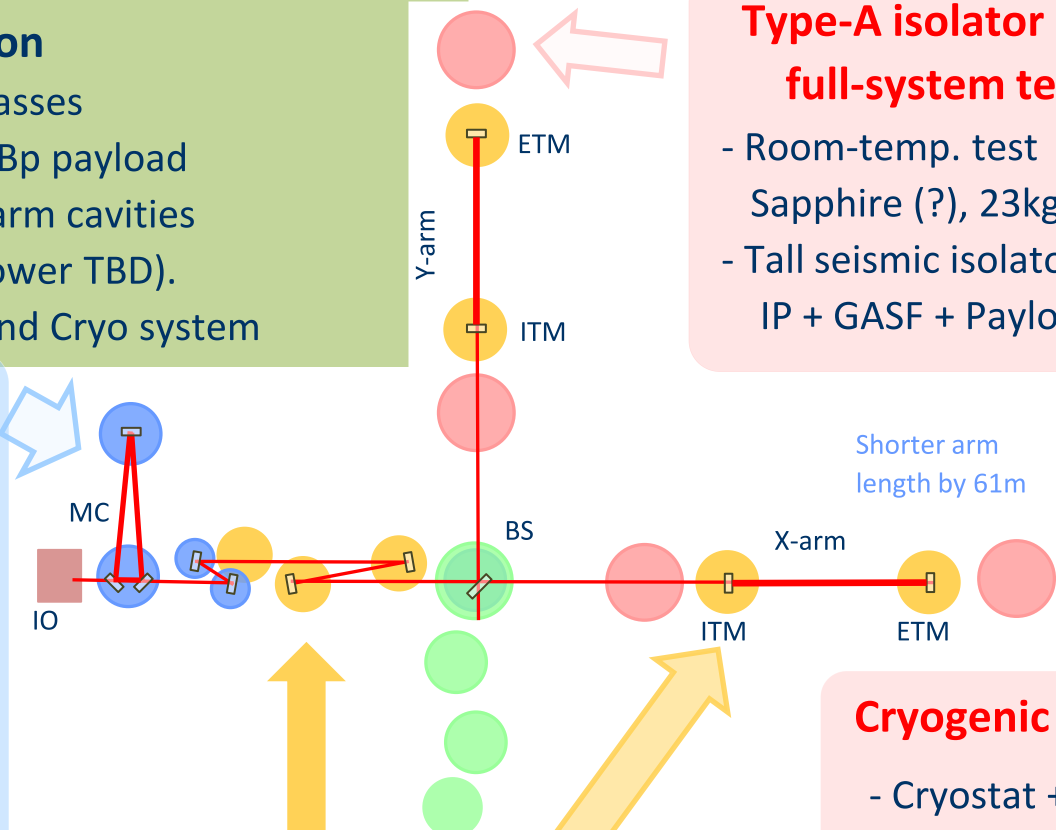
Onsite installation of iKAGRA; VACUUM

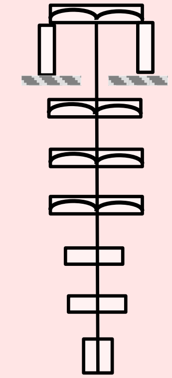
iKAGRA obs. Run in **Dec. 2015** ~1 month

iKAGRA configuration

- Room-temp. test masses suspended by Type-Bp payload
- FPMI with 2.94 km arm cavities
- Low laser power (power TBD).
- On-site test of VIS and Cryo system

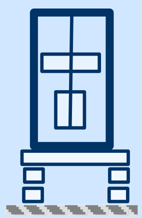


Type-A isolator full-system test



- Room-temp. test Sapphire (?), 23kg, 290K
- Tall seismic isolator IP + GASF + Payload

Type-C system

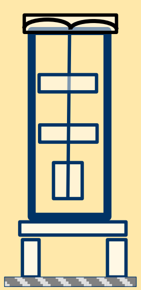


- Mode cleaner Silica, 0.5kg, 290K
- Stack + Payload

Cryogenic system test

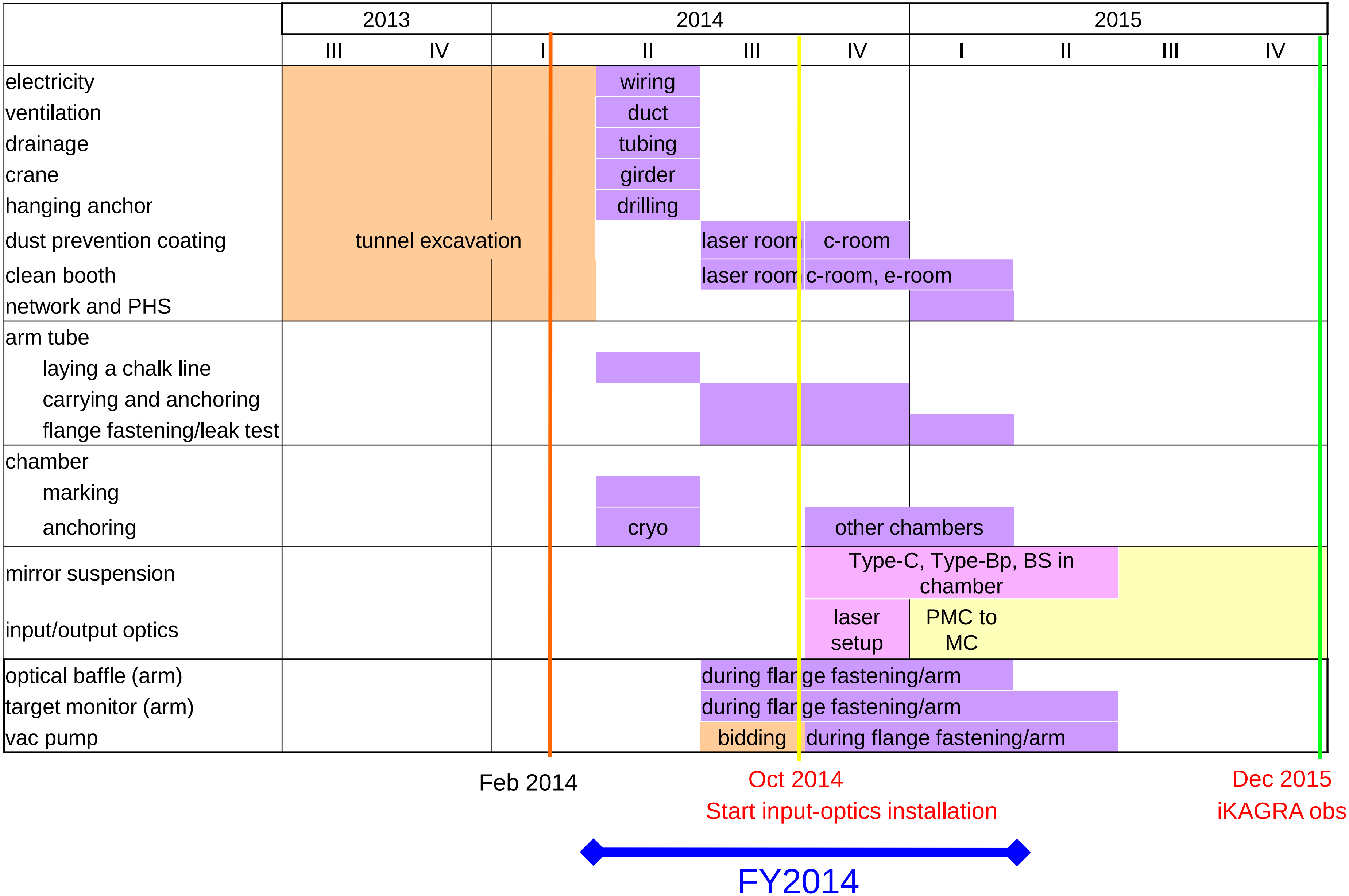
- Cryostat + Rad. shield duct
- Cryo-cooler
- Cryogenic payload
- Fixed Type-A SAS

Type-Bp payload

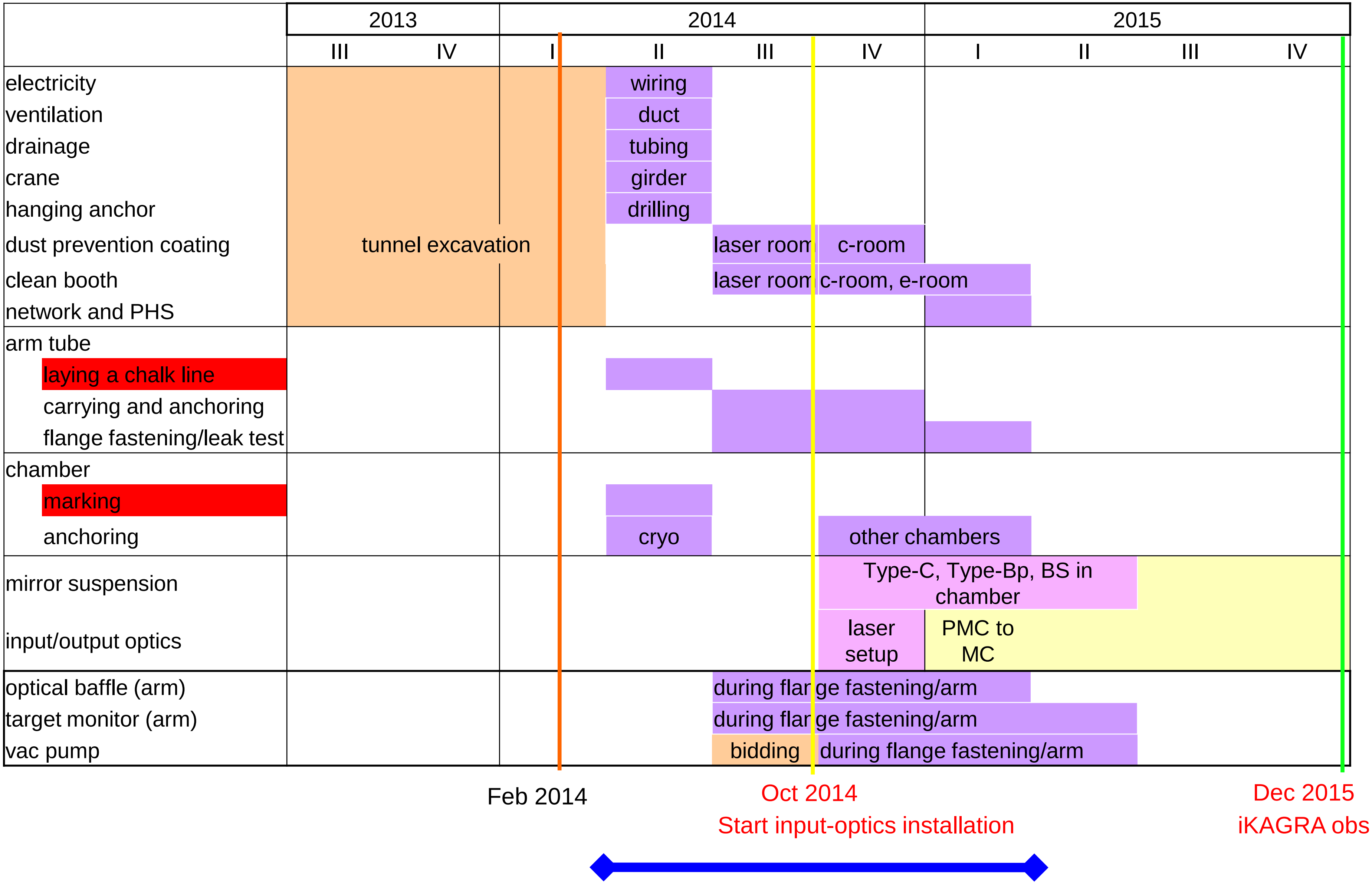


- Test mass and Core optics (BS, FM,..) Silica, 10kg, 290K
- Seismic isolator Table + GASF + Type-B Payload

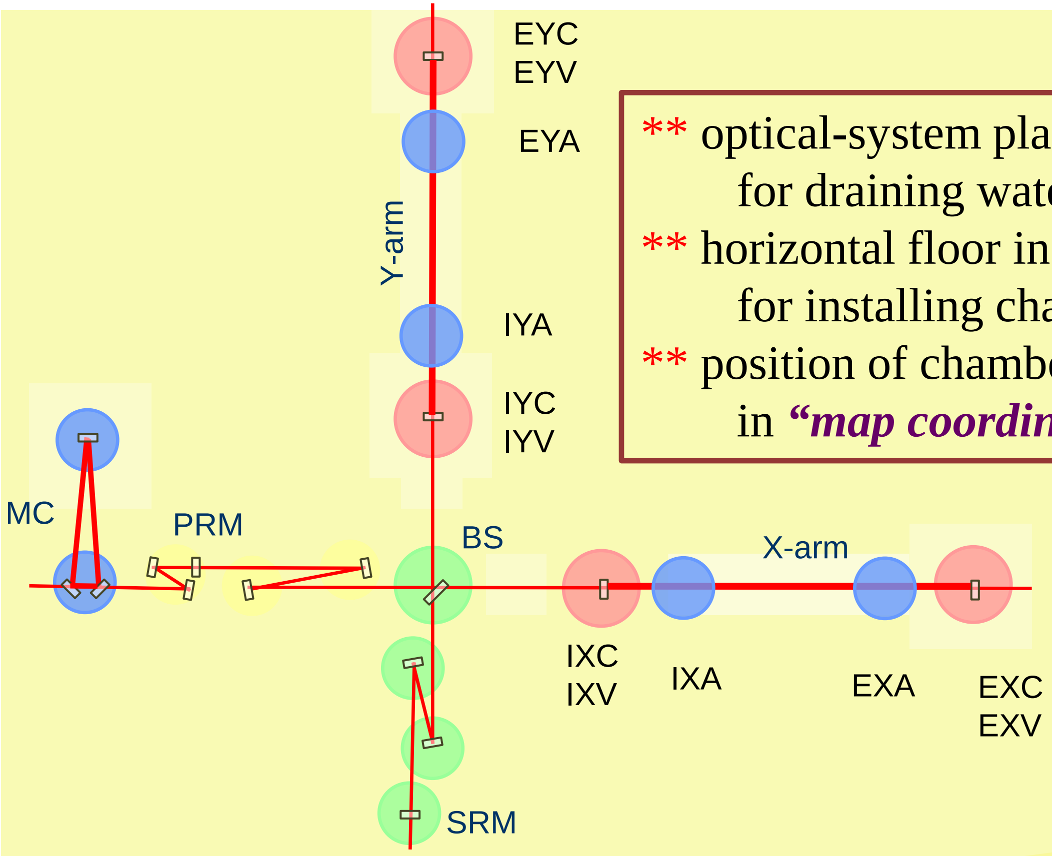
Onsite installation of iKAGRA: VACUUM



Onsite installation of iKAGRA: VACUUM



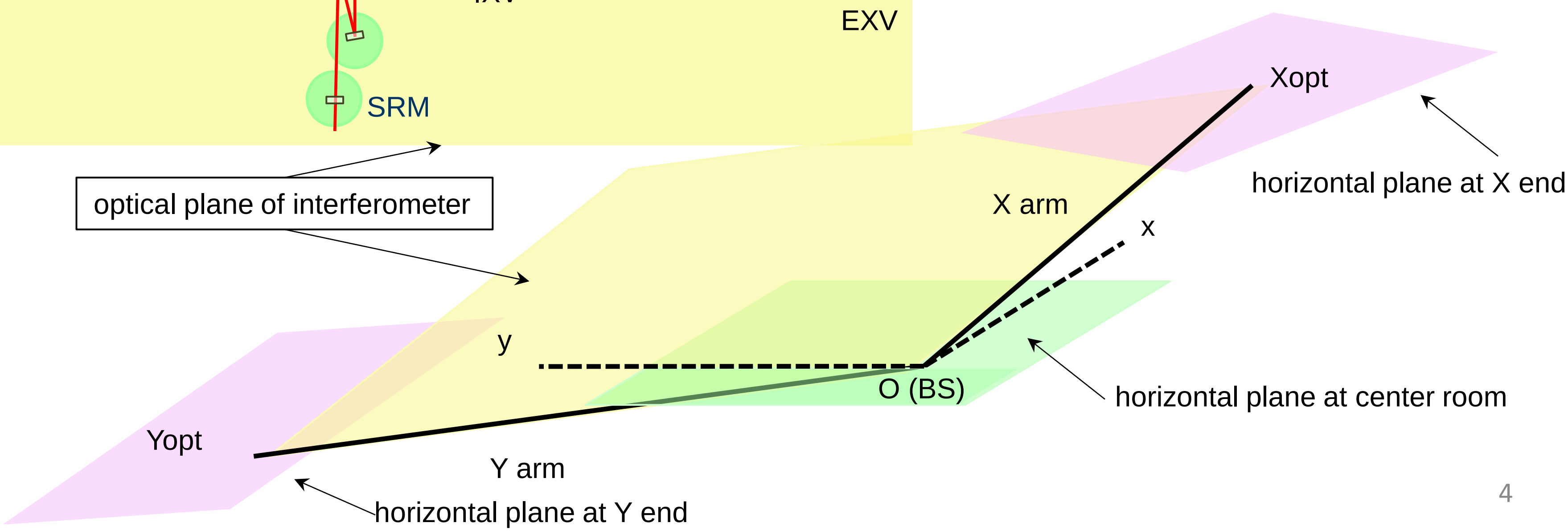
Laying a chalk line and Marking: (1) optical plane of the interferometer



** optical-system plane of interferometer is to be tilted for draining water.

** horizontal floor in each room is to be prepared for installing chambers.

** position of chamber/mirror is to be described in ***"map coordinates (survey map) of tunnel".***



Laying a chalk line and Marking: (2) interferometer on the globe

** position of chamber/mirror is to be described in ***"map coordinates (survey map) of tunnel".***

Geodetic coordinates: ***Latitude, Longitude, Height***
(B, L, $H+H_e$)

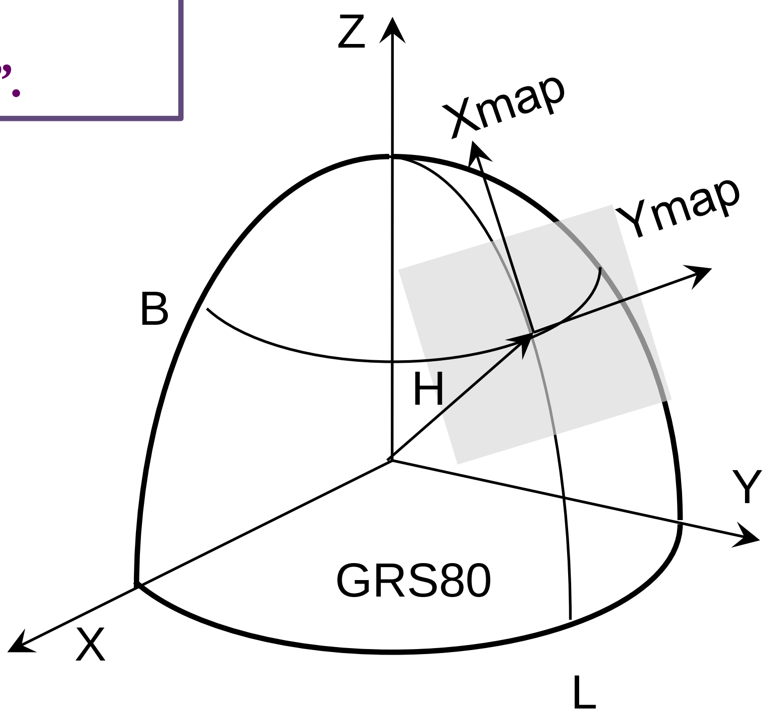
H; radius of GRS80 of ellipsoid earth
H_g; height of geoid surface from GRS80 surface

Japan rectangular plane coordinate: ***survey map***
(X_{map}, Y_{map}, H_o)

Takayama origin, zone VII, Japan
H_o: height from geoid surface

3D (orthogonal) terrestrial coordinate:
(X, Y, Z)

H_e (ellipsoid height) = H_o (orthometric height) + H_g (geoid height)



The position described in ***KAGRA optical coordinates,*** (X_{op}, Y_{op}, Z_{op}),
can be described in 3D (orthogonal) terrestrial coordinate, (X, Y, Z), by the conversion matrix;

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} - \begin{pmatrix} -3777336.0239 \\ 3484898.4107 \\ 3765313.6968 \end{pmatrix} = \begin{pmatrix} -0.37590014942 & 0.71643683491 & -0.58772216161 \\ -0.83615826266 & 0.01113873997 & 0.54837513460 \\ 0.39942263011 & 0.69756303661 & 0.59486752516 \end{pmatrix} \begin{pmatrix} X_{op} \\ Y_{op} \\ Z_{op} \end{pmatrix}$$

Laying a chalk line and Marking: (2) interferometer on the globe

** position of chamber/mirror is to be described in ***"map coordinates (survey map) of tunnel".***

Geodetic coordinates***: Latitude, Longitude, Height***
(B, L, H+H_e)

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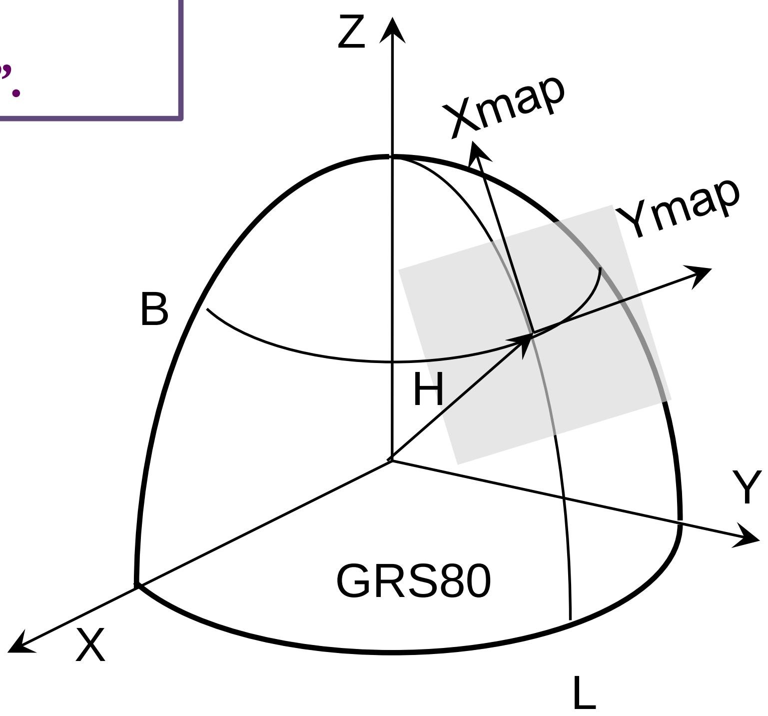


The position described in ***KAGRA optical coordinates,*** (X_{op}, Y_{op}, Z_{op}),
can be described in 3D (orthogonal) terrestrial coordinate, (X, Y, Z), by the conversion matrix;

HR center of mirror	Interferometer optical plane			3-D international terrestrial reference system		
	X_{op} [m]	Y_{op} [m]	Z_{op} [m]	X [m]	Y [m]	Z [m]
Beam Splitter (BS)	0	0	0	-3777336.024	3484898.411	3765313.697
X-front（IXC）	26.507	-0.016	0	-3777346.000	3484876.246	3765324.273
Y-front（IYC）	-0.008	23.222	0	-3777319.384	3484898.676	3765329.893
X-end（EXC）	3026.507	-0.016	0	-3778473.700	3482367.772	3766522.541
Y-end（EYC）	-0.008	3023.222	0	-3775170.073	3484932.092	3767422.582

Laying a chalk line and marking: (3) KAGRA location

Geodetic coordinates**: *Latitude, Longitude, Height***
(B, L, H+H_e)

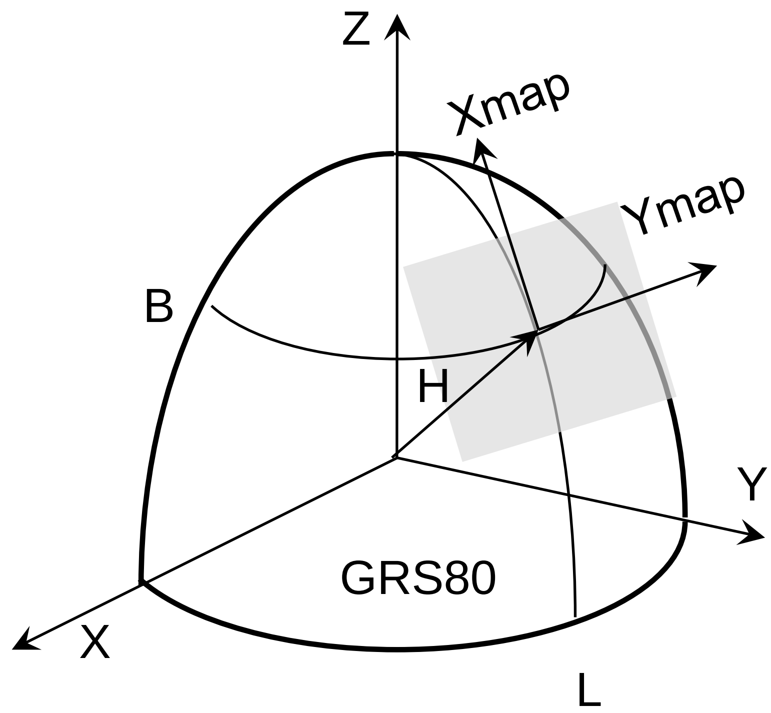
H; radius of GRS80 of ellipsoid earth
H_g; height of geoid surface from GRS80 surface

Japan rectangular plane coordinate: ***survey map***
(X_{map}, Y_{map}, H_o)

Takayama origin, zone VII, Japan
H_o: height from geoid surface

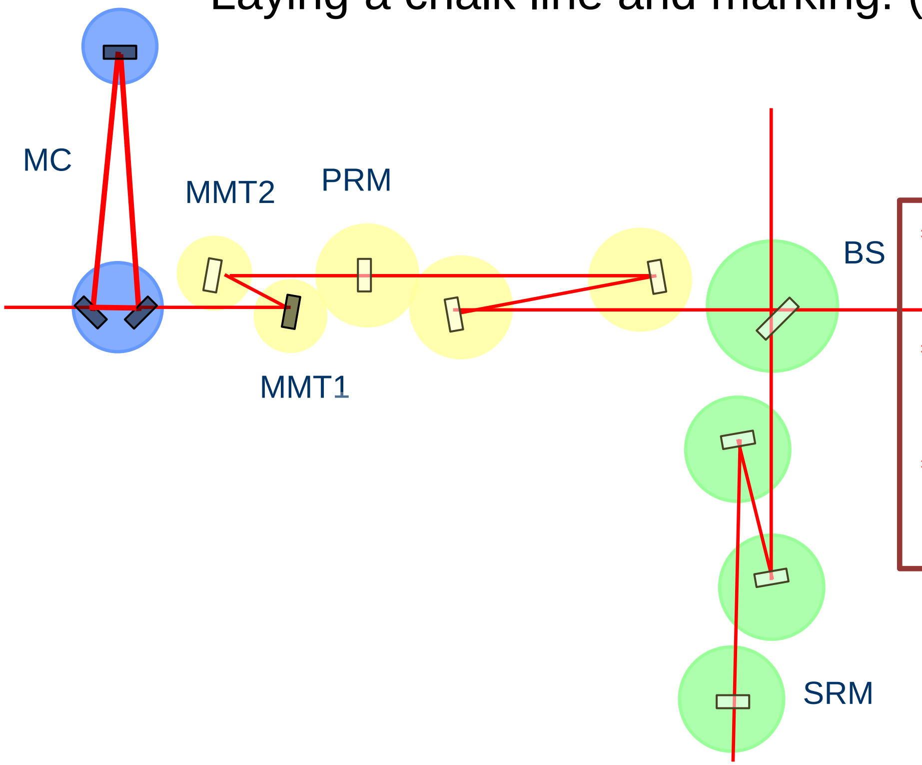
3D (orthogonal) terrestrial coordinate:
(X, Y, Z)

H_e (ellipsoid height) = H_o (orthometric height) + H_g (geoid height)



HR center of mirror	geodetic coordinate（ITRF94, GRS80）			Japan rectangular plane coordinate			3-D international terrestrial reference system		
	B [ddmmss]	L[dddmmss]	H_e [m]	X_{map} [m]	Y_{map} [m]	H_0 [m]	X [m]	Y [m]	Z [m]
Beam Splitter (BS)	362442.69722	1371821.44171	414.181	45705.629	12491.970	373.200	-3777336.024	3484898.411	3765313.697
X-front（IXC）	362443.12155	1371822.36703	414.264	45718.741	12515.003	373.282	-3777346.000	3484876.246	3765324.273
Y-front（IYC）	362443.35209	1371820.98104	414.097	45725.797	12480.465	373.117	-3777319.384	3484898.676	3765329.893
X-end（EXC）	362531.18475	1372007.07060	424.407	47204.264	15120.800	383.292	-3778473.700	3482367.772	3766522.541
Y-end（EYC）	362607.96387	1371721.48451	403.934	48331.612	10994.969	363.129	-3775170.073	3484932.092	3767422.582

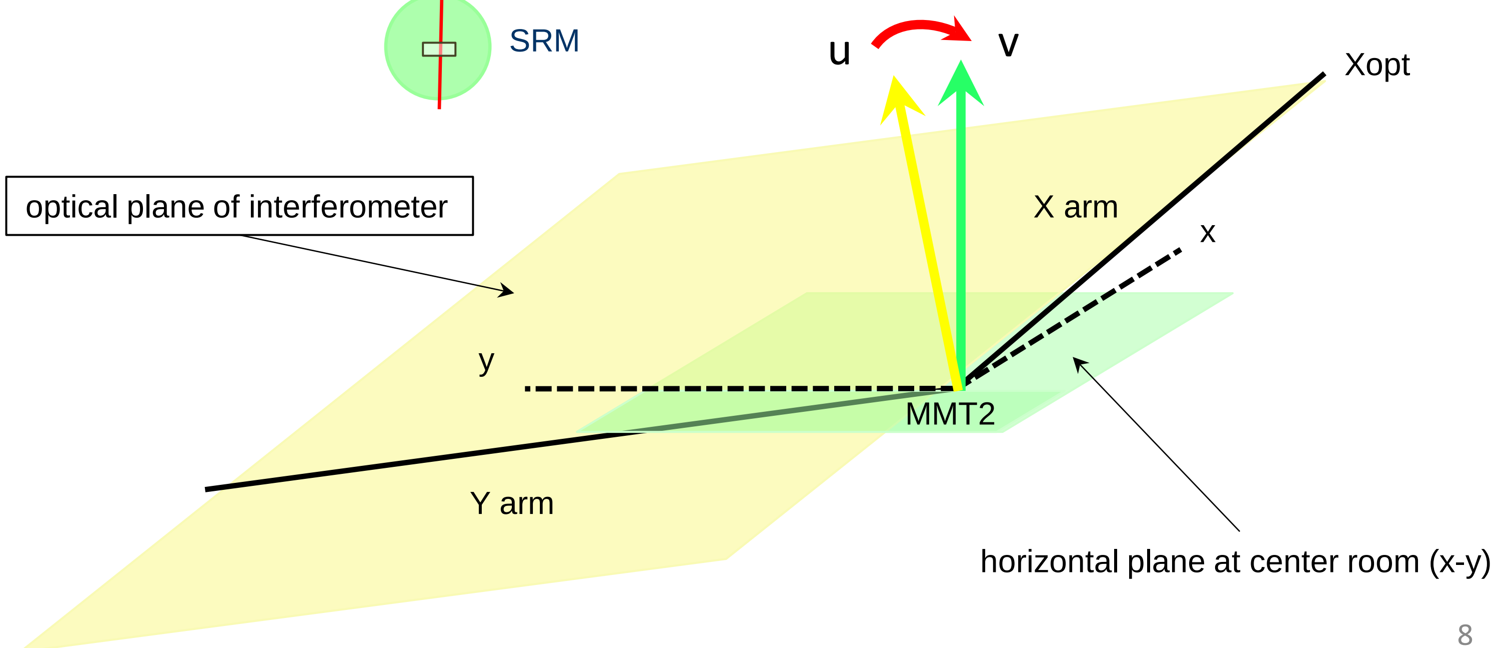
Laying a chalk line and marking: (4) rotating injection optical plane



** optical-system plane of interferometer is to be tilted for draining water.

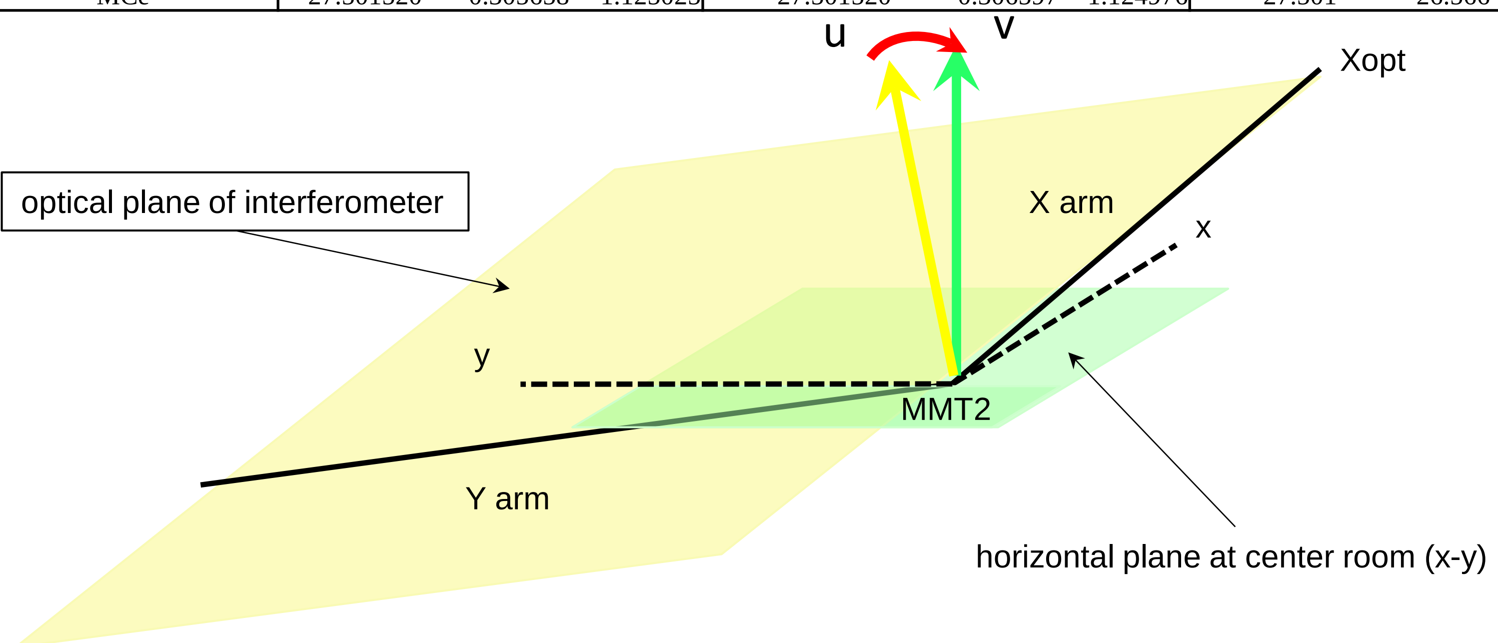
** horizontal floor in each room is to be prepared for installing chambers.

** injection optics is preferably installed on the plane parallel to the center-room floor.

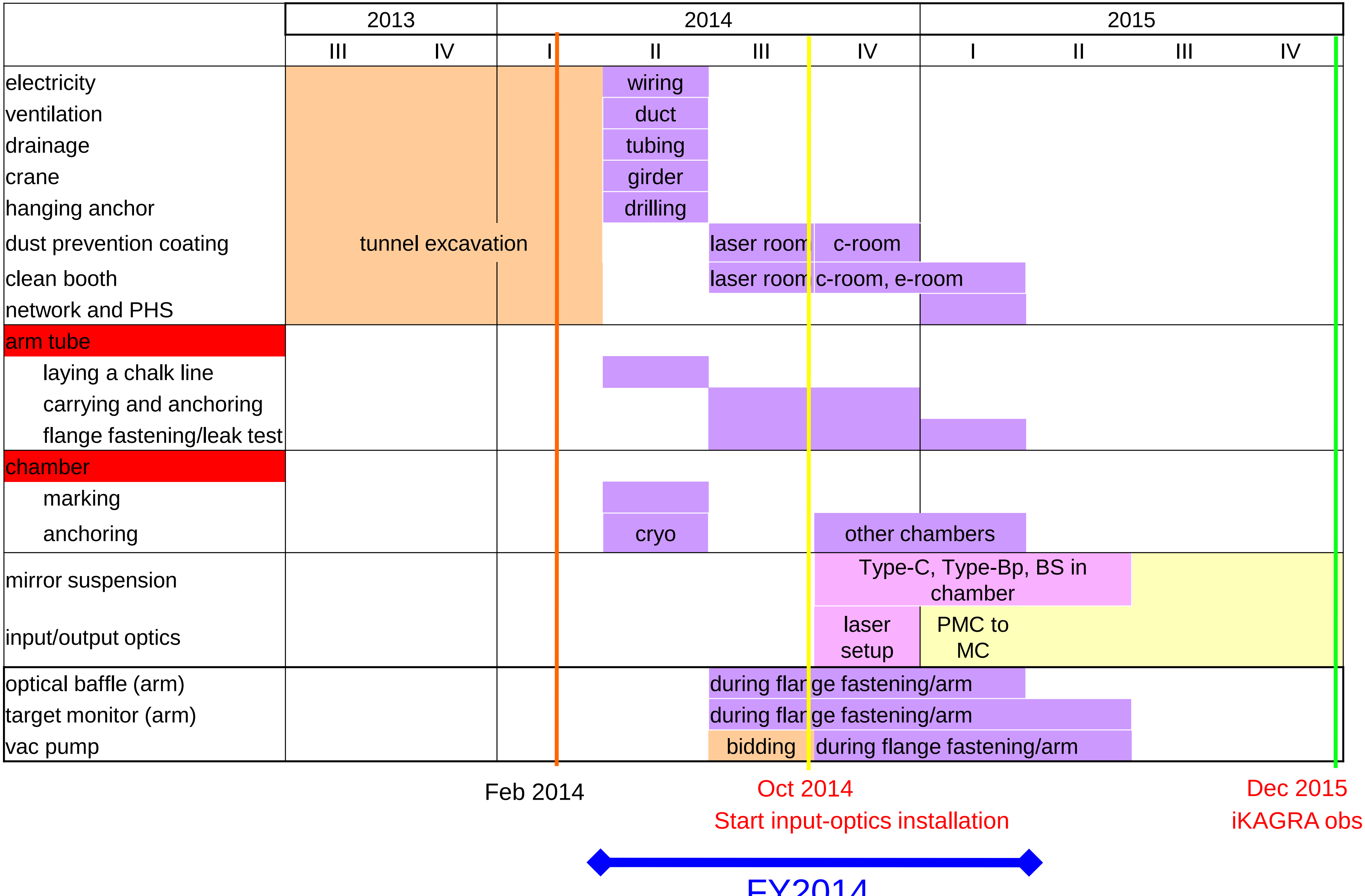


Laying a chalk line and marking: (4) rotating injection optical plane

		HR Center			Center of Mass			Center of Chamber_saito		
		Xop [m]	Yop [m]	Zop [m]	Xop [m]	Yop [m]	Zop [m]	Xop [m]	Yop [m]	Zop [m]
Un-rotated	BS	0.000000	0.000000	0	0.028278	-0.028291	0	0.028	-0.028	0
(in op coordinate)	MCo	-27.259072	0.136954	0	-27.248415	0.126398	0	-27.509	0.077	0
	MMT1(IMM)	-21.394078	-0.060797	0	-21.378992	-0.061897	0	-21.594	0.127	0
	MCi	-27.759072	0.136954	0	-27.769729	0.126398	0	-27.509	0.077	0
	MMT2(IFI)	-24.479078	0.289713	0	-24.493964	0.290652	0	-24.279	0.127	0
	MCe	-27.509048	26.535653	0	-27.509048	26.550622	0	-27.509	26.550	0
rotated	MCo	-27.259059	0.136939	0.008179	-27.248403	0.126383	0.008057	-27.509	0.077	0.010
(in op coordinate)	MMT1(IMM)	-21.394095	-0.060778	-0.010962	-21.379009	-0.061877	-0.011064	-21.594	0.127	-0.008
	MCi	-27.759057	0.136936	0.009750	-27.769713	0.126380	0.009695	-27.509	0.077	0.010
	MMT2(IFI)	-24.479078	0.289713	0	-24.493964	0.290652	0	-24.279	0.127	0
	MCe	-27.508884	26.535463	0.104707	-27.508884	26.550432	0.104711	-27.509	26.550	0.106
rotated	BS	-0.007626	-0.016281	1.199966	-0.035904	0.012009	1.200154	-0.036	0.012	1.200
(in c-r coordinate)	MCo	27.251327	-0.016281	1.122824	27.240670	0.012009	1.122773	27.501	-0.093	1.124
	MMT1(IMM)	21.386331	-0.152861	1.122636	21.371245	-0.142305	1.122586	21.586	-0.143	1.124
	MCi	27.751327	0.044809	1.122839	27.761984	0.045908	1.122788	27.501	-0.093	1.124
	MMT2(IFI)	24.471334	-0.152854	1.122756	24.486220	-0.142298	1.122706	24.271	-0.143	1.124
	MCe	27.501520	-0.305658	1.125025	27.501520	-0.306597	1.124976	27.501	-26.566	1.126

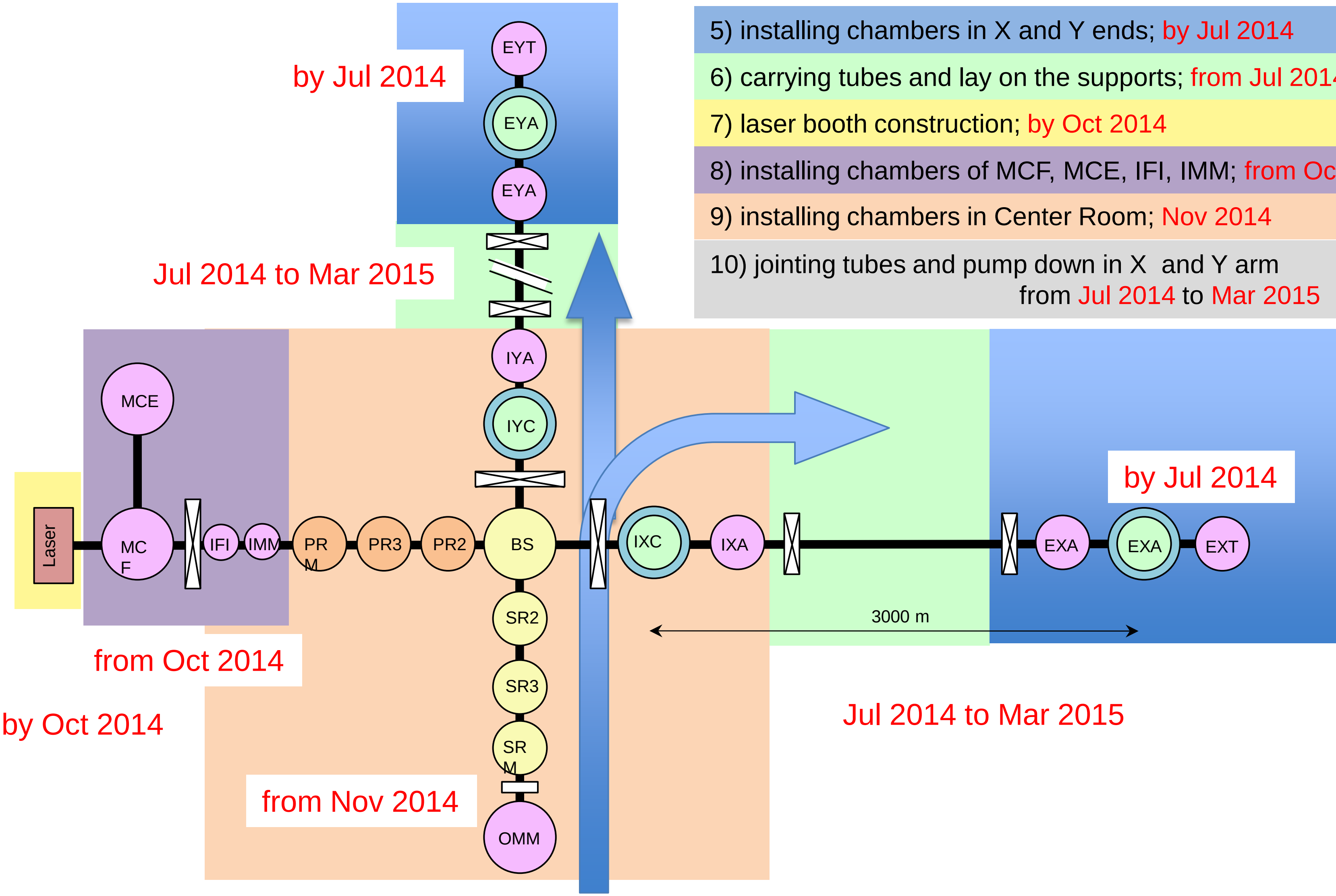


Onsite installation of iKAGRA: VACUUM

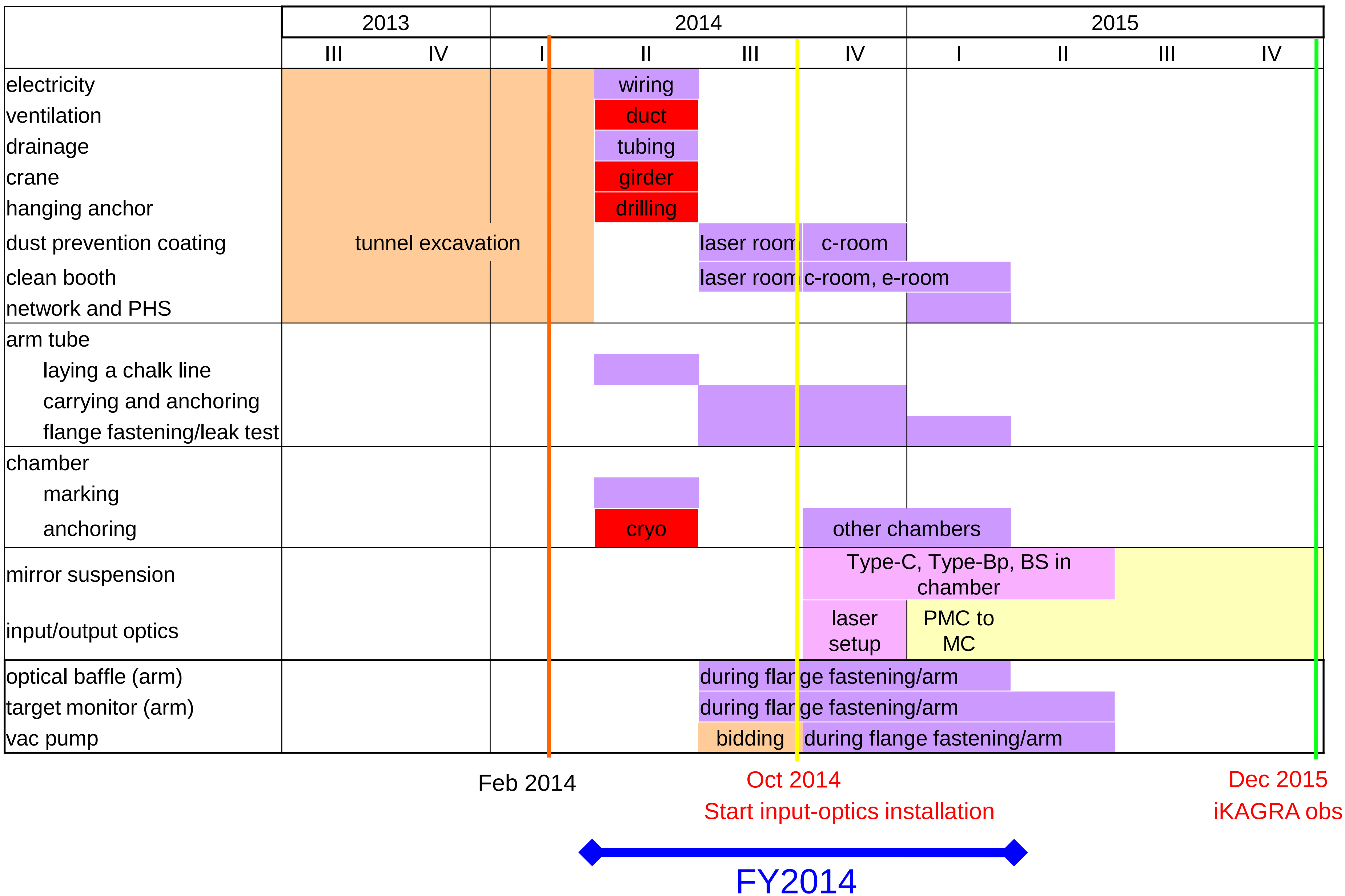


Installation of tubes and chambers

1) manufacturing 478 of tubes; from Apr 2011 to Mar 2013
2) manufacturing chambers; from Sep 2012 to Mar 2014
3) construction of tunnel facility equipments; from Mar 2014
4) laying a chalk line and marking; from May 2014
5) installing chambers in X and Y ends; by Jul 2014
6) carrying tubes and lay on the supports; from Jul 2014
7) laser booth construction; by Oct 2014
8) installing chambers of MCF, MCE, IFI, IMM; from Oct 2014
9) installing chambers in Center Room; Nov 2014
10) jointing tubes and pump down in X and Y arm from Jul 2014 to Mar 2015



Onsite installation of iKAGRA: VACUUM

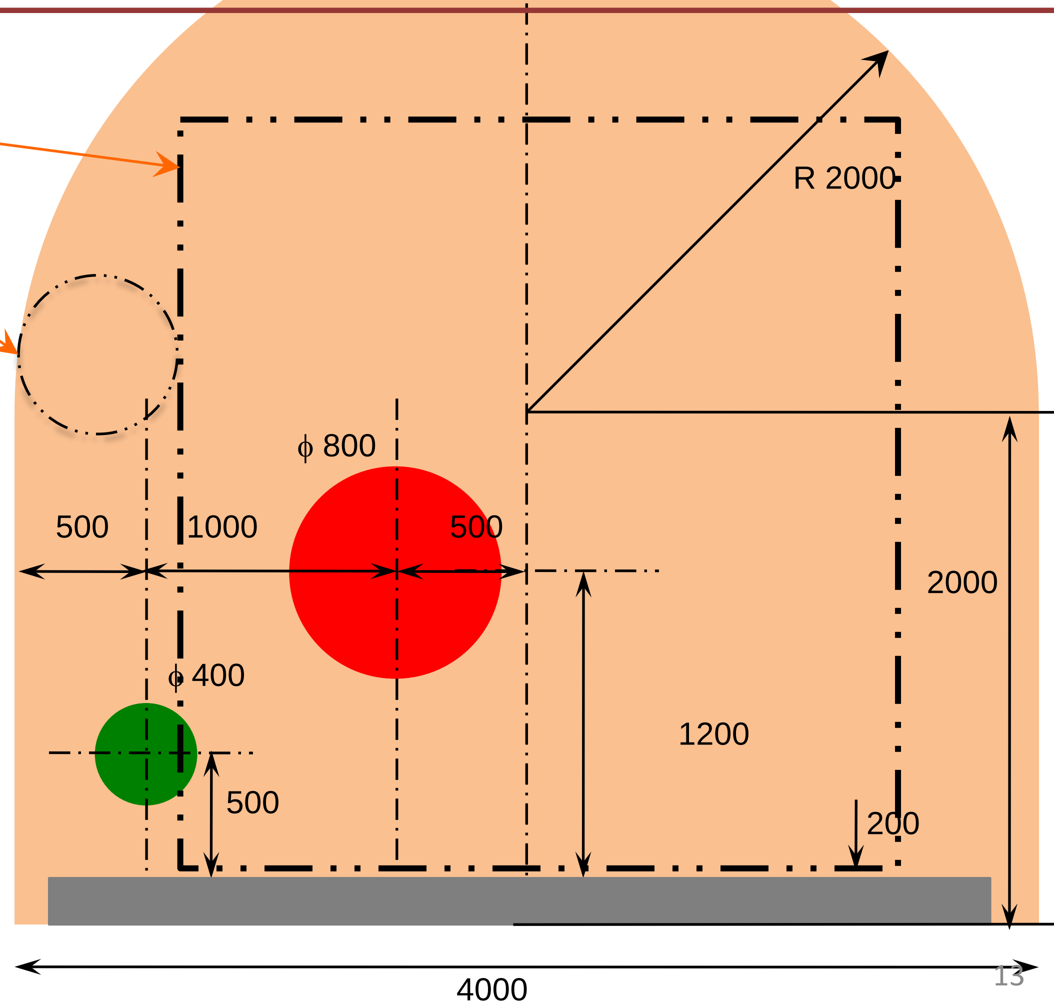


Installation of cryo-chambers: (1) carrying chambers inside the arm tunnel

** chambers can only be carried from the center-room
to the end-room through the arm tunnel.
** cryo-chambers to be installed in the end-room
should be delivered to the end before tube installation (~4 days per a cryostat chamber).

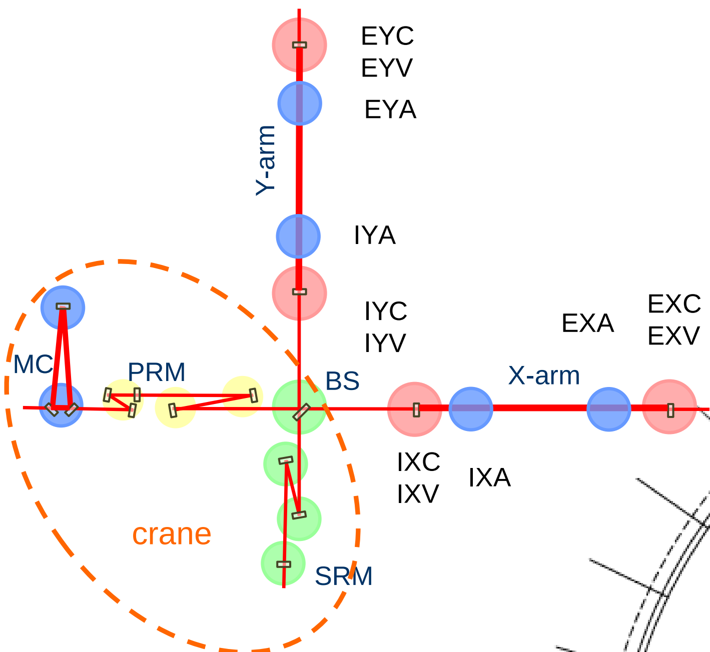
Cryo-chamber
weight; 14 t
height; 3150 mm
width; 2700 mm

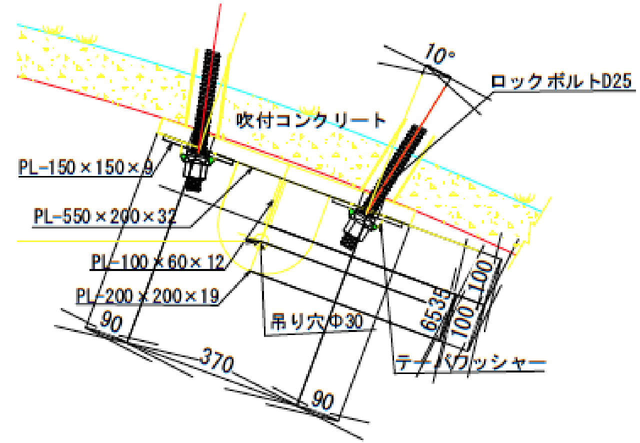
ventilating duct
ϕ 600 mm

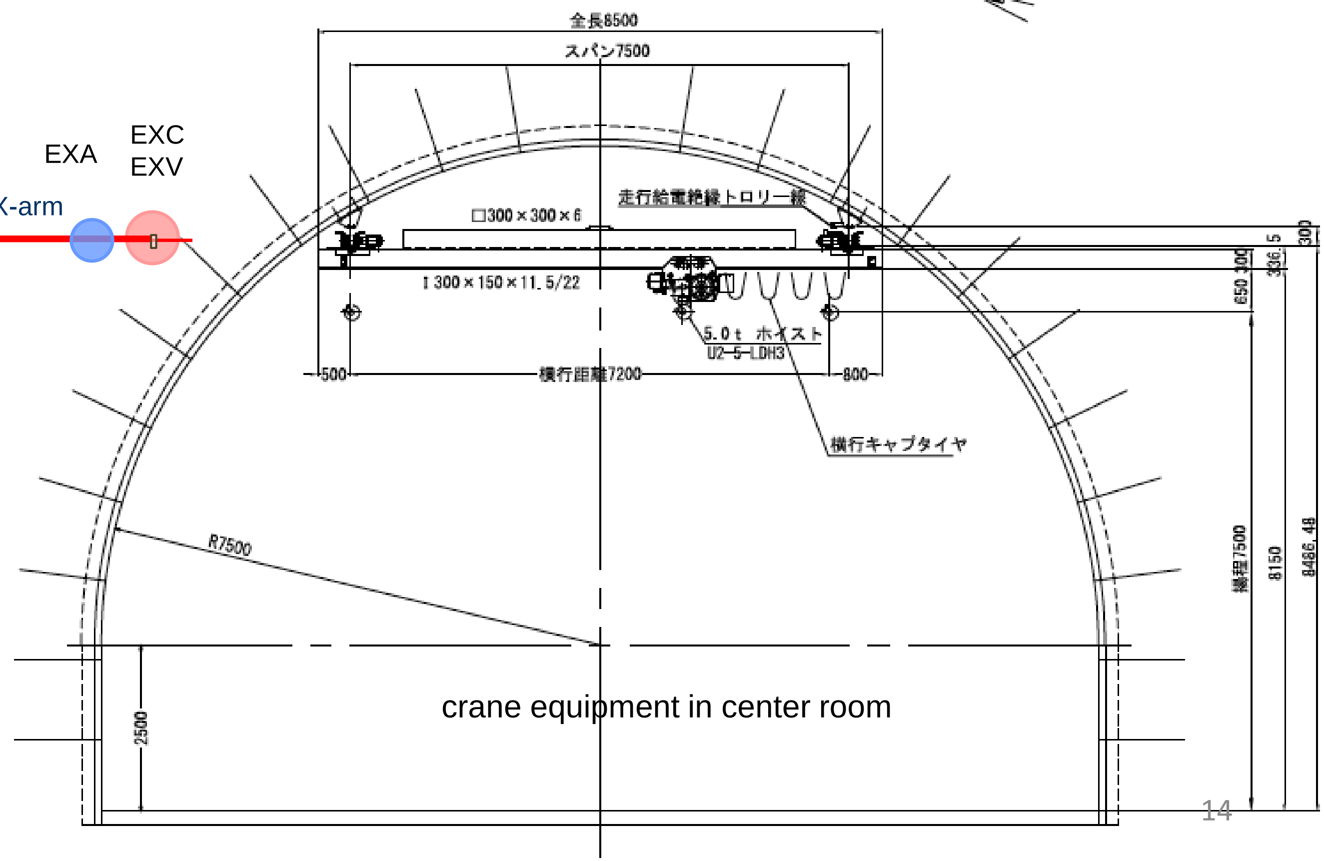


Installation of cryo-chambers: (2) crane and hanging anchor

** crane is equipped only in the center-room (~30 days).
** hanging anchor is available in other areas (~15 days).
** construction of crane girder is begun,
immediately after excavation is finished.

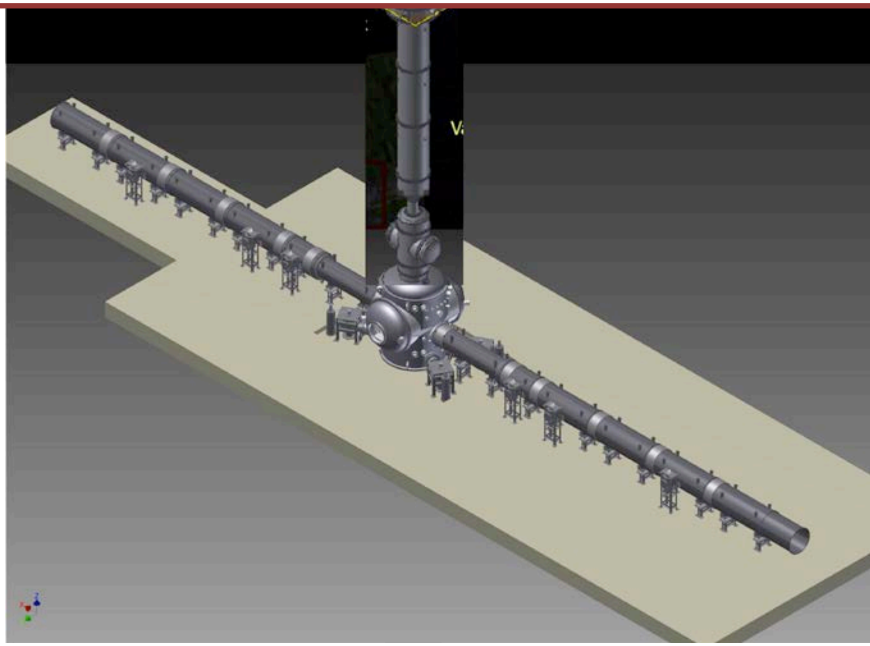


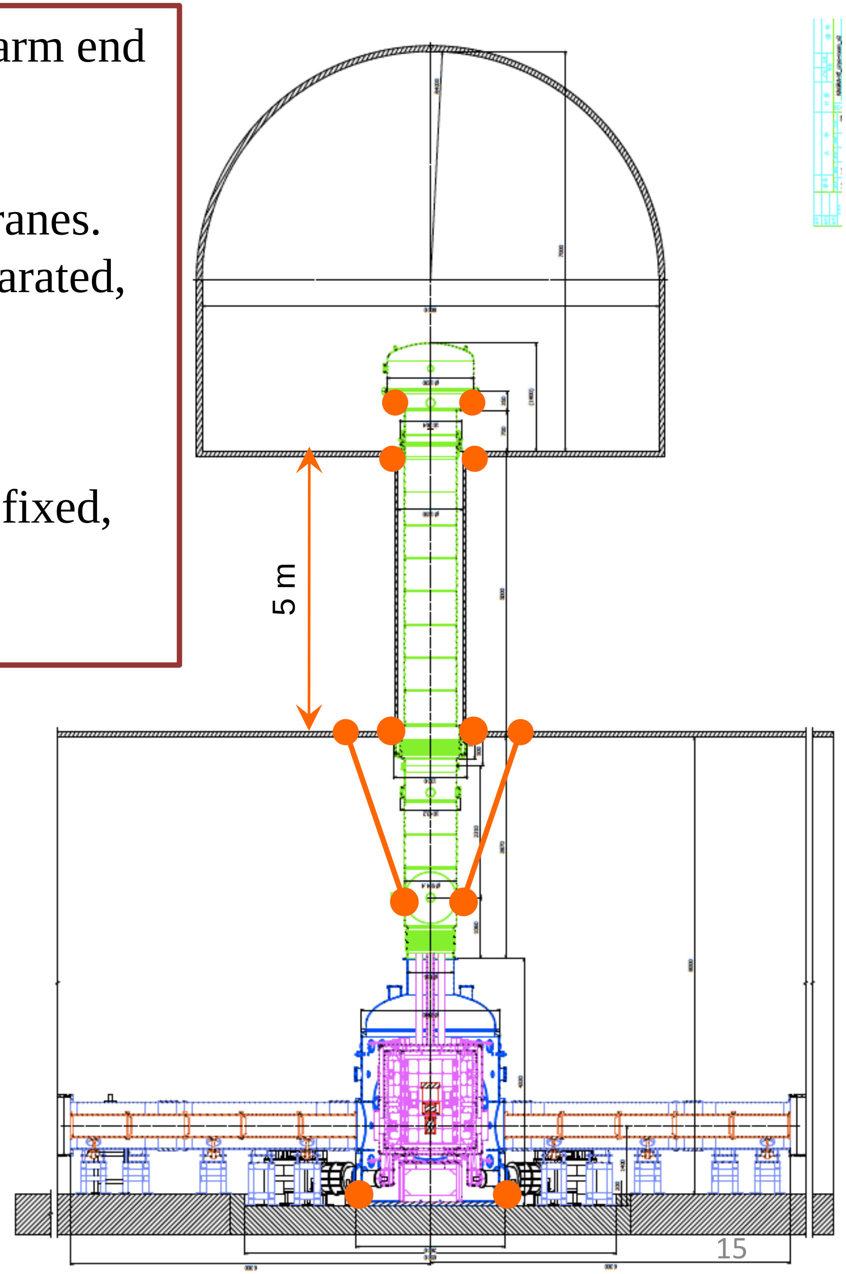




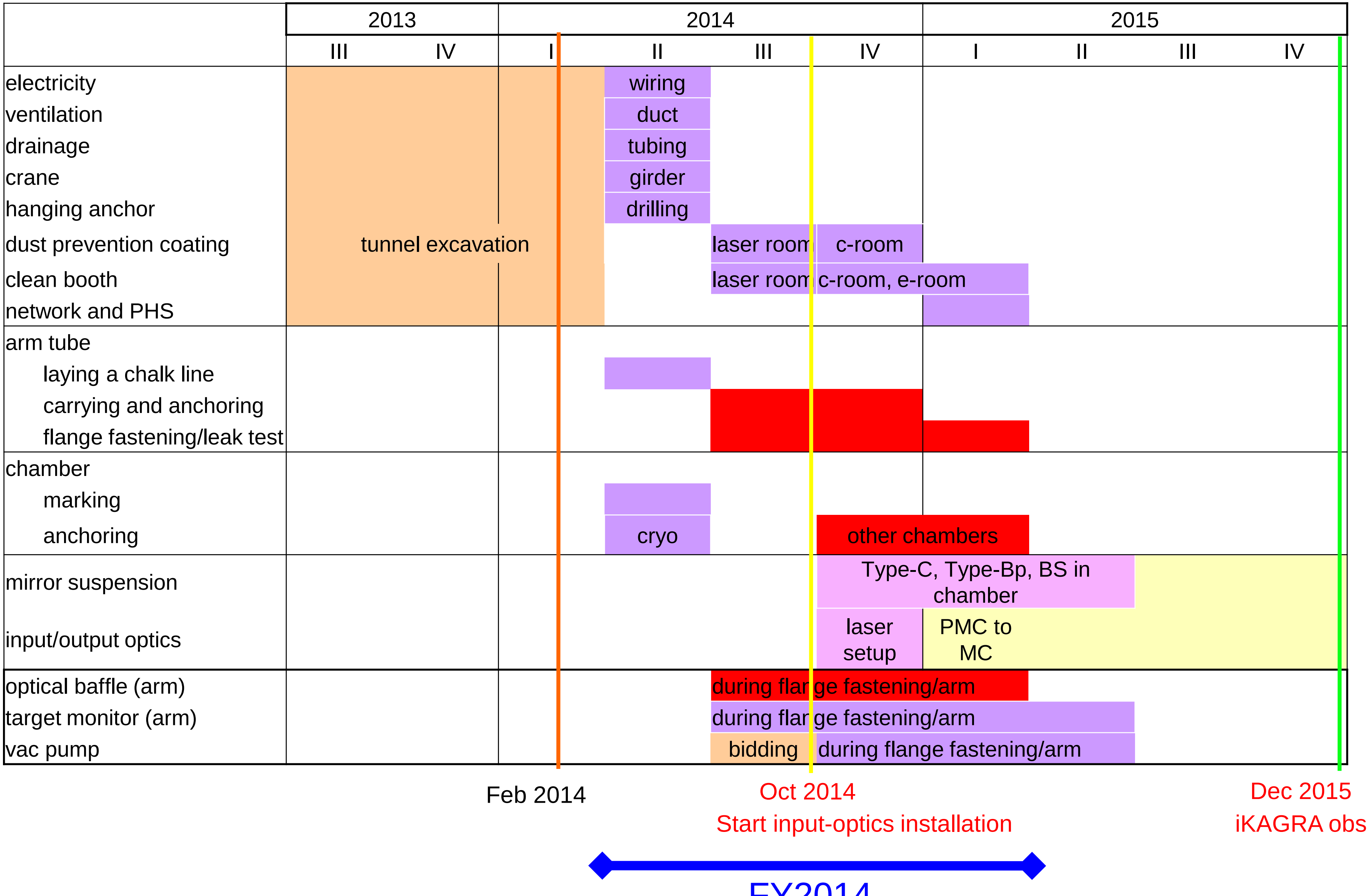
Installation of cryo-chambers: （3）1st and 2nd floor

** two of cryostat chambers are to be carried to the arm end and to be first set on the floor.
** hanging anchors from the ceiling are available, for chamber alignment, although there are no cranes.
** two of cryostat chambers in the end room are separated, from the arm tube vacuum.
** chambers in the middle should be supported, by the hanging anchor from the ceiling.
** vertical tubes (5 m long and 900 mm in dia.) are fixed, for avoiding unnecessary vibration.
(~15 days per a chamber)



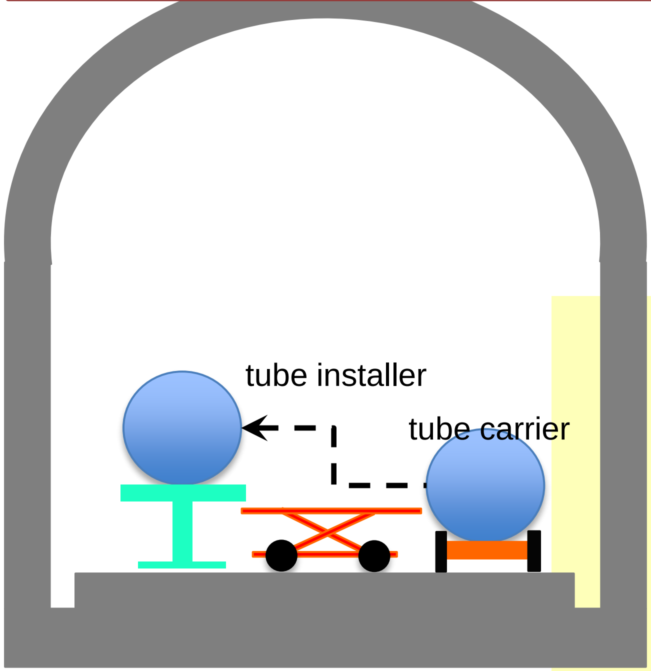


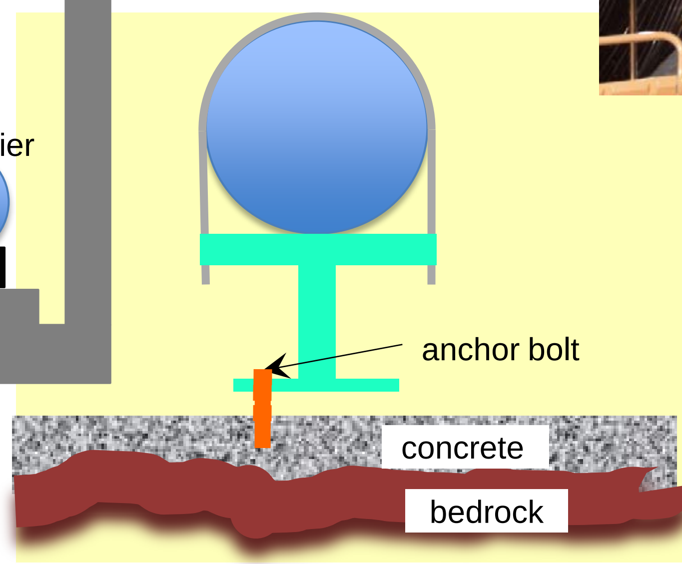
Onsite installation of iKAGRA: VACUUM

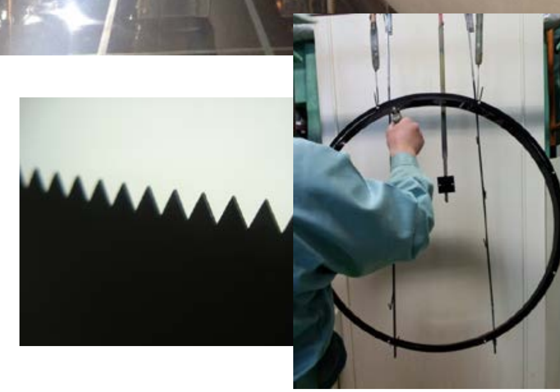


Installation of tubes: anchoring, baffle installation, leak testing

** a tubes of 800 mm in diameter and 12 m long will be carried, by electric motor car in the arm tunnel.
** 8 tubes per day are to be set on the support (~90 days)
** 8 flanges of tubes with optical baffles will be fastened per day (~90 days), in the mobile clean booth.
** leak test is performed at every 100 m (9 tubes), and is finished at 30 days after the last flange fastened.

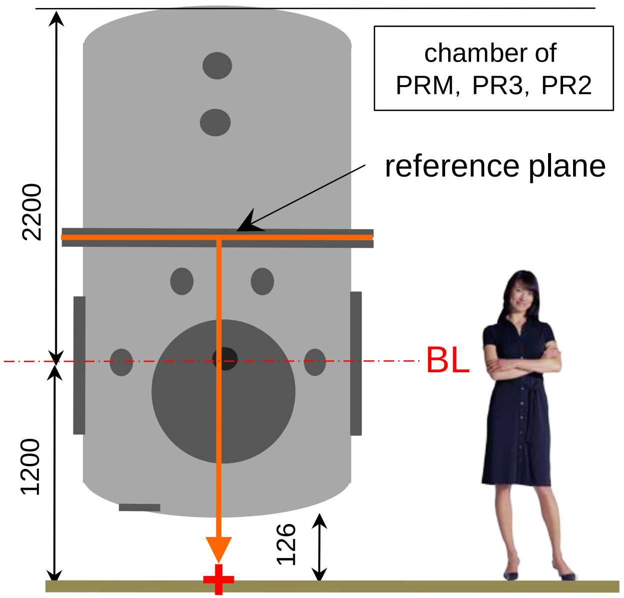


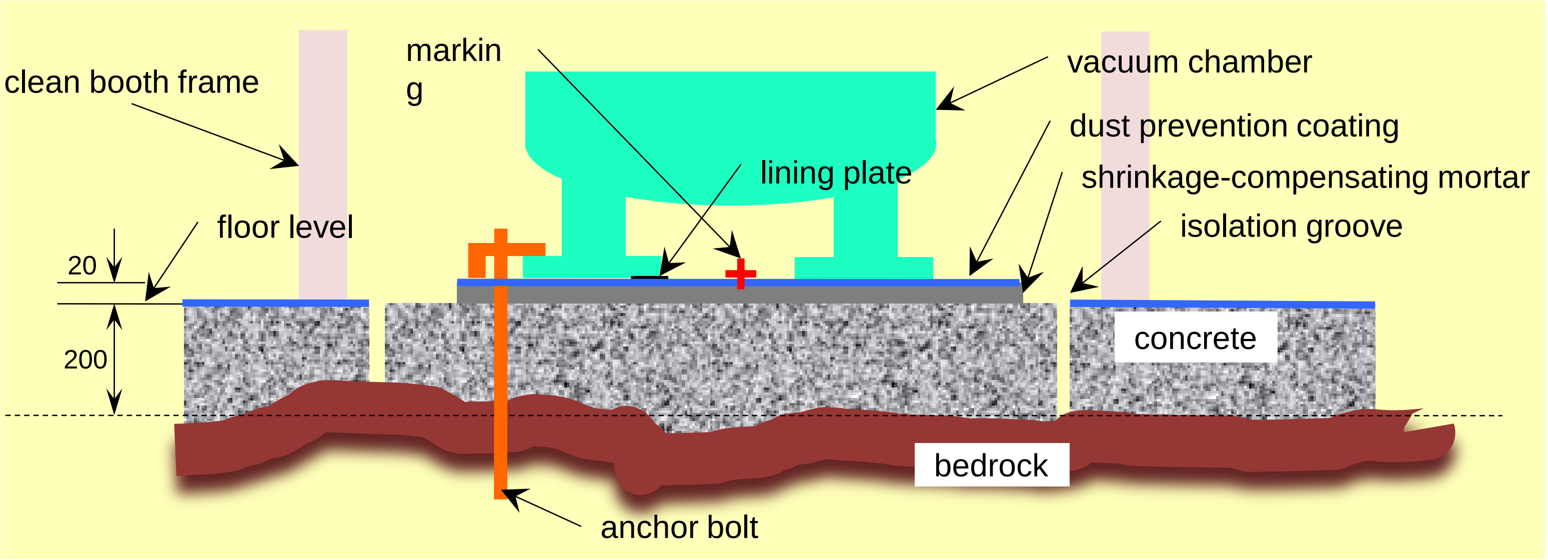



optical baffle

Installation of chambers: anchoring to a bedrock

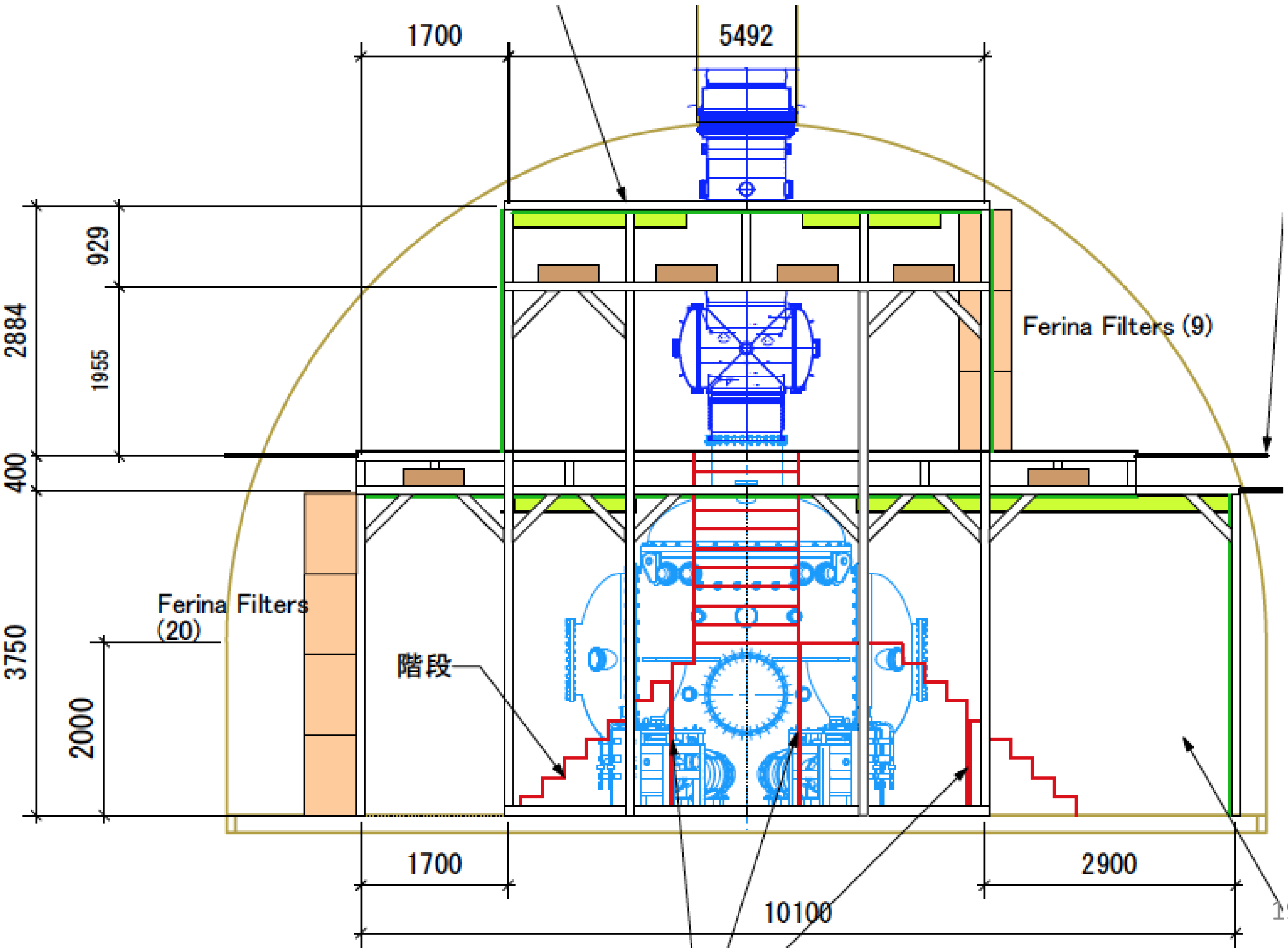
** floor surface is finished by mortar of 20 mm thick,
so as to be flat within 2 mm.
** direct alignment can be done by using a plumb,
being hung from a reference plane of the chambers.
** construction of crane equipment should be finished,
before chamber installation.
** chambers are fixed by anchor bolts,
reaching to the bedrock.
** 15 of chambers are to be fixed,
before constructing a clean booth.
(~7 days per a chamber)





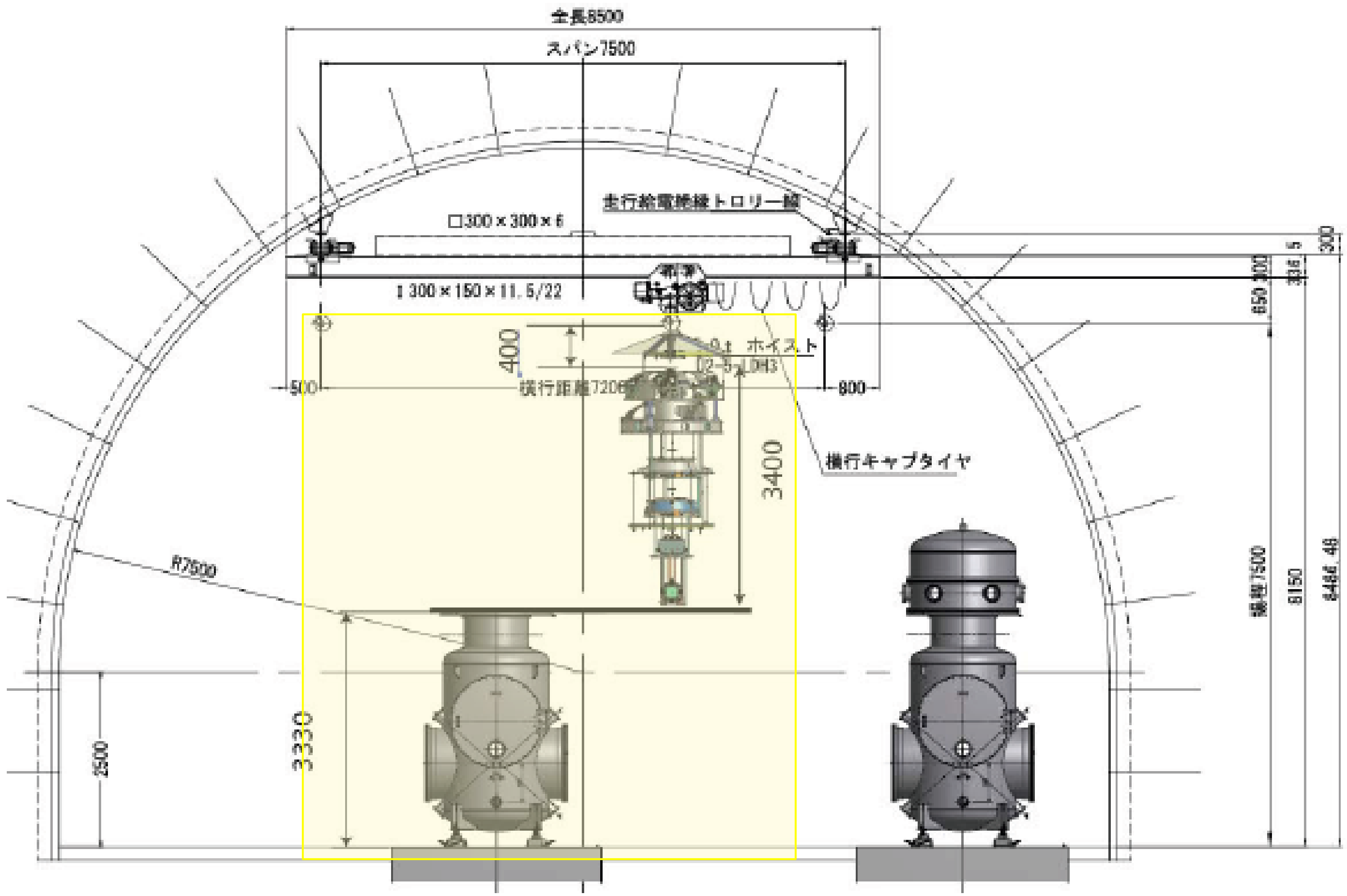
Installation of chambers: clean booth construction

** clean air-flow is horizontal. (class is not yet decided.)
** second floor is necessary for installing and tuning the vibration isolation system.
** construction of clean booth is begun after chamber installation,
and finished before installing mirror and suspension system (~15 days per a section).



Installation of mirror suspension system inside a vacuum chamber

** details of installation processes are not yet fixed.
** a vibration isolation system with a mirror is to be assembled in advance,
then hanged by the crane to set in the vacuum chamber.
** installation is to be performed in each clean booth, having a hatch opening.
(~7 days for assembling and setting per a suspension)



Onsite installation; facility construction and vacuum installation