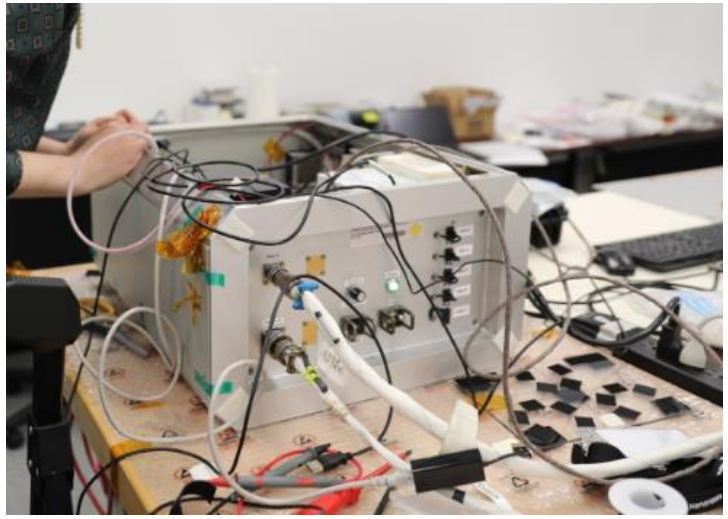
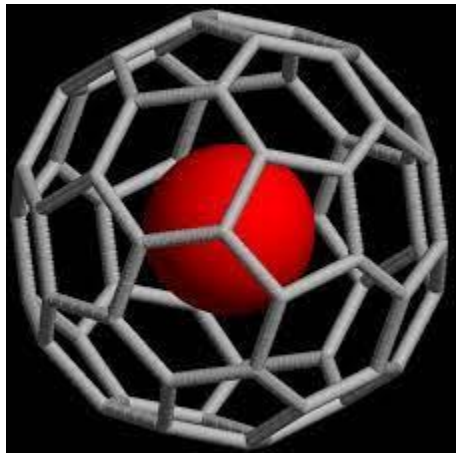


EVI-EFF



Buckyballs with a purpose

Enhanced Vibration Isolation - Endohedral Fullerenes Factory

WidgetBlender LLC (Jeff Morse Principal Eng, Susan Morse Esq.)
+ Crointel LLC (Dr. Steve Wu, PhD Chemistry, Taiwan)

EVI-EFF for Reef Starter Competition

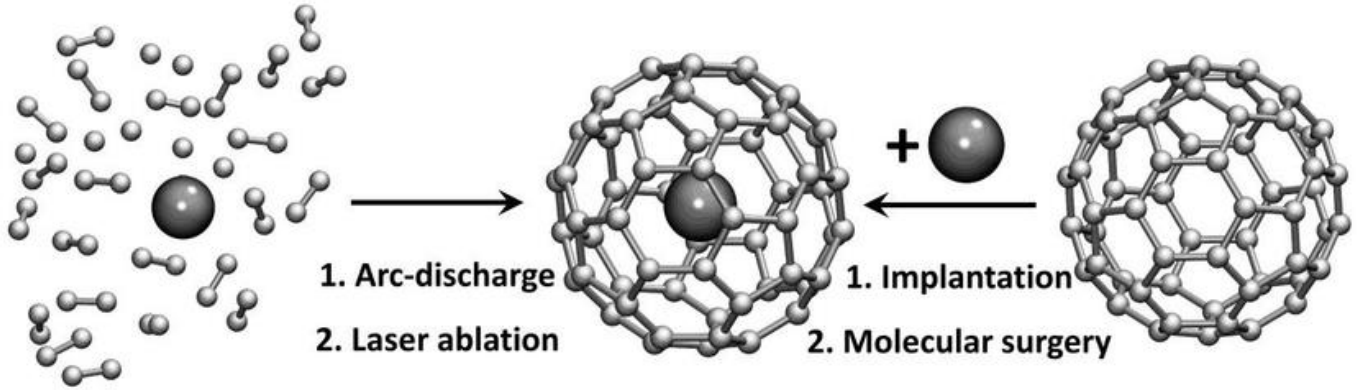
November 16, 2022

Why Make Endohedral Fullerenes (EF)?

- EF currently has very high price per gram (~$100M/g) – second only to anti-matter
- EF has several current and future commercial uses on Earth
- Research (current): organic photovoltaic cells, cancer treatment, nanoelectronics …
- Medicine (future): cancer treatments
- **Handheld atomic clocks (future) – using caged Nitrogen**
  - *The material, which essentially is a cage of carbon atoms with a nitrogen atom inside, could be used for very small and very accurate atomic clocks, which are currently of the size of a room.*
  - *“Imagine a miniaturized atomic clock that you could carry around in your smartphone,” the company's founder Dr. Kyriakos Porfyrakis told The Telegraph. “This is the next revolution for mobile.”*
  - *One of the problems a miniature atomic clock can solve is the positioning of driverless cars. With normal GPS navigation offering an accuracy to within a few yards, it could be tricky to properly track and control the vehicles. Throw an atomic clock into the mix, however, and you can get the accuracy resolution down to around 1mm.*

Ref: https://arstechnica.com/science/2015/12/oxford-company-now-selling-endohedral-fullerenes-priced-at-110-million-per-gram/

Methods for Synthesizing EF



Two types of approaches for synthesizing EF (https://bit.ly/3Gcpwhp):

(1) Encapsulation during the fullerene formation

(2) Encapsulation into already available empty fullerene

Among them, arc discharge is the most productive and common:

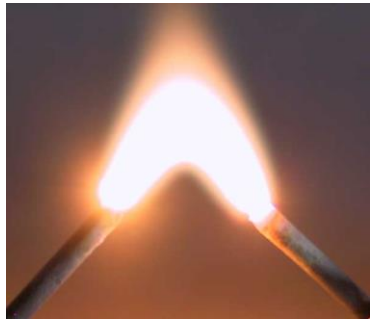
(1) it is simple enough to introduce atoms into the plasma from solids and gases

(2) its performance is the highest among other methods

(3) it gives a wide range of produced types of metallofullerenes

(4) it provides the greatest energy potential, which helps include metal atoms with higher ionization energies and yield more metal endofullerenes.

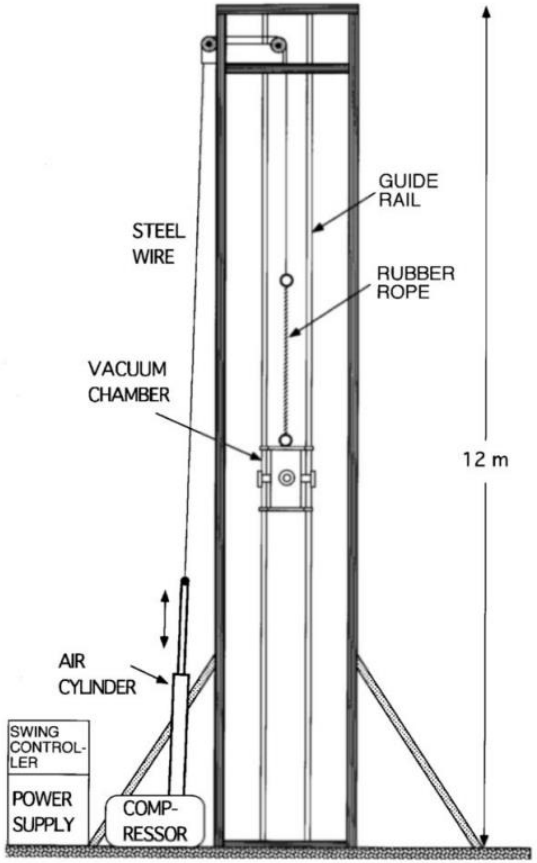
(https://bit.ly/3UTvLe8)



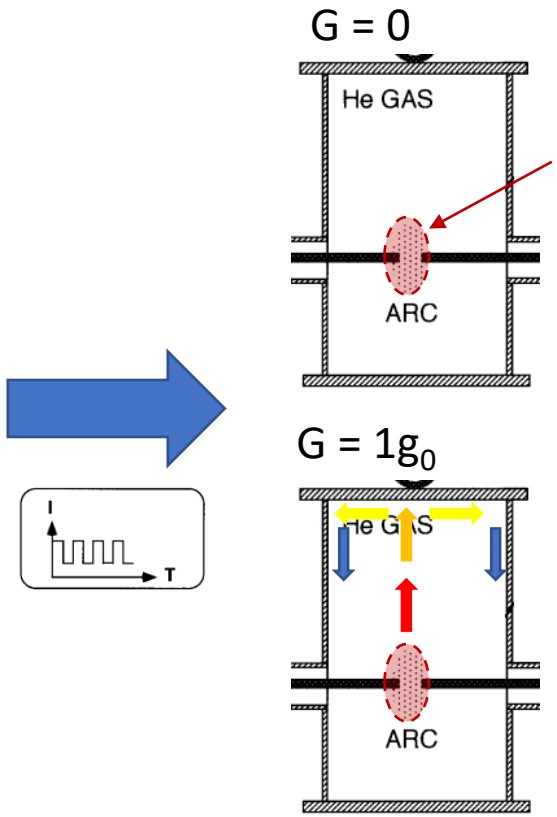
(https://bit.ly/3Ab6GDc)

Concept summary by Dr. Steven Wu, PhD Chemist, Taiwan

Gravity-free Condition Enhances EF Production

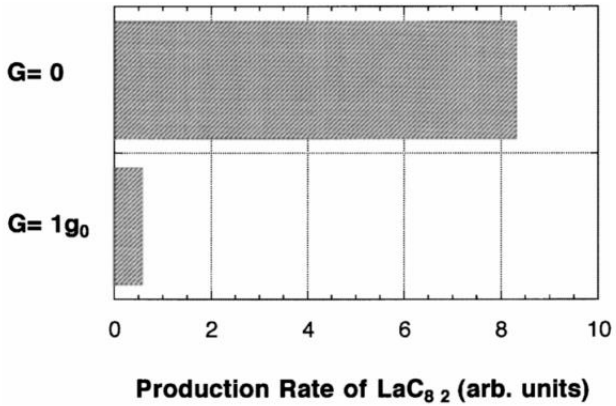


Using a vertical swing tower to mimic G = 0 (https://bit.ly/3EuPVWu)



Thermal convection of hot gas in the arc region is suppressed in G = 0

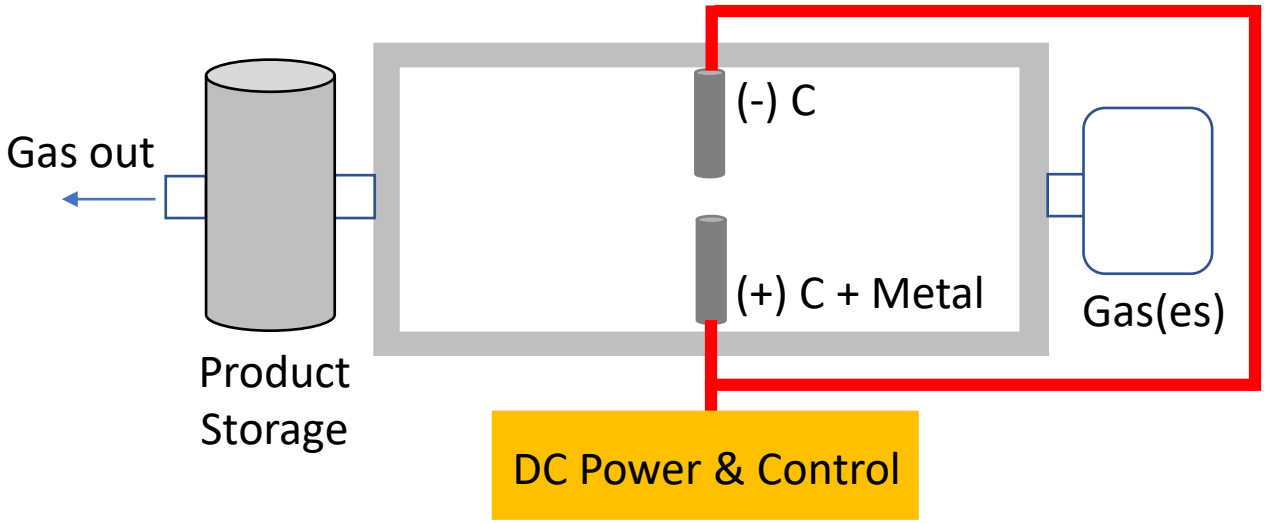
EF Formation



EF production significantly increases in G = 0 (> 10x)

Concept summary by Dr. Steven Wu, PhD Chemist, Taiwan

Development of EF Production Factory



Device Features:

(1) It is designed for batch production of EF in space. Separation and purification will be performed on Earth.

(2) Arc discharge will generate a mixture containing EF molecules which eventually attaches to the wall of the reactor. A mechanism to remove the mixture and transfer it to the product storage tank will be included.

(3) Many parameters will be optimized/adjustable for further enhancing EF production efficiency.

Parameters for optimization:

(1) Conditions of the process in the reactor: gas pressure, flow rate, temperature, amperage, distance between electrodes, etc.

(2) The composition of solid additives: salts, oxides, metal alloys in the graphite anode (+) and their quantitative ratio with carbon

(3) Replacement of the inert atmosphere (helium) with the active one: nitrogen, ammonia, water vapor, CO, etc. (https://bit.ly/3UTvLe8)

Potential co-manufacturers:

Taiwan Plasma Corp. https://www.plasma.com.tw/

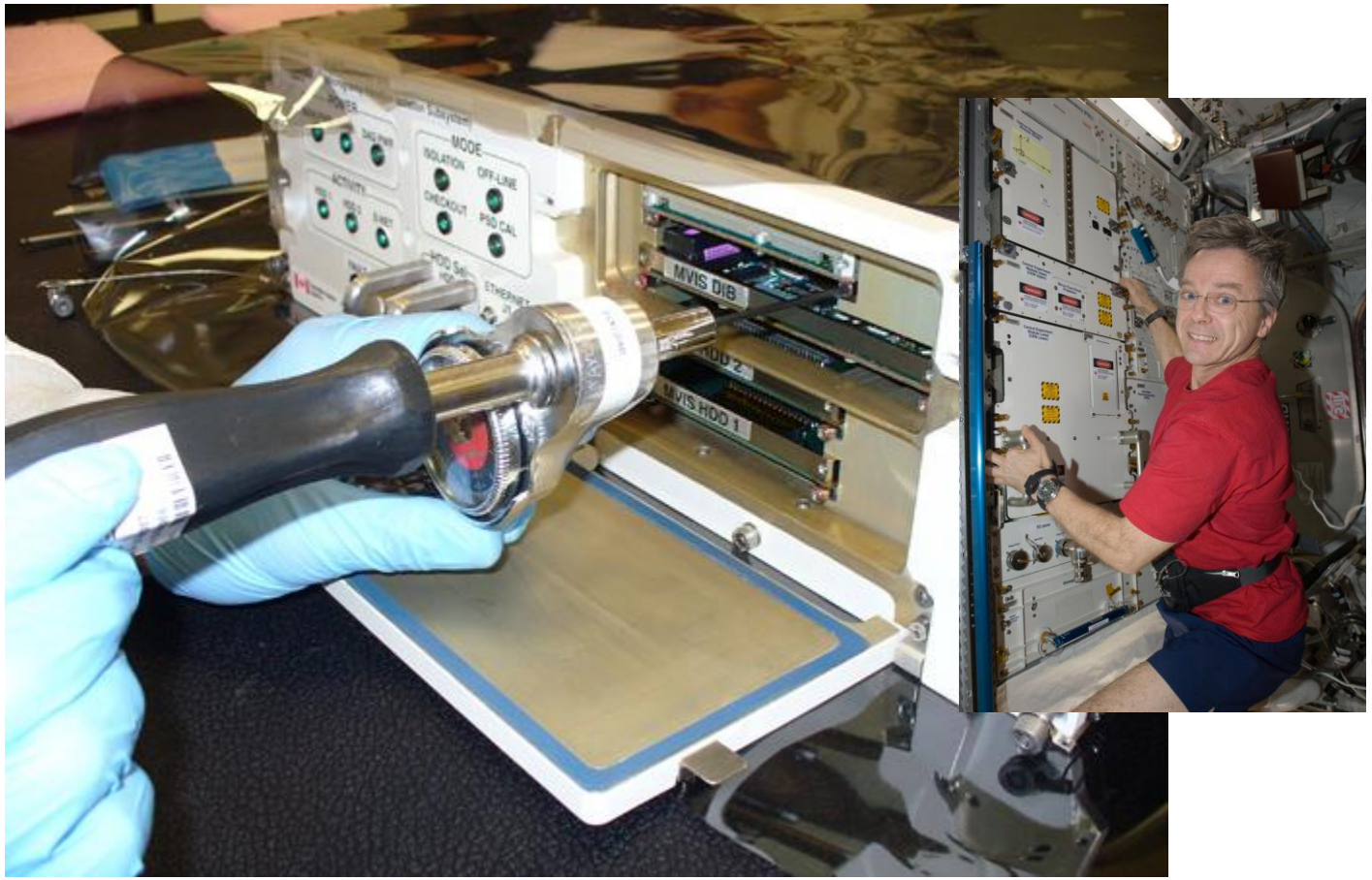
台灣亞弧科技有限公司 TAIWAN ARC TECHNOLOGY CO.,LTD. 傑煇實業有限公司 https://www.taiwanarc.com.tw/

森積科技有限公司 SJ High Technology Company https://www.sjcom.com.tw/en/index.html

Inspiration #1: ISS-MVIS: Shielding science experiments from vibrations

- These jolting movements can be strong enough to interfere with delicate experiments, like those involving fluid physics, crystal growth and the development of metal alloys.
- By using a series of electromagnet coils and magnets to suspend its inner container, MVIS guards against vibrations that could alter the results of these experiments.
- Developed by the Canadian Space Agency (CSA), the microwave-sized device was added to the ISS's Fluid Science Laboratory in 2008.

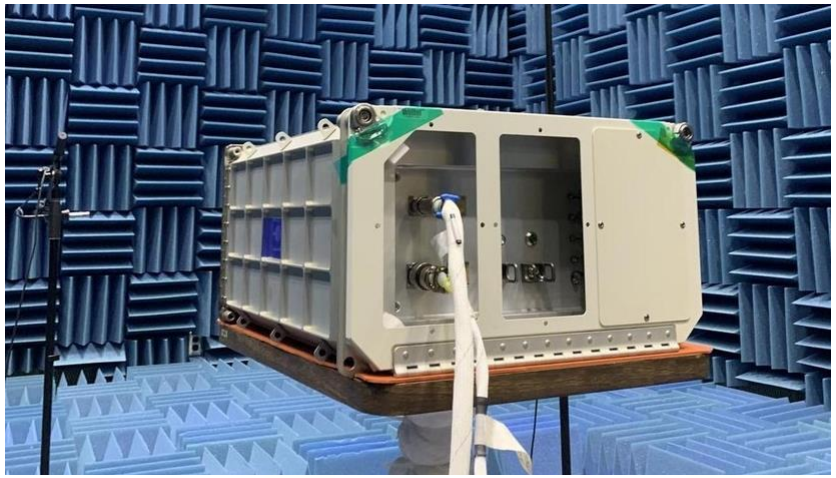
Microgravity Vibration Isolation Subsystem



https://www.asc-csa.gc.ca/eng/sciences/mvis.asp

Assumption: Nanoracks BlackBox or Redwire ADSEP a good EVI-EFF size

- BlackBox provides an industry standard container for microgravity work
- RedWire ADSEP also offers standard cassette-based operations for multi-purpose microgravity processing
- Either can be made to work with concept



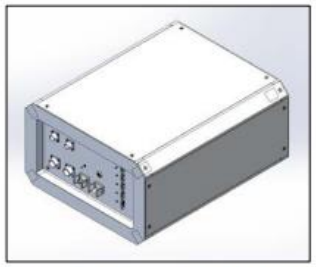


Figure 3-1: Nanoracks Black Box

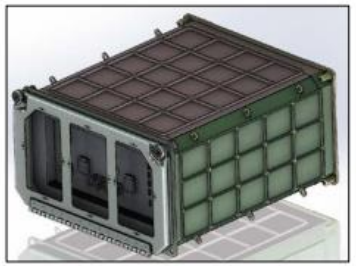


Figure 3-2: Nanoracks Black Box in locker

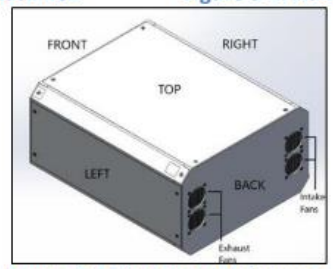
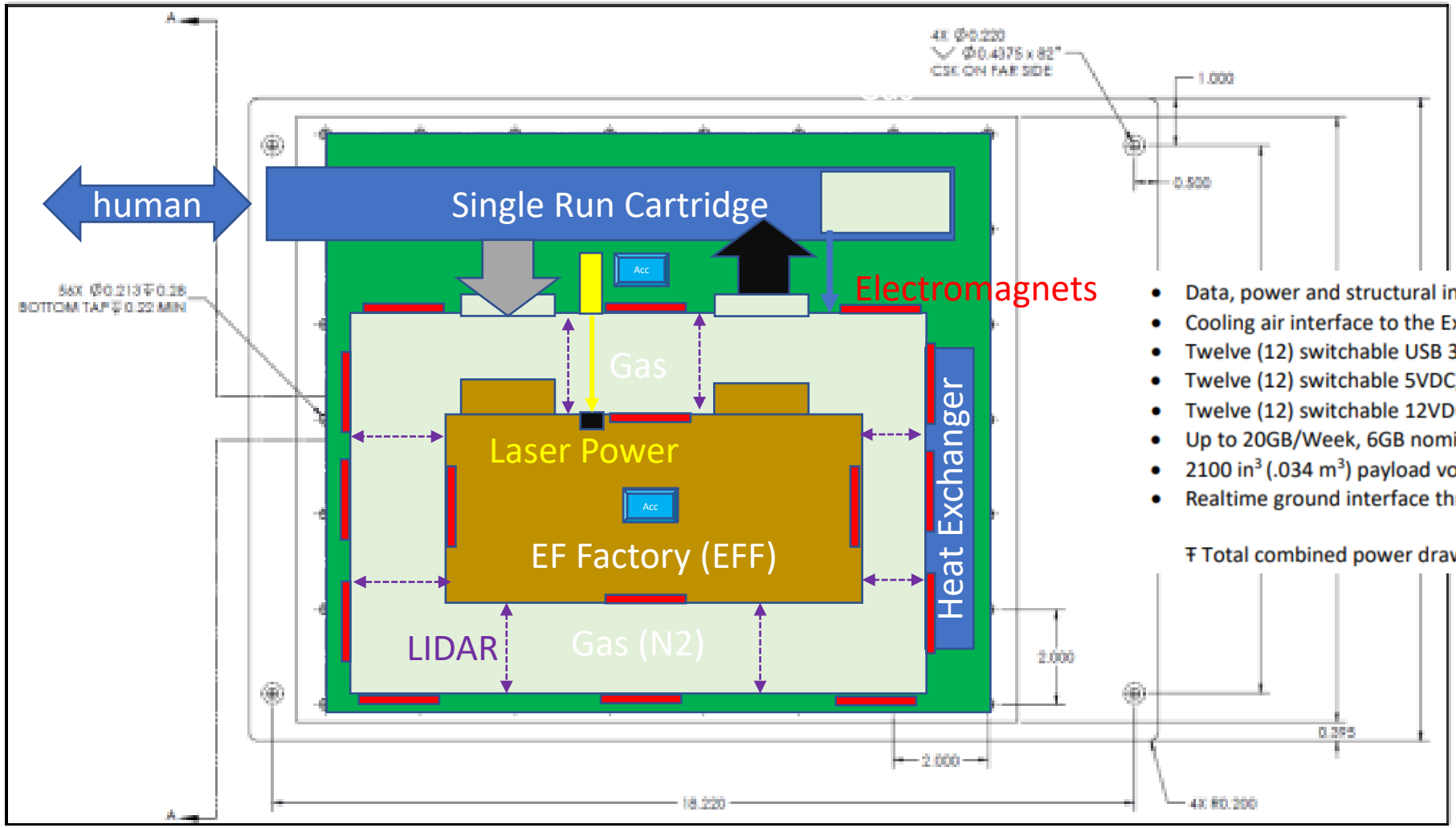


Figure 3-3 Directional References

https://brand.redwirespace.com/wp-content/uploads/2022/03/redwire-adsep-flysheet.pdf

Conceptual View EVI-EFF (Floating Mode)

https://nanoracks.com/wp-content/uploads/Nanoracks-Blackbox-IDD.pdf (page 4)



- Data, power and structural interface to the ISS
- Cooling air interface to the ExPRESS Rack AAA Plenum
- Twelve (12) switchable USB 3.0 Ports, 2A max current ₸
- Twelve (12) switchable 5VDC, 5A power ports ₸
- Twelve (12) switchable 12VDC, 3A power ports ₸
- Up to 20GB/Week, 6GB nominal, data download.
- 2100 in^3 (.034 m^3) payload volume
- Realtime ground interface through Nanoracks operations

₸ Total combined power draw from all ports (USB, 5VDC, 12VDC) is limited to 500W

Orbital Reef is the Optimal Facility for EVI-EFF

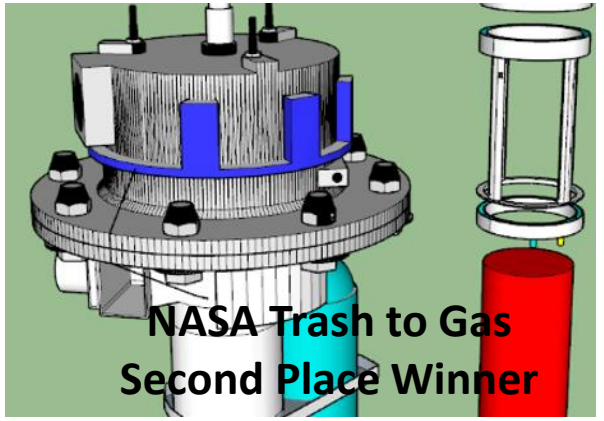
- **Orbital Reef**
  - LEO microgravity
  - Consistent onboard atmosphere
  - Standard DC power
  - Amazon robust 24x7 comms/Web Services
  - Standard rack + Redwire occasional short human intervention
  - Expected streamlined commercial process "mixed-use business park“ (vs ISS and anything connected to it)
  - Starliner and/or Sierra Space cargo one time device up (20-30 kg), recurring feedstocks up product down (< 5kg)
- **Other Possibilities**
  - ISS (+ now operational, - NASA process, limits and academic priorities, - limited comms)
  - Varda (+ pure freefall, - comms?, - 100% automation needed, - in early development)

Image Credit: Blue Origin

EVI-EFF Status/Process

- **Current Plan (Patent Centric)**
  - Funds from #1 NASA Orbital Alchemy ($30K) & #2 NASA Trash-to-Gas ($10K) created some initial funding
  - Now waiting on DoD, DoE prize announcements
  - Completion of US patent filing (Susan)
    - WidgetBlender LLC Owner, Susan Morse: 25+ year patent attorney
    - Offer concept presentation to some of entrepreneurs and VCs Susan has worked with
  - Washington beltway presentations – since we are Northern VA based (Jeff)
    - With NDA, show to Pale Blue of Japan to gauge interest
  - Search of DoE "Maker" Network with their Connector Programs (Jade Garrett) to find potential fabricators and DoE grants

- **With Reef Starter funding (credibility boost, more partner funding, R&D)**
  - Global patent filing (Susan)
  - Post to the MIT Aerospace Alum Network for potential contributors (Jeff)
  - As with previous projects, contact the Taiwan Gov't Space Orgs (Steve)
    - NSPO, CASID, TSIDA
  - Contact Taiwan Companies (Steve)



Both were particle management in microgravity concepts

Taiwan Plasma Corp.

台灣亞弧科技有限公司
TAIWAN ARC TECHNOLOGY CO.,LTD.
傑煇實業有限公司

森積科技有限公司
SJ High Technology Company

Thanks!

Questions?

Jeff Morse, jmorse@widgetblender.com