

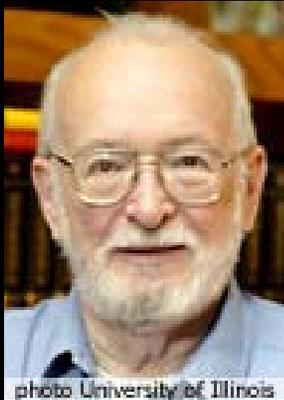
An Overview of Magnetic Resonance Imaging

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2004.02.18

The Nobel Prize in Physiology or Medicine 2003

Paul C. Lauterbur, PhD and Sir Peter Mansfield, PhD



發現以梯度磁場來作空間編碼,重建過去所作不到的二維影像,利用RF激發身體所得到的迴訊,來探索疾病的位置



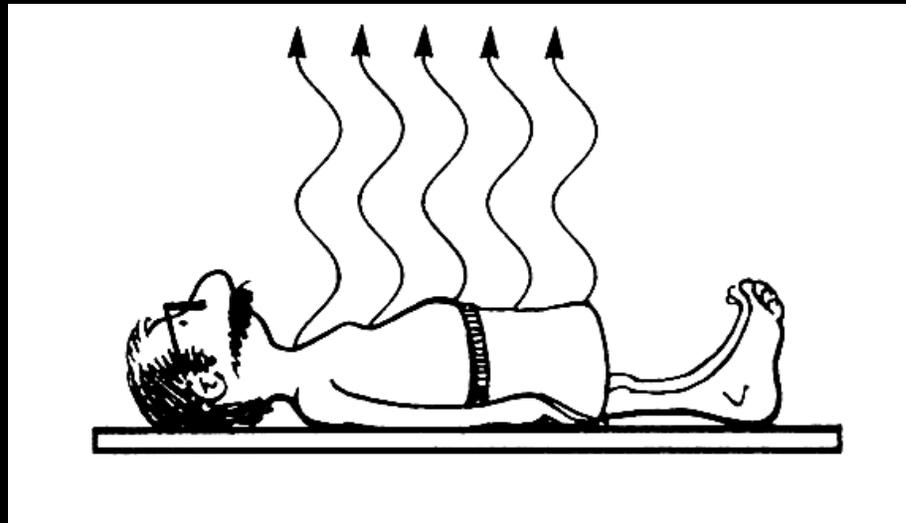
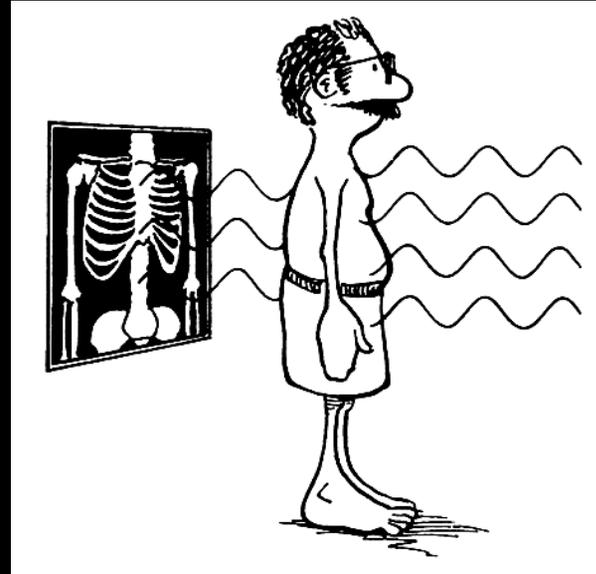
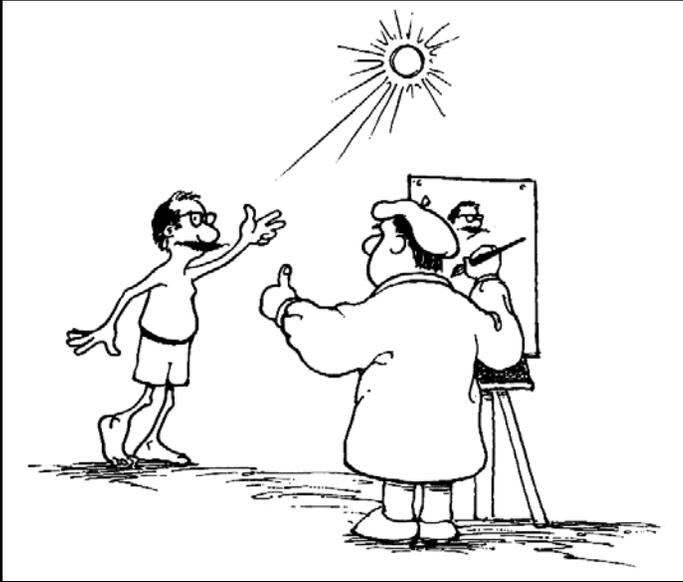
進一步利用梯度磁場的變化來分析訊號,並且使之成為有用的成像技術,導入以快速梯度磁場變化來加速成像的技術可能性(EPI),引領後續十年磁振醫學重要發展

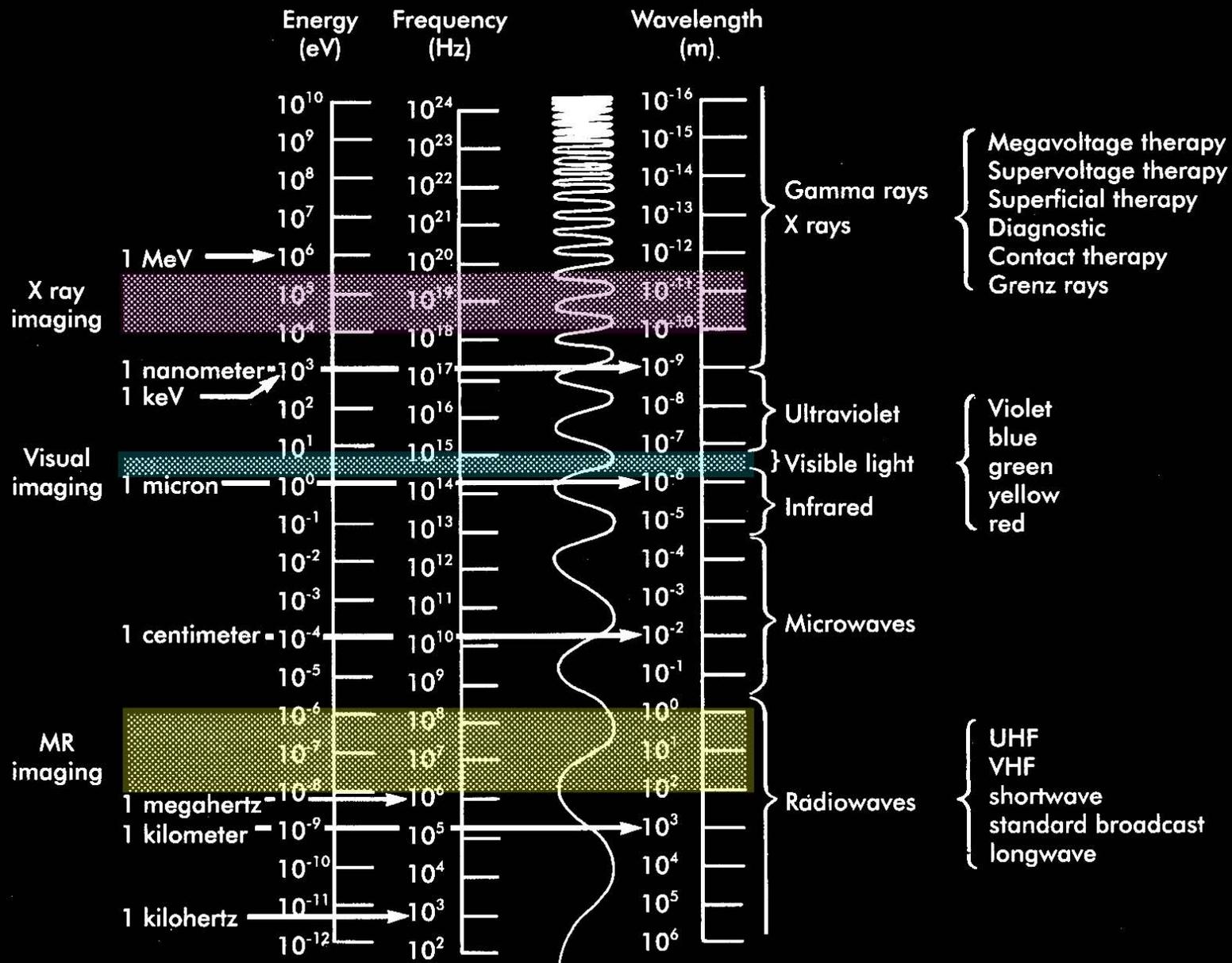
The History of MRI (1)

- 1946 – Felix Bloch & Edward Purcell
 - Discovered the magnetic resonance (MR) phenomenon
 - Nobel Prize in 1952
- 1950~1970 – used for chemical and physical molecular analysis
- 1971 – Raymond Damadian
 - The differences of nuclear magnetic relaxation time between tissues and tumors

The History of MRI (2)

- 1973 – Paul Lauterbur
 - Magnetic Resonance Imaging (MRI)
- 1975 – Richard Ernst
 - Proposed the basis of current MRI techniques
 - 1991 Nobel Prize in Chemistry
- 1977 – Peter Mansfield
 - Produce images at video rates (30ms/image)
- 1980~





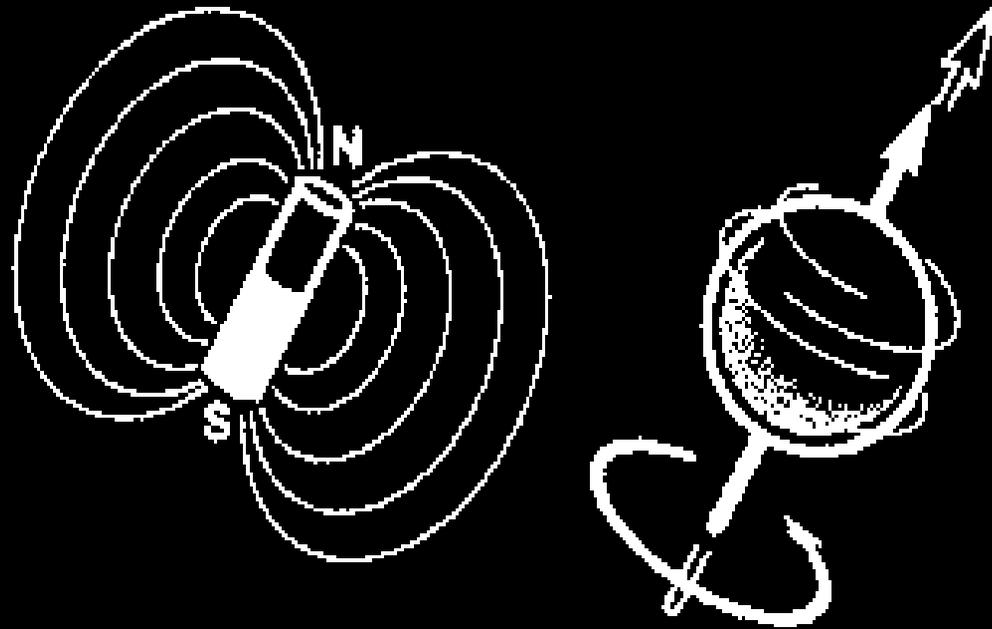
什麼是 MRI (磁振造影) ?

- 原名:
Nuclear Magnetic Resonance (NMR) Imaging
- M : magnetic 磁
- R : resonance 共振
*the radio frequency of an oscillating magnetic field v.s.
the “precessional” frequency of the spin of some
nucleus*
- I : imaging 影像

MRI 的產生

- 人體 = 磁鐵
- 磁鐵運動 = 感應電流
- 偵測之前的信號變化
- 經過計算 = 影像

“器官小磁鐵”

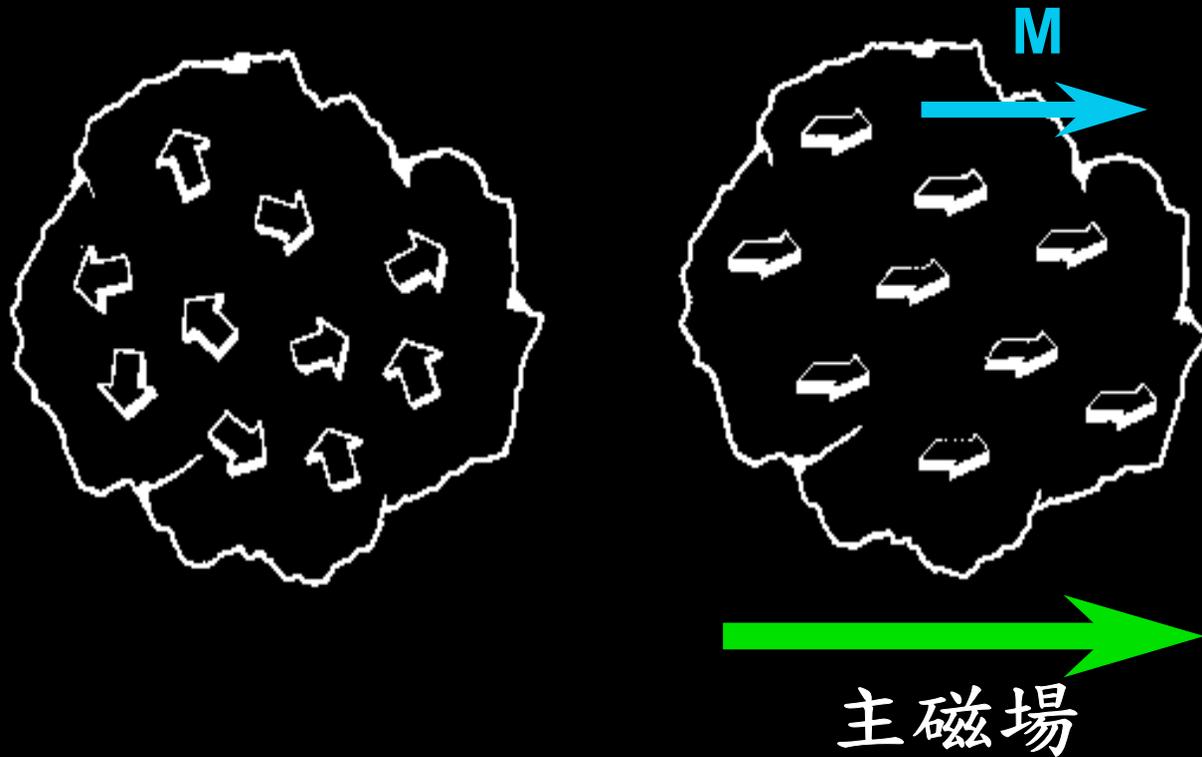


器官內的氫原子核酷似小磁鐵

MRI 的產生

- 產生信號源 (磁化現象)
- 射頻激發 (切面選擇)
- 空間編碼 (頻率、相位)
- 信號的弛緩 (影像對比)
- 偵測、計算 (傅立葉轉換)

外加磁場對氫原子核小磁鐵的影響



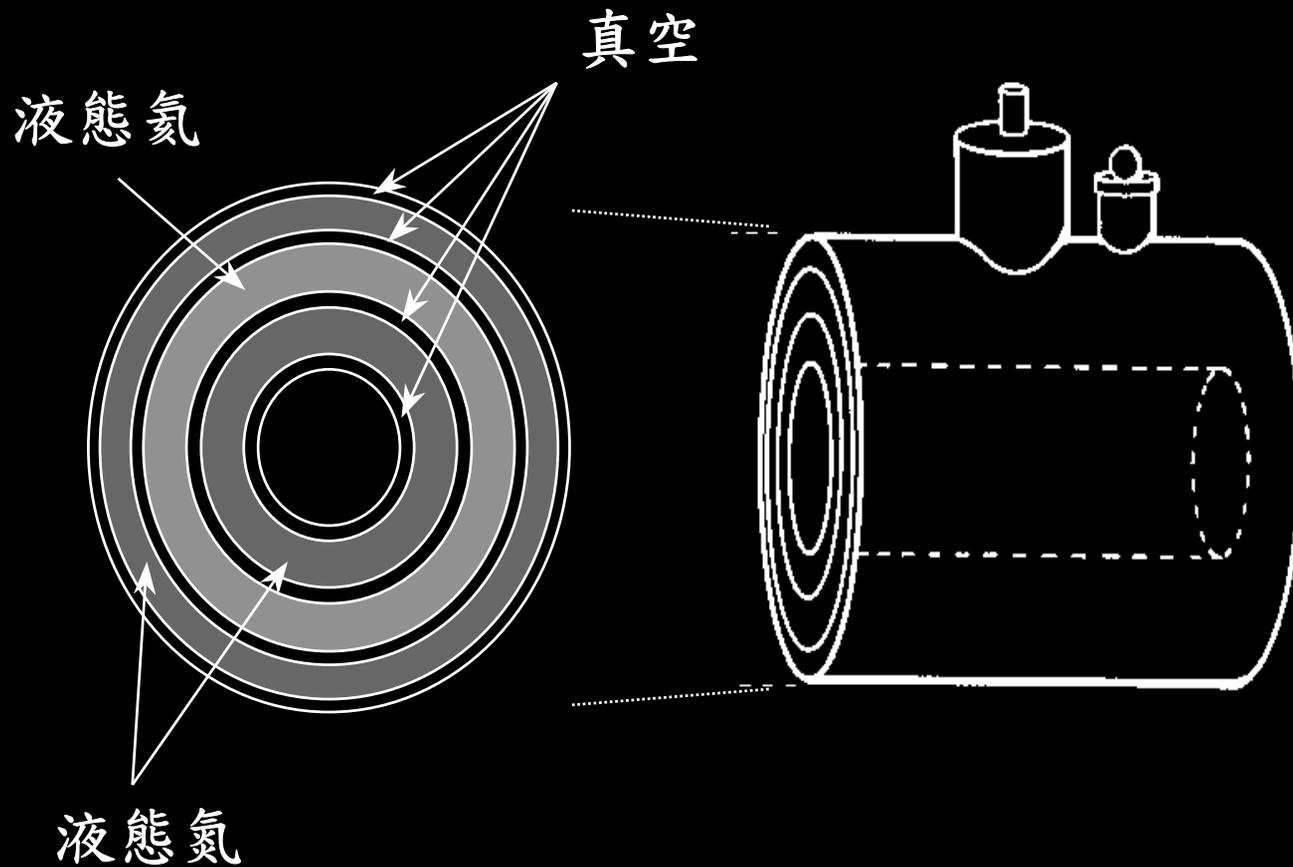
不規則排列

規則的排列

MRI 的信號源

- “人體磁鐵”可由氫原子核而來
- 氫原子核磁性由電荷與自轉而來
- 利用外加磁場，使排列整齊

超導體電磁鐵構造



磁場強度可達 4 Tesla 以上

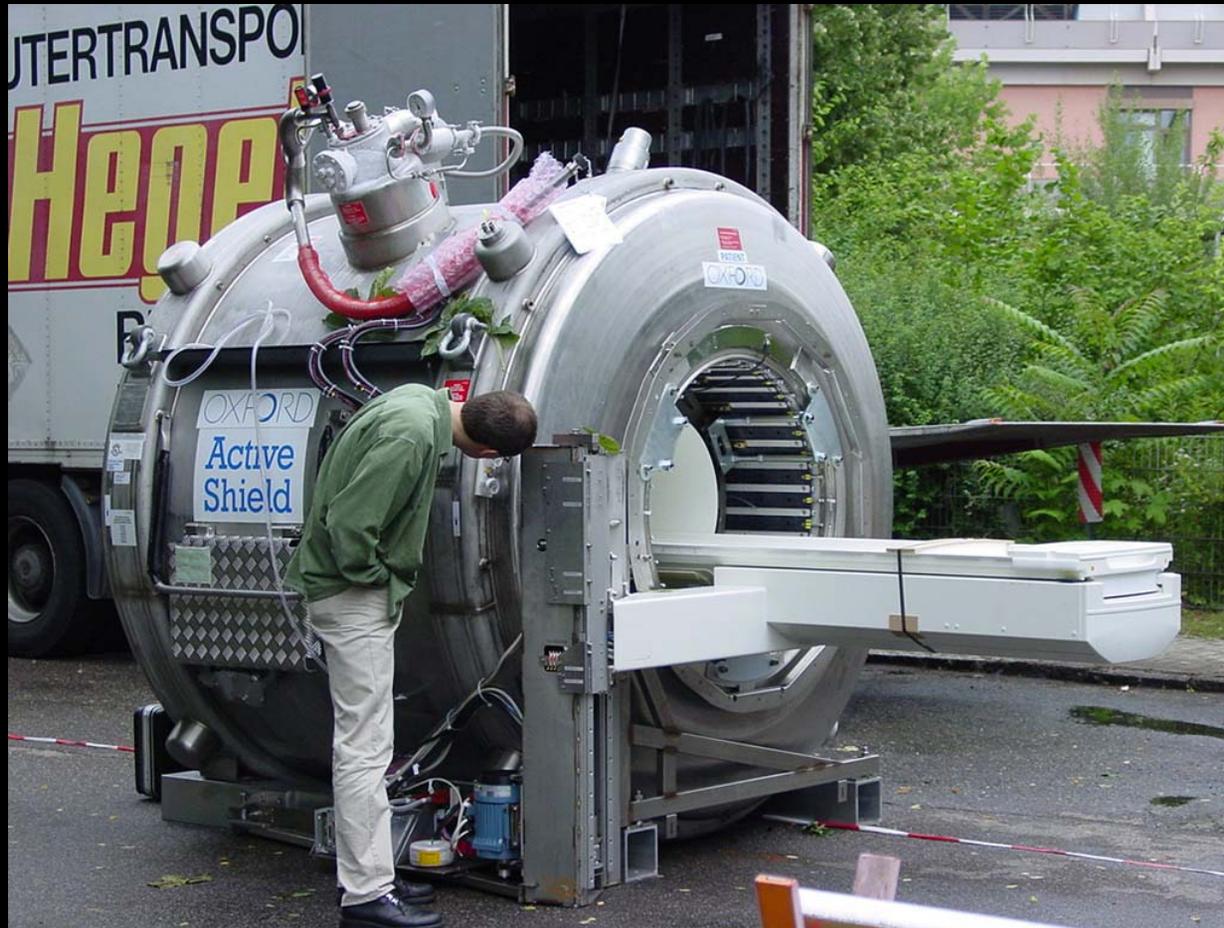
Siemens Sonata, 1.5 Tesla



(c.f.)地磁大小約0.5 gauss (1Tesla = 10000 gauss)

Siemens Trio, 3T

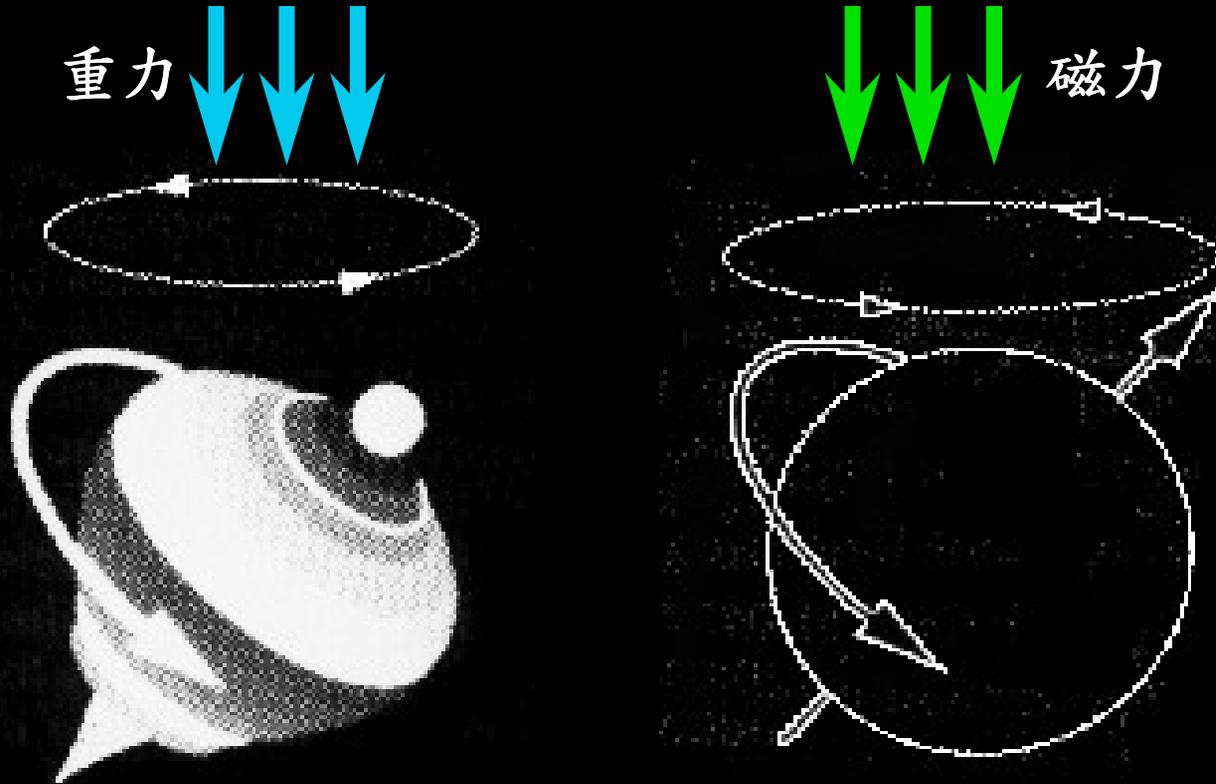
University Hospital Freiburg, Germany



信號的激發與接收

- 氫原子核自轉：磁性 + 慣性 = 旋進
- 以旋轉磁場把人體磁鐵拉離 B_0
 - 人體磁鐵開始繞著 B_0 運動
- 信號接收：磁鐵運動產生感應電流

磁場中的氫原子核旋進現象

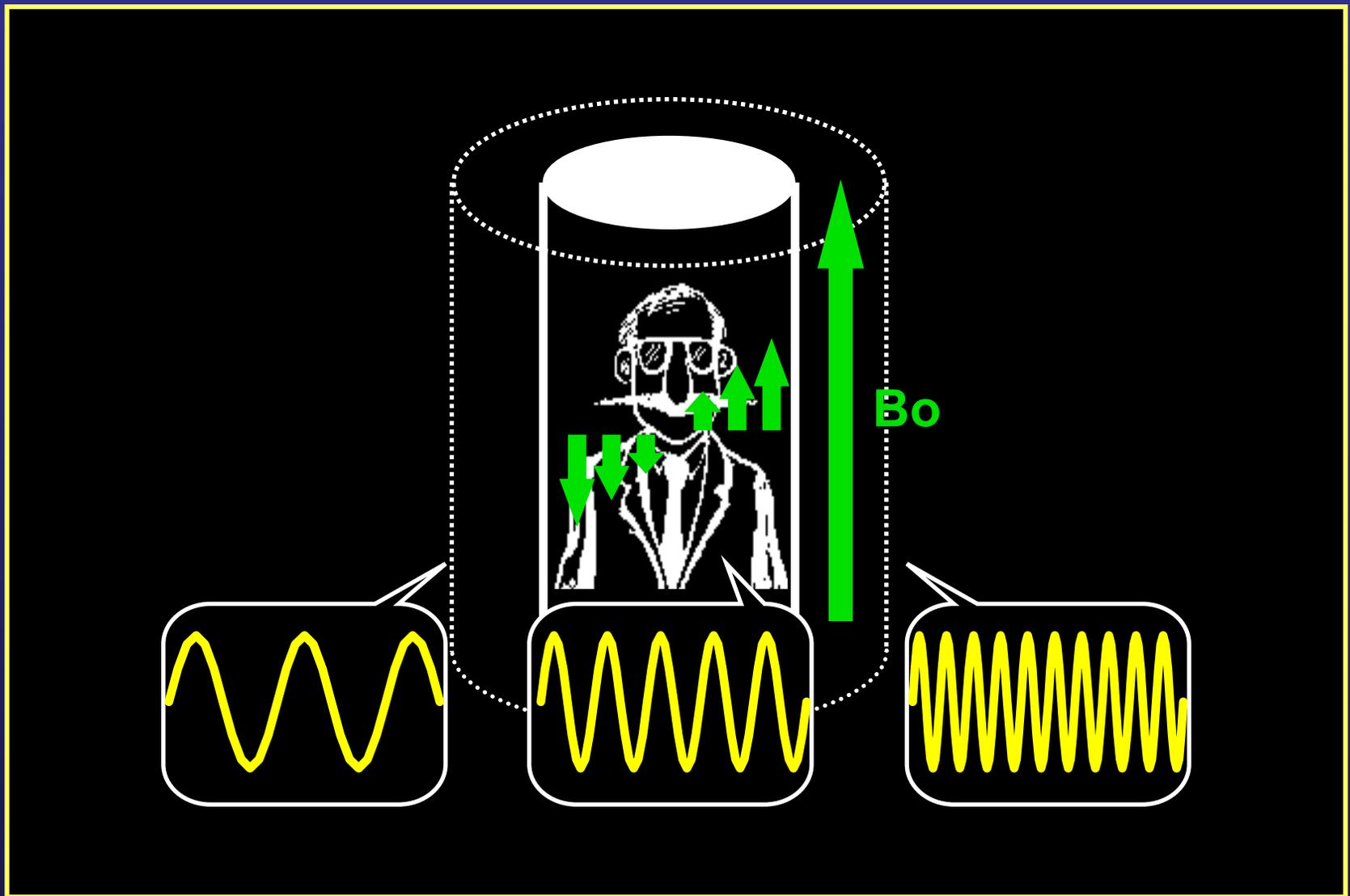


繞著主磁場的方向旋進

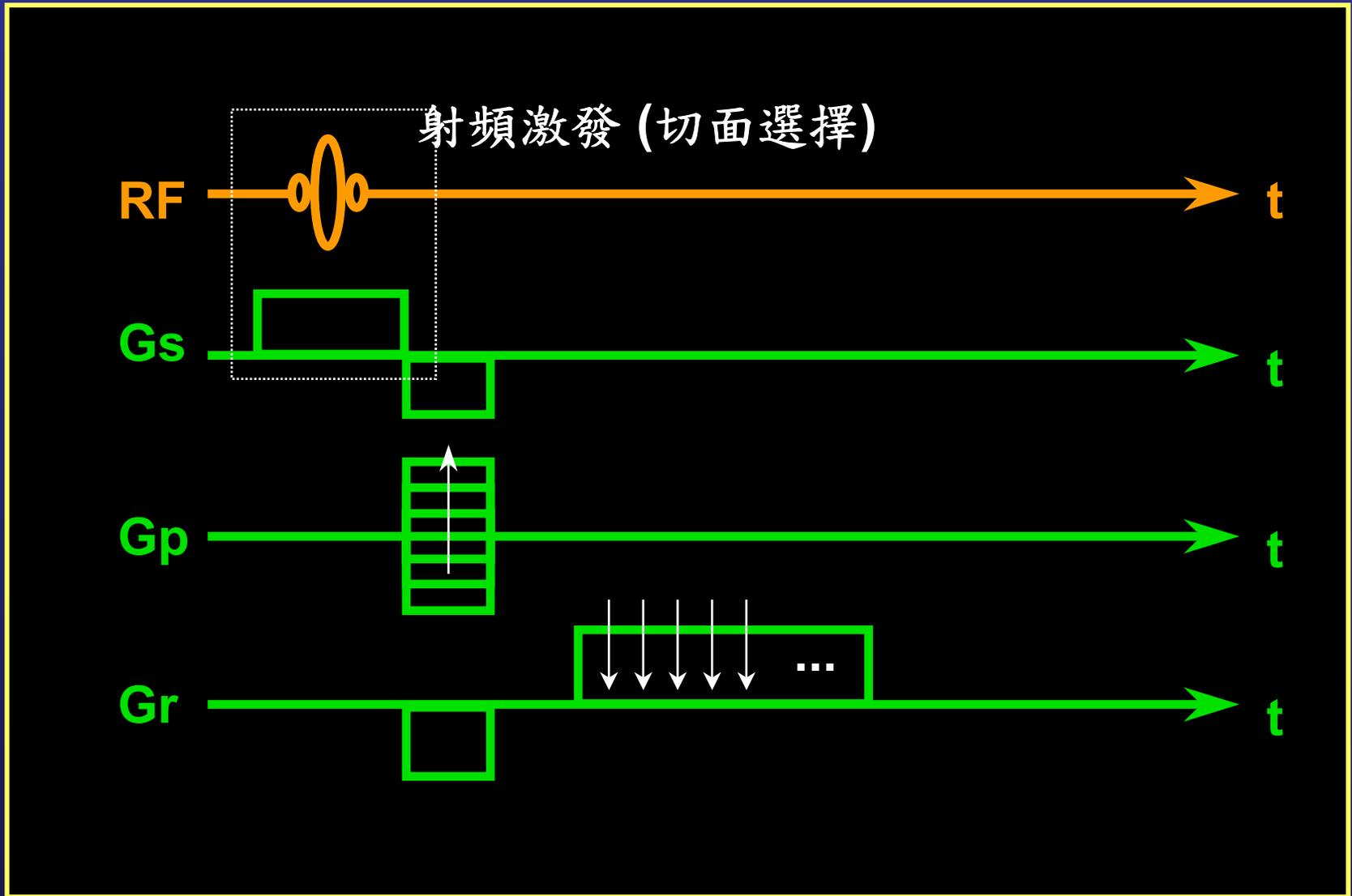
空間編碼

- 利用磁場梯度產生頻率變化
- 切面選擇 (只激發部份氫原子核)
- 相位編碼 (相角變化求得位置)
- 頻率編碼 (利用頻率反推位置)

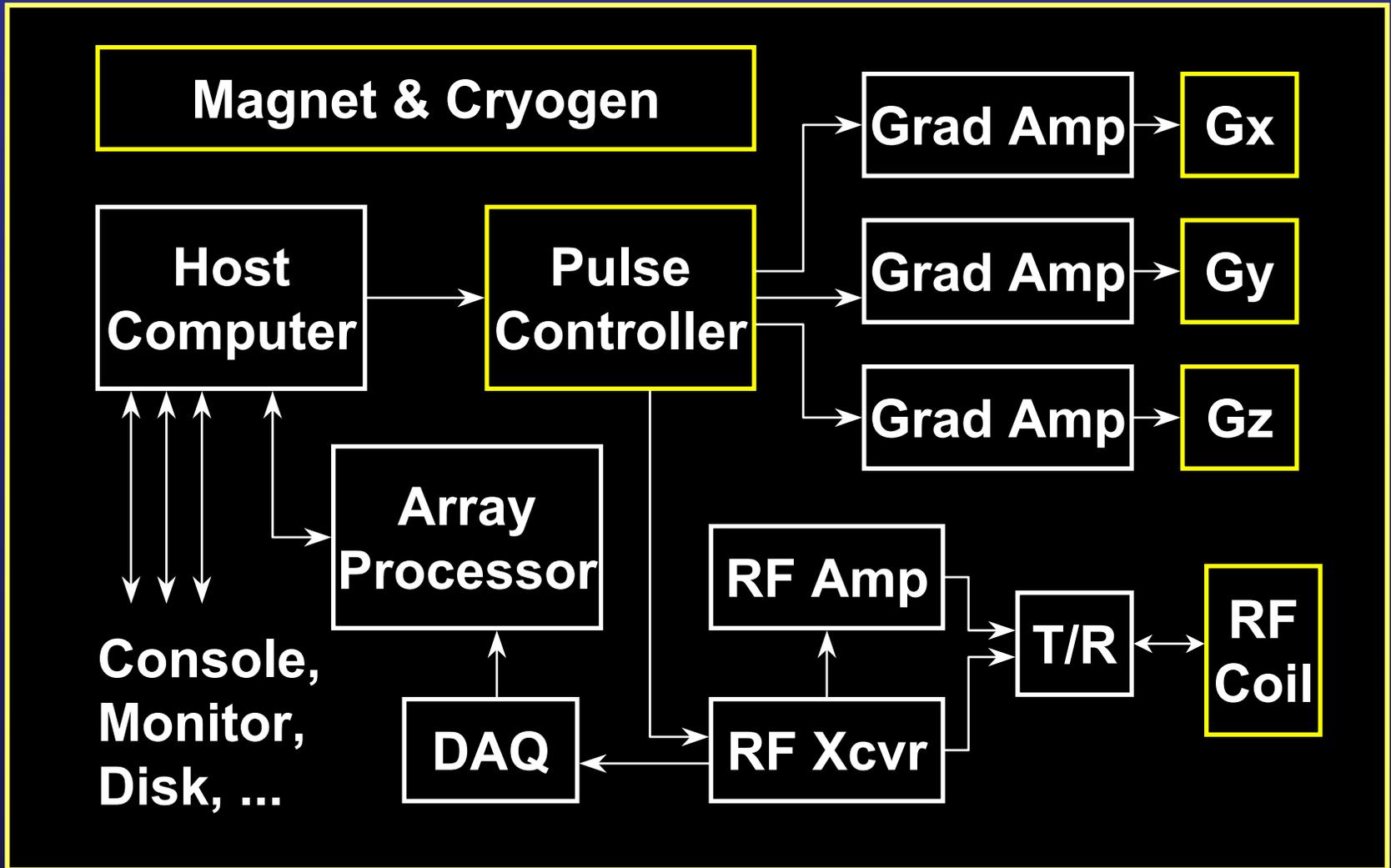
氫原子核旋進頻率隨 X 位置而變化



梯度迴訊 (Gradient Echo) 脈衝序列



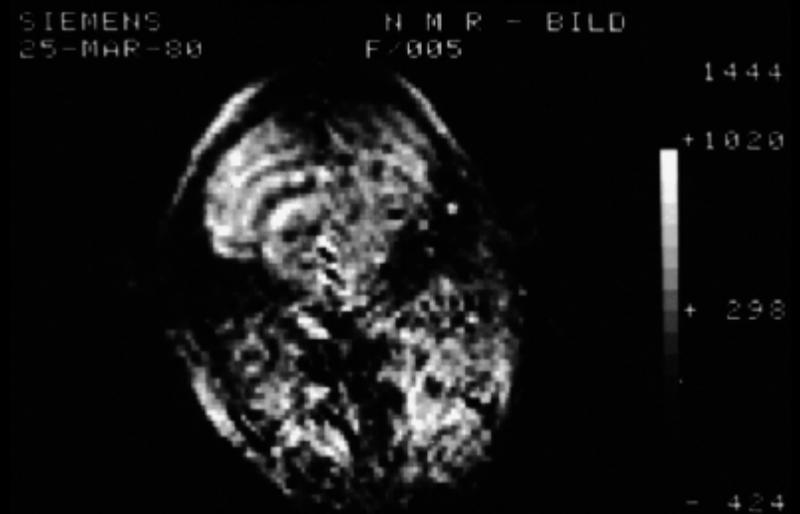
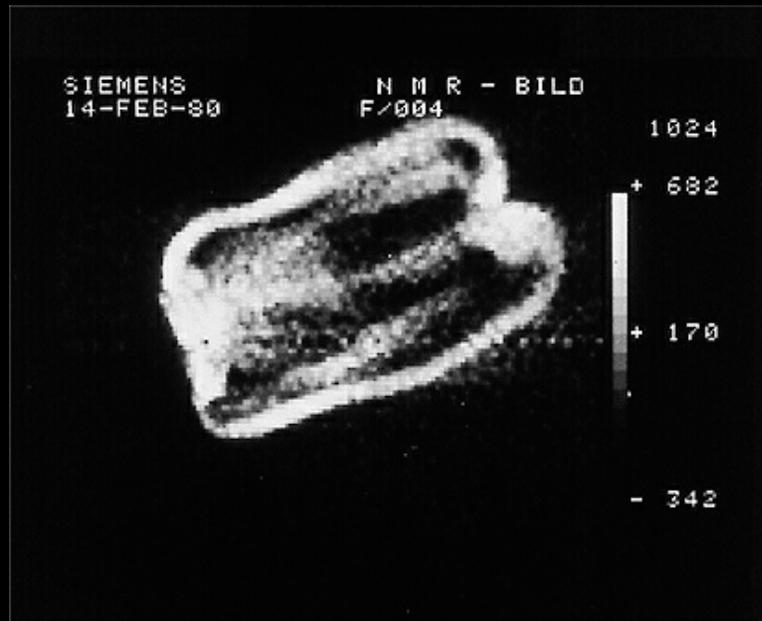
MRI 系統架構



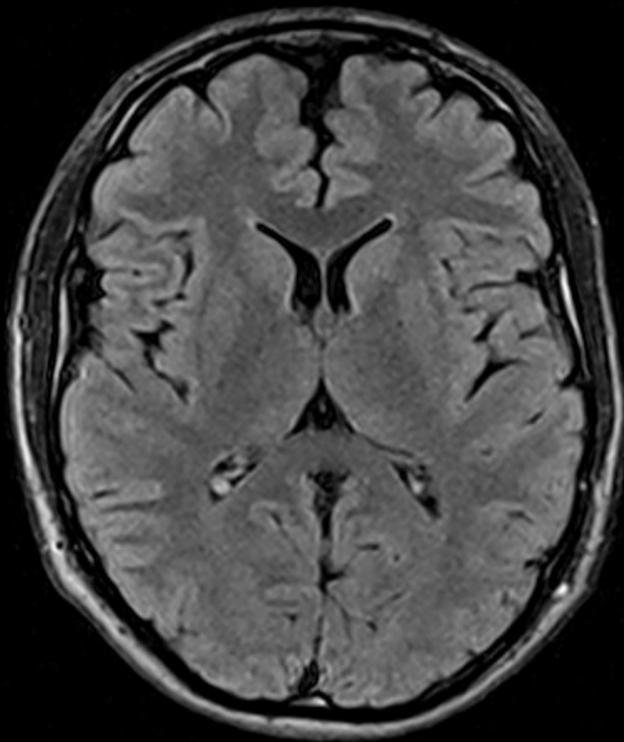
摘要：MRI

- 各組織水的氫原子核所在環境不同
- 對於外加磁場的「反應」也就有所差別
- 造成影像上的對比

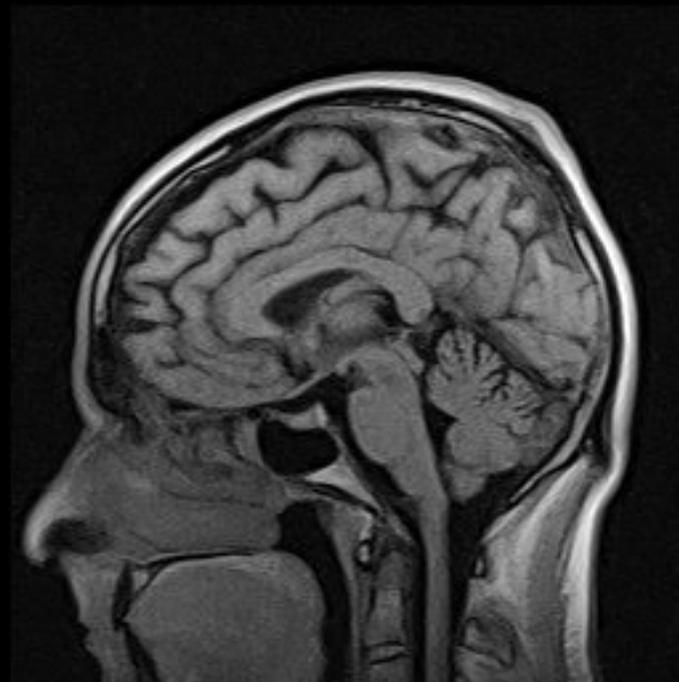
MRI 的發展



Siemens first MRI --1983



tir2d, TI 1600, TR 6160,
TE 91, TA 7:11, matrix
173x230, SL 5.0



tir 2d, TI 800, TR 1430,
TE 15, TA 1 :51, matrix
192x256, SL 5.0



CE-MRA of
the Lungs
(Philips.com)



BolusTrak CE-MRA of
the hand , 1024 matrix
(Philips.com)



FFE image of the ankle scanned with
1024x1024 matrix at 1.0T
(Philips.com)



Fast, easy, automated whole body imaging using new table extension, a single bolus injection, scanned in 68 seconds and providing coverage which exceeds 6 feet.

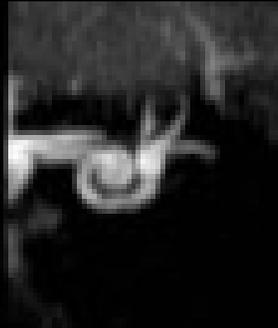
(from: University Hospital Uppsala, Sweden, Philips.com)



Whole body imaging with MobiTrak. Head to toe coverage in 2 minutes.

(Philips.com)

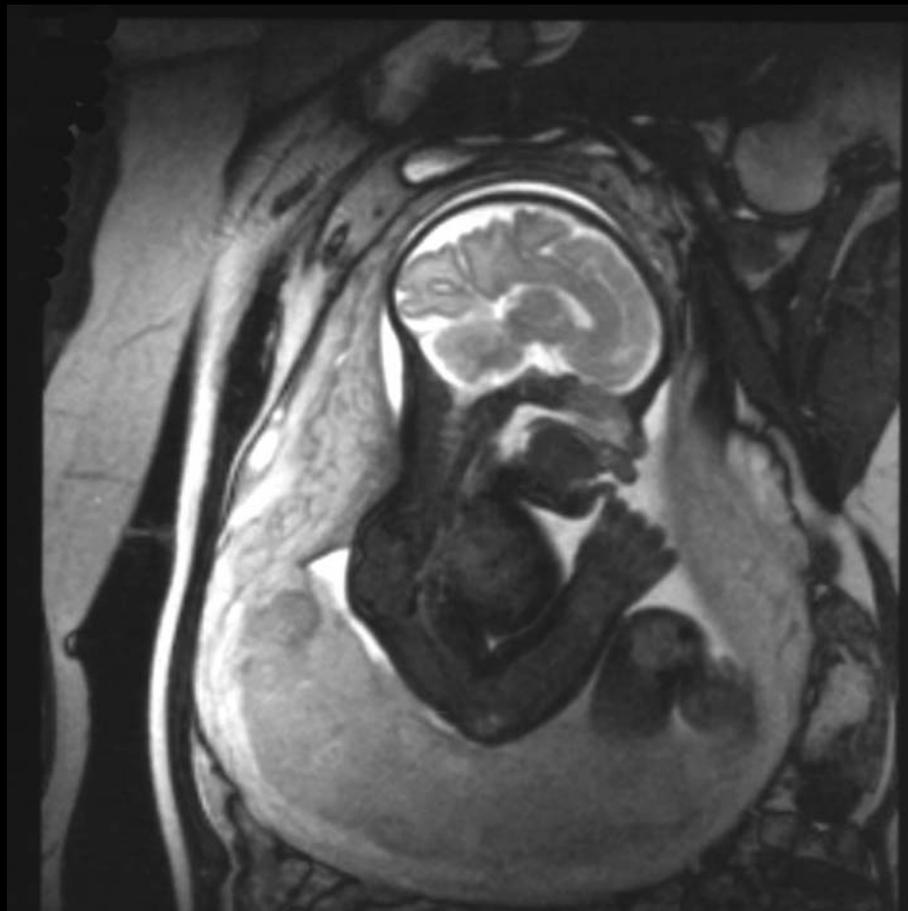
Applications in Practice



University Hospital Freiburg, Germany, 2002

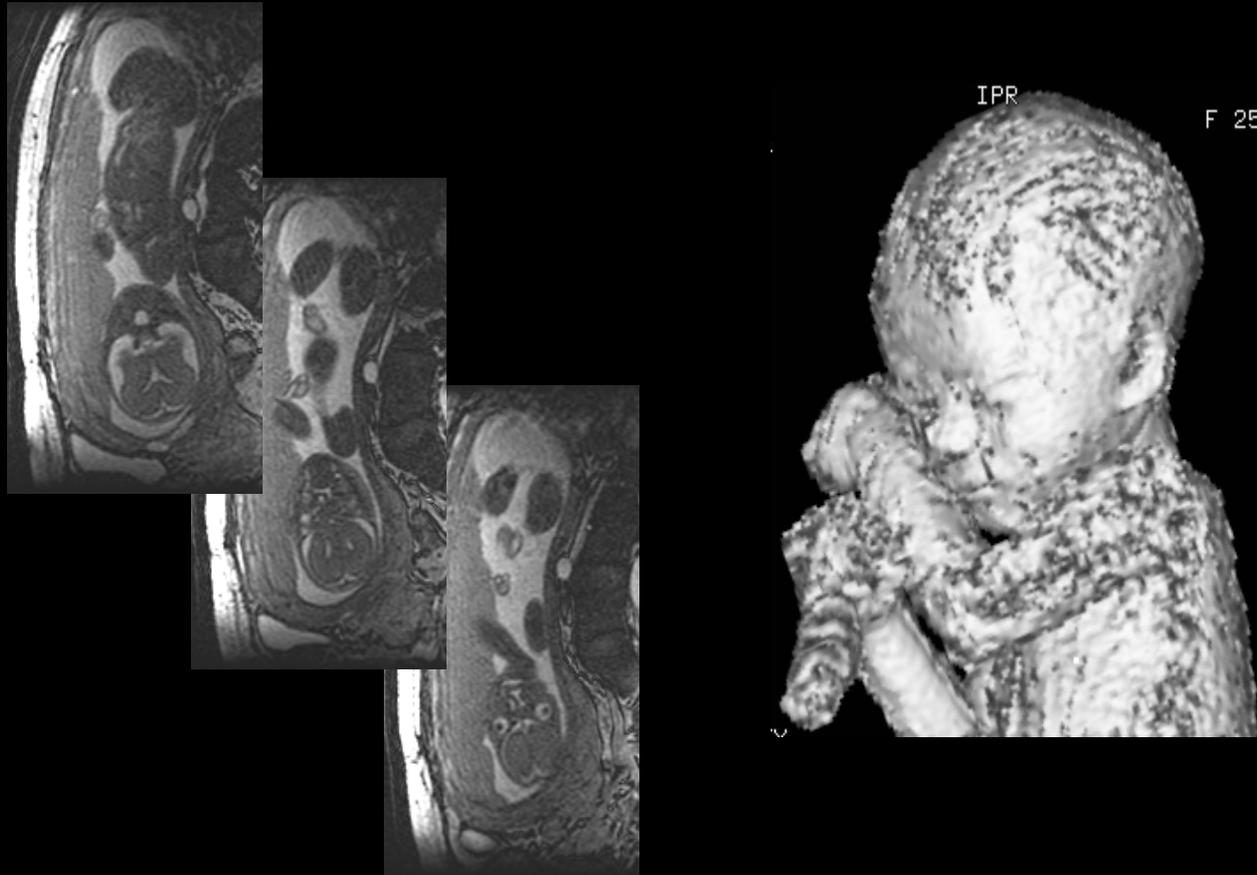


University Hospital Freiburg, Germany, 2002



嗯！手好好吃哟！
(TSGH, Taipei)

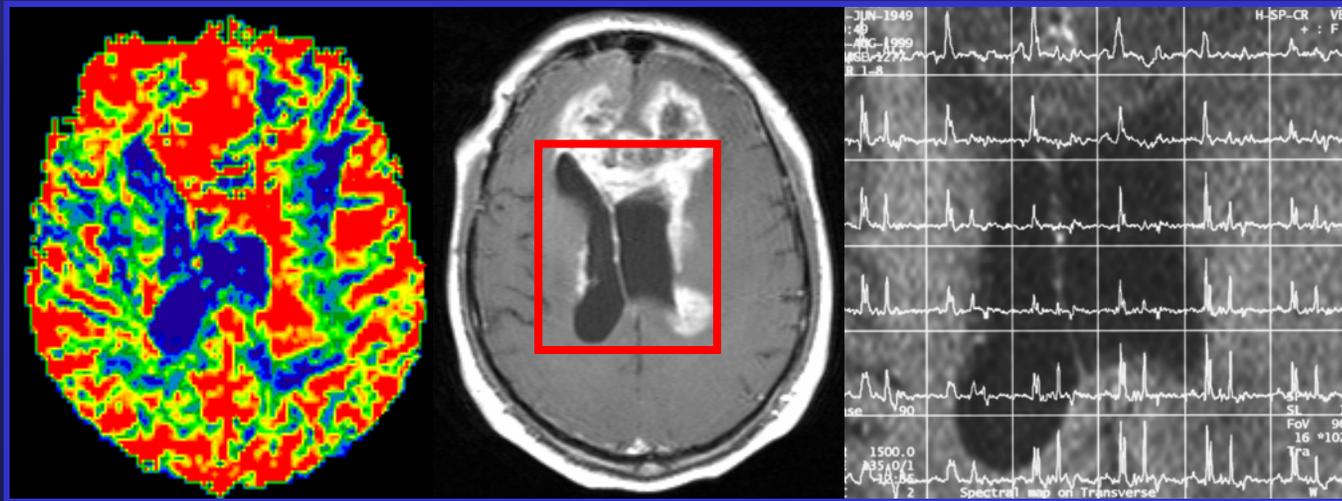
3D TrueFISP 影像：Fetus in uterus



3D Scan time : 17 ~ 19 sec
(榮總郭萬祐主任提供)

Cerebral Glioma Study

- 三軍總醫院放射部
- Multi-modality --
rCBV map, T1 post contrast, MRS
(Spectroscopic image)



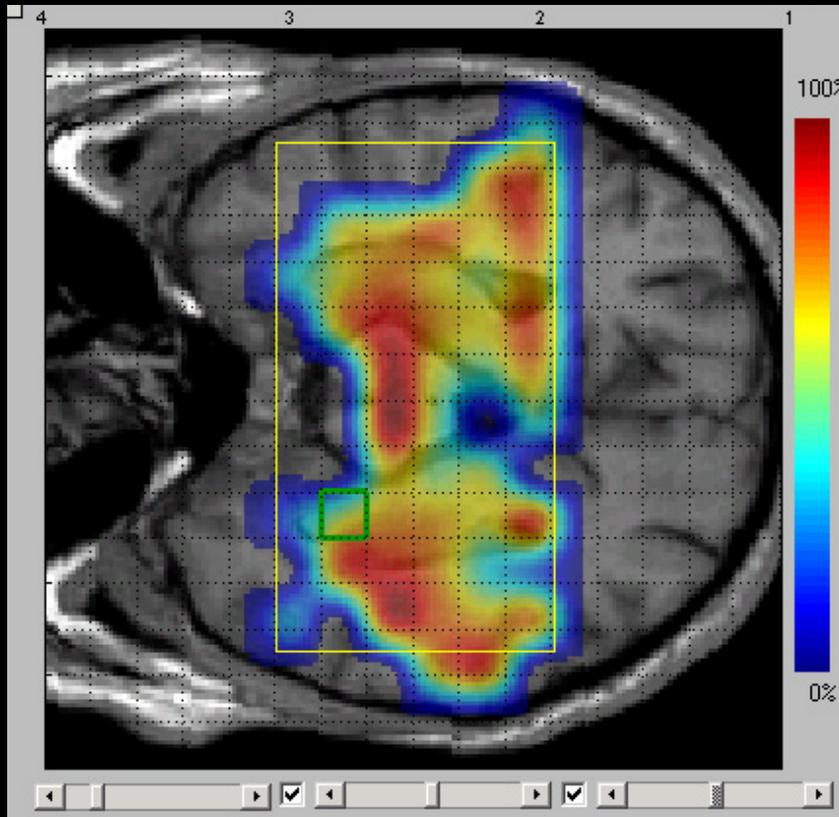
rCBV map

T1 post contrast

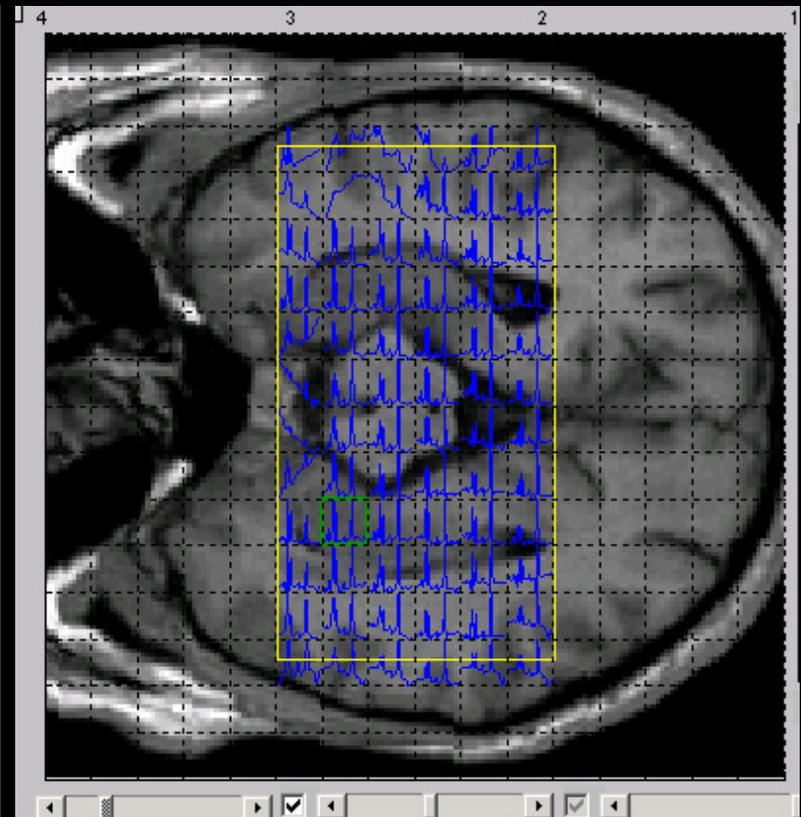
MRS (Spectroscopic image)

MRS : spectroscopic imaging

NAA: neuronal marker



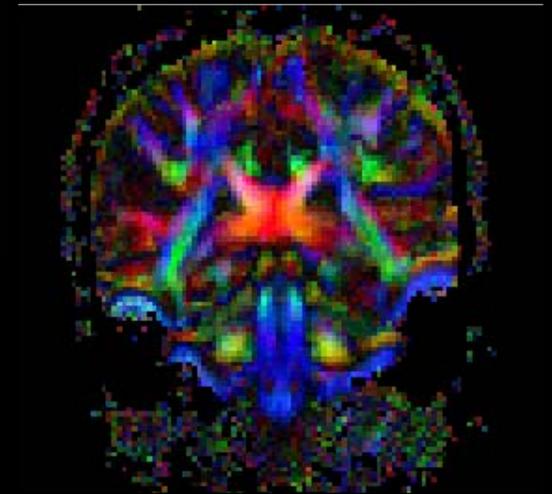
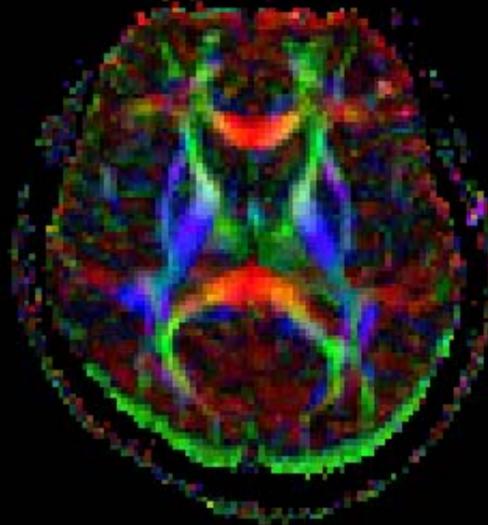
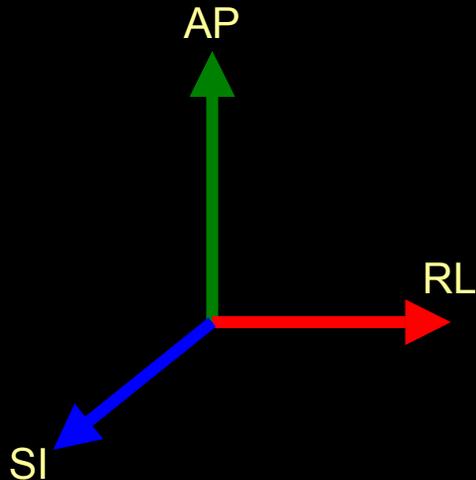
NAA map



Spectra

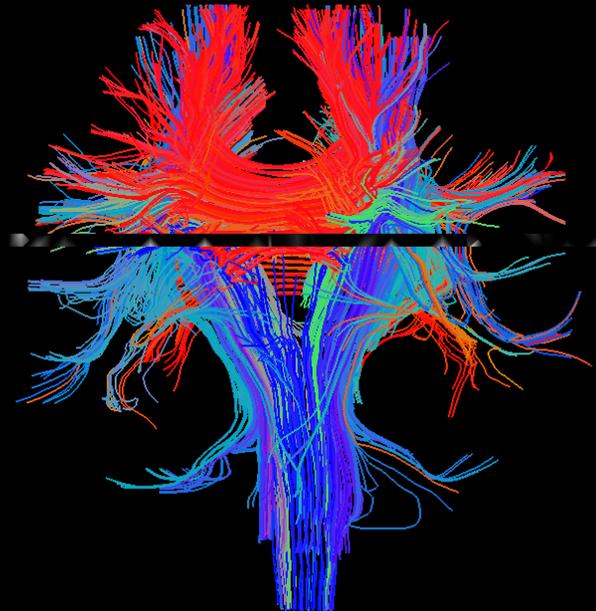
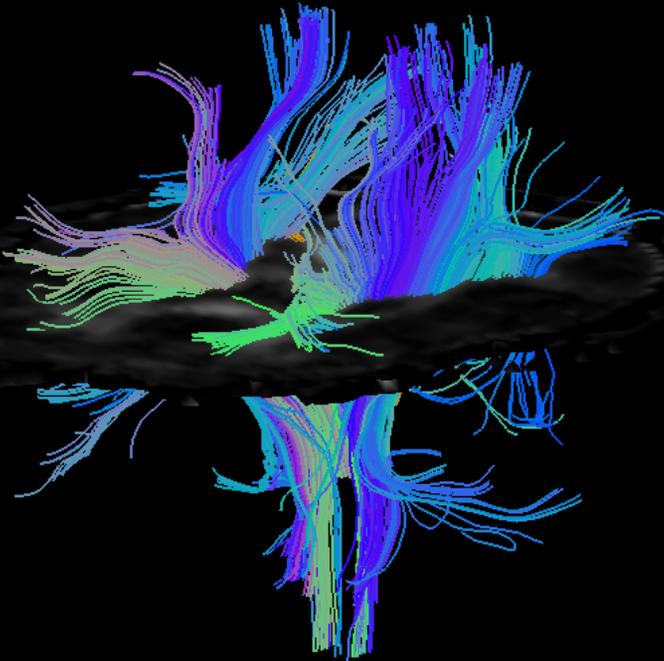
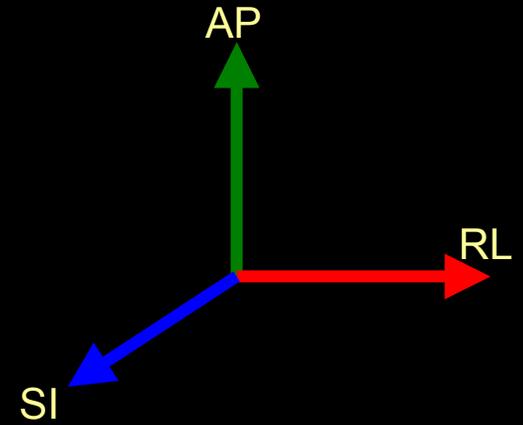
Diffusion Tensor Imaging

Diffusive Direction



周銘鐘, PhD student, NTU EE, Taipei, 2003

Diffusion Tensor Imaging Cortico-Spinal Tract

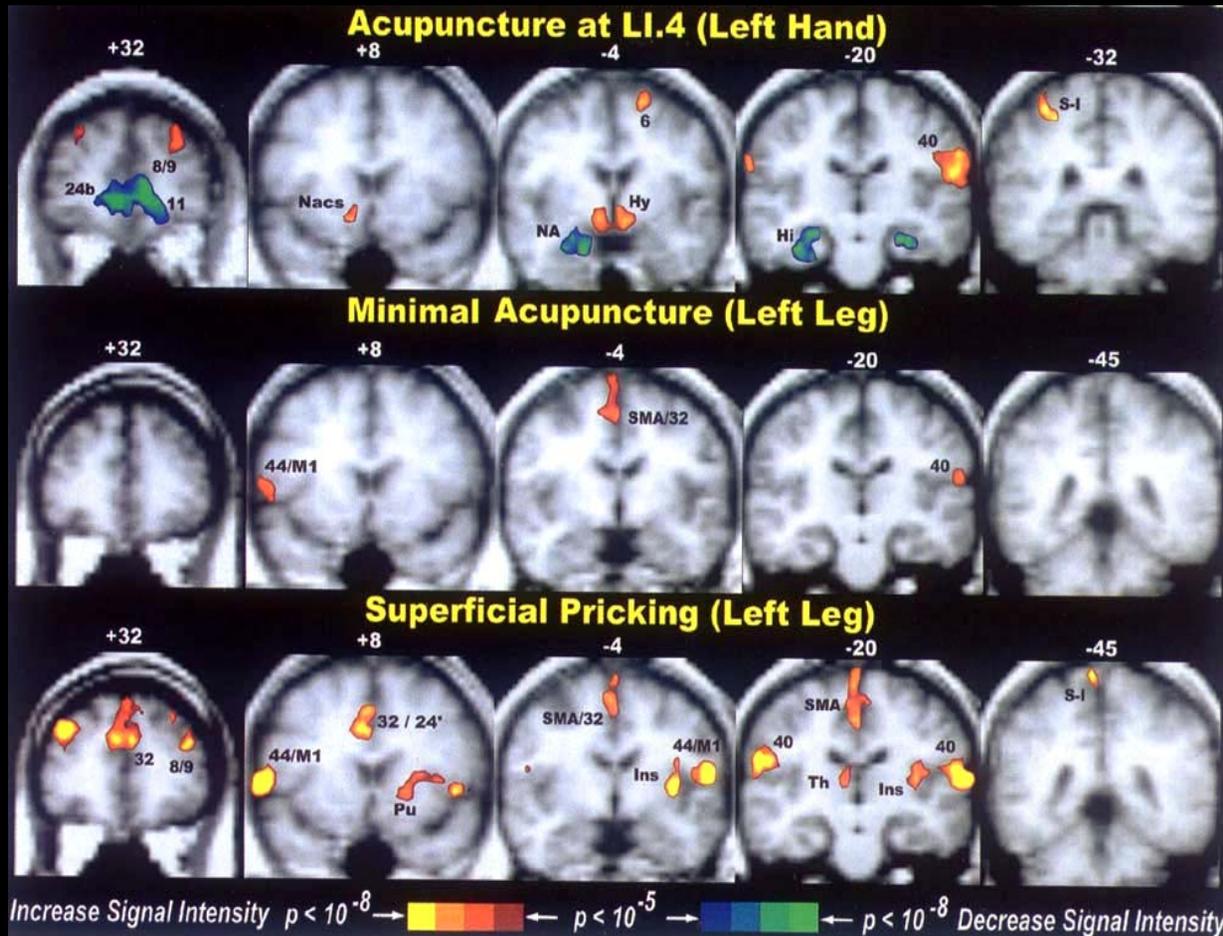


Red: Corpus Callosum

Functional MRI

- MRI 還能顯示什麼訊息？
- 腦神經細胞活動情形？
 - 你的腦袋瓜在想些什麼？
 - 刑事案件測謊??
 - 政治人物誹聞案???
 - 內分泌控制????

針灸刺激的中樞神經系統反應



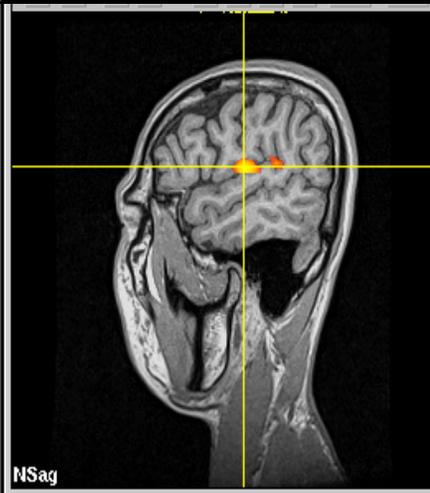
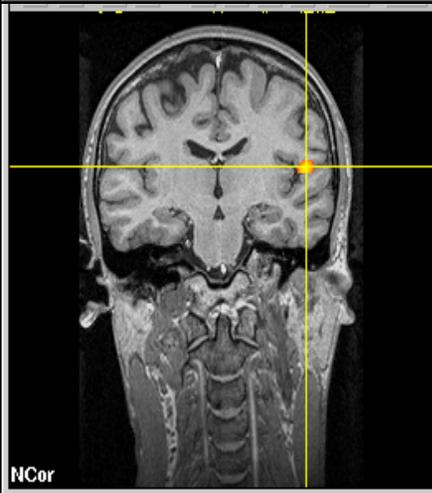
Courtesy Wu (KSVGH), Radiol 1999

腦功能影像 (左耳聽覺刺激)

L

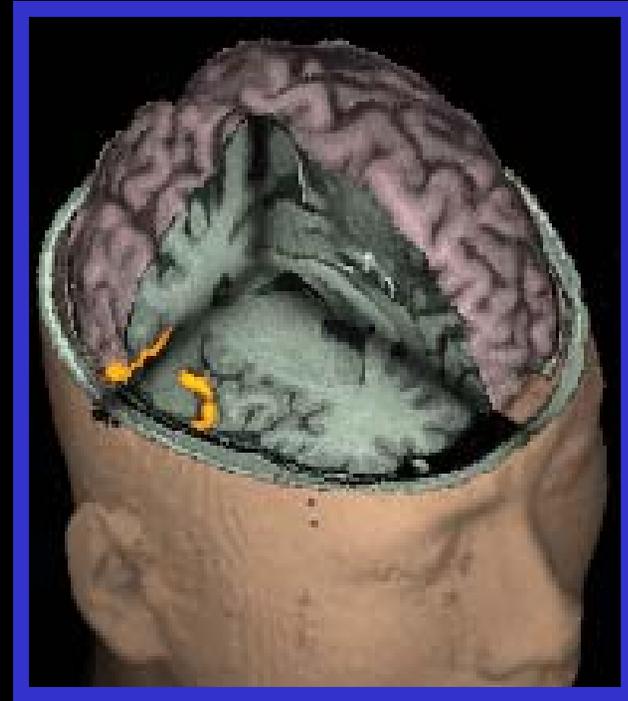
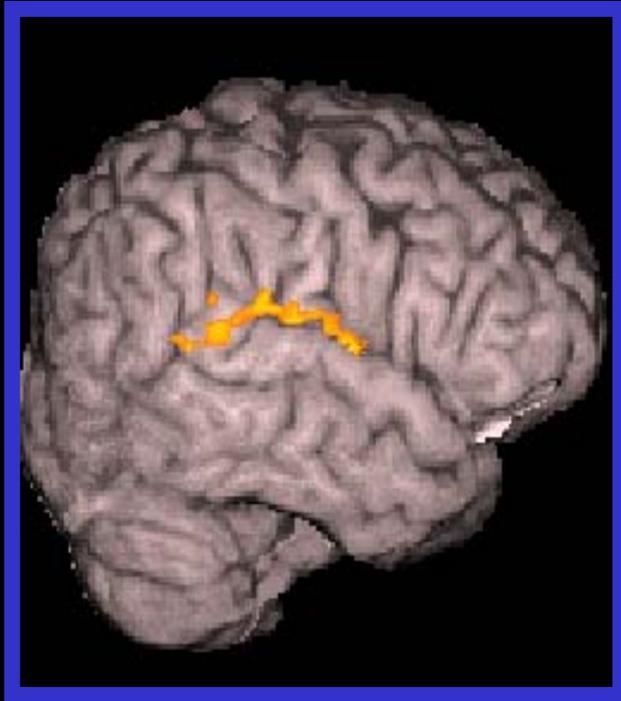


R



灰階：解剖位置
彩色：神經元活化區

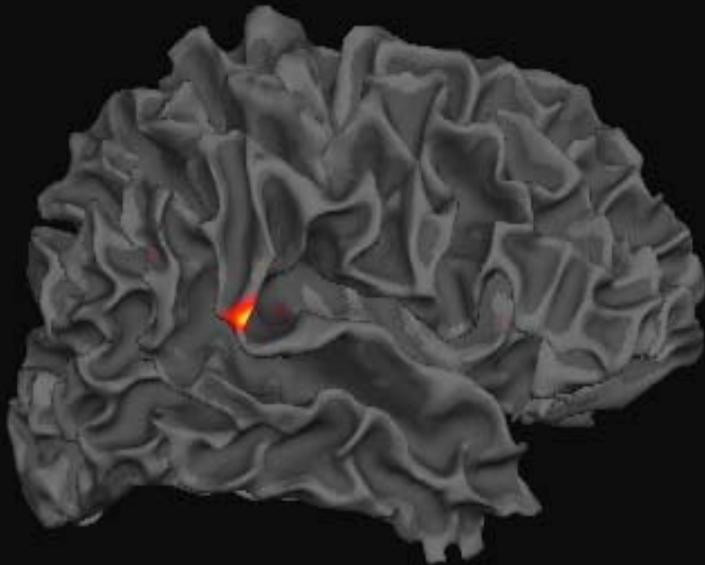
腦功能影像 (左耳聽覺刺激)



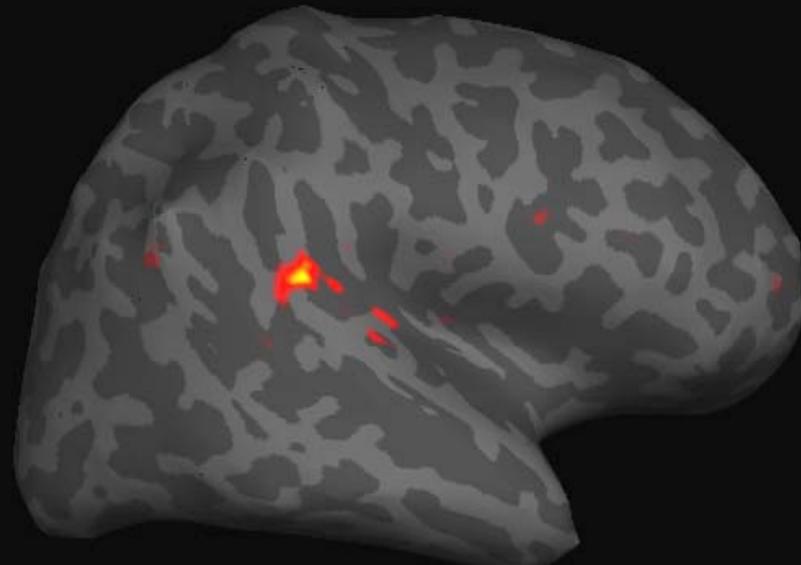
灰階：解剖位置 彩色：神經元活化區

黃英傑, PhD, NTUEE, Taipei, 2003

Cortical Surface and Inflation

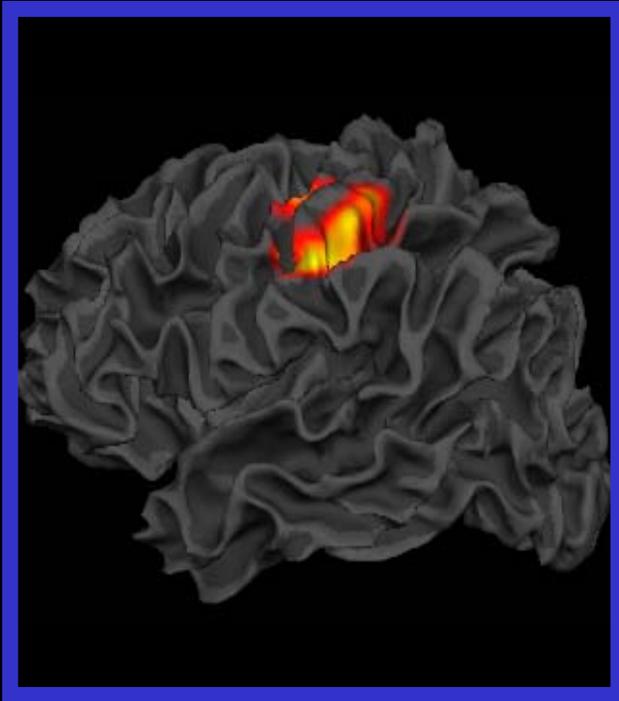


Cortical surface



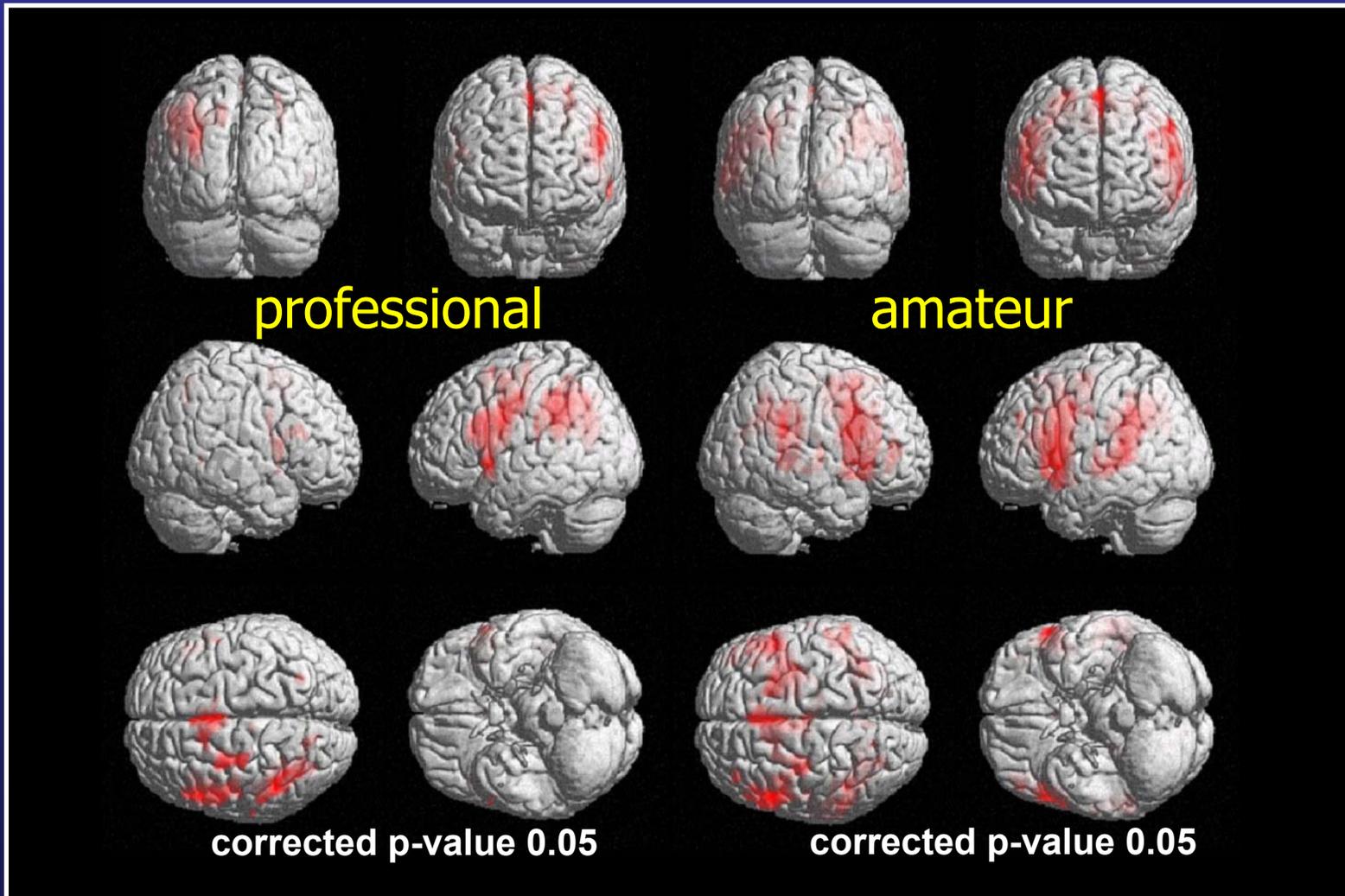
Cortical inflation

腦功能影像 (右手手指運動)



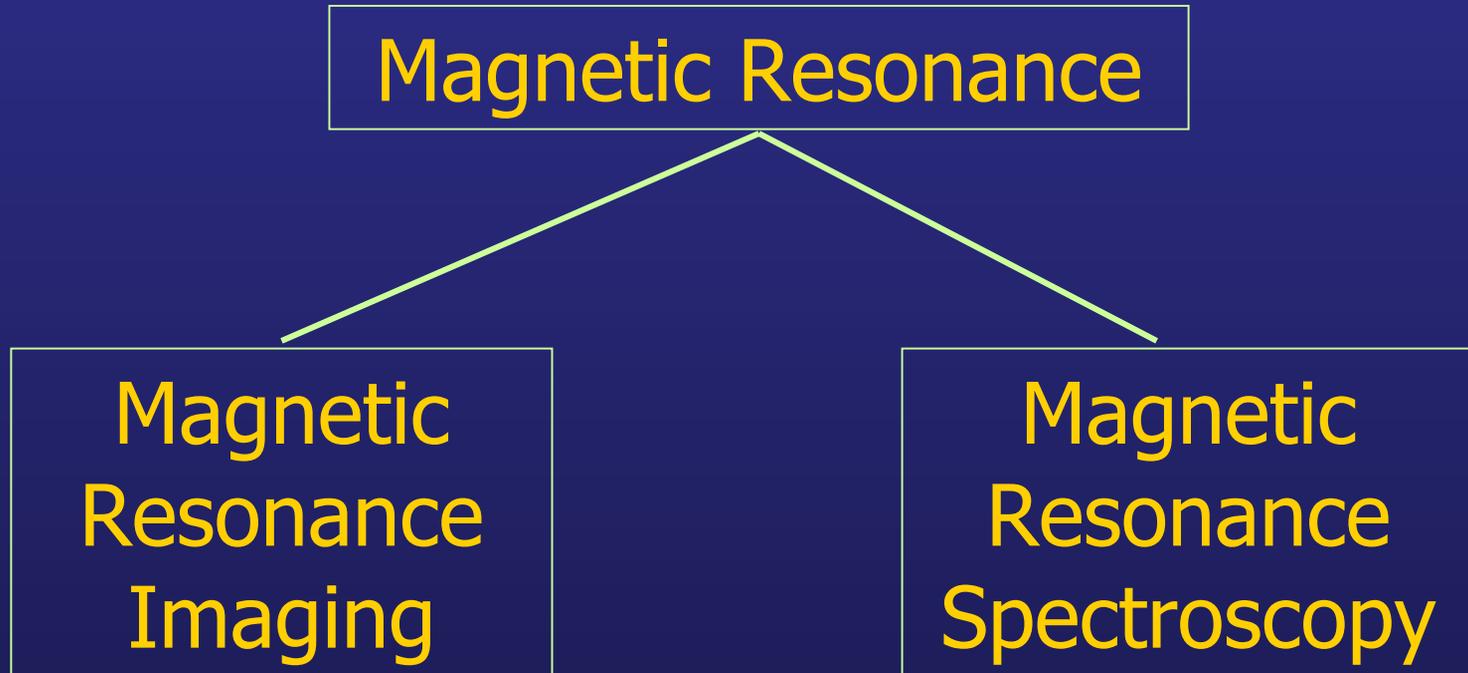
灰階：解剖位置 彩色：神經元活化區

fMRI : 和弦辨識測試

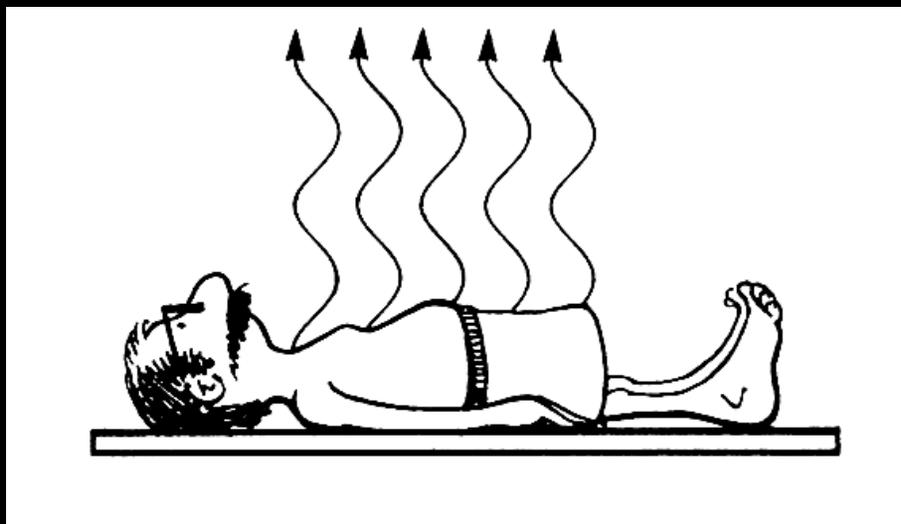


王福年, PhD student, NTUEE, Taipei, 2003

Summary



Thank You !



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