Surface Coils for High-Field MRI / NMR

Numerically optimized surface coils
Up to twice the S/N
Not all Surface Coils are Created Equal

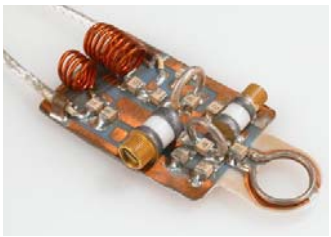
- Doty surface coils feature conductor geometries optimized for best sensitivity and B_1 homogeneity with biological samples.
- Non-magnetic sealed tuning capacitors mounted adjacent to the coil on a low-loss dielectric substrate - either polyimide or Teflon.
- Fitted with double-shielded flexible rf line (Teflon or polyethylene) with BNC connector.
- Diode-clamped versions are available for homonuclear experiments using a volume transmit coil.
- Double-tuned surface coils are also available.
- Standard coil diameters include 8, 12, 16, and 24 mm. Other sizes are available on special order.

Specify type, diameter, frequencies, and dielectric materials. Balanced circuits are used except for small coils at low frequencies. The prices shown are typical for fd (frequency x diameter) of 7 MHz • m or less, as for example, 24 mm @ 300 MHz. For fd greater than 7 or for non-standard sizes, prices are higher.

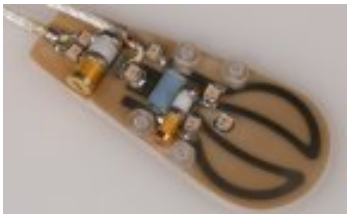
#99657Single-tuned surface coil ……..... $1900
For transmit-receive with detuned volume coil.

#99656 Single-tuned, passively detuned ….. **$2300**
For receive only with separate transmit coil.

#99652 Double-tuned single-loop .....…….. **$4800**
For transmit-receive and hetero nuclear decoupling in small coils at well spaced frequencies.



#99651 Double-tuned loop/butterfly…….. **$5500**
For transmit-receive and hetero nuclear decoupling, for close resonances and larger coils.



#99648 Remote coil matching network **$1000**
Allows remote impedance matching and limited (2%) frequency tuning of surface coils. Specify high-range (above 200MHz), mid-range, or low range (below 80MHz).

#99647 50mm RF Tuning Shield ….....…..... **$700**
For bench tune-up of surface coils to be used in DSI 50-72 gradient coil.

(Foreign prices higher, plus taxes)

Vertical Bore Imaging, 3-Axes Gradient Probes

Gradient Probes

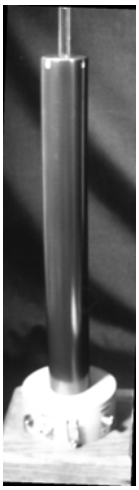
for High-Field Vertical Bore MRI Microscopy

5 mm to 12 mm Imaging Probes

- Highest S/N
- 350 G/cm at 2.3% duty cycle, water cooled
- Quick, convenient, multi-X tuning
- For NB magnets up to 900 MHz
- 5, 8, 10, or 12 mm *RF* Coils

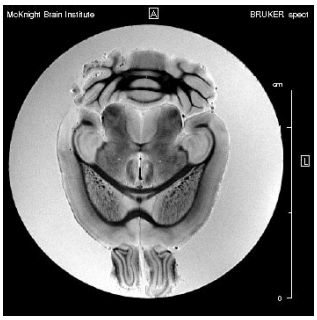
Our MRI probe is designed for high-field magnets with 40 to 72 mm inside the RT shims. The MRI probe includes the 26-40 (or 16-39) gradient coil* and ^{1}H or ^{1}H/X, rf *Litz* coils. This probe is normally provided with conventional top "NMR-tube" access. The probe permits highest gradients at highest fields.

Effectiveness of the litzcage coil can be seen in the 50 micron resolution of the mouse brain and baby shark taken at 750 MHz.

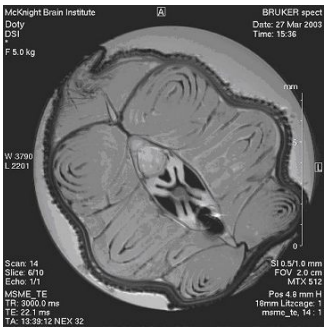


MRI Probe (with Gradients & RF)

Mouse Brain



50-micron resolution. using 21 mm CP *Litzcage* at 750 MHz inside a Doty vertical bore imaging probe. Courtesy of Dan Plant, Univ. of Florida



Baby Atlantic Sharpnose Shark,

RF Litz Volume Coils For NB or WB Vertical Bore Probes

Probe O.D. (mm)	*RF* Coil I.D. (mm)	Shield Diameter (mm)	Tuning	^{1}H MHz	Mod. Load τ_{90}'s (µs)		Heavy Load τ_{90}'s (µs)	
					^{1}H	^{31}P	^{1}H	^{31}P
40-72	10	26	^{1}H/X	500	9	12	10	14
40-72	12	26	^{1}H	500	9	-	12	-
40-72	10	26	^{1}H/X	600	11	13	12	15
40-72	12	26	^{1}H	800	10	-	16	-

For the above coils, the length of homogeneous region is 80% of the coil ID. Coils with a multi-x channel normally tune ^{31}P through ^{13}C simply by changing plug-in capacitors. All coils feature simple tuning, high B_1 homogeneity, external *rf* shield, and susceptibility matching near the sample region.

Small MRI 3-Axes Gradient Coils

All models feature active shielding and B_0 eddy current compensation.

✓Maximum Sample Volume ✓Low Noise and Vibration ✓High Continuous Gradients

Advances in hardware for magnetic resonance imaging (MRI) are needed to improve image quality, ease of use, and functionality in high-field MRI research using small-animal models. Doty's MRI gradient coils fill this need.

Low-amplitude B_0 eddies are induced in the magnet radiation shields primarily from minute variations in coil diameters along the axis or from axial registration errors between the gradient and shield coils. Our use of alumina ceramic for both the gradient and shield formers allows higher precision to be maintained, and low-amplitude eddy current to be minimal. Ceramic coil forms, together with heavy Golay windings dramatically reduce vibration and noise, even at the highest fields.

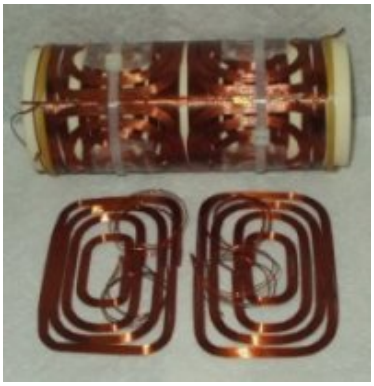
Any remaining B_0 eddy is compensated by a time-dependent correction applied to a B_0 shim coil. Another advantage of the alumina coil form is its very high thermal conductivity, which helps equilibrate hot spots. The cooling requirements are then satisfied with relatively minor constraints on the winding geometry.

Higher-order eddies are minimized by active shielding. Our coil designs often achieve a factor of 2 better shielding of the transverse gradients than alternative designs.

There is a strong benefit from gradient coil construction with an alumina ceramic coilform and multilayer windings. We significantly reduce acoustic noise, vibration, and recovery time.

Parameter	Model 26-40	Units
Cooling method	water	
diameter (d_i) for 4% local deviation	14	mm
length (z_i) for 4% local deviation	17	mm
diameter (d_i) for 10% local deviation	18	mm
length (z_i) for 10% local deviation	22	mm
Nearest Gradient Null point	15.4	mm
Outside diameter, d_O	39.6	mm
Coil half-length, h_1	36.1	mm
RF shield diameter, d_S	26	mm
Clear bore, d_i	23.6	mm
Max inductance, L	37	μH
Max DC resistance, R_E	1.4	Ω
Min gradient gain, α	48	mT/Am
Max shielding error at 1.5 d_0	0.4	%
Min slew rate, G_S=αV/L, at 1 V	1,189	T/m/s
Continuous current, I_{RMS}	11	A
Continuous gradient, G_C	**53**	**G/cm**
Peak Voltage	120	V
Approx. EPI Acoustic Noise, 7 T	70	dBa
Rise time to G_C for 100 V	4.6	μs
Total mass	0.4	kg

Gradients partially assembled



Local deviation (or differential linearity) is defined as the rms deviation from the mean gradient over the specified diameter, d_i, and length, z_i, of the cylindrical sample region. The half-length h_1 is the distance from the center to the closer of the two external end surfaces. Eddy currents from the internal RF shield are negligible. The gradient slew rate G_S is the instantaneous rate of change in gradient when a 1 V step is applied. The continuous current ratings are *true* continuous ratings for a single axis with no time limit and adequate cooling. Derate the current 30% when all three axes are driven simultaneously.

Knee, Other Extremities, or Primate Head High-Field RF Imaging Coils

Doty *rf Litz* and *Litzcage* Modules

- Highest homogeneity
- Highest S/N
- Quick, simple tuning for all sample sizes
- Double-resonance, multi-nuclear tuning available

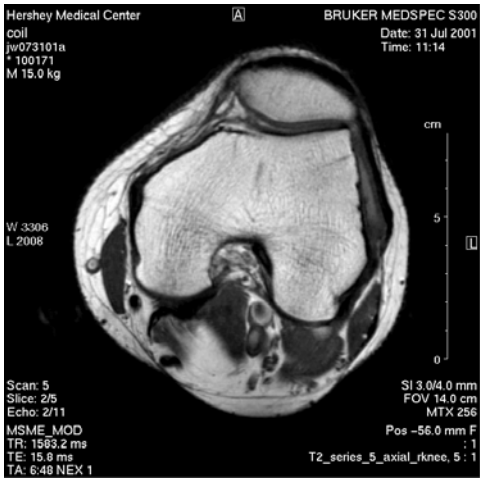
Knee imaging at high fields with conventional coils has often been problematic because of the enormous difference in loading between a small and a large patient. The unique tuning/balancing methods utilized in all Doty coils make tune-up predictable, simple, and quick.

18 x 18 cm FOV CP *Litzcage* Knee Coils			
^{1}H MHz	τ_{90}, µs	Square pulse, Power, W	
		Light load	Heavy load
64	120	180	1000
80	100	350	1500
125	100	500	1500
170	125	500	1500
200	150	500	1500
Light load – 35 mM Saline, **Heavy Load** –100 mM Saline, at 75% of ID			

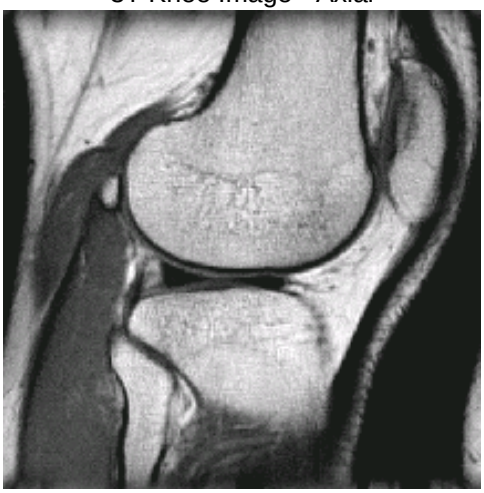
Our linear Litz coils are recommended for double-resonance applications, and their exceptional sensitivity and homogeneity are demonstrated in the images shown at the right. Typical efficiency of a double-resonance Litz coil is illustrated in the table below.

18 x 18 cm FOV H/P *Litz* Knee Coils					
Tuning	^{1}H MHz	Light Load τ_{90} (µs) @ 500 W		Heavy Load τ_{90} (µs) @ 1 kW	
		^{1}H	^{31}P	^{1}H	^{31}P
^{1}H/X	64	100	170	110	130
^{1}H/X	80	120	180	130	150
^{1}H/X	125	150	230	200	200
Light load – 35 mM Saline, **Heavy Load** –100 mM Saline, at 75% of ID					

Other Typical RF *Litz* Volume Coils							
Clear I.D. mm	O.D. mm	Tuning	^{1}H MHz	Moderate Load τ_{90}'s (µs) @ 500 W		Heavy Load τ_{90}'s (µs) @ 1 kW	
				^{1}H	^{31}P	^{1}H	^{31}P
100	150	^{1}H	128	36	-	82	-
100	150	^{1}H /X	200	58	80	110	160
130	200	^{1}H/X	170	85	110	160	200
135	200	^{1}H	128	70	-	130	-
150	220	^{1}H	128	90	-	200	-
150	230	^{1}H/X	128	100	140	210	200
150	220	^{1}H	170	120	-	270	-
200	300	^{1}H/X	128	160	320	300	340
Length of homogeneous region - 80% of the coil ID. **Moderate load** –50 mM saline, 70 % of the coil ID **Heavy load** –100 mM saline, 75% of the coil ID							

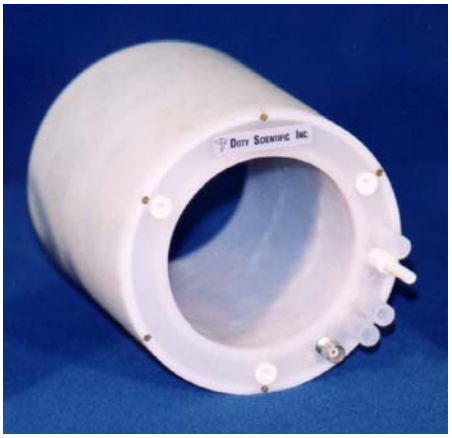


3T Knee Image - Axial



3 T Knee Image - Sagittal

Images: Courtesy of Dr. Qing X. Yang
Hershey Medical Center, Penn State Univ.



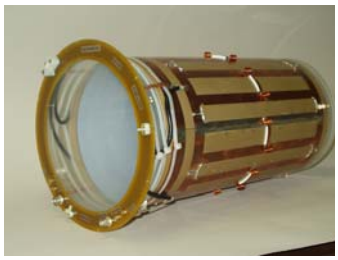
*RF **Litz*** coil module

For additional information about the Doty ***Litz*** coil design:

F. David Doty, George Entzminger Jr, and Cory D. Hauck, "Error-Tolerant RF Litz Coils for NMR/MRI", *J. Magn. Reson.,* 1999, 140:17-31.

Simple-tune Litz and Litzcage RF Coils up to 750 MHz

What is a Doty RF Litzcage Coil?

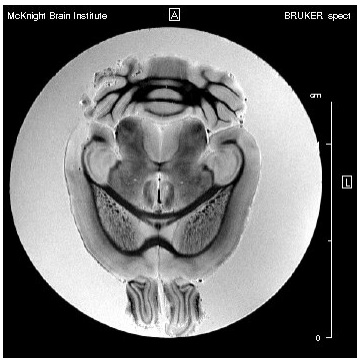


Doty *Litzcage* coils combine the Circular-Polarization (CP) of a *rf* birdcage coil and the insulated crossovers of the Doty *rf Litz* coil to produce a superior quadrature coil with easy tuning.

What is a Doty RF Litz Coil?

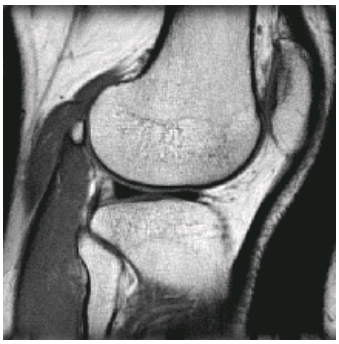
The *Litz* (woven) coil utilizes etched foil patterns with insulated crossovers to obtain *rf* flux transparency and improved S/N. Special symmetries permit an ideal current distribution that is largely independent of tuning, matching, and balancing adjustments. Homogeneity is excellent and tuning is simple.

How do Litz coils or Litzcages compare to Birdcages?



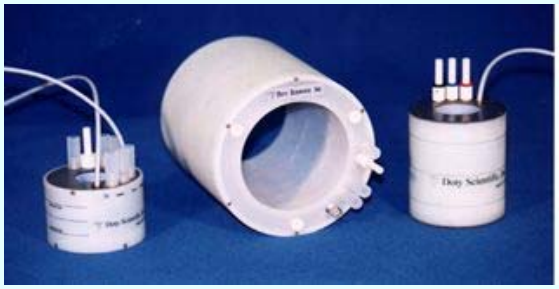
50-micron resolution. Mouse brain image, using 21 mm CP *Litzcage* at 750 MHz (inside a Doty vertical bore imaging probe). Courtesy of Dan Plant, Univ. of Florida.

- **Much Easier Tuning.**
  They easily tune and match to a wide range of samples.
  The *Litz* coil can be single-tuned or double-tuned.
- **B_1 homogeneity is typically 10-40% better.**
- **SNR is at least 10% higher – up to 30% higher.**
- **Substantial cost advantage.**



The T2 knee image was acquired at 3T with a 16 cm Doty *Litz* coil. Courtesy of Qing Yang, Ph.D. Hershey Medical Center, Hershey, PA.

RF Litzcage Small Animal Platform



RF Litz or *Litzcage* Modules

Vertical Bore MRI Probe
with *RF Litz or Litzcage*