Extending the Promise: A decade for science and exploration on the International Space Station

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APPEL Masters Forum

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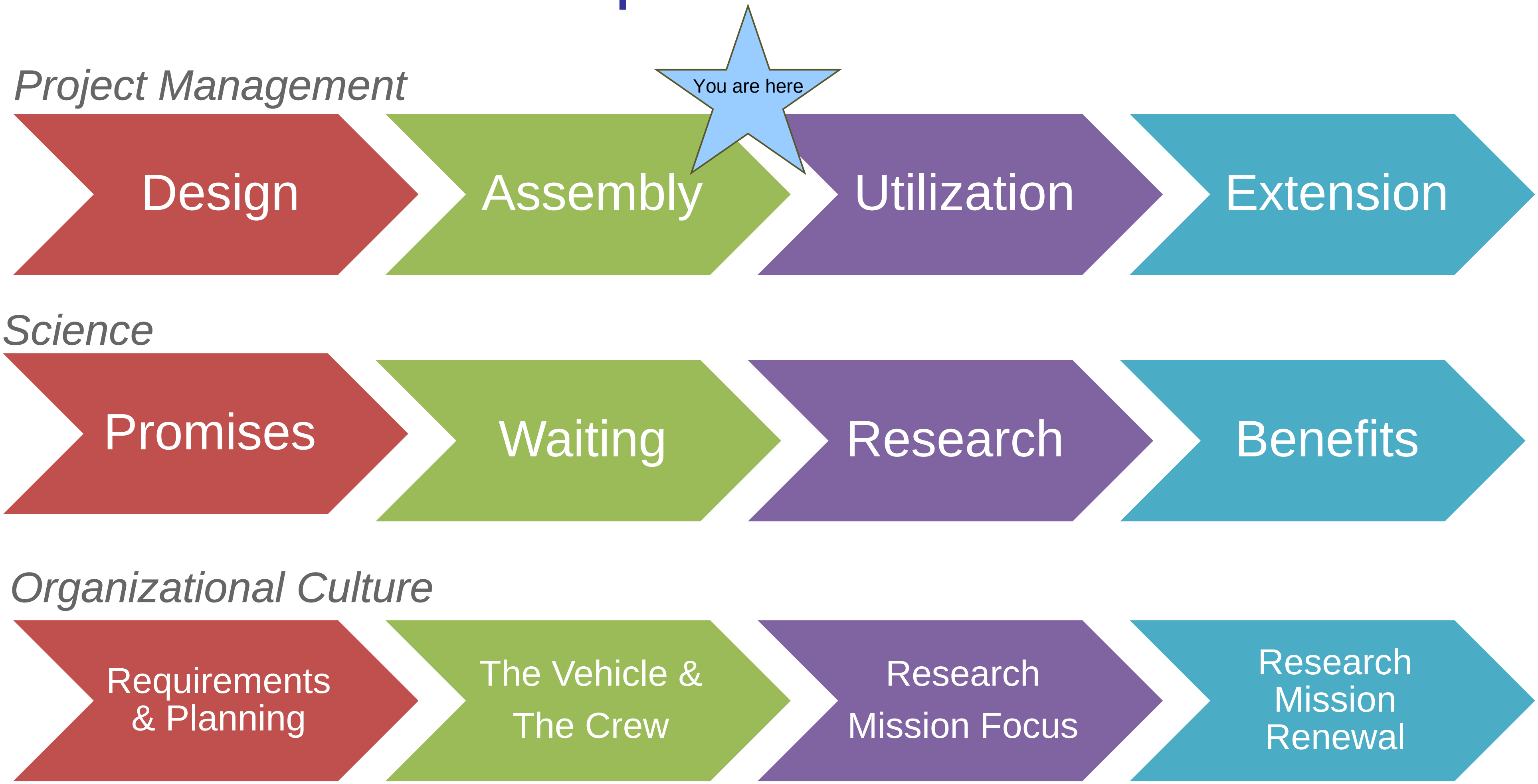
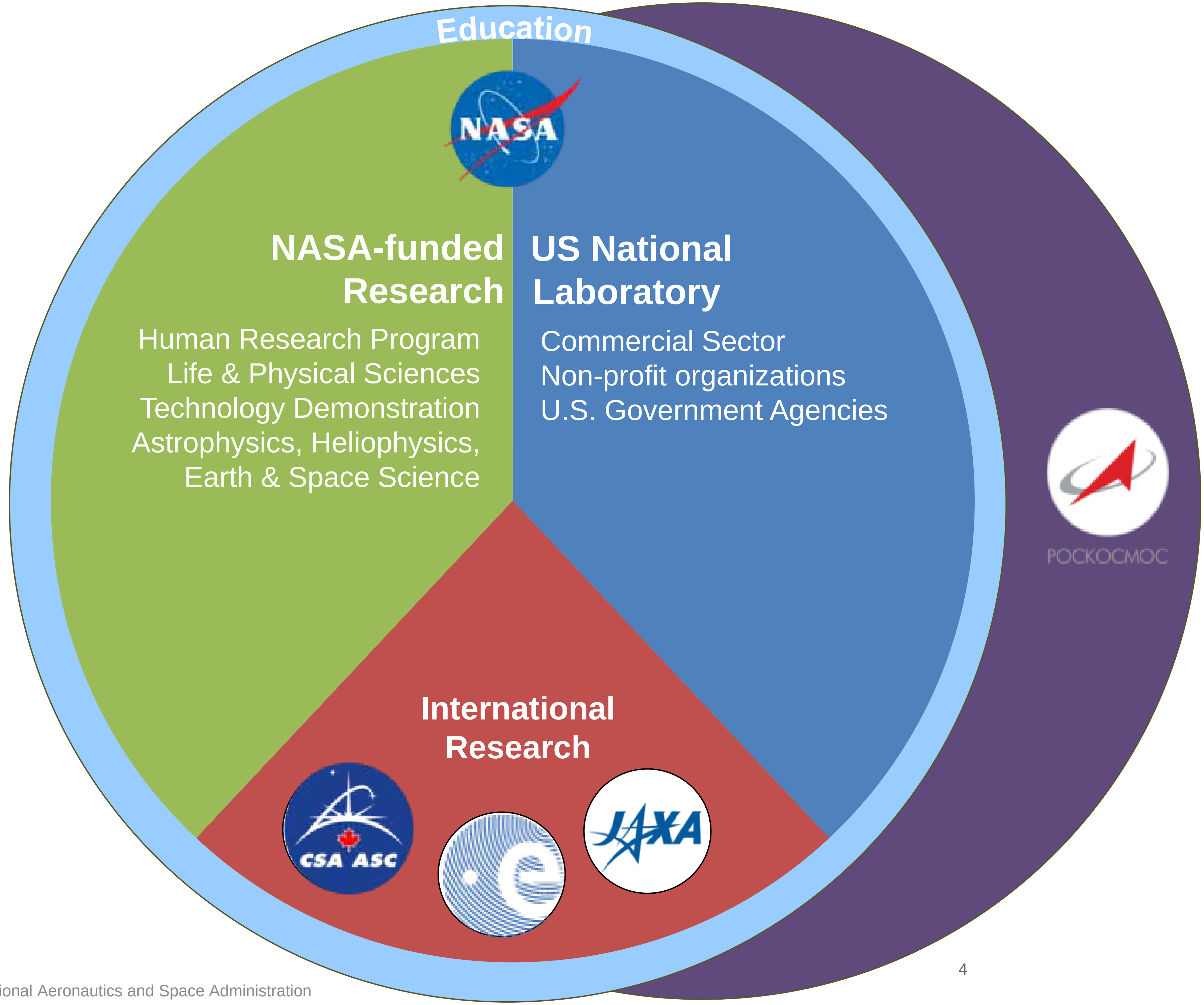
ISS Laboratory 101

Stages of the International Space Station from a scientist's point of view



Paradigm Shifts
-Operating safely is not enough
-Experienced system managers and operations teams judge researchers
-ISS is a real laboratory—it's OK if things don't work the first time!

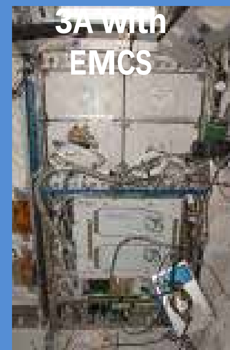
Objectives for Research on ISS

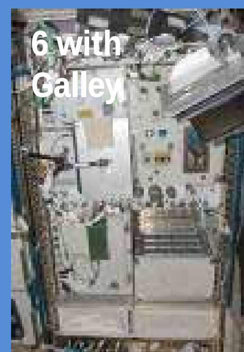


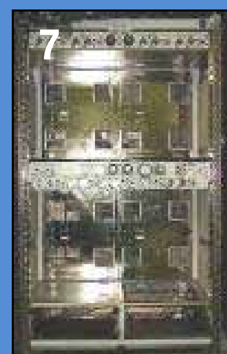
NASA Research Infrastructure

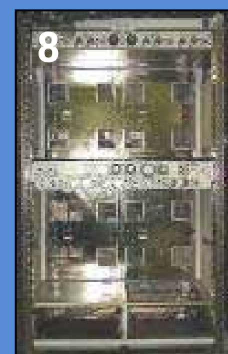
2 Human Research Facility Racks

8 ExPRESS Racks

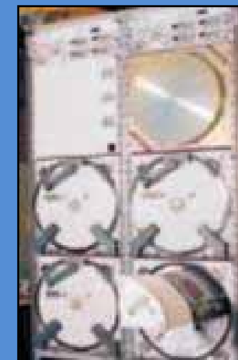


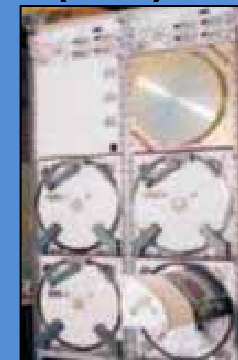






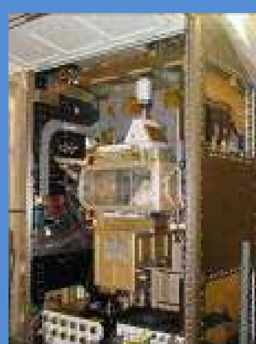
3 Minus Eighty-Degree Laboratory Freezers for ISS (MELFI)





Microgravity Science Glovebox (MSG)

Fluids Integrated Rack (FIR)



Combustion Integrated Rack (CIR)

Materials Science Research Rack

Window Observational Research Facility (WORF)

Source: ISS Program Scientist

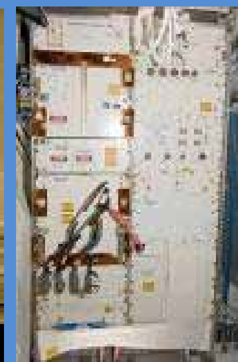
ESA and JAXA Research Infrastructure


Biolab


European Drawer Rack (EDR)


European Physiology Module (EPM)


European Transport Carrier (ETC)


Fluid Science Lab (FSL)


Solar


Muscle Atrophy Research Exercise System (MARES)


Ryutai (Fluids)

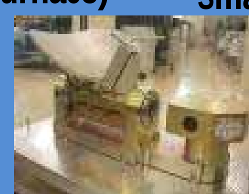

Saibo (Cell Biology)


Kobairo (Gradient Heating Furnace)


Multi-Purpose Small Payload Rack (MSPR)

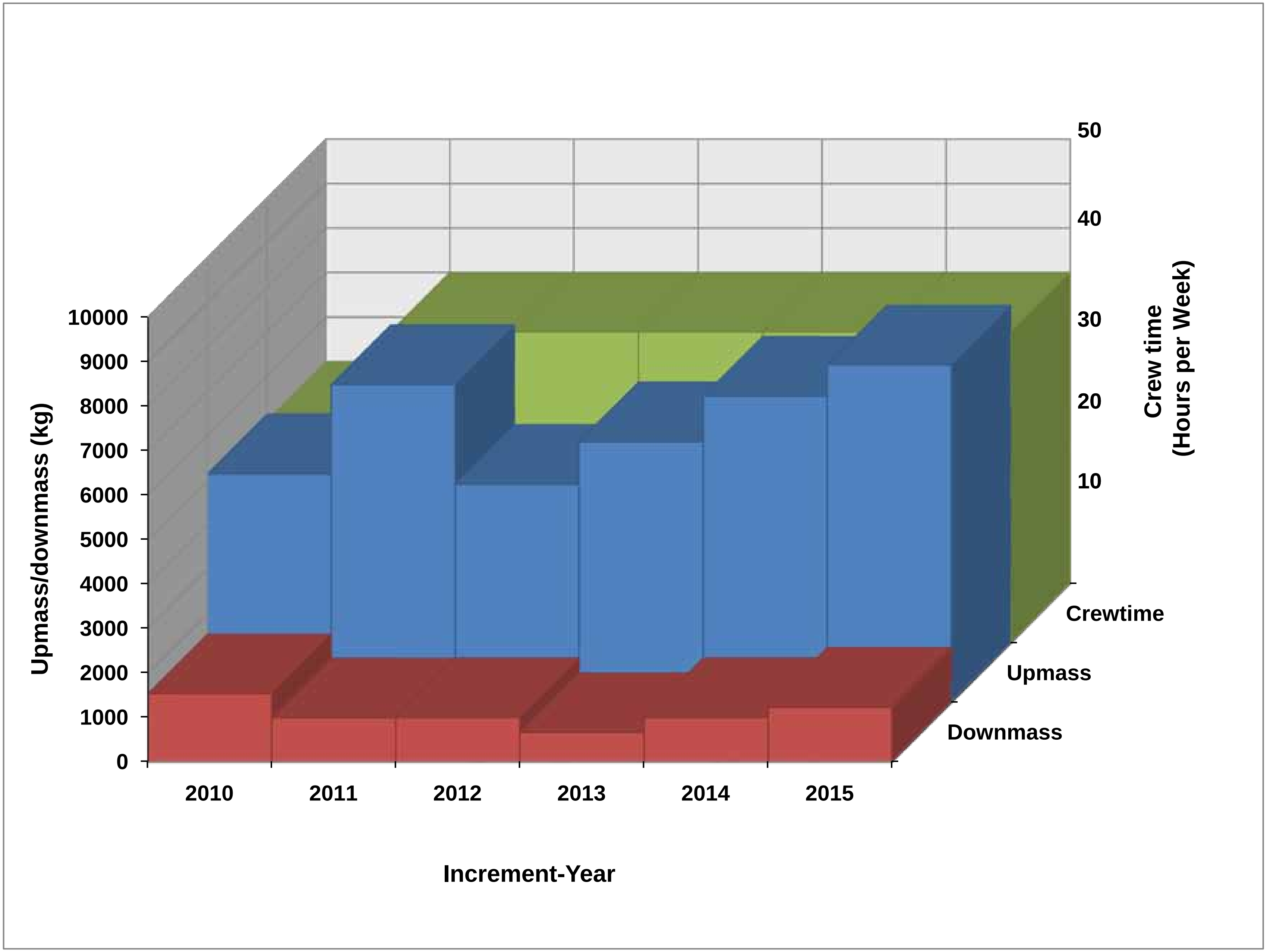

Monitor All-sky X-ray Image **(MAXI)**


Space Environment Data Acquisition **(SEDA)**


Superconducting Sub millimeter-wave Limb-Emission Sounder **(SMILES)**

Source: ISS Program Scientist

3 Primary Resource Dimensions
each affect the capacity for the other



Major factors influencing research use of ISS

Resource limitations (e.g., upmass, downmass, crewtime)

- Flight delays to resupply and return plan
- Operations scenarios that reduce crew time for research

Cost to use the platform

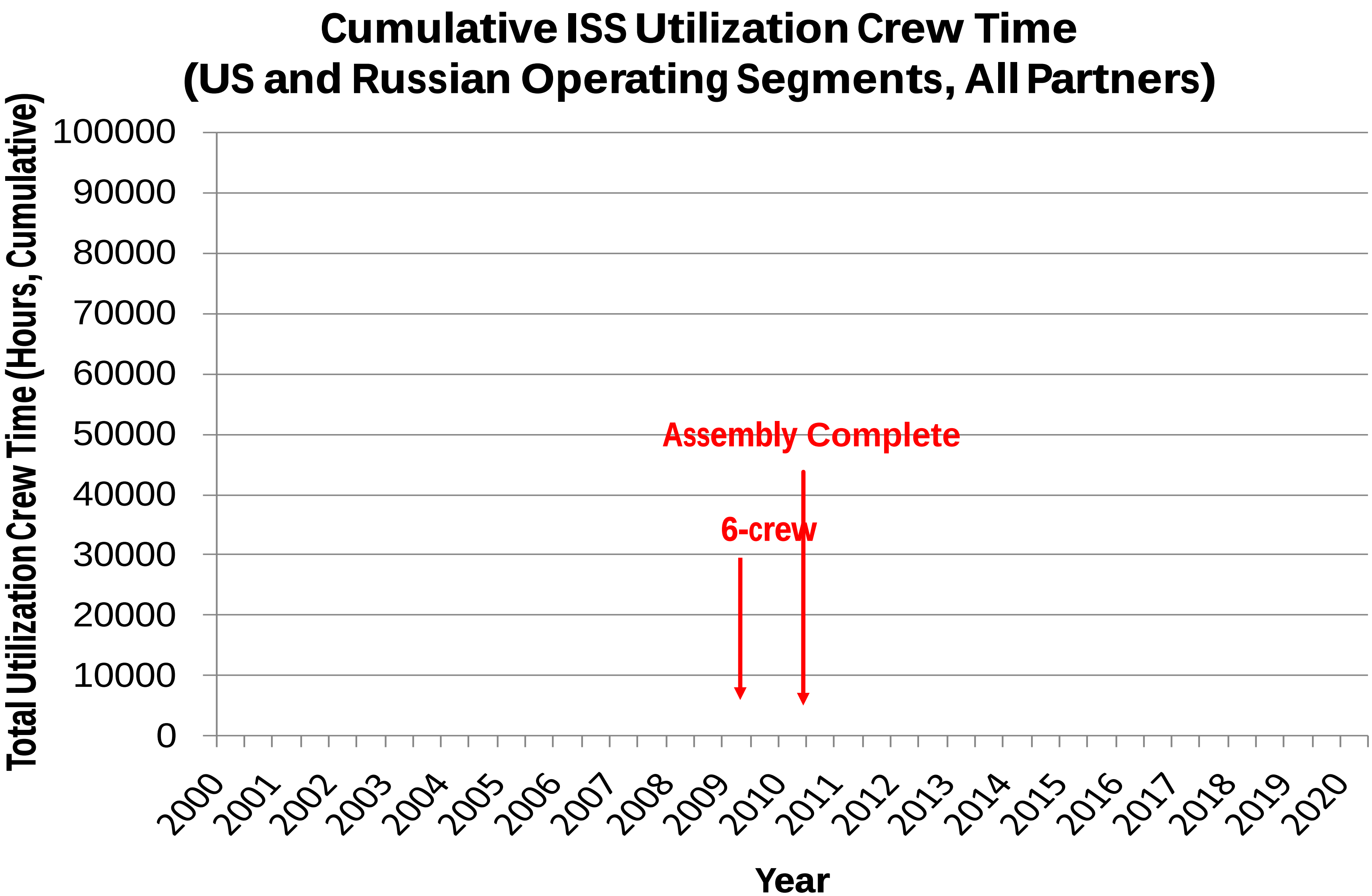
- Transportation costs
- Costs of payload development

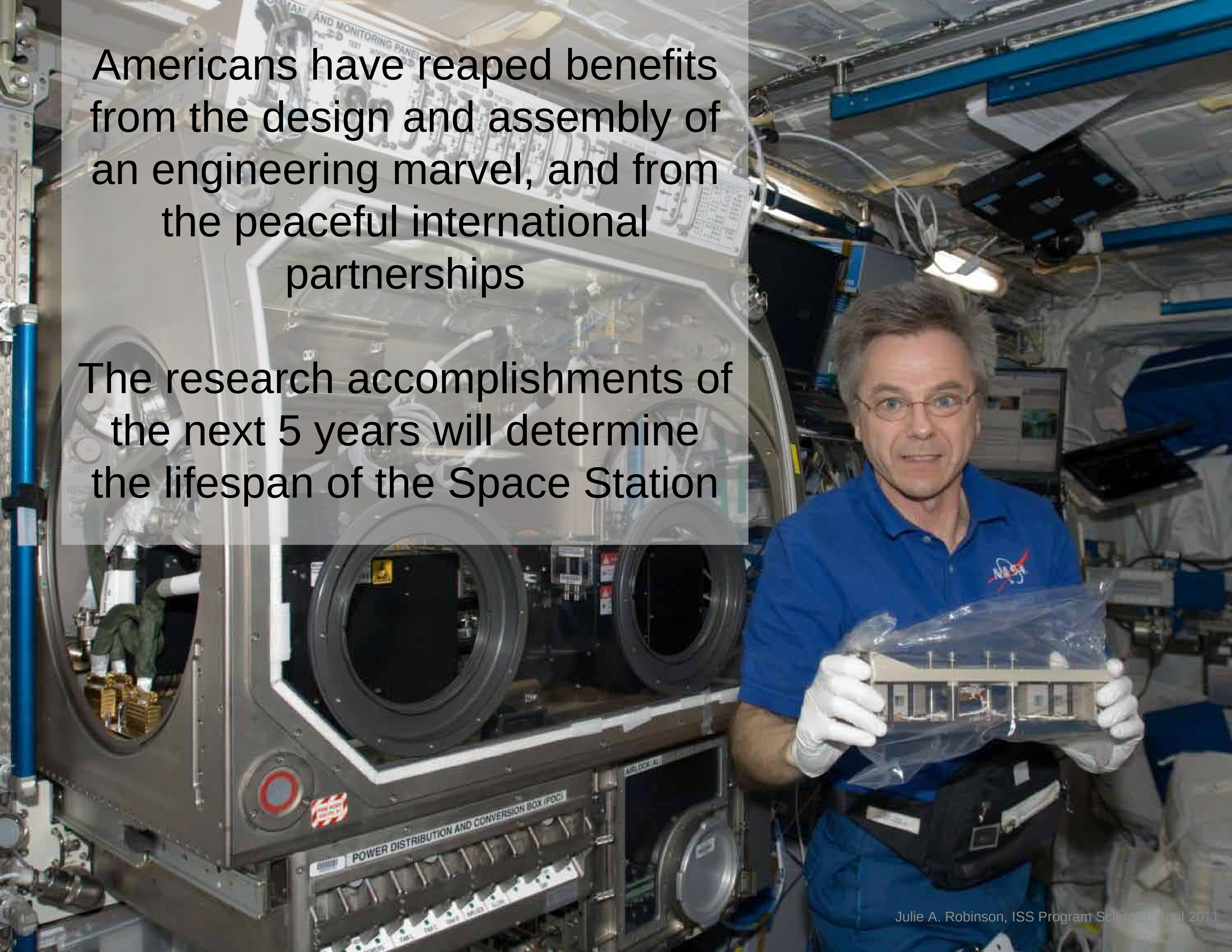
Strategies to tip the balance: diverse transportation providers, procure upmass for more users, simplify integration, communicate successes

Research Demand

- NASA Funding
- Non-NASA Funding
- Research breakthroughs that drive funding (Earth benefits & applications)

The Beginning of the “Era of ISS Utilziation”

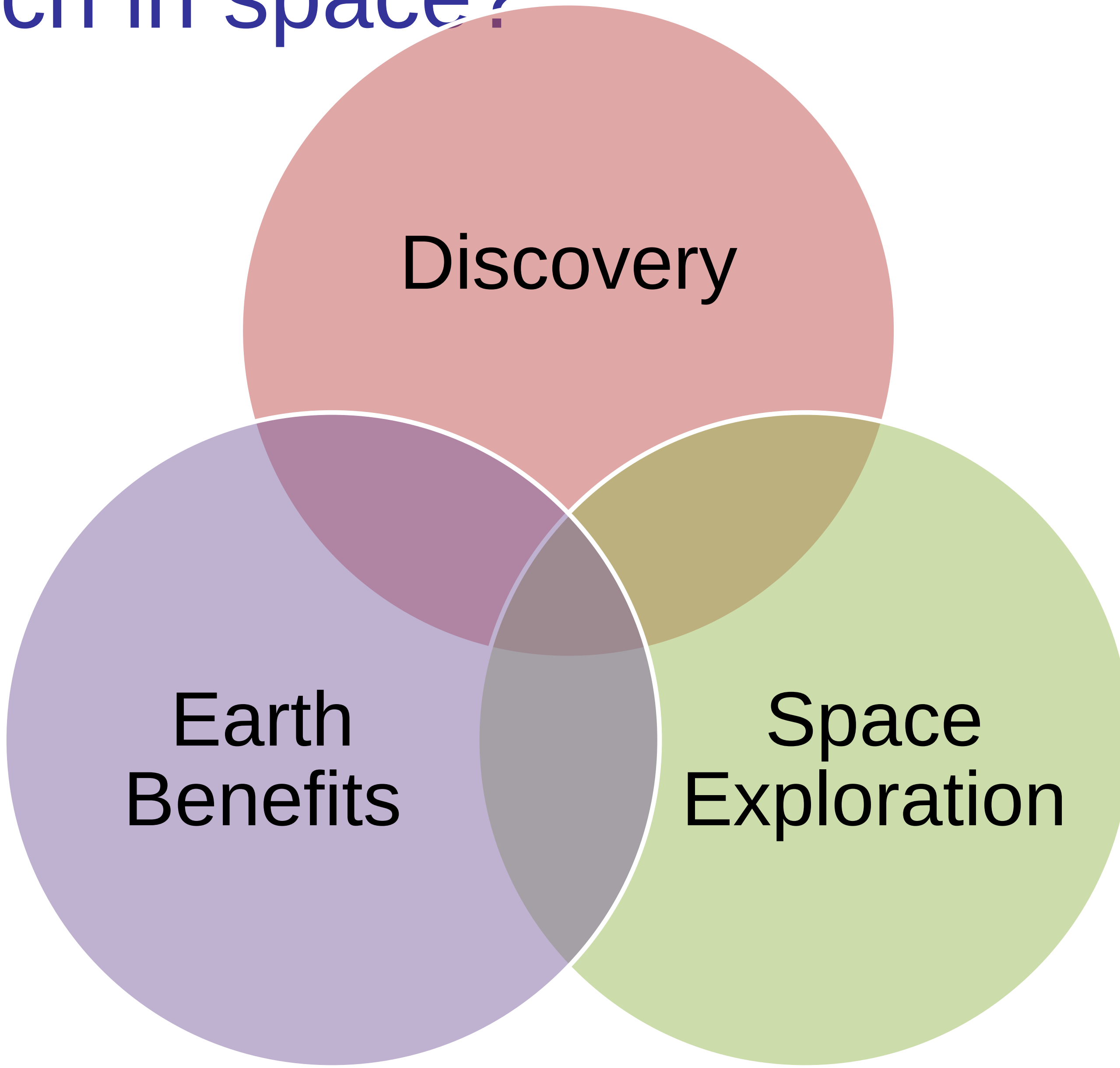


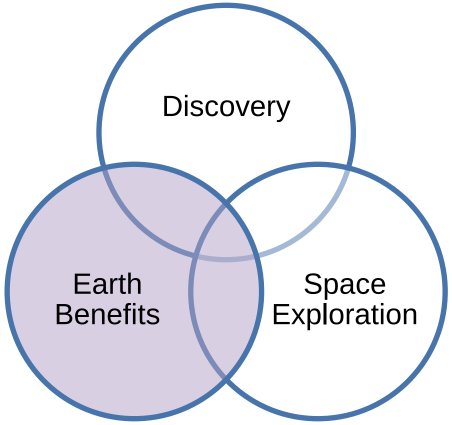


Americans have reaped benefits from the design and assembly of an engineering marvel, and from the peaceful international partnerships

The research accomplishments of the next 5 years will determine the lifespan of the Space Station

What kind of benefits come from research in space?

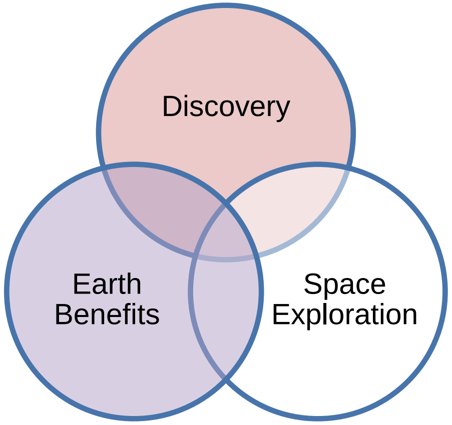




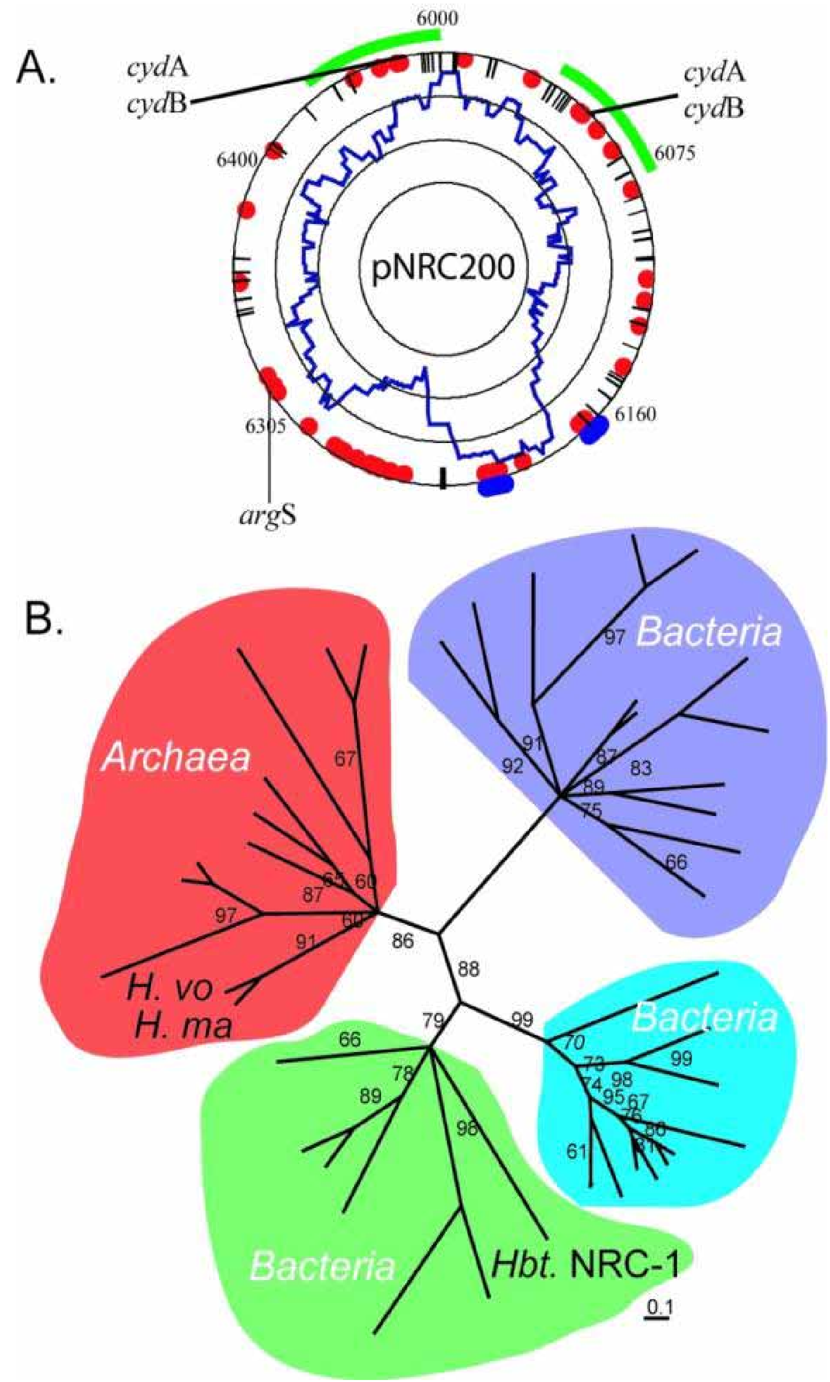
Top 5 results from “early” ISS research—primarily biotech and applied physics

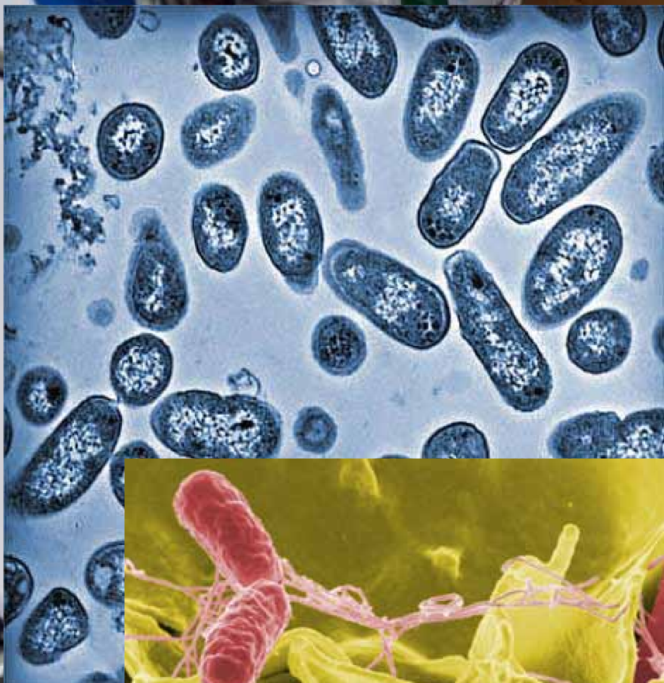
- Bacterial virulence and candidate vaccines
- Duschenne’s muscular dystrophy
- Compact gravity-feed water purification technology being used in disaster areas
- Patent for microencapsulating drug for treating testicular cancer.
- New fundamental equations for capillary flow

Biology: Microbes in Space



3 modes of response





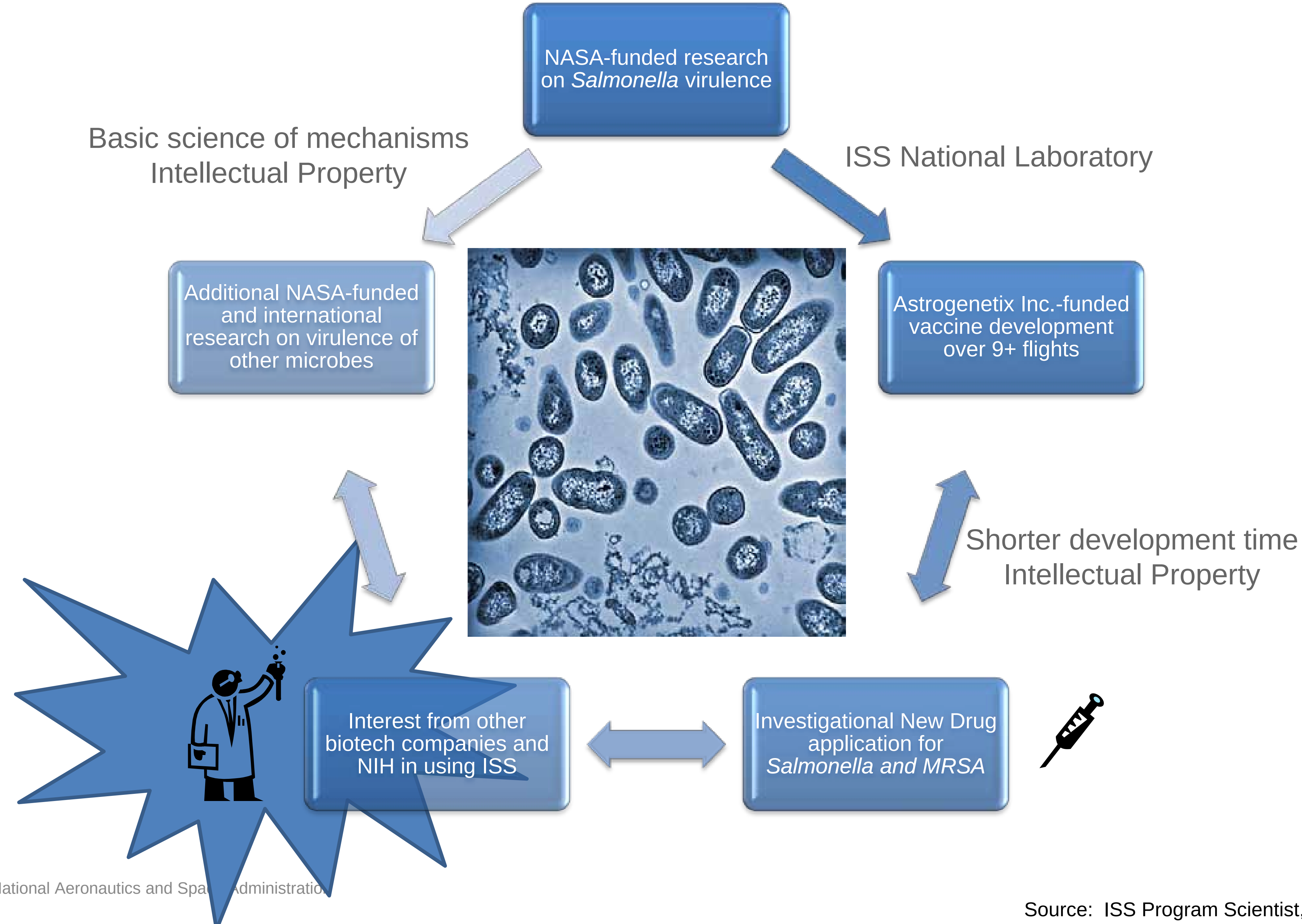
Microbial Vaccine Development – Scientific findings from ***International Space Station*** research have shown increased virulence in *Salmonella* bacteria flown in space, and identified the controlling gene responsible. AstroGenetix, Inc. has funded their own follow-on studies on ISS and are now pursuing approval of a vaccine as an Investigational New Drug (IND) with the FDA. They are now applying a similar development approach to methycillin-resistant *Staph aureus* (MRSA).

Top image credit: Pacific Northwest National Laboratory

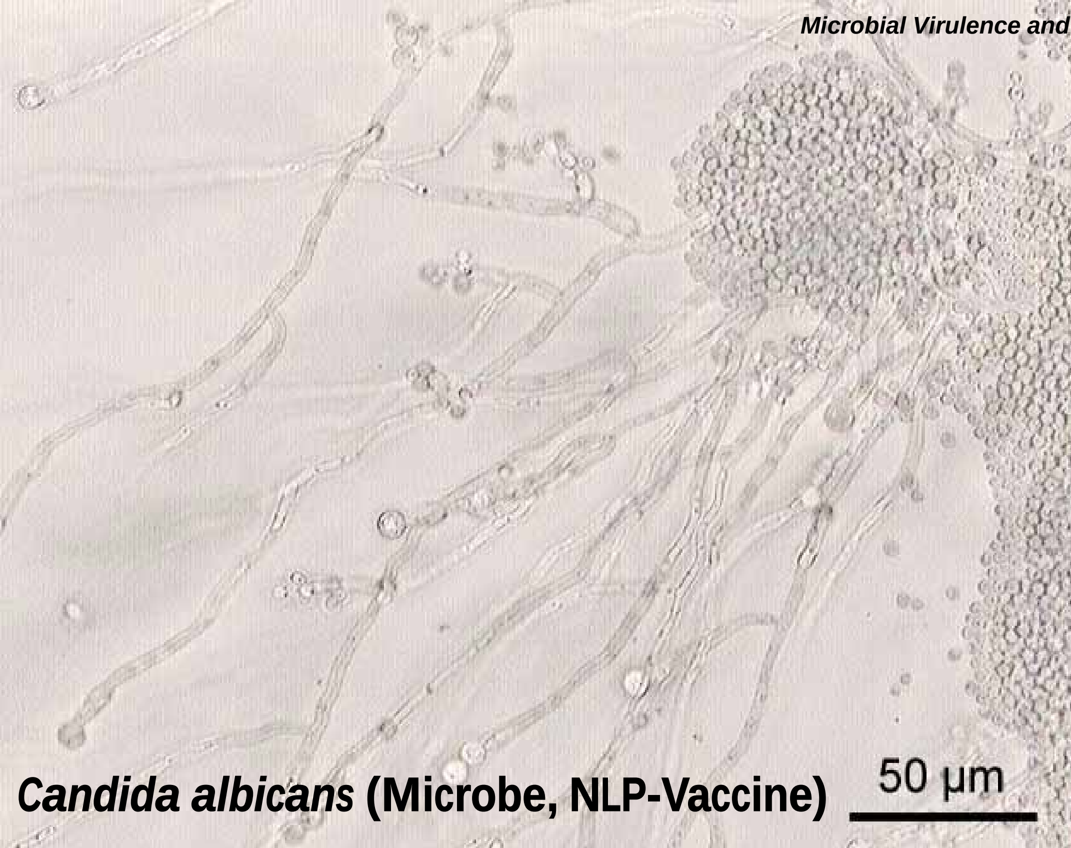
Bottom image credit: Rocky Mountain Laboratories

Source: ISS Program Scientist, NASA

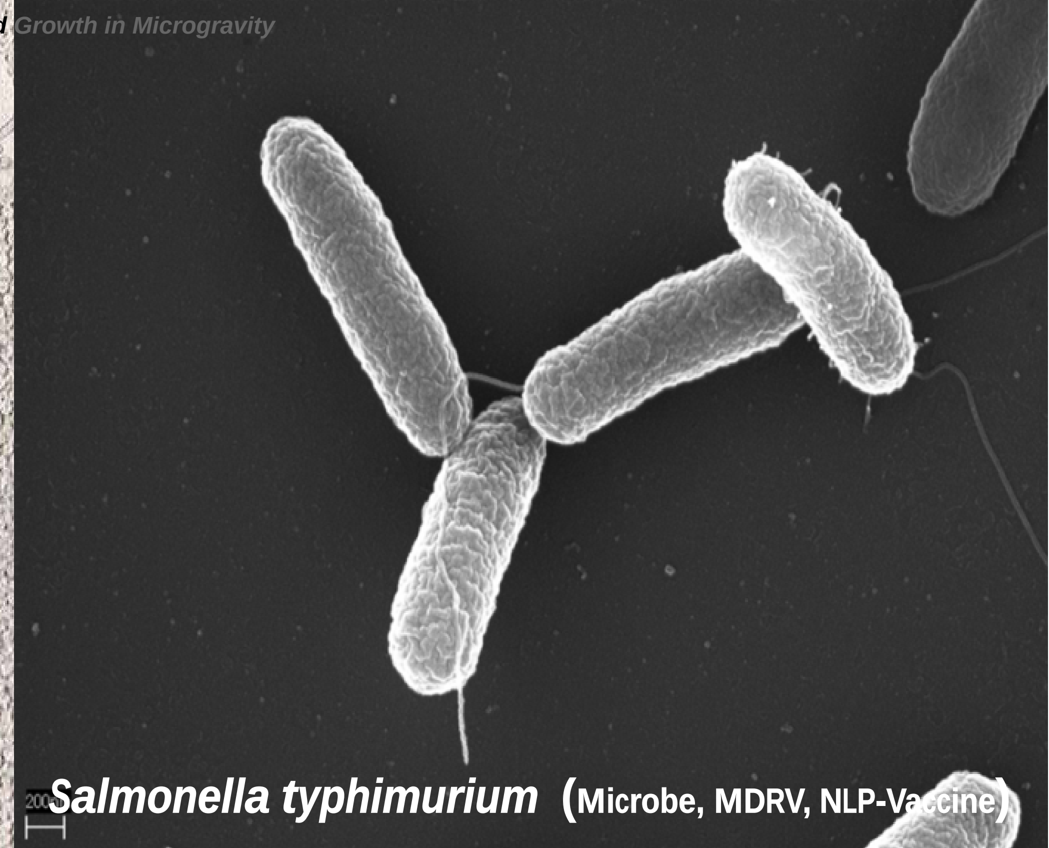
Example: Competing approaches to vaccine development



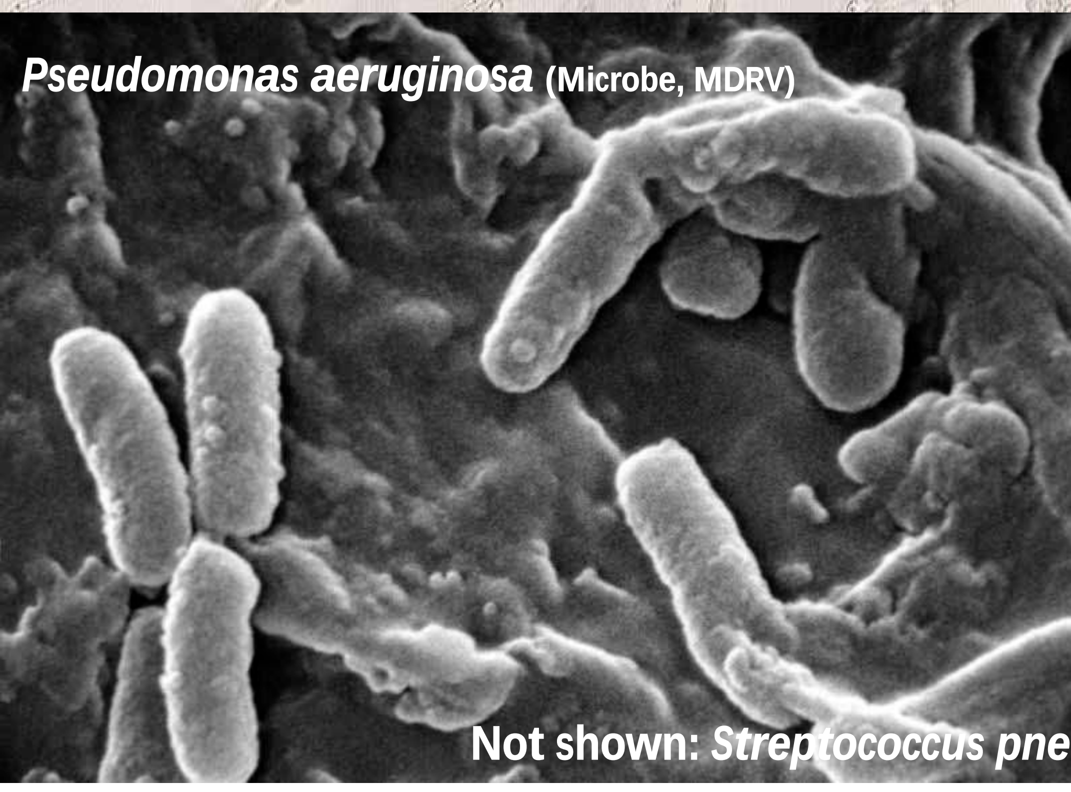
Source: ISS Program Scientist, NASA



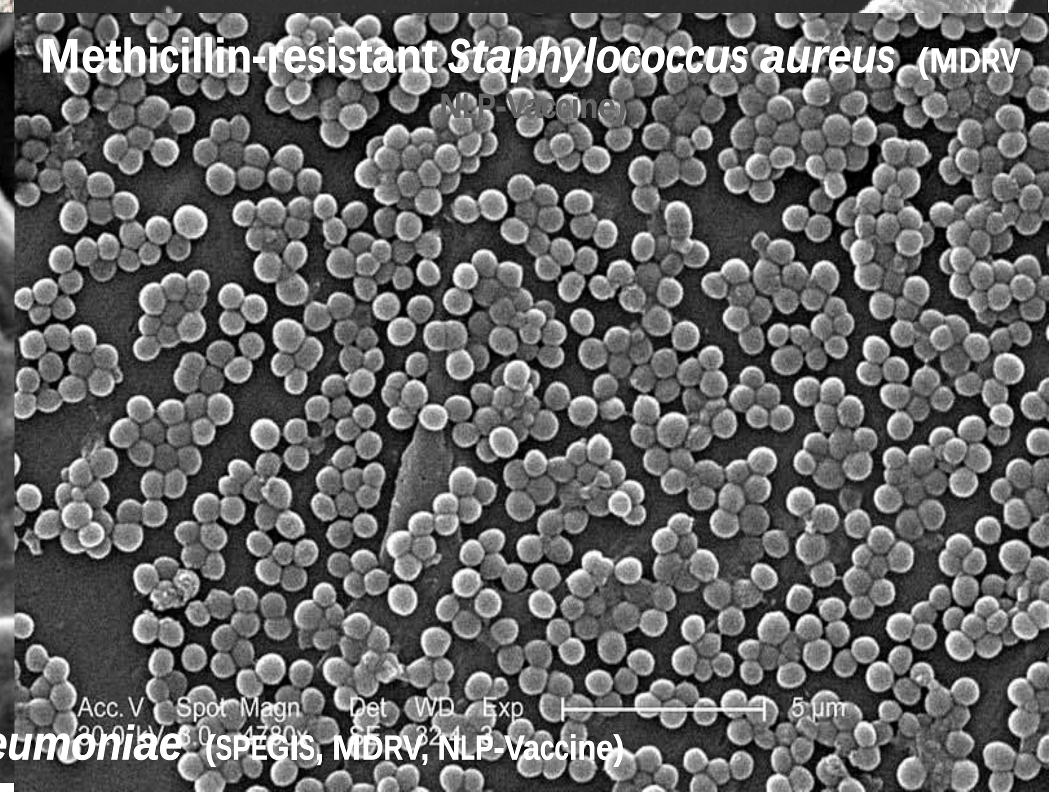
Candida albicans **(Microbe, NLP-Vaccine)**



Salmonella typhimurium **(Microbe, MDRV, NLP-Vaccine)**



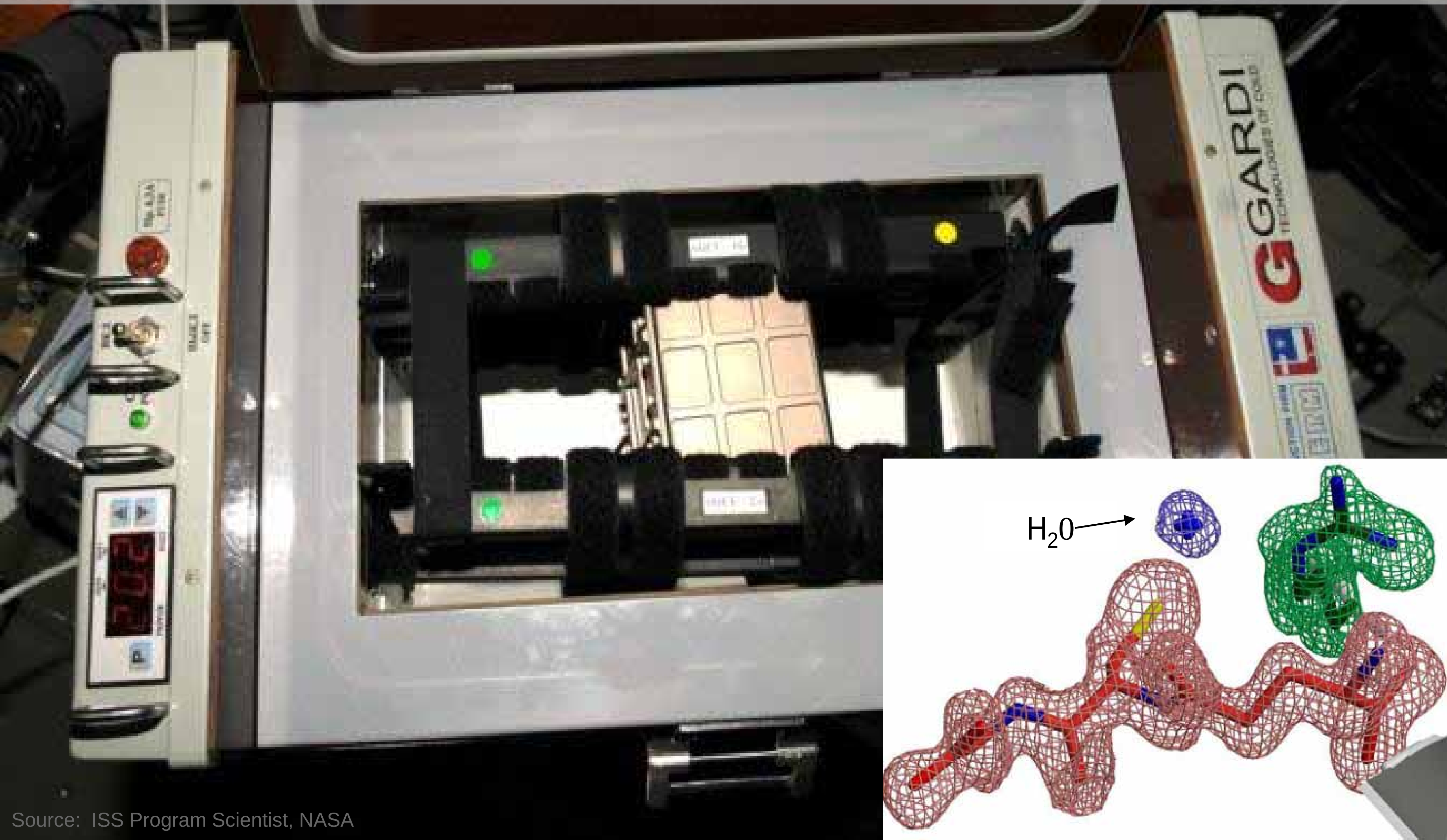
Pseudomonas aeruginosa **(Microbe, MDRV)**



Methicillin-resistant *Staphylococcus aureus* **(MDRV NLP-Vaccine)**

Not shown: *Streptococcus pneumoniae* **(SPEGIS, MDRV, NLP-Vaccine)**

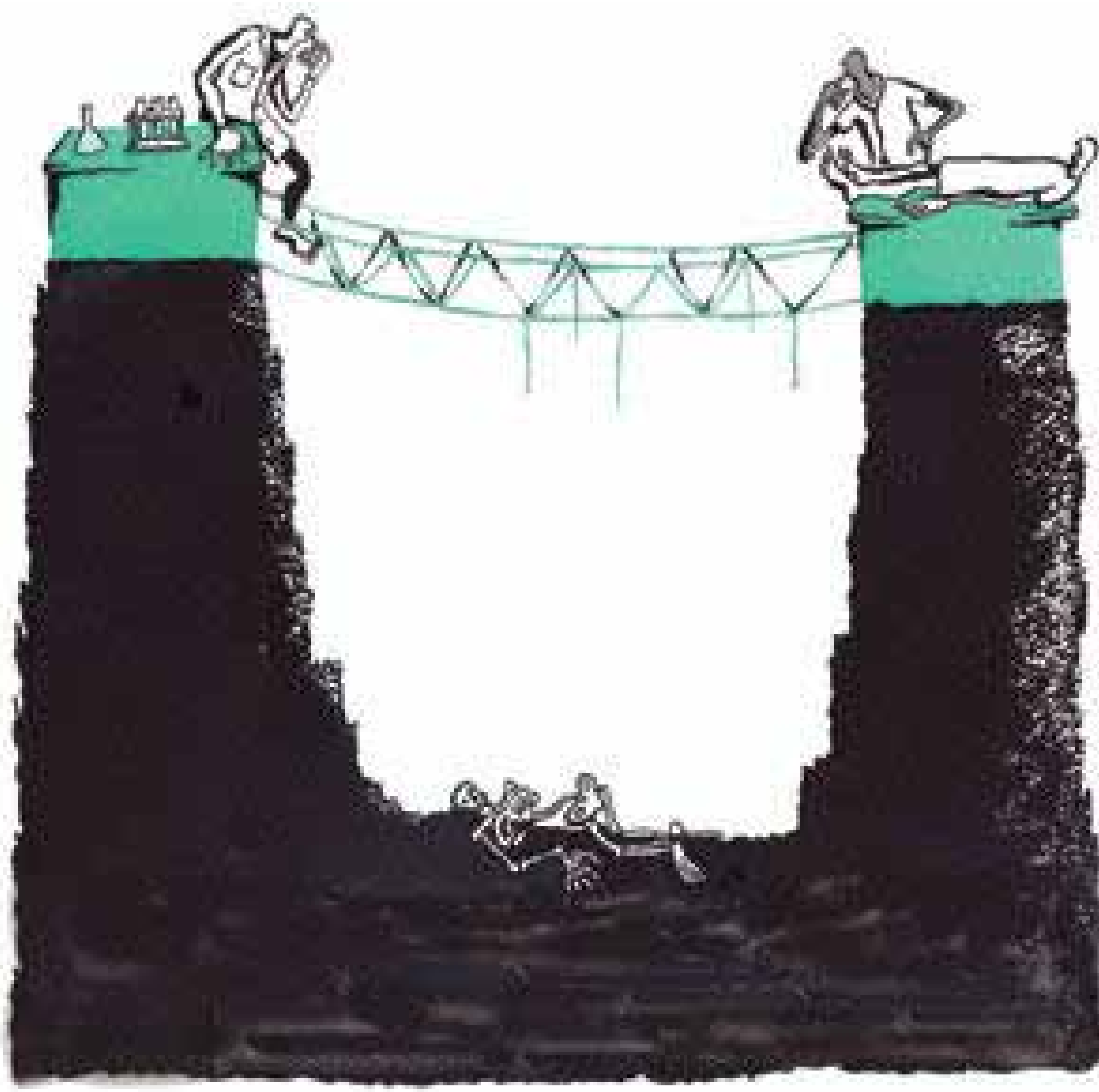
Macromolecular Crystallization– A Japanese scientist crystallized HQL-79 (human prostaglandin D2 synthase inhibitor protein) on the ***International Space Station***, identifying an improved structure and an associated water molecule that was not previously known. This protein is part of a candidate treatment for inhibiting the effects of Duchenne’s muscular dystrophy. Continuing work is looking at other proteins and viruses.



Source: ISS Program Scientist, NASA

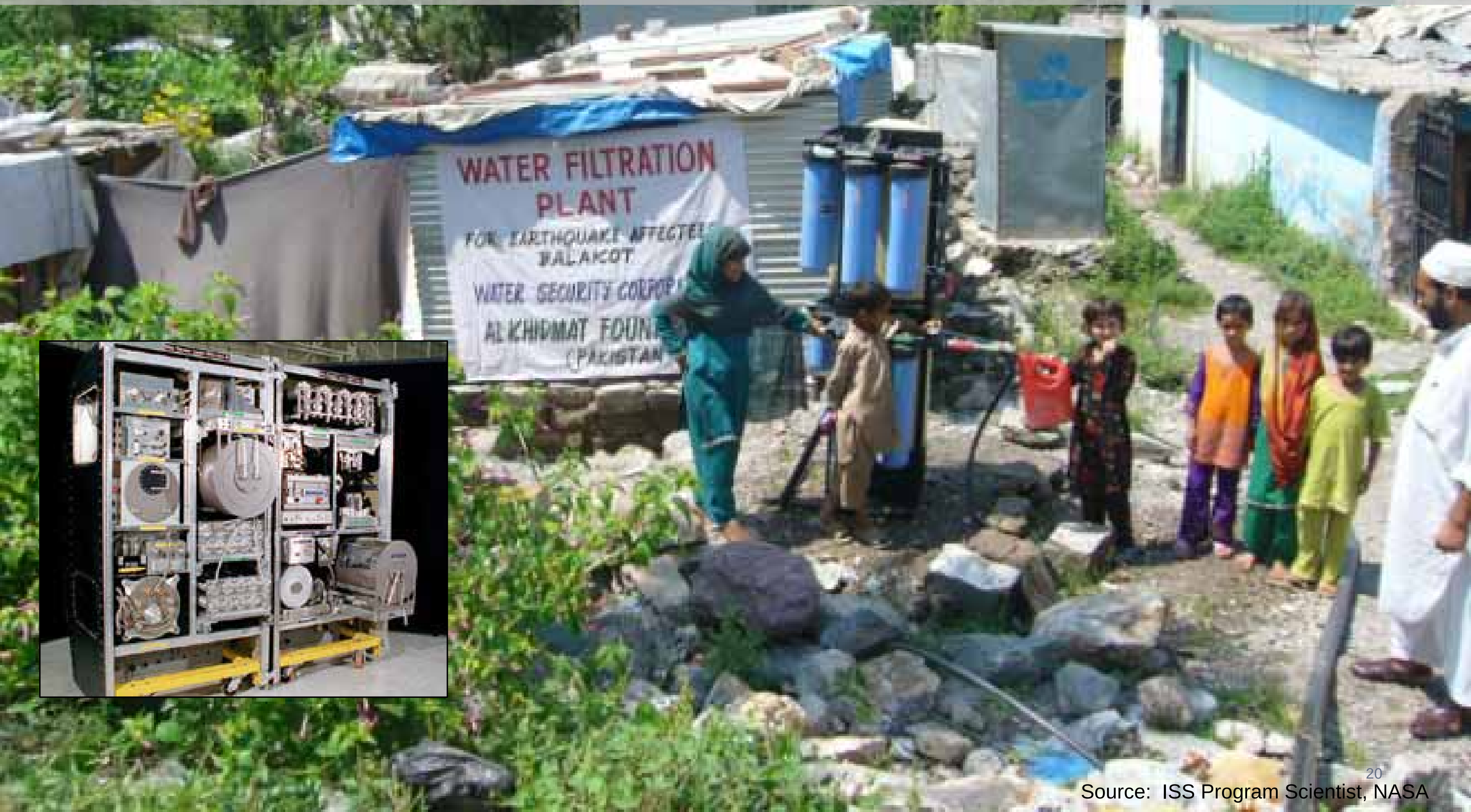
Cancer Treatment Delivery– Microcapsules (micro-balloons) for drug with desirable properties developed on the ***International Space Station*** were reproduced on Earth and were successful in targeting delivery of anti-cancer drugs to successfully shrink tumors in ground tests. A device to produce similar capsules on Earth has now been patented, and clinical trials of the drug delivery method are beginning.

Source: ISS Program Scientist, NASA



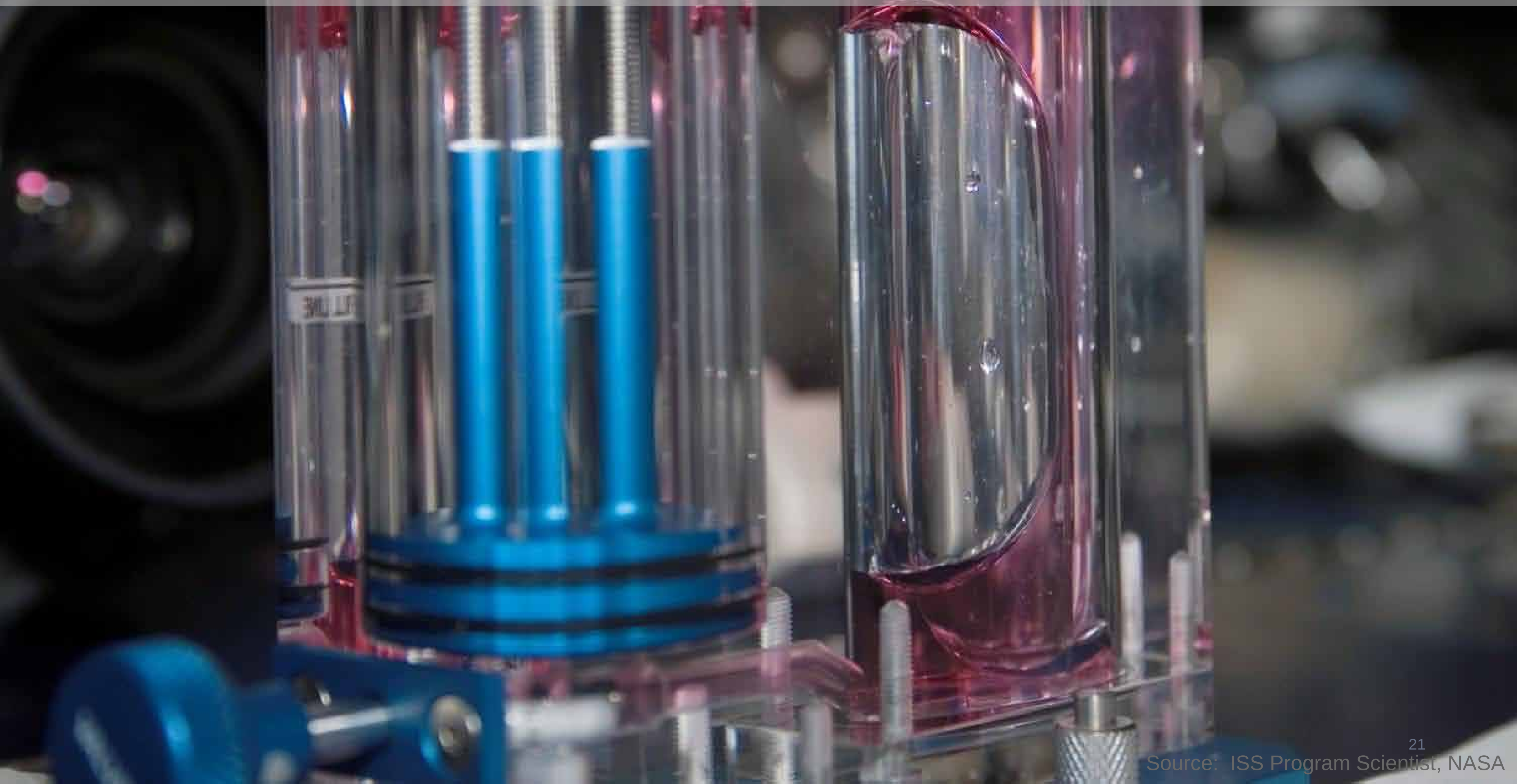
B. Mellor/Nature

Regen ECLSS – Water recycling, oxygen generation, and carbon dioxide removal are critical technologies for reducing the logistics re-supply requirements for human spaceflight. The ***International Space Station*** demonstration project is applying lessons learned form operational experiences to next generation technologies. The resin used in the ISS water processor assembly have been developed as a commercial water filtration solution for use in disaster and humanitarian relief zones.



Source: ISS Program Scientist, NASA

Fluid Flow – Controlling the flow of fluids in the absence of gravity is a challenge for designing spacecraft liquid propellant, water and recycling systems. In space, liquids can climb container walls, making it hard to empty containers, measure the contents of storage vessels, and obtain consistent performance in devices where liquids and vapor mix. Capillary flow experiments on the ***International Space Station*** produced the first space-validated models describing fluid behavior in space. Three patents have been filed.



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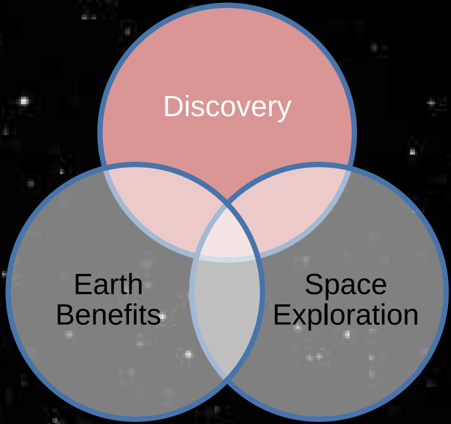


Discovery in our Future

Disciplines that use the Laboratory

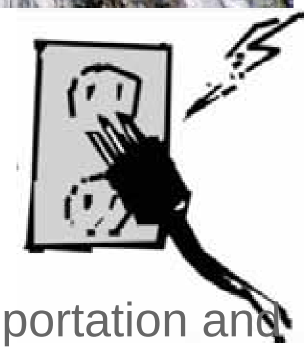
- Biology & Biotechnology
- Human Physiology & Performance
- Physical Sciences (Microgravity)
- Technology Development & Demonstration

- Gravity is a constant force on Earth
- It cannot be completely controlled or removed in experiments
- It dominates and masks other forces in processes
- The ISS provides a laboratory environment to control this force

Disciplines that use the Laboratory

- Earth Science*
- Fundamental physics and Astrophysics*
- Education*

• ISS has the most capable power system EVER in orbit



•Its frequent transportation and serviceable external attachment points

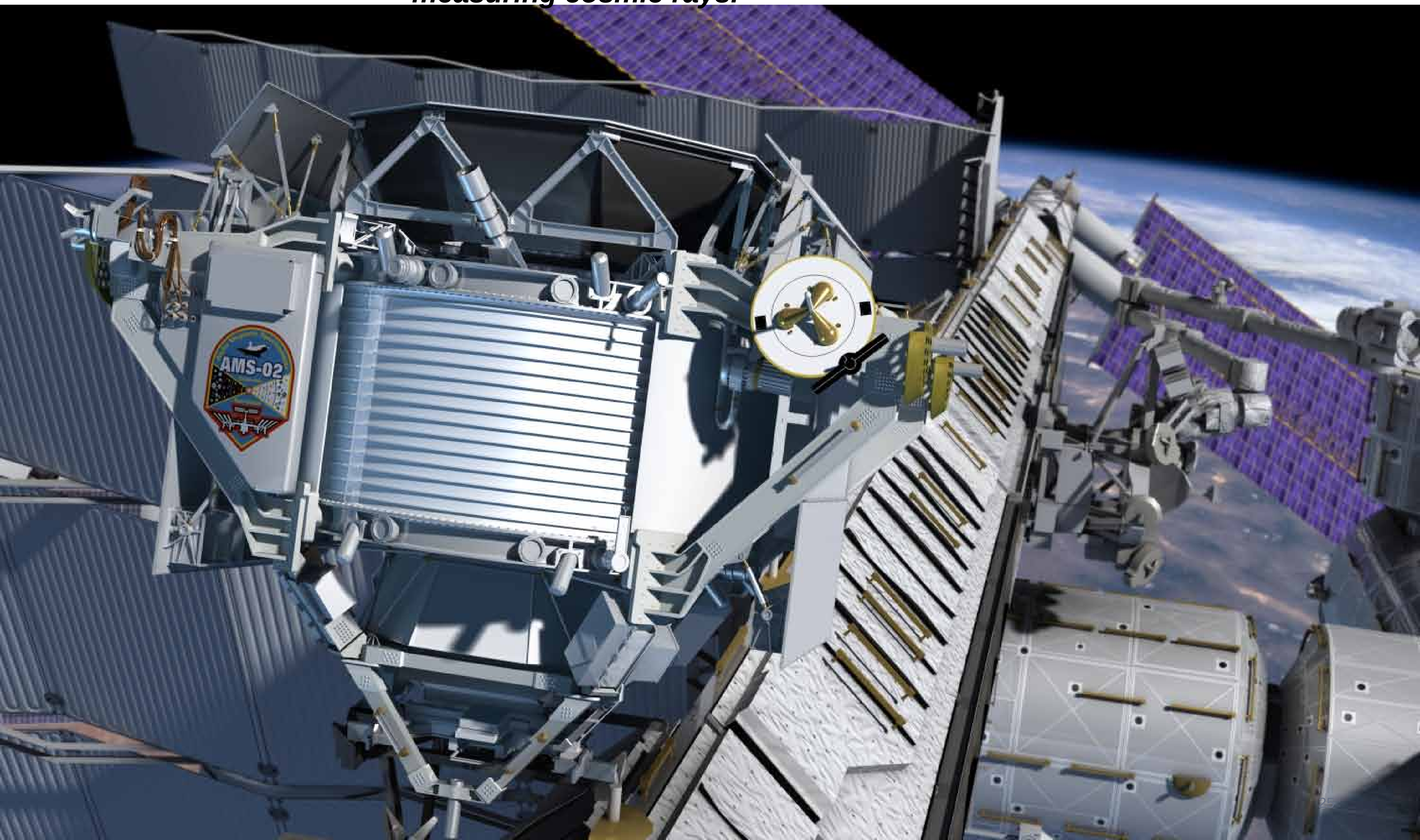
•Power, data, and thermal for a wide variety of instruments

Alpha Magnetic Spectrometer

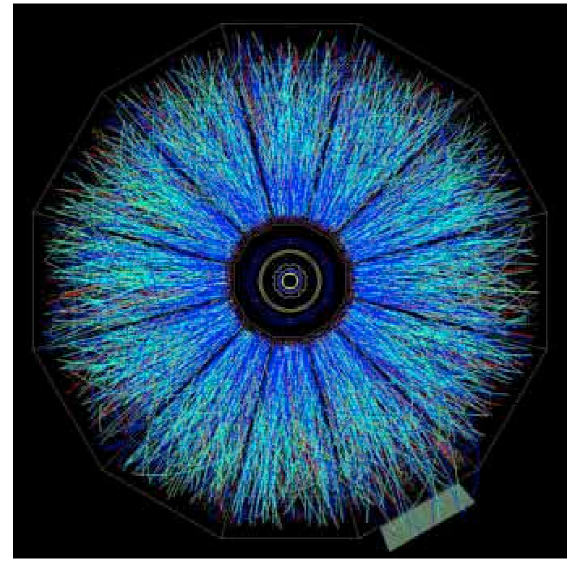
(AMS-02), Cosmic Ray detector, Nobel Laureate, Samuel Ting

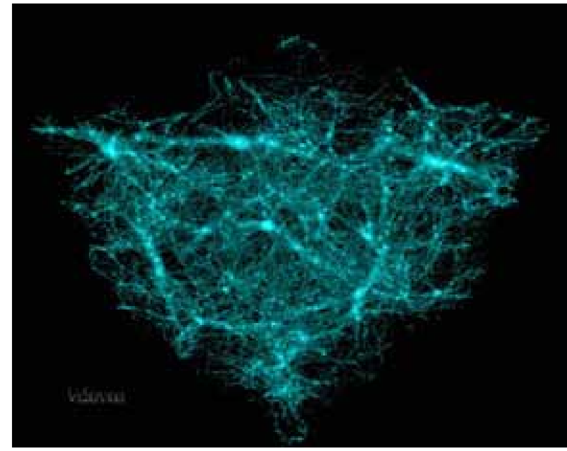
Collaboration of DOE and multiple organizations

***Mission:* to advance knowledge of the Universe and lead to the understanding of its origin by searching for antimatter, dark matter and measuring cosmic rays.**



Why does AMS measure the particles in cosmic rays?





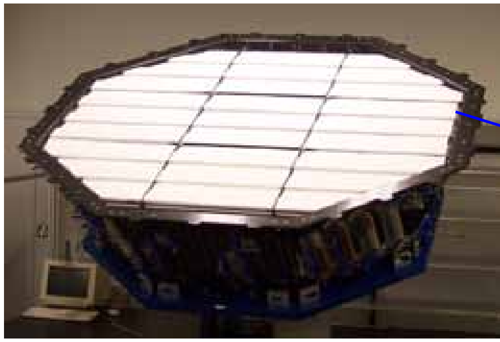
- Antimatter
  - Any observation of an antihelium nucleus
  - 1999, AMS-01 10^{-6} for the antihelium/helium flux ratio
  - AMS-02 will search with a sensitivity of 10^{-9}
- Dark matter
  - If neutralinos exist, they should collide and give off an excess of charged particles
  - Peaks in the background positron, anti-proton, or gamma ray flux
- Strangelets
  - Six types of quarks (up, down, strange, charmed, bottom and top) experimentally, but only up and down quarks on Earth
  - Strangelets might have extremely large mass and very small charge-to-mass ratios, detectable by AMS

Alpha Magnetic Spectrometer (AMS)

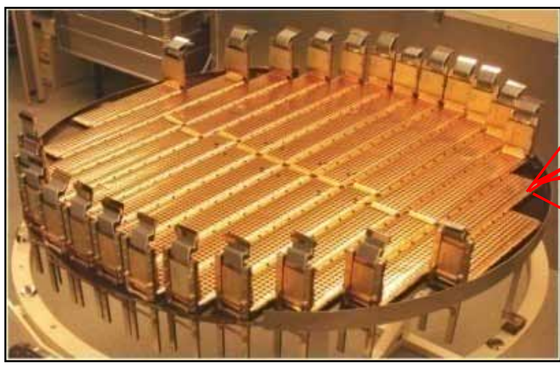
A TeV Precision, Multipurpose Spectrometer

Particles and nuclei are defined by their charge (Z) and energy (E ~ P)

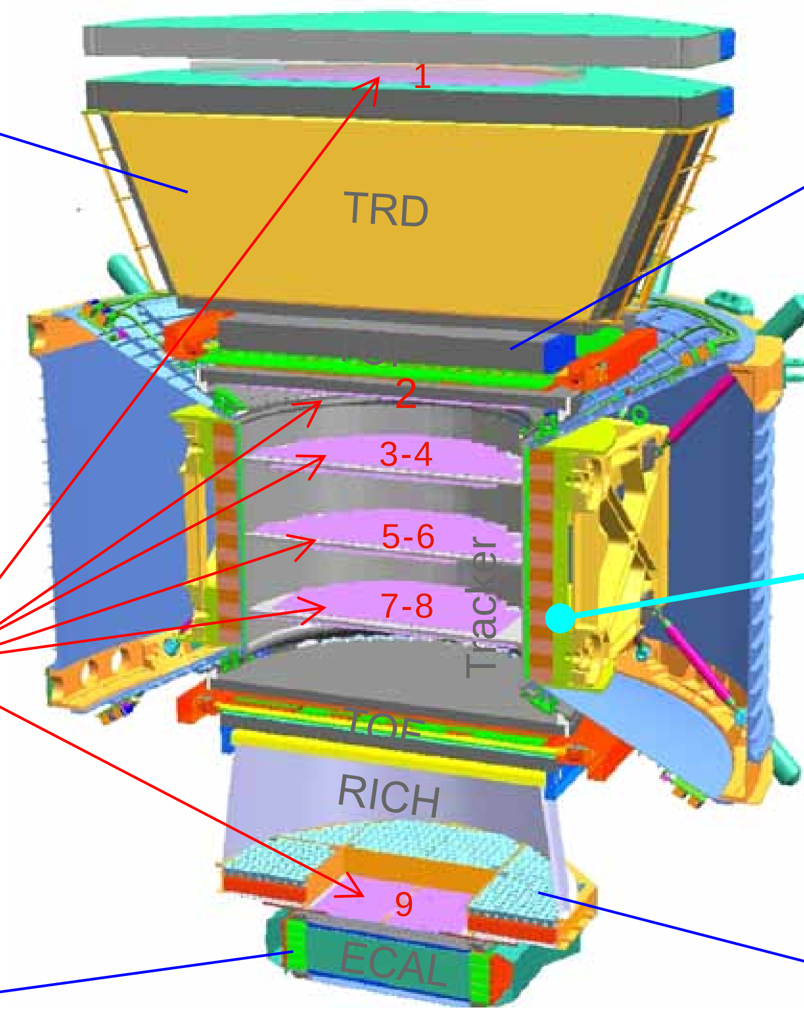
TRD
Identify e+, e-



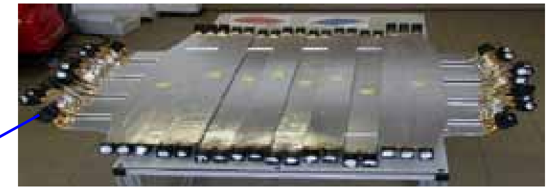
Silicon Tracker
Z, P



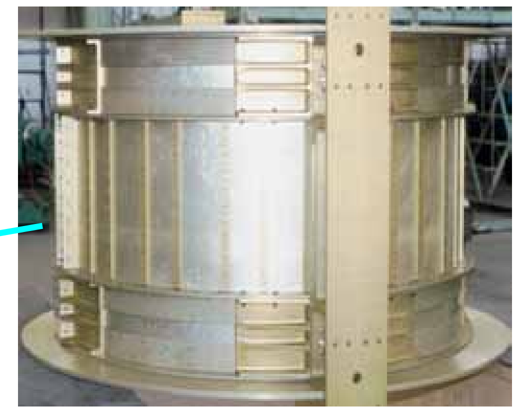
ECAL
E of e+, e-, γ



TOF
Z, E



Magnet
Z



RICH
Z, E

Z, P are measured independently from Tracker, RICH, TOF and ECAL

Chart Courtesy of Vernon Jones, NASA HQ

AMS PI: “Exploring New Territory with a Precision instrument is the Key to Discovery”

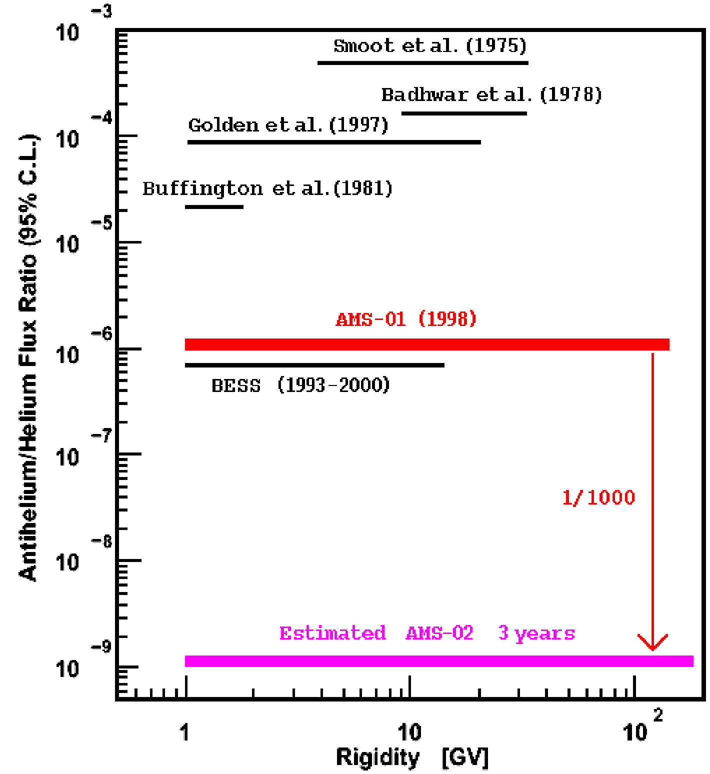
Facility	Original purpose, Expert Opinion	Discovery with Precision Instrument
P.S. CERN	p N interactions	Neutral Currents -> Z, W
Brookhaven	p N interactions	ν_e, ν_μ CP violation, J
FNAL	Neutrino physics	*b, t quarks*
SLAC Spear	ep, QED	Scaling, **Ψ**, **τ**
PETRA	t quark	*Gluon*
Super Kamiokande	Proton decay	Neutrino oscillations
Hubble Space Telescope	Galactic survey	*Curvature of the universe, dark energy*
AMS on ISS	Dark Matter, Antimatter Strangelets,…	*?*

Chart Courtesy of Vernon Jones, NASA HQ

AMS goals: He/He = $1/10^{10}$, $e^+/p = 1/10^6$, Spectra to 1%

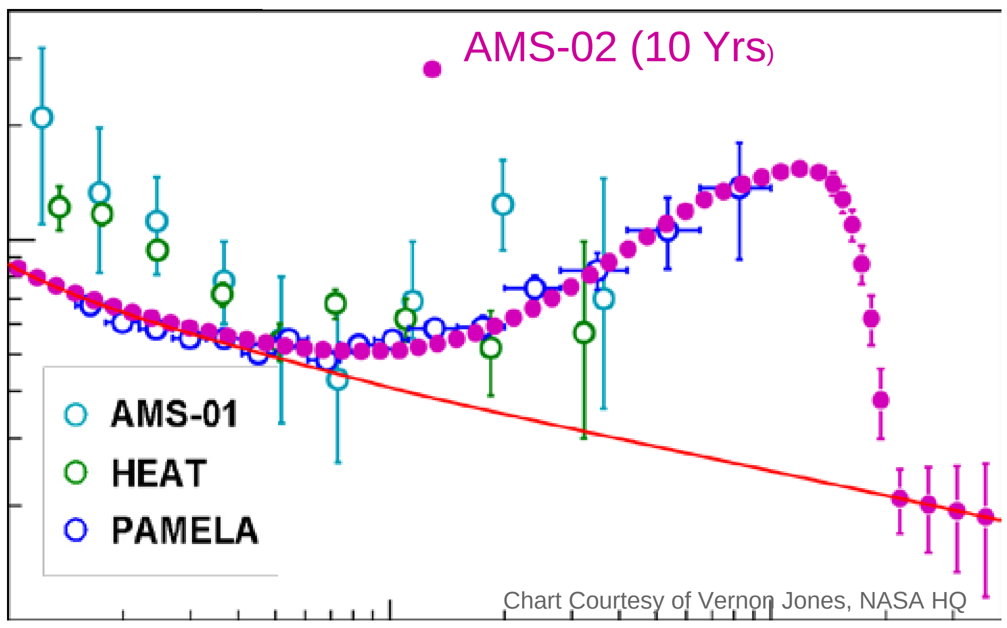
AMS is DOE sponsored International Collaboration, including:

- 16 Countries, 60 Institutes, and 600 Physicists
- NASA/SOMD will have contributed about $100M to the mission.



Unexpected results from first flight (AMS-01)

- Many more positrons (e^+) than electrons (e^-)



- AMS will measure cosmic ray nuclei energy spectra from 100 MeV to 2 TeV, with 1% accuracy over the 11-year solar cycle.
  - These spectra will provide experimental measurements of the assumptions that go into calculating the background in the search for Dark Matter, i.e., p + C →e^+, p,

For More Information

ISS Reference Guide

Cumulative Results Reports:

NASA/TP–2009–213146–REVISION A

Education on ISS 2000-2006:

NASA/TP-2006-213721

World Wide Web

http://www.nasa.gov/iss-science/

Facilities Catalog

click on “Facilities” at web link above

ISS Research Blog “A Lab Aloft”

http://go.usa.gov/atl

Twitter @ISS_Research

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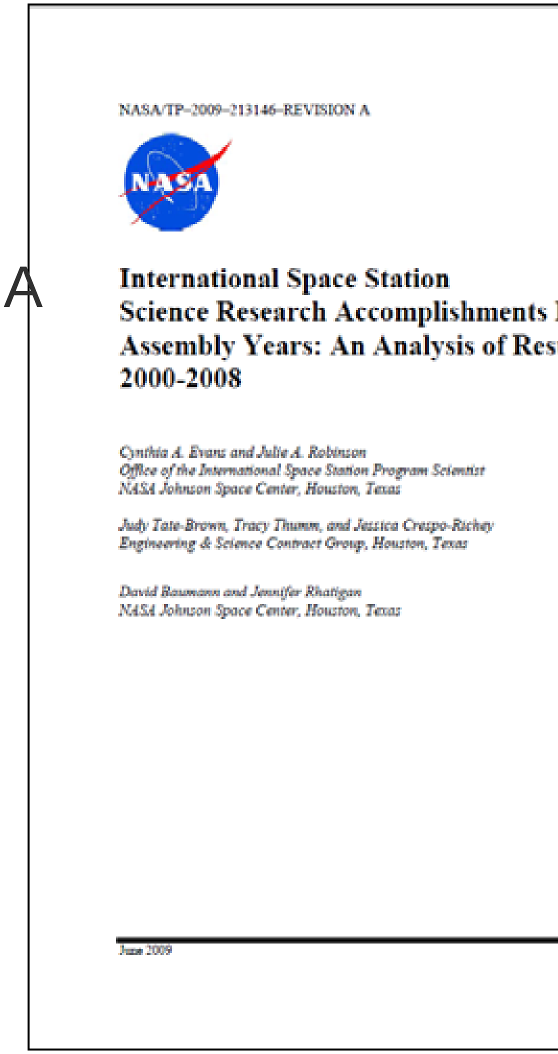
NASA/TP–2009–213146–REVISION A

International Space Station
Science Research Accomplishments I
Assembly Years: An Analysis of Res
2000-2008

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