

Personalised Brain Cancer Treatment: Improving Drug Delivery with Electric Fields

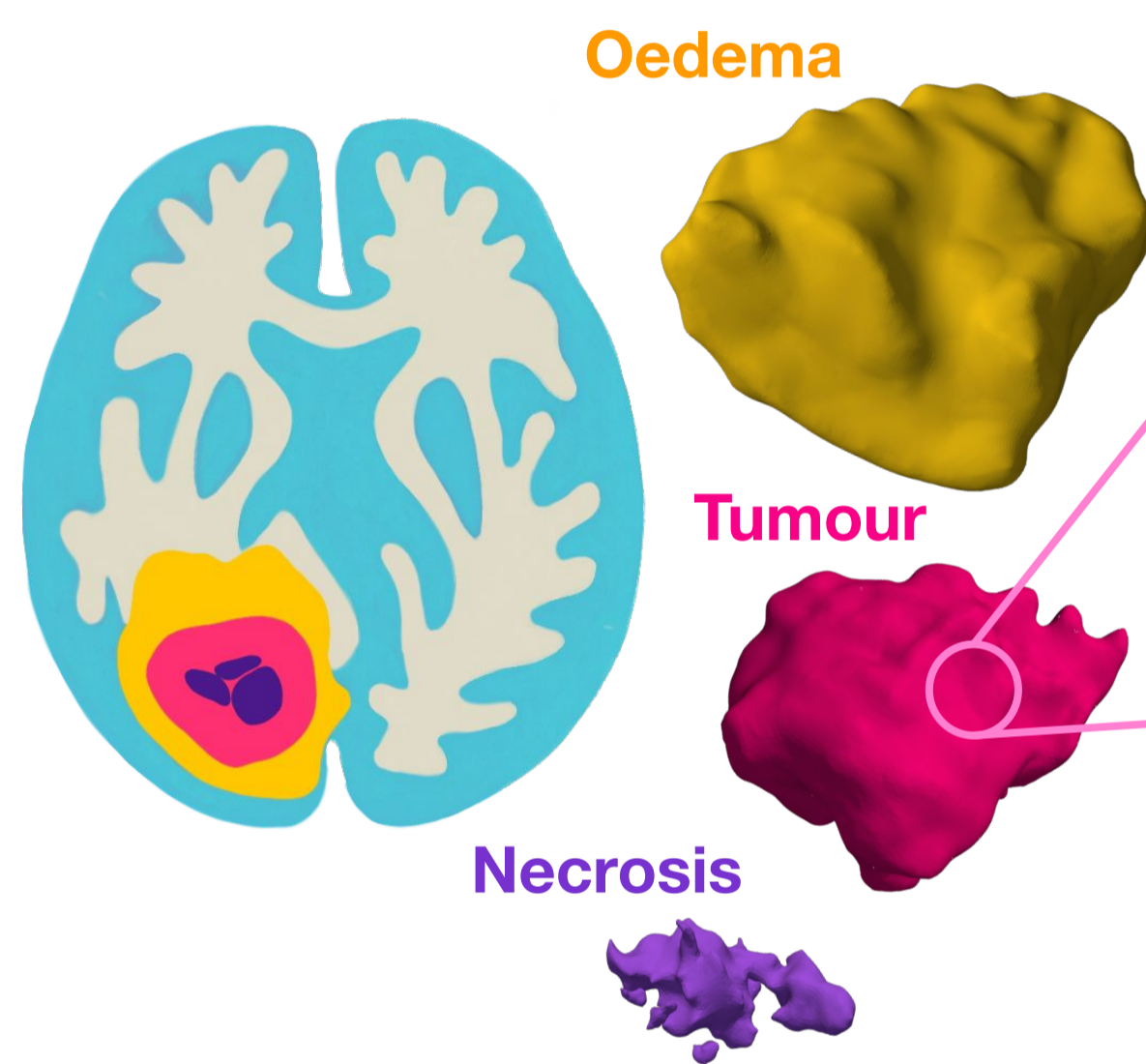
The Challenge: Glioblastoma → A Promising Solution: Electrochemotherapy

- Most aggressive brain cancer
- **£1.44 bn/yr NHS cost** for primary and metastases (up to £180k/patient)
- Over 70% of tumours return within a year
- Standard treatments (including surgery) are ineffective

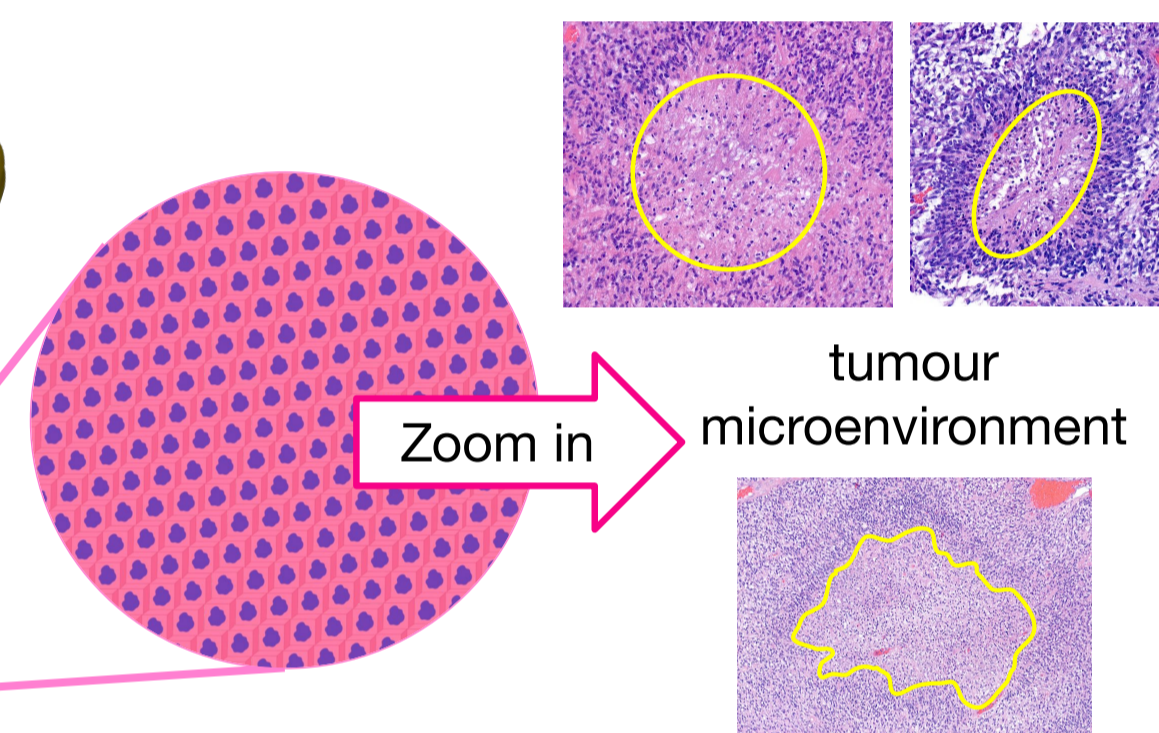
- Combine chemotherapy with **electric field** for better outcome
- **Selectively targets cancer cells**, sparing healthy brain tissue
- Short electric pulses temporarily open cancer cell membranes, **letting more drugs in**
- Already used in skin cancers, but we need **mathematical models** to guide treatment in more complex, larger tumours

Why Multiscale Modelling?

What MRI shows (macroscale)



What MRI misses (microscale)



Need maths to link **macro** and **micro** features to achieve a realistic model

Computational Framework

Inputs:

MRI data (macroscale)

Parameters from literature (microscale)

Multiscale Modelling

$$\nabla_x \cdot (\hat{K} \nabla_x \bar{p} + \mathbf{u}) = -\nabla_x \cdot ((\hat{K} + \hat{F}) c \nabla_x \phi)$$

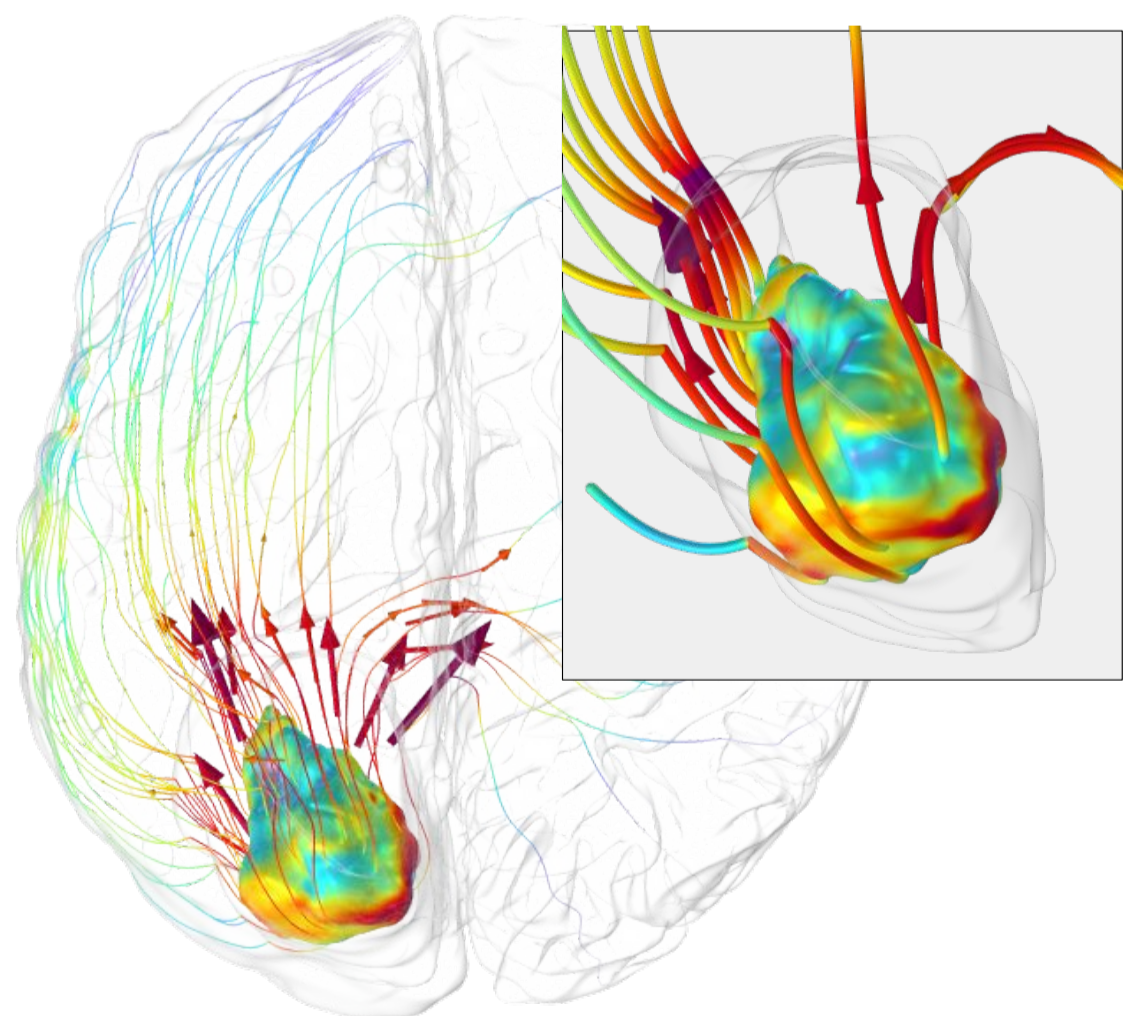
Maths Model:

Novel mathematical model describes the macro and microscale physics of glioblastoma

Outputs:

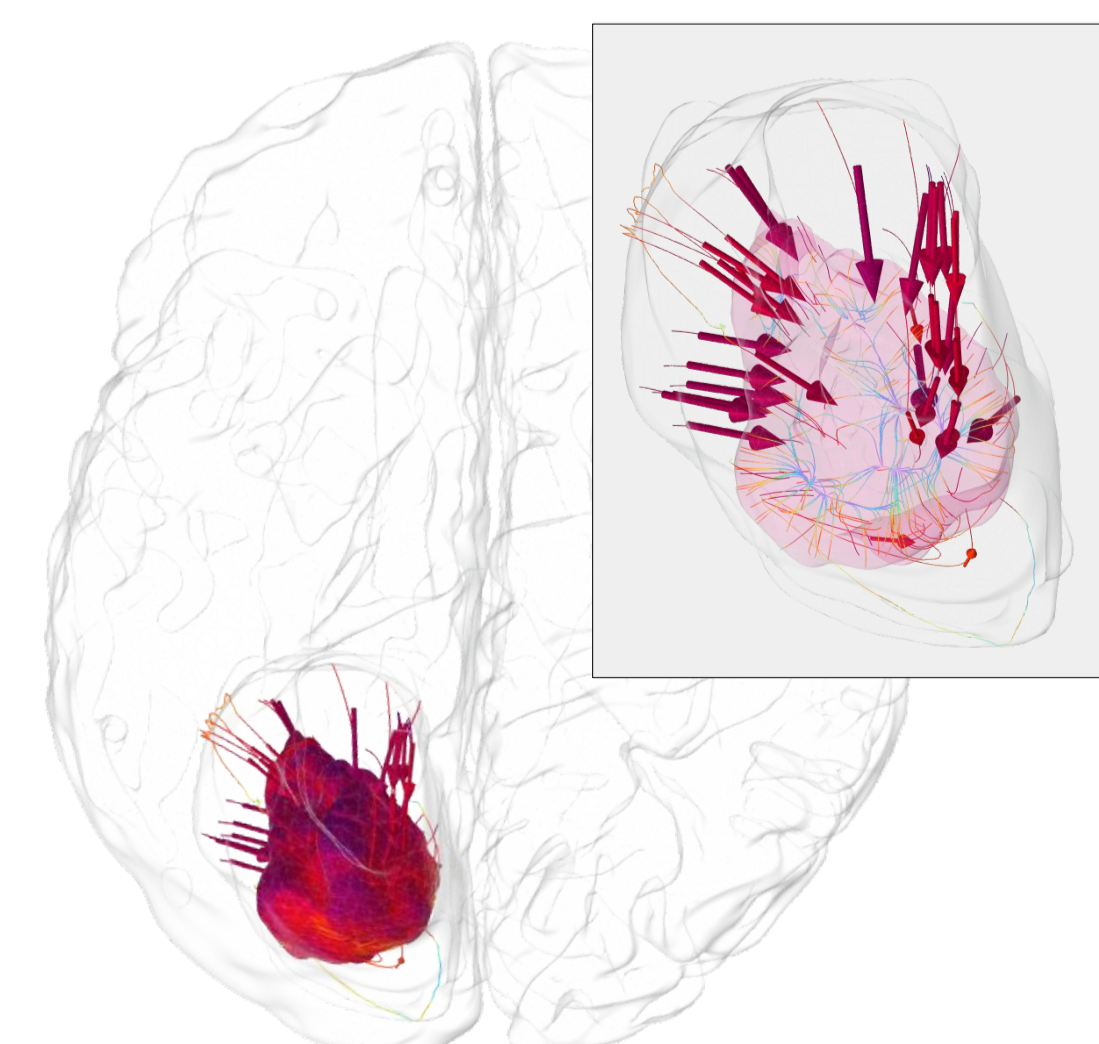
- ✓ **Personalised** tumour recurrence & therapy response predictions
- ✓ **Fast**
- ✓ **Realistic**

Virtual Tumour Modelling: A Case Study



Without electric field

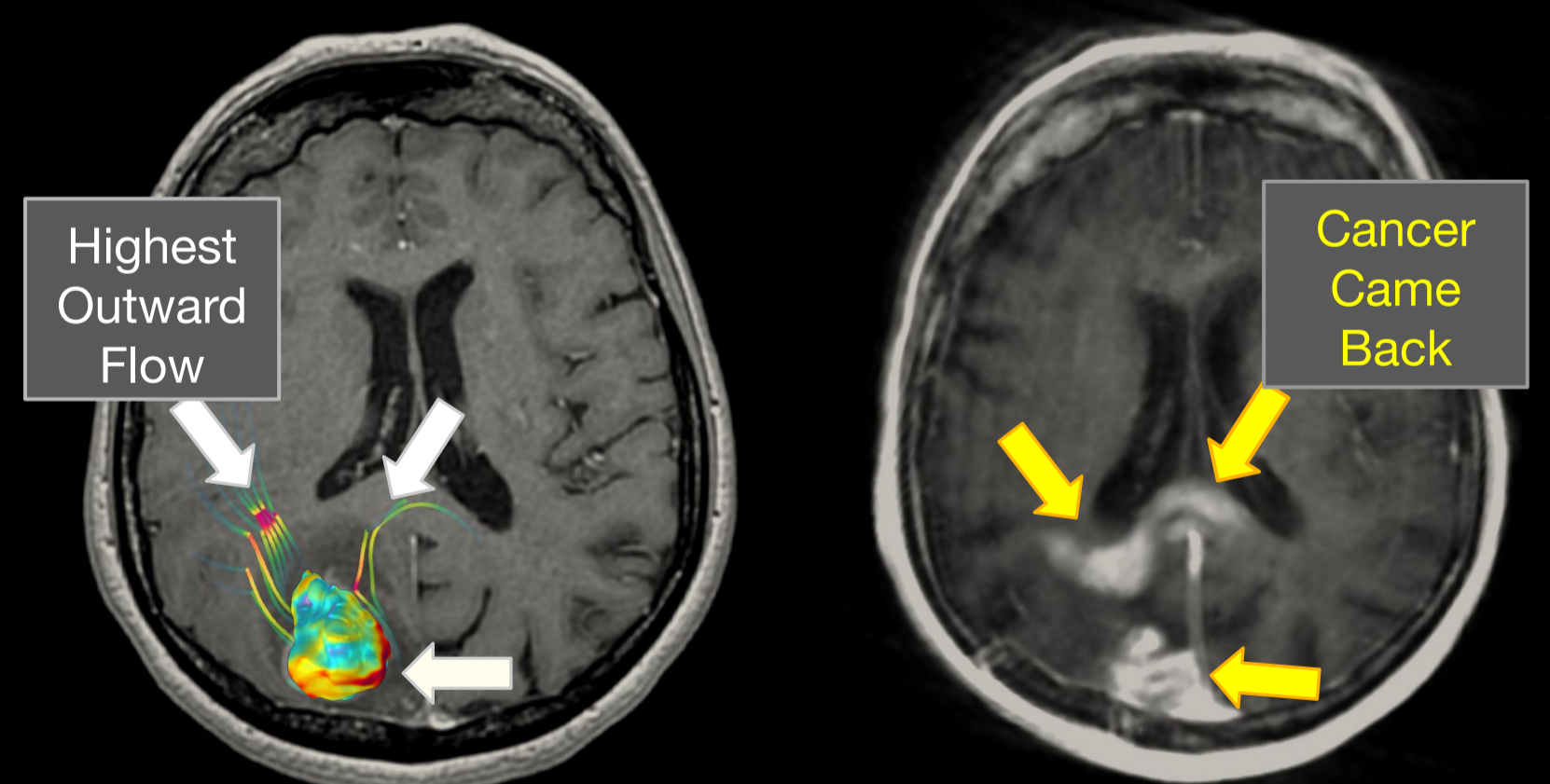
- **Outward flow** blocks drug entry
- Delivery is **uneven** and **limited**
- **Simulations pinpoint** high risk areas for **recurrence** and future targeting



With electric field

- **Inward flow** drives drug into tumour
- Delivery becomes **more uniform**
- Up to **650% more drug uptake**
- Simulations help find the safest way to deliver the most drugs

Predicting Tumour Recurrence



Model prediction at diagnosis

Actual outcome 1 yr later

Smarter Treatment Planning

1. Support clinicians to choose the best treatment
2. Personalise electric field for each tumour
3. Test options virtually before real treatment begins

IMPACT

- **Better outcomes for patients**
- **Lower NHS costs**
- **Truly personalised cancer care**