

DEAR COLLEAGUE:

It has been a busy year. We may have seen you at last year's ENC at Asilomar, ISMRM in Honolulu, or EuroMar in Oulu. Maybe in Chamonix for the Alpine Solids NMR Conference, or in Gainesville, Florida for SEMRC. A lot of time zones and a lot of good science.

We hope to see you at ENC where we will present – in the instrumentation session on Tuesday afternoon – our ultra-high-field NB H/F/X/Y No-E two coil NMR Probe.

Last year we pushed fields higher with our No-E two-coil XVT $^1\text{H}/\text{X}/\text{Y}$ **1200 MHz NMR probe** (with two broadband channels). In the second section of this newsletter we share some of Univ. of Lille's low temperature results.

In MRI, we built a **15.2 T $^1\text{H}/\text{X}$ coil** for mouse or rat head with which the Weizmann Group have gotten remarkable $^1\text{H}/^2\text{H}$ pregnant mouse images with the X coil tuned to ^2H .

David and Judy Doty

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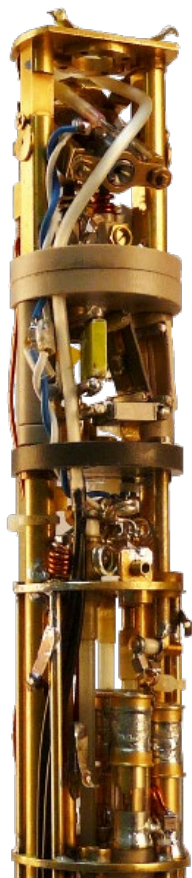
Images From Doty MRI Dual-Frequency and Multinuclear Coils, 3 T to 15.2 T

The Doty ENC Suite is "Surf and Sand".

Come by and learn more details about these products, see what else we do, and enjoy ice cream.

Open 7:00 to 11:00 PM Sunday through Wednesday. See the map at the end of this newsletter.

The New $^1\text{H}/^{19}\text{F}/\text{X}/\text{Y}$ Ultra High Field, NB, No-E Two-coil NMR Probe



The NB probe is suitable for HR-MAS – on liquids, semi-solids, tissues, and solids – at fields from **7 T to 23.4 T** with rotors from 1.3 mm to 3 mm. Up to 30 T with 1.3 mm.

Probe tuning was simulated to 1300 MHz. The probe was physically tuned to 500 MHz, 800 MHz, and 1 GHz. Clean UHF H/F tuning on the H/F/X/Y probe was captured with spectrum analyzers showing ^{19}F at 752 MHz and ^1H at 800 MHz simultaneously, also ^{19}F at 941 MHz and ^1H at 1 GHz.

Details and NMR results will be presented at a talk given by David Doty on Tuesday afternoon in the instrumentation session.

Probe Specs

- High Performance Quad Resonance Circuit $^1\text{H}/^{19}\text{F}/\text{X}/\text{Y}$ with Separate ^1H and ^{19}F Channels; can also be configured as $^1\text{H}/^{19}\text{F}/\text{X}$.
- Outer No-E ^1H Coil for ^1H decoupling with minimal RF heating
- An Inner Solenoid for the ^{19}F and X and Y Broadband Channels
- Linewidth below 2 Hz with excellent lineshape
- High power ^1H and ^{19}F simultaneous decoupling
- Very Low ^{19}F backgrounds
- Rotor diameters: 1.3 mm and 3 mm
- Extended VT (XVT)
 - 160 to +160 °C for MAS
 - 170 to +150 °C for Wideline

Low Temp Results from a Doty XVT, 1200 MHz, No-E Two-coil,

We would like to highlight the following work done with this Doty probe at Lille Univ., France. The spectra show the value of the low temperature capabilities of this 1.2 GHz probe.

⁹¹Zr NMR on Metal-organic framework, 28.2T, 110 K sample temp.

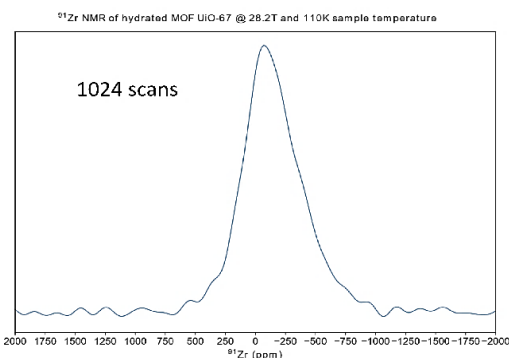


Fig 1. ⁹¹Zr spectrum of UiO-66 MOF sample at 28.2T, T=110 K. The Doty 5-mm 28.2-T WL XVT probe allowed a factor of 64 reduction in signal averaging time at 110 K compared to what was seen at 140 K in a 4-mm 18.8-T WL probe by another vendor for the same ⁹¹Zr experiment – from the combination of higher field, larger sample, and lower temperature [1]. In this case, the lower temperature helped in multiple ways: allowing more echoes (from increased CPMG relaxation rate), increased Boltzmann factor, and reduced thermal noise.

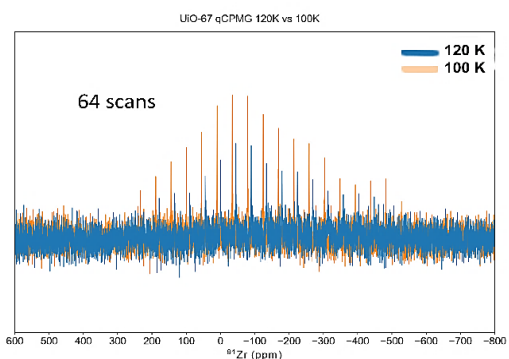


Fig 2. UiO-66 qCPMG echo decay at 100 K and 120 K. Changing the set point from 100 K to 120 K the signal is reduced due to relaxation effects. Echoes are lasting longer at lower temperature.

[1] Nadol, A. et al. Probing the Water Adsorption and Stability under Steam Flow of Zr-Based Metal–Organic Frameworks Using ⁹¹Zr Solid-State NMR Spectroscopy. *Chem. Sci.* **2024**, *16* (1), 69–82. <https://doi.org/10.1039/D4SC04589K>.

Thanks to Julien TREBOSC and Bertrand Doumert for recording the spectrum; and to Frédérique Pourpoint and Christophe Volkringer for providing the sample. Univ. of Lille.

Probe Specs

- High Performance Triple Resonance ¹H-¹⁹F/X/Y Circuit, with the proton channel tunable from ¹H to ¹⁹F
- Outer No-E ¹H Coil for ¹H decoupling and an inner solenoid for the X and Y broadband channels
- Extended VT (XVT)
-170 to +180°C for Wideline
-160 to +180°C for MAS
- 1.3 mm to 5 mm for Wideline
3 mm or 4 mm for MAS
- Together the 2 broadband channels (with appropriate inserts) can cover the entire periodic table, from ³¹P on down.



The 1200 MHz, 5 mm ¹H-¹⁹F/X/Y probe shown here is Wideline, but MAS is also available.

Images From Doty MRI Dual-Frequency and Multinuclear Coils, 3 T to 15.2 T

Over the years, Doty Scientific has maintained a reliable reputation for providing excellent Dual-frequency MRI research coils, ^1H /Fixed-Frequency as well as $^1\text{H}/\text{X}$ with the X channel multinuclear with tuning inserts. These coils range from mouse coils to primates, 3 T to 15.2 T. Images from a few are presented below.

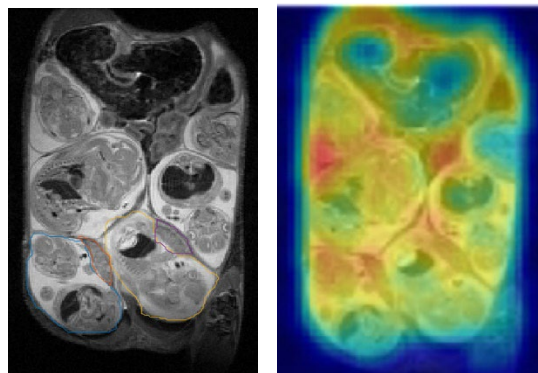
$^1\text{H}/\text{X}$ Multinuclear Coil



15.2 T, ^1H and ^2H Imaging on a Dual-Frequency ^1H - $^{19}\text{F}/\text{X}$ Mouse Volume Coil

MRI ^1H and ^2H results on a pregnant mouse (E16.5) were recorded in ~ 2 minute intervals following injection of saline D_2O , providing water transport information across the placentas and into individual fetal organs at a level never before seen. ^1H image on left. ^2H image on right.

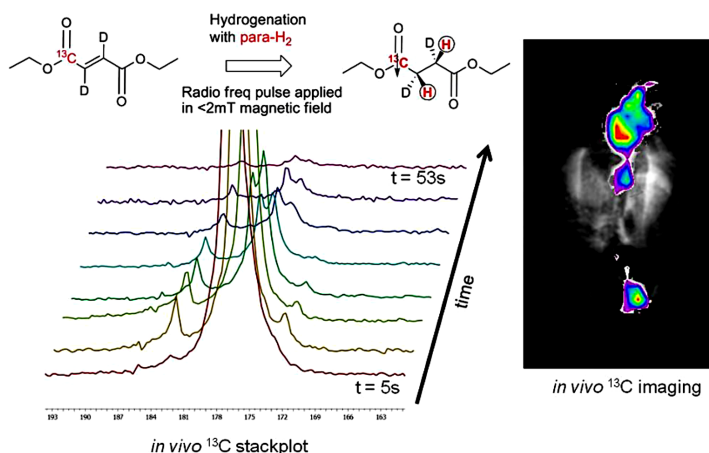
Images from Weizmann Institute of Science, Rehovot, Israel.



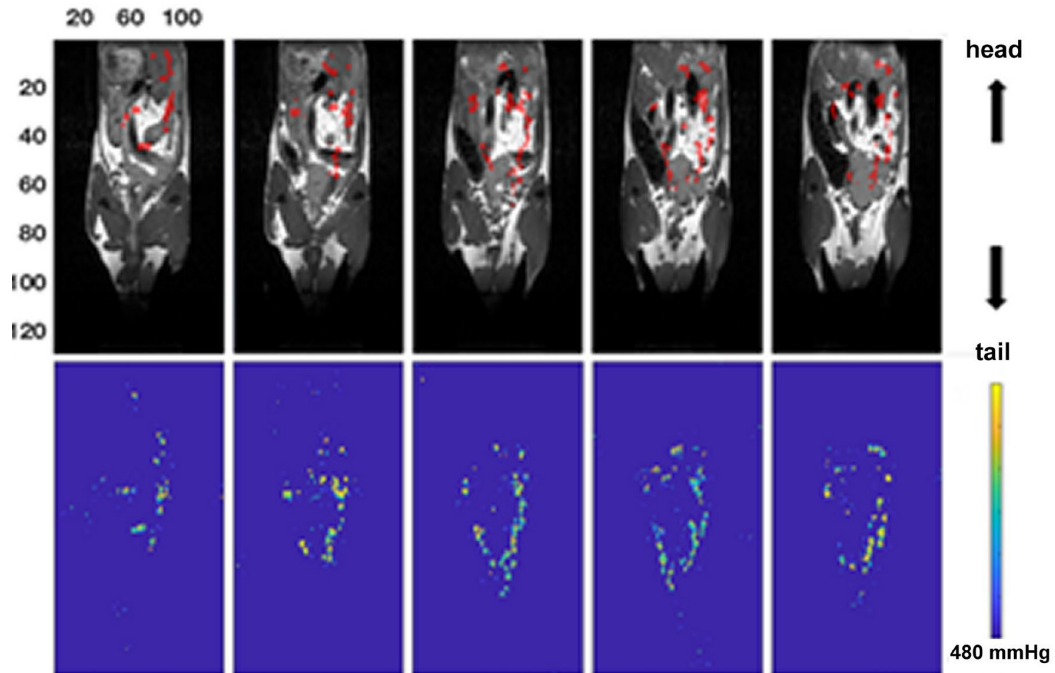
Results Obtained at 4.7 T with a Doty $^1\text{H}/^{13}\text{C}$ Full Body Mouse RF Volume Coil

^{13}C magnetic resonance spectroscopy (MRS) and magnetic resonance imaging (MRI) of the TCA cycle were achieved seconds after injection of 10 to 20 mmol of hyper-polarized diethyl succinate into normal mice.

Courtesy of N Zacharias, H Chan, N Sailasuta, B Ross, and P Bhattacharya, JACS 2012 Jan 18: 134(2):934-43.



Results Obtained with a Doty 7 T 38 mm ¹H/¹⁹F Mouse Body Volume Coil



Above: Spatiotemporal in vivo pO₂ tracking and clustering of biomaterial implants in mouse.
 Top: in vivo slice-by-slice fused MRI images, collected with 7 T Doty ¹H/¹⁹F module, of fluorocapsule distribution (¹⁹F-MRI, red) and soft tissue anatomy (¹H-MRI, grayscale) at day 1 post implantation for 1.5 mm fluorocapsules implanted in a healthy mouse.
 Bottom: Calculated pO₂ spatial color maps (brighter colors correspond to decreased pO₂).

Spanoudaki V, Doloff JC, Huang W, Norcross SR, Farah S, Langer R, Anderson DG. Simultaneous spatiotemporal tracking and oxygen sensing of transient implants in vivo using hot-spot MRI and machine learning. Proc Natl Acad Sci U S A. 2019 Mar 12; 116(11):4861-4870.

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