Study of Industrialization and Factory Layout for Cryomodule Assembly

T. Semba,
Hitachi, Ltd.

2011.7.24

HITACHI
Inspire the Next

The 2nd workshop on SCRF Cavity Technology and Industrialization for the ILC , Chicago, 24th July 2011

© Hitachi,Ltd.2011 All rights reserved

Outline

1. Introduction to Hitachi
2. Motivation for This Study
3. A Model for Industrialization
4. Study of Cryomodule Mass Production
5. Examples of Factory Layout
   - 5-1. An Assembly Hall in KEK
   - 5-2. Night and Day Shifts
   - 5-3. New Assembly Building
6. Summary/Conclusions

HITACHI
Inspire the Next

© Hitachi,Ltd.2011 All rights reserved

1 Hitachi Company Profile

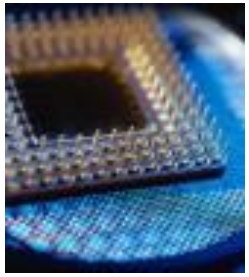




- **Founded : 1910**
- **Consolidated Revenue*: ¥9,315 Billion**
- **Employees*: 361,745**
- **Group Companies*: 913**
- **Main business activities in :**
  - **Power and Industrial Systems**
  - **Electronic Devices**
  - **Information and telecommunication systems**
  - **Digital Media & Consumer Products**
  - **High Functional Materials and Components**

***FY 2010**











© Hitachi,Ltd.2011 All rights reserved

Development of Accelerator Devices by Hitachi

Project(Institute)	1971～	1981～	1991～	2001～	2011～
Proton Synch. (KEK)					
Photon Factory (KEK)					
CDF (Tukuba Univ./FNAL)					
TRISTAN (KEK)					
HIMAC (NIRS)					
Spring-8 (RIKEN)					
KEK-B (KEK)					
RIBF (RIKEN)					
J-PARC (JAEA/KEK)					
STF (KEK)					
Super KEK-B (KEK)					
ILC (KEK/International)					

We are here.



RIKEN Superconducting Ring Cyclotron



J-PARC 50GeV Synchrotron



KEK STF1 Cryostat

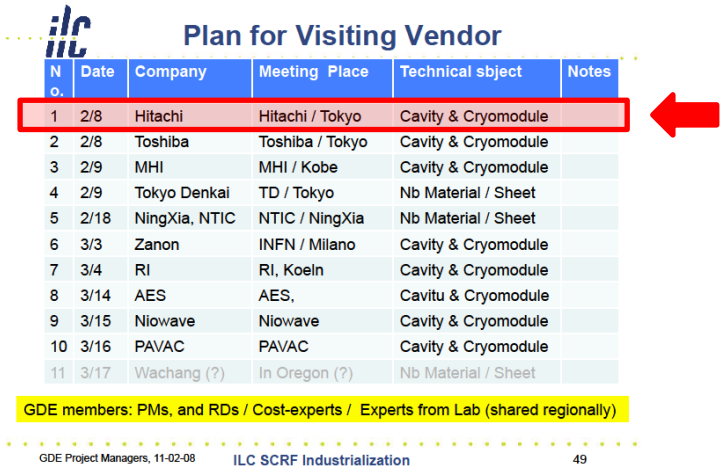
© Hitachi,Ltd.2011 All rights reserved

2 Motivation for This Study

- Experienced in Accelerator Devices, Magnets(Normal/Superconducting), Vacuum Chambers, etc.
- Contribution to ILC development and production
- Participation in SRF2005, Visit to DESY in 2005
- Manufacture of KEK STF1 Cryostat
- Launch Cavity Development, Completed our First Cavity (TUPO030)

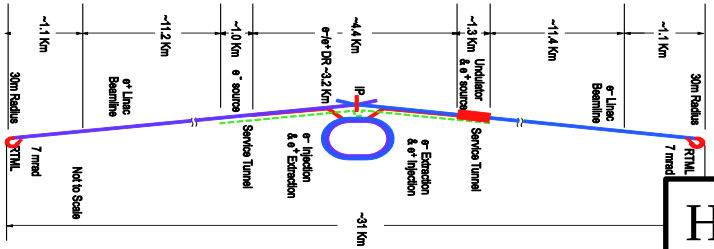
GDE/KEK members visit Hitachi on Feb. 8th, 2011





© Hitachi,Ltd.2011 All rights reserved

3 A Model for Industrialization



ILC Site

Host-Laboratory

Responsibility
- Lab : performance
- Company : build-to print manufacturing

Hub-Laboratory A

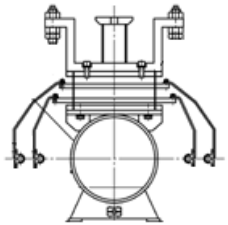
- cryomodule testing facility
- cryomodule assembly factory (including cavity string assembly)

Hub-Laboratory B

Cavity & Q-mag (performance is comfirmed by Lab)

pre-assembly factory

support post + 2K GHe return pipe + + upper radiation shields



parts supply company

parts supply company

.....

parts supply company

© Hitachi,Ltd.2011 All rights reserved

4 Study of Cryomodule Mass Production



Specification of ILC Cryomodule

Total Length	12m
Cryogen	Saturated Superfluid He
Cooling Temperature	2K
Radiation Shields	Dual Shields (5K, 80K)
Support Post	GFRP Cylinder Type
Average Field Gradient	31.5MV/m (Operation)

© Hitachi,Ltd.2011 All rights reserved

Boundary Condition of this study

- Production Quantities and Period (presented by GDE)

Parameters	Value
# 9-cell cavity	14,560 ---> 16,000
# cryomodule	1,680 ---> 1,700
Set-up & Pre-production period	2 years
Full production period	5~6 years
# cryomodule / year (total)	280~340 cryomodules / year

  - 20% quantities production in 6 years @one factory
  - Cryomodule : KEK-STF type, Dual shields (5K, 80K)
  - Regulation : High Pressure Gas Safety Code in Japan
  - Scope : performance in room temperature

© Hitachi,Ltd.2011 All rights reserved

Cryomodule Assembly Flow

Cryomodule Assembly Flow developed in STF1

① **Upper Cold Mass Assembly**

↓

② **Cavity String Assembly, Alignment**

↓

③ **Cold Mass Assembly, Alignment**

↓

④ **Tube Welding, Leak Test**

↓

⑤ **Pressure Test, with Examiner**

↓

⑥ **Lower Cold Mass Assembly**

↓

⑦ **Cold Mass Insertion into Vacuum Vessel**

↓

⑧ **Outer Parts Installation (Couplers, etc.)**

↓

⑨ **Vacuum Vessel Closing**

with Preparation for Low Temperature Test









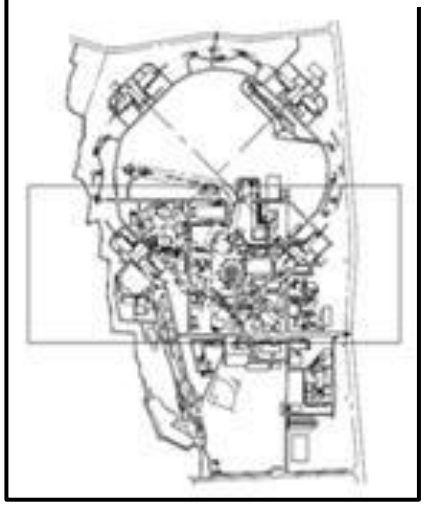




© Hitachi,Ltd.2011 All rights reserved

5 Examples of Factory Layout

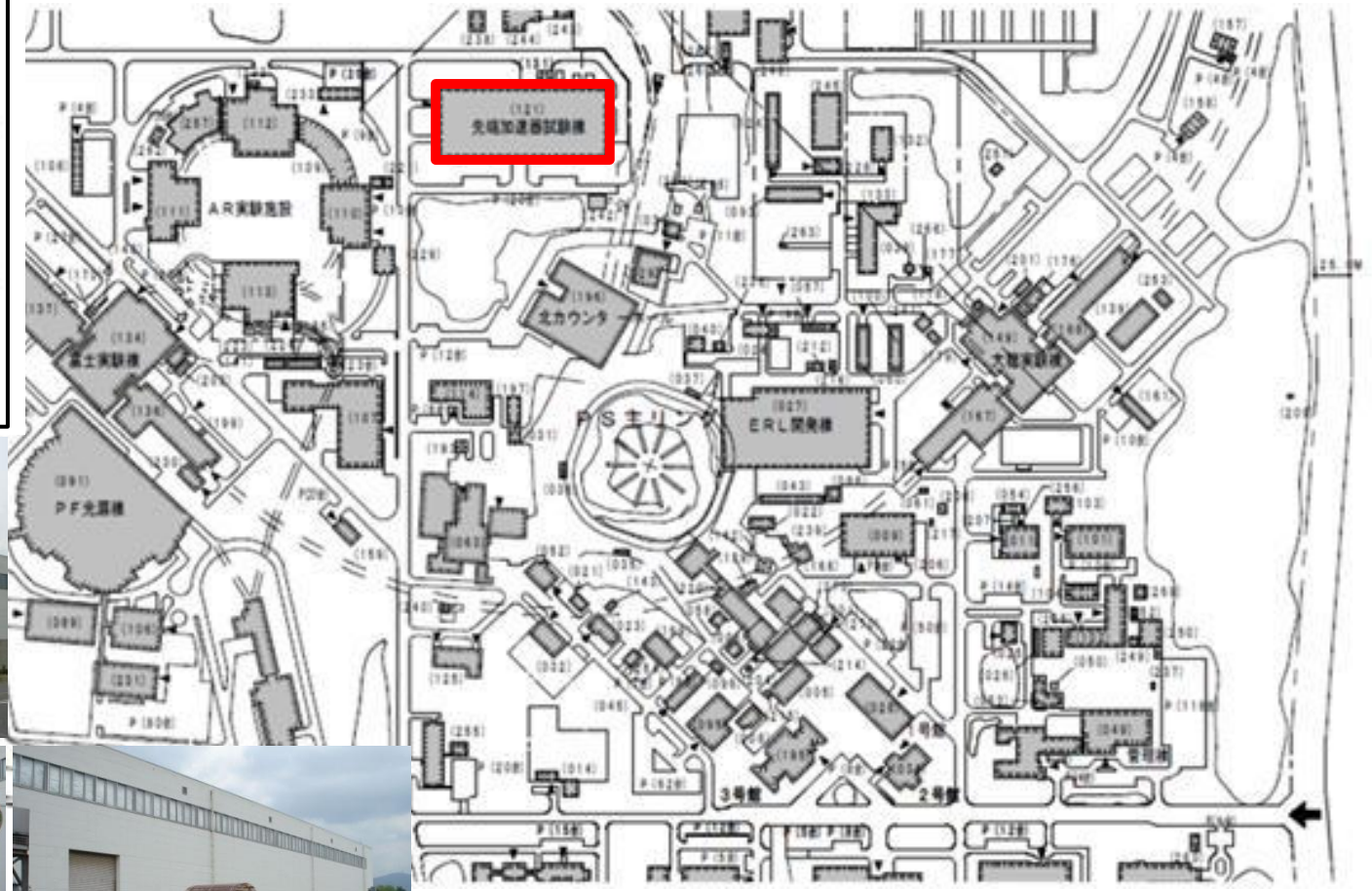
- Mass production layout study using KEK existing assembly hall







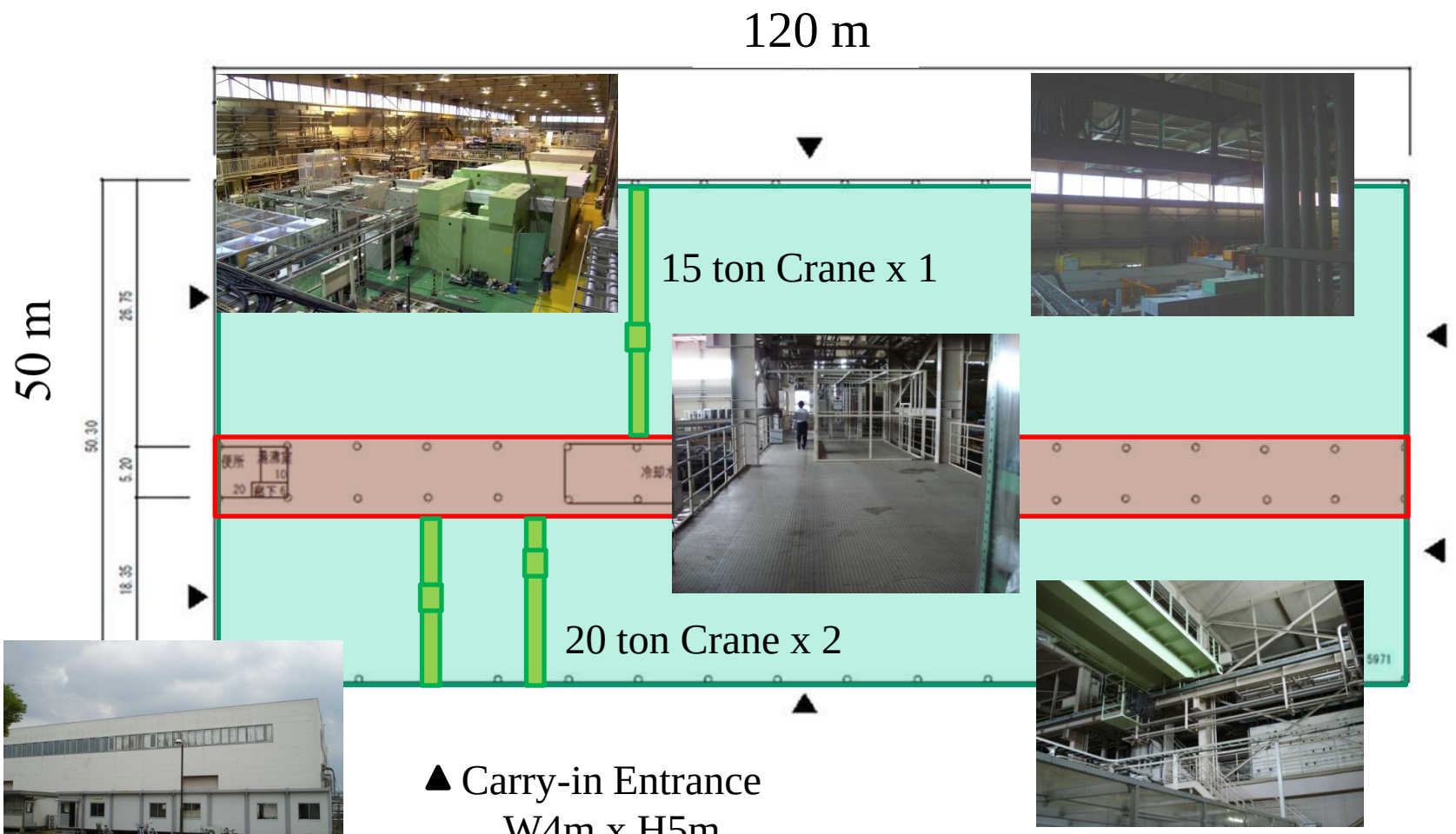




© Hitachi,Ltd.2011 All rights reserved

5-1 An Assembly Hall in KEK site

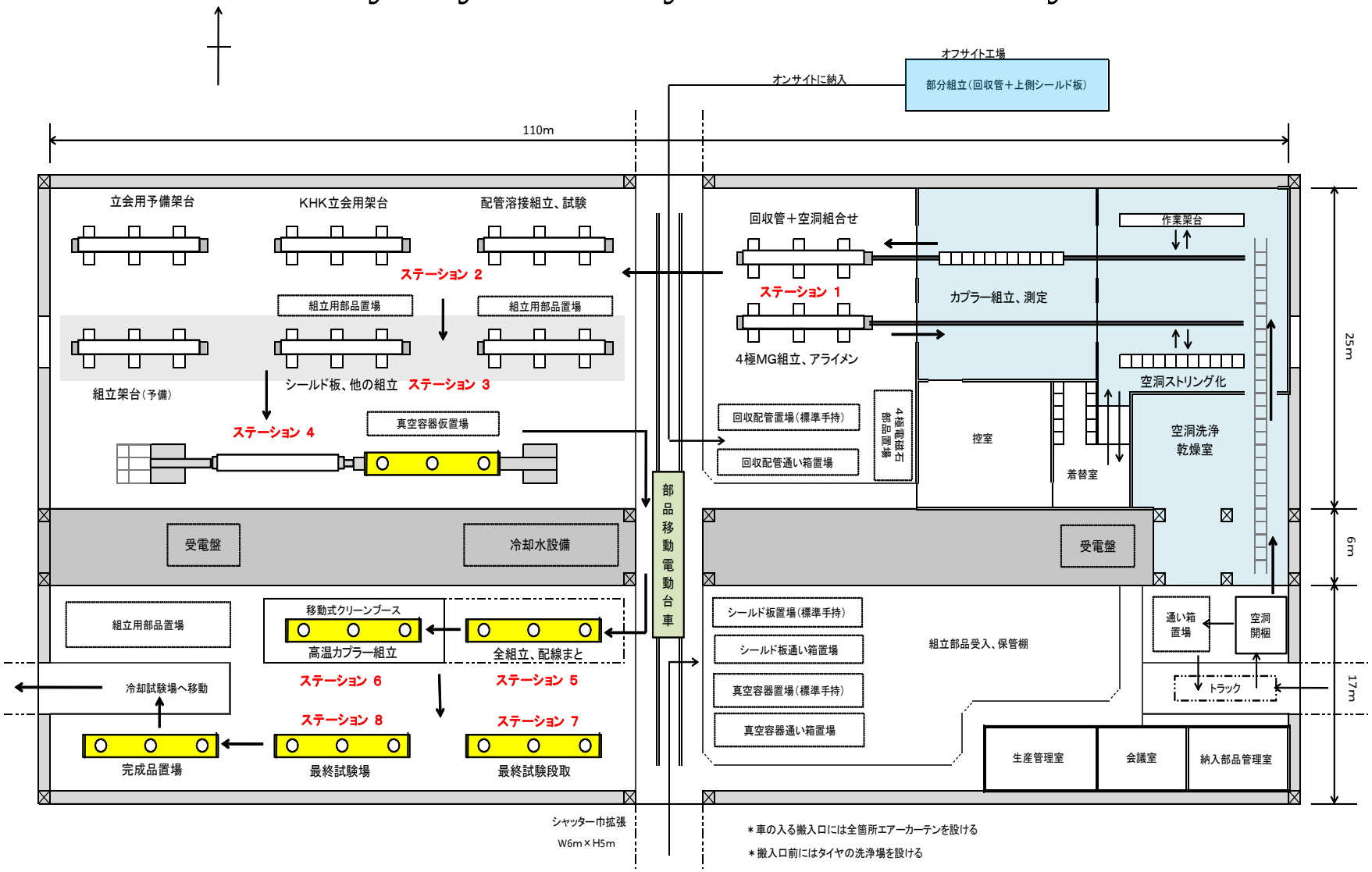
Size of an Assembly Hall Building : 120 m x 50 m
Infrastructure : Crane, Electricity, Water



© Hitachi,Ltd.2011 All rights reserved

An Assembly Hall in KEK site

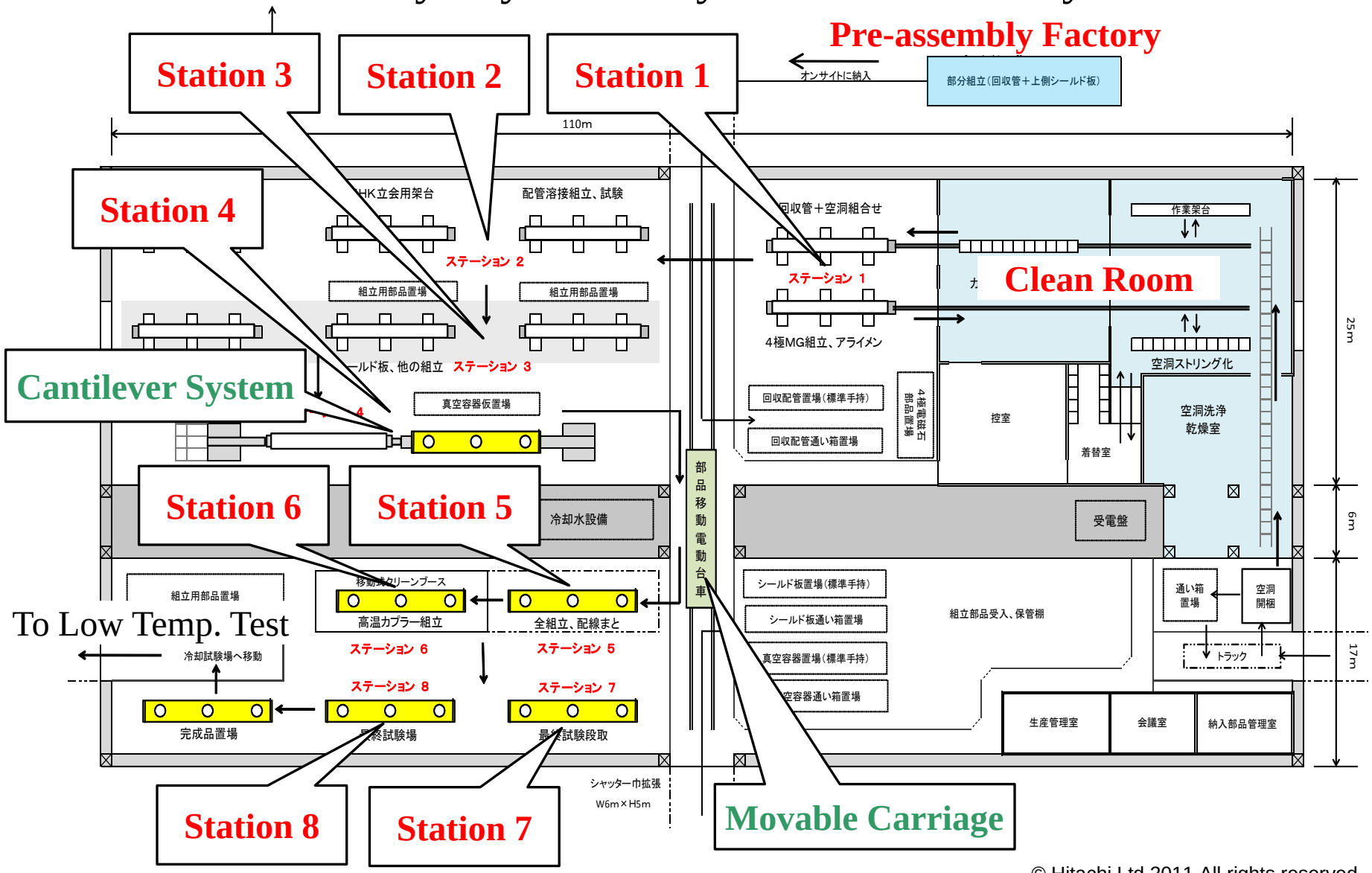
Factory Layout of Cryomodule Assembly



© Hitachi,Ltd.2011 All rights reserved

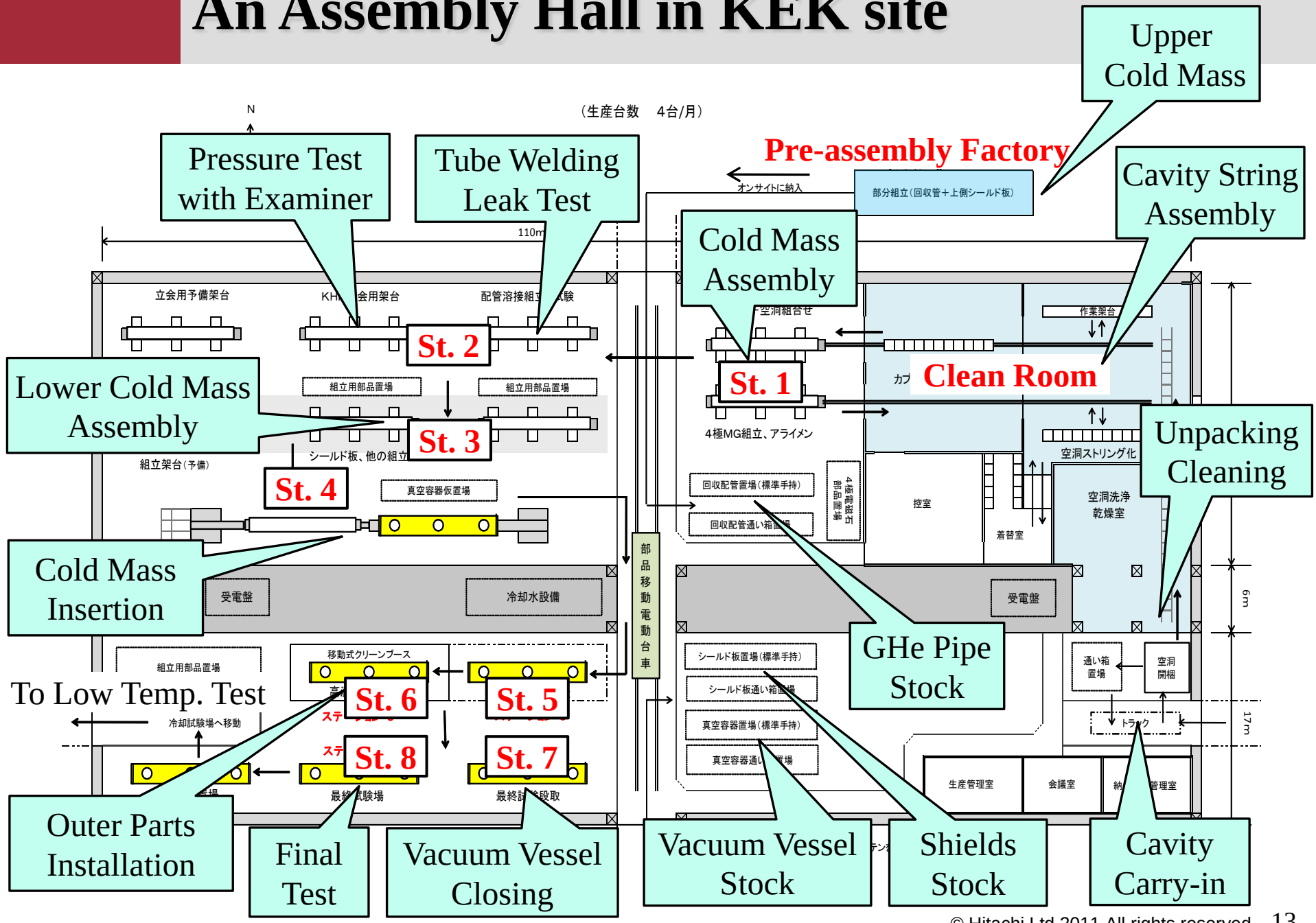
An Assembly Hall in KEK site

Factory Layout of Cryomodule Assembly



© Hitachi,Ltd.2011 All rights reserved

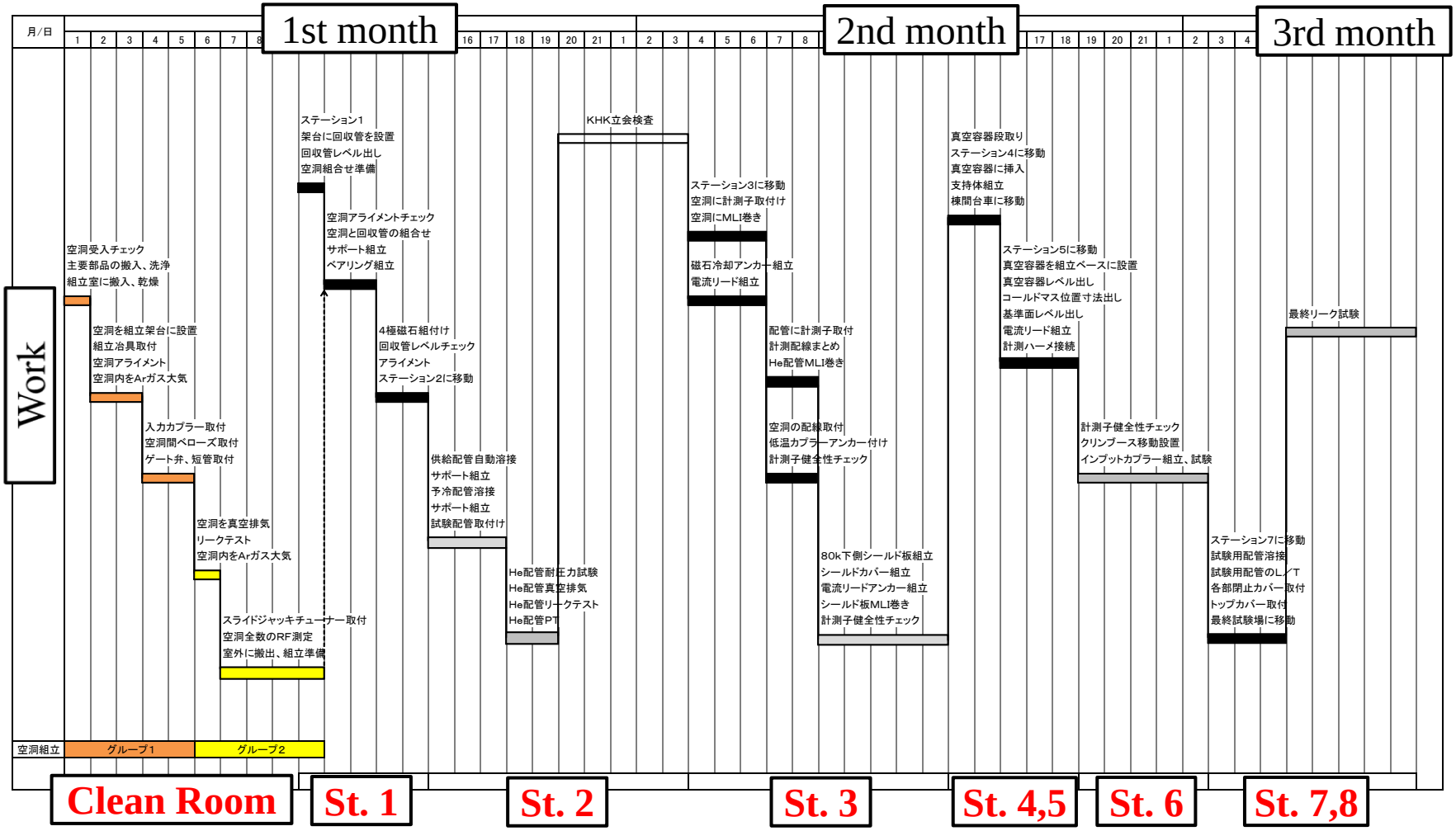
An Assembly Hall in KEK site



© Hitachi,Ltd.2011 All rights reserved

An Assembly Hall in KEK site

Takt time 5days/1module

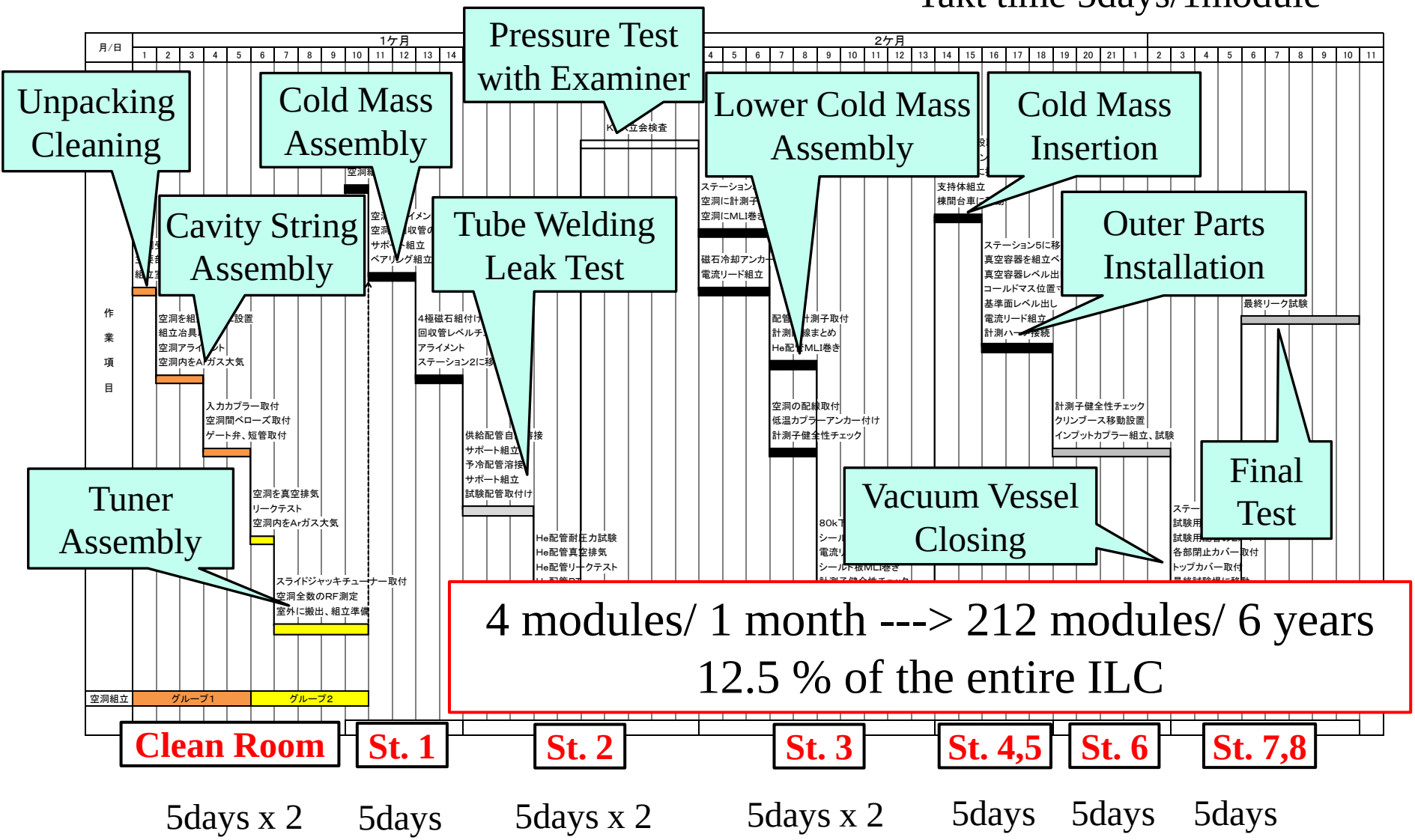


Production Schedule of Cryomodule Assembly

© Hitachi,Ltd.2011 All rights reserved

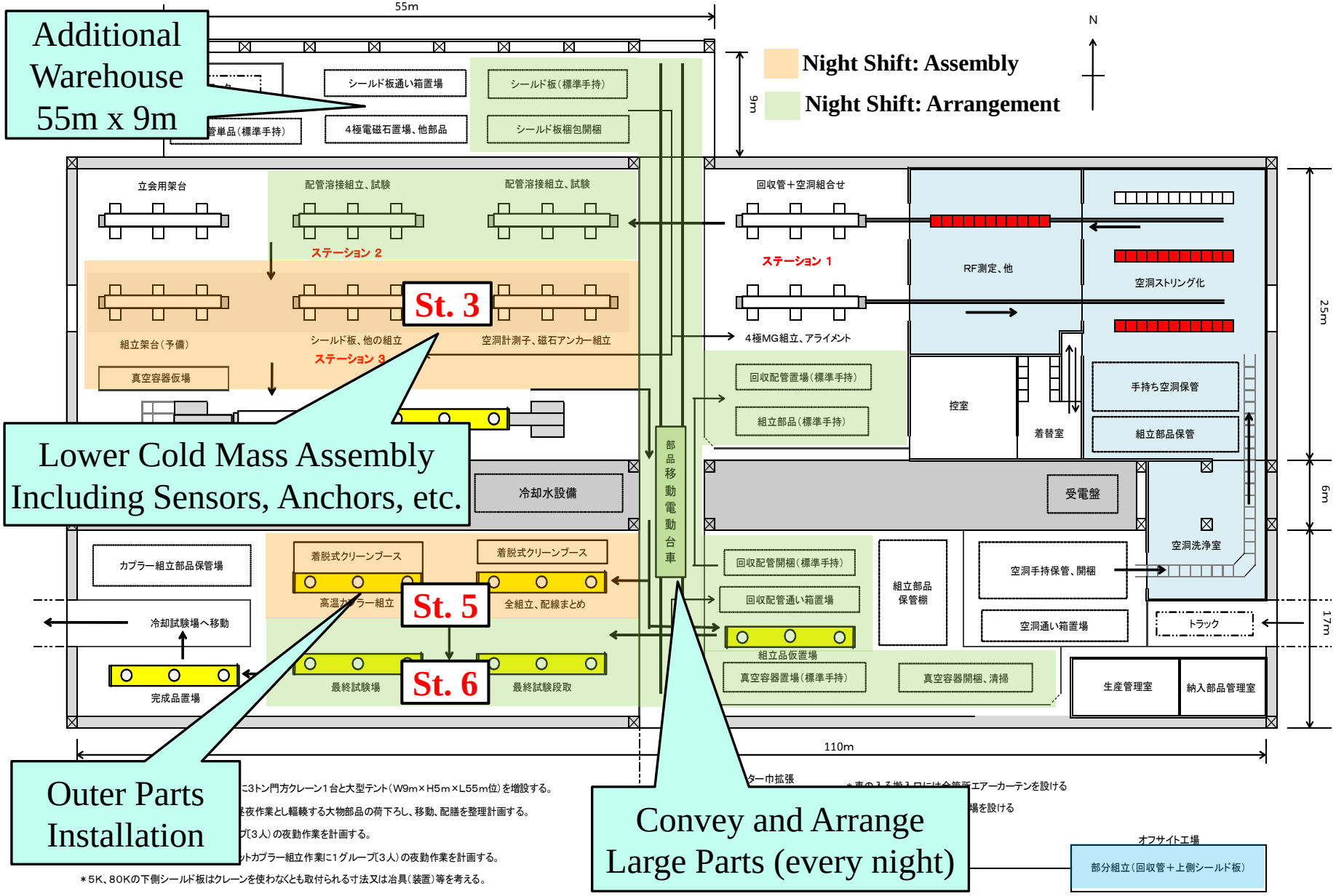
An Assembly Hall in KEK site

Takt time 5days/1module



© Hitachi,Ltd.2011 All rights reserved

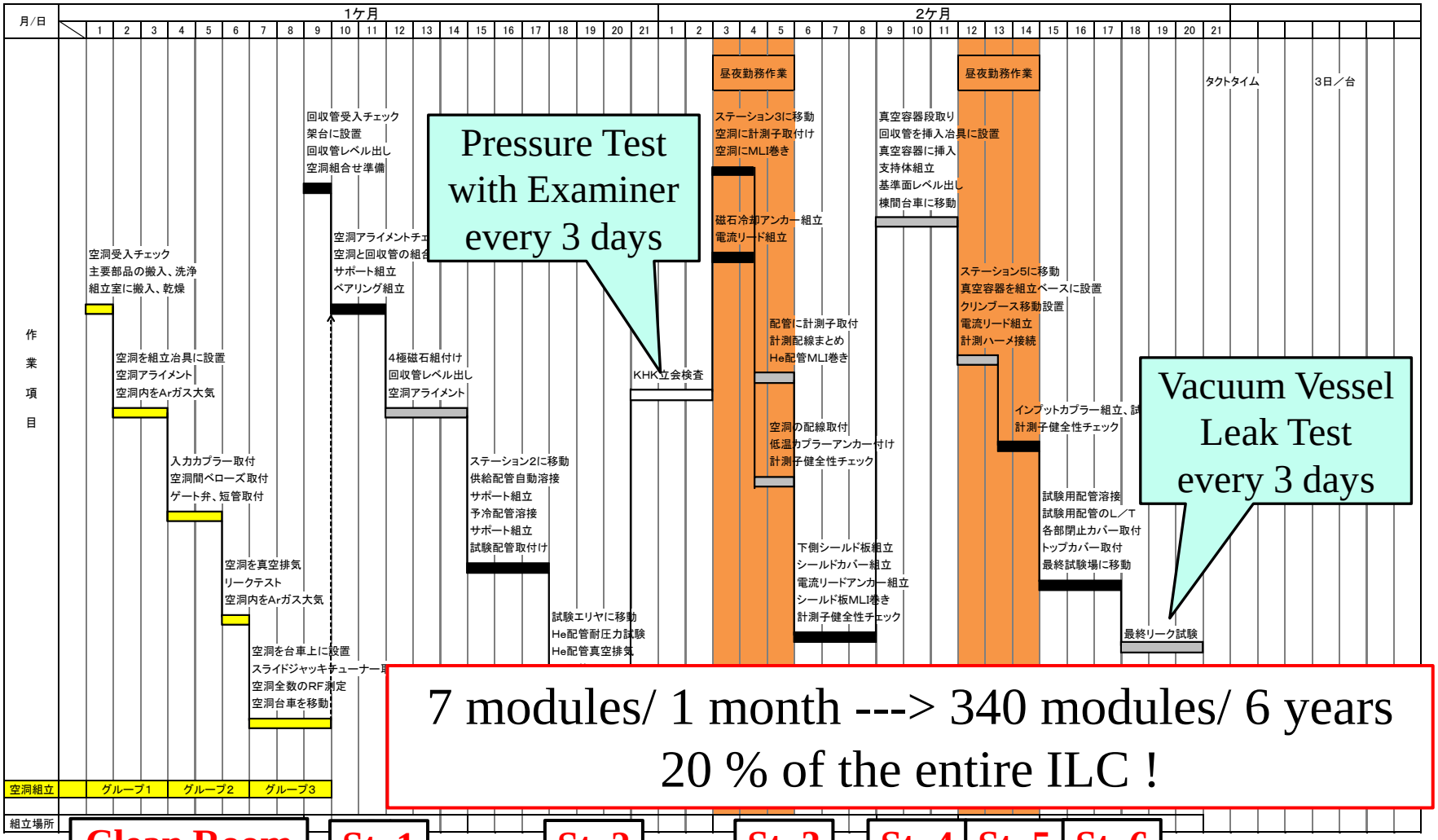
5-2 Night and Day Shifts at an Assembly Hall



© Hitachi,Ltd.2011 All rights reserved

Night and Day Shifts at an Assembly Hall

Takt time 3days/1module



Pressure Test with Examiner every 3 days

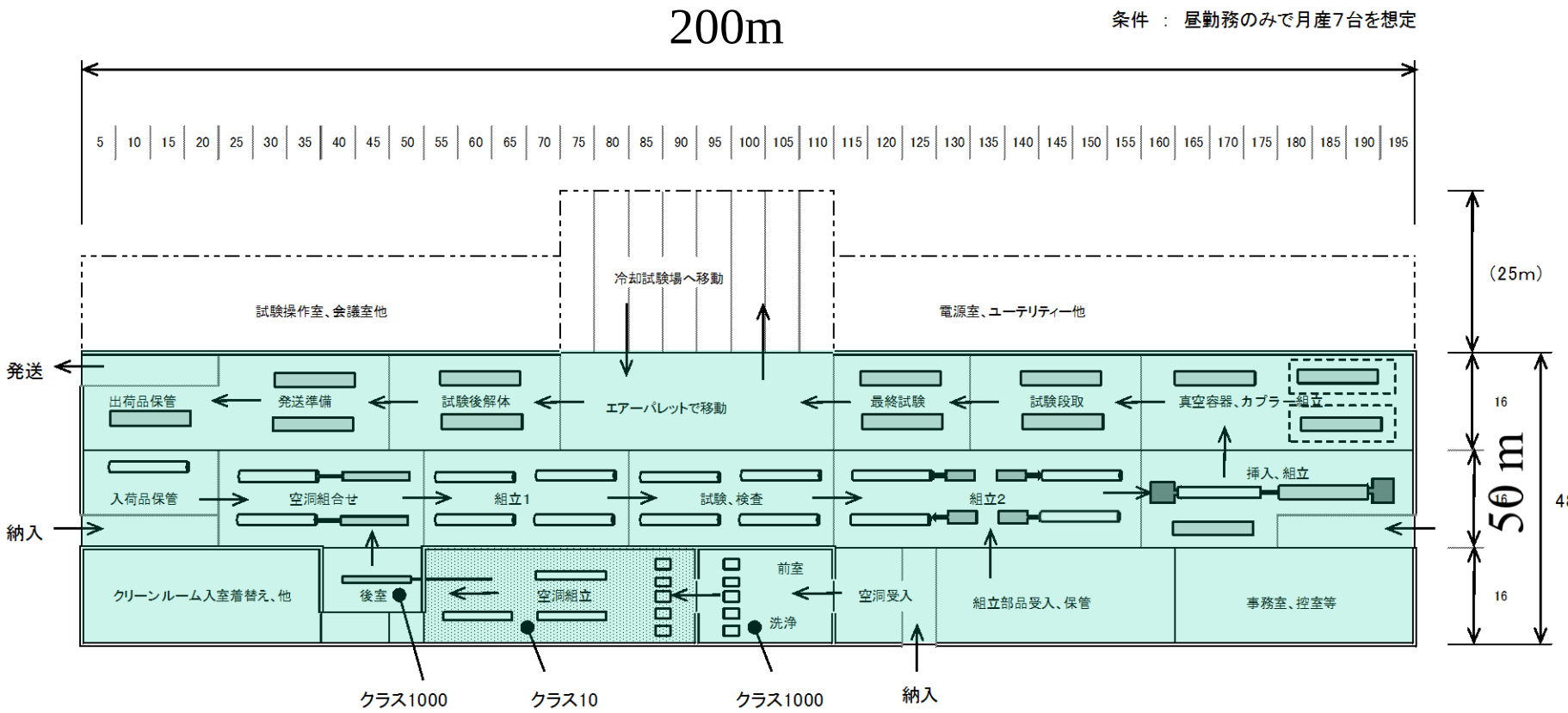
Vacuum Vessel Leak Test every 3 days

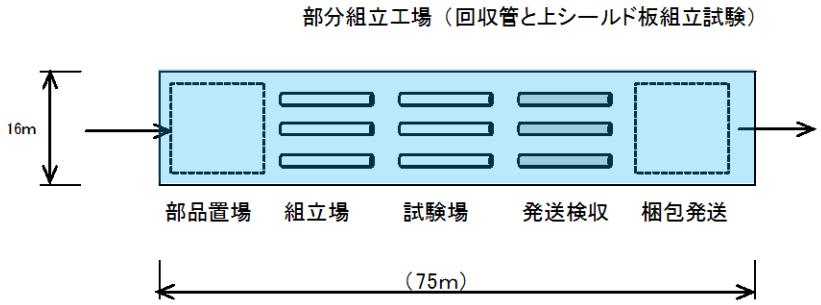
7 modules/ 1 month ---> 340 modules/ 6 years

20 % of the entire ILC !

© Hitachi,Ltd.2011 All rights reserved

5-3 New Assembly Building

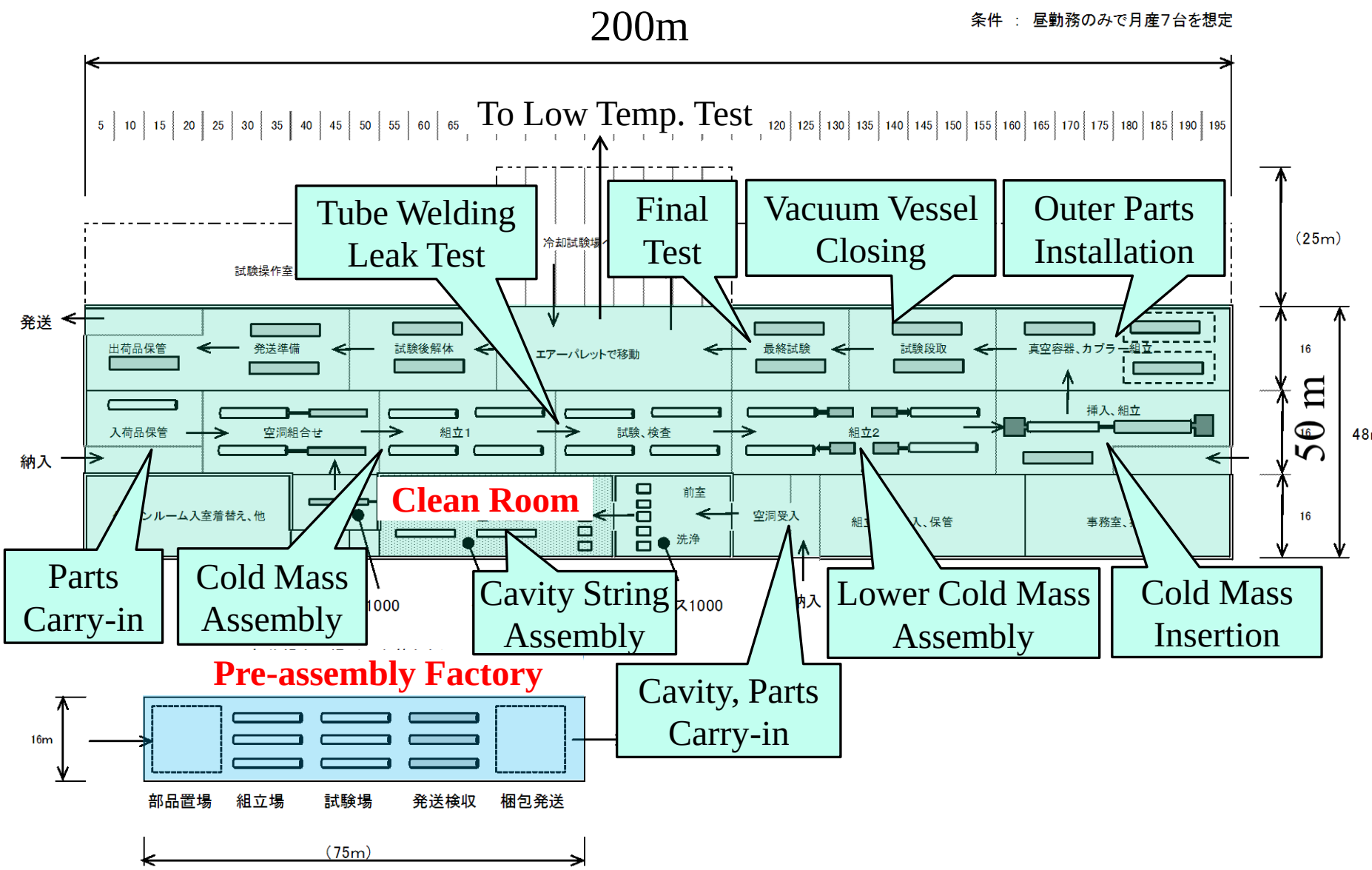




Optimized Placement
for Cryomodule Mass Production

© Hitachi,Ltd.2011 All rights reserved

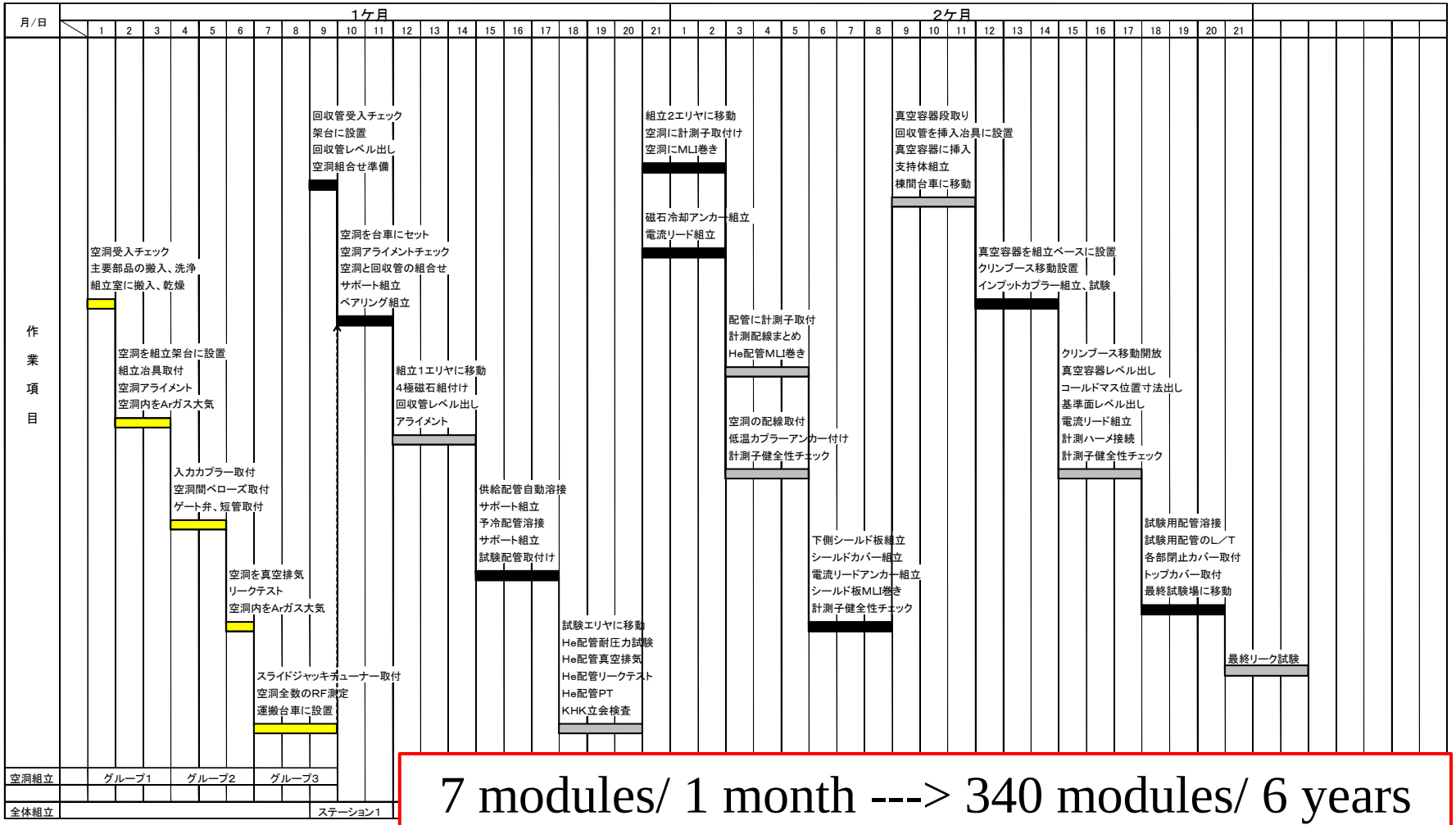
5-3 New Assembly Building



© Hitachi,Ltd.2011 All rights reserved

New Assembly Building

Takt time 3days/1module



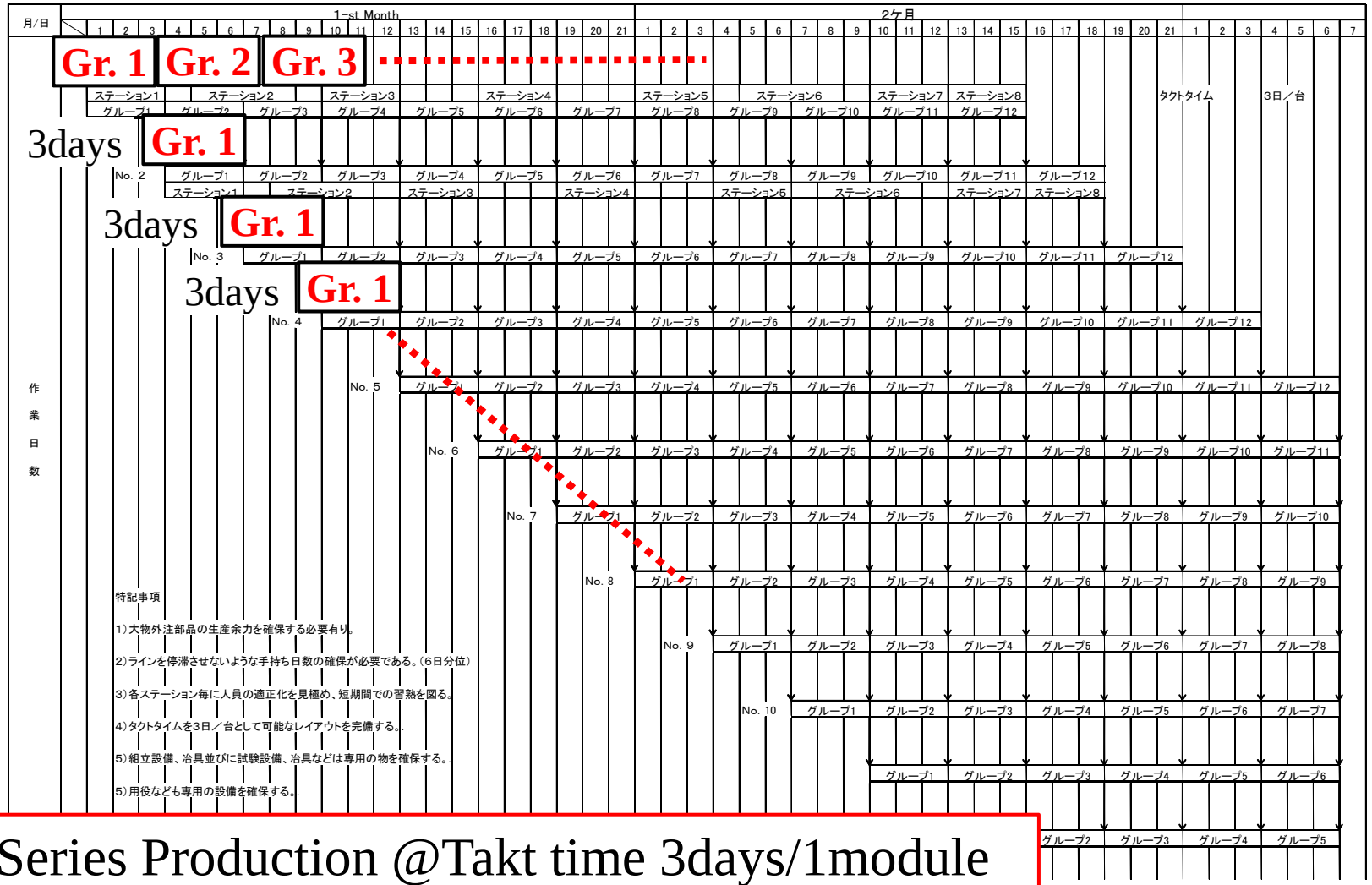
7 modules/ 1 month ---> 340 modules/ 6 years

20 % is possible only with day shifts

© Hitachi,Ltd.2011 All rights reserved

New Assembly Building

Takt time 3days/1module



Series Production @Takt time 3days/1module

© Hitachi,Ltd.2011 All rights reserved

Cost study of Cryomodules mass production

unit:%

	Case	A Use of an Existing Assembly Hall	B Case A with Night and Day Shifts	C New Building	D Case C built at Company
	Quantities of cryomodule	【212】	【340】		
1	All parts production cost (excluding cavities)	62 %	96 %	96 %	96 %
		@ 1.00	@ 0.96	@ 0.96	@ 0.96
2	Labor cost	29 %	48 %	36 %	36 %
		@ 1.00	@ 1.04	@ 0.77	@ 0.77
3	Buildings cost	9 %	11 %	22 %	22 %
3-1	Pre-assembly Bldg	(1.9%)	(3.1%)	(3.1%)	(3.1%)
3-2	Cryomodules Assembly	(7.0%)	(7.6%)	(19.1%)	(19.1%)
3-2-1	Equipement (Clean Room etc.)	((6.2%))	((6.2%))	((8.7%))	((8.7%))
3-2-2	Remodeling	((0.8%))	((0.8%))		
3-2-3	Building		((0.5%))	((10.3%))	((10.3%))
		(120m x 50m)	Warehouse	(200m x 50m)	(200m x 50m)
3-3	Extra	–	–	–	(Land, depreciation charges etc.)
	Total	100 %	155 %	154 %	154 % +α
		@ 1.00	@ 0.96	@ 0.96	@ 0.96

>Labor cost : estimated by workhours of direct workers (rate :200$/Hr)

>Industrial Studies for the 12% and 20% production in 2+6 years

© Hitachi,Ltd.2011 All rights reserved

6 Summary/Conclusions

1. Studied cryomodule mass production in 2 cases
2. Got 12.5% production @an assembly hall
3. Got 20% production with night and day shifts @an assembly hall
4. Show 20% production @ new building
5. Cost study in 4 cases
   > @ an assembly hall with night and day shifts & @ new building >> similar
   > Company site cost will depend on the site
   Need more concrete study

© Hitachi,Ltd.2011 All rights reserved

Inspire the Next Accelerator

HITACHI

HITACHI
Inspire the Next

© Hitachi,Ltd.2011 All rights reserved