



Instituto Tecnológico y de Estudios Superiores de Monterrey

MRI activity

**BI2009B Procesamiento de imágenes médicas
para el diagnóstico (Gpo 201)**

Equipo #4

Maxine Annel Pacheco Ramírez	A01551933
Dacia Martínez Díaz	A01733799
Kristen Aideé Pérez Alvarez	A00829551
Allison Hernández Sánchez	A01366543
René Jahaziel Rangel Yáñez	A00826919

Asesor: Dr. José Tamez

Open the simulator in <https://phet.colorado.edu/en/simulations/mri>

1. NMR

Place yourself in the tab *Simplified NMR*. Remember that the Larmour relationship relates the magnetic field to the resonant frequency:

$$\nu_L = \frac{\gamma}{2\pi} B_0$$

where ν_L is the resonant frequency, $\frac{\gamma}{2\pi}$ is the gyromagnetic ratio and B_0 is the magnetic field.

Table1. Gyromagnetic ratios for different nuclei.

Nuclei	Gyromagnetic ratio	Nuclei	Gyromagnetic ratio
¹ H	42,58	⁶⁵ Cu	12,09
⁷ Li	16,55	⁷⁵ As	7,291
⁹ Be	5,984	⁷⁷ Se	8,118
¹¹ B	13,66	⁸¹ Br	11,50
¹³ C	10,71	⁸⁷ Rb	13,93
¹⁵ N	4,314	⁹³ Nb	10,41
¹⁷ O	5,772	¹¹⁷ Sn	15,17
¹⁹ F	40.05	¹²¹ Sb	10,19
²³ Na	11,42	¹²⁷ I	8,518
²⁷ Al	11,09	¹³³ Cs	5,584
²⁹ Si	8,458	¹⁹⁵ Pt	9,153
³¹ P	17,24	¹⁹⁹ Hg	7,590
³⁵ Cl	4,172	²⁰³ Tl	24,33
⁵¹ V	11,19	²⁰⁷ Pb	8,907
⁵⁵ Mn	10,50	²⁰⁹ Bi	6,841
⁵⁹ Co	10,05		

Use the Larmour relationship and the gyromagnetic ratios of various nuclei shown in table 1 to complete table

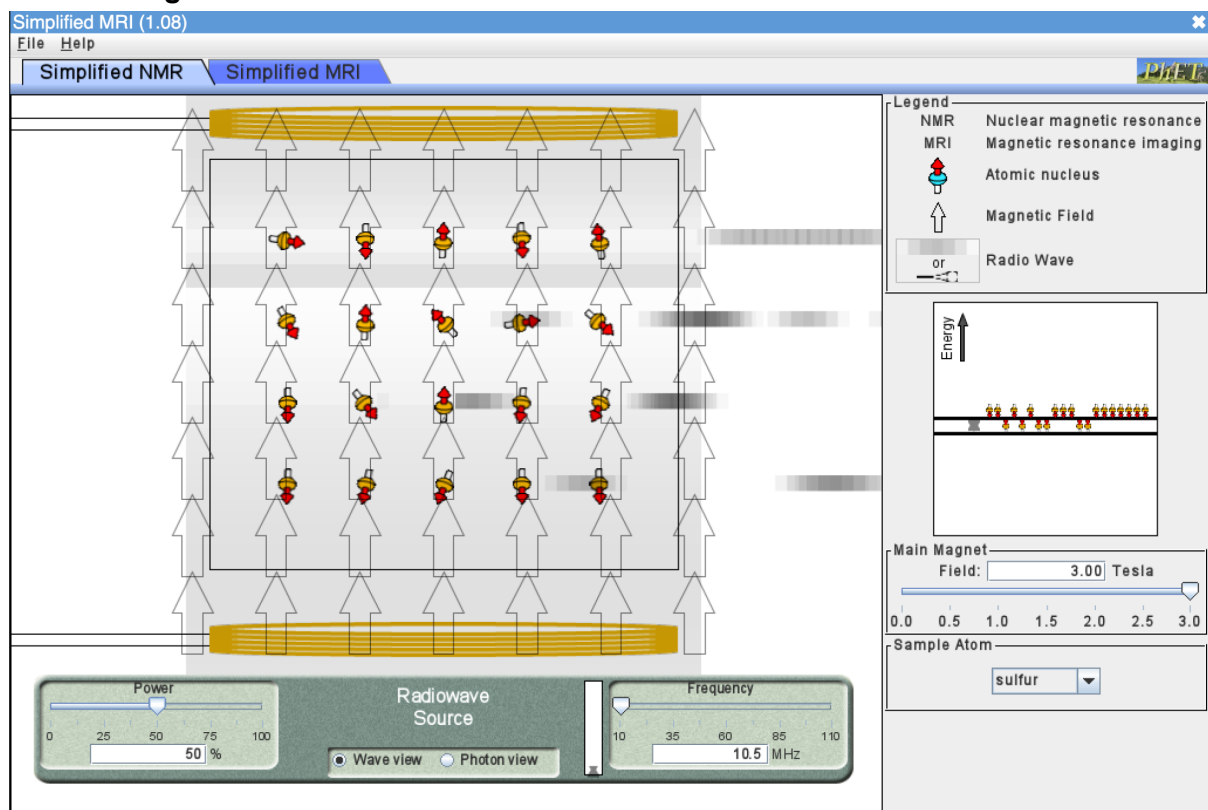
2. Check your results in the simulation by setting the appropriate frequencies and main magnet field, take a screenshot of the nuclei emitting energy to include in the report. Try to

find the last nuclei (????) by playing with the simulation and register the frequency at two different magnetic fields.

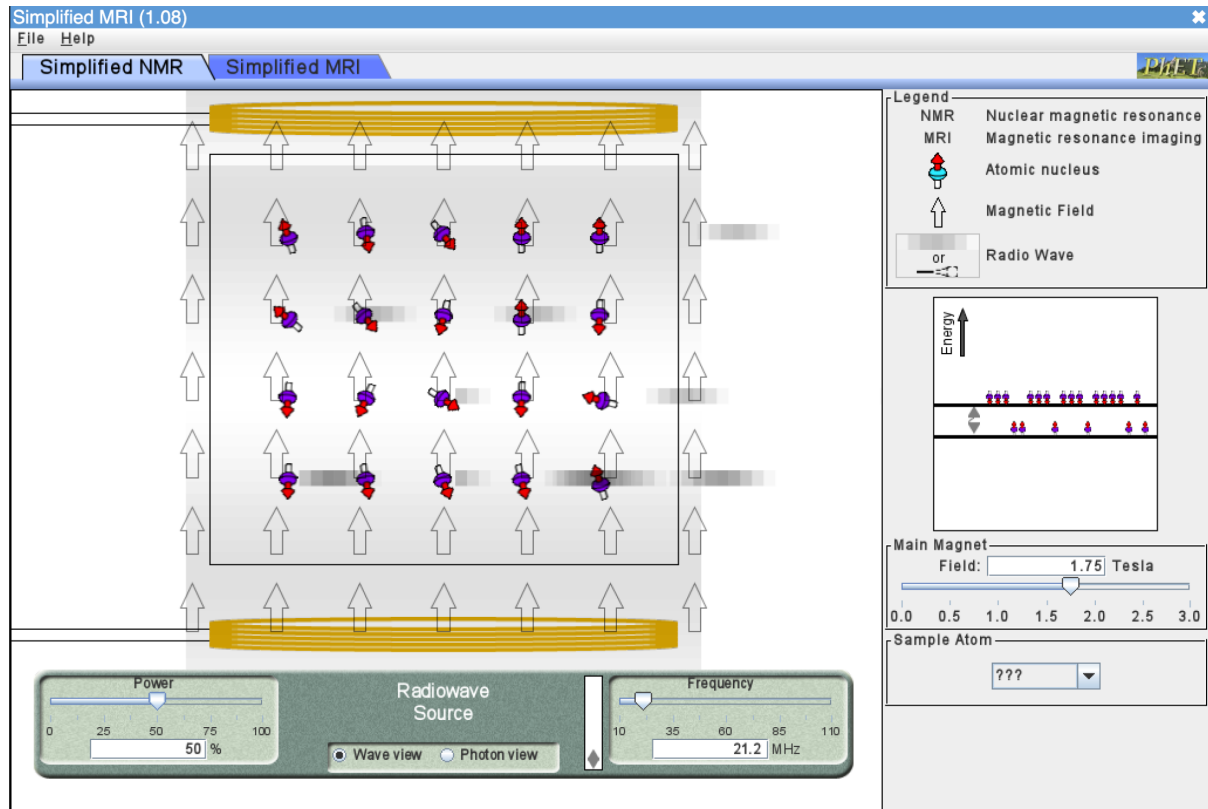
Table 2. Different settings to achieve energy emission.

Nuclei	Magnetic Field	Resonant Frequency	Magnetic Field	Resonant Frequency
Hydrogen	0.75	31.93	2.5	106.45
Nitrogen	2.5	10.5	-	-
Sodium	1.51	17.24	2.75	31.40
Carbon-13	1.75	18.74	2.5	26.77
Oxygen	1.99	11.54	3.0	17.32
Sulfur	3.0	10.5	-	-
$\frac{\gamma}{2\pi} = 12.1 \rightarrow 65\text{Cu}$	1.75	21.2	3	36.3

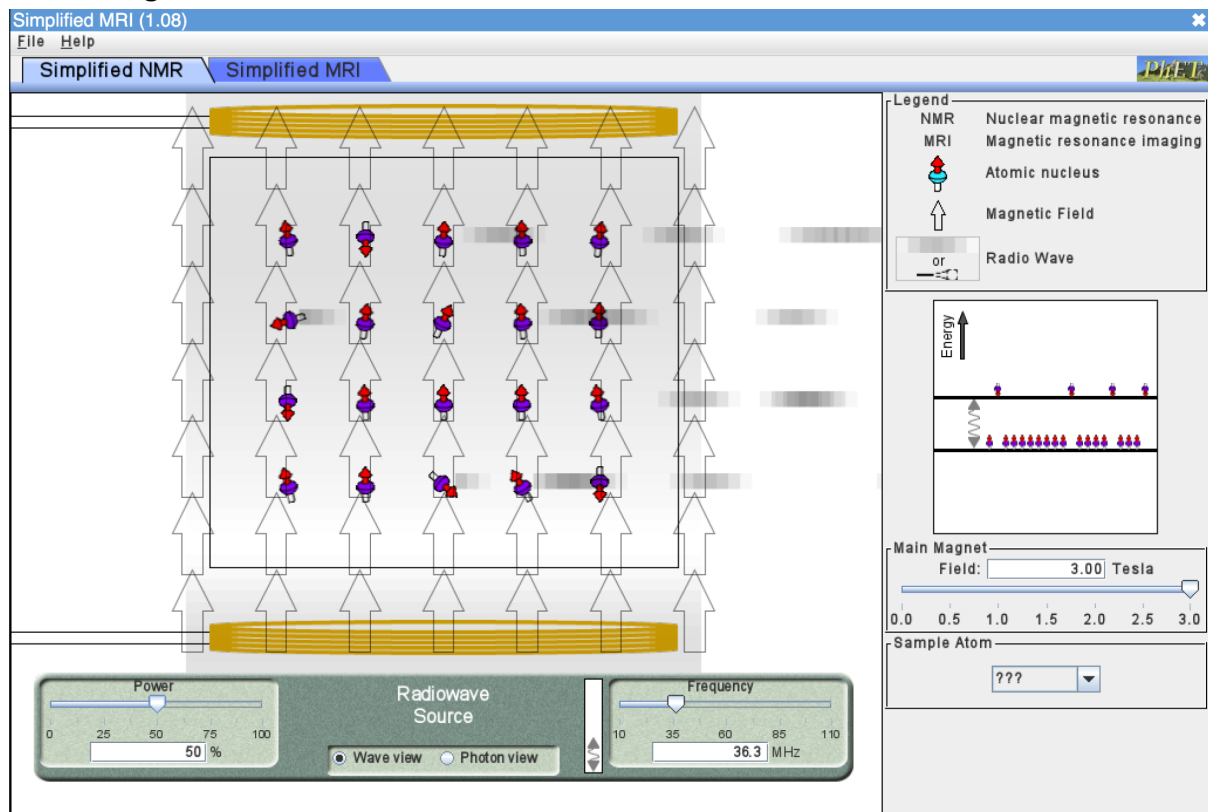
Sulfur - Magnetic Field = 3 Tesla



???? - Magnetic Field = 1.75 Tesla



???? - Magnetic Field = 3 Tesla



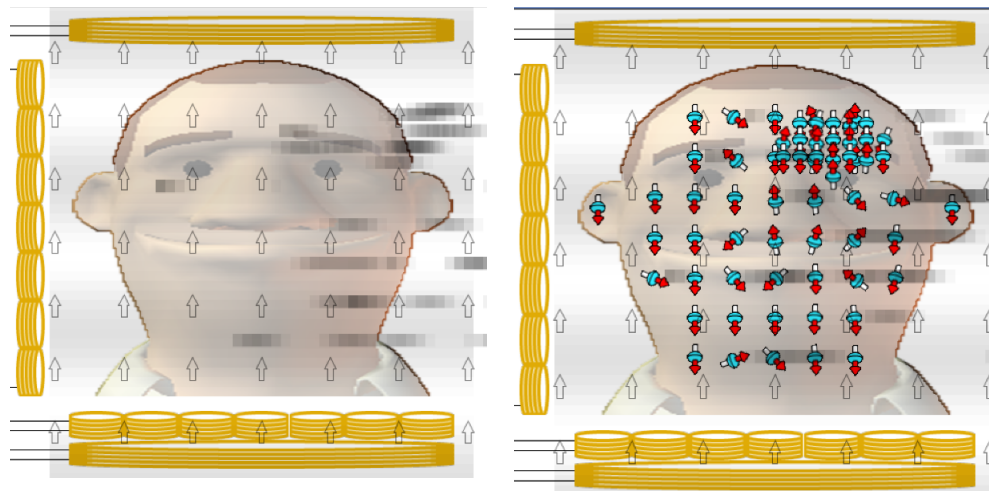
2. MRI

Move to the *Simplified MRI* tab

- Set the *main magnet field* to 1.0 Tesla, leave the *gradient magnets* in zeros, activate only *show head*, and *show magnetic field* (be sure that *show atomic nuclei* is deactivated), set the frequency in 43 MHz. Finally set the *power* to 50% and observe the flow and distribution of the emissions. After a while observing the emissions, click on *add tumor*, wait for around 7 seconds so the flow distribution stabilizes, look at how the emission changed and try to guess where the tumor is located.

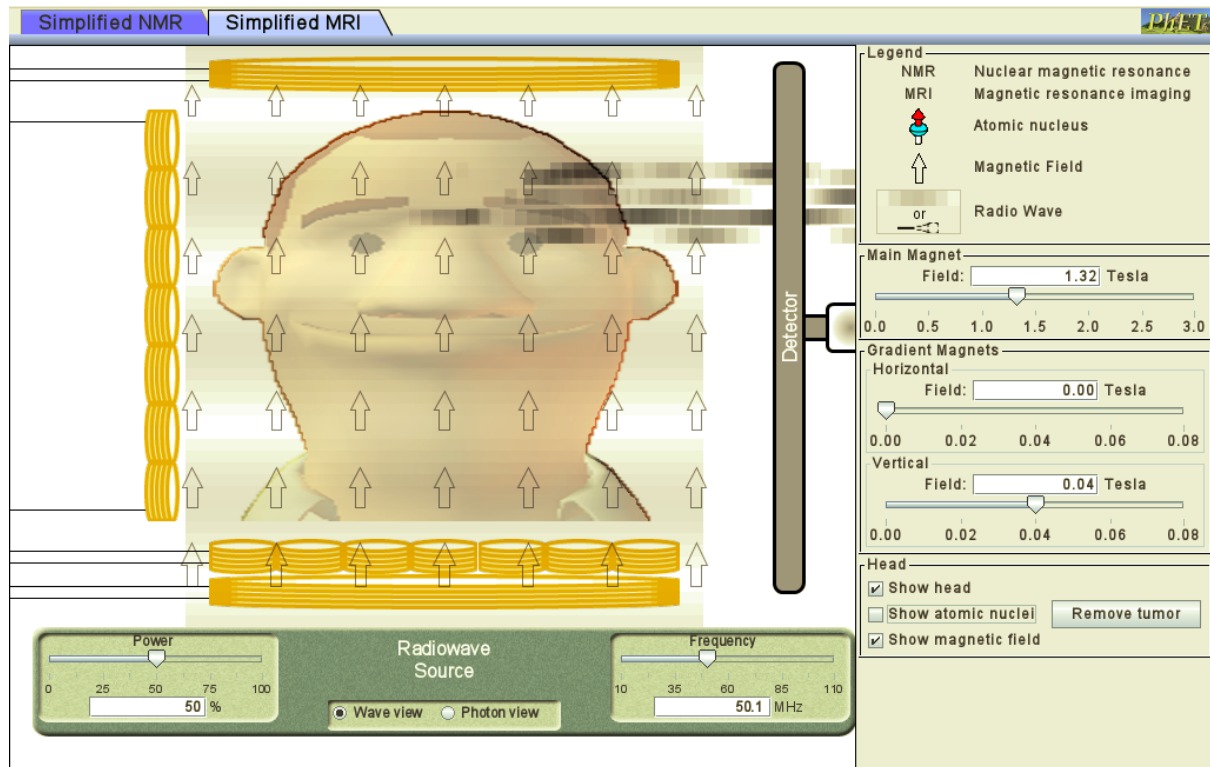
Explain how the emission allowed you to find the correct location:

Observando la emisión de fotones que se veía en el paciente, logramos identificar que el tumor se encontraba del lado izquierdo de la cabeza (lado derecho para quien lo observa de frente), ya que ahí encontramos la mayor acumulación de fotones debido a la cantidad de golpes de hidrógeno haciendo así que donde se encuentra el tumor exista una mayor cantidad de emisión en esta zona.



- Play with the main magnet field, frequency, and gradient magnets (both, horizontal and vertical) to try to obtain an emission focused mainly in the zone of the tumor (register your best guess, it doesn't need to be perfect). Answer the following questions.

Best guess: main magnet: 1.32 horizontal gradient: 0.00 vertical gradient: 0.04 frequency: 50.1



What happens when the horizontal gradient increases its magnitude? How does it affect the emissions? Al aumentar el gradiente horizontal se logra observar que la detección de los golpes de hidrógeno se vuelve más dispersa, al igual que se puede notar una menor intensidad en esta detección. Hay una mayor distribución de emisión de fotones a lo largo del eje vertical.

What about vertical gradient? Al aumentar el gradiente magnético vertical se logra observar una mayor distribución a lo largo del eje horizontal detectando golpes de hidrógenos desde partes más alejadas del detector haciendo así un poco más complicado observar la ubicación del tumor.