Characterisation of high bandwidth 0.8µm laser diodes at EADS-ASTRIUM

WORKSHOP Laser diodes in Space
CNES – 12 mai 2006

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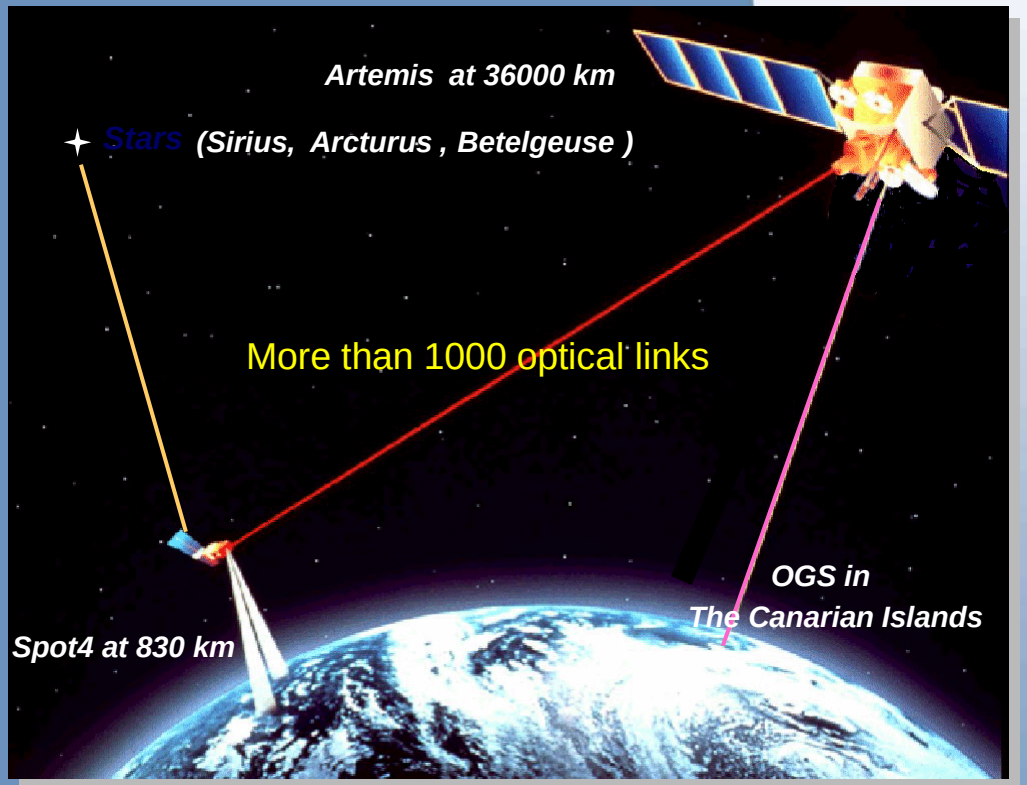
1. Current 0,8 µm optical link : SILEX program

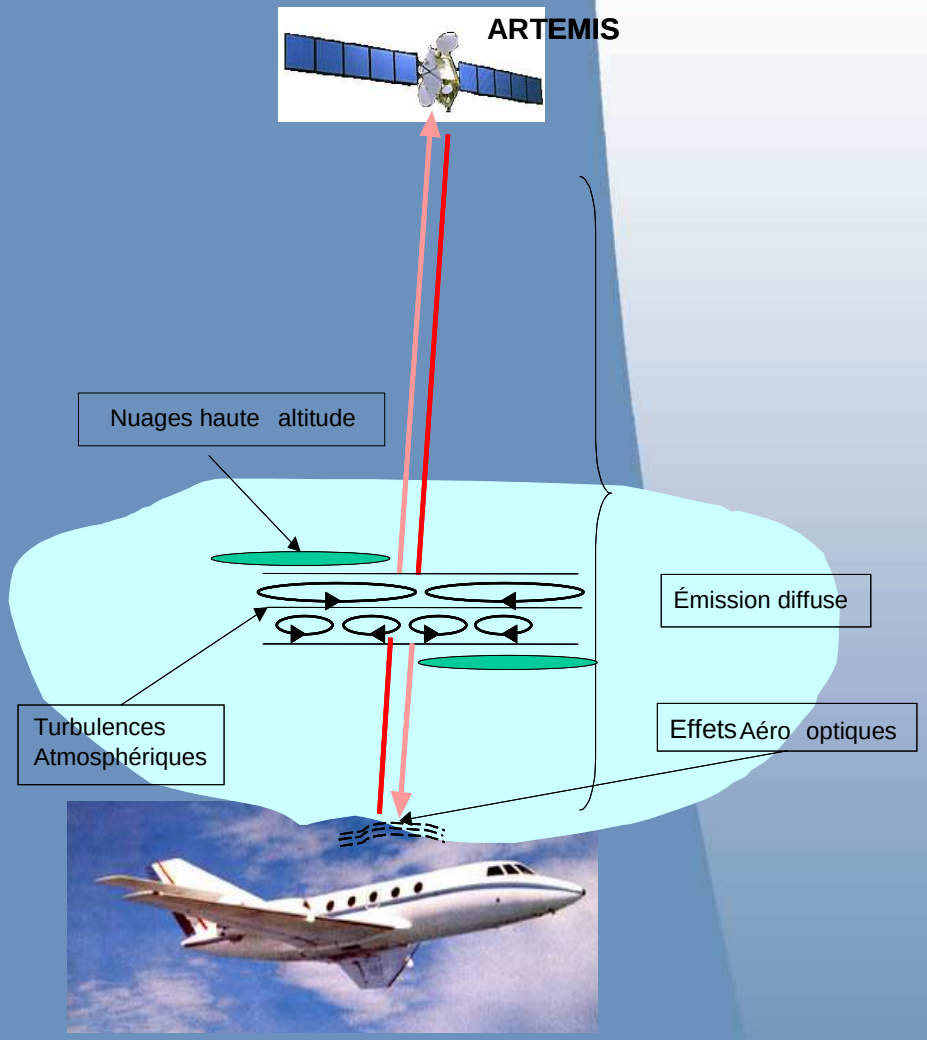
- Operational System used every day
- More than 1200 successfull links between SPOT4 and ARTEMIS (with quasi error free quality)
- About 200 links with the ground
- Interoperability validated with the Japonese Luce terminal

SILEX IN ORBIT SUCCESS

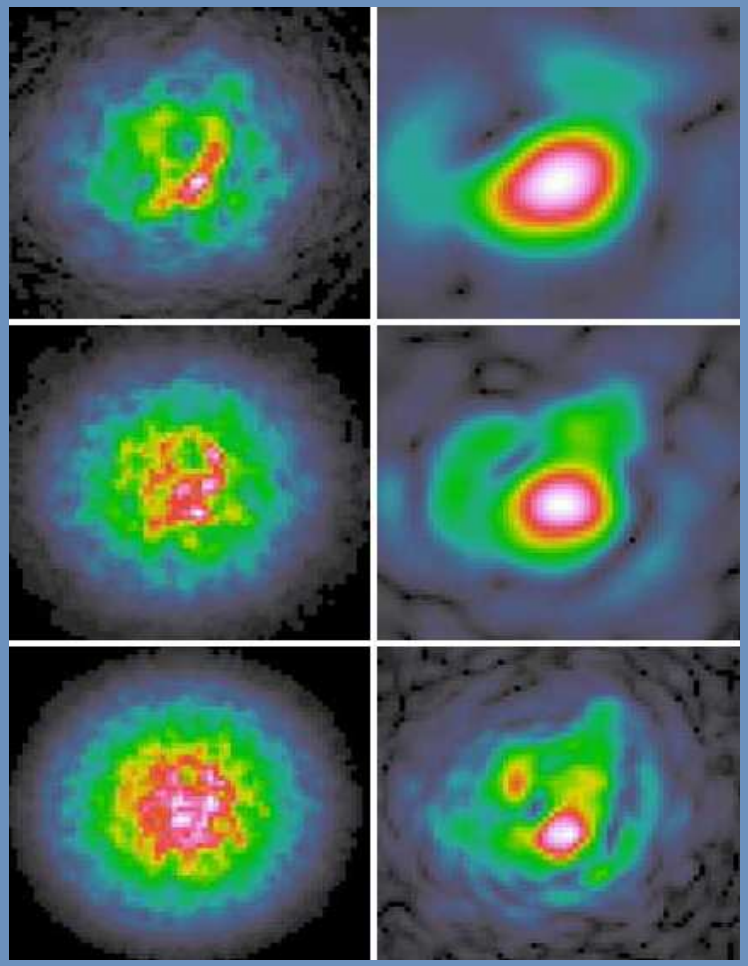


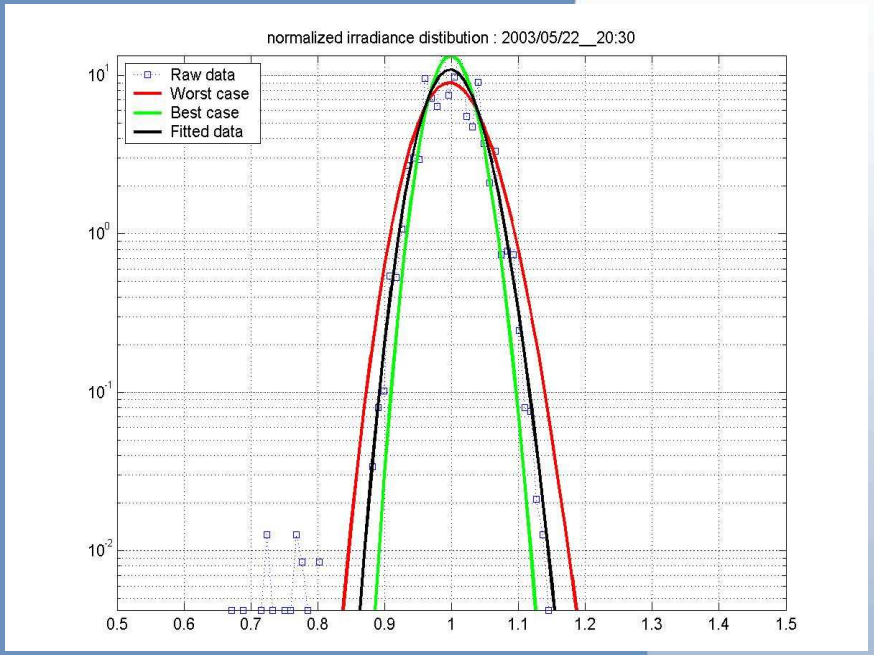
Current 0,8 µm optical link : LOLA PEA

- Customer: DGA
- Prime: Astrium / responsible for communication equipments: AAS
- Demonstration of a real time link between an airplane and the ground through a satellite
- Objective is to characterise the performance of bi-directional link between the airplane and Artemis
  - with atmosphere perturbation (turbulence, clouds, …)
  - Dynamical perturbation of the platform
- Planning : flights are planned starting summer 2006 until march 2007



Link and propagation channel modelling
Correlation with OGS down link





Good correlation between channel model developped by Astrium in the frame of LOLA program on OGS link

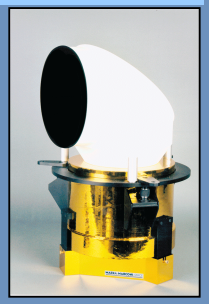
Although this disturbing channel simulation show that transmission through atmosphere is achieved with direct detection at 0,8 µm

2. Product evolution at Astrium

Hemispherical pointing for LEO – GEO link

1995
SOUT

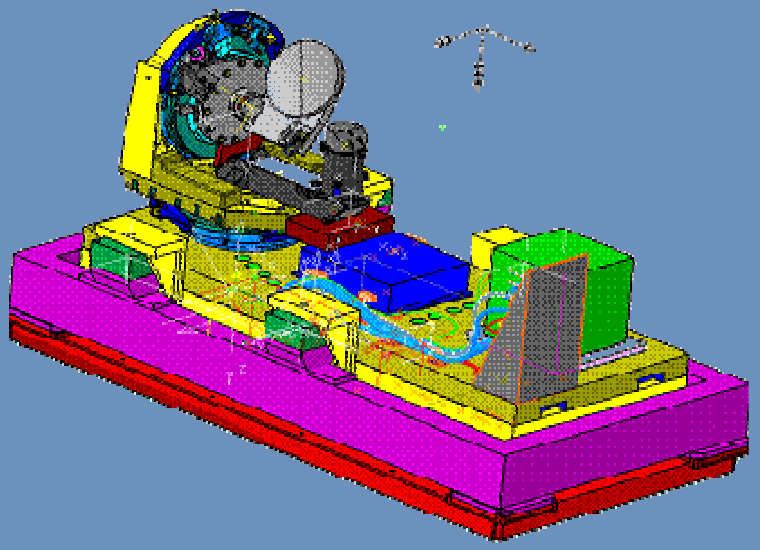
1997
OMNIS



1998
OMNIX

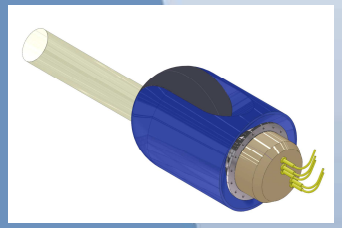
Terminal	Mass	Data Rate	Distance
SILEX	158 Kg	50 Mbits/s	45.000 Km
SOUT	50 Kg	50 Mbits/s	45.000 Km
OMNIS	30 Kg	2400 Mbits/s	< 4.000 Km
OMNIX	20 Kg	150 Mbits/s	< 7.000 Km

New optical terminals at Astrium : current design



LOLA

LIO



UAV

Terminal	Mass	Data rate	Distance
LOLA	-	50 Mbits/s	45 000 Km
LIO LEO	36 Kg	2 x 300 Mbits/s	45 000 Km
LIO GEO	45 Kg	3 x 300 Mbits/s	45 000 Km
UAV	65 Kg	2 x 300 Mbits/s	45 000 Km

3. Future applications of 0,8 µm optical link

- 0,8 µm laser technology well suited for :
  - data relay services inter-orbital link including GEO-LEO, GEO-UAV, GEO-Ground : long distance with frequent re-acquisitions
  - Short distance cluster or formation flying satellites
  - Compatible with Silicon sensors (several thousand of pixels) for Pointing, Acquisition & Tracking
  - Compatible with communication data rate up to 600 Mbit/s

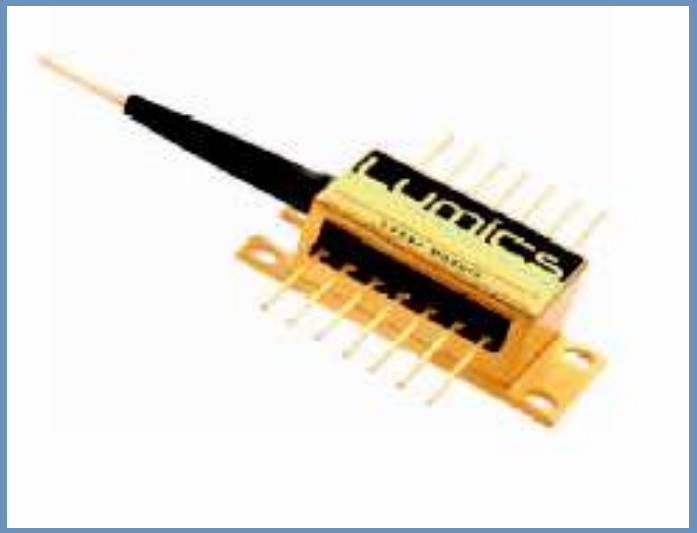
- Several missions to be launched in the period 2010 to 2015:
  - Military or European relay satellites: < 400 Mbps
  - Cluster of co localised GEO satellites < 600 Mbps
  - Formation flying satellites (scientific, observation) < 100 Mbps

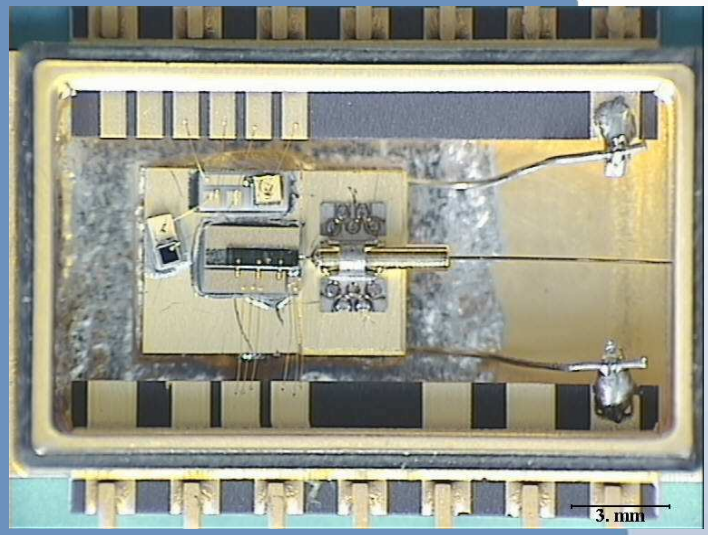
  ➔ Need for high power monomode laser diode source with bandwidth up to 600 Mbps.

4. Need for European laser diode manufacturer

- SILEX and OICETS communication laser diode :
  - SILEX :
    - SDL 5411 G1 & 5421 G1(JDSU)
    - Operating conditions: 120 mW p-p, OOK, 50 Mbps
  - LUCE (OICETS) :
    - SDL 5430 G1
    - Operating conditions: 200 mW p-p, OOK , 50 Mbps
- Current in orbit laser diodes are submitted to ITAR restrictions
- Technology available in Europe, requires space qualification:
  - LOLA demonstrator laser diode :
    - LUMICS LU848M160, identified by Alcatel Alenia Space (responsible of communication equipments, metrology and optical critical components procurement in the frame of LOLA)
    - Operating conditions: 320 mW p-p, OOK, 50 Mbps

5. Today's Lumics laser diode for LOLA demonstrator



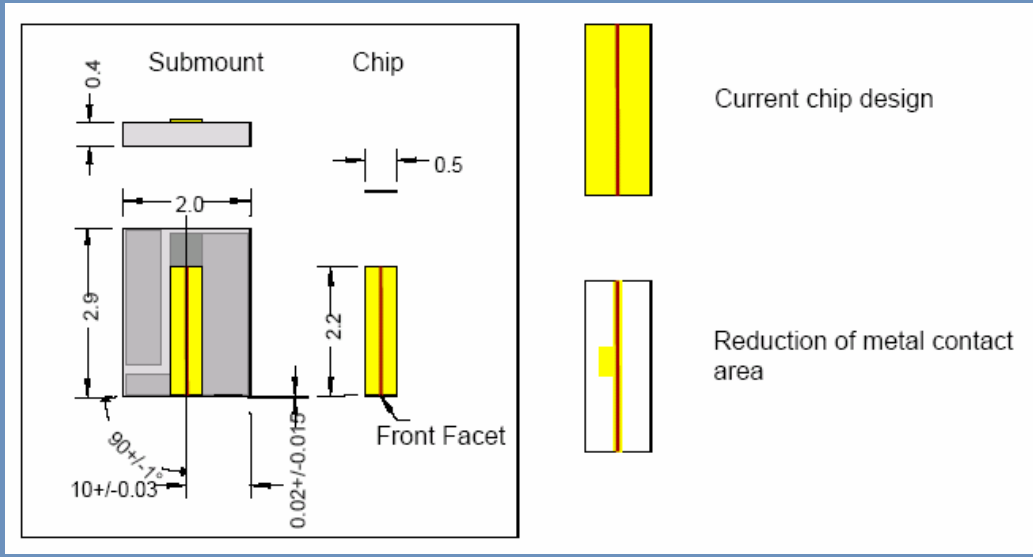


View inside Lumics package
(with the courtesy of Alcatel Alenia Space)

- Quantum well high powerlaser diode
- Mirror passivation with mono crystalline layer on facet (LUMICS patent)
- LOLA laser module bandwidth < 100 Mbps, used at 50 Mbps
- Ouput power : 160 mW average power ex-PM fiber
- Lot qualification for LOLA program
- Butterfly package 14 pins with PM fiber
- Fiber Bragg Grating

6. Lumics laser diode improvements to increase bandwidth

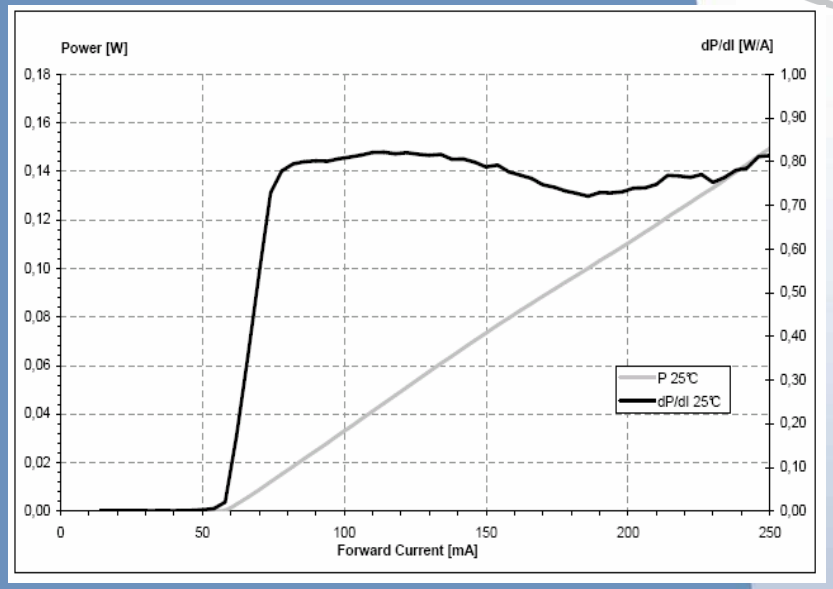
- Reliability improvements :
  - Reduction of optical power density at chip facet
- Bandwidth improvements :
  - Reduction of metallization (reduce package capacitance)

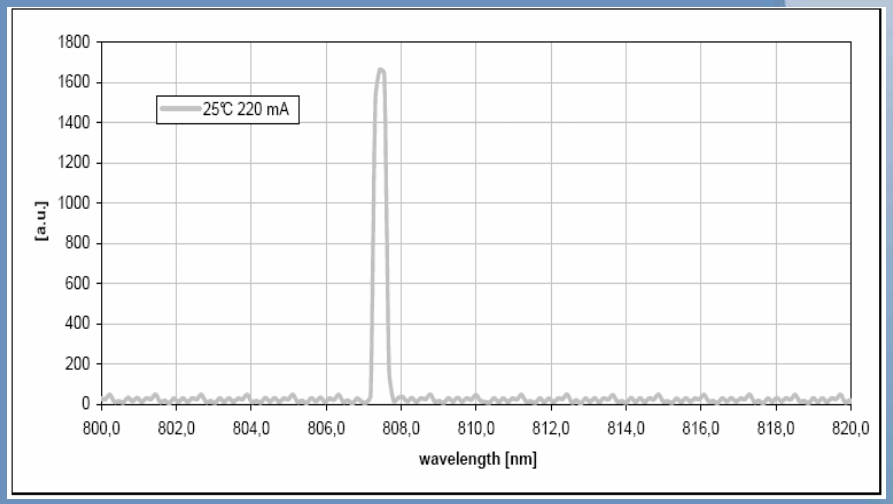


  - Wire bonding diameter increase (reduce package inductance)
  - Coplanar transmission line for HF signal current
  - Reduction of chip length (reduce laser diode capacitance)
- Power improvement:
  - Optimisation of ridge waveguide structure to improve chip-fiber coupling

7. High bandwidth Lumics laser diode (LUM0808M100, SN#136451)

- PM fiber 14 pins butterfly package with TEC
- Reduced length: 1,76 mm
- Reduced metallization
- No FBG
- CW 100 mW . Peak-Peak: 200 mW
- Design wavelength: 808 nm
- Specification: bandwidth > 600 Mbps

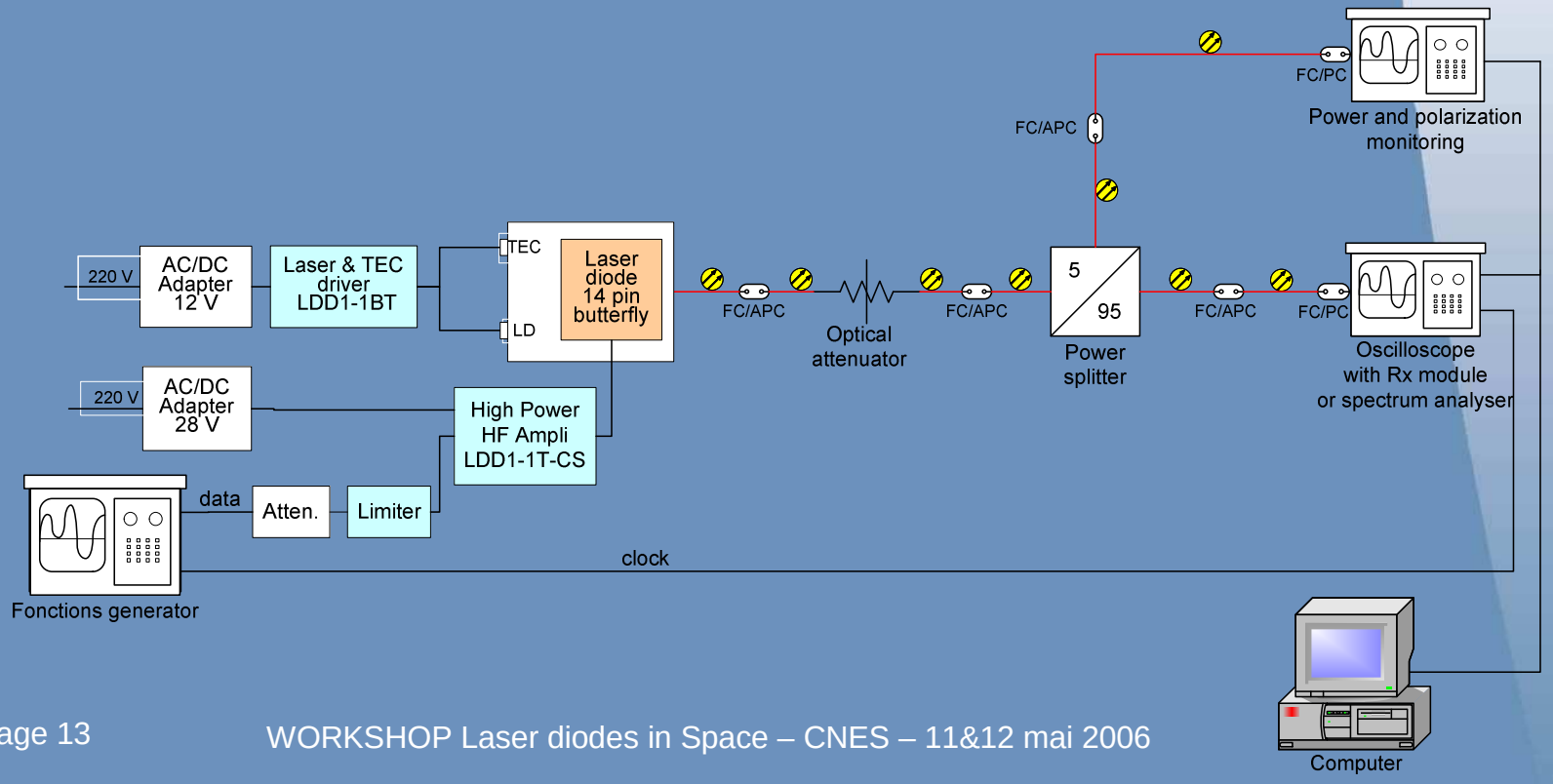




8. First characterisation results

Laser diode characterisation test bench

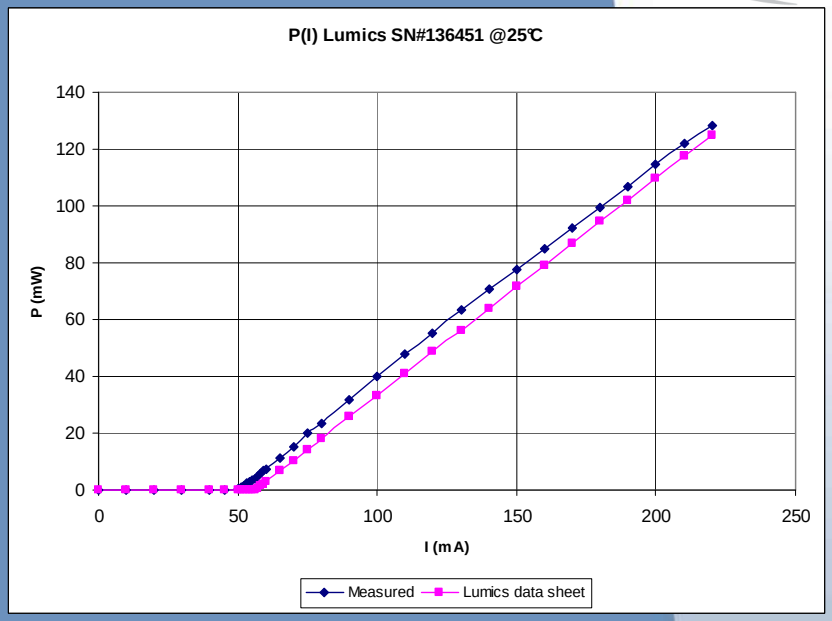
- Custom specific high frequency & high power laser driver LDD1-1T-CS developed by Alphalas:
  - · 1 GHz bandwidth
  - · up to 400 mA DC current and +/-350 mA modulation current
- Laser diode module on butterfly laser mount
- Modulation through external bias Tee (AC coupling)



First characterisation results on SN#136451

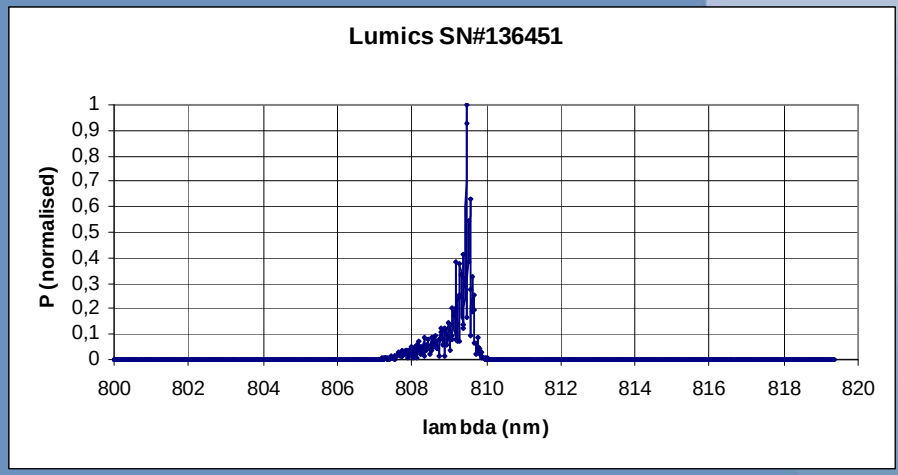
- L(I) measurements

Good correlation between measured and Lumics data sheet P(I)



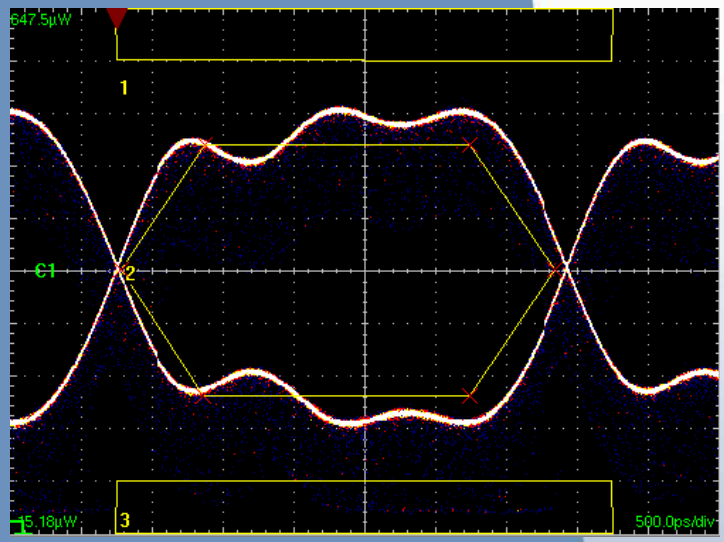
- Optical spectrum measurement

Delta of 1.9 nm between measured and Lumics data sheet central wavelength under investigation

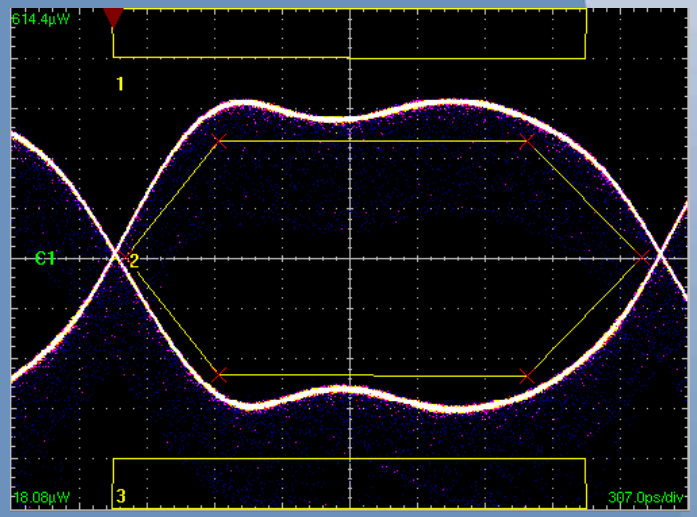


First characterisation results on SN#136451

- Transmit eye diagram with “1010” input signal at 311 Mbps
- Rise time & fall time < 900 ps
- Jitter rms < 100 ps
- Small infringement of transmit mask

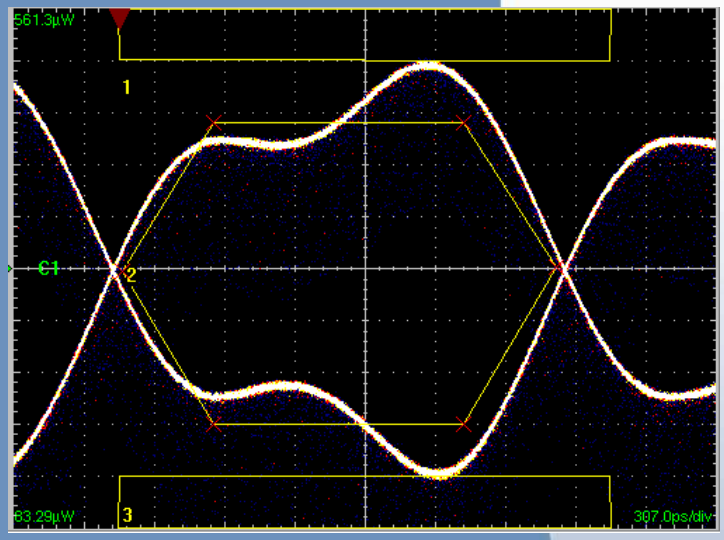


- Transmit eye diagram with “1010” input signal at 400 Mbps
- Rise time & fall time < 750 ps
- Jitter rms < 75 ps
- No infringement of transmit mask

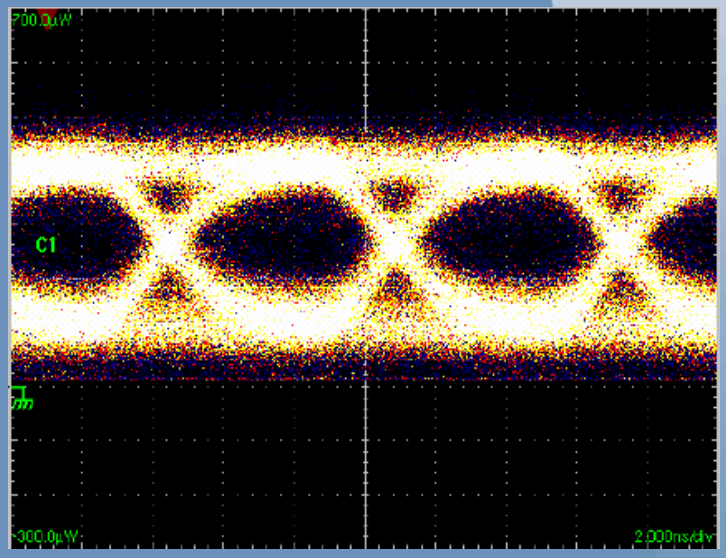


First characterisation results on SN#136451

- Transmit eye diagram with “1010” input signal at 500 Mbps
- Rise time & fall time < 560 ps
- Jitter rms < 60 ps
- Small infringement of transmit mask & pulse shape distortion

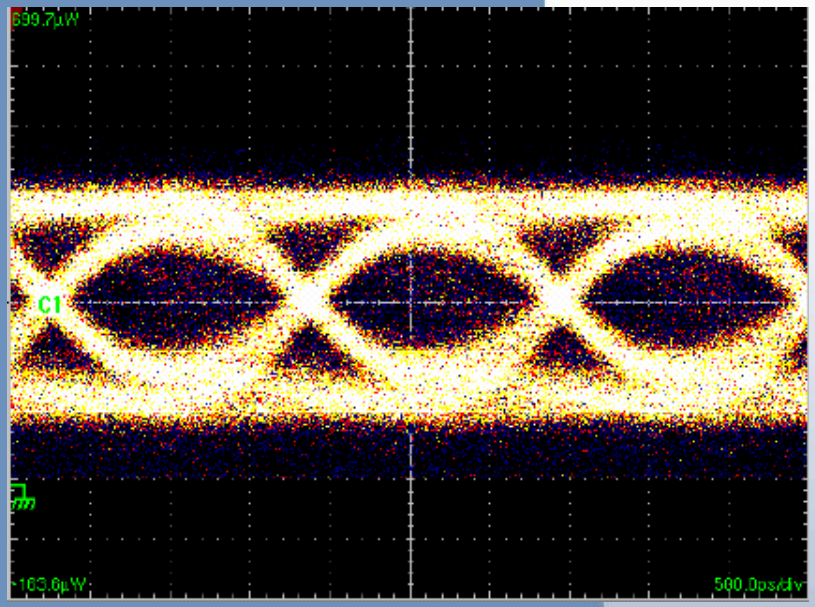


- Receive eye diagram with PN7 input signal at 155 Mbps
- Receiver with STM1 data filter
- Transmitter baseline wandering effect enlarged the eye traces
- Eye opening acceptable



First characterisation results on SN#136451

- Receive eye diagram with PN15 input signal at 622 Mbps
- Transmitter baseline wandering effect enlarged the eye traces
- Receiver with STM4 data filter
- Eye diagram starts to close



9. Conclusion

- Promising preliminary results :
  - Technology compatible with 500 Mbps data rate (demonstrated with test bench limitation, bandwidth limit of laser diode in the same order)
  - Optical spectrum bandwidth < 1 nm
- Next activities:
  - Improvement of test bench metrology : more integrated coupling of HF laser driver with laser diode
  - Characterisation of all diode items
- Future activities:
  - Increase of power of high bandwidth laser diode above 200 mW
  - Increase of bandwidth from 500 to 600 Mbps
  - Optimisation of coupling with FBG (for wavelength stabilisation)
  - Space qualification of laser module