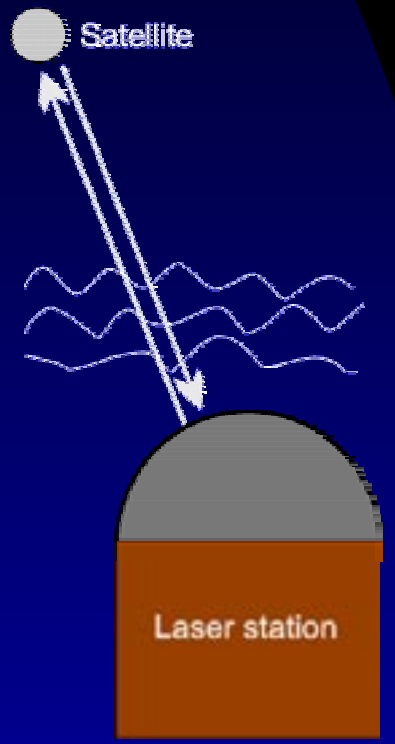
Atmospheric Contribution to the Laser Rangign Jitter

Ivan Prochazka, Lukas Kral

13th International Workshop
on Laser Ranging, Washington D.C.
October 7-11,2002

Czech Technical University in Prague
Prague, Czech Republic

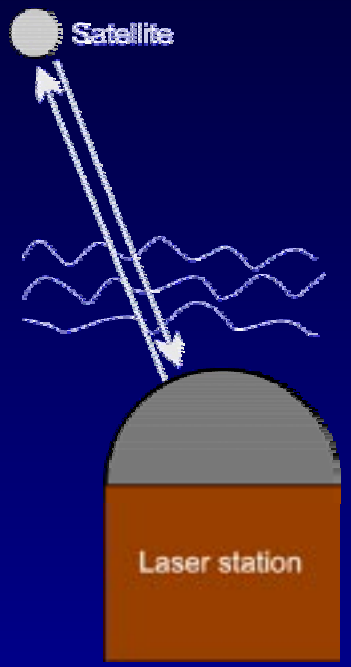
Goals:



- Evaluate the contribution of the atmosphere fluctuations to the overall SLR jitter budget
- Create model of propagation of a picosecond laser pulse through atmosphere, consider turbulence, dispersion and diffraction

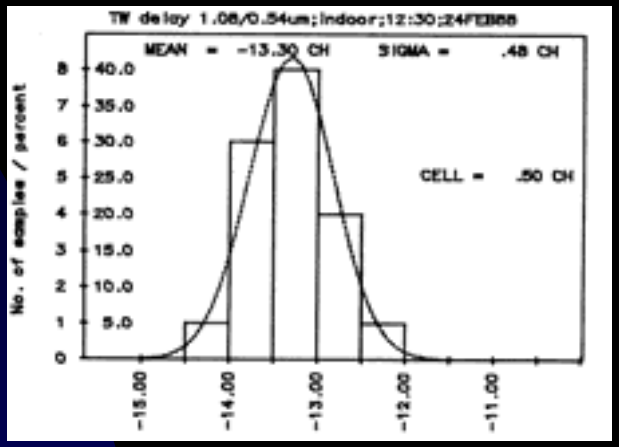
I.Prochazka, L. Kral, CTU Prague, Oct.2002

Motivation

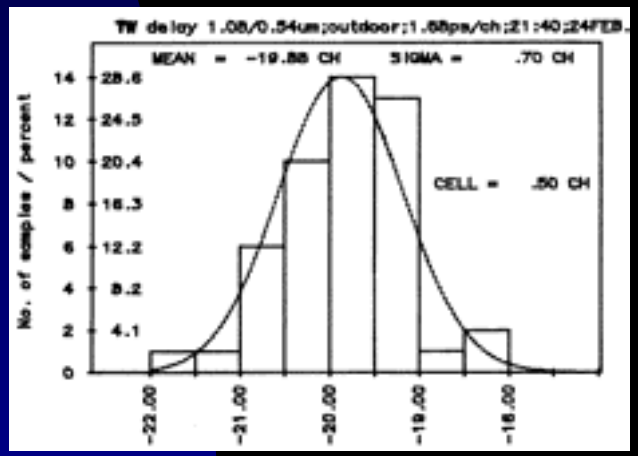


- The observed discrepancy in laser ranging jitter for different atmosphere path length
- EXPERIMENTs
  streak camera TW (Prague 1988)
  0.8 ps (indoor) --> 1.2 ps (outdoor)
  => 0.9 ps contribution of 106 m path
- ground taget ranging (Graz, 2000)
  7 ps (1 m) --> 11 ps (6 km)
  => 8.5 ps contribution of 6 km path
- high precision SLR (Graz, MLRO, 2002)
  7 ps (calib) --> 18 ps (low sat.)

Two wavelength streak camera ranging



Indoor path ~ 1m
TW delay jitter 0.8 ps / shot

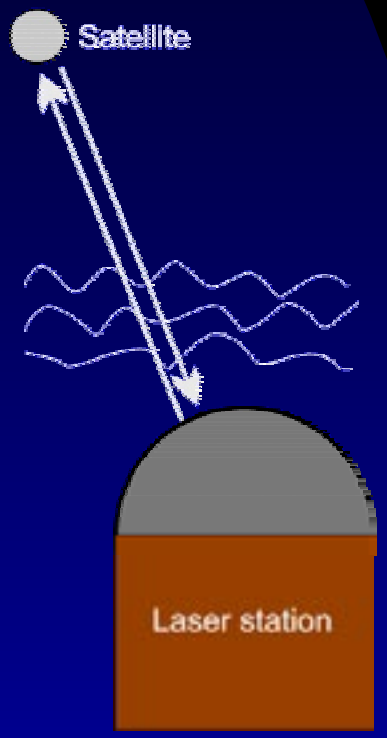


Outdoor path ~ 106m
TW delay jitter 1.2 ps / shot

=> contribution of 106 m 0.9 ps

Hamal, Prochazka, Schelev et al,Prague, 1988

Initial Modelling Conditions

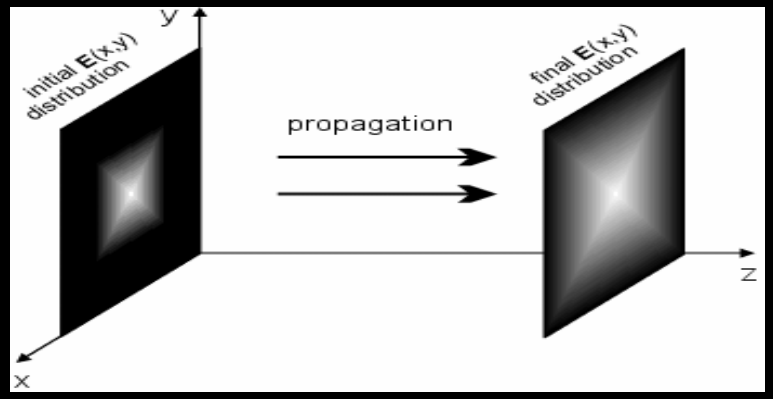


- 35 ps pulse at 532 nm has effective spectral width < 0.1 nm
- Characteristic time of atmospheric turbulence changes is > 1 ms

- = > all wavelengths in the pulse „see“ the same state of atmosphere
  = > chromatic dispersion (pulse spectrum) does not contribute

Modelling Methods

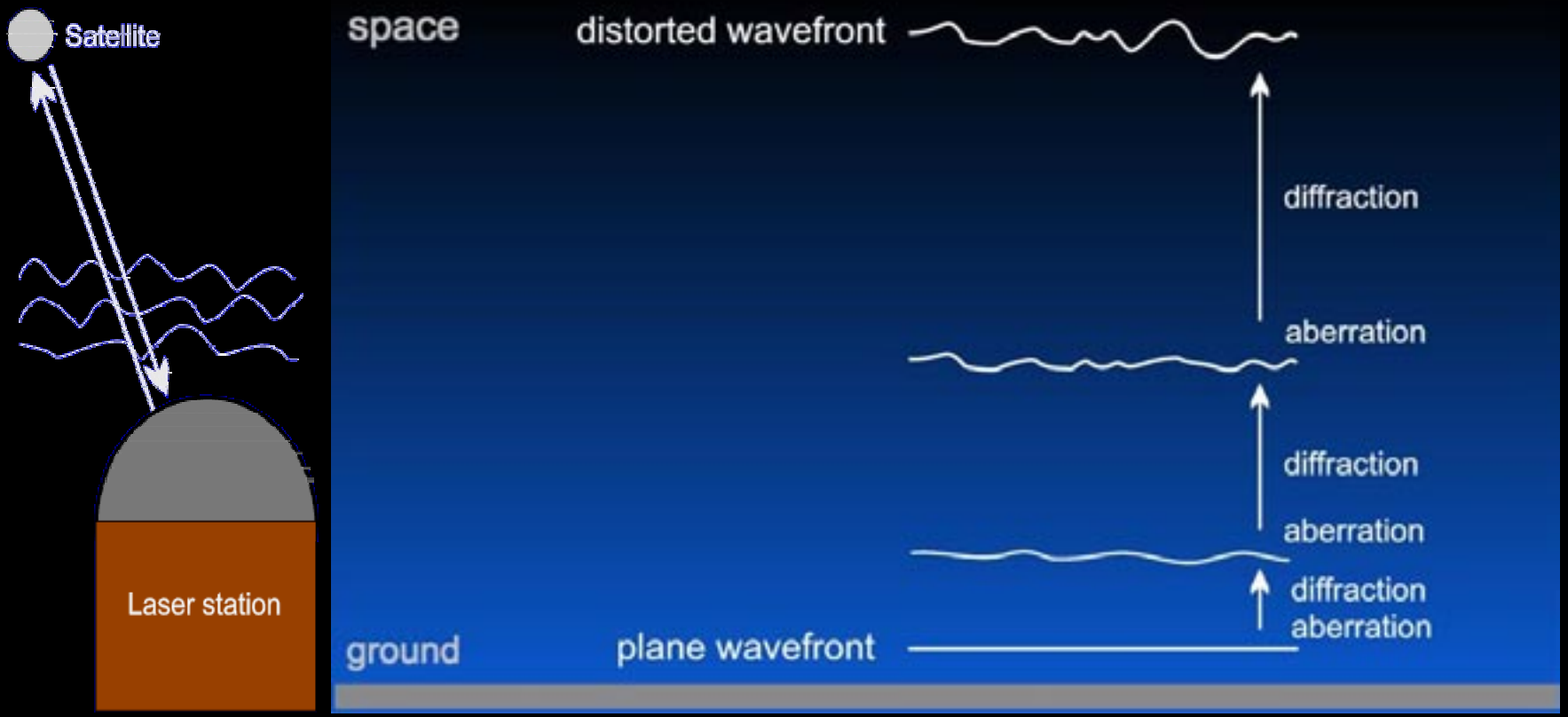
- **GLAD code**
- Beam is represented by complex arrays describing transversal field distribution
- the atmospheric propagation routines available



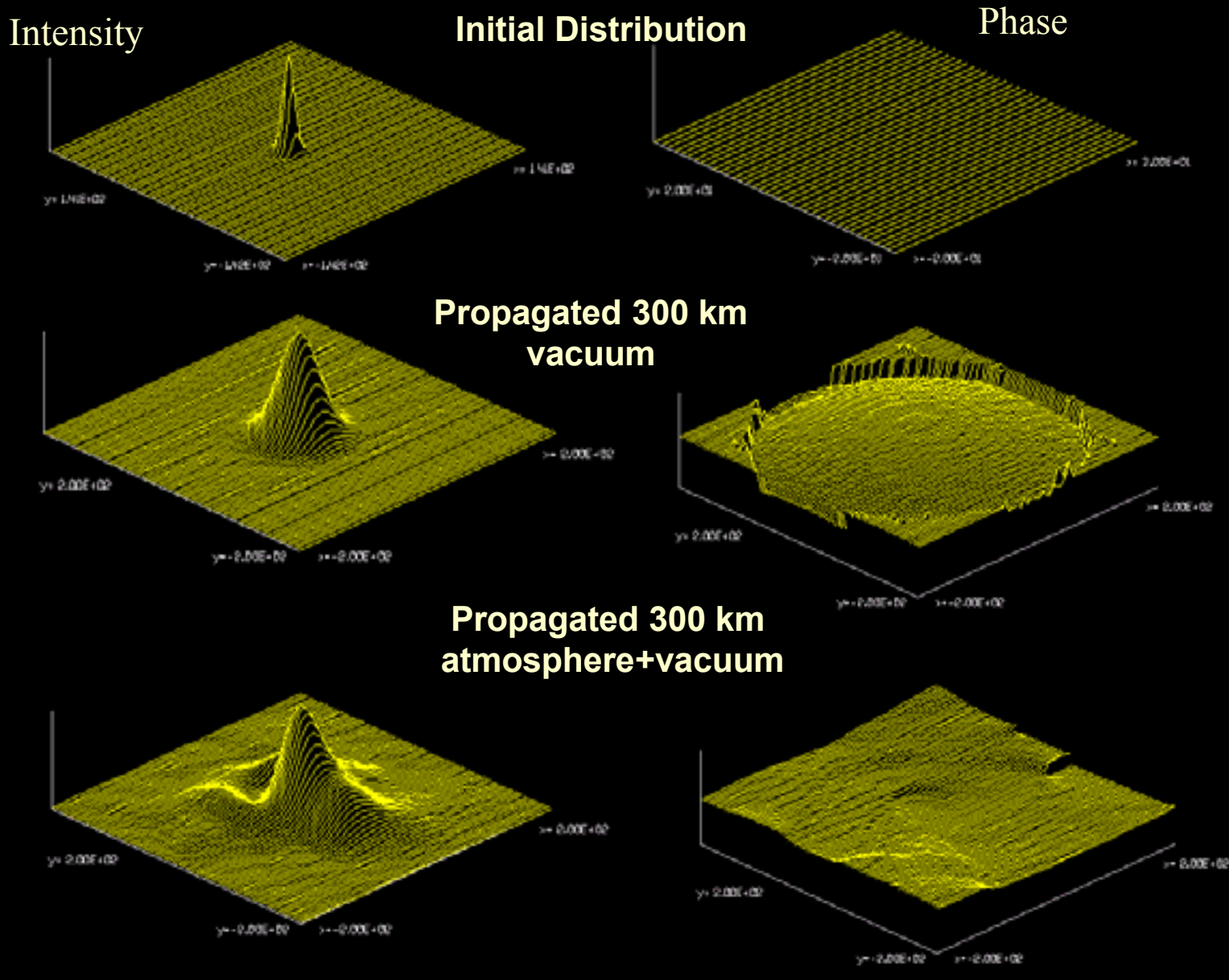
- **Pure geometrical path solution**
- seeing angles, atmospheric path length => path difference estimate

Propagation Model Scheme

- Alternating steps of aberration and diffraction

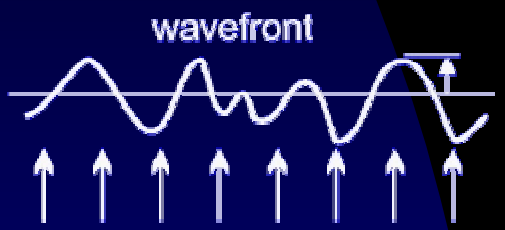


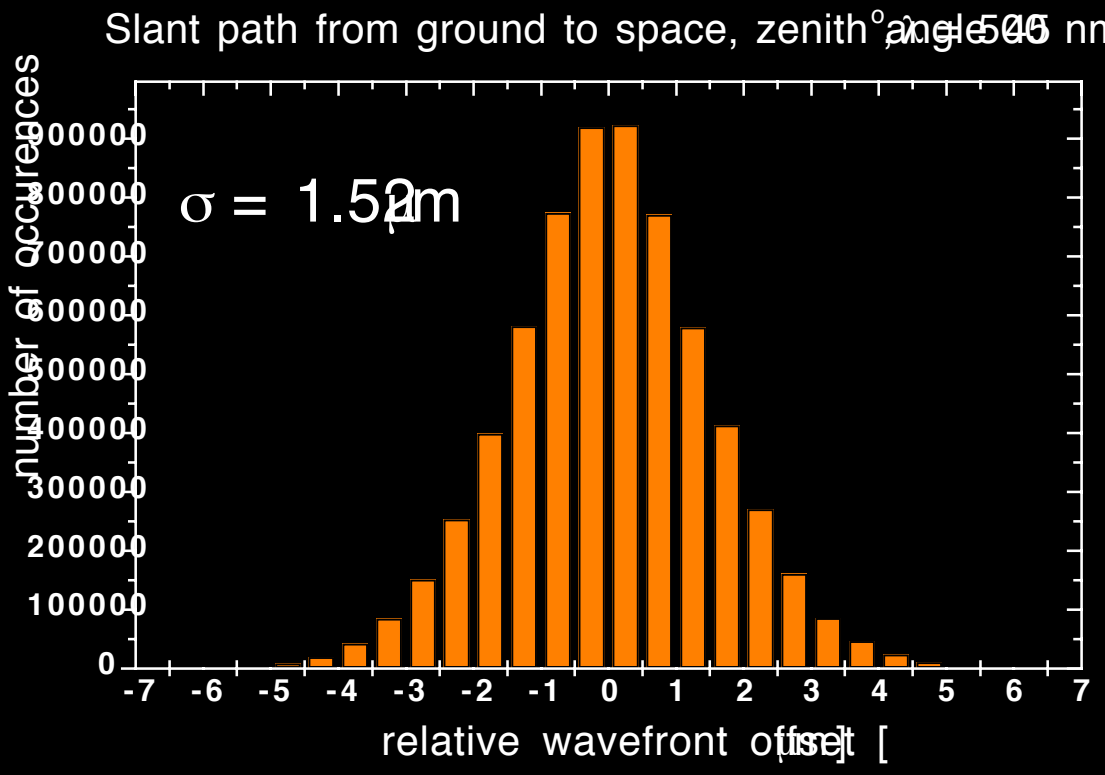
Modelled Wavefronts



Results 1 – Slant Path to Space

- Path ground to space (300 km), zenith angle = 45°, λ = 500 nm, plane wave

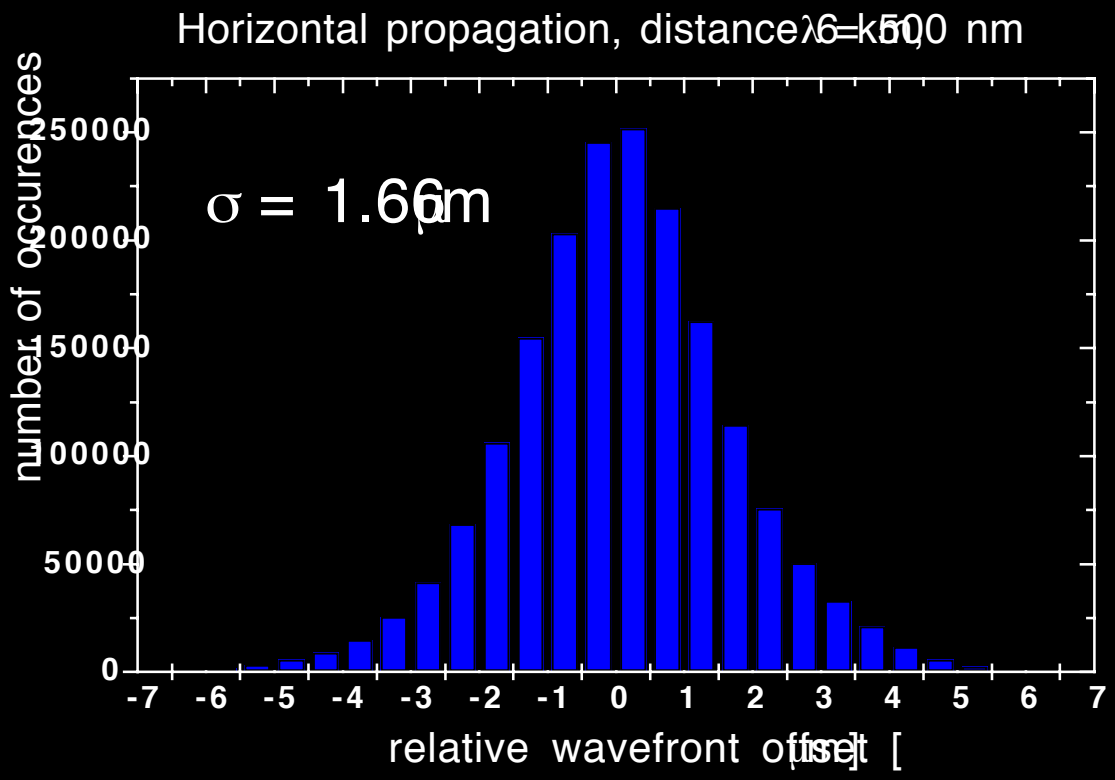




I.Prochazka, L. Kral, CTU Prague, Oct.2002

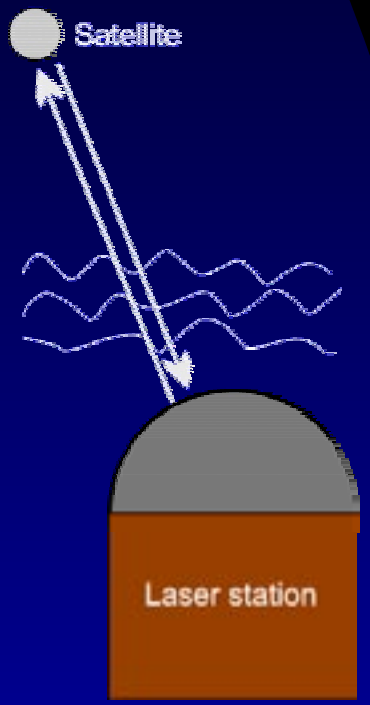
Results 2 – Horizontal Propagation

- 6 km long horizontal path, λ = 500 nm, plane wave



I.Prochazka, L. Kral, CTU Prague, Oct.2002

Results 3 – Gaussian Beam Direction Fluctuations



a) Slant path to space, h=300 km, zenith angle 45º, λ = 500nm

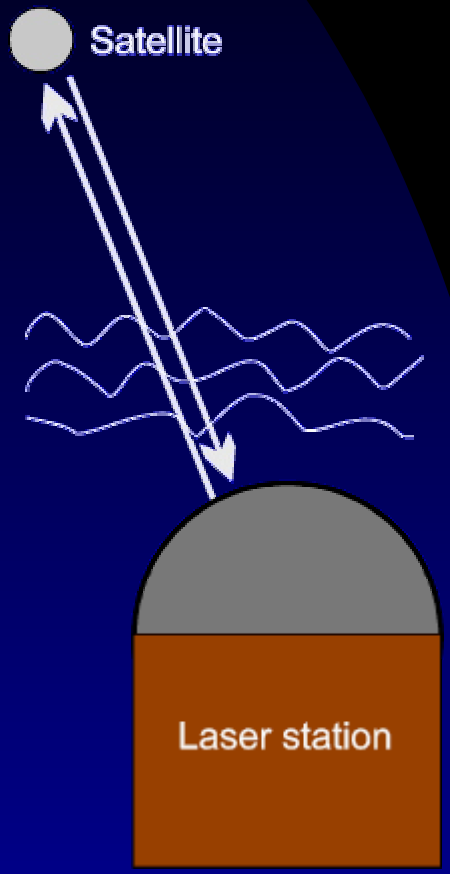
R_i [cm]	σ_{off} [m]	R_{avg} [m]	R_{th} [m]
2,5	2,12	1,85	2,7(
5,0	1,88	1,59	1,3
10,0	1,58	1,54	0,6

b) Horizontal path 6 km, λ = 500nm

R_i [cm]	σ_{off} [m]
0,5	8,2(
2,5	4,1
5,0	0,3(

I.Prochazka, L. Kral, CTU Prague, Oct.2002

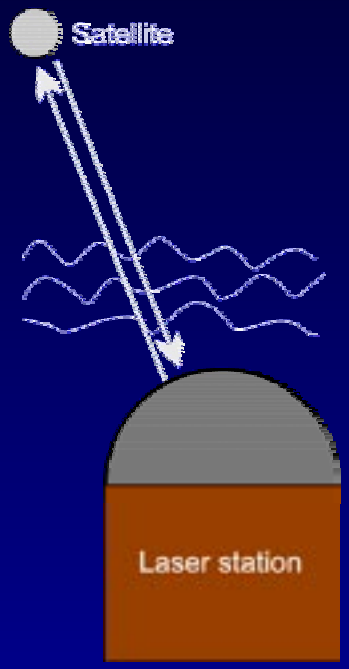
Conclusion

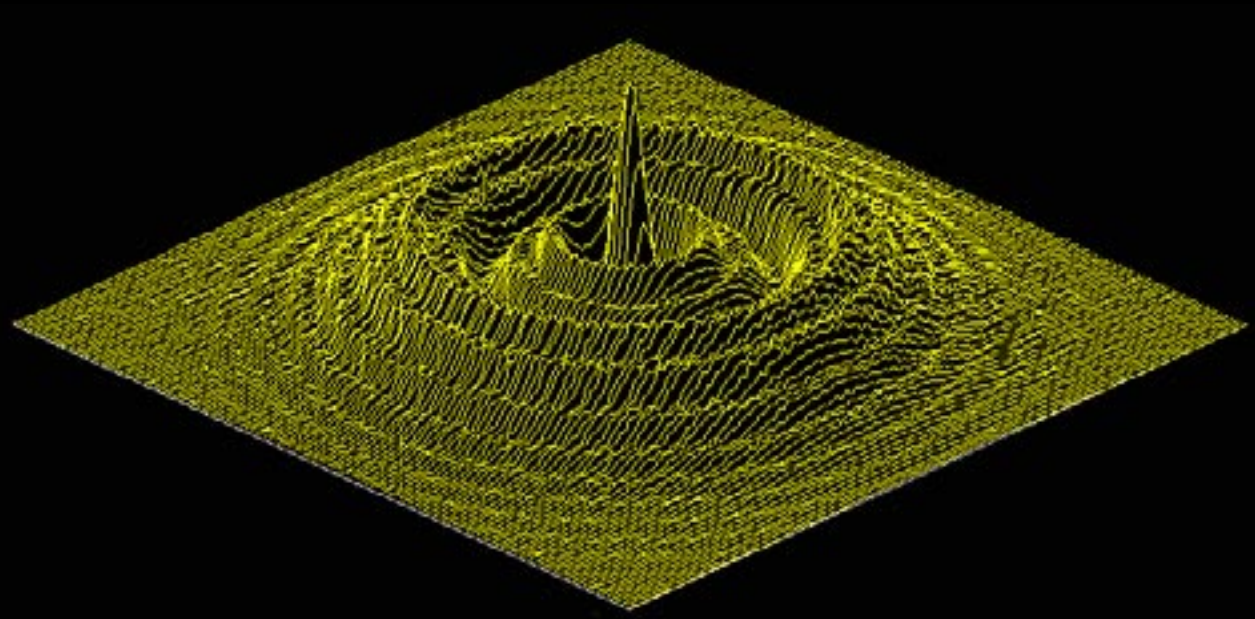


- Wavefront variance caused by atmospheric turbulence is < +/- 5 um under normal observing conditions
- both models (Glad, geometry) give the same answer
- The observed laser ranging jitter increase is caused by other effect(s)

I.Prochazka, L. Kral, CTU Prague, Oct.2002

Thanks for your attention





circular aperture diffraction pattern
log scale

I.Prochazka, L. Kral, CTU Prague, Oct.2002