What type of 'Choppers' do we use?

(i) Background Suppressing Choppers (Nimonic Choppers)

On some of the instruments the signals of interest to the scientists are quite weak and can be swamped by background 'noise' signals which arise from the scattering of high energy neutrons in parts of the instrument other than the sample under investigation and from the flash of gamma-rays which occurs when the ISIS protons hit the spallation target.

To elimate these background signals these nimonic choppers are fitted into beamlines, at a point just beyond the ISIS biological shield. These shutters are in the form of bars of a nickel alloy, (called Nimonic 75) 300mm thick in the direction of the beam, phased to obscure the beam at t=o, thus removing the gamma-flash and unwanted high energy (>10eV) neutrons. A short time later the bar has rotated out of the beam in time to pass the neutrons of interest to our studies.

To withstand the huge centrifugal forces (>10,000'g'), which arise when these massive bars are rotated at speeds up to 700 km per hour the rotors of the choppers are themselves very heavy but, because they need only to be phased to the ISIS source to an accuracy of $\pm$ 50 millionths of a second (50μs), we can use conventional precision ball-races in their support bearings.

(ii) Waveband Selecting Choppers (Disc Choppers)

These choppers are designed to pass broad bands of neutron velocities which are selected to give maximum utilisation of the 1/50 s timeframe.

The rotating shutters in these are in the form of annular sections of neutron absorber set into the peripheral region of aluminium discs.

On many of the choppers 2 discs are fitted in such a way that by mutual rotation the aperture can be varied in length so the transmitted velocity range can be altered to suit a particular experiment or detector arrangement.

For high resolution instruments, such as H.R.P.D., where the flight path is 100 metres long and where a more than 1/50 s time frame is needed to record a complete powder pattern, a second disc chopper, synchronised to rotate at a sub-multiple of the ISIS pulse rate is fitted in the beam to totally block out the unwanted pulses of neutrons and the first chopper is run at a slower speed to increase the spread of the transmitted velocity band.

Dependant on the value of the chosen sub-multiple (2,3,...9,10) so the 'frame time' can be varied in multiples of 1/50 s.

(iii) Monochromating Choppers (Fermi drum choppers)

In these choppers the 'shutter' is in the form of a complex 'slit package' of alternating neutron opaque and neutron transmitting layers curved in the beam direction in such a way that at a particular speed of rotation and phasing they appear straight only to neutrons with the narrow band of velocities required to be selected. By having a 'family' of rotors with slit packages of different curvatures, and by altering their rotational speed and phasing, a range of neutron energies E from a few electron volts (eV) to a few tens of milli electron volts (meV) can be chosen with a resolution dE/E of 0.01 to 0.001 (1% to 0.1%).

To achieve such resolution the 'open times' of the shutters must be of the order of 1 millionth of a second (1μS). To attain this we have to spin the drum-like rotors, in which the slit packages are housed, at rotational frequencies of 600 times per second (600Hz) and they must remain in phase with the source pulse to a fraction of 1μS.

Such precise rotation cannot be achieved using conventional bearings and so the RAL Chopper Group have equipped these choppers with 'active magnetic suspensions' which enable them to be frictionlessly rotated, in a vacuum at a pressure of only five hundred millionths of the earth's atmospheric pressure (5×10^{-5} bar), totally isolated from mechanical contact with the outside world.