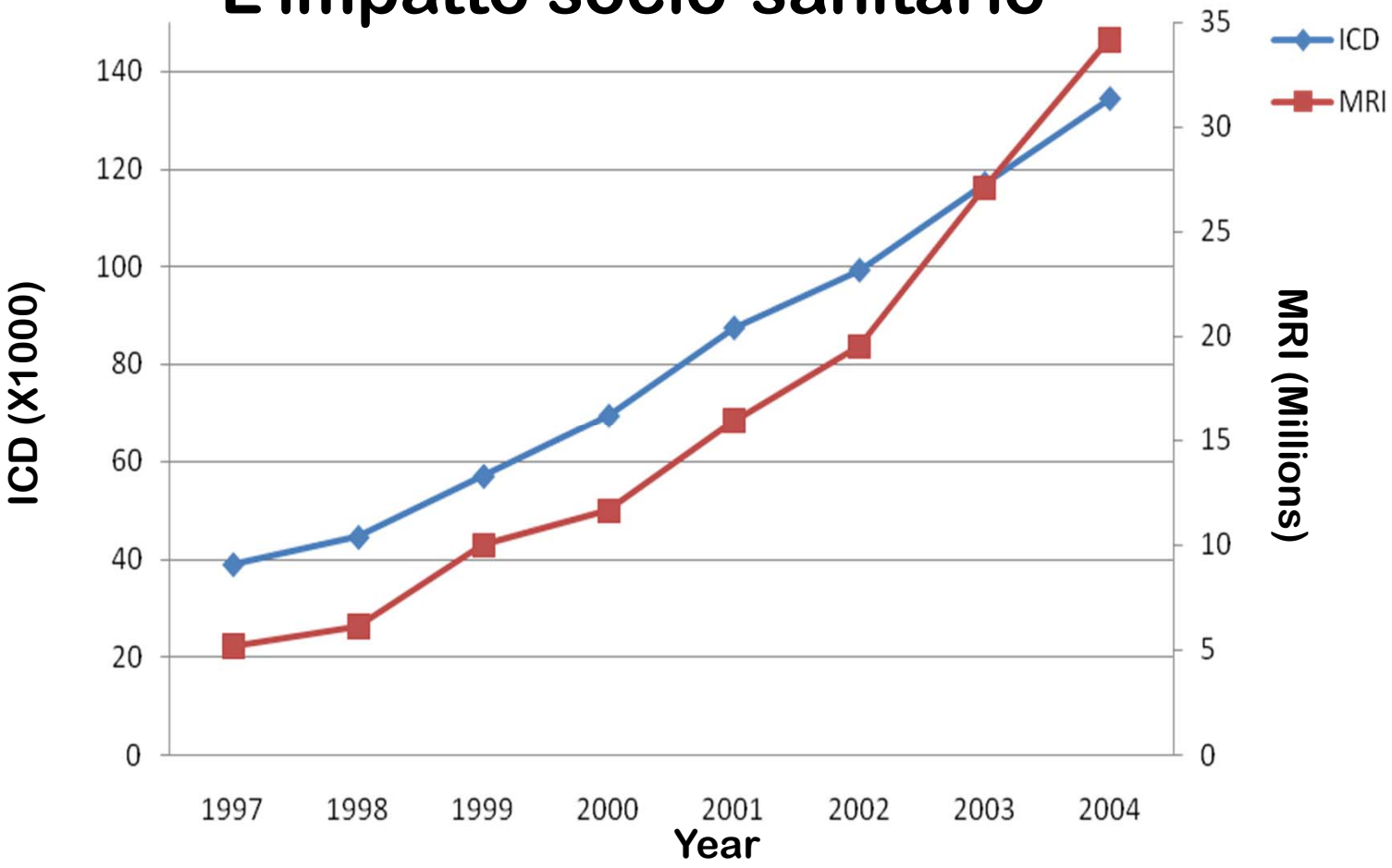
RISONANZA MAGNETICA E DISPOSITIVI MEDICI IMPIANTABILI ATTIVI

(pacemaker, defibrillatori, stimolatori neurali, impianti cocleari)

Reparto di Bioingegneria Cardiovascolare .

L’impatto socio-sanitario



“Each year, approximately 1 million people worldwide are implanted with a pacemaker, hundreds of thousands of whom may be able to benefit from an MRI scan. A study published in Circulation shows that an MRI procedure is requested by a physician for 17 percent of pacemaker patients within 12 months of device implant. Every three minutes in the U.S. and every six minutes in Europe, a patient is denied an MRI scan due to the presence of an implantable cardiac device” (Medtronic website)

Risonanza magnetica e dispositivo impiantabile attivo

- **Effetto meccanico:** → Momento torcente generato dal campo statico sulle componenti ferromagnetiche del dispositivo.
- **Effetto interferente:** → Alterazioni del corretto funzionamento del dispositivo ad opera del campo RF e di gradiente.
- **Effetto termico:** → Aumento della temperatura nei tessuti causato delle perdite resistive conseguenti al fenomeno di induzione di corrente sulle componenti metalliche del dispositivo da parte del campo RF.

Implantable Cardioverter Defibrillator Dysfunction During and After Magnetic Resonance Imaging

OLE-GUNNAR ANFINSEN, ROLF FRANCK BERNTSEN, HALFDAN AASS, ERIK KONGSGAARD, and JAN PEDER AMLIE
From the Department of Cardiology, Rikshospitalet, University Hospital of Oslo, Oslo, Norway

"Electromagnetic noise induced during the MRI was detected as ventricular fibrillation and nearly caused inappropriate shocks. Charge time during MRI was prolonged. The battery indicator switched to "end of life," but this was reversed by capacitor reformation. It is still uncertain whether radiofrequency current heating at the electrode tip caused the increased pacing threshold or if this would have occurred independently of the MRI"

J. of Pacing and Clin. Electr., Volume 25, No. 9 - 2005.

Do we need pacemakers resistant to magnetic resonance imaging?

Werner Irnich [a,*], Burkhard Irnich [b], Christine Bartsch [a], Wilhelm Alfred Stertmann [c], Hubert Gufler [b], Guenter Weiler [a]

"Neither inhibition of PM nor heating of the electrode poses real risks. So far, we have examined eight patients 12 times in MRI triggered mode without problems"

Europace 7, 353e365 - 2005.

***November 17, 2008**: the first pacemaker and lead system to be designed and tested in patients for safe use in MRI systems under specified conditions becomes commercially available in Europe and under clinical evaluation in the U.S.*

RISONANZA MAGNETICA E PACEMAKER/ICD

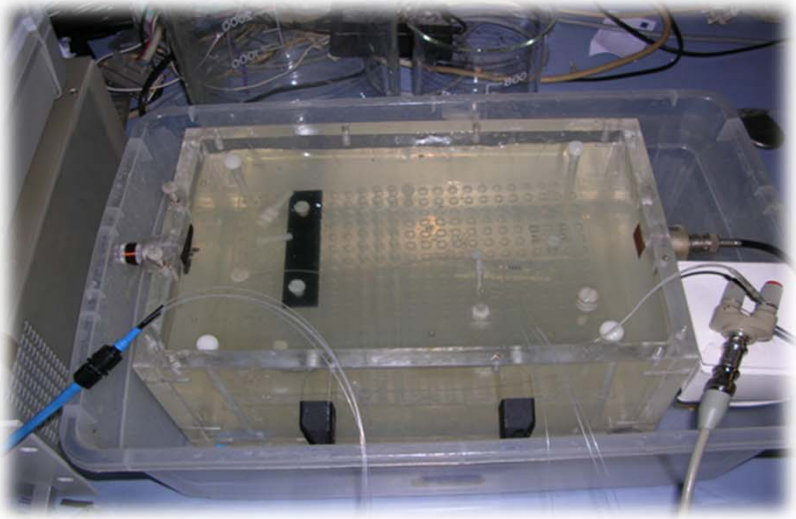
Riscaldamento indotto da campo RF su elettrocateteri

E. Mattei, M. Triventi, G. Calcagnini, F. Censi, W. Kainz, H. I. Bassen, P. Bartolini. Temperature and SAR measurement errors in the evaluation of metallic linear structures heating during MRI using fluoroptic® probes. Physics in Medicine and Biology, 2007 Mar 21;52(6):1633-46.

E. Mattei, M. Triventi, G. Calcagnini, F. Censi, W. Kainz, G. Mendoza, H. I. Bassen and P. Bartolini. Complexity of MRI induced heating on metallic leads: experimental measurements of 374 configurations. BioMedical Engineering OnLine 2008, 7:11.

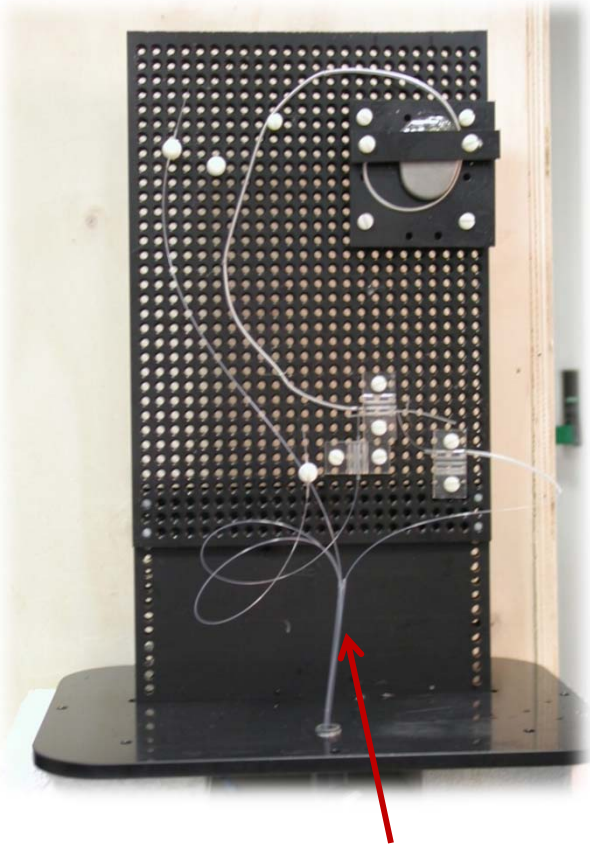
G. Calcagnini, M. Triventi, F. Censi, E. Mattei, P. Bartolini, W. Kainz, H. Bassen In-vitro investigation of pacemaker lead heating induced by magnetic resonance imaging: the role of the implant geometry. J Magn Reson Imaging. 2008 Oct;28(4):879-86.

- **Misure Sperimentali**



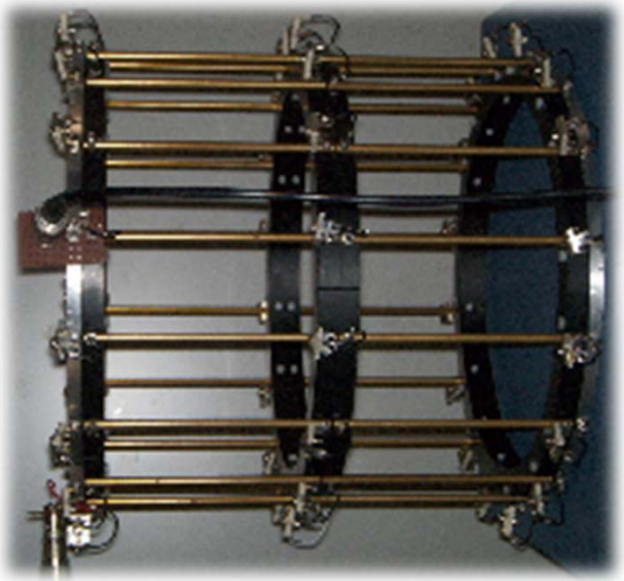
SIMULATORI DI TRONCO

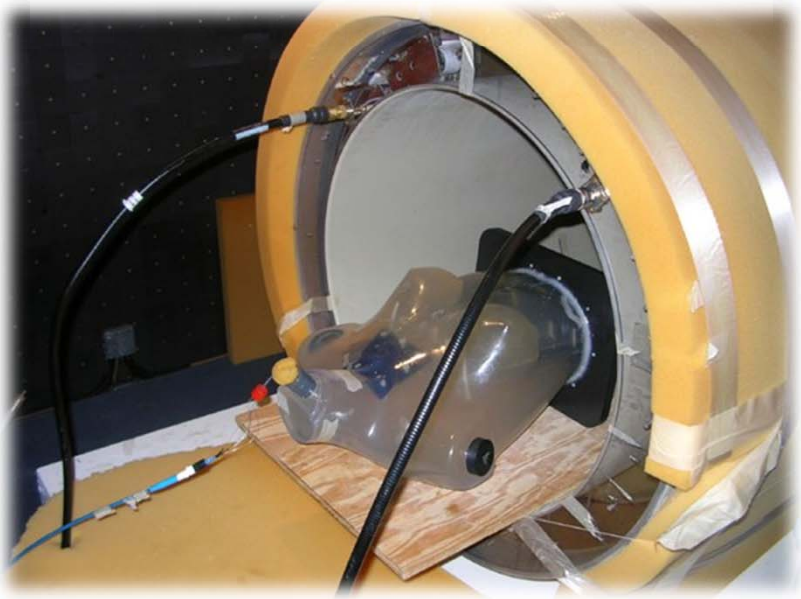
Simulatore di tronco allestito con una griglia in PVC per il fissaggio del pacemaker e per il posizionamento delle sonde di temperatura



Sonde in fibra ottica a fluorescenza (*Luxtron) per la* misura di temperatura in ambiente RF.

Simulatori di Tronco con PM posti all'interno di scanner di MRI clinici e da laboratorio (solo bobina RF)



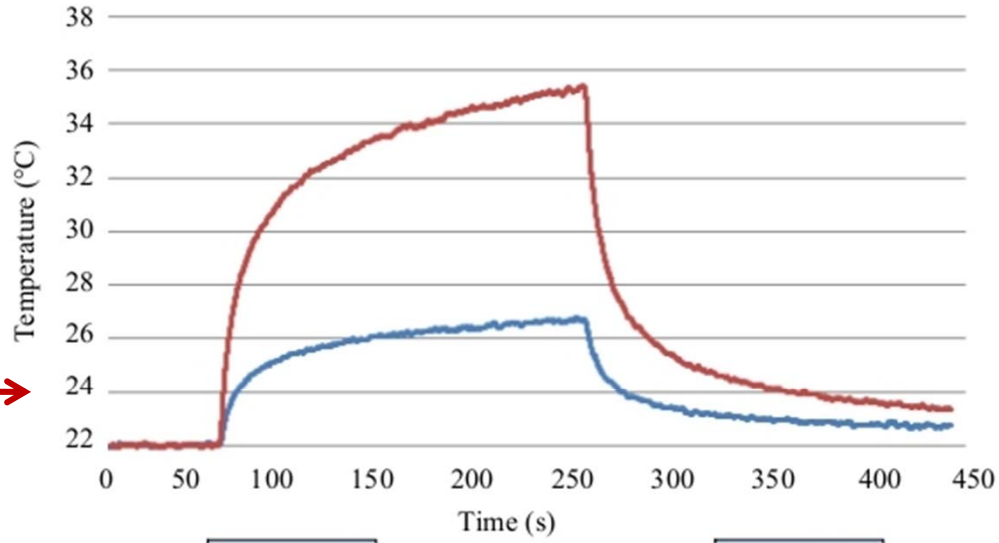


Food and Drug Administration

Center for Devices and Radiological Health

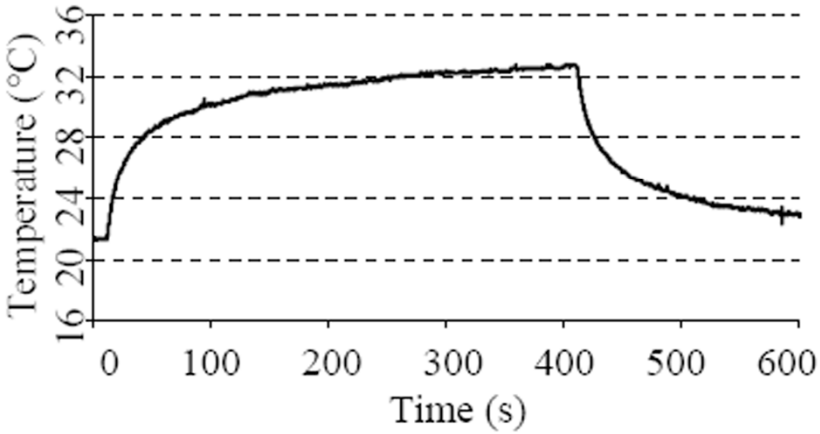
Esempi di incrementi di temperatura durante MRI

Fili metallici

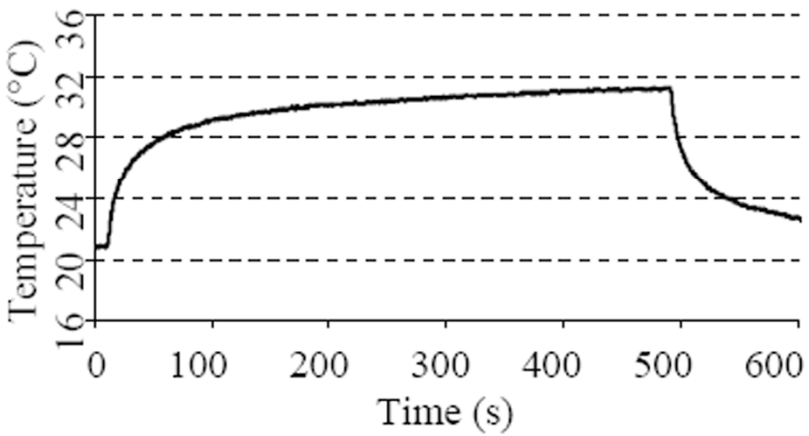


Elettrocateteri di PM

MRI SCANNER



MRI SIMULATOR



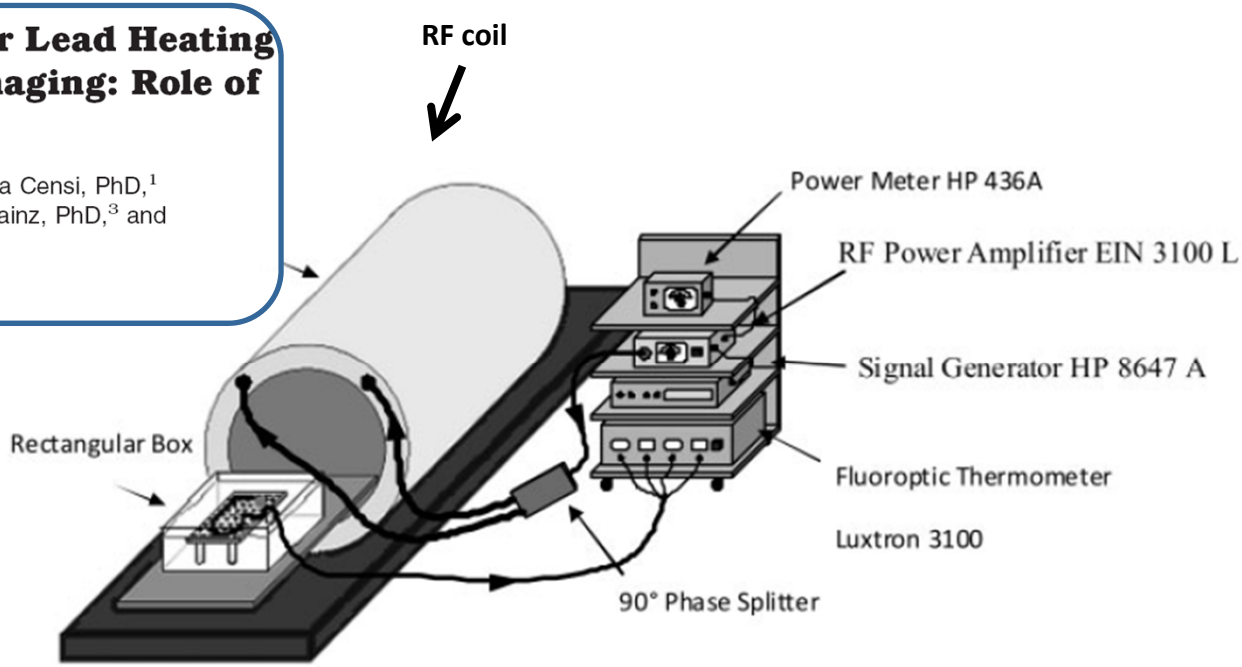
Riscaldamento in simulatori di bobina

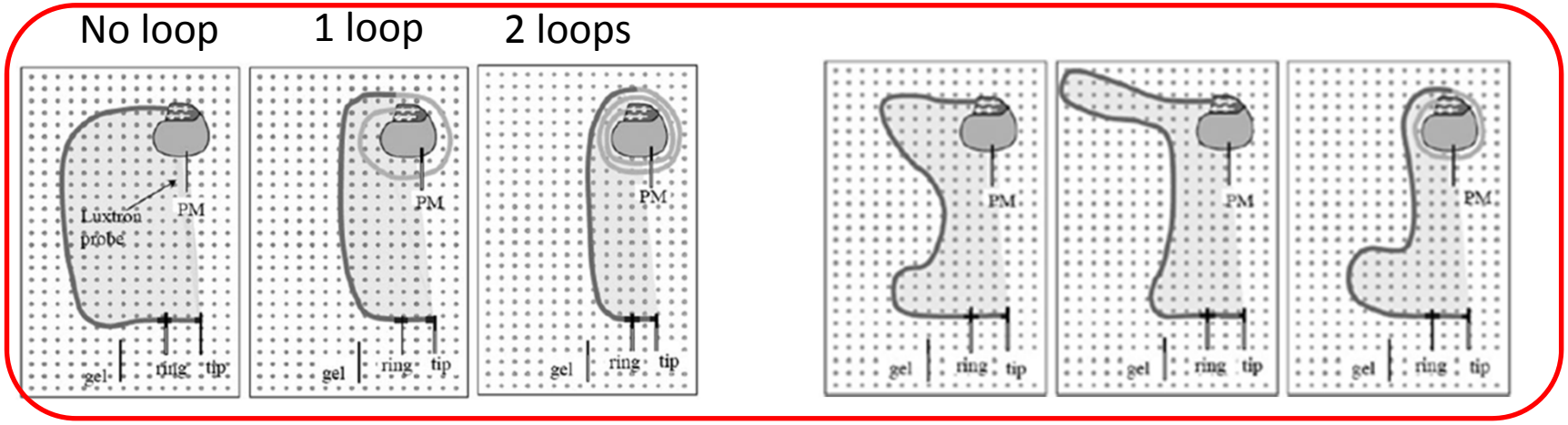
In Vitro Investigation of Pacemaker Lead Heating Induced by Magnetic Resonance Imaging: Role of Implant Geometry

Giovanni Calcagnini, PhD,[1*] Michele Triventi, EEng,[1] Federica Censi, PhD,[1] Eugenio Mattei, EEng,[1,2] Pietro Bartolini, EEng,[1] Wolfgang Kainz, PhD,[3] and Howard I. Bassen, EEng, MS[3]

JOURNAL OF MAGNETIC RESONANCE IMAGING 28

1° setup:
fantoccio parallelepipedo
Bobina RF



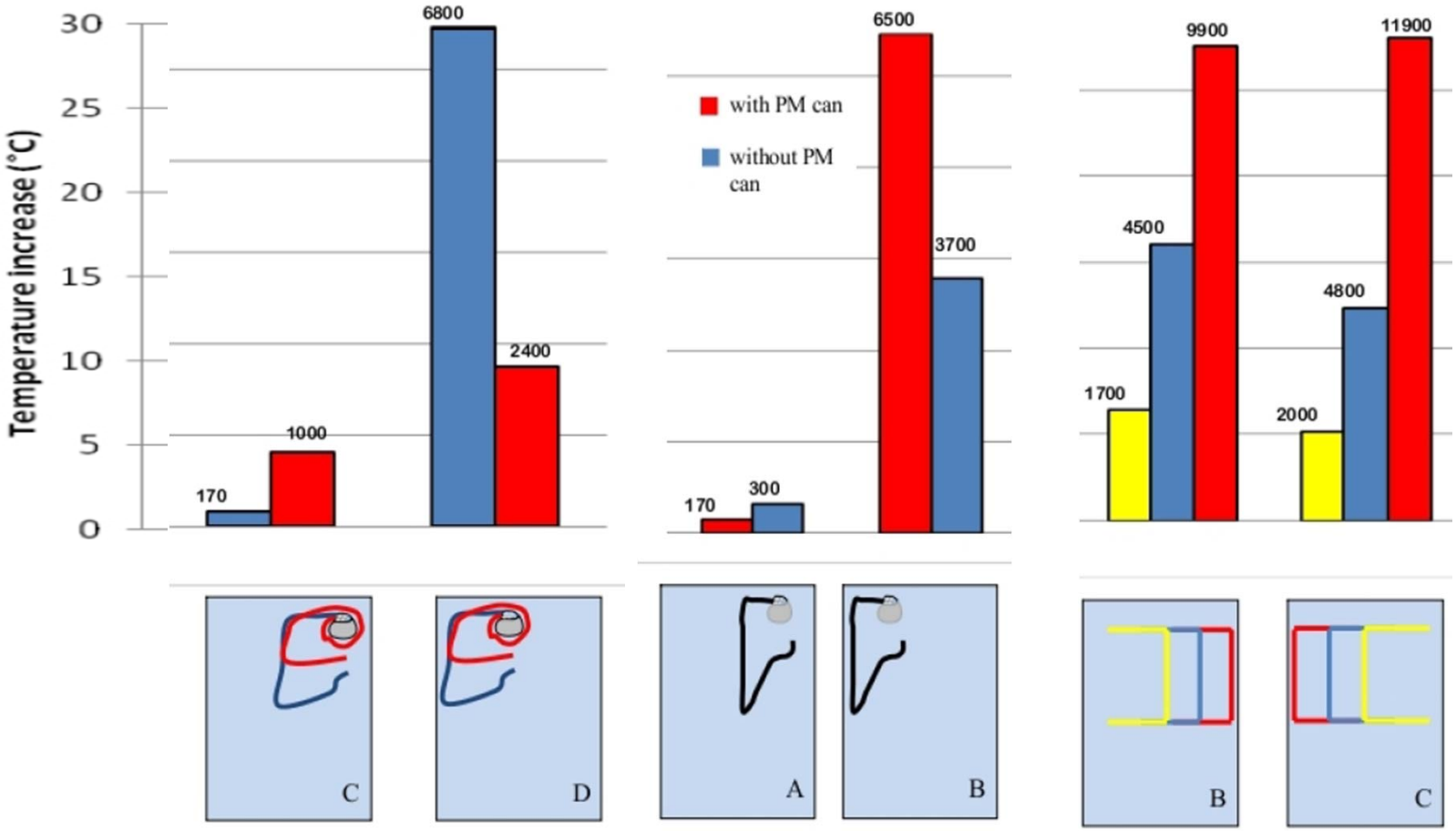


Riscaldamento in simulatori di bobina

Complexity of MRI induced heating on metallic leads: Experimental measurements of 374 configurations

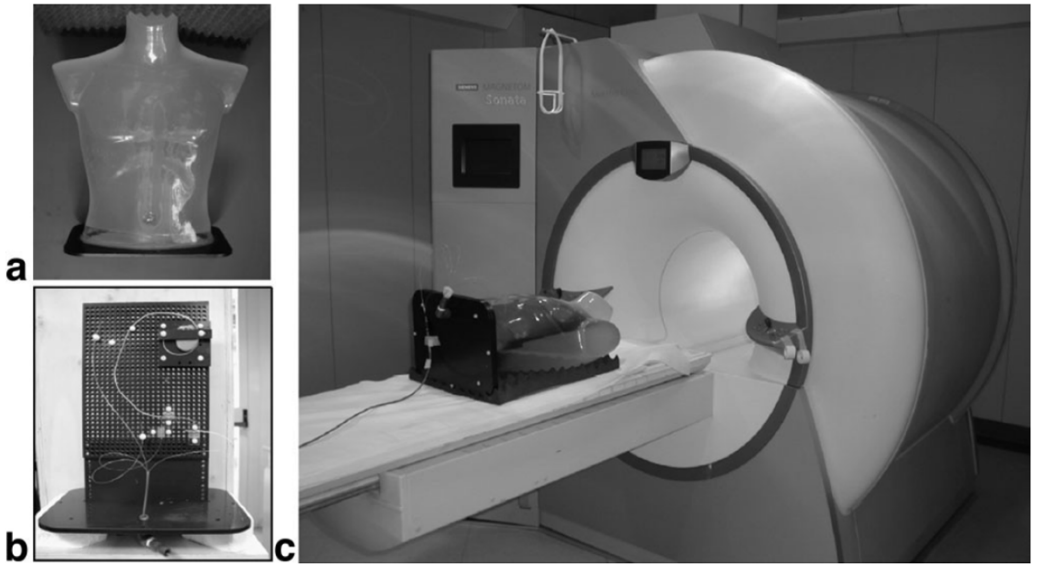
Eugenio Mattei*[1], Michele Triventi[1], Giovanni Calcagnini[1], Federica Censi[1], Wolfgang Kainz[2], Gonzalo Mendoza[2], Howard I Bassen[2] and Pietro Bartolini[1]

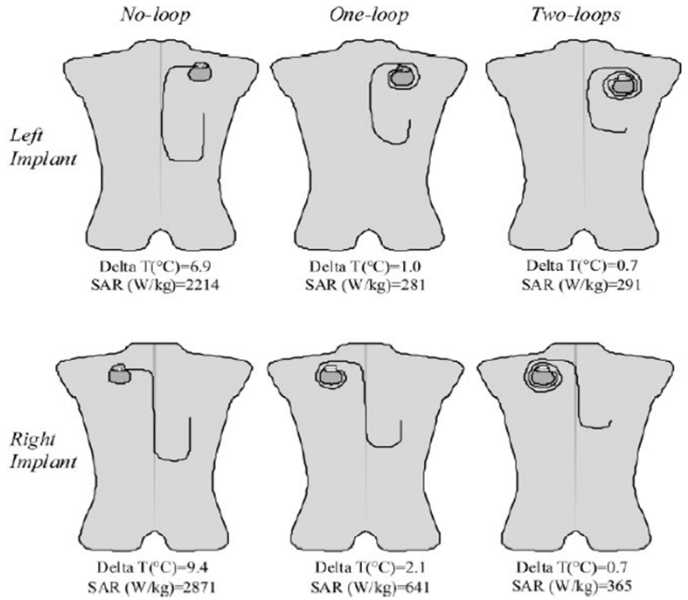
BioMedical Engineering OnLine 2008, **7**:11



Riscaldamento in sistemi clinici MRI

2° setup:
fantoccio antropomorfo
RM commerciale



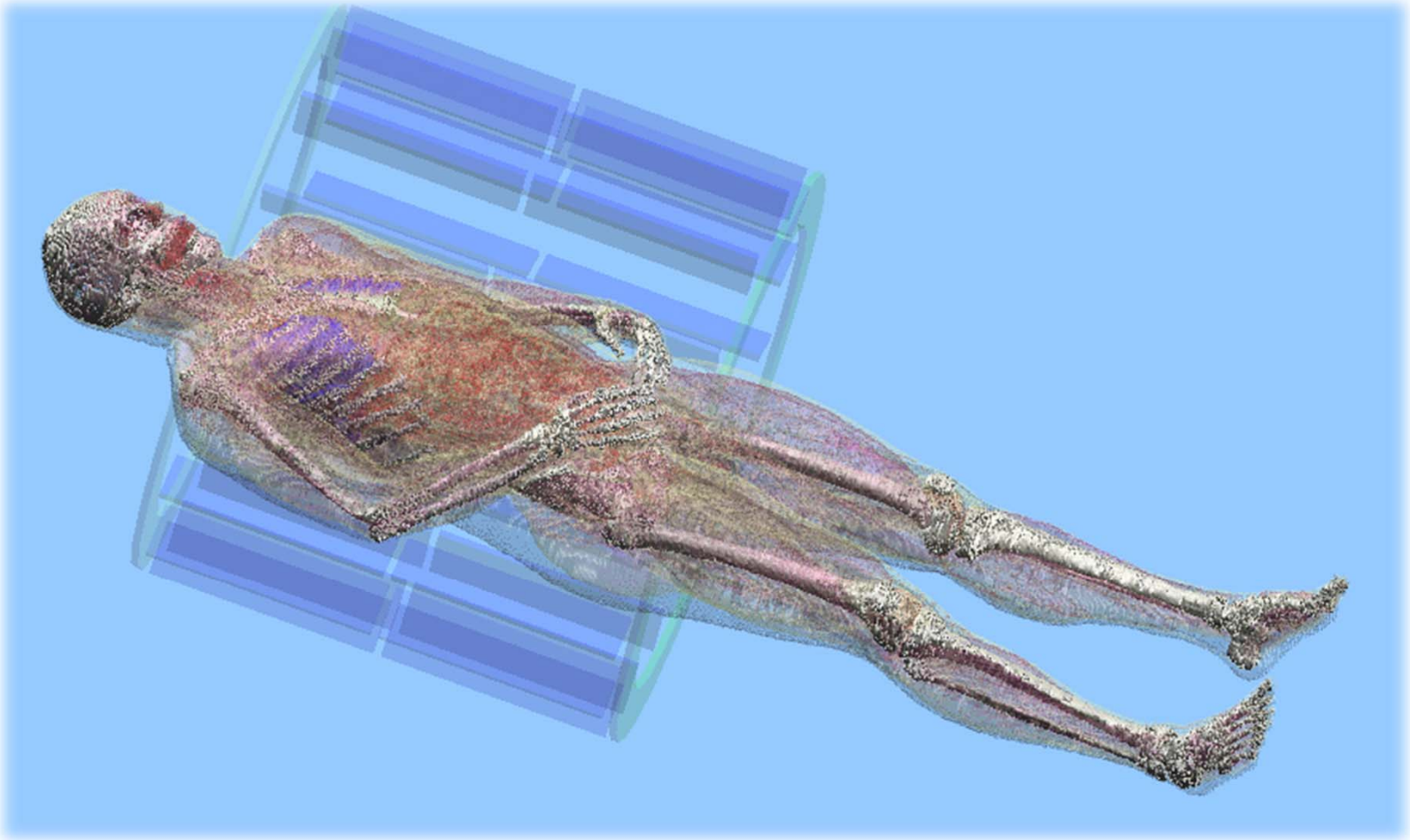


Impianto a sinistra

Impianto a destra

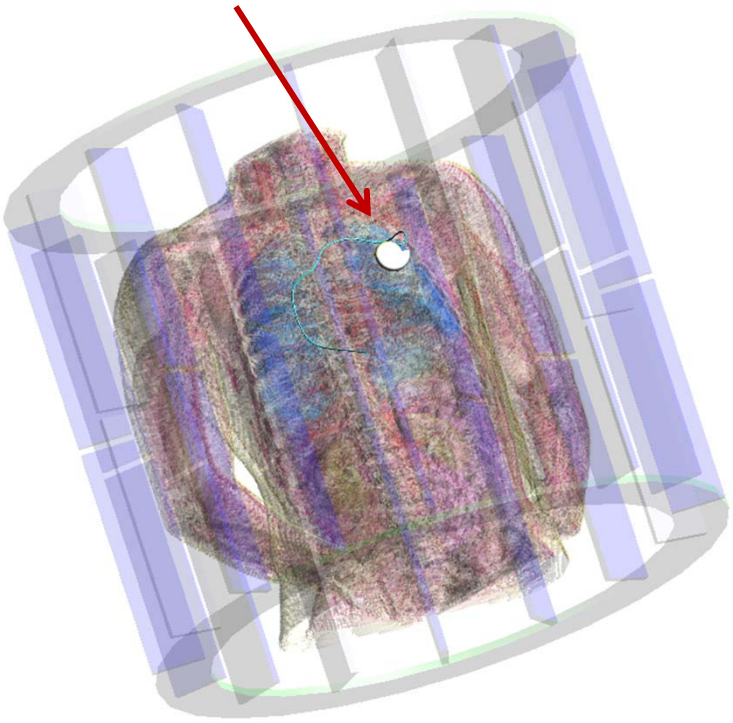
Modello numerico FDTD di bobina RF per RM e Human Visible

FEMLAB - COMSOL MULTIPHYSYCS **SEMCAD X - SPEAG**

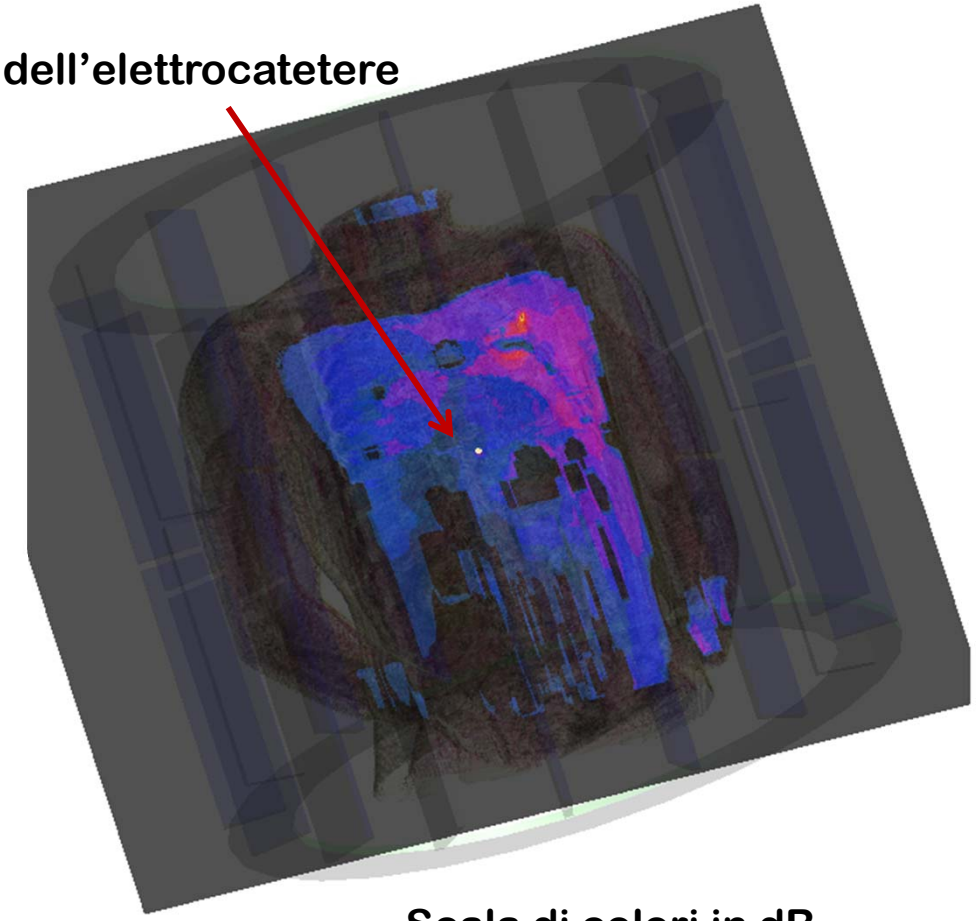


Human Visible integrato con modello di pacemaker e distribuzione di SAR risultante

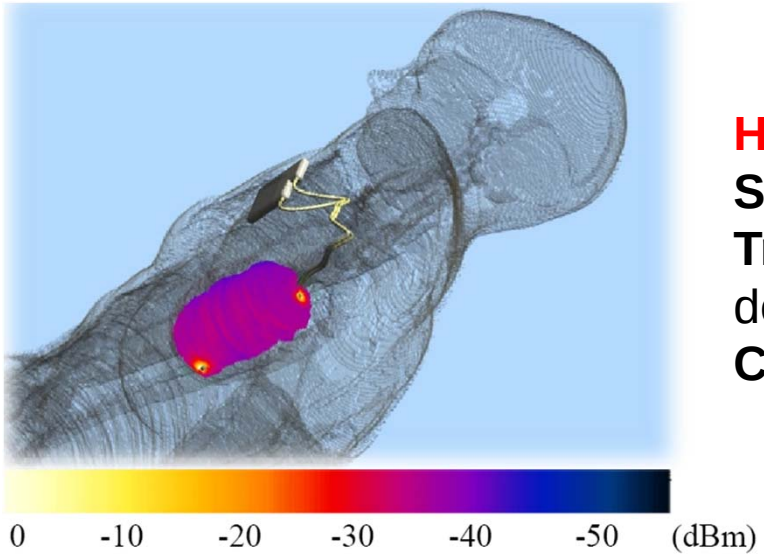
pacemaker



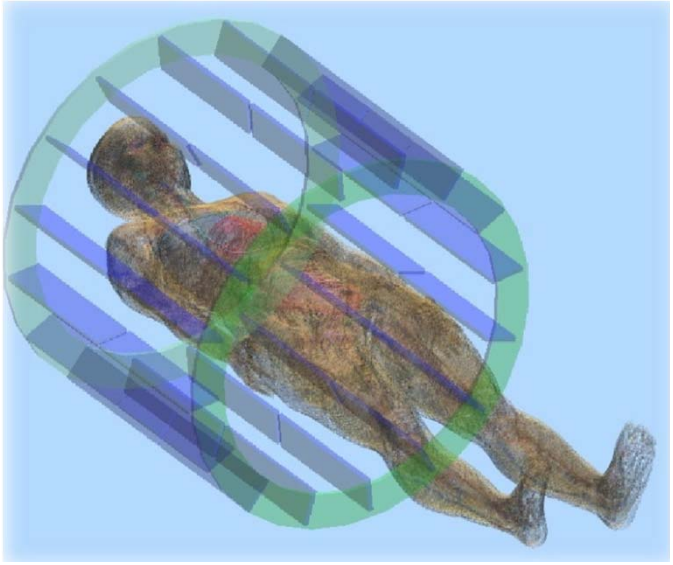
Punta dell'elettrocatetere

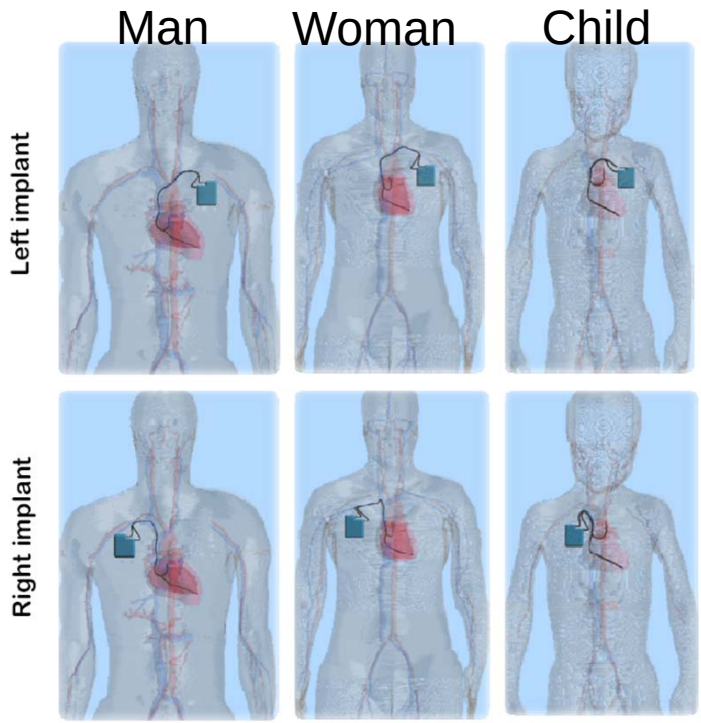


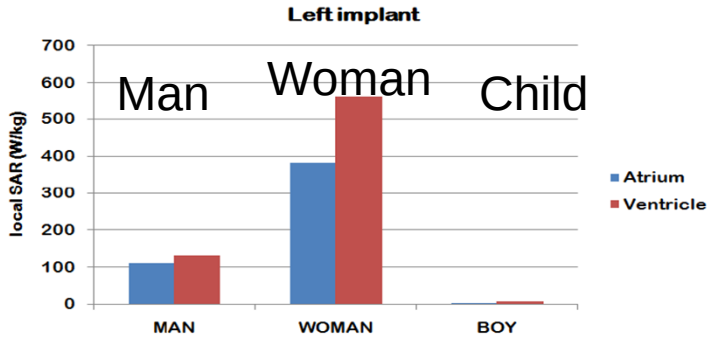
Scala di colori in dB normalizzata a 2000 W/kg

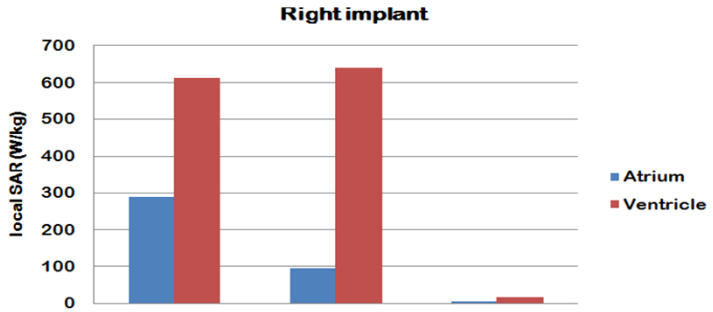


Human visible:
Simulatore Virtuale Tridimensionale dell'**Anatomia del Corpo Umano**







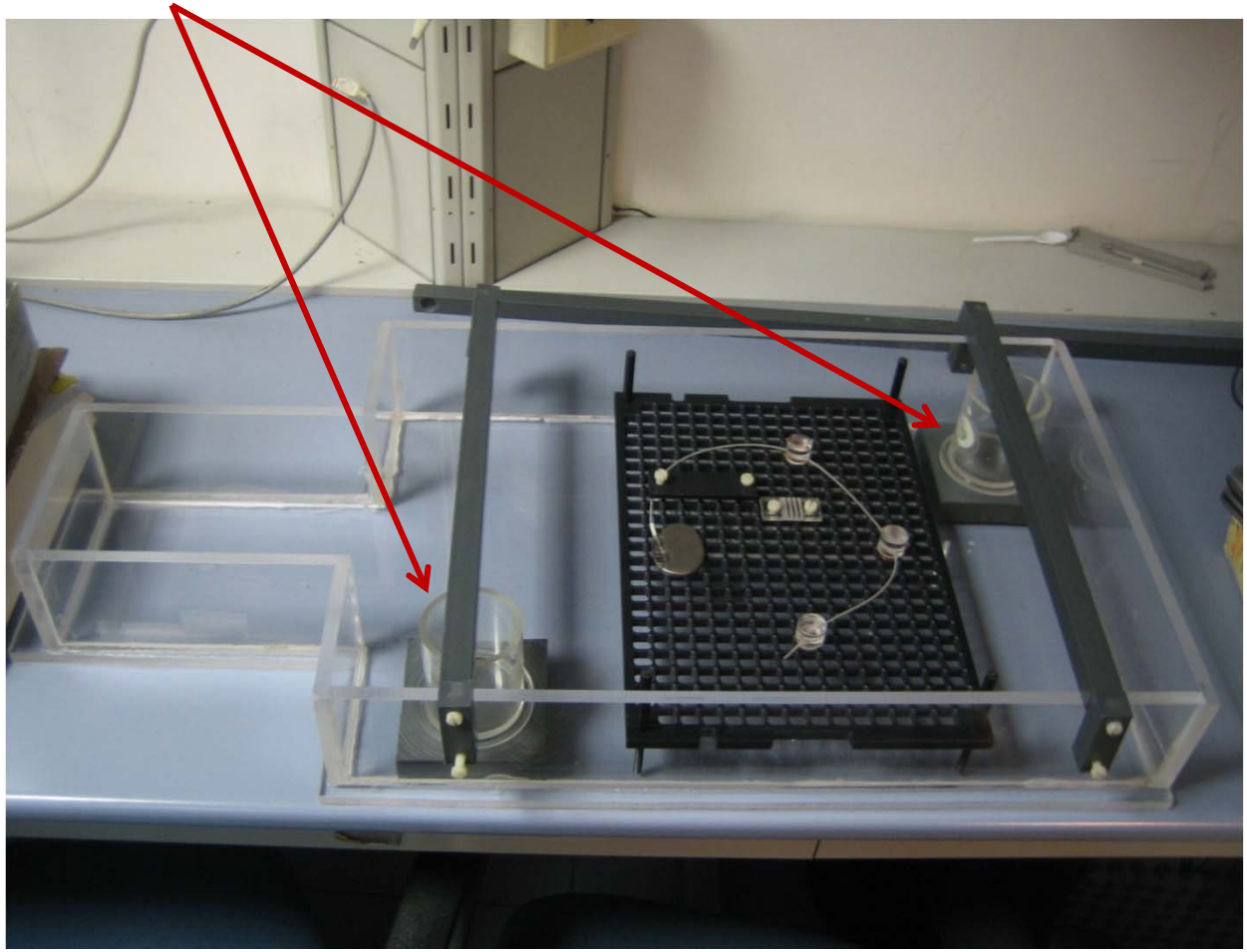


Problematiche Aperte

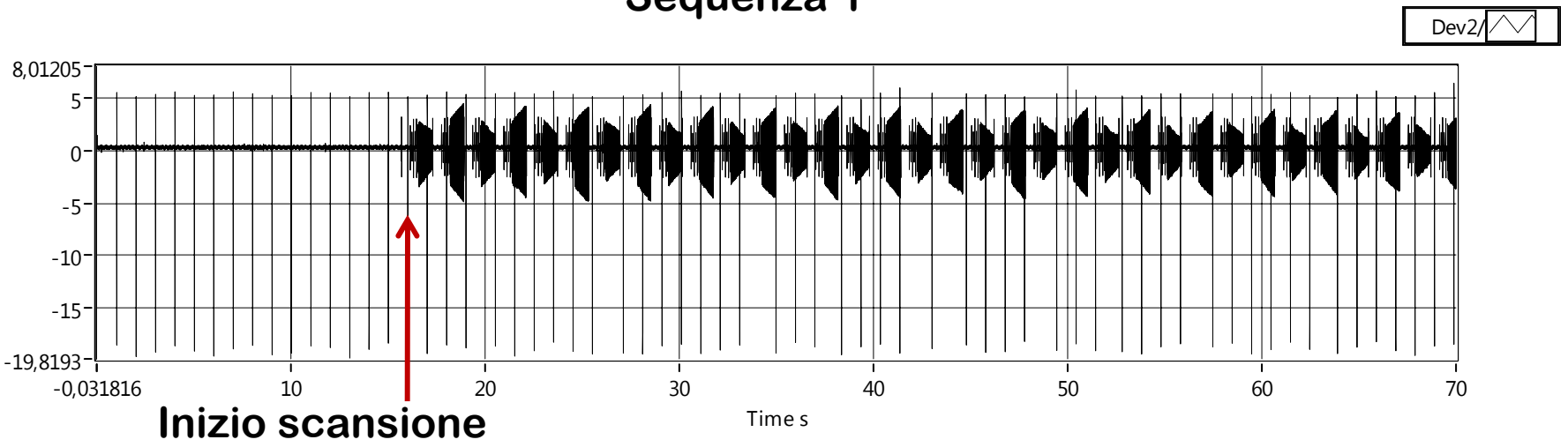
- Analizzare altri dispositivi impiantabili attivi (stimolatori neurali, impianti cocleari,…)
- Studiare i meccanismi e valutare il danno cellulare indotto dalla deposizione di energia termica
- Valutare anche effetti non termici (interferenza su funzionamento del dispositivo)
- Perfezionare gli aspetti modellistici (es. modello elettrico del PM)

Pacemaker e Campi di Gradiente

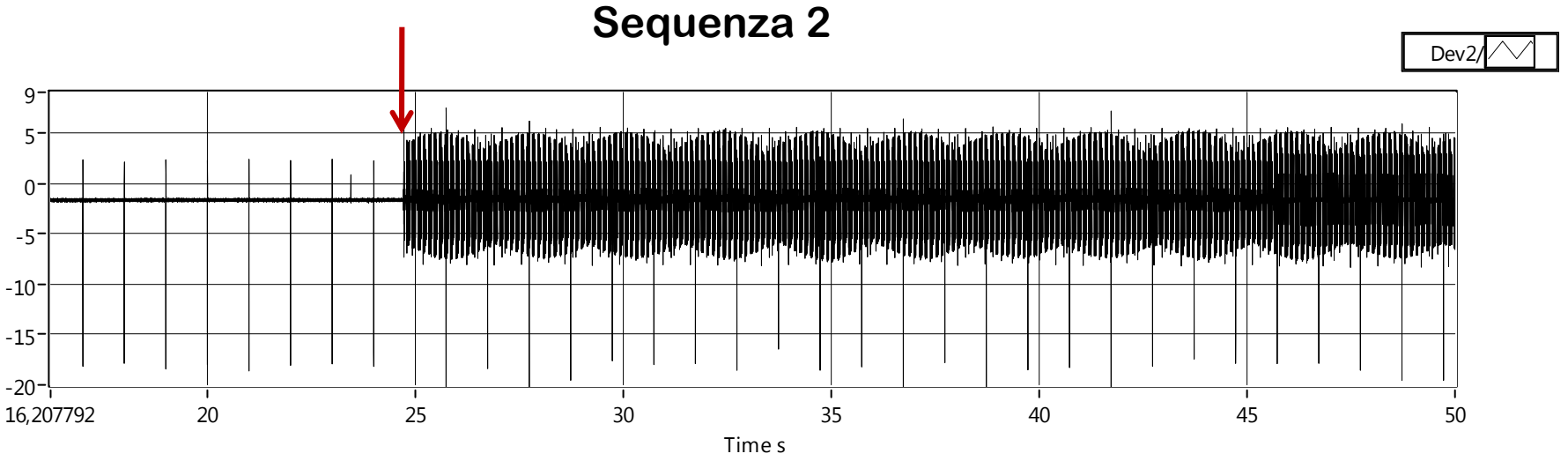
Elettrodi ECG



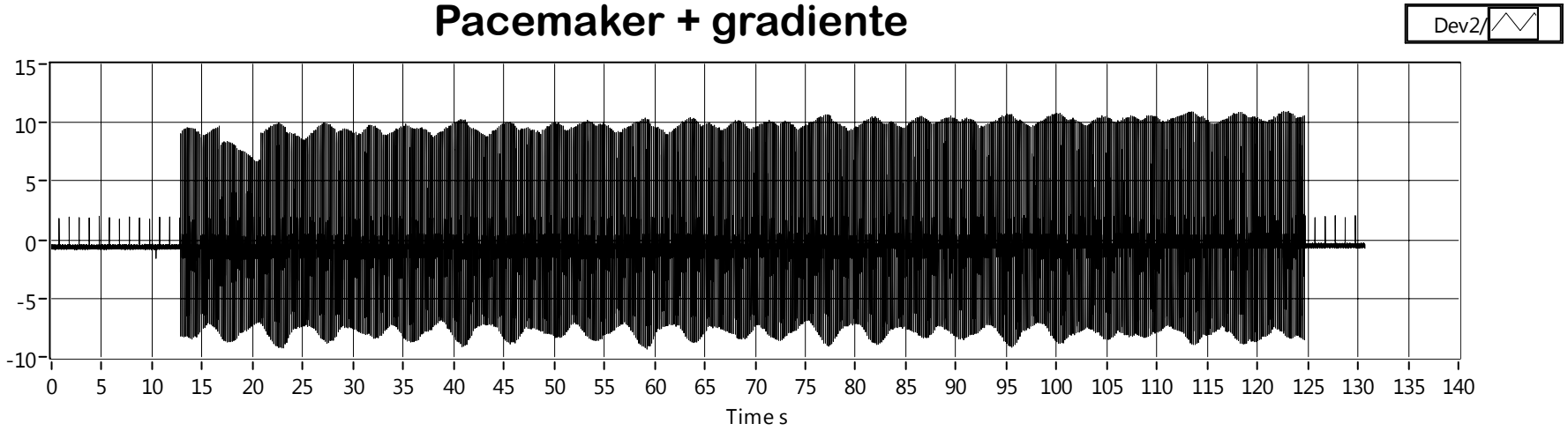
Sequenza 1



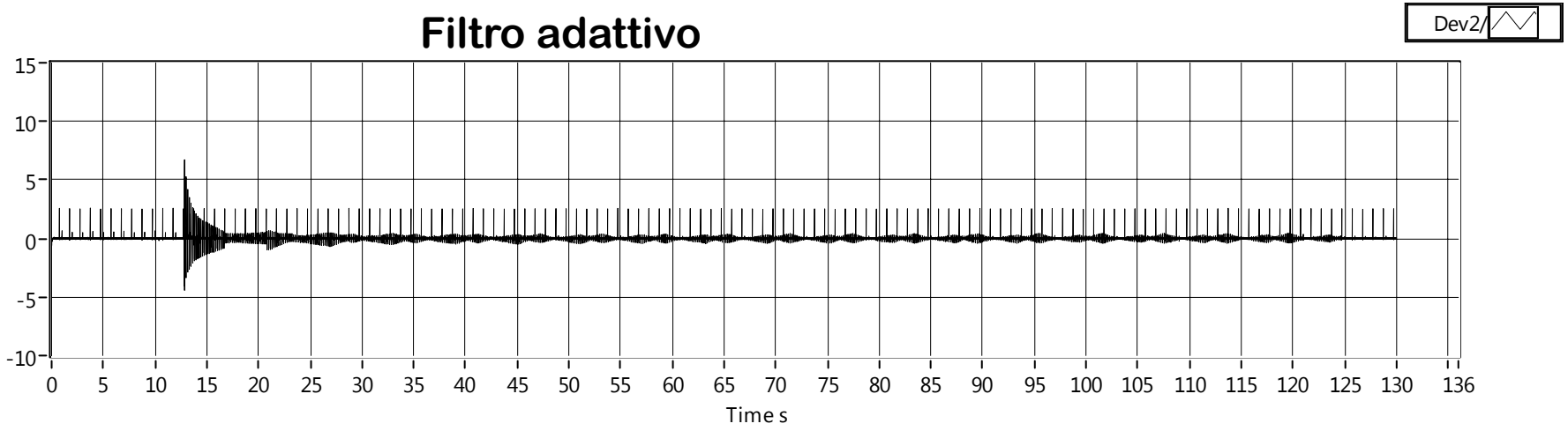
Sequenza 2



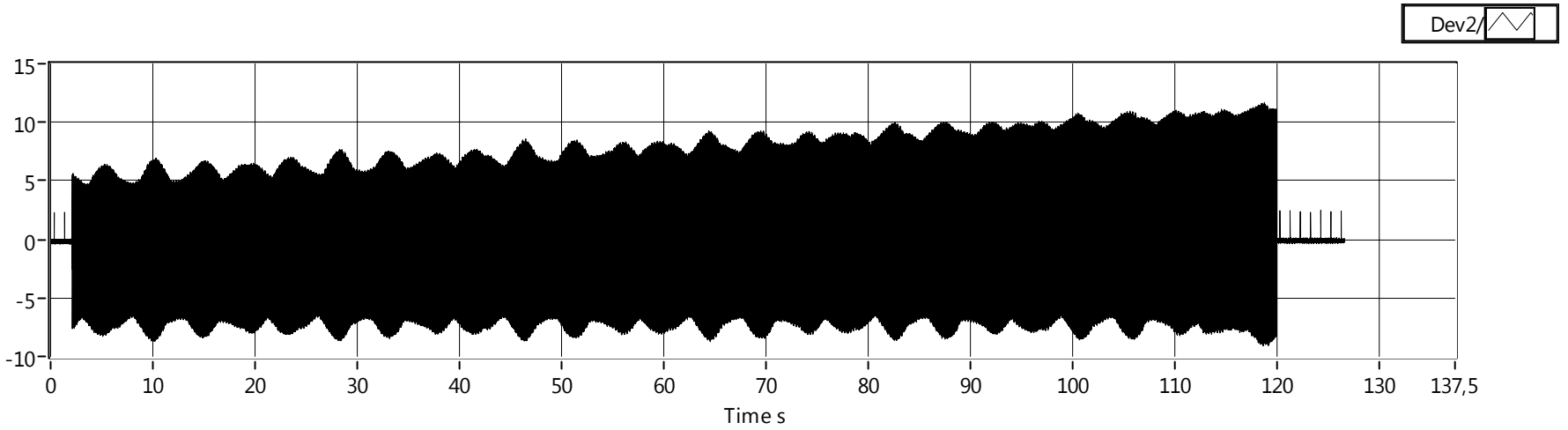
Pacemaker + gradiente



Filtro adattivo



Pacemaker + gradiente



Filtro adattivo