Current Status of RENO Experiment

14th International Workshop on Neutrino Telescopes

March 15-18, 2011, Venice, Italy

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Seoul National Univ.

March 16, 2011

RENO

ν ~~~~ θ_{13}

ν_e ν_μ ν_τ

KNRC

Korea Neutrino Research Center

Outline

- **Experimental Goal**
  - **Systematic & Statistical Uncertainties**
  - **Expected θ_{13} Sensitivity**

- **Overview of the RENO Experiment**
  - **Experimental Setup**
  - **YongGwang Power Plant**
  - **Schedule**

- **RENO Construction (completed as of Feb. 2011)**
  - **Tunnel**
  - **Detector**
  - **DAQ**

Goal of RENO Experiment

- **CHOOZ : R_{osc} = 1.01 ± 2.8% (stat) ± 2.7% (syst)**
  $\sin^2(2\theta_{13}) < 0.17$ (90% C.L.)

- **RENO : $\sin^2(2\theta_{13}) > 0.02$ (for 90% C.L.)**
  $\sin^2(2\theta_{13}) > 0.035$ (for 3σ discovery potential)
  statistical error : 2.8% → 0.3%
  systematic error : 2.7% → <0.5%

- Larger statistics
  - More powerful reactors (multi-core)
  - Larger detection volume
  - Longer exposure

→ Obtain <1% precision !!!

- Smaller experimental errors
  - Identical multi detectors

- Lower background
  - Improved detector design
  - Increased overburden

RENO Proposal, hep-ex/1003.1391 (2010. 03)

Expected Number of Neutrino Events at RENO

- 2.73 GW per reactor × 6 reactors
- 1.21×10^{30} free protons per targets (16 tons)

- Near : 1,280/day, 468,000/year
- Far : 114/day, 41,600/year

✓3 years of data taking with 70% efficiency

Near : $9.83 \times 10^5 \approx 10^6$ (0.1% error)

Far : $8.74 \times 10^4 \approx 10^5$ (0.3% error)

Expected Systematic Uncertainty

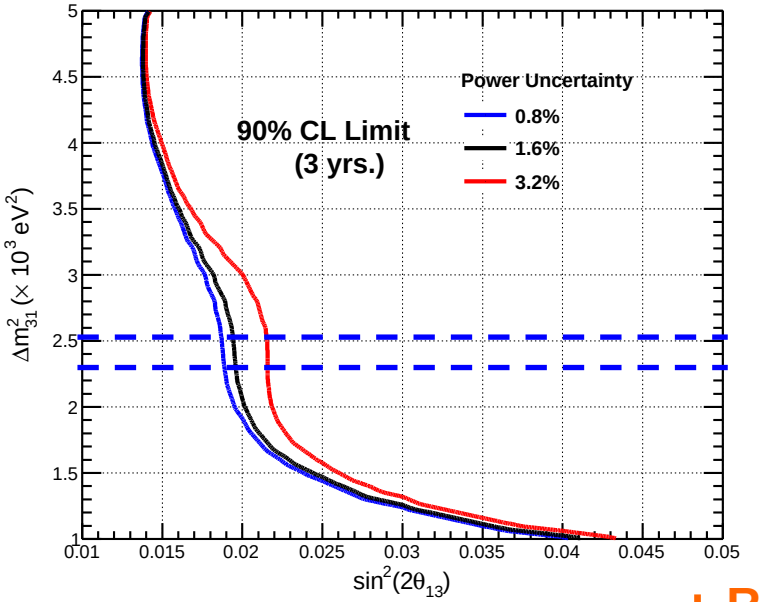
Systematic Source		CHOOZ (%)	RENO (%)
Reactor related absolute normalization	Reactor antineutrino flux and cross section	1.9	< 0.1
	Reactor power	0.7	0.2
	Energy released per fission	0.6	< 0.1
Number of protons in target	H/C ratio	0.8	0.2
	Target mass	0.3	< 0.1
Detector Efficiency	Positron energy	0.8	0.1
	Positron geode distance	0.1	0.0
	Neutron capture (H/Gd ratio)	1.0	< 0.1
	Capture energy containment	0.4	0.1
	Neutron geode distance	0.1	0.0
	Neutron delay	0.4	0.1
	Positron-neutron distance	0.3	0.0
	Neutron multiplicity	0.5	0.05
combined		2.7	< 0.5

Expected Number of BG Events

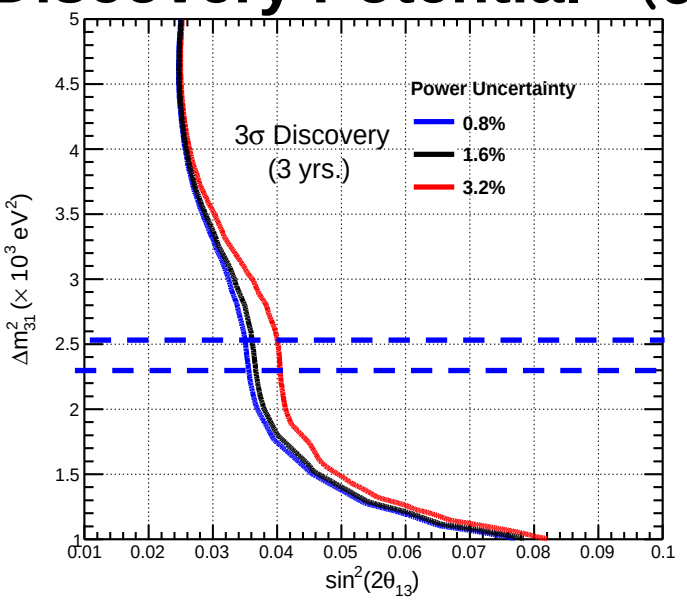
Source	Near	Far
Gamma Single Rates due to Radioactivity (^{238}U, ^{232}Th, ^{40}K)	**~30Hz (removable)**	**~30Hz (removable)**
Cosmogenic Isotopes (^{8}He, ^{9}Li)	**2.8 /day**	**0.7 /day**
Correlated BG due to fast neutrons from cosmic muons	**3.0 /day**	**1.0 /day**
Total	**~6 /day** (<0.5%)	**~2 /day (<2%)**

RENO Expected Sensivity

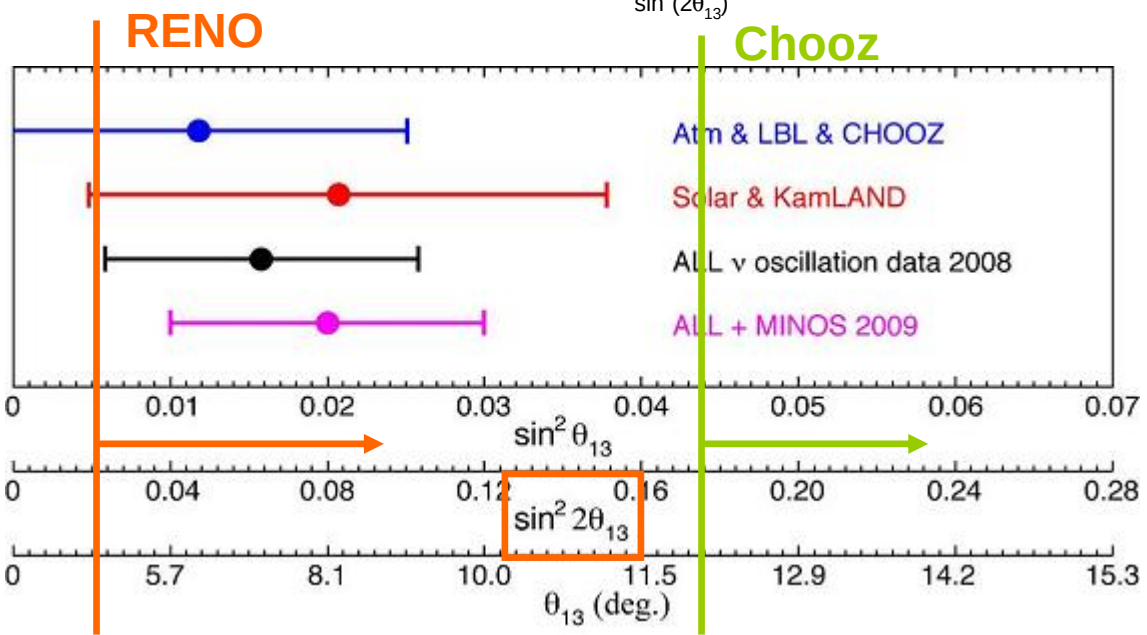
90% CL Limits



Discovery Potential" (3σ)



• **10 times better sensitivity than the current limit**



G. Fogli *et al.* (2009)

Comparison of Reactor Neutrino Experiments

Experiments	Location	Thermal Power (GW)	Distances Near/Far (m)	Depth Near/Far (mwe)	Target Mass (tons)	$\sin^2(2\theta_{13})$ 90% C.L.	Start (yr)
Double-CHOOZ	France	8.7	410/1050	115/300	8/8	0.03	?
RENO	Korea	17.3	290/1380	120/450	16/16	0.02	2011
Daya Bay	China	17.4	360(500)/1985(1613)	260/910	40×2/80	0.01	?

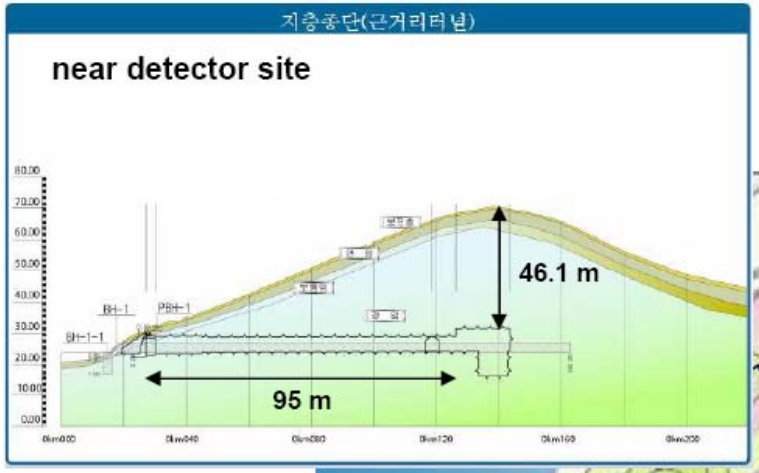
YongGwang (靈光) :

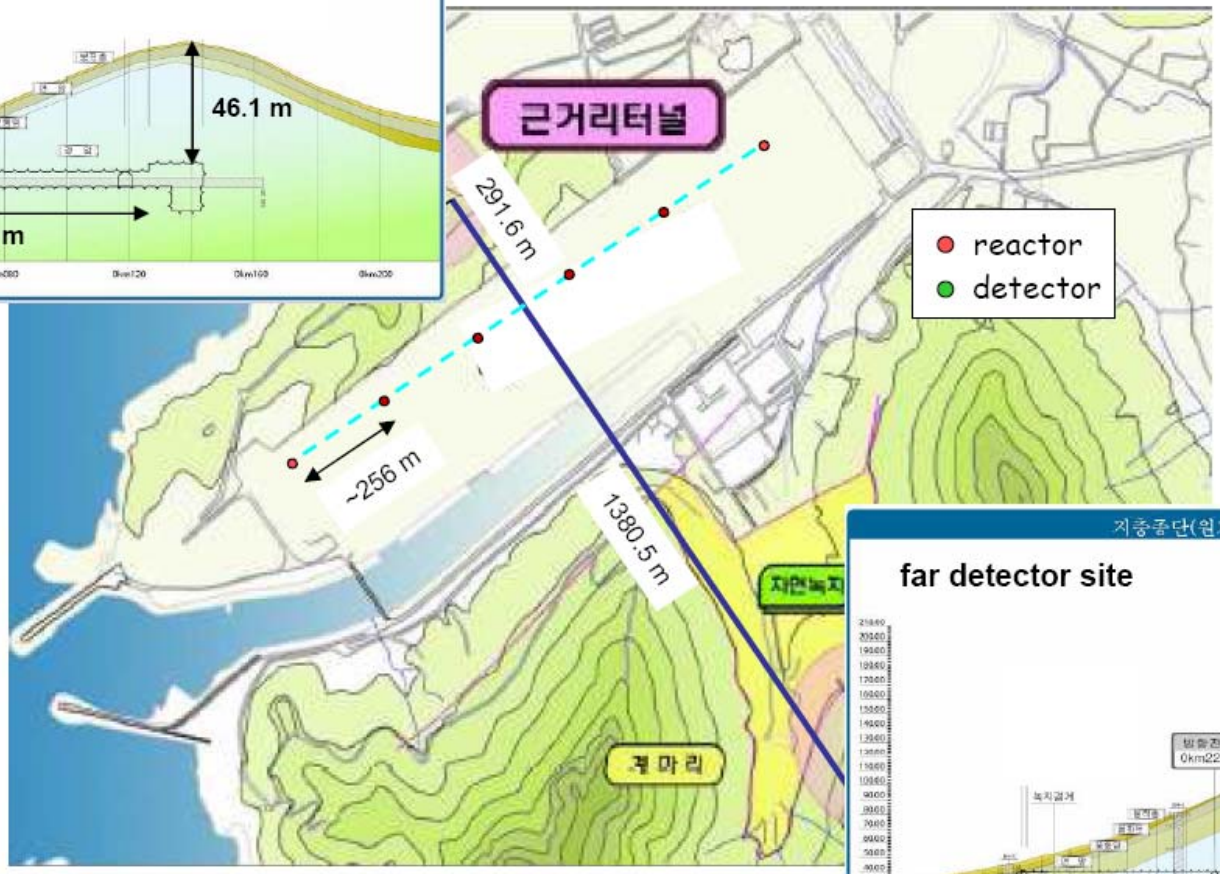
RENO Collaboration

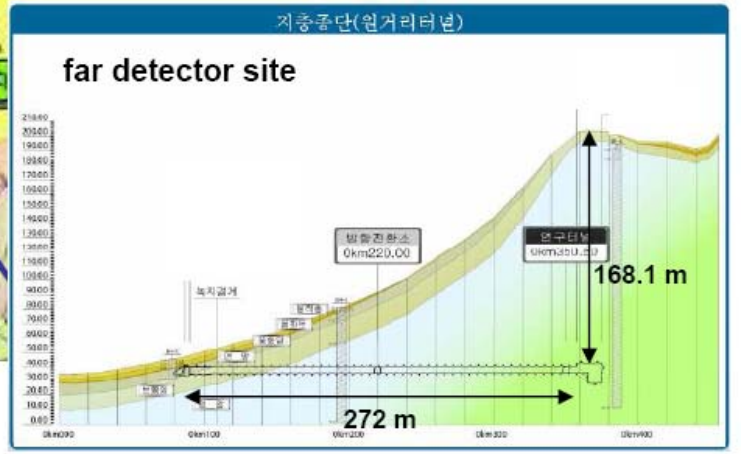
(13 institutions and 40 physicists)

- Chonnam National University
- Chonbuk National University
- Chung-Ang University
- Dongshin University
- Gyeongsang National University
- Kyungpook National University
- Pusan National University
- Sejong University
- Seokang Information University
- Seokyeong University
- Seoul National University
- Sungkyunkwan University
- California State University Dominguez Hills (USA)

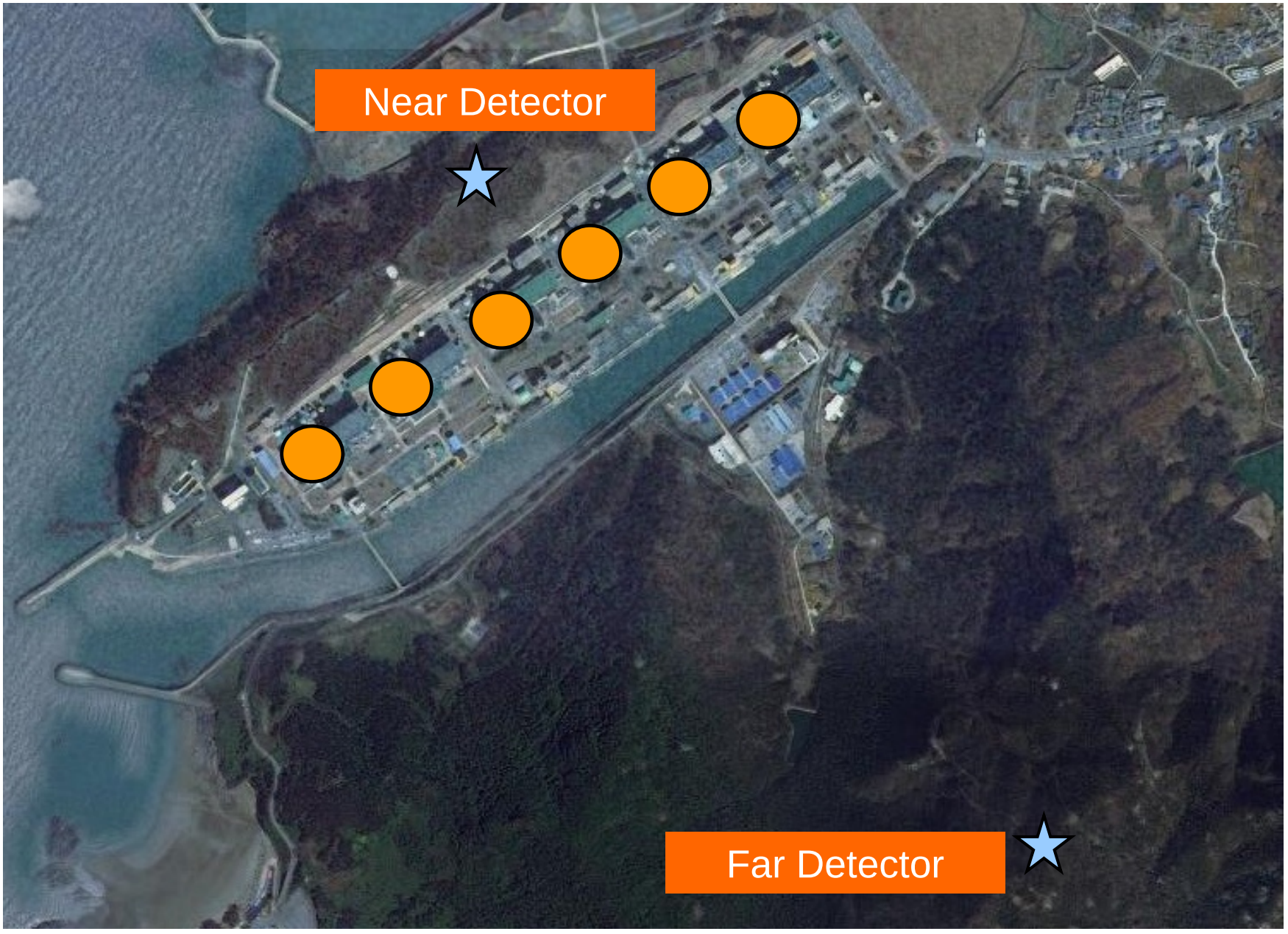
RENO Experimental Setup



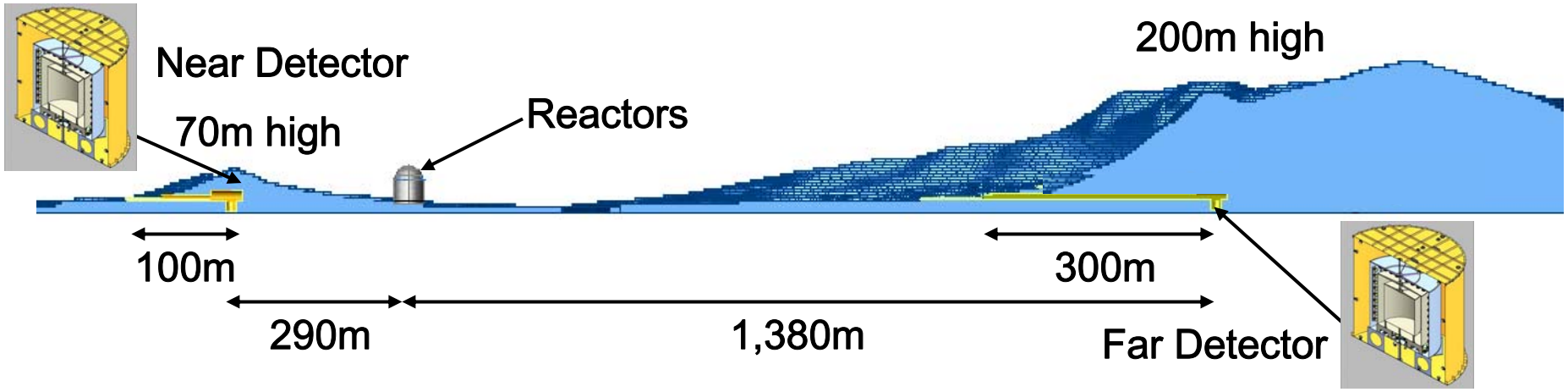


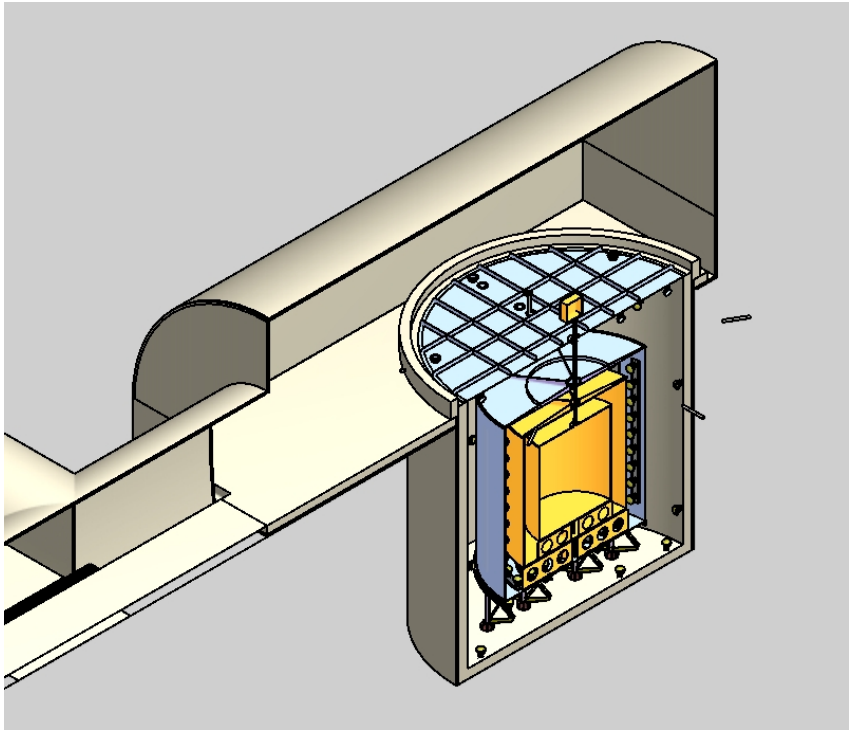


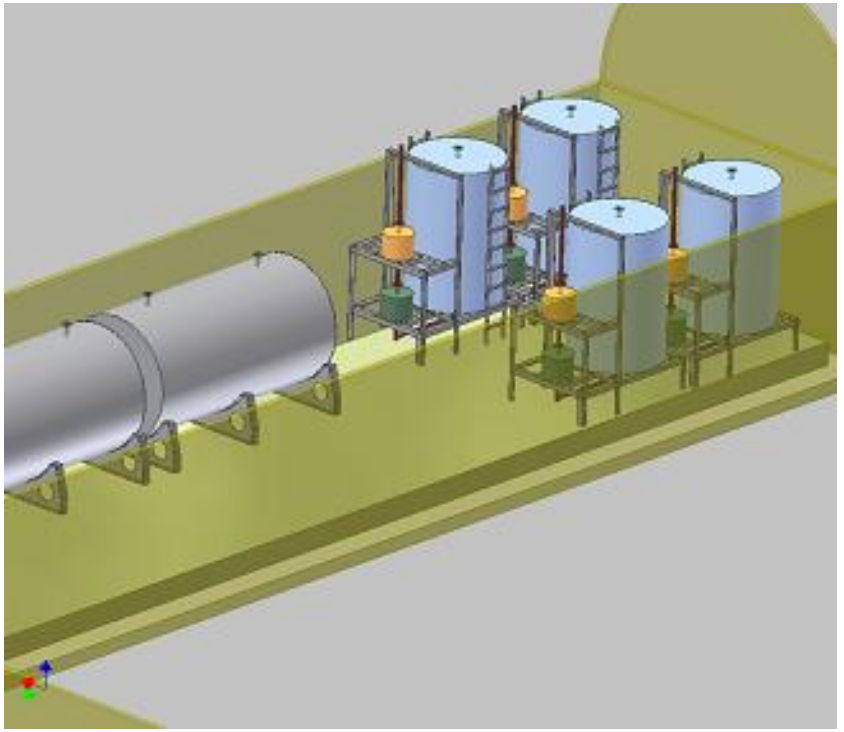
Google Satellite View of Experimental Site



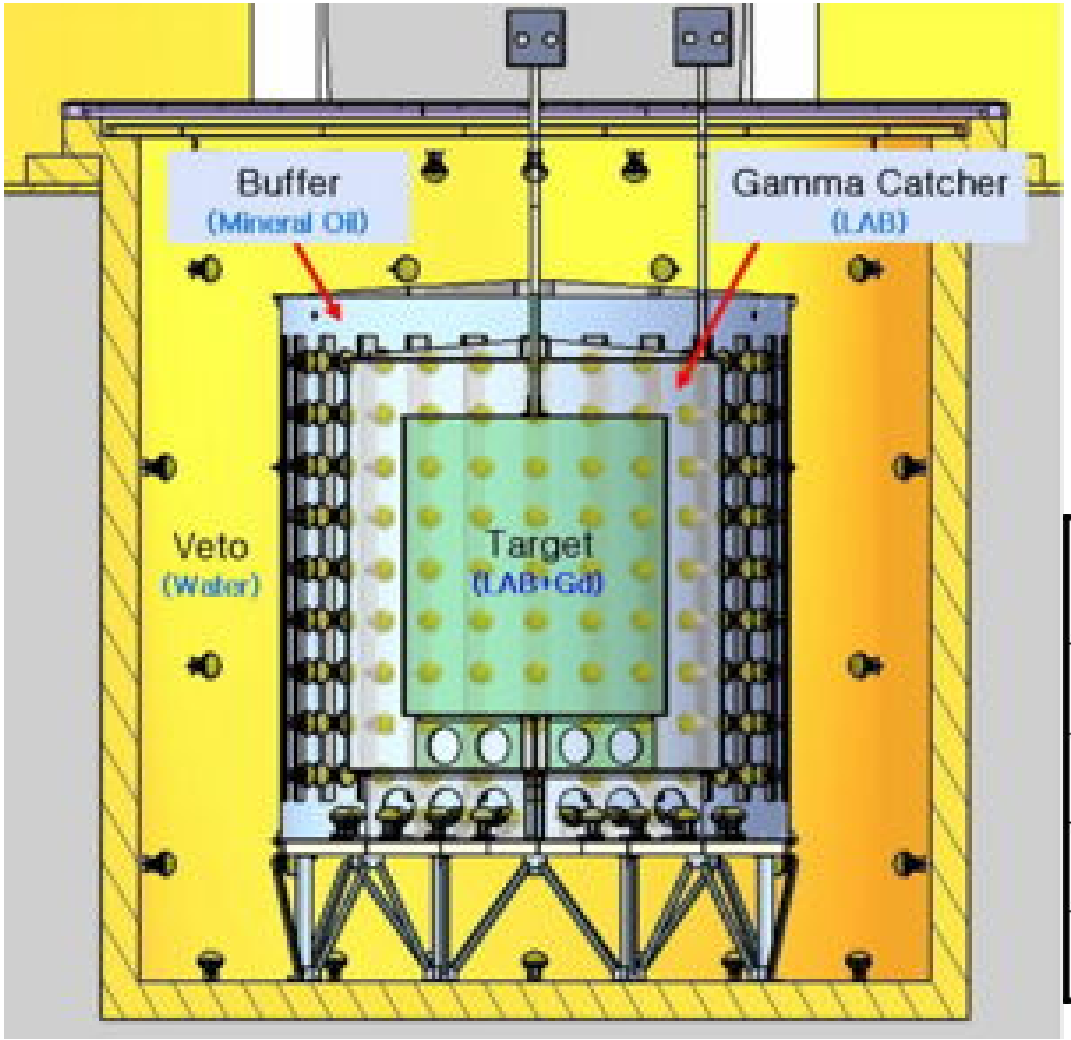
Schematic View of Underground Facility







RENO Detector



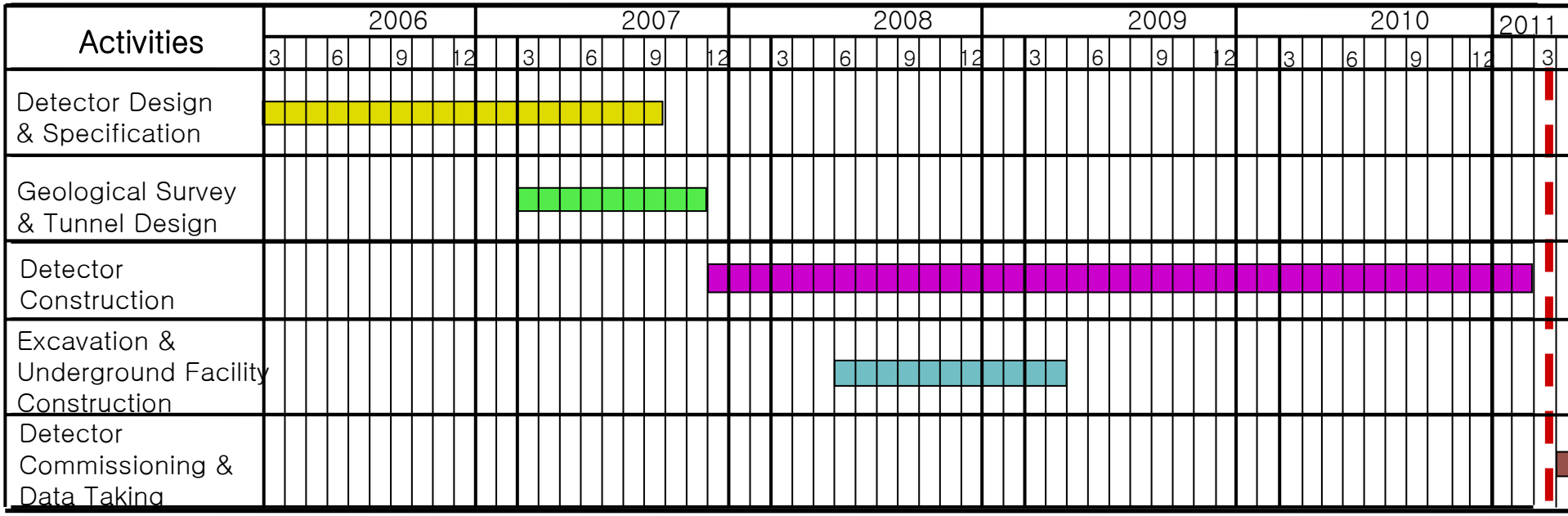
- 354 10” Inner PMTs :

  14% surface coverage

- 67 10” Outer PMTs

	Inner Diameter (cm)	Inner Height (cm)	Filled with	Mass (tons)
Target Vessel	280	320	Gd(0.1%) + LS	16.5
Gamma catcher	400	440	LS	30.0
Buffer tank	540	580	Mineral oil	64.4
Veto tank	840	880	water	352.6

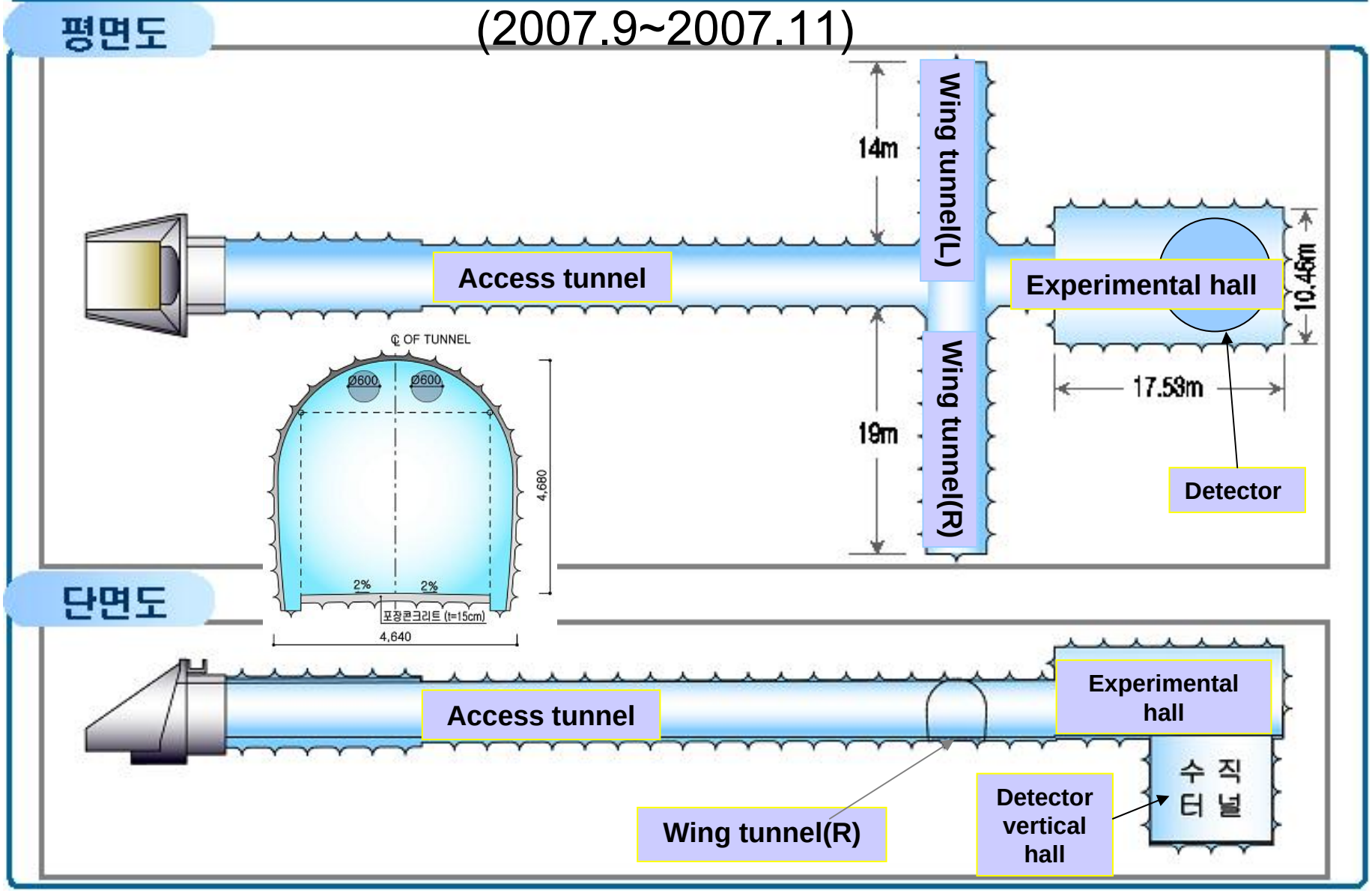
Schedule



- ❑ Tunnel facility, detector structure & buffer steel tanks completed
- ❑ June 2010 : Acrylic containers installed
- ❑ Jun. ~ Dec. 2010 : PMT test and Installation/ Veto tyvek installed
- ❑ Jan. 2011 : Detector closing/ Electronics hut & control room built
- ❑ Feb. 2011 : Installation of DAQ & HV/ Dry run
- ❑ Mar. 2011 : Installation of liquid production system
- ❑ May 2011 : Start data taking

Design of Tunnel

(2007.9~2007.11)



Tunnel Construction for Underground Facility

- ❑ Approval from government regulation (‘08. 01/05)
- ❑ Cleared local government regulations (‘08. 01～’08. 06)
- ❑ Preparation for tunnel excavation (‘08. 07)

Near & far tunnels are completed

(2008.6~2009.3)

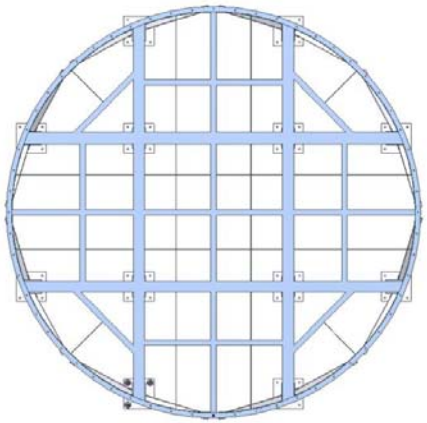
by Daewoo Eng. Co. Korea

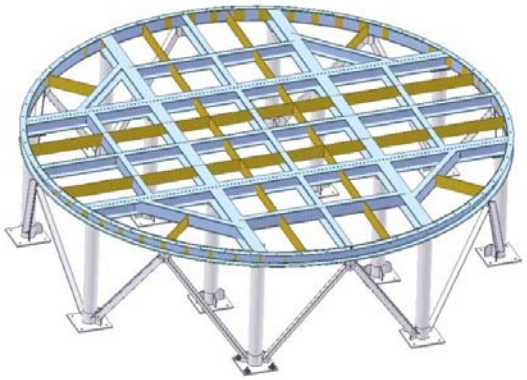
Far site

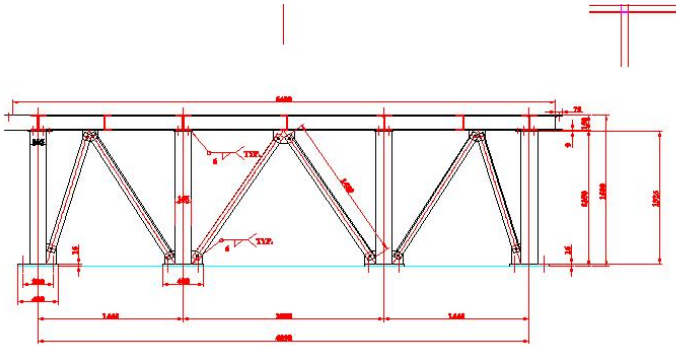
Near site

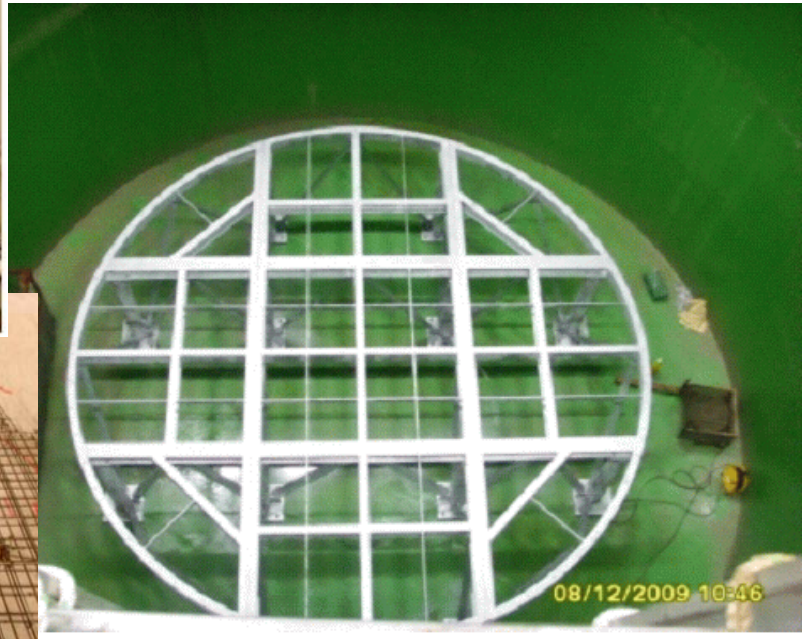
Vertical detector halls & steel structure are ready (2008. 12~2009. 06)

by NIVAK Co. Korea

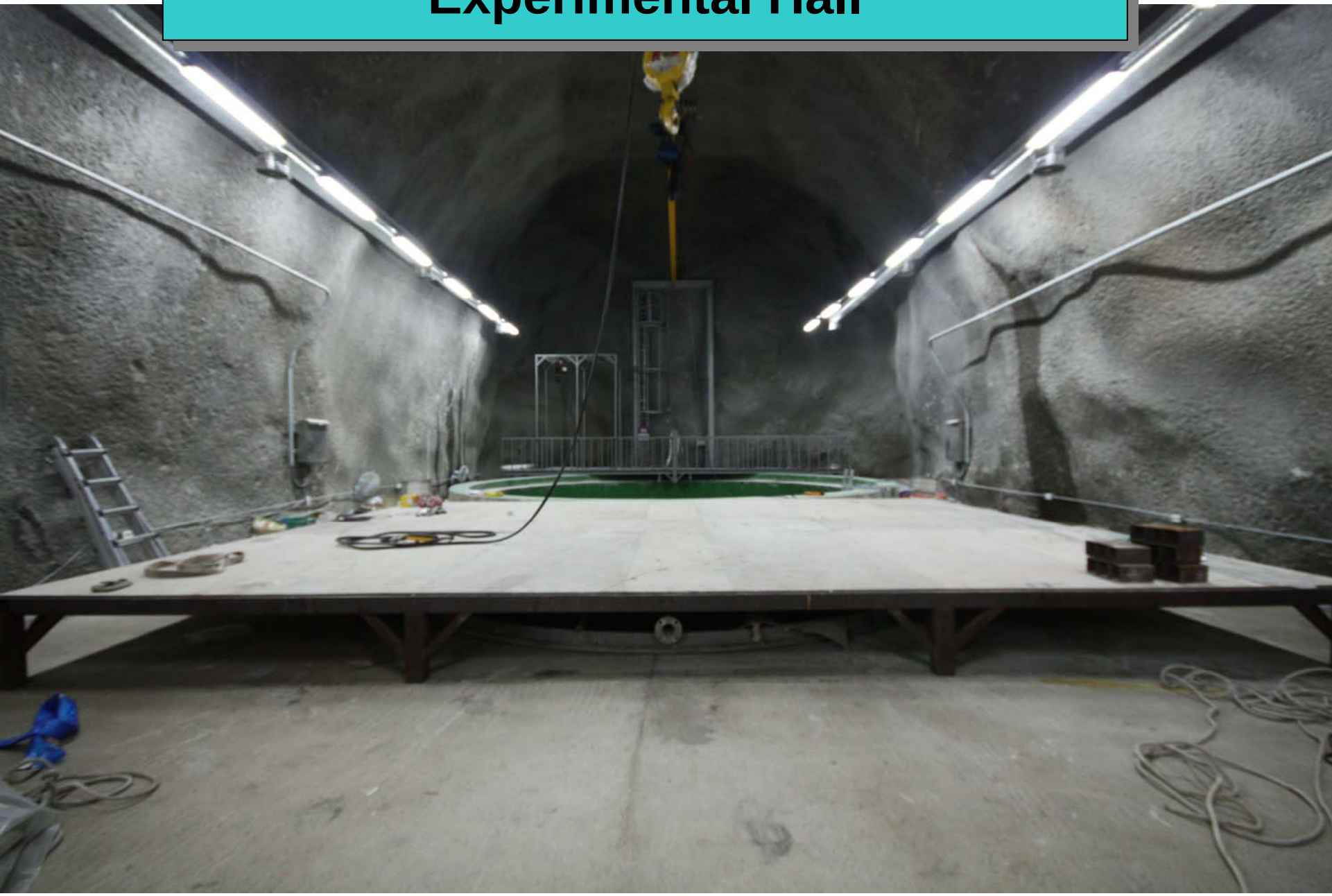








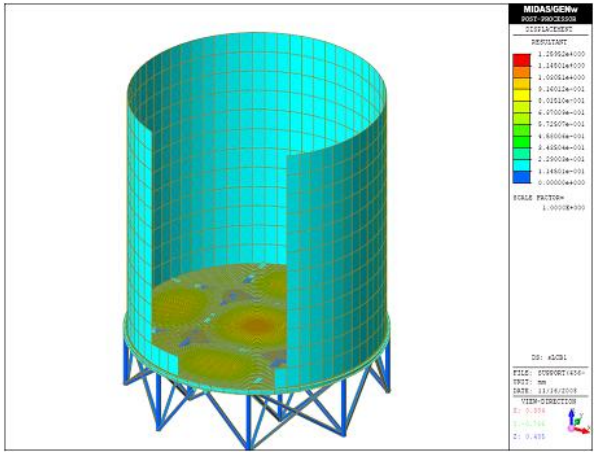
Experimental Hall

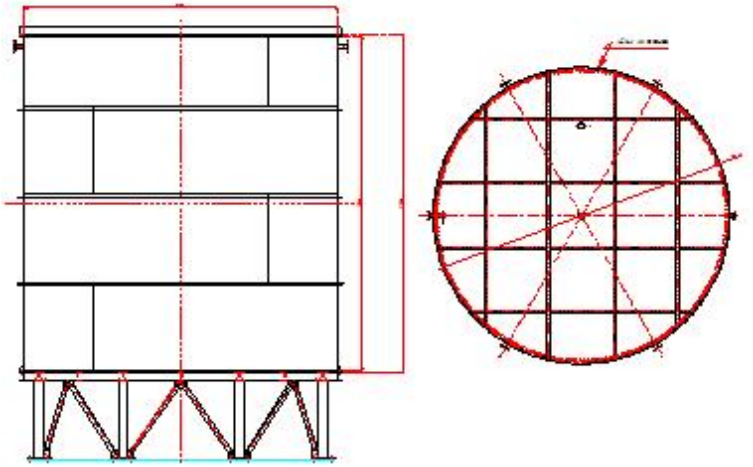


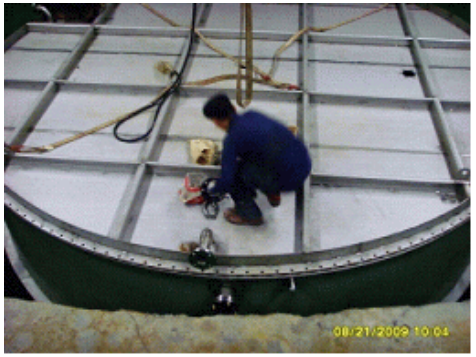
Buffer steel tanks are installed

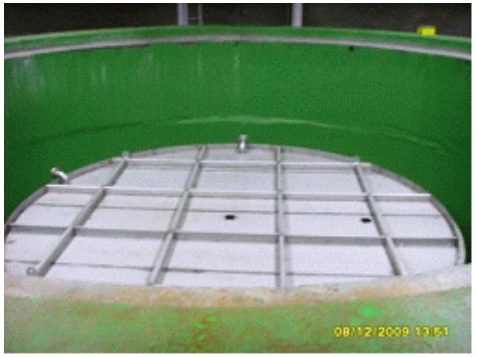
(2009.6~2009.11)

by NIVAK Co. Korea





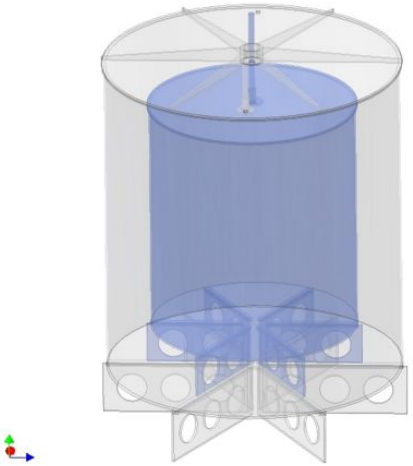


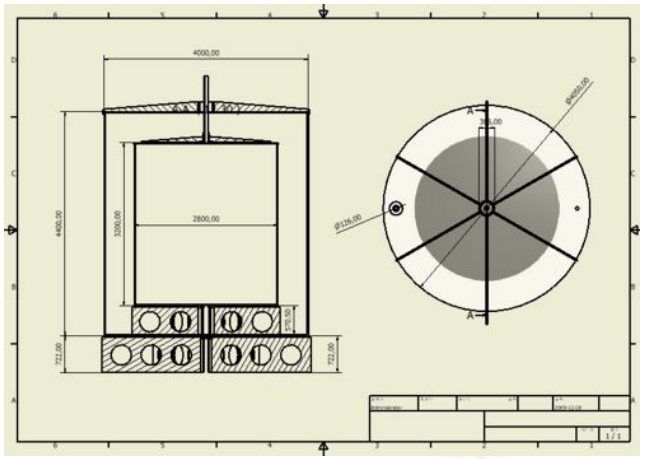


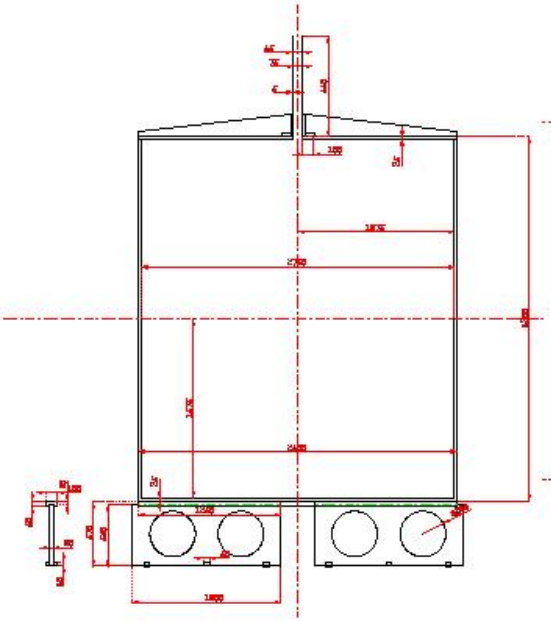
Acrylic vessels are made and installed

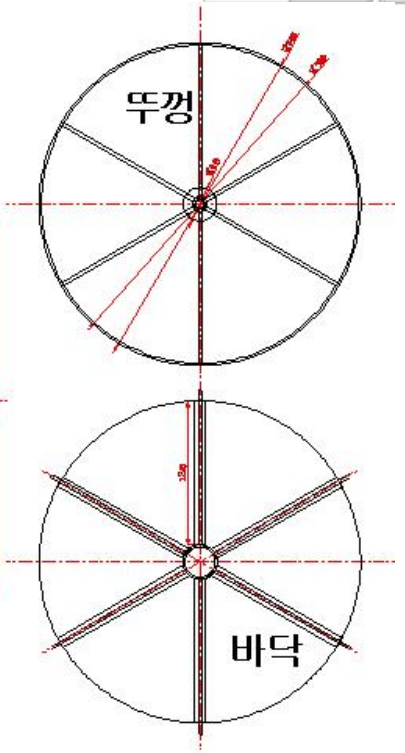
(2009.7~2010.6)

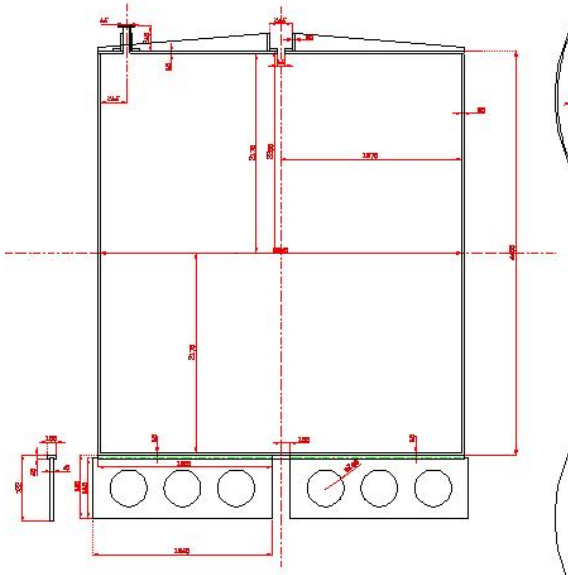
by KOATECH Co. Korea

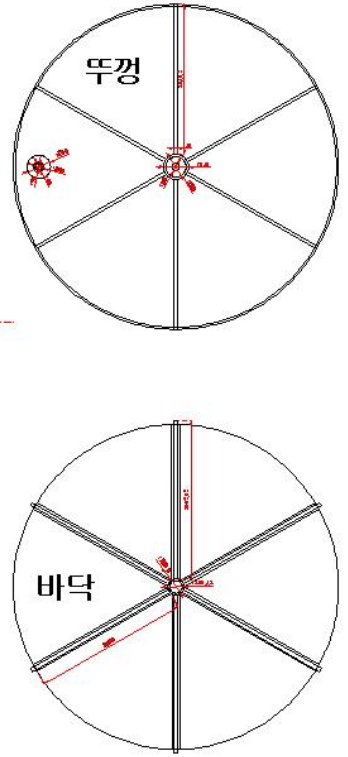


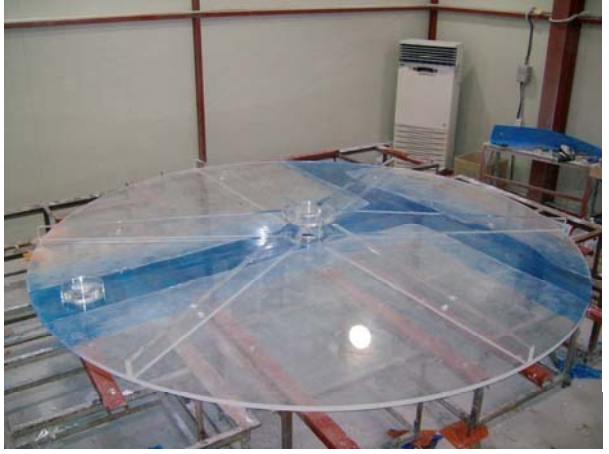













01/26/2010 12:30


01/26/2010 15:25


01/21/2010 17:52

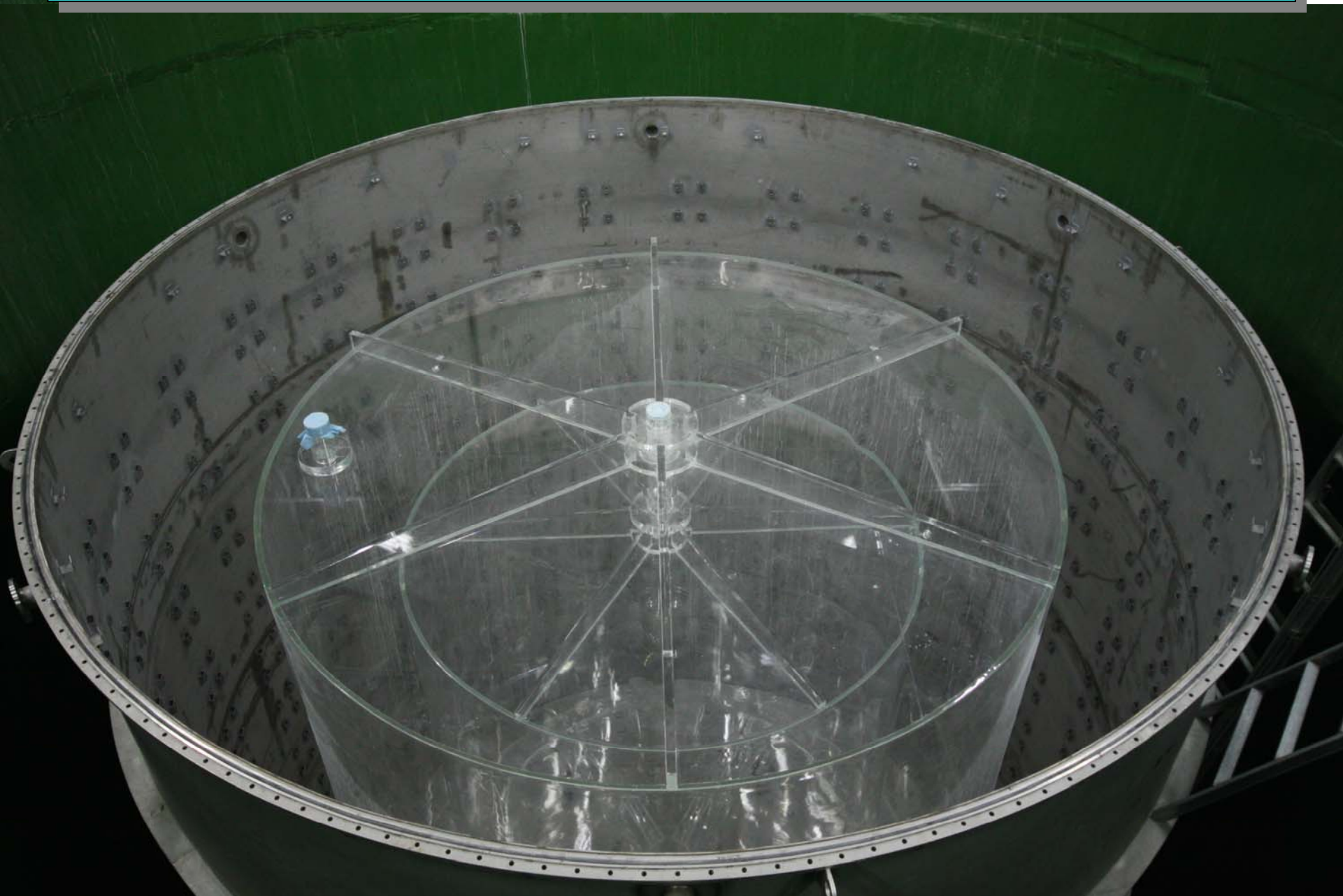

01/29/2010 12:25


02/10/2010 17:46

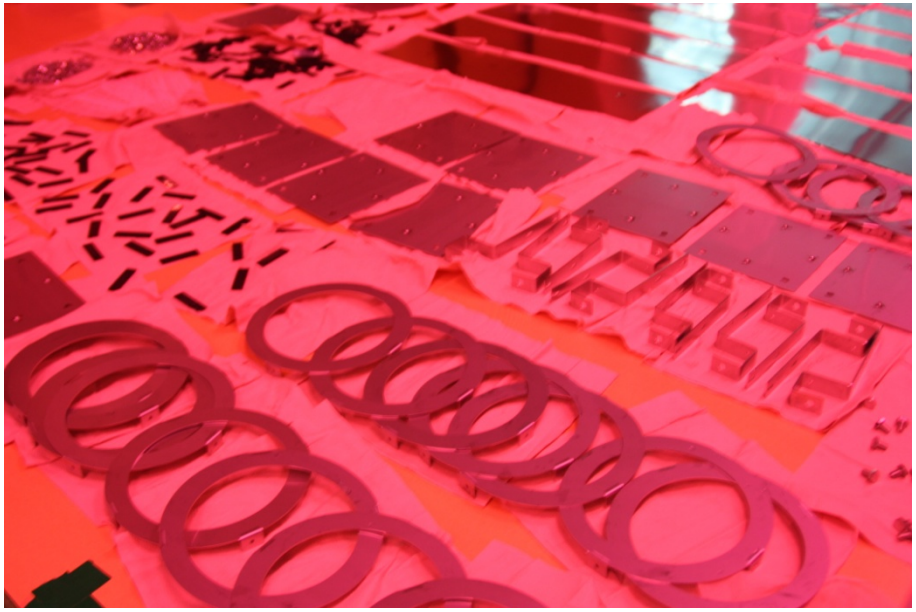

02/05/2010 15:01


03/18/2010 13:29

Installation of Acrylic Vessels (2010. 6)

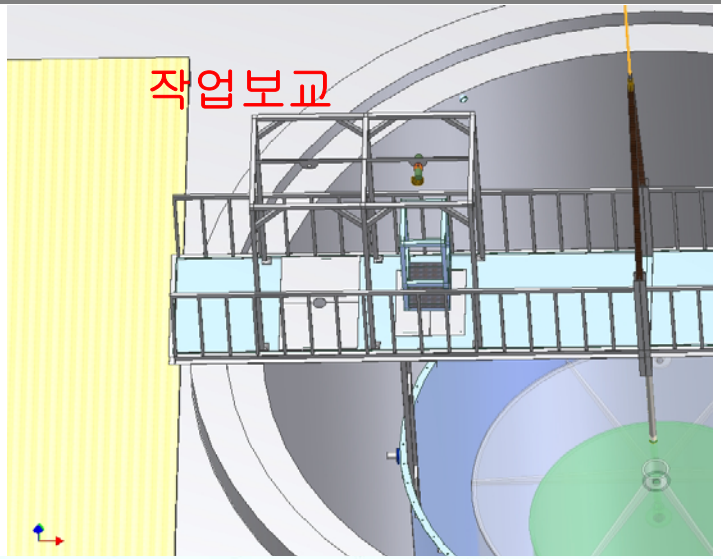


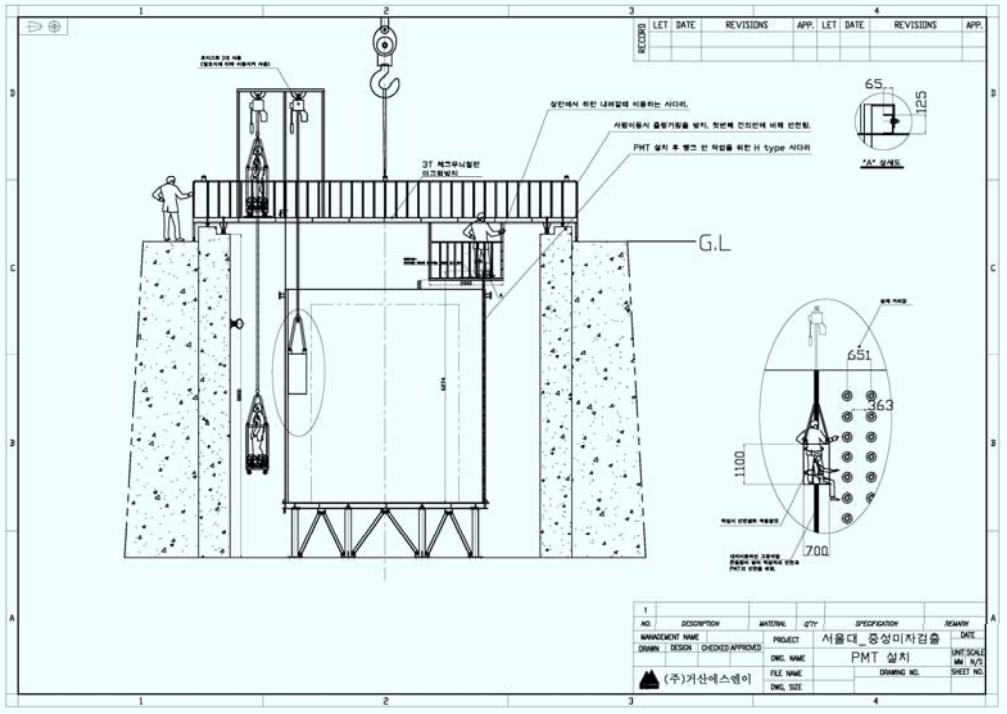
PMT Assembling (2010. 8~10)



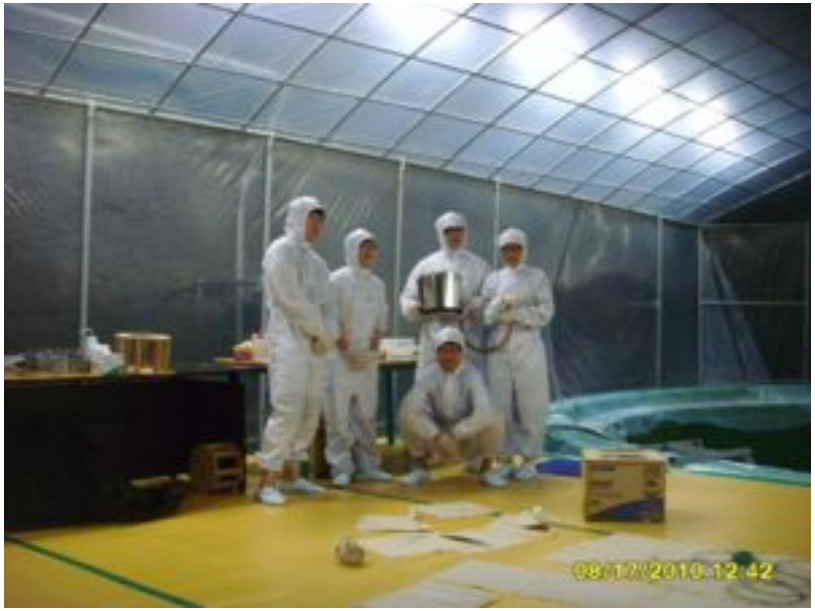
PMT Installation (2010. 8 ~ 2011. 1)

작업대

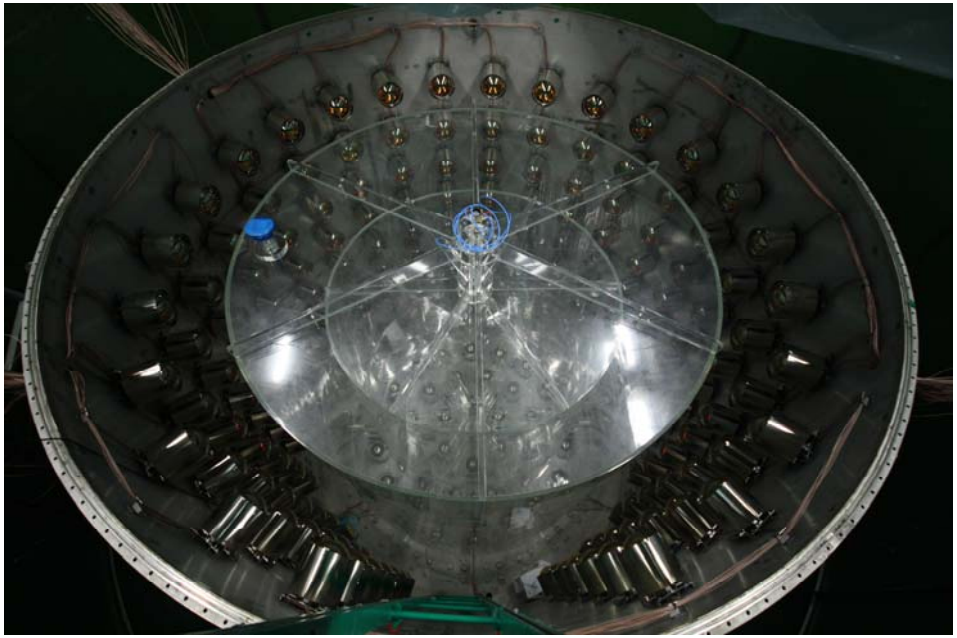




1st & Bottom PMT Mounting (2010. 8. 17)

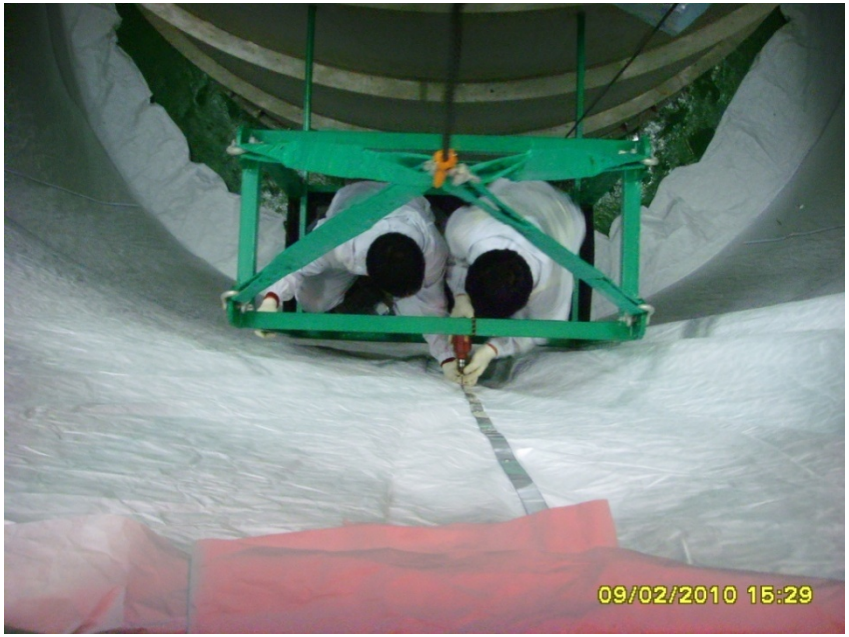


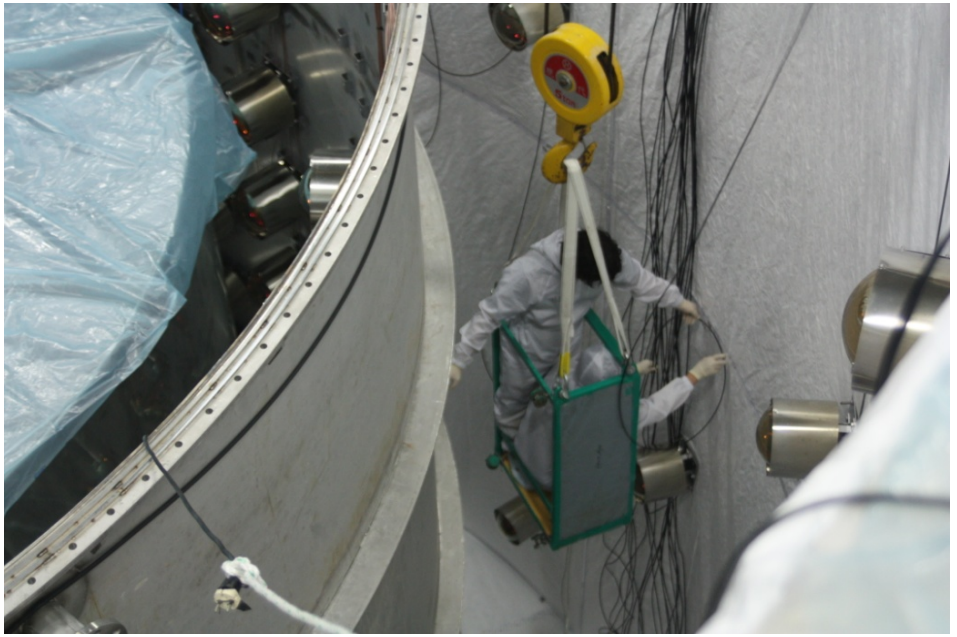
PMT Mounting (2010. 8~10)

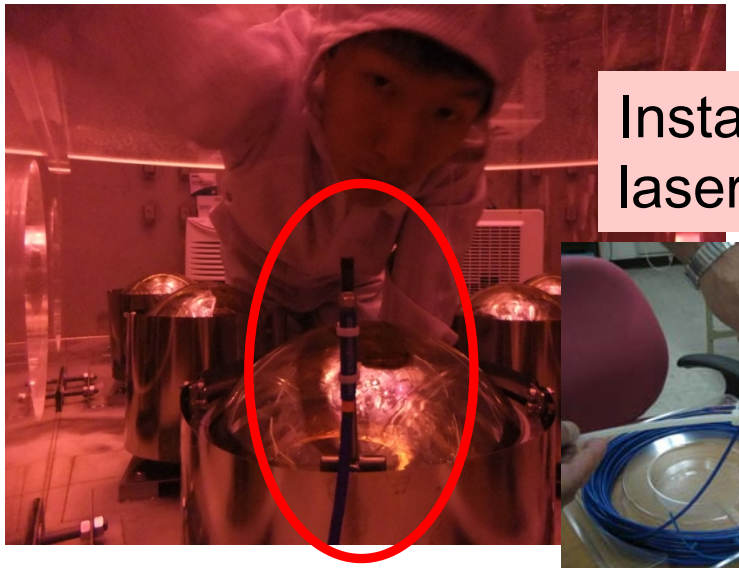


Finishing PMT installation (2011. 1)

Veto Tyvek and PMTs (2010. 10)

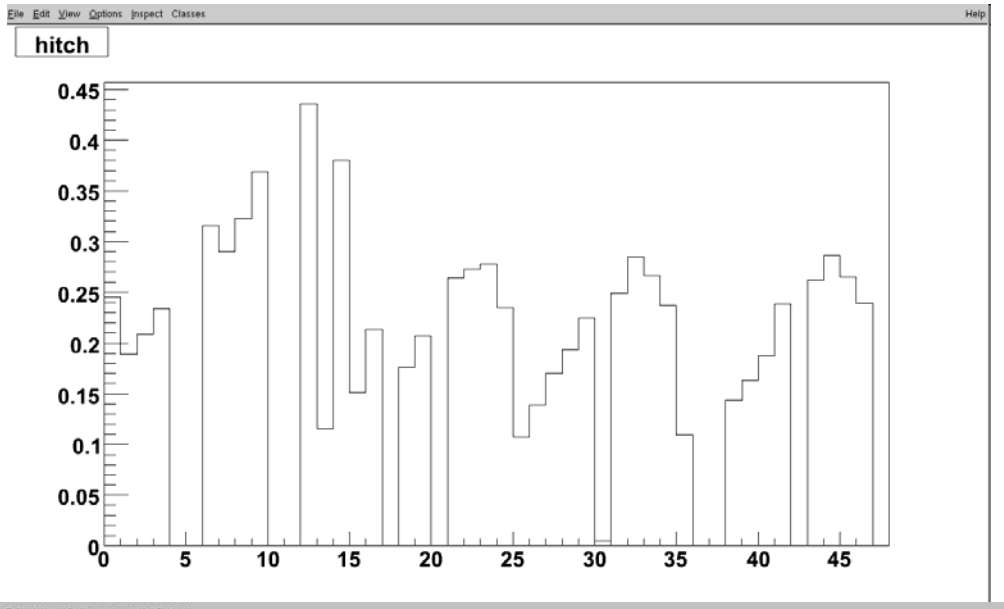


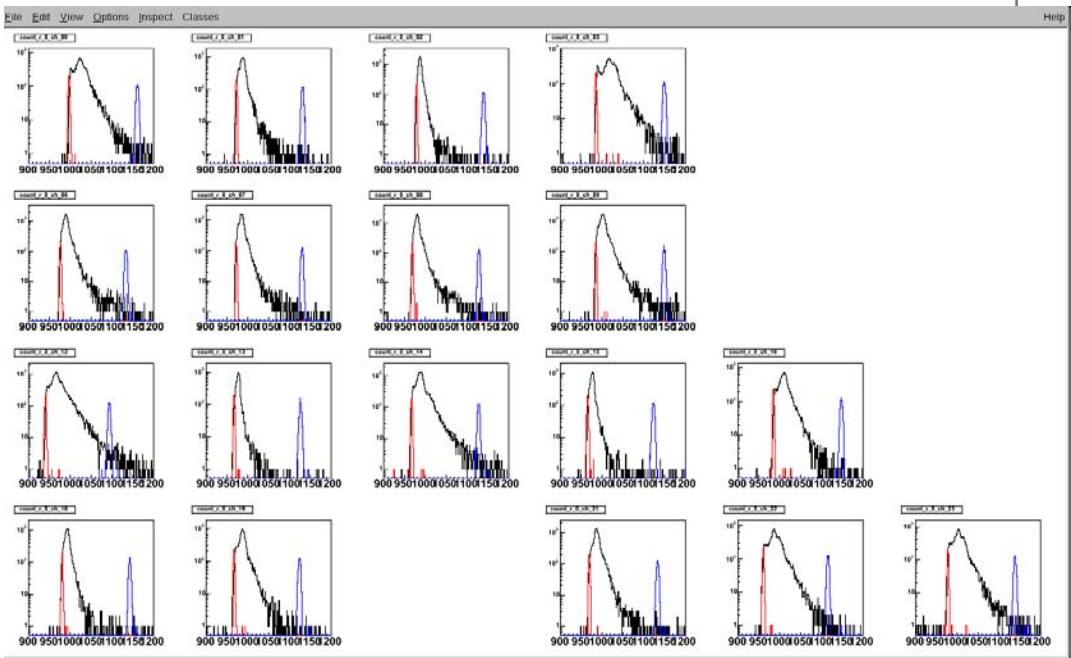




Installation of laser injector

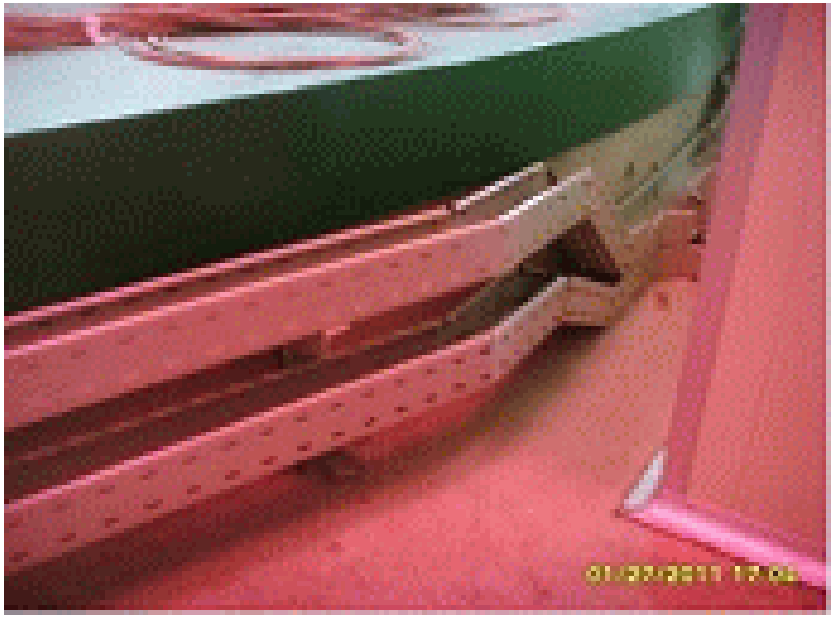
PMT Signal Check (2010. 10~12)



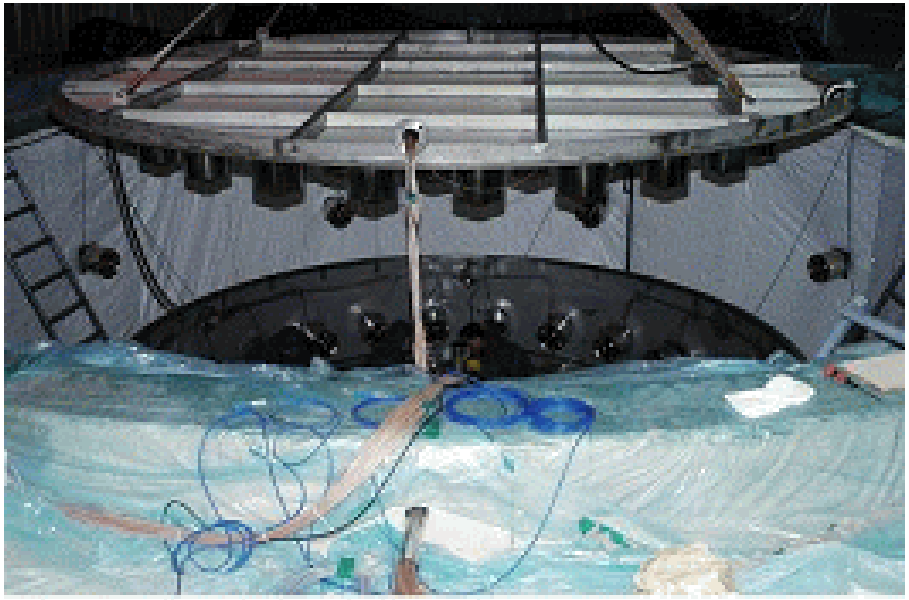


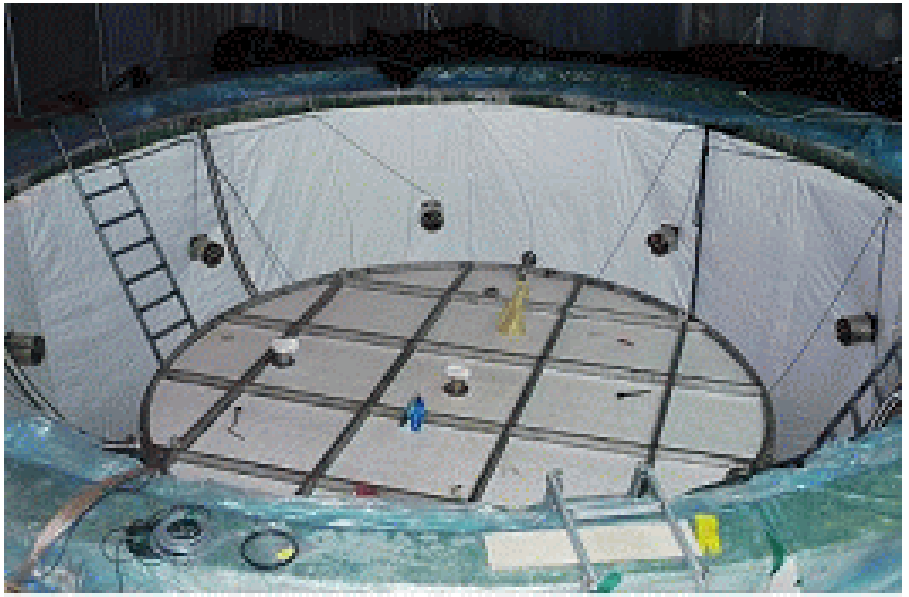
Tyvek Installation (2011. 1)

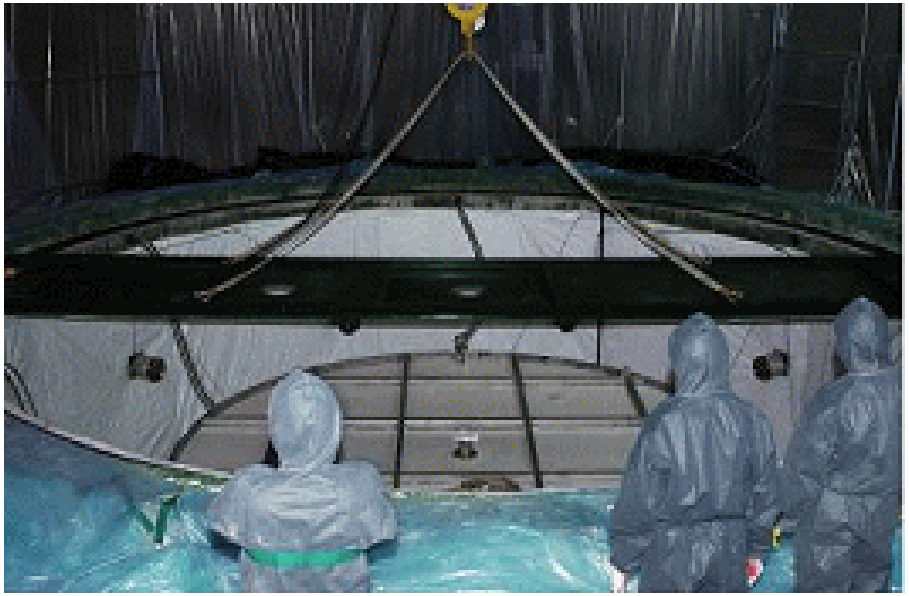
PMT Cable Outlet Tube & Cable Tray (2010. 11~2011.1)



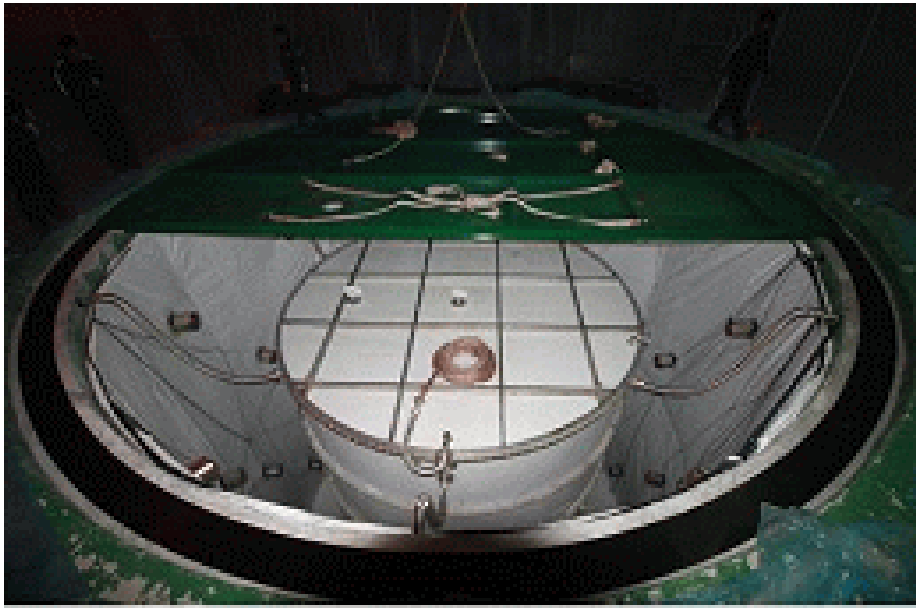
Detector Closing (2011. 1)

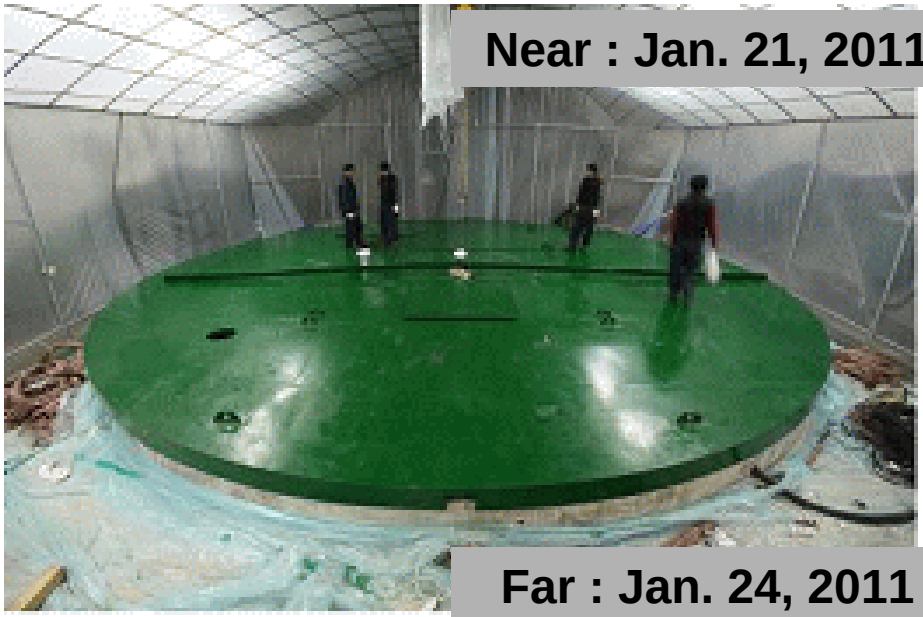






Detector Closing (2011. 1)

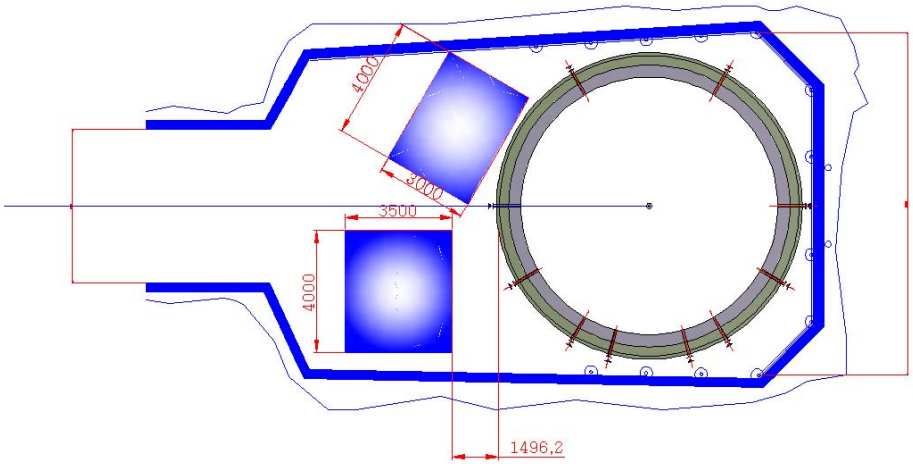


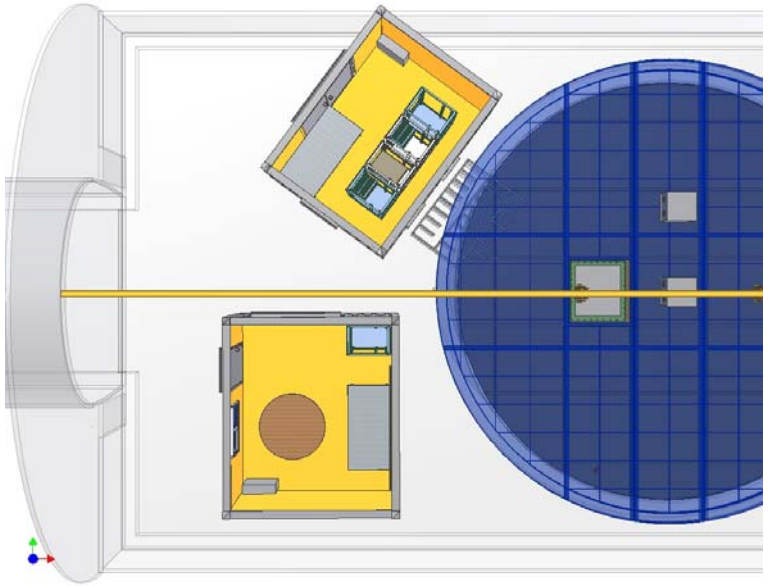


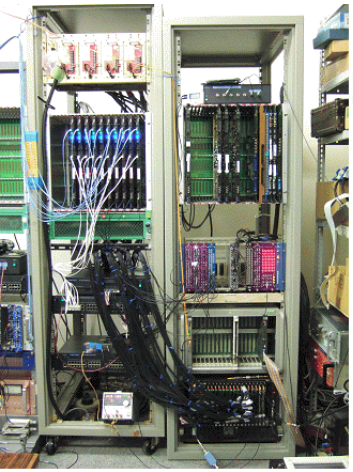
Near : Jan. 21, 2011

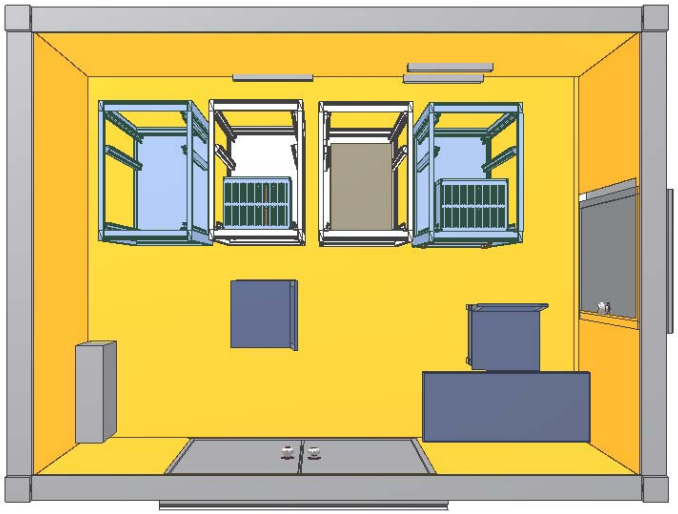
Far : Jan. 24, 2011

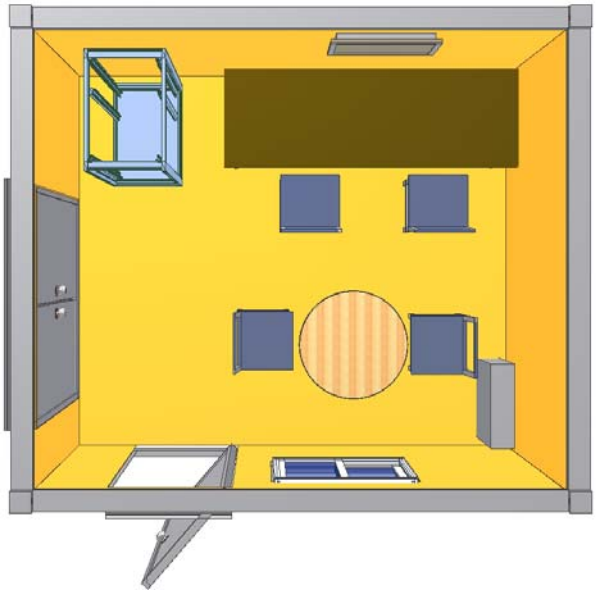
Design of Electronics Hut & Control Room (2010. 11)





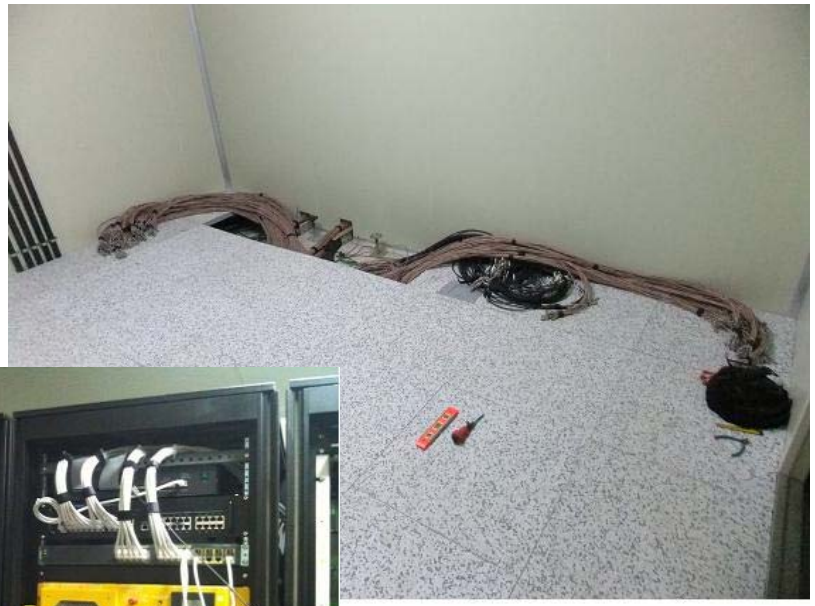


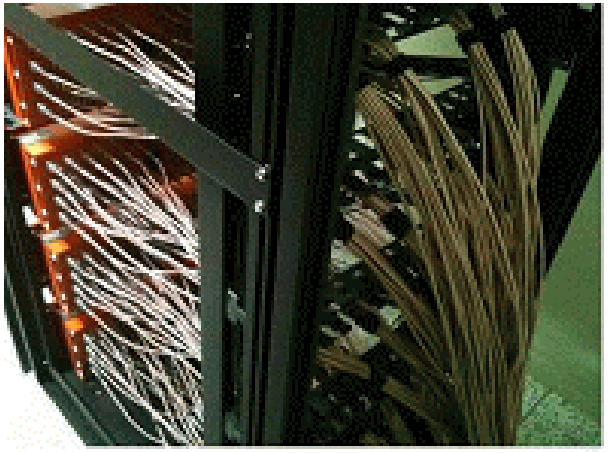


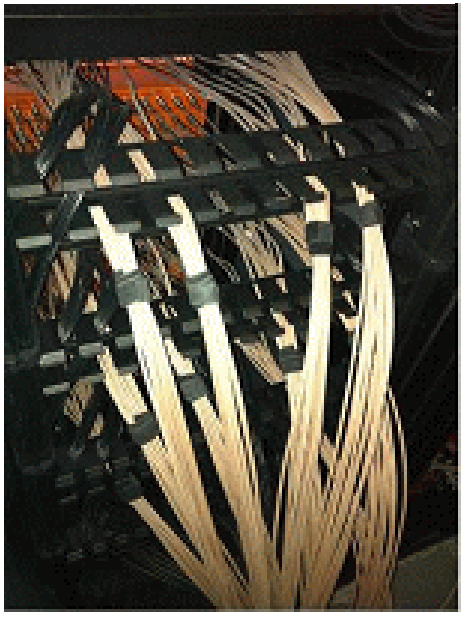


Electronics Hut & Control Room Installed (2011. 1)

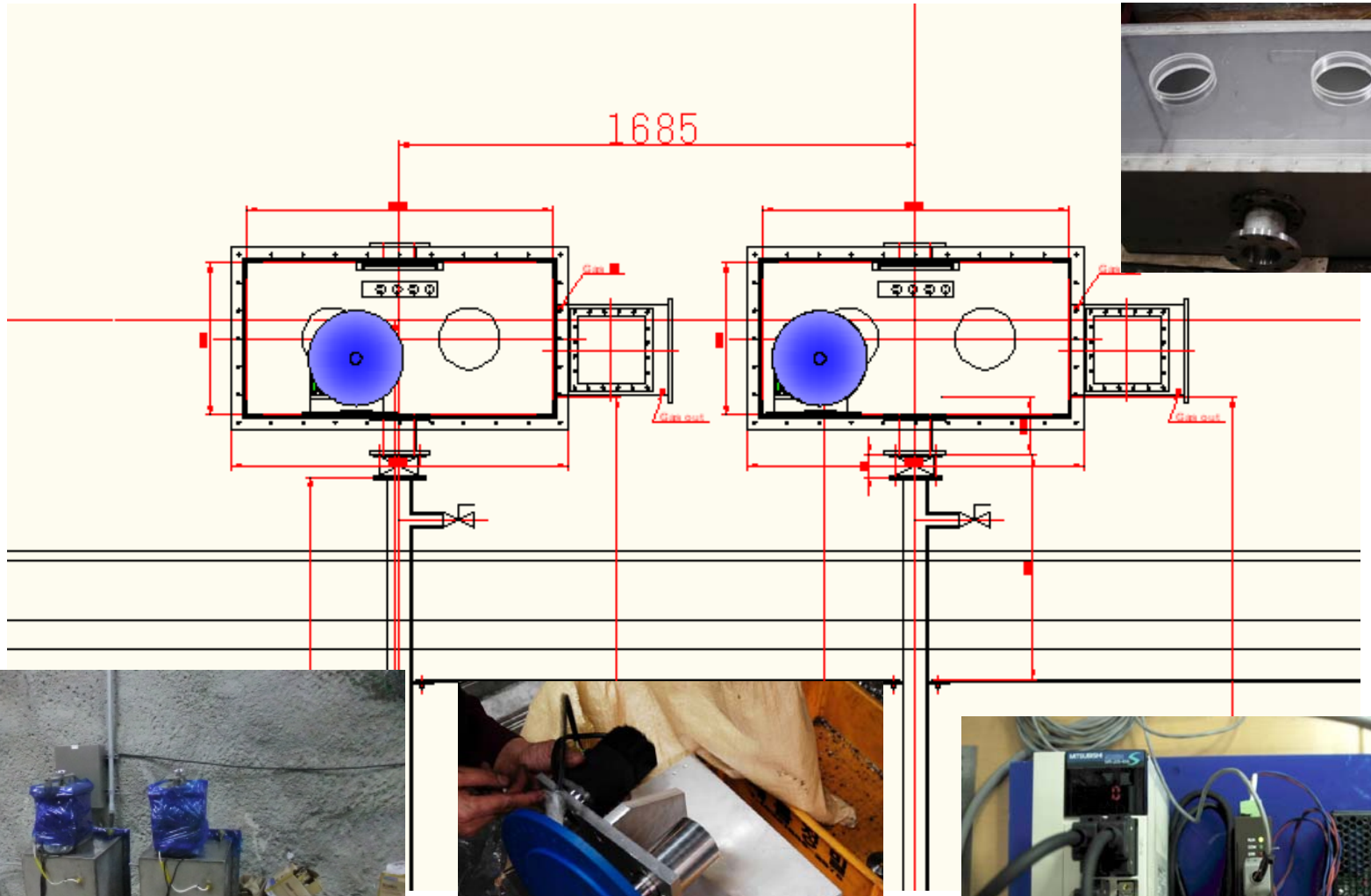
PMT Cable Connection to DAQ Electronics (2011. 2)

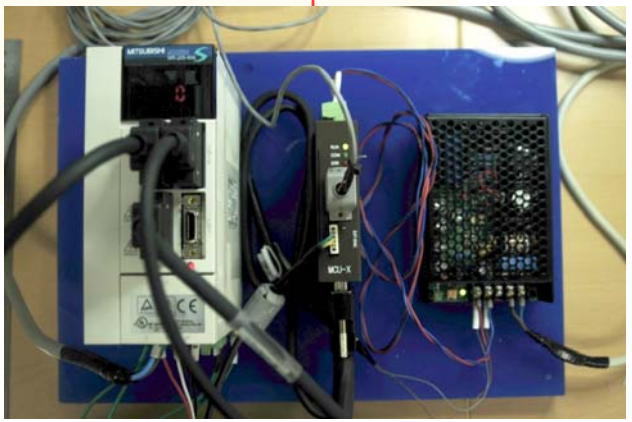




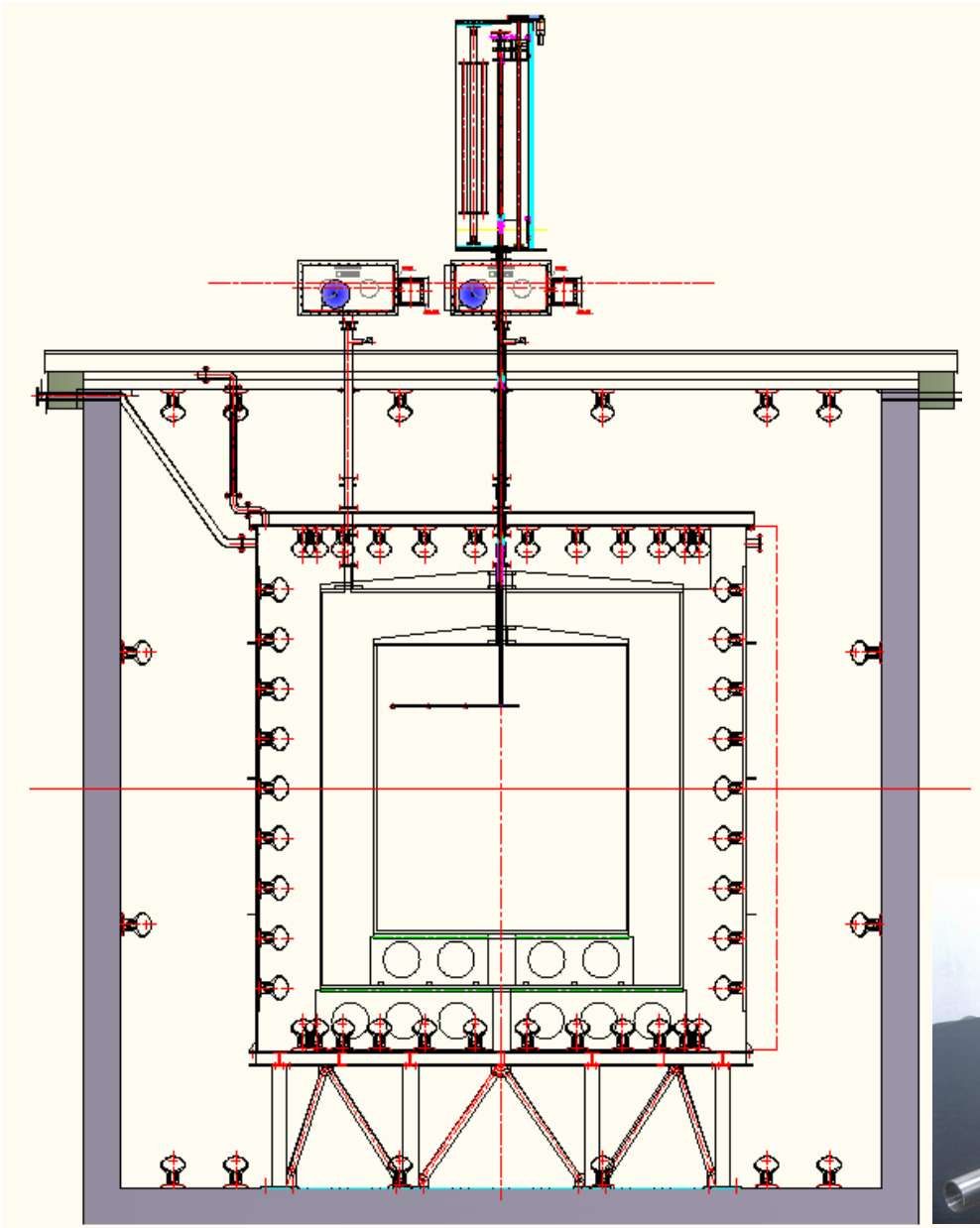


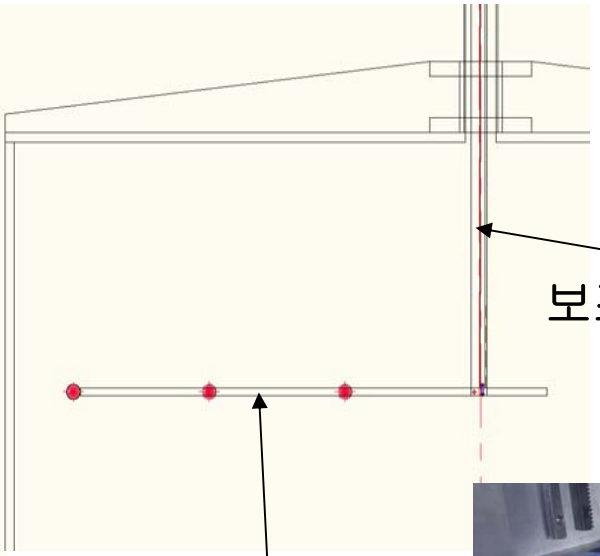
Glove Box and Source Driving System (2010. 10~12)

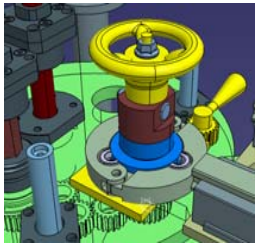




3D Calibration System (2010. 8 ~ 2011. 2)







Trailer Research Facility & Guest Room (2009. 11~2010. 2)

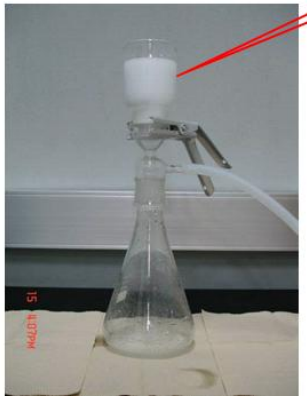
Gd loading into LAB

precipitation

$$RCOOH + NH_3 \cdot H_2O \rightarrow RCOONH_4 + H_2O$$

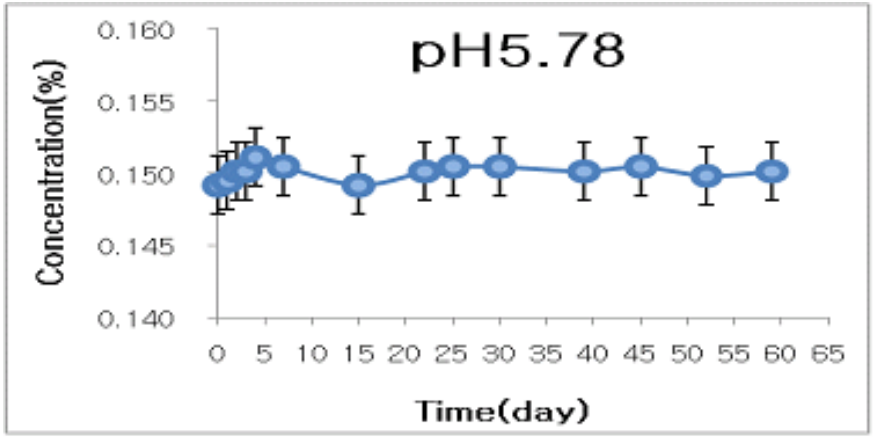
$$3RCOONH_4(aq.) + GdCl_3(aq.) \rightarrow Gd(RCOO)_3 + 3NH_4Cl$$

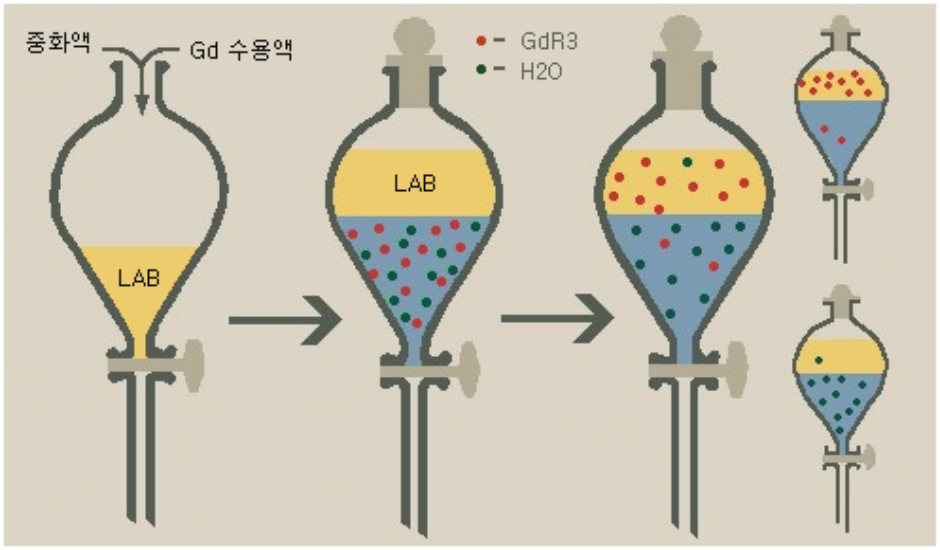
Rinse with 18MΩ water



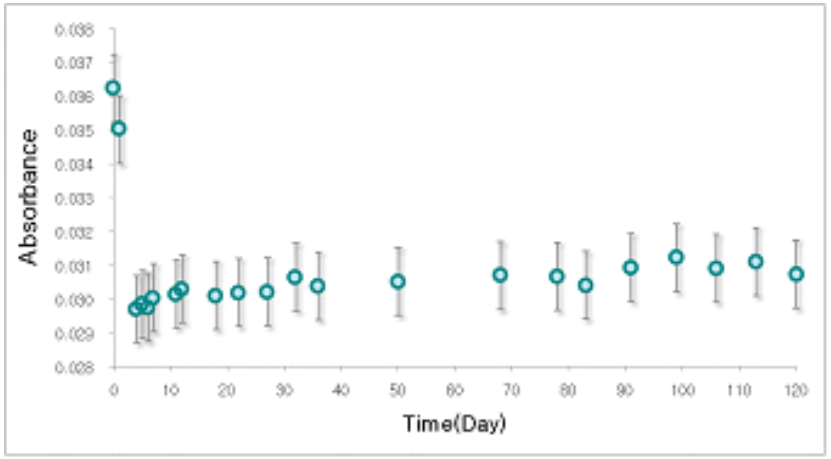
Dryer

Stability of Gd concentration





Stability of Absorbance



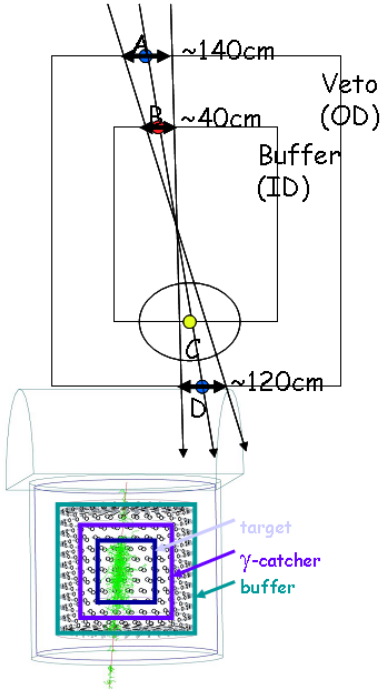
Liquid Production System (2010. 11~2011. 3)

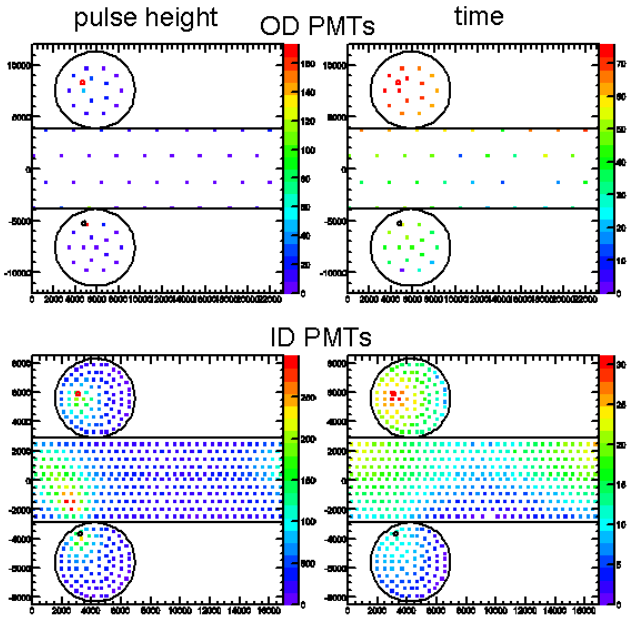
RENO Event Display & Analysis Code

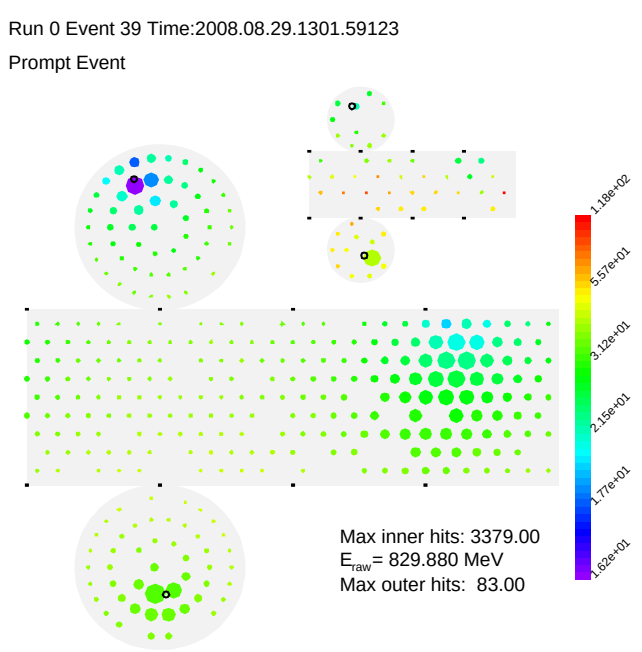
RENO Analysis Control

RACFrameWork

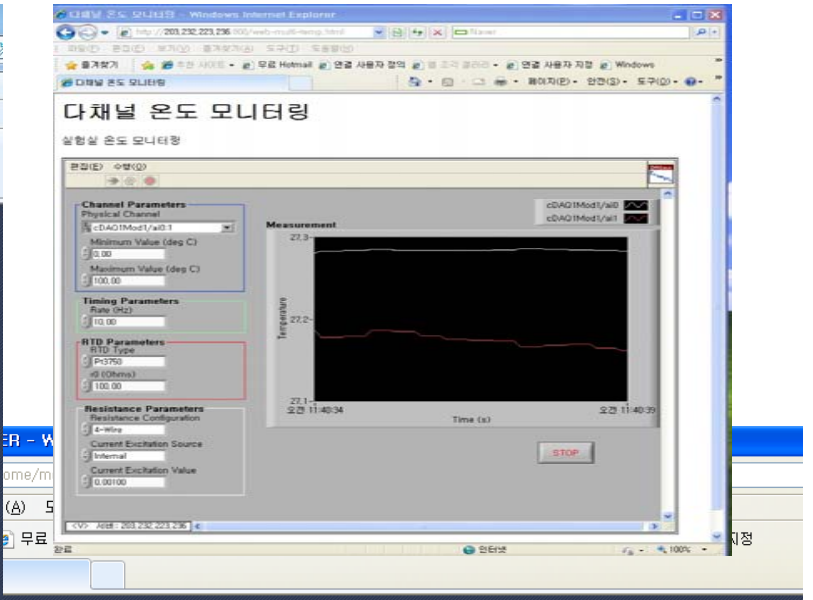
- MC :
- Reconstruction programs
- Event display

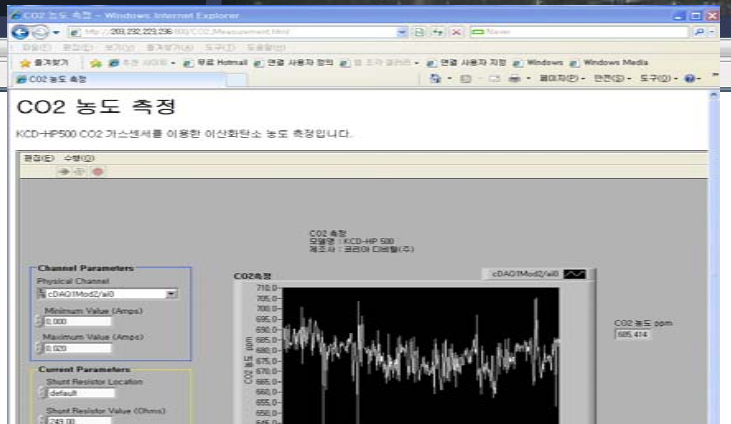






Detector Monitoring System (2010. 12~2011. 2)





Summary

- RENO is expected to measure θ_{13} **if $\sin^2(2\theta_{13}) > 0.02$**
- RENO construction is basically completed.
- LS production system is ready to fill the detectors.
- Data –taking is expected to start in May 2011.
- International collaborators are welcome to join this exciting journey!

Thank you!

서울대 김수봉 교수가 이끄는 RENO 실험팀. 30여년간 관측에 실패한 마지막 중성미자 변환상수를 밝히기 위해 프랑스 중국과 치열한 경주를 벌이고 있다.