Free-Space Optical Communication

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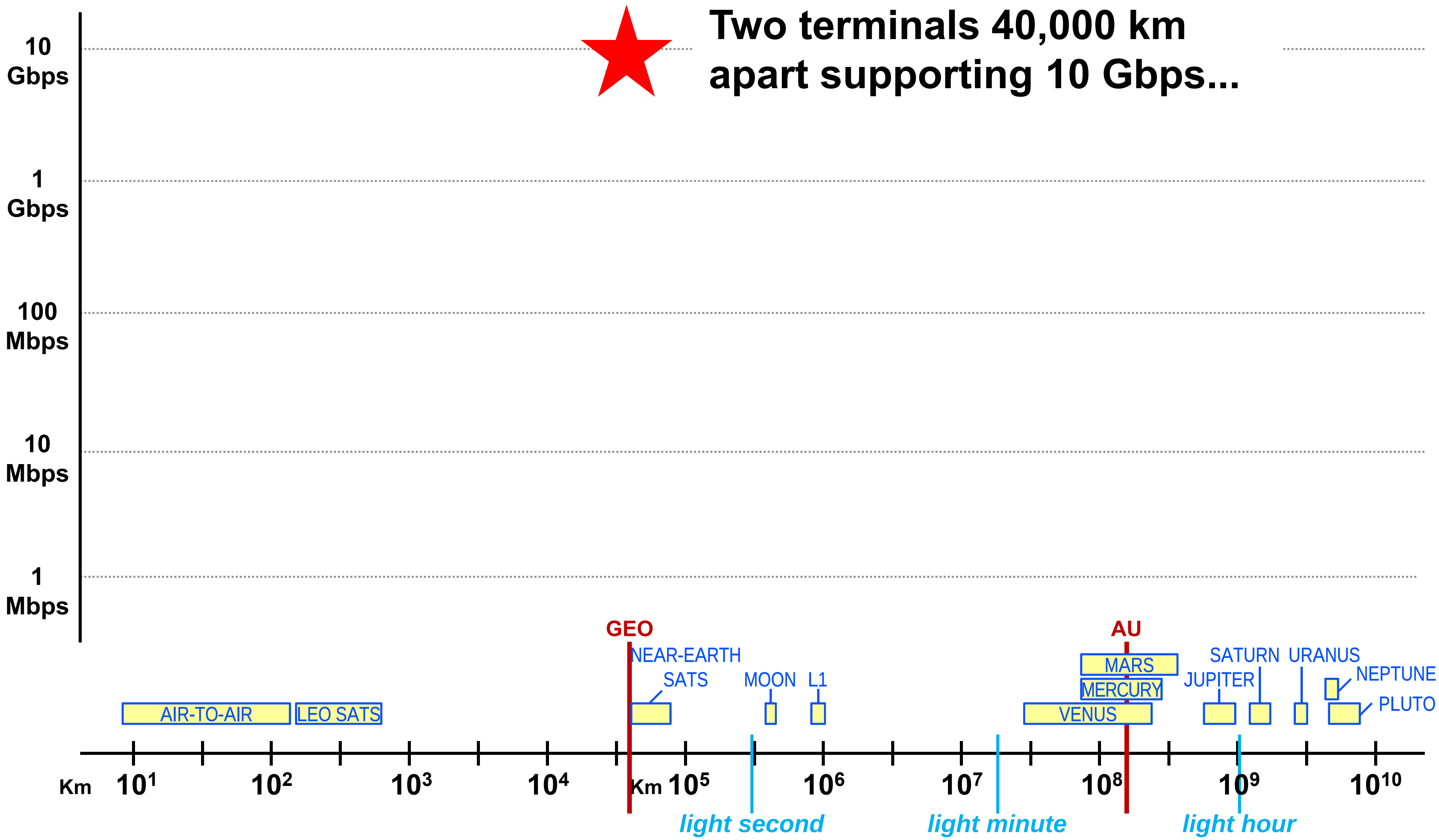
- Factoids
- Opportunities & challenges
- The technology
- An example

The Diffraction Limit



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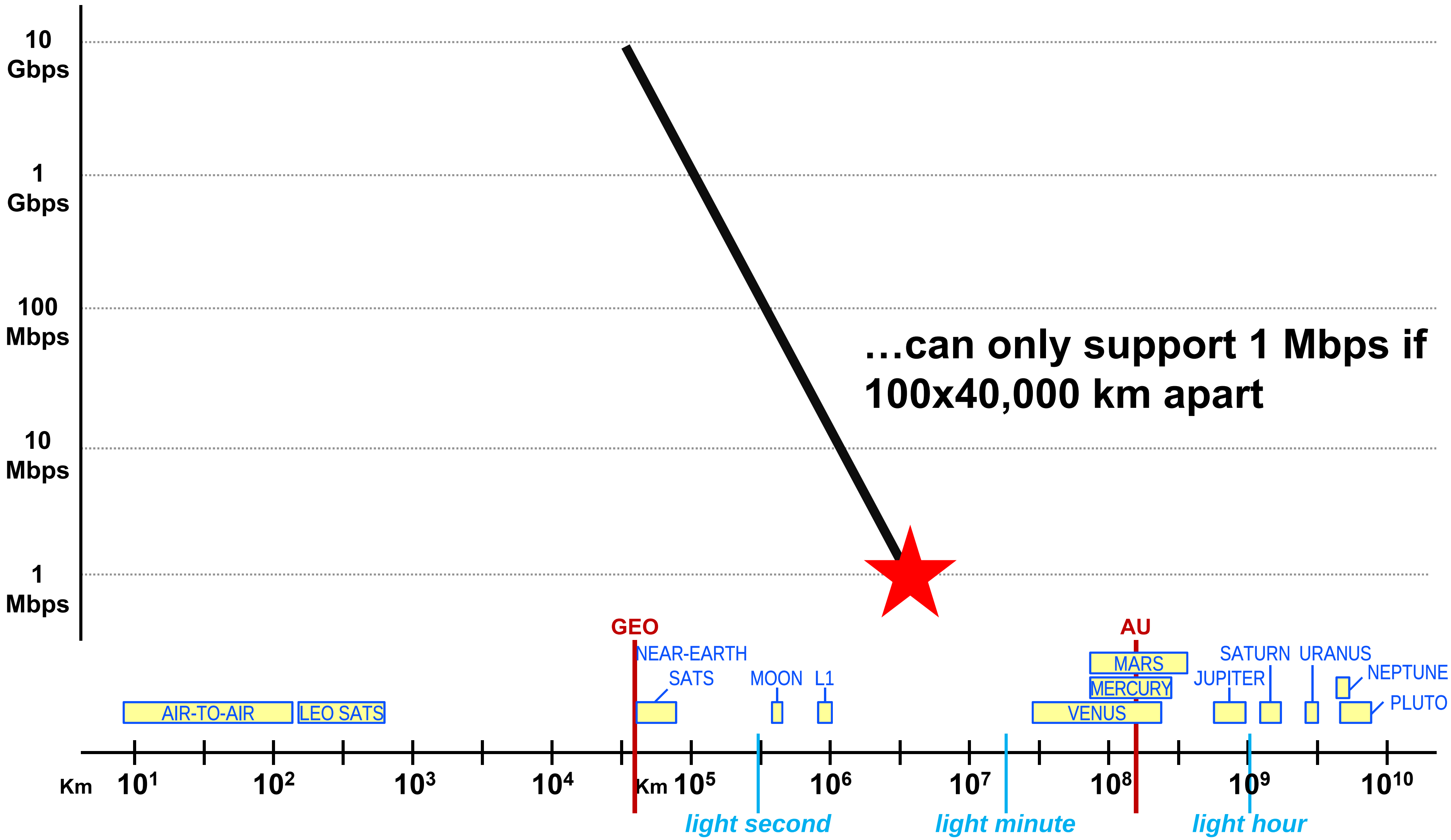
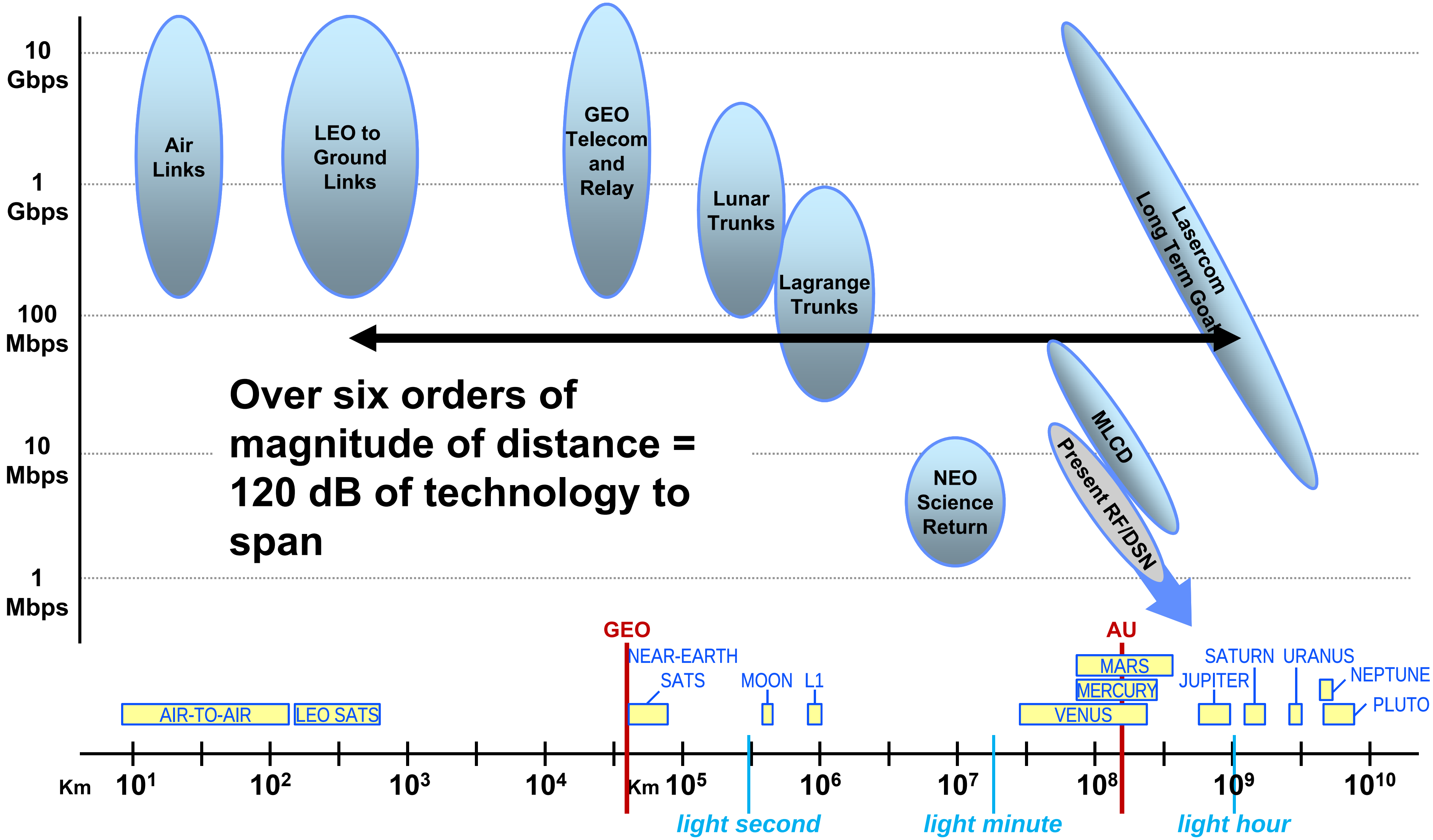


All the High-Rate Links Anyone Could Be Interested In (until we travel to the stars)



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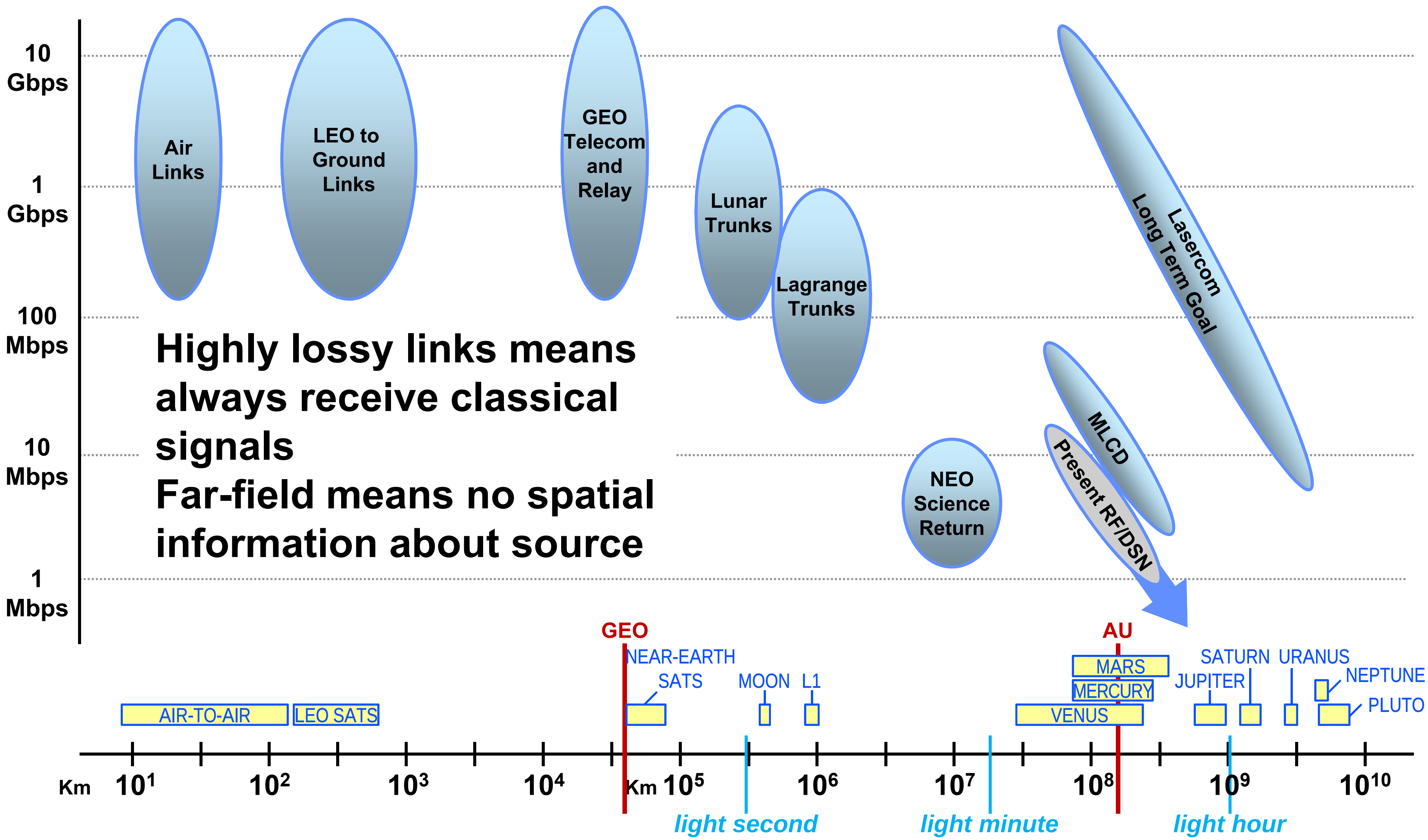
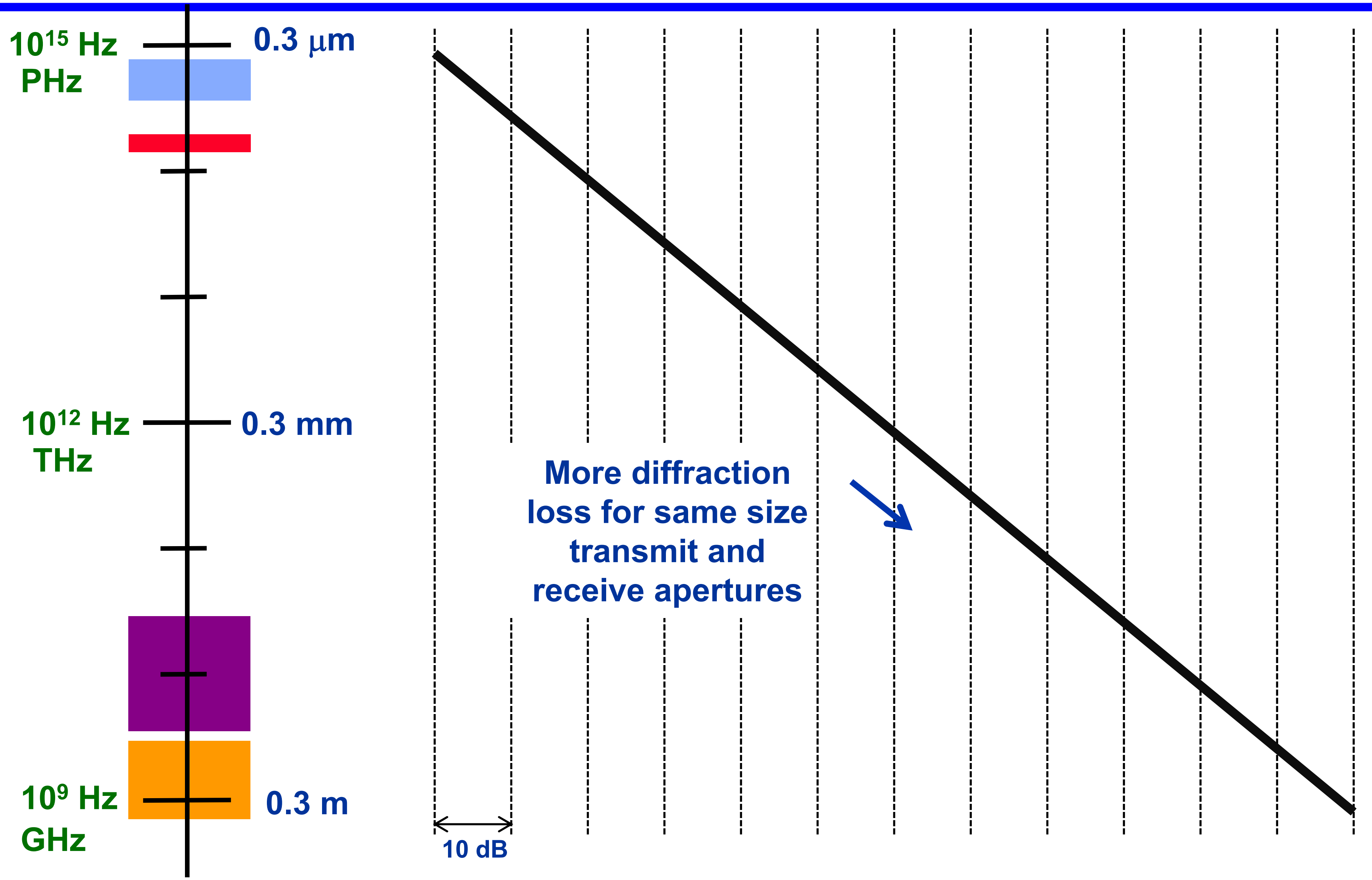


Highly lossy links means always receive classical signals

Far-field means no spatial information about source

Radio Frequency (RF) vs Optical



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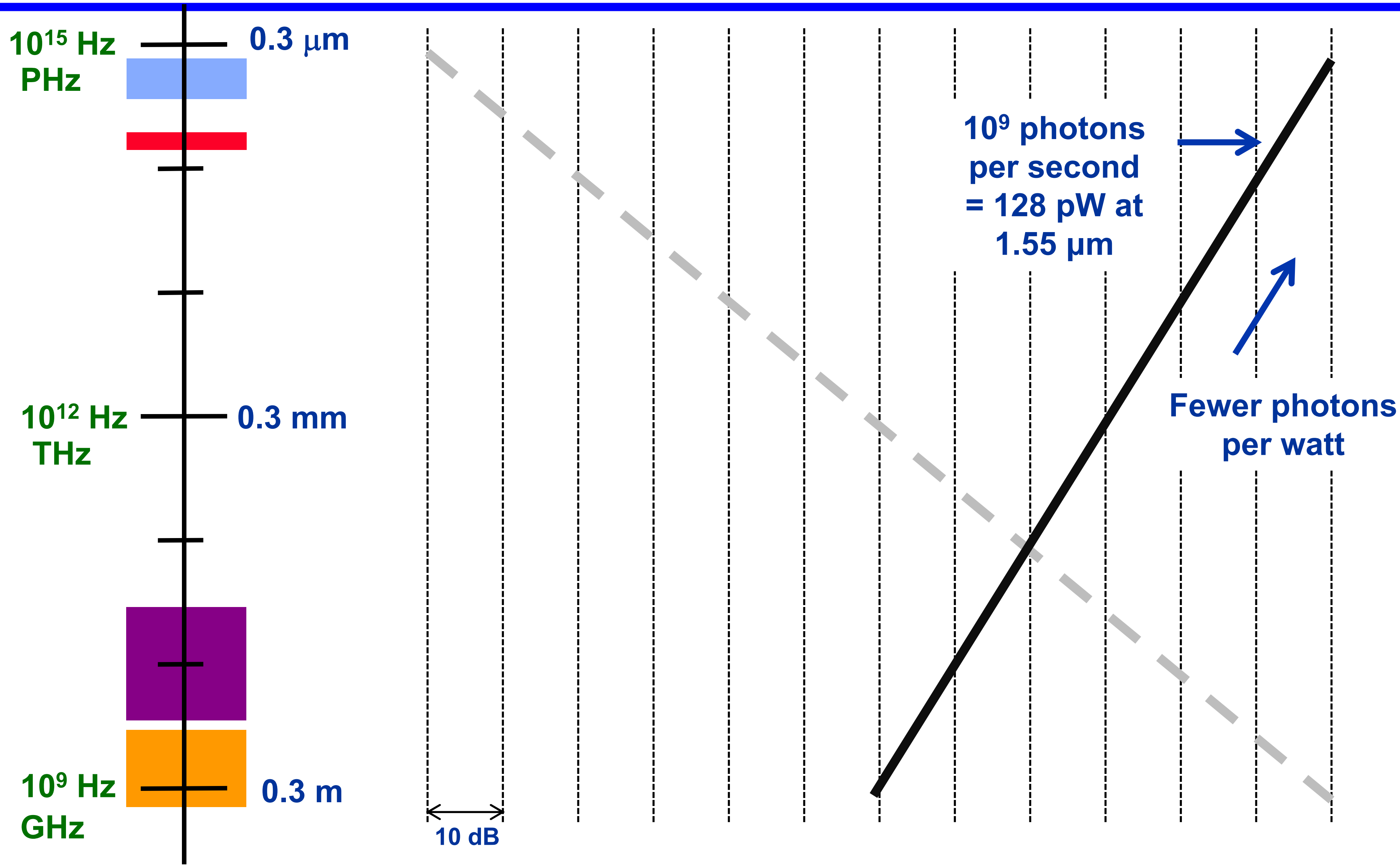

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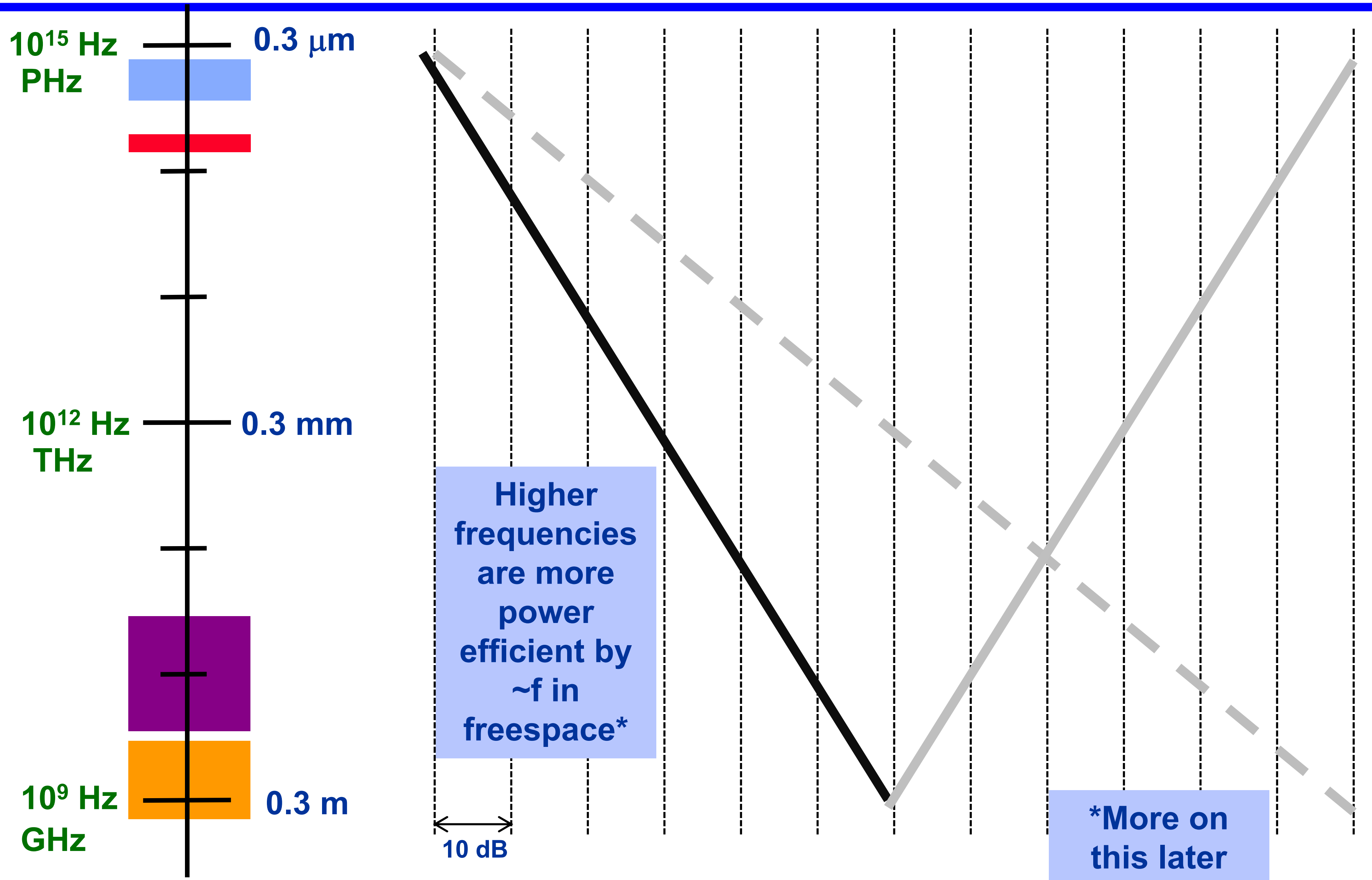
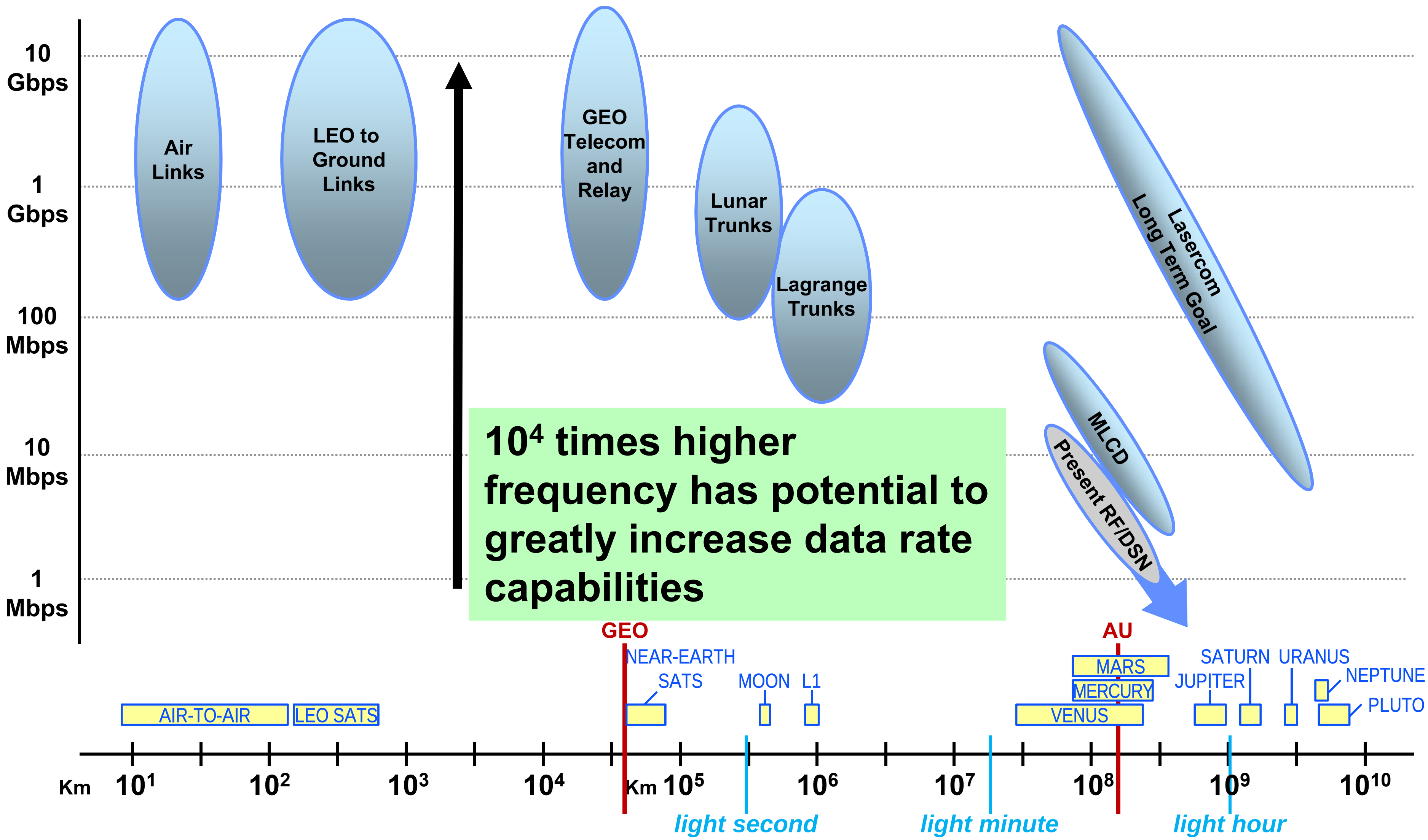
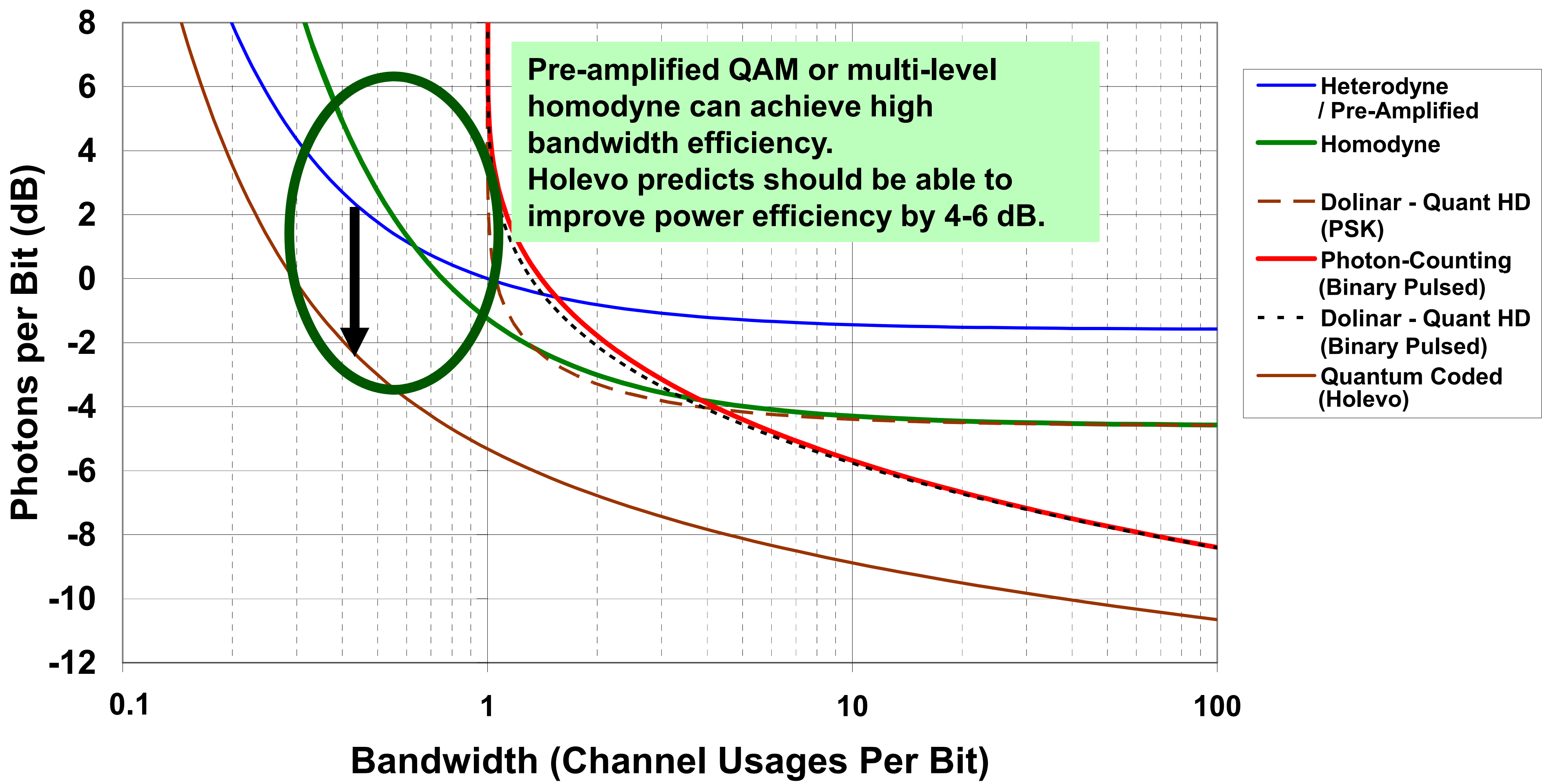


Opportunity/Challenge –
Achieve Narrow-Beam Benefits of Optical



Challenge –
Achieve Optimum Coded Efficiency

*Channel/noise-limited capacities
Arbitrary modulations



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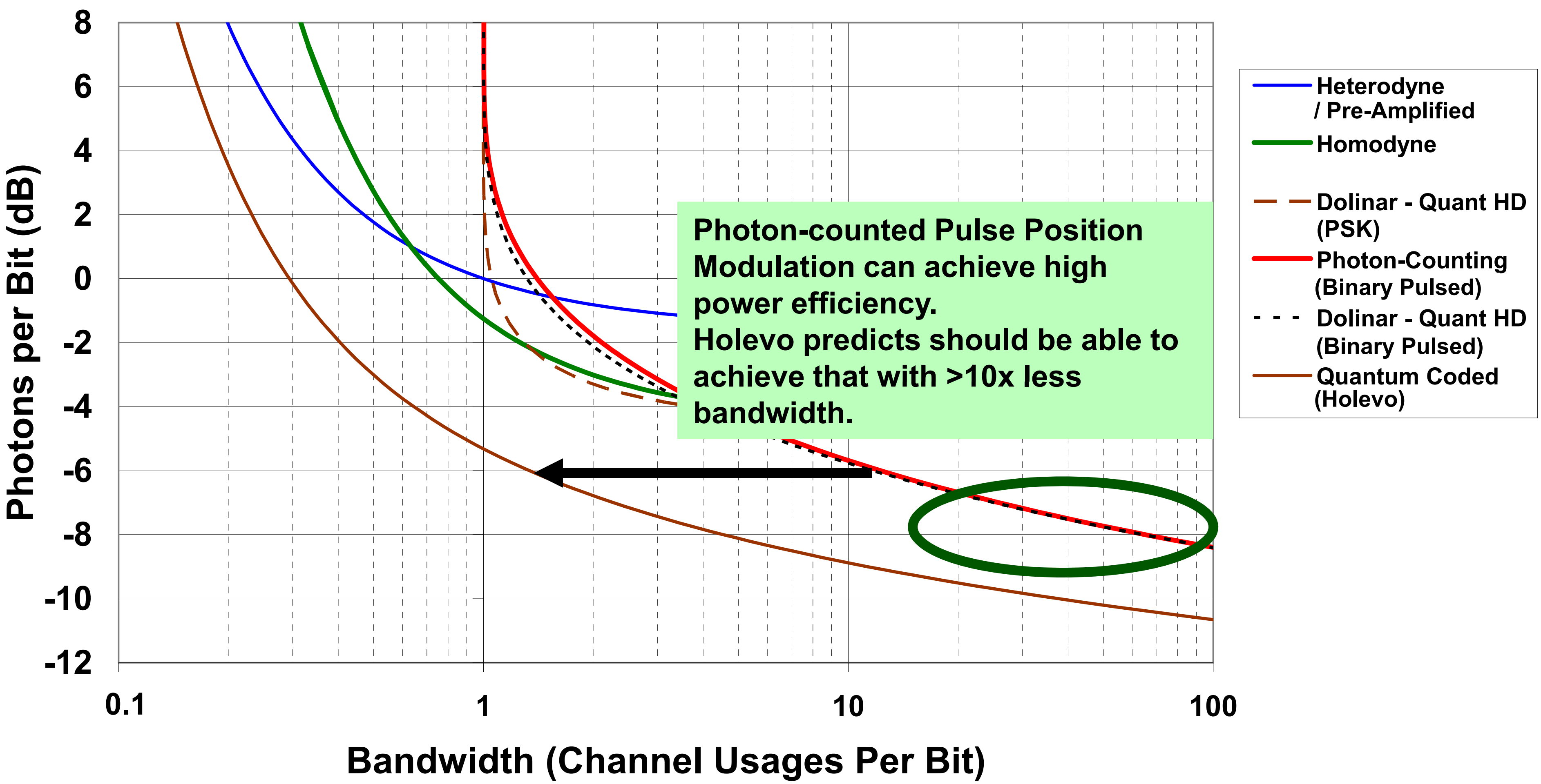

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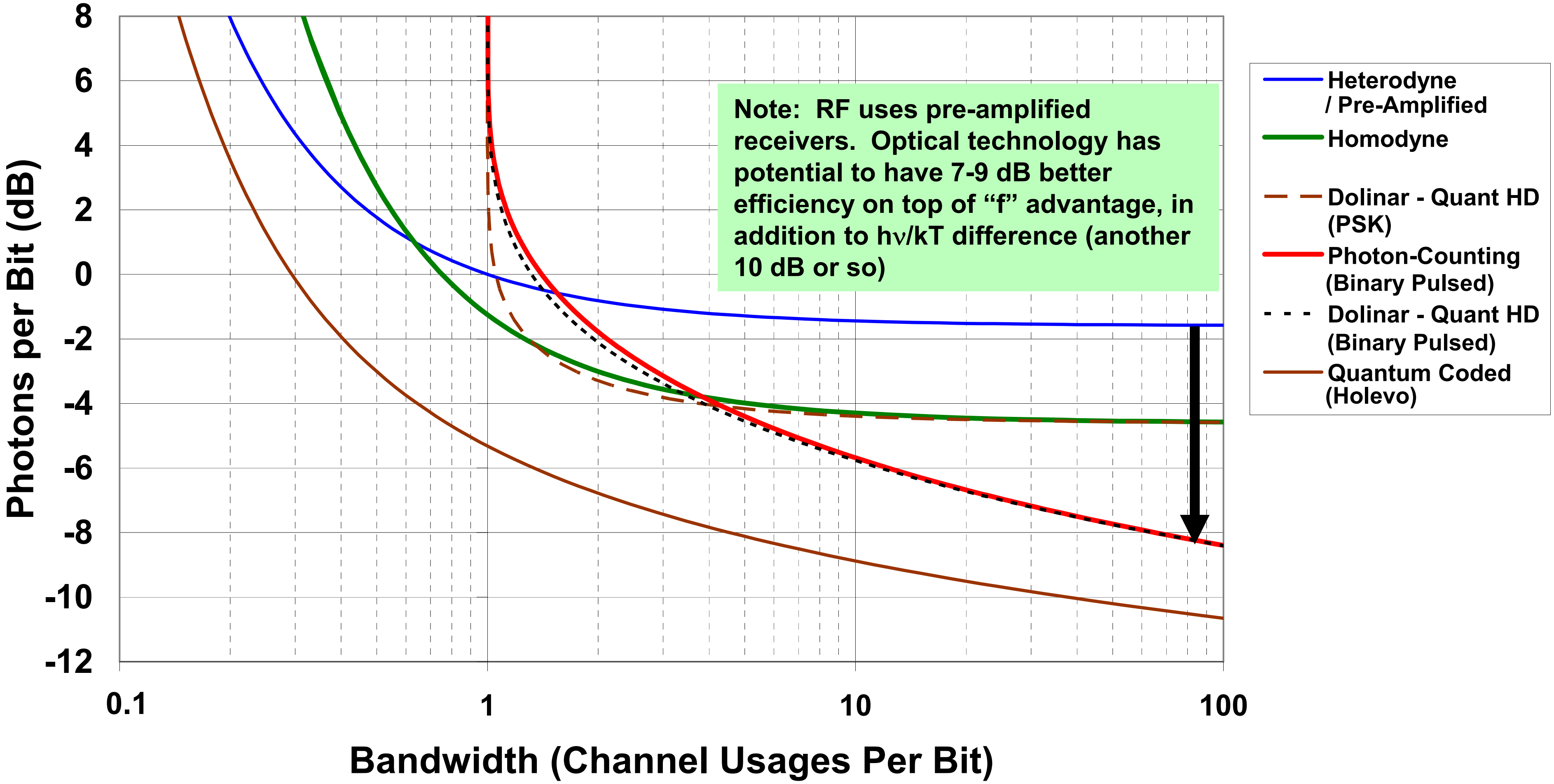

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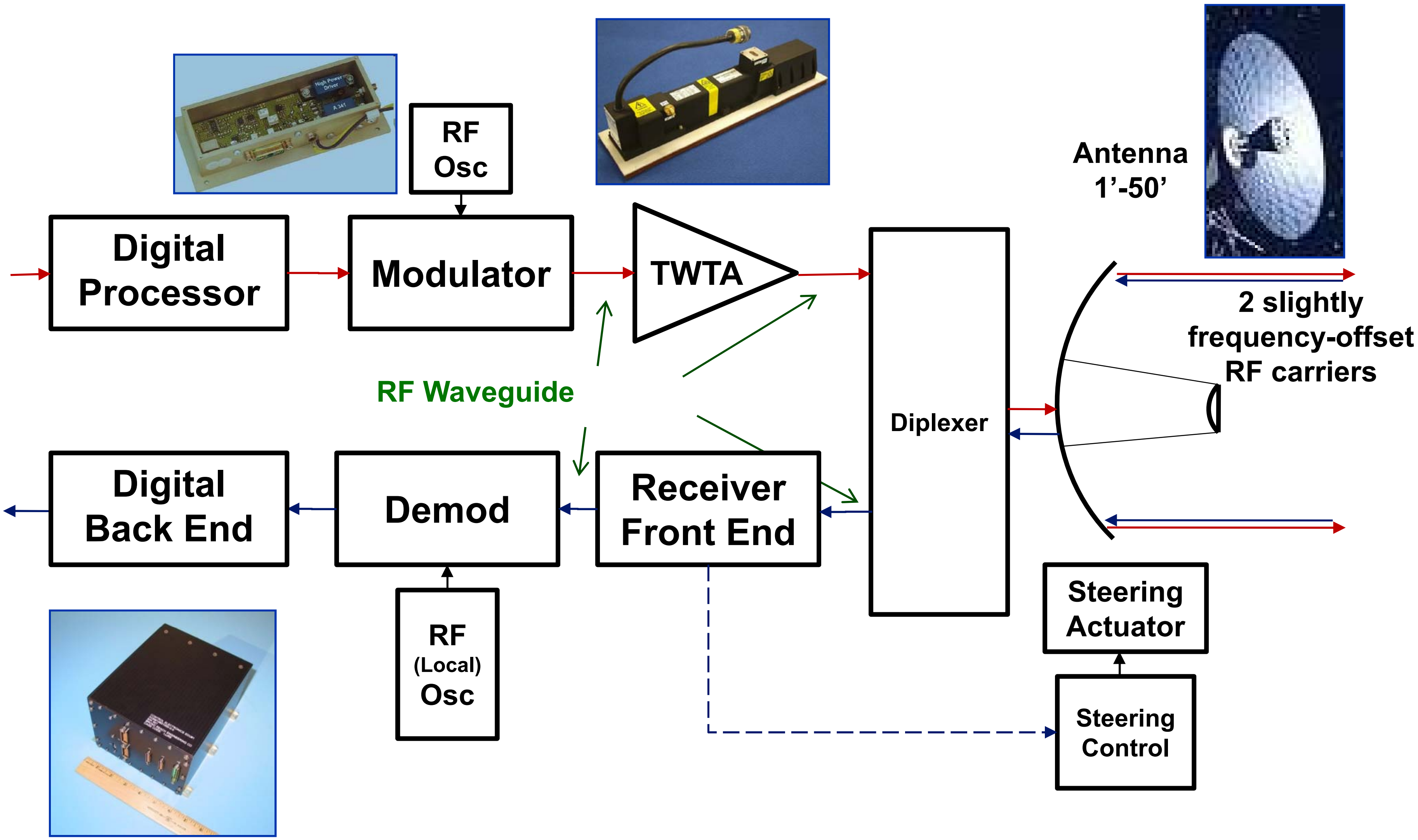
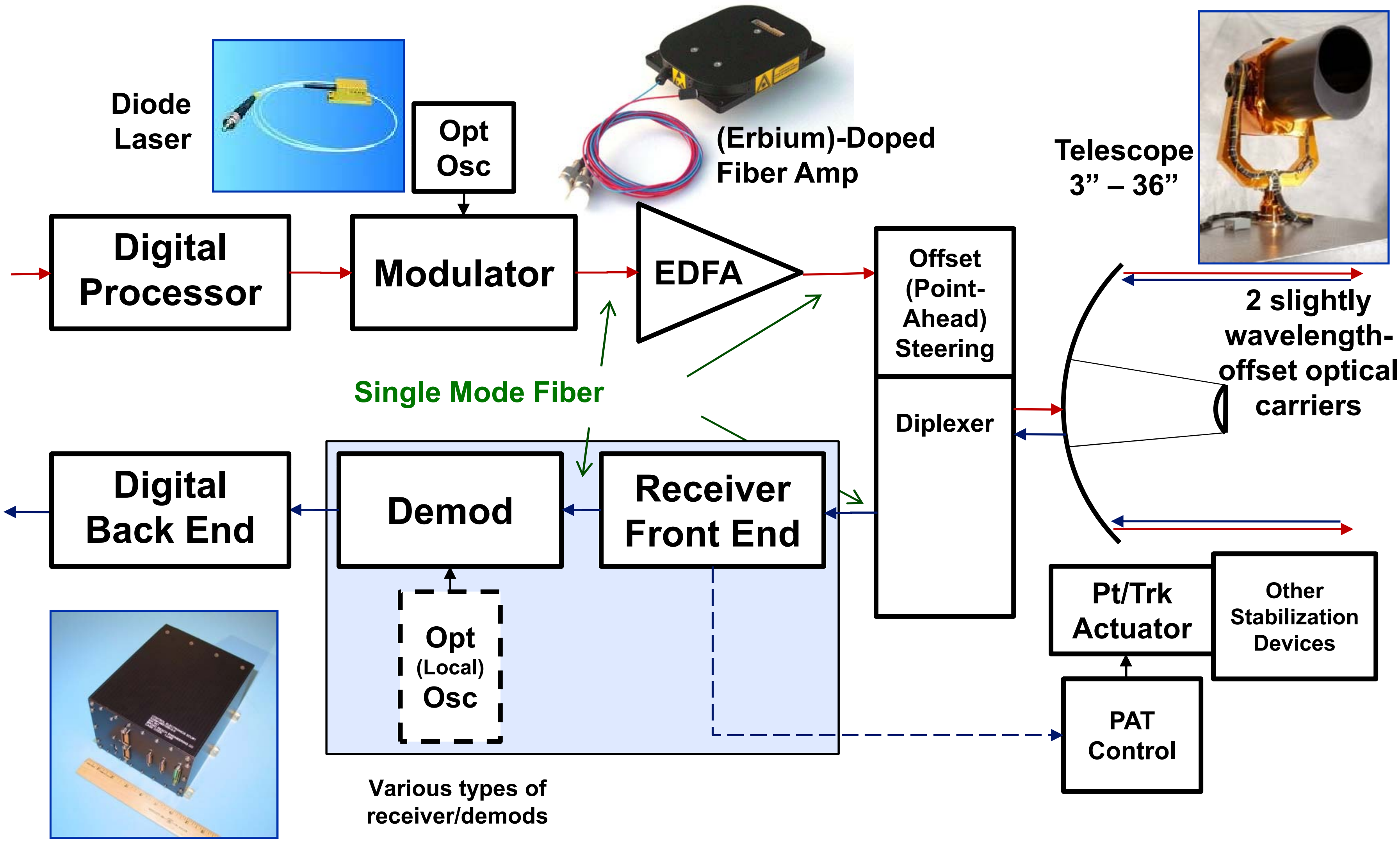
Parts of a Free-Space Communications System – RF



Parts of a Free-Space Communications System - Optical



What's Hard About Optical?
In Both Vacuum and Atmospheric Links

- Finding (acquiring) where to point
- Stabilizing (tracking) very narrow beam in face of platform micro-vibrations
- Subsystems must withstand vibrations of launch, wild temperature swings, and radiation

What's Hard About Optical?
In Atmospheric Links

- Transmitting beam up through atmosphere and preserving high gain in face of turbulence
- Receiving low-power signal via large aperture and coupling light into single-mode (or other small) receiver in face of turbulence
- Extremely narrow-band filtering of received light when pointed near sun
- Dealing with wide power fluctuations
- *Clouds, fog, trees…..*

What's Hard About Optical?
Technologies

- High-optical-power, low-electrical-power transmitters that can achieve high speed, high peak powers, high optical quality, etc
- Receiver components and architectures that can achieve near-optimum performance at desired rates and desired aperture sizes
- Present-day photon-counting technologies not simply suitable for space environment

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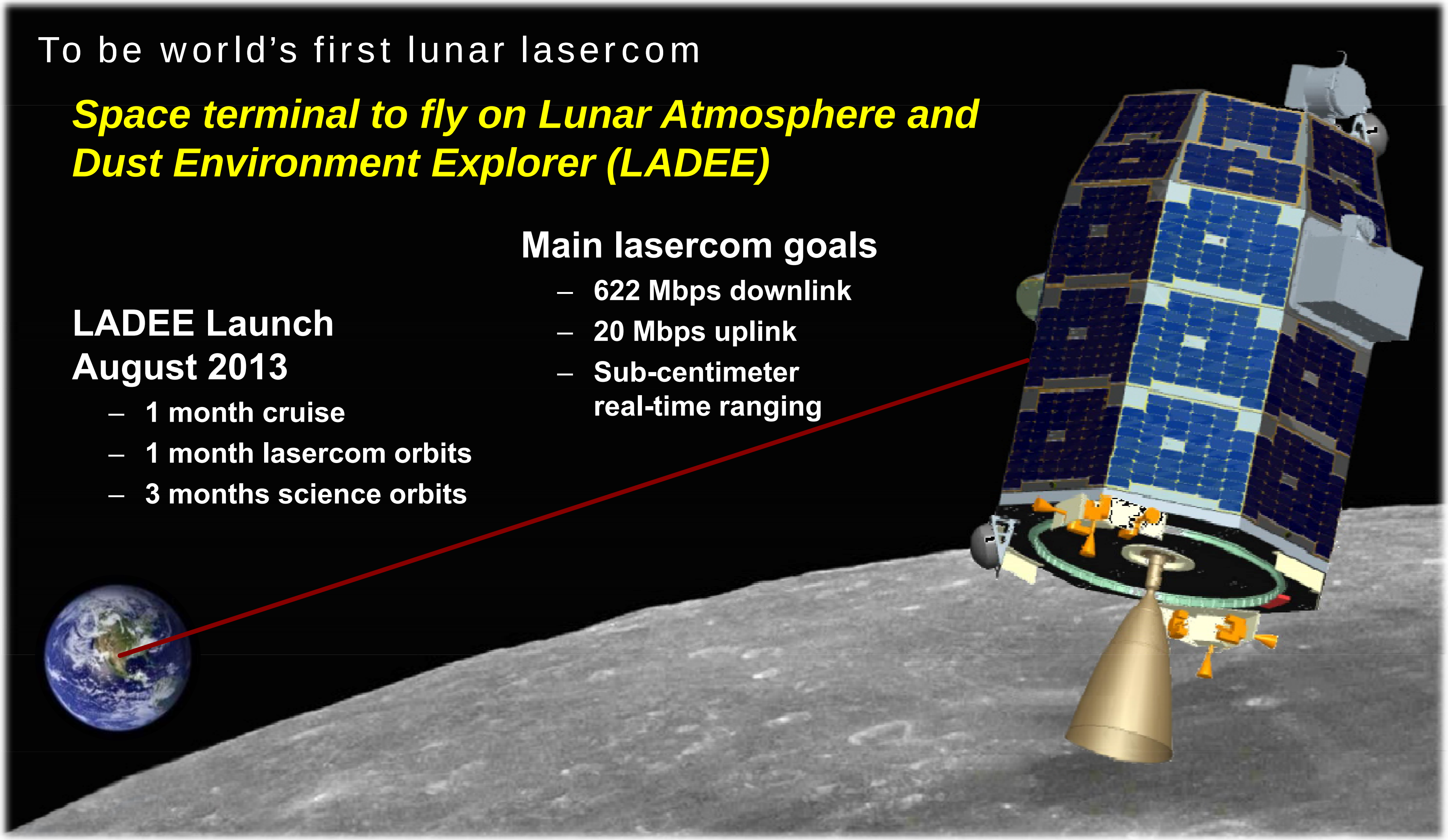
Lunar Laser Communication Demonstration Program

To be world's first lunar lasercom

Space terminal to fly on Lunar Atmosphere and Dust Environment Explorer (LADEE)

LADEE Launch August 2013
- 1 month cruise
- 1 month lasercom orbits
- 3 months science orbits

Main lasercom goals
- 622 Mbps downlink
- 20 Mbps uplink
- Sub-centimeter real-time ranging



Summary

- Present technologies adequate for achieving wide range of high-performance (optical) communications systems
- Stage is set for optical transmission and reception based on quantum properties of light