# LHeC
# CIVIL ENGINEERING

# Special thanks to:

- Chris Adolphsen
- Chiara Bracco
- *Oliver Bruning*
- Helmut Burkhardt
- Edmond Ciapala
- Miriam Fitterer
- Brennan Goddard
- Friedrich Haug
- Bernhard Holzer
- *Max Klein*
- Antoine Kosmicki
- Karl H Mess
- Steve Myers
- Daniel Schulte;
- Joachim Tuckmantel
- *Frank Zimmermann*

# Overview talk

- Site Features
- Construction methods
- Civil engineering LHeC options
  - Ring – Ring
  - Linac – Ring (baseline solution)
- Costing & Planning
- LHeC and the FCC (Future Circular Collider) Study
- Conclusion and Next Steps

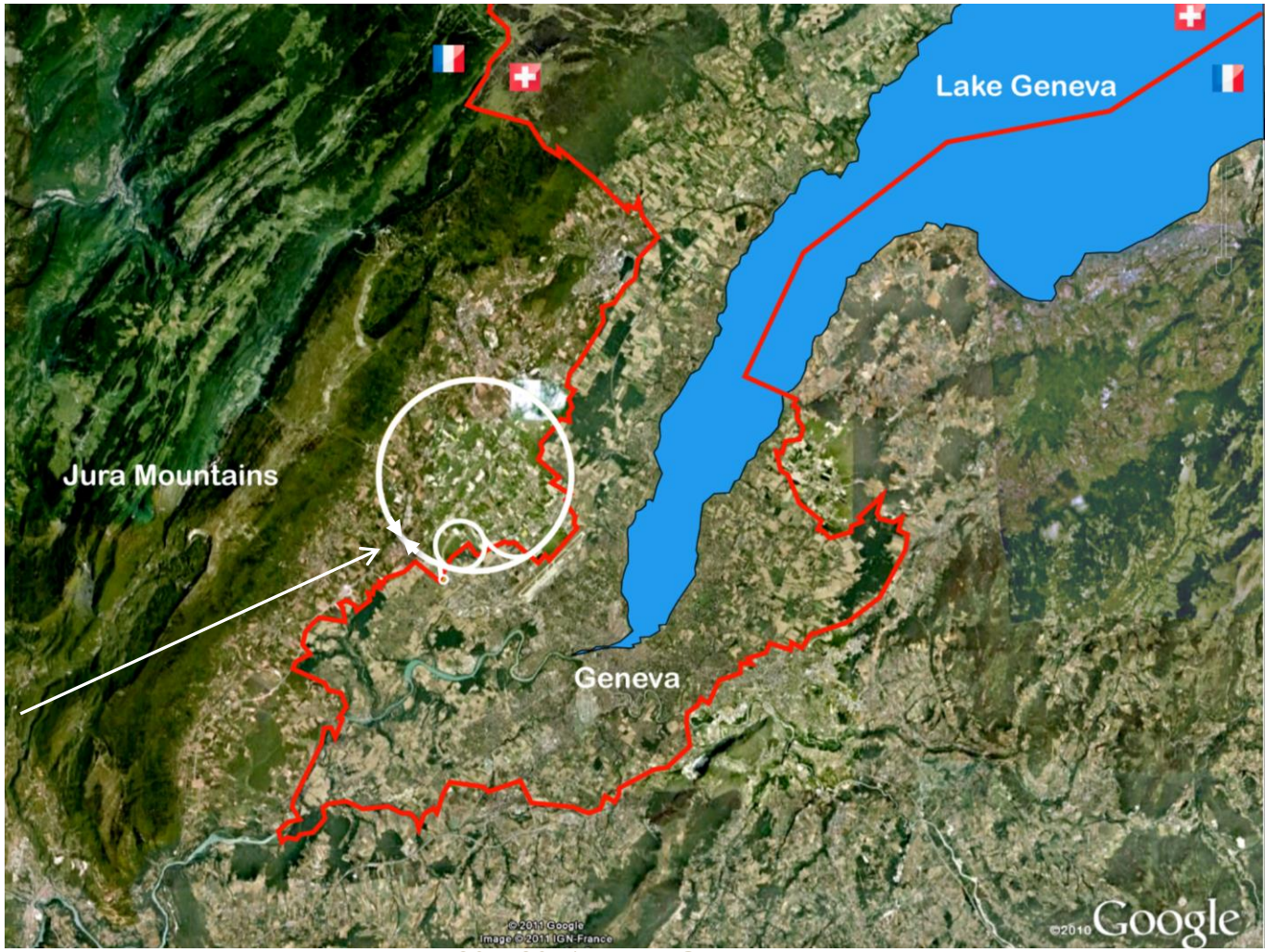
LHeC

# SITE FEATURES

# Site Features

## *Location*

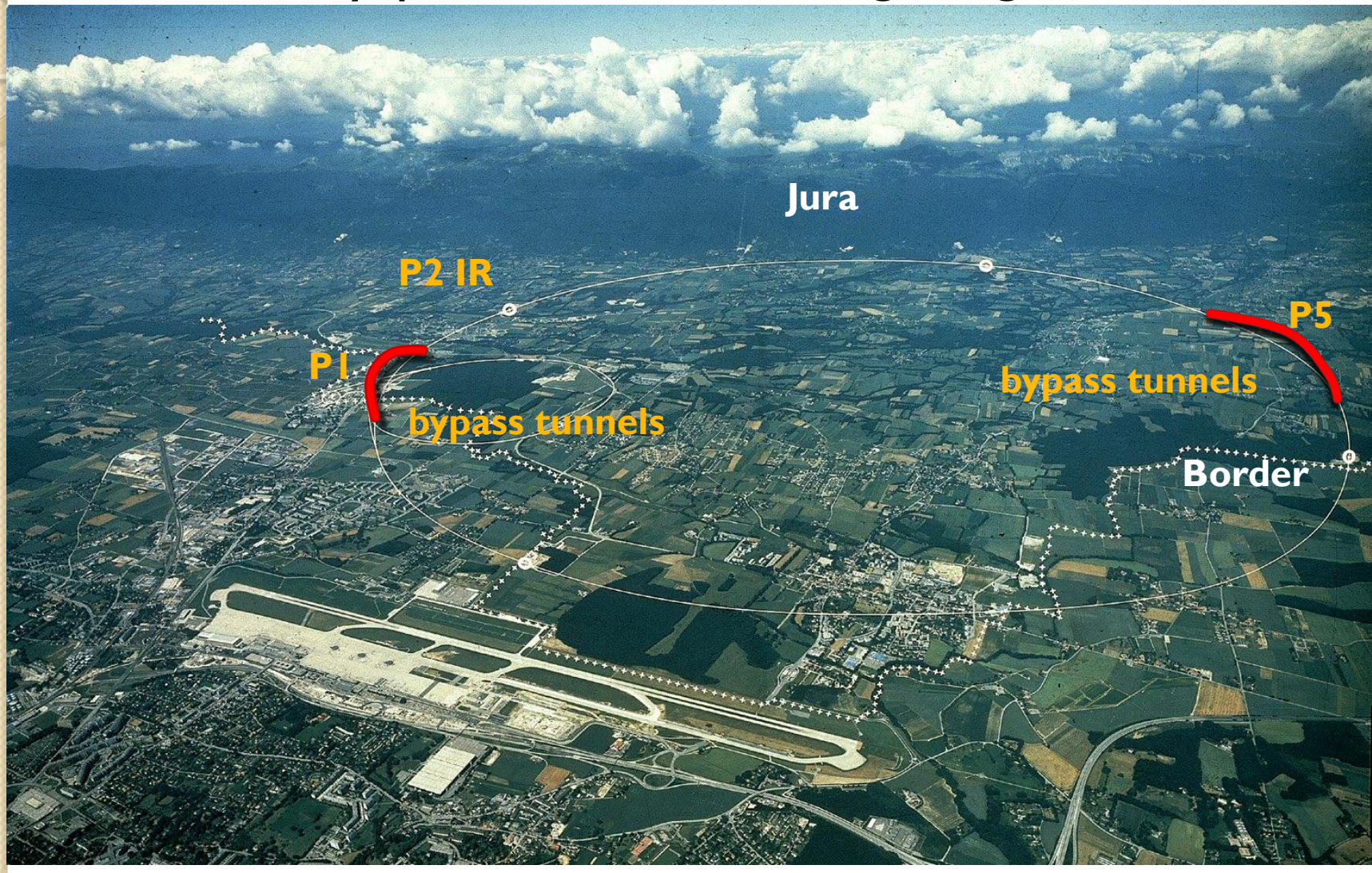
- Location: CERN - Geneva region
  - Proposed Interaction Point at LHC Point 2




LHeC Interaction Region at LHC Point 2

# Site Features *Location*

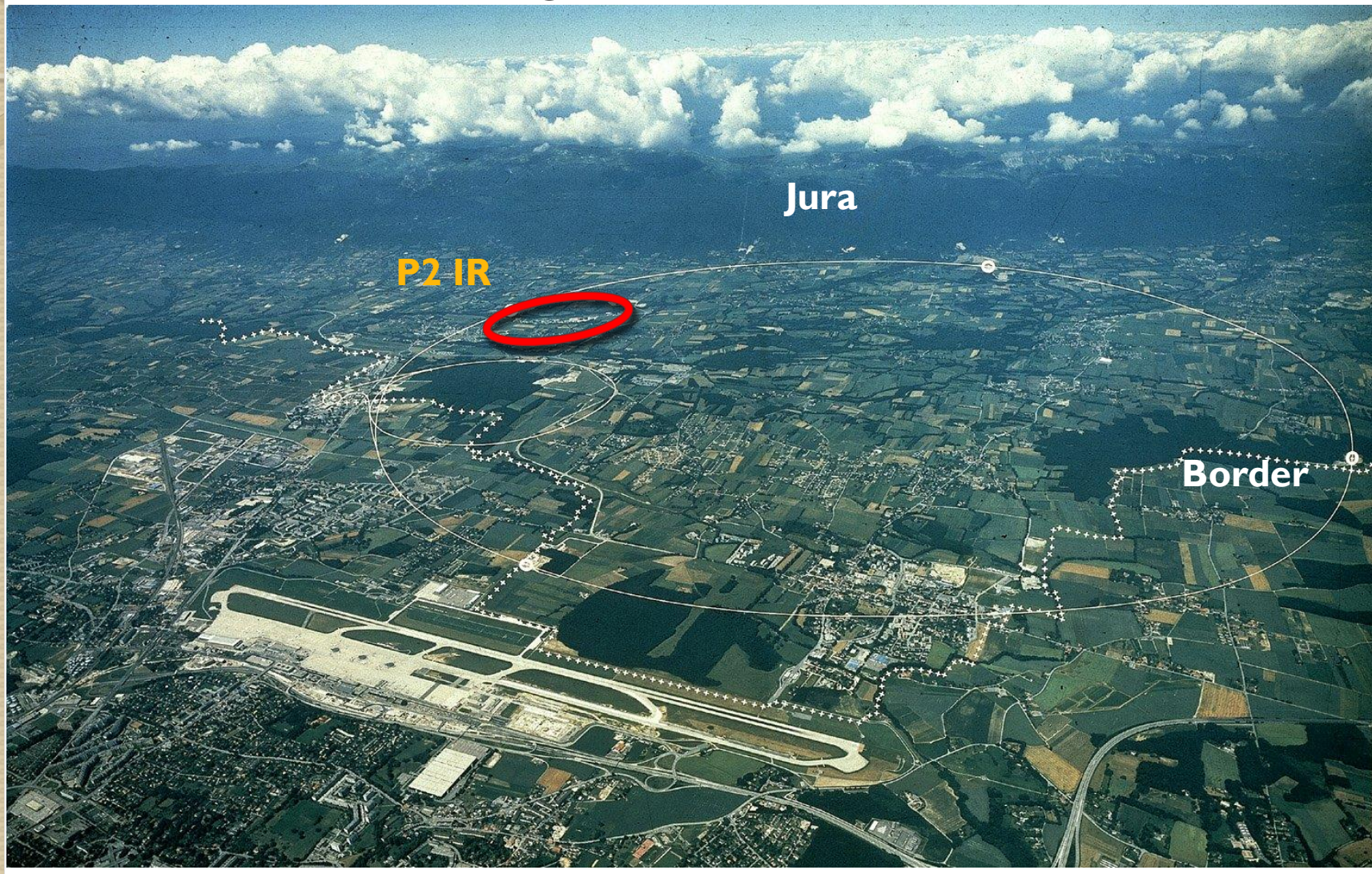
- Location: By-pass tunnels for Ring-Ring



# Site Features

## *Location*

- Location: Linac-Ring ERL

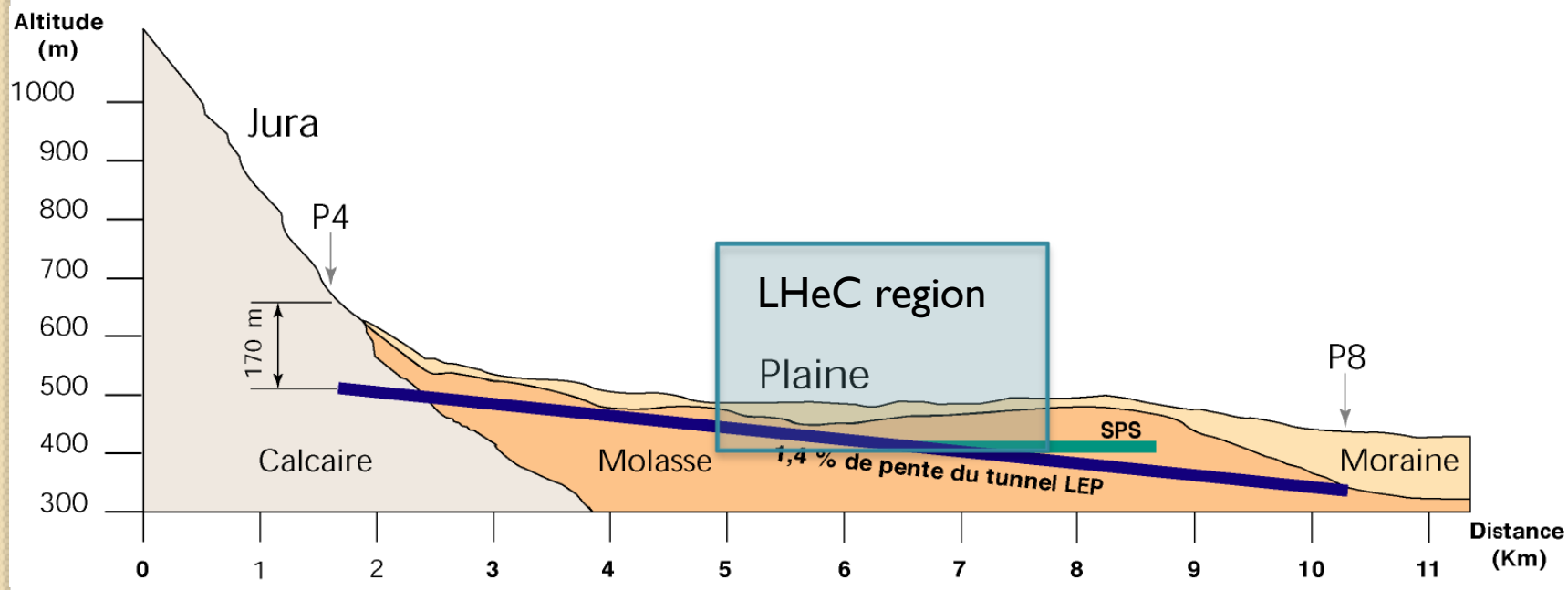


# Site Features *geology*

- Geology:
  - Molasse Basin (sub-basin of the Northern Alpine Foreland Basin)
  - Filled with Molasse deposits:
    - Alternating sequences of sandstones, marls, marly sandstones, sandy marls etc.
    - Relatively dry formations
  - Overlain by glacial moraines:
    - Gravel, sand
    - Water bearing units.

# Site Features *geology*

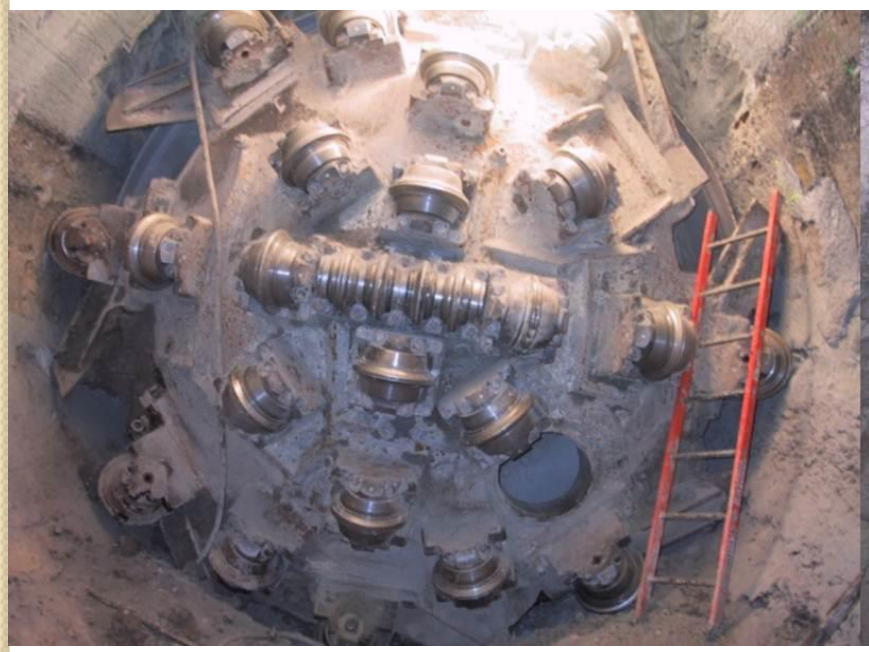
- Geology:
  - Molasse – Moraine
    - Profile LHeC region (showing also location of LHC and SPS)



# LHeC
# CONSTRUCTION METHODS

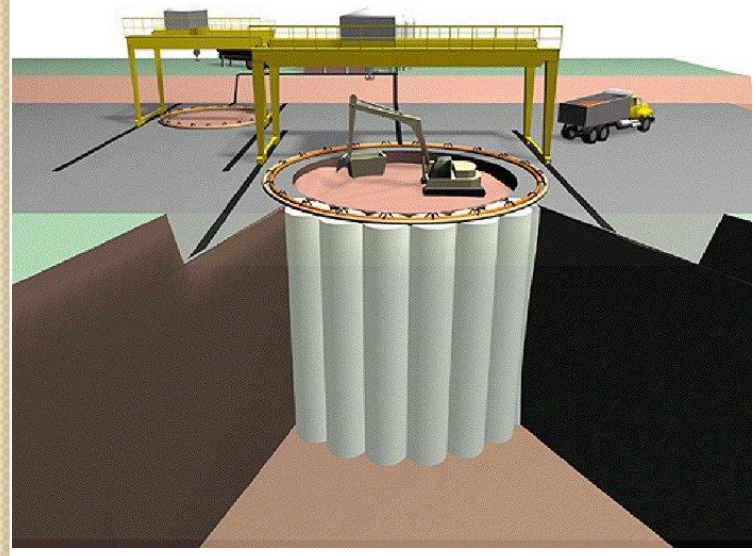
# Construction methods

- Construction methods (standard):
  - Tunnel boring machine (TBM)
    - Single pass precast segmental lining
    - Grout injection
    - 150m/week
  - Roadheader
    - 30m/week



# Construction methods

- Construction methods (non-standard):
  - Local geology can lead to some challenges
  - Glacial moraines can contain water Bearing units, underground channels:
    - experiences from LHC – CMS (point 5)



# LHeC

## CIVIL ENGINEERING OPTIONS

# Civil Construction *LHeC options*

- Two Layouts considered for CDR
  - Ring – Ring
    - New bypass tunnels outside of the LHC ring at Point 1 and Point 5
    - Minimum of 5m separation LHC
      - Radiation shielding during LHeC construction & undisturbed LHC operation during excavation
  - Linac – Ring
    - Energy Recovery Linac (ERL) around St. Genis-Pouilly area, injecting into LHC (Point 2) cavern
    - Tunnel generally horizontal at same level as P2 region
    - Tunnel crosses over the LHC twice in the P2 region
    - ~ 10km of tunneling (SPS: ~7km tunnel circumference)

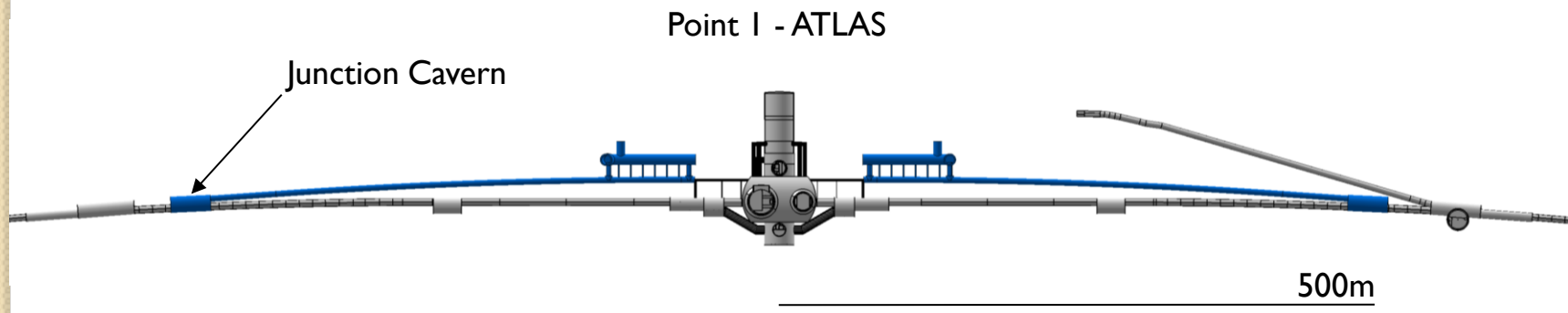
# Civil Construction *LHeC options*

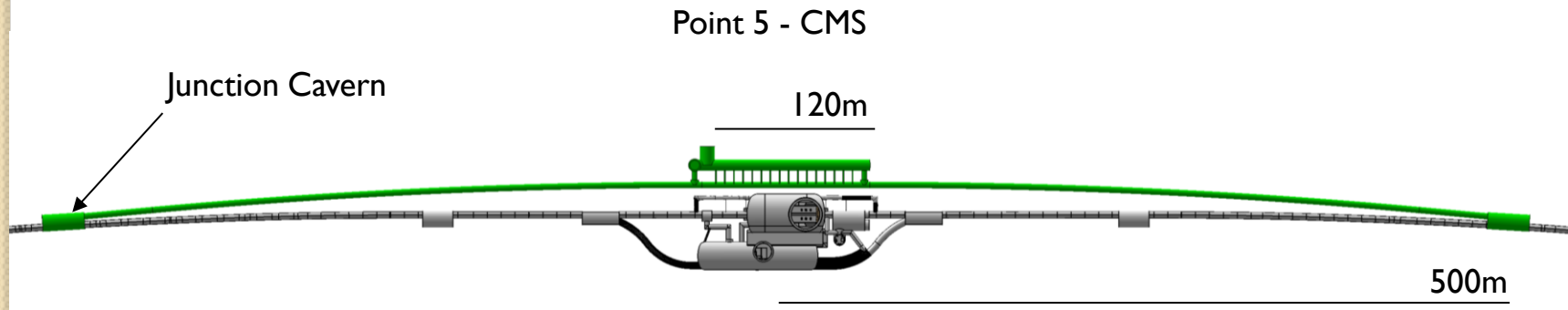
- Two Layouts
  - Ring – Ring
    - New bypass tunnels on the outside of the LHC tunnel at Point 1 and Point 5
  - Linac – Ring
    - Energy Recovery Linac (ERL) around St. Genis-Pouilly area, injecting into LHC ALICE (Point 2) cavern
    - Tunnel generally horizontal at same level as ALICE region
    - Tunnel crosses LHC twice in the ALICE region

# Civil Construction *Ring-Ring scheme*

*(not being studied further at this stage)*

- Ring – Ring
  - New bypass tunnels on the outside of the LHC tunnel at Point 1 and Point 5
    - Assumed no bypass tunnel needed at Point 7 (LHCb)

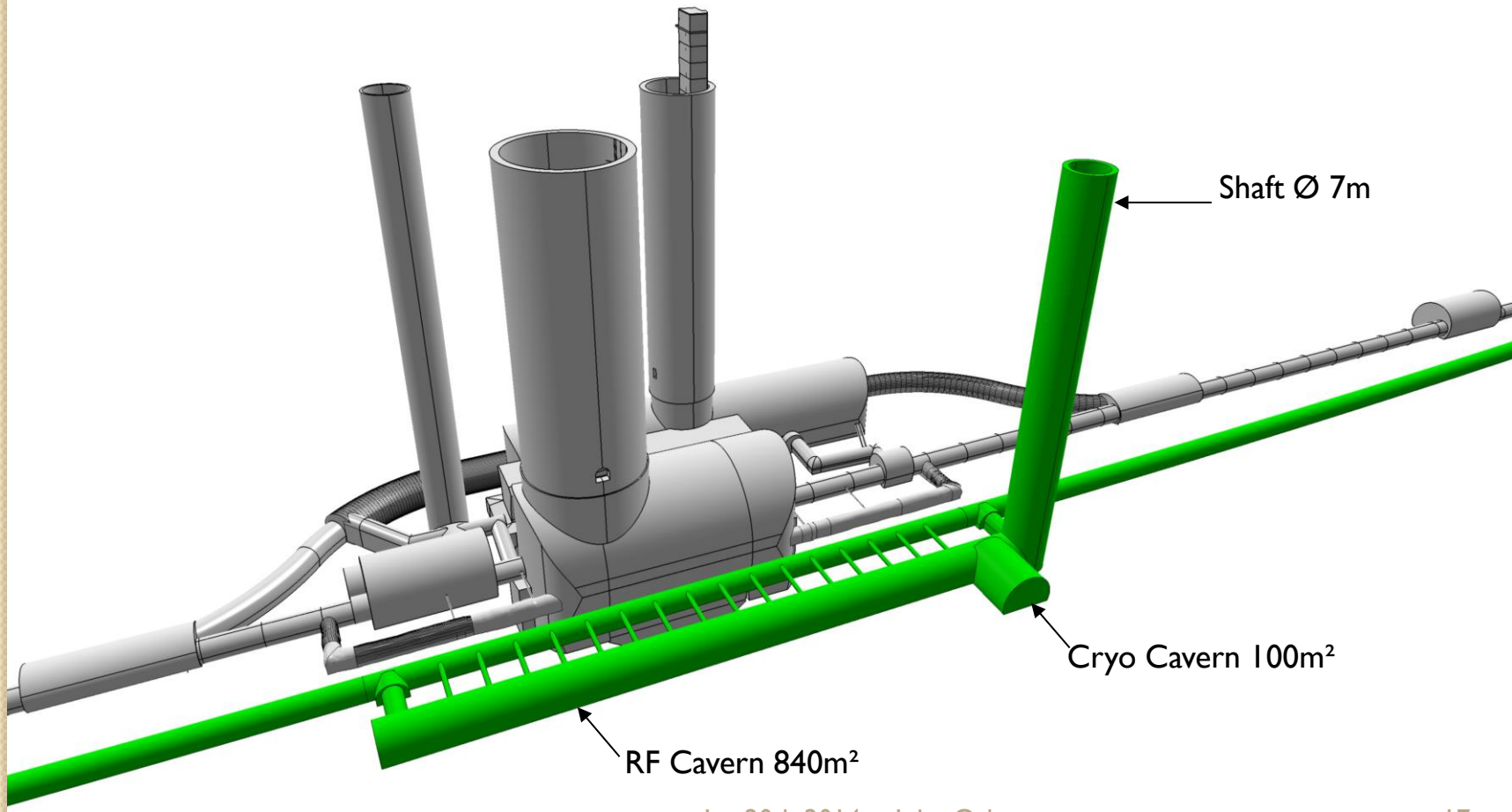


# Civil Construction *Ring-Ring scheme*

*(not being studied further at this stage)*

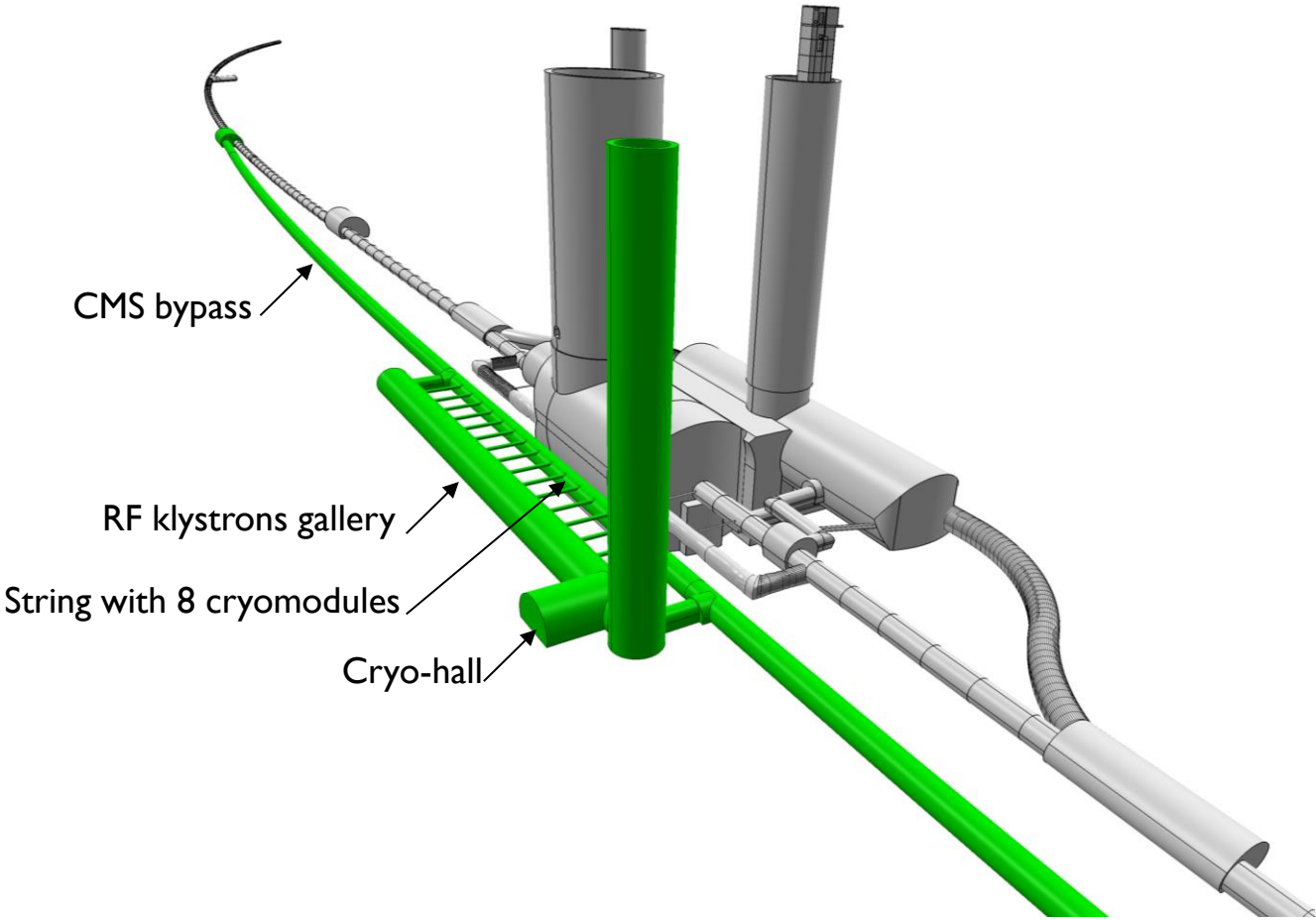
- Ring – Ring
  - New bypass tunnel at CMS(P5)



# Civil Construction *Ring-Ring scheme*

*(not being studied further at this stage)*

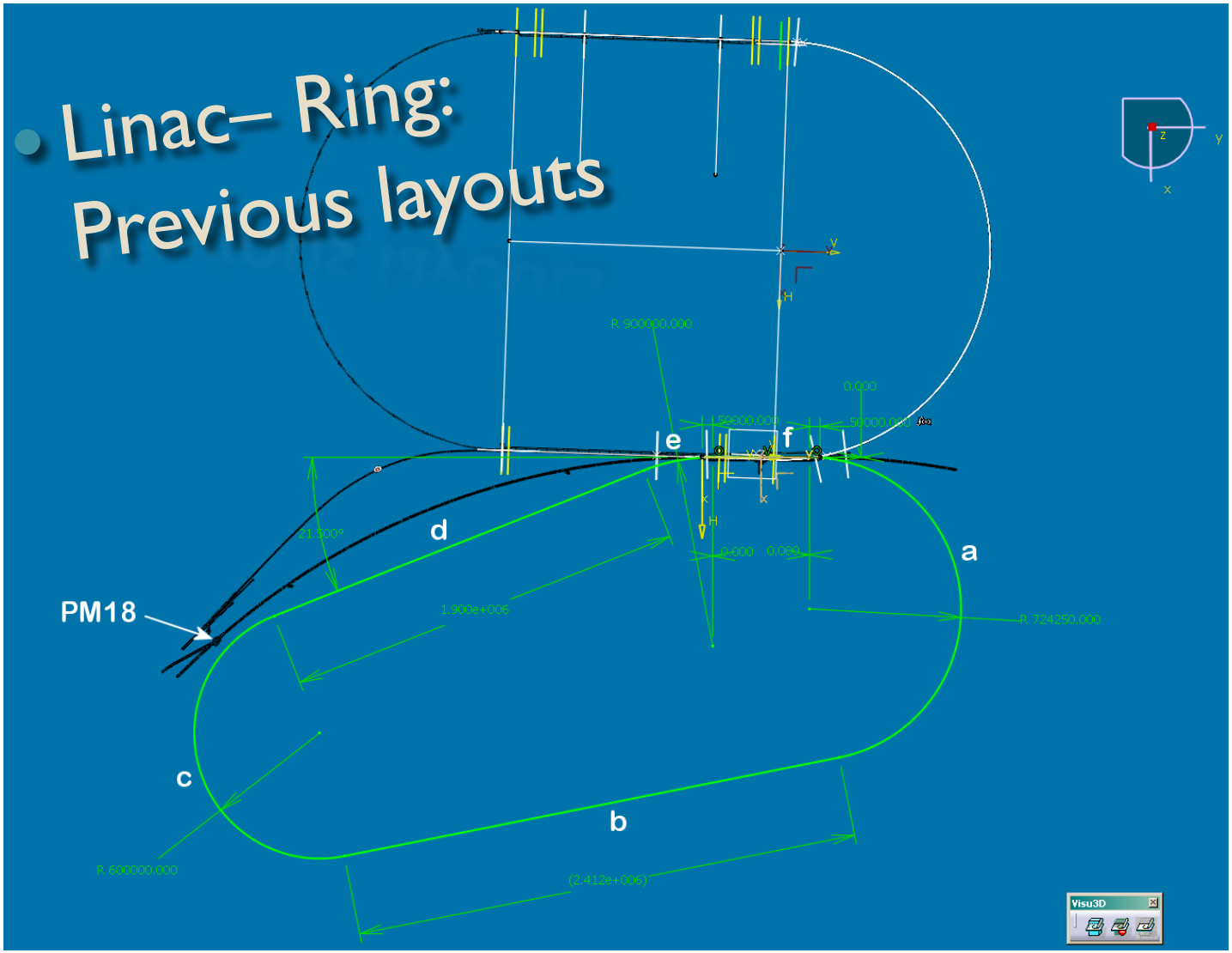
- Ring – Ring
  - New bypass tunnel at CMS(P5)



# Civil Construction *LHeC options*

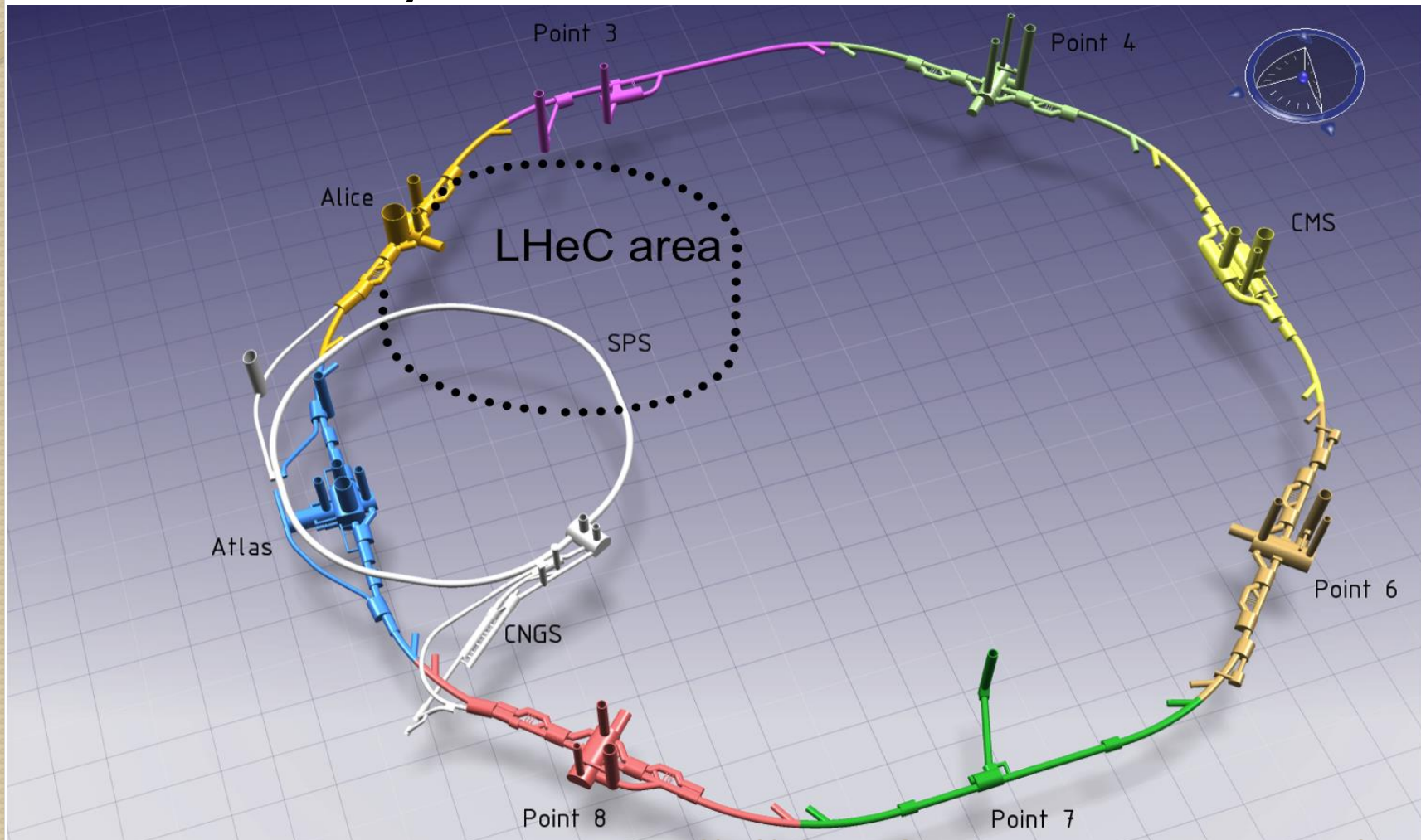
- Two Layouts
  - Ring – Ring
    - New bypass tunnels on the outside of the LHC tunnel at Point 1 and Point 5
  - Linac – Ring (BASELINE Solution)
    - Energy Recovery Linac (ERL) around St. Genis-Pouilly area, injecting into LHC (Point 2) cavern
    - Tunnel generally horizontal at same level as ALICE region
    - Tunnel crosses over LHC twice in the P2 region

# Civil Construction *Linac-ring scheme*



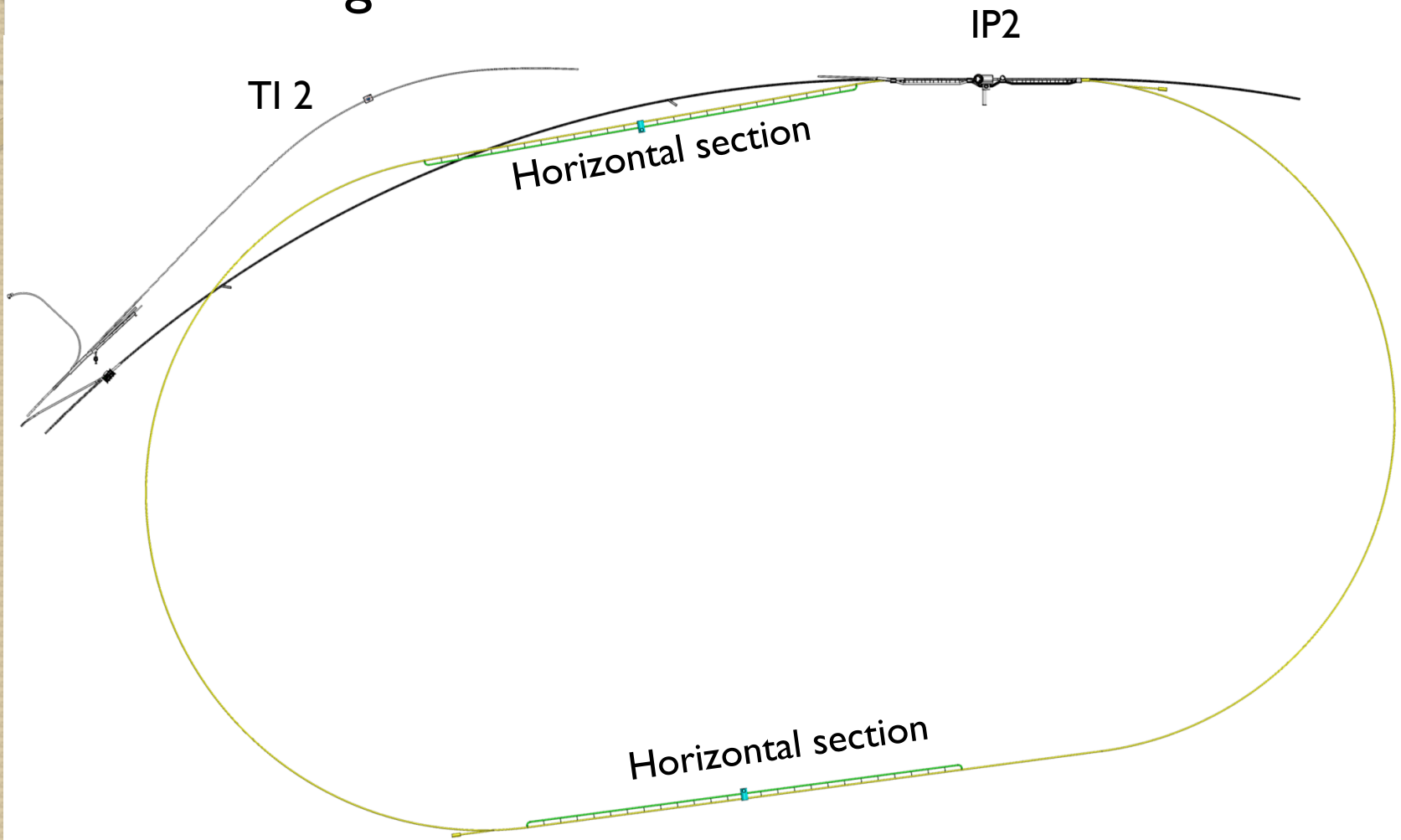
# Civil Construction *Linac-ring scheme*

- Linac– Ring: Injection point at P2
- Tunnel mostly horizontal



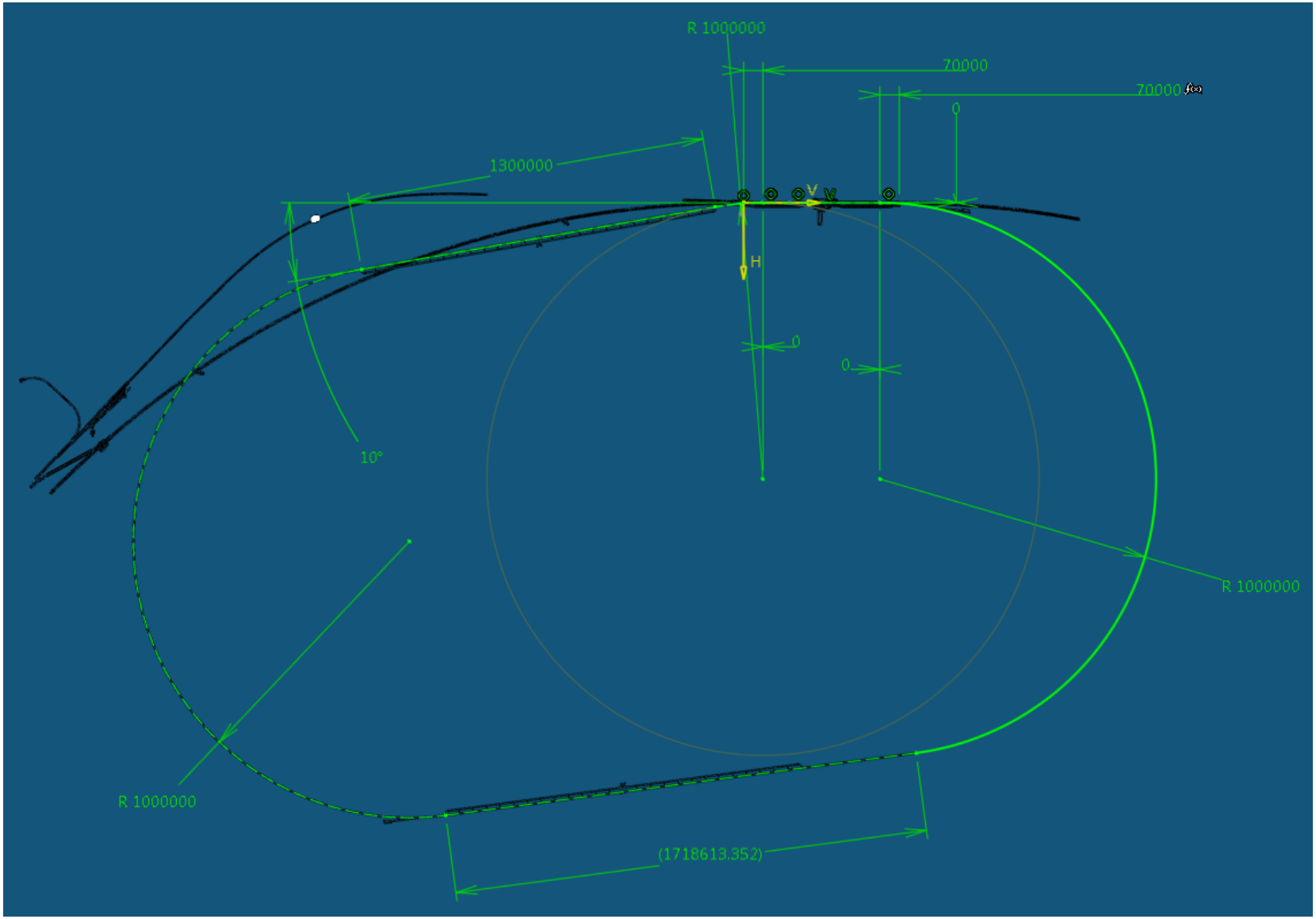
# Civil Construction *Linac-ring CDR scheme*

- Linac– Ring:



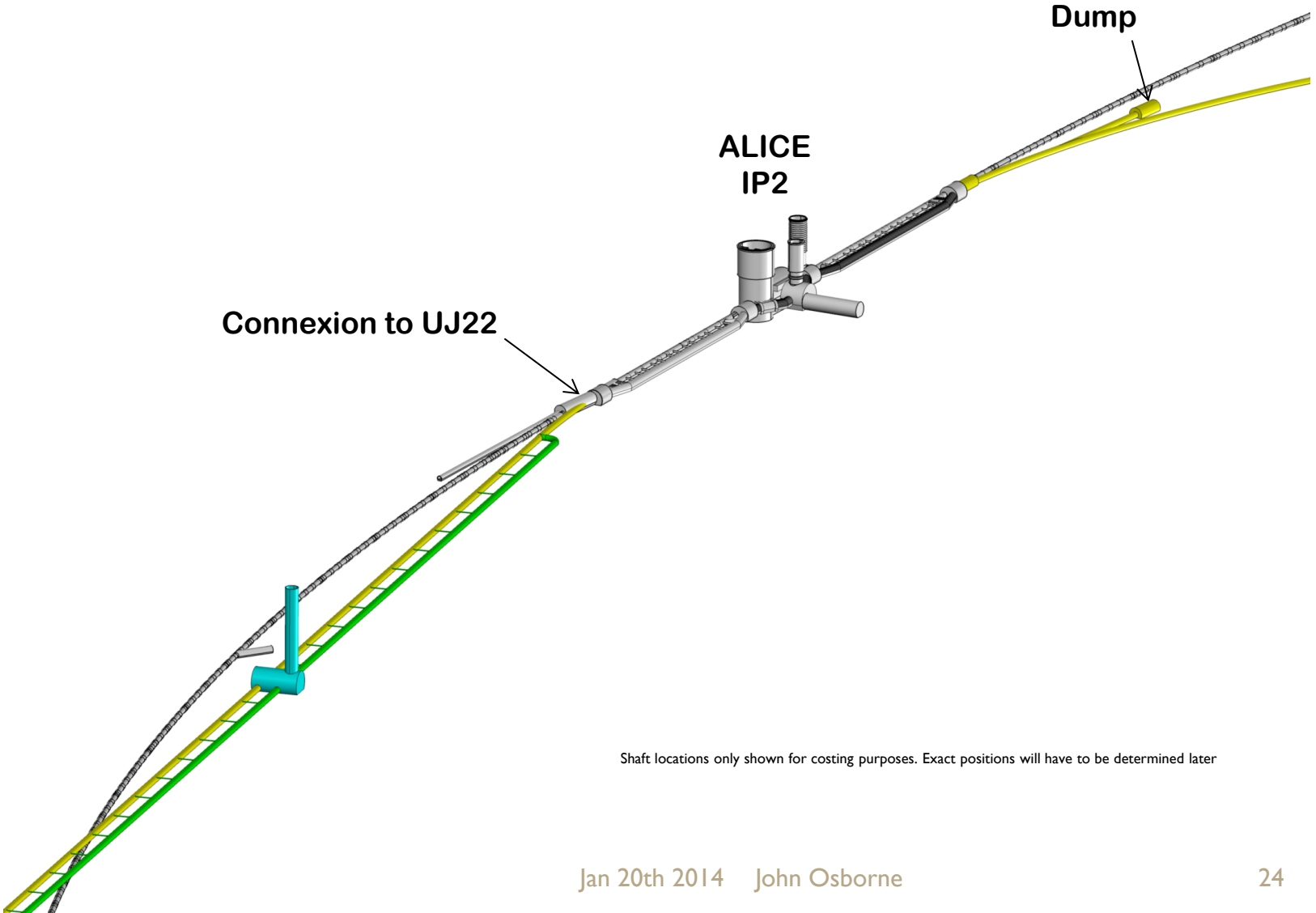

Shaft locations only shown for costing purposes. Exact positions will have to be determined later, but it is assumed that they can be on or very close to existing CERN property

- Linac– Ring: Dimensions



# Civil Construction *Linac-ring scheme*

- Linac– Ring:

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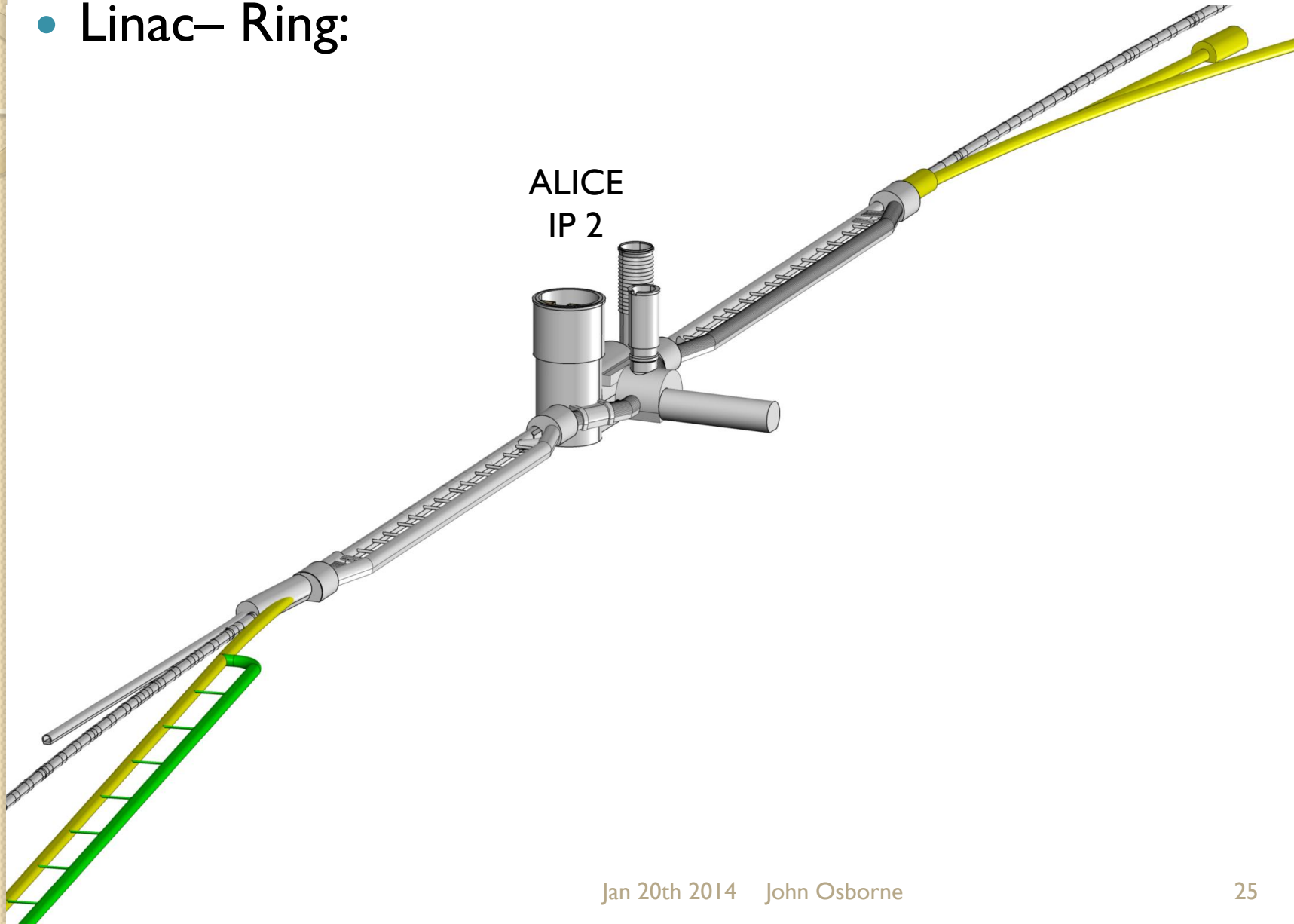
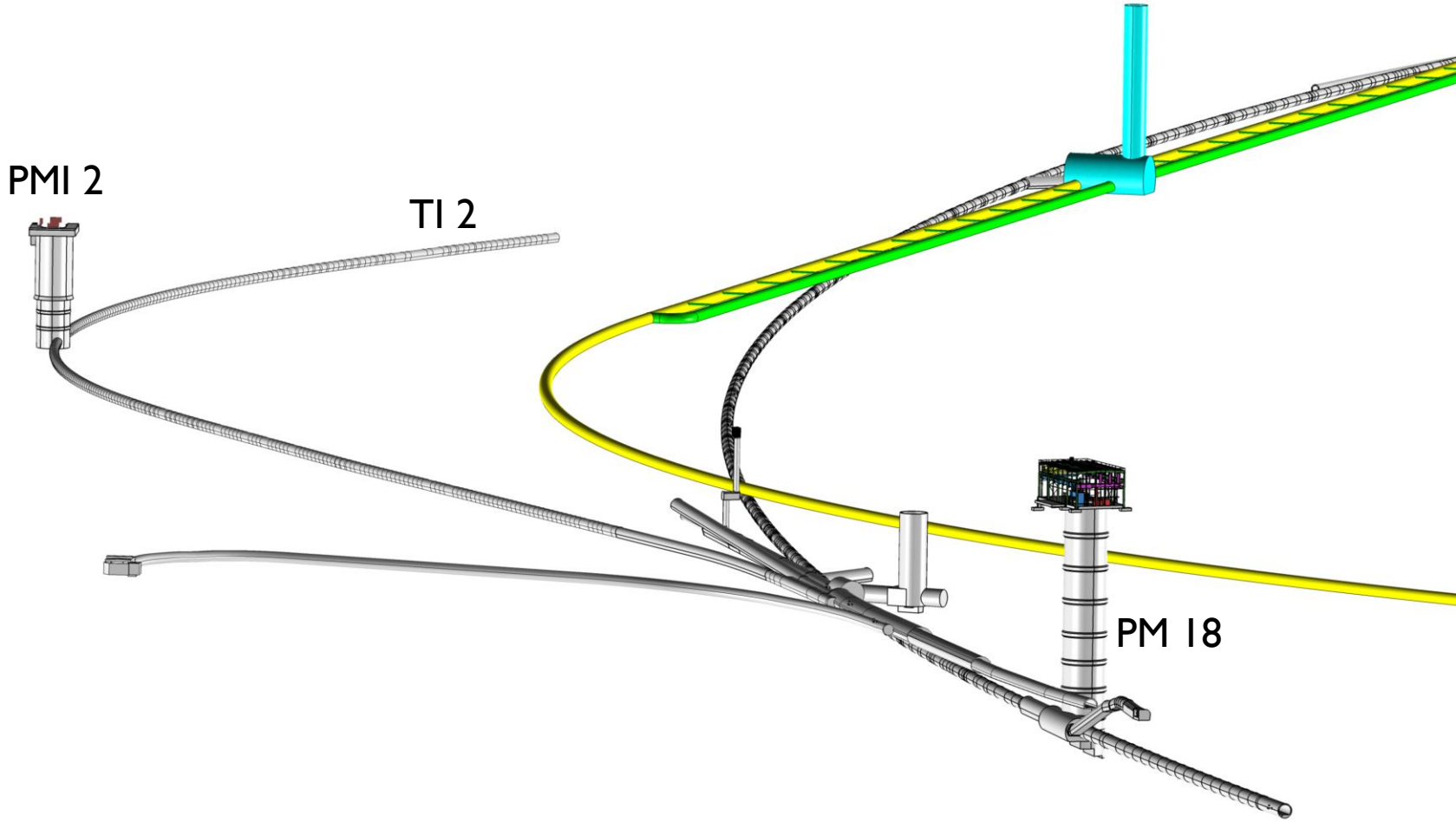
# Civil Construction *Linac-ring scheme*

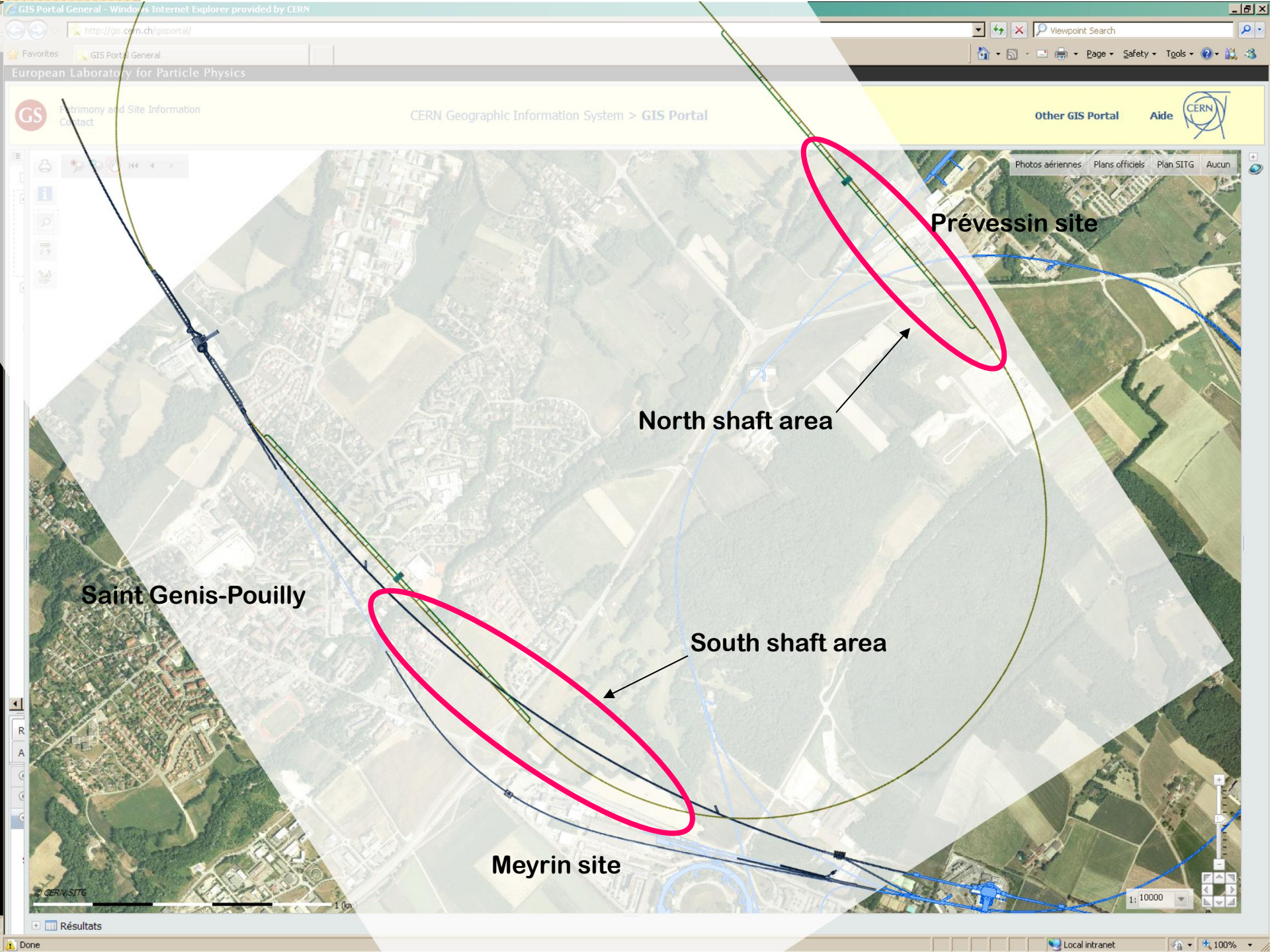
- Linac– Ring:



# Civil Construction *Linac-ring scheme*

- Linac– Ring:




Prévessin site
North shaft area
Saint Genis-Pouilly
South shaft area
Meyrin site

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# COSTING & PLANNING

# Costing and Planning

## **Preliminary** *LHeC* ***underground*** *costs*

| | Ring – Ring * | | | Linac-Ring |
|---|---|---|---|---|
| | P1 (Atlas) | P5 (CMS) | Total | Total |
| Underground | 40,156 | 38,445 | 78,602 | 226,983 |
| Consultancy | 4,059 | 3,886 | 7,946 | 22,945 |
| Total KCHF | 44,216 | 42,331 | **86,547** | **249,928** |

*** Ring-Ring costs do not include : Bypass tunnels at Point 8 (LHCb) or Injection Complex**

No surface structures included in this cost estimate. Integration with other services (Cooling & Ventilation, Electricity etc) needed in the next phase to better define underground volumes and surface building requirements.

*Cost estimation by Amberg Engineering*.

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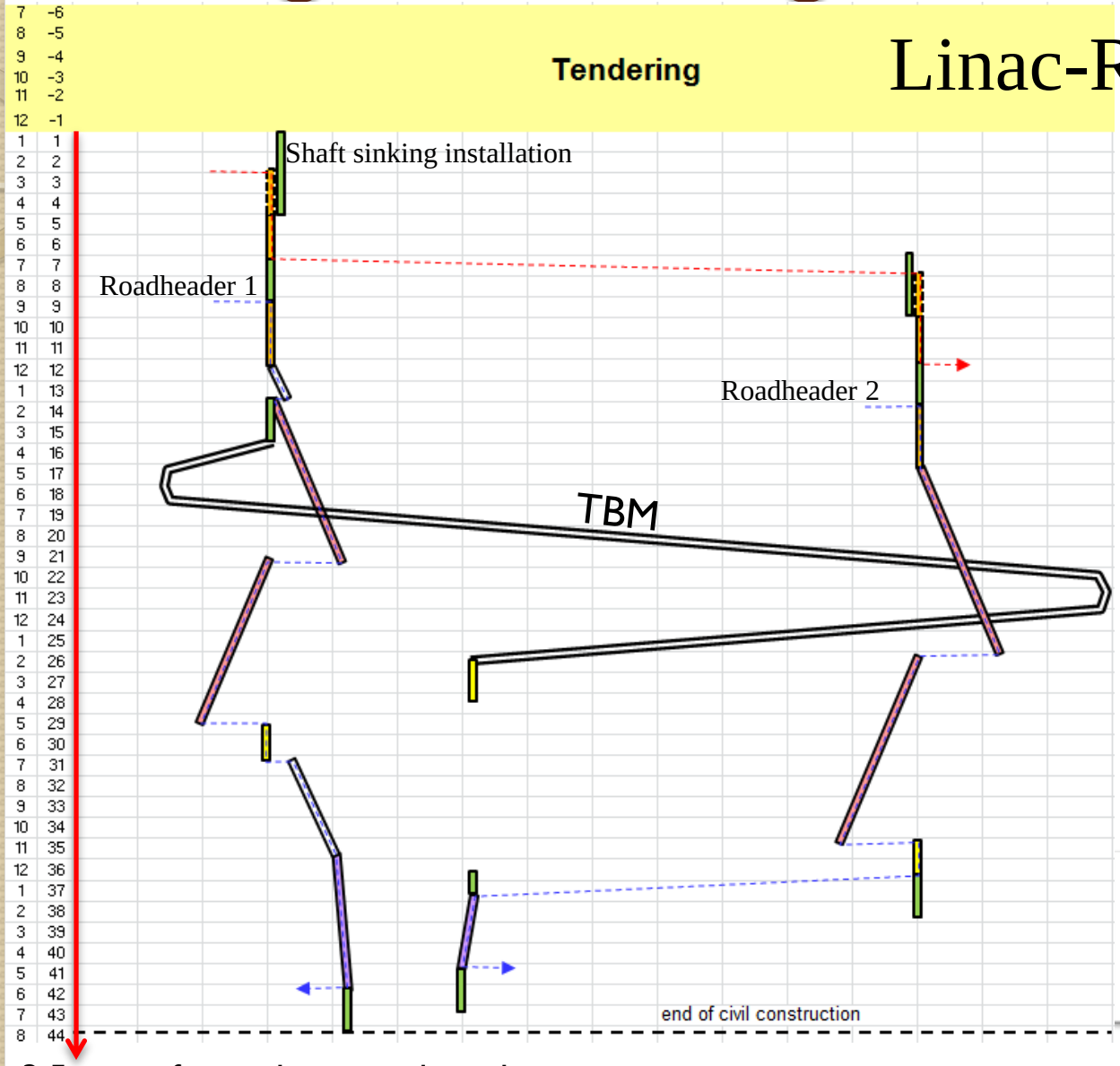
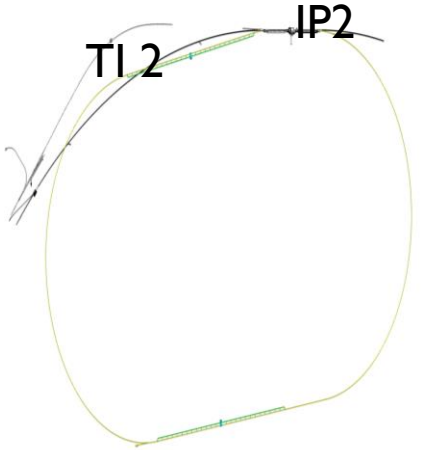
# Costing and Planning *LHeC planning*

## Linac-Ring option




3.5 years for underground works
using 2 roadheaders and 1 TBM



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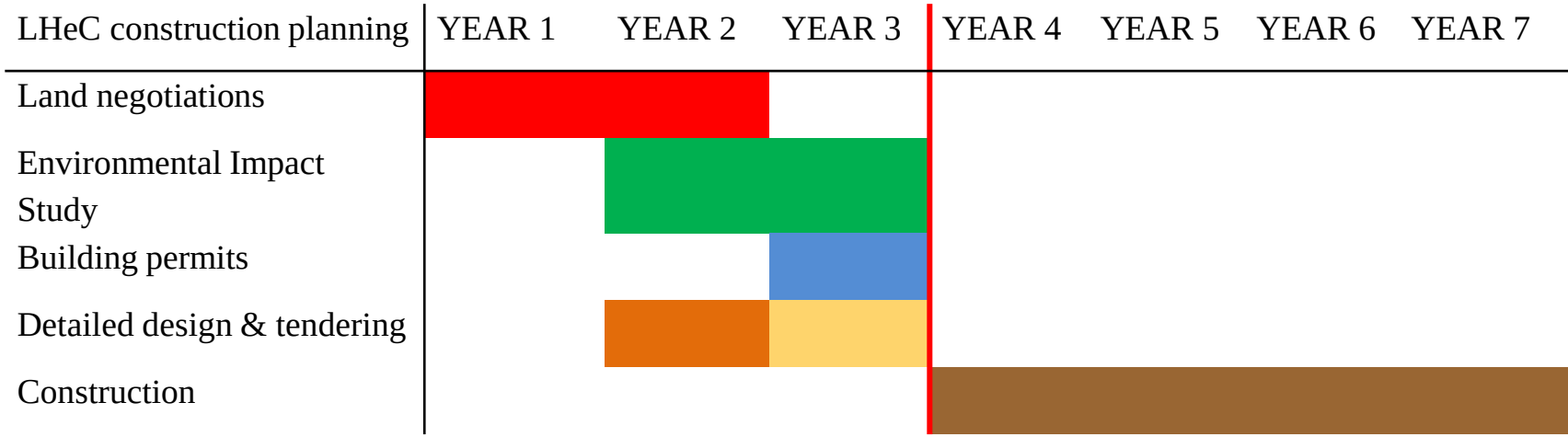
# Costing and Planning *LHeC planning*




4 year Construction schedule for either LHeC option:

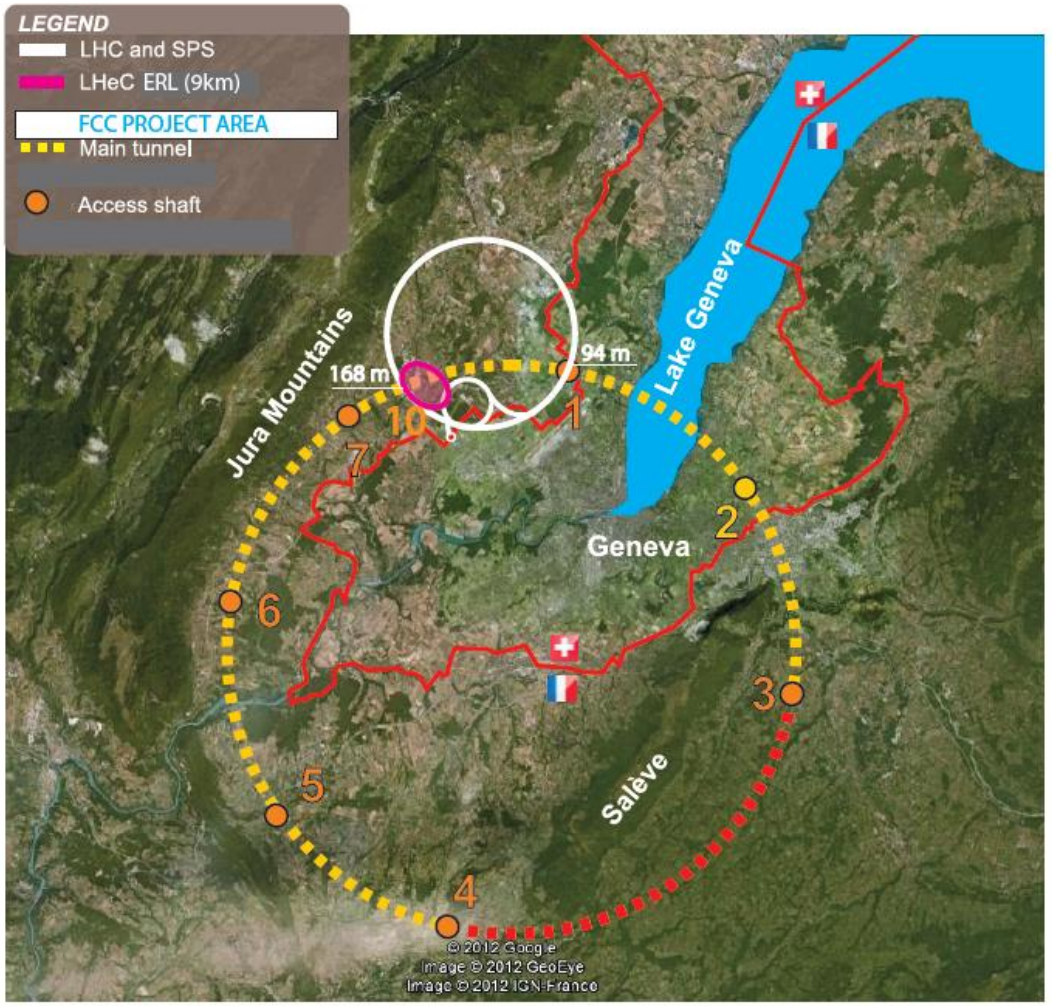
- Ring-ring:
  - Assuming 2 roadheaders with excavation progress of 30m/week
- Linac-Ring:
  - Assuming 2 roadheaders and 1 shielded TBM (TBM excavation progress of 150m/week)

# LHeC and the Future Circular Collider (FCC)

- **Phase 1** : ep collisions at LHC P2
- **Phase 2** : ep collisions in FCC near LHC P2
- European Strategy Paper (2012), the 'plan' position for passes under the LHeC ERL
- However, FCC is 150m deeper than ERL
- FCC tunnel location/depth still to be optimised

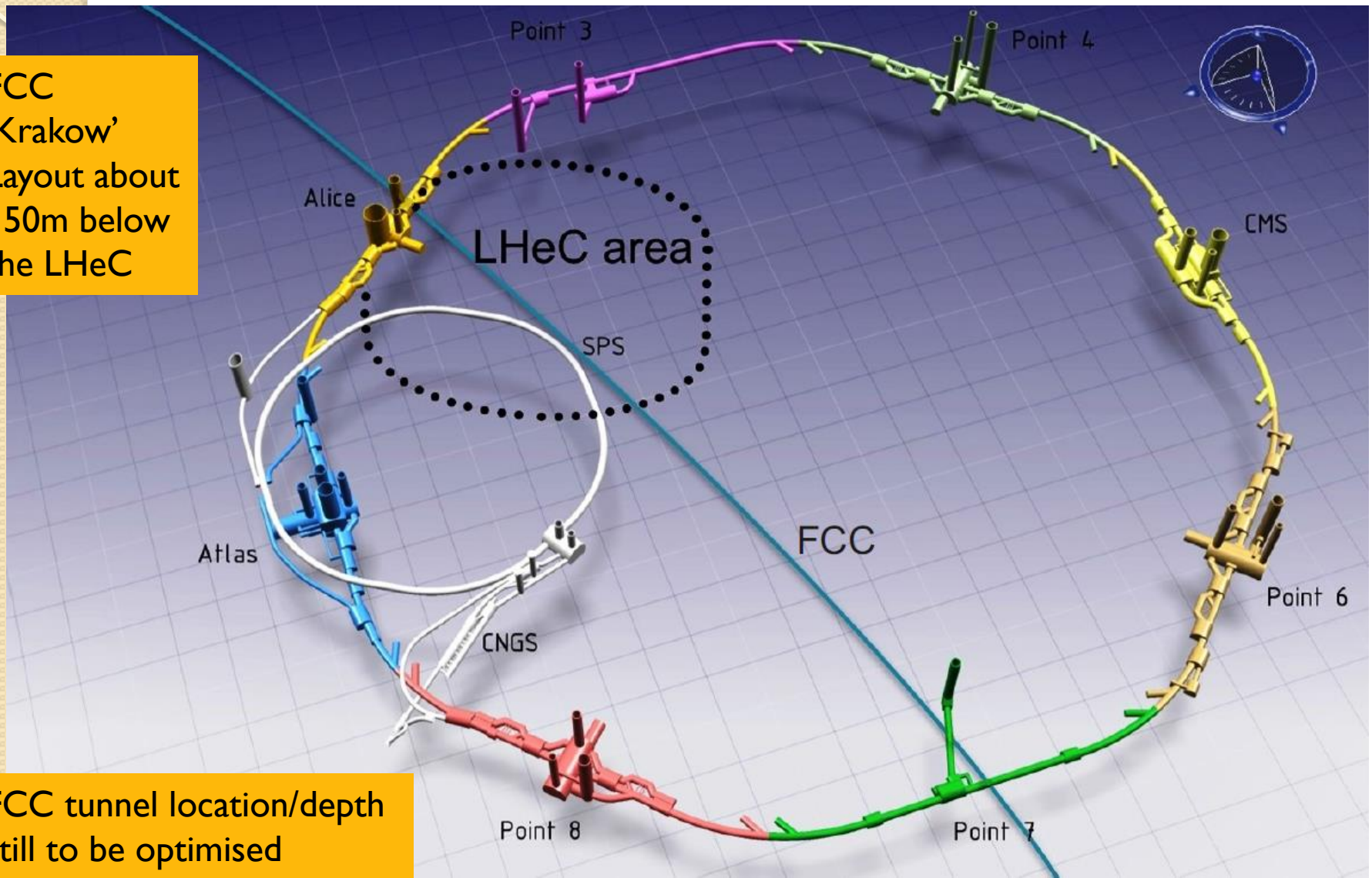
## Version 230 mASL

| | SPS | LHC | FCC | Between LHC/FCC |
|---|---|---|---|---|
| Point 1 | 40m | 96m | 190m | 94m |
| Point 10 | 40m | 50m | 218m | 168m |



# LHeC and the Future Circular Collider (FCC)

- FCC 'Krakow' Layout about 150m below the LHeC




- FCC tunnel location/depth still to be optimised

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# CONCLUSIONS & NEXT STEPS

# Conclusions & Next Steps for *Civil Engineering*

- Both the Ring-Ring and Linac – Ring options are feasible.
  - Ring-Ring: cheaper, but increased risk to LHC activity
  - Linac-Ring: lower risk to LHC, but more expensive + more time needed for :
    - building permits
    - environmental impact study
- More studies needed for
  - Integration with all services (EL, CV, transport, survey etc).
  - Geology
  - Understanding vibration risks
  - Environmental impact assessment
- LHeC and FCC Layouts to be carefully studied