



# Feasibility of an 80km tunnel project

Monday 18 June 2012 CERN

## EuCARD LEP3

chaired by Frank Zimmermann (CERN), Marco Zanetti (Massachusetts Inst. of Technology (US))

Monday, 18 June 2012 from **08:00** to **21:30** (Europe/Zurich)  
at **CERN ( 6-R-012 )**

# Overview

- Project introduction
- Feasibility issues
- Previously proposed schemes (LEP, VLHC)
- 80km tunnelling studies (ARUP)
- Conclusions / Next steps

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# Project introduction

- Study the possibility for the construction of an 80km long ‘circular’ tunnel in the Geneva region
  - Location constraint:
    - The tunnel needs to be ‘connected’ as some point to the LHC
- Pre-feasibility study is being performed with the help of the well-known British consultancy firm ARUP and local expert Geologist (GADZ)
  - CLIC, ILC
- The study focuses on the following aspects:
  - Geology
  - Tunnelling & Construction
  - Planning & Costs

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# Feasibility issues

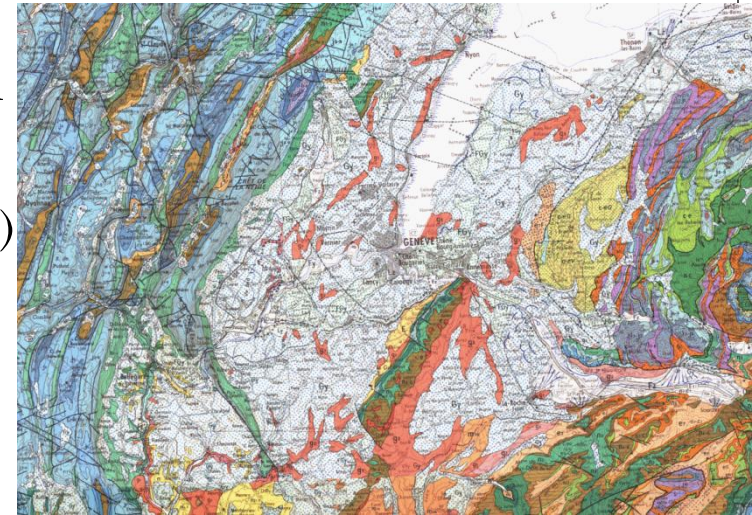
- Some challenges will have to be considered:
- *Geology*
  - Karstified limestones Jura and the Salève
  - Marls (anhydrite)
  - Fractures
    - NW-SE (mostly subvertical) crossing from prealps to Jura
    - SW-NE (mostly inverse) mainly at the foot of the Jura
  - Moraines (unforeseen channels may be encountered during construction)
  - Unknown geology under lake of Geneva (only interpretative seismic profiles) and to some extent in the Jura Mountain
- *Hydrology*
  - Groundwater quantity and quality
  - Surface water quality
- *Environment*
  - Protection of water resources
  - Natural parks
  - Landscape

# Feasibility issues

# Geology

- Basic description geology Geneva region

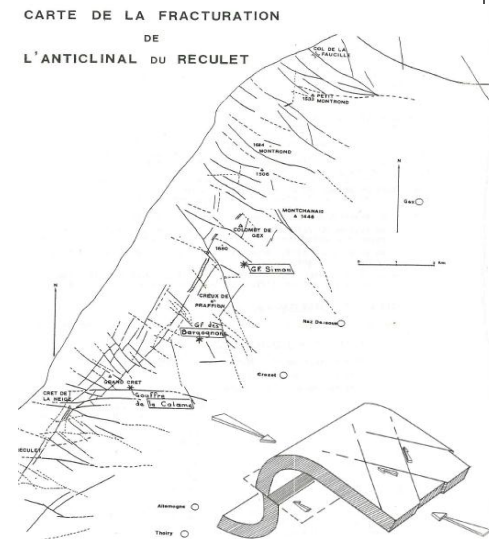
- Sub-basin of the North Alpine Foreland Basin
  - Crystalline basement
  - Triassic marls (with anhydrite and possible gypsum)
  - Jurassic – cretaceous limestones
  - Tertiary molasse
  - Quaternary fluvio-glacial moraines
    - Different rock properties, strength etc.



Source: InfoTerre.

- Most common fractures

- NW-SE (subvertical) crossing from prealps to Jura
  - SW-NE (inverse) mainly at the foot of the Jura
- Low seismic activity (that's OK, not a feasibility issue!)



18/06/2012

- Why is geology a feasibility issue?
  - Different rocks have different properties, strength etc.
  - Triassic marls (with anhydrite and possible gypsum):
    - Plastic deformation, recrystallization, swelling
      - Causes problems during construction ('bad rock')
      - Causes problems after construction such as possible tunnel movement
        - Therefore lot of extra support material needed for stabilization during and after construction (rock bolts, concrete lining etc)
  - Jurassic – cretaceous limestones
    - Karstic limestones
      - Hard rock (more difficult to excavate)
      - Water conduits (danger for water ingress during excavation & pressure build up behind tunnel lining)
      - Underground caves

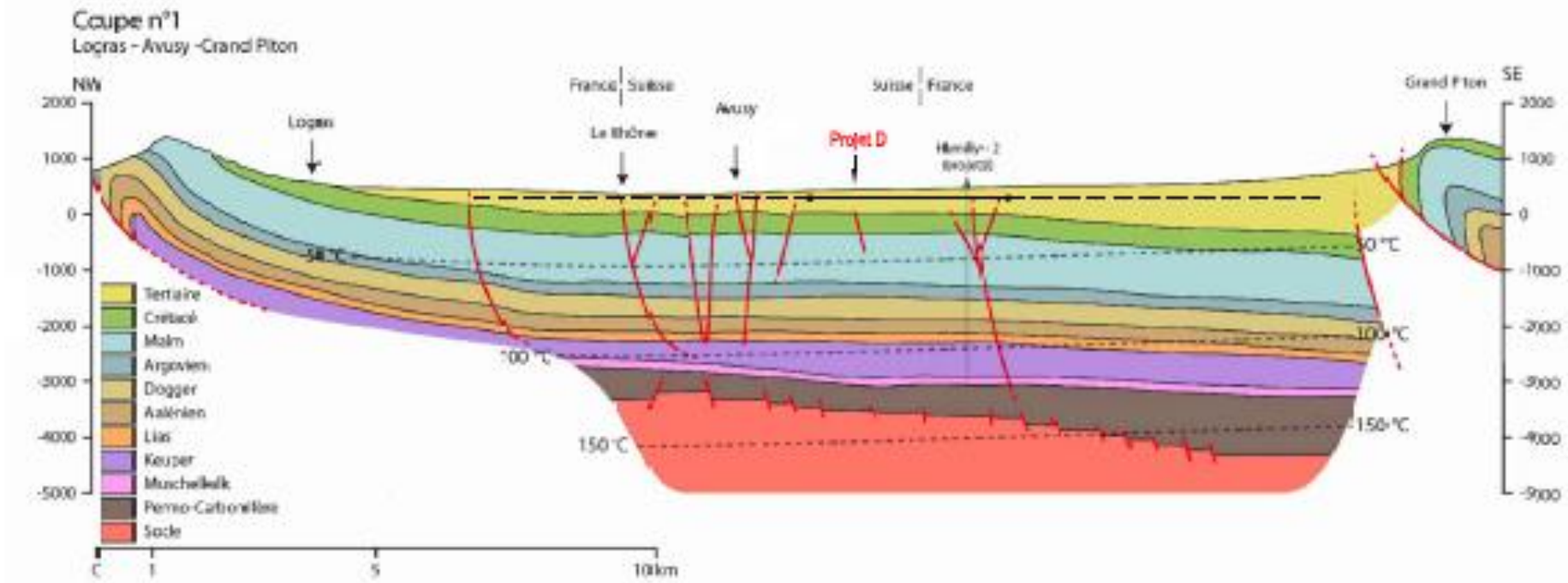


- Why is geology a feasibility issue?
  - Different rocks have different properties, strength etc
  - Tertiary molasse
    - Alternating sequences of sandstones, marls and formations of intermediate composition.
    - Soft rock (can be excavated using conventional machines such as TBM, roadheader)
    - Dry rock
      - Good for tunnelling -> the molasse is the **PREFERRED** rock for excavation
  - Quaternary fluvio-glacial moraines
    - Gravels, sands
    - Water bearing units (Unforeseen channels may be encountered, e.g. CMS)
    - Aquifers -> drinking water supply
    - Variable thickness

# Feasibility issues

# Geology

- Geology Geneva region

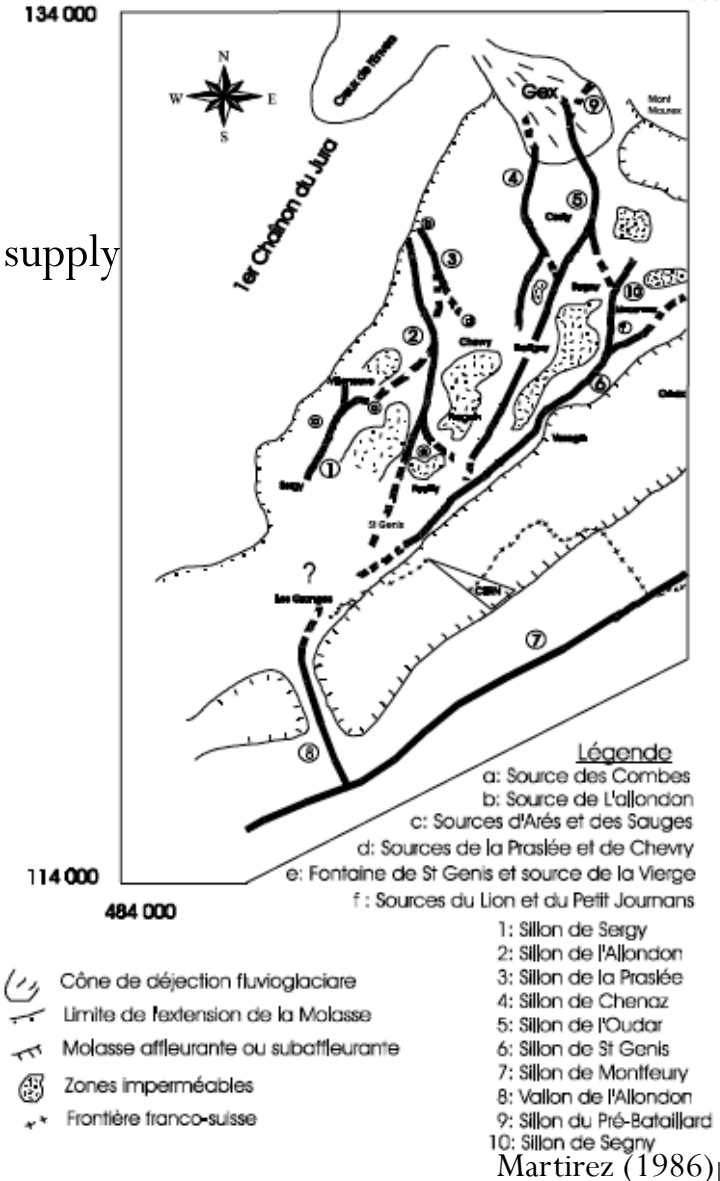


GADZ (2012)

# Feasibility issues

- Hydrology Geneva region: groundwater
  - Moraines
    - Channels mostly oriented in NE-SW direction
    - Aquifers are often protected, used for drinking water supply
    - Most important aquifers:
      - Geneva (under strict protection by Swiss Law)
      - Allondon (under strict protection by Swiss Law)
      - Montfleury
      - Several in Pays de Gex (see map ->)
  - Limestones
    - Jura:
      - near Thoiry (Puits Mathieu, Allemogne source)
      - Exchenevex (Allondon source)
    - Salève:
      - Annemasse – Etrembières (Eaux Belles source)
      - Cruseilles (Doua source)

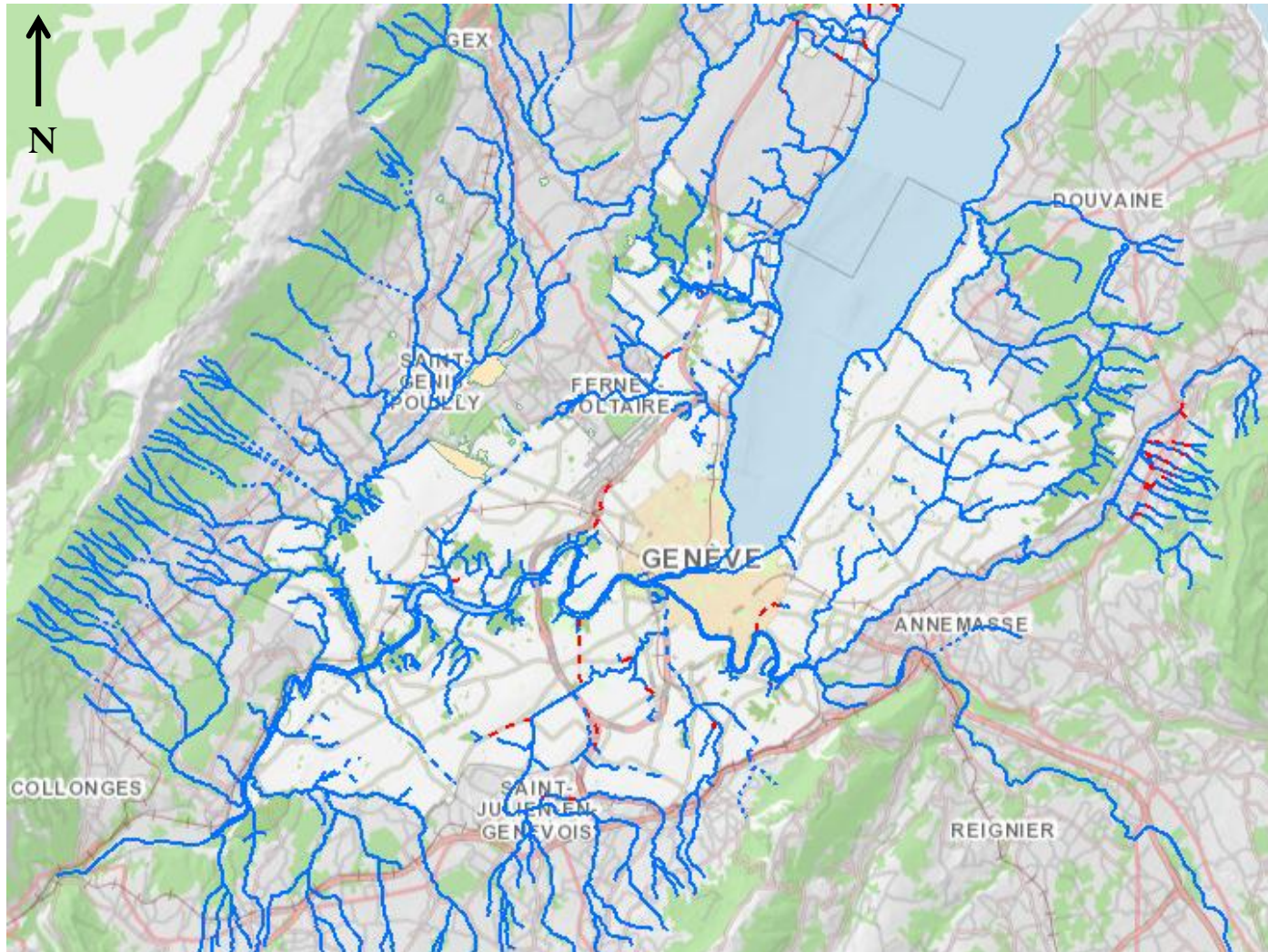
# Hydrology



# Feasibility issues

# Hydrology

- Hydrology Geneva region: surface water

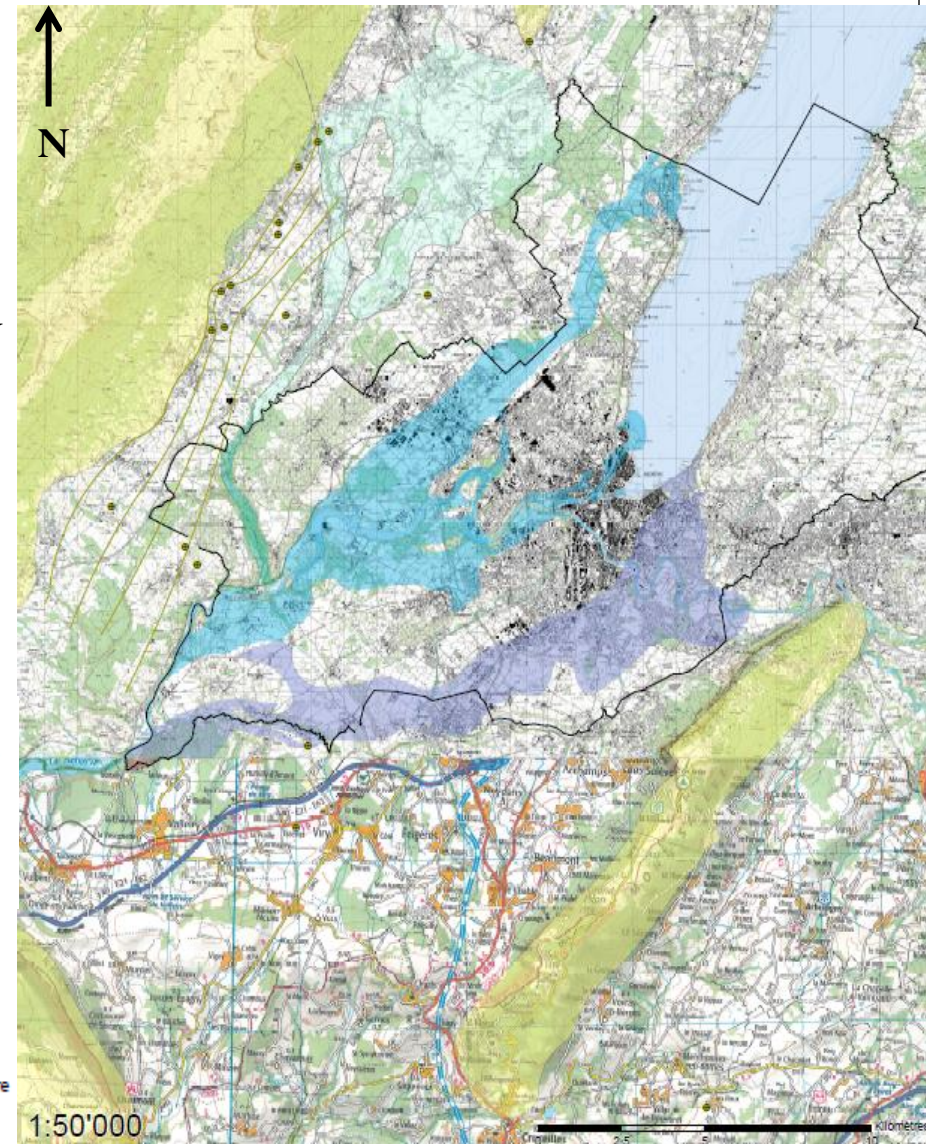


Source: SITG

# Feasibility issues

# Environment

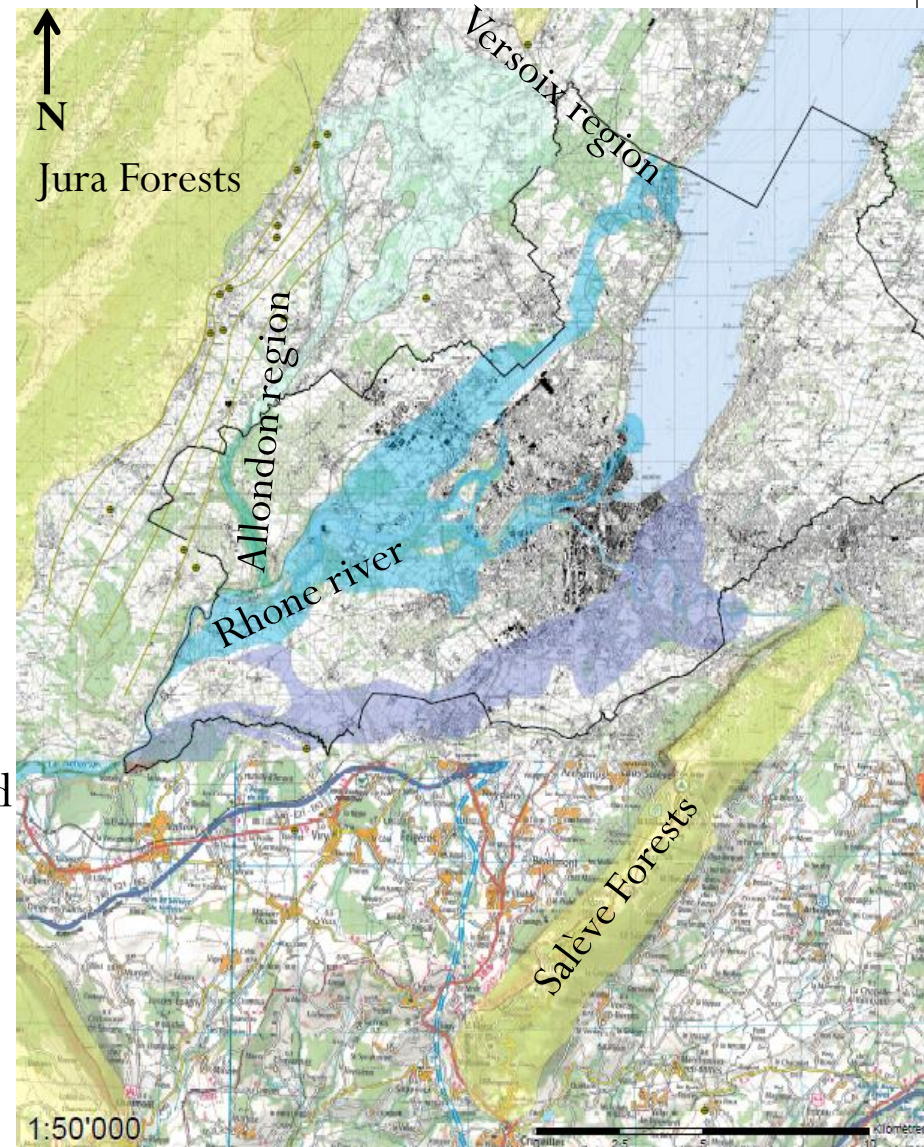
- Environmental issues to be considered
  - Impact on water resources
    - Jura karst & Moraines
    - Reservoirs used for drinking water supply
      - Jura & Pays de Gex
      - Along the river Allondon
      - In and near Geneva



# Feasibility issues

# Environment

- Environmental issues to be considered
  - Impact on protected natural areas
    - Jura
    - Allondon river region
    - Versoix river region
    - Salève
    - Rhone river region
  - Impact on landscape
    - Will be a big challenge in the lake area and other populated areas such as Geneva, Annemasse...

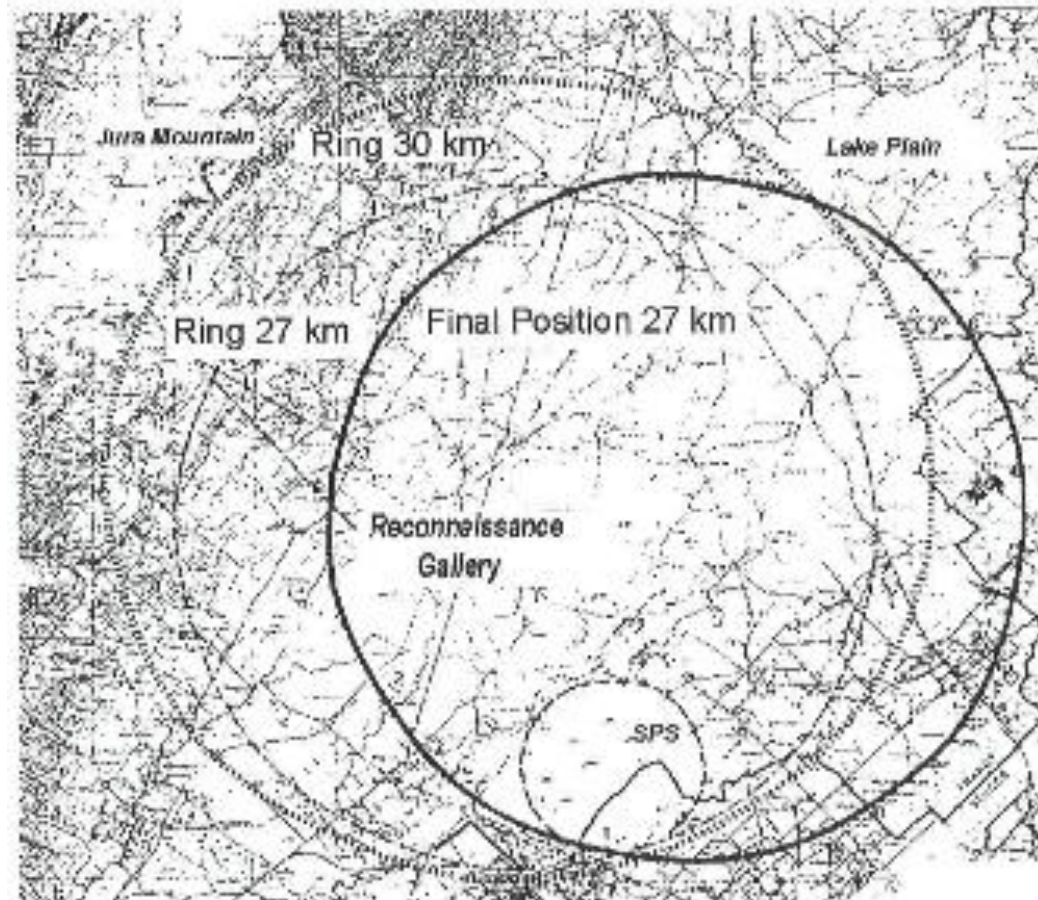


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# Previously proposed layouts

- Layouts that have already been studied in the past:
  - LEP 30km, 27km

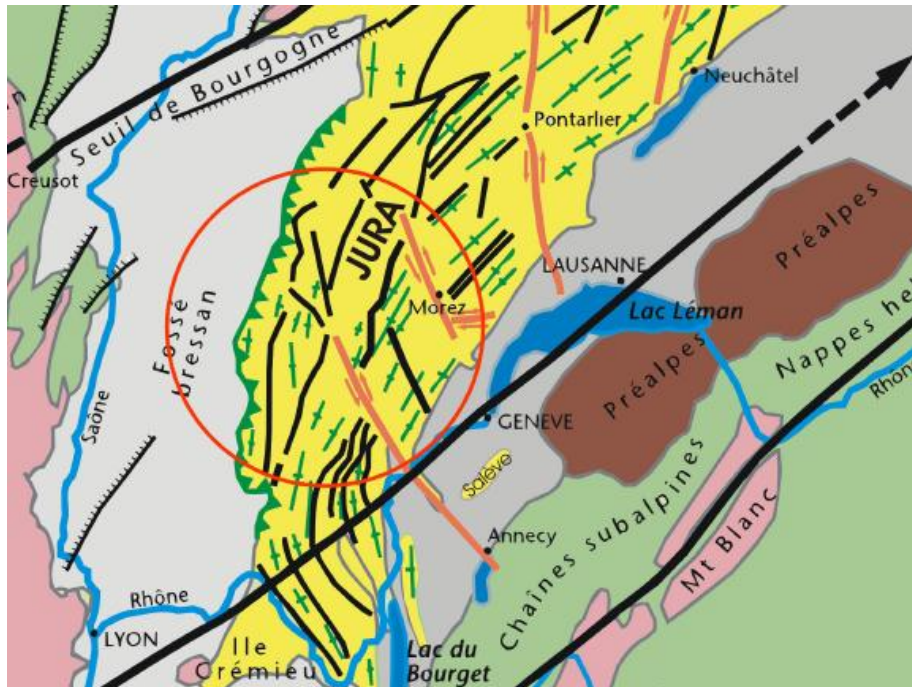


LEP location options

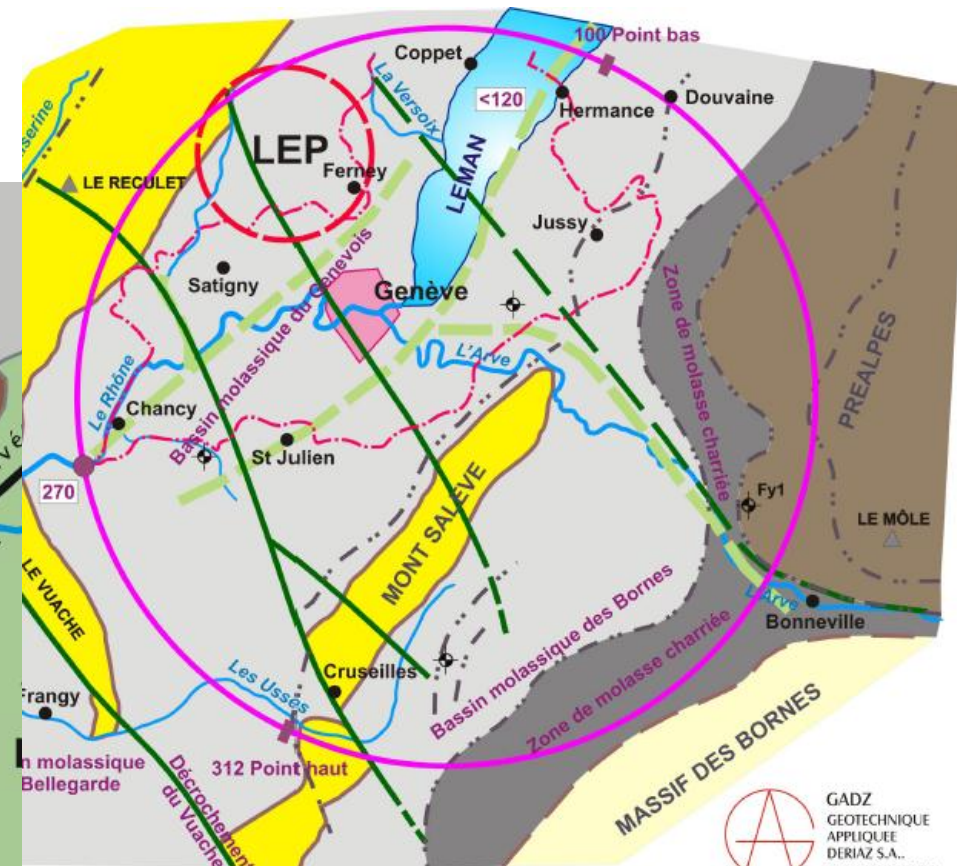


# Previously proposed layouts

- Layouts that have already been studied in the past:
  - VLHC (2001): 113km, 240km



VLHC 240km tunnel



VLHC 113km tunnel

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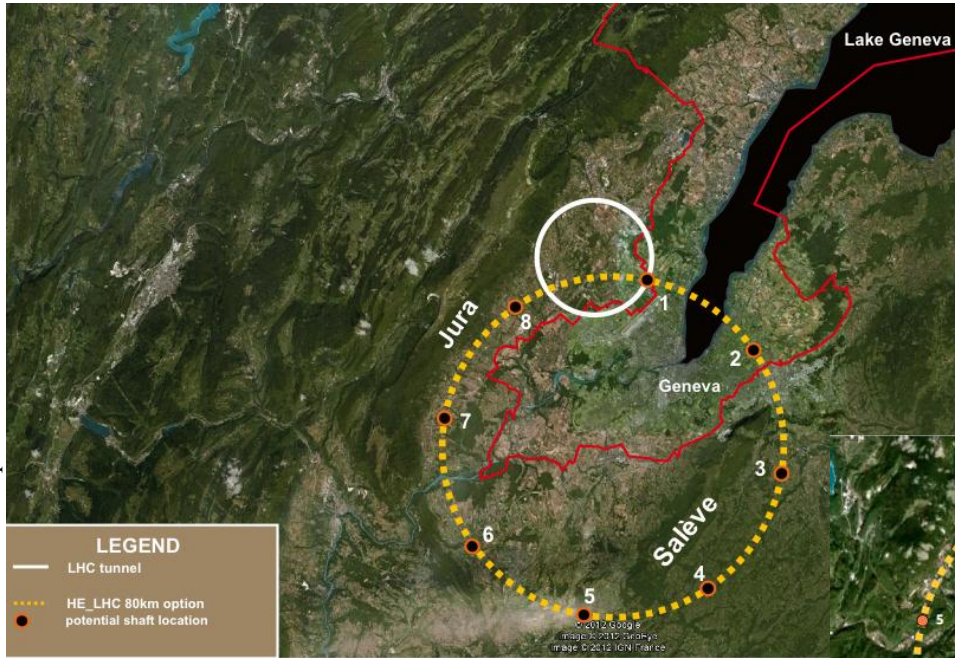
# 80km tunnel project

- New Ring of about 80km, connected to the existing LHC.
- Two possible alignments considered:
  - 80km tunnel in the plain (option 1)
    - Passing under the Lake of Geneva
    - Passing behind the Salève mountain
    - Partially in limestones
    - Located both in France and Switzerland
    - Shafts every 10km (or inclined /double tunnel if shafts are not possible)
  - 80km tunnel in the Jura Mountain chain (option 2)
    - Vast majority in the Jura limestones
    - Fully located in France
    - Shafts every 10km (or inclined/double tunnel if shafts are not possible)
- The ring should be ‘connected’ to the LHC
- For this study we are **only** looking at the tunnel and shaft components.

# 80km tunnel project

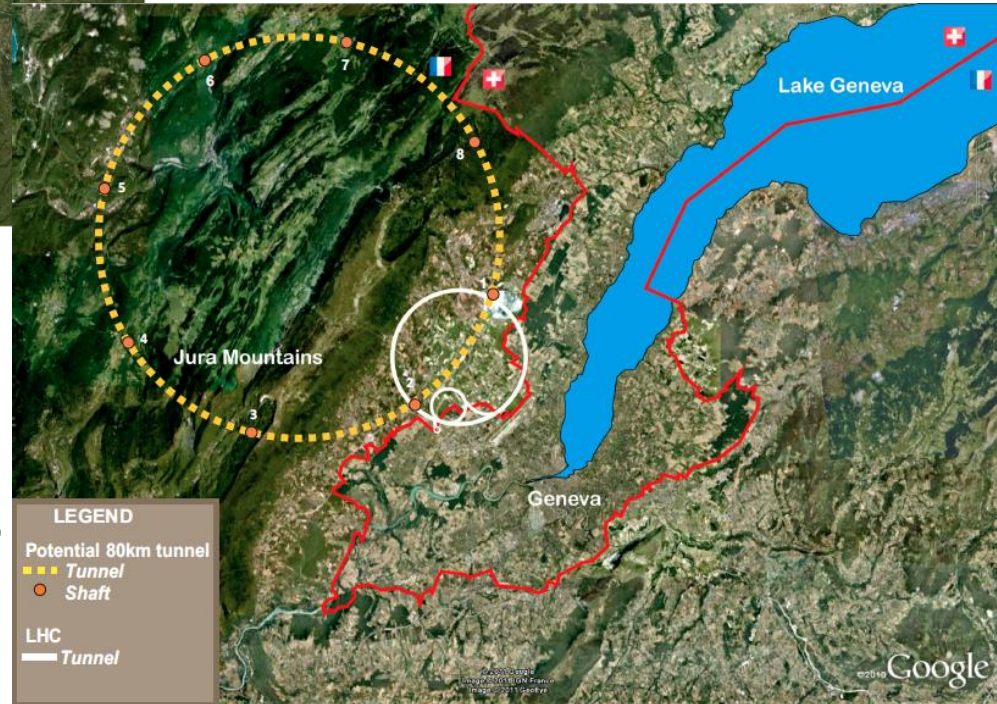
# Layouts

Shaft locations are only  
indicative not permanent



## Option 1

Shaft locations are only  
indicative not permanent



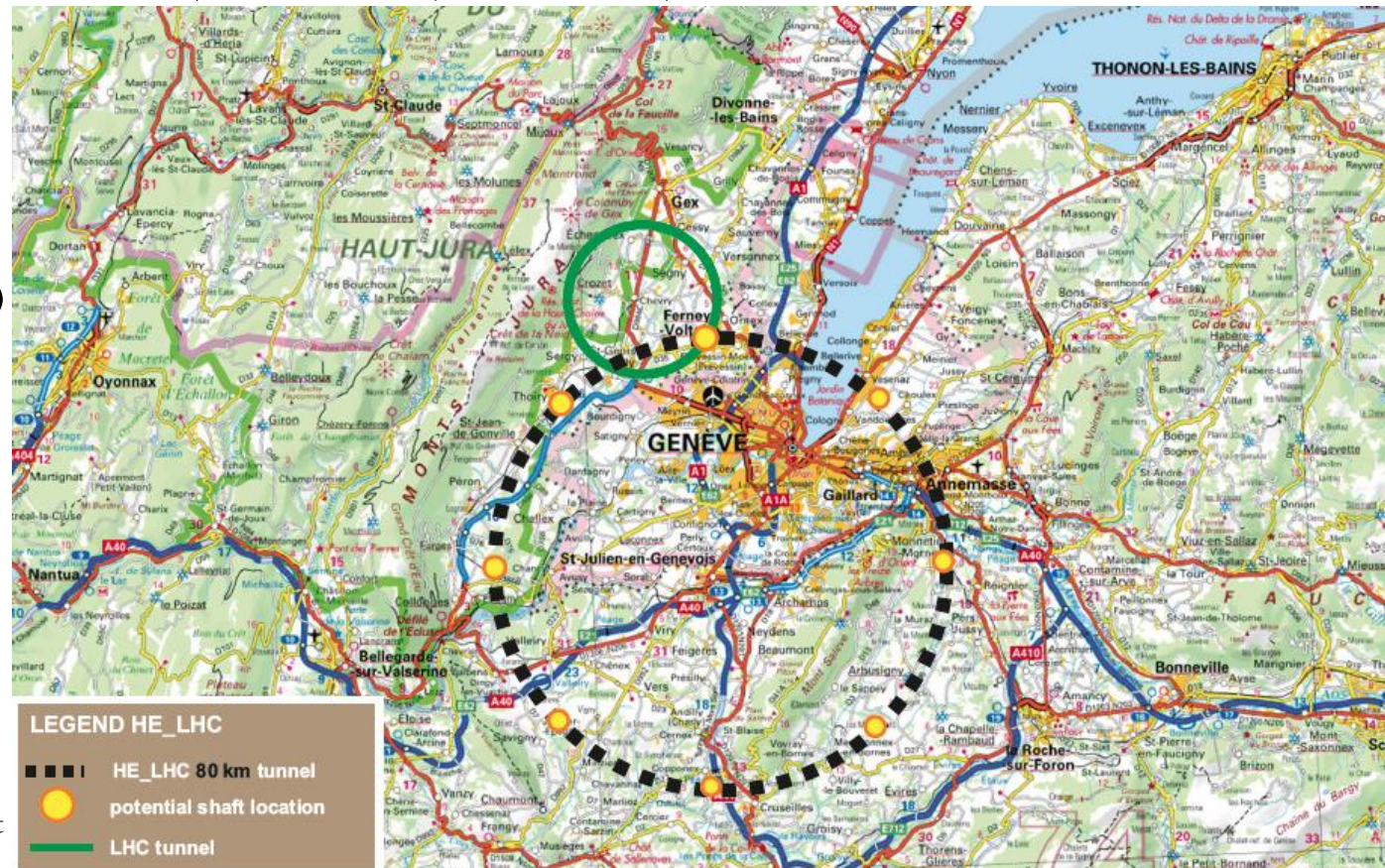
## Option 2

# 80km tunneling studies

# Option 1

- Geographical location 80km tunnel in the plain (option 1)
  - Ferney Voltaire (CERN)
  - Bellevue (W-side lake) -Vesenaz (E-side lake)
  - Annemasse
  - Cruseilles
  - Pougny (rhone river)
  - Thoiry

# Option 1



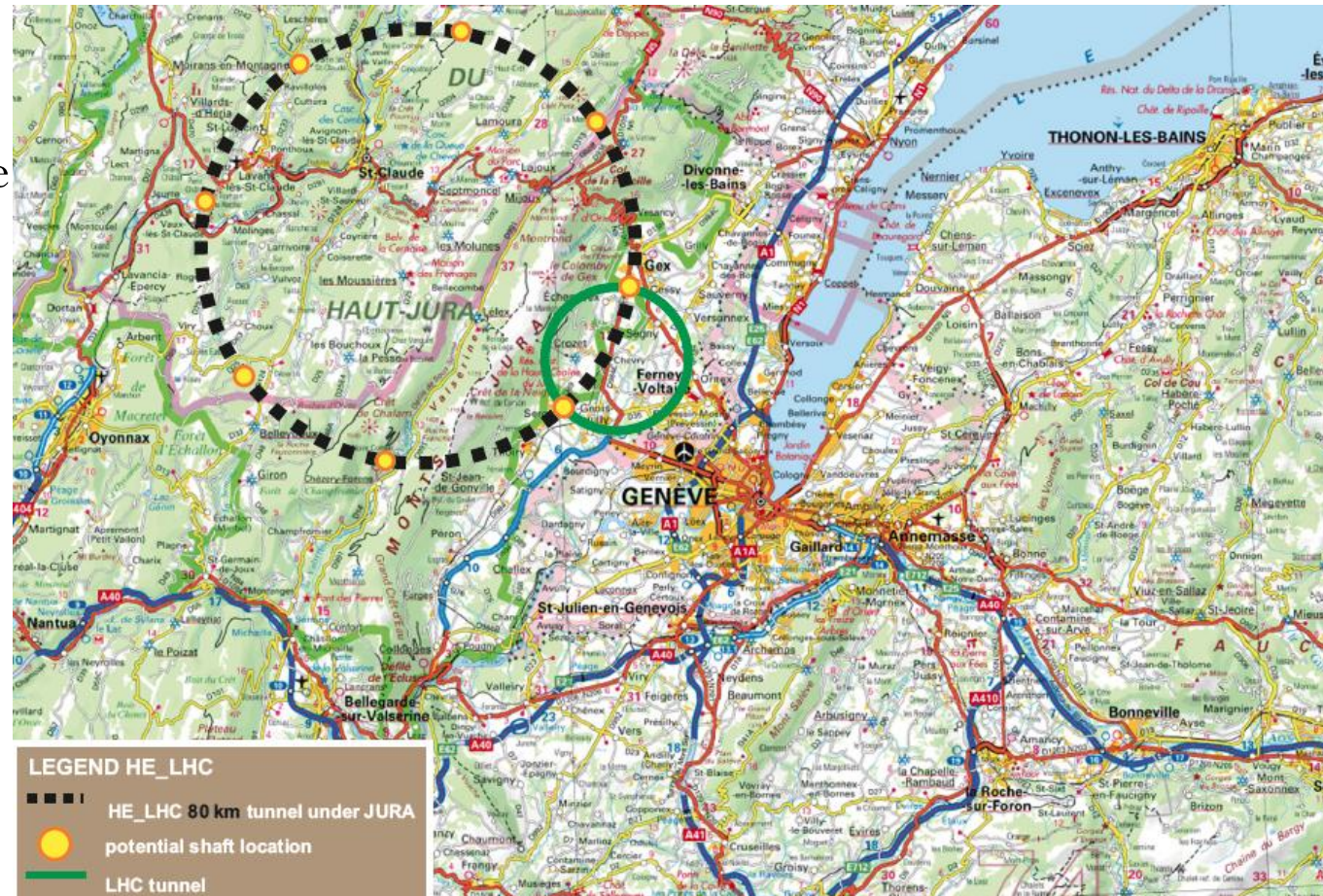
Shaft locations are only indicative not permanent

# 80km tunneling studies

# Option 2

- Geographical location 80km tunnel in Jura (option 2)
  - St. Genis (CERN)
  - Cessy (CERN)
  - Ravilloles
  - Vaux-Les-St-Claude
  - Chézery-Forens

Option 2



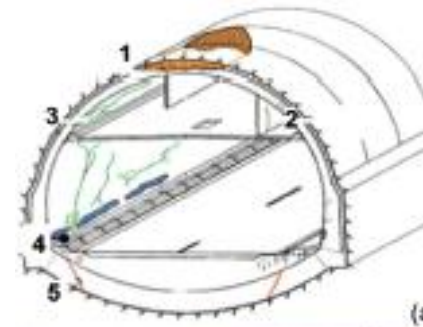
Shaft locations are only indicative not permanent

# Tunnel examples in the Jura region

- Belchen tunnel in Jura

- Gipskeuper

- Heave
- Swelling pressure
- Suphate rich water



Type of damage

- 1: Crown fissuration
- 2: Pannel fissuration
- 3: Vault cracking
- 4: Abutment spalling
- 5: Invert-arch shear failure



(b)

- Chienberg tunnel in Jura

- 1.5m heave of the top heading floor during construction



- Topography & depth constraints
  - Depth constraints determined by location of Molasse rock
- Jura
  - Foot in Pays de Gex: 400-600m asl
  - High chain: 600-1700m asl
  - Plateau: 900-1300m asl
  - High Jura – West: 600-800m asl
    - Lowest point: Vaux les St.Claude ~ 330m asl
      - Shafts in Jura extend to depths of 600-1000m
- Lake Geneva
  - Depth of Molasse increases dramatically the further away from Geneva (direction Nyon) :
    - approx. 100m (Geneva)
    - approx. 300m (Nyon)



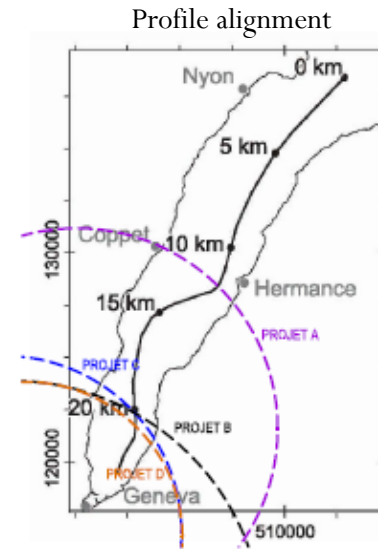
# 80km tunnelling studies

*Excluded*

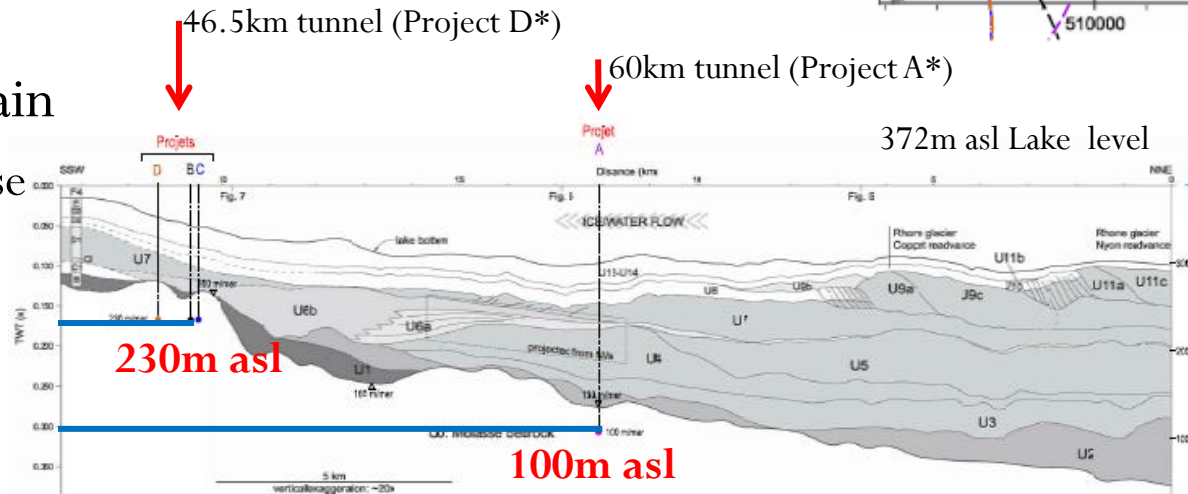
- Other alignments\* considered but excluded:

\* These alignments are called projects (A-D) and can be found in report:  
nr 4291/03 by GADZ (12 June 2012)

- 60km tunnel in the plain
  - Would be almost fully located in the Molasse
  - passing in front of Salève
  - Passes under the Lake of Geneva
    - Problem is depth of Molasse under lake



- 46.5km tunnel in the plain
  - Fully housed in the Molasse
  - Passes under Lake Geneva
  - Possibly too short?



Profil synthétique longitudinal du Petit-Hac

d'après Fiore-Girardot et al. (2010)  
18/06/2012

John Osborne (CERN), Caroline Waaijer (CERN)

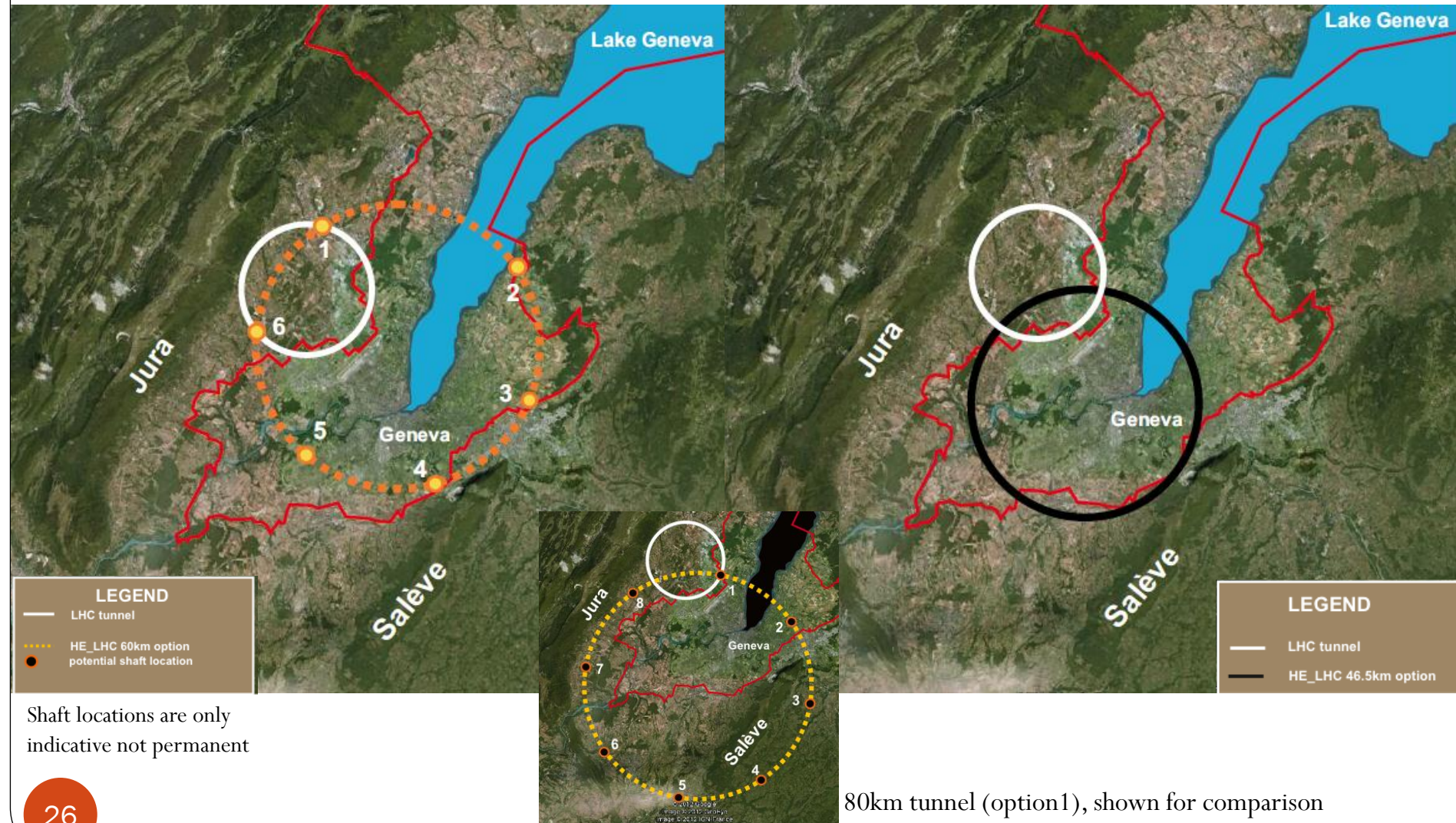
From seismic profile

# 80km tunnelling studies

*Excluded*

60km under lake (project A) too deep

46.5km under lake (project D) too short?



# ARUP mandate

- General:
  - Prefeasibility study of the HE-LHC ring
- Specific
  - Task 1 – Geological assessment
  - Task 2 – Tunneling assessment
  - Task 3 – Construction assessment
  - Task 4 – Approximate Civil Engineering cost estimate
  - Task 5 – Site meeting with CERN geologist, June 22<sup>nd</sup> 2012
- Expected output:
  - HE-LHC prefeasibility report **end of July 2012**
  - Planning & Costs assessment report **end August 2012**

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# Conclusions/next steps

- 80km tunnel will face some major challenges related to geology, hydrology and the environment
- A shorter ring (46.5km) would be the best option from civil engineering point of view
- A detailed pre-feasibility study is being conducted by ARUP
  - Study of two options (80km tunnel in Jura and under the lake)
    - **Geology, tunneling, construction, planning & costs**
  - End products ARUP:
    - Formal report end of July 2012
    - Planning and costs assessments in separate report end of august 2012

# References

- GADZ (2012), *Projets HE-LHC. Eléments géologiques pour l'étude de faisibilité (4291 /03)*
- GADZ (2001) , *Projets VLHC. Eléments géologiques pour l'étude de faisibilité (4291 /02a)*
- Martinez, Jean-Francois, (1986), *Etude du fonctionnement d'aquifères complexes, pays de Gex, Ain- France-Jura*, University of Grenoble
- Fiore, Julien, Stephanie Girardclos et al., (2010), *Würmian deglaciation of western Lake Geneva (Switzerland) based on seismic stratigraphy*, *Quaternary science reviews* V30, issue 3-4, 377-393