TESAT

Diode Laser Modules

and their Qualification

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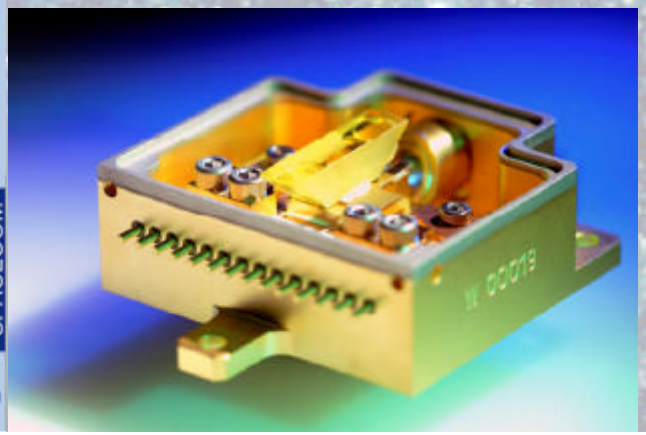
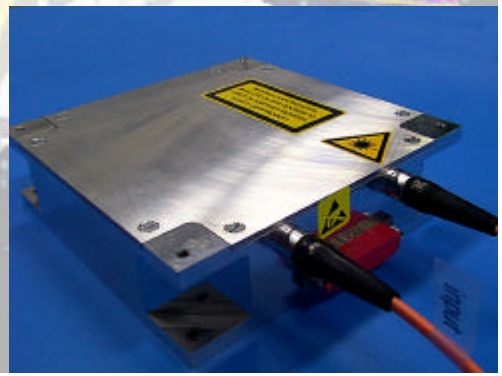
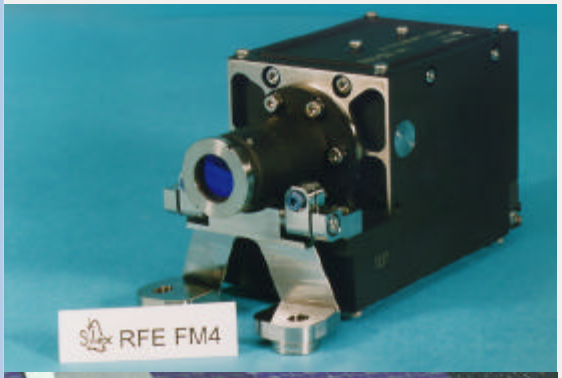
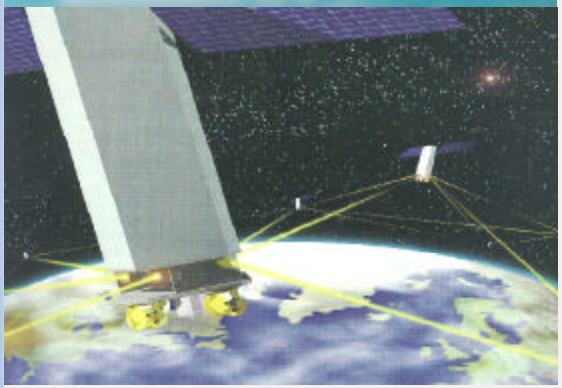
Toulouse, 11th May, 2006

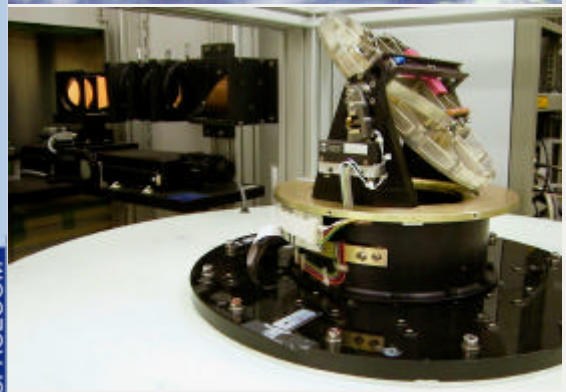




TESAT Laser Communication Terminal (LCT) Heritage 1/2





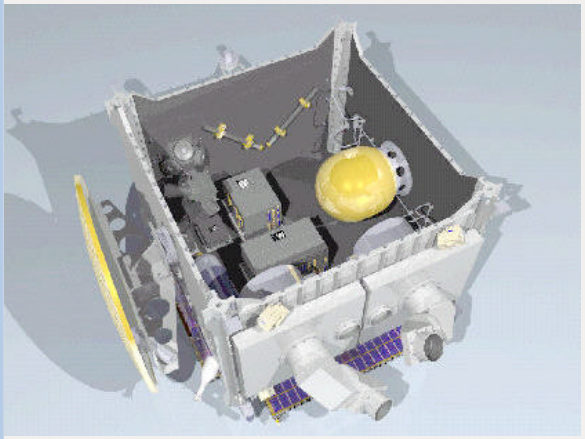


SILEX: LEO and GEO terminal
Prime: MATRA
Tesat: Communication subsystem,
Laser diode procurement (1987),
Receiver front end
In-Orbit-Verification in 2002

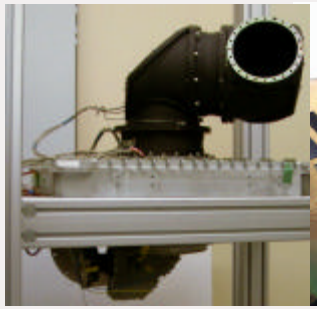
Teledesic: LEO network (500 LCTs)
Prime: Tesat
Program stopped in 1999 but
„Risk Mitigation Phase“ successfully closed
including pump diode procurement, test and first pump module design

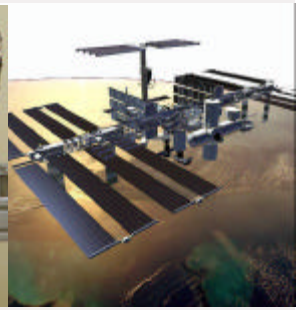
DLR program DLR-LCT:
LEO LCT - demonstrators
Performance verified under in-orbit conditions
Prime: Tesat
2001 successfully closed

TESAT Laser Communication Terminal (LCT) Heritage 2/2

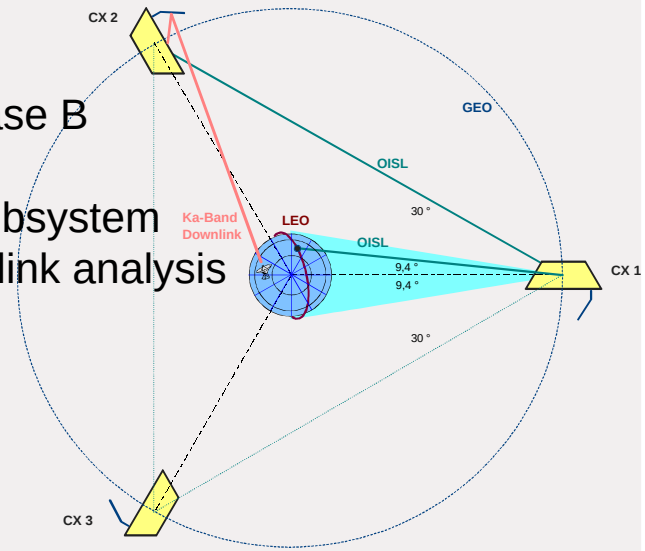


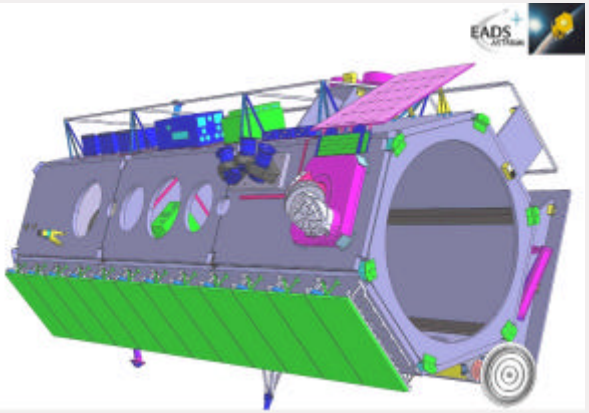
DLR Program MEDIS Phase A/B:
MEO LCT - demonstrator
ISS - MEO - MEO link analysis
Prime: Tesat
2002 successfully closed





ESA Program ConeXpress Phase B
Prime:Dutch Space
Tesat: Laser communication subsystem
LEO - GEO - GEO LCT link analysis
Phase B successfully closed





LCTSX: LEO LCT on TerraSAR-Satellite
Prime: Tesat
LCT delivery in 2006
In-Orbit-Verification in 2007

TESAT Heritage on Laser Diode Procurement

SILEX (1987 - 1994)

15 manufacturers and 30 different types of laser diodes investigated,
4 potential candidates selected,
more than 200 laser diodes tested in mech./ rad./ env./ 9600h life test program
(1.9 Million device hours)

InP SEMICONDUCTOR FACTORY AT BACKNANG (1987 - 1997)

Well funded physical understanding based on own technological experience in laser diode design, manufacturing, and test

TELEDESIC/ DLR-LCT (1997 - 1999)

2 suppliers out of 12 candidates selected,
3 different assembly techniques investigated on AlN, TcBN, diamond heatsinks,
life test performed with 150 Laserdioden in 13 groups (0.5 Million dev. hrs)
ILT, Aachen selected for coupling optics design and assembly

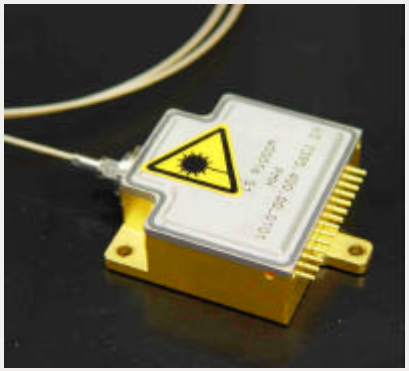
MEDIS TV (2001 - 2002)

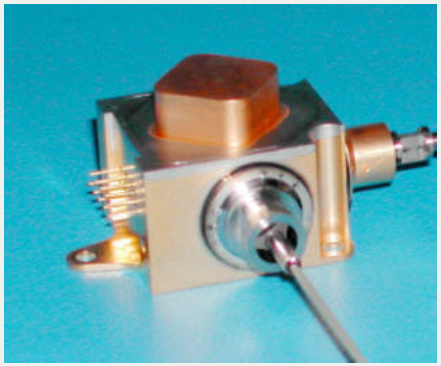
FBH Berlin selected as 808nm laser bar supplier
Life test performed with 20 bars (120 individual devices, 0.6 Million dev. hrs)

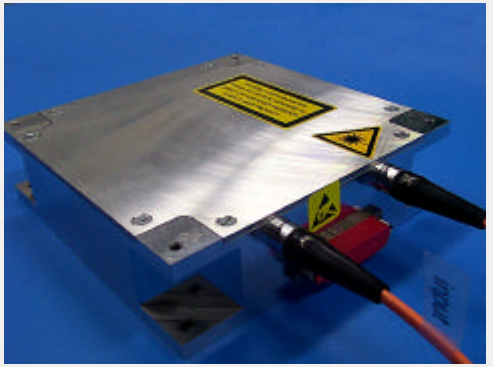
LCTSX (2003 - 2006)

Diode test programs, pump module manufacturing, tests in coop. with FBH, ILT

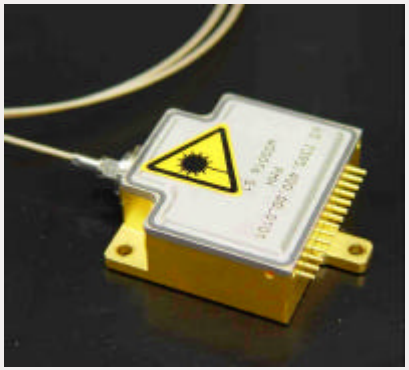
Space Qualified Laser Transmitters for Laser Comms

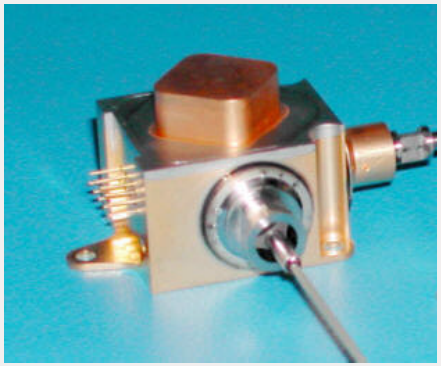


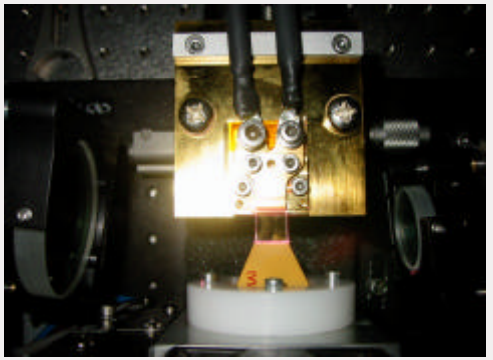




Short Range: NPRO Laser plus 1 W Yb:fiber amplifier







Long Range: NPRO Laser plus 10 W crystal amplifier

TESAT Frequency Reference Lasers in EO and Science

- DWL, ESA: Injection seeder BB for Doppler Wind LIDAR delivered September 2001
- GIFTS, NASA: Reference laser BB for Fourier Transform Spectrometer delivered in May 2002
- SMART-2, ESA: Laser BB for gravitational wave detection test program delivered in November 2002
- GIFTS, NASA: FM delivered in February 2005
- ALADIN, ESA: Cavity locked, dual laser, injection seeder FM Units for Doppler Wind LIDAR, to be delivered in 2006
- LTP, DLR: Laser FM for gravitational wave detection test program, to be delivered in 2007
- QSL, U.S. aerospace company: Q-switched Reference Laser FMs, to be delivered in 2006

TESAT Module Qualification Strategy 1

A module will never be more reliable than the parts it consists of !

Investigations start at lowest critical part level, the laser diode itself

Sequential qualification test flow:

1. Processes
2. Laser diode (bar)
3. Assembled laser bar (“bench”)
4. Pump module

TESAT Laser Diode Pump Module Heads (PMHs)

1W (CW) up to 1.5 kW (QCW)

Built-in redundancy

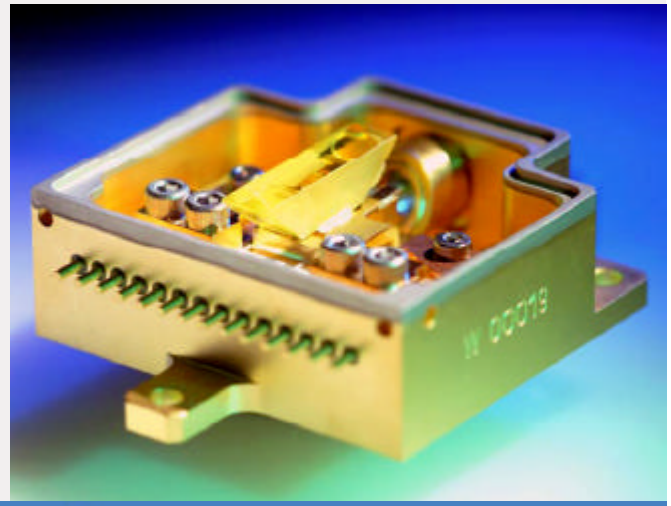
Scalable configuration

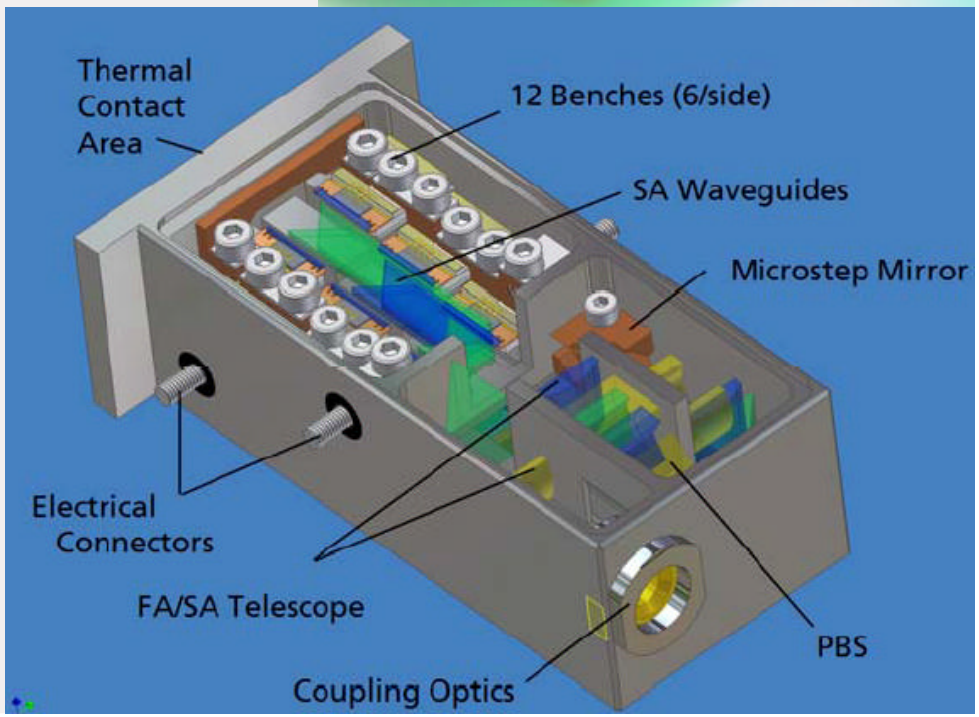
Polarisation multiplexing

High reliability over
up to 10 - 15 years

Fiber coupled

Hermetic (< $5x10^{-9}$ mbar l/s)

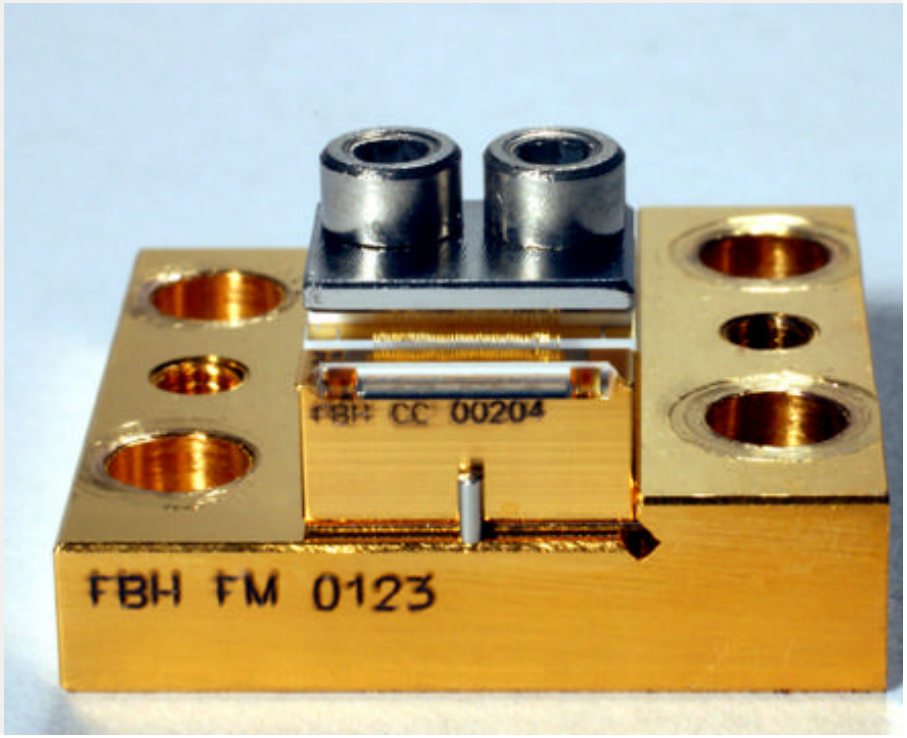




in cooperation with ILT, Aachen and FBH, Berlin

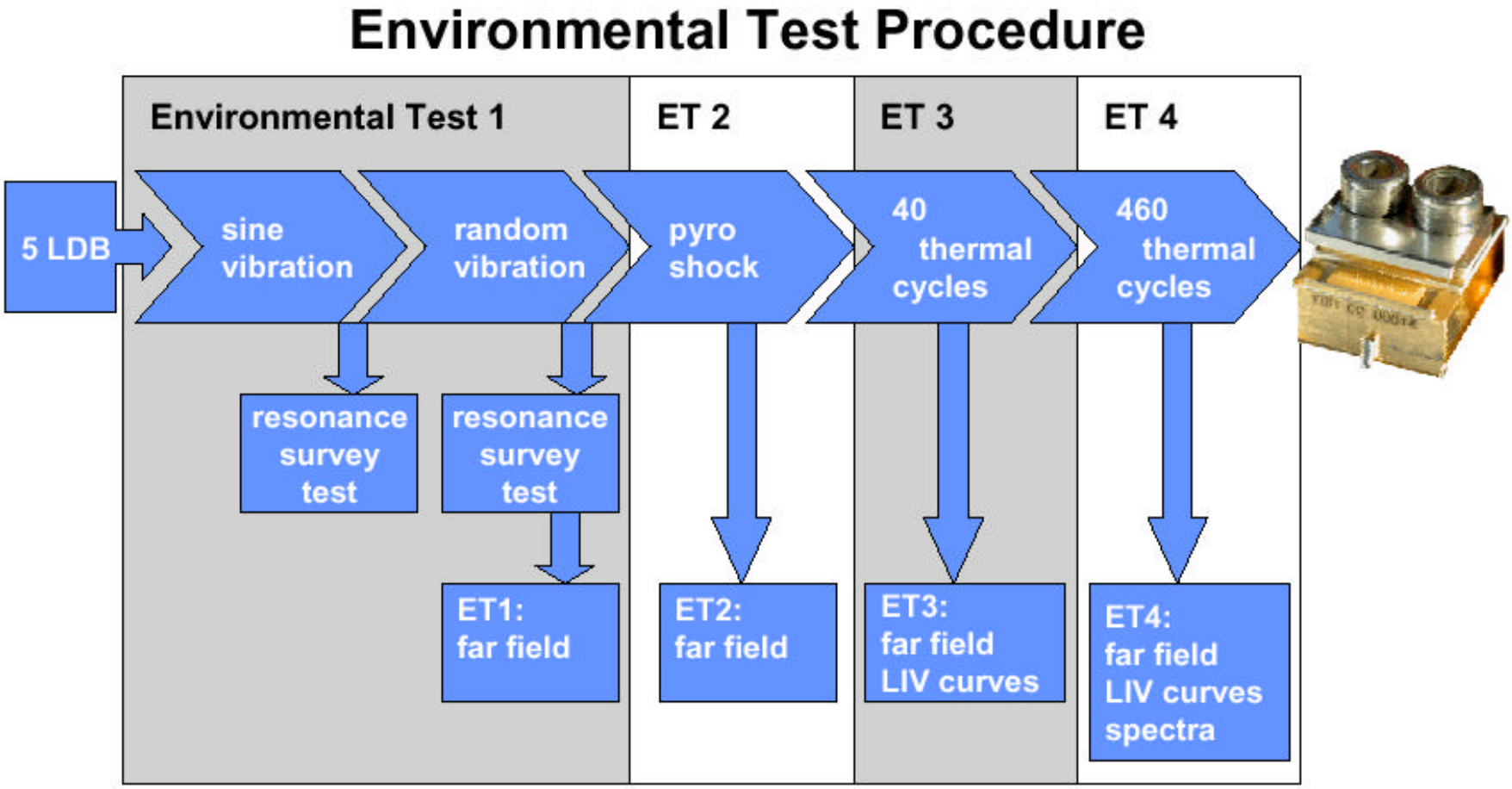
Multiple Laser Diode Bench (LDB) Approach

- Identical LDB approach gives maximum design flexibility on PMH level
- Clearly defined interfaces
- Special space-suited processes
- Easy and cost saving testing on LDB level
- Qualification status applicable to various PMHs



picture courtesy of FBH, Berlin

LDB Standard Test Program as Performed in LCTSX, ...



courtesy of FBH, Berlin

+ Gamma irradiation + Proton irradiation + life test + ...

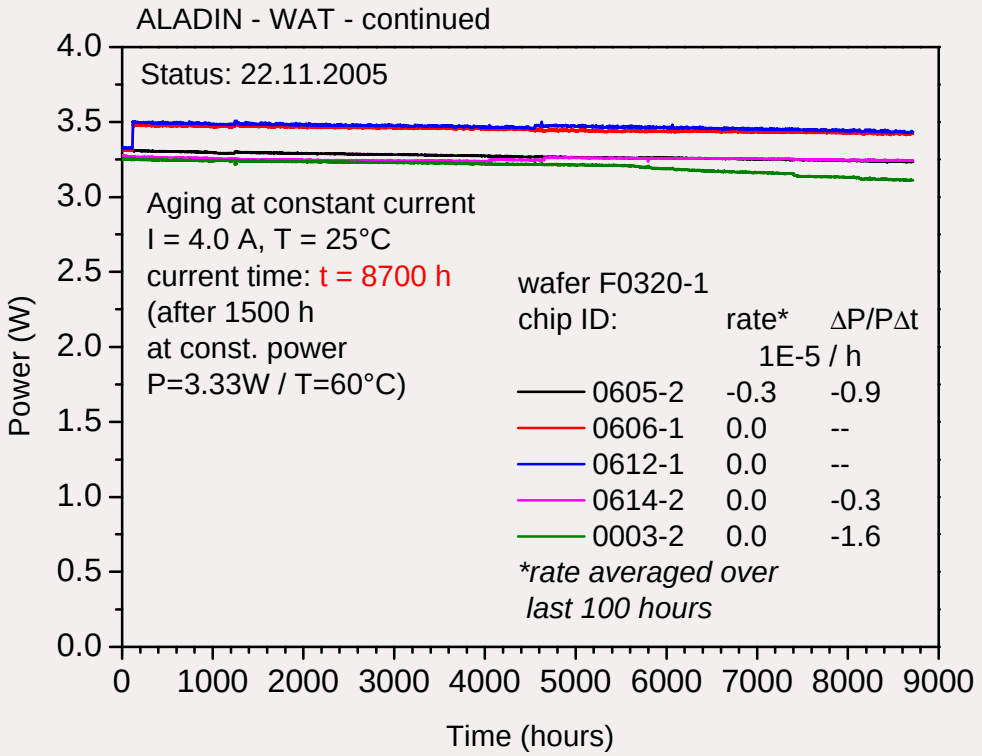
Laser Diode Bench (LDB) Life Tests

Several life test campaigns since 1997

Accelerated aging over more than 10,000 hours per test

Various test conditions

1.) Weakly accelerated test campaign



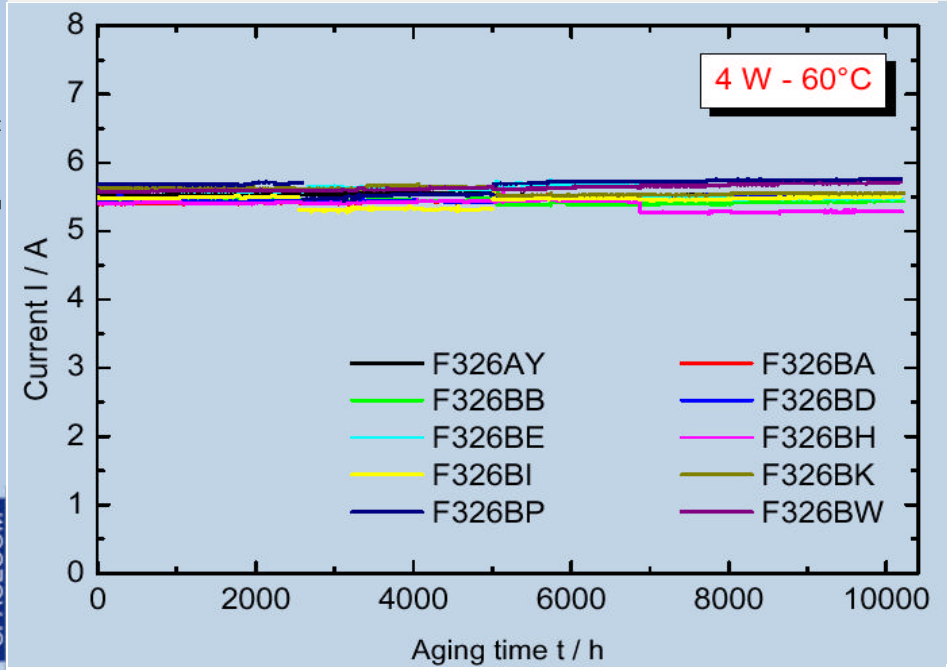
courtesy of FBH, Berlin

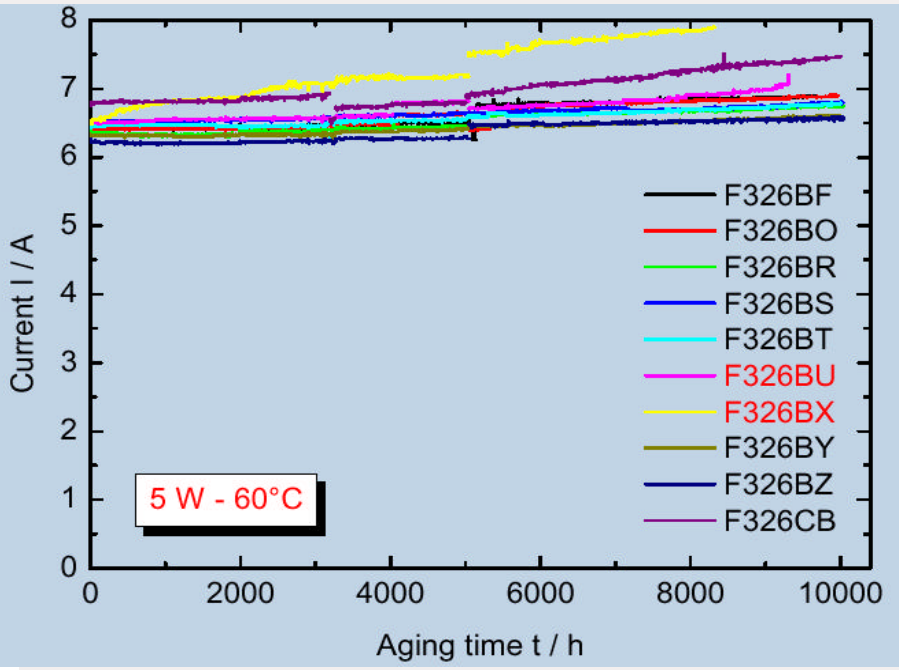
Laser Diode Bench (LDB) Life Tests

2.) Strongly accelerated aging over 10,000 hours

4 to 5 times power and 40°C over operating temperature

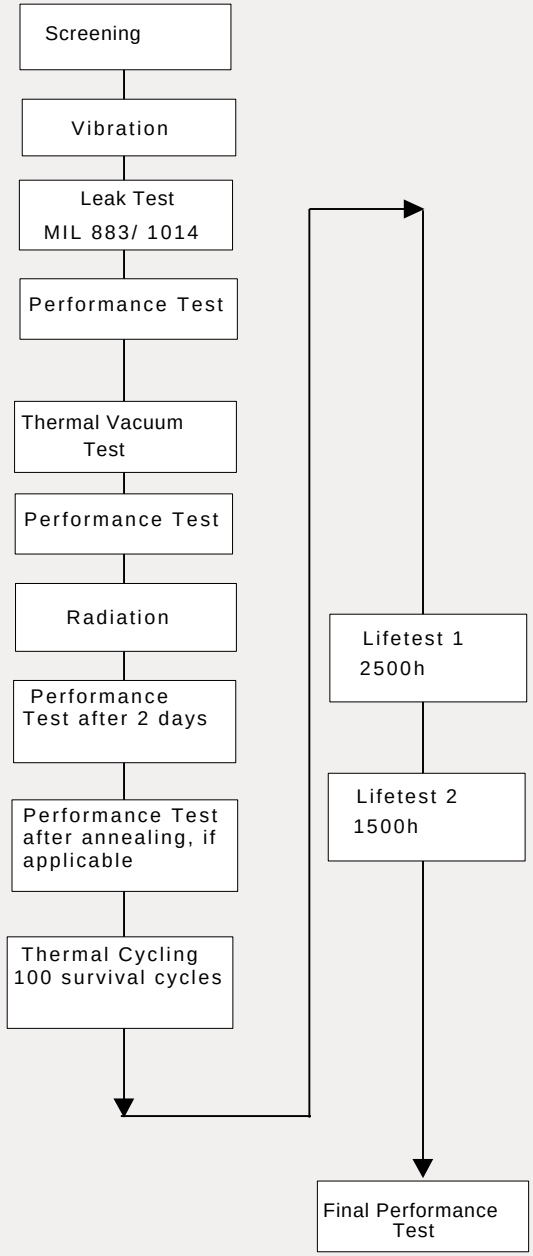
>5 Million hours MTTF under mission operational condition for each individual diode



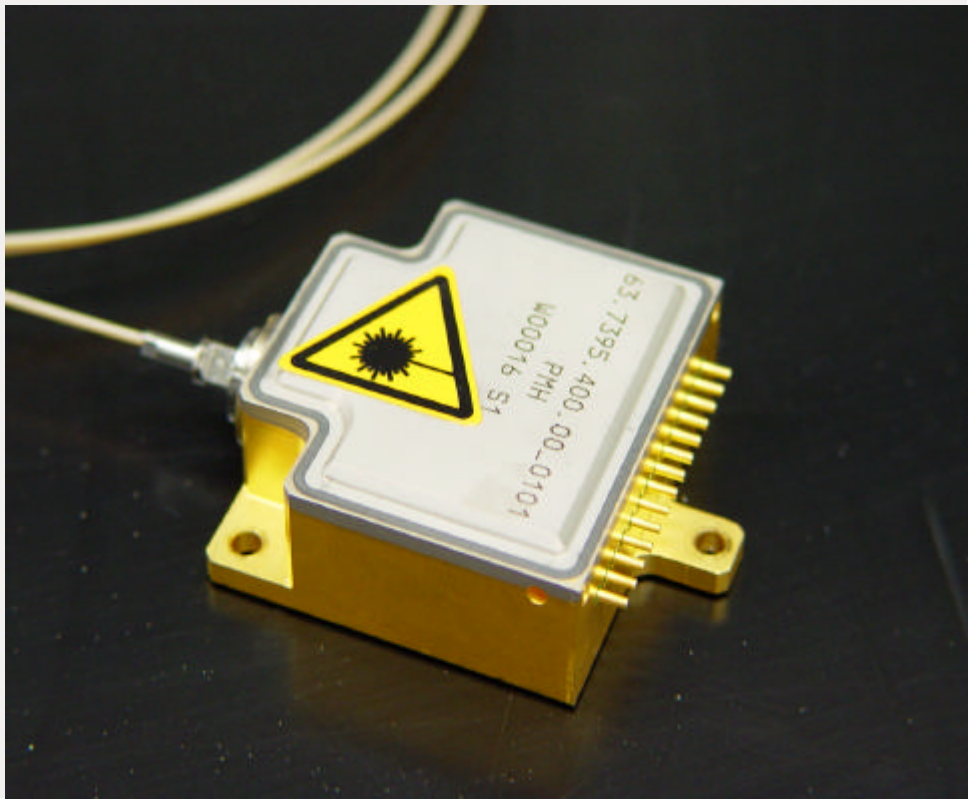


diagrams: courtesy of FBH, Berlin

Laser Diode Pump Module Head Qualification

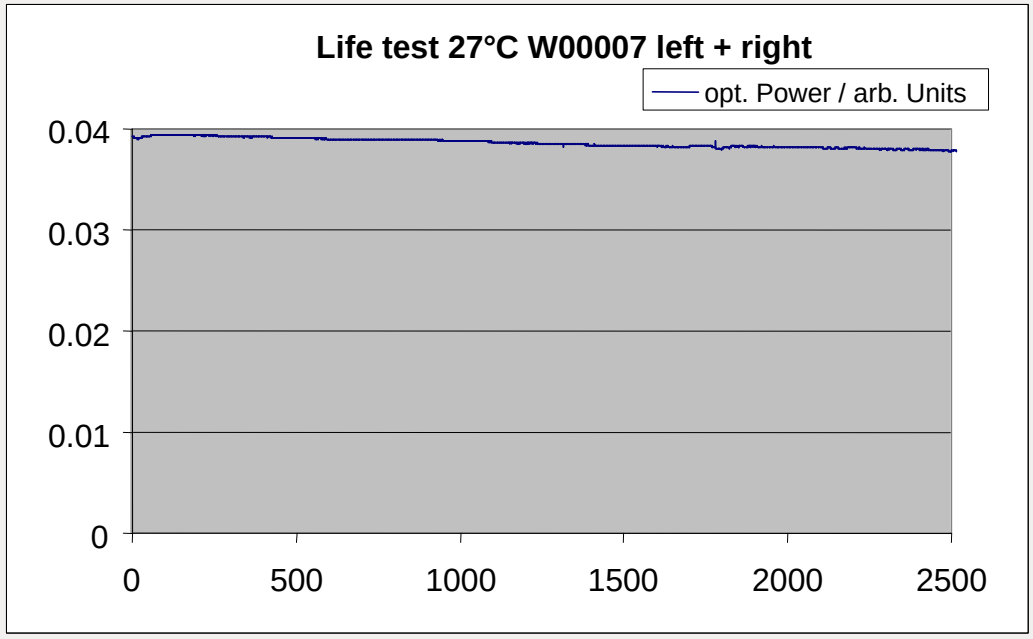


passed within LCTSX test campaign

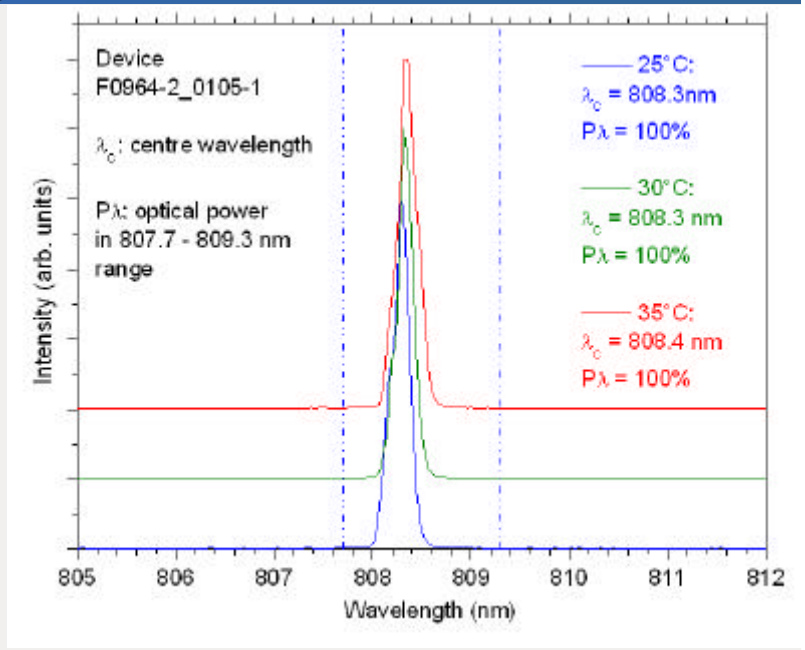


Laser Diode Pump Module Head Qualification

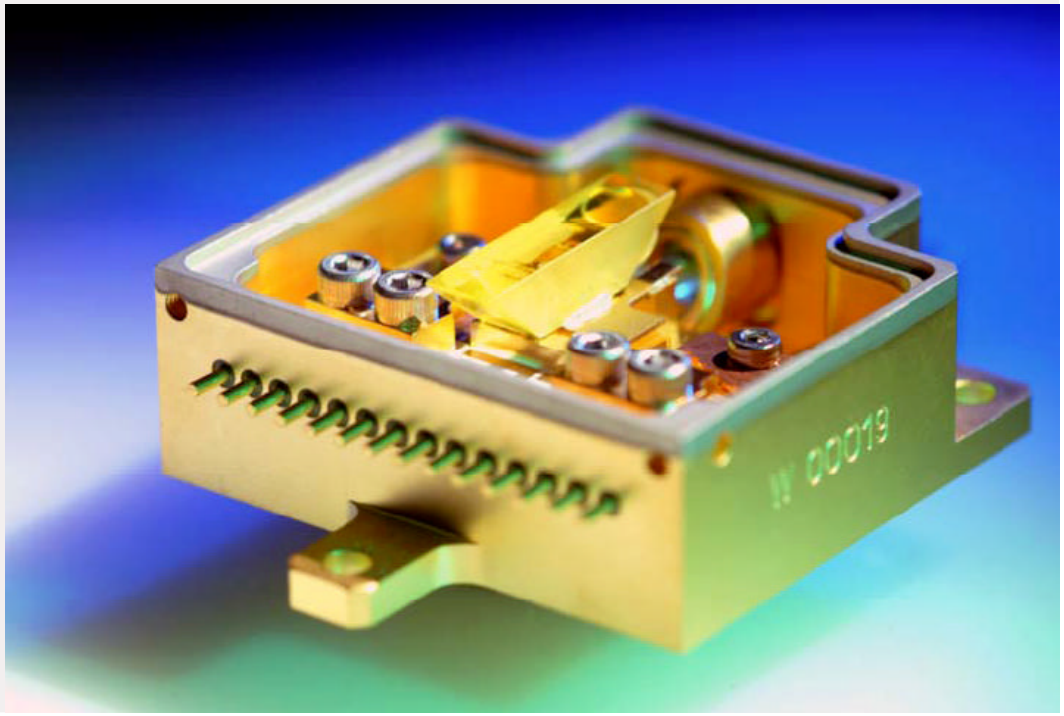
Random vibration (27 g rms, 3 axes) passed
Sine vibration (20 g) passed
TV cycling (including 8 non op cycles) passed
150 krad Gamma irradiation passed
1300 g shock test passed
100 passive cycles -35°C - + 60°C passed
Life tests at 4 x Pop passed (2500h @ 27°C + 1500h @ 47°C)



Standard Low Power Pump Module



- Cold 1-out-of-2 redundancy
- Polarisation multiplexed
- Bragg-Reflector stabilized
- Max. output power: 5 W
- up to 0.9998 reliability
- 100 µm, 0.22 NA fiber
- Real hermetic package with N_2/O_2 filling
- 40mm x 45mm x 20mm



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TESAT Module Qualification Strategy 2

Modular approach of Tesat PMHs enables easy testing and easy transfer of qualification results

Only “Delta-qualification” after minor changes

Superior performance due to Bragg-stabilization

Superior diode lifetime due to special processing

Only laser material of qualified provenience used

Don’t trust in “screening” procedures, which promise to select pears (space suited, lifetime optimized laser bars) from apple trees (“$ per W” - commercial 808nm market)