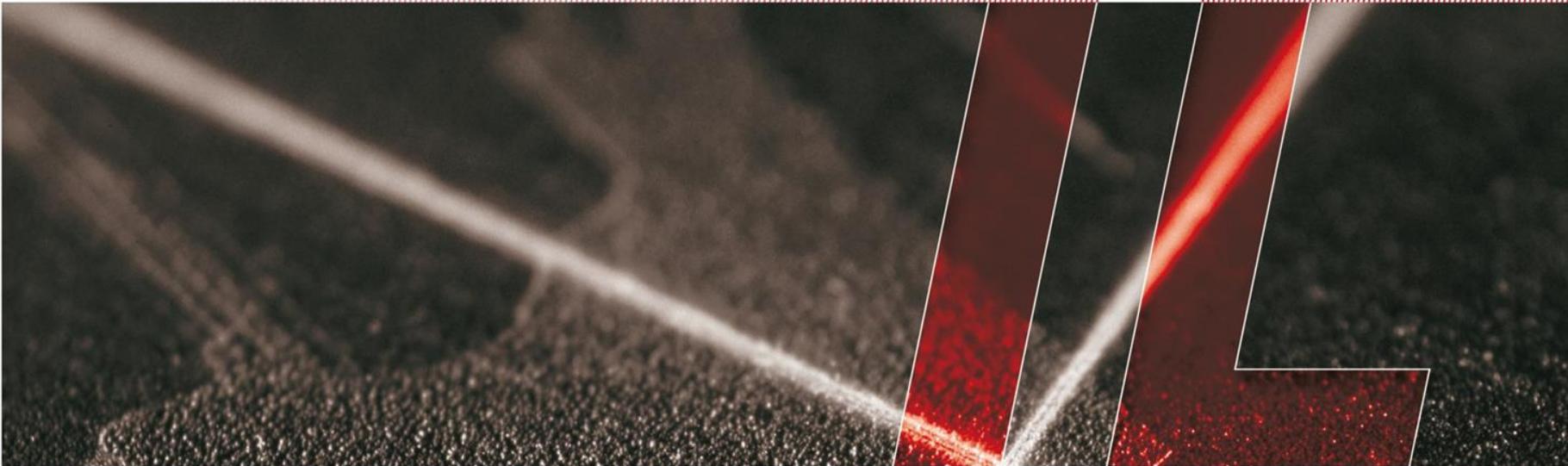


# Monolithic high energy picosecond laser sources for laser ranging applications

*Andreas Boerner, Norbert Graf, Reinhard Kelnberger*

*20th Int. Workshop on Laser Ranging, GFZ Potsdam, 2016*



# InnoLas Laser GmbH: Company Overview

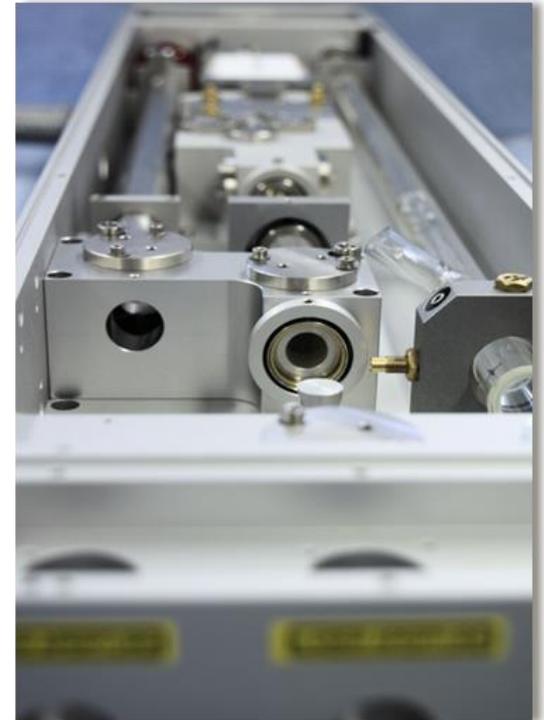
- Located near Munich / Germany
- 25 people (mainly engineers)
- Founded 1995
- High Energy Nano- and Picosecond Lasers for scientific and industrial markets



# InnoLas Laser GmbH: Company Overview

High Energy, Q-switched Nd:YAG lasers with <10 ns pulse width:

- Flashlamp Pumping:  
up to 2.5 Joule pulse energy, up to 30 Hz repetition rate
- Diode Pumping (DPSS=Diode Pumped Solid State):  
up to 1 Joule pulse energy, up to 100 W, up to 1000 Hz



# InnoLas Laser GmbH: “Ranging” experience



**1) Previous cooperation with High Q Laser for high energy Picosecond Lasers → SLR**

New InnoLas product: **Monolithic high energy picosecond lasers**

**2) Nanosecond Lasers for demanding LIDAR applications**

(truck/plane/container mounted, remote access, maintenance free)

→ Suitable sources for **Space Debris tracking** (up to 100 W, up to 1000 Hz)

# *Finished projects of picosecond amplifiers*

## 1) Wettzell (Germany) – Günther Herold

Satellite and Lunar Ranging

Cooperation of InnoLas Laser and High Q Laser

Regenerative Amplifier system (1 mJ) +  
combined diode pumped (DPSS)/Flashlamp amplifier:

100 mJ at 1064 nm, 50 mJ at 532 nm

12 ps pulse duration

20 Hz repetition rate



Courtesy of BKG

# *Finished projects of picosecond amplifiers*

## **2) U of Applied Sciences Giessen-Friedberg (Germany) – Johannes Ohlert**

**Ablation Experiments, future plan to use for SLR**

**Cooperation of High Q Laser and InnoLas Laser**

**Regenerative Amplifier system (1 mJ) + Flashlamp amplifier:**

**100 mJ at 1064 nm, 50 mJ at 532 nm, 25 mJ at 355 nm**

**12 ps pulse duration**

**10 Hz repetition rate**

# *PSA – Picosecond Amplifier Systems*



**Picosecond seeder and High Energy amplifier**

**in one compact, monolithic housing**

# PSA – Picosecond Amplifier Systems

Integration of Picosecond seeder and Post-Amp in monolithic housing leads to compact size and high alignment stability

Picosecond source: industrial fiber system

- Fixed pulse width 10-100 ps
- Designed for maximum up-time in 24/7 operation

High-Energy amplifier:

- Flashlamp or Diode pumped Nd:YAG modules
- Using long-term evaluated standard components from nanosecond products



Footprint: Min. 50 x 50 cm<sup>2</sup>

# PSA – Lunar Ranging Laser Source

## 1) Lamp Pumped amplifier

High energy at low repetition rates (max. 20-30 Hz)

### Flash Lamp Pumped - 10Hz

	100 ps		10 ps	
	1064 nm	532 nm	1064 nm	532 nm
PSA III	200mJ	100 mJ	20 mJ	10 mJ
PSA IV	500 mJ	250 mJ	100 mJ	50 mJ
PSA V	1000 mJ	500 mJ	200 mJ	100 mJ

→ Enough energy for Lunar Ranging

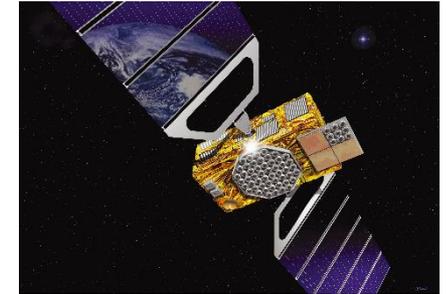


Courtesy of NASA

# PSA – Satellite Ranging Laser Source

## 2) Diode pumped amplifier

High average power, high repetition rates (max. 1000 Hz)



Courtesy of ESA

### Diode Pumped – 100 Hz

	100ps		10 ps	
	1064 nm	532 nm	1064 nm	532 nm
PSA EVO I	30 mJ	15 mJ	10 mJ	5 mJ
PSA EVO II	100 mJ	50 mJ	40 mJ	20 mJ
PSA EVO III	200 mJ	100 mJ	100 mJ	50 mJ

### Diode Pumped - 1KHz

	100 ps		10 ps	
	1064 nm	532 nm	1064 nm	532 nm
PSA EVO I	4 mJ	2 mJ	4 mJ	2 mJ
PSA EVO II	10 mJ	5 mJ	10 mJ	5 mJ
PSA EVO III	20 mJ	8 mJ	20 mJ	8 mJ

High Energy



Allround Solution!



High Repetition Rate

# *PSA – Picosecond Amplifier Systems*



- Flexible system layout allows tailored systems for your setup
- Various integrated monitoring options available (Energy Monitor, Beam Profiler...)
- We can match our amplifiers to all kinds of existing picosecond seed lasers → contact us for your solution!

# *SpitLight EVO – Nanosecond DPSS Lasers*

**Q-switched lasers with <10ns pulse duration**

**up to 1000 mJ at 100 Hz / up to 60 W at 532nm**



**Space Debris Detection**



Courtesy of ESA

# SpitLight EVO – Space Debris Ranging Source

Power 1064 nm	EVO I	EVO II	EVO III	EVO IV
100 Hz	20 W	40 W	60 W	100W
200 Hz	24 W	50 W	100 W	-
300 Hz	25 W	40 W	75 W	-
500 Hz	25 W	40 W	75 W	-



Courtesy of ESA

Energy Conversion to:

532 nm → 60%

355 nm → 30%

For dual output: energy distribution can be remote controlled via software

# *SpitLight EVO – Space Debris Ranging Source*



## **Advantages of DPSS lasers:**

- >> 2 billion shot diode lifetime → maintenance free over long time
- High Average Power (up to 100 W at 1064 nm) at 100 – 1000 Hz
- Compact and rugged: mounting on telescope arm?

# SpitLight EVO – Space Debris Ranging Source

Small Footprint, rugged housing:

EVO III:



500 x 272 x 125 mm, 30 kg

100 Watt!

EVO IV:



500 x 425 x 125 mm

# *MAGNA series*

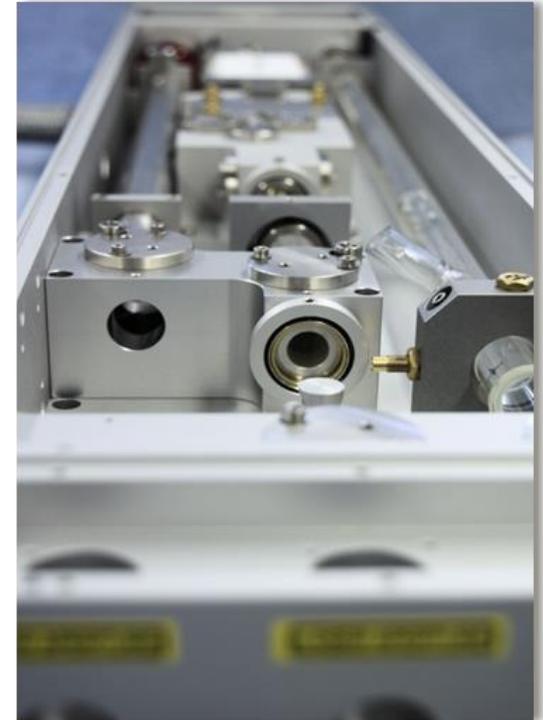


Q-switched lasers with **500 ps** pulse duration

up to 2000 mJ / up to 1000 Hz / up to 25 W

# MAGNA – Basic setup

- Combination of two standard systems:
  - **pico**: sub-nanosecond oscillator
  - **SpitLight**: Flashlamp or DPSS amplifier stages
- Integration in one monolithic housing → maximum alignment stability
- Using long-term evaluated standard components from nanosecond products



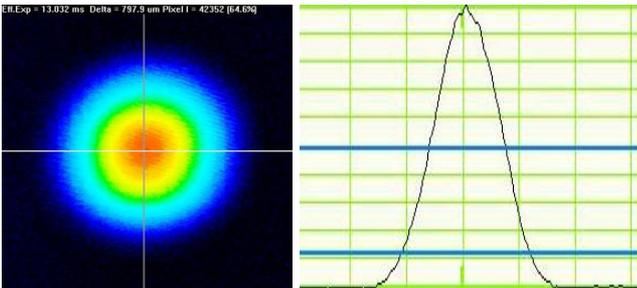
# *picolo / picolo MOPA*

## picolo: Sub-nanosecond Nd:YVO<sub>4</sub> oscillator



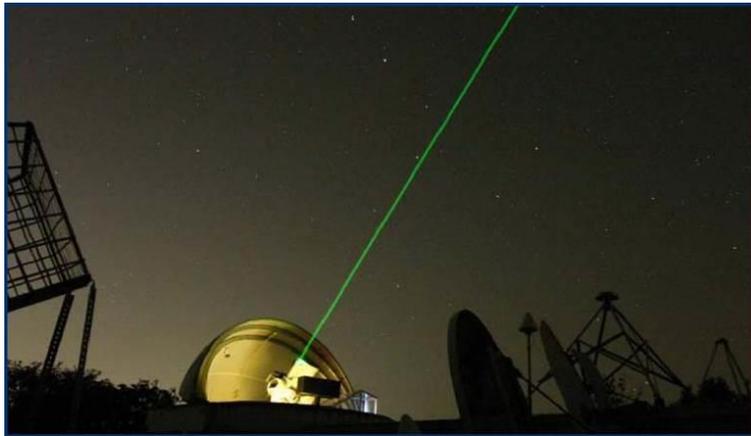
### Advantages:

- Short oscillator and fast q-switch → pulses down to 500 ps
- Good beam quality: TEM<sub>00</sub>, M<sup>2</sup> < 1.3
- Compact laser head and power supply with small footprint (19", 1 RU)
- No external cooling required

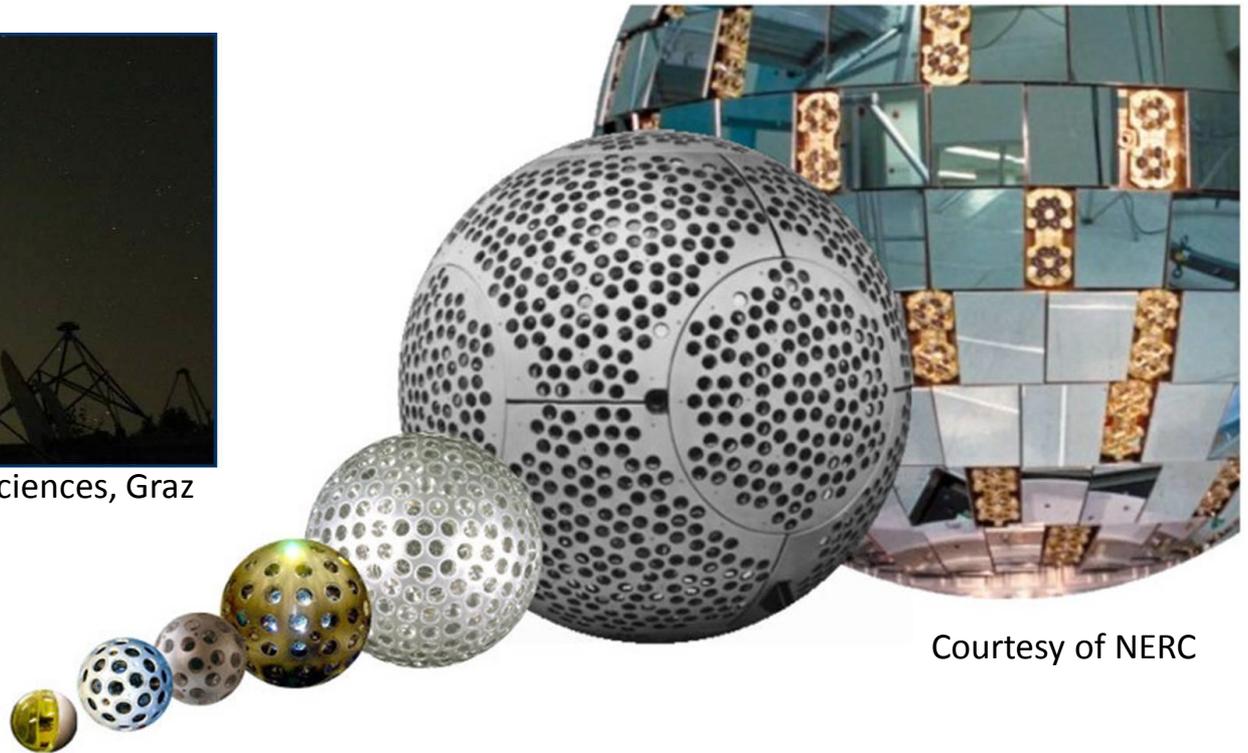


*Thank you!*

Let's discuss your laser needs!



Courtesy of Austrian Academy of Sciences, Graz



Courtesy of NERC