CubeSat Propulsion Research at the University of Auckland

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

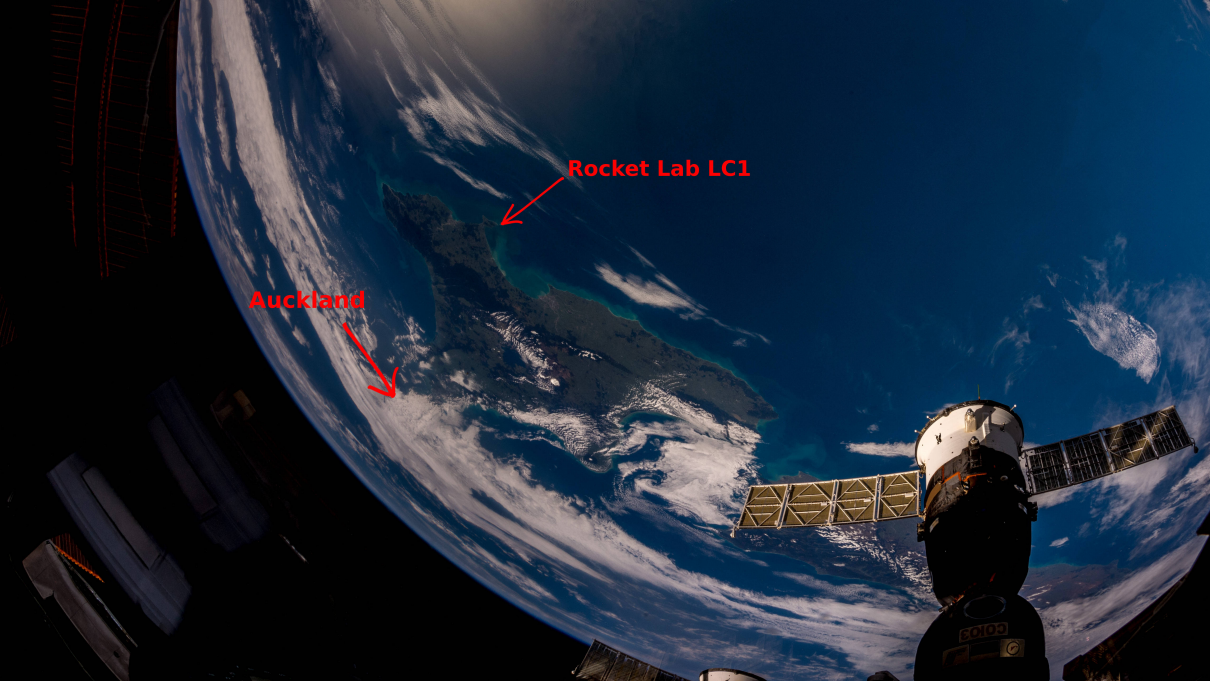
Review and Upcoming Activities

April 23-25

Félicien Filleul

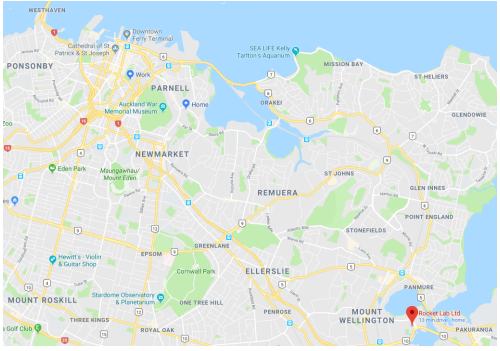
2019 Cubesat Developers Workshop

San Luis Obispo, California


Rocket Lab LC1
Auckland

- Rocket Lab. founded in New Zealand 2006
- New Zealand Space Agency founded in 2016
- Auckland Programme for Space Systems (APSS) 2016

A nice neighbourhood



Electron, credit: Rocket Lab.

APSS: a space for students

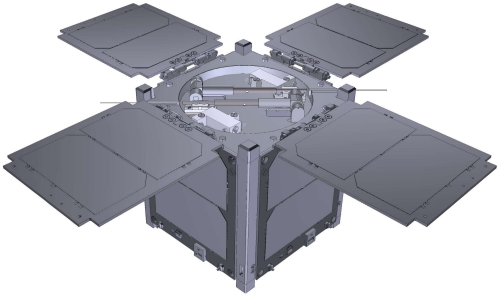
UoA Ground Station

- Cross-faculty programm
- Design a mission answering a societal need
- 200-400 students / year
- 1 CubeSat / year

QuakeTEC in the clean room

APSS-1: QuakeTEC

- Ionospheric plasma measureaments with Langmuir probe
- Launch in June !



QuakeTEC, credit: QuakeTEC team

APSS-2: Kessler

- Eelectrodynamic tether for CubeSats deorbiting
- Launch next year

APSS-3: TBD

Te Pūnaha Ātea - The Auckland Space Institute

Prof. Richard Easther, Head

Dr. John Cater, Engineering Lead

Dr. Nicholas Rattenbury, Science Lead

- To coordinate the university research in space science and space policy
- To help forster and support the nation new space economy

Low Δv trajectories for CubeSat missions

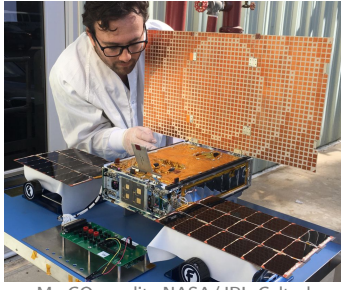
- Find a trajectory to send a CubeSat to Venus
- Define system dynamics, following trajectory optimisation

GOAL:

- Different solving algorithms available
- Find Venus trajectory with minium Δv

Collaboration: Scott Dahlke, USAF

Darcey Graham, UK



MarCO, credit: NASA/JPL-Caltech

CubeSat Deployable SAR System

- Evaluate concept of Synthetic Aperture Radar (SAR) on 6U CubeSat

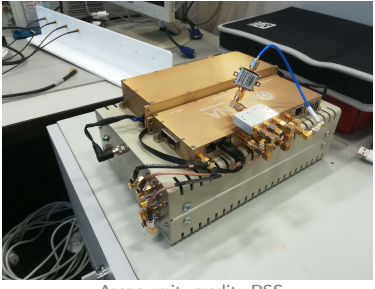
GOAL:

- Multi-satellite constellation for sea vessel monitoring

Collaboration:

- Remote Sensing Solutions (RSS), USA
- Brian Pollard, ex JPL and Curiosity Rover radar chief engineer
- DLR

Jan Krecke, Germany

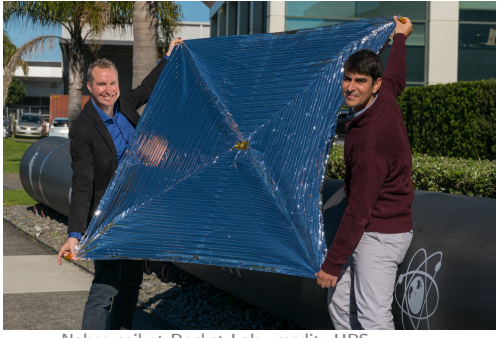


Arena unit, credit: RSS

CubeSat Drag Sails

- CubeSat end-of-life mitigation

Nico Reichenbach, Germany

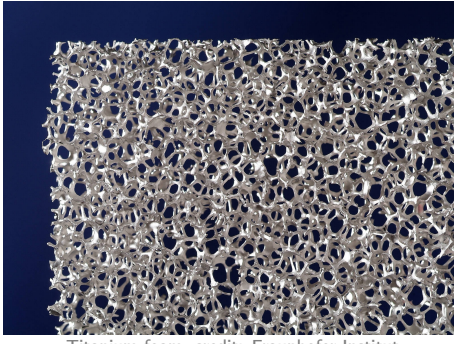


Nabeo sail at Rocket Lab., credit: HPS

Titanium Foam Thermal Shield

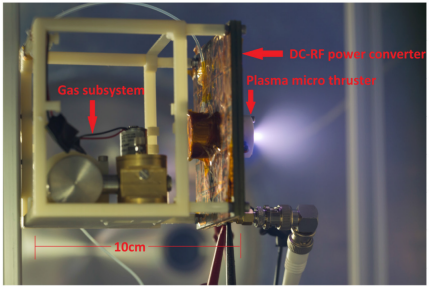
- Lightweight, easy to shape

Dr Peng Cao, New Zealand



Titanium foam, credit: Fraunhofer-Institut

A next step for CubeSat EP

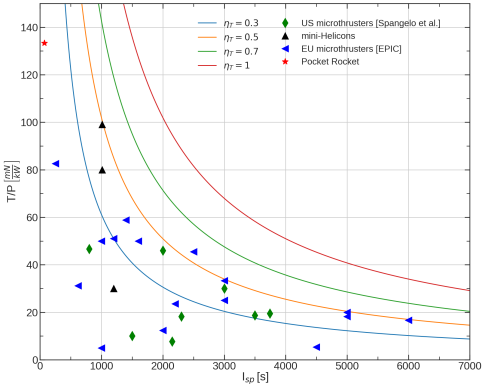


ANU Tiny Pocket-Rocket & Stanford PPU, credit [1]

Figures of merit:

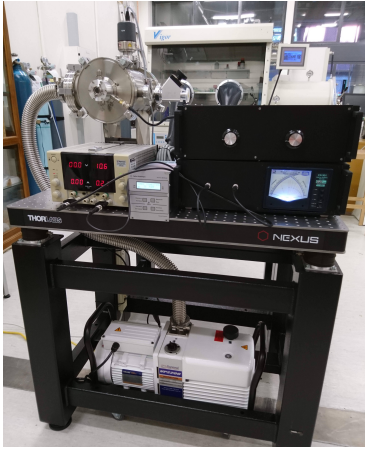
- $T = 2\,\mathrm{mN}$
- $P_T = 15\,\mathrm{W}$
- $I_{sp} = 70\,\mathrm{s}$

Australian National University



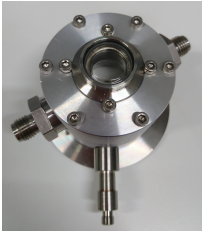
PR vs other microtrusters [2]

ePR: Neutralizer Pocket Rocket



UoA ePR experiment

GOAL: An Alternative to Hollow Cathode

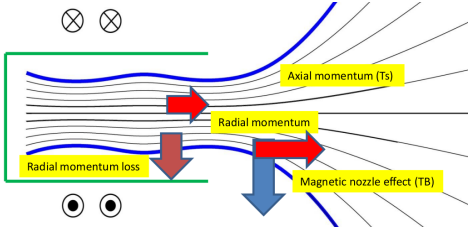


UoA Pocket Rocket unit

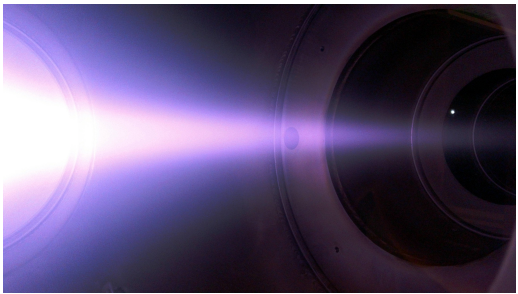
- No heater element ⇒ instant-on
- No doped insert ⇒ longer lifetime

My Personal Favourite

- Helicon waves give high ionization rate
- Quasi-neutral plasma plume ⇒ no neutraliser
- No active elements in the plasma ⇒ no critical erosion
- Structurally simple
- Cool physics

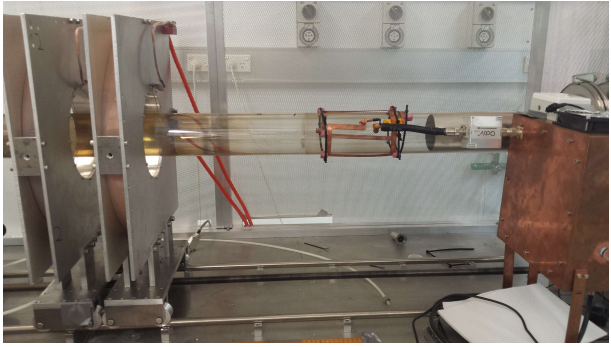


Magnetic Nozzle, credit [3]



Helicon plasma in a magnetic nozzle at EPFL. 70 W,450 G

Magnetic Nozzle physics has been identified as key to helicon thruster promised performances [4]



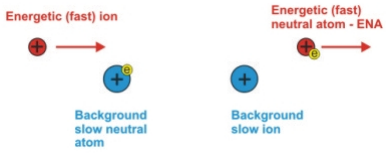
Magnetic Nozzle Experiment at SP3-ANU, credit: SP3

Australian National University

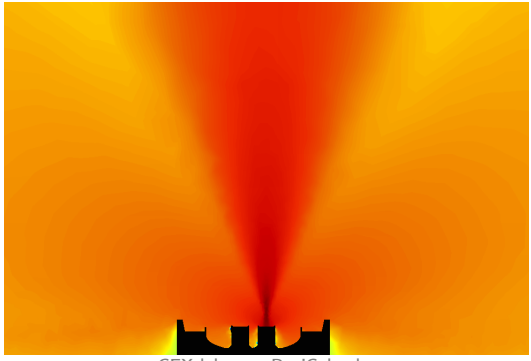
Laplace

Electrical Interactions with the S/C

$$\begin{cases} Xe^{+}_{fast} + Xe_{slow} \rightarrow Xe_{fast} + Xe^{+}_{slow} \\ Xe^{++}_{fast} + Xe_{slow} \rightarrow Xe_{fast} + Xe^{++}_{slow} \end{cases}$$

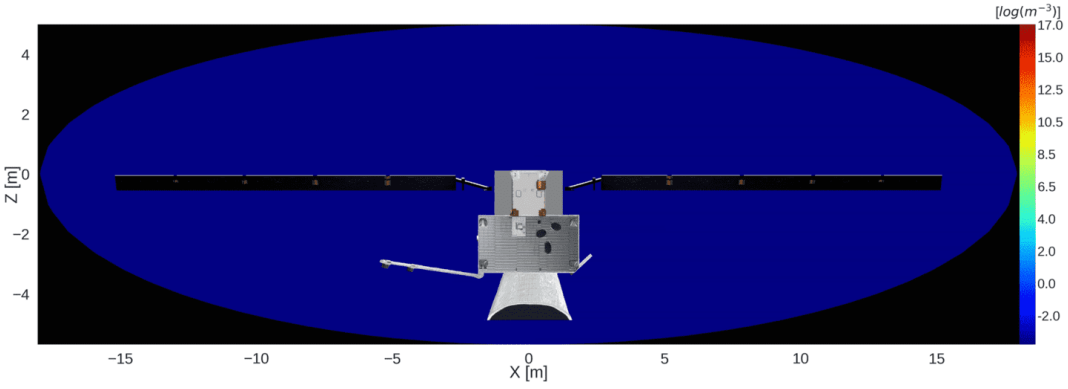


- Drives the S/C charging
- Erosion of thruster components
- Can cause sputtering on S/C
- Can limit thruster lifetime

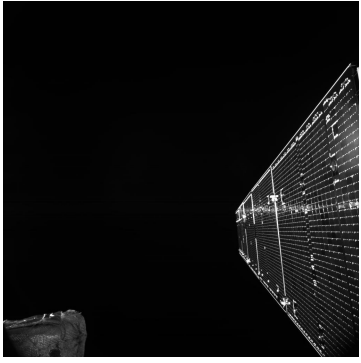


CEX lobes on BepiColombo

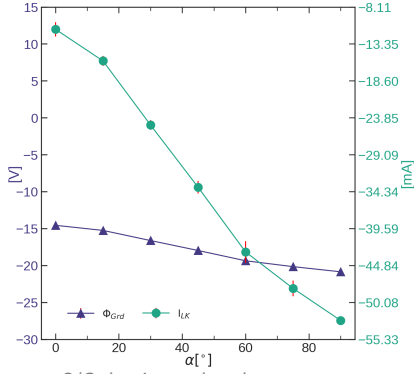
BepiColombo SEPS PLume Dynamics



Numerical Simulations and Flight Telemetry Comparison



BepiColombo SA rotation, credit: ESA



S/C charging as the solar arrays rotate

Telemetry pipeline with ESA-ESOC ⇒ S/C charging model improvements and basic plasma physics

Thank you !

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