How can Lasers help?

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University of Auckland, TEC and MBIE

The Dodd-Walls Centre for Photonic and Quantum Technologies

Outline

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- What is laser light?

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- Communications

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- Sensors
- “blowing stuff up”

Why Laser Light?

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Why not a light bulb?

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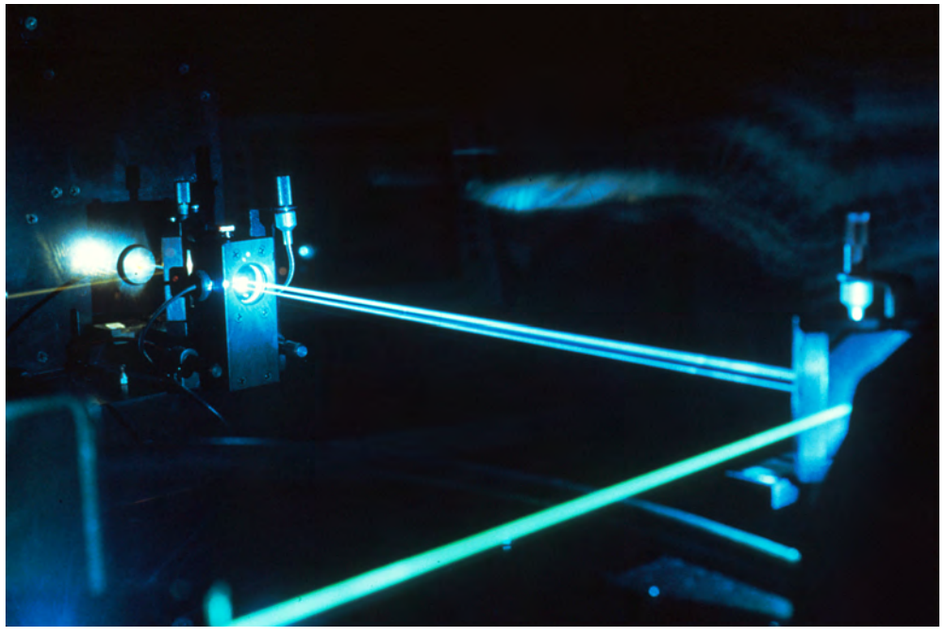

Lasers are a source of incredibly bright narrow frequency light!

Laser Light

- Laser light is single frequency ($\Delta\nu / \nu < 10^{-14}$)
- Laser light is collimated
- Laser light has high spatial and temporal coherence
- This allows you to focus a large amount of energy into very small volumes.

Communications

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- **Annual global IP traffic will pass the zettabyte (1000 exabytes) threshold by the end of 2016, and will reach 2 zettabytes per year by 2019.** By 2016, global IP traffic will reach 1.1 zettabytes per year, or 88.4 exabytes (nearly one billion gigabytes) per month, and by 2019, global IP traffic will reach 2.0 zettabytes per year, or 168 exabytes per month. (source cisco.com)

Erbium doped fibre Amplifier

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- The key component enabling this is the EDFA invented in 1987 by researchers at the University of Southampton.
- First sub-sea all-optical fibre link using EDFAs was installed in 1996.
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This means that optical components designed for communications wavelengths are cheap and reliable. The cost can be an order of magnitude cheaper than components designed for other wavelengths!

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Both devices use the same physical principals!

Our Sensors

Canterbury Ring Lasers
sensitive to rotation, can detect the rotation of the earth.

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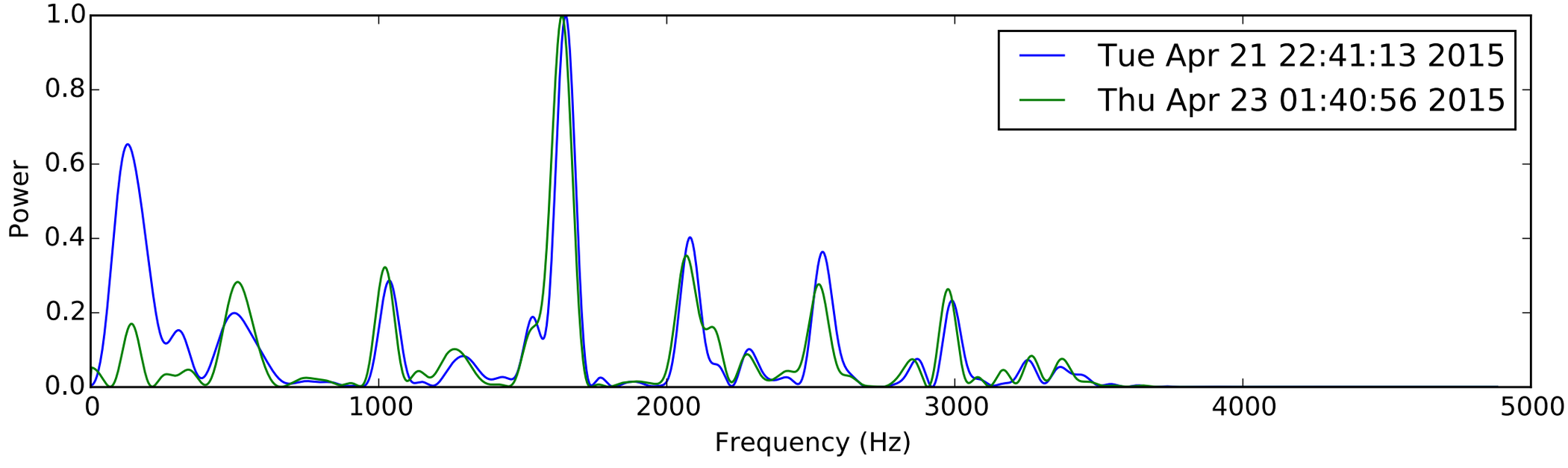
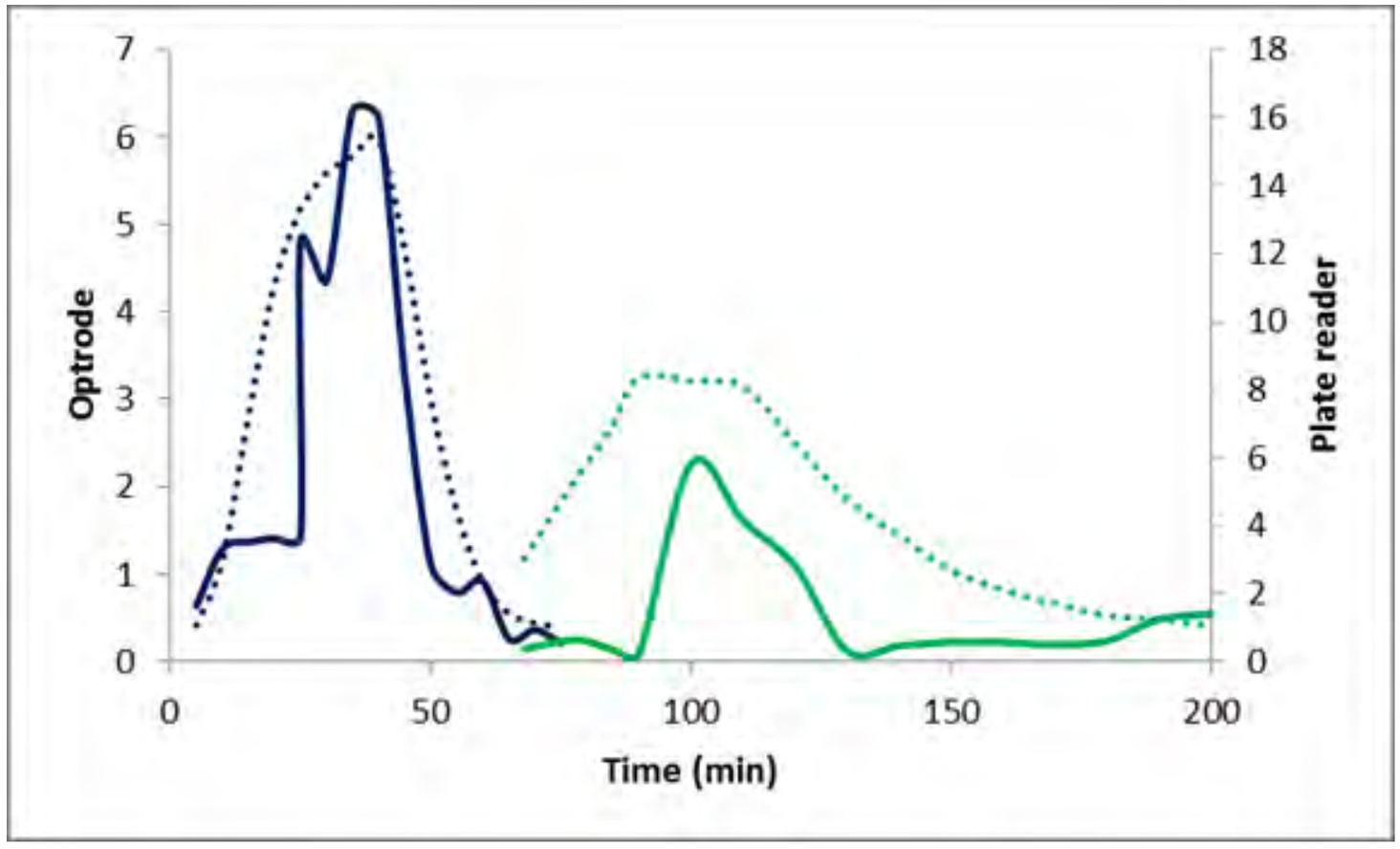
Laser Doppler Vibrometer
can detect ripeness of fruit!
or cracks in wine bottles.



More Sensors



Fluorescence sensing
Used for real time bacteria counting

Laser absorption spectroscopy

- Can detect trace amounts of gases.
- Works best in the mid-IR and we are developing new lasers to access this region.

Object detection

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[Mercedes-Benz factory]

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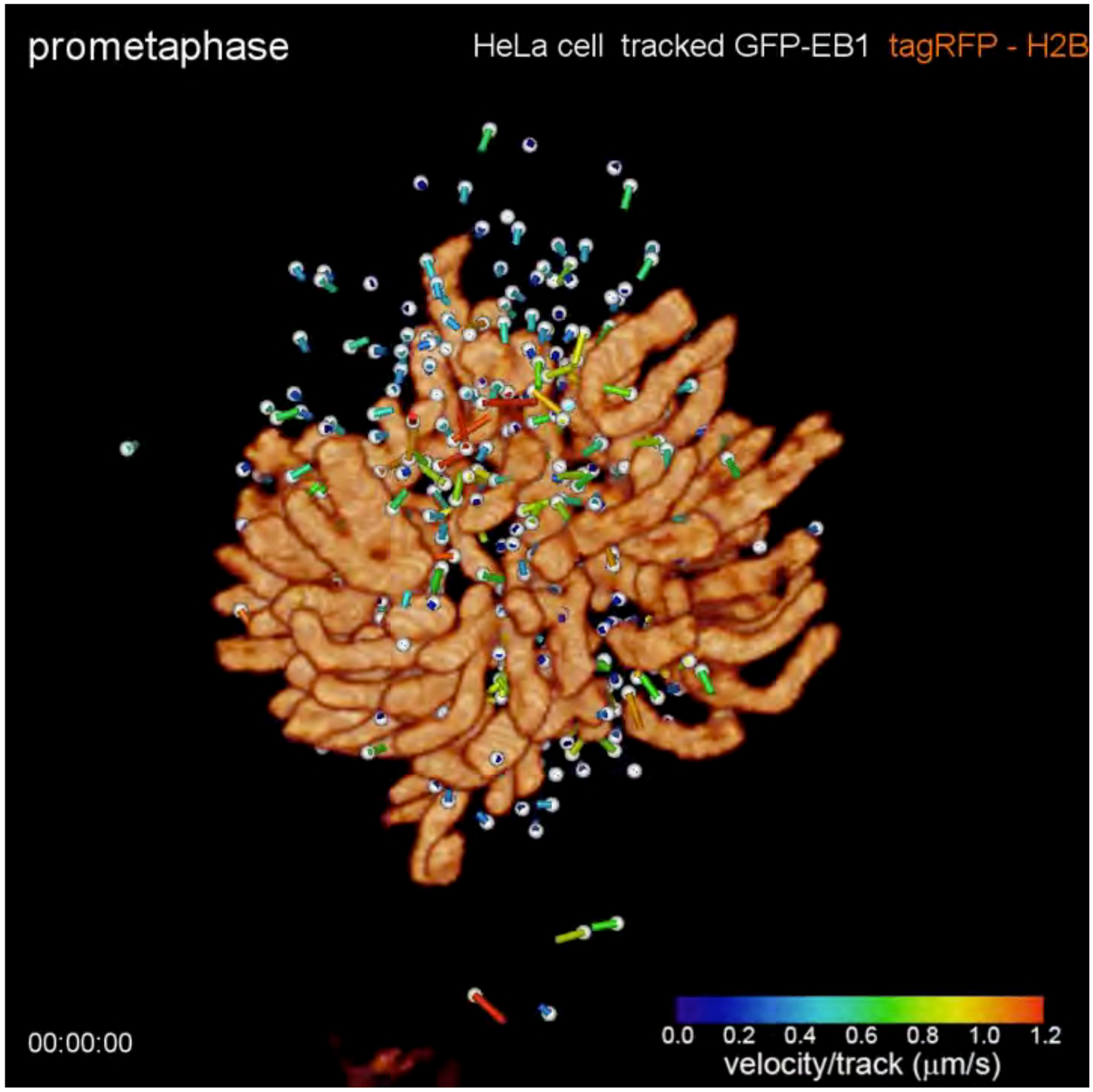
- Image analysis is important, they test for aesthetic appeal rather than for structural quality.
- Other robots test glue thickness, alignment of welds etc.

Structured Light Microscopy



Structured Light can be used for imaging with sub wavelength resolution, low optical powers and high speeds.

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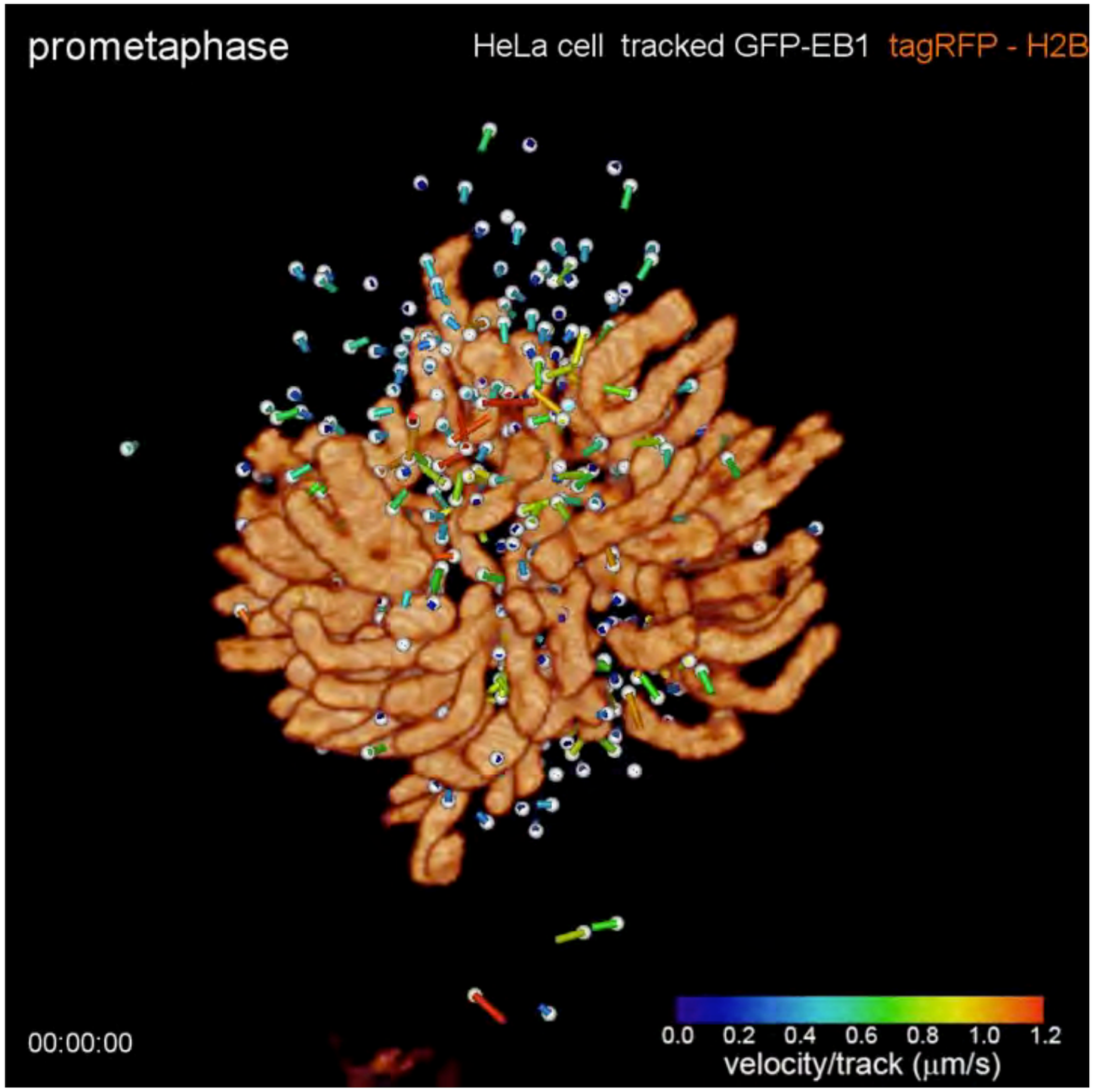

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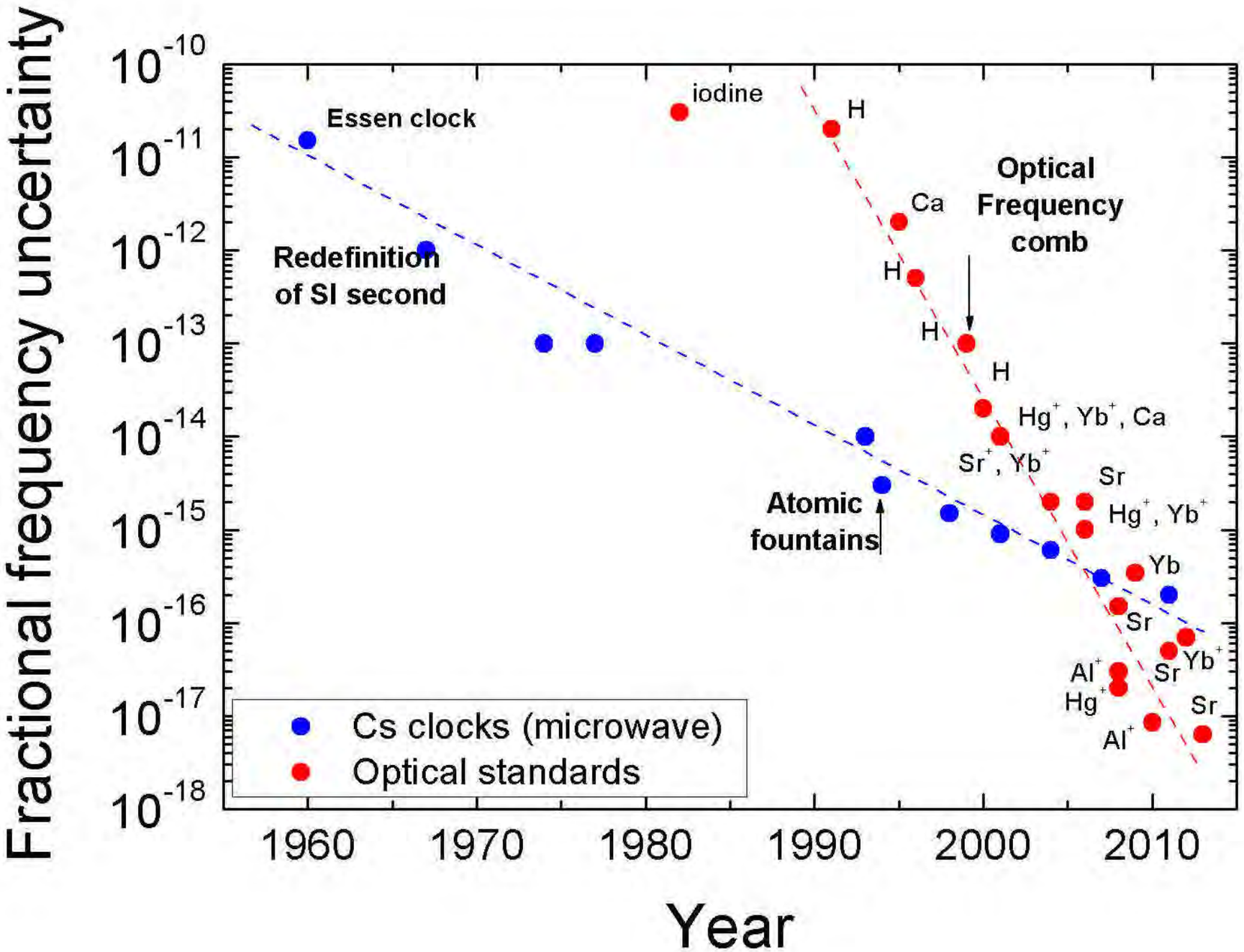
Measuring Time



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—Currently clocks are limited by the general relativity.

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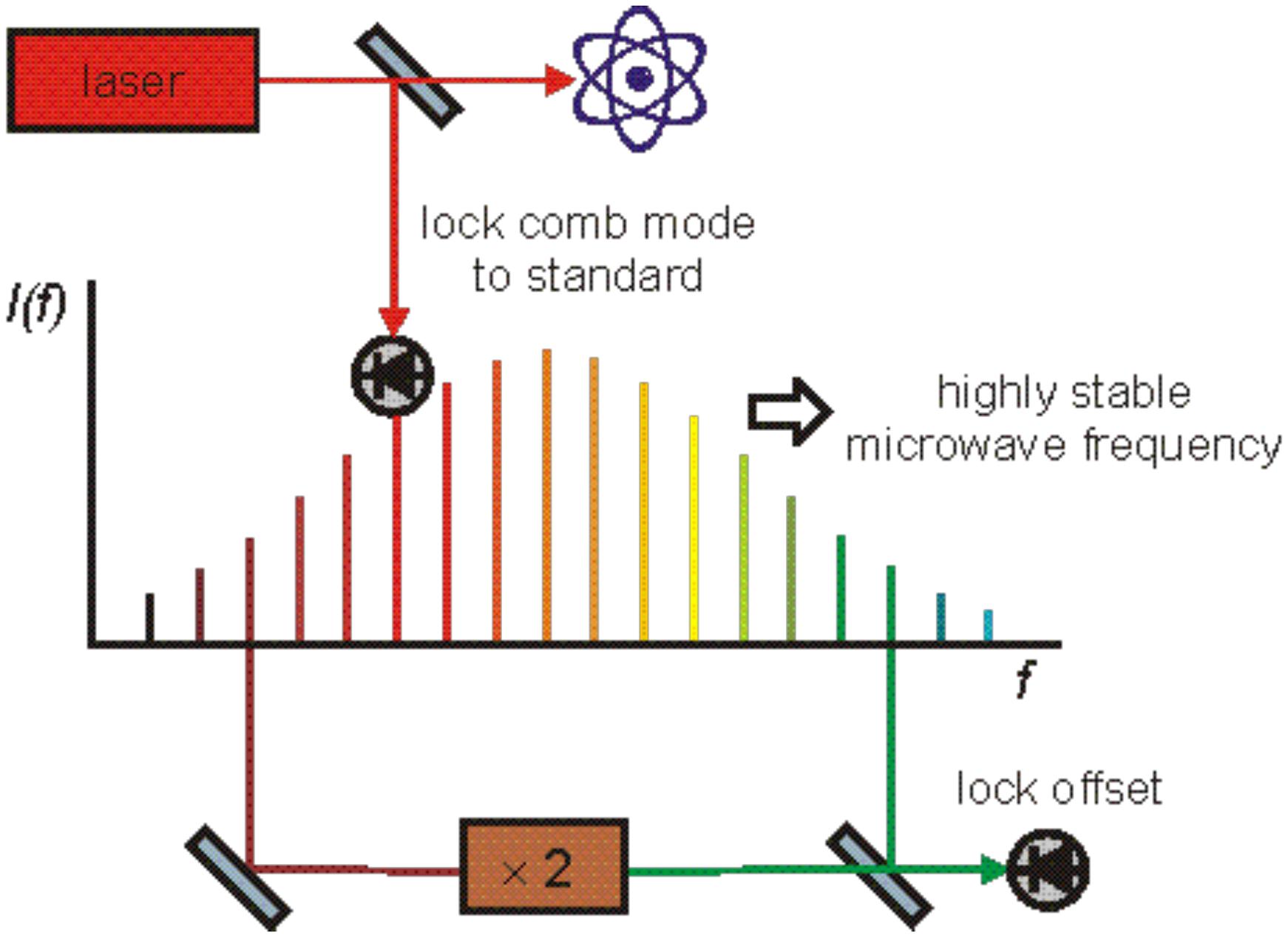

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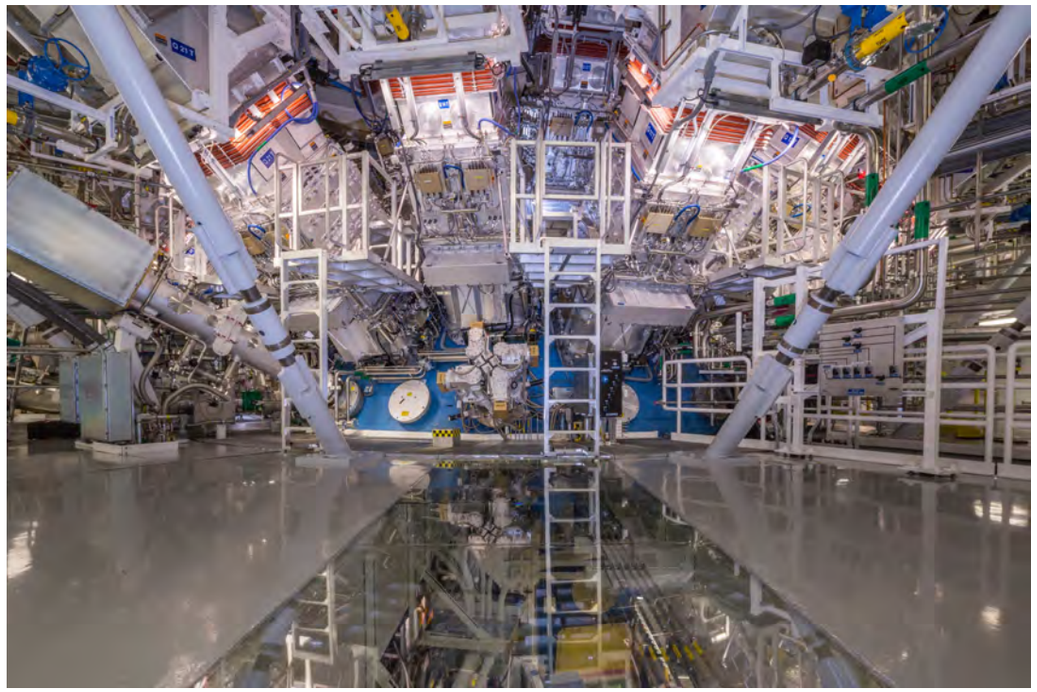

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- $7 Billion USD
- 500 Tera Watts, few picoseconds pulses

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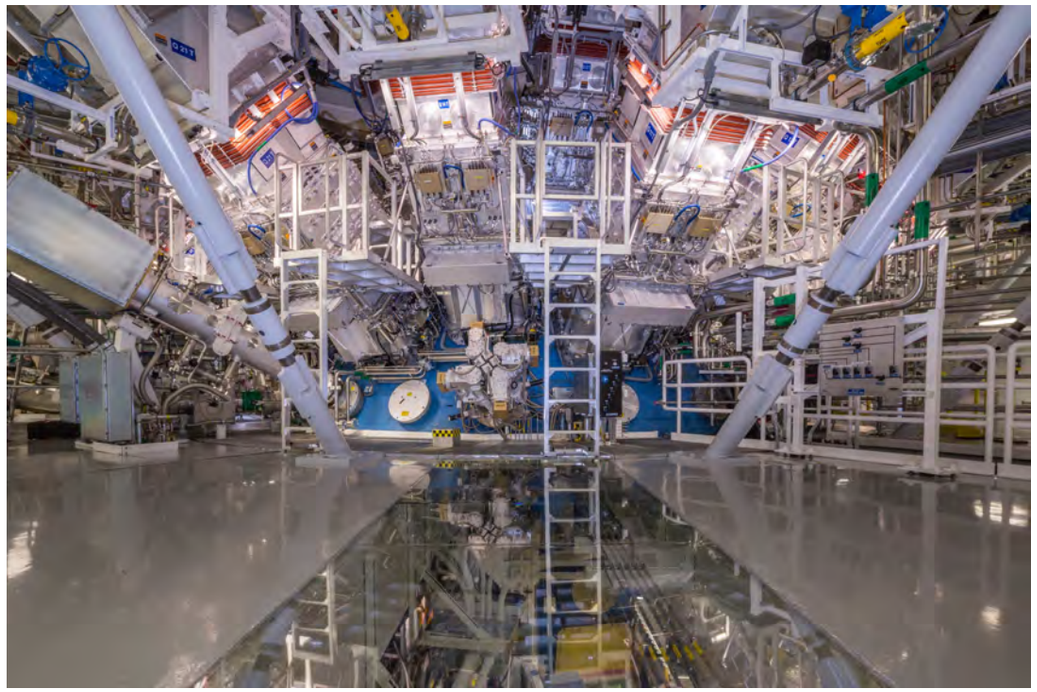

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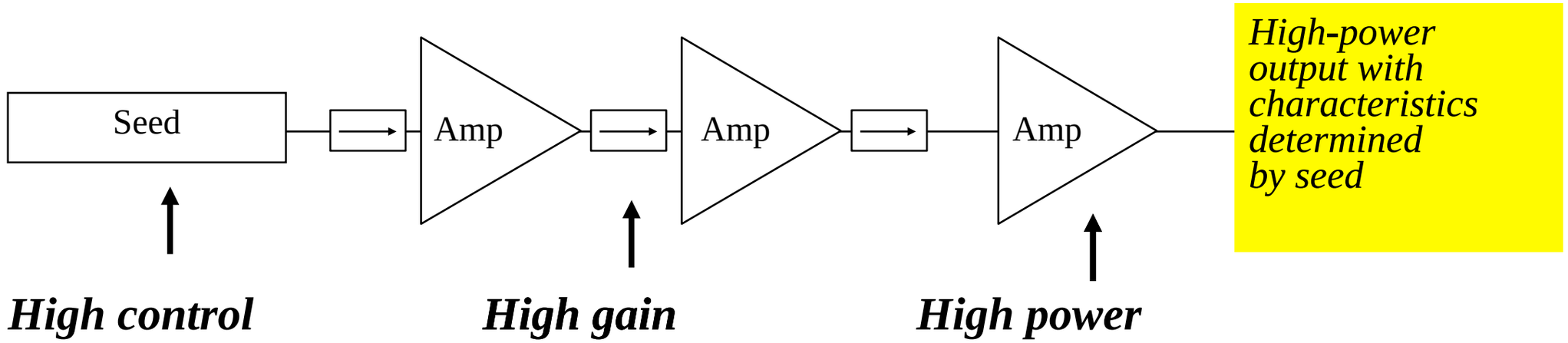
- Wicked Lasers
- $200 USD
- 2 Watts. Continuous Wave

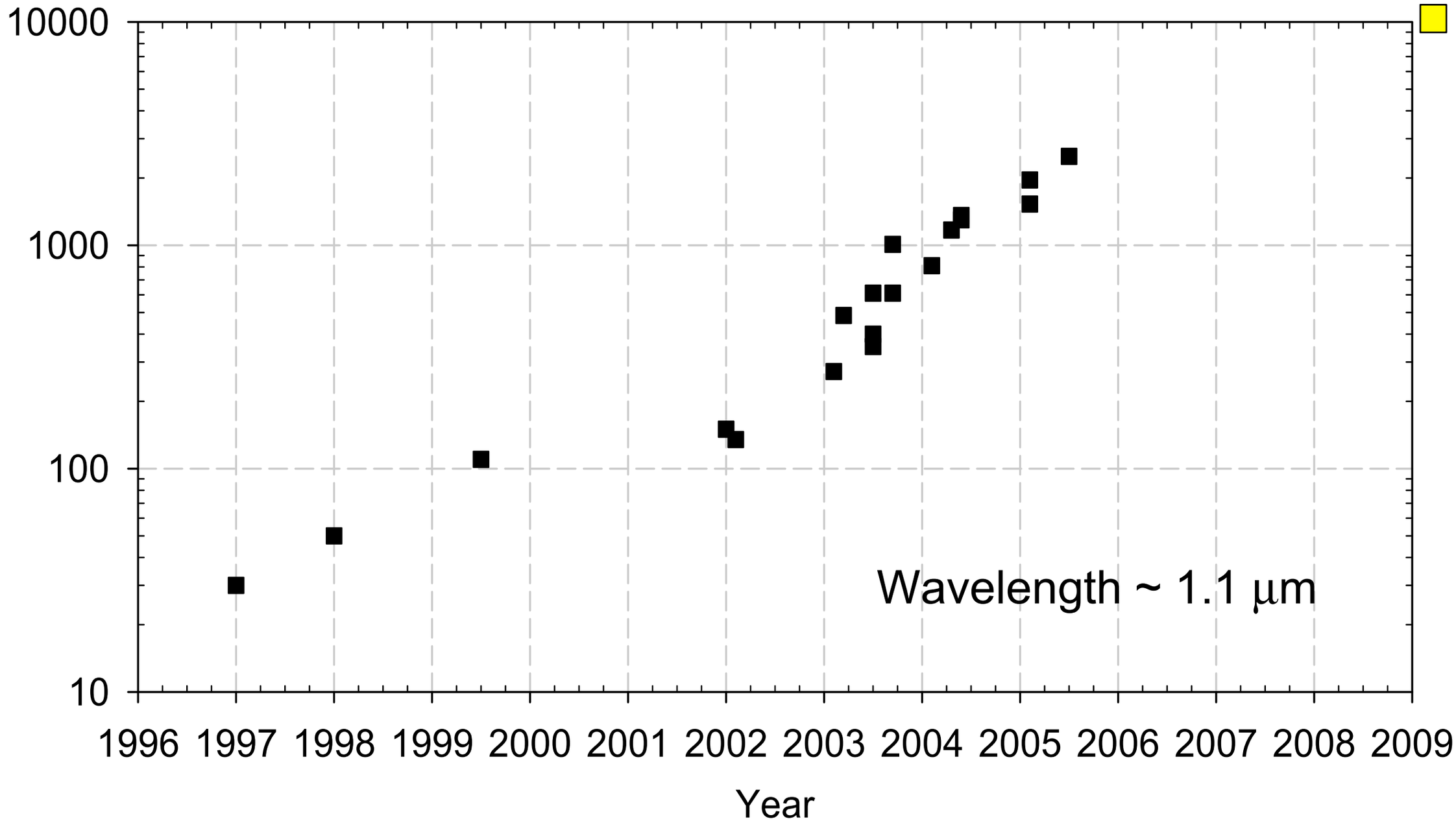
How to make a TW laser

- Master Oscillator, power amplifier (MOPA).



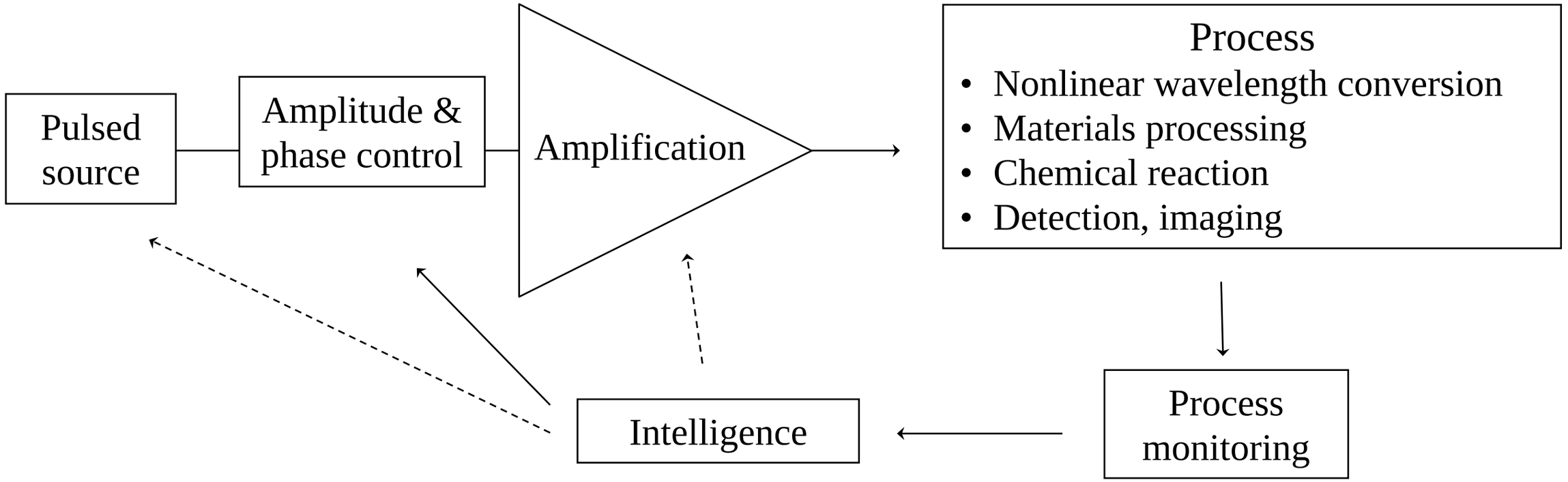
- The seed can be any laser you like.
- You then keep adding amplifiers until you get bored or run out of money.

The Remarkable Increase in CW Fibre Laser Power



Same picture of growth for all wavelengths and modes of operation

Fibre Lasers – the ideal light source



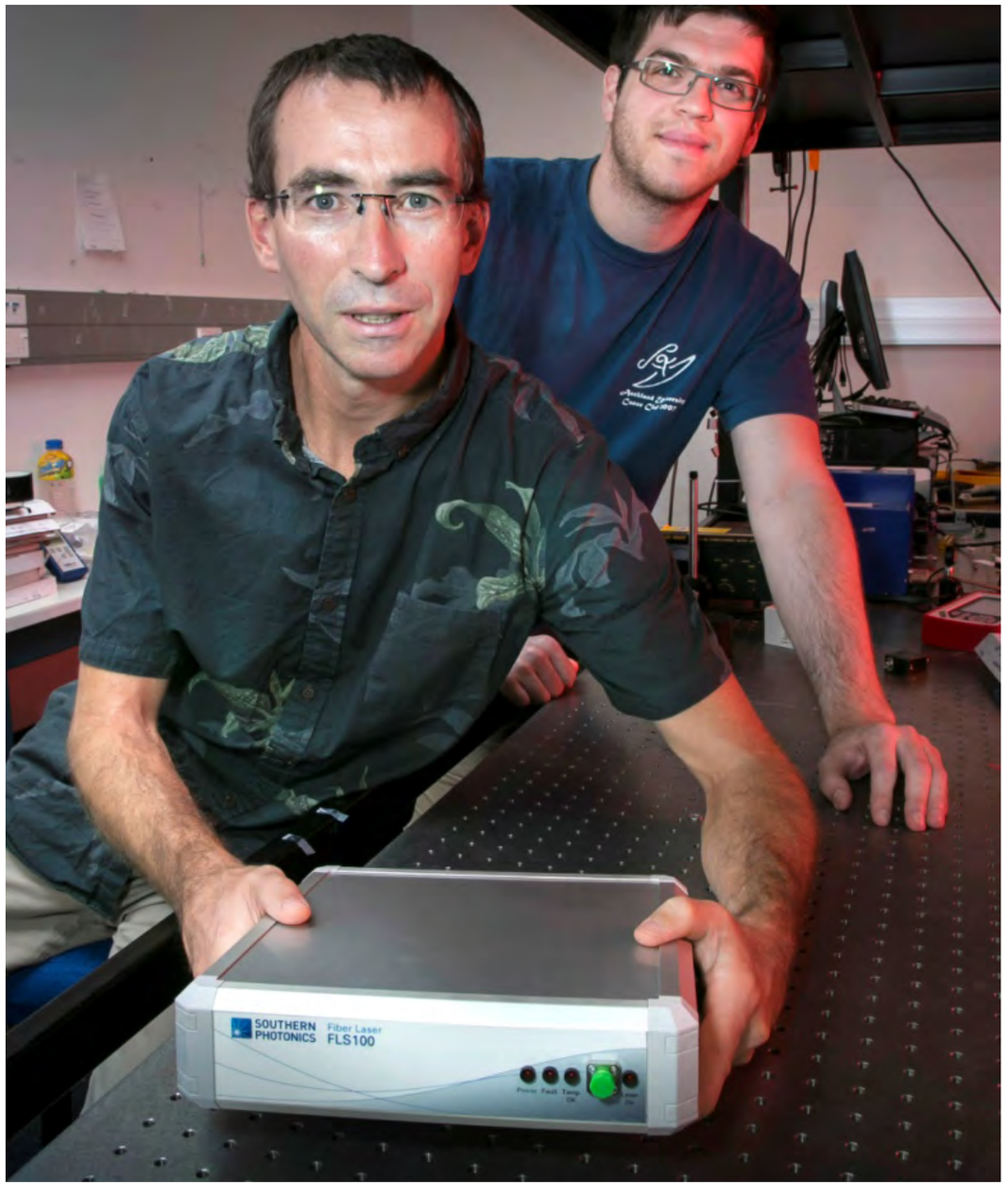
- A Learning loop can be used to optimize the source properties for a given end application
- The powers required for industrial processes are easily achievable
- Flexibility, rapid control, near-linearity of fiber MOPAs greatly enhances scope for adaptive control
- The technology is now available for this.

Pulsed Source

- Patented femtosecond technology developed at University of Auckland through a contract with Southern Photonics.

- Robust, self-starting, stable with push-button operation.

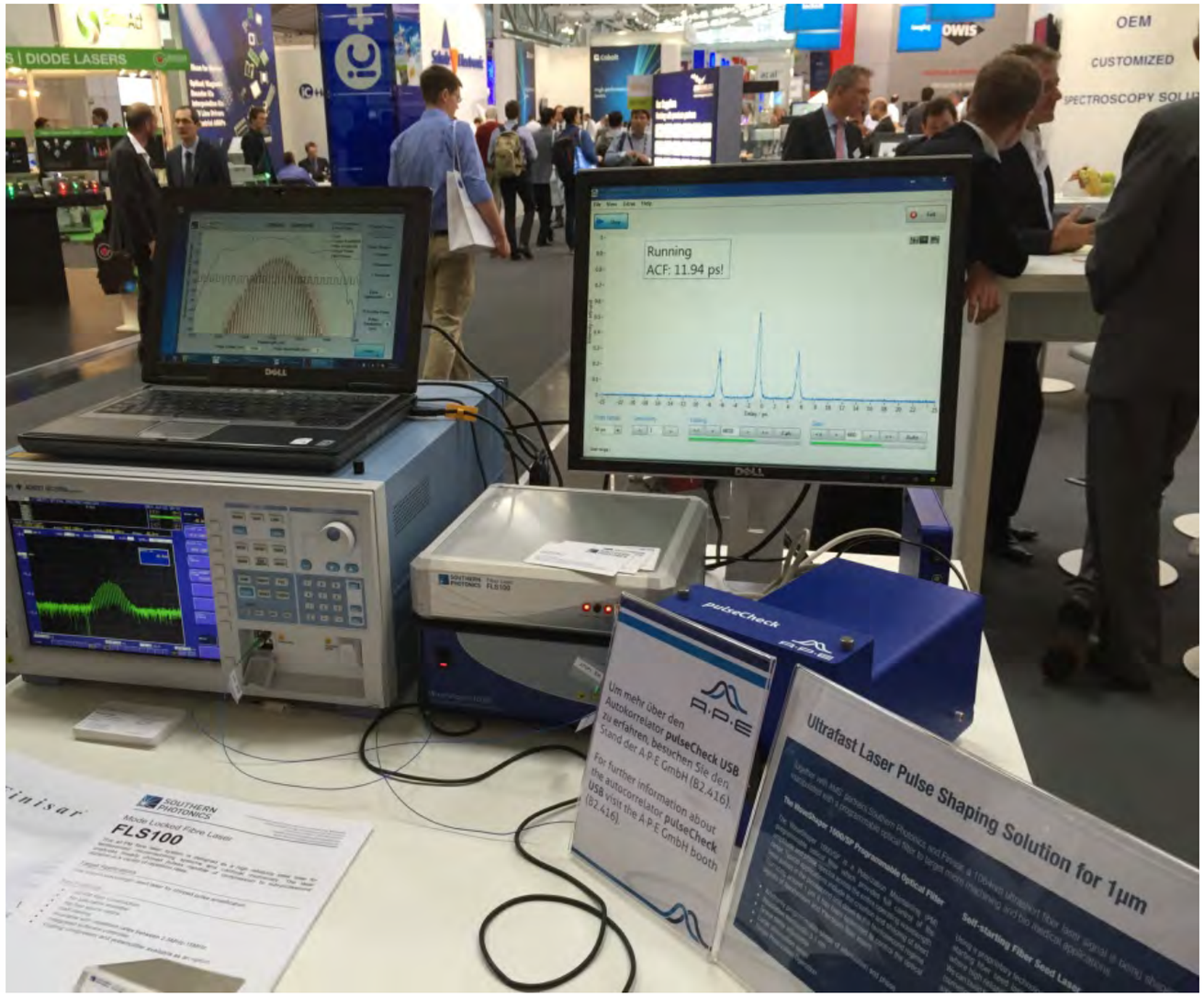
- Delivers 200fs pulses that can be used directly or as a seed.



Intelligence

- MBIE targeted research grant with Finisar, Southern Photonics and the UoA (Photon Factory)

- Uses a “wave-shaper” to turn our femtosecond source into an arbitrary pulse shape. Can then be amplified further to the required power level.



kW fibre lasers

Applications

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- Welding

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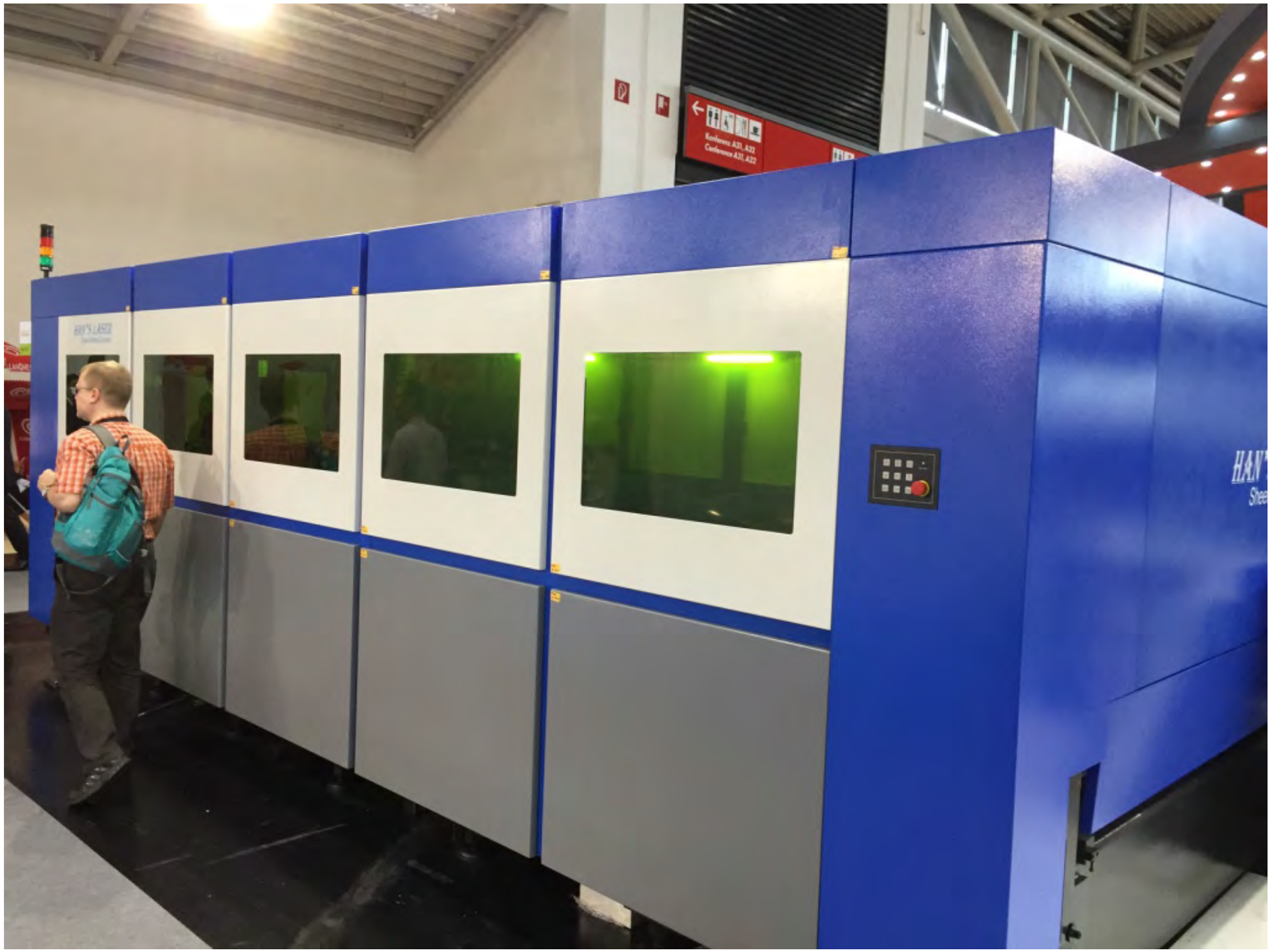
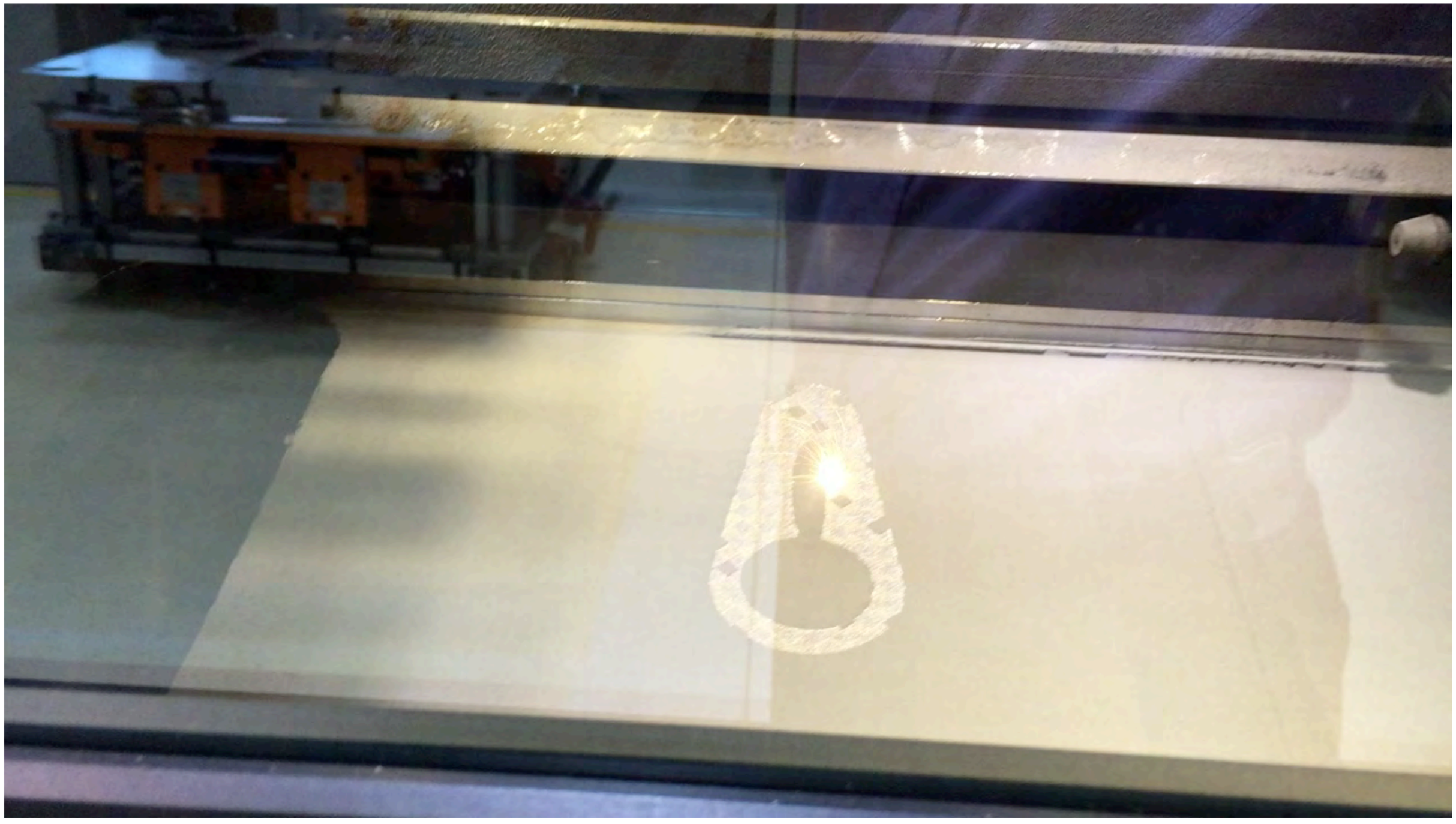


- Cutting

Applications

- Joining - Microstructuring of surfaces allows better gluing of different materials.

Applications



- Additive Manufacturing

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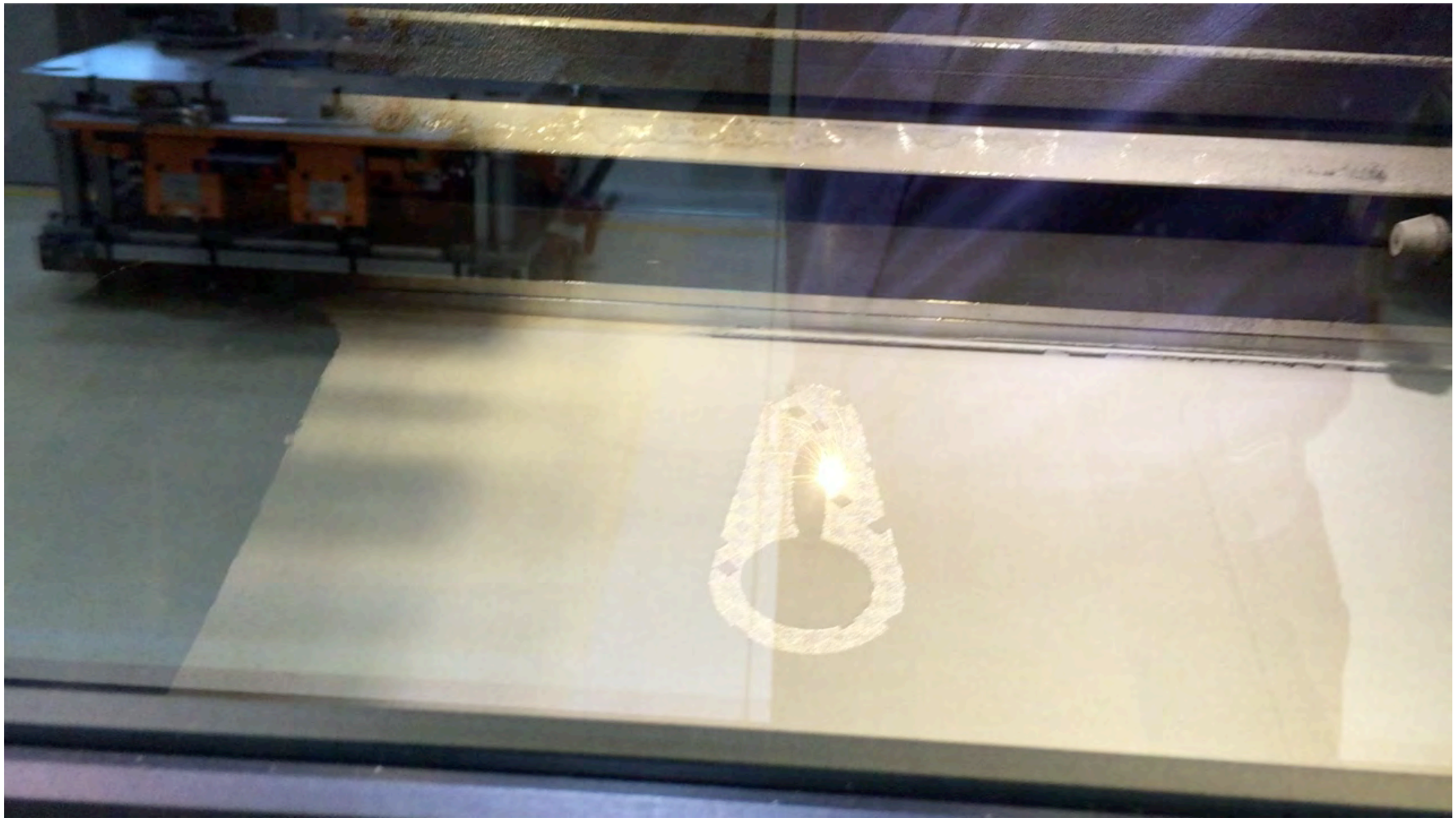

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- LED lighting is perhaps the most efficient use of laser light to save money.

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