LHeC
CIVIL ENGINEERING

Special thanks to:

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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

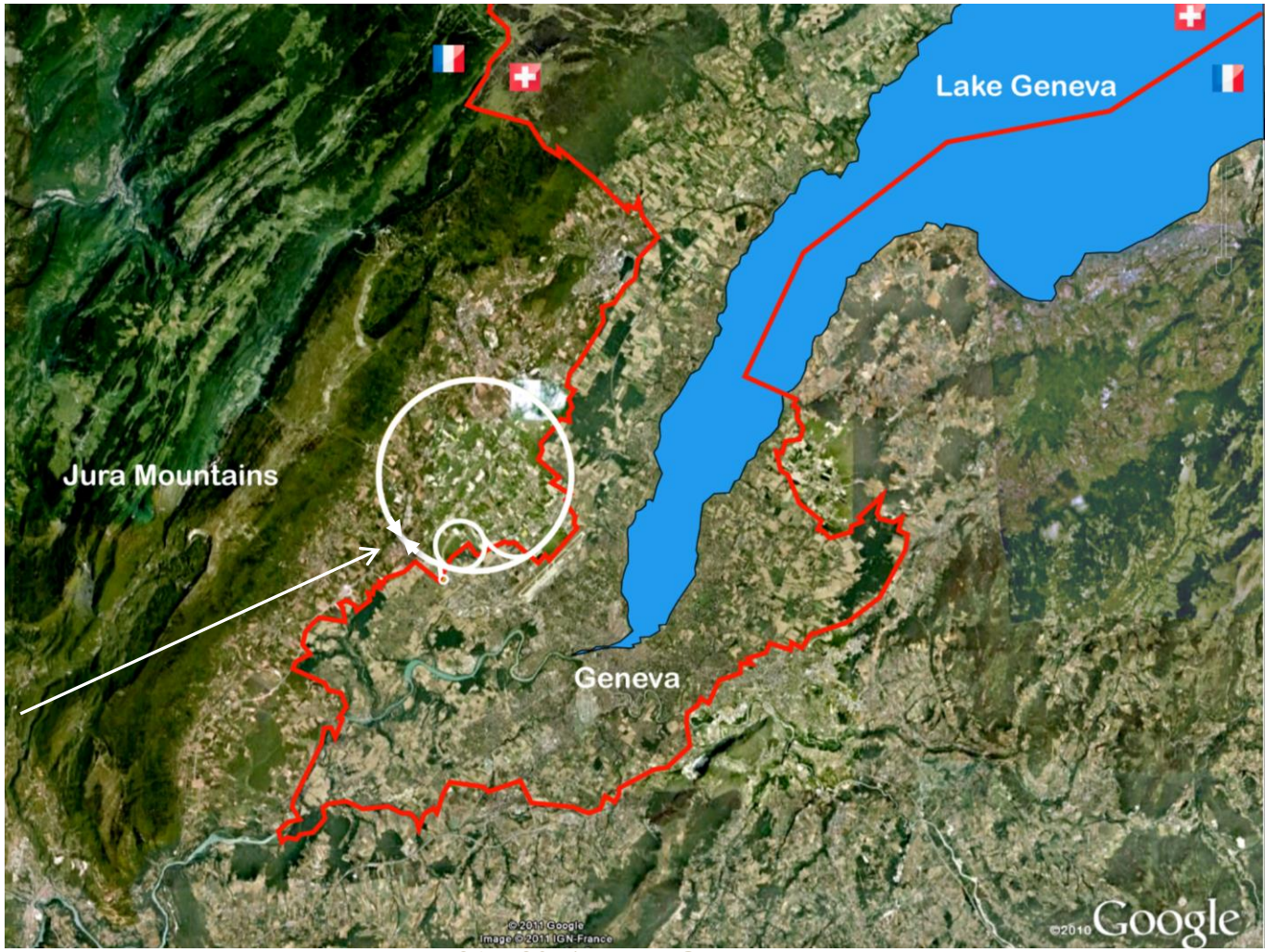
LHeC

SITE FEATURES

Site Features

Location

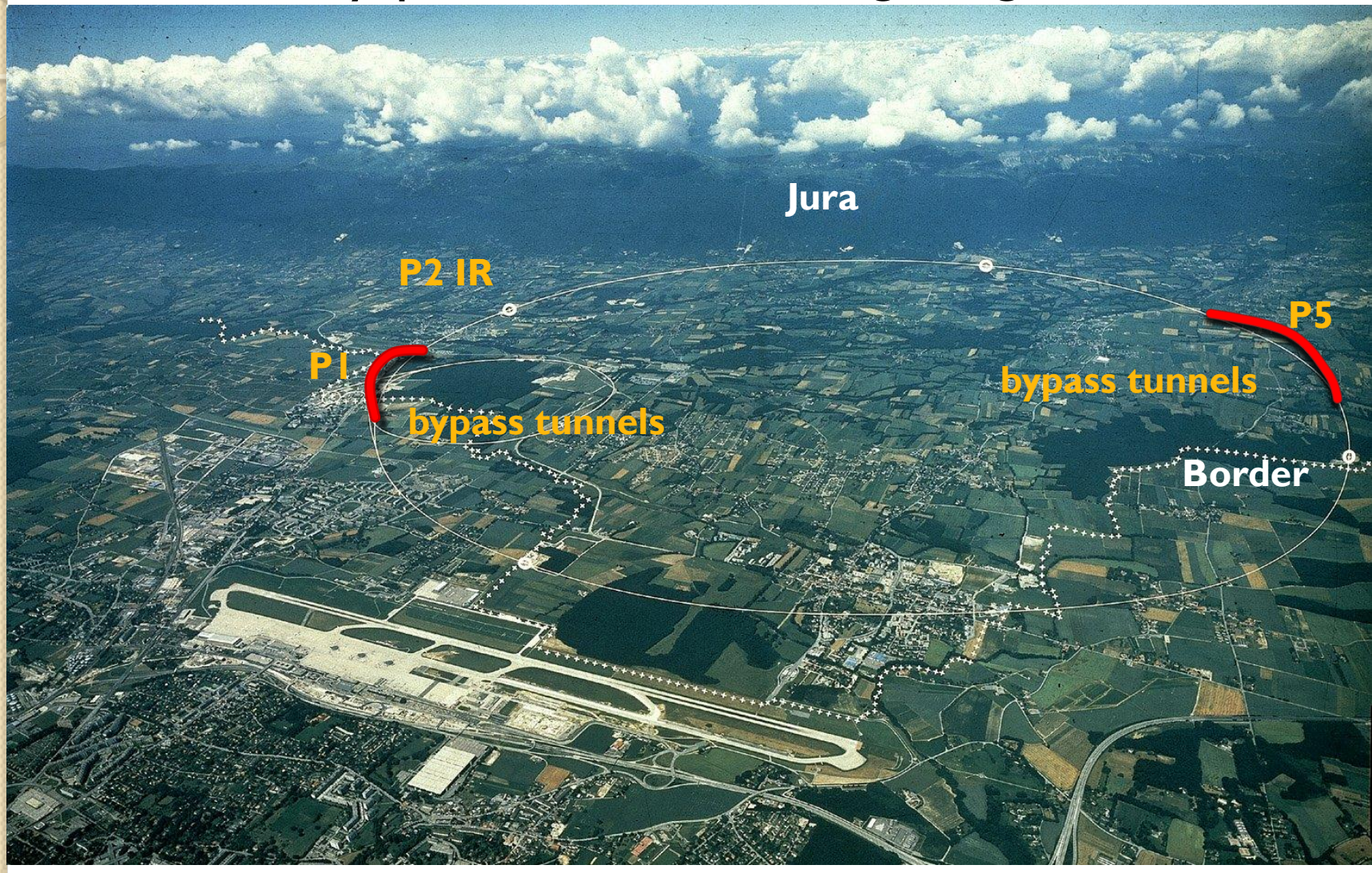
- Location: CERN - Geneva region
  - Proposed Interaction Point at LHC Point 2



LHeC Interaction Region at LHC Point 2

Site Features *Location*

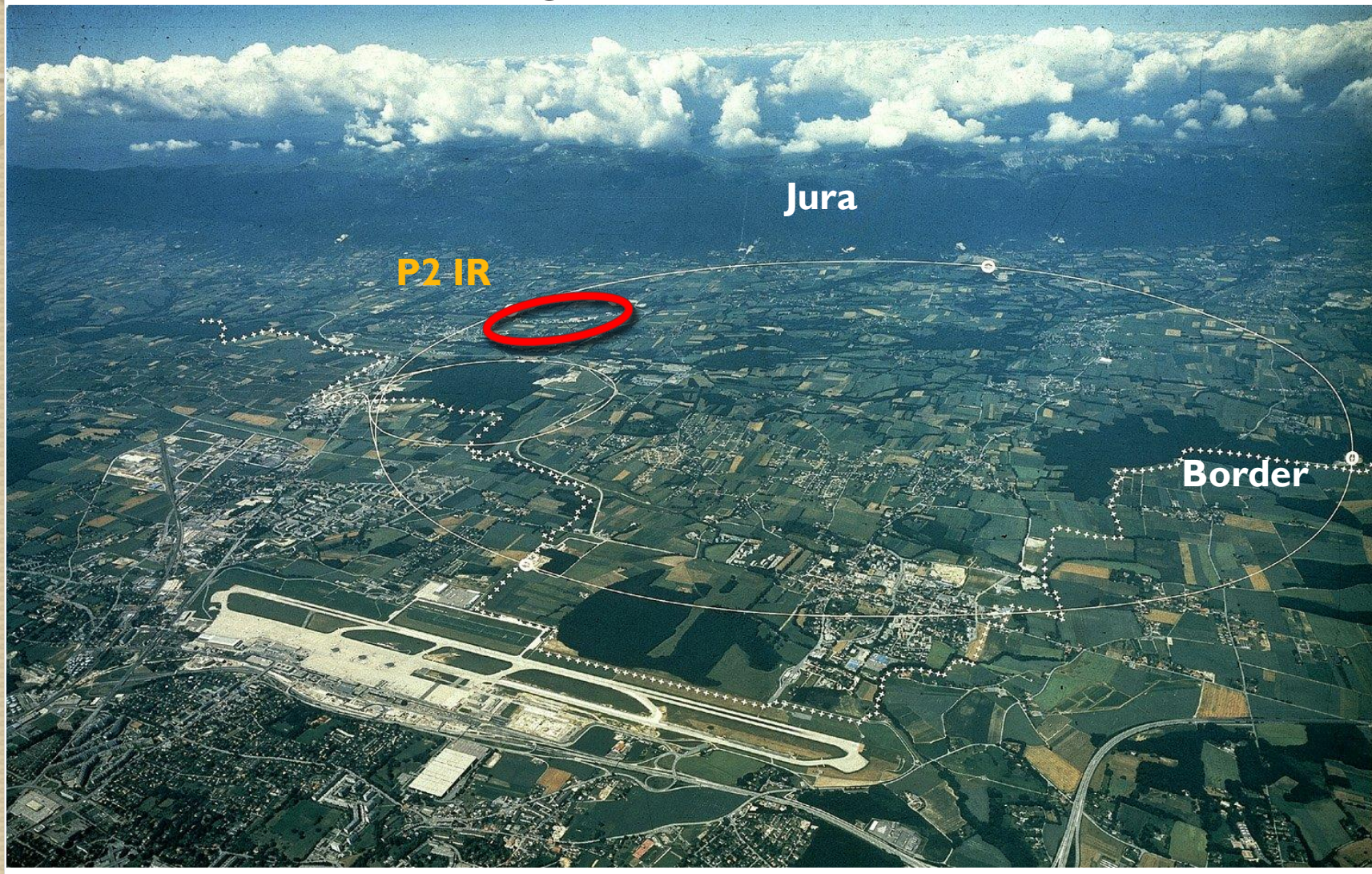
- Location: By-pass tunnels for Ring-Ring



Site Features

Location

- Location: Linac-Ring ERL

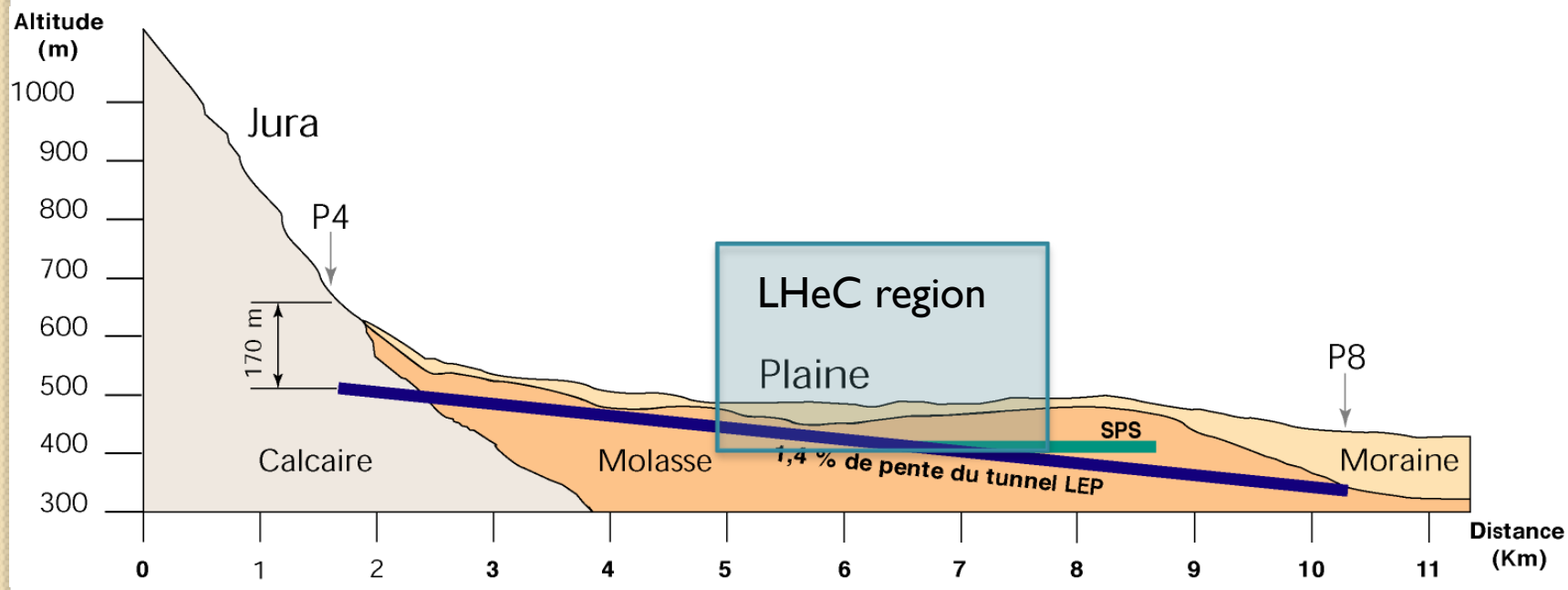


Site Features *geology*

- 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*

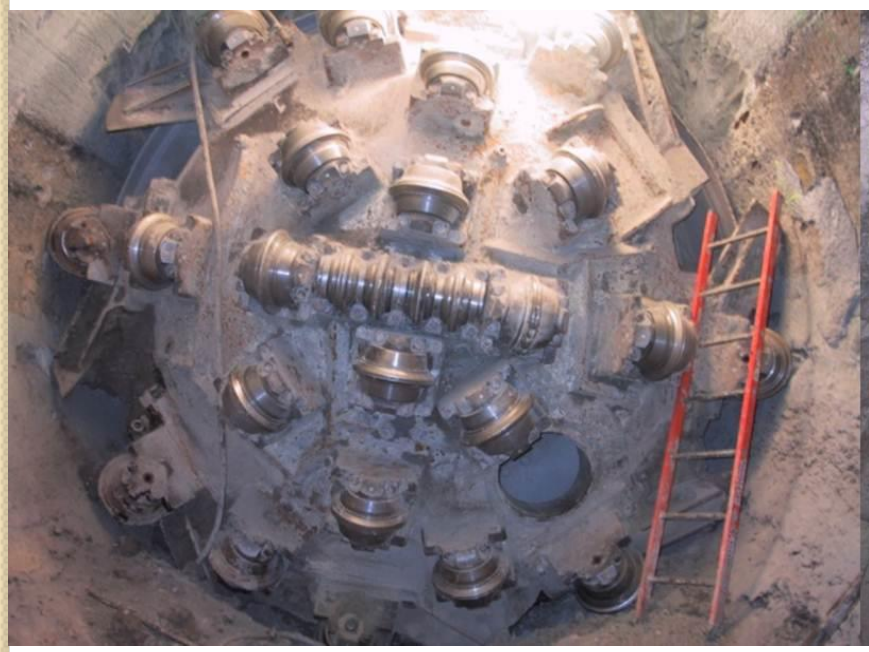
- Geology:
  - Molasse – Moraine
    - Profile LHeC region (showing also location of LHC and SPS)



LHeC
CONSTRUCTION METHODS

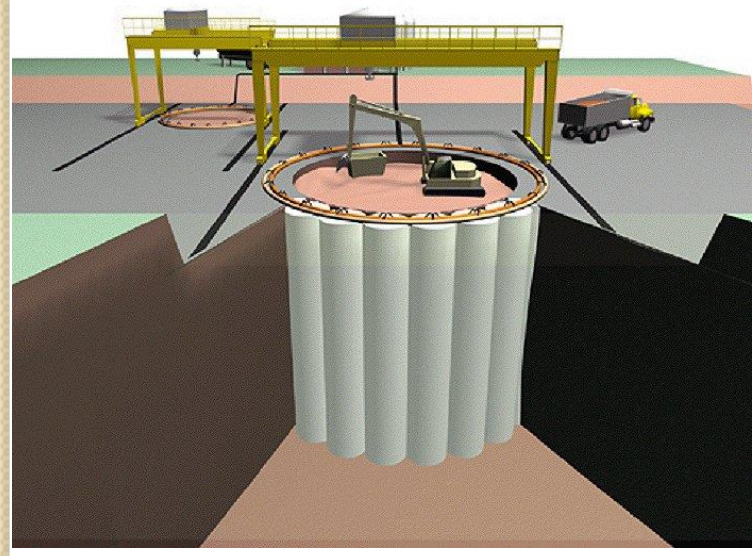
Construction methods

- 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)

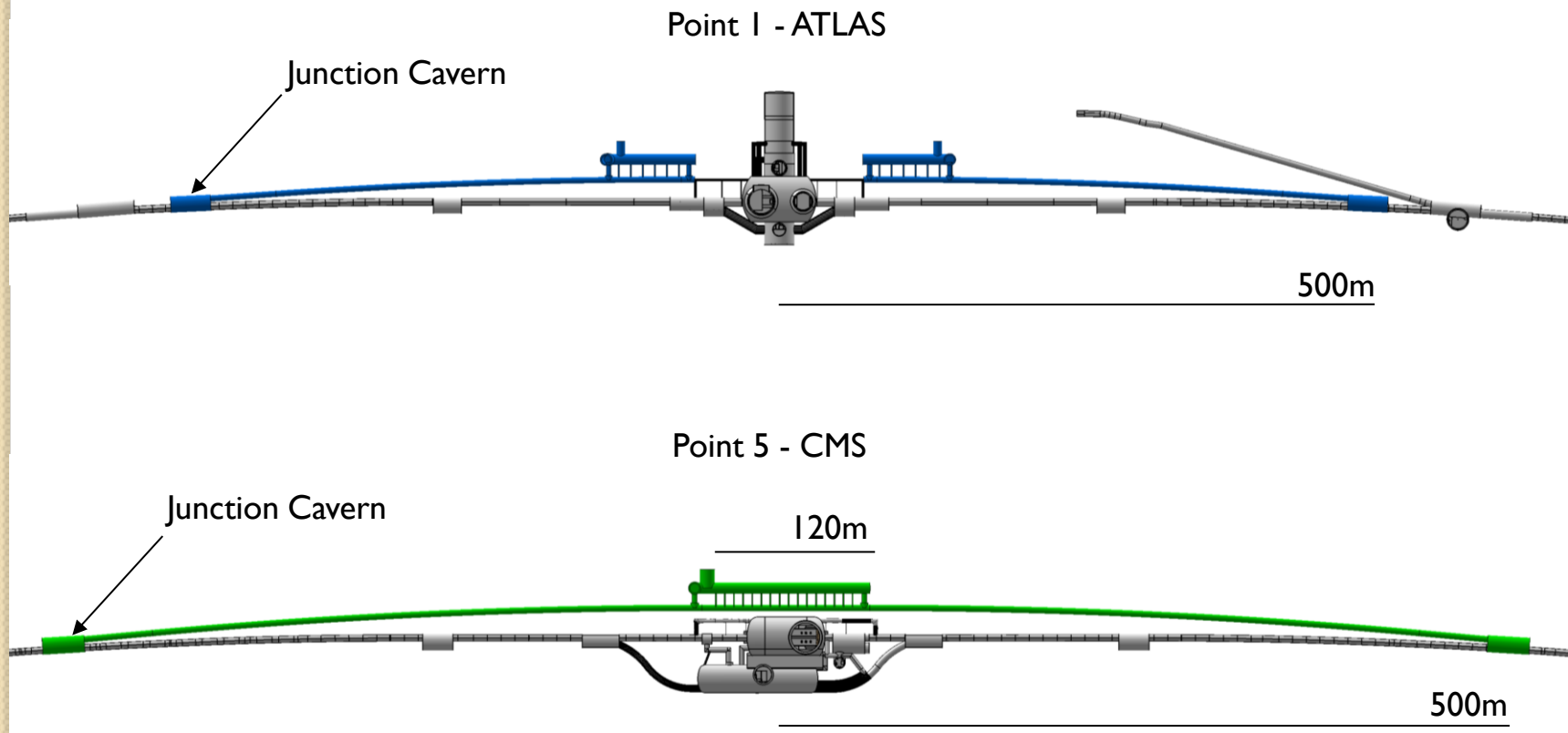
Civil Construction *LHeC options*

- 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)

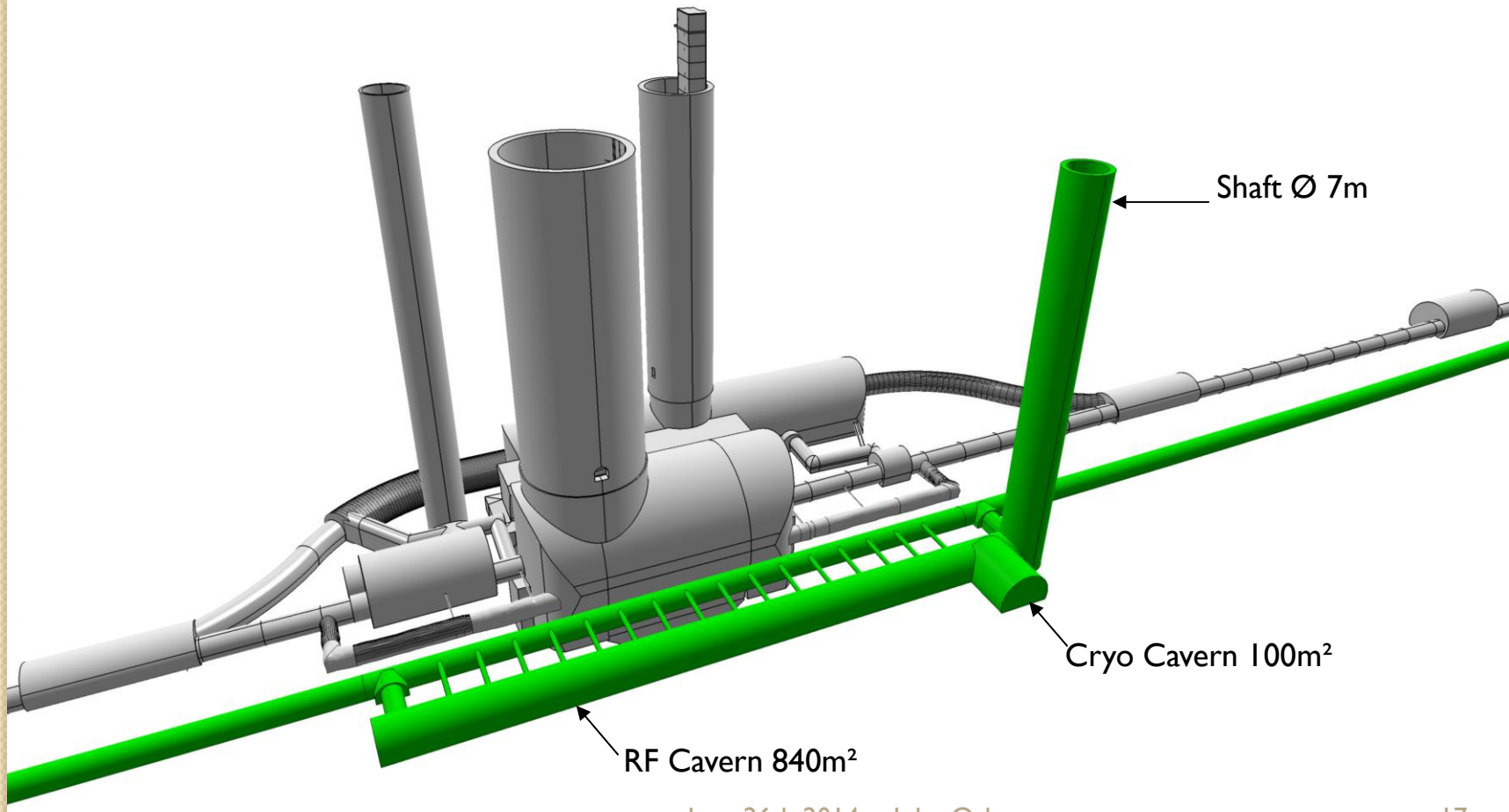
- Ring – Ring
  - New bypass tunnels on the outside of the LHC tunnel at Point 1 and Point 5
    - Assumed no bypass tunnel needed at Point 7 (LHCb)



Civil Construction *Ring-Ring scheme*

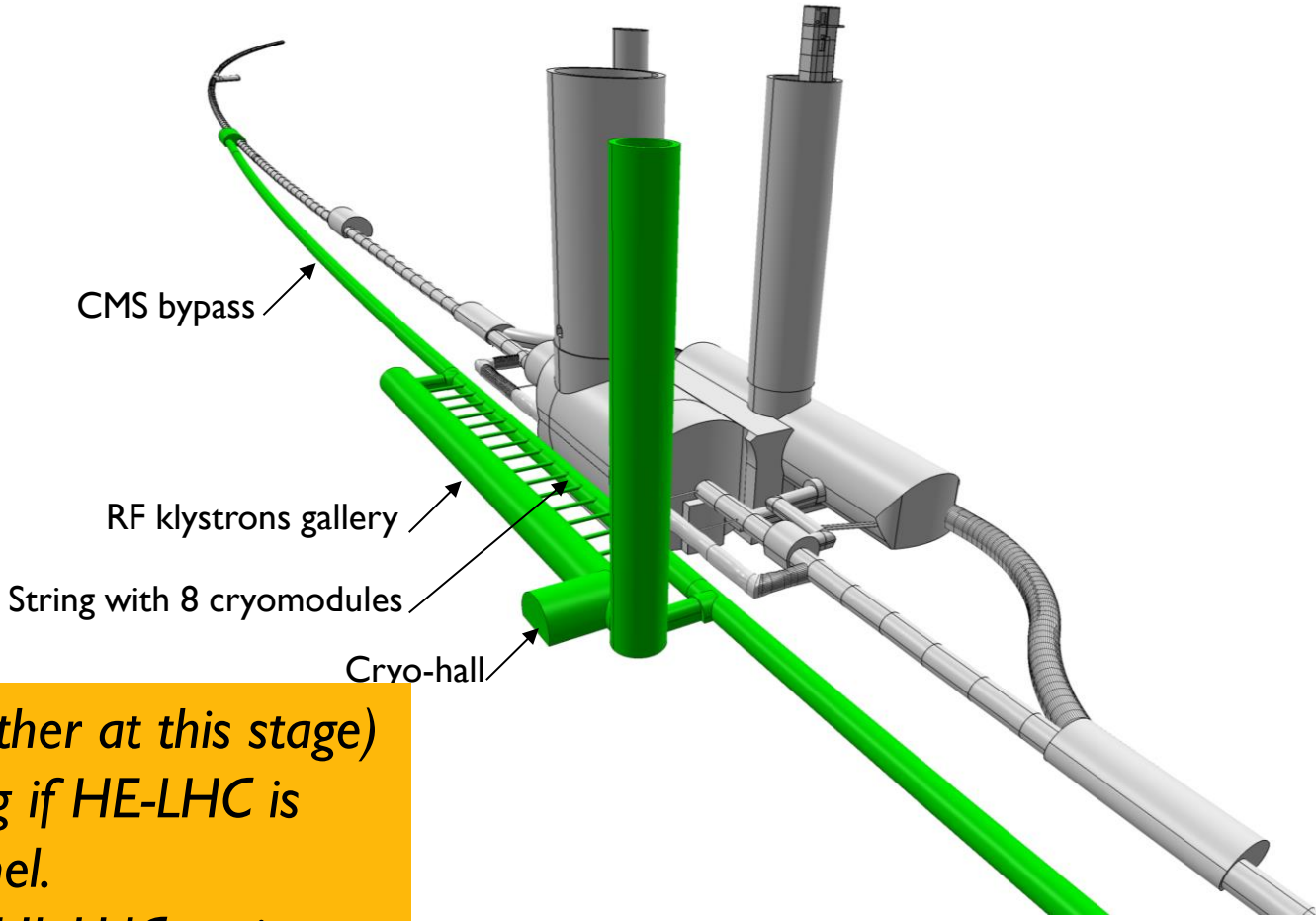
(not being studied further at this stage)

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



Civil Construction *Ring-Ring scheme*

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

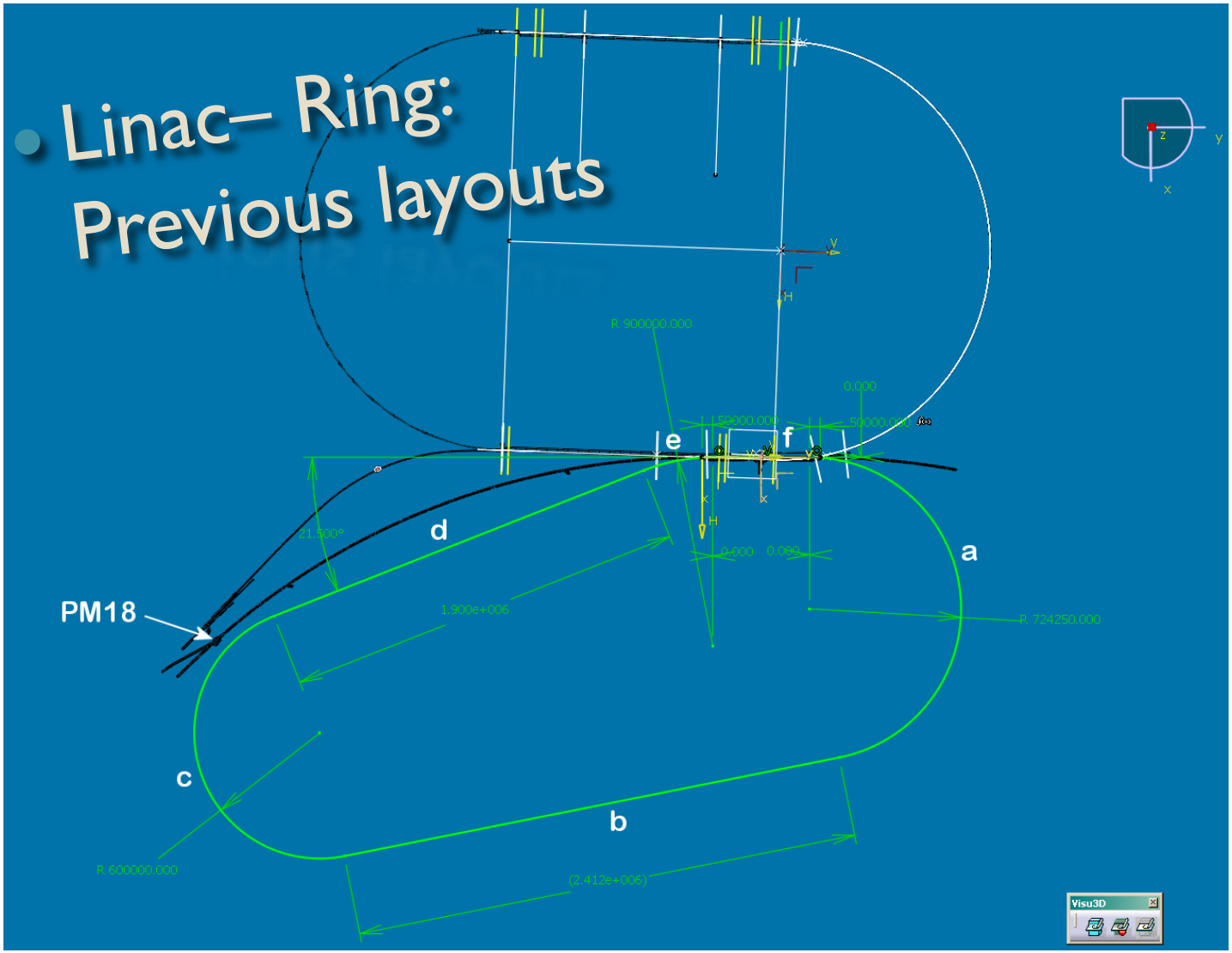


(not being studied further at this stage) but may be interesting if HE-LHC is built in the same tunnel.
Possible synergy with HL-LHC project

Civil Construction *LHeC options*

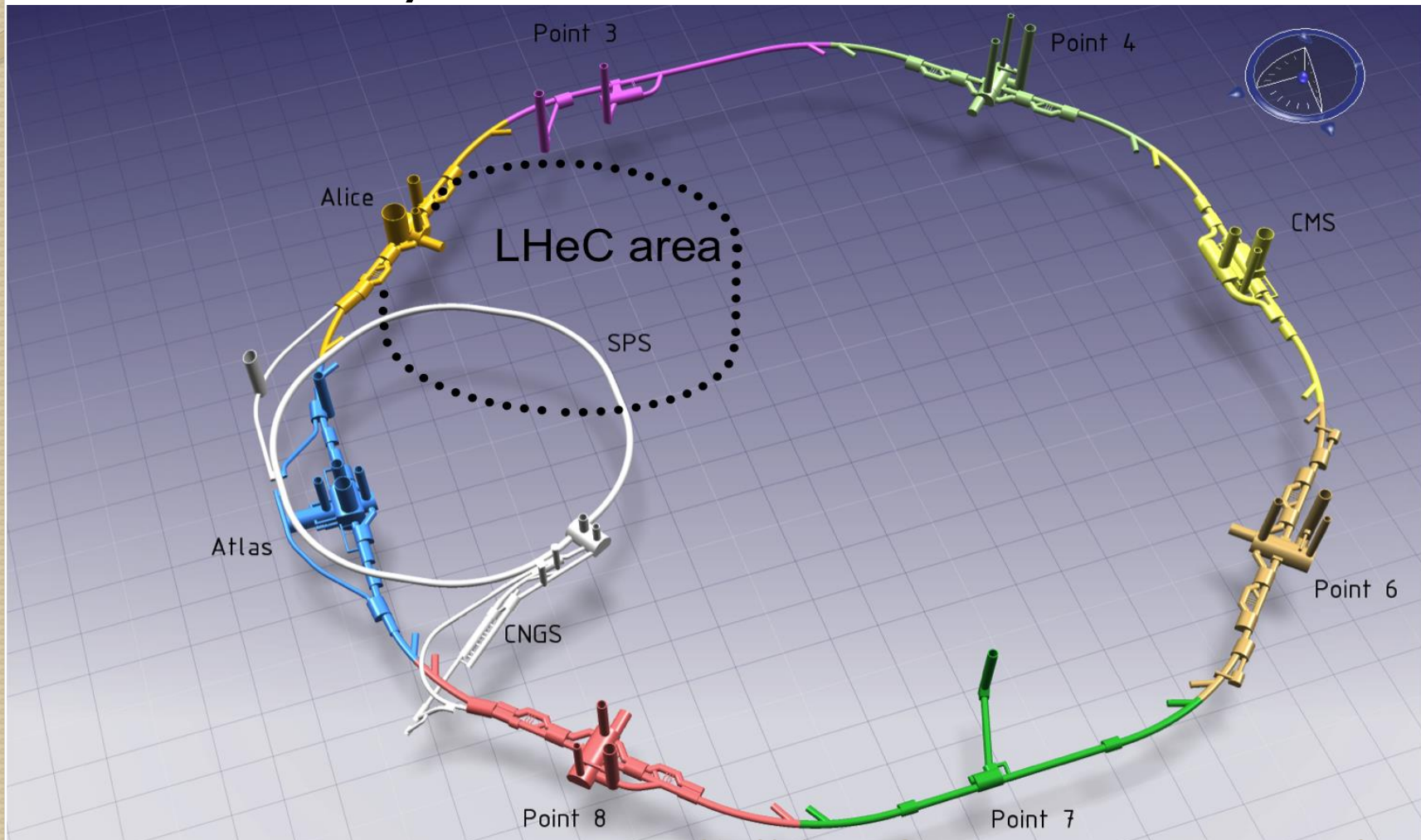
- Two Layouts
  - Ring – Ring
    - New bypass tunnels on the outside of the LHC tunnel at Point 1 and Point 5
  - Linac – Ring (BASELINE Solution)
    - Energy Recovery Linac (ERL) around St. Genis-Pouilly area, injecting into LHC (Point 2) cavern
    - Tunnel generally horizontal at same level as ALICE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

Civil Construction *Linac-ring scheme*



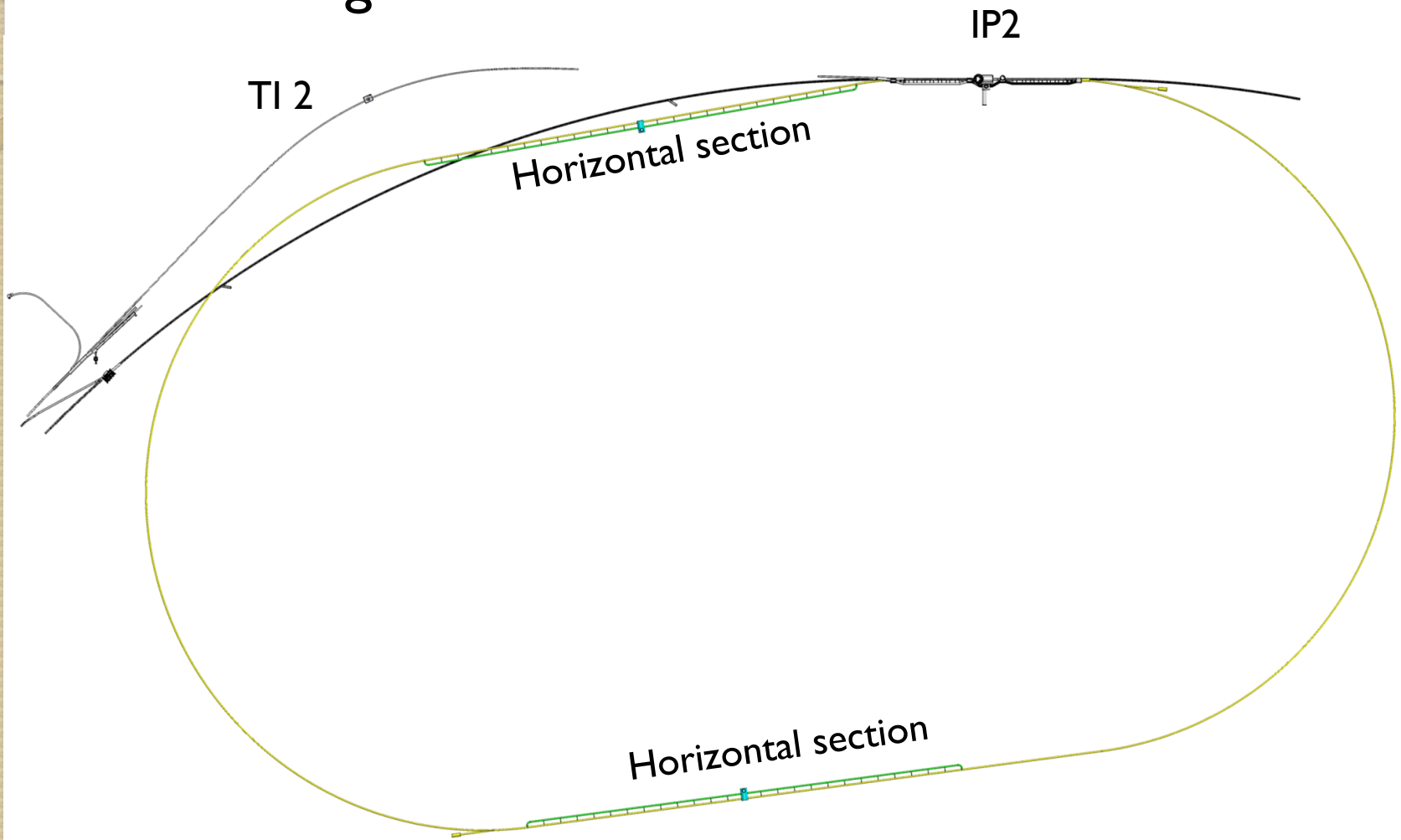
Civil Construction *Linac-ring scheme*

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



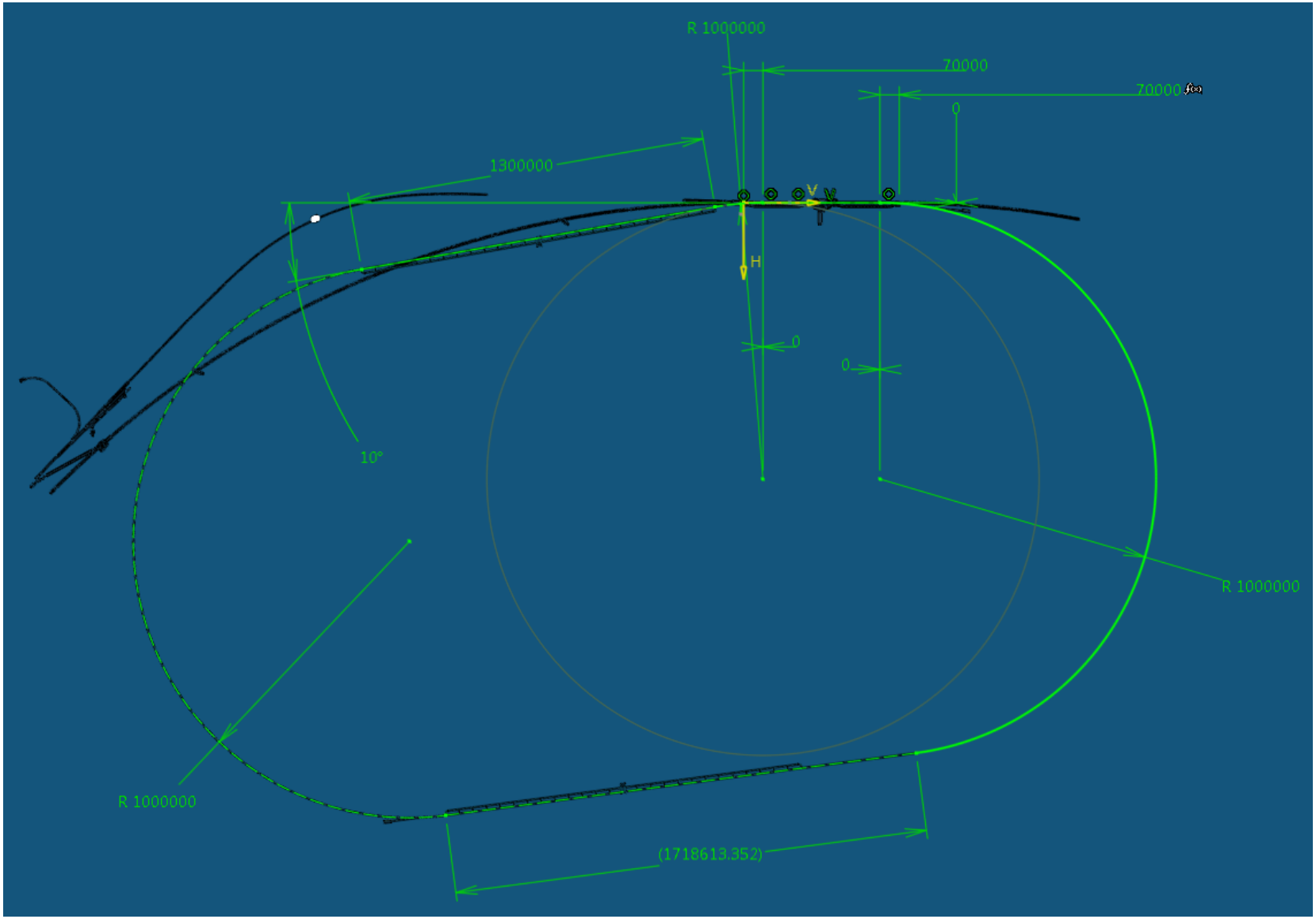
Civil Construction *Linac-ring CDR scheme*

- Linac– Ring:



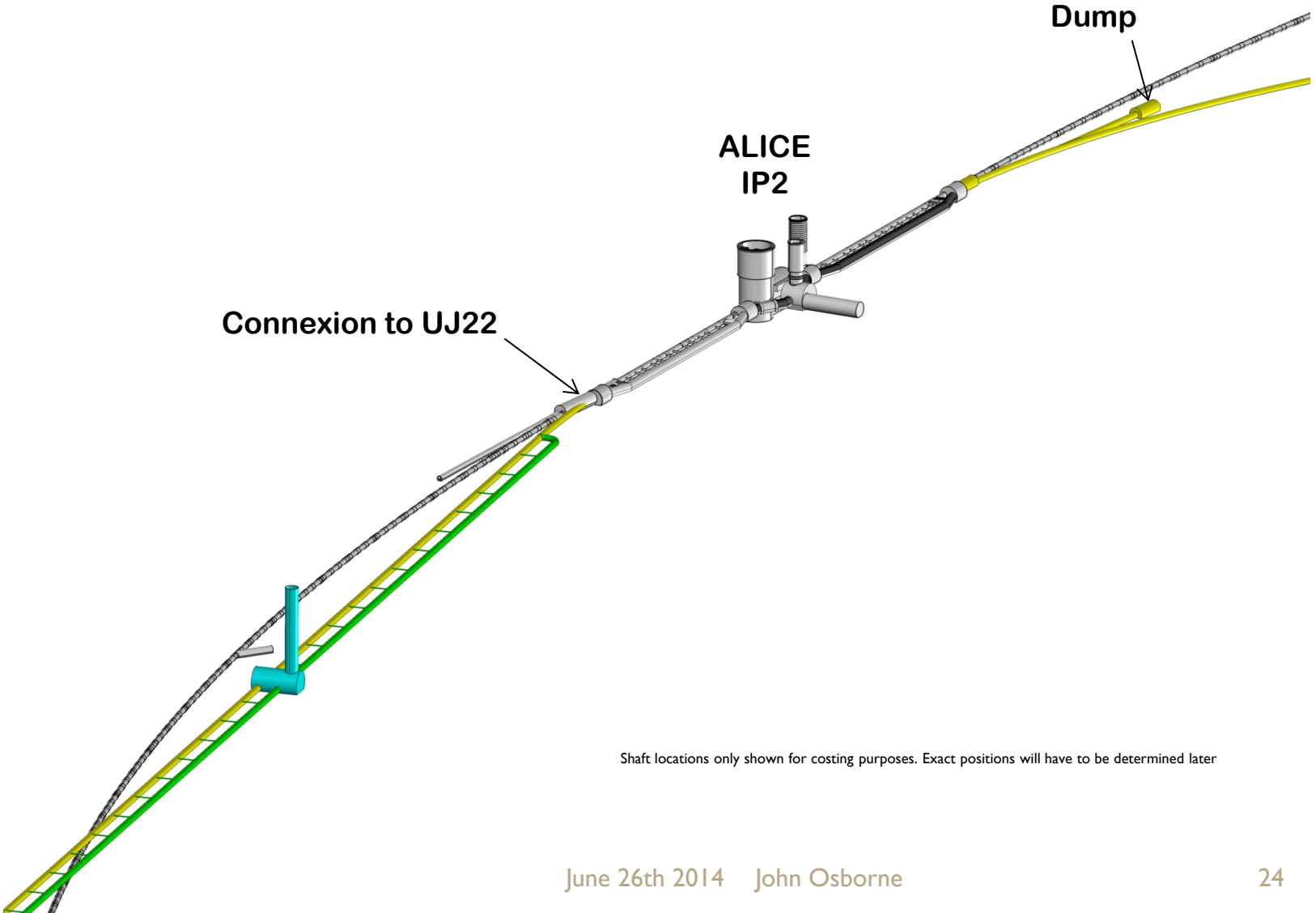
Shaft locations only shown for costing purposes. Exact positions will have to be determined later, but it is assumed that they can be on or very close to existing CERN property

- Linac– Ring: Dimensions



Civil Construction *Linac-ring scheme*

- Linac– Ring:



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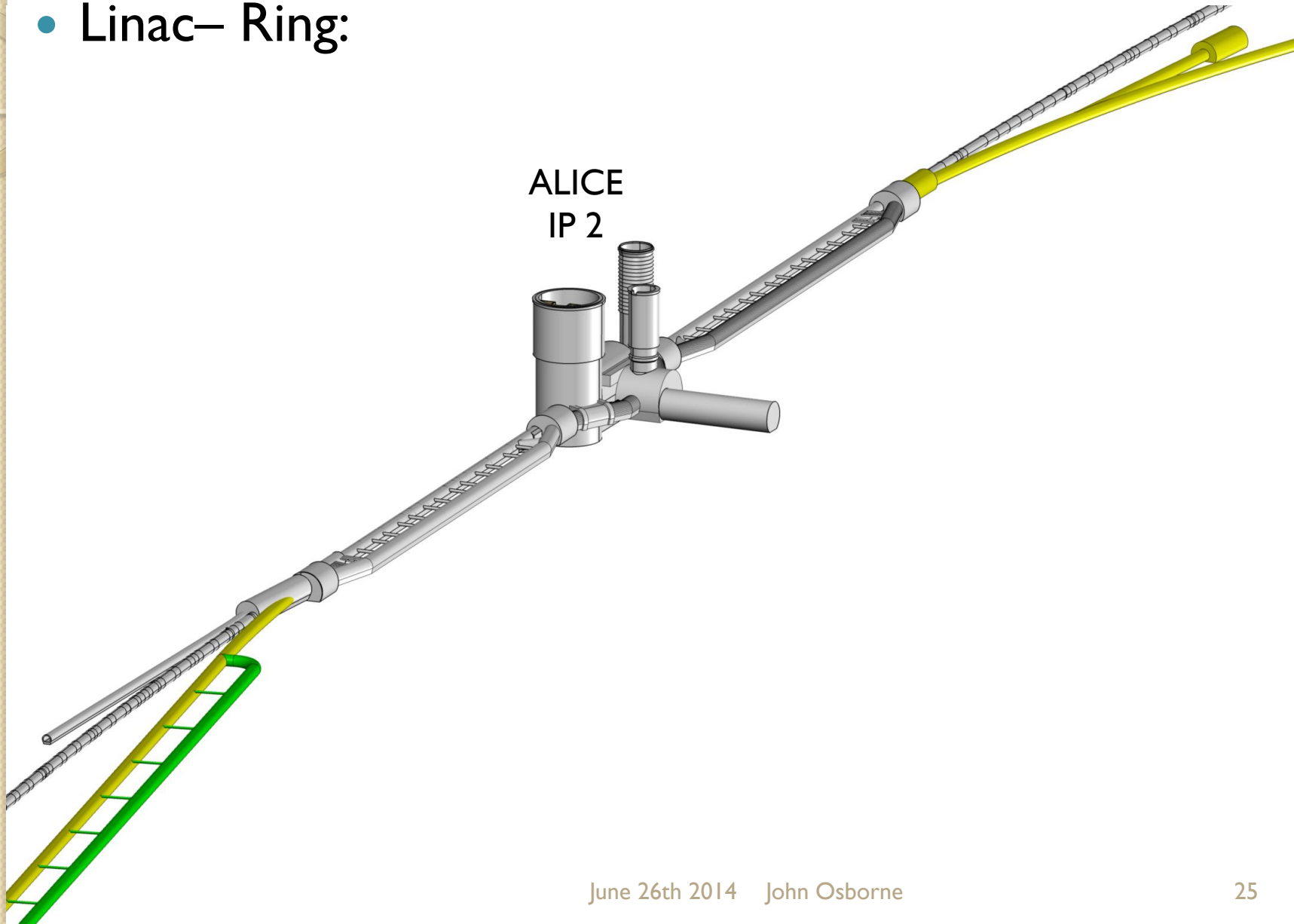
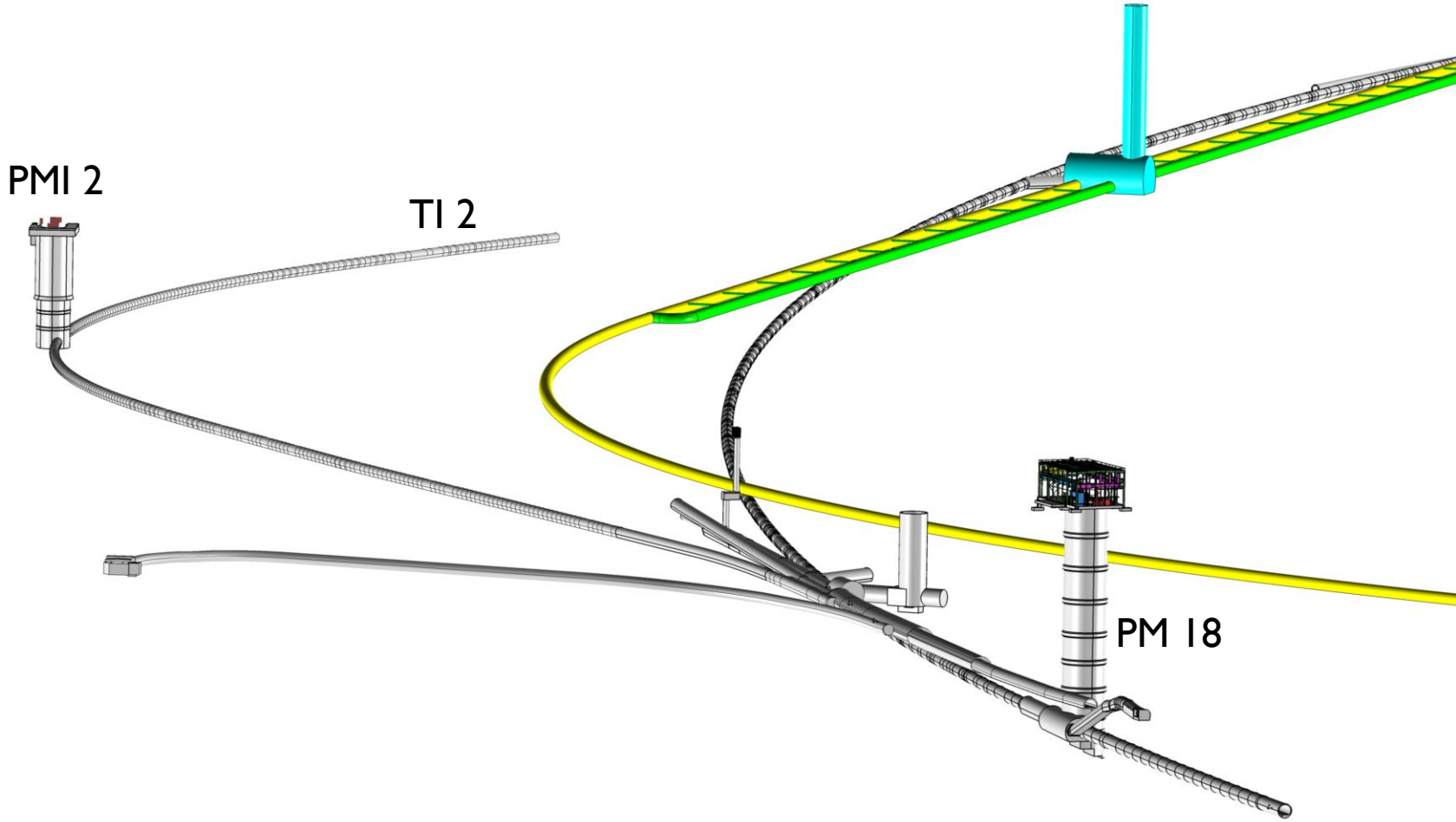
Civil Construction *Linac-ring scheme*

- Linac– Ring:



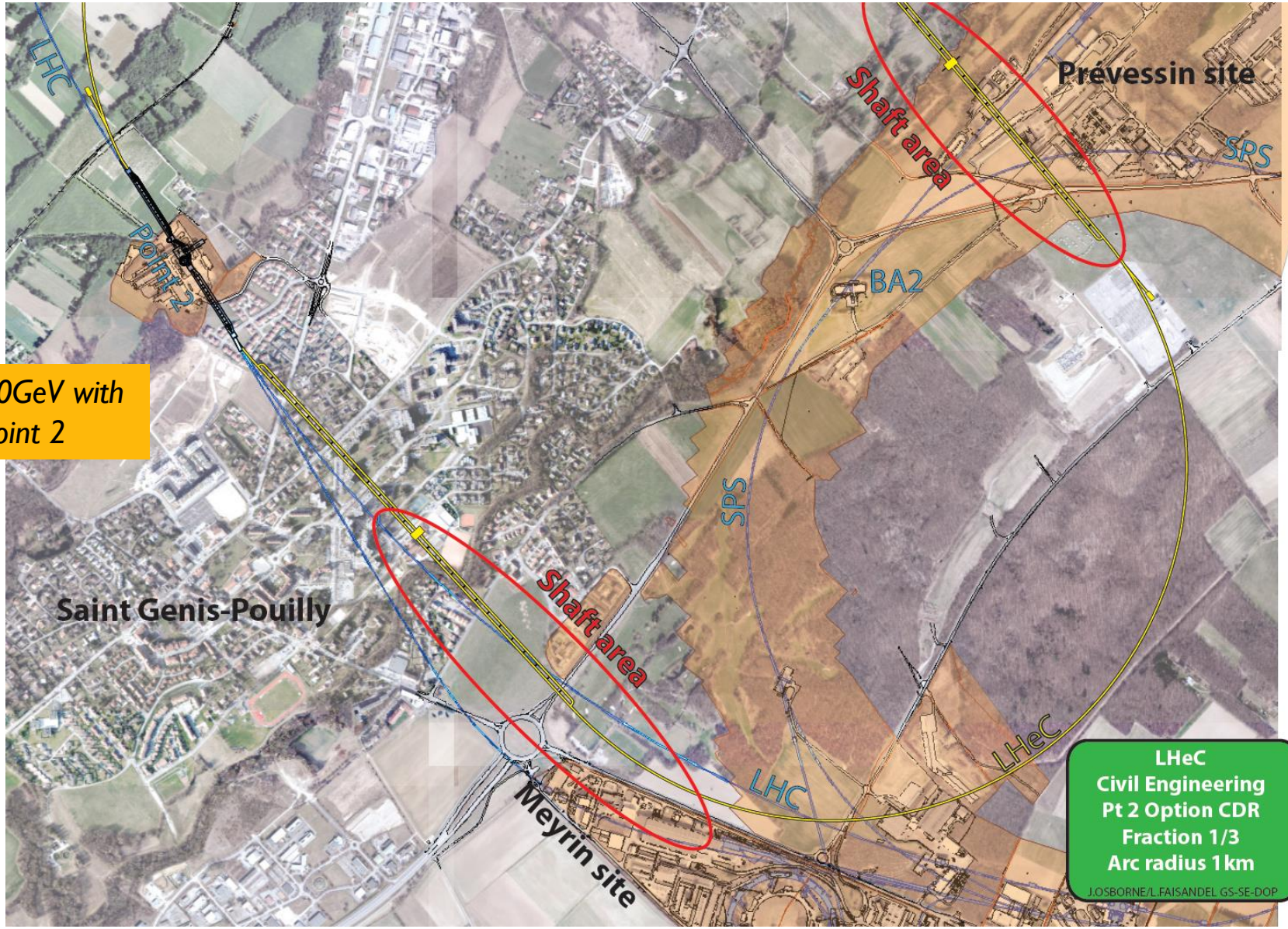
Civil Construction *Linac-ring scheme*

- Linac– Ring:

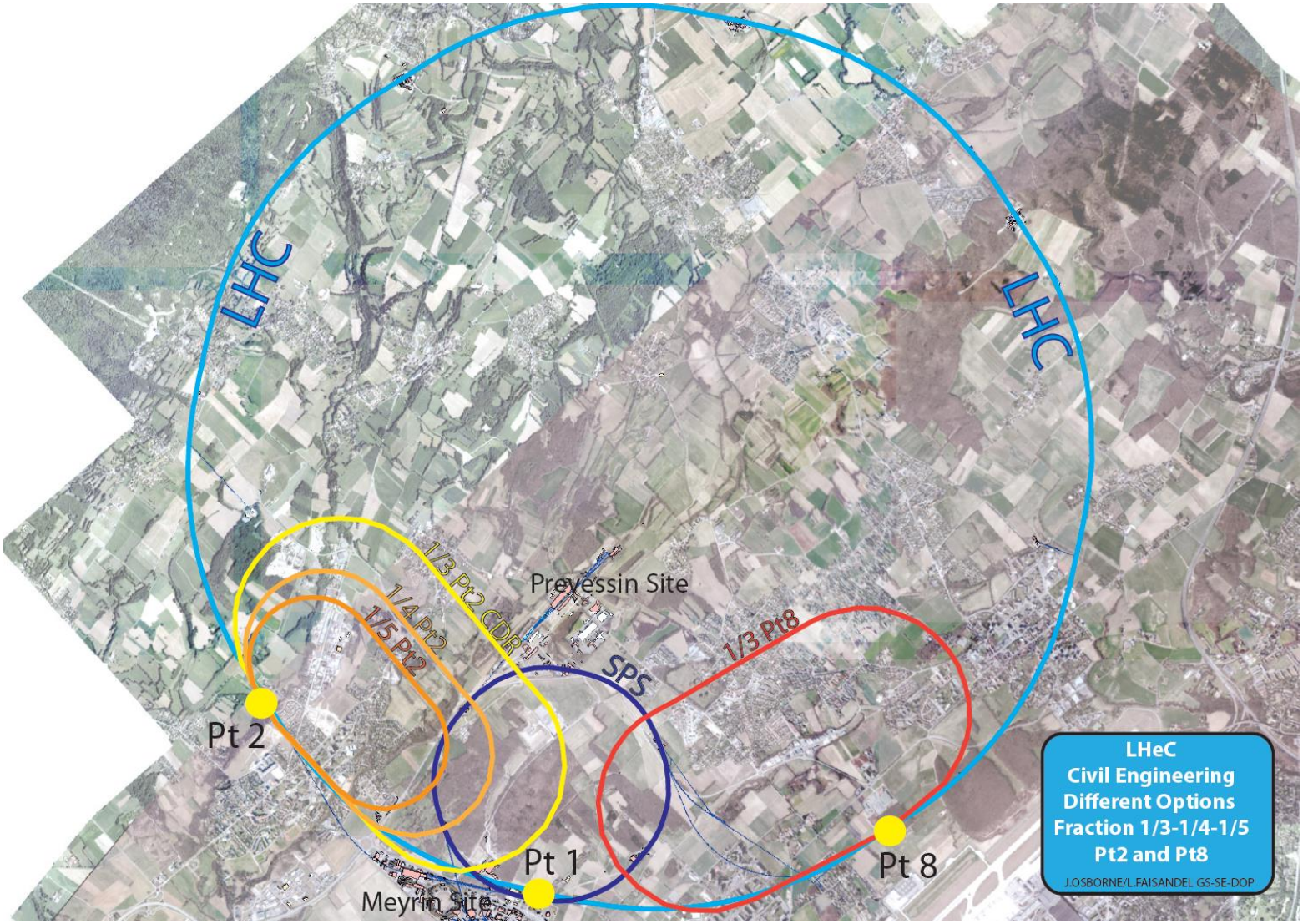


Civil Construction *Linac-ring 60GeV CDR scheme*

CDR 60GeV with IR at Point 2

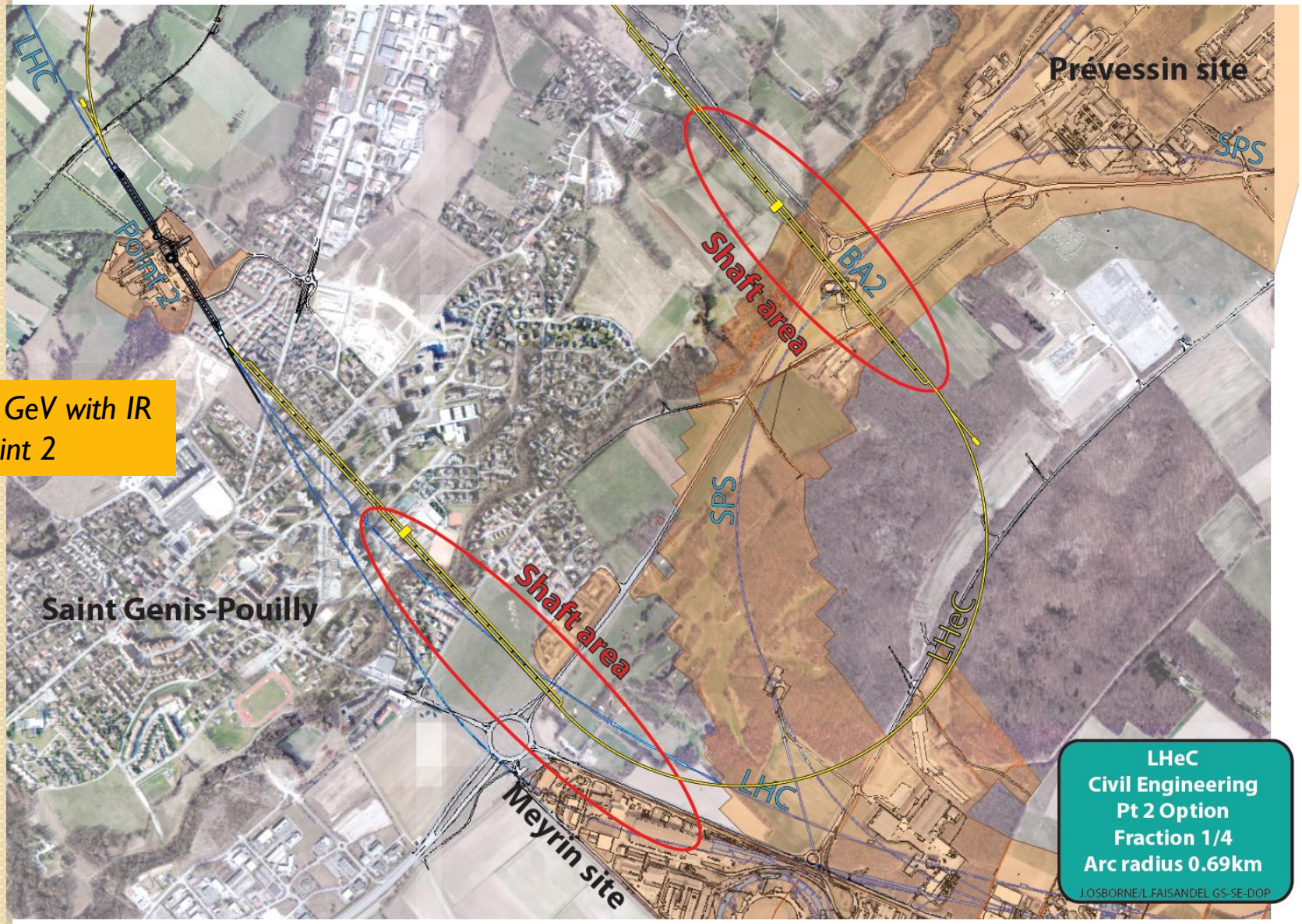


Civil Construction *Linac-ring : other options*



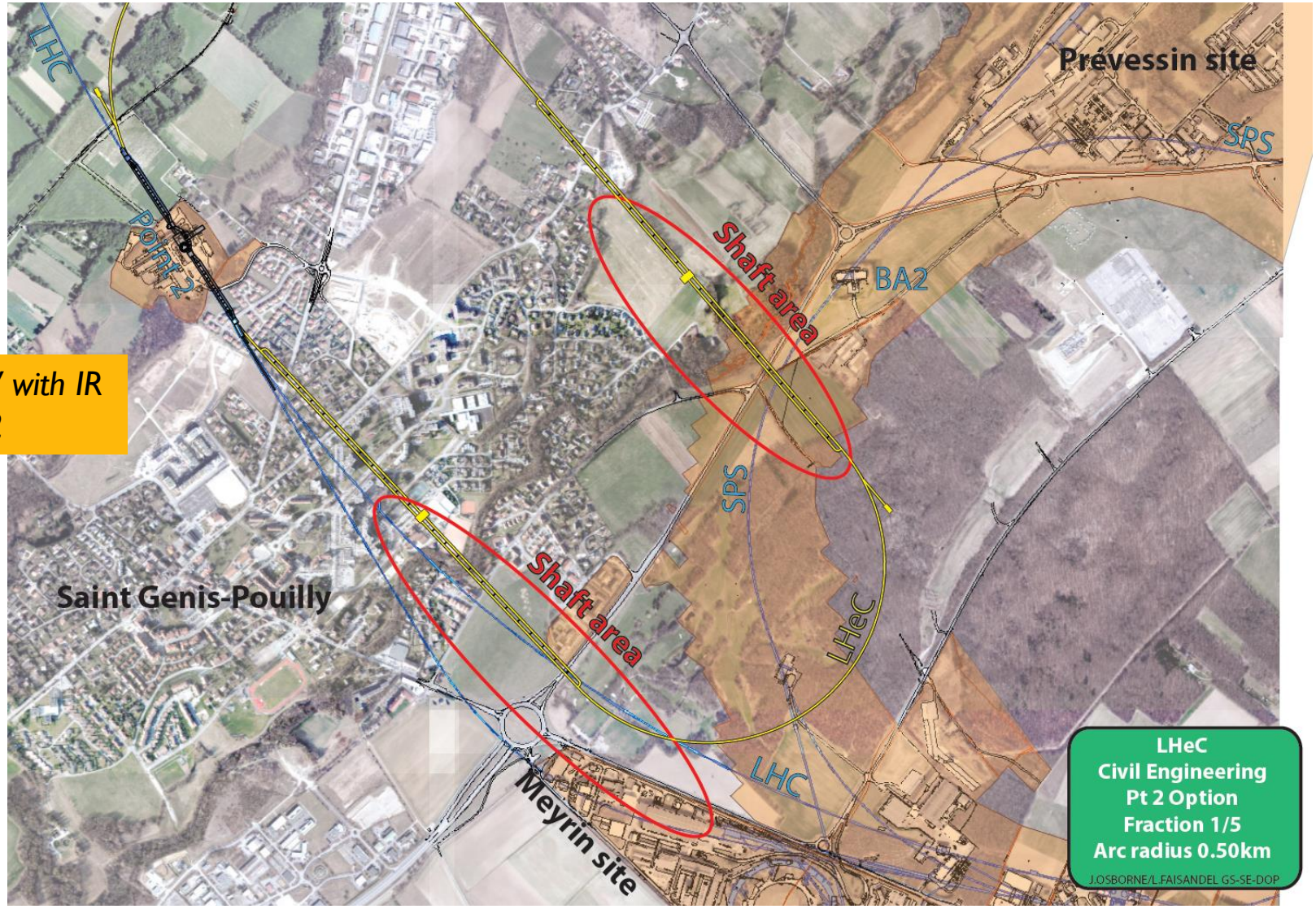
Civil Construction *Linac-ring 54.6GeV*

54.6 GeV with IR at Point 2



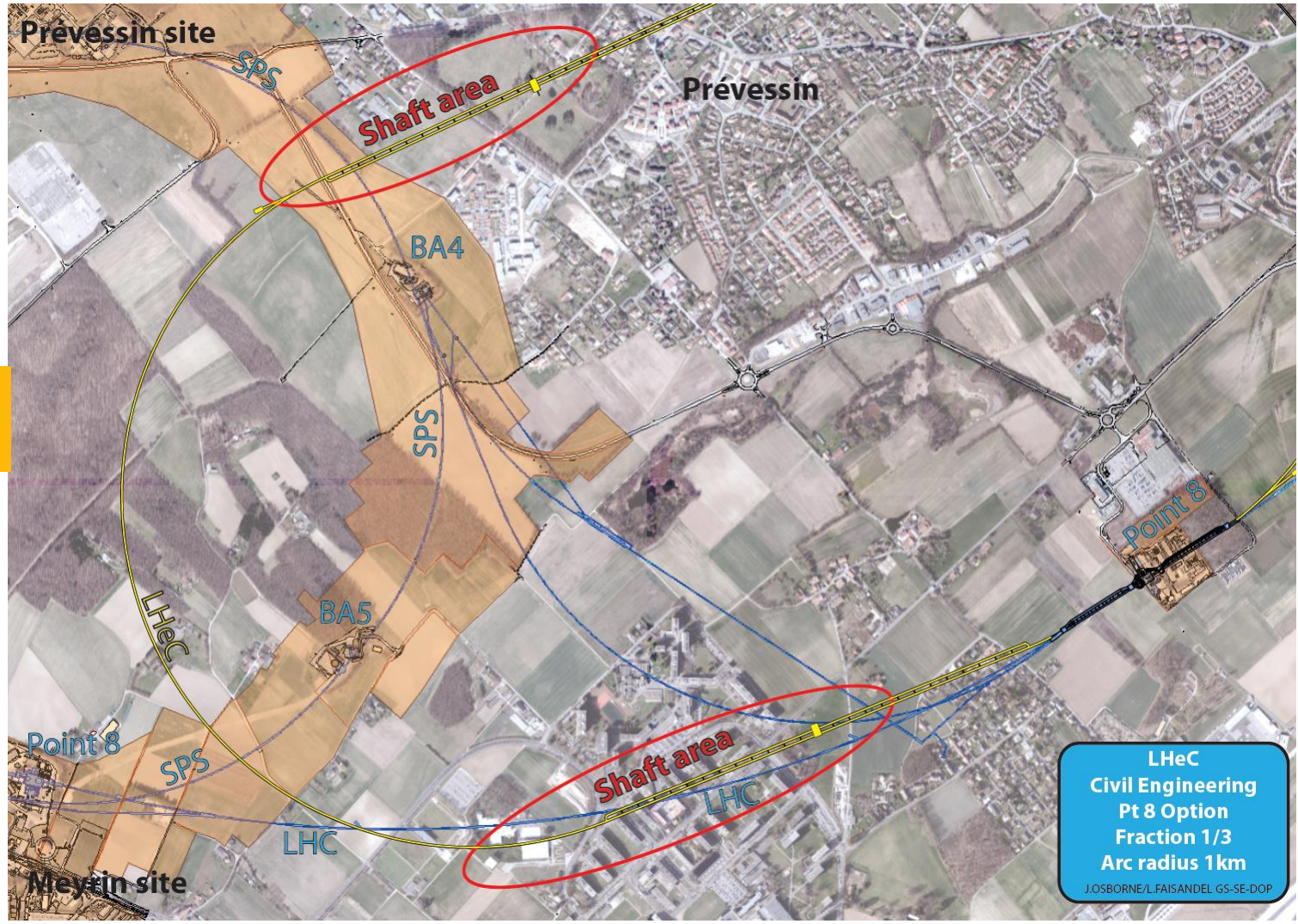
Civil Construction *Linac-ring 50.4GeV scheme*

50.4 GeV with IR at Point 2



Civil Construction *Linac-ring P8 scheme*

CDR-like 60GeV with IR at Point 8



LHeC

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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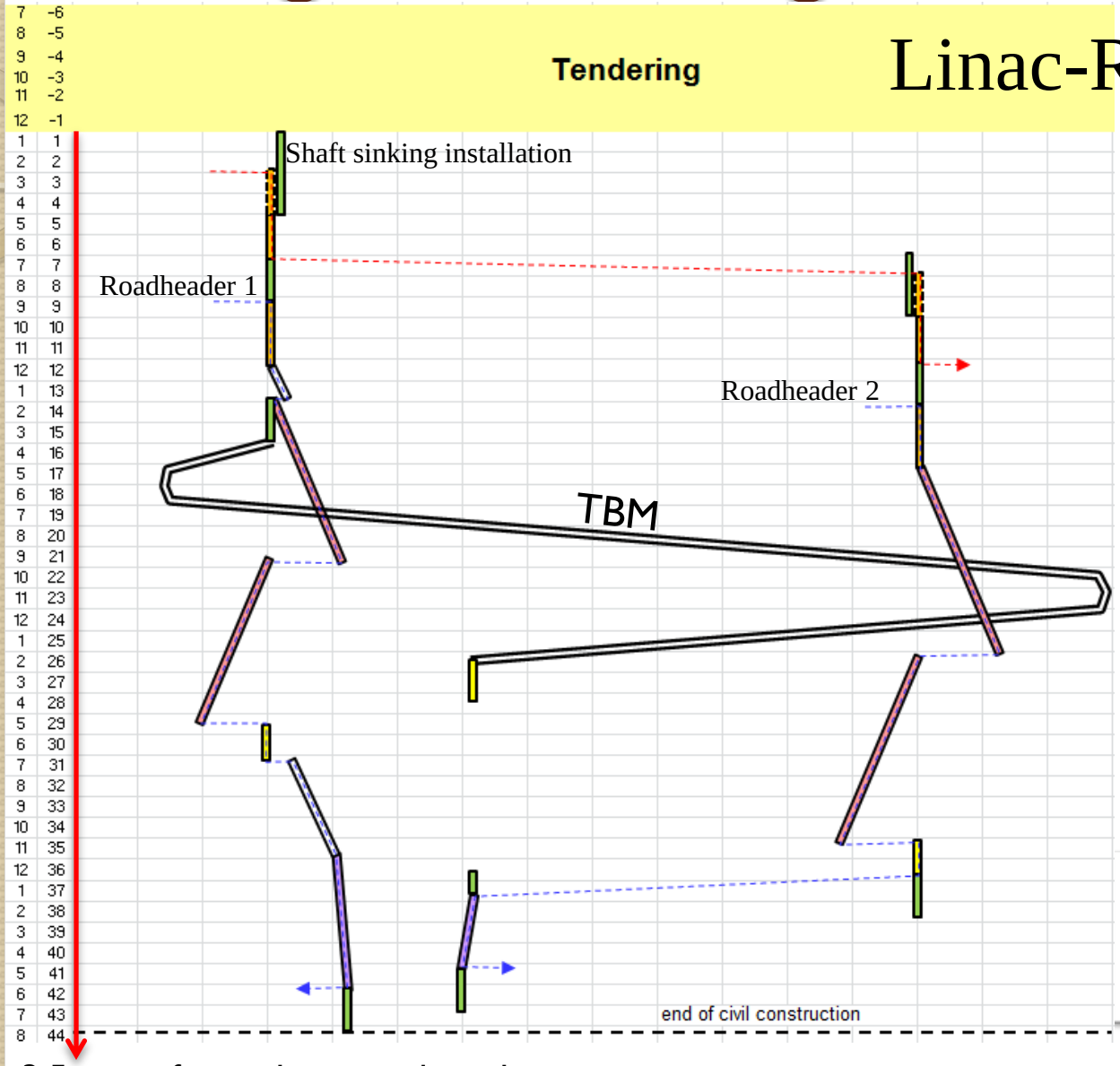
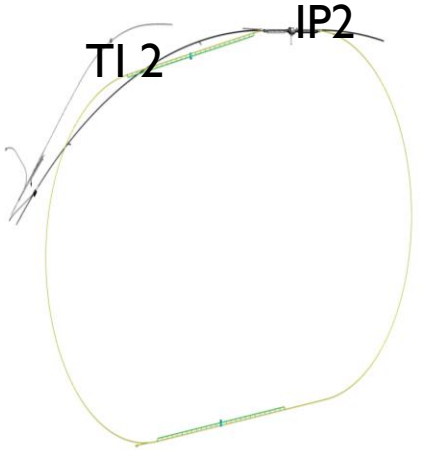
Costing and Planning *LHeC planning*

Linac-Ring option





3.5 years for underground works
using 2 roadheaders and 1 TBM

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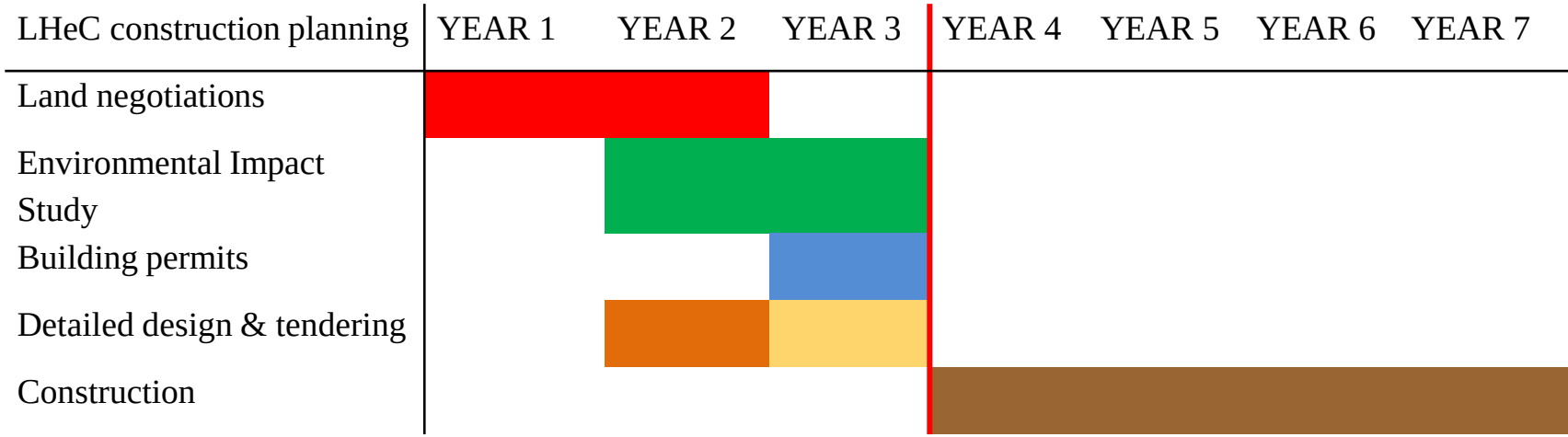
Costing and Planning *LHeC planning*



4 year Construction schedule for either LHeC option:

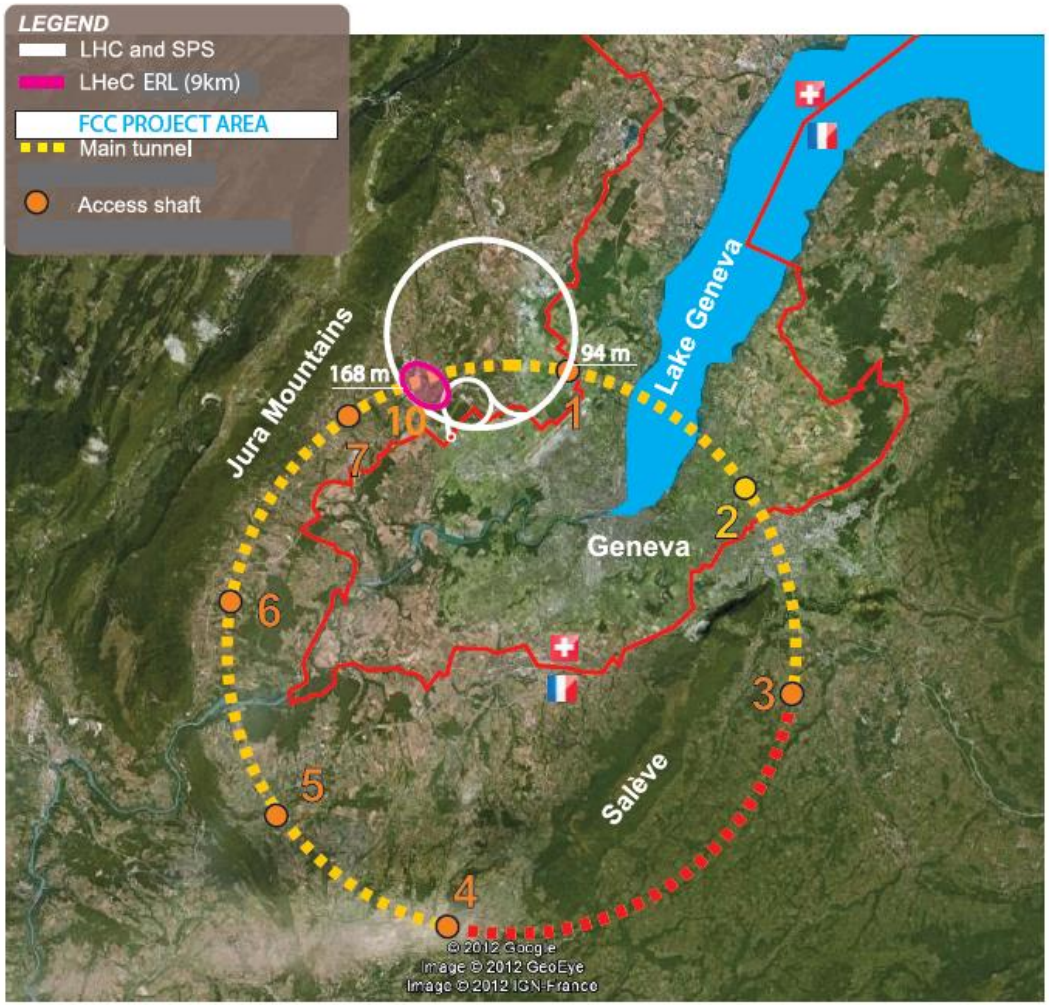
- Ring-ring:
  - Assuming 2 roadheaders with excavation progress of 30m/week
- Linac-Ring:
  - Assuming 2 roadheaders and 1 shielded TBM (TBM excavation progress of 150m/week)

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

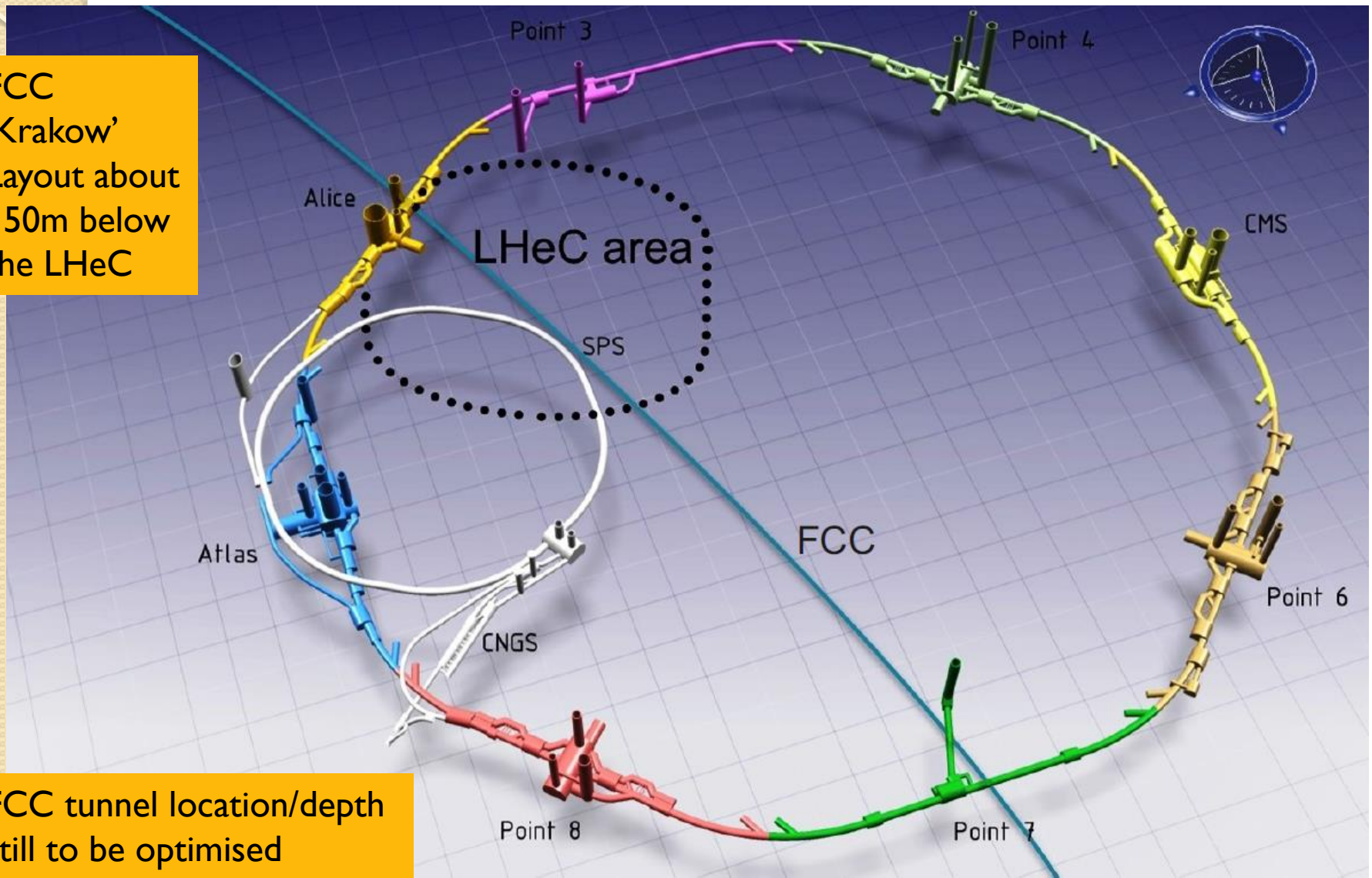
Version 230 mASL

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



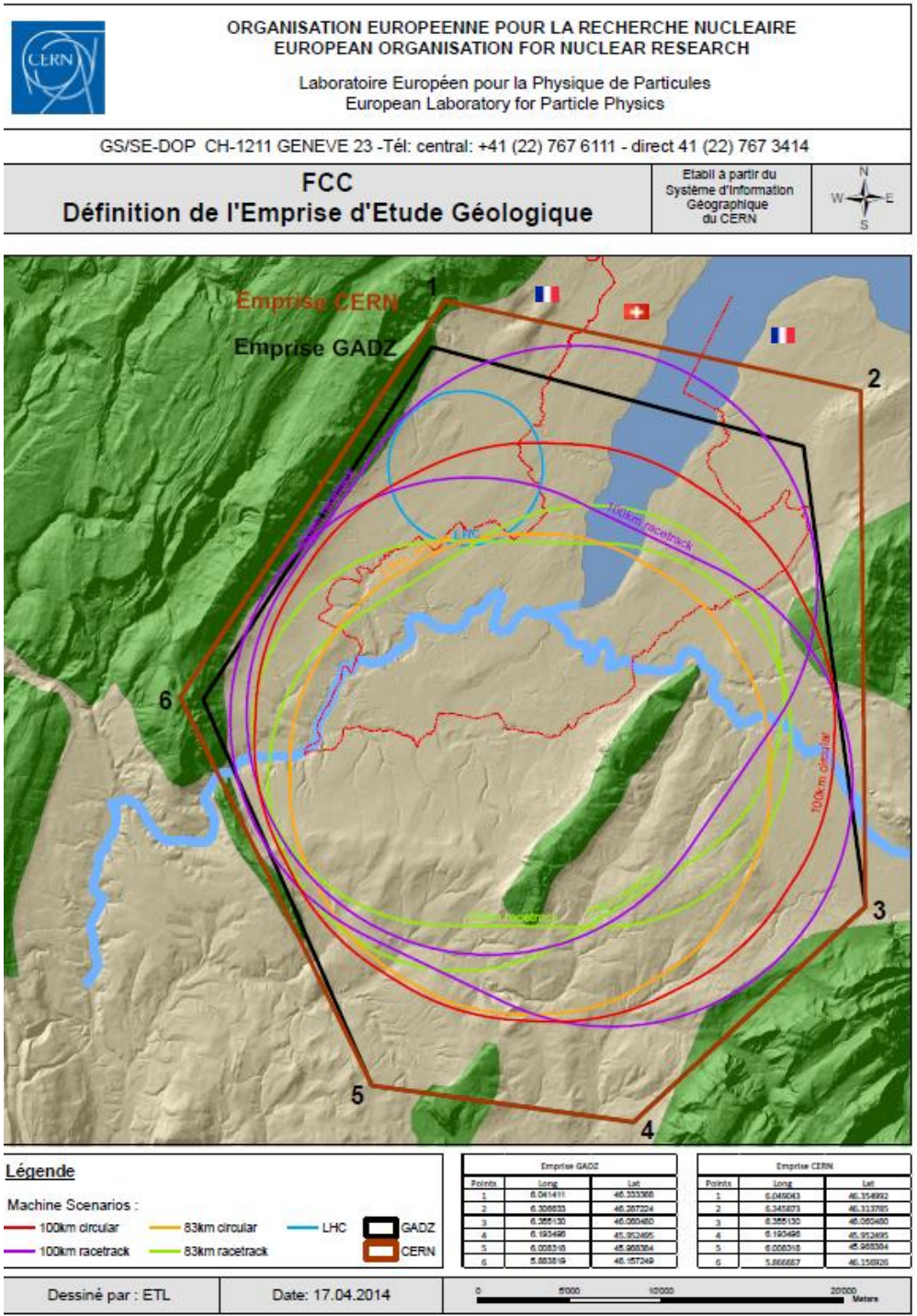
LHeC and the Future Circular Collider (FCC)

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

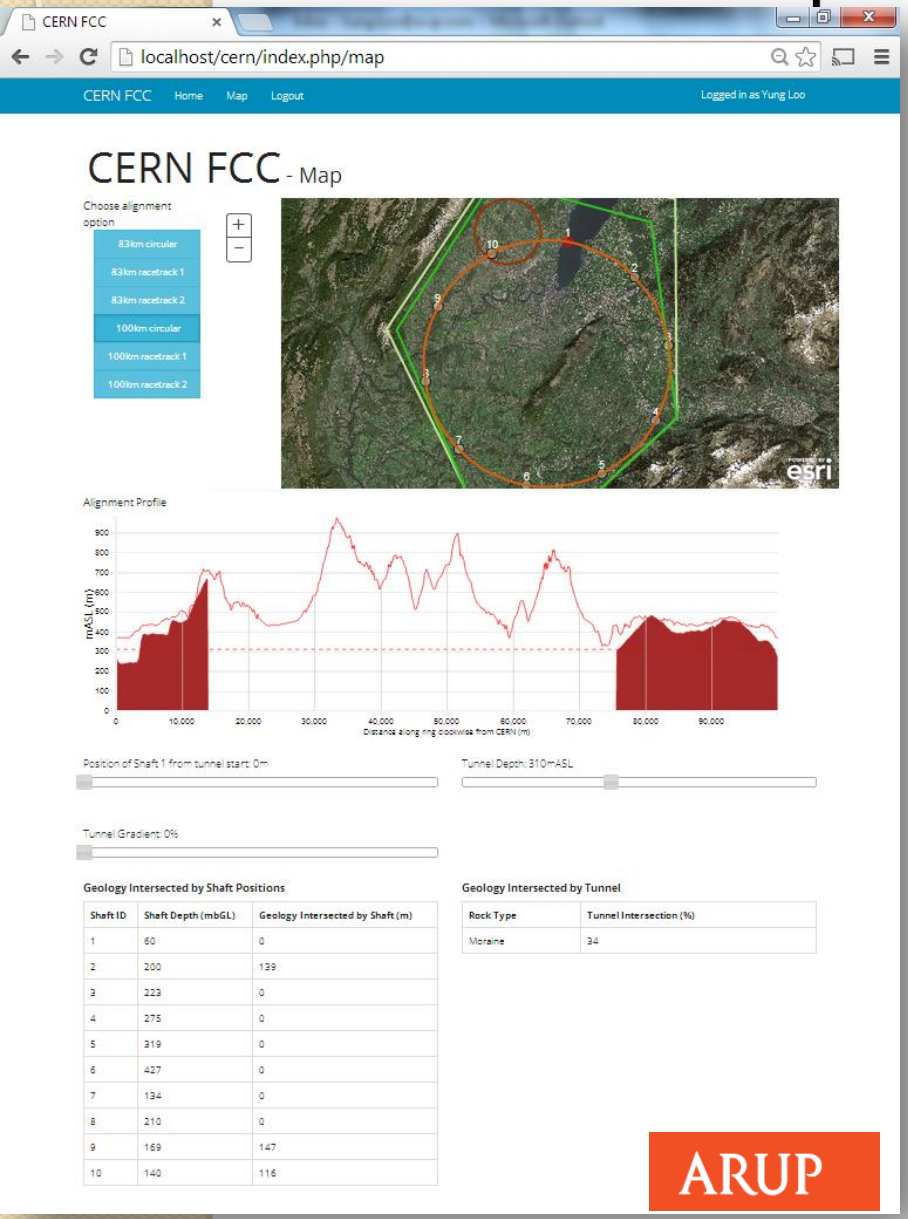


- FCC tunnel location/depth still to be optimised

FCC Study Area defined



GIS Tool Development – Current Status



Web-based GIS Decision Aid Tool

User Inputs

- Alignments of 6 FCC Options
- Interactive alignment location on map
- Alter Shaft locations (10%) - slidebar
- Select Tunnel Depth - slidebar
- Select Tunnel Gradient - slidebar

Outputs

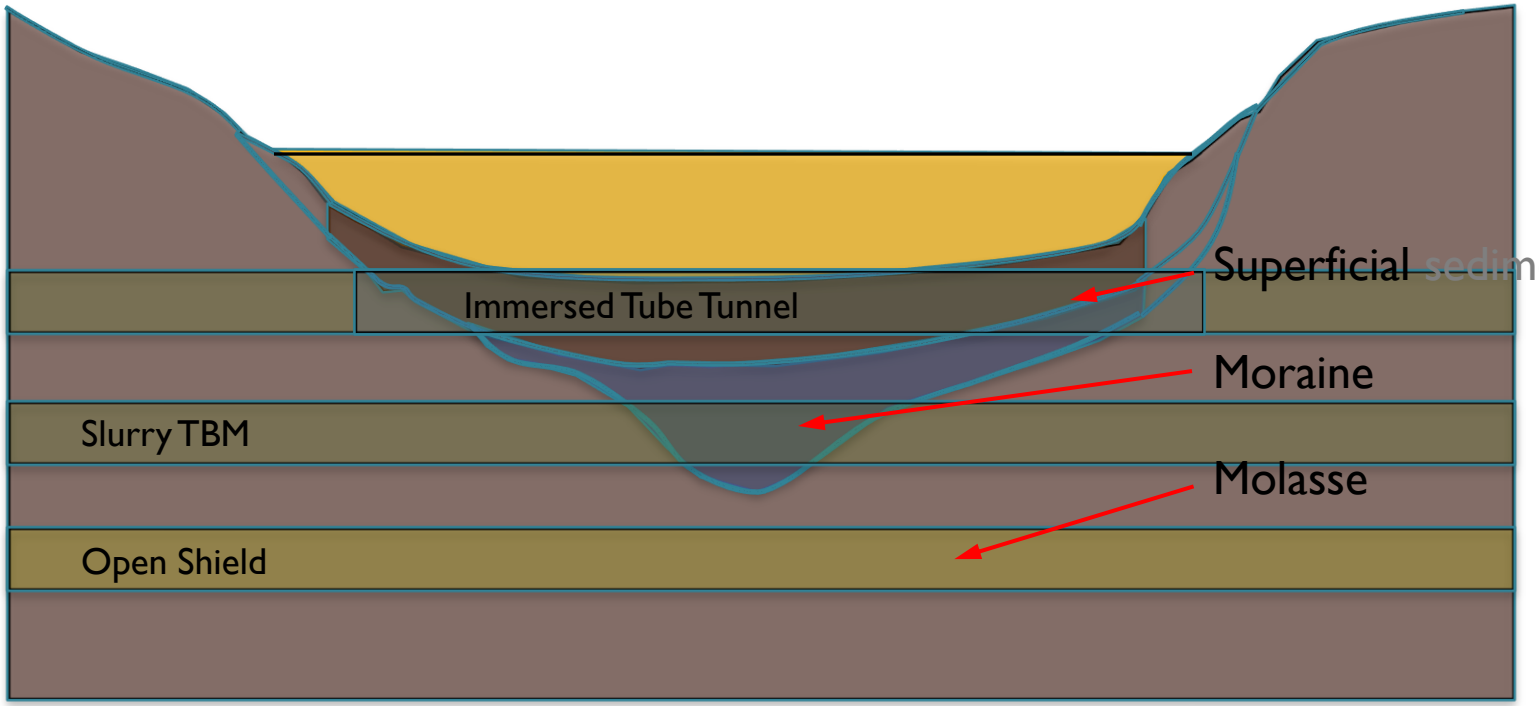
Dynamic Chart:

- Profile surface elevation and geology
- Profile of tunnel
- Shaft Locations
- Warnings when tunnel above ground level

Dynamic Tables:

- Depth to tunnel (mASL)
- Shaft Length intersecting geology layer
- % age of tunnel intersecting geology

Lake Crossing: Tu



Lake Crossing: Tunnelling Considerations

REPUBLIQUE ET CANTON DE GENEVE
Département des constructions et des technologies de l'information
Office du génie civil

TRAVERSEE DU LAC

CONTOURNEMENT EST DE GENEVE

RAPPORT DE SYNTHESE

DES ETUDES DE FAISABILILTE

Mars 2011

Version 22 28 mars 2011

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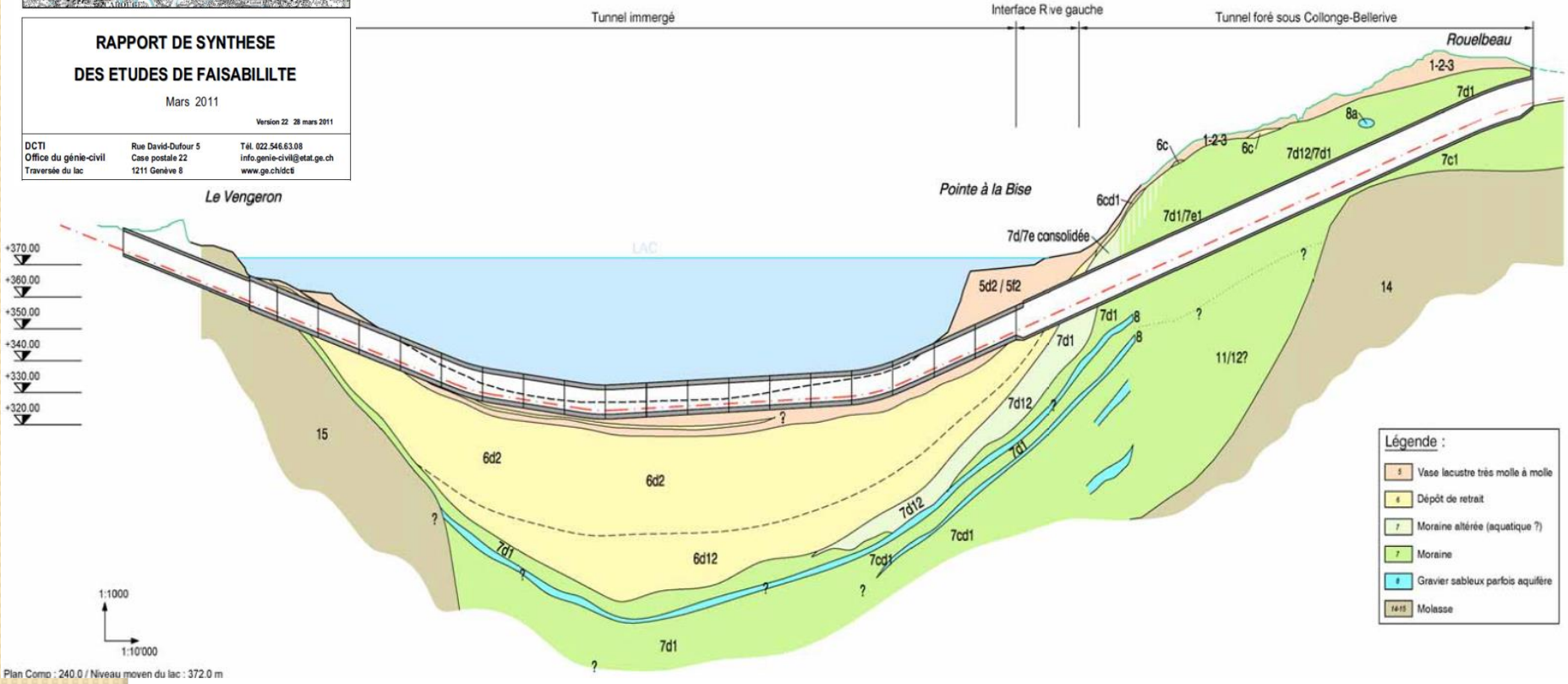


Plan Comp : 240.0 / Niveau moyen du lac : 372.0 m

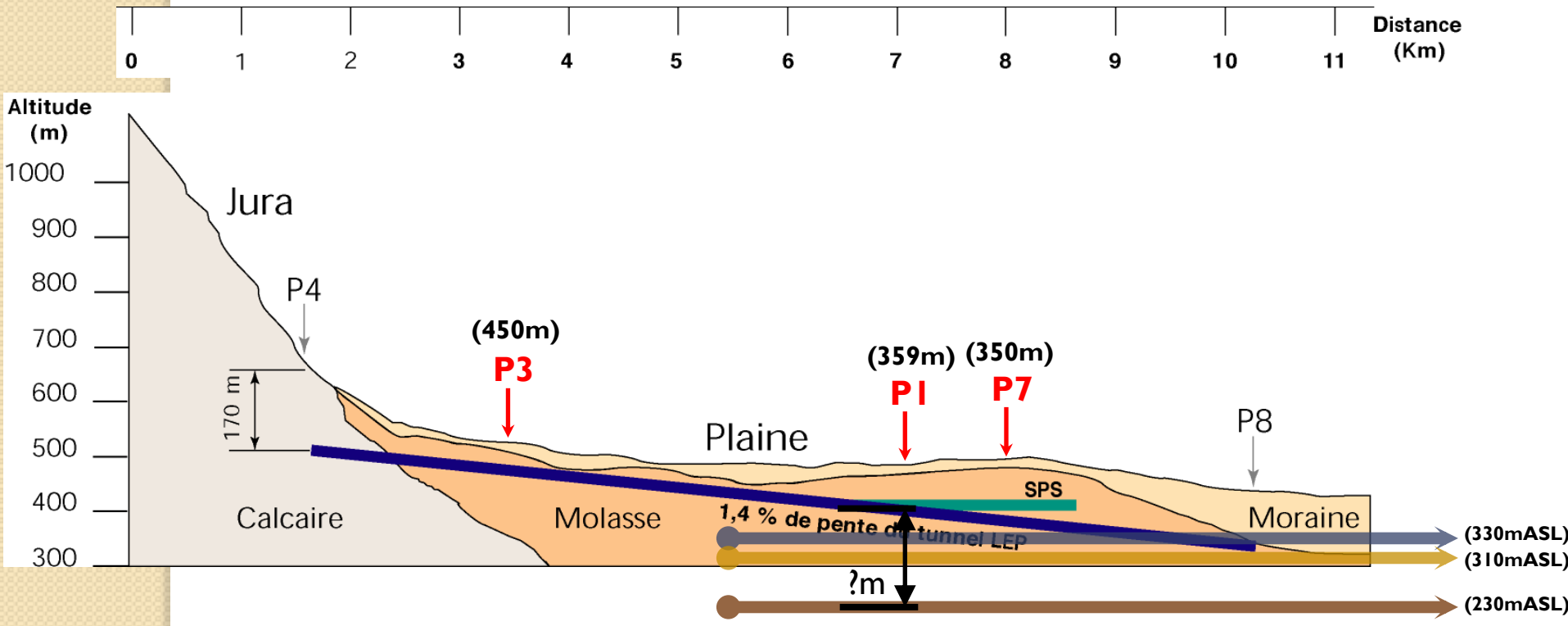
Immersed tube tunnel examples :

River Conwy Tunnel, North Wales

Immersed Tube Tunnel examples :

River Medway Tunnel Crossing

Effect of tunnel position on LHC Injection



Tunnelling under lake	Vertical depth below Point 1	
Superficials	30m	FCC (horizontal)
Moraine	50m	
Molasse	130m	FCC (inclined)

LHeC

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