CFS GLOBAL Group

Status of CFS
Design and Cost Study

J.L. Baldy, A. Enomoto, V. Kuchler,

Status of CFS Design and Cost study

Summary

- **Basis of the Civil Engineering Layouts**
- **Specificities for each Sample Site**
- **Basis of Costing Exercise**
- **From Vancouver to Valencia**
- **Summary of some Cost Findings**
- **Time Schedules**
- **Conclusions**

Acknowledgement

The work to generate CFS layouts and estimates required information from most parts of the ILC Global Design Effort.

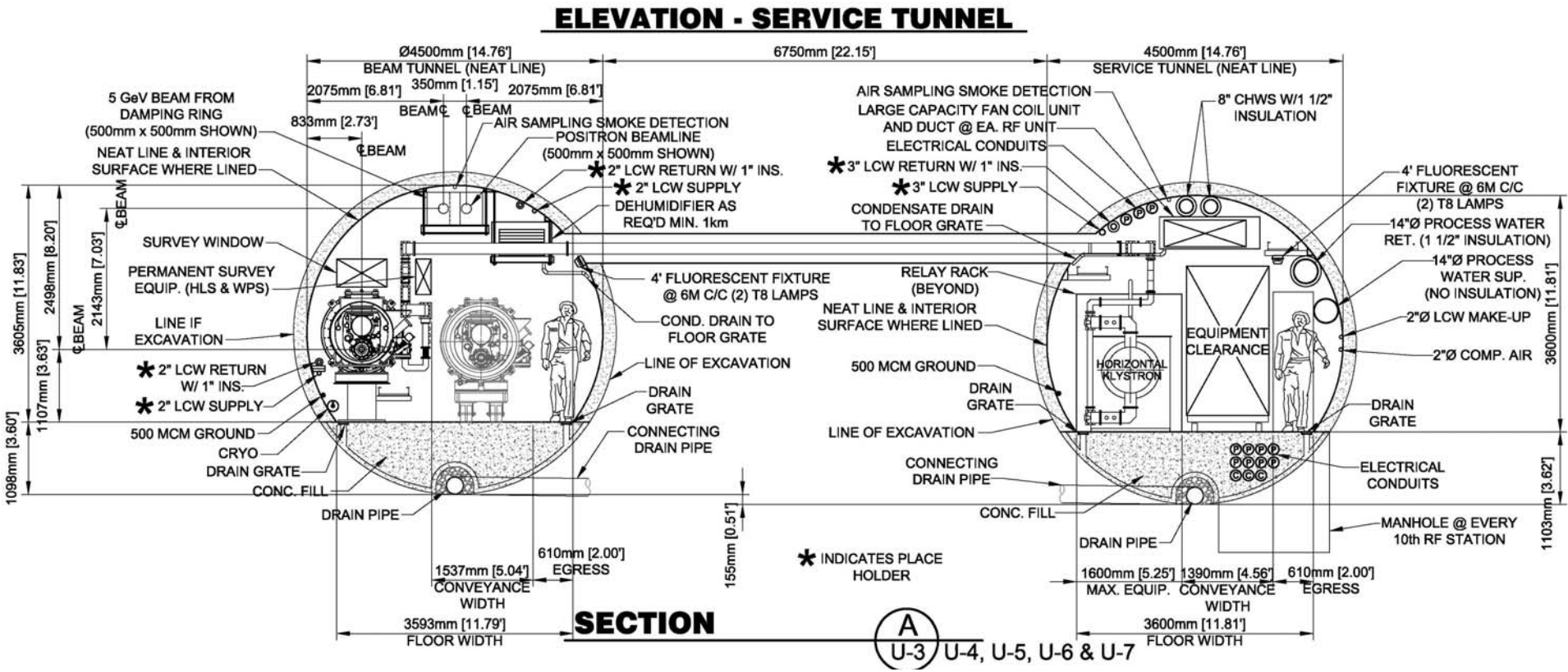
The CFS group would like to thank everyone for their collaboration and valuable input.

Basis of The Civil Engineering Layouts

- All information received from area, technical, global systems until 10.24.06
  - **Many iterations (i.e. Alternative E for Central Layout!)**
- All Decisions (Mostly Cost Saving) made in KEK, Caltech
  - **Approved trough CCB procedures**
  - **Likely to be retained**
- Existing Projects like TESLA, X-FEL, LEP, LHC (i.e. CMS Technology)
- Constant check of CE feasibility and optimization of cost and time.
- Input from proven CE Consultants
- Specificities of different sample sites are not shown,
  - **but they have been taken into account for costing, including the geological ones**
- For BDS are considered:
  - **Two IR 2 fixed Detectors as the baseline,**
  - **One IR 2 mobile Detectors Push-Pull as an alternative**

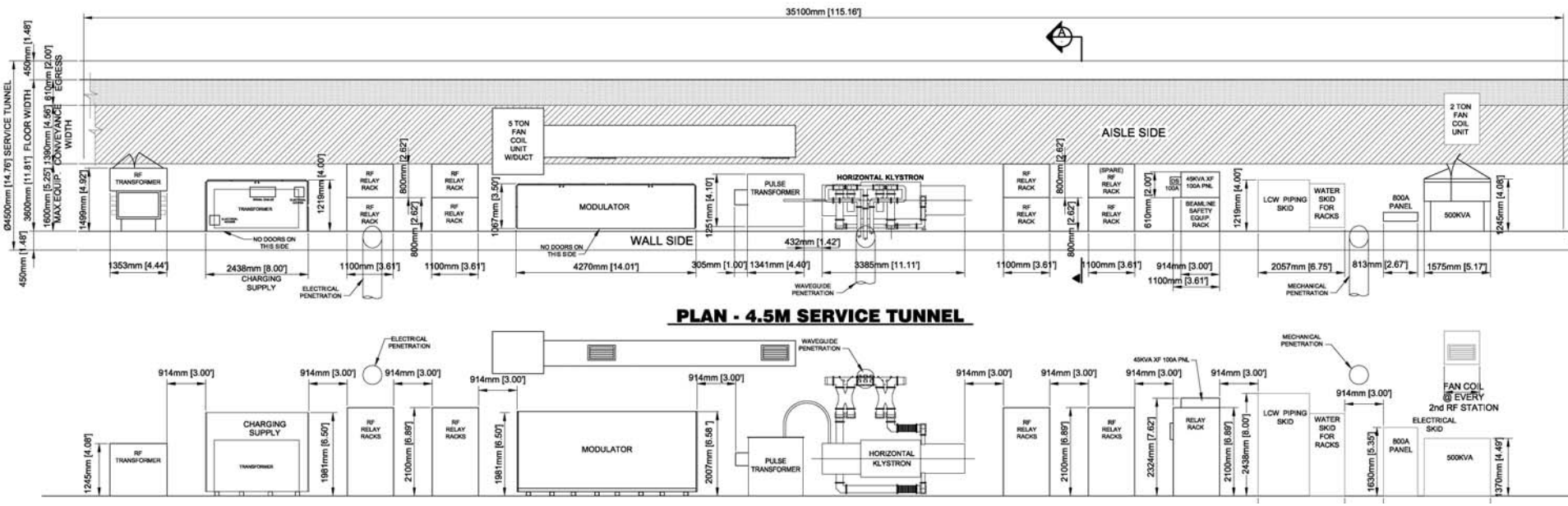
Examples of Civil Engineering Layouts (1)

From CFS - Fermilab

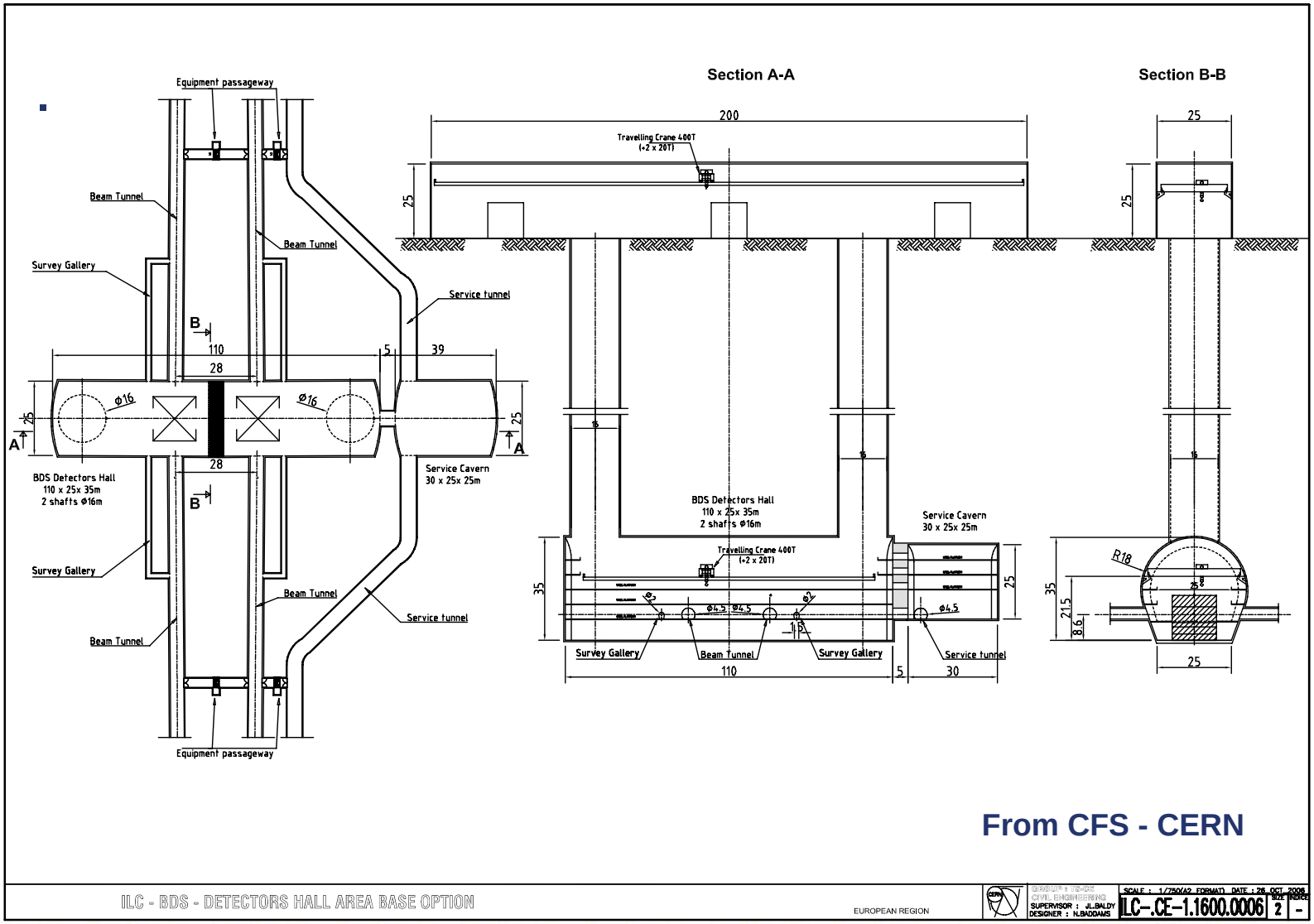


Examples of Civil Engineering Layout (2)

From CFS - Fermilab

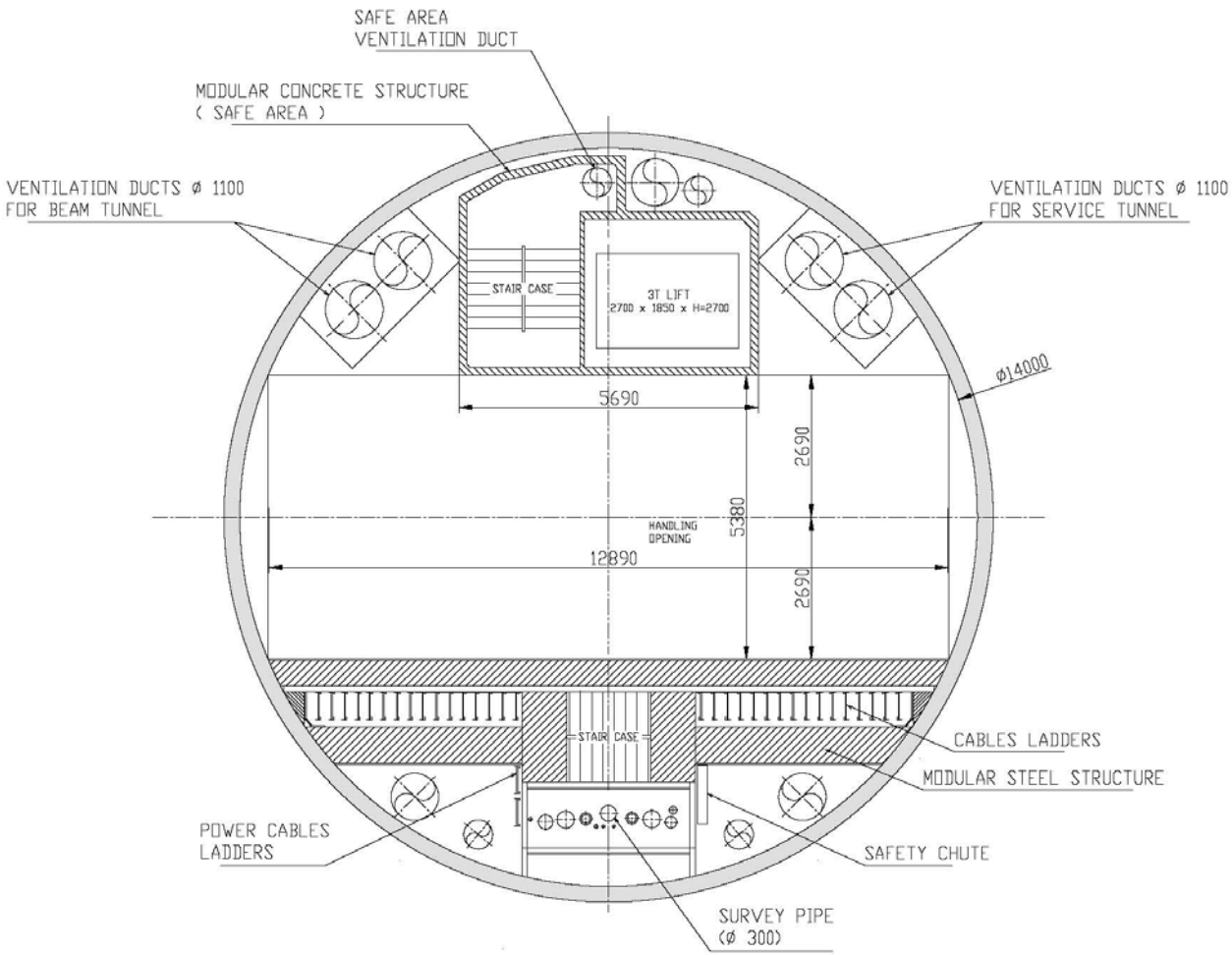


Examples of Civil Engineering Layouts (3)



Examples of Civil Engineering Layouts (4)

From CFS - CERN



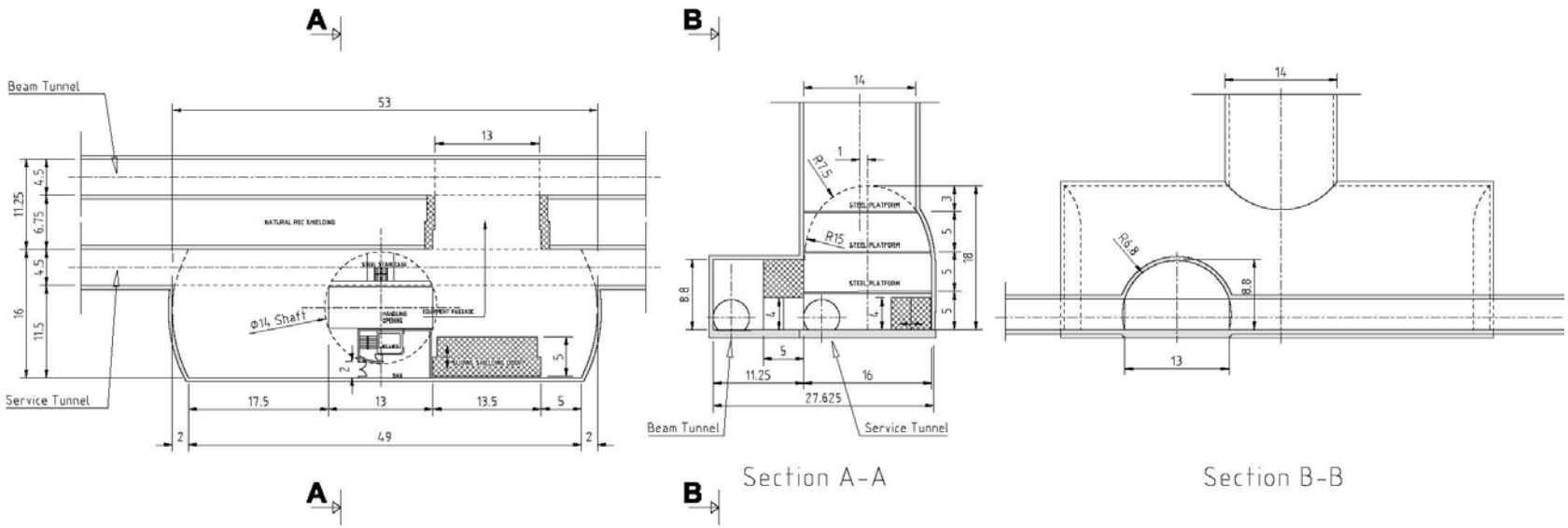
ML SHAFTS 2, 3, 4, 5
AND RTML SHAFTS 10, 11

Examples of Civil Engineering Layouts (5)

From CFS - CERN

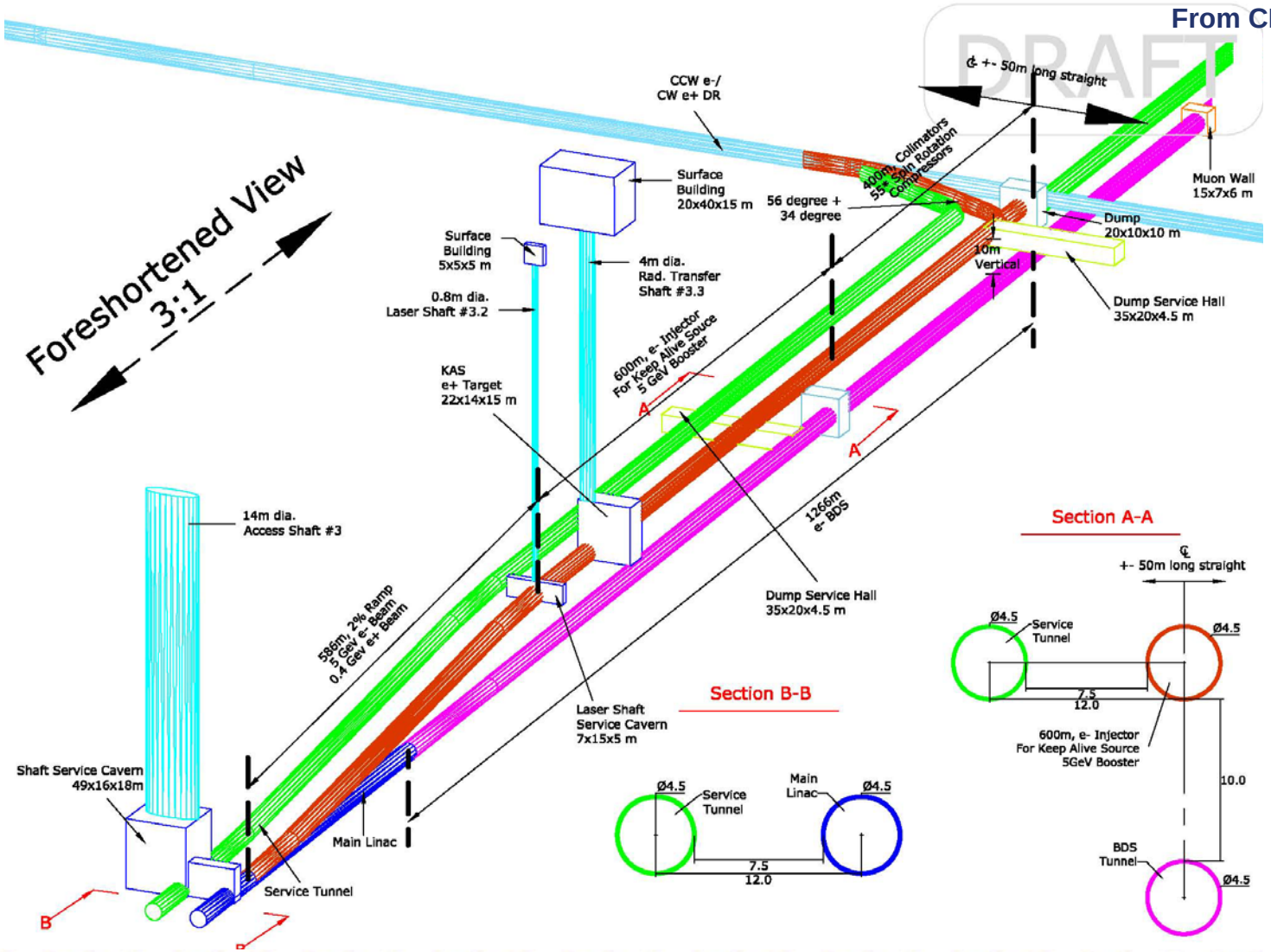
SHAFTS 2, 4 + 3, 5 + 10, 11

(for TBM Installation, access and services)



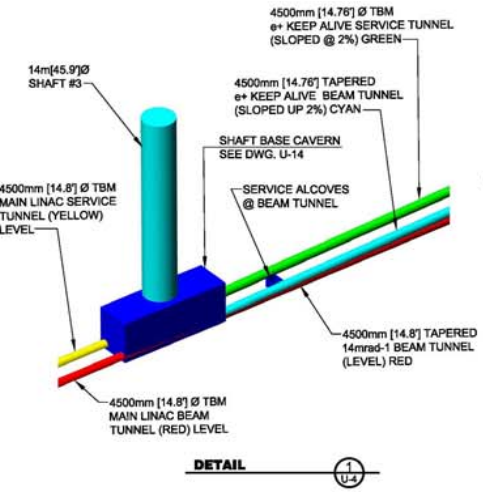
Examples of Civil Engineering Layouts (6)

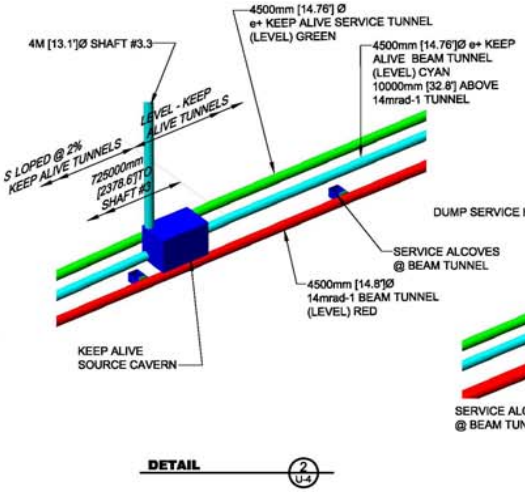
From CFS - SLAC

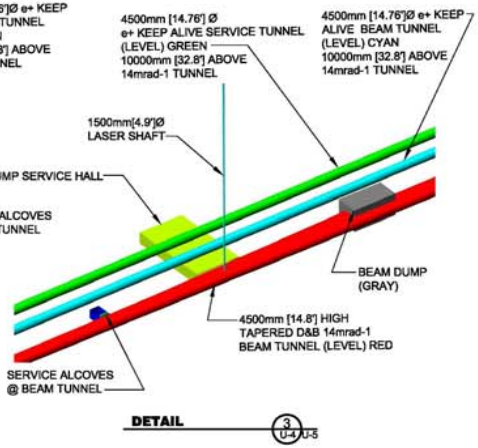


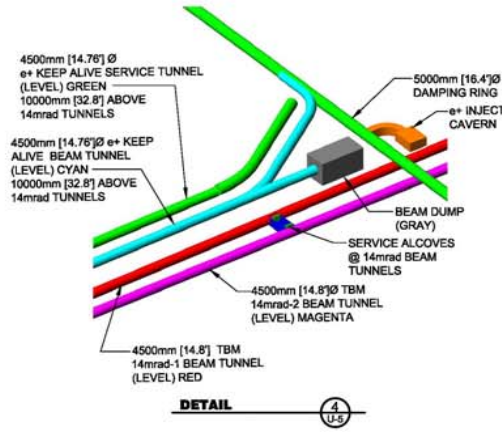
Examples of Civil Engineering Layouts (7)

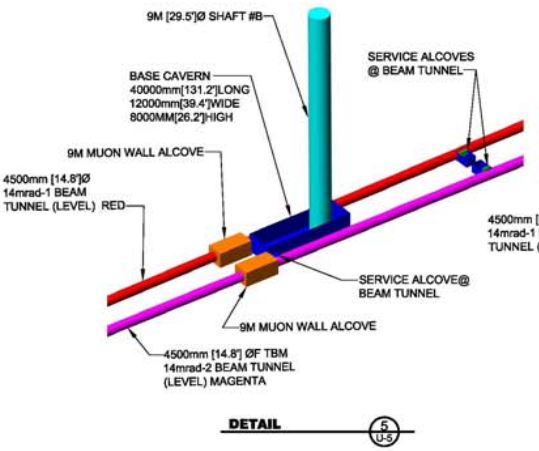
From CFS - SLAC

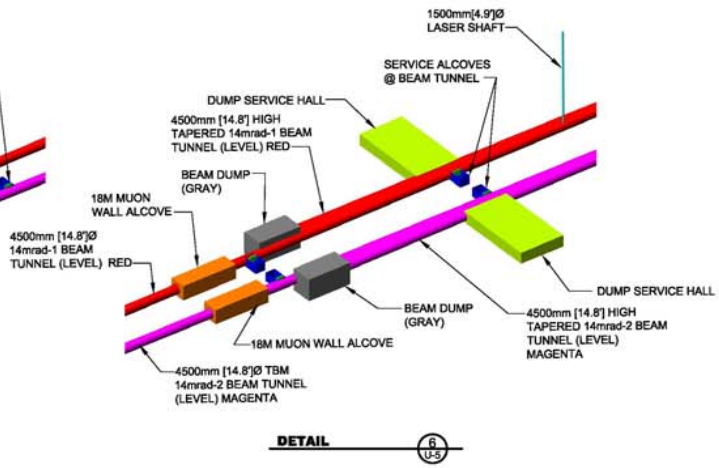


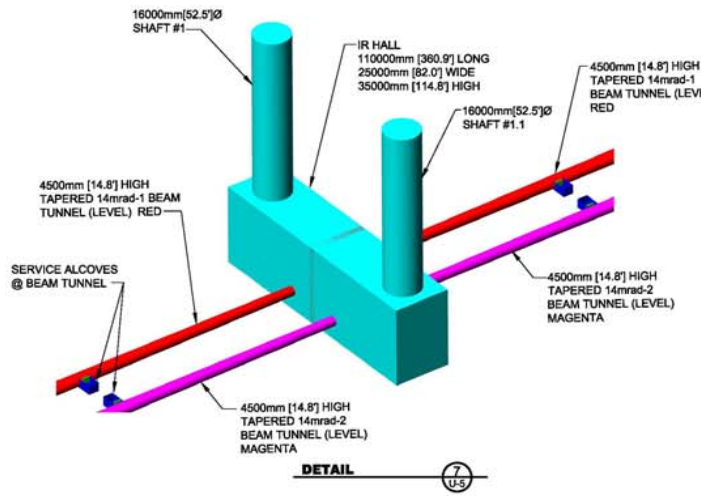










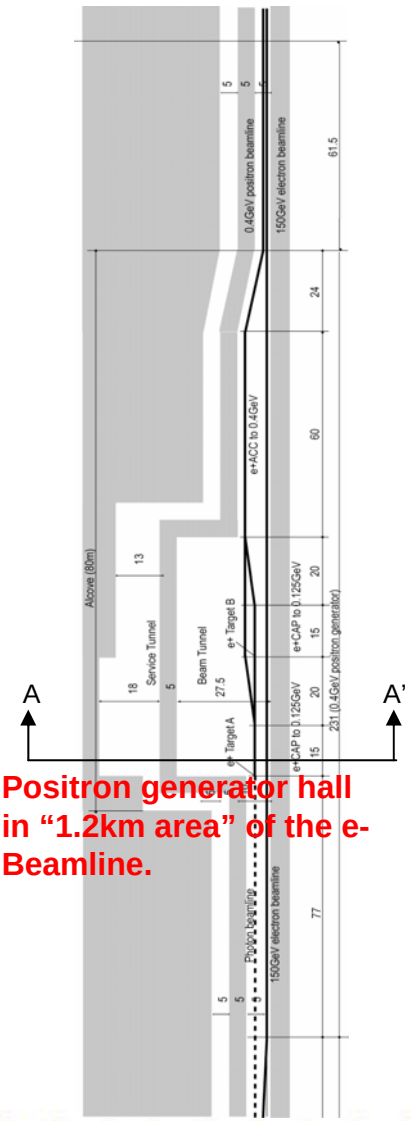


Example of Civil Engineering Study (8)

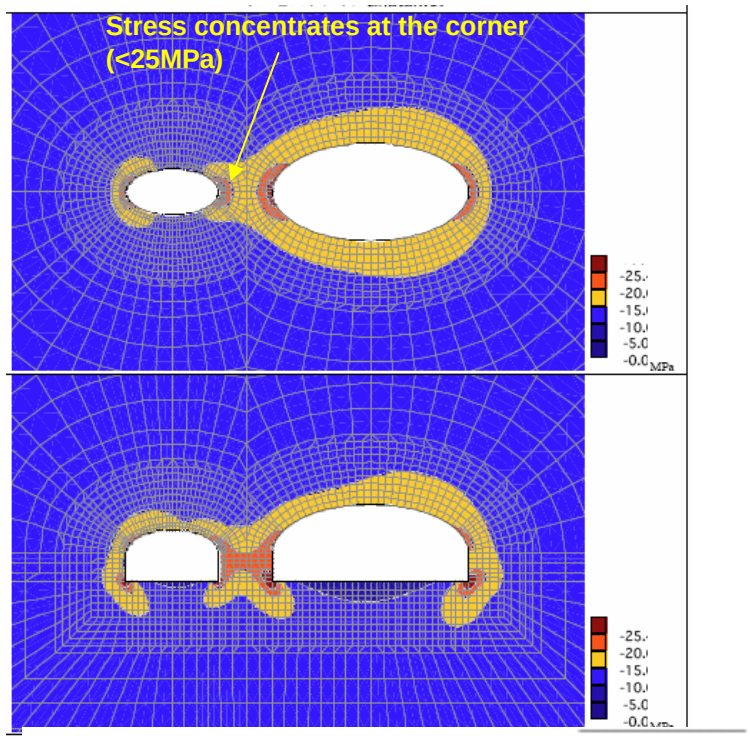
From CFS - KEK

Design of the underground cavern

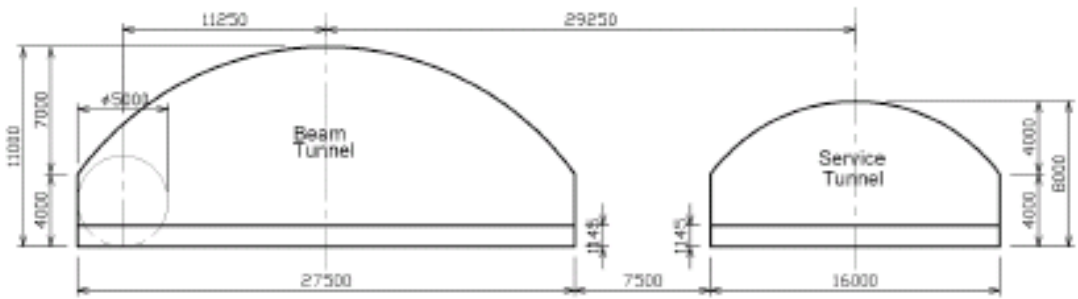
Positron Generator Hall



Positron generator hall in "1.2km area" of the e- Beamline.



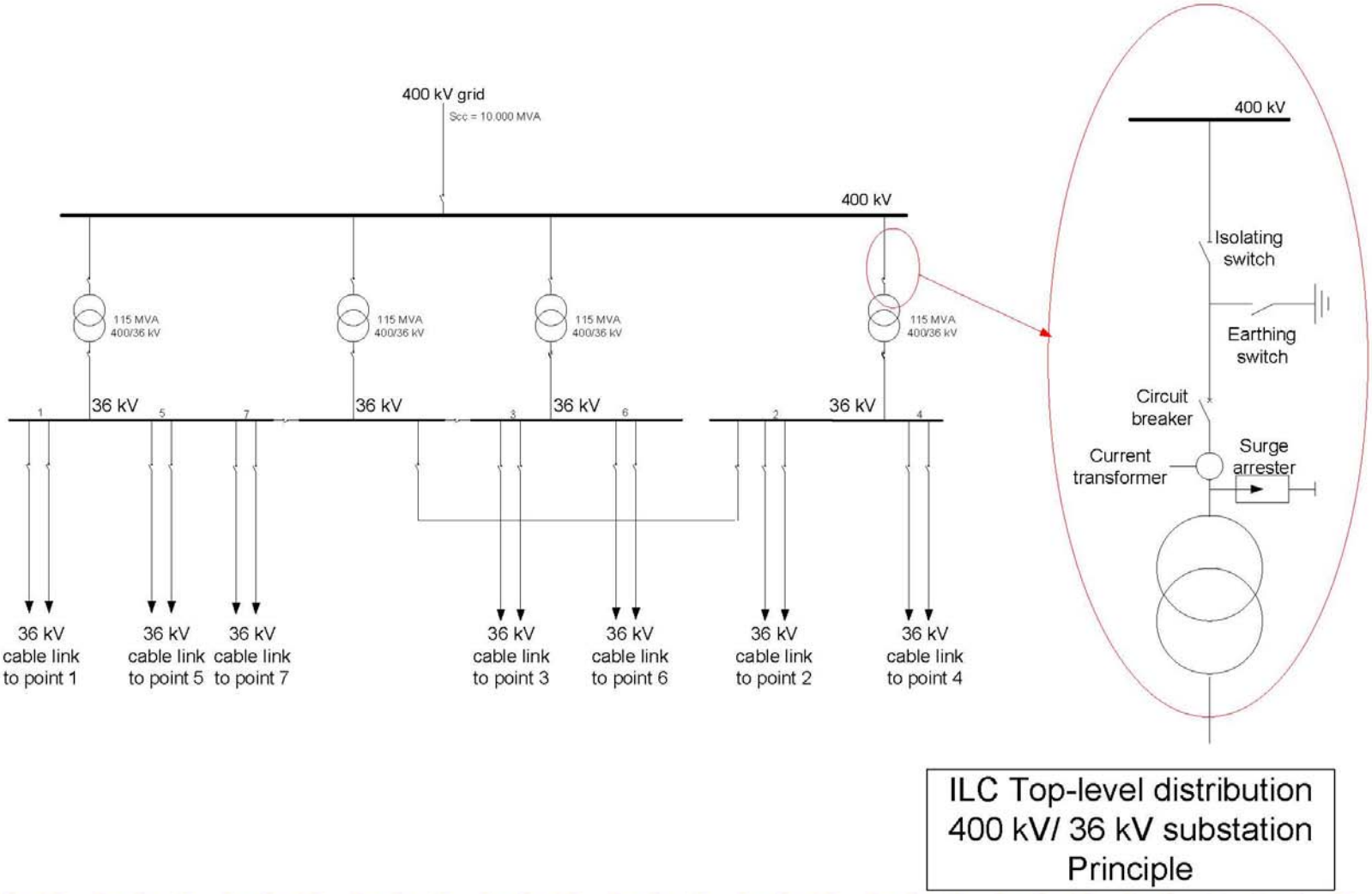
- Design depends on the geology
- Compressive strength of the Asian site is ~100Mpa
- Isotropic stress.
- Need no concrete lining.



SEC. A – A'

Examples of Electrical Layouts (1)

From CFS - CERN

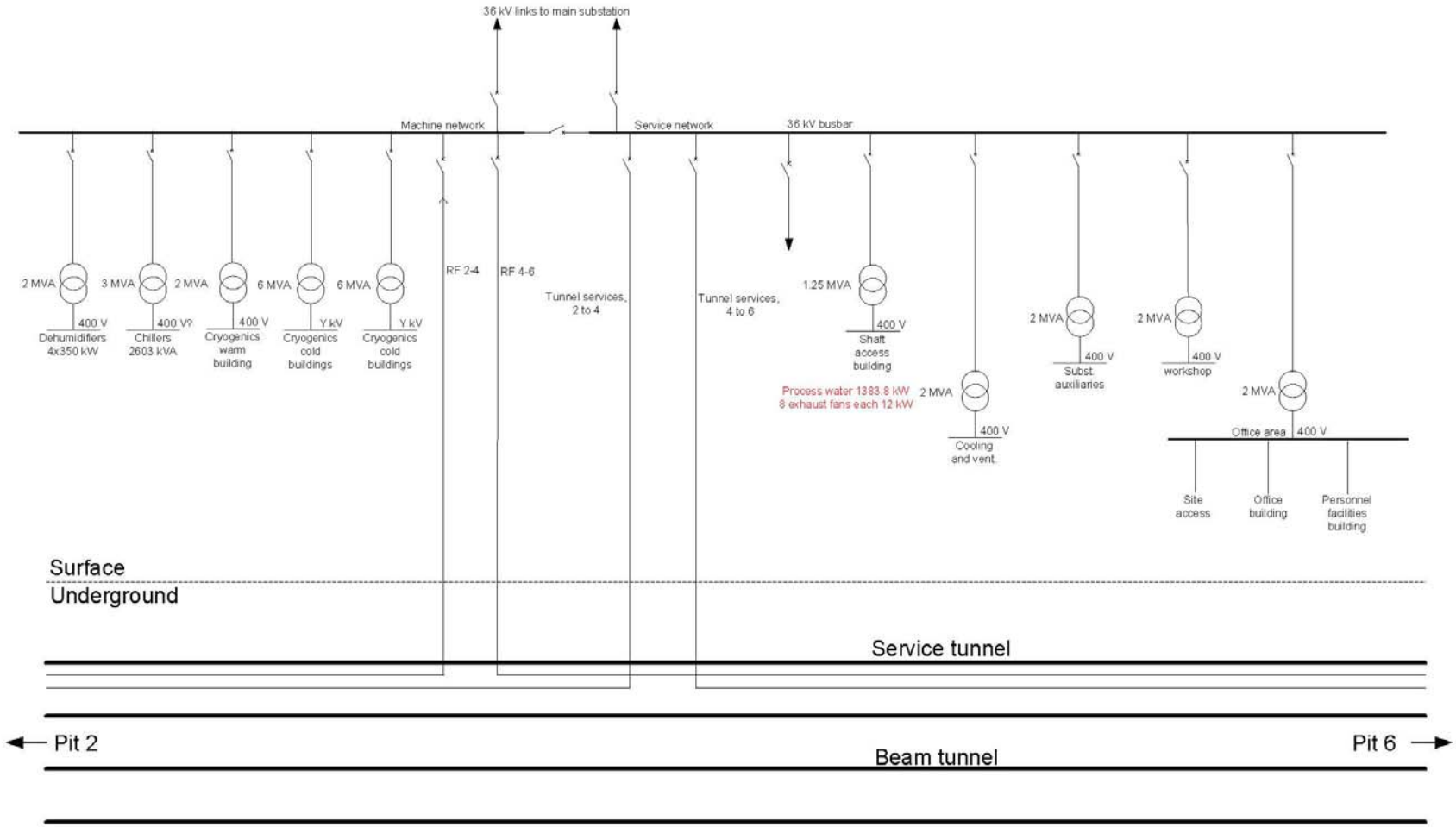


ILC Top-level distribution
400 kV/ 36 kV substation
Principle

Examples of Electrical Layouts (2)

From CFS - CERN

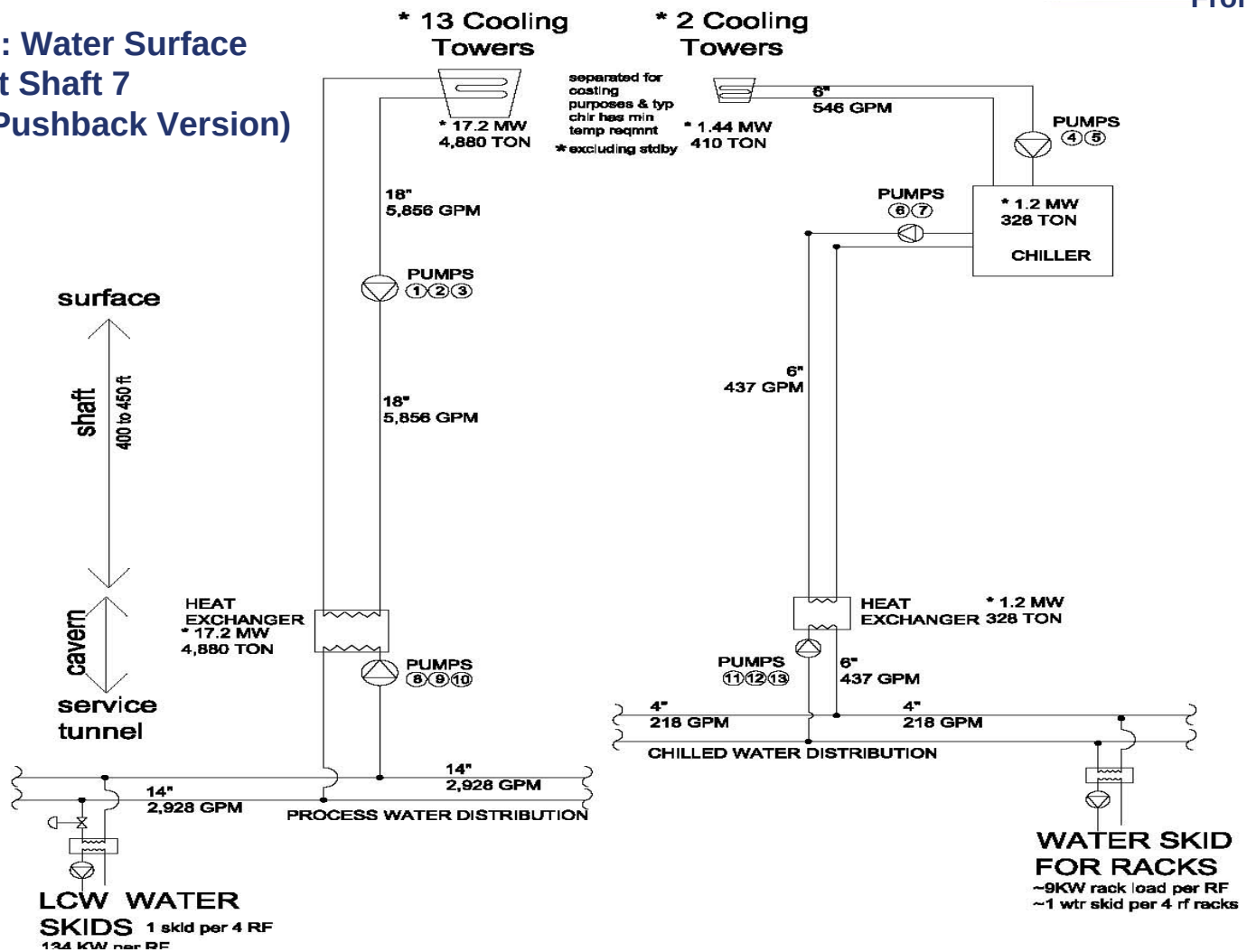
36 kV Substation, pit 4



Examples of Mechanical Layouts (1)

From CFS - Fermilab

BASIS : Water Surface Plant at Shaft 7 (Load Pushback Version)



Specificities for each Sample Site – AMERICAS

Situation :

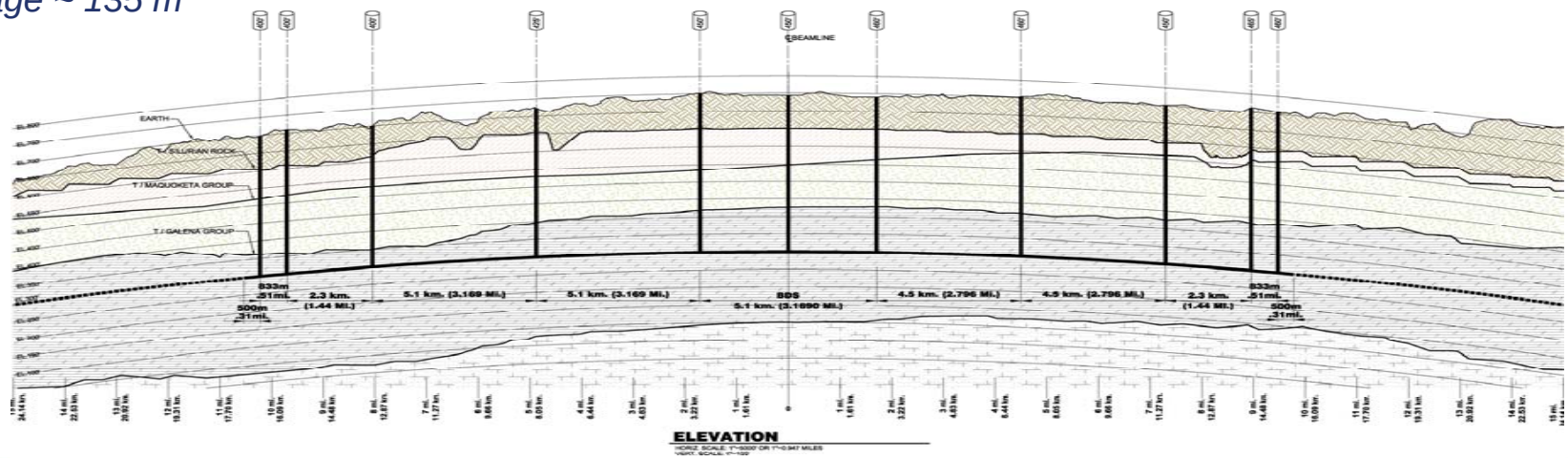
In solid rock, close to existing institute, close to the city of Chicago and international airport, close to railway and highway networks.

Geology :

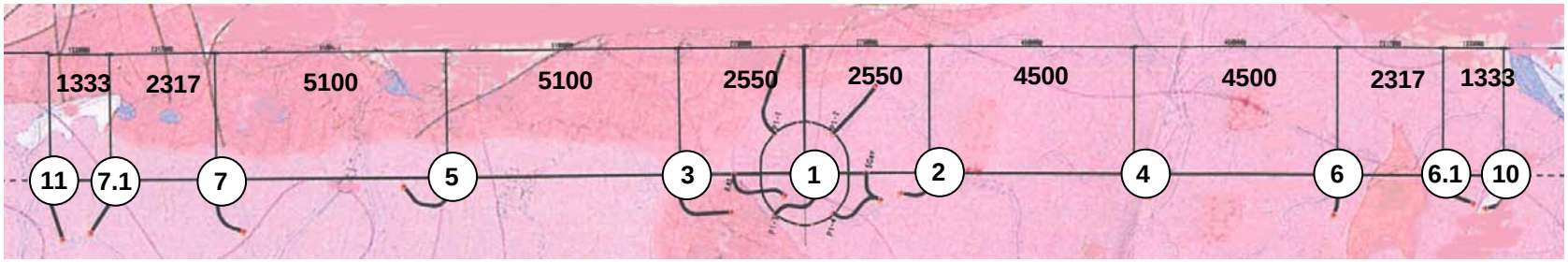
Glacially derived deposits overlaying Bedrock. The concerned rock layers are from top to bottom the Silurian dolomite, Maquoketa dolomitic shale, and the Galena-Platteville dolomites.

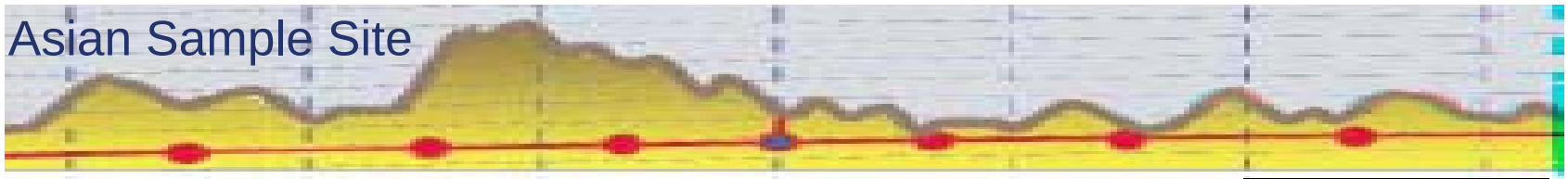
Depth of main tunnels:

Average ~ 135 m



Specificities for each Sample Site - ASIA





- Following requirements were imposed for the sample site:
- Firm and uniform geology.
- Large enough area spanning over 50km.
- Absence of active dislocations, wide faults in the neighbourhood.
- Absence of epicenters of earthquakes exceeding M6 within 50km from anywhere in the site since AD1500.
- Terrain uniformity to maintain the ILC Tunnel depths less than 600m anywhere. Granite (compressive strength~100MPa).
- Excavation: TBM (~300m/month)
- Finish: Sprayed concrete (+ Rock-bolts)
- Access by sloped tunnel instead of vertical shafts

Point	Elevation (m)	Access Tunnel Diatance (m)
11	178	1323
7	330	1455
5	344	1636
3	493	1842
1	228	(148)*
2	188	992
4	173	671
6	161	887
10	160	960
12	312	1178
13	192	1235
14	247	1382
15	361	1945
Beamline	80	

* Access shaft

Specificities for each Sample Site – CERN

Situation :

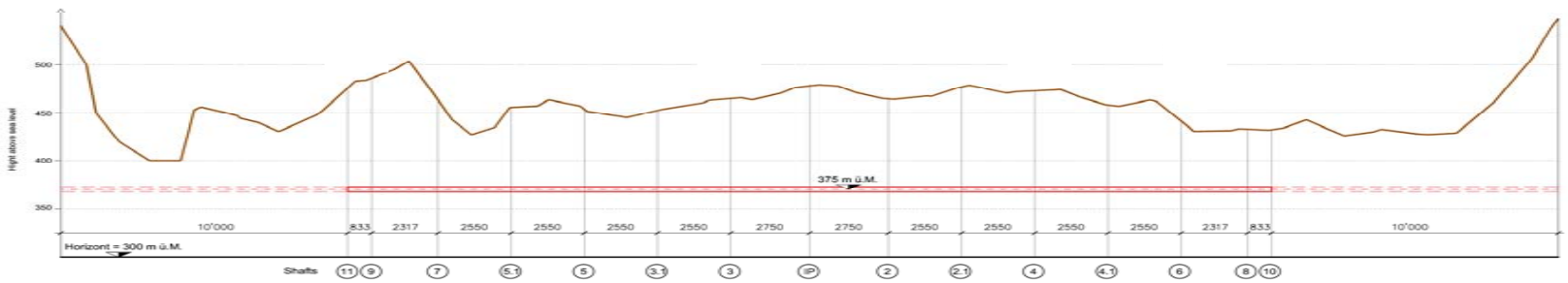
Proximity of CERN existing site with its 400 kV grid connection. Close to the city of Geneva with its international airport, railway and highway network connections.

Geology :

Solid and stable bedrock called “molasse” (sandstone), which stretches between the Jura mountains and the Lake of Geneva. A layer of moraines ranges from 0 to 50 m on top of the sandstone. Low seismic activity and no active faults.

Depth of main tunnels :

average ~ 100 m



Specificities for each Sample Site – DESY

Situation :

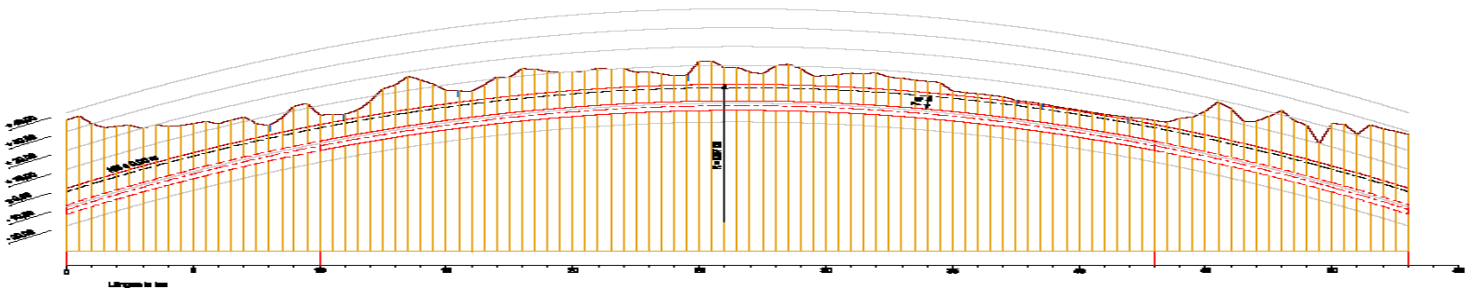
Close to DESY existing site and the city of Hamburg with its international airport and seaport. The ILC layout will follow closely the TESLA layout on the first 32.8 km and could then be extended to 50 km in the same direction. Close to railway and highway network connections.

Geology :

Quaternary sand and smaller part in marl. Tunnel situated below the ground water table over nearly the entire length.

Depth of main tunnels :

Shallow position, average ~ 18 m



Basis of Costing Exercise (1)

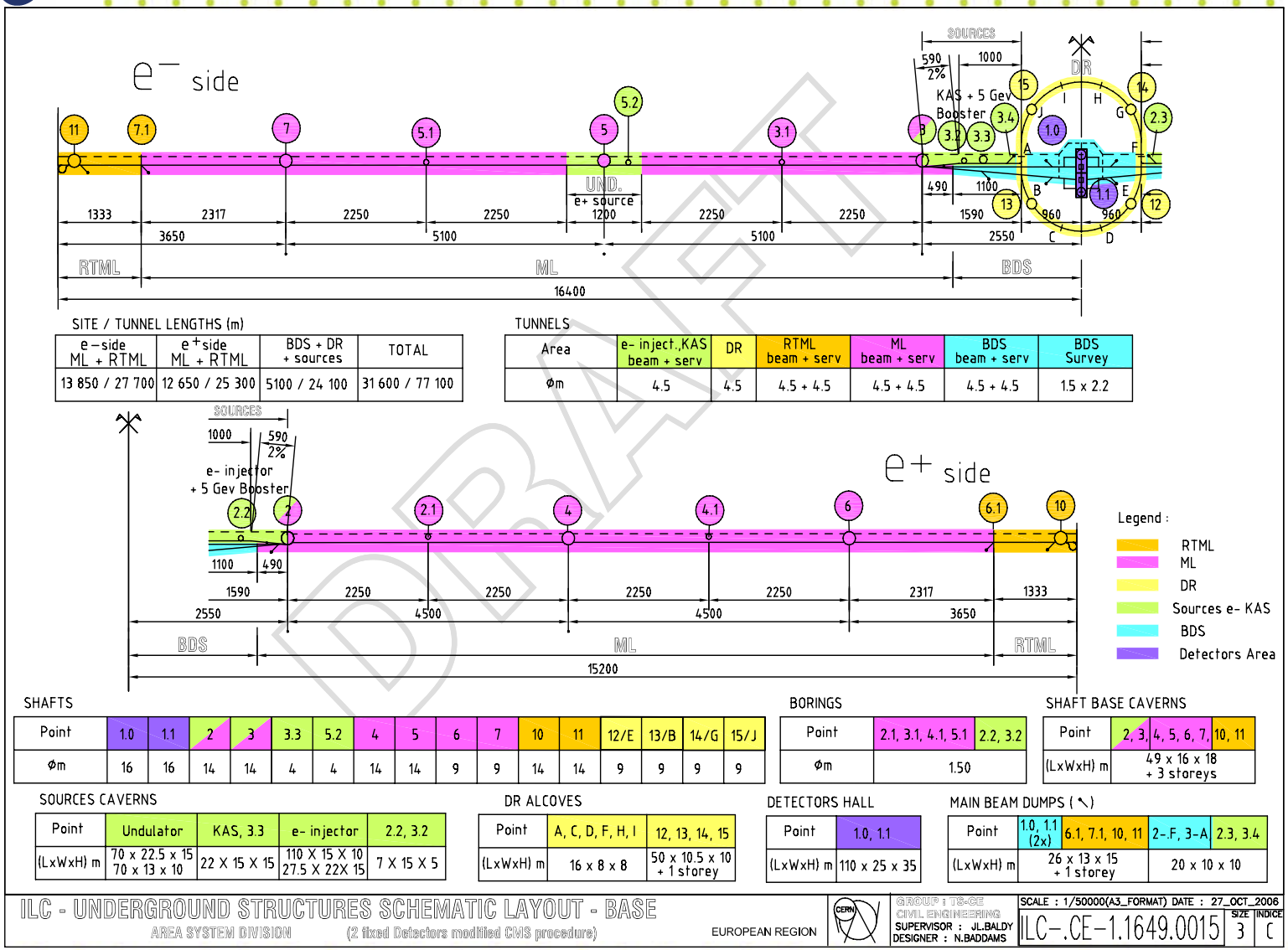
Regional Source for CFS Cost Estimate

				Americas Region	European Region	European Region	Asian Region
					CERN	DESY	
1.7.1	Civil Engineering						
	1.7.1.1	Engineering		Regionally Developed	Regionally Developed	Regionally Developed	Regionally Developed
	1.7.1.2	Underground Facilities		Regionally Developed	Regionally Developed	Regionally Developed	Regionally Developed
			Tunnels				
			Shafts				
			Caverns				
			Alcoves				
			Penetrations				
			X-Overs				
	1.7.1.3	Surface Structures		Regionally Developed	Regionally Developed	Regionally Developed	Regionally Developed
	1.7.1.4	Site Development		Regionally Developed	Regionally Developed	Regionally Developed	Regionally Developed
1.7.2	Electrical						
		Site Dependent		Regionally Developed	Regionally Developed	Regionally Developed	Regionally Developed
		Site Independent		Use Cern Estimate	Use Cern Estimate	Use Cern Estimate	Use Cern Estimate
1.7.3	Air Treatment Equipment			Use America's Estimate	Use America's Estimate	Use America's Estimate	Use America's Estimate
1.7.4	Piped Utilities			Use America's Estimate	Use America's Estimate	Use America's Estimate	Use America's Estimate
1.7.5	Process (Cooling) Water			Use America's Estimate	Use America's Estimate	Use America's Estimate	Use America's Estimate
1.7.6	Handling Equipment			Use Cern Estimate	Use Cern Estimate	Use Cern Estimate	Use Cern Estimate
1.7.7	Safety Equipment			Use Asian Estimate	Use Asian Estimate	Use Asian Estimate	Use Asian Estimate
1.7.8	Survey and Alignment			Use Cern Estimate	Use Cern Estimate	Use Cern Estimate	Use Cern Estimate

Basis of Costing Exercise (2)

- Layouts as per Valencia workshop.
- Unit costs from previous projects applied to calculated quantities.
- Parametric approach.
- Several review sessions with regional Civil Engineering Consultants
- Cross checks with existing Projects: X-FEL, TESLA, LEP and LHC, …
- Distribution of costs between Area Systems as shown on coloured schematic layouts

ILC Underground Schematic Layout 2 IR



SITE / TUNNEL LENGTHS (m)

e−side ML + RTML	e+side ML + RTML	BDS + DR + sources	TOTAL
13 850 / 27 700	12 650 / 25 300	5100 / 24 100	31 600 / 77 100

TUNNELS

Area	e- inject.,KAS beam + serv	DR	RTML beam + serv	ML beam + serv	BDS beam + serv	BDS Survey
Øm	4.5	4.5	4.5 + 4.5	4.5 + 4.5	4.5 + 4.5	1.5 x 2.2

SHAFTS

Point	1.0	1.1	2	3	3.3	5.2	4	5	6	7	10	11	12/E	13/B	14/G	15/J
Øm	16	16	14	14	4	4	14	14	9	9	14	14	9	9	9	9

BORINGS

Point	2.1, 3.1, 4.1, 5.1	2.2, 3.2
Øm	1.50	

SHAFT BASE CAVERNS

Point	2, 3,	4, 5, 6, 7,	10, 11
(LxWxH) m	49 x 16 x 18 + 3 storeys		

SOURCES CAVERNS

Point	Undulator	KAS, 3.3	e- injector	2.2, 3.2
(LxWxH) m	70 x 22.5 x 15 70 x 13 x 10	22 X 15 X 15	110 X 15 X 10 27.5 X 22X 15	7 X 15 X 5

DR ALCOVES

Point	A, C, D, F, H, I	12, 13, 14, 15
(LxWxH) m	16 x 8 x 8	50 x 10.5 x 10 + 1 storey

DETECTORS HALL

Point	1.0, 1.1
(LxWxH) m	110 x 25 x 35

MAIN BEAM DUMPS (↖)

Point	1.0, 1.1 (2x)	6.1, 7.1, 10, 11	2-.F, 3-A	2.3, 3.4
(LxWxH) m	26 x 13 x 15 + 1 storey		20 x 10 x 10	

ILC - UNDERGROUND STRUCTURES SCHEMATIC LAYOUT - BASE
AREA SYSTEM DIVISION (2 fixed Detectors modified CMS procedure) EUROPEAN REGION

GROUP : TS-CE
CIVIL ENGINEERING
SUPERVISOR : JL.BALDY
DESIGNER : N.BADDAMS

SCALE : 1/50000(A3_FORMAT) DATE : 27_OCT_2006
ILC-.CE-1.1649.0015 SIZE 3 INDICE C

Basis of Costing Exercise (3)

- Assumptions :
  - **No costs before t_0 are taken into account**
  - **Tunnel lining:**
    - Concrete lining over 100% of the length for the European Sites,
    - Concrete lining over 20 % of the length for the Americas Site,
    - 0% for the Asian Site (Shotcrete 100 %)
  - **"CMS Modified" Alternative for the Detectors Area**
  - **Respecting the presented Time Schedules (4.5 Y for CE, one year extension as an option)**
  - **Sites close to existing HEP Laboratories + facilities**
  - **No Contingencies added**
  - **Value of prices: 2006**

Basis of Costing Exercise (4)

- **Included in cost estimates:**
  - Consultants, Architects, Experts fees
  - All Civil Engineering works from earthworks to “last layer of paint”
  - Spoil transport/disposal and related landscaping
  - Connection to all existing infrastructure
  - All internal Metallic Structures, according to site conditions
  - All installations necessary for Power Distribution, Air Treatment, Piped Utilities, Process Cooling Water
  - Handling and Safety Equipment
  - Survey and Alignment, including Equipment

Basis of Costing Exercise (4)

- **Not included in cost estimates：**
  - **All R&D (before t_0)**
  - **Geotechnical investigations (before t_0)**
  - **Purchase of Land (Surface, and underground if needed)**
  - **Cost of Local Formalities like Environmental Impact Study, Building Permits, Authorizations from Local and National Authorities**
  - **Furniture, telephones and PCs**
  - **DC Cabling, signal and control cabling not related to power distribution**
  - **Horizontal Handling and transport/installation of equipment**

From Vancouver to Valencia (1)

Main Retained Cost Saving Design Options

- Reduction of all Tunnels diameters to 4.5 m (except DR Tunnel from 4.0 m to 4.5 m)
- One big Detectors Hall, not two
- Two mobile Detectors “Push-Pull” as an alternative
- One Damping Ring Tunnel only, central location
- Suppression of Shaft + Cavern 8+9
- Suppression of 1.2 km Beam + Service Tunnels at Shaft 4
- Reduction in size of Base Shafts Caverns (except DR and Detectors)
- Reduction in number and size of Surface Buildings

From Vancouver to Valencia (2)

European CERN Site

Total Number of Shafts

Vancouver	21	288’170 m^3
Valencia	14 + 2 ∅4	181’429 m^3
Savings		37%

Total Number of Caverns and Alcoves

Vancouver	42	587’984 m^3
Valencia	35	466’429 m^3
Savings		21%

Length of Tunnels

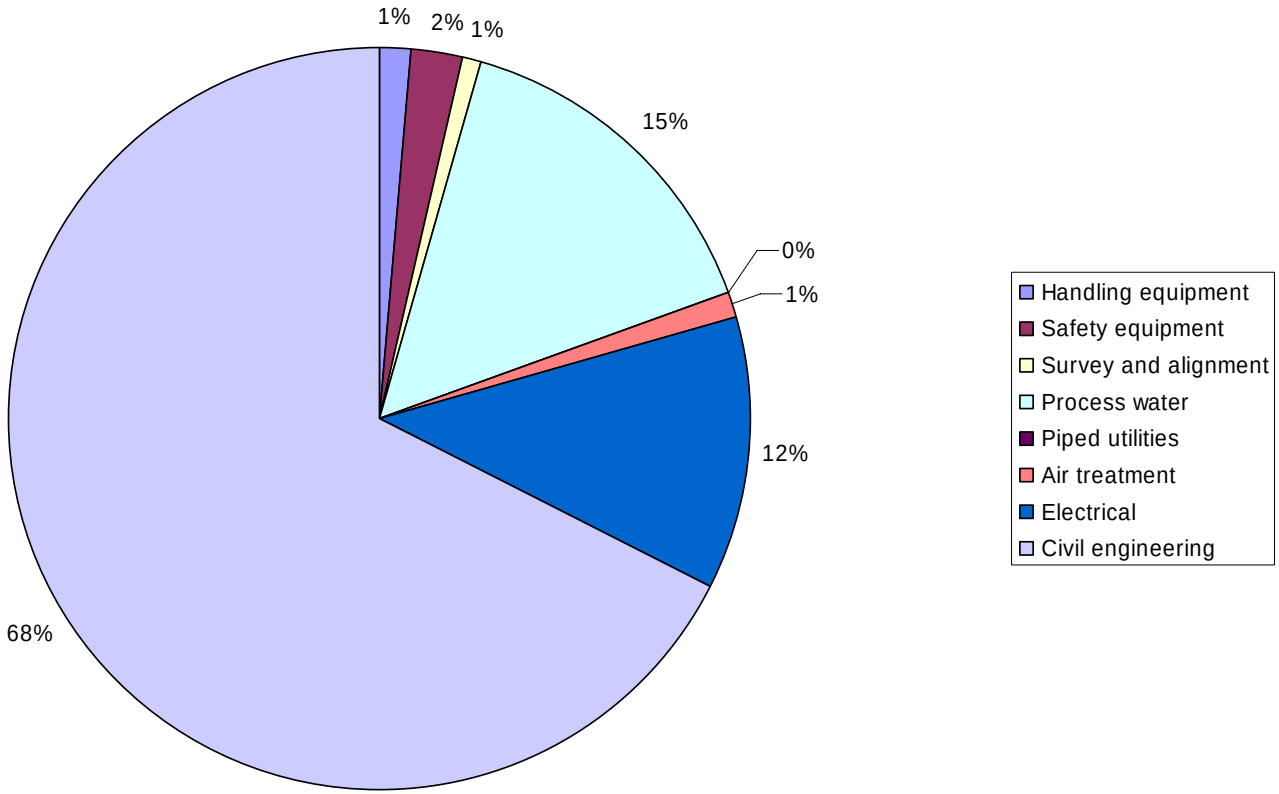
Vancouver	88.9 km	2’410’913 m^3
Valencia	73.1 km	1’643’895 m^3
Savings		32%

Total Number of Buildings

Vancouver	191	137’304 m^3
Valencia	152	92’867 m^3
Savings		32%

Summary of Costs Findings (1)

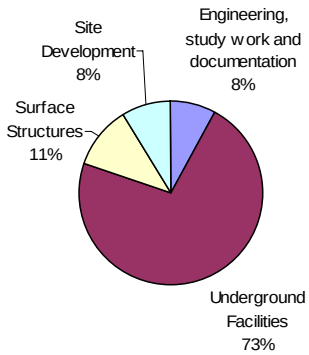
Breakdown of overall CFS costs



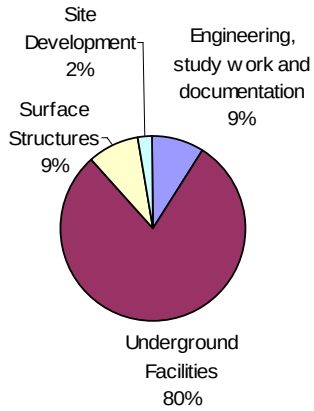
Summary of Costs Findings (2)

- Distribution of CE Costs (One IR Alternative)

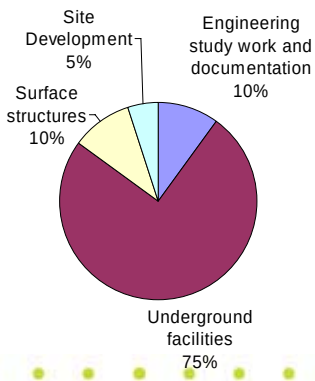
Europe CERN Site



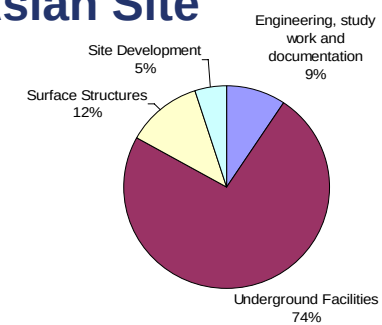
Europe DESY Site



Americas Site



Asian Site



Summary of Costs Findings (3)

- Total Savings for civil engineering (Vancouver/Valencia)

	2 IR Alt %	Add. Savings One year ext. %	1 IR PP Alt %	Add. Savings One year ext. %
Americas Site	**-25.8 %**			
Asia Site	**-19.8 %**			
Europe CERN Site	**-21.2 %**	**-1.6 %**	**-25.2 %**	**-1.1 %**
Europe DESY Site	**-16.9 %**	**-1.8 %**	**-25.8 %**	**-1.8 %**

Summary of Costs Findings (4)

Works other than CE, for which Americas is Lead Region

Mechanical Engineering :

- Air Treatment Equipment
  decreased heat load, increased air recycling, temperature rise.
  reduction: 66.8 %
- Piped Utilities
  reduction in number of buildings and shafts,
  reduction: 53.4 %
- Process Cooling Water
  reduction of number of cooling skids and overall heat load
  Reduction: 30.0 %

Works other than CE, for which Asia is Lead Region

- Safety Equipment
  Valencia estimates more precise. Further the number of smoke detectors reduced
  Reduction: 68.7 %

Summary of Costs Findings (5)

Works other than CE, for which Europe is Lead Region

Vertical Handling :

- See Table and Comments on JLB “Design” Presentation

  Decreases

  - **37.4 % (Americas, CERN)**
  - **48.0 % DESY**
  - **54.9 % ASIA**

Electrical Engineering

- See Specific Presentation from John Pedersen

  Decreases

  - **18.8 % Site independent part, all Sites**

Survey and Alignment

- See Specific Presentation on S and A

  Same as at Vancouver (+ and – compensate)

Summary of Costs Findings (6)

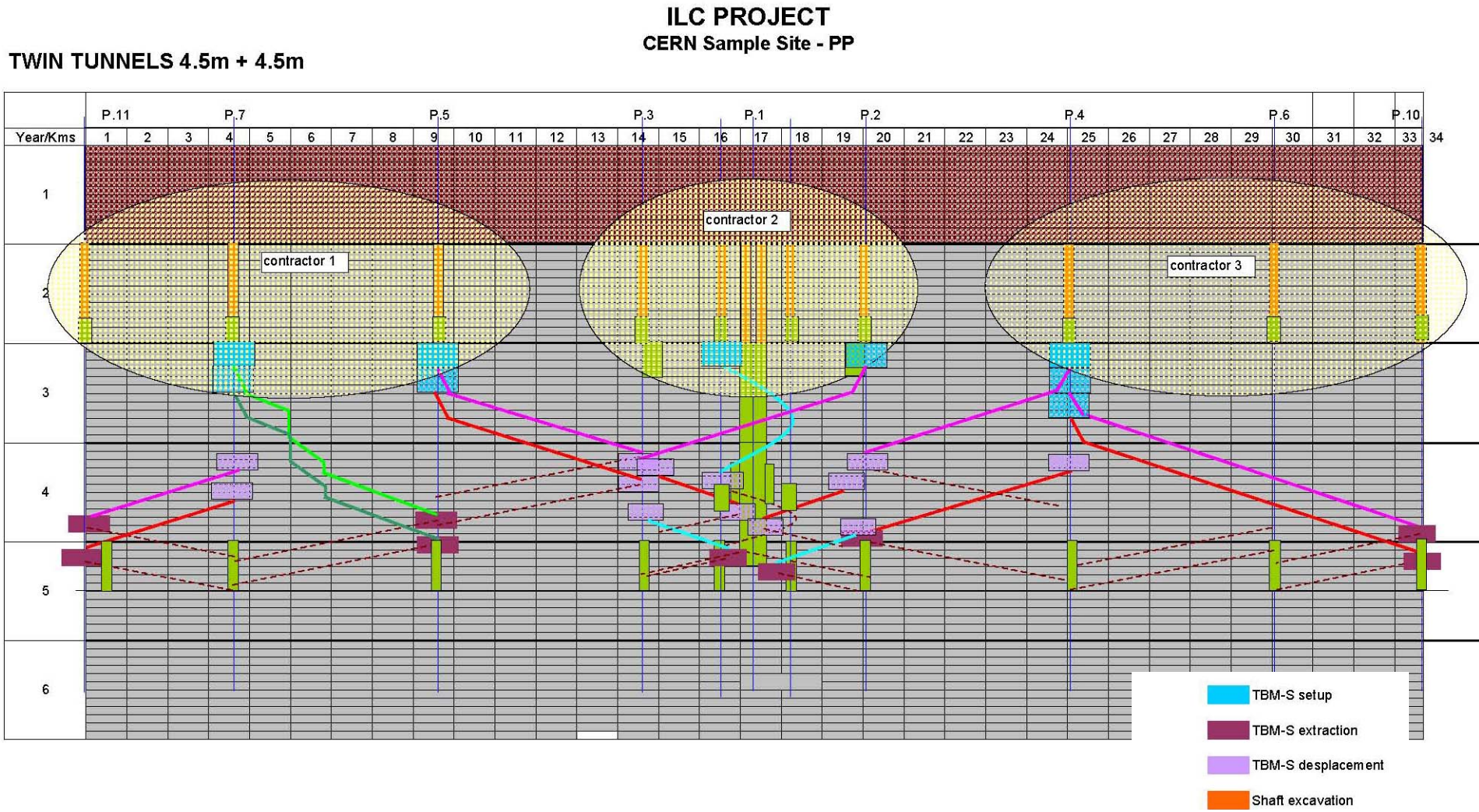
Total CFS savings with respect to Vancouver estimates, in %:

Sample site	Americas	Asia	Europe CERN	Europe DESY
Baseline: 2 IR	-26.3	-23.3	-22.9	-20.0
Alternative: 1 IR PP			-25.5	-26.1

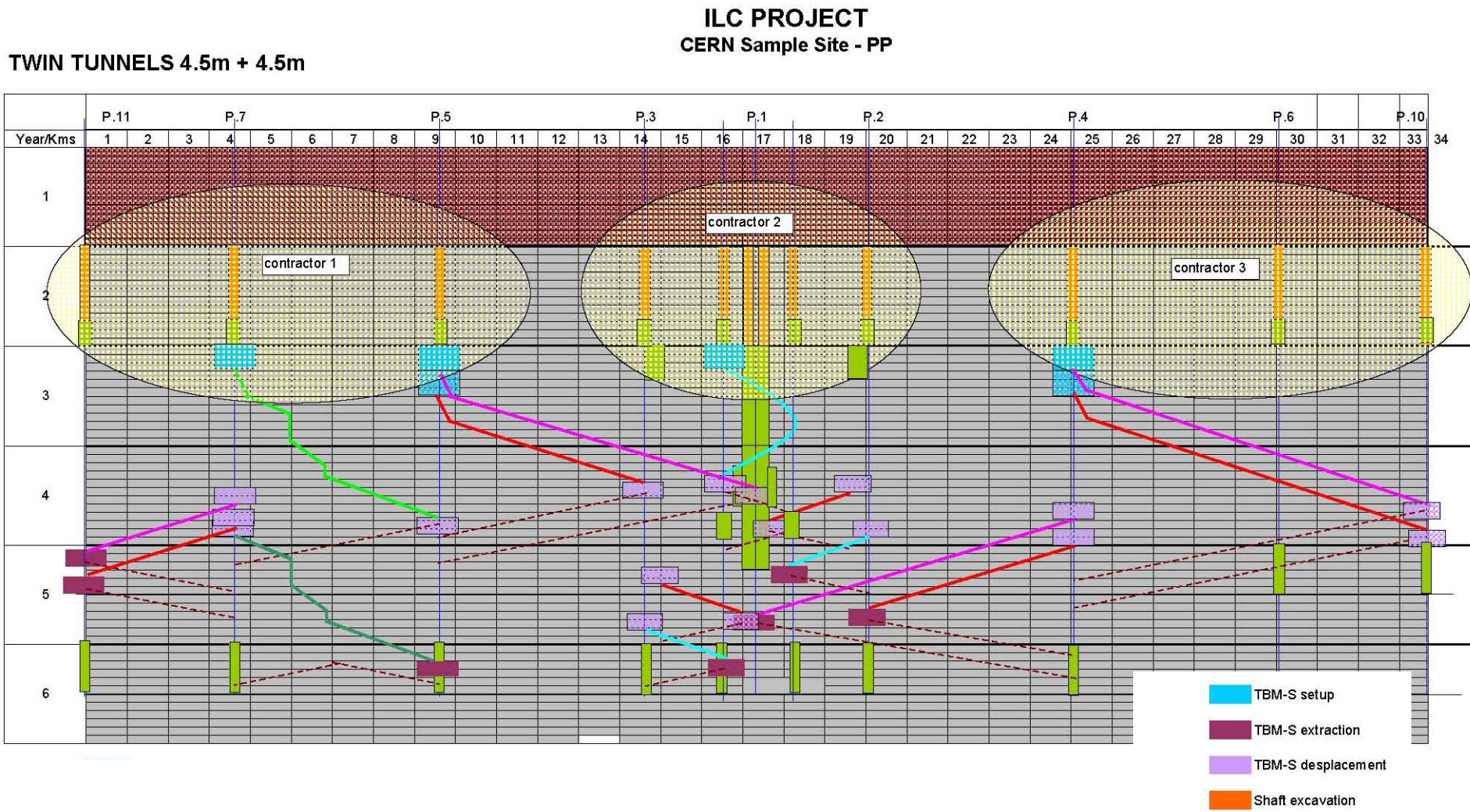
Time Schedule Issues

- Time Schedules updated to new Configuration
  - **Same schedule for Americas and Europe CERN**
  - **Specific schedule for Asia**
  - **Specific schedule for Europe DESY**
- 4.5 years for CFS Works;
  - **compatibility with 7 years overall time span still to be confirmed**
- The first year (Impact Study, Call for Tender, Selection, …) could be saved under certain Conditions
- Obtaining up to 15 TBM of the same diameter during the same period will most likely be difficult!
- For more : see presentation by Martin Gastal on Wednesday, at 17:30

Time Schedule - 4.5 years - 9 TBM



Time Schedule – 5.5 years - 6 TBM



CONCLUSIONS

- Results reached thanks to a good collaboration between CFS and other systems.
- Uniformity of approaches within CFS Group improved
- Overall Cost Savings meet Goal (and over) thanks to:
  - **Changes in project design**
  - **Increased confidence in CFS design**
- CFS believes that cost numbers given reflect well the level of detail available today.

CONCLUSIONS continued

- Remains to be carried out :
  - **Last design modifications as decided in Valencia.**
  - **Corresponding update of cost estimates**
  - **RDR writing accordingly**