In NMR, a radiofrequency field (RF) is used along the x-axis to apply a pulse. It is convenient to represent this RF as two counter-rotating fields with magnitude B_1.

1. Represent these two rotating fields on a scheme.

2. Represent the variation of the field along x (detection) vs. Time.

In the rotating frame, if the RF is chosen properly, the apparent Larmor frequency of the spin is zero. We now introduce the difference frequency, called offset, that is given as:

$$\Omega = \varpi_0 - \varpi_{rot}$$

3. Give the expression of the reduced field ΔB in function of the offset frequency.

In the rotating frame, the reduced field (along the z-axis) and B1 field add vectorially to give an effective field B_{eff}.

4. What is the size of this effective field?

The tilt angle is the angle, θ, between B_{eff} and the reduced field.

5. Write the *sin, cos* and *tan* of θ. What happen when θ is π/2, π?

6. Do the same geometrical construction for the offset frequency and the effective frequency.

When the offset is zero, we talk about an "on-resonance pulse".

7. What is the tilt angle is this case?

8. After the RF is applied, the magnetization is moved away from it original position. Represent on a scheme with the magnetization the different steps before a pulse, during the pulse and after the pulse.

In NMR, most experiments start with a hard pulse. As we usually have several resonances in the spectrum, each of which having a different Larmor frequency, it is not possible to be on-resonance for all the lines in the spectrum. However, it is possible to make the RF field strength sufficiently large that for a large range of resonances the effective field lies very close to the z axis. Then, the magnetization behaves as if the pulse is on-resonance.

We want to acquire a proton spectrum covering a range of 10 ppm. The transmitter frequency is places in the middle of the spectrum and we work on a 500 MHz apparatus.

9. What is the Lamor frequency?

10. What is the maximum offset?

In the documentation of the apparatus, it is written that the pulse duration is 12 μs for this experiment.

11. Calculate the frequency ω_1 (or field strength of RF)

12. Calculate the associated tilt angle.

13. How would you measure the most efficient pulse length?

14. Do the same calculation than in 11. and 12. for a proton spectrum recorded on a 300 MHz instrument with a spectrum covering 200 ppm.

The gyromagnetic ratio of ^{31}P is 1.08×10^8 rads^{-1} T^{-1}. This nucleus shows a wide range of shifts, covering some 700 ppm.

15. Estimate the minimum 90° pulse length you would need to excite peaks over this complete range to within 90 % of their theoretical maximum for a spectrometer with a B_0 field strength of 9.4 T (the offset frequency must be 1.6 time larger than the RF field strength).