# Laser System for the Lunar Laser Ranger

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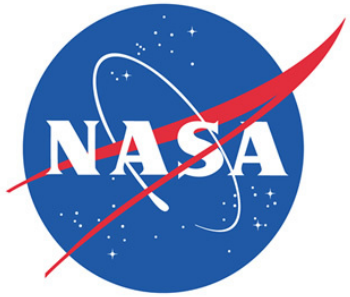


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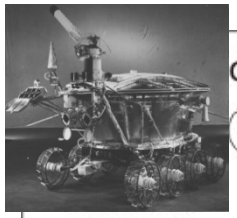
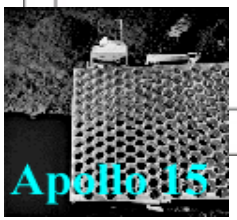
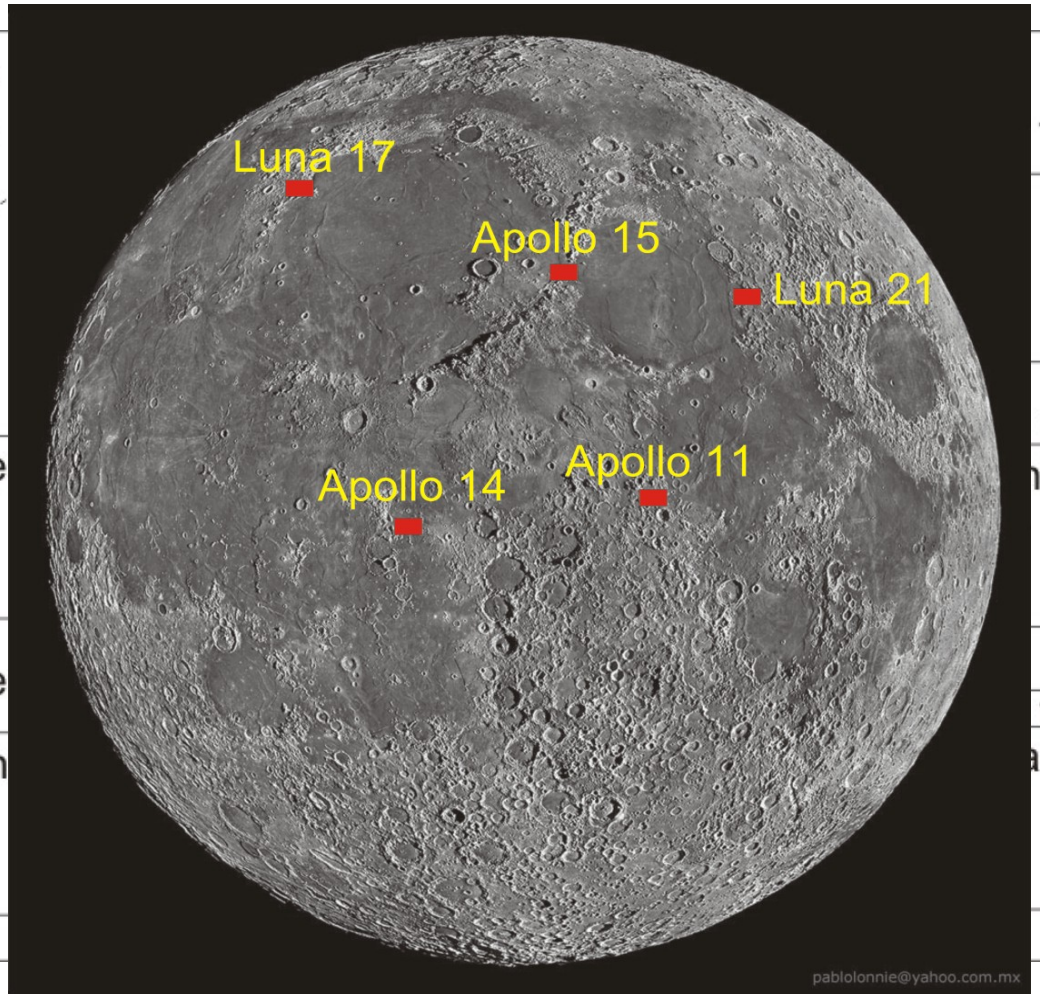
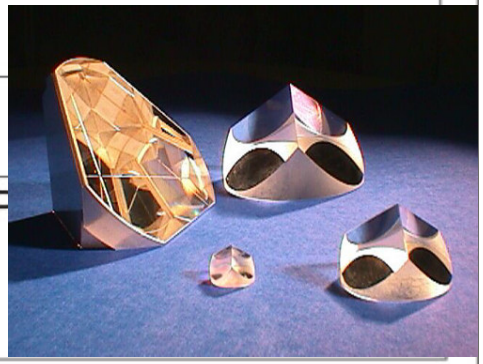
# Fundamental Motivation: LLR







# Goals

Obtain state-of-the-art diode pumped solid state (DPSS) YAG lasers:

- that are capable of supporting Next Generation SLR as well as LLR
- taking into consideration all the laser ranging system engineering issues involved.

# Design Specifications

**Low Energy, 1 KHz laser for SLR only (Specification in**

**Major Features:** The proposed laser has the following desirable features

Hermetically sealed **DPSS** master oscillator
DPSS regenerative amplifier producing ~0.5mJ per pulse @ 1000 Hz@ 25 ps pulses; sub-mm NP accuracy

**High Energy, 10/20 Hz laser for SLR (may be used for GNSS, GEO) and LLR**

**Major Features:** The proposed laser has the following features

Flashlamp pumped (FLP) power amplifier producing up to ~100 mJ per pulse @ 20Hz@532nm

Trigger pulse with **<30 ps** jitter

Excellent beam pointing **stability**

Thermo stabilized second harmonic generator options

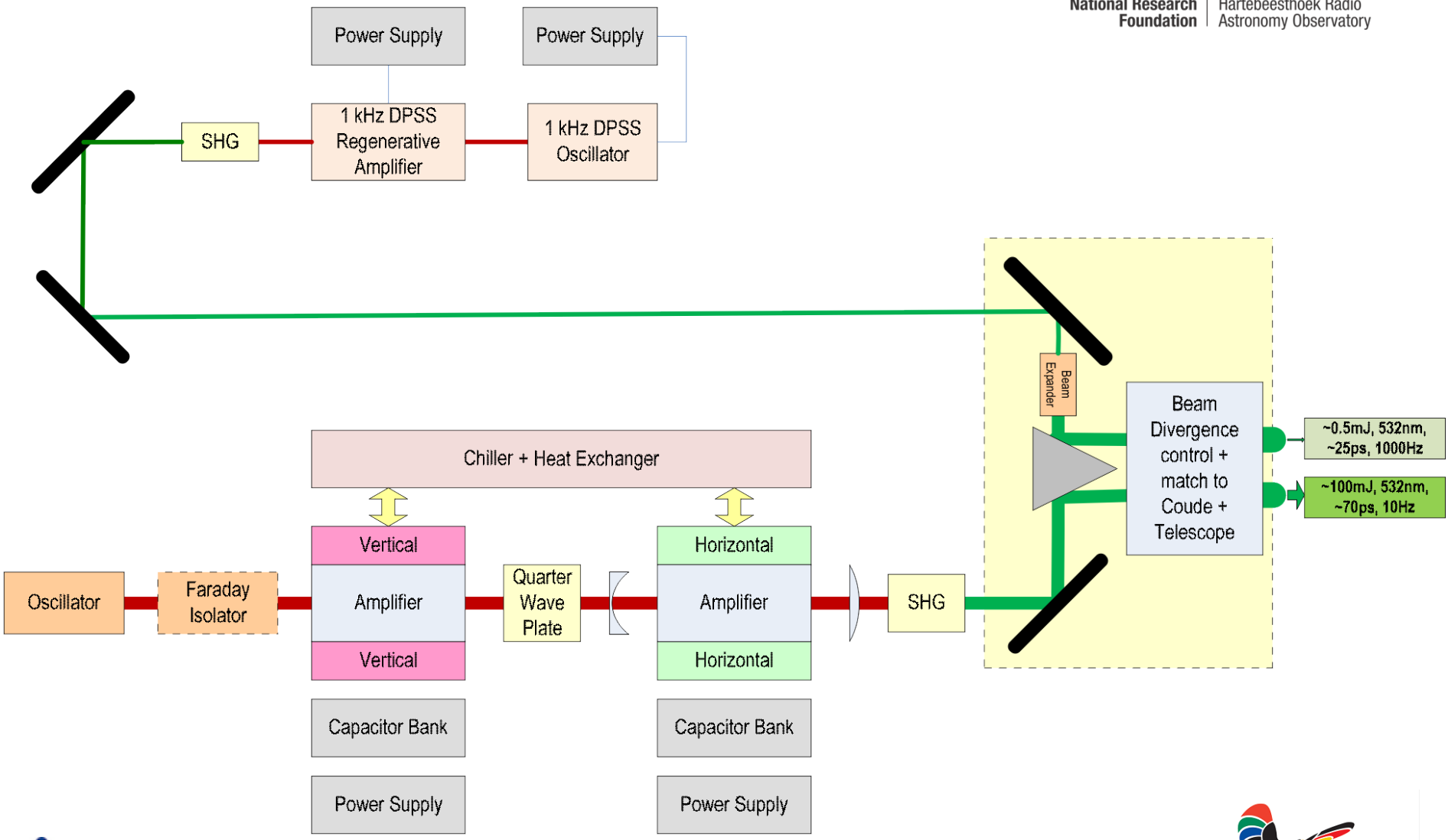
**PC control** via USB using Windows OR LabVIEW™ drivers;

Remote control via keypad

## SPECIFICATIONS [1]

| Model | Model 1a, kHz Laser | Model 1b, kHz Laser | Model 2 |
|---|---|---|---|
| Output energy, mJ | | | |
| at 1064 nm | ~0.9 mJ | ~2.5 mJ | ~200 mJ |
| at 532 nm | **~0.45 mJ** | **~1.3 mJ** | **~100 mJ** |
| Pulse energy stability (Std. Dev), % [2] | | | |
| at 1064 nm | ~0.5% | ~0.5% | < 0.8 % |
| at 532 nm | ~0.8% | ~0.8% | <1.0 % |
| Pulse duration (FWHM) at **1064nm**, ps [3] | **25±2 ps** | **<80±2 ps** | **<80 ± 3 ps** |
| Pulse duration stability, ps [4] | ±1 | ±3 | ±3 |
| Pulse repetition rate, Hz | **1000 Hz** | **1000 Hz** | **10 or 20 Hz** |
| Triggering mode (Internal/External) | internal/external | internal/external | internal/external |
| Typical SYNC OUT pulse delay, ns [5] | -500...50 | -500...50 | - 500...50 ns |
| SYNC OUT pulse Jitter (Std. Dev), ns | <0.1 | <0.1 | < 0.1 ns |
| Spatial mode [6] | $TEM_{00}$ | $TEM_{00}$ | $TEM_{00}$ |
| Beam divergence, mrad [7] | <1.6 | <1.6 | < 0.5 mrad |
| Typical beam diameter, mm [8] | ~3 | ~3 | ~12 mm |
| Beam pointing stability, µrad [9] | <30 | <30 | < 50 µrad |
| Pre-pulse contrast | >200:1 | >200:1 | > 200:1 |
| Polarization | linear, >100:1 | linear, >100:1 | linear, vertical, > 100:1 |
| *Laser head size (W x L x H), mm* | *455 x 1035 x 242* | *455 x 1035 x 242* | *453x1224x250* |
| *Power supply size (W x L x H), mm* | | *472 x 460 x 290* | *550x550x600* |
| *Chiller* | *not required, air cooled* | *not required, air cooled* | *Rate of ~ 8 l/min* |
| *Relative humidity (non condensing), %* | *Oct-80* | *Oct-80* | *20-80 %* |
| *Operating ambient temperature, °C* | *22 ± 2* | *22 ± 2* | *22 ± 2 °C* |
| *Mains requirements* | *100-240 VAC, single phase, 47-63 Hz* | *100-240 VAC, single phase, 47-63 Hz* | *Single phase, 208 or 230 VAC, 16A, 50/60 Hz* |
| *Power consumption, kW* | *<1* | *<1* | *< 2.5 kVA* |
| *Typical warm-up time* | *30 min* | *30 min* | *30 min* |

# Schematic


Power Supply
Power Supply
SHG
1 kHz DPSS Regenerative Amplifier
1 kHz DPSS Oscillator
Beam Expander
Beam Divergence control + match to Coude + Telescope
~0.5mJ, 532nm, ~25ps, 1000Hz
~100mJ, 532nm, ~70ps, 10Hz
Chiller + Heat Exchanger
Vertical
Horizontal
Oscillator
Faraday Isolator
Amplifier
Quarter Wave Plate
Amplifier
SHG
Vertical
Horizontal
Capacitor Bank
Capacitor Bank
Power Supply
Power Supply

# Additional Requirements

- Beam Divergence control & Optics *(Roelf / student project)*
- Fast low-jitter detector with a QE of ~ 40% @ 532 nm → very high normal point accuracy on SLR and LLR and Event Timer, swappable with NASA SLR systems capable of single shot RMS < 4 ps and < 4 ps accuracy (*A033-ET http://eventechsite.com/en/timing-technologies/product-created-56503* )


- Optical Shutter operable at 1kHz that is capable of suppressing backscatter to the detector (*Buy from Cybioms Corporation*)
- Servo-system capable of sub-arcsecond pointing accuracy similar to the new NASA servo-systems (*Under developement by Ludwig*)