



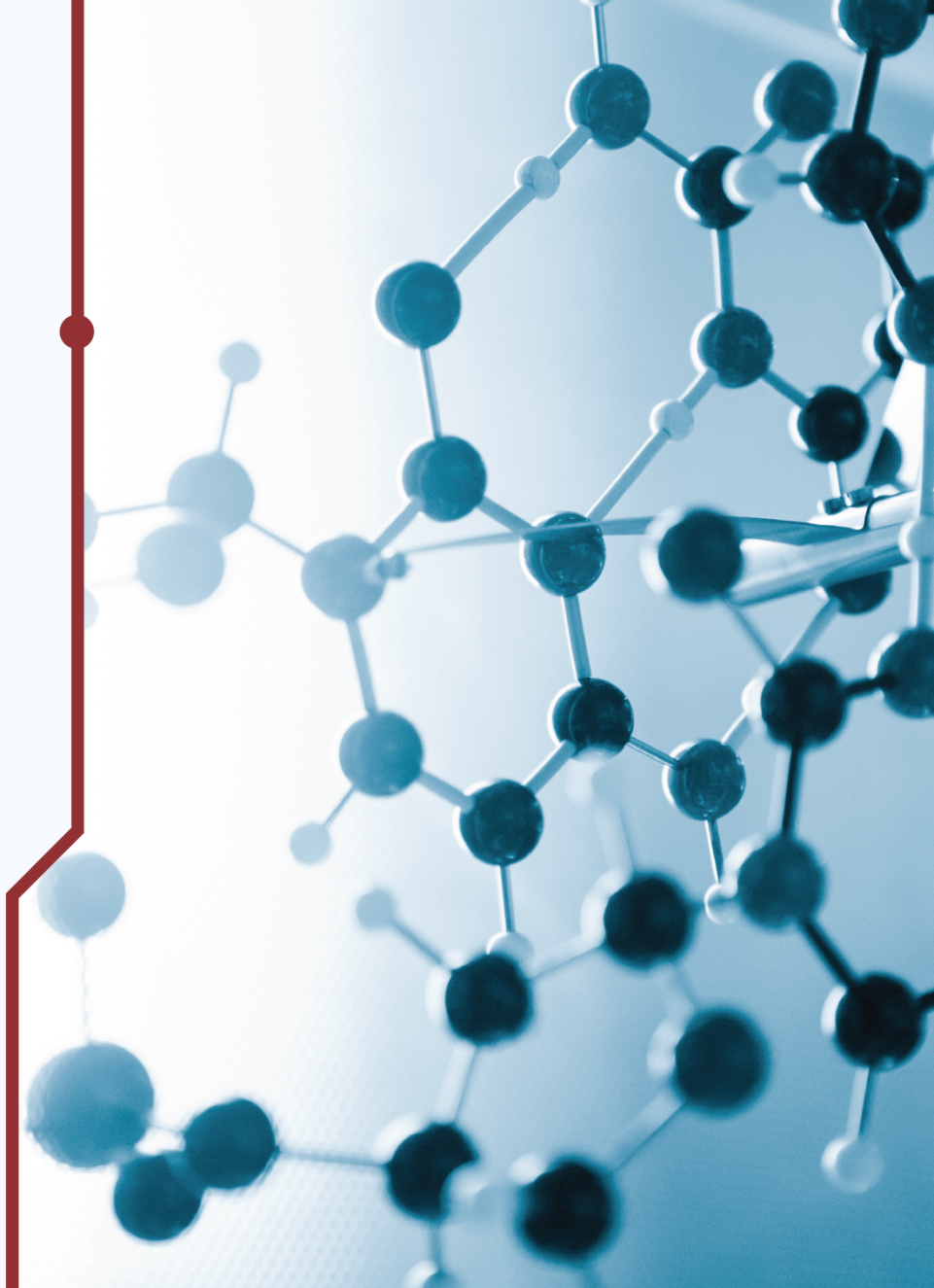
REINFORCE

REsearch INfrastructures FOR Citizens in Europe

Because boring is not boring: an application of muography in civil engineering

WEBINAR

May 11, 2021, 15:00 CEST





1. Grand Paris Express

TBM contractors needs:

- + **Daily reporting:**
 - 3D density reconstructions in front of TBM
- + **Throwing Alert when crossing anomalies:**
 - Size & density estimate

Technical challenges:

- + Several Mobile Detectors over 50 to 100m
- + Different Type of Detectors
- + Data scarce compared to TBM speed

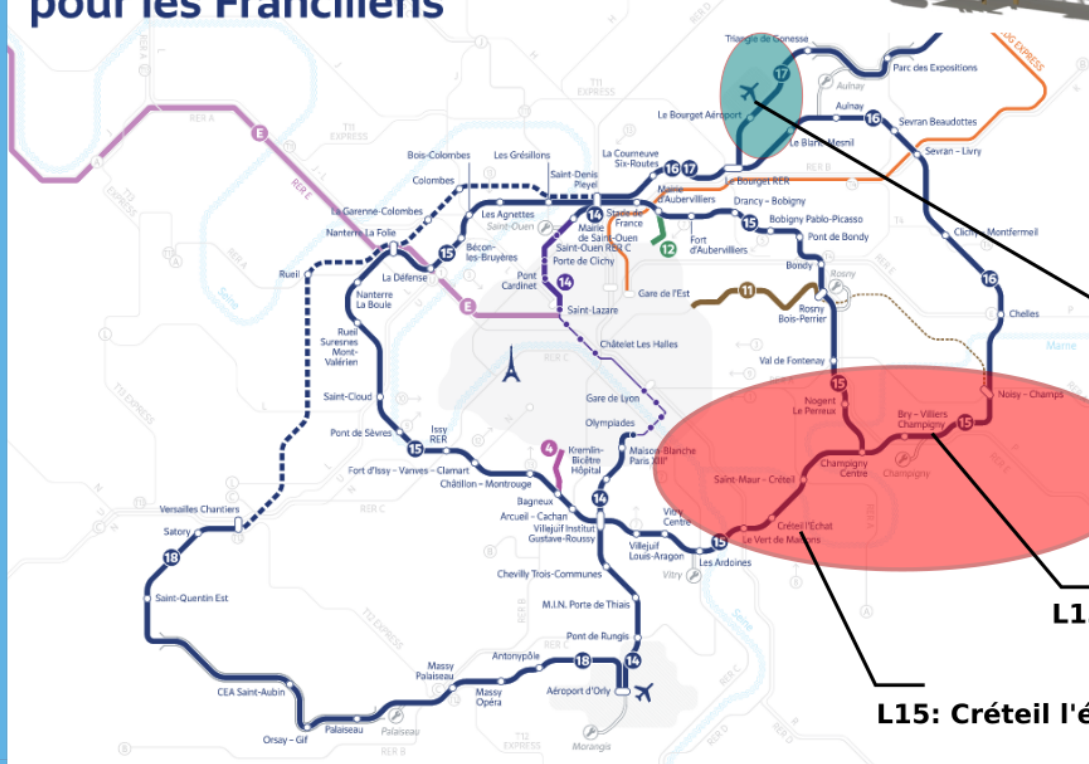
Scientific issues:

- + Resolution improvement ?
- + Ability to Detect anomalies ?
- + Quality of 3D Density estimates ?

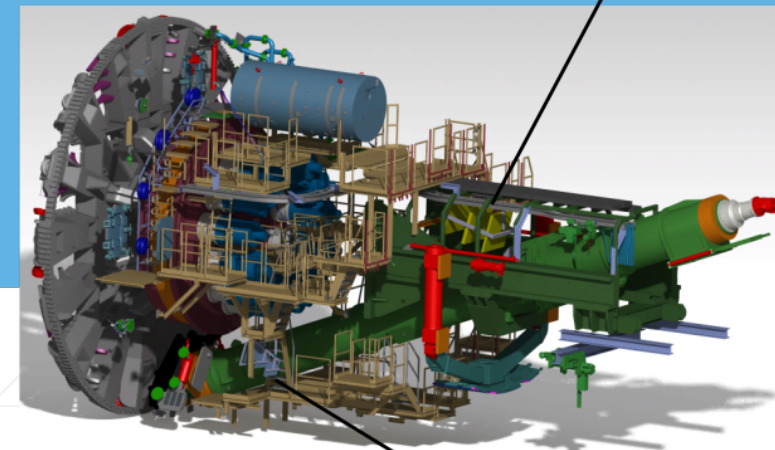
Applications:

"Mobile Array of Muon Detectors onboard a Tunnel Boring Machine"

Les nouvelles lignes de métro et de RER pour les Franciliens



"Deep Purple" (Large)



Courtesy of J.-C. Ianigro

"Purple Haze" (Mini)

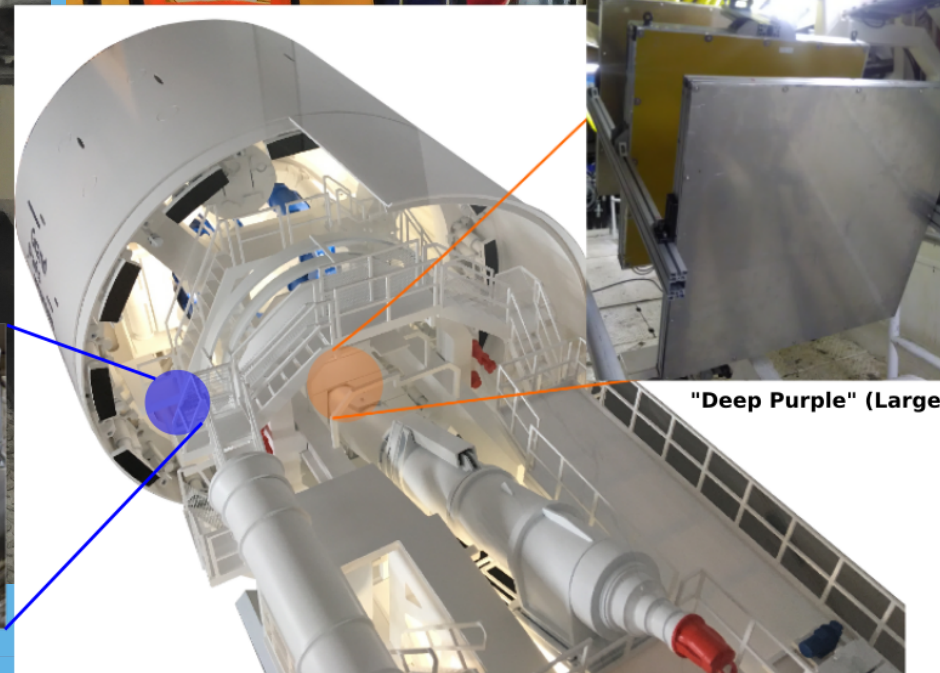
L17: one segment (le bourget)

L15: Bry-Villiers-Champigny

L15: Créteil l'échat segment T2C



2. Tunnel Boring Machine

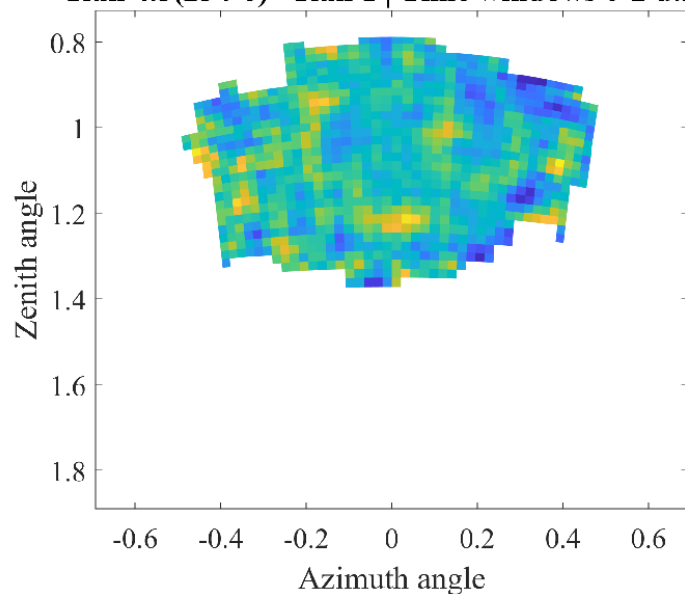




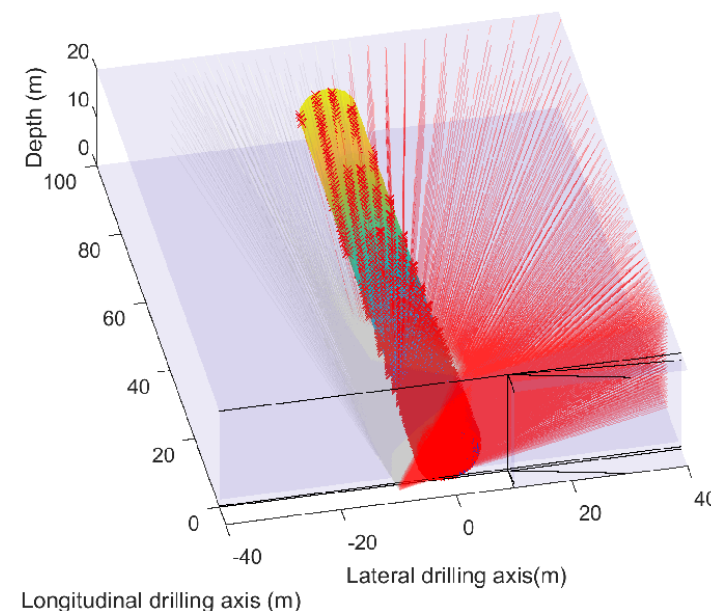
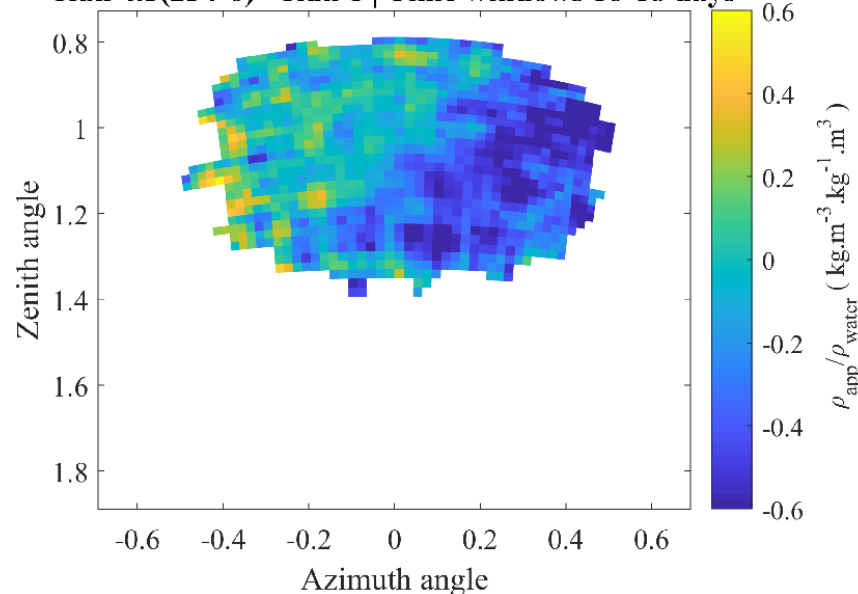
3. First try out: looking at a TBM from the side



Run 4.5(234-0) - Run 1 | Time windows 0-2 day



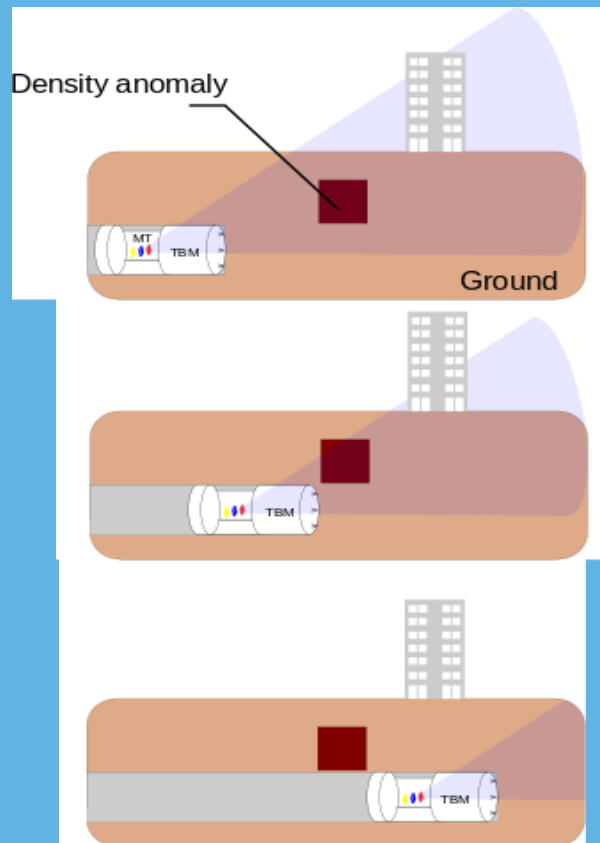
Run 4.5(234-0) - Run 1 | Time windows 16-18 days



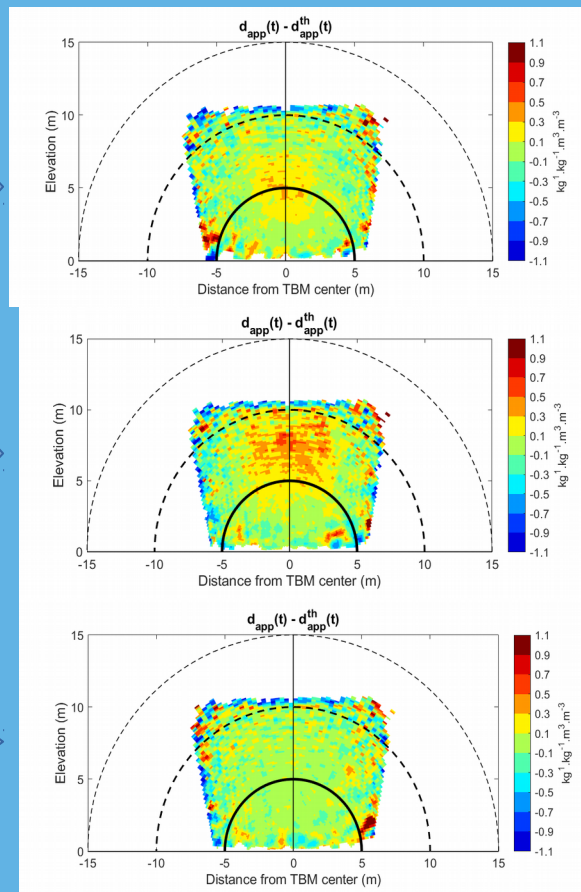


4. Mobile detectors: stereoscopy 3D

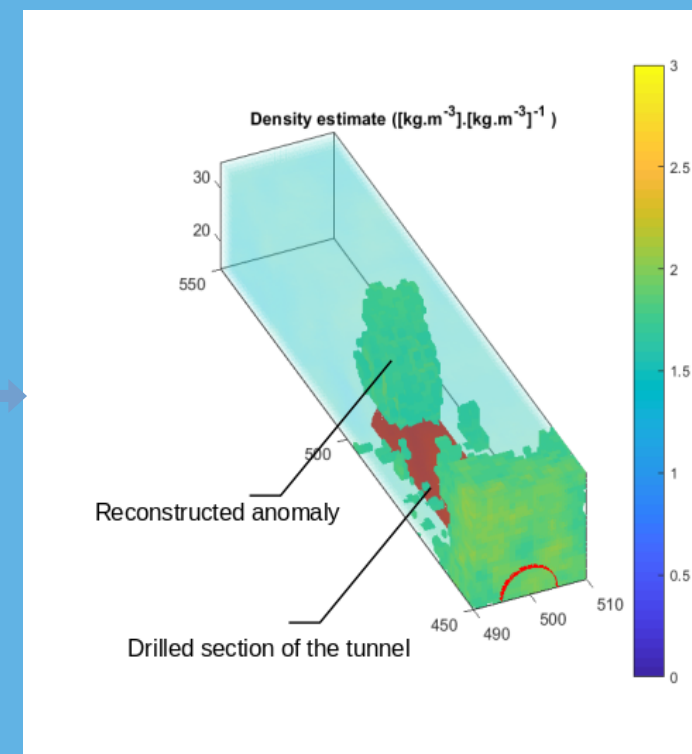
TBM-ground situation



2-D Muographies
Apparent density

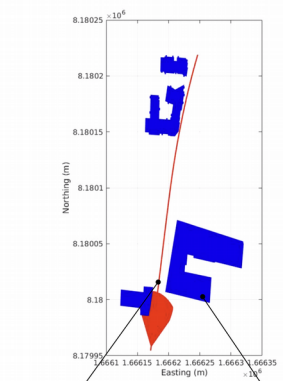


3-D reconstruction
3D density estimate



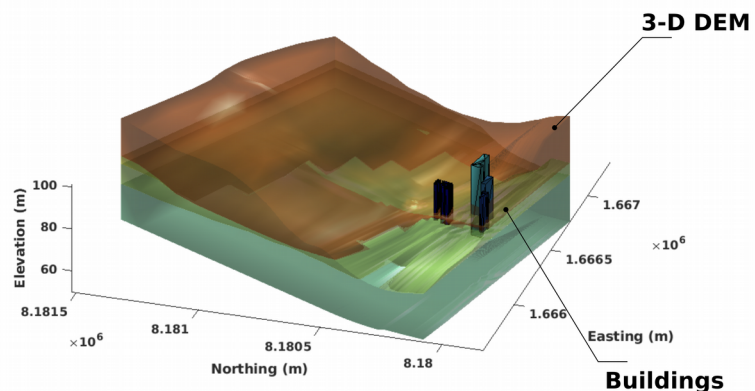
5. 3D reconstruction inputs

TBM path with buildings (top view)



TBM trajectory

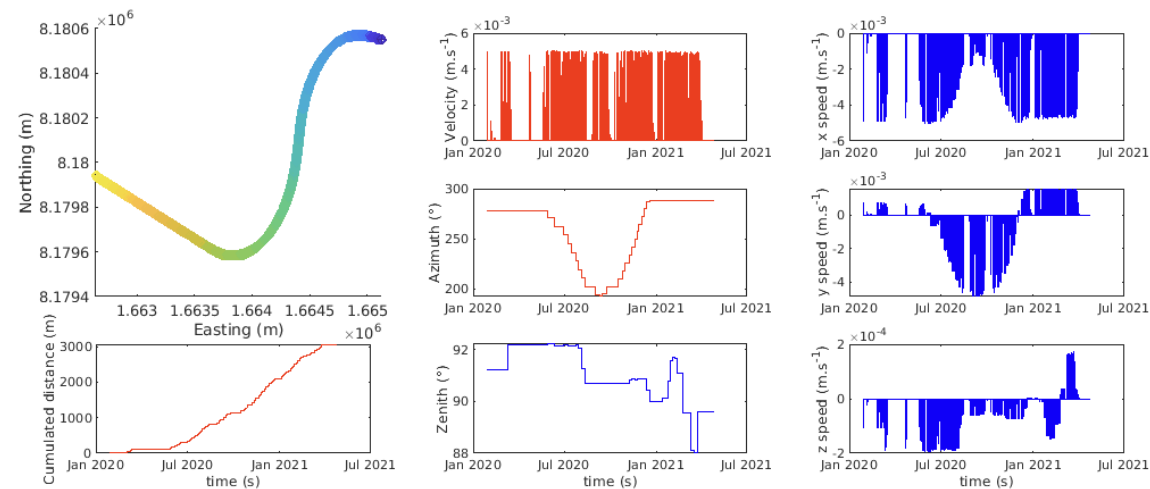
Buildings



3-D DEM

Buildings

Digital Elevation Model (DEM)



TBM navigation data

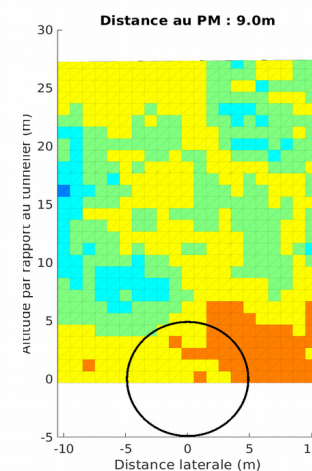
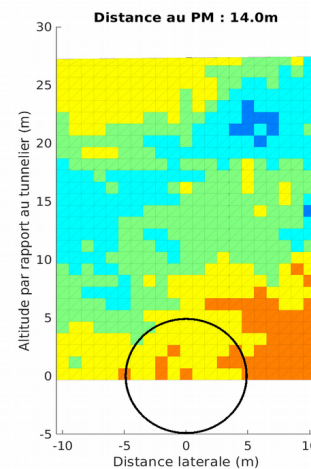
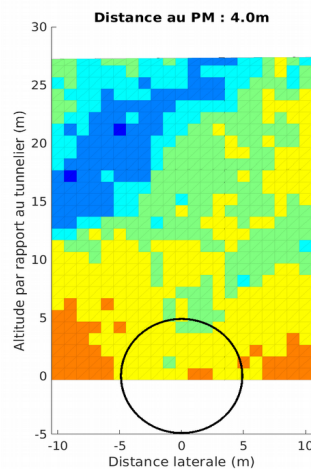
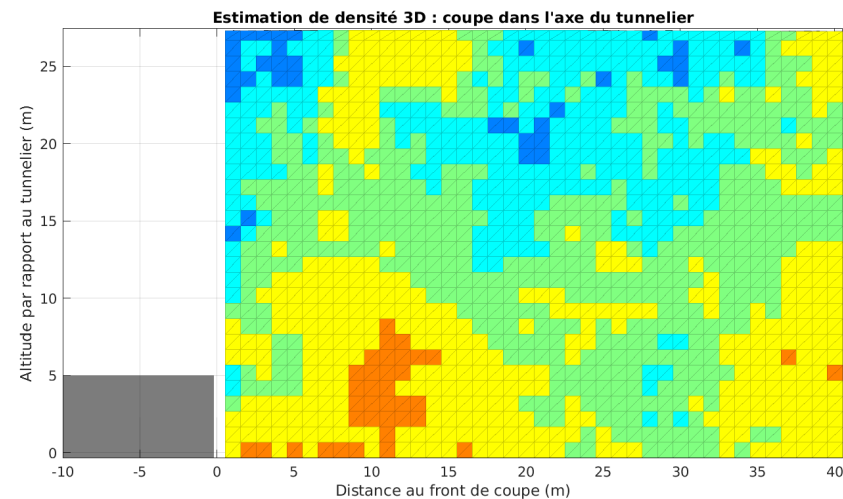
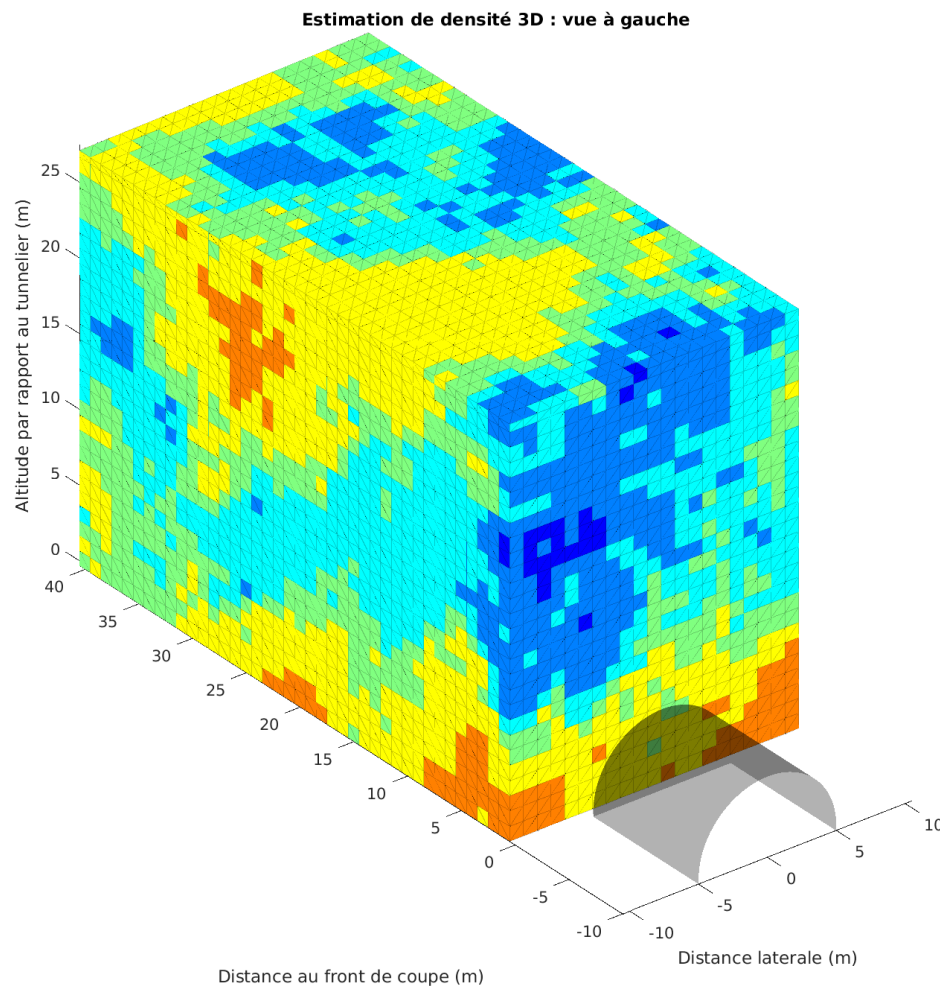


Building footprints Model





6. Example of 3D density estimates



3.00-3.30 g.cm⁻³

2.50-3.00 g.cm⁻³

2.00-2.50 g.cm⁻³

1.75-2.00 g.cm⁻³

1.50-1.75 g.cm⁻³

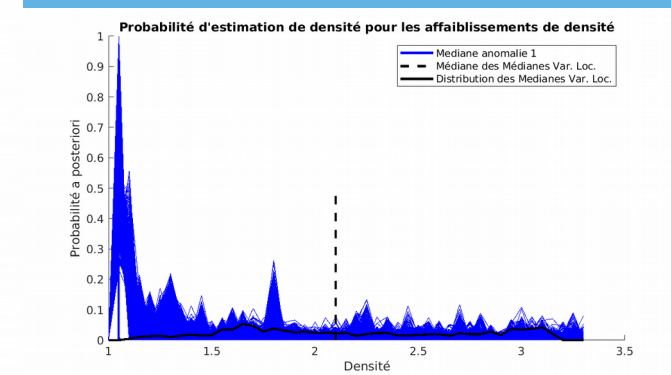
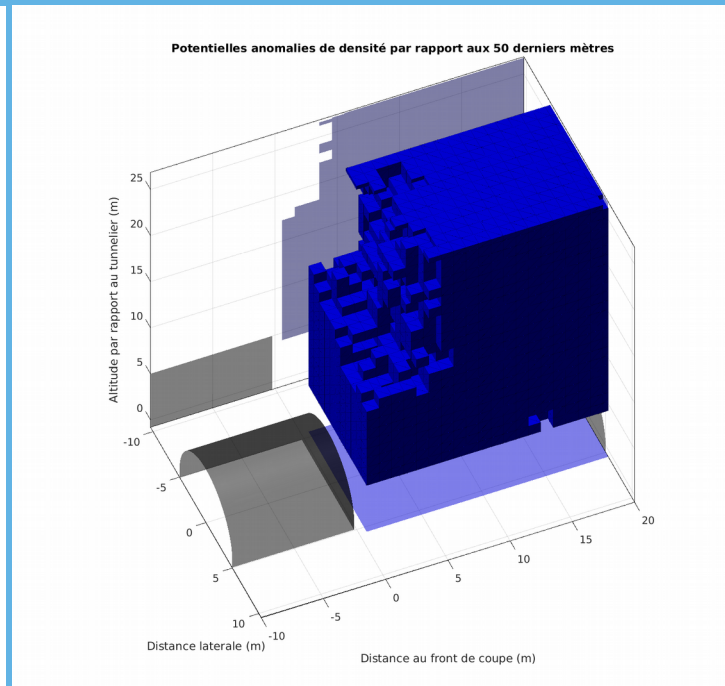
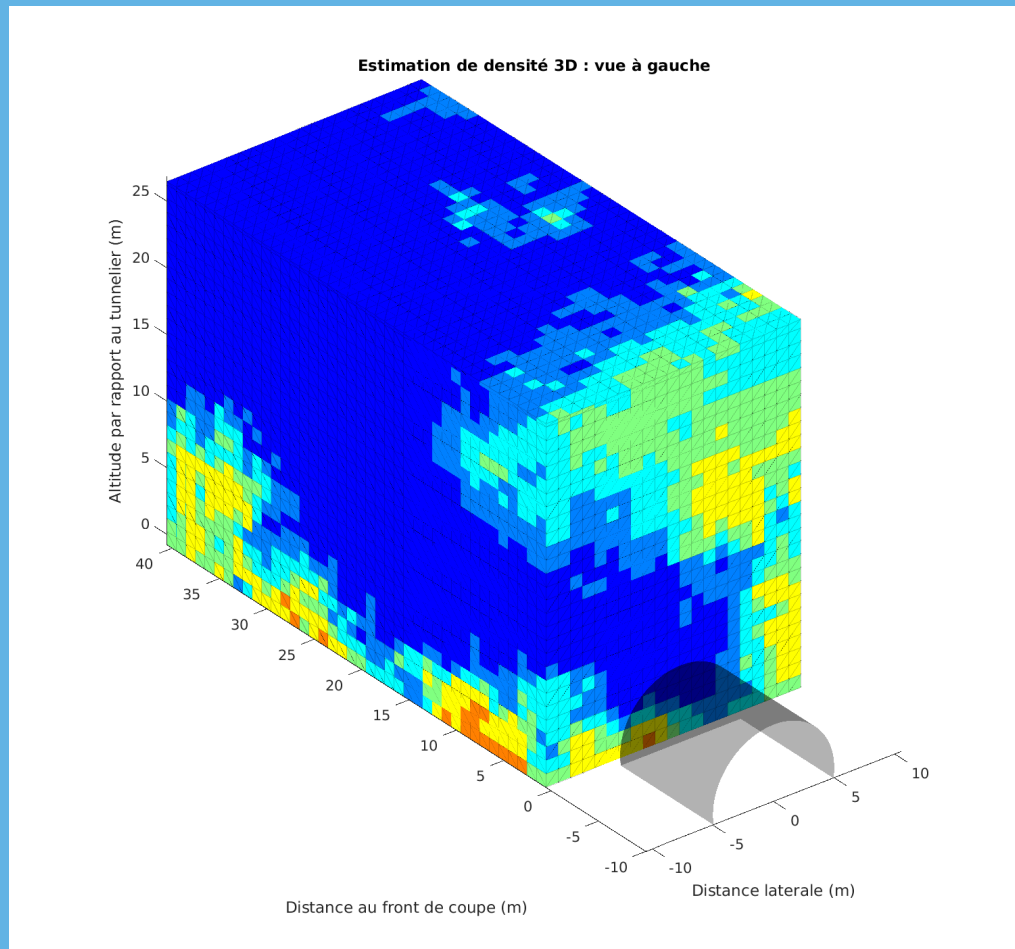
1.25-1.50 g.cm⁻³

1.00-1.25 g.cm⁻³





8. Arriving in futur station « gap » (Anomaly)



Density chart

Anomaly detection alert
Massive weakening detected

9. Conclusions

(1) The results are promising. Many improvements are still ongoing.

(2) 3D reconstruction techniques applied to moving TBM are still in their infancy. :

- + TBM specific detectors are designed
- + 3D algorithm needs to be refined (prior information integration, speed ...)

Thank you for your attention !





REINFORCE

REsearch INfrastructures FOR Citizens in Europe

Join our community



www.reinforceeu.eu



company/reinforceeu



[@ReinforceEU](https://twitter.com/ReinforceEU)

