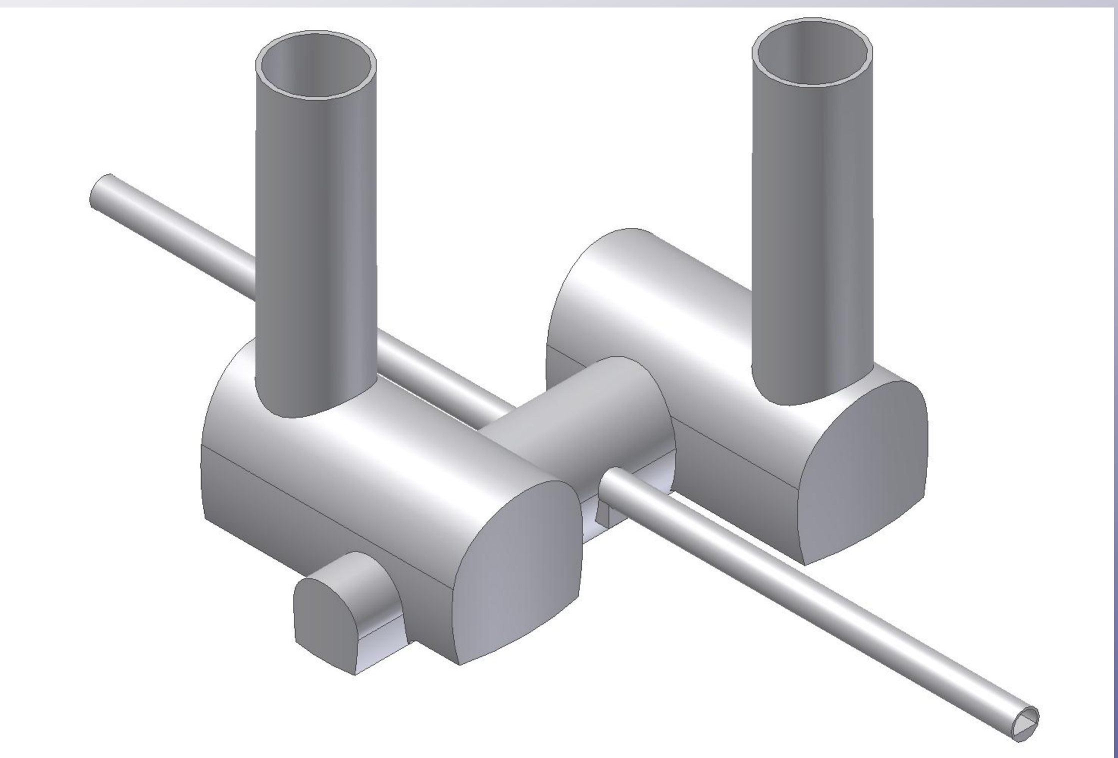
CLIC Experimental Area Layout
Design Considerations & ARUP Study



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Contents.

The design of the CLIC Experimental Area has evolved in time, following the requirements coming from the MDI working group and the feed-back given by CERN Civil Engineering expert (J. Osborne) and the Arup company.

In the present talk we have summarized:

1) The optimization of the EA layout, following the detectors requirements.

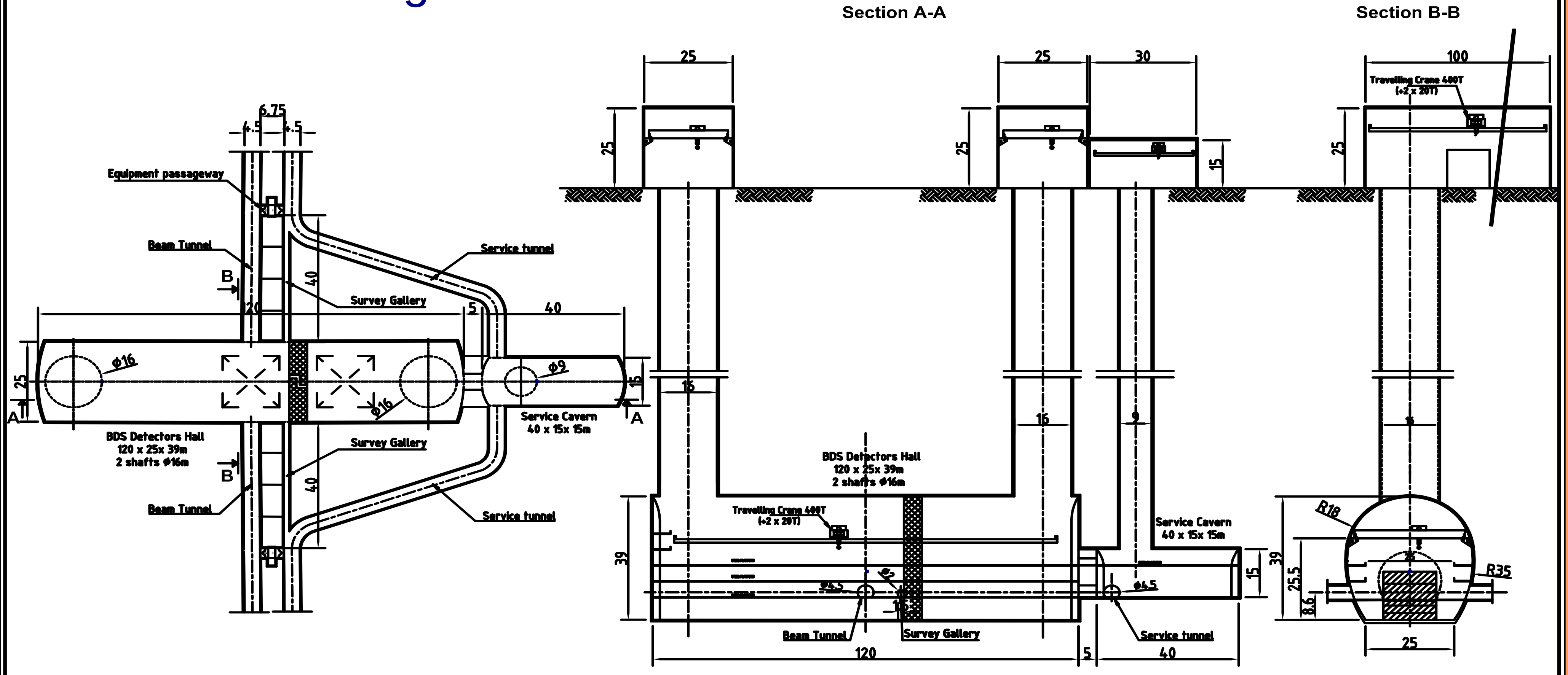
2) The study performed by Arup and their suggestions to improve the EA design.

Part 1)
Introduction.

The push-pull scenario and the coexistence of two detectors in the same experimental area set some specific requirements to the civil engineering and to the design of underground infrastructures.

- ❑ The most basic one being a fair sharing of the underground facilities between the two detectors → symmetric layout.
- ❑ Then the possibility to move the detector form garage to beam in the fastest and safest way → detector platform, cable-chains.
- ❑ Third, to guarantee, by an appropriate design, that the personnel safety (radiation shielding, ventilation, escape routes) is always assured → shielding/separation of beam-area wrt service area.
- ❑ The detector assembly scenario plays a fundamental role in the design of the underground facilities → position of shafts, cranes capacity, assembly space.
- ❑ Finally, contribute to reduce the noise injected to the machine final focus magnets → integrate a passive isolator at the interface between machine and detector, remote services skids.

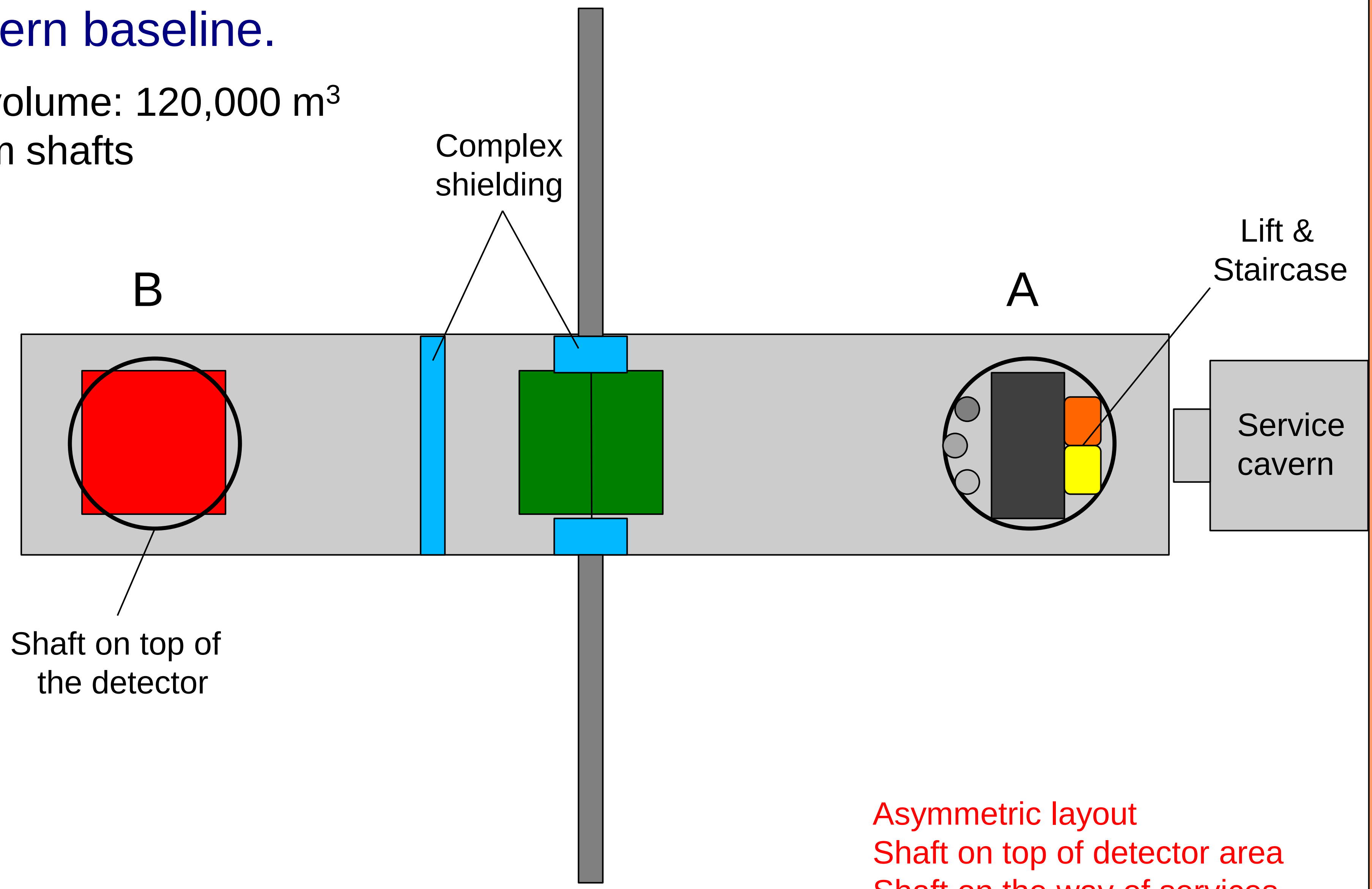
ILC baseline design.



ILC - BDS - DETECTORS HALL AREA LAYOUT AND SECTIONS (PUSH PULL OPTION) RDR IV 2 ANNEX 4

UX Cavern baseline.

Cavern volume: 120,000 m^3
2 x Φ16m shafts



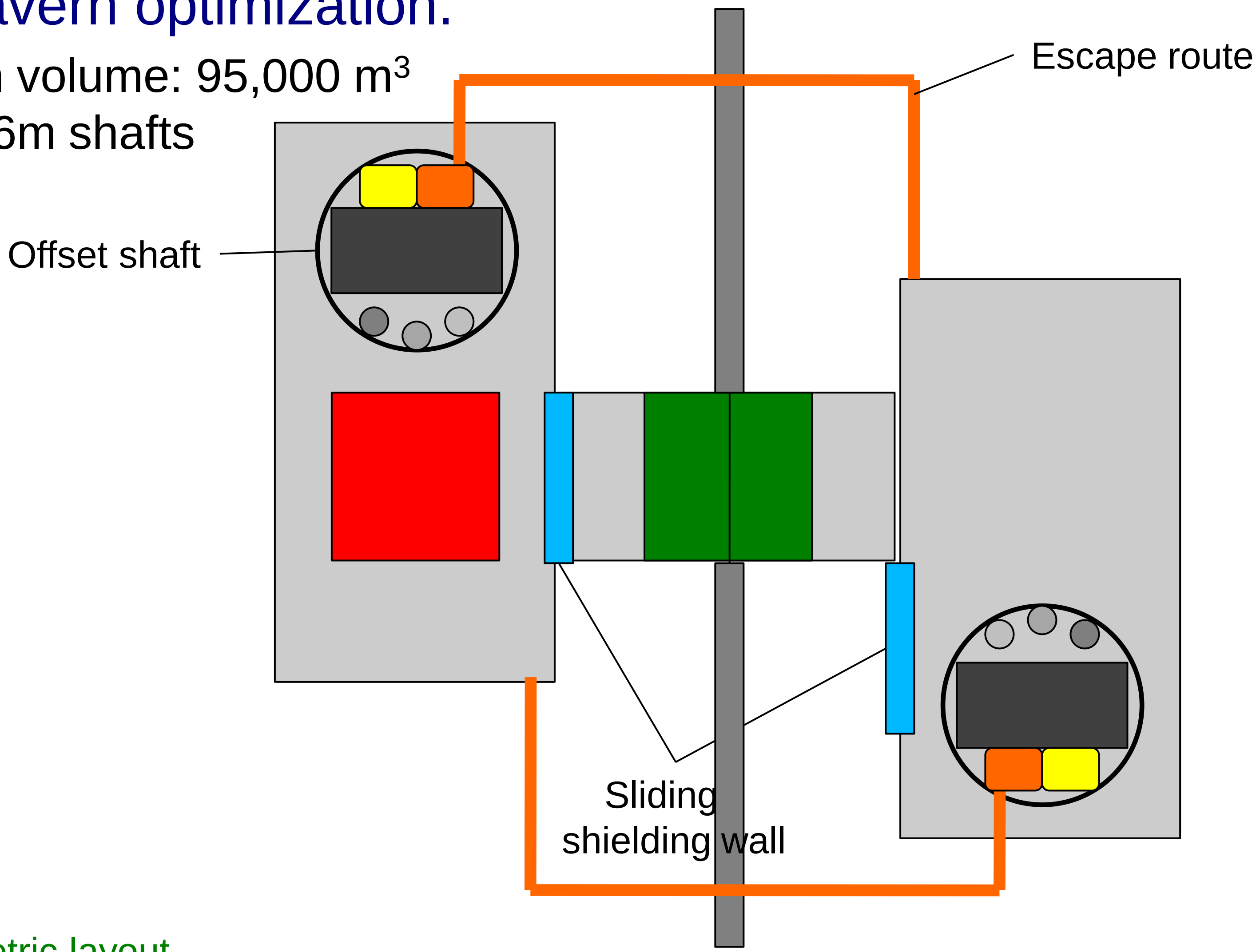
Asymmetric layout
Shaft on top of detector area
Shaft on the way of services
No escape route for detector B

Easy to build

UX Cavern optimization.

Cavern volume: 95,000 m^3

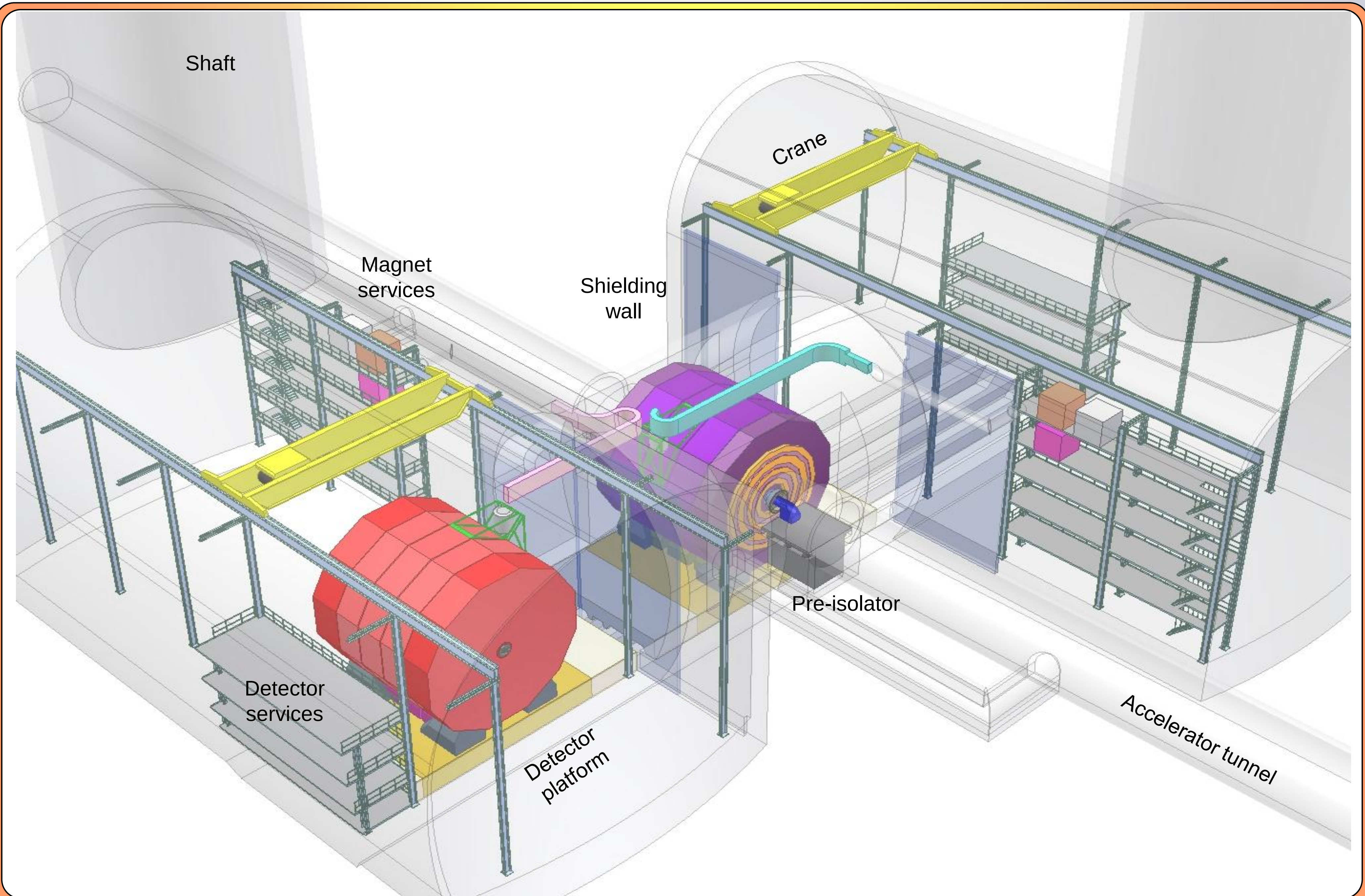
2 x Φ16m shafts



- Symmetric layout
- Redundant escape routes
- Easy shielding
- Large assembly area

- No detector opening when on-beam
- Complex escavation

CLIC Experimental Area Layout



Civil Engineering issues.

Considering the complex escavation, a geological study by independent experts has been suggested by J. Osborne to evaluate the feasibility of the layout and the long term stability of the experimental area, in view of the push-pull scenario.

The study has to consider the local geology by analysing ground samples at different depths, the survey measurements taken in the last years after the excavation of the two large underground caverns of Atlas & CMS experiments and the proposed cavern geometry.

Part 2)
Arup study.

ARUP is a civil engineering consultant company that has been mandated by CLIC/ILC to perform the following study (splitted into task 1 & 2):

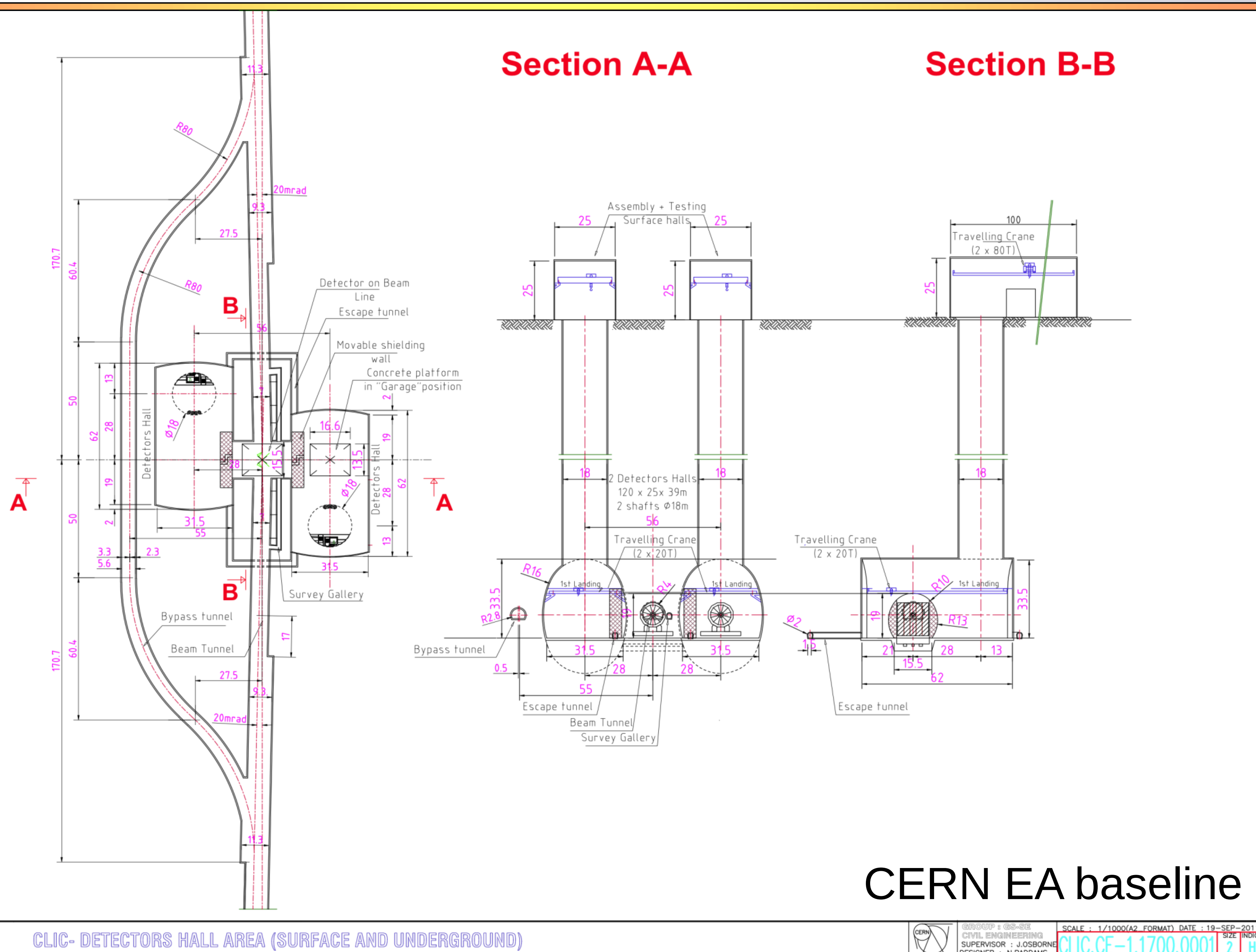
Task 1: Development of a design concept for a detector platform that is compatible with both air-pad and roller movement systems to move the detectors in and out of the beam-line.

Task 2: Study the layout of the experimental cavern complex from a geotechnical standpoint, using the CLIC layout and CERN geology as reference model.

Task 2 Cavern Study

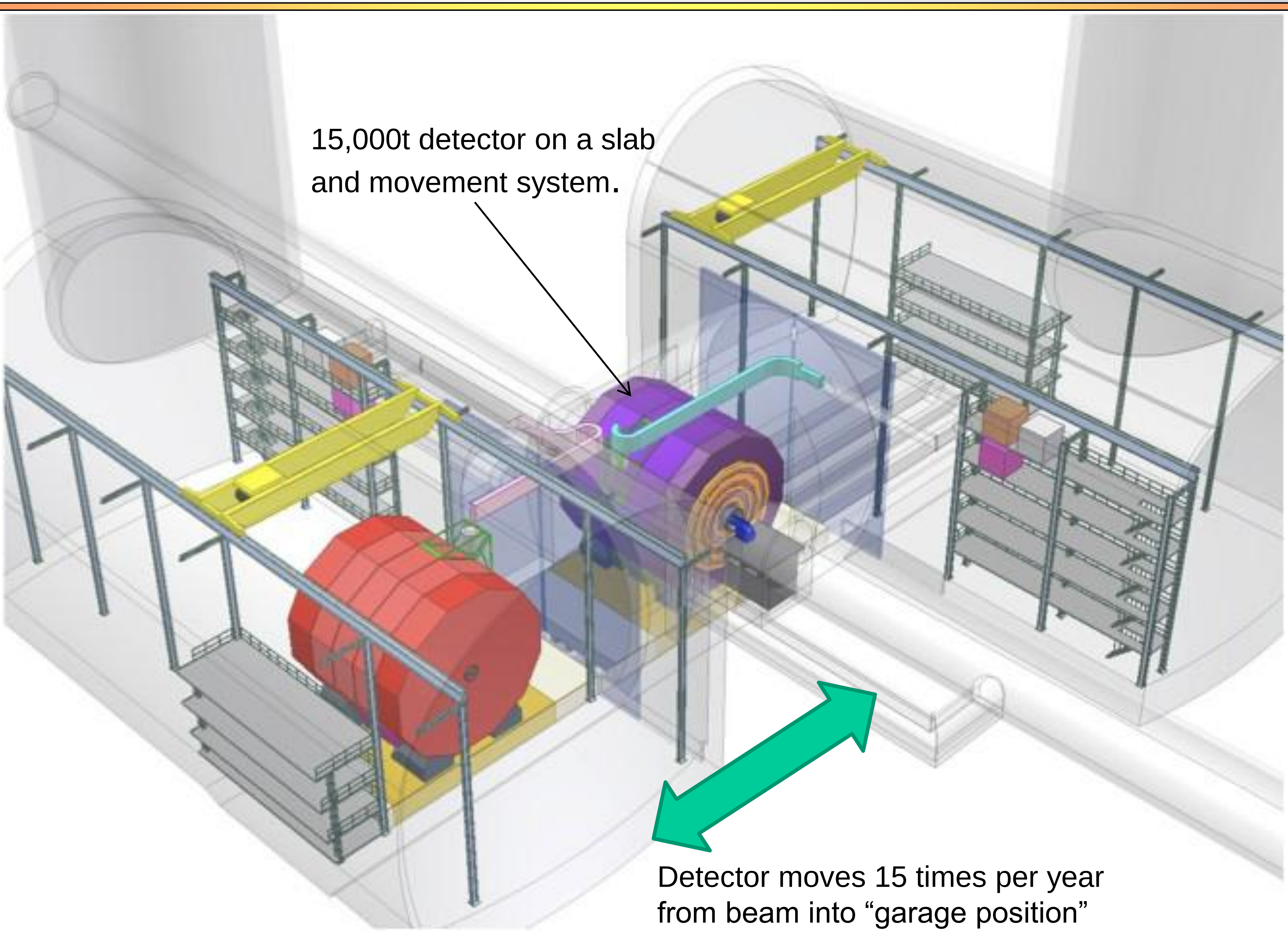
Ground model and 3D cavern layout

Matt Sykes
Eden Almog
Alison Barmas
Yung Loo
Agnieszka Mazurkiewicz
Franky Waldron

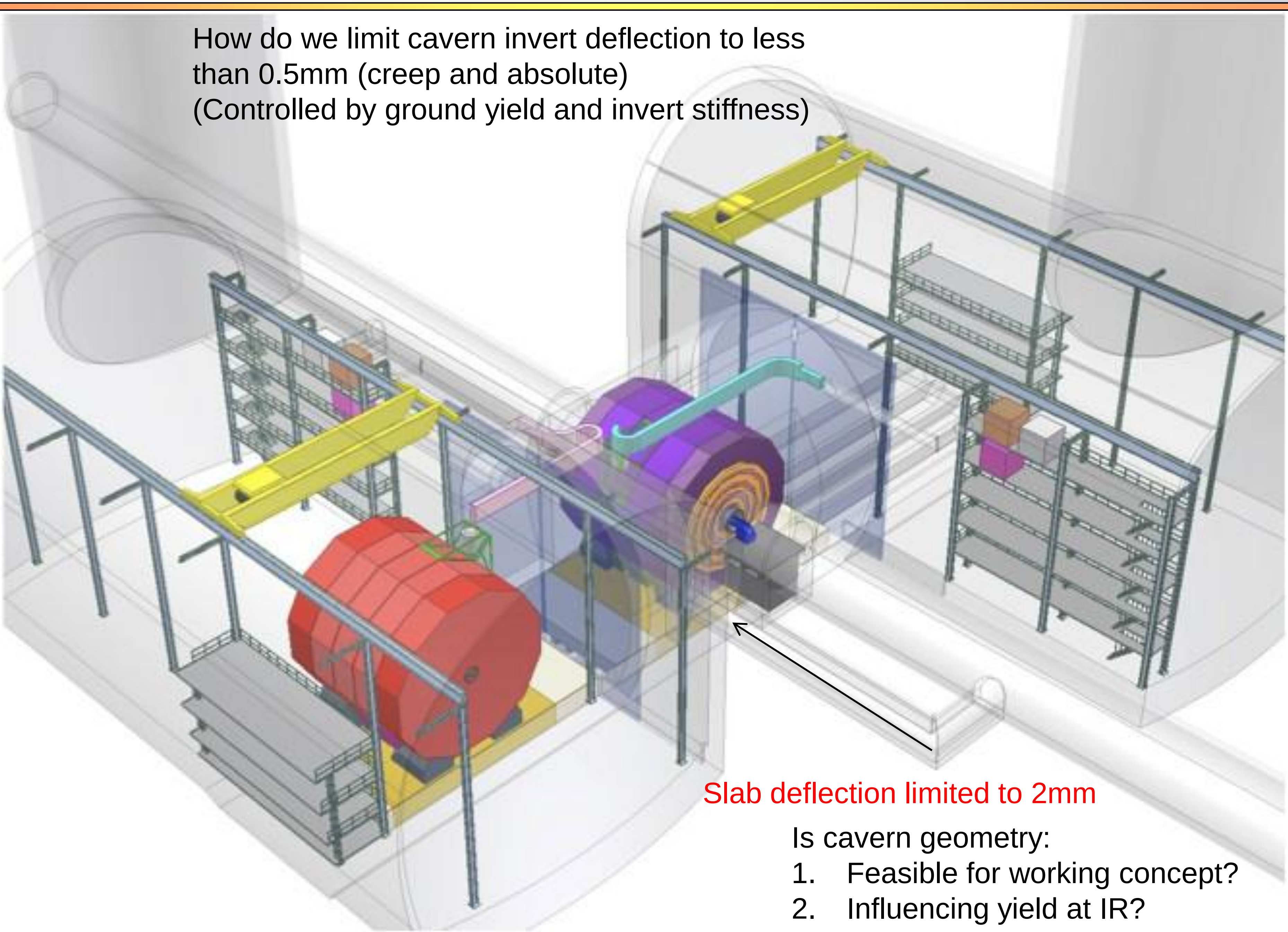


CERN EA baseline

CLIC Experimental Area Layout



How do we limit cavern invert deflection to less than 0.5mm (creep and absolute)
(Controlled by ground yield and invert stiffness)

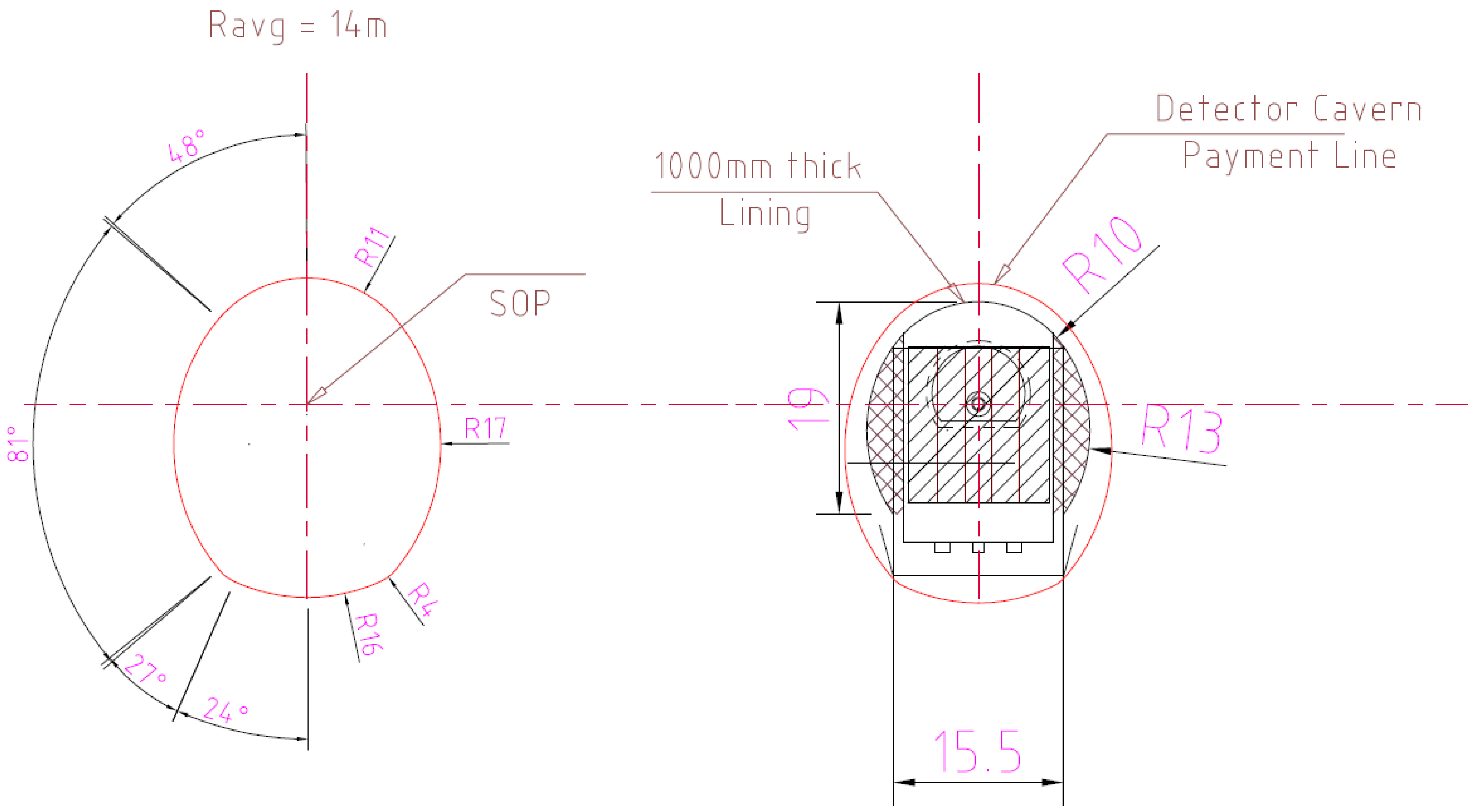


Slab deflection limited to 2mm

Is cavern geometry:

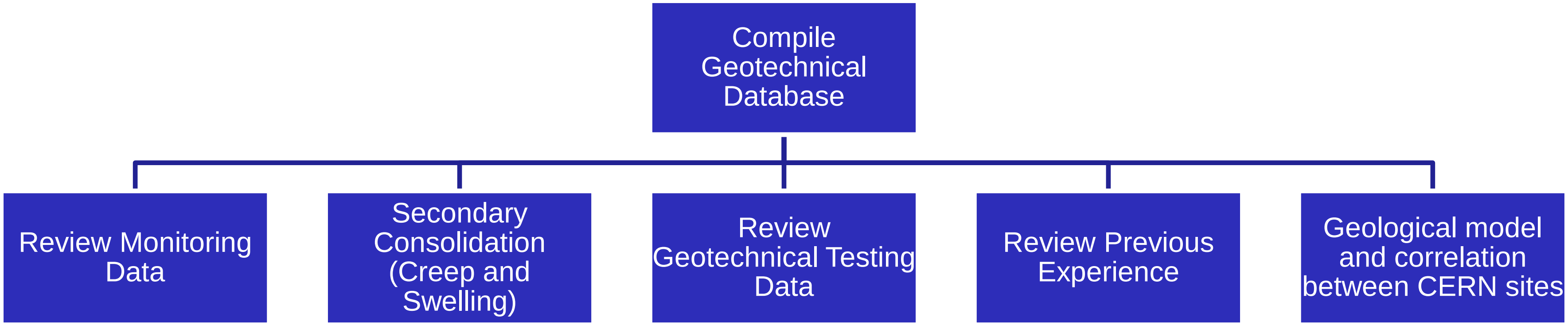
1. Feasible for working concept?
2. Influencing yield at IR?

Interaction Cavern Outline Geometry

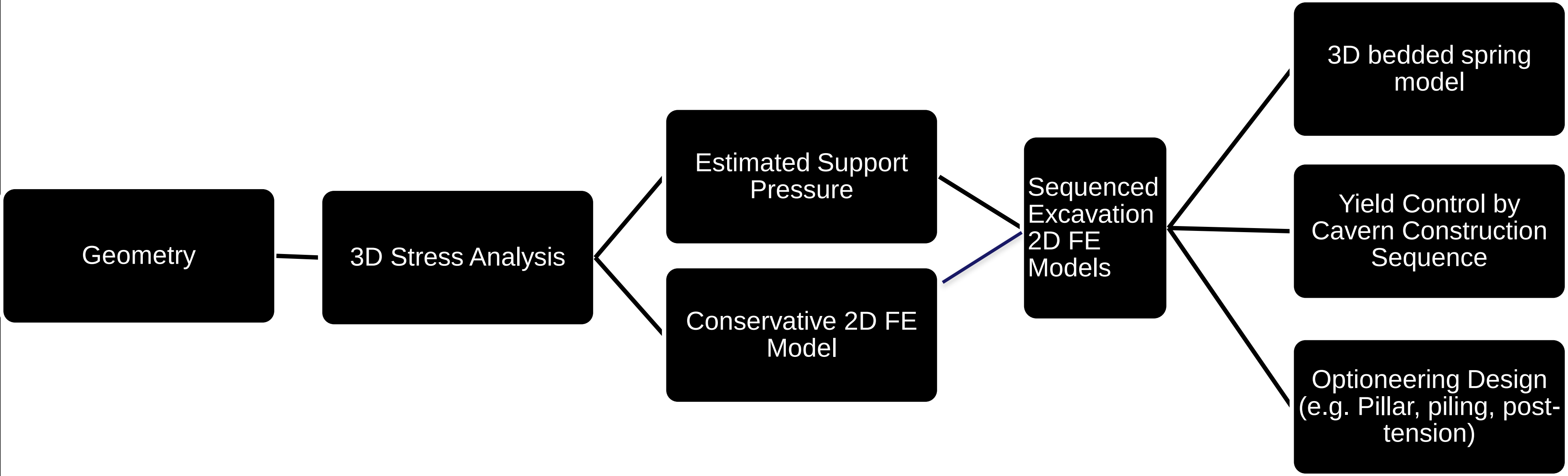


Task 2 – Study Summary

Geotechnical Review



Cavern Design



Task 2 Cavern Study

Stress Analysis & Ground Yielding

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Alison Barmas
Yung Loo
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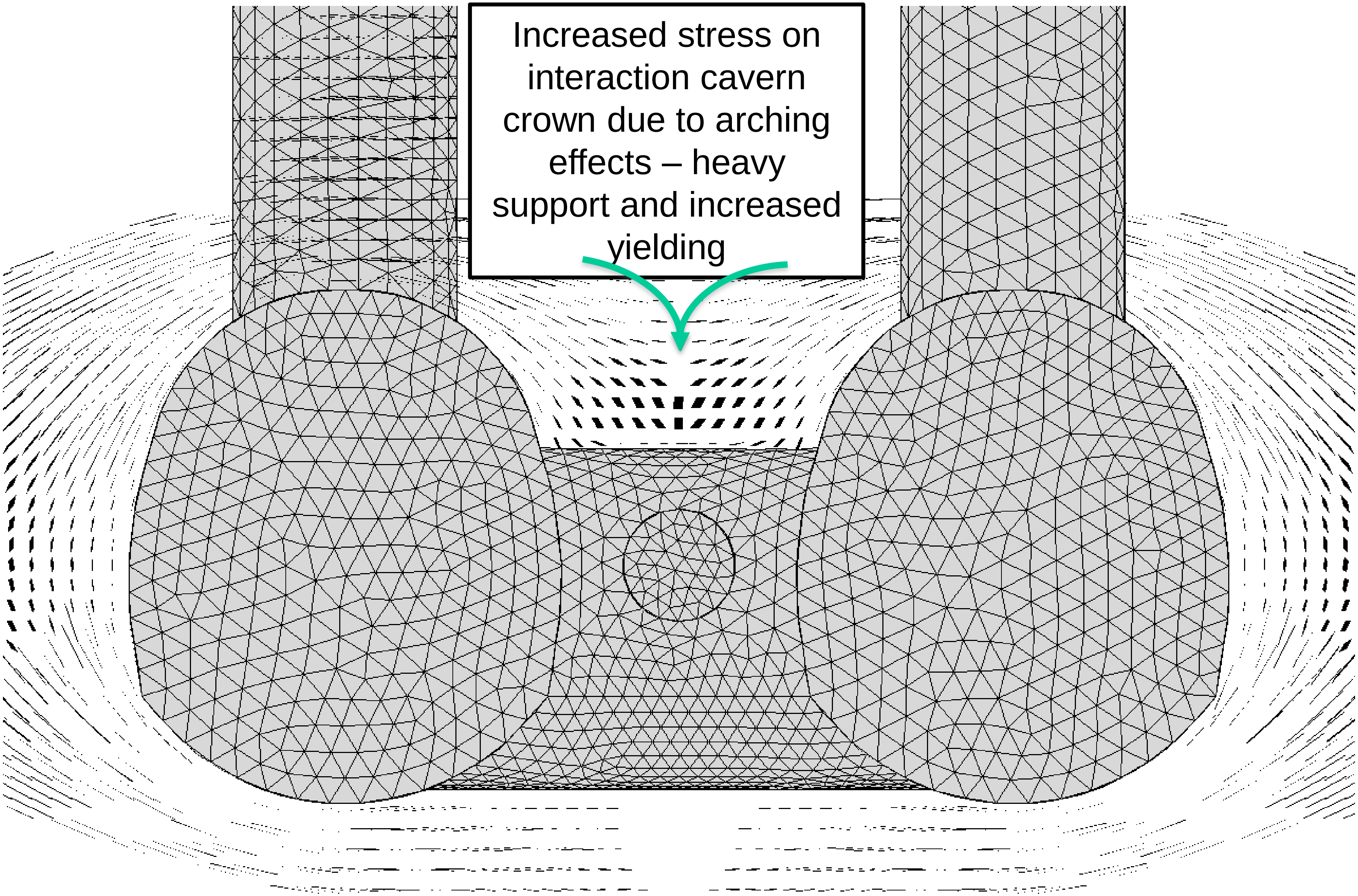
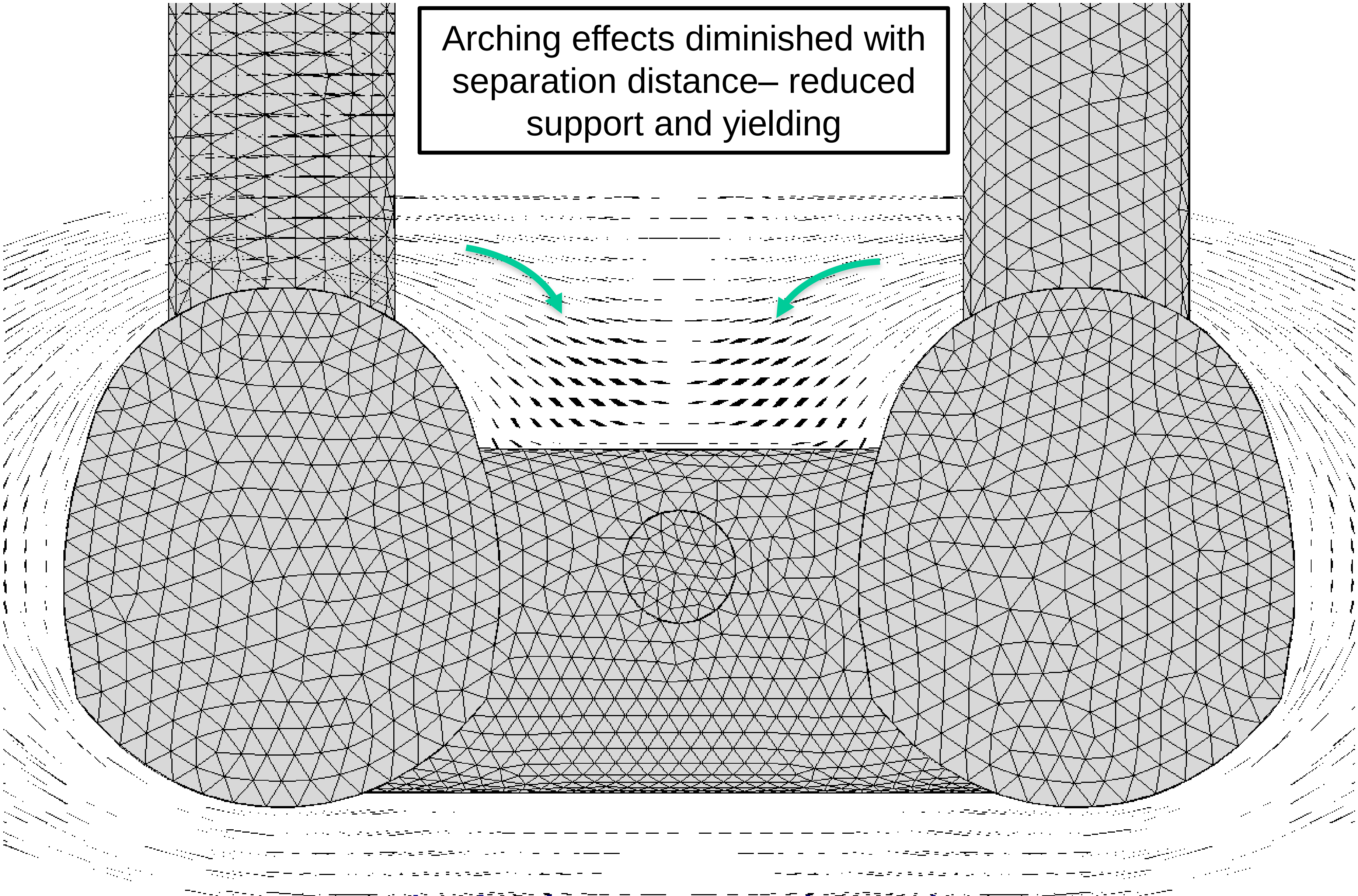
Franky Waldron

Boundary Element Modelling (3D Stress Analysis)

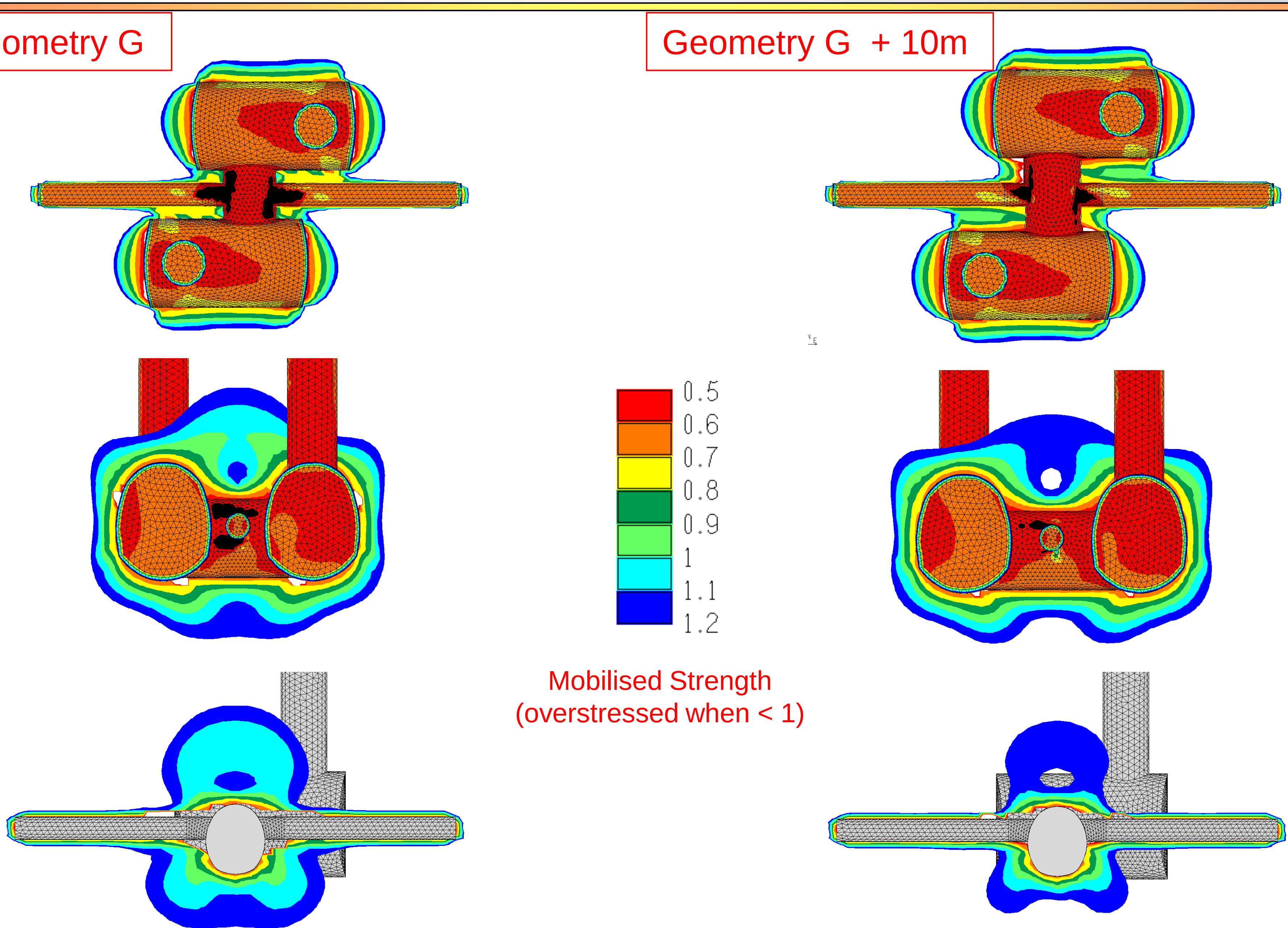
- Linear elastic stress analysis in *Examine3D* s/w.
- Indication of how stress manifests at the interaction of the cavern's boundary and the ground.
- Analyses carried out comparing Layout G and a <u>new layout where the caverns are pushed apart by 5m each.</u>
- Effective strength criteria used to estimate rock mass yielding.



Layout G – Principal Stress Trajectories

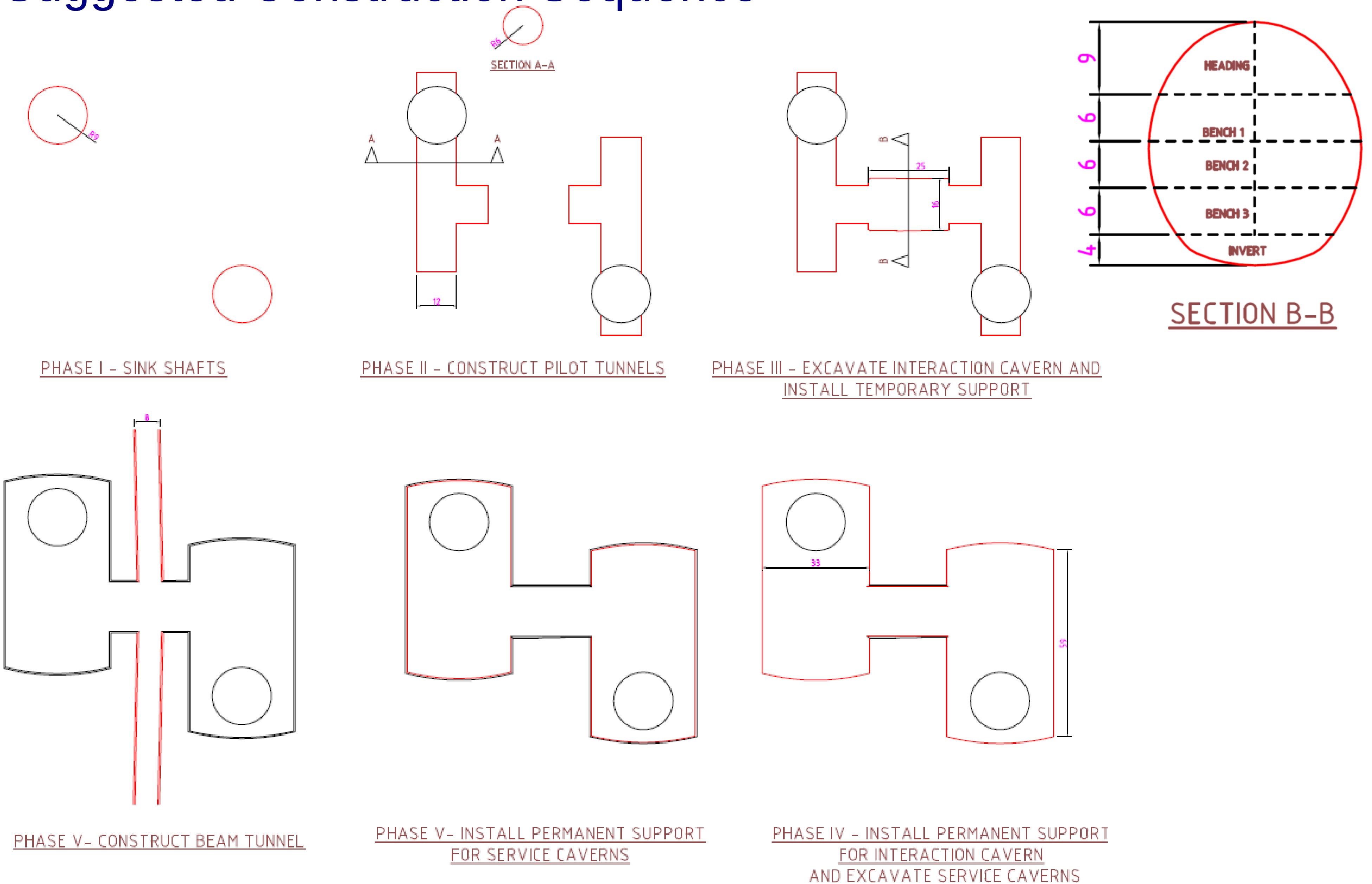


Layout G + 10m – Principal Stress Trajectories



Contours of Overstress

Suggested Construction Sequence



Task 2 Cavern Study

3D Bedded Spring Model

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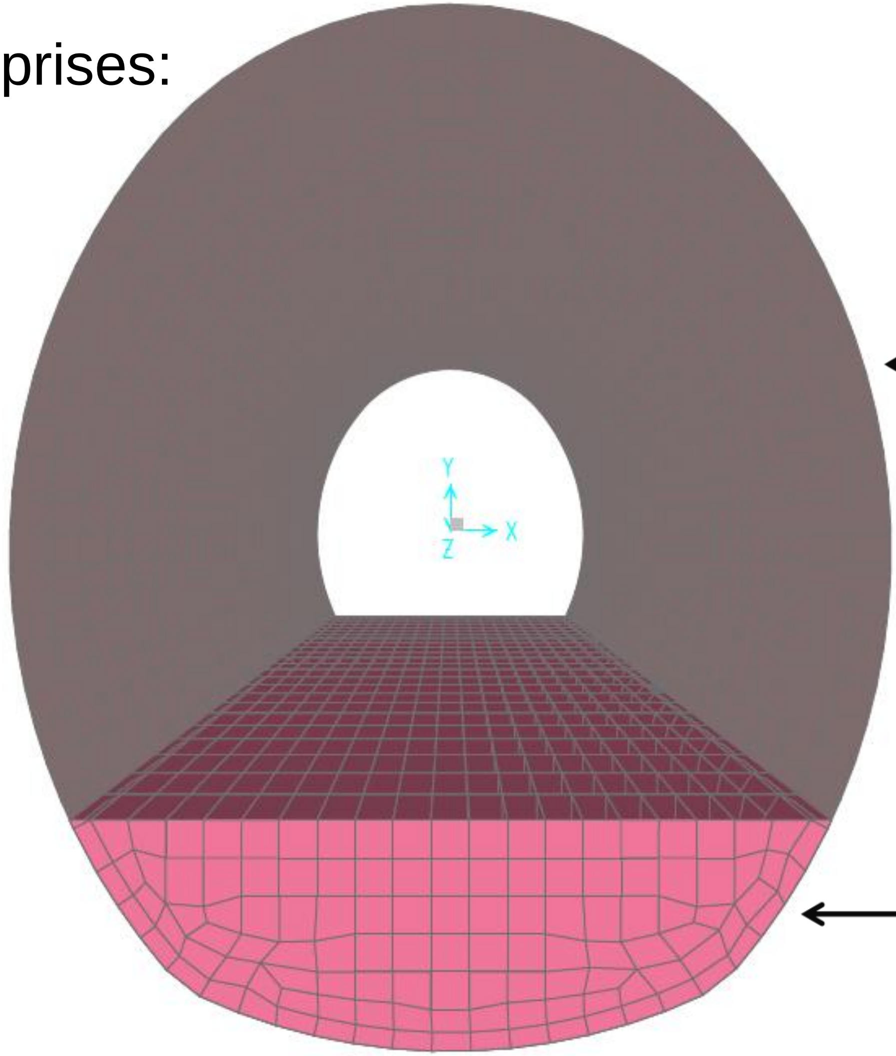
Yung Loo
Agnieszka Mazurkiewicz
Franky Waldron

3D Finite Element Analysis Structural Design

- Interaction Cavern
- 3D-model comprises:
  - Lining
  - Invert Slab



Lining

Thickness: 1.0m

Concrete C50/60

(G = 37 GPa)

Invert Slab

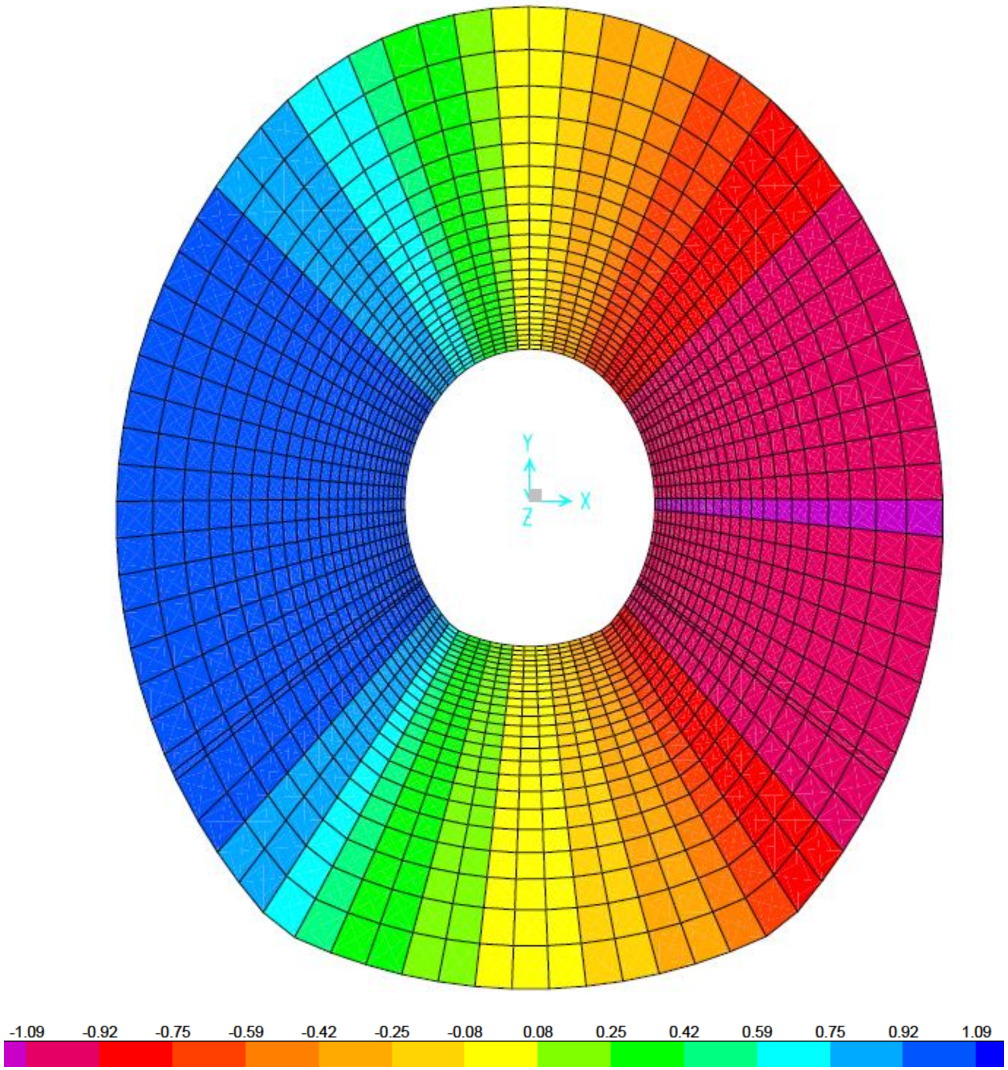
Thickness: 5.6m

Concrete C50/60

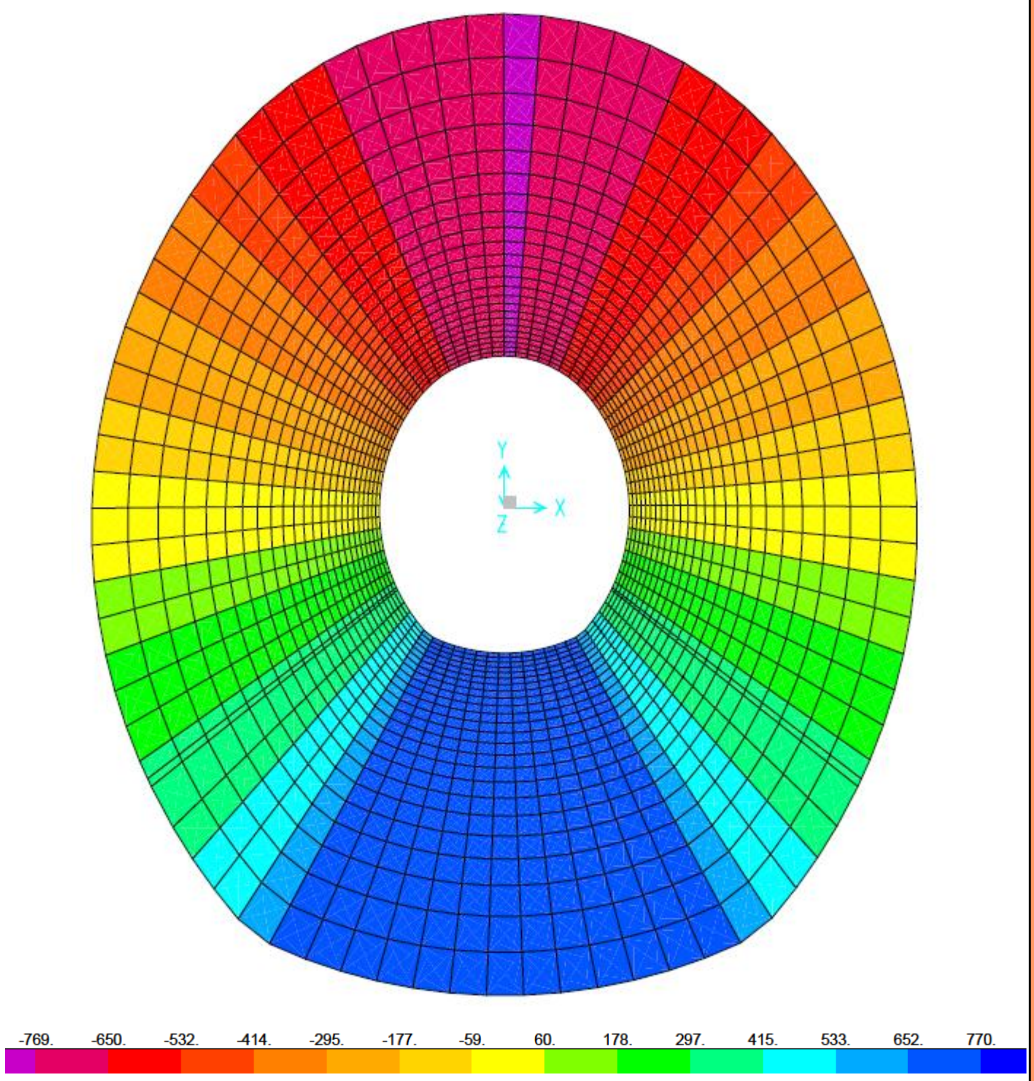
(G = 37 GPa)

Ground Pressure (Including Stress Arching)

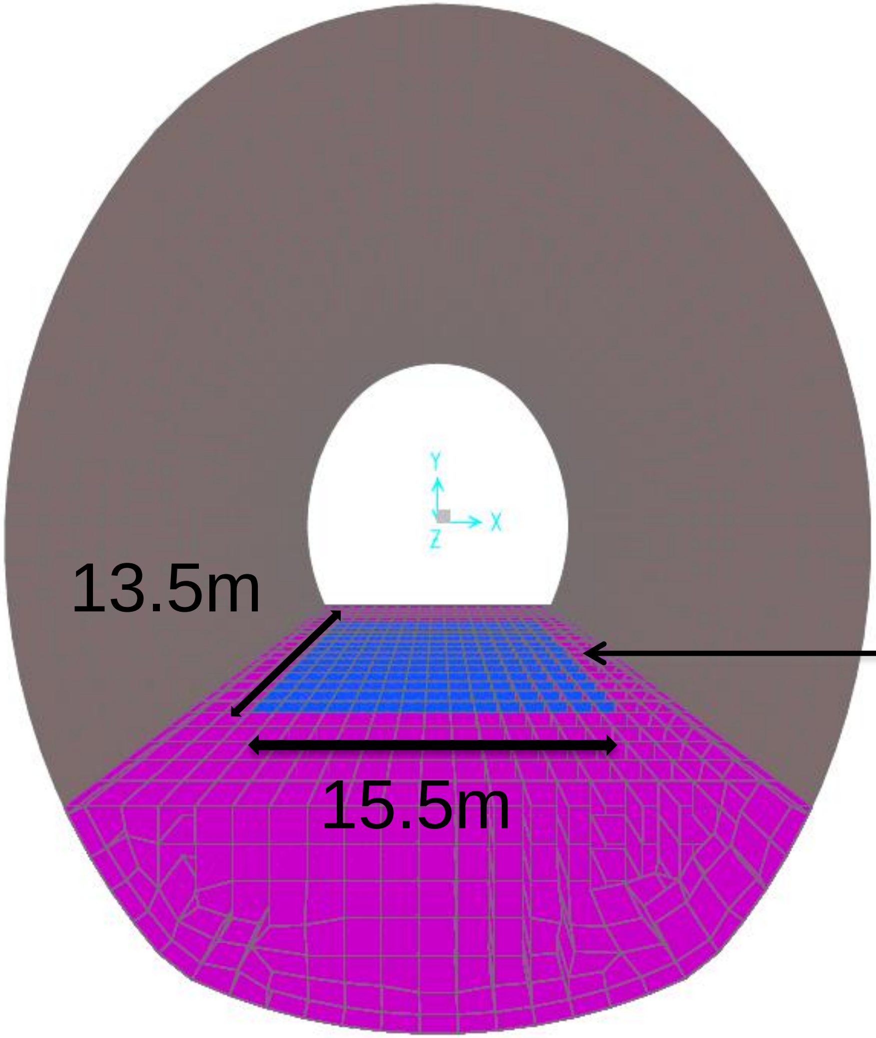
Max Horizontal Pressure: 1090 kPa



Max Vertical Pressure: 770 kPa



Moving Slab Distributed Load

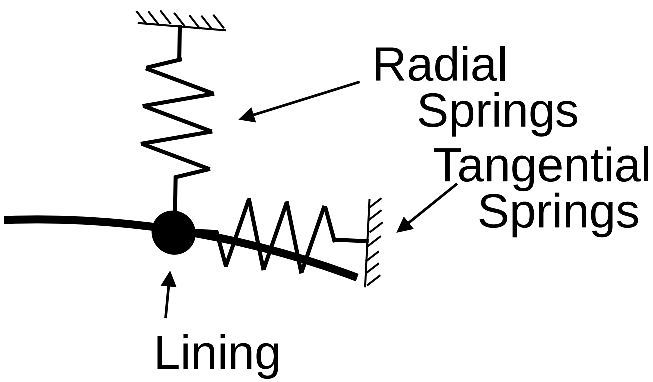


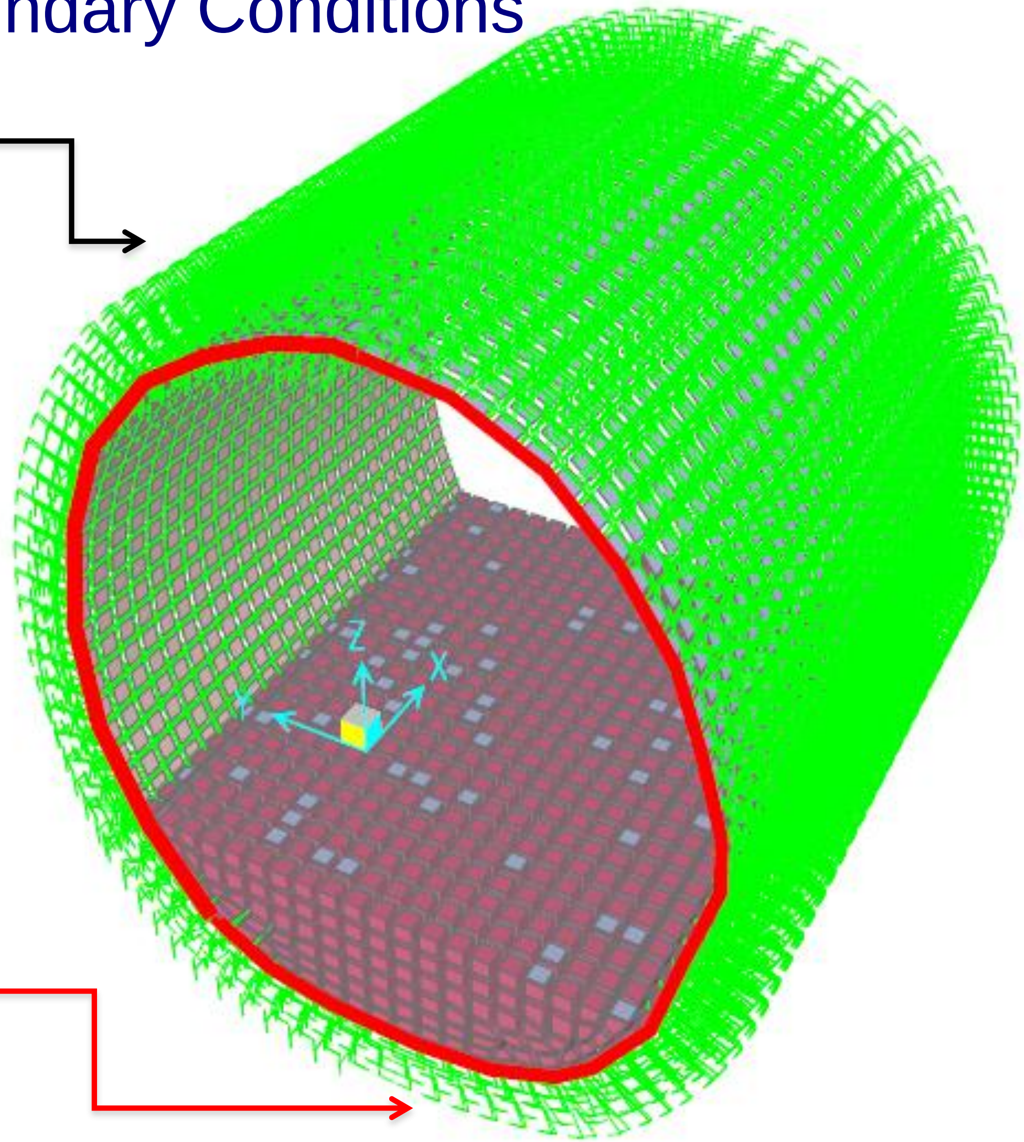
800 kPa

Moving slab distributed load applied in the middle of the cavern span.

Boundary Conditions

Springs represent ground stiffness



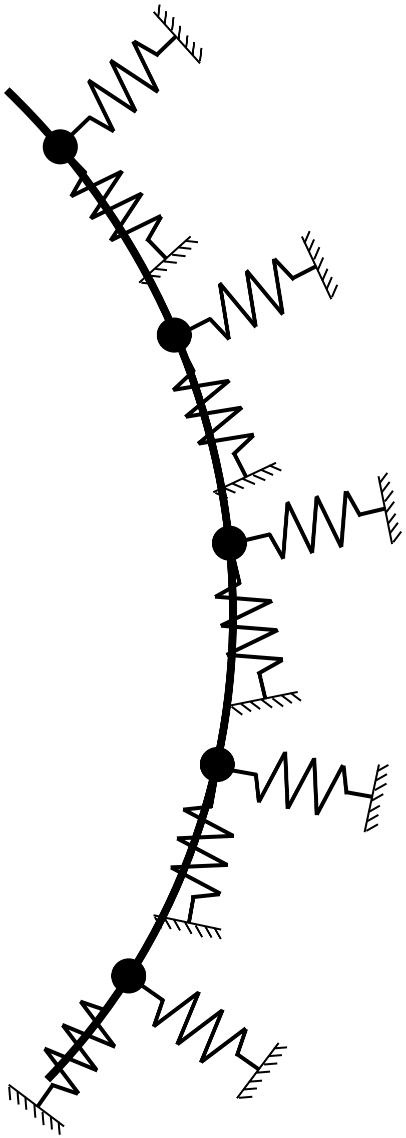


Pinned connection at interaction cavern and the service caverns interface

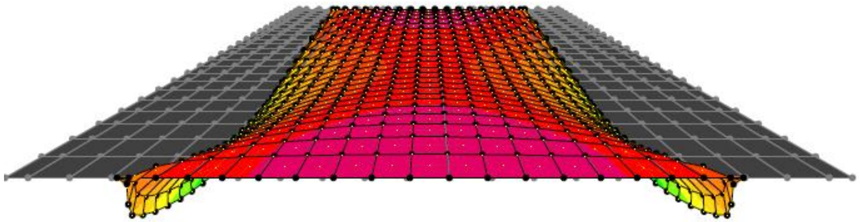
Boundary Conditions

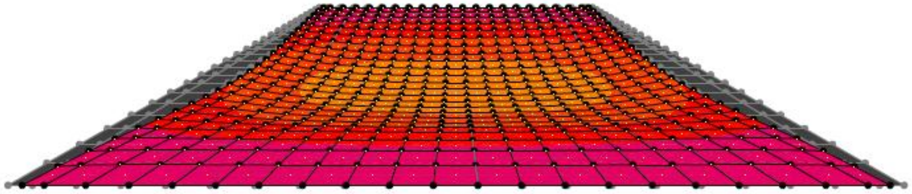
Three following ground stiffness has been investigated in order to evaluate the ground-structure interaction:

- 2D FE non-linear model stiffness:
  - Radial Springs: 100 kPa/mm
- 2x FE model stiffness
  - Radial Springs: 200 kPa/mm
- 3x FE model stiffness
  - Radial Springs: 300 kPa/mm



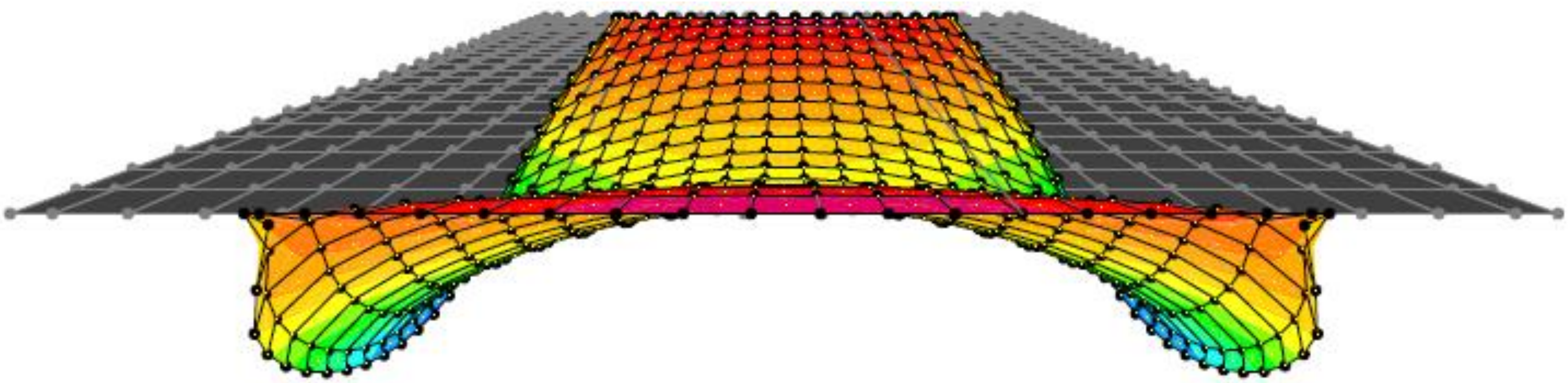
Serviceability Limit State Analysis
Invert Slab Deformed Shape



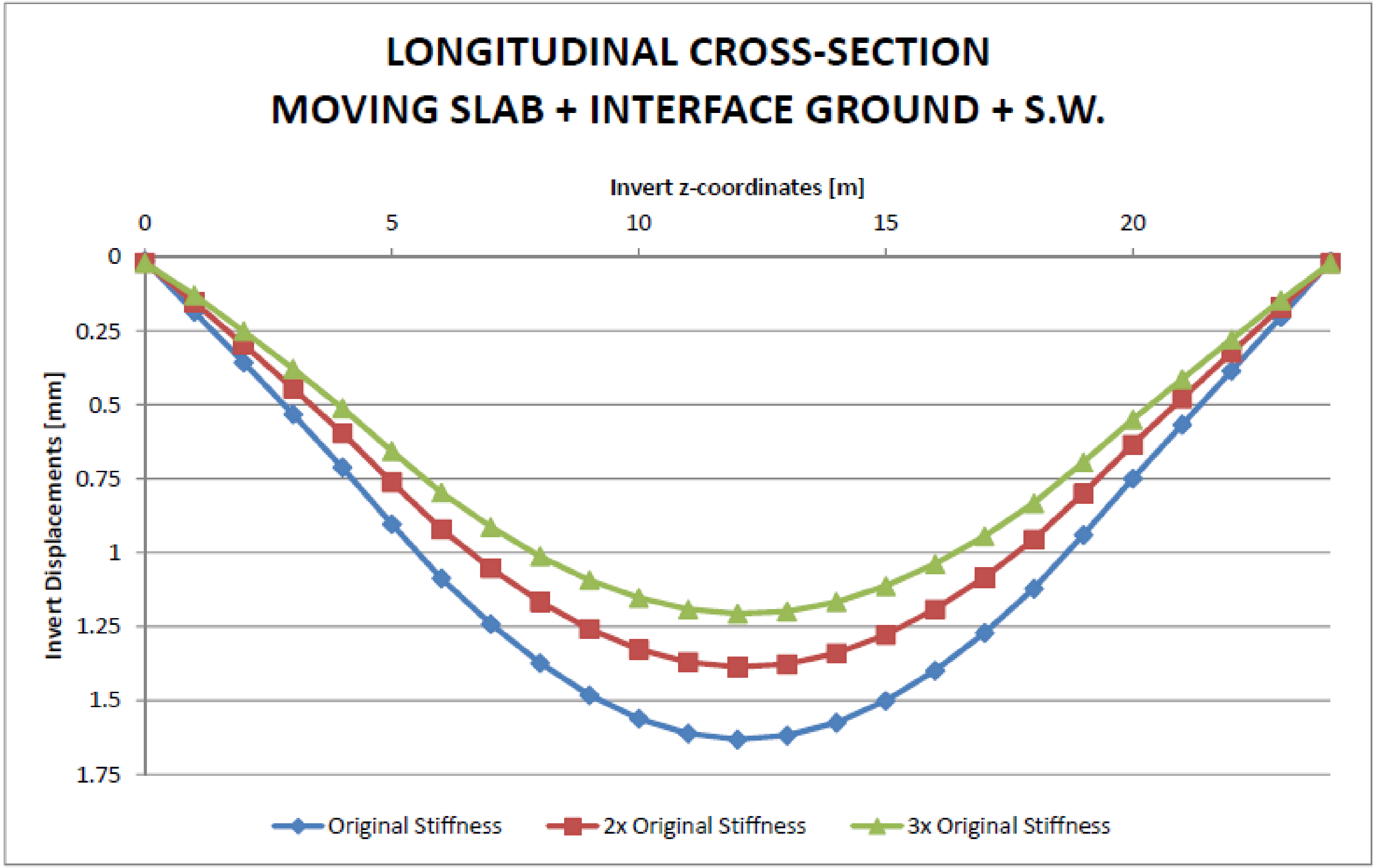


Ground Pressure + Moving Slab +

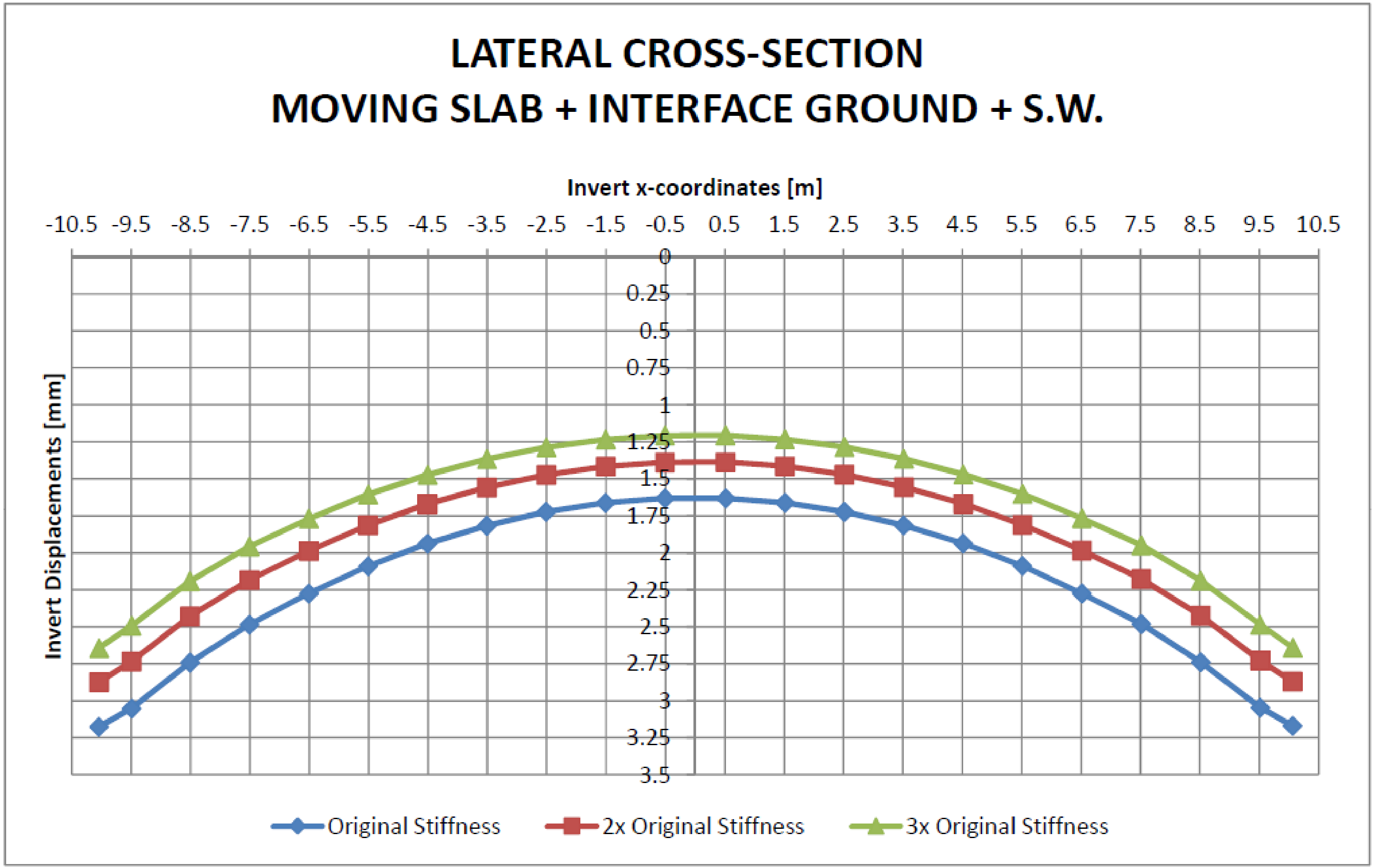
+ Self Weight



Final Deformation



2D FE model stiffness	2x FE Stiffness	3x FE Stiffness
1.6 mm	1.4 mm	1.2 mm



2D FE model stiffness	2x FE Stiffness	3x FE Stiffness
1.55mm	1.5mm	1.44mm

Task 2 Cavern Study

Conclusions and Recommendations

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Alison Barmas
Yung Loo
Agnieszka Mazurkiewicz
Franky Waldron

Conclusions & Recommendations from Arup.

- Assuming a conservative model, invert static deformations exceed acceptable limits. This depends on extent of yielding around cavern during construction (i.e. EDZ[(1)]).
- An appropriate construction sequence should limit this. Construction of shaft and interaction cavern prior to service caverns sequence would limit soil yielding at the invert.

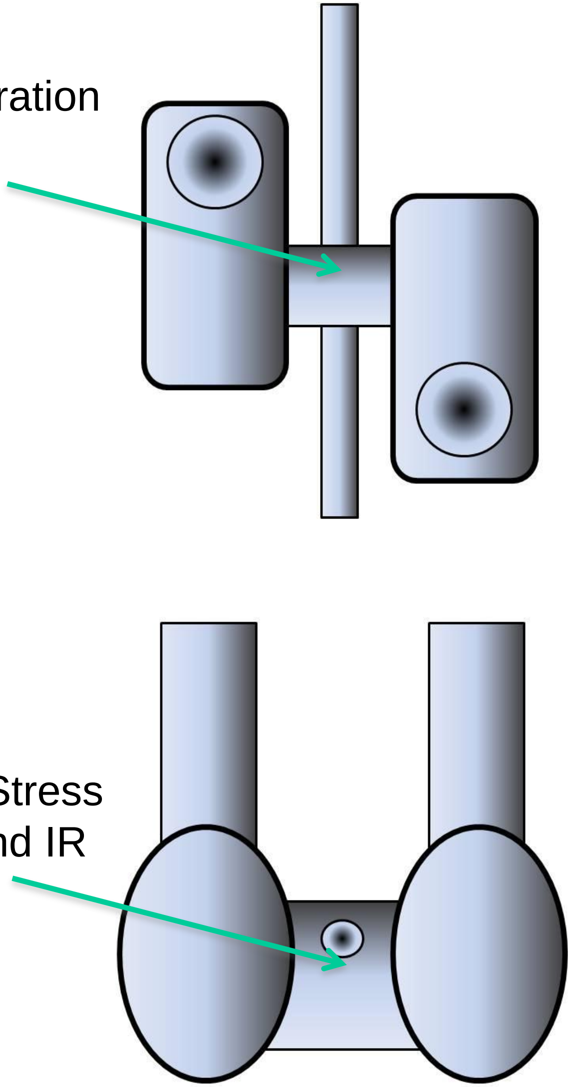
However significant support (piling under invert and pre-stressing) will be required to assure the long term stability of the invert.

- Alternatives to consider…

(1) Excavated Damaged Zone

Revision G

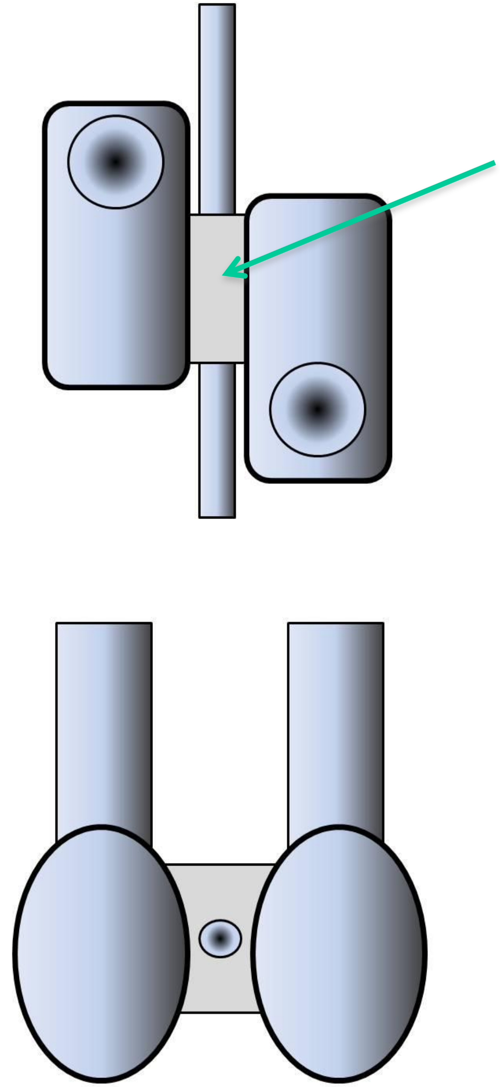
~20m separation



High Stress around IR

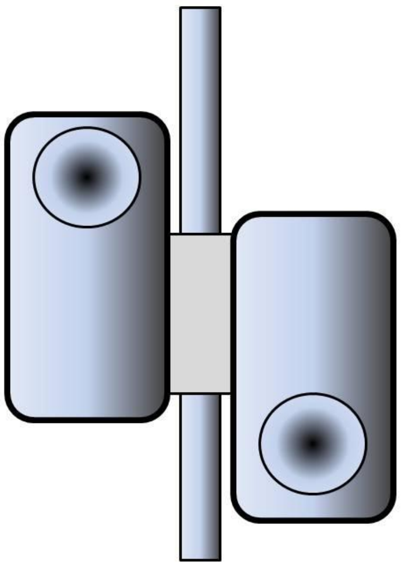
Caverns Moved Closer

Concrete pillar, separation governed by detector proximity



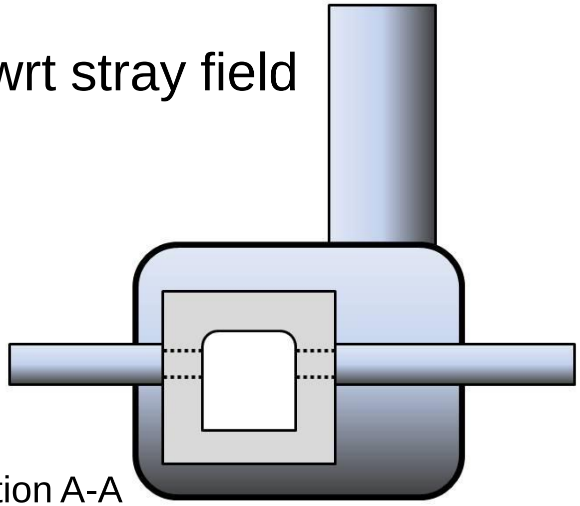
Potential Advantages:

- Reduces lining stress around caverns
- Slab foundations likely to be extremely stiff
- Vertical walls at IP, machine/detector
- Slab size potentially independent of detector width
- Minimum travel time and umbilical lengths

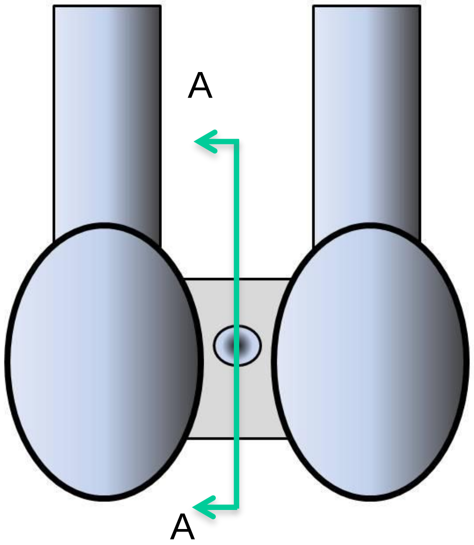


Potential drawbacks:

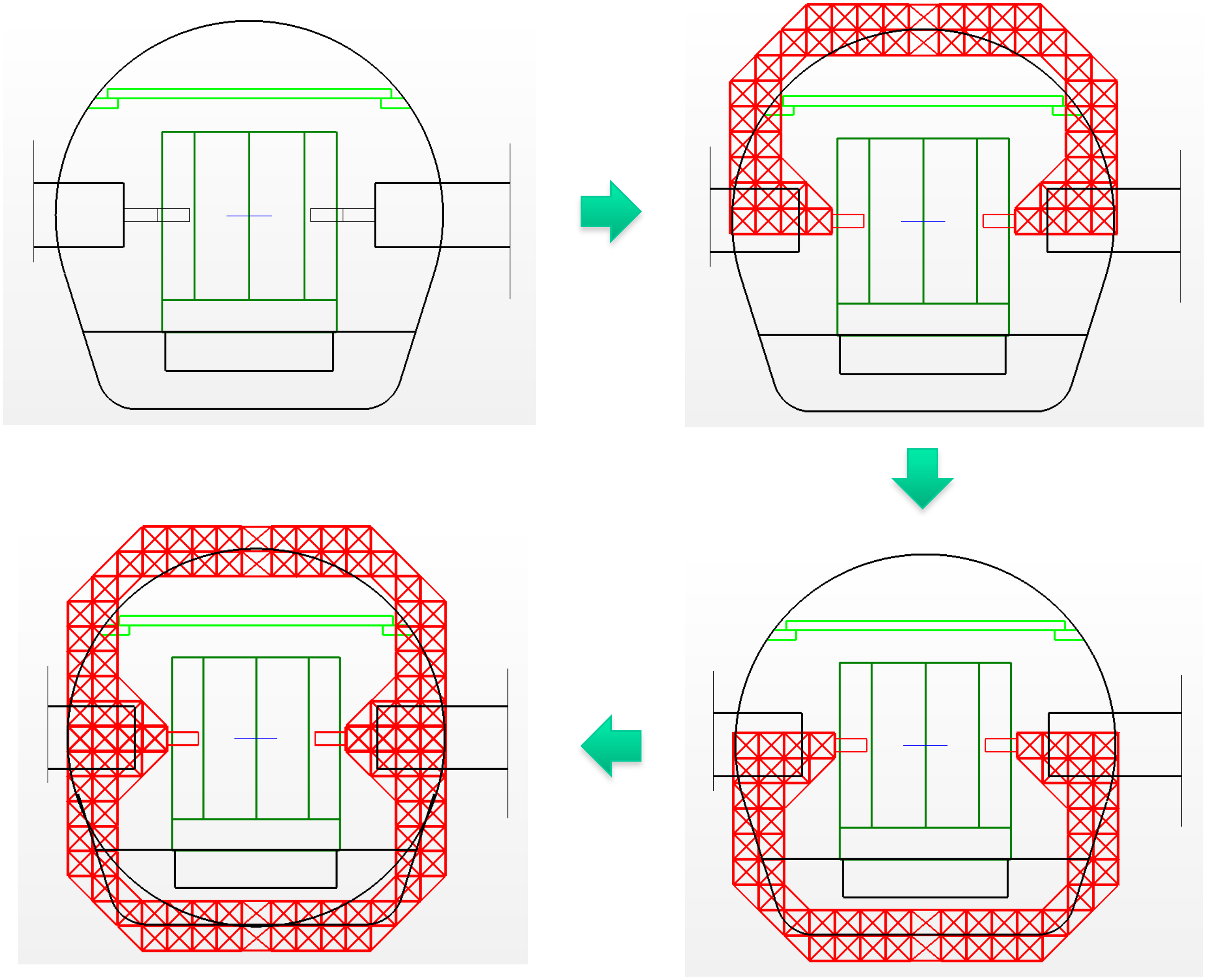
- Detectors too close wrt stray field
- …



Section A-A



CLIC Experimental Area Layout



N.B. *A similar proposal has been done times ago under the name of the Quads' Bridge, the aim being to assure a "rigid link" between the two QD0 and thus minimize their relative movements.*

Talk conclusions.

The optimization of the CLIC experiment area layout has involved the detector and civil engineers for a couple of years, including very useful discussions with our ILC colleagues from the MDI & CFS groups.

The proposed design has been validated by an external consultant, who has looked in detail to the geological aspects, with particular attention to the long term stability of the cavern slab.

We are now working on the implementation of Arup's recommendations into the CLIC Interaction Region baseline design.

Exchange of ideas is continuing with ILC MDI community, under a very positive and collaborative spirit, also in view of the new requirements given by the proposed ILC Japanese mountain site.

Backup slides