

Subtle White Matter Lesion Detection in Traumatic Brain Injury Using *TractSpLearn*

Jiqing Huang¹, Yi Chen^{2,3}, Laurent Lamalle¹, Ali Al-Husseini⁴, Anna Gard⁴, Niklas Marklund⁴, Markus Nilsson⁵, Mohamed Ali Bahri¹, Christophe Phillips^{1†}, Evgenios N. Kornaropoulos^{1,5,6*†}

¹GIGA-CRC Human Imaging, University of Liège, Liège, Belgium, ²AMIIC-Lab, College of Computer Science and Technology, Guizhou University, ³The D-Lab, Department of Precision Medicine, Maastricht University, ⁴Department of Clinical Sciences Lund, Neurosurgery, Lund university, Skane University Hospital, Sweden, ⁵Department of Clinical Sciences Lund, Diagnostic Radiology, Medical Faculty, Lund University, Sweden, ⁶Aix-Marseille Univ, CNRS, CRMBM, Marseille, France

c.phillips@uliege.be

jiqing.huang@uliege.be

ekornaropoulos@uliege.be

Marbel 2026

Poster #22

Oral #10

Introduction



Traumatic brain injury (TBI) is brain damage resulting from an external mechanical force. Patients may experience persistent cognitive, emotional, sensory, and motor deficits; which can lead to long-term disability in severe cases.

Objective: To develop a tract-wise manifold-learning framework for personalized lesion detection that:

- 1) leverages 7T DKI to capture subtle microstructural changes;
- 2) jointly models between-group differences (HC vs. TBI) and within-group variability.

Methods

Data & Cohort:

- **Participants:** 20 healthy controls (HC), 20 athletes with repeated head injuries (RHI), 16 former athletes with persistent post-concussive syndromes (PPCS)
- **MRI acquisition:** 7T Philips Achieva, 3D T1 MPRAGE (TR = 8ms, TE = 1.97ms); DWI: FOV 224×224×110 mm³, TR = 9200 ms, TE = 65 ms (b = 0, 100, 500 1000, 2000 s/mm²).

Data processing:

- **Preprocessing**^[1]: Marchenko–Pastur PCA denoising; non-iterative Gibbs-ringing correction; TOPUP susceptibility-distortion correction; and eddy-current and motion correction.
- **DKI parameters estimation:** DKI parameters (FA, MD, AD, RD, MK, AK, RK) were estimated by linear least-squares fit in DIPY (*DiffusionKurtosisModel*)
- **TractSpLearn:**
 - 1) Tract segmentation^[2]: White matter tracts segmented using TractSeg in subject space;
 - 2) Features extraction: Manifold learning via UMAP to obtain low-dimensional embeddings in latent space.
 - 3) Two-step projection and back-projection
 - 4) Z-score based abnormality detection

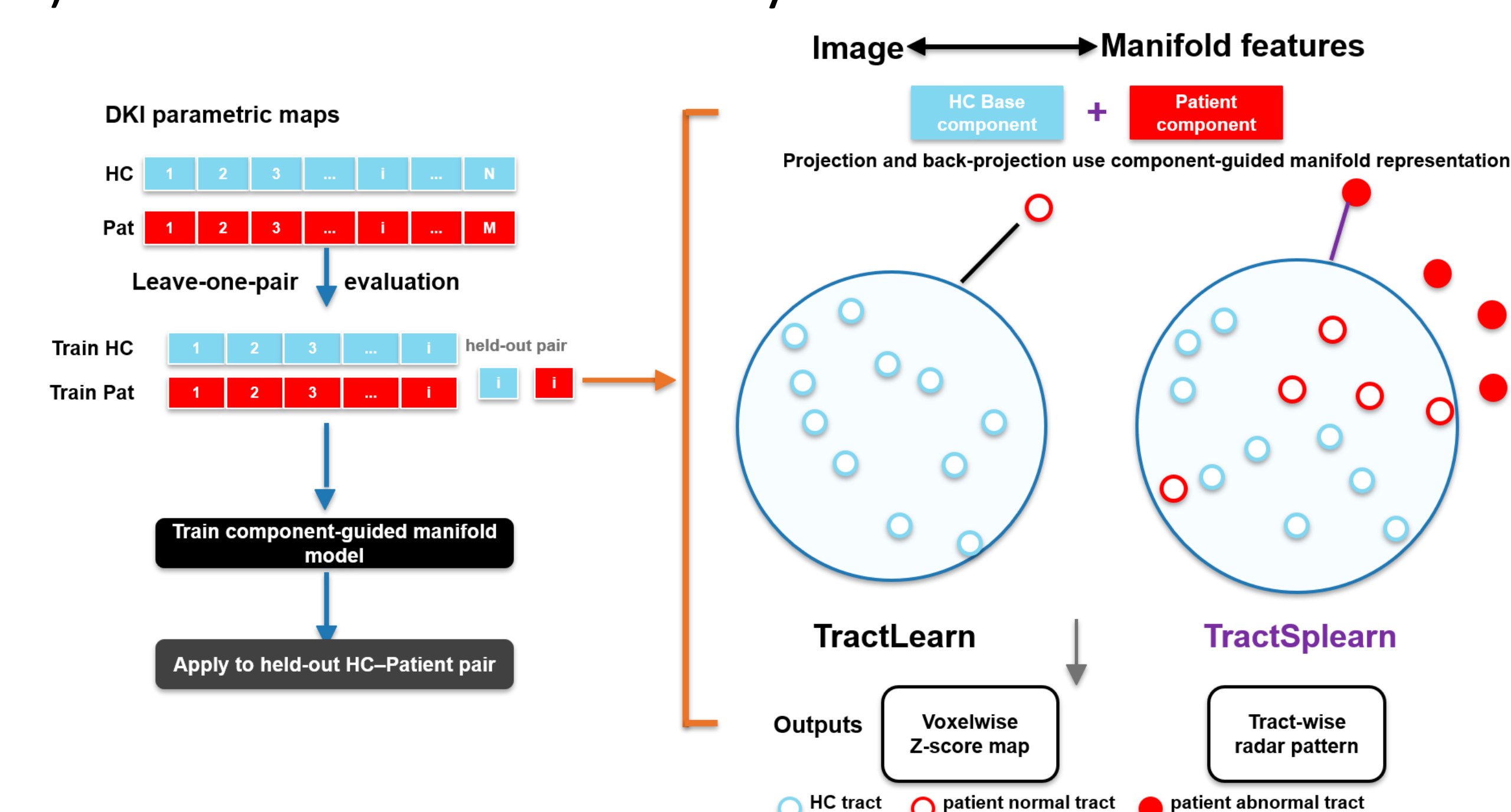
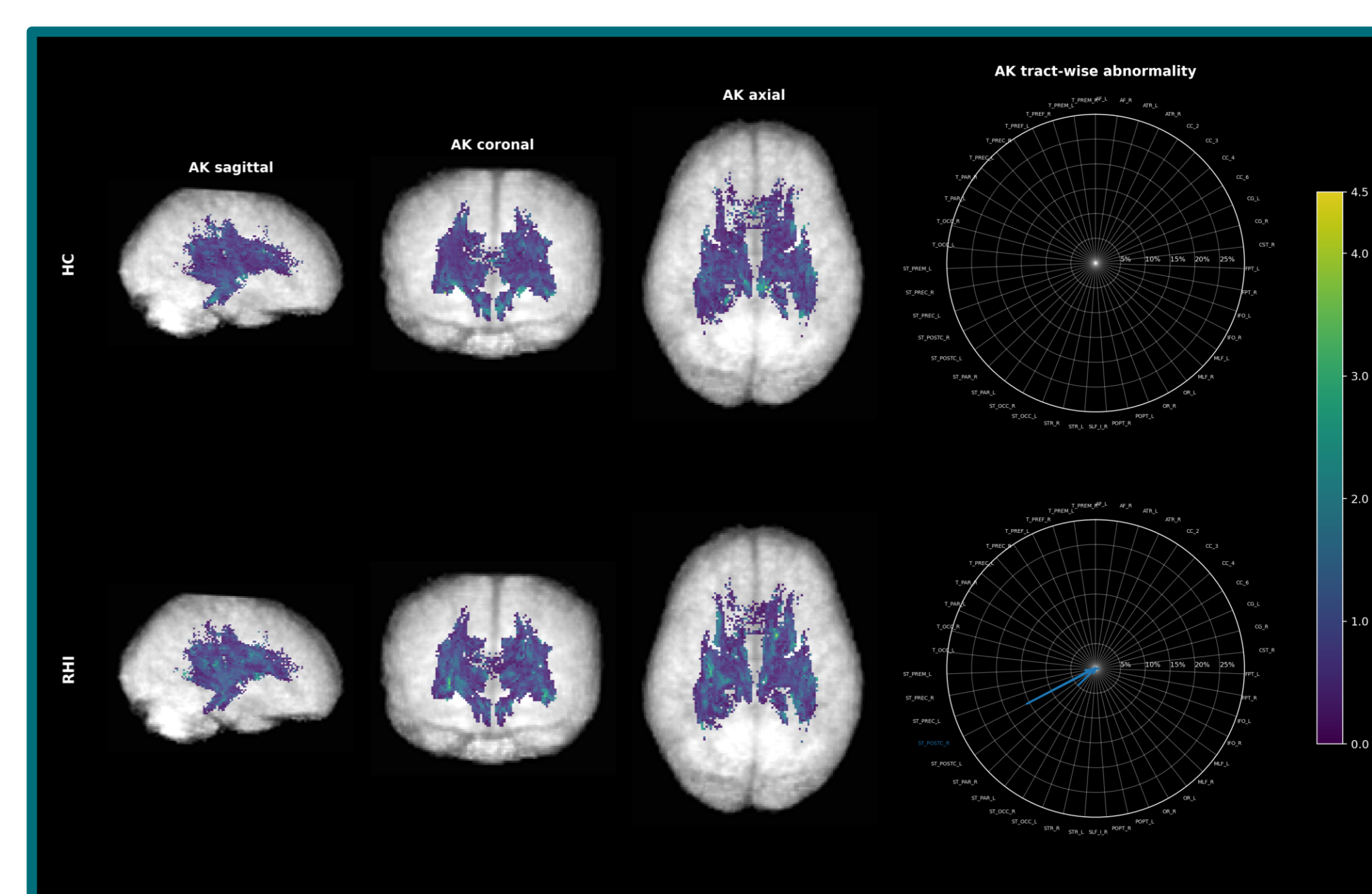


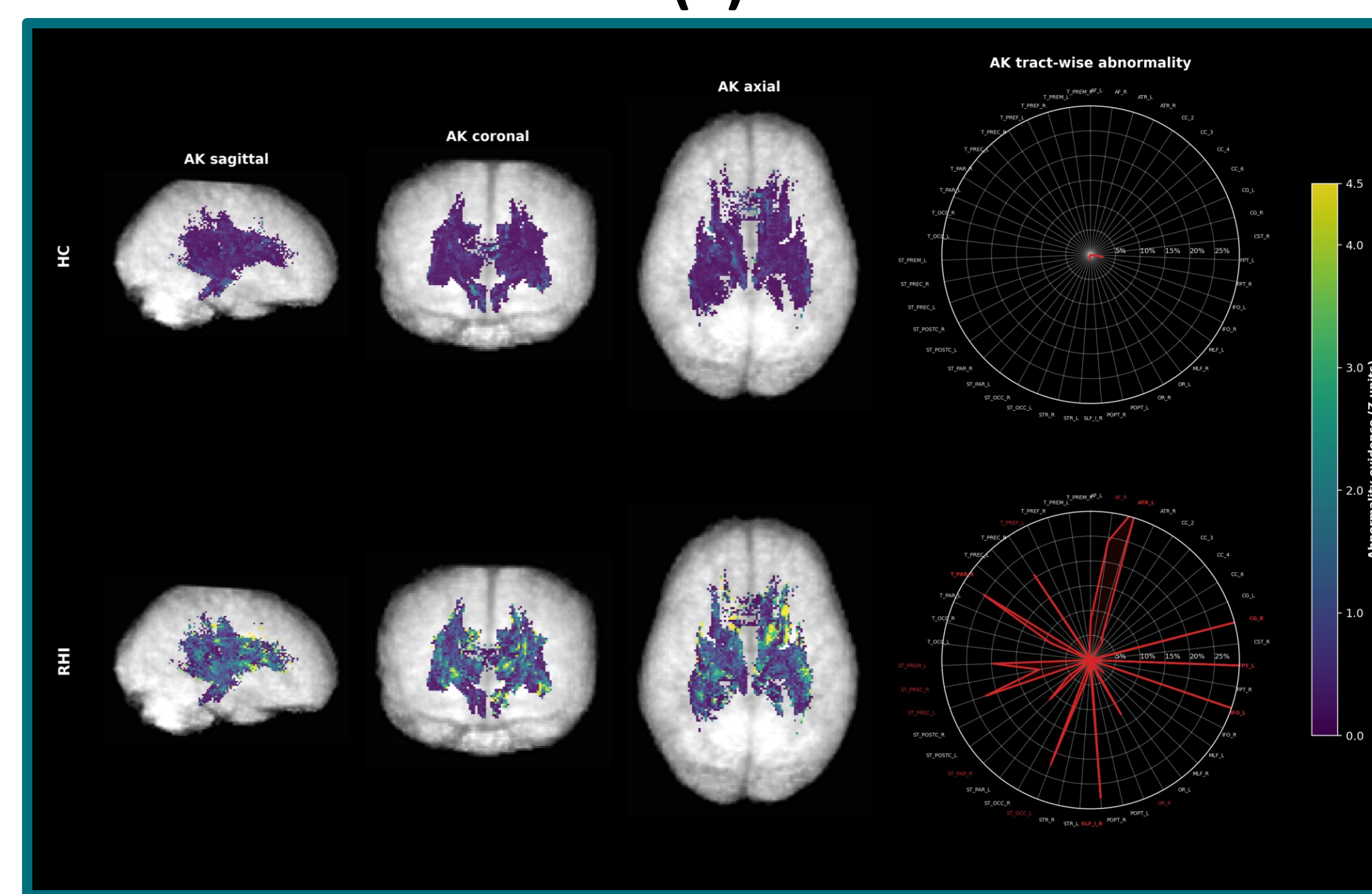
Fig. 1 Overview and key differences between *TractLearn* and *TractSpLearn*

Results

Patients showed stronger abnormality evidence than HC, with clearer group separation in RHI than in PPCS. In RHI, *TractSpLearn* showed significant HC–patient differences across all seven diffusion parameters, compared with four using *TractLearn*. Fig. 2 presents AK abnormality maps and tract-wise profiles for a representative HC and RHI athlete. Compared with TractLearn, TractSpLearn showed lower abnormality evidence in the HC and broader tract involvement in the RHI athlete.



(a)



(b)

Fig. 2. AK abnormality maps and tract-wise profiles for a representative HC and RHI athlete using (a) *TractLearn* and (b) *TractSpLearn*. Upper row: HC; lower row: RHI.

Discussion & Conclusion

Principal findings:

Our primary results suggest that *TractSpLearn* can provide individualized maps of subtle white-matter abnormalities in sports-related TBI and clearer patient–control differentiation compared with the original *TractLearn*.

Limitation:

- Small cohorts, particularly PPCS.
- No independent lesion-level ground truth.
- Diffusion parameters were modeled independently.

Future works:

- Validate *TractSpLearn* in larger independent cohorts.
- Link *TractSpLearn* findings to clinical outcomes

References: [1] Anna Gard, et al., J Neurotrauma, 2024; [2] Jakob Wasserthal, et al., NeuroImage, 2018; [3] Arnaud Attyé, et al., NeuroImage, 2021

