# Analysis of Multiple Scattering Contribution in cirrus clouds from dual FOV Lidar Observations At Palaiseau

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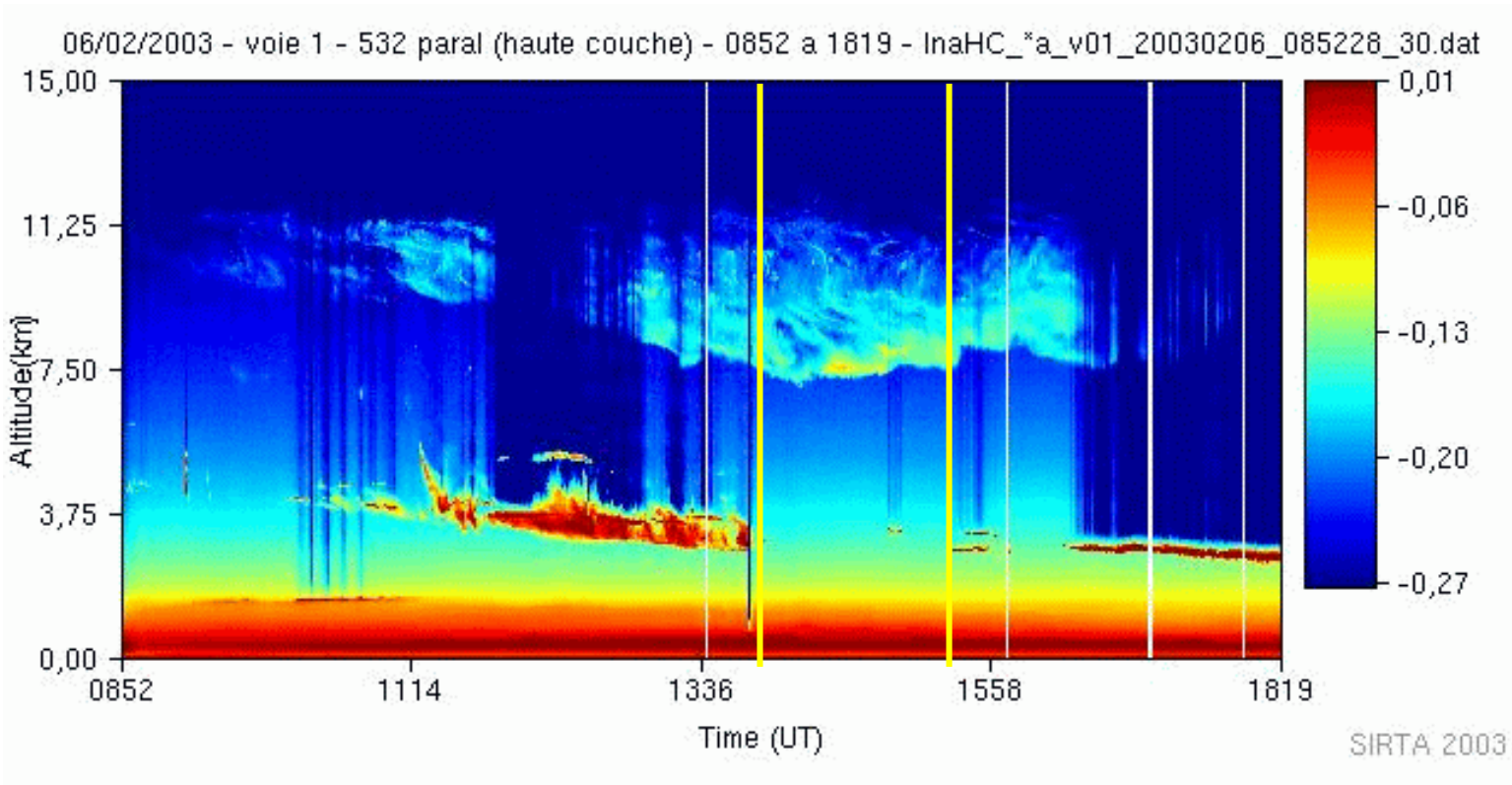
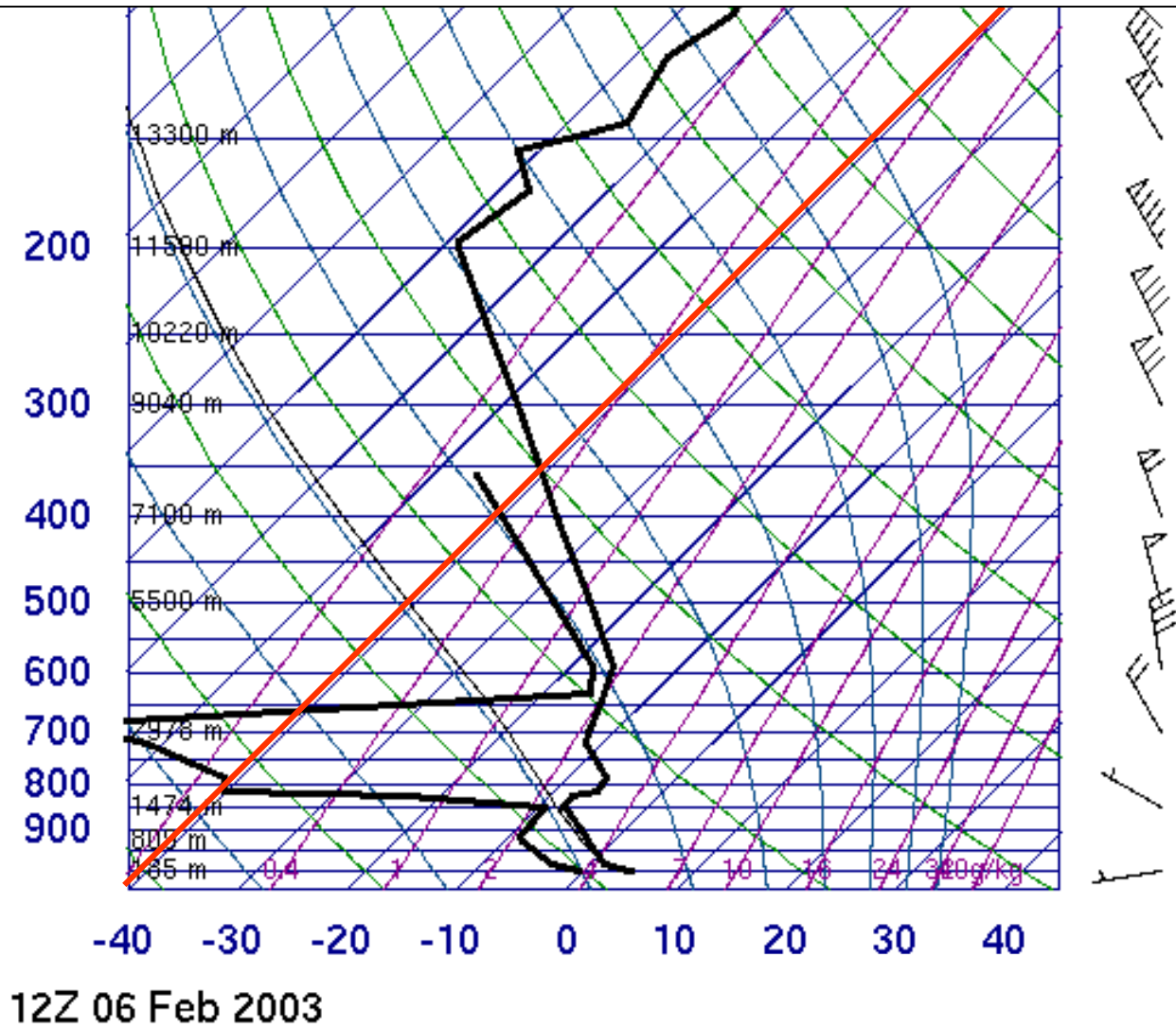
# Selected case : 6 February 2003



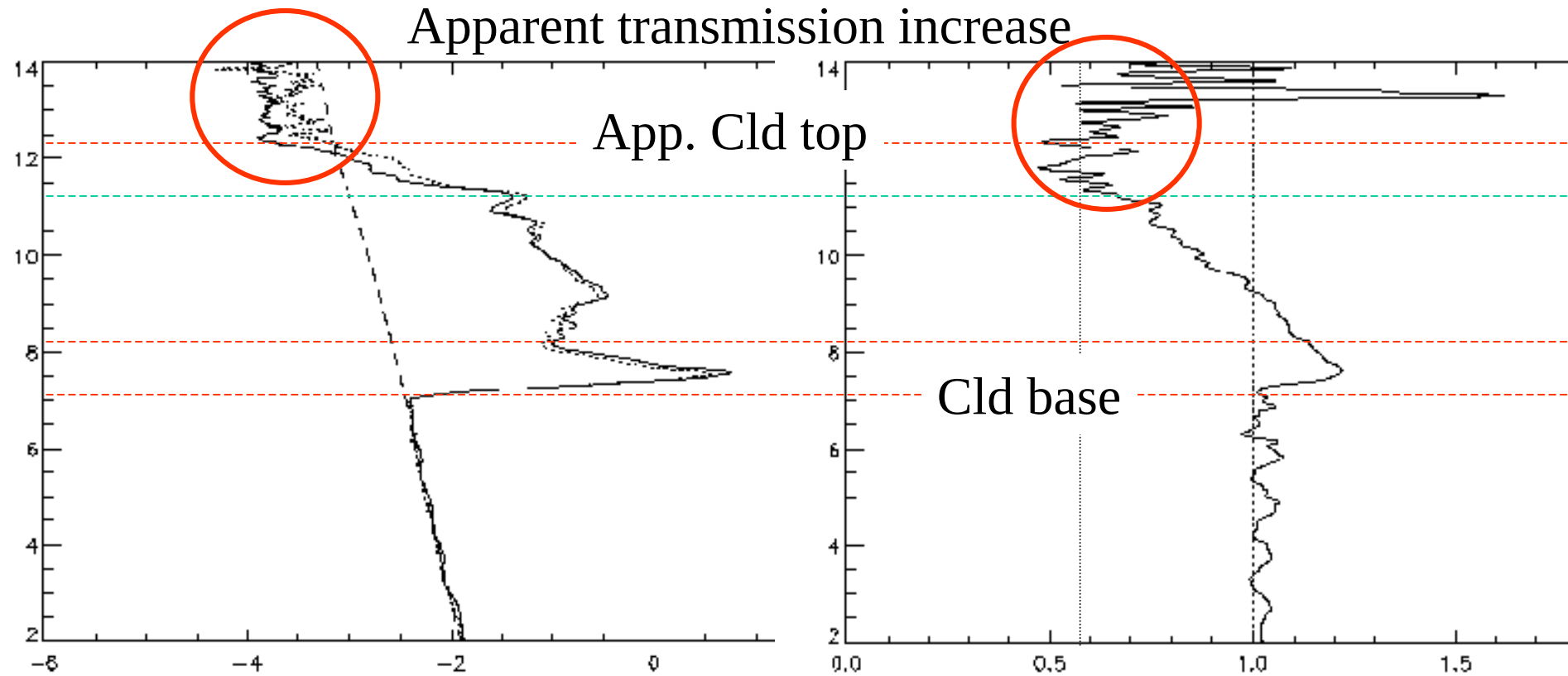

**Single Cirrus Layer with a Vertical extent of about 5 km**

# Radiosonde Measurement




**Ice above 8200 m**

# Signal Analysis

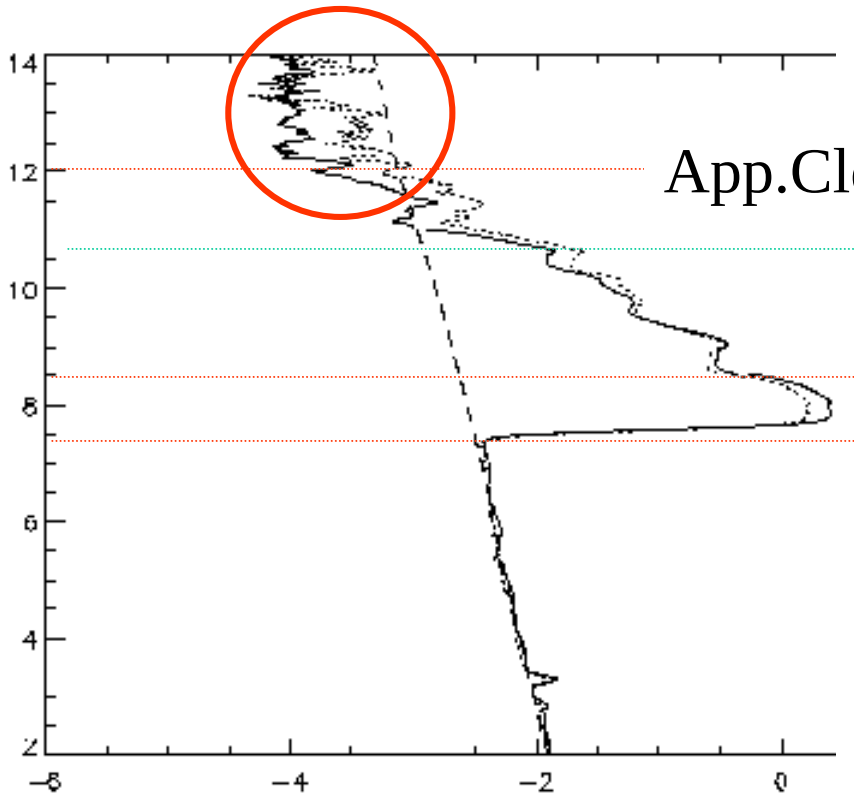



**Beta1 and Beta2**
**FOV 1 < FOV2**

**14h18**

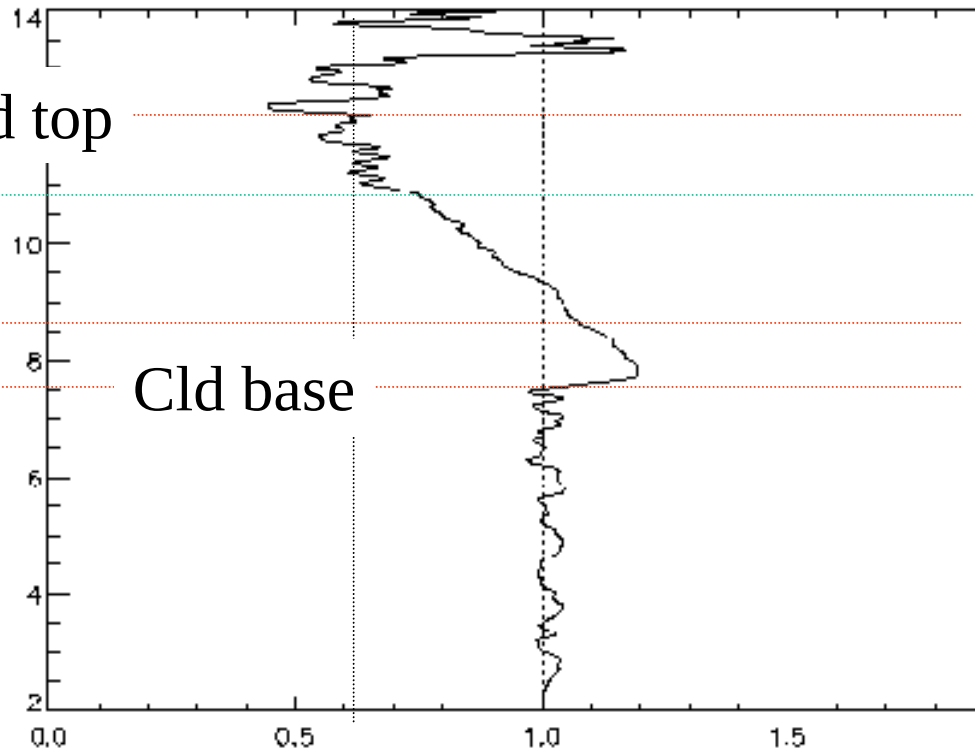
**Beta1/Beta2**

# Signal Analysis




App.Cld top

Cld base




**Beta1 and Beta2**

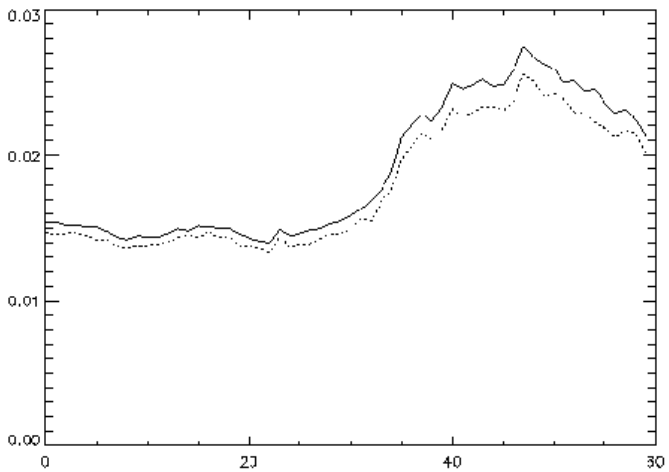
**15h18**

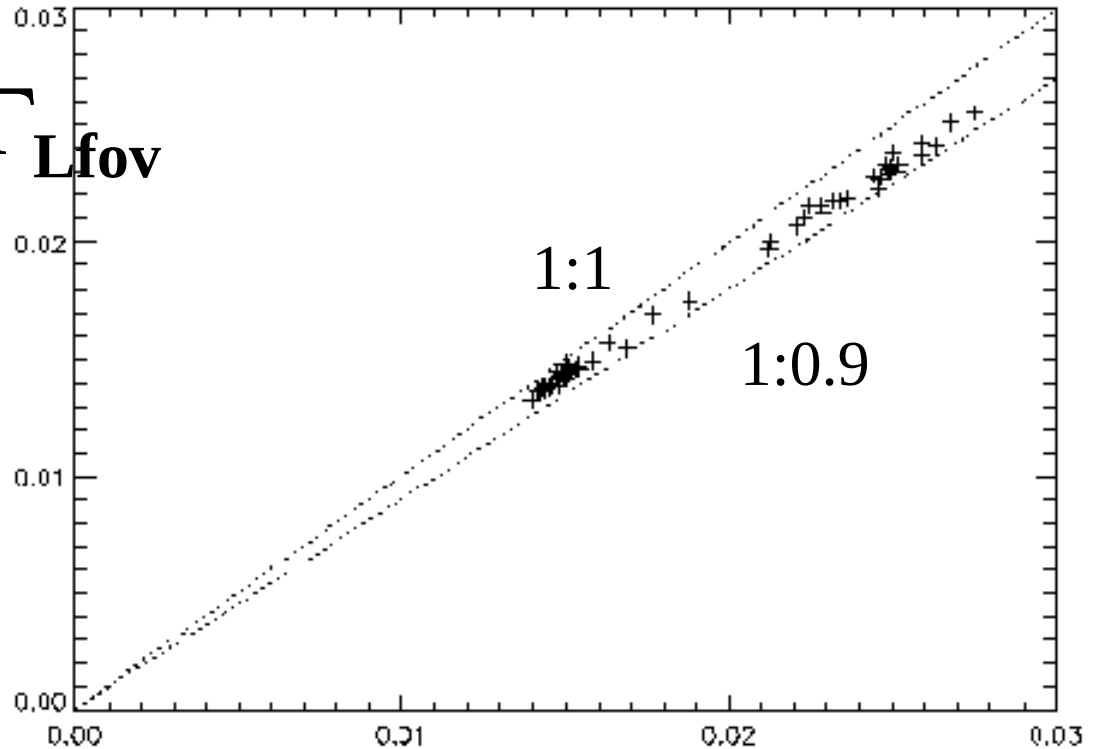
**Beta1/Beta2**

# Determination of MS contribution

**Calculation of integrated Apparent Backscatter Γ**

$$\Gamma = k/2\eta(1-T^2)$$




$\Gamma_{Sfov} > \Gamma_{lfov}$ **(5-7%)**

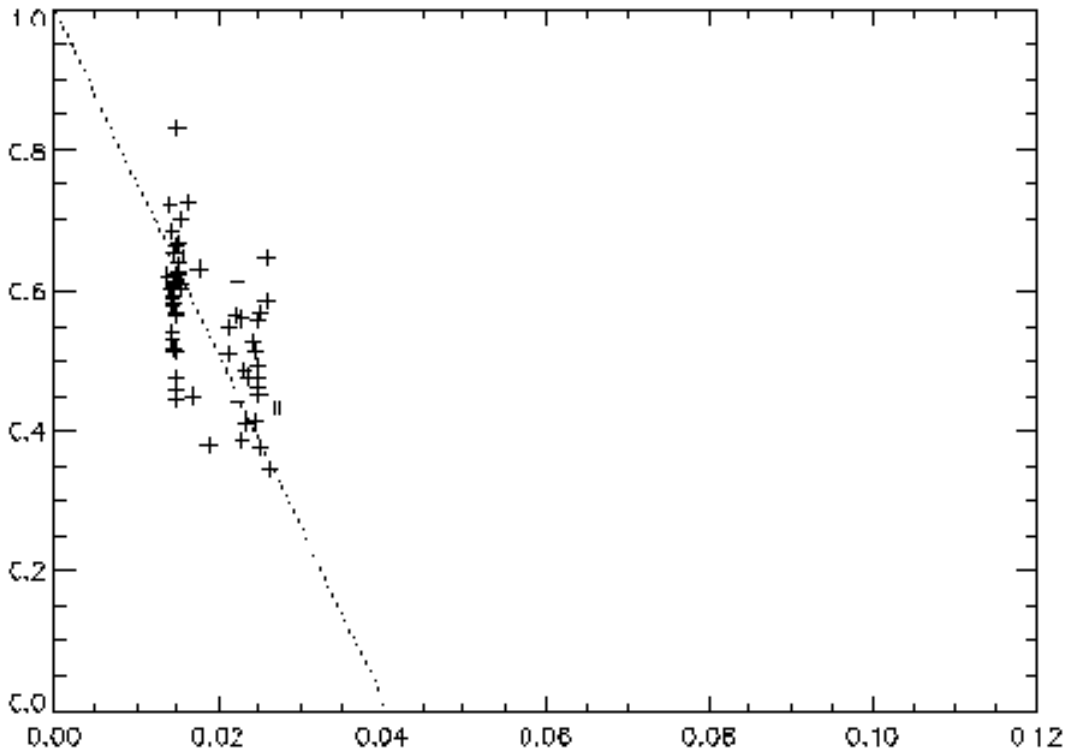
$\Gamma_{Sfov}$

# Determination of MS contribution

$\Gamma = k/2\eta(1-T^2)$

$T^2$

**Small field of View measurements Show a reduced Dispersion (good SNR)**



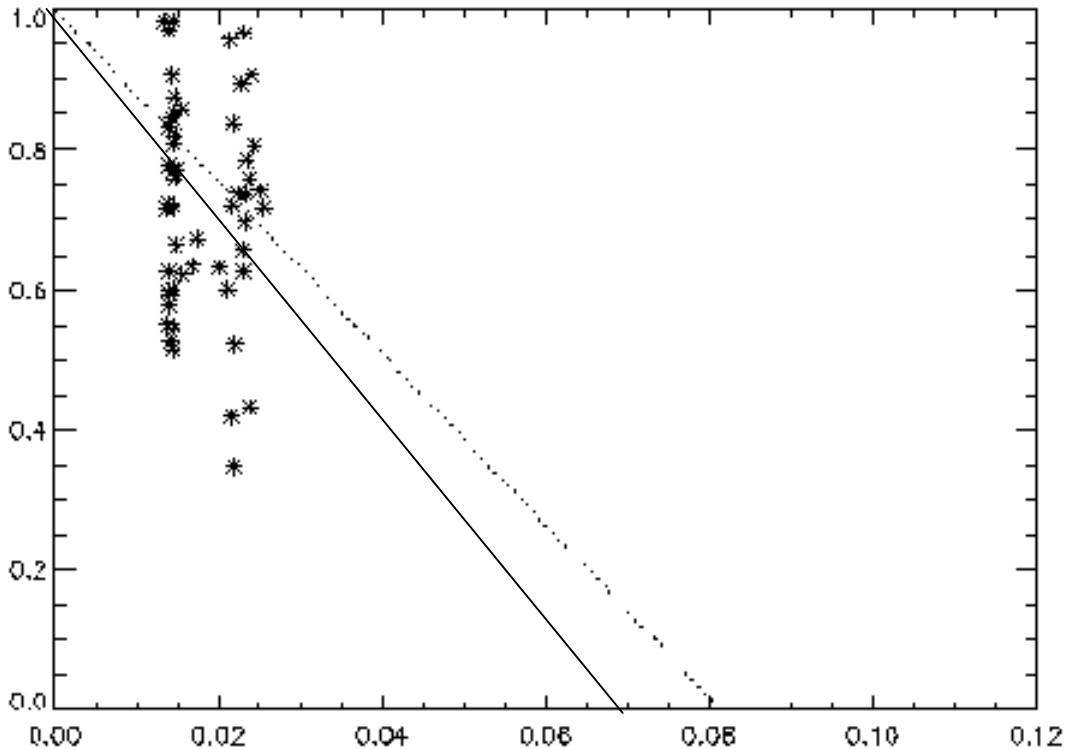

$k/2\eta_1$

$\Gamma_{Sfov}$

# Determination of MS contribution

**The large field of View shows increased Transmission and Increased k/2η value But also a larger dispersion In the data**

$T^2$




$\Gamma = k/2\eta(1-T^2)$

$k/2\eta_2$

$\Gamma_{Lfov}$

**Almost a Factor 2 increase in η ?**

# Main observed features

- **Apparent Optical depth is less than 0.3**
- **Observable differential signature on the two channels**
- **Equivalent MS factor $\eta$ significantly varies between the two FOVs whereas $\Gamma$ stays almost constant**
- **Multiple scattering varies almost linearly with height**
- **The ratio of backscattering at the two FOVs varies between 1.2 (cloud base) and 0.6 (cloud top)**
- **It becomes close to minimum before reaching cloud top (coda ?)**

# Comparison to calculations

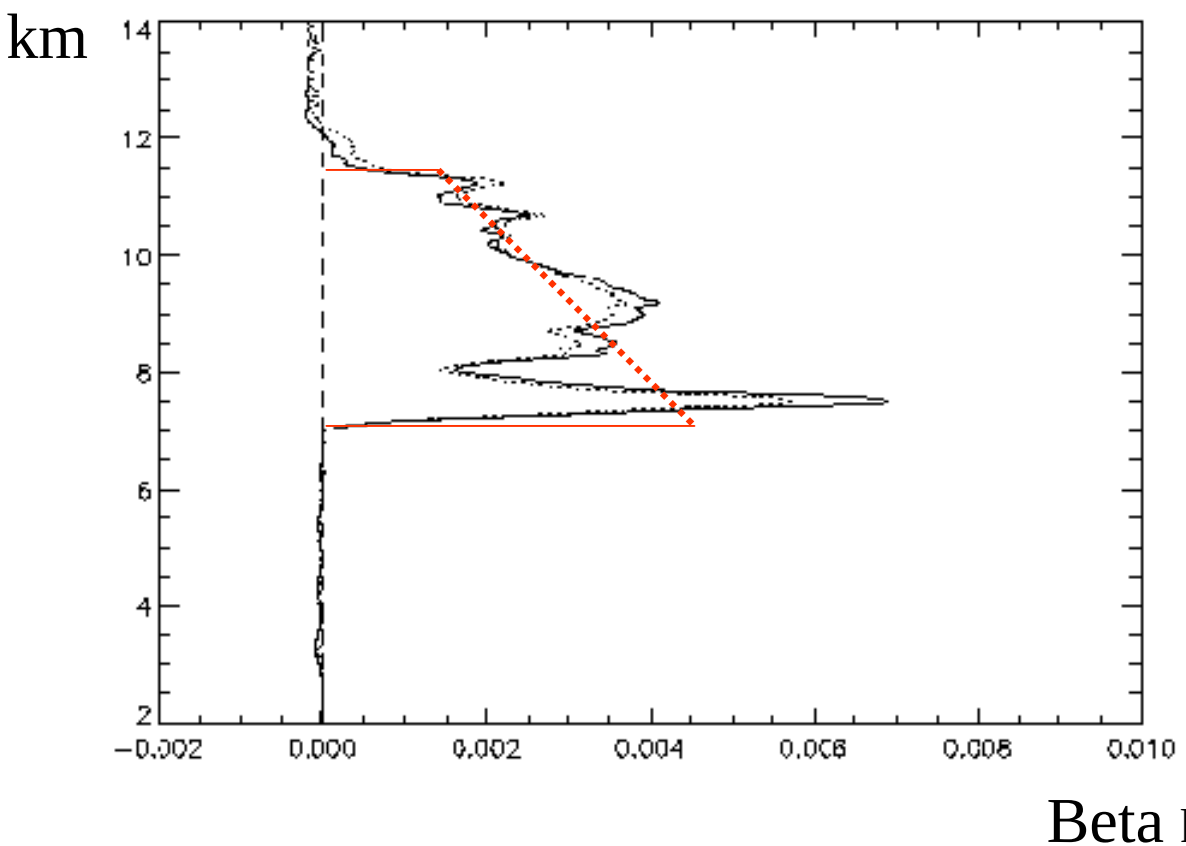
**MS : use of Eloranta's Model (main contribution from diffraction)**

**Extinction profile from observations**

**Sensitivity analysis as a function of diameter**

**→ 4 diameters considered 10, 30, 50 and 100 µm for the two fields of view**

# Extinction profile




**Simplified Extinction Profile from :**

**Ext = S.Beta**

**Hyp : S =<S>= 25**

**Optical depth (true) = 0.4**

# Comparison to calculations

| **Altitude** (km) **Diameter** (μm) | **7** | **8** | **9** | **10** | **11** | **12** |
|---|---|---|---|---|---|---|
| **10** | 0 | 0.90 | 0.90 | 0.88 | 0.88 | 0.87 |
| **30** | 0 | 0.96 | 0.90 | 0.85 | 0.81 | **0.78** |
| **50** | 0 | 0.98 | 0.93 | 0.88 | 0.83 | 0.79 |
| **100** | 0 | **0.99** | 0.97 | 0.94 | 0.90 | 0.81 |
| **Obs** | **0** | **1.20** | 1.05 | 0.85 | 0.68 | **0.65** |

# Conclusion

- **Lidar signals at 1 and 5 mrd FOVs show different behaviour in cirrus clouds with increased transmission at larger FOV**

- **Ratio of attenuated backscattering coefficients is larger than 1 at cloud base. This is not represented by the model**

- **Minimum value of 0.6 at cloud top much smaller than model**

- **Possible error on cloud top due to MS**

**→Check experimental parameters**
**→ Look to other cases esp. lidar/radar cases (De)**