Infrared Laser Ranging to Space Debris – *a chance for ILRS*

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Starting with the conclusion …☺

What we would like to see at the end:

- Several ILRS stations could upgrade to debris laser ranging capability:
  - With low cost – no additional laser – and with acceptable effort
  - Without interruption / restriction of routine ILRS tracking

The real low-cost debris laser ranging system ☺

Main idea:

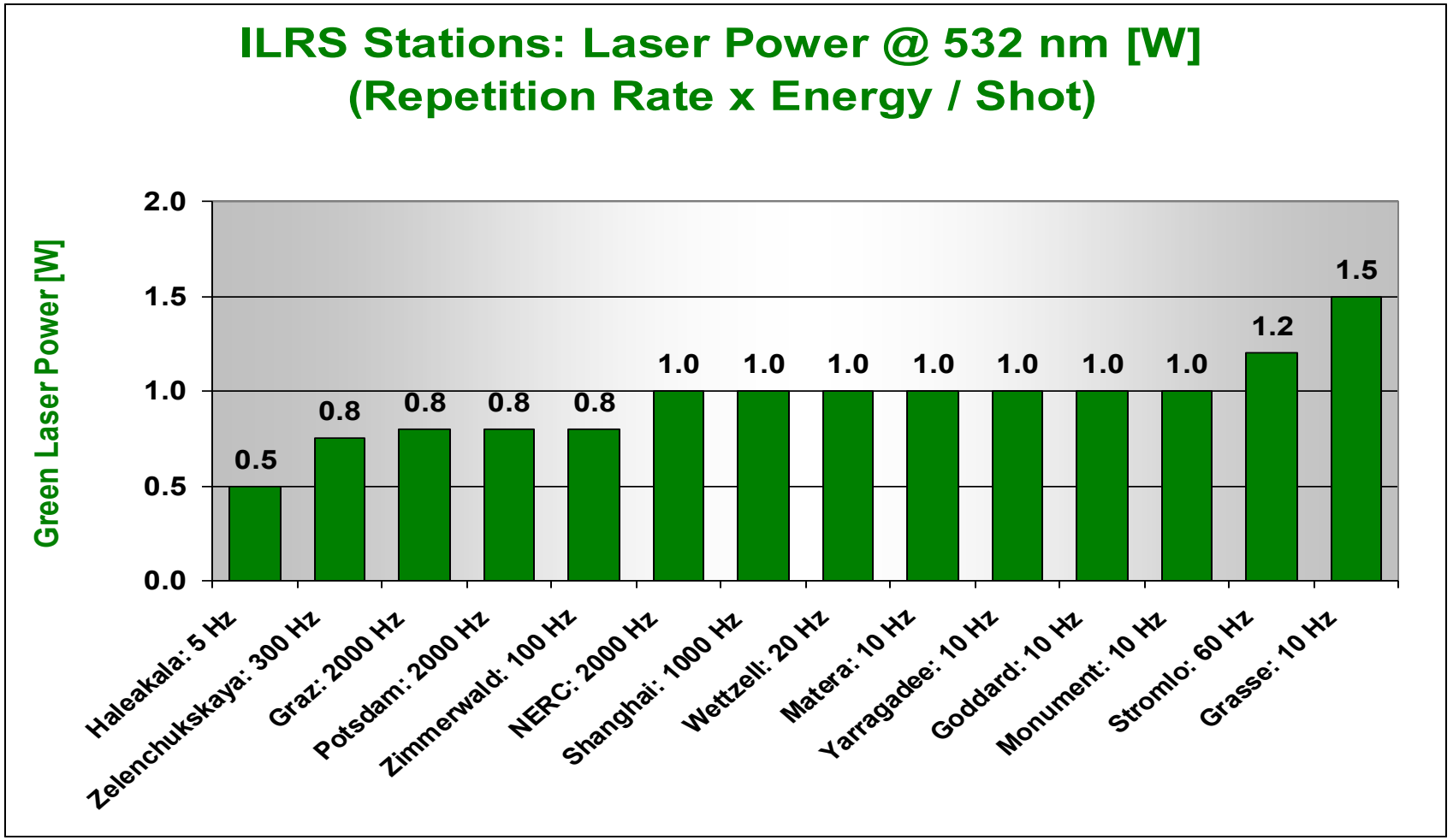
- Remove the Frequency Doubler of your laser

  => Range with 1064 nm to space debris

Frequency Doubler Crystal

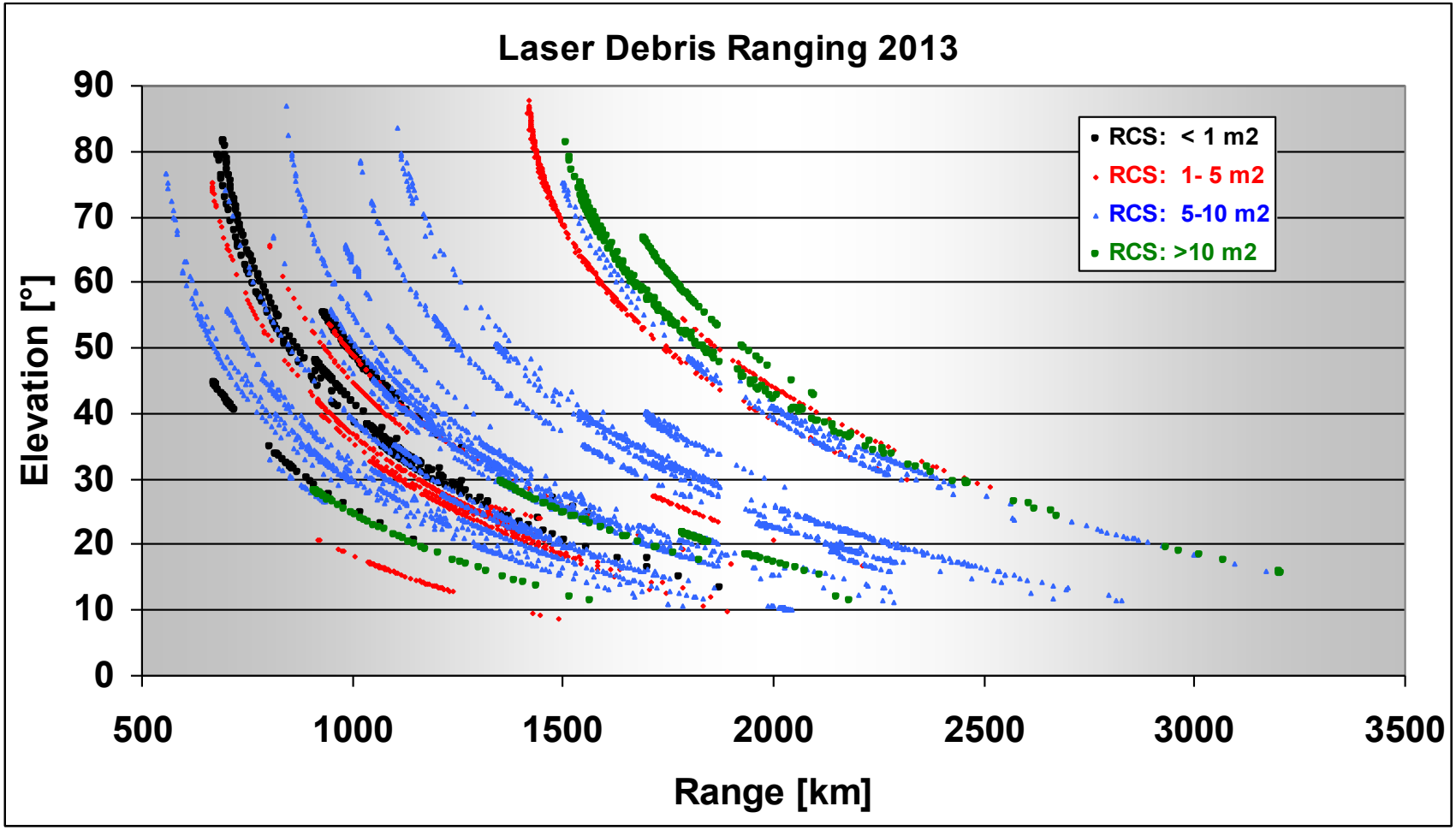
- Continue to range with 532 nm to ILRS satellites

Laser Power of ILRS stations: Comparable …



- Most ILRS stations use around **1 W** of laser power; at rep rates of 5 – 2000 Hz
- They all send more or less a similar amount of photons/second into space …
- However: These green photons are not enough for debris laser ranging ☹

GREEN Space Debris Measurements in Graz 2013



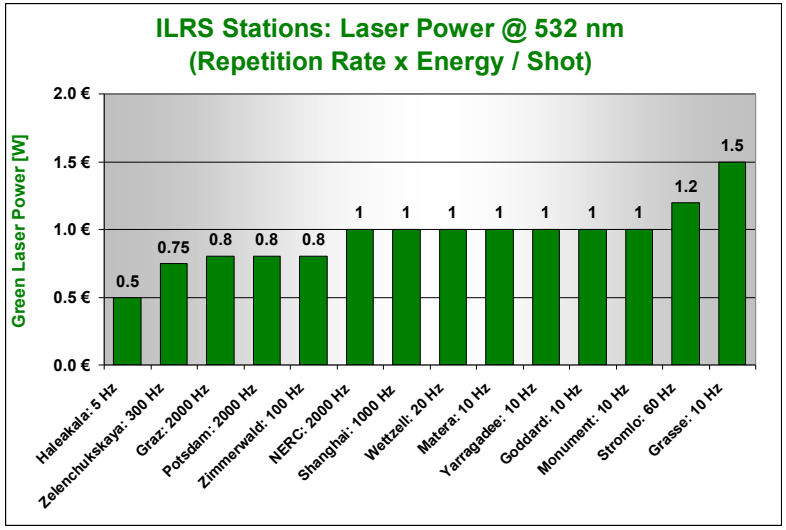
- Graz debris laser ranging: Using STRONG, additional laser with **16 to 20 W**:
- All measurements with **532 nm / 200 mJ / 3 ns / 80 – 100 Hz**
- Majority of data: At relatively low elevations (due to LEO orbits)

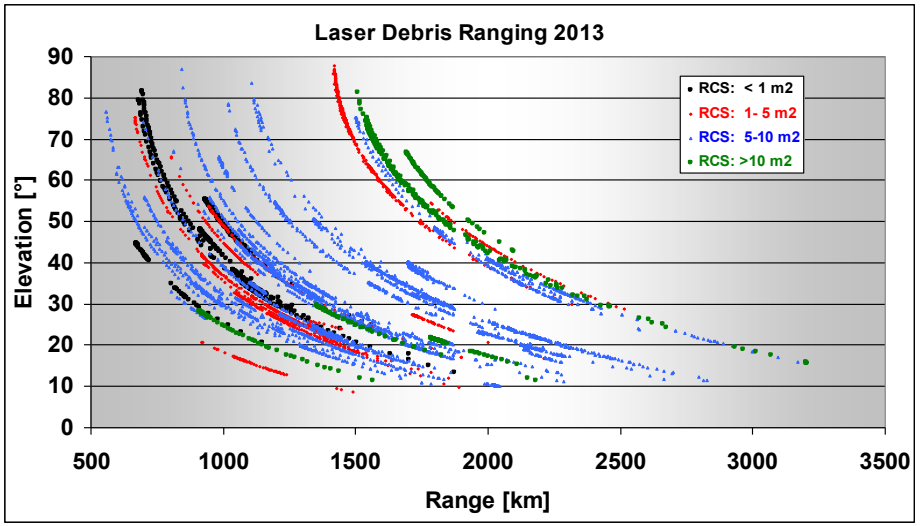
Changing to 1064 nm for debris laser ranging

Expected advantages for debris ranging, when changing from 532 to 1064 nm:

- ≈ 10 times increased efficiency expected at zenith / 90° elevation*)
- ≈ 50 times increased efficiency expected at 20° *)
- Relatively low cost upgrade: No additional laser needed…
  - Remove the Frequency Doubler Crystal (switch in/out)
  - Change Coude Mirror Coatings (for 532 nm *and* for 1064 nm)
  - Add another SPAD detector (InGaAsP; 80µm diameter, > 30% QE)
  - Graz: We are just doing it …☺
- Easy switching between standard ‚ILRS sats' mode and ‚debris' mode
- No need for additional high power laser etc.
- Disadvantage: We will have to proof it first ☺ => in next few months ….

*) *U. Voelker et al, 2013: Laser based observation of space debris: Taking benefits from the fundamental wave*





Applying an efficiency factor of 10 to 50 ….

…should put the station close to the ‚16 - 20 Watt ‘ specs …

Expected: Ranging to debris with **standard ILRS lasers @ 1064 nm** should deliver similar results as the Graz debris laser with **16 to 20 W @ 532 nm**

Benefits of debris laser ranging for ILRS *and* stations

- *For ILRS: Extend the application of laser ranging:*
  - e.g. in case of predicted conjunctions of debris + active satellites / ISS:
  - Such conjunctions are usually predicted several days ahead
  - Debris laser ranging of ILRS stations then can improve debris orbit prediction accuracy by a factor of 10 or more
  - This will help to avoid / reduce collision avoidance maneuvres (saving fuel)
  - Including part of ILRS network in this task could effectively provide such services: To overcome weather problems, pass visibility etc.

- *For SLR Stations:*
  - Debris ranging adds another application / project to your station
  - Graz experience: This is a much more convincing argument to get financial support as opposed to ‚only' continuous LAGEOS ranging…

- *Once operational, the added derbis tracking effort is relatively low:*
  - It is NOT planned to schedule many passes per day etc.
  - It is NOT planned to use debris laser ranging to setup debris catalogues etc.

Conclusions:

Graz will test the feasibility within the next few months:
Ranging to space debris with **HQ laser @ 1064 nm / 800 µJ / 2 kHz**

IF these tests are successful:

IMPLEMENT THE **‚1064 nm debris ranging‘** IN YOUR STATION !

Thank you !