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Next generation space and airborne laser technology

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SpaceLab, Imperial College, 29th September 2015

esa

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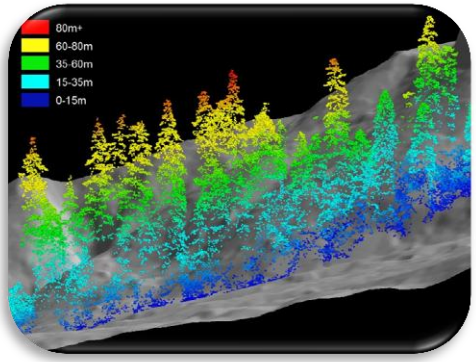
Outline

- Some background: who are we?
- Motivation
- Space-borne remote sensing
- Our laser technology
- Scope for future developments



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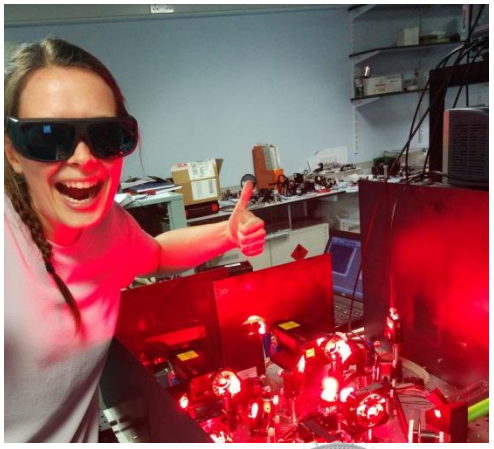
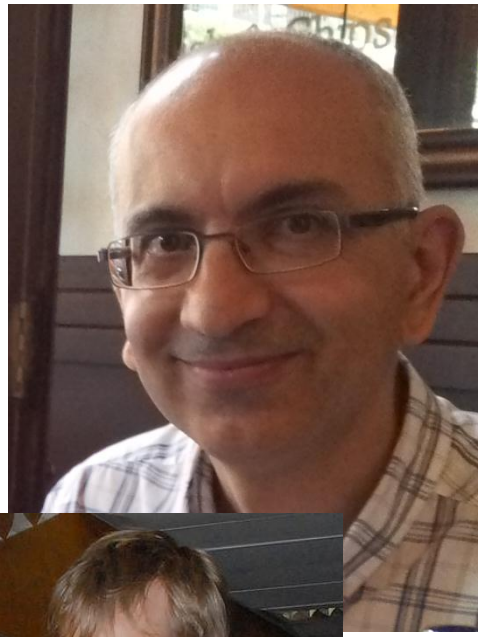
Who are we?





Expertise in laser development and photonics

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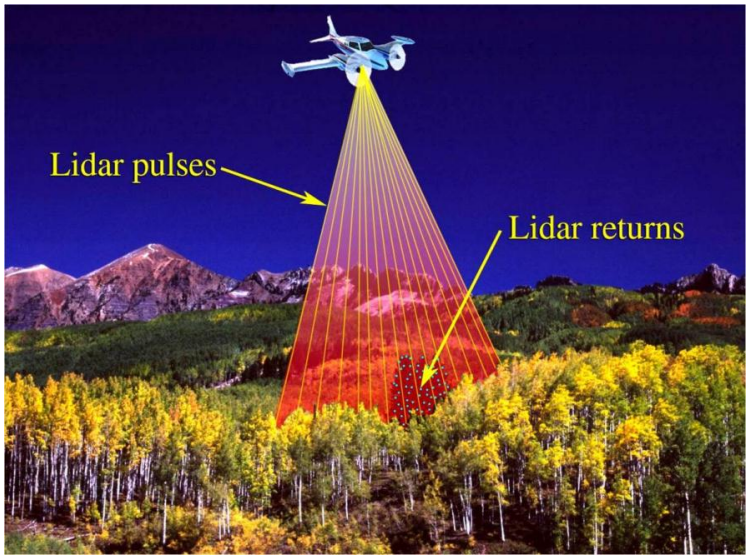
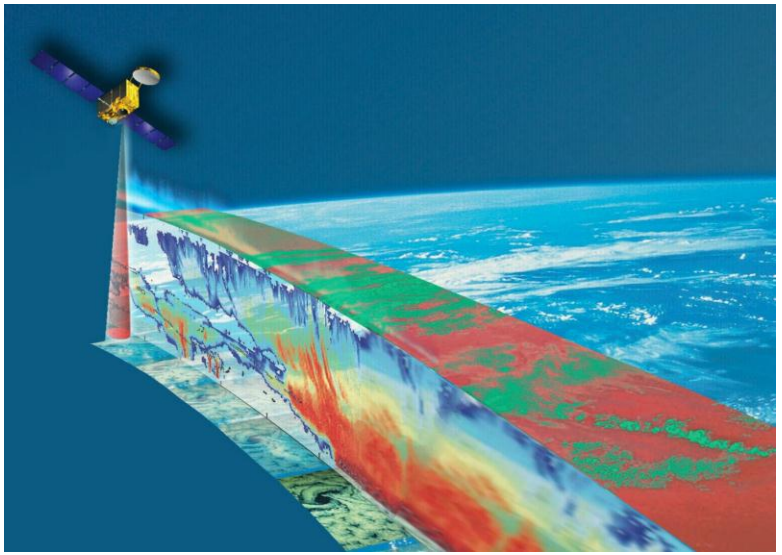
Who are we?

- Developing lasers for space-borne remote sensing since 2009 – supported by ESA
- Currently building two breadboard lasers for ESA:

Altimetry/Vegetation LIDAR



Atmospheric LIDAR



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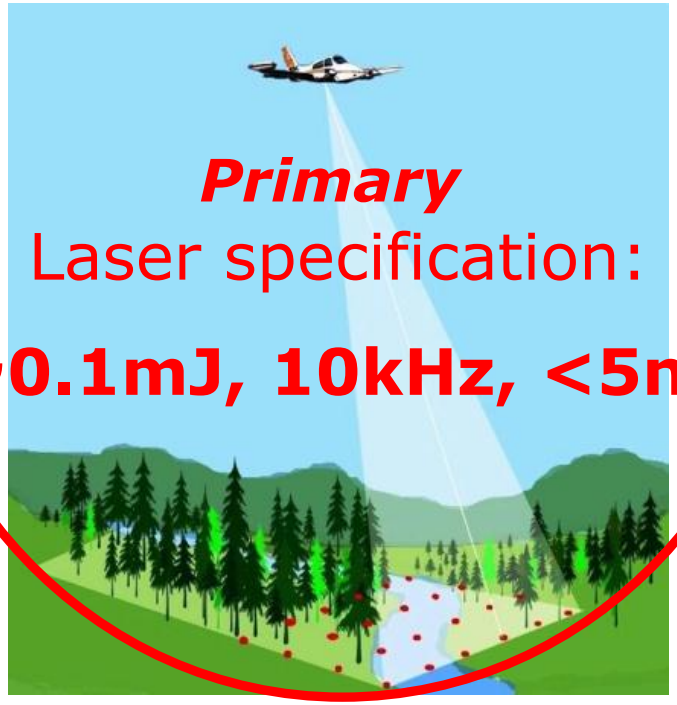
Motivation

Remote sensing

Altimetry/Vegetation LIDAR

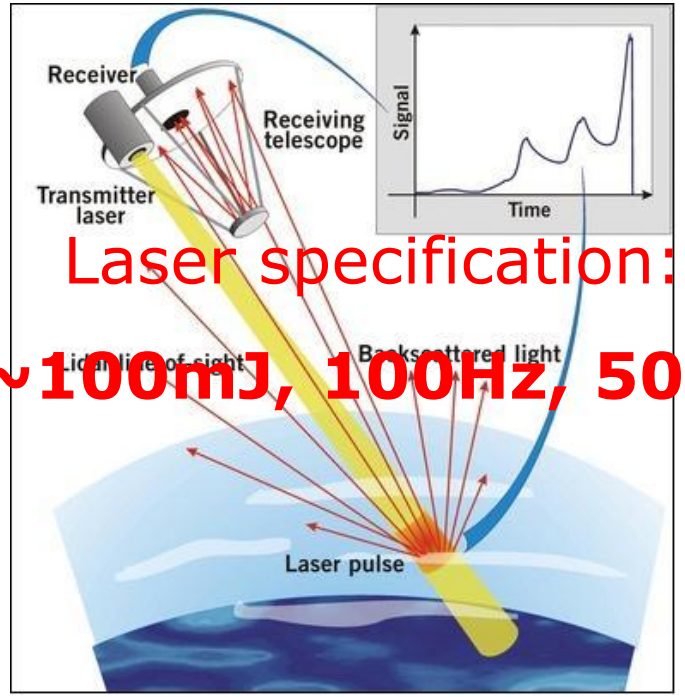


Primary

Laser specification:

~0.1mJ, 10kHz, <5ns

Cloud / aerosol or wind-speed LIDAR



Laser specification:

~100mJ, 100Hz, 50ns

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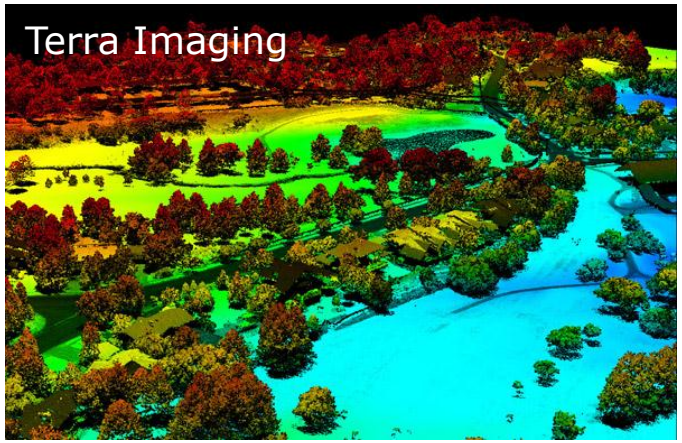
Space-borne remote sensing

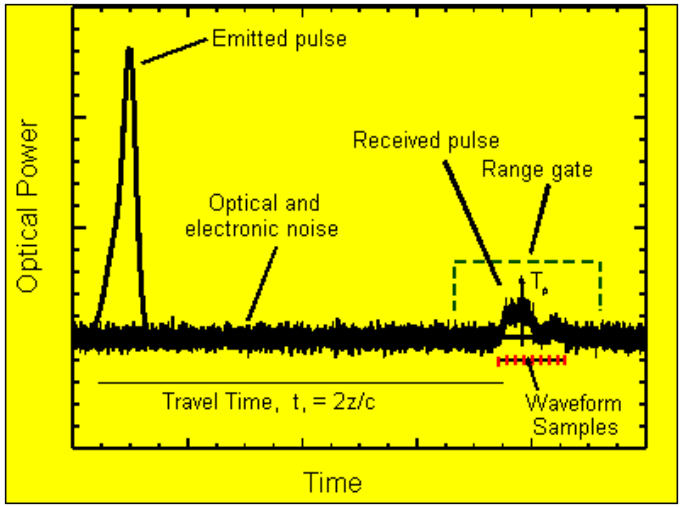
Active laser-based LIDAR: seeing the world in 3D

Pulsed laser technology provides:

- Vertical profiling (altimetry)
- Day / night operation
- Spectral selection
- High spatial resolution



$$z = \frac{c\Delta t}{2} \rightarrow 1\text{ns} = 15\text{ cm}$$



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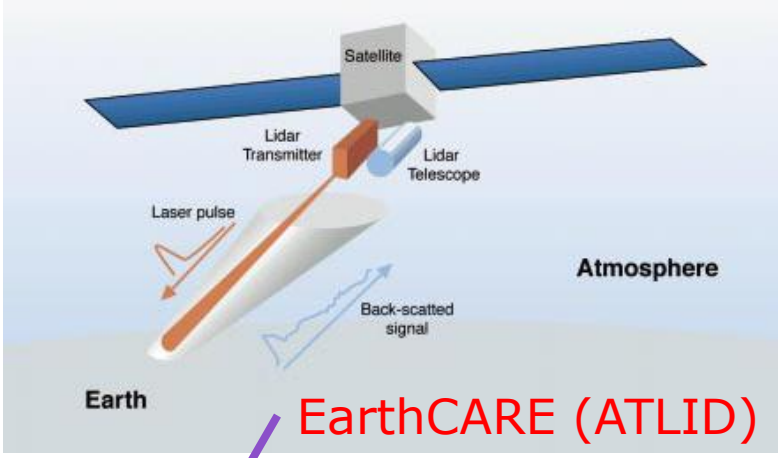
Space-borne remote sensing

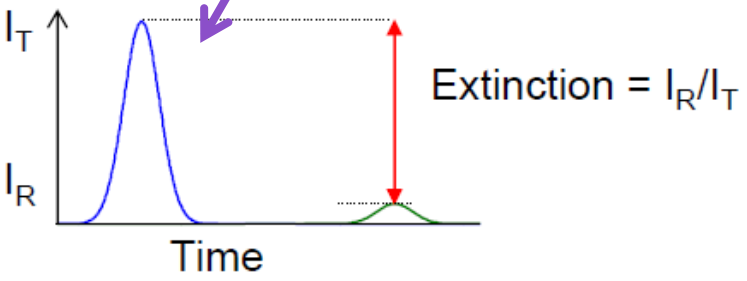
e.g. Atmospheric LIDAR

Pulsed laser technology used to acquire global observations:

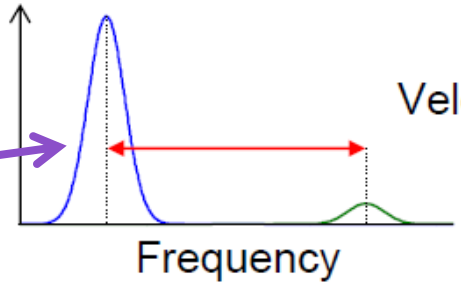
- Cloud vertical profile
- Aerosol vertical profile
- Line-of-sight profiling wind vectors



EarthCARE (ATLID)



ADM Aeolus (ALADIN)



Velocity = $\lambda/2*\Delta f$

Images: ESA

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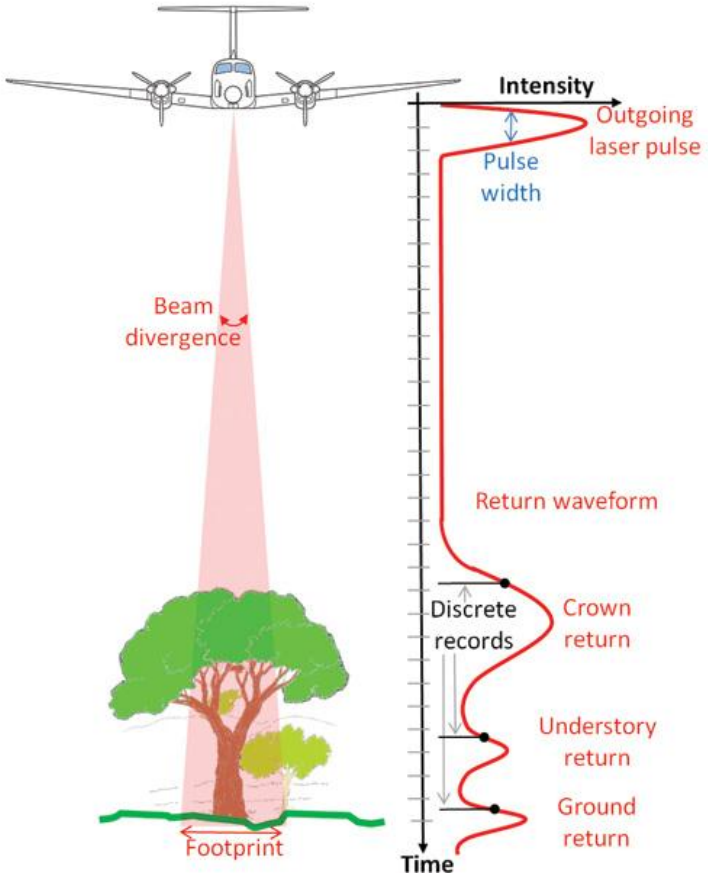
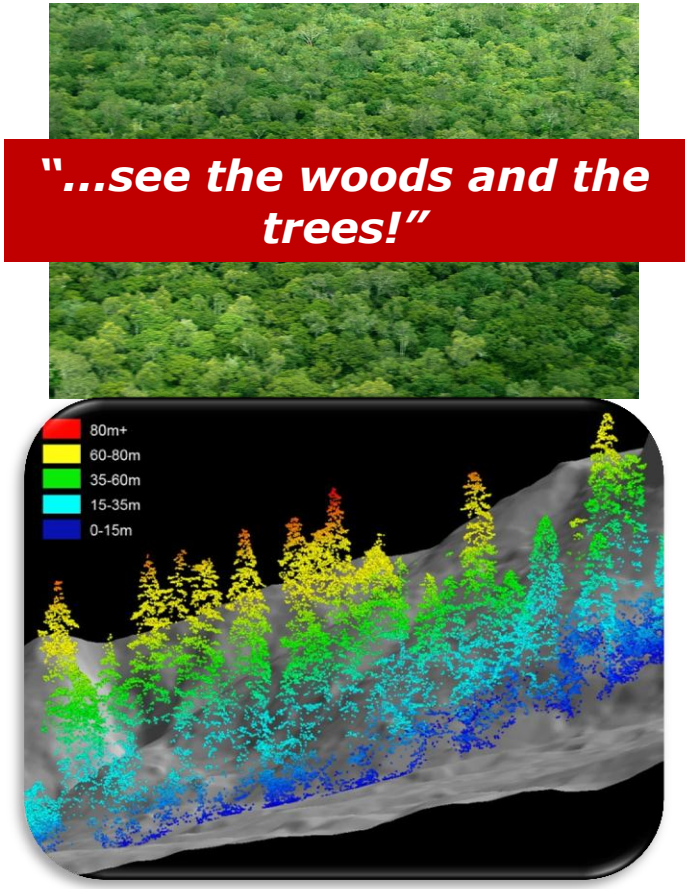
Space-borne remote sensing

e.g. Vegetation LIDAR



Imaging Notes Magazine:
Lifting the Canopy Veil (2011)



Oregon University:
Andrews Experimental Forest

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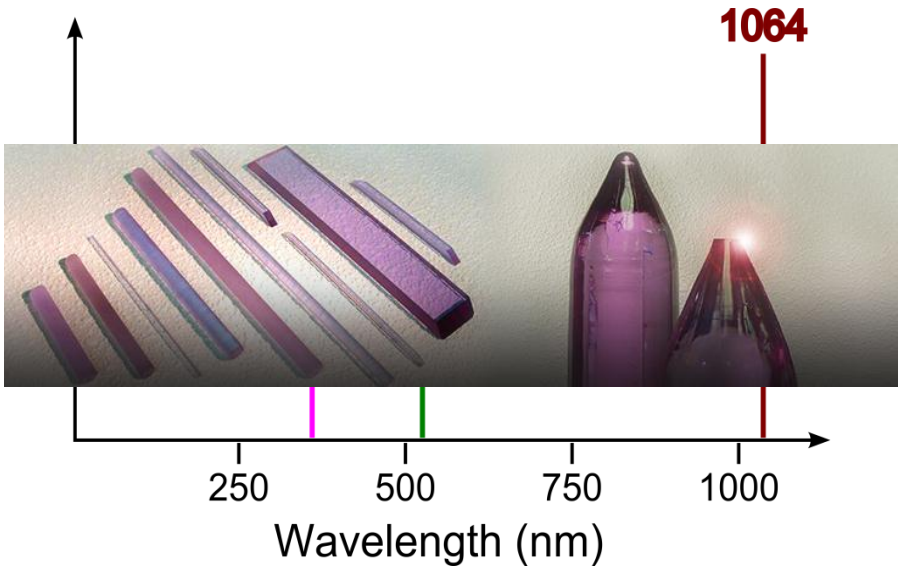
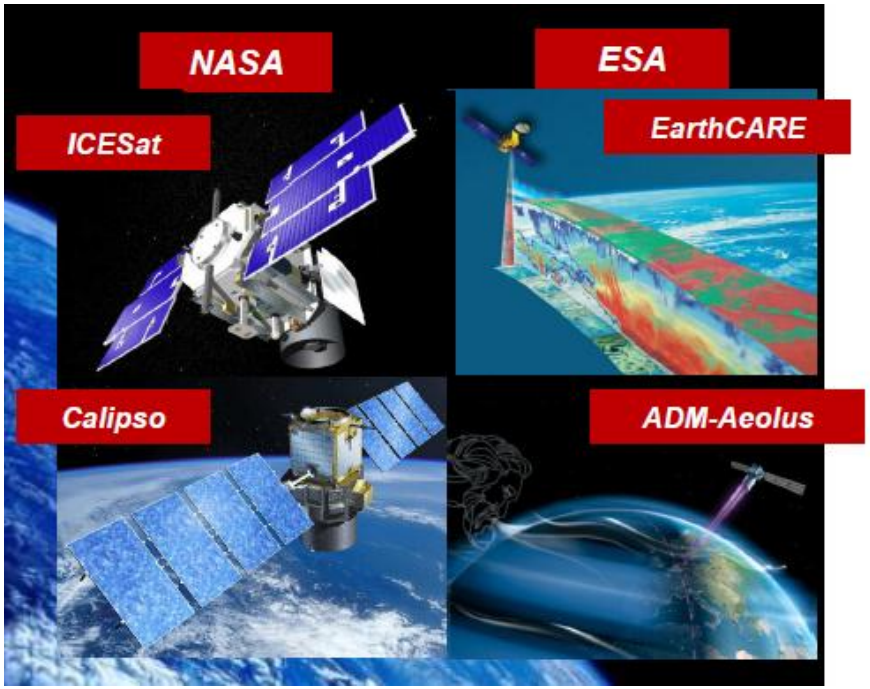
Lasers for space-borne remote sensing

Demanding space & high energy laser requirements:

→ Nd:YAG lasers one of few lasers qualified for space missions, BUT…

- No wavelength tunability
- Low wall-plug efficiency





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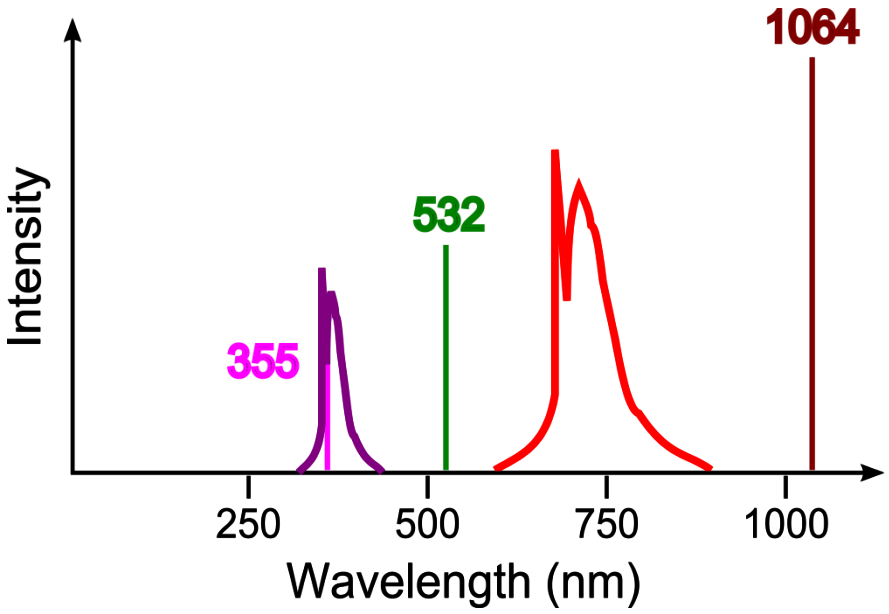
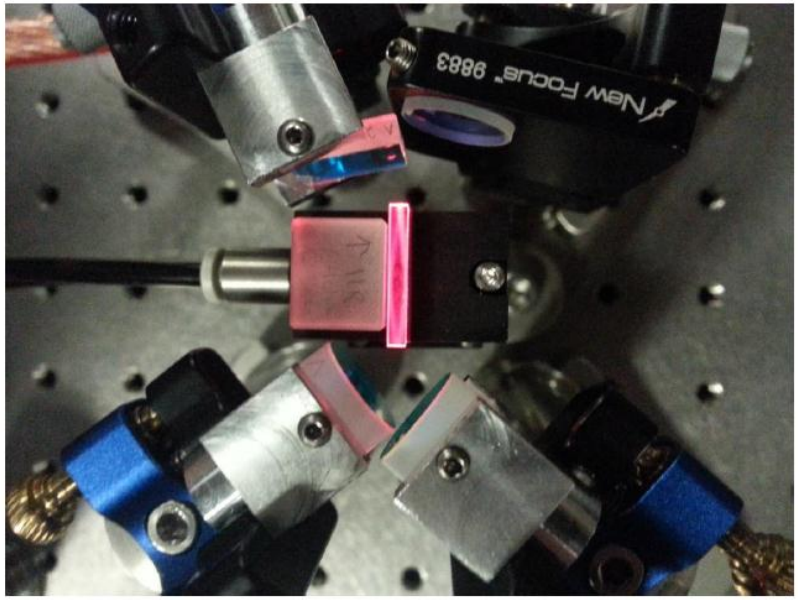
New laser technology: Alexandrite

Alexandrite offers new solution as a LIDAR source

- Flexible wavelength
- Better spectral match to application
- Higher efficiency





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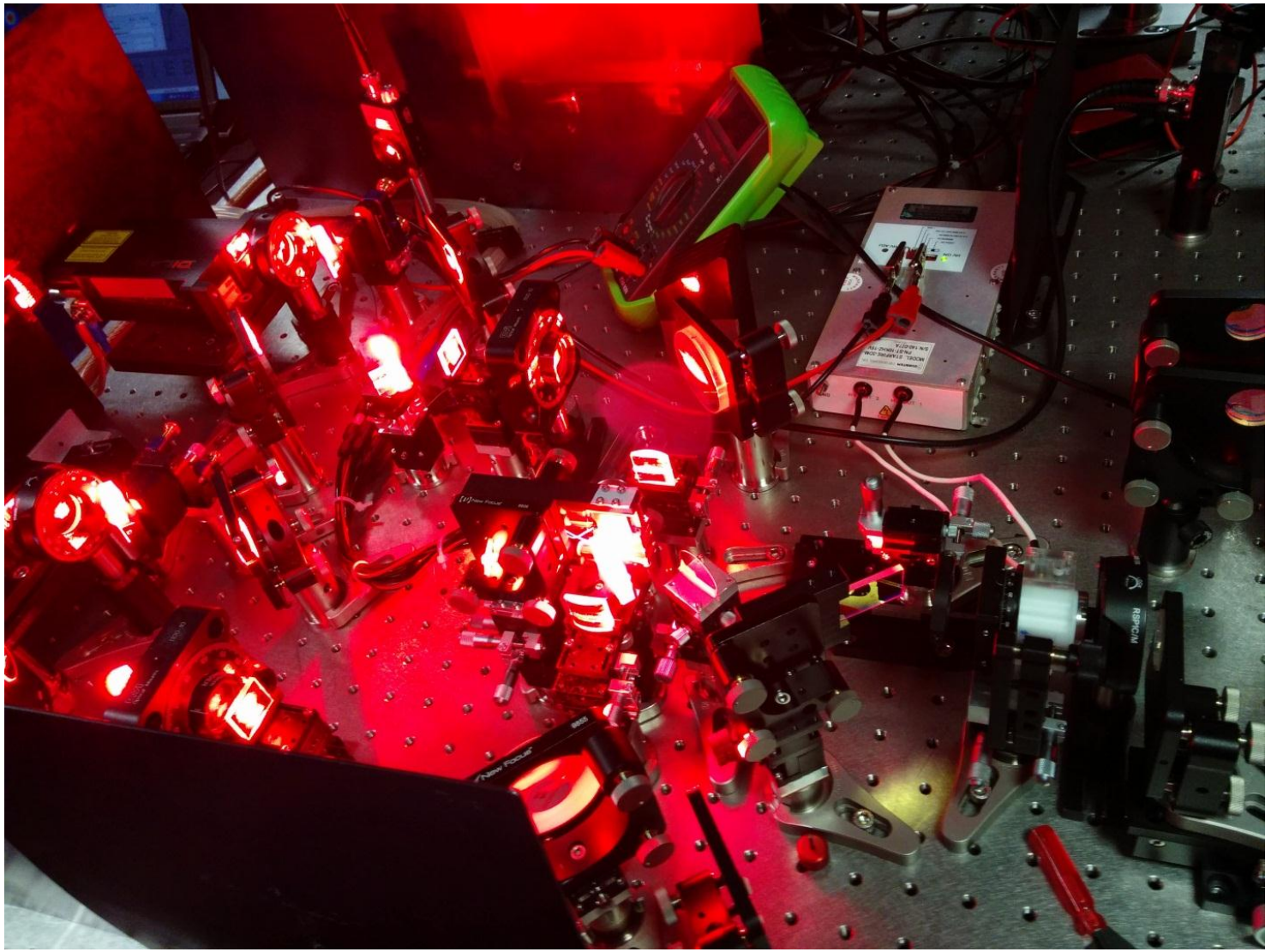
New laser technology: Alexandrite



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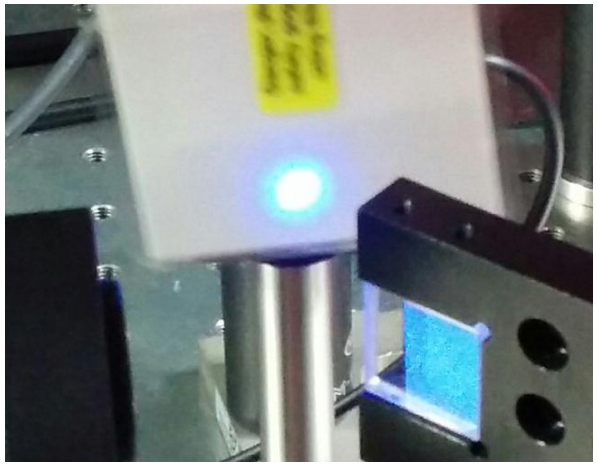
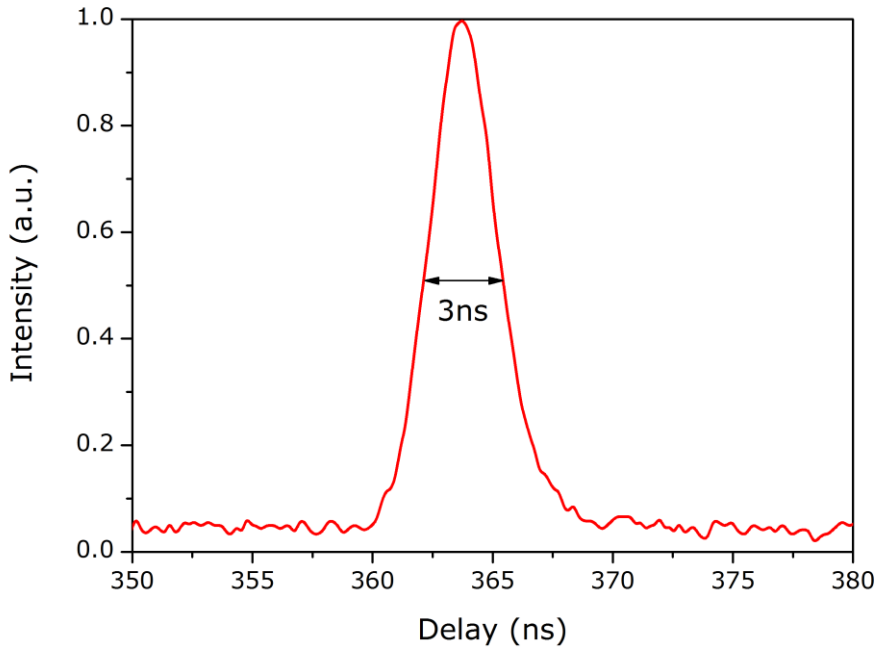
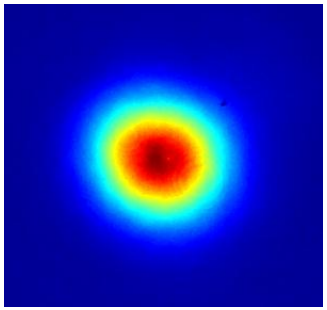
New laser technology: Alexandrite

We've demonstrated:

- Record powers
- Efficient operation
- Short pulses at high pulse rates
- Efficient conversion to UV







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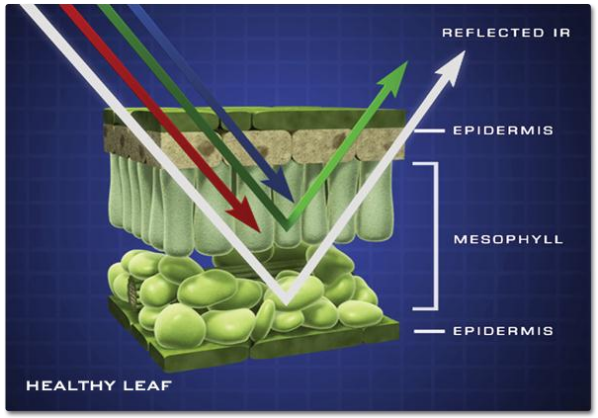
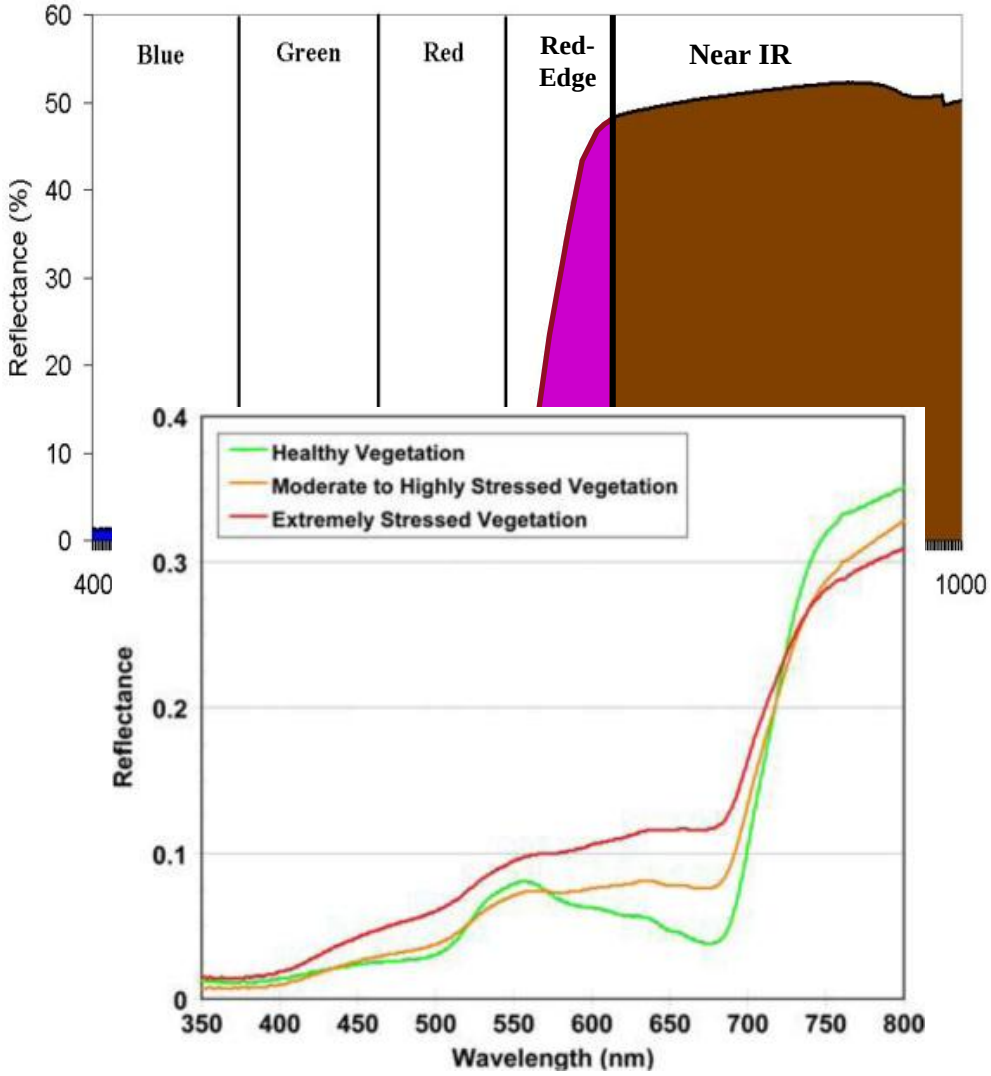
Alexandrite for vegetation LIDAR

Vegetation has unique spectral reflectivity:

- Low reflectivity (high absorption) in visible
- High reflectivity in near-IR
- Steep reflectivity transition at 'red-edge' (~690 – 750nm)





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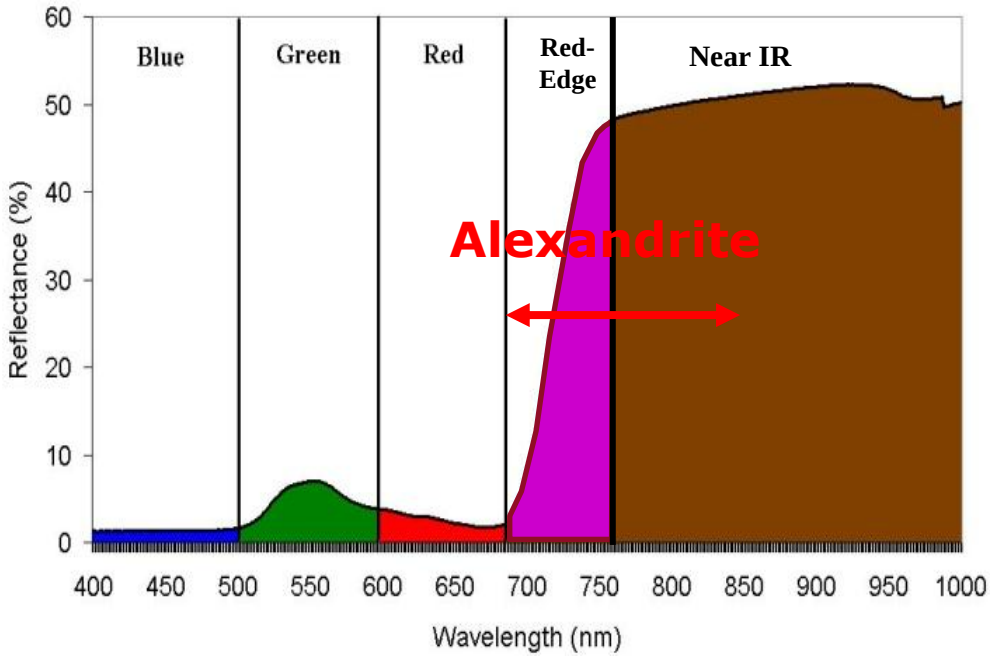
Alexandrite: new opportunities

Our laser technology *uniquely* operates across red-edge

- Multi-spectral probing across red-edge
- Short pulse duration **(3ns)**
- High pulse rate **(10kHz)**
- Compact, micropulse laser → small satellite & airborne UAV



High resolution mapping of canopy or crop height (yield)

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Red-edge vegetation LIDAR: unique & compelling opportunity

Commercial large business sector (crops & forestry)

Drivers:

- Maximising and predicting crop yield (food security)
- Cost-saving by minimising resource use (fertiliser, pesticide, water…)
- Farming in areas of low resources (limited water…)
- Reducing adverse environmental impact
- Monitor Governmental environmental regulations

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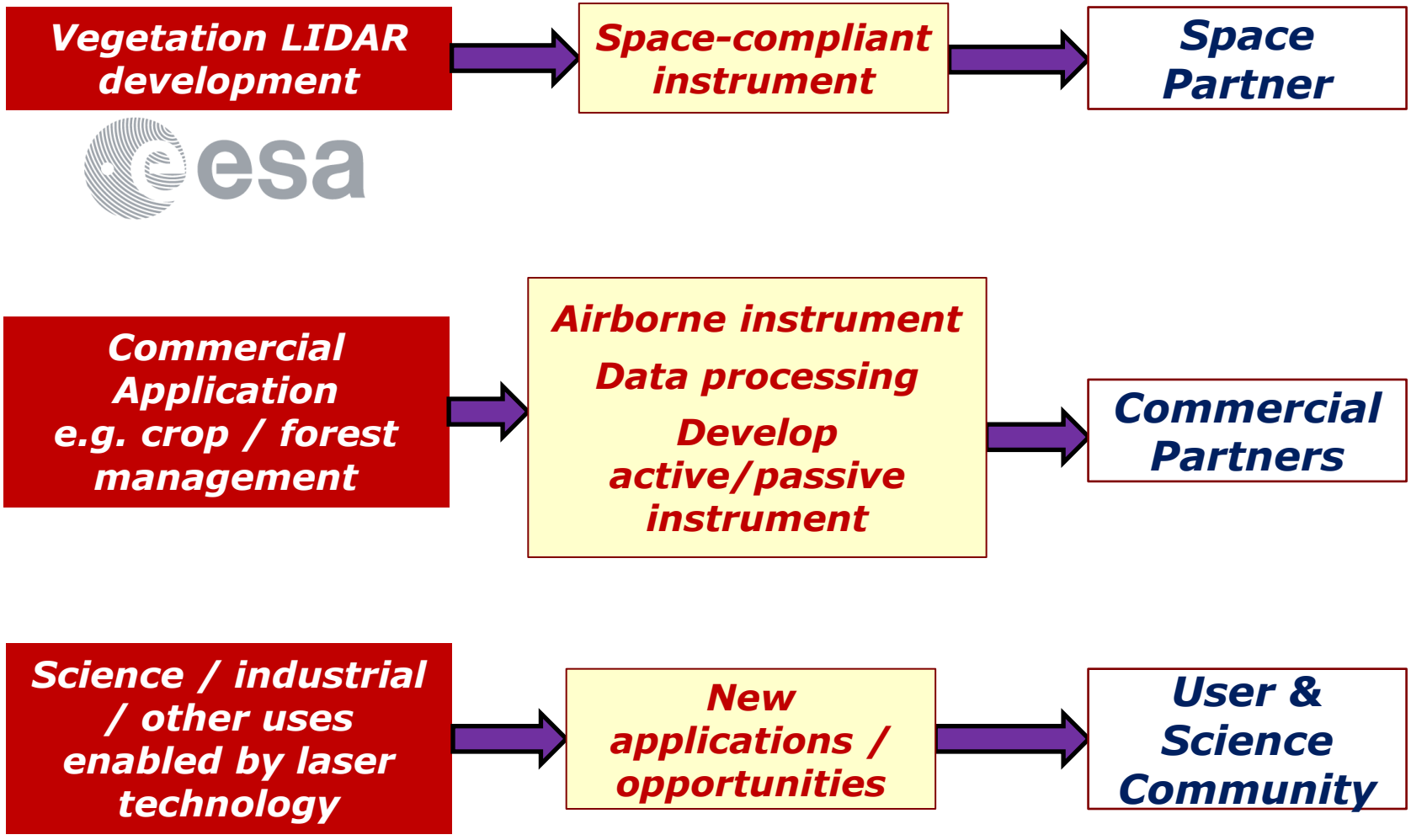
Areas for development & collaboration



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Conclusions

- **Alexandrite Lidar technology offers new potentials**
  - Vertical profiling & hyperspectral capability
  - ESA & more commercial opportunities
- **Next steps to raise TRL & find new applications**
  - Productive opportunities for collaboration between Imperial and space / commercial / broader users!

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Acknowledgements

Errico Armandillo and Michael Jost *(ESA ESTEC)*

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