MRI activity.
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:

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

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

Procedure.-

- Hydrogen:
  1. $v_L = \frac{\gamma}{2\pi}B_0 = 42,58 \times 0.75 = 31,935$
  2. $v_L = \frac{\gamma}{2\pi}B_0 = v_L = 42,58 \times 2.5 = 106,45$

- Nitrogen: $v_L = \frac{\gamma}{2\pi}B_0 = 4,314 \times 2.5 = 10,785$
- Sodium:
  1. $v_L = \frac{\gamma}{2\pi}B_0 \rightarrow 17.3 = 11,42 \times B_0 \rightarrow B_0 = 1,514$
  2. $v_L = \frac{\gamma}{2\pi}B_0 = 11,42 \times 2.75 = 31.405$
- Carbon-13:
  1. $v_L = \frac{\gamma}{2\pi}B_0$
  2. $v_L = \frac{\gamma}{2\pi}B_0 = 10.71 \times 2.5 = 26.775$
- Oxygen:
  1. $v_L = \frac{\gamma}{2\pi}B_0 \rightarrow 11,54 = 5,772\, B_0 \rightarrow B_0 = 1.999$
  2. $v_L = \frac{\gamma}{2\pi}B_0 = 5,772 \times 3 = 17,316$
- Sulfur:

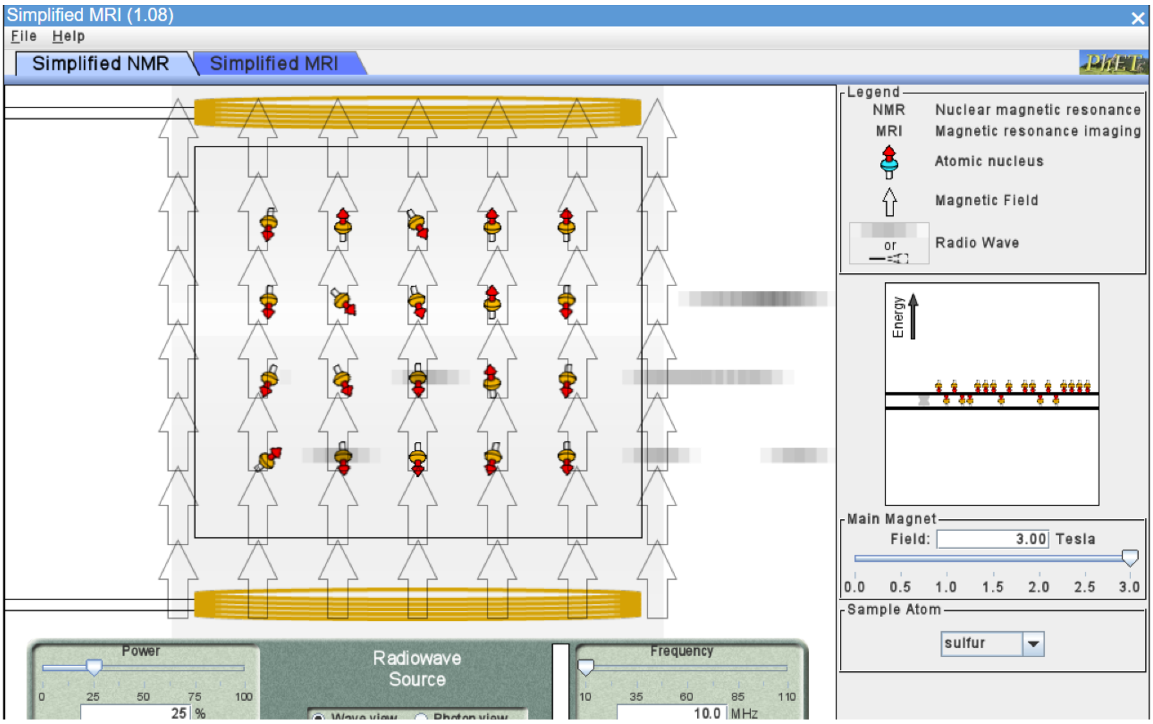


Table 2. Different settings to achieve energy emission.

Nuclei	Magnetic Field	Resonant Frequency	Magnetic Field	Resonant Frequency
Hydrogen	0.75	31.935	2.5	106.45
Nitrogen	2.5	10.785	-	-

Sodium	1.514	17.3	2.75	31.405
Carbon-13	1.75	18.7425	2.5	26.775
Oxygen	1.999	11.54	3.0	17.316
Sulfur	3.0	10 MHz	-	-
????	0.8	10 MHz		

2. **MRI**

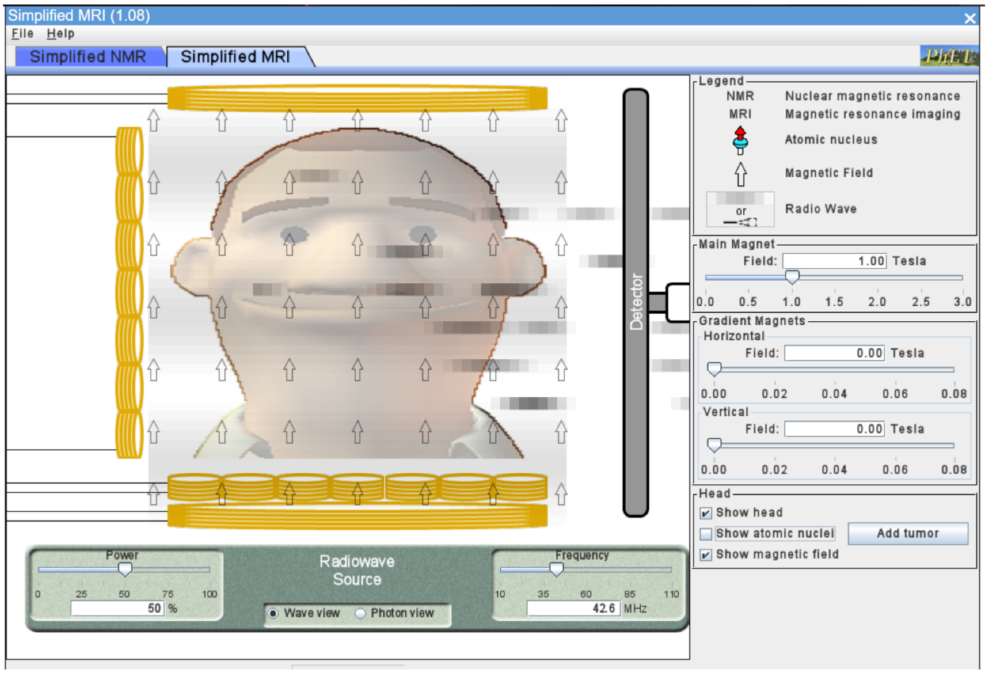
Move to the *Simplified MRI* tab

a. **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 the *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.**

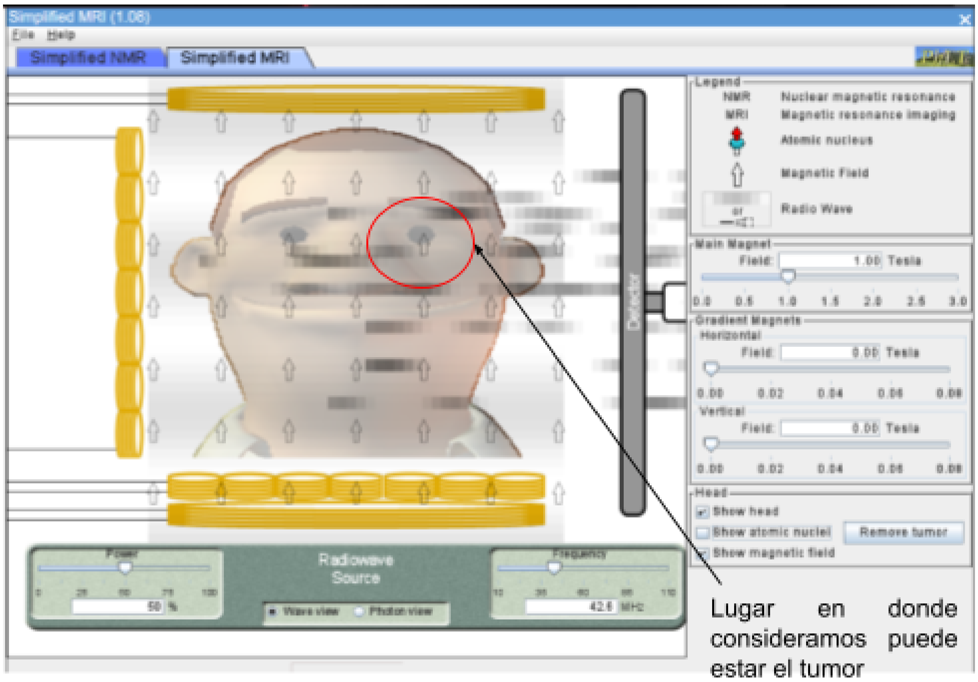
Explain how the emission allowed you to find the correct location:

La cantidad de emisiones incrementa en el lugar en donde está localizado el tumor, por ende se puede deducir donde se encuentra el tumor observando en qué lugar se incrementaron las emisiones y en qué lugar se mantuvieron igual al momento de añadir el tumor a la simulación.

Sin tumor:



Con tumor añadido:



b. 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: __ horizontal gradient: __ vertical gradient: __ frequency: __
What happens when the horizontal gradient increases its magnitude? How does it affect the emissions? ____

What about vertical gradient? ____