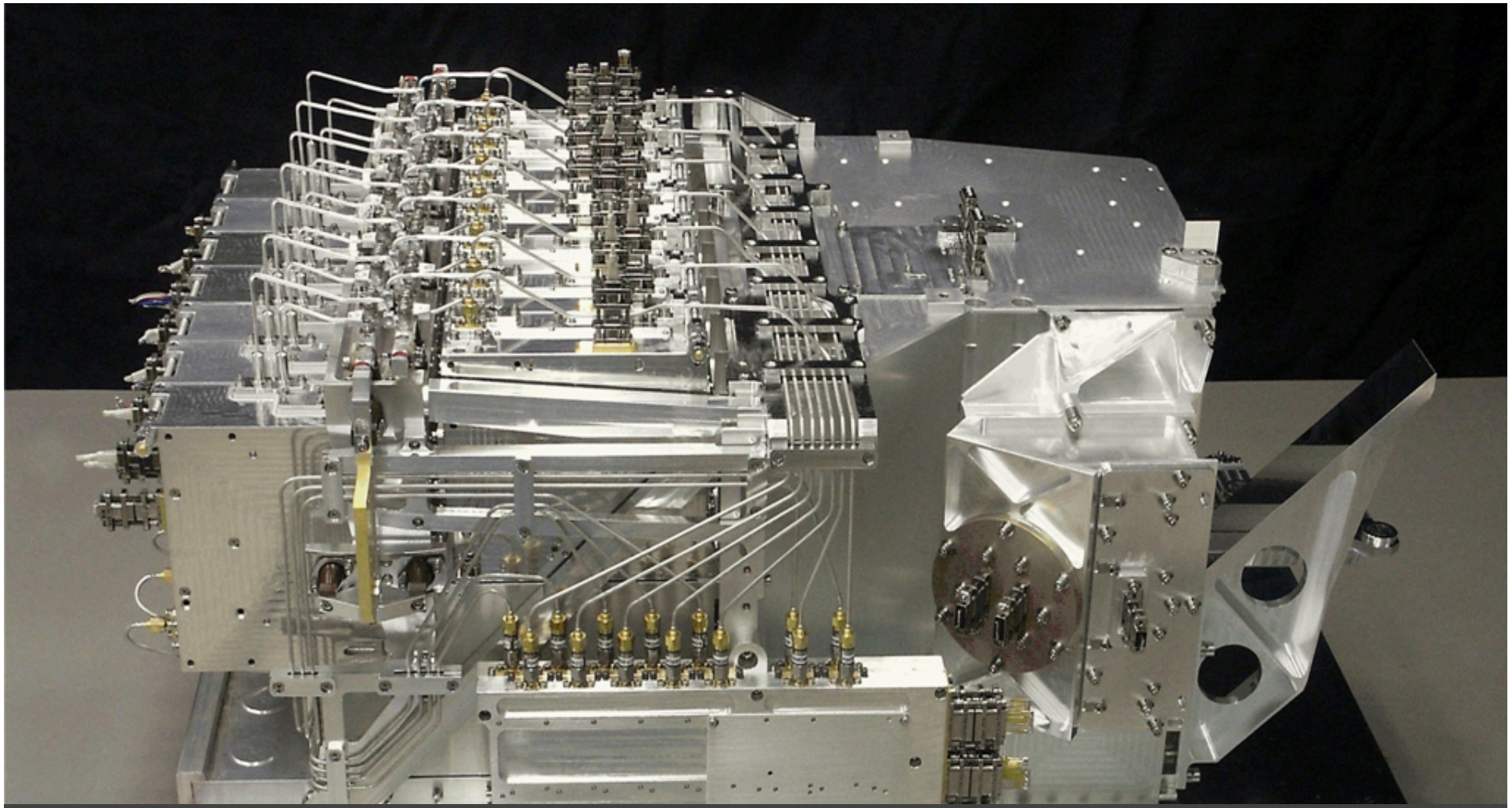

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Netherlands Institute for Space Research

# HIFI status and science high-lights

Frank Helmich – Principal Investigator for HIFI

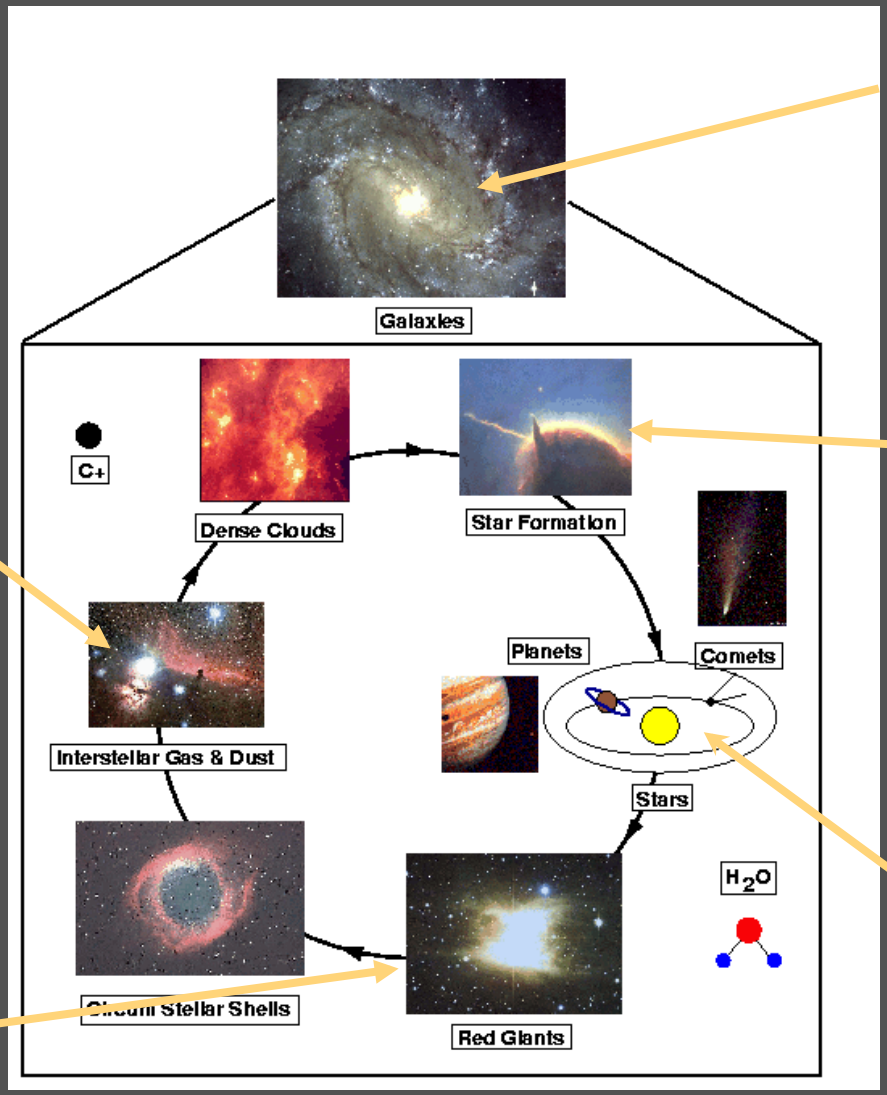
Netherlands Organisation for Scientific Research

# Overview

- Science
- Instrument status since SDP workshop
- Commissioned observational modes and AOTs
- Problem areas and other issues
- Science highlights

# 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

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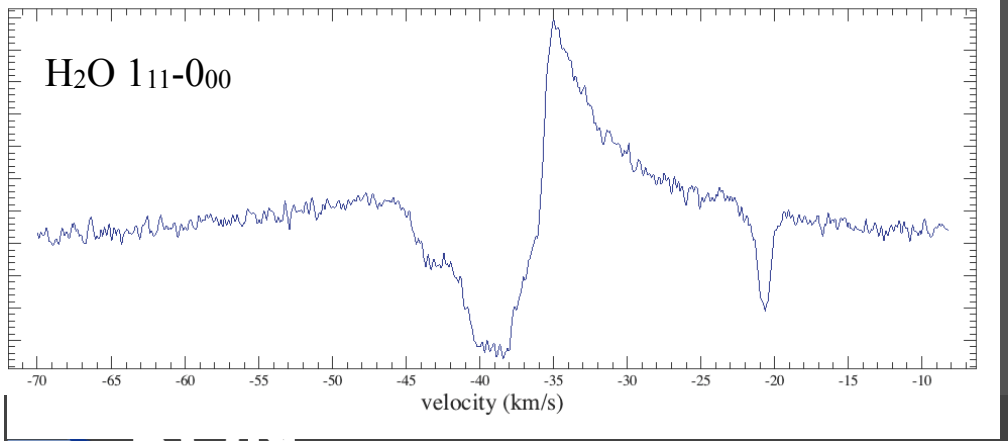
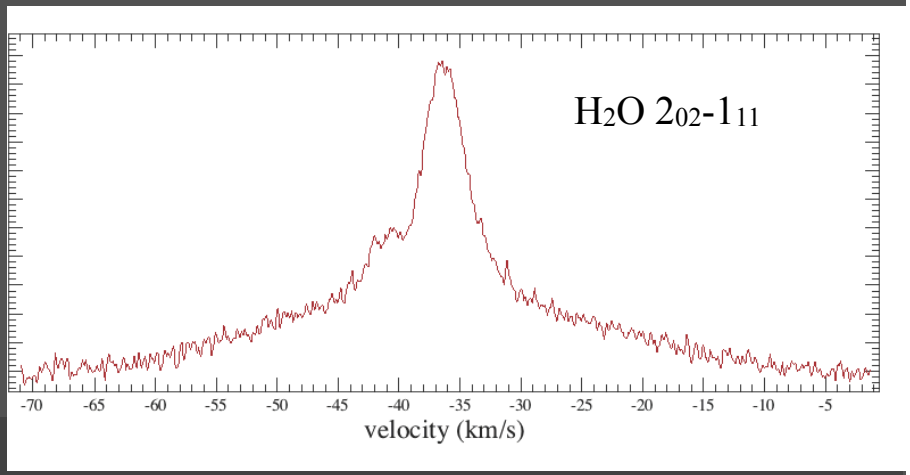
# Science

- HIFI can be used for many astrophysical questions for which ultra-high spectral resolution is required
- This delivers:
  - Kinematics and dynamics
  - To avoid line confusion
  - To discriminate between emission and absorption



## HIFI status

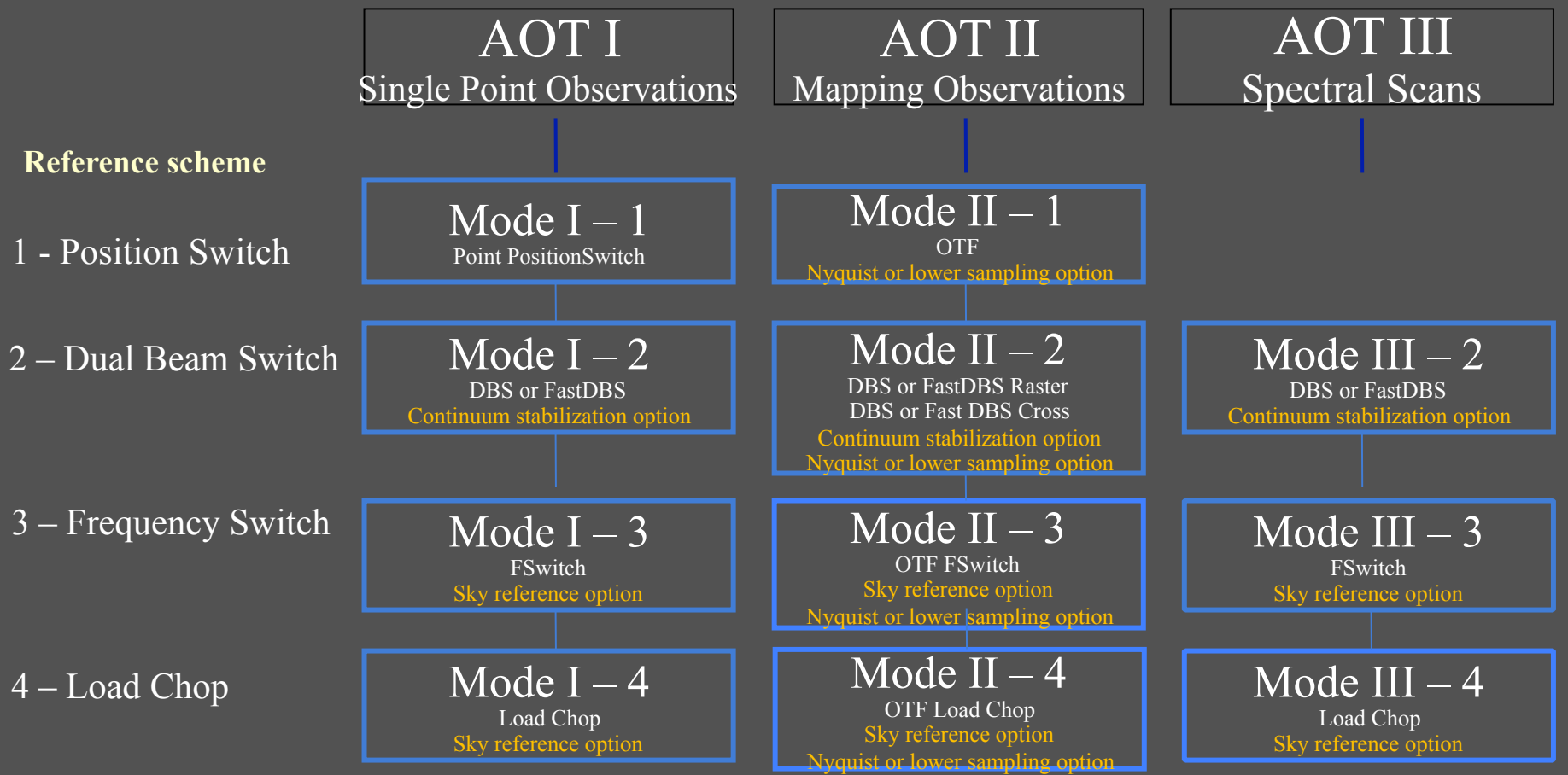
- August 2009: LCU (Local Oscillator Control Unit) anomaly
  - Single event upset in memory bank of LCU
  - Microcontroller confused and starts a “reboot”
  - The standby relay is switched
  - a diode failed in one of the DCDC convertors
- January 2010 and further
  - Restart of HIFI with redundant electronics
  - A short recommissioning is done of the redundant electronics
  - An accelerated Performance Verification is started
  - Double Beam Switch point modes are released
  - Priority Science Programme started
  - Other pointed modes released

# HIFI Status (continued)

- We have experienced 4 SEU's since the start-up in January
- Some time has been lost, but no harm is done to the instrument
- The instrument is never switched-off completely: the LCU is kept in a so-called dissipative mode

- Software is in place to detect SEU's and to trigger actions in the instrument or of the MOC during the DTCP, HIFI personnel on stand-by
- We expect to do once every year a power cycle of the LCU

# Performance Verification- AOT Schemes for Phase 3

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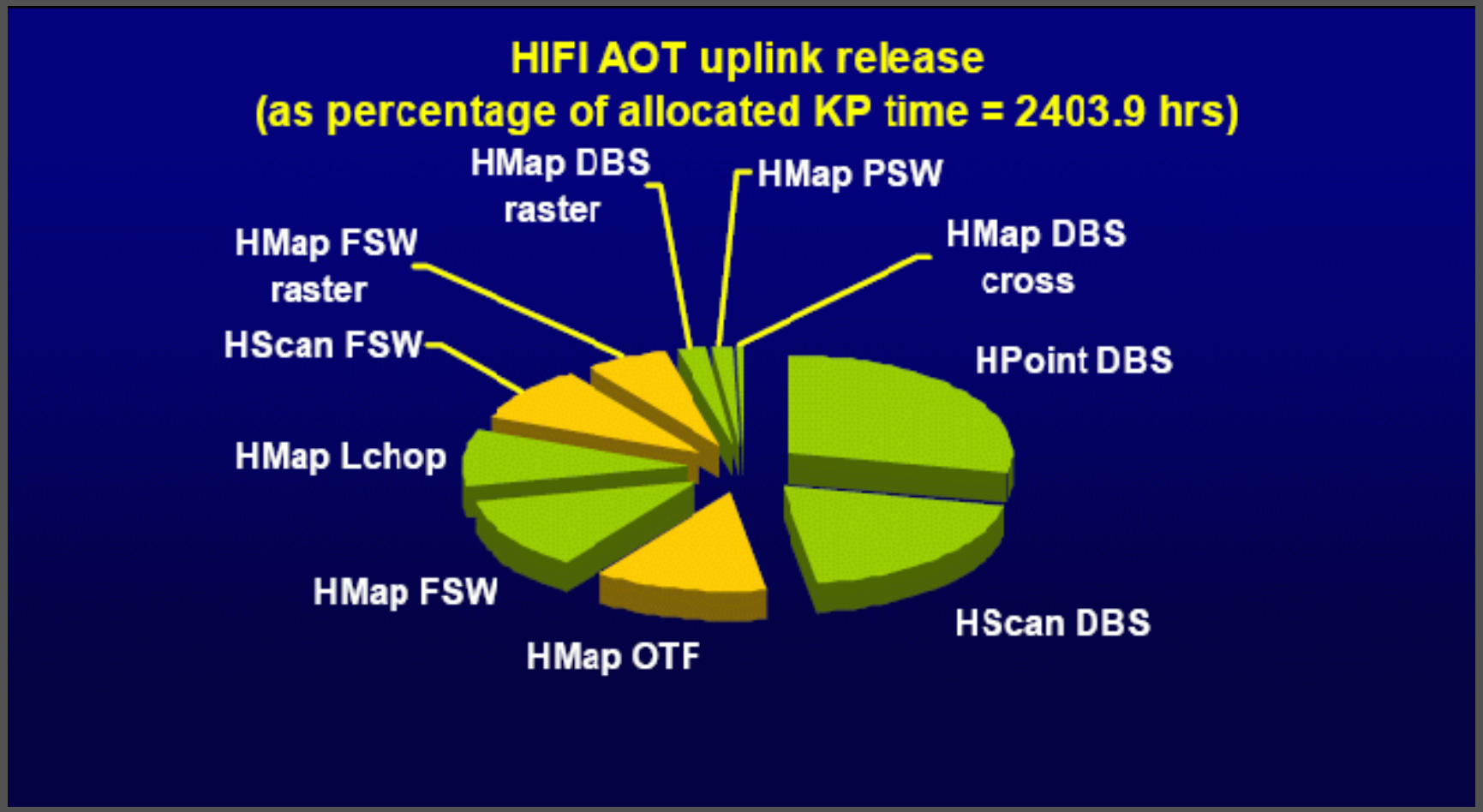
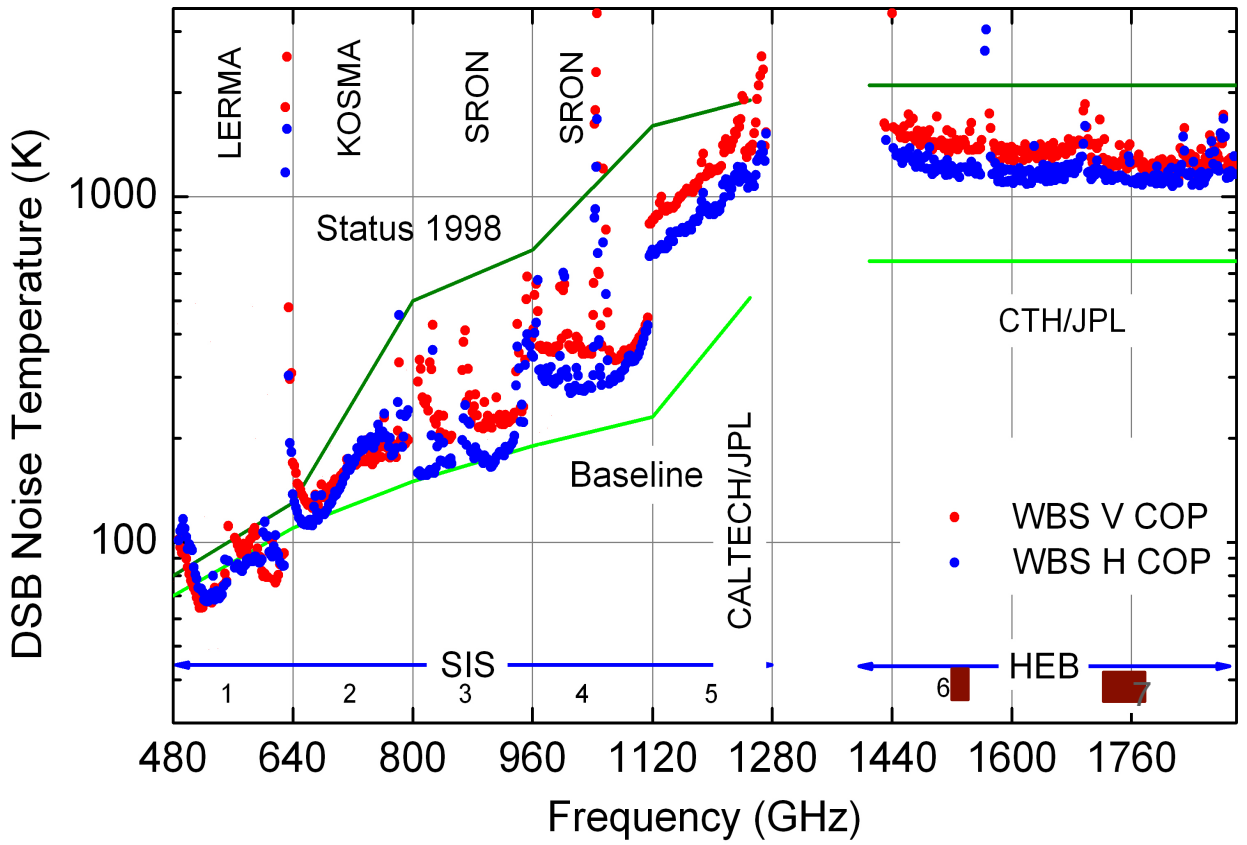
# AOTs and mode release




http://herschel.esac.esa.int/AOTsReleaseStatus.shtml

Release notes are available

# System Temperature/radiometry




The noise in the measurements generally corresponds very well with the HSPOT predictions

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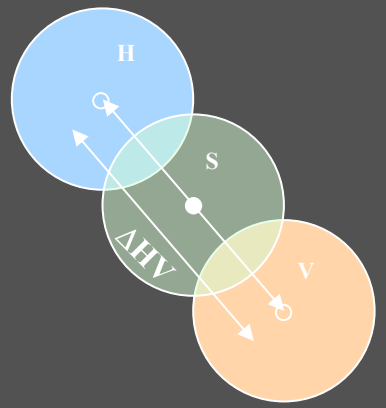
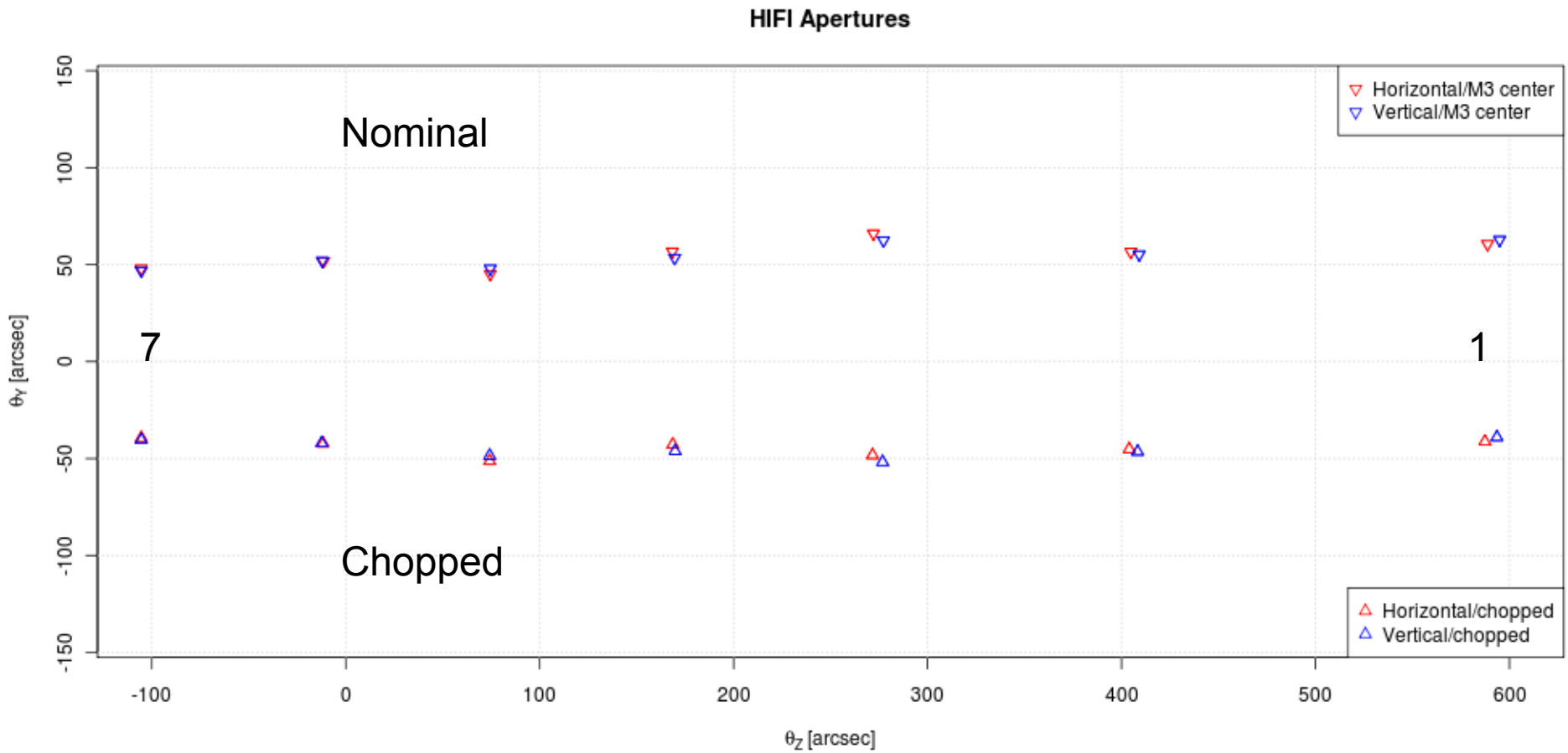
# Pointing and beam properties

- HIFI measures two polarizations simultaneously in essentially one single pixel
- HIFI is not well suited for determining pointing offsets or drifts
  - No SIAM update done lately
  - Track this in routine calibrations
- Co-alignment between pixels is very good but not perfect –> pointing towards synthetic aperture




| Band | f (GHz) | λ (mm) | FWHM (“) | $\Delta HV_{ILT}$ in Y; Z (“) | $\Delta HV_{COP}$ in Y; Z (“) | Coupling loss (%) |
|---|---|---|---|---|---|---|
| 1 | 480 | 0.625 | 44.3 | -14.5; +1.5* | -6.2; +2.2 | 0.8 |
| 2 | 640 | 0.469 | 33.2 | -4.3; -1.5 | -4.4; -1.3 | 0.7 |
| 3 | 800 | 0.375 | 26.6 | -5.1; -4.3 | -5.2; -3.5 | 1.9 |
| 4 | 960 | 0.312 | 22.2 | -1.5; -2.2 | -1.2; -3.3 | 0.9 |
| 5 | 1120 | 0.268 | 19.0 | +1.5; +3.6 | 0.0; +2.8 | 0.8 |
| 6 | 1410 | 0.213 | 15.2 | +0.7; 0.0 | +0.7; +0.3 | 0.1 |
| 7 | 1910 | 0.157 | 11.2 | +0.7; -1.5 | 0.0; -1.0 | 0.2 |

# HIFI apertures on M3 (pick-off mirror)

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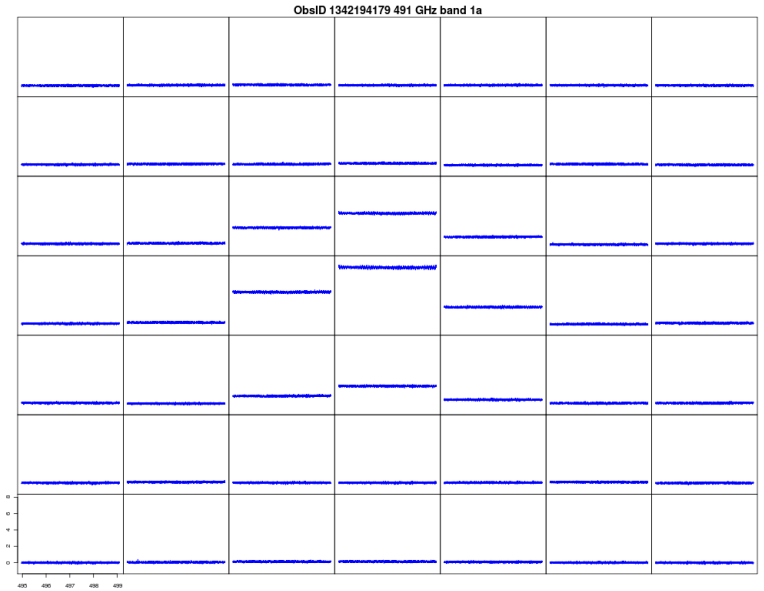
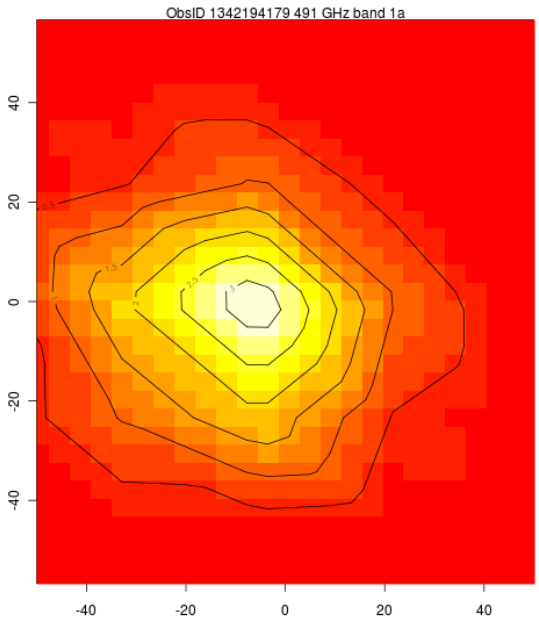
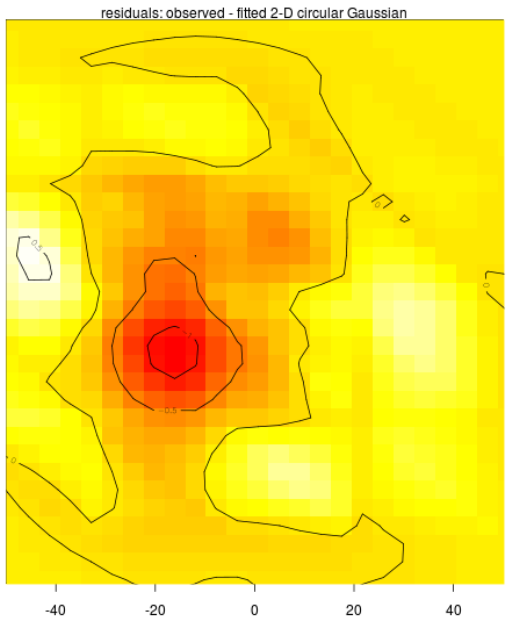
# Beam maps and beam profiles

- Measurements have been made on Mars for every HIFI band a few weeks ago and analysis is ongoing




Band 1 spectra (left), simple triangulation (below, left) and residual after Gaussian beam subtraction (below, right)

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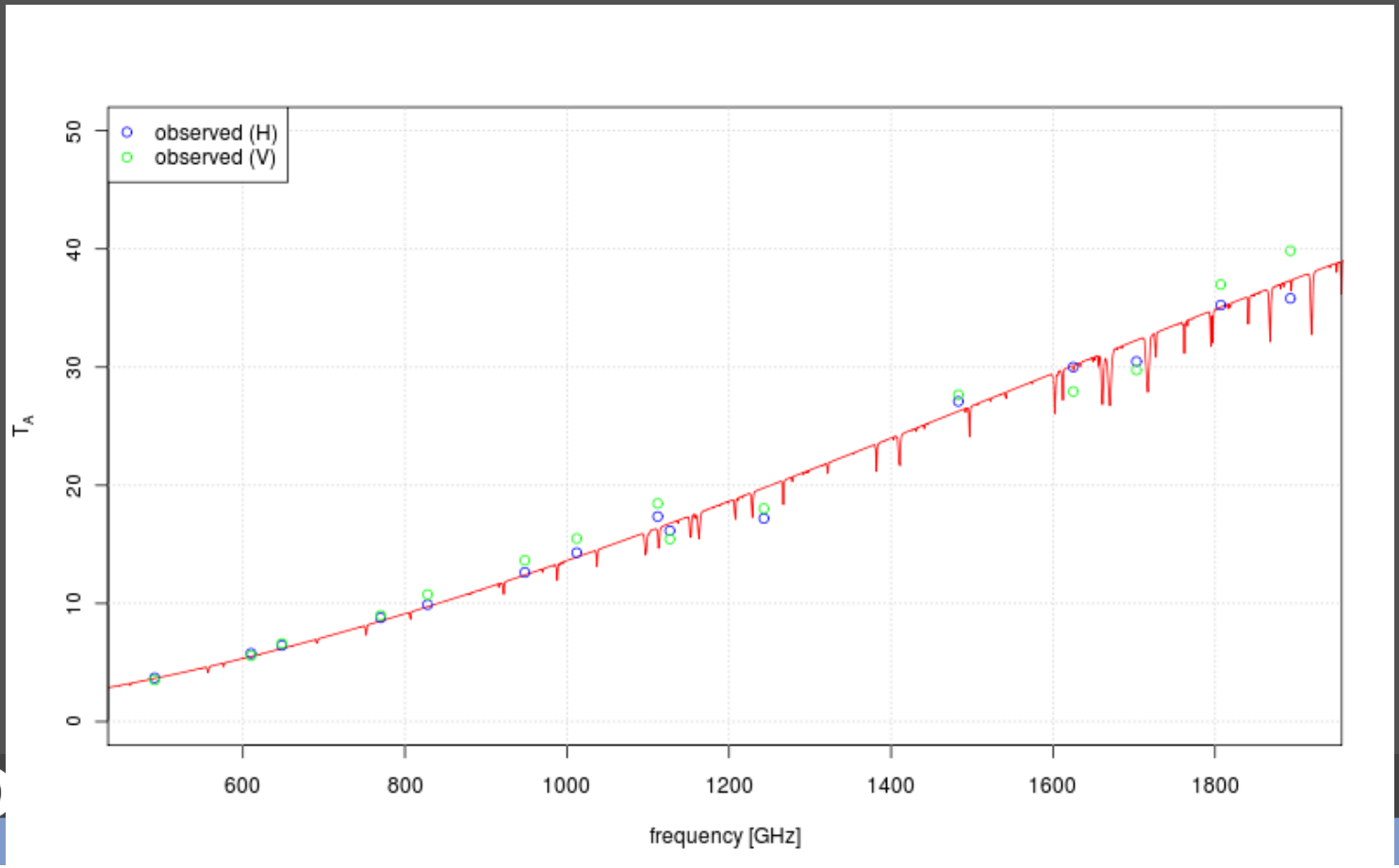
# Beam efficiencies

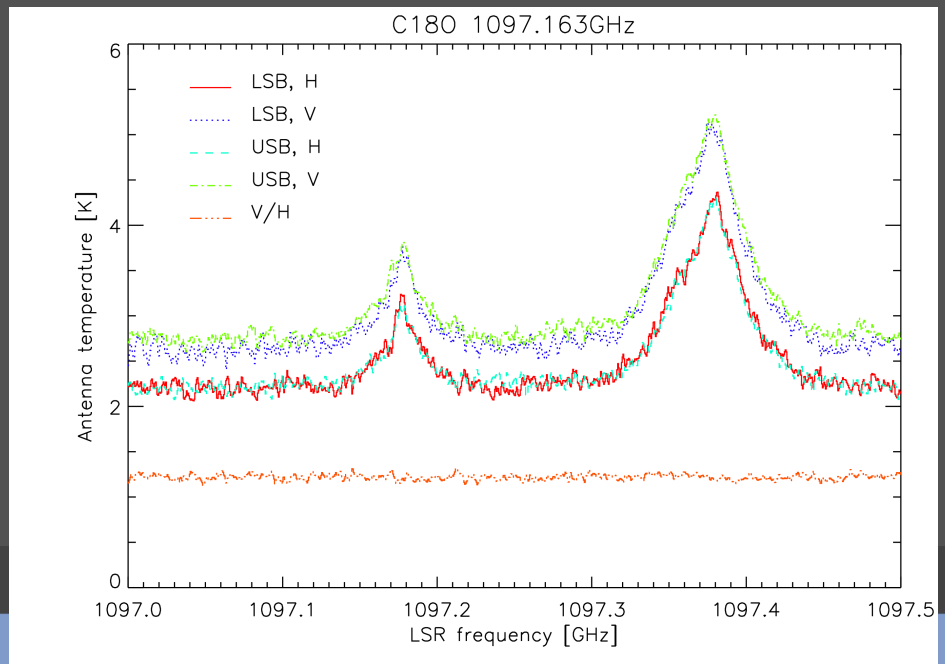
- Observations were confronted with Mars model
- Forward efficiency = 0.96
- Beam efficiency = 0.657+/-0.015
- Aperture efficiency = Beam efficiency/1.015



# Polarization

- HIFI's H and V polarization do not always yield the same intensities
- Due to the source or to the instrument?

- We have not found any instrumental polarization (yet)
- All (but one) can be explained by source structure and the not perfect co-alignment

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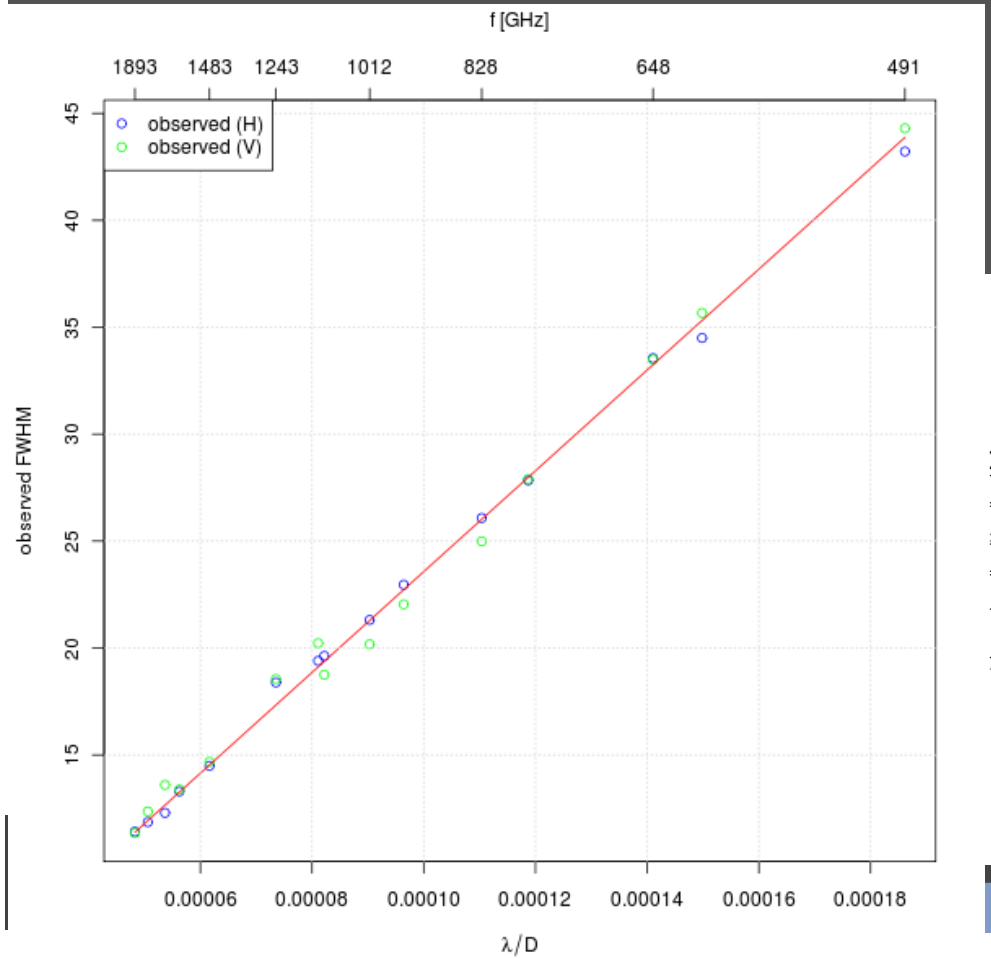
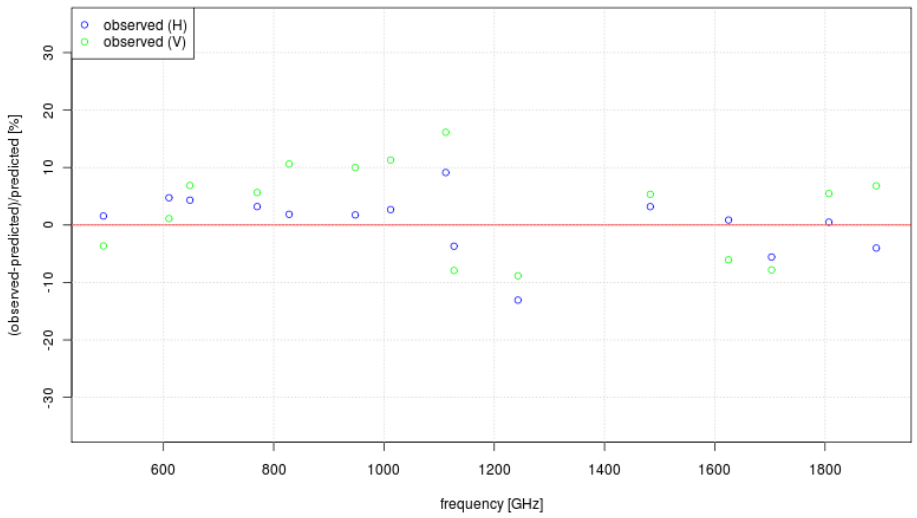
# Beam efficiencies and beam widths

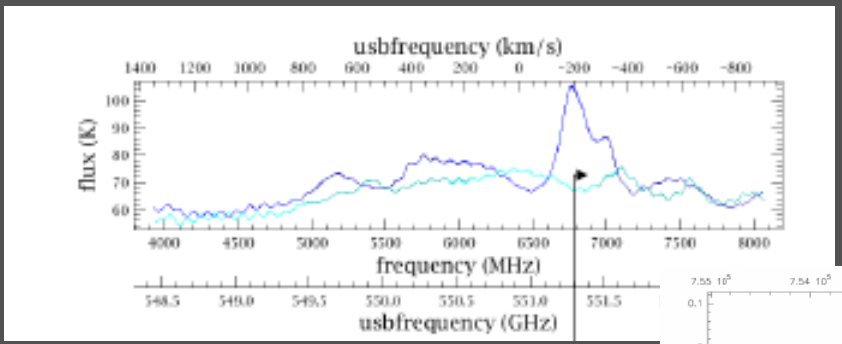
- Beam width fitted very well by theoretical predictions, but with a 9.7dB edge taper rather than the expected 11dB
- Why is the residue in Band 5 so low?

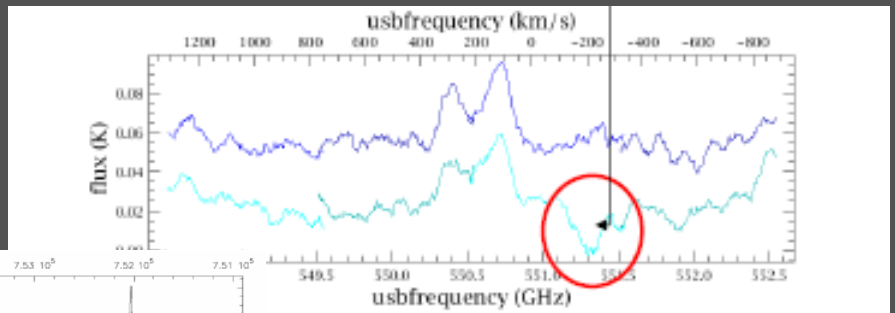


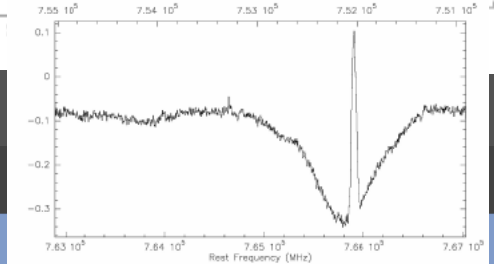



# Frequencies and IF effects

- Generally HIFI's frequency calibration is excellent!!
- In data processing  we only see problems in spectral scans where bulk velocity shifts are occurring
  - Cause unknown and under investigation – likely a data processing problem
- Note that diplexer bands have higher noise at IF edges – understood - etalon or FP effect
- In areas where high Tsys is seen in the IF, strange baseline effects occur – cause unknown and under investigation – stability problem?



# Spurs and impure LO

- HIFI has several areas in which the Local Oscillator is giving an extra signal

- These areas you find in HSPOT when observations are planned
- Generally these areas can be avoided, except in spectral scans, where data need to be masked-out, before further processing is done.
- **In total less than 2% of the frequency range available to HIFI has problems like spurs or IF effects**

- Bands 3B, 5A, 5B, 6AB, 7AB have some areas with an impure LO
  - Band 5B is not currently used
  - Some areas in bands 6 and 7 are not scheduled yet

## Stability

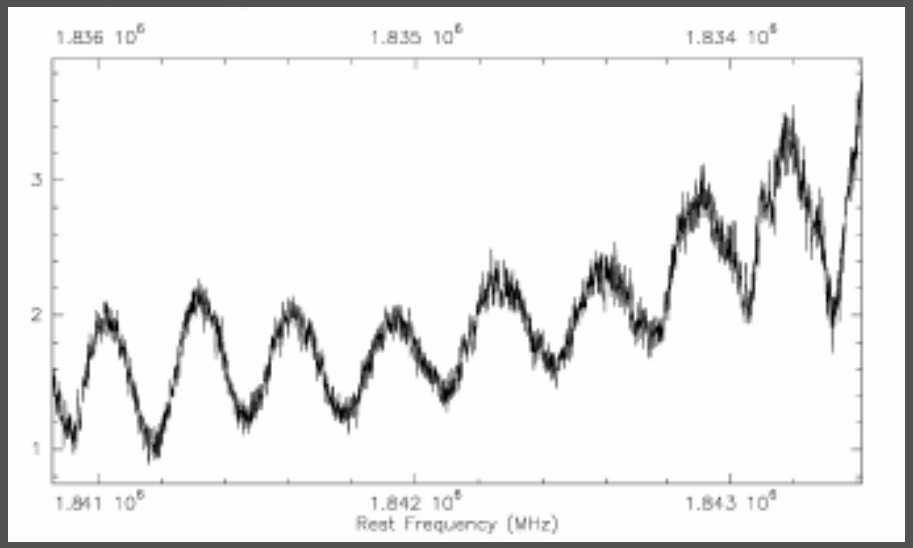
- HIFI is susceptible to (electronic) drifts
- Observing modes are tailored to suppress these drifts as much as possible – observing modes always include a REFerence

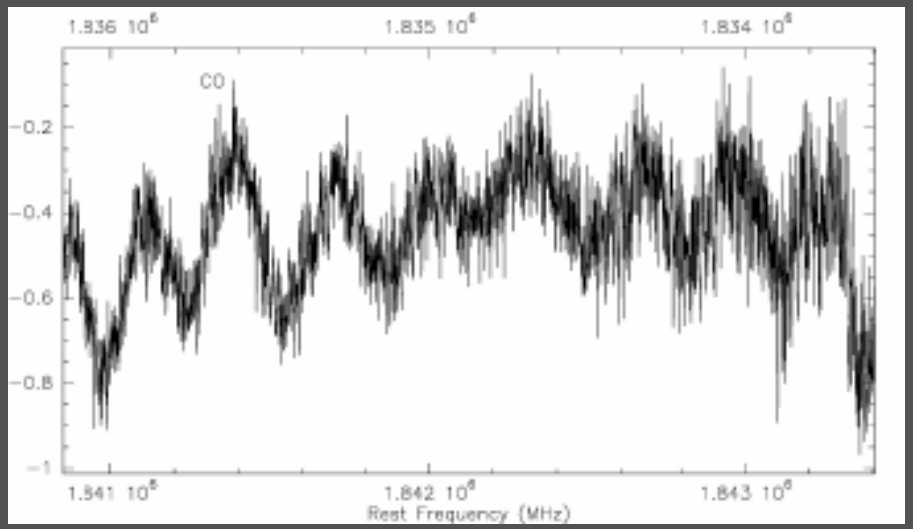
- For Bands 6 and 7 we decided that fast chopping is mandatory to reduce drifts – generally the overheads increase with a few percent
- For wide lines fast chopping is recommended also in the SIS bands
- Observing without regular checks of a REF should be avoided (also because of standing wave issues)

## Standing waves

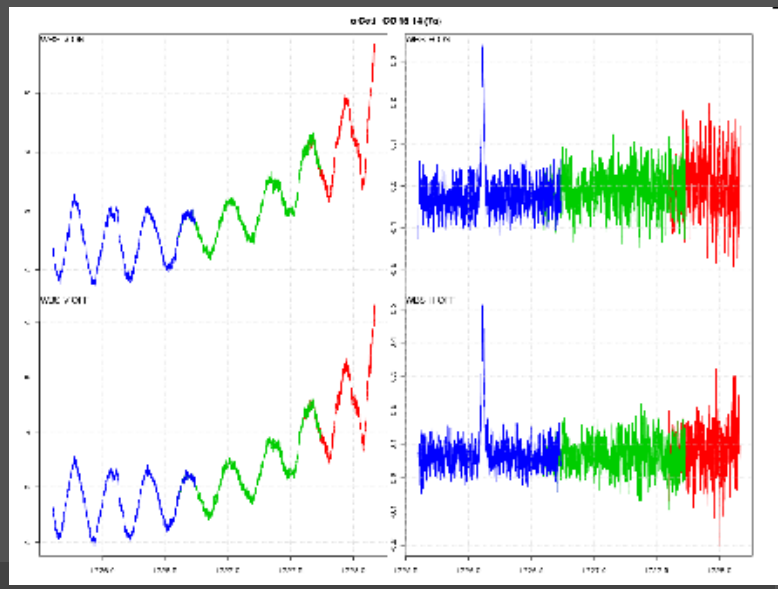
- Optical:
  - Towards the **internal cold load** (~100 MHz)
  - Towards the **Herschel secondary mirror** (~25 MHz), but to a very low level  thanks to a scatter cone
  - Towards the **diplexer roof top mirrors** (~650 MHz) in bands using Martin-Pupplett for LO injection
  - Towards the **LO horns** (~94 MHz) – this modulation is observed on the mixer current (LO power modulation), esp. in HEBs
- Electrical
  - Due to the lacking Isolator between the mixer and low noise amplifier in HEBs
  - Shows up as a ~320 MHz standing wave, but structure more complex than simple sine wave
  - Amplitude scales with mismatch of mixer current between ON and OFF phases (impedance change)

# Standing waves - examples




Standing waves stronger in V – FitFringe removes most of them very well



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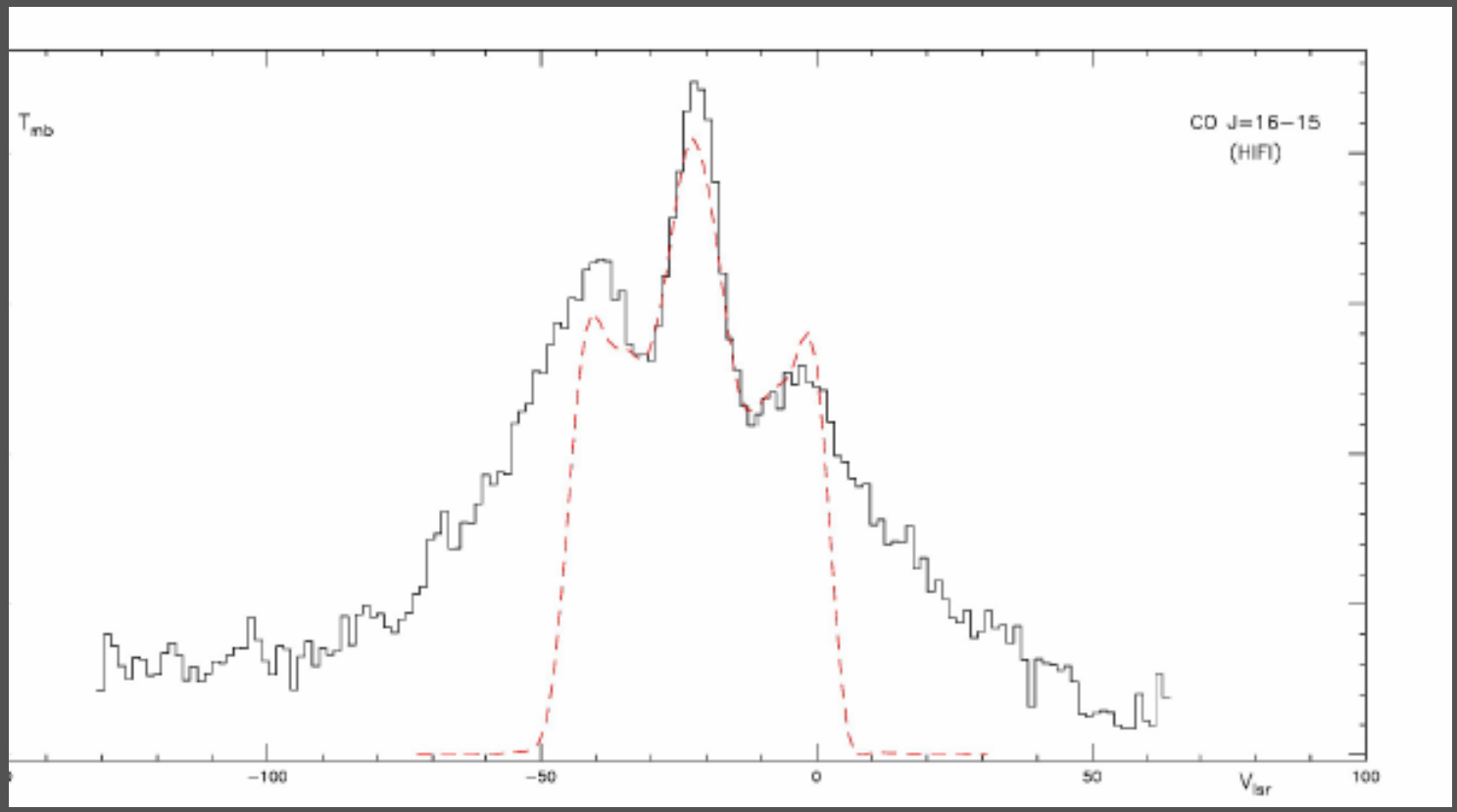
## Conclusions

- All pointed and raster map modes are released
- Band 5B not offered and some impure regions not scheduled
- Frequency switch not in Bands 6 and 7
- DBS Cross removed for OT AO – solving the last issues needs more time
- OTF
  - On-the-fly mapping is a sort of scan-map in which observing (integrating) is done, while moving the telescope
  - It crucially depends on timing between instrument and telescope
  - We are close too finalizing the last issues with this mode, but have not yet released it

- In general: HIFI works very well

# Science high-lights




Outflowing hot material in CRL 618

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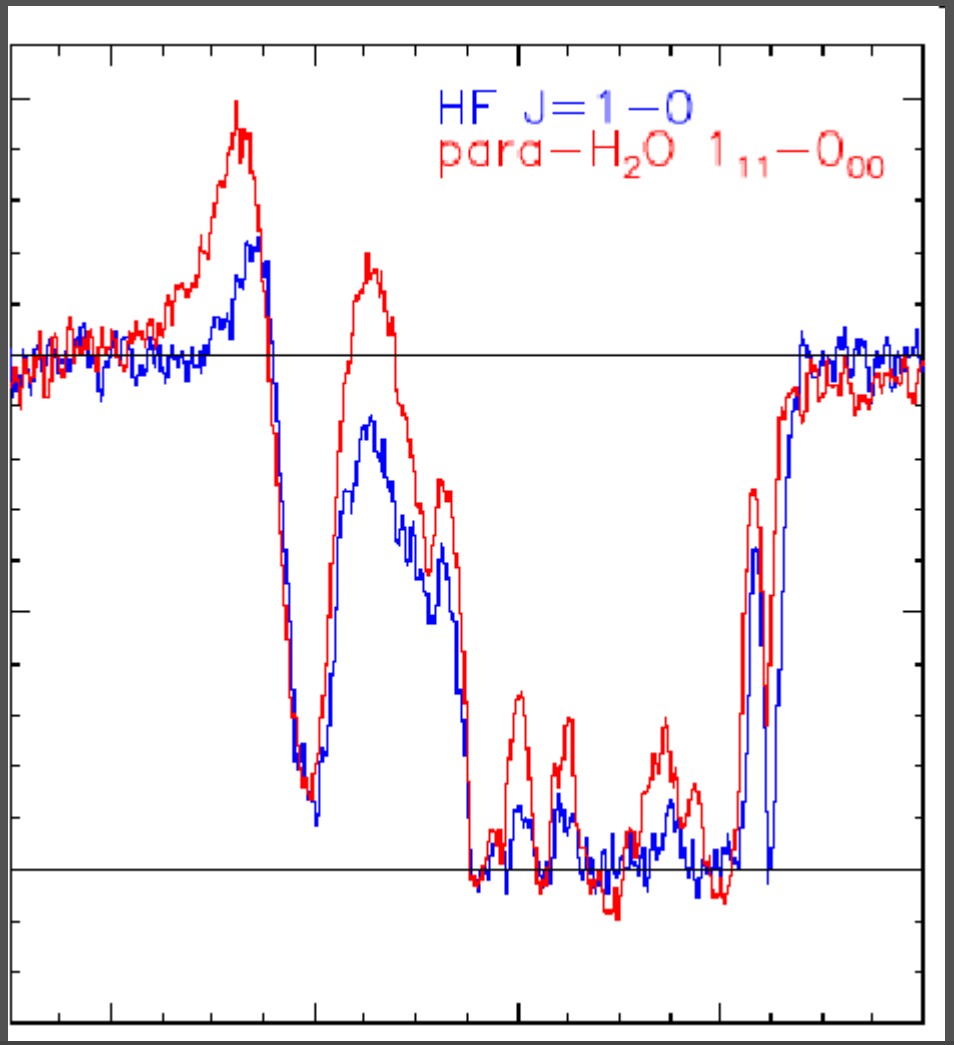
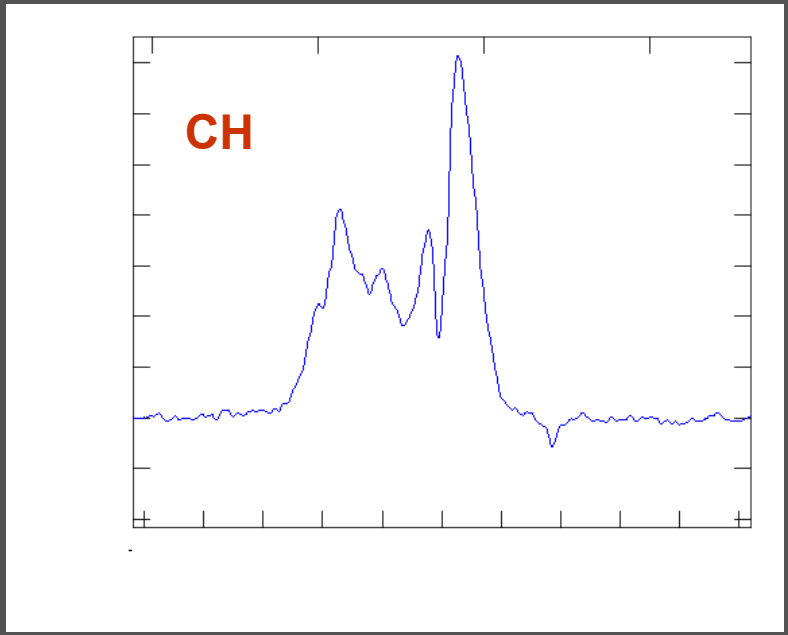
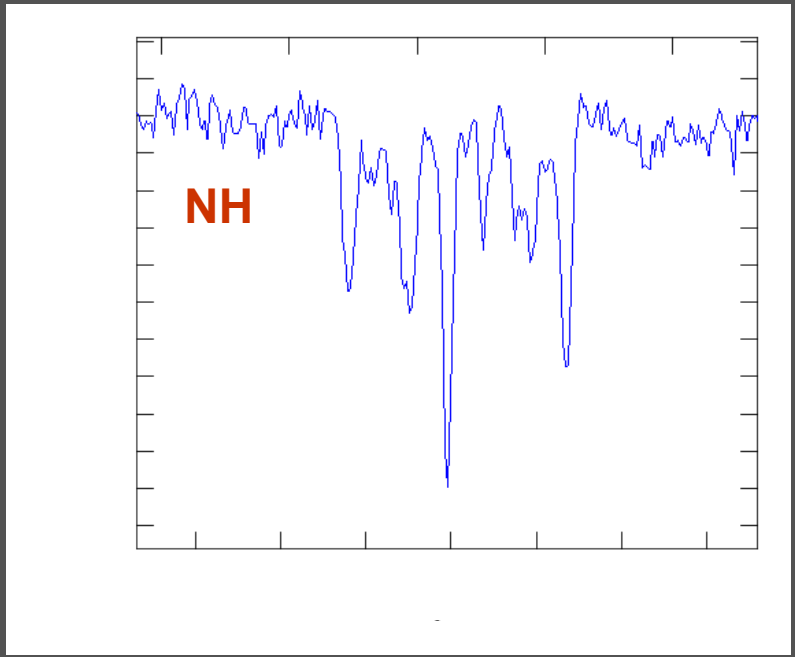
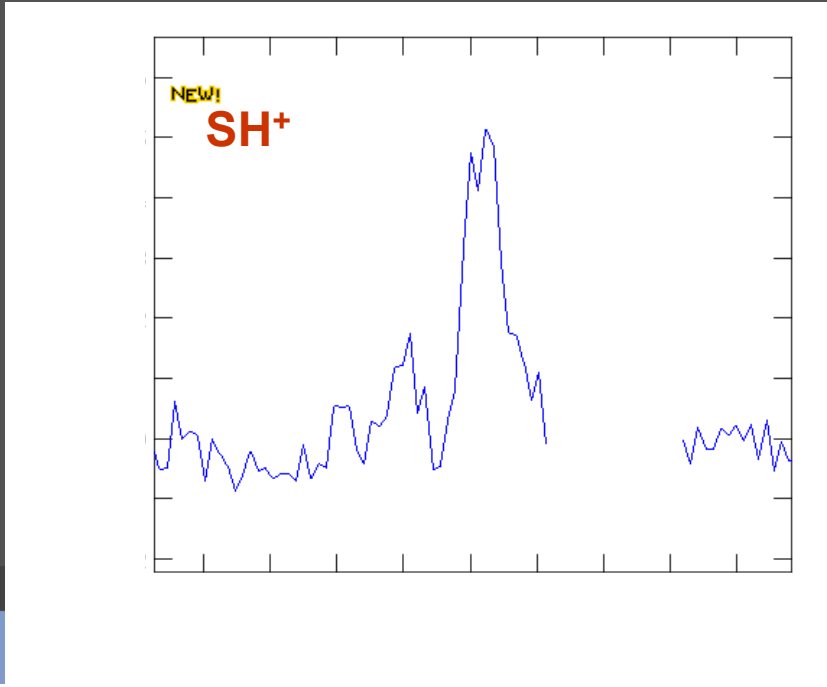
# HF and para-water

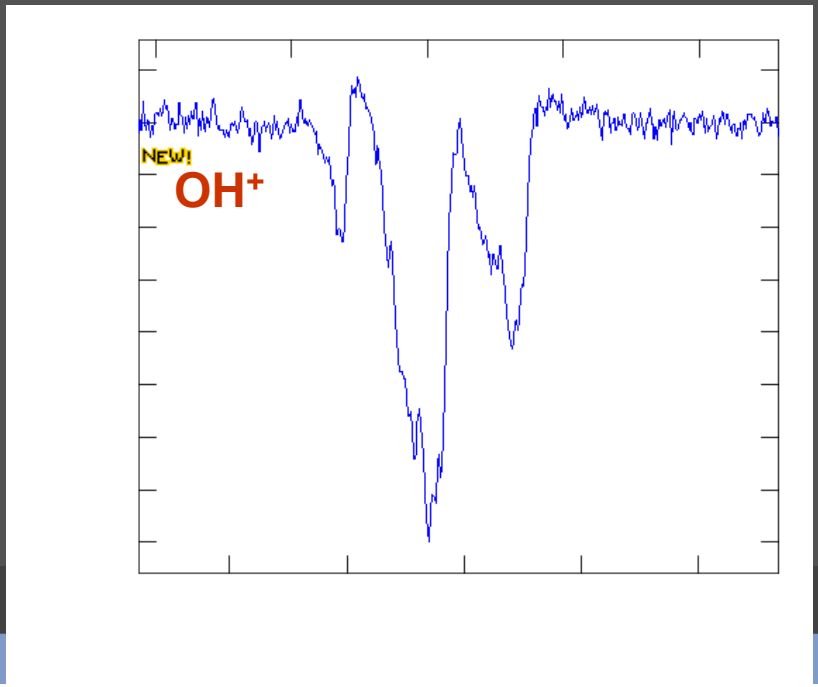


# Hydrides in High-mass Star Forming Region

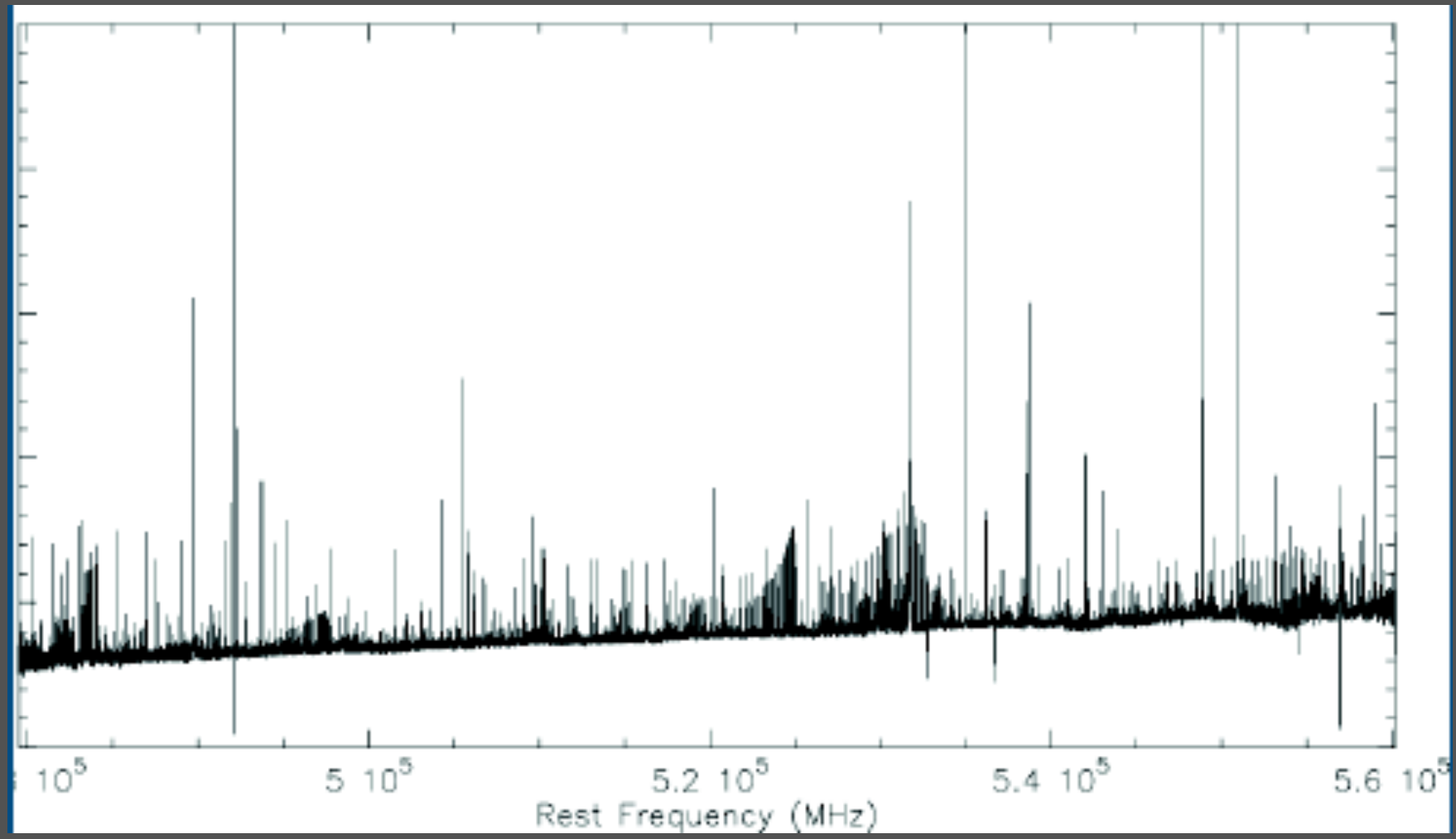


# A high-mass star forming region

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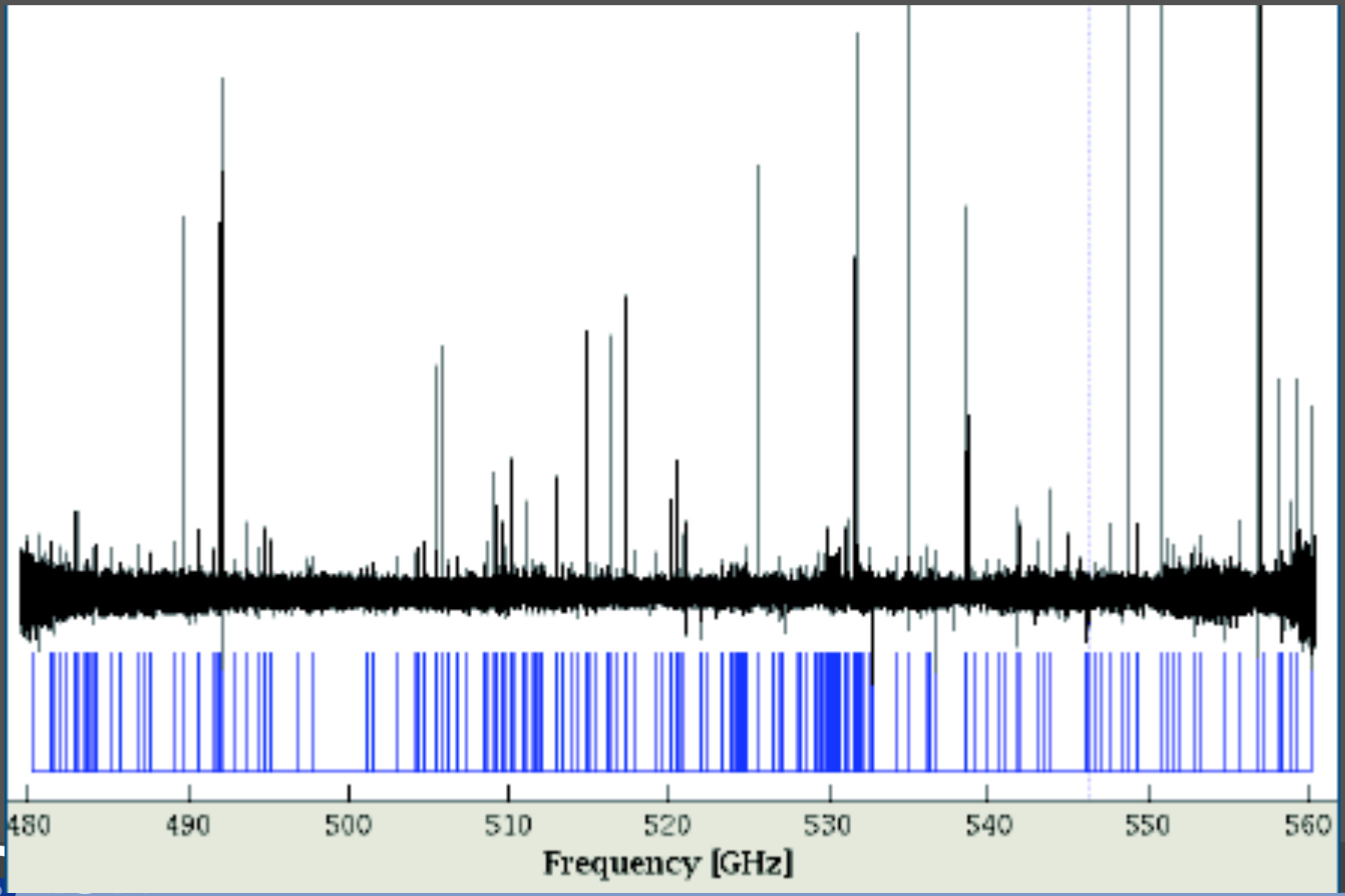
# A low mass star-forming region



## Conclusions II

- HIFI is working very well
- A lot of new molecules are already discovered
- The spectral shapes vary from very predictable to very awkward

- The molecules first probe the chemistry of the region, but the fact that they are there; and the use of the spectral shapes allow a physical interpretation to be made of the state and evolution of the regions under study

# People and institutes instrument development/ICC

Th. deGraauw, F.P.Helmich, T.G. Phillips, J. Stutzki, E.Caux, A.G.G.M.Tielens, N.D.Whyborn, P. Dieleman, P.R.Roelfsema, H.Aarts, R.Assendorp, R. Bachiller, W.Baechtold, A. Barcia, D.A.Beintema, V. Belitsky, A.Benz, R. Bieber, A.Boogert, C.Borys, B. Bumble, P.Caıs, M. Caris, P.Cerulli-Irelli, G. Chattopadhyay, S.Cherednichenko, M. Ciechanowicz, O.Coeur-Joly, C.Comito, A. Cros, A. de Jonge, G. de Lange, B.Delforges, Y.Delorme, T. den Boggende, J.-M.Desbat, C.Diez-Gonzalez, A.M.DiGiorgio, L.Dubbeldam, K. Edwards, M. Eggens, N. Erickson, J. Evers, M. Fich, T. Finn, B. Franke, .Gaier, C.Gal, Gao, J.R., J.-D.Gallego, S.Gauffr, J.J.Gill, S.Glenz, H.Golstein, H.Goulooze, T.Gunsing, R Guesten, P.Hartogh, W. A.Hatch, R.Higgins, E.C.Honingh, R.Huisman, B.D. Jackson, H. Jacobs, K. Jacobs, C. Jarchow, H. Javadi, W. Jellema, M. Justen, A.Karpov, C.Kasemann, J.Kawamura, G.Keizer, D.Kester, T.M.Klapwijk, Th.Klein, E.Kollberg, J.Kooi, P.-P.Kooiman, B.Kopf, M.Krause, J.-M.Krieg, C.Kramer, B.Kruizenga, T.Kuhn, W. Laauwen, R. Lai, B. Larsson, H.G. Leduc, C. Leinz, R.H. Lin, R. Liseau, GS Liu, A. Loose, I. Lopez-Fernandez, S. Lord, W. Luinge, A.Marston, J.Martın-Pintado, A.Maestrini, F.W.Maiwald, C.McCoey, A.Megej, M.Melchior, L.Meinsma, H.Merkel, M.Michalska, C.Monstein, D.Moratschke, I.Mehdi, P.Morris, H.Muller, J.A.Murphy, A.Naber, E.Natale, W.Nowosielski, F.Nuzzolo, M.Olberg, M.Olbrich, R.Orfei, P.Orleanski, V.Ossenkopf, T. Peacock, J.C. Pearson, I. Peron, S. Phillip-May, L. Piazzo, P. Planesas, M. Rataj, L.Ravera, C.Risacher, M. Salez, L.A. Samoska, P. Saraceno, R. Schieder, E. Schlecht, F. Schloeder, F. Schmuelling, M. Schultz, K. Schuster, R.Shipman, O. Siebertz, H. Smit, R. Szczerba, R. Shipman, E. Steinmetz, J.A. Stern, M. Stokroos, R. Teipen, D. Teyssier, T. Tils, N. Trappe, C. van Baaren, B.-J. van Leeuwen, H. van de Stadt, H.Visser, K.J.Wildeman, C.K.Wafelbakker, J.S.Ward, P.Wesselius, W.Wild, S.Wulff, H.-J.Wunsch, X. Tielens, P. Zaal, H. Zirath, J. Zmuidzinas, and F. Zwart

M.Aykilmaz, R. Assendorp, I.M.Avruch, N.Biver, J.Braine, T.Cavalie, J. Cernicharo, E. Debeck, F. Flederus, F.Herpin, D.R.Higgins, A.Hoac, R. Lombaert, A.Lorenzani, M.Marseille, M.Melchior, R.Moreno, Z.Nagy, Y.Okada, D.Rabois, J.Rector, M.Rengel, H.Sagawa, W.Salomons, E.Sanchez-Suarez, M.Soldati, B.Thomas, C.Vastel, Q.Xie, M.Xilouris, M.van der Wiel

And many people in the workshops of all the institutes involved

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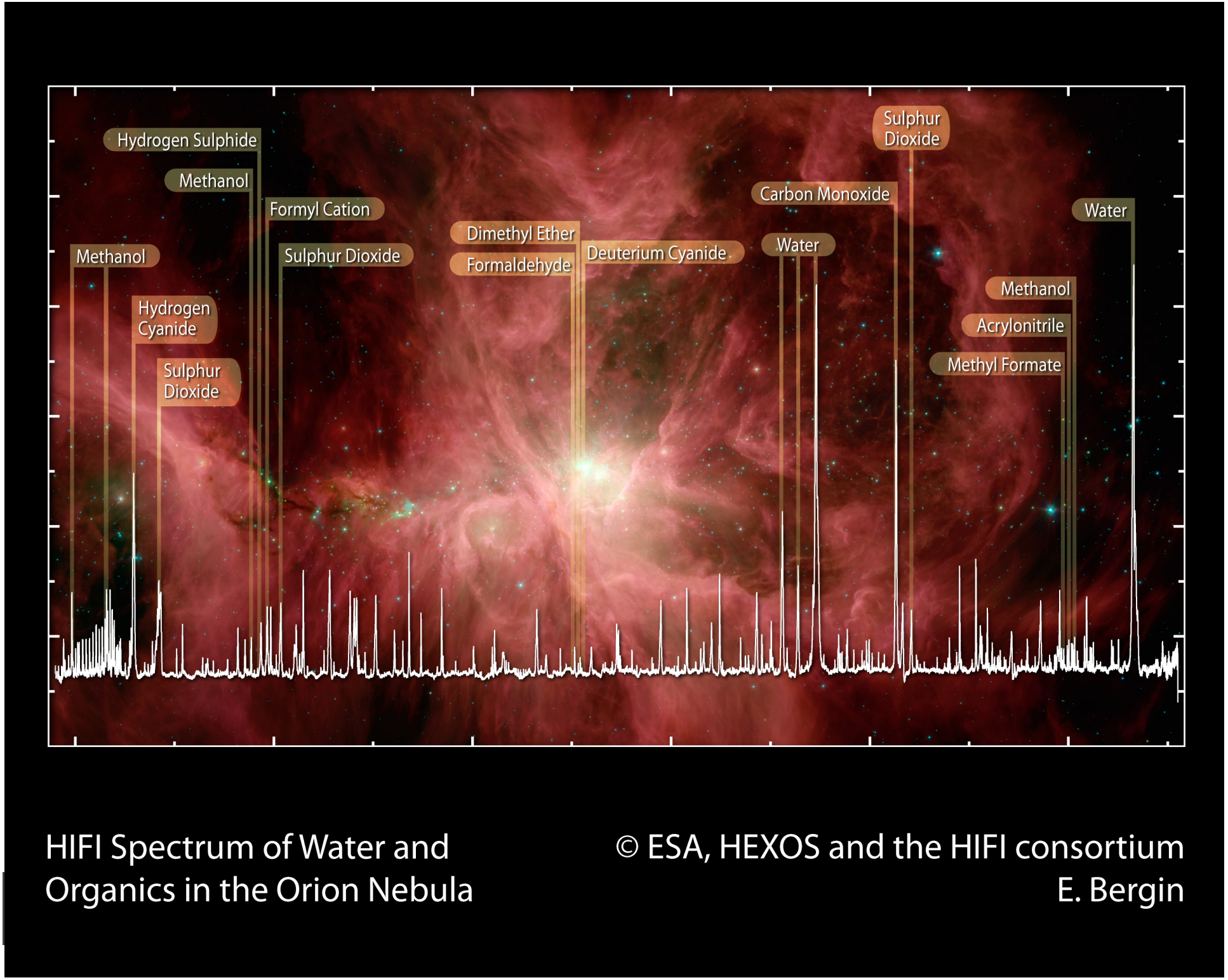


HIFI Spectrum of Water and Organics in the Orion Nebula



E. Bergin