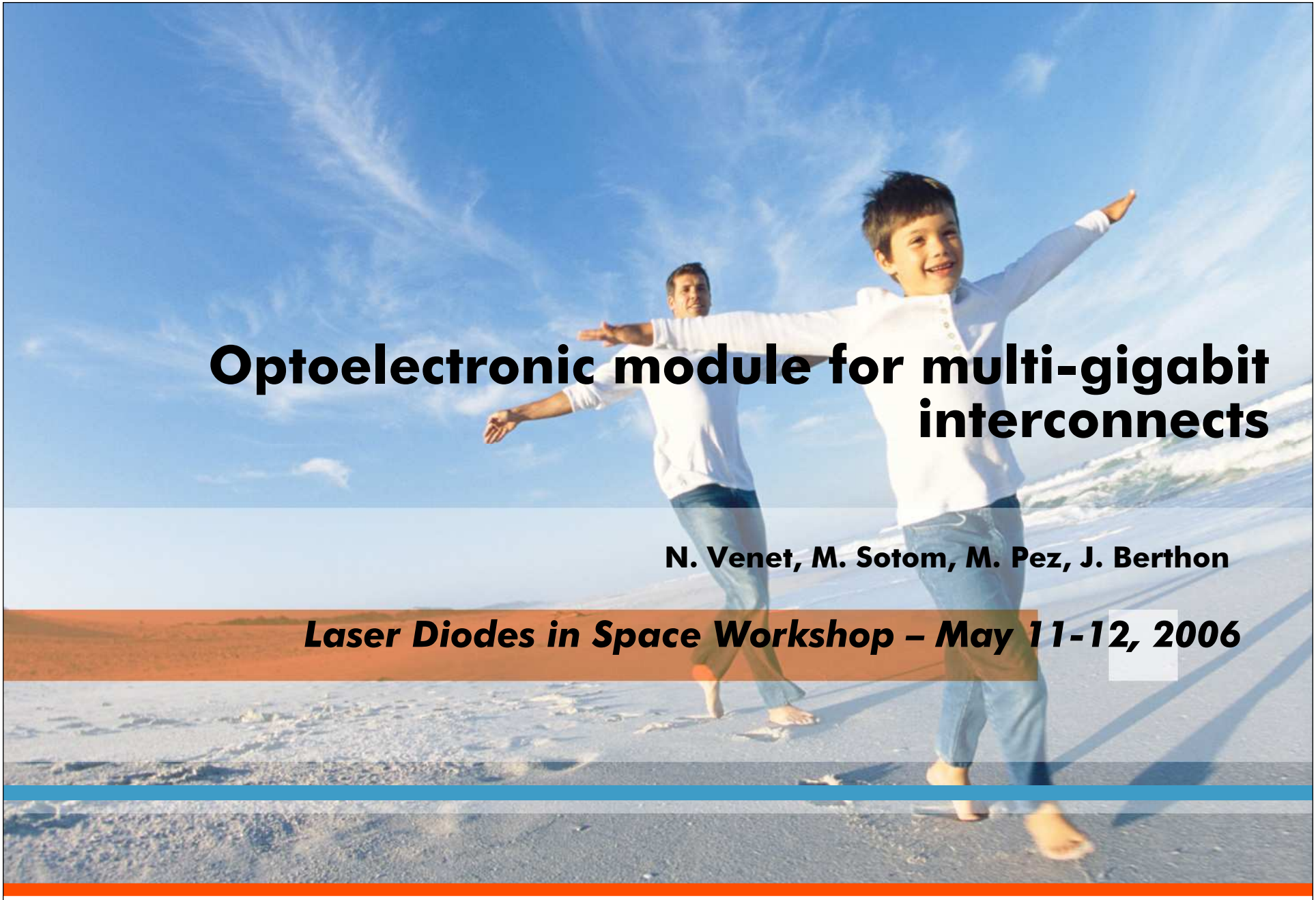


# Optoelectronic module for multi-gigabit interconnects

**N. Venet, M. Sotom, M. Pez, J. Berthon**

***Laser Diodes in Space Workshop – May 11-12, 2006***

# Outline



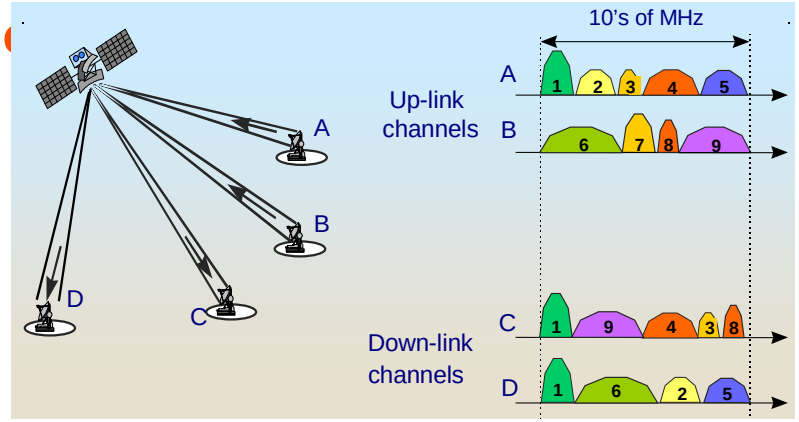
- Optical interconnects: applications & requirements
- Space-qualifiable optoelectronic module
- Module testing results
- Conclusions

# Optical interconnects: applications & requirements



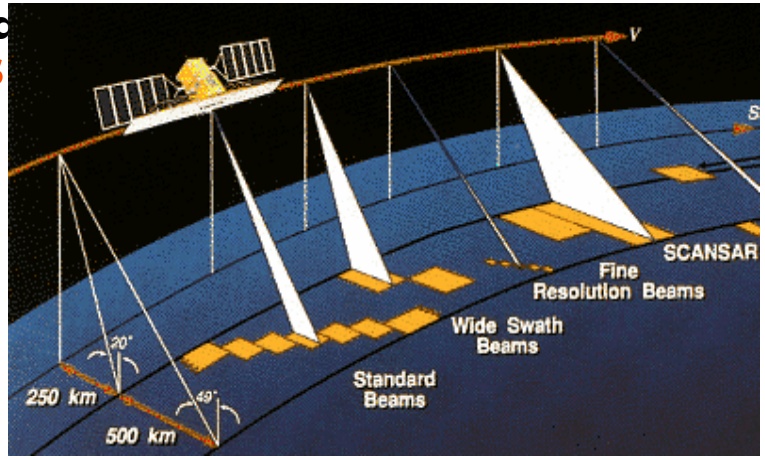
## Digital processing in Telecom payloa

- **Digital Transparent Processors**
  - **re-configurable beam-to-beam connectivity**
  - **variable bandwidth-per-channel allocation**
  - **including Digital Beam-Forming Network**
  - **flexible, multiple-beam antenna covera**




## Digital processing in Remote Sensors

- **Synthetic Aperture Radar**
- **Mass memories & data handling units**





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# Optical interconnects: applications & requirements



## Interconnects are becoming the bottleneck

- Moore 's law : complexity of ASIC's x 2 every 18 months
- for system performance continue to grow

  ➨ commensurate data handling & interconnect capabilities to be provided

## Emerging interconnect requirements

- higher throughput x longer transmission distance
- low mass & volume of connectors & cables
- high connector density, low insertion force
- suppression of EMI/EMC, electrical crosstalk issues
- simpler design & routing
- easier integration & test

# Optical interconnects: applications & requirements

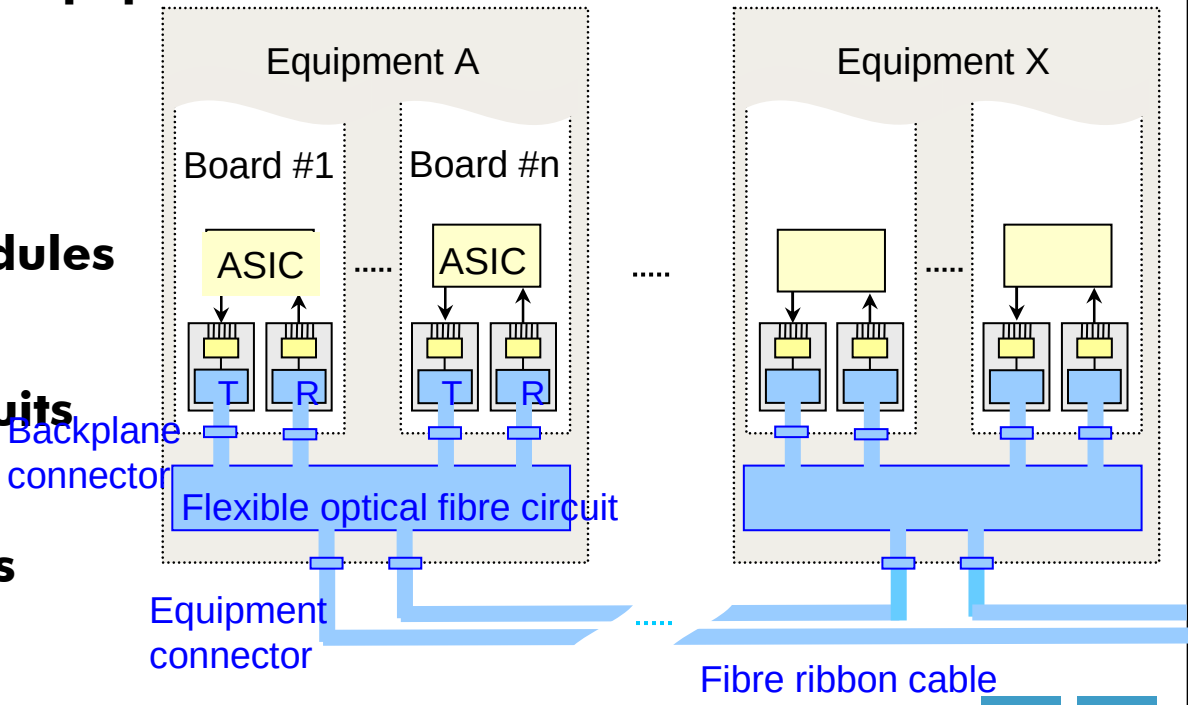


## Parallel optical links as a generic interconnect solution

- for both intra- and inter-equipment

## Optical interconnect technologies

- multi-channel transmitter/receiver modules
- serialisers/deserialisers
- flexible optical fibre circuits
- fibre « shuffles »
- multiple-fibre connectors
- fibre ribbon cables



# Optical interconnects: applications & requirements



## Commercial component offer

- Transmitter (electrical to optical conversion)
- Receiver (optical to electrical conversion)
- Transceiver
- 12 channels - 72 channels @ 2.5 Gbps
- 850 nm VCSEL Array
- w/ multimode fibres

## but

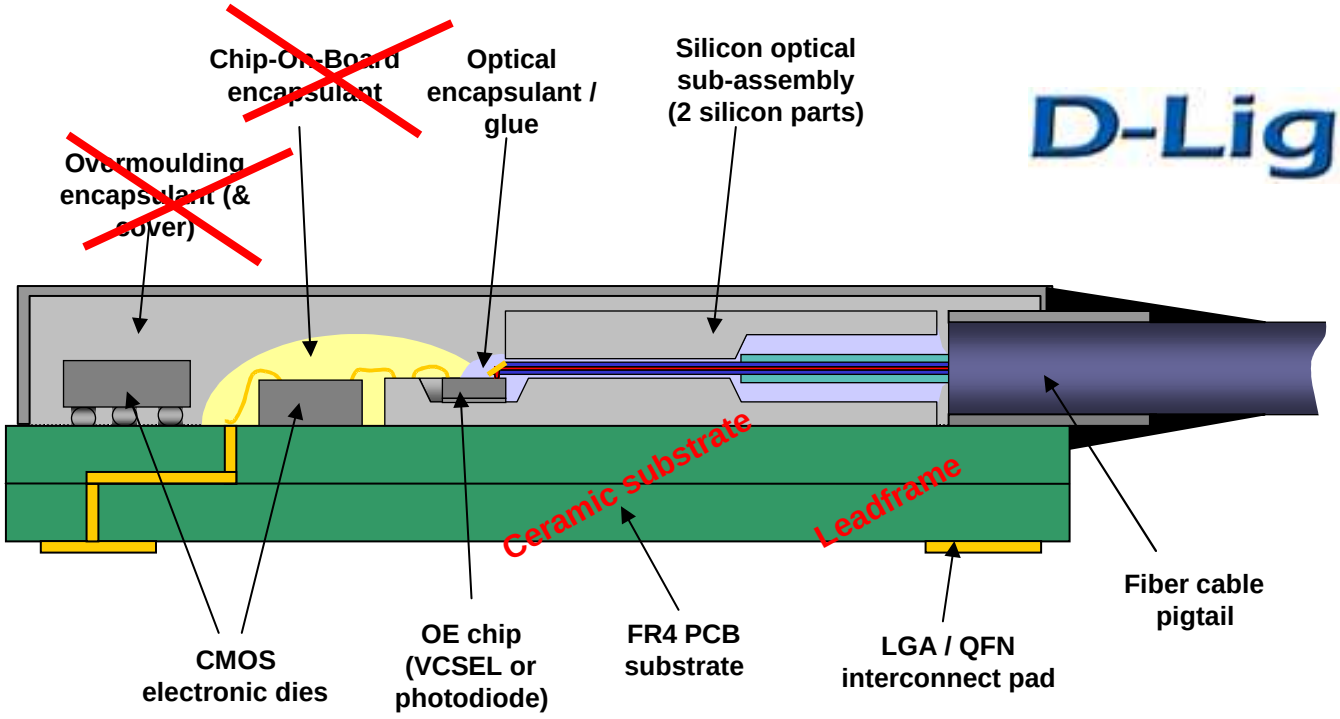
- Temperature range 0°C-70°C
- Non hermetic module
- Electrical leads not compatible with Space mounting process

# Space-qualifiable optoelectronic module



## MCM-C developed by D-Lightsys (F)

- Multichannel Tx (or Rx) module
- Reuse of OSA developed for terrestrial applications
- 850 nm VCSEL, PIN photodiode and graded-index multimode fiber





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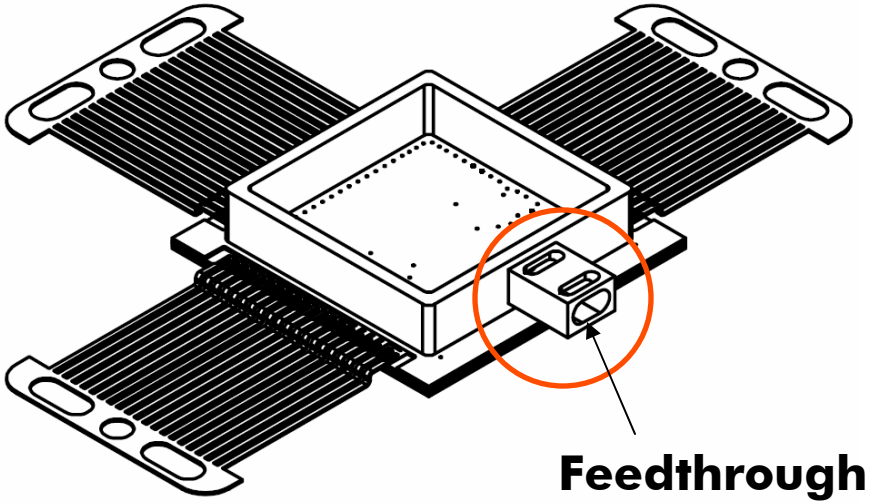
# Space-qualifiable optoelectronic module



## Hermetic package

- Multilayer ceramic package with leadframe
- Hermetic fiber feedthrough design




D-Lightsys



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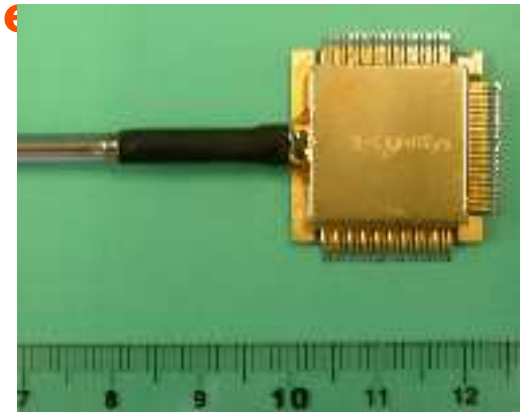
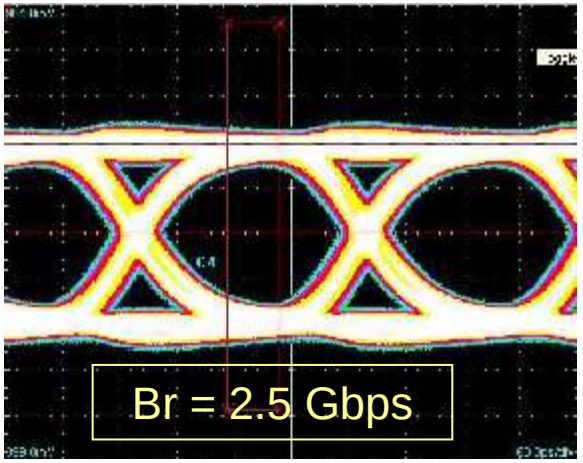
# Space-qualifiable optoelectronic module



## Space-qualifiable multichannel module

- 12-channel Tx or Rx @ 2.5 Gbit/s
- low power consumption
- extended temperature range
- small-size, hermetic ceramic package





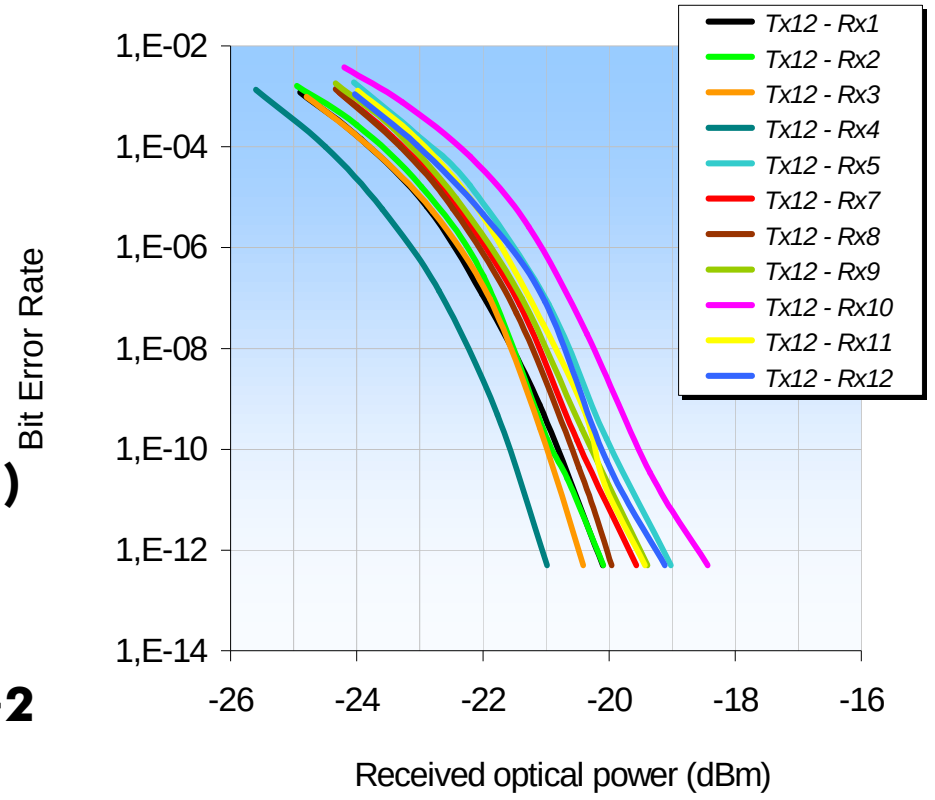
# Module testing results



## Testing of the 12-channel Rx module

- @ 2.5 Gbit/s
- using same transmitter
- no Bit Error Rate (BER) floor
- detection threshold (@ $10^{-9}$ BER )

  < -20 dBm @ 2.5 Gbit/s
- low performance distribution (~2 dB)

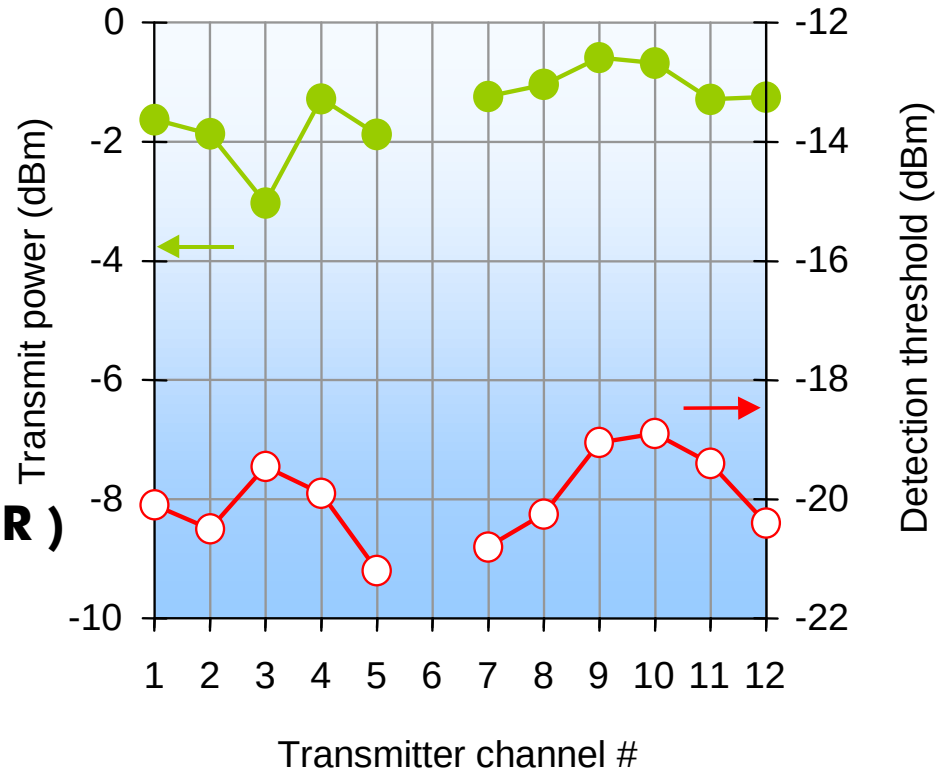


# Module testing results



## Testing of the 12-channel Tx module

- @ 2.5 Gbit/s
- using same receiver
- output power >-3 dBm
- detection threshold (@ $10^{-9}$ BER ) < -19 dBm @ 2.5 Gbit/s
- low performance distribution (~2dB)





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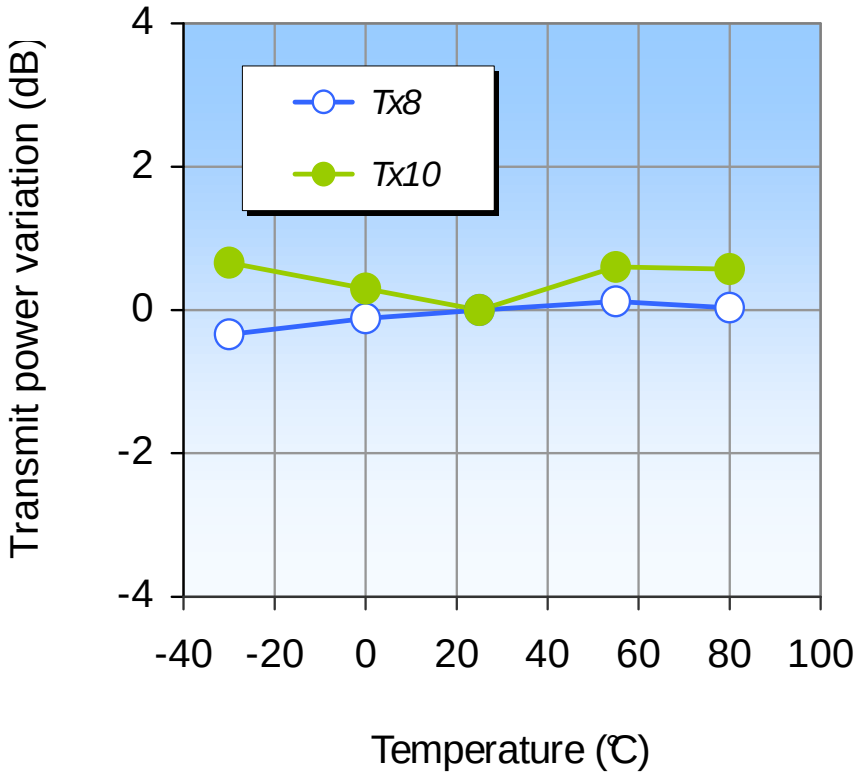
# Module testing results



## Thermal testing of the Tx module

- operation maintained over T° range of [-30 ; +80 °C]
- transmit power variation < 1.5 dB
- D-Lightsys proprietary algorithm for laser control
- detection threshold variation <1.5 dB





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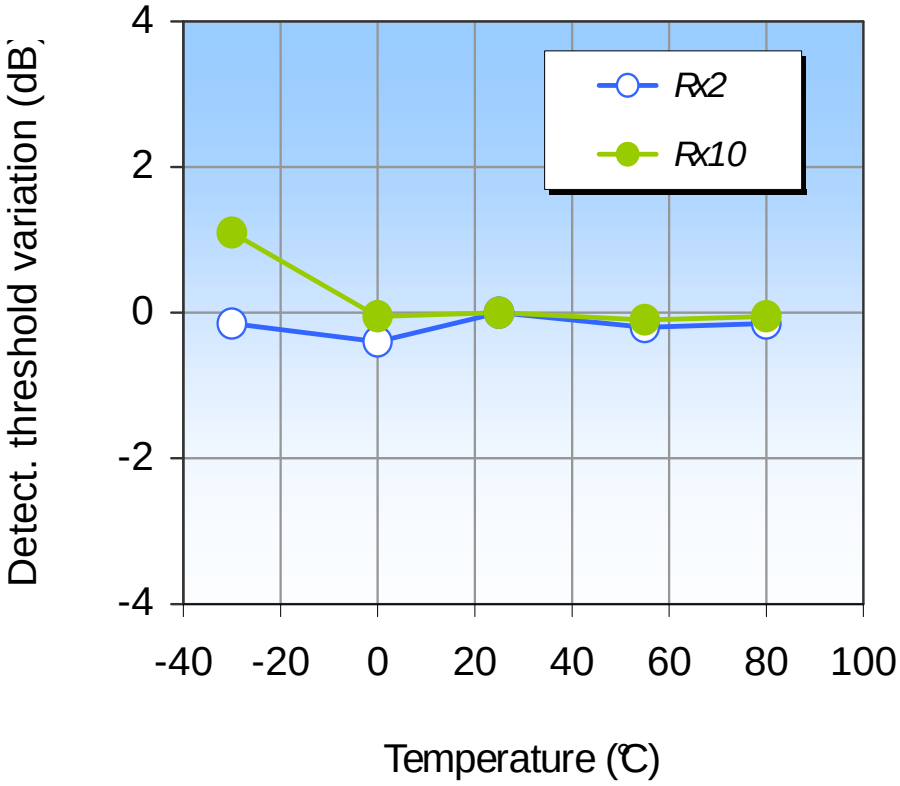
# Module testing results



## Thermal testing of the Rx module

- **operation maintained over T° range of [-30 ; +80 °C]**
- **detection threshold variation < 1.5 dB**





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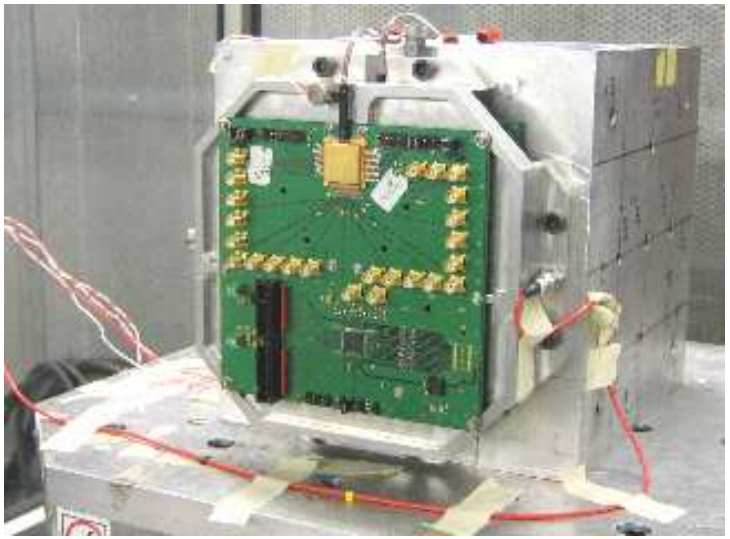
# Module testing results



## Mechanical testing of the Tx & Rx modules

- cumulative shocks (4 levels)
- above standard qualification level
- performed on the 3 axis

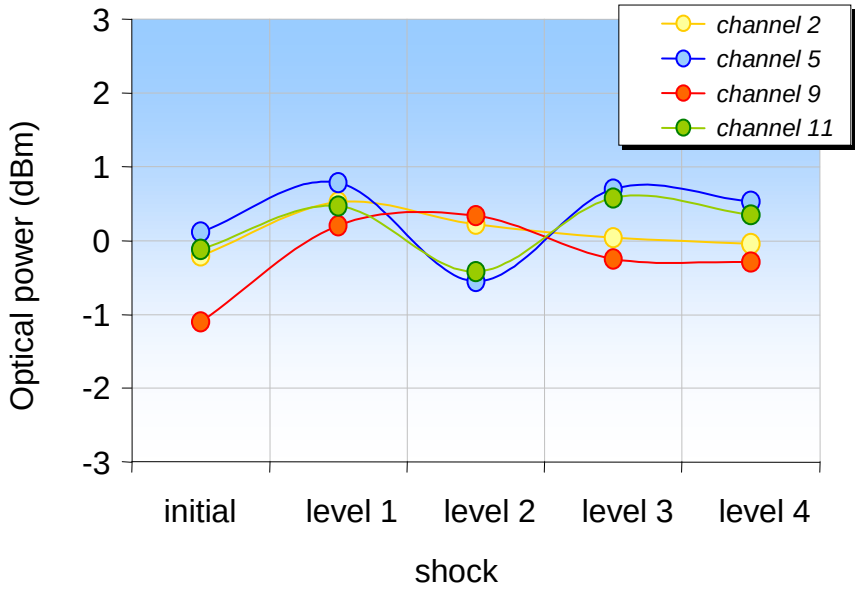


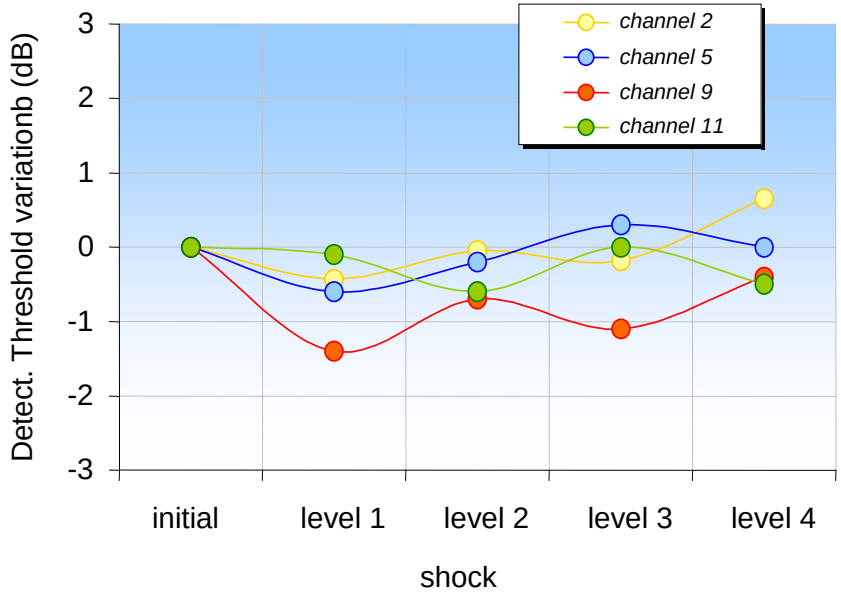
# Module testing results



## Mechanical testing of the Tx & Rx modules

- **both Tx and Rx are functional after cumulative shocks**
- **almost no decrease in optical power at Tx module**
- **detection threshold variation ~ 1dB at Rx module**





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# Conclusions



## Development of space-qualifiable O/E interface modules

- by D-Lightsys (France), based on modules for harsh environments (avionics, defence ...)
- 12 x 2.5 Gbit/s : aggregate rate of 30 Gbit/s !
- designed for extended operating temperature range
- hermetic housing

## Testing of space-qualifiable O/E interface modules

- all Tx and Rx channels have similar performance
- Tx and Rx performance maintained over [-30 ; +80 °C]
- Tx and Rx performance maintained after cumulative shocks above standard qualification level

# Acknowledgements

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- The authors are grateful to D-LIGHTSYS, Marcoussis (France), for fruitful cooperation in the development of the optoelectronic modules