Progress of Laser Time Transfer at China Space Station

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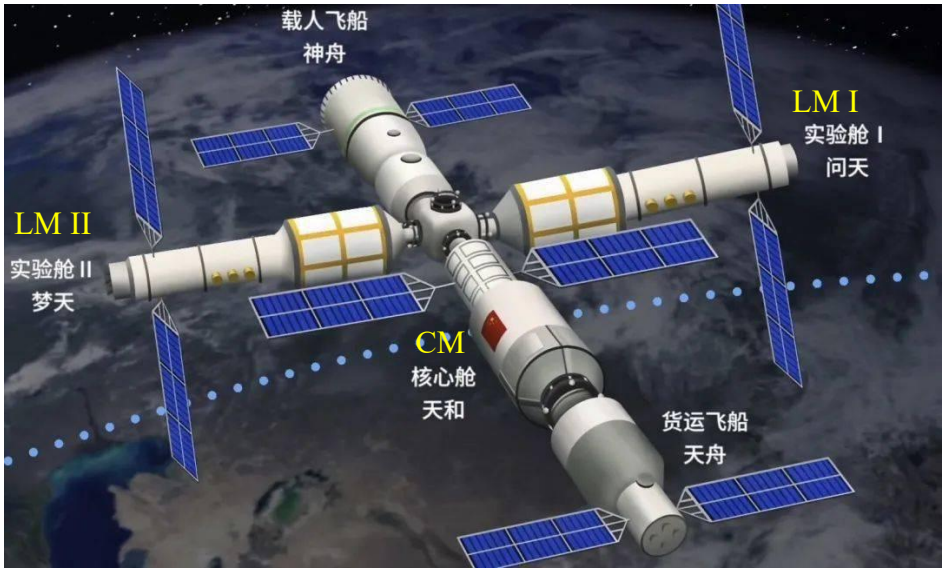
Outline

- **Description**
- **Payload**
- **Ground station**
- **Conclusion**

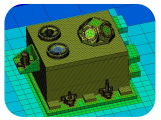
Description

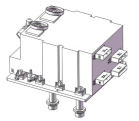
- China Space Station is under construction. The **C**ore **M**odule and **L**aboratory **M**odule **I** have been successfully sent to the outer space in April, 2021 and July, 2022 respectively.
- **L**aser **T**ime **T**ransfer (LTT) payload as a part of **H**igh **P**recision **T**ime **F**requency **S**ystem (HPTFS) is on **L**aboratory **M**odule **II** which was launched in the past week.



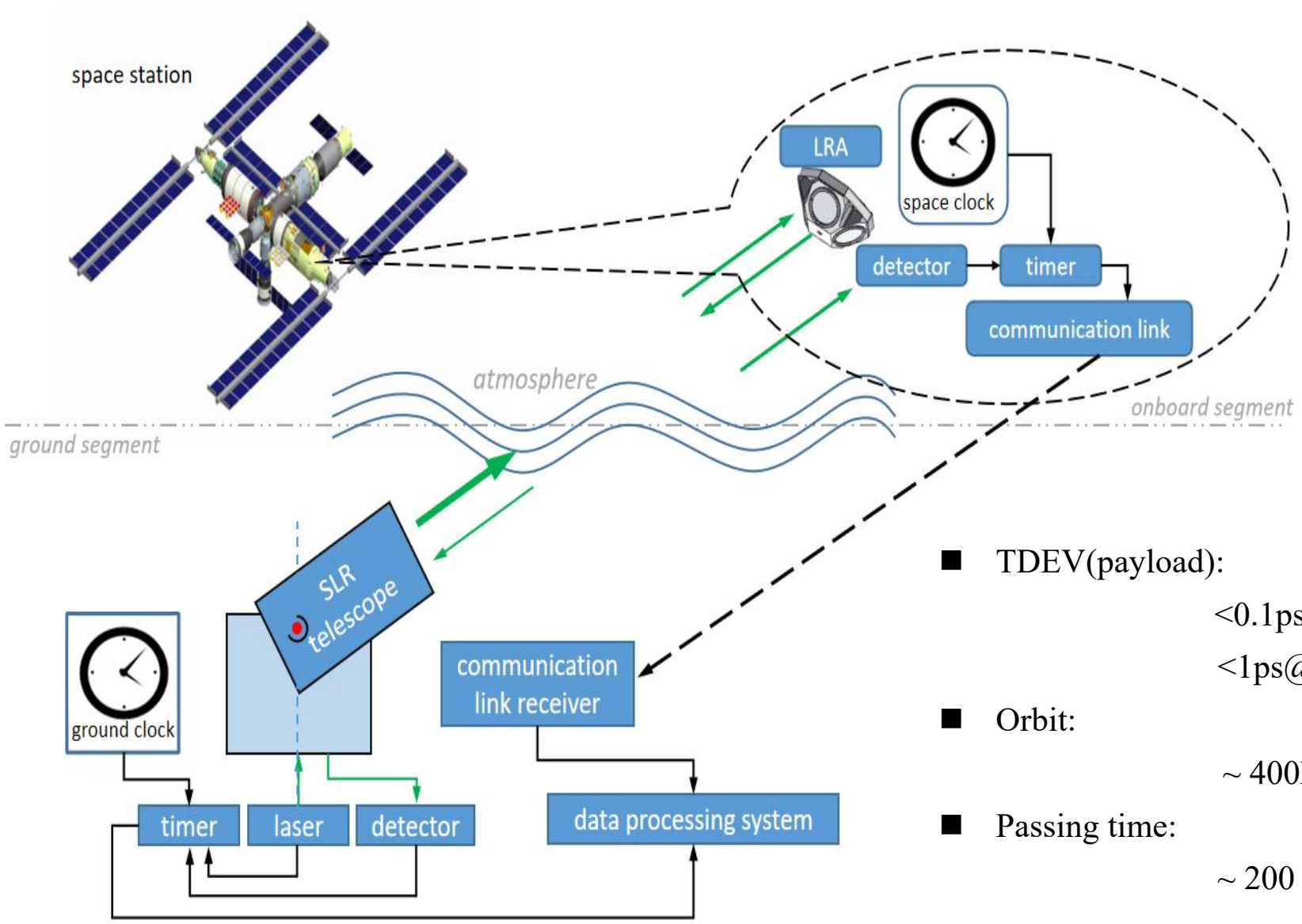

HPTFS

- Inside cabin equipments
  - Hydrogen atomic clock
  - Cooled atom microwave clock
  - Sr optical clock
  - . . .
- Outside cabin equipments
  - **Laser link payload**
  - Microwave link payload



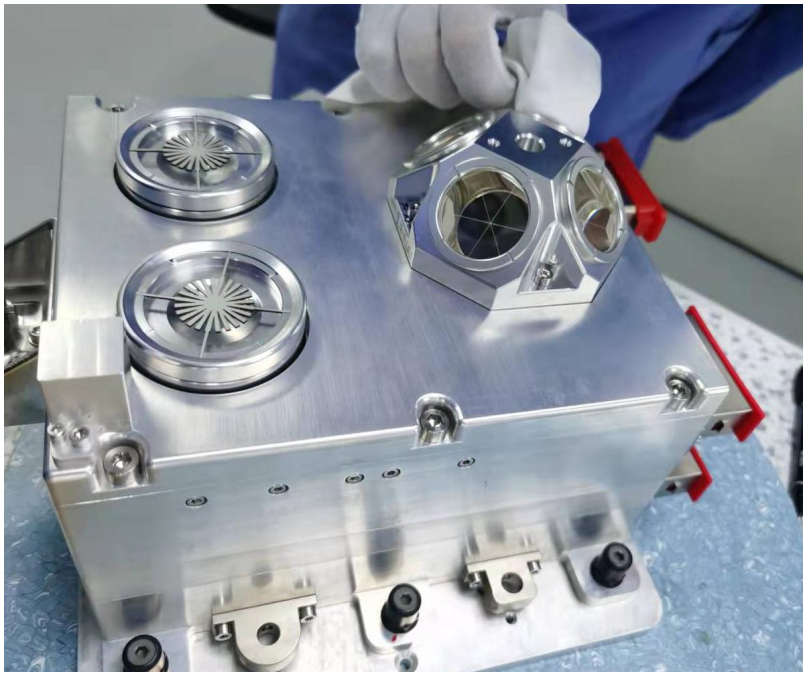


Description



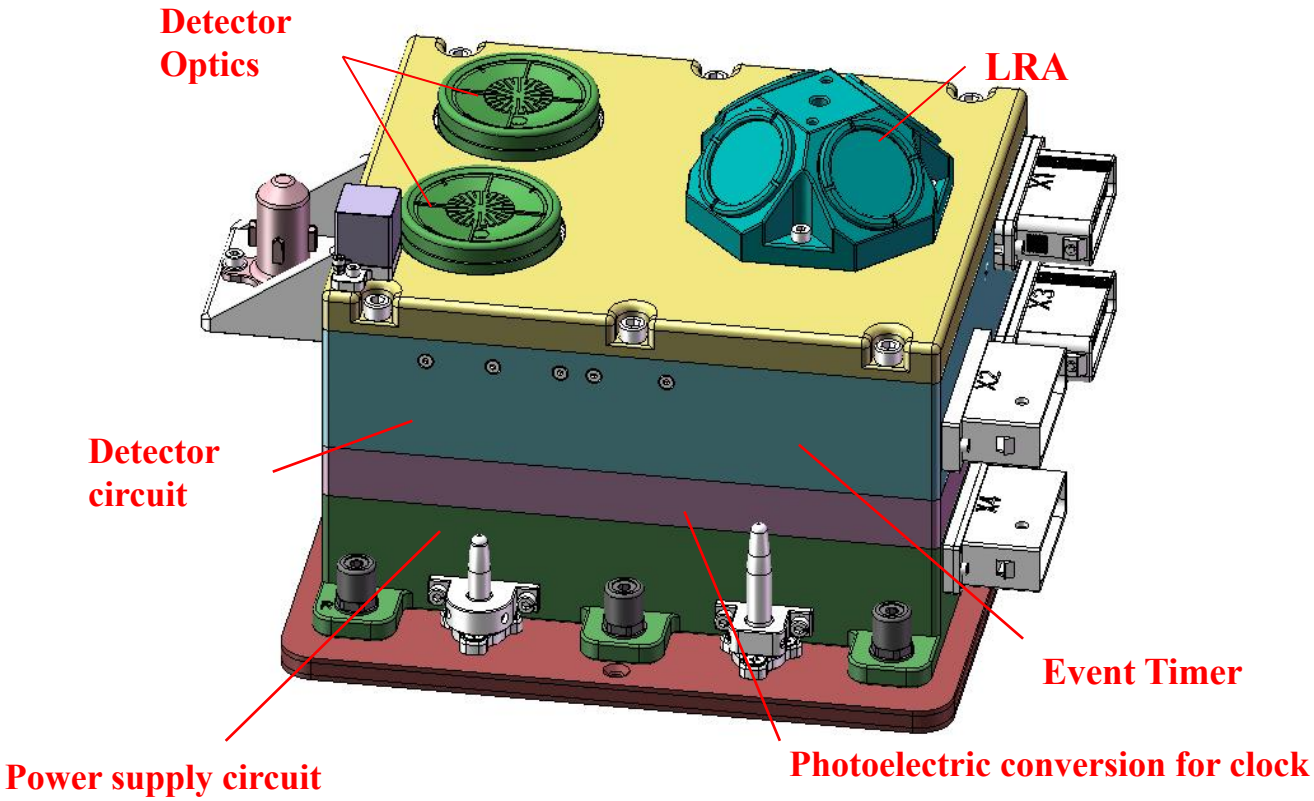
- TDEV(payload):
  <0.1ps@300s
  <1ps@1day
- Orbit:
  ~ 400km
- Passing time:
  ~ 200 sec

Payload



- Wavelength: 532nm
- Repetition rate: 1kHz, 2kHz, 10kHz
- Parameters
  - FOV : ~120°（14~60° incidence)
  - Detector precision: ~25ps
  - Timer precision: ~8ps
  - Clock reference: 200MHz (optical comb)
  - Gate mode :synchronized with 1pps from GNSS
  - LRA with 4 CCRs (CA~33mm)

Payload

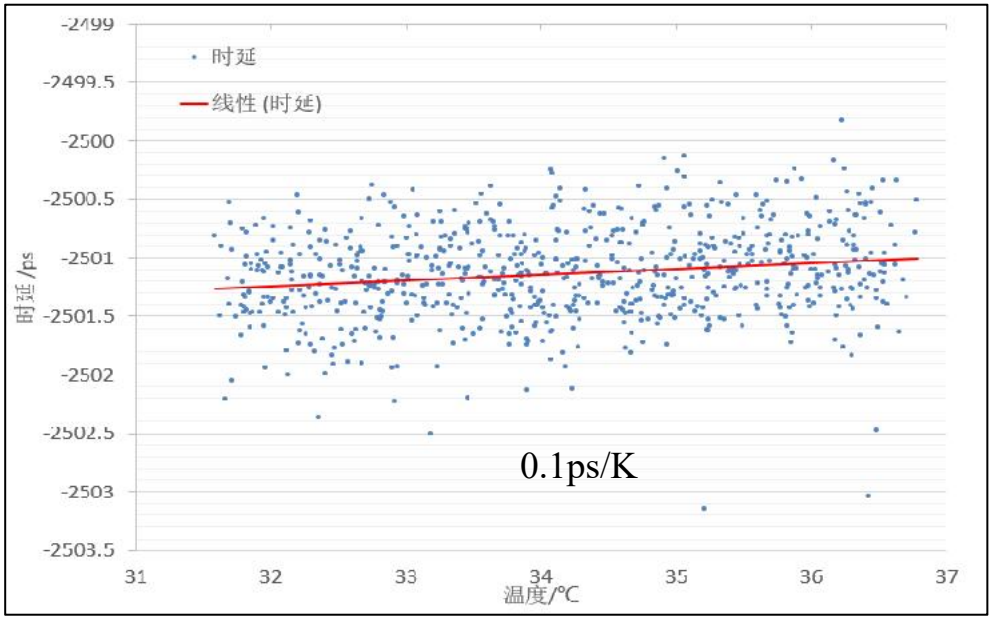


- Weight: ~ 6 kg ;
- Power consumption： ~ 24 W；
- Hydrocooling

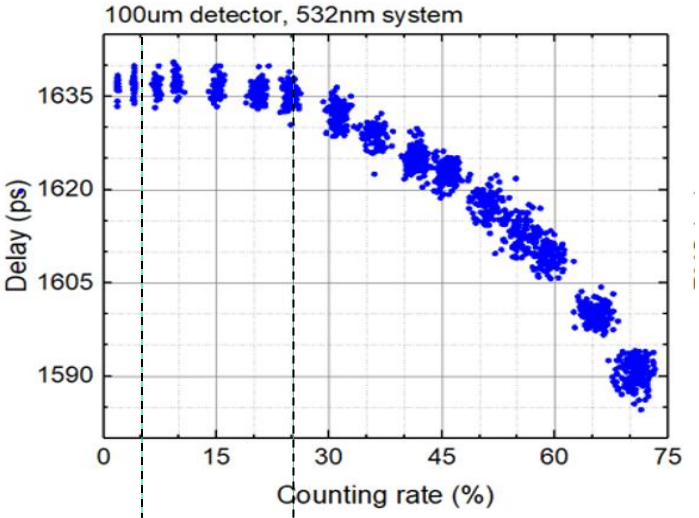
Payload

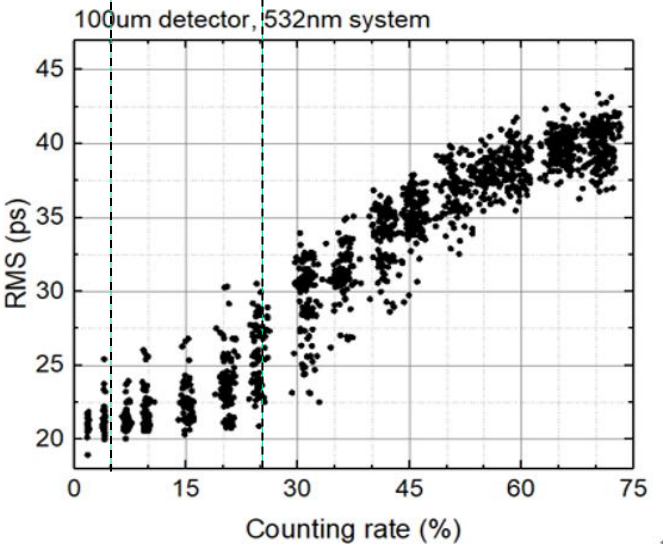
Detector

- K14 SPAD (CTU): 100μm
- Precision : ~ 25ps
- Best operating rate: 5~20%

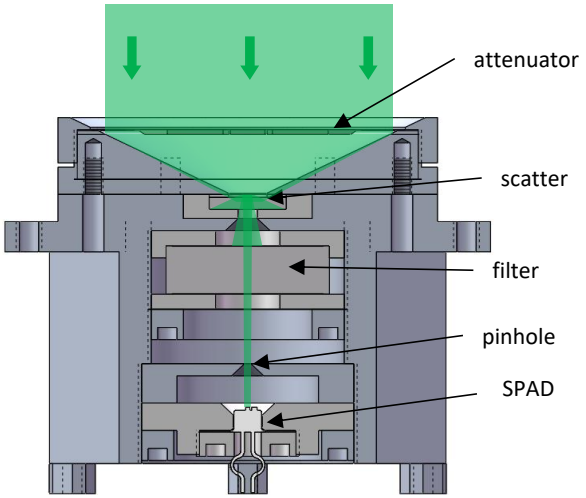


Temperature drift rate



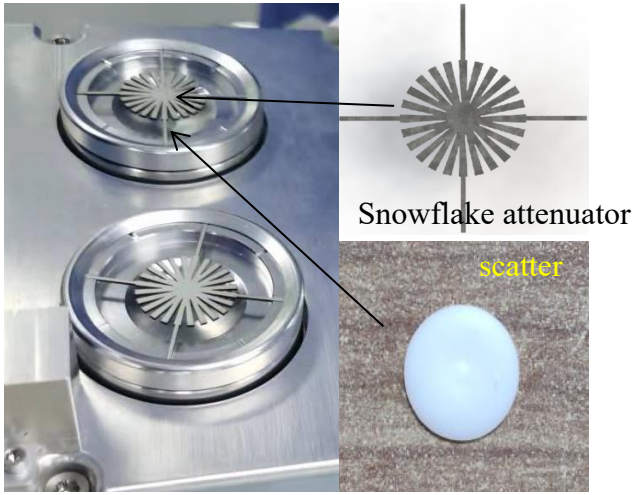


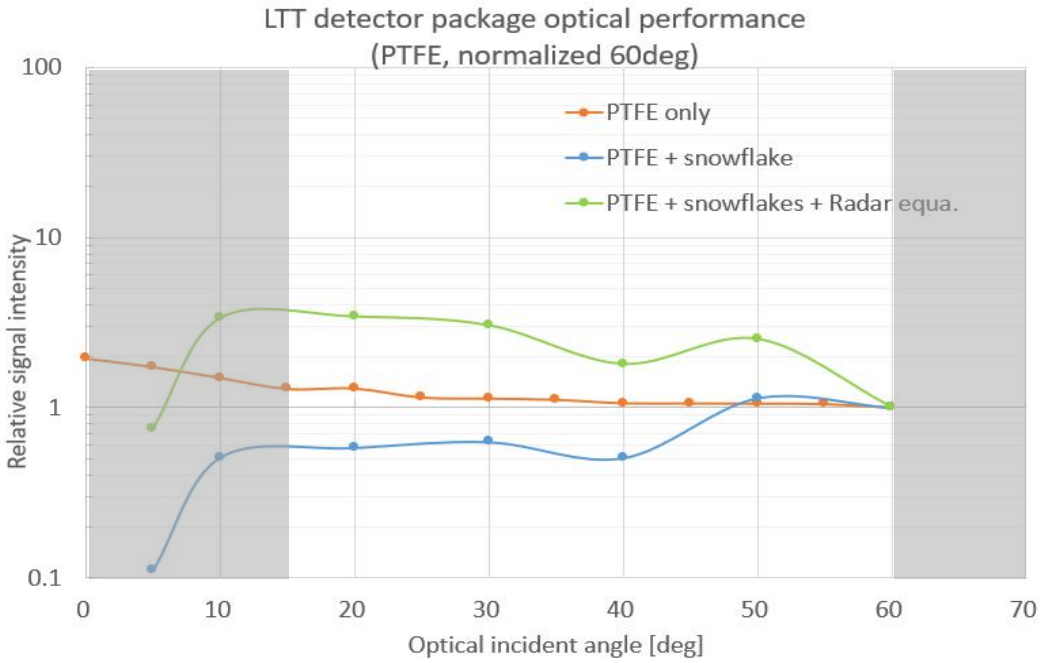
Payload



- Optics partly borrows from ELT
- Polytetrafluorethylene (PTFE) scatter
- Narrow bandpass filter: 4nm FWHM
- Pinholes
- Snowflake attenuator + scatter

  → relative change of photons 25%

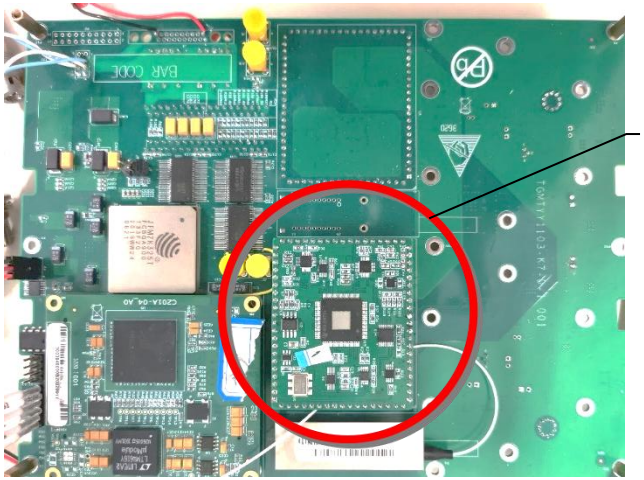


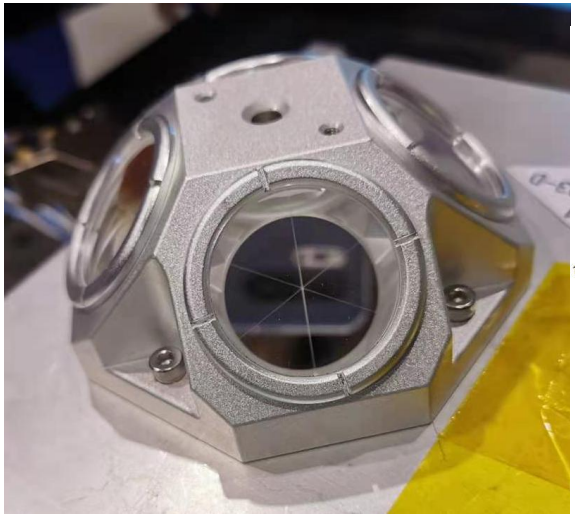


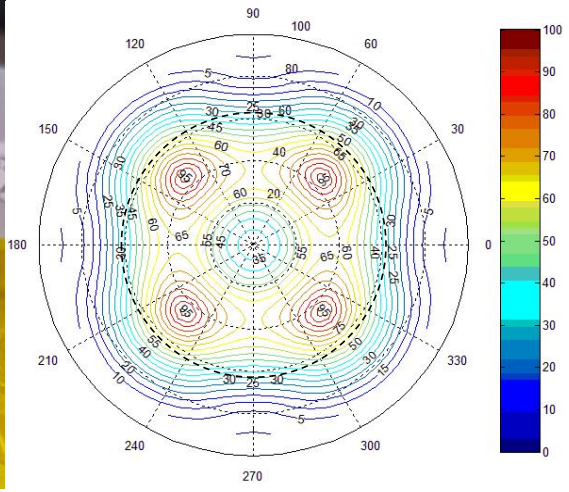
Payload

Event timer： FPGA + TDC (THS 788)

- Precision ： ～8ps
- Repetition rate： up to 20kHz
- 2 channel delay compensation
- Time stability (TDEV) : < 40fs@300s, 100fs@1day



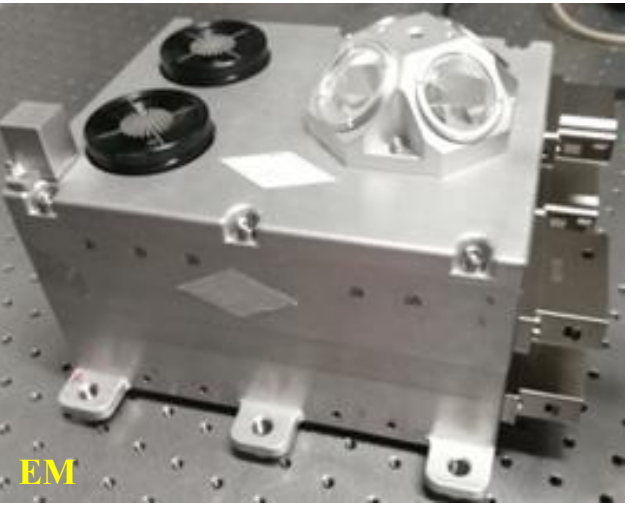


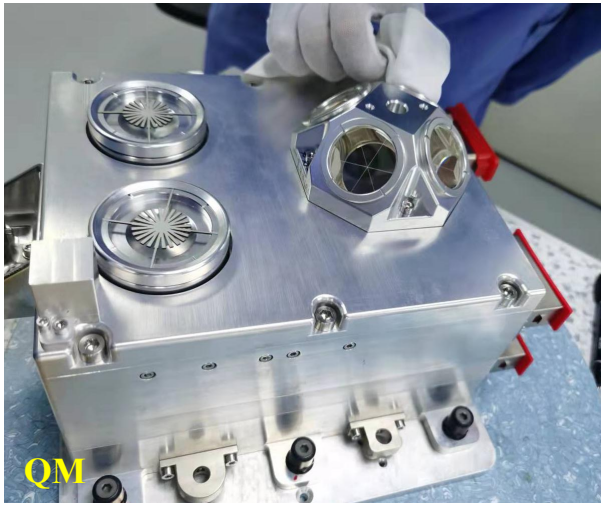


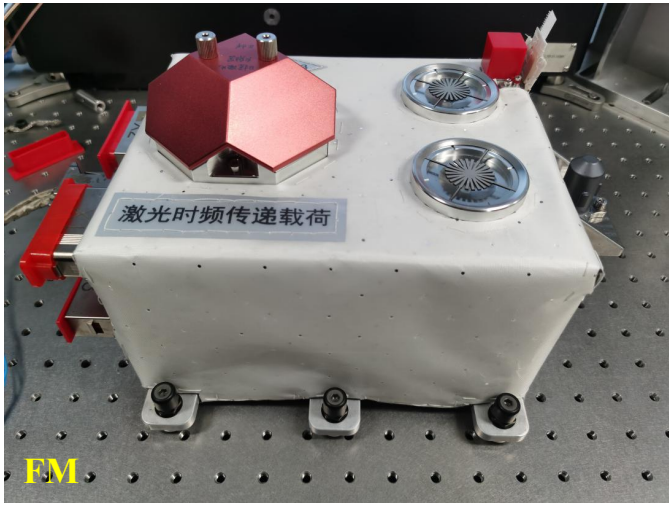
The laser retro-reflector array：

- Pyramid-shaped
- Size: 92×92×45mm
- Weight: 320g
- Active reflecting area ＞30% of maximum within 120°

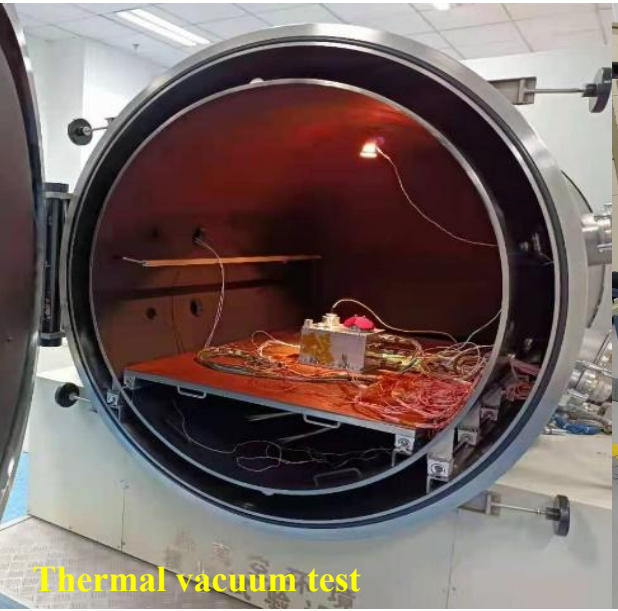
Payload


EM

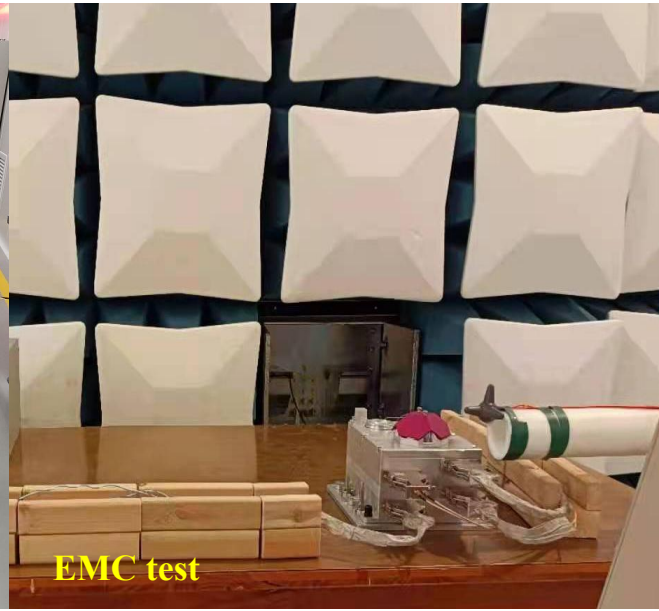

QM



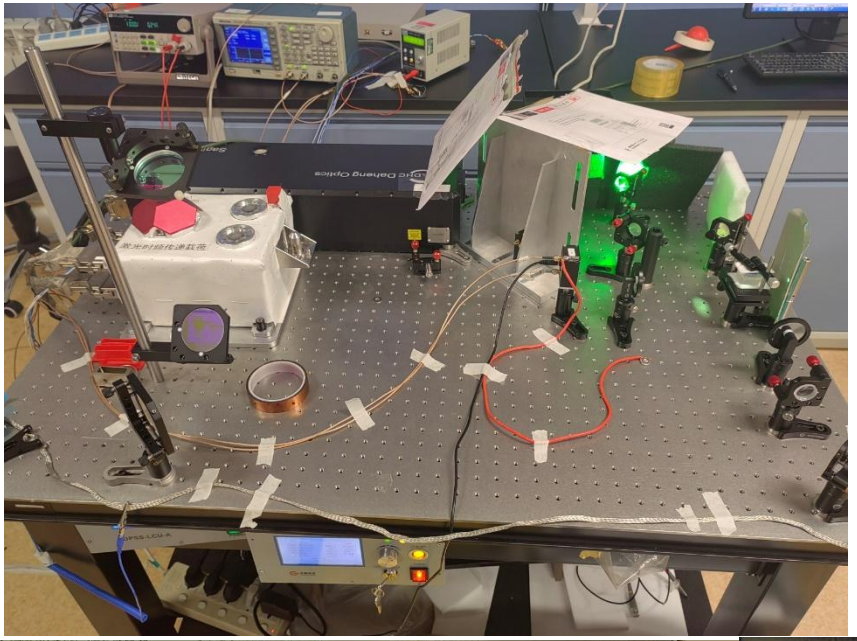
FM

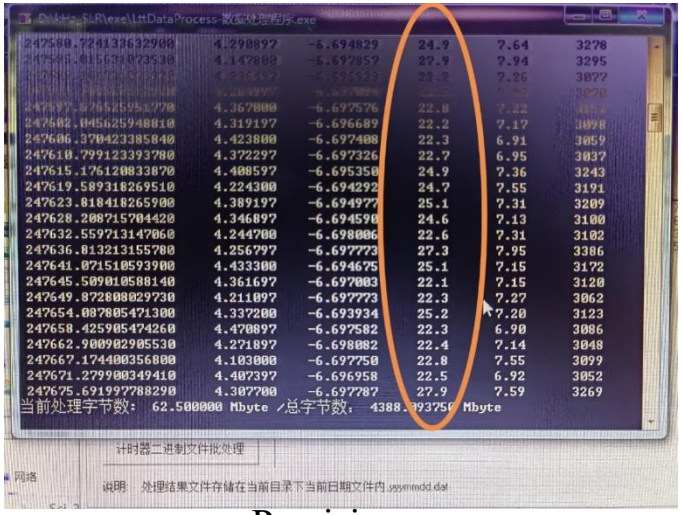

Thermal vacuum test


Mechanical test

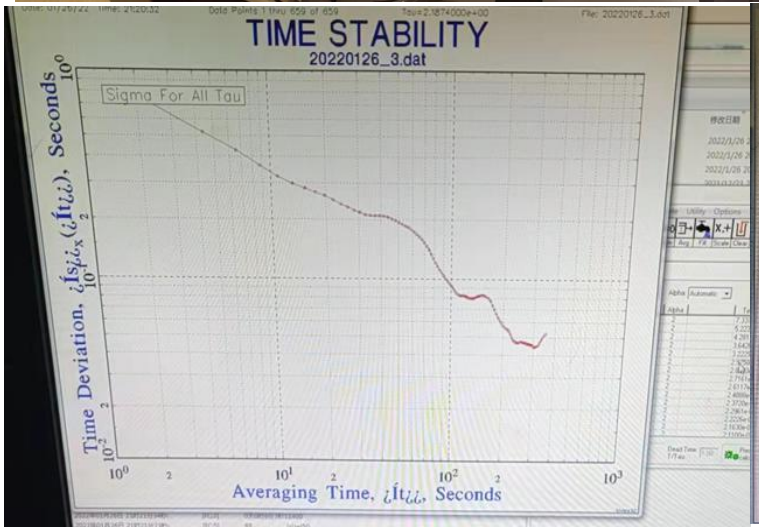

EMC test

Payload

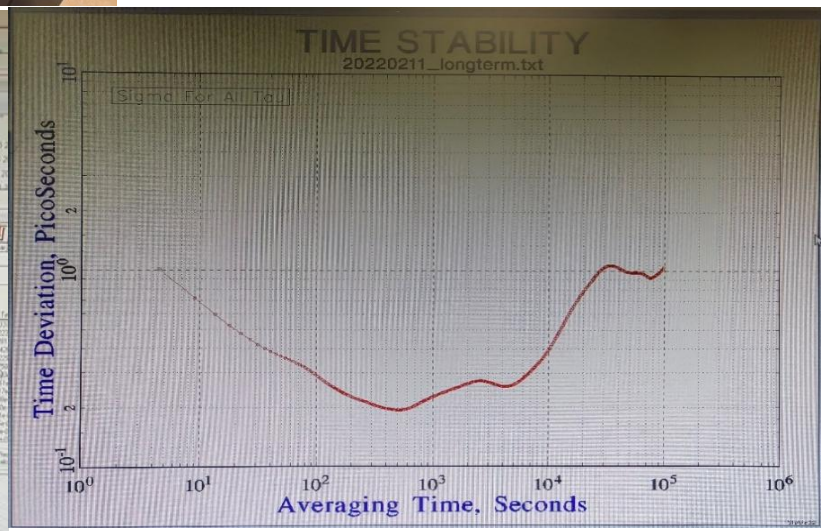




Precision

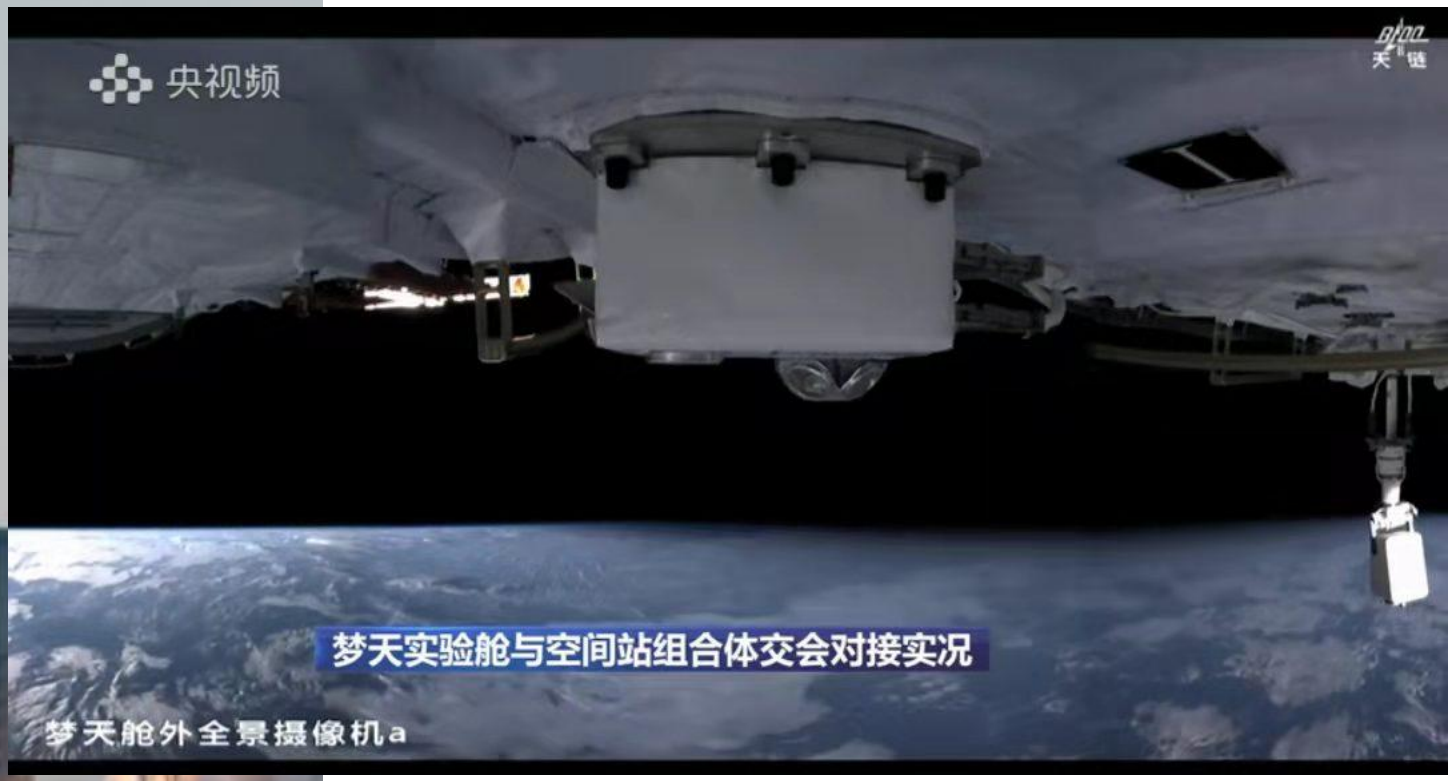


Short term stability

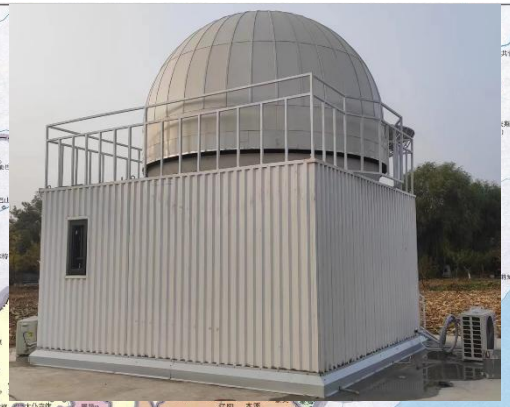


Long term stability

Payload



Ground station



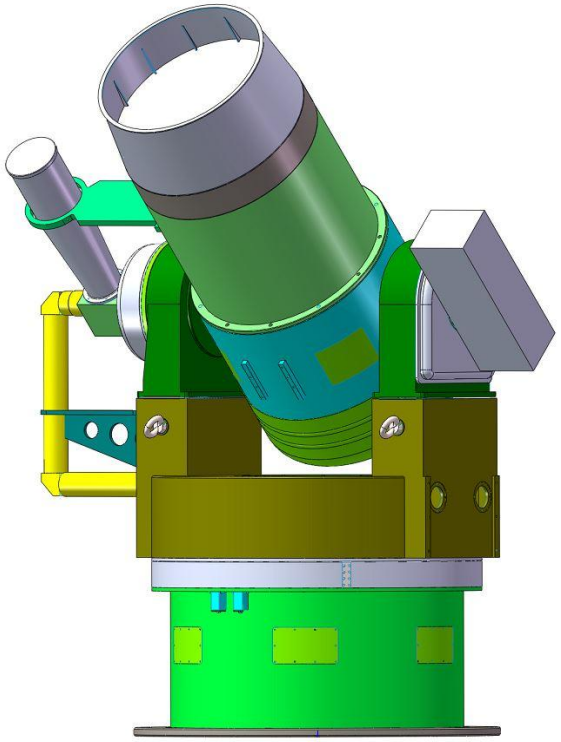
Beijing

Xi'an

Ground station

Two new ground stations for laser time transfer are under construction in Xi'an and Beijing.

- Receive aperture 40cm
- Transmit aperture 10cm
- Laser 532nm / 30ps / 0.4mJ
- Transmit divergence < 10″
- Laser transmitting time precision: <10ns
- Clock reference source 200MHz from fibers that connect clocks between stations
- Return rate control
  - Laser transmitting energy adjustable
  - Receiving energy adjustable
- Temperature control for detector
- Calibration target attached on telescope



Conclusion

- Laser Time Transfer payload on China Space Station has been developed and launched. After months of preparation on orbit, there will be oppotunities to carry out experiment.
- The payload has been measured at Lab:
  - Precision : 22-27ps (including laser and other test instruments)
  - Time stability: 0.09ps@ 300s, ~0.8ps@1day
- More stations and ideas are welcome to do experiment with LTT on CSS.

More information about China Space Station on website (http://cmse.gov.cn)


Thank you !