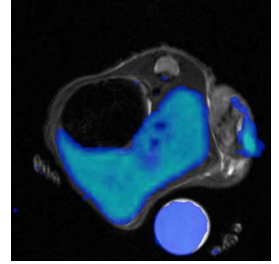Oct 02, 2023

🌐 How to 19F MRI: Supplemental protocol

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Abstract

This protocol is intended as a general guideline for *in vivo* 19F MRI experiments on a 7T Bruker system and ParaVision 6.0.1 software. Specific sequence parameters depend on the intended application and the imaging agent used.

Image Attribution

All images and illustrations were produced by the authors.

Materials

- 7 Tesla MRI (Bruker Biospec 70/20)
- 1H/19F transmit-receive volume coil (40 mm inner diameter)
- Bruker ParaVision 6.0.1
- 19F reference tube containing your imaging agent of interest
- Ventilation system which can mix oxygen, air and isoflurane
- Anaesthesia induction box
- Animal bed
- Lubricated rectal thermometer cover (scan time >20 min)
- Ophthalmic ointment
- Circulating warm water blanket
- Respiratory pillow
- Surgical tape
- Warmth pad for recovery

Troubleshooting

Safety warnings

> ⛔ Prior to conducting any MRI experiments take all the necessary safety precautions and be aware of potential hazards caused by the strong magnetic field (e.g. projectile hazards, medical implants). Follow the safety guidelines as instructed by your facility.

Ethics statement

Imaging with laboratory animals requires approval from an animal ethics committee and should be performed according to internationally-accepted standards to ensure animal welfare.

Before start

NOTE: Since this is a general 19F MRI protocol, it is assumed the 19F MRI probe has already been administered to the animal.

Preparation of the instruments

1   Check whether the desired RF coil (e.g. a dual-tuned 1H/19F birdcage coil) and animal cradle are connected to the MRI.

2   If inhalation anaesthetics are used, control the tubing towards the induction chamber and the animal cradle. Refill the isoflurane vaporiser if needed.

3   Turn on the circulating warm water blanket system.

4   Place and secure the respiratory pillow on the cradle, where the thorax of the mouse will be.

5   Place the absorbing tissue on the animal bed. Have the ophthalmic ointment ready.

6   In the control room, turn ON the system and start ParaVision 6.0.1. Select: File > New Study and fill in the required fields. Click **"Create"** followed by **"Exam"**

Animal preparation

7   Place the mouse cage in the flow hood. Open the valve of the vaporiser towards the induction box, and set the O2/air flow rate at 1 l/min. Move the mouse from the cage to the anaesthesia induction box.

8   Set isoflurane at 2-3%. Assess the level of anaesthesia via the pedal reflex. Open the valve to the MRI and close the valve to the induction box.

9   Move the mouse to the animal bed, ensuring adequate contact with the respiratory pillow. Apply ophthalmic ointment and secure the animal with its teeth to the toothbar in the prone position. To monitor the animal's body temperature, insert the anal probe that is covered in the lubricated cover and tape the wire to the bed.

10 For quantitative 19F MRI, place a reference tube with a known concentration of 19F atoms alongside the mouse.

11 Cover the animal with the circulating warm water blanket and secure in place.

12   Place the 1H/19F volume coil over the animal bed. Check for any restriction of cables or tubing.

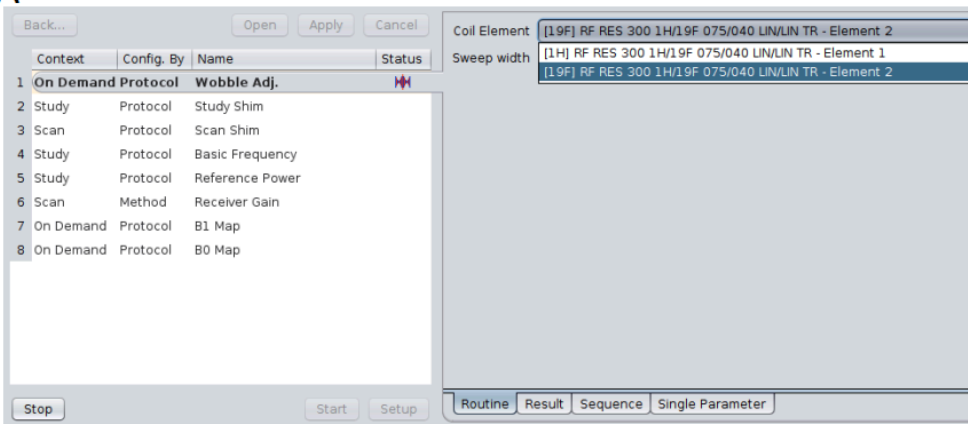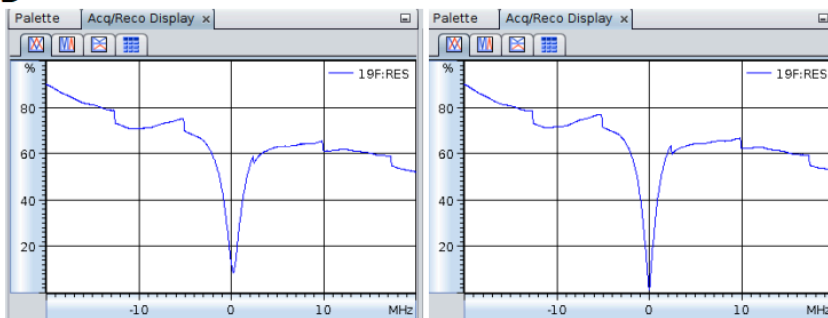13   **Wobble adjustment of the RF coil**

> **Note**
>
> Some scanners perform the wobble adjustment automatically.

Tune and match the RF coil to the correct resonance frequency and impedance, respectively. Back at the computer, open the adjustment platform on the examination card. Select "Wobble Adjustment" and click "Setup". Choose the desired coil element (Supplementary figure 1a). The wobble curve should appear at the Acq/Reco display; if not, increase the sweep width. Go to the MRI room. Manually turn the tune/match capacitor rods on the RF coil and monitor the wobble curve on display at the monitor located in the back of the scanner. Adjust until the wobble curve is centred at 0 MHz and the vertex approximates the minimum (Supplementary figure 1b). Press "Stop" to finalize the wobble adjustment.

A

B

Supplementary figure 1. Coil tuning and matching. A. Screenshot of the adjustment platform and the Routine card on the wobble adjustment displaying the selected coil element. B. Example of wobble curves at the 19F channel. The left curve represents a poorly tuned and matched RF coil. The curve on the right is obtained after tuning and matching.

14 Repeat step 13 for the other coil element.

15 Insert the 1H/19F coil with the animal bed into the MRI, and position it at the isocenter of the magnet.

Imaging of the animal

16

> **Note**
>
> The default protocols in ParaVision serve as a starting point as they are already optimised for in vivo 1H MRI. In addition, users can adopt and store customised protocols.

In the Palette > Explorer window, select Object (Mouse), Region (Abdomen) and Application (Anatomy). Drag the "1_Localizer" protocol to the scan queue and acquire the

scan by pressing continue. Prior to imaging, the scanner system will perform several automated calibration steps.

Adjust the position of the animal or the geometry of the scan and repeat the scan as needed.

17 To acquire an anatomical 1H image, drag the desired protocol (e.g. T2_TurboRARE) into the scan queue and adjust the geometry (FOV, slices, slice thickness etc.). Store changes by clicking on "Apply". At the beginning of a study, the system performs iterative shimming, but additional scan shim adjustments may be required depending on the selected protocol.

18 For this coil set-up the reference power calibrated using the 1H channel can be used on 19F (Supplementary figure 2). This value can be found at the setup card or at the adjustment platform. Note this number.

Supplementary figure 2. Manual adjustment of the required reference power for the 19F channel on a dual-tuned 1H/19F volume coil. Due to the small number of 19F spins in a sample, automated coil adjustments are performed on 1H, including the calculated reference power (green box). By changing the coil operation and navigating to the adjustment platform, the reference power for the 19F channel can be adjusted (blue box) and stored.

19 Acquire a non-localized 19F NMR spectrum using the Singlepulse sequence and following the next steps.

20 Go to Object (Mouse), Region (Head), Application (Spectroscopy) and drag the Singlepulse protocol to the scan queue. Adjust the flip angle to 90 degrees.

21 Change coil operation from 1H to 19F: go to the [System] tab → Operation mode → [F19] Tx/Rx Volume. Enter the adjustment platform and from the list select "Reference Power" > "Result". Change the 19F reference power to the value obtained from the 1H calibration (step 18). Right click on "Reference Power" on the list and select "Save Adjustment Result" to use this value with different scans during a single study.

22 Go to "Palette" > "Explorer" > "Datasets". To load the NMR spectrum, right click the Singlepulse sequence and select "Load in Topspin".

23   1. Insert the following commands in Topspin sequential order:
"lb", "ef", "apk" and "pp". For the "lb" command use a value of 10.
While the commands above are recommended in the Bruker manual (ParaVision 6.0.1 Operating Manual p.571), readers are also advised that it might be possible to achieve this by using the magnitude spectrum.
Supplementary figure 3 is an example of an acquired 19F NMR spectrum depicting the chemical shift offset of perfluoropolyether (PFPE)
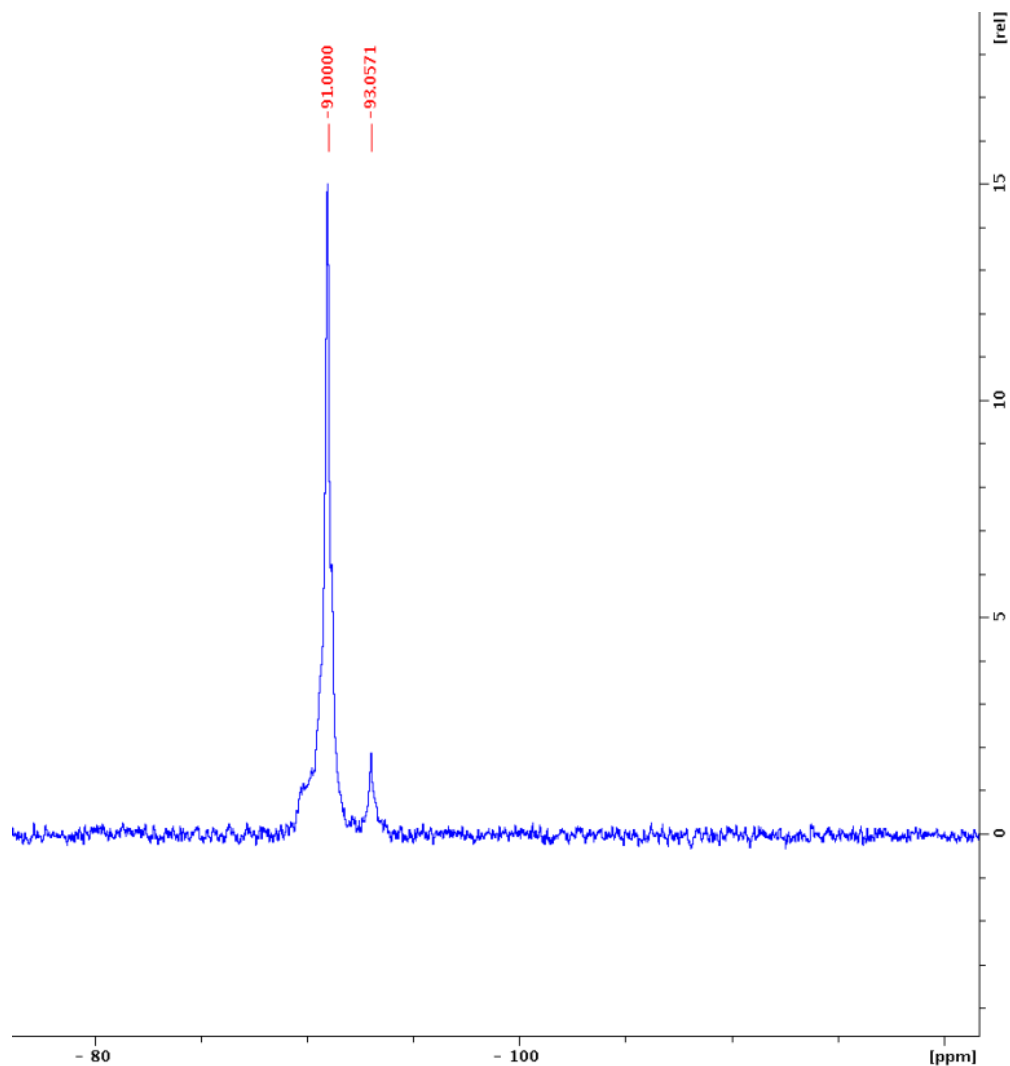
Supplementary figure 3. Perfluoropolyether (PFPE) NMR spectrum obtained on a Bruker 7T MRI system. The major and minor NMR peaks of PFPE correspond to a chemical shift of -91 and -93.06 ppm, respectively. The minor peak is not detectable via 19F MRI at typical concentrations in vivo.

24 In the adjustment platform go to "Basic frequency">"Result" and enter the chemical shift offset of your peak of interest e.g. the major peak at -91 ppm. Right click on "basic frequency" to save the adjustment result.

25 Set up the 19F MRI protocol (e.g. T2_TurboRARE). Make sure to change coil operation from 1H to 19F.

26 Insert imaging parameters appropriate to the relaxation properties of your 19F agent.

27 Copy the slice geometry from the 1H anatomical scan by dragging that protocol on top of the 19F protocol. Adjust matrix size to an attainable 19F resolution and start the scan.

28 After imaging export the images in DICOM (or other relevant format) for subsequent image analysis.