EJSM-Submillimetre Wave Instrument

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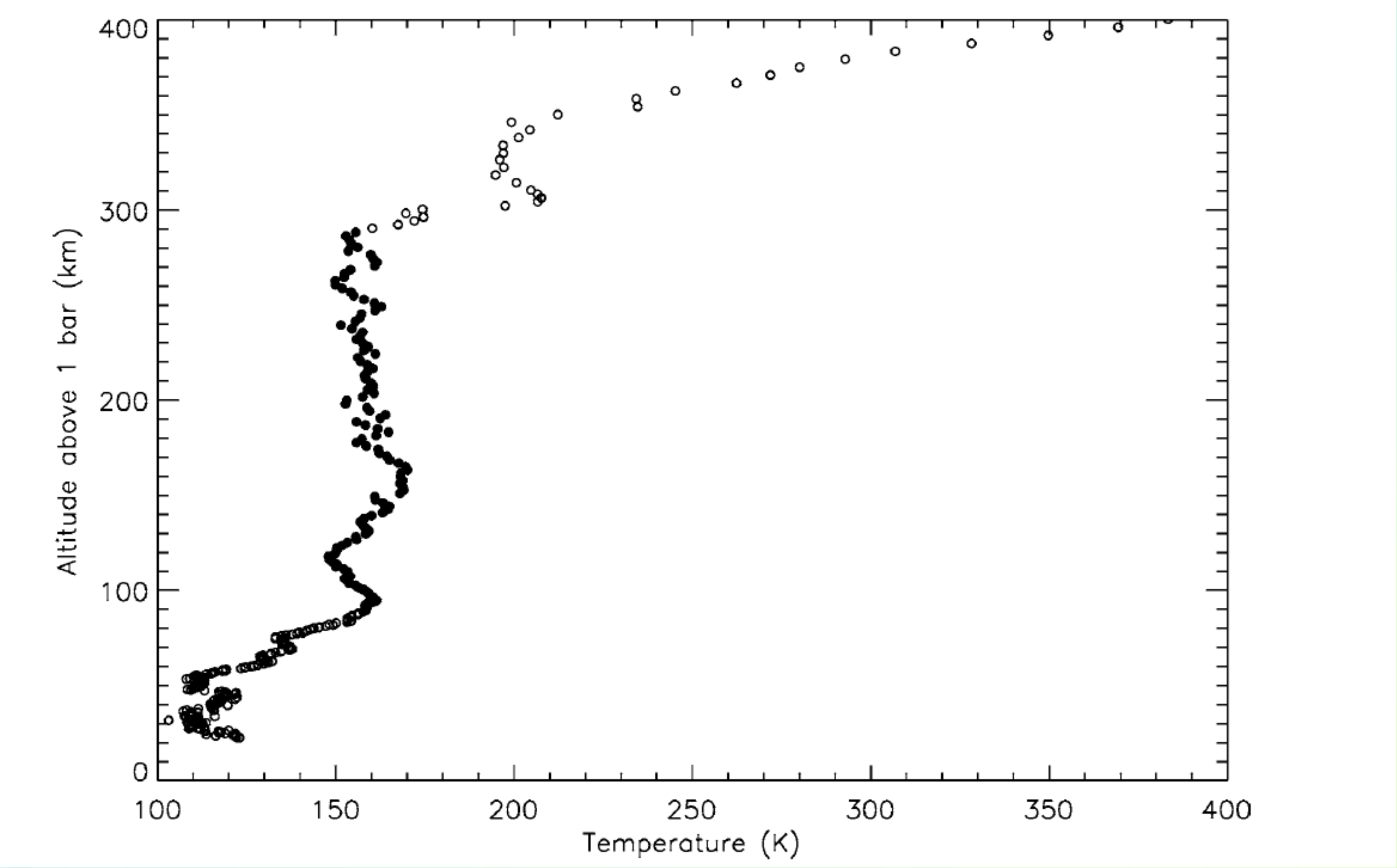
Galileo Probe Temperature Profile

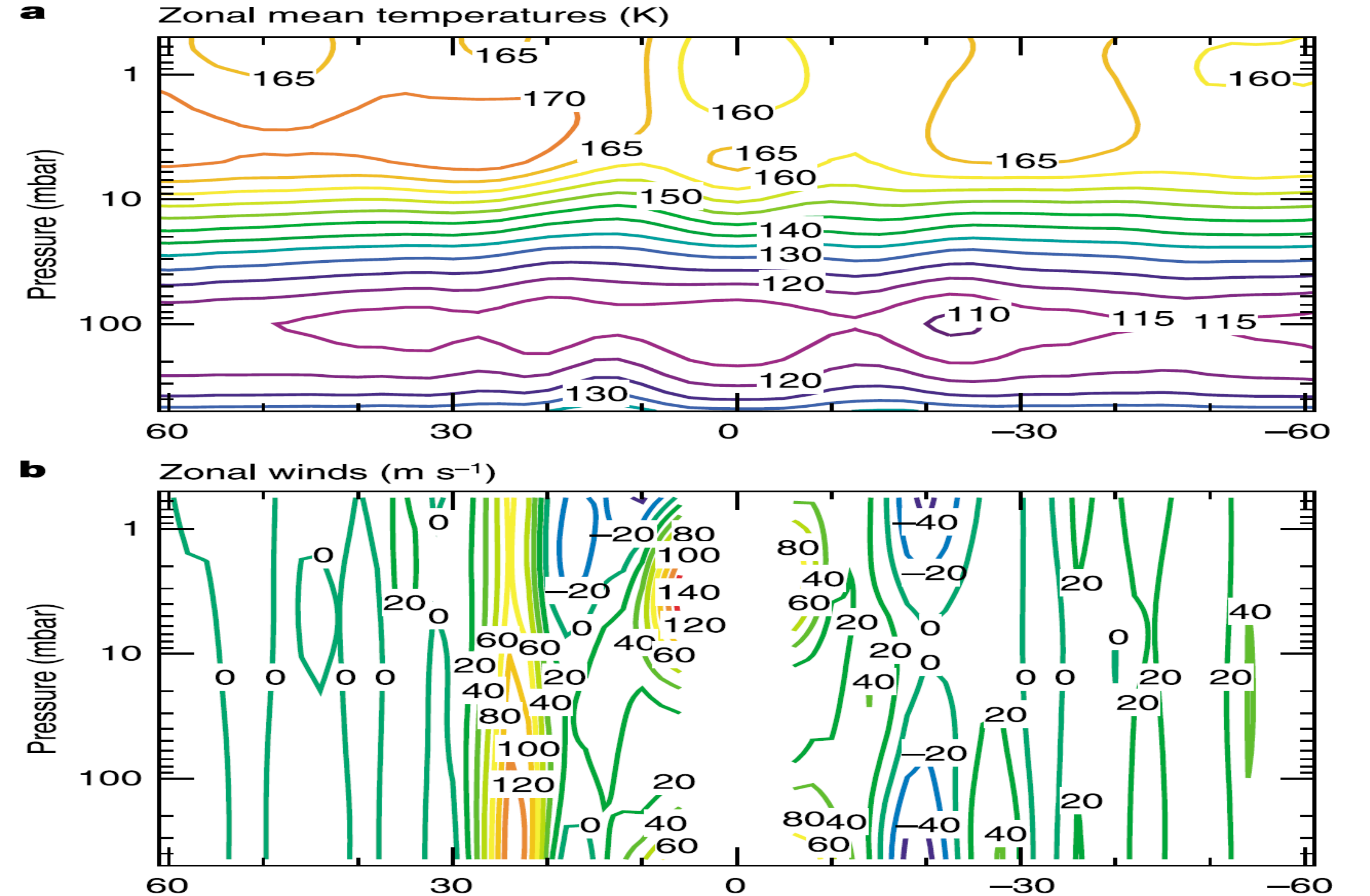


Young et al., JGR, 2005

Jupiter‘s middle atmosphere

- *Couples deeper tropospheric layers with the upper atmosphere*
- *Structure, circulation and composition poorly determined*
- *No cloud tracer, i.e. no direct wind measurements so far*
- *Ground-based observations and Voyager/Cassini provide:*
  - *temperature fields and thermal winds except around the equator*
  - *long term temperature variations (QQO)*

CIRS temperatures and thermal winds



Flasar et al, 2004

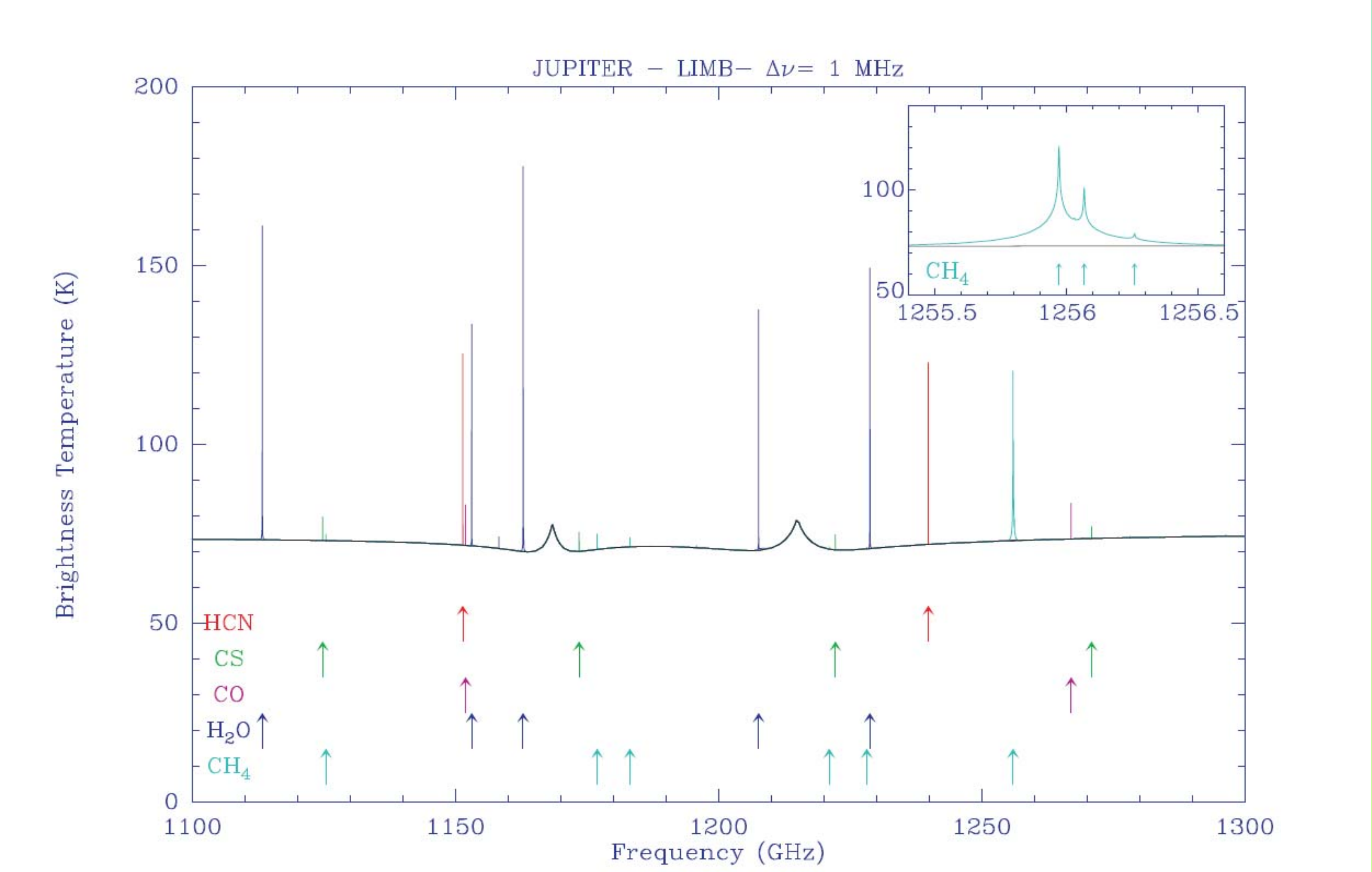
- *Meridional and vertical transport only little constrained by tracer observations after the SL-9 impact*
- *Future Herschel observations will provide new valuable data, however only on long transport time scales*
- *Waves seem to play a role in driving the circulation*
- *However role of mechanical and thermal forcing not clear, because no constraints of models by data*
- *Simultaneous temperature and direct wind measurement required*

Submm Wave Instrument

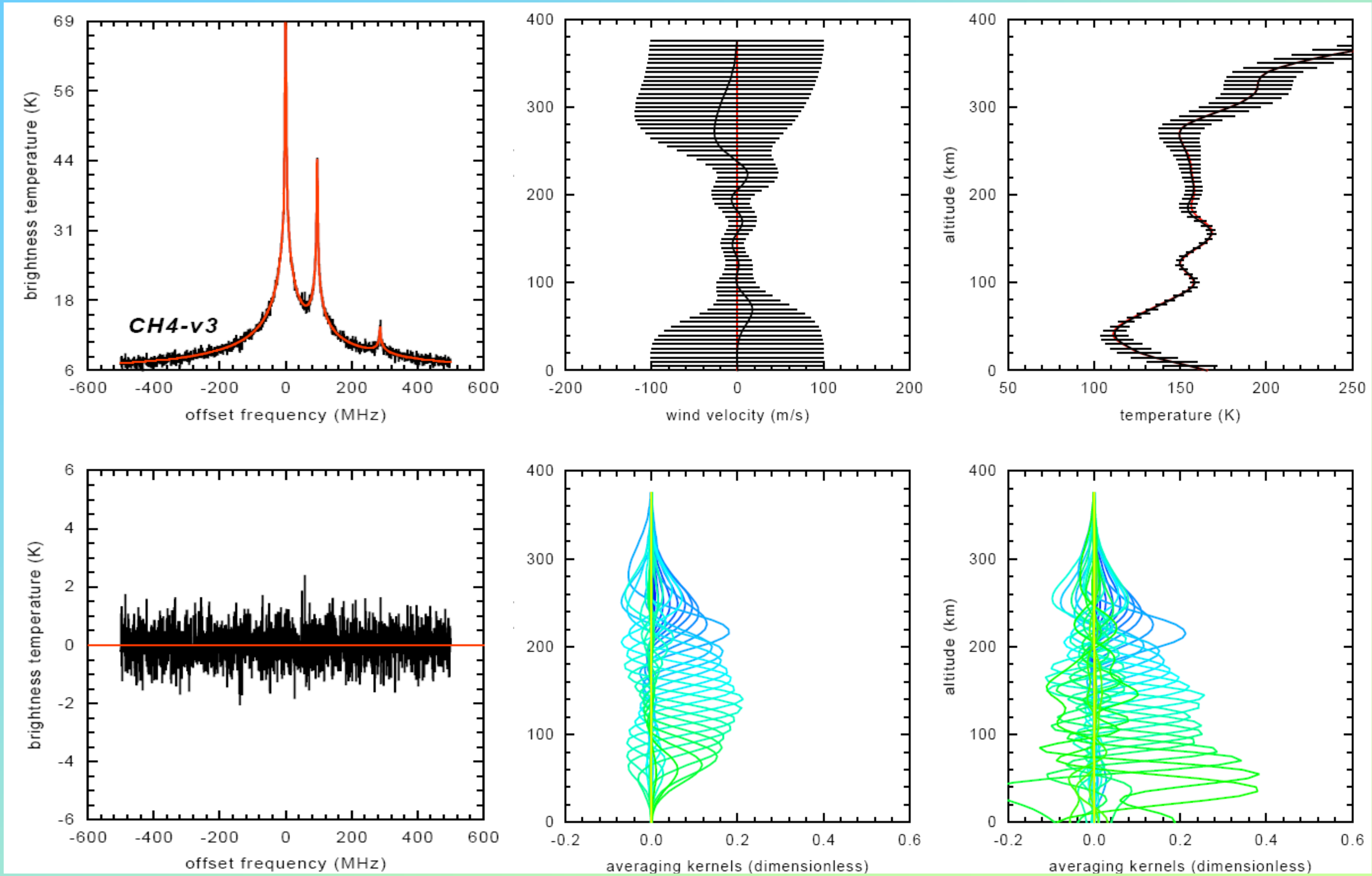
- *Vertical profiles of temperature*
- *Direct (Doppler) wind measurements*
- *Highly resolved 3-D monitoring of tracers:*
  - *SL-9 impact: CS, HCN, CO*

  external oxygen/water supply of uncertain origin
- *Search for new molecules: CH_3OH, H_2CO,HC_3N, CH_3CCH halides(HCl…)…*
- *SWI observes in limb and nadir mode*

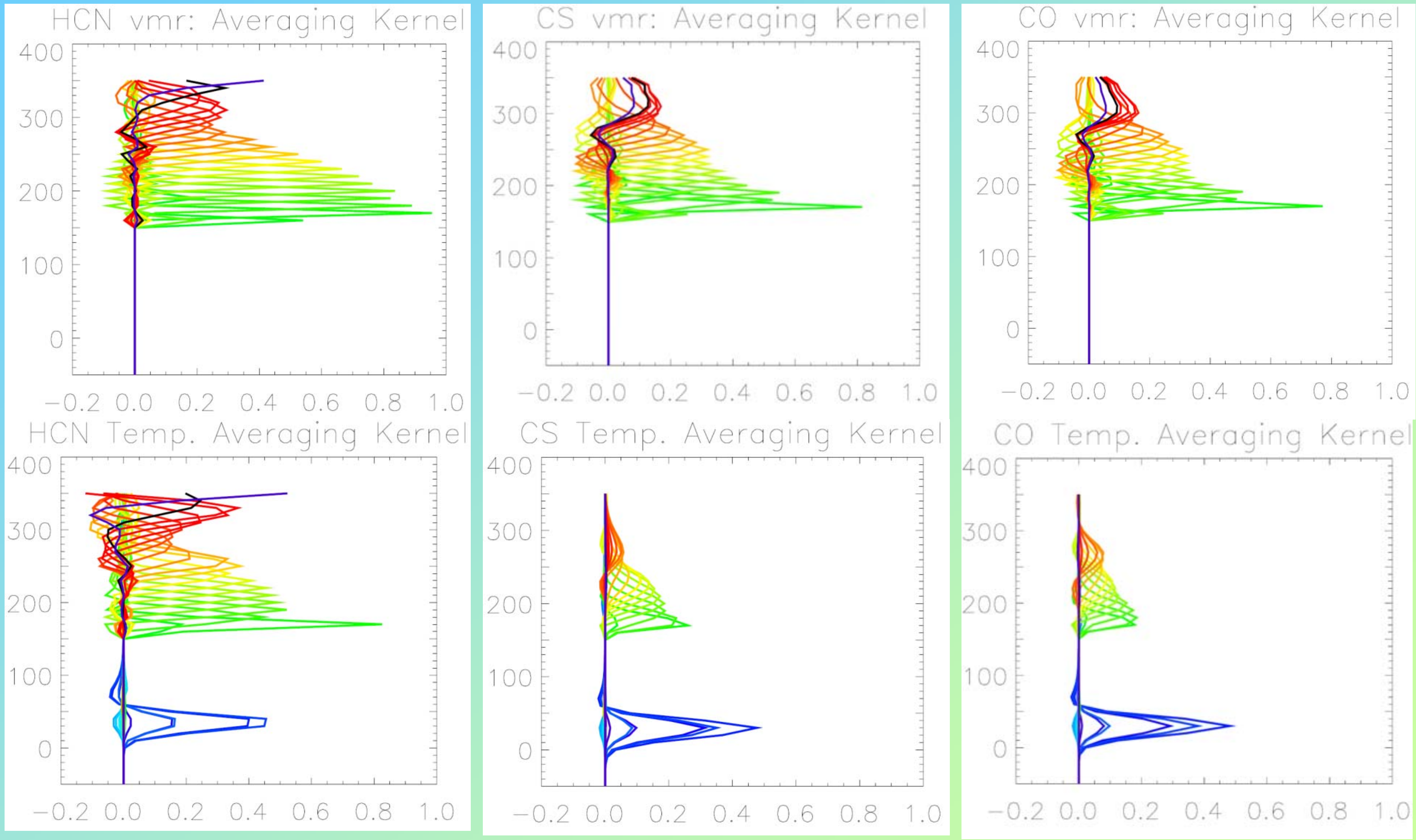
Jupiter submm limb spectrum around 1200 GHz



1256 GHz Methane: wind and T retrieval simulation



VMR &T AKs of HCN, CS and CO



Atmospheres of Io & Europa

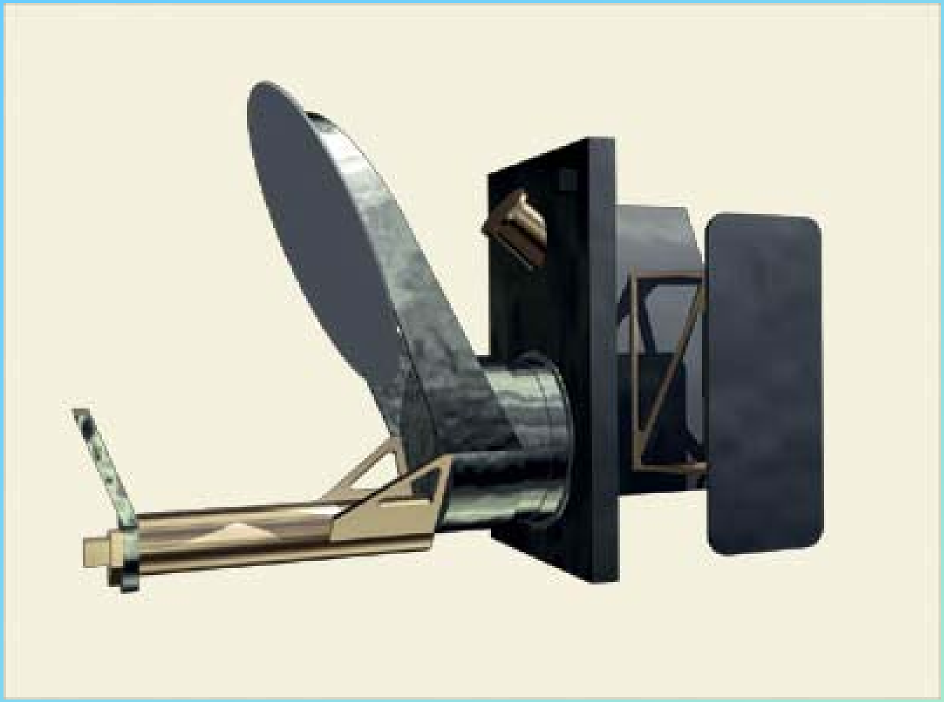
- 1000-1300 GHz : map SO_2/SO lines + isotopes and search for S_2O
- 400-500 GHz : map SO_2/SO/NaCl lines + isotopes and search for S_2O, OCS, KCl, ClO, SiO
- 557 GHz and 1097 GHz water observations (Europa)
- Relative importance of sputtering vs sublimation
- Inferior conjunction observations (5-10 points for antenna diameter 30 cm, 25-100 points for 60 cm aperture)

Ganymede: regolith studies

- *Determine surface brightness temperatures in 600 and 1200 GHz bands with high spatial resolution*
- *Constrain amplitude and phase of thermal wave within the first centimeter of the regolith*
- *Determine thermo-physical properties of the regolith*

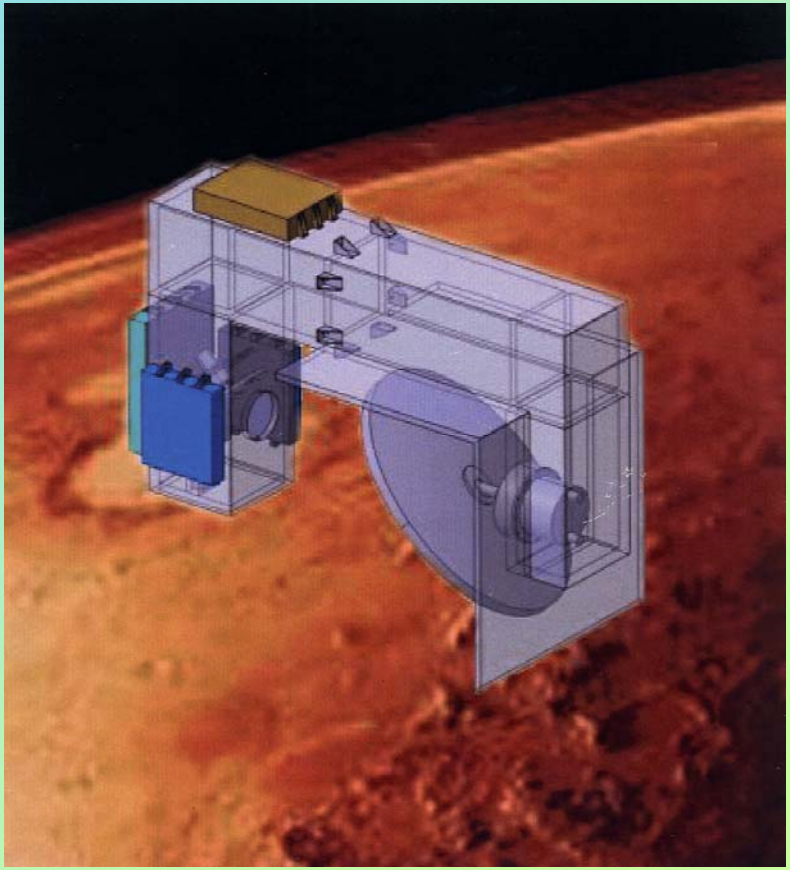
Kick-off meeting 18-20 November

- Science review and refinement
- Observation strategy studies
- Instrument study progress:
  - Optical and receiver design
  - Mechanical design
  - Thermal design
  - Spectrometer design
  - Electronic Unit design



MIRO / Rosetta

SWI – ESA Study



Instrument characteristics

– Baseline

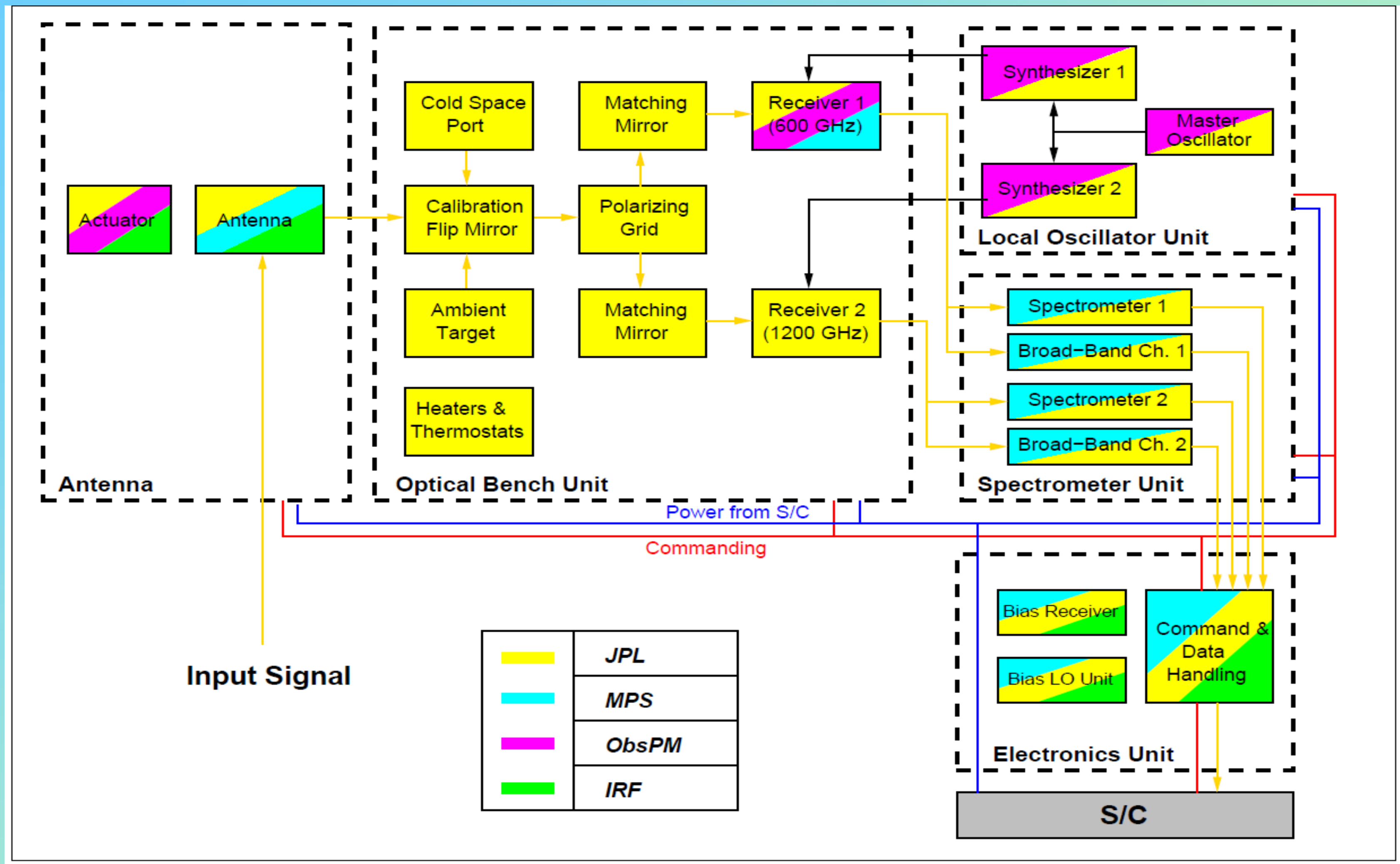
- Telescope D ~ 30 cm
    - » Spatial resolution ~ 800 km @ 15 RJ distance
    - » Vertical resolution: < ~ scale height
- Two spectral bands: 400-600 and 1080-1280 GHz
- Instantaneous bandwidth ~1 GHz, resolution ~200 kHz
- Tunable LO
- Uncooled Schottky receiver: T_{sys} (DSB) ~6000 K at 1 THz, 2500 K at 500 GHz

  Detection capabilities

  1 min: line contrast ~ 0.6 – 1.65 K

  1 hour: line contrast ~ 0.1 – 0.25 K
- Heritage: MIRO/Rosetta (in flight), MIME (proposed for Mars Express) + SWI (ESA-CDF study for Mars)
- ~10 kg, 48 W

SWI block diagram and responsibilities



SWI M&P Budget

	Submm Instrument breakdown			
	MIRO		SWI	
	Dual channels; fixed tuned; fixed antenna; CTS backend		Dual channel; tunable; articulated antenna; digital backend	
	Mass, kg	Pwr, W	Mass, kg	Pwr, W
Telescope	2.1	0	4	8
Detectors	5	20	2	16.4
Backend	5.8	20	1	5
USO	1.12	3	0.5	2
Electronics	5.87	25	4	15
Wiring	0.45	0	0.3	0
Totals	**20.34**	**68**	**11.8**	**46.4**

- 30 cm primary~1kg, 3x for support
- Based on 2 separate RFEs
- ASIC approach 400 MHz BW x2
- Non-redundant existing unit
- Based on FPGA approach, No bias for mixers etc, custom DC/DC
- Modular design
- **Need to include MLI blankets, thermal hardware**

Budgets

Mass budget

primary mirror (Mg)	1020 g
actuator (ESA study)	1800 g
receivers (both)	280 g
spectrometers (CTS)	1500 g
electronics	1000 g
synthesizers	500 g
optics	500 g
structure	2910 g
cables, screws, mountings	1000 g
total:	10.51 kg

Power budget

actuator (ESA study)	5 W
receivers (both)	20 W
spectrometers (CTS)	10 W
control electronics	2 W
synthesizers	5 W
cal. mirror	2 W
sum	44 W
DC/DC overhead (80% eff.)	11 W
total:	55 W

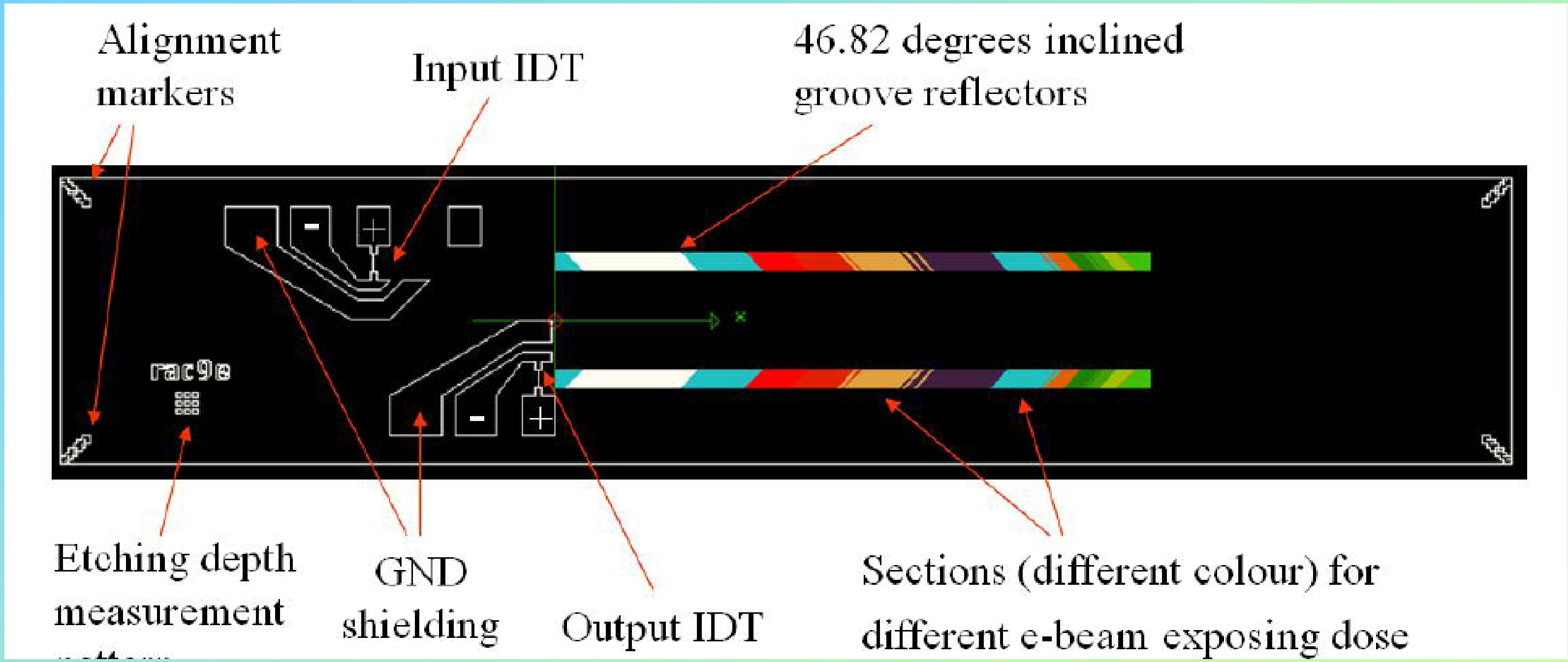
Actual and predicted performances

	600 SHM	600 SHM	600 FBM	600 FBM	1200 SHM	1200 SHM
Tamb (K)	**295**	120	**295**	120	295	120
Tmix DSB range (K)	**3000 4000**	1500 2000	**2000 3000**	1000 1500	4000 5000	2000 2500
CLmix DSB (dB)	**10-12**	10-12	**7-8**	7-8	12-14	12-14
LO power (mW)	**3-5**	3-5	**1-2**	1-2	3-5	3-5
IF band (GHz)	**2-8 GHz**					
T_{IF} (K)	**85**	10	**85**	10	85	10
Trec DSB range (K)	**3900 5400**	1600 2150	**2500 3550**	1050 1600	5500 7200	2200 2750
Delta T (K) *	**3.9-5.4**	1.6-2.1	**2.5-3.5**	1-1.6	5.5-7.2	2.2-2.7

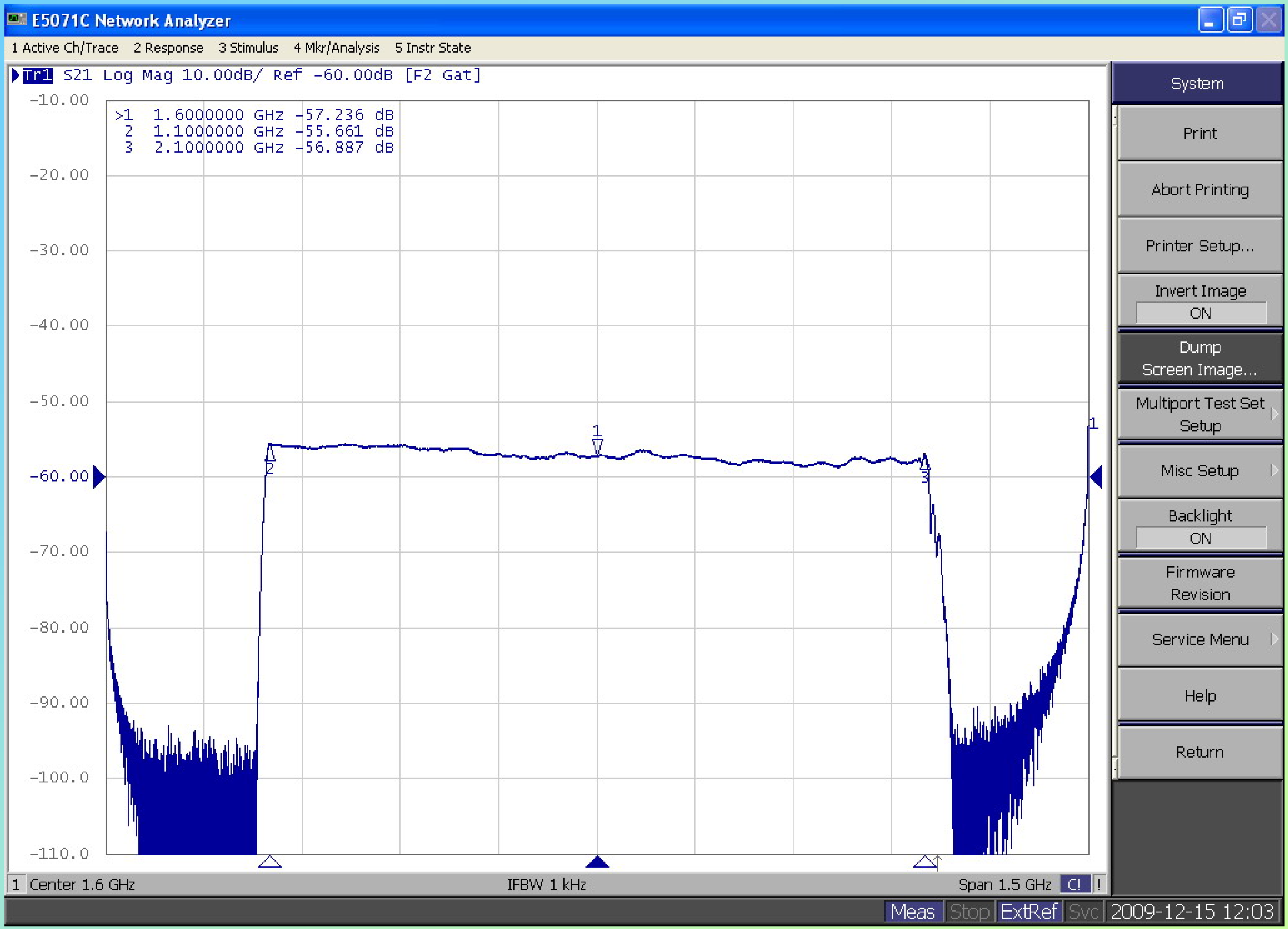
* B = 1 MHz, σ = 1 sec, and Trec assumed

Spectrometer: status reflective array compressor (Dispersive Delay Line, DDL)

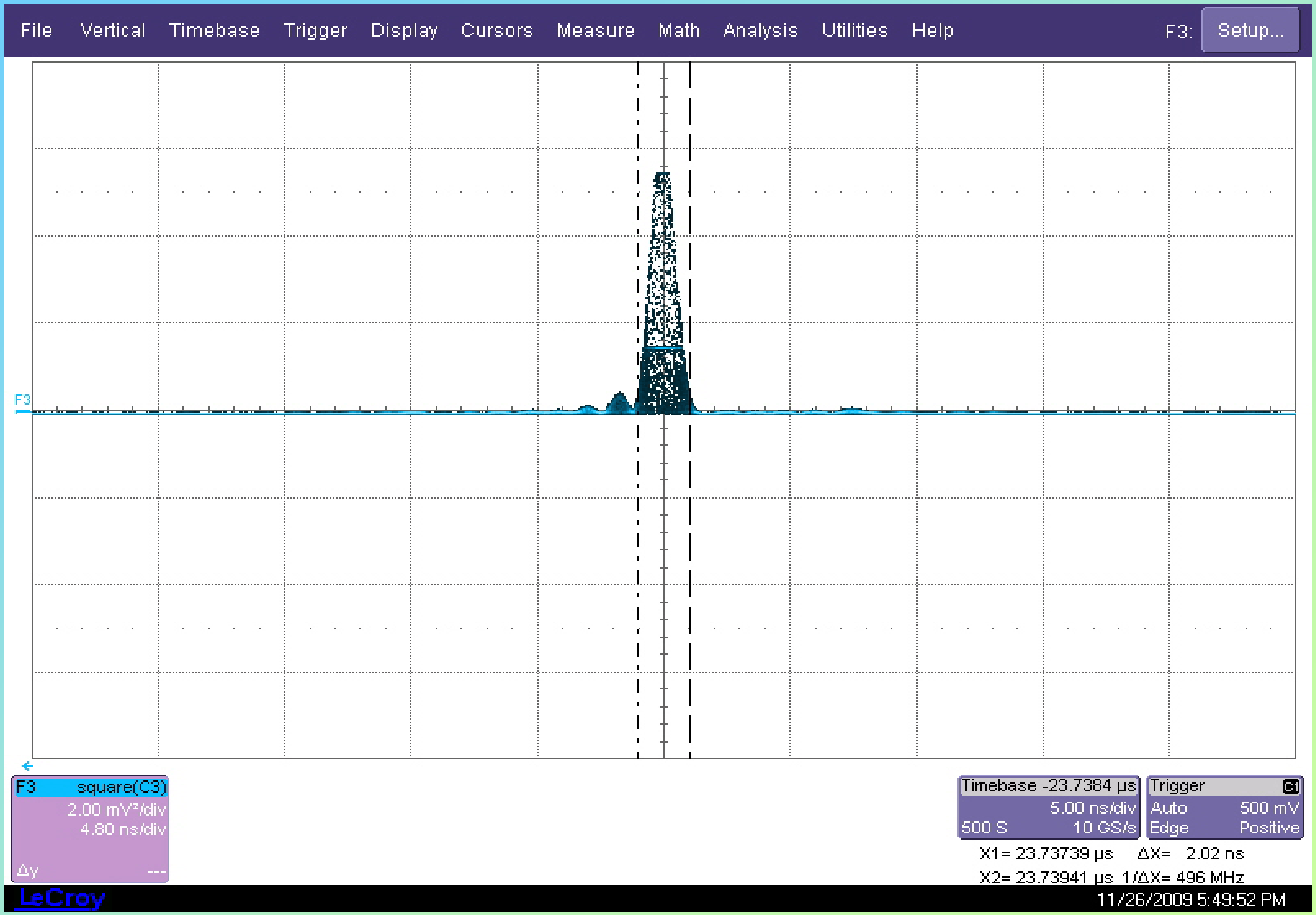
Optimize the reflection coefficient by adjusting the groove depth to the reflective wavelength. Duty cycle weighting helps to optimize the bandpass characteristics (ratio of groove widths to groove distance)



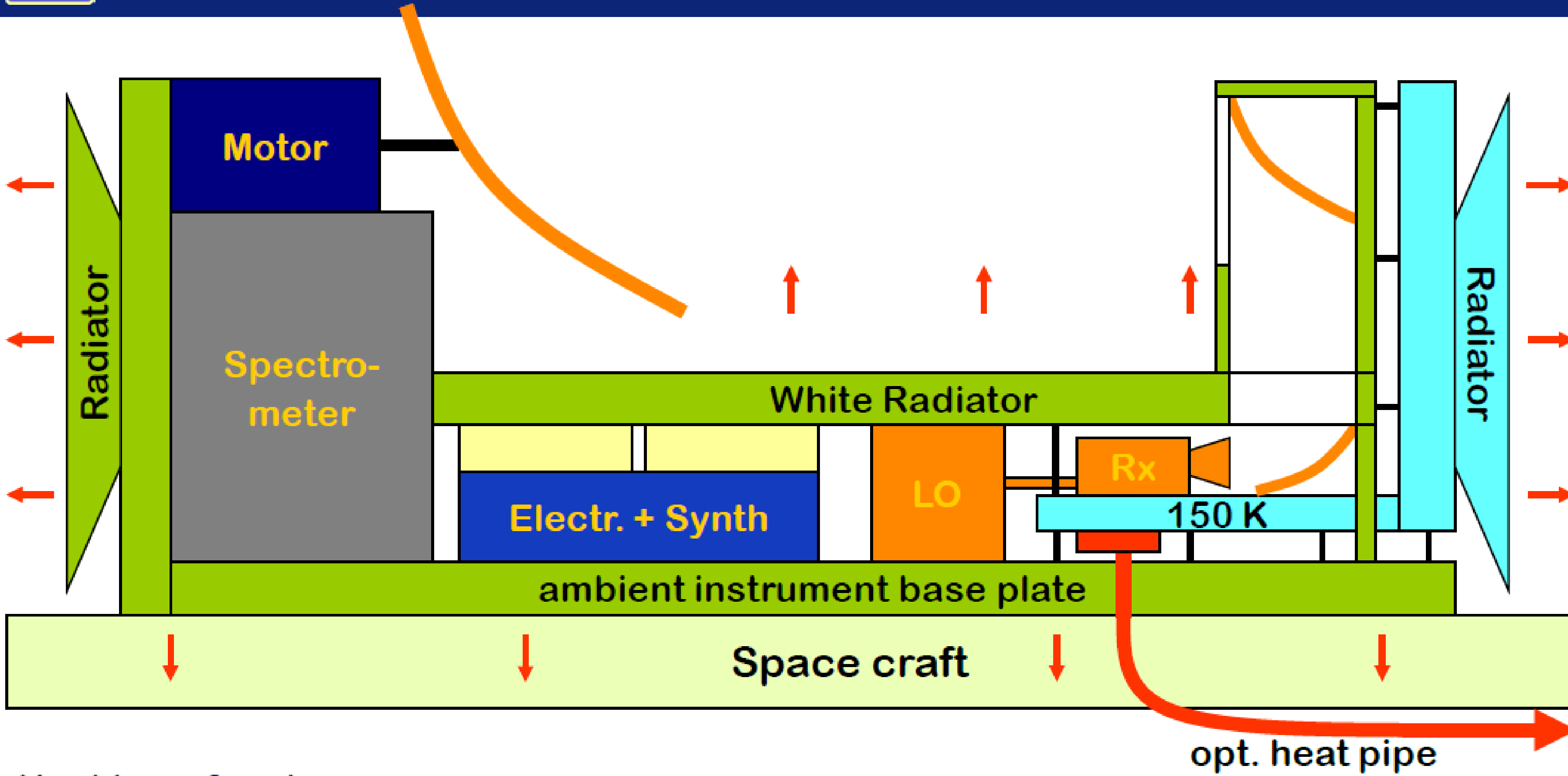
Latest DDL results: IL=57 dB



Envelope of compressed pulse power



Thermal Design B – Cooled Receiver



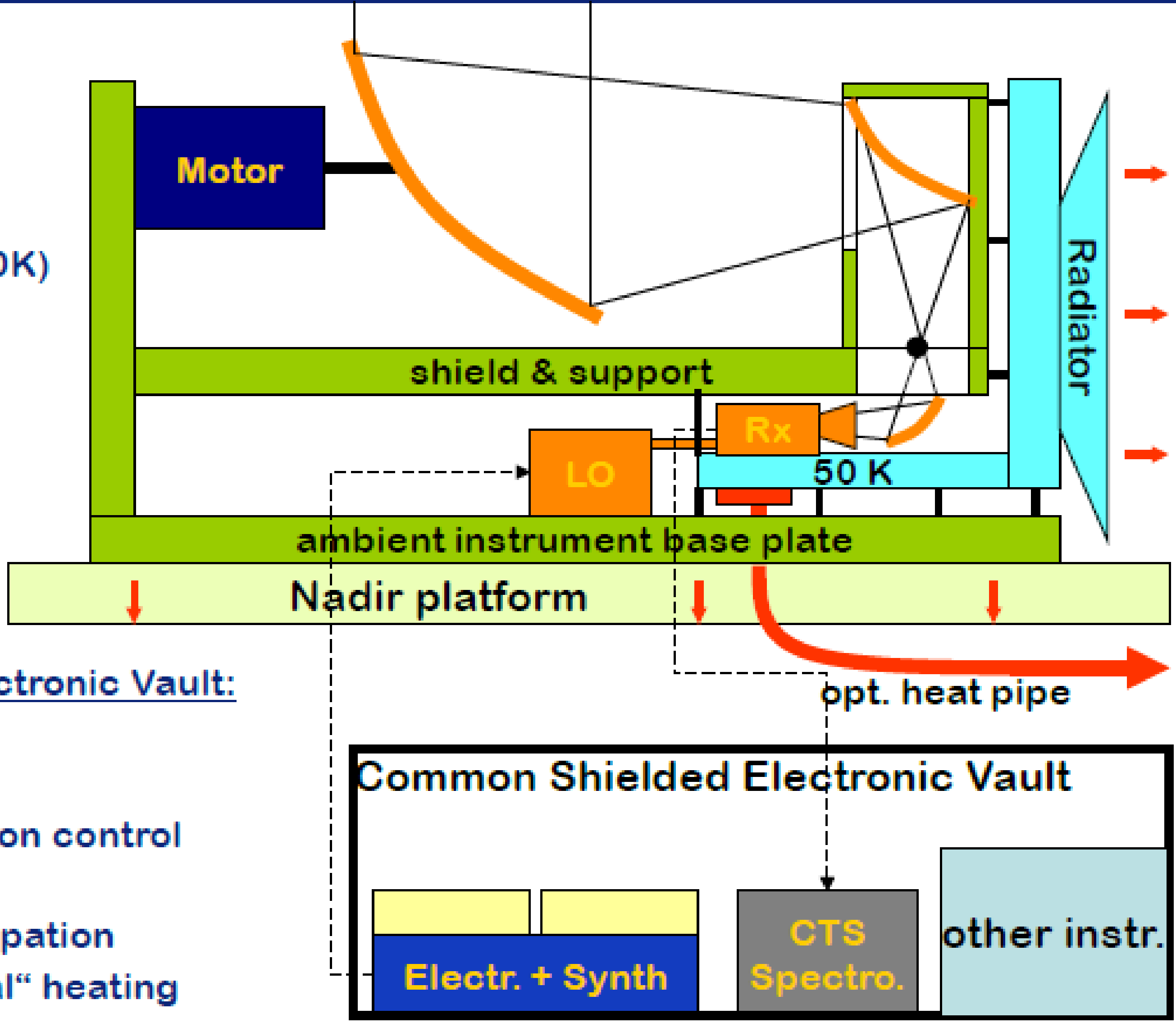
Heat transfer via:

- space craft mounting plate (ambient)
- optional radiator for ambient electronics and motor
- optional radiator for cooled receiver (0.036 m^2 ~ 0.6W @ 150K)
- optional heat pipe / thermal strap for cooled receiver

Thermal Design C – Distributed Receiver

<u>Instrument Level:</u>

- cooled receiver
  ~ 0.6W @ 50K
- local oscilator
  ~ 20 W @ 150K (300K)
- Nadir view
- scanning mech.
  +/- 90° / +/- 4°
- opt. radiator
  ~ 0.036 m^2
- opt. heat pipe



<u>Common Shielded Electronic Vault:</u>

- synthesizer
- CTS Spectrometer
- TM/TC data & operation control

- Operation : 30W dissipation
- Stand-by : "collateral" heating

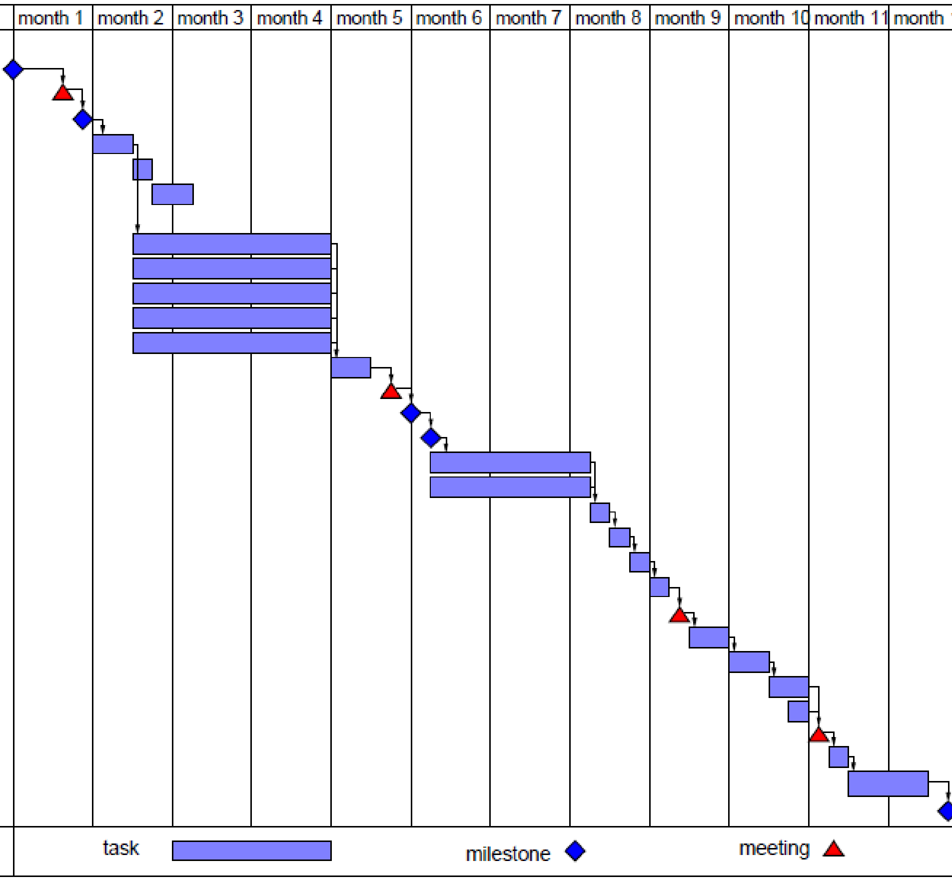
Next Steps

- Proceed with RTE/retrieval simulations
- Iterate with science requirements
- Evaluate observing scenarios vs mission phases
- Optimize two actuator optical design
- Proceed with thermal design
- Proceed on Electronics Unit
- Start radiation analysis
- Next team meeting end of February

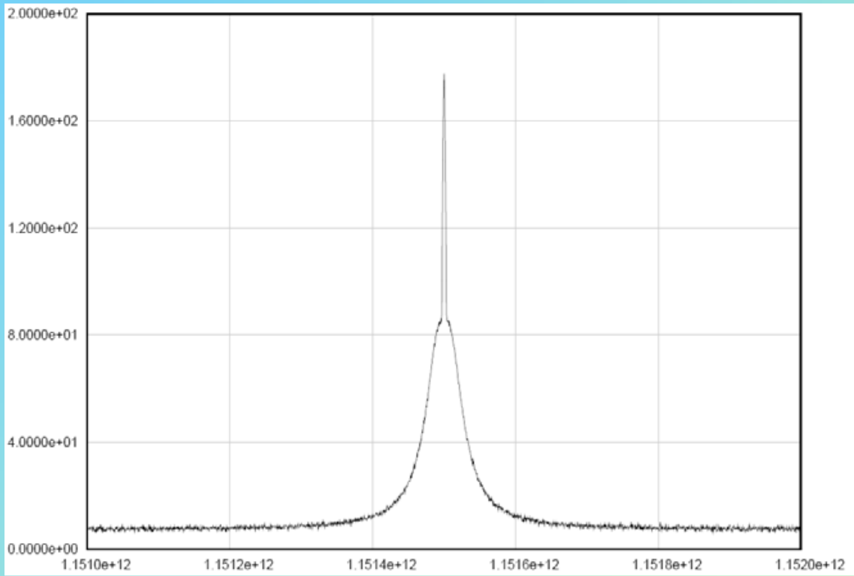
Schedule of Phase-A Study

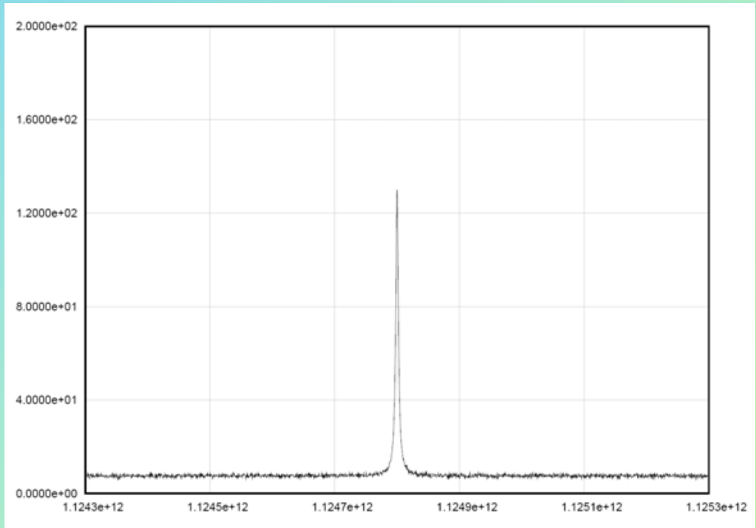
Kick-off meeting: 18-20 Nov. 2009

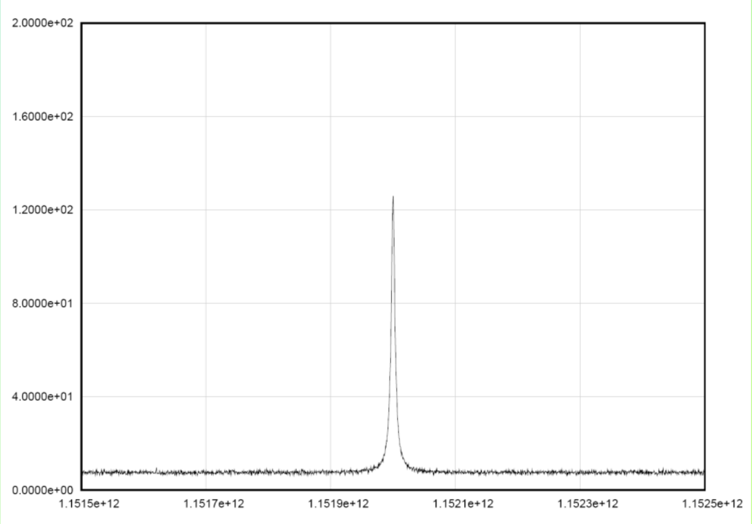
ID	Task Name	Duration
1	Study team teleconference	every two weeks
2	ESA approval	milestone
3	Kickoff Meeting at MPS	2 weeks after ESA approval
4	SWI functional definition	milestone
5	Requirements flow	2 weeks
6	Determination of mission radiation requirement	1 week
7	Risk Identification/initial list of technology development tasks	2 weeks
	Trade studies (each one running concurrently for 3 months)	
8	Antenna	2.5 months
9	Optical Bench	2.5 months
10	Local Oscillator	2.5 months
11	Spectrometer	2.5 months
12	Electronics	2.5 months
13	TRL classification	2 weeks
14	Tag–up meeting at Observatoire de Paris, France	1 week
15	Selection of baseline approach	milestone
16	Selection of alternative approach	milestone
17	Preliminary design of baseline approach	2 months
18	Preliminary design of alternative approach	2 months
19	Initial rackup of instrument TRL	1 week
20	Initial rackup of instrument mass, power, and data	1 week
21	Initial rackup of grassroots SWI ROM cost	1 week
22	Initial list of technology development tasks	1 week
23	Tag–up meeting at JPL, USA	1 week
24	Final determination of instrument TRL	2 weeks
25	Final determination of instrument mass, power, and data	2 weeks
26	Final grassroots SWI ROM cost	2 weeks
27	Assessment of member state interest	1 week
28	Tag–up meeting at MPS, Germany	1 week
29	Technology development plans	1 week
30	Preparation of study report	1 month
31	Submission of study report	milestone



Upper stratosphere: HCN, CS & CO







1097 GHz H_2O & isotope: wind & T retrieval simulation