



# Institute of Astronomy ETH Zurich

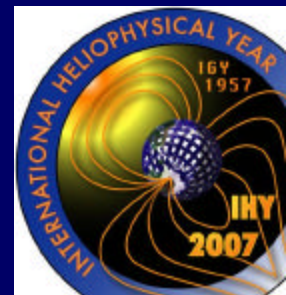
„From long to short waves...“,

Presentation of projects and instruments  
of RAPP

(Radio Astronomy and Plasma Physics group)



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# Directory

- Our own instruments
  - Callisto solar spectrometer at different places worldwide
  - Phoenix-2 solar, frequency agile spectrometer
  - Phoenix-3 solar FFT spectrometer
  - Argos FFT spectrometer at different places worldwide
- Cooperations
  - Herschel submm-space-telescope (ESA)
- Conclusions



# Solar Instruments

- Callisto as ETH - contribution to IHY2007

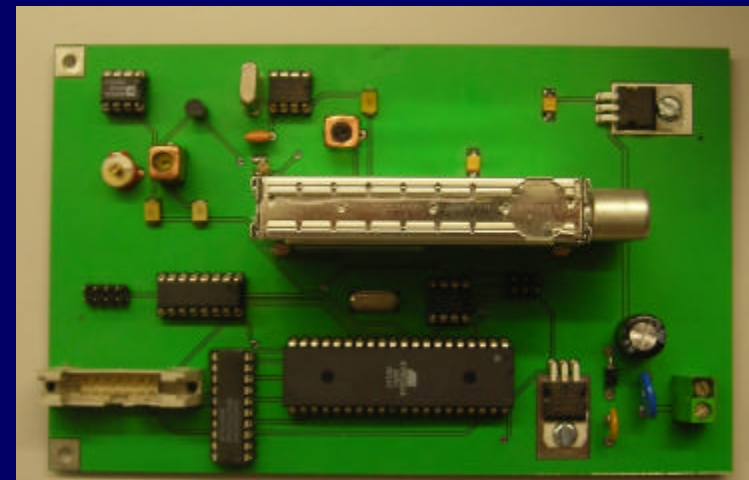
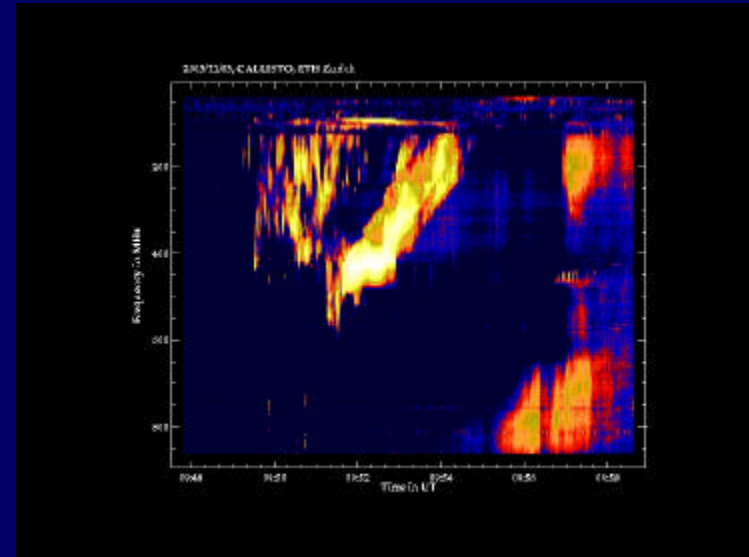
**Compound  
Astronomical  
Low cost  
Low frequency  
Instrument for  
Spectroscopy and  
Transportable  
Observatory**

- 45MHz ... 870MHz = 6.6m ... 34cm
- 10 ... 1000 measurement points / sec
- 1 ... 400 pixels per sweep stored in eeprom

# IHY2007 24h observation



# Callisto #1 Bleien Switzerland

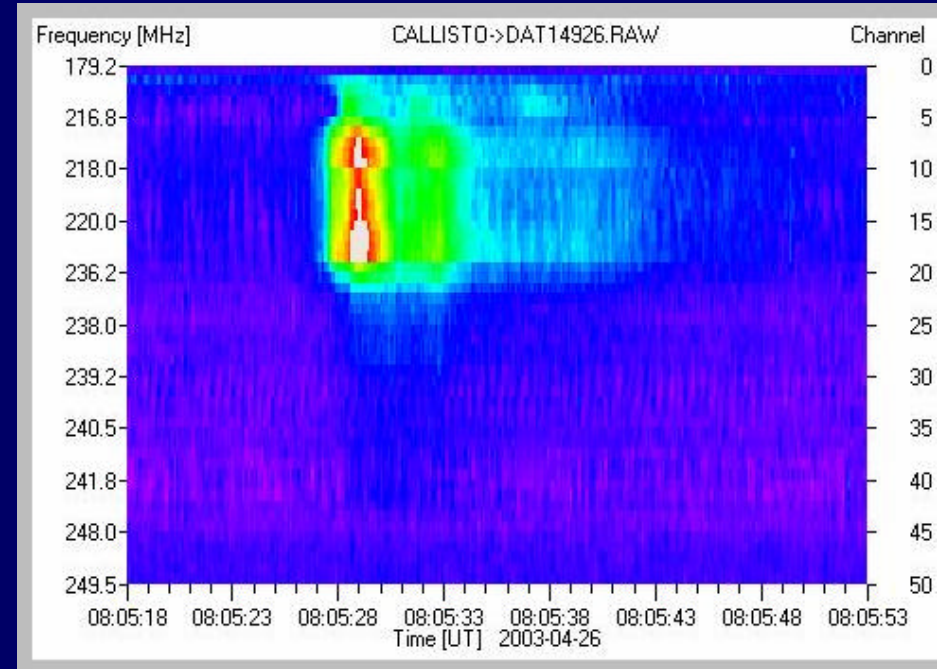


Top left: Antenna  
Top right: Complex spectrum  
Bottom right: PCB Callisto

# Callisto #2 Zurich Switzerland



Antenna at suntower  
of Zurich observatory



Decimeter spectrum  
captured by Callisto  
on 26th of April 2003

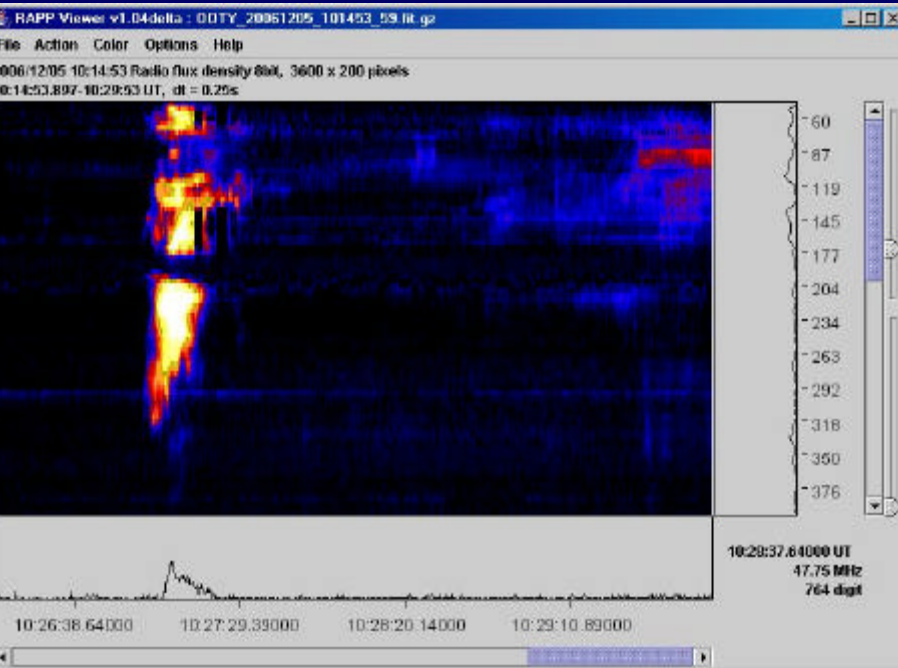
# Callisto #3 Ootacamund India



Self built antenna left,  
operator right at the  
Institute of Radioastronomy  
and Nuclear Physics,  
Tamil Nadu in Ooty India



# Callisto #3 Ootacamund India



Astronomical outcome, first light

Gastronomical highlight



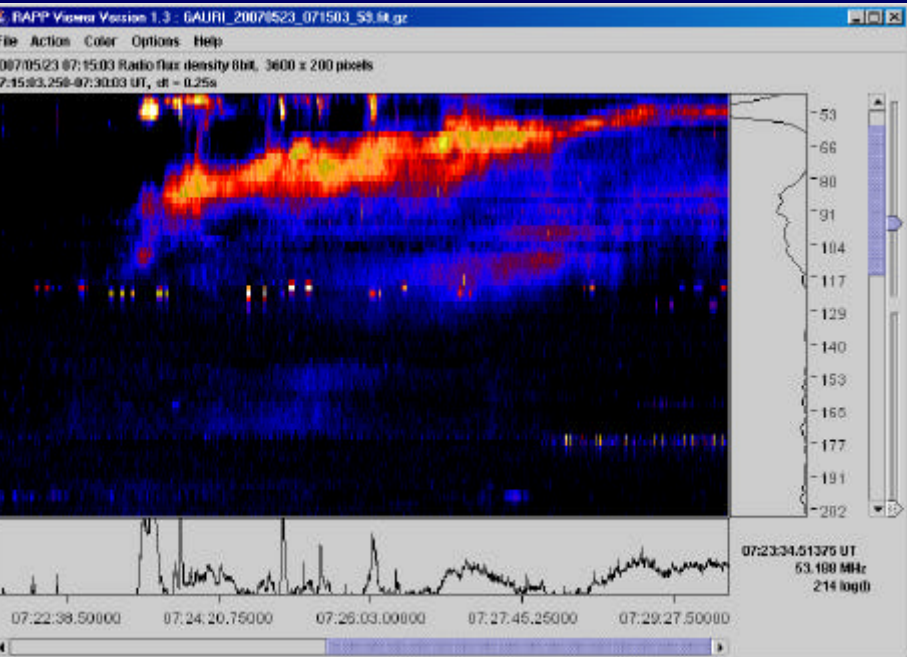
# Callisto #4 Gauribidanur India



Self built antenna left,  
Dr. Kathirvaran right at  
Indian Institute of Astrophysics  
Gauribidanur / Bangalore



# Callisto #4 Gauribidanur India



Astronomical outcome, first light

Gastronomical highlight

# Callisto #5 Badary/Siberia



Antenna farm at SSRT

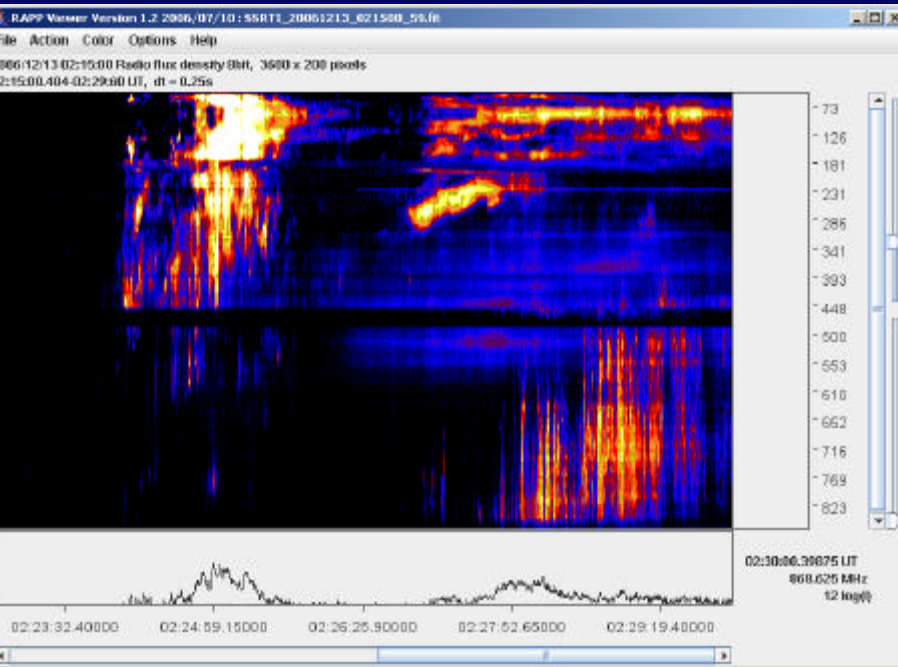


Antenna attached to dish



Sergey and Andrey in Badary/Siberia

# Callisto #5 Badary/Siberia



Astronomical outcome, first light

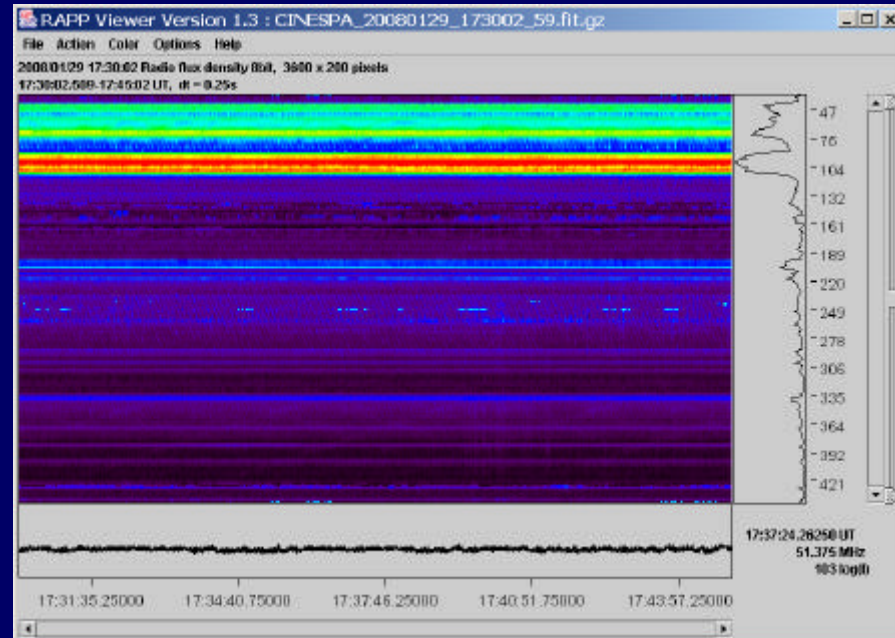
Gastronomical highlight



# Callisto #6 Costa Rica



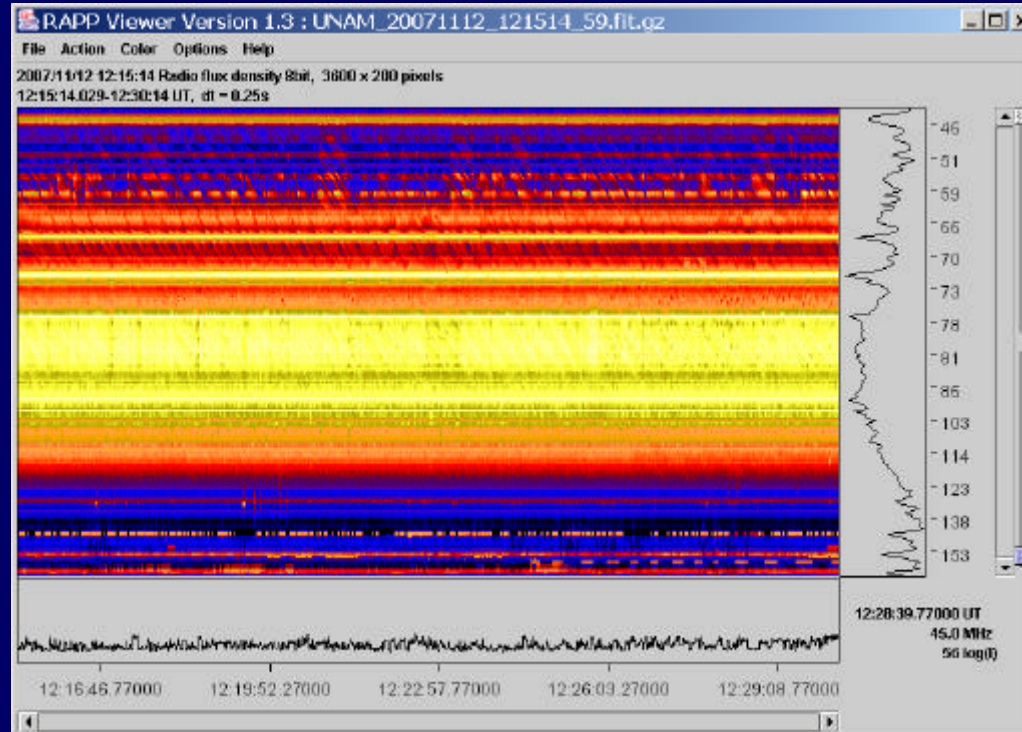
Jorge Paez, San Jose de  
Costa Rica, 7m Parabolic dish



Recent data without any solar  
signature



# Callisto #7 Mexico



Recent data without any solar signature but a lot of rfi

Alejandro Lara, Mexico  
logarithmic-periodic antenna

# Callisto #8 South Korea



Antenna tower of Solar and Space  
Weather Group of Korea Astronomy  
And Space Science Institute (KASI)

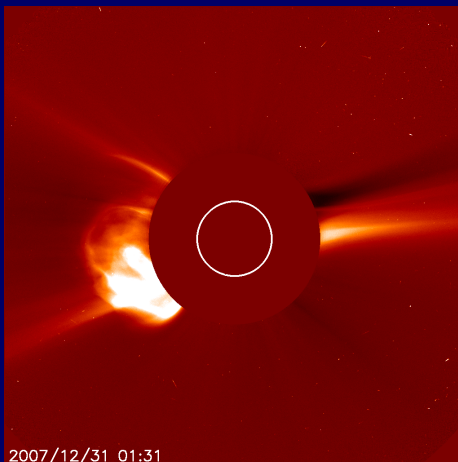
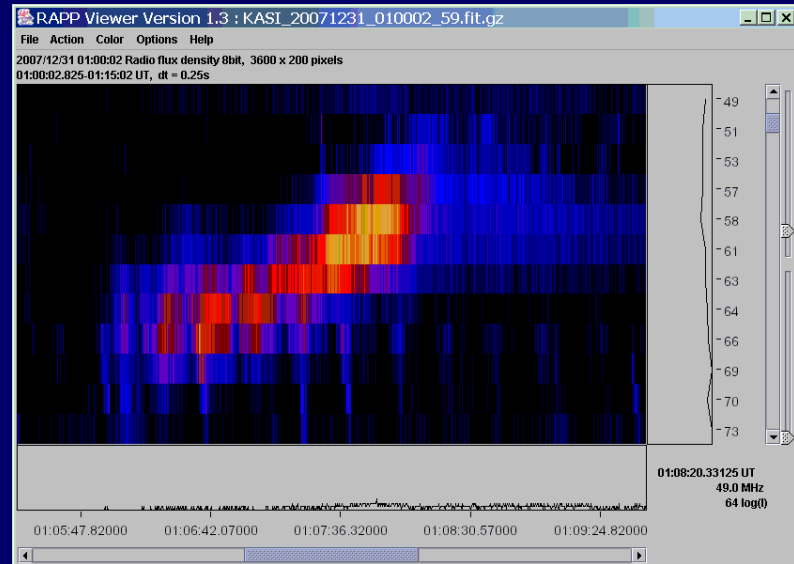
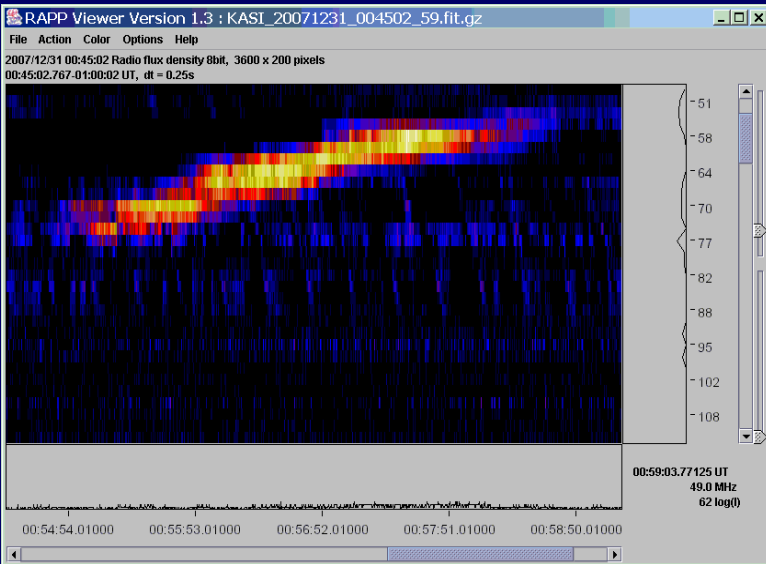


Student Hee-Sun reproducing  
a Callisto-spectrometer



# Callisto #8 South Korea

Astronomical outcome, first light



Type II burst associated  
with limb CME of Dec. 31th 2007



# Callisto #8 South Korea

One of the gastronomical highlights



# Callisto #9 Humain ROB



Broad band log-per  
attached to 4m dish

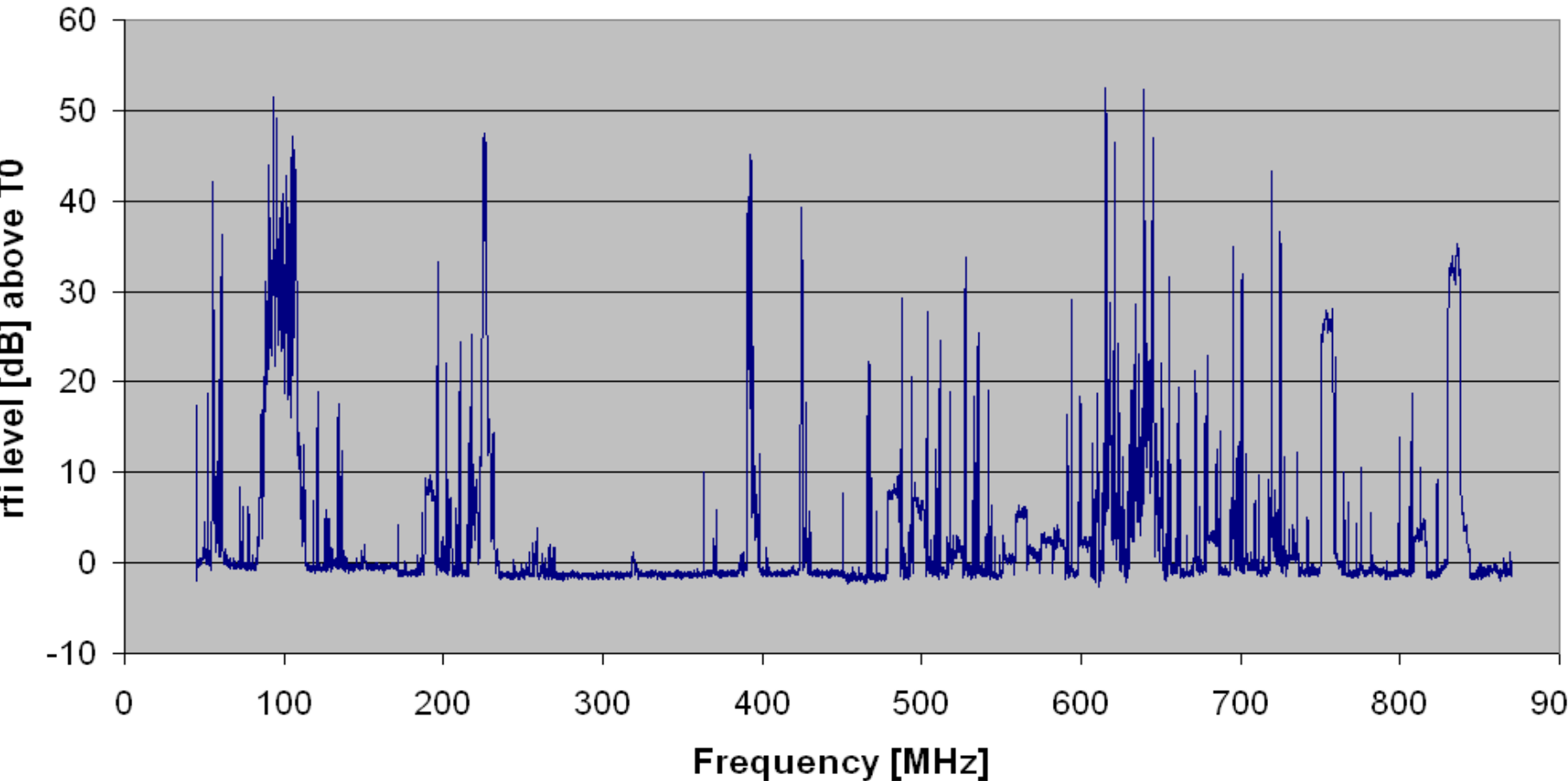


Where is this strong rfi coming from.....?



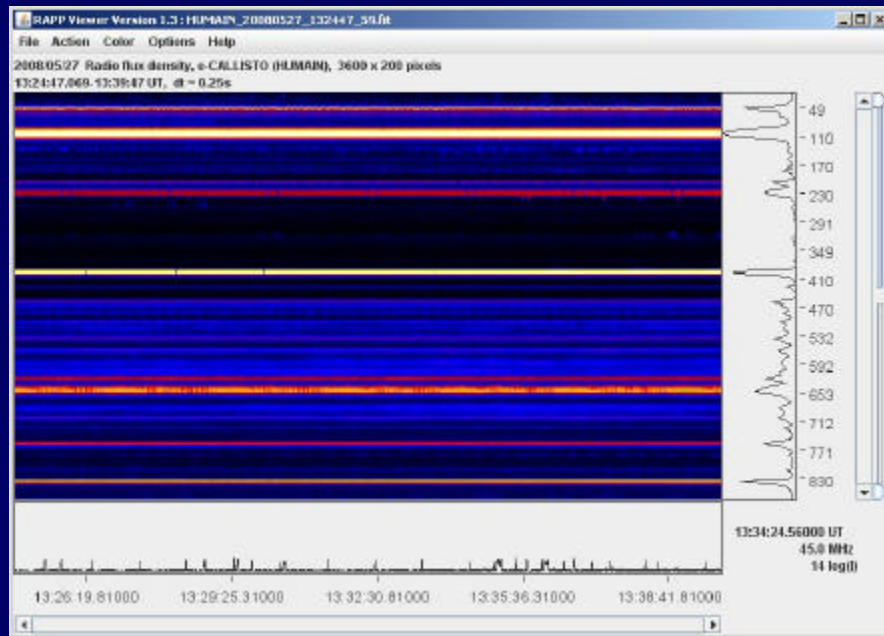
# Callisto #9 Humain ROB

Spectral overview Humain + Kuhne preamplifier at pwm=70 in the afternoon





# Callisto #9 Humain ROB



Astronomical outcome, no first light yet because the sun is absolutely quiet. But a lot of rfi (FM-band, TetraPol, DVB-T and DAB-T and still some analog terrestrial TV etc. etc. etc.)

Gastronomical result...



# Main solar instrument

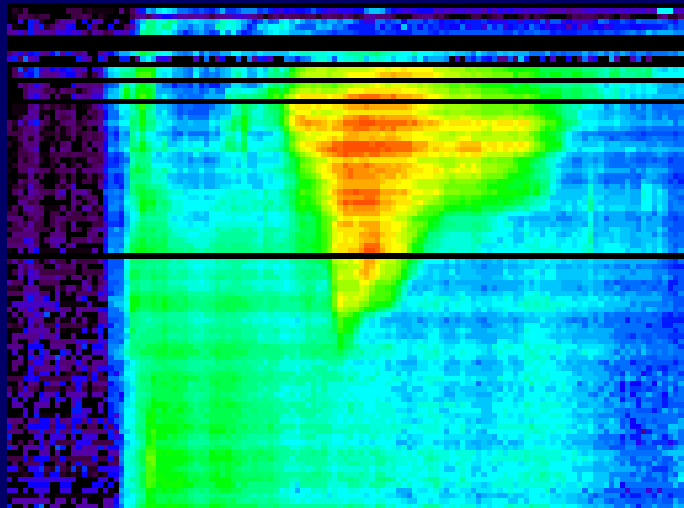
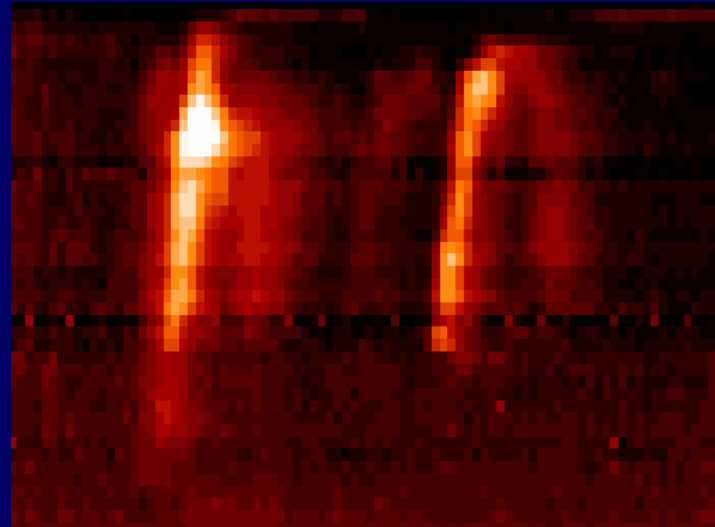
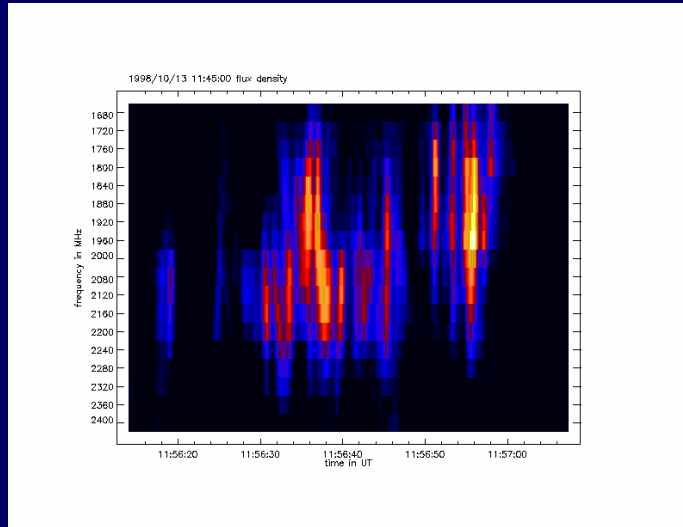
- Phoenix-2 frequency-agile spectrometer
- 100MHz ... 4000MHz = 3m ... 7.5cm
- 2 polarizations
- 2000 frequencies / sec ? 4KByte / sec
- ~200 MByte data per day
- Antenna: 7m parabolic dish in Bleien

# Phoenix-2 Bleien Aargau



7m parabolic dish 100MHz until 4000MHz in 2 polarisations

# Phoenix-2 Bleien Aargau



Examples for complex spectra  
with interesting features in it.

# New solar Instrument

- Phoenix-3 FFT Spectrometer
- 1GHz ... 5GHz = 30cm ... 6cm
- 2 polarisations
- $2 \times 4 \times 16 \times 384 = 131 \times 072$  channels
- 2,6 MByte / second = 132 Gbyte / day
- Antenna: 5m parabolic dish in Bleien
- KTI-Project Agilent + FHS Brugg/Windisch



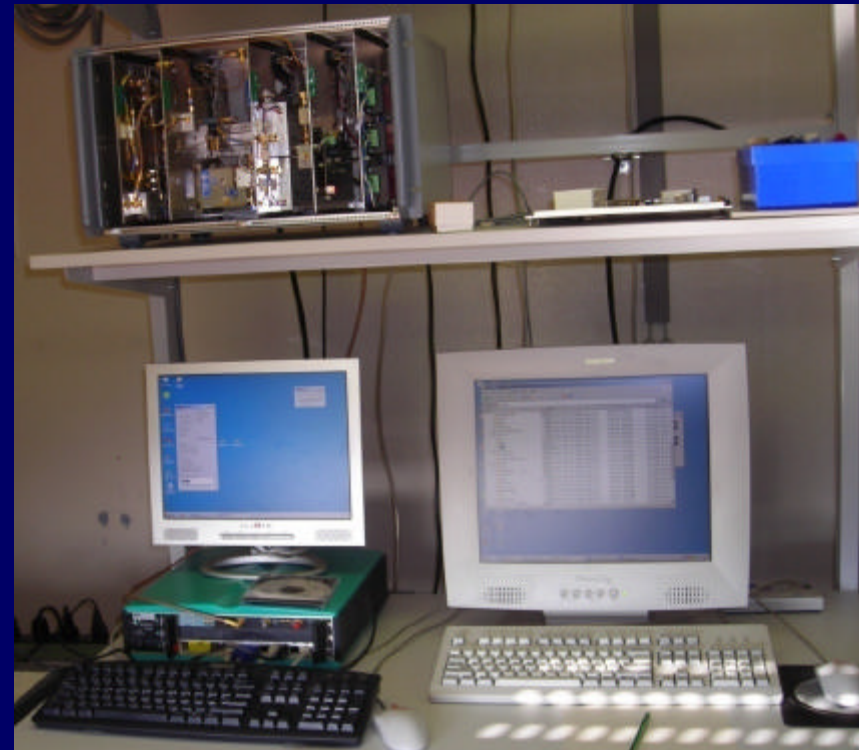


# Phoenix-3 Bleien Switzerland

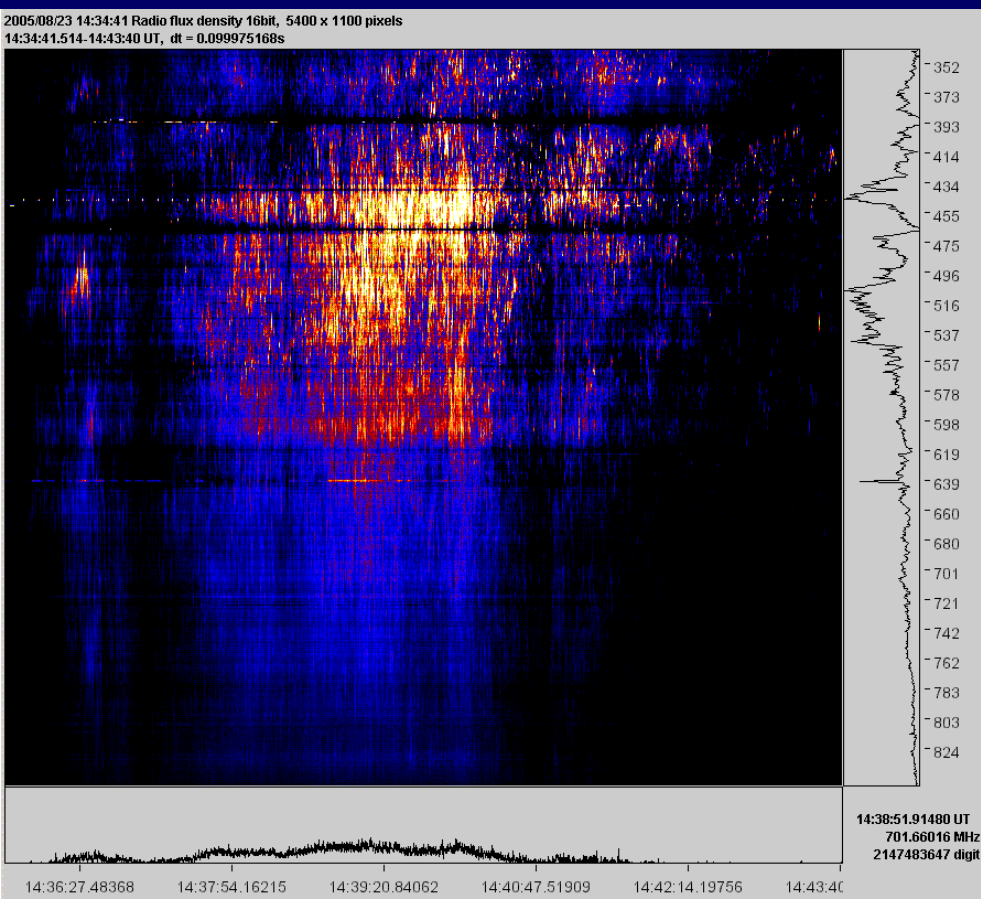


5m parabolic antenna  
with feed 1GHz - 5GHz

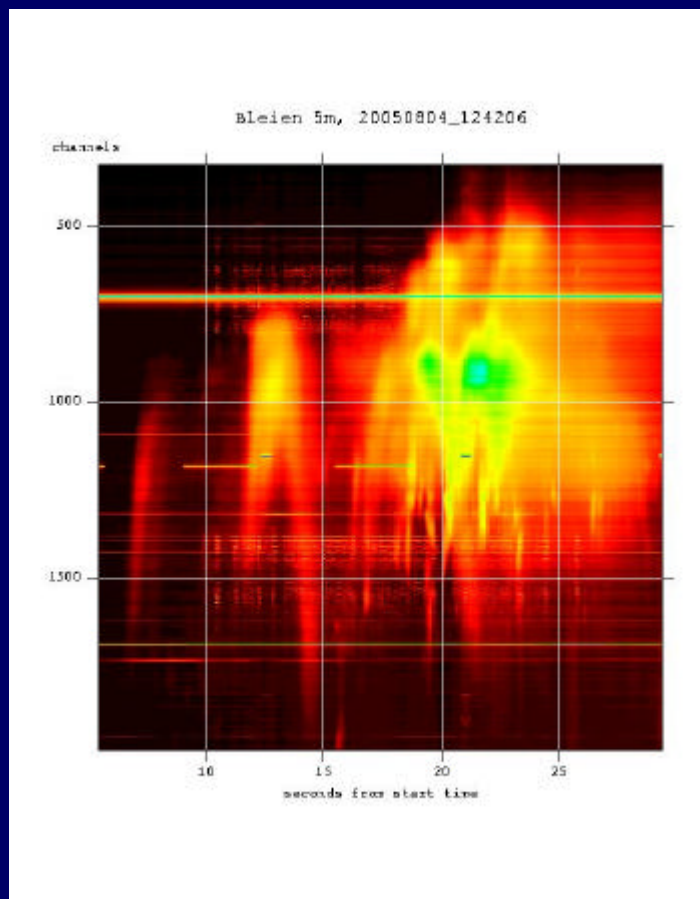
Receiver 1 - 5GHz  
FFT - spectrometer  
FTP - server



# Phoenix-3 first results



Microflares at decimeter wavelength



U-bursts at decimeter wavelength

# Sub-mm Instruments

- ARGOS FFT Spectrometer
- 16'384 channels from dc ... 1GHz with about 10 to 100 spectra per second
- Observation of any frequency range using heterodyne- or homodyne-receiver
- Mostly: Molecules, ions, atoms in the atmosphere or in interstellar dust-clouds



# Instrument at Gornergrat

- Gornergrat KOSMA, University of Cologne
- 245GHz ... 800GHz = 1.2mm ... 375um
- 10 spectra per second
- 3m parabolic dish
- Test bed for new instruments
- Test bed for new methods



# KOSMA Gornergrat



Left dome contains a 3m dish



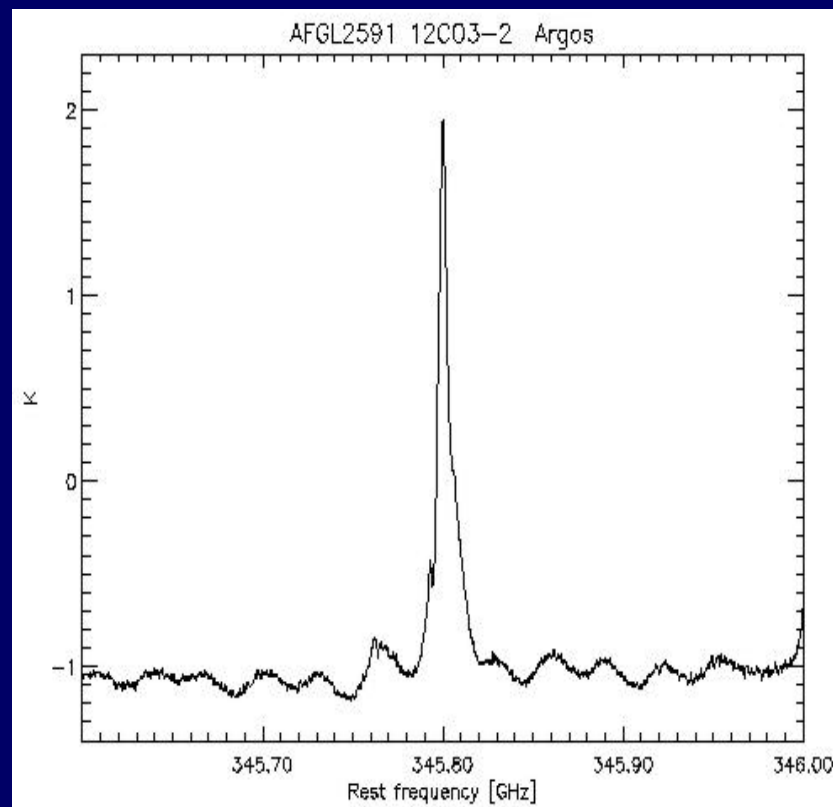
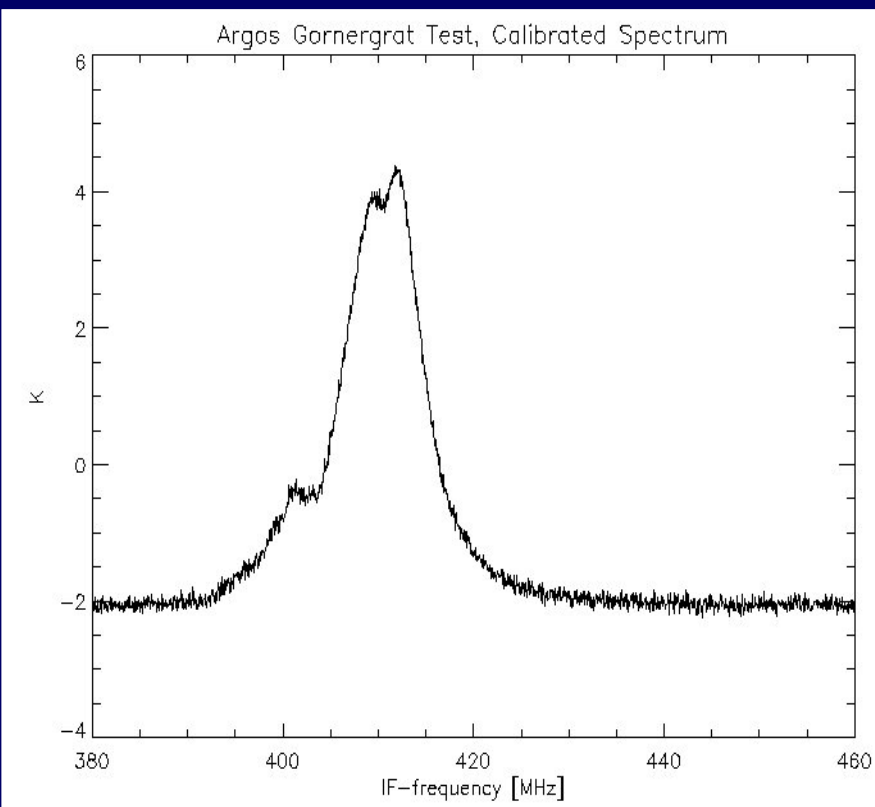
Open dome



FFT - Spectrometer



# Results KOSMA Gornergrat



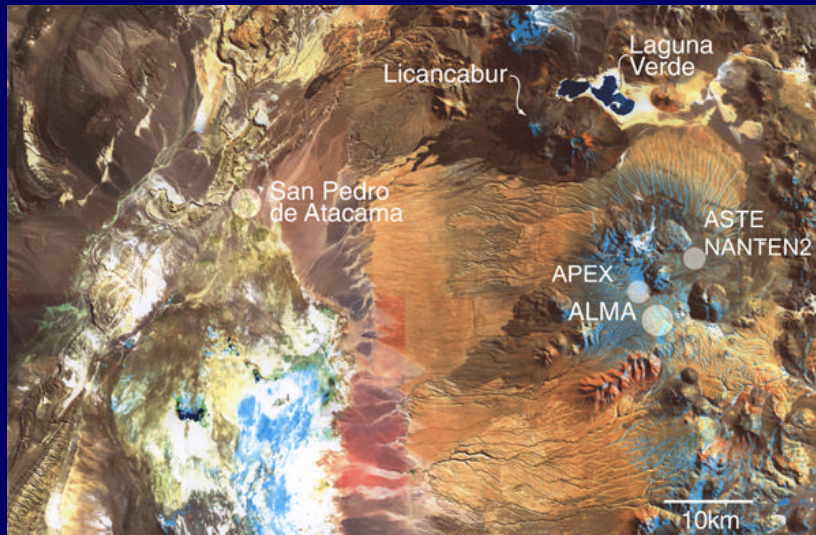
DR21K  $^{12}\text{CO}$  2? 1 at 230.5GHz

AFGL 2591  $^{12}\text{CO}$  3? 2 at 345.8GHz



# Instrument at Nanten2

- Chile NANTEN2, university of Cologne
- 115GHz ... 880GHz = 2.6mm ... 340 $\mu$ m
- ~10 spectra per second
- 4m parabolic dish





# Nanten2 Chile



Left: 4m parabolic dish  
Right: observatory with Dr. Martin Miller  
of KOSMA  
and former colleague Hansueli Meyer



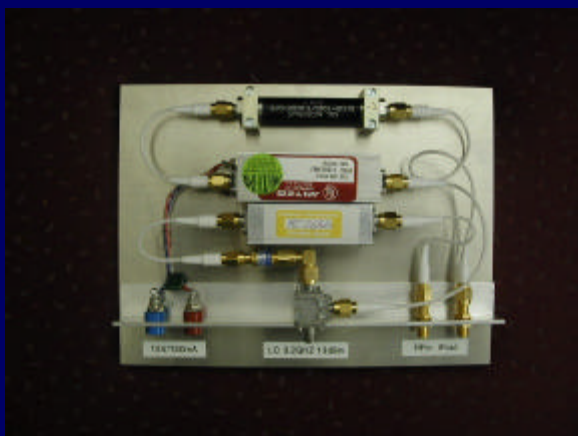
# Ozone at 174GHz Univ. Berne



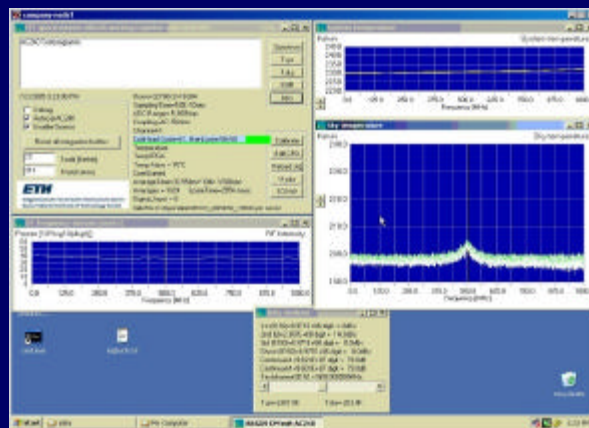
Radiometer side view



Radiometer front view



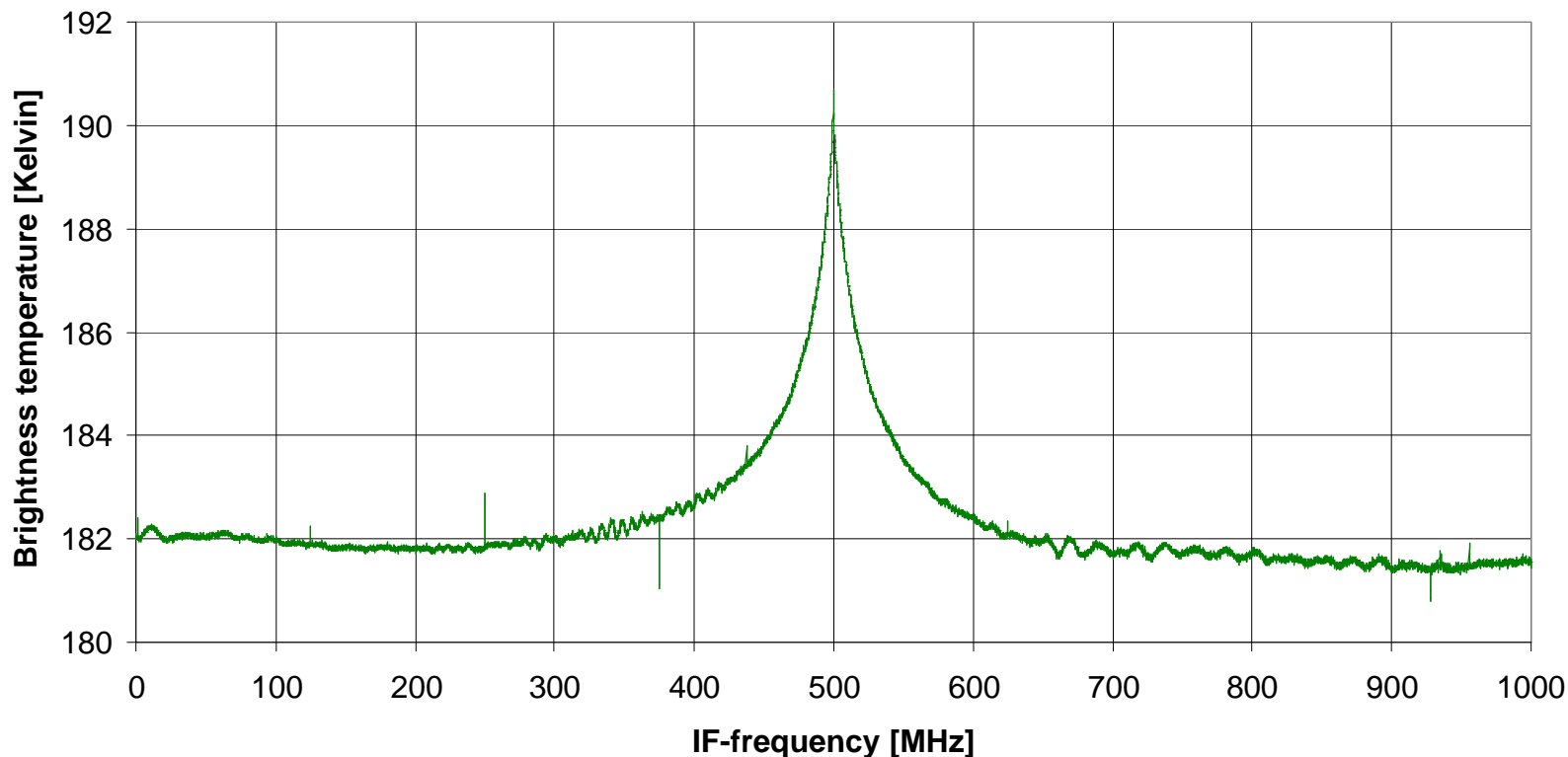
Heterodyne-converter



FFTS-screen

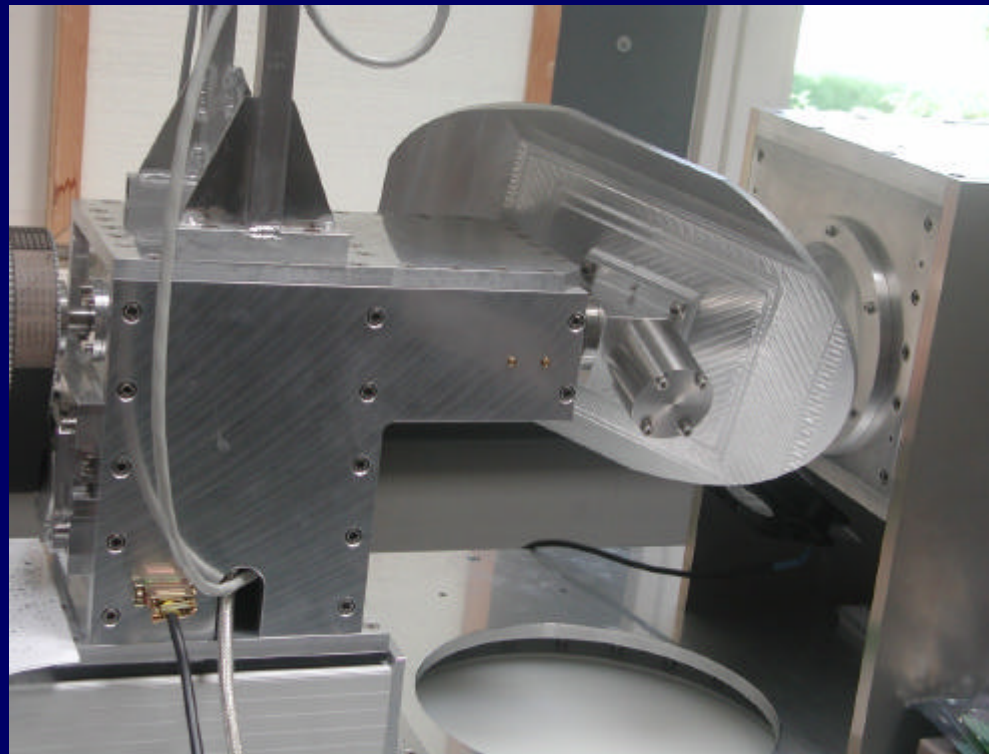
# Ozone at 174GHz Univ. Berne

Ozone 17.06.2005 - 01.07.2005 using FFT spectrometer ARGOS



2 weeks of observation with totally 94h integration time on sky  
1s = 31 Milli Kelvin

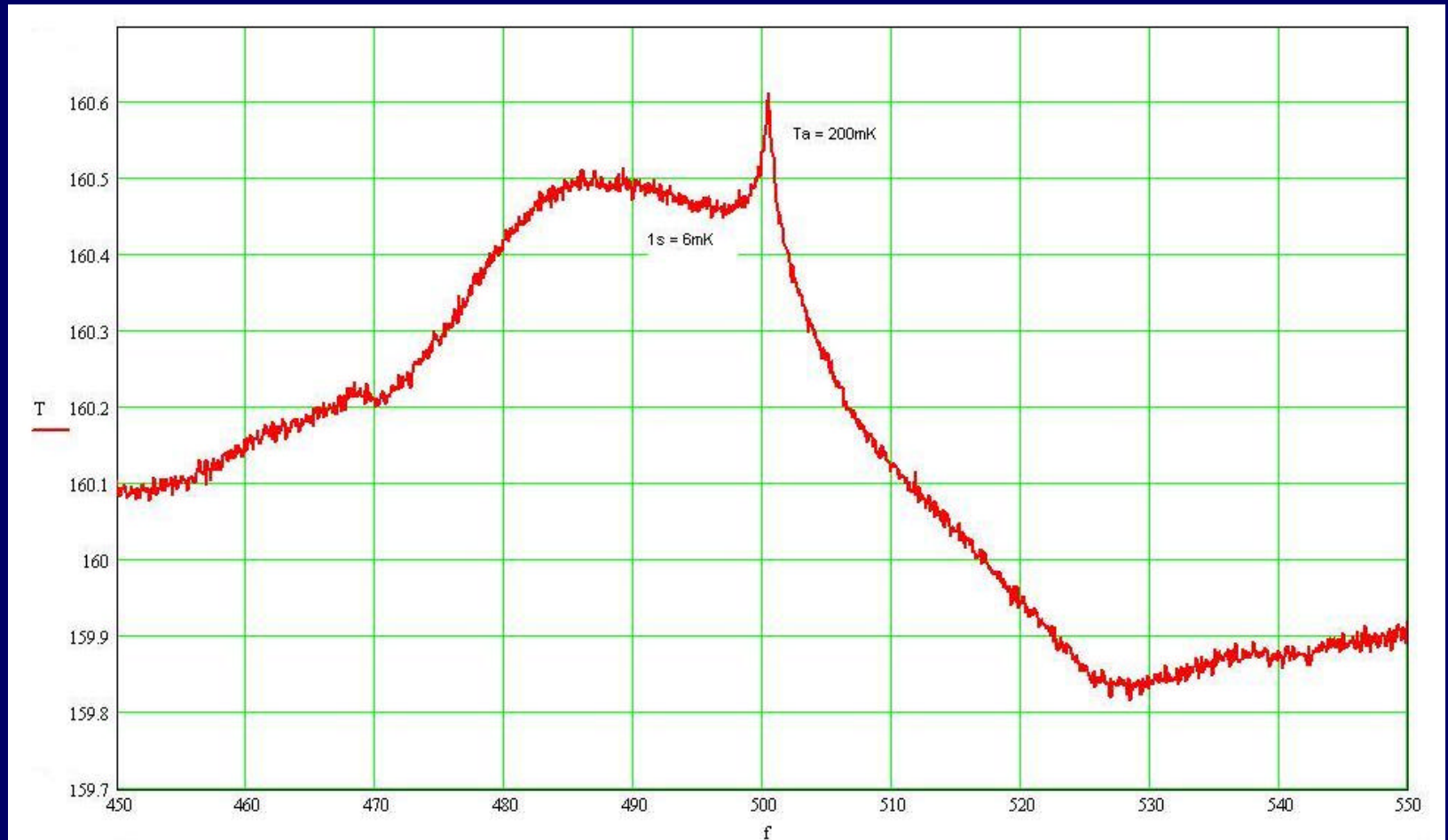
# Wasser vapour at 22GHz



Site of Max Planck Institut  
für SonnenSystemForschung in  
Lindau northern Germany

Rotating mirror of H<sub>2</sub>O-radiometer

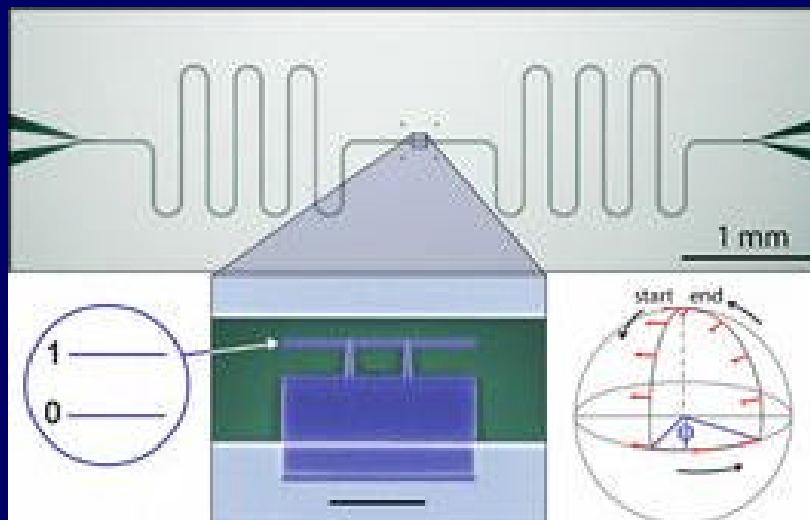
# Result water vapour at 22GHz



$\text{H}_2\text{O}$ -line after 12h of observation and integration

# Our Instruments at ETH

- ETH Institut für Quantenelektronik
- Observation of resonance conditions  
( $6\text{GHz} \pm 10\text{MHz}$ ) of a QUBIT in a microwave -  
resonator while feeding in single photons at very  
low temperature ( $< 200\text{mK}$ )

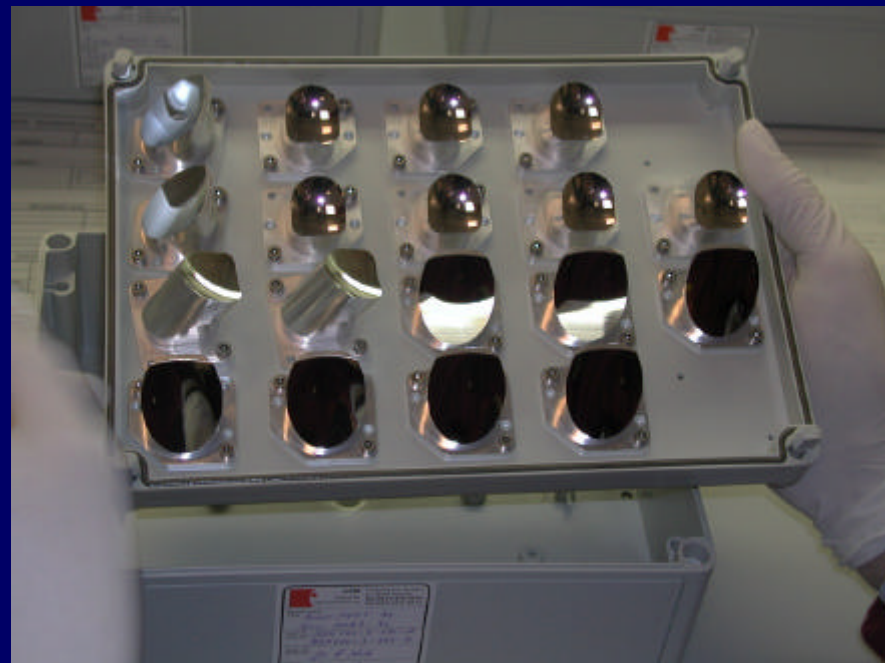
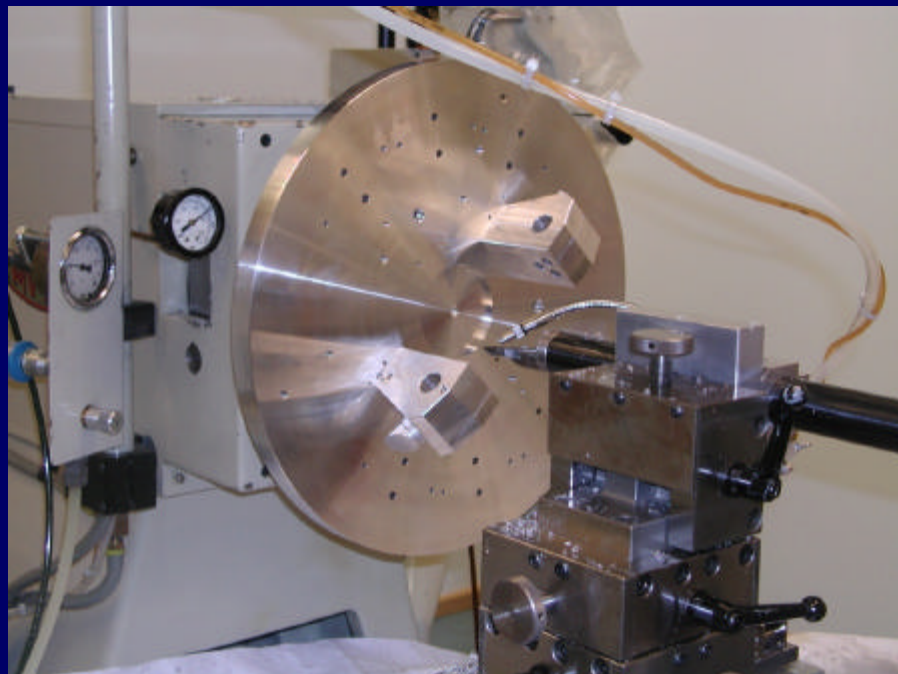


# Cooperation ESA

- Herschel heterodyne space telescope
- 200GHz .. 2THz = 1.5mm ... 150 $\mu$ m
- Design 1985 until 2007
- Start with Ariane V+ at 31. Juli 2008  
delayed to early 2009
- Large contribution of ETH



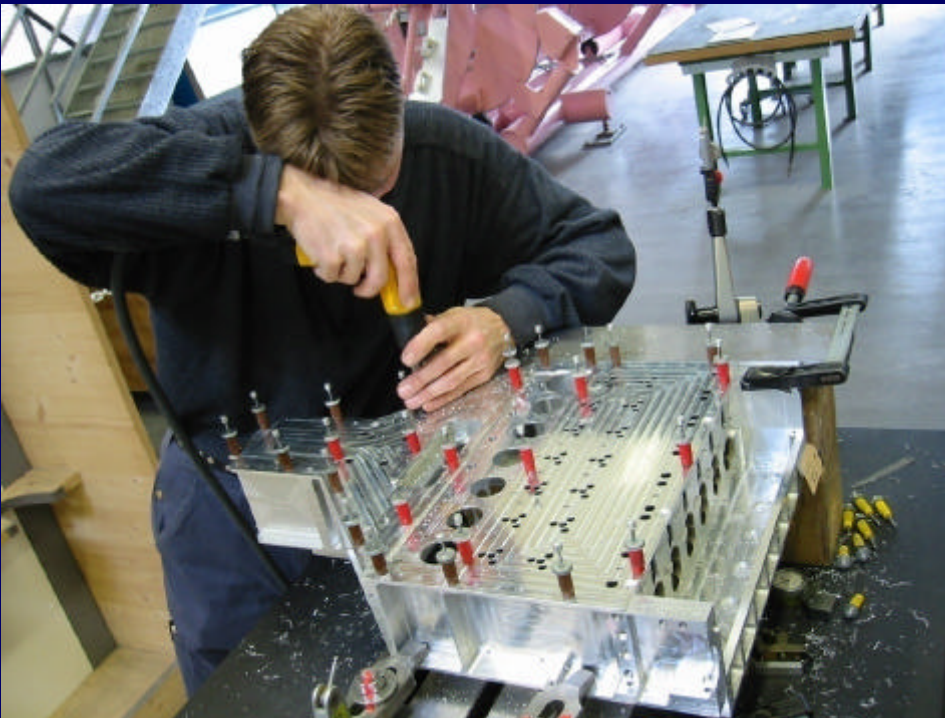
# Herschel space telescope



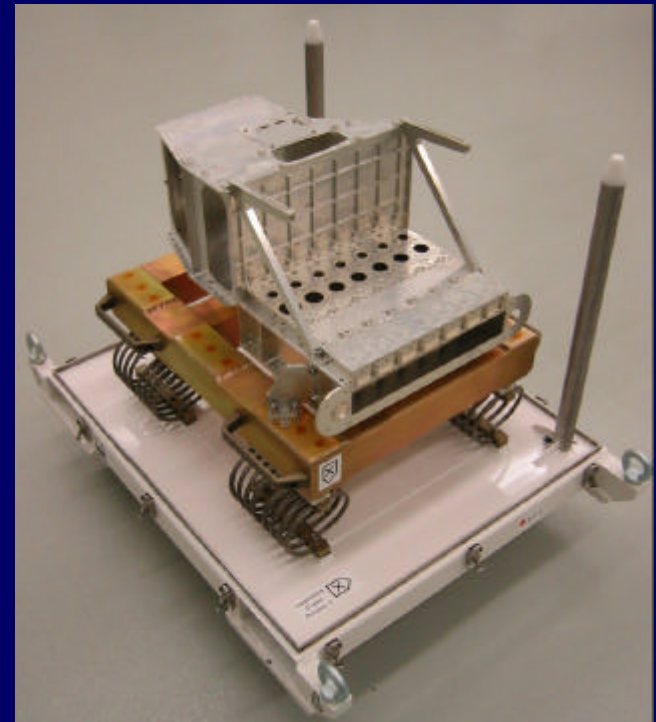
Precision lathe for production  
of metal mirrors (Aluminum)  
at University of Bremen / Germany

Quality control at  
TPD/TNO in Delft / Holland

# Herschel space telescope



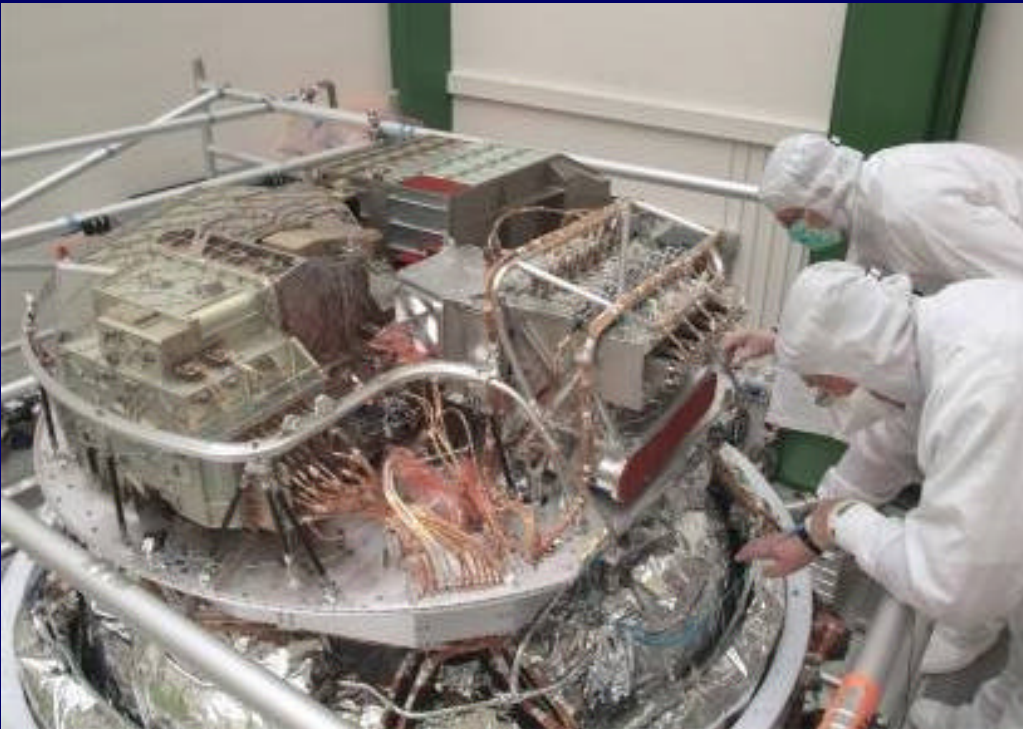
Optics Housing:  
Hand riveting Mr. Portmann  
at RUAG in Emmen 2005



Delivery of Common  
Optics Assembly  
from HTS Wallisellen  
to SRON Groningen 2006



# Herschel space telescope



Assembly of the satellite  
at EADS / Astrium Dec. 2007  
in Friedrichshafen Germany

# Herschel space telescope



Heat shield  
at EADS /  
Astrium in  
Friedrichshafen



# Conclusion

- We daily observe the whole spectrum from short waves to X-rays using others and our own instruments (ground based and space).
- We do our best to keep our own instruments running and to improve them
- I hope, ROB will also be operational soon at radio wavelength using Callisto



IRSOL

