Asian Site-specific Design of Civil Work for the ILC Conventional Facility

-ILCWS11 Granada Workshop -

GDE CFS Asian Team

September 29, 2011

Asian Site-specific Design of Civil Work for the ILC Conventional Facility

Firstly we appreciate your cooperation to have a WebEX session for us!

Contents

History of our study

RDR 2007

VE

SB2009
Single-Tunnel Configuration

Asia: DRFS
Americas：KCS

Optimization for the Asian site condition

Proposal of Japanese type of Single-Tunnel Accelerator

- Elimination of service tunnel and reduction of surface structures
- However, introduce a small side-tunnel for the purpose of pre-survey, de-watering, and safety

Review and Close Investigation

Clarify infrastructure needs, sizes and transportation for cryogenic, mechanical and electric plants

Needs access tunnel(shaft)-base caverns every 5 km, and local caverns every 500 m

Establish a DRFS tunnel layout

Fast half of FY2010

Case studies of cost and schedule for DRFS, KCS, XFEL, and RDR

- Different high-level RF systems
- Tunnel excavation using NATM or TBM, with local cavern excavation issue
- Is overall single-tunnel configuration impossible in Asian sites?

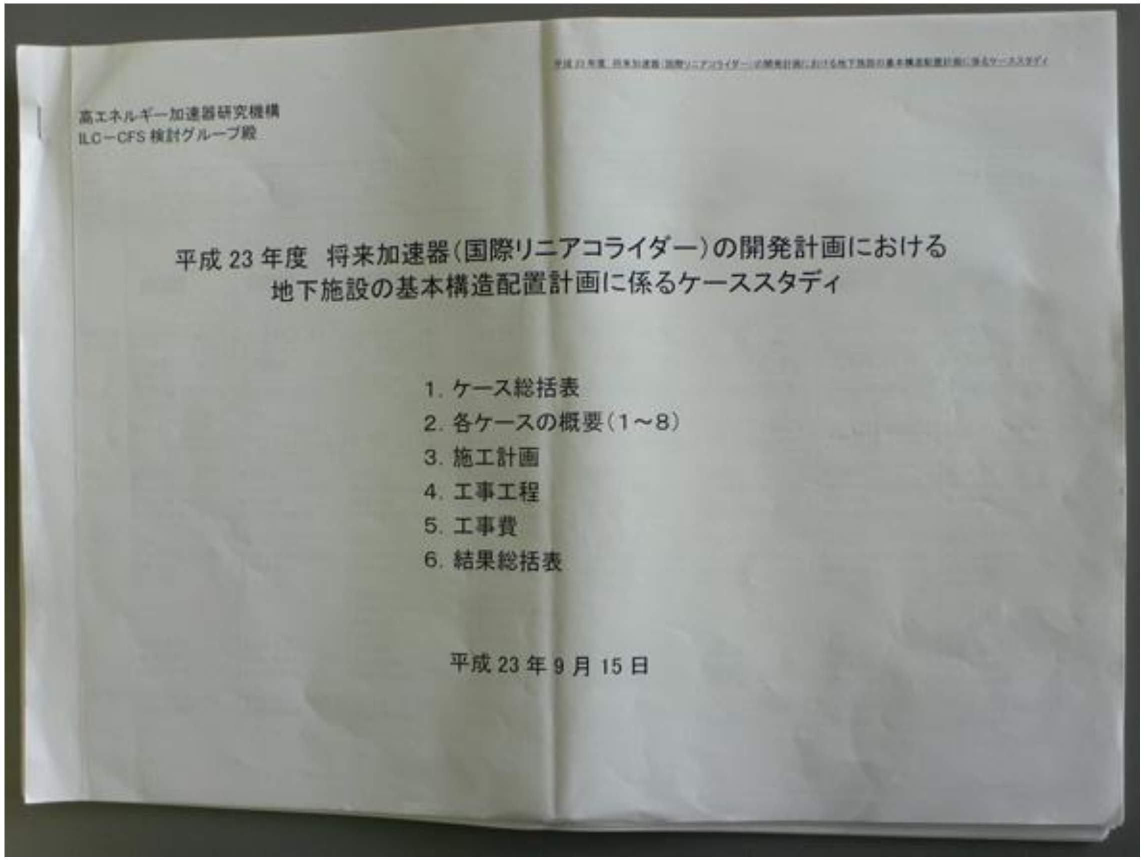
Compare of costs and schedule for 8 cases possible in Asian sites

Second half of FY2010

FY2011 activity

History of the Asian Team Activities

- After RDR, according to SB2009, we had been studying a ML (main linac) single-tunnel scheme matched with Asian mountainous sites.
- The first approach was to keep using TBM (tunnel boring machine) as a tunneling method as in RDR.
- We then proposed a realistic single-tunnel scheme called "Japanese-type of Single-tunnel Accelerator".
- However, it has not given sufficient results in accelerator layouts or cost case study.
- We started focusing on the NATM (new Austrian tunneling method) as an alternative tunneling method since the latter half of FY2010.
- The activities of the first half of FY2011 was disrupted by the Great East Japan Earthquake, but in this half year we have refined the civil case study since FY2010 and could collect site information (interim reports) for civil design from two potential sites.

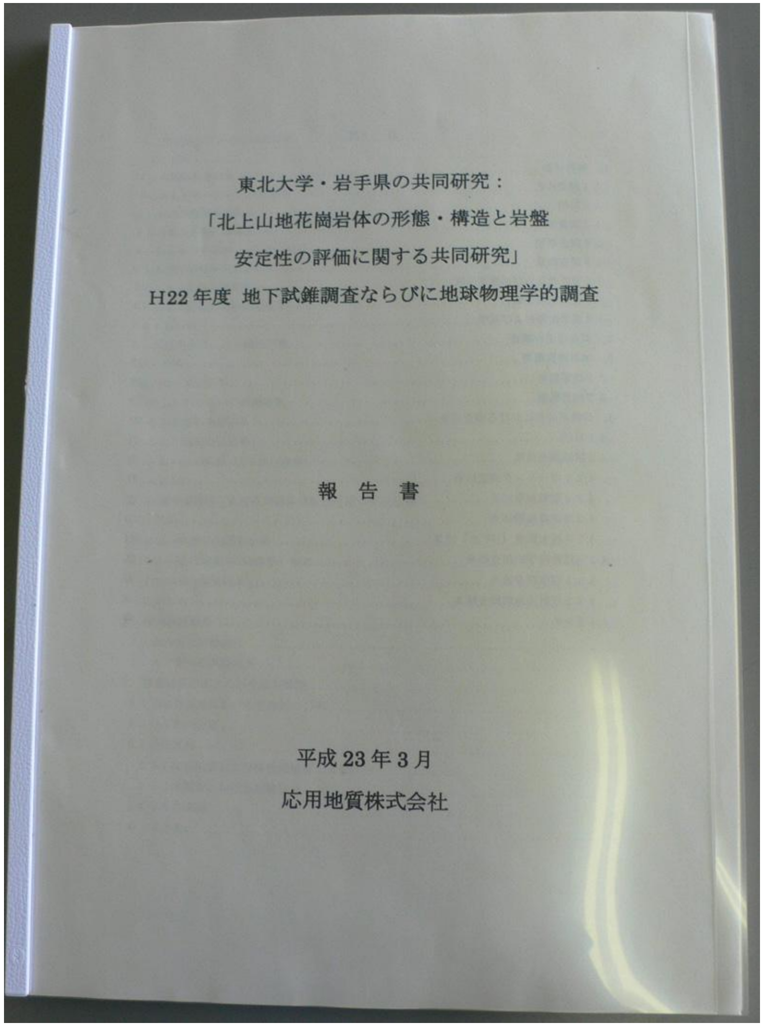

高エネルギー加速器研究機構
ILC－CFS 検討グループ殿

平成 23 年度　将来加速器（国際リニアコライダー）の開発計画における
地下施設の基本構造配置計画に係るケーススタディ

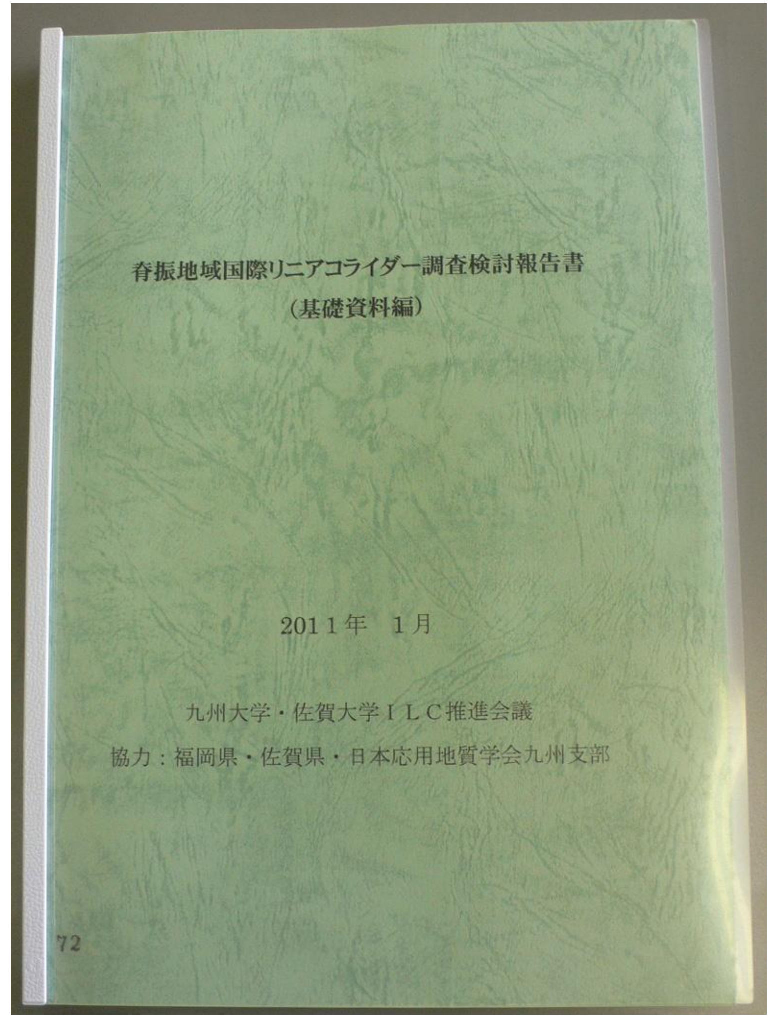
1．ケース総括表
2．各ケースの概要（1～8）
3．施工計画
4．工事工程
5．工事費
6．結果総括表

平成 23 年 9 月 15 日

Case studies on the underground structure configuration for ILC (Interim report from JPOWER, September 15, 2011).



Collaboration study report by Tohoku University and Iwate prefecture.



Report from ILC Promotion Society of Kyushu University and Saga universities with Fukuoka and Saga prefectures, and Kyushu blanch of Japan Society of Engineering Geology.

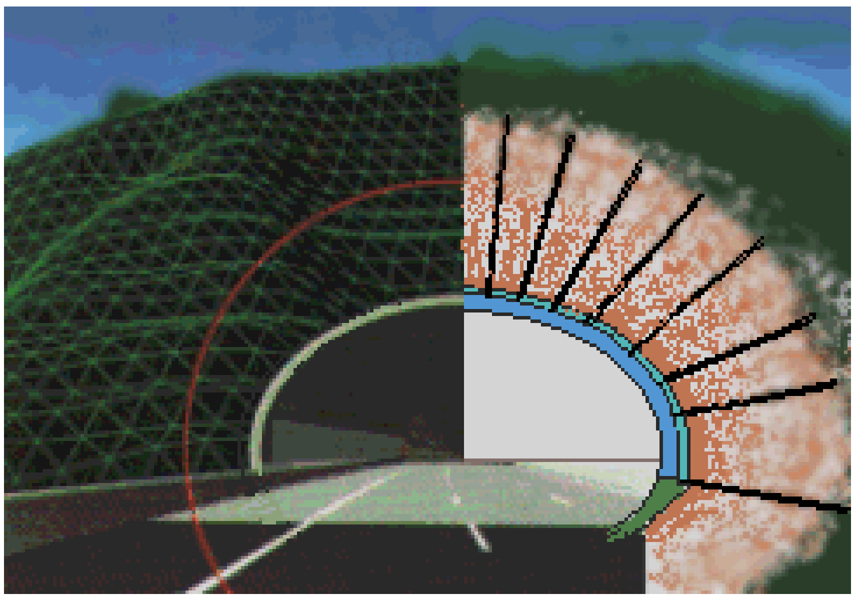
This is an introduction for the incoming CFS face-to-face meeting at KEK.

Asian-site Specific Design (1)
- Tunneling Method -

Why is the NATM focused in TDR?

NATM New Austrian Tunneling Method

- Blasting is used for hard rock and drill for soft rock.
- Loose bedrock is supported by rock bolt and/or sprayed concrete ("shotcrete") .



Blasting

- Make blast hole
- Charge
- Blasting
- Remove loose rock
- Remove muck
- Shotcrete
- Rock bolt
- Concrete lining

Drilling

- Drill machine

- Remove muck
- Shotcrete
- Rock bolt
- Concrete lining

- Blasting method is efficiently used for rocks from hard to soft.
- But difficult to use in resident area because of shock noise and vibration.

(1) Excavation Speed

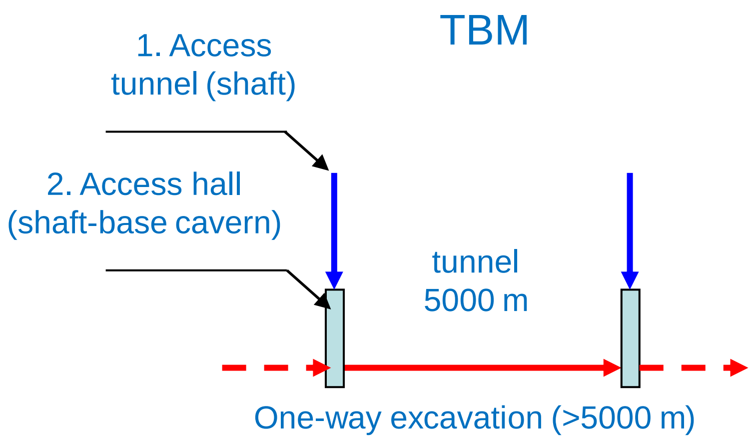
TBM was first adopted because of it's faster excavation speed.

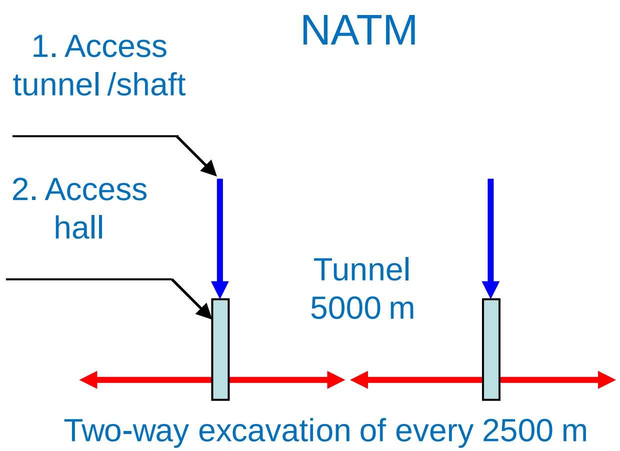
However, through the single-tunnel study, it has become clear that this advantage is not necessarily the case for the Asian mountainous sites.

-**Reported the averaged actual TBM performances is ~220 m/month in Japan. (~300 m/month is assumed for the selected good geology of an Asian sample site in RDR.) The NATM speed is roughly ~100 m/month.**

-**But the TBM speed advantage would be eliminated because the actual construction period is limited by some other factors, such as excavation length of one TBM and trouble frequency.**

-**TBM can only starts after shaft-base cavern where TBM trains are assembled. In NATM constructions of the shaft-base cavern and the tunnel can be simultaneously started.**


TBM
1. Access
tunnel (shaft)
2. Access hall
(shaft-base cavern)
tunnel
5000 m
One-way excavation (>5000 m)


NATM
1. Access
tunnel /shaft
2. Access
hall
Tunnel
5000 m
Two-way excavation of every 2500 m

(2) Cost Performance

The construction cost reduction is one of the most important goal in TDR.

The unit tunneling cost is generally cheaper in NATM than TBM.

The cost of TBM itself is expensive and longer use as long as ~10 km is cost effective, though this distance is 4 times longer than the NATM construction zone (2.5 km) in ILC ML.

Ex.) ϕ4.5-m TBM (5-km use), A=16 m2: Y/m= 1

4.5 m (W) x 4.5 m (H), A=18 m2: Y/m=0.825

Cost ratio = 0.725 /volume

(From Asian unit costs used in RDR)

(3) Construction Risk

The risk using TBM increases in bad geology.

Even though we selected uniform geology of granite for the Asian potential sites, we might have risk to encounter bad geology locations along the 50 km long site.

One of the reason because we introduce a smaller ‘Sub-tunnel’ in ‘Japanese-type ML single-tunnel’ is to avoid this risk.

The construction risk is less in NATM.

(4) Convenience of local-cavern construction

In the study of ‘Japanese-type single tunnel’ for the DRFS, because of accelerator installation in a 5.7-m diameter tunnel, we need local caverns for utility every ~600 m.

These local caverns have quite a volume and need additional work <u>‘after’ the ML tunnel excavation by TBM</u>. The local cavern excavation machines are limited by the ML tunnel size and the cost and schedule are inevitably increased.

(5) Tunneling flexibility

The obvious advantage in NATM is <u>free shape of tunnel cross sections</u>.

In DRFS, all the service components are installed in the beam tunnel and they should be protected from radiation by shield wall.

For this purpose, the circular section of TBM has disadvantage. The shield thickness is added to the tunnel diameter but the excessive tunnel diameter makes difficult space to use.

On the contrary, the NATM can provide an appropriate space not only for the beam tunnel but also the complicate shapes of alcoves, local cavern, deviations, etc., in all the machine areas.

(6) Disadvantages of NATM

Critical issues for NATM .

(1) Construction Speed →OK. See the case study.

(2) Noise →OK without near surface in access tunnel excavation.

(3) Geological →OK.

(4) Loosening of bedrock →Worse than TBM but not much.

Asian-site Specific Design (2)
- Surface Structure -

ILC PROJECT - SURFACE BUILDINGS AND ANCILLARY FACILITIES

ASIAN REGION

Draft 4/2/07

international linear collider

WBS		Building Type / Area System	Shaft Area	sources e- (1/2 2)	sources e+ (1/2 3)	Damping (12-13)	RTML (10-11)	Main linac (4-5-6-7+1/2 (2+3))	BDS (1 - 1.1)	Experiment (1 - 1.1)	General (1 - 1.1)	Total
			# buildings	0	0	0	0	0	0	2	0	**2**
1.7.3.3.2	1	Detector Assembly	Tot. surface	0	0	0	0	0	0	5000	0	**5,000**
			"	1/2	1/2	2	2	5	1	1	0	**12**
1.7.3.3.3	2	Offices for Technical Staff	"	100	100	400	400	1000	200	3600	0	**5,800**
			"	1/2	1/2	2	2	5	1	1	0	**12**
1.7.3.3.4	3	Electrical building	"	450	450	1800	1800	3600	800	800	0	**9,700**
			"	1/2	1/2	2	2	5	1	2	0	**13**
1.7.3.3.4	4	Cooling Tower & Pump Station	"	325	325	1300	1300	3250	650	1500	0	**8,650**
			"	1/2	1/2	2	2	5	1	1	0	**12**
1.7.3.3.4	5	Cooling Ventilation building	"	400	400	2000	1400	4000	600	1200	0	**10,000**
			"	0	0	0	0	0	4	0	0	**4**
1.7.3.3.4	6	Beam dump cooling building	"	0	0	0	0	0	600	0	0	**600**
			"	1/2	1/2	2	2	5	1	1	0	**12**
1.7.3.3.5	7	Cryo - Warm Compressor	"	200	200	500	500	3600	400	400	0	**5,800**
			"	1/2	1/2	2	2	5	1	1	0	**12**
1.7.3.3.5	8	Cryo - Surface Cold box	"	300	300	800	1200	3000	600	600	0	**6,800**
			"	1/2	1/2	2	2	5	1	0	0	**11**
1.7.3.3.6	9	Control Rooms	"	50	50	200	200	500	100	0	0	**1,100**
			"	0	0	0	0	0	0	0	1	**1**
1.7.3.3.6	10	Control Room	"	0	0	0	0	0	0	0	1000	**1,000**
			"	1	1	2	2	2	1	2	0	**11**
1.7.3.3.7	11	Workshop	"	450	450	900	900	900	800	900	0	**5,300**
			"	1/2	1/2	2	2	5	0	0	1	**11**
1.7.3.3.8	12	Site Access building	"	50	50	200	200	500	0	0	100	**1,100**
			"	1/2	1/2	2	2	5	1/2	1/2	0	**11**
1.7.3.3.9	13	Shaft Access	"	350	350	1200	1400	3300	325	325	0	**7,250**
			"	1	2	0	0	0	0	0	0	**3**
1.7.3.3.10	14	Laser building	"	25	50	0	0	0	0	0	0	**75**
			"	0	2	0	0	0	0	0	0	**2**
1.7.3.3.10	15	Rad building	"	0	1600	0	0	0	0	0	0	**1,600**
			"	0	0	0	0	0	0	1	0	**1**
1.7.3.3.10	16	Gaz building	"	0	0	0	0	0	0	400	0	**400**
		CENTRAL CAMPUS BUILDINGS (basis : 1500 staff in total)										
			# buildings								1	**1**
1.7.3.3.1	1	Main building (offices)	Tot. surface								10000	**10,000**
			"								1	**1**
1.7.3.3.3	2	Service building	"								14000	**14,000**
			"								1	**1**
1.7.3.3.4	3	Main heating plant	"								600	**600**
			"								1	**1**
1.7.3.3.4	4	Garage - Maintenance vehicules	"								1000	**1,000**
			"								1	**1**
1.7.3.3.4	5	Computer Center	"								1200	**1,200**
			"								1	**1**
1.7.3.3.10	6	Safety Building	"								1400	**1,400**
			"								1	**1**
1.7.3.3.11	7	Reception	"								1400	**1,400**
			"								1	**1**
1.7.3.3.11	8	Restaurant & Cafeteria	"								1200	**1,200**
			"								1	**1**
1.7.3.3.11	9	Hostel	"								2200	**2,200**
			"								1	**1**
1.7.3.3.11	10	Wharehouse / Goods reception	"								1200	**1,200**
											TOTAL # Buildings	**140**
											TOTAL Surface Area m2	**104,375**
		OTHER SURFACE STRUCTURES										
			#	0	0	0	0	0	0	0	1	**1**
1.7.3.3.4	1	Electrical transformer	Tot. surface	0	0	0	0	0	0	0	15600	**15,600**
			#	0	0	0	0	0	0	0	1	**1**
1.7.3.3.10	2	Survey gallery	Tot. Length	0	0	0	0	0	0	0	800	**800**
			#	0	0	0	0	0	0	0	1	**1**
1.7.3.3.10	3	Survey calibration (piles)	Tot. Length	0	0	0	0	0	0	0	0	**0**
			#	1	1	2	2	5	1	1	1	**0**
1.7.3.3.10	4	Underground galleries	Tot. Length	100	100	300	300	750	200	400	600	**2,750**
			#	1/2	1/2	1	2	5	1	1	1	**12**
1.7.3.3.10	5	Platform tank helium	Tot. surface	500	500	200	2000	5000	1000	500	500	**10,200**

RDR 地上施設内訳

Legend :
- RTML
- ML
- DR
- Sources e- KAS
- BDS
- Detectors Area

11 (ϕ14)

建物数	12	
建物床面積	5,800	
敷地面積	19,333	
技術職員棟	1	200
電気棟	1	900
冷却塔	1	650
空調機械棟	1	700
コンプレッサー棟	1	250
コールドボックス棟	1	600
ローカル制御棟	1	100
工作棟	1	450
受付棟	1	100
アクセストンネル入口棟	1	700
Underground Galleries Services, W=	1	150
Heタンクプラットフォーム	1	1,000
		5,800

7 (ϕ9)

建物数	11	
建物床面積	5,900	
敷地面積	19,667	
技術職員棟	1	200
電気棟	1	900
冷却塔	1	650
空調機械棟	1	800
コンプレッサー棟	1	800
コールドボックス棟	1	600
ローカル制御棟	1	100
受付棟	1	100
アクセストンネル入口棟	1	600
Underground Galleries Services, W=	1	150
Heタンクプラットフォーム	1	1,000
		5,900

5 (ϕ14)

建物数	13	
建物床面積	7,250	
敷地面積	24,167	
技術職員棟	1	200
電気棟	1	900
冷却塔	1	650
空調機械棟	1	800
コンプレッサー棟	1	800
コールドボックス棟	1	600
ローカル制御棟	1	100
工作棟	1	450
受付棟	1	100
アクセストンネル入口棟	1	700
Underground Galleries Services, W=	1	150
放射化物保管棟	1	800
Heタンクプラットフォーム	1	1,000
		7,250

3 (ϕ14)

建物数	15	
建物床面積	6,850	
敷地面積	22,833	
技術職員棟	1	200
電気棟	1	900
冷却塔	1	650
空調機械棟	1	800
コンプレッサー棟	1	400
コールドボックス棟	1	600
ローカル制御棟	1	100
工作棟	1	450
受付棟	1	100
アクセストンネル入口棟	1	700
Underground Galleries Services, W=	1	100
放射化物保管棟	1	800
レーザ棟	2	50
Heタンクプラットフォーム	1	1,000
		6,850

13 (ϕ9)

建物数	12	
建物床面積	5,000	
敷地面積	16,667	
技術職員棟	1	200
電気棟	1	900
冷却塔	1	650
空調機械棟	1	1,000
コンプレッサー棟	1	250
コールドボックス棟	1	400
ローカル制御棟	1	100
工作棟	1	450
受付棟	1	100
アクセストンネル入口棟	1	600
Underground Galleries Services, W=	1	150
Heタンクプラットフォーム	1	200

1(ϕ9, ϕ16, ϕ16)

	BDS	Exp.	Gen.	(Center)
建物数	14.5	14.5	17	46
建物床面積	6,275	15,625	52,800	74,700
敷地面積	20,917	52,083	176,000	249,000
研究棟			1 / 10,000	1 / 10,000
検出器組立ホール		2 / 5,000		2 / 5,000
事務棟			1 / 14,000	1 / 14,000
技術職員棟		1 / 3,600		1 / 3,600
技術職員棟	1 / 200			1 / 200
電気棟	1 / 800	1 / 800		2 / 1,600
トランスヤード			1 / 15,600	1 / 15,600
冷却塔	1 / 650	2 / 1,500		3 / 2,150
空調機械棟	1 / 600	1 / 1,200		2 / 1,800
ビームダンプ冷却塔	4 / 600			4 / 600
暖房設備棟			1 / 600	1 / 600
計算機センター			1 / 1,200	1 / 1,200
自動車保守保管庫			1 / 1,000	1 / 1,000
コンプレッサー棟	1 / 400	1 / 400		2 / 800
コールドボックス棟	1 / 600	1 / 600		2 / 1,200
中央制御棟			1 / 1,000	1 / 1,000
ローカル制御棟	1 / 100			1 / 100
工作棟	1 / 800	2 / 900		3 / 1,700
受付棟			1 / 100	1 / 100
アクセストンネル入口棟	0.5 / 325	0.5 / 325		1 / 650
測量器校正用建物			1 / 800	1 / 800
測量器校正用パイル			1	1 / 0
Underground Galleries Services, W=	1 / 200	1 / 400	1 / 600	3 / 1,200
安全管理棟			1 / 1,400	1 / 1,400
ガス管理棟		1 / 400		1 / 400
Heタンクプラットフォーム	1 / 1,000	1 / 500	1 / 500	3 / 2,000
ユーザーレセプション棟			1 / 1,400	1 / 1,400
売店			1 / 1,200	1 / 1,200
レストラン			1 / 1,200	1 / 1,200
宿泊施設			1 / 2,200	1 / 2,200

12 (ϕ9)

建物数	11	
建物床面積	4,800	
敷地面積	16,000	
技術職員棟	1	200
電気棟	1	900
トランスヤード		
冷却塔	1	650
空調機械棟	1	1,000
コンプレッサー棟	1	250
コールドボックス棟	1	400
ローカル制御棟	1	100
工作棟	1	450
受付棟	1	100
アクセストンネル入口棟	1	600
Underground Galleries Services, W=	1	150
		4,800

2 (ϕ14)

建物数	13	
建物床面積	6,025	
敷地面積	20,083	
技術職員棟	1	200
電気棟	1	900
冷却塔	1	650
空調機械棟	1	800
コンプレッサー棟	1	400
コールドボックス棟	1	600
ローカル制御棟	1	100
工作棟	1	450
受付棟	1	100
アクセストンネル入口棟	1	700
Underground Galleries Services, W=	1	100
レーザ棟	1	25
Heタンクプラットフォーム	1	1,000
		6,025

4 (ϕ14)

建物数	12	
建物床面積	6,450	
敷地面積	21,500	
技術職員棟	1	200
電気棟	1	900
冷却塔	1	650
空調機械棟	1	800
コンプレッサー棟	1	800
コールドボックス棟	1	600
ローカル制御棟	1	100
工作棟	1	450
受付棟	1	100
アクセストンネル入口棟	1	700
Underground Galleries Services, W=	1	150
Heタンクプラットフォーム	1	1,000
		6,450

6 (ϕ9)

建物数	11	
建物床面積	5,900	
敷地面積	19,667	
技術職員棟	1	200
電気棟	1	900
冷却塔	1	650
空調機械棟	1	800
コンプレッサー棟	1	800
コールドボックス棟	1	600
ローカル制御棟	1	100
工作棟		
受付棟	1	100
アクセストンネル入口棟	1	600
Underground Galleries Services, W=	1	150
Heタンクプラットフォーム	1	1,000
		5,900

10 (ϕ14)

建物数	12	
建物床面積	5,800	
敷地面積	19,333	
技術職員棟	1	200
電気棟	1	900
冷却塔	1	650
空調機械棟	1	700
コンプレッサー棟	1	250
コールドボックス棟	1	600
ローカル制御棟	1	100
工作棟	1	450
受付棟	1	100
アクセストンネル入口棟	1	700
Underground Galleries Services, W=	1	150
Heタンクプラットフォーム	1	1,000
		5,800

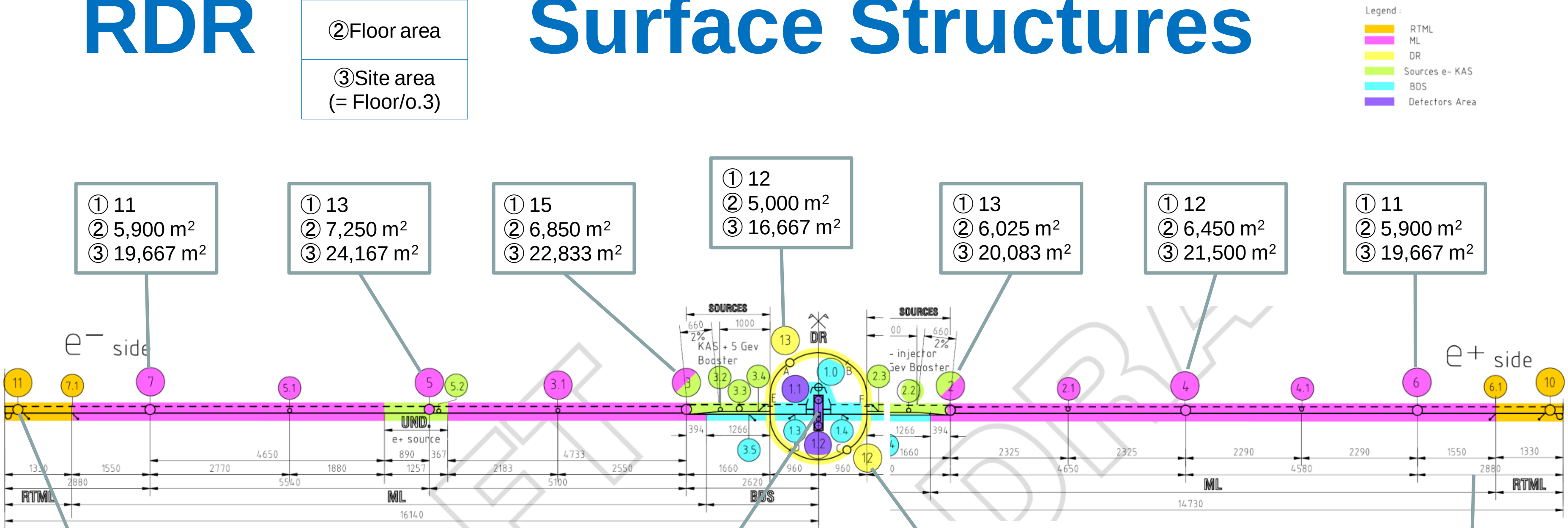
地上建物数: 167

地上建物床面積: 134,476 m^2

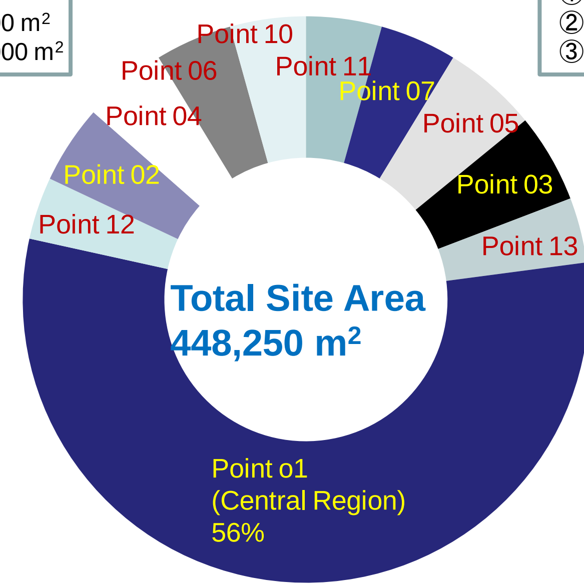
敷地面積: 448,253 m^2

RDR Surface Structures

①Building No.
②Floor area
③Site area (= Floor/o.3)



Access Point	Area (m2)
Point 11	19,333
Point 07	19,667
Point 05	24,167
Point 03	22,833
Point 13	16,667
Point 01	249,000
Point 12	16,000
Point 02	20,083
Point 04	21,500
Point 06	19,667
Point 10	19,333
Total	448,250



Surface Structure Strategy in TDR

Surface structures supposed in RDR are 167 in building numbers, ~135,000 m2 in total floor area of buildings, and ~450,000 m2 in ILC site area.

Here the site area was calculated assuming a building coverage of 30%.

The site area is ~20,000 m2 per each of 10 area gates, and ~250,000 m2 for central region.

The site area in TDR will be considered for each of two candidate sites.

However, at least, areas of ~5,000 m2 per each area gates have to be developed for underground construction support and they are used to built facilities such as entrance control and cooling towers.

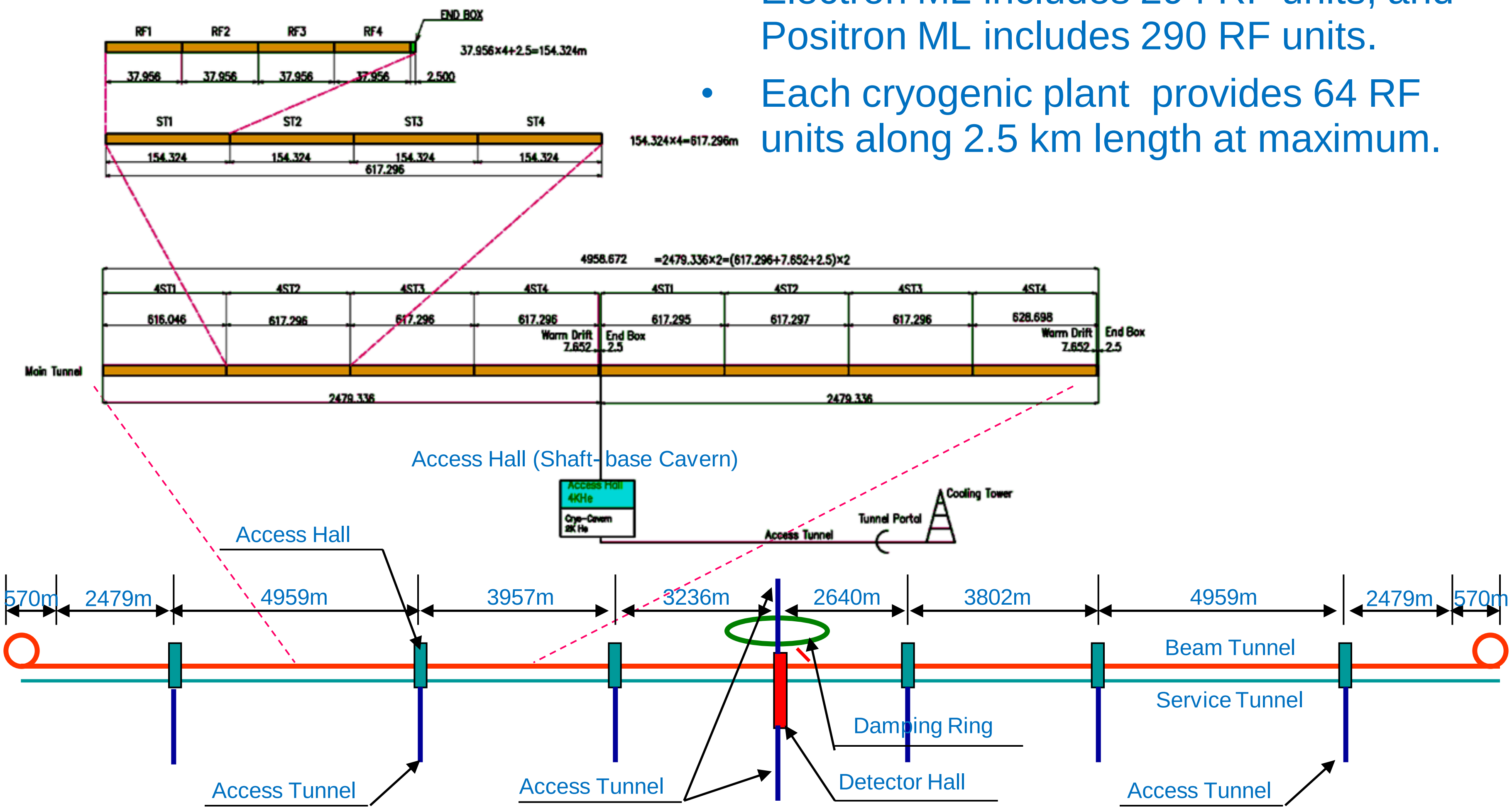
In central region, at least an area of 6,000 m2 necessary for the detector assembly, 16,000 m2 for the main substation, etc.

Asian-site Specific Design (3)
- Case Study on Underground Structure -

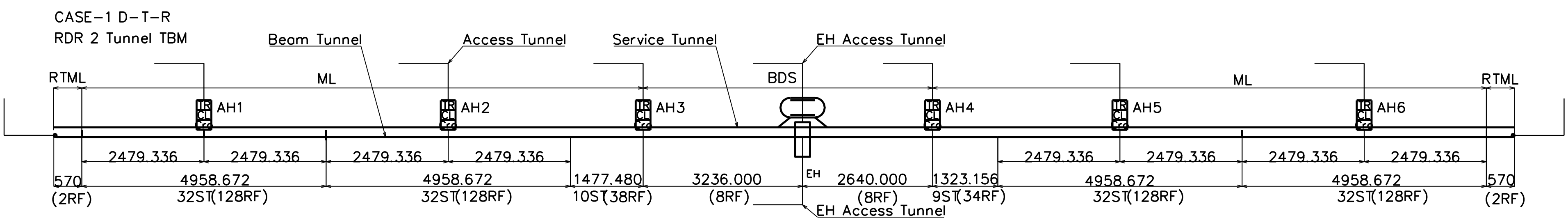
3. Baseline Conditions to evaluate costs and schedule

3.1 General Layout of the underground structure

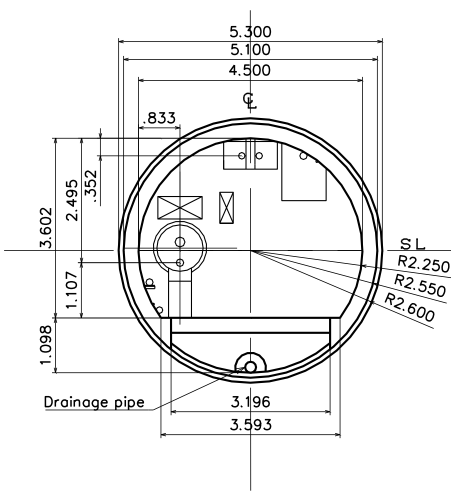
- Electron ML includes 294 RF units, and Positron ML includes 290 RF units.
- Each cryogenic plant provides 64 RF units along 2.5 km length at maximum.



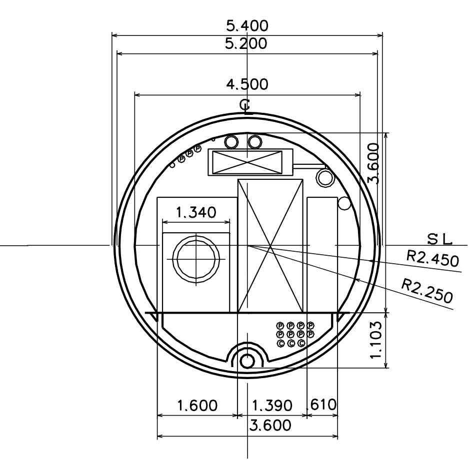
Case1 DTR (double tunnel, TBM, RDR)



- Based on the RDR ML tunnel design: keep the ML tunnel inner diameters 4.5 m.
- But the tunnel inner finish is changed from “shotcrete” to 30-cm thick concrete lining. This is the same for all the following cases in order to compare them in the same condition.
- Using TBM to excavate tunnel.
- 6 access halls (shaft-base cavern) at every 5 km; each hall has one 1 km long sloped tunnel to access ground surface.
- Access halls include infrastructure such as cryogenic, cooling-water, air, and electric plants.
- One Detector Hall and one Damping ring service halls with access tunnels (see the later picture).

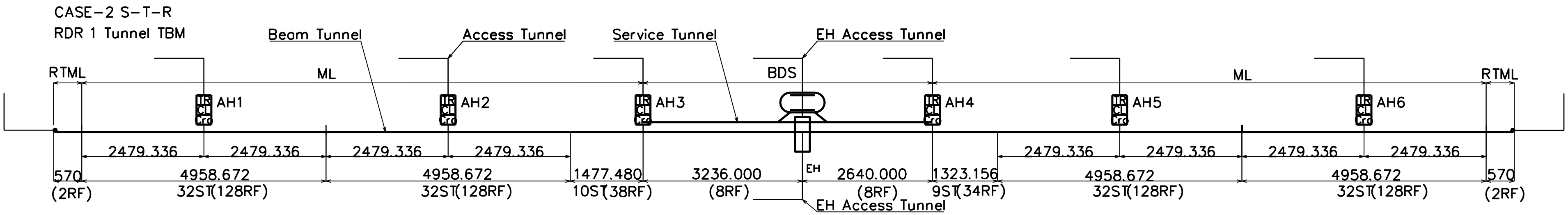


Beam Tunnel

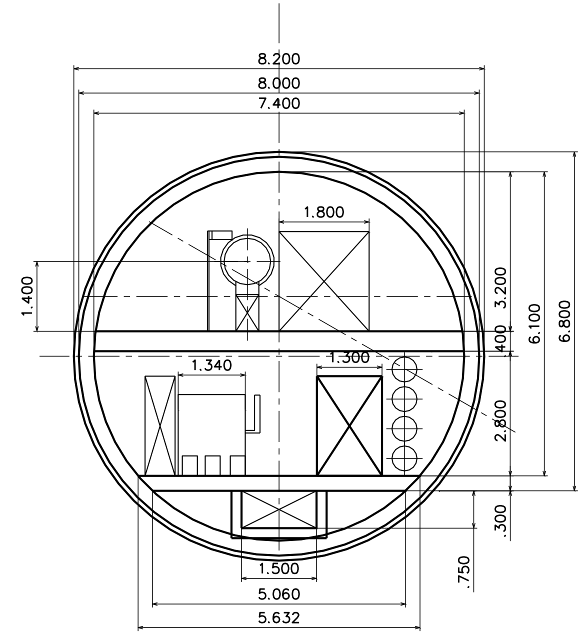


Service Tunnel

Case2 STR (single tunnel, TBM, RDR)

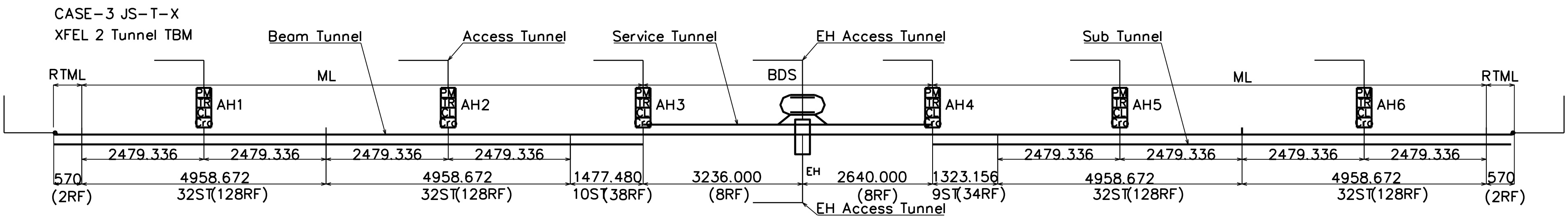


- Single large-bore tunnel includes all ML equipment.
- Using TBM to excavate tunnel.
- Beam tunnel and service tunnel are separated with a 40-cm thick floor.
- 6 access halls (shaft-base cavern) at every 5 km; each hall has one 1 km long sloped tunnel to access ground surface.
- One Detector Hall and a Damping ring service halls with access tunnels (see the later picture).

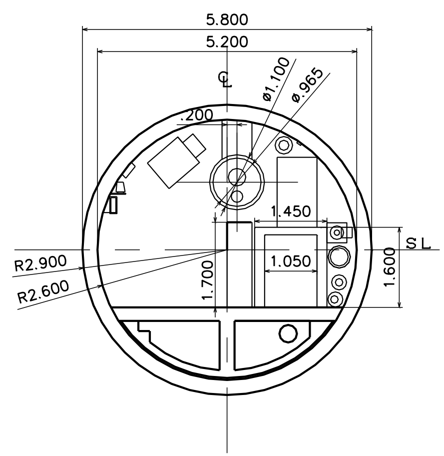


Beam/service tunnel, all in one accelerator tunnel.

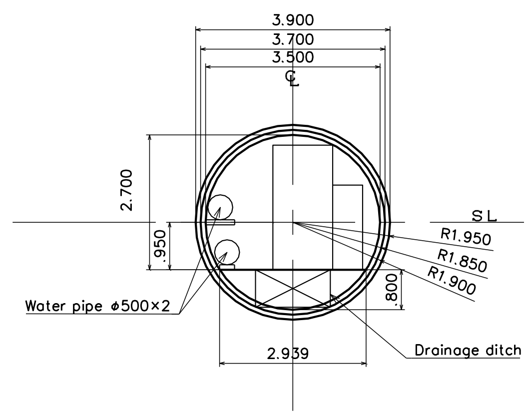
Case3 JSTX (Japanese-type single tunnel, TBM, XFEL)



- XFEL-type HLRF layout
- Japanese-type single-tunnel accelerator configuration with a small side tunnel.
- Using TBM to excavate tunnel.
- 6 access halls (shaft-base cavern) at every 5 km; each hall has one 1 km long sloped tunnel to access ground surface.
- One Detector Hall and a Damping ring service halls with access tunnels (see the later picture).
- HLRF pulse modulators are installed in 6 access halls (shaft-base caverns).

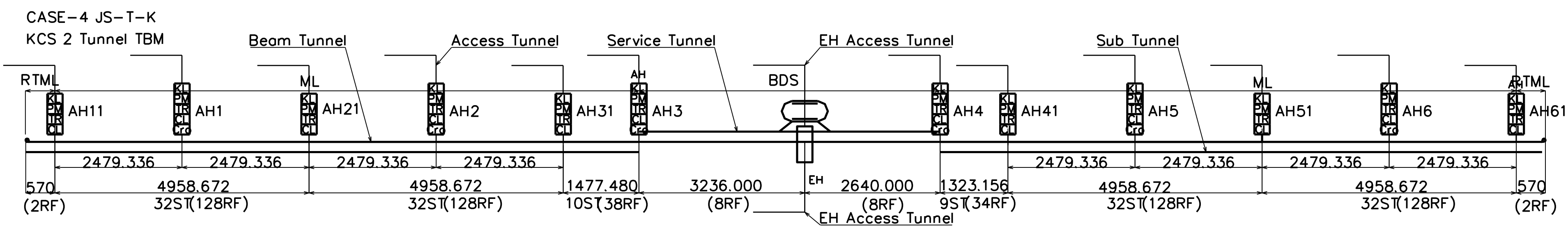


Accelerator tunnel in XFEL-type

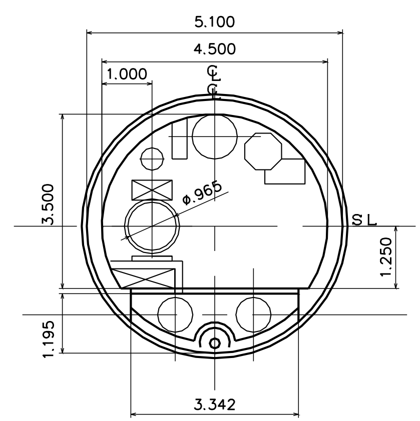


Side tunnel

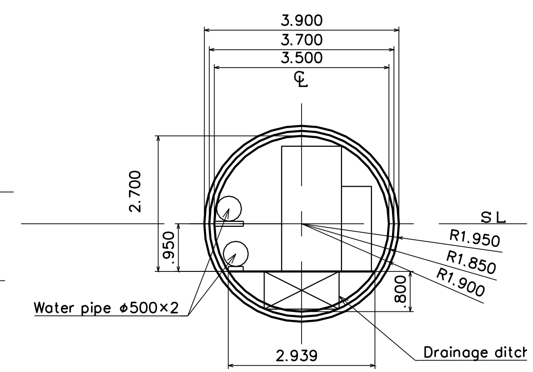
Case4 JSTK (Japanese-type single tunnel, TBM, KCS)



- KCS-type HLRF layout
- Japanese-type single-tunnel accelerator configuration with a small side tunnel.
- Using TBM to excavate tunnel.
- 12 access halls (shaft-base cavern) at every 2.5 km; each hall has one 1 km long sloped tunnel to access ground surface.
- One Detector Hall and a Damping ring service halls with access tunnels (see the later picture).
- HLRF systems are installed in 12 access halls (shaft-base caverns).

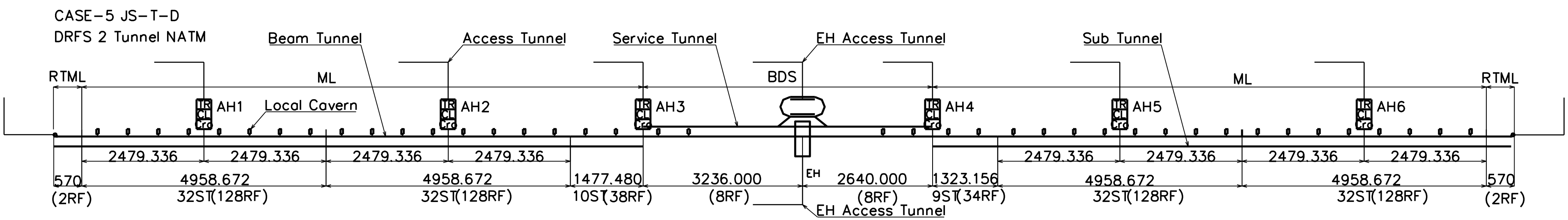


Accelerator Tunnel in KCS type

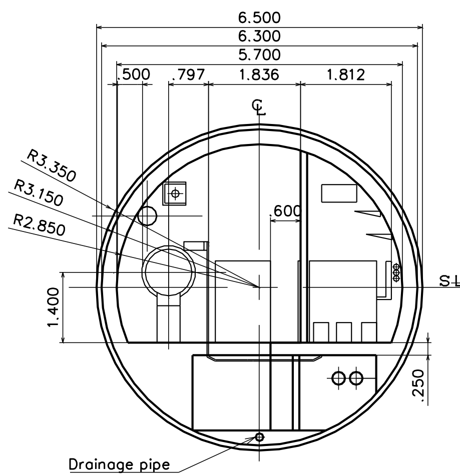


Side Tunnel

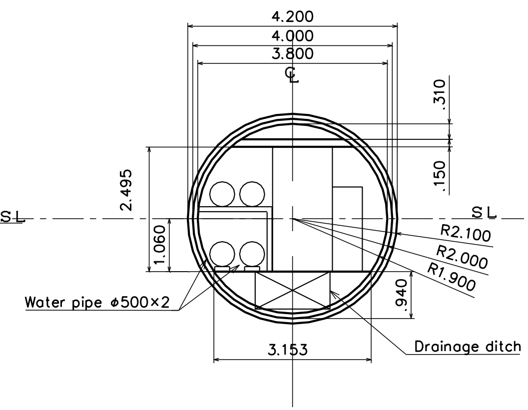
Case5 JSTD (Japanese-type single tunnel, TBM, DRFS)



- DRFS-type HLRF layout
- Japanese-type single-tunnel accelerator configuration with a small side tunnel.
- Using TBM to excavate tunnel.
- 6 access halls (shaft-base cavern) at every 5 km; each hall has one 1 km long sloped tunnel to access ground surface.
- One Detector Hall and a Damping ring service halls with access tunnels (see the later picture).
- Local caverns at 617 m (4-cryo-string length) for cooling DRFS equipment.



Accelerator Tunnel



Side Tunnel

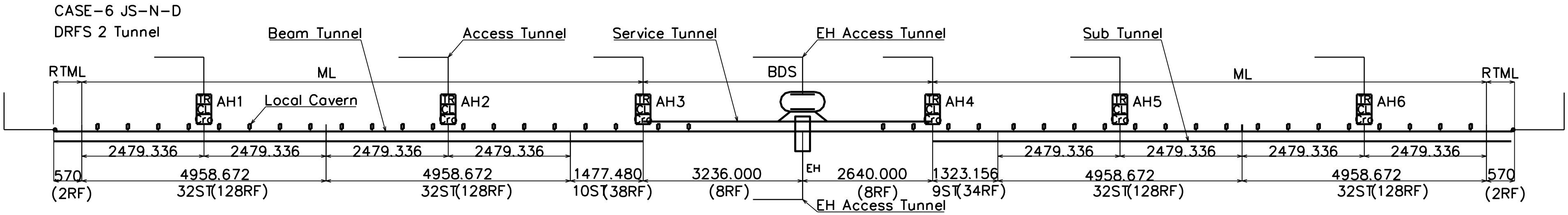
From here is the progress in the second half of FY2010!

In the progress in Japanese-type single-tunnel scheme, we met inconvenience such as …

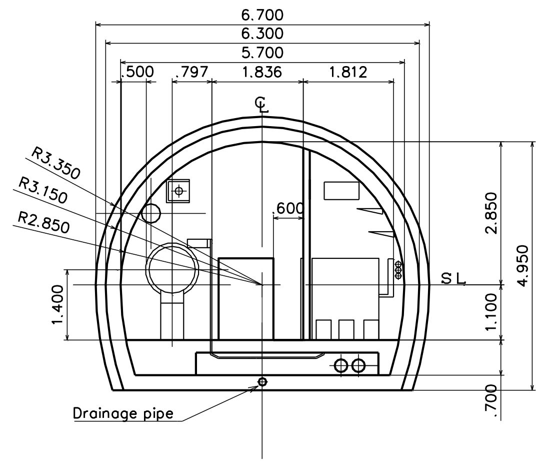
- For longer cooling-water distribution of Japanese-type single tunnel which has, ex., only two cooling-tower plants on the surface, we found we need a volume of local caverns for pumps to boost the water pressure.
- In the case of using TBM, these caverns have to be excavated after finishing the tunneling work.
- How to establish radiation shield for more DRFS equipment than KCS/XFEL in a small circular tunnel section.

Then we have picked NATM, which is widely used for Japanese tunnel excavation, also for the ML tunnel excavation.

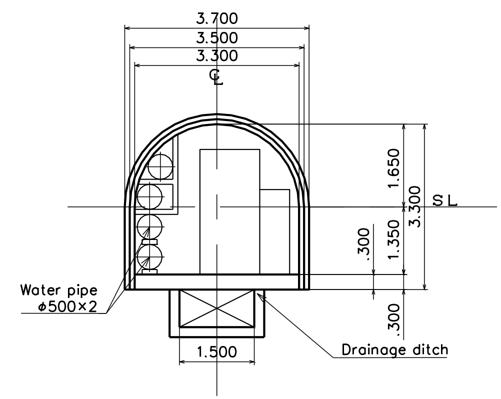
Case6 JSND (Japanese-type single tunnel, NATM, DRFS)



- DRFS-type HLRF layout
- Japanese-type single-tunnel accelerator configuration with a small side tunnel.
- Using NATM to excavate tunnel.
- 6 access halls (shaft-base cavern) at every 5 km; each hall has one 1 km long sloped tunnel to access ground surface.
- One Detector Hall and a Damping ring service halls with access tunnels (see the later picture).
- Local caverns at 617 m (4-cryo-string length) for cooling DRFS equipment.

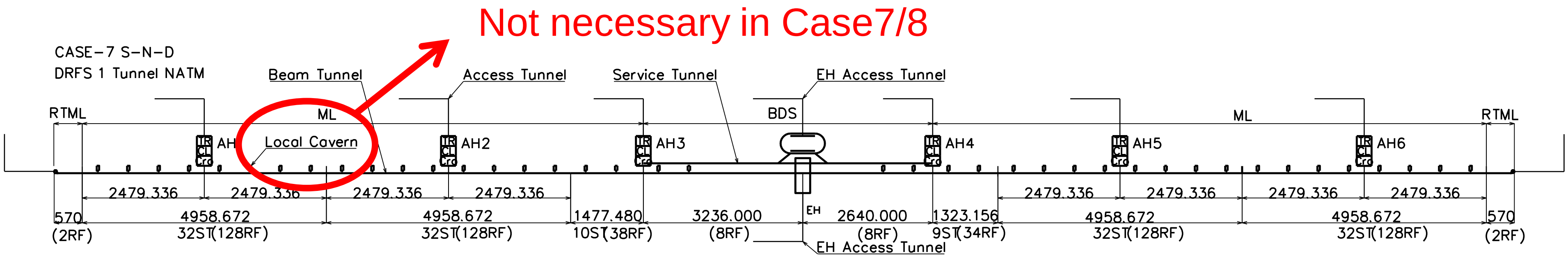


Accelerator Tunnel

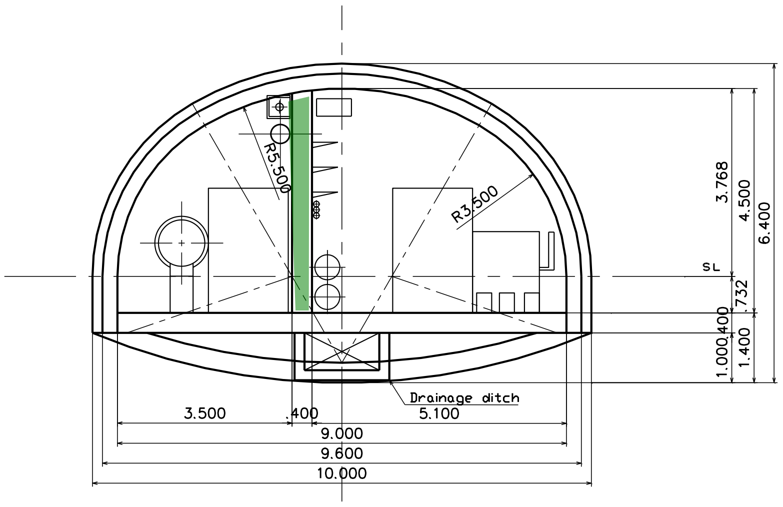


Side Tunnel

Case7 SNDR (Single tunnel, NATM, DRFS/RDR)

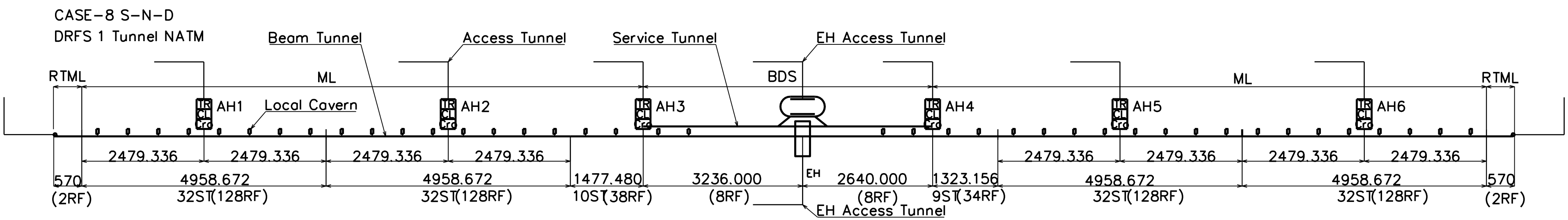


- DRFS/RDR-type HLRF layout
- By using NATM more suitable section can be excavated to accommodate accelerator equipment.
- Taking flat section beam tunnel and service tunnels are separated with a 40-cm concrete shield. The shield thickness is chosen to be sufficient to protect service tunnel equipment from radiation.
- 6 access halls (shaft-base cavern) at every 5 km; each hall has one 1 km long sloped tunnel to access ground surface.
- One Detector Hall and a Damping ring service halls with access tunnels (see the later picture).
- Due to enough space for machine installation, local caverns for utility can be eliminated.



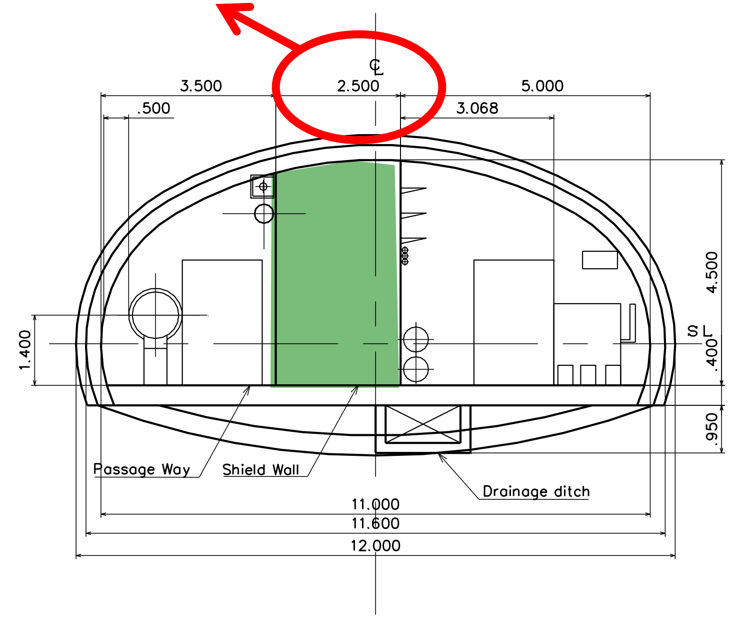
Beam/service tunnel, all in one accelerator tunnel.

Case8 SNDR (Single tunnel, NATM, DRFS/RDR)



Changed to 3.5 m according to RDR but should be discussed later

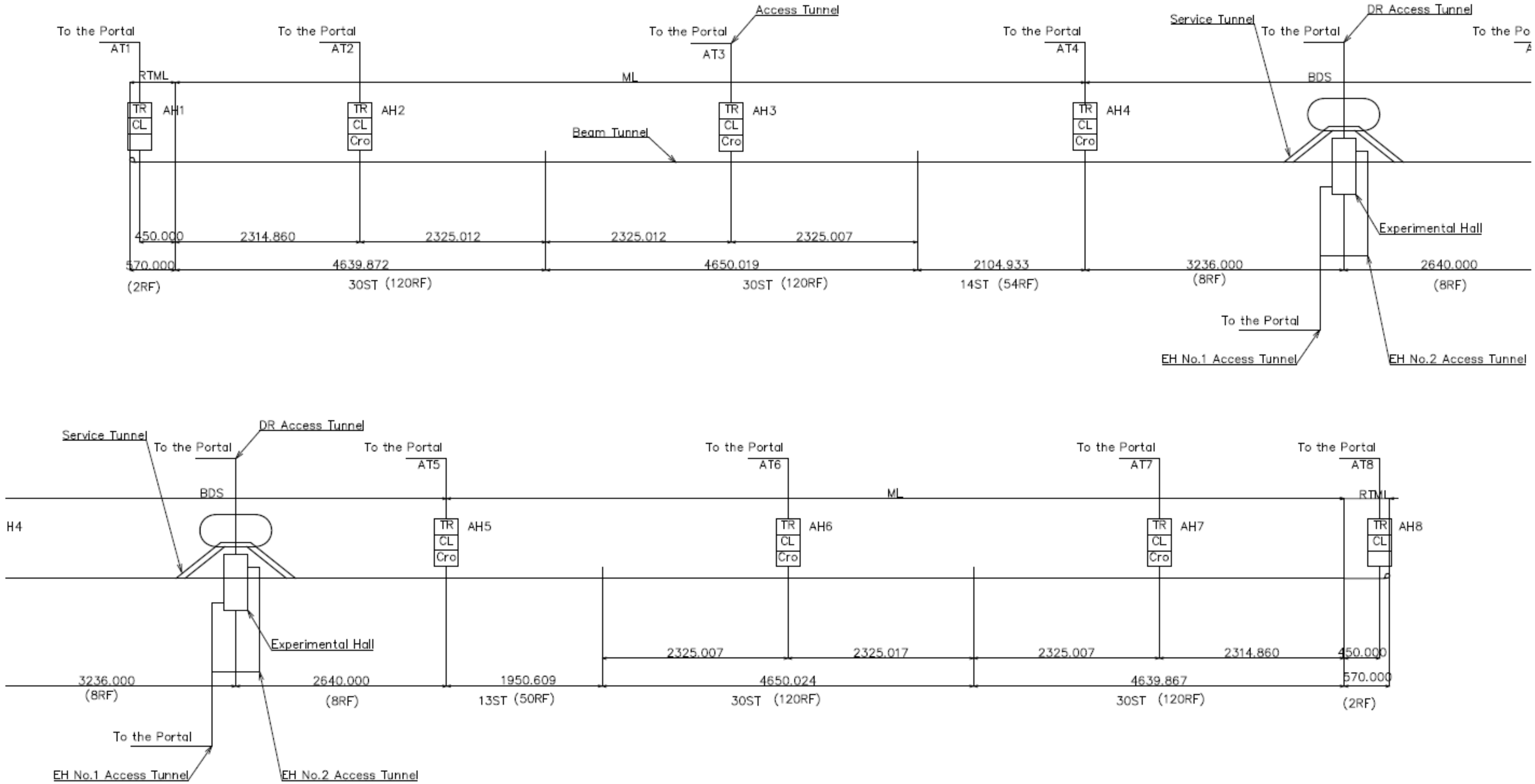
- DRFS/RDR-type HLRF layout
- By using NATM more suitable section can be excavated to accommodate accelerator equipment.
- Taking flat section beam tunnel and service tunnels are separated with a 3.5-m concrete shield. The shield thickness is chosen to be sufficient to protect personnel in service tunnel from radiation.
- 6 access halls (shaft-base cavern) at every 5 km; each hall has one 1 km long sloped tunnel to access ground surface.
- One Detector Hall and a Damping ring service halls with access tunnels (see the later picture).
- Due to enough space for machine installation, local caverns for utility can be eliminated.



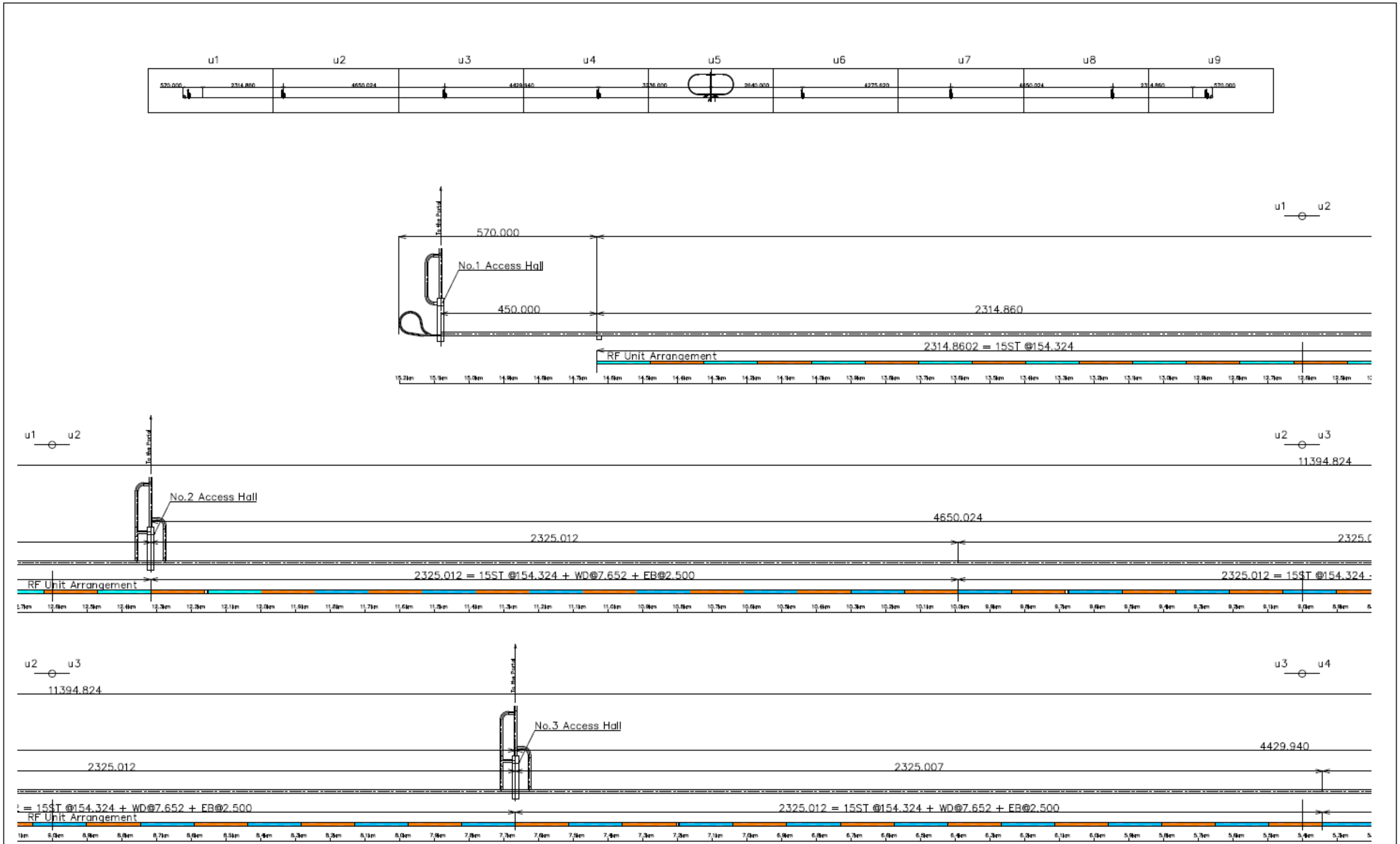
Beam/service tunnel, all in one accelerator tunnel.

Progress of Drawing

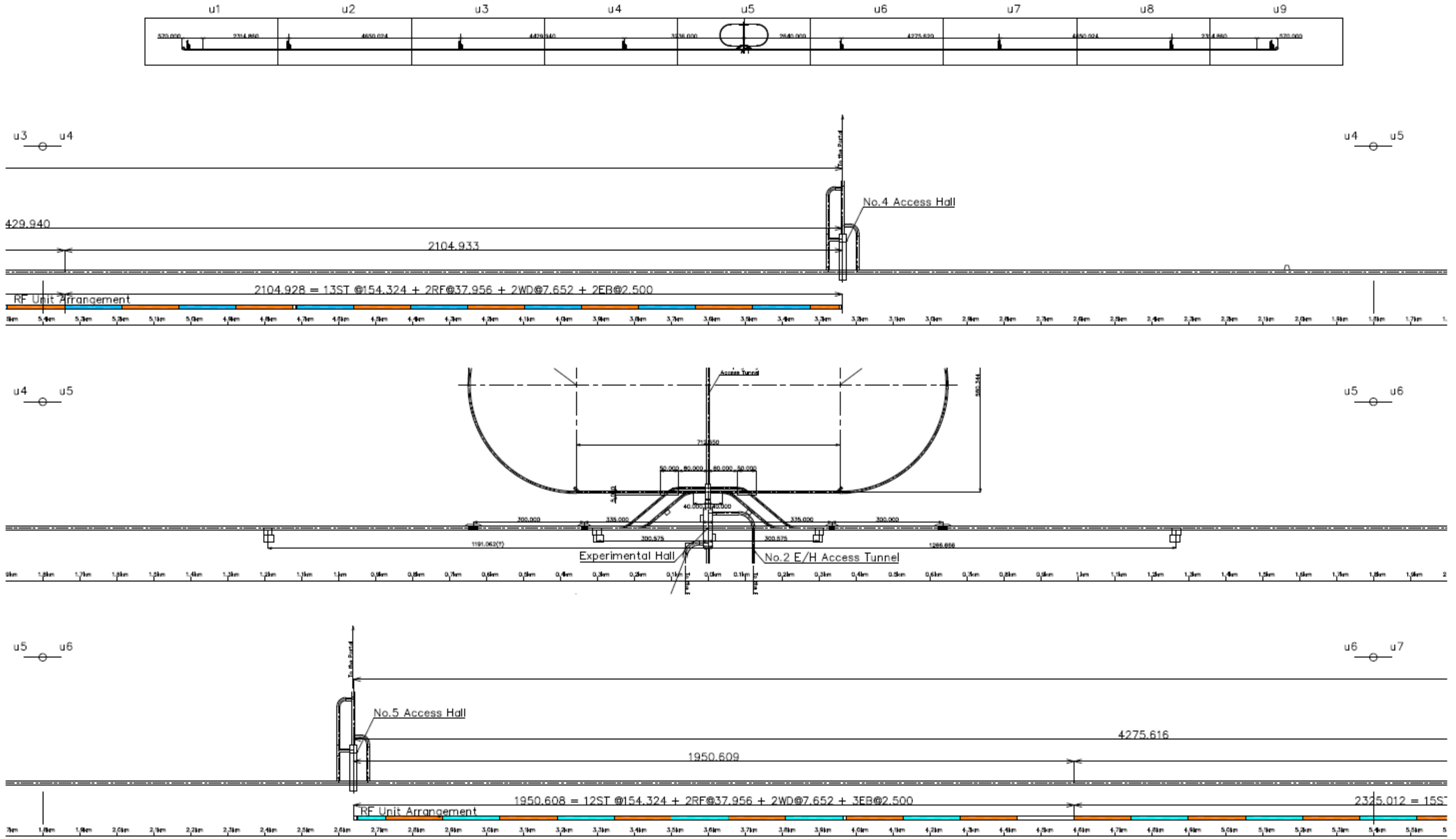
Drawing sets have been prepared to estimate costs and schedules for each case.
The followings are the drawing set for the Case8.



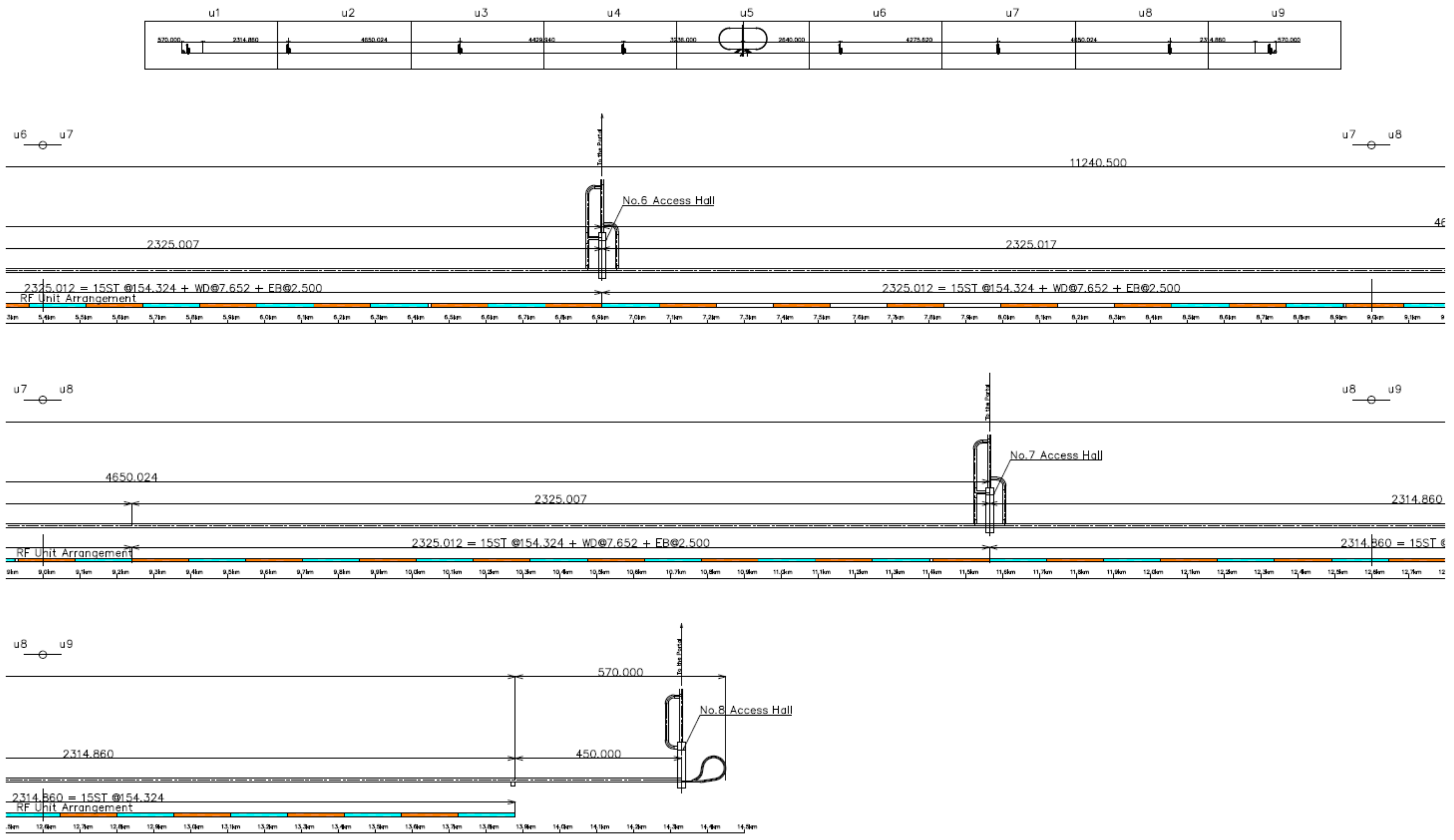
GLOBAL DESIGN EFFORT ASIA REGION	CASE 8-wSND Schematic Layout	KEK	DRAWING NO. CASE8-wSND-A01 REVISION SCALE 1/XXXX DATE 31/08/2011



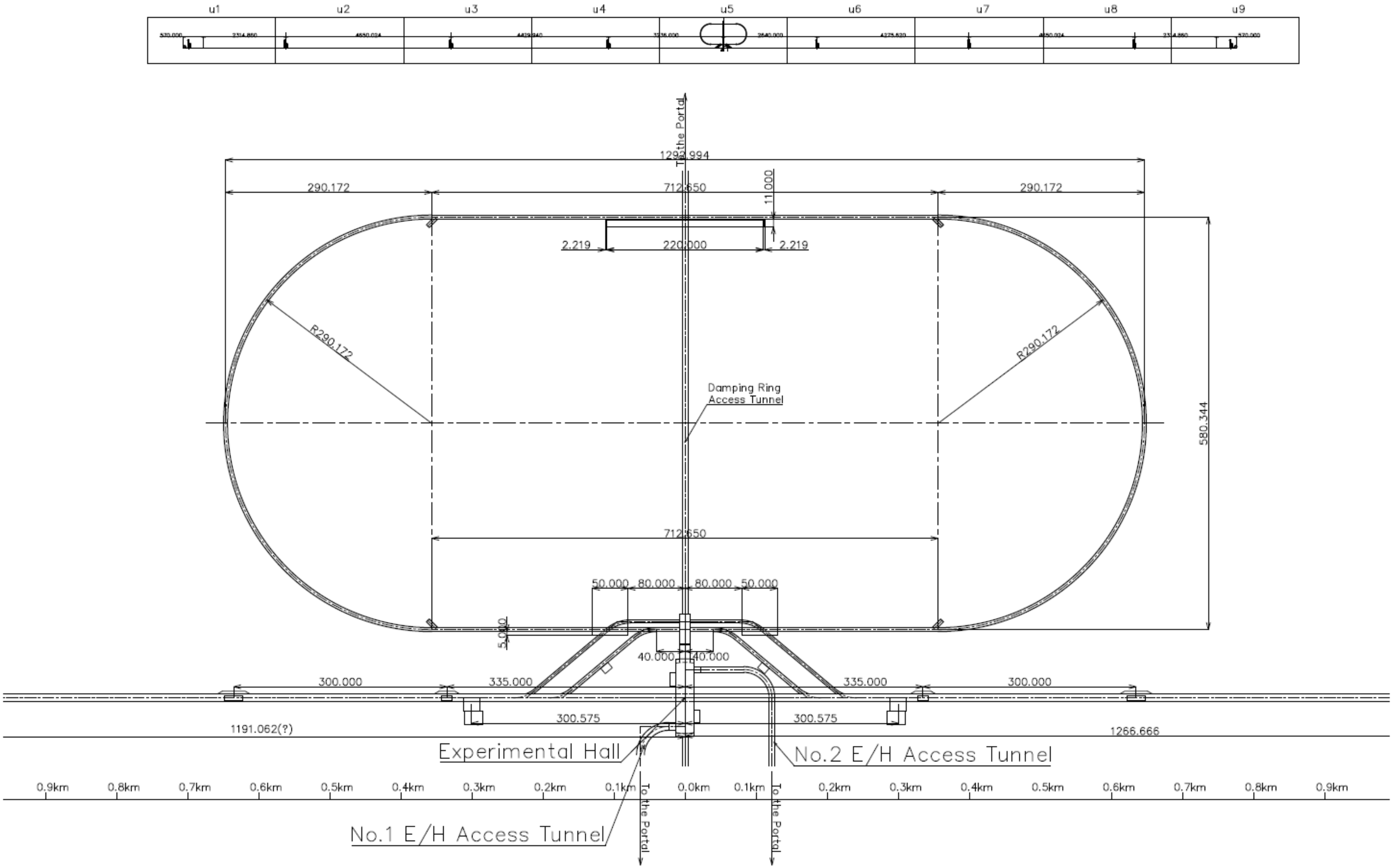
GLOBAL DESIGN EFFORT ASIA REGION	CASE 8-wSND Sectional Plan u1 u2 u3	KEK	DRAWING NO. CASE 8-wSND-B01	REVISION	
			SCALE 1:10,000	DATE 31/08/2011	



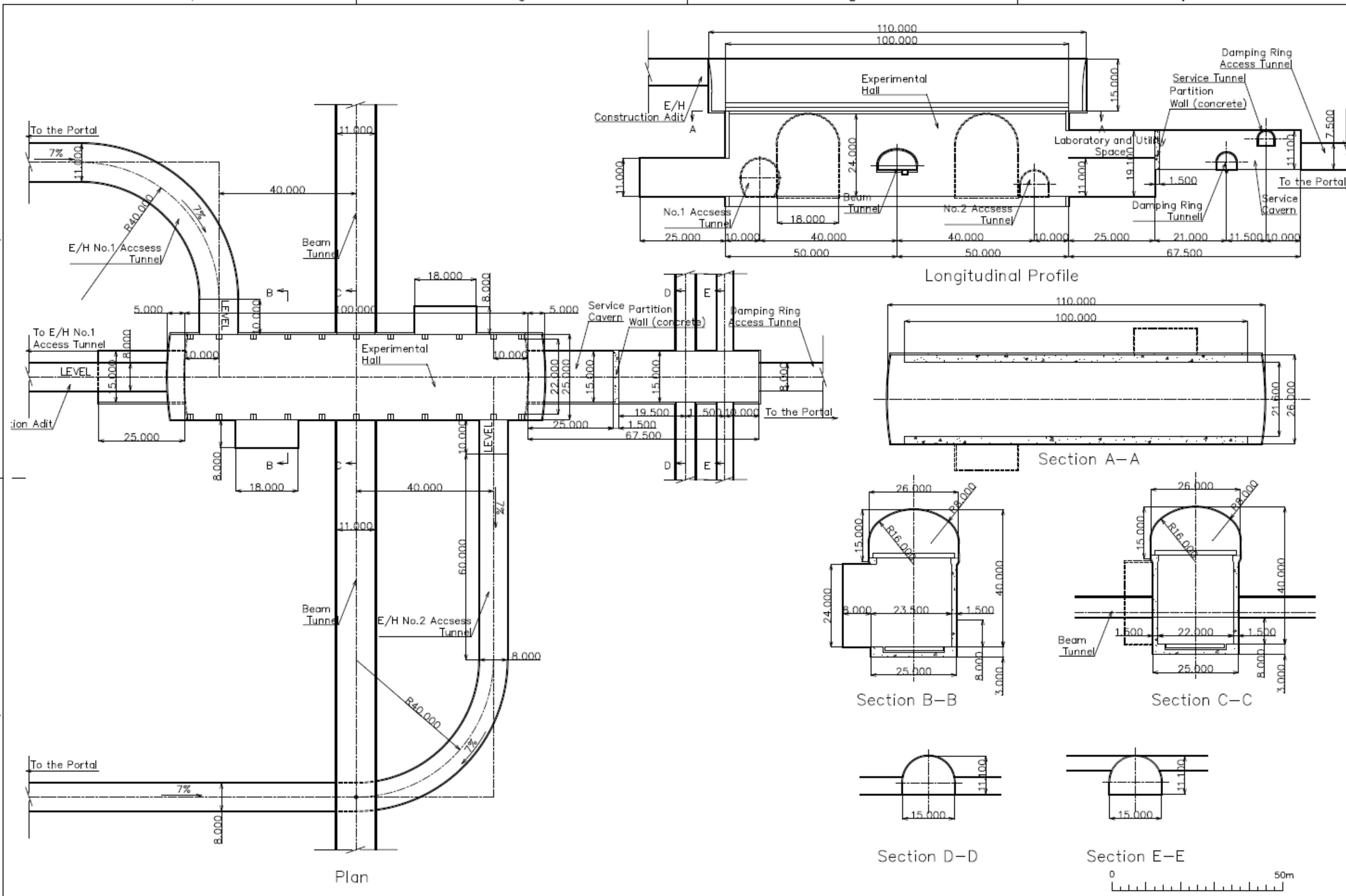
GLOBAL DESIGN EFFORT ASIA REGION	CASE 8-wSND Sectional Plan u4 u5 u6	KEK	DRAWING NO. CASE 8-wSND-B02 SCALE 1/10,000	REVISION DATE 31/08/2011



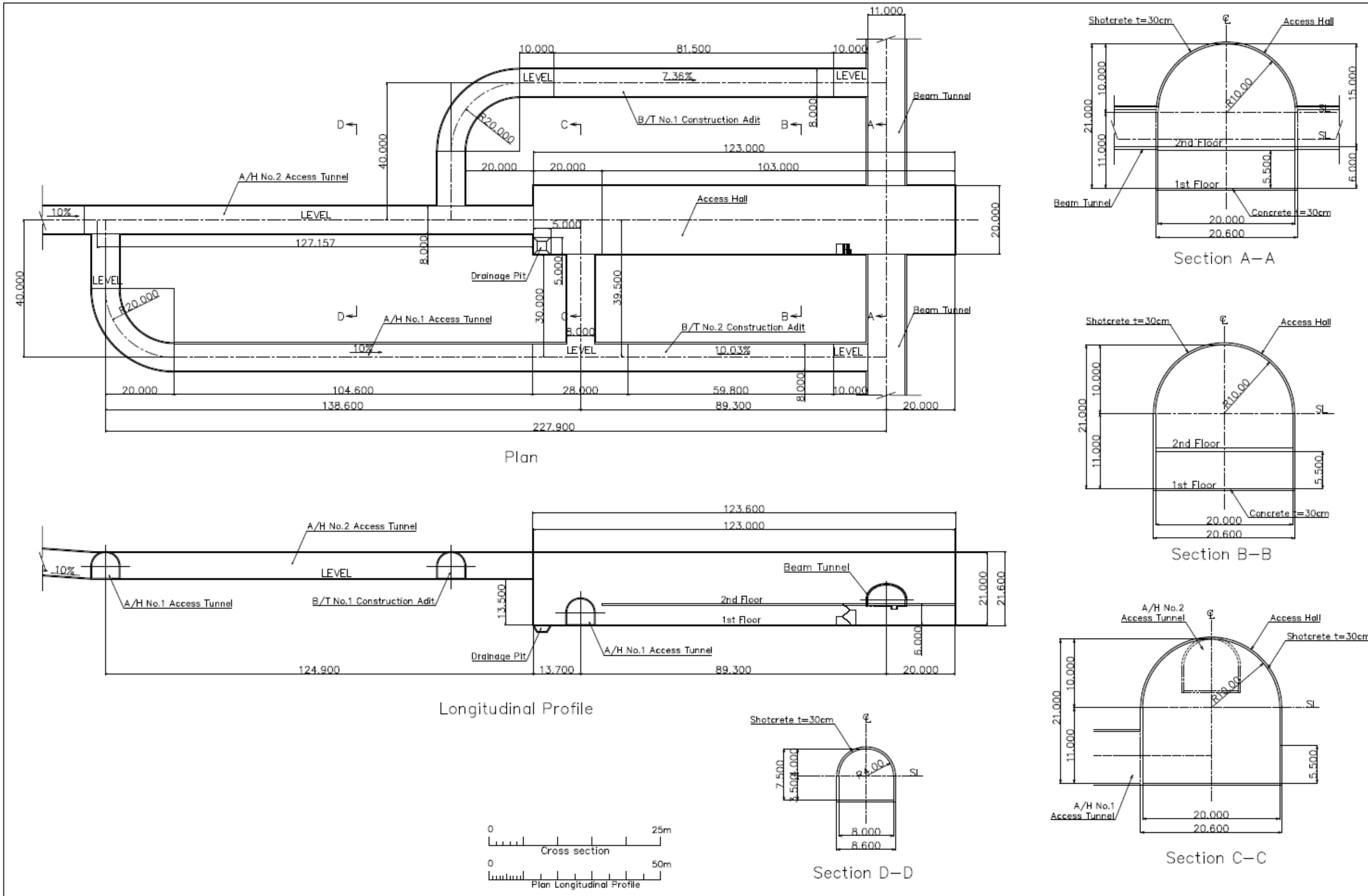
GLOBAL DESIGN EFFORT **ASIA REGION**	**CASE 8-wSND** **Sectional Plan u7 u8 u9**	KEK	**DRAWING NO. CASE 8-wSND-B03**	**REVISION**
			SCALE 1/10,000	**DATE** 31/08/2011



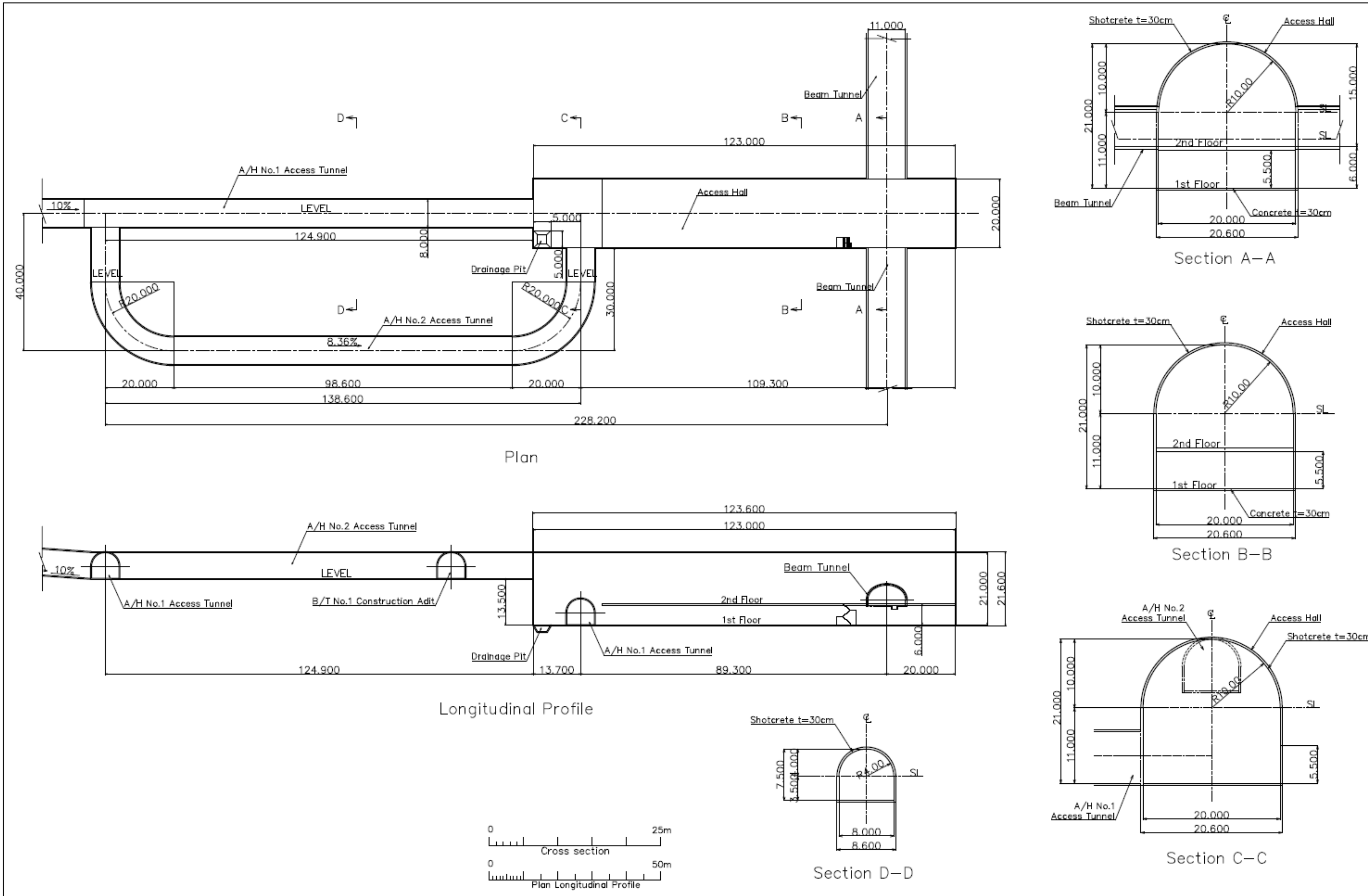
ilc	**GLOBAL DESIGN EFFORT** **ASIA REGION**	**CASE 8-wSND** **Plan of Central Regeon and Danping Ring**	KEK	**DRAWING NO. CASE 8-wSND-C01** **SCALE 1/5,000**	**REVISION** **DATE 31/08/2011**



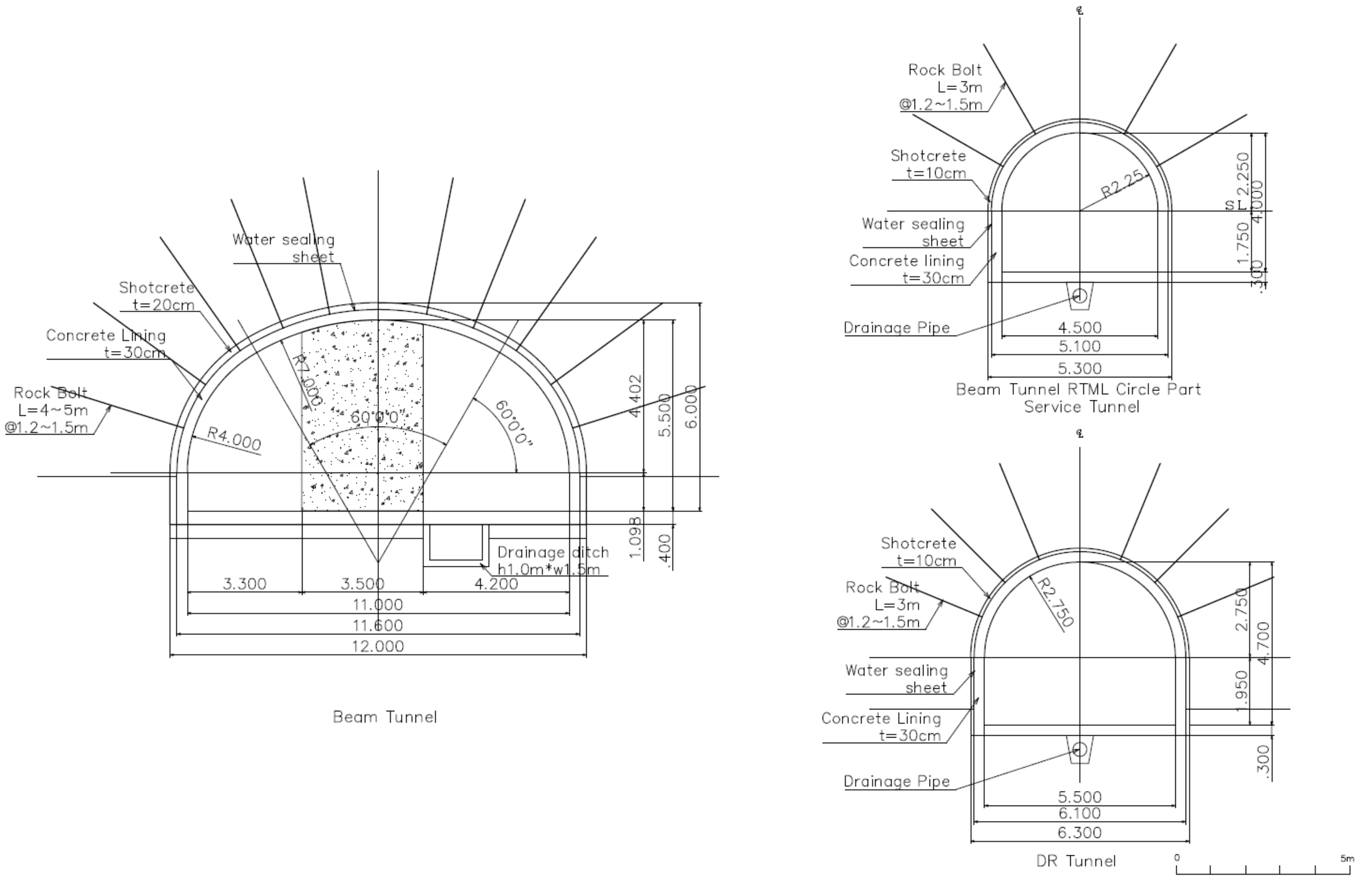
ilc	**GLOBAL DESIGN EFFORT** **ASIA REGION**	**CASE 8-wSND** **Experimental Hall**	KEK	**DRAWING NO. CASE 8-wSND-D01** / **REVISION** **SCALE 1/1000** / **DATE 31/08/2011**



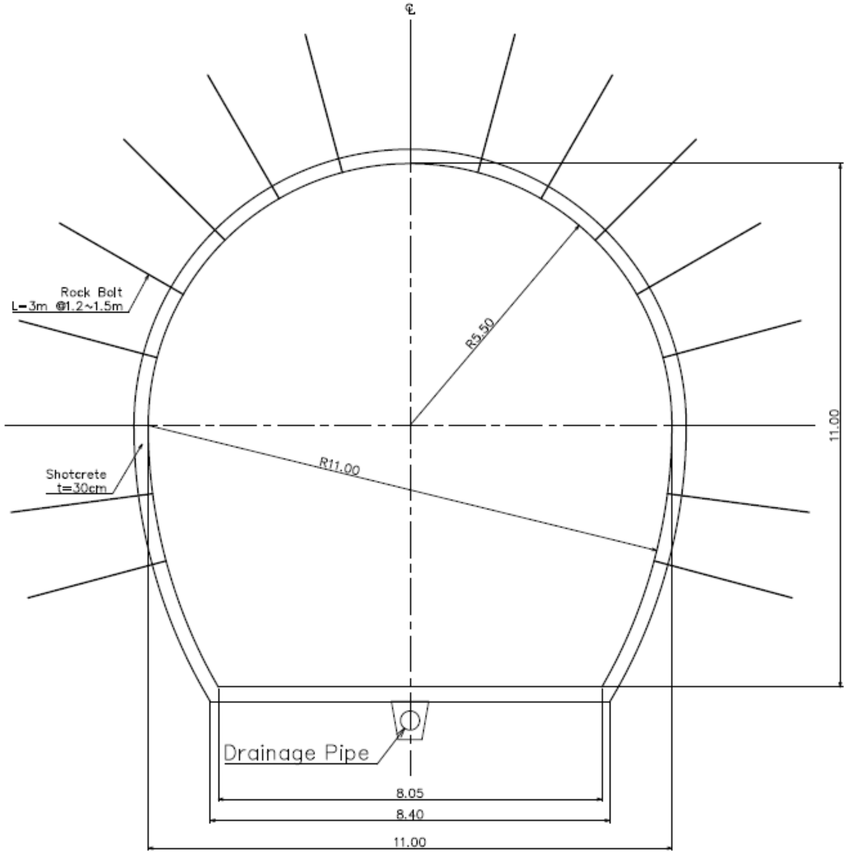
ilc	GLOBAL DESIGN EFFORT ASIA REGION	CASE 8-wSND Access Hall	KEK	DRAWING NO. CASE 8-wSND-E01 SCALE 1/500 ,1/1,000	REVISION DATE 31/08/2011



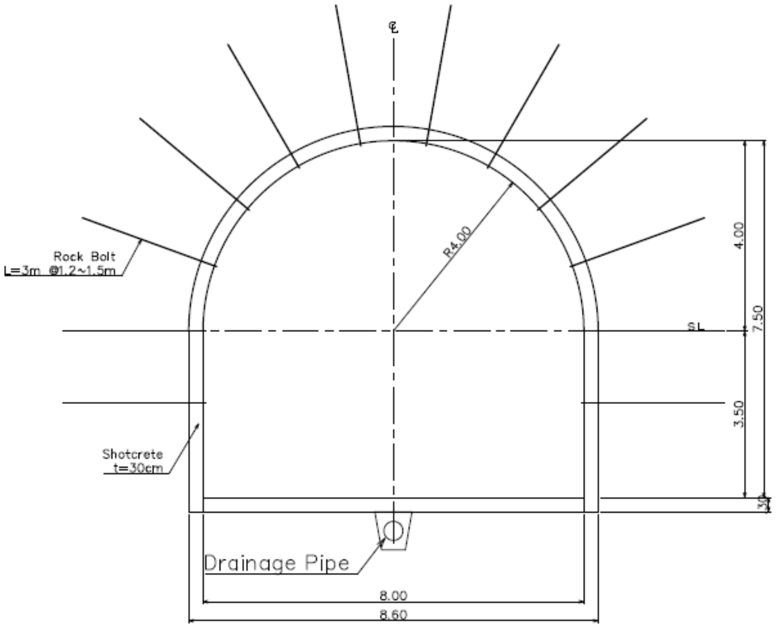
GLOBAL DESIGN EFFORT ASIA REGION	CASE 8-wSND Access Hall for RTML	KEK	DRAWING NO. CASE 8-wSND-E02	REVISION
			SCALE 1/500 ,1/1,000	DATE 31/08/2011



ilc	GLOBAL DESIGN EFFORT ASIA REGION	CASE 8-wSND Tunnel Typical Section 1/2	KEK
DRAWING NO.CASE 8-wSND-G01		REVISION	
SCALE	1/100	DATE	31/08/2011



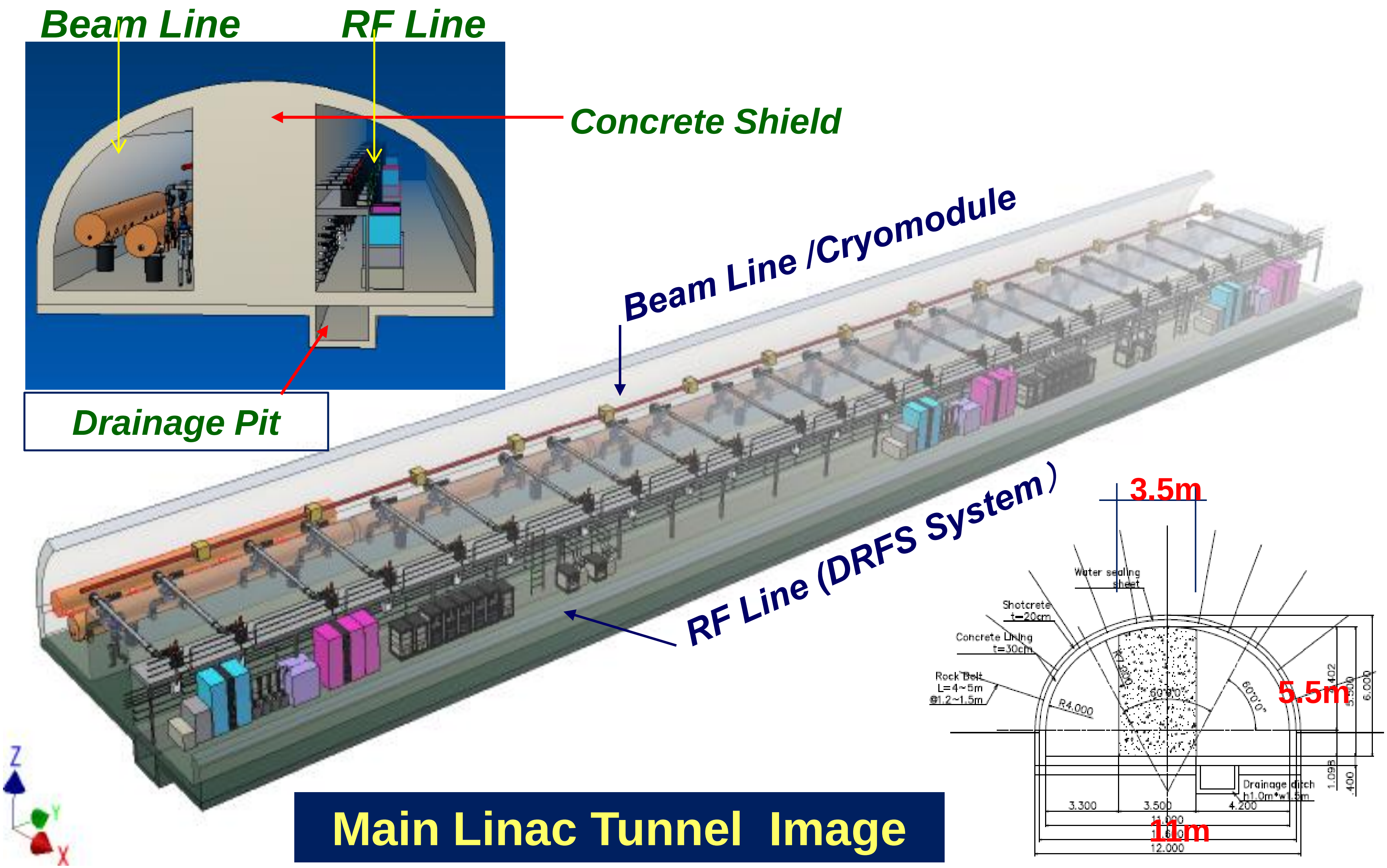
E/H No. 1 Access Tunnel



E/H No. 2 Access Tunnel
A/H Access Tunnel
B/T & E/H Construction Adit
DR Access Tunnel

0 5m

ilc	GLOBAL DESIGN EFFORT ASIA REGION	CASE 8-wSND Tunnel Typical Section 2/2	KEK	DRAWING NO. CASE 8-wSND-G02 / REVISION SCALE 1/100 / DATE 31/08/2011



Main Linac Tunnel Image

Detector Hall

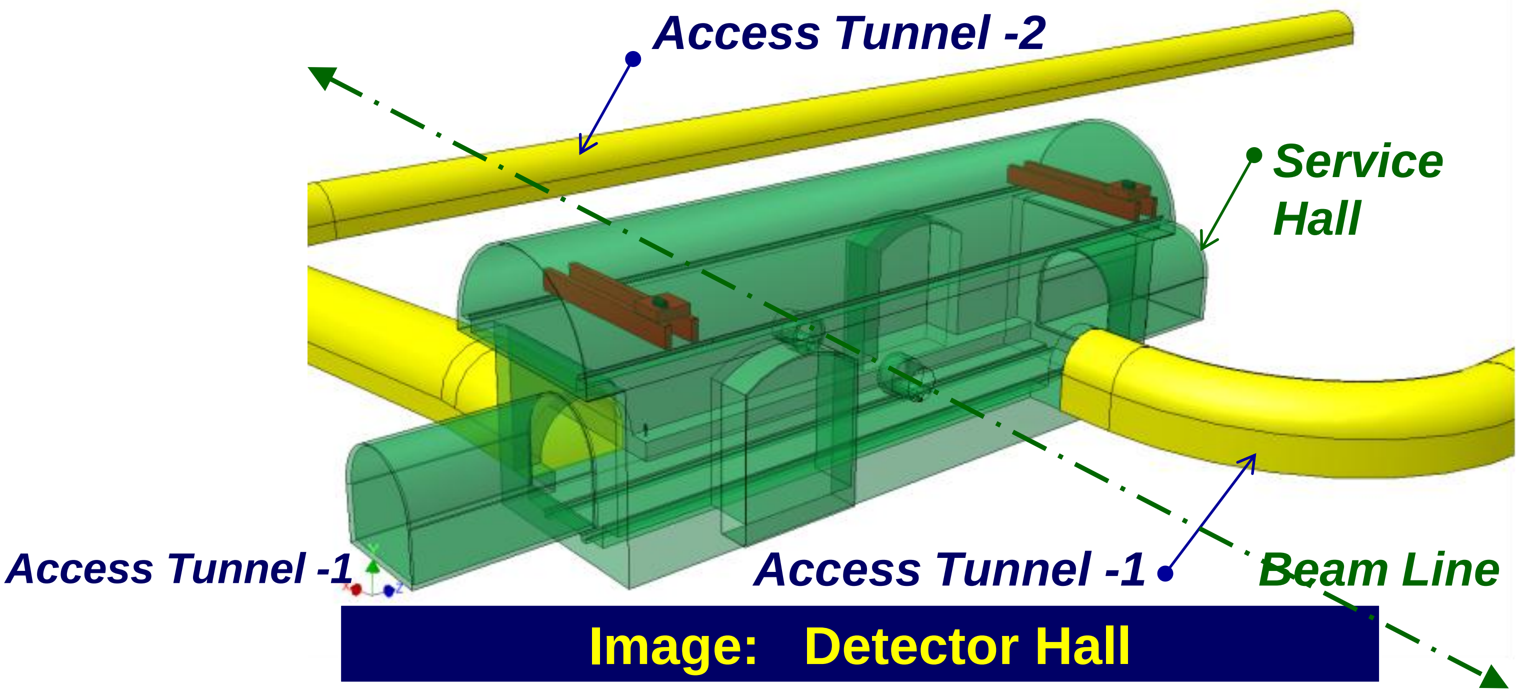
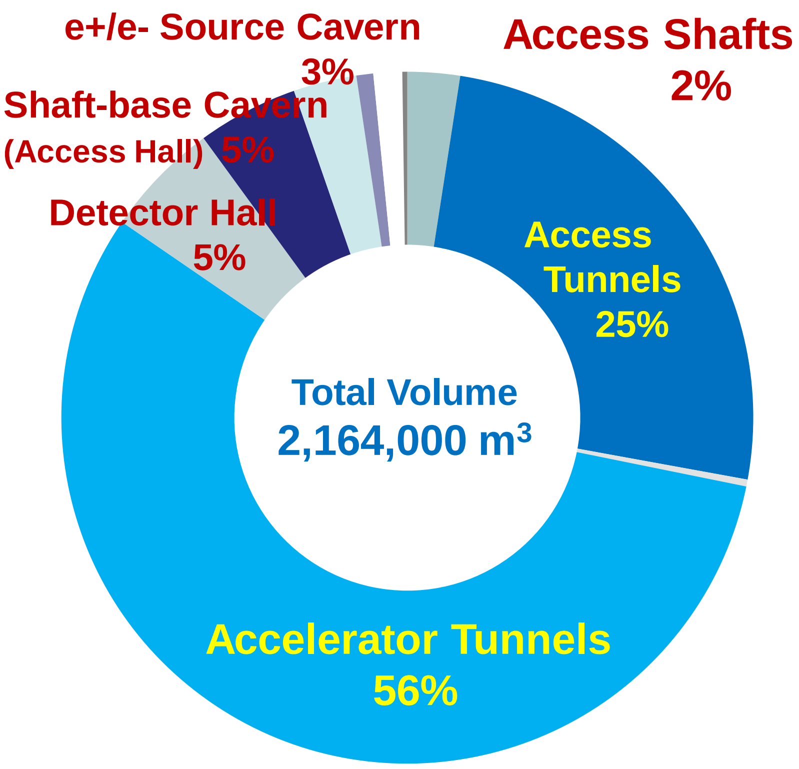


Image: Detector Hall

Underground Structure Volume

Underground Structure Volume in RDR (Asia)

Name	#	Volume(m3)
Access Shafts	3	53,000
Access Tunnels (Horizontal shafts)	10	550,000
Survey Shafts	18	7,000
Accelerator Tunnels		1,220,000
Detector hall	1	117,000
Shaft-base Caverns (Access Halls)	8	102,000
e+/e- Source Caverns	2	64,000
Damping Ring caverns	6	17,000
Beam dump tunnels	14	29,000
Passage ways and penetrations		5,000
Total		2,164,000



Underground Structure Volumes in 8 Case Studies

Case	RDR		Case1		Case2		Case3		Case4	
Tunneling Method	TBM									
Tunnel Scheme	Double				Single		Japanese-Type Single			
High-Level RF	RDR						XFEL		KCS	
	#	Vol(m^3)	#	Vol(m^3)	#	Vol(m^3)	#	Vol(m^3)	#	Vol(m^3)
Shafts	3	53,000	3	0	3	0	3	0	3	0
Sloped tunnels (horizontal shafts)	10	550,000	11	647,027	11	647,027	11	647,027	15	859,558
Survey shafts	18	7,000	18	0	18	0	18	0	18	0
Beam/Service tunnels		1,220,000		1,036,897		1,300,484		977,378		866,183
Detector hall	1	117,000	1	121,320	1	121,320	1	121,320	1	121,320
Shaft-base Caverns (Access Halls)	8	102,000	8	371,046	8	371,046	8	532,739	12	1,042,074
Local Caverns (@every 600 m)										
e+/e- Source Caverns	2	64,000	2		2		2		2	
Damping Ring caverns	6	17,000	1	6,050	1	6,050	1	6,050	1	6,050
Beam dump tunnels	14	29,000	14		14		14		14	
Passage ways and penetrations		5,000								
Total		2,164,000		2,182,340		2,445,927		2,284,514		2,895,185

Underground Structure Volumes in 8 Case Studies

Case	Case5		Case6		Case7		Case8	
Tunneling Method	TBM		NATM					
Tunnel Scheme	Japanese-Type Single				Single			
High-Level RF	DRFS				DRFS/RDR			
	#	Vol(m^3)	#	Vol(m^3)	#	Vol(m^3)	#	Vol(m^3)
Shafts	3	0	3	0	3	0	3	0
Sloped tunnels (horizontal shafts)	10	647,027	10	647,027	10	647,027	10	647,027
Survey shafts	18	0	18	0	18	0	18	0
Beam/Service tunnels		1,115,271		1,030,173		1,074,647		1,473,566
Detector hall	1	121,320	1	121,320	1	121,320	1	121,320
Shaft-base Caverns (Access Halls)	8	371,046	8	371,046	8	371,046	8	371,046
Local Caverns (@every 600 m)	40	167,486	40	167,486				
e+/e- Source Caverns	2		2		2		2	
Damping Ring caverns	6	6,050	6	6,050	6	6,050	6	6,050
Beam dump tunnels	14		14		14		14	
Passage ways and penetrations								
Total		2,428,200		2,343,102		2,220,090		2,619,009

Current Results

Case	1	2	3	4	5	6	7	8
Tunnel Configuration	RDR Double T	RDR	XFEL	KCS	DRFS	DRFS NATM	DRFS NATM Flat Section	DRFS/RDR NATM Flat Section Thick Wall
Schedule (Month)	77	79	79	81	75	79	61	63
Cost (Relative)	1	0.85	0.94	1.01	1.07	0.79	0.60	0.79

Current Results

Case	1	2	3	4	5	6	7	8
Schedule (Month)	77	79	79	81	75	79	61	63
Cost (Relative)	1	0.85	0.94	1.01	1.07	0.79	0.60	0.79

Summary

- We have been developing a single-tunnel configuration suitable for the Asian regional site.
- Various tunnel configurations which could be taken in Asian region were compared in their construction costs and schedules.
- We found an Asian regional specific solution of Single-Tunnel Configuration using a tunneling method by NATM.