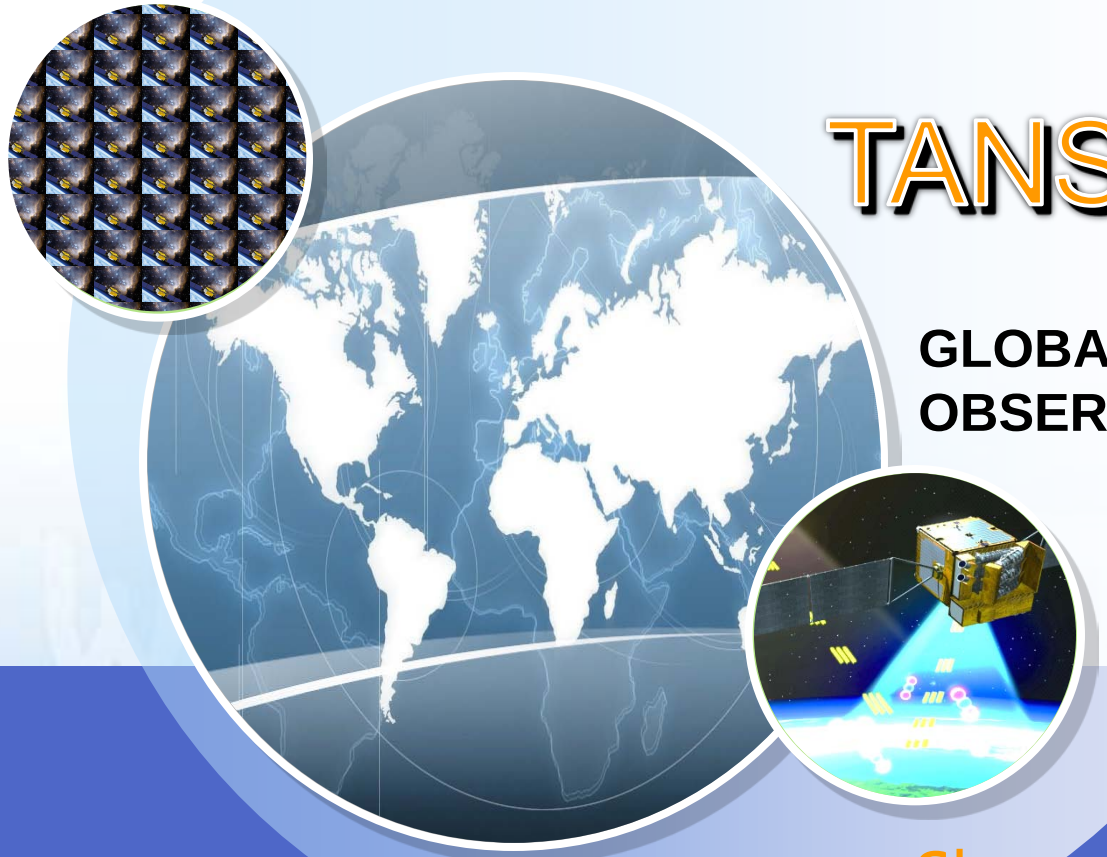
TanSat

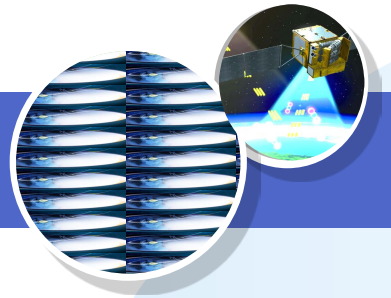


# TANSAT MISSION

## GLOBAL CARBON DIOXIDE OBSERVATION AND MONITORING

Shanghai Engineering Center for microsatellites

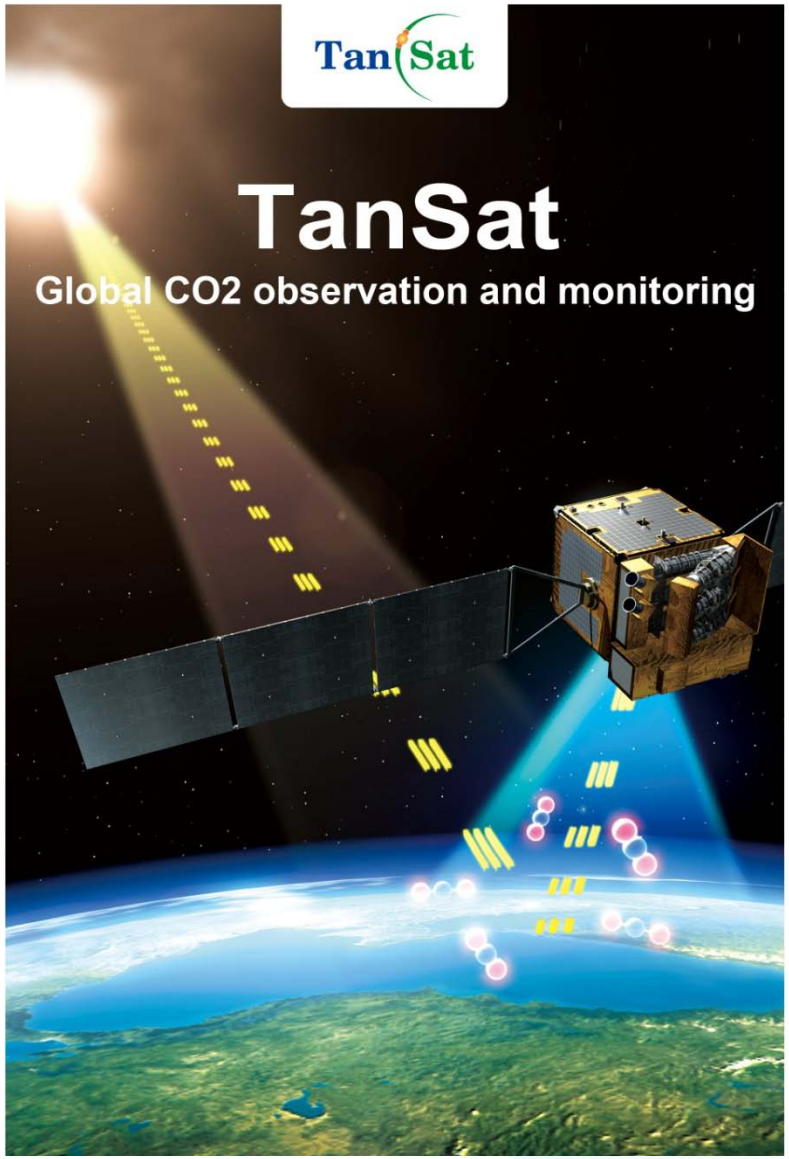
2013.5



# Outline

- Mission Background
- Scientific Instruments
- Observation Modes
- Cal/Val
- Current Status
- Development Schedule

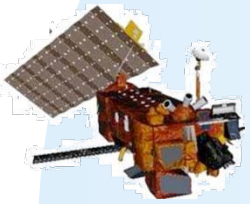
# Mission Objective



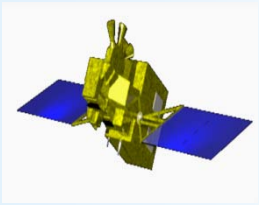

**To retrieve the atmosphere column-averaged CO2 dry air mole fraction (XCO2) with precisions of 1% (4ppm) on national and global scales.**

# Greenhouse Observation Missions

2002 2009 2012 2014 2015

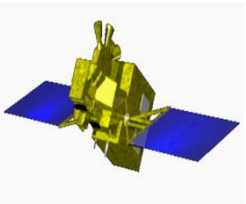


SCIAMACHY on ENVISAT

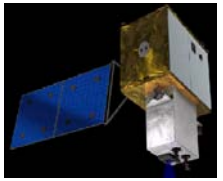


GOSAT

OCO-2(2014.7~2016.6)

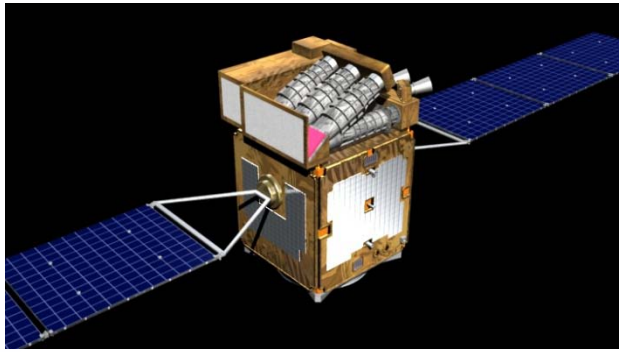


GOSAT2



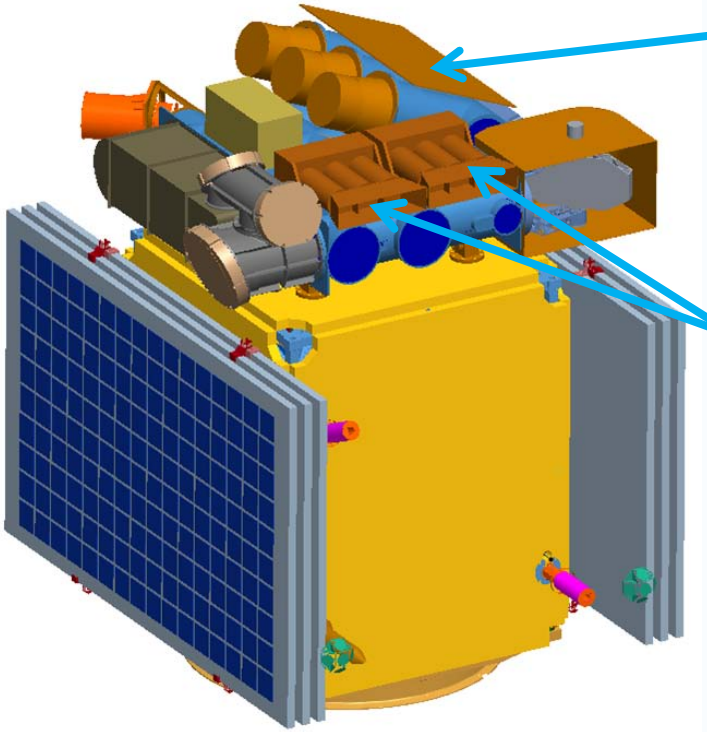
Carbonsat

- **Founded by NRSCC, The project started at the beginning of 2011**
- **Tansat is planed to be launched in 2015**



TanSat(2015.7~2018.6)

# Payload of TanSat

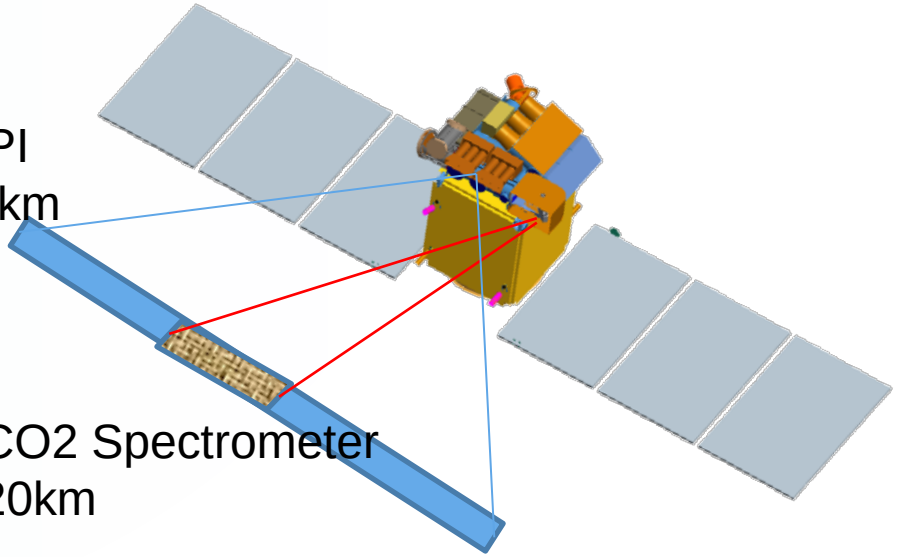


Platform

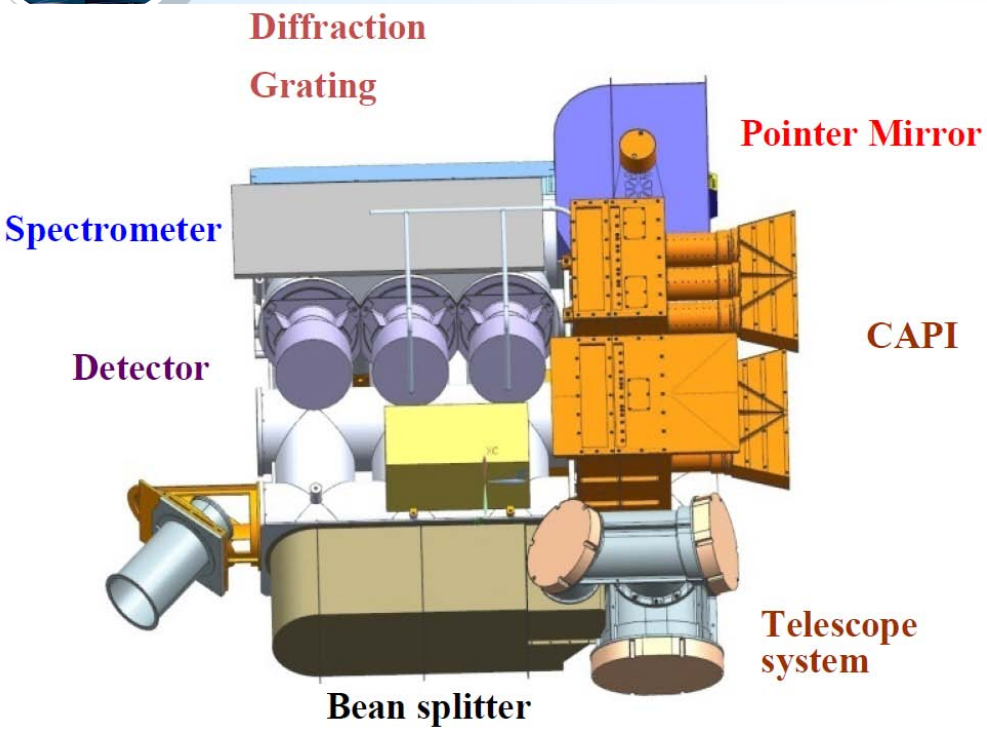
**CO2 Spectrometer**

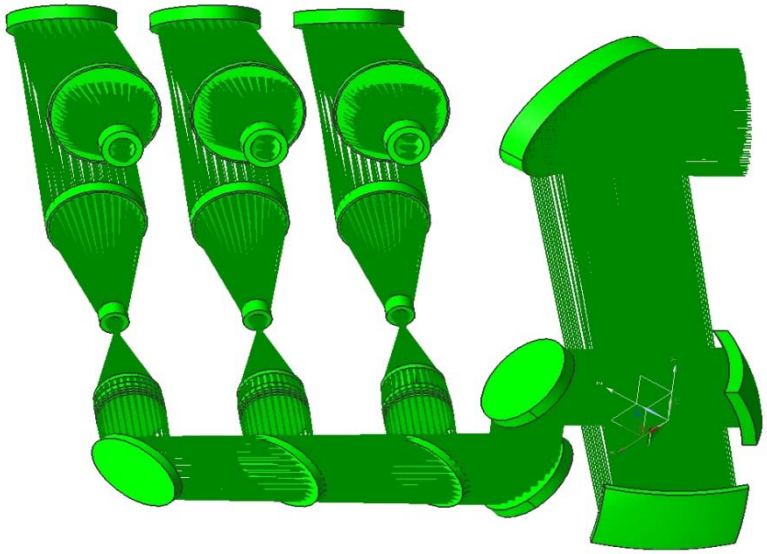
**Cloud and Aerosol Polarimetry Imager (CAPI)**

A wide field of view moderate resolution imaging spectrometer with polarization channel



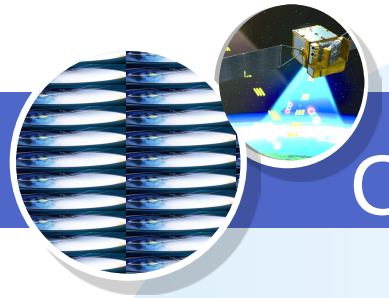
# CO2 Spectrometer



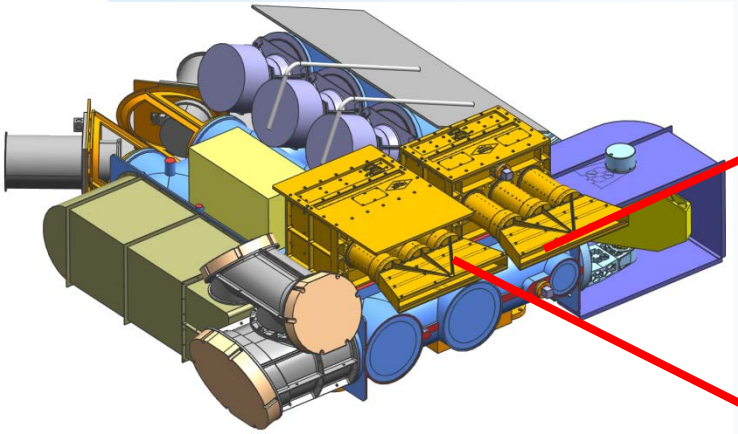



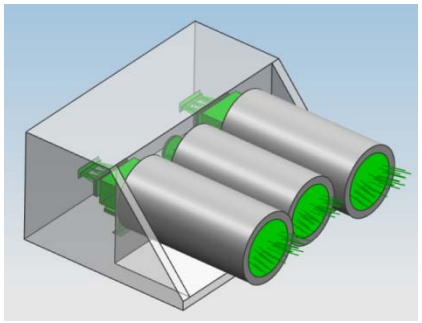
Optical Schematics

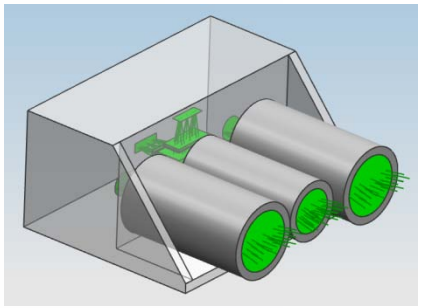
| | O2-A | $CO_2$ weak | $CO_2$ Strong |
|---|---|---|---|
| Spectral Range(nm) | 758-778 | 1594-1624 | 2042-2082 |
| Spectral Resolution | 0.044 | 0.081 | 0.103 |
| SNR | 360 | 250 | 180 |
| Spatial Resolution | 1km×2km, 2km×2km | | |
| Swath | 20km | | |



# Cloud and Aerosol Polarimetry Imager



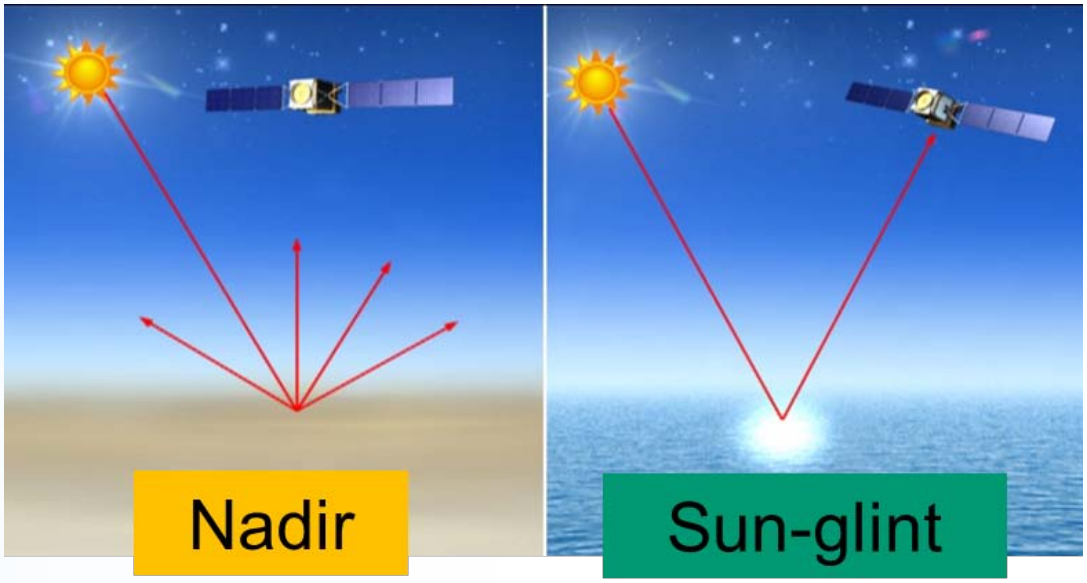


| | |
|---|---|
| 1 | 0.38μm |
| 2 | 0.67μm_0°、0.87μm |
| 3 | 0.67μm_60°、0.67μm_120° |
| 4 | 1.375μm、1.64μm_0° |
| 5 | 1.64μm_60° |
| 6 | 1.64μm_120° |

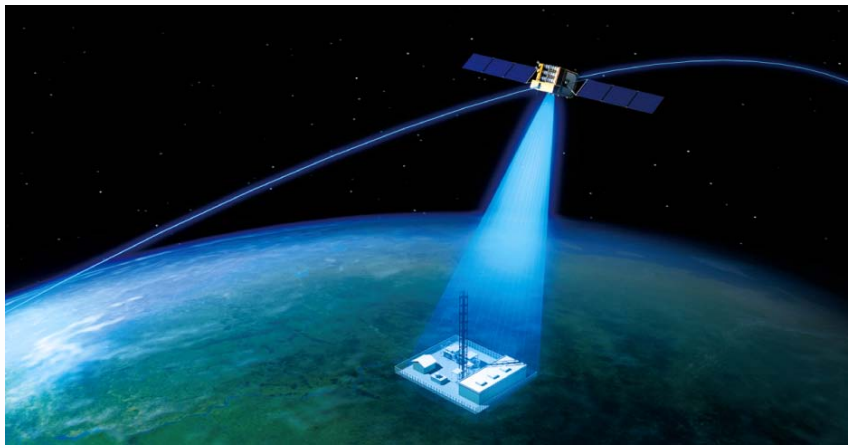
| | Band (nm) | SNR | Polarization (deg) | FOV | Pixel Num. |
|---|---|---|---|---|---|
| 1 | 365-408 | 260 | | 400× 1km² | 1600 |
| 2 | 660-685 | 160 | 0/60/120 | | 1600 |
| 3 | 862-877 | 400 | | | 1600 |
| 4 | 1360-1390 | 180 | | | 800 |
| 5 | 1628-1654 | 110 | 0/60/120 | | 800 |

# Observation Modes

- Nadir mode
  - land observation
  - solar zenith angle<80 deg
  - Principle plane track

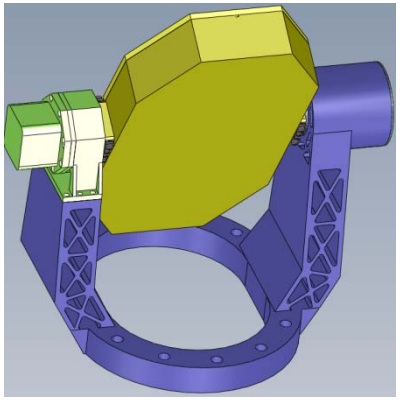


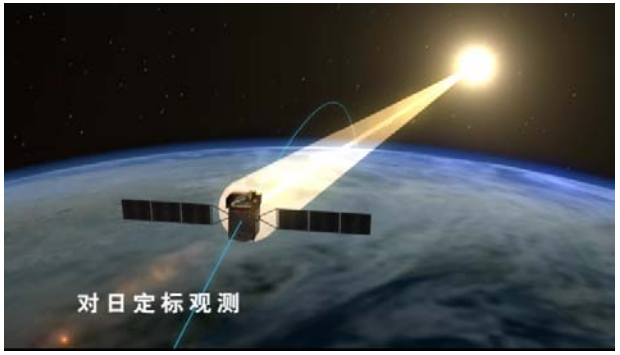

- Sun-glint mode
  - Ocean observation
  - solar zenith angle <70 deg
  - Principle plane track

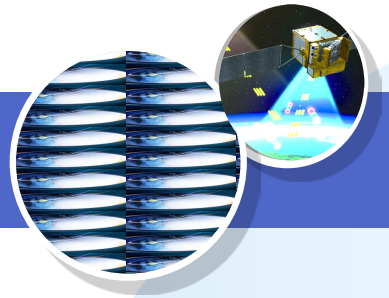


# Cal/Val

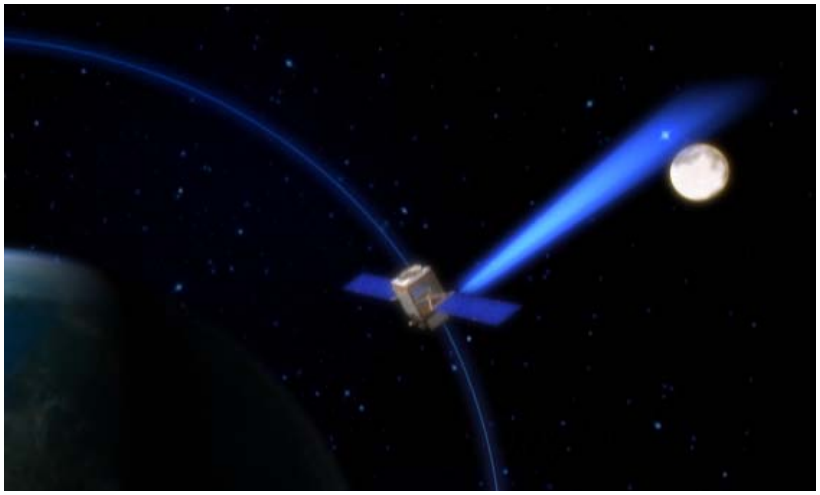
- **Specification**
  - 5%(absolute), 3%(relatively)
- **CO2 Spectrometer(Once a day)**
  - Cal:
    - LED in instrument for spectrometric
    - Sun Calibration (by diffuser)
      - ✓Spectrometric: look through atmosphere(limb)
      - ✓Radiometric: look directly to
  - Val
    - TCCON





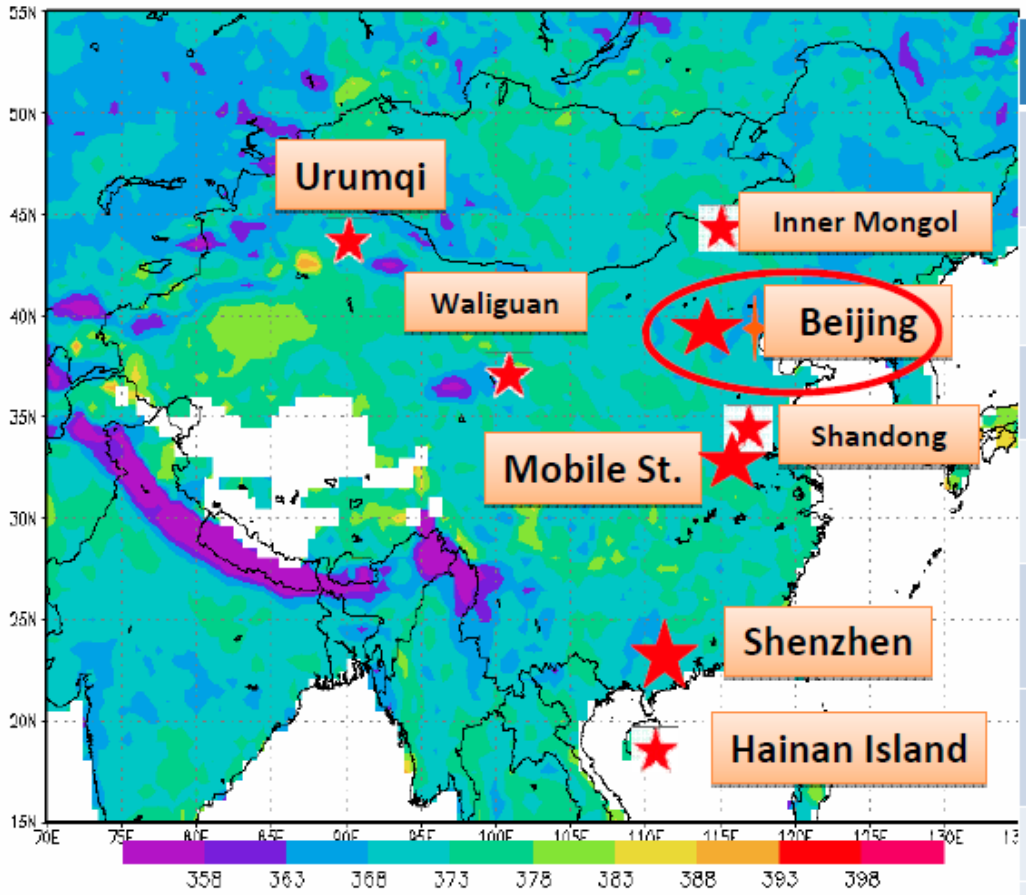


- **CAPI(radiometric, once a month)**
  - **Calibration**
    - **LED in instrument**
    - **Sun: for relative and absolute**
    - **Moon for redundancy of Sun**
  - **TCCON for Validation**



# Ground Validation Stations

## Ground-based Measurement Sites in China




## Ground sites

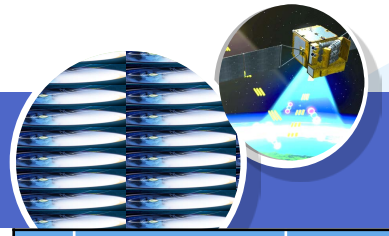
| Site | Instrument |
|---|---|
| Beijing | IFS125/HR +325mTower+7 Licor |
| Shenzhen | IFS125/HR CIMEL+MWR |
| Mobile St. | IFS 125/M |
| Shandong | Optical Spectrum Analyzer(OSA) |
| Inner Mongol | Optical Spectrum Analyzer(OSA) |
| Hainan island | Optical Spectrum Analyzer(OSA) |
| Urumqi | FGGA/LGR |
| Waliguan | FGGA/LGR |

**Calibration, Validation & a priori information**

# Validation Equipments

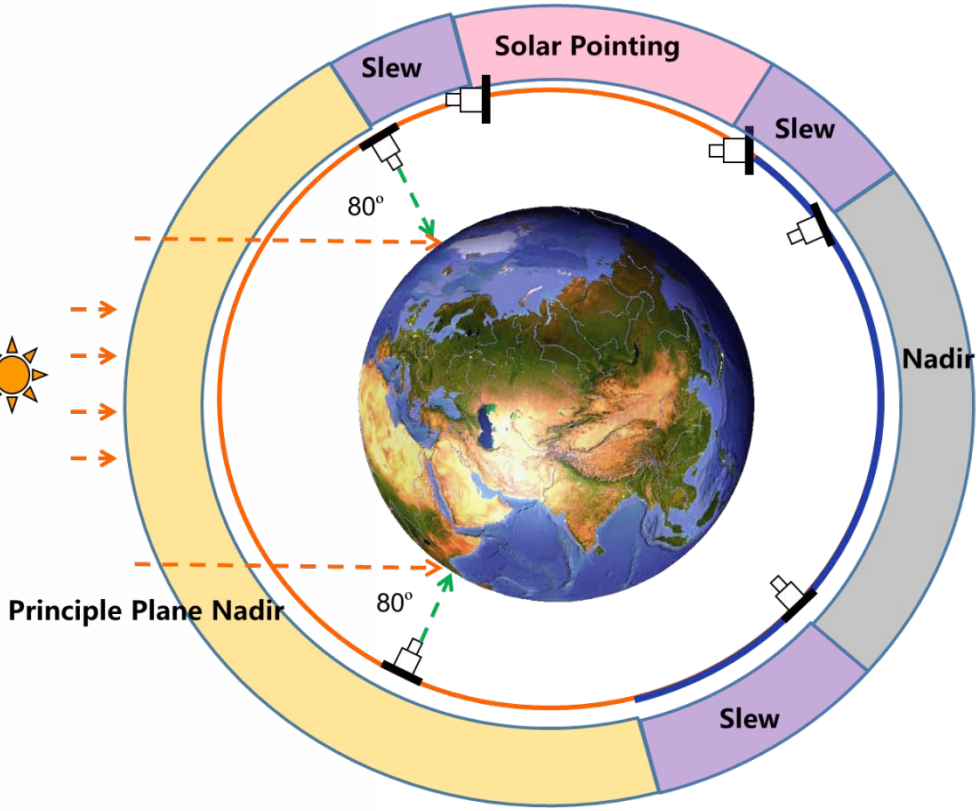






# Pointing Sequence

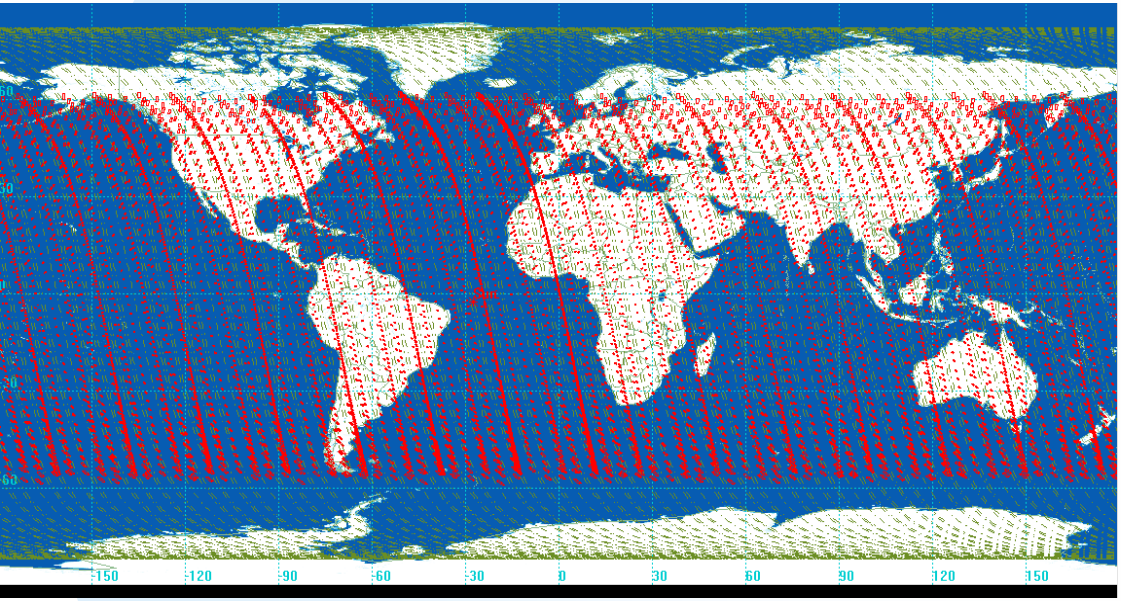
| No. | Pointing Mode | Attitude description |
|---|---|---|
| 1 | Principal Plane Nadir | Zs points along Nadir, under Principal Plane constraints |
| 2 | Sun-glint Pointing | Zs points to Sun-glint location, under Principal Plane constraints |
| 3 | Forward Nadir | +Xs points along velocity, Zs points along Nadir |
| 4 | Backward Nadir | -Xs points along velocity, Zs points along Nadir |
| 5 | Target Pointing | +Zs points to the target, small sinusoidal periodic slew on pitch axis |
| 6 | Area Steering | Fixed roll angle, maneuver on pitch axis, decreasing velocity to earth surface |
| 7 | Direct Solar Pointing | Xs points to the sun, periodic slewing , -90° mirror rotation |
| 8 | Diffusion Solar Pointing | Zs points to the sun with 15° bias on pitch axis, 180° mirror rotation |
| 9 | Moon Pointing | Zs points to the moon, small sinusoidal periodic slew on pitch axis |
| 10 | Solar Panel Pointing | -Xs points to the sun, Ys is parallel to earth equator plane |
| 11 | Attitude Slew | For pointing mode change |




Nadir observation + Sun calibration

# Mission Animation

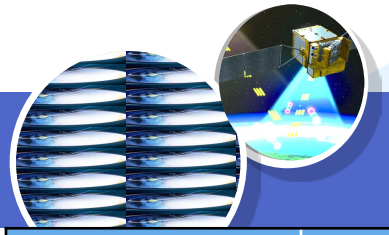
# Soundings & Coverage



Coverage at Naidr/Sunglint mode

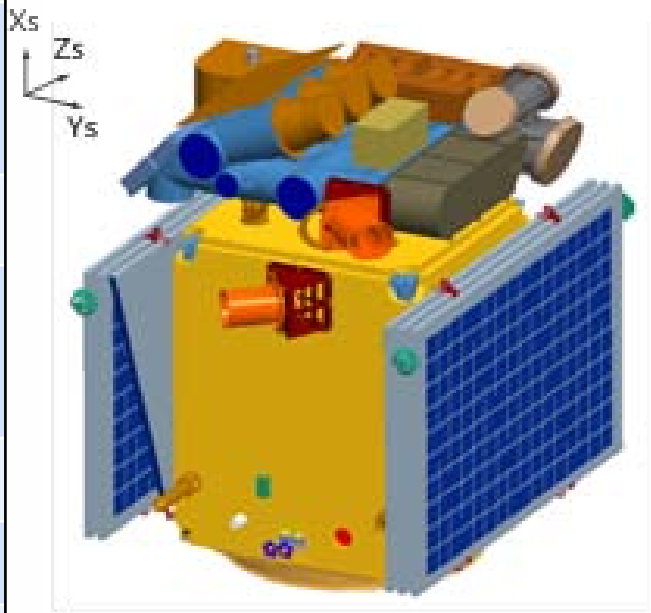
| solar zenith angle | Nadir 80deg | Sunglint 70deg |
|---|---|---|
| vernal equinox | Lat [-73 79] | Lat [-66 70] |
| midsummer | Lat [-51 82] | Lat [**-43** 79] |
| midwinter | Lat [-82 56] | Lat [-86 **46**] |

- CO2 Spectrometer
  - 3.3 Hz sample frequency
  - 20 soundings each exposure time
  - Spatial resolution: 2kmx1km
  - 2 soundings merged to increase SNR
- CAPI
  - 27 Hz sample frequency
  - 800 soundings each sample for VNIR, 500m resolution
  - 400 soundings each sample for SWIR, 1km resolution



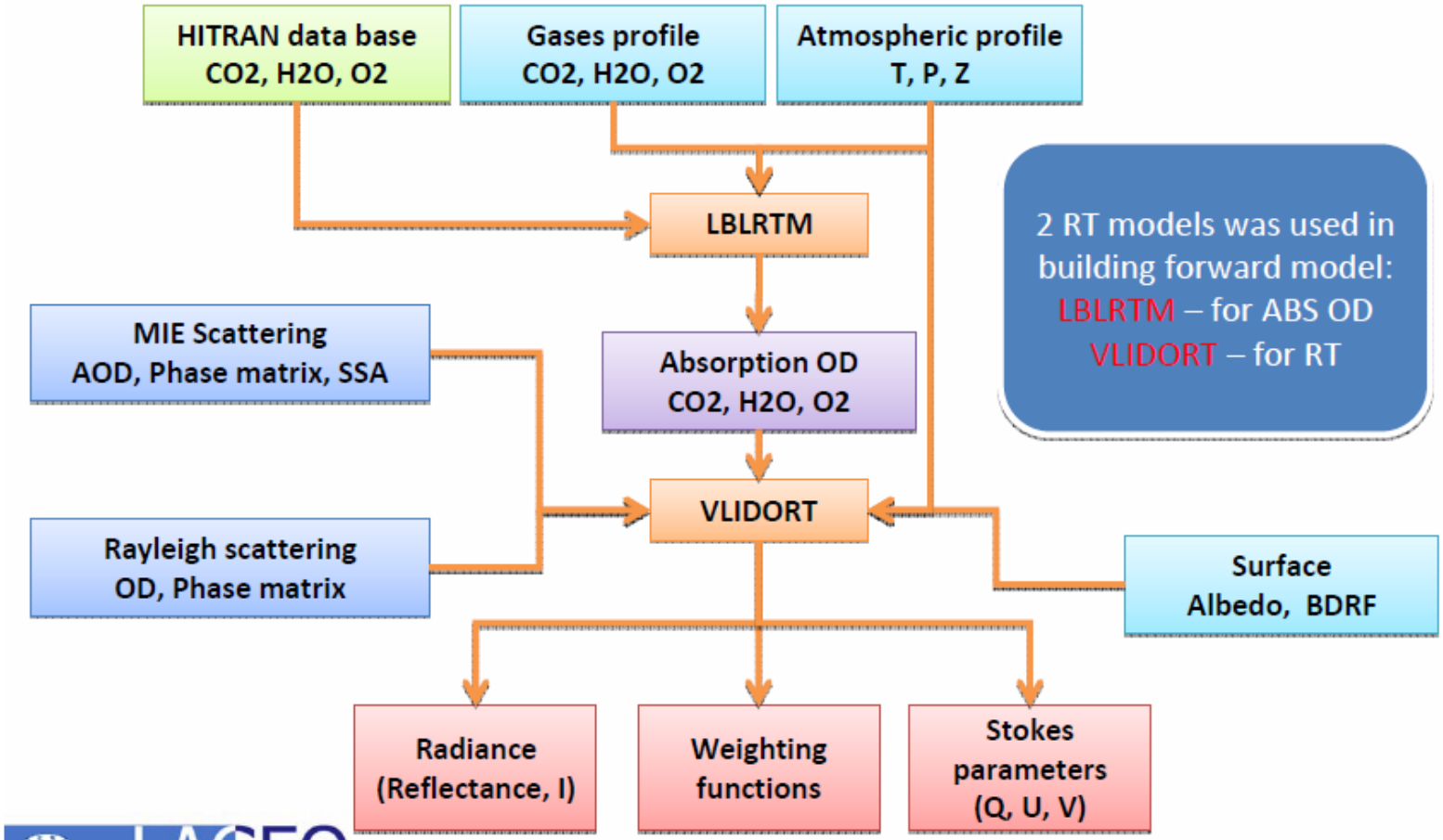
# Satellite Specifications

| Item | Parameter |
|---|---|
| Orbit | 700 km, 13:30, Local Time |
| Mass | ~600 kg |
| Power | 420W ~ 610W<br>10m$^2$ solar array<br>Li-battery, 80Ah |
| Dimensions | 1500mm(Ys) × 1800mm(Zs) × 1850mm(Xs) |
| AOCS | Attitude pointing accuracy: ≤0.1°;<br>Pointing stability:≤0.001°/s;<br>Slew rate: 180°/240s (Zs) , 150°/100s (XsYs) |
| Propulsion | 4×1N thruster, 10kg propellant |
| Data Link | X-band, 64 Mbps |
| Data Storage | 128 Gbits |
| TT&C | S-band, Downlink 8192bps, Uplink 2000bps |
| Design Life | 3 years |

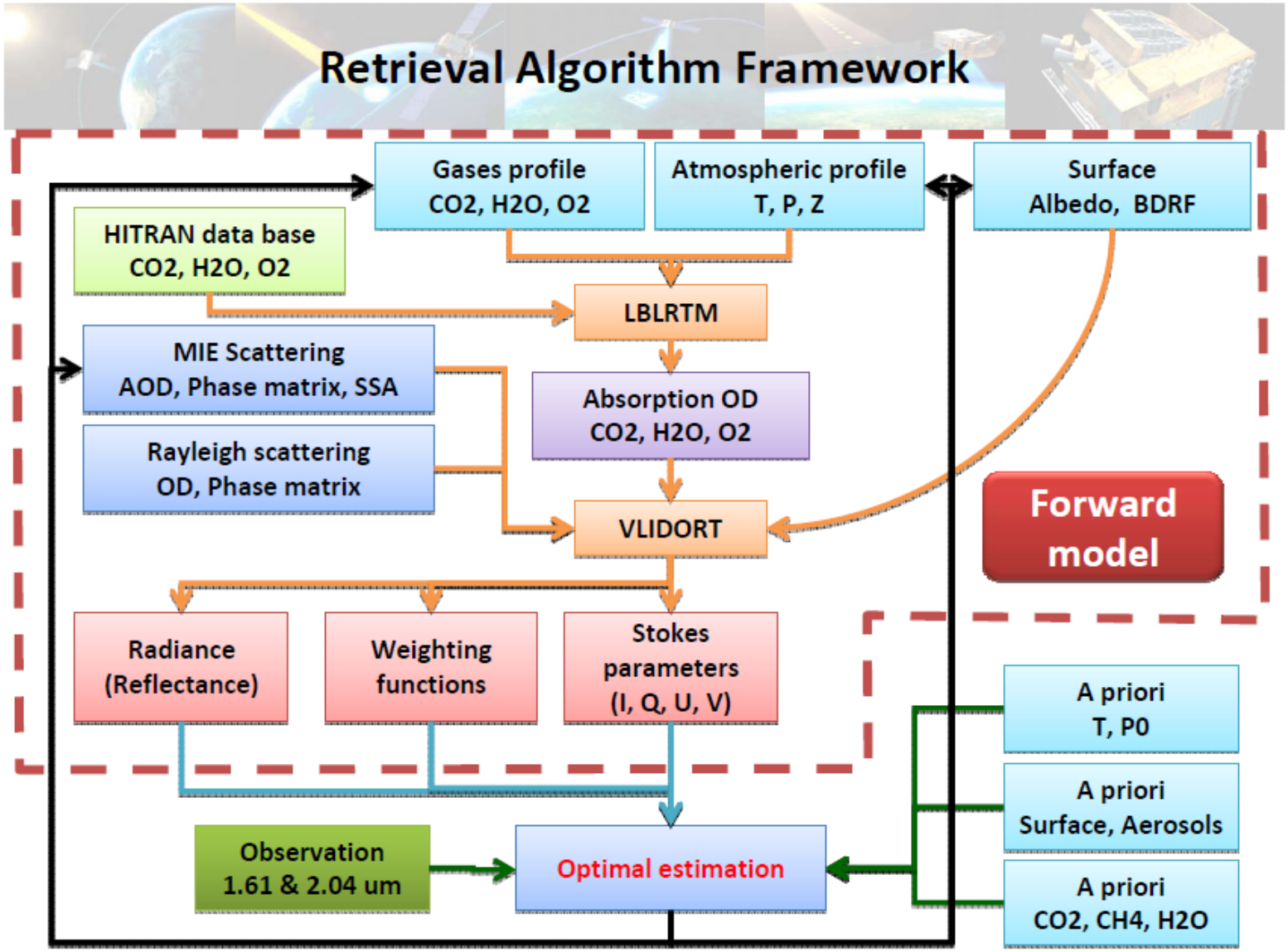


# CO2 Retrival

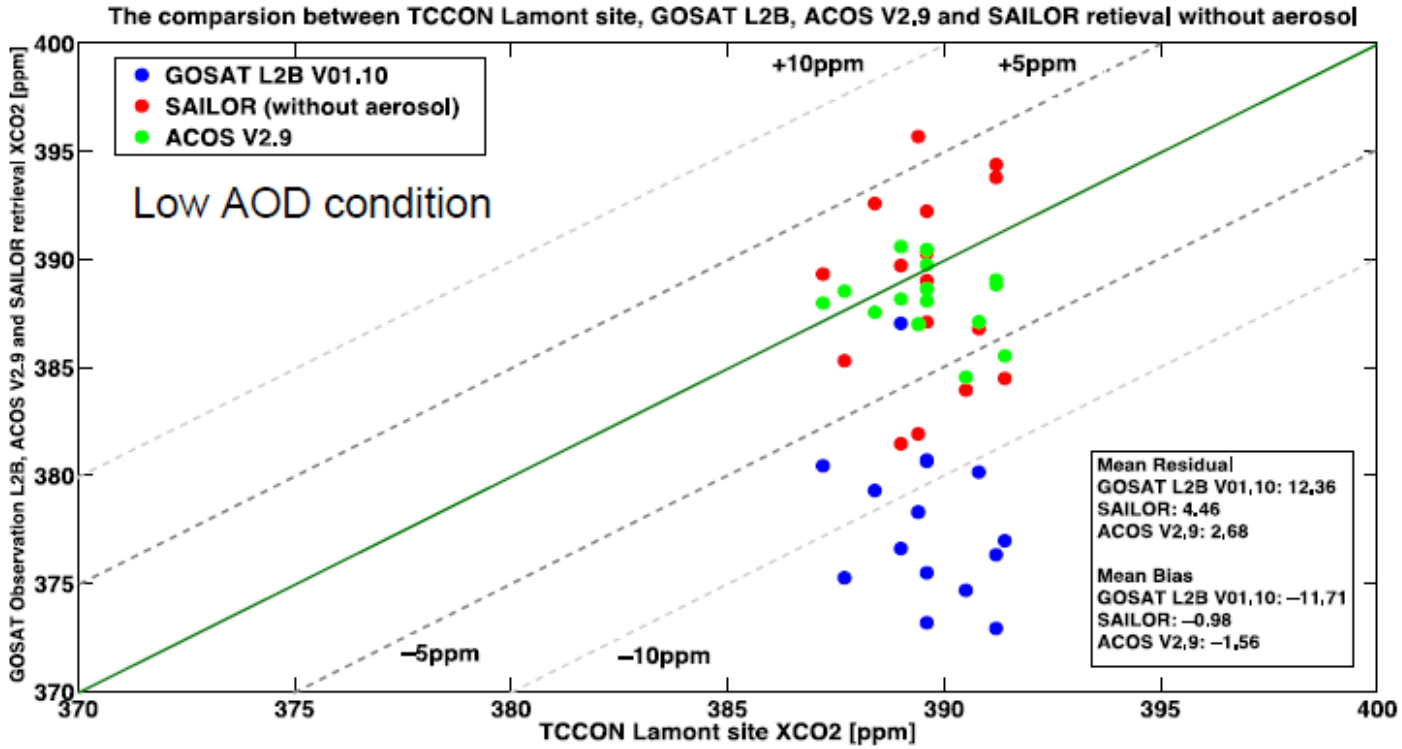
## Forward Model Framework



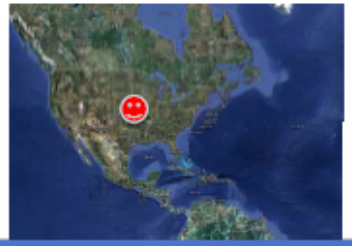
# CO2 Retrival



# Preliminary retrieval test



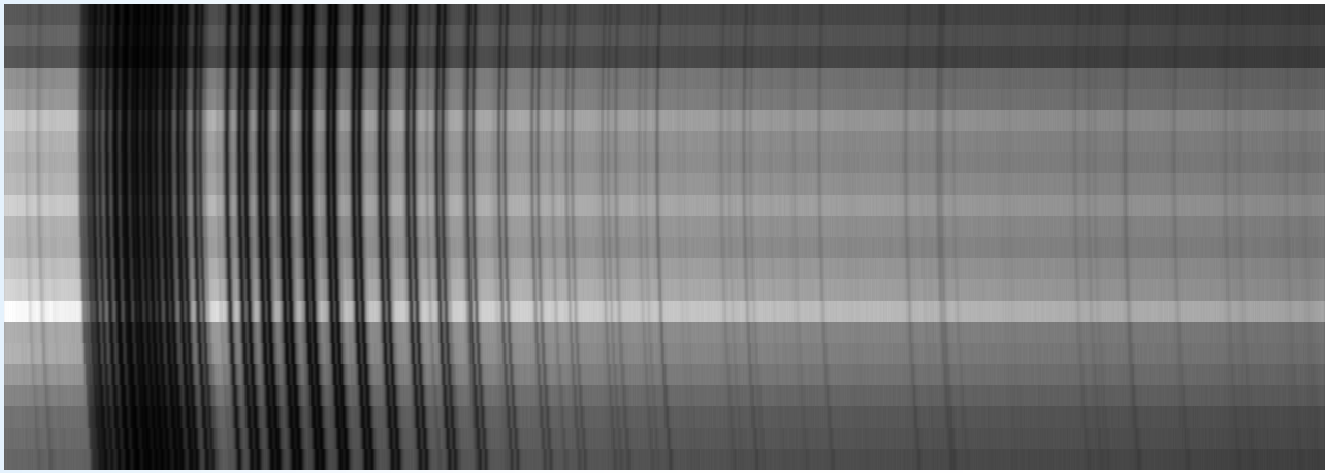

Lamont, Oklahoma, US
36.604 N, 97.486 W

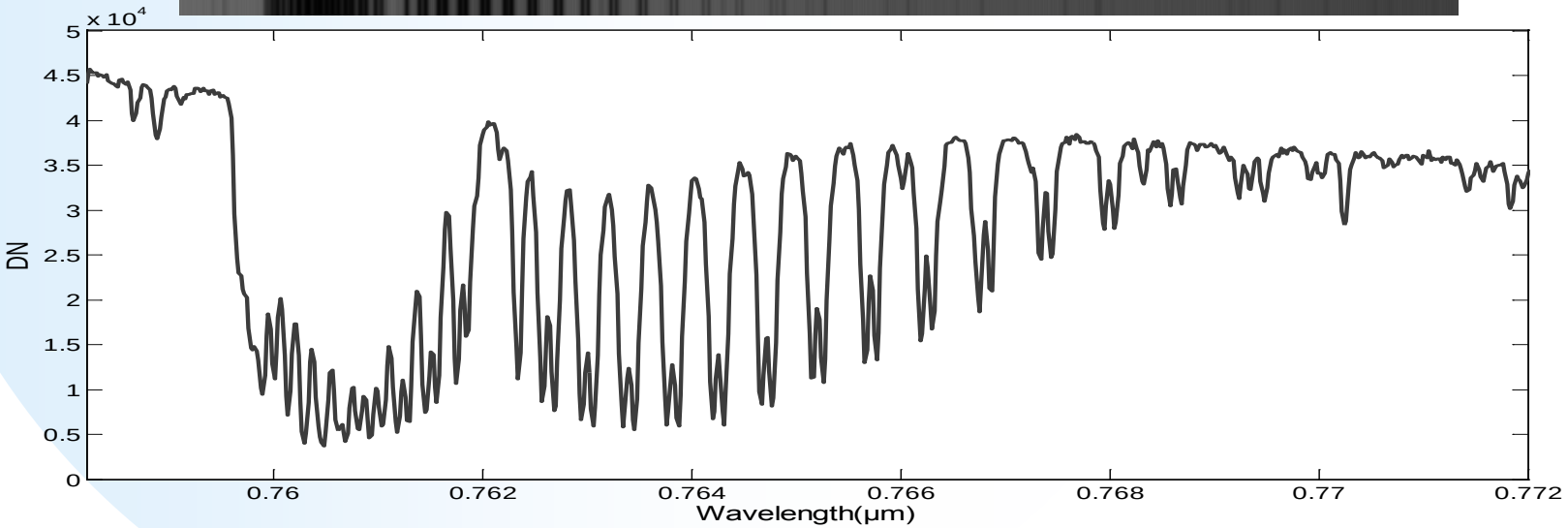


LAGEO - Key Laboratory of the Middle Atmosphere and Global Environmental Observation

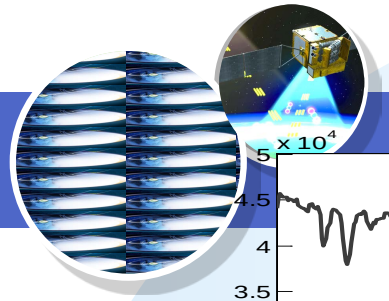
# Current Status – CO2 Sounder

**760nm spectrometer prototype with partial fore-optics and small-area grating**



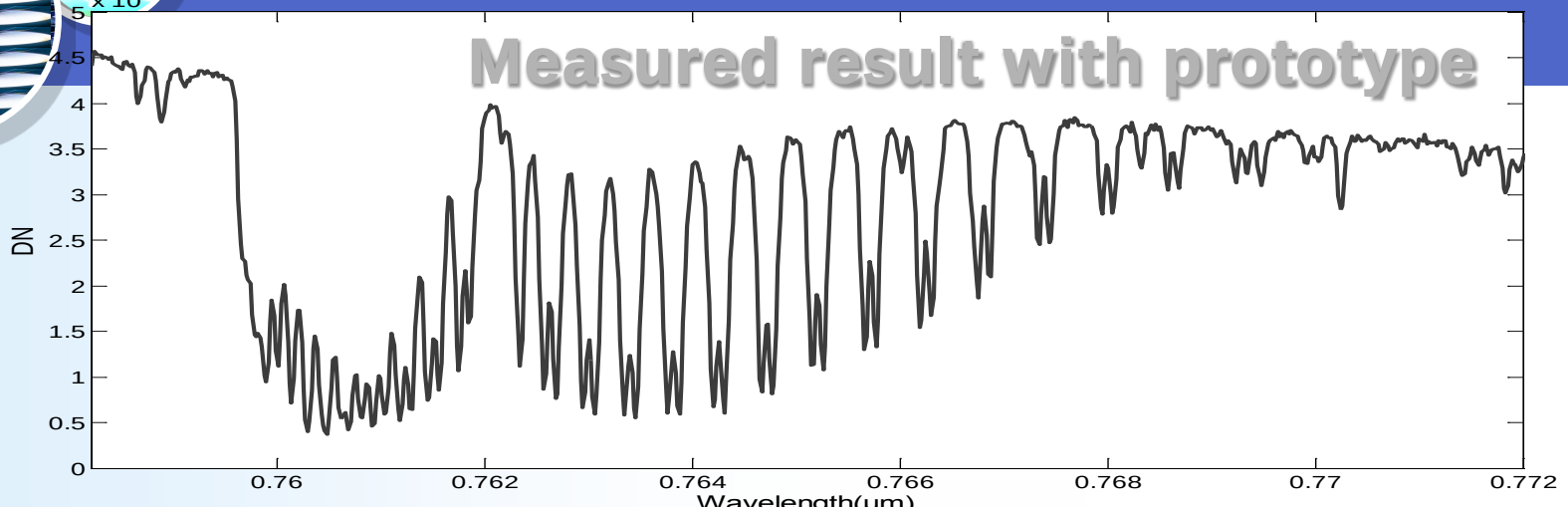


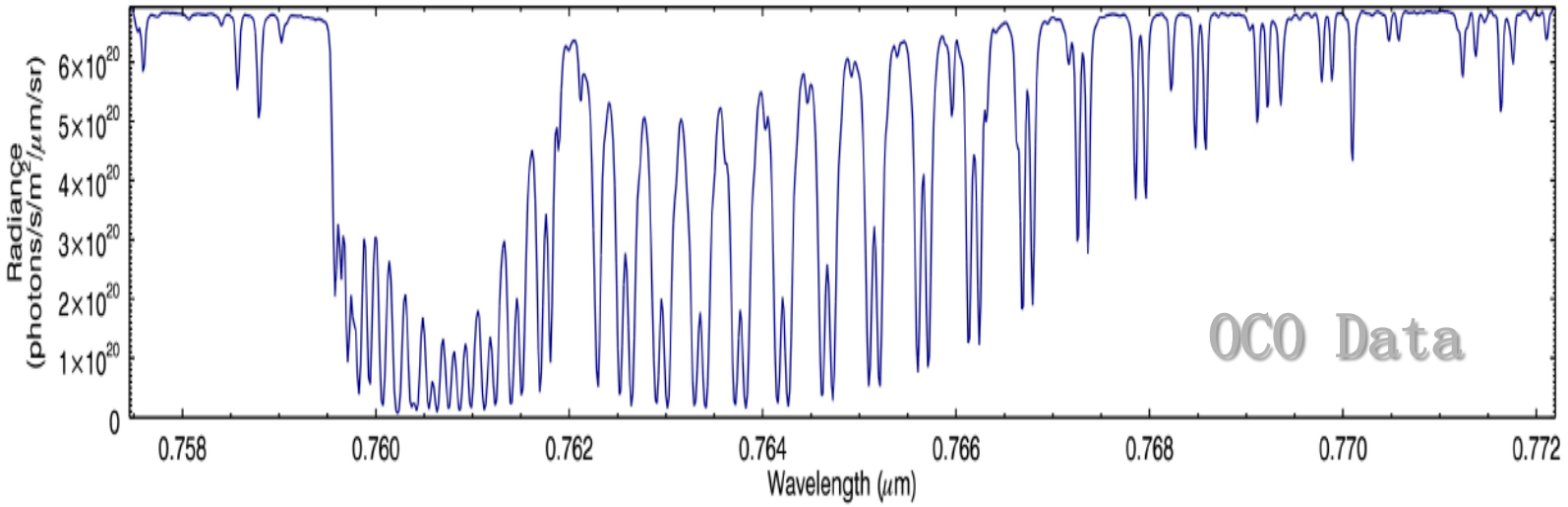

**Measured O2 absorption spectrum at 760nm with prototype**



Tan Sat

## Measured result with prototype

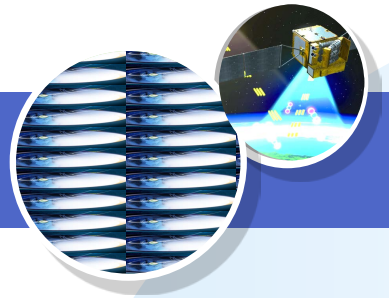



## Compare with OCO measured result from reference data

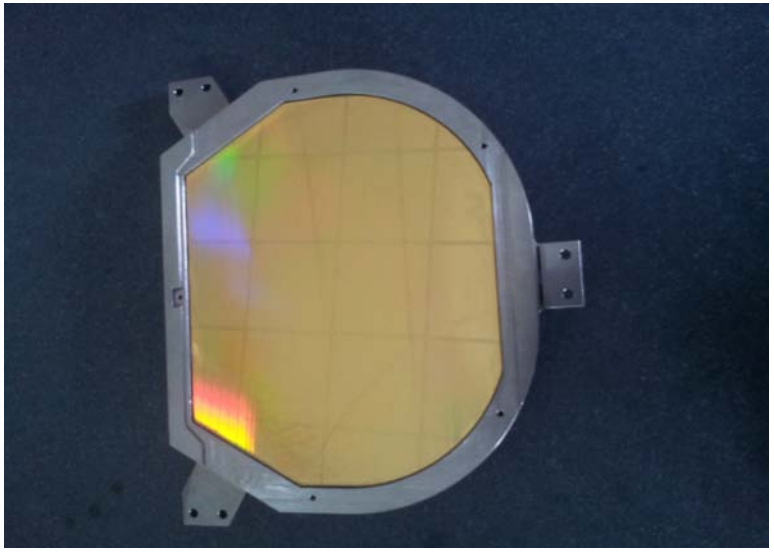
# 1610nm spectrometer prototype

- same construction as 760nm channel
- use a large-area diffraction grating, the size is 190mm by 154mm
- use a long linear InGaAs FPA

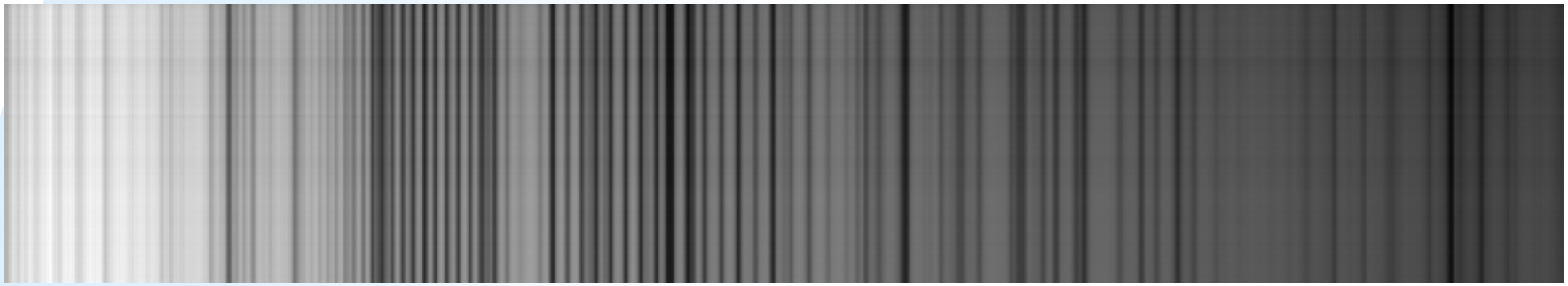


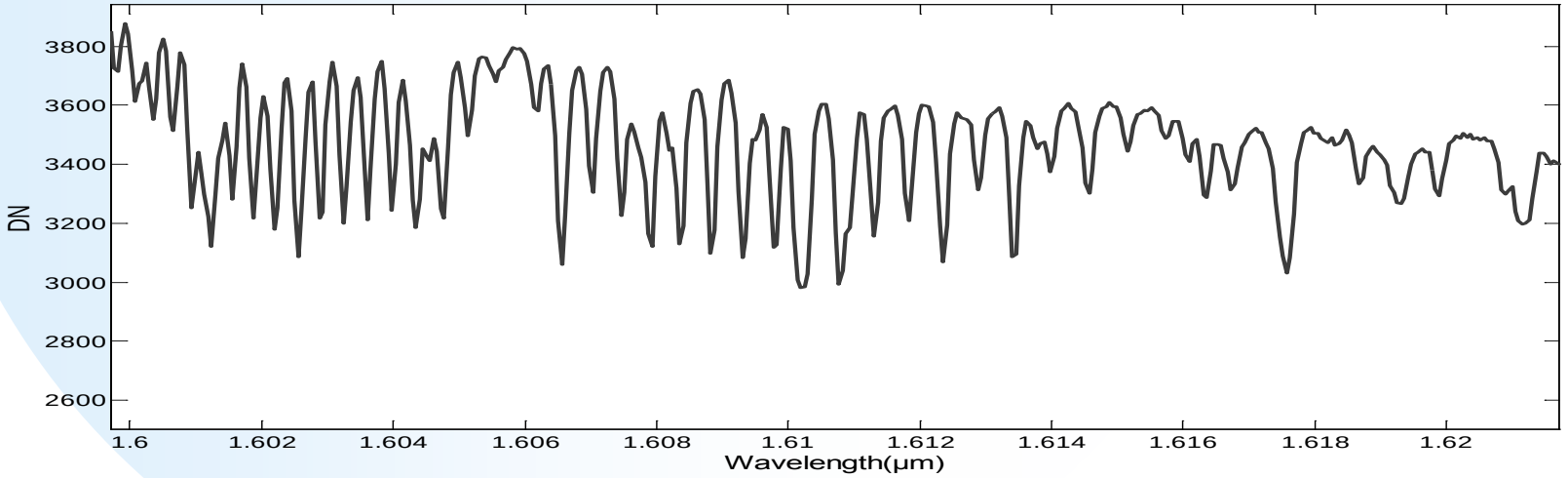
# Large-area Grating Sample

- Low diffractive efficiency, high stray light and worse wavefront
- still obtain the clear spectrum
- improved technique adopted, new sample will be tested in June



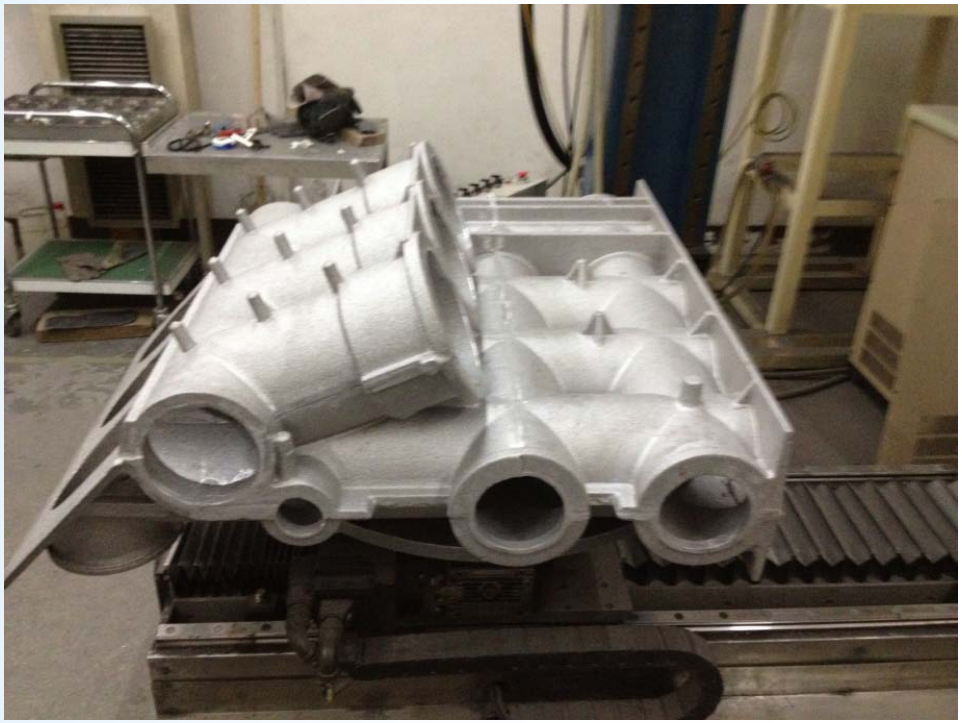
# Measured spectrum with 1610nm prototype





# Payload Mechanical prototype

- Main frame is cast with aluminium alloy
- 960mm by 900mm by 540mm

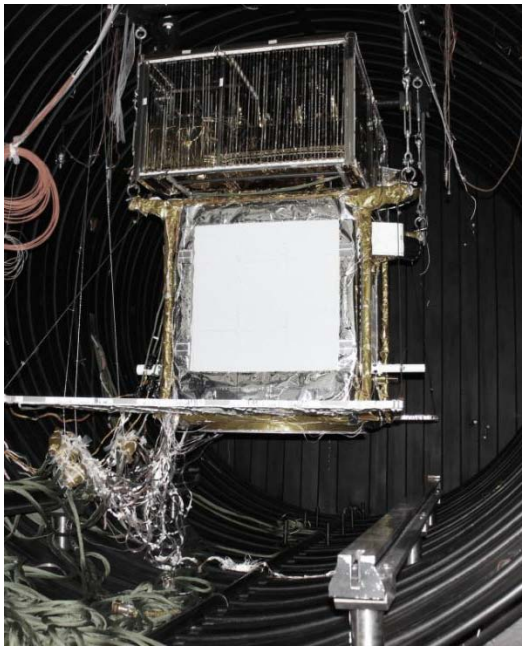


# Satellite Tests

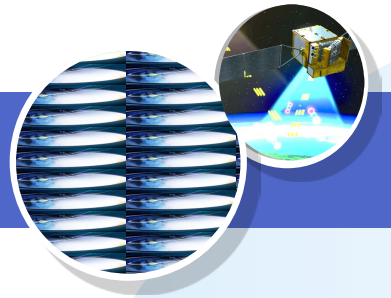
- Satellite electrical interface tests in 2012.8
- Satellite mechanical test in 2013.1
- Satellite thermal test in 2013.4

EM of Onboard Computer

**Satellite on vibration bench**



**Satellite in KM3**



# Development Plan

| | |
|---|---|
| 2011.2 | Kick off of project |
| 2011.9 | SRR |
| 2012.9 | PDR |
| 2013.6 | Kick off phase C |
| 2014.5 | CDR |
| 2015.6 | SRR |

**TanSat is to be launched in 2015!**


Thank You !