Einstein Telescope

Status of WG1: site selection and infrastructure

2nd Annual ET meeting

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Jo van den Brand
Nikhef / VU Amsterdam

jo@nikhef.nl

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- Infrastructure issues
  - Site selection, geophysical issues
  - Seismic data
  - NN noise, modeling (e.g. FEA)
  - Infrastructure and safety
  - Suspensions, vacuum and cryogenic systems
- Goals for year 2
  - Progress on vacuum and infrastructure
  - Costing

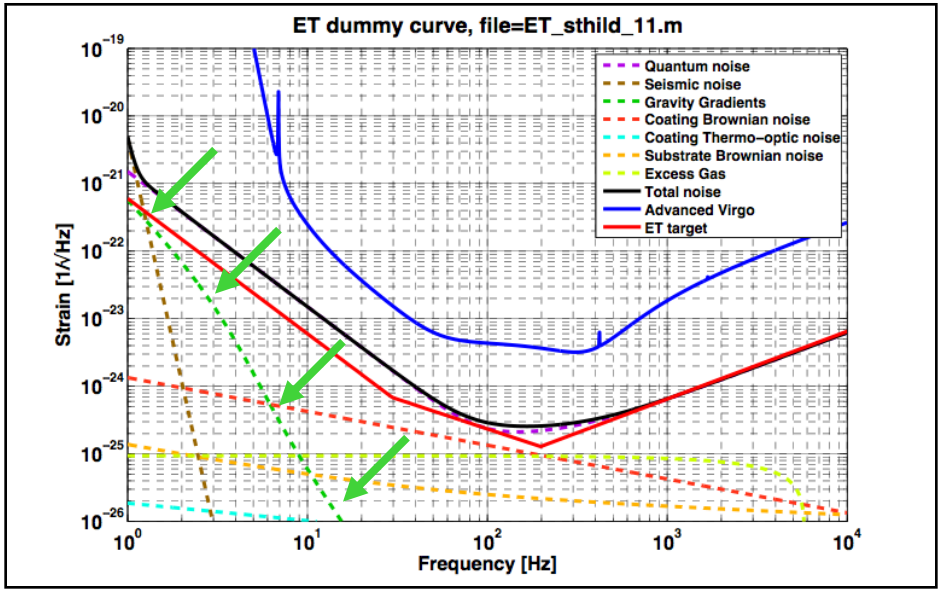
Progress overview of year 1

- WG1 meetings
  - Stuva (May. 2008)
  - COM (Oct. 2008)
  - Nikhef (Oct. 2008)
  - Gran Sasso (Feb. 2009)
  - Ft. Lauderdale (May 2009)
  - EGO (Sep. 2009)
- Seismic data
  - Data collection
  - Joined Homestake activity
  - RealMonte mine (Oct. 2009)
  - Kamioka (2010)
  - Ilias Next proposal
- GGN
  - Analytical calculation (Cella)
  - Stochastic simulations (Harms)
  - Impulse excitations (Beker)
  - Adaptive filtering (Harms, Rabeling)
- ET design progresses
  - Optical design
  - Suspensions
- After 2nd ET meeting
  - WG leader discussion
- Reporting
  - General site issues
  - Seismic issues
  - GGN conclusions

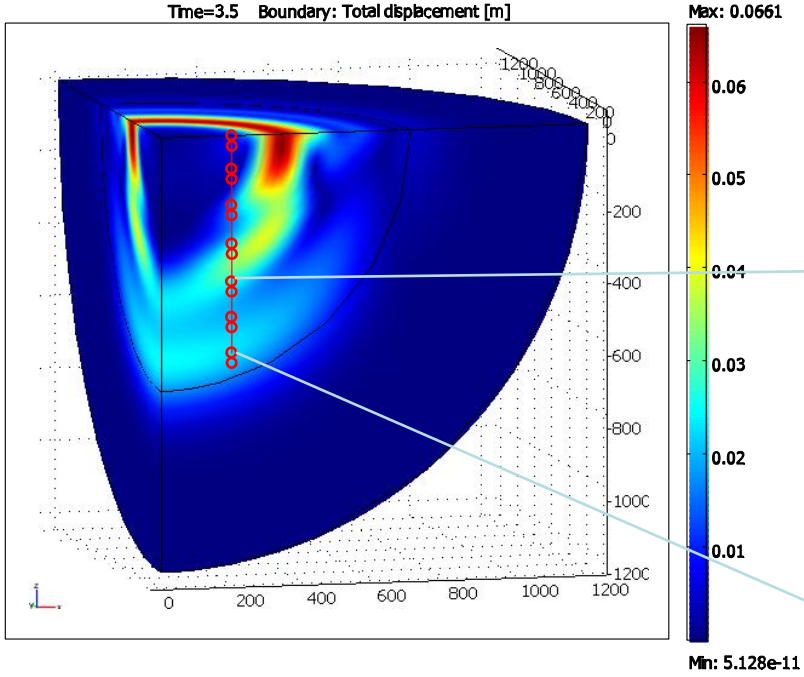
Table 1.3-e: List of milestones

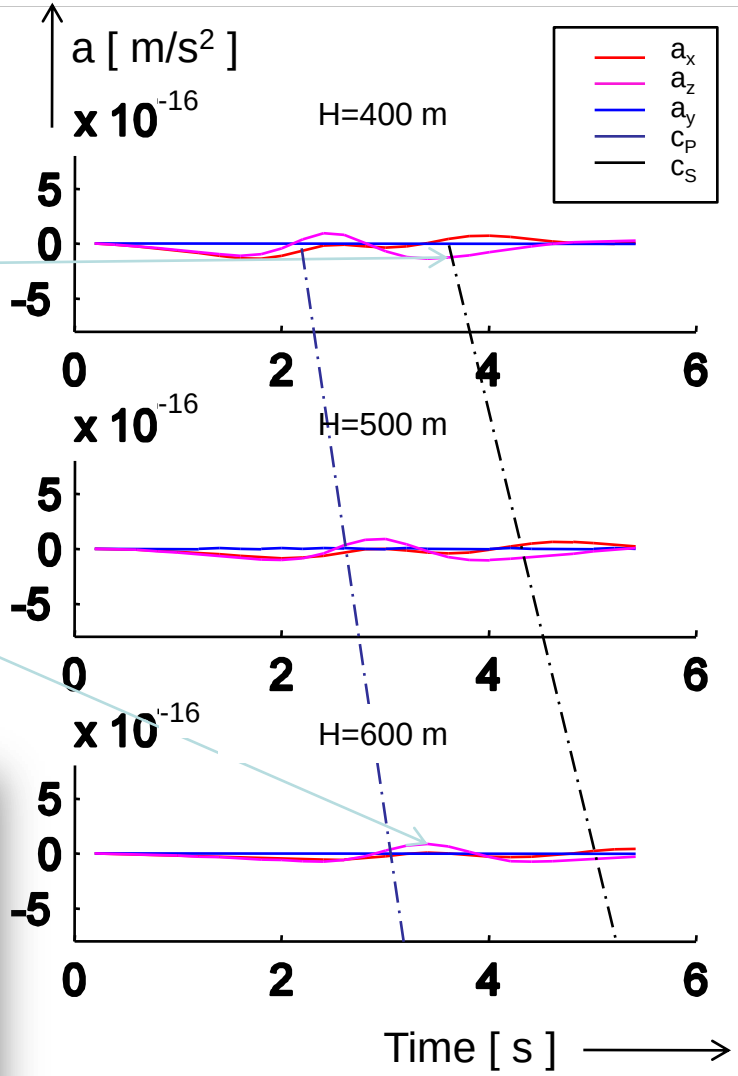
Milestone number	Milestone name	Work package(s) involved	Expected date	Means of verification
WP1.1	Site requirements definition	WP1	M12	Report
WP1.2	Site noise evaluation	WP1	M18	Report
WP1.3	Site selection and evaluation procedure	WP1	M24	Report
WP1.4	Main infrastructure conceptual design	WP1	M33	Report

Seismic noise and GGN Status

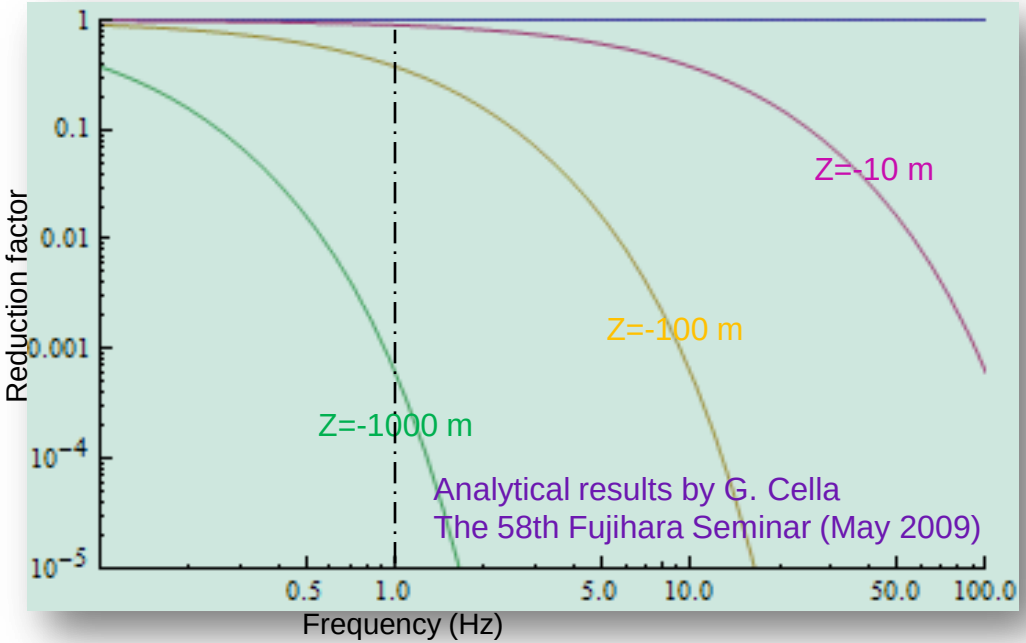


- Seismic noise
  - Assumptions by Stefan Hild
    - Ambient seismic noise around 5 nm/rtHz at 1 Hz
    - For frequencies > 1 Hz noise depends on $1/f^2$
    - Need a factor 50 for GGN!
  - Several existing sites feature
    - Ambient seismic noise below 1 nm/rtHz at 1 Hz
    - Cultural noise sources dominate
  - Get suppression from going underground
    - Tough at 1 Hz
    - Suppression factors 10 – 100 possible for continuous noise (Cella, Harms, Beker)
    - More difficult for impulse type excitations (Beker)
    - Employ filtering / subtraction schemes (Cella, Harms, Rabeling)





Surface



FEA model and impulse response Beker

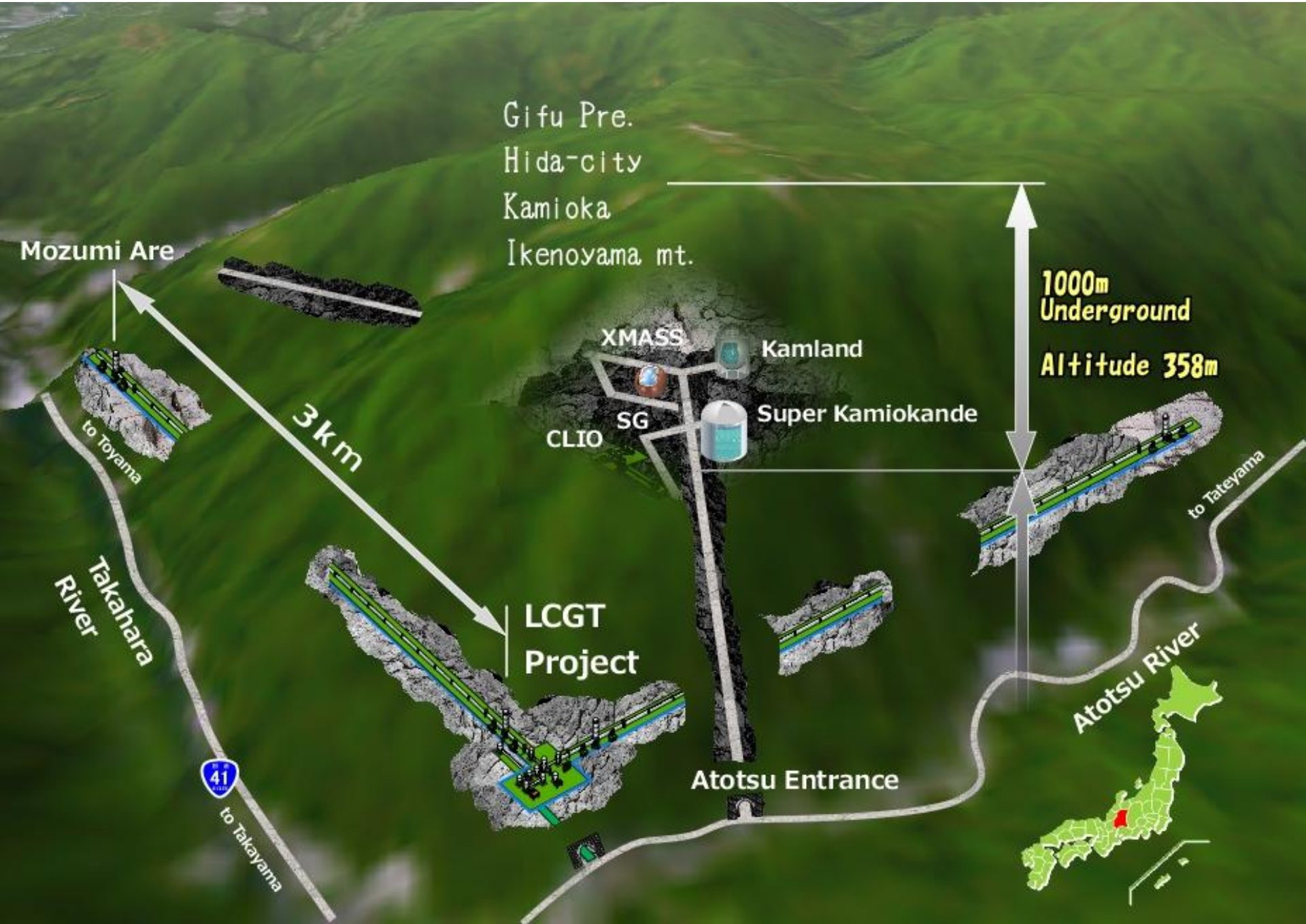
- All wave types included
- GGN drops less than order of magnitude
- Little geometric suppression

Homestake - Dusel

Safety issues: training, guides (by appointment)
CAPACITY
DANGER
KEEP DOOR CLOSED
DANGER 12,000 VOLTS
EXIT
Elevator: access (operators)

Level 4880 ft (1600 m)
Water at 5100 ft
Infrastructure replaced
Significant local expertise
Dust
Water
Air circulation

Schematic view of Kamioka Research Facility (Kuroda, Ft. Lauderdale, May 09)

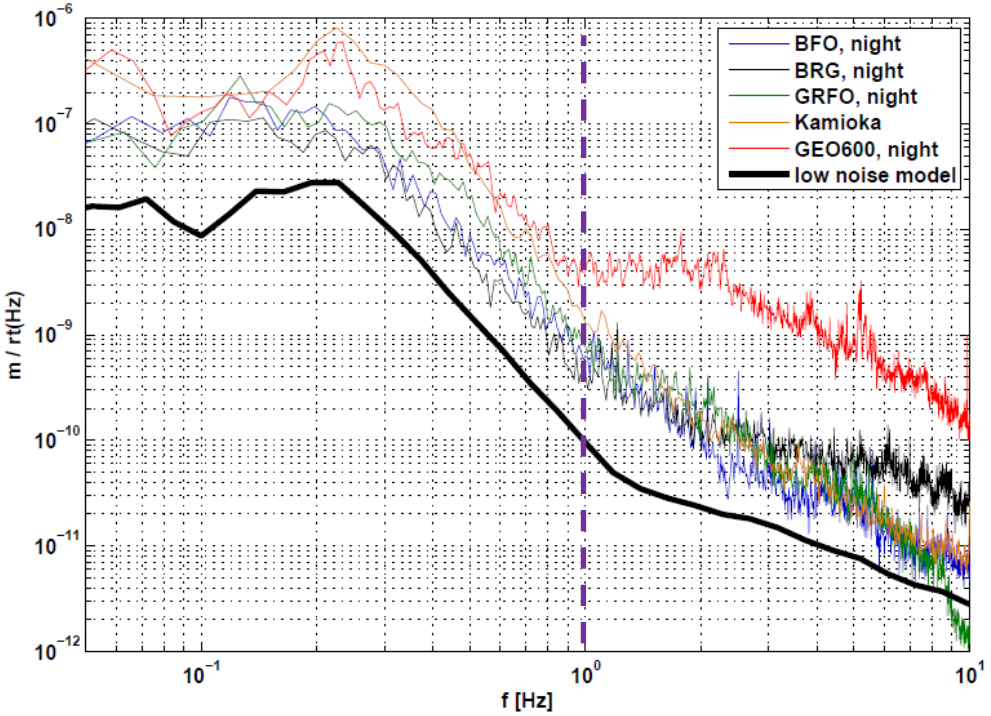


The goodness of underground must be tested using interferometers

Kuroda et al.

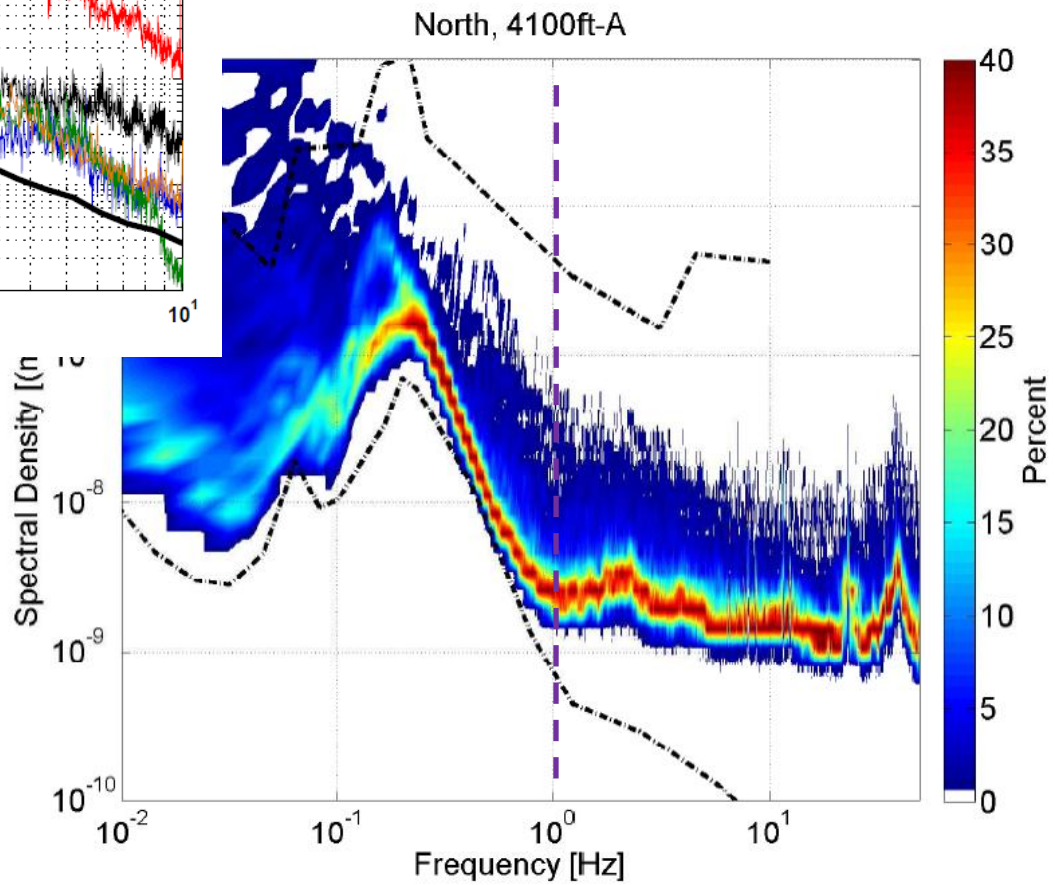
- Long term stability
  - Checked by a practical interferometer
- Harmful environment of high humidity
  - Vacuum pump and optics
- Dust contamination due to mining history
  - Optics
- Other harmful factors

Seismic data



Grote

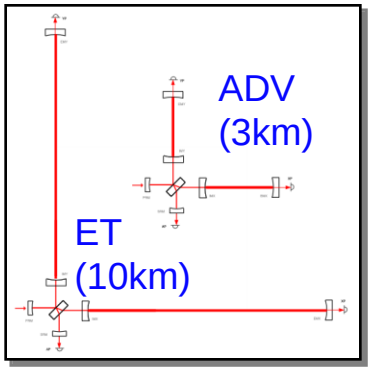
Harms et al.



ILC database:
http://vibration.desy.de
Asse, Moxa, LHC

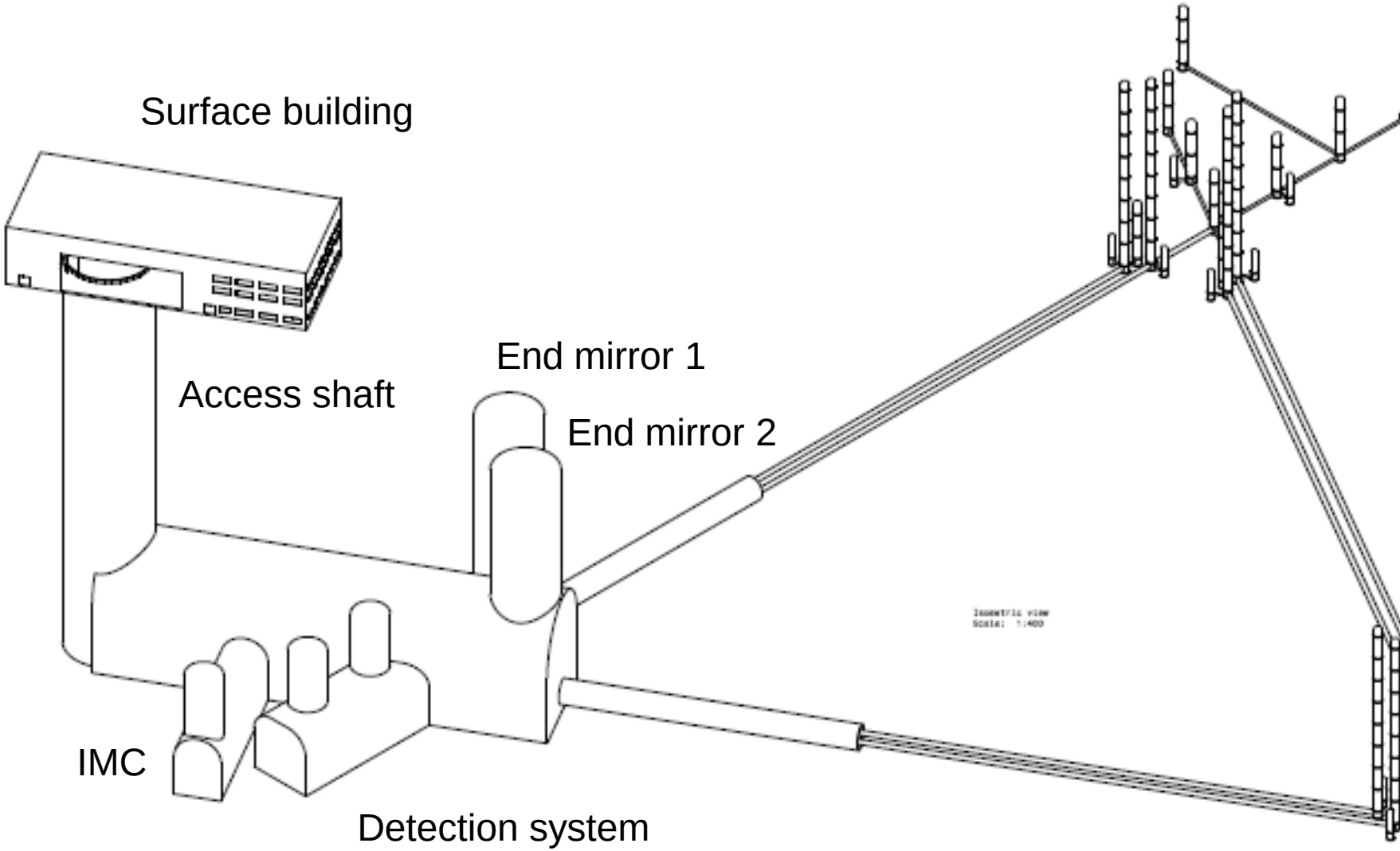
Einstein Telescope

- Main characteristics
  - Arms 10 km length
  - 3 ITFs
  - Separate LP and HP ITF?
  - Underground
  - Cryogenic

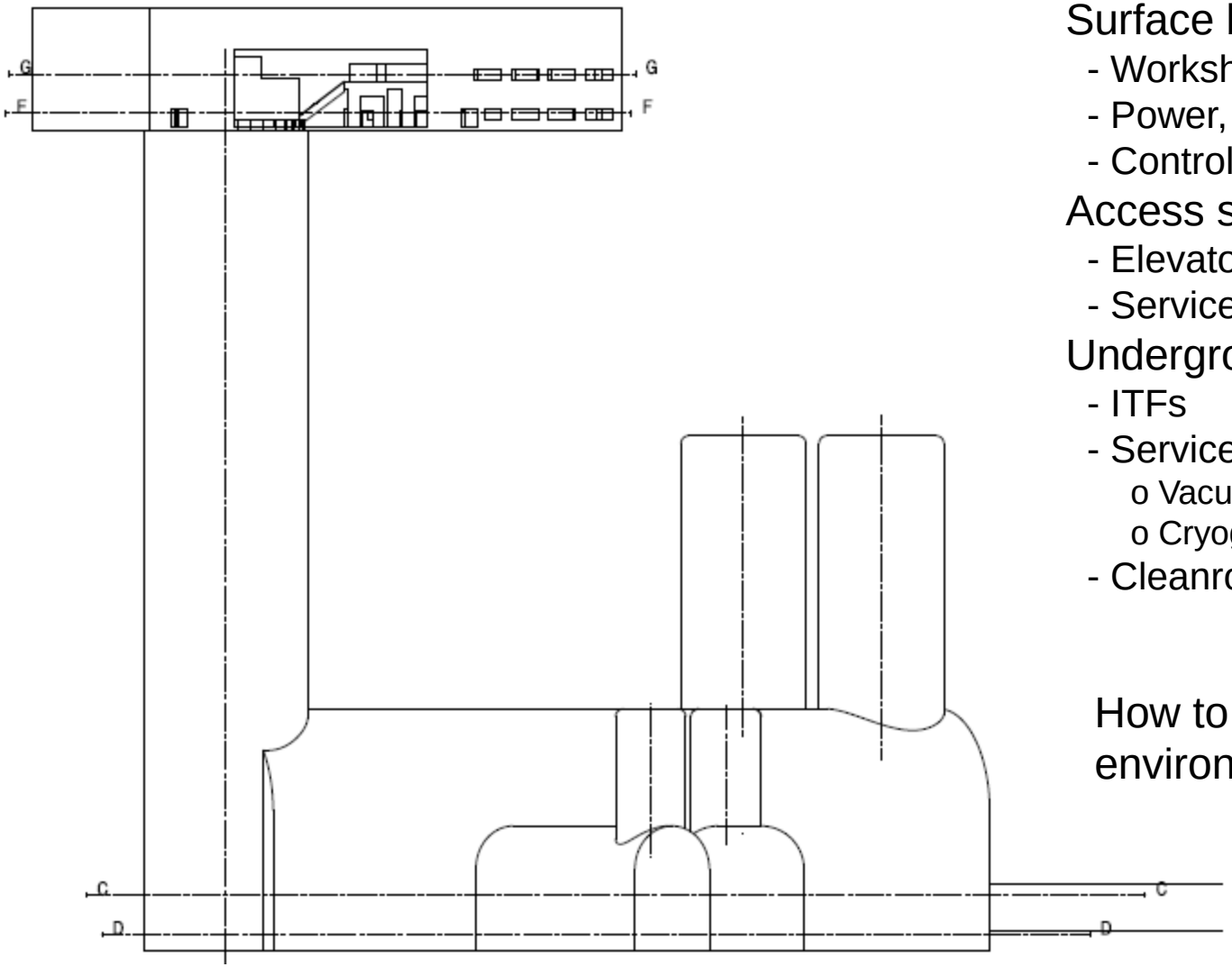


Infrastructure design

Martin Doets



General layout



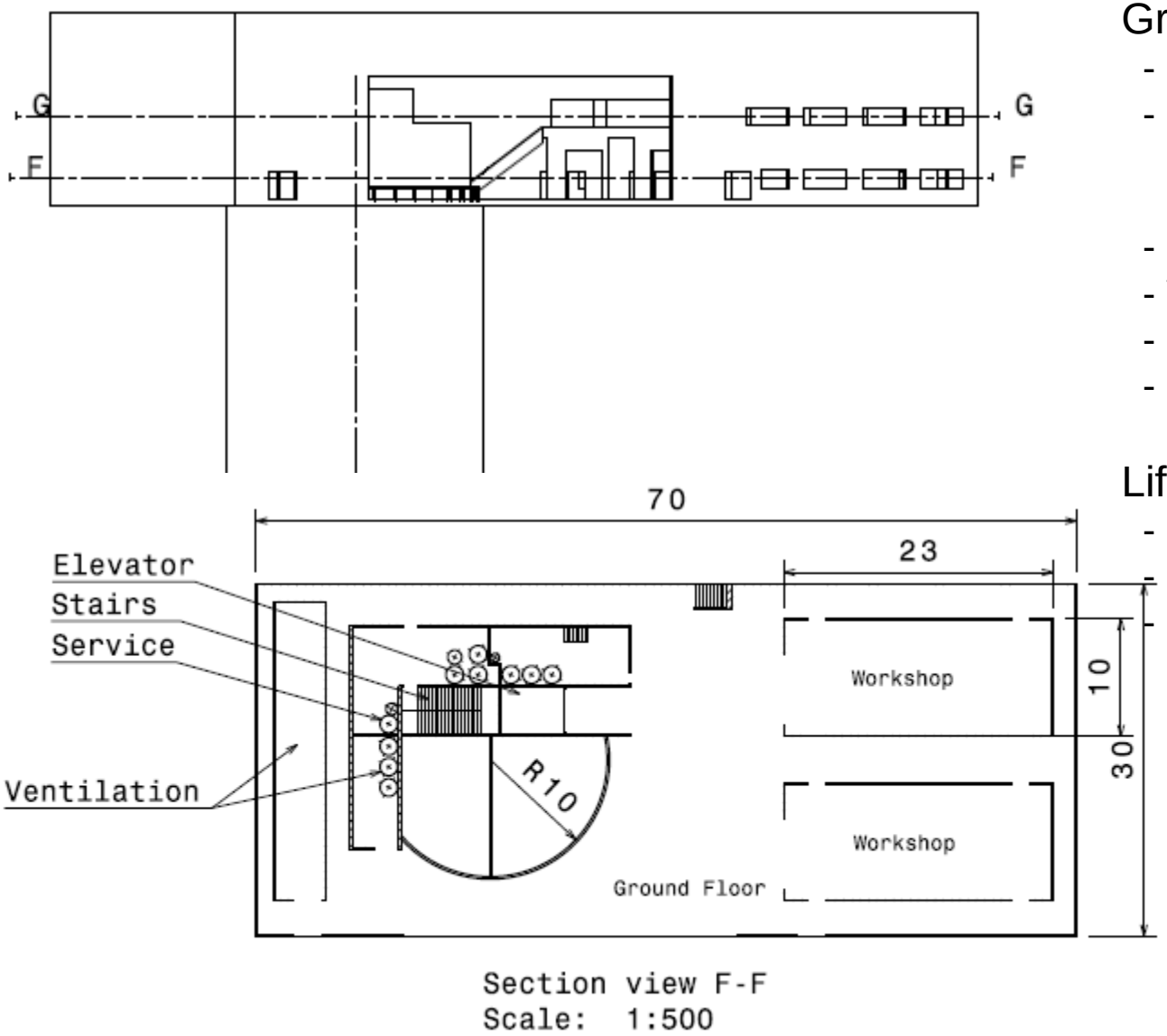
Surface building
- Workshops, cleanrooms, offices
- Power, ventilation, etc.
- Control room

Access shaft
- Elevator, stairs
- Services

Underground facility
- ITFs
- Services
  - o Vacuum
  - o Cryogenics
- Cleanrooms

How to create low noise environment

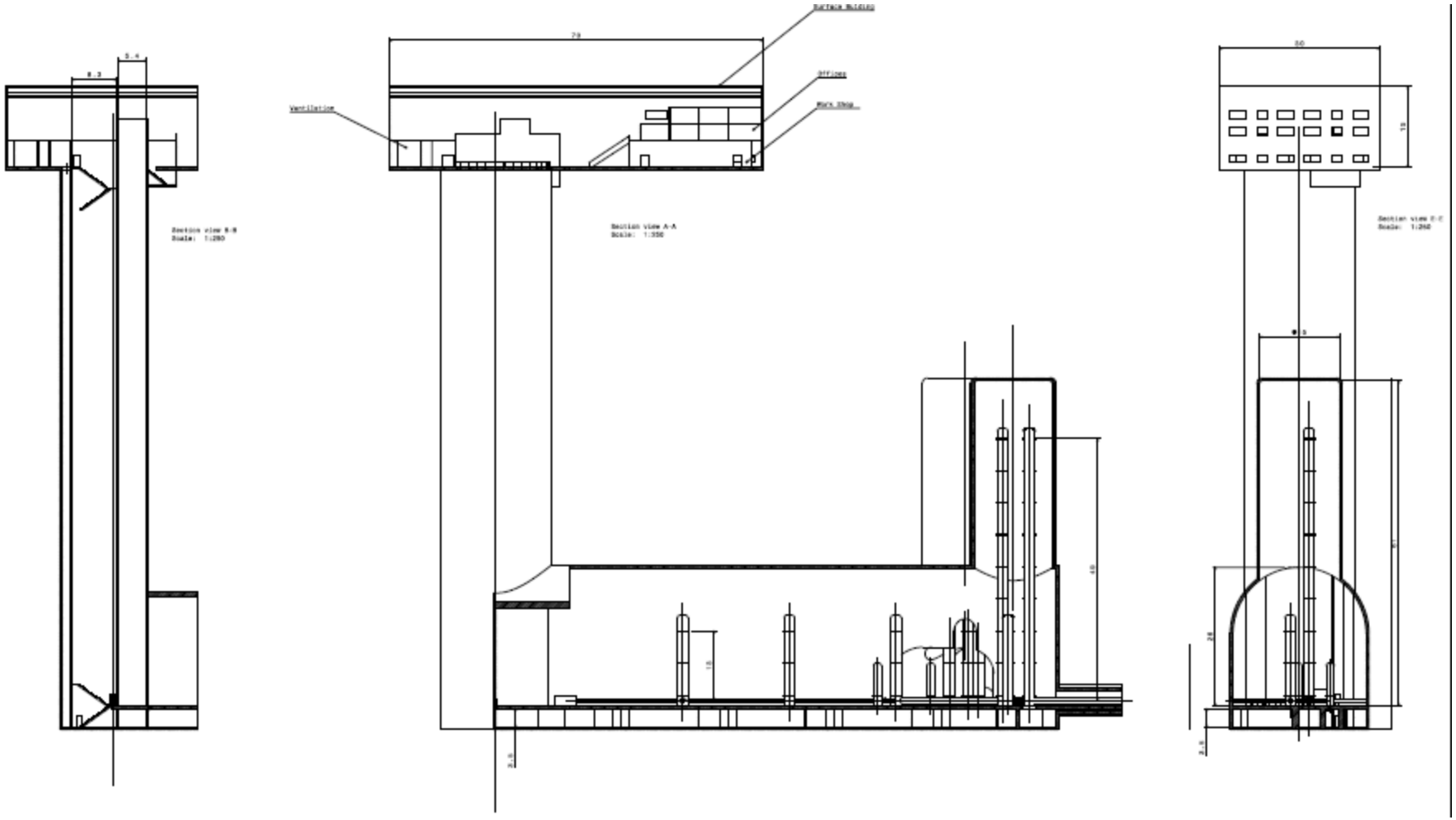
Surface buildings



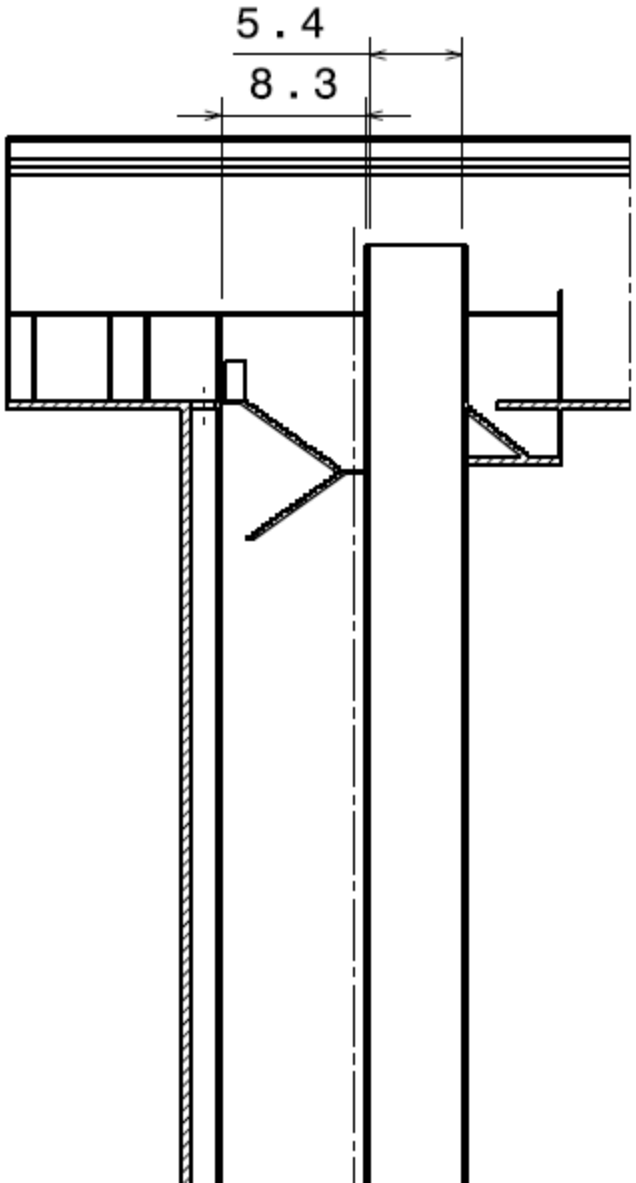
Ground floor
- L = 70 m, W = 30 m
- 2 workshops (23 m x 10 m)
  - o vacuum tubes
  - o cleanrooms later?
- Large entrance doors
- Ventilation system (outside?)
- Cryocoolers?
- Services

Lifting facility
- D = 20 m
- Excavation entrance (TBMs?)
- Stairs, Elevator

Access shafts



Access shafts

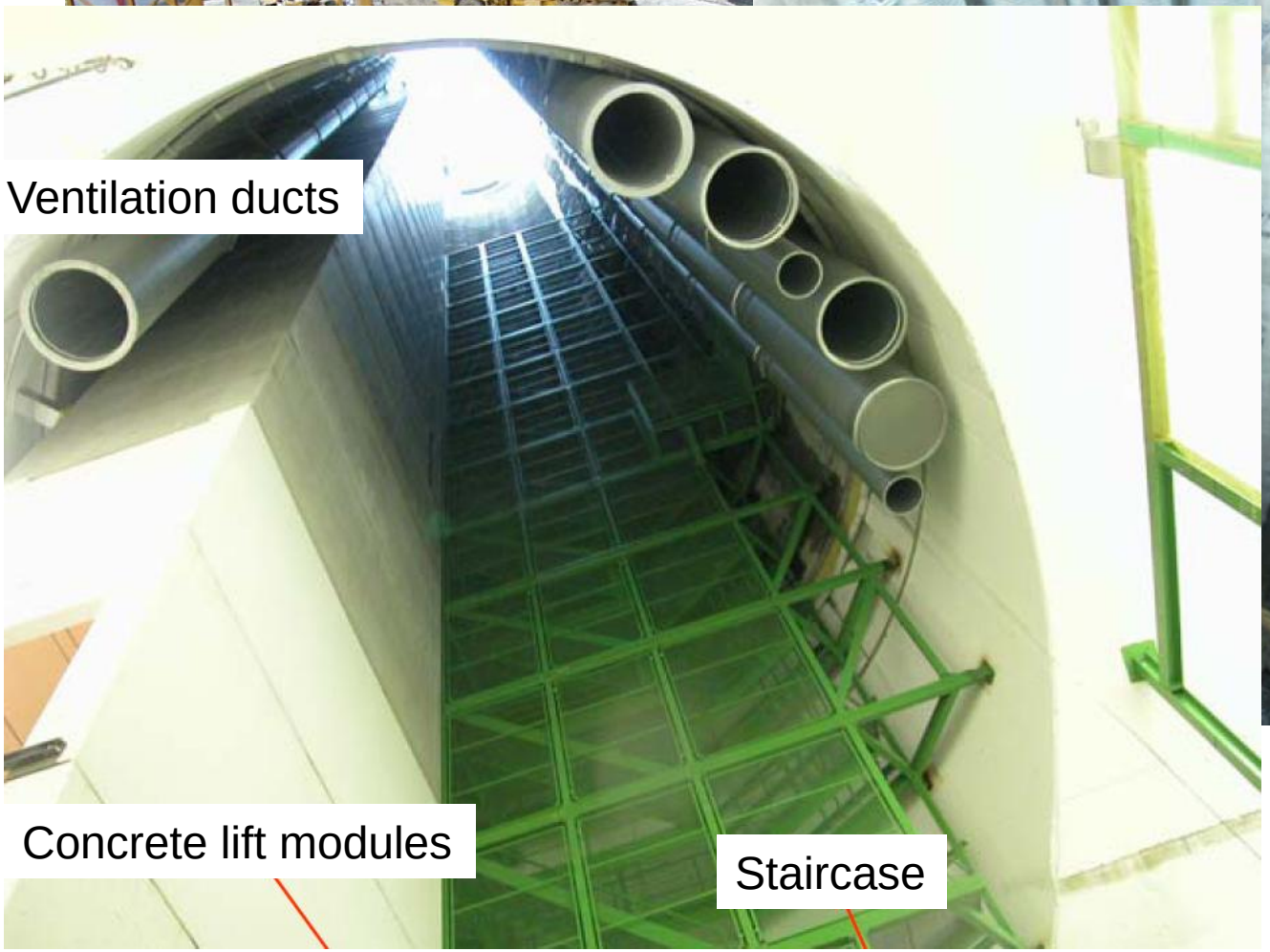


Elevator
- 5.4 m x 4.0 m
- Pressurized (fire containment)

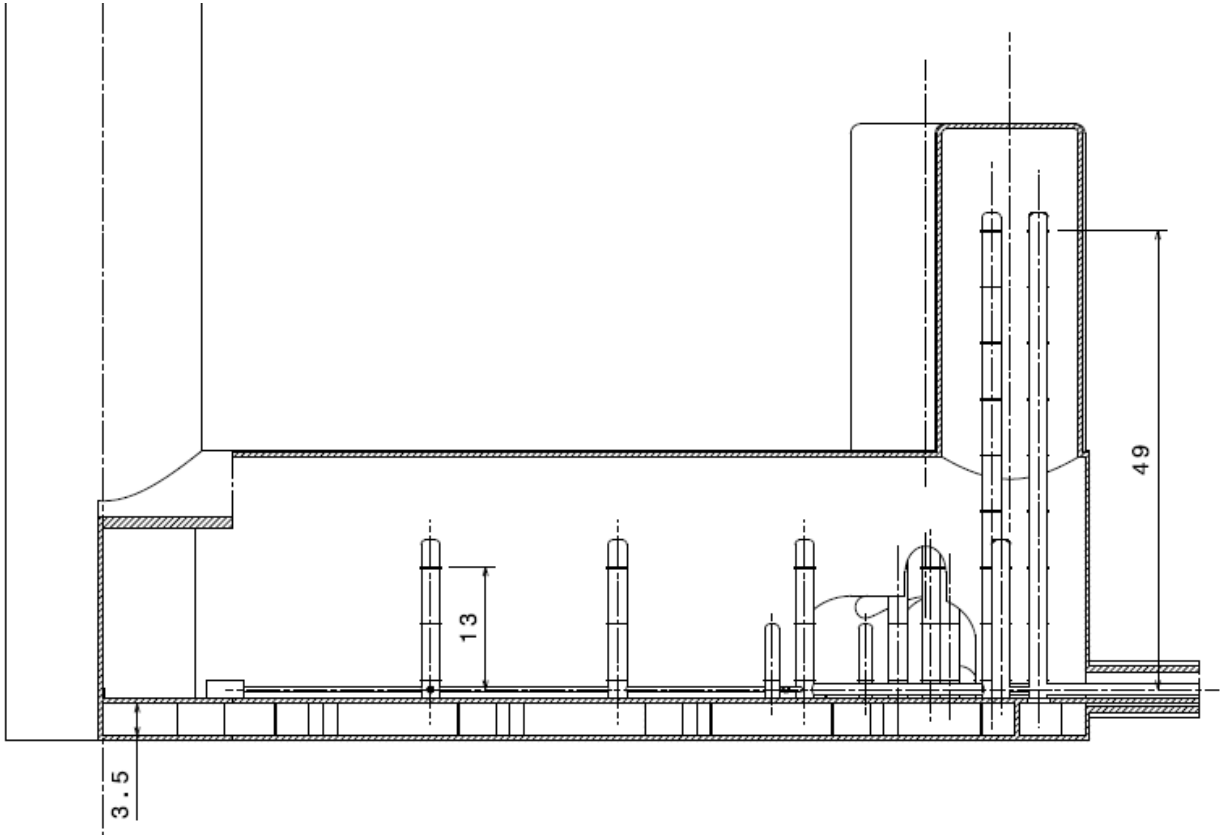
Stairs
- W = 2 m
- Fire doors

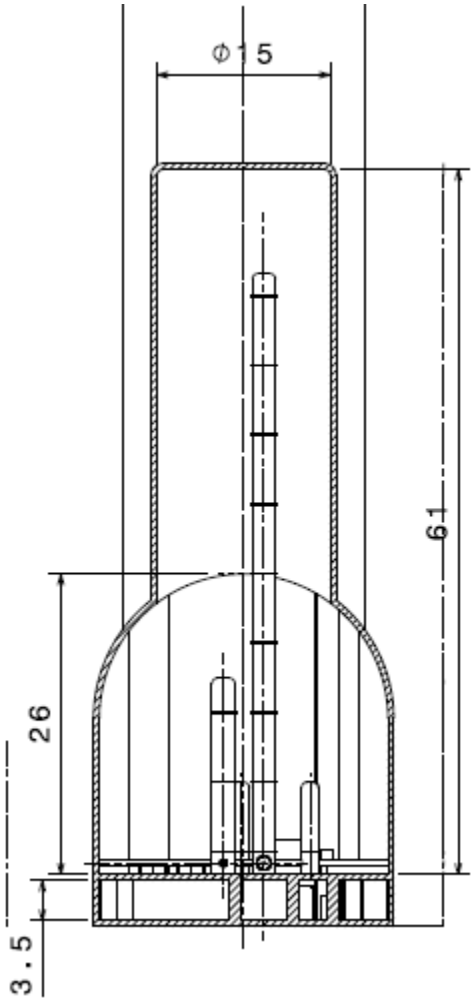
Concrete construction
- Fire proof

LHC project: CMS shaft



Infrastructure design





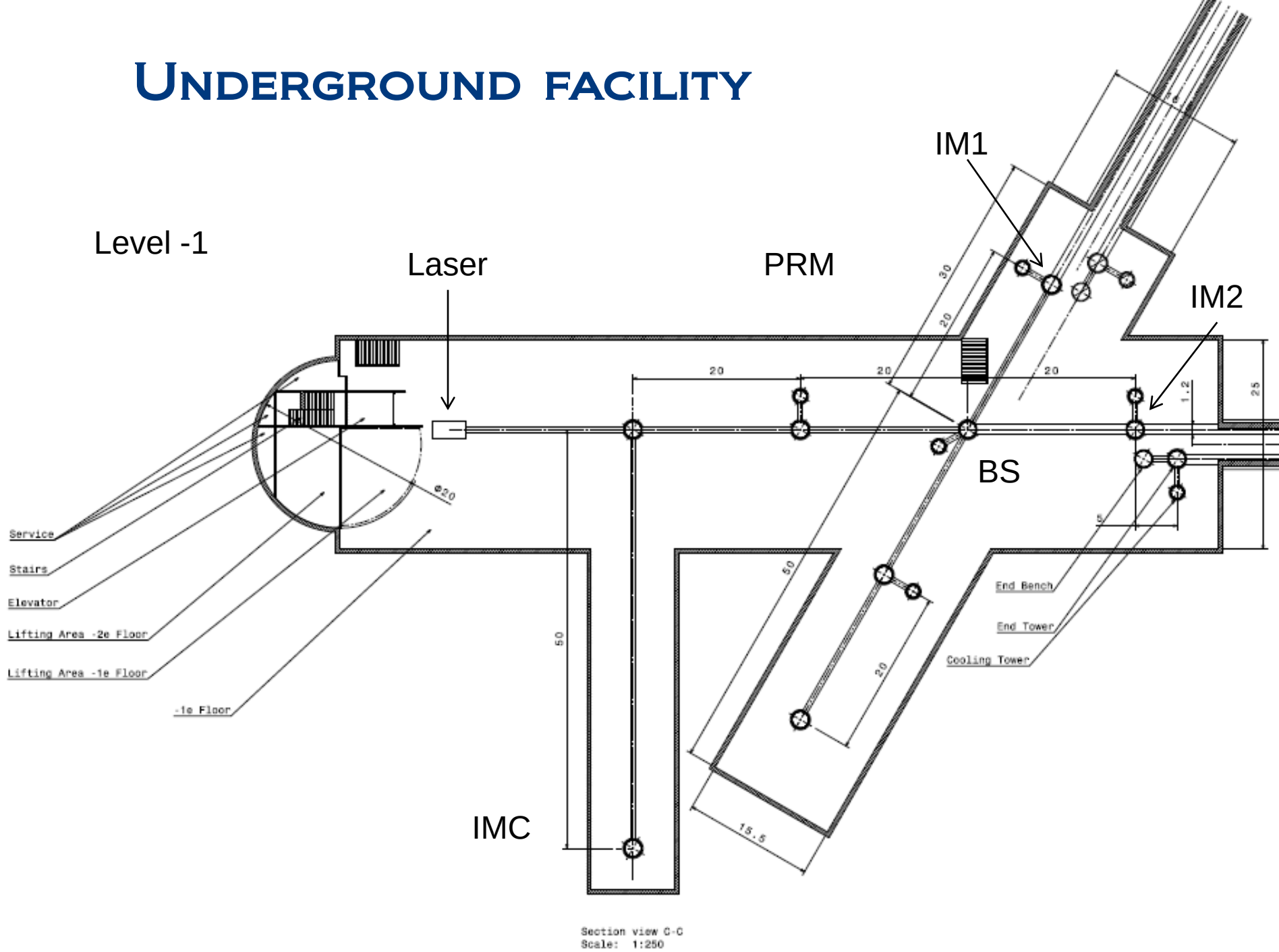
Dimensions:

L = 105 m

W = 25 m

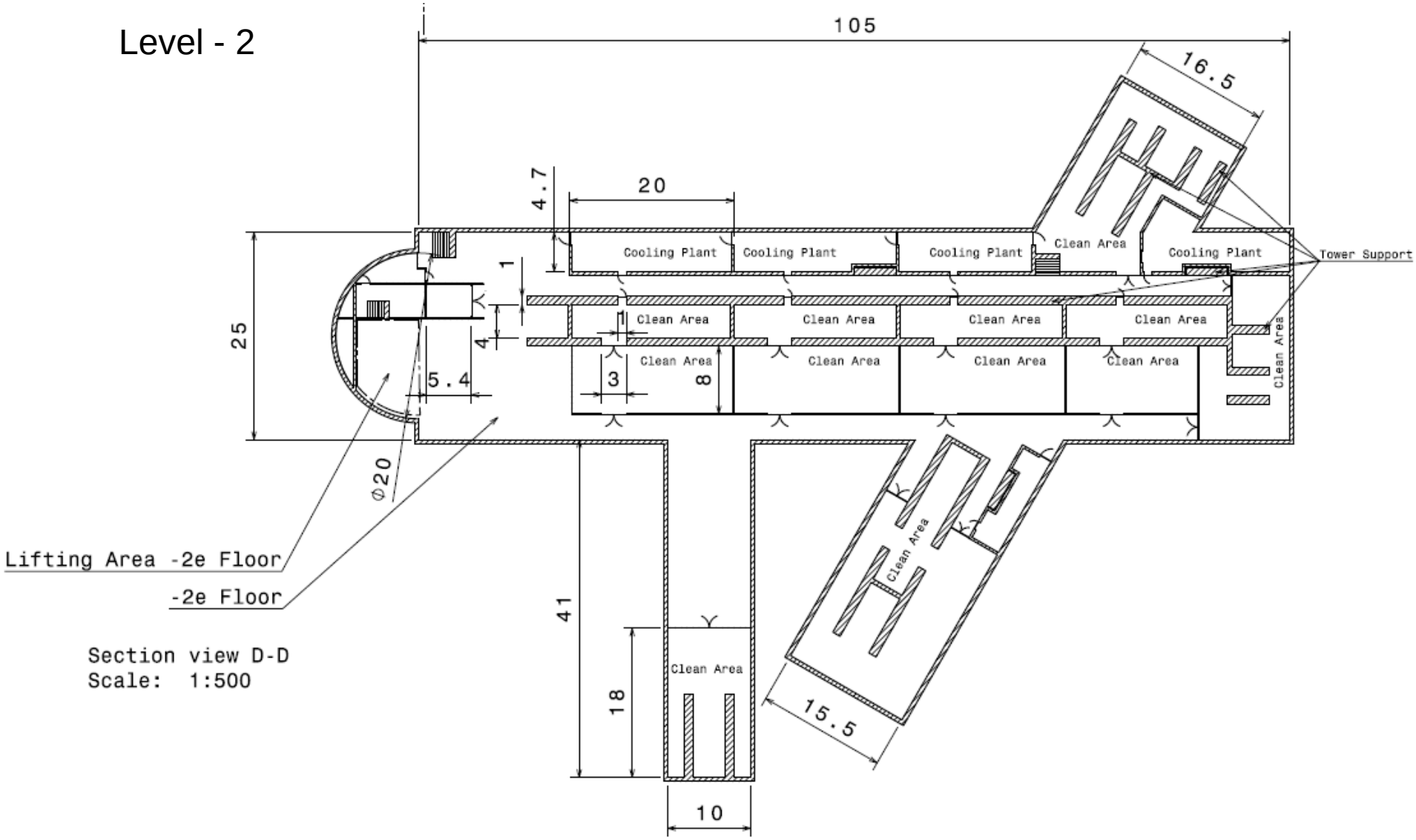
H = 26 + 3.5 m

Underground facility



Underground facility

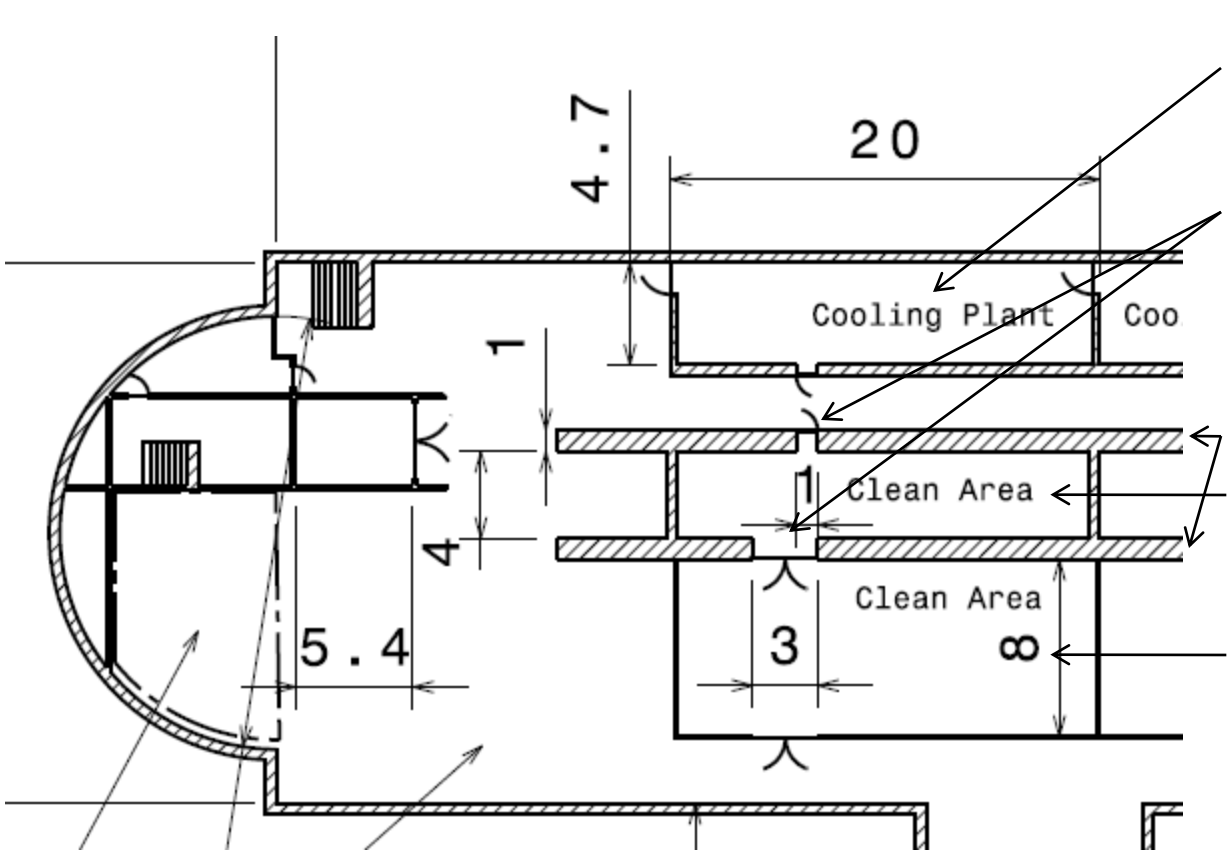
Level - 2



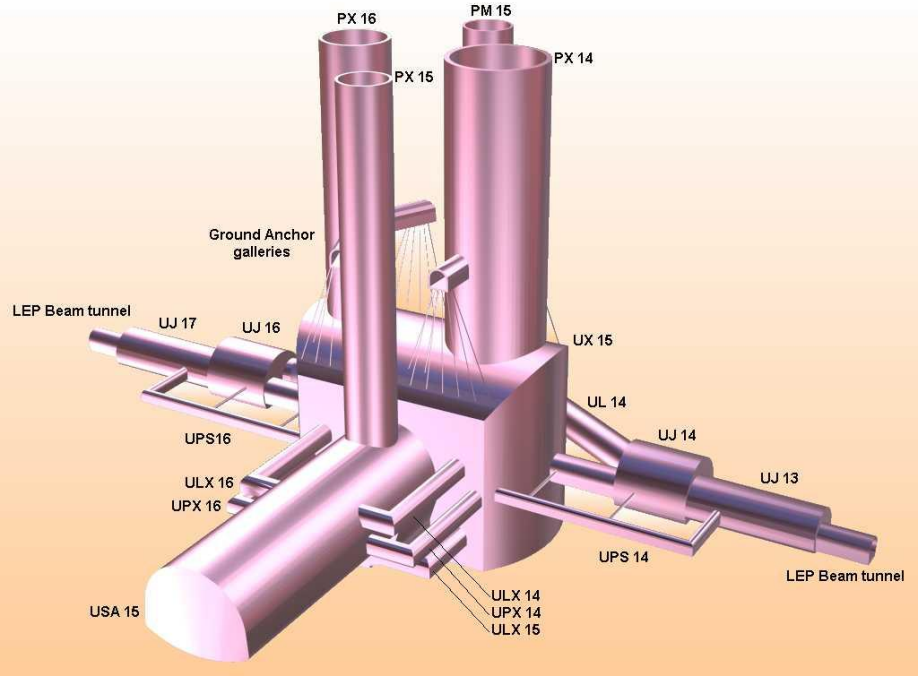
Section view D-D
Scale: 1:500

Underground facility

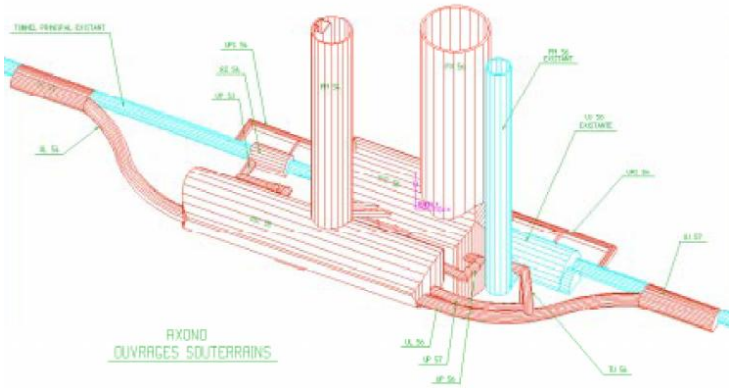
Level - 2



LHC project: Cern Atlas and CMS



- Point 1 (depth ~ 92 m)
  - Shaft PX14 (D = 18, l = 60 m)
  - Shaft PX16 (D = 12.6, l = 60 m)
  - Cavern UX15 (h, w, l = 35, 32, 55 m)
  - Service cavern USA15 (l = 62 m)
  - Construction 4.5 yr



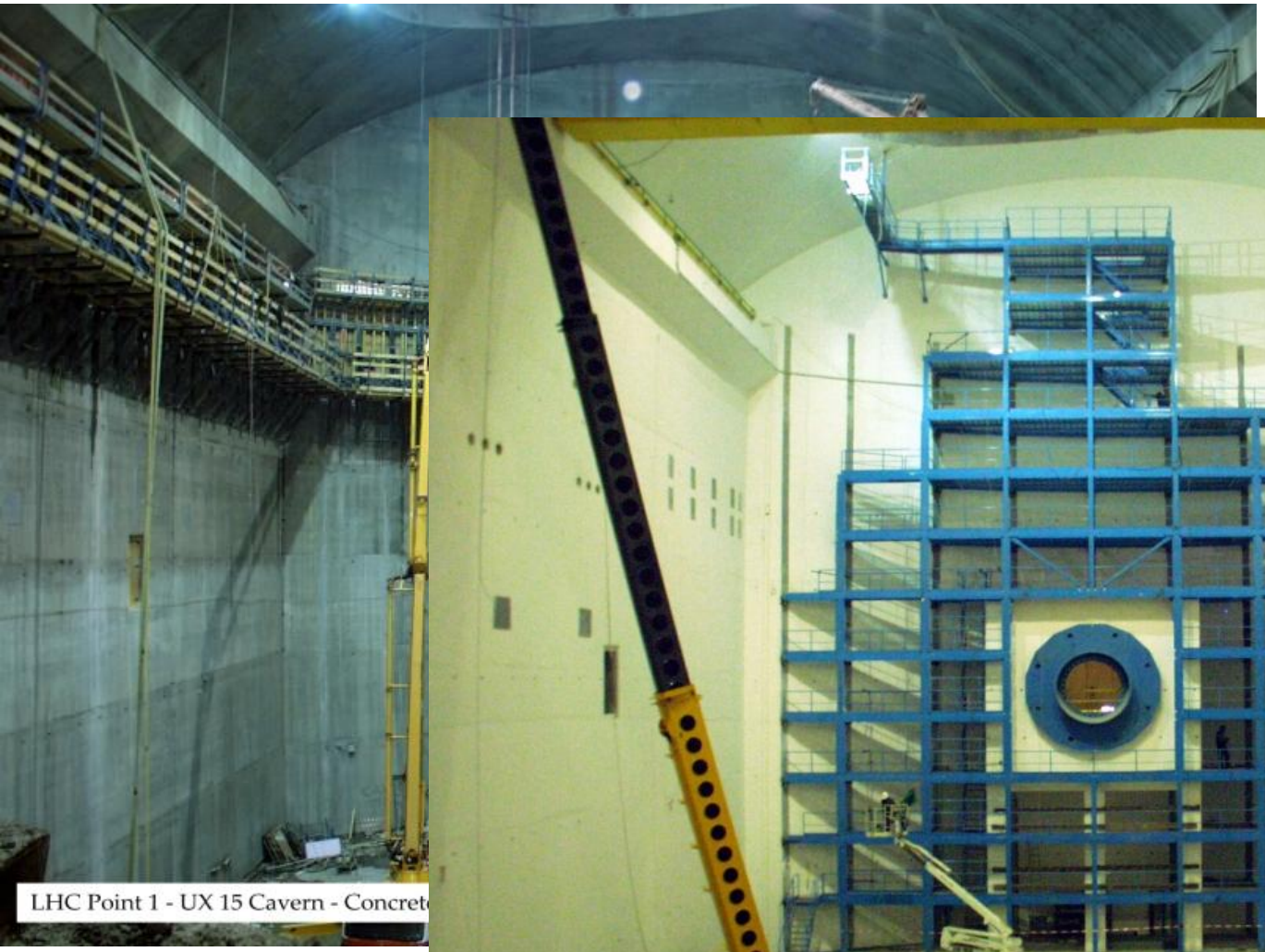
- Point 5 (50 m moraine on top)
  - Shaft : 20.4 m
  - Shaft : 12 m
  - Cavern UX55 (h, w, l = 25, 27, 53 m)
  - Service cavern US5 5 (w = 18 m)
  - Construction 6.5 yr

CIVIL ENGINEERING (ST/CE)

Packages	Location	Works	Engineering Consultant	Main Works Contractors
1	Point 1	Caverns, tunnels, shafts, building for ATLAS U + S Structures for LHC	EDF (F) KNIGHT & PIESOLD (GB)	TEERAG-ASDAG (A) BARESEL (D) LOCHER (CH)
2	Point 5	Caverns, tunnels, shafts, building for CMS U + S Structures for LHC	GIBB (UK) GEOCONSULT (A) SGI (CH)	DRAGADOS (E) SELI (I)
3a	Other areas (except TI 8)	U + S Structures for ALICE (P2) and B-Physics (P8) Transfer tunnels, TI 2, Beam Dump and other U + S Structures for LHC	BROWN & ROOT (UK) INTECSA (E) HYDROTECHNICA (P)	TAYLOR-WOODROW (GB) AMEC (GB) SPIE-BATIGNOLLES (F)
3b	TI 8	Transfer tunnel TI 8	Dito	SCRASA (CH) LOSINGER (CH) REYMOND (CH) PRADER (CH)

LHC project: CMS cavern

LHC project: Atlas cavern



LHC Point 1 - UX 15 Cavern - Concret

LHC Point 1 - UX 15 Cavern - Installation of HO steel stucture - 16-07-2003 - CERN ST/CE

Vacuum issues: partial pressures

- PSD depends on
  - Length of beam path
  - Gaussian beam radius
  - Most probable velocity
  - Spectral frequency
  - Molecular number density
  - Polarizability
  - Apparent length difference amplitude SD

$$S_L(f) = \frac{4\rho(2\pi\alpha)^2}{v_0} \int_0^{L_0} \frac{\exp\left[-2\pi f\, w(z)/v_0\right]}{w(z)}\, dz$$

$$\Delta\tilde{L}(f) \equiv \sqrt{S_{\Delta L}(f)} = \sqrt{2S_L(f)}$$

- Consequences for ET
  - Length helps
  - Larger beam size (12 cm radius) helps
  - Sensitivity ET about 10^{-25} /rtHz
  - AdV for 1.5×10^{-25} /rtHz we need $P_{H2O} \approx 10^{-10}$ mbar, $P_{H2} \approx 10^{-9}$ mbar
  - For ET we need order of magnitude and thus lower partial pressures (factor 5 or so)

Under study at EGO

Vacuum issues: coating Brownian noise

- Assume beam size radius 12 cm
  - Mirrors of 60 – 65 cm diameter
  - Diffused light

$$S_x(f) = \frac{4k_B T}{\pi^2 f Y} \frac{d}{r_0^2} \left(\frac{Y'}{Y} \phi_{\parallel} + \frac{Y}{Y'} \phi_{\perp} \right)$$

- Criteria applied in Virgo to moderate diffused light
  - Minimum free aperture radius is 5 times larger than the average beam radius.
  - Any discontinuity (potential reflecting spot) of the vacuum enclosure is hidden by suitable absorbing glass baffles, with respect to the beam spot on any mirror.
  - No point of the smooth surface of the vacuum enclosure can be seen contemporarily by the beam spots on two facing mirrors.
  - Moreover, in the main part of the arm tubes, between two large valves, all the inner surface is hidden by conical stainless steel baffles, with respect to the beam spots on the mirrors

Simple scaling from Virgo+:

Dmirror = 35 cm

Dbaffles up to 85 cm

Dvessel = 1.2 m

	input mirror	end mirror
beam radius [mm]	56	65
ROC [m]	1416	1646

Table 8: Design parameter of the AdV arm cavity geometry

Consequences for ET vessel diameter!?

ET Tunnel: at least 2 beams, maybe 4 beams

Summary

- Year 2 goal: formulate a first-order design for ET
  - Suspensions
  - Optics
- Draw first conclusions from GGN simulations
  - Depth
  - Cavern size
  - Preferred geology
- Prepare infrastructure design
  - Homestake type facility
  - Cern / Gran Sasso type facility
- Prepare cost estimate
- Other issues
  - Safety issues