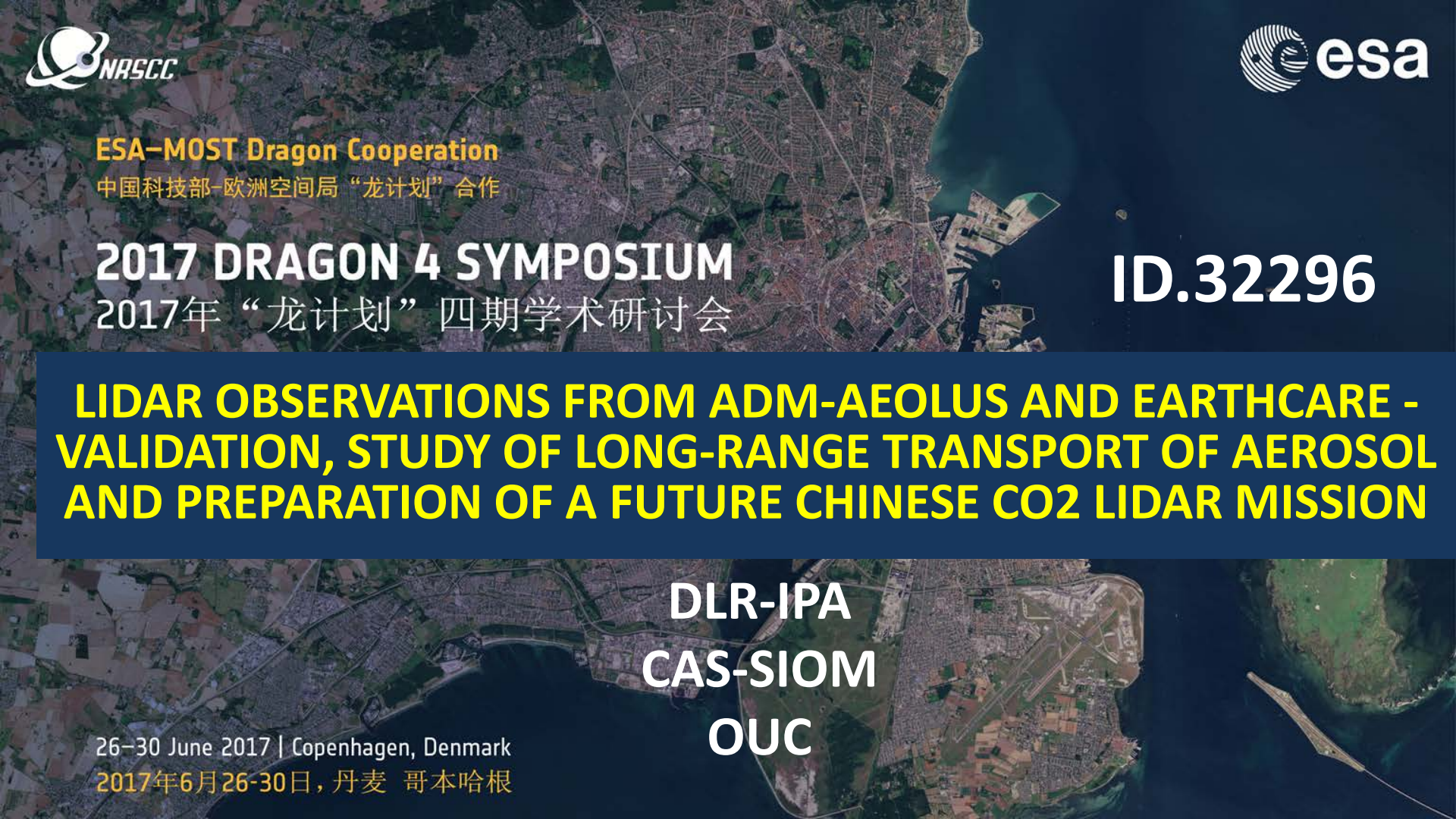
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中国科技部-欧洲空间局“龙计划”合作
2017 DRAGON 4 SYMPOSIUM
2017年“龙计划”四期学术研讨会
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LIDAR OBSERVATIONS FROM ADM-AEOLUS AND EARTHCARE - VALIDATION, STUDY OF LONG-RANGE TRANSPORT OF AEROSOL AND PREPARATION OF A FUTURE CHINESE CO2 LIDAR MISSION
DLR-IPA
CAS-SIOM
OUC
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Lidar Observations from ADM-Aeolus and EarthCARE-Validation, Study of Long-range Transport of Aerosol and Preparation of a Future Chinese CO_2 Lidar Mission

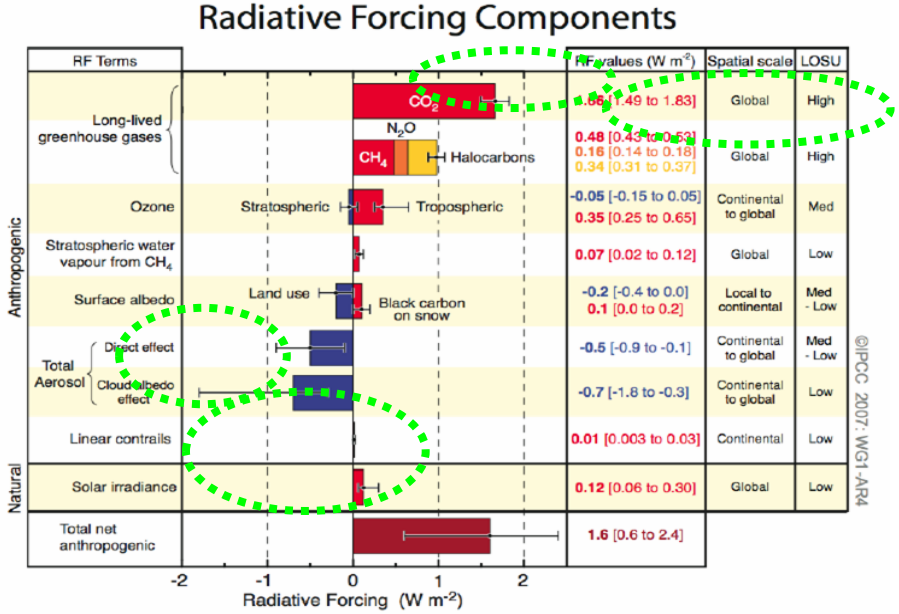
Topic Nr.	PIs	Title
32296_1	O. Reitebuch, DLR W. Chen, CAS-SIOM	Preparation of Cal/Val of spaceborne **Aerosol** and **Carbon dioxide Detection Lidar (ACDL)** by ground-based and airborne sounding instruments observations

CAS-SIOM: *W. Chen, J. Liu;*
CAS-AIOFM: *D. Liu;*
OUC-ORSI: *S. WU,*
DLR-IPA: *O. Reitebuch, G. Ehret, A. Fix,*

Outline

- Background
- Spaceborne Aerosol and CO_2 Detection Lidar (ACDL) development
- Ground-based lidar experiment
- Summary

1.Background



Climate change important components and requirments：

①Greenhouse gas CO_2\CH_4

②Aerosols

③Cloud

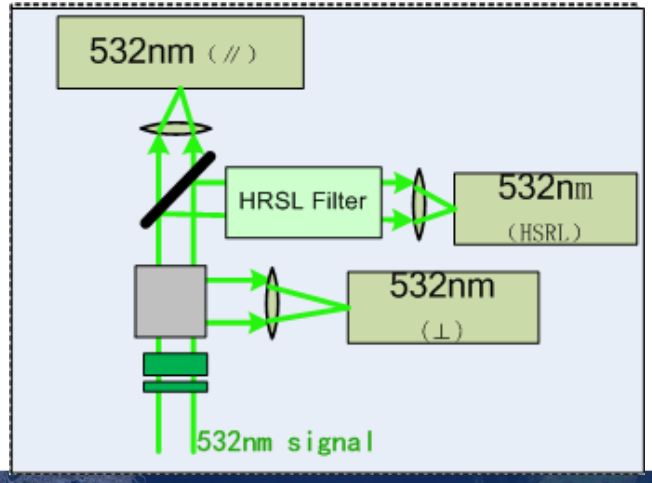
2. Spaceborne Aerosol and CO_2 Detection Lidar (ACDL) development

- **principle methods**
  - High spectrum resolution lidar(HSRL) to measure aerosol profiles, improve air quality monitoring and forecast
  - Integrated path differential absorption(IPDA) Lidar to measure CO2 column concentrations
  - Two lidar techniques combined with same laser source and telescope

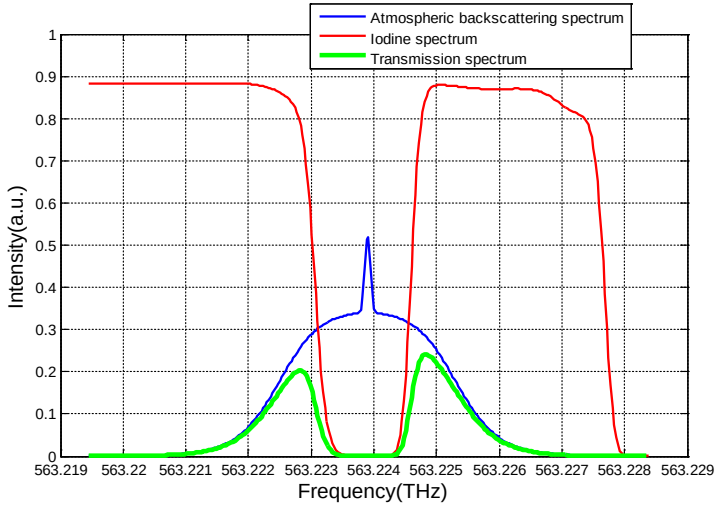
HSRL in ACDL

Aerosol measurements:

- 532nm HSRL channel(‖)
- 532nm polarization channel(⊥)
- 1064nm channel

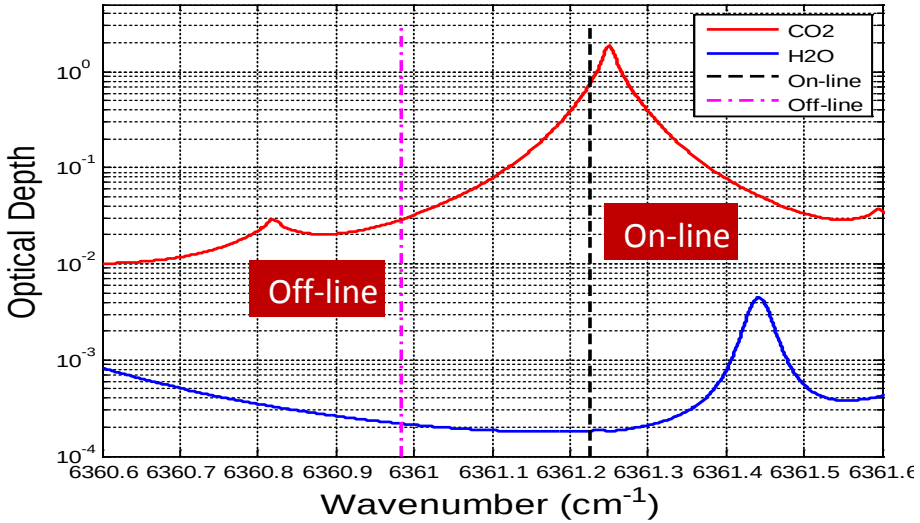


Iodine HSRL



Iodine cell is acted as the HSRL filter

- 1572 nm Wavelength selected: On/Off separated by 200 μs;
- Optimal On/Off line:
  - On-line: 6361.2250cm^{-1}
  - Off-line: 6360.979cm^{-1}

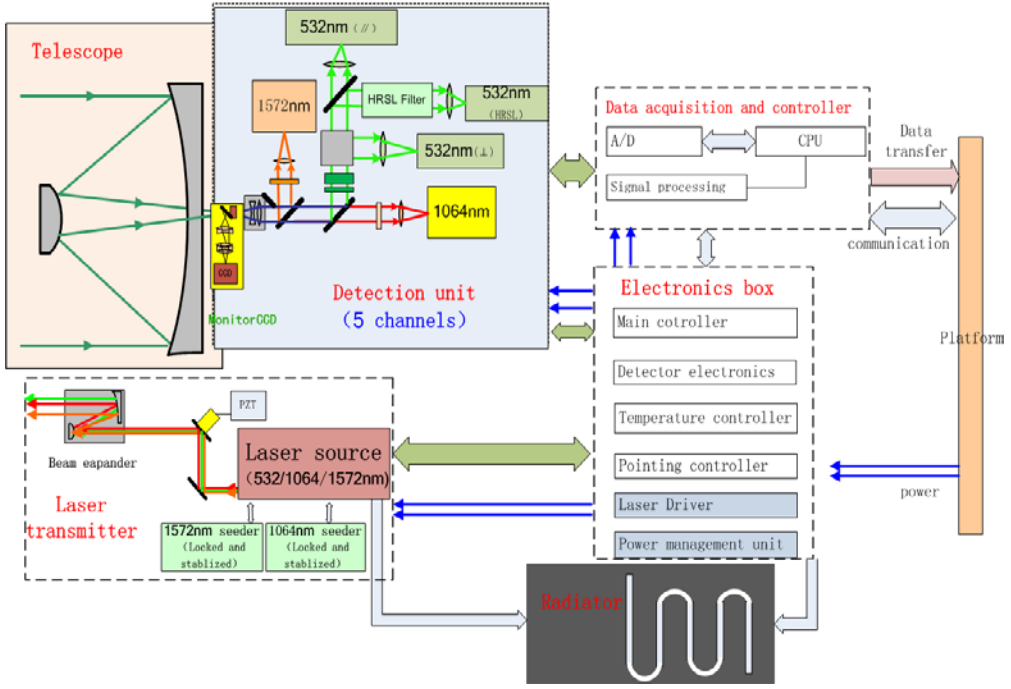


ACDL Measurement capabilities

Parameters	Wavelength	Downlink data（20Hz）	Data products
Aerosol backscattering and extinction profiles	532nm	Horizontal：337.5m Vertical：3m/30m	Accuracy～20% Vertical resolution- 60/120m Horizontal resolution-5--20km
Mixing layer height	532nm、1064nm	Horizontal：337.5m Vertical：3m/30m	Vertical resolution -30m Horizontal resolution -5km
Cloud top height	532nm、1064nm	Horizontal：337.5m Vertical：30m	Vertical resolution -30m Horizontal resolution -5km
CO_2 column concentrations	1572nm	Horizontal：337.5m	1ppm（50km@land） 1ppm（100km@ocean）

✓Strong Requirements: ACDL lidar validation & Science data retrieval

ACDL lidar schematic diagram



Main six parts:

- Laser transmitter: three wavelength
- Telescope: 1m
- Detection unit: 5 channels
- Data acquisition and controller
- Electronics Box
- Thermal management unit

ACDL lidar system parameters

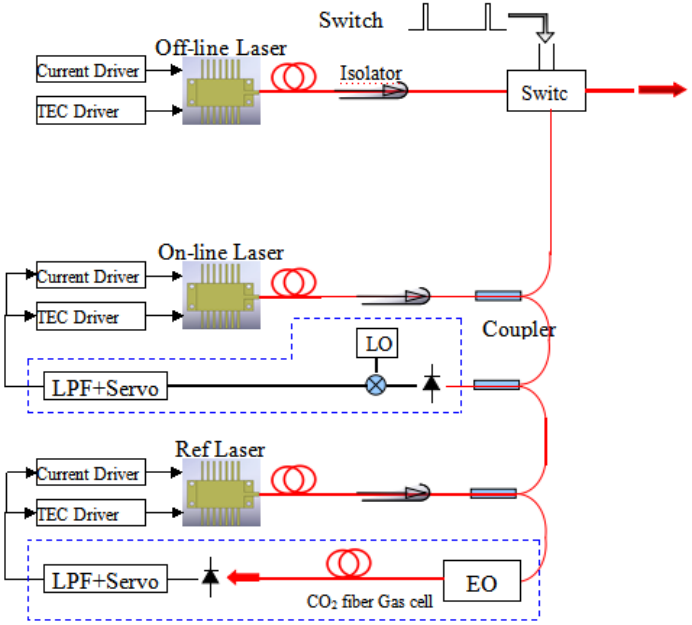
Orbit	**Sun synchronous orbit, 705km**
Transmitter	**Energy: 150mJ @ 532nm， 150mJ@1064nm , 75 mJ @ 1572 nm**
	PRF: 20Hz (double pulses)
	Pulse width: 10~50 ns
	Linewidth: <60 MHz @ 1572 nm **Frequency: 0.3MHz@1572nm/10MHz@532nm**
	Divergence :≤0.1mrad
Optical receiver	**Diameter:Φ1000 mm** **FOV: 0.2 mrad**
Detection unit	**Detector: 532nm/1064nm/1572 nm (5 Channels)** **Digitizer: 14 bit, 50M/s**
Design life:	≥5 years
Power	**< 1300 W**
Mass	**<780kg**

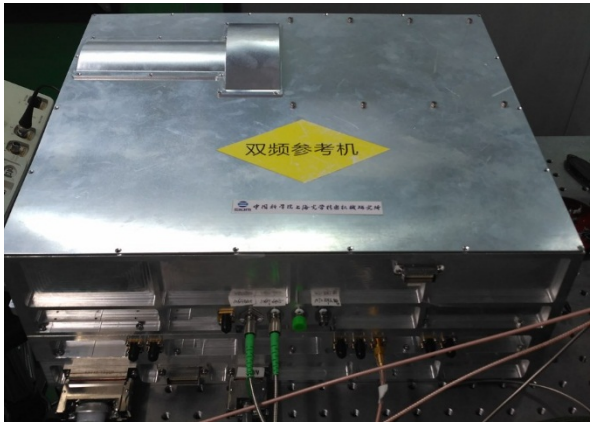
High pulse energy and three wavelength laser with long-term low frequency jitter and long lifetime is challenging!

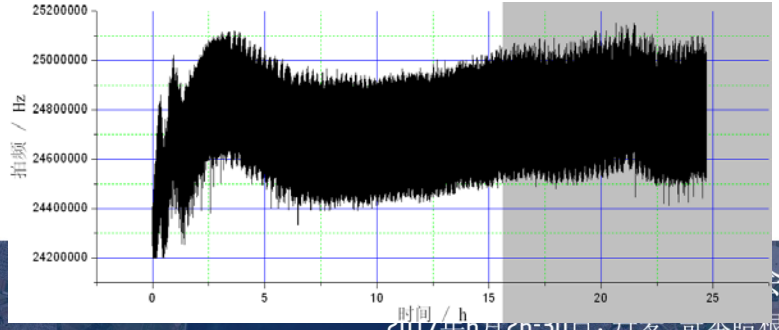
Key technologies progress

- **Φ1000 mm telescope based SiC mirror is developed**
- **Frequency stabilized 1572 nm laser prototype is developed with on-line and off-line wavelength output**
- **High power 532nm/1064nm/1572nm pulsed single frequency laser engineering prototype is developed**

Frequency stabilized 1572 nm laser prototype







Free Space CO2 cell with 10m path is developed

➢**Frequency jitter RMS error of 0.14MHz @24h**

High power pulsed single frequency laser engineering prototype

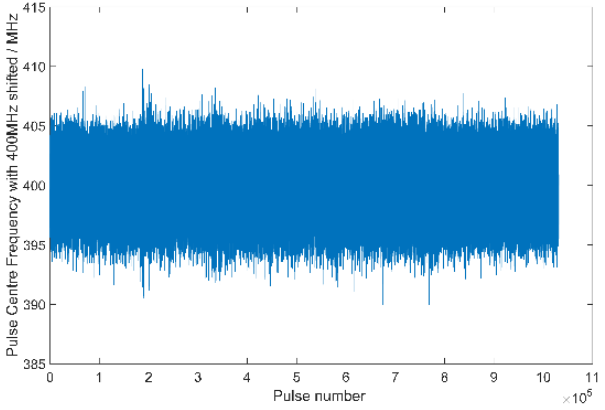
- **532nm/1064nm/1572nm laser**

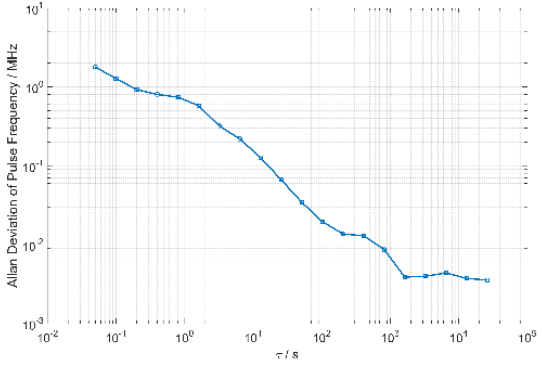
Energy measurement:

- **156mJ @532nm**
- **140.0mJ @1064nm**
- **79mJ @1572nm。**

1572nm pulsed laser
Frequency stability measurement

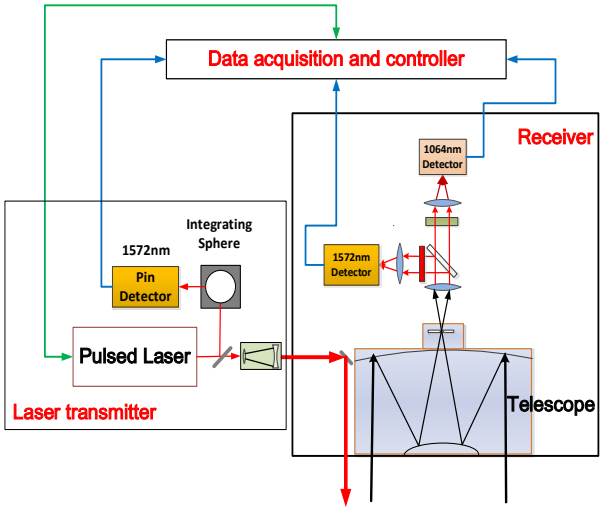
Allan deviation <100kHz(>14s)



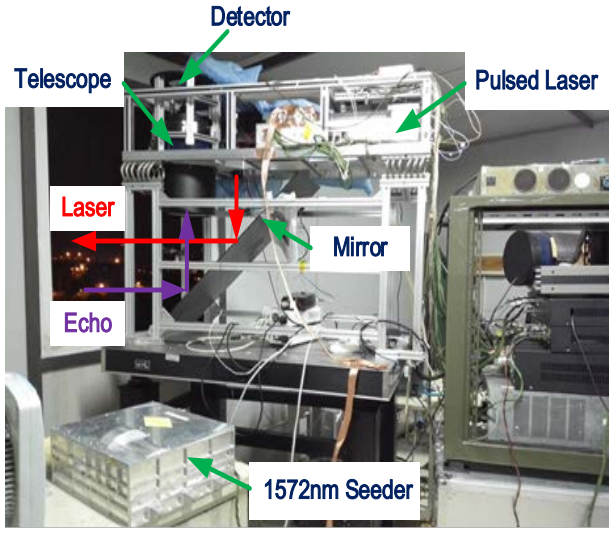


3. Ground-based lidar experiment

IPDA lidar diagram



IPDA lidar prototype

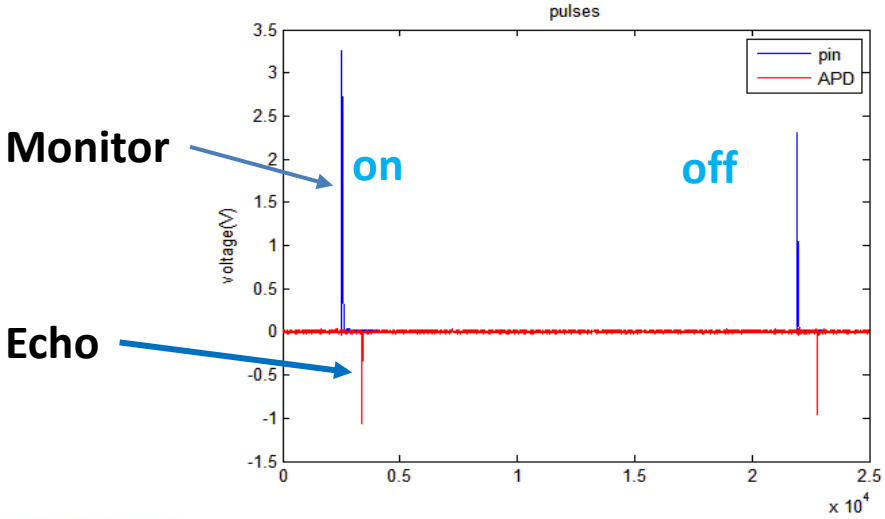


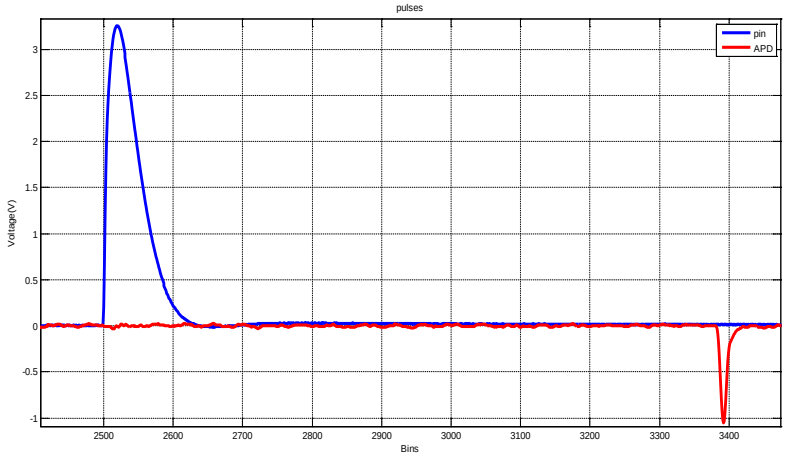
- **1572nm laser :1mJ**
- **Telescope: 200mm aperture**

- **The lidar transmit 1572 nm and 1064 nm double-pulse laser simultaneously with 200 μs separation.**
- **The 1064nm laser is used to measure range to hard target.**
- **The 1572nm laser is used to measure CO_2 concentrations**

3. Ground-based lidar experiment

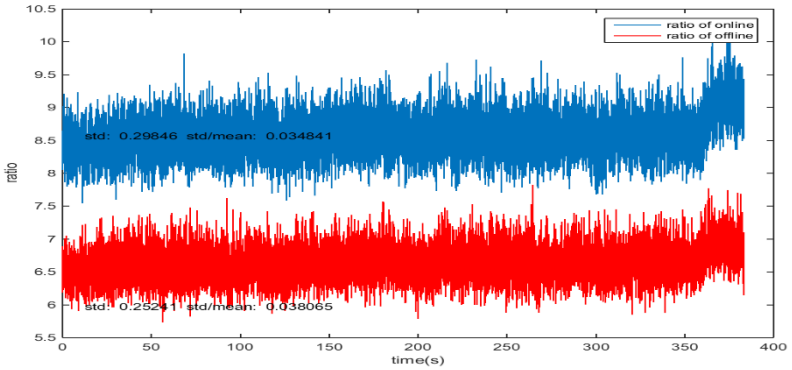
- **On-line and off-line monitor and echo signals**
- **About 1300m path integrated CO2 is measured**





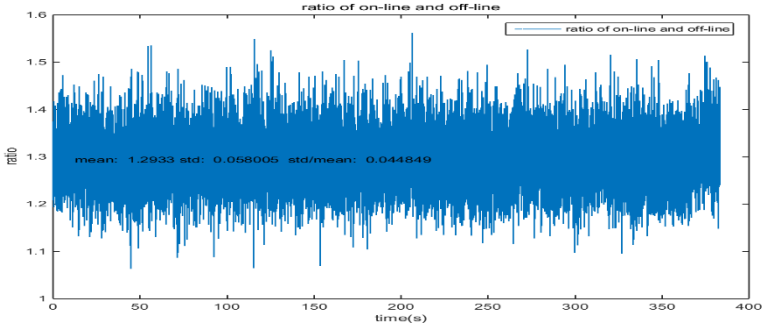
3. Ground-based lidar experiment

- **Off-line normalized signal**



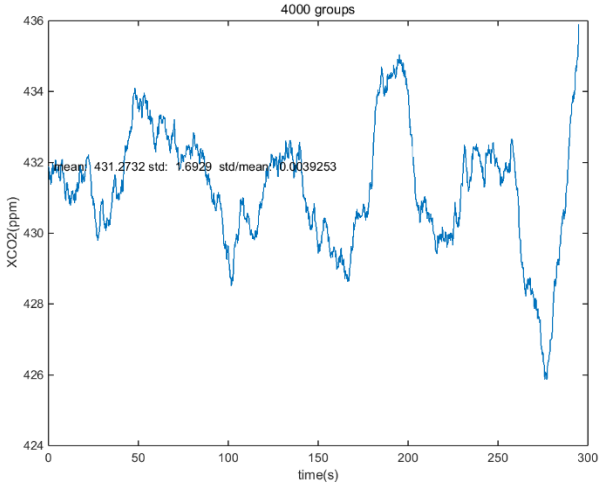
- **On-line normalized signal**

- **Ratio of Off-line to On-line signal**



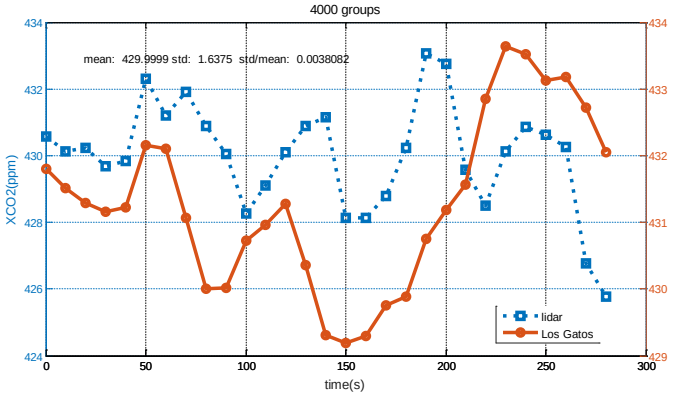
3. Ground-based lidar experiment

- **The mean XCO2 from lidar is about 430 ppm with 1.64 ppm standard error.**

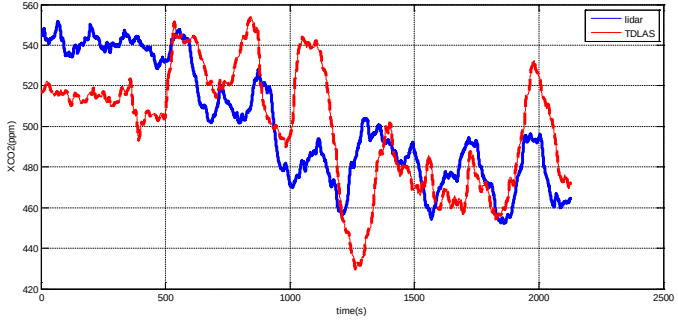


3. Ground-based lidar experiment

➢Compared with Los Gatos in-situ analyzer



➢Compared with TDLAS analyzer



Summary

- The ACDL lidar is developing and some key techniques and prototypes are developed.
- The mean XCO2 of 1300m path length from ground IPDA lidar is about 430 ppm with 1.64ppm standard error and 4000 pulses averaged.
- Airborne flight is scheduled in next year with longer absorption path.