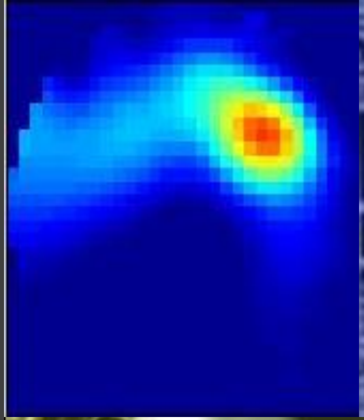


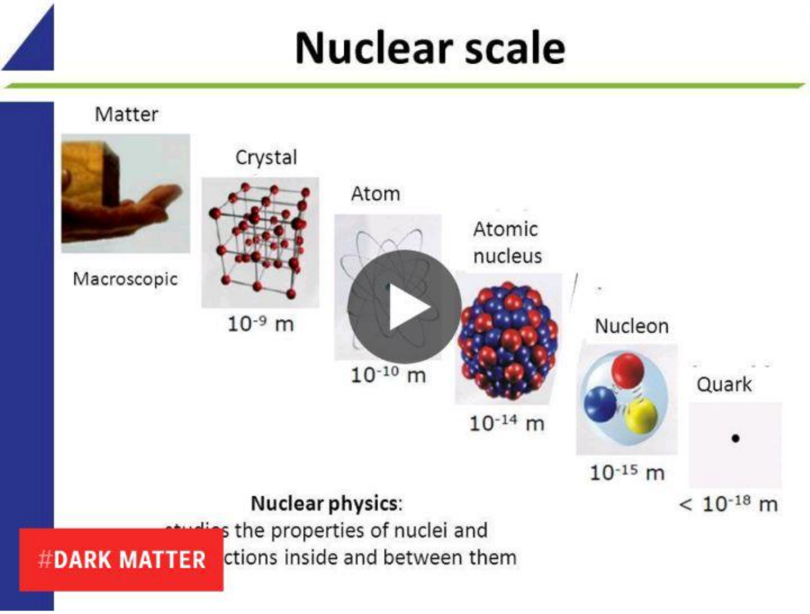
Mechanisms of Interaction with Living Tissue: Cancer Treatment Applications of EMF Radiation

Development of Electro-Capacitive Cancer Therapy

warsito p taruno

Low level energy sources for diagnosis and treatments

C-TECH LABS EDWAR TECHNOLOGY
C-TECH SPORT
Care CANCER RESEARCH INSTITUTE
edwar healthcare



At Last, Physicists Understand Where Matter's Mass Comes From

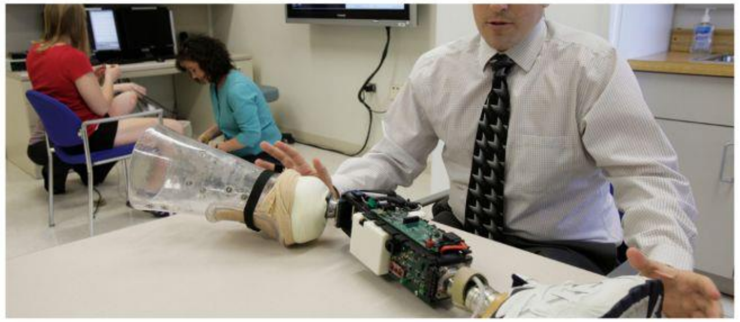
Forbes · 20h · Ethan Siegel

In this Universe, there are very few fundamental properties that cannot be derived from something simpler. The rules governing biological systems are rooted in chemical interactions, bonds, and applied voltages. The rules of ...

Wayne Neumann
added to MScience108 · 20h

1 comment · 80 likes

Electricity could be the future of medicine. Here's why



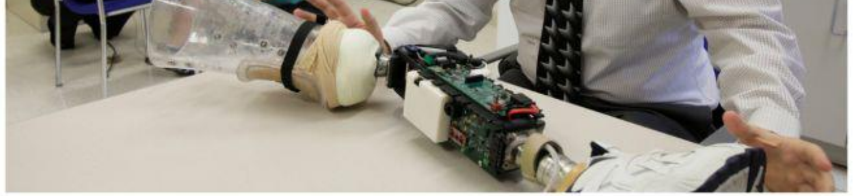
A new tool in doctors' toolboxes?
Image: REUTERS/John Gress

This article is published in collaboration with
The Conversation

15 Nov 2018

Benjamin W Metcalfe
Assistant Professor of Engineering, University of Bath

When your only tool is a hammer, every problem looks like a nail. This saying is particularly apt in medicine where doctors treat nearly every condition



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When your only tool is a hammer, every problem looks like a nail. This saying is particularly apt in medicine where doctors treat nearly every condition – from depression to hypertension – with a pill. If your doctor prescribed you anything other than a pill (assuming you don't need surgery), you might think they were a quack. But this will soon change. Medicine is getting radical, and one of the radical new approaches for treating disease is electricity.

Why electricity? Well, everything you do, from

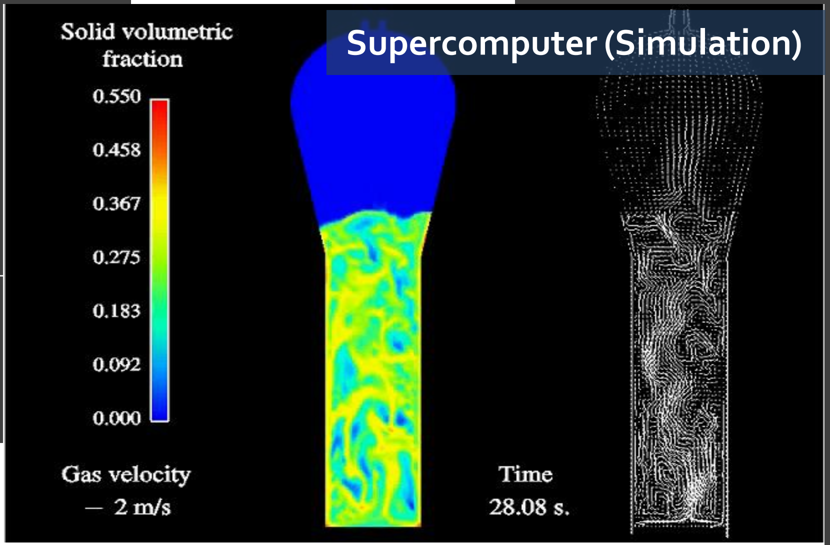
ECVT for Supercomputer Simulation Verification.

US Dept. of Energy Project on Advanced Research to Support Development of Next-Generation Power Plants (2008—2011):

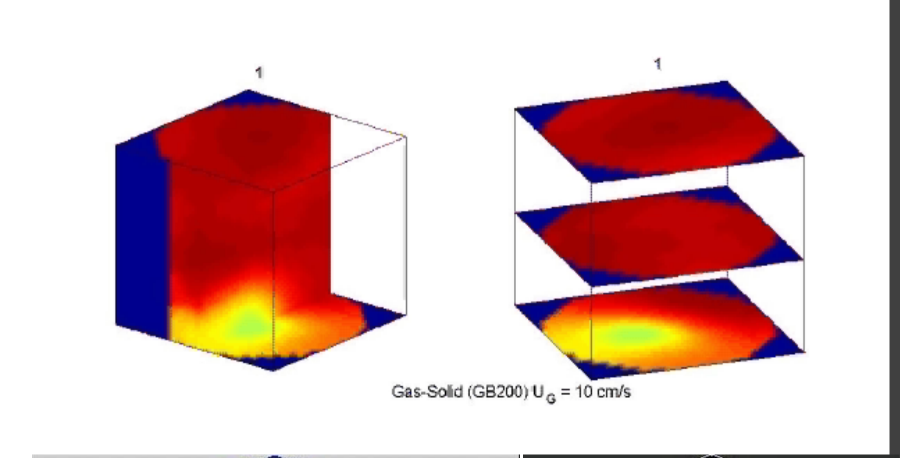
"Fluid bed characterization using Electrical Capacitance Volume Tomography (ECVT), compared to CPFD Software's Barracuda; Powder Technology (2013); Justin M. Weber et.al., U.S. Department of Energy, 3610 Collins Ferry Road, Morgantown, West Virginia 26507-0880 USA

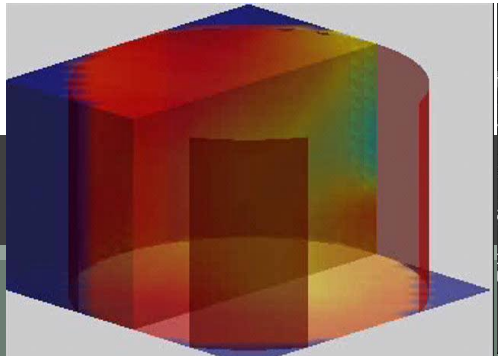
ECVT (Real)

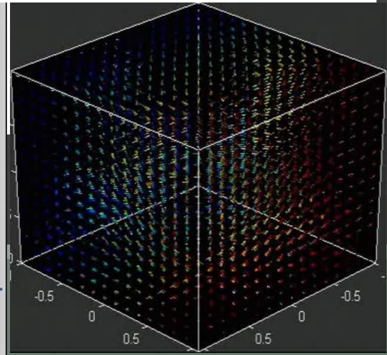
128CH ECVT SYSTEM
4th Generation



Supercomputer (Simulation)



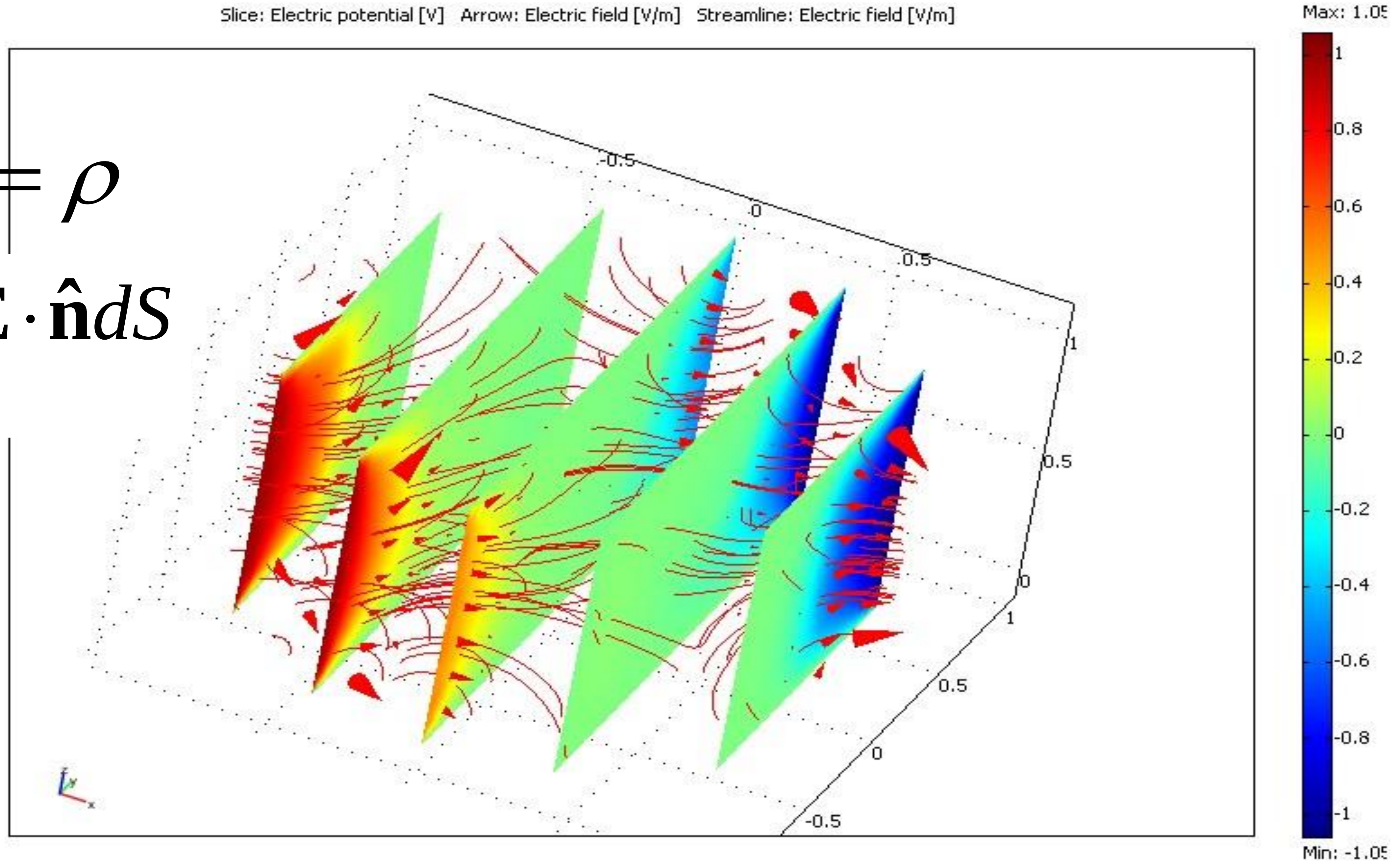




Principles of ECVT & ECCT

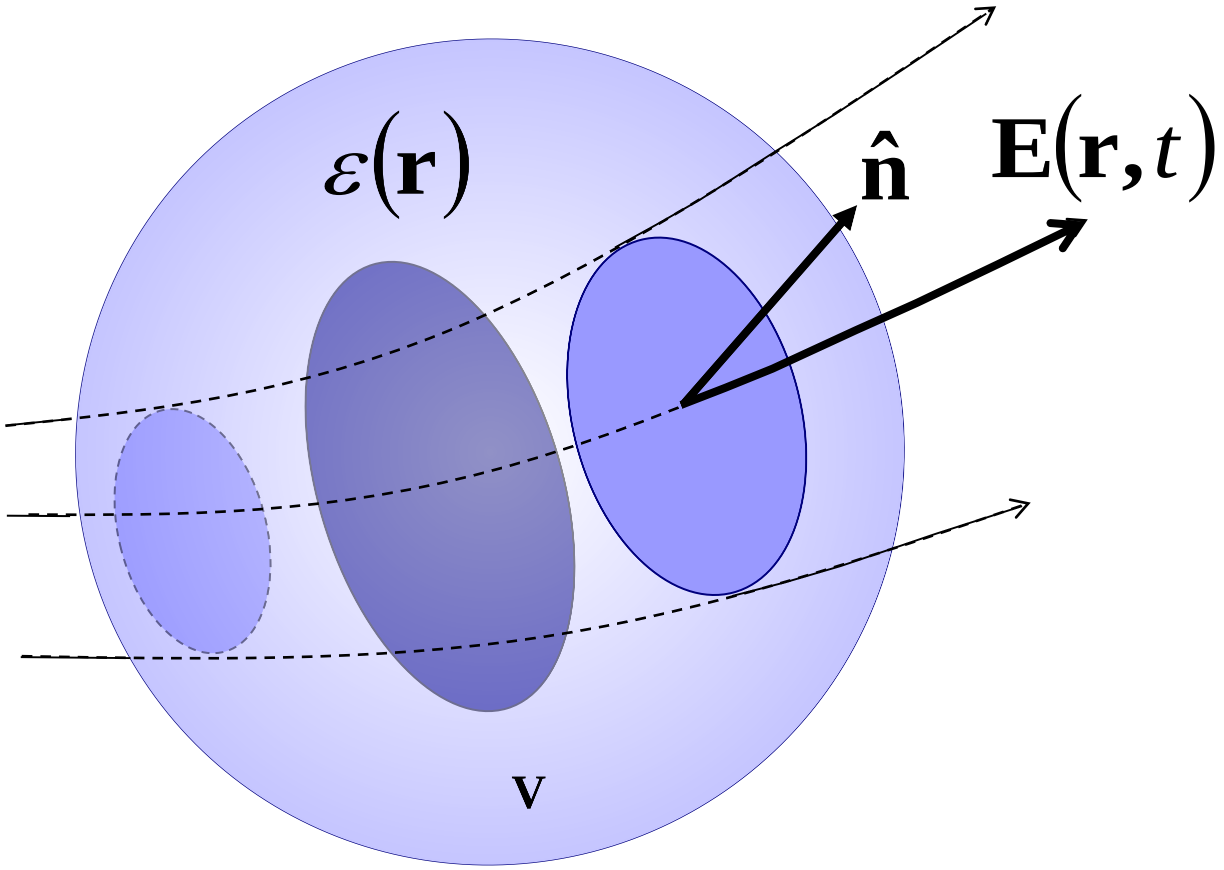
$$\nabla \cdot \varepsilon \mathbf{E} = \rho$$

$$Q = \oint_S \varepsilon \mathbf{E} \cdot \hat{\mathbf{n}} dS$$



ECVT: Electrical Capacitance Volume Tomography

Integral boundary problem—Inverse Problem



$$Q = \int_V \mathbf{div}(\mathbf{D})dV = \oint_S \mathbf{D}\cdot\hat{\mathbf{n}}dS$$

$$\mathbf{D} = \varepsilon(\mathbf{r})\mathbf{E}(\mathbf{r})$$
$$= \varepsilon(\mathbf{r})\mathbf{grad}(\phi)$$

↓

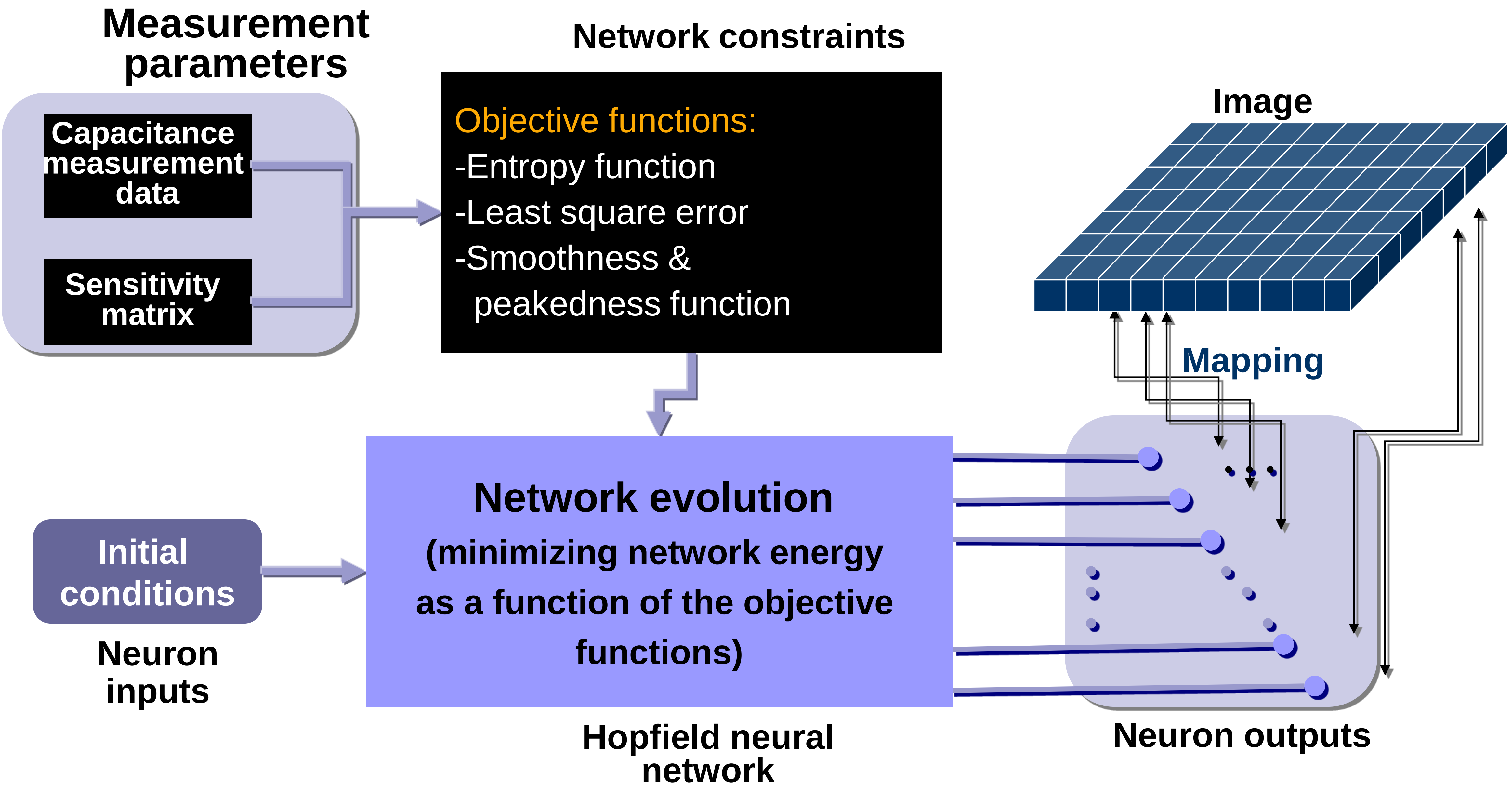
$$Q_1[\xi(\mathbf{r},t)], Q_2[\xi(\mathbf{r},t)], \cdots$$
$$Q_i[\xi(\mathbf{r},t)], \cdots, Q_m[\xi(\mathbf{r},t)]$$

↓

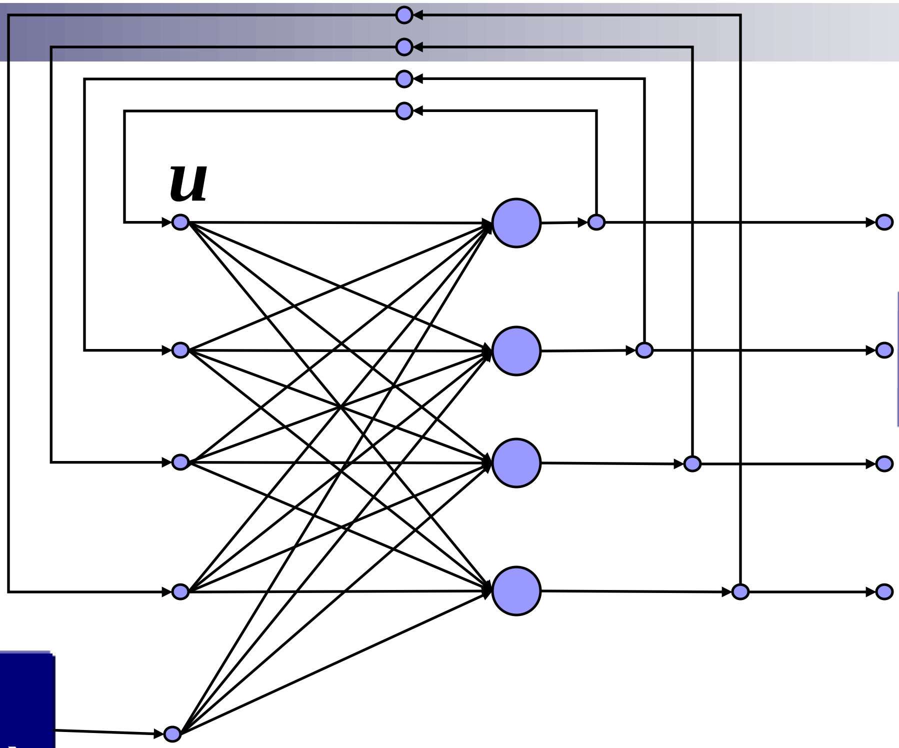
$$\varepsilon(\mathbf{r})$$

i = integration domain number

NN-MOIRT algorithm (Warsito et al., 2001)



Hopfield Network



INPUTS

(Initial conditions)

OUTPUTS v

$$v_j = f_\Sigma(u_j)$$

$$\frac{dE(\mathbf{v})}{dt} = \sum_{j=1}^{N} \frac{\partial E(\mathbf{v})}{\partial v_j}\frac{dv_j}{dt} = -\sum_{j=1}^{N} C_{0j}\frac{du_j}{dt}\frac{dv_j}{dt}$$

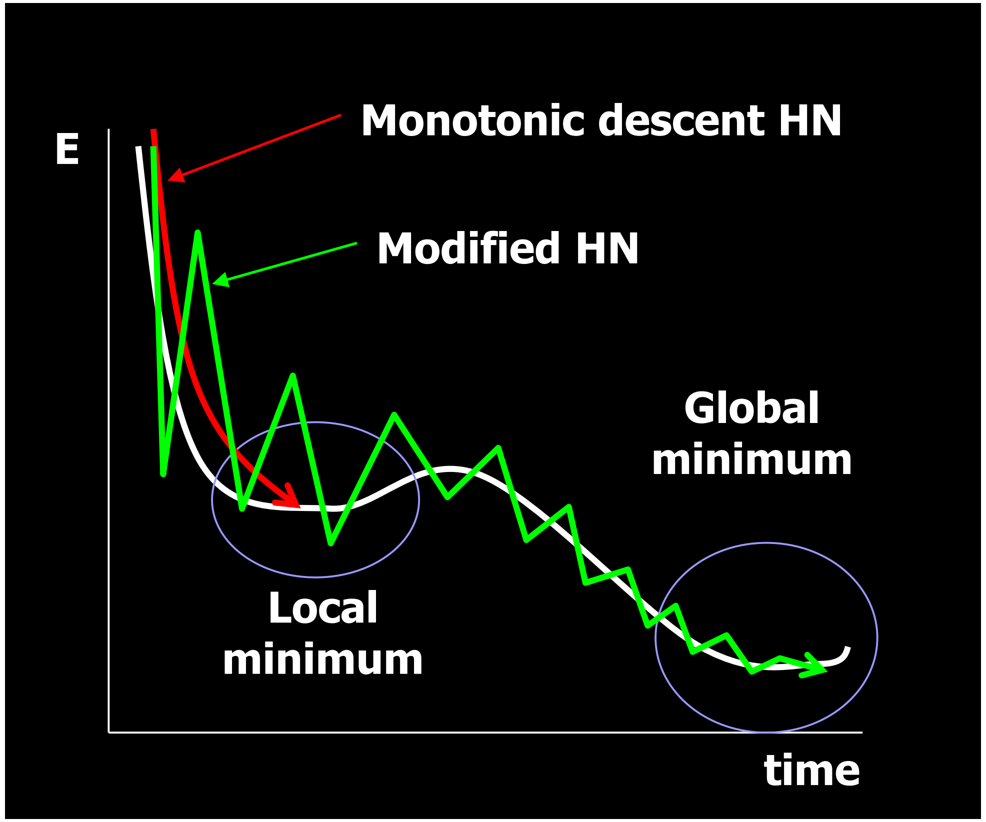
$$C_{0j}\frac{du_j}{dt} = -\frac{\partial E(\mathbf{v})}{\partial v_j}$$

$$= -\sum_{j=1}^{N} C_{0j}\left[\frac{\partial f_\Sigma(u_j)}{\partial u_j}\right]\left(\frac{du_j}{dt}\right)^2 = -\sum_{j=1}^{N} C_{0j}\left[\frac{\partial f_\Sigma^{-1}(v_j)}{\partial v_j}\right]\left(\frac{dv_j}{dt}\right)^2$$

$$\frac{dE}{dt} \le 0; \frac{du_j}{dt} = \frac{dv_j}{dt} = 0, t \to \infty$$

Network evolution

$$\mathbf{u}'(t) = -\frac{1}{C_0}\nabla E(\mathbf{G}) = -\frac{\mathbf{u}(t)}{\tau} - \Big[\omega_1\gamma\big(\mathbf{1} + \ln\mathbf{G}(t)\big) + \omega_2\gamma_2\mathbf{S}^T\mathbf{z}(t) + \omega_3\gamma_3\big(\mathbf{X}\mathbf{G}(t) + \mathbf{G}(t)\big) + \boldsymbol{S}^T\delta\big(\boldsymbol{z}(t)\big)\Big]$$



$$\nabla E(\mathbf{G}) = \left[\frac{\partial E(\mathbf{G})}{\partial G_1}, \frac{\partial E(\mathbf{G})}{\partial G_2}, \cdots, \frac{\partial E(\mathbf{G})}{\partial G_N}\right]^T$$

$$\boldsymbol{u}(t) = [u_1(t), u_2(t), \cdots, u_N(t)]^T$$

$$\mathbf{G}(t) = [G_1(t), G_2(t), \cdots, G_N(t)]^T$$

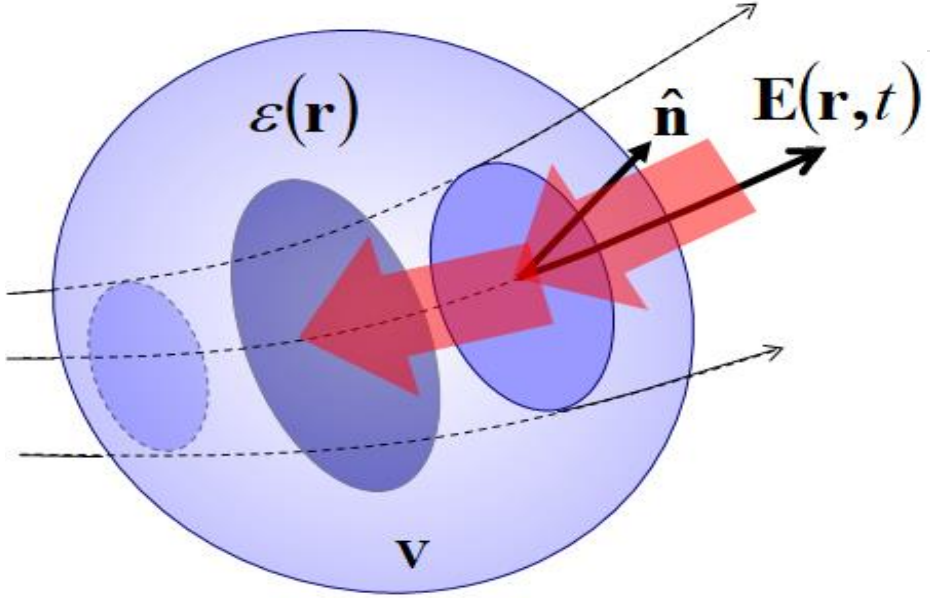
$$\boldsymbol{z}(t) = [z_1(t), z_2(t), \cdots, z_N(t)]^T$$

$$\frac{d\Psi}{dz_i} = \delta(z_i) = \begin{cases} 0 & \text{if } z_i \le 0 \\ \alpha z_i & \text{if } z_i > 0 \end{cases}$$

$$\alpha(t) = \alpha_0 + \varsigma\exp(-\eta t)$$

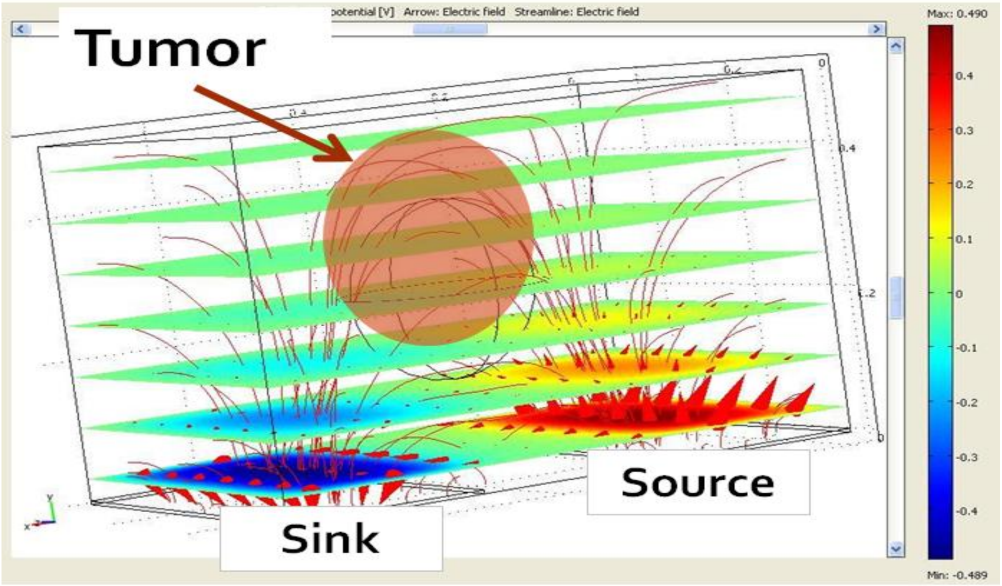
Electrostatic-Stimulation

Integral boundary problem—Forward Problem



$$\nabla \cdot \varepsilon \mathbf{E} = \rho \qquad Q = \oint_S \varepsilon \mathbf{E} \cdot \hat{\mathbf{n}} dS$$

$$C = \frac{Q}{V} \qquad W = V \frac{dQ}{dt} \mathrm{t}$$

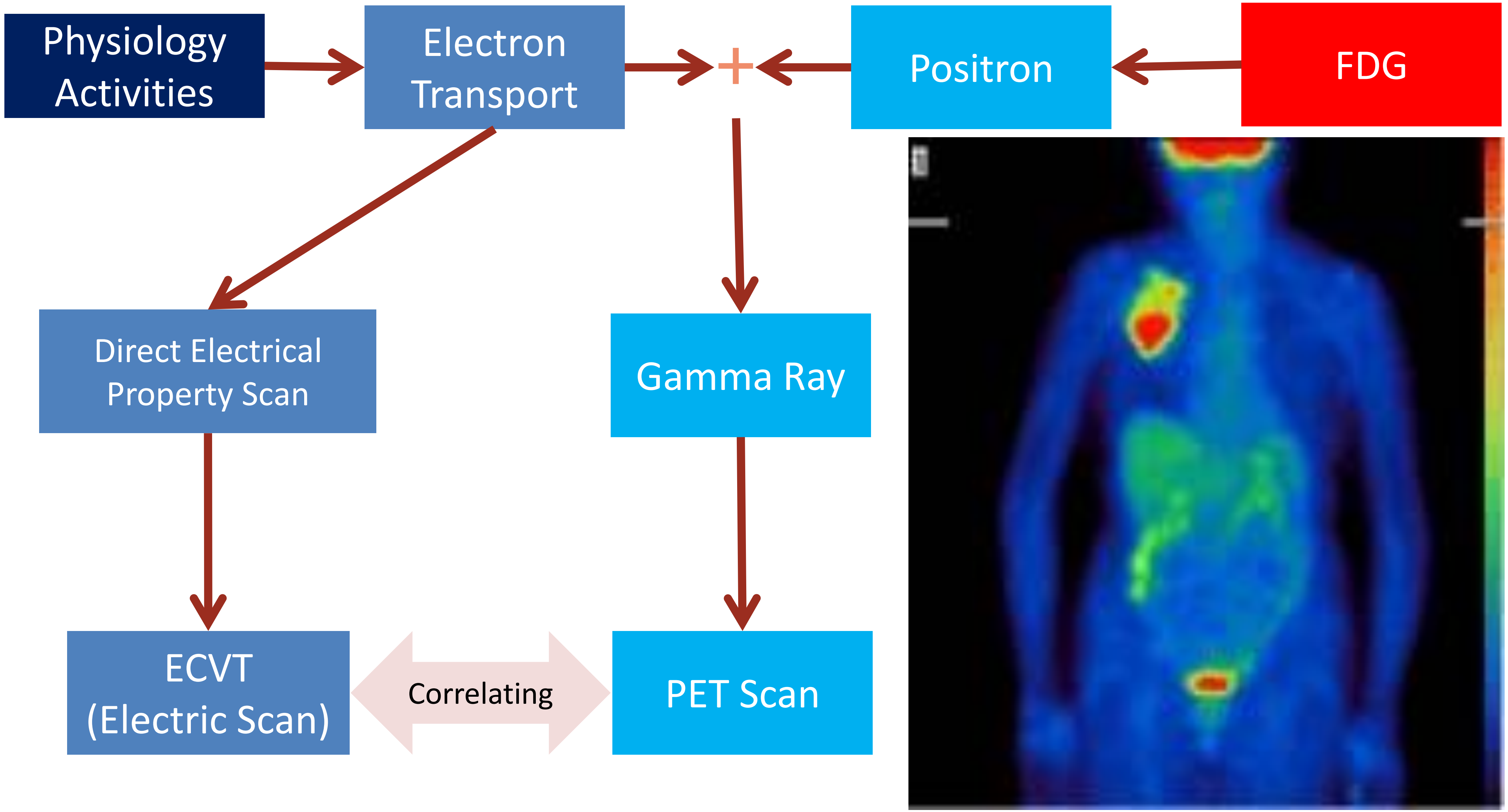


Applications:
- Cancer treatment
- Brain stimulation
- Muscle stimulation
- Degenerative diseases treatment

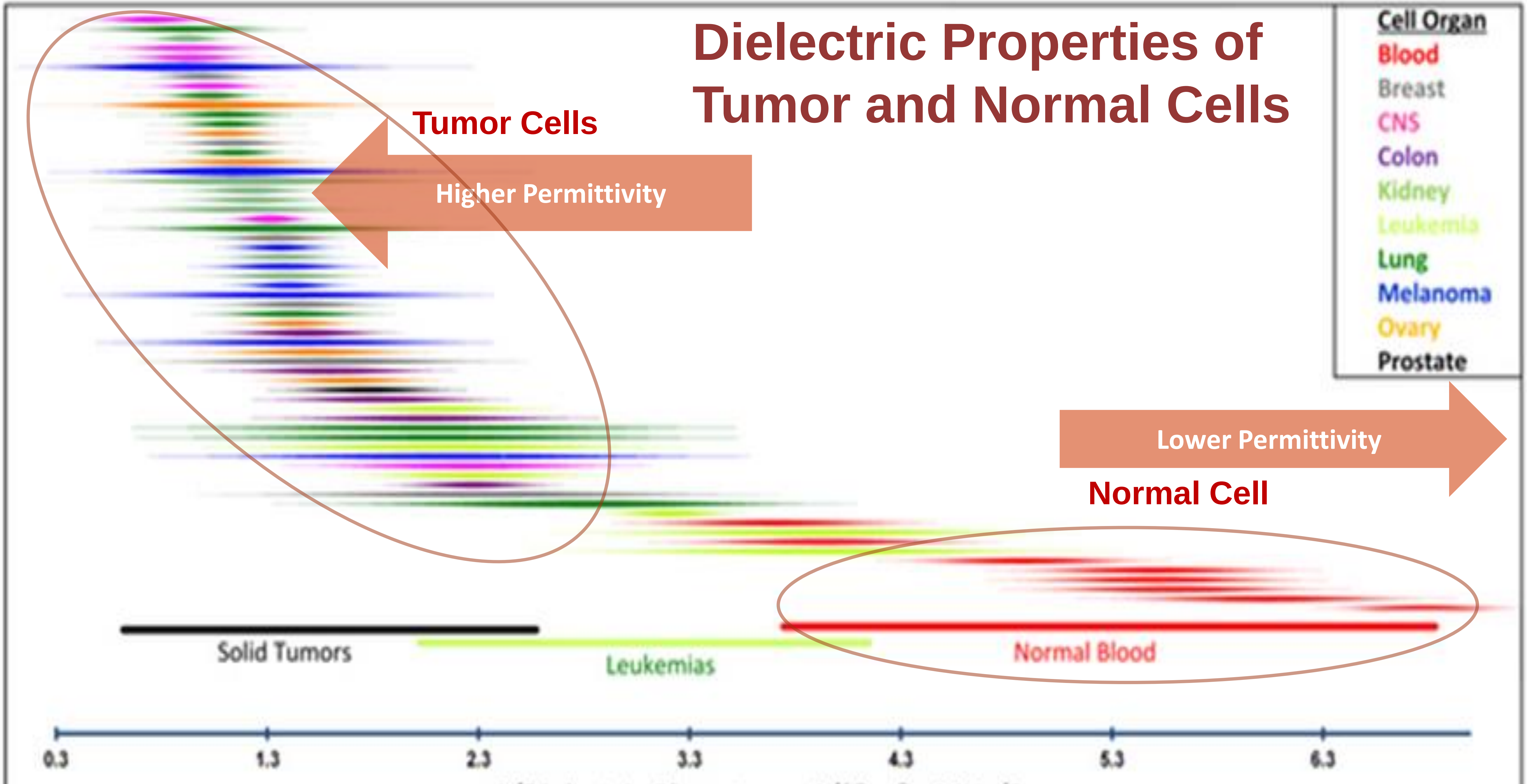
Biomedical Imaging Applications

BREAST ECVT, BRAIN ECVT

Physiological imaging of human body



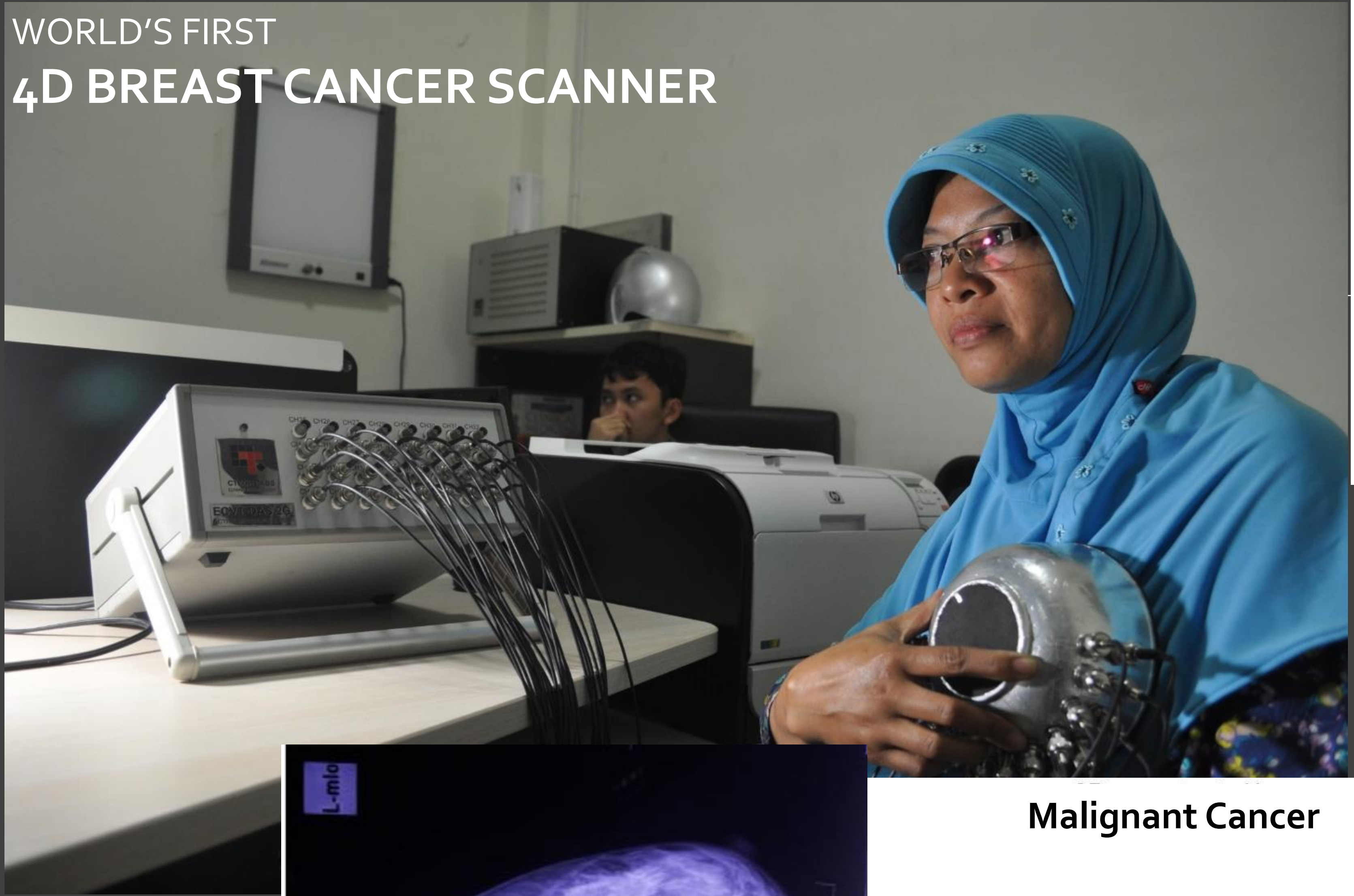
Dielectric Properties of Tumor and Normal Cells

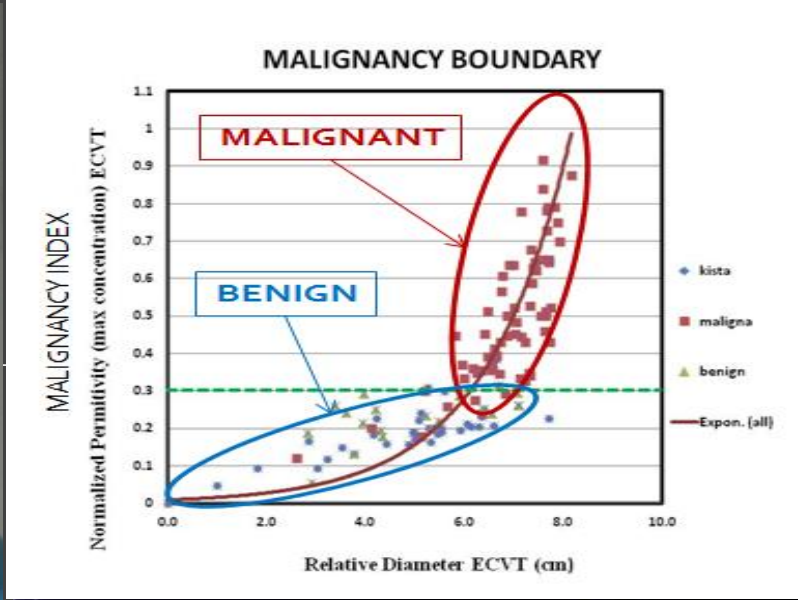


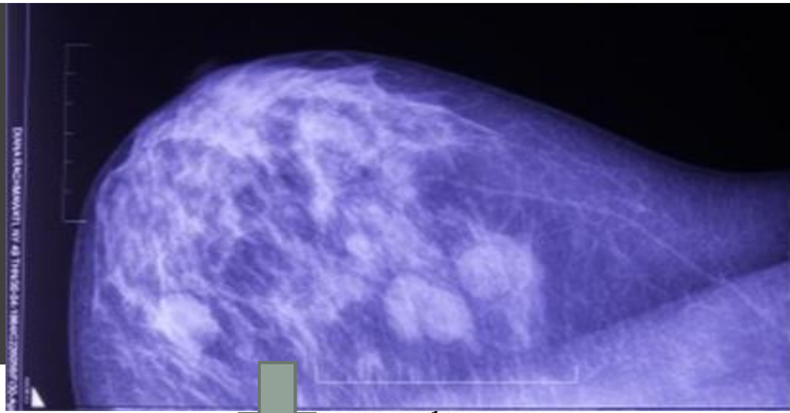
Gascoyne and Shim, 2014

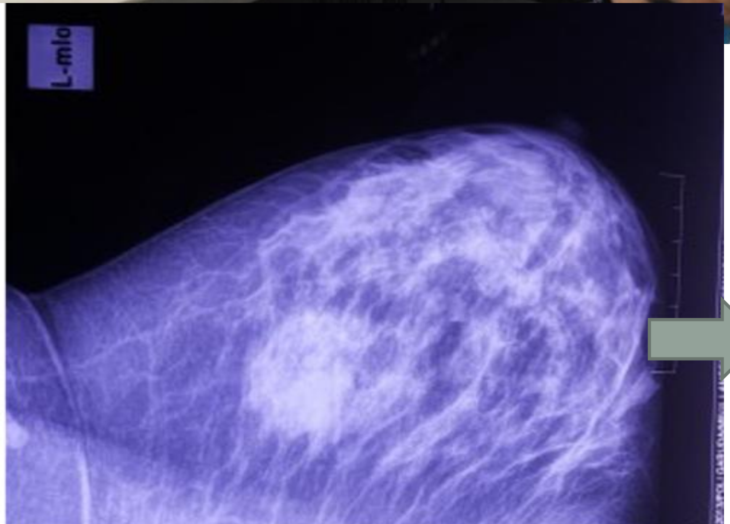
WORLD'S FIRST

4D BREAST CANCER SCANNER

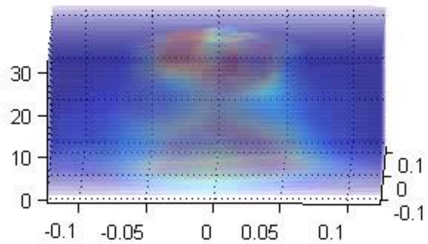




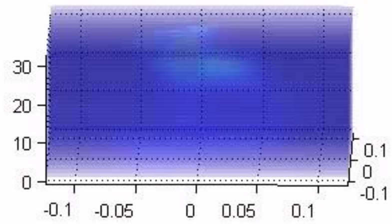




Malignant Cancer



Benign Tumor



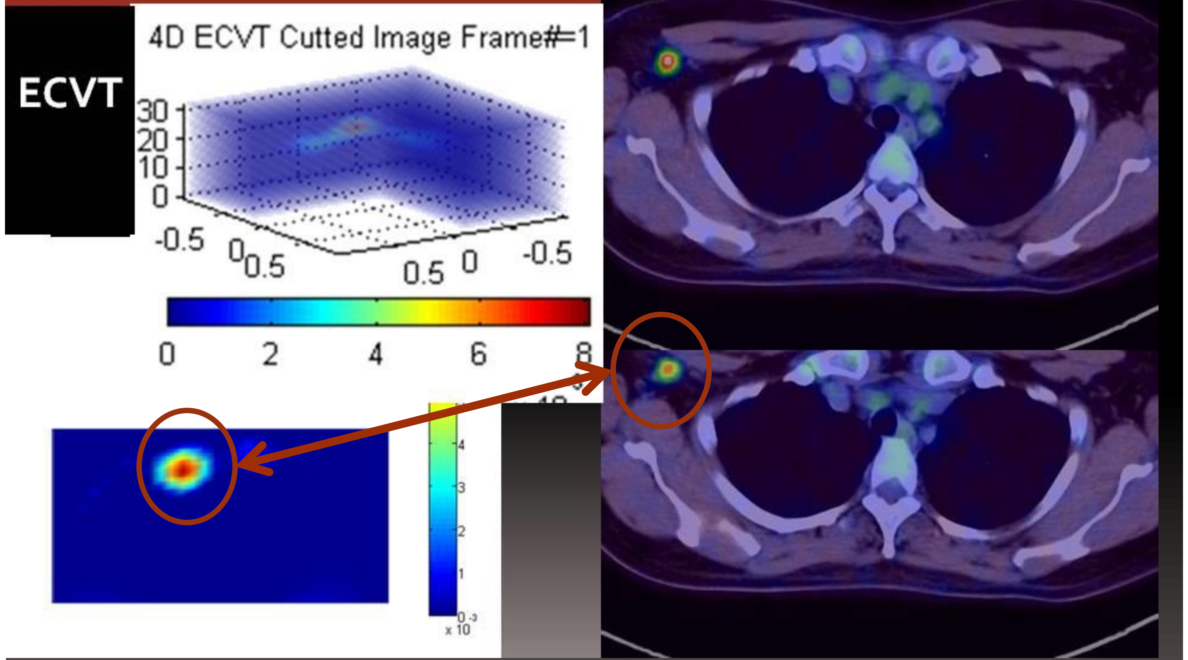
C-TECH LABS
EDWAR TECHNOLOGY

ECVT BREAST

Differentiating Malignancy from Benignity

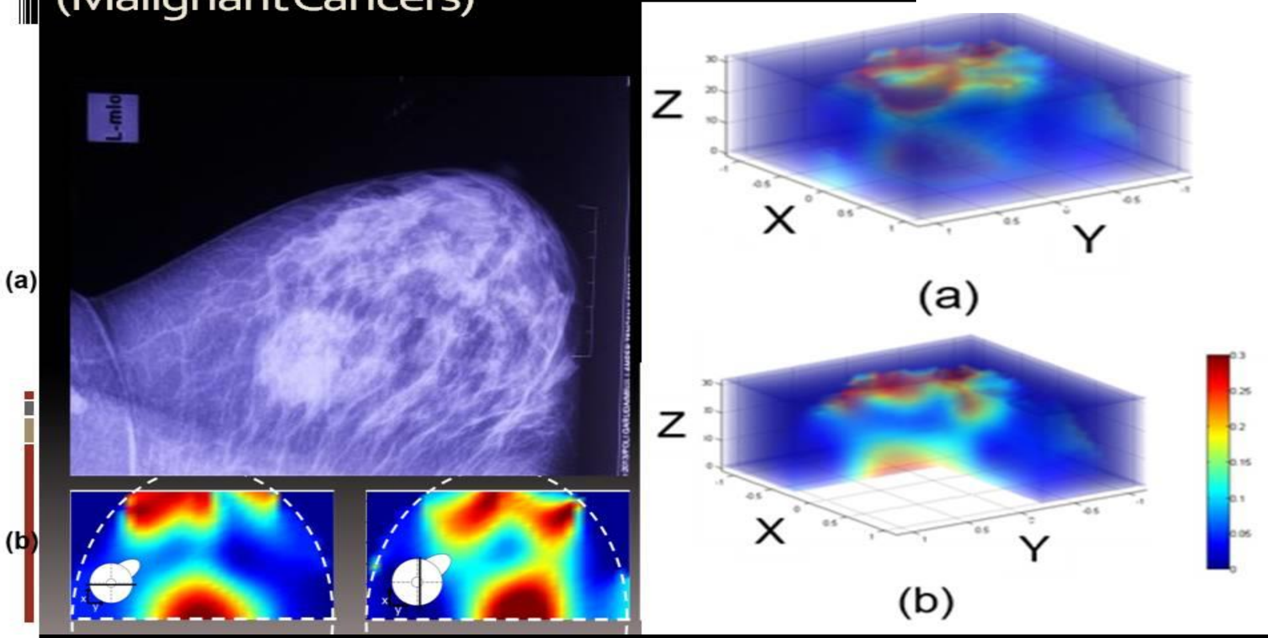
C-TECH LABS
EDWAR TECHNOLOGY

PET—CT Vs. ECVT

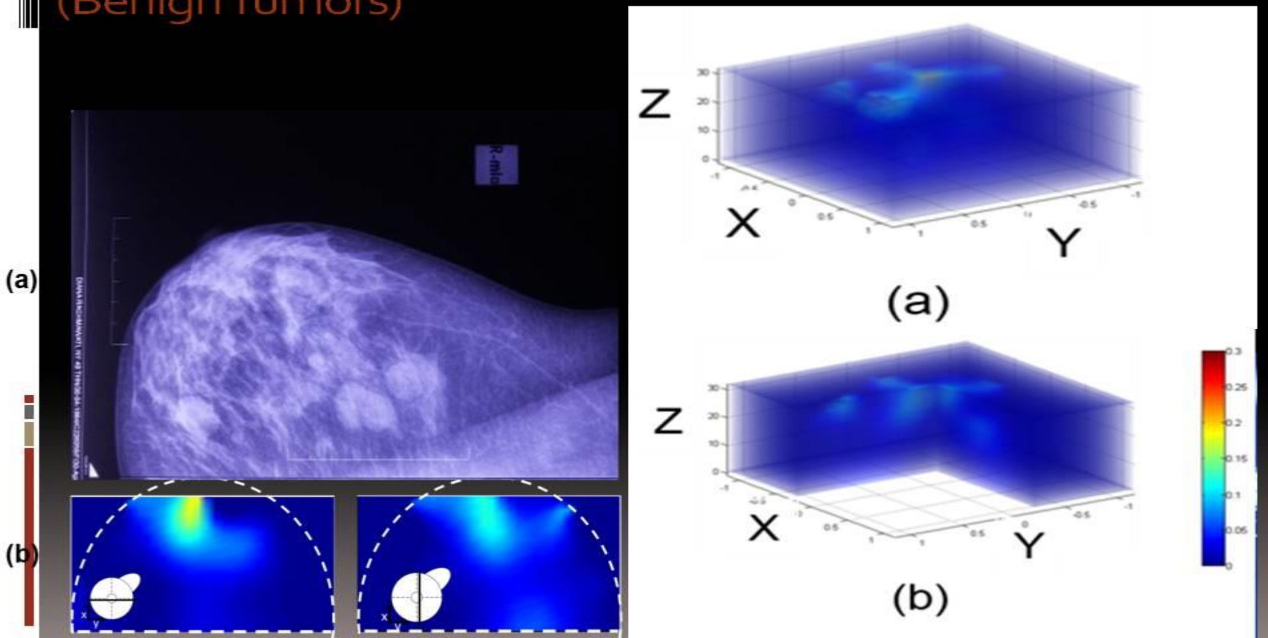


ECVT images of breast tumors show physiological abnormality of the electrical activity generated by the tumor, in conformity with FDG activity in the image of PET—CT. RIGHT: Images of malignant breast cancer and benign tumor obtained using mammography and ECVT.

ECVT vs. Mammography (Malignant Cancers)



ECVT vs. Mammography (Benign Tumors)

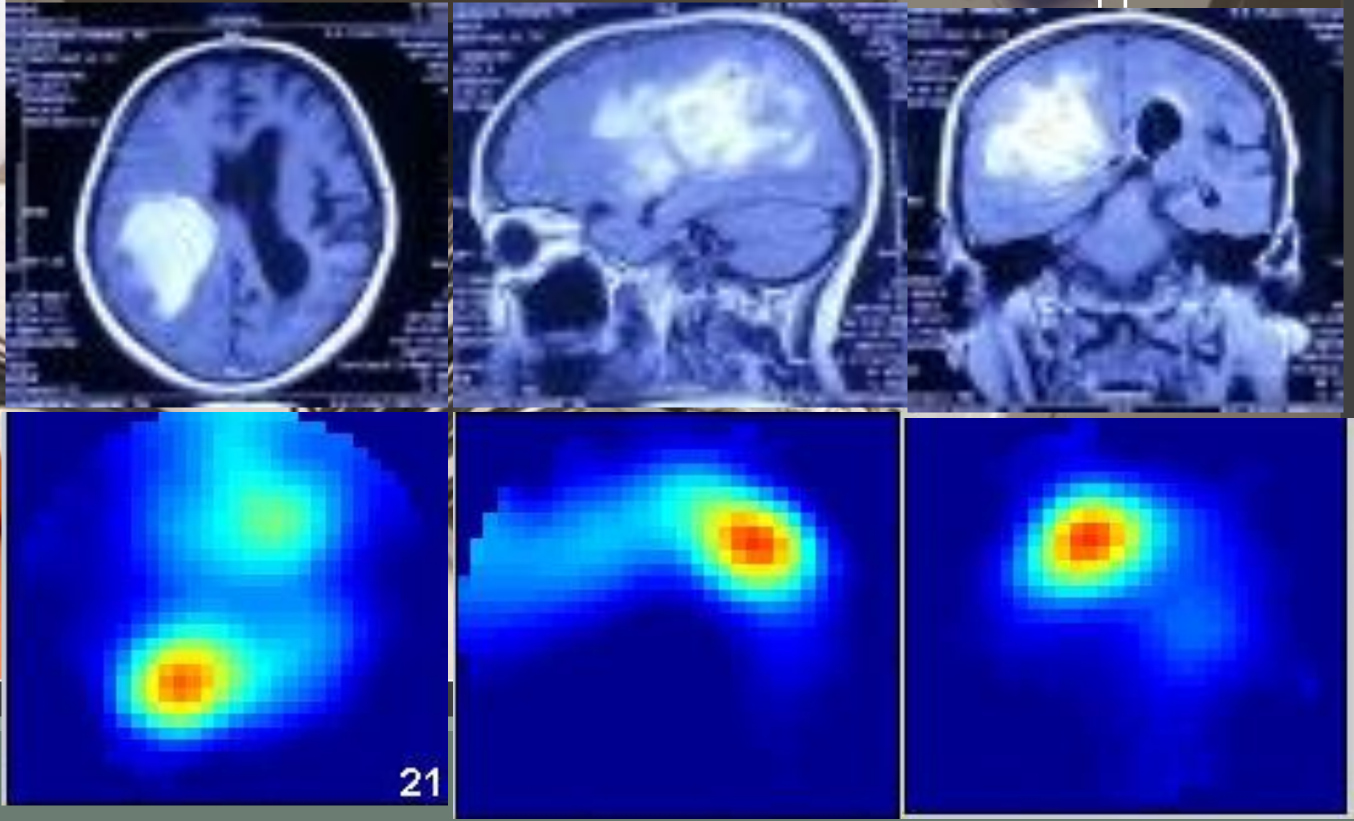


WORLD'S FIRST

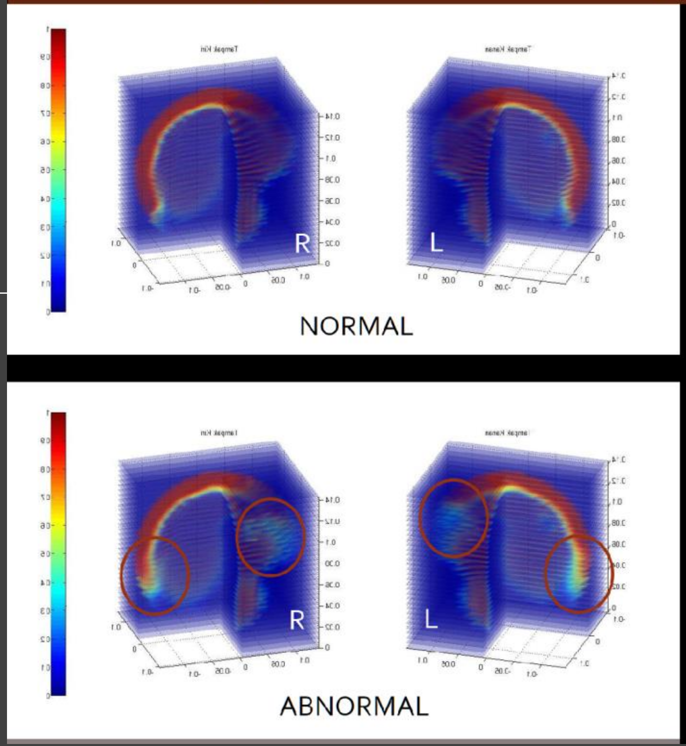
ECVT Brain

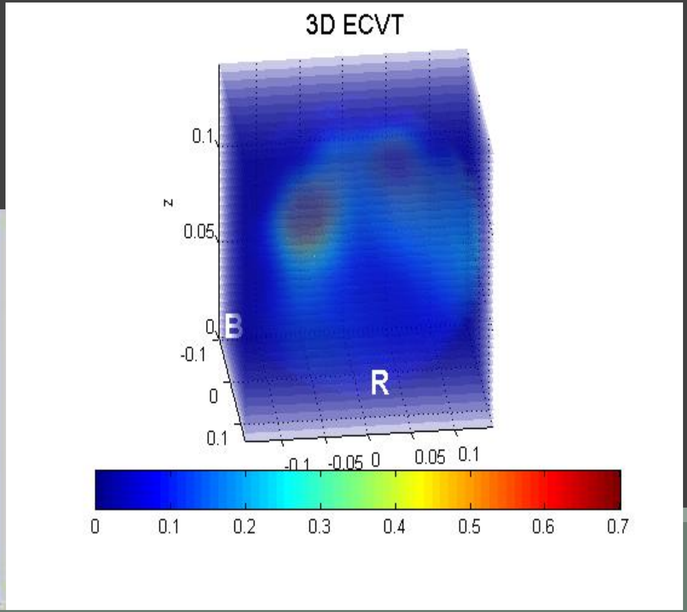
4D Brain Activity Scanner

ECVT Brain Scanner offers a low-cost, radiation-free, instantaneous detection of physiological abnormalities in the brain caused by tumors, epilepsy, Alzheimer's Disease and other brain dysfunctions. The technology opens new possibilities for neuroscience researches and other applications.



ECVT Image of Brain Activity





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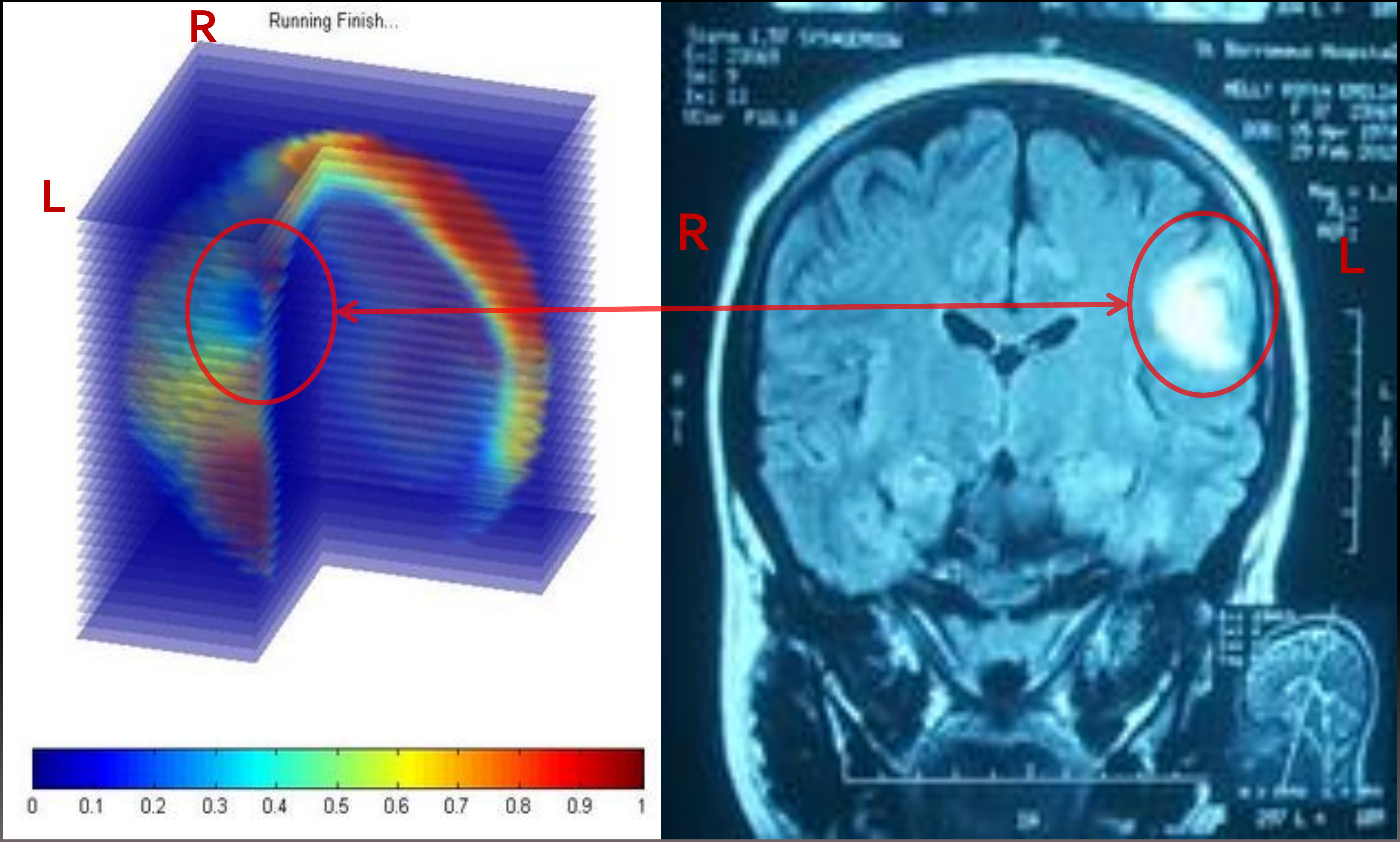
ECVT: Brain Cortical Electrical Activity



ECVT MRI

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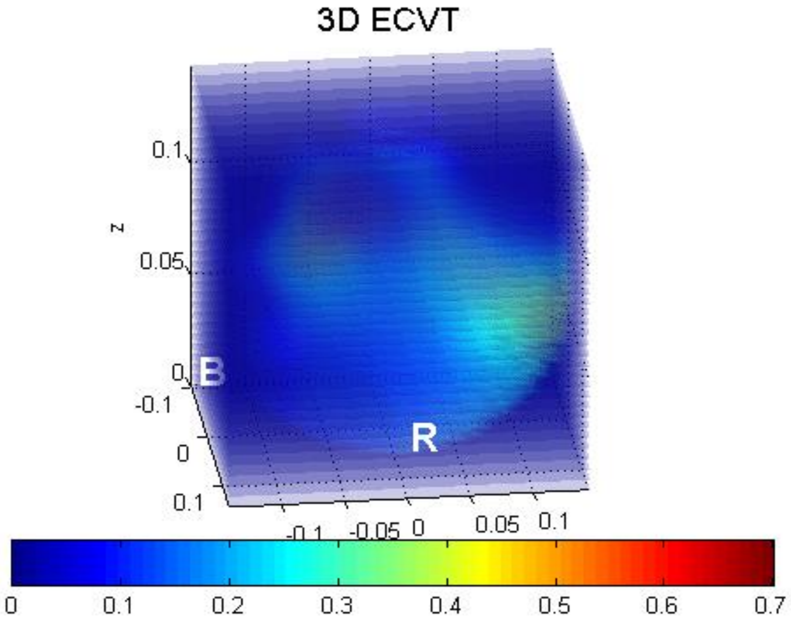
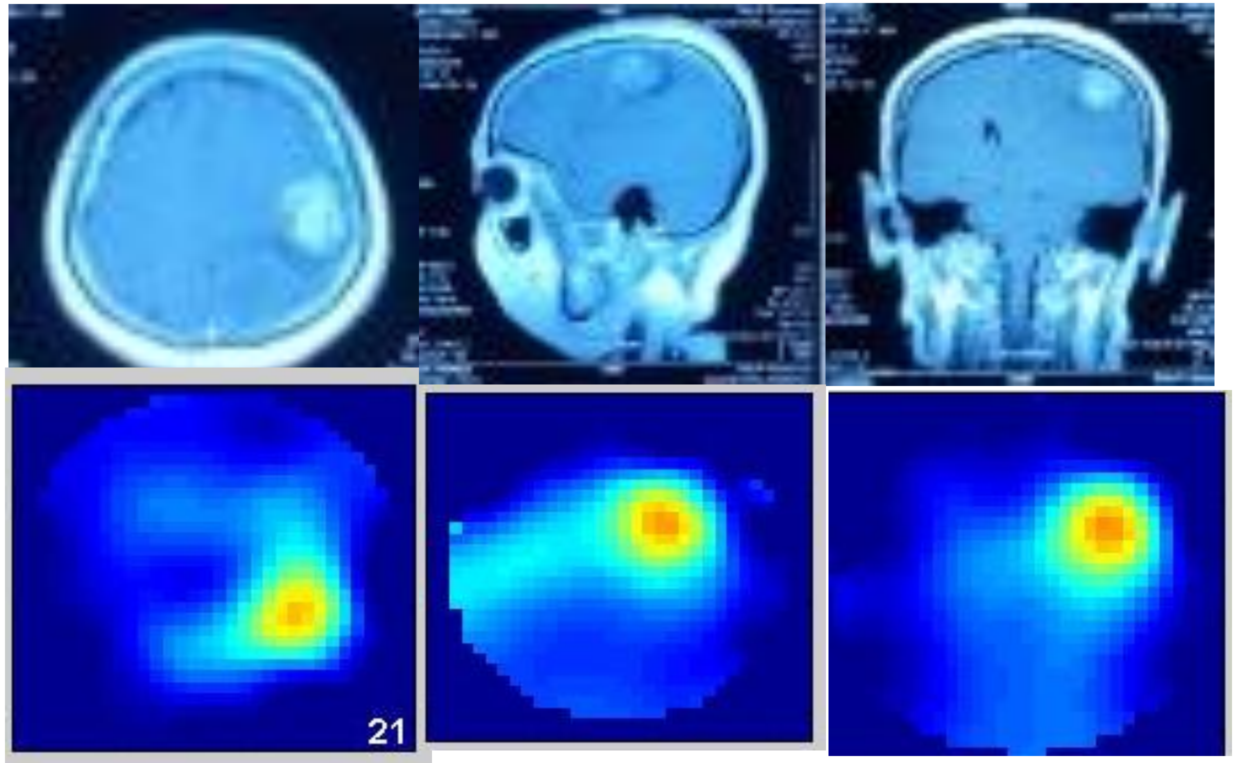
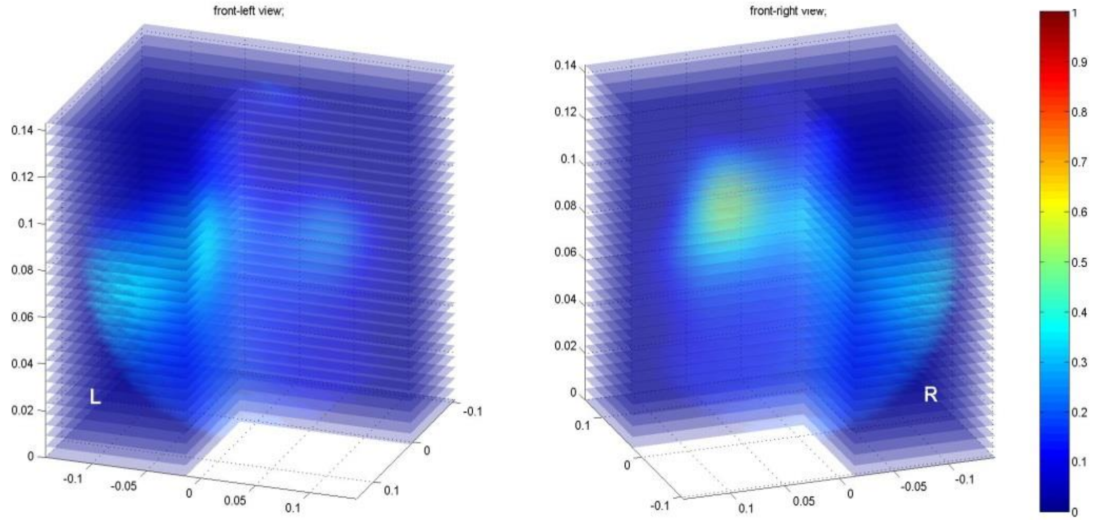
EDWAR TECHNOLOGY

C-TECH LABS
EDWAR TECHNOLOGY

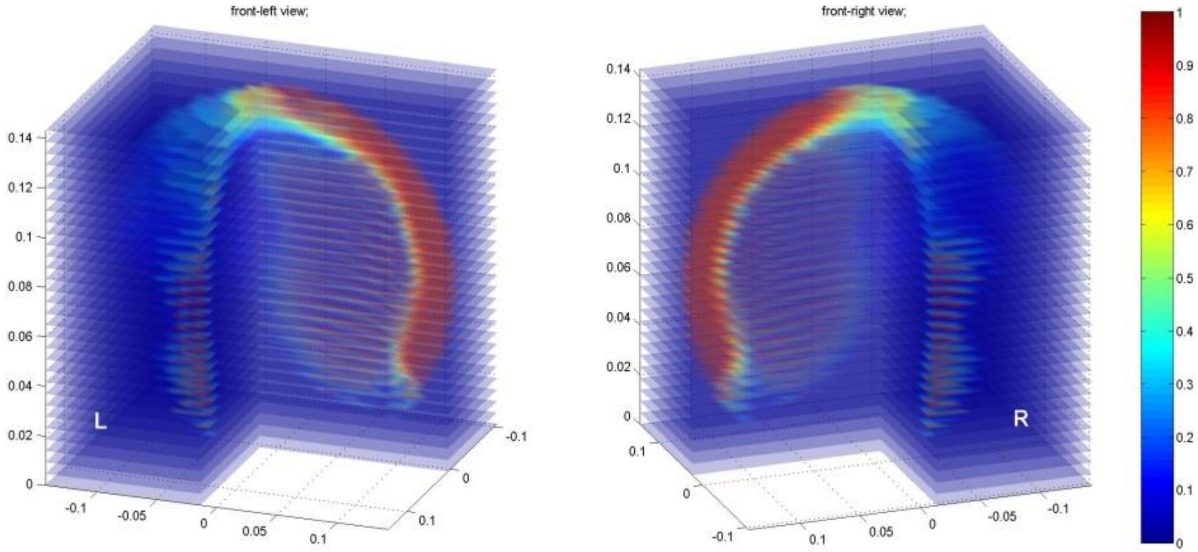
CASE: Brain tumor at left cerebrum







Intracranial Brain Electrical Activity



Cortical Brain Electrical Activity

Applications for Cancer Treatment

ECCT=ELECTRO-CAPACITIVE CANCER THERAPHY

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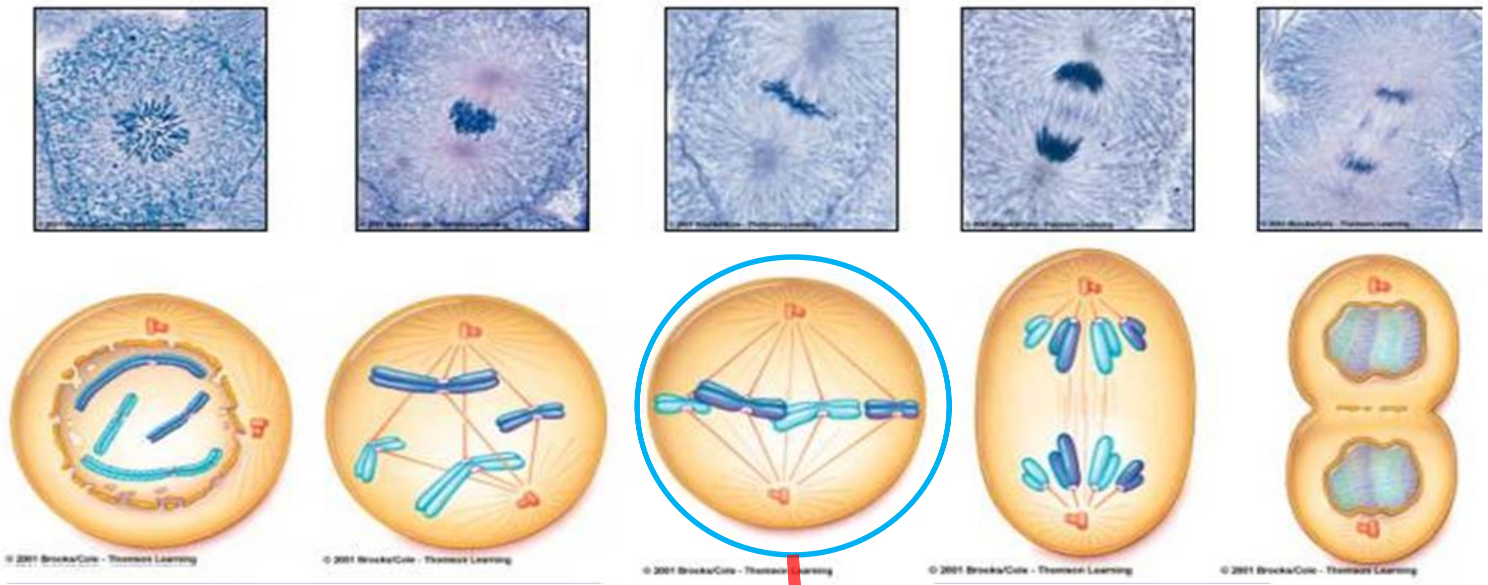
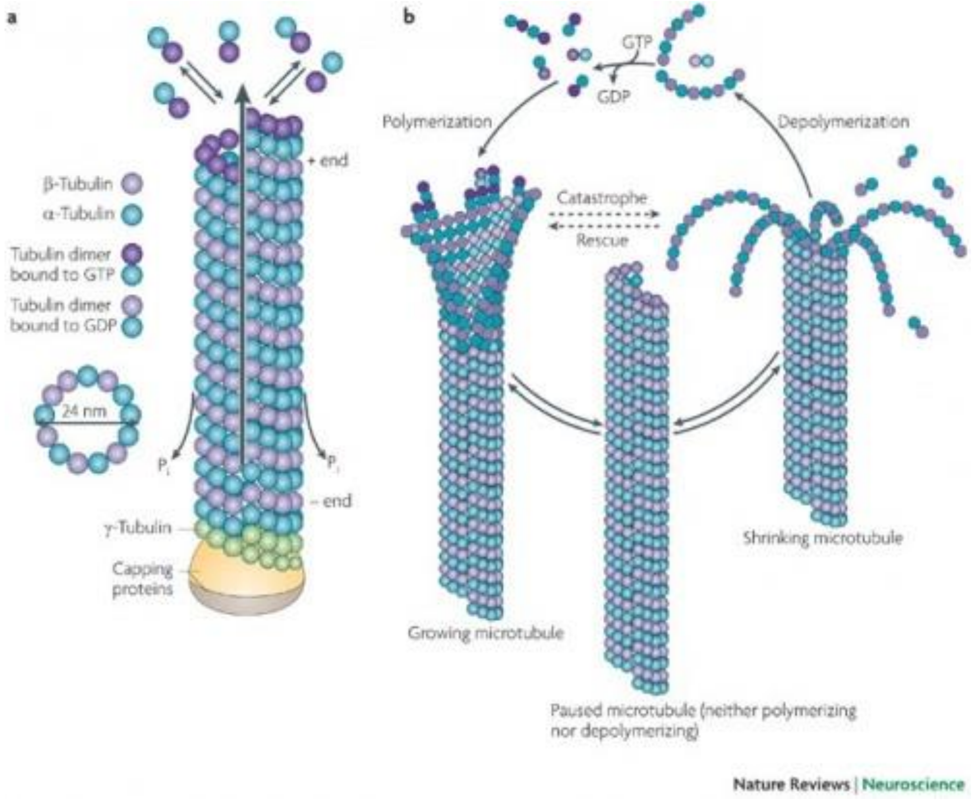
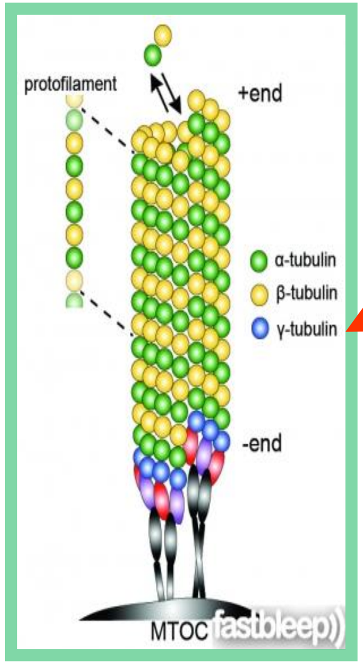
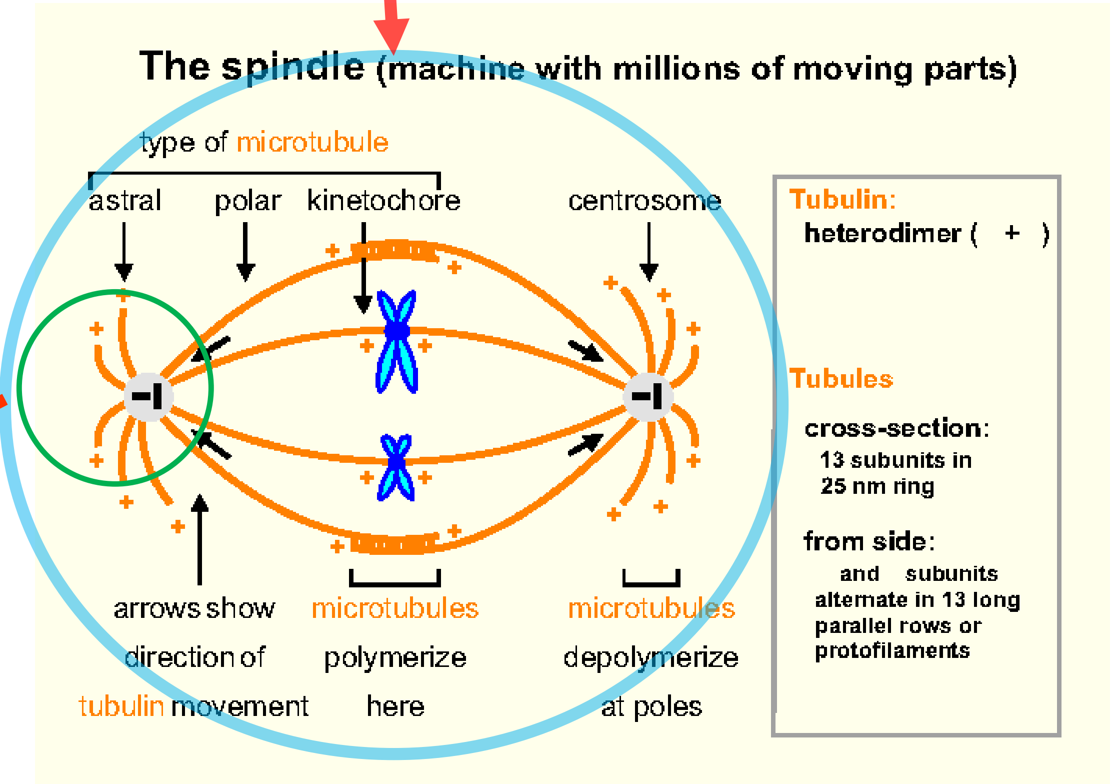
Cell Electricity during Mitosis

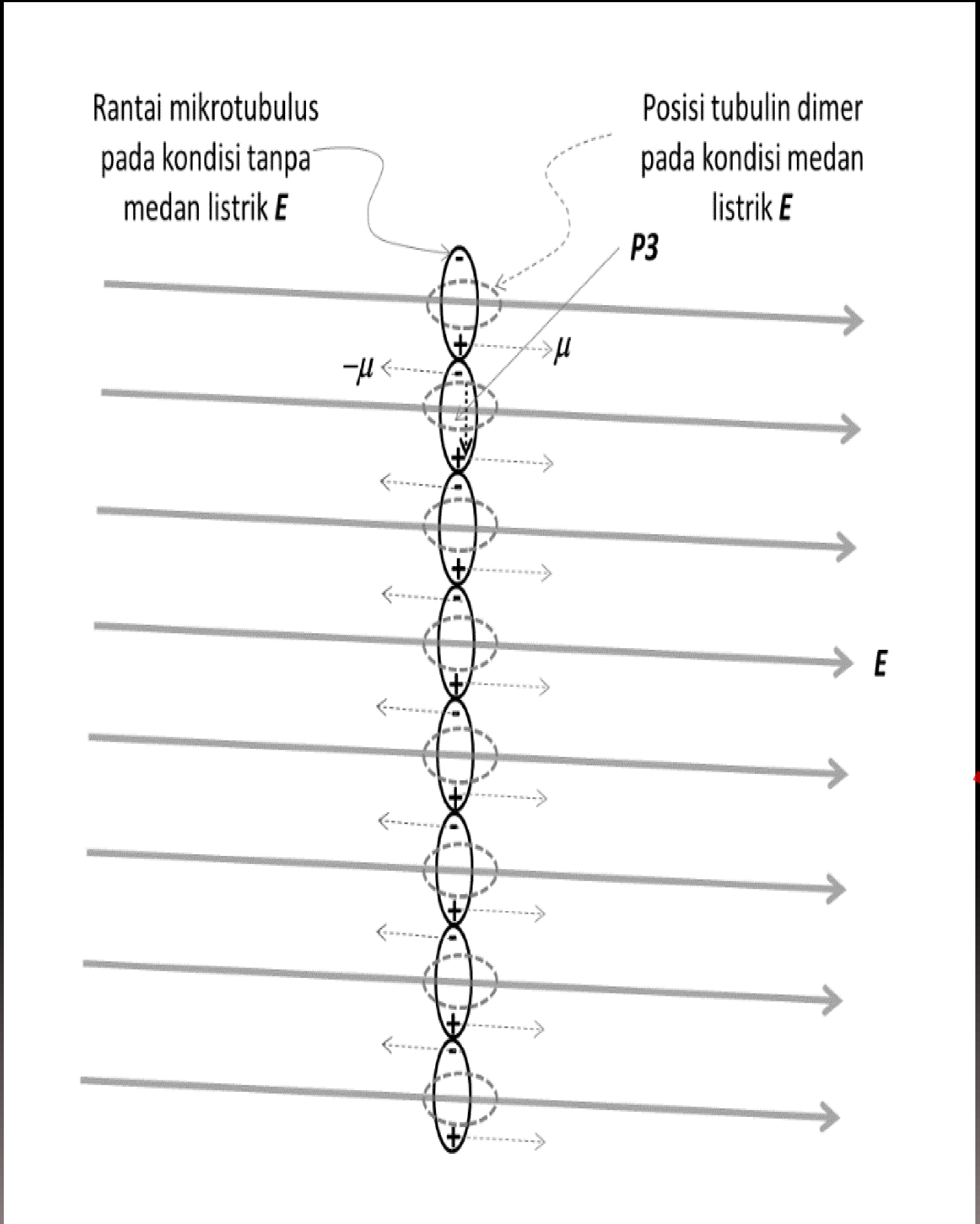








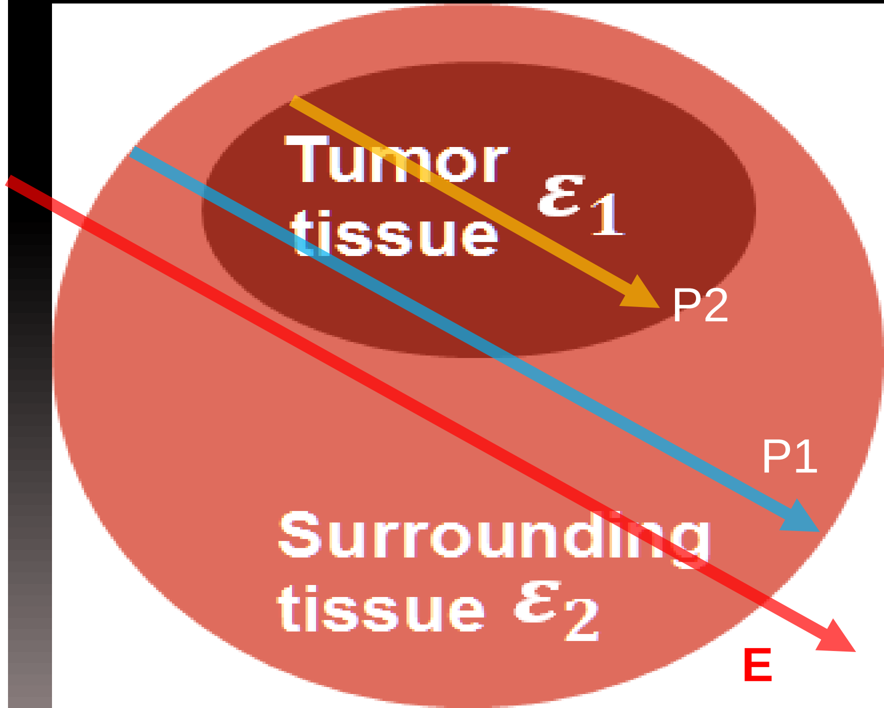
Principles of ECCT



$$\mu = \vec{P}_3 \times \vec{E}$$

$$|P_3| \propto |P_2| \propto \left(\frac{\varepsilon_1}{\varepsilon_2}\right) |E|$$

$$\mu \propto \left(\frac{\varepsilon_1}{\varepsilon_2}\right) |E|^2$$



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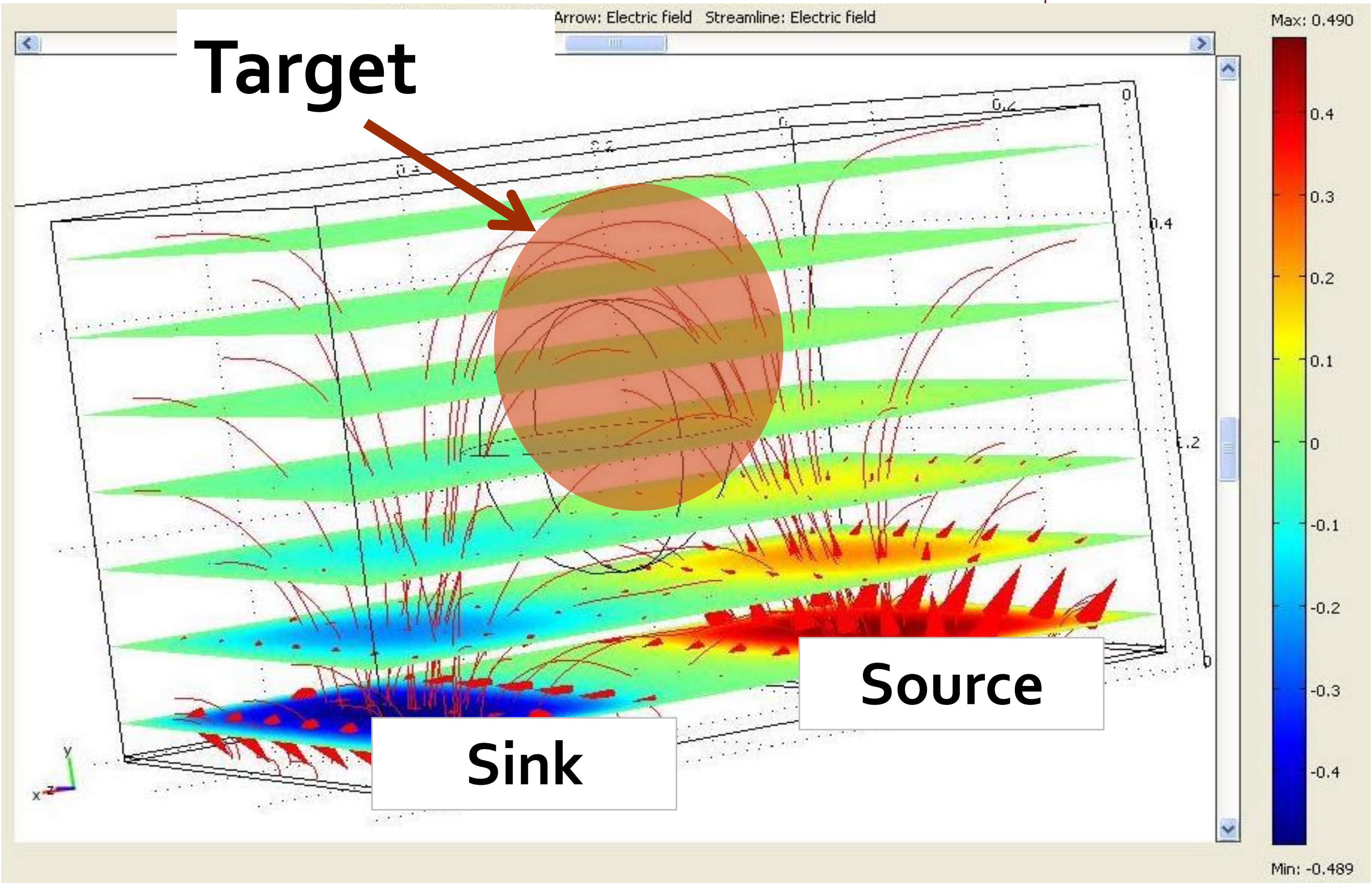
Principle of ECCT

ECCT: Electric stimulation (can be regarded as non-contact electric acupuncture) at the location of the target using one pair of capacitive electrode attached outside of the scalped.

$$\nabla\cdot(\varepsilon+\sigma)\mathbf{E}=\rho$$



ε : Permittivity

σ : Conductivity

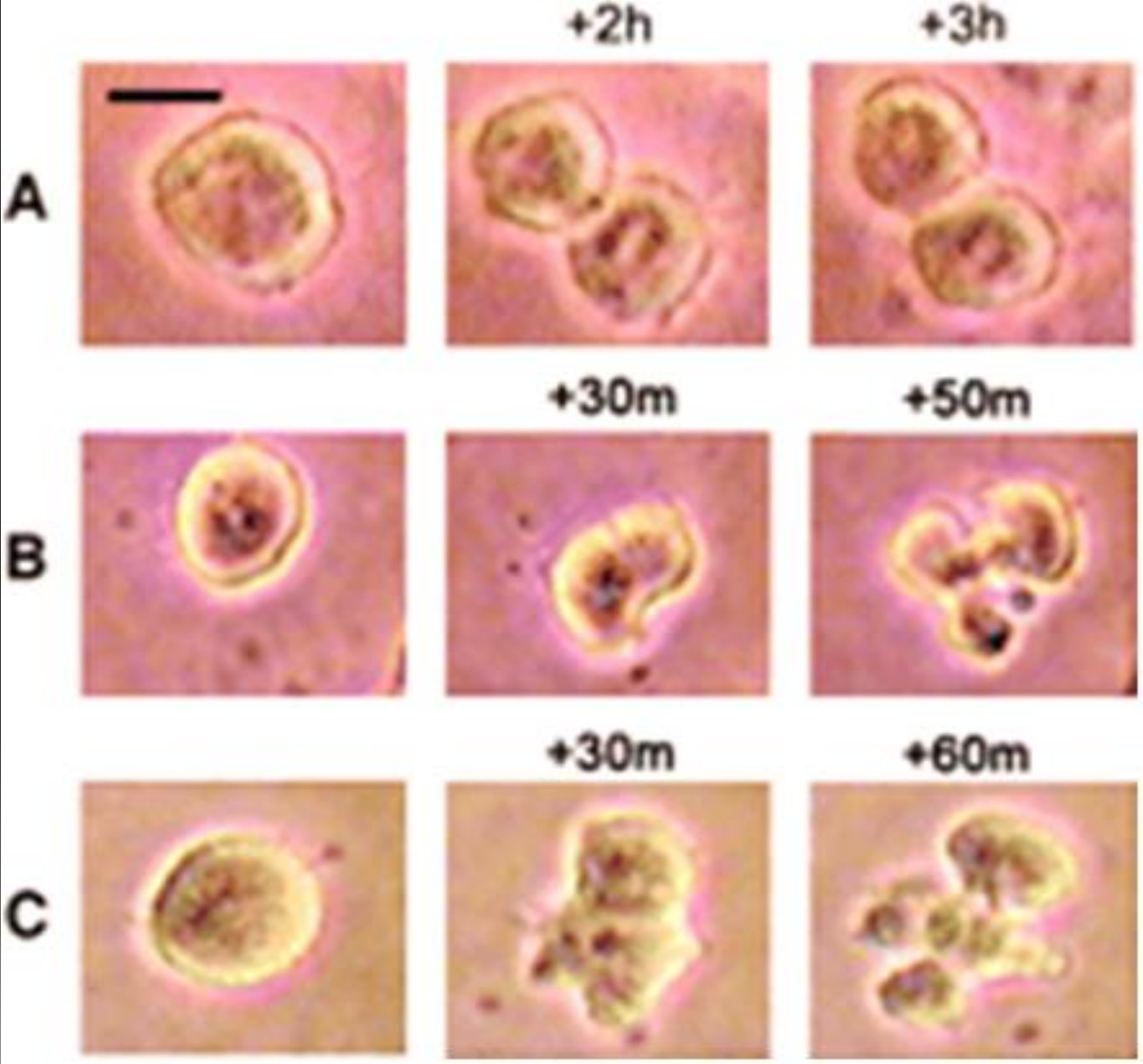
$\mathbf{E}$: Electrical field intensity (V/m)

ρ : charge density

Effect of electrical field on cancer cell growths

(High voltage, using quasi-conductive electrode)
(Yoram & Palti, 2004)

Electrical field inhibiting cell growth (A); Splitting cell destroyed under electrical field (B,C)



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What difference from TTF (Optune Co.) Method?

ECCT

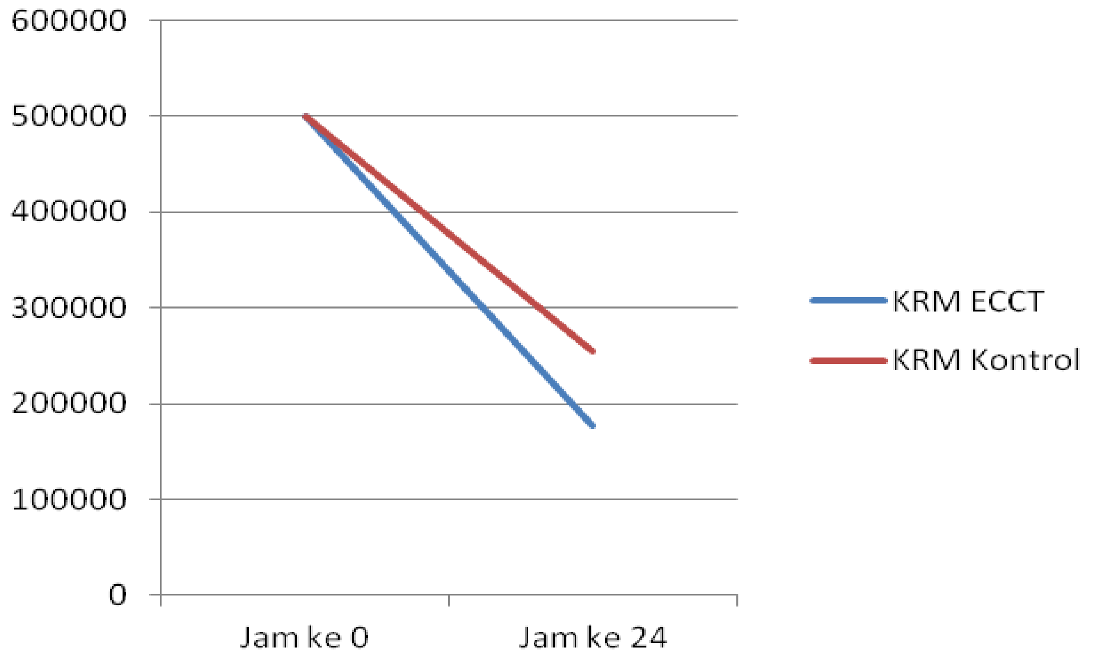
- Capacitive (pure electric field, no current)
- Completely Non-contact
- Penetrating through air layers
- Low voltages (<50Vpp)
- Effective to air-contact or interfacial tumors (not good to bulk solid tumor)

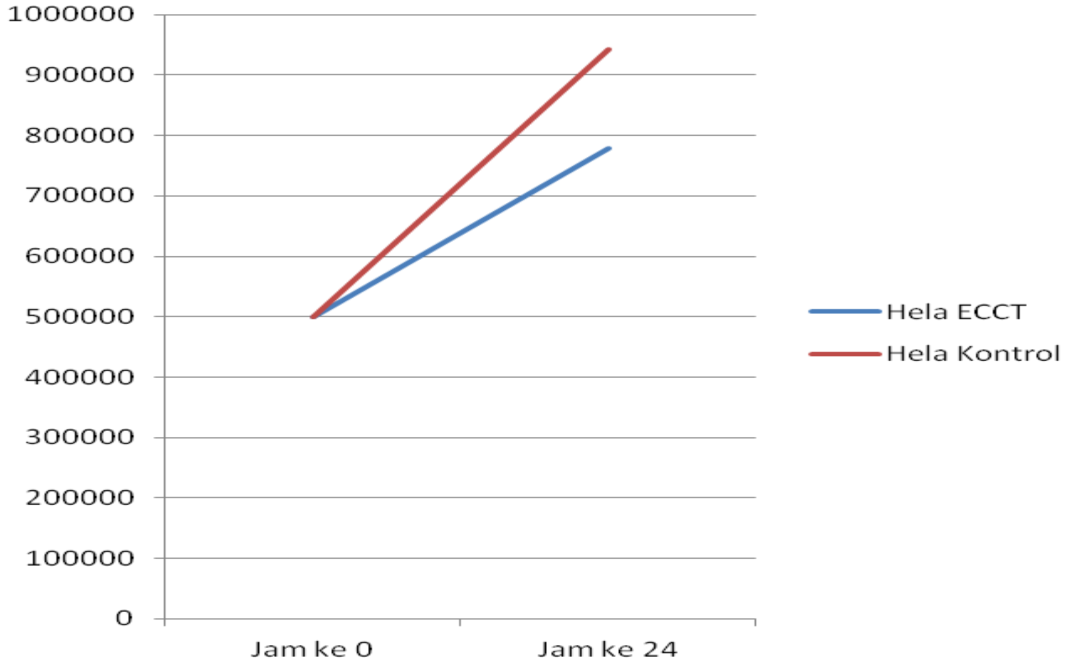
NovoCure

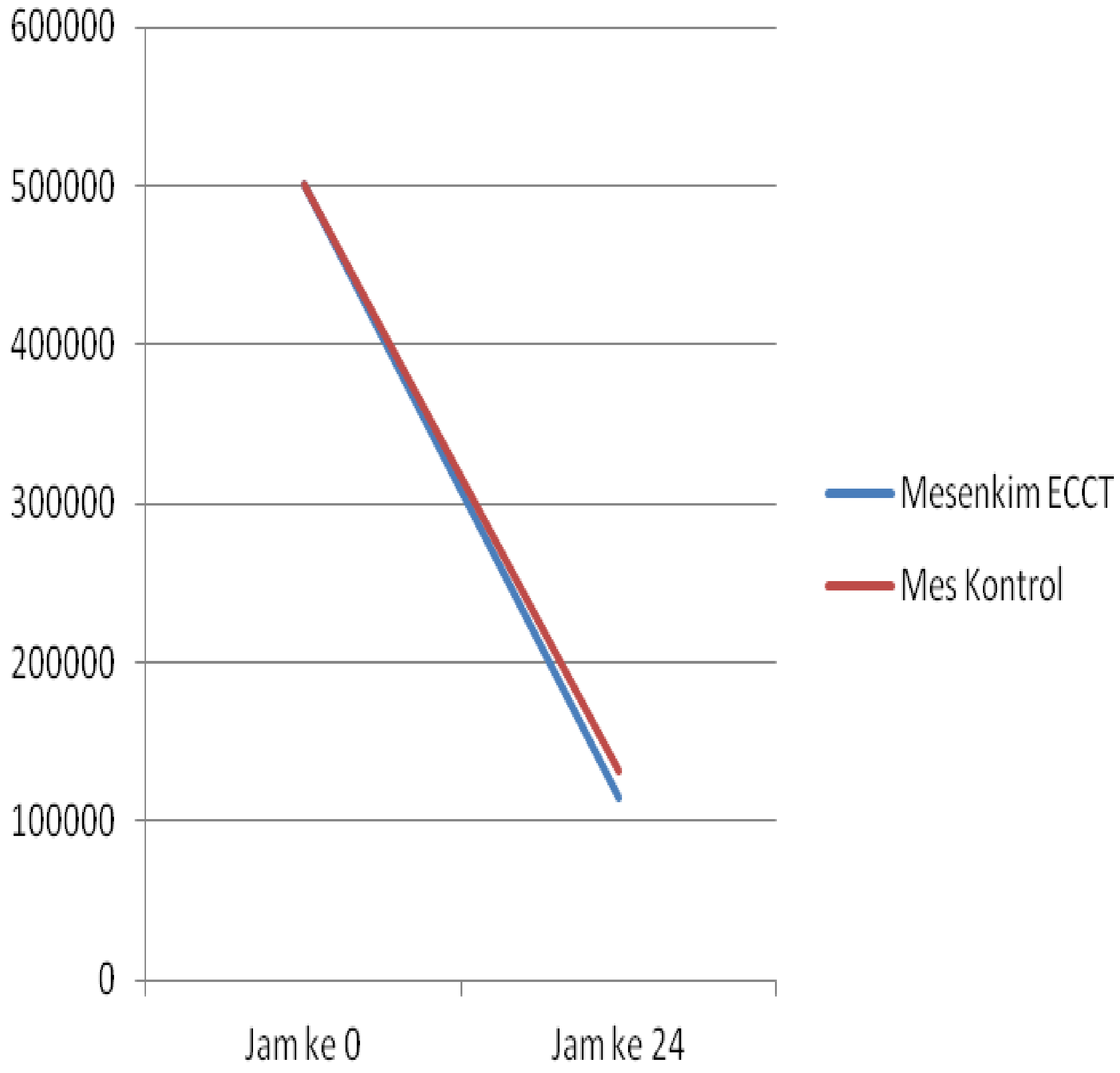
- Quasi-Electrostatic (quasi-conductive, electric field containing current)
- Using high-conductive ceramic electrodes with direct contact to skin
- No-air layer permitted
- Higher voltages (>50V)
- Work only to bulk solid tumor (Not possible for air-contact tumor)

TTF (NovoCure)

Cell Viability (Sahudi, 2015)







In Vivo Tests

(Alamsyah et al, 2015)

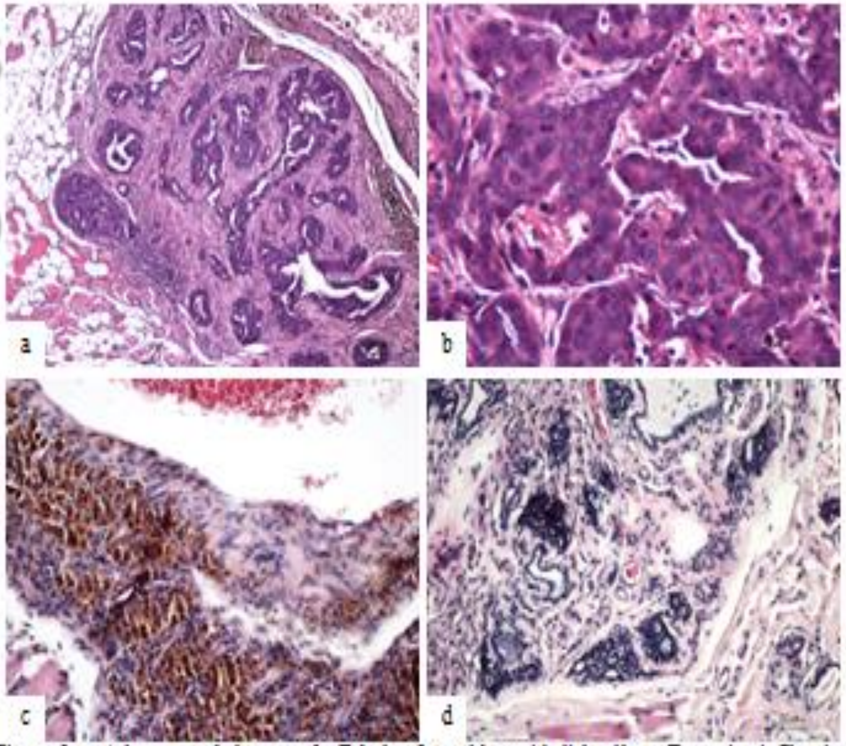


Figure 5. a. Adenoma, tubular type. b. Tubules formed by epithelial cells. c. Extensive infiltration of macrophage with hemosiderin accumulation on the wall of the blood vessel. d. The infiltration of lymphocytes around the blood vessels.

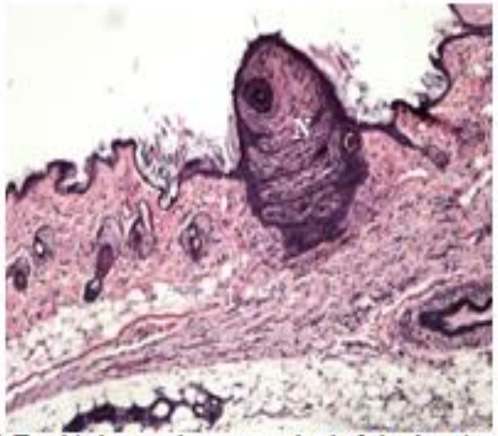


Figure 6. The skin layer and mammary gland of placebo mice; N, nipple

Test on C3H mice (*Mus musculus*) animal model:

Inoculation of tumor cells from C3H donor sized of 8.59-10.91 mm in length.

After 2 weeks of exposure to external electric field:

Placebo mice were physically normal; Tumorous mice: 67% shrinkage in size.

Physiological effects *in vivo* experiment:

No changes in the rate or regularity of cardiac and breathing rhythm, no significant changes in the complete blood count of the tumour-implanted and placebo mice.

Histopathological analysis:

inflammation in the area of breast cancer with macrophages and other immune cells infiltrate through the blood vessel (Fig. 5). No abnormality in the skin layer and mammary gland of placebo mice (Fig. 6).

Findings: Histopathological analysis shows how macrophages would digest any debris resulted from cancer cell destruction (Brooker et al., 2008).

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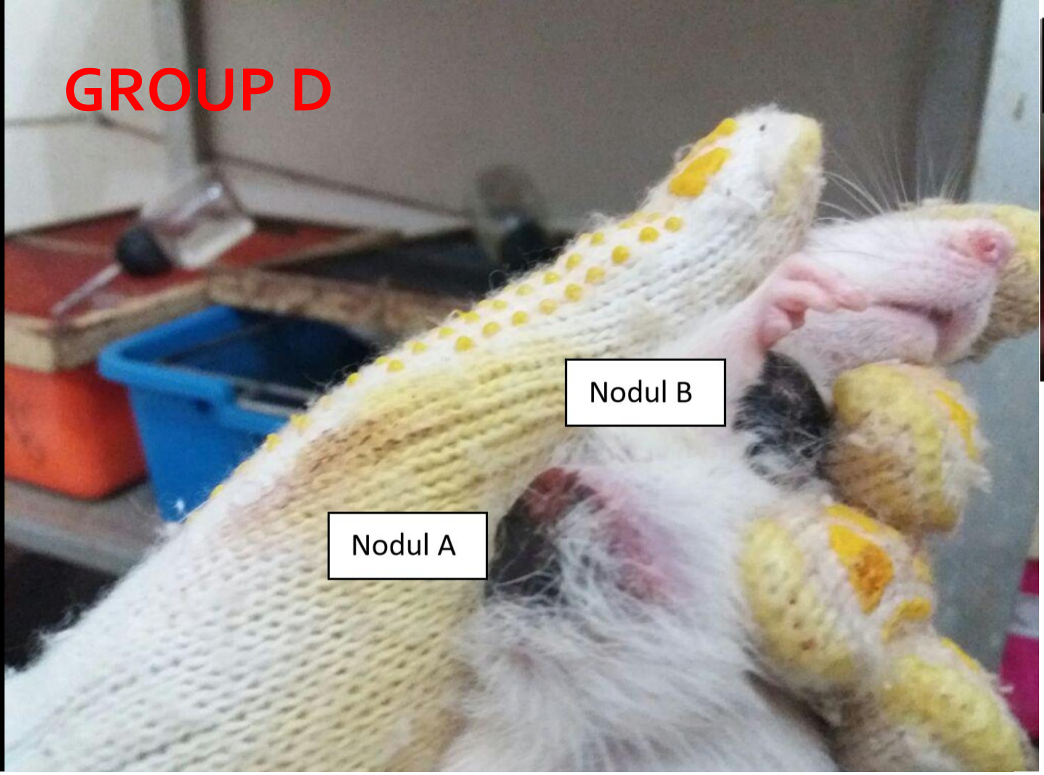
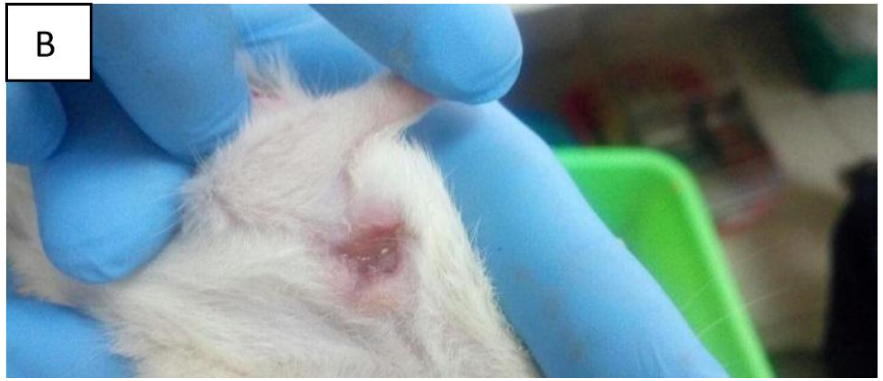
Cancer Death Mechanisms in Mice Test:

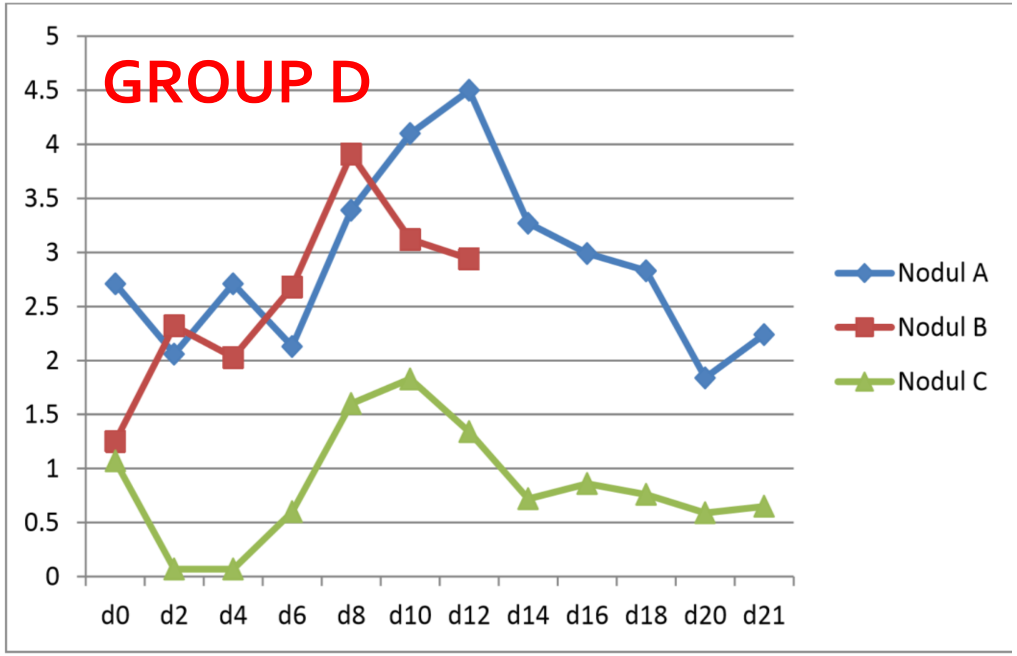
Group A: Cystic Type;

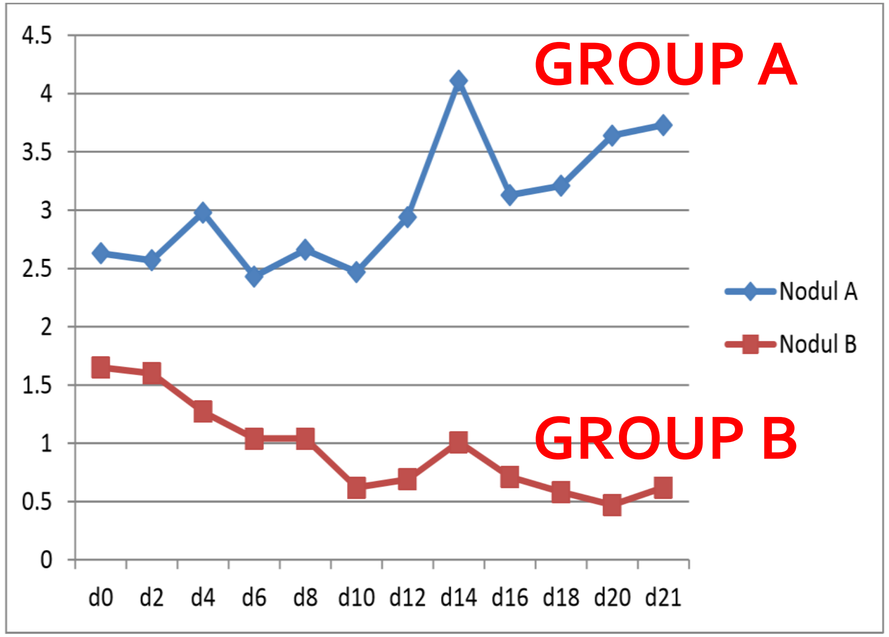
Group B: Complete Lysis/Opoptosis;

Group D: Slow Death (Senescence).

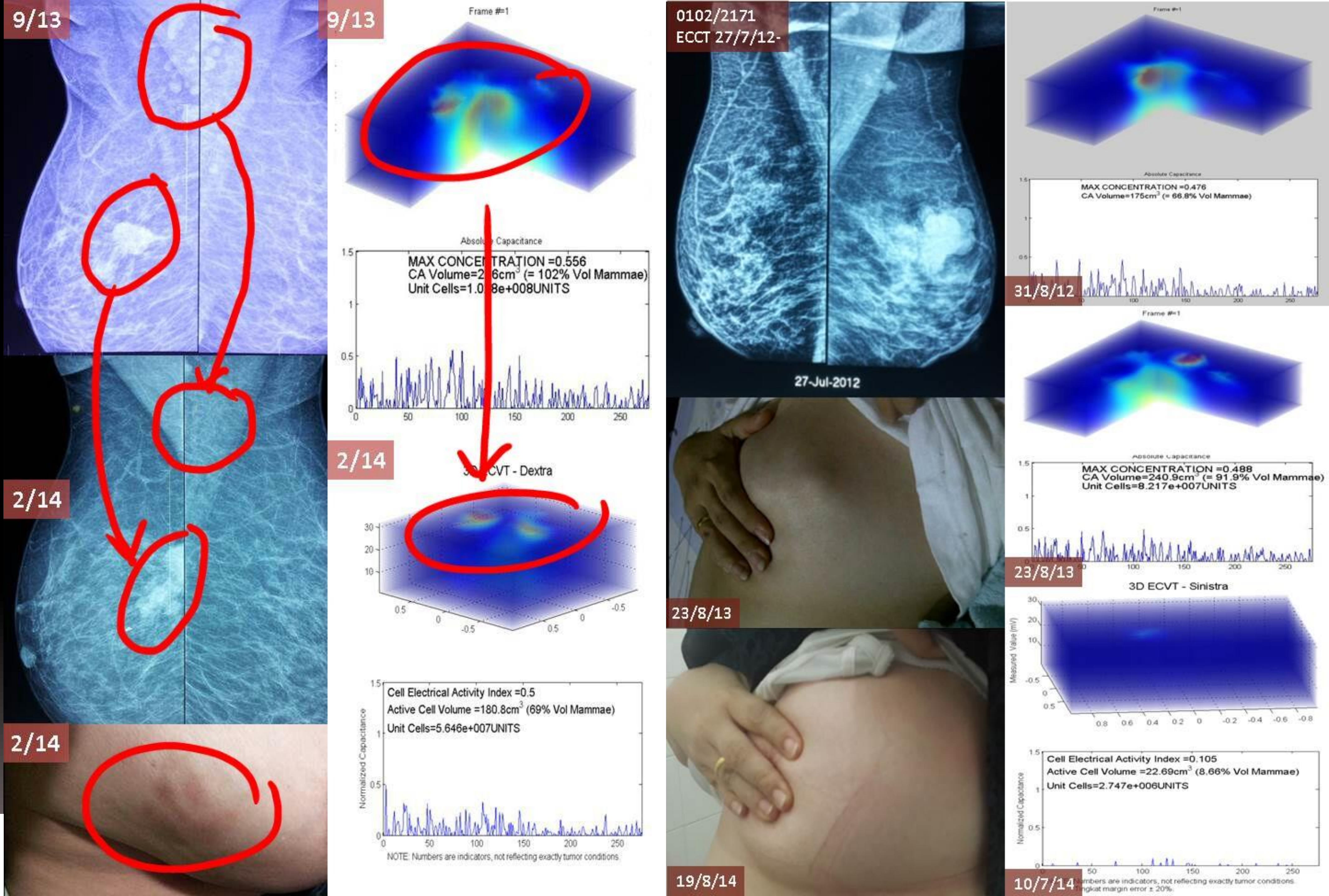








Radiology analysis of ECCT treatment



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ECCT Treatment for Advanced Metastasis Cancers