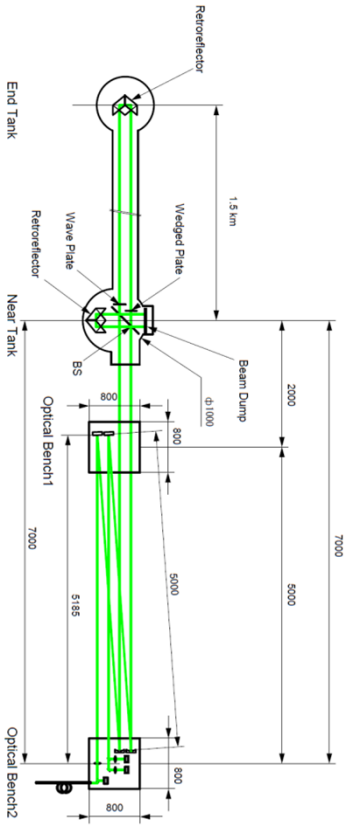
Geophysics interferometer (GIF)

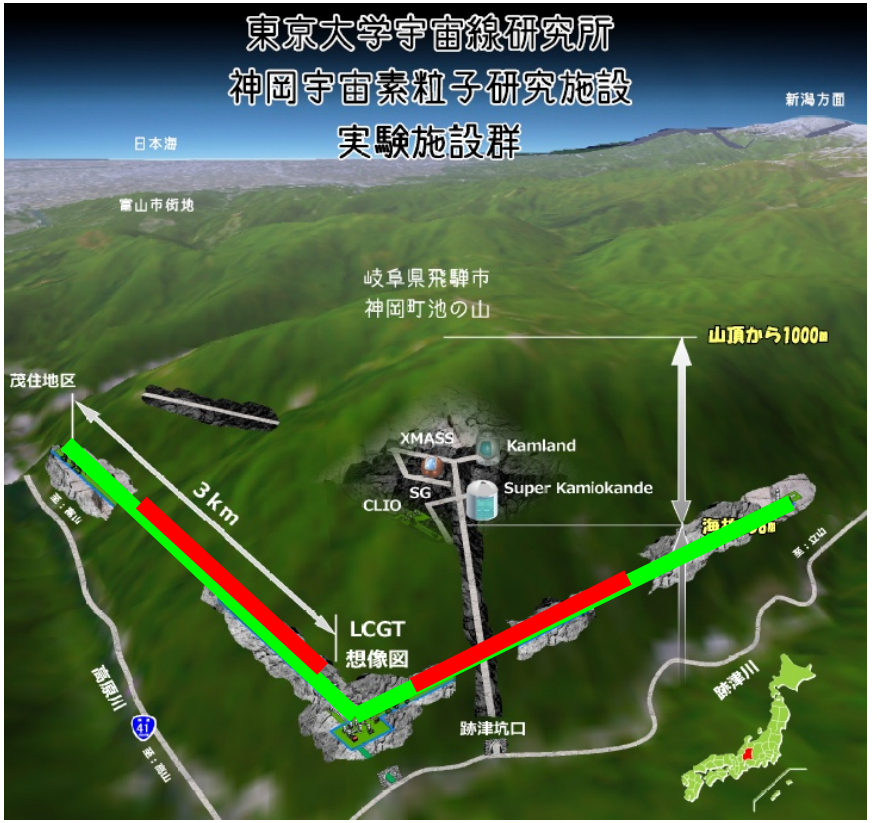
Tasks

1. Construction of two baseline-monitor interferometers (1.5km) along LCGT

2. Arrangement of sensors and benchmarks for monitoring environmental condition



Geophysics Interferometers along LCGT



Optical layout of a geophysics interferometer:

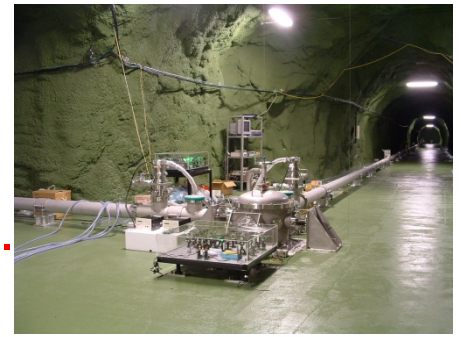
Baseline 1500m

Asymmetric Michelson interferometer with two retroreflectors

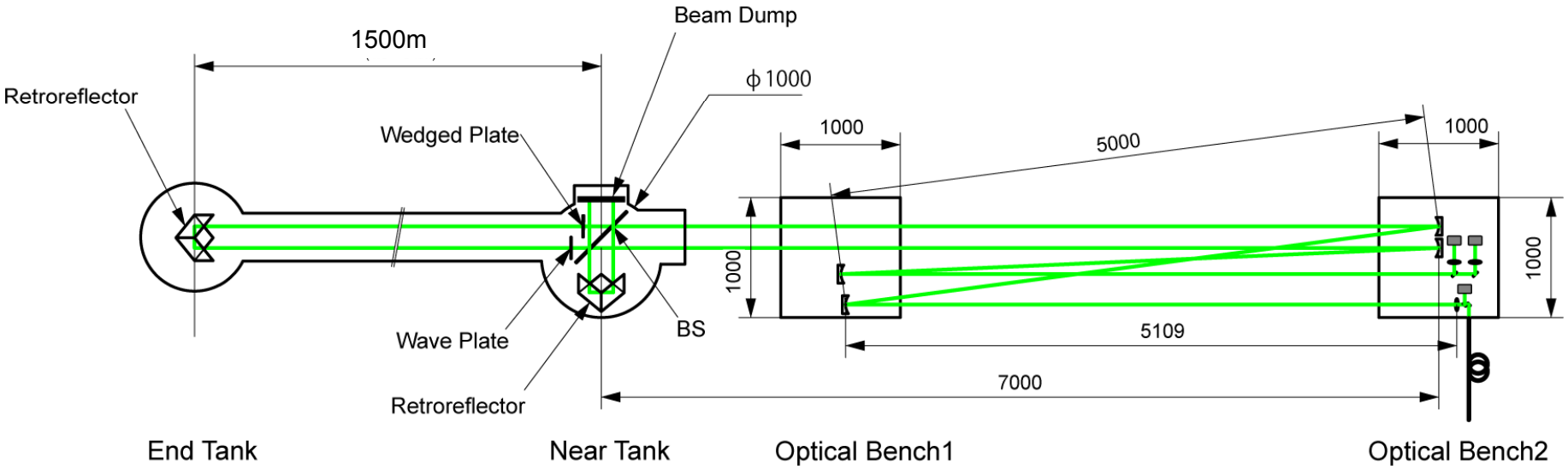
A 5-m input baseline

Iodine-stabilized 532nm laser

φ400mm vacuum tubes



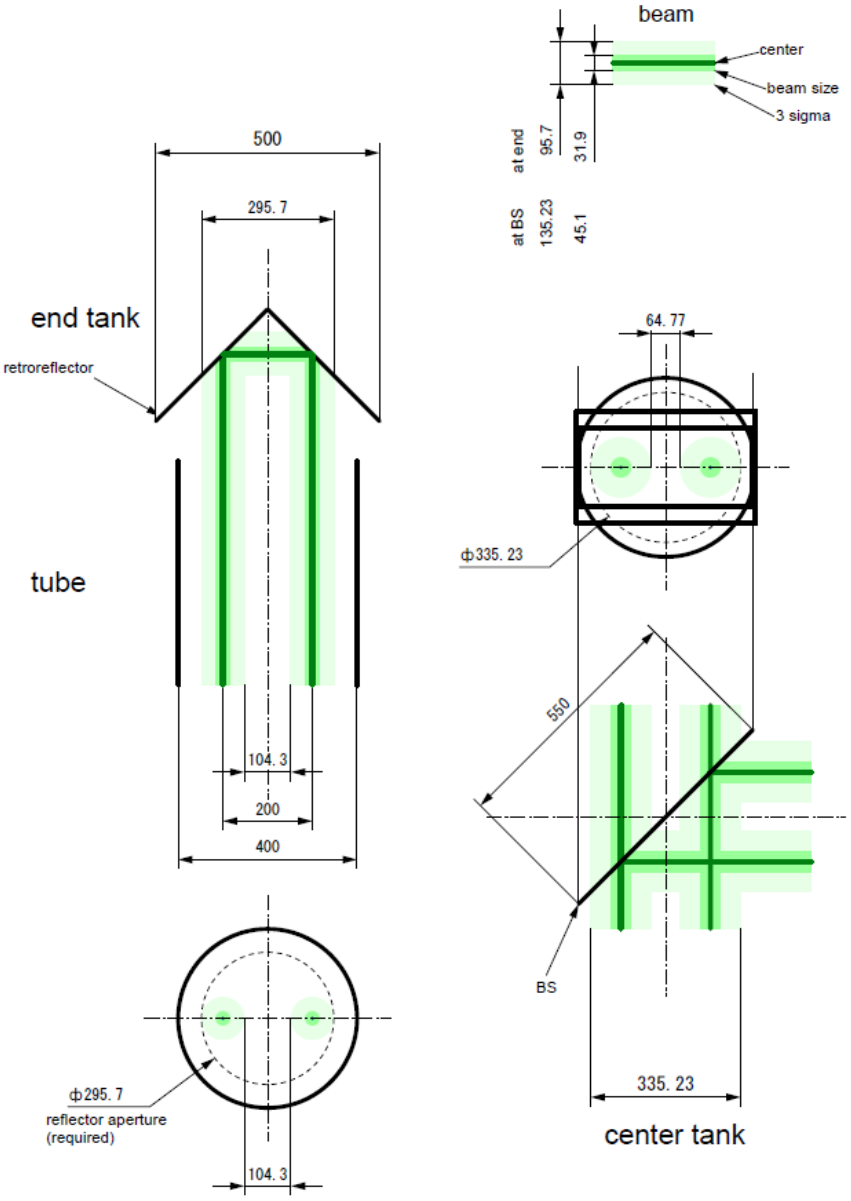
Essentially based on the current 100-m IFO system.



Optical layout

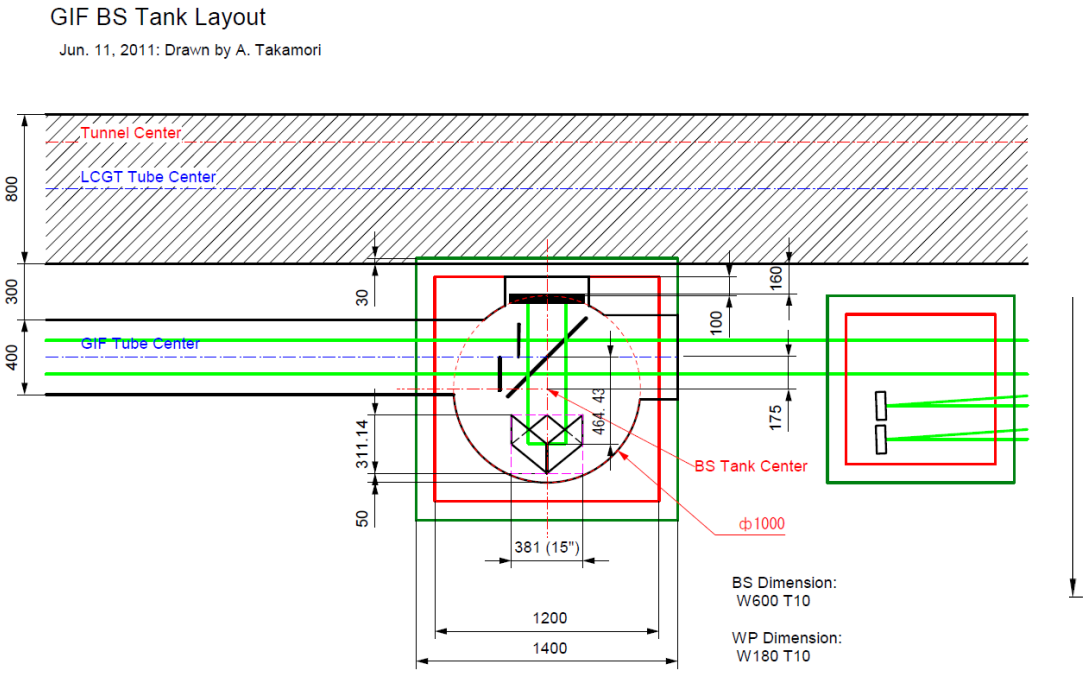
Optical parameters for
1500m baseline:
Beam diameter (waist) 32mm
Beam diameter (max.) 45mm
Visibility 0.7

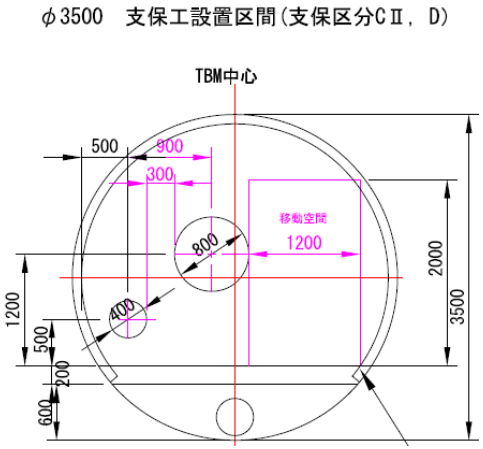
Diameter of 400mm is required for vacuum tubes.

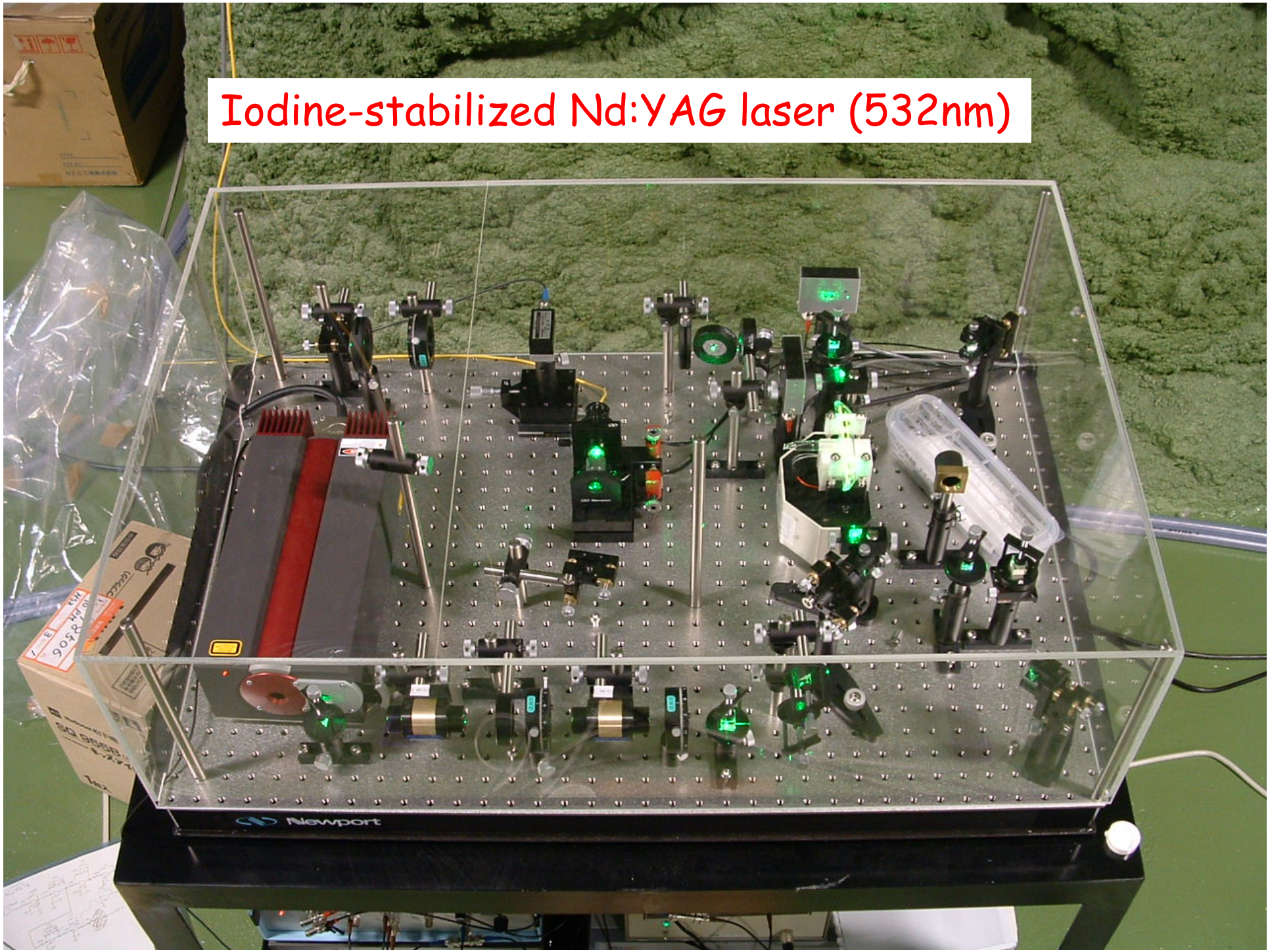


Optical layout around the front chamber

Compatible with the φ4500 tunnel.
Separation from the KAGRA duct (φ800) is secured.



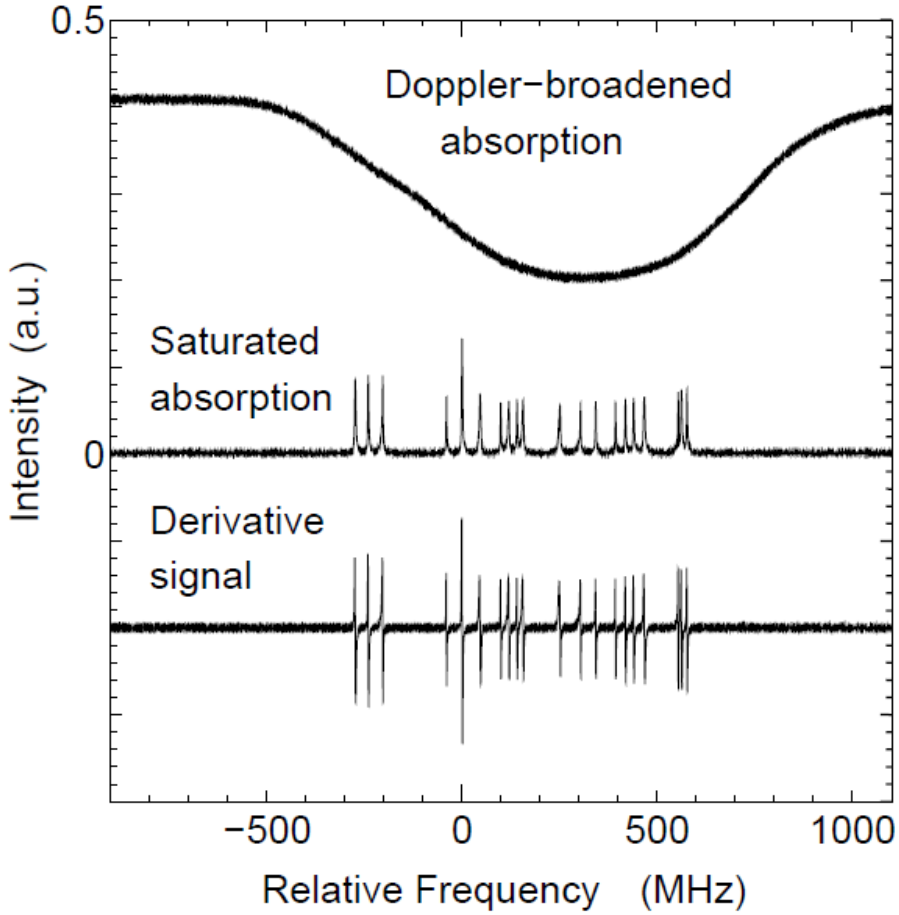



Iodine-stabilized Nd:YAG laser (532nm)
Newport

Iodine-stabilized system

Locked to a saturated absorption line

Frequency stability dv/v ~ 10^{-13}



Layout of vacuum system and benchmarks

Strain sensitivity ~10^{-13}

Baseline 1.5km x 2

Chamber diameter 1.0m

Chamber height 1.0m

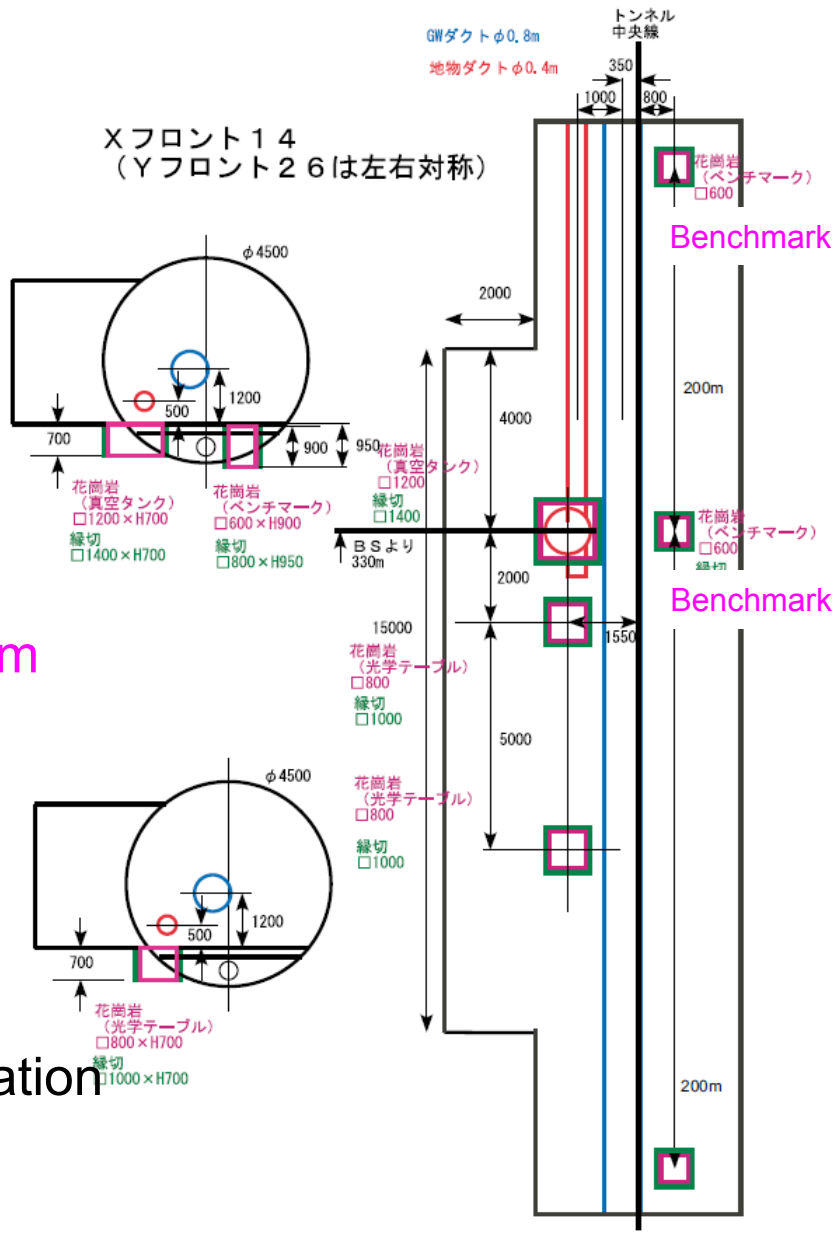
installed on a granite base 1.2m x 1.2m

Vacuum pressure ~10^{-4}Pa

Granite benchmarks 0.6m x 0.6m,

200-m separation used for

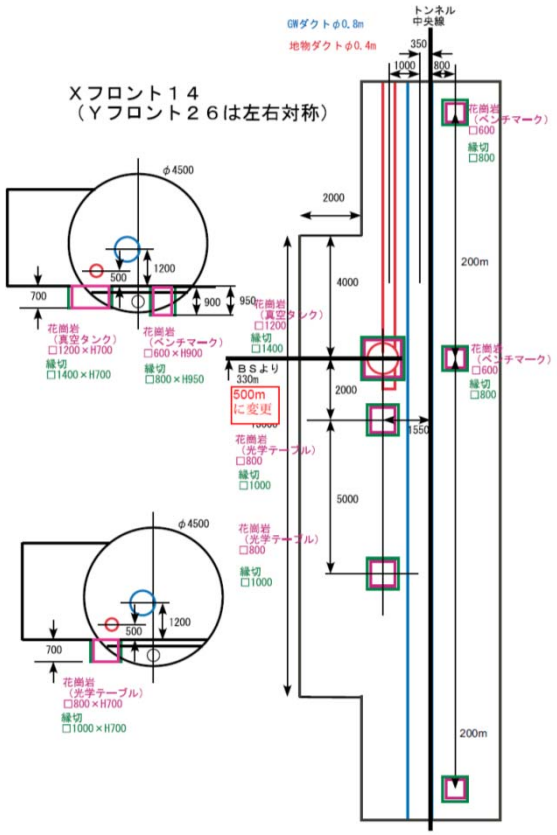
1. reference of vacuum system installation
2. monitoring tunnel deformation
3. research on standard of length



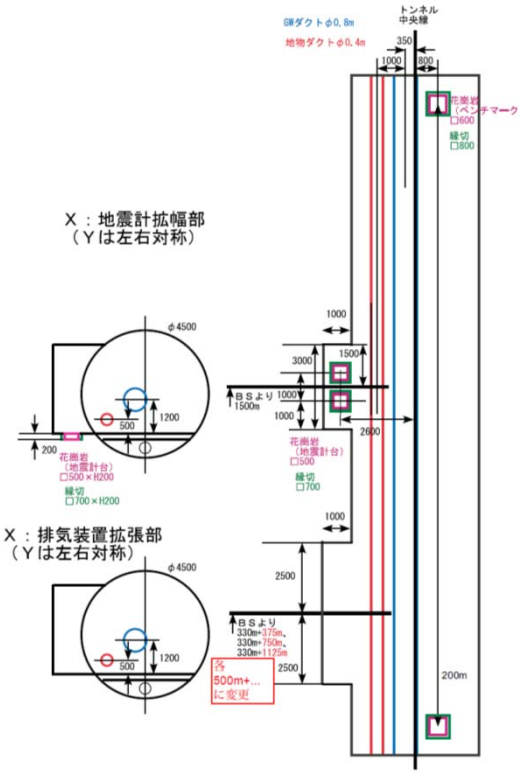
Granite base of the 100-m IFO

Layout of vacuum system and benchmarks

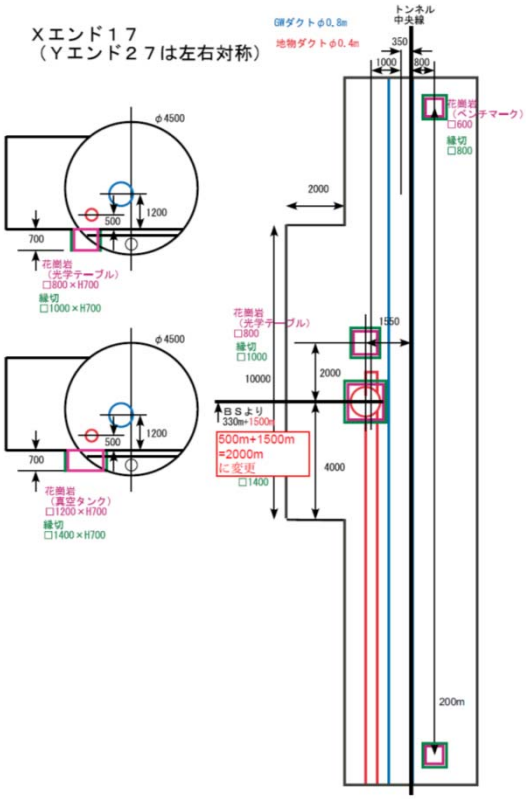
X-Front (input)



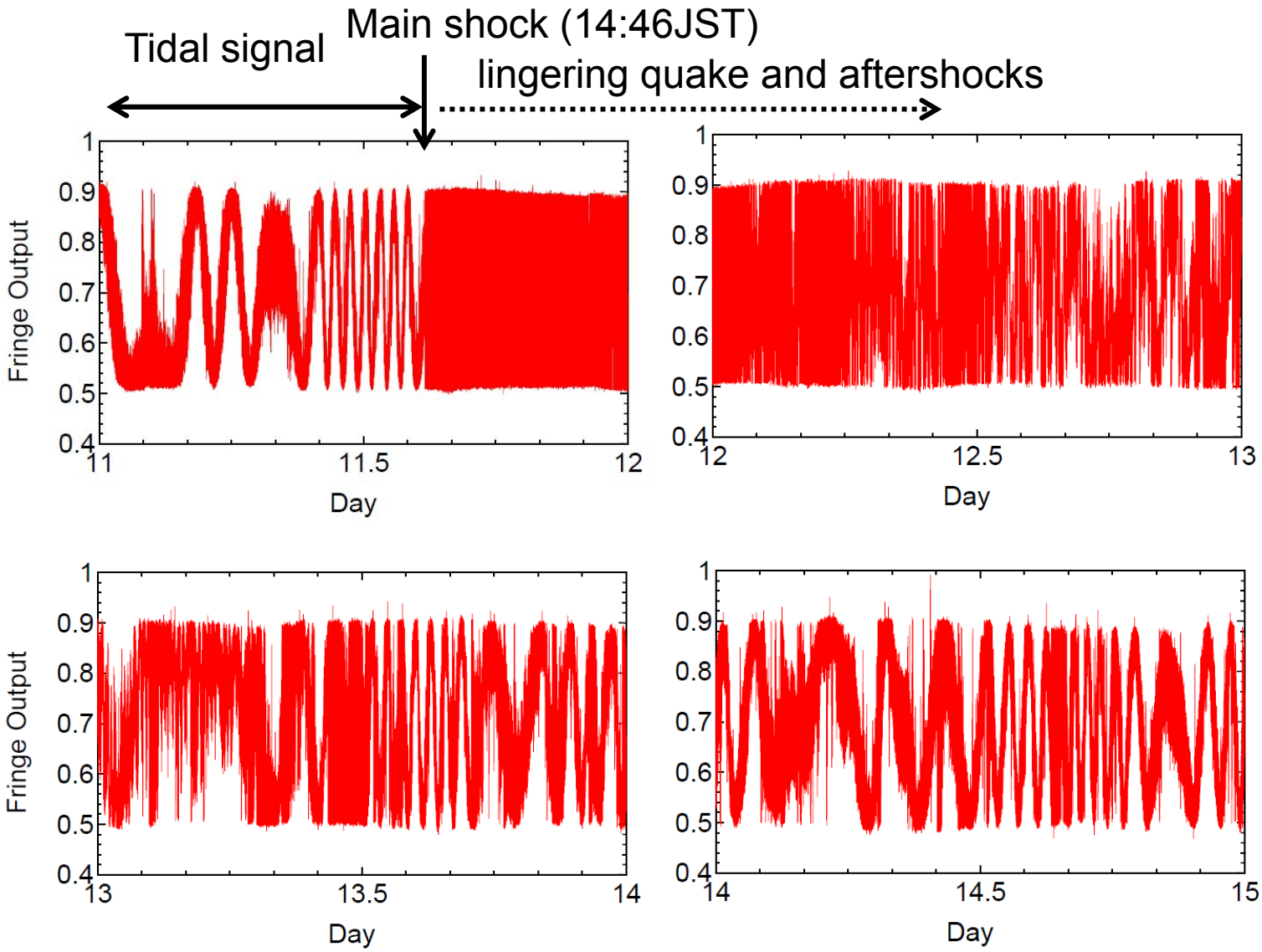
X-Middle (seismometer)



X-End (reflector)



Fringe output of the 100-m IFO laser on Mar.11, 2011

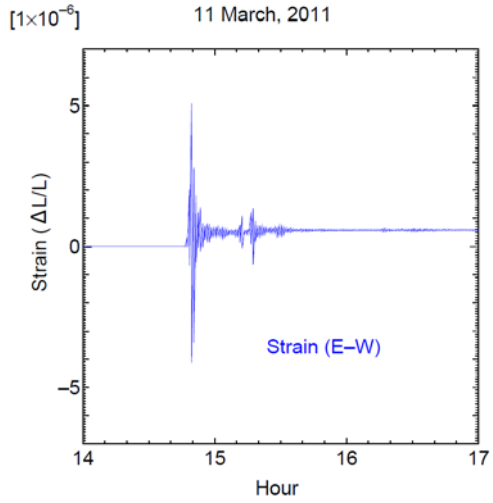


So rapid fringe change … even 1kHz sampling is not enough for fringe detection.

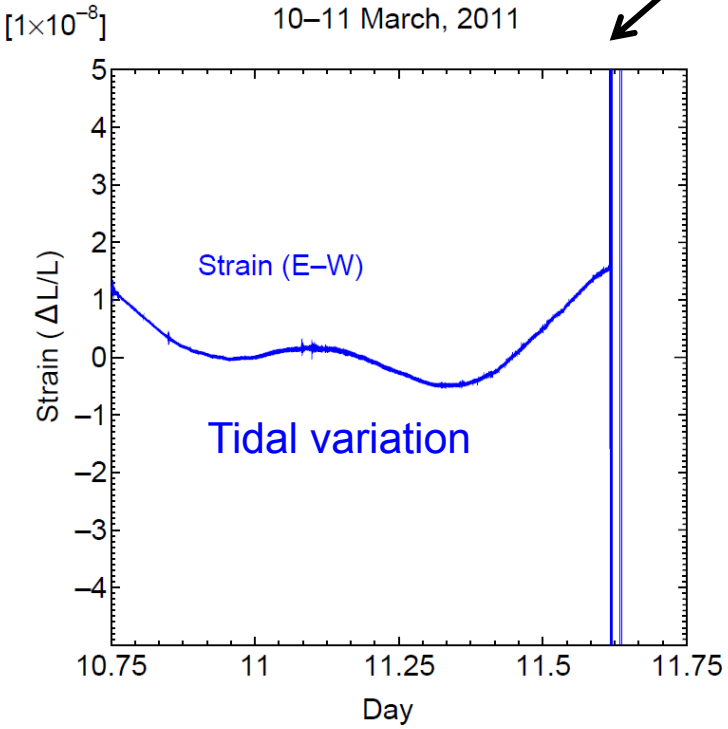
For 1500-m GIF… requiring higher sampling rate for DAQs (5kHz~50kHz)

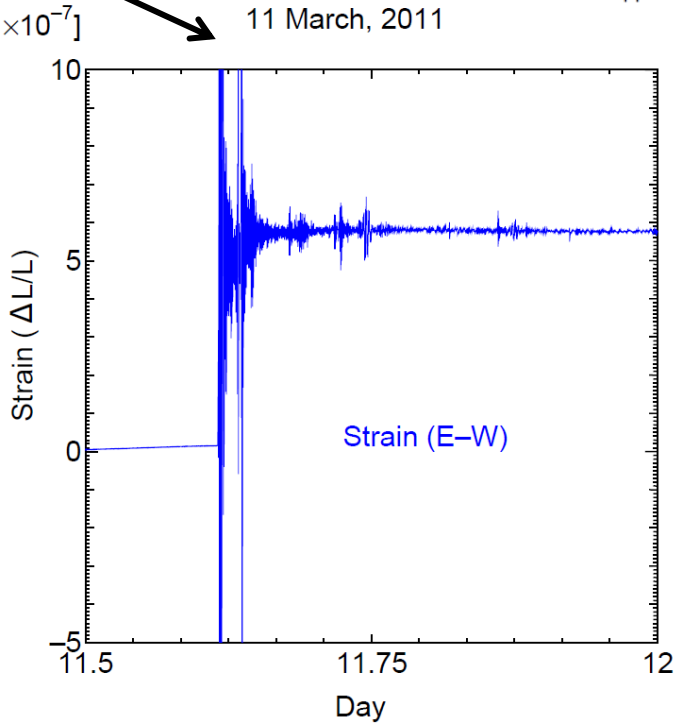
Strain step associated with Tohoku earthquake on Mar.11, 2011

Coseismic expansion ε_{EW} ~6x10^{-7} was observed.



Main shock(14:46JST)





Data Acquisition system (GIF-DAQ)

Requirements:

>>Two systems for both interferometers

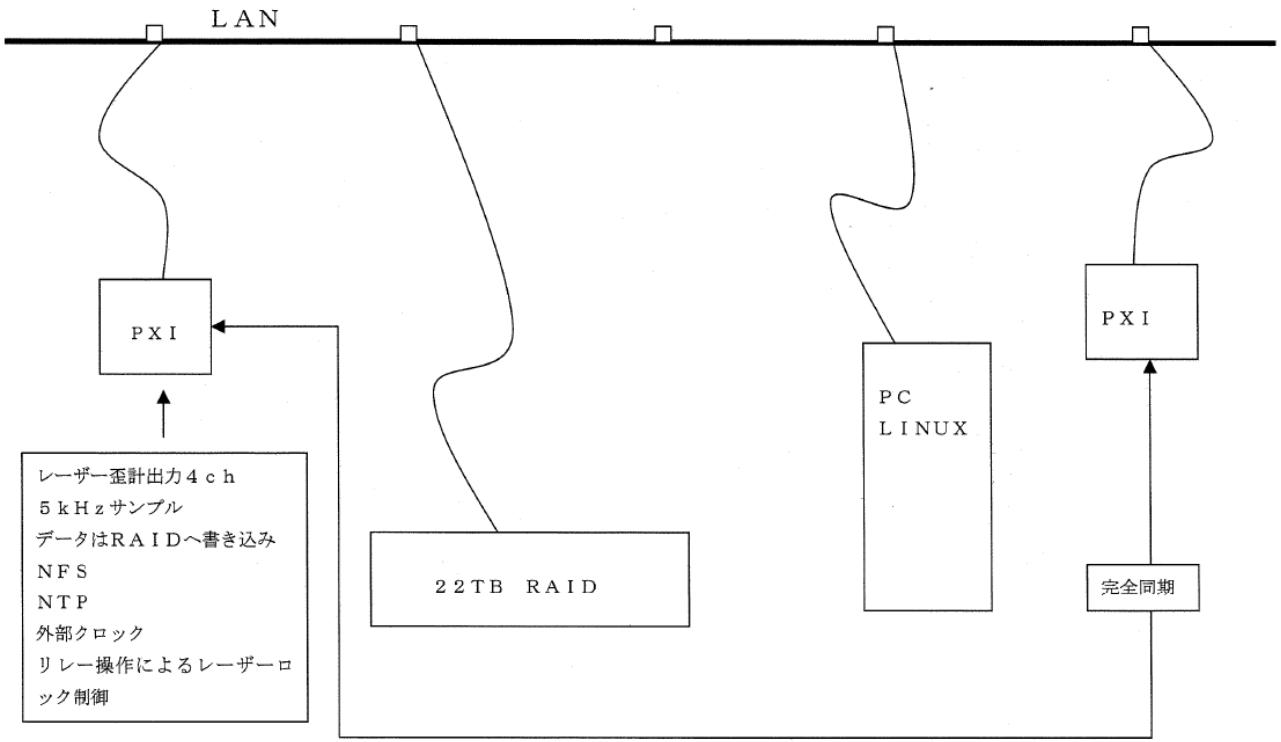
>>Synchronized sampling and time stamps
(Standard time, 1PPS, 10MHz clock)

Functions:

>>Fringe data acquisition (5k-50kHz x 4ch for each IF)
>>Laser stabilization control (relock, remote control)
>>Data acquisition of environment-monitor sensors
>>Data sharing

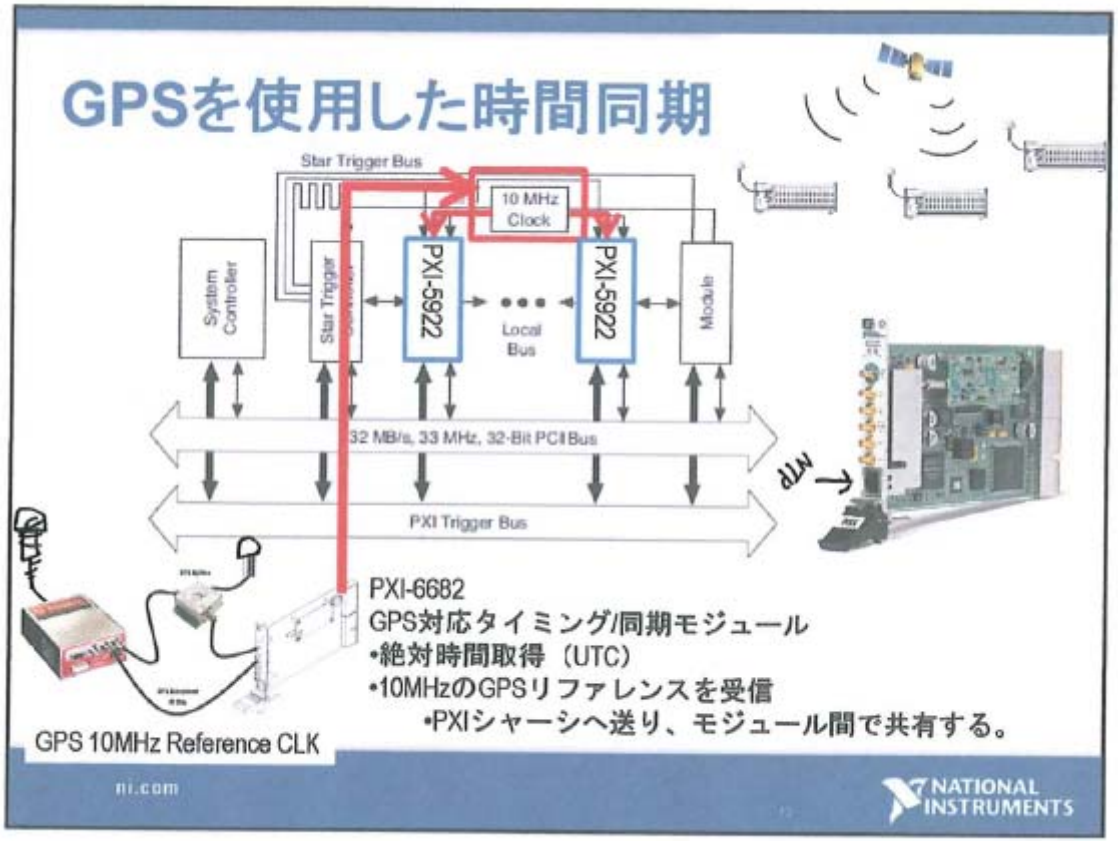
GIF-DAQ

GIF data are acquired by PXIs and stored on RAIDs through LAN.
Two PXIs are synchronized with the GPS clock.



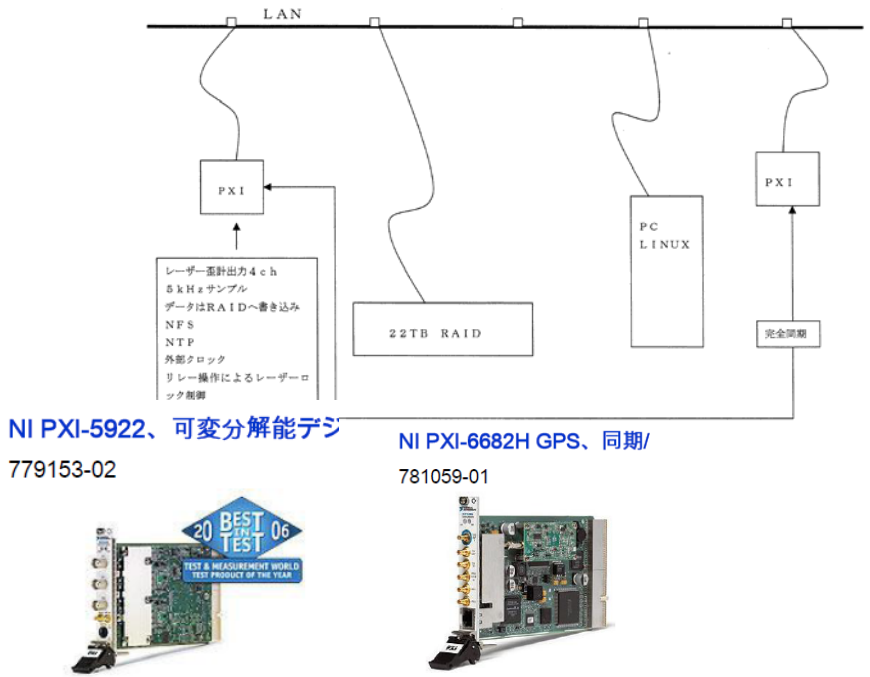
GIF-DAQ

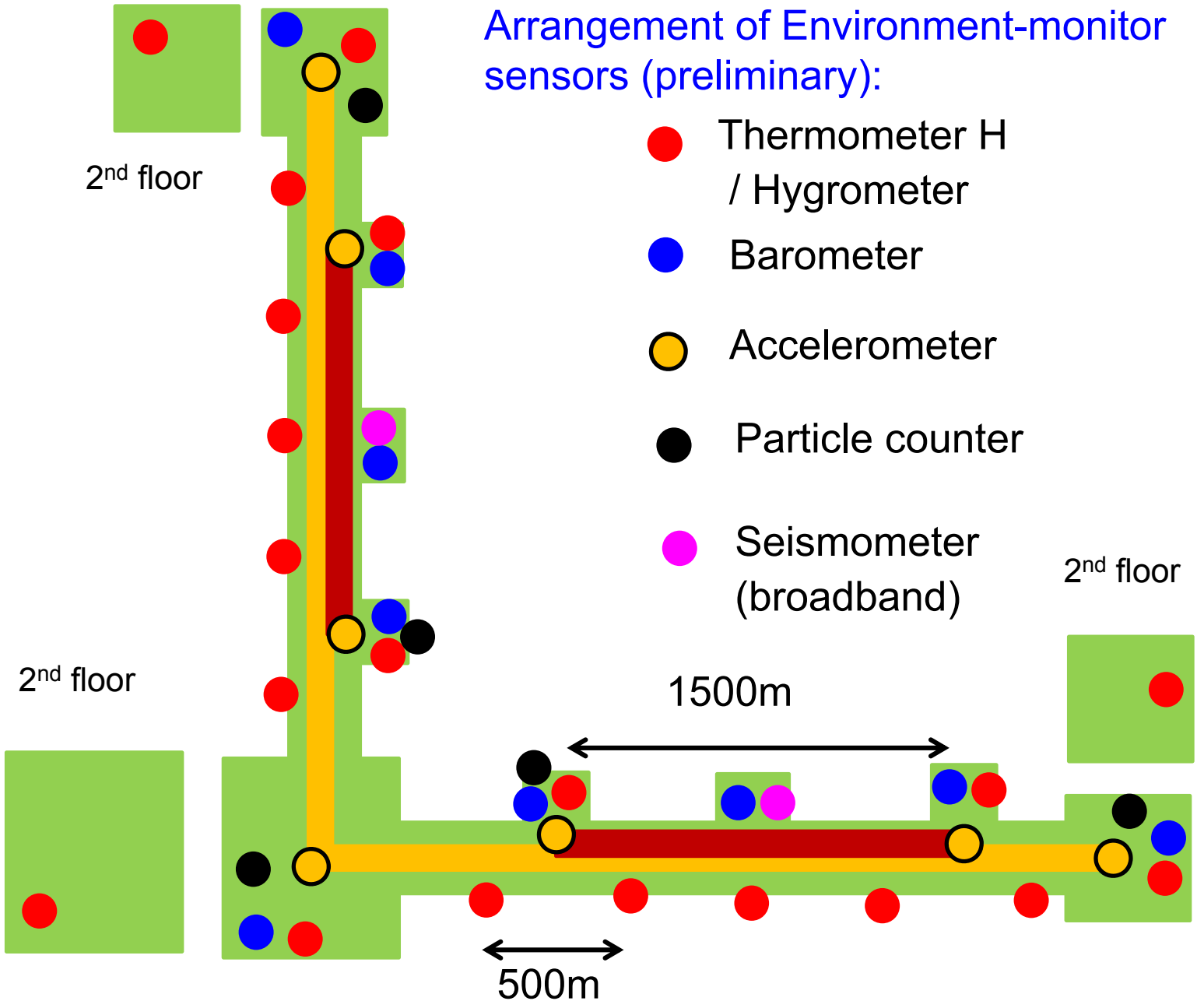
Synchronization with the GPS clock by PXI-5922.



Data acquisition system for GIF(geophysics interferometer)

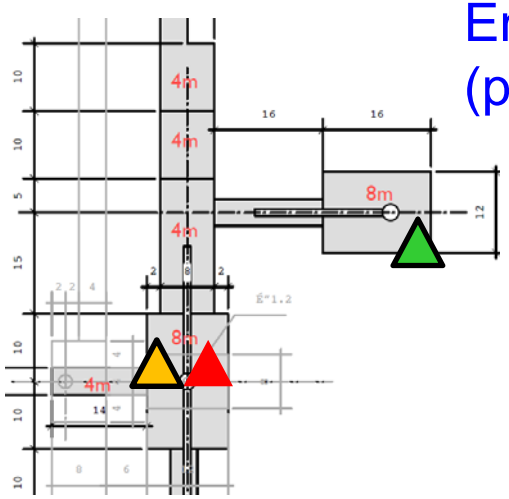
1. GIF-DAQ (two PXI systems) acquires GIF signals and stores the data on RAIDs through LAN. A/Ds are 24-bit 50kS/s, and are synchronized with GPS. The system also includes relay switches for controlling laser locking, etc.




Arrangement of Environment-monitor sensors (preliminary):
Thermometer H / Hygrometer
Barometer
Accelerometer
Particle counter
Seismometer (broadband)
2nd floor
2nd floor
2nd floor
1500m
500m

Environment-monitor sensors (preliminary):

End room

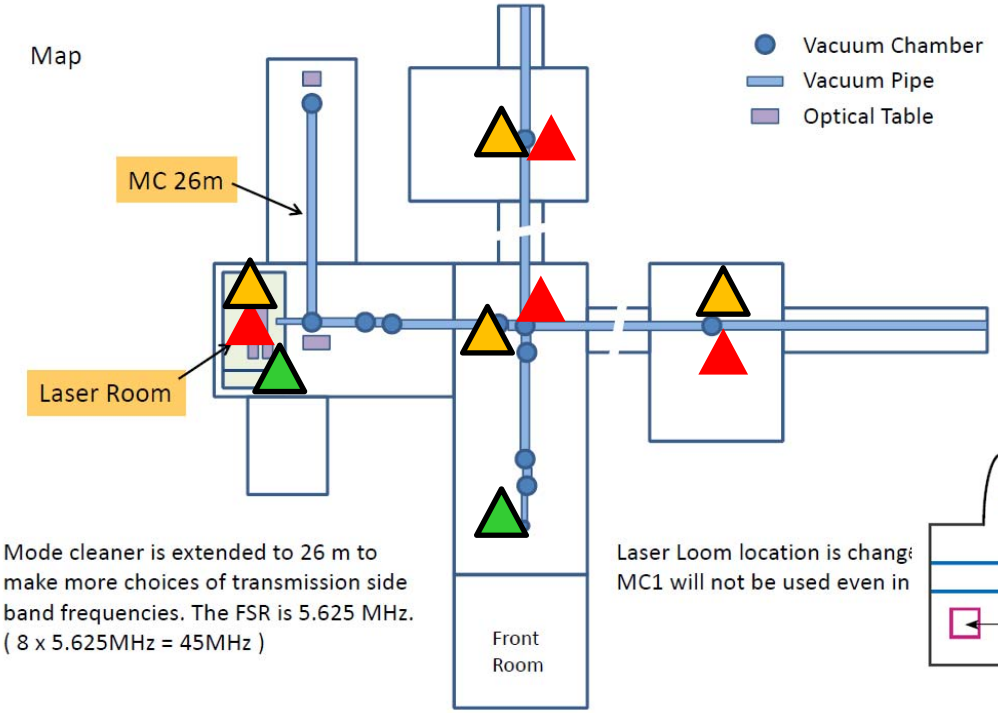


Thermometer L

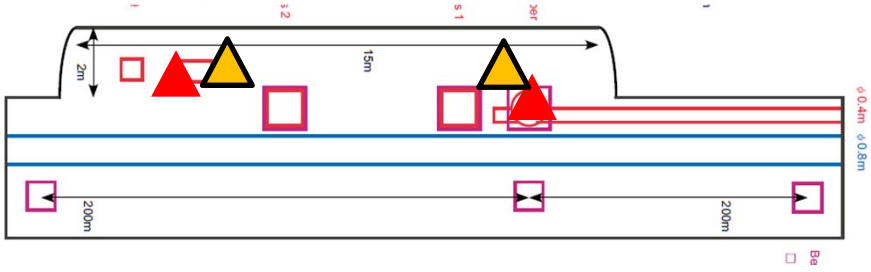
Accelerometer L

Center room

Microphone, EM sensor



Geo area



High end (absolute) Low end (relative, low resolution)

Thermometer δt~ 0.1deg

voltage

USB

δt~ 1deg

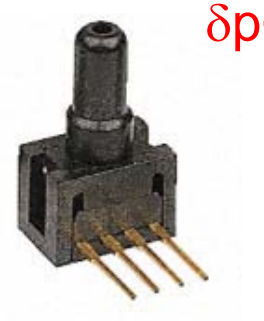
voltage

Barometer

δp~ 0.1hPa

voltage/RS232c

δp~ 1hPa



voltage

Accelerometer

ICD parameters (preliminary)

Sensor	range	resolution	response
Thermometer(abs.)	-50–50deg.	0.15deg.	DC-0.1Hz
Thermometer(rel.)	-50–100deg.	1deg.	DC-0.1Hz
Hygrometer	0-100%	3%	DC-0.1Hz
Barometer (abs.)	850–1050hPa	0.15hPa	DC-0.1Hz
Barometer (rel.)	TBD	TBD	TBD
Accelerometer (abs.)	-20-20m/s^2	1.e-5m/s^2	DC-500Hz
Accelerometer (rel.)	-50-50m/s^2	1.e-2m/s^2	1-5kHz
Seismometer	1.5e-2m/s	1.e-9m/s	4m-200Hz
Particlemeter	TBD	TBD	TBD
Microphone	TBD	TBD	TBD
EM sensor	TBD	TBD	TBD

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
barometer	TBD		barometer resolution		FA	VA	VI			IF	DG					**GI**	DA
hygrometer	TBD		hygrometer resolutio		FA	VA	VI			IF	DG					**GI**	DA
thermometer	TBD		thermometer resoluti		FA		VI			IF	DG					**GI**	DA
microphone	TBD		microphone resolutio		FA		VI			IF	DG					**GI**	DA
particlemeter	TBD		particle meter resol	TU	FA	VA	VI			IF	DG					**GI**	DA
accelerometer	TBD		accelerometer resolu				VI			IF	DG					**GI**	DA
seismometer	TBD		seismometer resoluti	TU	FA		VI			IF	DG					**GI**	DA

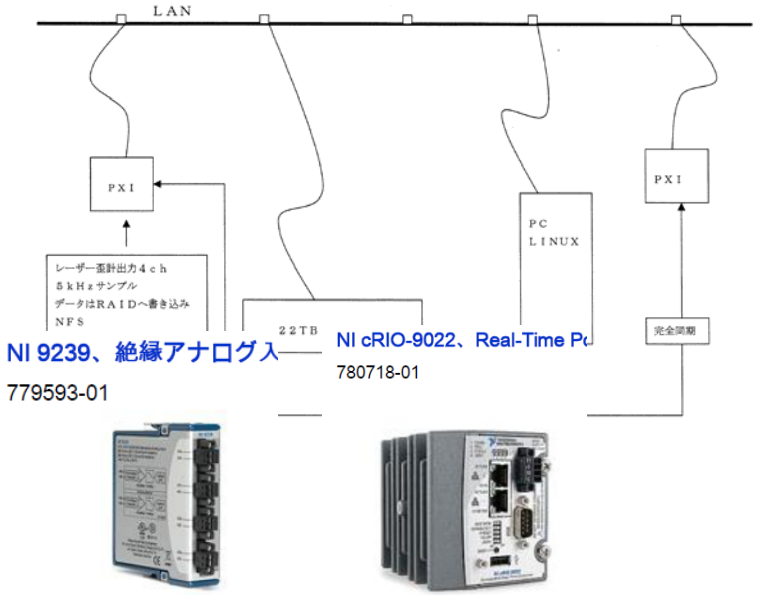
Data acquisition system for EM (environmental monitor)

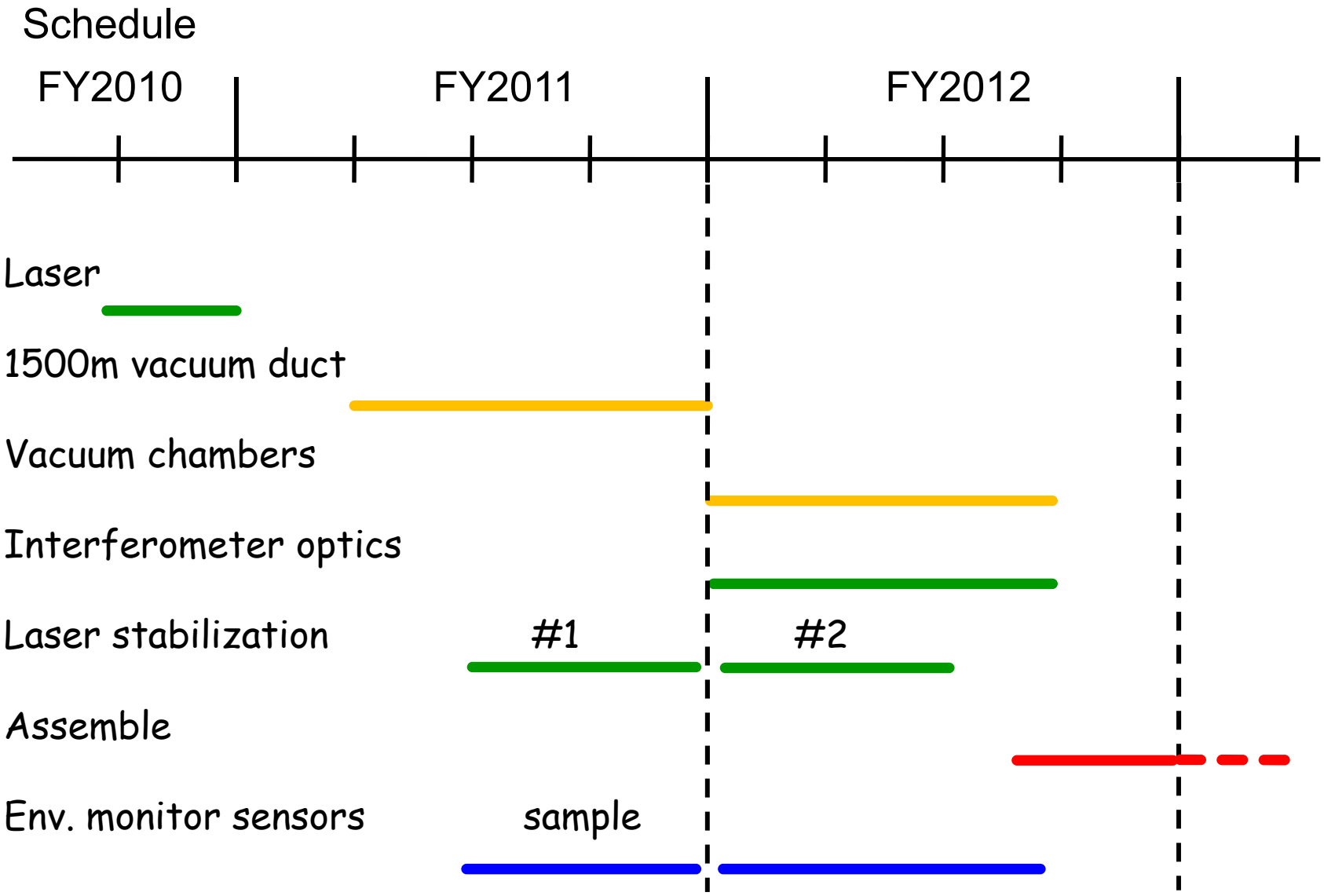
1st phase (before iKAGRA)

EM-DAQ (cRIO systems) acquires EM signals and stores the data on RAIDs through LAN. The system accepts voltage and serial (RS232c) signals. Typical configuration of a cRIO system includes A/Ds (24-bit 12.5kS/s) and a serial module. The modules may be changed upon request. The cRIO systems are planned to be arranged on 9-10 locations in the tunnel, including center/end rooms.

2nd phase (after iKAGRA in operation)

iKAGRA-DAQ acquires EM signals, which are divided from the sensors, in parallel with EM-DAQ.




Schedule
FY2010
FY2011
FY2012
Laser
1500m vacuum duct
Vacuum chambers
Interferometer optics
Laser stabilization
#1
#2
Assemble
Env. monitor sensors
sample

Φ400-mm vacuum tubes are in production

A first bunch of tubes were delivered at Kamioka on 20 Jan., 2012, and were stored in the tunnel.

Milestones (Geophysics interferometer)

		related sub-groups
2012.3	vacuum pipes delivery	Vacuum
	optics final design	Tunnel
	EM sensor determination	Det Char
2012.9	vacuum valves / pumps delivery	Vacuum
	infra specification (clean booth, LAN)	Fac. Sup.
2013.3	optical components delivery	
	vacuum components delivery	Vacuum
	EM sensors delivery	Det Char
(2014.3)	tunnel excavated	Tunnel
2014.6	vacuum & granite base installation	Vacuum/ Fac. Sup.
2014.12	vacuum installation	Vacuum
2015.3	optics installation	
	EM-DAQ operation	Det Char
2015.6	test observation start	
	safety management	Fac. Sup.
2015.9	observation & maintenance	
(2018.3)	bKAGRA	