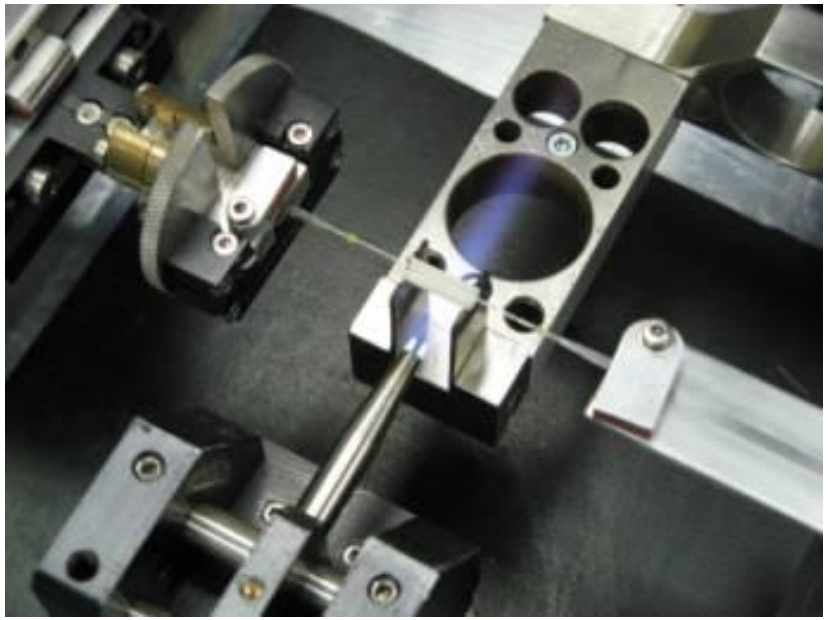
Gooch & Housego

Fibre Laser Components and Capabilities



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Presentation Contents

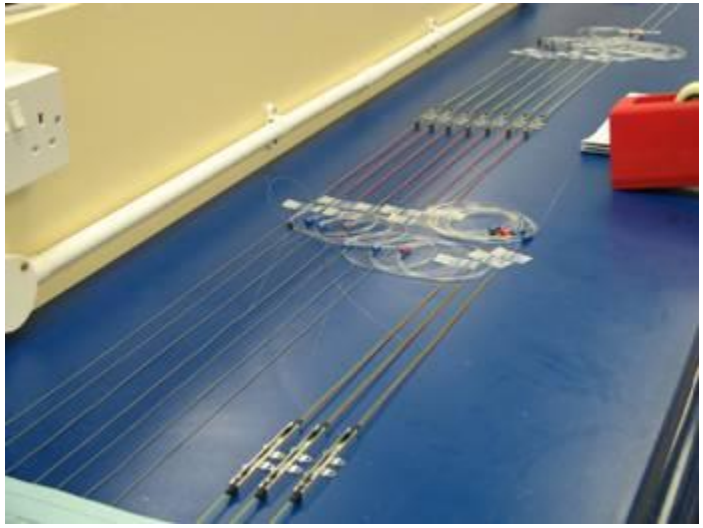
- Manufacturing Capability
  - Facility
  - Fused Components & performance
- Product Roadmap
  - Fibre Laser Isolator
  - Fibre-Coupled Q-switch

Fibre Optic Facility Basics

- **UK Factory**
  - 20,000 sq ft (ext. increasing by 7,000)
  - ISO 9001
  - 115 employees, 2 shifts
  - Submarine qualified

- **Czech Republic**
  - Contract Manufacturing
  - ISO 9001
  - 45 fused operators, 3 shifts

Coupler Manufacturing



Reliability

- Regular Telcordia qualification
  - Torquay & CZ facility
- Harsh Environment testing
  - Military & avionic requirements
- Customer specific testing programmes
  - Sub-marine cable customers
  - Avionic gyroscope customers
  - Satellite customers
  - Military customers

Fused Components

- Fibre laser component types
- MM Combiner Design
  - Bundle fusion
  - Power handling
  - Fibres
- Examples
- Additional component requirements

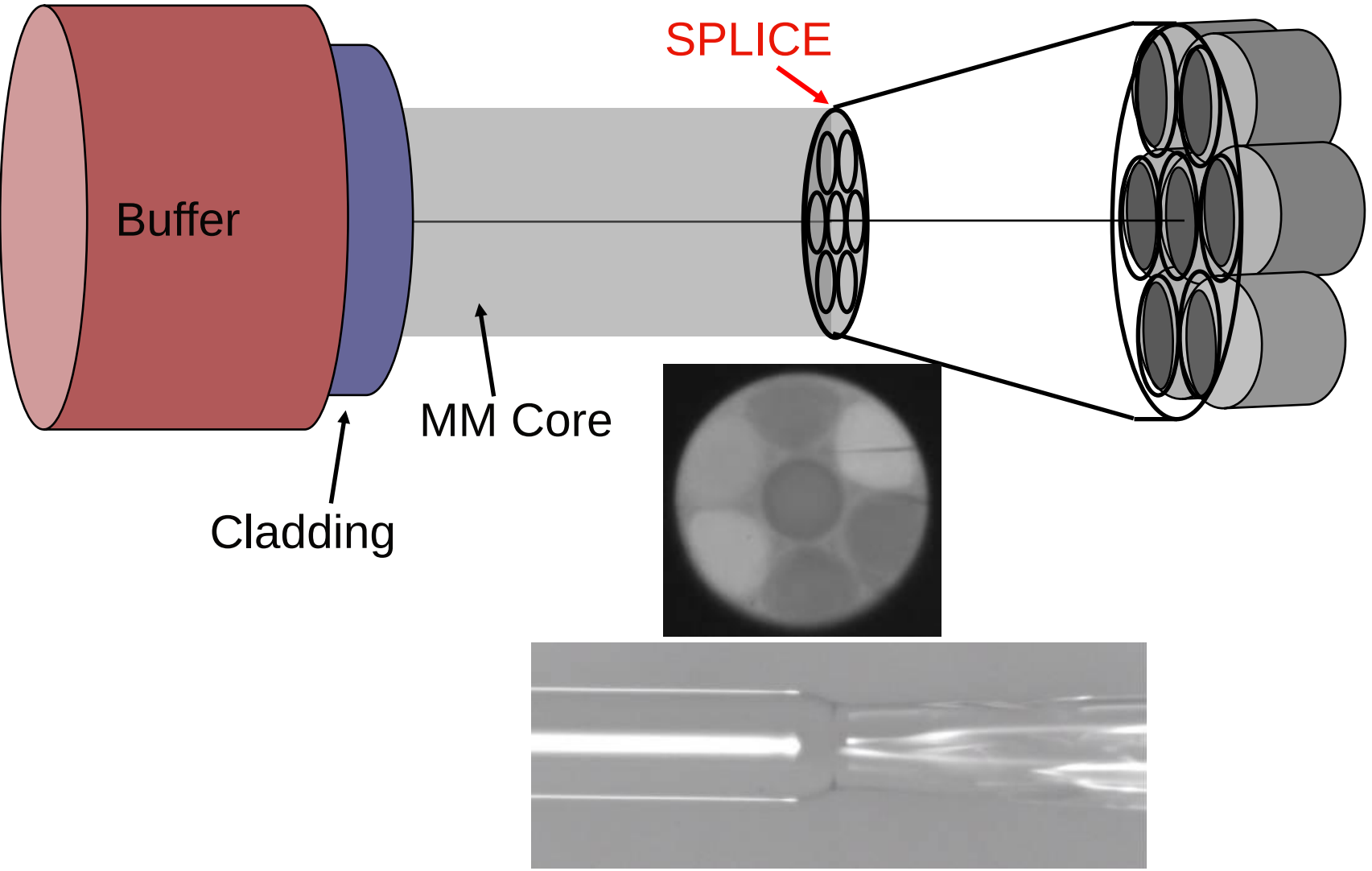
Fused fibre laser components

- MM Combiner
- MM Combiner with signal feedthrough
- PM MM combiner with signal feedthrough
- LMA Combiner with signal feedthrough
- PM LMA Combiner with signal feedthrough
- SM, DCF, LMA Tap couplers (PM)
  - Power monitor
  - Feedback monitor
- Pilot WDMs (red pilot beam)

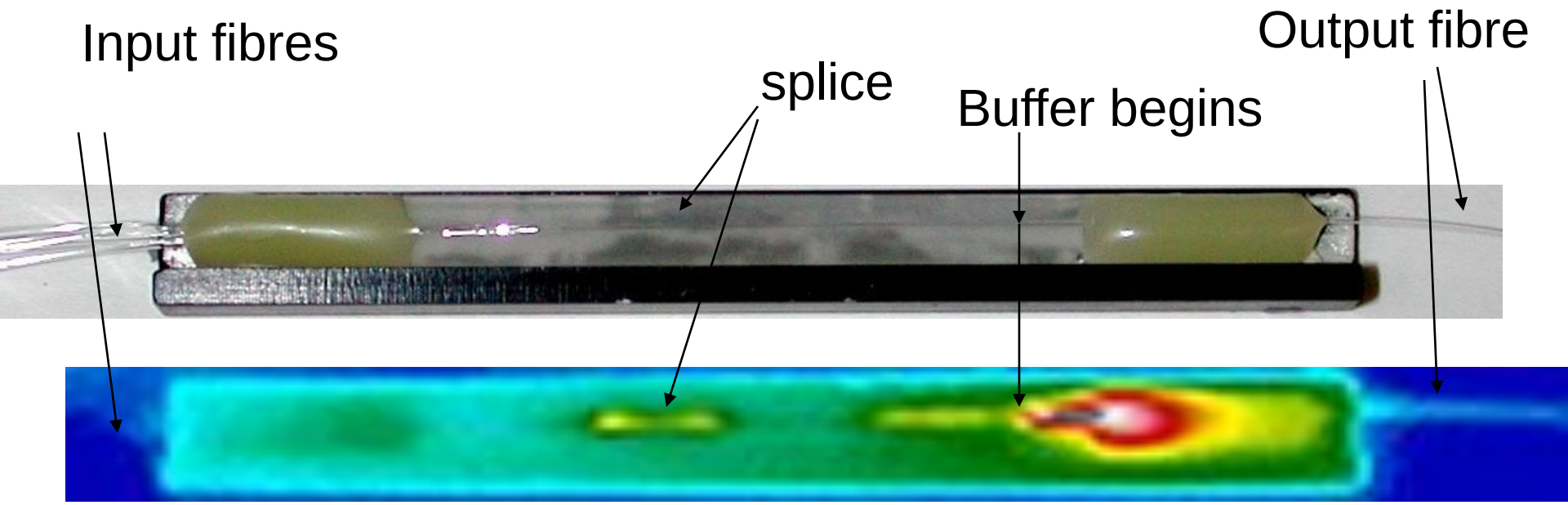
Tapered Fibre Bundles

e.g. Double Clad Fibre

Fibre Bundle



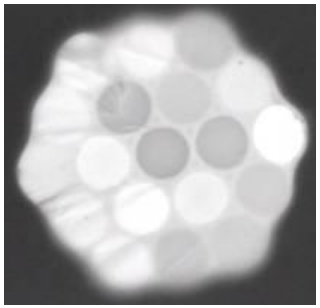
Tapered Fibre Bundles – power handling comments



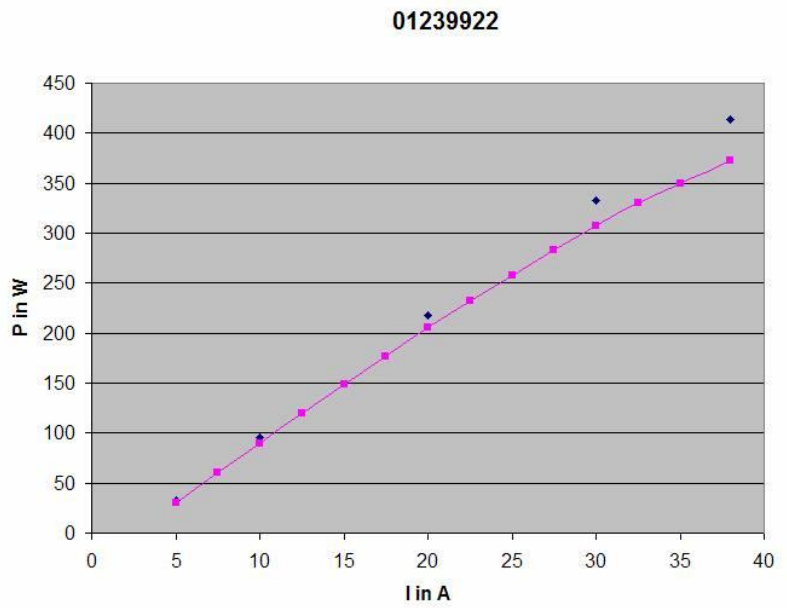
- Negligible power lost in down taper
- Small power lost in splice
- Most light lost where buffer begins
  - Light of higher NA cannot be captured
  - Buffer strips out light & generates heat
  - Thermal management required

Power Limits – MM Combiner

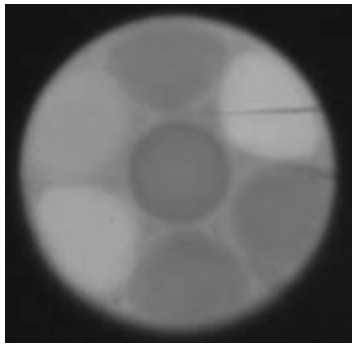
- Power combiner designs with acrylate buffer DCF probably limited to less than kW (CW) for long term use.
  - Cooling helps but acrylate weak point
  - Performs poorly in Damp Heat
- Alternative design requires different buffer
  - Polyimide, silicone
- Housing design for high power transmission
  - Improved thermal transmission
  - Heat removal

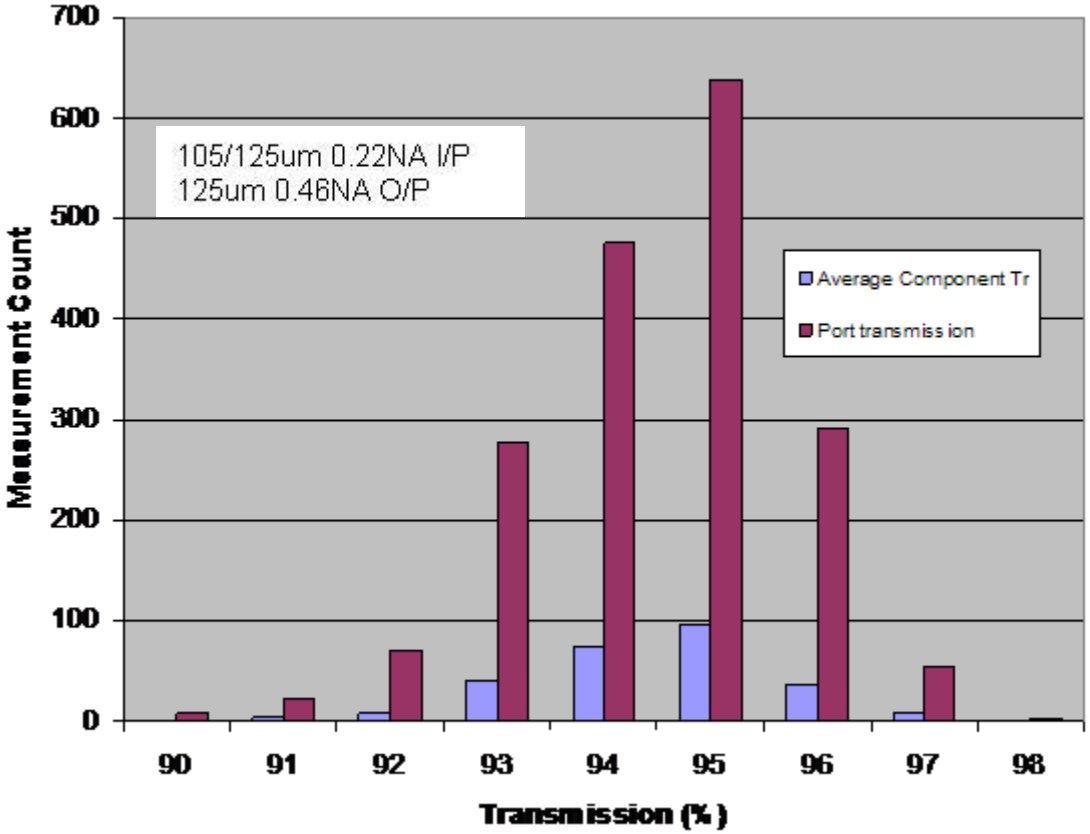


19x1 at 370W CW



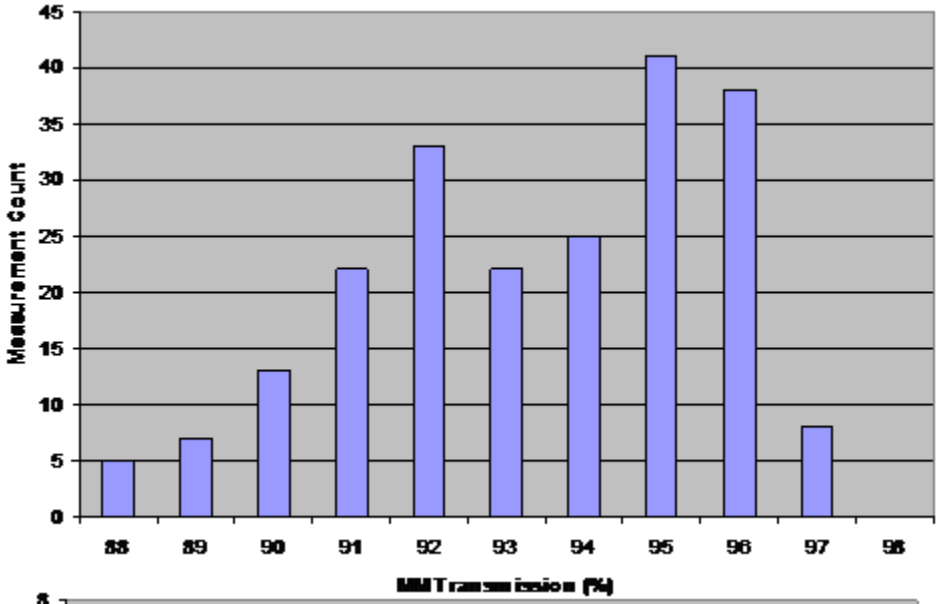
7x1 MM Combiner

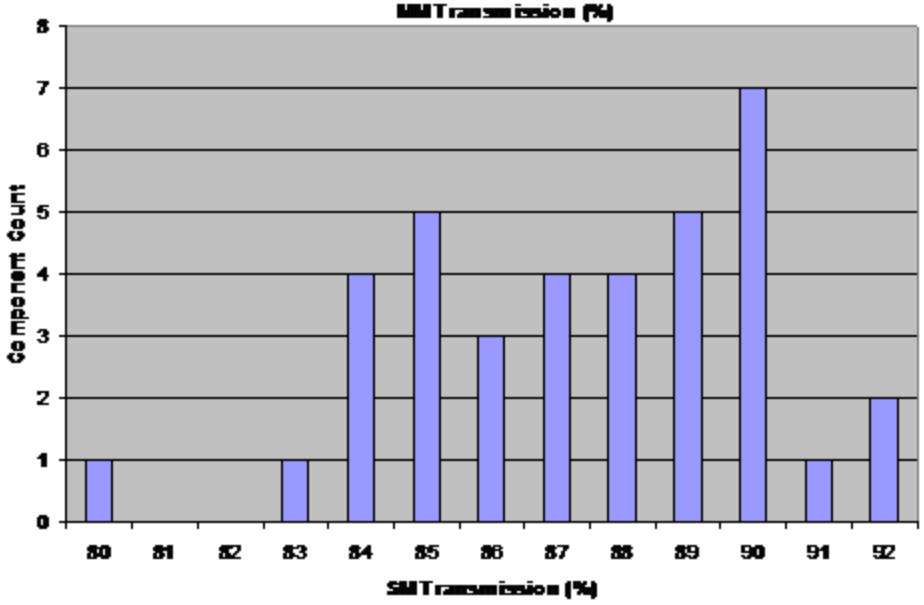




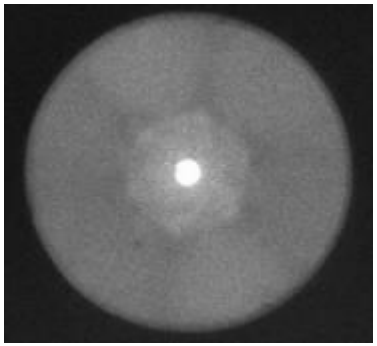
- 260 devices (1820 ports)
- Average port Tr = 94%
- Average combiner Tr = 94%
- Reliability Test program
  - 50,000 device hours under full operating conditions
  - Rapid temperature cycling
  - Mechanicals
  - Report available

6+1*1 Combiner



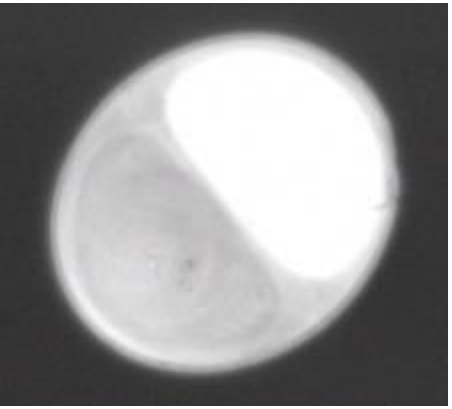


- Corning HI1060nm signal input
- 105/125um 0.22NA pump input
- 5/125um DCF (0.46 NA)

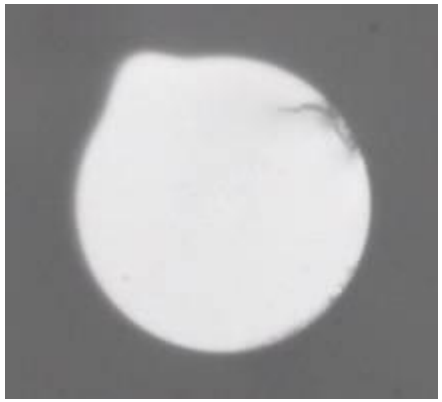


- 40 devices
- Average MM port Tr = 93%
  - In general, pump port transmission slightly slightly lower than 7x1
  - Mode conditioning of signal
- Average Signal Tr = 87%

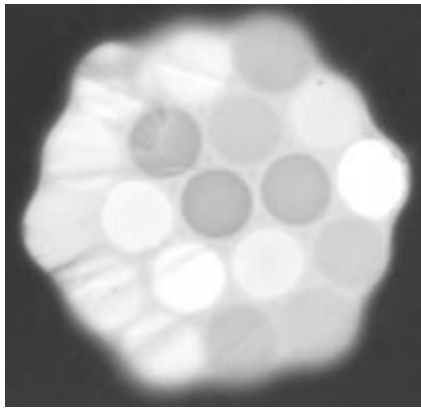
Other MM Combiners



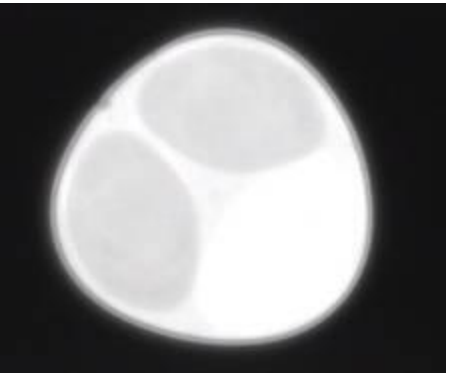
2x1



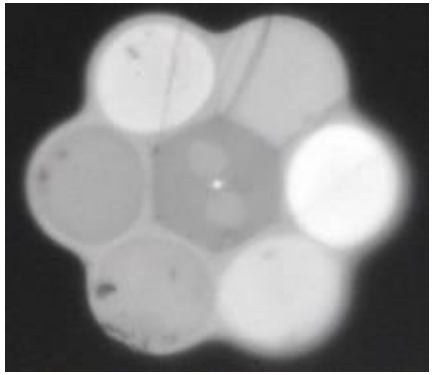
1+1x1



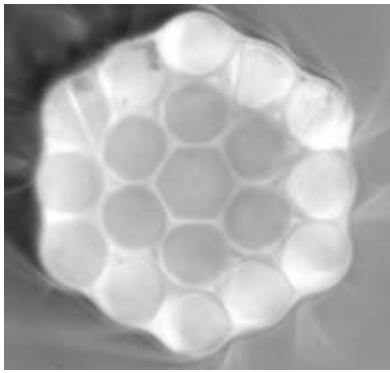
19x1



3x1



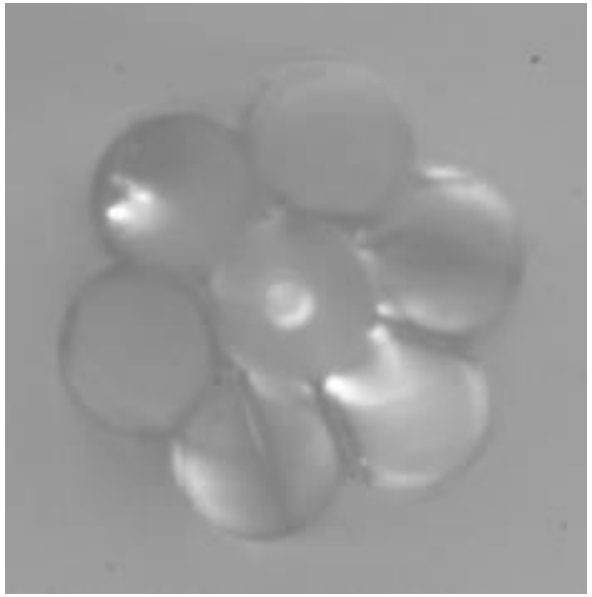
PM 6+1x1

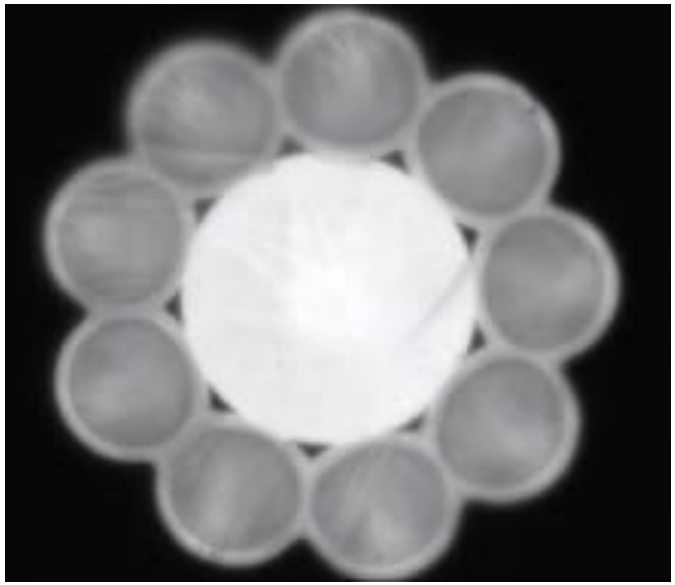


18+1x1

LMA Combiners & Novel designs

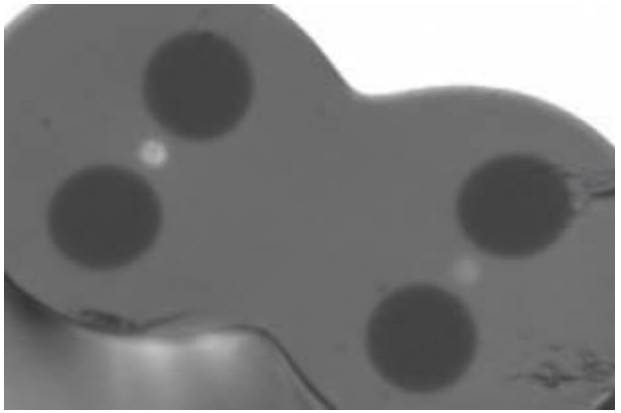
- LMA Fibres which support higher order modes
  - Simply handling fibre generates higher order modes
- Novel designs
  - Combination of SM outputs
  - Different fibre geometries





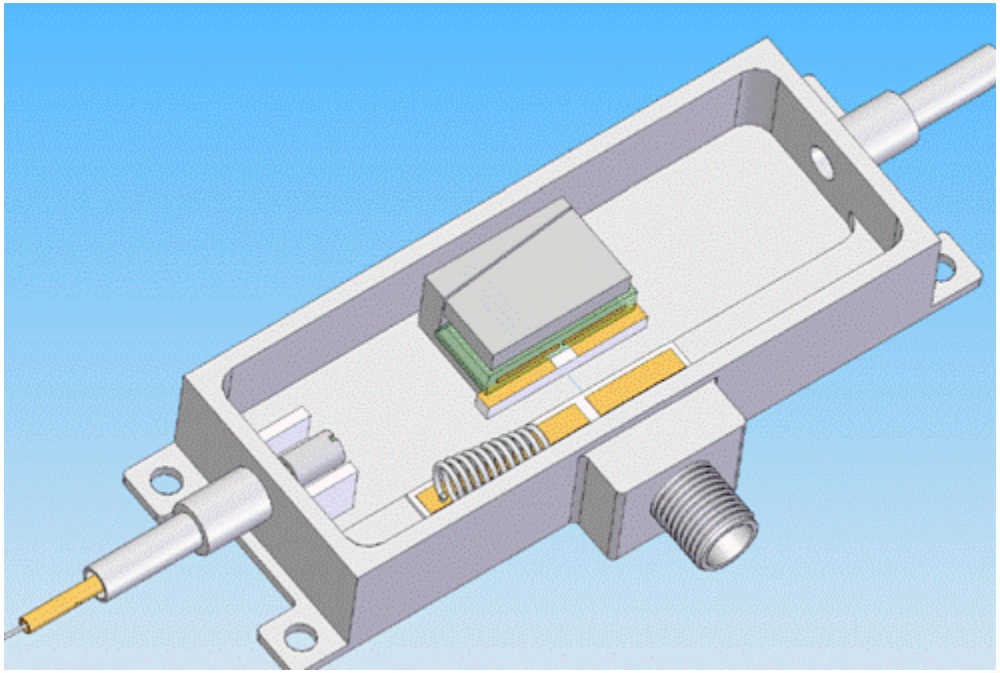
SM & Optical branching components

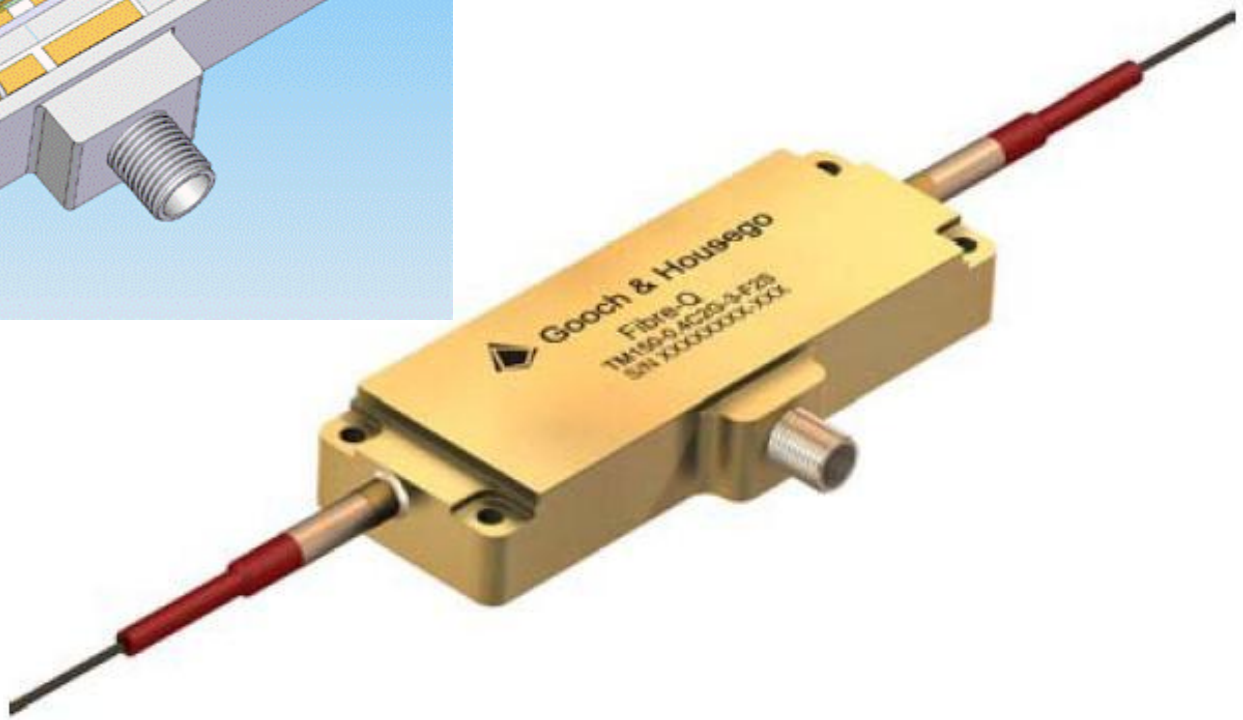
- **High Power Single Mode components**
  - **300W+ performance**
  - **Low Ratio Tap Monitors (0.1% - 0.001%)**
  - **Low Loss WDMs**
    - **Pilot WDMs (635/1060nm)**
    - **1060/1550nm & 980/1550nm**
    - **Custom wavelengths**
  - **PM Components**
    - **PM Tap**
    - **PM WDM**
- **MM Couplers**
  - **105/125um tap couplers**
  - **MM & LMA Low ratio tap monitors**



PM Coupler

Fibre Coupled Q-switch

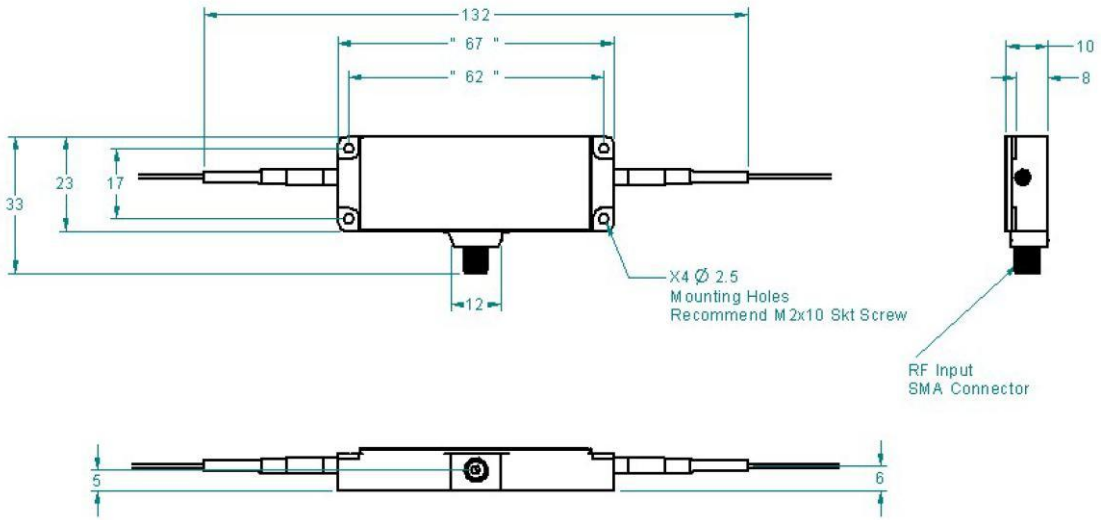




Key Specifications

General Specifications

Interaction material:	Tellurium Dioxide
Wavelength:	1060 - 1090nm (other wavelengths available on request)
Average optical power handling:	5W
Peak (pulse) optical power handling:	30kW typical (dependent on pulse width)
Insertion loss:	< 2dB
Return loss:	> 40dB (>50dB version available on request)
Extinction ratio (1st order on / off)	> 50dB
Rise-time / fall-time:	30ns
Frequency:	150MHz
VSWR:	< 1.2:1
Input impedance:	50Ω
RF power:	< 2.0W
Frequency shift:	150MHz (up-shift)
Fibre type:	Hi1060 (900µm sleeving, 1.5m length)
Fibre termination:	Bare fibre
Recommended RF driver:	MHC150-2AC-A1-TQ1



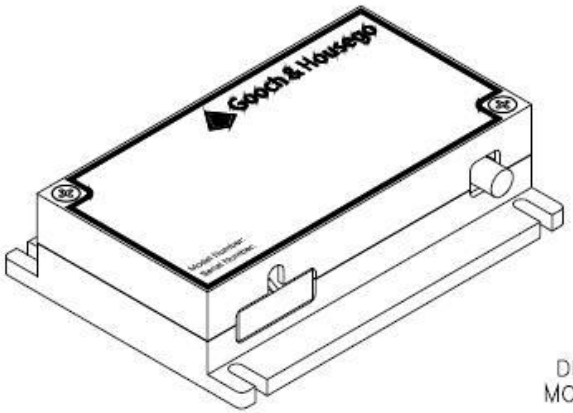
RF Driver For Fibre Coupled Q-switch

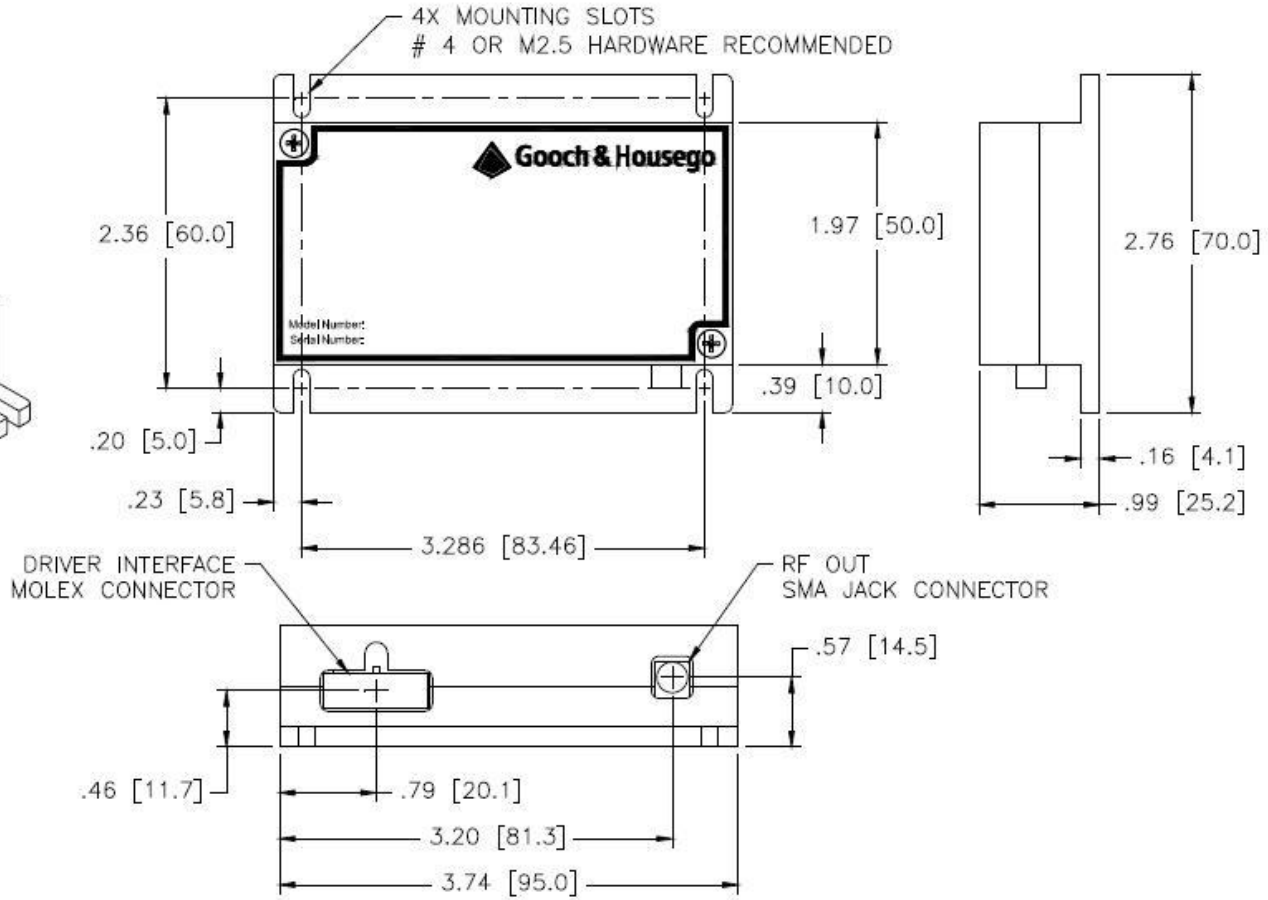
MHC150-2AC-A1-TQ1

SPECIFICATIONS:

PARAMETER:	**SPECIFICATION:**
Output Frequency: (150)	150 MHz ± 0.01% Quartz Stabilized
Spurious Levels:	-40 dBc Maximum
Harmonic Distortion:	-15 dBc Maximum
Analog Input: (A) (-A1)	0-1volt into 100 ohms 1 volt = Full RF Power 0 = RF Power off
Extinction Ratio:	40 dB Minimum
RF Rise / Fall Time:	20 ns Typical, 10 ns > 210 MHz P_{RF}: 10 to 90 %
RF Output Power: (2)	2 watts Nominal
Output Impedance:	50 ohms Nominal
Supply Voltage:	15 VDC
Supply Current:	1 amps Maximum
Cooling: (C)	This driver must be attached to a heatsink capable of dissipating 15 watts.
MAXIMUM RATINGS:	
Supply Voltage:	+18 VDC
Power Output:	No DC Feedback Allowed
Case Temperature:	+ 55^0 C

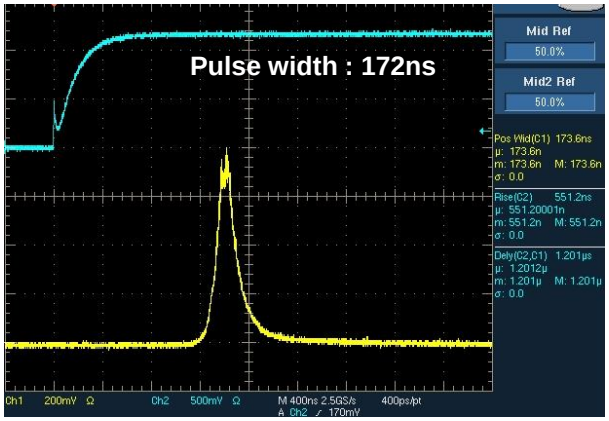
RF Driver For Fibre Coupled Q-switch (con't)



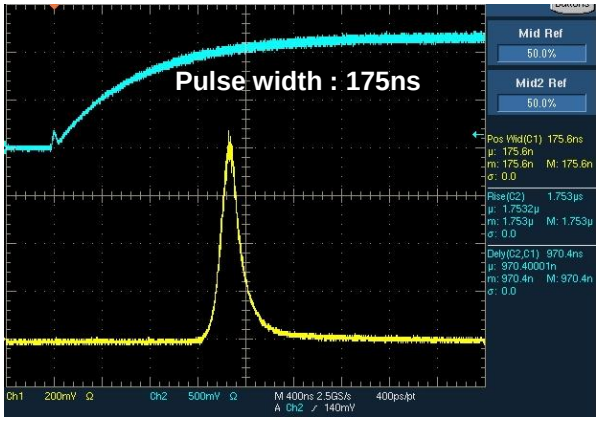


Initial prototype results

Part No.	23080-1-1.06-LTD-FO-HP	New Type FC-AOM
Mod. Type	Analog modulation	Analog modulation
RF Freq. / PW.	80 MHz / 2 W	150 MHz / 2 W
Loss	-2.5dB	-1.95dB
Size	129 x 44 x 37 mm	65 x 33 x 10 mm
Rise / Fall time	50 / 50 ns	20 / 20 ns



23080-1-1.06-LTD-FO-HP



New Type FC- AOM

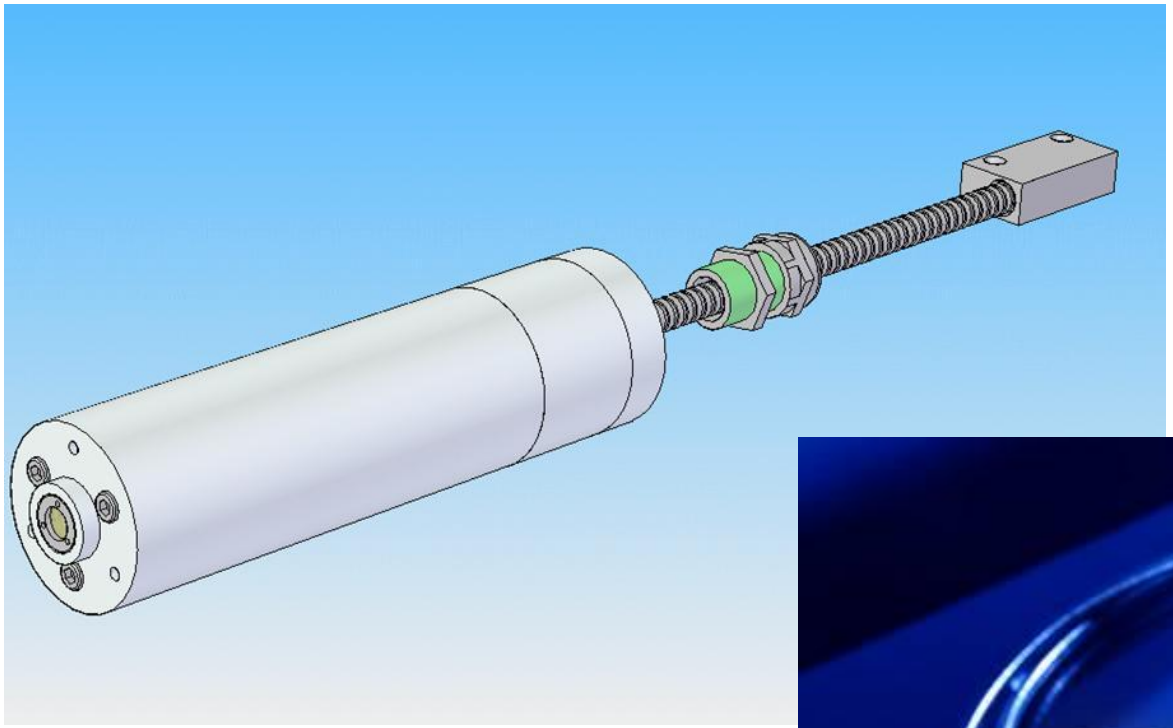
Conclusions :

- same pulse width, ~170ns
- new type is compact size.

Key features & milestones

- Key features
  - Low insertion loss
  - Miniature footprint
  - Ruggedized design
- Milestones
  - Preliminary Design Review held
  - July 08 – Prototypes in test
  - Aug 08 – pre-production build
  - Jan 09 – product launch

Fibre Coupled Isolator



Key Isolator Specifications

Parameter	
Forward Transmission	>90%
Wavelength	1060-1080nm
Isolation	>23dB
Average Power	20-30W
Pulse Power[1]	10-30kW
Beam Diameter	1-1.5mm
Fibre Type	LMA fibre

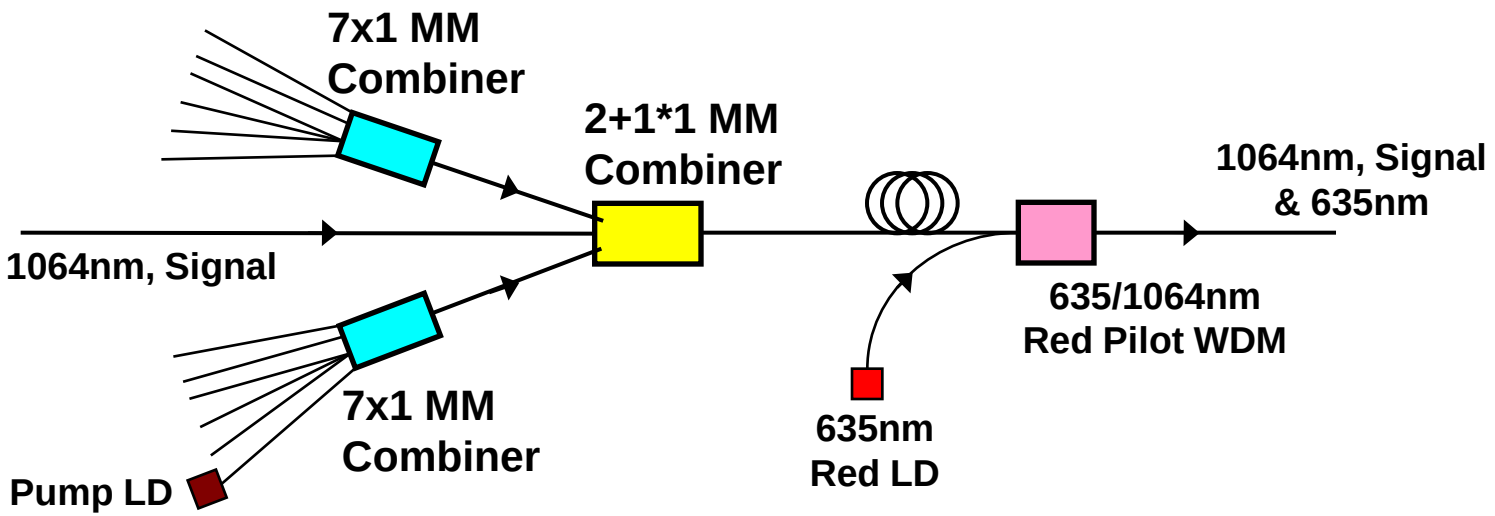
1. Depending on pulsewidth

Key features & milestones

- Key features
  - Fibre-in, Fibre-out & Fibre-in, Beam-out designs
  - Beam delivery optic option
- Milestones
  - Preliminary Design Review held
  - Aug 08 - Initial prototype build
  - Oct 08 – pre-production build
  - Jan 09 – product launch

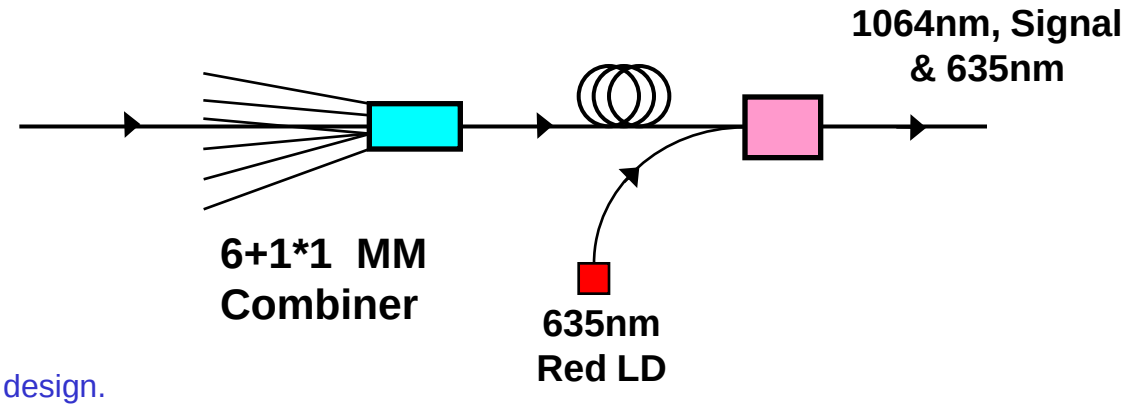
Fibre Laser design schematic

CW design (example) :



Gooch & Housego offer :

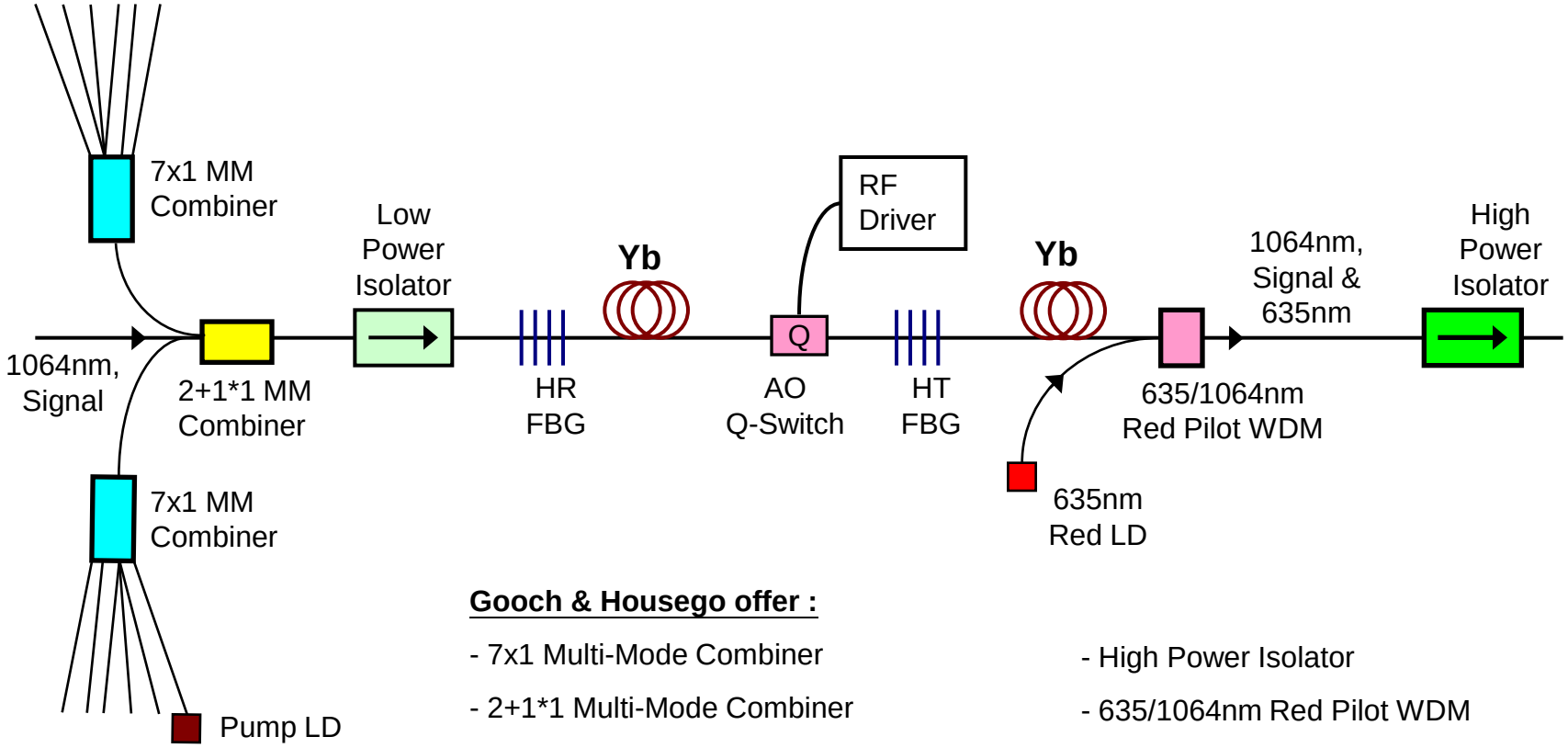
- 6+1*1 Multi-Mode Combiner
- 7x1 Multi-Mode Combiner
- 2+1*1 Multi-Mode Combiner
- 635/1064nm Red Pilot WDM



PS : This is only one example of CW fibre laser design.

Fibre Laser design schematic

Pulsed design (eg. Forward pumping) :



Gooch & Housego offer :

- 7x1 Multi-Mode Combiner
- 2+1*1 Multi-Mode Combiner
- Acousto-Optics Q-Switch (with fibre pigtail)
- RF Driver for AO Q-Switch
- High Power Isolator
- 635/1064nm Red Pilot WDM
- Ultra Low Ratio Coupler (eg. 1/99%)

PS : This is only one example of Q-switched pulse laser design.

Summary

- Over 5000 combiner components shipped
- Over 75 different specifications
- Many different fibre types used
- Over 10000 associated branching components shipped
- High power isolator in development
- Fibre Laser Q-switch in development

For more information contact

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