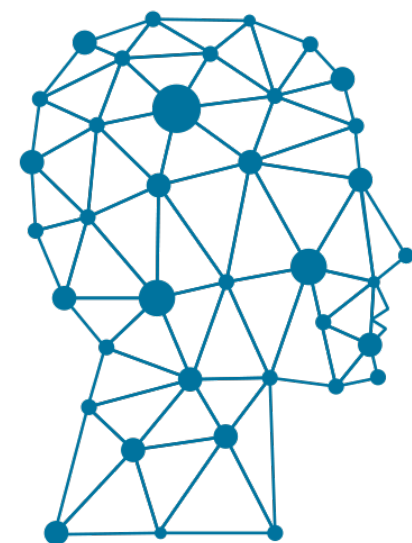


Medical image interpretation challenges and research activities of the *tAlmedIA* group at UniBS

Alberto Signoroni, Mattia Savardi, Davide Farina, Sergio Benini, Edoardo Coppola,
Damiano Ferrari, Mauro Massussi, Salvatore Curello, Michele Svanera, Giuseppe D'Ancona



Ital-IA
ITALIA INTELLIGENZA ARTIFICIALE
ini National Lab **AIIS**



May 29-31, 2023



UNIVERSITÀ
DEGLI STUDI
DI BRESCIA

Current main research activities

Brain imaging and Neuroscience

- Structural Brain imaging (MRI)
 - Brain segmentation, morphometry
- Functional Brain imaging (fMRI)
 - Brain decoding

Cardiothoracic imaging and signals

- COVID-19 severity assessment on Chest X-ray
- Cardiothoracic risk factors prediction on Chest X-ray and ECG

Trustworthy AI

- User-driven/Patient-driven design (Explainability, Deployment,...)
- Regulation (GDPR, SaMD, AI-acts)
- Ethics and Trustworthiness audits (e.g. Z-inspection)



Collaborations

Glasgow
Institute of Neuroscience and Psychology, University of Glasgow
Segmentation of brain structures from MRI
From 2018

Leiden
Leiden University Medical Center
Cardiac risk factors

Berlin
Vivantes Klinikum
Cardiotoracic imaging, ECG, Cardiac risk factors

ML and DL applied to medical image and signal understanding, digital microbiology, 3D computer vision and graphics, TLC and telemedicine
Brescia
University of Brescia
ASST Spedali Civili
Copan Italia
Open Technologies
Gexcel, Antares Vision
From 2019



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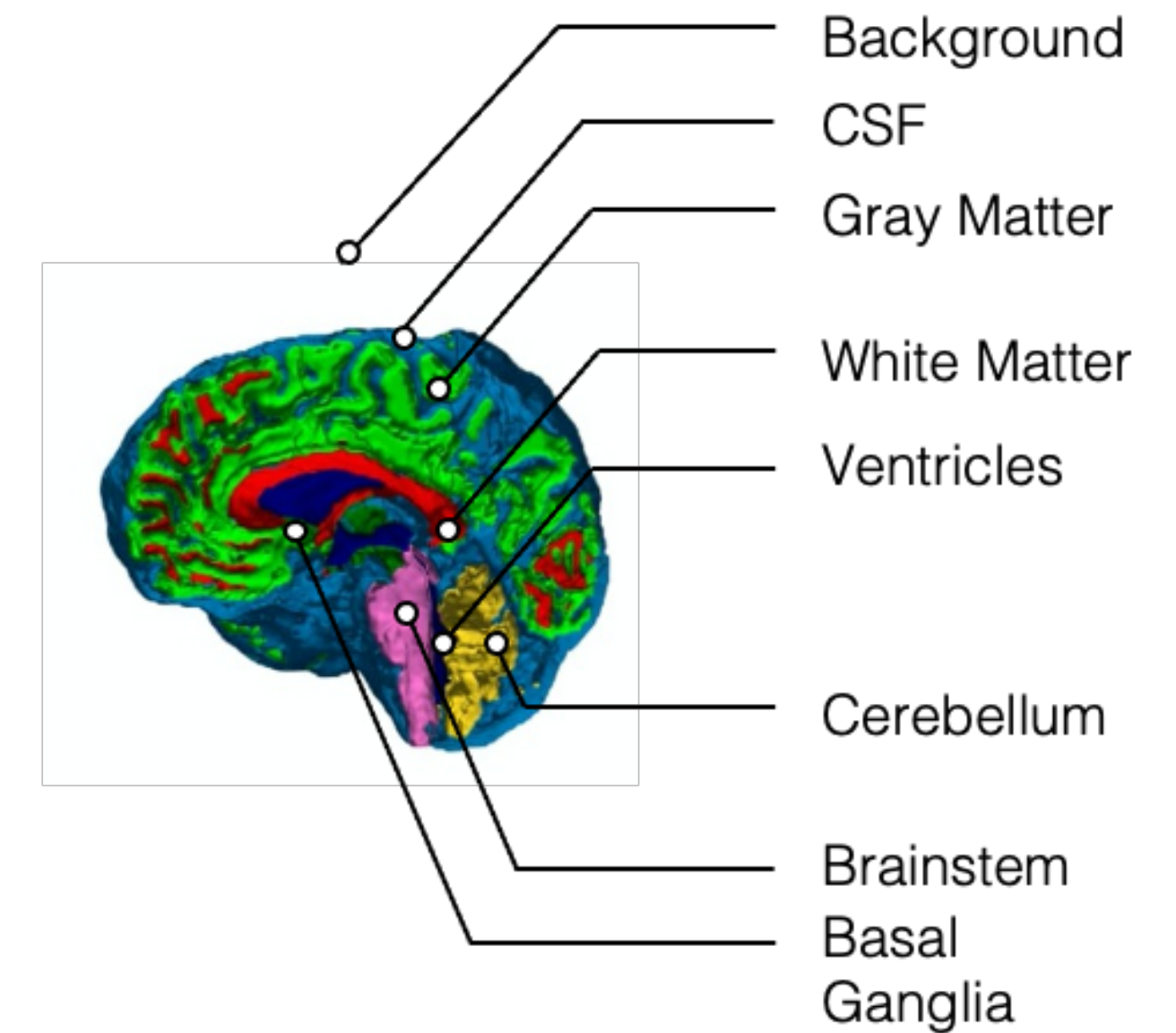
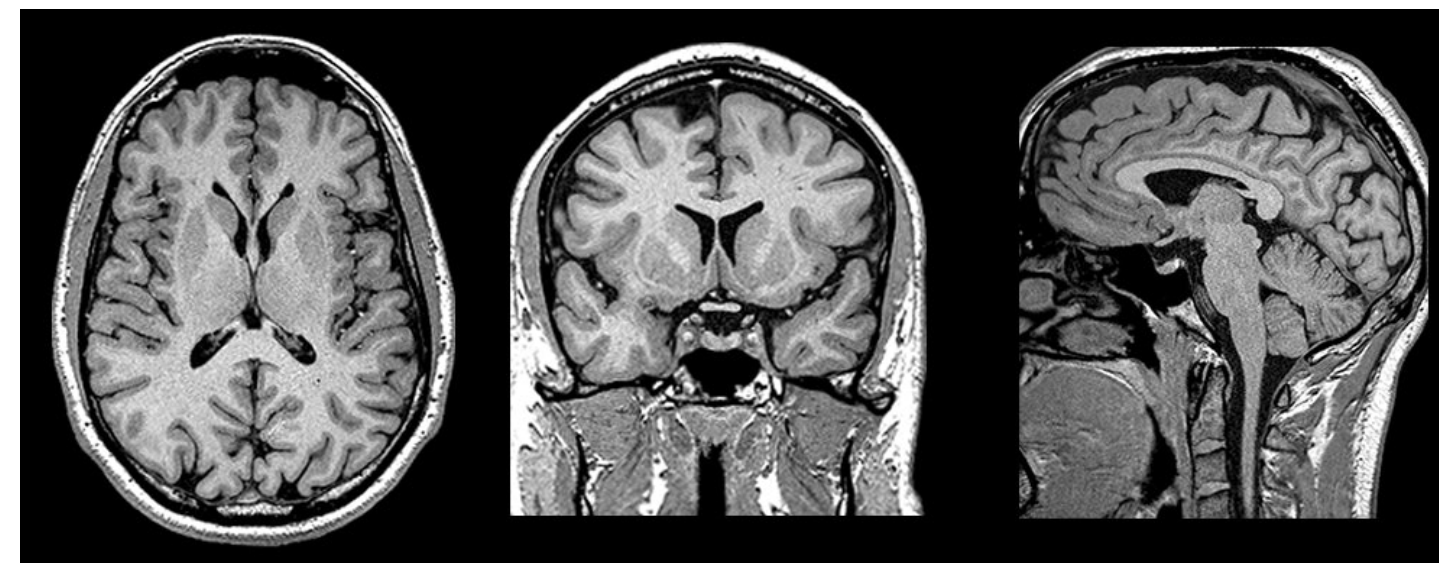
Cognitive Neuroscience: Functional fMRI image analysis, Deep Learning for Brain decoding
From 2018

Tel Aviv
Sagol Brain Institute,
Wohl Institute for Advanced Imaging



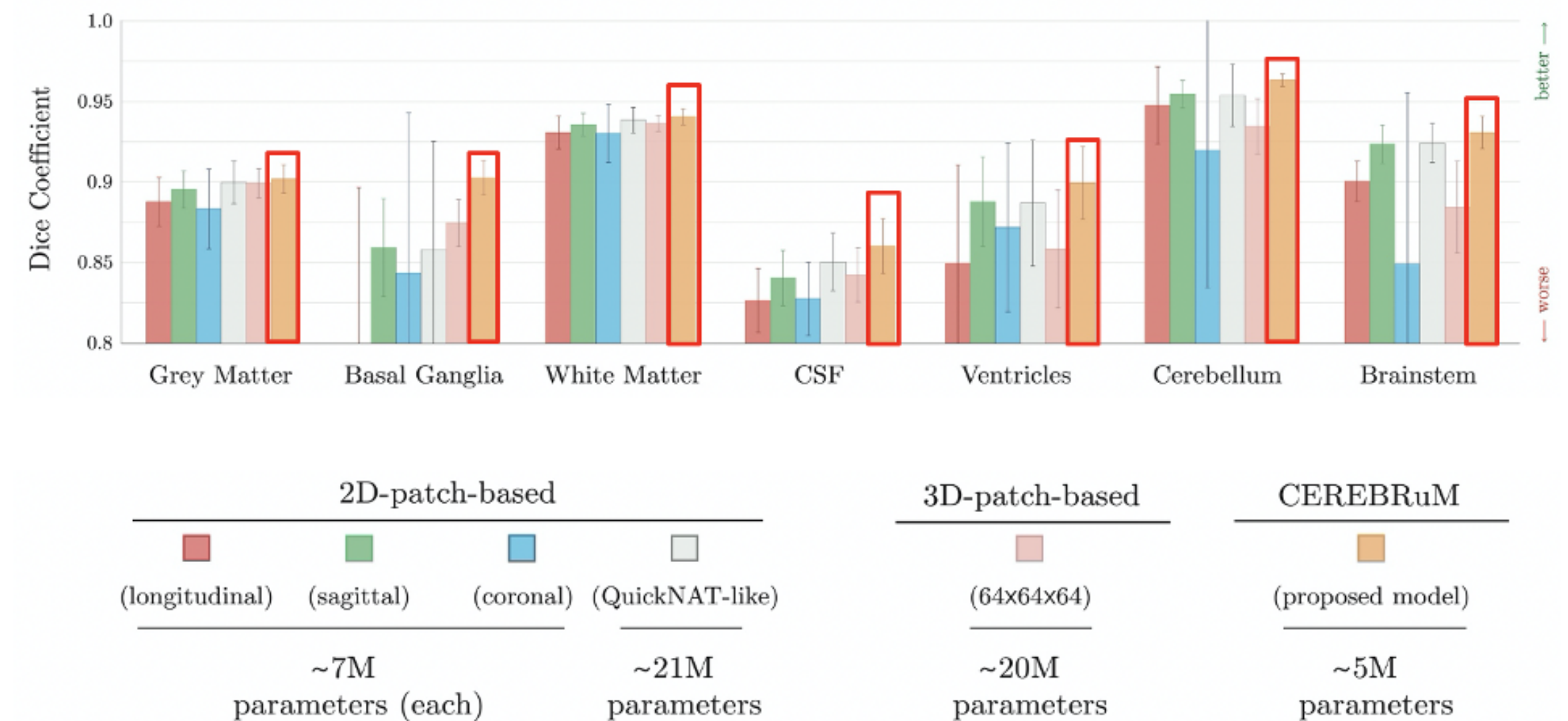
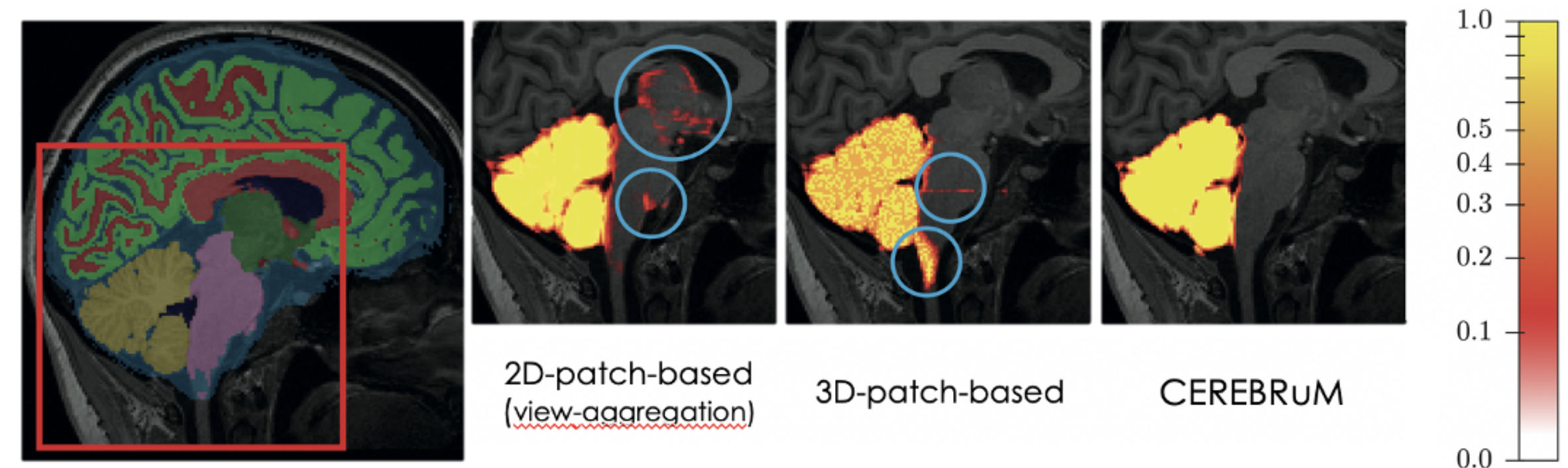
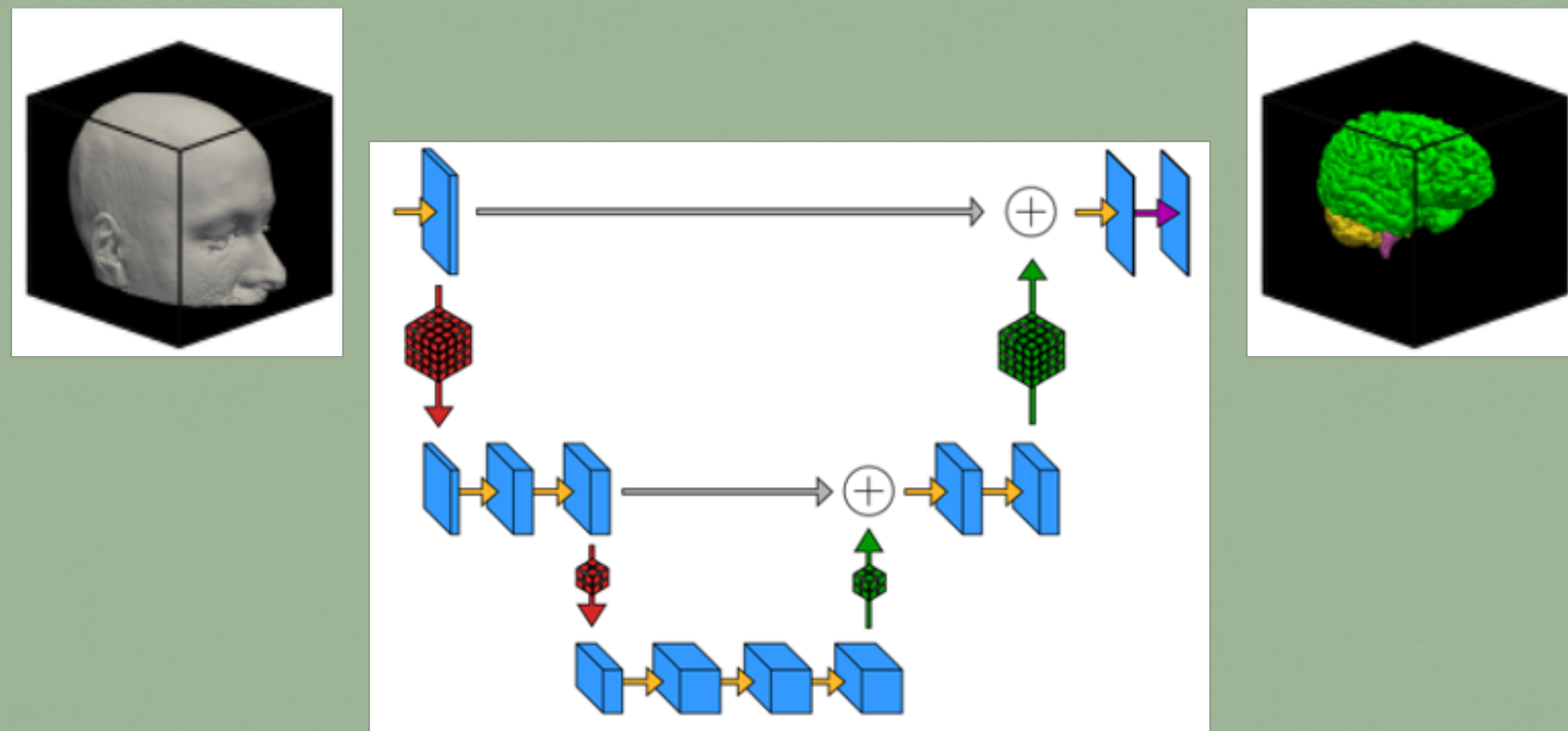
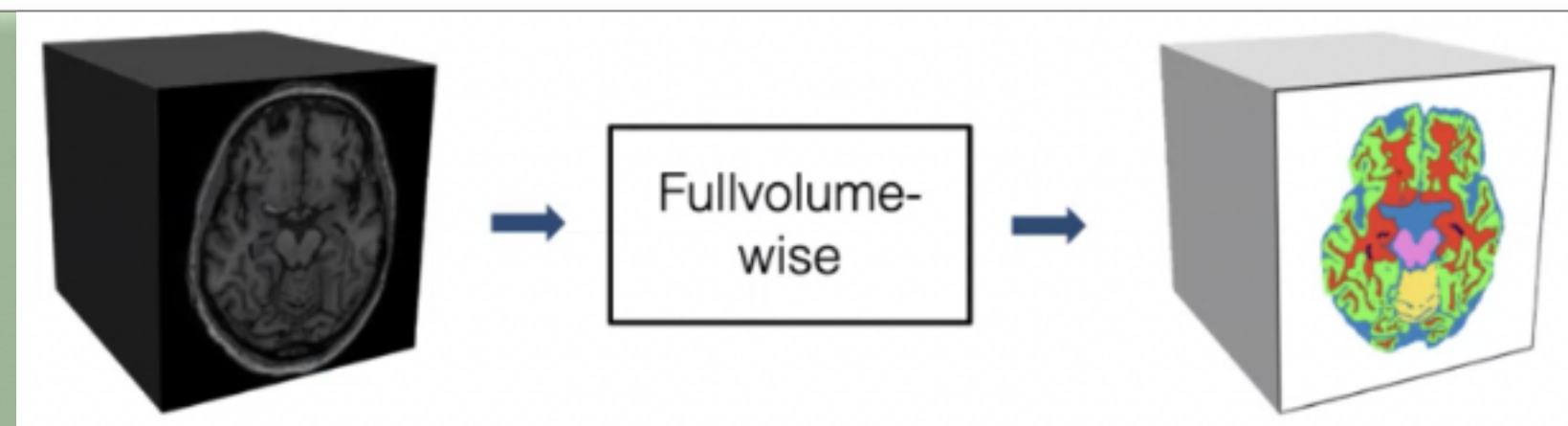
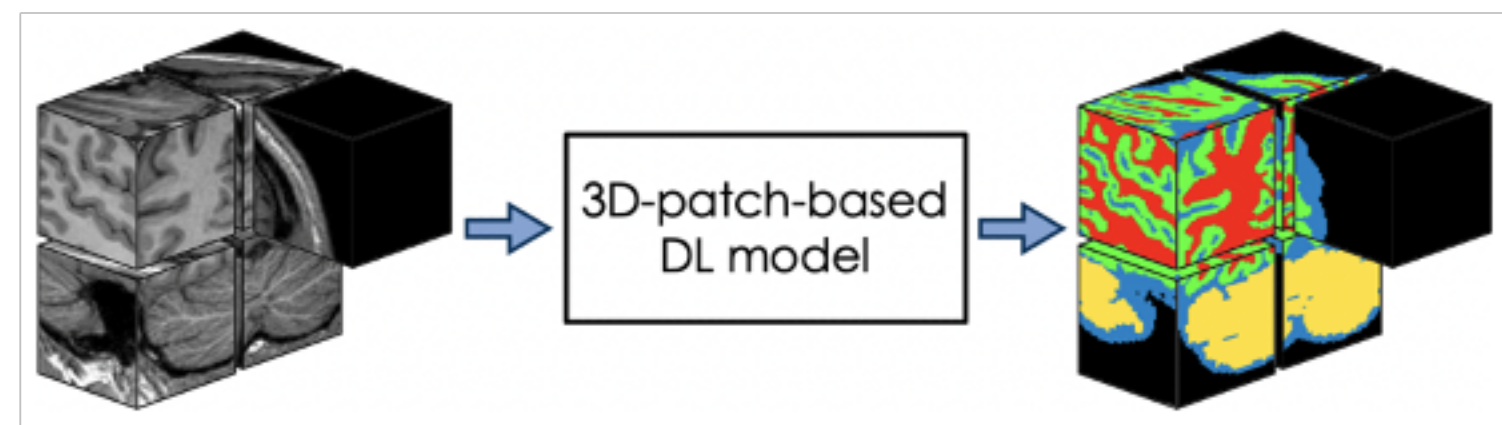
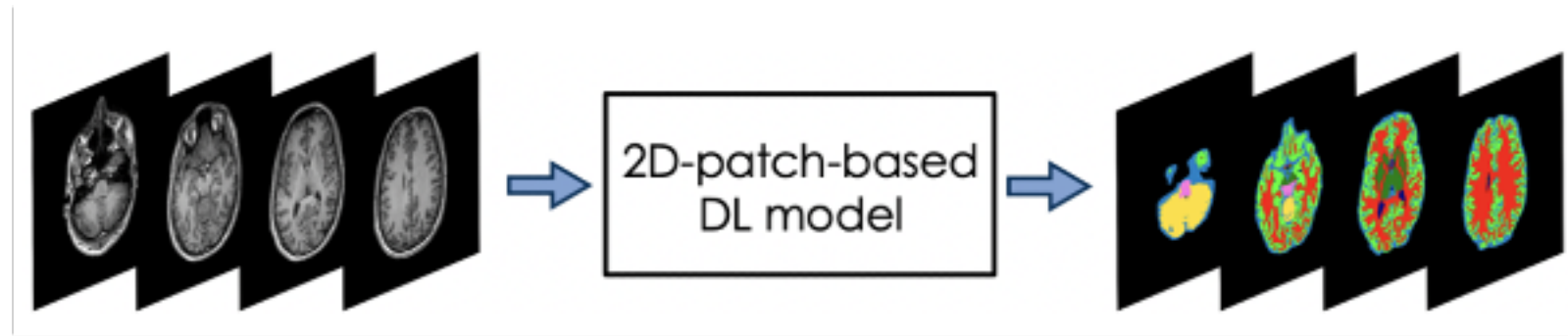
Brain MRI segmentation

3-Tesla



MICCAI
Challenge

Brain MRI segmentation

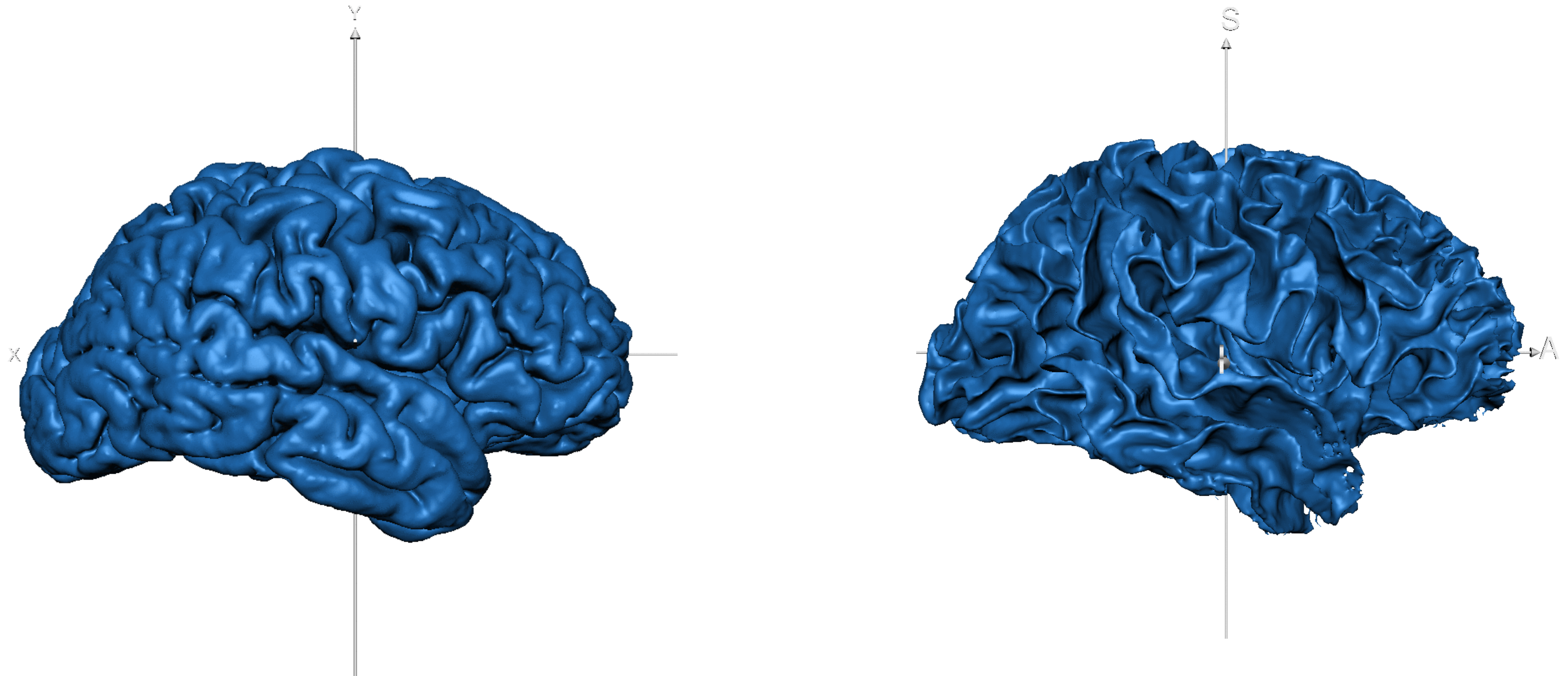


D. Bontempi, S. Benini, A. Signoroni, M. Svanera, L. Muckli,
 "CEREBRUM: a fast and fully-volumetric Convolutional Encoder-decoder for weakly-supervised segmentation of Brain structures from out-of-the-scanner MRI", in *Medical Image Analysis*, Volume 62, May 2020.

Extension to 7-Tesla

https://rocknroll87q.github.io/cerebrum7t/results_glasgow

Single-site

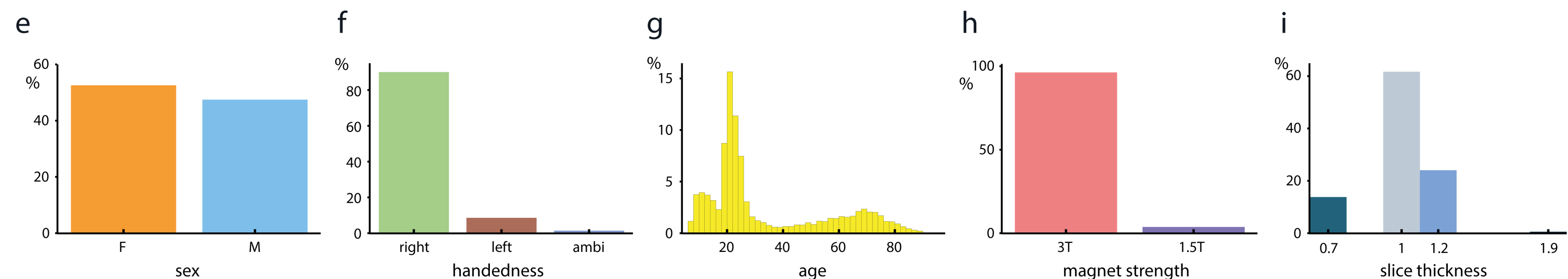
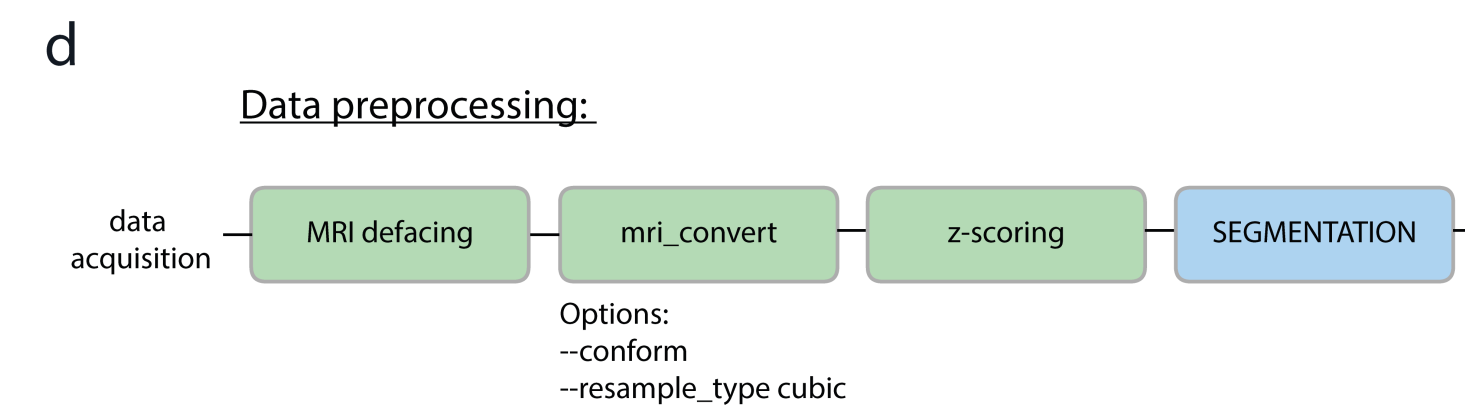
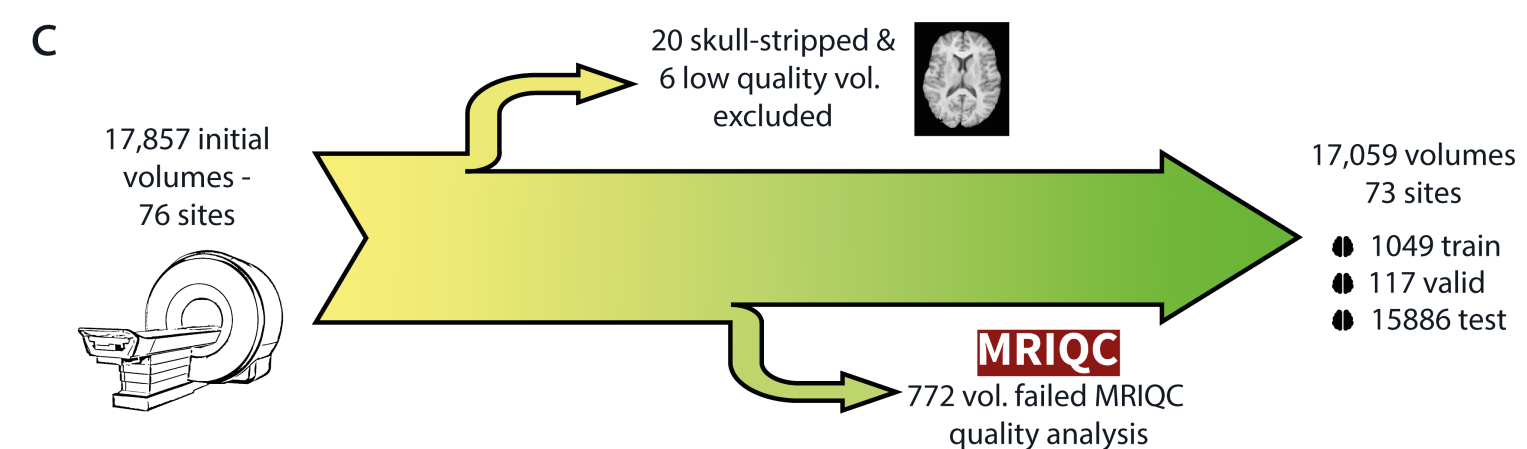
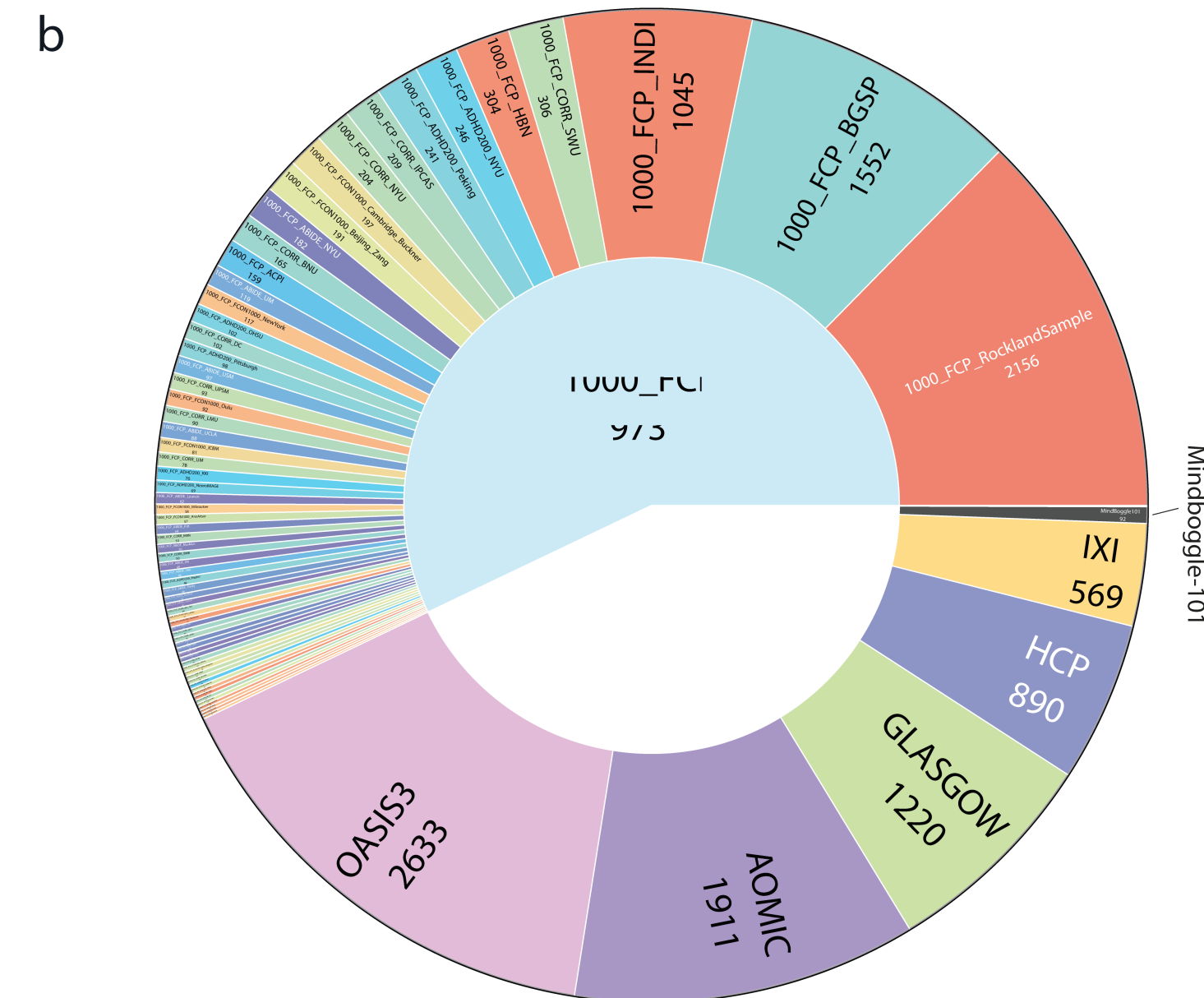
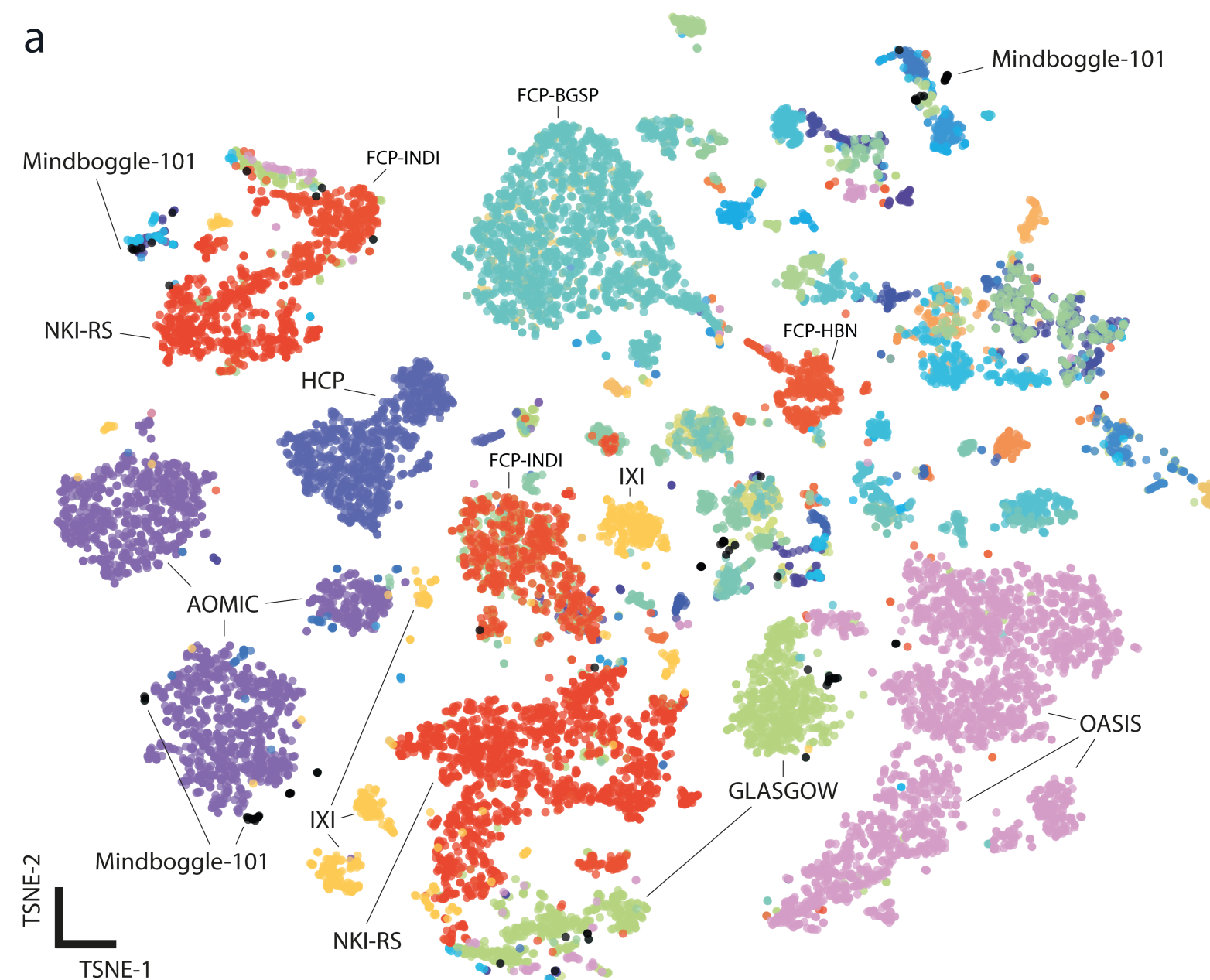
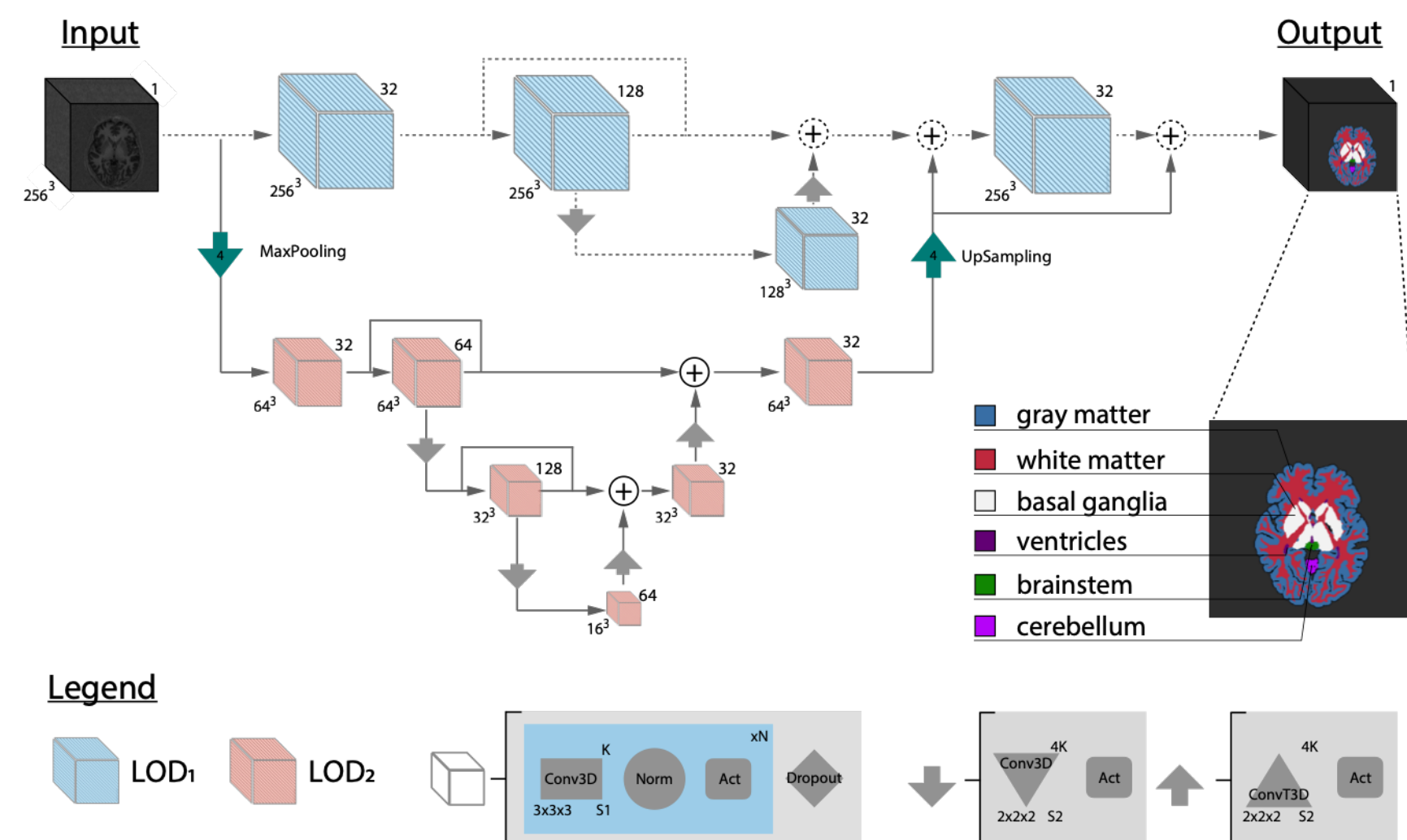


M. Svanera, S. Benini, D. Bontempi, and L. Muckli, "CEREBRUM-7T: Fast and Fully-volumetric Brain Segmentation of 7 Tesla MR Volumes", in *Human Brain Mapping*, Volume 42, Issue 17, December 1, 2021, Pages 5563-5580, October 2021.

Fighting the scanner effect in brain MRI segmentation on multi-site data

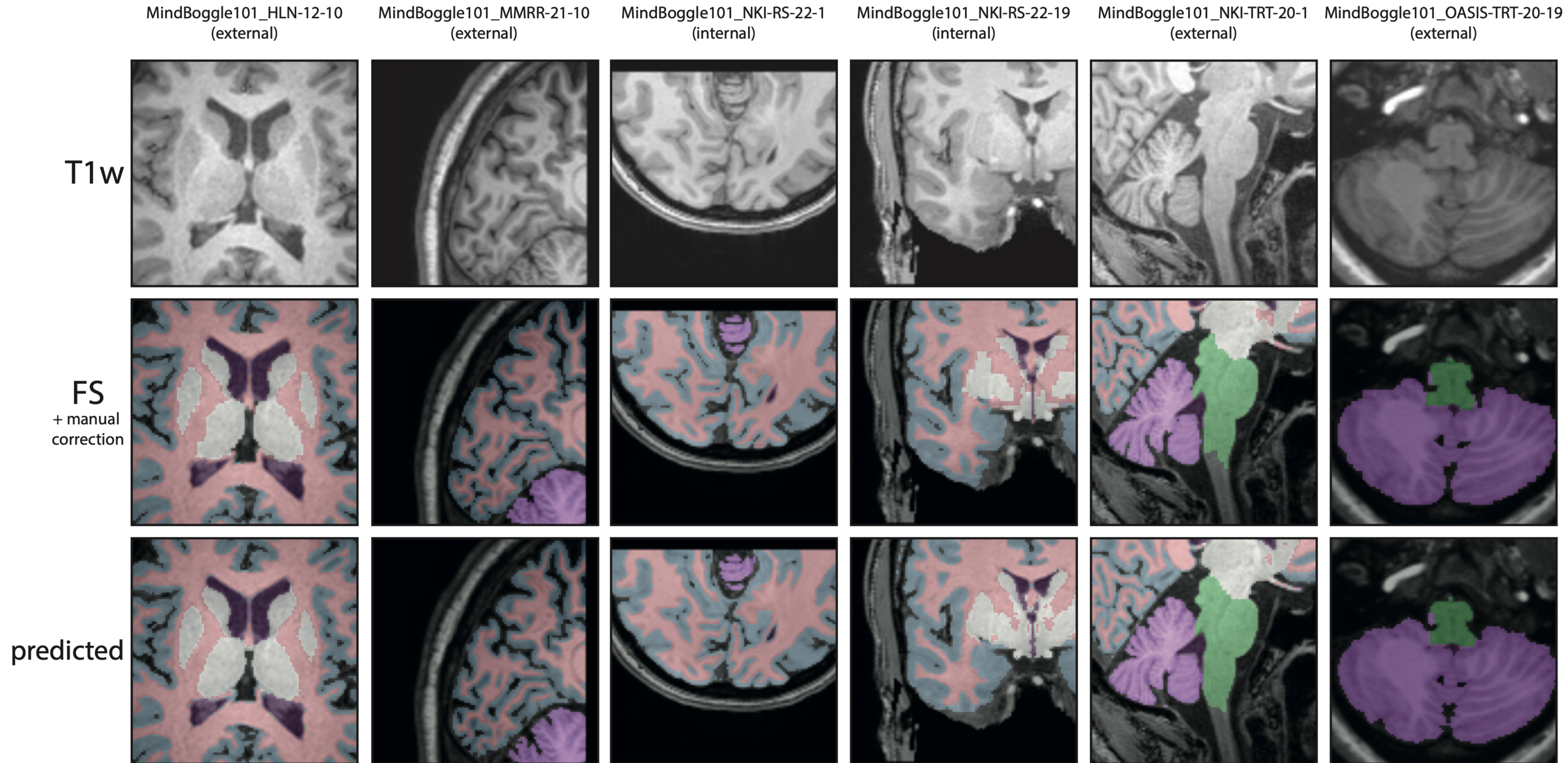
<https://arxiv.org/abs/2211.02400> (under review)

- 17,000 scans
- 73 sites
- 3T and 7T



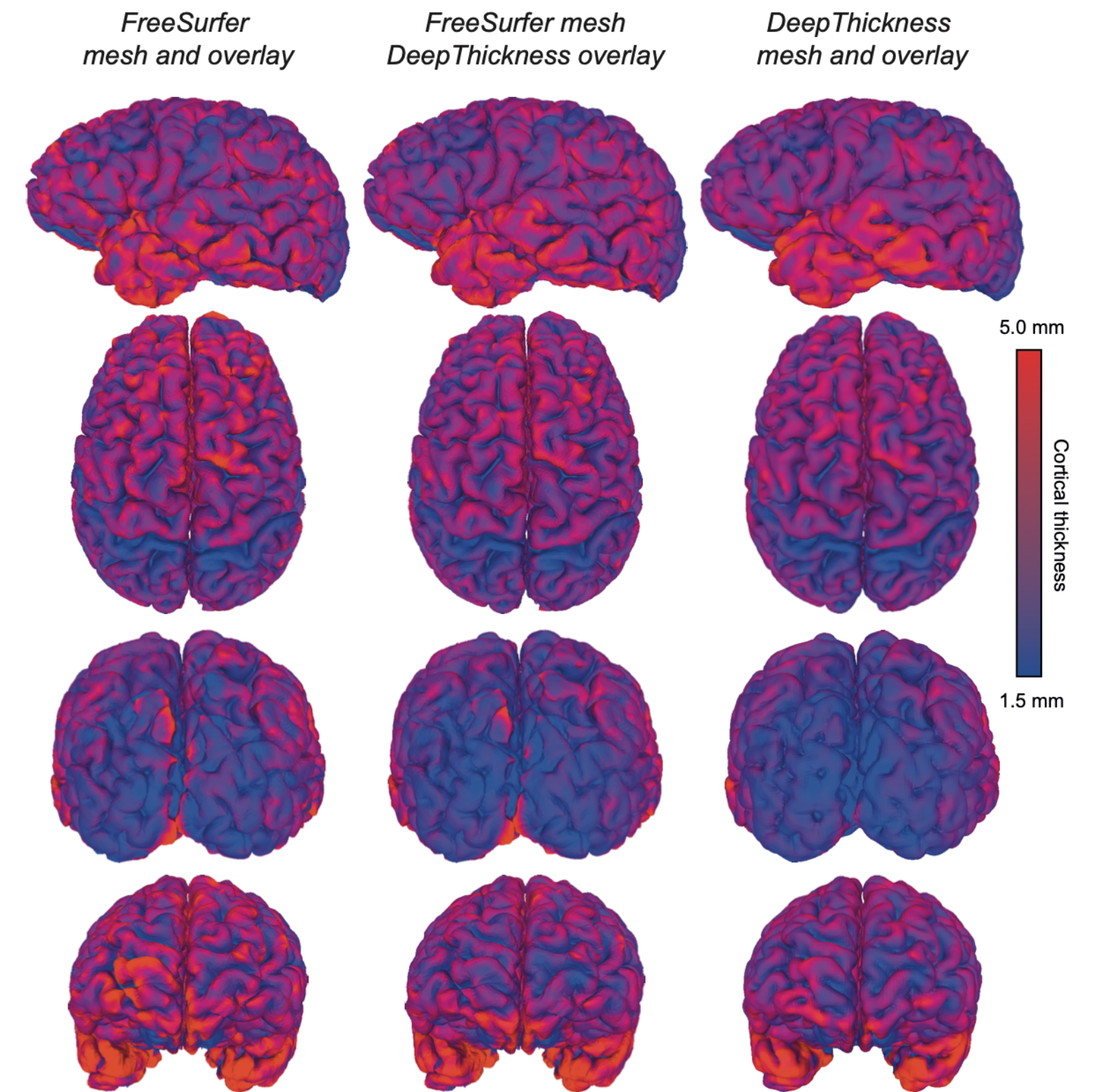
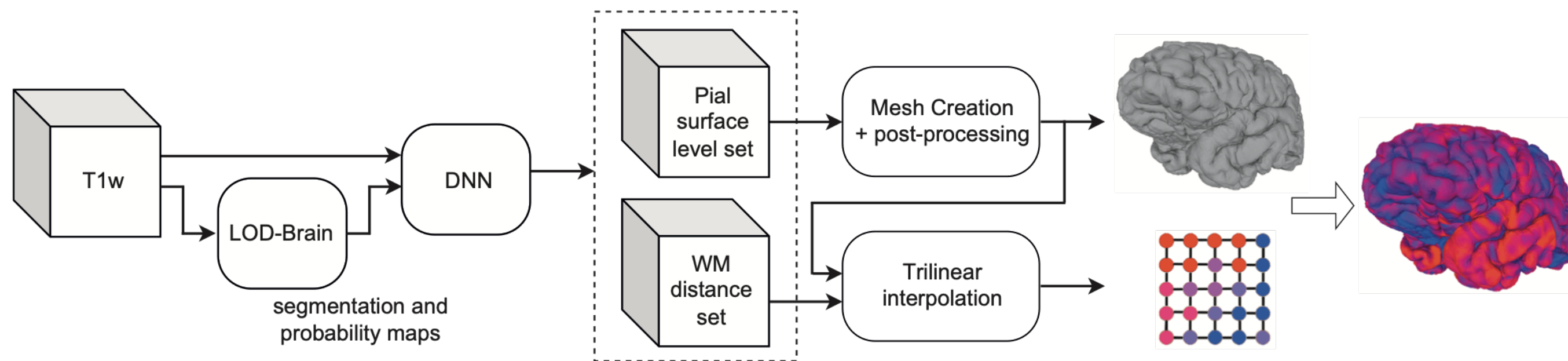
Multi-site brain MRI segmentation

Visual results: internal and external validation data



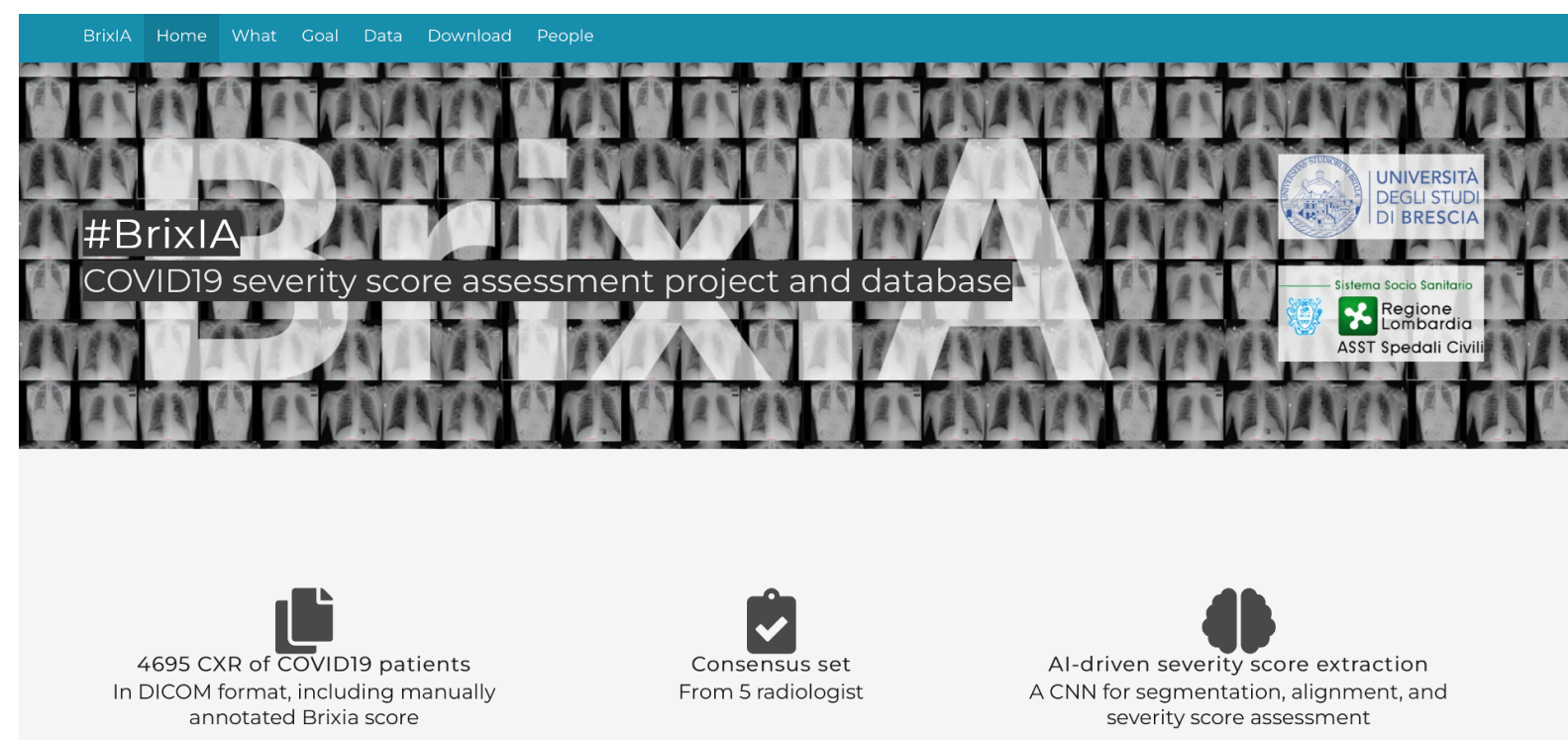
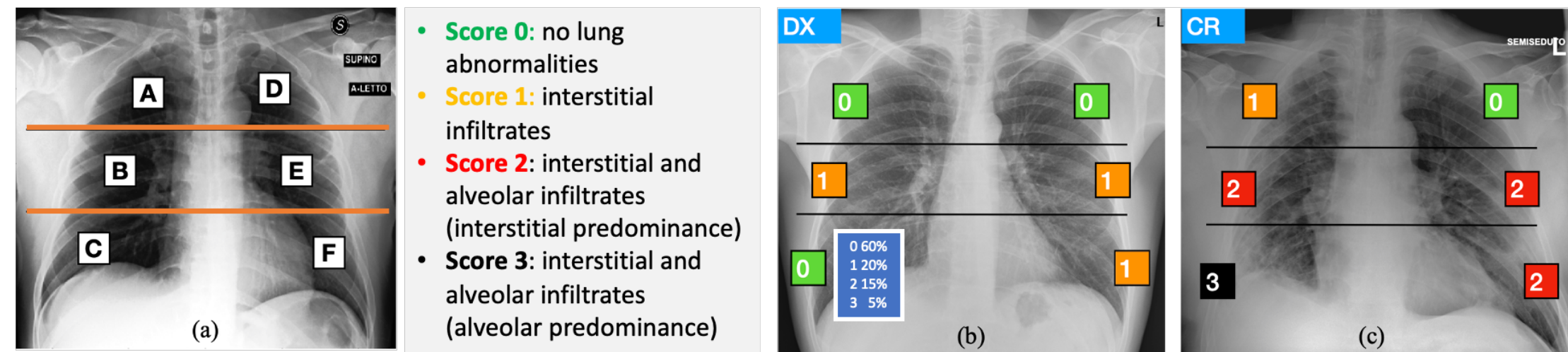
DeepThickness

a method for estimating cortical thickness in Brain MRI



- Cortical thickness across the brain is associated with normal ageing and neurodegenerative conditions
- **DL-based cortical thickness estimation from brain MRI** (in just a few seconds compared to hours with FreeSurfer)
 - The supervised model is trained to predict Level Set and "Distance Set" volumes with weak supervision (FreeSurfer)

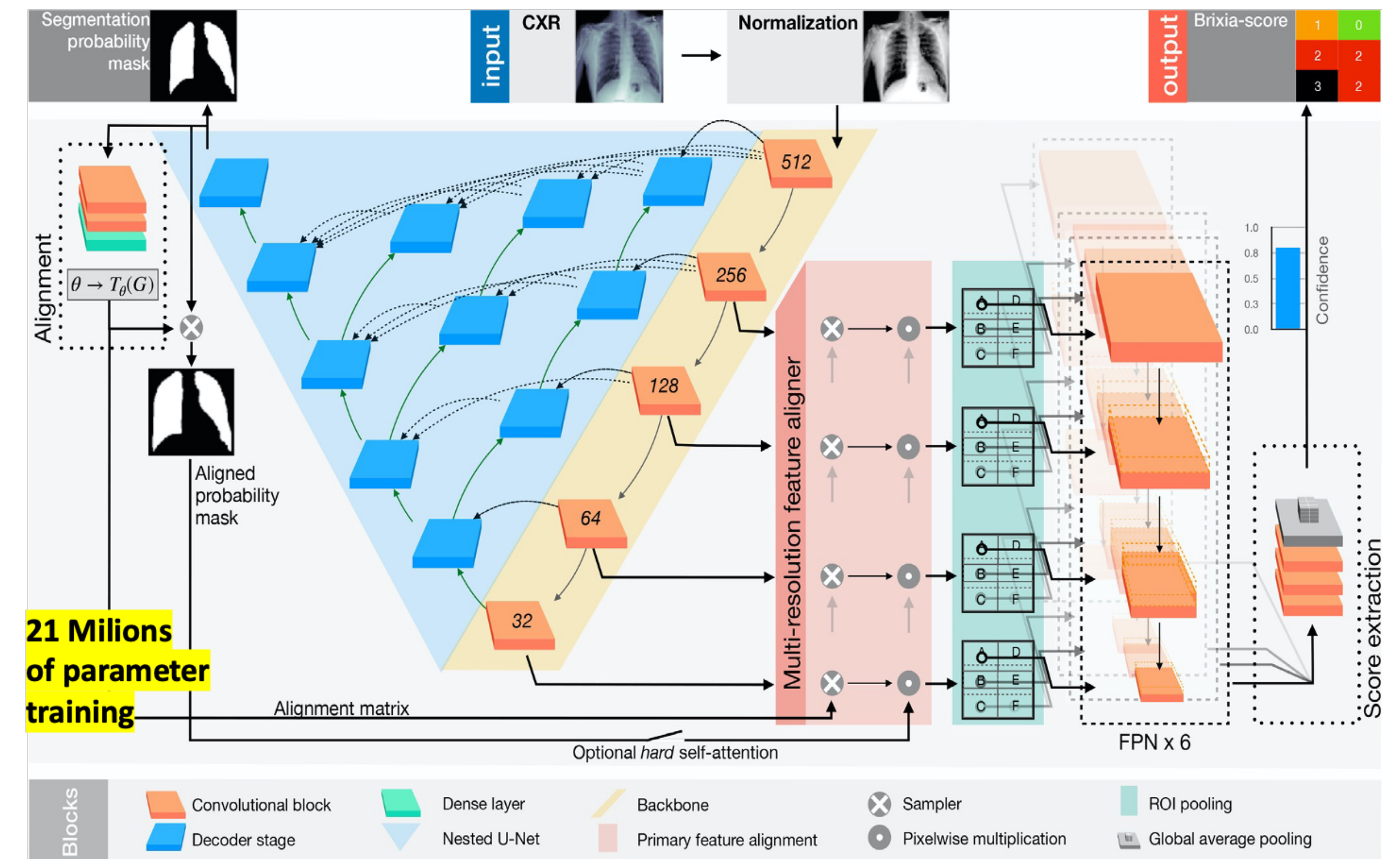
Trustworthy AI for COVID-19 severity estimation and prognosis



«Cognitive» workflow (multi-network)

1. Segmentation
2. Normalization (alignment)
3. Feature extraction (multi-scale, multi-region)
4. Score estimation (6-fold discrete regression)

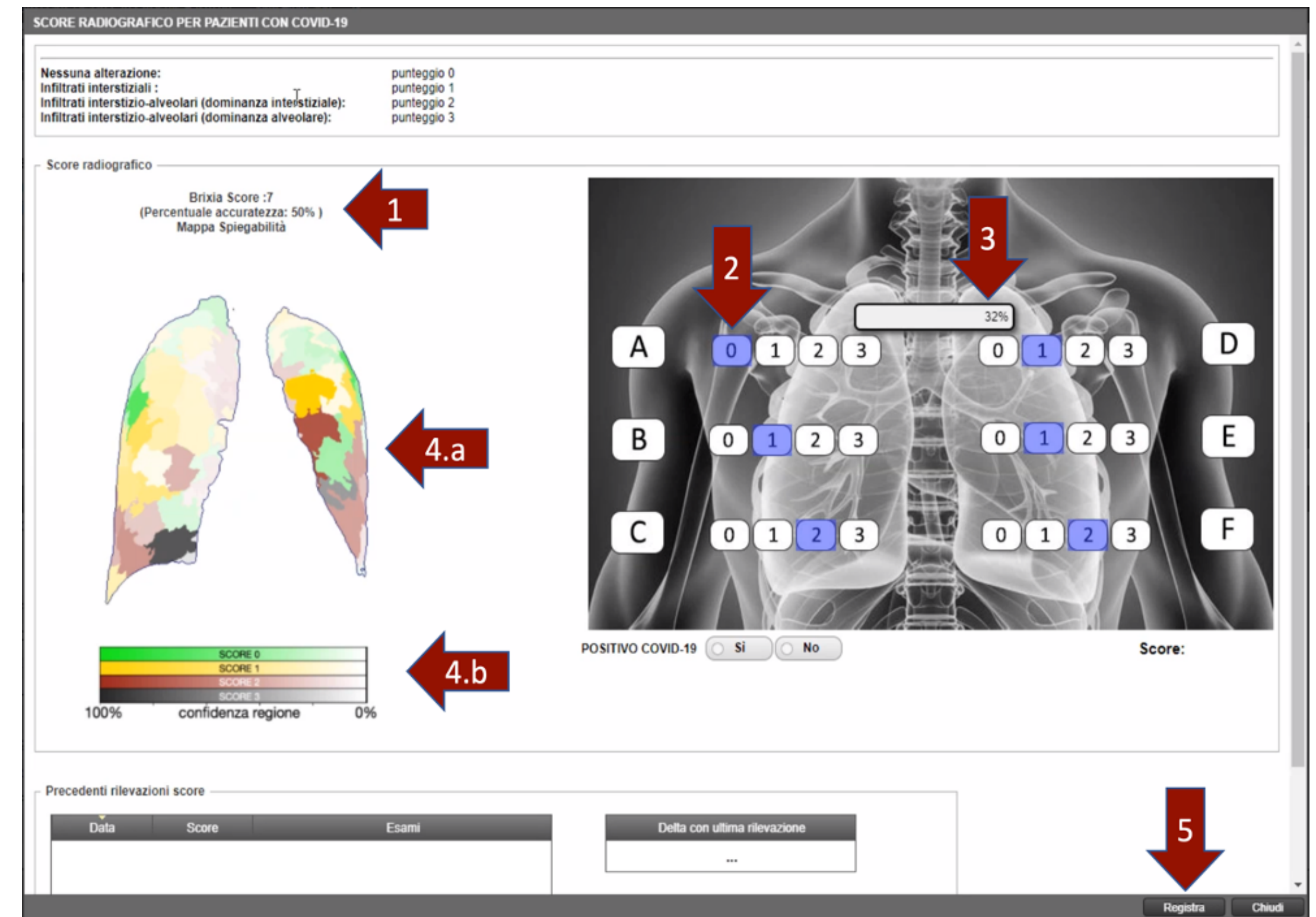
BrixIA-Net



Signoroni, Alberto, et al. "BS-Net: Learning COVID-19 pneumonia severity on a large chest X-ray dataset." *Medical Image Analysis* 71 (2021): 102046.
<https://doi.org/10.1016/j.media.2021.102046>

Trustworthy AI for COVID-19 severity estimation and prognosis

- **Deployment** in the Radiology Units of our Hospital (Spedali Civili di Brescia, counting about 50 radiologists) was made possible by integration made in collaboration with the RIS vendor.
 - Experimental and emergency driven activity
- **User-driven tests:** here is no statistical difference in the quality of human and AI produced scores.
 - Radiologists who consult the AI have a better inter-rater agreement (from moderate to substantial)
 - Can contribute to resident training/supervision
- **Z-inspection audit process**
 - Wide group of ~50 experts in different domains (CV, Clinicians, Radiologists, Law&Ethics), structured activity, high level of exchange
 - Multidisciplinary team > Interdisciplinary activities > Transdisciplinary synthesis



H. Allahabadi et al., "Assessing Trustworthy AI in Times of COVID-19: Deep Learning for Predicting a Multiregional Score Conveying the Degree of Lung Compromise in COVID-19 Patients," in *IEEE Transactions on Technology and Society*, Dec. 2022

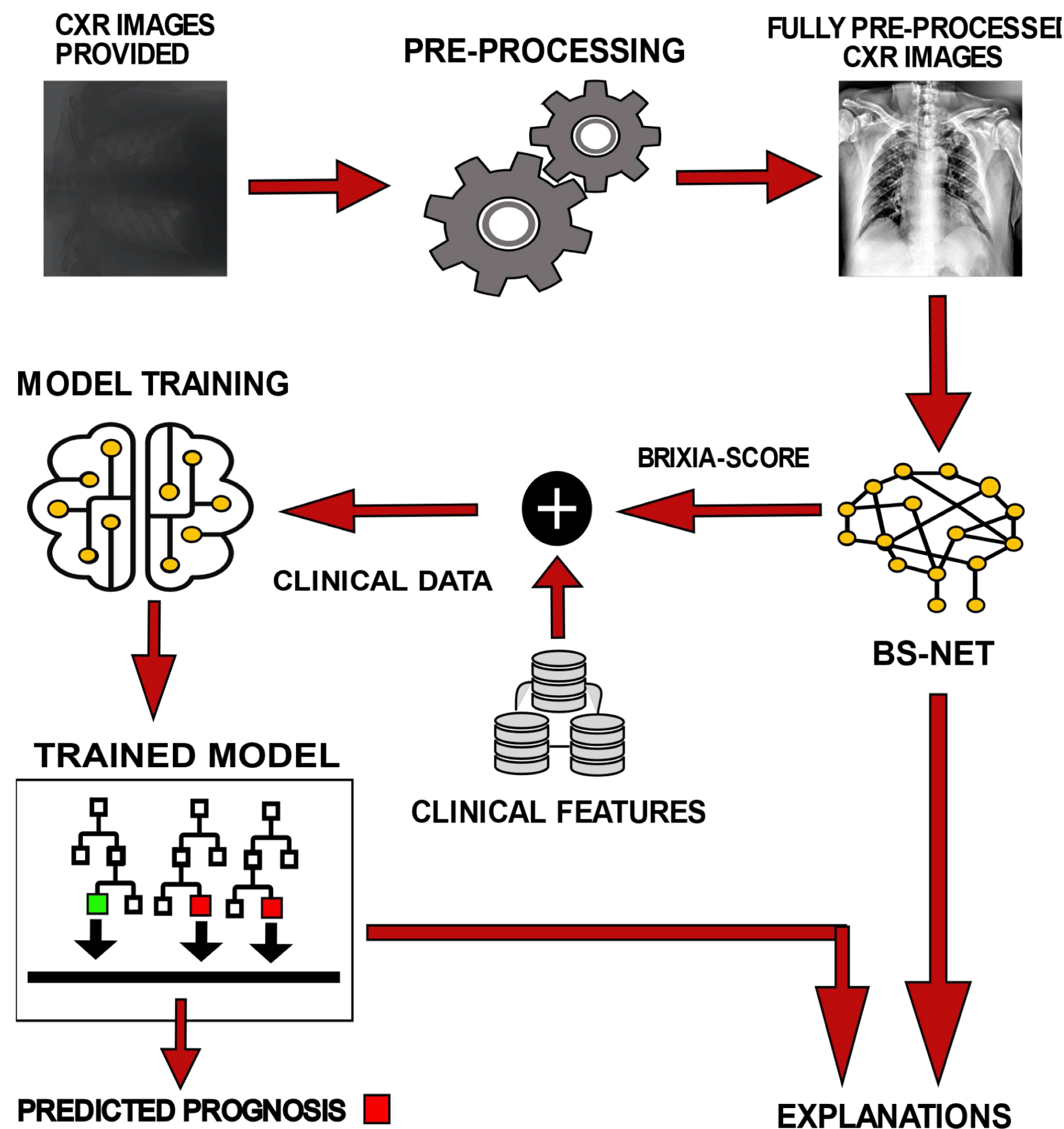
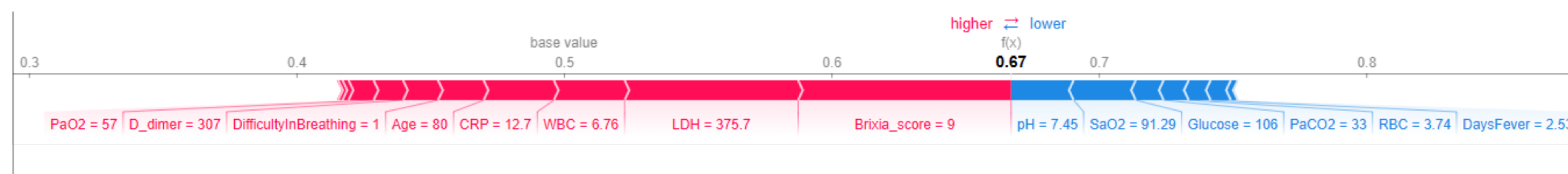
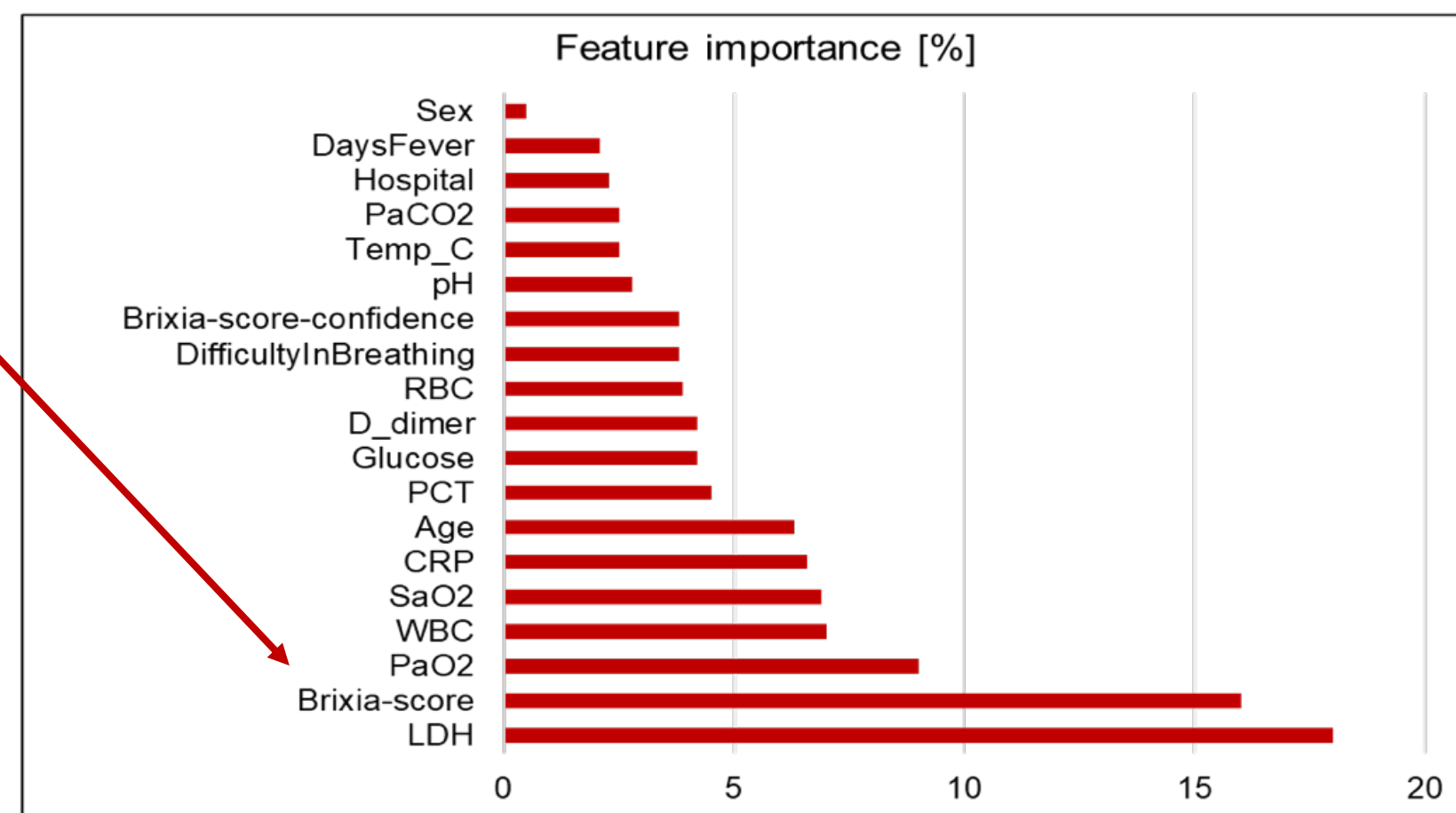
<http://z-inspection.org/best-practice-deep-learning-for-predicting-a-multi-regional-score-conveying-the-degree-of-lung-compromise-in-covid-19-patients/>

Trustworthy AI for COVID-19 severity estimation and prognosis

International COVID-19 prognosis Hackathon

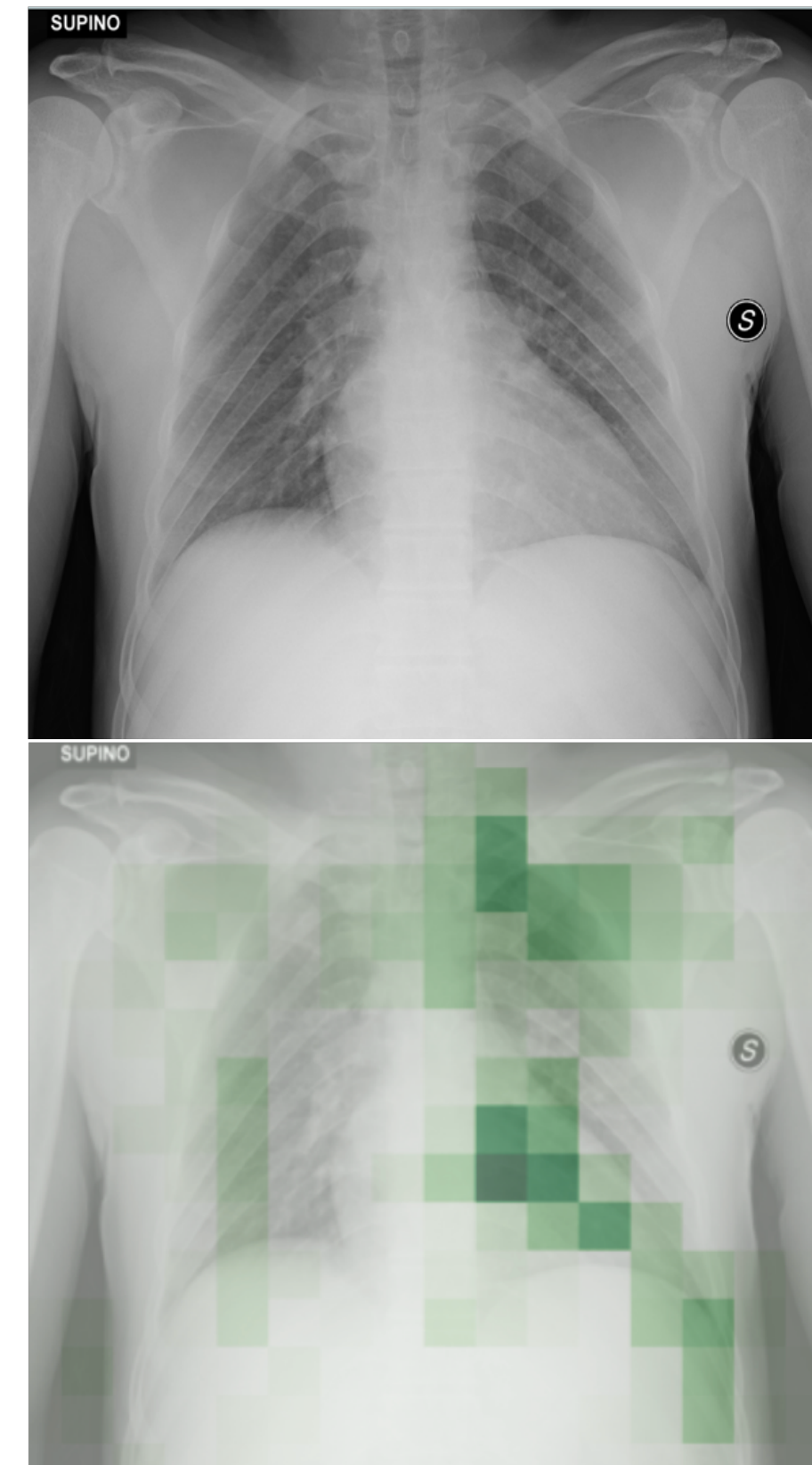
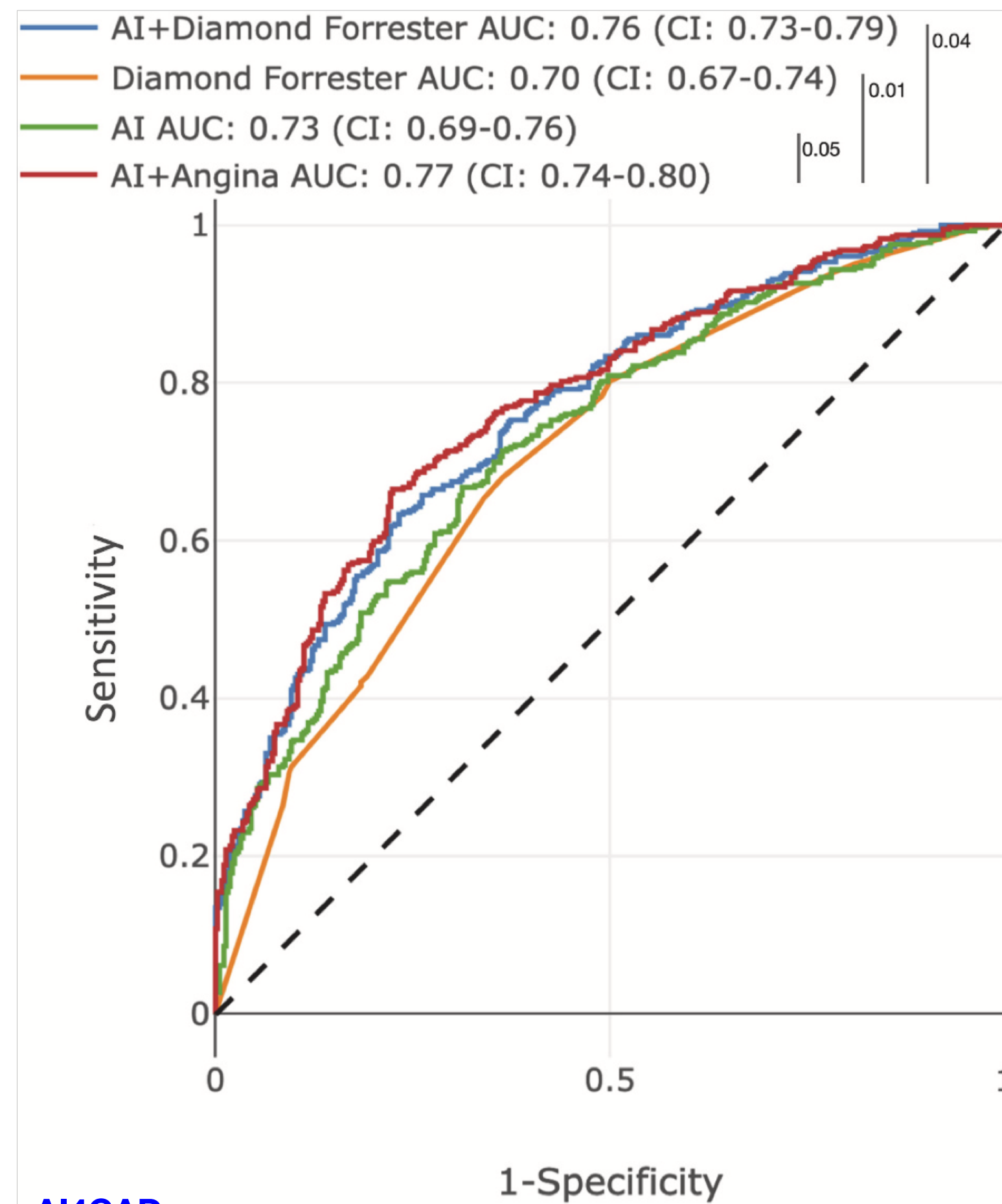
<https://ai4covid-hackathon.ing.unimore.it>

- Large dataset (~1500 CXR + 38 clinical parameters) from many Italian hospitals (AIforCOVID)
- With estimated Brixia score and BrixIA-Net we won the explainability competition
- High prognostic value of estimated BrixIA-score
- BrixIA-Net was also used by the team that won the accuracy competition



AI to predict cardiovascular risk factors from Chest X-rays

- Coronary Artery Disease (CAD) is the single leading cause of mortality worldwide
- The goal is to develop DL algorithms for **detecting the presence of CAD**
 - Dataset composed of ~10000 patients with CXR and Angiography (GT)
 - CNN can be used to identify CAD imaging biomarkers (risk factors)
 - **AI + patient symptoms produces results above all commonly used risk factors**

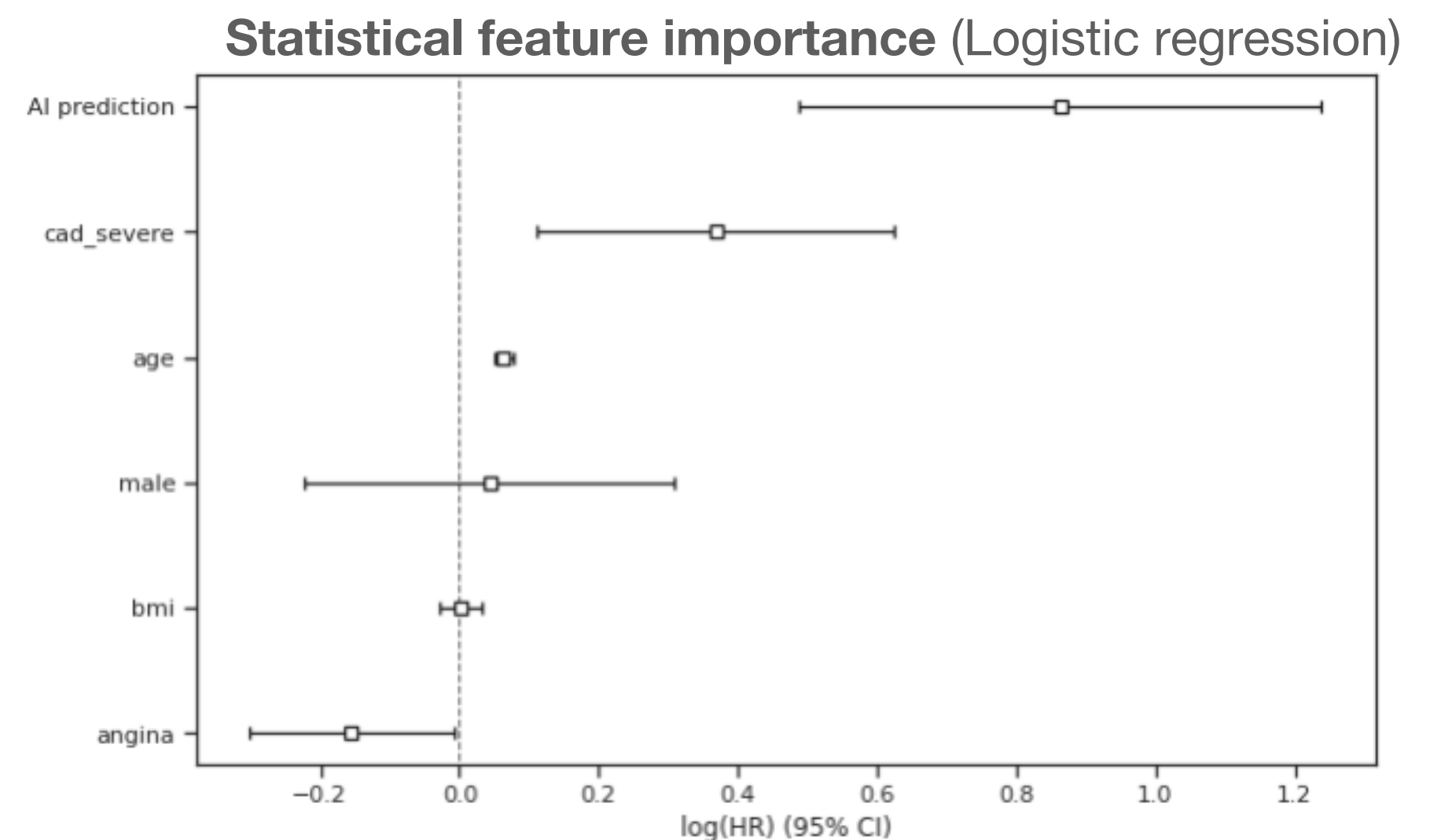
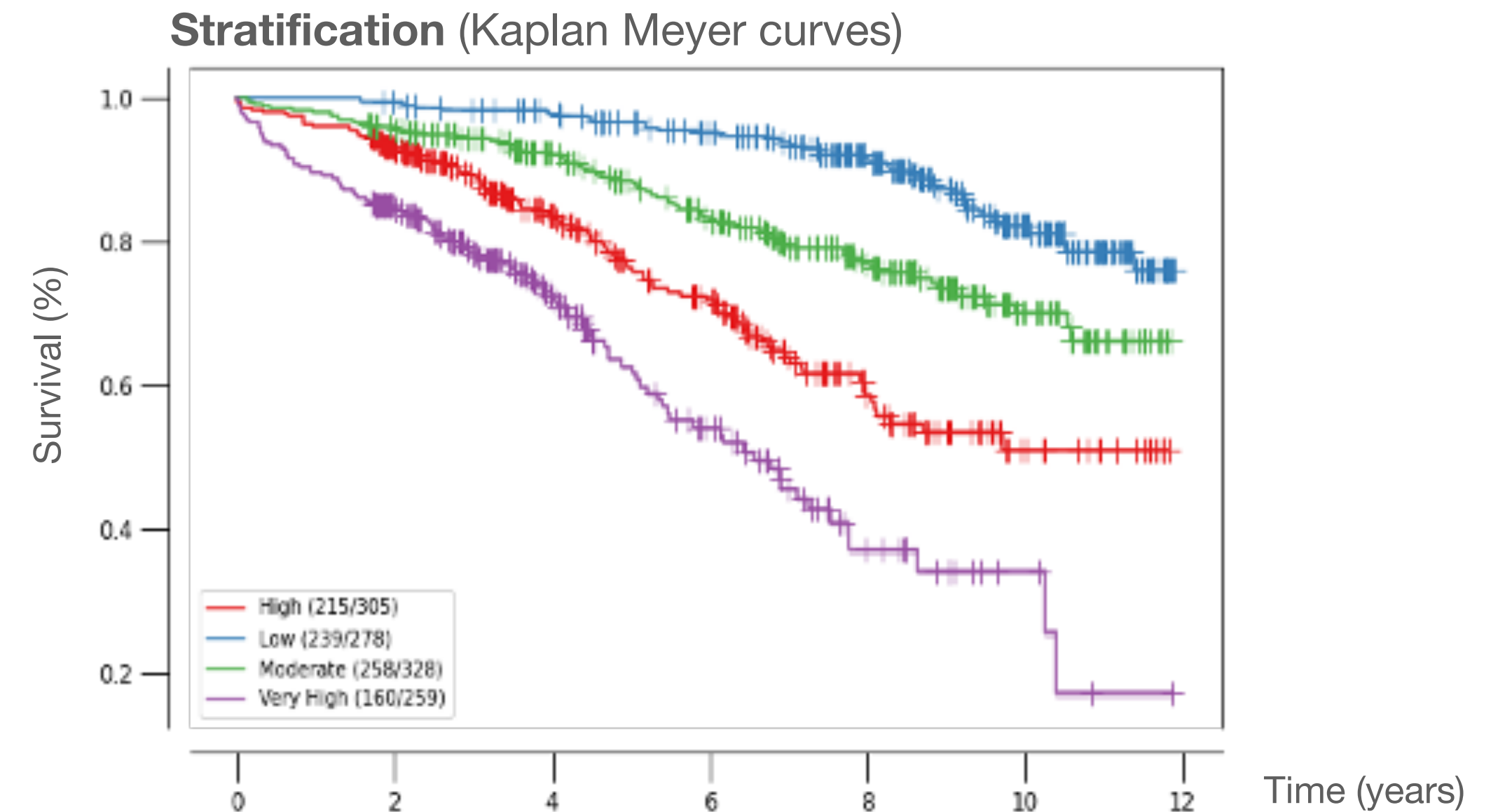
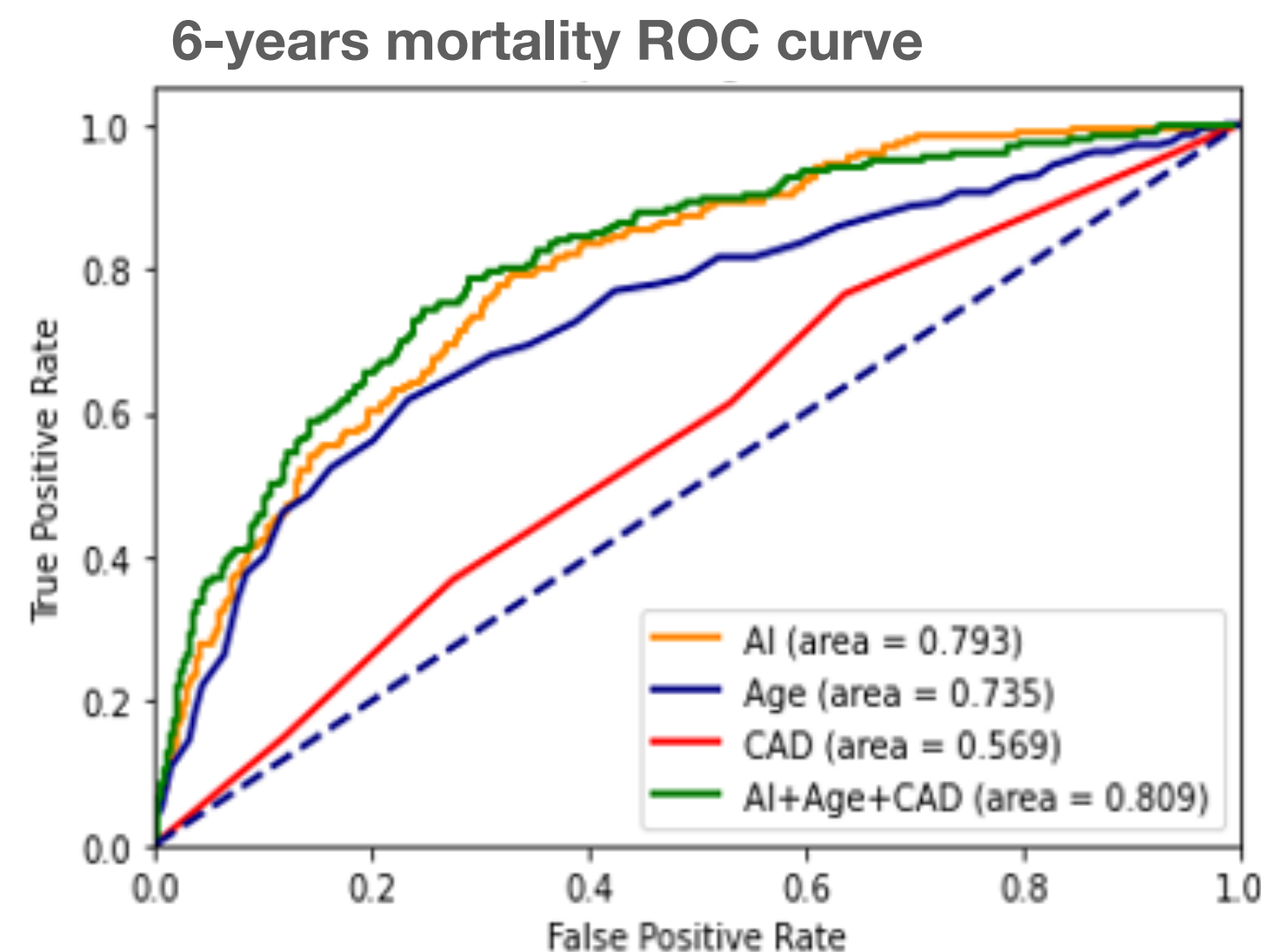


Artificial Intelligence to Predict Long-Term Mortality from CXRs of Patients Referred for Suspected Angina

Goal: predict long-term mortality from a single projection CXR (training on 3 and 6 years survival) of patients referred for angina and coronary angiography.

- External validation was performed on patients referred to a medical Institution in north-western Europe
- The DCNN predicted CXR-risk score can stratify long-term mortality risk better than any other risk factor.**

Giuseppe D'Ancona, Mattia Savardi, Mauro Massussi; Viktor van der Valk, Alberto Signoroni, Davide Farina, Hueseyin Ince, Stefano Benussi, Salvatore Currello, Fatih Arslan, "Artificial Intelligence to Predict Long-Term Mortality from Plain Chest Radiographs of Patients Referred for Suspected Angina", *Europa Society of Cardiology, ESC Congress 2023*



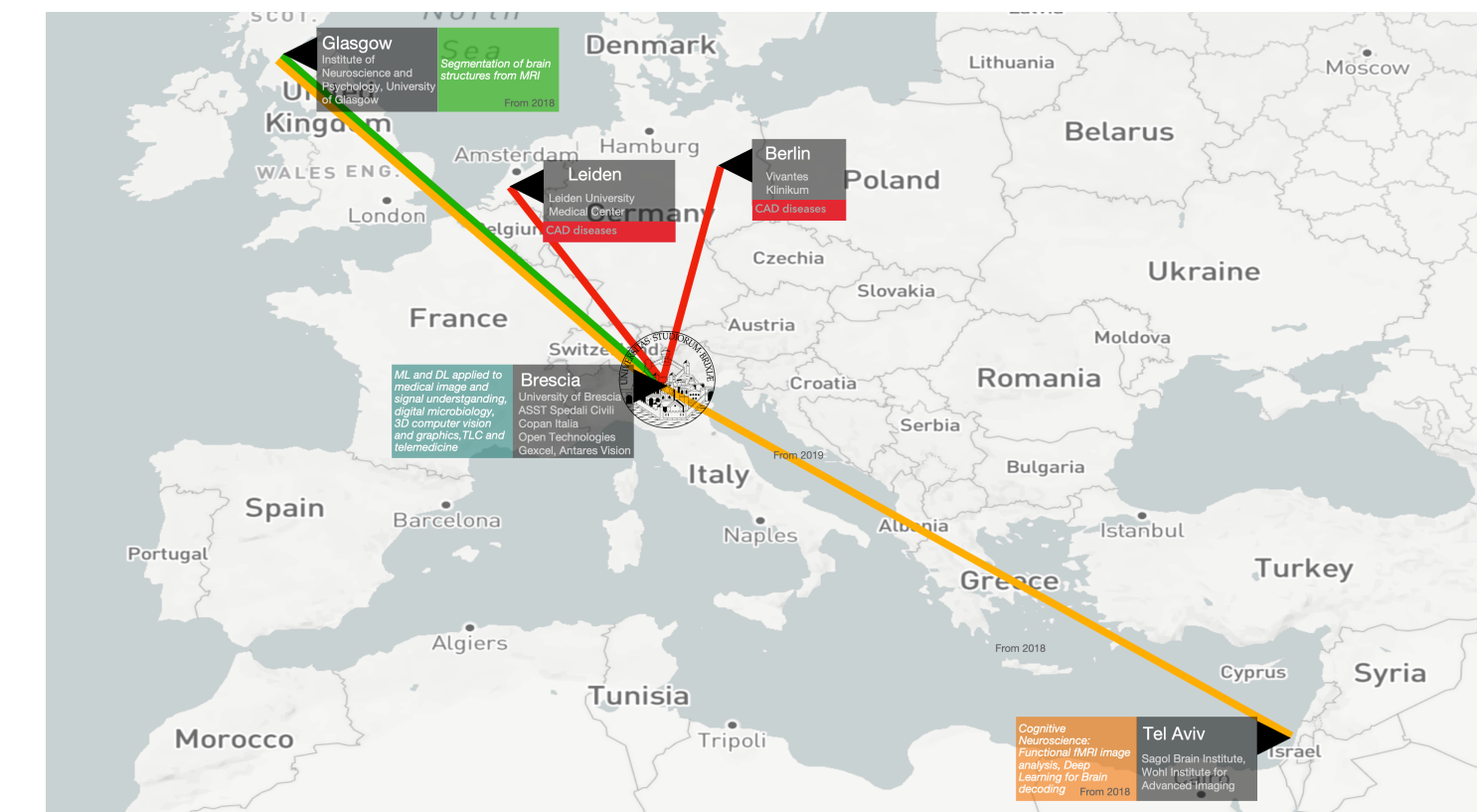
Thank you

... for being here and for interactions we will have in these days :-)

Group info

- Projects
 - FISR 2020: ResponsiX
 - PRIN 2022: QT-Seed
- 3 PhD students (3 different backgrounds)
- Company links
 - Copan WASP
 - El.Co.
 - Yonder

• Collaborations



• Facilities

- NVIDIA DGX (8 x A100 GPU 80GB)
- DELL Powerscale – 270TB DATA Lake
- DELL Server (2 x NVIDIA A100 80GB)

- Group Website [http comig.soon.;](http://.....comig.soon.;)-)