Parallel Imaging Made Easy

Matthew Benbow, Superintendent Radiographer, Royal Bournemouth Hospital

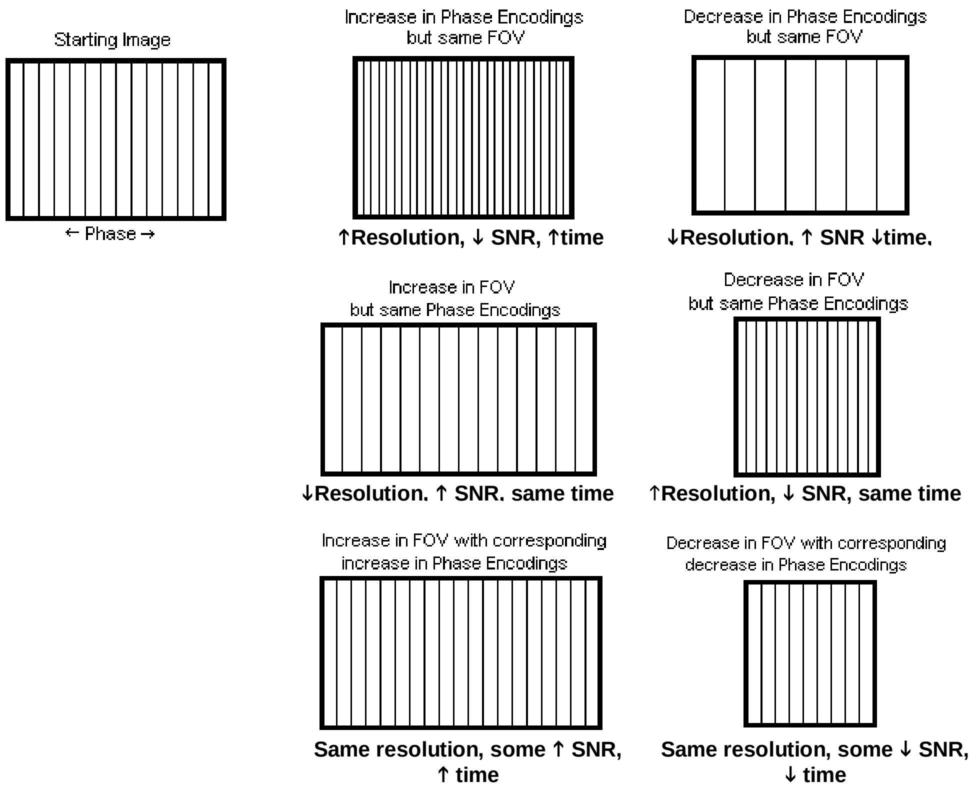
There is always pressure to scan more quickly and we therefore often seek to reduce individual sequence times.

What controls MR scan time?

- TR
- Number of Phase Encodings
- Signal Averages (NSA, NEX)

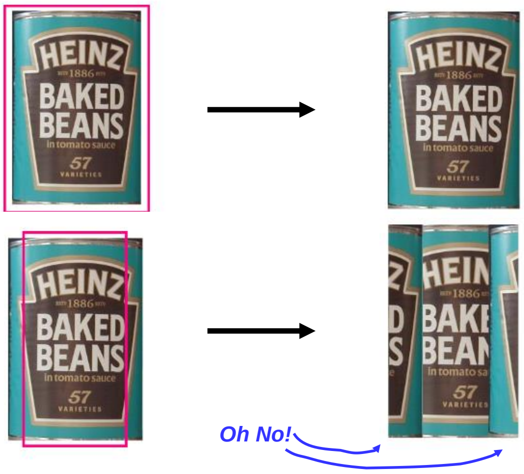
Other than scan time, what else is affected when we vary each of these?

- TR affects Image Weighting
- Number of Phase Encodings affects Resolution
- Signal Averages affects SNR, Resolution and FOV

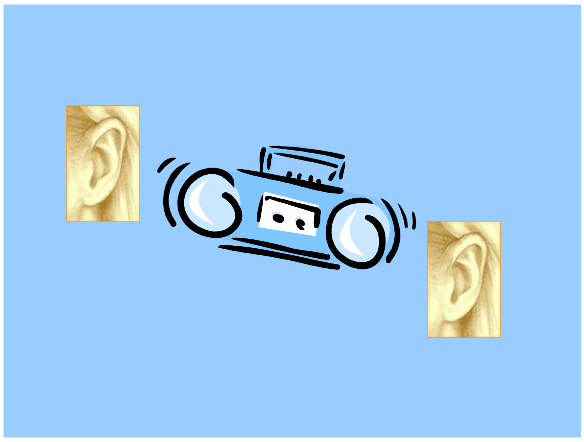


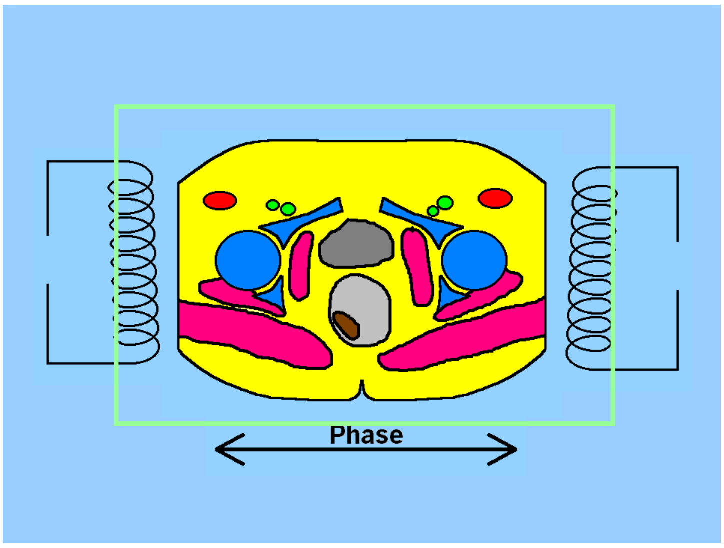
Using a Rectangular FOV (RFOV) as in the last drawing is a common way to reduce scan time whilst maintaining resolution though will reduce SNR somewhat.

The problem however with a reduced FOV is that if the anatomy is outside the field of view in the phase direction, phase wrap occurs. This is because anatomy outside the FOV still produces a signal and this signal is received well by the coil. The scanner will therefore happily include this data within the image and the spatial information it gets from it's phase encoding will suggest that it should be within the FOV, on the opposite side of the image as seen in the can of beans example below…

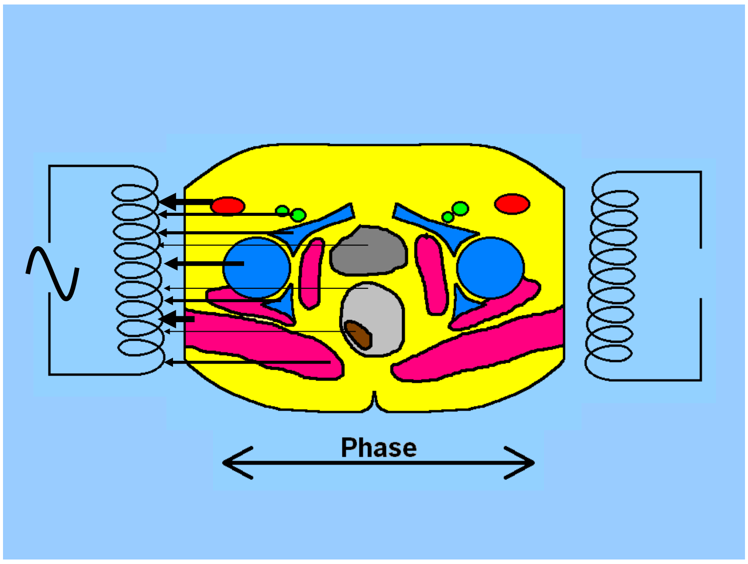


If you listen to two different sources of music at the same from a single position, it just sounds like a confusing din. Your ear is like a single MRI coil and cannot distinguish the source of the different tunes. However, if you listen from one side then the other and you should be able to distinguish which track is coming from which side. You don't need to do this for very long, just a quick scan for reference should suffice. So can the scanner do this? Can it make a quick reference scan to tell where the signals are coming from? YES, with Parallel Imaging!! So how does it work?

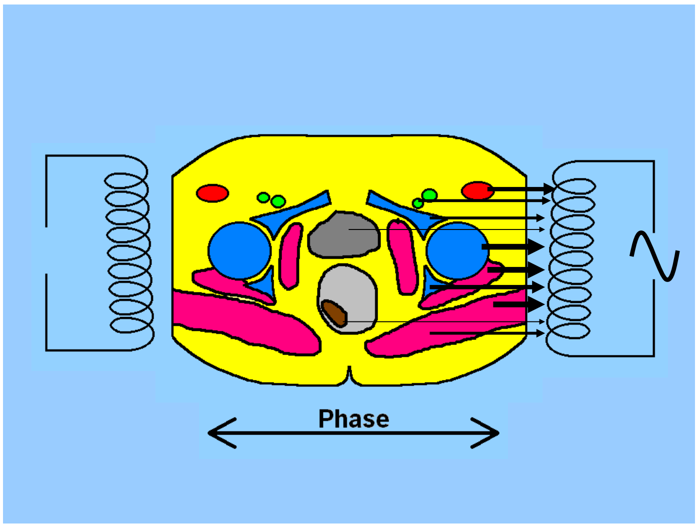




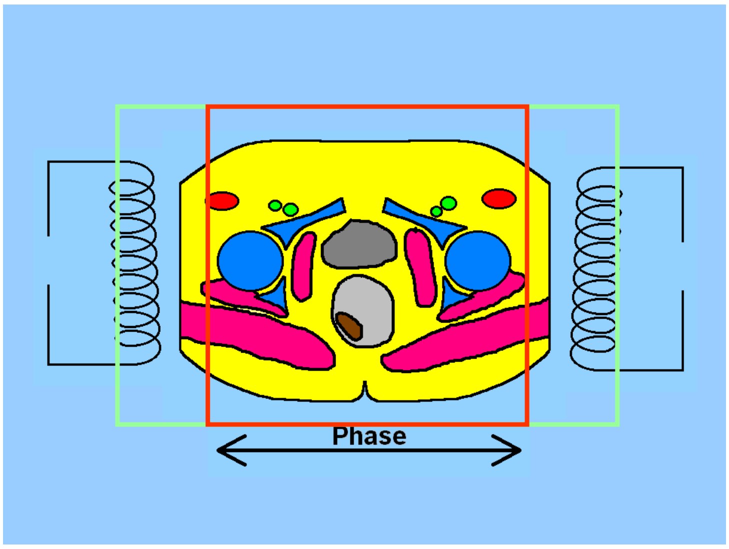
Here is an axial pelvis image which we will use as our example. To enable parallel imaging to be used, a coil with at least two elements must be used and we will see why this is necessary in a moment. These elements must be placed in the phase direction. The operator decides on the area of coverage desired just as normal (green box), i.e. does not reduce the FOV – the scanner takes care of this.



A short reference scan is then performed in two parts, so that the scanner can independently acquire spatial information using both of these coil elements – just like listening to the music tracks from one side then the other. From one coil element, some signals will be strong, and others weak. This is based on the tissue type and it's proximity to the coil element.



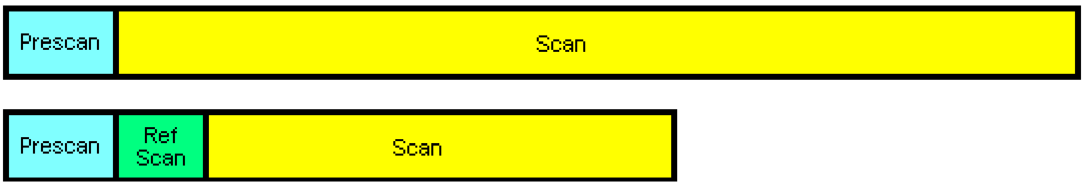
The second coil element is then used to perform the same task and the strengths of signal measured will differ from those measured from the first coil element. By comparing the signal strengths, the scanner can then correctly spatially encode anatomy that would otherwise be wrapped, i.e. map it correctly in the resulting image even though it has uncertainty from the phase encoding data alone.
This reference scan is performed automatically at the beginning of a scan sequence without the operator having to do anything. (With an older GE scanner the operator prescribes this scan and runs it manually).



The scan is then performed using a reduced FOV shown here by the red box, and a wrapped image is produced…

This wrapped image is not shown to the operator however. Instead the spatial information gathered by the reference scan is used…

…to unwrap the image ready for viewing.



The advantage is a significant reduction in scan time. Using a factor of two the scan acquisition time is reduced by half, although with the extra reference scan being needed, the overall reduction in scan time can never be quite this much.
The correct title for this technique is Parallel Imaging, but of course all manufacturers have their own name for it.

GE – ASSET
Philips – SENSE
Toshiba – SPEEDER
Siemens – i-PAT

Limitations and Considerations

Only use in areas where you can afford to lose signal. Remember, parallel imaging = less phase encodings = lower SNR.

You must use a coil with at least 2 elements (or 4 for factor 4 and so on). The coils elements must be locatable in the phase direction.

Beware of Intrinsic Wrap – if the FOV you prescribe is such that it would produce wrap anyway, then this will be unknowingly re-wrapped by parallel imaging and it will not be able to unwrap this. This is normally seen as a central artefact line, parallel to the phase direction – increasing FOV will cure this.

Weak Residual Folding – a poor reference scan will result in a poor unwrapping and a partially wrapped image. A better reference scan should cure this but will increase the scan time slightly. Coil to patient separation pads can also work here.

Flow problems – flow that was present during the reference scan can be mismapped and therefore not unwrapped (similar to the aorta artefact seen in axial liver scanning) – use SAT bands to help this.

Artefacts that would have been present anyway will still be there when using parallel imaging, but may be in very strange places!

Signal Averaging – There is no real benefit in using parallel imaging to reduce scan time unless you are down to one signal average for your acquisition already. Likewise there is little point in switching parallel imaging on and then thinking you need more signal, so going to two signal averages.

However, sometimes extra averages are used to blur our unavoidable movement such as swallowing in a neck scan. These extra averages can result in a long scan time, so parallel imaging with >1 signal average can be used to keep the scan time reasonable.