

**Philips 3T Achieva**

<b>3T Knee Invivo 8CH Knee Coil</b>	<b>Sequence</b>	<b>SagT1</b>	<b>SagPDFS</b>	<b>CorT1</b>	<b>CorPDFS</b>	<b>AxPDFS</b>	<b>SagPD</b>
	<b>Resolution (mm)</b>	0.42x0.52x3.00	0.45x0.63x3.00	0.30x0.58x3.00	0.40x0.63x3.00	0.28x0.44x3.00	0.32x0.51x3.00
	<b>FOV (mm)</b>	160x160	140x140	140x128	140x126	130x118	120x120
	<b>Matrix</b>	384x307	312x224	468x220	348x200	464x268	380x236
	<b>Phase Direction</b>	AP	FH	RL	RL	RL	AP
	<b># of Slices</b>	24	28	35	35	30	22
	<b>TR/TE (msec)</b>	581/20	3370/30	1046/7.6	4768/20	4060/20	2484/30
	<b>Echo Train (ETL/TF)</b>	6	14	7	17	17	15
	<b>WFS (BW)</b>	1.487/292.1	1.580/274.9	1.790/242.8	1.491/291.5	1.711/254.0	1.566/277.4
	<b>Parallel Imaging</b>	Yes-SENSEx2	Yes-SENSEx2	Yes-SENSEx2	Yes-SENSEx2	Yes-SENSEx2	Yes-SENSEx2
	<b>Foldover Supp (NPW)</b>	No	Yes	No	No	No	No
	<b>DRIVE (FRFSE)</b>	No	No	No	No	No	Yes
	<b>Fat Sat</b>	No	Yes-SPAIR	No	Yes-SPAIR	Yes-SPAIR	No
<b>NSA (NEX)</b>	6	6	4	4	4	6	
<b>Scan Time</b>	4:37	5:30	4:36	3:58	4:28	4:03	

<b>Abbreviations</b>	Asym.: Asymmetric k-space profile order (see over)
	ETL/TF: Echo Train Length or Turbo Factor, the number of k-space lines after an excitation pulse
	FOV: Field of View
	FFE: Fast Field Echo, also GRE
	DRIVE (FRFSE): Driven Equilibrium mode, also called Fast Recovery Fast Spin Echo
	IP: In-Phase, gradient echo TE to keep fat and water in resonance
	NSA (NEX): Number of Signal Averages or Number of Excitations
	FOS / NPW: Foldover Suppression / No Phase Wrap, conventional oversampling method to prevent image fold-over
	PD: Proton Density, weighting for short TE, long TR spin-echo scans
	POS: Phase OverSampling (see over)
	SAR: Specific Absorption Rate; tissue heating measure limited by the FDA
	SENSE: SENSitivity Encoding, Philips parallel imaging method (c.f. ASSET; iPAT) which uses the coil sensitivity profiles to speed up imaging or suppress wrap. All parallel imaging methods depend upon multiple-element coils
	SNR: Signal to Noise Ratio, measure of image quality
SPAIR: Fat suppression technique using adiabatic pulses (more details overleaf)	
WFS: Water-Fat Shift (see over), a measure of receiver bandwidth (BW)	

SAG T1



SAG PDFS



COR T1



COR PDFS



AX PD FS



SAG PD



## Philips Achieva Tips

<b>Protocol Optimization</b>	<p><b>3T SNR can be traded like currency for imaging speed or resolution</b></p> <ul style="list-style-type: none"> <li>When emphasizing resolution, high SENSE factors are not used for speedup. However, using SENSE with factor 1 further improves SNR over no-SENSE because coil sensitivity profiles are used for more optimized array reconstruction</li> <li>The high in-plane resolution in these 2-D scans could be traded for thinner slices. Inter-slice gaps are 10% of slice thickness</li> <li>Signal averages can be used to further improve SNR, but longer scans risk movement blurring</li> <li>Reducing SNA or increasing SENSE factors can achieve faster scanning. It may be necessary to use slightly larger voxels to maintain SNR.</li> <li>Dedicated multi-element receiver coils are recommended for the best signal.</li> </ul>	<b>Bandwidth &amp; Water-Fat Shift (WFS)</b>	<p><b>Direct specification of Water-Fat Shift in pixels is used as an alternative to bandwidth in kHz</b></p> <ul style="list-style-type: none"> <li>WFS is field strength, pixel size and FOV independent measure of potential artifact and impact on SNR.</li> <li>For MSK imaging, keep WFS between 1-2.5 pixels to avoid obscuring pathology (0.5-1.5mm shift).</li> <li>Reducing WFS, (increasing BW), reduces echo spacing, which reduces TSE shot length and reduces blurring.</li> <li>Reducing WFS (increasing BW) reduces SNR.</li> </ul> <p>Conversion Factors:            3T: BW kHz = (0.22kHz) (freq matrix)/(WFS pixels)            1.5T: BW kHz = (0.11kHz)(freq matrix)/(WFS pixels)            Example: WFS = 1.76 pixels with a 512 matrix on 3T            BW (kHz) = (0.22kHz)(512)/(1.76) = +/-64kHz</p>
<b>Turbo or Fast Spin Echo</b>	<p><b>Asymmetric k-space profile ordering is used to reduce scan time by 30% in PD and T1w exams while minimizing</b></p> <ul style="list-style-type: none"> <li>Asymmetric Turbo Spin Echo scans permit independent specification of TE, Echo Spacing and Echo Train Length.</li> <li>Shot length (ETL x Echo Spacing) should not exceed 4 x TE.</li> <li>If a different profile order is used (such as linear or centric), reduce the ETL on these protocols by about 30%. Scan times will increase proportionately.</li> <li>DRIVE (Driven Equilibrium) or Fast Recovery FSE (FRFSE)               <ul style="list-style-type: none"> <li>Consider use to brighten fluid when TR &lt; 3000ms</li> <li>Can be applied to adjust contrast for longer TRs</li> </ul> </li> <li>Alternative approach: 3D gradient echo scans can supply high resolution and SNR with T1 or T2 weighting, and permit reformatting. Apply SENSE to lower scan times</li> </ul>	<b>Image Resolution</b>	<p><b>Voxel size is specified explicitly. This provides a direct measure of lesion size conspicuity.</b></p> <ul style="list-style-type: none"> <li>Resolution remains fixed independent of FOV changes, and precludes the need for other adjustments, such as rectangular FOV or scan percentage, that could inadvertently change voxel dimensions.</li> <li>The in-plan voxel size is related to the FOV/Matrix; voxel dimensions presented correspond to the frequency x phase x slice thickness.</li> <li>Reconstruction resolution can be independently specified. Display resolution should not be confused with the acquired voxel size.</li> <li>Interpolation (ZIP) is used to reduce the reconstructed voxel size, which can improve the visualization of thin curved structures like cartilage.</li> <li>higher field strength, new coils, hardware and pulse sequences have allowed us to reduce voxel sizes at 3T by a factor of 2-3 versus 1.5T for comparable protocols.</li> <li>For example: Sagittal TSE PD Knee at a 12cm FOV;            1.5T MRI: 384x256 matrix, 4mm slice thk = 0.58mm<sup>3</sup>            3.0T MRI: 600x424 matrix, 2.5mm slice thk = 0.14mm<sup>3</sup></li> </ul>

<p style="text-align: center;"><b>Fat Suppression Techniques</b></p>	<p><b>Uniform fat suppression improves CNR for better specificity</b></p> <ul style="list-style-type: none"> <li>• SPAIR (Spectral Attenuated Inversion Recovery) <ul style="list-style-type: none"> <li>-Fat saturation very robust against RF inhomogeneity</li> <li>-Adjustable degree of fat suppression: Increase SPAIR inversion time (T1) for softer fat sat</li> <li>-Preferred at 3T for PD, gadolinium enhanced T1 scans (T1 range: 70-200ms based on degree of fat suppression desired).</li> </ul> </li> <li>• SPIR (Spectral Presaturation Inversion Recovery) <ul style="list-style-type: none"> <li>-Uses smaller flip angle inversion pulse than SPAIR</li> <li>-More vulnerable to RF inhomogeneity at 3T, but shorter prepulse may be helpful in some applications and scan times</li> </ul> </li> <li>• ProSet (Water selective excitation) <ul style="list-style-type: none"> <li>-Best for 3D gradient echoes</li> </ul> </li> <li>• STIR (Short Tau Inversion Recovery) <ul style="list-style-type: none"> <li>-Robust against B<sub>0</sub> and RF inhomogeneity</li> <li>-Helpful with metal artifact imaging</li> <li>-Do not use with contrast enhancement</li> </ul> </li> <li>• Higher-order Shimming (PB-Volume) <ul style="list-style-type: none"> <li>-For off-center imaging such as shoulder and wrist imaging</li> <li>-Better fat suppression by improving field homogeneity</li> </ul> </li> </ul>	<p style="text-align: center;"><b>Turbo or Fast Spin Echo</b></p>	<p><b>Phase wrap control varies with the acquisition technique (multiple choices)</b></p> <ul style="list-style-type: none"> <li>• Define a large enough FOV to completely cover the anatomy. This will prevent aliasing, but may require zooming during image review to focus on the anatomy of interest.</li> <li>• Use foldover suppression: <ul style="list-style-type: none"> <li>-If NSA = 1, Aliasing is avoided by use of saturation bands.</li> <li>-If NSA is 2 or 3, the acquired FOV is doubled or tripled respectively "behind the scenes", the # of averages actually obtained is 1.</li> </ul> </li> <li>• For SENSE imaging, use SENSE Phase OverSampling (POS) by a sufficient factor to account for anatomy outside the FOV. <ul style="list-style-type: none"> <li>-SNR, scan time and resolution are not affected.</li> <li>-POS is independent of NSA.</li> <li>-POS requires SENSE capability in the given direction.</li> </ul> </li> <li>• Use saturation bands to eliminate signal from adjacent anatomy that is vulnerable to motion (e.g. lungs in shoulder imaging).</li> </ul>
<p style="text-align: center;"><b>Metal Implants or Prior Surgery</b></p>	<p><b>Implanted metal may produce artifacts, but that doesn't preclude diagnostic-quality images.</b></p> <ul style="list-style-type: none"> <li>• Consider scanning at a lower field strength (1.0, 1.5T)</li> <li>• Use Spin echo and Turbo Spin Echo methods.</li> <li>• Use 7-8ms echo spacing, for a TSE, select echo spacing</li> <li>• Shortest€ Use WFS &lt;1.5 pixels, on 3T, &lt;0.7 pixels, on 1.5T or select minimum. This typically corresponds to a BW over 50 kHz.</li> <li>• Consider swapping phase and frequency directions and using thinner slices (&lt;4mm) to reduce through-plane dephasing.</li> <li>• If fat suppression doesn't work, use STIR.</li> </ul> <p>A T2-weighted gradient echo (FFE) scan can be used to identify prior surgical procedure sites.</p>	<p style="text-align: center;"><b>Contrast Options</b></p>	<ul style="list-style-type: none"> <li>• TSE PD FS provides excellent contrast between fluid, cartilage, and bone.</li> <li>• FFE Variations (set contrast method to): <ul style="list-style-type: none"> <li>-No enhancement (GRASS) for high fluid signal using steady state imaging and 20°-90° flip angles/</li> <li>-T1 enhancement (SPGR) for high cartilage signal using low flip angles.</li> <li>-Balanced FFE (TrueFISP, FIESTA). For best 3T results, use in-phase TR/TE, e.g. 9.2/4.6msec and careful shim.</li> </ul> </li> <li>• Quantified values: T1 and T2-maps</li> <li>• For gradient echo scans at 3T, a volume shim is often applied to improve a joint's B<sub>0</sub> homogeneity.</li> </ul>
<p style="text-align: center;"><b>MR Angiography</b></p>	<p><b>MR Arthrography is commonly based on T1-weighted fast suppressed imaging.</b></p> <ul style="list-style-type: none"> <li>• T1-weighted scans are split into multiple "packages" to keep TR short but not restrict the number of slices. <ul style="list-style-type: none"> <li>-Selecting a "TR range" between 450-700 sets this up.</li> </ul> </li> <li>• SPIR or SPAIR may be used (do not use STIR)</li> <li>• Isotropic 3D gradient echo scans using water excitation such as ProSet can supply high SNR with T1-weighting, permitting arbitrary slice plane reformatting. Apply SENSE to lower scan times.</li> </ul>	<p style="text-align: center;"><b>RF Management</b></p>	<p><b>3T Turbo Spin Echo scans don't have to be slow because of SAR limitations.</b></p> <ul style="list-style-type: none"> <li>• Refocusing control <ul style="list-style-type: none"> <li>-Consider lowering the refocusing angle to 100-120 degrees</li> <li>-Flip angle sweep allows a smooth transition to the steady state for scans using refocusing control.</li> </ul> </li> <li>• B1 mode <ul style="list-style-type: none"> <li>-Consider reducing the B1 amplitude to 12 mT for multi-package scans.</li> </ul> </li> <li>• Knee/Ankle/Foot imaging <ul style="list-style-type: none"> <li>-The system uses anatomy specific, more permitting SAR calculations with SENSE knee and SENSE foot/ankle coils.</li> </ul> </li> </ul>