Interferometric observations of planets: Mars and Titan

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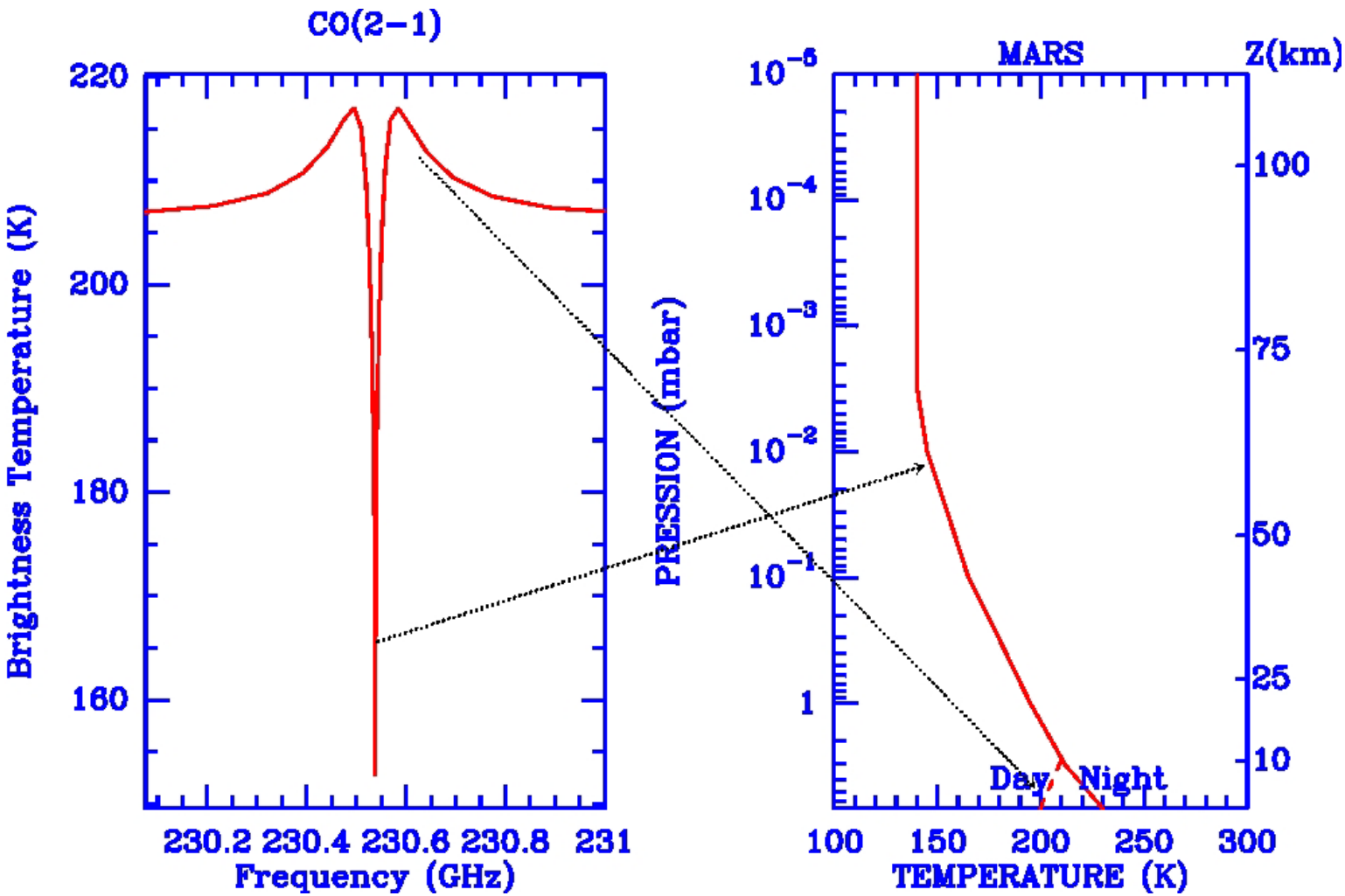
Introduction

Science goal : Wind measurement on Mars

How: Measuring the CO Doppler lineshift

CO on Mars


CO(2-1)
220
200
180
160
Brightness Temperature (K)
230.2 230.4 230.6 230.8 231
Frequency (GHz)
PRESSION (mbar)
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
MARS
Z(km)
100
75
50
25
10
Day
Night
100 150 200 250 300
TEMPERATURE (K)

Observations of line & continuum

- Observed Line-to-Continuum = x % (L/C)
- Needed Line Signal-to-Noise = y (S/N)

➔RF calibration accuracy = x/y %

Example :

L/C = 10 % ; S/N = 20; RF= 0.5%

Measure Strongest Quasar (~ 10 Jy) during ~0.5-1H

Observations

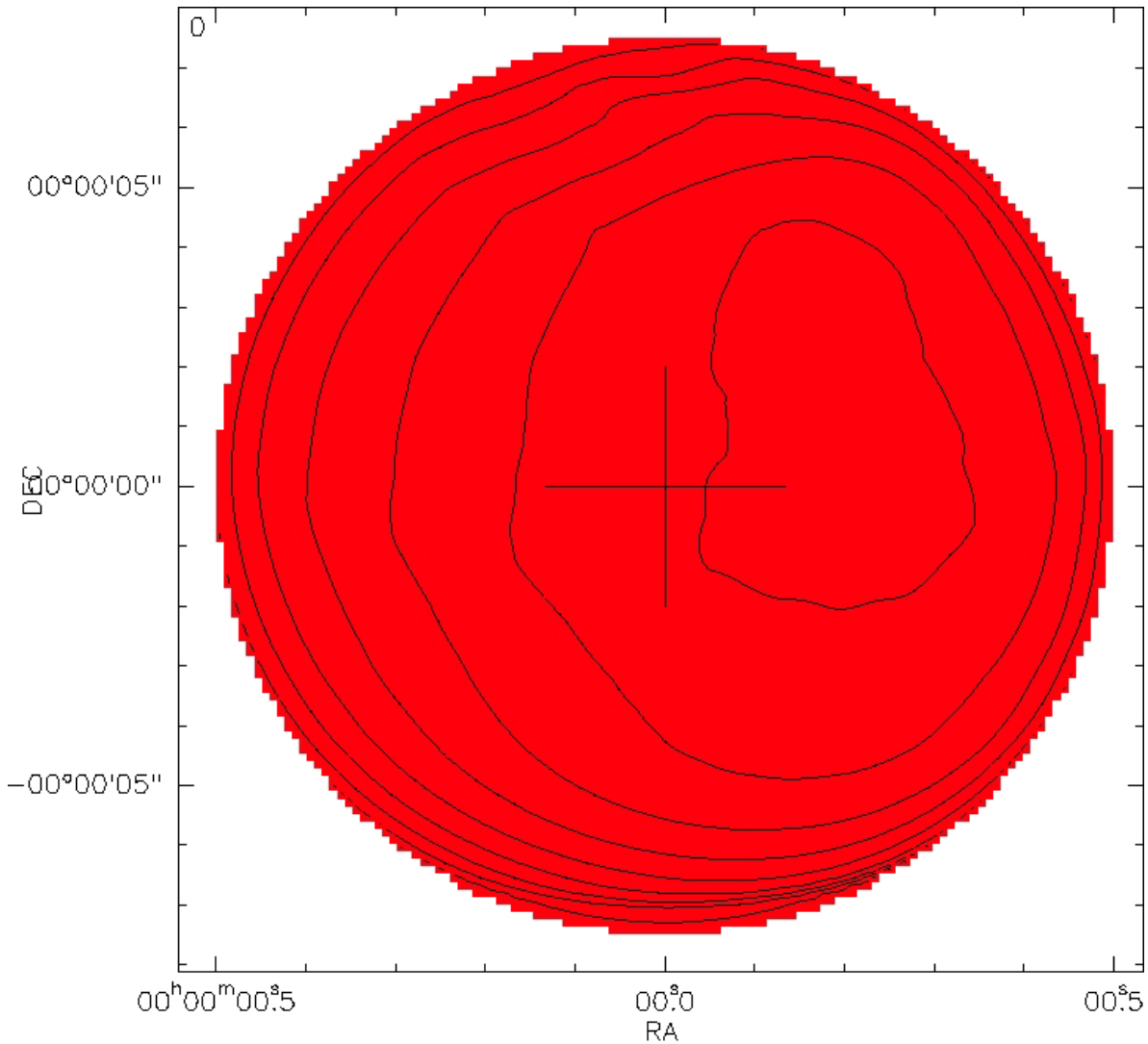
- CO(1-0) at 40 kHz
- Synthetized beam : 3×5” (CD)
- Phase rms : 20-30º

Date	Diameter (“)	North pole PA(º)
05 15 99	15.64	36.8
05 24 99	14.94	36.4
05 25 99	14.85	36.4
06 04 99	13.89	36.3

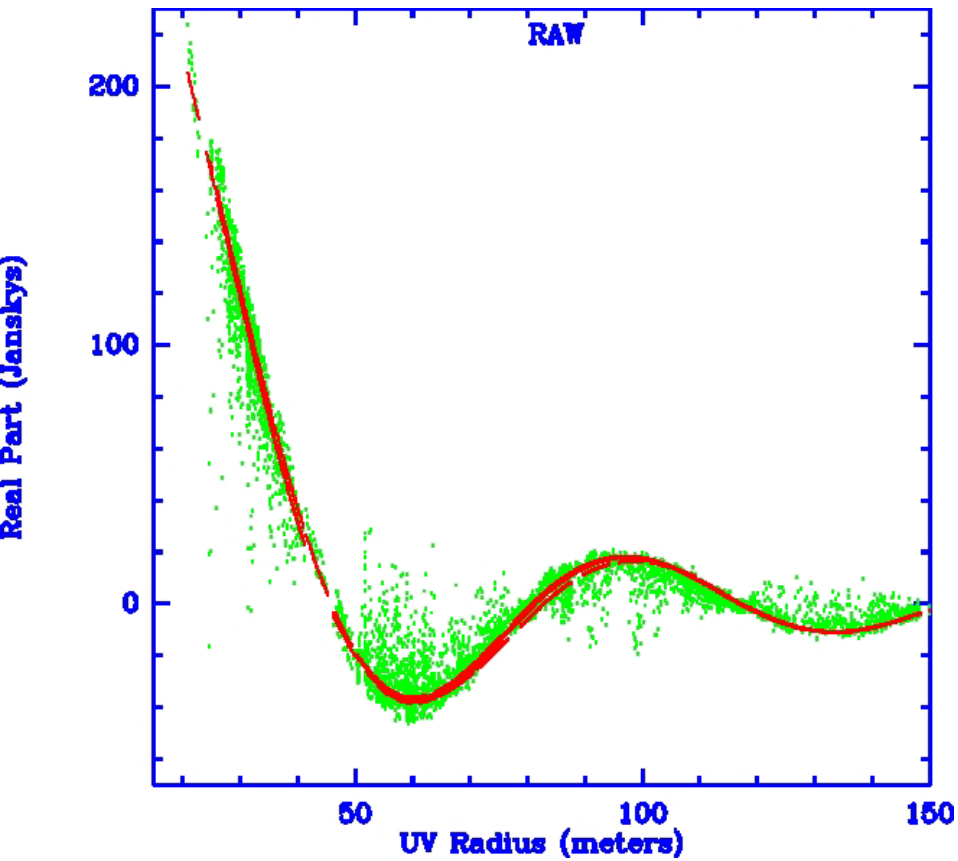
Data Reduction

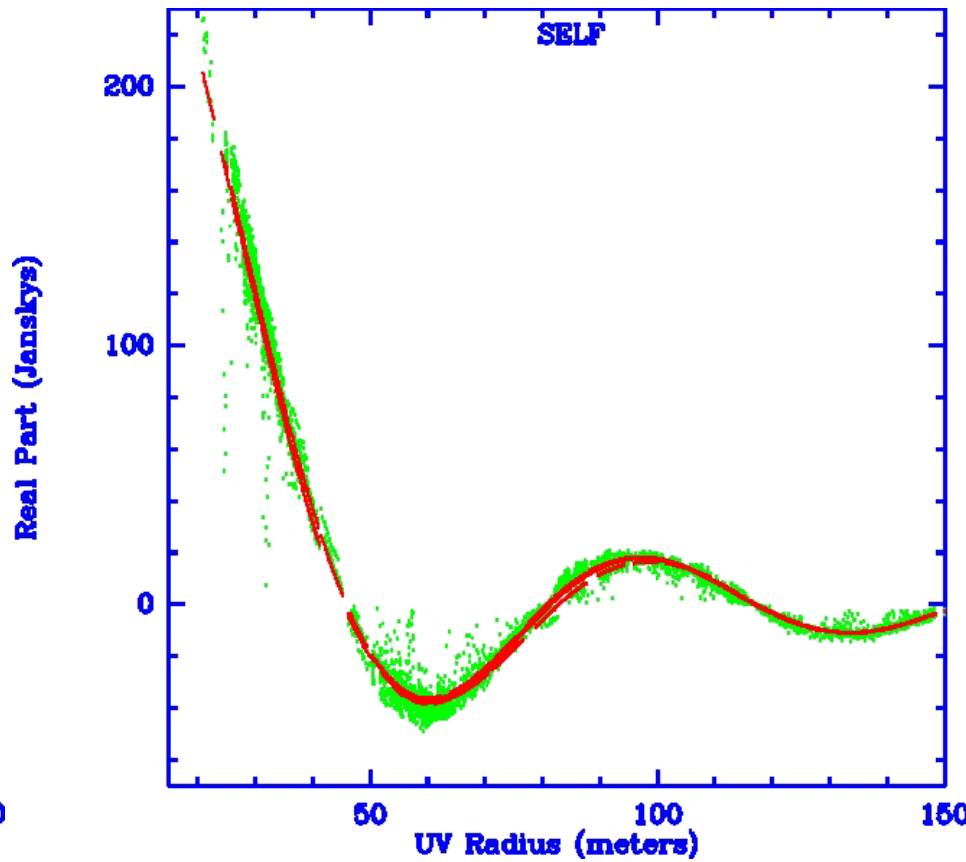
- Amplitude/phase calibration versus 3C273
- Scaling uv-data to single diameter (uv_mult)
- Add the visibility of the ≠ periods (uv_merge)
- Compute the visibilities from Mars continuum model (image+uv_model)
- Phase Self-Calibration (uv_mcal)
- Reject data which continuum depart by more than 25% (uv_mflag)
- Amplitude Self-calibration (uv_mcal)

Mars Model

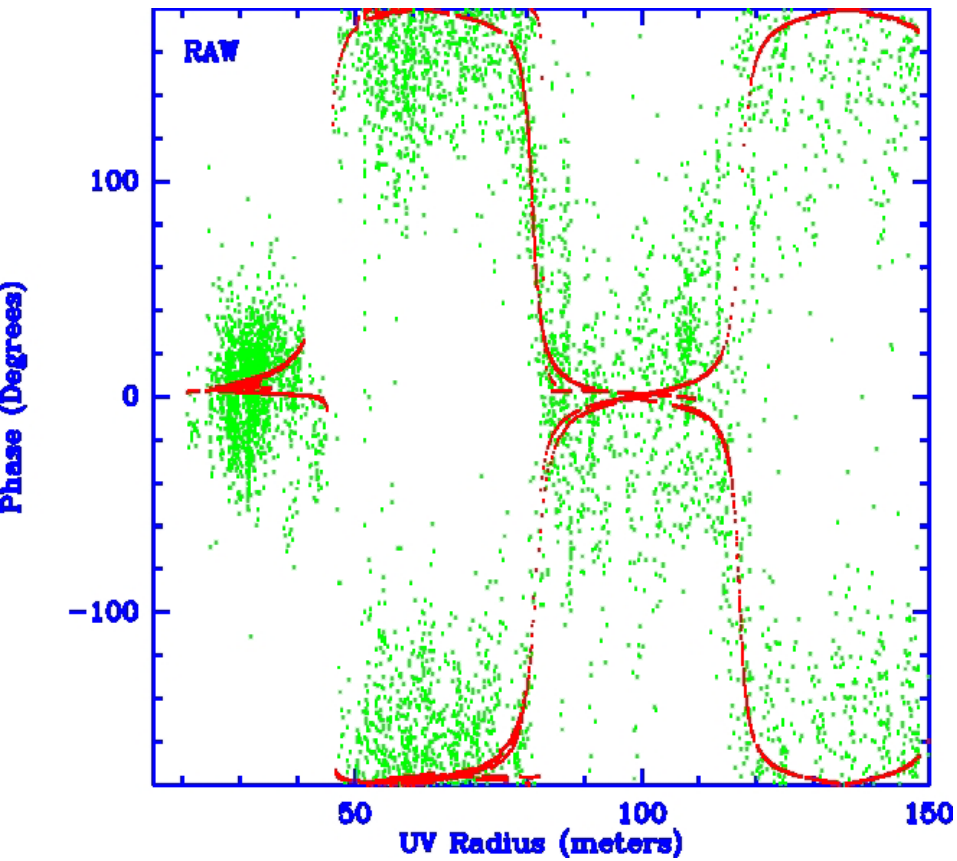


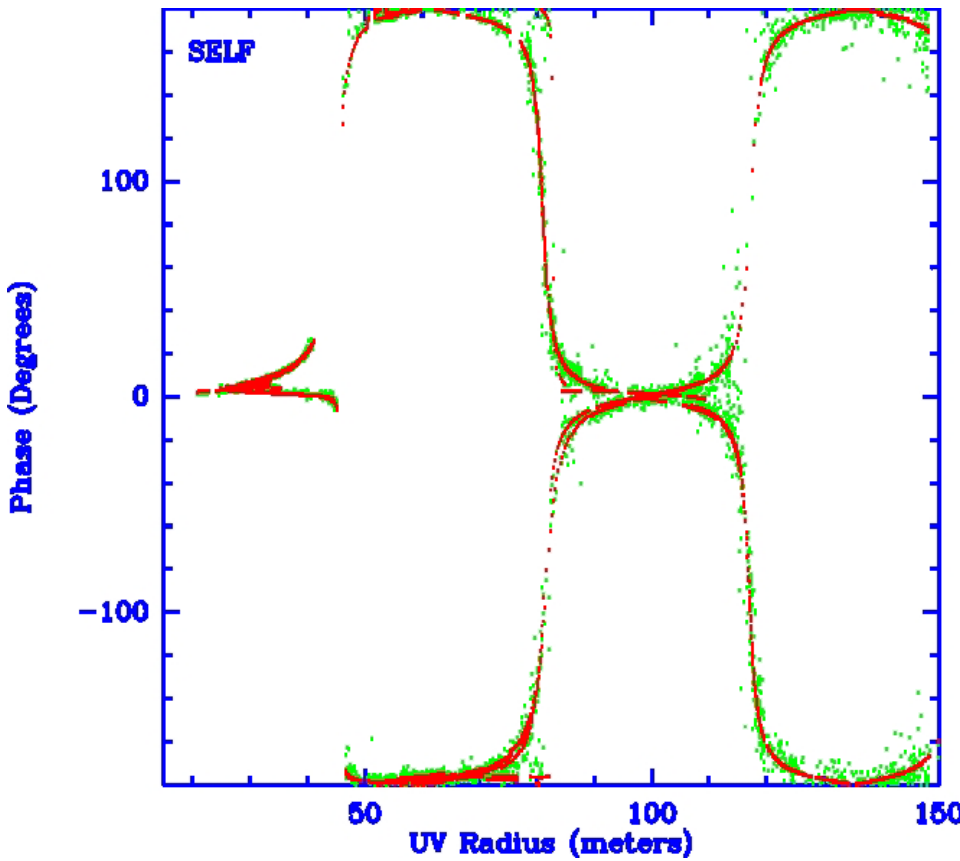
Phase Self-calibration





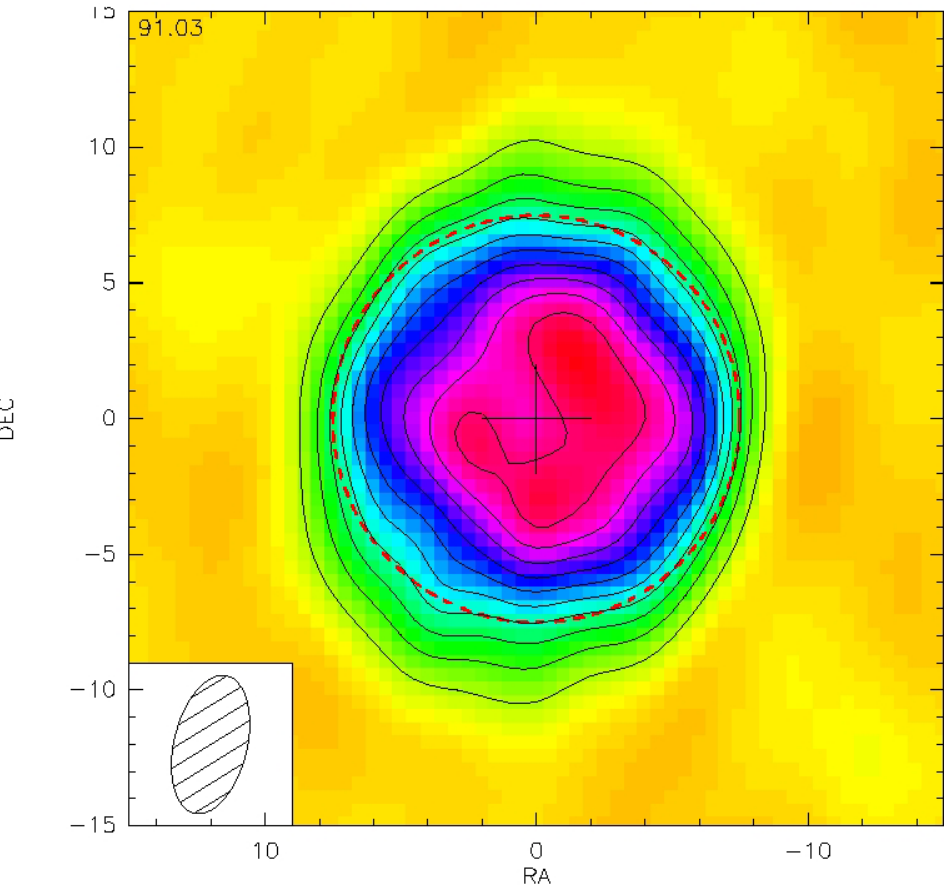
Phase Self-calibration (II)



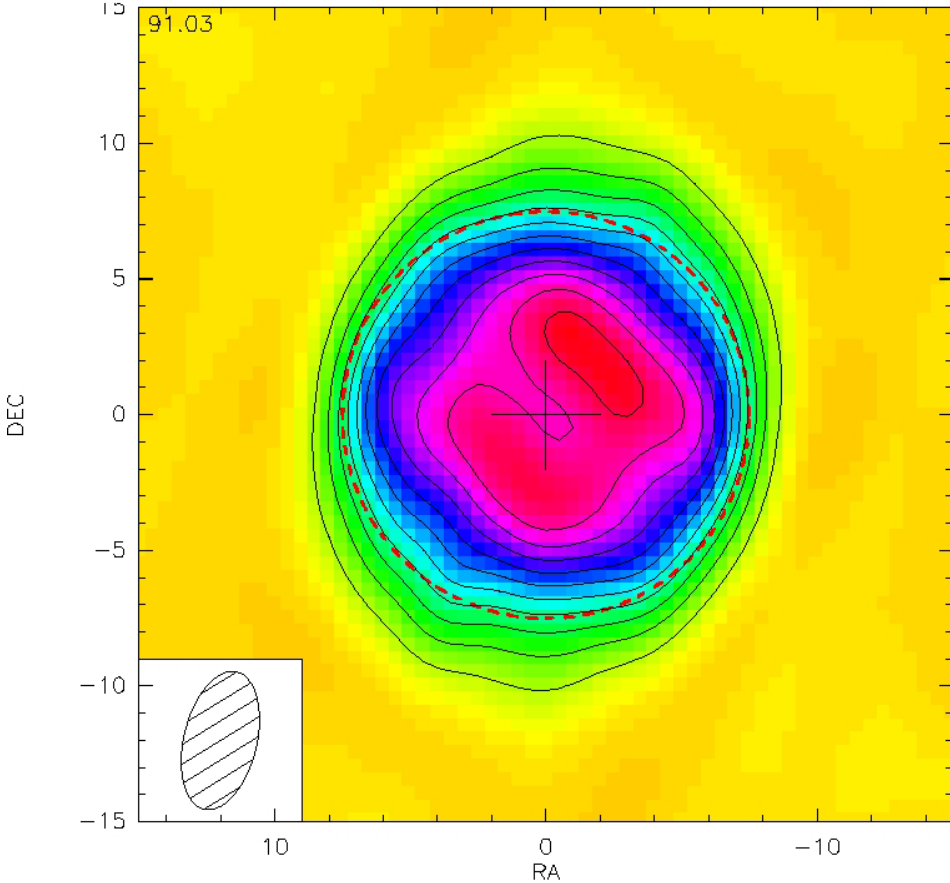


Mars Continuum map

RAW

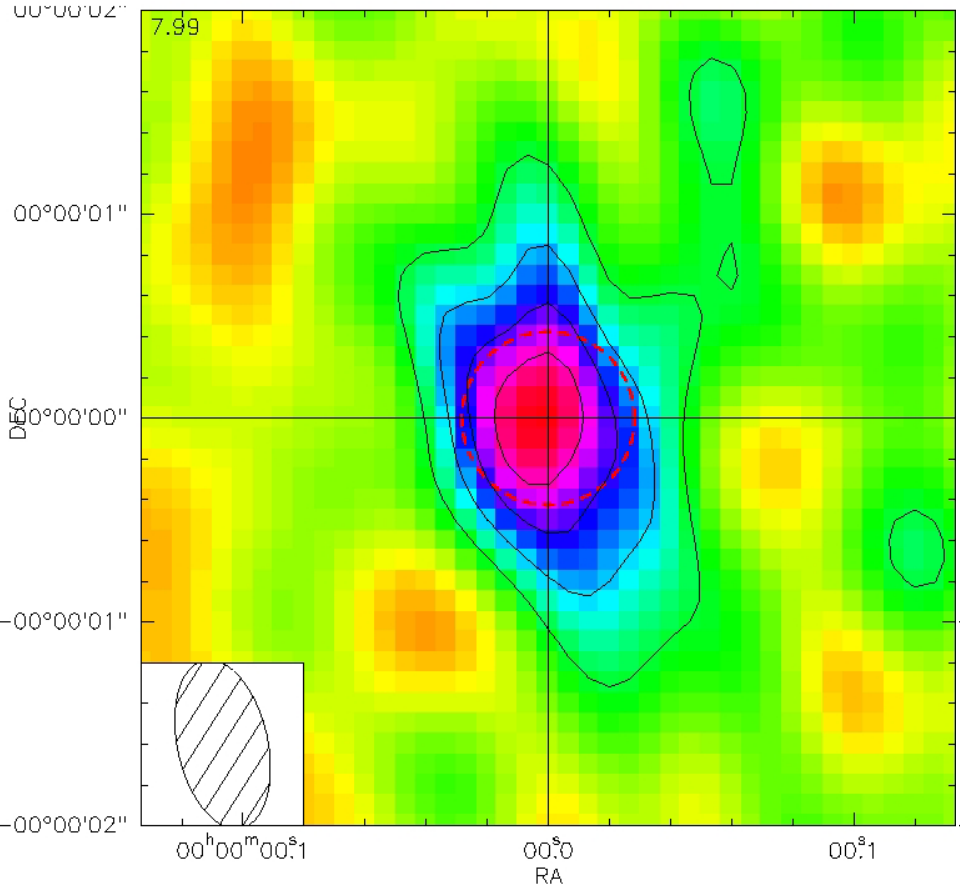


SELF



Titan Continuum map

RAW



SELF

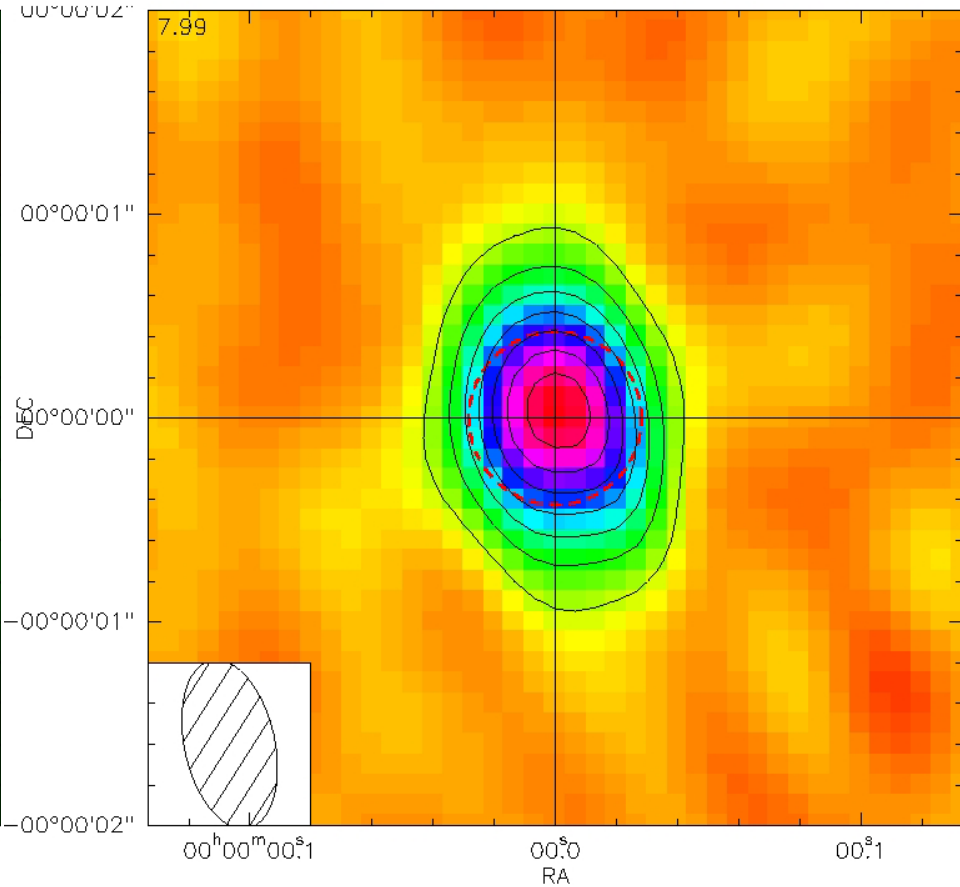
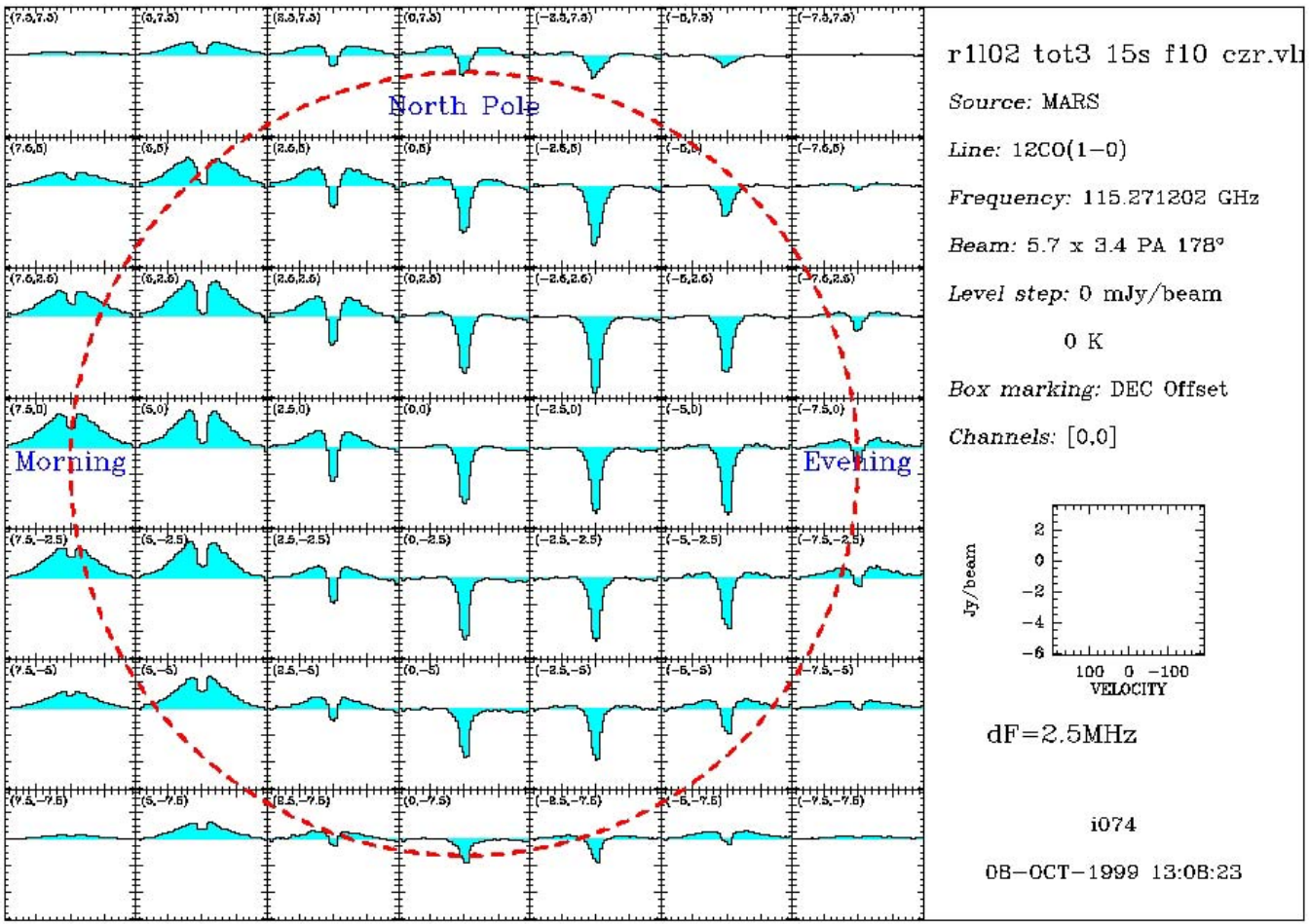


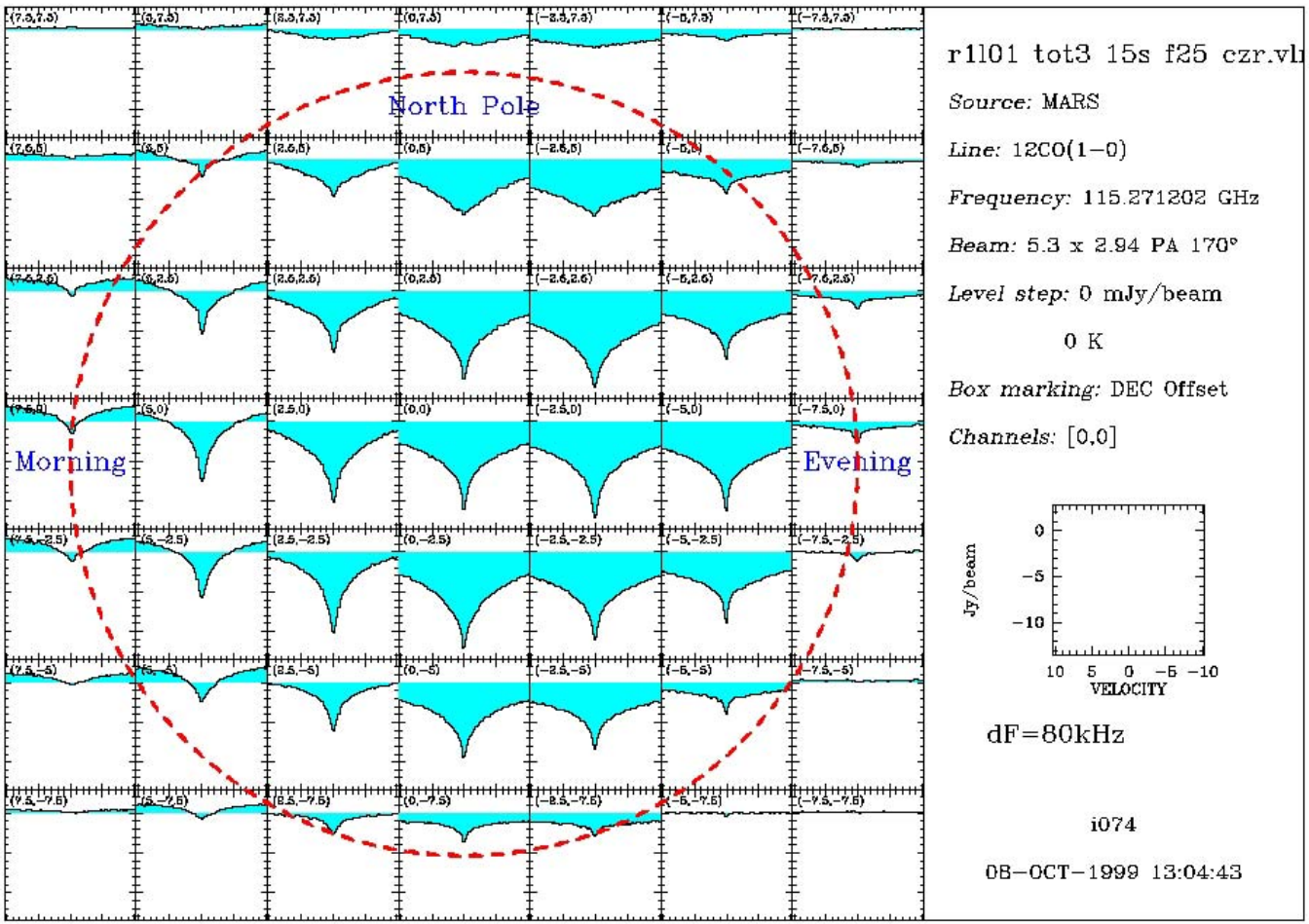
Image Reconstruction

- Rotate Mars visibilities to put north pole on top (uv_shift)
- Subtract continuum from visibilities (uv_subtract) and add zero spacing (uv_zero) to improve deconvolution
- Fourier transform the visibilities (uv_map) to create dirty map
- Deconvolve the image using CLEAN/CLARK
- Obtain the final image

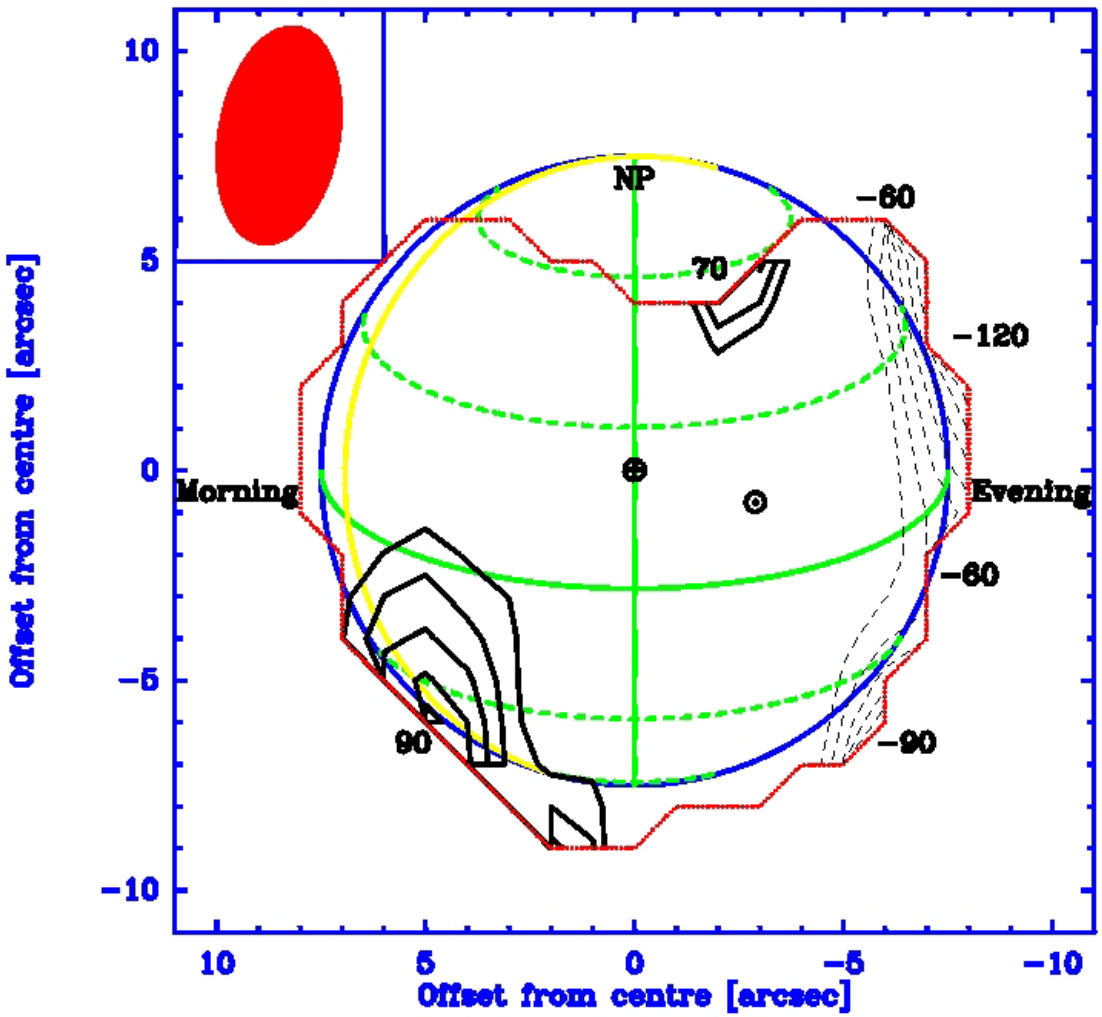
Maps


North Pole
Morning
Evening
r1102 tot3 15s f10 czr.vl
Source: MARS
Line: 12CO(1−0)
Frequency: 115.271202 GHz
Beam: 5.7 x 3.4 PA 178°
Level step: 0 mJy/beam
0 K
Box marking: DEC Offset
Channels: [0,0]
Jy/beam
2
0
−2
−4
−6
100 0 −100
VELOCITY
dF=2.5MHz
i074
08−OCT−1999 13:08:23

Maps (II)


North Pole
Morning
Evening
r1101 tot3 15s f25 czr.vl
Source: MARS
Line: 12CO(1−0)
Frequency: 115.271202 GHz
Beam: 5.3 x 2.94 PA 170°
Level step: 0 mJy/beam
0 K
Box marking: DEC Offset
Channels: [0,0]
Jy/beam
0
−5
−10
10 5 0 −5 −10
VELOCITY
dF=80kHz
i074
08−OCT−1999 13:04:43

Final result: Wind Map



Summary

- Line-to-Continuum ratio observations need excellent RF (< 1%)

- Known Continuum source can be self-calibrated

➔Improve image accuracy and dynamic