Conceptual Design Works on the Single Tunnel Configuration in Mountain Regions

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KEK-CFS

AAA Conventional Facility Working Group

AAA

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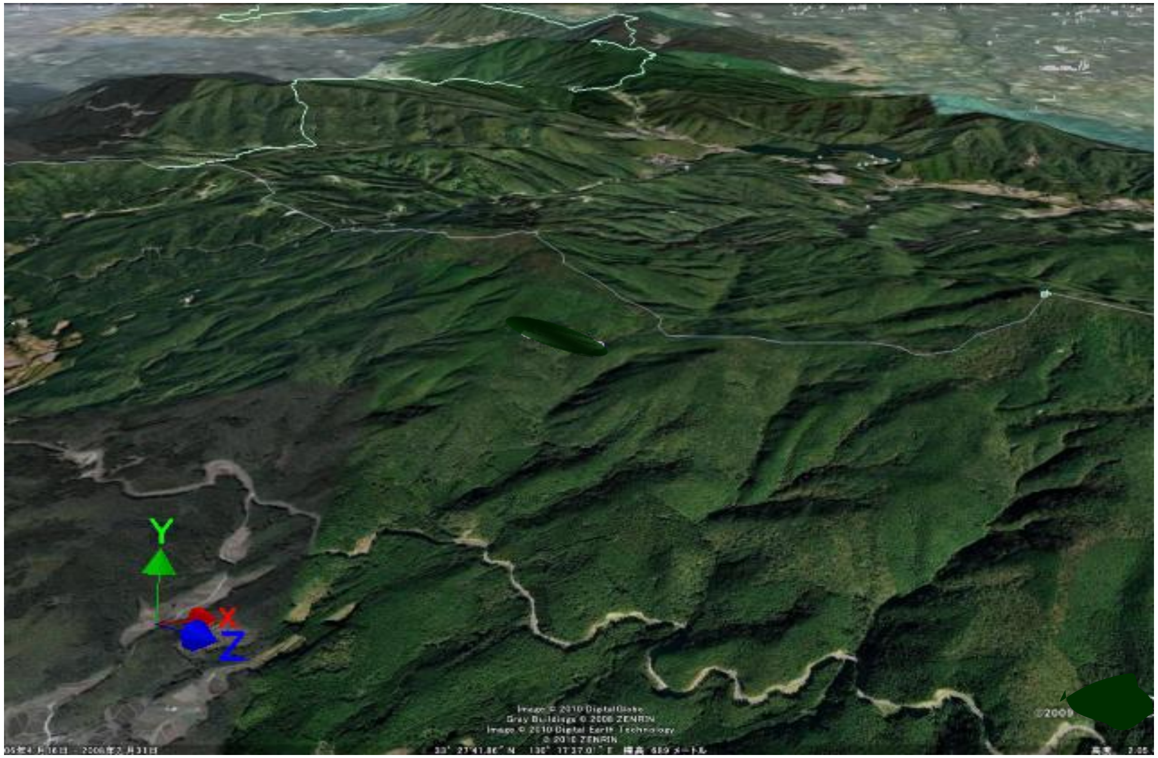
Presentation Outline

- *Introduction*
- *Design Works on Conventional Facility*
- *Recent Development and Some Issues*
- *Summary*

Introduction



Object of this Design Works

This Report is Conceptual Design Works about the Single Tunnel Configuration in the ILC Conventional Facility in Mountain Regions

1. *We Studied the Feasibility of the ILC Accelerator Facility Plan in the Japanese Mountainous Regions from the Side of the Civil Engineering*

2. *We Studied a Plan Based on the Situation and the Reality that were Peculiar to the Japanese Mountains Site*

Basic Proposition of the Works

Technical Study on the Following Main Issues about the ILC Accelerator Facility Design in the Mountainous Region

- ***Harmonized Design With the Complicated Topography and Natural Environments***
- ***Drainage Design of the Ground Water : Important Issue to Control the Success or Failure of the Project in the Mountain Area***
- ***Coolant Facility Design to Control the Thermal Energy in the Tunnel: Cooling Water Issue***
- ***Power Supply System Design as the Core Facility of Energy Source of the Accelerator***

A Characteristic of Asian Sample Site

1. All the Sample Site is Located on the Stable Bedrock Such as the Granite Zone
2. Mountain Site Generally Form the Complicated Topology
3. Surface is almost Forest Zone which is full of Nature, But some Districts are developed as a Ranch Area , Farmland, and Residential Neighborhood
4. Some Rivers Often Cross in the Area at Low Altitudes
5. Even If the Bedrock of the Sample Site is Good Granite, Should Predict that there is a Bad Ground Partially Because of a Long-Scale Tunneling Site

Precondition for Layout Planning (1)

1. Two Tunnels of Main Tunnel (MT) and Sub-Tunnel (ST) are basically arranged in Parallel

- Main Tunnel: Accelerator Tunnel for E^-E^+ Linac (Active use : Cryomodule and RF Facilities, etc)
- Sub Tunnel: Cooling-Water Piping, and Other many Functions Tunnel (Non Active use)

⇒ Reduce the CT Farm as much as Possible

⇒ Become Free from the Complicated Topography

Precondition for Layout Planning (2)

2. Place a Sub-Tunnel as the Pilot Tunnel

- Let the Sub-tunnel goes Ahead from a Main Tunnel, Serve as the Role of an Investigation and Drainage

⇒ Large Reduction of the Groundwater Processing and the Digging Risk

3. Plan the Tunnel Level to Higher Altitude as much as possible

- Assume the Cavern depth of the Collision Point around 100 Meters

⇒ The natural Discharge of the Groundwater Spring is Enable

Precondition for Layout Planning (3)

4. Install the Cryogenic Facilities (Compressor, Cold Box, Helium-Tank) in the underground as Possible

5. Plan the Number of Cooling Tower Farm at the Minimum to reduce Development of the Surface

6. Suppose the Quantity of Spring Water to be $0.9m^3$p/min/km and Plan the Free Discharge

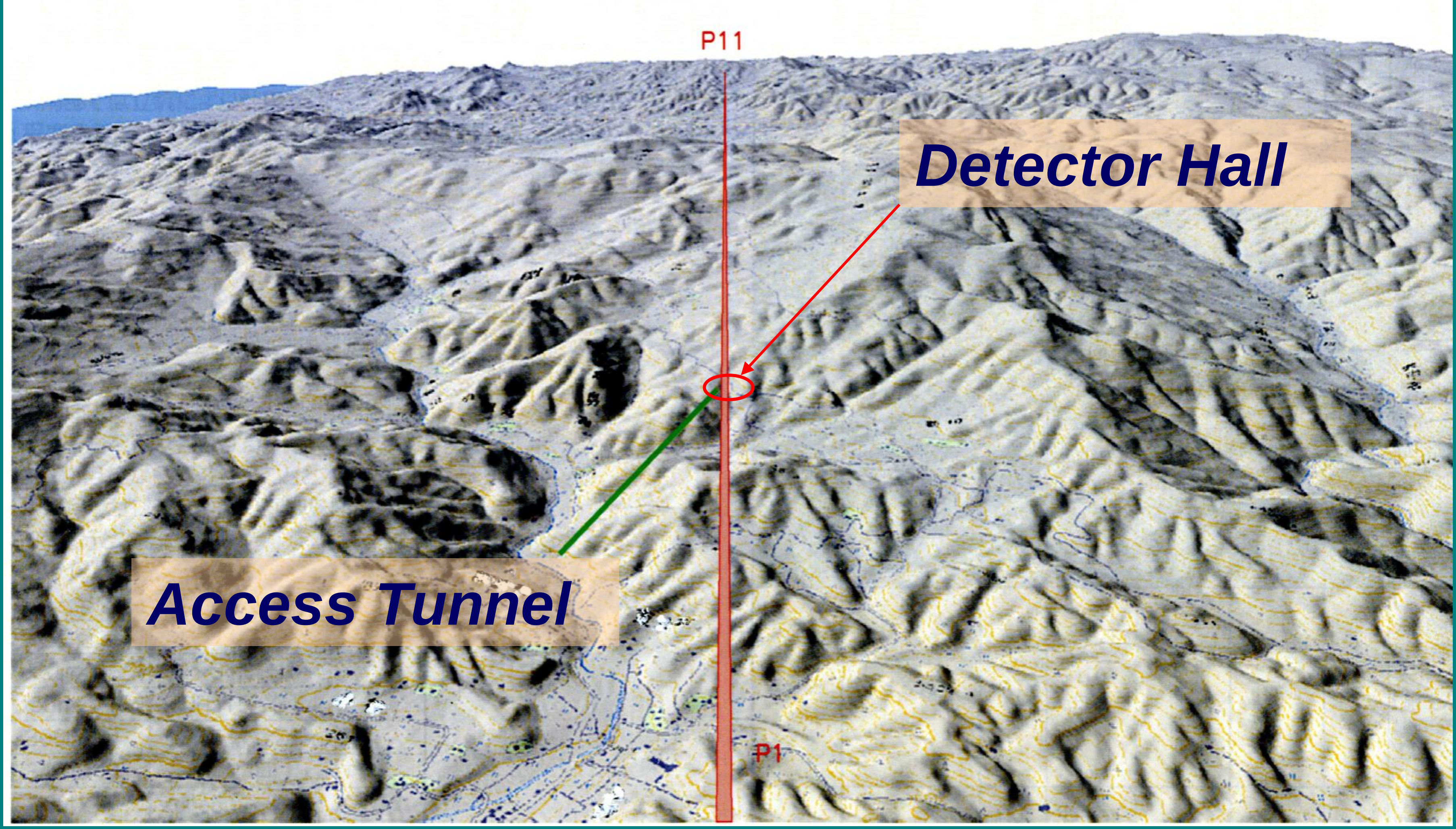
7. Division Number for Execution Work should be Decided in Consideration of the Construction Period and Individual Site Topography

Design Works on Conventional Facility

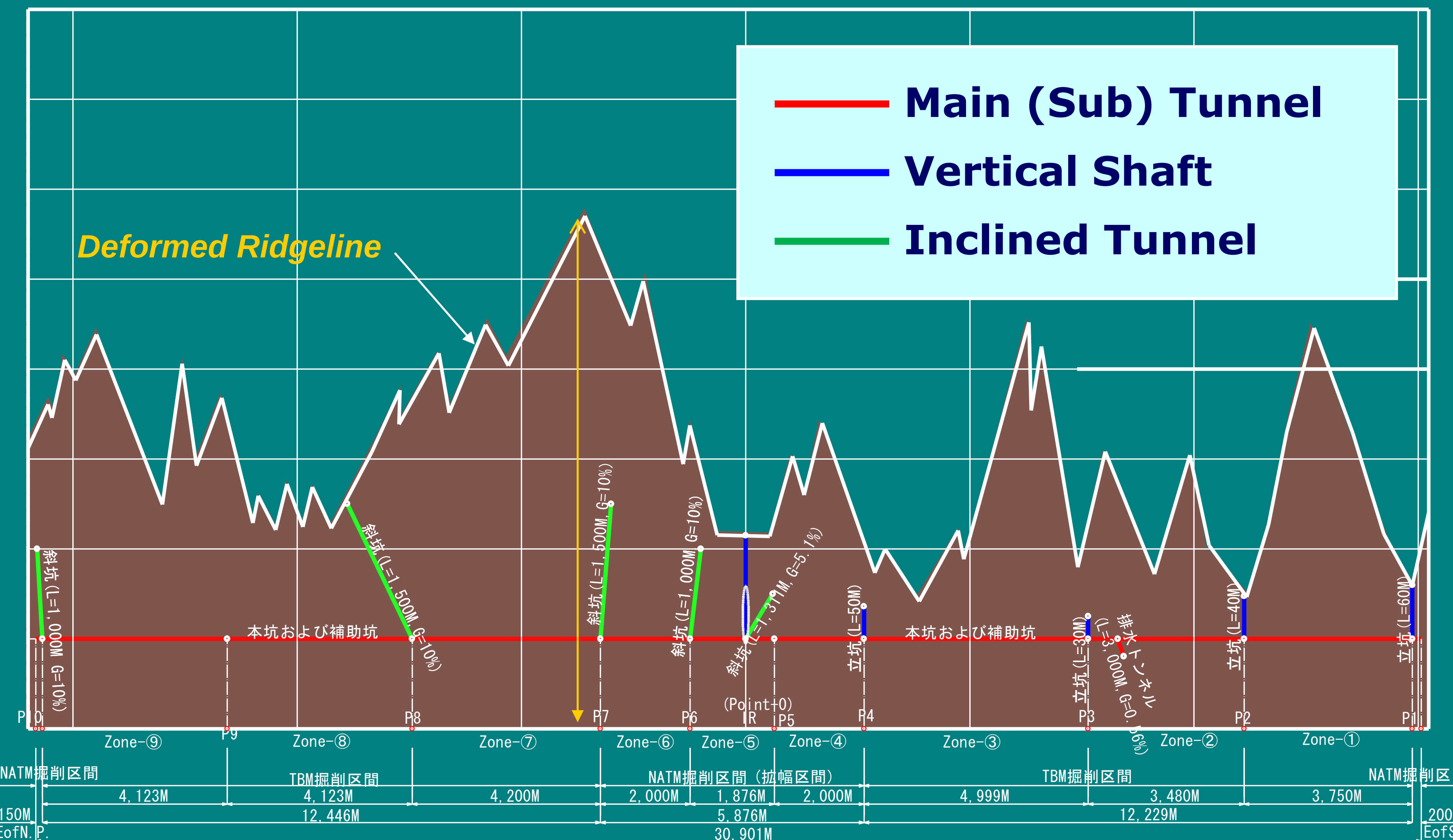
- *Layout Plan of the Underground Facilities*
- *Main Tunnel*
- *Sub-Tunnel & Access Tunnel*
- *Groundwater Drainage Scheme*
- *Cavern Design for the Detector Hall*
- *Cooling-water and Utilities*

Layout Plan of the Underground Facilities

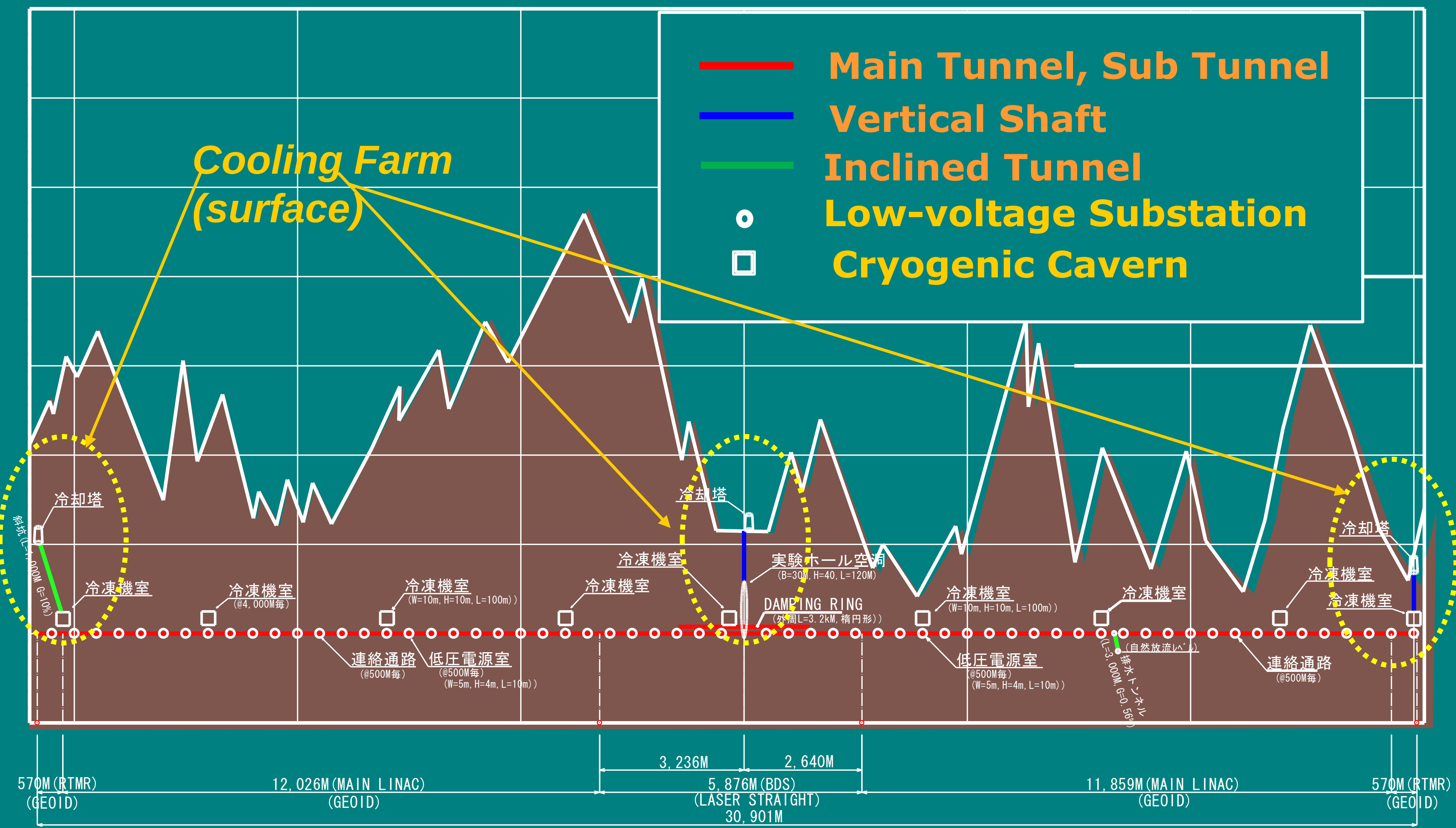
An Example of the Asian Sample Site



Layout: under Construction



Layout : after completion



Basic Policy on the Facility Planning (1)

1. Basic Plan of Tunnel Arrangement

- Security the Earth Covering on the Detector Hall more than minimum 100 meters
- Security the Earth Covering on the Main Tunnel and Sub Tunnel more than 2D (D=Tunnel Diameter)
- Security the Drainage of the Groundwater Spring from the Tunnel to the River of the Neighborhood

Basic Policy on the Facility Planning (2)

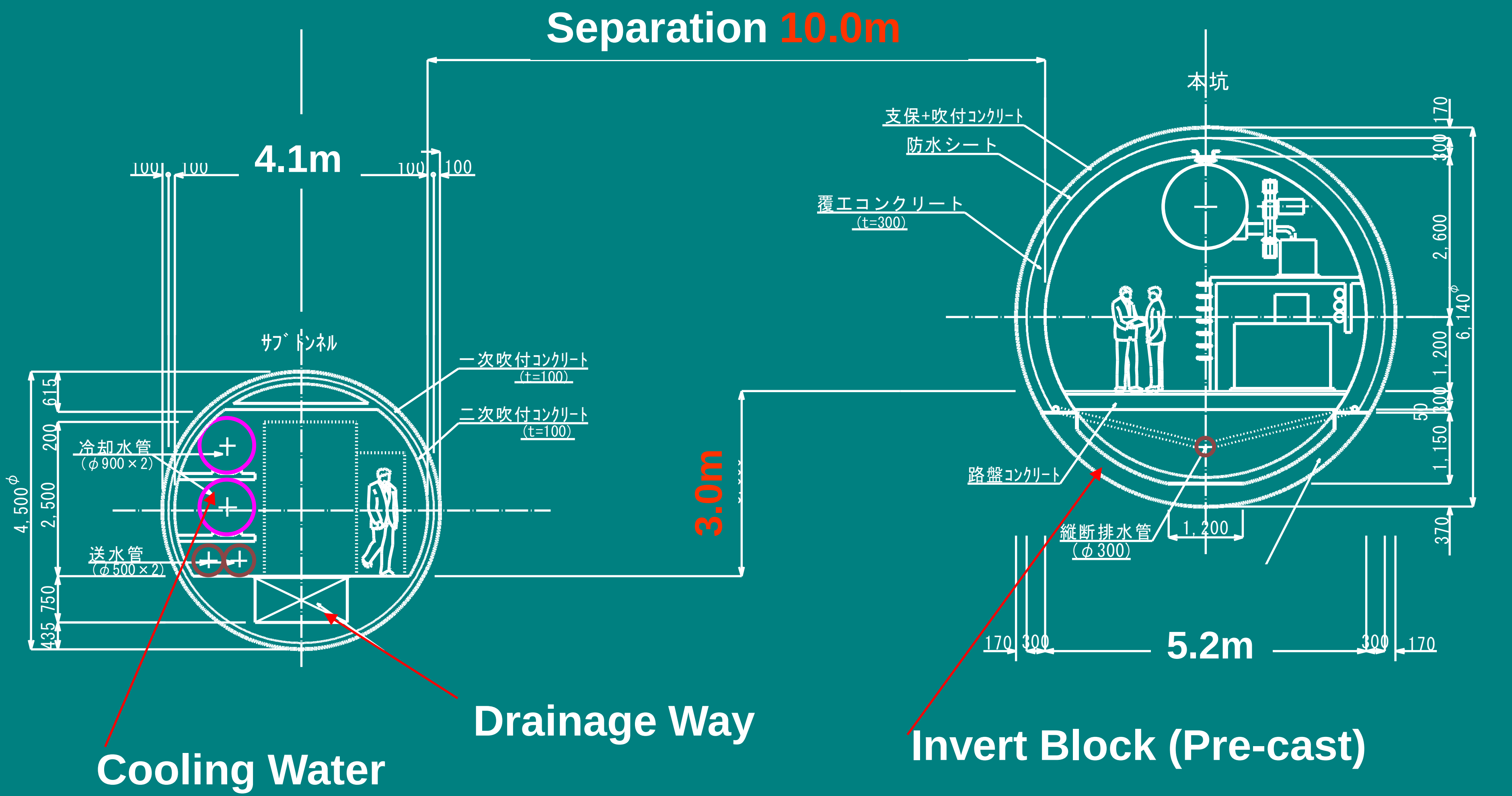
2. Separation between the Main Linac Tunnel and the Sub-Tunnel, other Tunnel

- Security the Separation Distance: 10 Meters (2D)

- Security the Level Difference: 3 meters

  Plan to Carry Away Groundwater from Main Tunnel to Sub-tunnel at a Natural Incline

Two Tunnels Layout



Basic Policy on the Facility Planning (3)

3. Access Tunnel

- Access Tunnels for Execution are Planned Vertical-Shaft or Inclined-Shaft (Slope Tunnel) according to the Site Geology

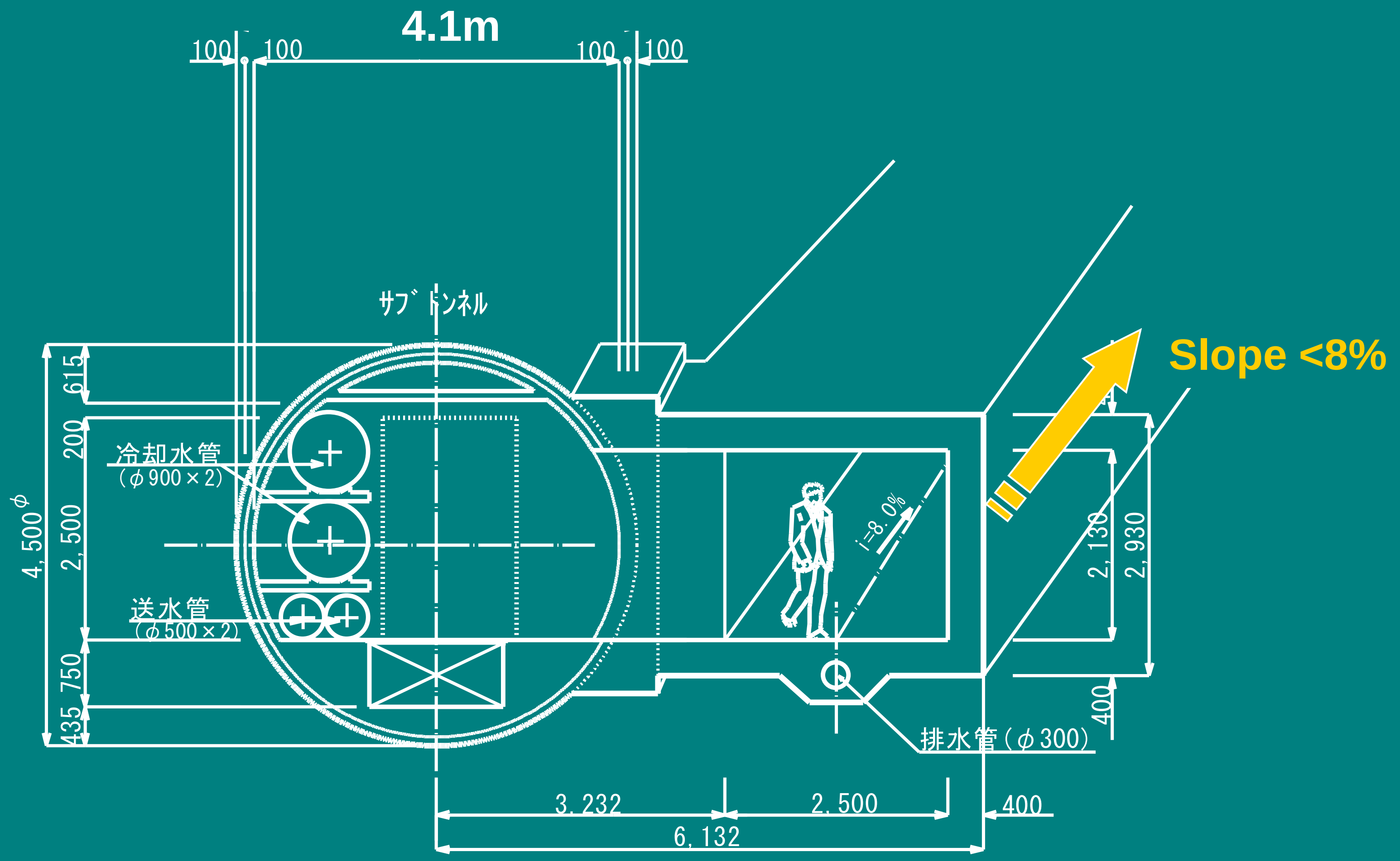
- Tunnel Excavation Method are selected TBM or NATM by the Each Geological Condition

Basic Policy on the Facility Planning (4)

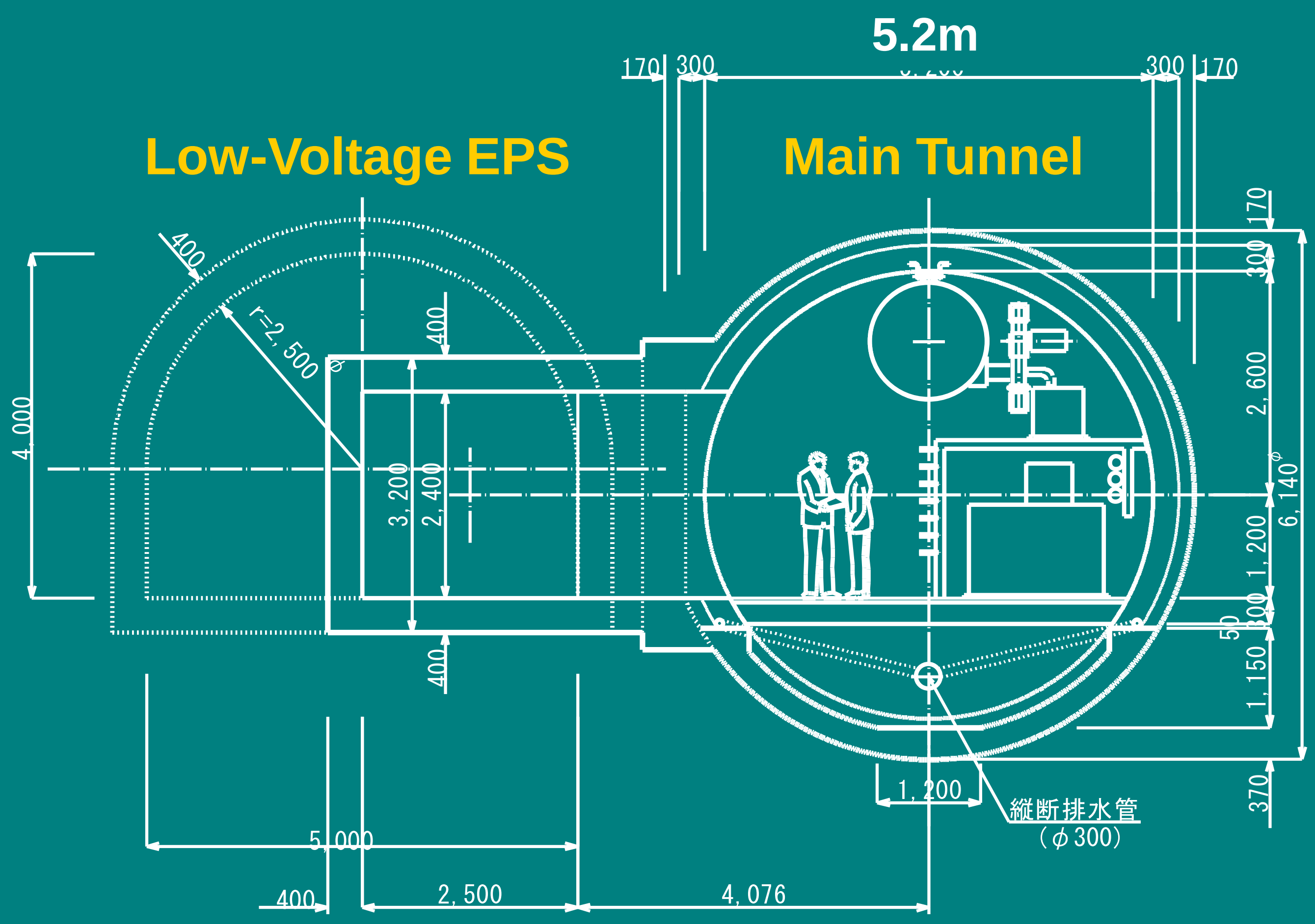
4. Connecting passage and Substation

- Connecting Passage is Planned Every 500m
- Passage is given an easier Slope to Consider the small-scale transportation
  (incline: about 8% and Under)
- Adoption of NATM as Excavation Method for Cave Tunnel (Include Substation beside the Main Linac Tunnel)

Sub-tunnel & Connection Passage



Main Tunnel & Low Voltage EPS



Main Linac Tunnel

Basic Design Policy

1. Tunnel Section

- Inner Space Dimension are Precondition from the Accelerator Device Side (Distributed RF System)
- Adopted it from the Demand Specification

⇨ Φ5.2m in Diameter (Inner diameter)

2. Tunnel Cross-Section

- Basic Assumption: a Good Site for the Geology
- Because a Pilot Tunnel Functions, Can Expect a Draining off Effect and Ground Information

⇨ Cercular Section: by Applied a TBM Excavation

Basic Design Policy

3. Radio Active Rays Management

- MLT is Set the Whole Line in the Radio Active Rays Management Area
- Lining Concrete in the Tunnel Inside :
  As Measures to Prevent the Radio-activation of Neighboring Ground water

⇒ WaterProofing of all Tunnel Laps

4. Drainage Type Tunnel

- Concept Like the general Mountains Tunnel

⇒ the Back Side Drainage System

Design and Specification

Vertical Shaft

- *Choice is possible in the case that Tunnel Depth is shallow (under 100 meters)*
- *About 9 meters in Diameter for TBM-Machine install*

Inclined Shaft (Sloped Tunnel)

- *In the case that Tunnel Depth is deep (over 100 meters)*
- *Tunnel Section; around 7.0m in Width, 5.0m in Height*
- *Assembling Space of TBM-Machine ; around 15.0m in Width, 9.0m in Height*

Basic Policy on the Execution Plan

1. TBM Form

■ In the Case that Most In-Situ Rock are Assumed to be the Good Ground

⇨ Open Type TBM

■ In the Case Assumed to be a Defectiveness Ground in Some Part

⇨ Improvement Open Type Model

2. TBM Excavation Diameter

■ Open Model: Φ6.10m or So

■ Improvement Open Model: Φ6.60m or So

Basic Policy of an Execution Plan

3. TBM Driving Speed

■ Assume that the Sub-tunnel Function as a Pilot Tunnel by going ahead

⇨ Progress : 350 m / Month

4. Suggestion of Construction Process Shortening

■ Execution Simultaneous by TBM Digging and Floor Concrete Casting

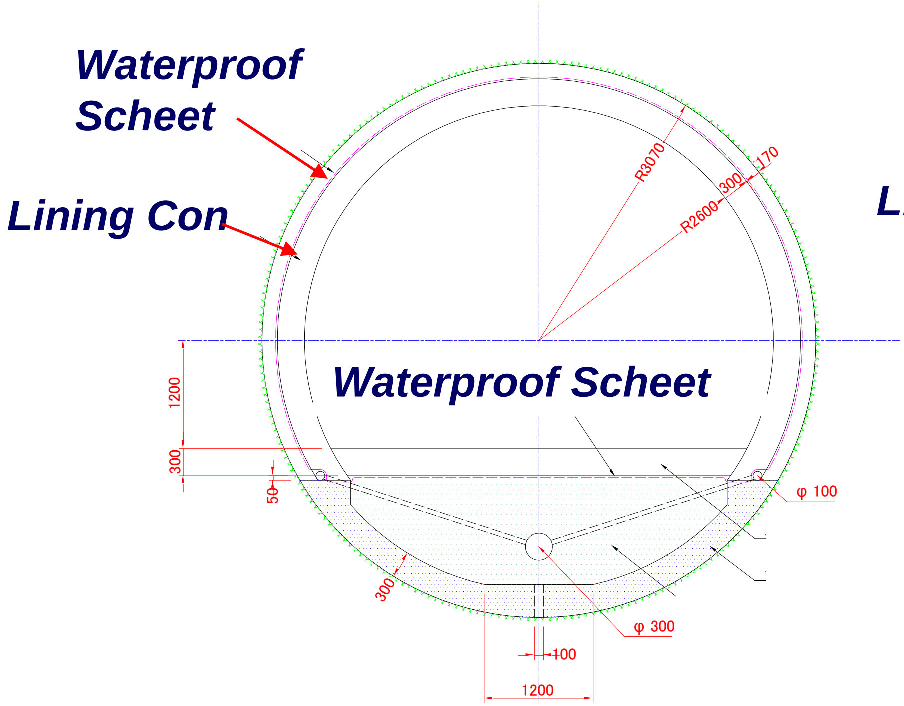
■ One Pass Lining by the Pre-cast Segment

■ Unifying Various Sections to Uniform Size

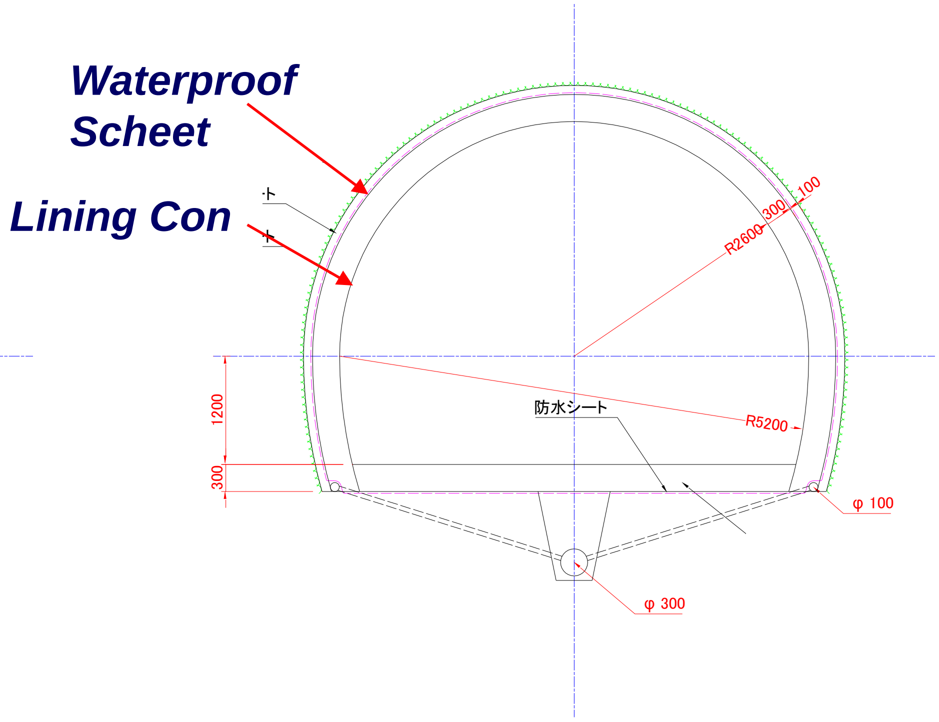
Execution Simultaneous by Digging and Lining

MLT Standard Section

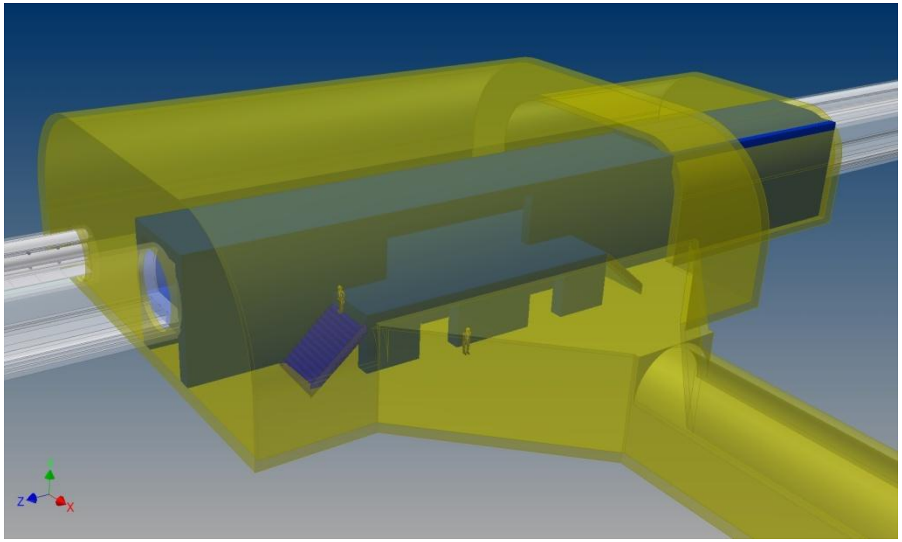
T B M



NATM



Sub-Tunnel & Access Tunnel



Access Tunnel Image

Design and Specification (Sub Tunnel)

1. Tunnel Section

- Φ4.5m in Diameter (Inner Diameter Φ4.1m)
- There are so much execution results in Japan

2. Tunnel Lining

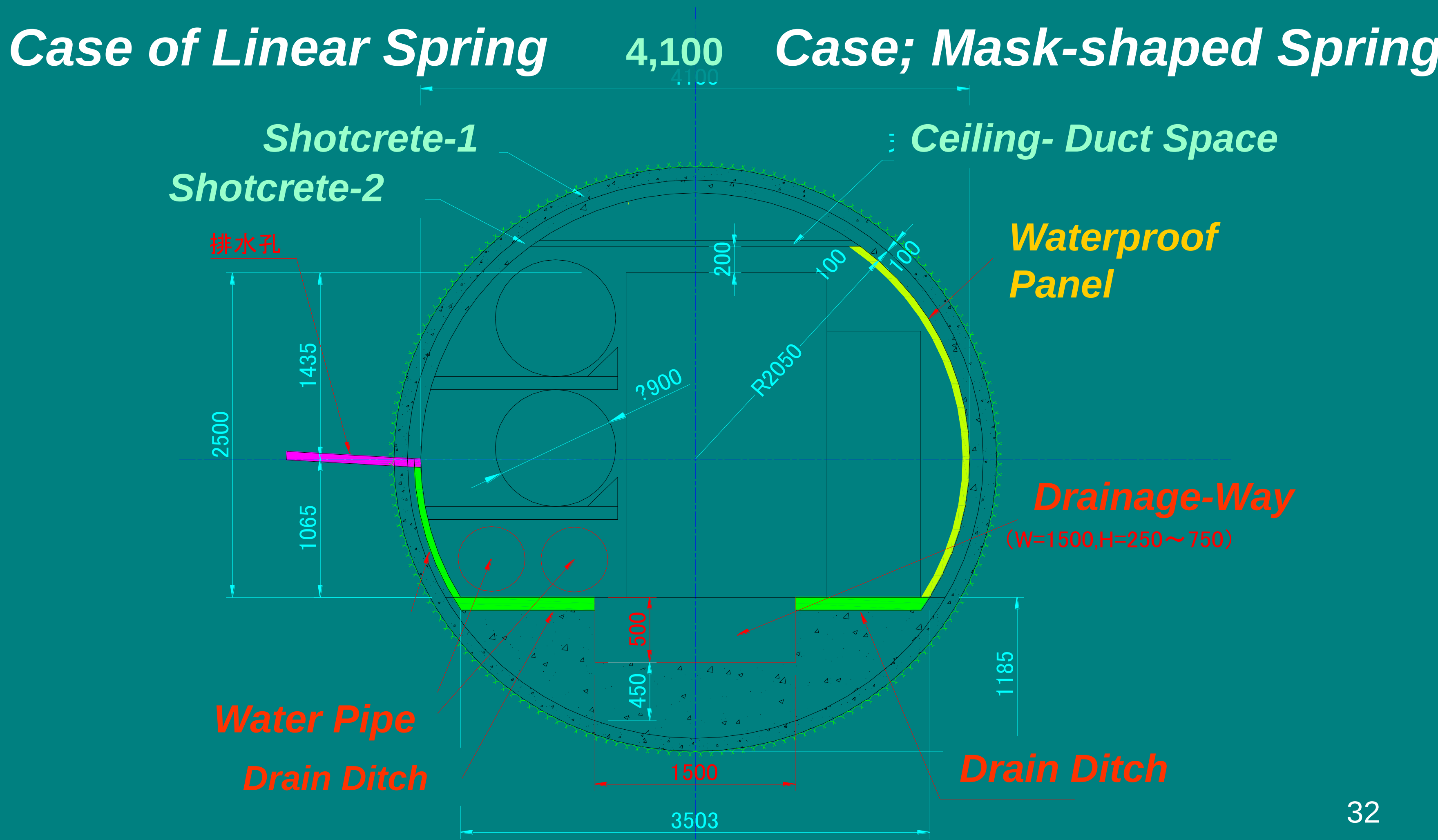
- Spray Concrete (thickness: 20 cm)

3. Process of the Sub-tunnel

- Consideration the Uncertainty of the Geological Feature State

⇨ Progress: 350 m / Month (Include Geological Survey Term)

Cross Section - Sub Tunnel



Decision Factor of the Section

1. During Execution

- The Setting Space of

  (1) Consecutive Belt Conveyors for Muck carry out

  (2) A Drill for Geological Feature Inquiries of Face Front

  (3) Drainage Facilities

- The Maximum Consideration to Rapid Execution Characteristics

2. During in-service Period

- Cooling Pipe, Drainage Pipe, Water Way, Air Duct Walk Passage, Roadway for Maintenance cars

Issues about the Sub Tunnel

■ Notice Matter to Keep Digging Speed

1. Investigation of Face Front Executing the Work
   Confirmation of the Geological Feature Situation of the Face Front by the Drill-Logging
   ⇨ Prior Preparation for Measures Work
2. Information Execution by Using TBM Machine Data

■ Term of Works Shortening of Main Linac Tunnel

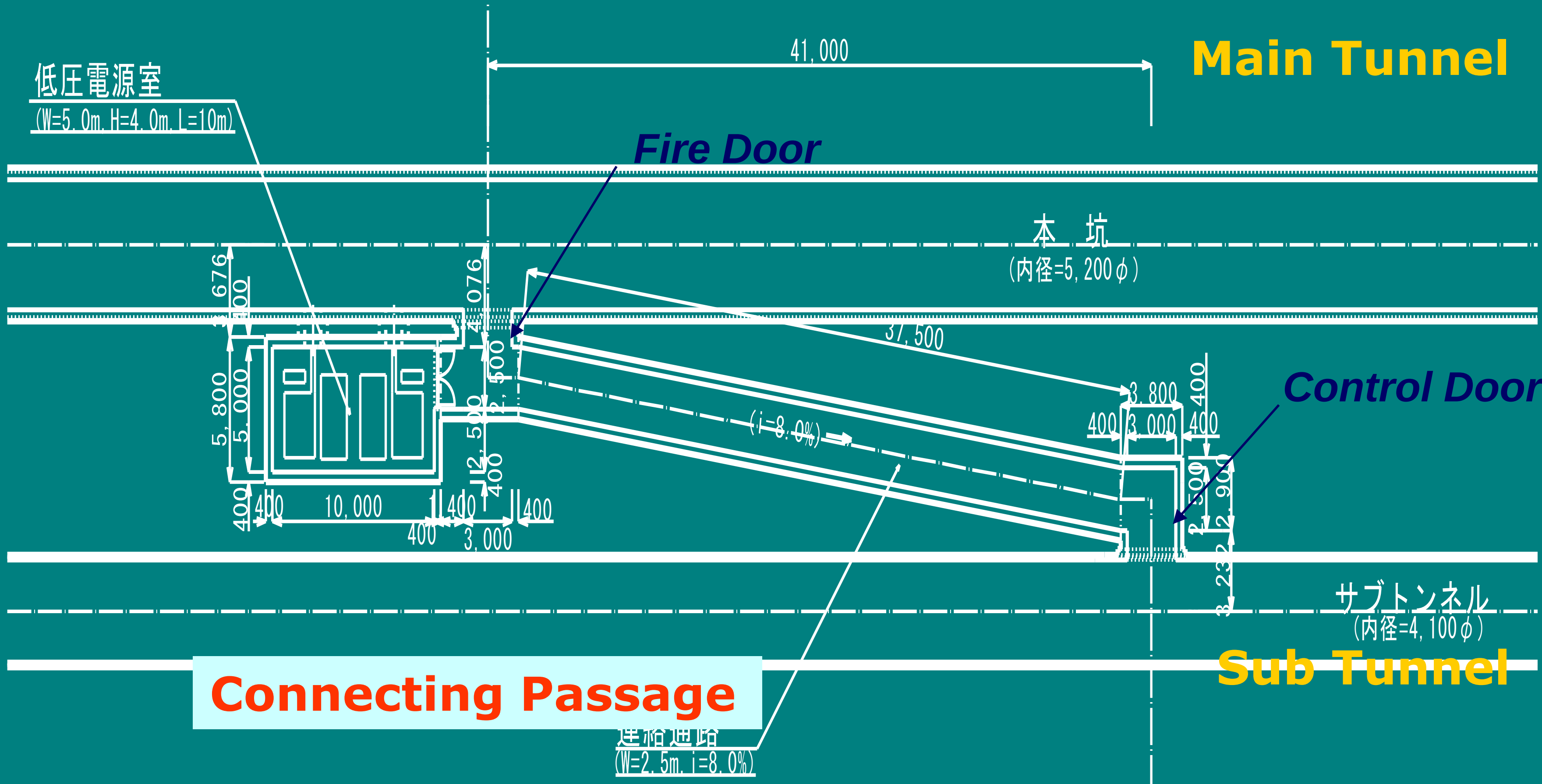
- Feedback of the Geological Survey Data
- Reduction the Quantity of MLT Spring by Precedent Draining off in Sub-tunnel

Main Functions of Sub-tunnel

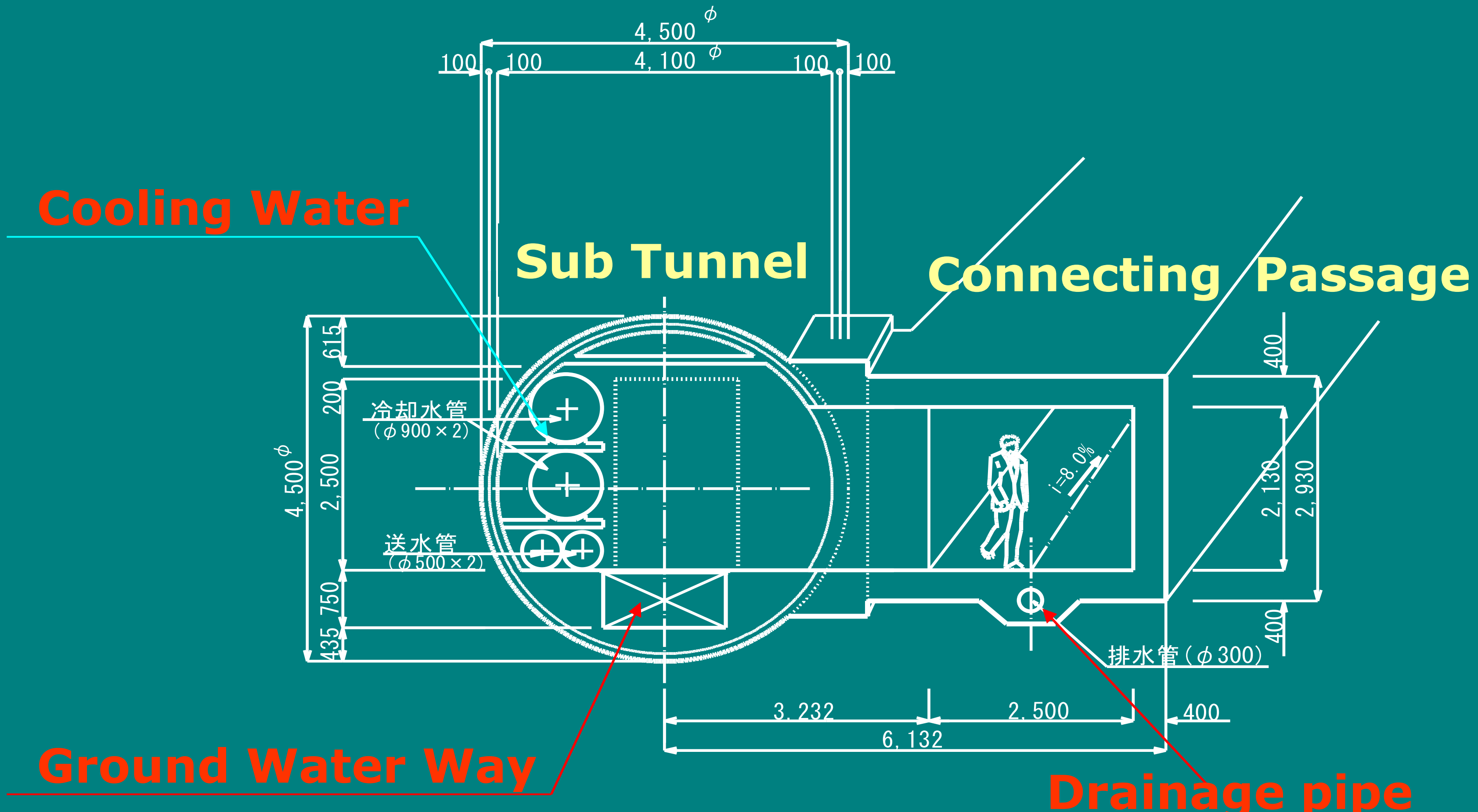
- ***Access Passage for Maintenance***
- ***Refuge Passage in the Emergency***
- ***Groundwater Drainage Piping***
- ***Cooling Water Piping***

We place it as a Pilot Tunnel
which as a geological feature inquiry and
Drainage off at the time of the Construction

Plan: Connected Passage Between Main tunnel and Sub tunnel



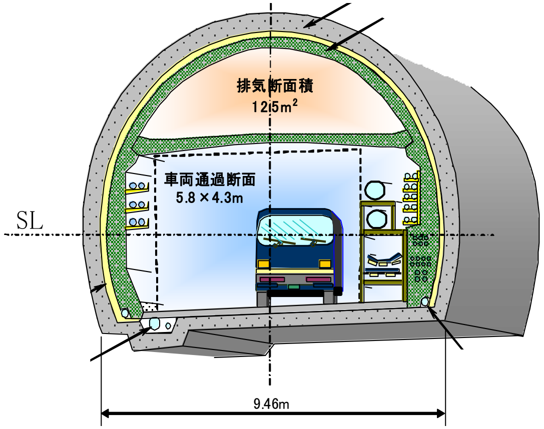
Cross Section: Sub tunnel



Design and Specification (Access Tunnel)

1. Vertical Shaft Section

- Inner Diameter Φ 9.0m
  (TBM Resolution Dimensions)



Sample Image

2. Tunnel Lining

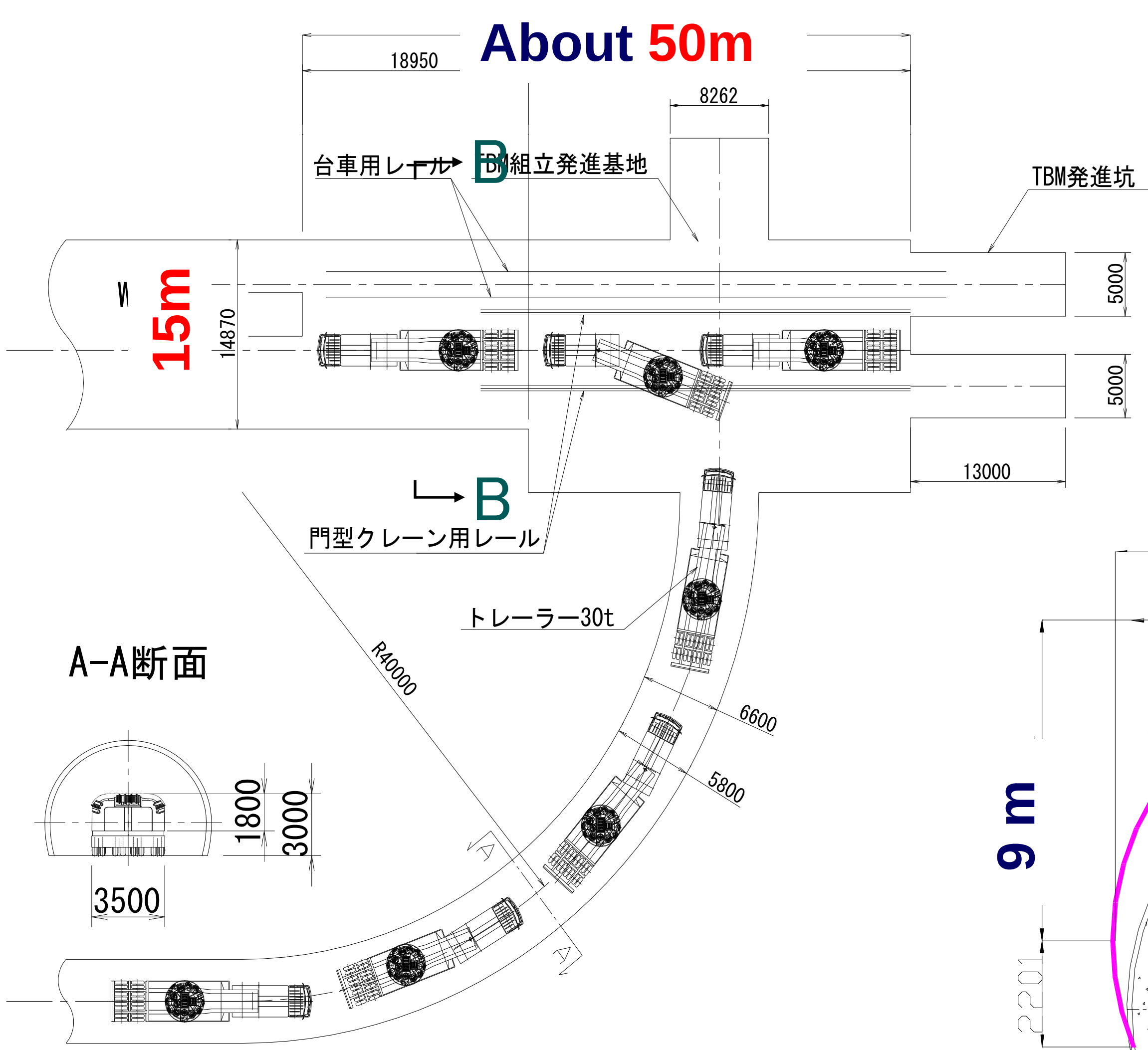
- Spray Concrete

3. Assembling and Departure of TBM

- TBM takes off after assembling in a Departure Base in a Tunnel (in the Terminal part of the Access Tunnel)

TBM Setting Up Hall: About w15m, h9m, L50m

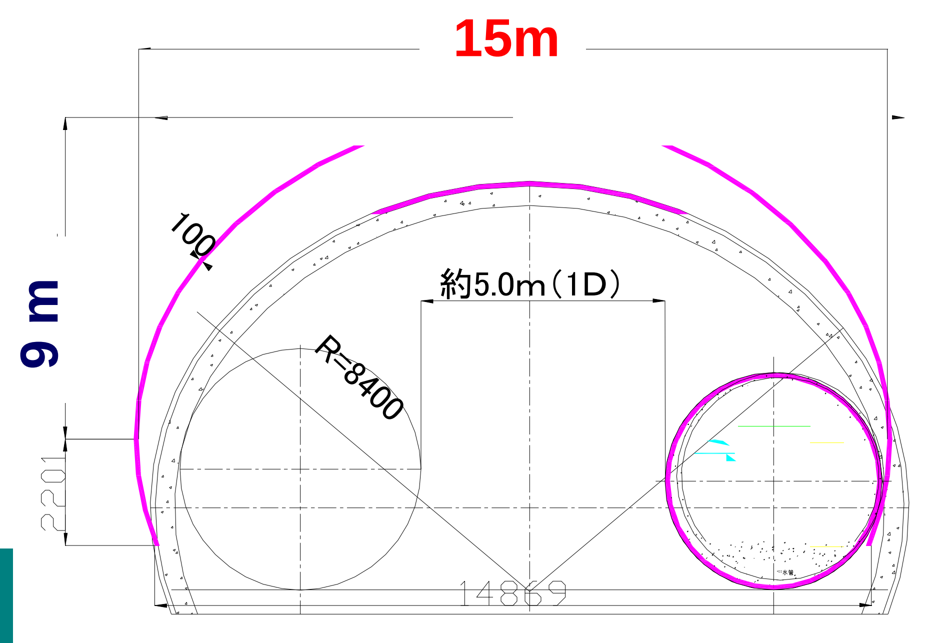
TBM Station（Real Execution Example）



・*TBM Carries an Access Tunnel With a Trailer*

・*Set Up in the Cavern for on the Both Tunnel Line*

B-B Section



Groundwater Drainage Scheme

Concept of Drainage Plan

1. Quantity of Constant Spring

- *The Quantity of Spring after Completion*

  27.9 m^3/min (Assumption: Plutonic Rocks)
- *Supposition that by the Half of the Quantity of This Spring occurs into Both Tunnels*

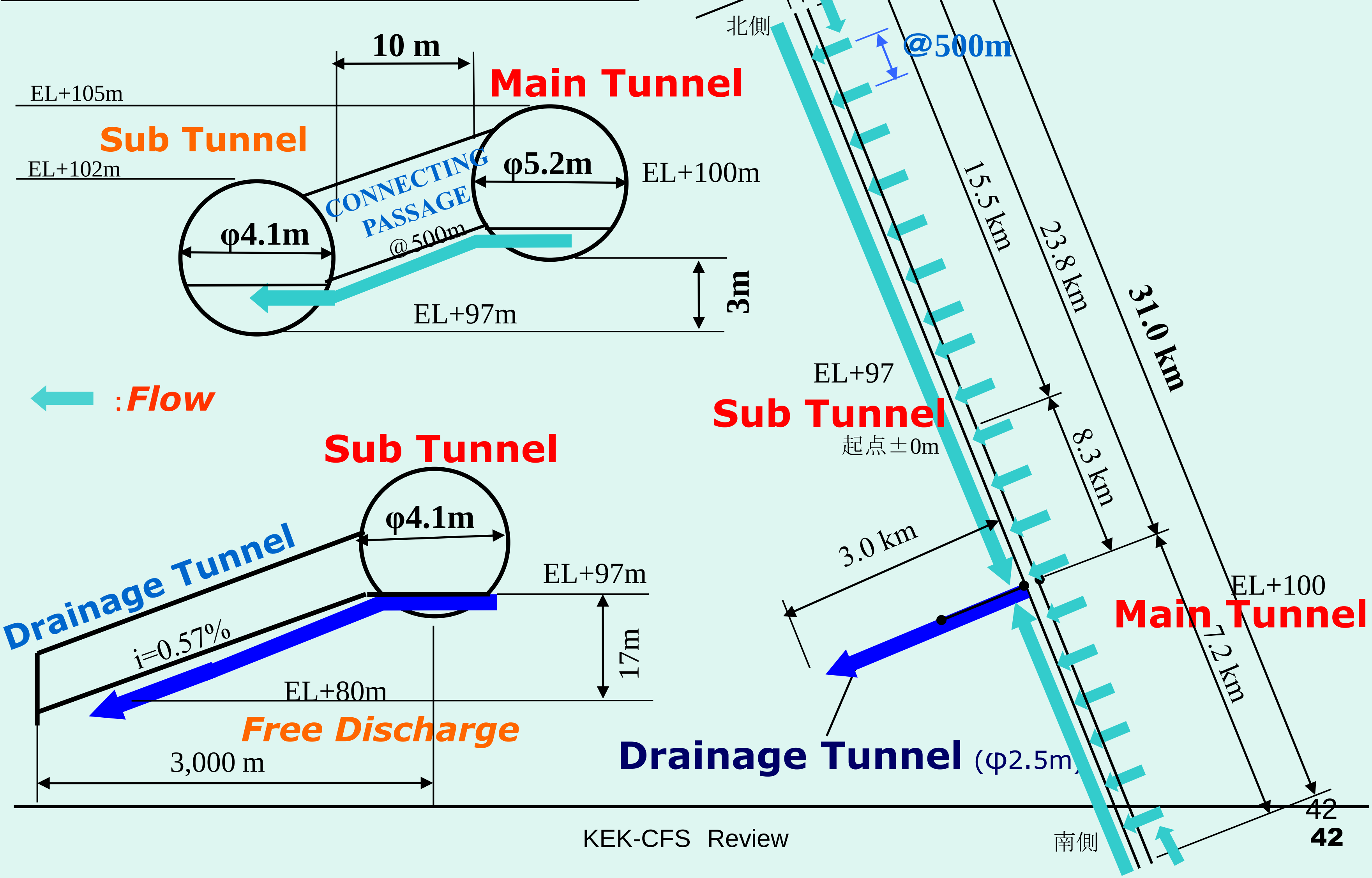
2. Basic Policy

- *Practical Use of the Sub-Tunnel as the Drainage Way*
- *Free Drainage of the Spring in the Tunnel*

  (Using a Difference of Elevation)
- *Easy Maintenance by Miniaturization of the Power Drainage improvement*

Design Study (Groundwater Drainage)

Constant Inflow : 28 m^3/min

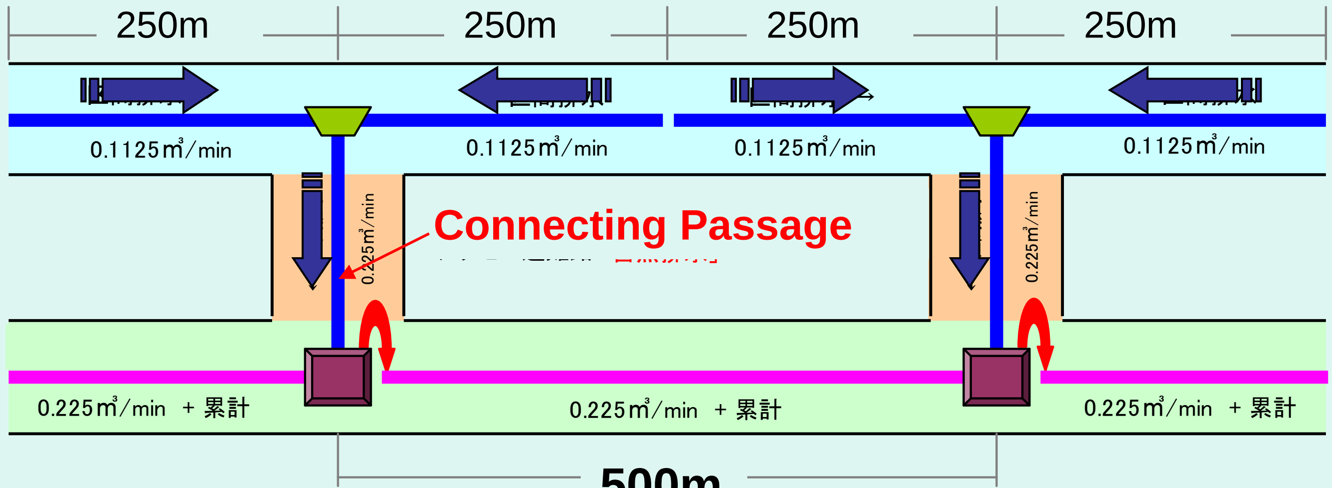


Design Study
(Groundwater Drainage)

(A) Water Flow Layout Plan

Main tunnel

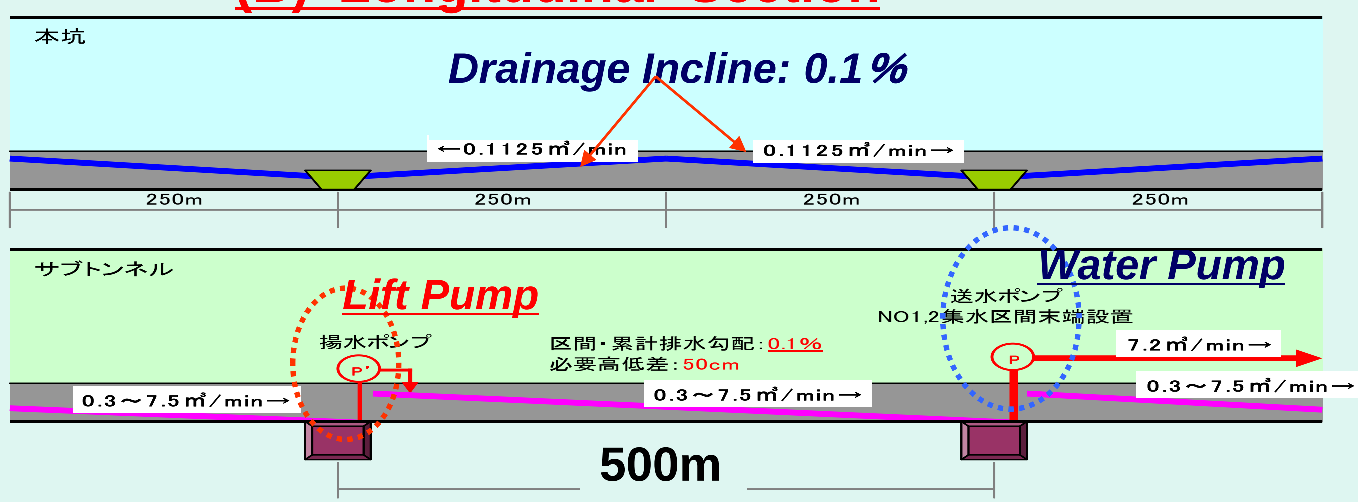
Sub-tunnel



(B) Longitudinal Section

Main tunnel

Sub-tunnel



Specification of Main Drainage Facilities

1. Main Tunnel

- The Central Drainage Pipe
  φ300mm (Porous Pipe) ⇔ Free Drainage

2. Sub Tunnel

- Longitudinal Drainage Way
  W1.5m, H0.25~0.75m (0.1% Slope) ⇔ Free Drainage
- Water Line Every Section
  φ500mm (6.0t /min, every Quarter of Tunnel Length)

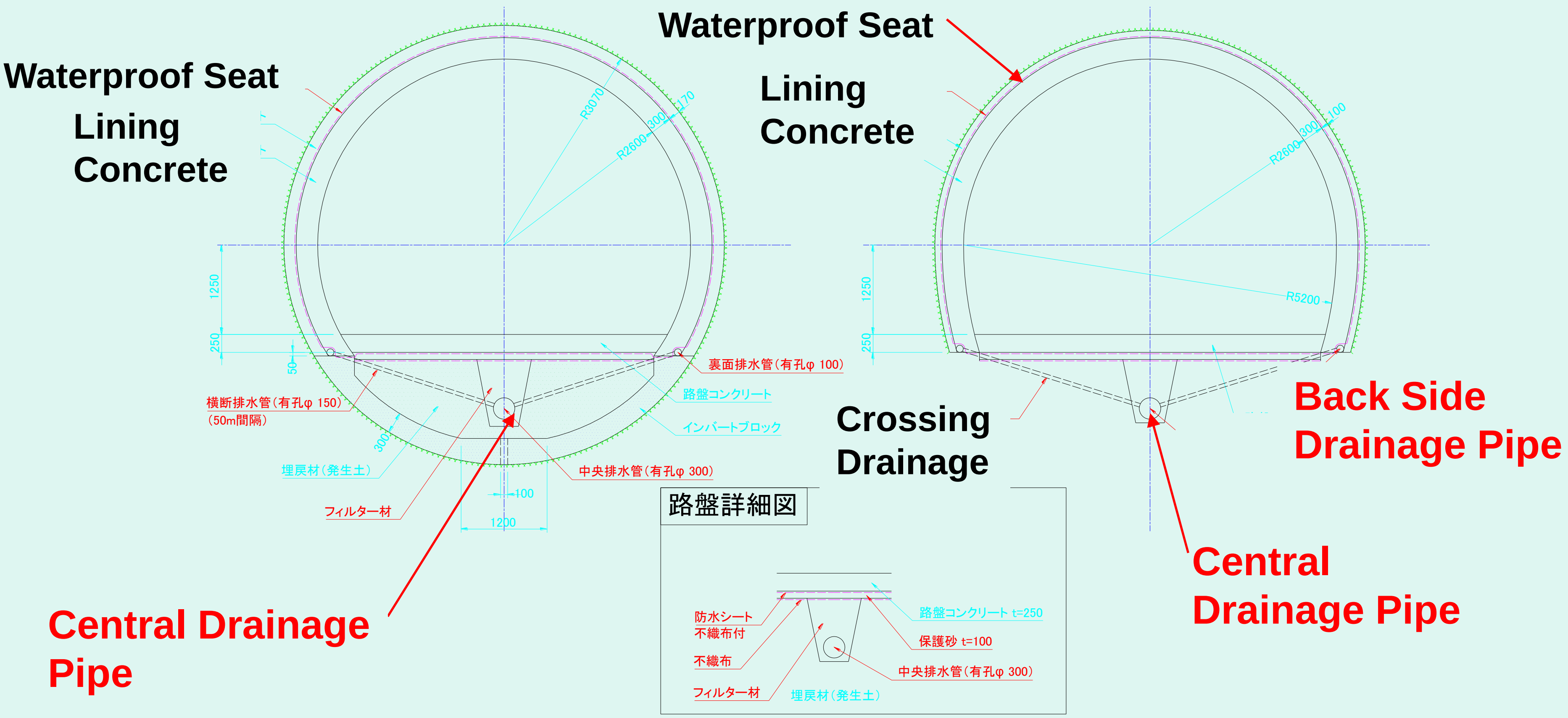
3. Drainage Tunnel

- Drainage Tunnel to Discharge Point; φ2.5m, L=3km
- Total Quantity of Drainage; 28m^3/min (Max)

Main Tunnel Drainage

TBM Section

NATM Section



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3. Drainage Tunnel

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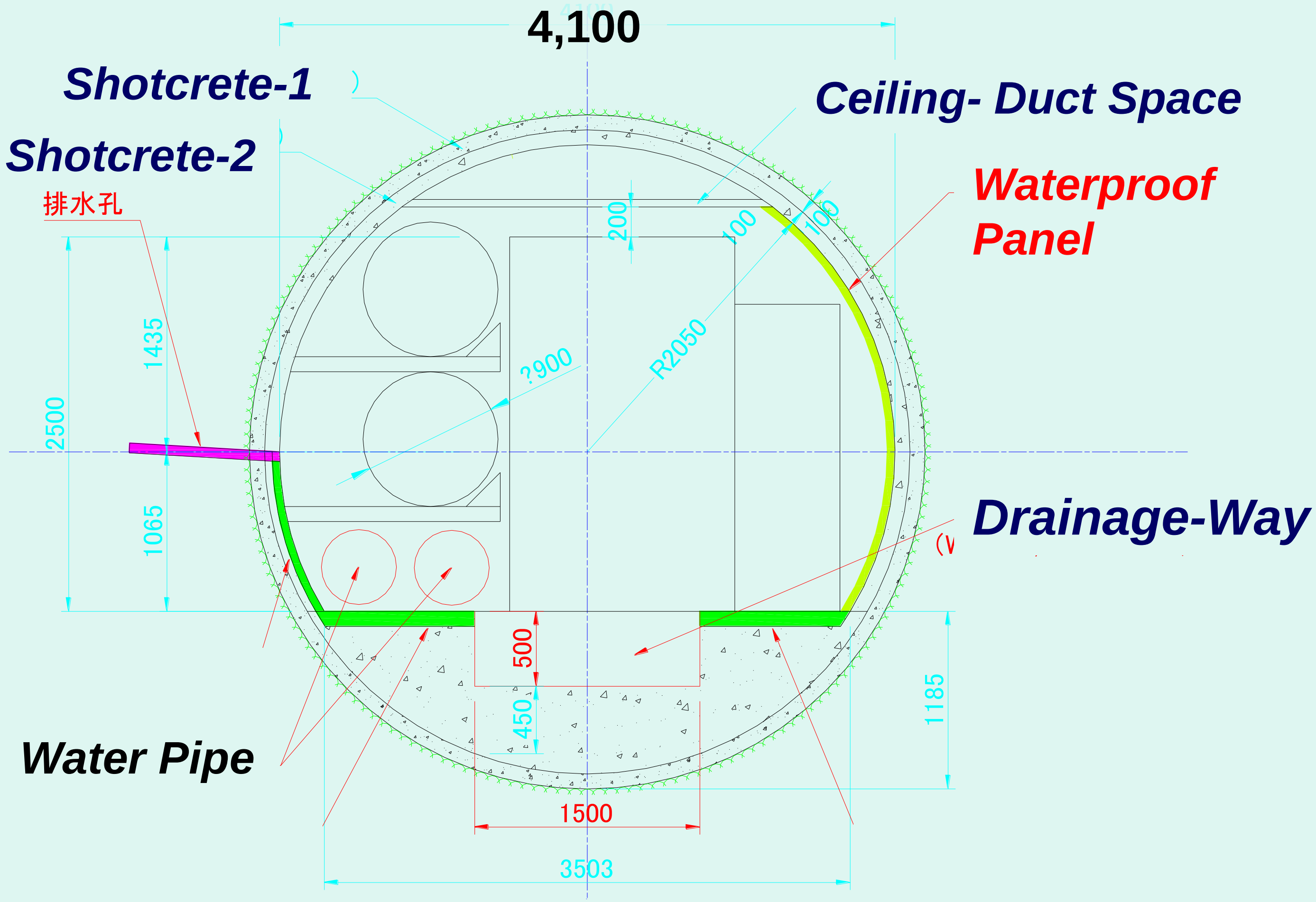
Sub Tunnel Drainage

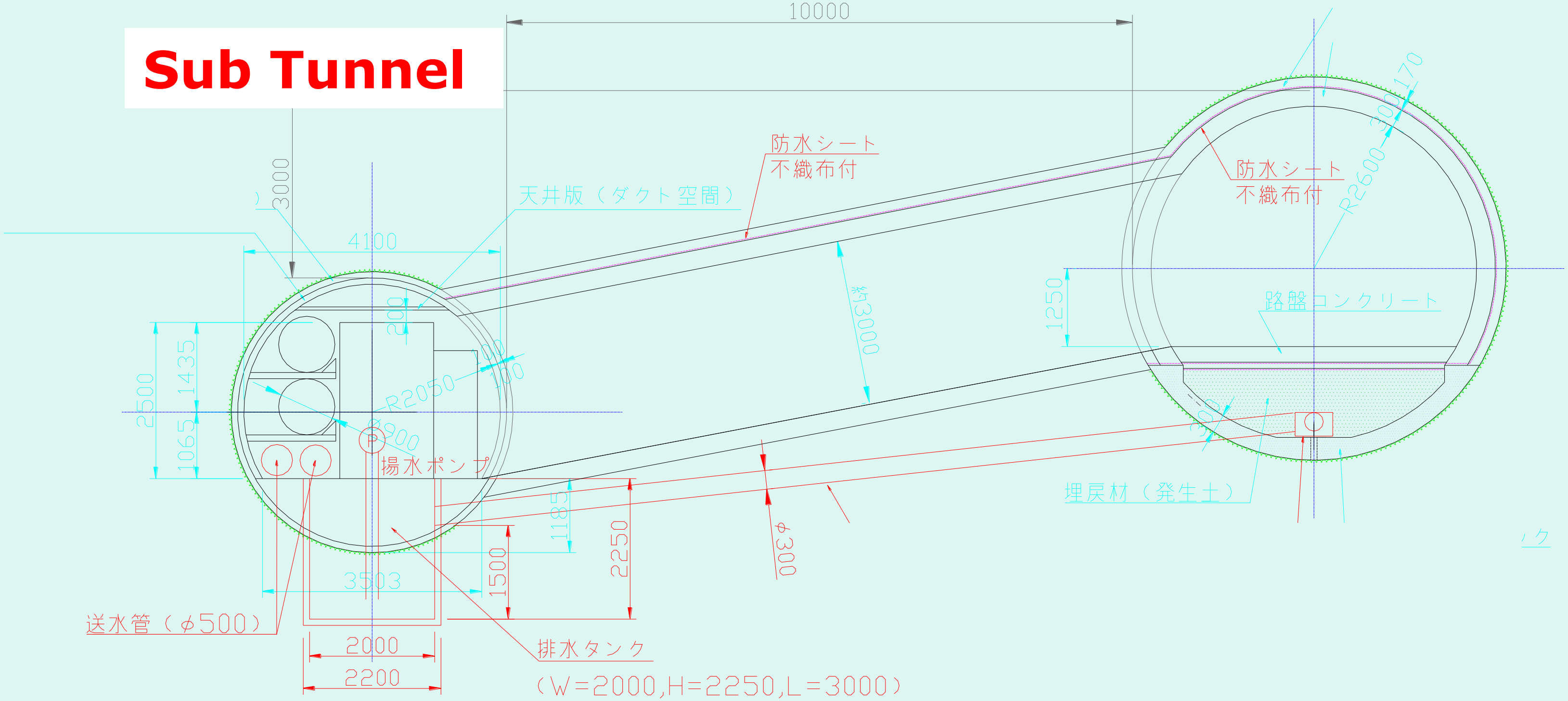


Design Study
(Groundwater Drainage)

Cross section of Connecting Passage

Main Tunnel

Sub Tunnel



- ◻ **free drainage by the level difference**
- ◻ **minimum forced drainage**

Cavern Design for the Detector Hall

Design and Specification

1. Detector Hall

- Object Bedrock ; Granite
- Earth Covering ; about 100m
- Cavern Scale ; W30m, H40m, L120m (RDR)
- Shape ; Bread Type (Arch + Vertical Wall)

2. Vertical Shaft

- Inside Diameter ; φ16m, Two Shafts

3. Access Tunnel

- Cross Section ; W10.2m, H7.2m (62㎡)
  (Shape; Horseshoe Shape)
- Tunnel Incline ; Around 5% Max. (Only Straight Line)

Scheme of Execution

Access Tunnel

- Excavation (NATM)

Vertical Shaft

- Heading Shaft (Raise Borer Method)
- Enlargement Excavation
- Lining Concrete (φ16m)

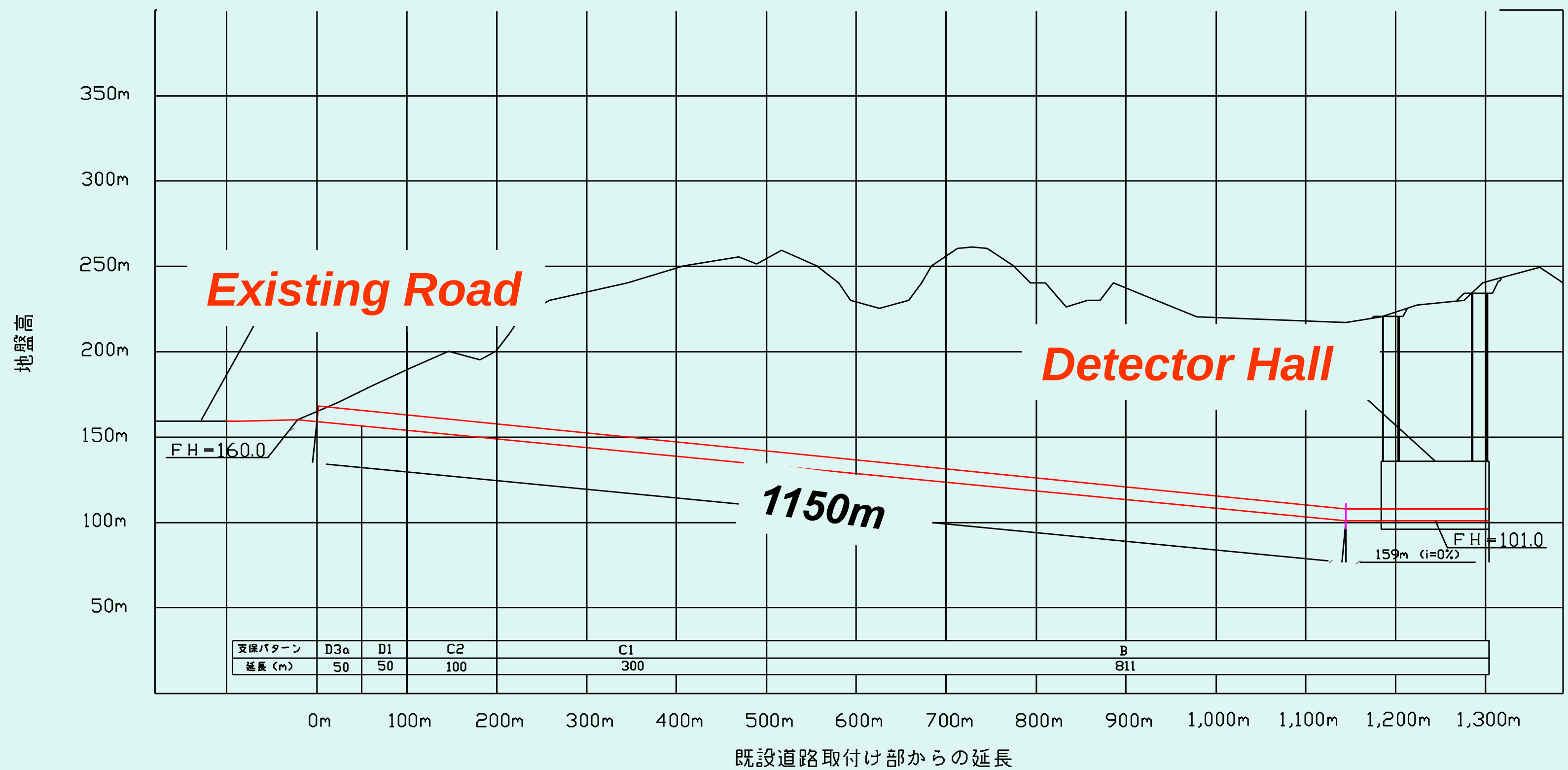
Detector Hall

- Bottom Heading Tunnel Excavation (NATM)
- Arch Section Excavation (Enlargement)
- Body Section Excavation (Bench Method)
- Botom Slab, Side Wall
- Arch Lining

Concrete Placement

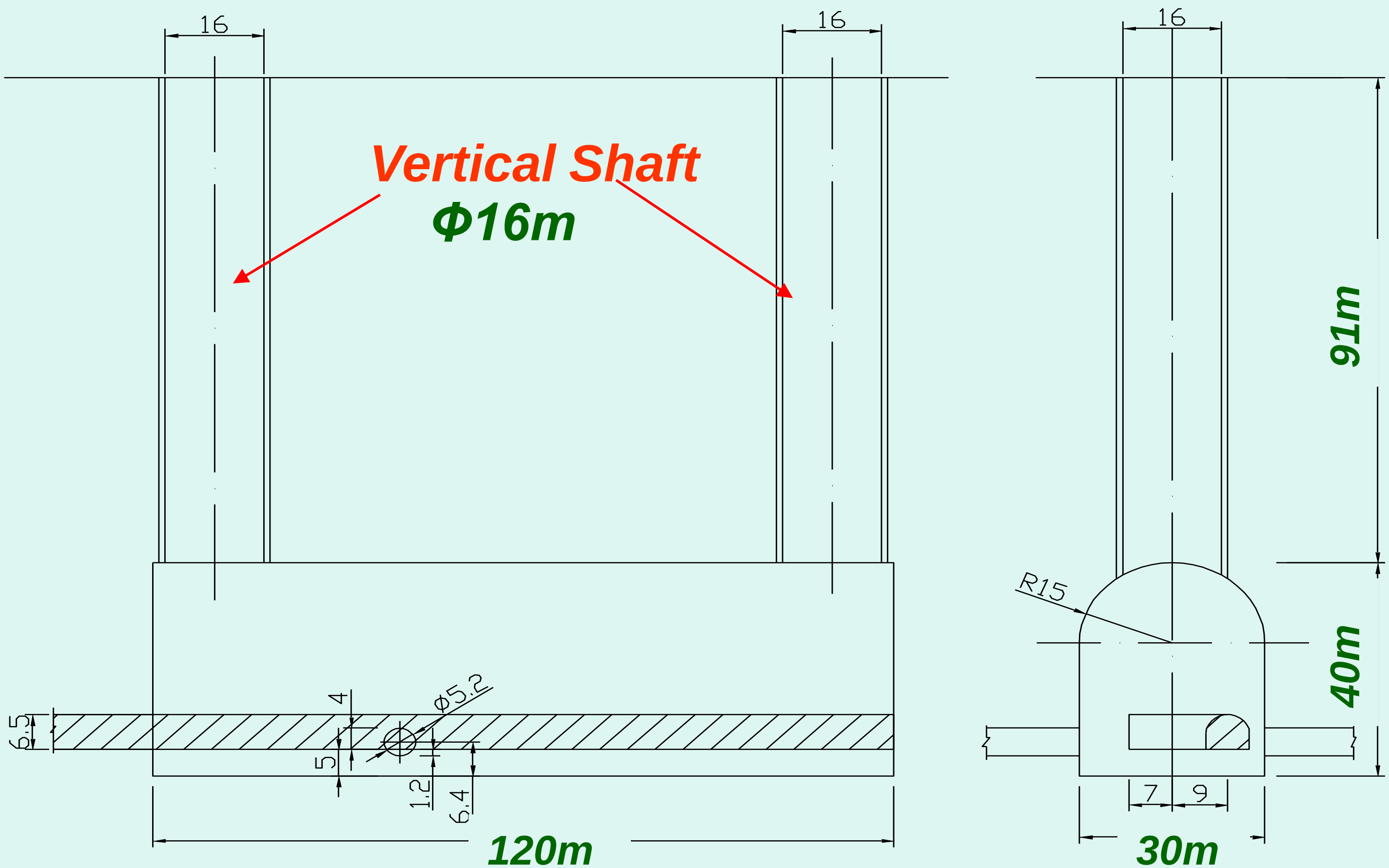
<Cast-in Concrete>

Access Tunnel for Detector Hall

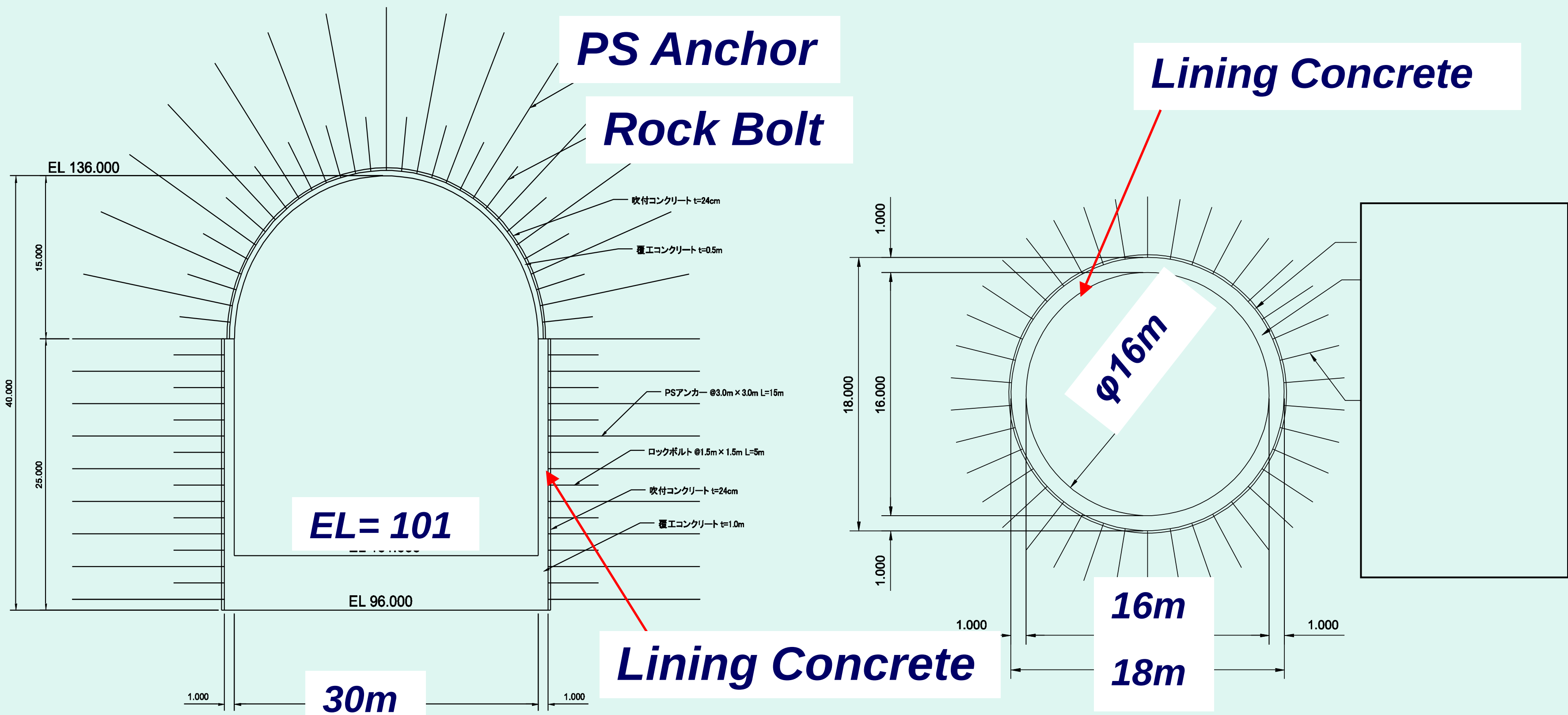


- **Access Tunnel: Connect to the Existing Road**
- **Incline of Access Tunnel: 5%(Straight) 0%(Arch)**

Detector Hall Outline



Timbering for Detector Hall



Detector Hall Section

Vertical Shaft Section

Cooling-water and Utilities

Cooling-water and Utilities

- ***Precondition, Contents of the Study***
- ***Investigation Model***
- ***Method of the Problem Solution***
- ***Summary***

1. Object the Study

● *We Plan Heat Radiation Rout of the Coolant by Three Routs (3 Places of Cooling Tower Farm)*

- *CT located in the Central of the Tunnel and Both Ends*

2. Precondition

- *Assume the Total HEAT Release:*
  130MW (Equal to Total Electric Energy)
- *Examination about the Second Coolant Corresponding to Heat Load 35MW per Tunnel Section 7.5km*
- *Heat Exchanger With the Primary Cooling Water :*
  10 Places（in the 750m Unit）

3. Contents of Study

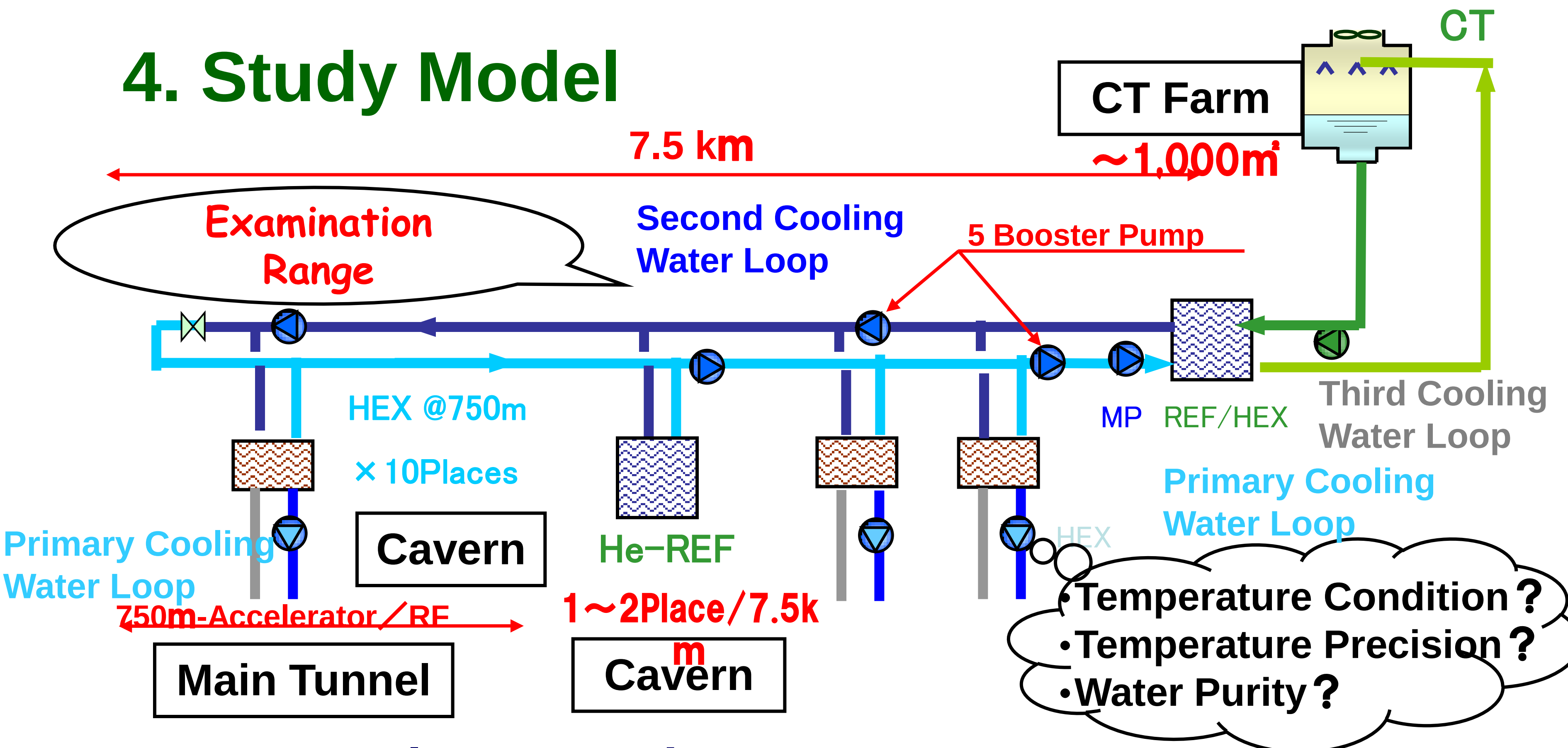
- *Is the Second Coolant Loop Really Formed?*
  7.5km Loop（Both of Outward and Return）

Key Point of the Study

- *Can we Suppress the Transportation Power of the Second Coolant (Pump Power) in 5MW Degree?*

- *The Realization Characteristics of This Plan?*
  The Most Suitable Design ?　　Future Study

4. Study Model



● Necessary Flow Quantity
Circulation at Δt=5deg
6,020m^3/h

● Necessary Pump Head
⇒ 540 mAq5,400kPa)

●Power of the Circulation Pump
Efficiency=0.9 ⇒ 9,840 kW

5. Result(Issue?)

About 2Times of the Aim

6. Method of the Problem Solution

Want to Make The Pump Power a Half

- Make the Flow Quantity or Pump Lift HARF
- Want to Keep a Temperature Condition at Δt=5deg
- Can not Change the Flow Quantity: as 6,020 m3/h
- We can make the Pump Lift half by Setting the Plumbing Diameter 10～15mmAq/m

MAX Diameter : 700A ⇒ 800A

7. Some Issues in the Future Consideration

- Detailed Check about the precondition and Design Specification This Examination is Necessary
  -Supply Temperature -Temperature Precision -Water Purity

8. Summary

- Transportation Power of the Second Cooling Water : 4MW and Below ⇒ Accomplishment
- Even the Most Large Capacity MP-Motor : 160Kw ⇒ Became the Realistic Value
- We Confirmed the Realization Characteristics of the Plan to Limit the Heat Radiation Route of the Cooling Water to 3 Places in the Main Tunnel

Recent Development and Some Issues

Some 3D Drawings

Recent Development and Some Issues

- *Cavern Design for Cryogenic Facilities*
- *Detector Hall with Sloped Access Tunnel*
- *Some Issues of Life Safety*

Recent Development (1)

Cavern for TBM Station

Under Construction

Review Points

1. TBM Setting-up Hall via Access Tunnel
2. Departure Station on the Linac Tunnel line

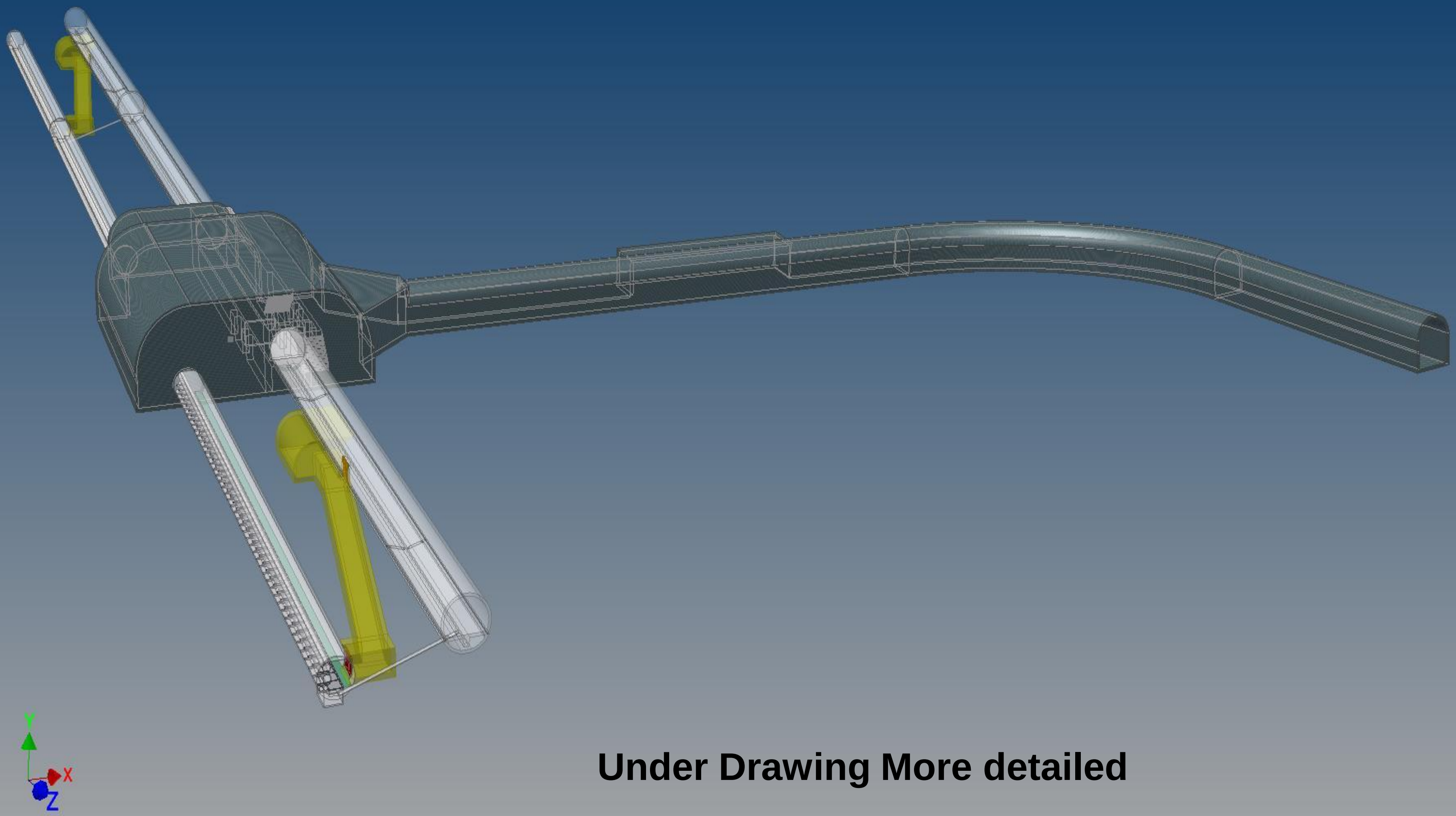
Cavern for Assembly Hall

After Completion

Review Points

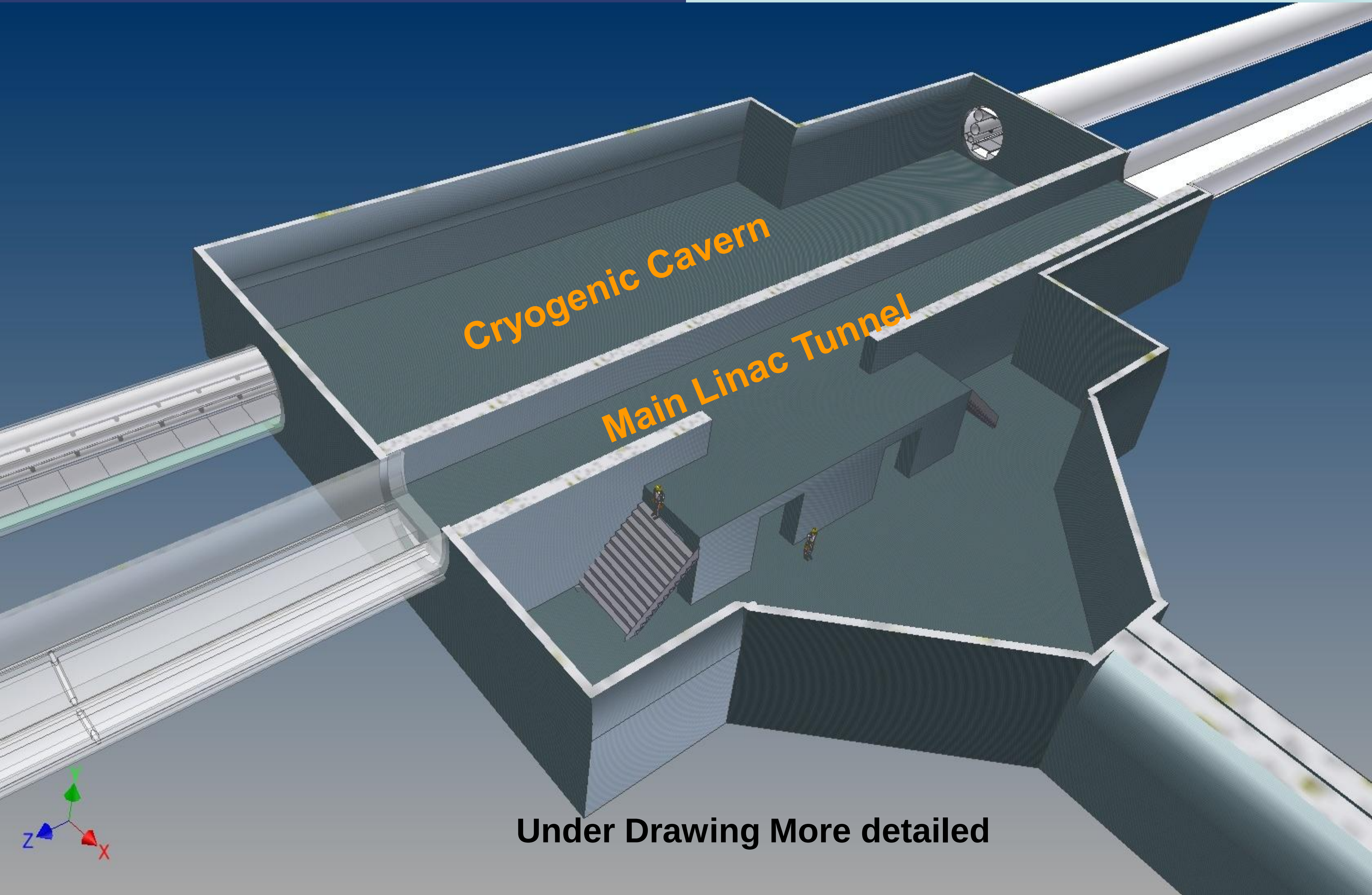
1. Access Hall for the Accelerator Facilities
   Cryomodule , RF Facilities and Cryogenic Facilities
2. Access Station for Maintenance and Refuge

Recent development

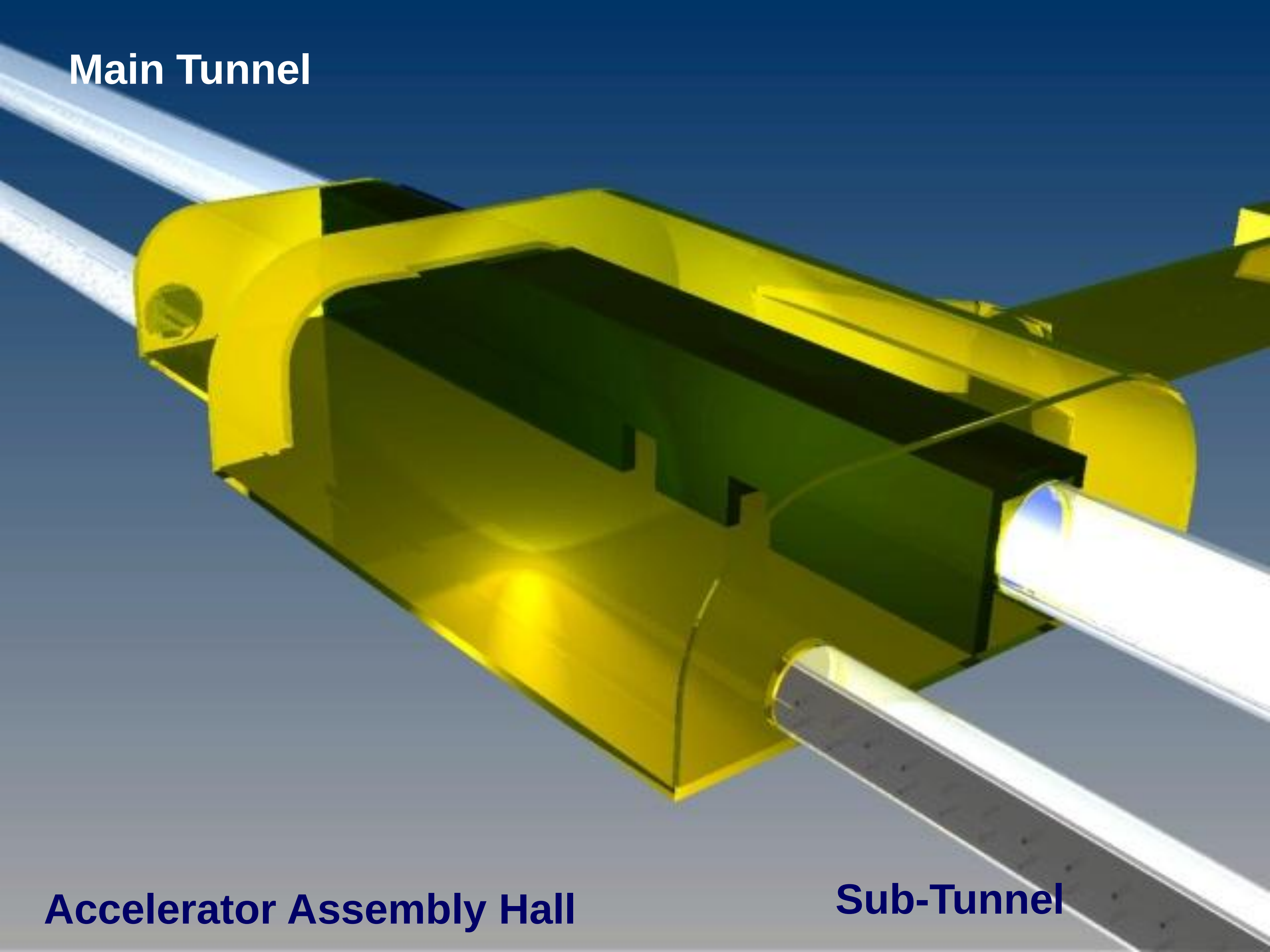


Under Drawing More detailed

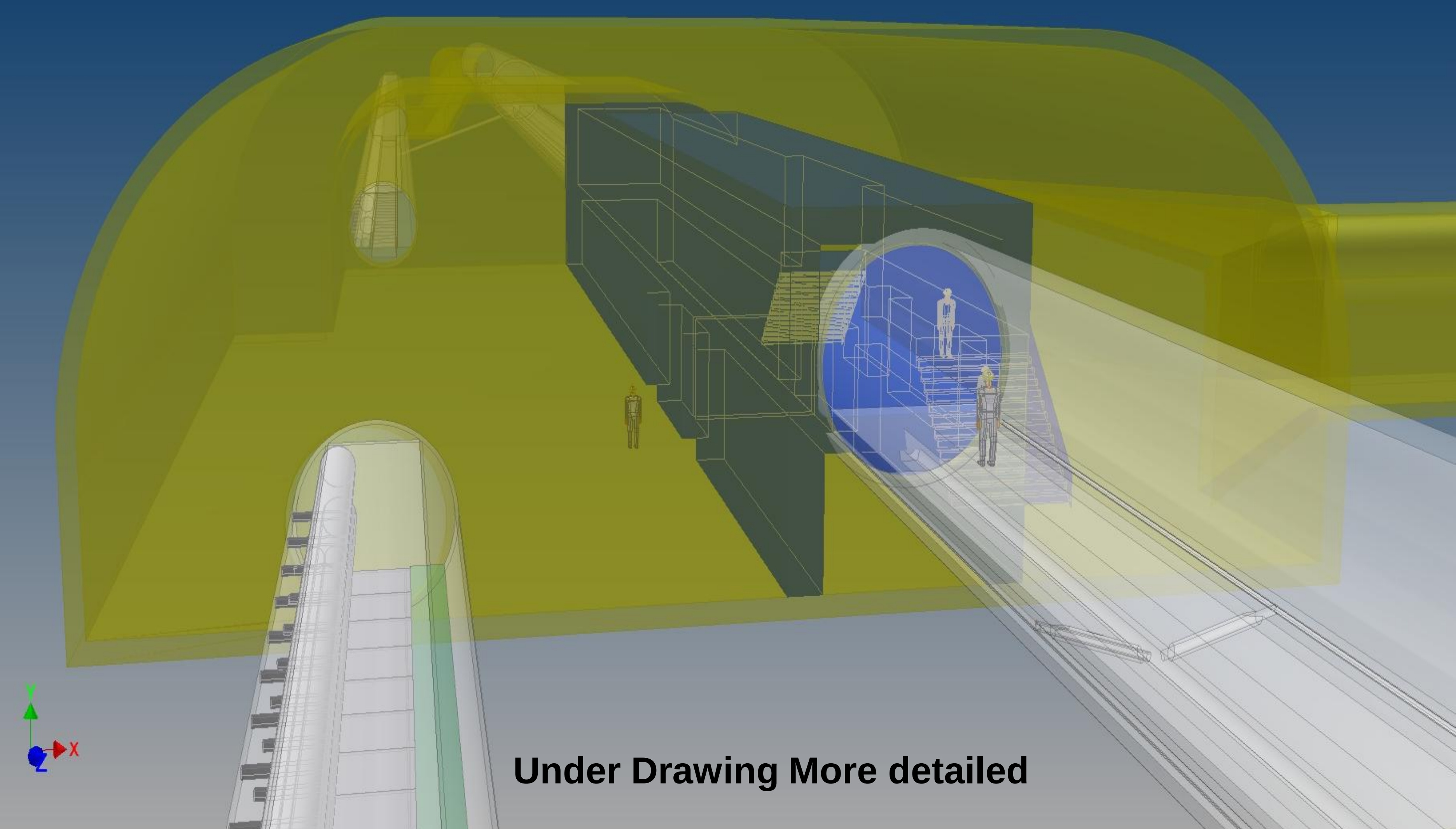
Recent development



Under Drawing More detailed


Main Tunnel
Accelerator Assembly Hall
Sub-Tunnel

Recent development



Under Drawing More detailed

Recent Development (2)

Cavern Design for Detector Hall

Review Points

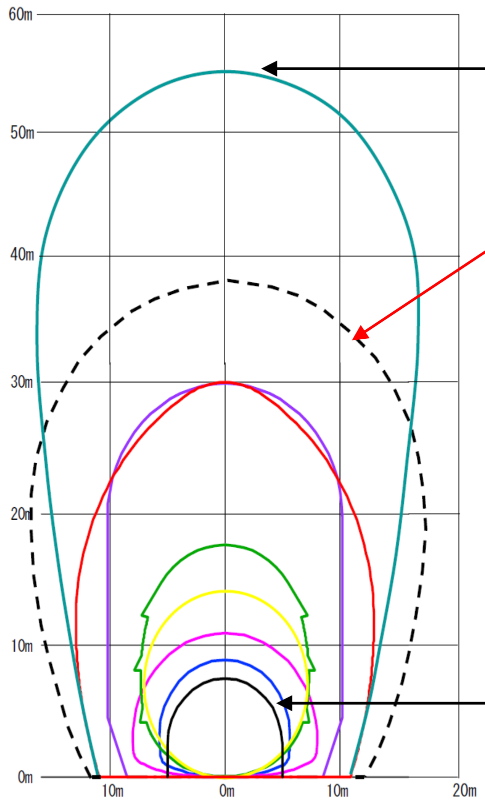
1. Scale and Shape of Cavern
2. Installation by only Sloped Access Tunnel
   (For a Case Without the Vertical Shaft)
3. Maintenance Method
4. Construction Schedule

Issue of under Consideration

1. How Much is the Reasonable Size of the Access tunnel (for installation of the Detector)
2. Where should the Detector be Assembled

Cavern for Detector Hall

Comparison of Cavern Section Size



Power Station

Detector Hall

Road Tunnel

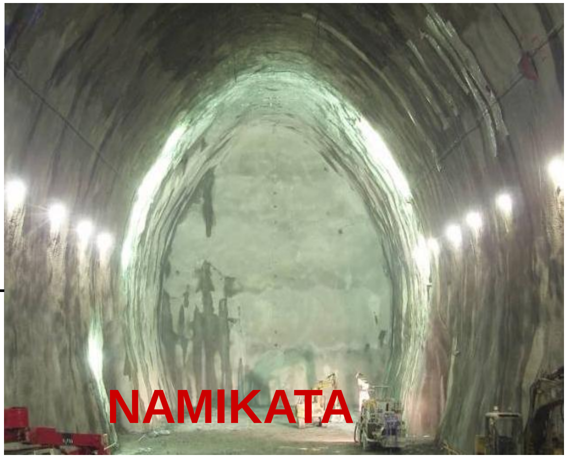
Oil Stock Base

H

W

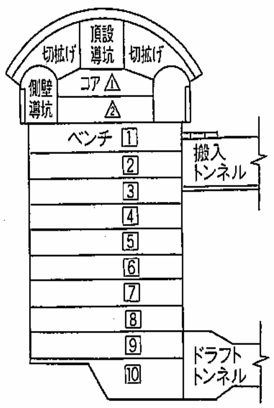
Underground Power S.

LPG Stockpiling Base

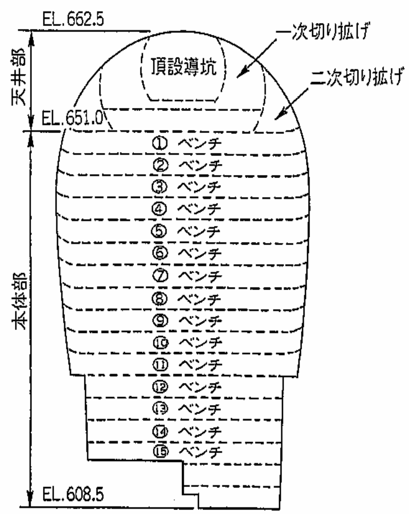


Cavern for Detector Hall

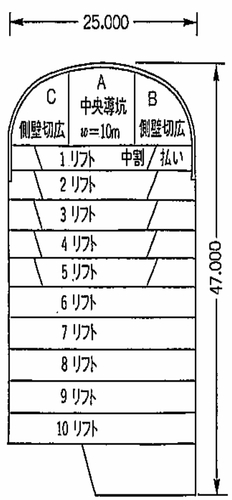
Typical Shape of Cavern for Underground Power Station



Mushroom

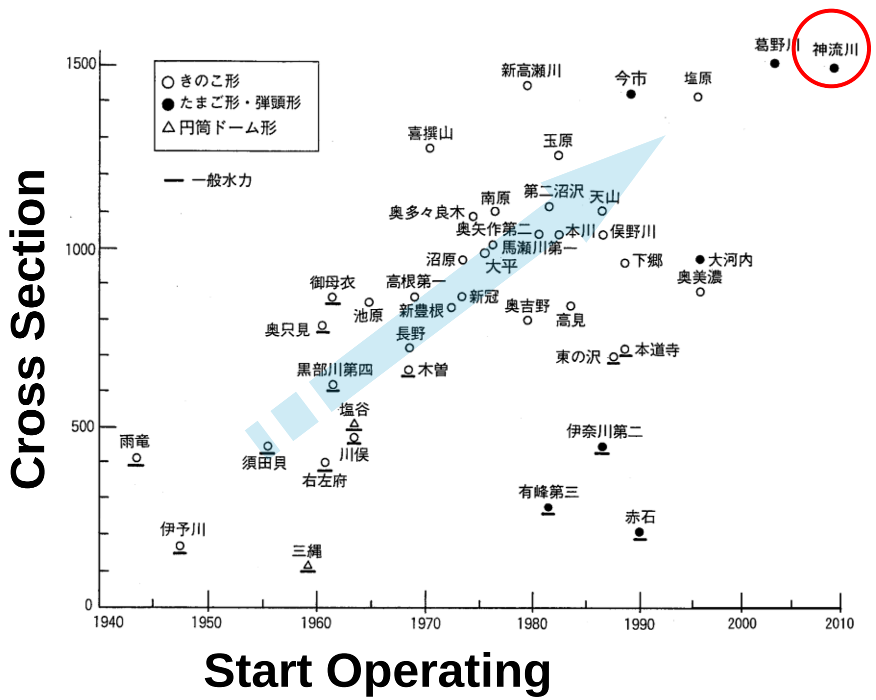


Egg

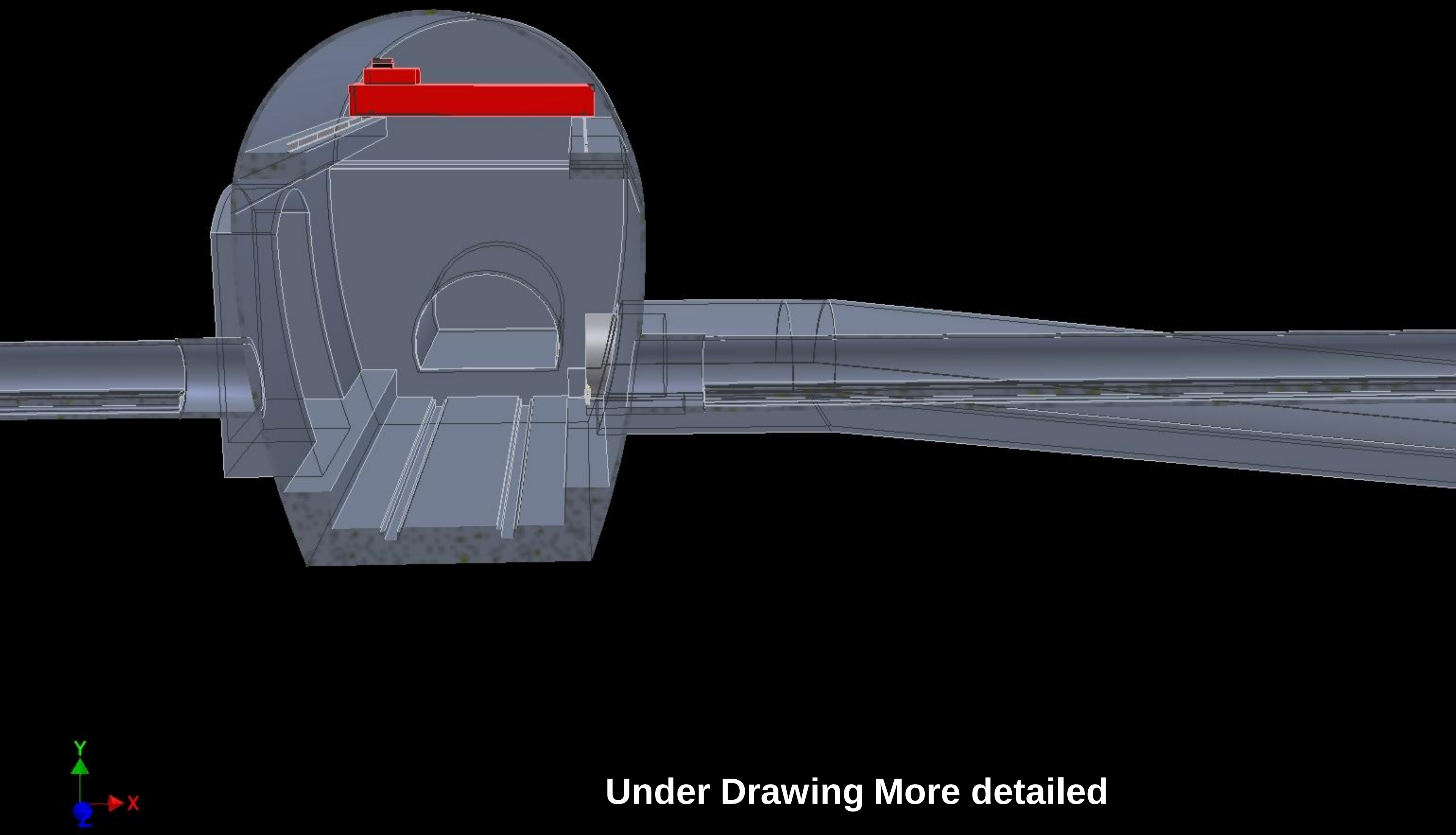


Warhead

Changes of Cavern Cross Section

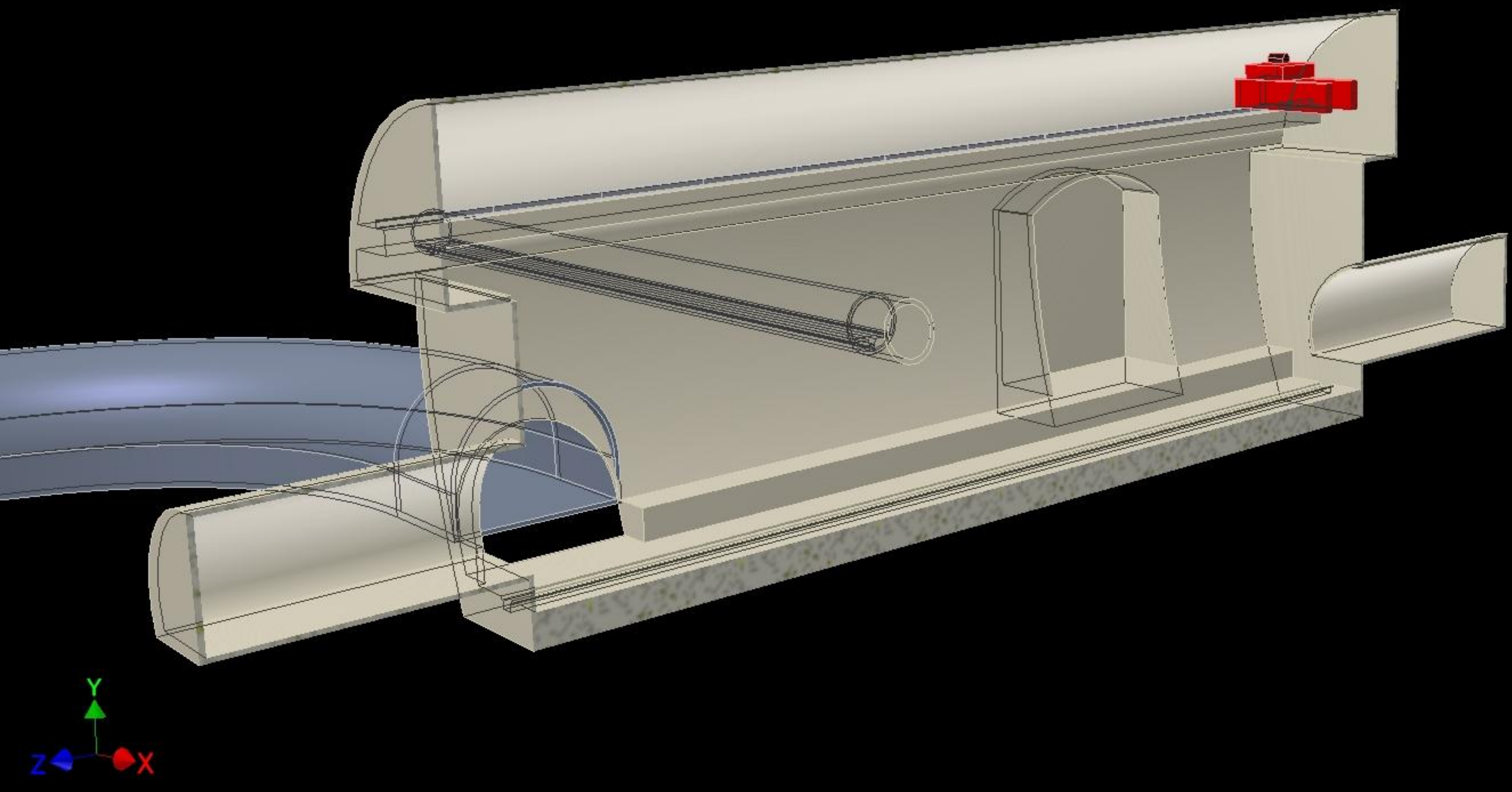


Detector Hall

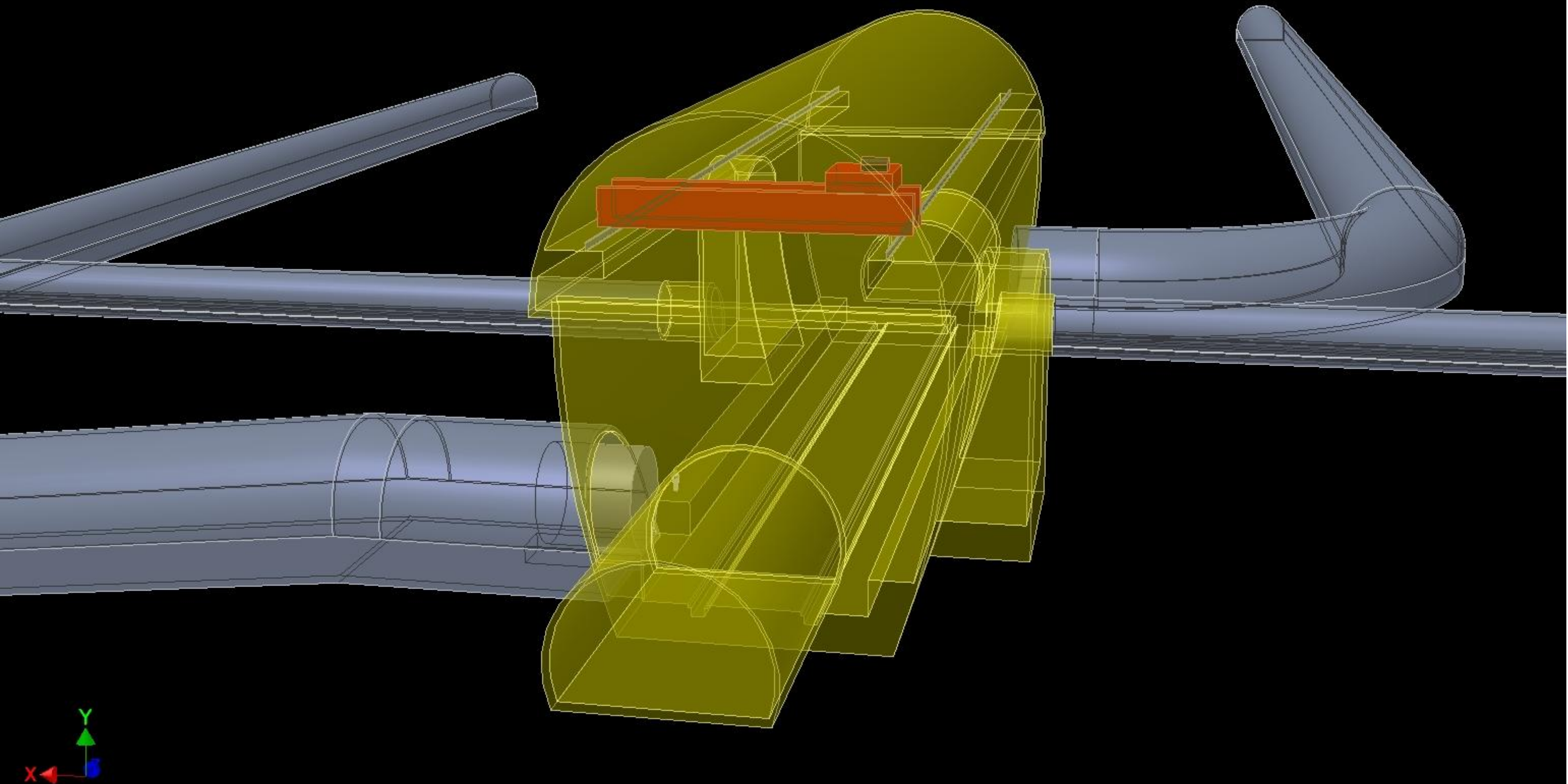


Under Drawing More detailed

Detector Hall



Detector Hall



Recent Development (3)

Life Safety and Refuge

Review Points

1. Refuge Route (Include Access Route)
   Main Tunnel ⇒ Sub Tunnel ⇒ Access Tunnel
2. Exhaust Course of the Smoke and He-Gas
   Main Tunnel ⇒ Access Tunnel
   (For a Case Without the Vertical Shaft)
3. Fire Prevention Division
   During Consideration

Summary

Summary (1)

We Got the Following Conviction by Doing the Design Which Utilized the Complicated Topography in the Mountainous Region

- ***We Can Overcome the Issue of Seductive Ground Water Processing***
- ***We Can Reduce the Environmental Load by Controlling the Scale of the Surface Building and Infrastructure Facility***
- ***We can Reduce the Maintenance Expense by Planning the Free Discharge System using the Natural Topography***

Summary (2)

We Confirmed that it was Got the Following High Performance by Designing the Single Tunnel Configuration with Sub-tunnel

- ***We Can Secure High Maintainability by Separating the Active Zone and Non-Active Zone in During an experiment***
- ***We Can Secure High Safety by Utilizing a Sub-tunnel as a Refuge Route in Emergency***