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0.1 kHz in Zimmerwald

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Grasse

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Why a new Laser?

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- Current laser
  - 10 years of operation
  - Some components are well-worn, difficult to replace
  - Intensive maintenance
  - Frequent adjustments
  - Pulse length too long, unstable
  - Difficult to track high satellites (energy budget)
  - Ti:Sapphire: "Exotic" wavelengths: 423/846 nm

  - Two-color operation: Infrared less accurate, but extended tracking possibilities

Main Questions:

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- Nd:YAG ←→ Ti:Sapphire
- Single color ←→ Two-color system
- Kilo-Hertz ←→ 100 Hz
- (Flash lamps ←→ Diode-pumped)

Nd:YAG ←→ Ti:Sapphire

- Transponder tracking → Nd:YAG
- Energy budget → (Nd:YAG)
- Background noise → Nd:YAG
- New optical components → Nd:YAG less expensive
  less sensitive

- Optical adaptations → Ti:Sapphire
- Two-color tracking → Ti:Sapphire

Single color ←→ Two-color system

- Cons
  - User of dispersion was not successful
  - More complicated system
- Pros
  - Extension of ranging capabilities (low elevation, haze)
  - Two rather independent measurement chains
  - Detection of systematic errors

Kilo-Hertz ←→ 100 Hz

• Precision	Short pulse length Number of returns ($1/\sqrt{n}$)
• Accuracy	Calibration, timers, electronic components. High correlation between high-rate data.
• Tracking efficiency	Total energy
• Maintenance	Diode-pumped laser
• Transponders	100 Hz probably better suited
• Target investigations	kHz better suited
• Price	not decisive

Decision

- 100 Hz system
- Nd:YAG
- Two-color ready
- Manufacturer: Thales

Oscillator

- *Time-Bandwidth*, Switzerland
- OEM custom version of a LYNX oscillator
- Passive mode locking
- Diode-pumped solid state
- 30 ps pulse length
- 100 MHz pulse rate
- Pointing stability < 5 arcsec/C
- Long term power stability < 0.1 % rms
- Sealed laser head → allows reliable and maintenance-free operation (low operation costs)
- Air cooled (only)
- „True“ turn-key system

Amplifiers

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One regenerative amplifier, one four-pass amplifier	
Diode-pumped solid state system	
Wavelengths	1064.14 and 532.07 nm
Wavelength stability	< 0.05 nm
Pulse length	<= 35 ps (1064 nm)
Pulse length stability	< 10 % for each colour
Pulse quality	TEM 00; M^2 <=1.2
Pulse rate	90-110 Hz
Pulse energy	> 12 mJ (532 nm, expected)
Energy stability (long term)	< 5 % (several months or between service intervals)
Individual energy attenuation	0 to 99 %
Pulse contrast	< 1:200 for each color
Beam divergence at laser output	< 50 arc sec ($1/e^2$, full angle)
Pointing stability	< 30 arc sec
Polarization	circular

Additional features

• Average power (532 nm)	> 100 * 12 mJ /sec = 1.2 W
• Pulse period	Variable between 9 and 11 ms in steps of 10 µs
• Period decimation	Either in integer fractions or pulse-per-pulse (?)
• Pulse synchronization	First pulse synchronized to selectable UTC time
• Receiver protection	Rotating shutter
• Collision avoidance	Several options, realized by software
• Transmitted energy	Variable by polarizer
• Beam divergence at telescope output	> +- 2.5 arc sec ($1/e^2$, adjustable)
• Two-color ready	Depending on availability of infrared receiver (1064 nm)

Realization

- Laser ordered in April 2007
- Optics, FPGA (Graz), signal distribution (Deggendorf), … ordered in summer 2007
- Delivery: Second half of October 2007 (expected)
- Implementation: Immediately afterwards…

- *SLR system will be out of order during full implementation phase (no parallel operation with old laser possible)*
- *New (even smaller) range bias to be expected*

- CCD system will remain operational

LRO mission support

- Pulse rate
  - Either pulse decimation to some pulse rate < 28 Hz, floating, e.g. 20 Hz
  - Or
    - generation of 111.982 Hz
    - decimation by 4 = 27.995 Hz
    - occasional shifts to keep pulses in LRO window
    - initial synchronization to first window
- Wavelength 532.07 nm (expected)
  → about 50 percent loss
- Pulse energy < 12 mJ per pulse, adjustable
- Beam divergence > +- 2.5 arc sec ($1/e^2$, adjustable)