Abstract
The internal surface of 50 cm long and 34 mm diameter stainless steel tubes were coated with TiV, TiZrV and TiHfV getter films using a cylindrical magnetron. The NEG coated tubes were baked for 24 hours at various temperatures ranging from 150°C to 300°C. The TiZrV film had the lowest activation temperature which was found to be 180°C. The TiV film had the highest activation temperature of 250°C and the highest saturation coverage for CO of about 3 monolayers. The TiZrHf film had the lowest activation temperature which was found to be 180°C. The evolution of surface chemical composition during the activation was determined by x-ray photoelectron spectroscopy (XPS) and the functional properties were evaluated by pumping speed measurements. Film composition was determined by Rutherford back scattering and the surface morphology was studied by SEM which revealed a columnar structure.

XPS Results
XPS analysis shows that in addition to dominant Zr, Ti, V and O peaks, a very small C 1s peak was also present. This was used to calibrate the energy scale (See Fig 1). High resolution XPS measurements of the core levels of V, O, Ti, Zr and C (for a given TiZrV sample) were also carried out at 180, 250 and 300°C. As shown in Fig 2, after heating to 300°C the two vanadium characteristic peaks are shifted from 524 and 517 eV, corresponding to vanadium oxide, to 521 and 512 eV, corresponding to metallic vanadium. The Ti at the surface behaves very similarly to vanadium after annealing at 300°C (Fig 3). However, the reactivation of Zr was less successful and, even after annealing at 300°C, there is still a considerable amount of zirconium oxide present at the surface (Fig 4). The residual oxygen peak observed at 532.5 ev is mostly associated with surface zirconium oxide.

SEM Results
The SEM images show that the morphology of the film depends on substrate topography, deposition conditions (e.g. pressure, pulsed vs. dc magnetron sputtering) and film composition. In pulsed magnetron where the surface of the film is bombarded with energetic ions the grain size are of order of 5 to 10nm (Fig 10). Tertiary alloys (e.g. TiZrV) result in a smaller grain size relative to binary alloys (e.g. TiV, TiZrHf, TiHfV) (See Fig’s 11 and 12).

Conclusions
• The RBS data suggests that the pumping capacity and sticking probability is not dependent on a particular composition but is instead dependent on the individual alloy composition, as well surface topography, film morphology and grain size (as shown by the SEM results).
• The XPS results show the change in composition from an oxide rich to metallic surface as a result of annealing to 300°C.
• The average grain size calculated from the XRD results is 5-6nm for TiZrV, and is independent of the substrate.
• The highest initial sticking probability was obtained using a TiZrV coating activated at 300°C.