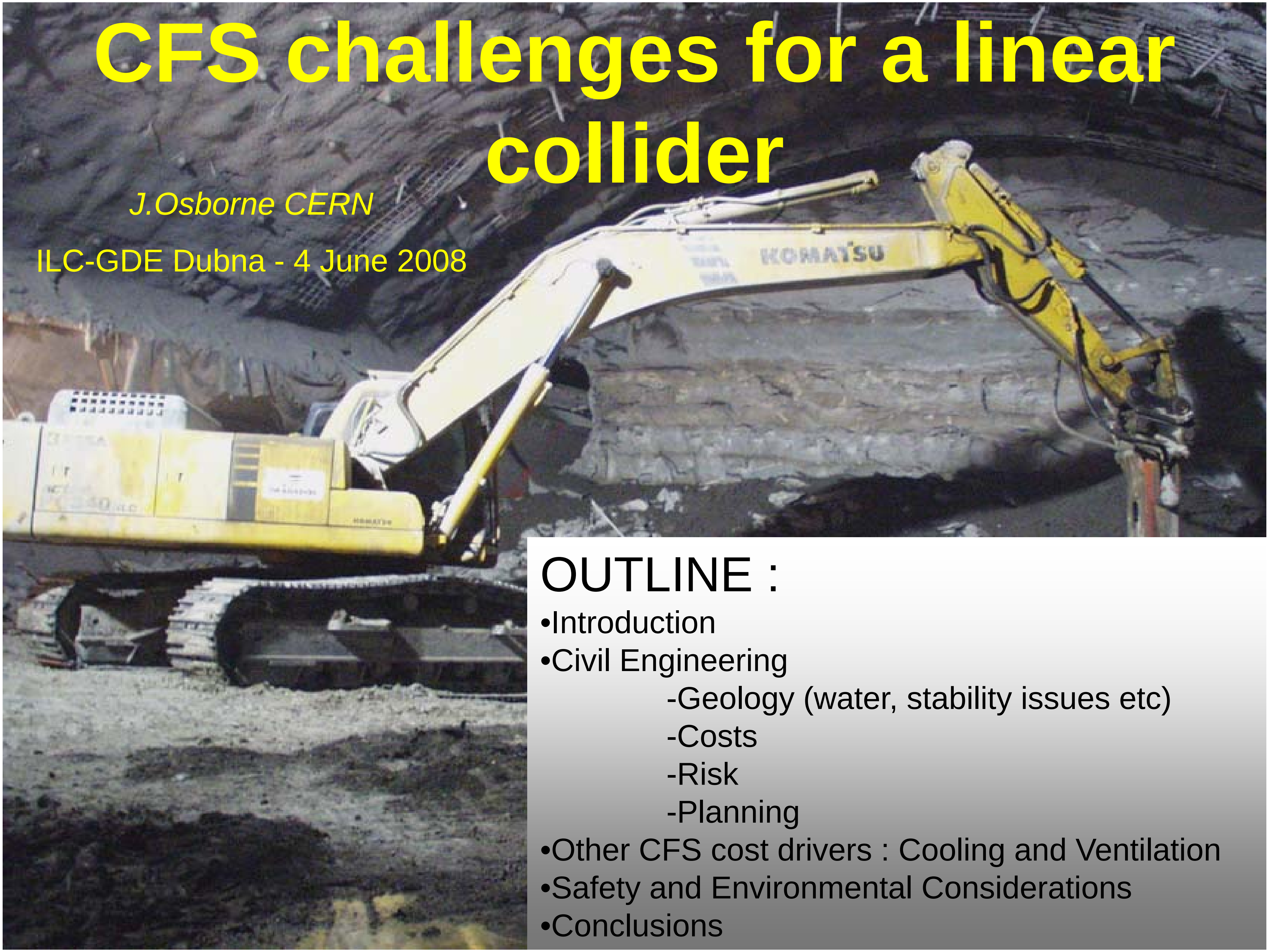
CFS challenges for a linear collider

J.Osborne CERN

ILC-GDE Dubna - 4 June 2008



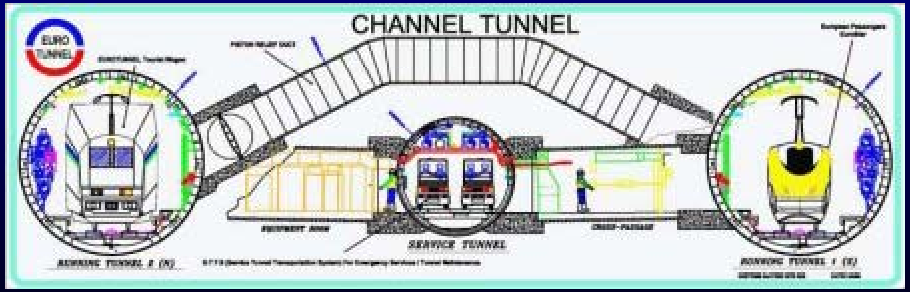
OUTLINE :

- Introduction
- Civil Engineering
  - -Geology (water, stability issues etc)
  - -Costs
  - -Risk
  - -Planning
- Other CFS cost drivers : Cooling and Ventilation
- Safety and Environmental Considerations
- Conclusions

Introduction

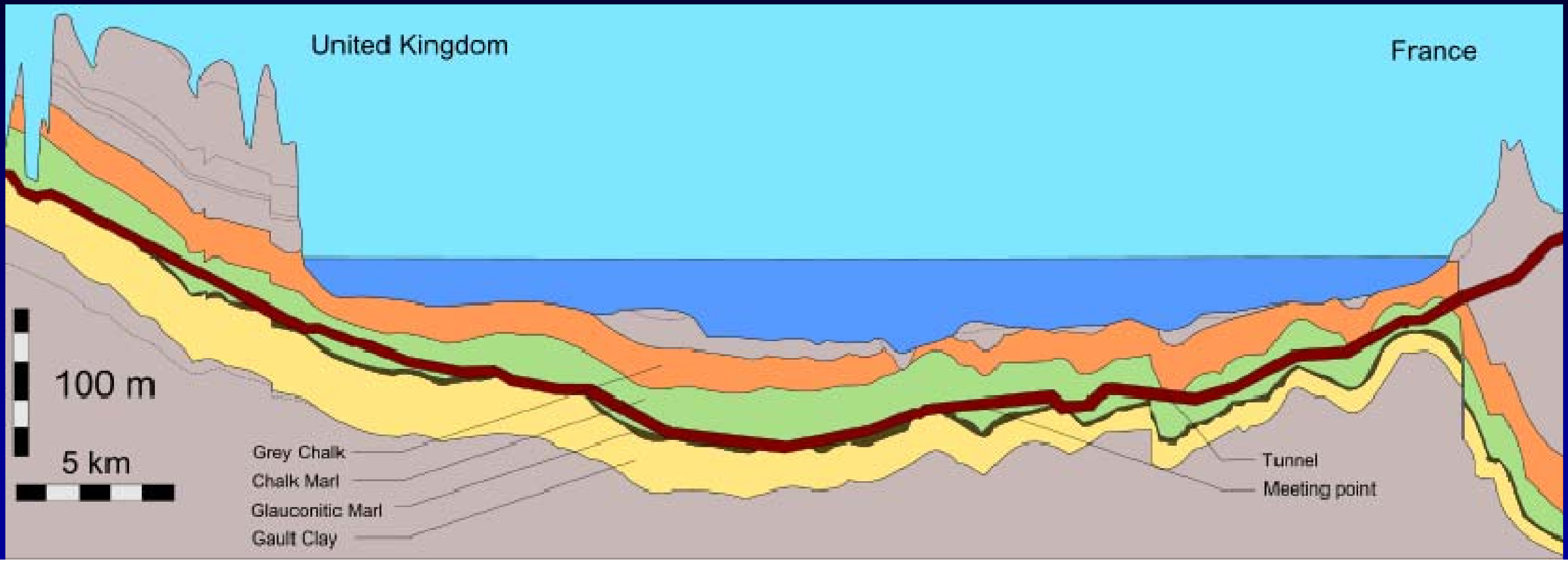
- Why are CFS being considered at such as early stage :
  - Approximately 40% of budget for linear collider
  - CFS can make or break projects
- What are the key challenges ?
  - 90% of CFS costs are for Civil Engineering, HVAC and Electricity
  - Safety, Environmental….
- CFS issues to a certain degree generic for CLIC & ILC Linear colliders
  - Further discussion on the CLIC/ILC CFS collaboration planned for this week
- Key CFS areas will be subject of Focus Groups this week

Similar World Projects: eg Channel Tunnel



7.6mØ 4.8m Ø 7.6mØ

50Km



Channel Tunnel Construction (2)

1987 - 15th December
Boring of the service tunnel starts on the UK side.

1988 - 28th February
Start of service tunnel boring on the French side.

1990 - 1st December
British and French teams achieved the first historic breakthrough under the Channel, in the service tunnel, 22.3 km from the UK and 15.6 km from France.

1991 - 22nd May
Breakthrough in the North rail tunnel.

1991 - 28th June
Breakthrough in the South rail tunnel.

1993 - 10th December
Handover from TML to Eurotunnel.

1993 - 1994
Equipment installation and testing.

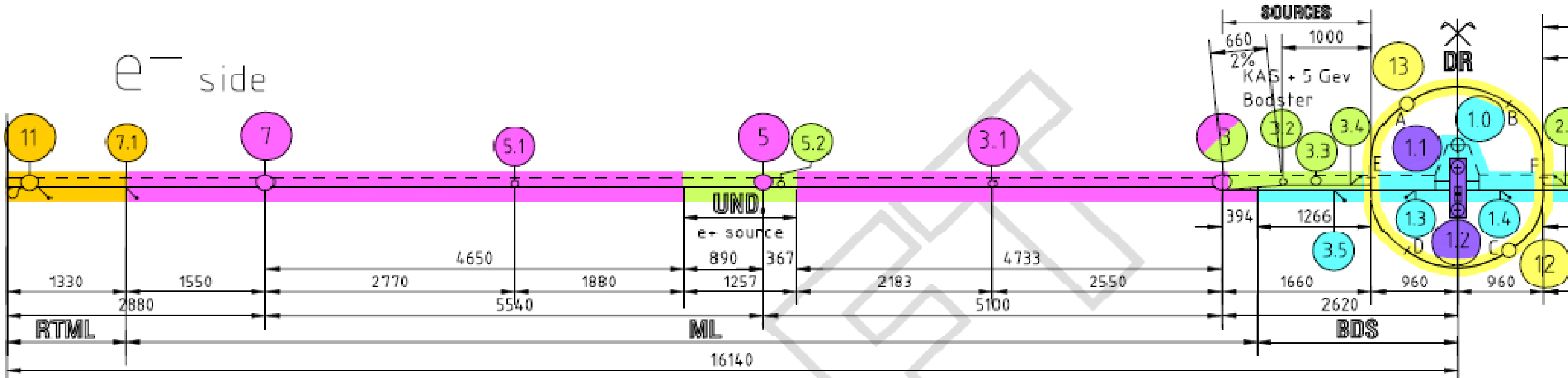
- 7 years from first excavation to operation
- At peak 15,000 workers
- 6 TBM's used for tunnelling
- Very approximate cost = $9.1billion (1985 prices)

- Difficulties :
  - Financing
  - Political
  - Water ingress
  - Safety (10 workers died), fire..
  - Cost overruns….

Feasibility studies started 200years ago with in **Napoleonic** times !!!

ILC – General Layout

Phase 1 (500GeV)

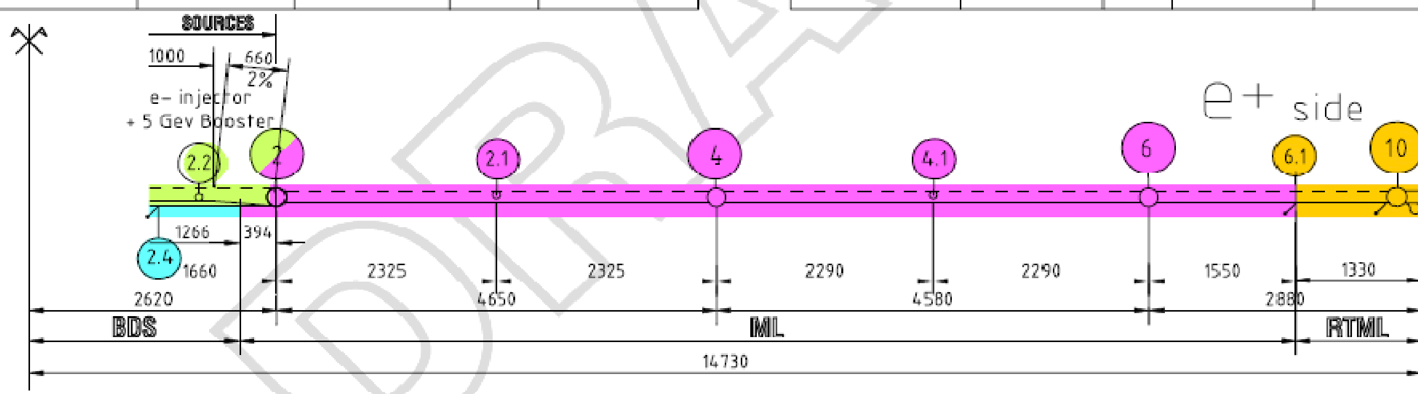


SITE / TUNNEL LENGTHS (m)

e− side + Undulator ML + RTML	e+ side ML + RTML	BDS + sources	DR	TOTAL
13 914 / 27 948	12 504 / 25 128	4452 / 12 236	0 / 6704	30 870 / 72 016

TUNNELS

Area	e− inject.,KAS beam + serv	DR	RTML beam + serv	ML beam + serv	BDS beam + serv	BDS Survey
Ø m	4.5	5.0	4.5 + 4.5	4.5 + 4.5	4.5 + 4.5	1.5 x 2.2



Legend :

- RTML
- ML
- DR
- Sources e− KAS
- BDS
- Detectors Area

SHAFTS

Point	1.0	1.1	1.2	2	3	3.3	5.2	4	5	6	7	10	11	12/C	13/A
Ø m	9	16	16	14	14	4	4	14	14	9	9	14	14	9	9

BORINGS

Point	2.1, 3.1, 4.1, 5.1	2.2, 3.2	1.3, 1.4, 2.4, 3.5
Ø m	1.50		

SHAFT BASE CAVERNS

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

MUON WALL WIDENINGS

Point	1.3, 1.4
(LxWxH) m	25 x7x6 +15x7x6

SOURCES CAVERNS

Point	Undulator 5.2	KAS 3.3	2.2, 3.2
(LxWxH) m	21 161m3	6 574m3	7 X 15 X 7.5

DR ALCOVES

Point	12/C, 13/A	B, D, E, F
(LxWxH) m	75 x 10 x 10 + 1 storey	16 x 8 x 8

DETECTORS HALL

Point	1.1, 1.2	1.0
(LxWxH) m	120 x 25 x 39	40 x 15 x 15

BEAM DUMPS CAVERNS (↖)

Point	SOURCES 2.3, 3.4	RTML 6.1, 7.1, 10, 11	BDS 1.3, 1.4, 2.4, 3.5
(LxWxH) m	5 x 4 x 4		20 x 9 x 15 + 1 storey

BEAM DUMP SERVICE HALLS (↖)

Point	BDS 1.3, 1.4, 2.4, 3.5
(LxWxH) m	30x20x 10

Main civil engineering **risks (1)**

*A full risk assessment must be carried out for both the **pre-construction phase and execution phase** of the works.*

*The **Pre-construction phase** must assess risks such as :*

- Delay during the planning permission approval process
- Objections raised from the public on environmental grounds
- Problems with the project management team
- Project financing uncertainties
- Tenders submissions not reaching minimum bidding standards
- Non appropriate sharing of risk in tender documents

Main civil engineering risks **(2)**

The execution phase of the works must assess risks such as :

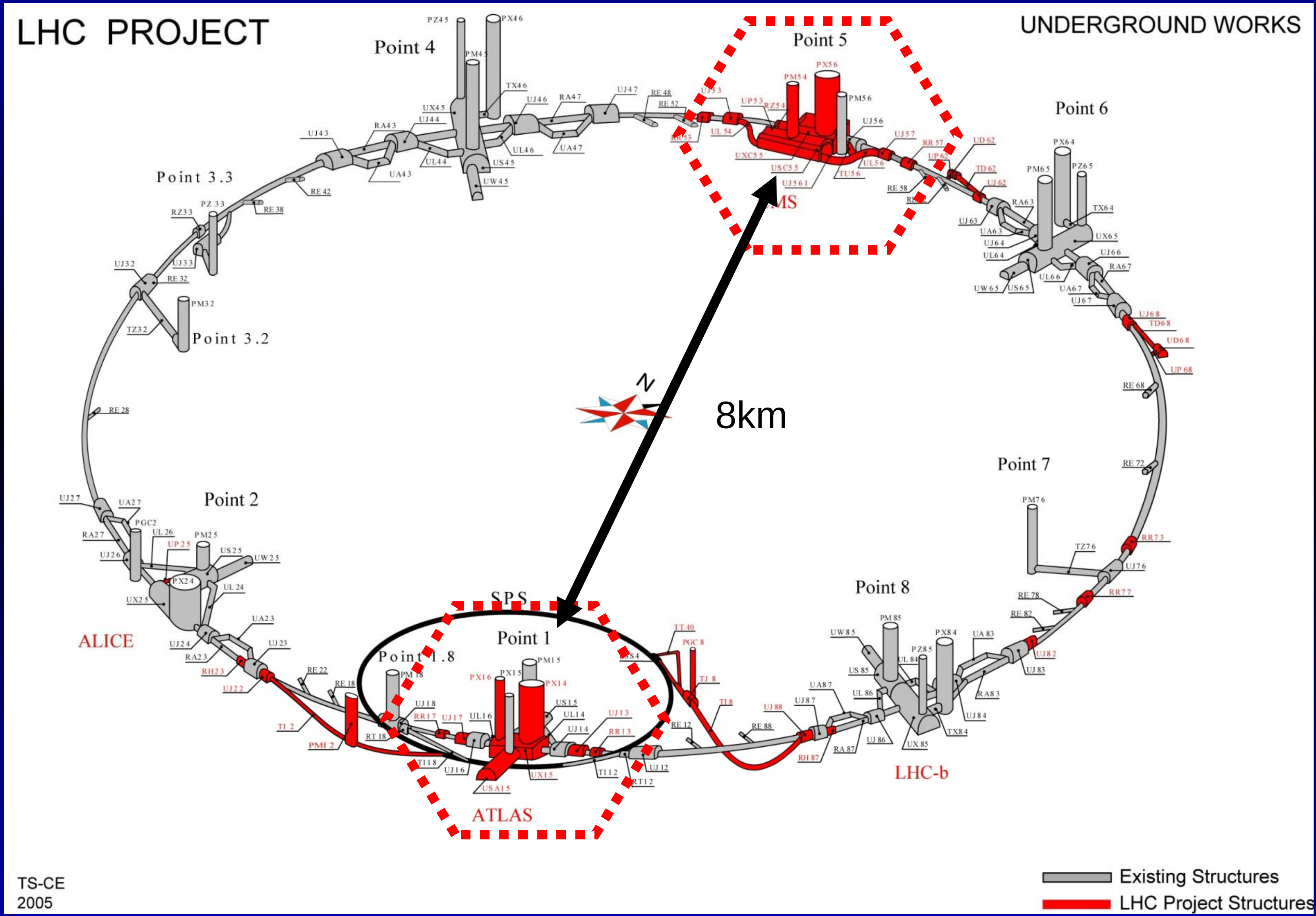
- Uncertainties with geological, hydrological and climate conditions, including:
  - Unstable tunnel excavation face
  - Fault zones
  - Large amounts of water inflow
  - Unexpected ground movements (especially in large caverns)
- Anomalies in contract documents (e.g. large quantity inaccuracies)
- Interference from outside sources
- Delayed submission of approved execution drawings
- Design changes from the consultants and/or owner
- Lack of thorough safety and/or environmental control
- Labour relations
- etc

Civil Engineering : Geology & Site Investigation

- Thorough site investigation is essential in order to avoid surprises during tendering/construction
- For LHC studies, all LEP geotechnical investigative reports were collated and new specific borings executed 3-4 years before the start of the worksite.
- As an example, for the CMS worksite, 11 new boreholes were drilled and tested. Information collated included :
  - Detailed cross sections of ground geology
  - Any known faults in the underlying rock identified
  - Ground permeability
  - Existence of underground water tables
  - Rock strengths etc etc
- Separate contracts were awarded for these site investigations prior to Tender design studies starting.
- Even with all this very detailed knowledge of the local geology some unforeseen ground conditions were encountered during the works

Importance of detailed site investigation :

EG LHC ATLAS and CMS Experimental Areas



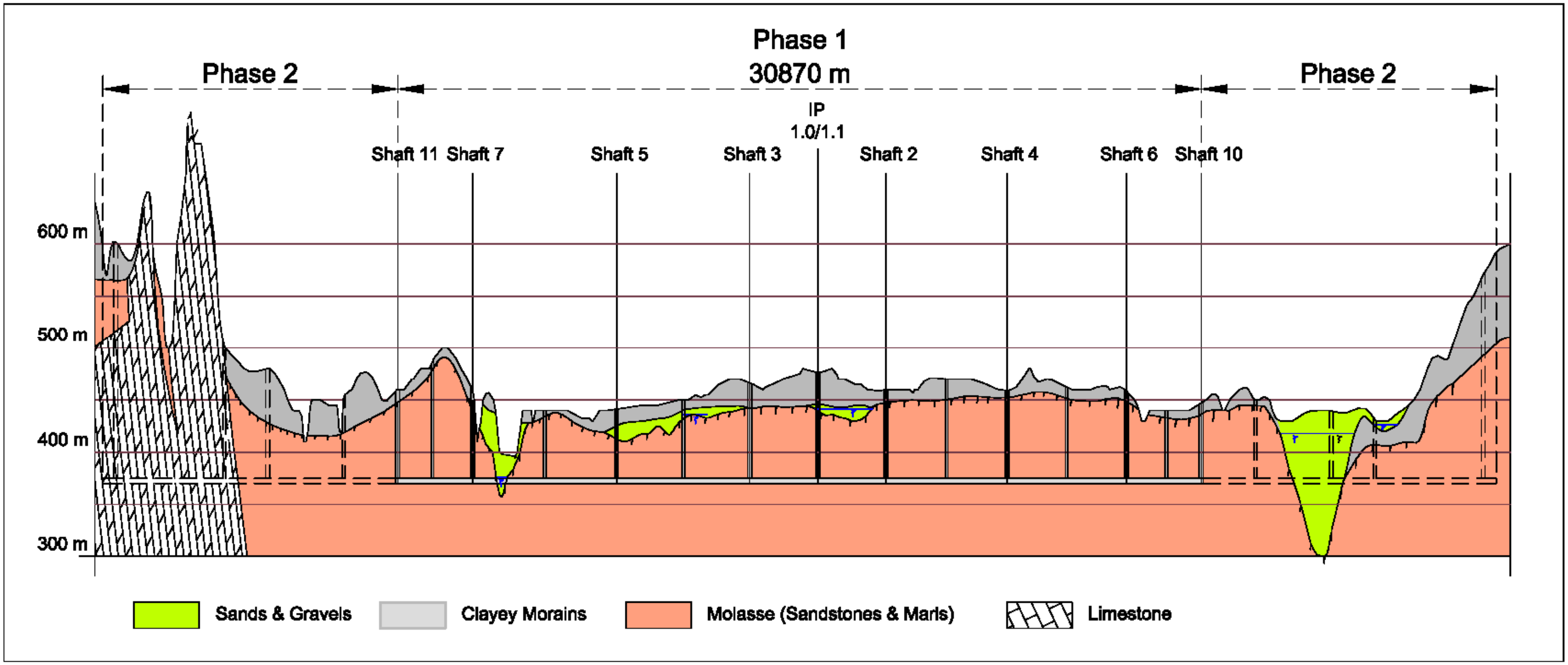
Unforseen problems during constrution :

Eg Ground Freezing for CMS shaft excavation

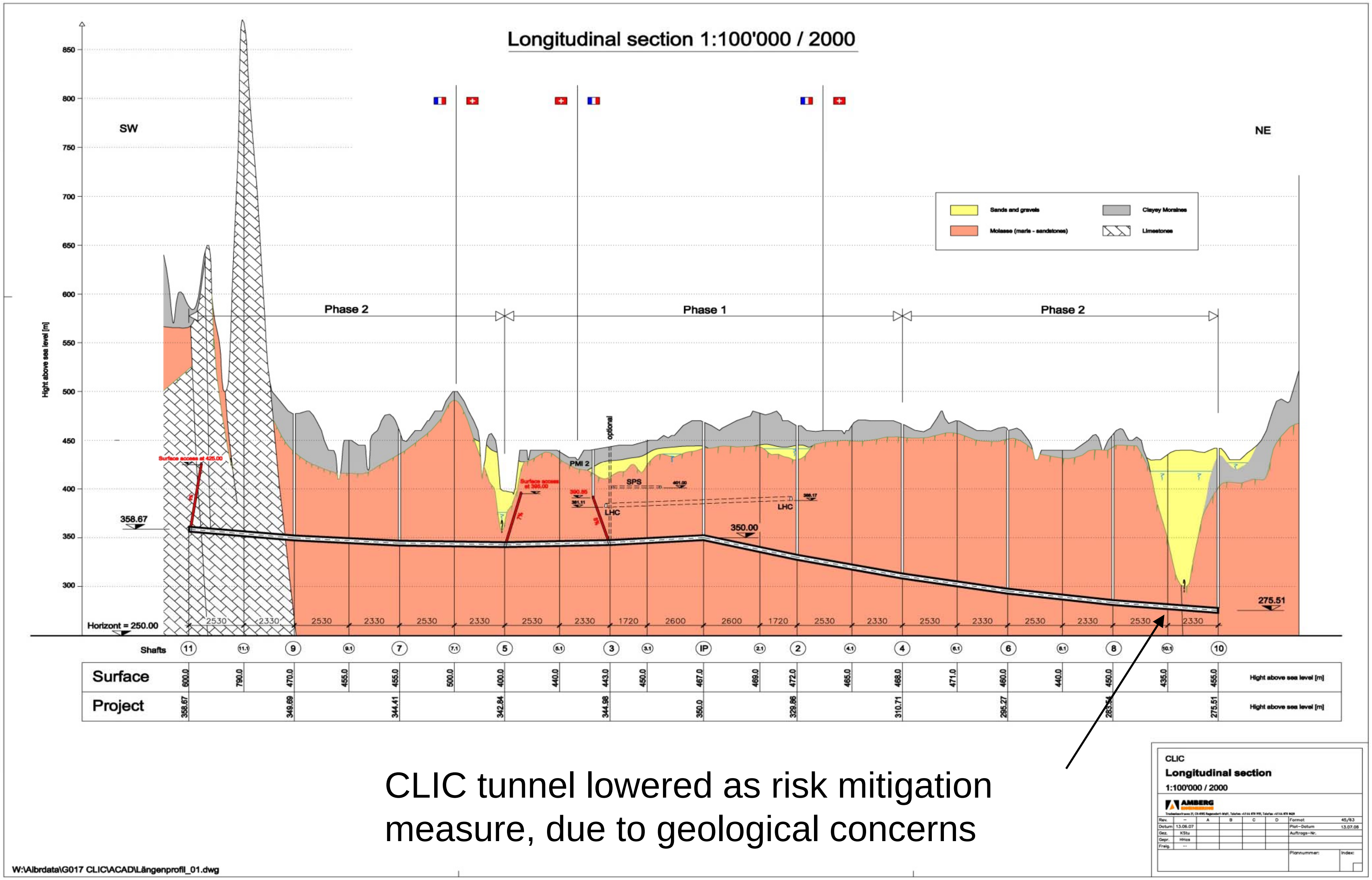
Point 5 -Excavation commencement of PM54 shaft - July 09, 1999 - CERN ST-CE

Civil Engineering Challenges :

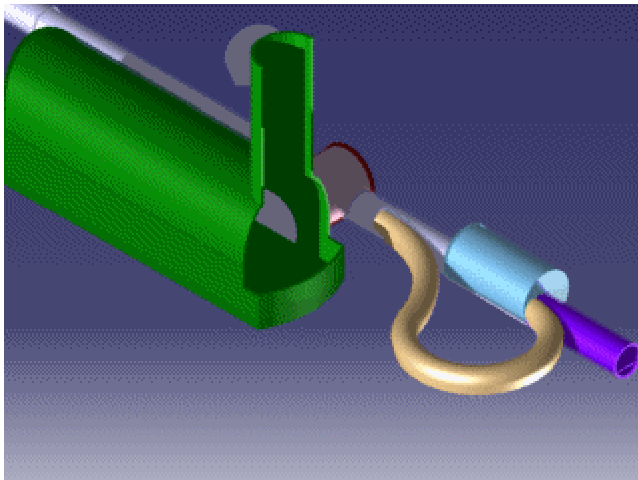
Eg ILC – Long Profile for CERN sample site



CLIC – Long Profile

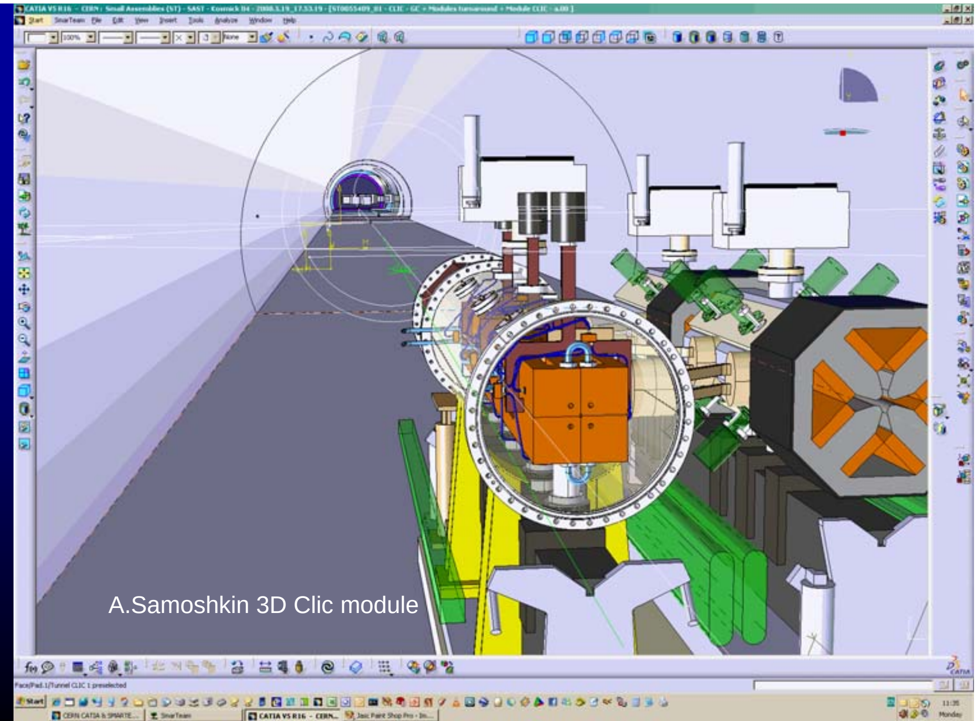


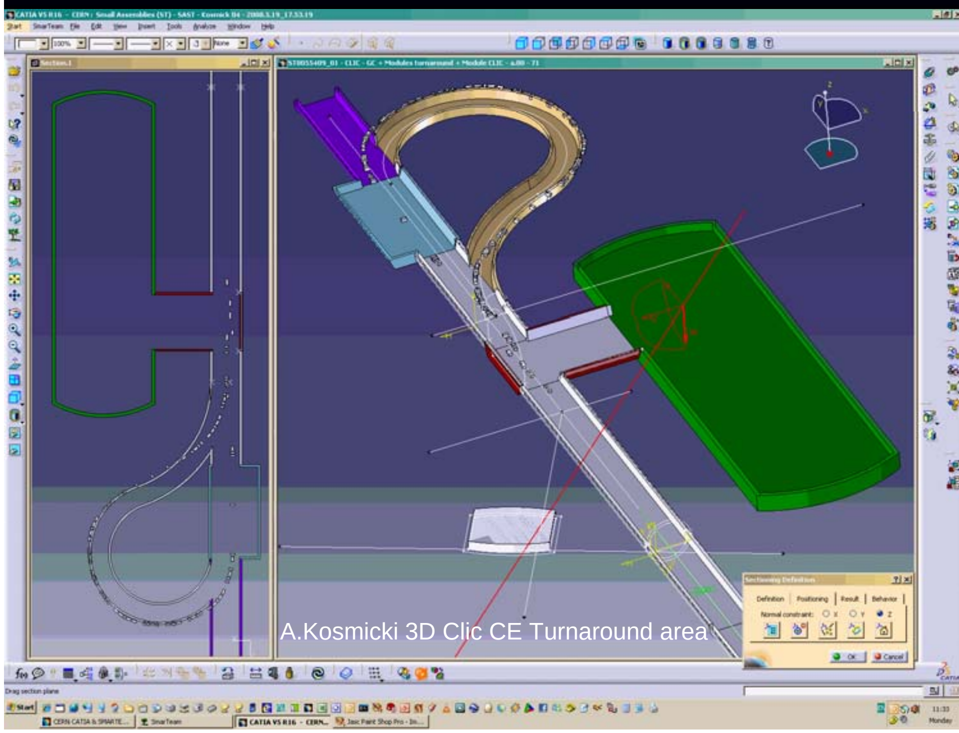
CLIC tunnel lowered as risk mitigation measure, due to geological concerns

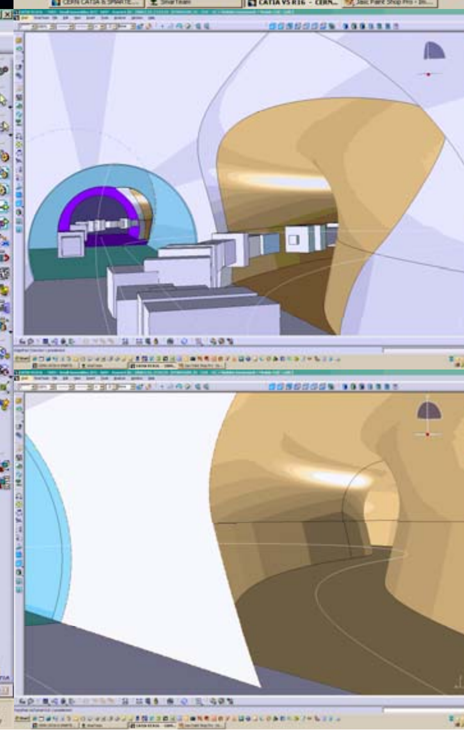


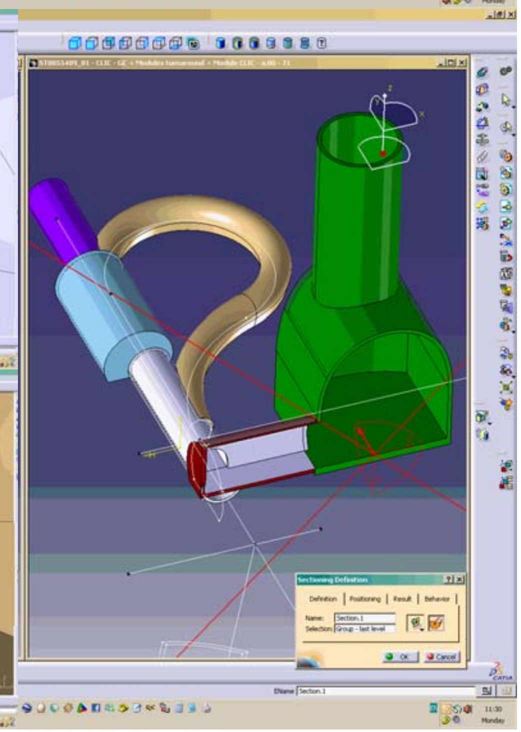
Integration of machine & services needed to define underground volumes

Integration issues to be studied this week in FG D

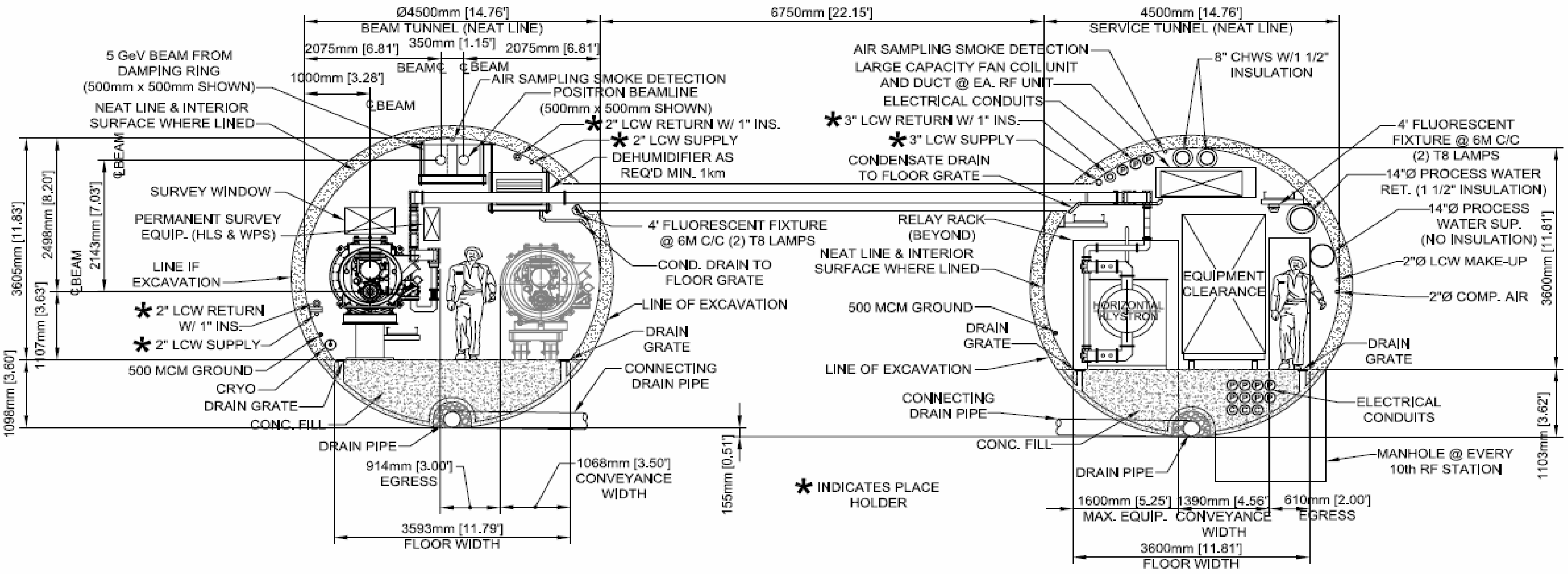






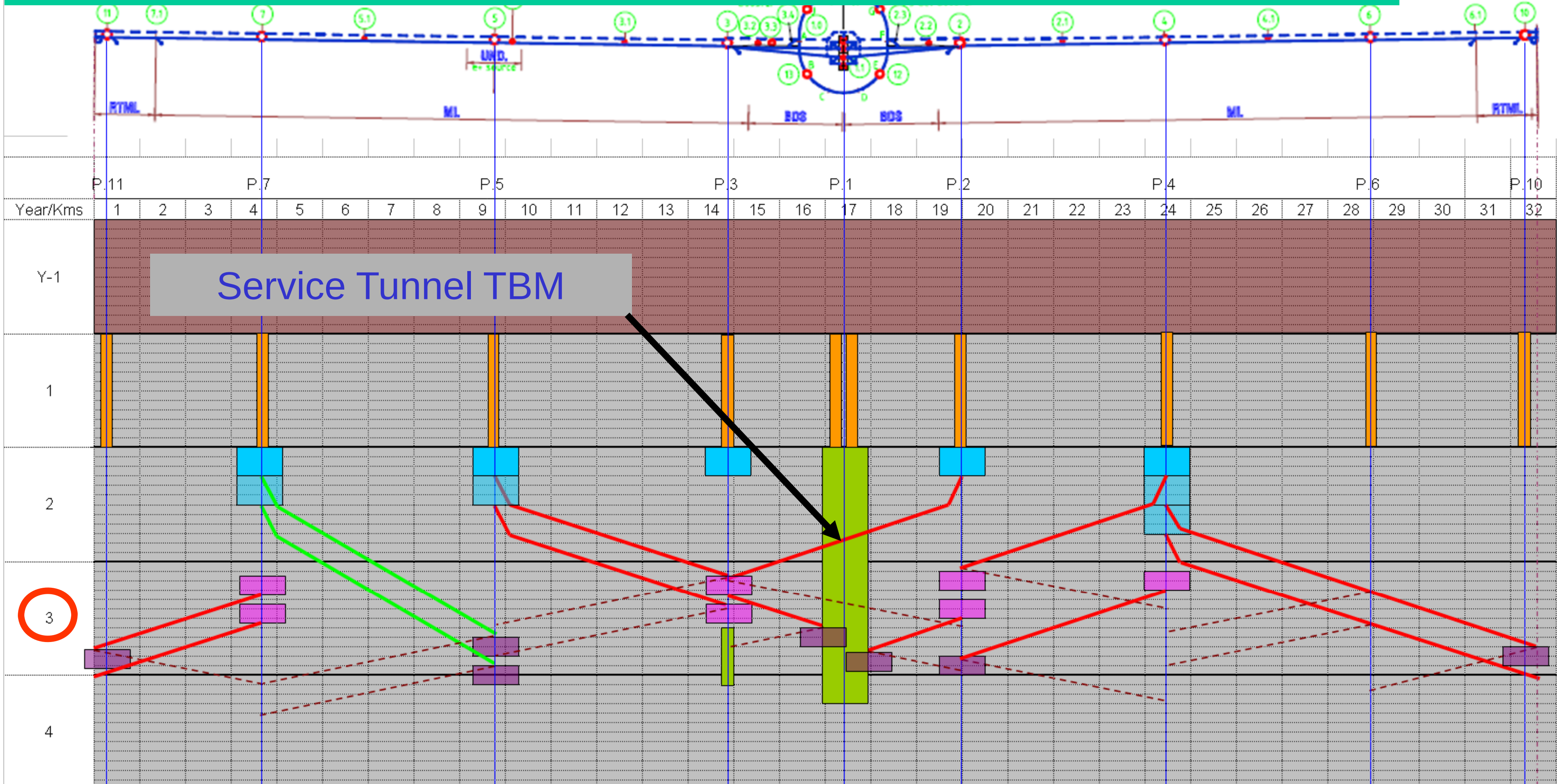


ILC Typical Cross Section



Integration Issues to be studied in Focus Group D….

Planning Challenges



- TBM $\varnothing_{finished}$=4.5m
- MS TBM ∅=4.5m
- Cavern finishing
- Shaft/cavern excavation
- TBM setup
- TBM transport
- TBM removal
- Finishing work

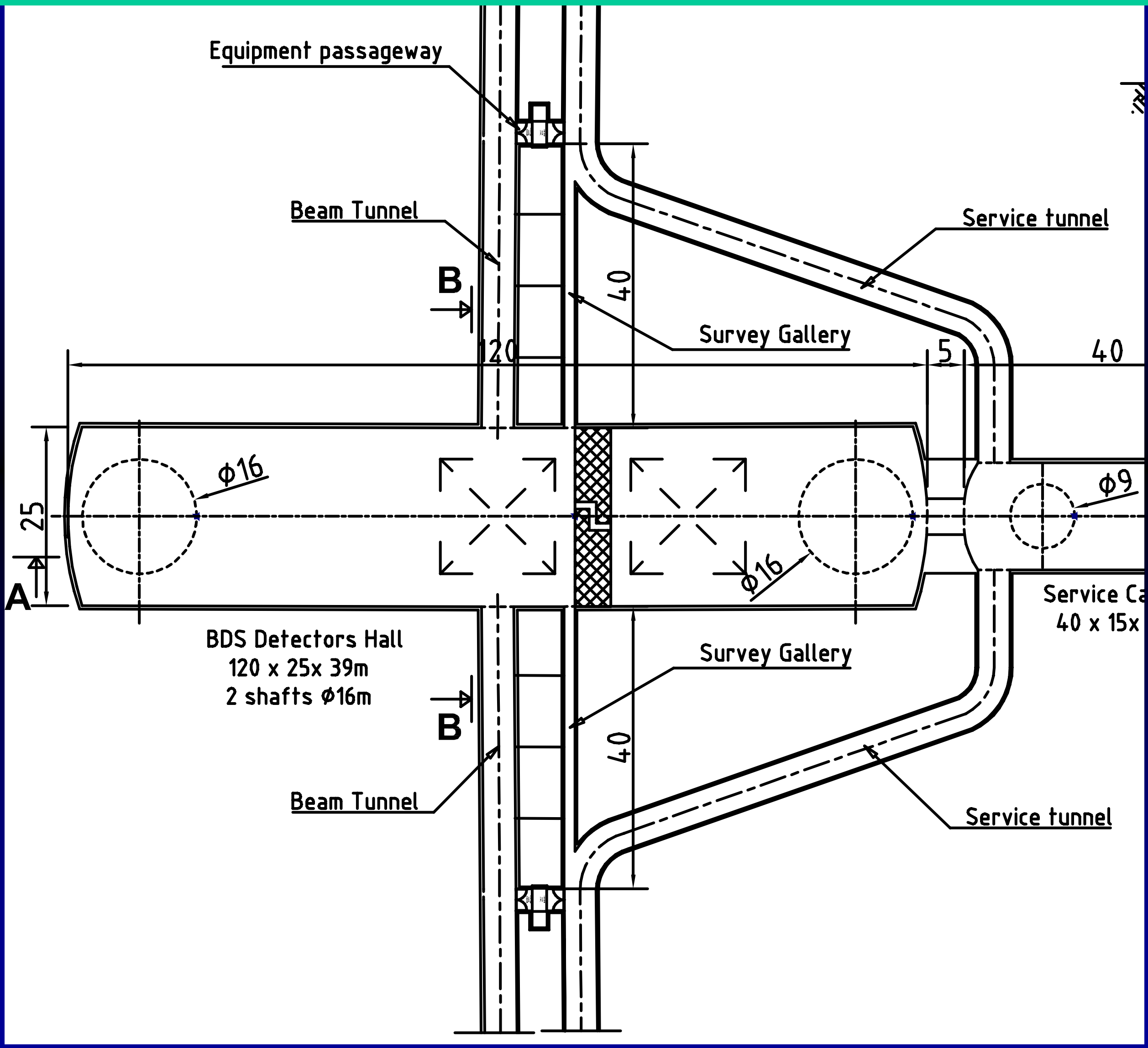
9 TBM's with 5 transported and re-used

Extract from Valencia Presentation Nov 06 by M.Gastal

Talk from CERN LHC Experience this week on Friday

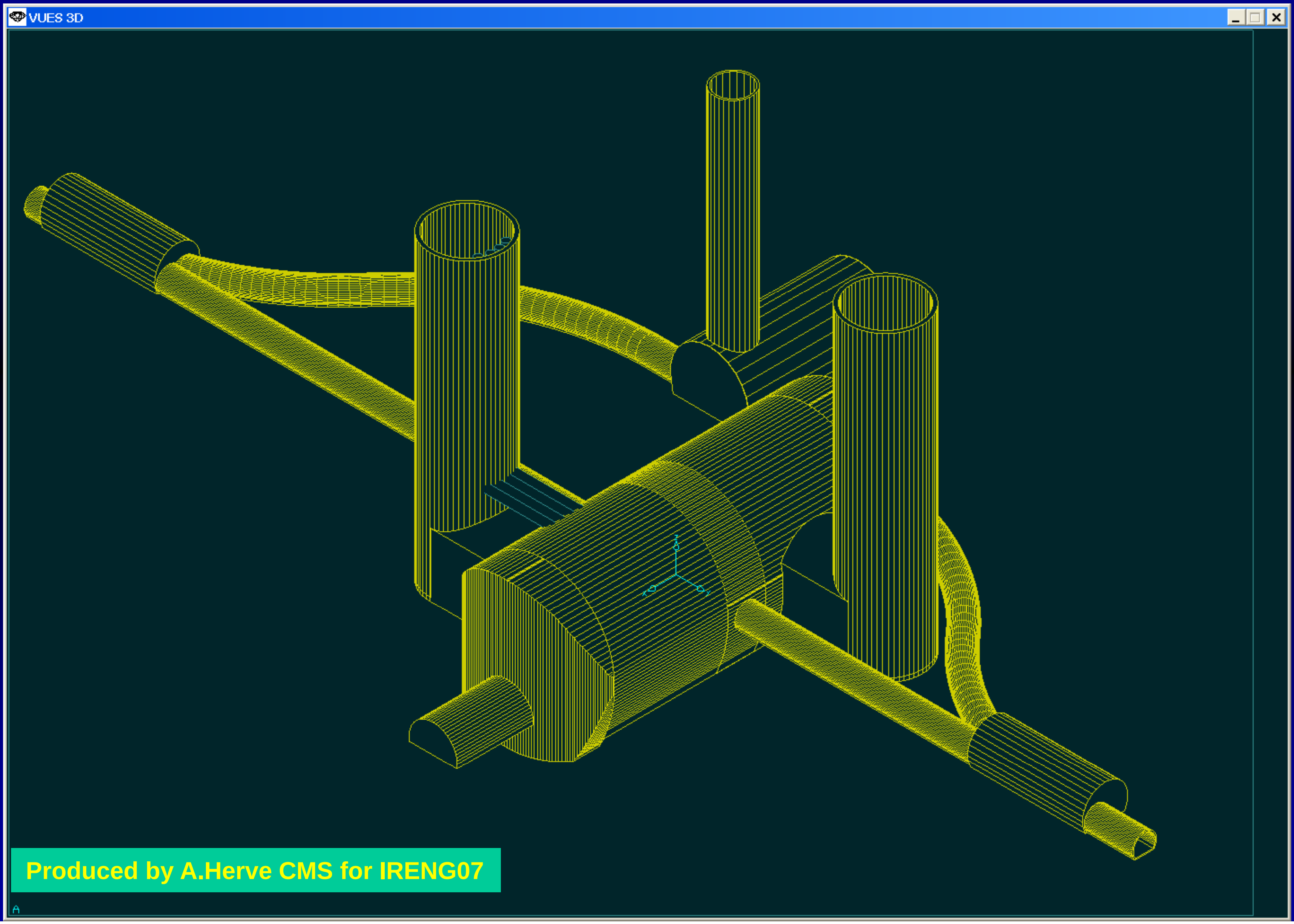
CFS Challenges for Interaction Region

10% of civil costs for IR Region

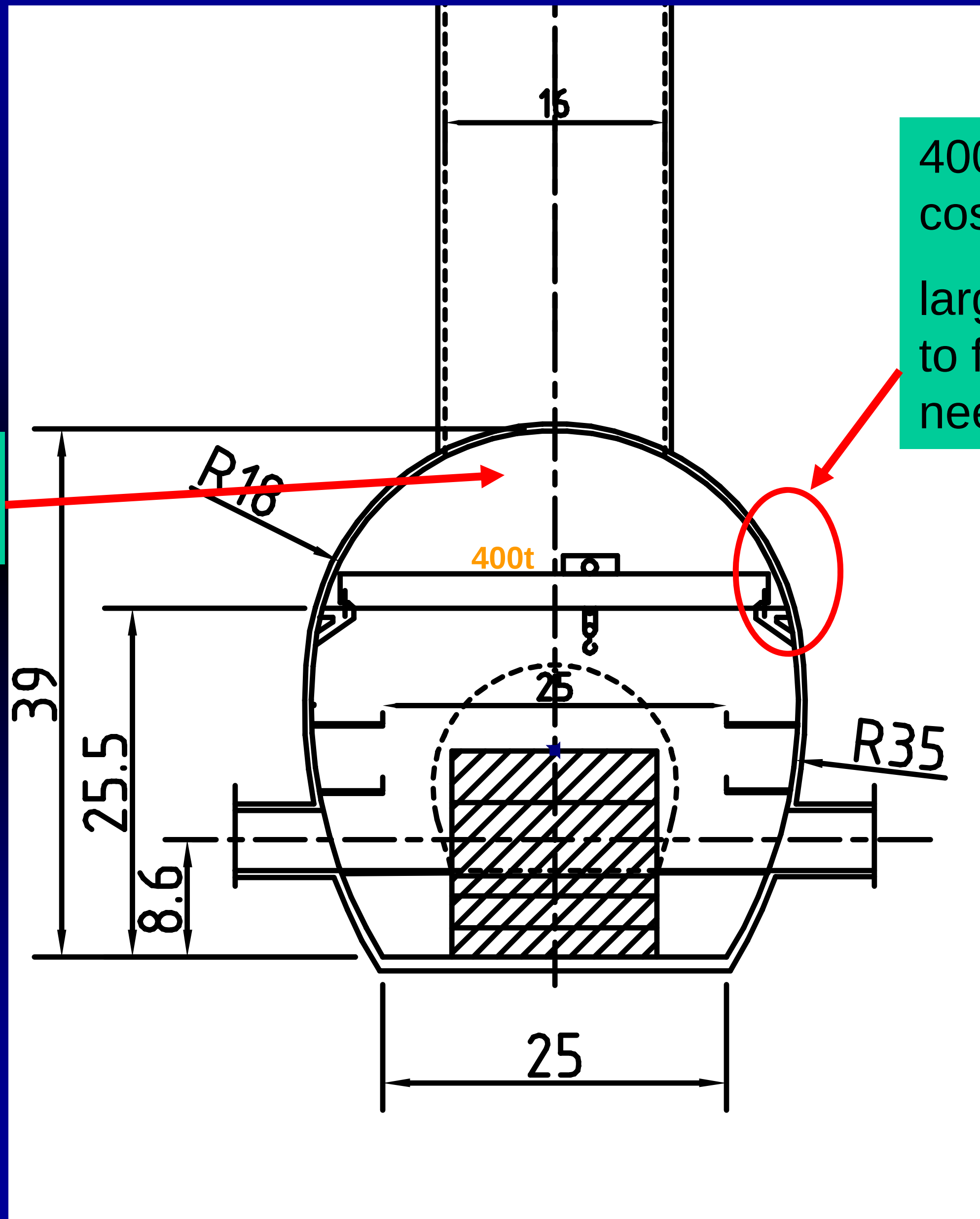


Layout for Interaction Region ILC RDR

Possible layout for ILC Interaction Region for Deep Tunnel Solution using CMS concept



RDR Baseline for IR cavern

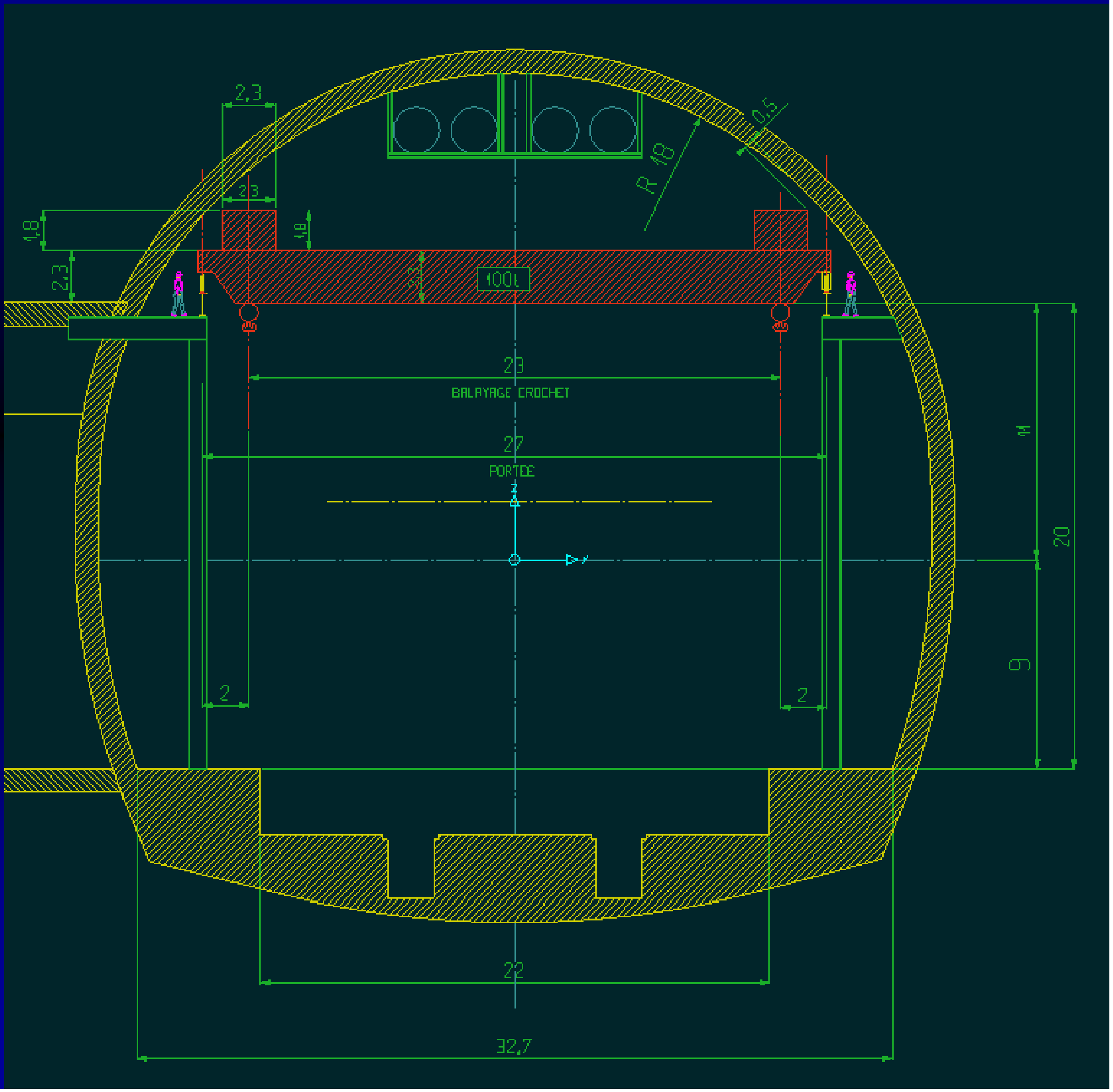


Lot of lost space

400 ton gantry crane is the cost driver

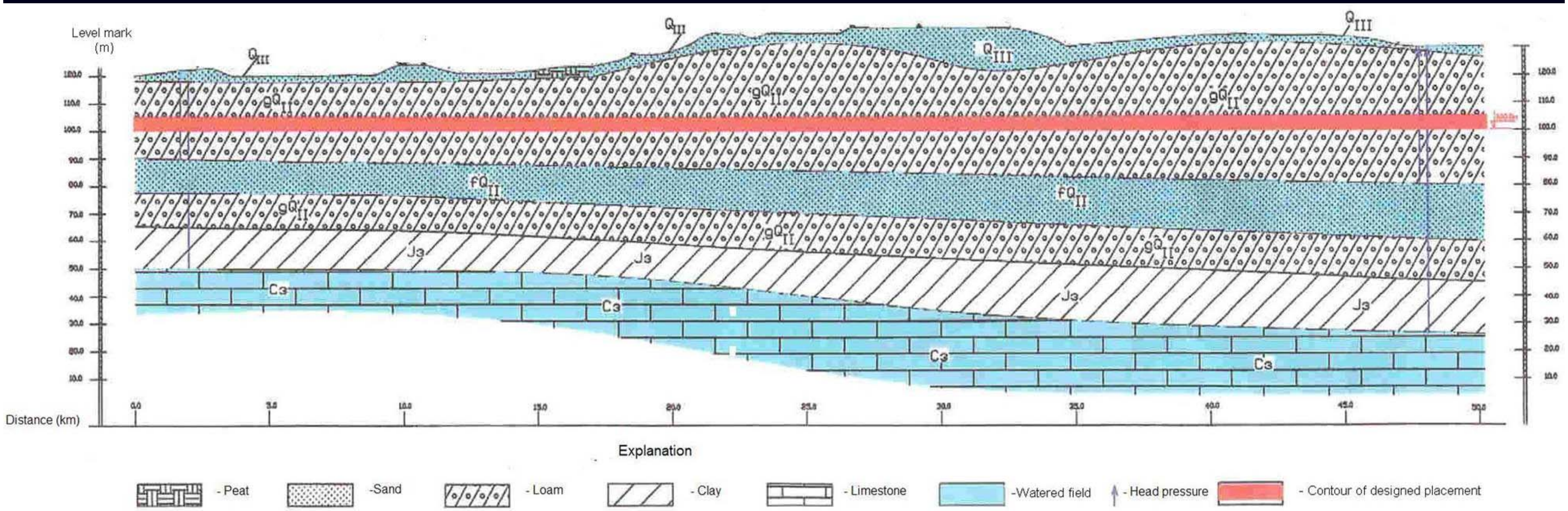
large steel columns down to floor level would be needed

Proposed new cross section for ILC Interaction Region

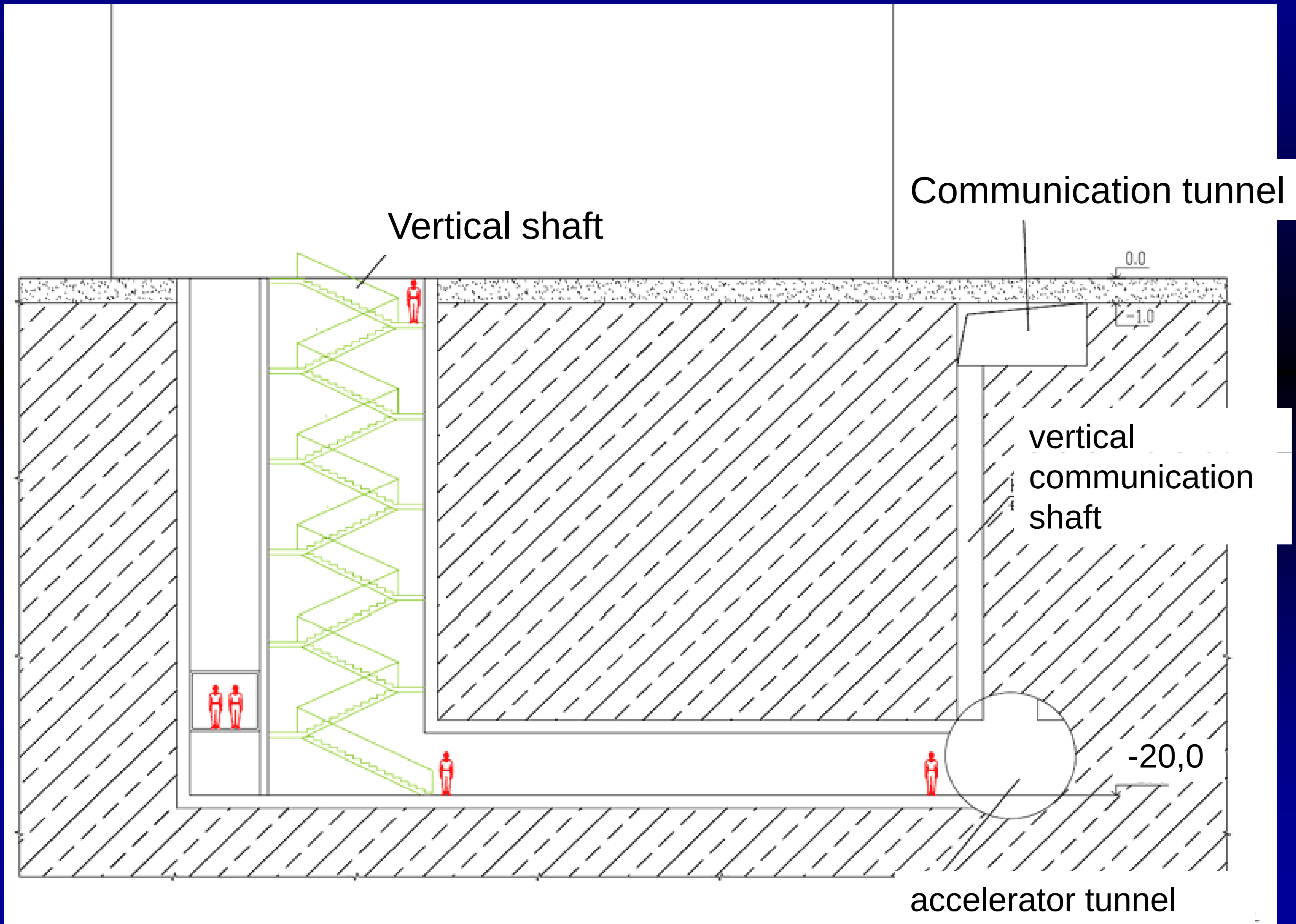


Proposed Dubna siting

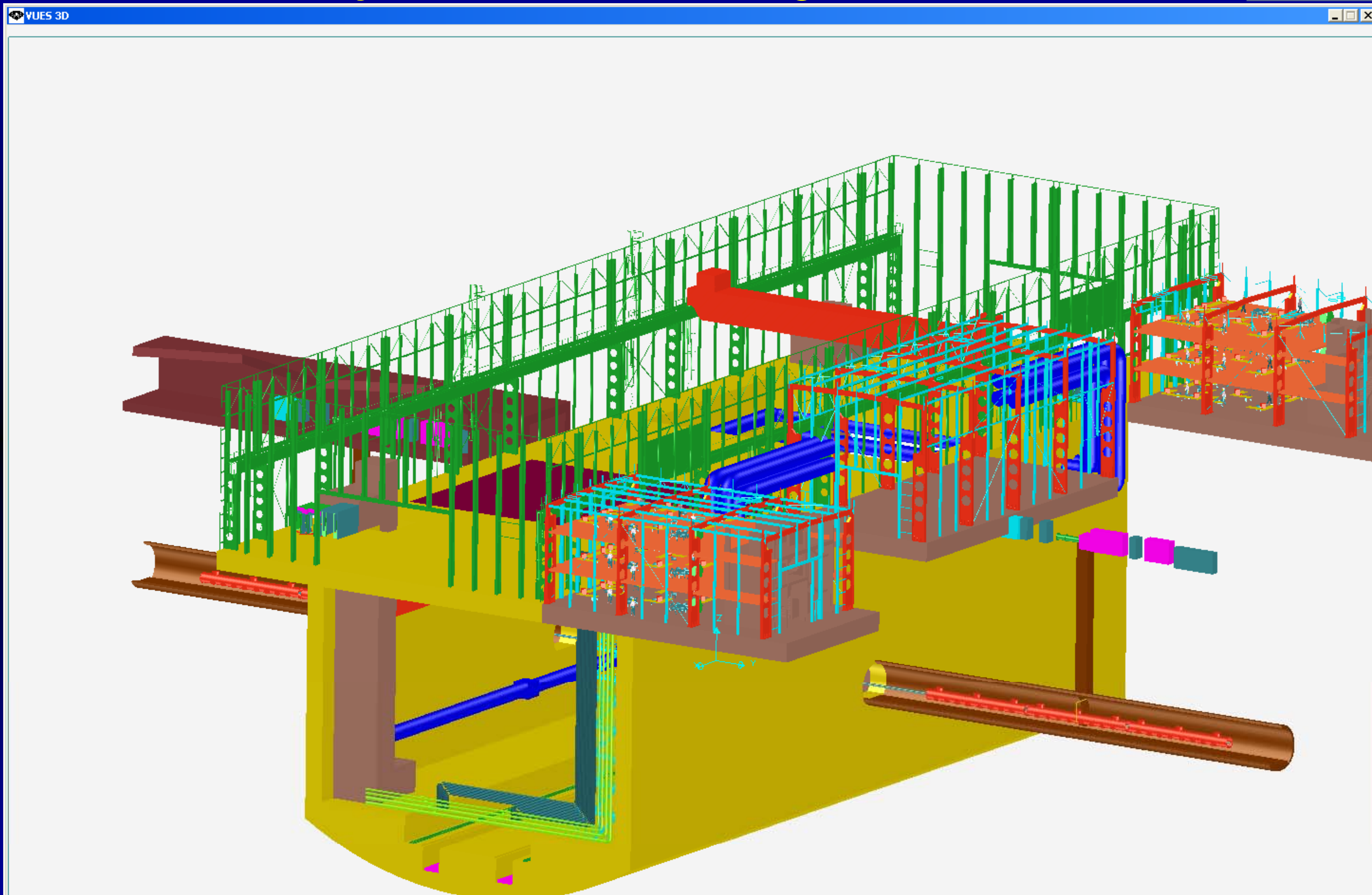
The ILC linear accelerator is proposed to be placed in the drift clay at the depth of 20 m (at the mark of 100.00 m) with the idea that below the tunnel there should be impermeable soil preventing from the underlying groundwater inrush. It is possible to construct tunnels of the accelerating complex using tunnel shields with a simultaneous wall timbering by tubing or falsework concreting.



Proposed Dubna typical cross section
Beam tunnel 20m below surface



Possible layout for interaction region for a Shallow Site



Near Surface Solution represents approx 5% saving on total CFS costs for experimental hall

+ much less risk

Diaphragm walling : excavation is supported via bentonite slurry, wall concreted in 'panels' down to required depth from surface

TI2 Area - PMI 2 shaft, diaphragm wall - November 24, 1998 - CERN ST-CE

Shaft or hall excavation within concreted wall

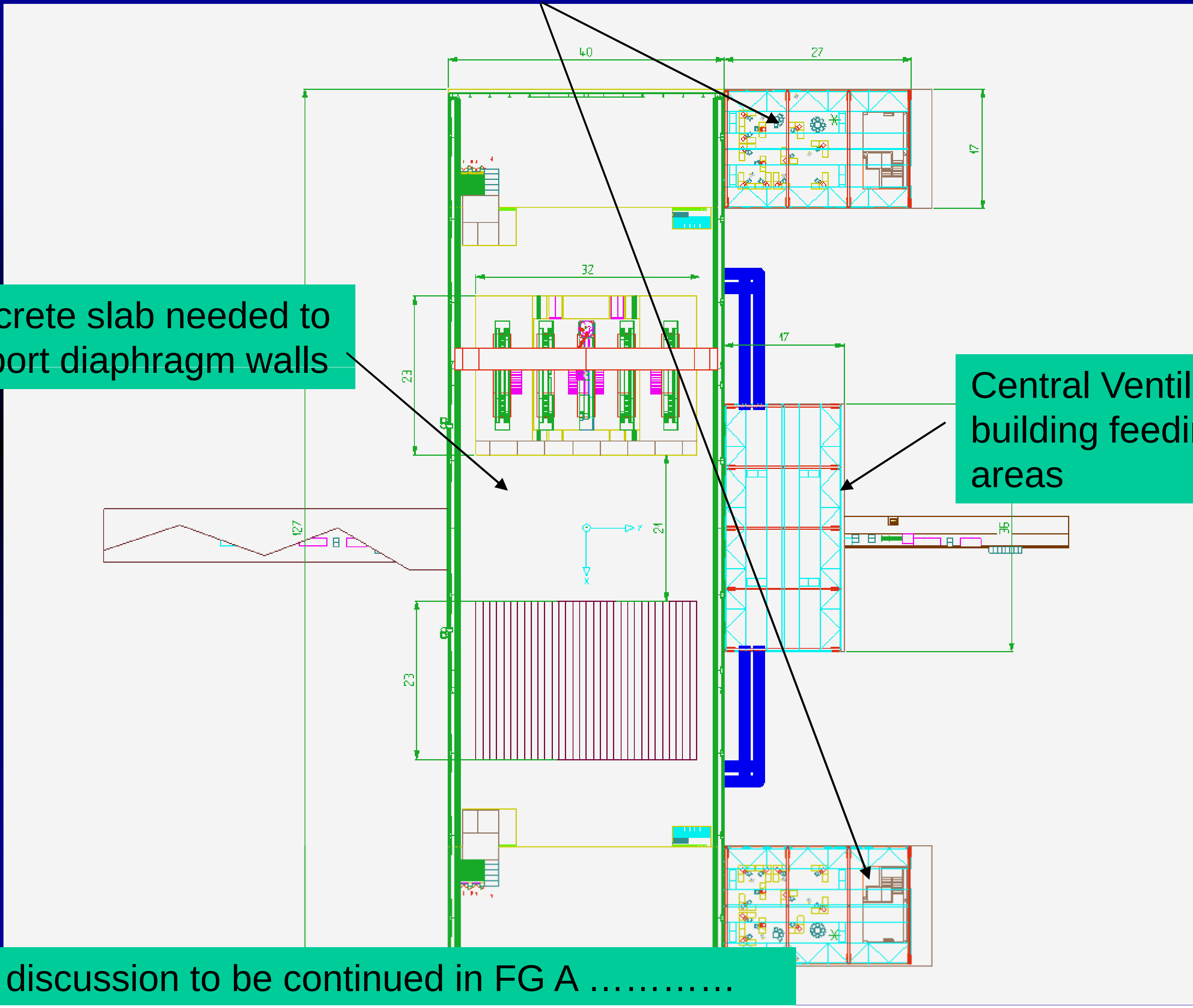
TI2 Area - Excavation for PMI2 - February 26, 1999 - CERN ST-CE

Shaft or hall excavation within concreted wall, often temporary internal struts are needed prior to permanent propping.

Control room for each detector

Concrete slab needed to support diaphragm walls

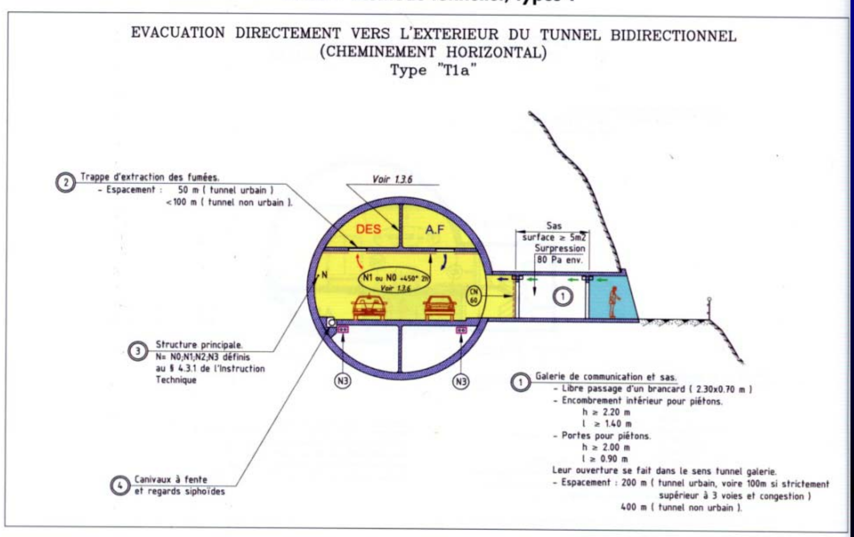
Central Ventilation building feeding both areas

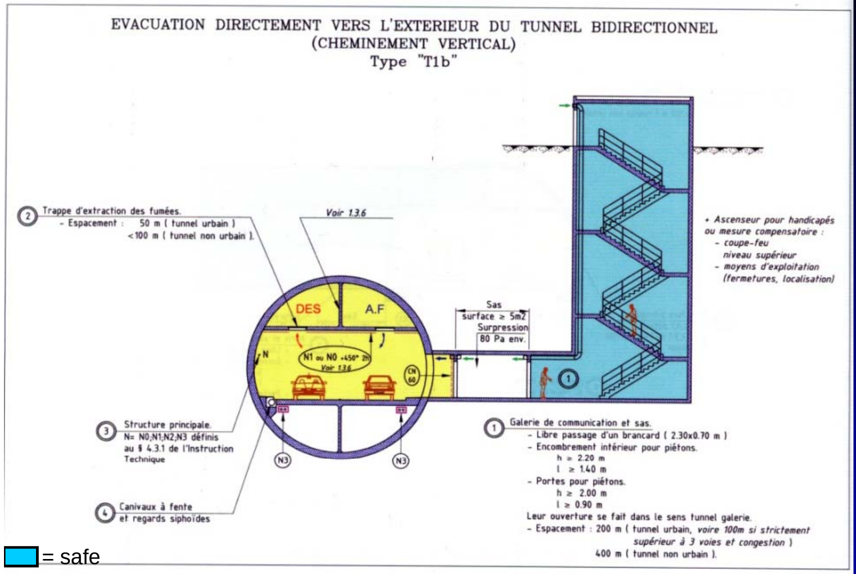


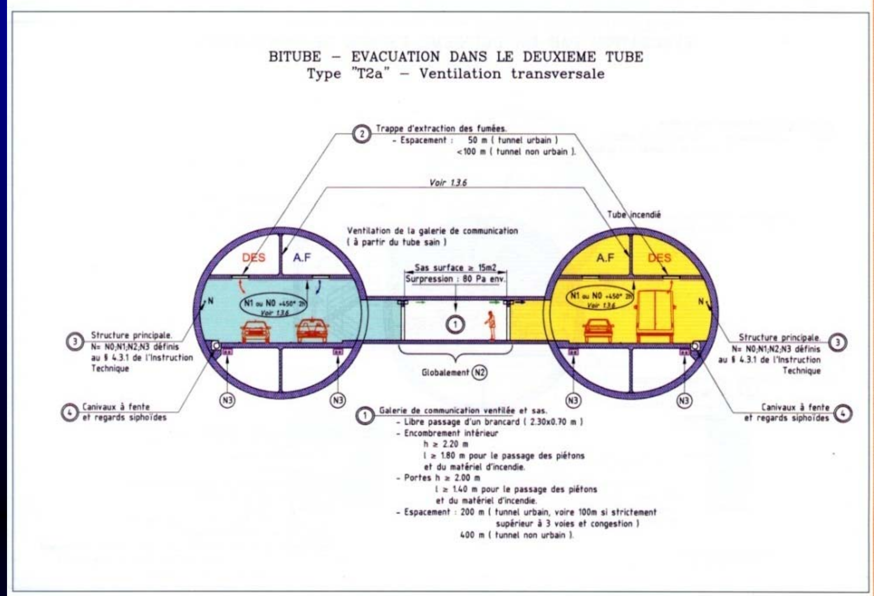
This discussion to be continued in FG A …………

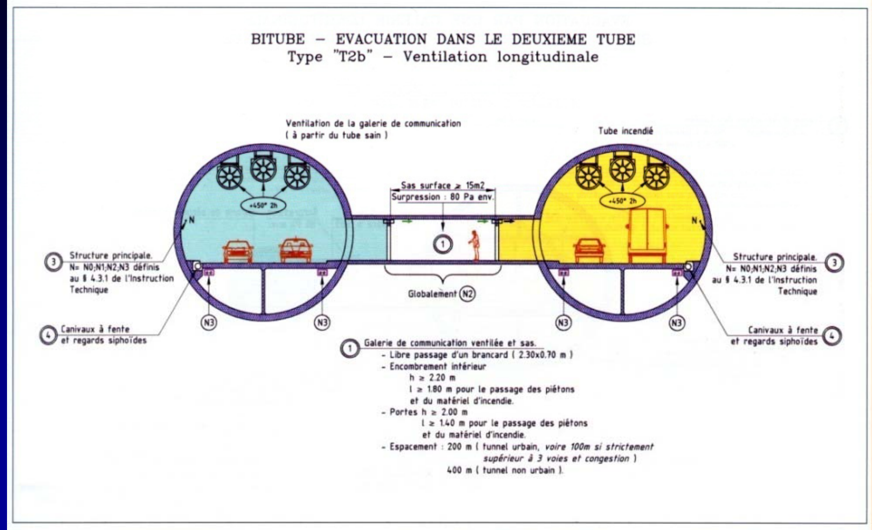
Possible Ventilation Safety Systems for road tunnels

1.4.2 - Méthode tunnelier, types T





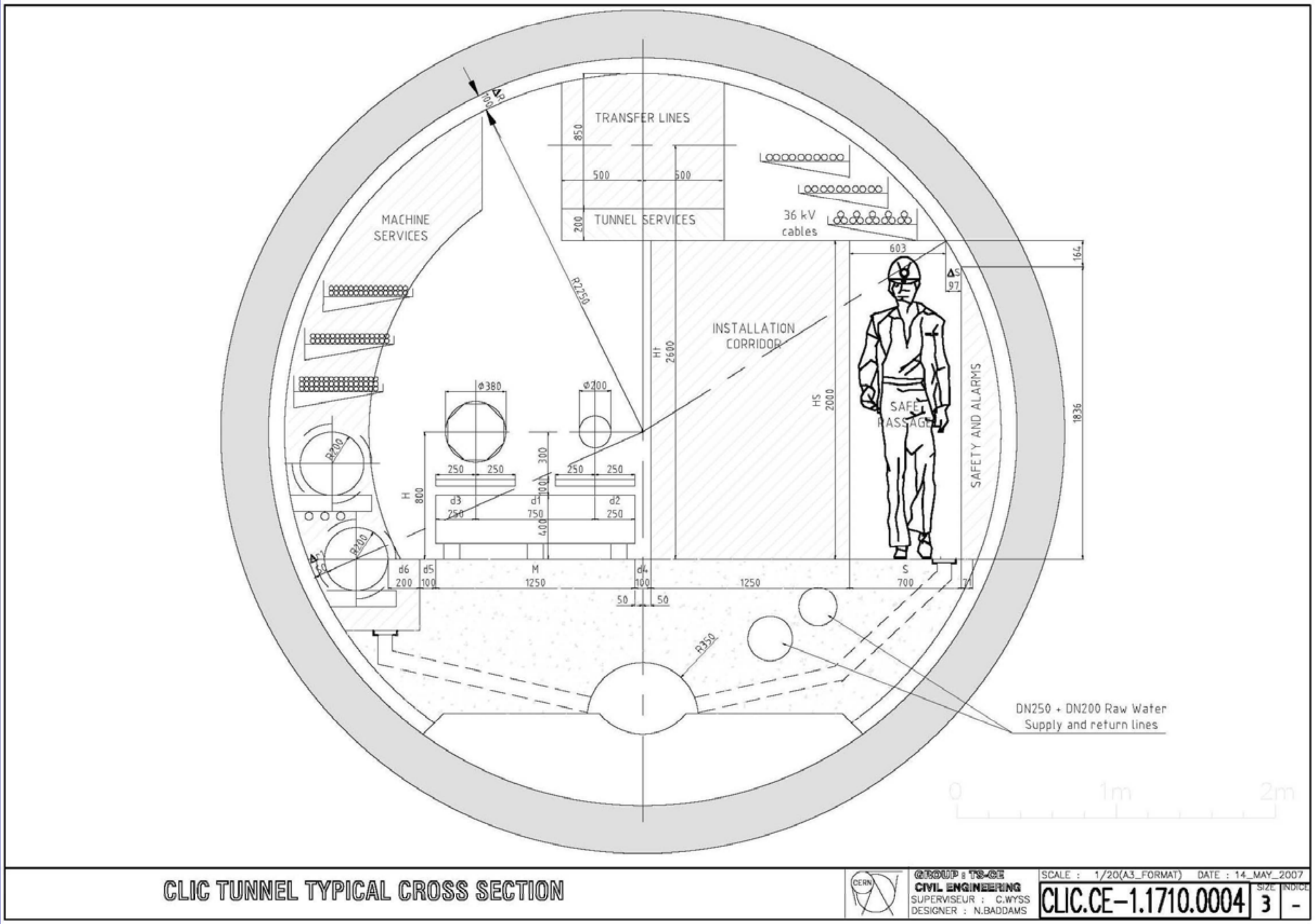




= safe

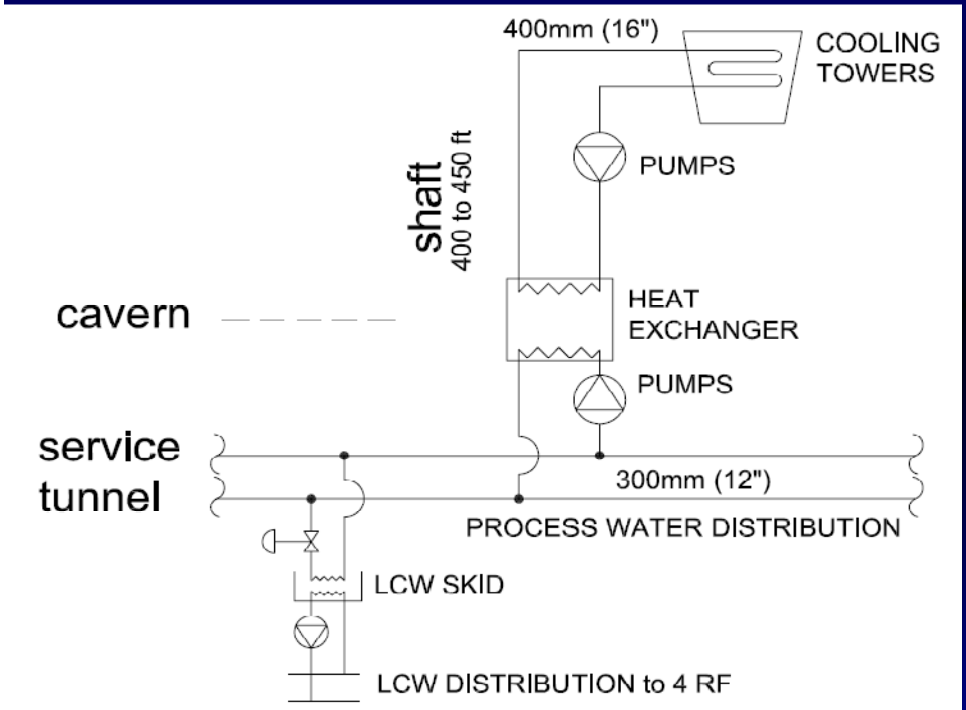
Extracted courtesy of 'French Tunnelling Association : AFTES : Tunnels routiers : resistance au feu Jan 2008'

CLIC – Typical Cross Section



The challenge is to fit all the services in the smallest underground volume, whilst respecting the **relevant** safety legislation

Other ILC infrastructure Challenges



Processed Cooling Water

-FNAL did RDR design

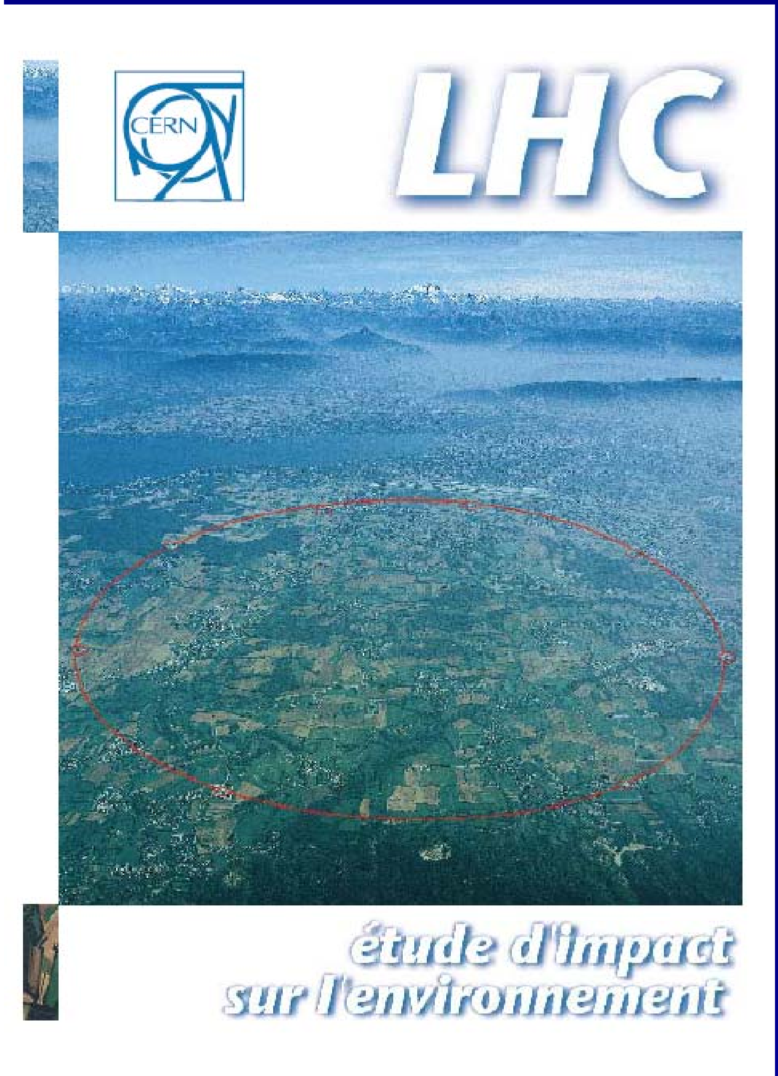
-Lots of useful dialogue with KEK and DESY on-going

Power Distribution

Ventilation….

These key issues will be discussed in FOCUS GROUP B

Formalities with Outside World
- Environmental Impact Study



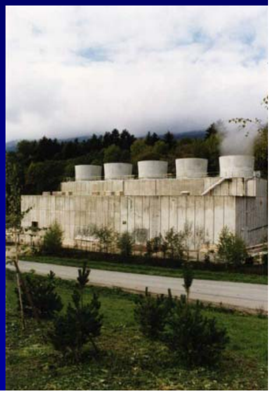
Main Contents :

- Scientific Basis of the Project
- Project Description (Machine & Detectors)
- Civil Engineering
- Works Management
- Impact on the Environment
- Measures in place to mitigate Impact

Study Example:

Cooling Towers :

In Europe, regulations with regard to Legionnaires are becoming stricter and stricter…….



Conclusions

•Approx. 40% of linear collider budget is for CFS works (with CE, HVAC and EL making up 90% of that), so it's imperative that they are well defined from early stages.

•Extremely difficult for engineers to examine in sufficient detail until site is known, maybe a 'generic' site is the way forward.

•Issues such as safety and environmental considerations must be studied from conceptual stage.

•A lot of CFS subjects are generic to CLIC & ILC. Common Working Groups are established.

•Looking forward to fruitful discussions this week on CFS challenges……….