1. Executive Summary

1.1 Overview of the SMILES mission

1.2 Scientific targets

1.3 SMILES observations

1.4 Launch schedule

1.5 Functional tests

1.6 Summary

JEM/SMILES Mission and History

(JEM/SMILES: Superconducting Submillimeter-Wave Limb-Emission Sounder designed to be aboard the Japanese Experiment Module on ISS)

Collaboration project of JAXA (Japan Aerospace Exploration Agency) and NICT (National Institute of Information and Communications Technology) to demonstrate superconductive mixer and 4-K mechanical cooler for the submillimeter limb-emission sounding in space and to observe atmospheric minor constituents in the stratosphere

Apr. 1997: Selection as the ISS Japanese Experiment Module (JEM) Exposed Facility 1st stage Utilization Mission

Dec. 1998: Mission Definite Review

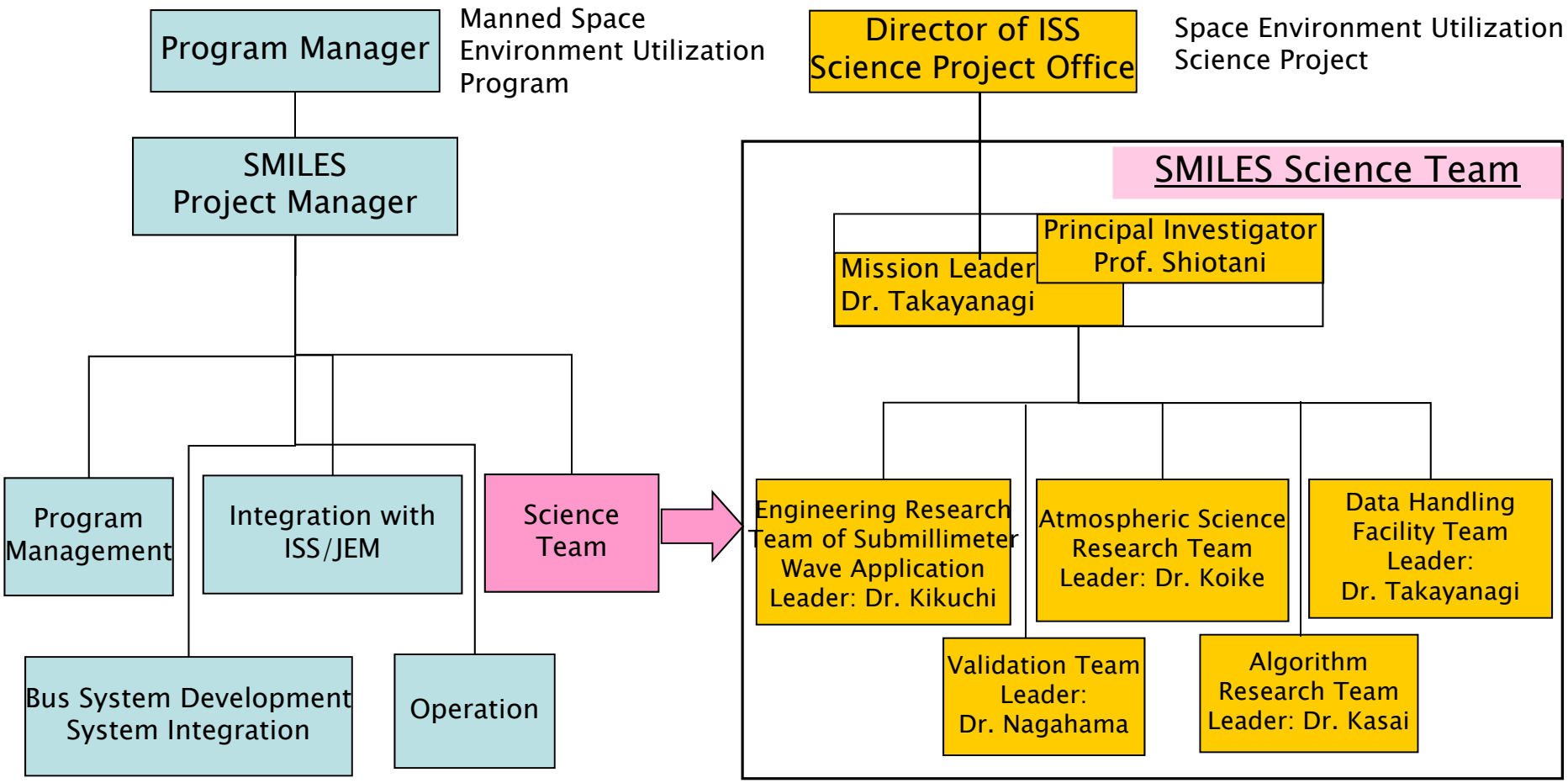
Sep. 2001: Preliminary Design Review

Mar. 2003: Interim Appraisal of the JEM Exposed Facility 1st stage Utilization Mission

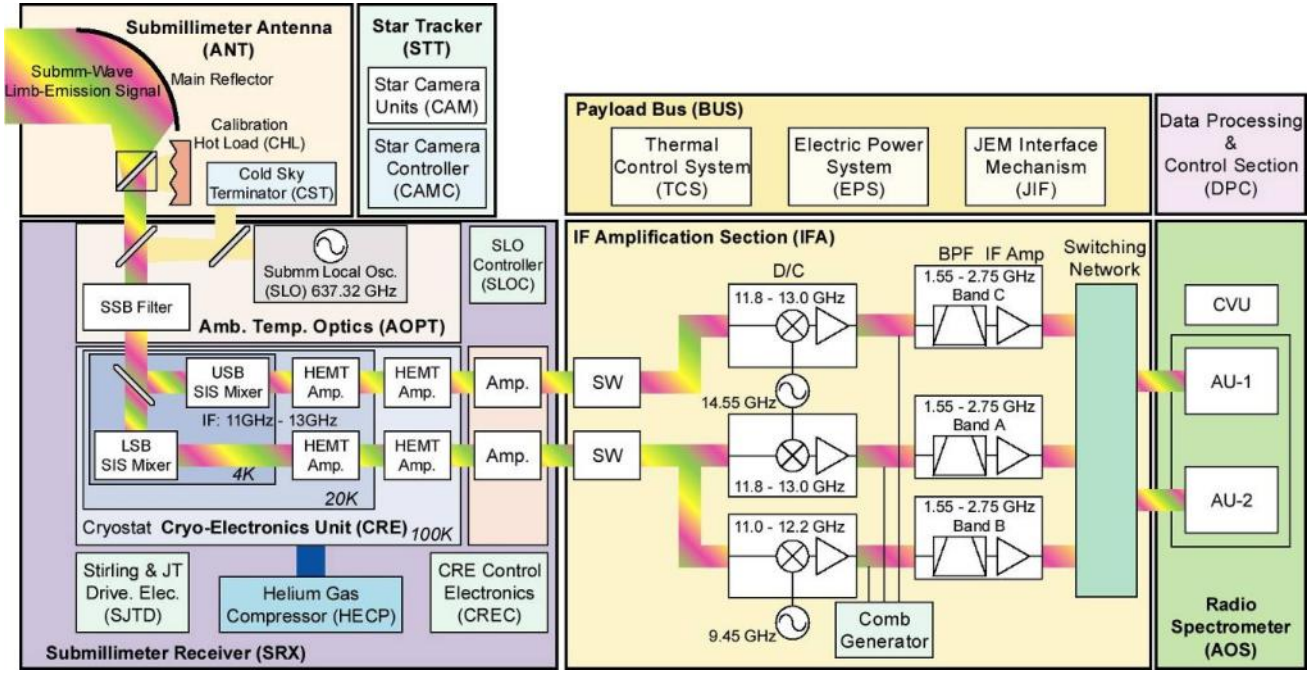
The SMILES instrument is now ready for launch.

Framework of SMILES Science Promotion

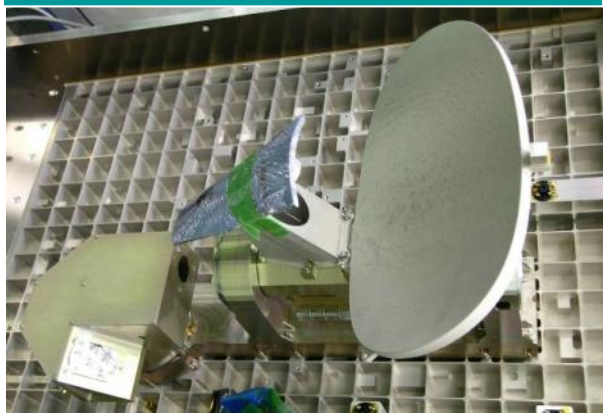
SMILES Science Team is set in ISS Science Project Office in Institute of Space and Astronautical Science, JAXA.



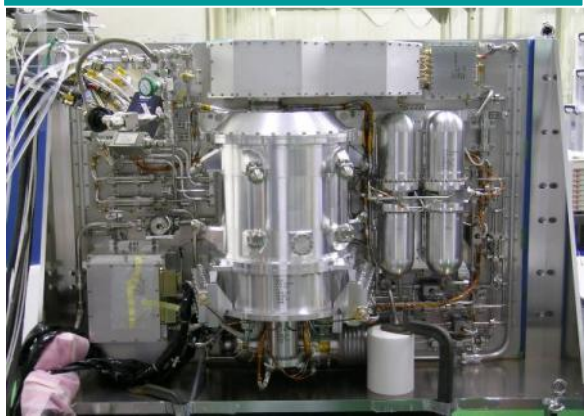
Block Diagram of JEM/SMILES



Submillimeter Antenna

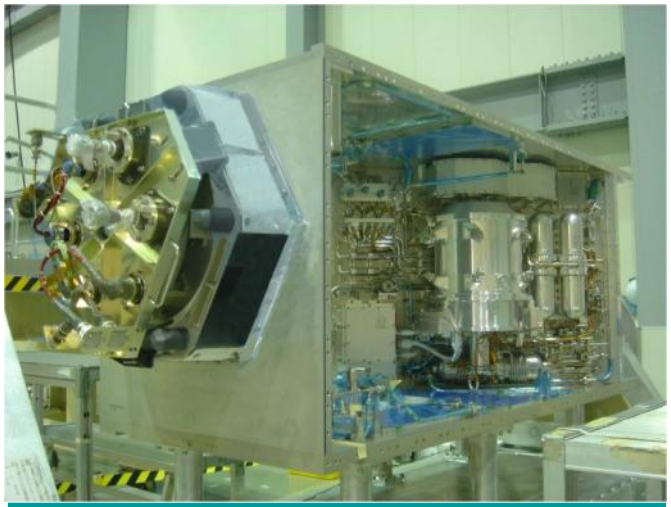


Submillimeter Receiver

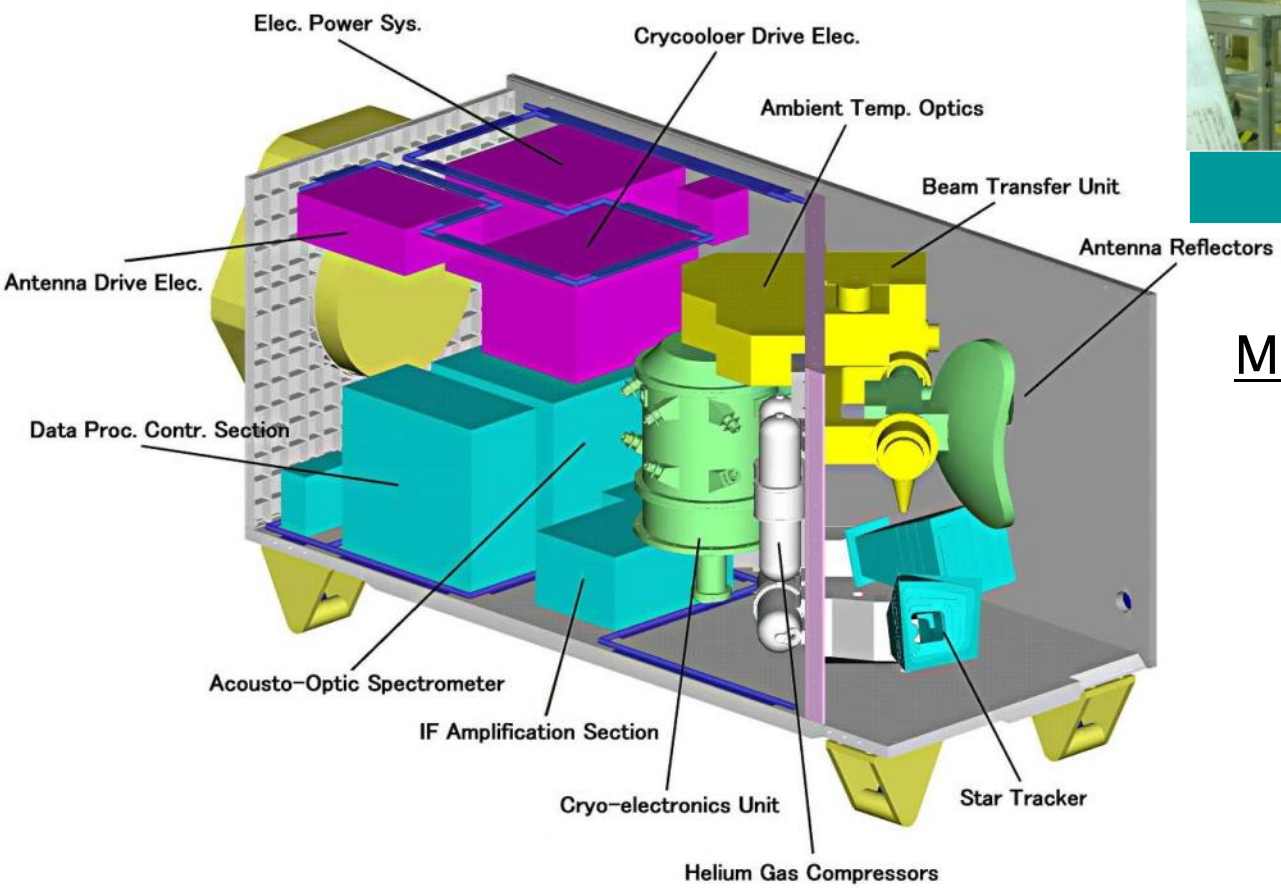


Radio Spectrometer

JEM/SMILES Payload



Flight Model

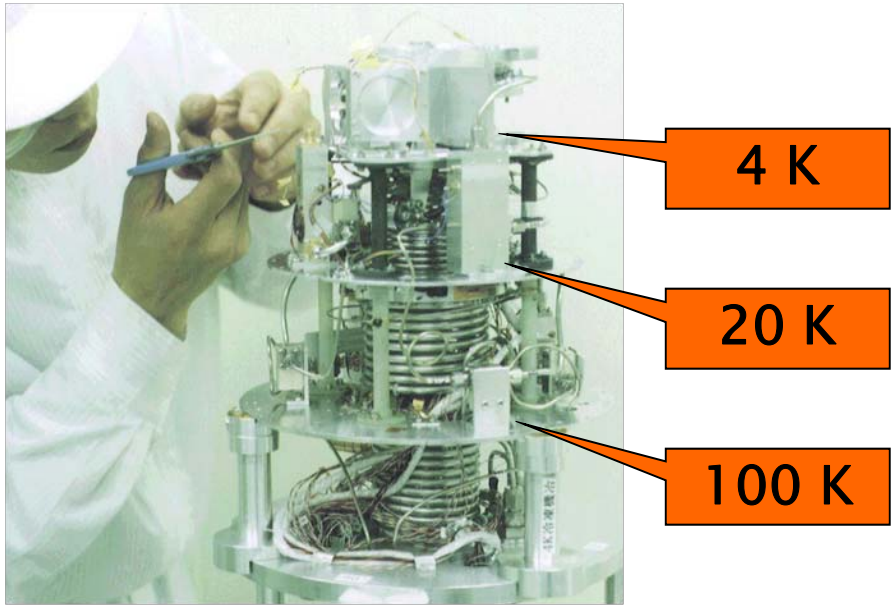


Major Design Parameters

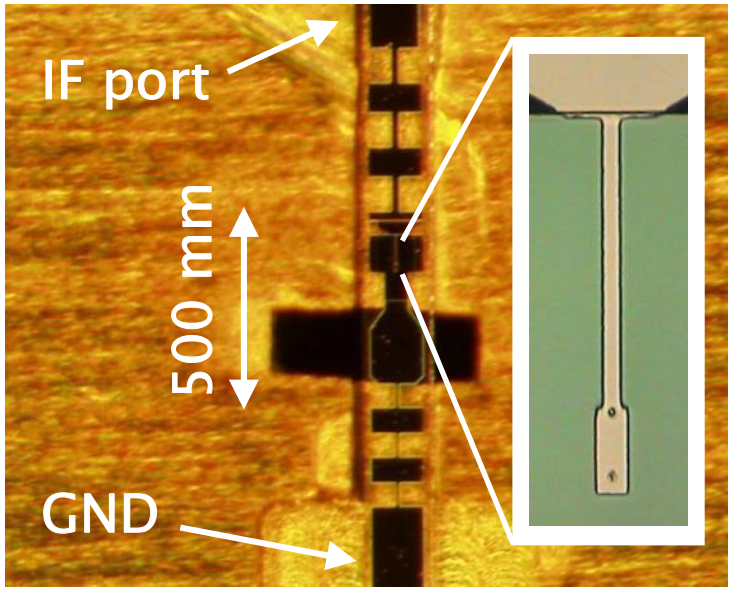
- RF : 640 GHz band
- Spectral Coverage: 1200 MHz x 2
- Antenna: 40 cm x 20 cm
- Weight: < 500 kg
- Mission Life: 1 year

Mechanical Cooler and SIS Mixer

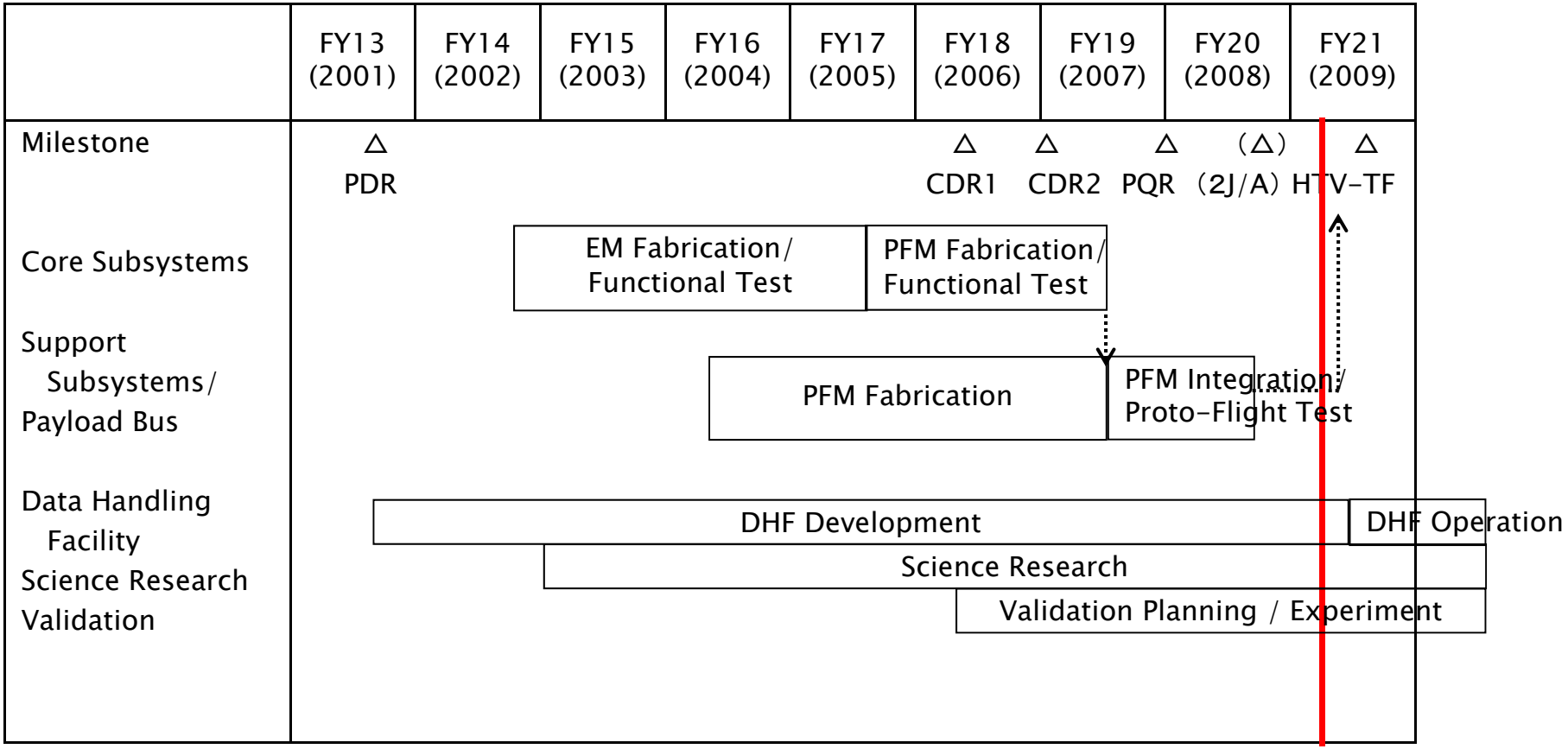
- Mechanical Cooler
  - Two-stage Stirling and J-T
  - Cooling Capacity:
    20mW @4K, 200mW @20K,
    1000mW @100K
  - Power Consumption: <300 W
  - Mass: 90 kg



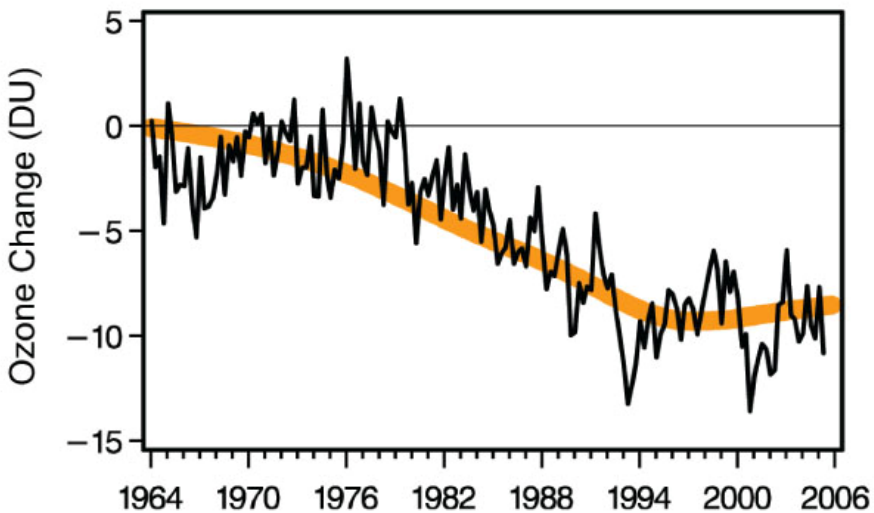
- SIS Mixer
  - RF: 640 GHz
  - IF: 11-13 GHz
  - Junction:
    Nb/AlOx/Nb, ~7 kA/cm^2
  - RF Matching:
    PCTJ with Integrated Circuit
  - Fabricated at Nobeyama RO

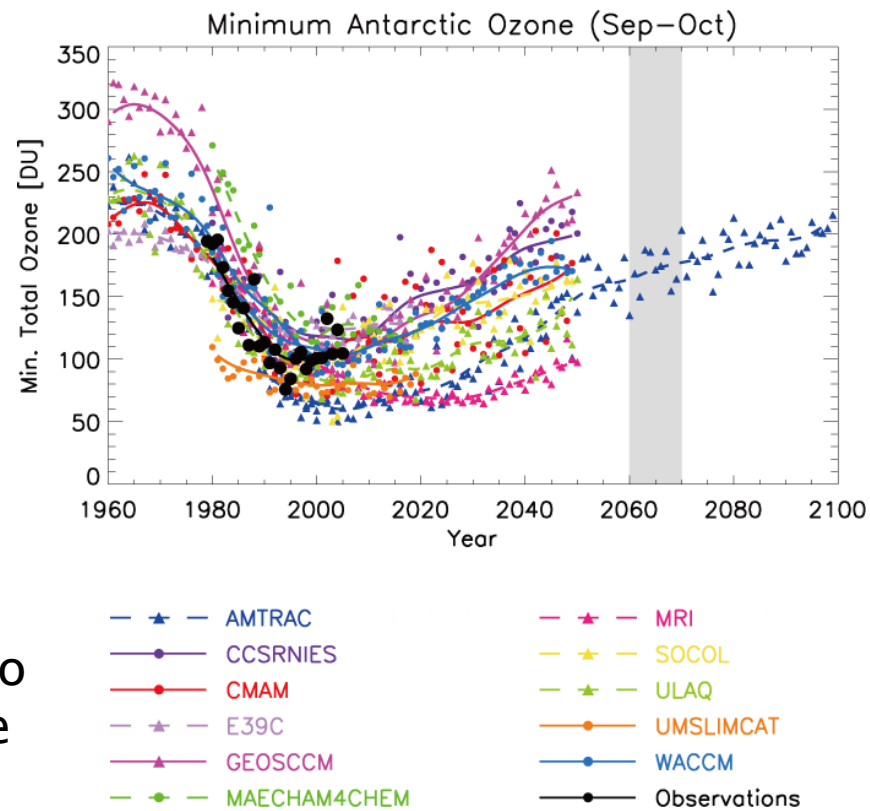


Development Schedule



Understanding the Future Ozone Layer

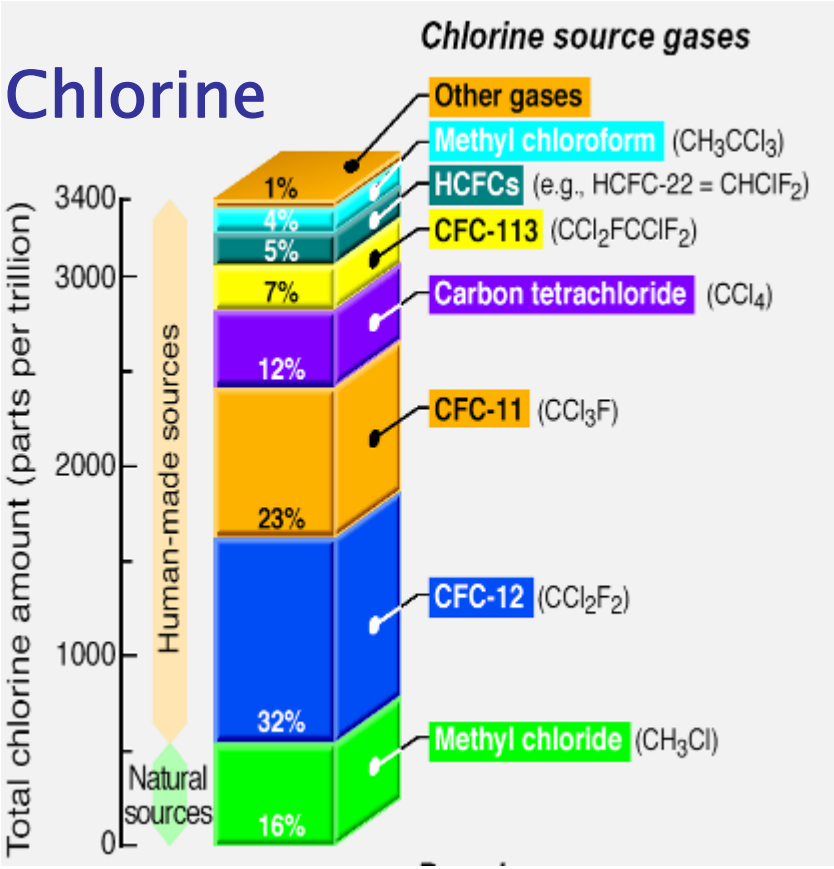


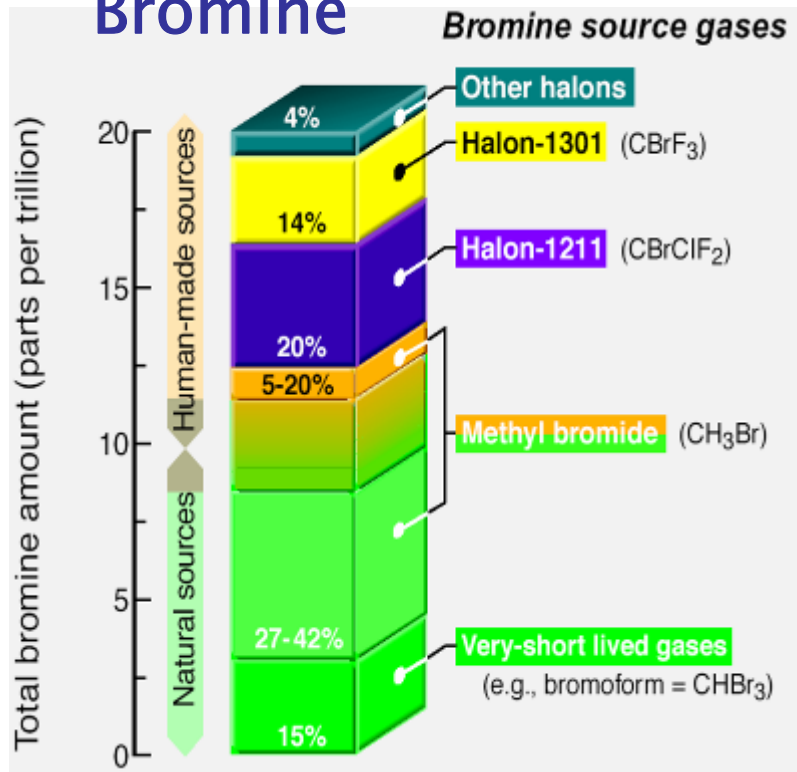


Not only in the polar latitudes, but also in the mid- and lower latitudes, ozone depletion is critical whole the globe. The recovery is estimated around 2060-2070, but there is very big uncertainty in association with the Cl and Br chemistries (WMO, 2006)

Model results for the future Antarctic ozone amount calculated from chemistry-climate models (WMO, 2006)

Origin of Cl and Br in the Stratosphere





Our quantitative understanding of how halogenated very short-lived substances contribute to halogen levels in the stratosphere has improved significantly since the 2002 Assessment, with brominated very short-lived substances believed to make a significant contribution to total stratospheric bromine and its effect on stratospheric ozone. (WMO Ozone Report, 2006)

Scientific targets of SMILES

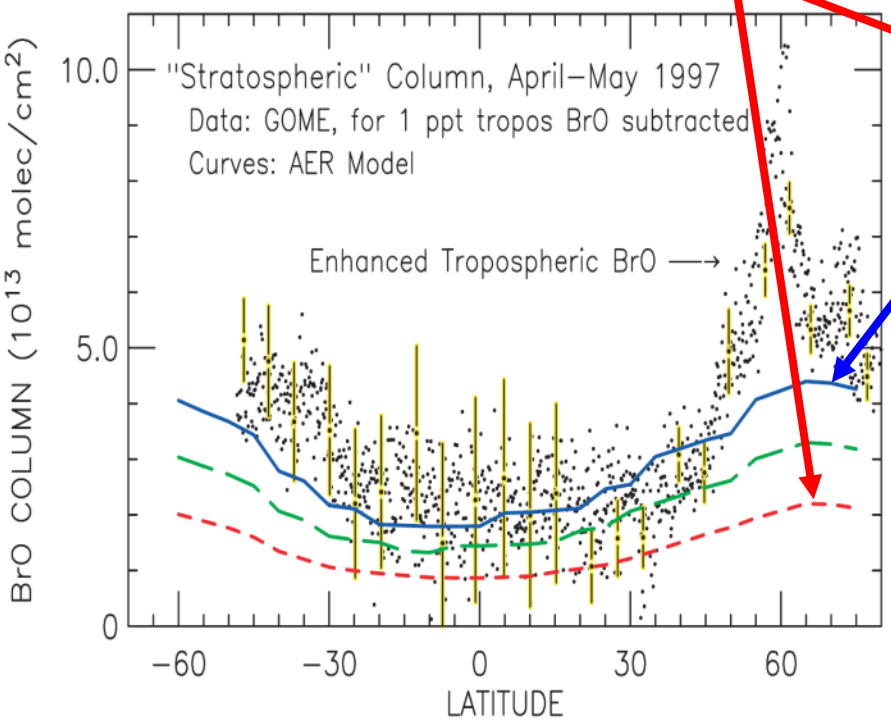
1. Inorganic Chlorine chemistry
   - ClO to HCl ratio (O_3 trend in the US)
   - HOCl production (O_3 trend in the LS)
   - Global ClO (background ClO)
2. Bromine budget (very short-lived source gas)
3. HO_x budget (HO_x dilemma)
4. Cirrus clouds (Het. reactions & rad. budget)
5. O_3 isotope (mass independent chemistry)

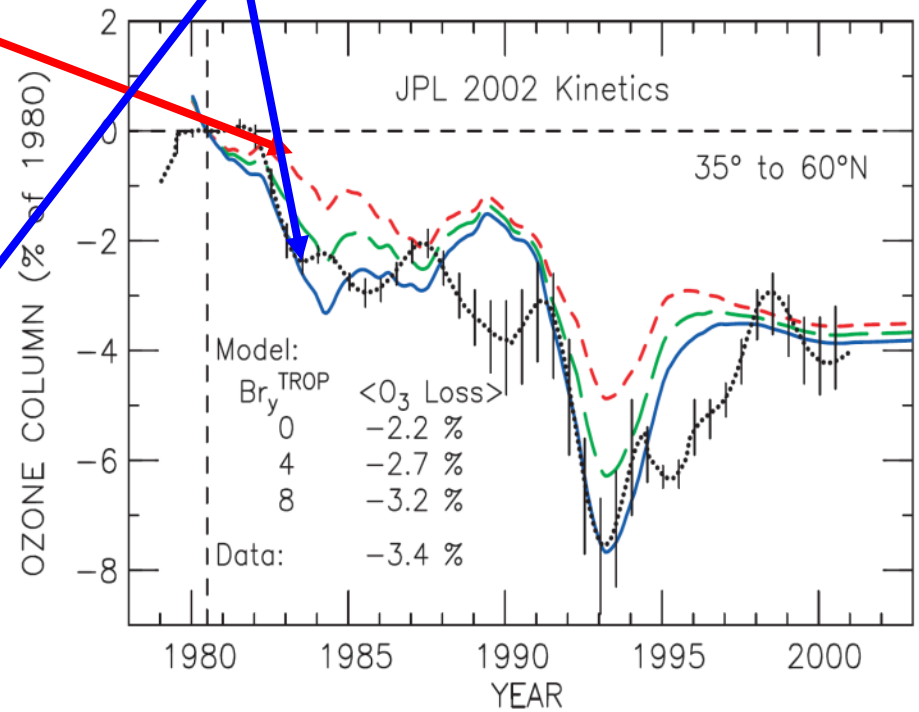
(6. UT/LS mixing (O_3 flux))

Bromine budget

Br_y from CH_3Br & Halons

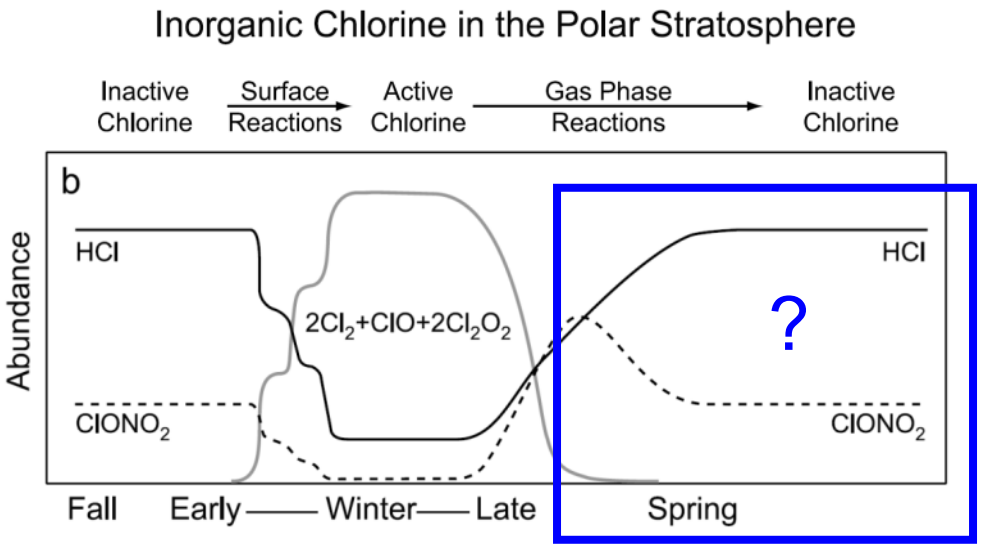
+ 8 pptv Br_y Source





BrO measurements suggest that in addition to long-lived source gases (halons and methyl bromide), very short-lived (τ < 6 months) source gases likely contribute to Br_y by about 5 pptv. This difference can be important for O_3 in the LS. (Salawitch et al., 2005)

Global ClO distribution



$Cl + CH_4 \rightarrow HCl + CH_3$

$ClO + OH \rightarrow HCl + O_2$ 6%

$ClO + OH \rightarrow Cl + HO_2$ 94%

$ClO + HO_2 \rightarrow HCl + O_3$ 1-5%

$ClO + HO_2 \rightarrow HOCl + O_2$ 95-99%

The background ClO_x level is important to quantify the in-situ O_3 loss at mid-latitudes. However, its global distribution has not been observed with high precision.

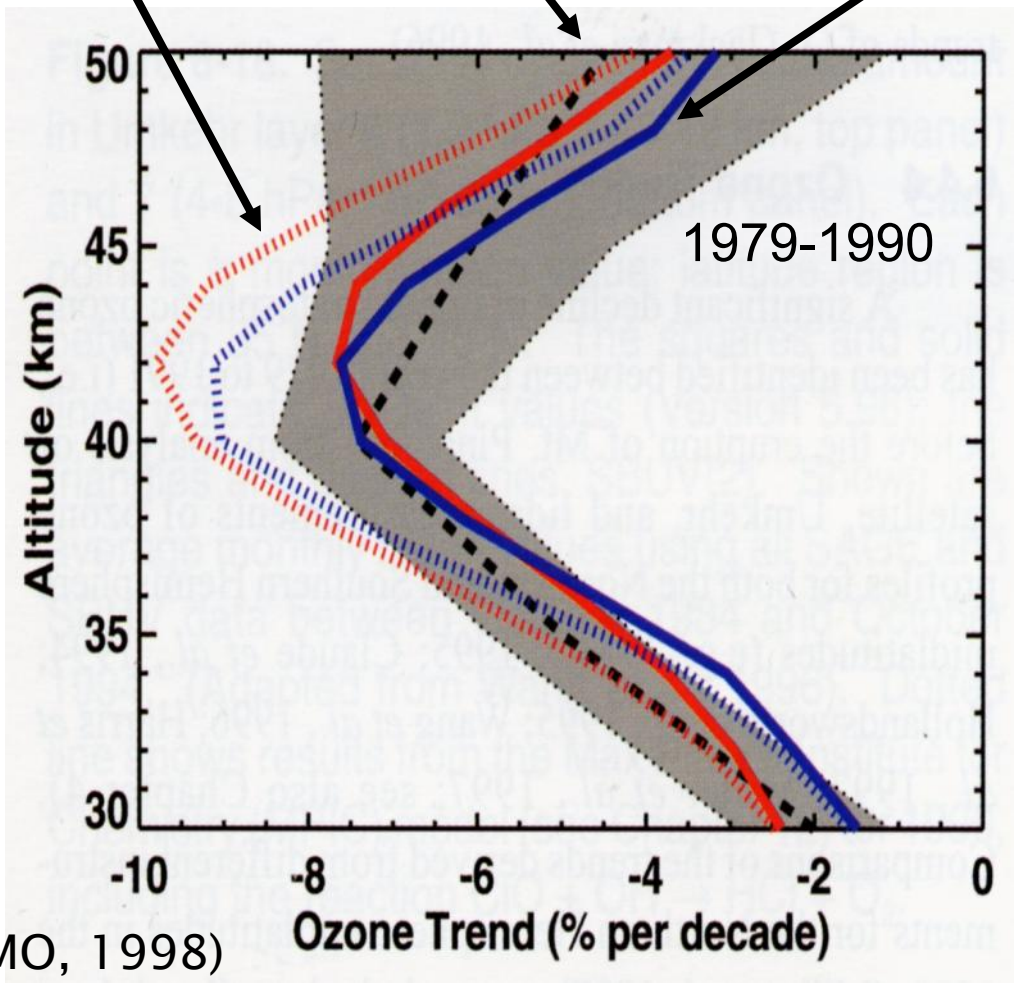
SMILES provides global ClO distribution with high precision. Furthermore, measurements of ClO, HCl, HOCl, and HO_2 can provide important insights into the Cl_y chemistry.

Partitioning within Cly in US

observations (SAGE, SBUV, Umkehr)

model without (2)

model with (2)



(WMO, 1998)

$$Cl + HO_2 \rightarrow HCl + O_2 \quad (1)$$

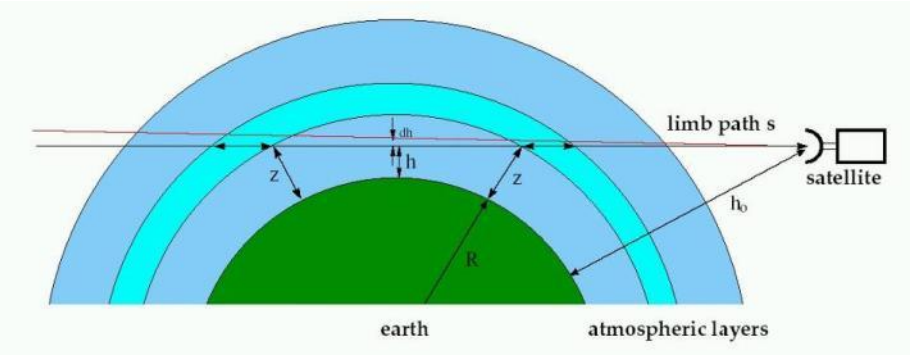
$$ClO + OH \xrightarrow{6\%} HCl + O_2 \quad (2)$$

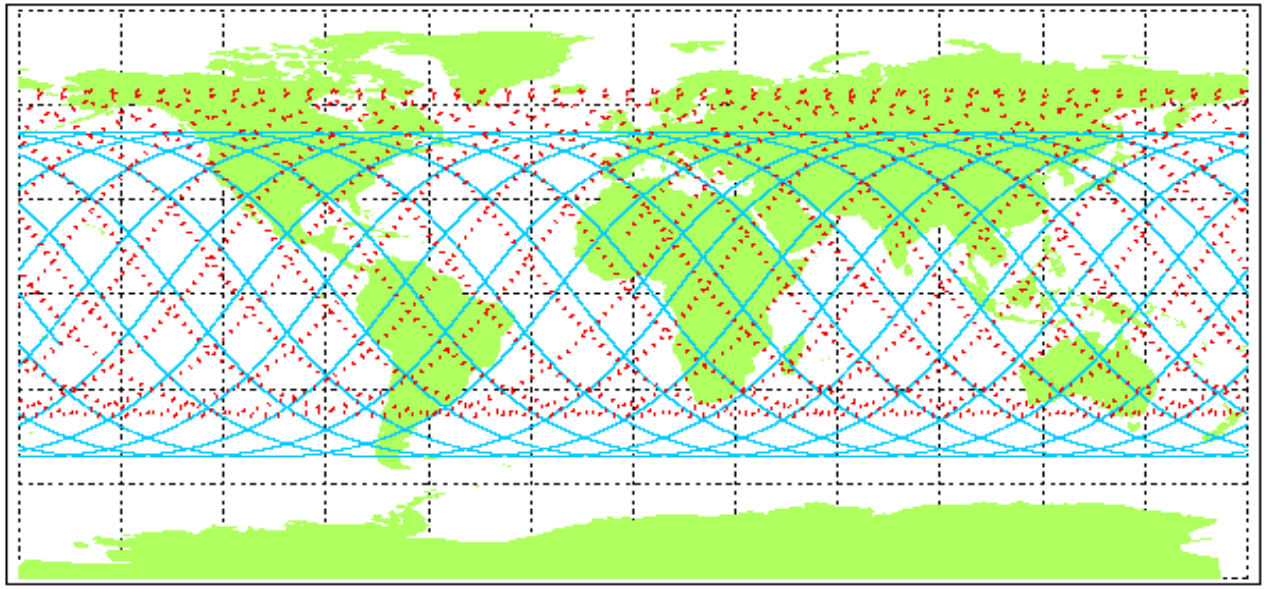
Inclusion of the reaction (2) results in a better agreement with observed [ClO]/[HCl] ratio (balloon) and O_3 trend in the upper stratosphere.

SMILES [ClO]/[HCl] measurements can be utilized further systematic test on Cly partitioning.

Submillimeter limb-emission sounding and global observation

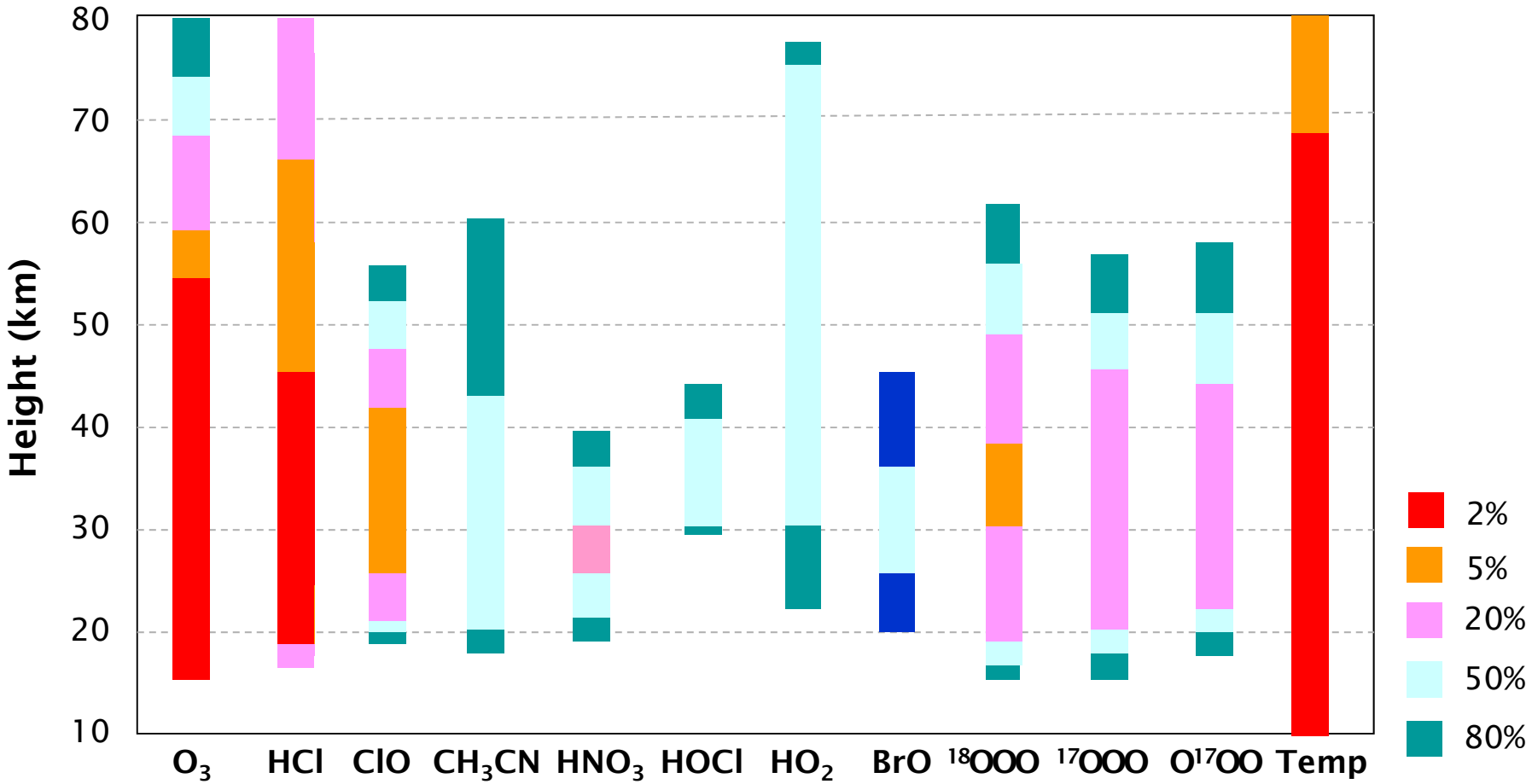
- High sensitivity in detecting atmospheric limb emission of the submillimeter wave range (640GHz)
- Vertical profiling (~3km) from JEM/ISS with latitudinal coverage of 65N to 38S





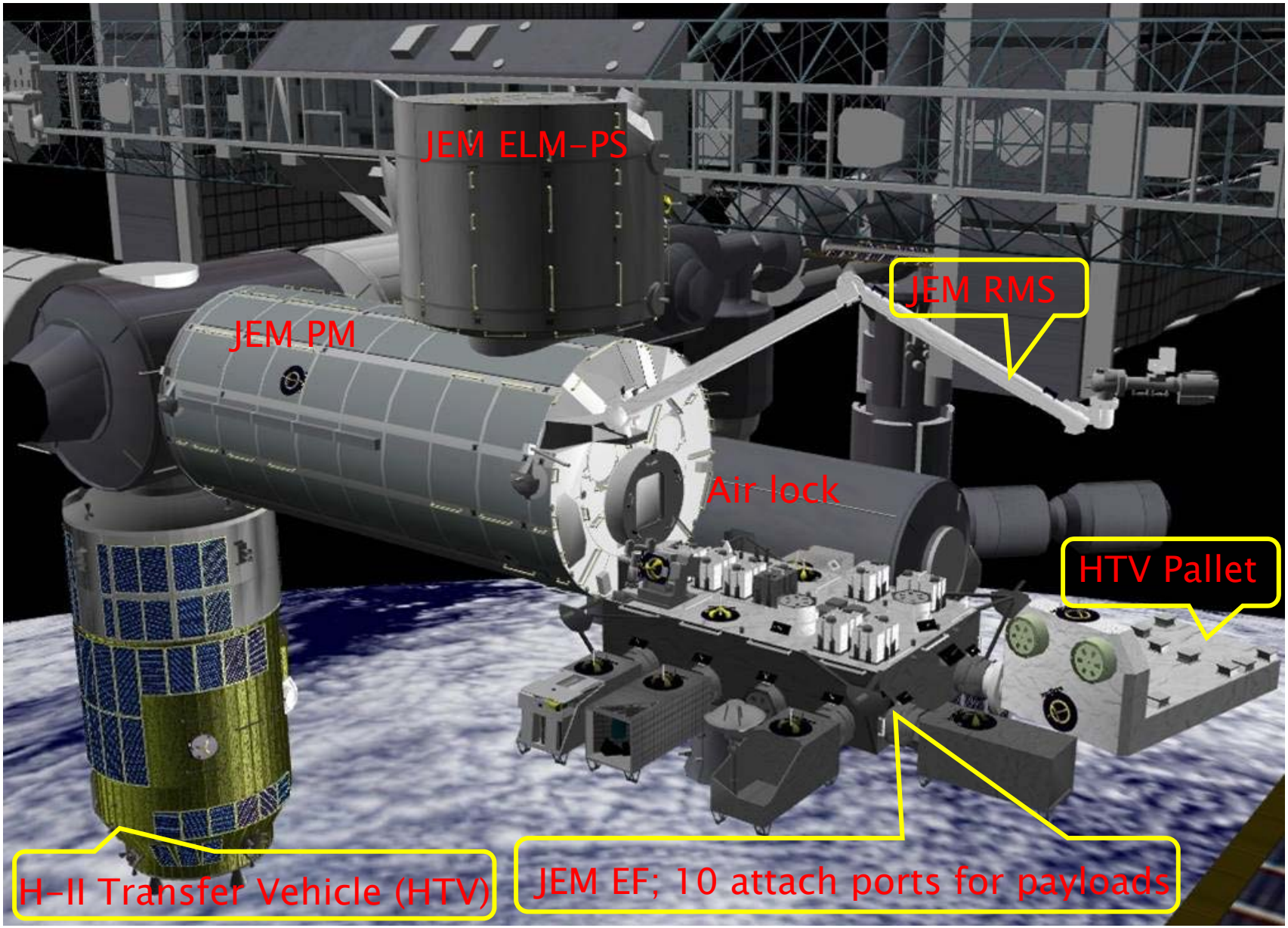
→ Measurements on several radical species crucial to the ozone chemistry (normal O_3, isotope O_3, ClO, HCl, HOCl, BrO, HO_2, H_2O_2)

JEM/SMILES observation performance

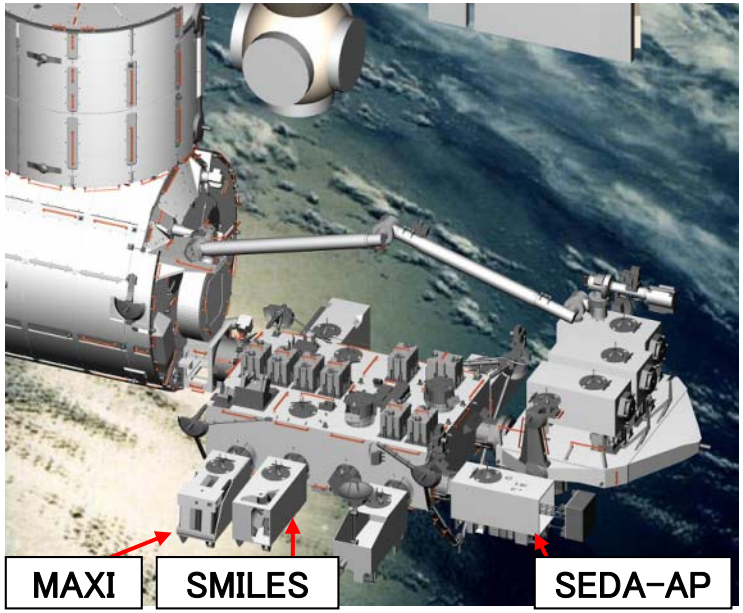


Error estimation for the mid-latitude case based on the single scan measurement

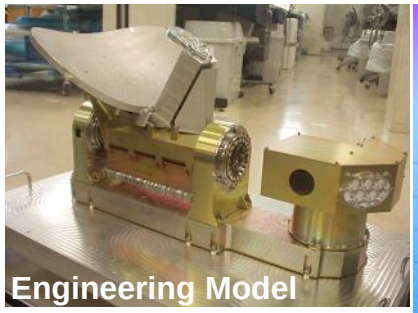
Japanese Experiment Module (JEM/Kibo)

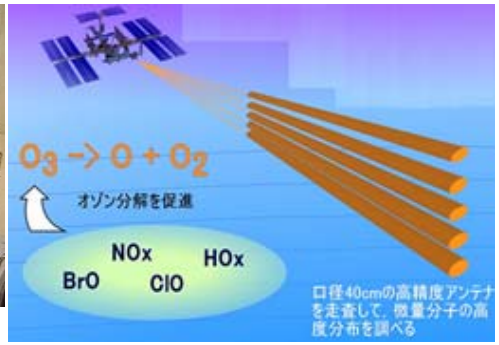


1st phase utilization of JEM Exposed Facility



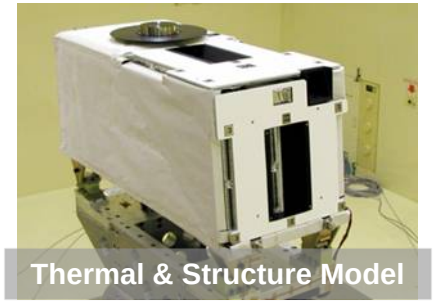
Superconducting Sub millimeter-wave Limb-Emission Sounder (SMILES)

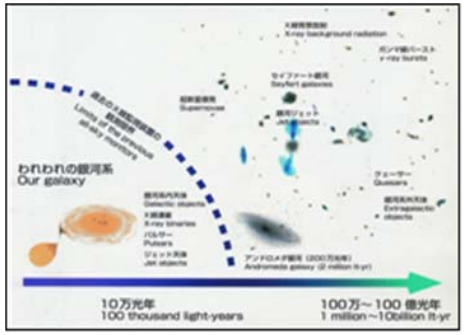




SMILES will be launched by HTV in 2009

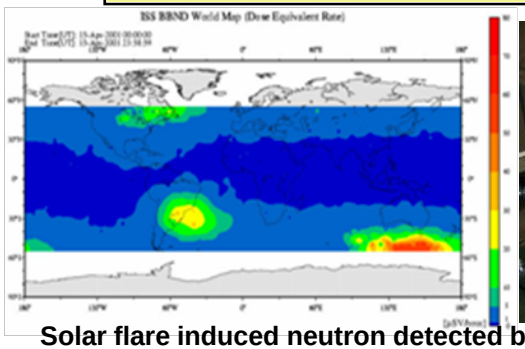
Monitor of All-sky X-ray Image (MAXI)

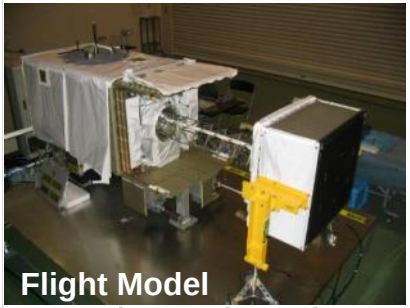




MAXI will be launched by Shuttle 2J/A

Space Environment Data Acquisition (SEDA)





Solar flare induced neutron detected by BBND in US Lab"Destiny"

SEDA-AP will be launched by Shuttle 2J/A

Launch schedule of experiment facilities for the 1st phase JEM utilization

FY 2008 | FY 2009 | FY 2010

March 11, 2008
JEM ELM-PS

June 1, 2008
JEM-PM

FY2009 (June 13)
JEM-Exposed Facility & ELM-ES

FY 2009
HTV#1 launch

FY 2010
HTV#2 launch

In the ELM-PS

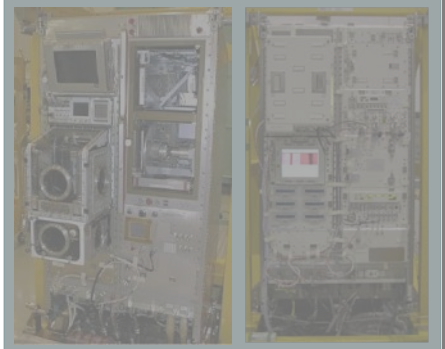
On the ELM-ES

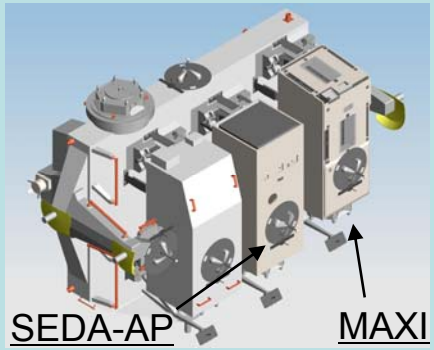
On the Unpressurized Logistics Carrier (ULC) of HTV.

In Pressurized Logistics Carrier (PLC) of HTV

SAIBO Rack
Ryutai Rack

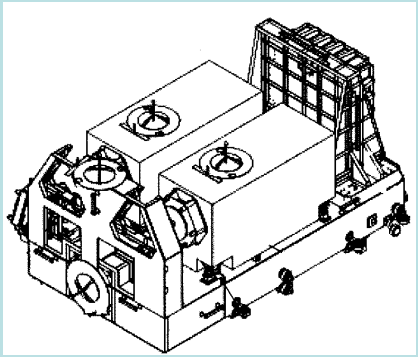
Both rack were installed in ELM-PS at NASA Kennedy Space Center.





SEDA-AP

MAXI



SMILES

HREP
US Utilization

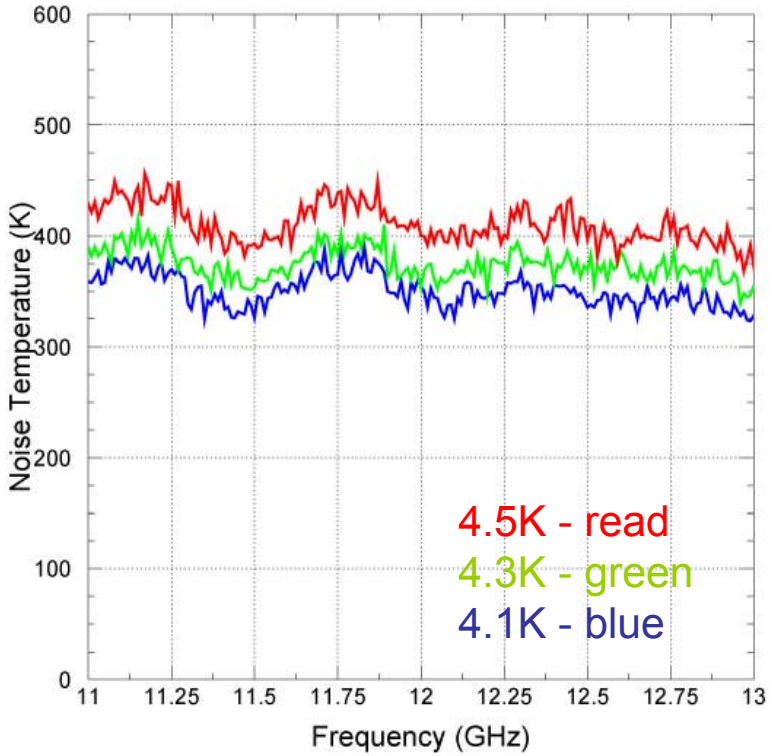
KOBIRO Rack

Development is completed

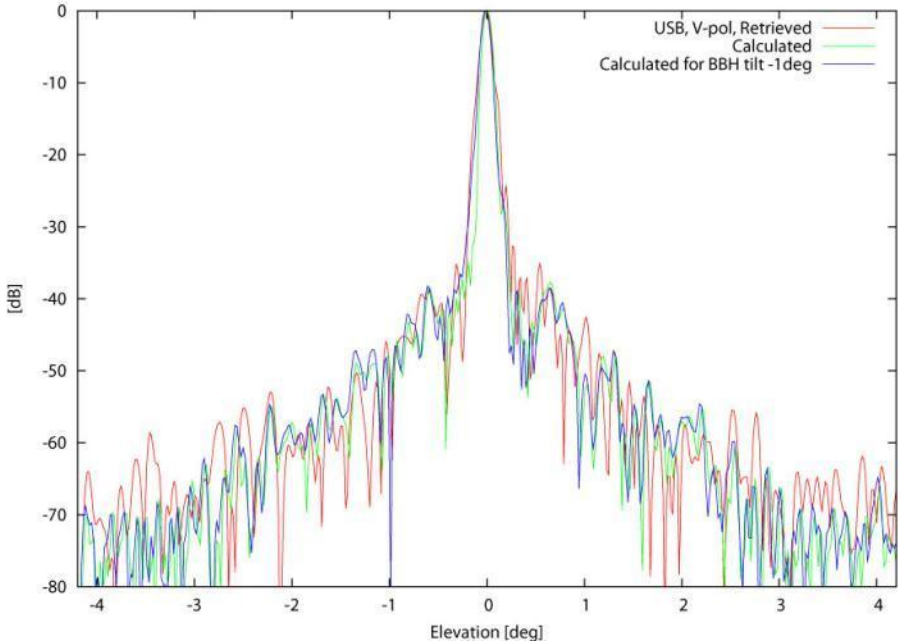
Functional test

Results from functional test – 1

Noise Temperature

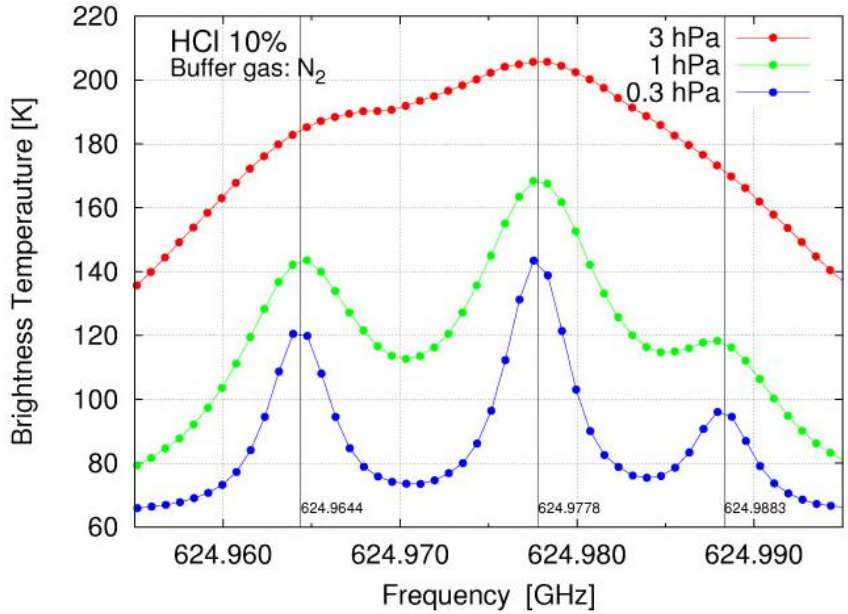


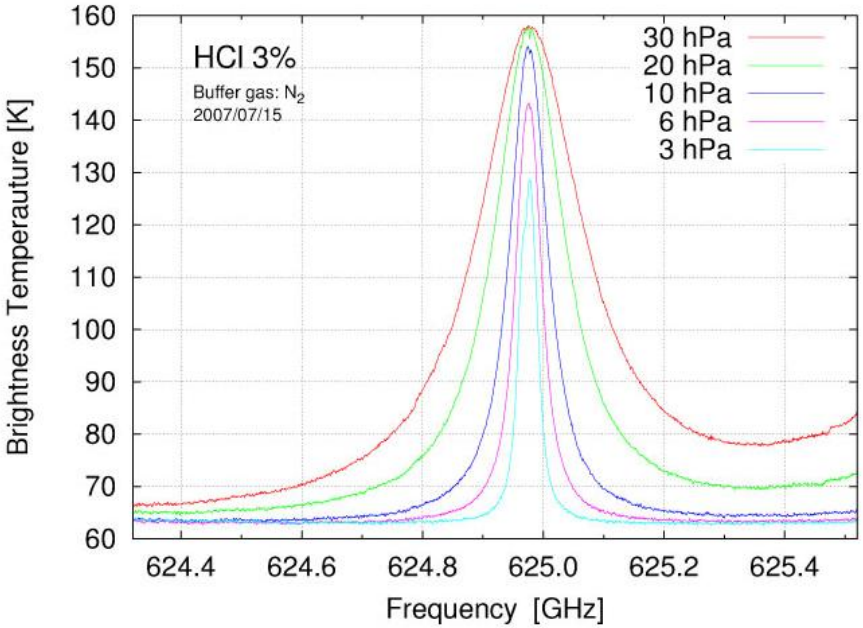
Antenna Pattern



Results from functional test – 2

Molecular Detection



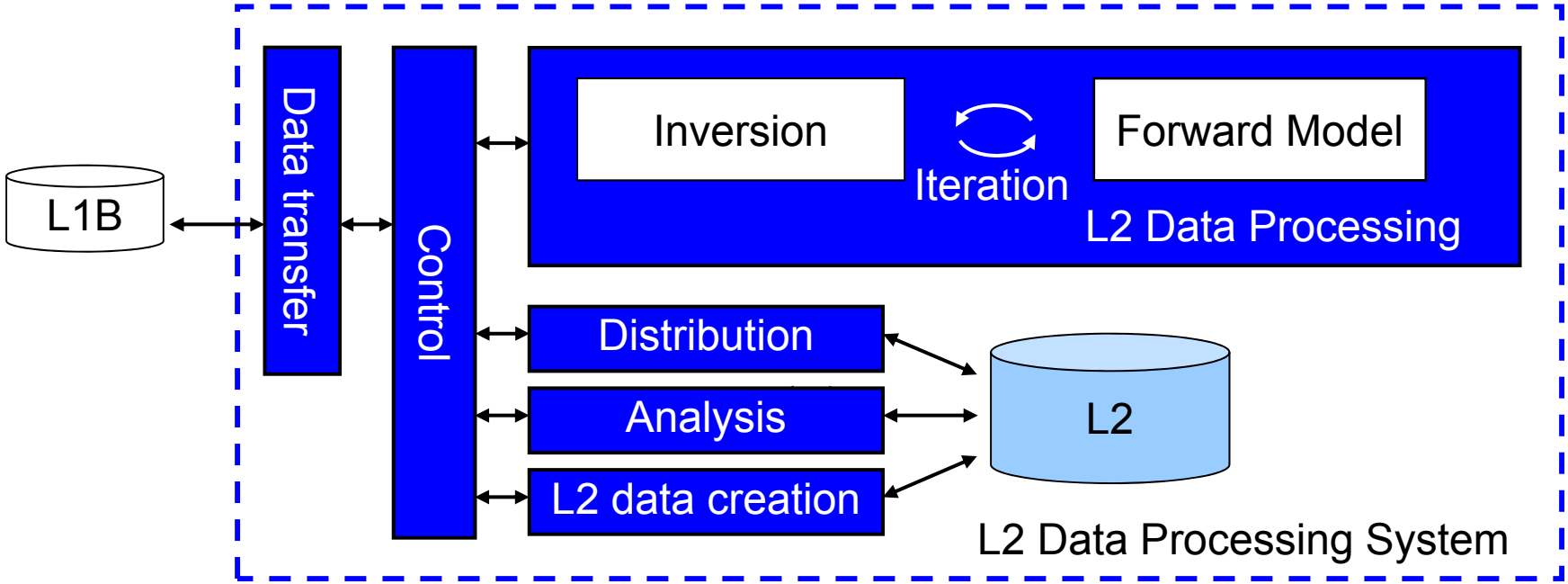


Interface testing with JEM-EF

- Interface test with JEM-EF and payloads in Dec. 2007.
- Telemetry communication between SMILES and operation system through JEM-EF was successfully demonstrated.

Level 2 Data processing system

- Level 2 Data processing
  - Convert emission spectra (Level1B data) into vertical profiles
  - Near-real-time processing (53sec./scan)
  - Automatic processing (without operators)



Summary

- JEM/SMILES will make measurements on several radical species crucial to the ozone chemistry with high-sensitivity observations.
- The SMILES instrument is now ready for launch in Tanegashima.
- SMILES will be scheduled for the launch using HTV in 2009 Sepetember.