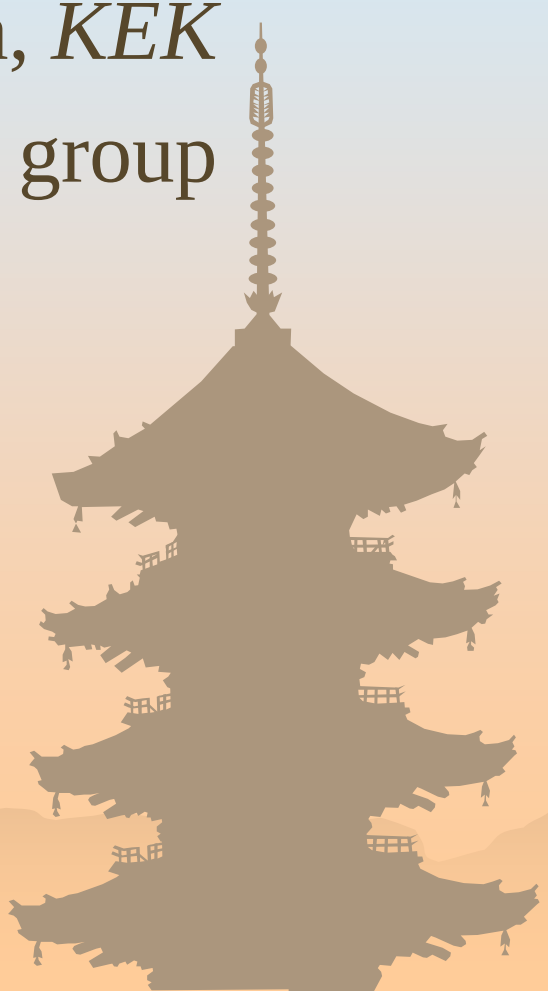
T2K Horns

A.K.Ichikawa, *KEK*

For T2K target & horn group

- Overview
- Support Module
- Maintenance
- Water System
- Summary



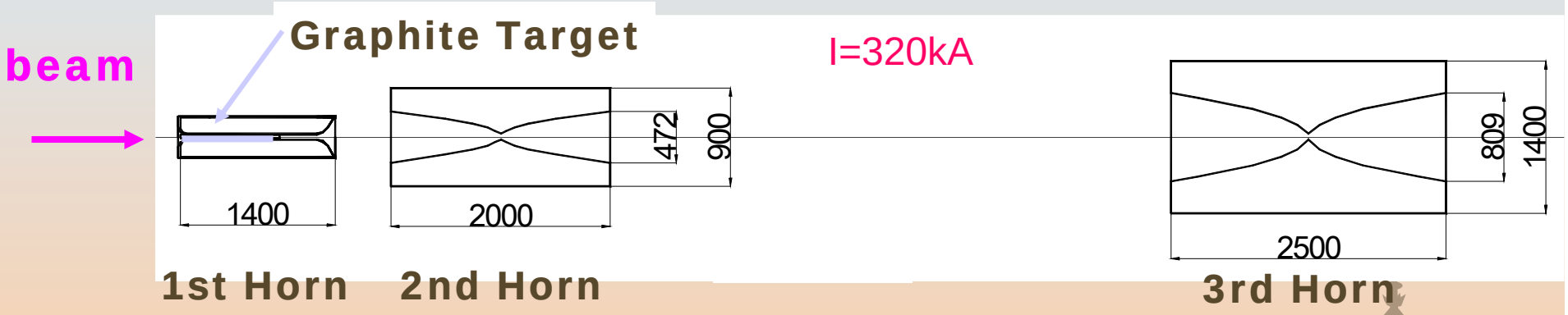
Acknowledgement

Many parts of the T2K horn system owe NuMI@FNAL, CNGS@CERN and TRIUMF.

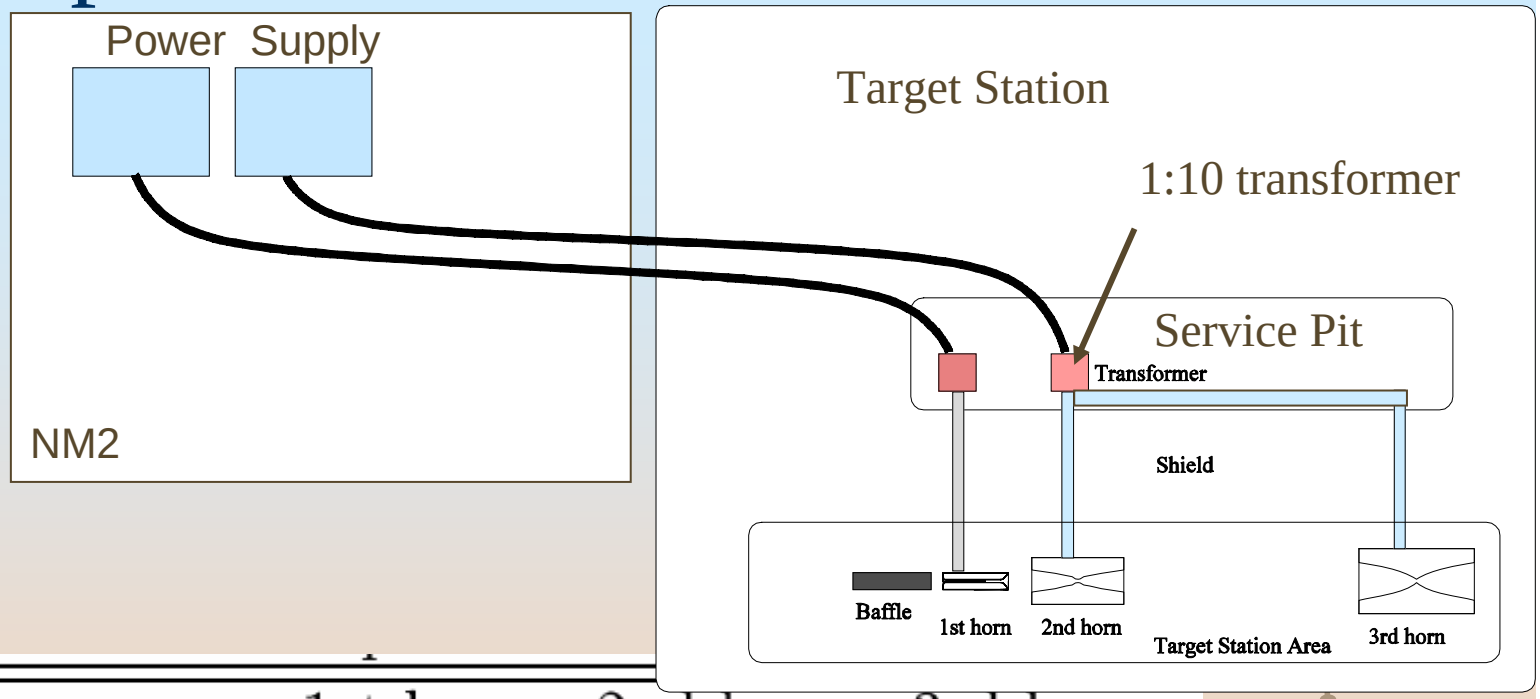
Especially ideas of the support module, remote coupling and water system comes from those for NuMI.

Many thanks!

J-PARC Three stages horn system with 320kA current



Electrical parameters

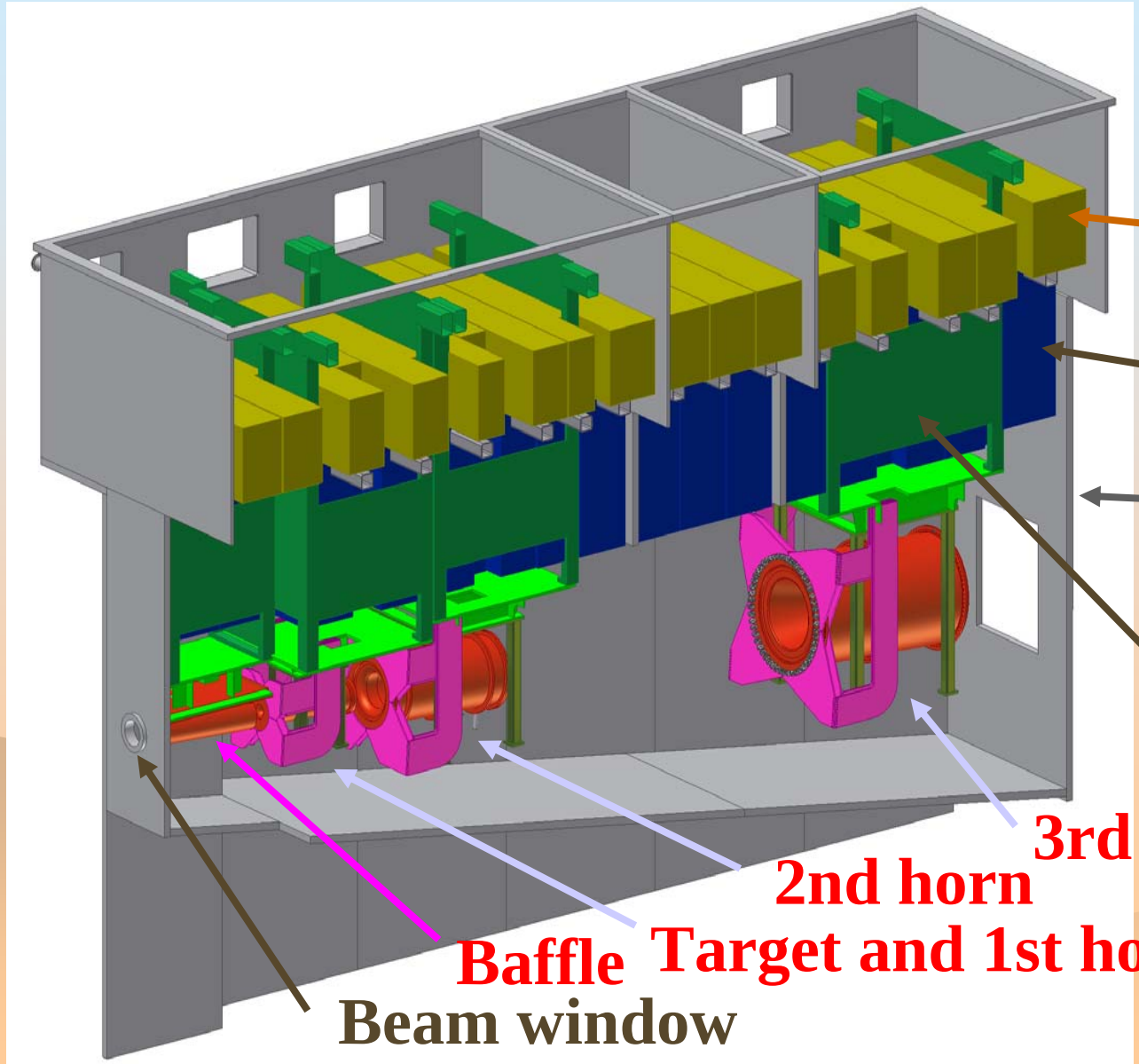


	1st horn	2nd horn	3rd horn
pulse full width (ms)	0.7	2.0	2.0
inductance (μH)	0.47	0.46	0.53
resistance ($\mu\Omega$)	101	35	23
voltage difference(V)	675	231	266

* To suppress Joule heating of the 1st horn, the pulse width is set to be small. Hence, the voltage is relatively high.

Repetition cycle is 2.1second@30GeV operation

Target area in Helium atmosphere



Concrete shields (1m thick)

Iron shields (2.2m thick)

Support structure = Helium vessel

Horn Support modules

3rd horn

2nd horn

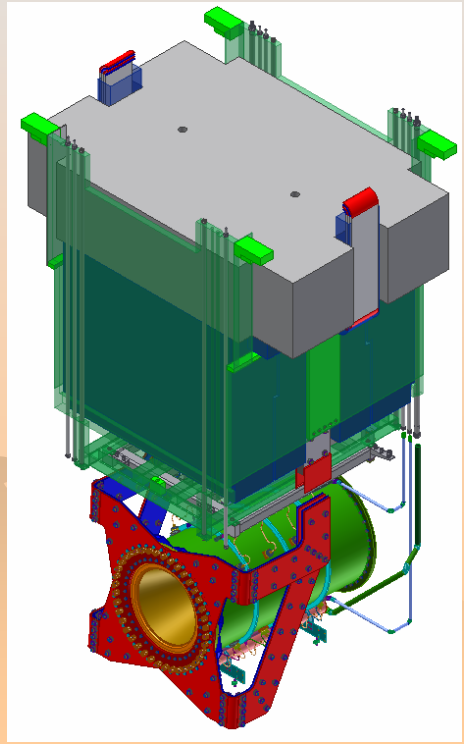
Target and 1st horn

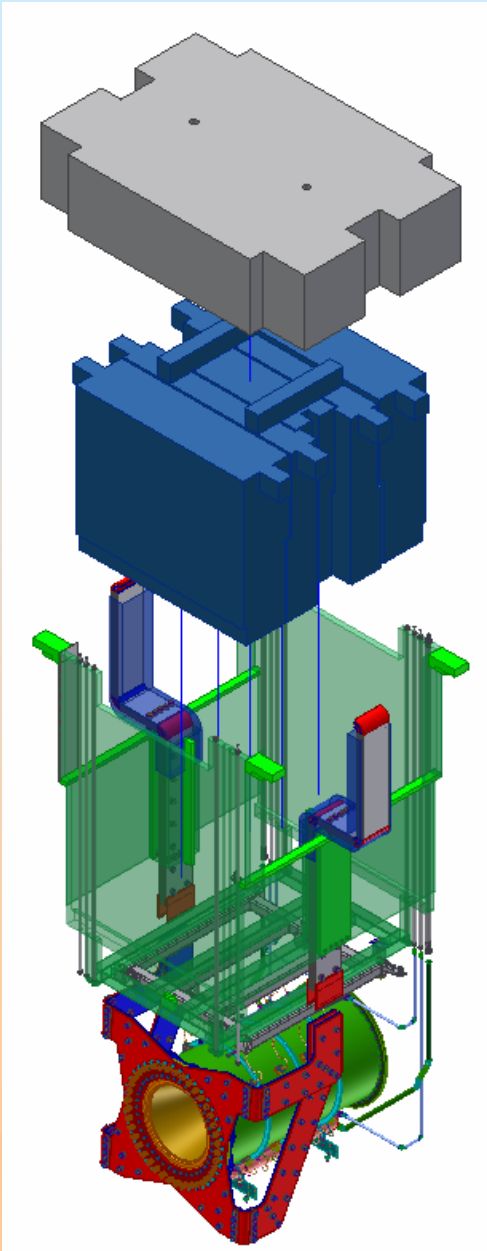
Baffle

Beam window

Support Module

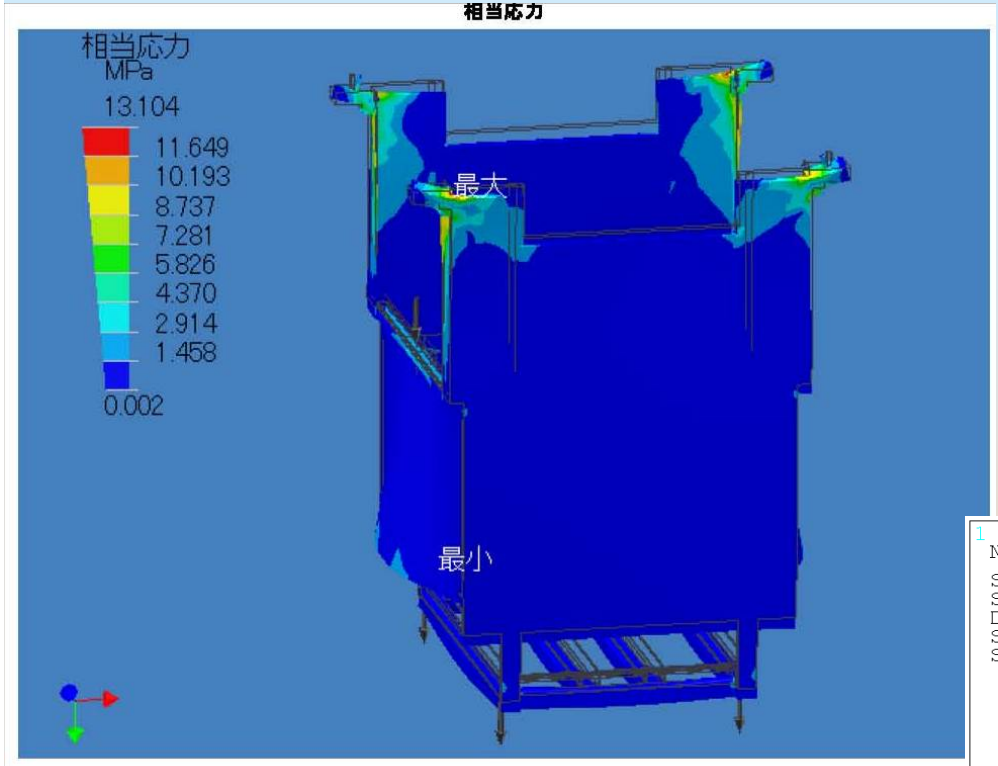
- Horn module and shielding blocks are supported independently at top by the He chamber.





S. Koike

FEM analysis for support module

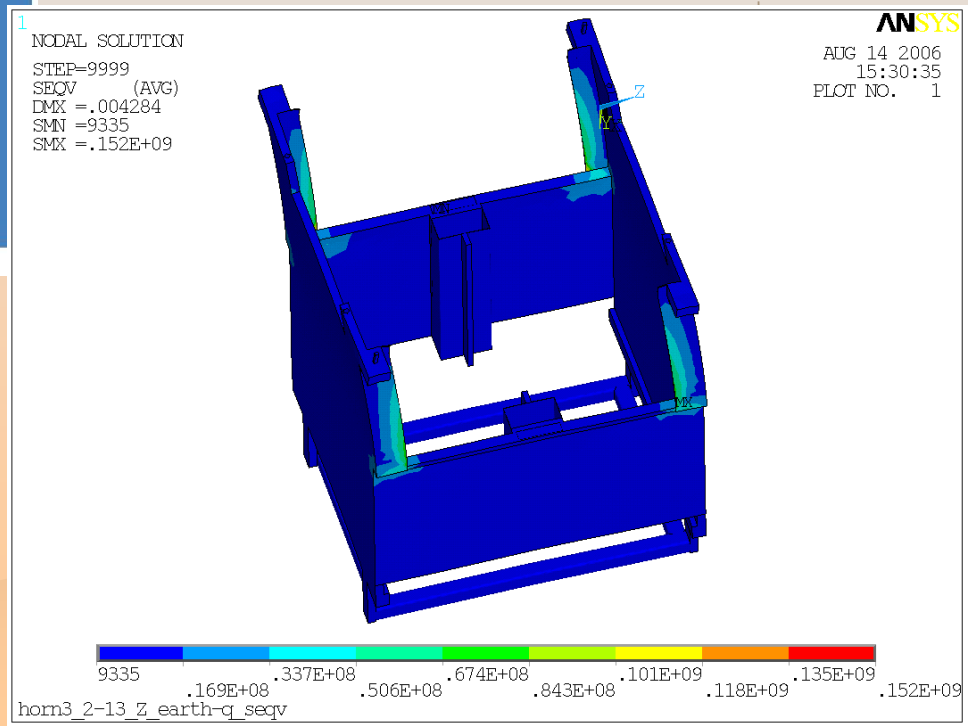


Seismic Analysis

lowest natural freq. ~6.7Hz

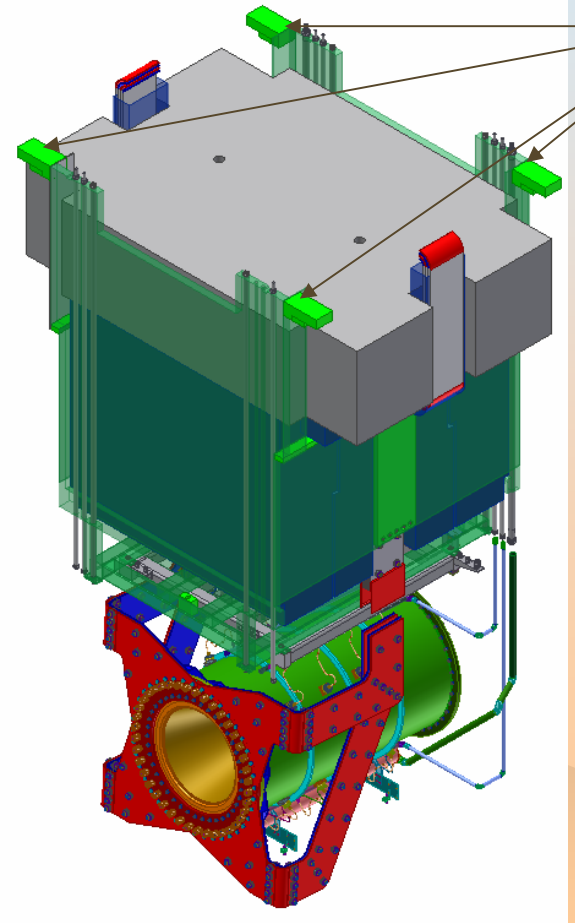
δ=4.3mm, σeq=152MPa

for 0.6G earthquake.



- Distortion by self weight <0.3mm

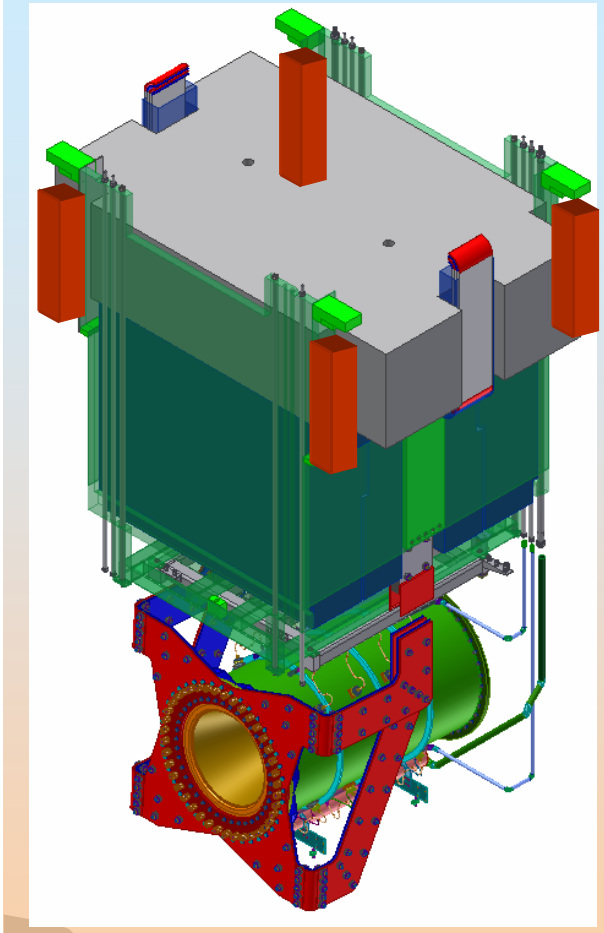
Alignment



Once the horn module is installed, horns will be aligned by alignment stages at four corners based on markers at four corners.

So the makers and the horn has to be aligned in good accuracy beforehand.

Alignment



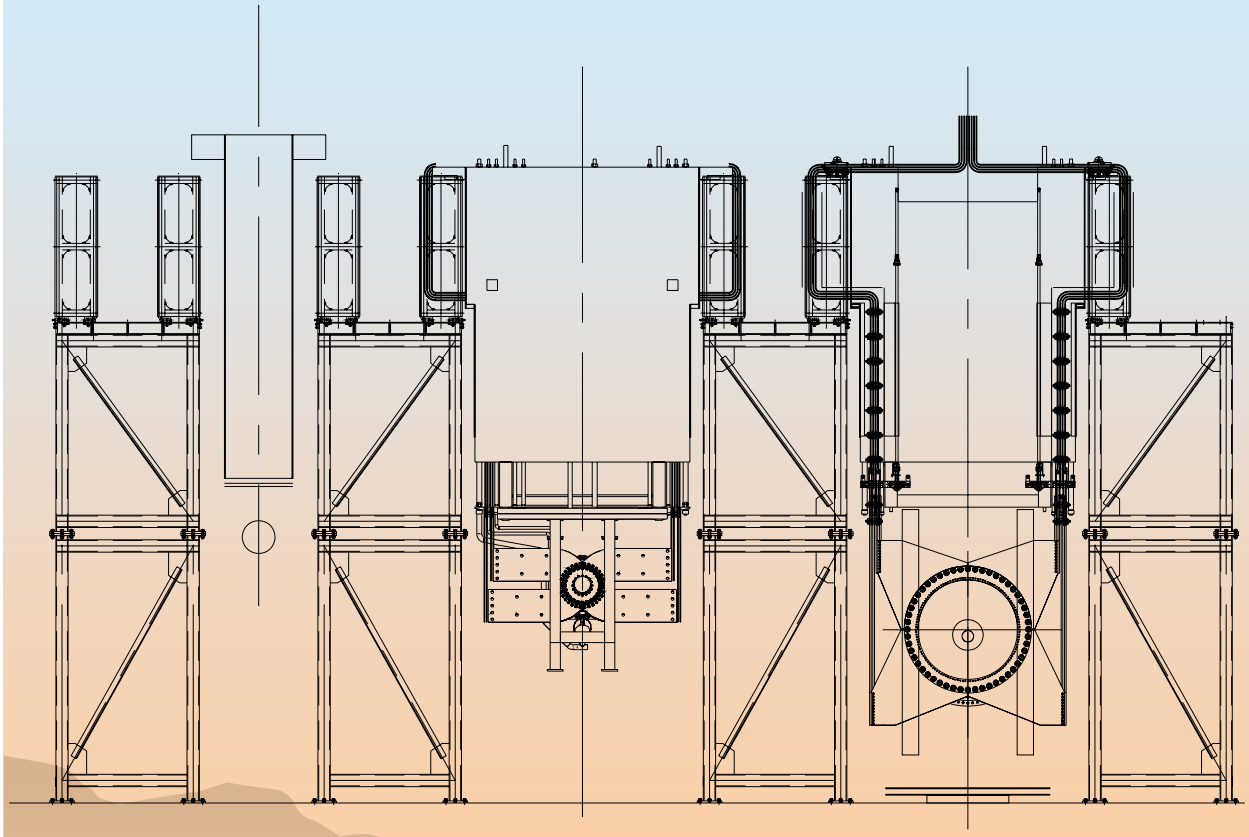
Kinematic mount on leveling block on xy-stage.

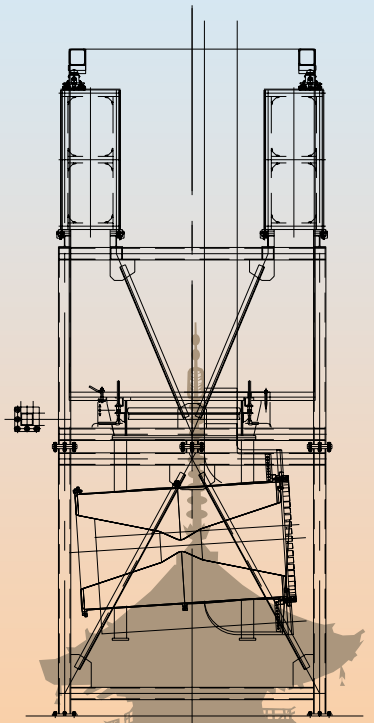
X,Y,Z position can be adjusted with freedoms to absorb manufacturing errors.

When the module installed remotely by crane, it can be positioned automatically while absorbing manufacturing errors.

H. Yamaoka

Adjustment stage “Dock”



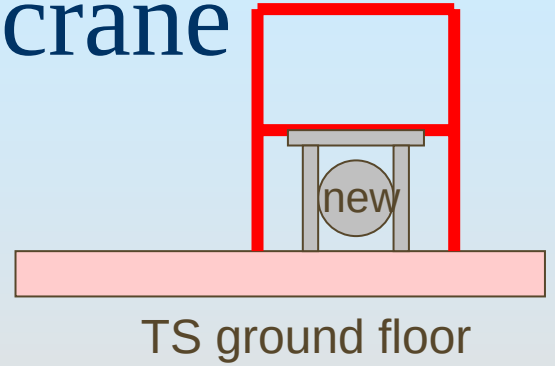


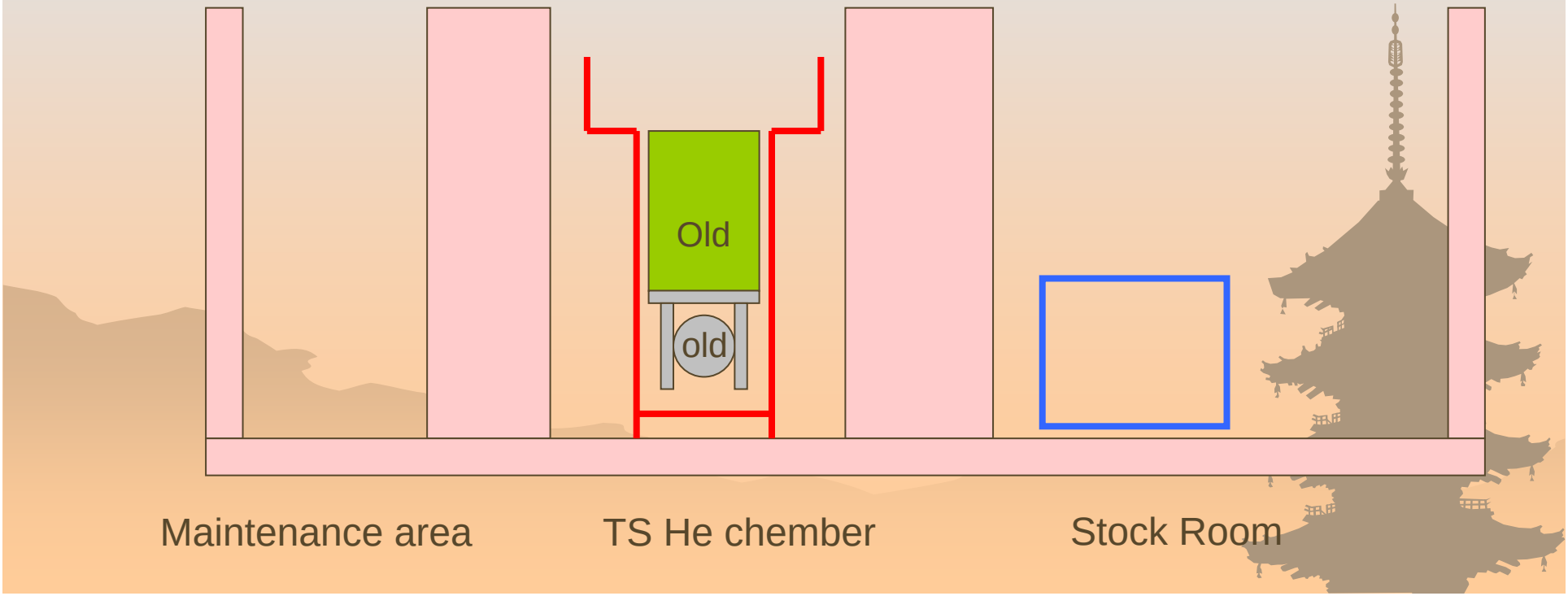
Alignment between the support module and horns.

Excitation test will be also performed here.

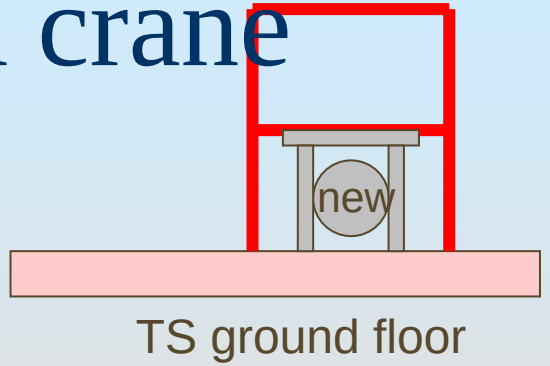
Maintenance Issues

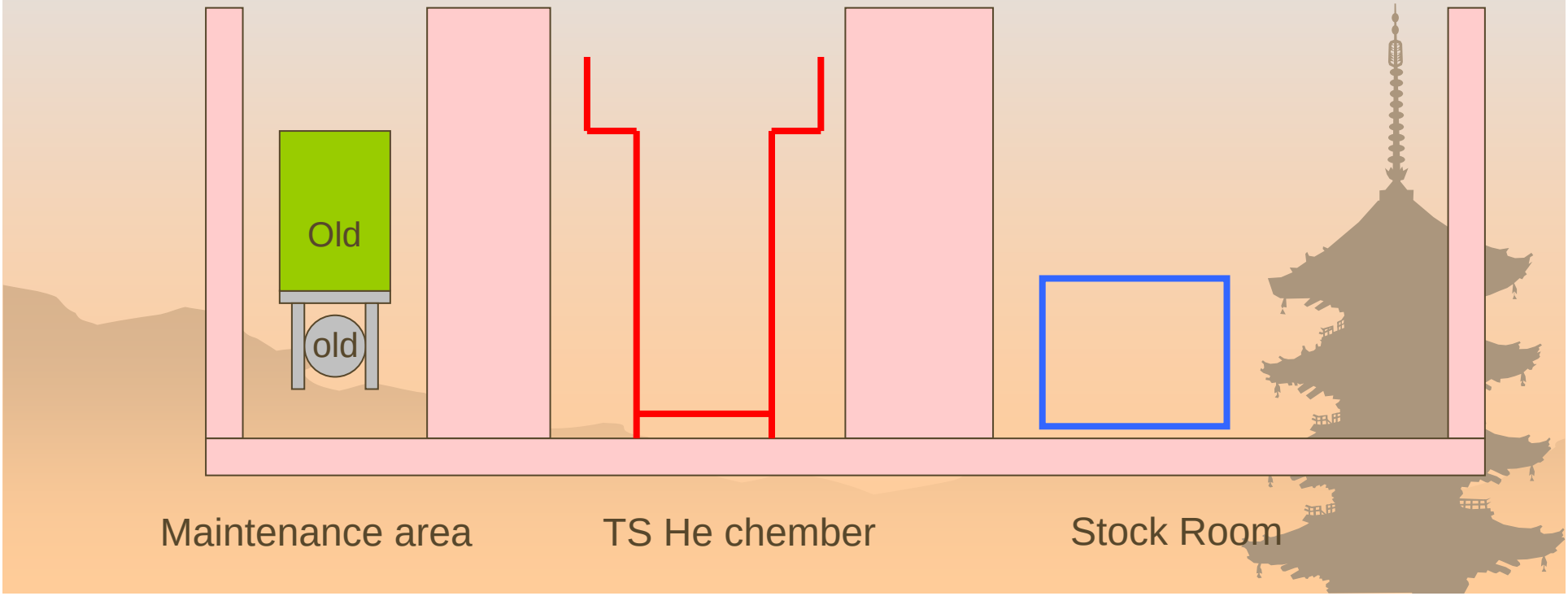
Replacement of a broken horn by Remotely-controlled crane



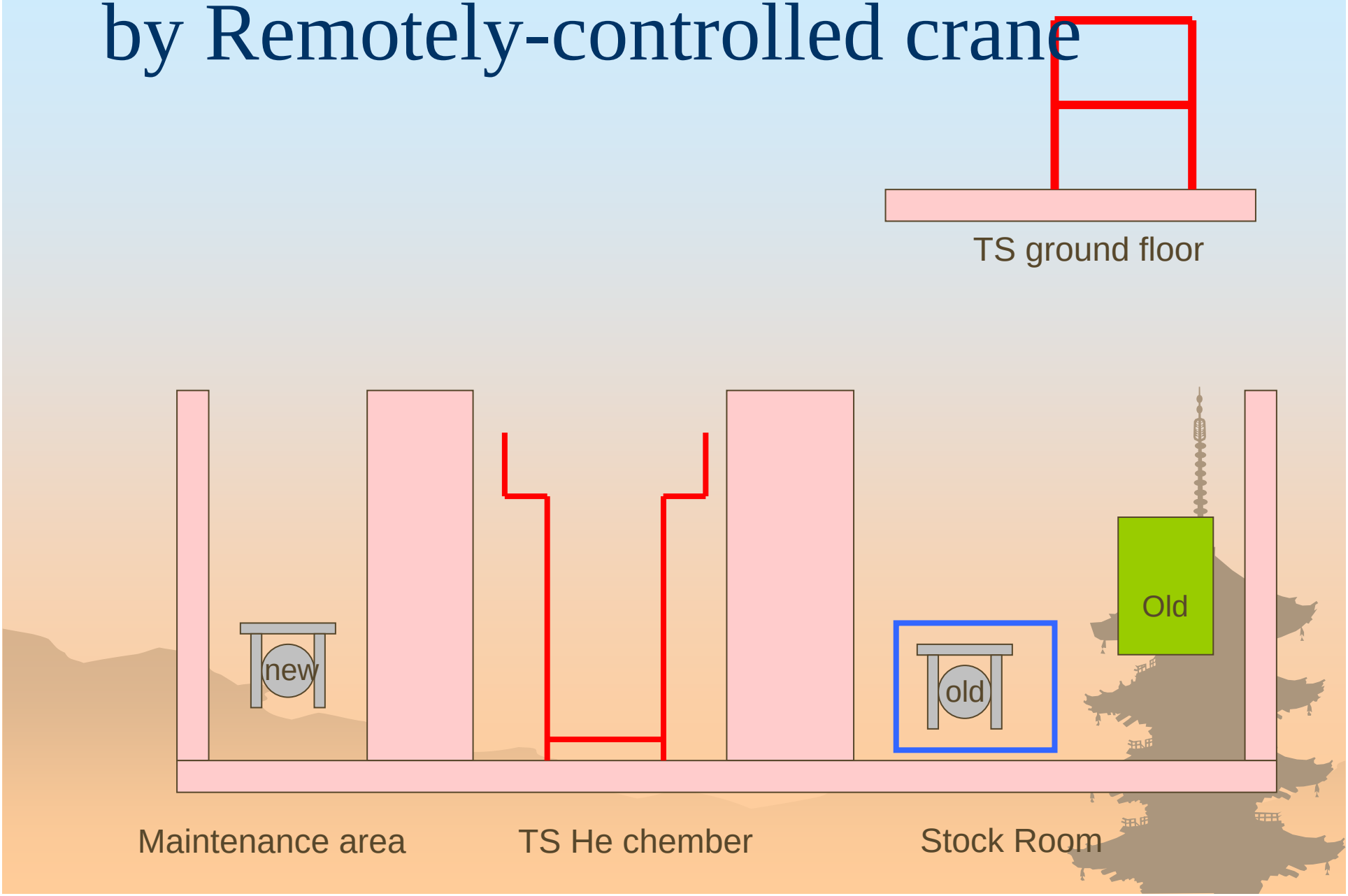


Replacement of a broken horn by Remotely-controlled crane

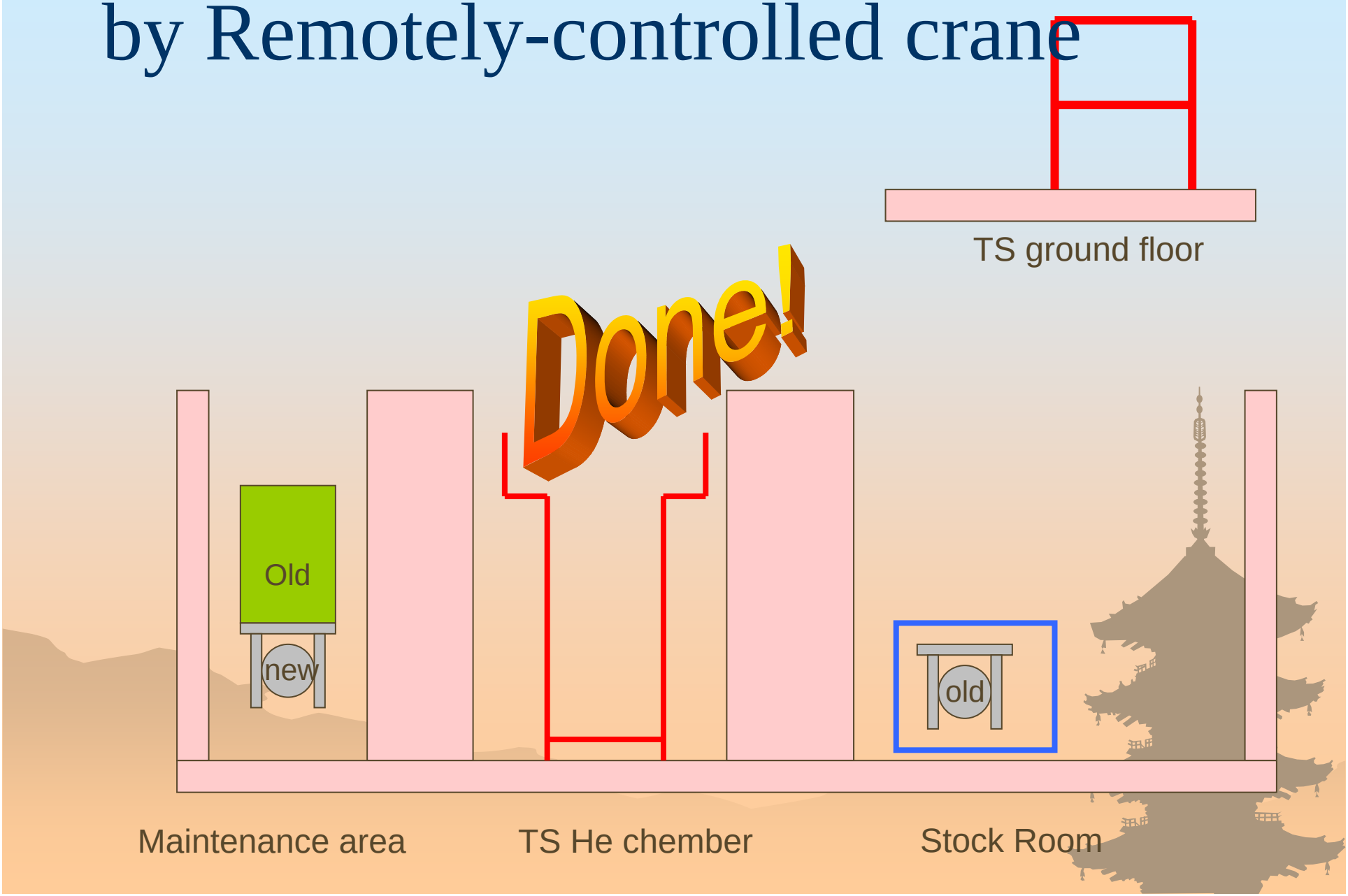




Replacement of a broken horn by Remotely-controlled crane

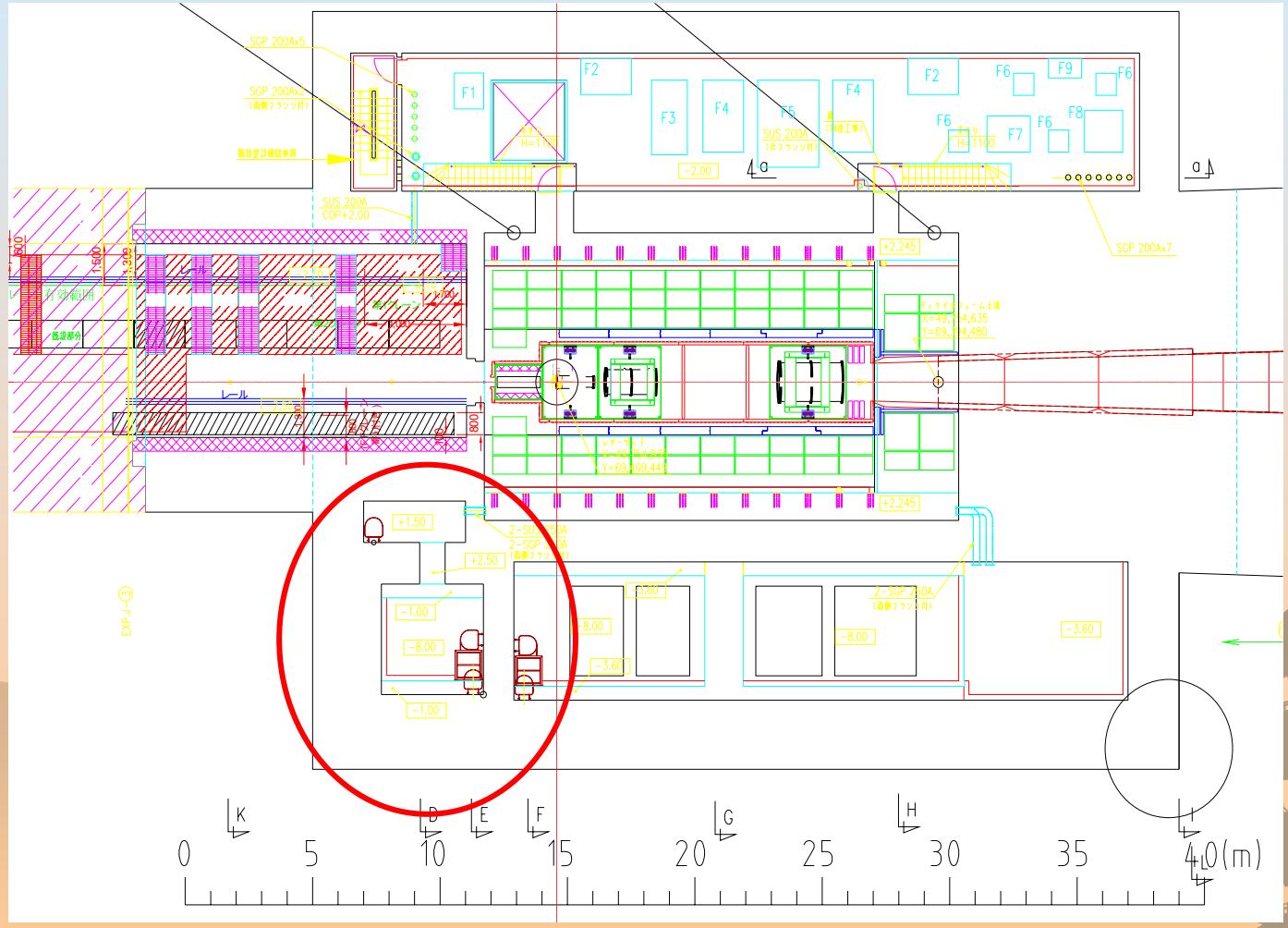


Replacement of a broken horn by Remotely-controlled crane



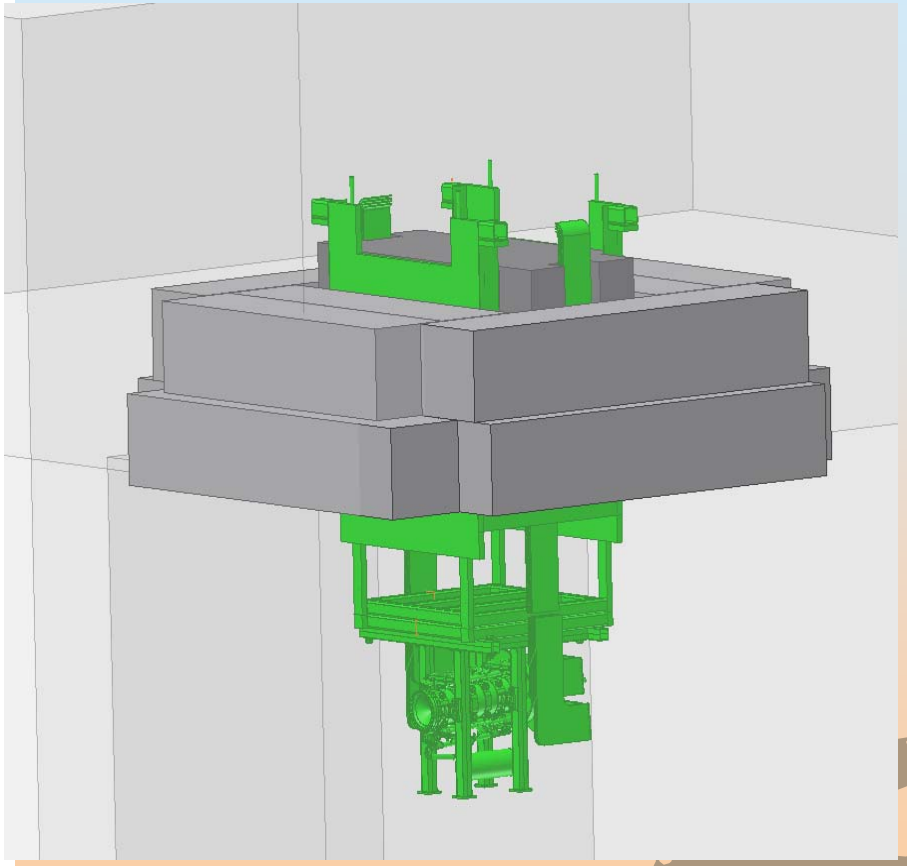
Maintenance Area

Target Station Top View



Remote disconnection/connection from this level

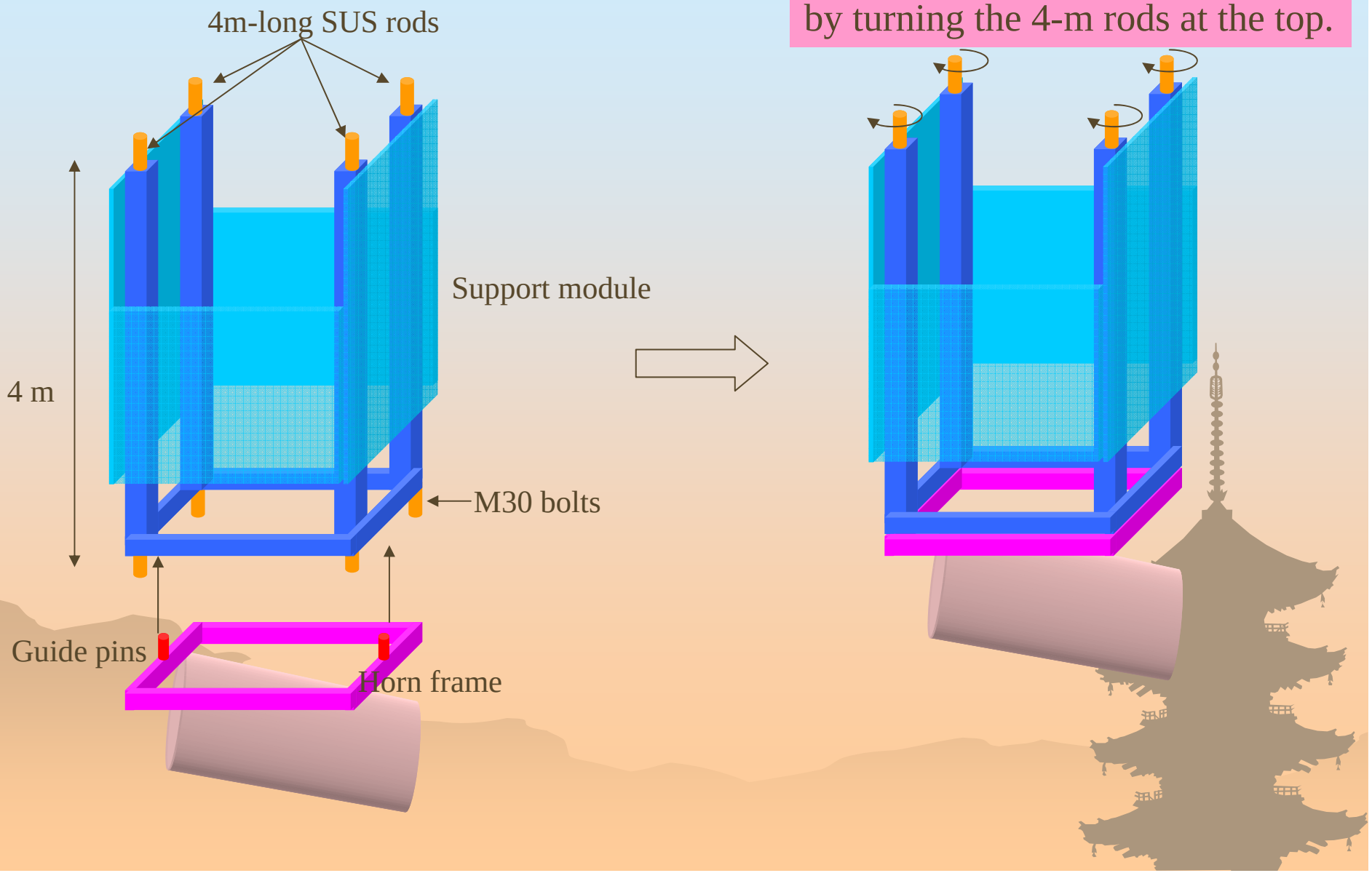
Some work via the Manipulator wall



Remotely-controlled Lift table

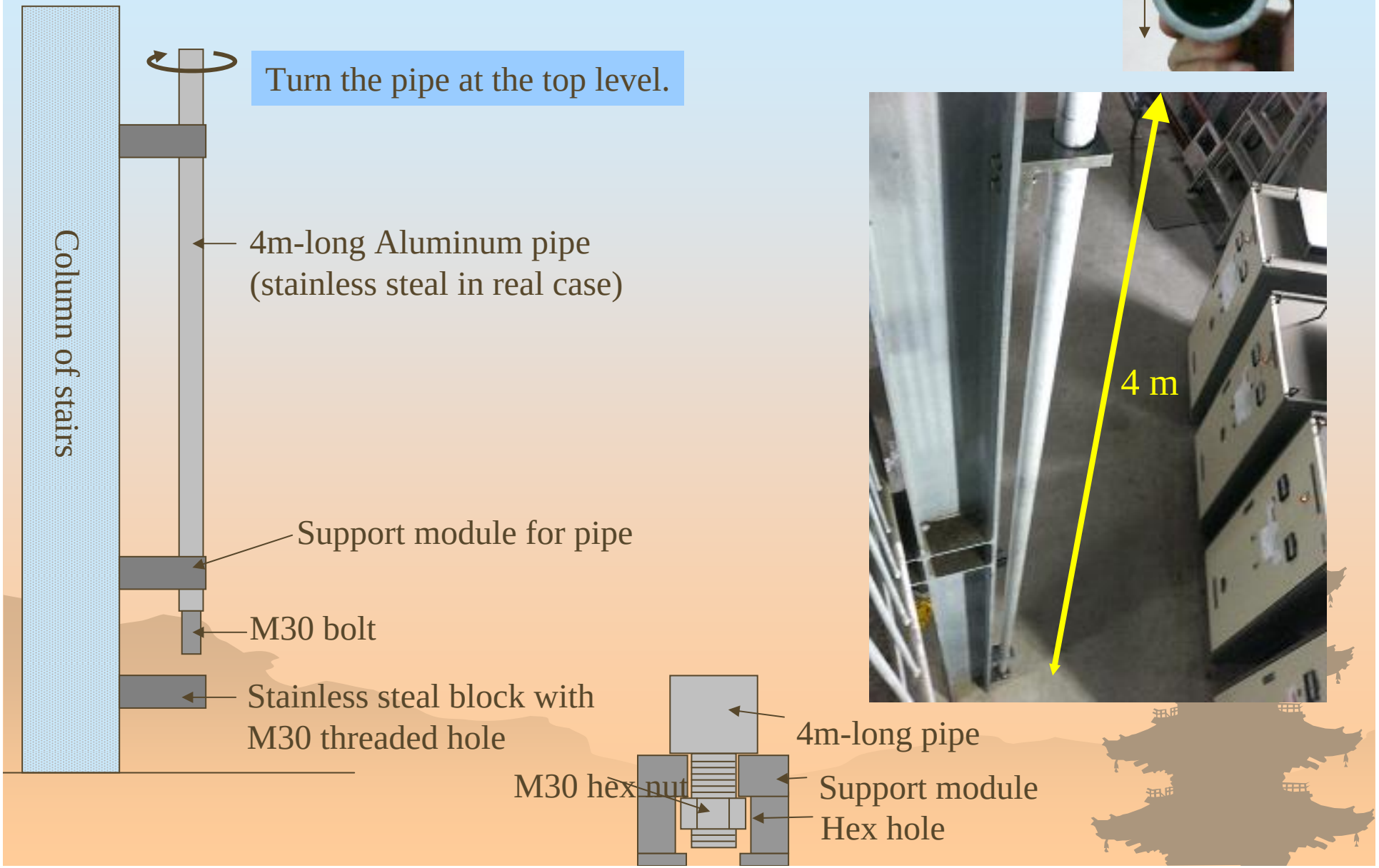
Horn remote connection

Tightening the bolts at the bottom by turning the 4-m rods at the top.



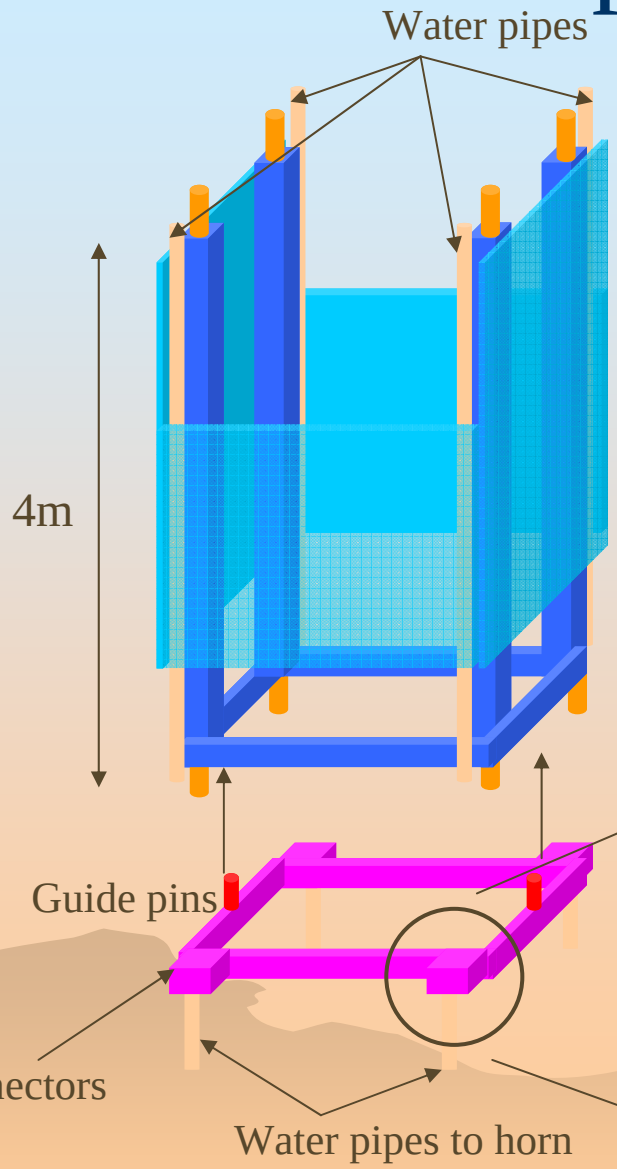
T.Sekiguchi

Test with 4m-long pipe



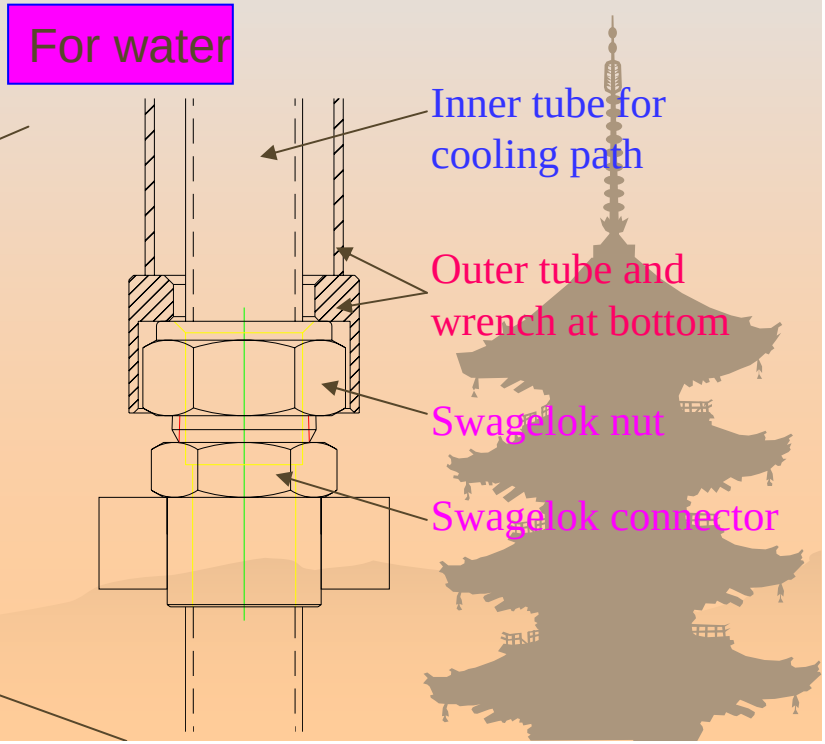
T.Sekiguchi

Remote coupling of water pipes

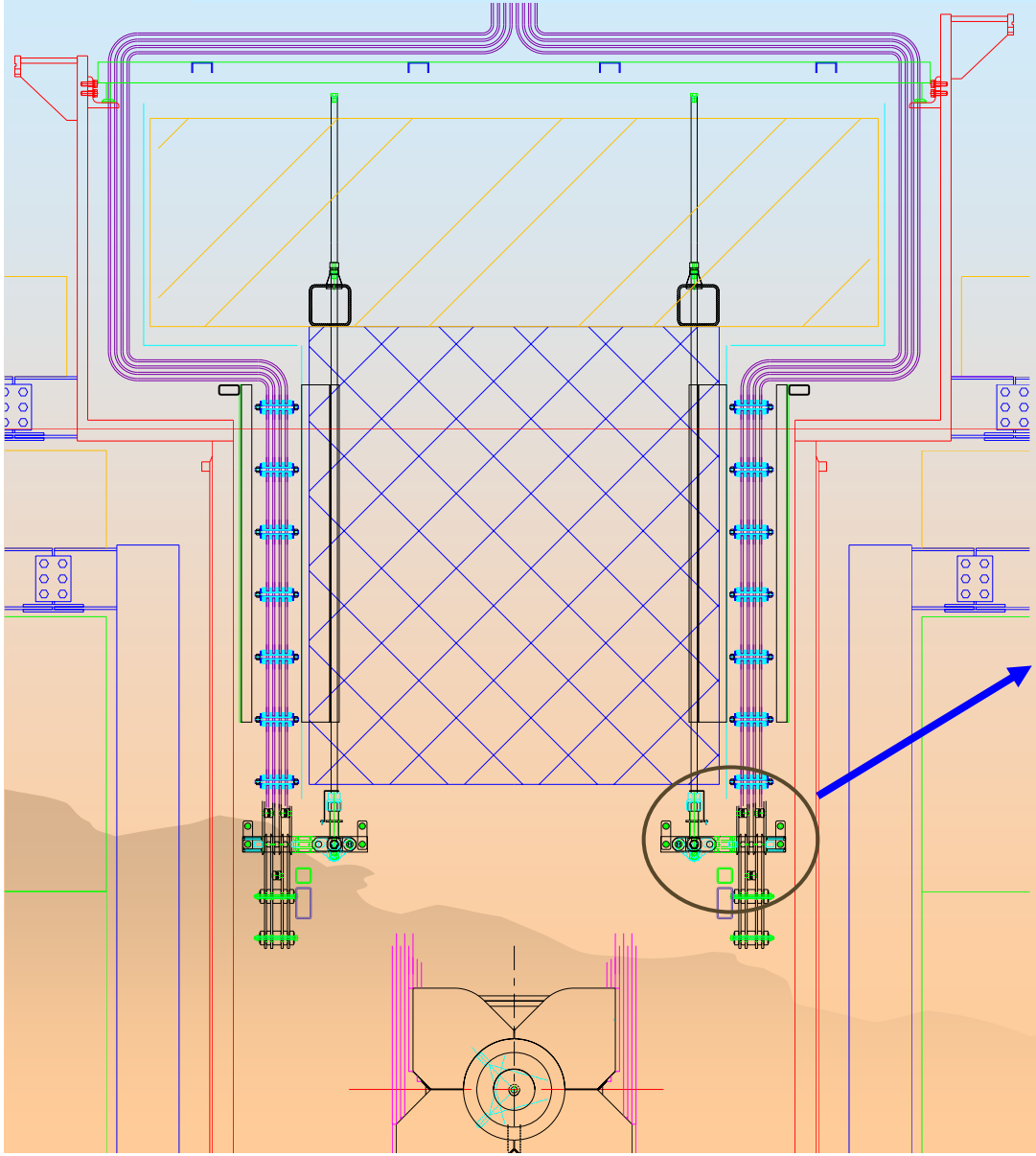


Swagelok with long wrench.

- Outer tube and Swagelok nut are independent.
  => Solve the alignment problem.
- Remote connection was succeeded.
- No water leak at 20 atm. pressure.

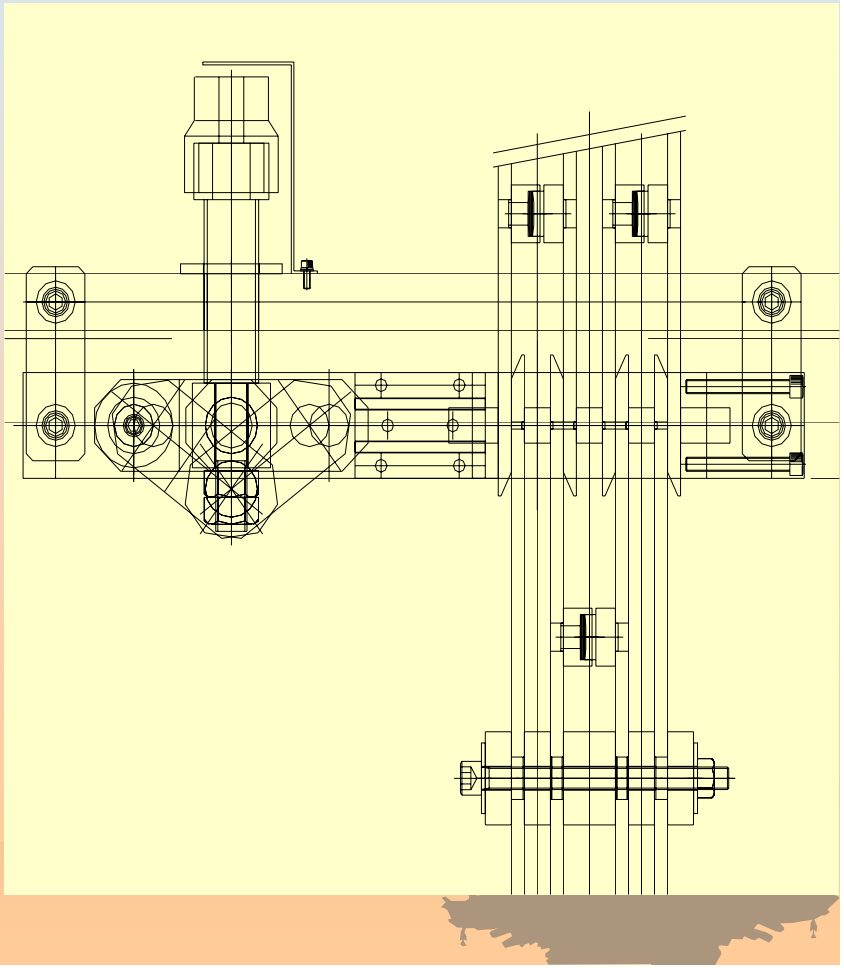


Stripline Remote Coupling



NuMI type

Prototype was made.

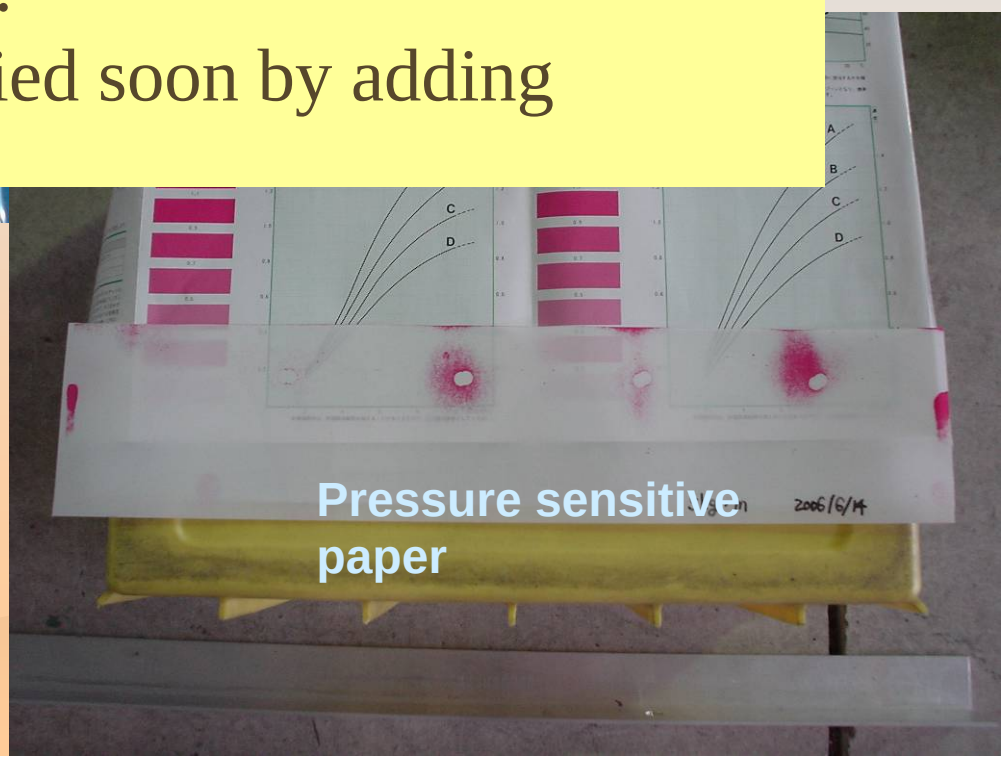


Tested by applying 15ton load.

Still there are two problems.

- Some bolts were broken at 10ton load.
- Pressure is not uniform.

Modification will be applied soon by adding Ballevile washers.



Pressure sensitive paper

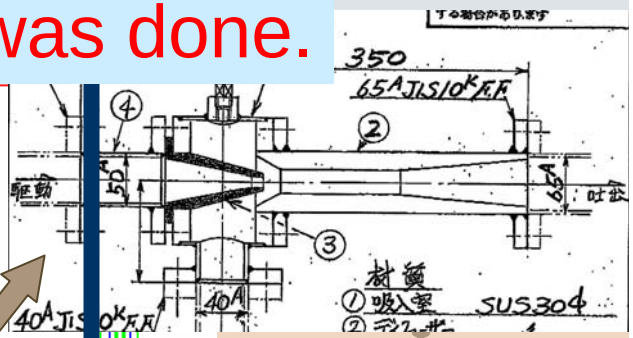
Cooling Water Circulation System

pumping up 7m in ultra-high radiation environment -two options-

Self priming canned motor pump

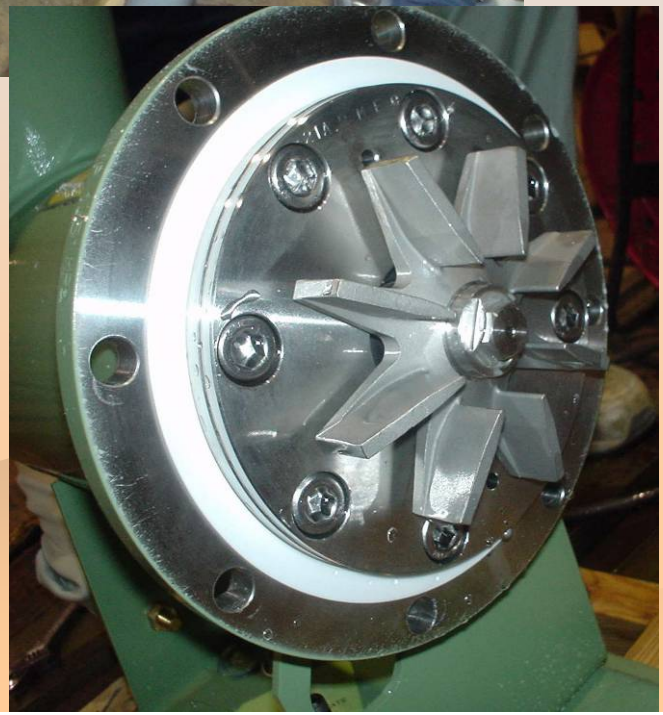
Test with self-priming pump was done.

7m



Ejector pump

Self-priming pump

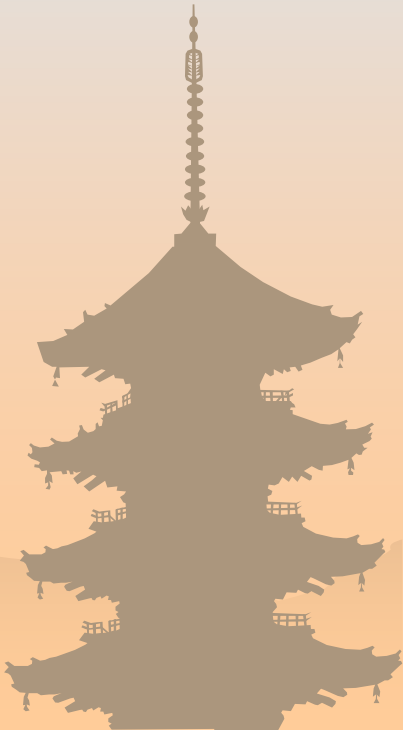


Succeeded to pump up 8 meters

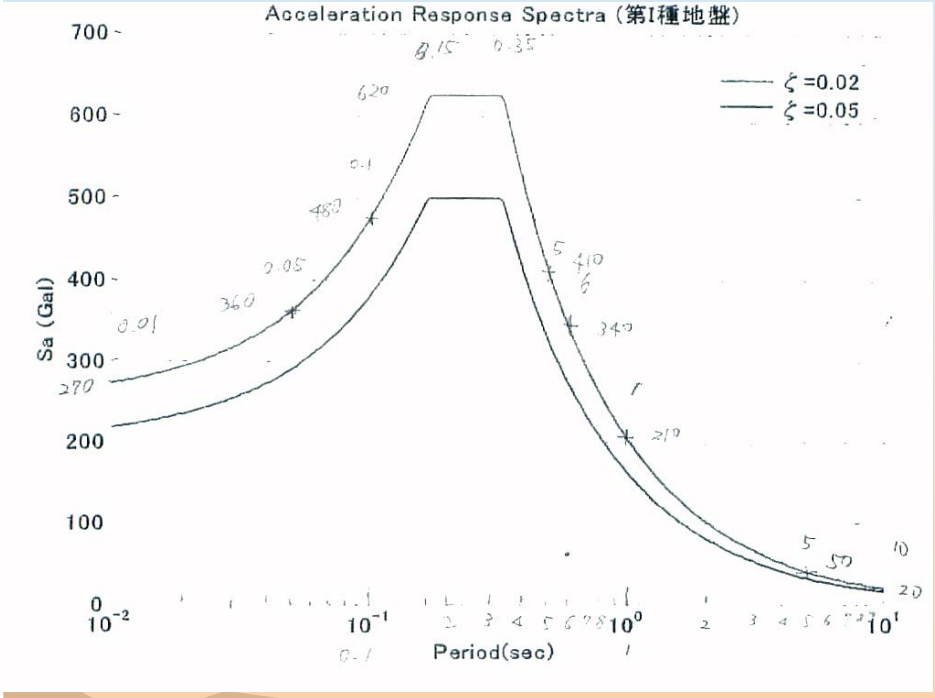
Proof of the steady operation with gas-mixed condition is a next step.

No Summary

- Still Many things to be developed……
- Let’s go to next two talks for the details of horn itself.



ホーン3固有振動数（4点固定）



入力した地震スペクトル

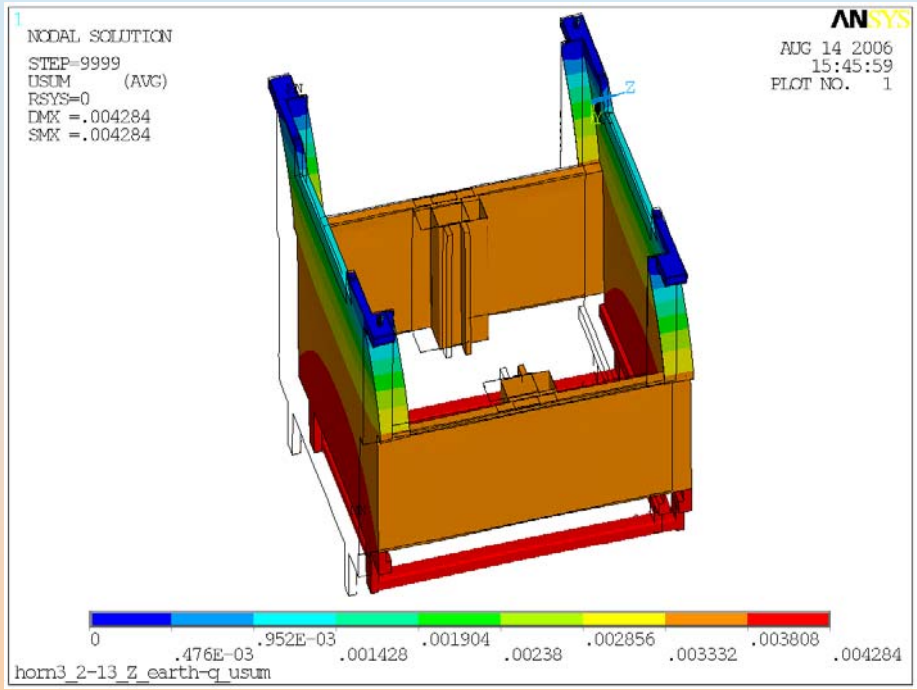
**** INDEX OF DATA SETS ON RESULTS FILE *****

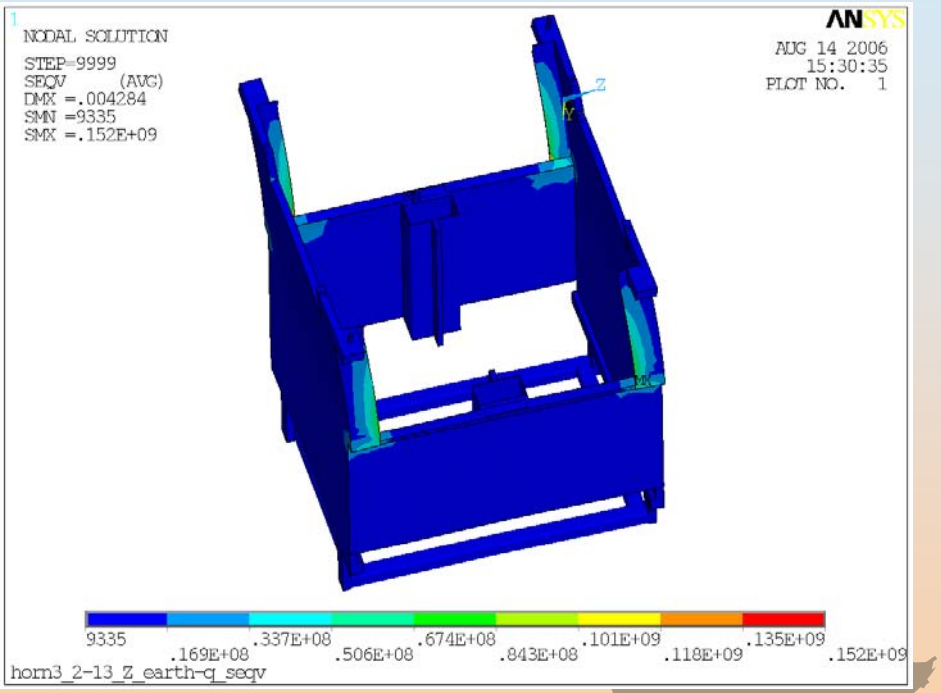
SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	6.7286	1	1	1
2	11.702	1	2	1
3	12.240	1	3	1
4	17.599	1	4	1
5	27.938	1	5	1
6	35.484	1	6	1
7	39.517	1	7	1
8	44.215	1	8	1
9	45.510	1	9	1
10	46.339	1	10	1
11	47.232	1	11	1
12	48.167	1	12	1
13	58.669	1	13	1
14	60.803	1	14	1
15	65.346	1	15	1
16	69.557	1	16	1
17	70.107	1	17	1
18	70.730	1	18	1
19	71.273	1	19	1
20	75.906	1	20	1

ホーン3の固有振動数
~20次

Seismic Analysis

- 標準加速度応答スペクトルに対する変形形状





- Z（ビーム軸）方向への加振に対する応答変形

  max 4.3mm

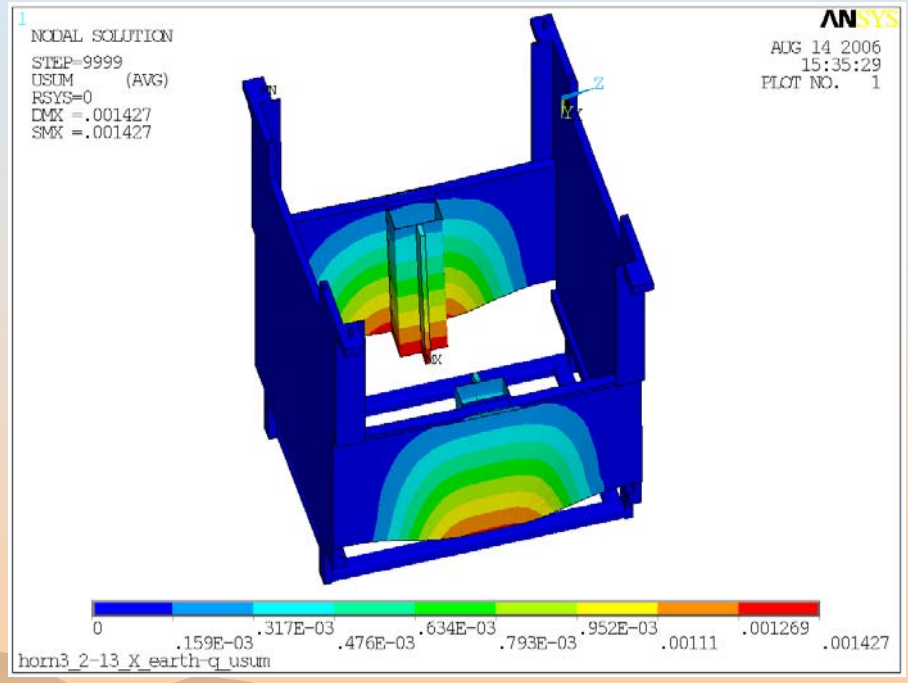
- 相当応力

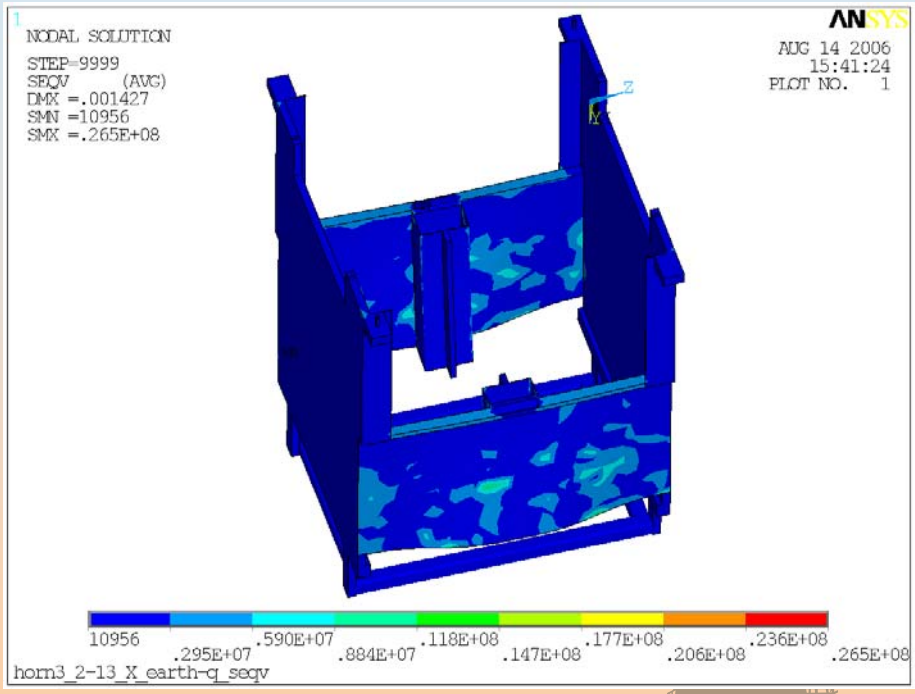
  max 152MPa

ビーム軸方向横0.25Gのときはそれぞれ1.99mm　56MPa

ホーン3支持箱のスペクトル解析

- 標準加速度応答スペクトルに対する変形形状





- X（ビーム軸）方向への加振に対する応答変形

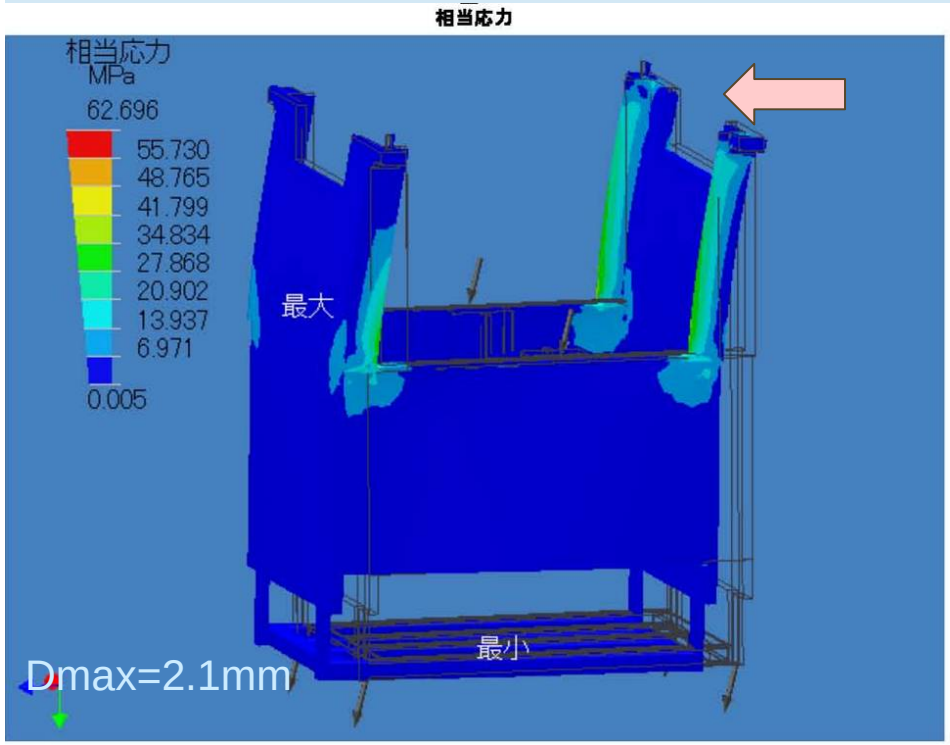
  max 1.4mm

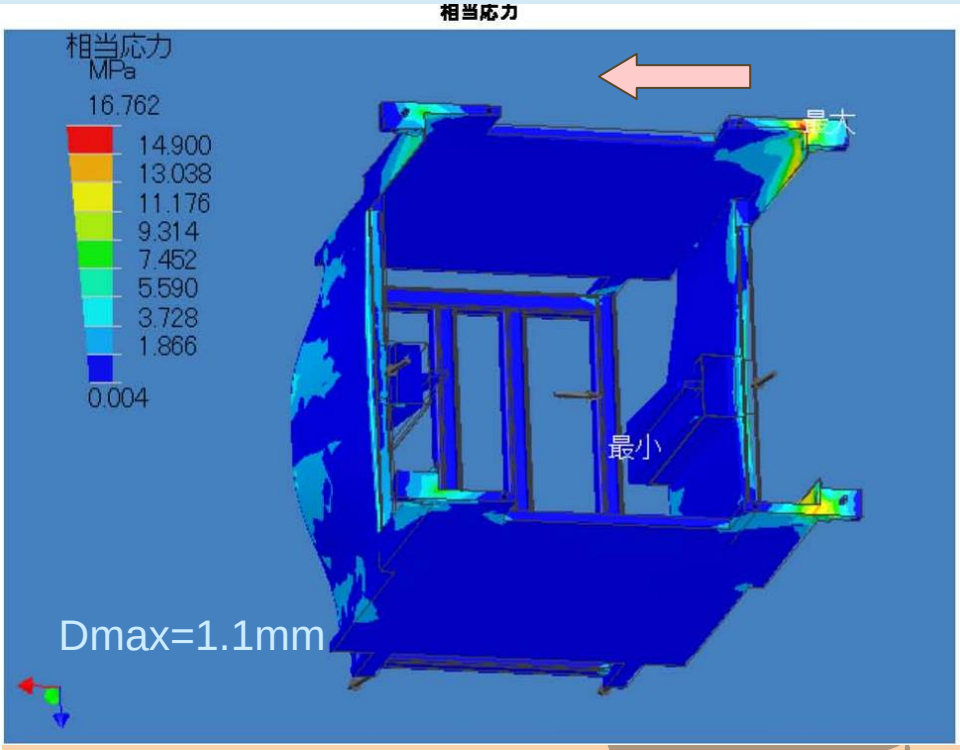
- 相当応力

  max 26MPa

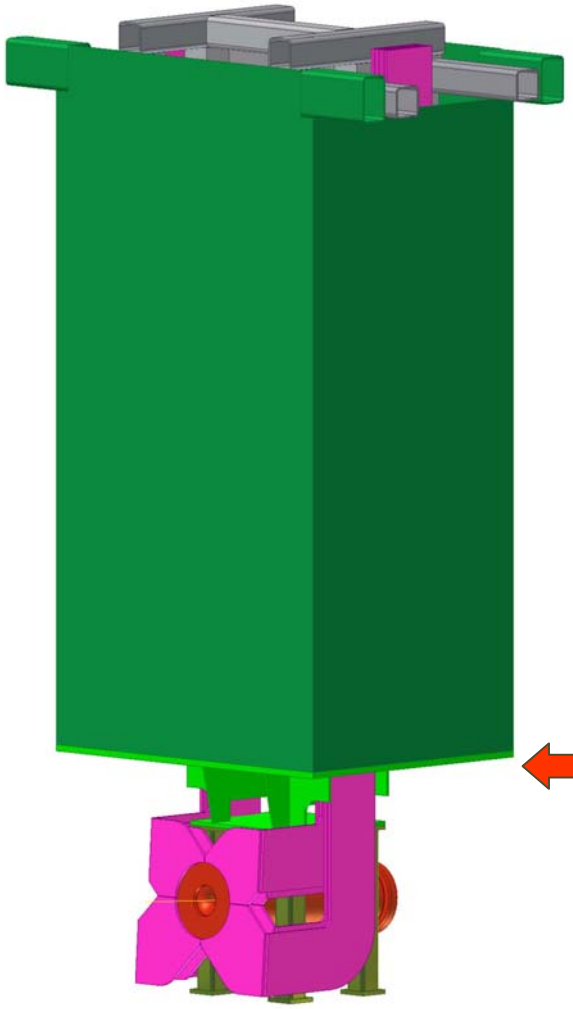
ビーム軸垂直水平横0.25Gのときはそれぞれ0.97mm　17MPa

地震で横0.25G掛かったとき。





Maintenance scenario



Target + 1st horn : exchange once per 2 years at most

2nd horn : exchange once per 4 years

3rd horn : exchange once per 4 years

Baffle : exchange once per 5 years

Requirement

Reproduce with 1mm accuracy

To save the waste stock room, it is desired that the equipment and support structure can be disconnected (remotely of course).

To save the waste stock room more, and to save the operation cost, it is preferred that the support structure is re-usable.

Remote disconnection/connection of horn stage, strip-line, water pipe, He pipe.

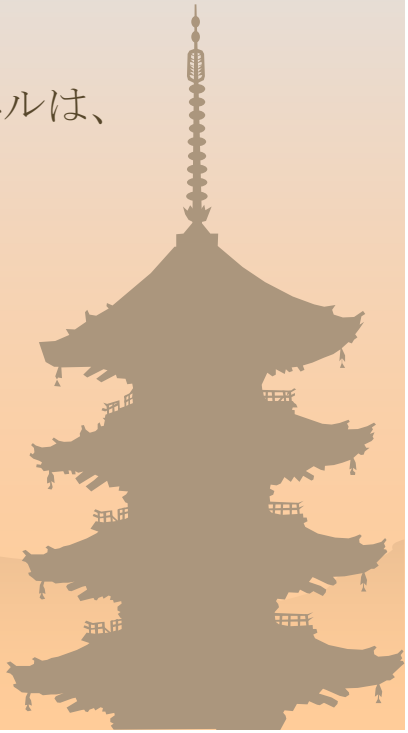
Estimate of residual dose

After 1 year operation, in unit of Sv/h

Cooling Time	1month	6months	1year	note
Target	12.3	(1.2)	0.16	^{7}Be 0.5MeV, half life 53.3day
1st horn	3.9	(3.4)	2.8	^{22}Na 1.3MeV, half life 2.6year

(calculated from half life)

６ヶ月冷却後、1メートル厚の上部コンクリートブロック上での放射線レベルは、2μSv/hと予想される。



自吸水ポンプ試験

７メートルの汲み上げに成功！！！

9メートルでも汲み上げられた。（流量が下がる）

⇒ サービスピットに自吸水ポンプを設置。エジェクターポンプは不採用。

課題

　コントロール。

　引き続けるか、制御するか。第１ホーン試作機の冷却系で試験。