NIAC
NASA Innovative Advanced Concepts

JPL
Jet Propulsion Laboratory
California Institute of Technology

A Breakthrough Propulsion Architecture
for Interstellar Precursor Missions

March 5, 2018

John Brophy (PI), James Polk, Leon Alkalai, Nitin Arora, Stacy Weinstein,
Bill Nesmith, Nathan Strange;
Jet Propulsion Laboratory, California Institute of Technology
Philip Lubin; *University of California, Santa Barbara*

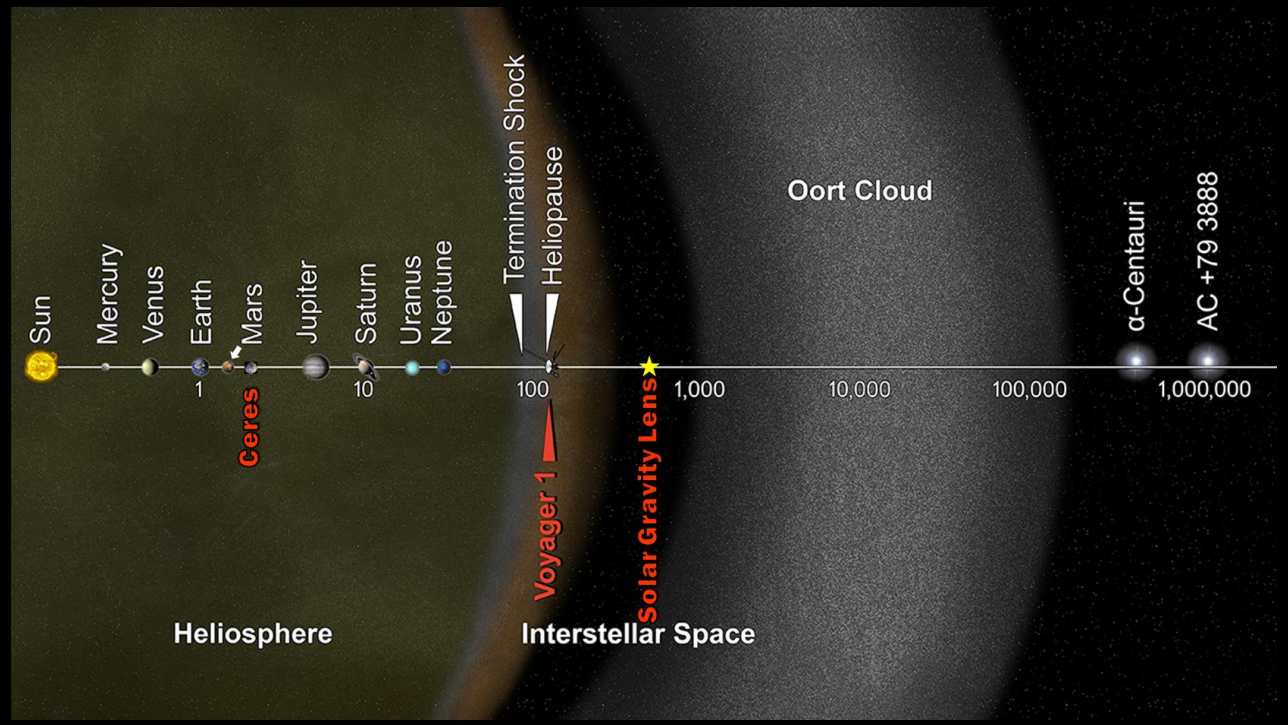
© 2018. All rights reserved.

Pre-Decisional Mission Concept

Must Go Faster

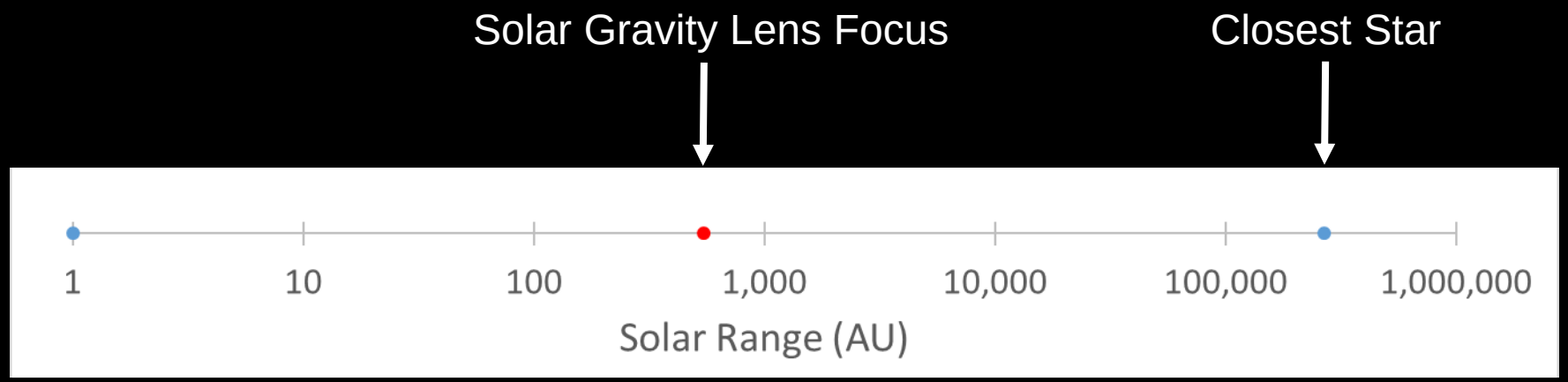
Voyager 1

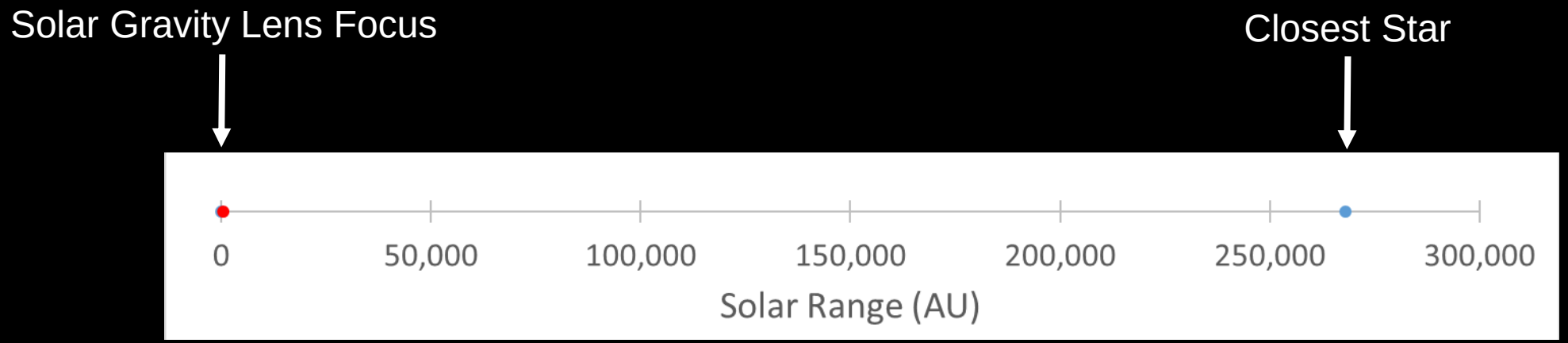
3.6 AU/year



- Voyager 1 is the fastest spacecraft in history
- Would take 150 years to get to the solar gravity lens focus at 550 AU

- We want to go 10x faster than Voyager 1, or about 40 AU/year
- How can we do this?


Solar Gravity Lens Focus
Closest Star
1
10
100
1,000
10,000
100,000
1,000,000
Solar Range (AU)


Solar Gravity Lens Focus
Closest Star
0
50,000
100,000
150,000
200,000
250,000
300,000
Solar Range (AU)

Three Key Features of Our Proposed Architecture to Go Fast

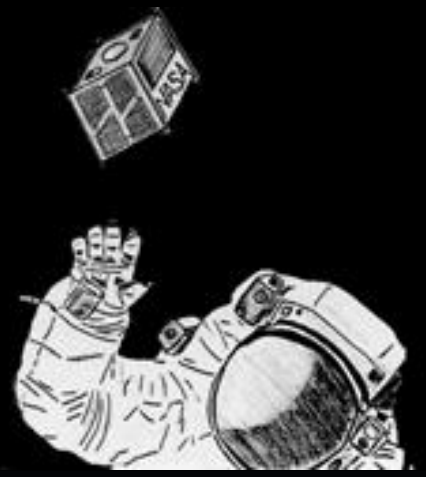
1

High Power

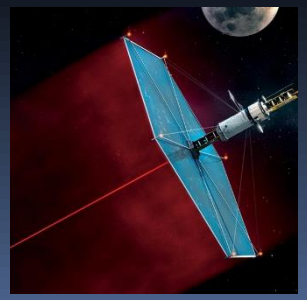
Don't carry the power source—laser beam power to the spacecraft

2

Small Mass

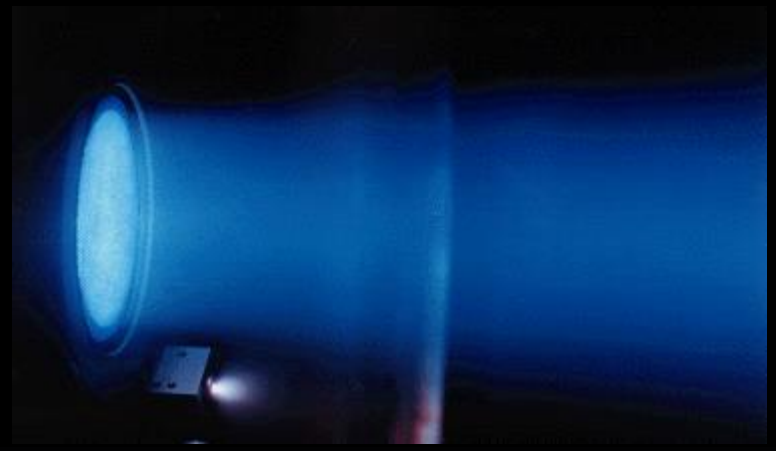


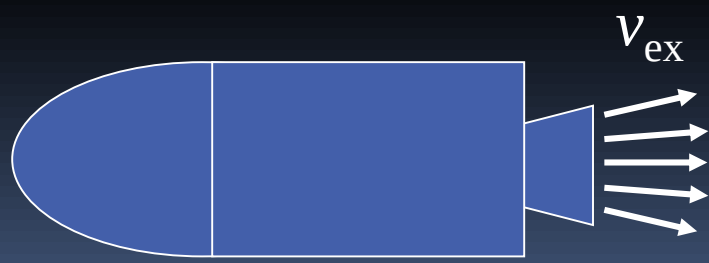
Collect the laser power and convert it to electricity to power the ion drive system



3

Not a Lot of Propellant





Increase the exhaust velocity, v_{ex} by a factor of 10 over the best ion engines today

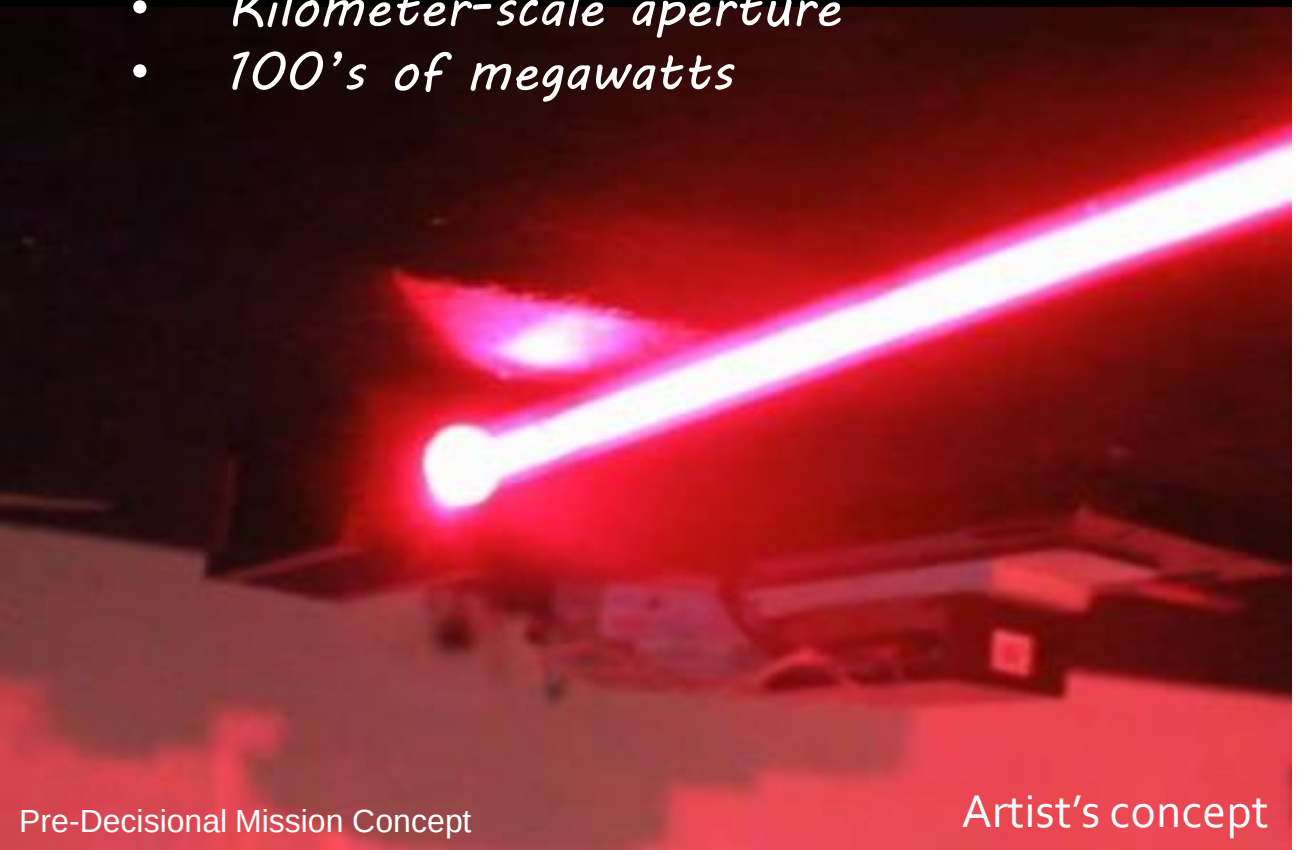
Artist's concepts

Pre-Decisional Mission Concept

LASER

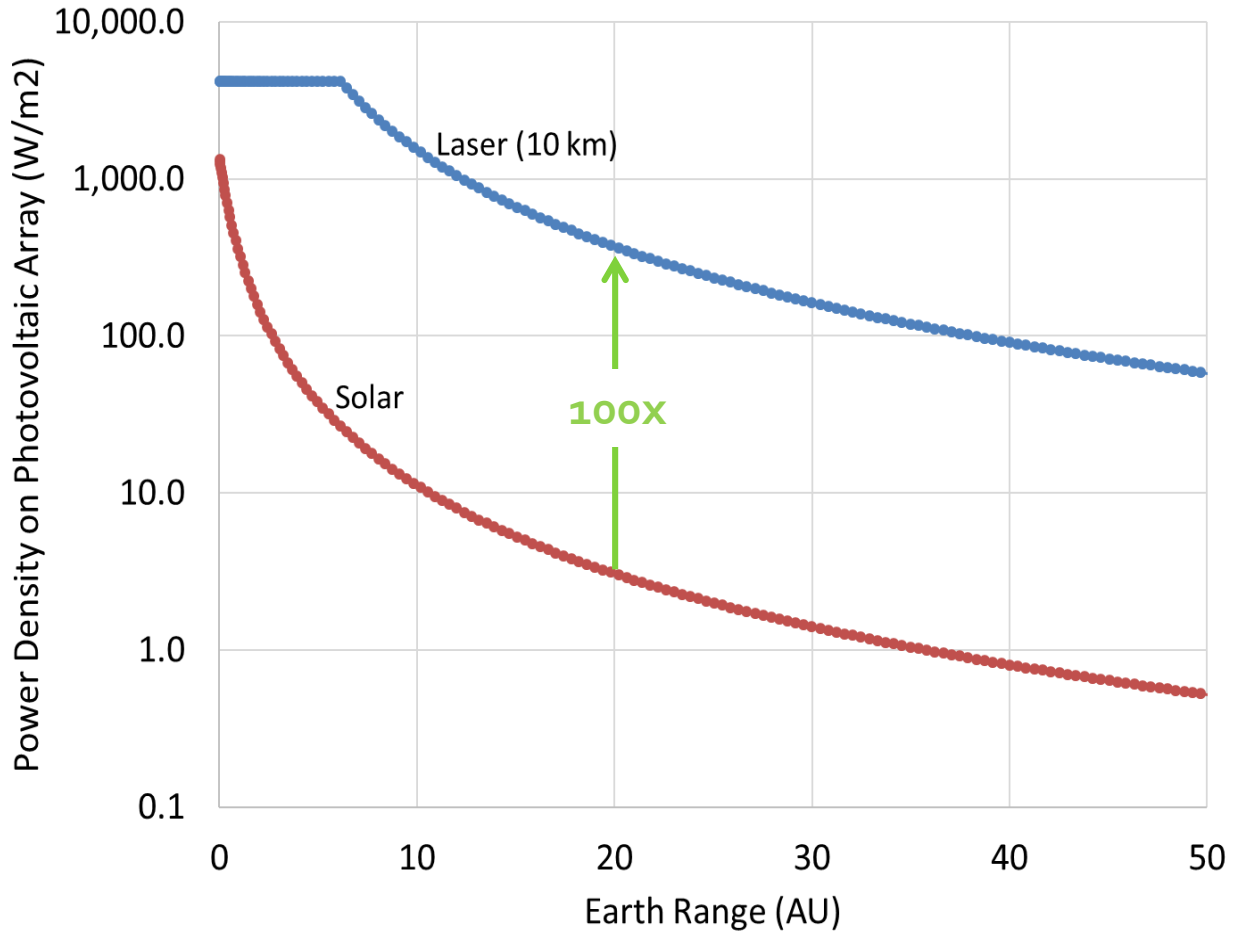
High-power, space-based laser

- Phased array
- Kilometer-scale aperture
- 100's of megawatts



Artist's concept

Beam Power Across the Solar System



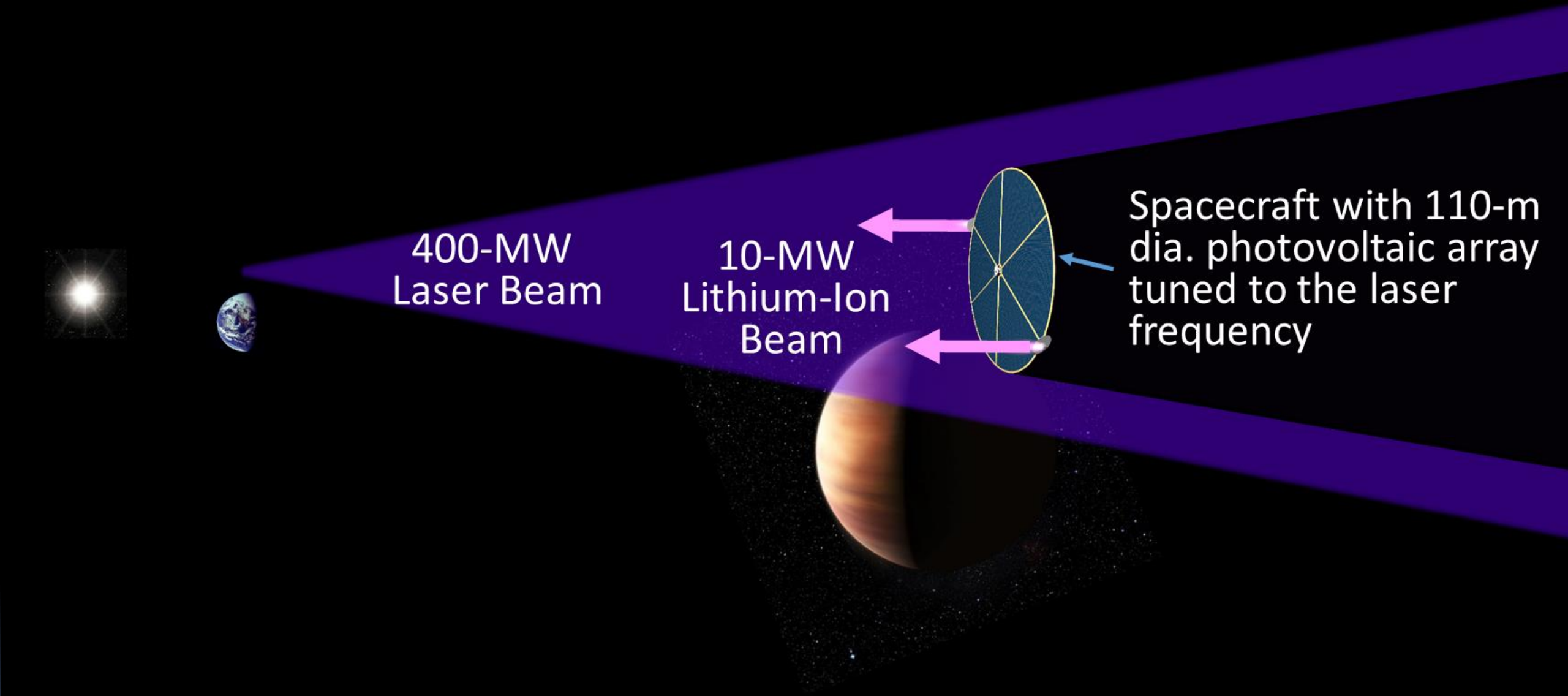
Pre-Decisional Mission Concept

Popular Mechanics

Humanity's Biggest Machines Will Be Built in Space

By Avery Thompson, Feb 16, 2018

“A mile-wide satellite might sound impossible, but that’s exactly where the space industry is headed.”



Space-based laser powers a 40,000-s Isp vehicle past Jupiter on a 13-year trip to 550 AU

Artist's concept

Pre-Decisional Mission Concept

110-m diameter Photovoltaic Array
Areal density < 200 g/m^2

Lithium-fueled ion engines

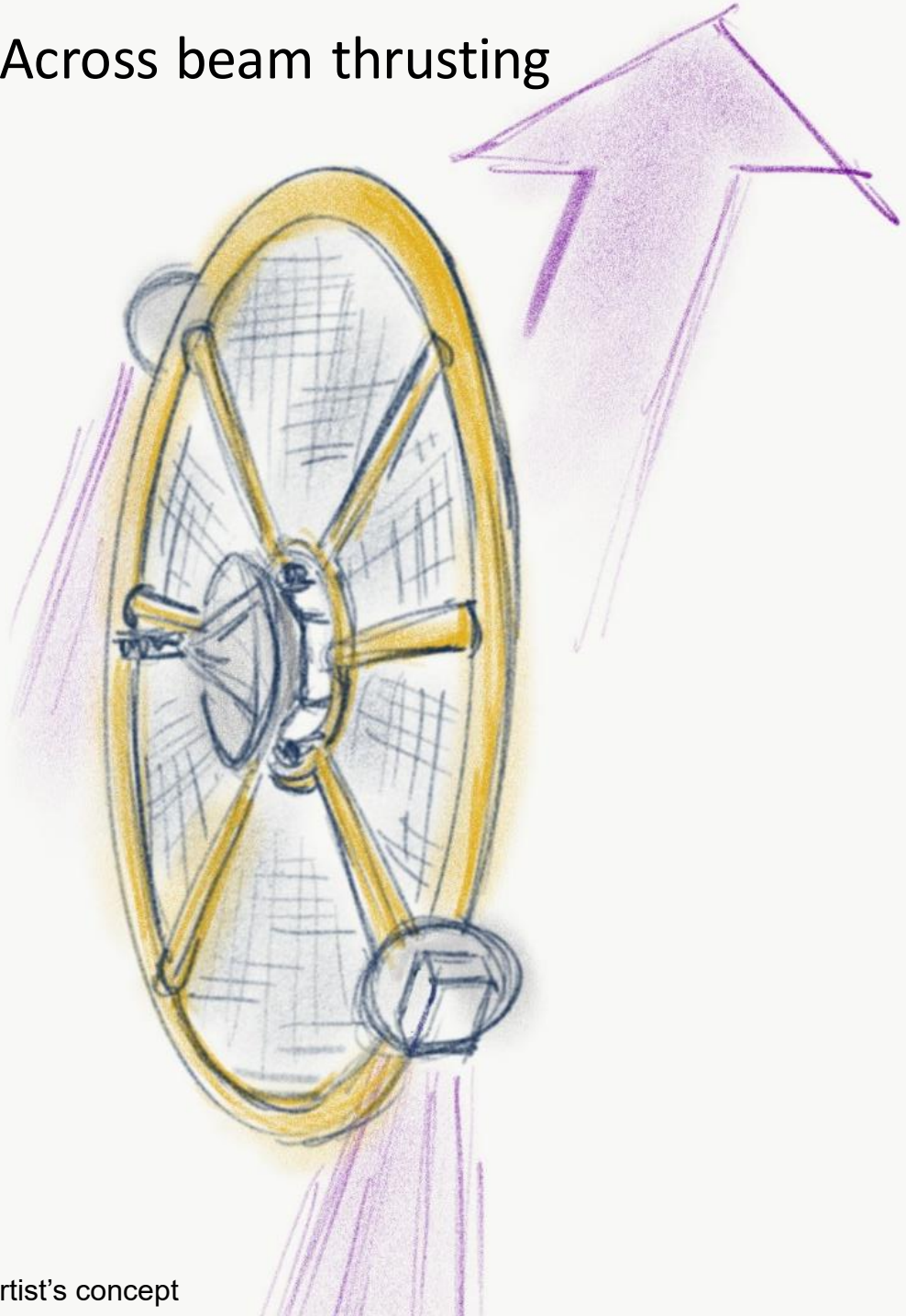
Array cells tuned to the laser frequency for efficiency > 50%

Array output voltage of 6 kV

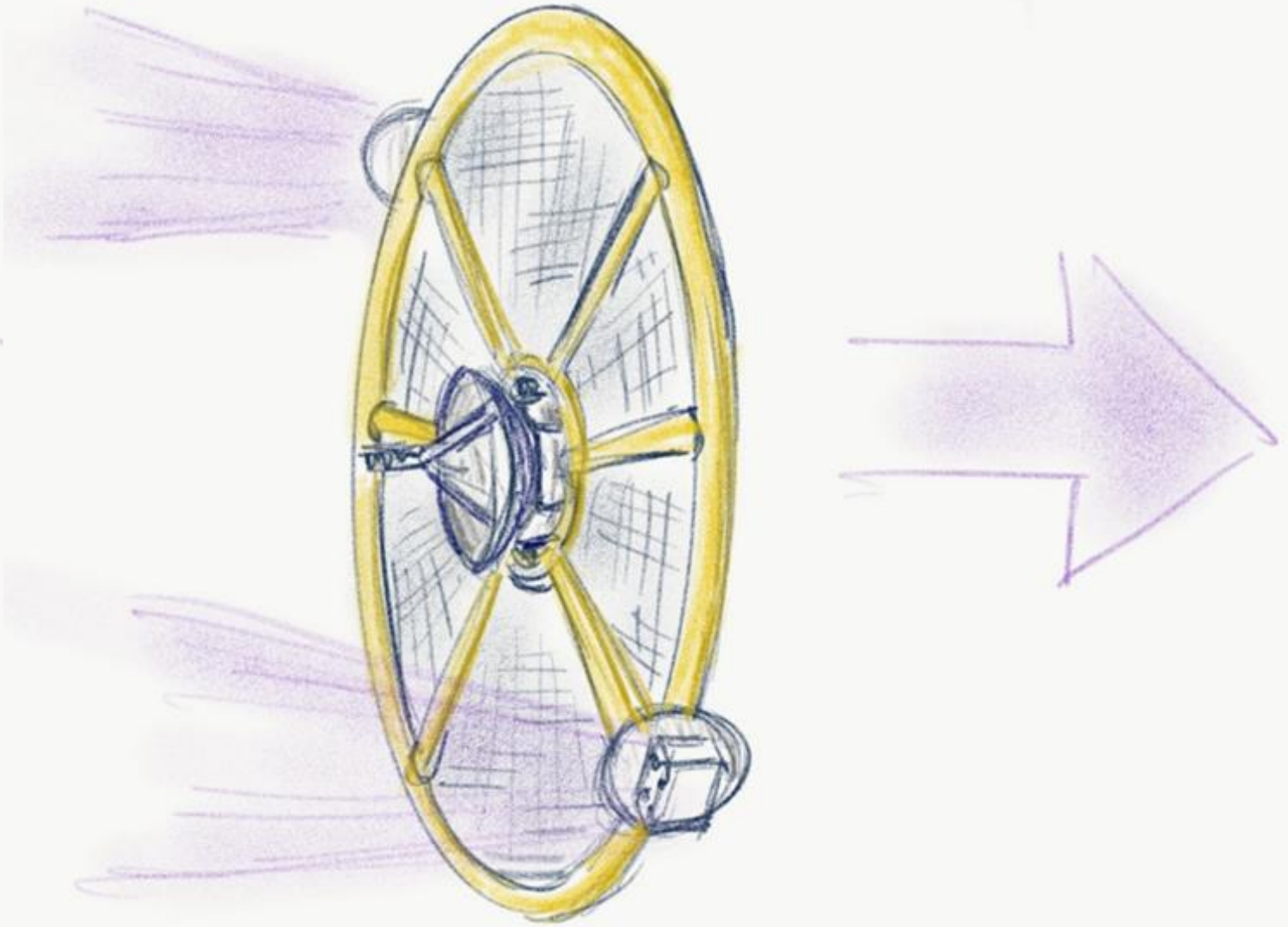
Artist's concept

Pre-Decisional Mission Concept

Across beam thrusting



Along beam thrusting



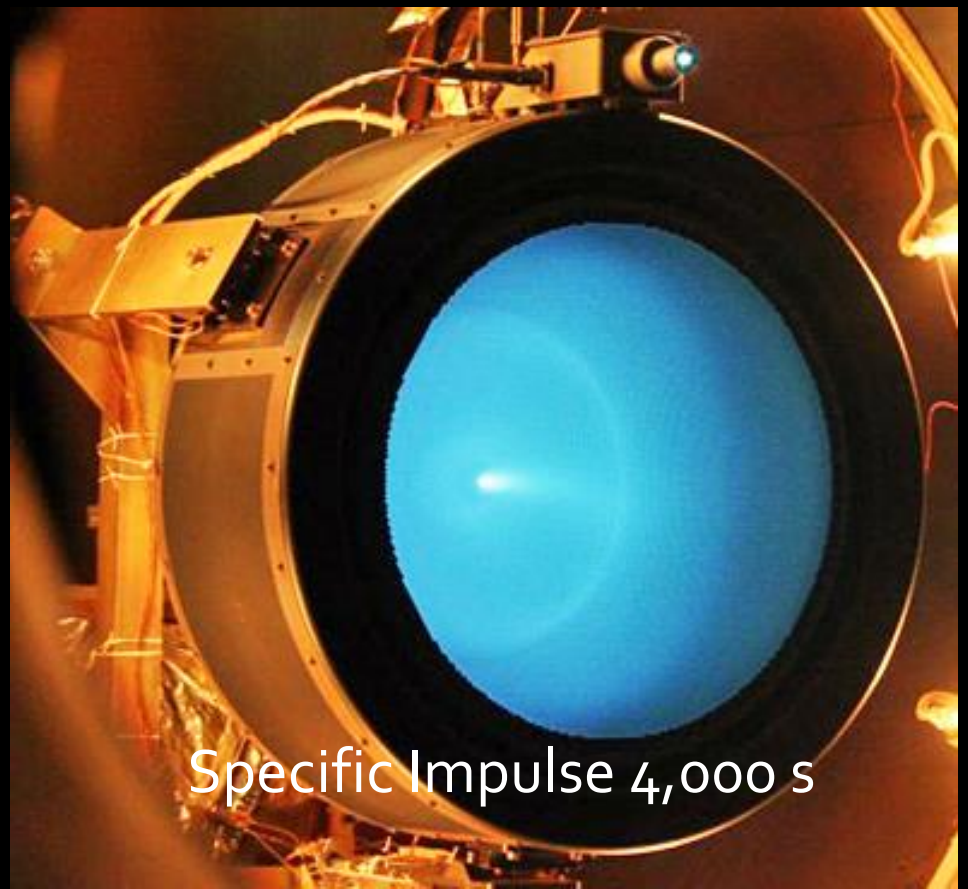
Artist's concept

Pre-Decisional Mission Concept

Lithium-fueled Ion Thruster

Xenon-fueled

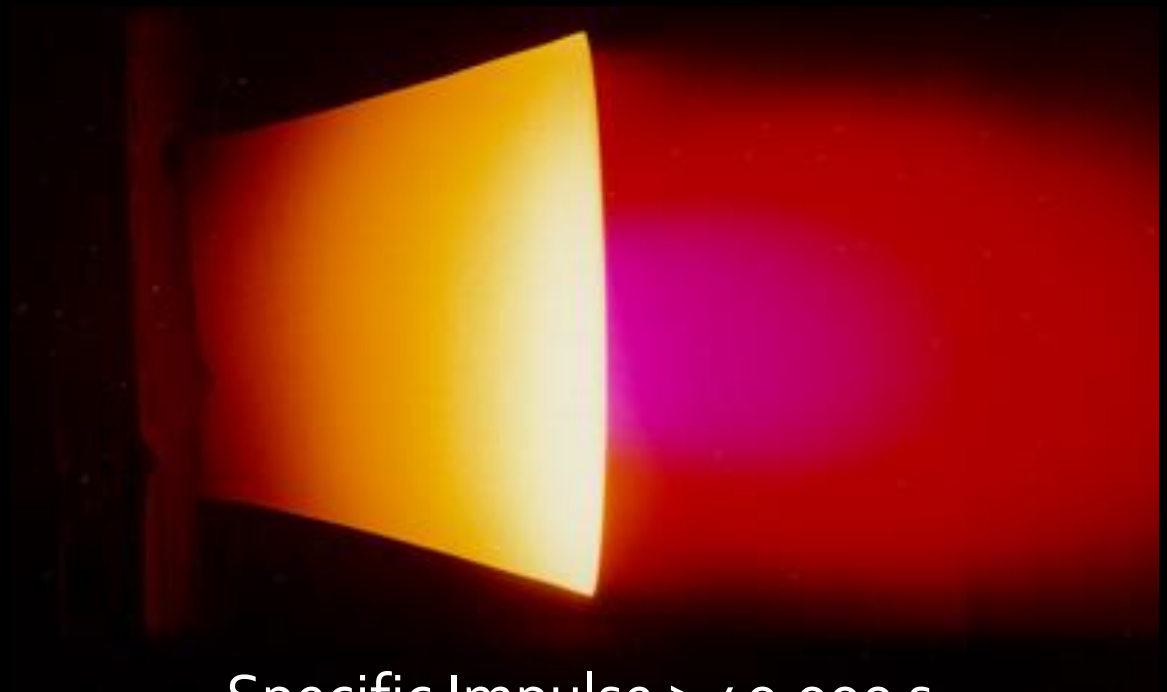
Today's ion engines have 10X the exhaust velocity of the best chemical rockets



Specific Impulse 4,000 s

Lithium-fueled

Our ion engines will have 10X the exhaust velocity of the best ion thrusters

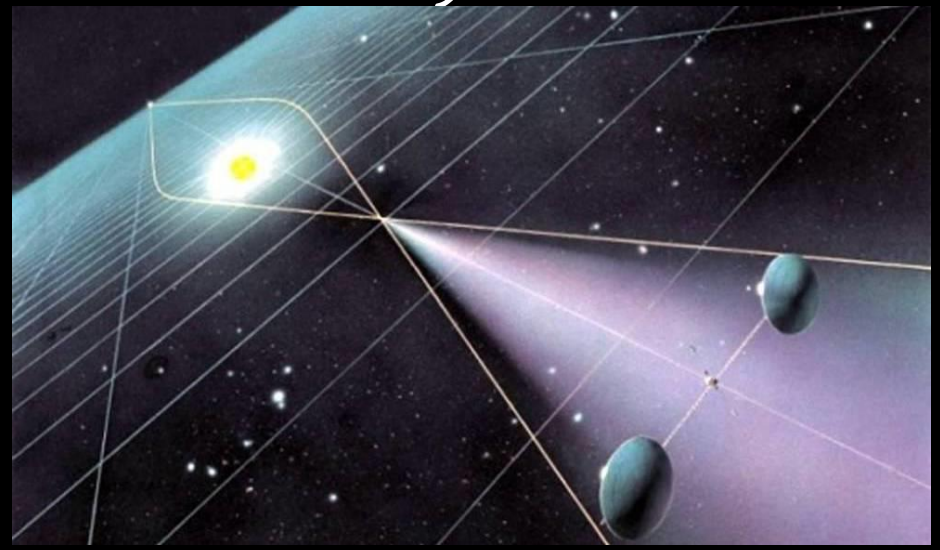


Specific Impulse > 40,000 s

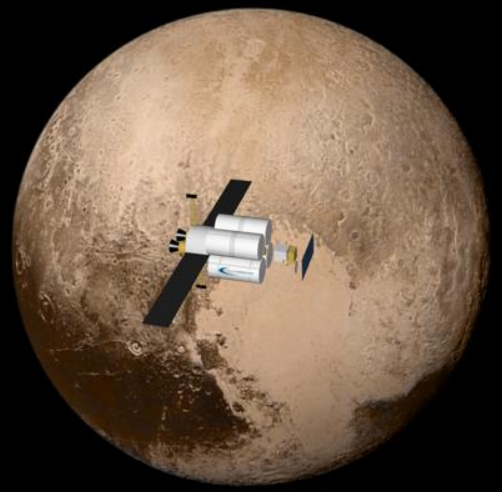
Pre-Decisional Mission Concept

What Might this Architecture Be Able to Do?

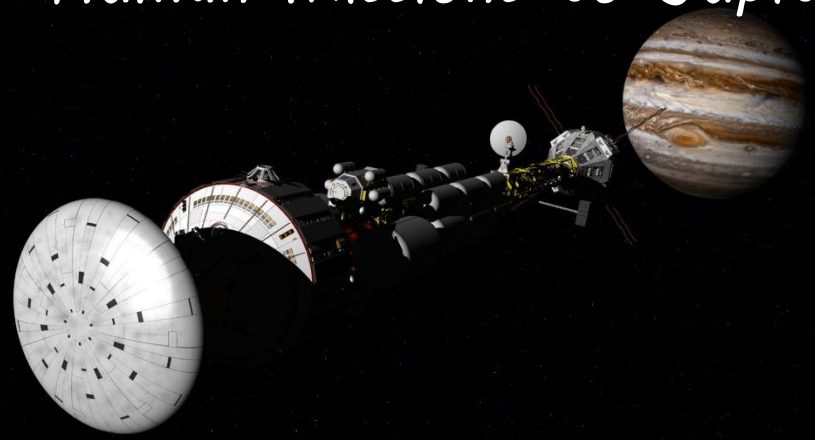
Solar Gravity Lens Mission



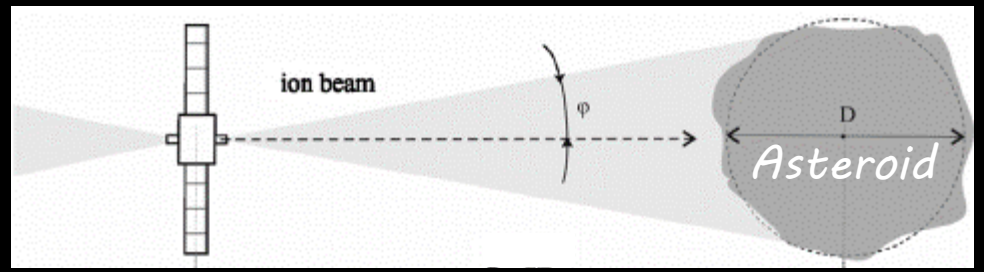
Pluto Orbiter Mission



Human Missions to Jupiter



Planetary Defense—Ion Beam Deflection



Artist's concepts

Pre-Decisional Mission Concept