DUST CONTENT IN THE MARTIAN ATMOSPHERE FROM PFS

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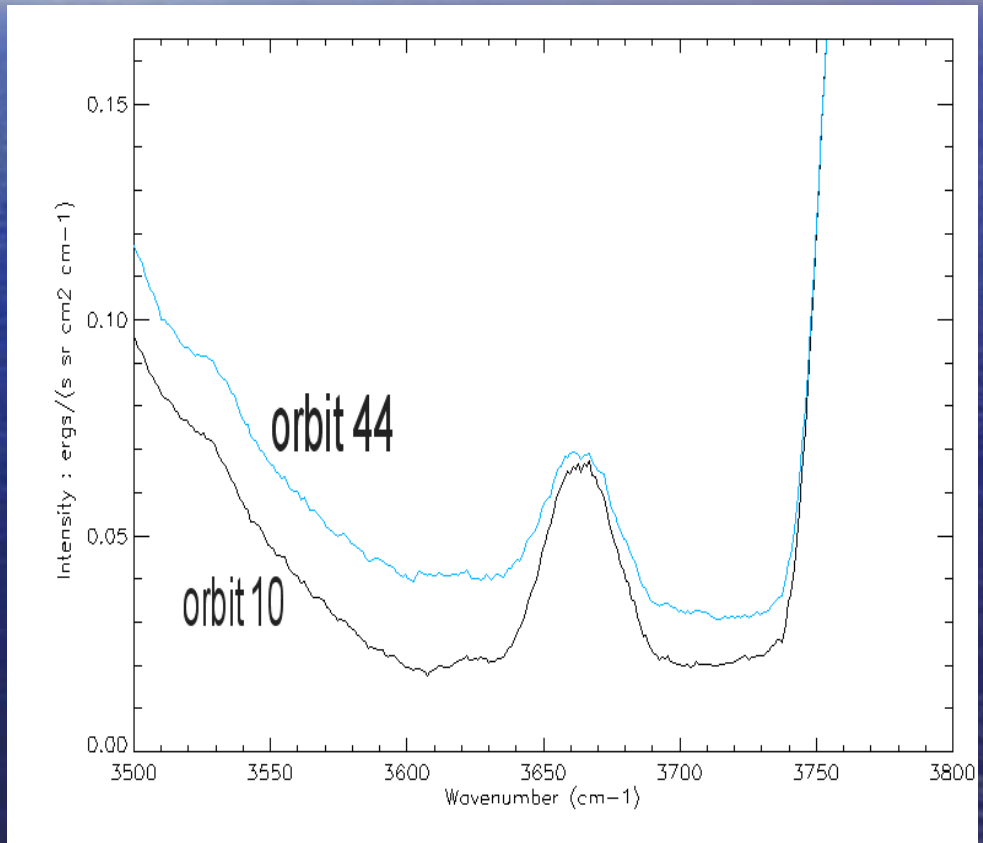
Summary

Study of CO2 band at 2.7 μm in order to know:

- dust history >> optical depth
- Empirical Phase function

CO_2 band at 2.7*μm*

A method for studying properties of the aerosols in the martian atmosphere is based on the mesurement of the solar radiation inside the 2.7 *μm* band.
We shall study radiance at 3625 (left side) and 3705 cm^{-1} (right side)



Why this band…

In the dust-free atmosphere, the radiance at the bottom of the band is equal to 0

then

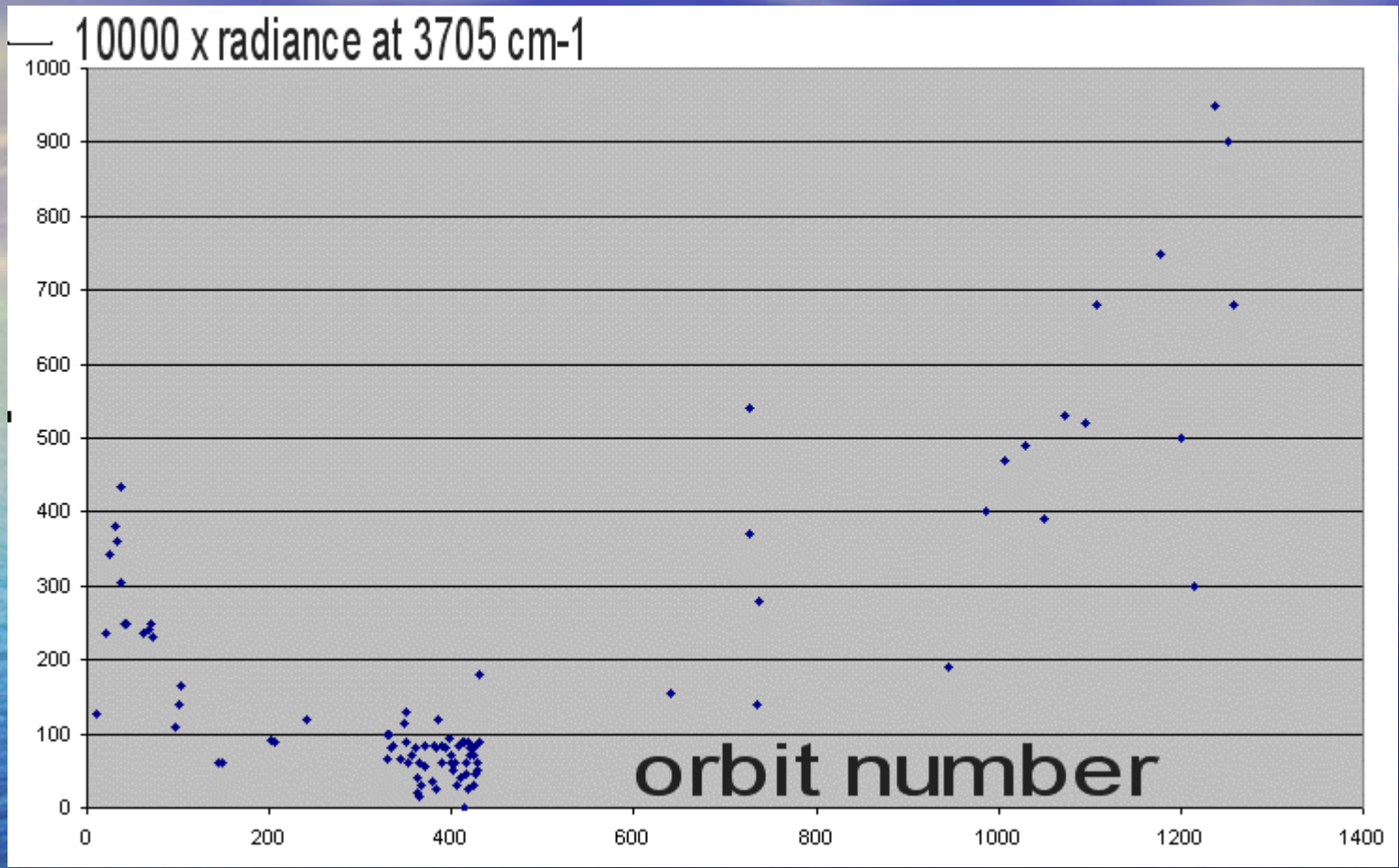
The light reflected by the surface is negligible

Why this band…

The intensity ,that differ from 0, mesured in the bottom of the band is due to the aerosols scattering

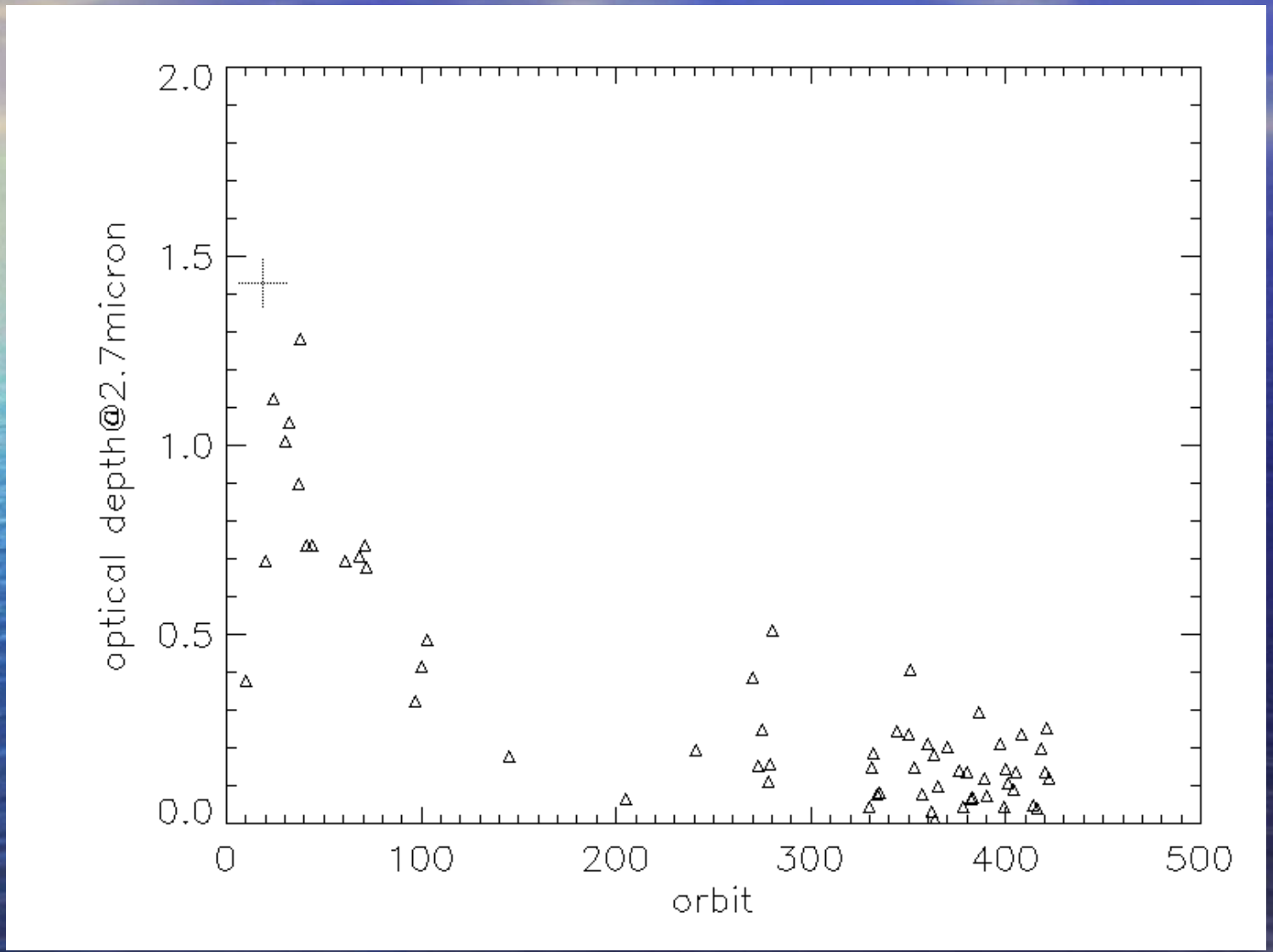
then

we can use this to determine the properties of aerosols (optical depth.)



In this plot the radiance at 3705cm^{-1} (2.7 *μm)*(average over each orbit) is plotted vs orbit number.

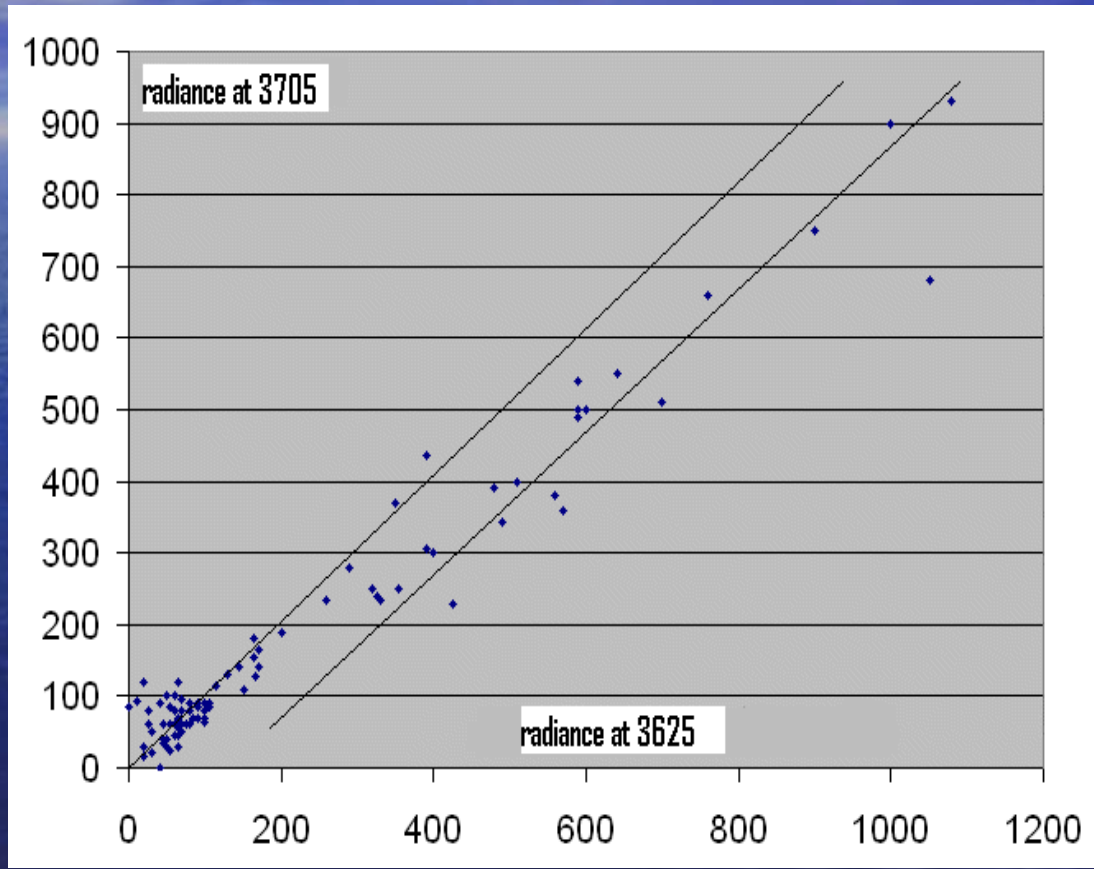
From the orbital averages we computed the optical depth at 3705 cm^{-1} using the model of Titov et al. (2000) for orbit number 10-422



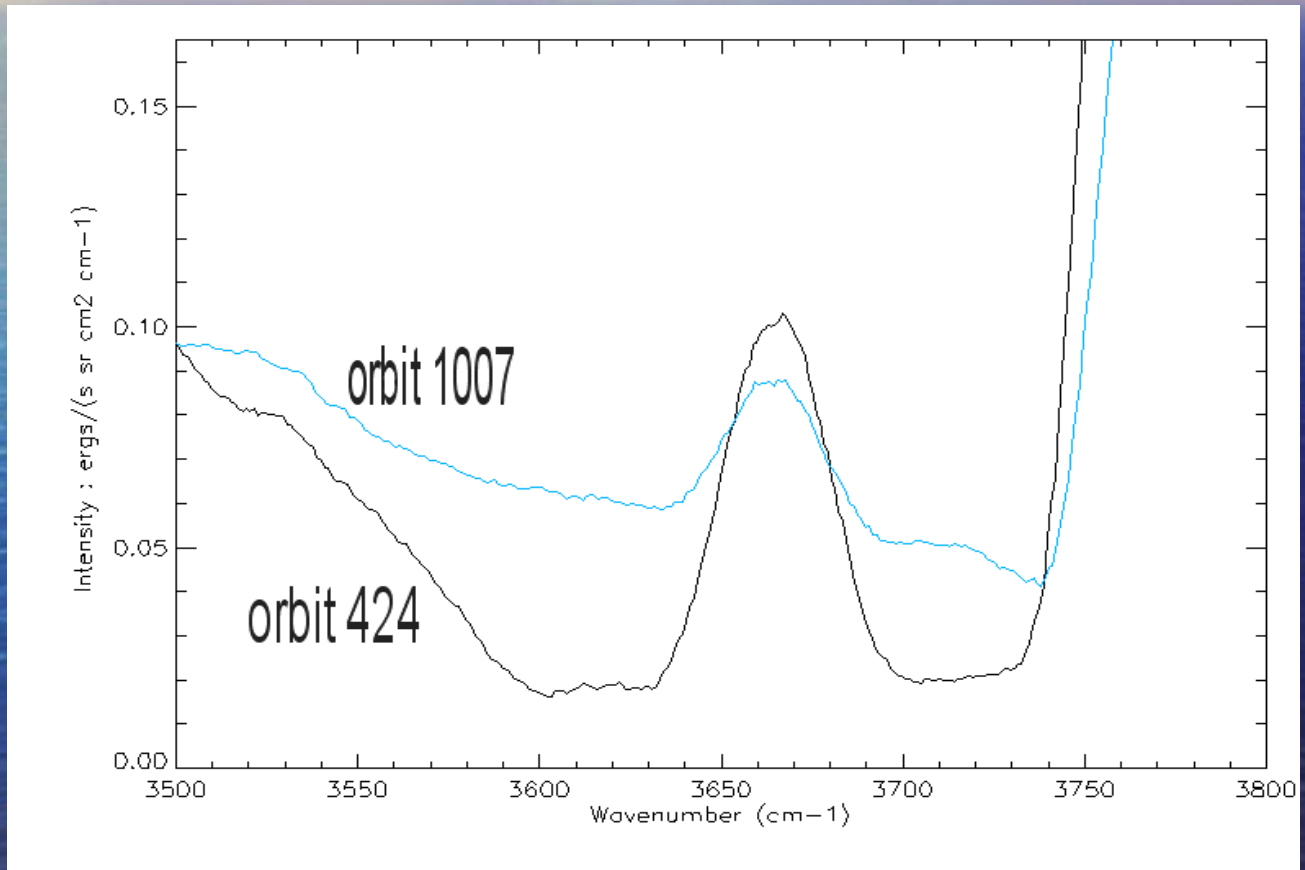
Comparison between radiance at 2.7 μm (3705 cm^{-1}) and radiance at 2.76 μm (3625 cm^{-1}).

The points follow two linear correlations, one in which the two values are equal, one in which radiance at 3705 cm^{-1} is lower than radiance at 3625 cm^{-1}.

The last condition occurs for large values of optical depth.



CO_2 band at 2.7μm
(averaged over each orbit)



Phase function

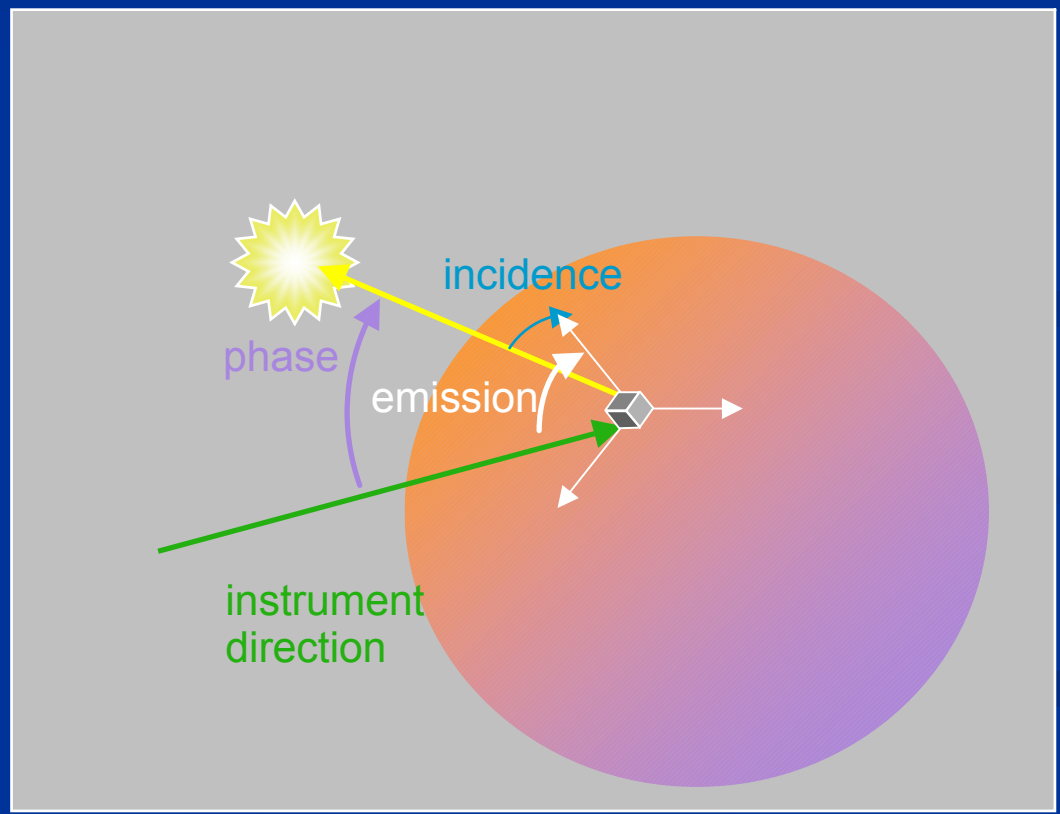
We can study the phase functions of the aerosols under the following assumptions:

1) properties are uniform along one orbit;

2) no local dust storm is present;

3) variation of the geometry (for a nadir pointing set of measurements) allows to explore large range of phase angles.

Given the direction of an instrument in a nadir pointing spacecraft, it is possible to compute the incidence, emission and phase angles of the measurements.

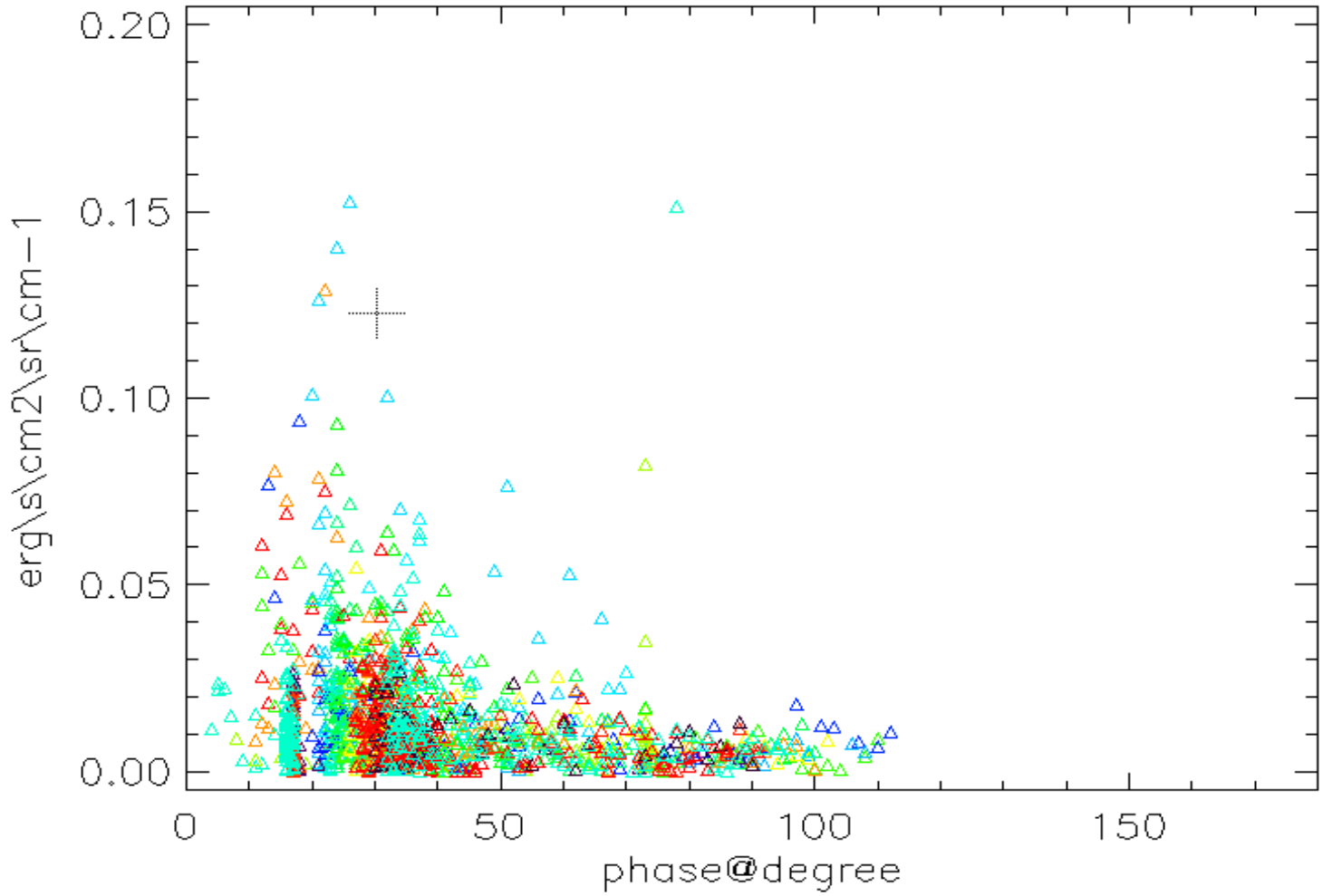


Along one orbit the phase angle changes because the mutual positions between sun,planet and the instrument FOV change.

then

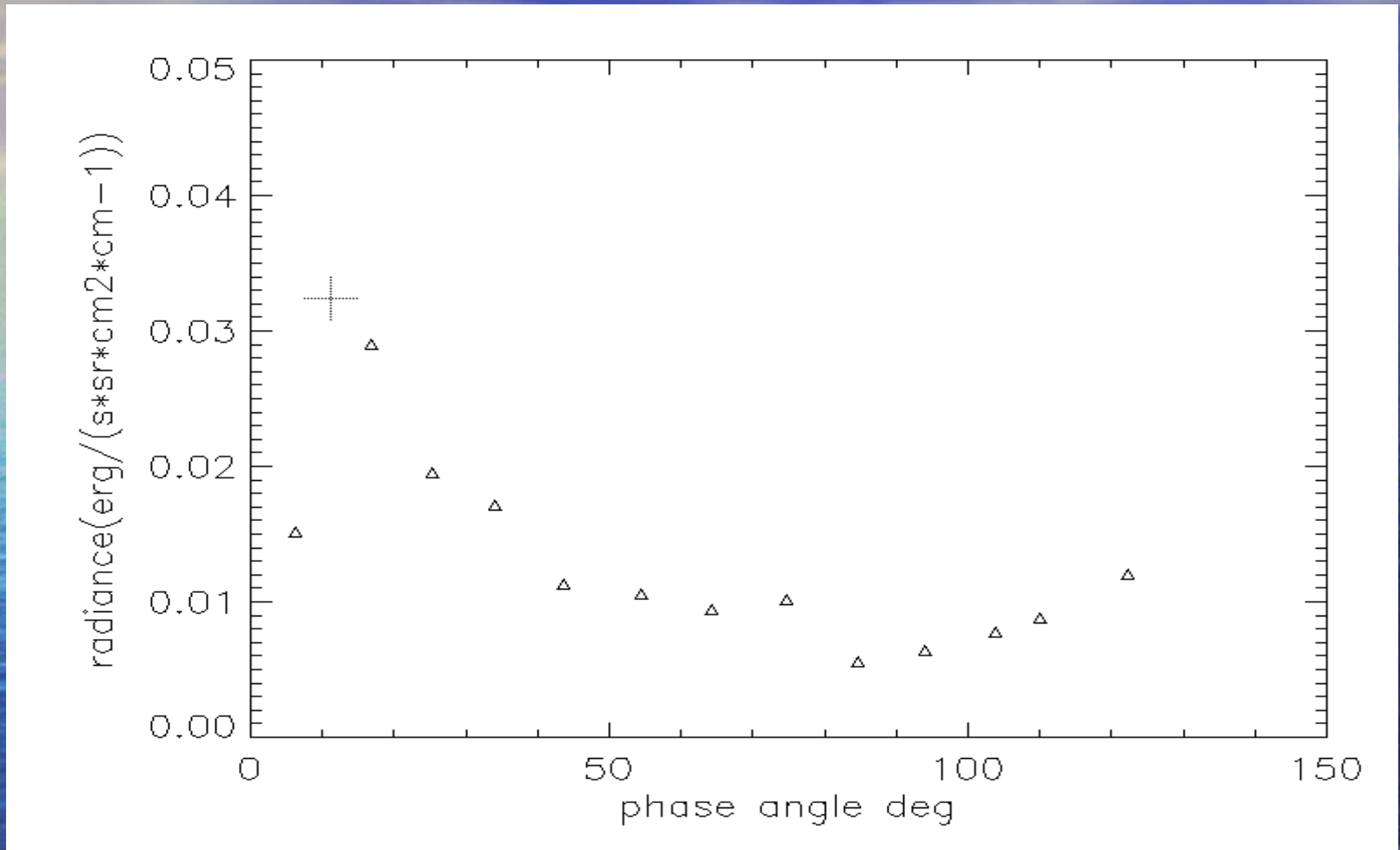
The solar radiation reflected by the planet (aerosols) is sensitive to this change

Rad(3705cm^{-1}) vs phase angle (orbit 241-422) low dust content



Each point of this plot is the average radiance of 10 spectra

Rad(3705cm^{-1}) vs phase angle (orbit 241-422)



Each point of this plot is the average radiance observed over 10 deg bins.

The scattered radiance is :

$$I(\Omega) = J(\Omega_0)\ \frac{\sigma Q_s\, p(g)}{\sigma Q_e\, 4\pi} = Jw\frac{p(g)}{4\pi}$$

where J = incident radiance

σ = geometrical cross section

Q_S = scattering efficiencie

Q_e = extinction efficiencie

w = single scattering albedo

Ω_0 = incidence angle

Ω = emission angle

p(g)= *particle phase function* = describe the angular pattern into which the power

Empirical scattering function

- Henyey and Greenstein introduced the empirical phase function:

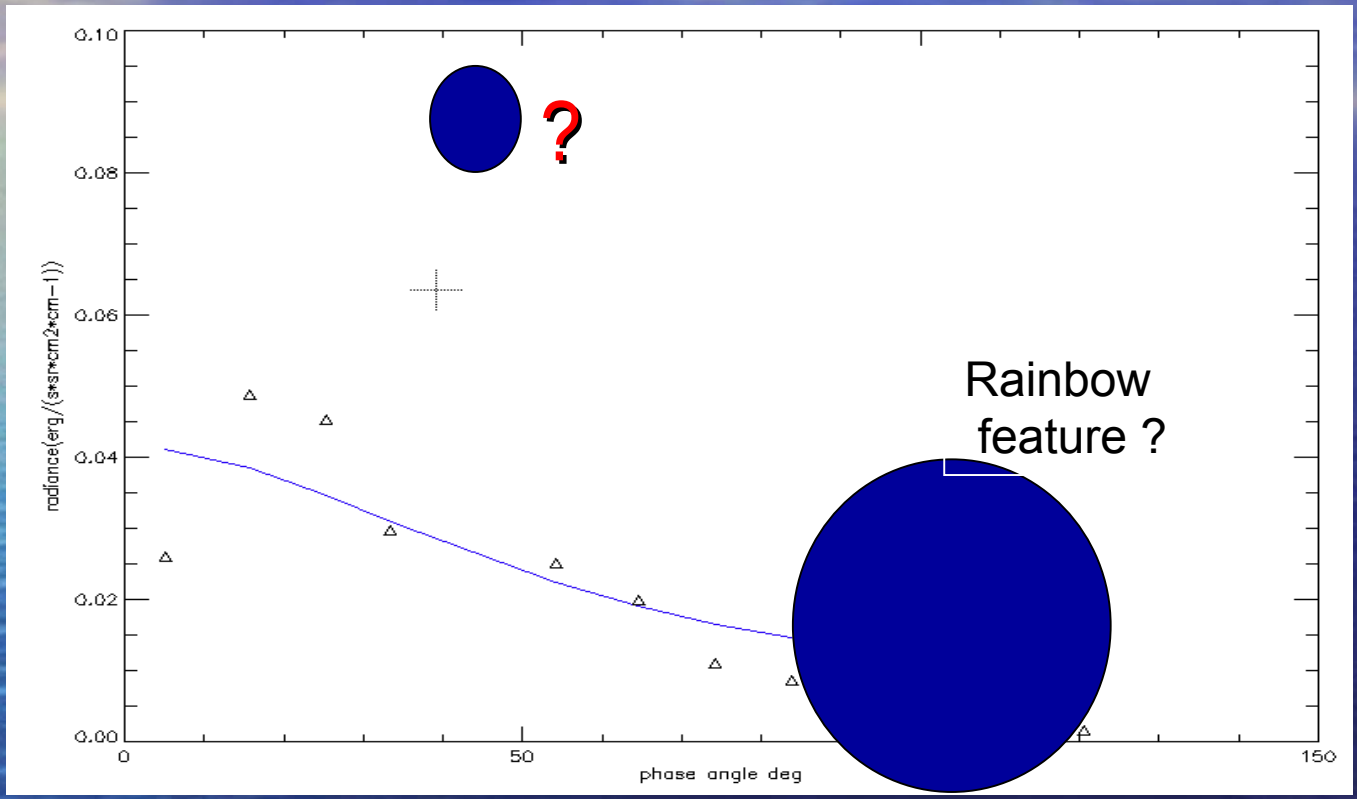
$$p(g) = \frac{1-\xi^2}{(1+2\xi\cos g+\xi^2)^{3/2}}$$

- Where ξ is the cosine asymmetry factor:

$$\xi = -\langle \cos(g) \rangle$$

radiance vs phase angle

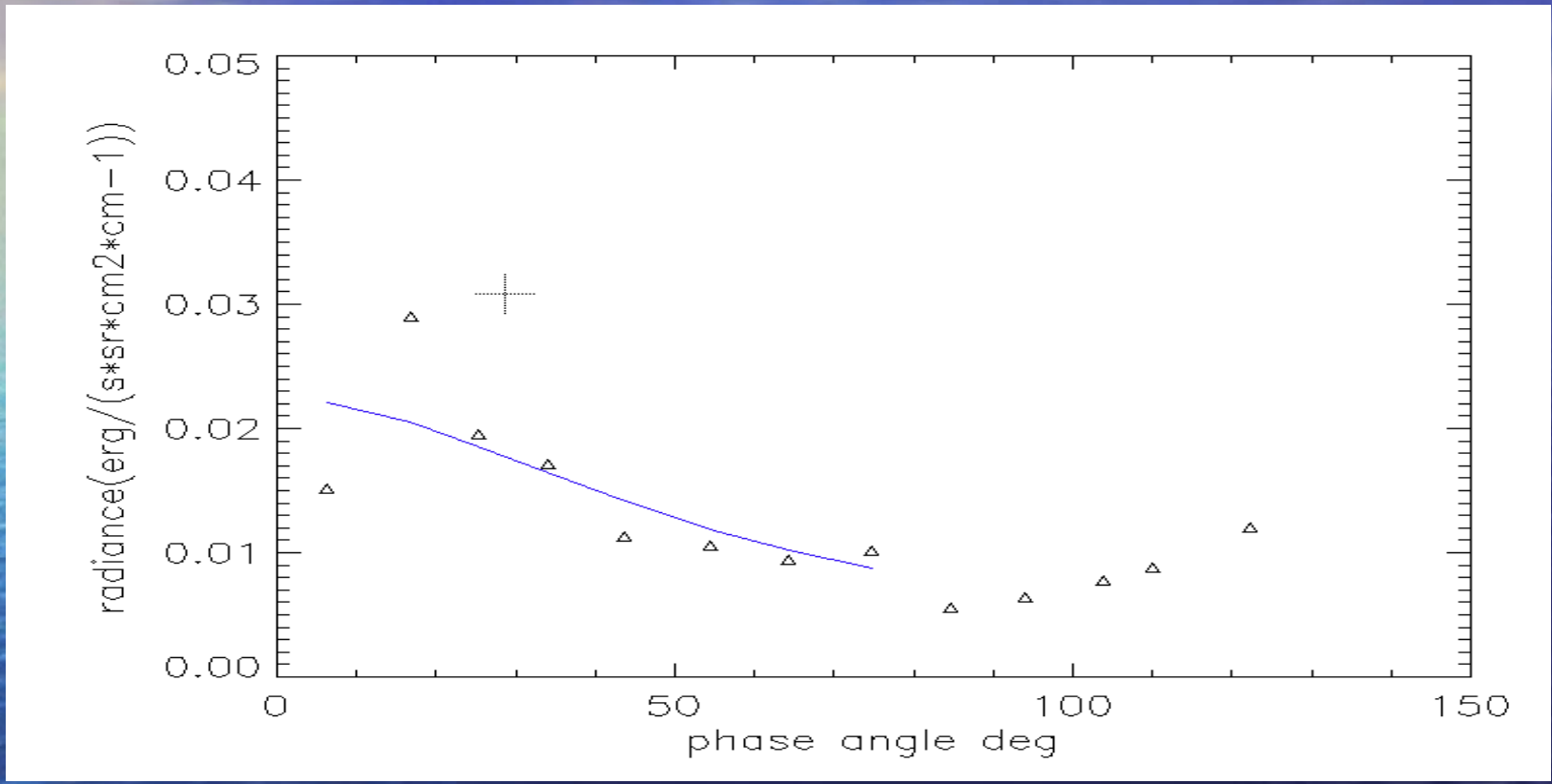
large dust content



Each point of this plot is the average radiance observed over 10 deg bins. The curve is the *Jwp(g)* best fit to the data up to 90 deg. The point with '?' has been neglected.

radiance vs phase angle

low dust content



Each point of this plot is the average radiance observed over 10 deg bins. The curve is the *Jwp(g)* best fit to the data up to 90 deg.

Results of best fit

- Best fit for the orbits with large dust content:

$$\xi = - < cos(g) > \; = -0.39$$

$$Jw = 0.018$$

- Best fit for the orbits with low dust content:

$$\xi = - < cos(g) > \; = -0.39$$

$$Jw = 0.009$$

Conclusions

The analisys of the radiance at 3625 and 3705 cm^{-1} allows us:

a) knowledge of dust history

b) phase function

c) size parameter :

- for the phase angle less than 90 degree
  size parameter = $r/\lambda < 1$ r(particle radius) < 2.7 μm

- for the phase angle greater than 90 degree
  size parameter = $r/\lambda > 1$ r(particle radius) >2.7 μm