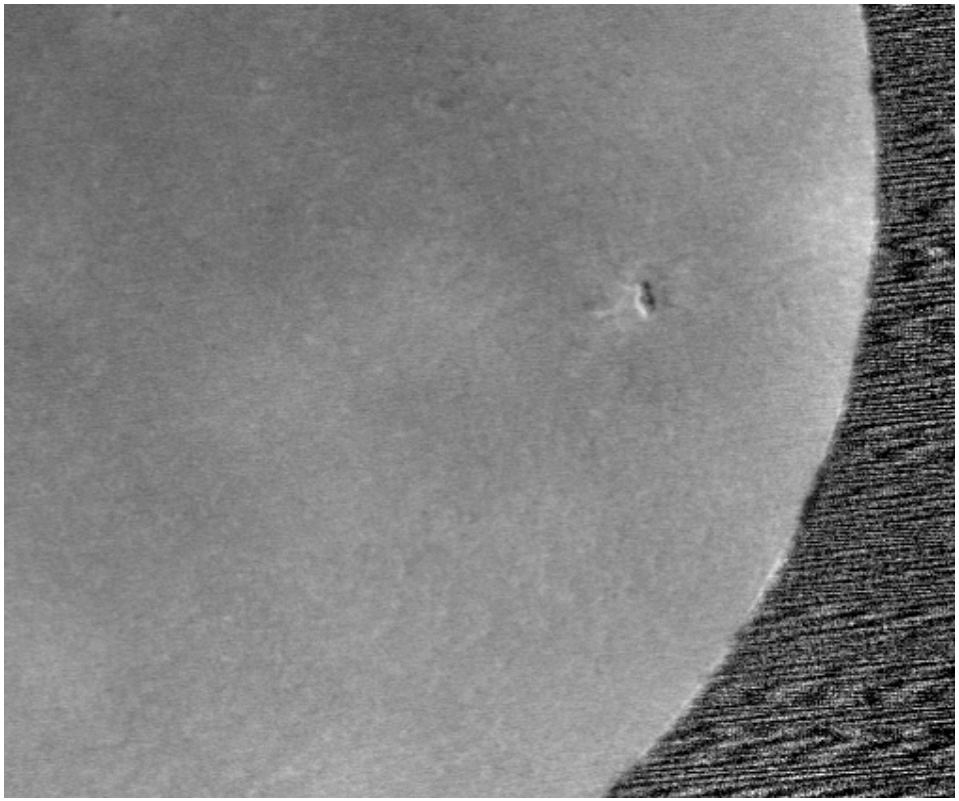
◆ As for the test observation in preparing phase, very simple instrument is OK, for example, it has only one aperture & one filter, so that it can monitor the weather condition, image quality by seeing and filter stability.

◆ As for the stable observation, we can consider several types of telescope structures. It may depend on difficulties of temperature controll, driving system and property of seeing condition.

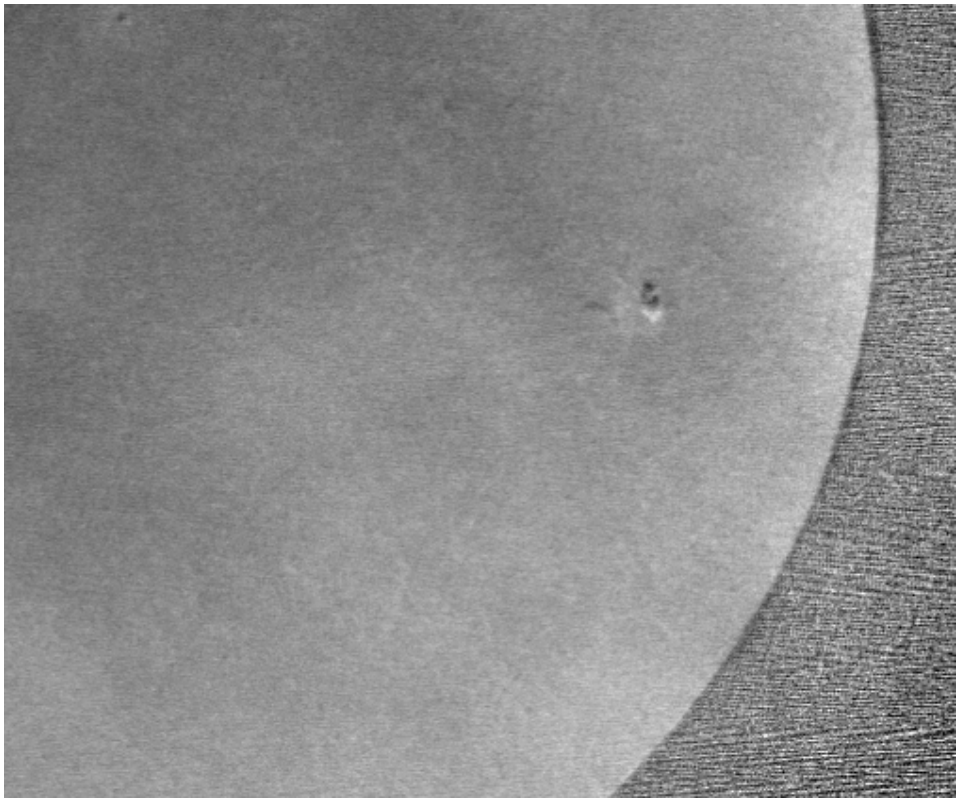
The End

視線方向速度のひとつの指標である (blue - red) ／(blue + red)
のイメージで同時撮像の効果を見てみると・・

2006.11.18 00:45:06, 00:45:08 2 sec ずれ



2006.11.18 00:40:01, 00:40:01 同時刻

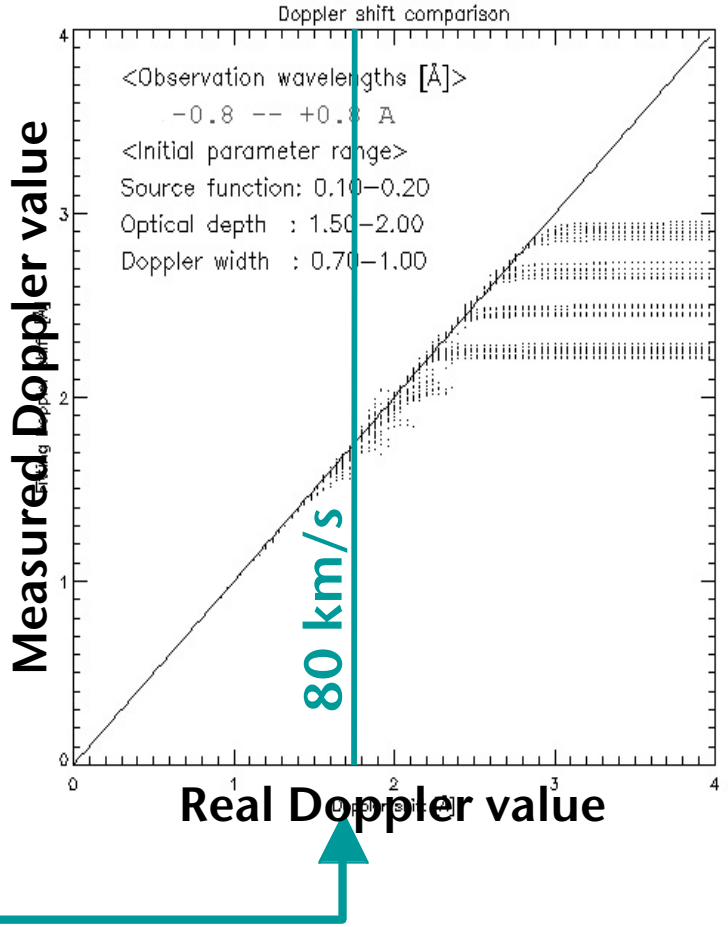


2 sec ずれのイメージどうしでは、リムの形状が歪み、黒点部で偽の速度場パターンが見えてしまっている。

Modified combination of observing wavelengths
(improvement of the measureable range of the velocity estimation)

By changing observation modes, we plan to <u>improve accuracy and expand the measureable range of the velocity estimation</u>.

At present:		Peru version:
• H α center	→	H α center
• H α +0.8 Å	→	H α +0.8 Å
• H α −0.8 Å	→	H α −0.8 Å
• H α Prominence	→	H α +3.2 Å
• Red Continuum	→	H α −3.2 Å
Observable range of the Doppler velocity		
0 ～ 80 km/s		0 ～ 130 km/



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