

# Laser Propulsion Demo Consideration

Ad-hoc working group:

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# Rationale

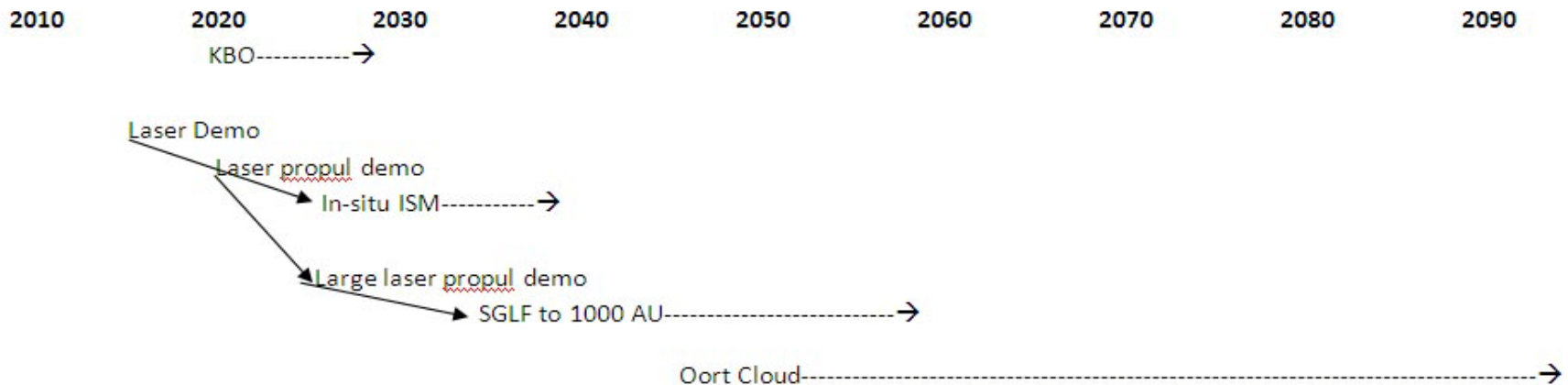
- Beamed energy propulsion is the only known technology leading to the stars
- Should provide some boost to ISM mission
- Supports concept of interstellar precursors
  - Technology advancement
  - Roadmap
- Can begin with small scale, low cost demo
  - Potential for private funding

# Laser System Technology Demonstrations

- **Smallsat Demo in Earth Orbit – A First Space-Based Laser Propulsion**
  - **Measure Acceleration**
  - **Implement gang of laser diodes with sufficient power**
  - **Advance New component technologies**
- **Ground Based beamed energy propulsion on a sail**
  - **Large Aperture Beam gossamer director**
  - **Direct conversion technologies in simulator chambers**
  - **High Power or phased array thrust measurement**
  - **3-6U CubeSat with Sail to be illuminated**
- **Adjunct to interstellar NEA Scout (or another)**
  - **Smallsat Burst Laser to chase and engage**
  - **Send cubesat Fresnel lens to concentrate (Beam) sunlight on to sail from close proximity**

# Building a Roadmap: The Dichotomy

- Beamed Energy is the Only Known Interstellar Propulsion Technology – Defines the Destination
- Small first-ever Laser Sail Demo is possible and likely affordable – Defines the Start
- The middle is muddled



# For the ISM Mission

## Physics is Good but the Math is Bad

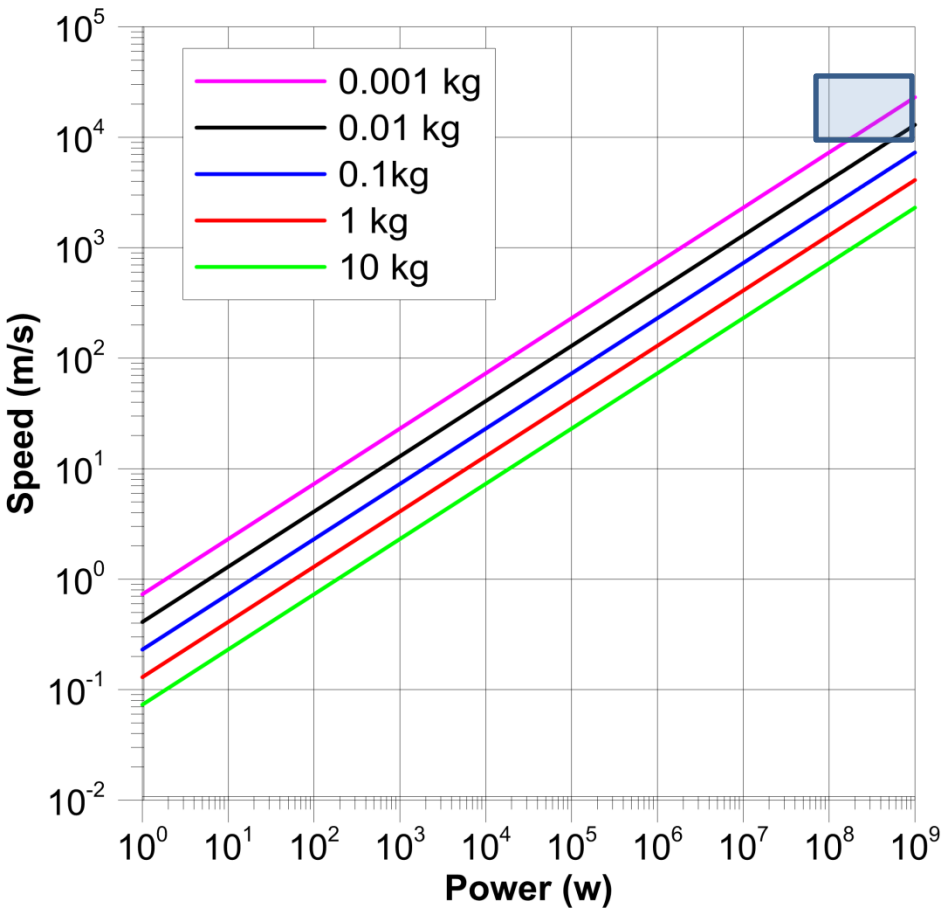
- Solar Sail to perihelion
  - $\sim 0.1 \text{ AU}$  and  $A/m \sim 200 \text{ m}^2/\text{kg} \Rightarrow v_{\text{esc}} \sim 13 \text{ AU/year}$
  - $\sim 0.1 \text{ AU}$  and  $A/m \sim 500 \text{ m}^2/\text{kg} \Rightarrow v_{\text{esc}} > 18 \text{ AU/year}$
- TeamX solid rocket sun-grazing  $\Delta v$  mission
  - $\Rightarrow v_{\text{esc}} \sim 13 \text{ AU/year}$
- REP with min Hall thrusters estimate extra  $\Delta v \sim 6 \text{ km/s/year}$ 
  - $\Rightarrow$  perhaps  $30 \text{ km/s} \sim 6 \text{ AU/y}$
- **CONCLUSION: For laser sail technology to be of ISM mission value we need boost  $\sim 10$  to  $30 \text{ km/s} = 2\text{-}6 \text{ AU/year}$**

# How to Achieve $\Delta v \sim 10$ to 30 km/s

## Parametric Analyses by Phil Lubin

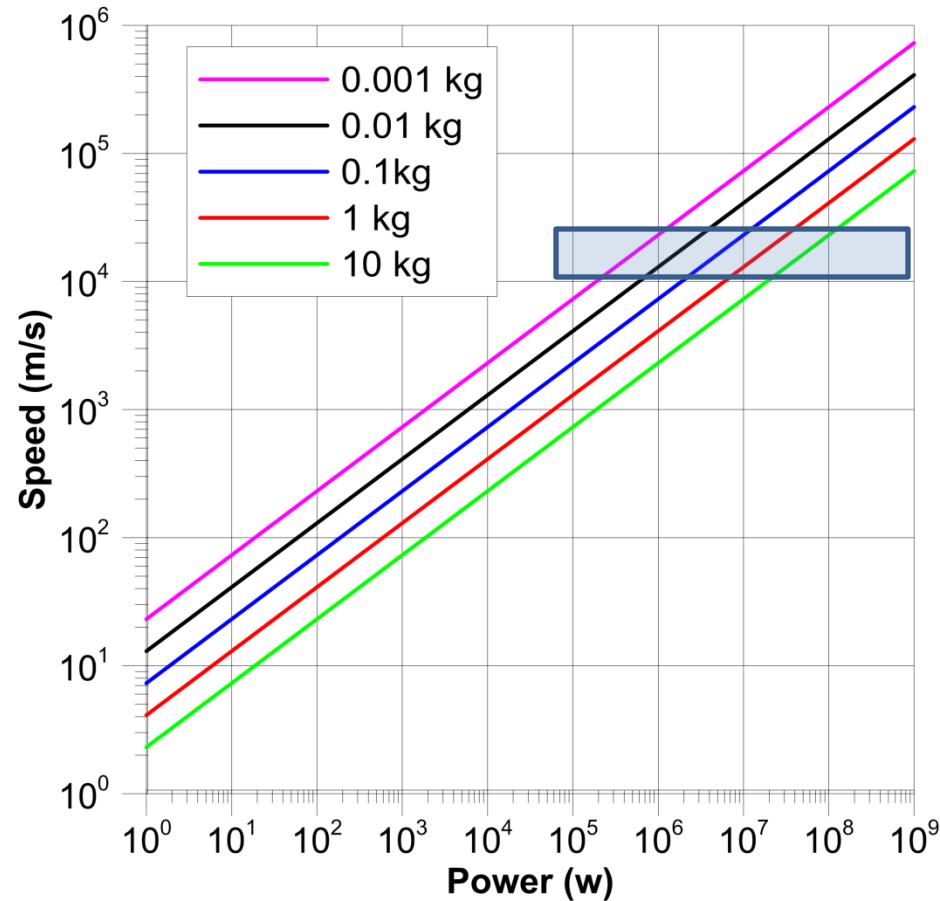
### Speed vs Laser Power and Spacecraft Mass

Optimized for Spacecraft Mass = Sail Mass  
Optics Size = 0.1m - Sail thickness =  $1\mu$   
Mass is bare spacecraft mass



### Speed vs Laser Power and Spacecraft Mass

Optimized for Spacecraft Mass = Sail Mass  
Optics Size = 100m - Sail thickness =  $1\mu$   
Mass is bare spacecraft mass



# Conclusions

- **The interstellar goal requires laser sailing technology demonstration and development**
- **Benefits of laser sailing for interstellar precursors require larger scale systems beyond the current planning horizon**
- **A small motivating demonstration should be considered, beginning with a preliminary design to define requirements**
- **Synergy with other technology of laser communication, power and defense applications will be of interest**
- **KISS study follow-on requirements study recommended to include ground and space based tests**