KNO (Korean Neutrino Observatory)

"**Detector Plan for Korea Neutrino Observatory** "

(On behalf of KNO detector R&D group)

K.K. Joo

(KNO detector R&D group convener)

Chonnam National University

July 11, 2019

KAIST-KAIX Workshop for Future Particle Accelerators @KAIST

KNO detector group R&D lists

1st setup meeting for KNO R&D group was called on Dec18, 2018 (by Prof. HJ Kim)
- KNO R&D group skype/offline meeting (2019/01, 0308, 0312, 05)
- Currently, ~40 peoples are on the lists & jobs will be assigned (in progress)

main topics

1) Detector hardware performance simulation
   Detector configuration, energy threshold, energy resolution optimization.
2) Detector materials
   Water purification, LSC or Gd-doping option
3) Photo. Sensor
   (1) PMT by Silicon base
   (2) Photo-sensor by gas
4) Electronics & DAQ
5) Proto-type
6) Tank and mechanical design
7) Detector calibration (source, LED, laser)
8) Computing, software, DB
9) Monitoring, safety etc

KNO

J-PARC off-axis neutrino beam comes to Korea
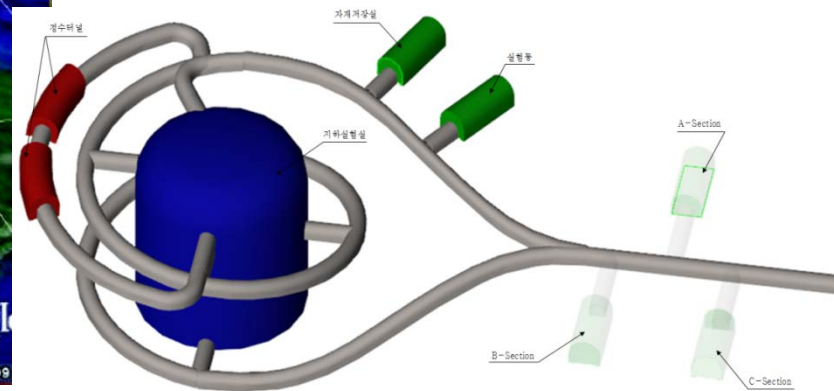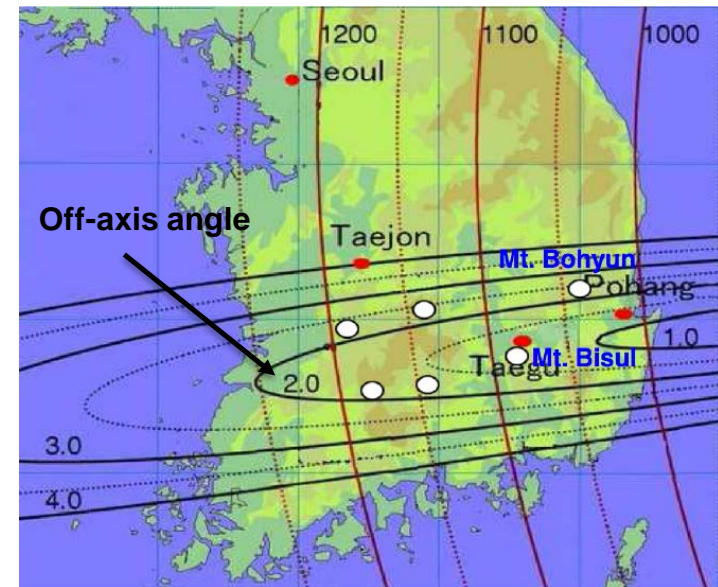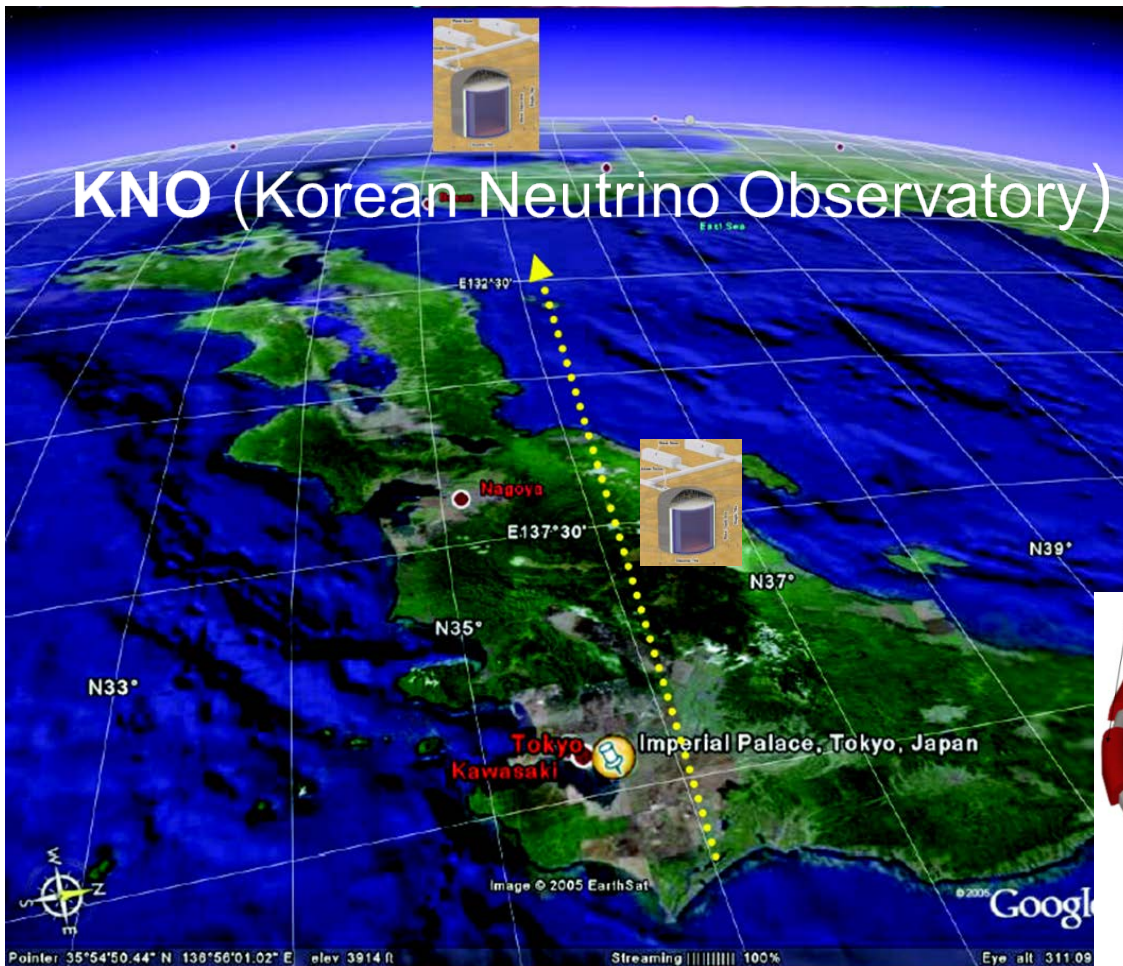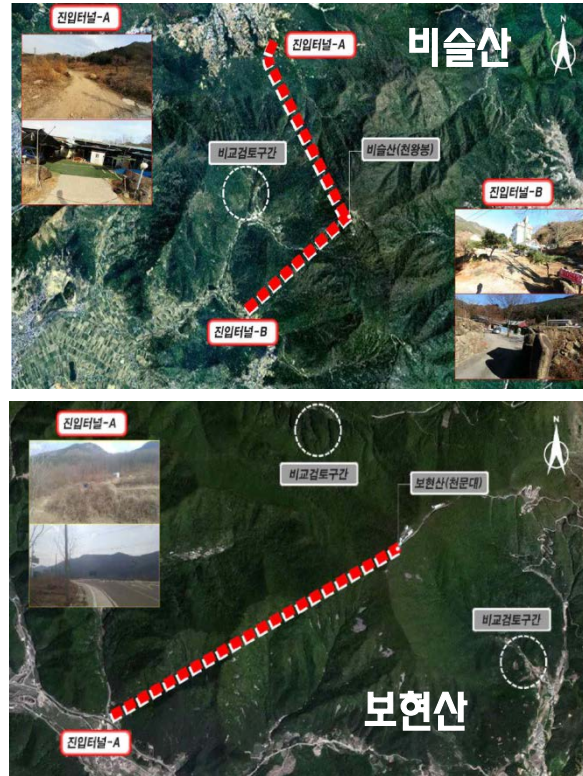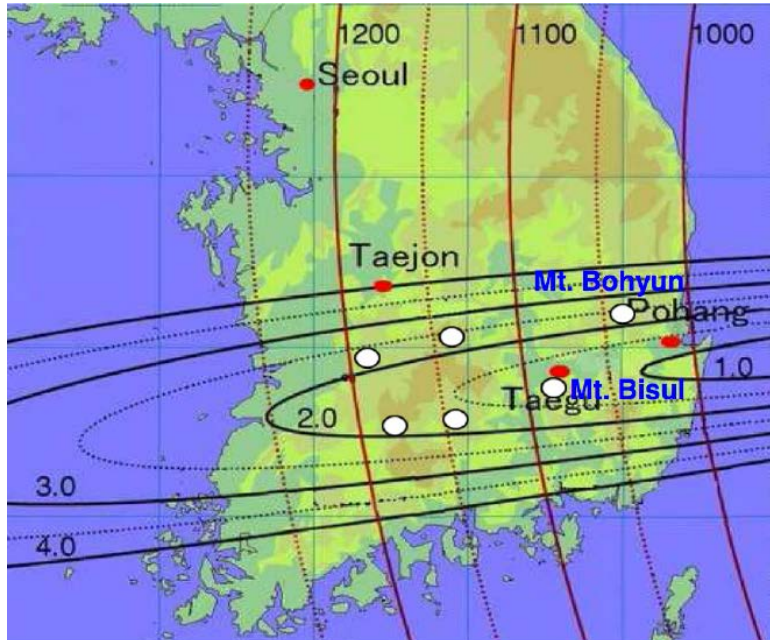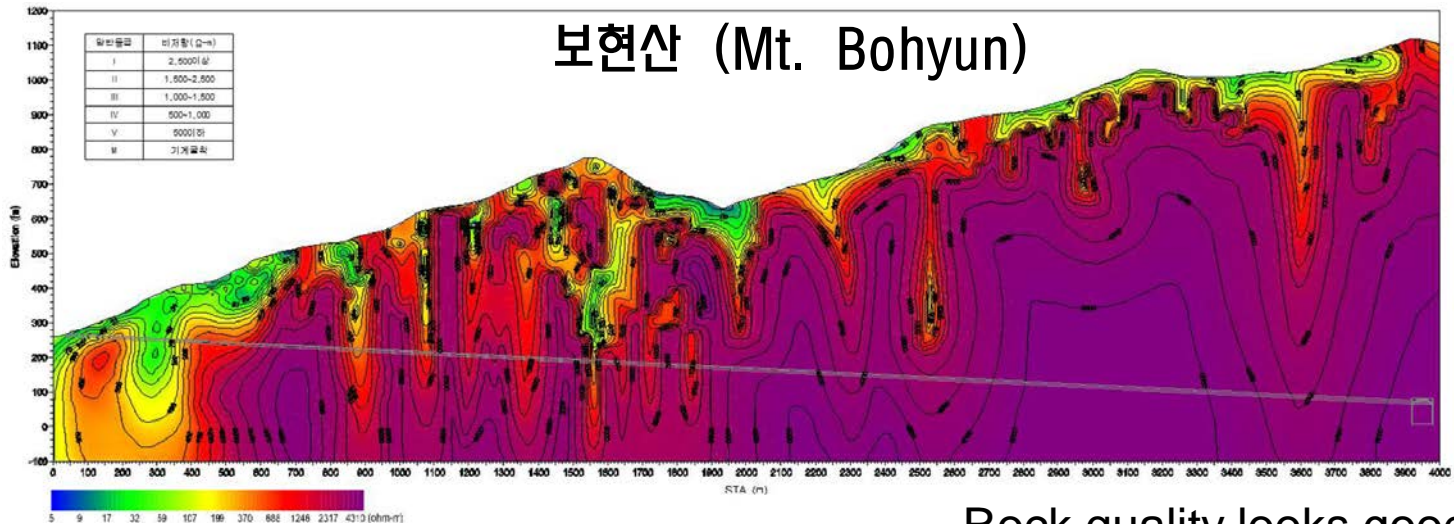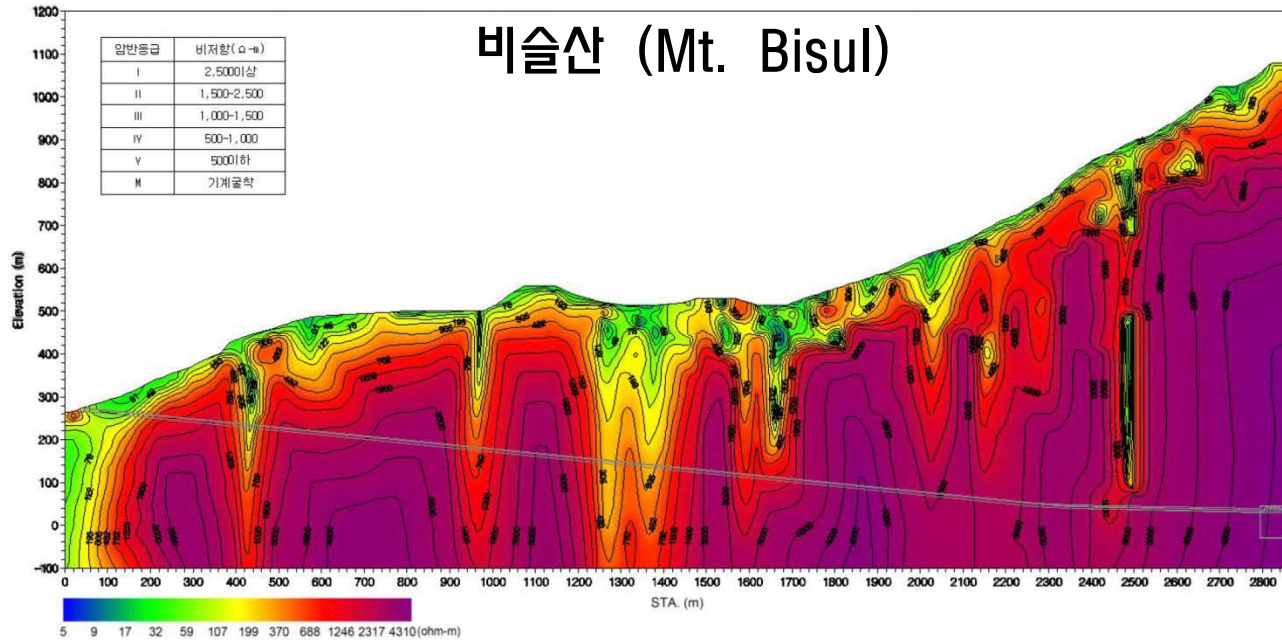
KNO Candidate Sites

- Bidding process for geological survey/tunnel design company was done (May, 2017)

- Seo young engineering company surveyed surface and underground of Mt. Bisul & Mt. Bohyun (1.5억원, ~$0.15M) (June, 2017)

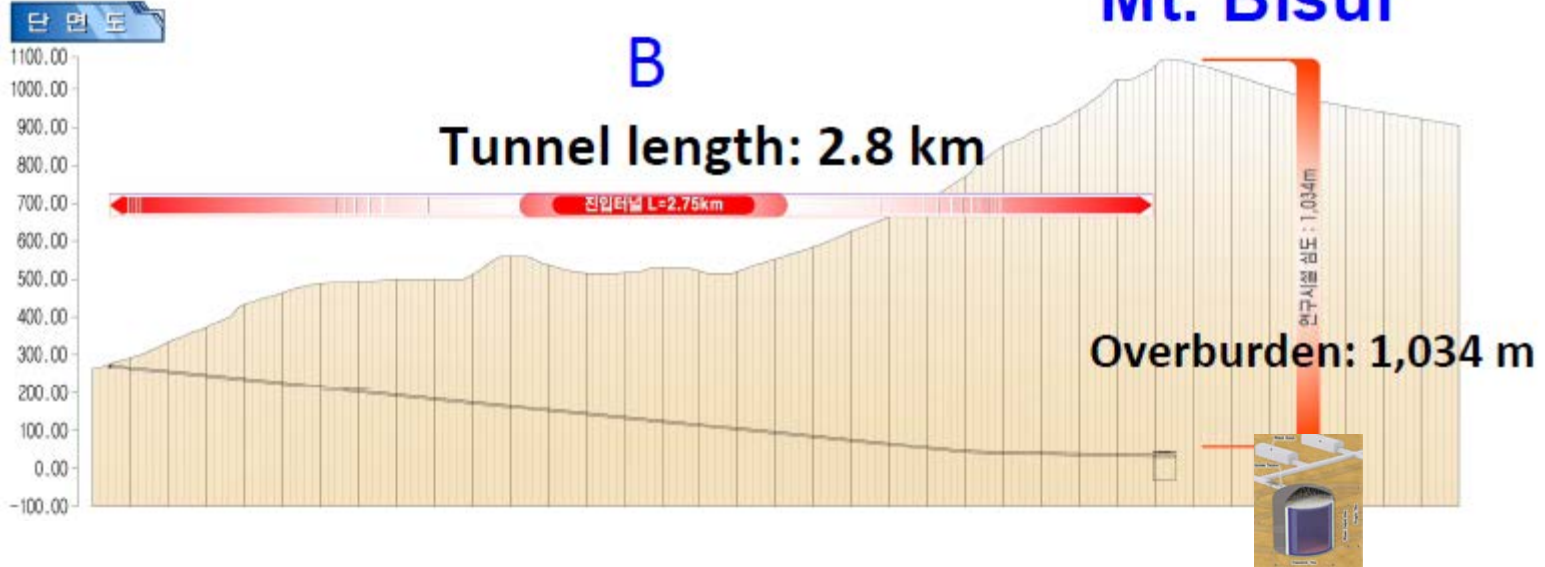- Conceptual design and construction cost estimation through stress analysis was reported (July, 2017)

KNO Rock Strength of Underground

비슬산 (Mt. Bisul)

보현산 (Mt. Bohyun)

Rock quality looks good

KNO Underground Facility

B구간 진입시 종단면도

단면도

B

Mt. Bisul

Tunnel length: 2.8 km

진입터널 L=2.75km

Overburden: 1,034 m

A구간 진입시 종단면도

단면도

Mt. Bohyun

Tunnel length: 3.9 km

진입터널 L=3.88km

Overburden: 1,038 m
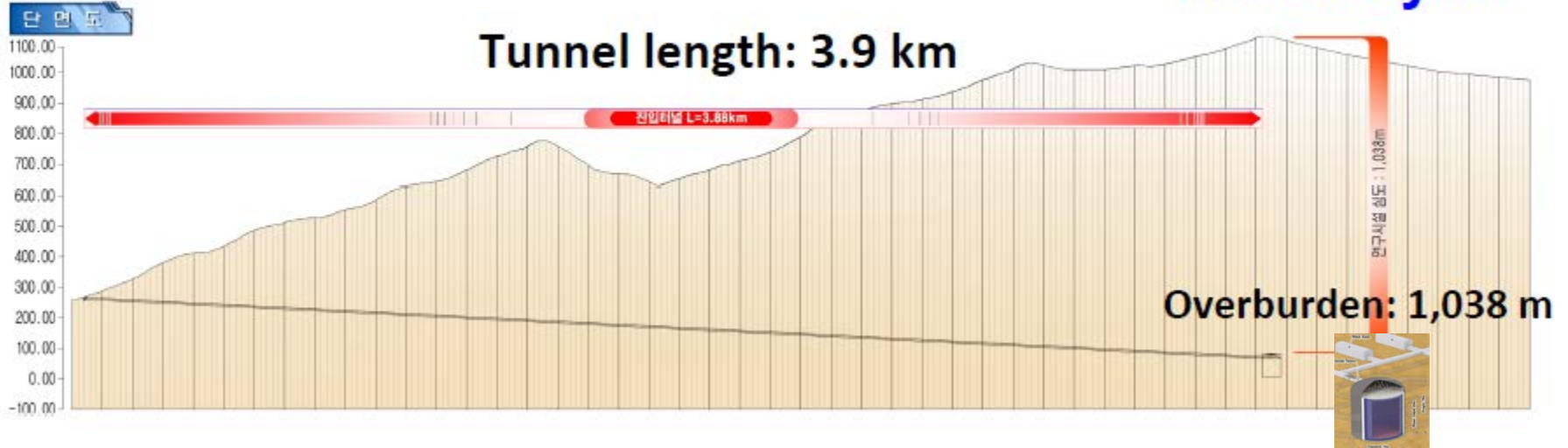
Stress Analysis for Tunnel Design
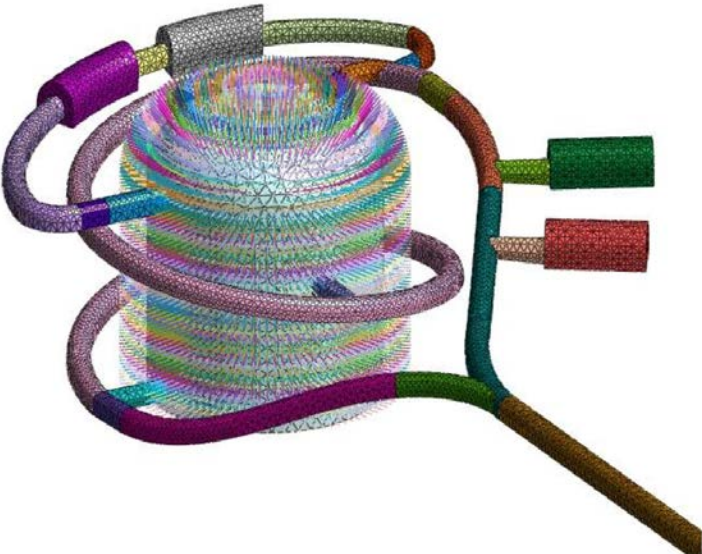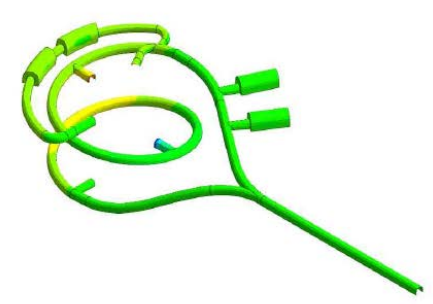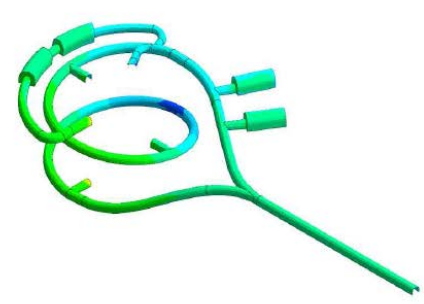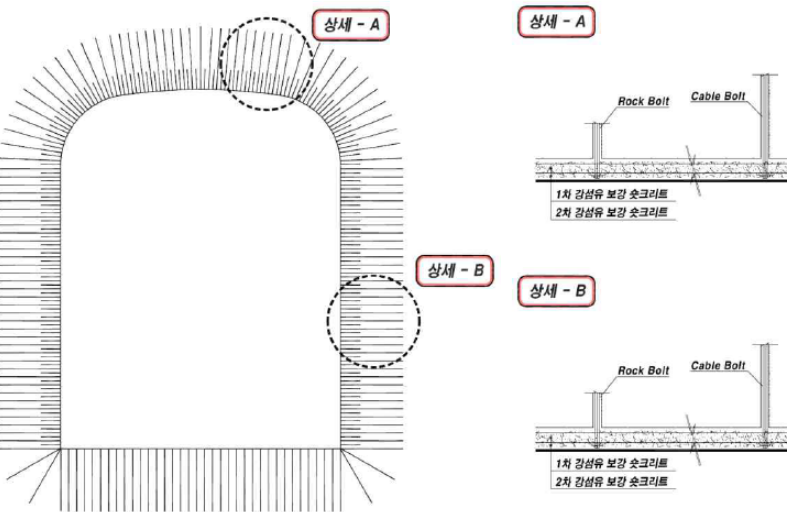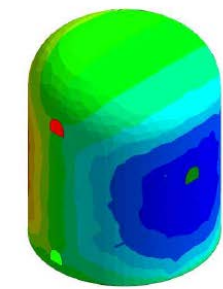
■ **예상된 지하시설 구축 비용: 600~700 억원**

Estimated cost for tunnel: $60 ~ 70M

■ Estimate quantity & quality of underground water

Experimental Hall (Cavern)

종단면도

Design and development of water purification system

Prof. SB Kim (SNU)

- With the help of HK, Decotech company completed cost estimation
- Amount of ultrapure water: initial ~78 m^3/hr   circulation supply ~310 m^3

Measurement of water quality at Mt. Bisul

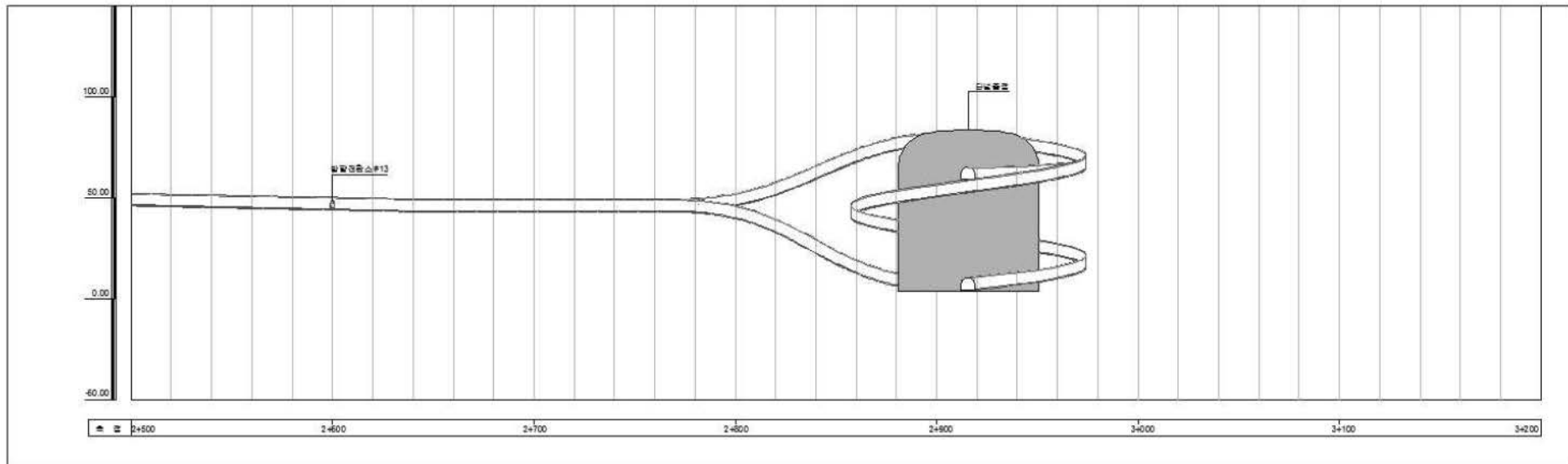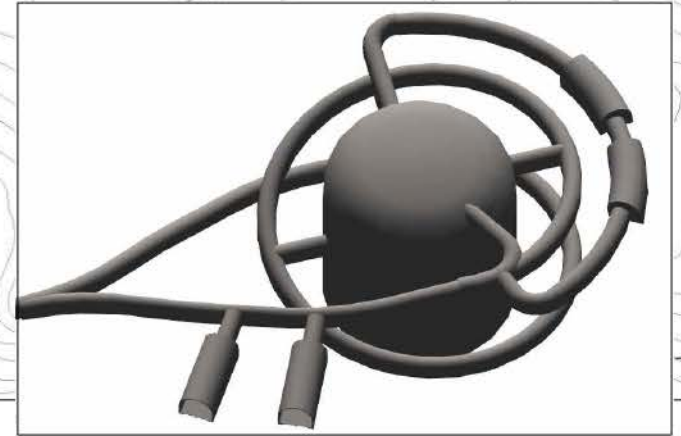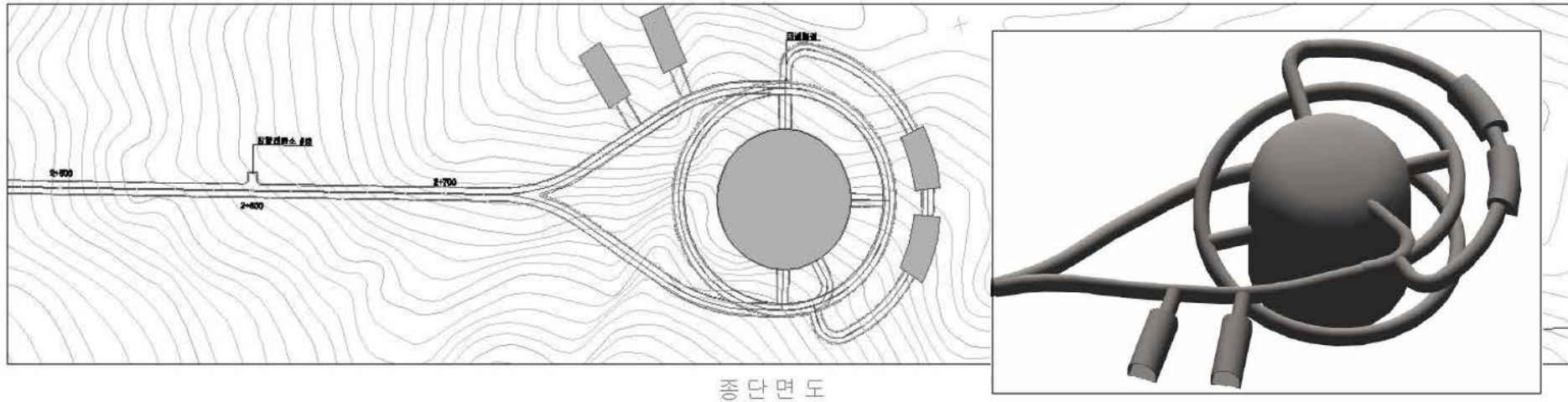| 항목	유가사 밑 (입구)	유가사 약수 지붕	비슬산수련원 참숯찜질방		
pH	6.33	6.45	7.39		
COND	30.3	31.6	94.7		
Turb	0.56	0.19	0.59		
T-Al (ppm CaCO3)	2.2	2.5	19.6		
Cl	3.5	3.7	11.6		
SO_4	2.5	2.3	3.3		
Aluminum	TR	TR	TR		
Ba	TR	TR	TR		
Ca (ppm CaCO3)	4.7	4.17	23.1		
Cu	TR	TR	TR		
Fe	TR	TR	TR		
K	0.2	0.17	0.11		
Mg(ppm CaCO3)	1.68	1.64	6.64		
Mn	TR	TR	TR		
Na	2.07	2.27	6.80		
P	TR	TR	TR		
Zn	TR	TR	TR		
SiO_2	6.4	6.62	24.6		
Sr	TR	TR	TR		
TOC	10.8	1.06	0.23		
SS	2.0	0.0	1.8		
Comments					
분석자	석 다 영				

* 시험방법 : ASTM에 의한 ICP와 TITRATION방법

- Water samples from Mt. Bisul was collected
- Water quality is found to be excellent and easy to make water transparency ~100 m by the KNO water purification system.

Development of radon vacuum degasifier (VD)

- 96% Rn removal efficiency to lower trigger efficiency at ~5 MeV (99% oxygen)
- HK: 300 tons/hr (3-4 M$/tower) ← SK: 60 tons/hr (1 M$/tower)
- Electric polished vacuum SUS tower: ~3 kPa
- Vacuum pump (SK): 410 m^3/hr, 11 KW

SK vacuum degasifier tower

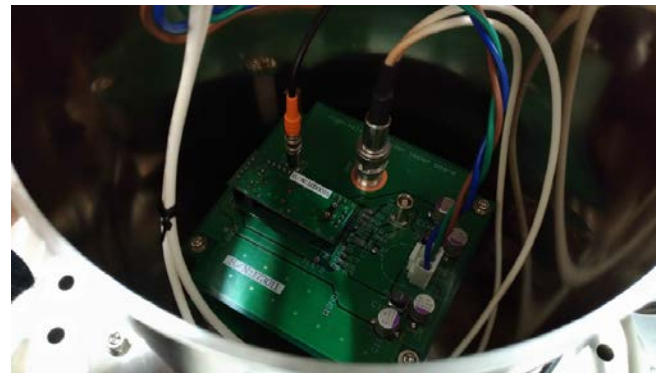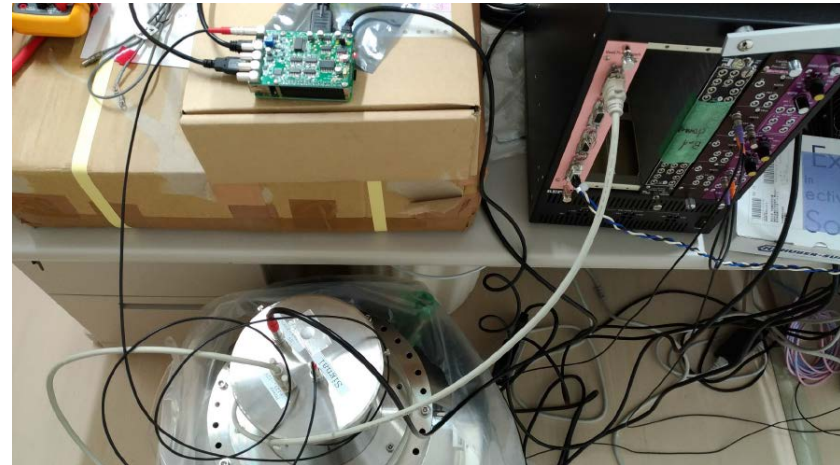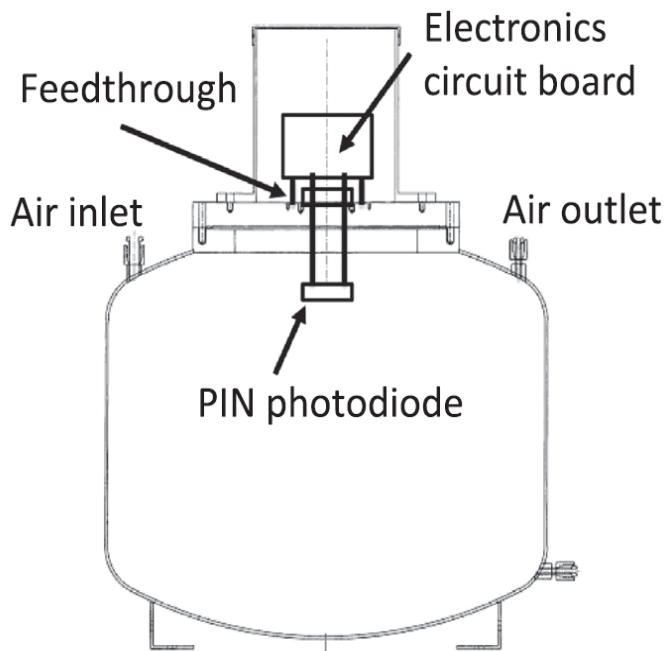

■ **Developing a prototype VD with DICOTECH Co.**

Key point: increase surface area by spraying

Radon measuring device in water

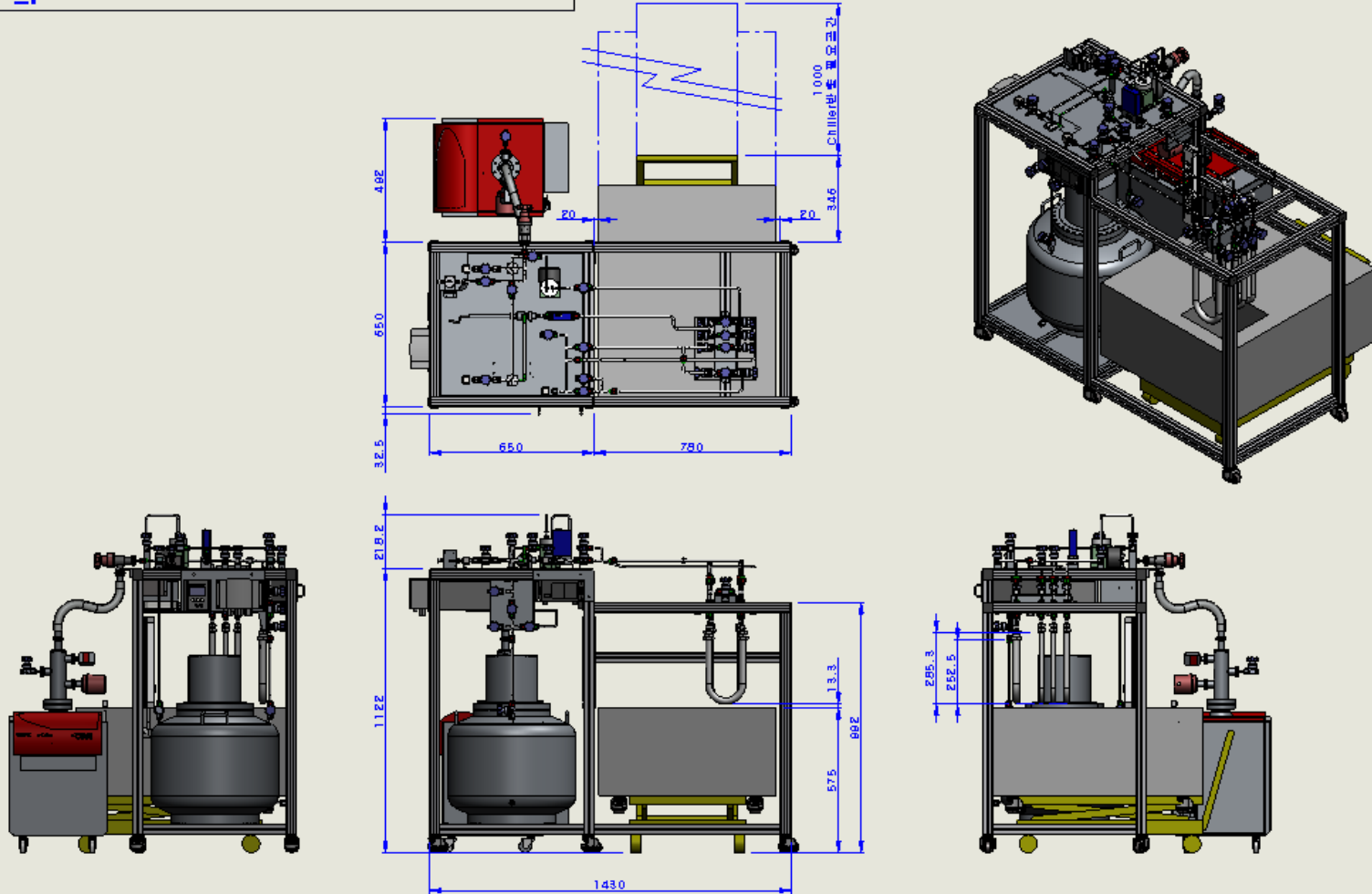**Prof. SB Kim (SNU)**

- 80 L SUS vacuum container with electric polishing:

- PIN photodiode sensor (Hamamatsu S3204-09 at -1.9 kV)

- Vacuum feedthrough and copper gaskets

- DAQ electric module system

→ Expected sensitivity of Rn concentration measurement: ± 0.1 mBq/m^3

Feedthrough

Electronics circuit board

Air inlet

Air outlet

PIN photodiode

Design for radon measuring device

PMT (status)

- PMT is an essential component in KNO

- Goal: replacing Hamamatsu Photonics Co. that exclusively produce large-diameter (~50cm) PMT in the world market

- Cooperate with Russian research institutes to seek domestic production through technology transfer (SNU, KNU, UOS, 메카로㈜ joint research in progress)

- Require uniform adsorption of alkali metal on glass surface and technology to assemble after installing dynode in the vacuum chamber

- First, developing 3 inches PMT, gradually moving to larger inches (also, trying a substitute for a large-diameter PMT made up of several small modules)
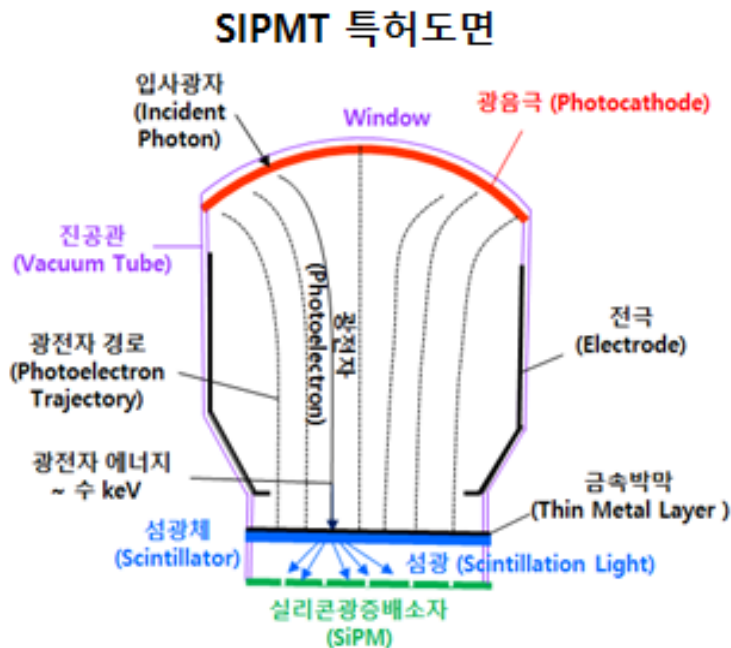
PMT

- In order to acquire photocathode deposition technology & vacuum packing, visit Russia Ektran company & BINP lab in May 2019

- UOS/메카로㈜ : developing photocathode alkali metal deposition technology by using dynode fabrication technology & Atomic Layer Deposition (ALD) , **(Prof I K Park)**

- KNU : Developing SiPMT to improve photon detection efficiency & resolution

Prof. HJ Kim, J. Lee (KNU)

SIPMT 특허도면

입사광자 (Incident Photon)
Window
광음극 (Photocathode)
진공관 (Vacuum Tube)
광전자 (Photoelectron)
광전자 경로 (Photoelectron Trajectory)
전극 (Electrode)
광전자 에너지 ~ 수 keV
금속박막 (Thin Metal Layer)
섬광체 (Scintillator)
섬광 (Scintillation Light)
실리콘광증배소자 (SiPM)

Photocathode + Vacuum Tube + Scintillator + SiPM

BINP 2" Photo-triode

Summary

- Recently KNO R&D group has been established and need to find more universities, institutes, people etc

- Several major job lists are set (various R&D for water purification, PMT in progress)

- Geological survey & tunnel design are in progress

- Seems to be various situation rapidly developing related to KNO (issue paper, block funding, etc by NRF)

- Welcome to join (KNO project)