

# White Matter Multi-Resolution Segmentation Using Fuzzy Set Theory

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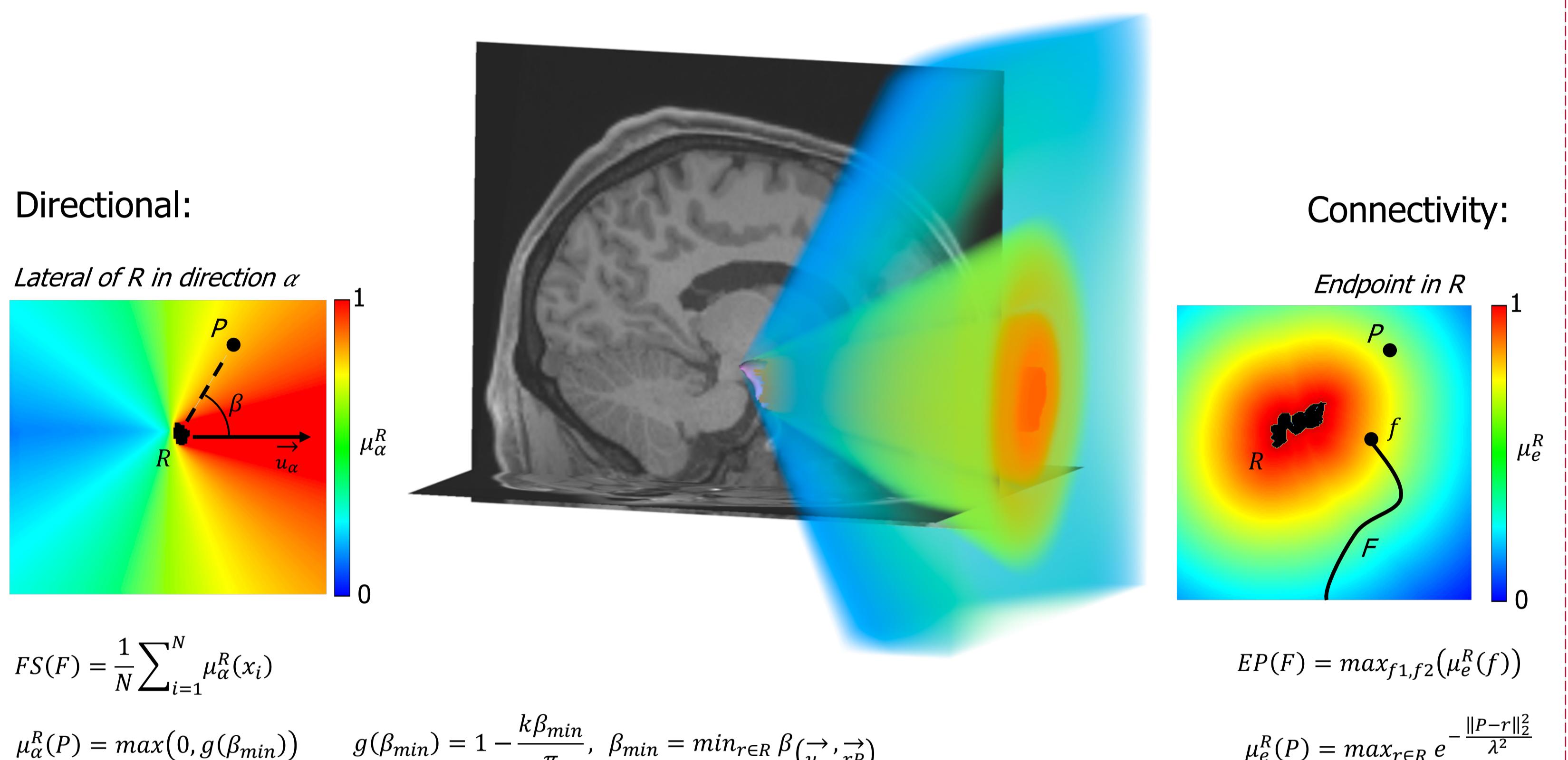
## INTRODUCTION / OBJECTIVE

White matter fiber bundles are often described using qualitative spatial relationships (e.g. anterior of Amygdala) [1]. We propose to model their inherent vagueness using the theory of fuzzy sets [2]. Furthermore, to cope with the high redundancy of tractograms and ease interpretation, we introduce an interactive navigation and exploration technique based on a multi-resolution representation.

## SPATIAL RELATIONS MODELING

Bundles are defined as logic combinations of spatial (*anterior of*, ...), connectivity (*endpoint in*, ...) and trajectory (*crossing*, ...) relations.

Membership functions  $\mu$ , describing the satisfaction degree to the relations, are evaluated for every point  $P$  in the image space. Spatial (*FS*) and connectivity (*EP*) fuzzy scores are computed for each fiber  $F$  (composed by  $N$  points and with endpoints  $f_1$  and  $f_2$ ).



In case of multiple relations, membership functions are combined in a conjunctive way. Finally, a single anatomical coherence score (*ACS*) [3] is assigned to each fiber.

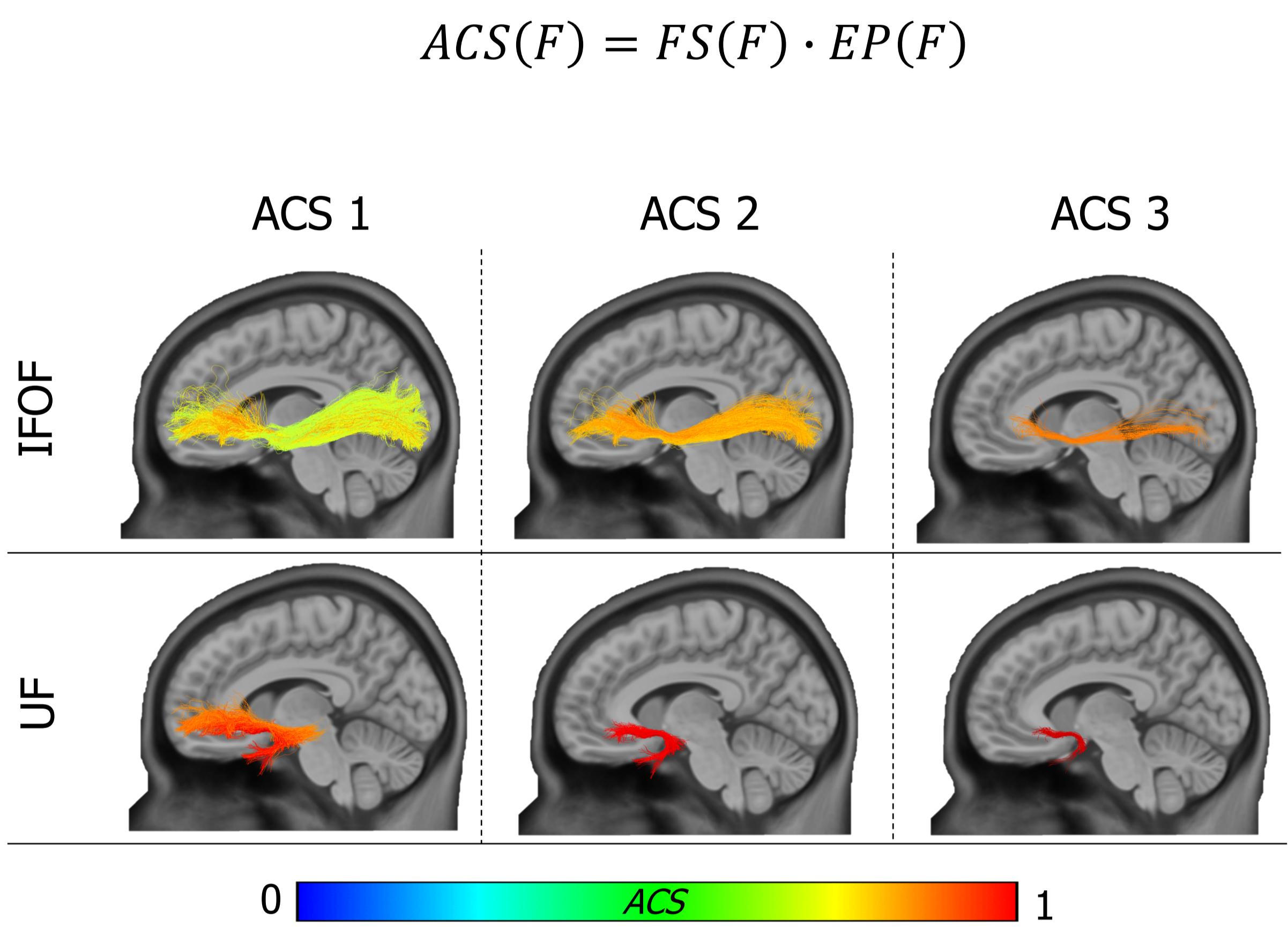


Fig. 1: Fibers of interest can be selected via an ACS based thresholding operation.

## MULTI-RESOLUTION REPRESENTATION

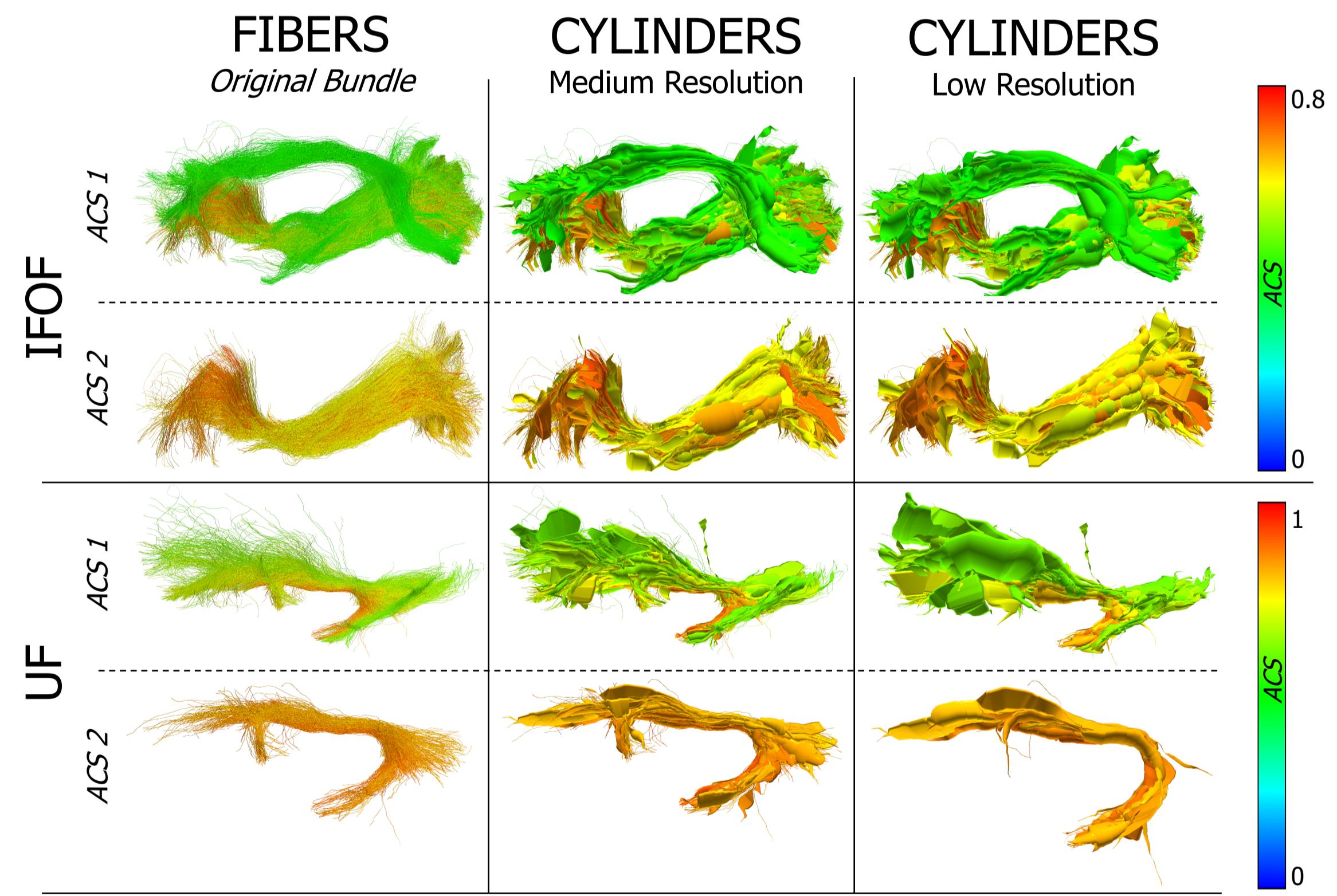
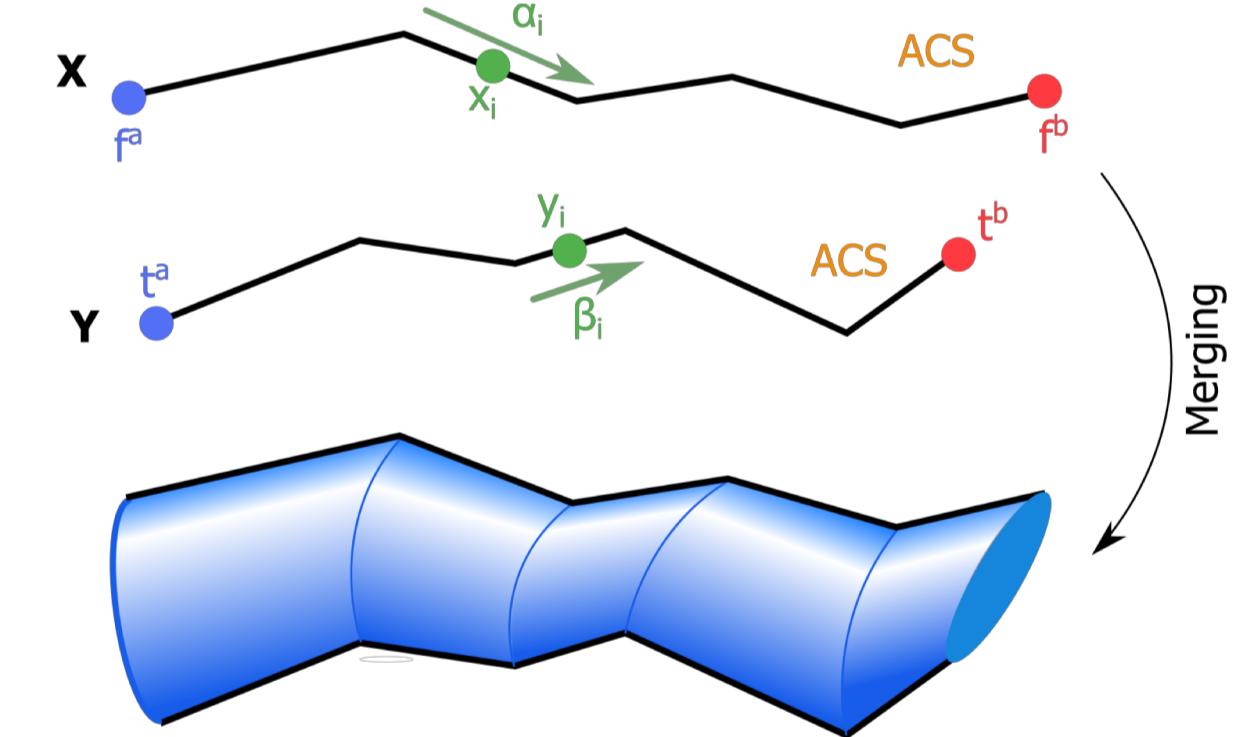


Fig. 2: Multi-resolution fiber bundles visualization

White matter multi-resolution [4] technique progressively merges fibers together in generalized cylinders.

- Real-time multi-resolution navigation
- Interactive ACS thresholding for segmentation



Fibers are selected using an extension of the Weighted Currents [5] similarity, containing an ACS term.

$$WC_{ext} = K_c(|ACS_x - ACS_y|) K_a(\|f_a - t_{all}\|_2) K_b(\|f_b - t_b\|_2) \left[ \sum_{i=1}^{N-1} \sum_{j=1}^{M-1} \alpha_i^T K_g(\|x_i - y_j\|_2) \beta_j \right]$$

with  $K_c(|A - B|) = 1 - |A - B|$ , and  $K_a$ ,  $K_b$ ,  $K_g$  being Gaussian kernels.

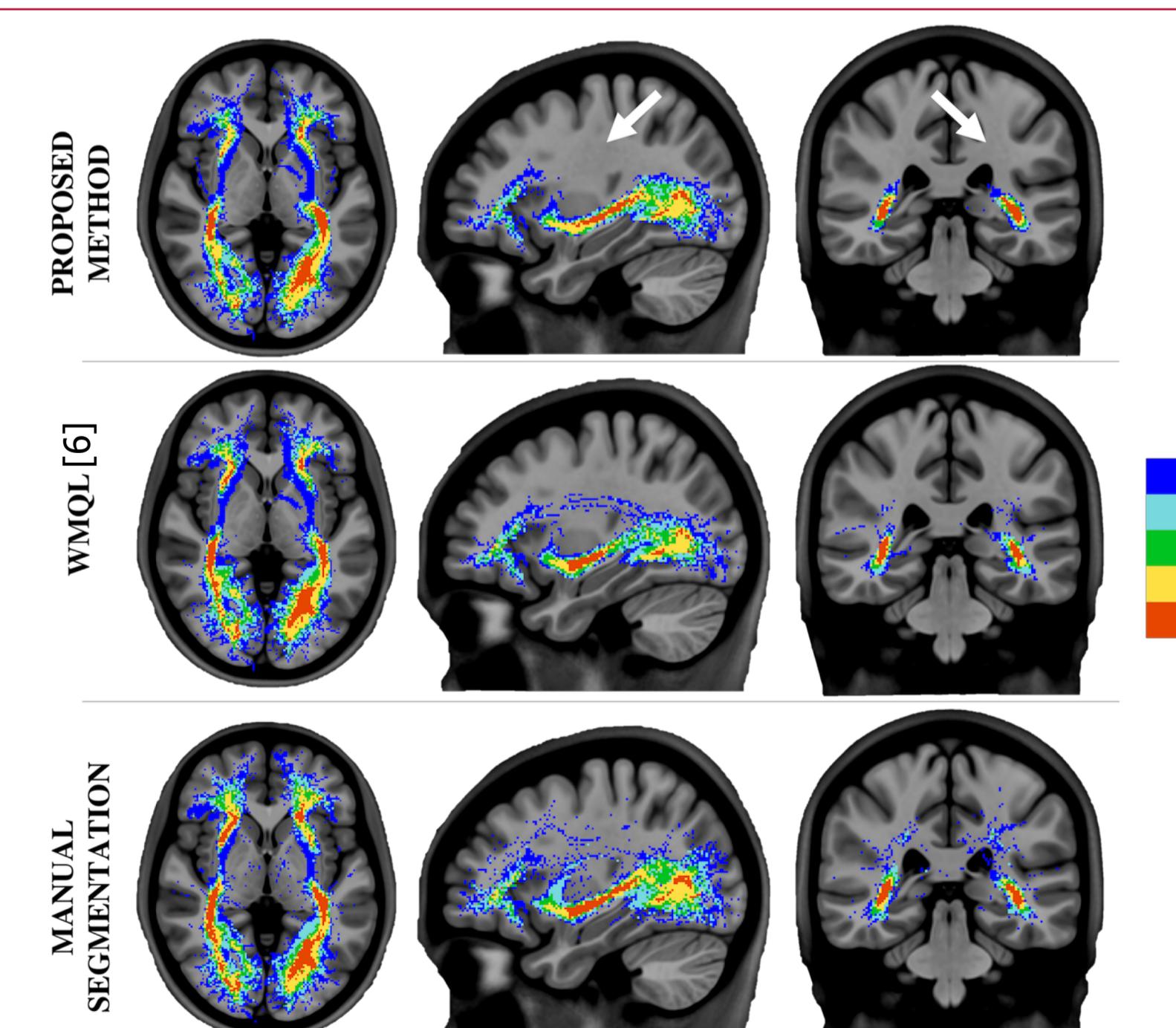


Fig. 3: Tracts dispersion map

