AF33 -0233 Nucleation in an ultralow ionization environment

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INTRODUCTION

We have studied aerosol formation at ultra-low ionization levels, using the deep underground science facility at Boulby mine, UK. At 1100 m depth, with a corresponding factor 10⁶ reduction in cosmic ray muon flux, the Boulby facility is an ideal place to study the role of ions in aerosol nucleation.

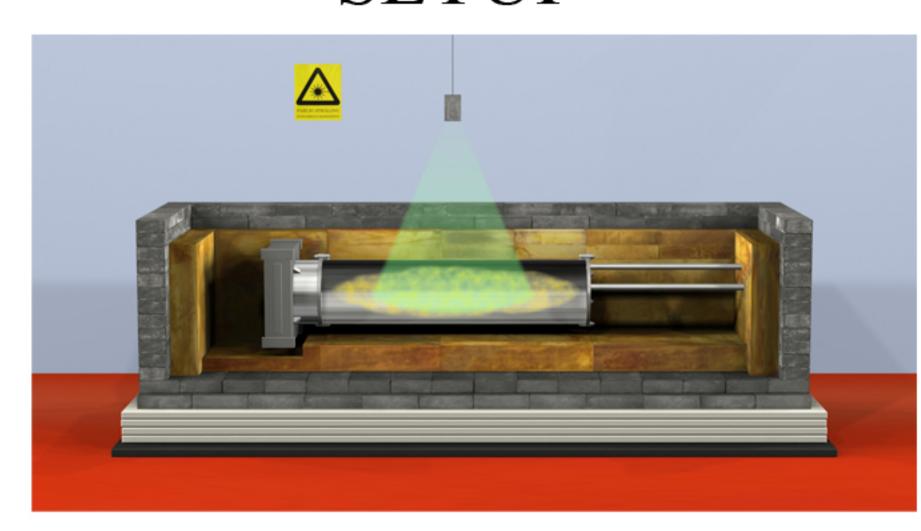
The lowest ion density is calculated to be 1 cm⁻³. Getting this close to zero ionization allows us to distinguish between the neutral and charged contribution better than previously. The effect is explored over a range of sulfuric acid concentrations.

ION CONTROL

1100 meter of rock shielding reduces cosmic muon intensity by a factor 10⁶. 10 cm of lead and 10 cm of copper shielded the chamber from gamma radiation from 5 sides. For very low ionization measurements the 6th side could be closed giving a total reduction in ion production rate through gammas of greater than a factor 10⁴. Stored synthetic air and activated charcoal filters were used to lower Radon levels.



SETUP



We used a 50 L electropolished stainless steel chamber (see previous poster AF22-0232). The low ionization environment is preferable to the use of electric clearing fields where complications arise because the field will also remove charged clusters and the ion-induced reactions may occur on a shorter time scale than the life time of the ions in the field.

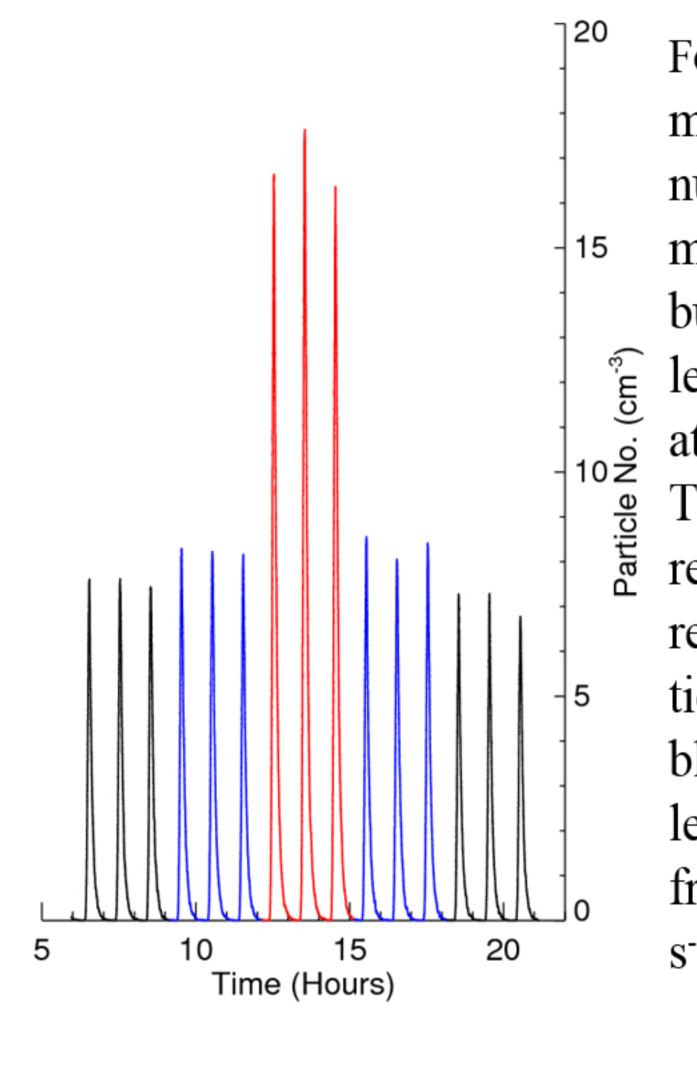
A 17 MBq Cs-137 gamma source was used to increase the ionization in the chamber.

Each measurement was initiated with the production of a 'burst' of H₂SO₄ following exposure of the chamber to UV light, resulting in the production of aerosols. The peak aerosol concentration lasted for a few minutes before decaying exponentially due to wall and dilution losses.

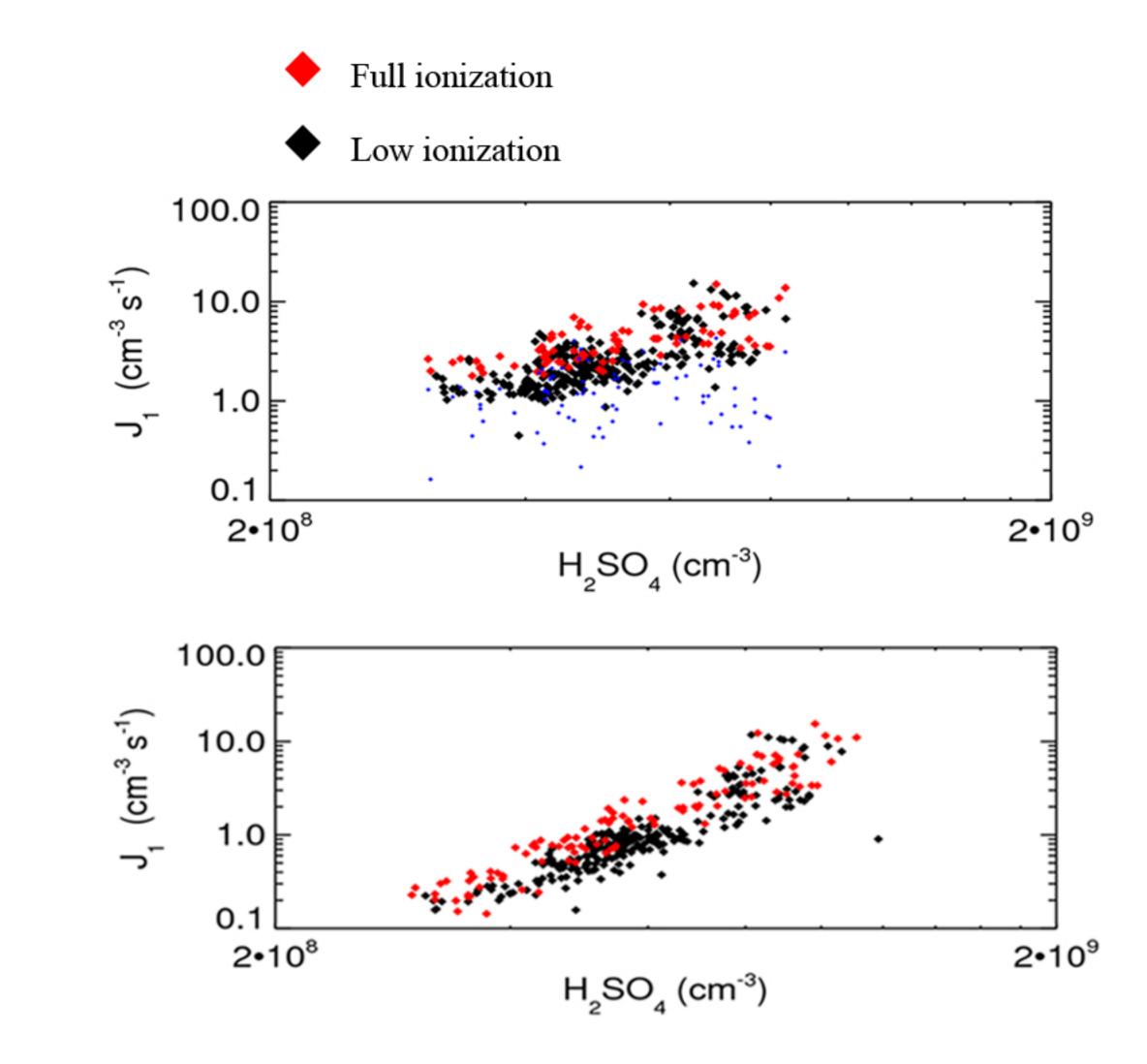
RESULTS

The figure below shows nucleation bursts with varying ionization levels.

To the right is seen calculated nucleation rate of 1 nm aerosols (based on mesurements of 4 nm appearance rates) as a function of sulfuric acid concentration.



For each series of measurements we performed a number of bursts with minimal ionization, followed by bursts at various ionisation levels, and ending with bursts at minimal ionization again. These bursts are used to correct for any drift. Black peaks result from minimum ionization bursts (0.04 cm⁻³ s⁻¹), blue from surface ionization levels (2.6 cm⁻³ s⁻¹), and red from high ionization (32 cm⁻³ s⁻¹).



CONCLUSION

A total of 258 peaks with minimal ionization and 110 with full exposure to the gamma source have been analysed. The figures aboveshow the output from two methods of analysis. The lower figure is from a loss rate method and the upper figure from an analytical model. The calculated nucleation rate J1 is shown as a function of the sulphuric acid concentration, in a log-log plot.

The slope of the plots are 3.1 for both lines in the upper figure. In the lower figure we get 1.8 and 1.3 for the low ionisation and full ionisation, respectively. Interestingly the ion contribution seems to be more or less independent of the sulfuric acid concentration.

The difference between the two methods makes any definitive conclusion difficult, however, the results from the analytical method are more in line with other observations that yield slopes between 1 and









