Multi Color Satellite Laser Ranging at Czech Technical University

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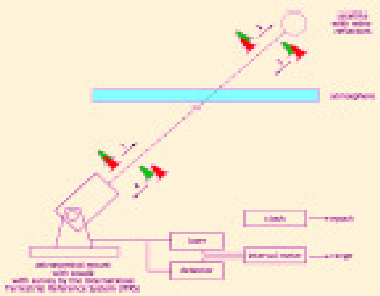
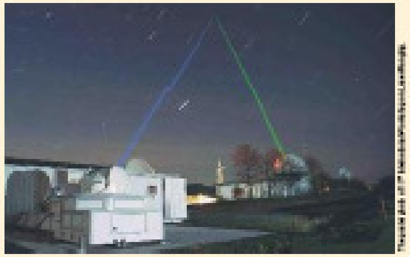
We are reporting on of our activity on satellite laser ranging (SLR) using multiple wavelengths. The design and diagnostics of a hydrogen Raman-shifted picosecond Nd:YAG laser operated on 10 Hz repetition rate are presented. Both the far-field beam structure and temporal picosecond pulse profile are monitored for different laser configurations. The optimum laser configuration has been implemented to the SLR station in Shanghai for two color ranging. To detect the returned signal, the single photon avalanche detector (SPAD) is operated in active gated and quenched photon counting mode. The silicon, germanium, and gallium arsenide phosphide-based SPAD are used depending on wavelength to cover nearly the entire optical region having the single photon response, temporal resolution better than 120 ps, and quantum efficiency of about 15 %.

Why ranging at multiple color simultaneously? Direct atmosphere dispersion measurement. How to generated more colors simultaneously?



The principle of multi color Satellite Laser Ranging (SLR) – optical radar with variable delay between pulses with different color due to variable group refractivity of various colors in the atmosphere.



To ensure required parameters (picosecond time jitter between pulses, temporal profiles, far-field spatial structure, energy in pulse) of laser signals on both used wavelengths the stimulated Raman shift in gases was selected. It is described by equation:

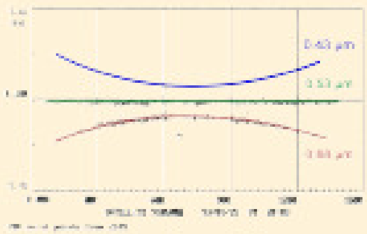
$$\frac{1}{\lambda_{shifted}} = \frac{1}{\lambda_{pump}} + k \cdot \nu_R$$

lambda is the wavelength, ν_R material constant for selected gas (see central graph), and k is 1 for the first antistokes, -1 for the first stokes, etc.

Wettzell, Germany: WLRS 532 / 1064 nm + TIGO 426 / 852 nm

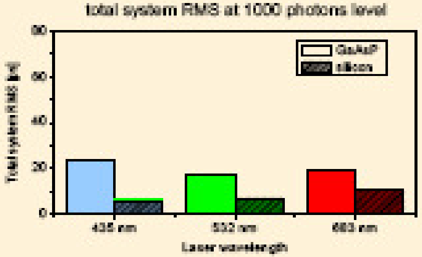
Wettzell Laser Ranging Station — Transportable Integrated Geodetic Observatory, presently moved to Concepción, Chile

Graz, Austria – 435 / 532 / 682 nm



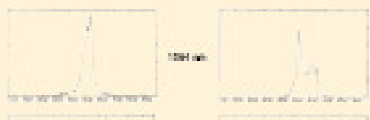
Range residuals with respect to predicted satellite orbit, multiple colors echoes signal are distort by elevation angle dispersion dependence [2, 3].

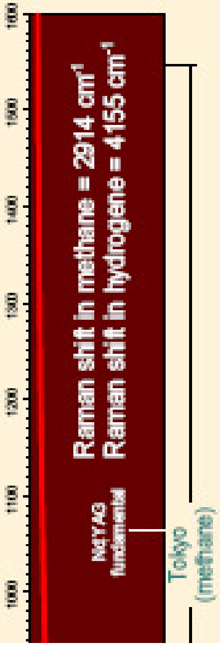
Graz SLR with GaAsP SPAD total system RMS at 1000 photons level



GaAsP and silicon SPADs comparison test over entire Graz SLR measurement chain.

Tokyo, Japan – 532 / 1543 nm

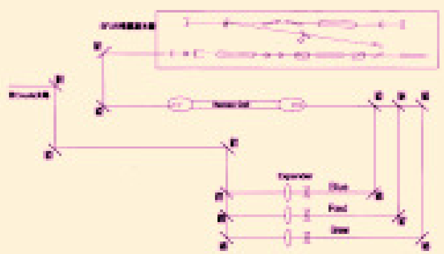




中捷卫星激光测距合作计划 China – Czech joint project for multiwavelength SLR

Shanghai, China 435 / 532 / 682 nm

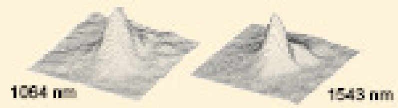
Prague, Czech Republic 435 / 532 / 682 / 1064 / 1543 nm



双/多波长分光发射激光光路

The optical scheme of Raman laser on new Shanghai SLR observatory.

CCD infrared beam profile diagnostics



The Nd:YAG laser oscillator with active-passive mode-locking and etalon as a front mirror to control output pulse width (30 ÷ 300 ps) (top line, output on left)

The Raman tube with refill valve and refocusing lens (bottom)

The part of Raman laser in Czech Technical University (CTU) lab for beam profile testing and tuning [4], results for 1064/1543 nm on top.