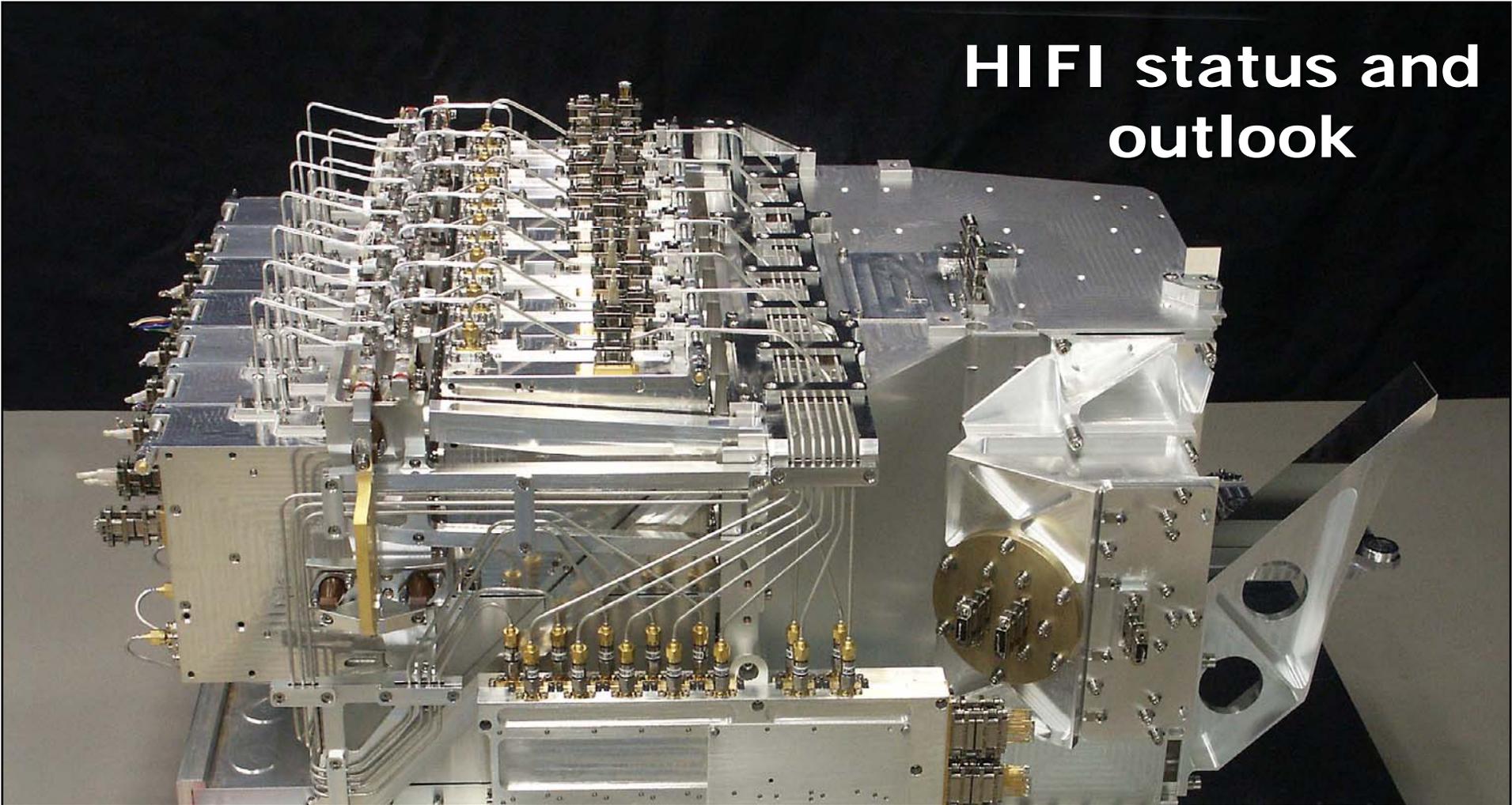


HIFI status and outlook



SRON

Netherlands Institute for Space Research

Frank Helmich, Principal Investigator for HIFI on behalf of the HIFI consortium

Netherlands Organisation for Scientific Research

Overview

- The instrument
- Scientific capabilities
- Current status
- The LCU anomaly
- Way forward



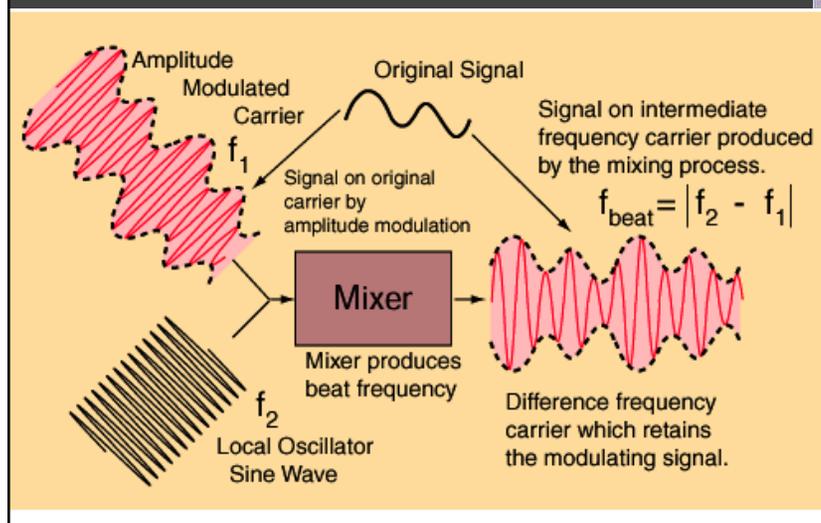
Prof. Dr. Thijs de Graauw looking at the truck (with HIFI in it) on its way to Friedrichshafen
Early July 2007

HIFI – Heterodyne Instrument for the Far-Infrared

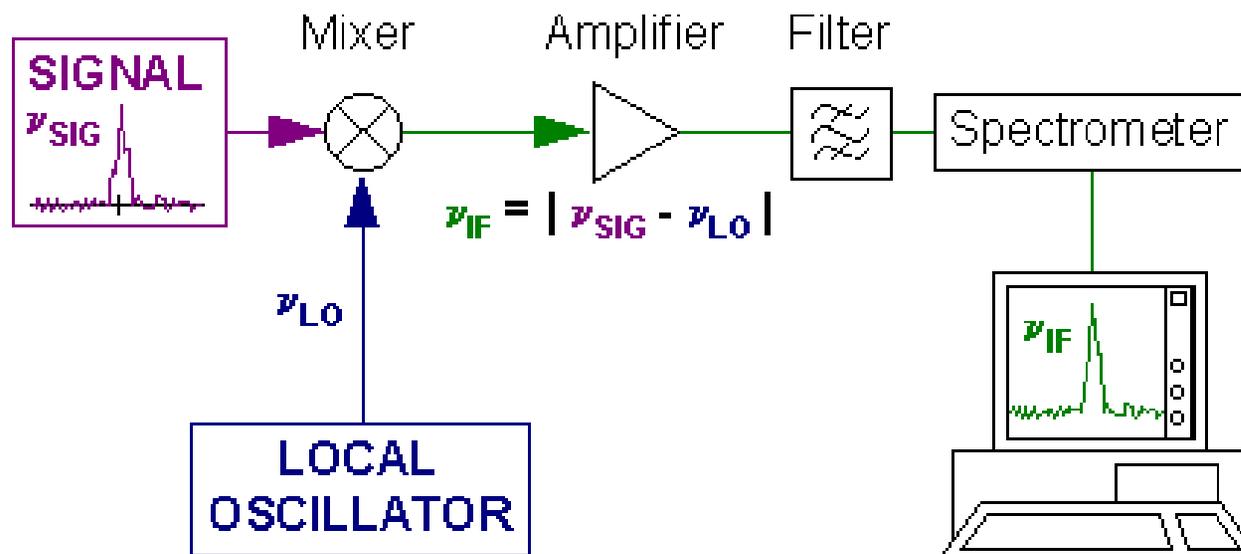
- HIFI is a high resolution spectrometer –resolutions range from 120 kHz (High Resolution Spectrometer) to 1MHz
- 0.1 km/s even at lowest frequencies
- Frequency range is 480-1250 GHz and 1410-1905 GHz
- 14 LO chains needed to cover the wide frequency range
- Intermediate frequency range is 4 GHz in lowest bands; 2.4 GHz in highest bands
- SIS mixers in lowest bands; HEB in highest
- Mixer noise less than $3h\nu/k$
- Single pixel on the sky but in two polarizations and with maximum 4096 channels
- Angular resolution 11-40"

The heterodyne principle – mixing light

- We mix the sky signal with an ultra-stable local signal such that the difference frequencies can be detected
- This difference signal can be electronically amplified and analysed
- The difference signal contains all information of the sky signal



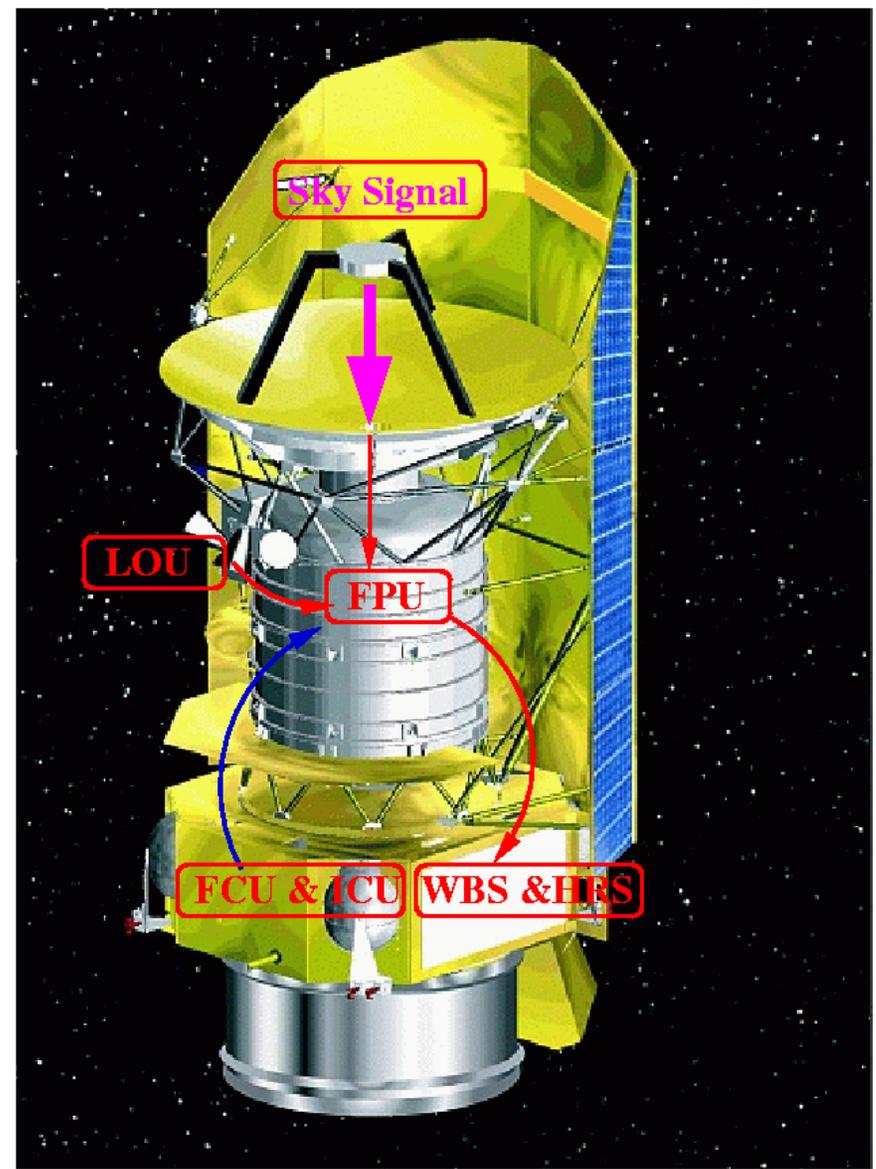
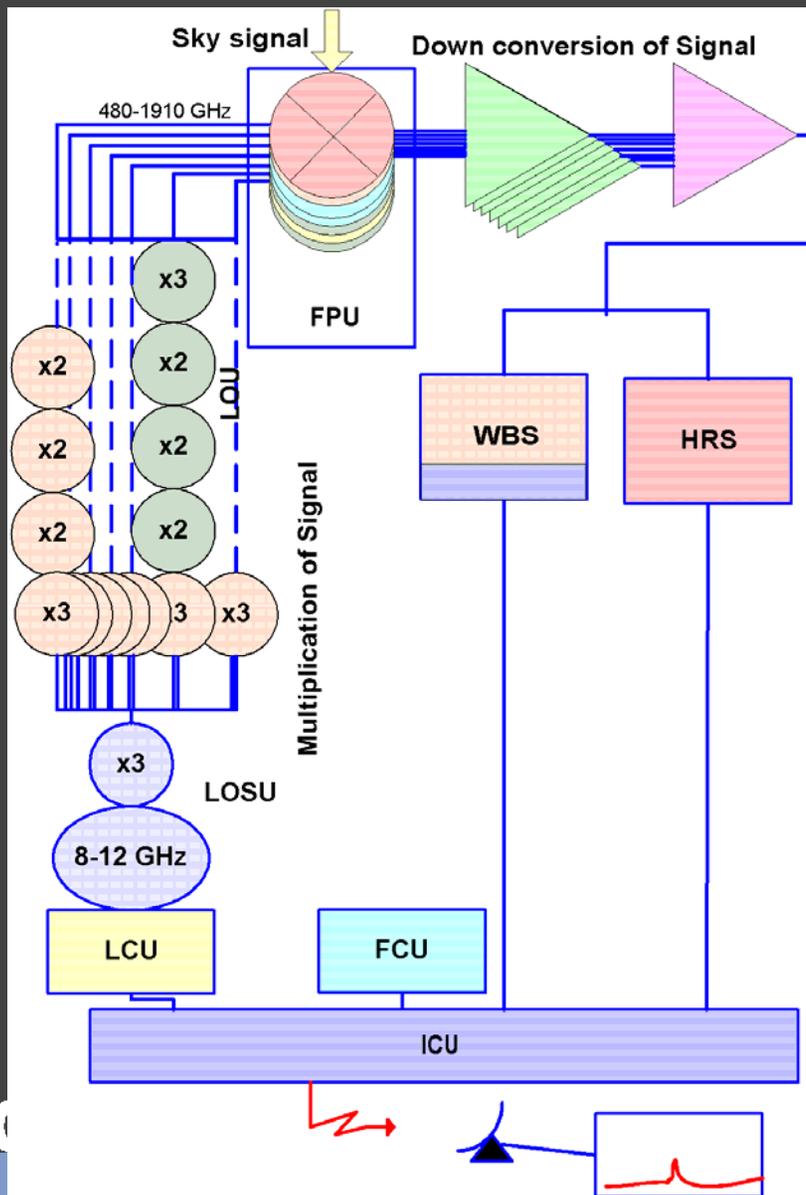
Heterodyne Spectroscopy



created by Erik Bründemann

March 1997

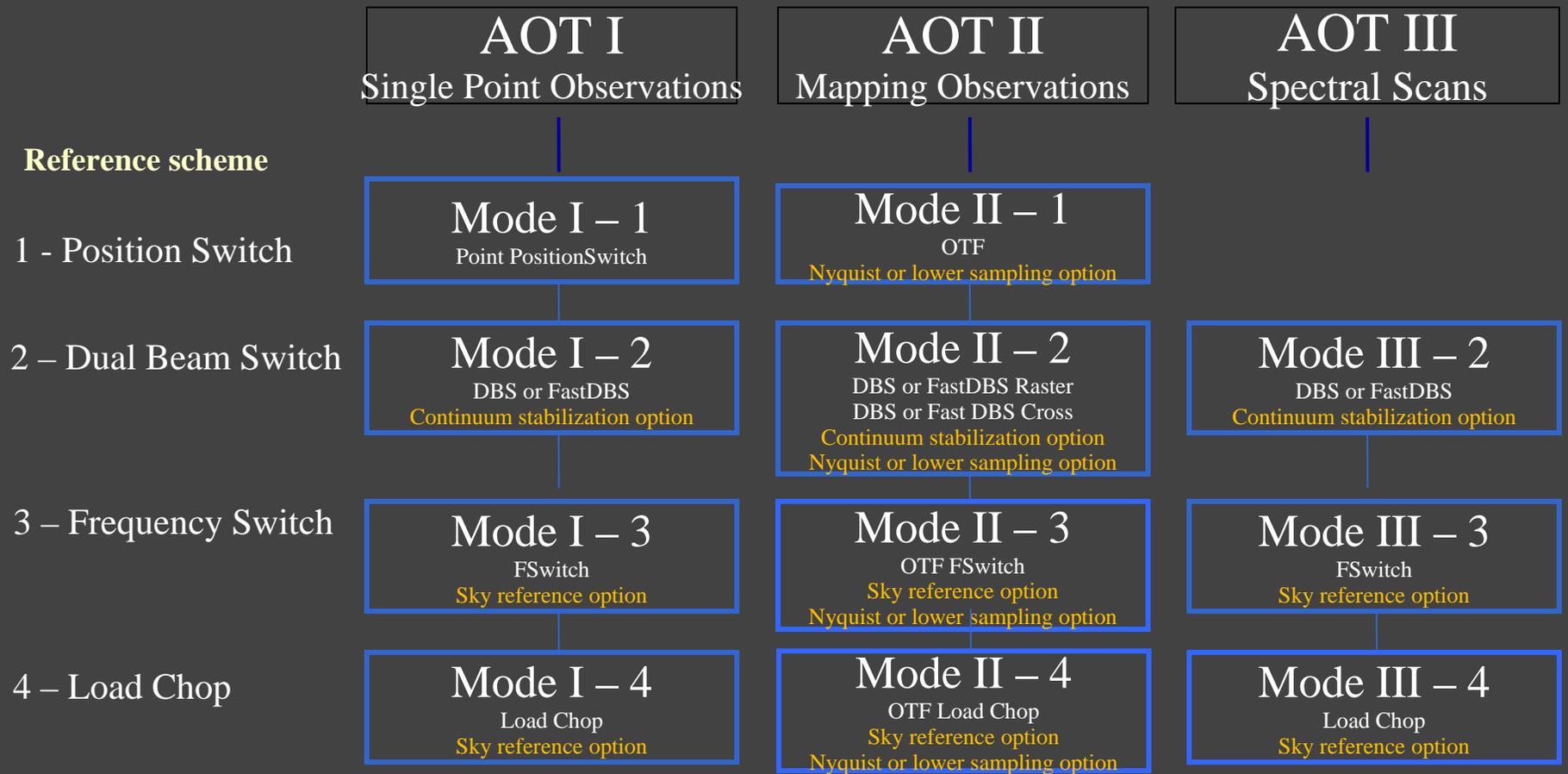
Heterodyne principle in Herschel



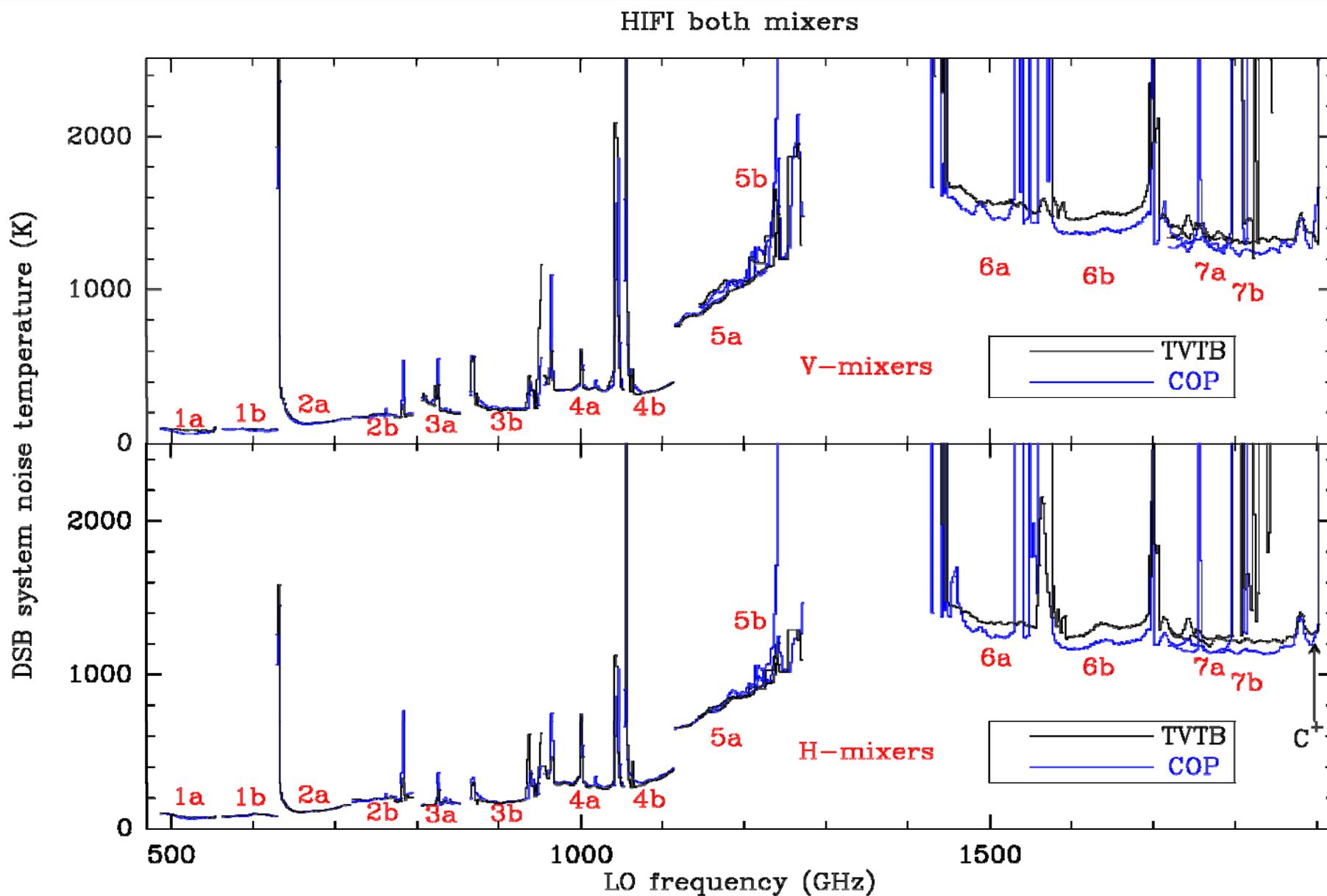
Observing modes

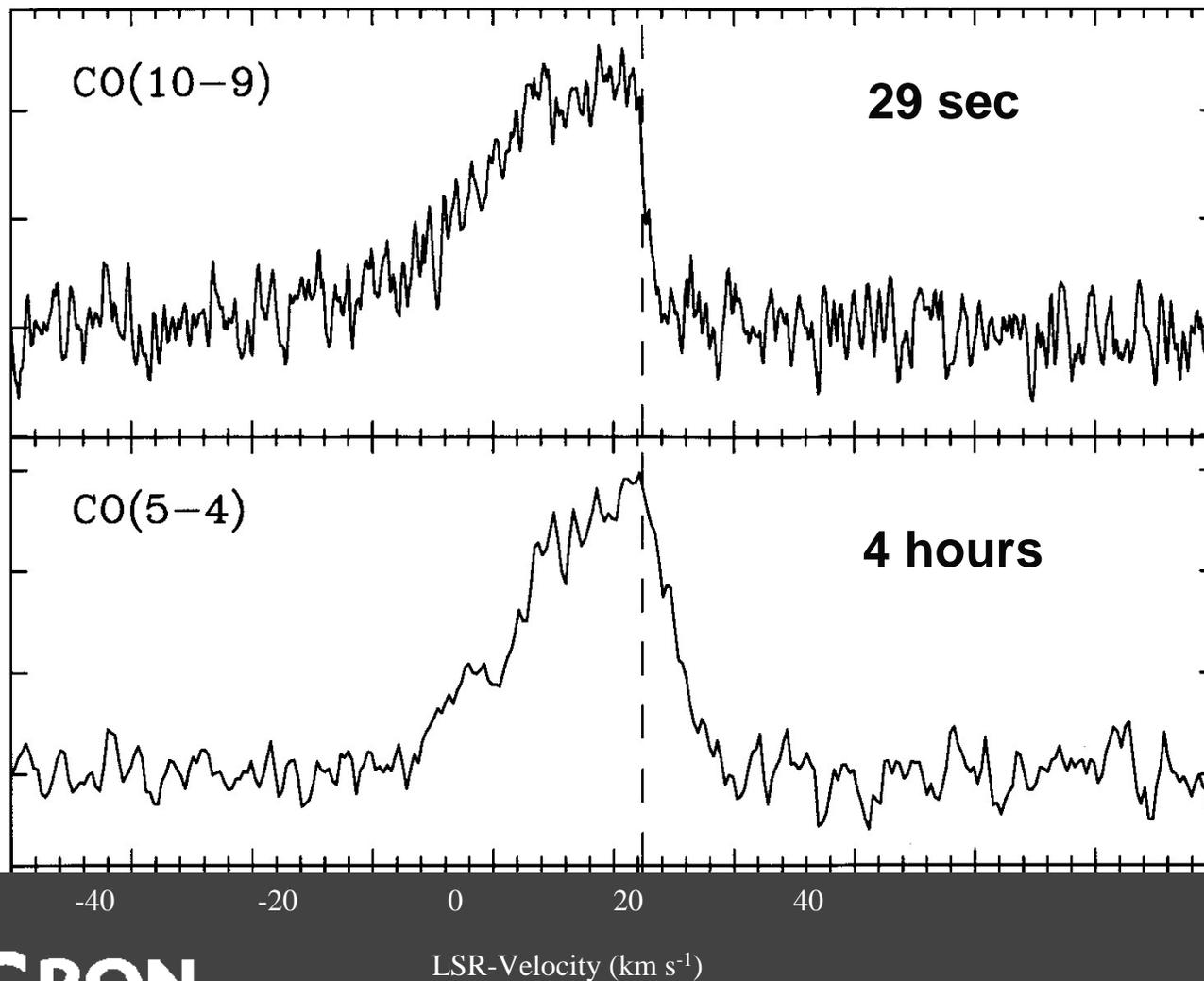
- HIFI uses standard observing techniques, as proven on ground-based observatories
- Generally a REFERENCE is needed:
 - REFERENCE can be a different direction (on the sky or on the load)
 - REFERENCE can be a slightly different frequency
- The difference signal takes out instrumental peculiarities
- For fixed pointings the Double Beam Switch (double difference) is the workhorse mode; frequency switch comes second
- In mapping On-The-Fly (OTF) is the main mode, followed by the raster scan

Performance Verification- AOT Schemes for Phase 3



HIFI sensitivity





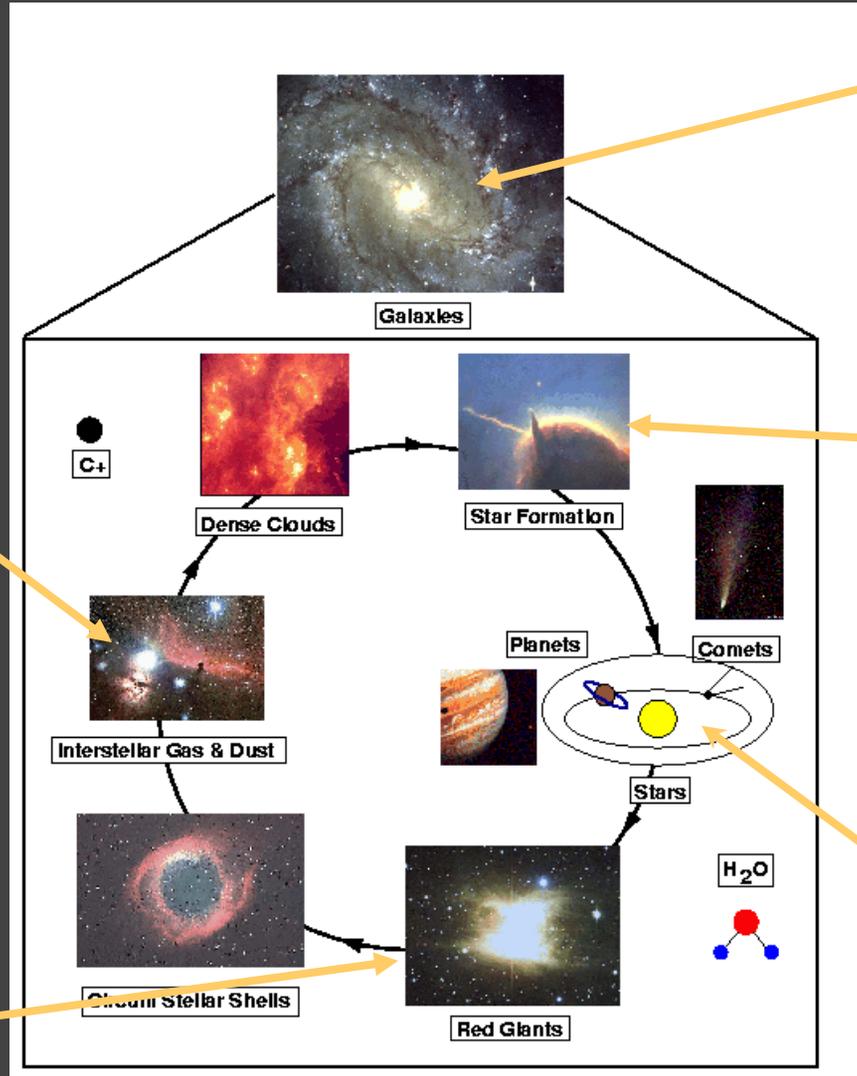
1.2 THz
Herschel-HIFI 3.5m
(L 2)

0.5 THz
Odin 1.1m
(LEO)

The life-cycle of gas and dust in galaxies

ISM in the Milky Way

- Physical conditions
- Chemistry
- Energetics
- Dynamics
- Isotopic gradients



ISM in Galaxies

- Physical conditions
- Star formation

Star formation

- Physical conditions
- Chemistry
- Energetics
- Dynamics
- Role of Water

Solar System

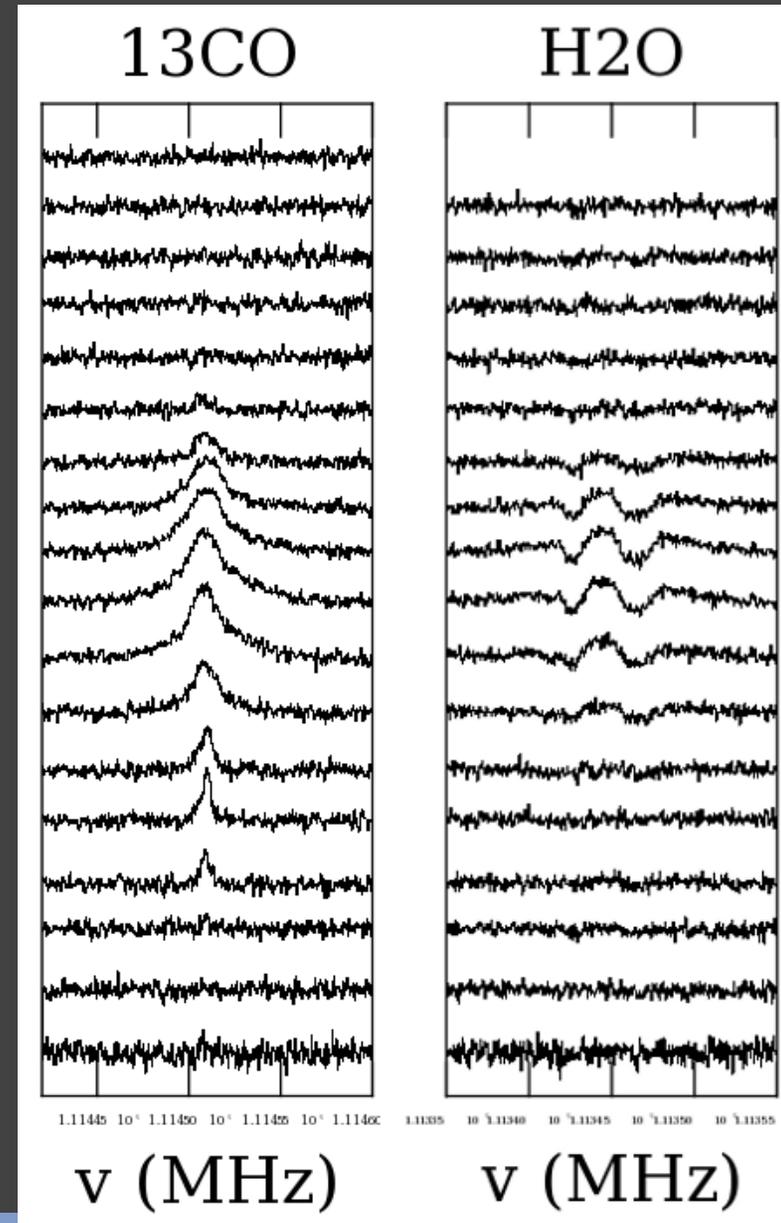
- Water in Giant Planets
- Chemistry Martian atmosphere

Stellar evolution

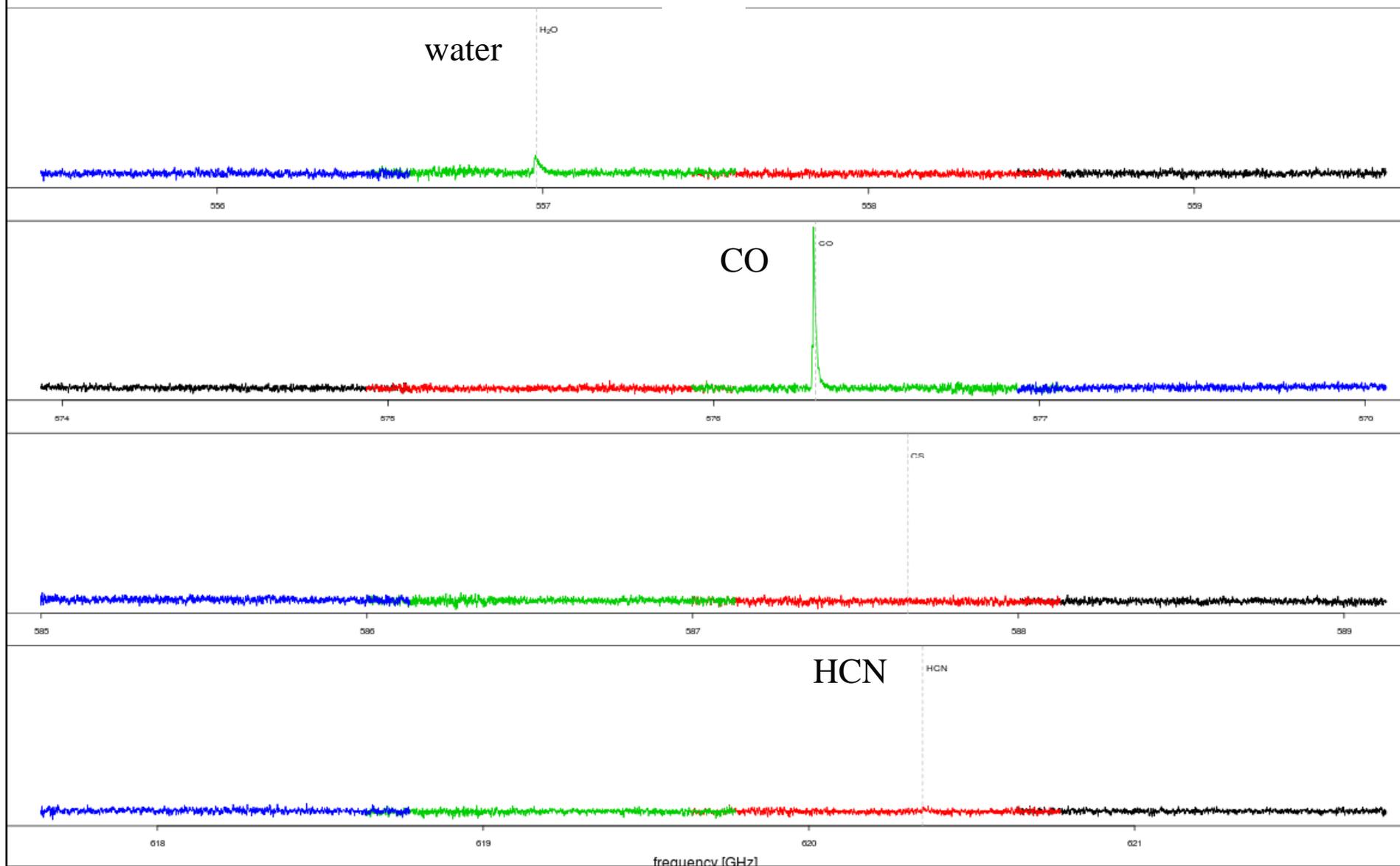
- Mass loss
- Composition

Science capabilities - Water

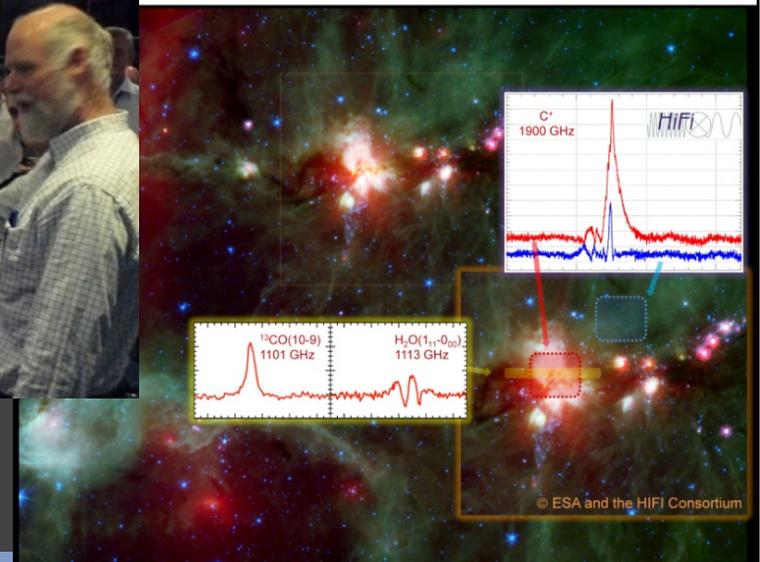
- Water can be used as chemical and physical filter to probe many different temperature and density regimes
- Line profiles carry this information



Science Capabilities – Spectral Surveys

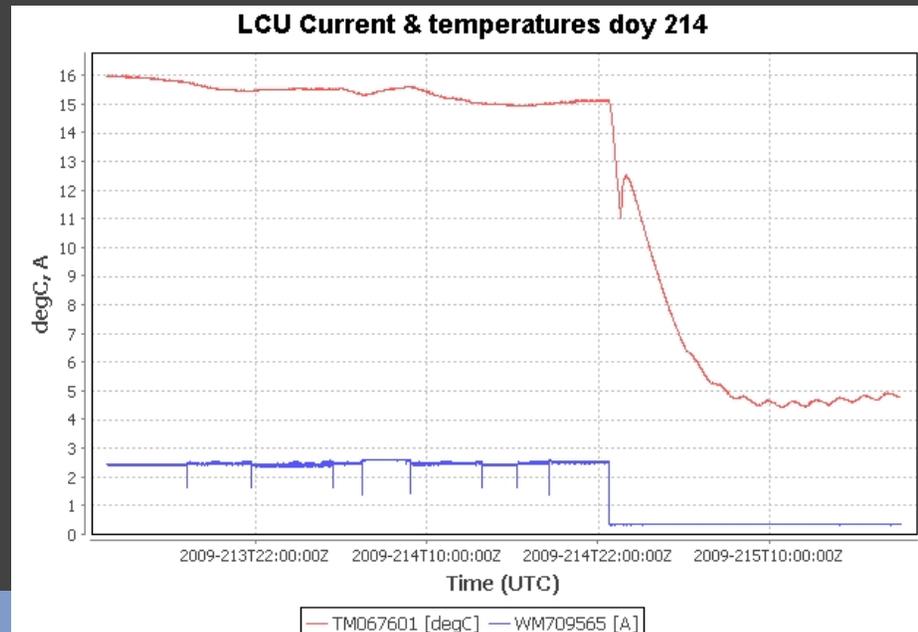


HIFI in pictures



The anomaly

- In OD81 at DTCP (August 3rd) HIFI was found with unknown LO status '14'
 - Change had occurred at 22:45z
 - HIFI LCU current had dropped to from 2.5A to 0.36A
 - Panel temperatures were dropping
 - HK for the LO subsystem contained many invalid values
 - No communication ICU-LCU
 - Restart (10th August) only restored communication, current was 0.36A



The LCU anomaly - history

- Timeline of events
 - 2nd August anomaly – HIFI team starts research
 - End August – ESA senior investigation team starts
 - End September – basic scenario uncovered
 - October – scenario refinement, design mitigating measures
 - November – full implementation and validation

A big Thank You to all involved in the investigation

- Teams involved
 - HIFI research team ~ 20 persons (HIFI consortium)
 - ESA senior investigation team ~ 10 persons
 - HIFI steering committee review team – 4 external specialists
- Review process
 - Thursday 26 November – ESA briefing
 - Monday 30 November – HIFI internal review 1st week
December switch-on readiness review (telecon)

Anomaly scenario

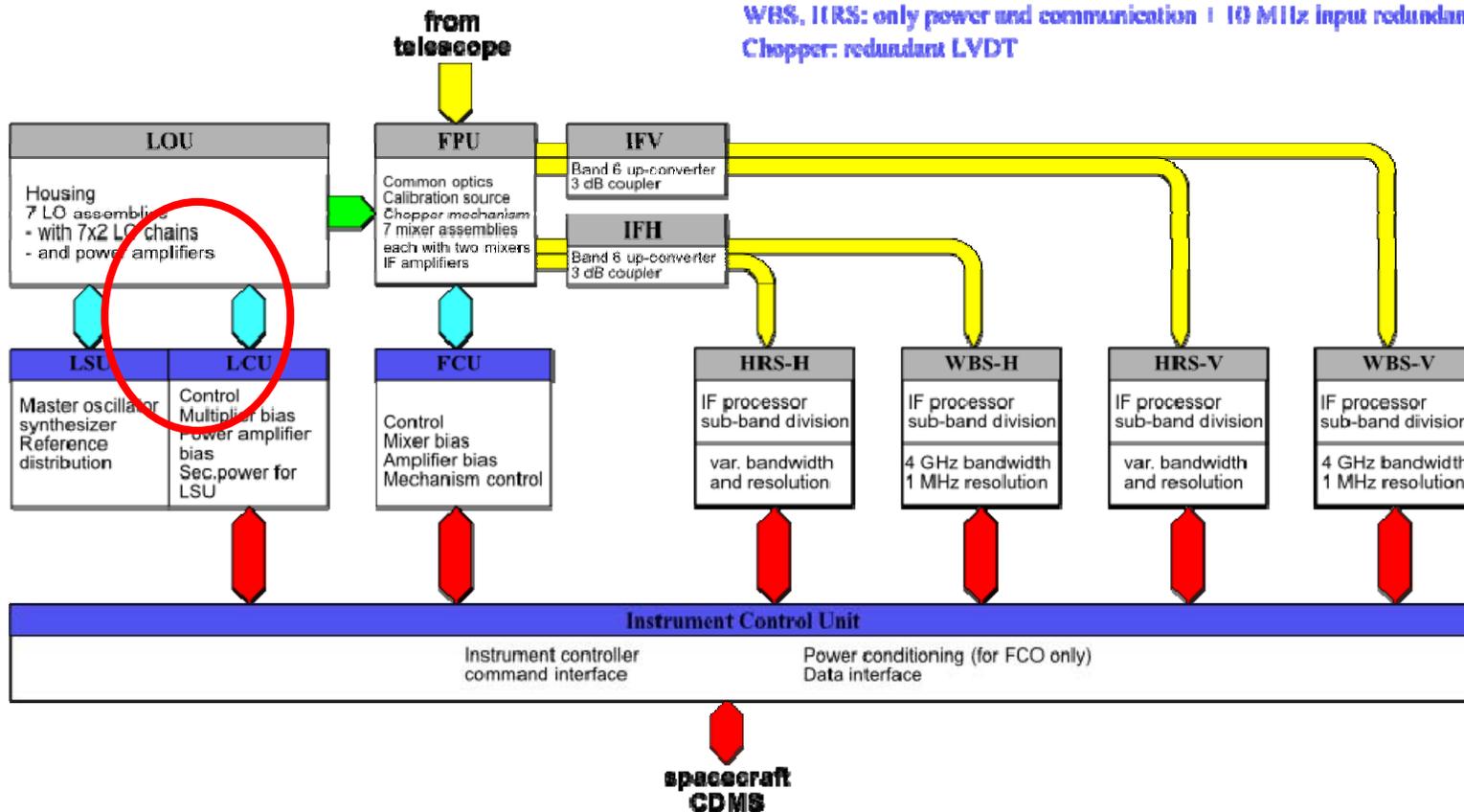
1. A single event upset corrupted the LCU memory.
2. Bit-flip brought the micro controller in non-communicado condition
3. Micro controller jumped to an erroneous program location
→ executed program code not meant for use during normal operation
4. After 1.6 sec. standby relay was switched
→ unit went instantly from full operational to standby
5. Power drop generates voltage transient on the internal 28V bus
→ fatal for a secondary rectifier diode in HRS4 DC/DC converter
6. End result:
 - instrument in stand-by
 - no LCU-ICU communication
 - LCU drawing ~0.36A (nominal is 2.8A)
 - significantly decreased power dissipation → unit/panel temperature drop

Important note; *NO* other scenario explains *all* observed behavior

HIFI units/redundancy

HIFI redundancy

ICU: fully redundant
 LSU: fully redundant
 FCU: redundant common board supplies mixer, diplexer, IF boards
 LCU: inputs, input EMC filters, DCDC converters, bias generators
 WBS, IRS: only power and communication + 10 MHz input redundant
 Chopper: redundant LVDT



The Priority Science Programme

The Science User Requirements Document defines HIFI's unique science:

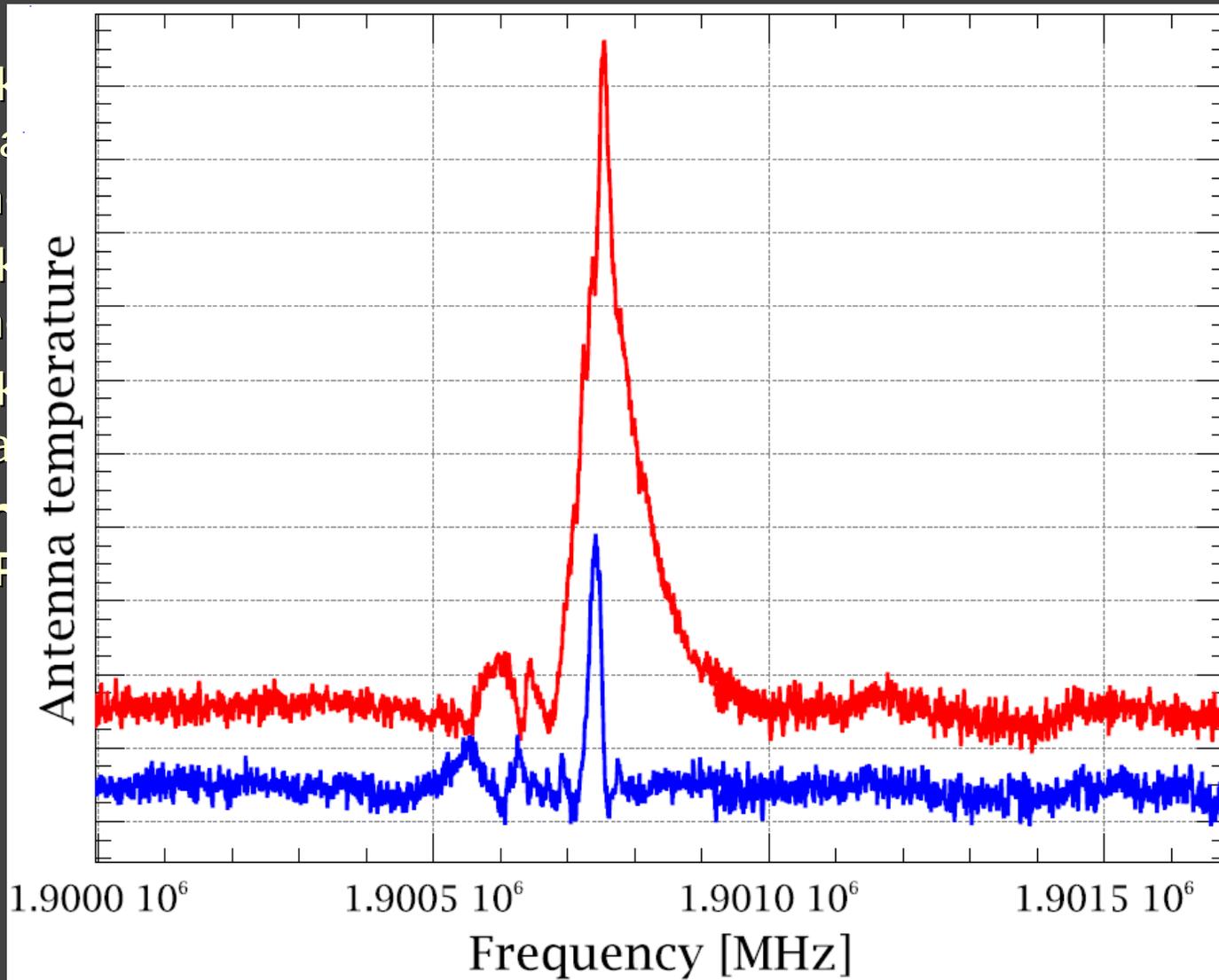
- HIFI is a versatile instrument
- Water lines to probe the role of water in the physics and chemistry in the Universe
- Unbiased spectral line surveys which will provide a new view of the molecular inventory and the physical conditions in space
- In addition:
 - Biased spectral surveys to probe chemistry
 - Atomic fine structure lines (CII/NII) to probe the ISM of galaxies, in particular the dynamical aspects
- The PSP is ~400 hours of HIFI unique observations largely selected from the GT & OT KPs
- PSP is fundamentally a rescheduling issue

Way forward – PV and PSP

- December 6/7: switch-on of redundant ICU and FCU plus HRS-V and WBS-V; upload of new OBSW; switch-off of HIFI
- January 10-12: Switch on of HIFI; temperature stabilization of the LO S/S; Short Functional Test on LO; Re-commissioning i.e. commissioning of the redundant electronics
- Middle of January: start of Performance Verification
 - Emphasis on Double Beam Switch modes
 - Release of DBS modes
- End of January: start of the **Priority Science Programme**
- February/March:
 - Release of OTF mode and rest of PV
 - Priority Science Observations
- April onwards: PSP-II or Routine observations

Conclusion

- I thank hardware
- I thank and the
- I thank this ha
- I wish HIFI P



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