High Power Pulse Q-band

Improve Pulse EPR Performance

The SuperQ-FT is a proven, versatile pulse Q-band EPR system which has undergone significant evolutions as more microwave power has become available for pulse Q-band frequencies. Designed to increase signal-to-noise, spectral resolution (electron and nuclear) and experimental sensitivity compared to X-band operation, the SuperQ-FT is complemented by a dedicated pulse Q-band resonator for outstanding performance.

Benefits of Pulse EPR

- Overall performance boost resulting from 2x the signal to noise
- Enhanced DEER sensitivity
- Extend experimental possibilities with access to high frequency nuclei
- Spectrum acquisition in a fraction of the time

State-of-the-art Pulse System

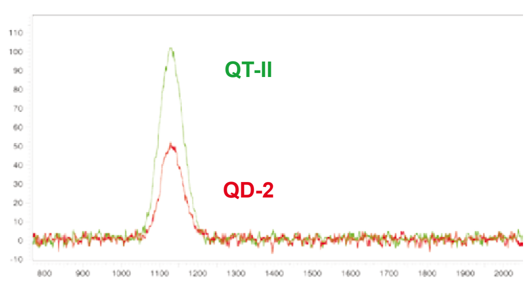
Matching Amplifiers & Resonators

The SuperQ-FT can be equipped with your choice of three different amplifiers and two different Q-band pulse resonators. Sample size will determine which combination will give you the best performance. For unlimited sample sizes, the large volume resonator with the highest power will give the best results, while for limited sample volumes the small volume resonator with medium power is recommended.

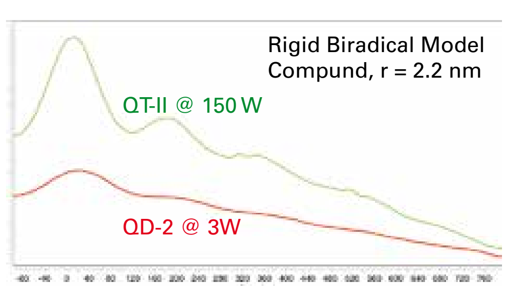
Resonator	Amplifier	Sample Amount
QD-2	Standard (3 W)	Limited
QD-2	AmpQ (10 W)	Limited
QT-II	TWT (40 or 150 W)	Unlimited

Increase Signal-to-Noise at Larger Bandwidth

For unlimited sample volume the QT-II out performs the QD-2 due to the increased useable sample volume. Combined with the increased power available with the 150 W TWT, the QT-II can provide $\pi/2$ pulse lengths as short as 6 ns at a bandwidth of 150 MHz.



The increased resonator volume in the QT-II (green) results in twice the signal-to-noise compared to the QD-2(red) with the 150 W TWT.

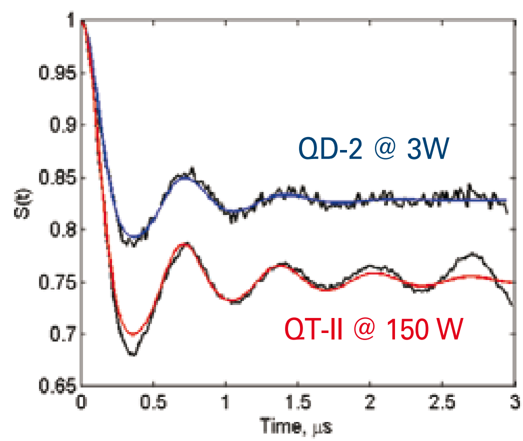


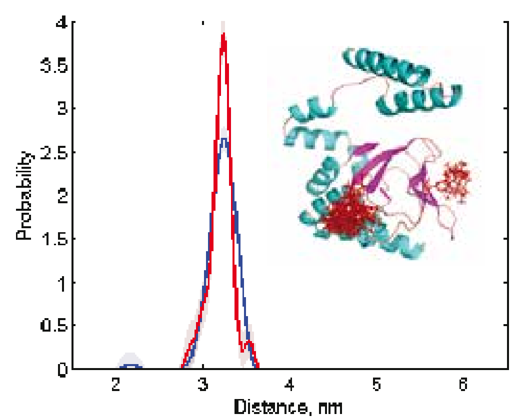
The QT-II with the larger sample volume and the Q-band TWT with more power provide a factor of 4 increase in the dipolar modulation depth (green) compared with the standard dielectric resonator and Q-band amplifier (red)

Deeper modulations

One critical parameter in the 4p-DEER experiment is the excitation bandwidth of the 'pump' pulse. Increasing the 'pump' pulse bandwidth lead directly to improvements in the dipolar modulation depth.

The combination of higher power and larger sample volume leads to a factor 4 improvement in the effect sensitivity, dipolar modulation depth. Sample volume increase accounts for a factor 2 improvement in signal to noise, while the short pump pulse length of 12 ns (π pulse) contributes up to a factor 3 modulation increase as demonstrated on both model compounds and protein models.





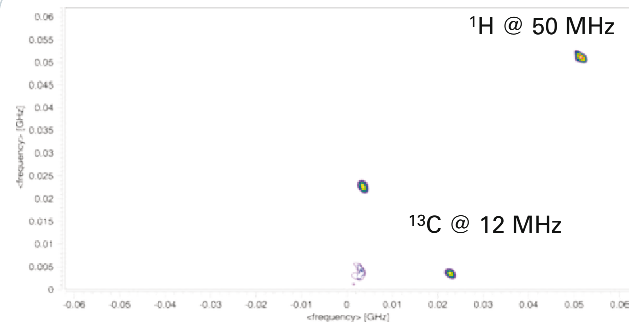
4p-DEER time trace and distribution determinations of 50 µM HCN2I protein doubly labeled with MTSL (563R1/608R1) measured with the dielectric QD-2 resonator at 3 W MW power (blue) and the QT-II resonator with 150 W power (red).

Data courtesy of Dr. S. Stoll University of Washington

Extending experimental possibilities

Increase in B_1 and Bandwidth

Pulse EPR experiments, such as ESEEM, HYSCORE, and ELDOR-NMR, at Q-band have been typically limited by both the available B_1 and the available bandwidth. The QT-II resonator features a bandwidth of up to 150 MHz regardless of the MW power available. With the 150 W TWT, the resulting combination of bandwidth and B_1 permit access to high frequency nuclei such as ^{1}H, ^{19}F and ^{31}P in ESEEM and HYSCORE experiments.

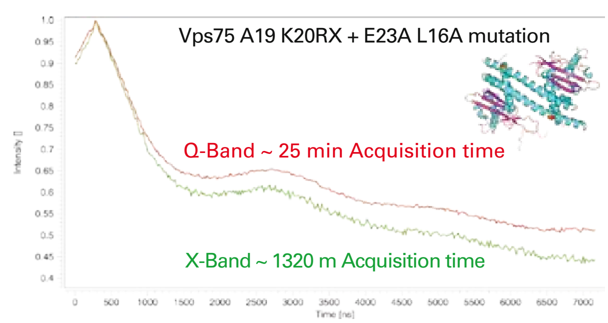


The combination of higher driving power (B_1) from the 150 W TWT and larger band width available with the QT-II permits a wider range of accessible nuclei in ESEEM and HYSCORE experiments.

Q-band vs X-band DEER

The increase in signal to noise on going from X-band frequencies to Q-band frequencies is well known and results in a factor of 20 better signal to noise. For pulse Q-band experiments, this increase in signal to noise has not always resulted in an improved 'effect' signal to noise due to limits in B_1 and bandwidth.

The advantage of Q-band over X-band is illustrated with the QT-II and the 150 W TWT, where the B_1 at both frequencies are similar. The normalized 4p-DEER signals show a slight decrease in modulation depth, however the signal to noise at Q-band is orders of magnitude larger.



Acquiring the 4p-DEER spectrum at Q-band (red) results in a better signal to noise in only 2 % of the total acquisition time compared to acquisition at X-band (greed). Q-band data acquired with the QT-II resonator and 150 W TWT. X-band data acquired with MD-5 resonator and 1000 W TWT.

Data courtesy of Dr. H. El Mkami, University of St Andrews and Dr. D. Norman University of Dundee

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