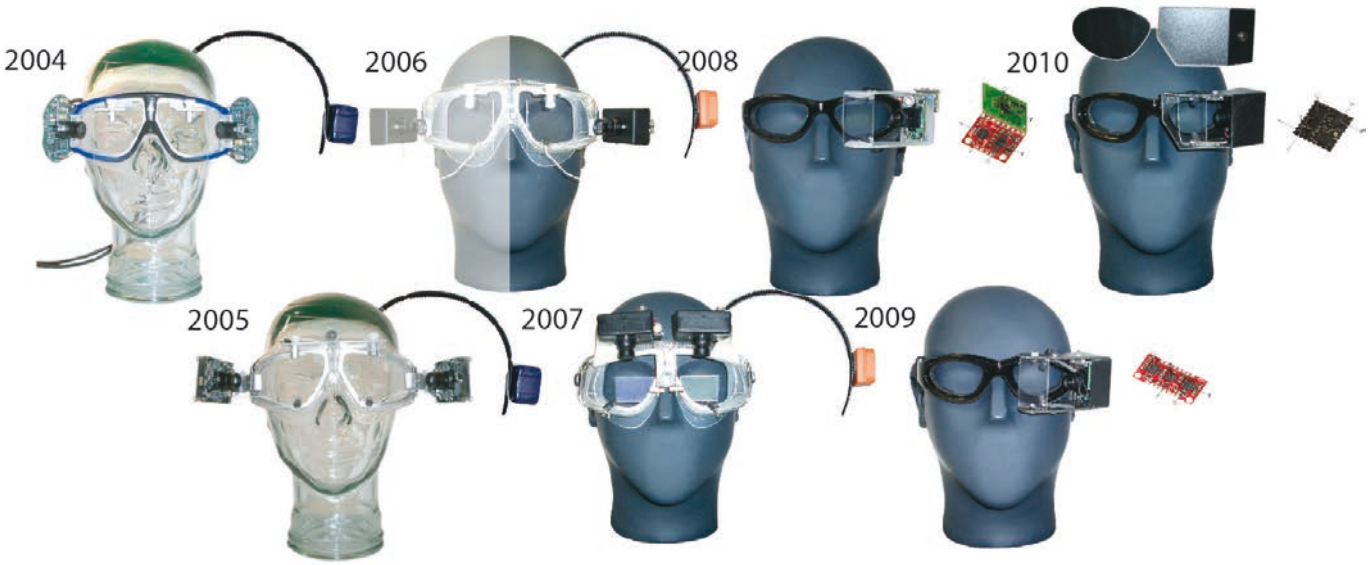
Years of research and development making vHIT feasible

Many years of trial and error went into developing a video goggle system that can accurately measure eye and head movement during the head impulse test. The pictures below display the research developments from the University of Sydney which resulted in the Impulse goggles.



Fit/weight/torque

In order to properly collect head impulse data you must have a goggle that fits securely to the patient's head. The goggles cannot have too much mass. The mass cannot be too far from the center of the head and it cannot sit away from the patient's face. If the goggles move on the face, this movement is seen as eye movement. This is an artifact but will be seen as valid eye movement. A small movement of the goggle will result in a huge movement of the eye. 1 degree of goggle rotation could be equal to 10 degrees of error in eye movement. The system cannot distinguish between artifact (goggle movement) and actual eye movement. The data are compounded by the amount of head movement. The mass of the goggle works against the movement of the head causing artifactual eye movements. This results in noisier eye tracings. The goal is to measure "true" eye movement without goggle movement artifact. The goggle must be close to the face at the nose and eye sockets in order to reduce the radius from the center of the patient's head and therefore reduce the torque.

Less mass, close to the head

More mass, protruding away from the head

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Earth-mounted camera

Earth-mounted cameras cannot distinguish between head rotation (movement around a fixed point) and head translation (movement with no fixed point). No matter which camera is used it will have lower resolution than Impulse because a lot of the image is used to track the head. The eye position measurement relies on measuring accurate head position. Errors are cumulative if the movement includes head translation. Impulse uses all of the camera resolution to track the pupil, measuring head movement independently with gyros that are very accurate especially for velocity. Our method is not confused by translation.

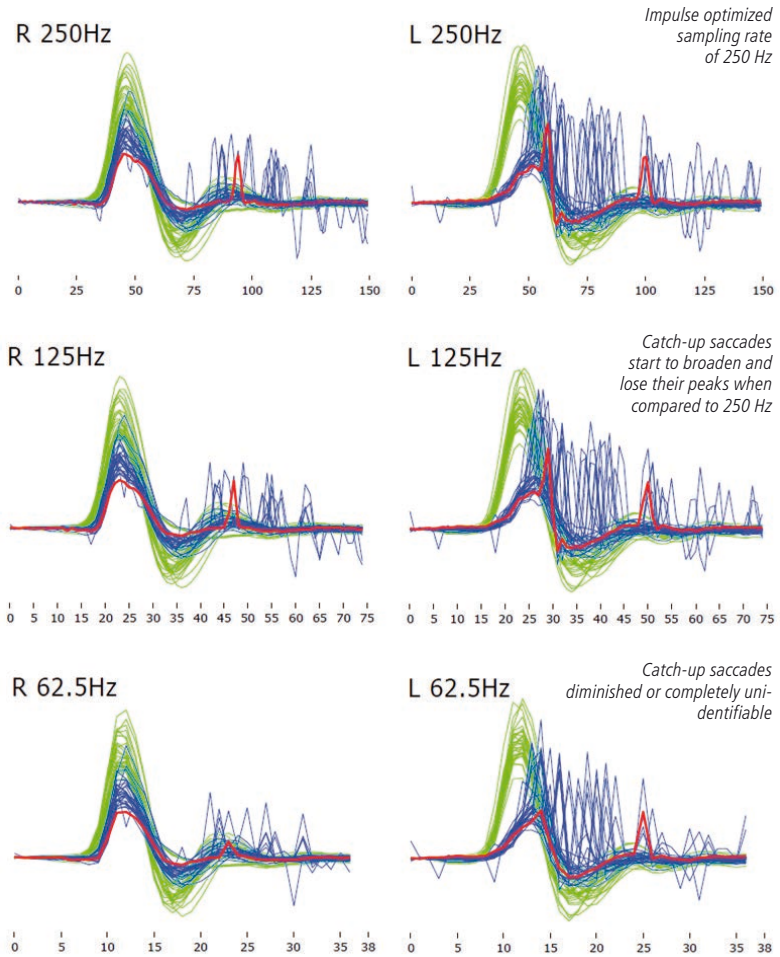
ICS Impulse

ICS Impulse goggles weigh 60 gram. The profile is close to the face eliminating torque. The fit is tight to the face. All of these attributes eliminate goggle movement artifact.

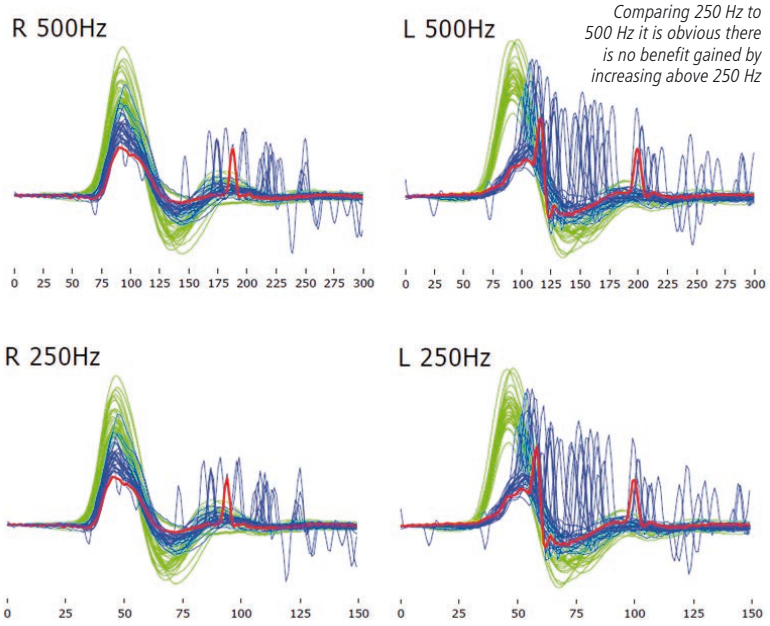
Camera frame rate

A 60 to 100 Hz video camera does not have enough bandwidth to identify catch-up saccades. A slower frame rate makes it more difficult to discern between VOR and catch-up saccades. A slower frame rate causes an aliasing problem that results in the loss of sharpness of the saccades and the waveform does not reflect the accurate shape of the eye movement.

Legend: **Green** = head trace, **Blue** = Eye trace, **Red** = single eye trace example

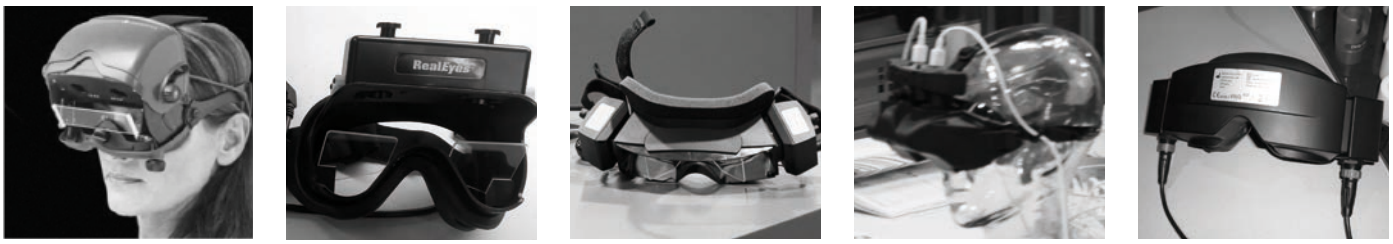


A frame rate of 250 Hz provides the best temporal and spatial resolution. Don't be fooled by tricky marketing that advertises data collection above 250 Hz. Increasing the temporal resolution decreases the spatial resolution. This will not provide you additional information but will result in noisier tracings.



Comparing 250 Hz to 500 Hz it is obvious there is no benefit gained by increasing above 250 Hz

Common VNG goggles



Goggles intended for videonystagmography are too heavy, result in too much torque and do not fit close to the face. All these attributes make performing a proper head impulse impossible

Head impulse using rotary chair

In 1988, Halmagyi and Curthoys identified that when performing head impulses using visual observation an acceleration of 3000 degrees/sec2 was needed to identify a unilateral loss.[1] Using video goggles a proper head impulse must have a stimulus with an acceleration of 1500 to 2000 degrees/sec2 (velocity of 150-200 degrees/sec).[2,3] When a head impulse is performed, the non-test side is inhibited (firing rate decreases below the resting rate) and the test side is excited (firing rate increases above the resting rate). You must have the proper stimulus in order to see the unilateral loss. If the acceleration is not high enough, a unilateral loss cannot be identified or cannot be determined as to which side the abnormality resides. Rotary chairs are typically limited to an acceleration (100-800 degrees/sec2) that is insufficient for proper head impulse testing.

1. *Halmagyi GM, Curthoys IS. A clinical sign of canal paresis. Arch Neurol 1988; 45(7):737-739.*

2. *Weber KP, Aw ST, Todd MJ, McGarvie LA, Curthoys IS, Halmagyi GM. Head impulse test in unilateral vestibular loss: vestibulo-ocular reflex and catch-up saccades. Neurology 2008; 70(6):454-463.*

3. *Weber KP, MacDougall HG, Halmagyi GM, Curthoys IS. Impulsive testing of semicircular canal function using video-oculography. Annals of the New York Academy of Sciences, 2009; 1164: 486-491.*

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