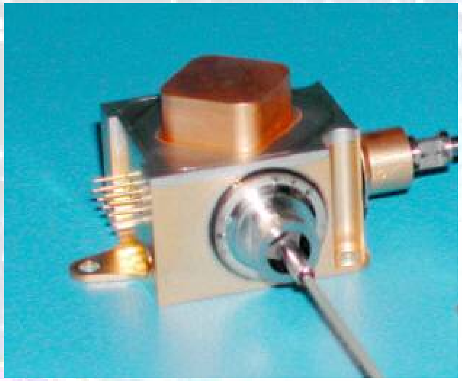
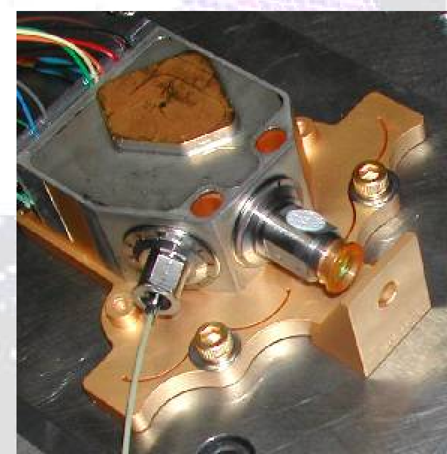


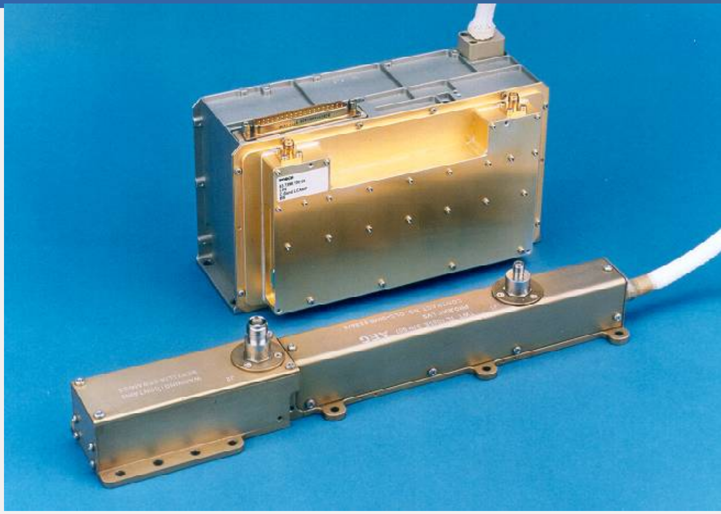
Truly Hermetically Sealed Lasers for Reliable Long Term Space Operation

Thomas Schwander
TESAT Spacecom GmbH & Co, KG
Backnang,
Germany

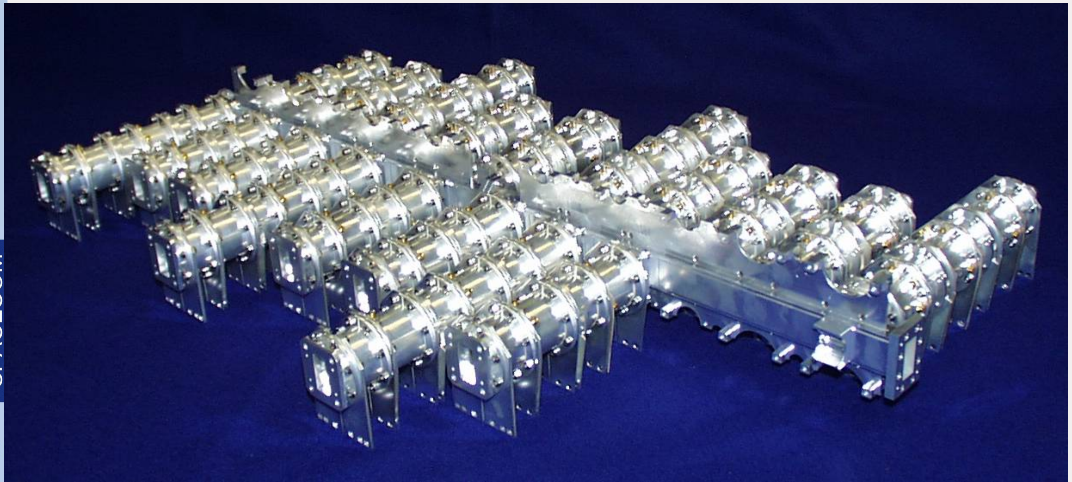
ESA-NASA Workshop, Noordwijk,
June 21st, 2006



TESAT Space Heritage



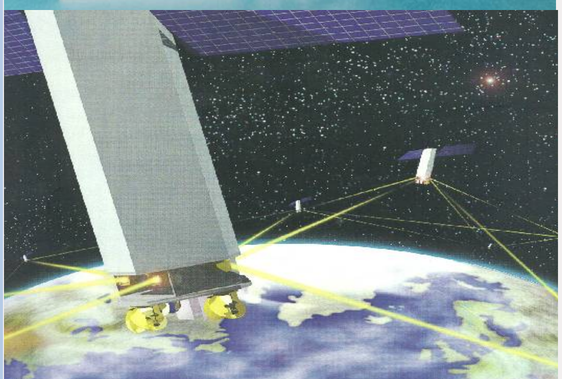
Space borne communication pay loads for commercial long term applications are our business for more than 40 years

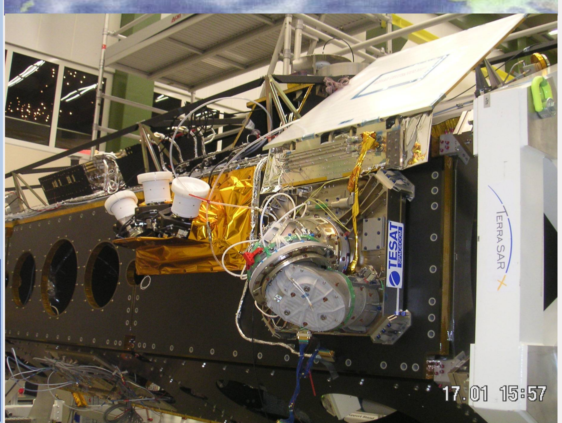


History & Heritage

- 1949: AEG Fernmeldetechnik
- 1955: Telefunken GmbH
- 1967: AEG Telefunken AG
- 1983: ANT Nachrichtentechnik GmbH
- 1995: Bosch Telecom GmbH
- 2000: Bosch SatCom GmbH
- 2001: Tesat-Spacecom GmbH & Co.KG

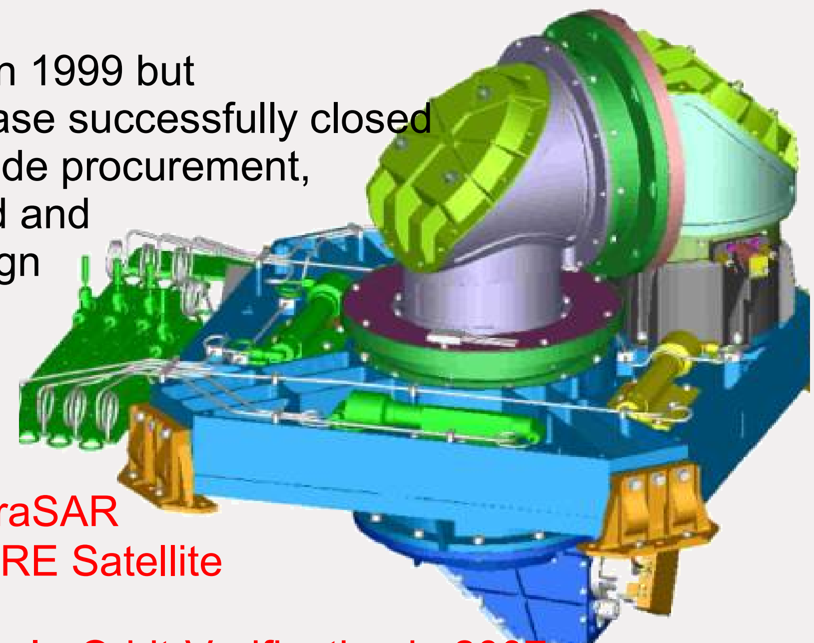
TESAT LCT (Laser Communication Terminal) Heritage





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

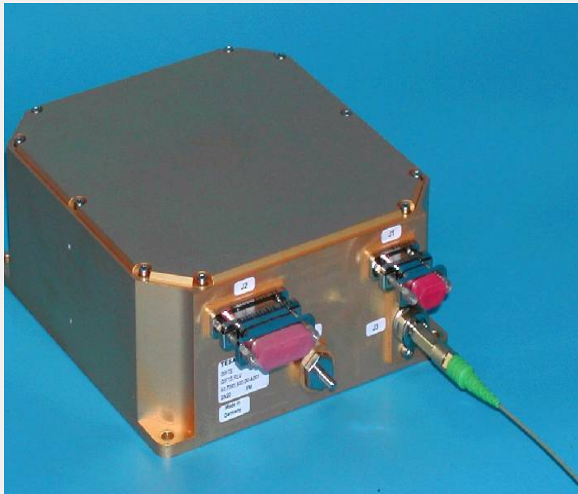
Teledesic: LEO network (500 LCTs)
Prime: Tesat
Program stopped in 1999 but
Risk Mitigation Phase successfully closed
including pump diode procurement,
and first laser head and
pump module design



LCTSX:
1 LEO LCT on TerraSAR
2nd LCT on US NFIRE Satellite
Prime: Tesat
LCT under delivery, In-Orbit-Verification in 2007
1064nm, 3 Gb/s, homodyne, 25kg, 35W

TESAT Space Borne Reference Laser Units (RLU) 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



Are there keys for reliable long term operation under space environment ?

What might hurt a laser in space environment – and before?

- Humidity !
- Dust
- Pressure difference during launch ?
- Wrong technology (In-solder, CTE-mismatch, ...)
- Optically induced deposition of hydrocarbons (“PIF”)
- Atomic Oxygen ?
- Protons, Electrons, Ions, ...

What's the consequence for the package ?

Fill it (with N_2/O_2)

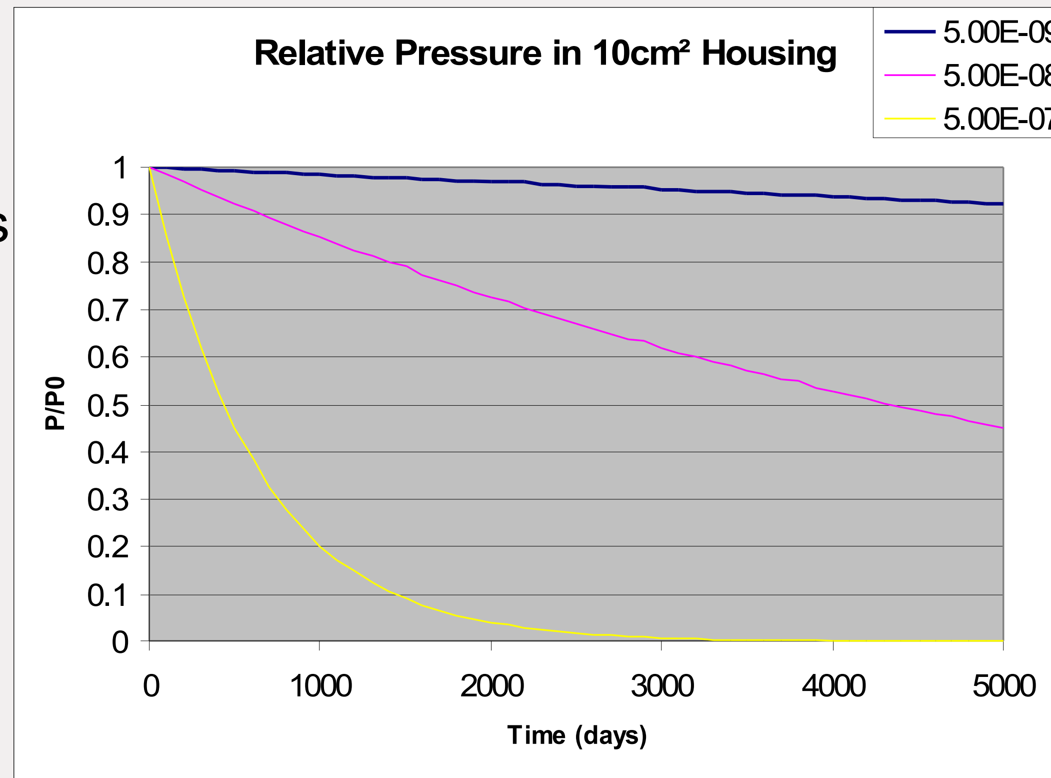
Seal it

Or

Forget it !

How do we define hermetic housings?

- Minimum standard acc. EN 600068 or MIL-883 is not sufficient (up to $1x10^{-6}$ mbar l/s allowed) !
- He leak rate below $5x10^{-9}$ mbar l/s (for 10 cm³), corresponding to > 90% of initial pressure after 15 years
- Laser-welded housings
- Electrical glass feed-throughs
- Soldered optical windows (no glued fibers)
- Qualified processes



Typical Laser Module Manufacturing Flow at TESAT

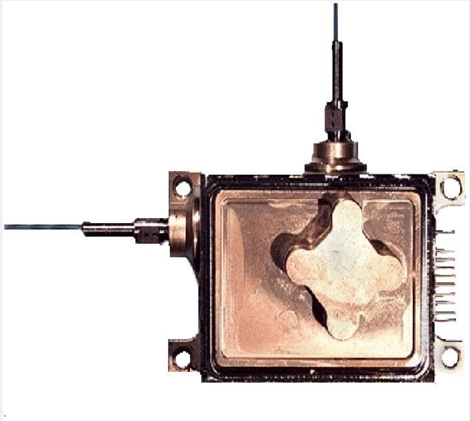
- Housing incoming insp
- Bake in
- Assembly
- Vacuum bake in
- Lid laser welding
- El.-opt. check
- Coupling
- Temp. storage
- Performance test
- He Leak test

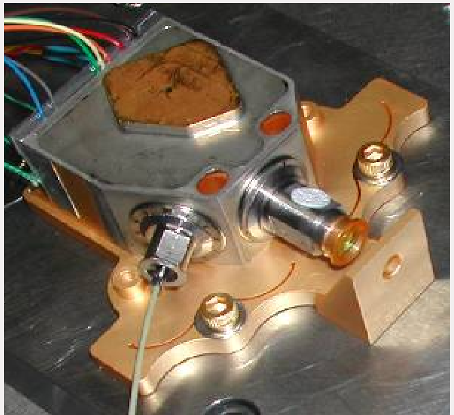
Includes He fine leak test

Test/ assembly step

Pre cap inspection
Fill gas: dry air with 20% He
PIND test

Laser welding of lens pipe(s)
Soldering of el. pigtail
Surface passivation



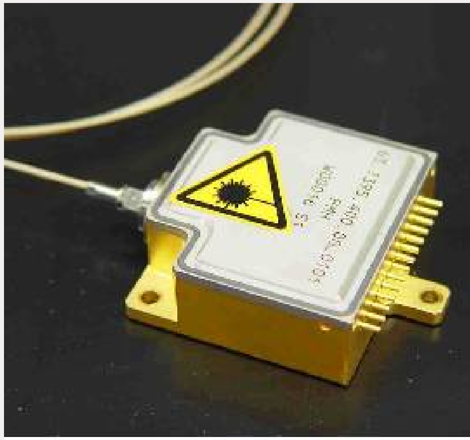


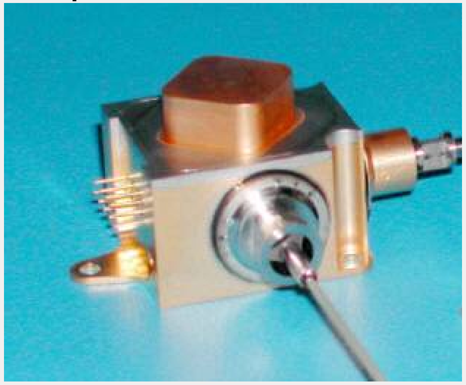
Typical Laser Qualification Flow at TESAT (e.g. PMH)

Test step	
Screening	Inspec., Burn in IFT
Vibration	27.7g_{rms} random 20g sine
TV Cycling	2 active 8 passive
Gamma irradiation	150 krad
Mech. shock test	1300g
Thermal cycling	100 x -35°C .. +60°C
Life test	2500h, 4x Pop, 27°C 1500h, 4x Pop, 47°C
FFT	

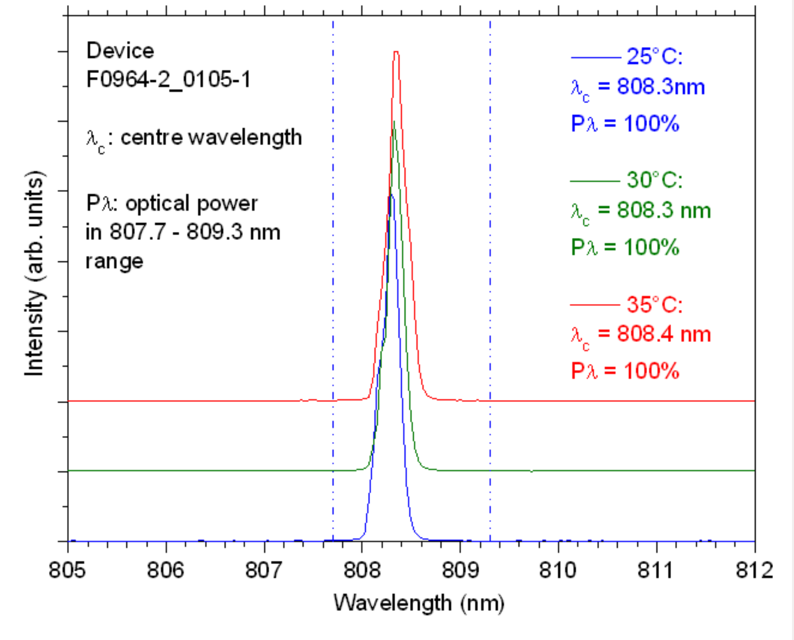
Includes He fine leak test

Test step





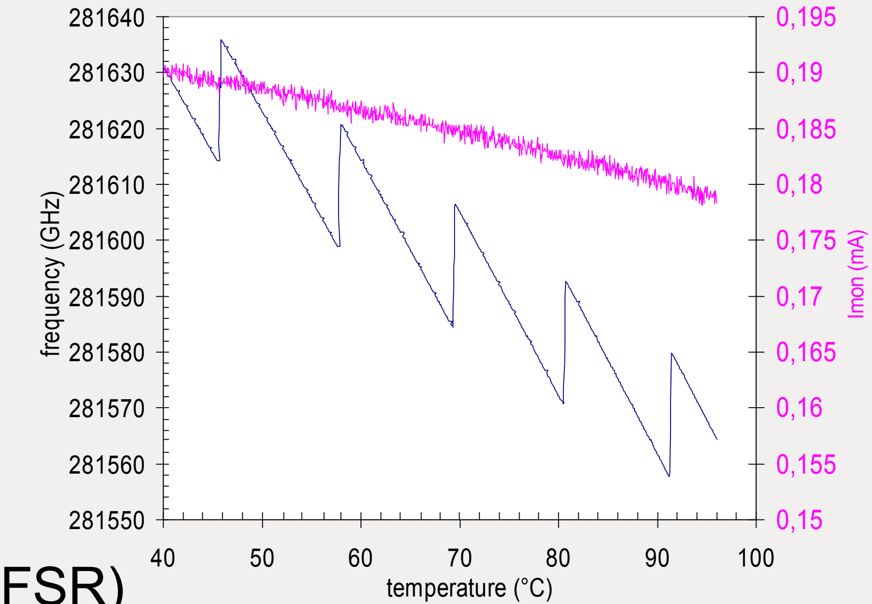
Standard Low Power Pump Module



- 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

in cooperation with ILT, Aachen and FBH, Berlin

Nd:YAG NPRO Reference Lasers



Output power: 50 mW - 300mW CW

or 1kW qs (5ns, 7.5kHz PRF)

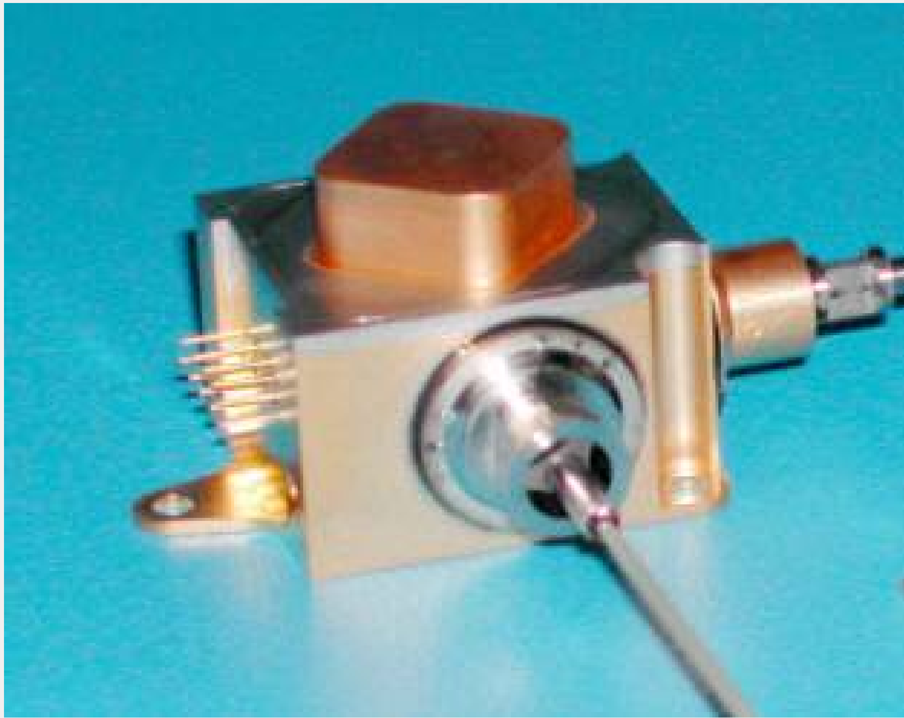
70 GHz tuning range (30GHz or 10GHz FSR)

Frequency stability in the kHz-regime

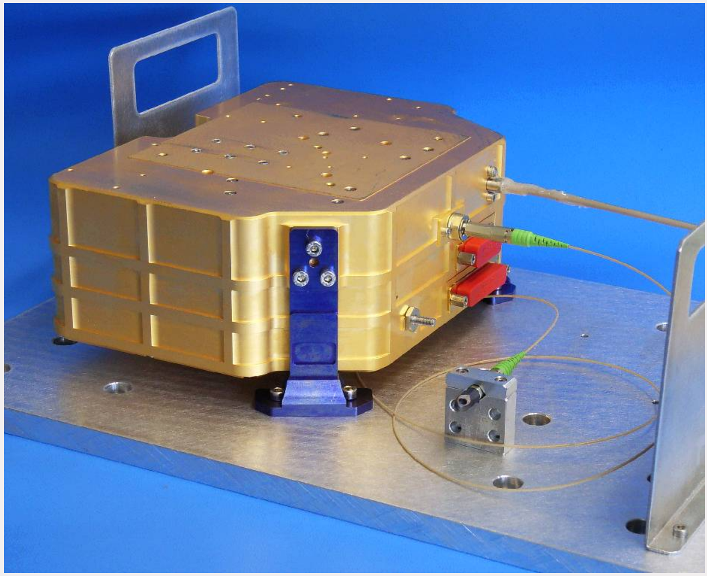
Collimated beam or Polarisation maintaining single mode fiber output with built in Faraday isolator

Real hermetic package with N_2/O_2

25mm x 20mm x 15mm



Conclusions



- Only laser welding, soldering, and glass feed throughs enable true hermeticity
- Stable atmosphere inside over more than 15 years with l < $5x10^{-9}$ mbar l/s
- Easy testing on earth (ambient)
- Improved safety against space environmental impact
- Qualified key components for TESAT LCTs and RLUs