

Laser development: Taking physics to industry

4th Biennial Conference

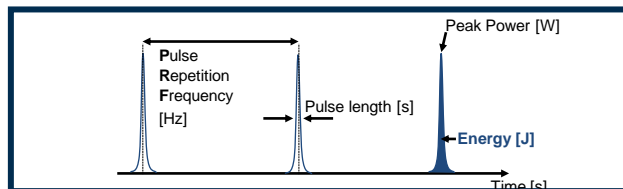
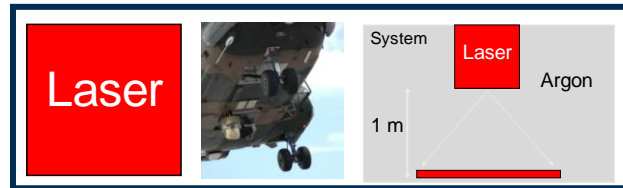
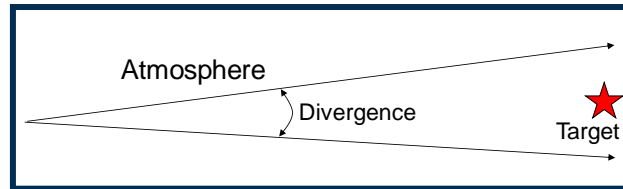
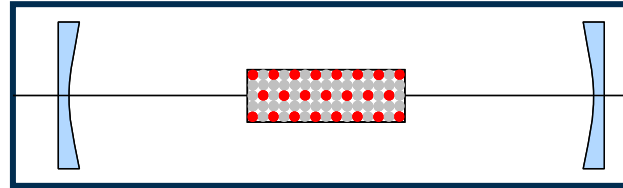


Presented by Dr Daniel Esser

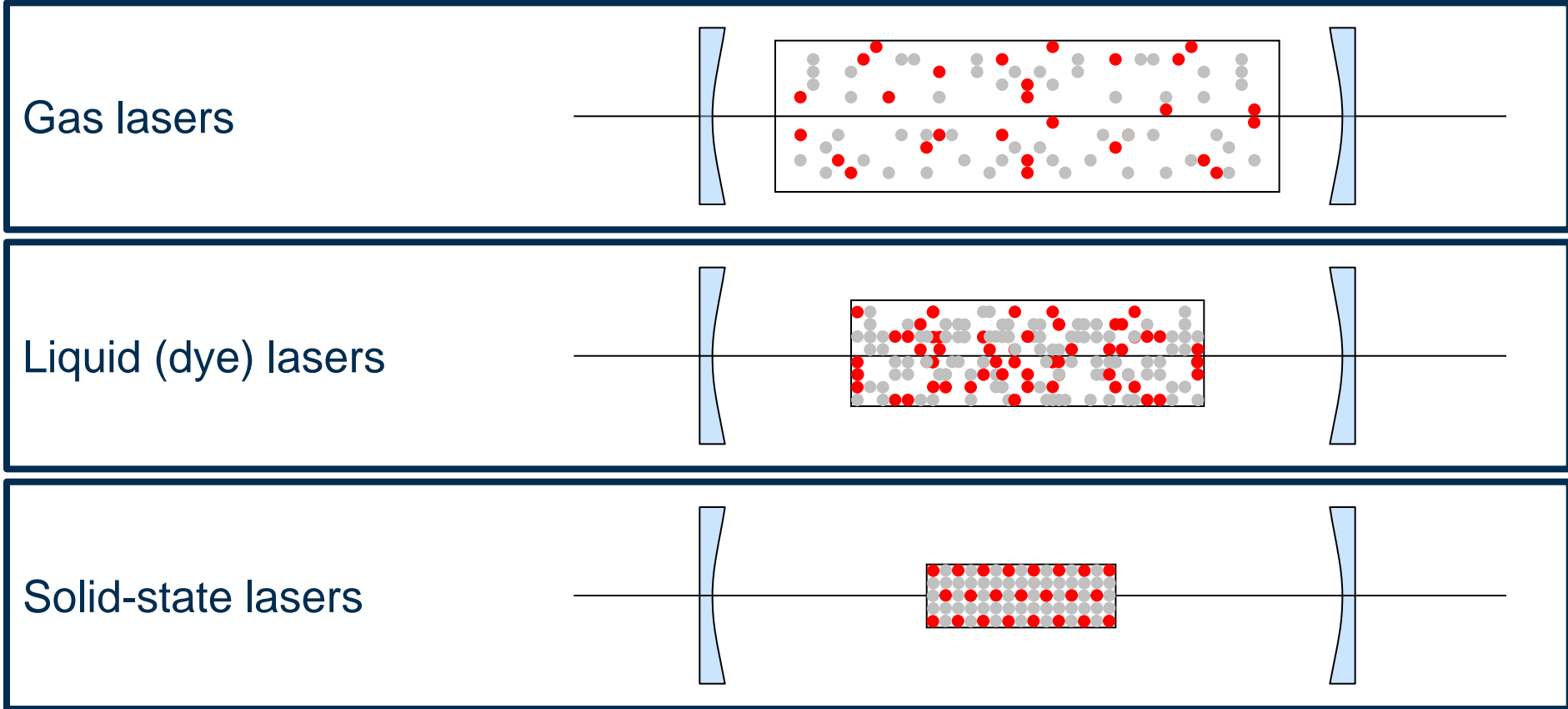
2012-08-09

Presentation Outline

- Modern laser development
 - Diode-end-pumped solid-state lasers
 - Fibre-laser-pumped solid-state lasers
- Applications & Specifications
- Few examples
 - Pumping another laser
 - Directed infrared countermeasures
 - 3D printing
 - Gated imaging
- Concept Laser Products
- Advanced Photonics Manufacturing Facility

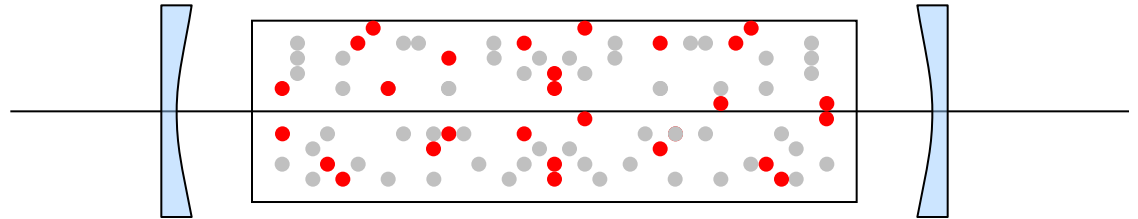


Lasers

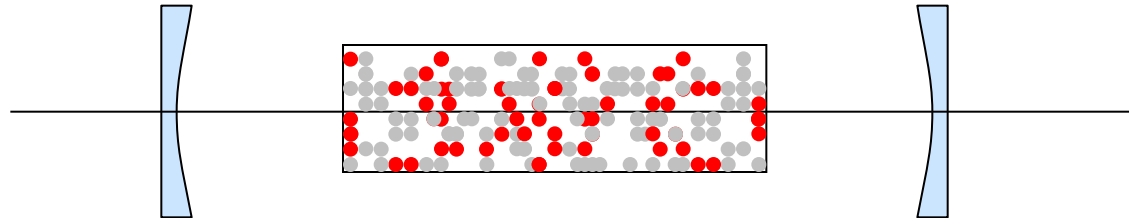


Solid-state Lasers

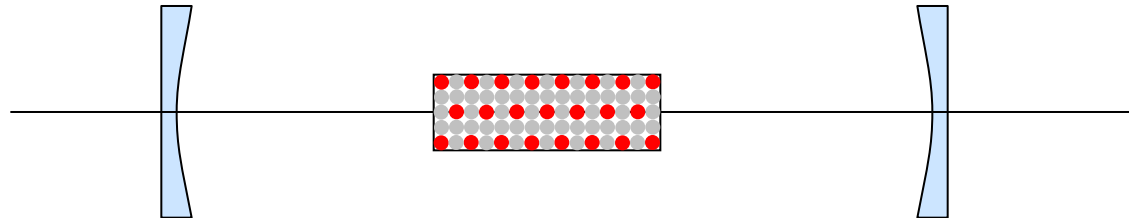
Gas lasers



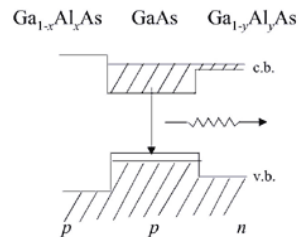
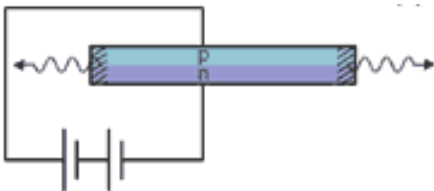
Liquid (dye) lasers



Solid-state lasers



Semiconductor (diode)

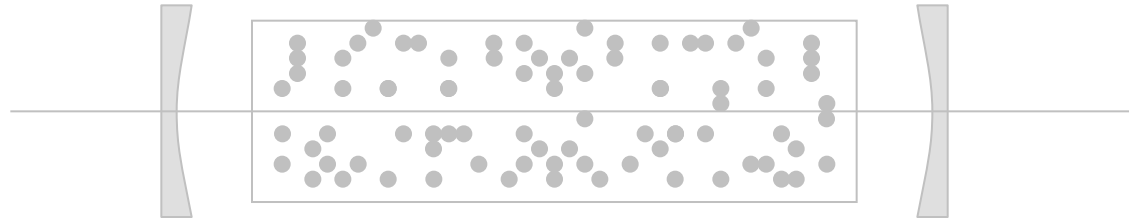


Fibre

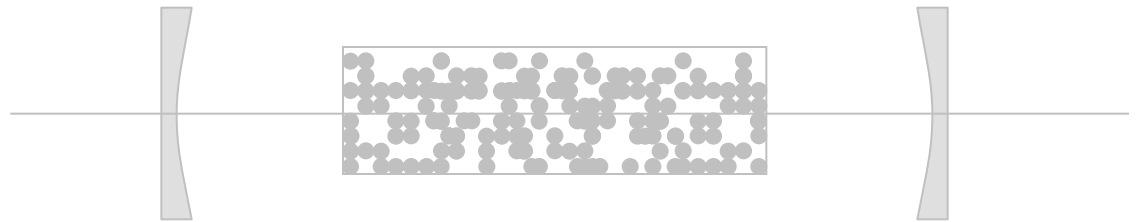


Diode-pumped Solid-state Lasers

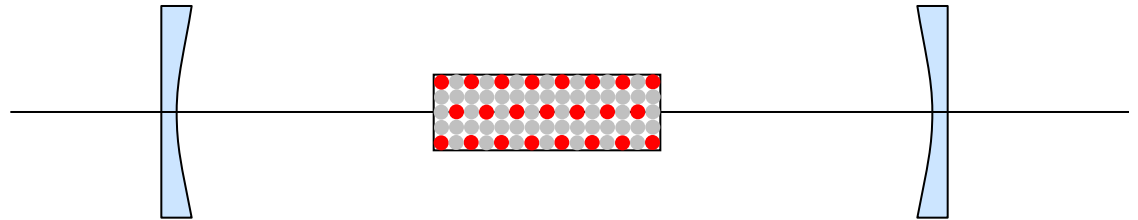
Gas lasers



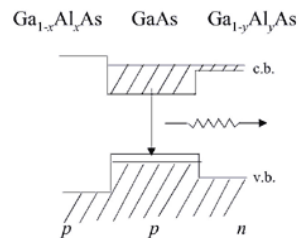
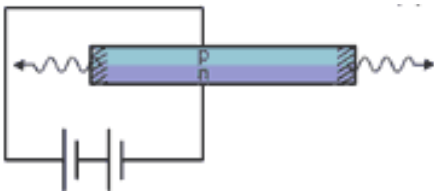
Liquid (Dye) lasers



Solid-state lasers



Semiconductor (diode)

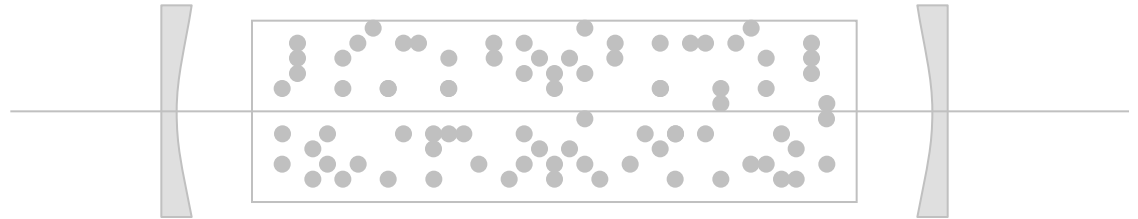


Fibre

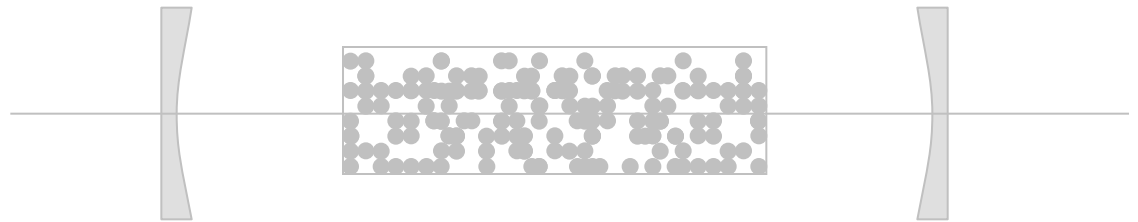


Diode-pumped Solid-state Lasers

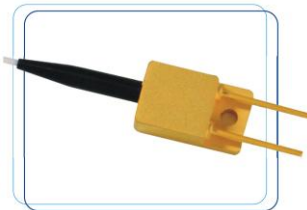
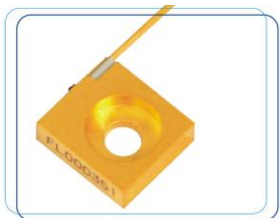
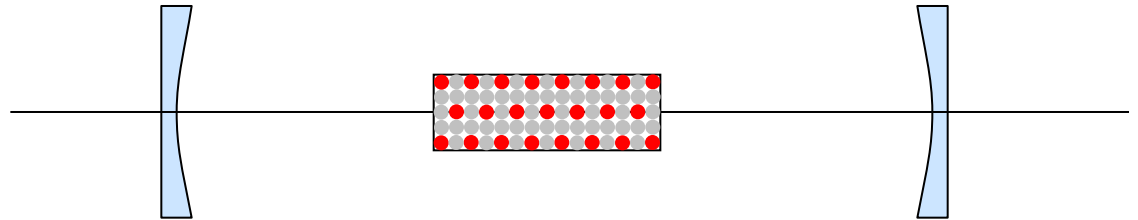
Gas lasers



Liquid (Dye) lasers



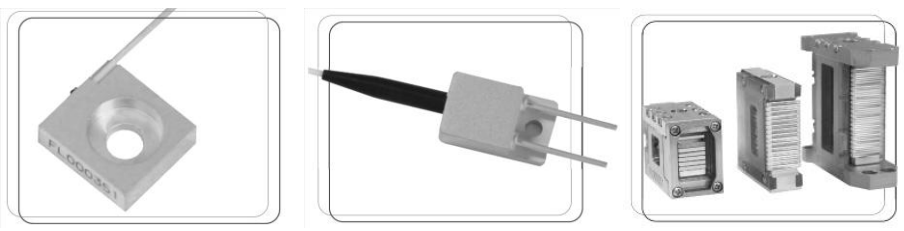
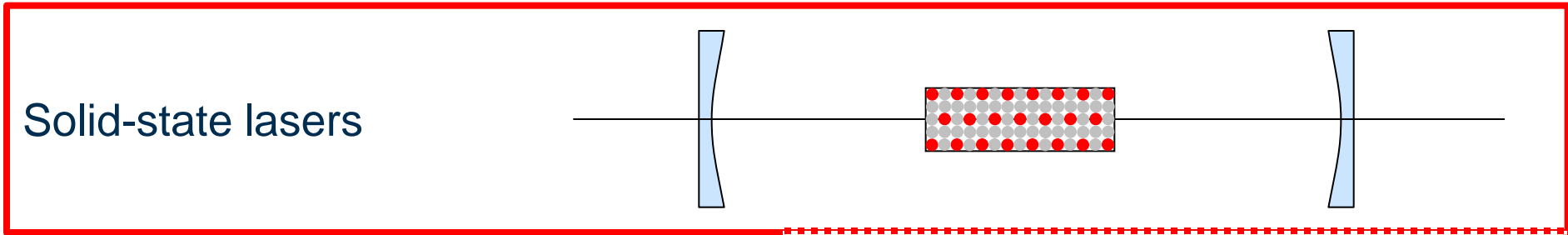
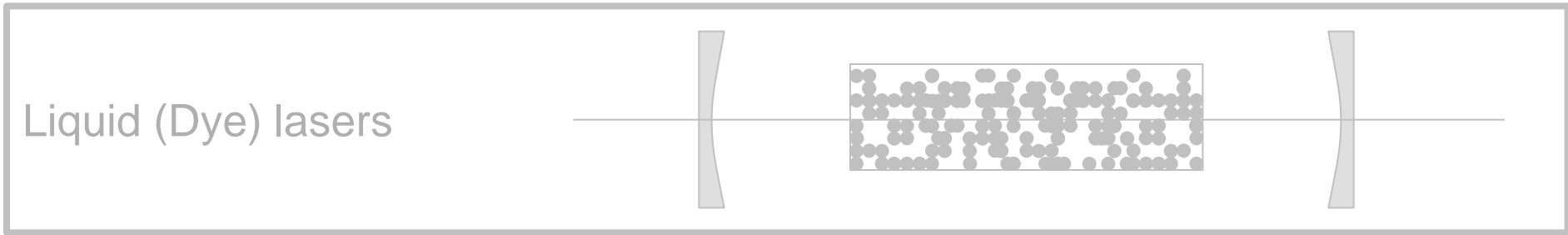
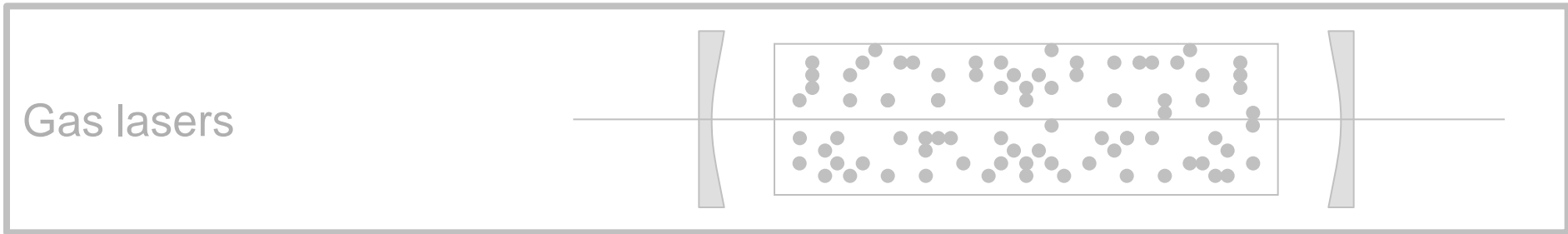
Solid-state lasers



Fibre



Fibre-laser-pumped Solid-state Lasers

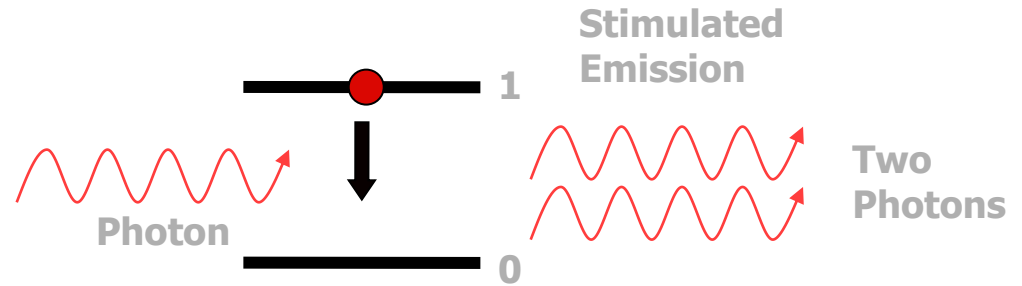


Fibre



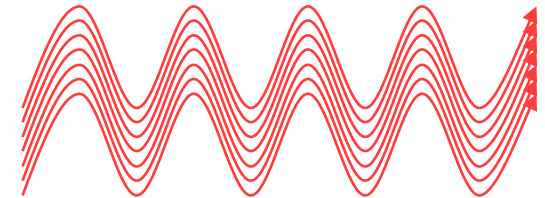
Unique laser properties lead to unique applications

Light
Amplification by
Stimulated
Emission of
Radiation



The laser slogan: *One colour, One direction, Too the point!*

Monochromatic One colour or wavelength

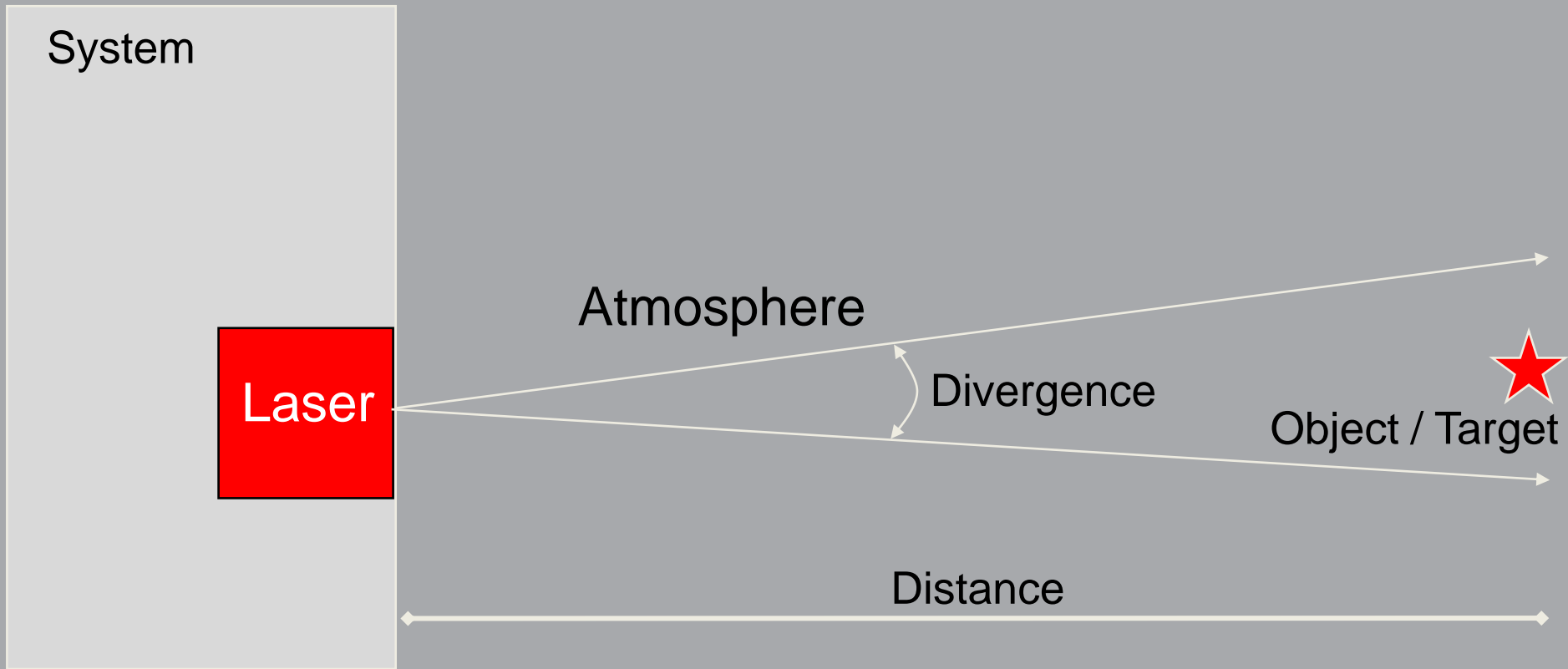


Directional Laser beam does not expand as 'quickly' as other light beams

Coherent All waves are generated in phase with each other → small focus

Generated at the same time → short laser pulse

Laser application – laser is part of system



Determine laser light characteristics

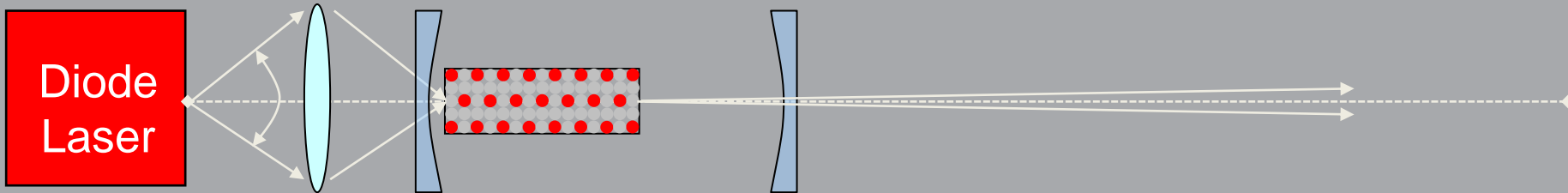
- Mode (Continuous / single shot)
- Power / Energy
- Beam Quality
- Wavelength(s)

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Determine system properties

- Efficiency
- Power supply
- Laser type / technology
- Size & weight

Laser application: to pump another laser



- Mode: Continuous
- Power : very high
- Beam Quality: very bad
- Wavelength: TBD
- Efficiency: 50%
- Power supply: DC
- Technology: Semiconductor
- Size & weight: small

Alkali Metals

Alkaline Earth

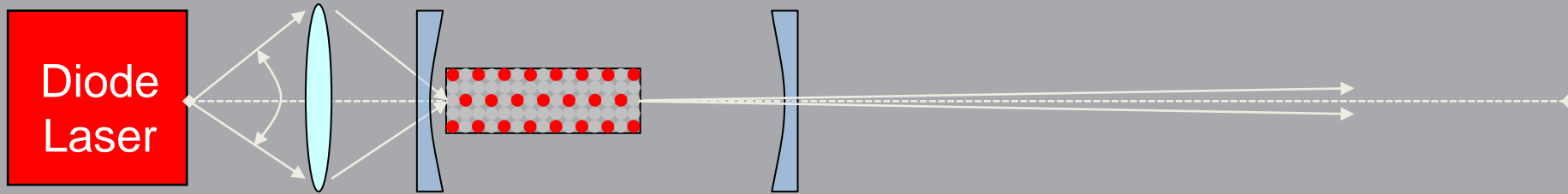
Noble Gases

Halogens

Transition Metals

H																	He
Li	Be	Transition Metals										B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						
Lanthanides		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
Actinides		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

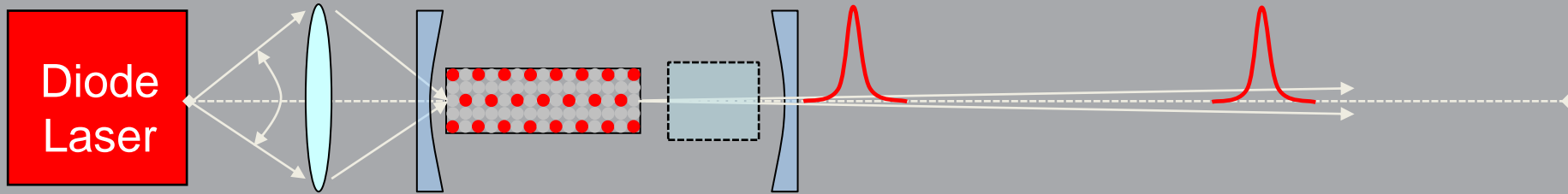
Laser application: to pump another laser



Mode: Continuous
Power : very high
Beam Quality: very bad
Wavelength: TBD
Efficiency: 50%
Power supply: DC
Technology: Semiconductor
Size & weight: small

Mode: Continuous
Power : high
Beam Quality: very good
Wavelength: choice
Efficiency: 10 - 40%
Cooling required
Technology: solid-state
Size & weight: compact

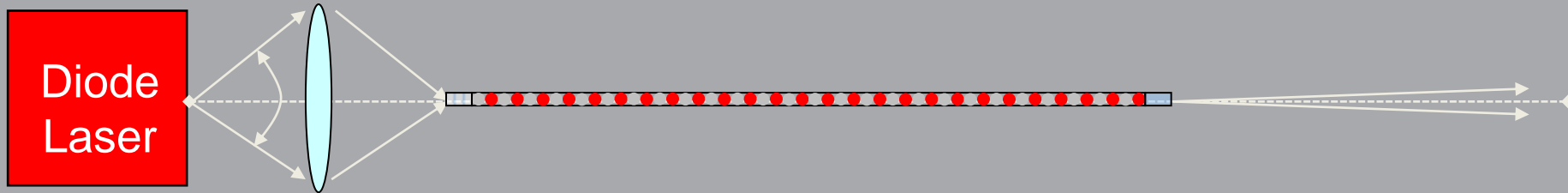
Laser application: to pump another laser



Mode: Continuous
Power : very high
Beam Quality: very bad
Wavelength: TBD
Efficiency: 50%
Power supply: DC
Technology: Semiconductor
Size & weight: small

Mode: Continuous or pulsed
Power : high
Beam Quality: very good
Wavelength: choice
Efficiency: 10 - 40%
Cooling required
Technology: solid-state
Size & weight: compact

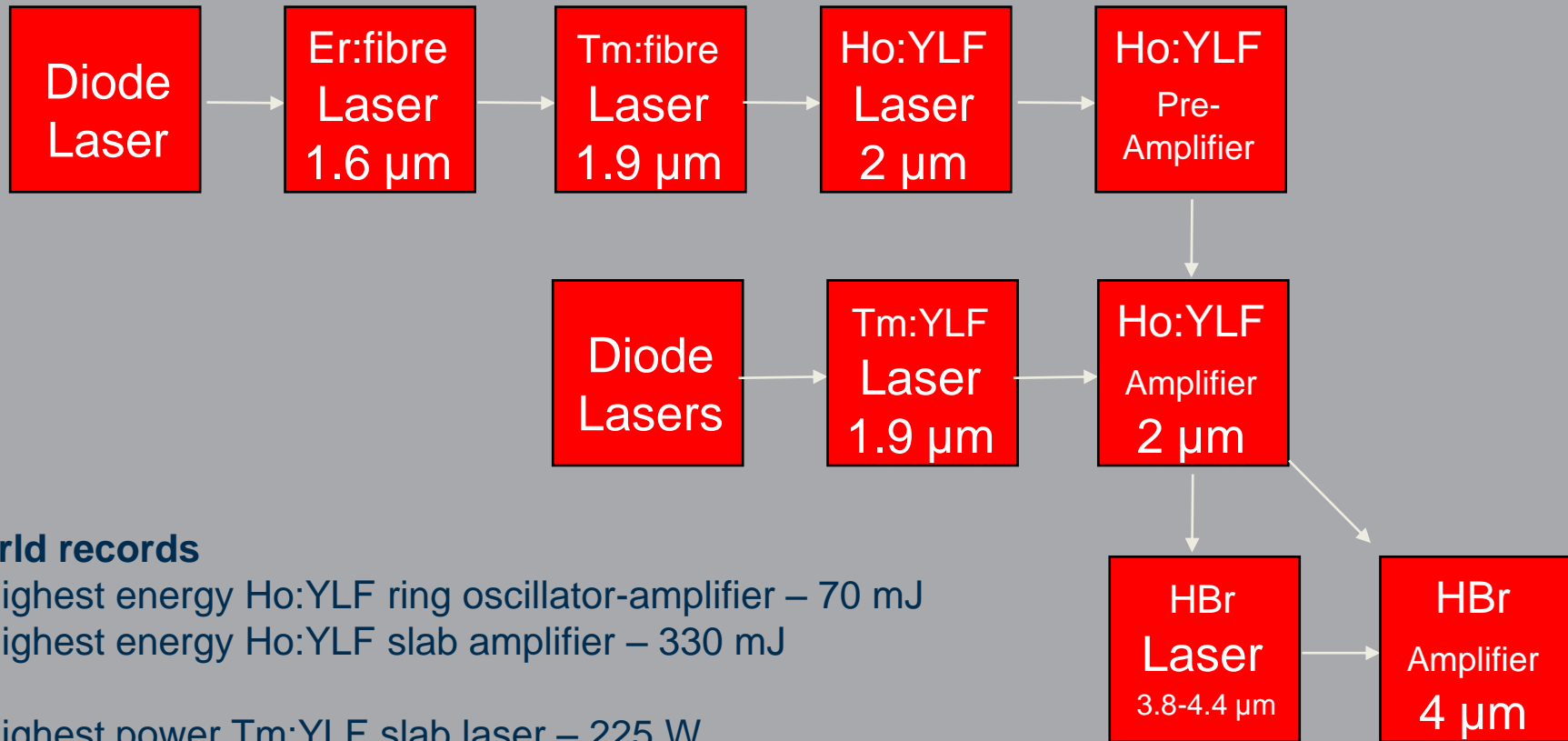
Laser application: to pump another laser



Mode: Continuous
Power : very high
Beam Quality: very bad
Wavelength: TBD
Efficiency: 50%
Power supply: DC
Technology: Semiconductor
Size & weight: small

Mode: Continuous
Power : high
Beam Quality: perfect
Wavelength: choice
Efficiency: 50-80%
Cooling required
Technology: fibre laser
Size & weight: compact

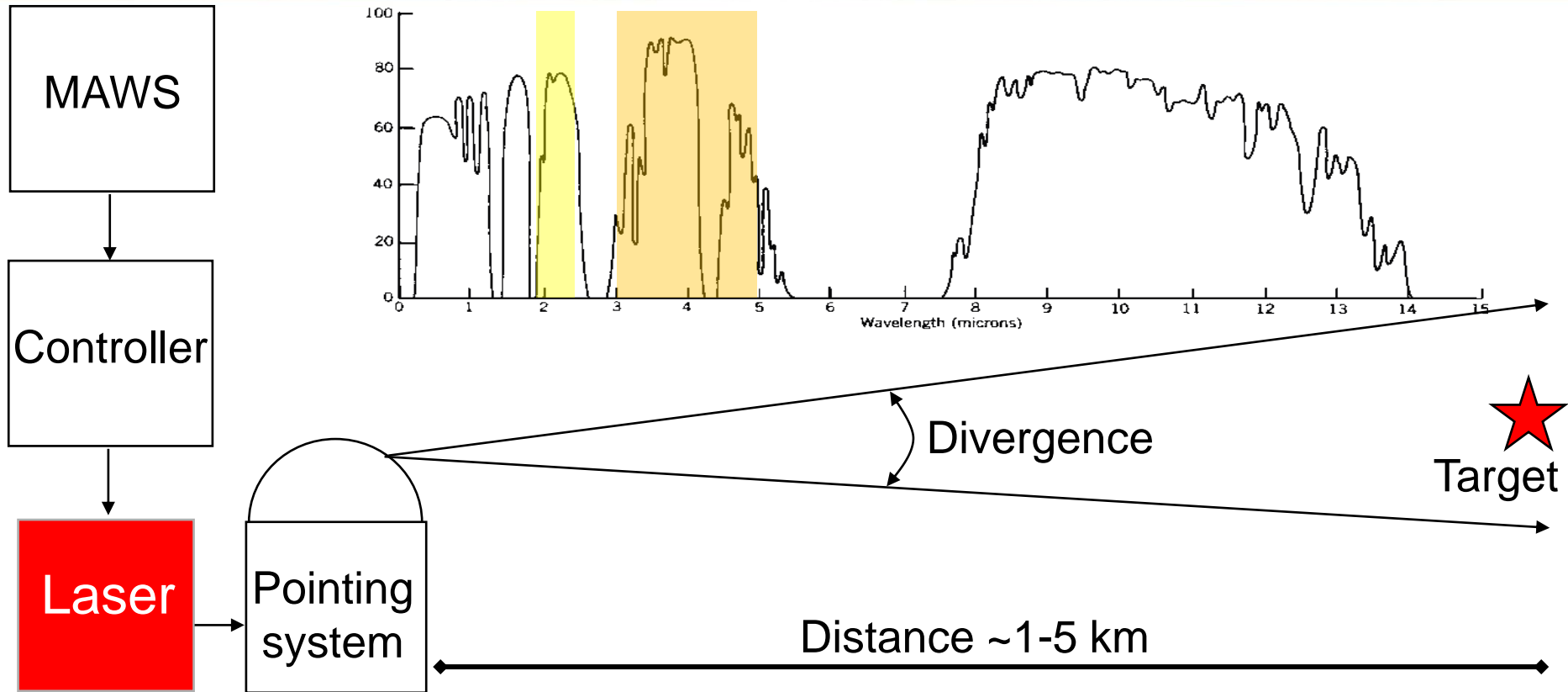
Laser application: to pump other lasers



World records

- Highest energy Ho:YLF ring oscillator-amplifier – 70 mJ
- Highest energy Ho:YLF slab amplifier – 330 mJ
- Highest power Tm:YLF slab laser – 225 W
- Highest energy HBr laser – 5 mJ per pulse
- First HBr amplifier – 10 mJ per pulse
- First HBr wavelength selection 3.8 – 4.4 μm

DIRCM: Directed Infra-Red Counter Measure



System & application determine specs

- ✓ Mode (Continuous / single shot)
- ✓ Power / Energy
- ✓ Beam Quality: Good
- ✓ Wavelengths: 2 μm ; 3-5 μm



Demonstrated laser technologies for DIRCM

Jamming

- Low Average Power Laser

1st Generation: Flight demonstration

- Solid-state technology
- 1 μm laser + converters
- Fieldable system
- Airborne jamming
- Jamming codes

Damaging/Hard-kill

- High Energy Laser

Lab demonstration

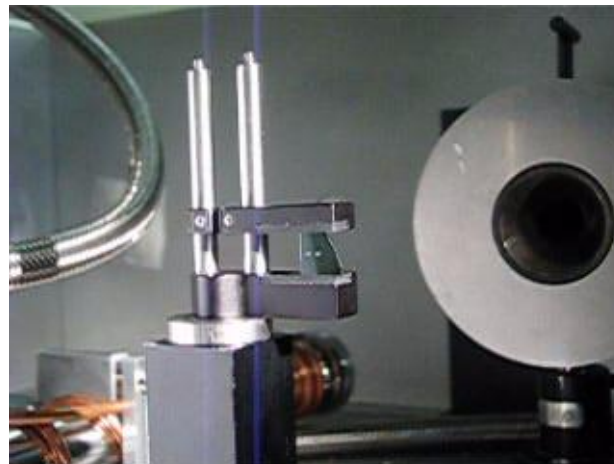
- Pulsed high-energy lasers
- 2 μm laser + converter
- Lab demonstrator
- Destroy detector material
- World leading

Dazzling

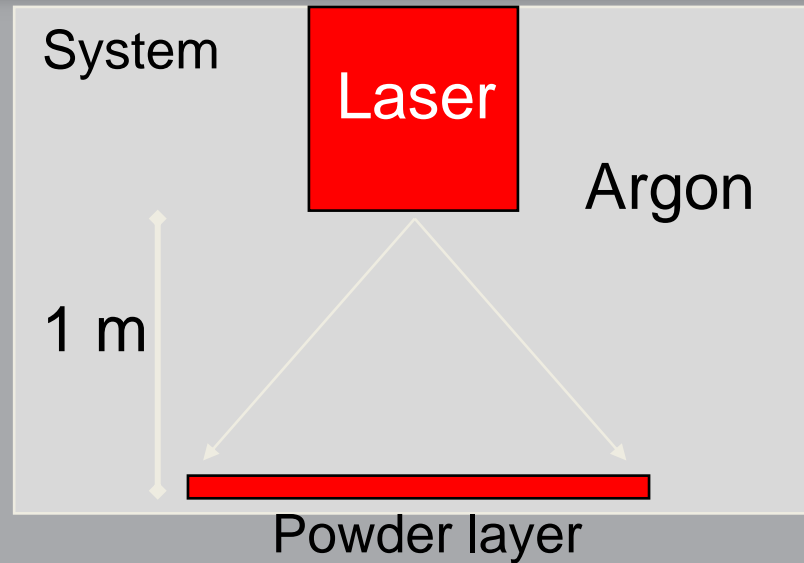
- High Average Power Laser

2nd Generation: Current development

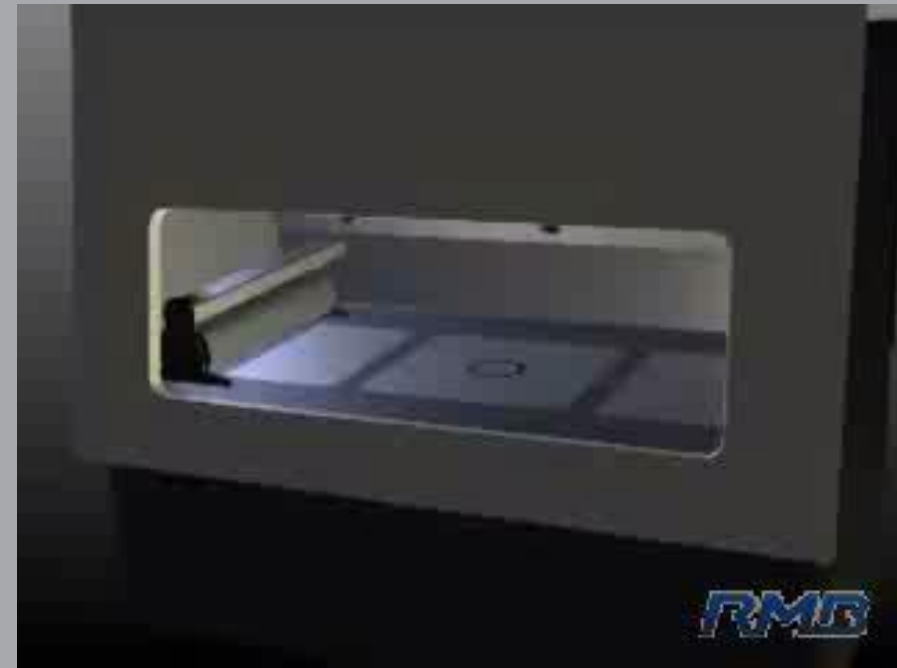
- Full multi-spectral system
- 2 μm lasers + converters
- Portable evaluation tool
- Demonstrate dazzling
- Route to industrialisation



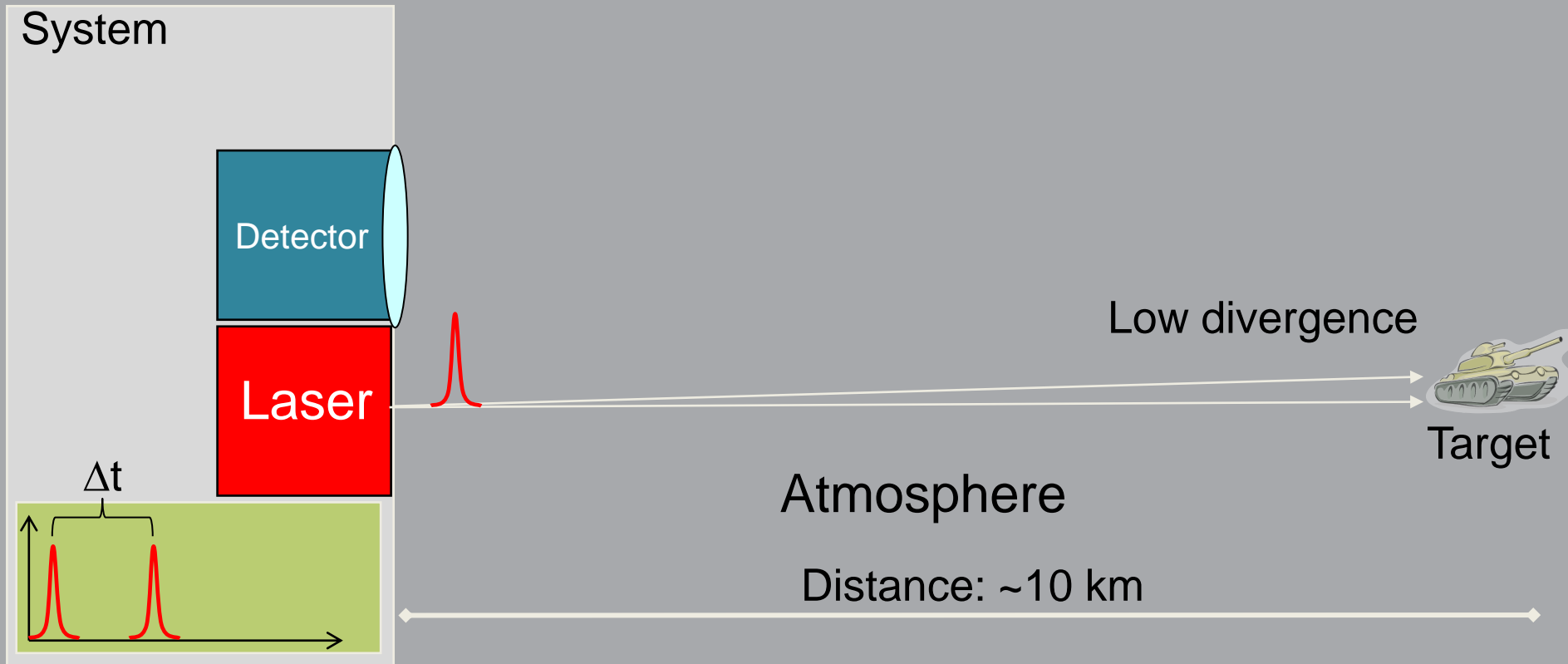
Laser application: Additive Manufacturing (3D printing)



Mode: Continuous & modulation
Power : 5 000 W
Beam Quality: extremely good
Wavelength: 1 μm
E-to-O Efficiency: 28%
3-phase power & water cooling
Technology: Yb:fibre oscillator-amplifier
Size & weight: typical fridge-size



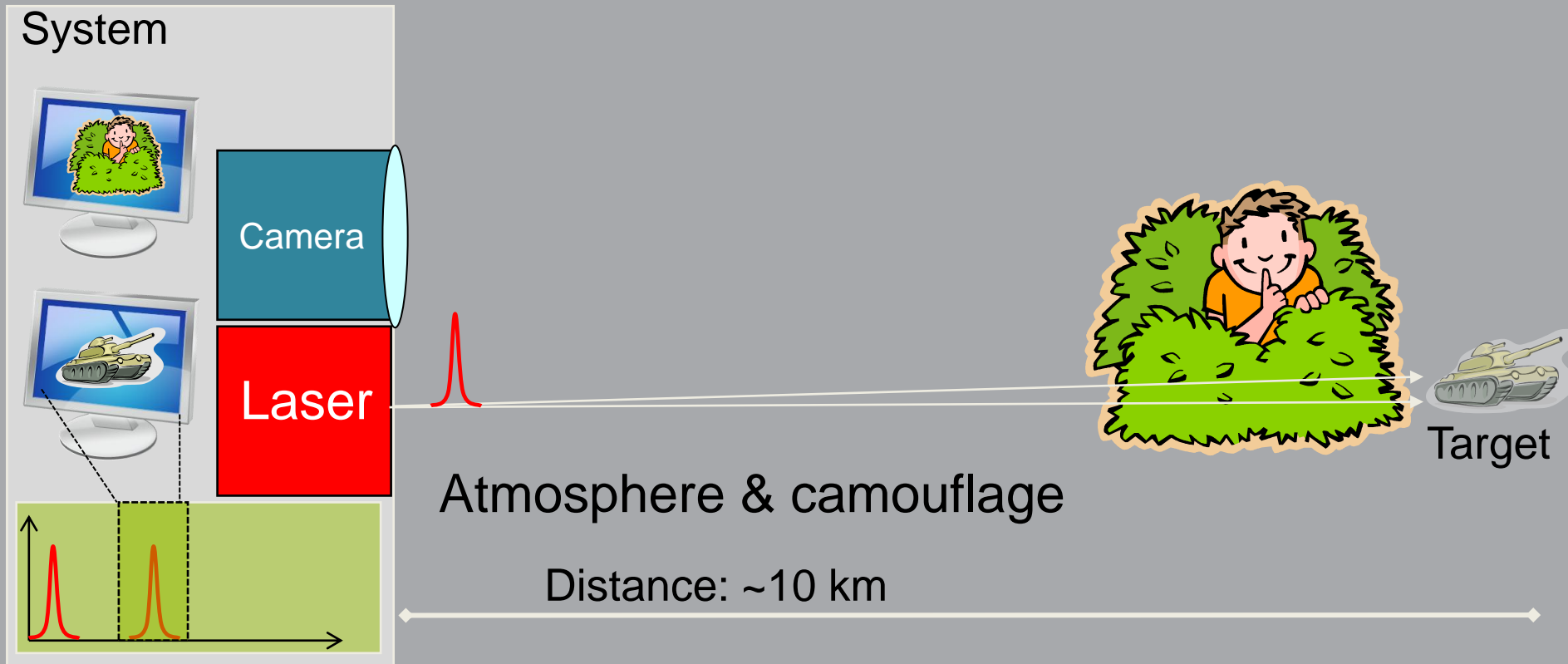
Laser application: Laser range finding



Determine laser light characteristics

- Mode: Pulsed
- Energy: 10-50 mJ
- Beam Quality: good
- Wavelength(s): eye safe?
- Efficiency
- Power supply: batteries
- Laser type / technology: solid-state
- Size & weight

Laser application: Gated imaging

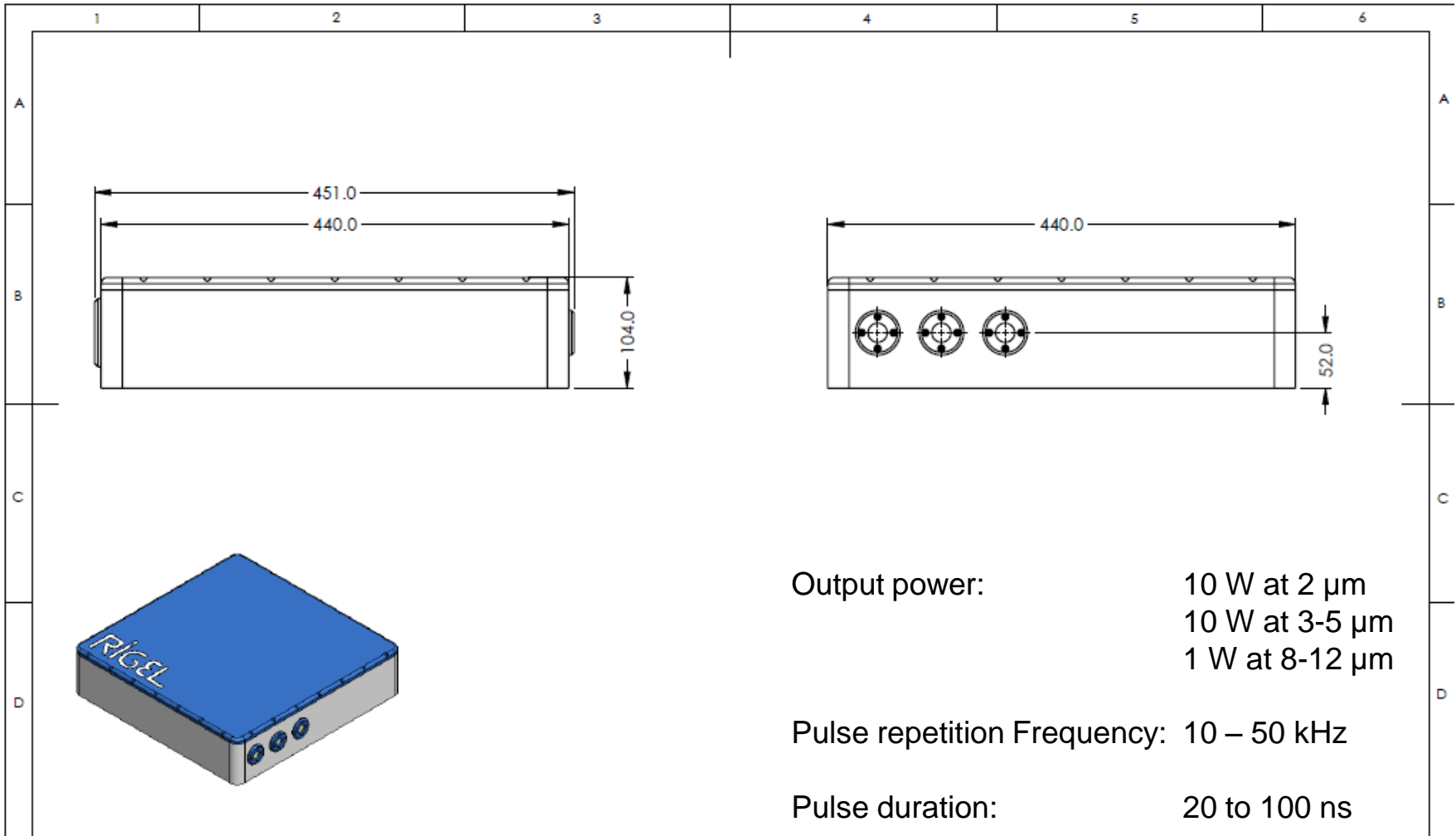


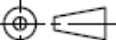

Determine laser light characteristics

- Mode: Pulsed
- Energy: 10-50 mJ
- Beam Quality: good
- Wavelength(s): eye safe?
- Efficiency
- Power supply: batteries
- Laser type / technology: solid-state
- Triggering of camera & laser

Concept Laser Product: Multi-wavelength high-power laser

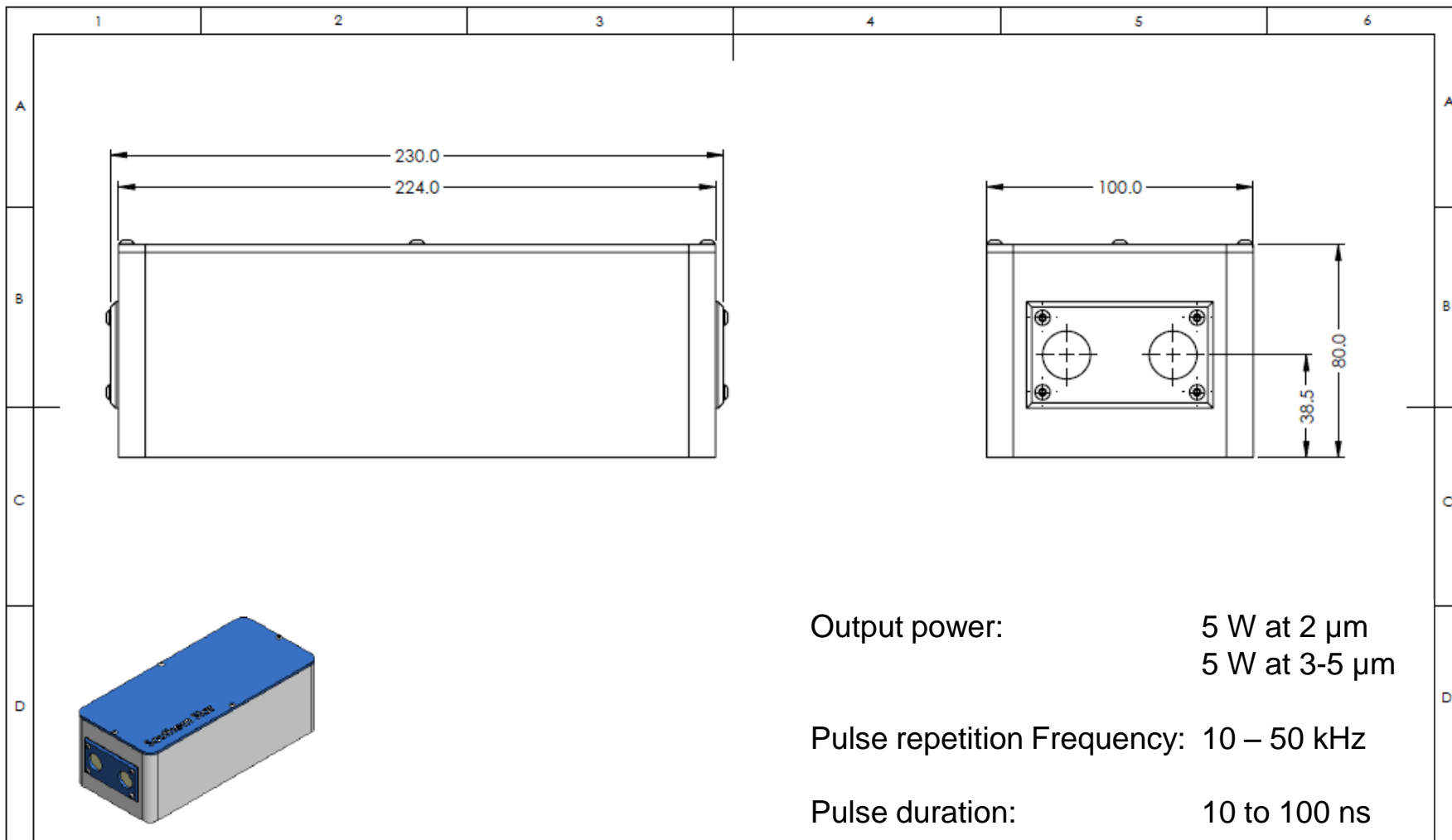
Applications: DIRCM evaluation tool; illumination; Gated imaging



TOLERANCES UNLESS OTHERWISE SPECIFIED LINEAR: TWO DECIMALS - $\pm 0.05\text{mm}$ ONE DECIMAL - $\pm 0.1\text{mm}$ NO DECIMAL - $\pm 0.5\text{mm}$ ANGULAR: $\pm 0.5^\circ$	DATE:	DRAWN BY:	CHECKED:	APPROVED:	DO NOT SCALE DRAWING	3 RD ANGLE PROJECTION 	TITLE:	QUANTITY	
	04-09-2012	C vd Westhuis			SURFACE FINISH 1,4 μm		MATERIAL:	Rigel assembly	1
					DEBUR SHARP EDGES		See bill of material	PART NO.	
					SHEET 1 OF 1	TREATMENT:			
A4	DRAWING STANDARD: BS 8888: 2002				DIMENSIONS ARE IN MILLIMETERS	COPYRIGHT RESERVED	SCALE: 1:5	REVISION: 01	 TEL: 012 841 3067

Concept Laser Product: DIRCM laser (Southern Star)

Application: Directed Infrared Countermeasures (DIRCM) on fixed & rotary wing platforms



Output power: 5 W at 2 μm
5 W at 3-5 μm

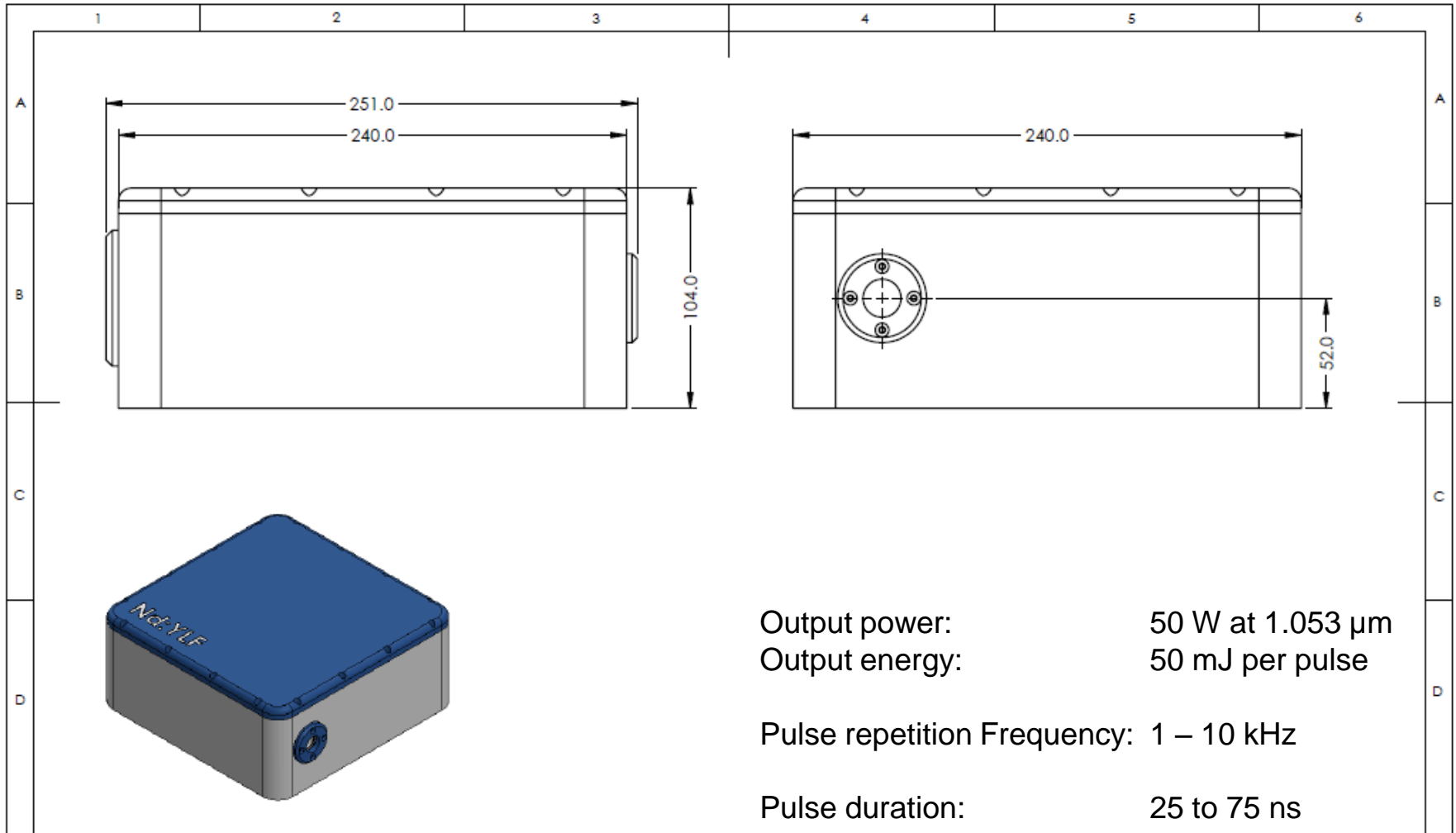
Pulse repetition Frequency: 10 – 50 kHz

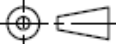

Pulse duration: 10 to 100 ns

TOLERANCES UNLESS OTHERWISE SPECIFIED LINEAR: TWO DECIMALS - $\pm 0.05\text{mm}$ ONE DECIMAL - $\pm 0.1\text{mm}$ NO DECIMAL - $\pm 0.5\text{mm}$ ANGULAR: $\pm 0.5^\circ$	DATE: 05-09-2012	DRAWN BY: C vd Westhuizer	CHECKED:	APPROVED:	DO NOT SCALE DRAWING	3 RD ANGLE PROJECTION	TITLE: Southern star assembly	QUANTITY: 1
					SURFACE FINISH 1.4 μm	MATERIAL: See bill of material	PART NO.	
				DEBUR SHARP EDGES	TREATMENT:			
SHEET 1 OF 1								

Concept Laser Product: High-energy laser (Nd:YLF)

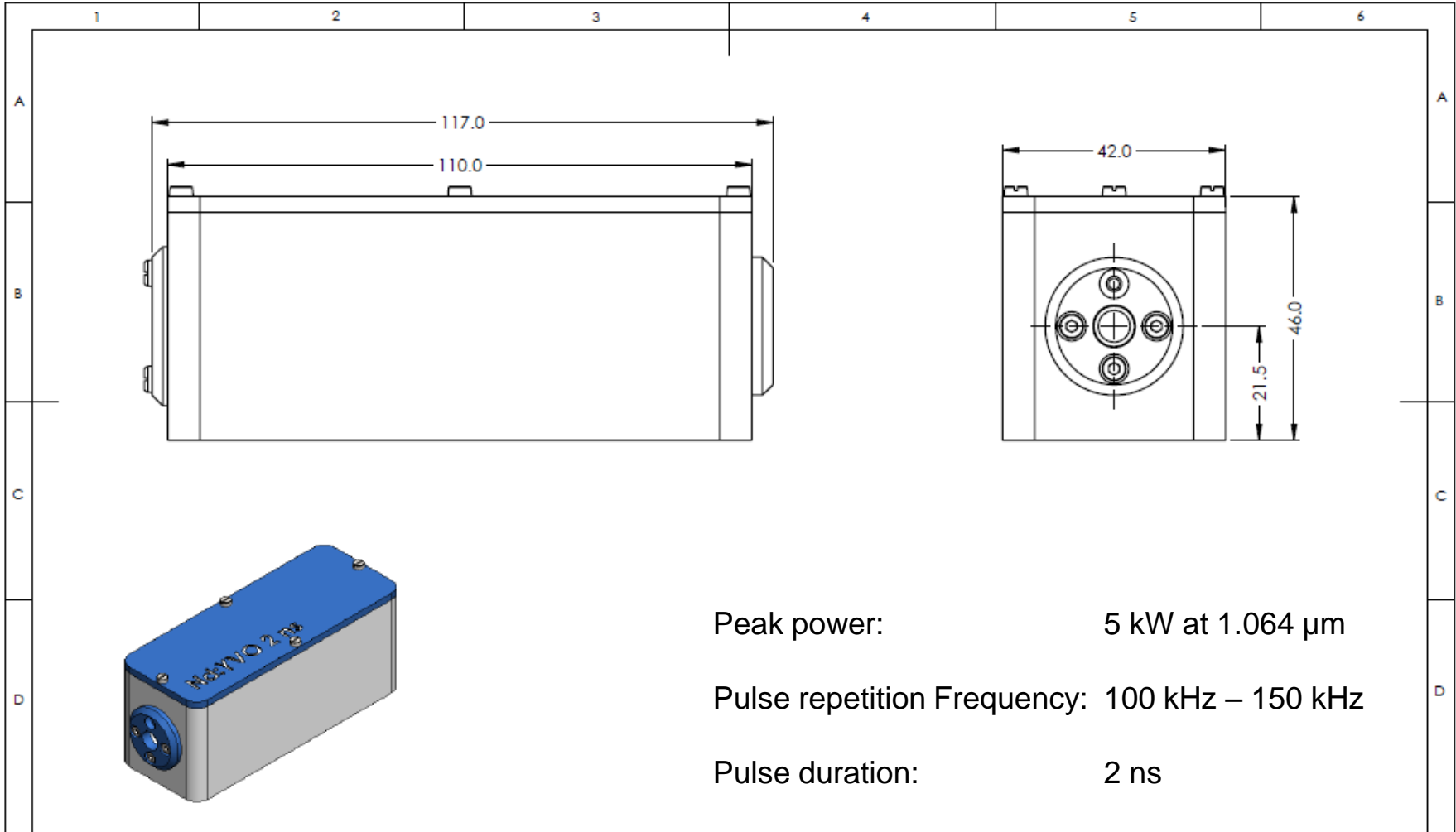
Applications: Laser ranging; Frequency conversion to green; Industrial materials processing



TOLERANCES UNLESS OTHERWISE SPECIFIED LINEAR: TWO DECIMALS - $\pm 0.05\text{mm}$ ONE DECIMAL - $\pm 0.1\text{mm}$ NO DECIMAL - $\pm 0.5\text{mm}$ ANGULAR: $\pm 0.5^\circ$	DATE:	DRAWN BY:	CHECKED:	APPROVED:	DO NOT SCALE DRAWING	3 RD ANGLE PROJECTION 	TITLE:	QUANTITY				
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					DEBUR SHARP EDGES		See bill of material	PART NO.				
SHEET 1 OF 1					DRAWING STANDARD: BS 8888: 2002		DIMENSIONS ARE IN MILLIMETERS		COPYRIGHT RESERVED	SCALE: 1:2.5	REVISION: 01	TEL: 012 841 3067

Concept Laser Product: Short-pulse laser (Nd:YVO 2 ns)

Application: Laser ranging; Laser mapping (3D image generation)



Peak power: 5 kW at 1.064 μm

Pulse repetition Frequency: 100 kHz – 150 kHz

Pulse duration: 2 ns

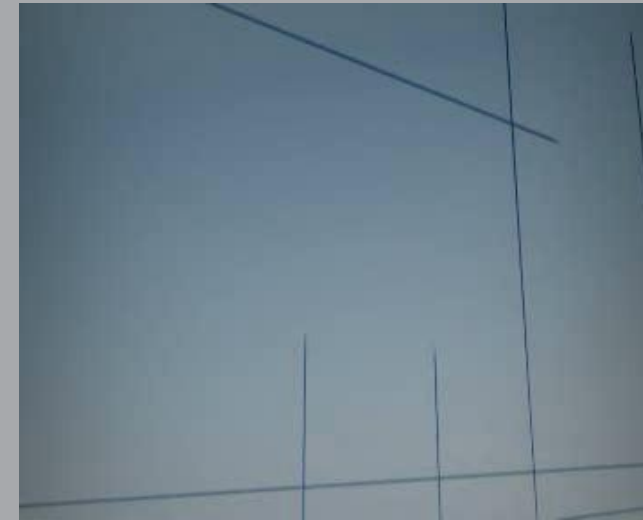
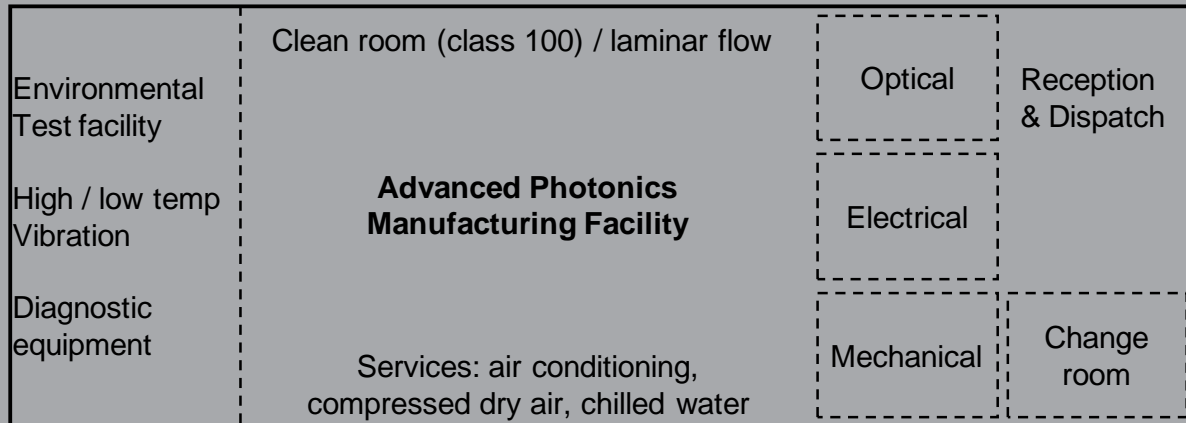
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	05-09-2012	C vd Westhuizen			SURFACE FINISH 1,4 μm		Nd:YVO 2 ns enclosure assembly	1
					DEBUR SHARP EDGES	MATERIAL:	PART NO.	CSIR <small>our future through science</small>
SHEET 1 OF 1					TREATMENT:	See bill of material		TEL: 012 841 3067
A4	DRAWING STANDARD: BS 8888: 2002			DIMENSIONS ARE IN MILLIMETERS		COPYRIGHT RESERVED	SCALE: 1:1	REVISION: 01

CSIR entry to photonics industry – Advanced Photonics Manufacturing Facility

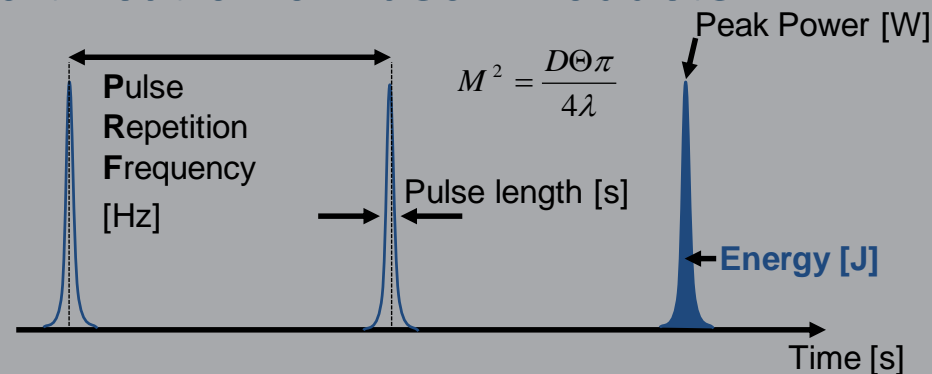
State of the art facility

Small-volume production of advanced laser products

Prototype development of photonic devices



Characterisation & Certification of Laser Products



Thank you

