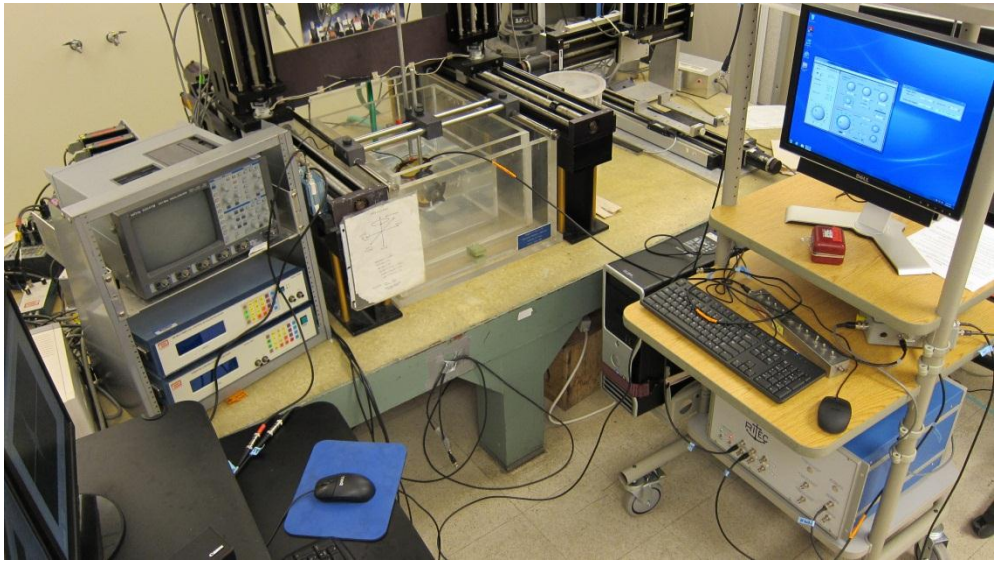
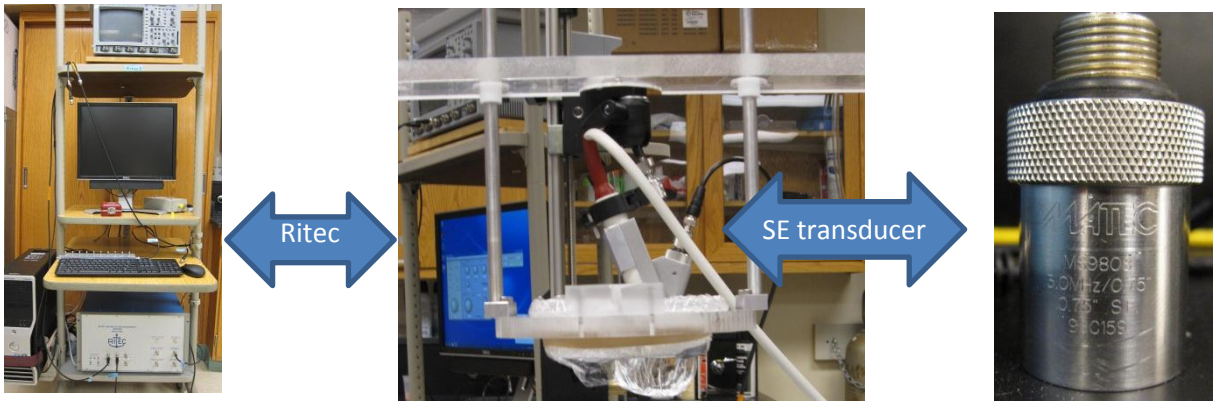
Calibration:
Single Element Transducer

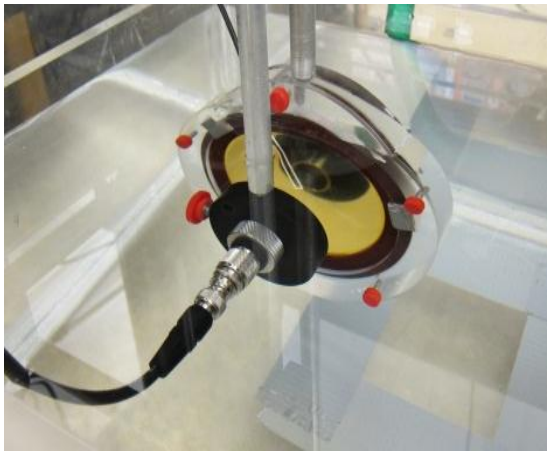
Updated: 11/21/2012
M Kurowski

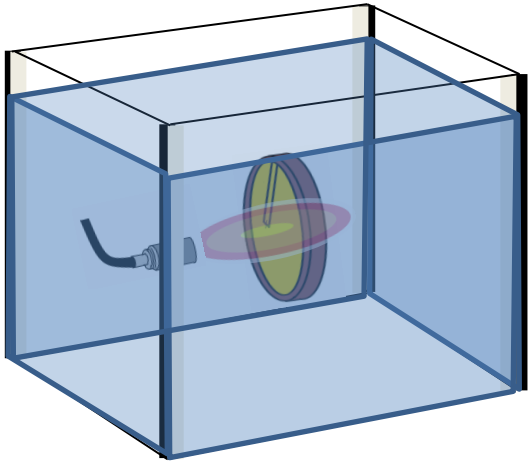


1 : Overview of Single Element Transducer Calibration

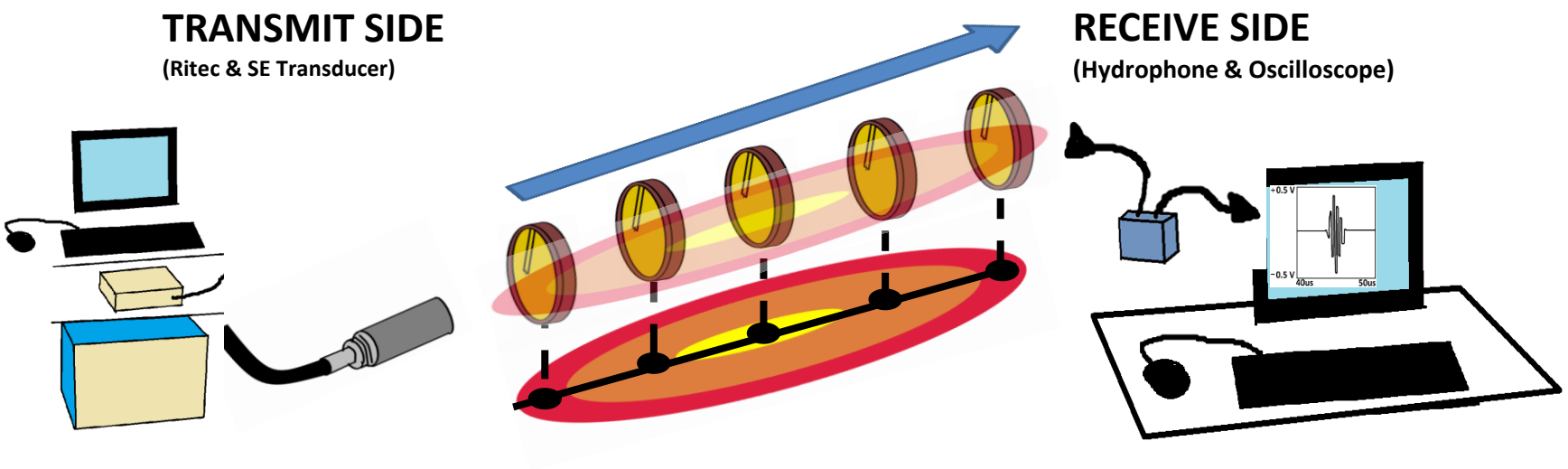


Many BRL experiments use a single element transducer with the Ritec system, as illustrated in the upper middle photo. It is usually desired to know the spatial pressure levels produced from an ultrasound device for the experimental design. Therefore, a calibration is performed. BRL SE transducers are designed to transmit through biological tissue. Since tissue is mainly comprised of water, the SE transducer are impedance matched to water and calibrations are done in water.

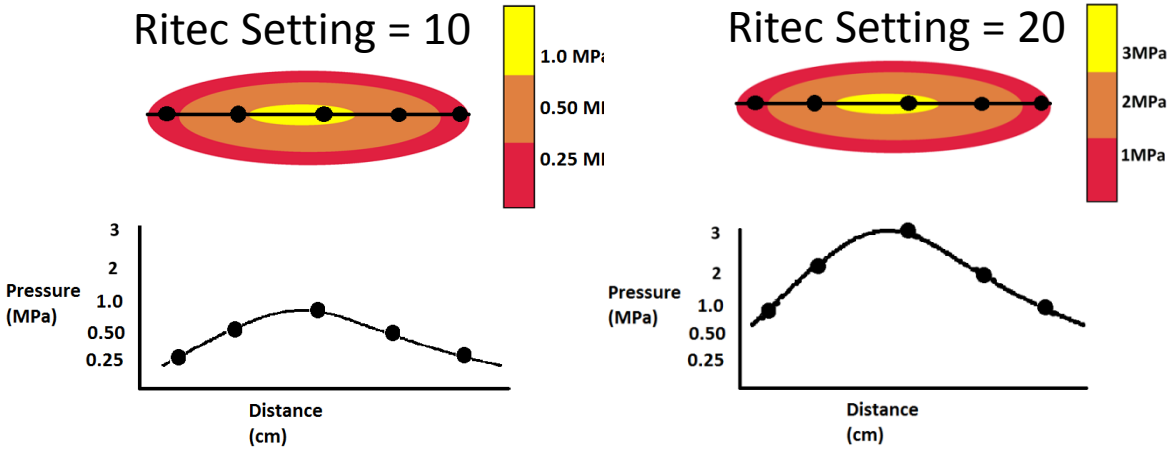




1 : Overview of Single Element Transducer Calibration (continued)



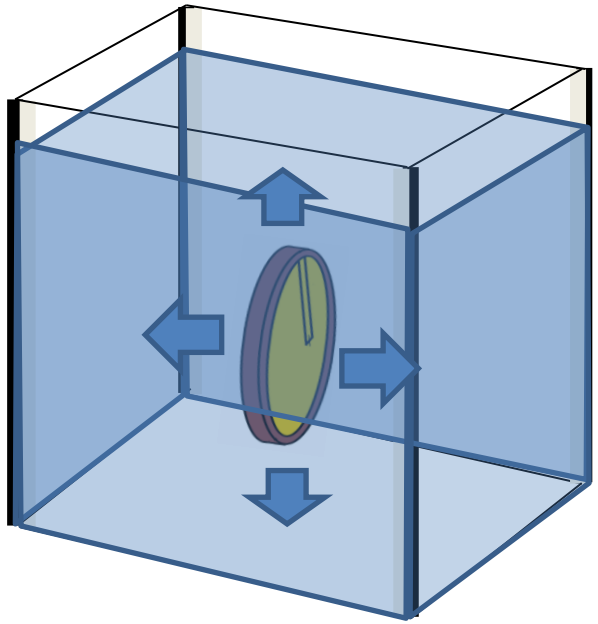
A single element transducer is calibrated by placing a hydrophone in the field of the ultrasound transducer. The daedal calibration program moves the hydrophone and measures the pressure level at specified intervals along the beam axis. Calibrations are performed to determine which Ritec settings produce specific pressure levels from an ultrasound transducer. Since the goal of a calibration is to determine the pressure level for experiments, **calibrations must be performed with the exact Ritec system, cables, and connections used during experiments.** Moreover, calibrations must be performed periodically to provide a baseline of information for the transducer. This information can tracked overtime to check the transducer and Ritec performance.



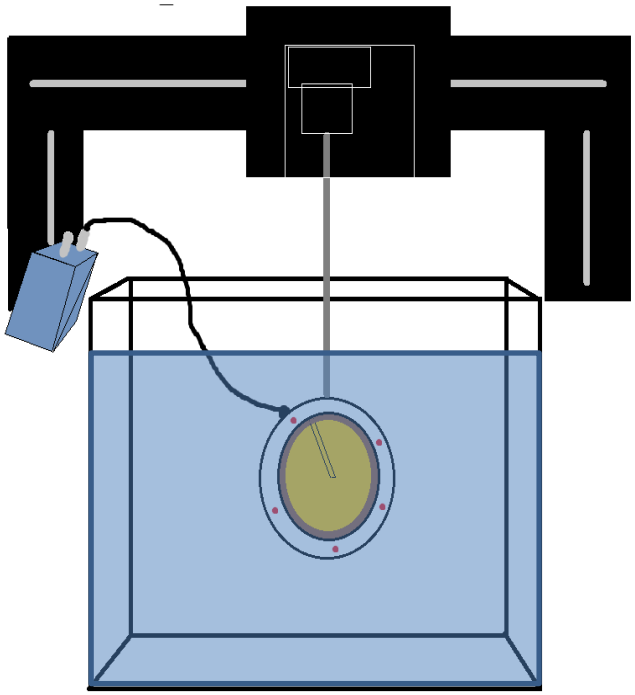
2 : Setup Tank

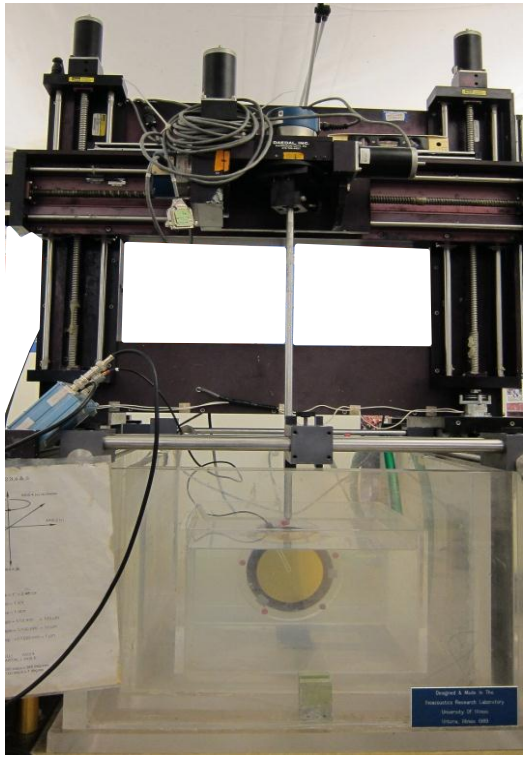
A. **Use the water cart to transport degassed water from the Ultrasonic Media Preparation Room (B420D) to the daedal tank**. Either one large bottle and two small ones, or three medium bottles will be needed. Make sure that the water is at room temperature, since water boiled the day before may not have cooled enough. The date should be labeled on each bottle. Make sure the inner and outer tanks are aligned straight with Daedal before filling the inner tank with water.

B. **Fill up the tank with degassed water to submerge the hydrophone**. The tank needs to be large and with enough water so that the hydrophone always remains completely submerged and will not run into the tank walls.



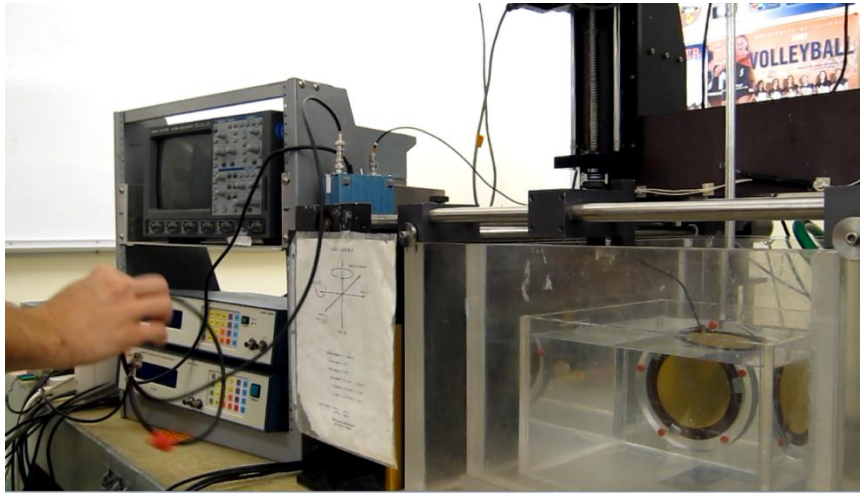
2 : Setup Receive Side (Hydrophone)



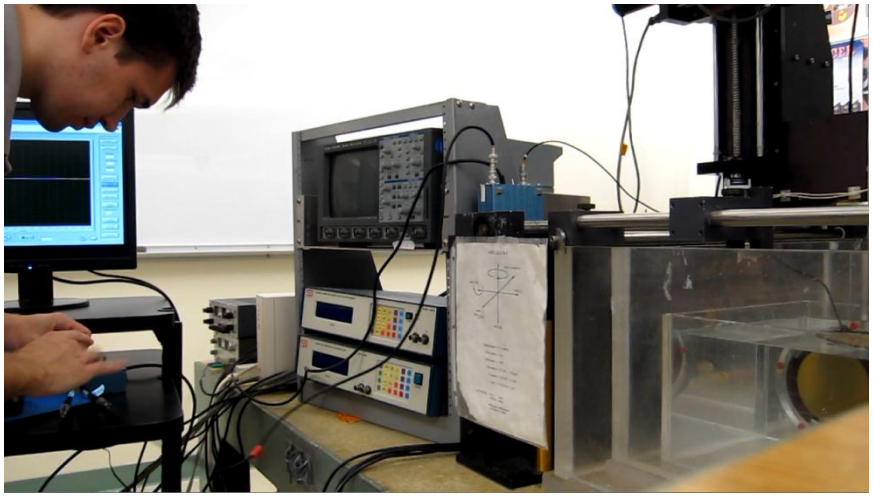


A. **Set up one of the Marconi hydrophones with accompanying pre-amplifier (Refer to the Hydrophone manuals for detailed instructions).**
The M1 and M3 hydrophones and their amplifiers are located in a drawer that is labeled with red tape to the lower left of the sink. The hydrophone case should contain the hydrophone, its associated amplifier, and a cable with a red piece of tape on it corresponding to the M# of the hydrophone.
B. **Find the plastic hydrophone holder ring with red screws**, on the daedal accessory table. Place the flat gold side down up in the ring. There is also a flat ring that fits on top of the first ring. Secure it down with the red screws. The screws should be "finger tight."
C. **Attach a long metal rod from the table to the hydrophone holder.**
D. **Place it in the Daedal positioning system with the flat, gold side pointing towards the front of the tank** (the red head screws should be pointing towards the front of the tank). The signal from the hydrophone needs to be connector to the per-amplifier before it is displayed on the scope. The switch on the amplifiers should be set on the X1 setting. The cable coming out of the hydrophone itself should go to the connection labeled input on the amp. The cable included in the hydrophone case should go from the connection labeled output on the amp to channel one on the scope. Make sure the amp is connected properly to the power supply. Turn on the power supply; the power supply settings should be15V and .15A, approximately.

2 : Setup Receive Side (Hydrophone to Daedal Oscilloscope)



Use the cable which came in the hydrophone case to connect the output of pre-amp to the input channel of the daedal.



Use the trigger out from the transmitting source as the trigger sync for the hydrophone's received input signals.

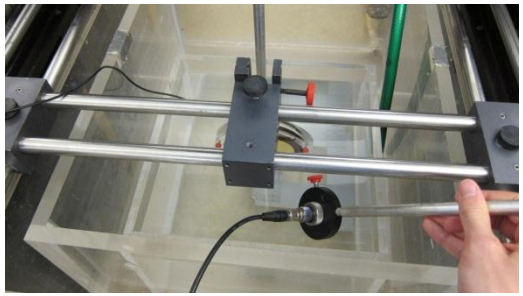
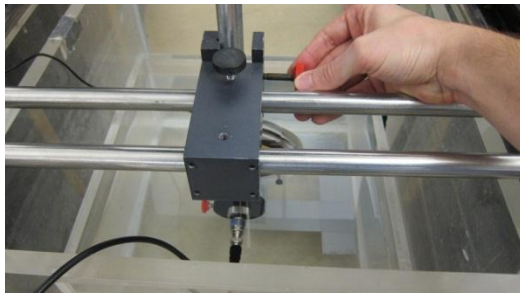
2 : Setup Transmit Side (Transducer)

A. Record the transducer properties. Write down the serial number, model number, frequency and f number (focal length/diameter) of the transducer as well as the date of the scan.

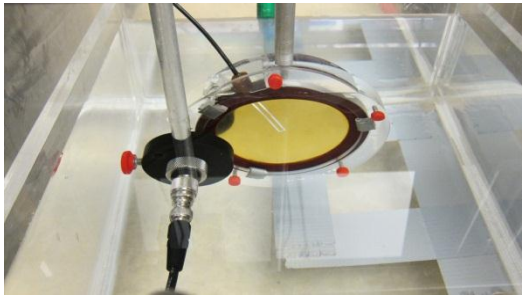
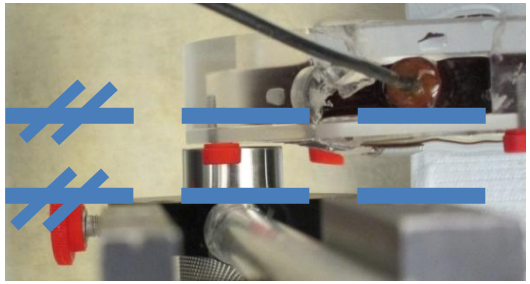
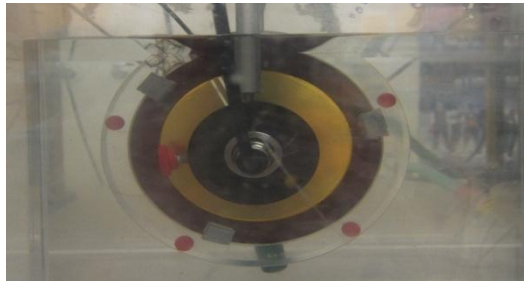
B. Attach the transducer-to-BNC adaptor found on the Ritec cart. Connect the Ritec “To Transducer” cable.

C. Set the transducer in an appropriate sized holder ring off of the daedal accessory table in the Daedal room. Make the screws finger tight. Screw in an aluminum rod to the holder ring.

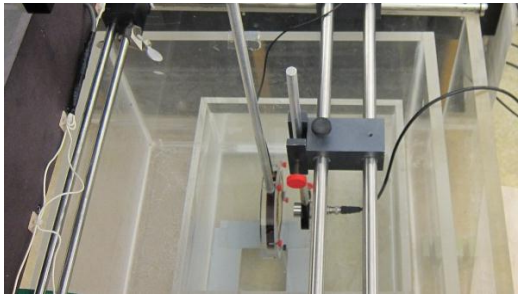
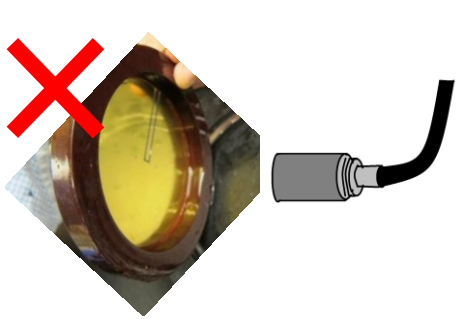
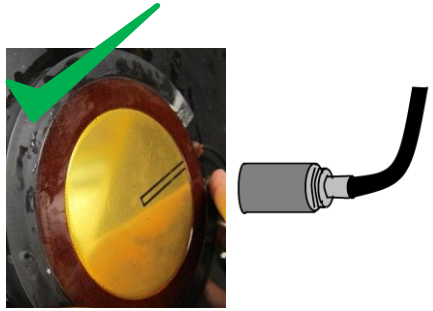
2 : Setup Transmit to Receive Side Manual Alignment


A. Secure the metal rod with the transducer to the sliding clamp on the rail above the Daedal tank. Make sure to align the face of the transducer with the ring. They must be parallel. If they are not parallel it will be impossible to find symmetry around the focus.

B. Slide the transducer to an edge of the hydrophone. Rotate the transducer to make sure it is parallel with the hydrophone. The transducer should be approximately centered along axis three in reference to the hydrophone and over the active element.

The flat gold side of the Hydrophone, must face the transducer.

2 : Setup Transmit Side (Ritec)

A. Setup the Ritec (Refer to Ritec Manual for detailed instructions)

Ritec 2 is located in the Ultrasonic Bioeffects Room (B420E) and Ritec 1 is in the Daedal Room. Bring this near the Daedal. Plug in the power strip to a nearby outlet and turn it on. Turn the computer on also.

NOTE: The fuses on the back of the RITEC should not be Orange/Red. ORANGE/RED light indicates the fuse is blown. No light indicates the fuse is functional. Extra fuses can be found in the cabinet near the door and thermostat on the north side of the lab in a brown box labeled “Ritec Fuses”. When replacing the fuse, be sure that Ritec is powered down and completely off.

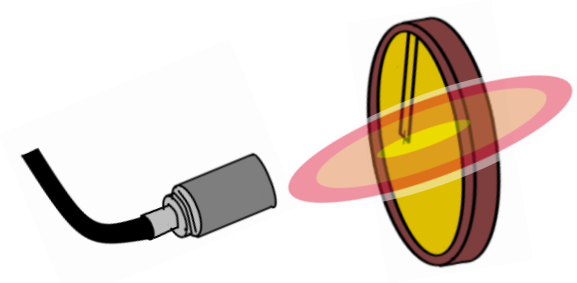
-Turn on the Ritec by flicking the power supply switch on the bottom left of the unit. Wait at least 30 seconds and proceed to flick the high voltage switch also.

-The box near the keyboard is the Ritec Clamped Diplexer. There is a connection labeled “To Transducer” which should be attached to the transducer. To make the cables connect, there is an adapter elbow that should also be near the keyboard on the Ritec unit. Set the transducer in a safe spot until it is aligned with the hydrophone in the following step (E).

-There should also be a cables coming out of the diplexer that is labeled “To Receiver.” It should be connected the “Receiver #1 In” on the Ritec unit. The other cable should be connected to the “From Pulser” input on the box to the “RF Burst no.2 High Power Out” on the Ritec unit. RF BURST NO.2 HIGH POWER OUT is also referred to as GA2, or Gate2.

-The cabled labeled “Trigger Out” on the back of the Ritec should go to the SYNC connection on the scope.

3 : Find the Focus



A. **Open the appropriate scope** (I.E. Agilent or PDA 14), under the Daedal menu. Adjust the Voltage/Division or Time/Division to the appropriate window

B**. Turn on the transducer with the Ritec program**.

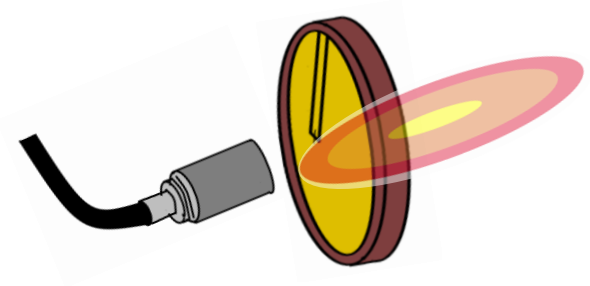
C. **Find a preliminary signal**. Align the transducer a few centimeters away from the center of the hydrophone.Knowing the F# and the focal distance can help with this procedure. Move the transducer along axis one to see where the signal reaches its maximum. This should give a rough estimate as to where the focus will occur on axis one.Now, move the transducer slowly along axis two to find the largest signal possible. This will be the starting point to find the focus more precisely using the computer controlled positioning system.

D. **Find the maximum amplitude**. Now use Position (Daedal computer) to move the signal along axes one, two and three. The size of the area to be scanned is the "box size." The box's dimensions can be estimated by using the TEMP program located in the Position and 2D programs. Move the signal a distance along axis one. If the amplitude increases continue to move in that direction. If the amplitude decreases, move back to the origin and continue to travel in the other direction. If the signal reaches a local maximum at any time move to that position and clear the axis on the Position program. Once a local maximum has been found on axis one, move the signal along axis two in the same fashion.. If the amplitude increases, continue to move in that direction. If the amplitude decreases, move back to the origin and continue to travel in the other direction. If the signal reaches a local maximum at any time move to that position and clear the axis on the Position program. Do the same for axis three. Repeat steps 2 and 3 until a maximum has been reached. A positional change on one axis changes the maximum on the other axis, so the maximum on both axes must be fine tuned until a global max has been reached.

E. **Check symmetry**. The signal should be symmetric about all axes near the focus, so it is necessary to center the maximum. To check symmetry move the signal away from the focus until it is at about half the maximum amplitude. Take note of the amplitude at this point. Then move the signal the same distance on the opposite side of the focus. The signal amplitude should be the same at both points. If it is not the same, the center needs to be moved towards the side that has greater amplitude. If the symmetry is exceptionally difficult to find it is an indication that the signal may be on a side lobe. If this is the case, return to C and move a large distance along axis one and two in order to determine if the focus was missed on the preliminary signal determination.

F. **Record useful data**. Record the time at which the signal starts. This time may be found by moving the cursor in the time domain to the beginning of the signal on the zoomed in graph. This value may be useful in the future when trying to find the focus of the same transducer. It is also useful to determine the maximum amplitude of the signal. It is generally 100-300mV at a Ritec setting of 10.

4 : Move the Hydrophone



A. **Move the hydrophone to prepare for FIND BEAM AXIS scan.**
In order for the scan to run properly, the hydrophone must start in the front left bottom corner of the scanning box. To do this, move half of the distance determined by EQ 1 from the TEMP program in the positive direction on axis one to the front of the box.
Move half of the distance determined by EQ 2 in step 3 in the negative direction on axes two and three to put the signal in its final position.
During the scan the computer will collect data from the trace window on the scope. It is important that the signal fits in this window throughout the scan. Move the signal the full distance to be scanned in axis one, two and three to make sure the signal fits in the window.
B. **Clear the axes position.**
c. **Exit out of the Position program.**

5 : Running the Calibration Program (Find Beam Axis)

A. **Open the Calibration program Daedal program menu.**

B**. Fill the appropriate values into each box** such as Temperature, Transducer Number, Frequency (center frequency), date, calibrator (your initials), and transducer number.

The first axis distance (Beam Distance) should be the total distance to be scanned along axis one. The step size on the first axis will only be used for Super Scans, and is the distance between each successive data point. This number should be set to about 1/40 of the Beam Distance for most cases, though this is not a rule.

The second and third axis box should be the total distance to be scanned along axes 2 and 3.

Step size should be set to about 50 um for all scan directions.

The number of steps can be found by dividing the total scanning distance by the step size. For routine calibration, number of steps should be around 50. This must be a whole number. If the distance divided by the step size is not a whole number adjust the step size to make it a whole number.

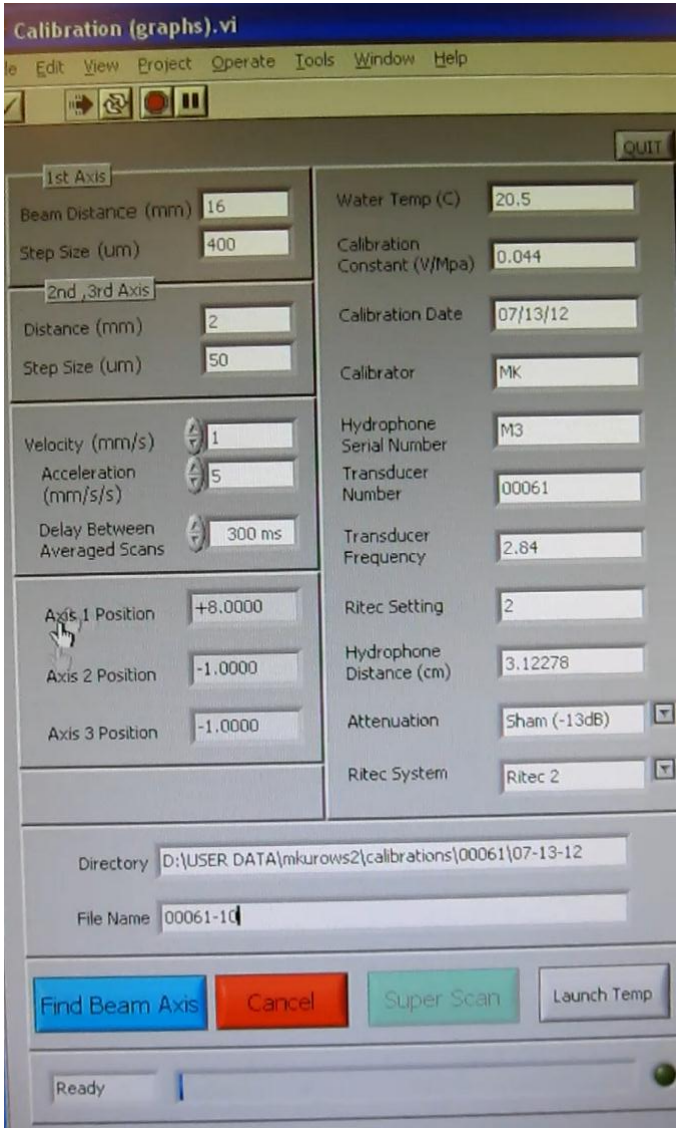
Velocity should be 1 mm/s. Acceleration should be 5mm/s/s.

Enter the hydrophone serial number that is being used. Each hydrophone has a specific calibration constant. The pressure constant used should be the one closest to the center frequency. The pressure constants can be found in the hydrophone drawers or on the desktop under the file "MarconiHydrophonePressureConstants", which is next to the calibration protocols.

The hydrophone distance is equal to the time which the signal begins (as found in step III.E.1) multiplied by the speed of sound in water. This can be determined by using the TEMP program from earlier. Typical speed of sound in fresh water at room temperature
~1481 m/s

Choose the directory to save the data files under the User Data folder created on the desktop.

C. **Run the "Find Beam Axis" function once**. This will find the proper axis of symmetry for the transducer and enable Super Scan. If you do not do this before using a super scan the data you collect will be incorrect. Note that finding the beam axis does not collect any data, it only sets up data collection for the next steps, but you do not have to repeat it unless you move the transducer by hand or reset the position.



5 : Running the Calibration Program (Super Scan)

D. **Run a Super Scan for each Ritec setting**. Determine the Ritec settings to be used for the scans. The desired scan settings for each transducer can be found on Joy under shares/brl/fun/calibrations/schedule. For each of the Ritec settings enter the appropriate value in the SNAP program, adjust the volts/div on the scope and enter the filename and Ritec setting in the Calibration Super Scan window. The filename should be of the form transducer_serial_number-ritec_setting. For example, for the transducer 98C157 at a Ritec setting of 9 the filename would be 98C157-09. Each scan should only take about a minute. The scan will produce a .bin and .dat file with the name specified above.

6 : Process the Data

A. **Log on to JOY and create a directory to place the files under**: /shares/brl/fun/*username*/calibrations/serial_number/date
After each scan has completed move these files onto JOY.

B**. Log onto JOY and create a VNC session**. Use the VNC viewer to log on to the graphical interface of JOY. Open a terminal in Joy go to the directory where you saved the files (STEP 12). In the command prompt in the location of the files, type MATLAB. After MATLAB initializes and the cursor is blinking on the prompt type in the matlab program marconiv3_atten and hit enter. (You may need to add the program to the directory which contains the files you whish to analyze. Or, you can use the matlab command "addpath" to add the path of where the program is. For example, if your programs are in /shares/username/mprogs you would type in the matlab command prompt "addpath ('/shares/mkurows2/mprogs')

C**. Run the program "calibration_se" in MATLAB**. Type in the name of the file and hit enter. Once the data has been loaded into Matlab a series of graphs should appear. Figure one will have three plots. The topmost plot is the most important. It should be nearly symmetrical and have a clear local maximum. If not then the focus is likely misaligned and must be adjusted.
Repeat this process for all the calibrated files scanned.

6 : Process the Data (continued)

A. **After all the data has been processed using the MATLAB program, open a terminal on Joy and type**:
> cd /shares/brl/fun/<username>/calibrations/<serial #>/<date>/
This changes the current working directory to the one in which your scan data has been placed.
B. **Concatenate the *-data.txt and *-intdata.txt files**. This essentially combines many small files into one larger file. To do this type:
> cat *-data.txt > date_data.txt
> cat *-intdata.txt > date_intdata.txt
Note: the above command combines all files that end with –data.txt into one larger file. The * is a shorthand referring to all of the files that end with a particular extension.
> mv *.txt /directory will move all files ending in the extension .txt into the named directory.
C. **Make a directory so the data files can be posted to the public on Joy.** To do this change directories:
> cd /shares/brl/fun/calibrations/<username>
Make a new directory to put the scan data into:
> mkdir <serial #>
D. **Now post the data files in the new directory**. To do this change working directory to the directory where the scan data is located:
> cd /shares/brl/fun/<username>/calibrations/<serial #>/<date>/
Now move the files to the new directory:
> mv <date>_data.txt /shares/brl/fun/calibrations/<username>/<serial #>
>mv <date>_intdata.txt /shares/brl/fun/calibrations/<username>/<serial #>
E. **Make three new directories in order to archive the rest of the scan data:**
> mkdir figures
> mkdir raw-data
> mkdir data-analysis
F. **Move all .jpg files go into figures/:**
> mv *.jpg figures/
G. **Move all .bin and .dat files go into raw-data:**
> mv *.bin raw-data/
> mv *.dat raw-data/
H. **Move all .txt files go into data-analysis:**
> mv *.txt data-analysis/
I. **Once the files have been placed in the correct directories compress the data:**
> cd ..
Note: the cd .. command simply moves the working directory one level higher.
> tar –cvf <date>.tar <date>
> gzip <date>.tar
J. **All of the data is now compressed but the uncompressed data must be deleted also**:
> rm –rf <date>