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# The role of onset location and edge resection in epileptic seizure propagation in mice brain: a computational study

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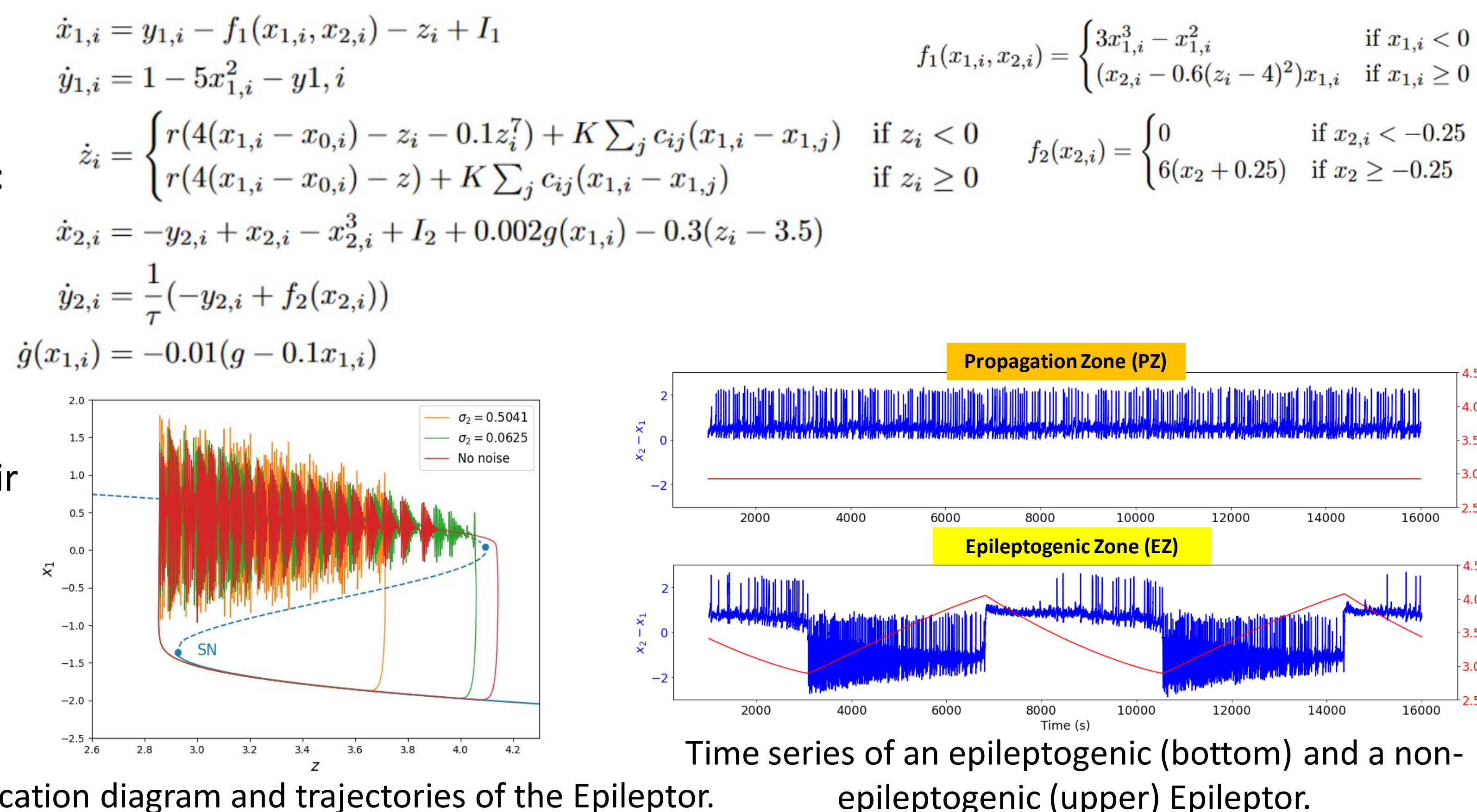
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## Introduction

Recent results on seizures' propagation employing dynamical models [1] have reproduced the recruitment order of brain areas in a mouse brain network [2,3]. However, the exact mechanisms of the onset and propagation of a seizure are still not fully understood. We investigate how the location and connectivity of the Epileptogenic Zone affects the spatio-temporal propagation of the seizure in mice brain. Our goal is to identify the underlying properties of critical edges that prevent seizure propagation when being resected.

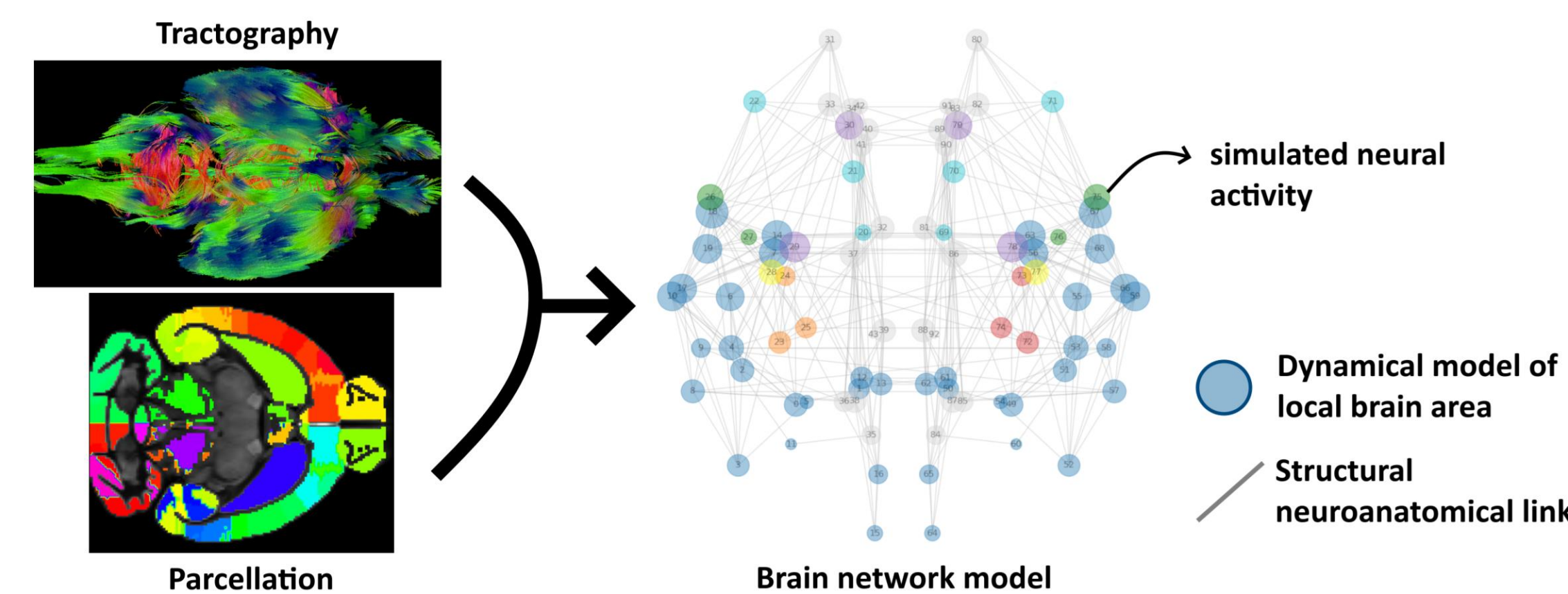
## The Epileptor model [1]

- Phenomenological model reproducing the main features of **epileptic seizures**: **slow spiking** ( $x_1, y_1$ ) [4] and **fast discharges** ( $x_2, y_2$ ) [5]
- Slow permittivity  $z$  acts as a control parameter. **Epileptogenicity**  $x_0$  determines the system's ability to produce spontaneous seizures and their intensity.
- Seizure onset via Saddle-Node bifurcation, offset via Homoclinic bifurcation.
- $x_2-x_1$  mimics the surface tension.



## Seizure propagation in a large brain network

- Network of Epileptors coupled via mouse brain structural connectivity [6], using The Virtual Brain framework
- Definition of an **Epileptogenic Zone** [7] (EZ) and a **Propagation Zone** (PZ). EZ's activity triggers **seizure propagation** in PZ



## References

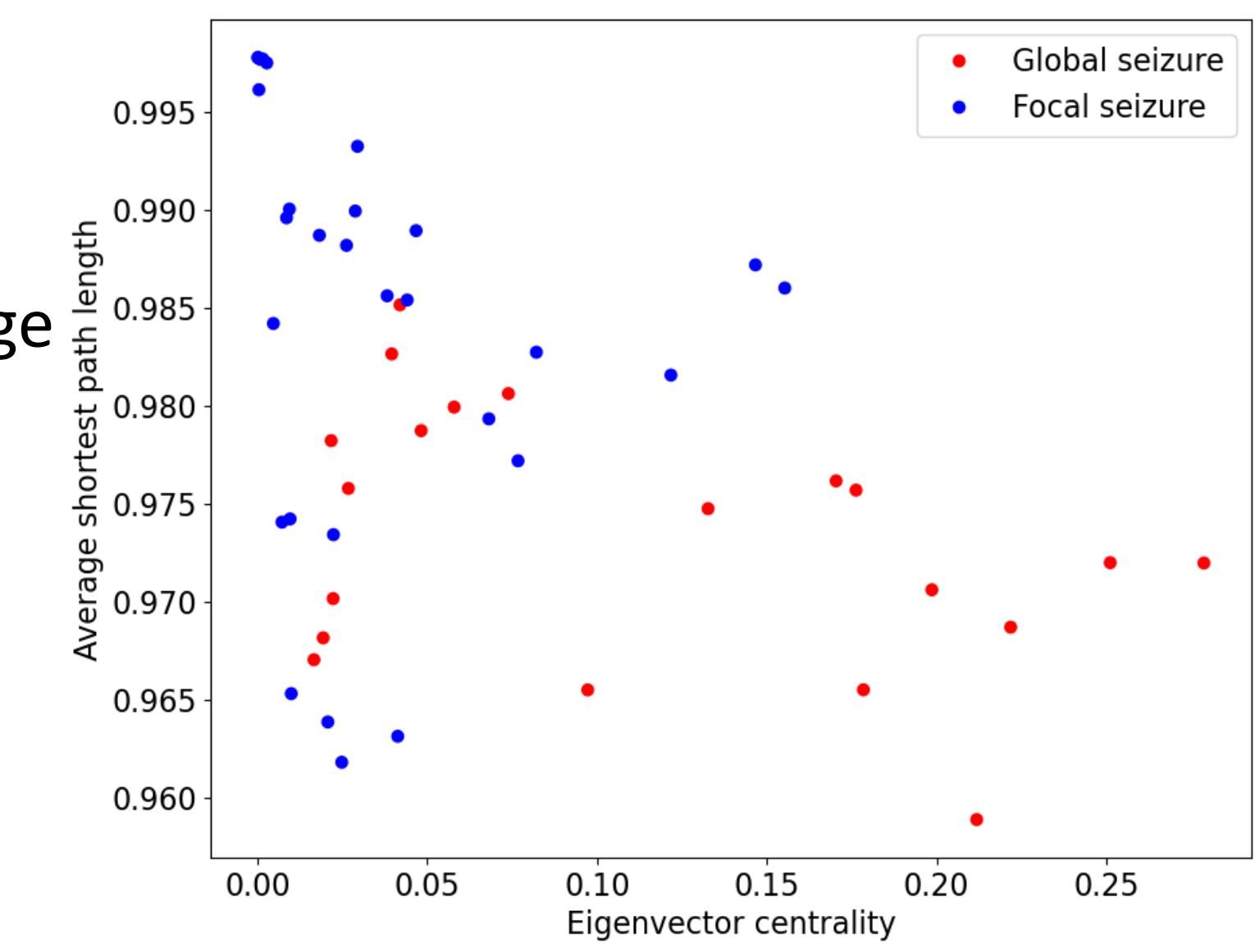
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## Results: 1. Effect of the EZ's connectivity on seizure propagation

- To characterize the network's nodes, we use their average shortest path length and their eigenvector centrality

$$x_v = \frac{1}{\lambda} \sum_{t \in V} a_{v,t} x_t$$

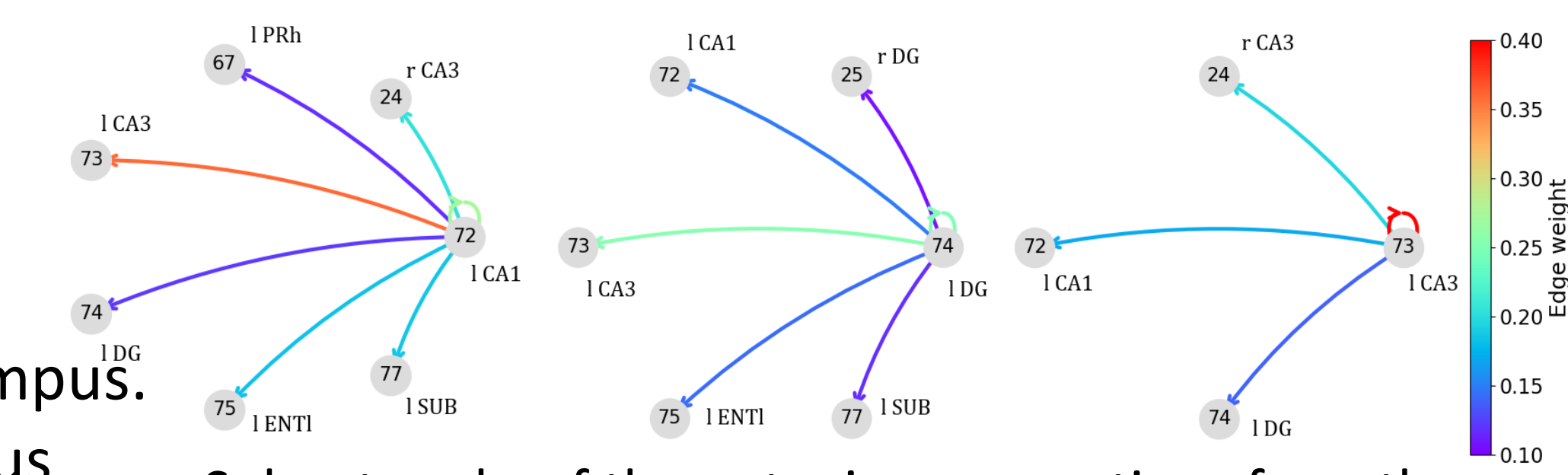
- EZ with high centrality and low shortest path length generate global seizures
- EZ with high shortest path length only generate local seizures
- Hippocampal nodes** have intermediate values. **CA1** and **Dentate Gyrus (DG)** generate global seizures. **CA3** generate local seizures.



Map of the nodes' connectivity properties. Red nodes generate global seizures when being set as the EZ. Seizure initiating at the blue nodes do not spread.

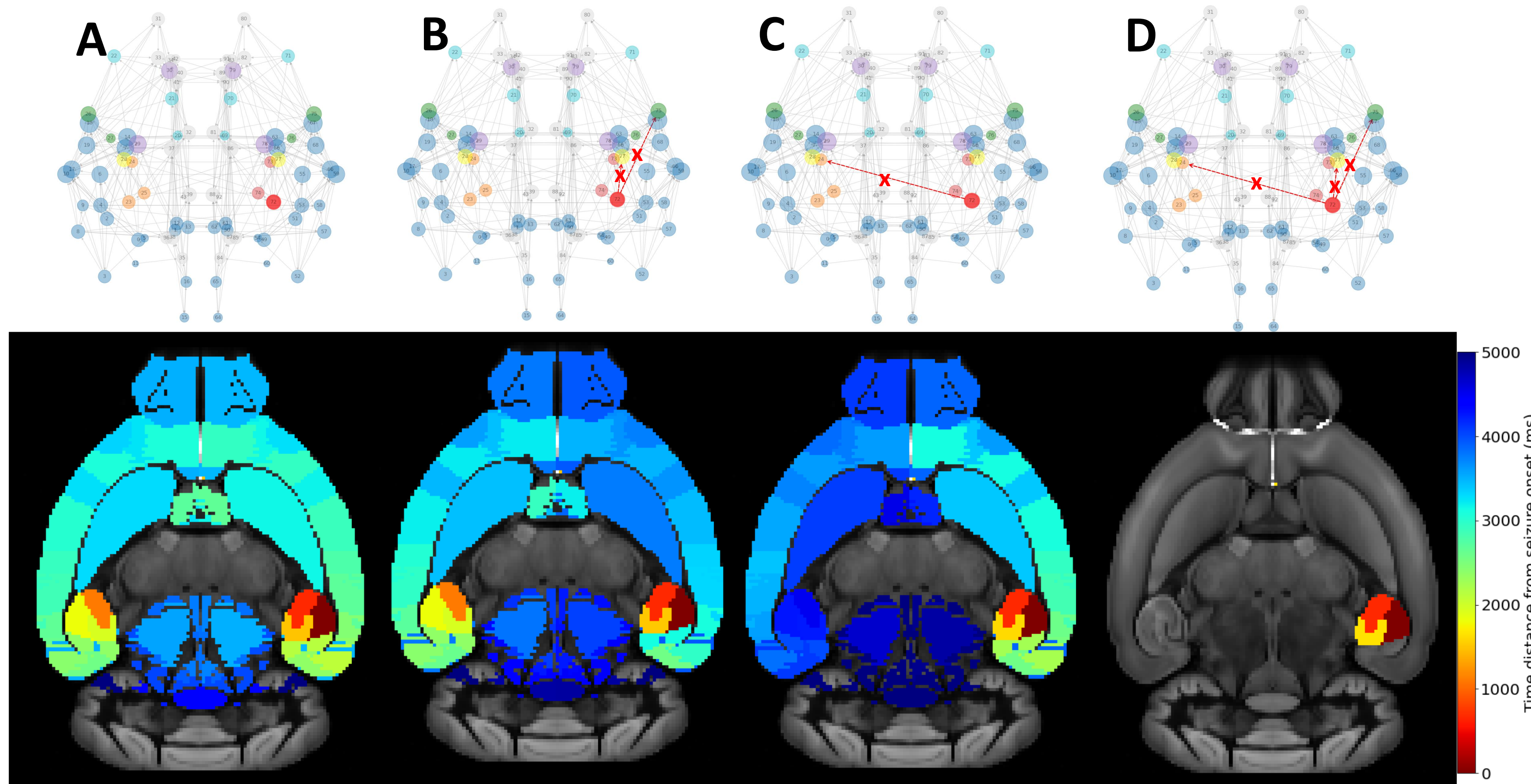
## 2. Connectivity of the Hippocampal nodes

- l CA1, l DG: stronger connections to left **Entorhinal lateral cortex (l ENTl)** and **left Subiculum (l SUB)** areas and right Hippocampus.
- l CA3: mainly connected to the Hippocampus



## 3. Effect of edge removal on seizure propagation

- A: standard seizure** propagation in a mice brain network, when the EZ is left CA1.
- B, C: delayed seizure** propagation. Removing the strongest outgoing connections of l CA1 within the left hemisphere (resp. with the right hemisphere) slows down seizure propagation, mostly in the left (resp. right) hemisphere.
- D: halted seizure** propagation when removing these three connections.



Upper: graph of the brain network. The red node is the EZ, the red edges are removed. Bottom: projection of the time distance from seizure in the brain template.

## Conclusions

- Global seizures are produced by the brain network's hubs, but also by some less central areas.
- Both strong connections within the hippocampal loop (Hippocampus, Entorhinal cortex, Subiculum) and between right and left Hippocampus have strong impact in the seizure propagation [8].
- Seizure confinement can be achieved by removing a minimal number of three connections [8] instead of all as presented in [2]