EcAMSat: Small Satellite to Examine E. coli's Response in Microgravity to the Antibiotic Gentamicin

National Aeronautics and Space Administration

Matthew Lera
ASGSR
November 3, 2018

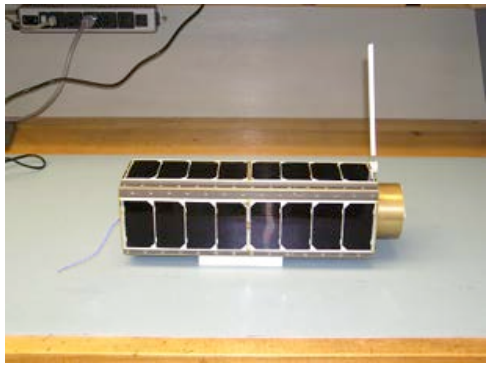
Michael R. Padgen, Matthew P. Lera, Macarena P. Parra, Antonio J. Ricco, Matthew Chin, Tori N. Chinn, Aaron Cohen, Charlie R. Friedericks, Michael B. Henschke, Timothy V. Snyder, Stevan M. Spremo, AC Matin

For Astronaut Health During Long Term Spaceflight, Many Questions Remain

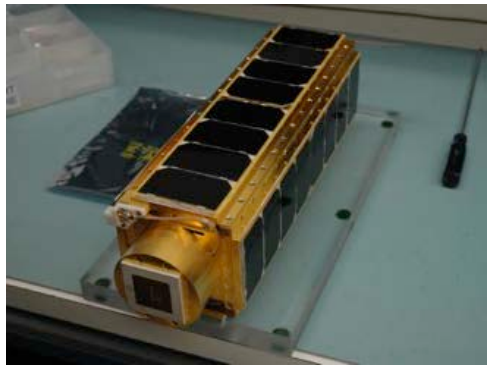
- **Immediate need to understand antibiotic resistance in microgravity**
  - Evidence that bacteria become more virulent and resistant than in normal gravity
  - Astronaut's immune system is compromised in microgravity

- **Model Organism: uropathogenic *Escherichia coli* (UPEC)**
  - Urinary tract infections have been reported in astronauts
  - WT and ΔrpoS mutant strains
  - Gentamicin has been used to treat UTI

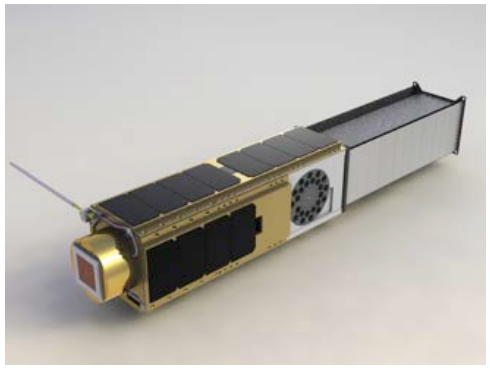
A History of Successful Bio NanoSats at Ames



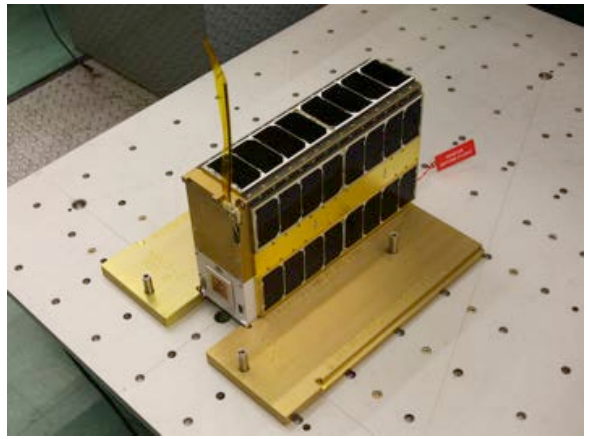
GeneSat-1 - 2006



PharmaSat- 2009



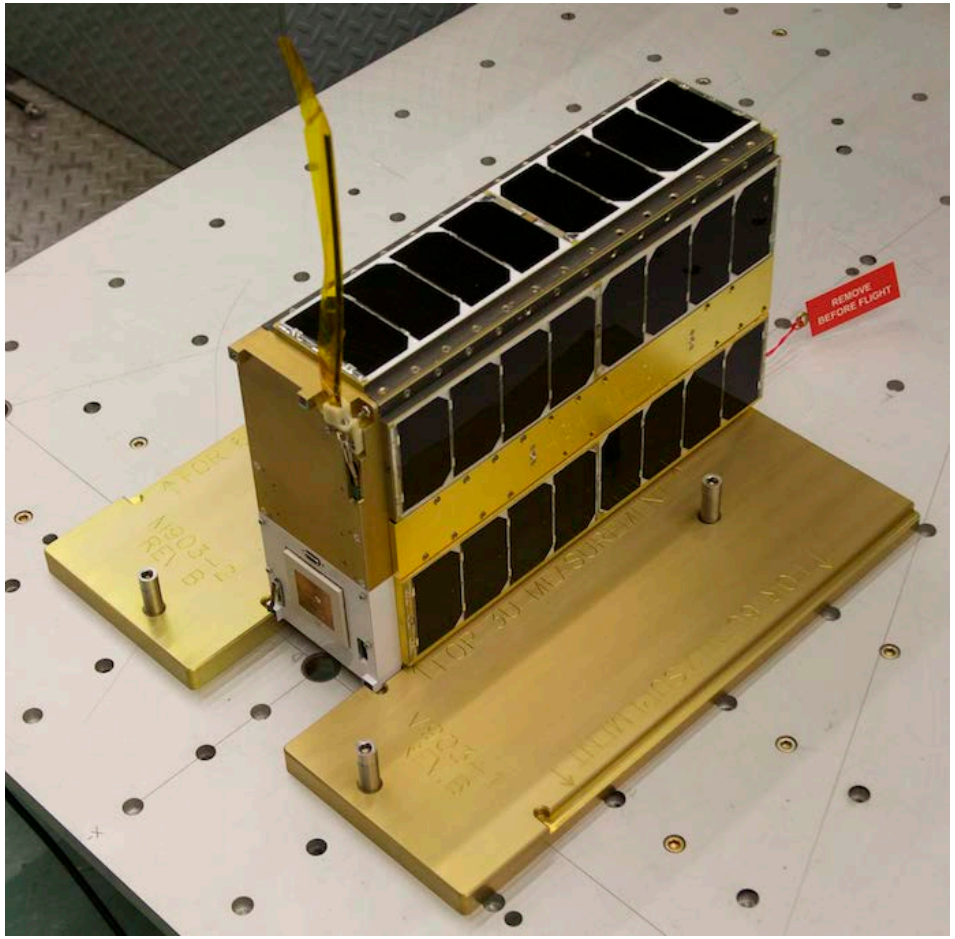
O/OREOS - 2010



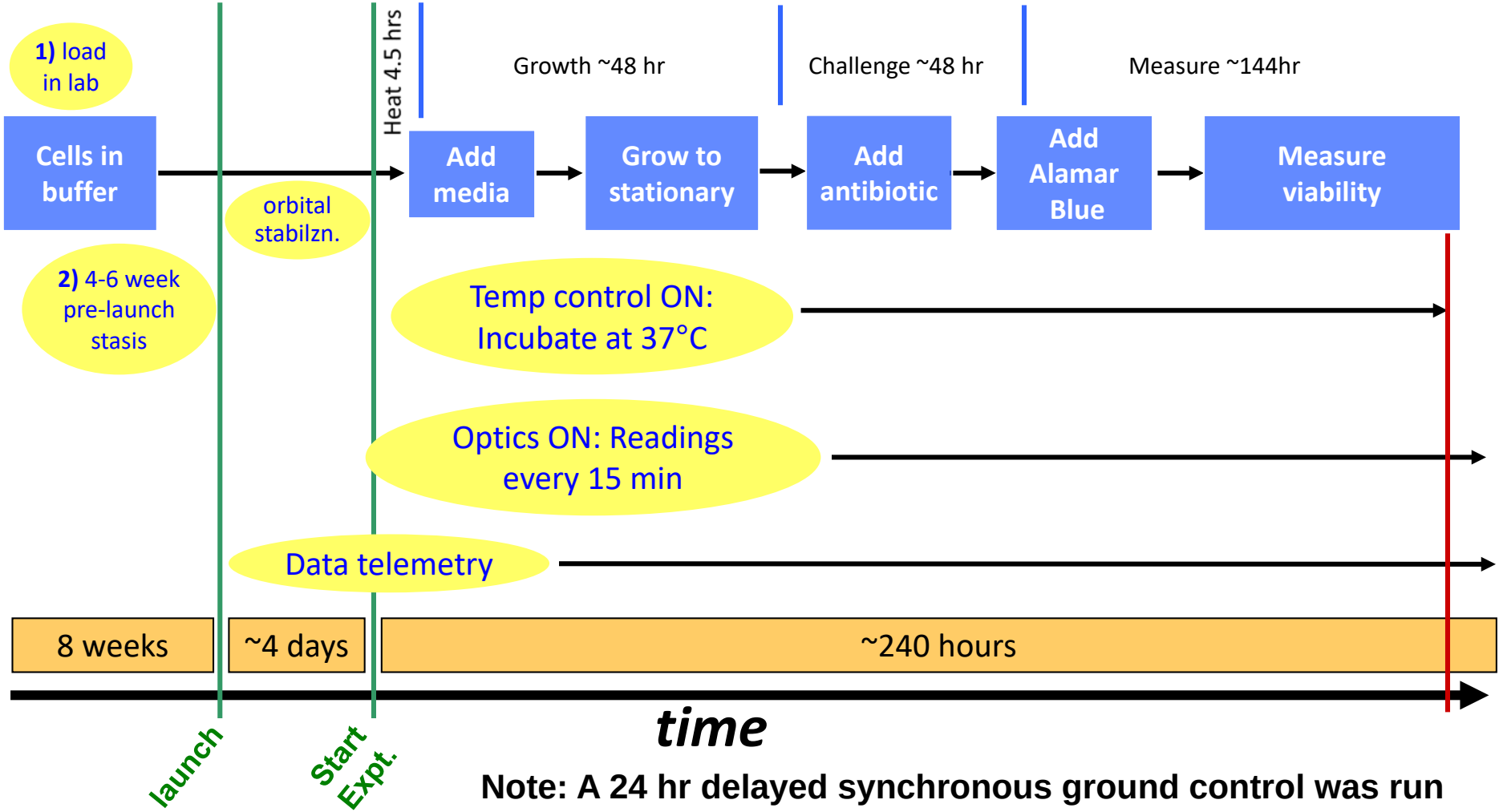
EcAMSat – 2017

EcAMSat is First NASA 6U Mission

- Passive magnetic orientation
- UHF Beacon and S-band radio
- Extensive thermal power management testing and modeling
- Mission Ops run by Santa Clara University

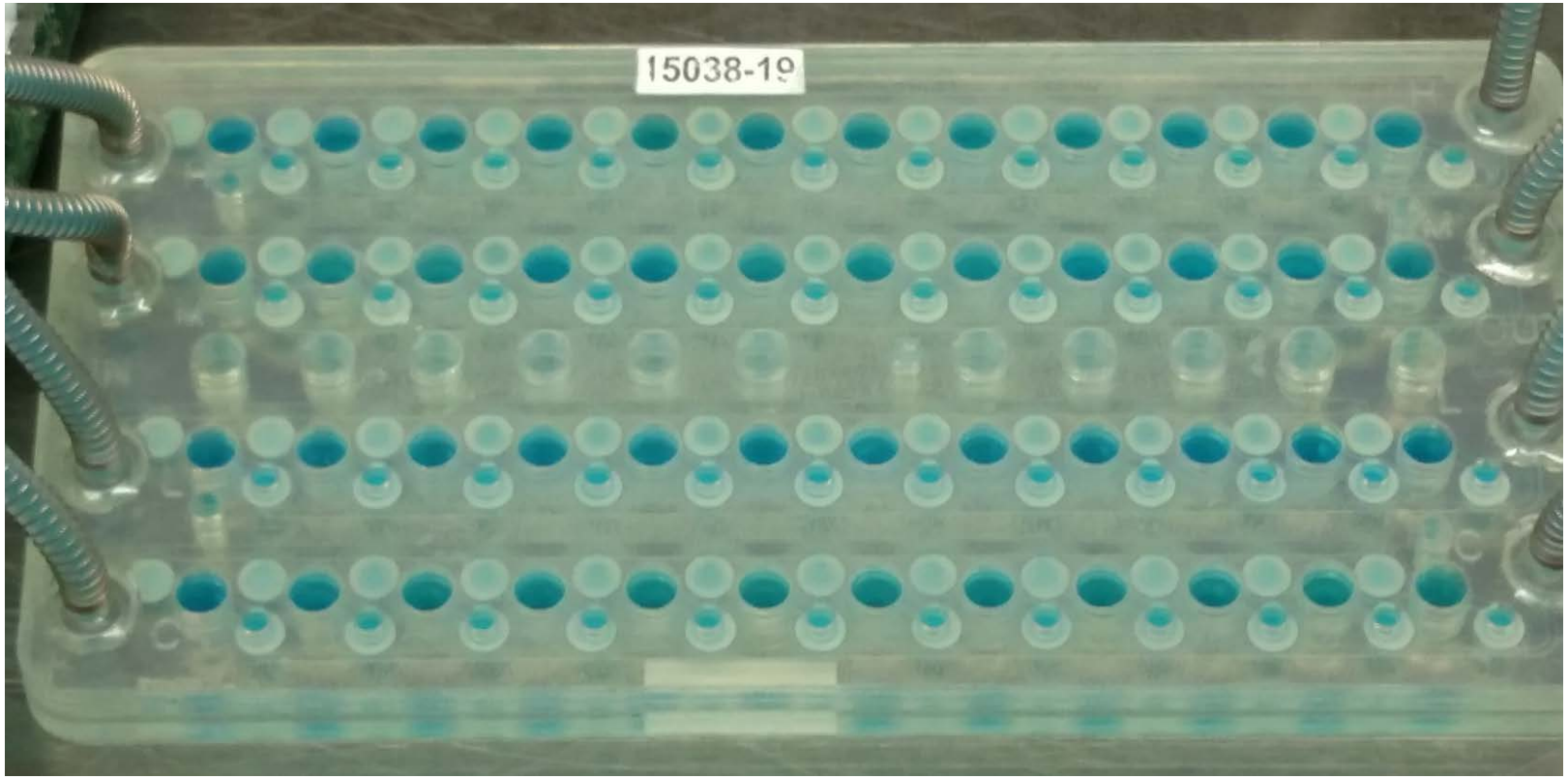


Experiment Design



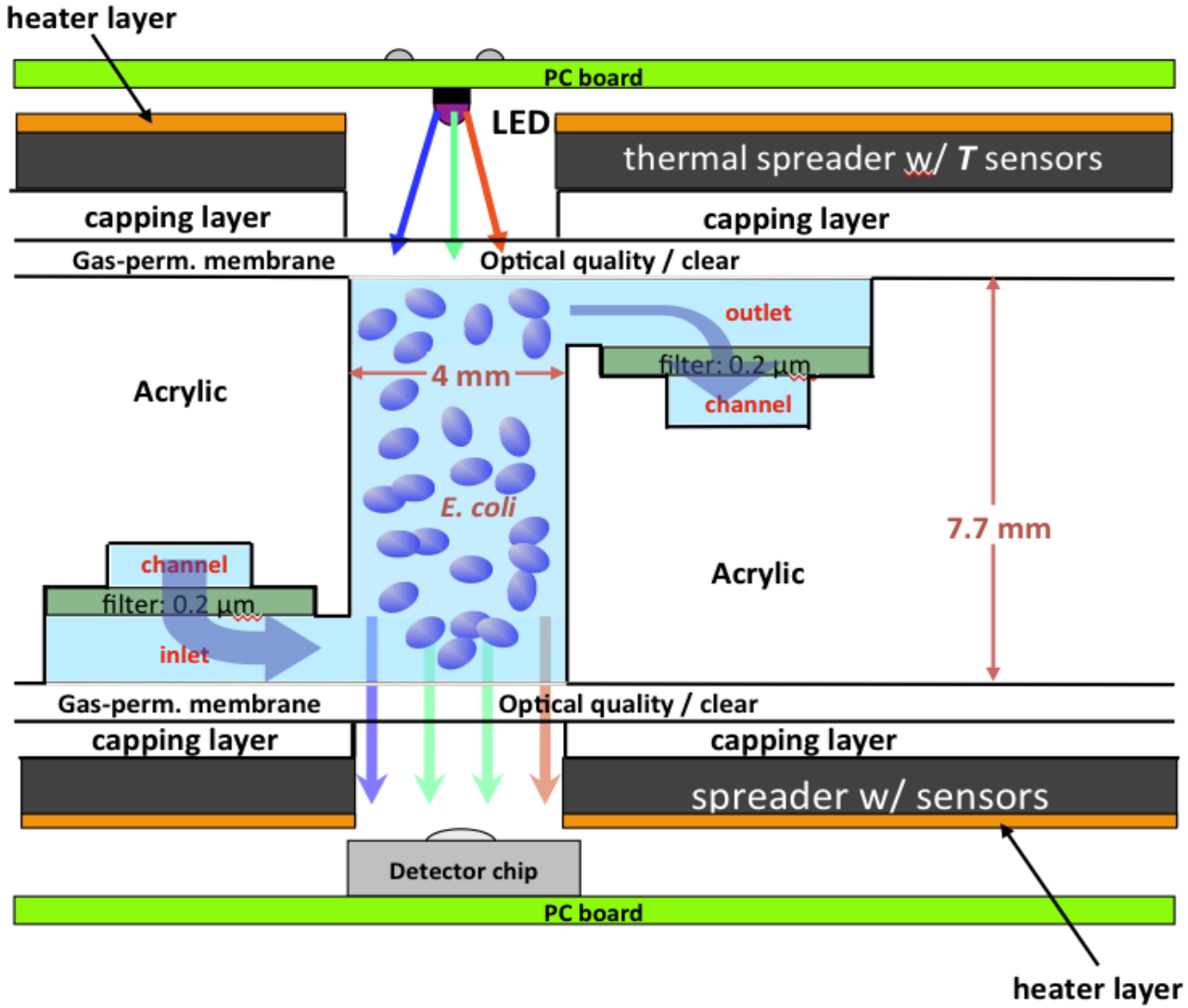
Note: A 24 hr delayed synchronous ground control was run

48 Well Fluidic Card

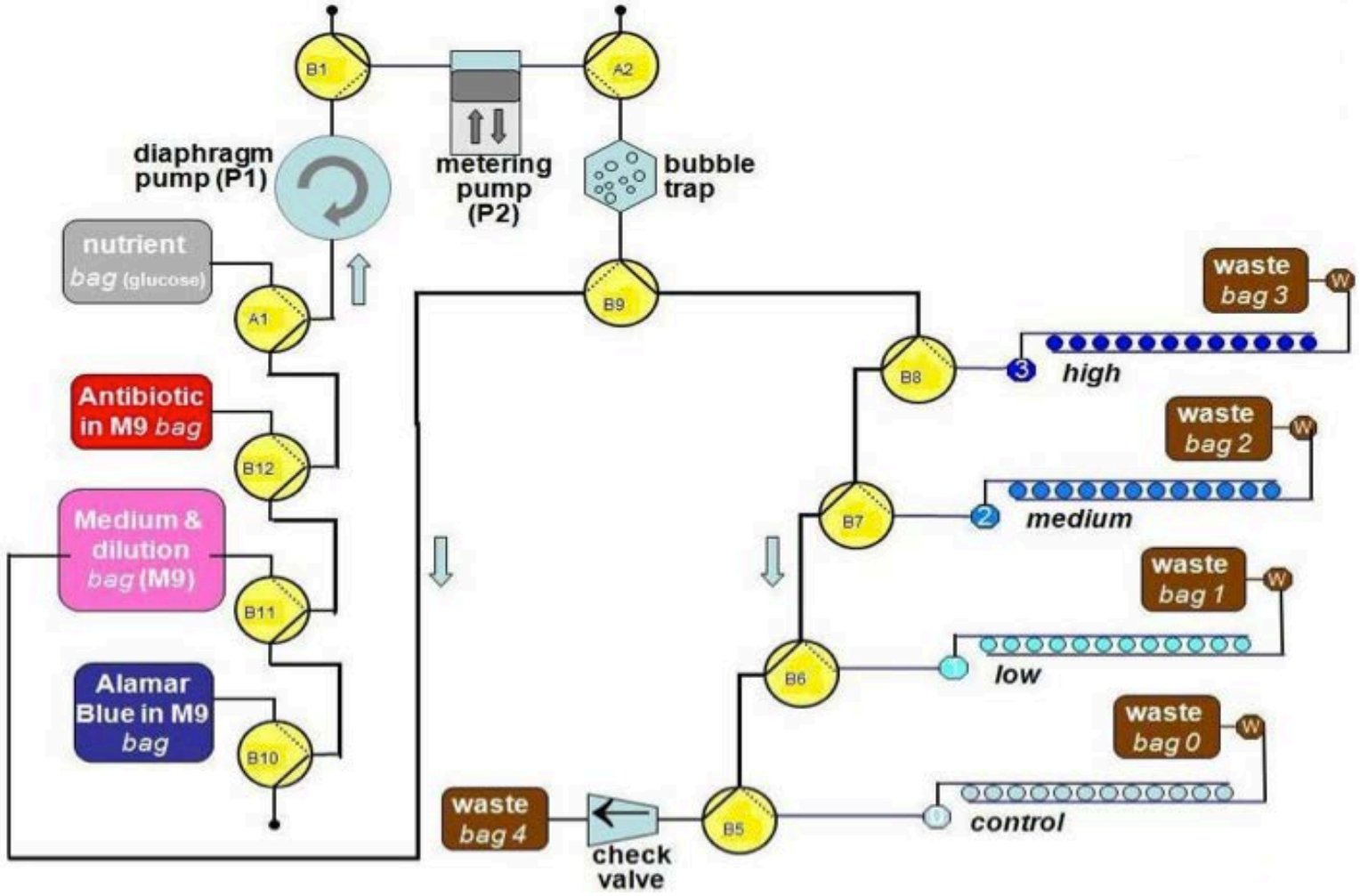


- **Alternating wells loaded with WT and mutant strains**
- **Each bank receives different antibiotic dose**

Optical System Tracks Growth & Metabolic Activity



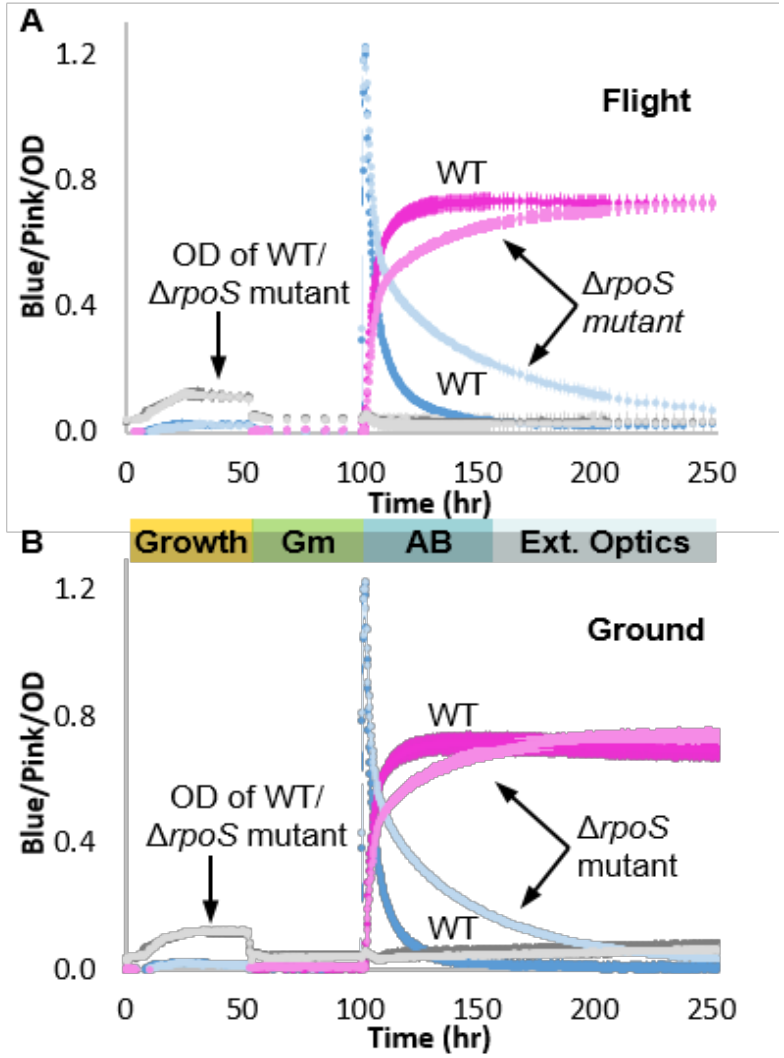
Fluidic System Schematic



EcAMSat Launch and Deployment

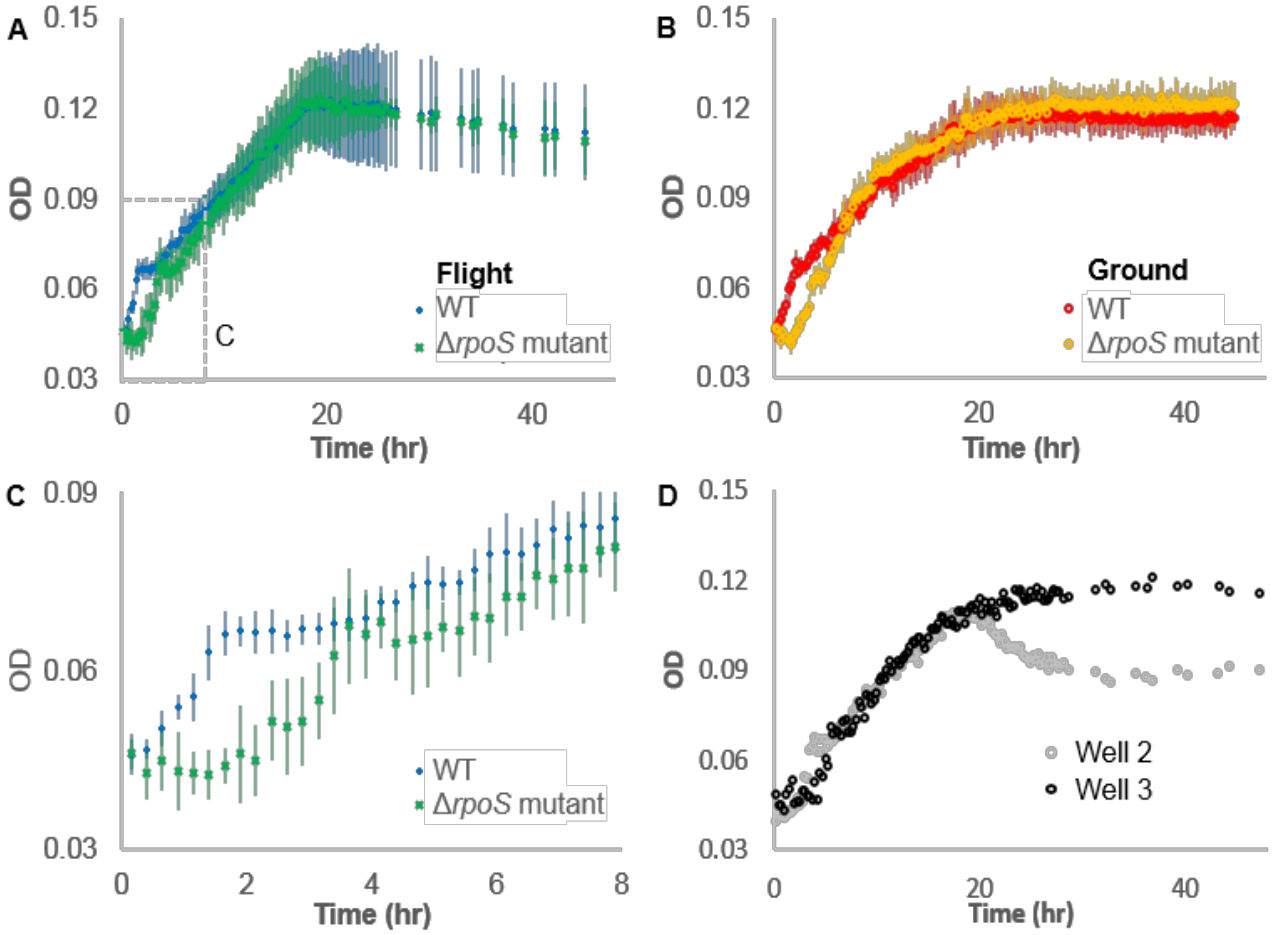
- **Launched on OA-8 mission – November 12, 2017**
- **Deployed from ISS on NanoRacks deployer – November 20, 2017**
- **Mission Ops conducted from Santa Clara University**

Flight and Ground Experiment Optics Results



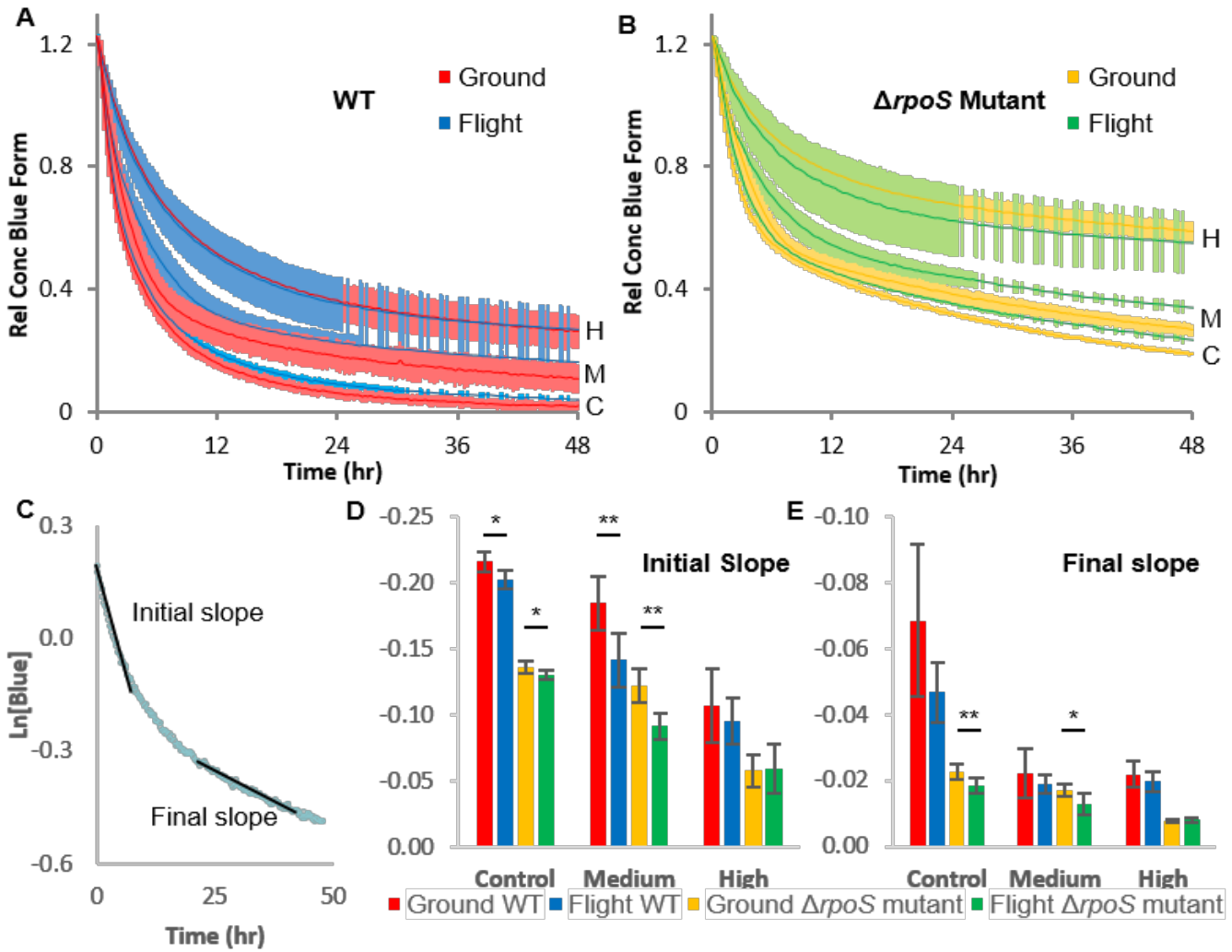
- **The relative concentrations of the oxidized (Blue) and reduced (Pink) forms of AlamarBlue® are shown for Flight (top) and Ground (bottom).**
- **The cell OD throughout the experiment is also shown (gray)**
- **Control bank shown suggests no large differences in timing between flight and ground and no difference in baseline stress between card load and experiment initiation**

OD during growth phase



- Growth of single wells of WT and mutant in flight and ground
- Some wells in flight experienced a dip in OD while approaching stationary phase. Such wells were random and did not correlate to differences in AlamarBlue® reduction later in the experiment.

AlamarBlue® reduction after exposure to varied Gm concentrations



- AlamarBlue® reduction shown for wildtype and mutant strains at no, medium, and high concentrations of gentamicin in flight and ground
- Averages of all banks showed a combined effect of microgravity and gentimicin on reducing AlamarBlue® reduction in the medium dose exposure
- No significant difference seen in high dose banks

Conclusions

- **EcAMSat mission achieved full success, completing all required objectives.**
- **While the various stresses imposed on the cells by the payload hardware, by the antibiotic, and due to microgravity could not be completely separated, it appeared that the effect of microgravity was greatest for both strains in the medium Gm dose case.**
- **The largest difference between the two strains was at the high dose.**
- **The results demonstrate that the *rpoS* gene and its downstream products are important therapeutic targets for treating bacterial infections on Earth and in space.**

Acknowledgements

- **Support from Space Life and Physical Sciences Research and Applications in NASA's Human Exploration and Operations Mission Directorate (HEOMD) as a Small Complete Mission of Opportunity in Fundamental Space Biology.**

Special thanks:

- **Professor Christopher Kitts, Mike Rasay, and the Santa Clara University Robotics Systems Lab for performing mission operations.**
- **Shannon Ross, Christina Mayberry, Sungshin Choi, Diana Wu, Ming Tan, Travis Boone, Christopher Beasley and Matthew Piccini for their contributions to the development of the technology and success of the mission.**
- **Ms. Mahmonir Keyhan and Dr. Zeeshan Fazal at Stanford University.**