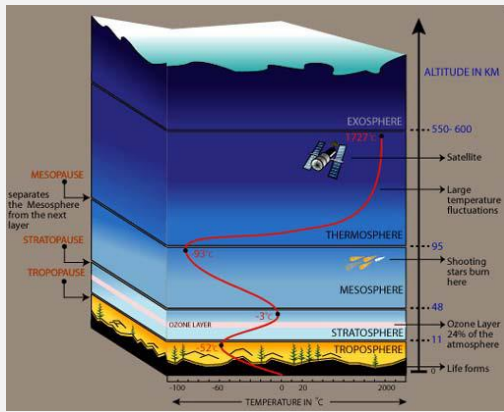


# The Ion and Neutral Mass Spectrometer for the CIRCE Mission

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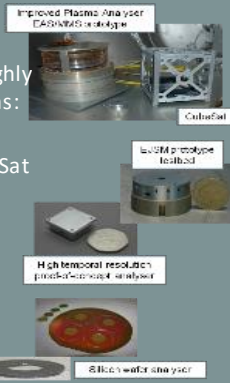
## Summary

The Coordinated Ionospheric Reconstruction CubeSat Experiment (CIRCE) is a 2 x 6U CubeSat mission to the upper thermosphere carrying a suite of remote sensing and in-situ payloads. Details of the mission are presented in a contributed talk to session 12 on Space Weather Instrumentation at this conference. This poster describes the Ion and Neutral Mass Spectrometer (INMS), one of the in-situ particle instruments on CIRCE.

The INMS is a miniaturised analyser designed for sampling of low mass ionised and neutral particles in the spacecraft ram direction with the instrument resolutions optimised for resolving the major constituents in the lower thermosphere, i.e., O, O<sub>2</sub>, NO and N<sub>2</sub>. 11 INMS instruments were developed for the EU QB50 CubeSat constellation mission, 9 were launched on their respective educational CubeSats and to date, data has been returned over a six month period from the one working QB50 CubeSat. CIRCE will fly the two remaining flight instruments from QB50.

## Instrument miniaturisation at MSSL

- Low resource analyser development using MEMS-based (Micro-Electro-Mechanical Systems) fabrication techniques
- Generic technologies suitable for creating highly integrated "matchbox" sized analyser systems: small, low resource, more capable
- Technology demonstration on UK TechDemoSat mission
- Strongly linked to CubeSat R&D programme



## Nano-satellite advantages

- Low cost constellations
- Rapid turnaround

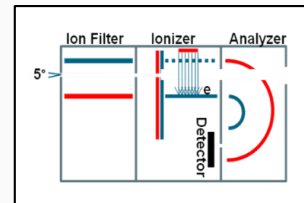
## CIRCE Coordinated measurements

- Ground based radar
- Ground based Fabry Perot Interferometer measurements

## Ion and Neutral Mass Spectrometer

- Measure dominant species: O, O<sub>2</sub>, N<sub>2</sub>, NO
- Density and possibly temperature

## Principle of operation

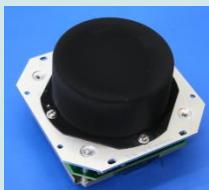


- Voltages on the ion filter reject ions but transmit neutral particles which can be ionised in the ionizer and then detected in the analyser
- With no voltages on the ion filter and ionizer, neutral particles pass through a gap in the analyser

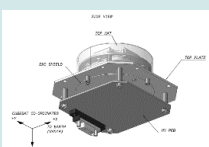
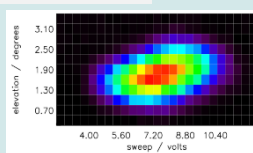
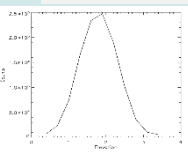
## Features

- Ping-pong ion-neutral operation
- Two independent sensors with different instrument parameters
- Provides clean separation of the major constituents in both the upper and lower thermosphere

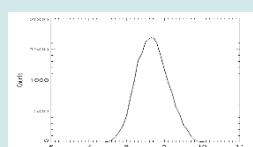
## INMS units for CIRCE



### Ground Calibration data



Mass: 220 gms  
 Power: 0.85W  
 Energy Res: 9/4%  
 Elevation: 1.3°



## QB50 in-flight

- QB50 Phoenix Satellite (Taiwan team)
- Satellite in Y-Thomson spin
- Particles enter when instrument faces ram direction
- Instrument set for O+
- X-axis – Voltage (Energy)
- Y-axis – Time
- Data taken in conjunction with World Radar days for calibration
- Tested for ions only
- Anna Apsit (2018), Ali Ozkadir (2019) Masters thesis
- Discrepancy with IRI results

