INTEGRATED SAMPLING AND MASS SPECTROMETER SYSTEMS FOR VENUS PROBE AND BALLOON MISSIONS

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Applicable Venus science objectives

- understanding the atmospheric cycling of compounds of *carbon, sulphur, oxygen & chlorine*
- high precision measurements of the *noble gas* elemental and isotopic composition (+ *nitrogen*)
- seeking evidence of *volcanic emissions* or *crustal outgassing*
- investigating whether cloud droplets harbour molecules of *astrobiological* significance
- Understanding lower atmosphere through instrumented microprobes
- (aerosol/dust science on orbiter??)

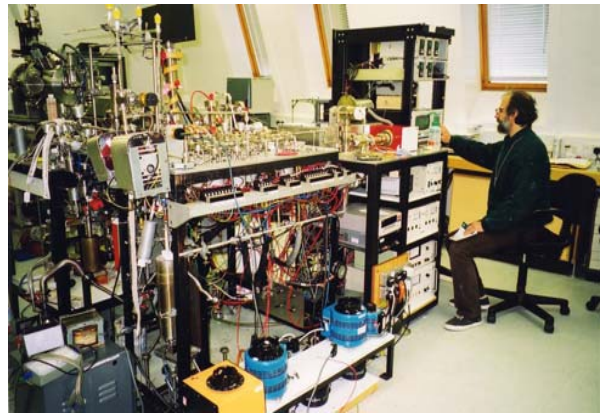
Talk overview: a mass spectrometry technology update

- Isotope ratio mass spectrometry ≥5 kg
- Gas chromatography / mass spectrometry (GC/MS) ~2 kg
- Miniature mass spectrometers <0.2 kg

Isotope ratio mass spectrometry

The chosen technique should be as close as possible to laboratory based measurements

- sample preparation technique then analysis in “simple” magnetic sector MS
- For high precision (<< ±1%), need *relative* not absolute measurements
- Measure reference material in-situ to overcome instrument instabilities and fractionation effects
- Laboratory instruments are optimised for small samples: < ± 0.1% precision for Ar, Kr, Xe isotopes on sample of 10^{-10}cc of gas



How to repeat this at Venus?

1) Take the state of the art:

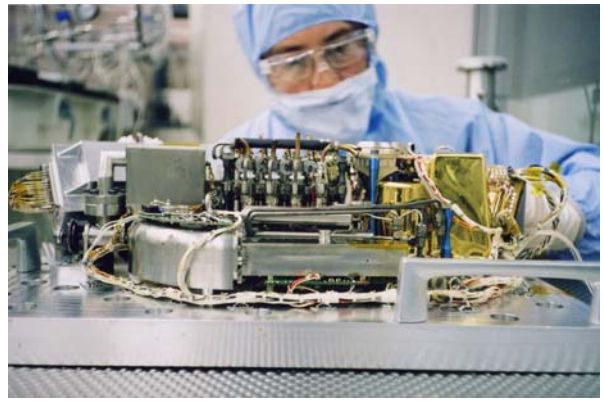
- 6 kg GAP (Gas Analysis Package) on Beagle 2, for C, O, H isotopes at ± 0.1% precision

2) Adapt for Noble gas analysis

- increase mass resolution

3) Make repeat analyses (of same sample)

- miniaturisation reduces precision but repeated analysis reclaim precisions (there is plenty sample at



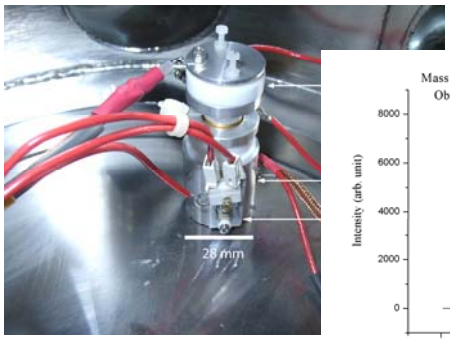
Miniature GC-(ir)-MS

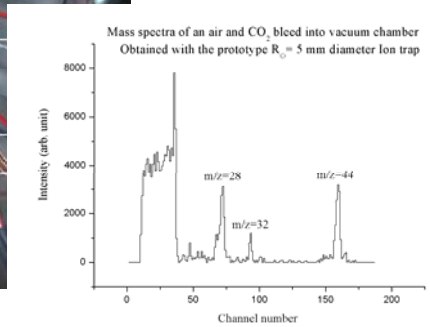
Ptolemy on Rosetta lander (<5 kg) launched 2004

- Solid sample inlet (carousel, MPAe)
- Chemical sample processing
- 3-4 channel gas chromatograph
- Ion trap mass spectrometer (500 g, 1 W)

Next generation GC/MS - Ion Traps

a) PSSRI prototype ion trap

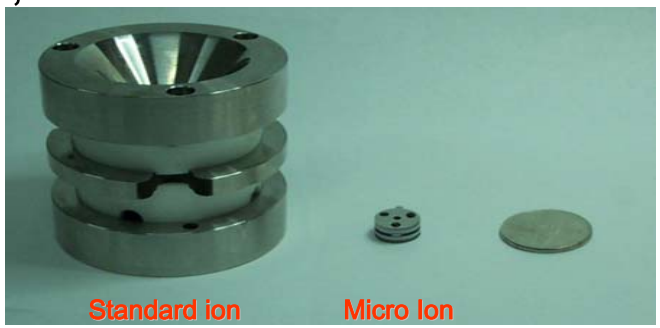


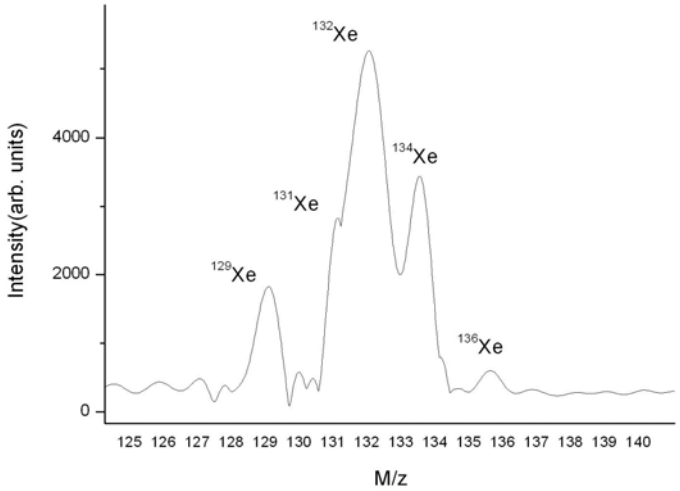


b) Palm-portable MS (S. Korea)
Mass Range: 40~300 amu
Mass Resolution: 2 amu at m/z=106
Size: 8.2 x 24.5 x 7.7 cm, 1.44 kg (without battery)
Average Power 5 W

Miniature Mass Spectrometers (<10 gram exc. electronics)

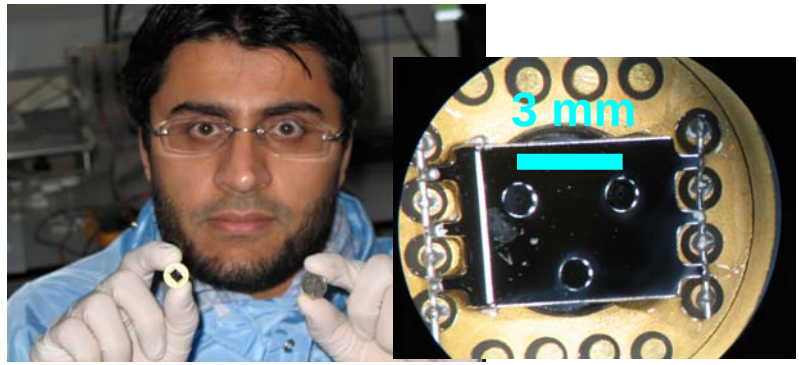
Partnership with Sam Yang Chemical Co., Seoul





Partnership with Rutherford Appleton Laboratory, UK

- MEMS ion trap arrays in silicon
- first prototypes built and ready for test



Conclusions

Technology is at a fairly good level of Readiness for the following:

- **Magnetic sector MS** for isotope ratio measurements (Noble gases + C, N, O, S) – balloon??, entry probe?
- **Ion trap MS** for GC/MS – balloon?

Technology is being actively developed for the following:

- **Micro ion trap MS** for chemical sensing – microprobes?

- *Also we are investigating a <2 kg **Dust detector / Aerosol Mass Spectrometer** (positive and negative ion spectra from single ≥100nm particles impacting a target on an orbiter around a planetary body)*

Thanks to:
•CCLRC, UK: Adnan Malik, Bob Stevens - images of MEMS ion trap
•Sam Yang Chemical Co., S. Korea: Palm Portable MS Team: Do-hoon Kim, Hyun-chul Hwang, Tae-young Kim, Suk-kyung Lee, Jung-hoon Jung, Han-gyu Kim and Mo Yang, Director – images and data from PPMS