PRELIMINARY STUDY

If we extend the LHC or SPS straight insertion where would the neutrinos come out to the surface of the earth?

PRELIMINARY STUDY
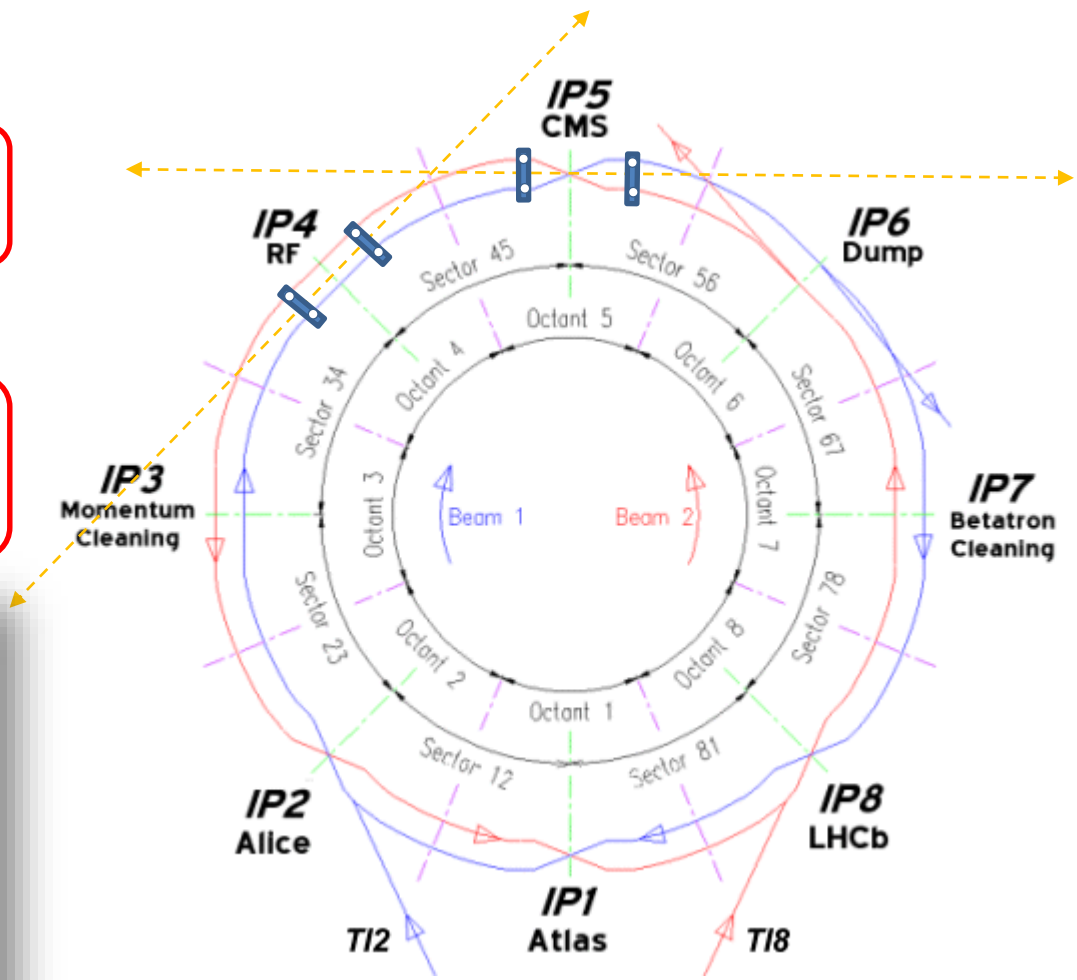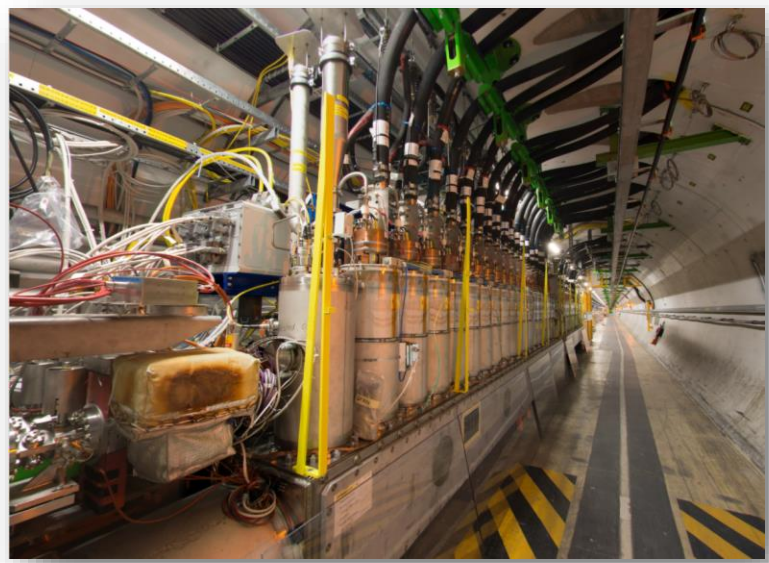*If we extend the LHC straight insertion*
where would the neutrinos come out to the surface of the earth?

Problem:

« If we extend the LHC straight insertions where would the neutrinos come out the surface of the earth?"

Hypothesis:

The LHC straight insertions directions are given by the lines built **from the middle of Beam 1 and Beam 2 DFBA elements** on each side of the Insertion Point.
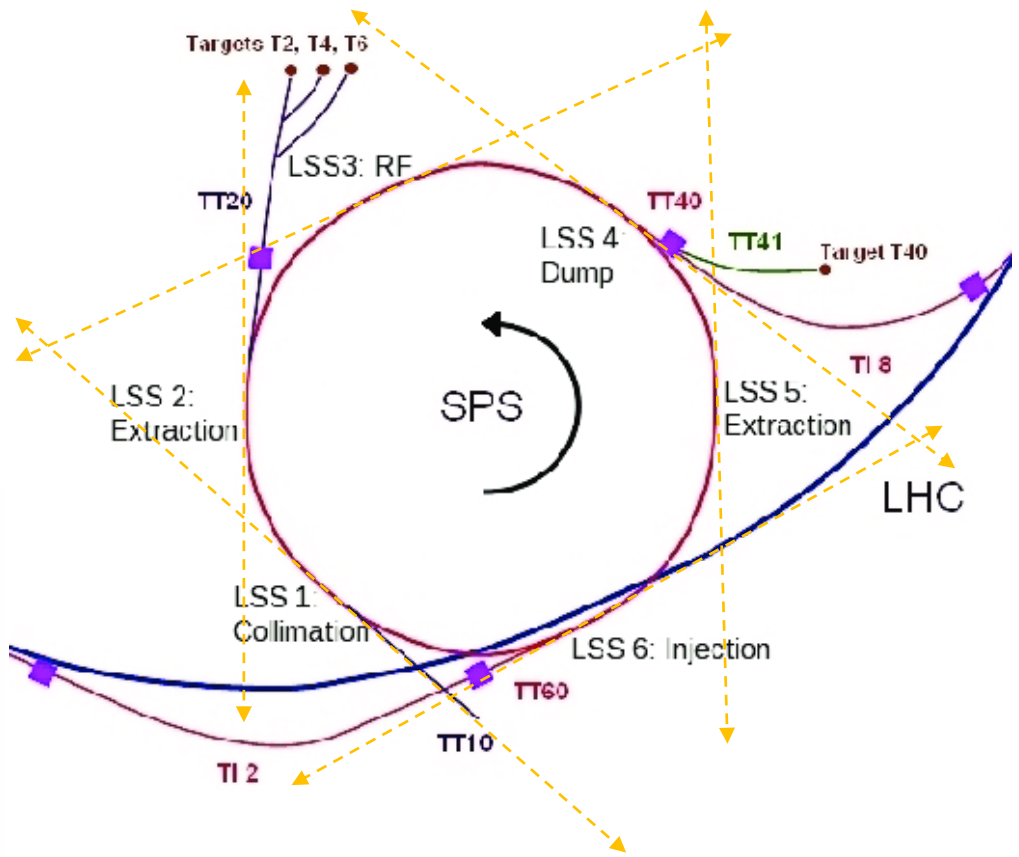
PRELIMINARY STUDY
*If we extend the SPS straight sections
where would the neutrinos come out to the surface of the earth?*

Problem:

« If we extend the SPS straight sections where would the neutrinos come out the surface of the earth?"

Hypothesis:

The SPS straight sections directions are given by the lines built on dipole **MBA X1590 beam exit points on one side and MBA X2030 beam entrance point on the other side.**   *(X for the SPS point)*
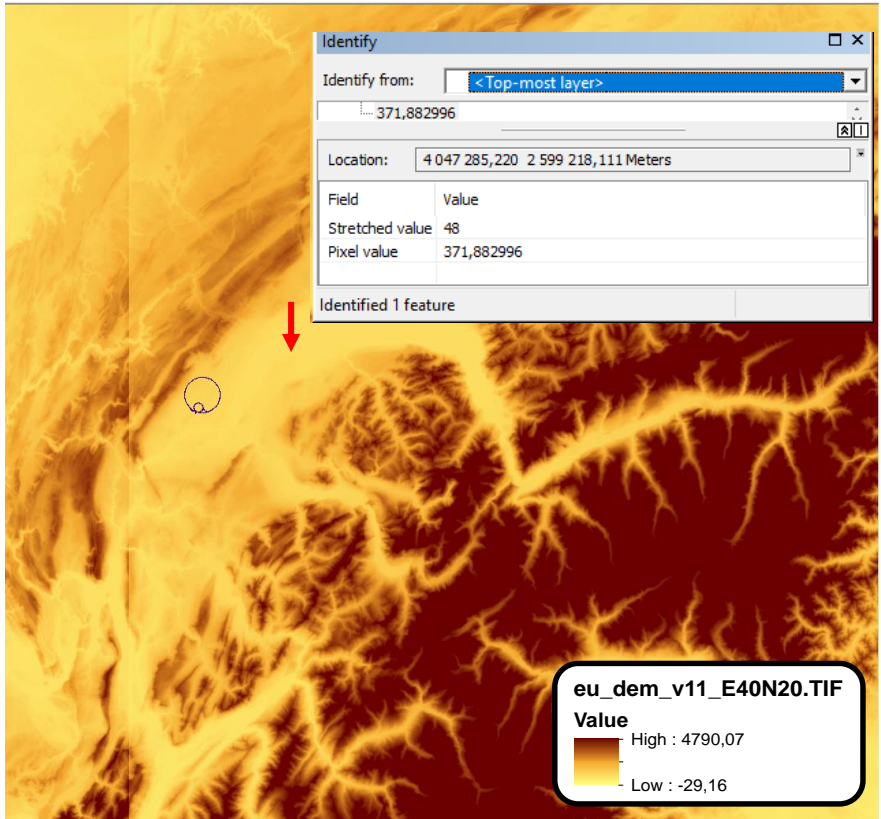
PRELIMINARY STUDY
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Data:

➢ **Coordinates of DFBA beam points**

    ❖ from Geode Survey database

    ❖ in CCS (XYZ) coordinate system

➢ **EU-DEM v1.1 : Digital Surface model for Europe**

    ❖ The spatial reference system is geographic, lat/lon with horizontal datum ETRS89, ellipsoid GRS80 and **vertical datum EVRS2000 with geoid EGG08.**

    ❖ https://opendem.info/opendemeu_meta_eudem.html

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Methodology:

1) LHC straight insertions lines are extended in CCS coordinate system

2) One point is created every **200 m** along these lines (CCS coordinate system) – (**Discretisation of the Beam lines**)
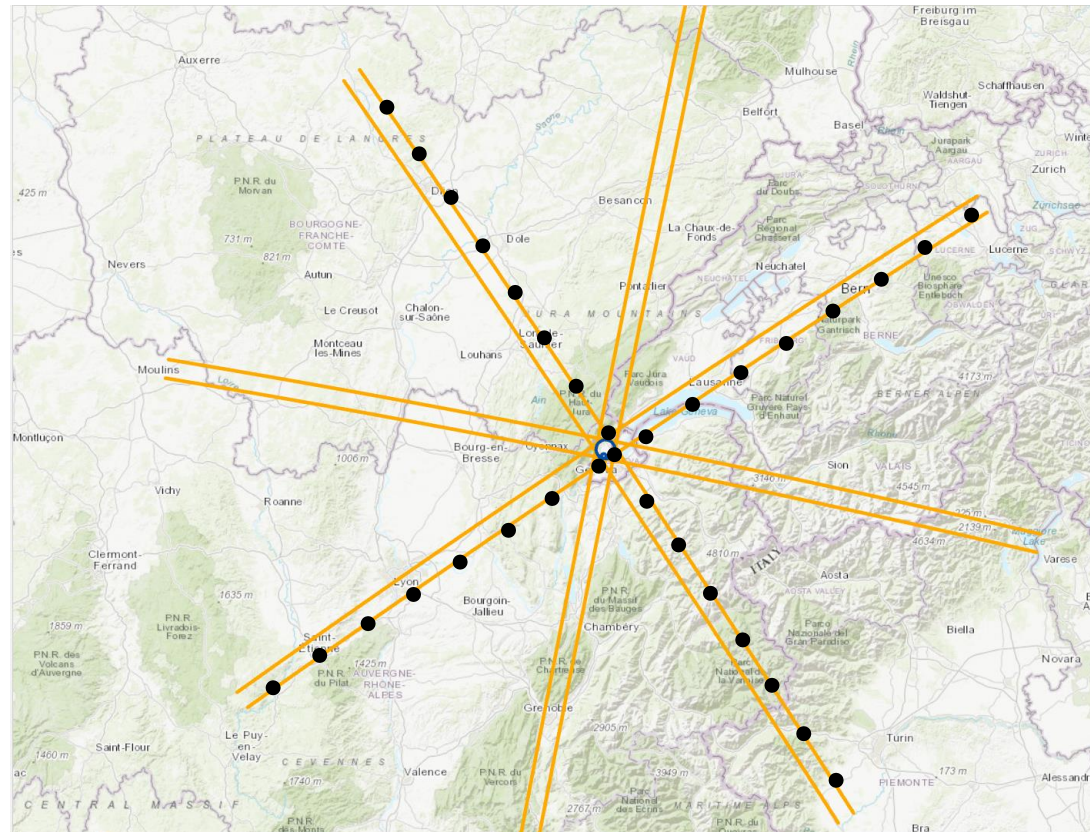
3) **XYZ Coordinates of each point are converted to WGS84 Geodetic Coordinates System**

   ❖ The results is geographic coordinates (lat, long) with ellipsoidal heights (He) of each point.

4) **The EU-DEM is converted to WG84**

   ❖ The Geoid heights (Hg) are unchanged as the ellipsoids WGS84 and GRS80 are slightly equivalent).

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*If we extend the SPS straight sections
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Methodology:

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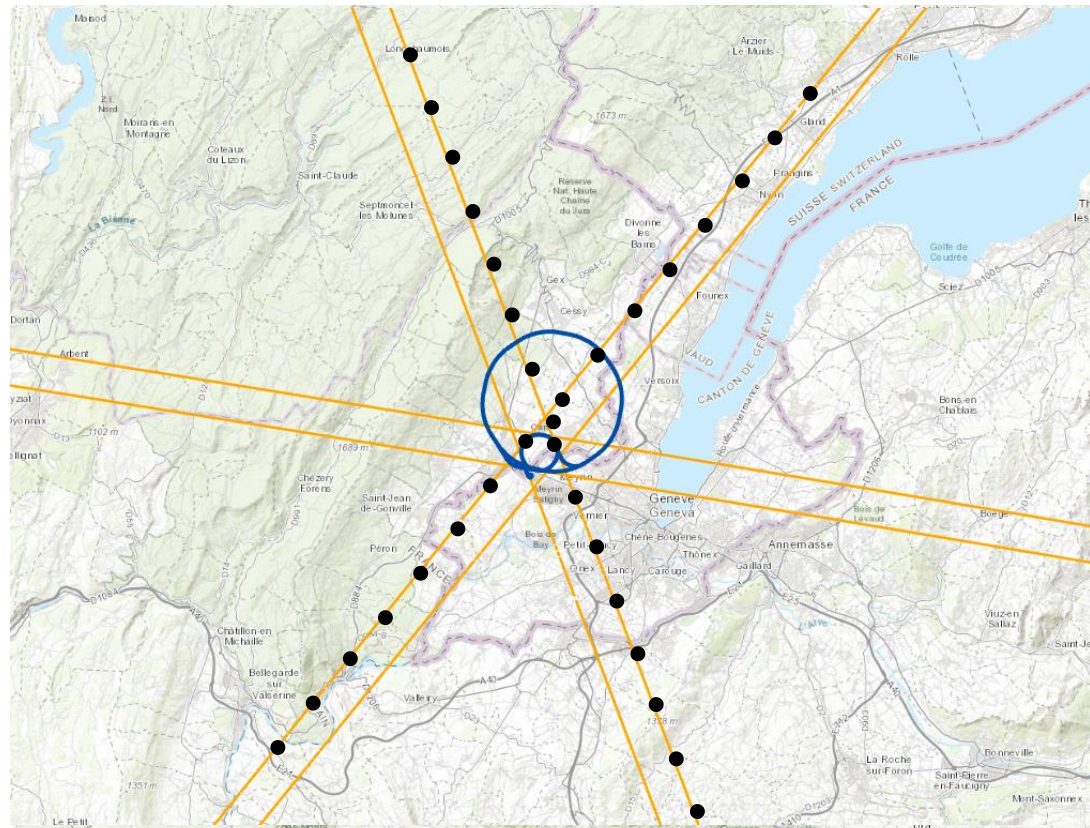
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Methodology:

5) **The Geoidal ellipsoidal heights (He) of the beam points are converted to Geoidal Heights (H)** : $\boxed{\textbf{H = He} - \textbf{N}}$
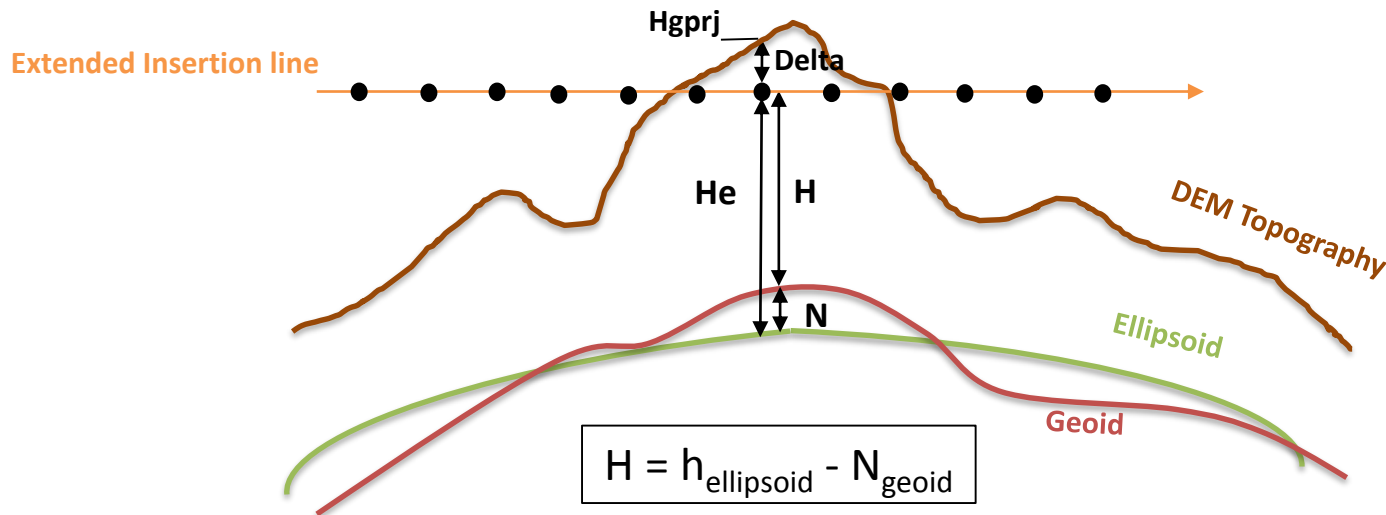
❖ **N** is the ondulation of geoid in the studied area **estimated to 50 m**. In reality it varies from + 47 m to + 54 m.

6) **The difference between the heights (H) of each point and their projection to the DEM (Hgprj) is calculated**.

❖ If the Delta > 0, the point is at the surface of the earth

❖ If Delta is < 0 the point is underground.

$\boxed{\textbf{Delta = H} - \textbf{Hgprj}}$

$$H = h_{ellipsoid} - N_{geoid}$$

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Results:

Point	Side	First exit to the surface of the earth (Distance from IP in Km)
1	L	263
1	R	40
2	L	258
2	R	25
3	L	17
3	R	74
4	L	37
4	R	30
5	L	26
5	R	237
6	L	35
6	R	255
7	L	76
7	R	161
8	L	145
8	R	35

Min	**17 km**
Max	**263 km**

Legend:
- – – – The line is underground
- ——— The line is at the surface
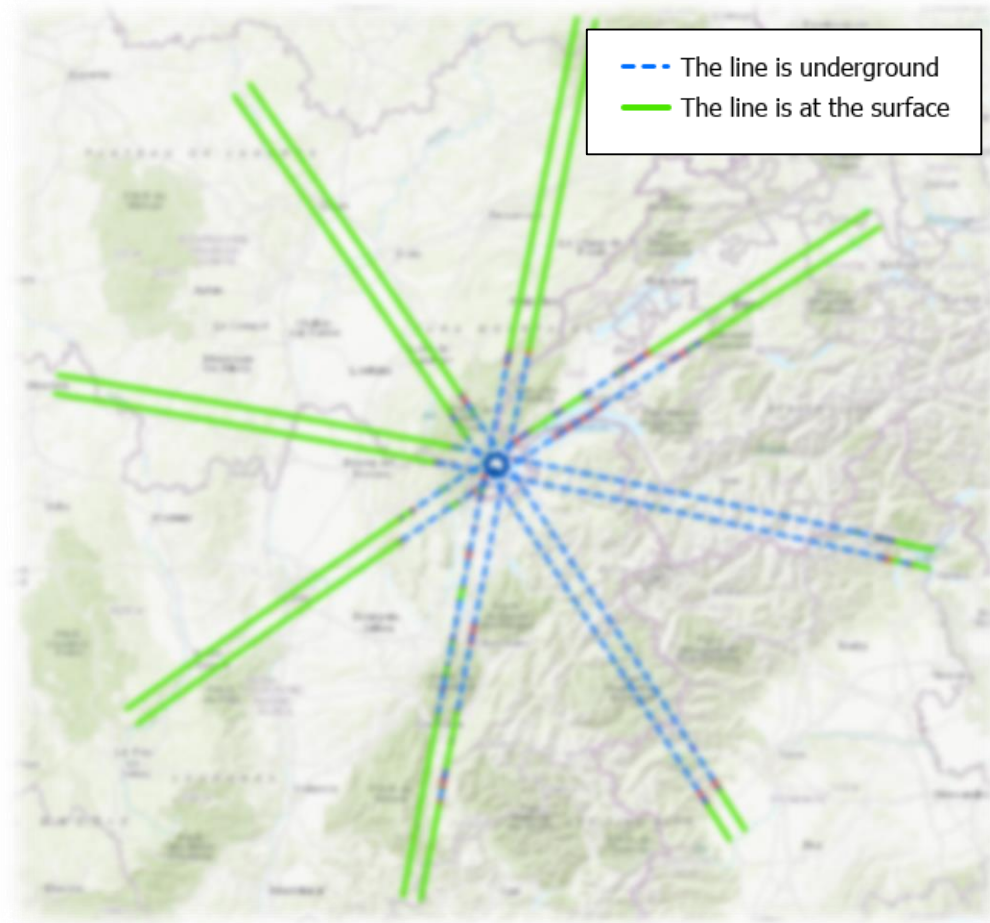
PRELIMINARY STUDY
*If we extend the SPS straight insertion
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Results:

Point	Side	First exit to the surface of the earth (Distance from SPS point in Km)
1	L	64
1	R	7
2	L	28
2	R	35
3	L	44
3	R	10
4	L	80
4	R	6
5	L	10
5	R	21
6	L	51
6	R	10

| Min	**6 km**
Max	**80 km**

- - - The line is underground
—— The line is at the surface

☐ Area where the beam would hit the surface of the earth and get out of it
☐ Tolerance margin

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**Tolerance and accuracy:**

- Heights

    o EU-DEM: Accuracy : **+/- 7.0 m** RMSE
    o EU-DEM is a DEM, and not a DTM (Digital terrain Model).
       An error of **+ 20.0 m is** estimated
    o The assumption for the Geoid undulation is **+/- 3.0 m**

    = > The accuracy of the DTM is roughly evaluated to +/- 30 m

- LHC straight insertions directions:

    The error is estimated to max **0.1 degree** in both horizontal and vertical directions. This corresponds to **20cm /100 m**
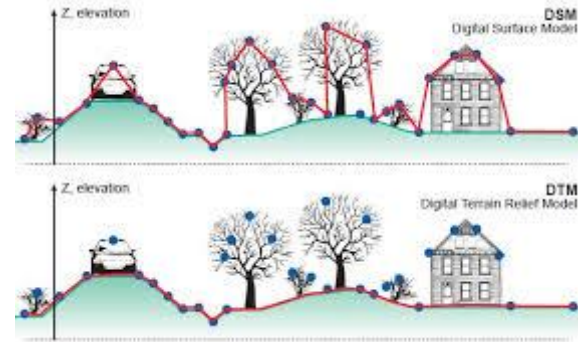
=> To simulate the uncertainty of the results, the calculations are made for the worst possible cases

=> To get rid of the influence of any parameter that would not have been taken into account in this preliminary study a buffer of 1000 m is added
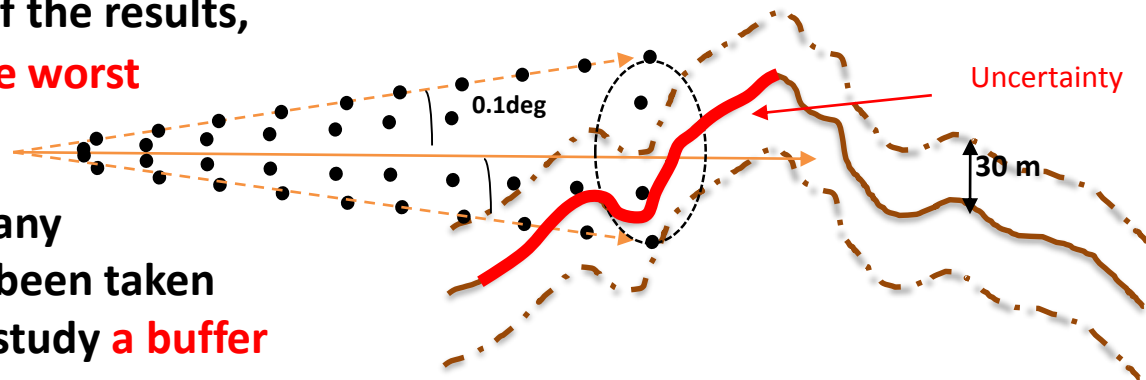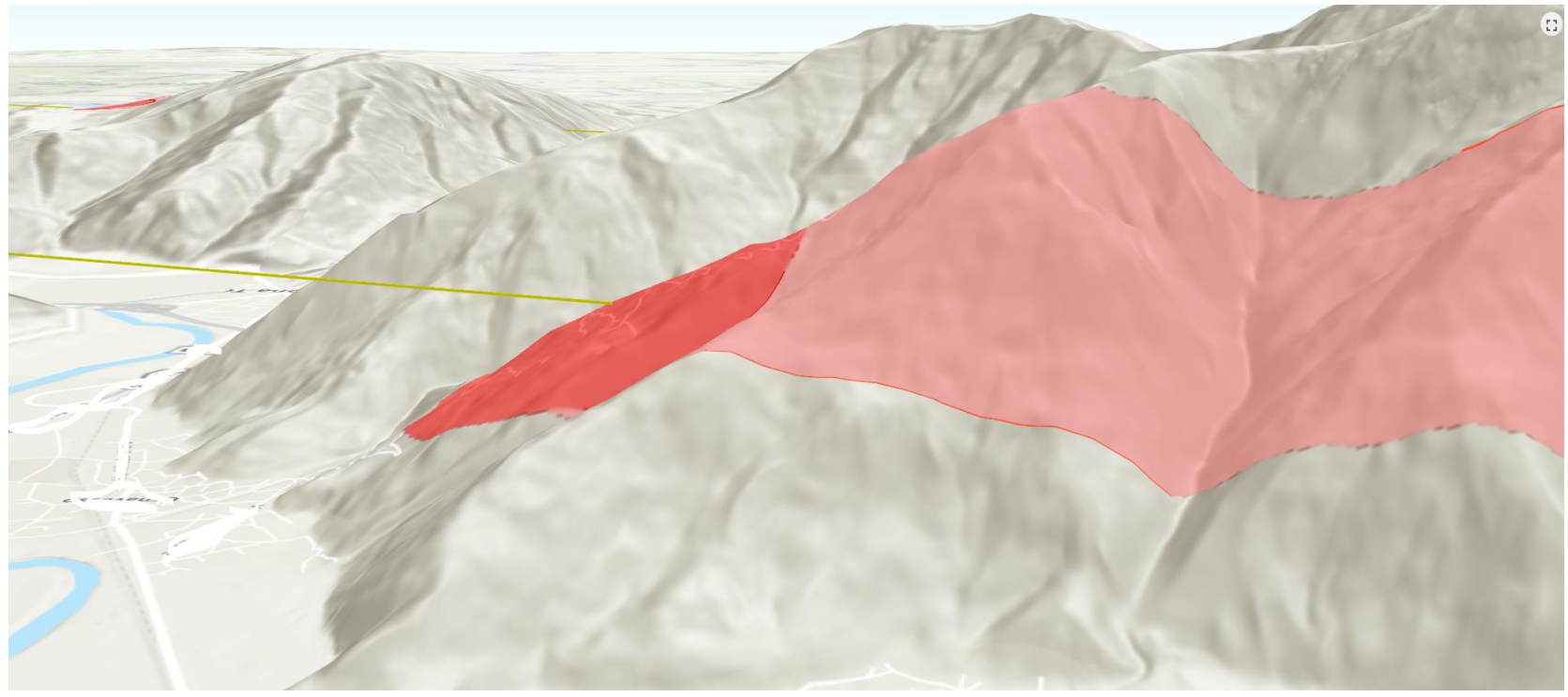
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3D View

🟥	Area where the beam would hit the surface
🟥	Tolerance margin

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Conclusions:

➤ The presented maps are a very quick and preliminary study of the question. But the geographic tools and the data are available.

➤ For LHC the longest distance is on the other side of the alps. For SPS, it is on the other side of the Jura

➤ The depth of the SPS and its "horizontality" bring some uncertainty on the exact locations. The beam is grazing the surface of the earth

➤ For a more precise study, some more investigations have to be performed

➤ We now have Gil a technical Student to automatise the production of such maps according to the collider position