Single Tunnel CF Design Status

GDE Conventional facility & Siting (CFS) Team

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Contents of this talk

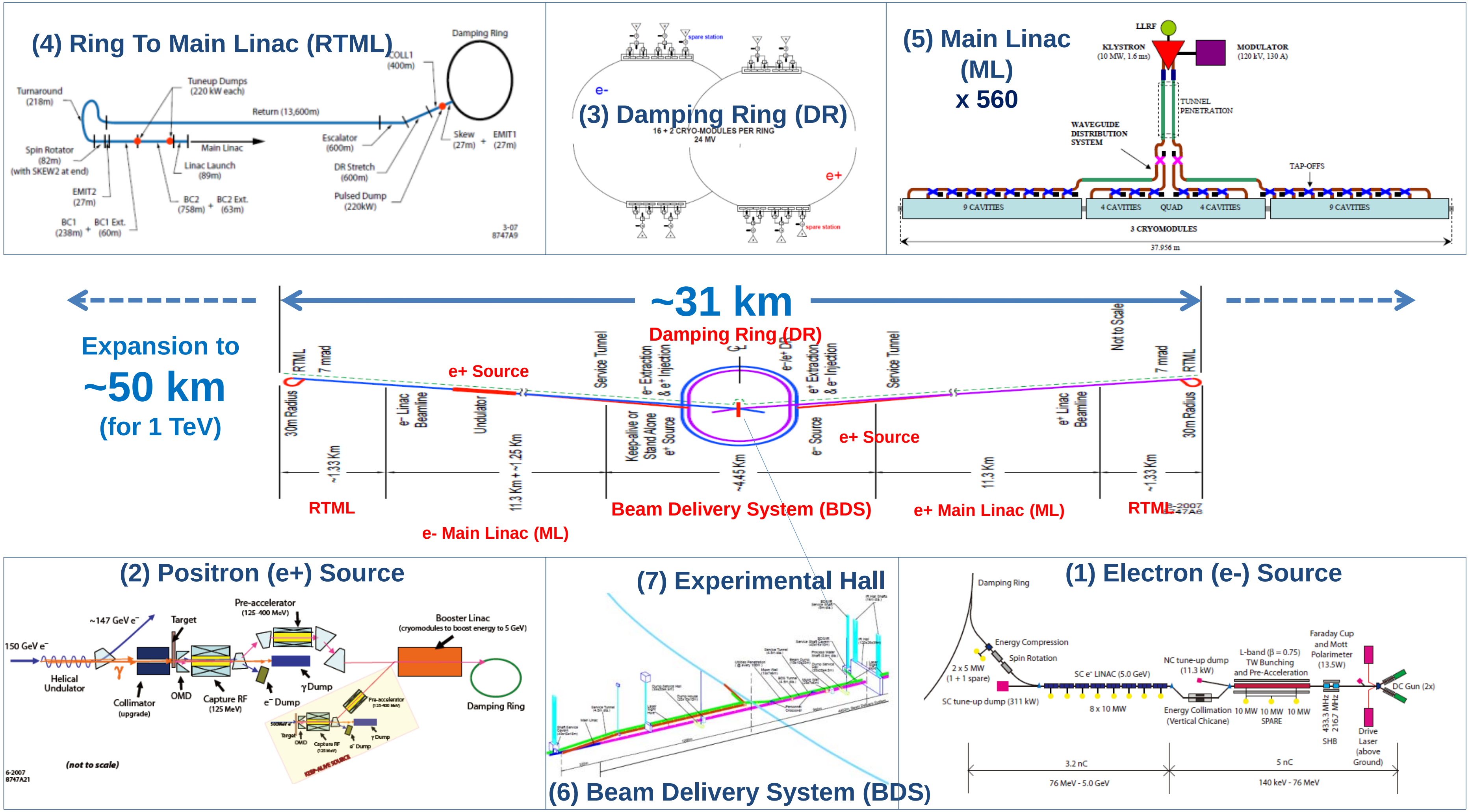
- ILC Area system and layout
- Cost impact on Single-tunnel
- Single-tunnel configuration
- Single-tunnel Availability and Safety
- Single-tunnel design Criteria
- Single-tunnel design Progress

Introduction

ILC AREA SYSTEM AND LAYOUT

ILC Area System

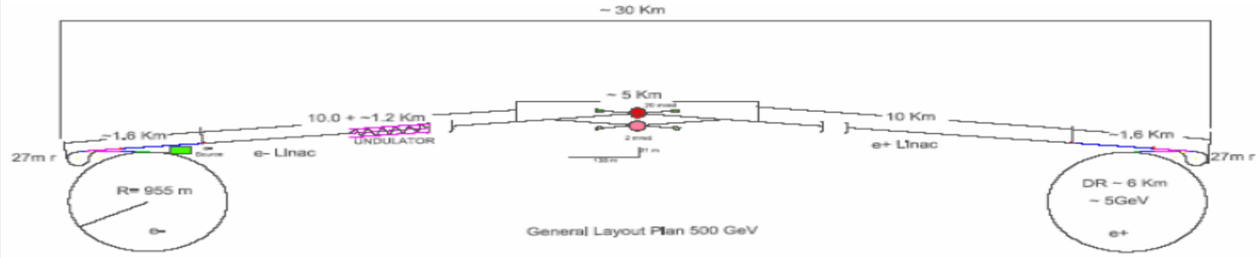
- Superconducting Electron/Positron Linear Accelerators-



Design Progress from 2005 to 2009

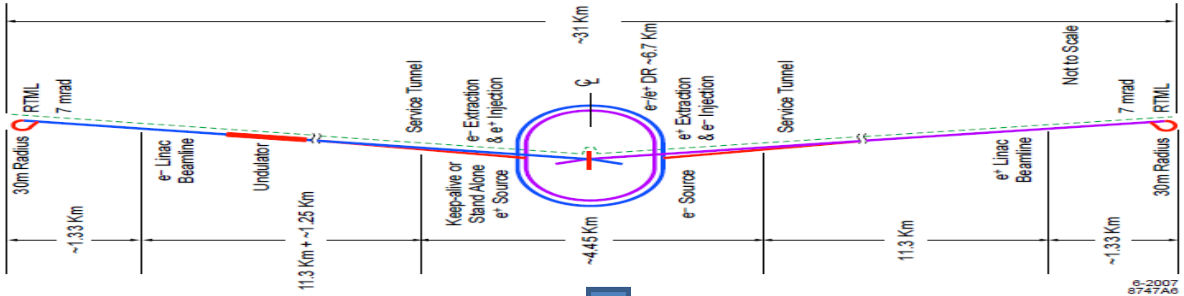
Reference Design Report (RDR) published in 2007.

Re-baselining for cost containment undergoing.



Baseline Configuration Document

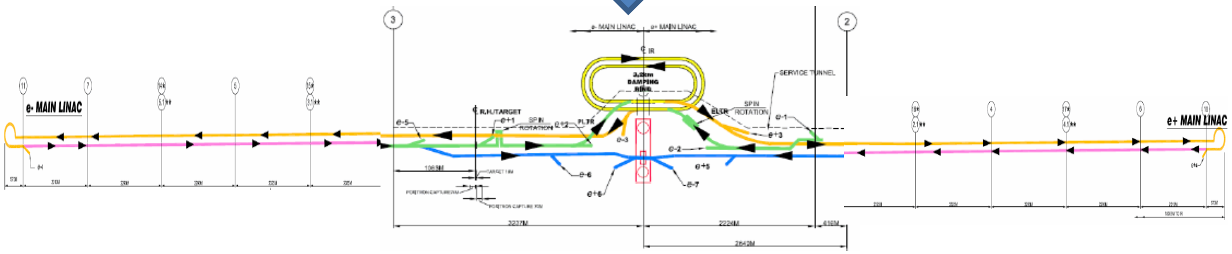
BCD (2005)



Reference Design Report

RDR (2007)

Current Baseline



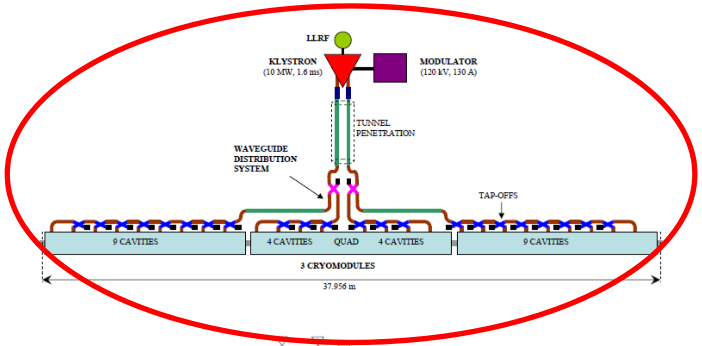
Strawman Baseline for Technical Design Phase2 (2010-2012)

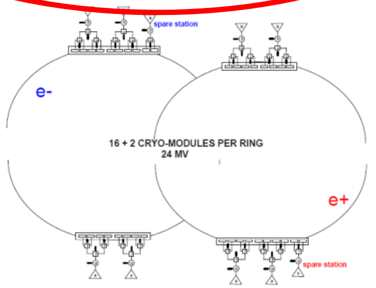
SB2009

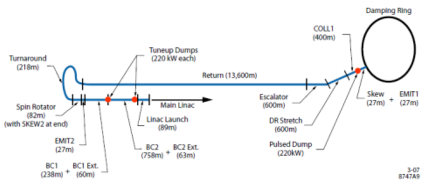
Re-baselining

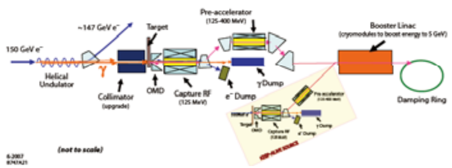
COST IMPACT ON SINGLE-TUNNEL

Construction Cost Profile









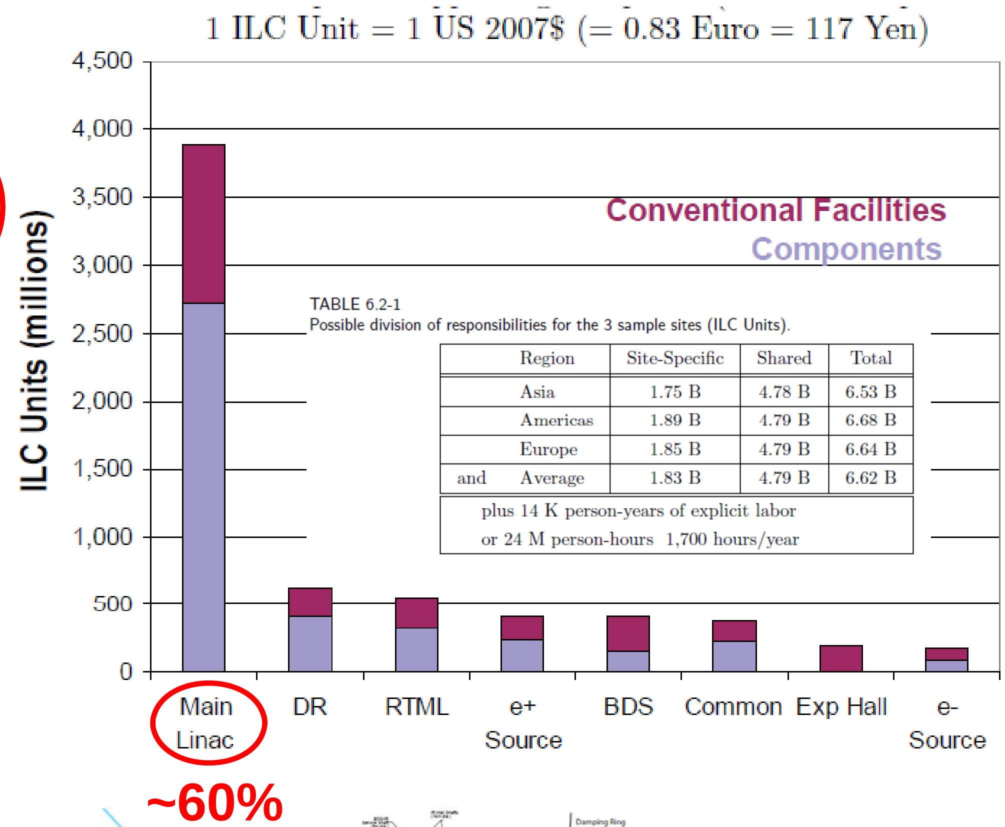
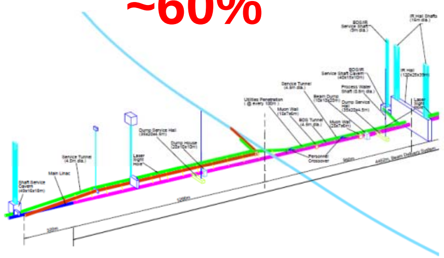
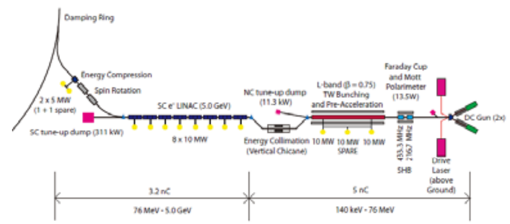


TABLE 6.2-1
Possible division of responsibilities for the 3 sample sites (ILC Units).

Region	Site-Specific	Shared	Total
Asia	1.75 B	4.78 B	6.53 B
Americas	1.89 B	4.79 B	6.68 B
Europe	1.85 B	4.79 B	6.64 B
and Average	1.83 B	4.79 B	6.62 B

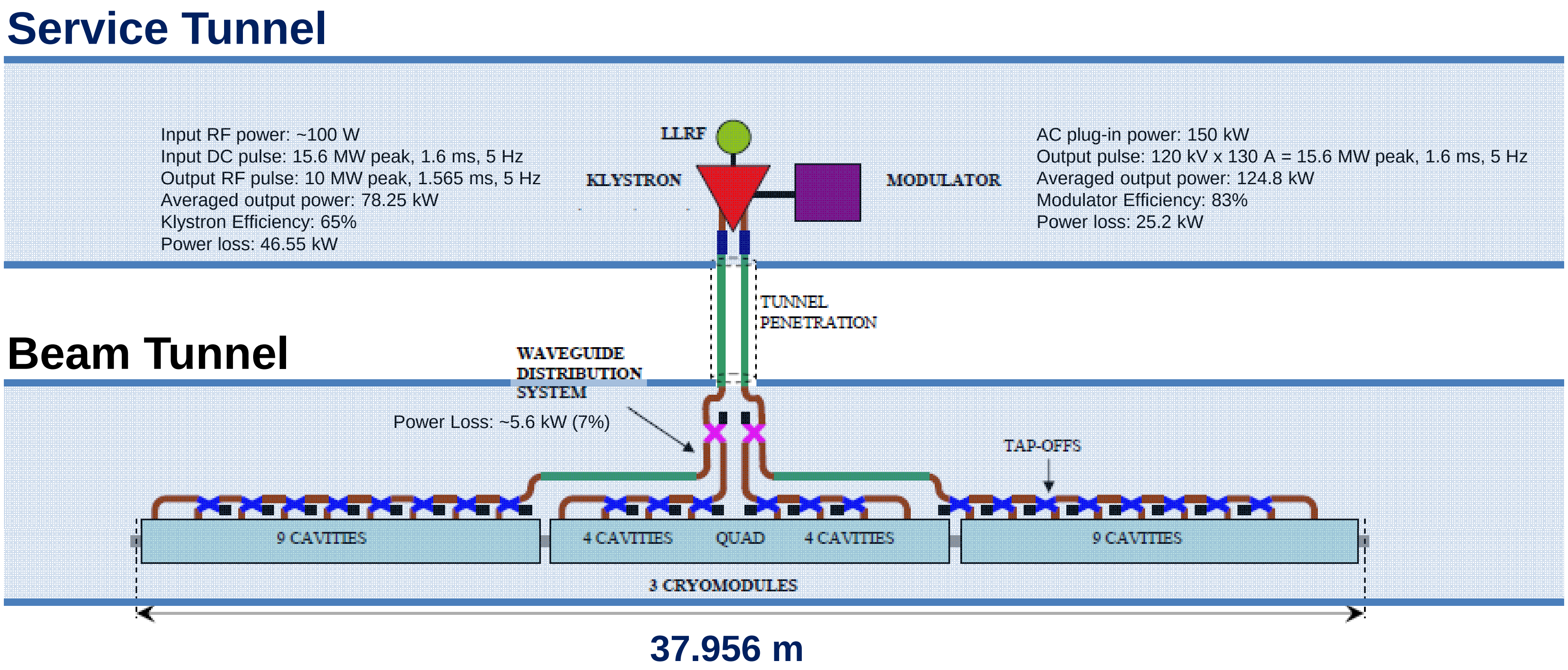
plus 14 K person-years of explicit labor
or 24 M person-hours 1,700 hours/year





Main Linac (ML) RF Unit in RDR

- **Twin-tunnel** accelerator configuration -



e- ML	282 RF units		Field gradient:	31.5 MV/m
e+ ML	278 RF units		Energy gain per RF unit :	**850 MeV**
Total	**560 RF units**		(with 22% tuning overhead)	

RDR(2007) to TDR(2012)
- Cost Containment -

- RDR: 6.62 BILCU* (4.80 Shared + 1.82 Site Specific) + 14.1 kPerson
- SB2009: 7 working assumptions with ~13% cost reduction
- One of the most cost-effective assumptions is:

(*: 1 ILC Unit = 1 US 2007$ (= 0.83 Euro = 117 Yen))

2. **A single-tunnel solution for the Main Linacs and RTML, with two possible variants for the High-Level RF (HLRF):**

ML tunnel length = 22.635 km
(Very rough estimate:
If tunnel unit cost/km = 10 MILCU, Single tunnel cost = 226 MILCU
This is ~ 10% of CF cost (2,472 MILCU in RDR),
~3.4% of Total construction cost.

SINGLE-TUNNEL CONFIGURATION

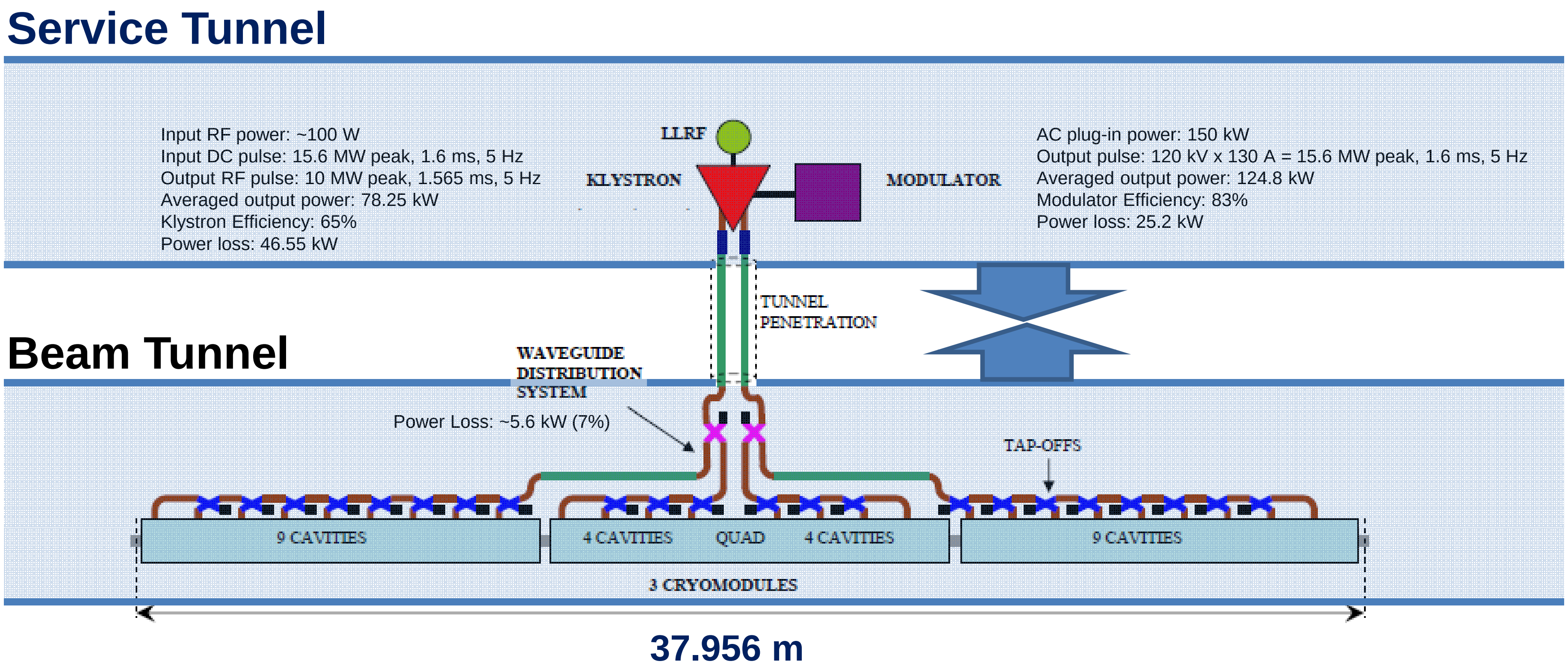
ML Single-Tunnel Configuration

- 4 HLRF variations -

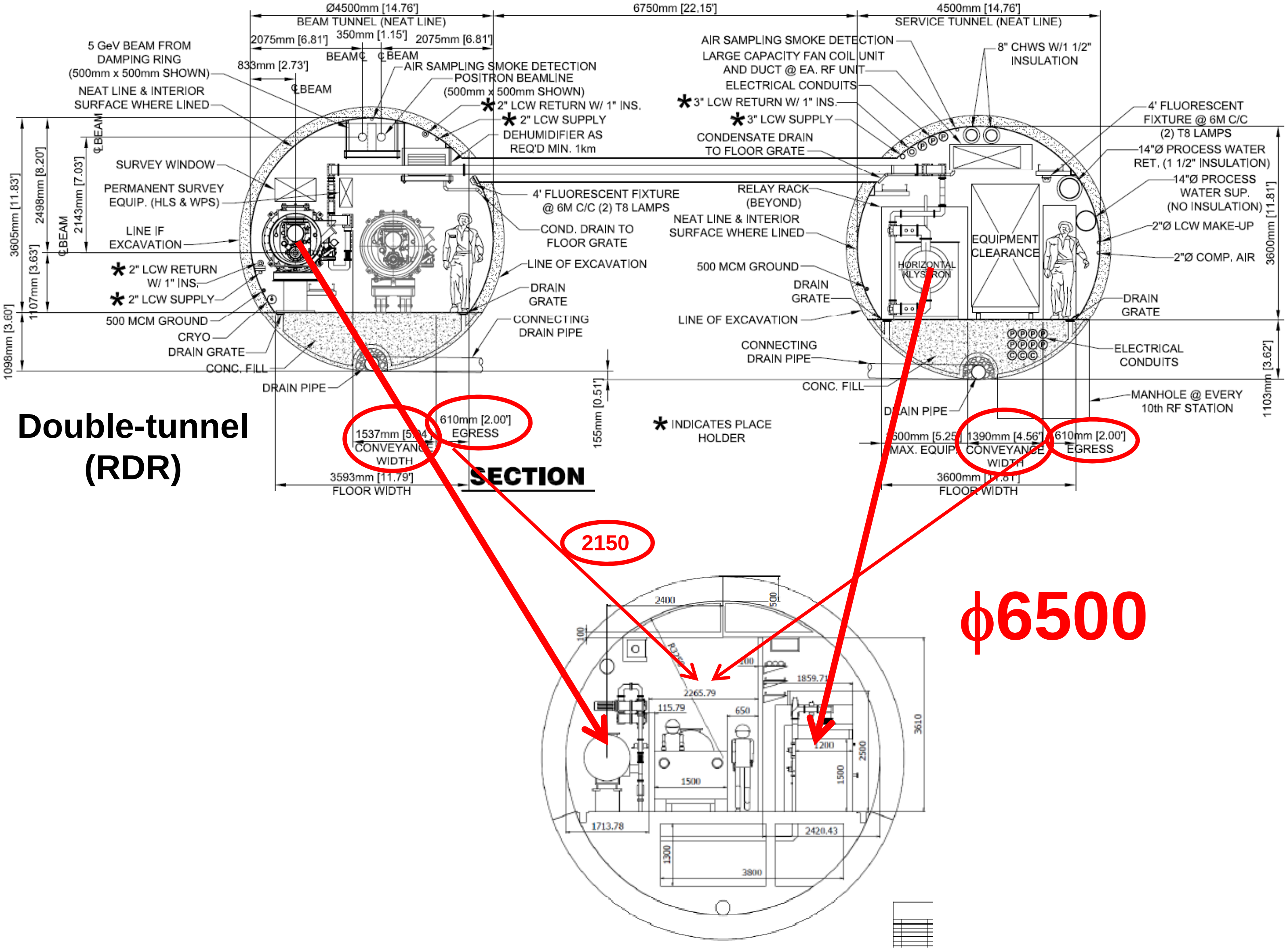
(1) RDR Type
(2) DRFS Type
(3) TESLA / XFEL Type
(4) KCS Type

(1) RDR Type Single Tunnel

- Combination of RDR Beam and Service Tunnel -

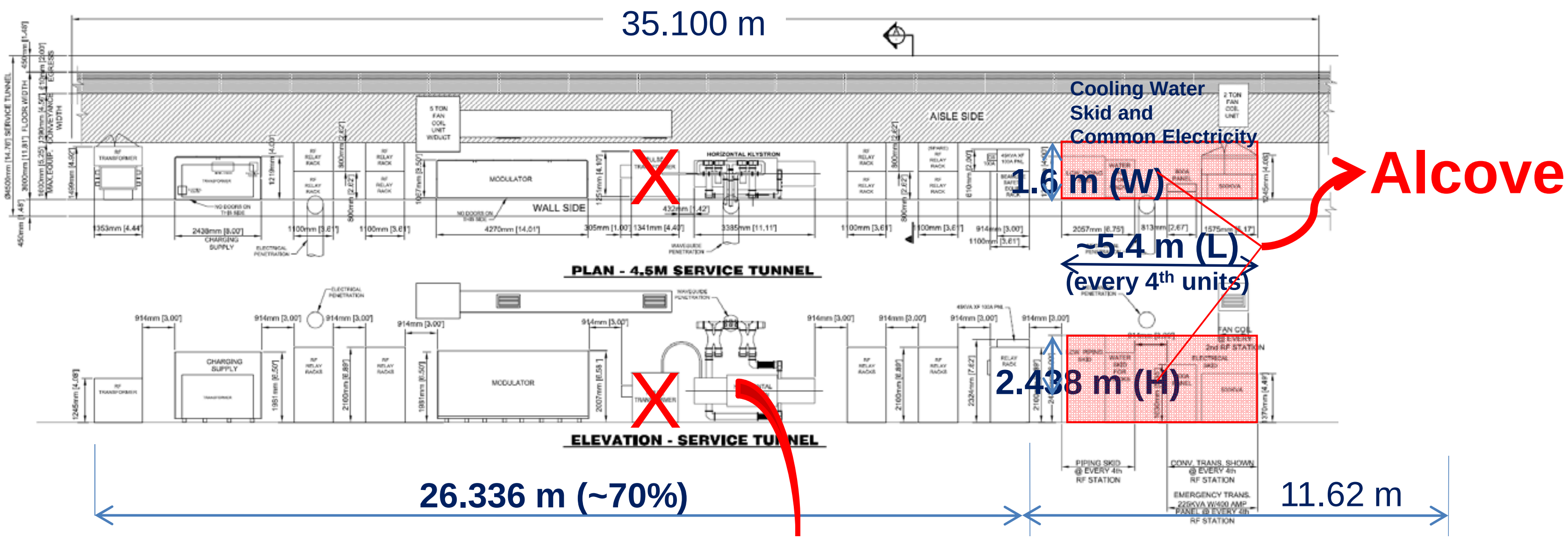


RDR-Type HLRF Single Tunnel

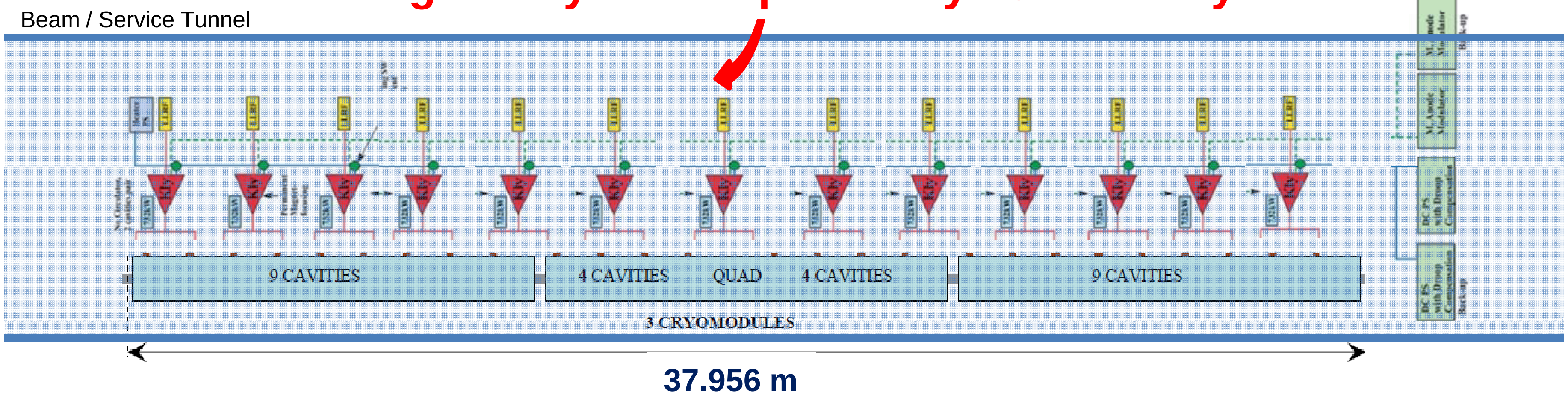


(2) DRFS-Type Single Tunnel

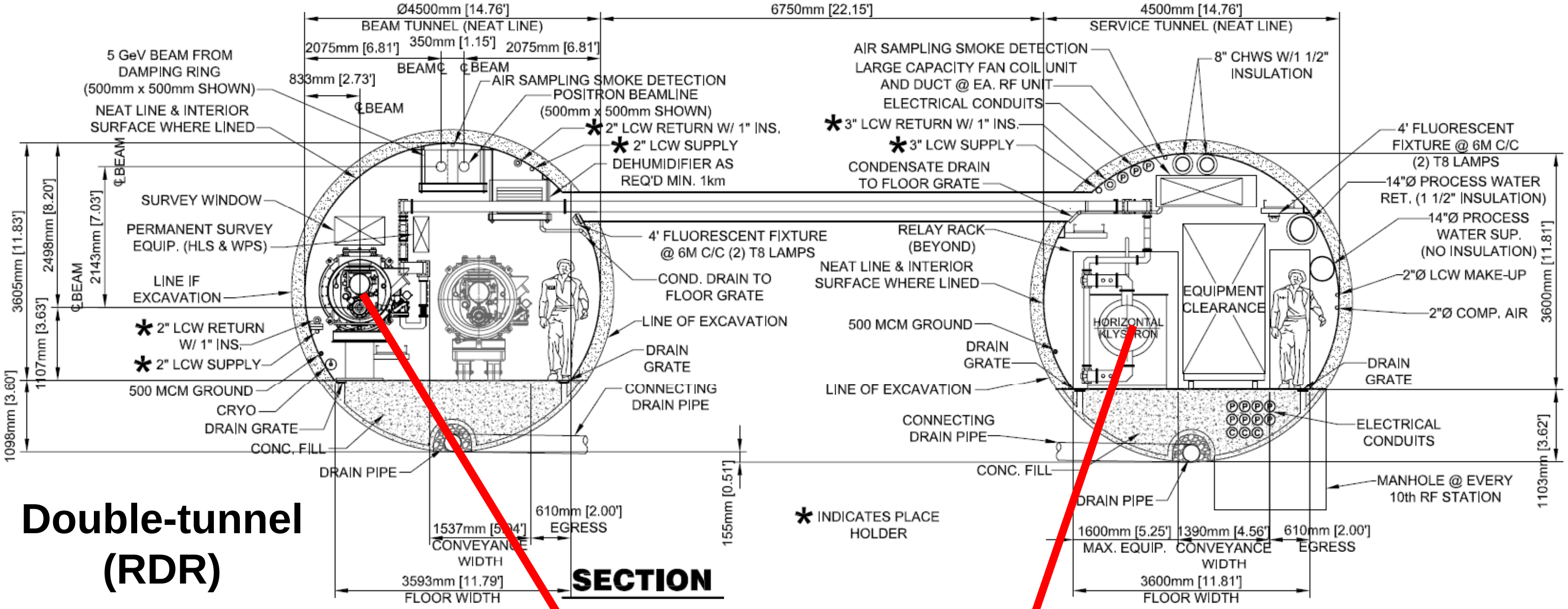
- Improved Space Factor -



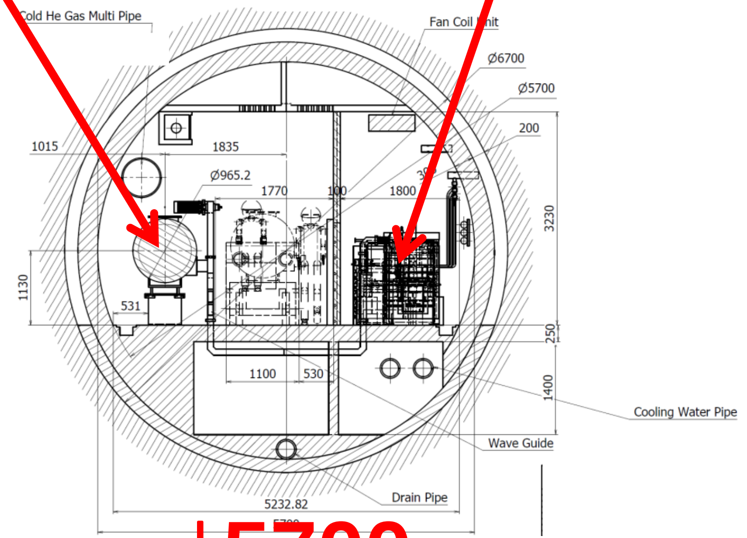
One big HV klystron replaced by 13 small klystrons



DRFS-Type HLRF Single Tunnel



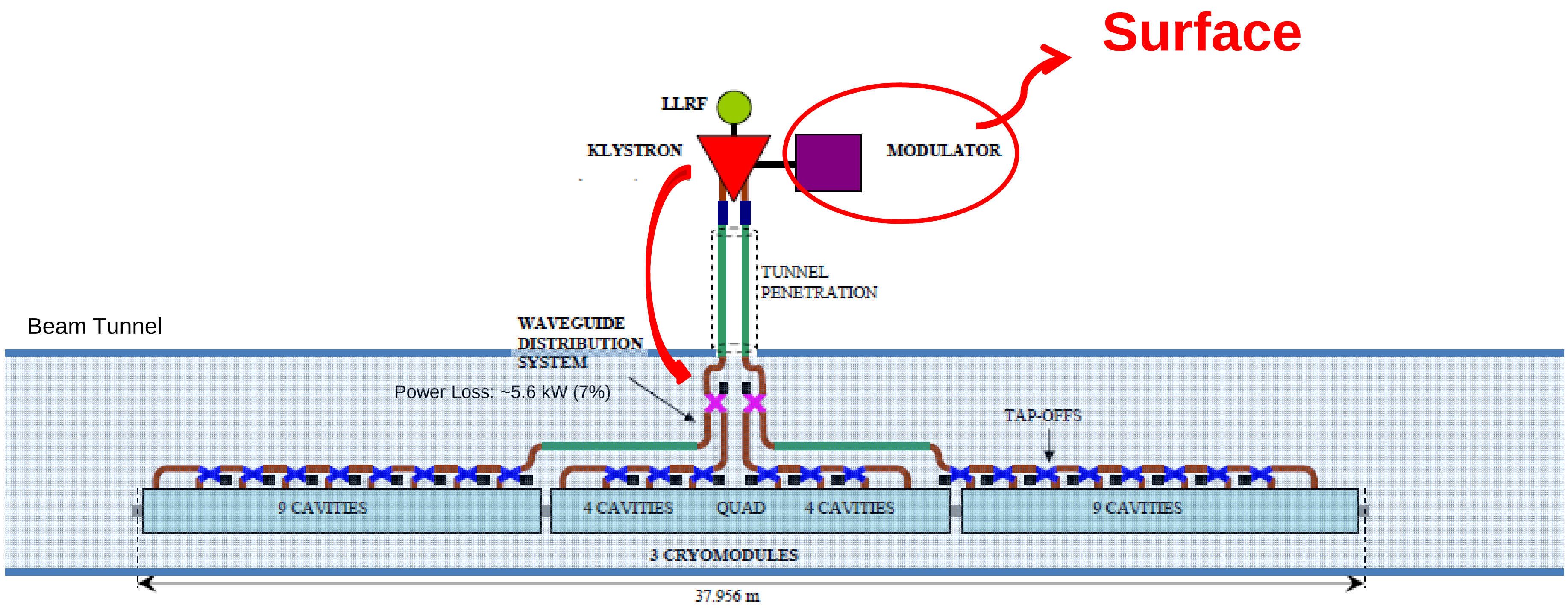
Double-tunnel (RDR)



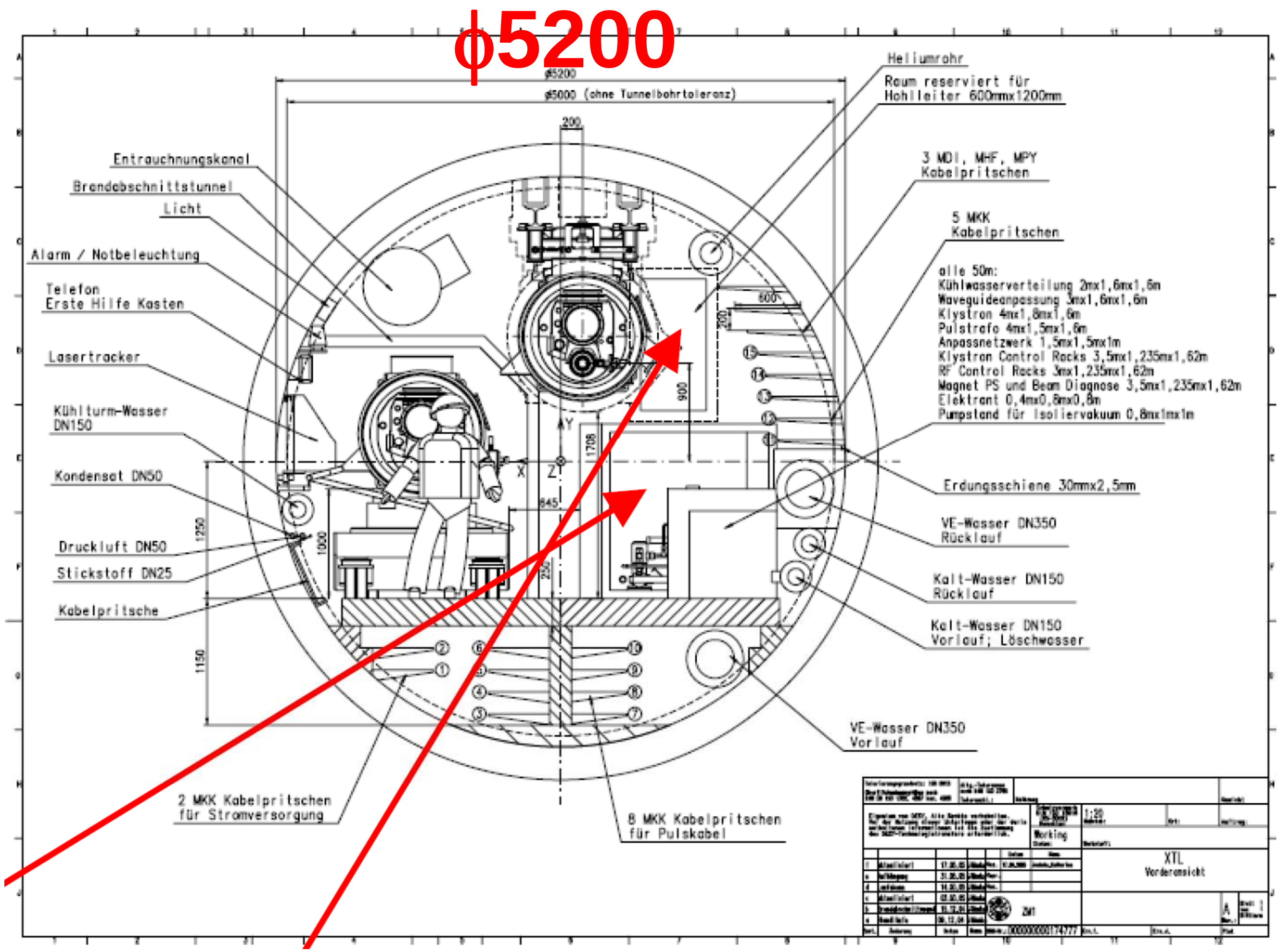
Single-tunnel (SB2009)

ϕ5700

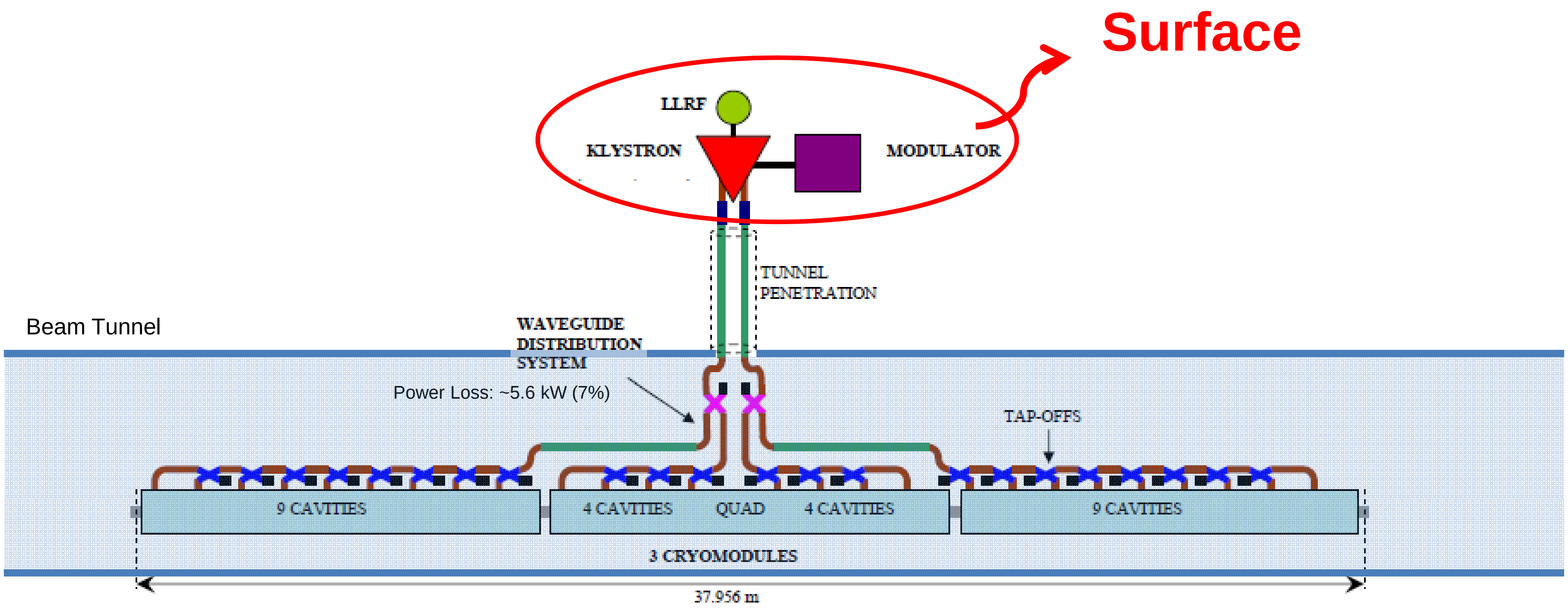
(3) TESLA/XFEL-Type Single-Tunnel



TESLA/XFEL-Type Single-Tunnel



(4) KCS-Type Single-Tunnel

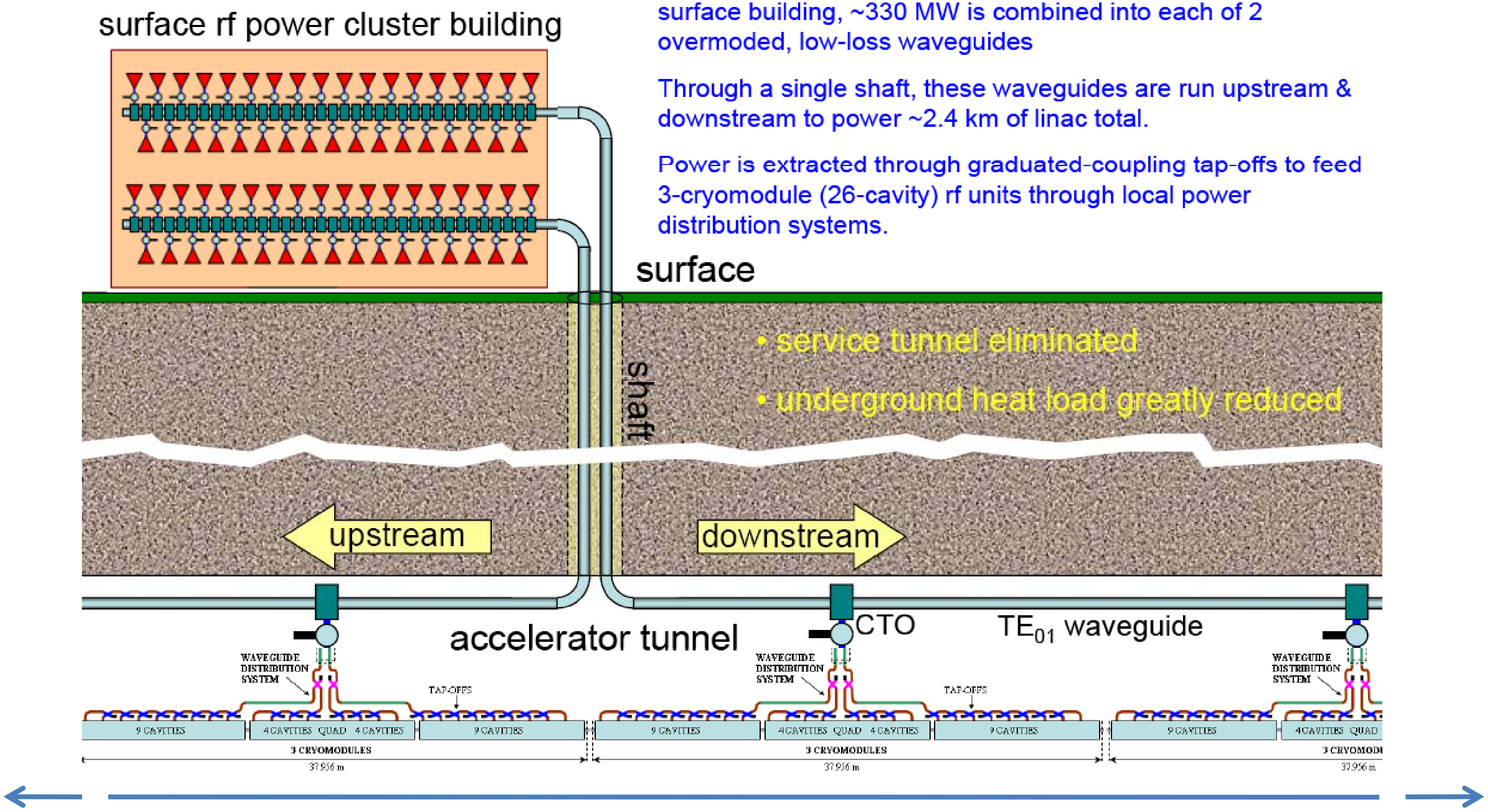


KCS-Type Single-Tunnel

From 2 groups of ~35 klystrons & modulators clustered in a surface building, ~330 MW is combined into each of 2 overmoded, low-loss waveguides

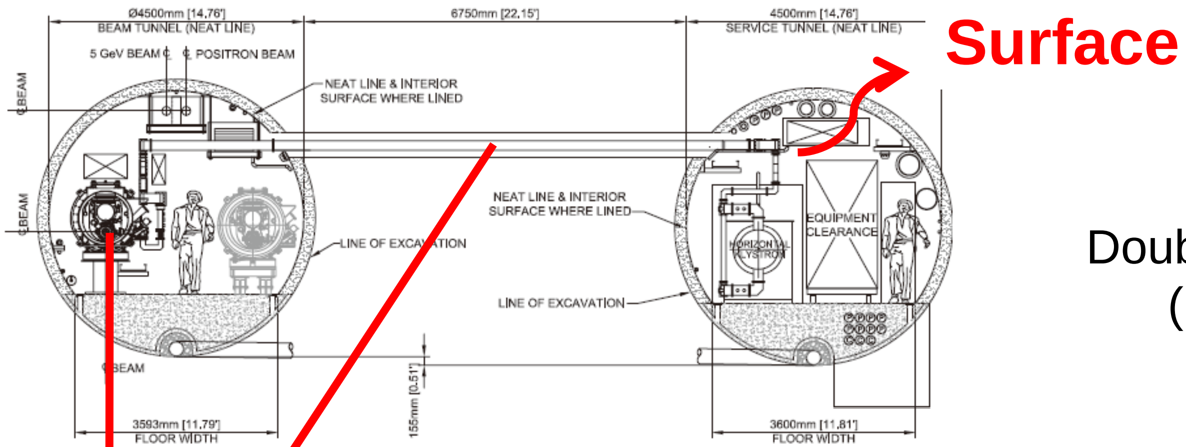
Through a single shaft, these waveguides are run upstream & downstream to power ~2.4 km of linac total.

Power is extracted through graduated-coupling tap-offs to feed 3-cryomodule (26-cavity) rf units through local power distribution systems.

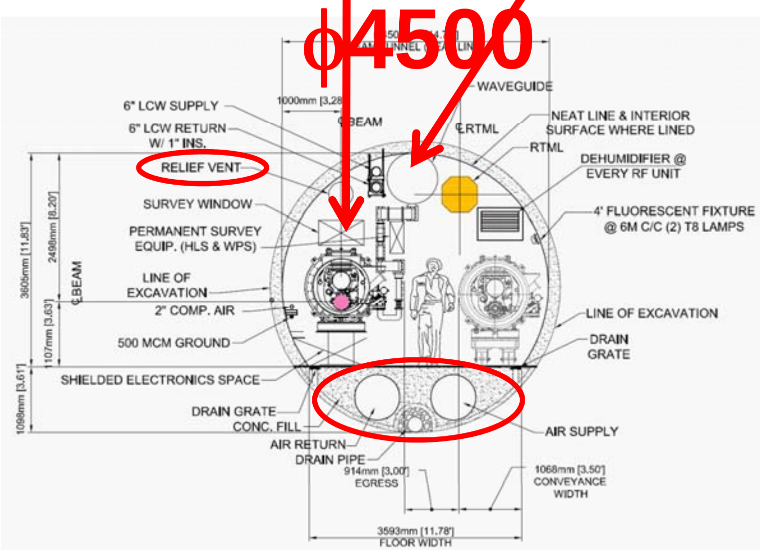


~2.4 km (32 x 2 RF units)

KCS-Type Single-Tunnel



Double-tunnel (RDR)



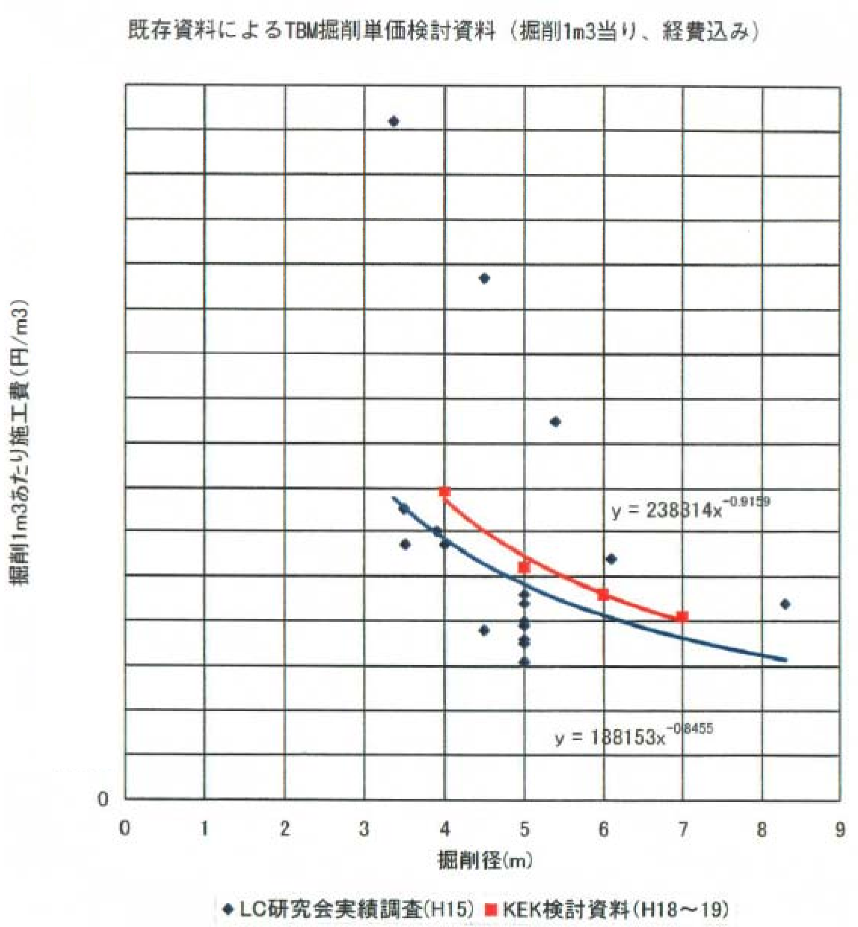
Single-tunnel (SB2009)

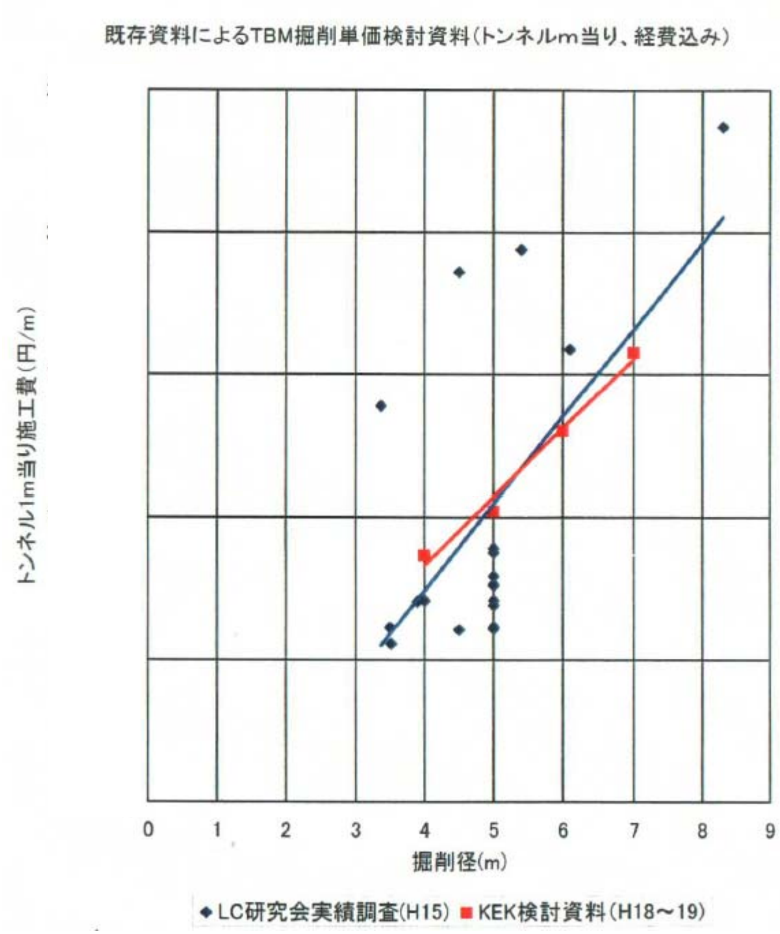
Single-Tunnel Configuration Summary

- from CFS viewpoints -

	Tunnel Dia. (m)	Surface Area	Tunnel Heat Loads	Transmission Power Loss
(RDR double)	4.5 x2	-	-	-
RDR	6.5	-	-	-
DRFS	5.7	Small	-	
XFEL	5.2	↓	↓	
KCS	4.5	Large	Small	~10%

Tunnel Cost vs. Diameter



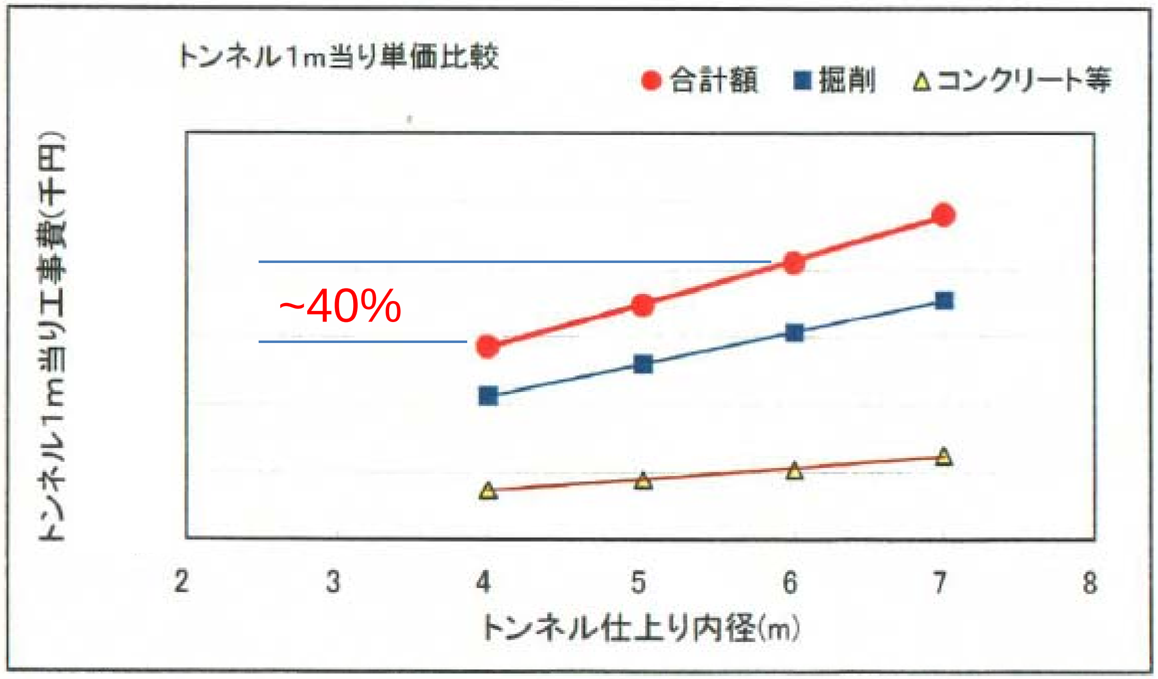


Tunnel Cost vs. Diameter

施工条件

①TBM1台あたり施工延長　5000 m
②覆工コンクリート施工延長　2500 m （2パーティ）
③想定施工順序

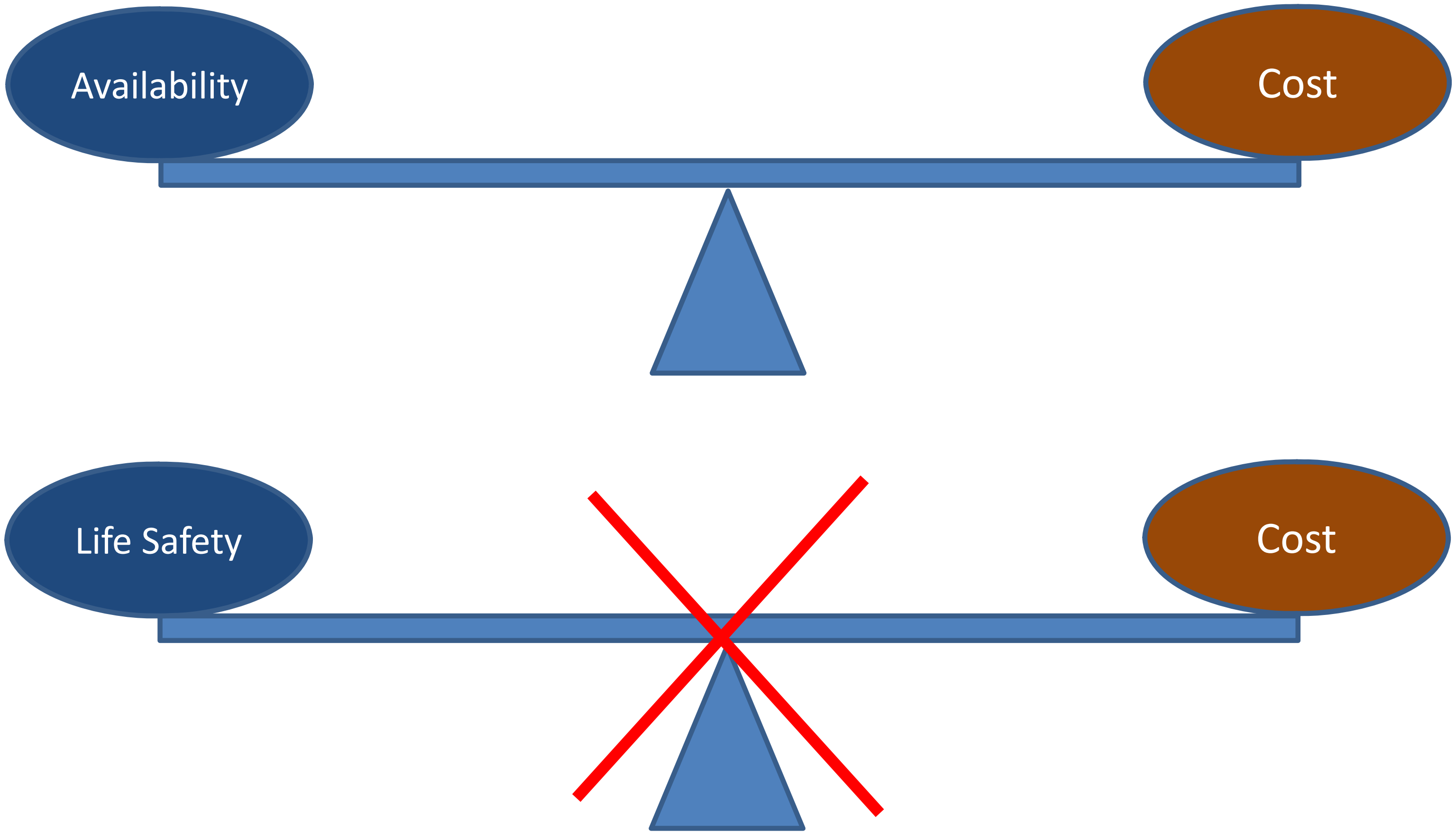
TBM掘削（インバートセグメント同時施工）
↓
路盤材を兼用する充填材施工（砕石）
↓
アーチコンクリート（防水材同時施工）
↓
底版コンクリート



(This does not include land developing cost.)

SINGLE-TUNNEL AVAILABILITY AND SAFETY

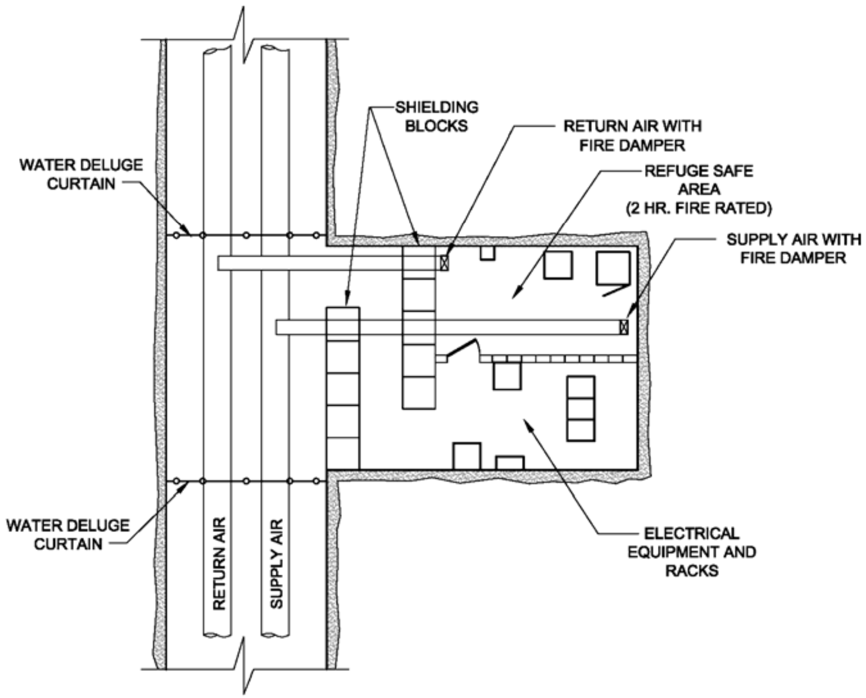
Machine Availability and Life Safety



We can never weigh the cost against life safety

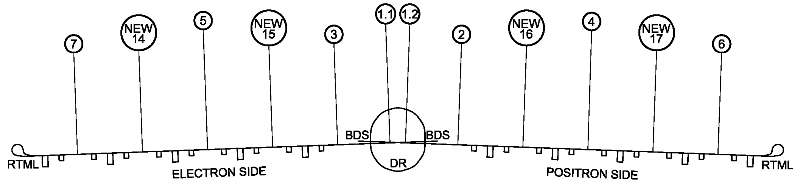
ML Single-Tunnel Life Safety

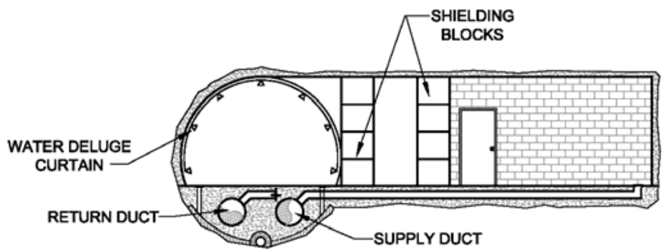
- Americas Region-

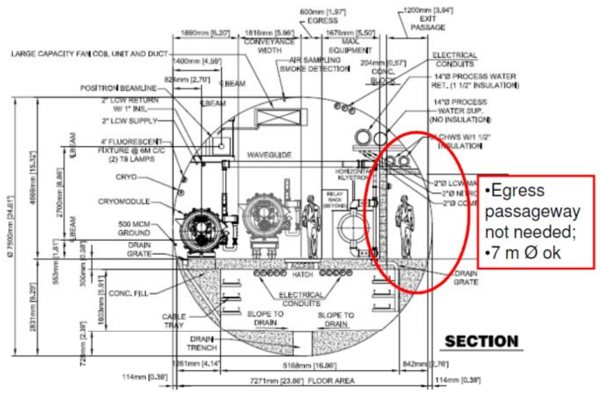


NFPA 520-2005 (Subterranean Spaces)

Prescribes 2 paths of travel to an exit or refuge area. The travel distance to be less than 610 meters.

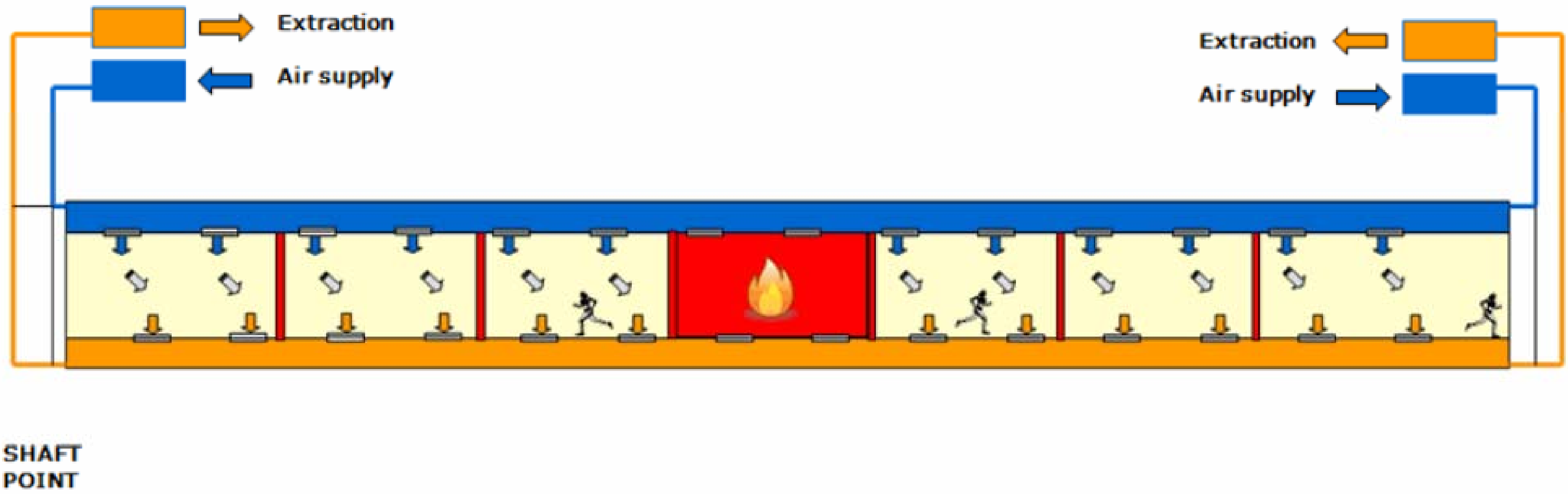






ML Single-Tunnel Life Safety

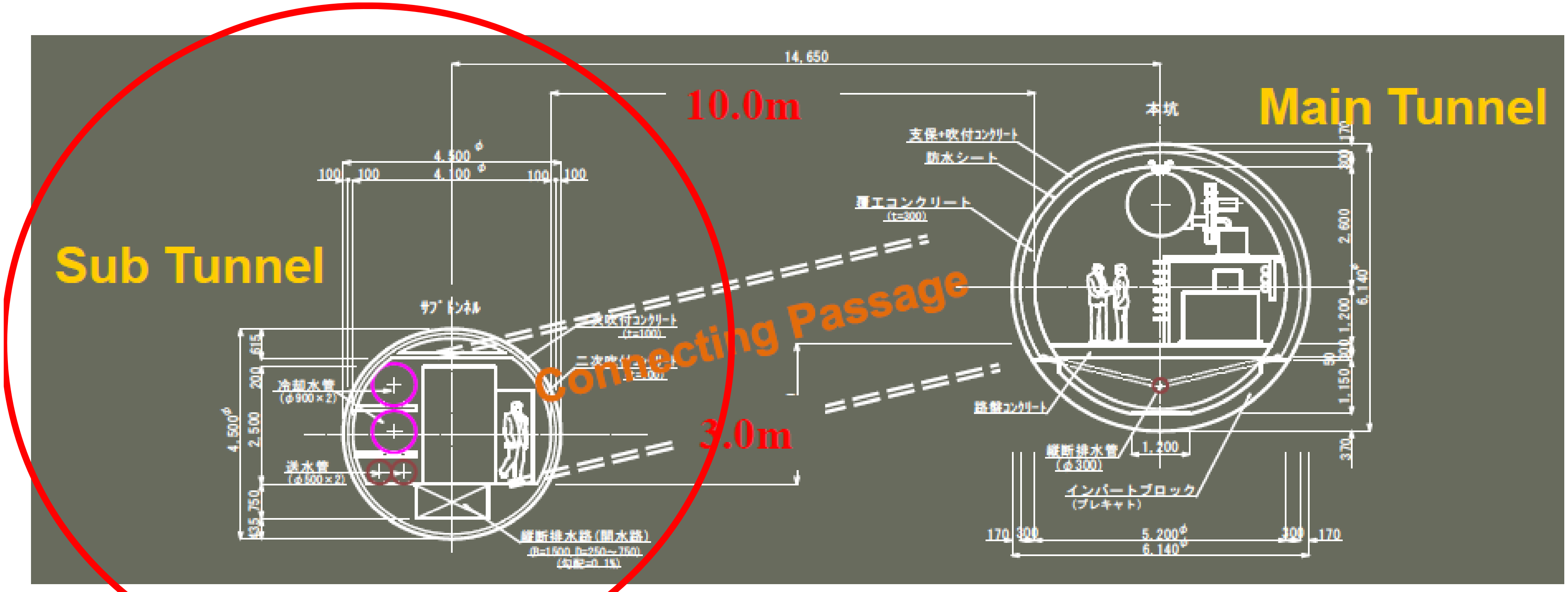
- European Region-



- Control of the pressure from both ends of a sector.
- Control of the pressure (overpressure or underpressure in each area).
- Fire detection per sector compatible to fire fighting via water mist.

ML Single-Tunnel Life Safety

- Asian Region-



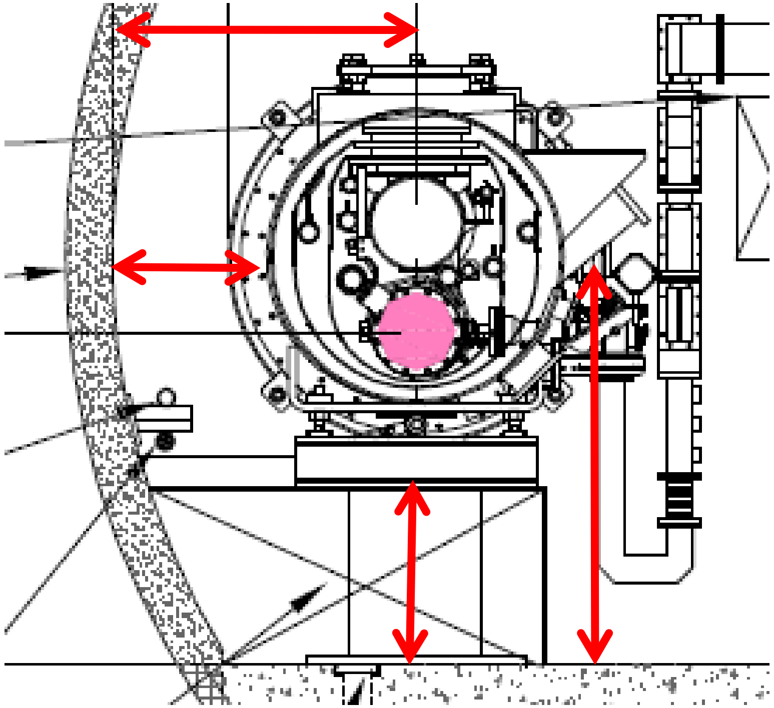
Sub-Tunnel
with non-active components
used for egress,

access,
water utility,
geology survey in construction
etc.

SINGLE-TUNNEL DESIGN CRITERIA

Boundary Condition to Determine Tunnel Diameter

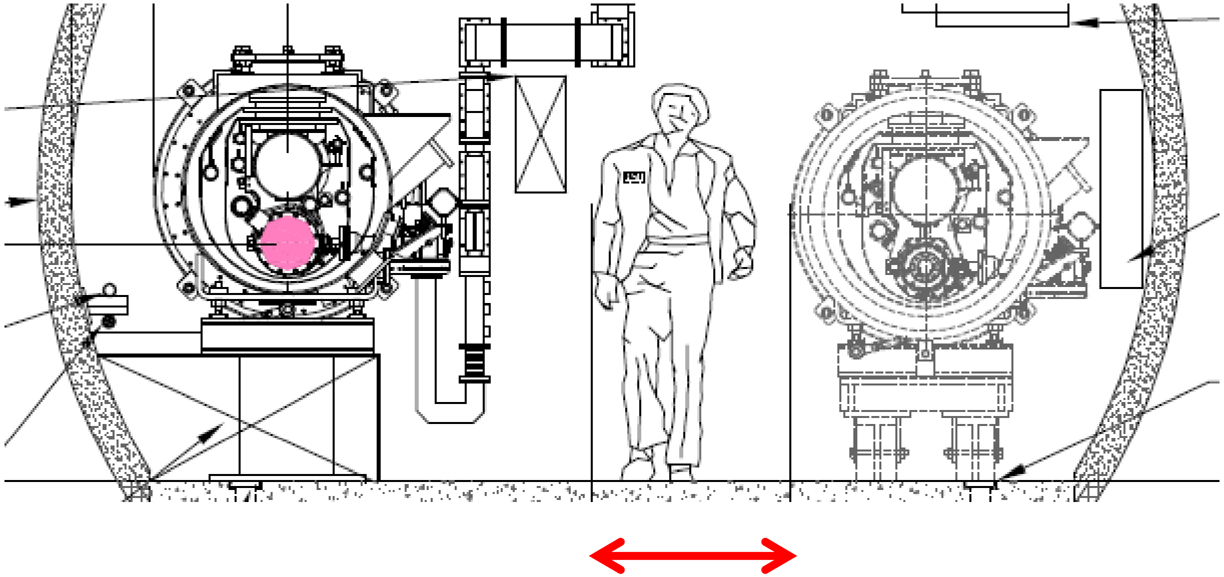
- Cryomodule positioning



The Cryomodules and other floor standing components are placed on short stands mounted to a concrete floor. The beam is centered 1.1 meters above the floor and 0.8 meters away from the wall, which is considered sufficient to allow for cryomodule installation (welding)

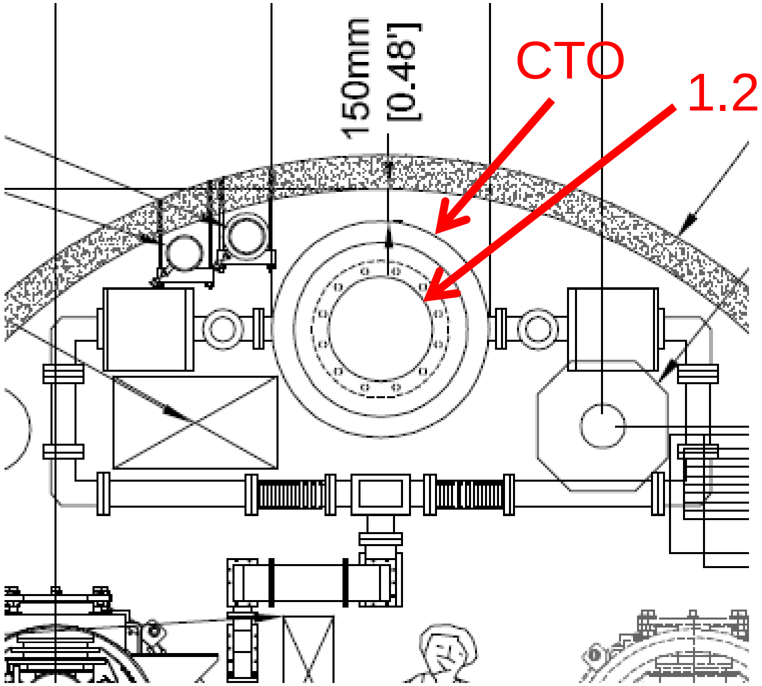
(RDR III-213)

- Safety Clearance



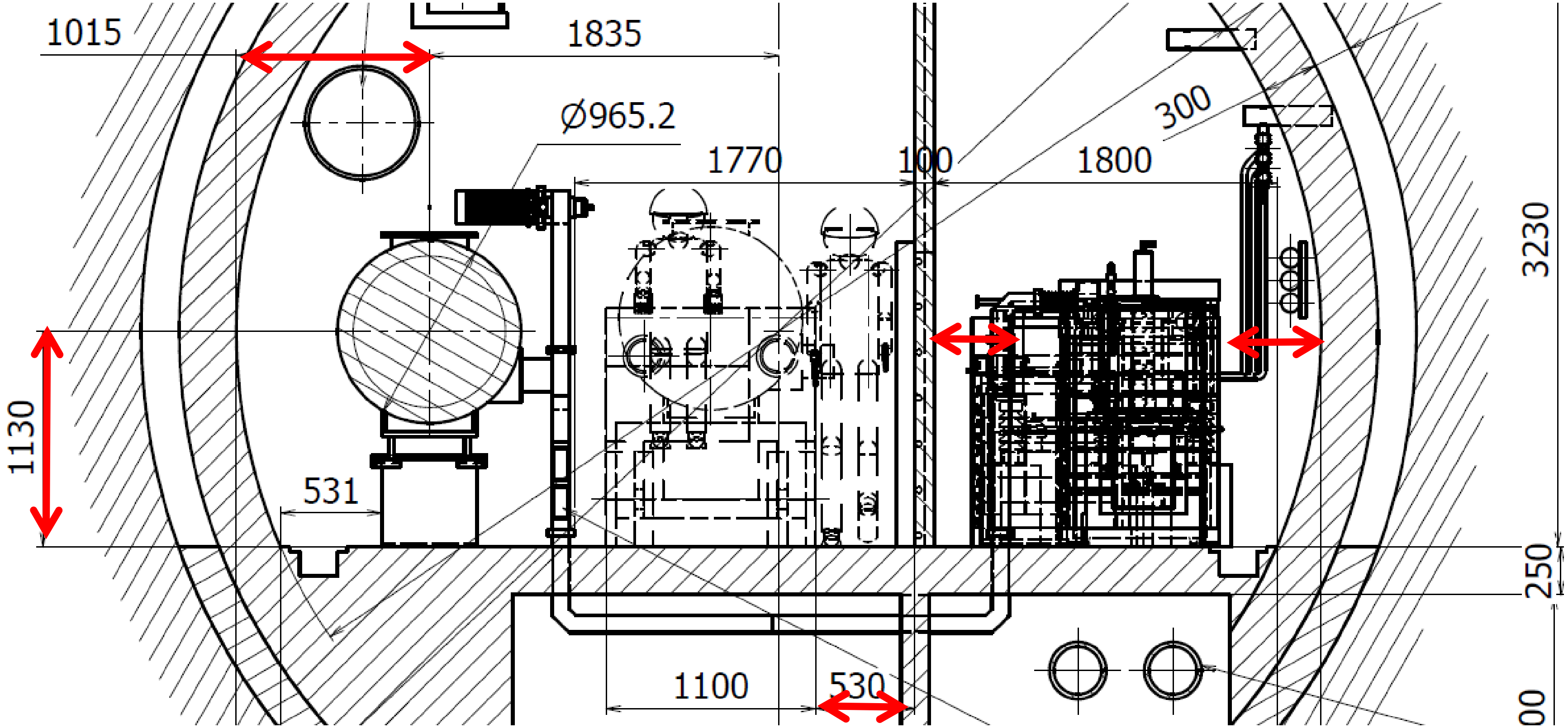
(RDR III-213)

KCS



In progress

DRFS


1015
1835
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1770
100
1800
300
3230
1130
531
250
1100
530
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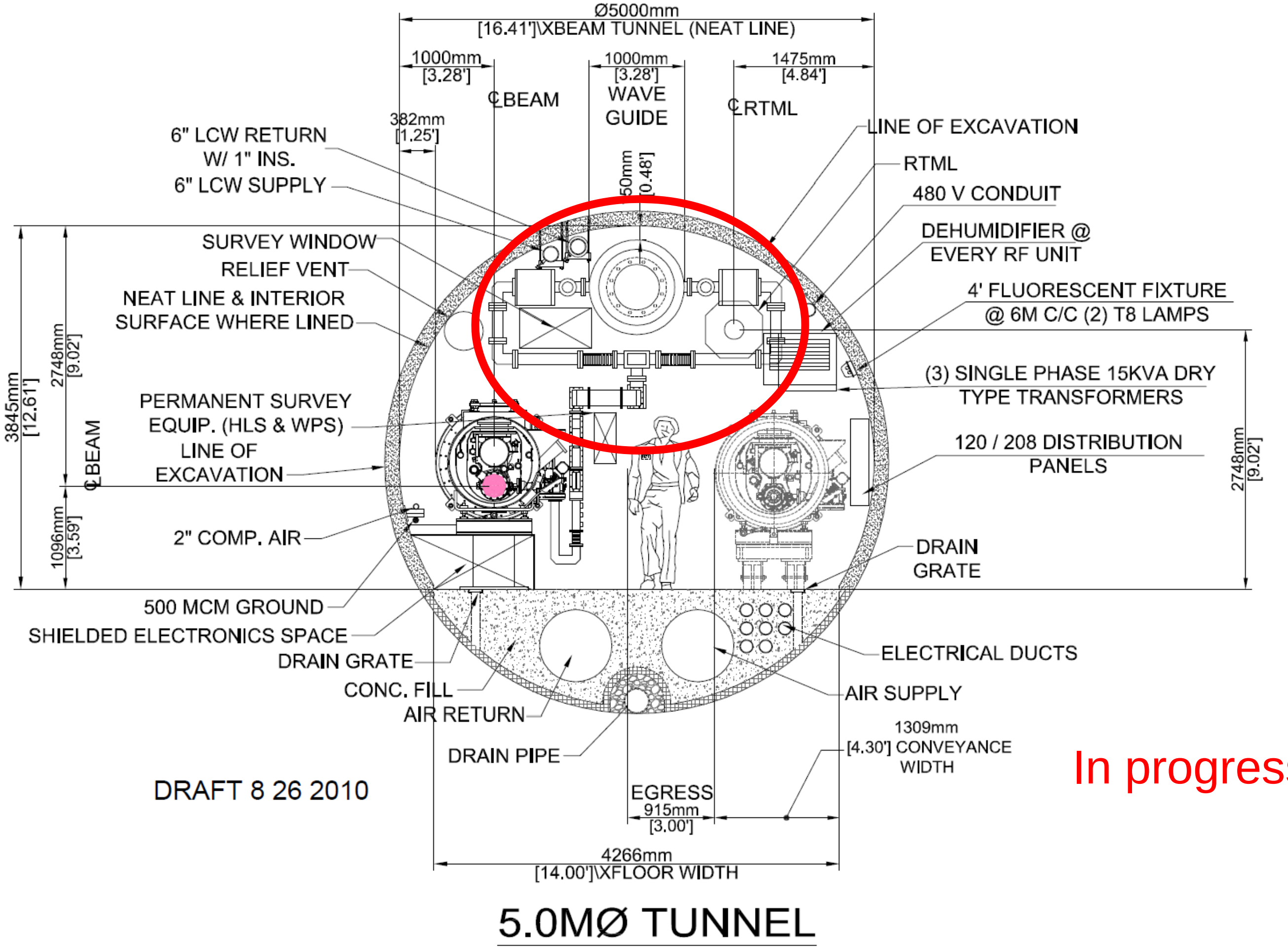
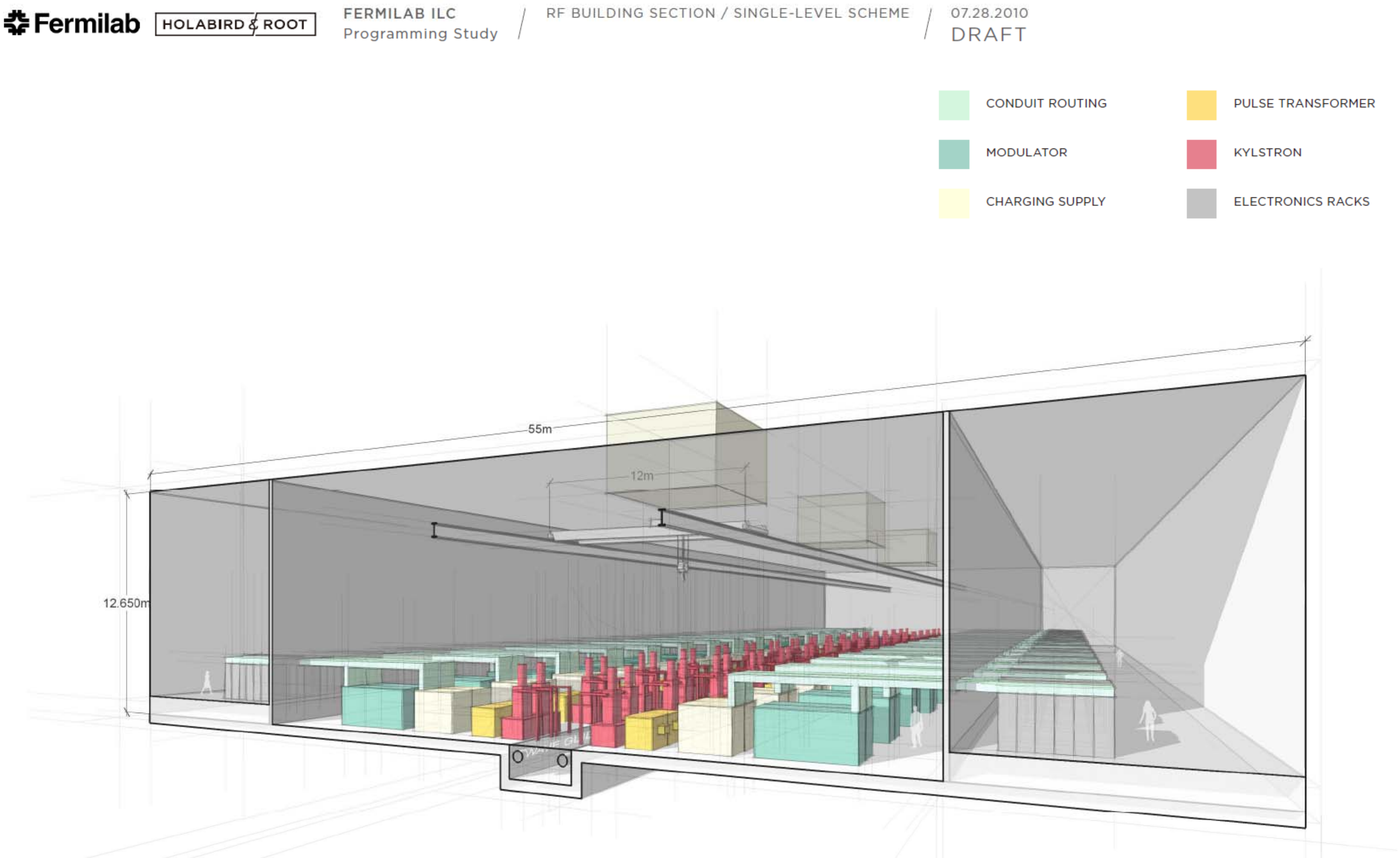
SINGLE-TUNNEL DESIGN PROGRESS

- # Americas Regional Design (KCS)
- Americas team leads single-tunnel design with klystron cluster system.



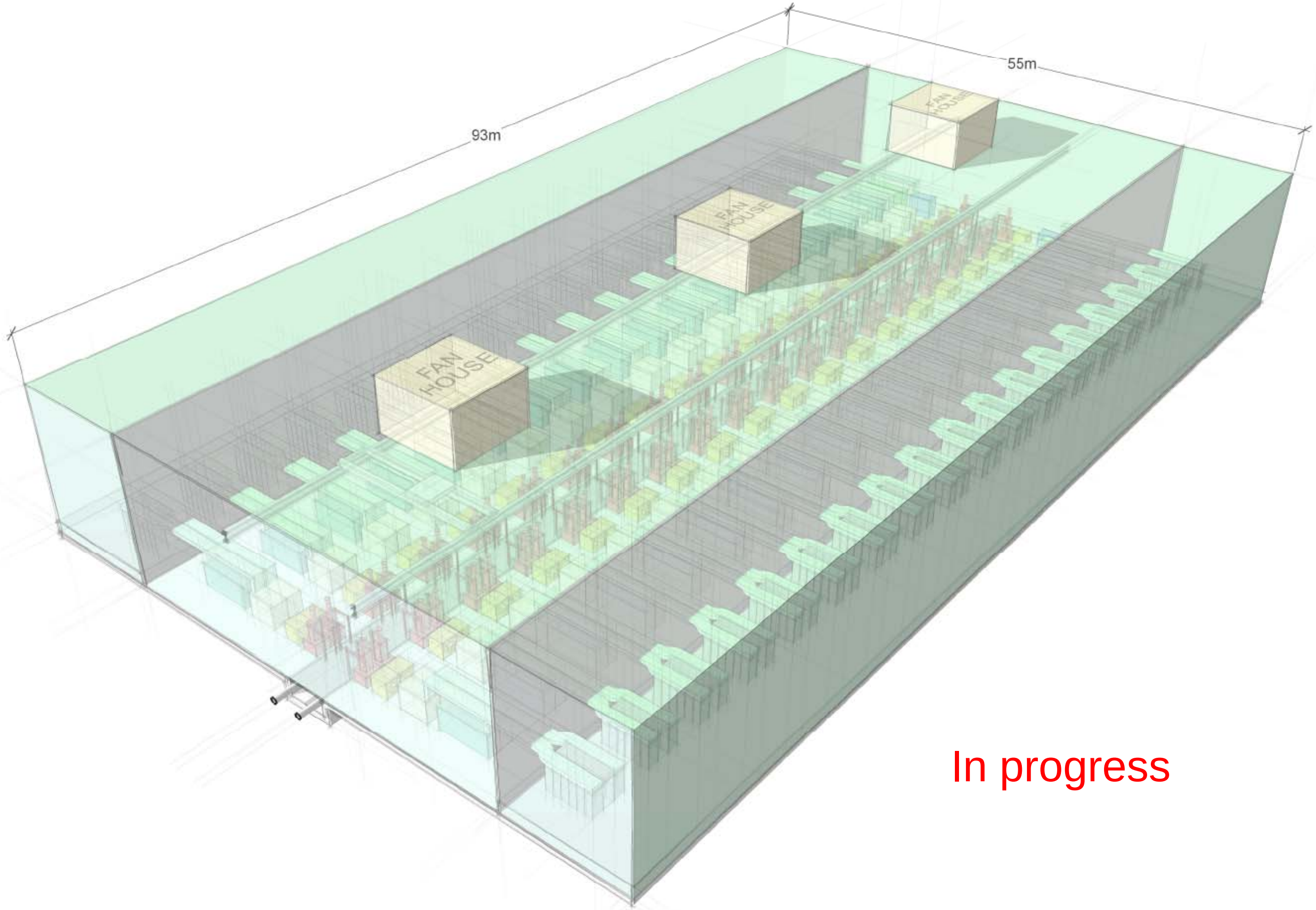
In progress

- Americas Regional Design (KCS)



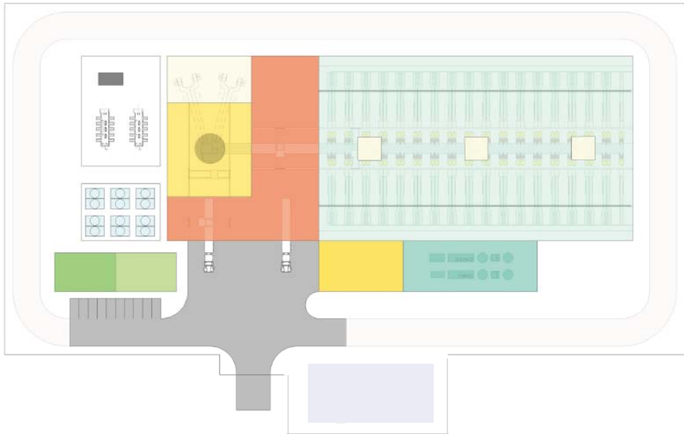
- Americas Regional Design (KCS)

Fermilab HOLABIRD & ROOT FERMILAB ILC Programming Study / RF BUILDING / SINGLE-LEVEL SCHEME / 07.28.2010 DRAFT



In progress

- Americas Regional Design (KCS)



SITE AREA // 21,109.812 M²

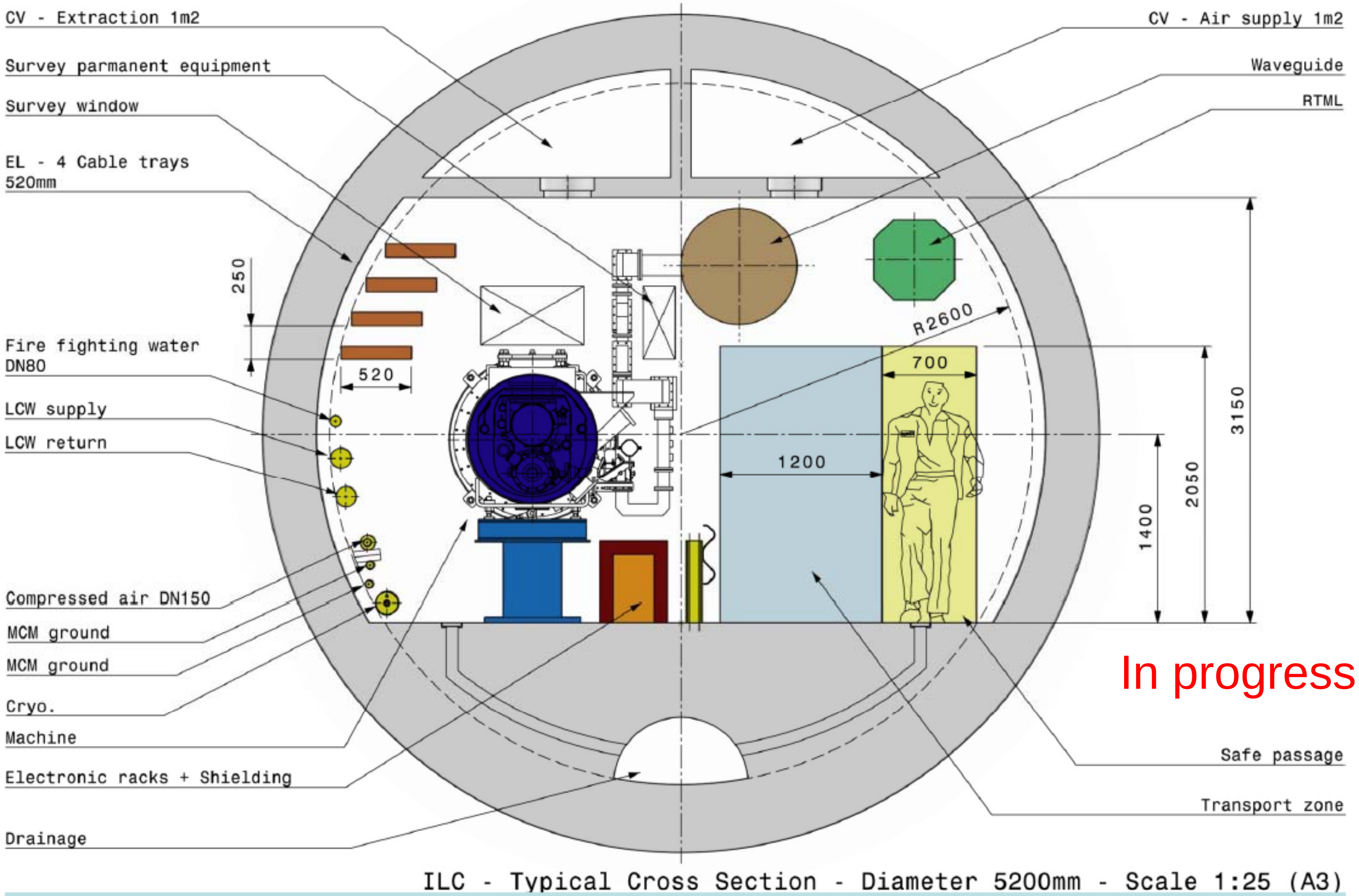
SITE PLAN / SINGLE-LEVEL RF BUILDING; 3M SHAFTS
SHAFTS 14, 15, 16, & 17

07.28.2010
DRAFT

SITE AREA // 24,799.446 M²
2.48 HECTARES
6.128 ACRES

In progress

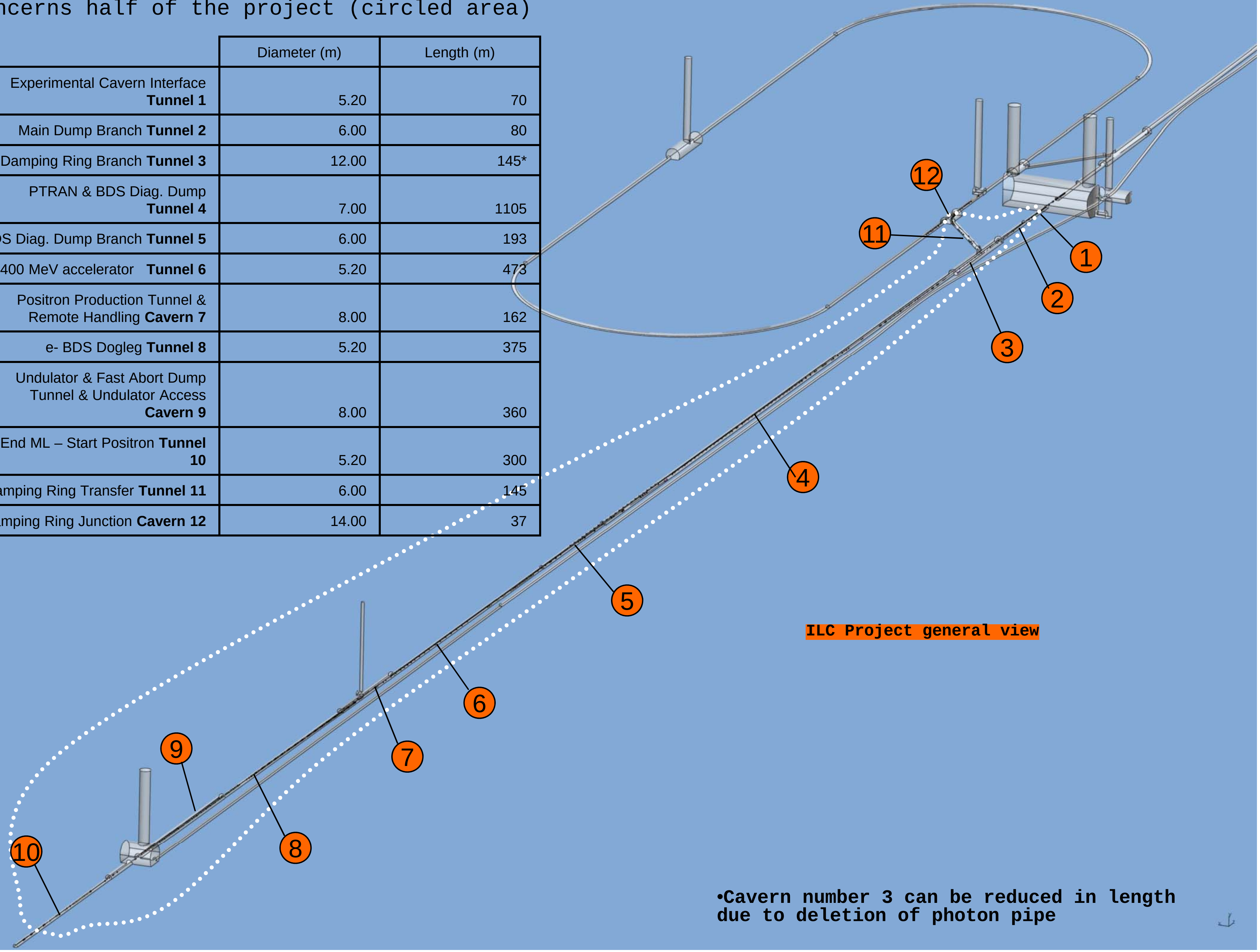
- # European Regional Design (KCS)
- European team develops single-tunnel design with klystron cluster system.



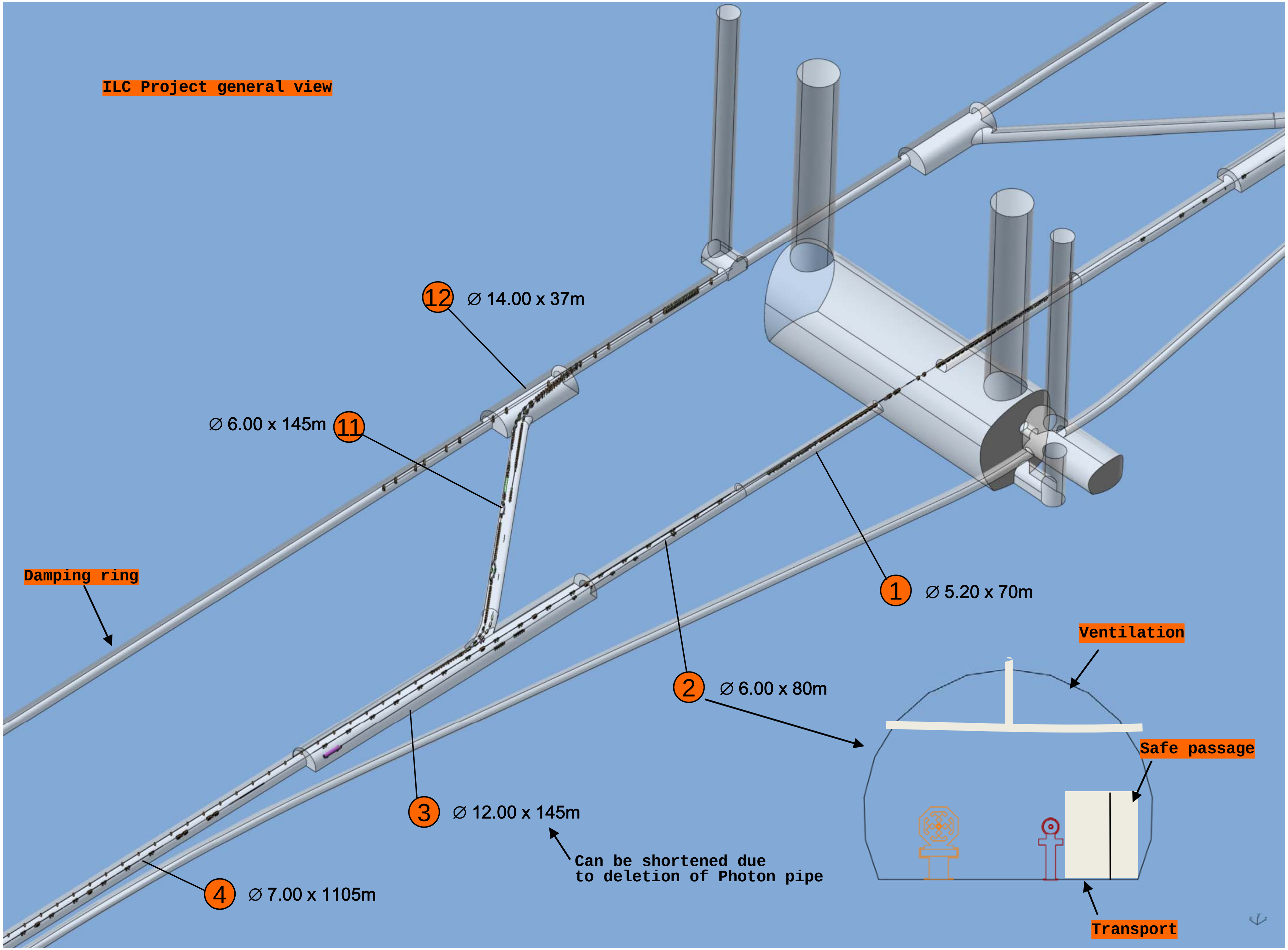
Cross section for Europe (CERN) 5.2m diameter for Kly Cluster

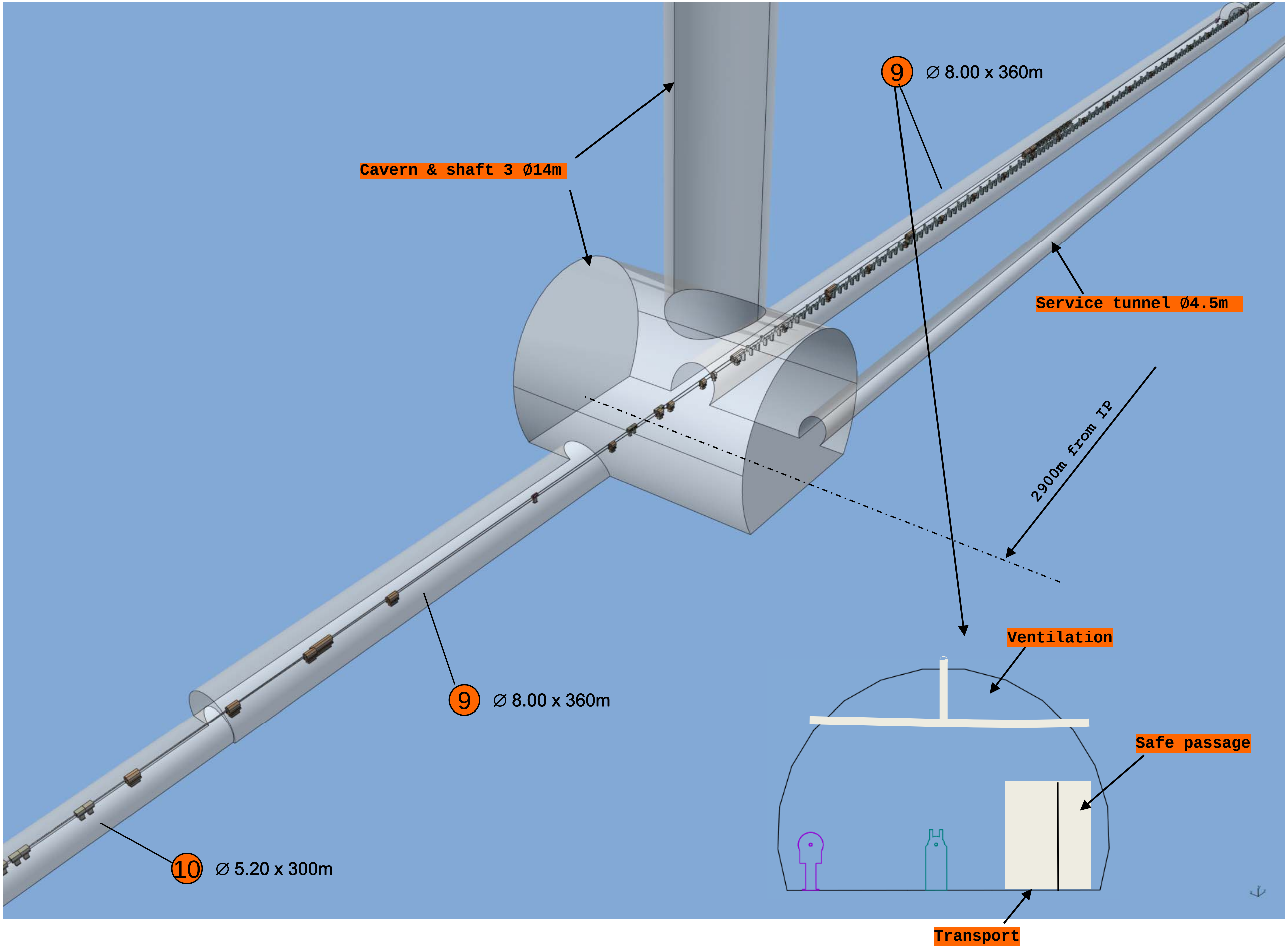
Concerns half of the project (circled area)

	Diameter (m)	Length (m)
Experimental Cavern Interface **Tunnel 1**	5.20	70
Main Dump Branch **Tunnel 2**	6.00	80
Damping Ring Branch **Tunnel 3**	12.00	145*
PTRAN & BDS Diag. Dump **Tunnel 4**	7.00	1105
BDS Diag. Dump Branch **Tunnel 5**	6.00	193
400 MeV accelerator **Tunnel 6**	5.20	473
Positron Production Tunnel & Remote Handling **Cavern 7**	8.00	162
e- BDS Dogleg **Tunnel 8**	5.20	375
Undulator & Fast Abort Dump Tunnel & Undulator Access **Cavern 9**	8.00	360
End ML – Start Positron **Tunnel 10**	5.20	300
Damping Ring Transfer **Tunnel 11**	6.00	145
Damping Ring Junction **Cavern 12**	14.00	37



•Cavern number 3 can be reduced in length due to deletion of photon pipe

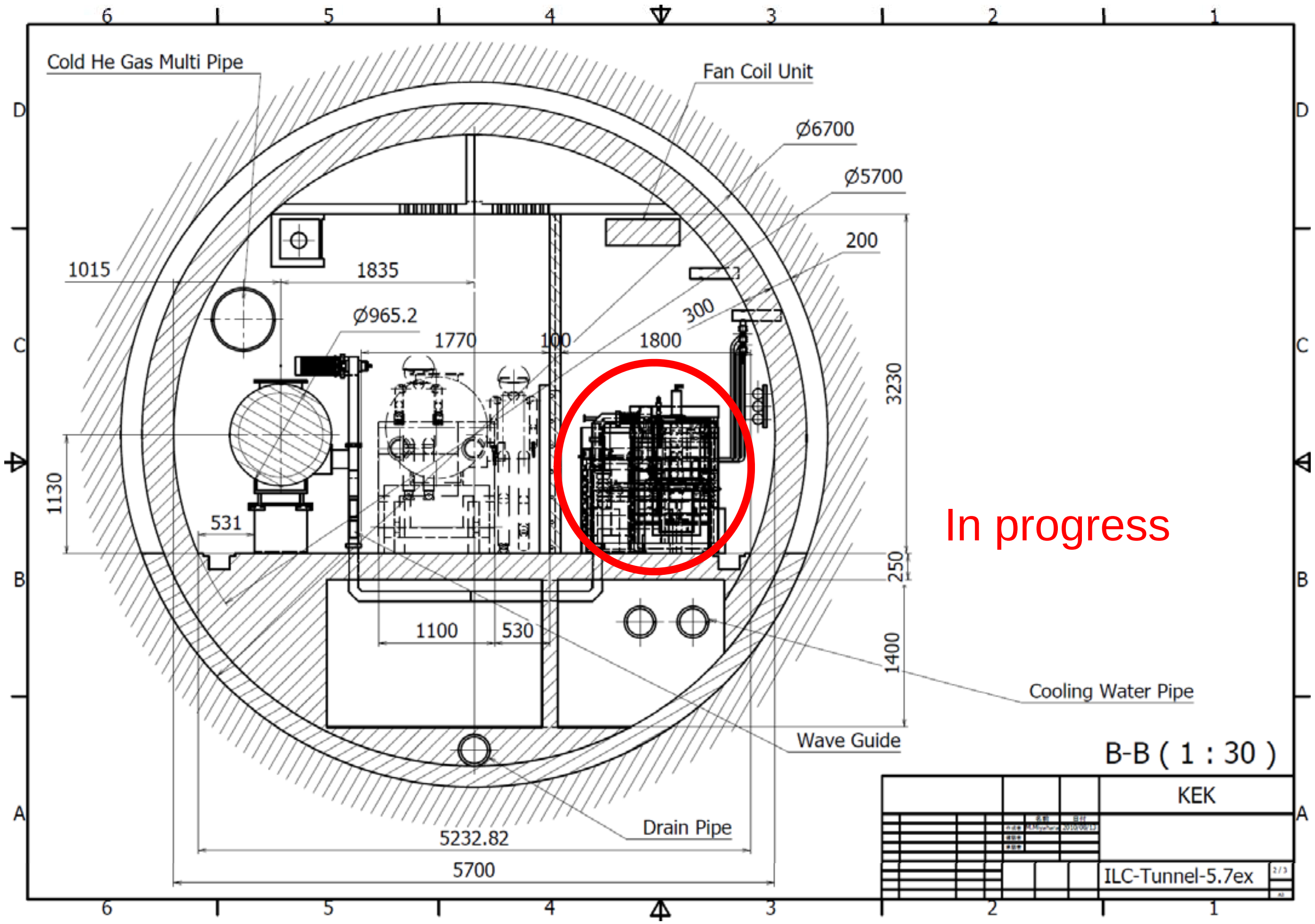

ILC Project general view
12 ∅ 14.00 x 37m
∅ 6.00 x 145m 11
Damping ring
1 ∅ 5.20 x 70m
Ventilation
2 ∅ 6.00 x 80m
Safe passage
3 ∅ 12.00 x 145m
Can be shortened due
to deletion of Photon pipe
4 ∅ 7.00 x 1105m
Transport



9
∅ 8.00 x 360m
Cavern & shaft 3 Ø14m
Service tunnel Ø4.5m
2900m from IP
9
∅ 8.00 x 360m
Ventilation
Safe passage
10
∅ 5.20 x 300m
Transport

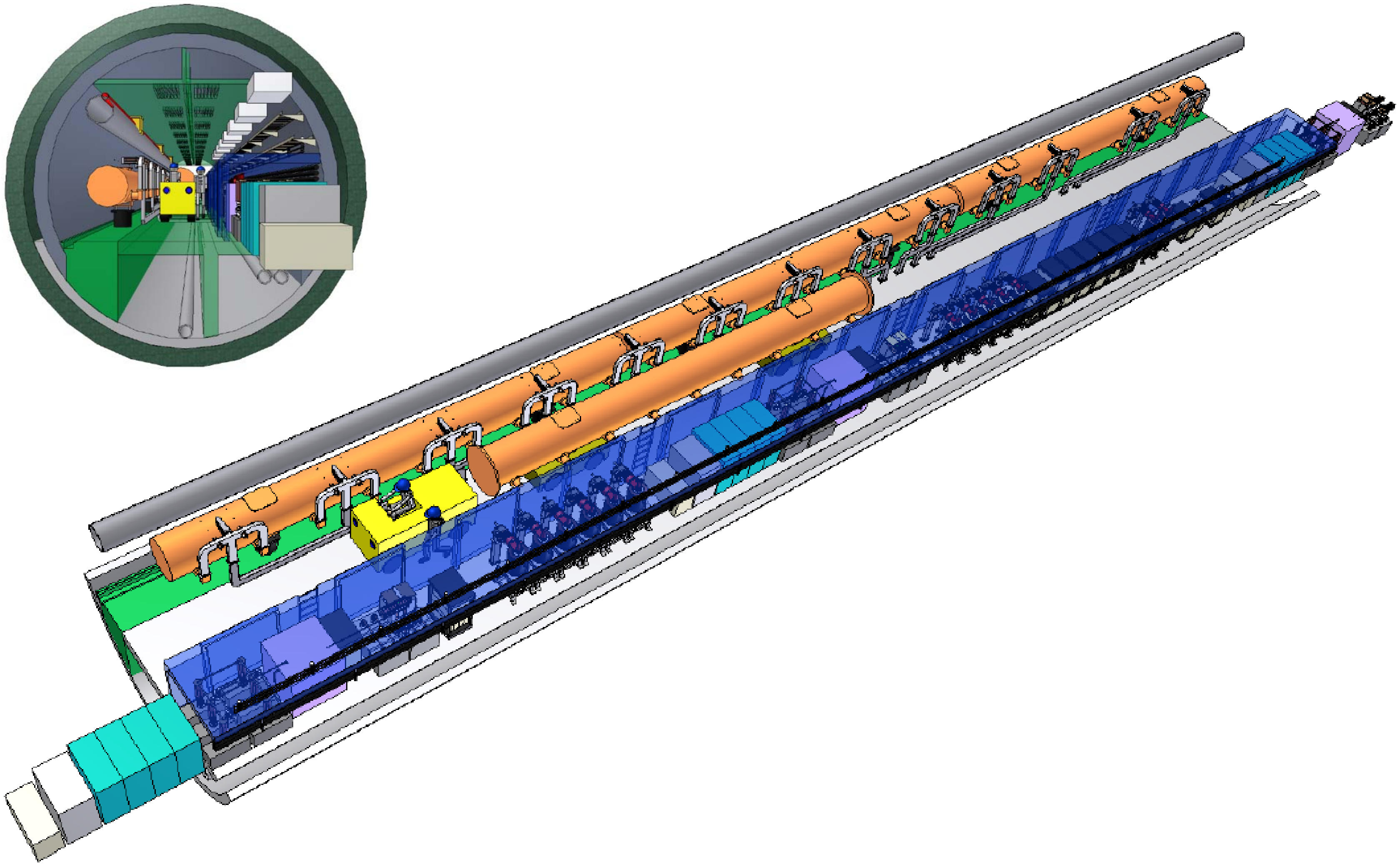
Asian Regional Design (DRFS)

- Asian team leads single-tunnel design with distributed RF system.

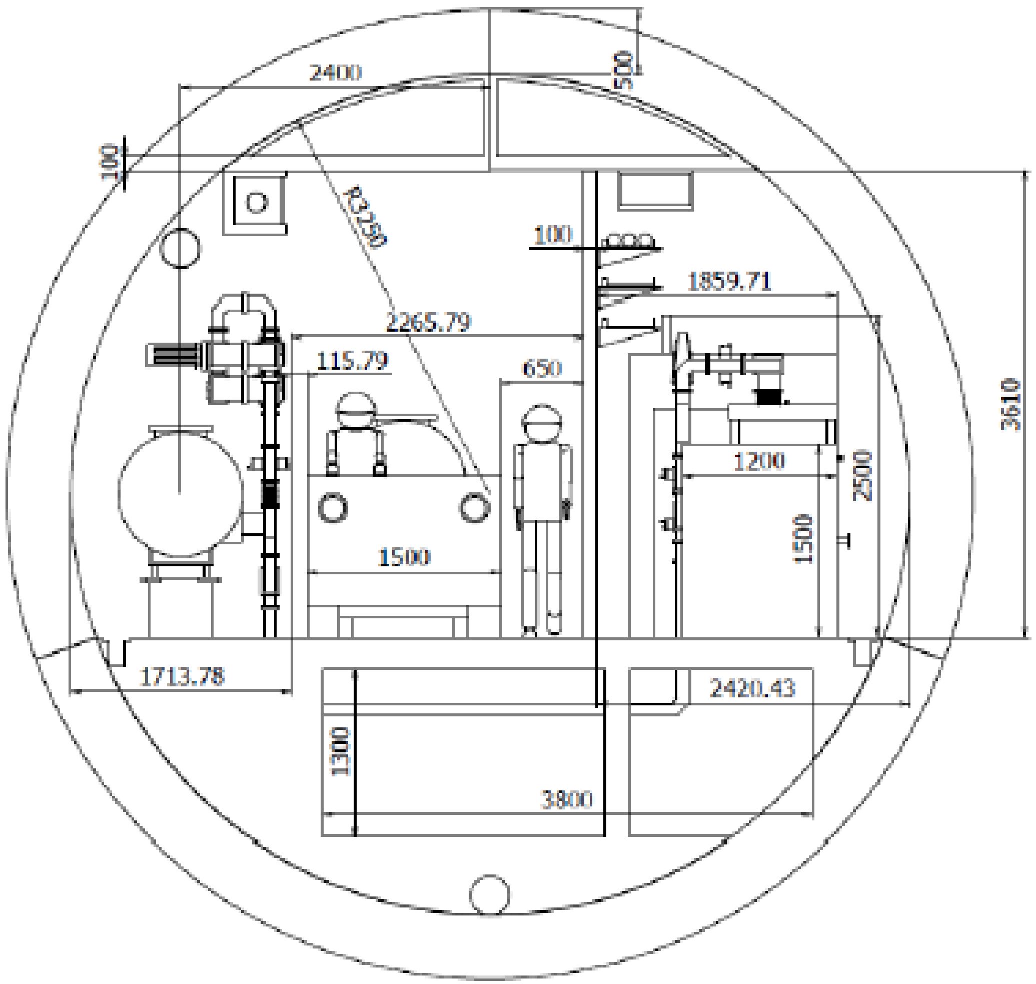


In progress

Asian Regional Design (DRFS-3D)



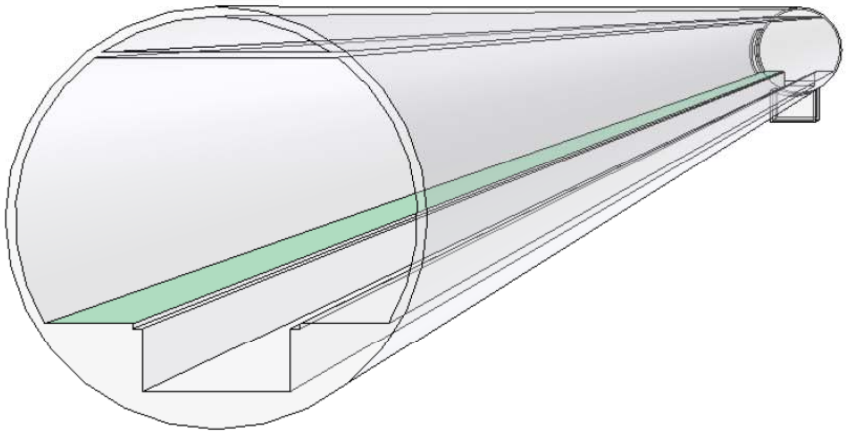
Single-Tunnel Design with RDR RF unit

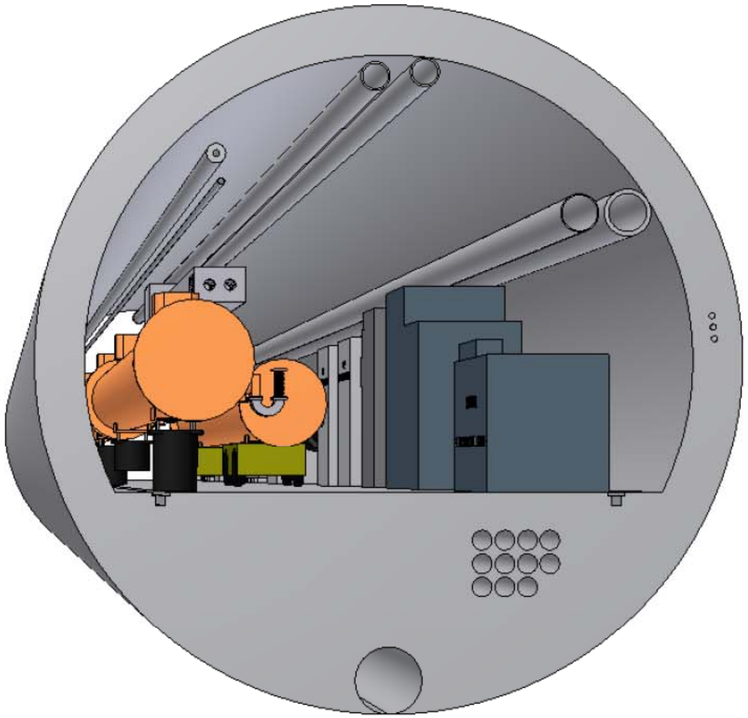


In progress

Single-Tunnel Design with RDR RF unit – 3D

- Import Americas' u-11 Main Linac Plan & Section 061106 AutoCAD data -





Sub Tunnel in Asian Region

(1) It is used as an escape passage in case of emergency. The Asian regional single-tunnel with DRFS or RDR type RF source has more fire loads than those with TESLA type or KCS. And it has longer access paths to the surface ground. We should be more careful of safety.
(2) It will be used as a pilot tunnel to excavate the main tunnel. A very serious accident with a large-diameter tunnel boring machine (TBM) is to be trapped with bad geology. To avoid such risk, the geological survey function of the pilot-tunnel will work. This will be more effective when the sub tunnel is excavated for several months in advance. And it is cost effective when the main tunnel diameter is much larger than the pilot tunnel.
(3) It is used for drainage of inflow water in both construction and operation phases. The sub tunnel itself does not care wet condition and is located in lower position than the main tunnel. The water flows down to the sub tunnel to keep the main tunnel always dry. Further, the inflow water along the underground tunnel is gathered and transferred through the sub tunnel and it may be spontaneously drained to a river taking an advantage of the mountainous topography.

SUMMARY

Summary

(1) Single-tunnel design with KCS/DRFS is underway..

(2) Consistent boundary conditions from both technical group and CFS criteria should be discussed at BAW.

(3) Single-tunnel design with RDR RF unit is under preparation to compare with KCS and DRFS.

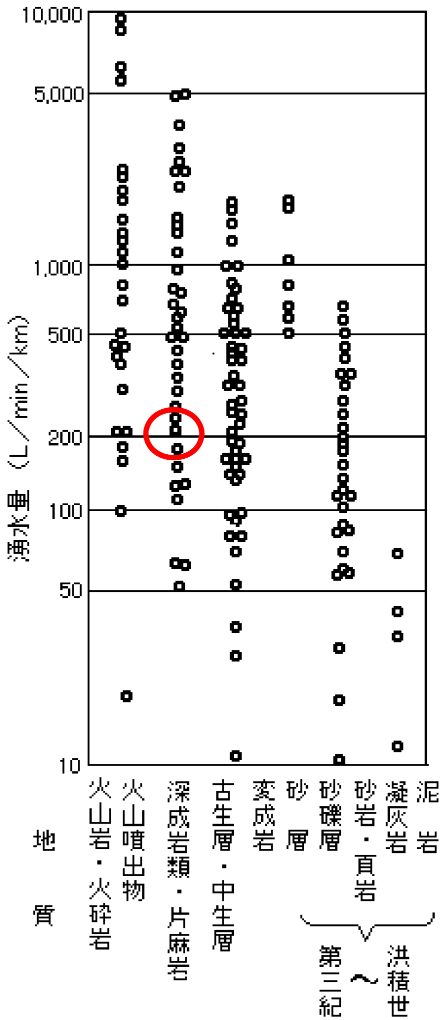
APPENDIX

Drainage System

- Sump water and Geology in Japan-

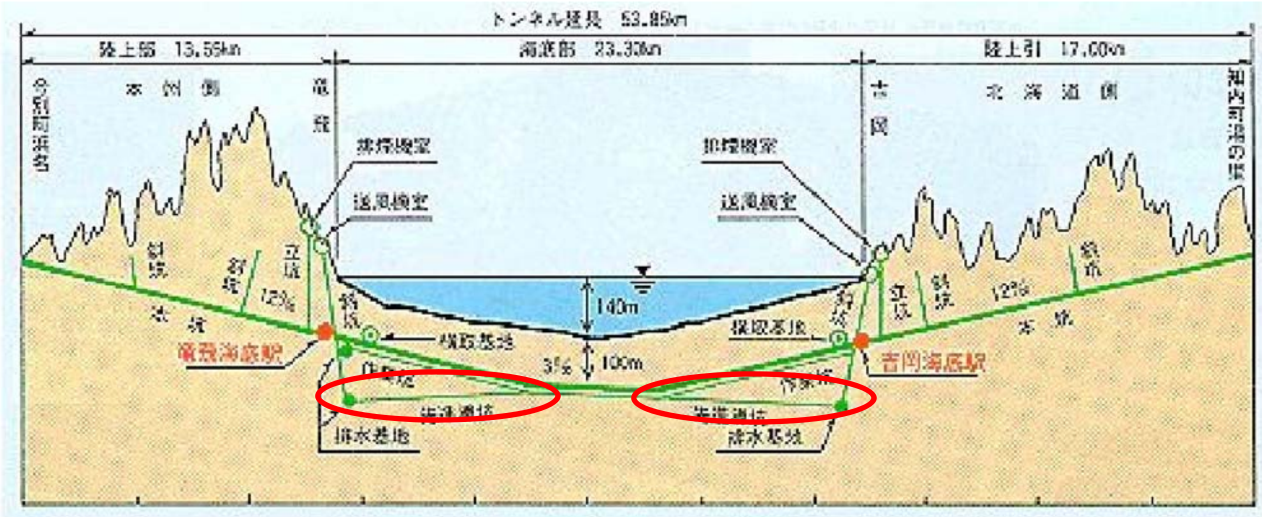
地質分類		比湧水量の範囲 m³/min/km	平均比湧水量 m³/min/km
火山岩、火山砕屑岩		0.85 ～ 10	3.71
		0.035 ～ 0.9	0.30
深成岩類（含片麻岩）		0.17 ～ 3.8	1.38
		0.018 ～ 0.84	0.20
古生層、中生層		0.10 ～ 4.5	0.79
		0.0 ～ 0.95	0.17
第三紀｜洪積世	砂礫層	0.02 ～ 3.6	0.84
	砂岩・頁岩・凝灰岩	0.014 ～ 0.95	0.25
	泥岩	0.0 ～ 0.26	0.07

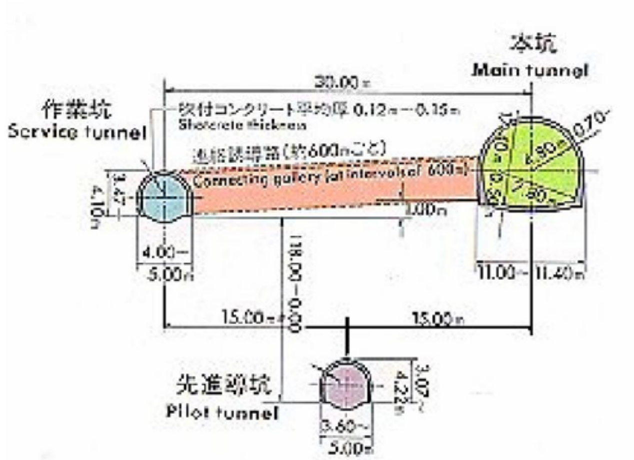
（出典：（社）日本トンネル技術協会『トンネル施工に伴う湧水渇水に関する調査研究（その２）報告書』昭和 58 年 2 月）



Drainage System

- An Example of Drainage Tunnel in Japan-





海底部標準断面図（単位：m）

排水設備

名称	ポンプ1	ポンプ2	ポンプ3
位置	竜飛 作業坑	竜飛 斜坑	吉岡 斜坑
排水量（ポンプ室への流水量）	19m3/分	8m3/分	16m3/分
ポンプ台数	10m3/分×3	9m3/分×3	12m3/分×6

Tunneling

- Rock hardness and Geology-

表－　岩の分類と判定基準

名称 A	名称 B	名称 C	説明	適用	国土交通省岩分類
岩または石	岩塊玉石	岩塊玉石	岩塊、玉石が混入して掘削しにくく、バケット等に空隙のでき易いもの 岩塊、玉石は粒形7.5cm以上としまるみのあるものを玉石とする。	玉石まじり土 岩塊起砕された岩 ごろごろした河床	
	軟岩	軟岩 I	第三紀の岩石で固結の程度が弱いもの、風化がはなはだしくきわめて脆いもの、指先で離しうる程度のもので亀裂の間隔は1～5cmくらいのもの及び第三紀の岩石で固結の程度が良好なもの、風化が相当進み多少変色を伴い軽い打撃で容易に割れるもの、離れやすいもので、亀裂間隔は5～10cm程度のもの	地山弾性波速度 700～2800m/sec	軟岩 I
		軟岩 II	凝灰質で堅く固結しているもの、風化が目にそって相当進んでいるもの、亀裂間隔が10～30cm程度で軽い打撃により離しうる程度、異質の硬い互層をなすもので層面を楽に離しうるもの		軟岩 II
	硬岩	中硬岩	石灰岩、多孔質安山岩のように、特にち密でなくても相当な堅さを有するもの、風化の程度があんまり進んでいないもの、硬い岩石で間隔30～50cm程度の亀裂を有するもの	地山弾性波速度 2000～4000m/sec	中硬岩
		硬岩 I	花崗岩、結晶変岩等で全く変化していないもの、亀裂間隔が1m内外で相当密着しているもの、硬い良好な石材を取り得るようなもの	地山弾性波速度 3000m/sec以上	硬岩 I
		硬岩 II	けい岩、角岩などの石英質に富む岩石で最も硬いもの、風化していない新鮮な状態のもの、亀裂が少なく、よく密着しているもの		硬岩 II

名称 C	岩種グループ別	変成岩および堆積岩										堆積岩								火成岩									
		主として古生代										中世代				第三紀				深成岩					火山岩				
		片麻岩	砂質片岩	黒色片岩	緑色片岩	千枚岩	珪岩・角岩	石灰岩	砂岩	粘板岩	輝緑凝灰岩	粘板岩	頁岩	砂岩	れき岩	頁岩泥岩	砂岩	凝灰岩	凝灰角礫岩	花こう岩	セン緑岩	ハンレイ岩	カンラン岩	蛇紋岩	流紋岩	ヒン岩	安山岩	玄武岩	集塊岩
岩塊玉石																													
軟岩 I	A B	●		△	●	●		●	●	● ▲	●	● ▲	▲	●	●	△ ○	▲ △	● ▲	● ▲	● ▲	●			● ▲	●		●	●	▲ △
軟岩 II	A B	▲	● ▲	○	● ▲	▲	●	▲ △	▲	▲ △	▲ △	▲ △	△	▲	▲ △	◎	○ ◎	△ ○	△ ○	▲ △	▲	● ▲	● ▲	△ ○	▲	● ▲	▲	▲	○ ◎
中硬岩	A B	△	▲ △	◎	△	△	▲	○ ◎	△	△ ○	△ ○	△ ◎	○ ◎	△	○ ◎			◎	◎	▲ ○	△ ○	△ ○	△ ○	◎	△	△	△	△	
硬岩 I	A B	○ ◎	△ ○		○ ◎	○ ◎	○		○	◎	○			○ ◎						◎	◎	◎	◎		○ ◎	○ ◎	○ ◎	○ ◎	
硬岩 II	A		◎				○ ◎		◎																				

● 全体に変化が進み変色しているもの。
▲ 割れ目に沿って幅広く風化しているが球状、レンズ状に未風化部を残すもの。
△ 割れ目に沿って風化変色が少なく、岩片内部は新鮮なもの。
○ 割れ目が少なく風化変色がほとんどなく新鮮で硬いもの。
◎ 岩石が特に硬く全く新鮮なもの。

＊　Aグループは、花崗岩・安山岩・砂岩・珪岩のように、造岩物質、固結度共に固く、風化が進み、亀裂が入って、弾性波速度が遅くても、岩片耐圧強度の高い岩種類。
＊　Bグループは、頁岩・粘板岩・黒色片岩のように、造岩物質が軟らかく、風化が進むと泥化し新鮮なもので弾性波速度が早くても、岩片耐圧強度の低い岩種類。
注)　輝緑凝灰岩は、地質資料によっては玄武岩質火山噴出物（火砕岩、溶岩）と呼称される。

metamorphic
sedimentary
igneous
Paleozoic
Mesozoic
sandstone
limestone
granite
weathered
fresh
~40 MPa
~80 MPa
~120 MPa
~160 MPa
~200 MPa