

# Leica's Pinpoint EDM Technology with Modified Signal Processing and Novel Optomechanical Features

Fadi A Bayoud  
Ph.D. Geomatics Engineering

- when it has to be **right**



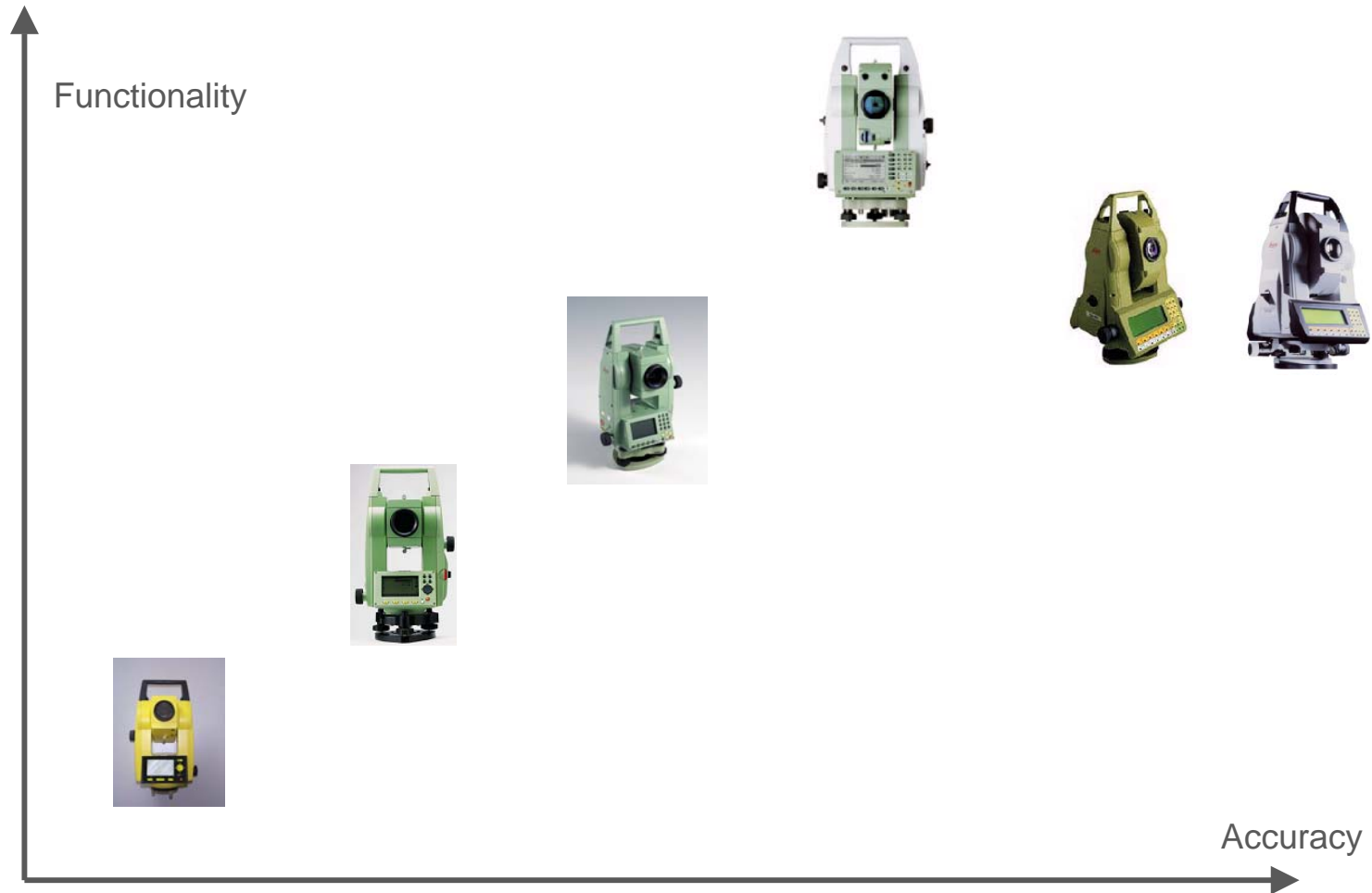
# Contents

- Leica's Total Stations and Telescope
    - ATR
    - PS
  - Leica's EDM – System Analyser
    - Comparison with other EDM's
- 
- New Optomechanical features
- 
- Conclusions

- when it has to be **right**

**Leica**  
Geosystems

# Leica's Total Station



- when it has to be **right**

**Leica**  
Geosystems

# Leica's Telescope

- High quality optics
- Accurate reflector, reflector-less and long range EDM
- Automated prism finding
  - Automatic Target Recognition (ATR)
  - Power Search (PS)
- Small and coherent laser spot
- Emitted Guiding lights (EGL)

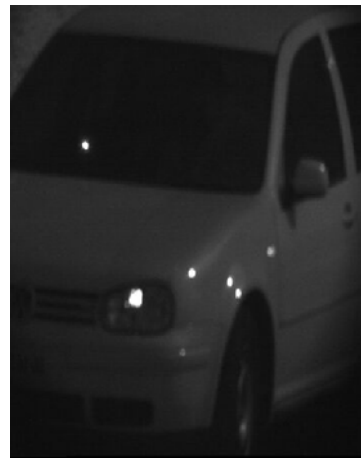
- when it has to be **right**

**Leica**  
Geosystems

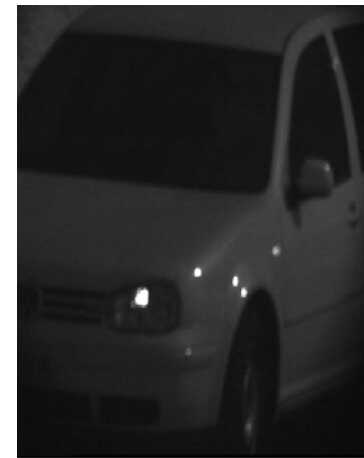
# ATR

- Emits infra-red light while video-imaging is on
- Locates reflected light
- Steers the cross-hair to the lightened spot until the angular offset is less than 50 cc (16 arcsec)
- Measures angle and distance

In case there are more than one reflecting spot, the emitter goes on and off to find the activated prism



Emitter on

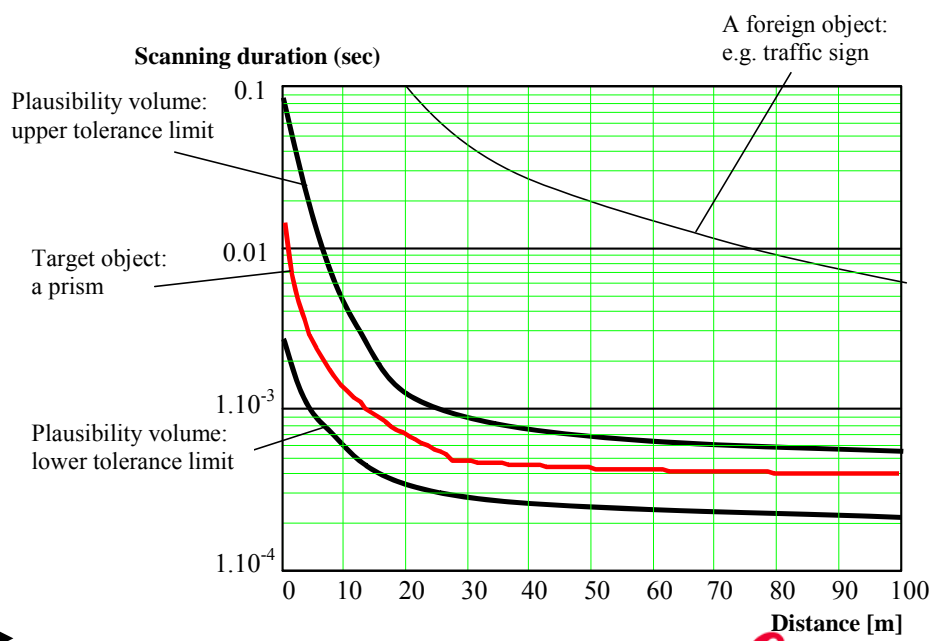
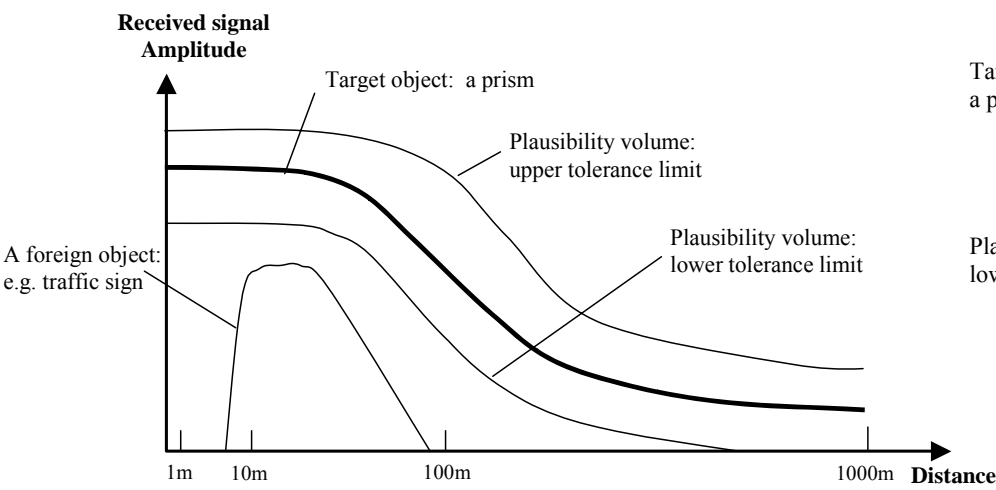
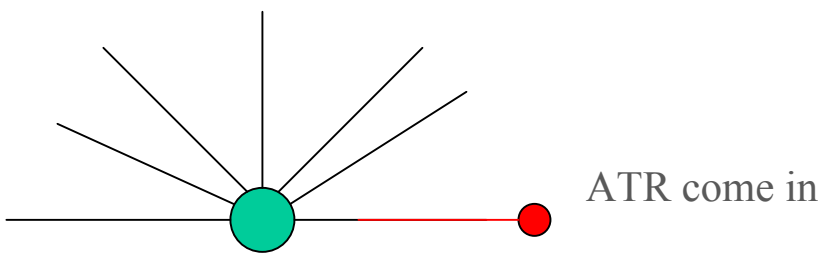


Emitter off

- when it has to be **right**

**Leica**  
Geosystems

# Power Search (PS)



- when it has to be **right**



# EDM Current Technologies

## Time of Flight (TOF) & Phase Shift

Time of Flight	Phase Shift
OK > 500 m but less accurate	Difficult > 400 m
multi-target realisation, but needs excellent laser coherence (expensive)	multi-target realisation not possible (inseparable signals)
Highly affected by environmental conditions	

- when it has to be **right**

**Leica**  
Geosystems

# Leica's EDM Technology - System Analyser

- Permit accurate (in the mm range) RL measurements to objects over large distances ( $> 500$  m) within few seconds ( $< 12$  sec).
- Permit identification (and correct surveying) of multiple targets.
- Permit distance measurements independently of general atmospheric influences, such as, dust, smoke, mist, rain or snowfall, etc.
- Make on-board distance calibration available which runs simultaneously with the distance measurement to avoid thermal drifts and interrupts of measurement flow.

- when it has to be **right**

**Leica**  
Geosystems

# System Analyser

- Large number of high frequencies (100MHz) are emitted to collect distance information with exclusively high resolution
  - Every frequency contributes to the final result giving high accuracy ( $\lambda \sim 1.5\text{m}$ )
  - Sub-mm distance resolution is achievable
  - No time is wasted for ambiguity resolution.
  - Selective w r t hard targets and blind w r t soft targets that have low-pass behaviour: 1 to 5 MHz
  - Large number of frequencies causes redundancy: any interruption in the signal path can be detected and neglected
- Ultra short laser pulses in sub-nsec range within pulse-trains of  $\geq 100\text{MHz}$ 
  - Energy's emitted at higher harmonics (1GHz) supporting high distance resolution
  - Noise is minimised due to the steepness of the wave

- when it has to be **right**

**Leica**  
Geosystems

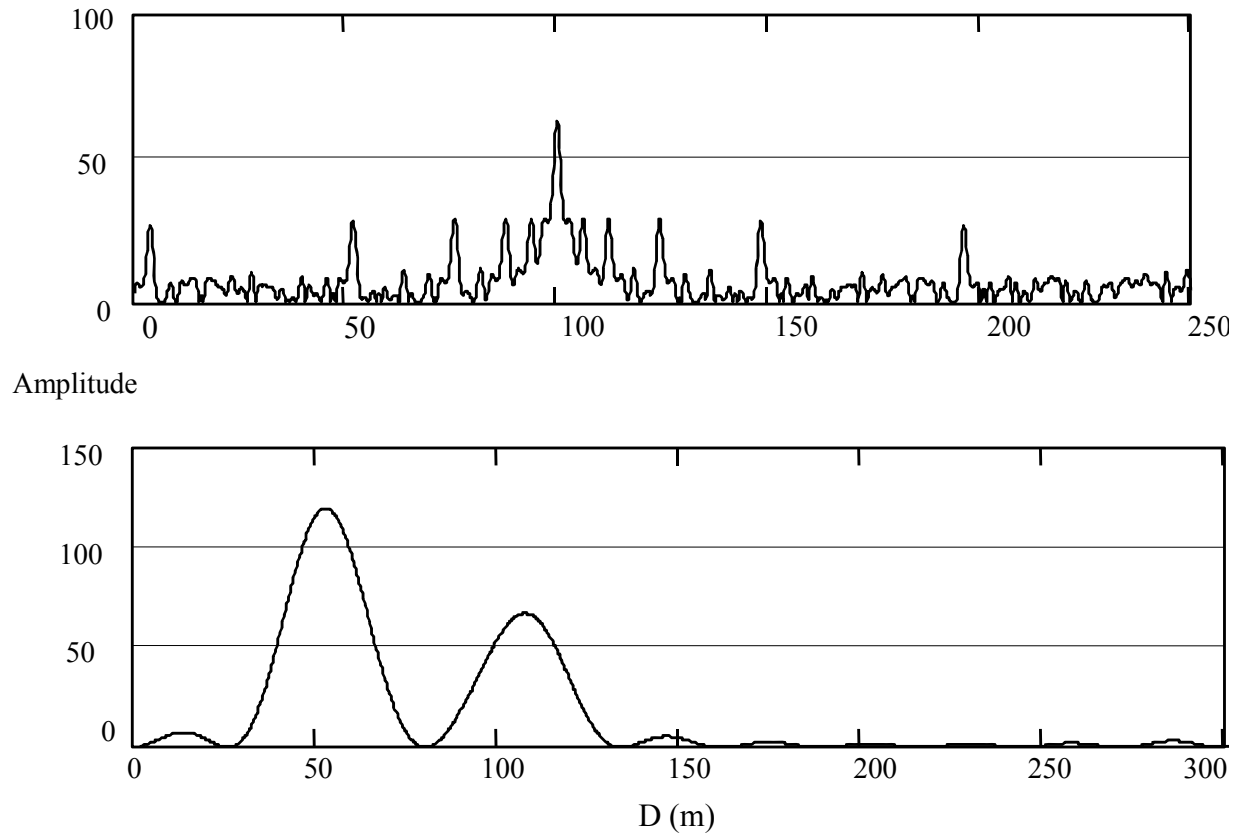
# System Analyser

- After sampling the received signals, a merit-function (which is comparative to a time-of-flight signal) is constructed based on using all the incoming signal information
  - Thus, all the information between the EDM and Target is included in a quasi-continuous system
    - Advanced algorithms perform a **System Analysis** to get the function whose **maximum is the sought distance**
- Number of used modulation frequencies depends on the received signal strength
  - At high signal levels 4 frequencies are sufficient
  - At low signal levels up to 10 frequencies are emitted and analysed

- when it has to be **right**

**Leica**  
Geosystems

# System Analyser

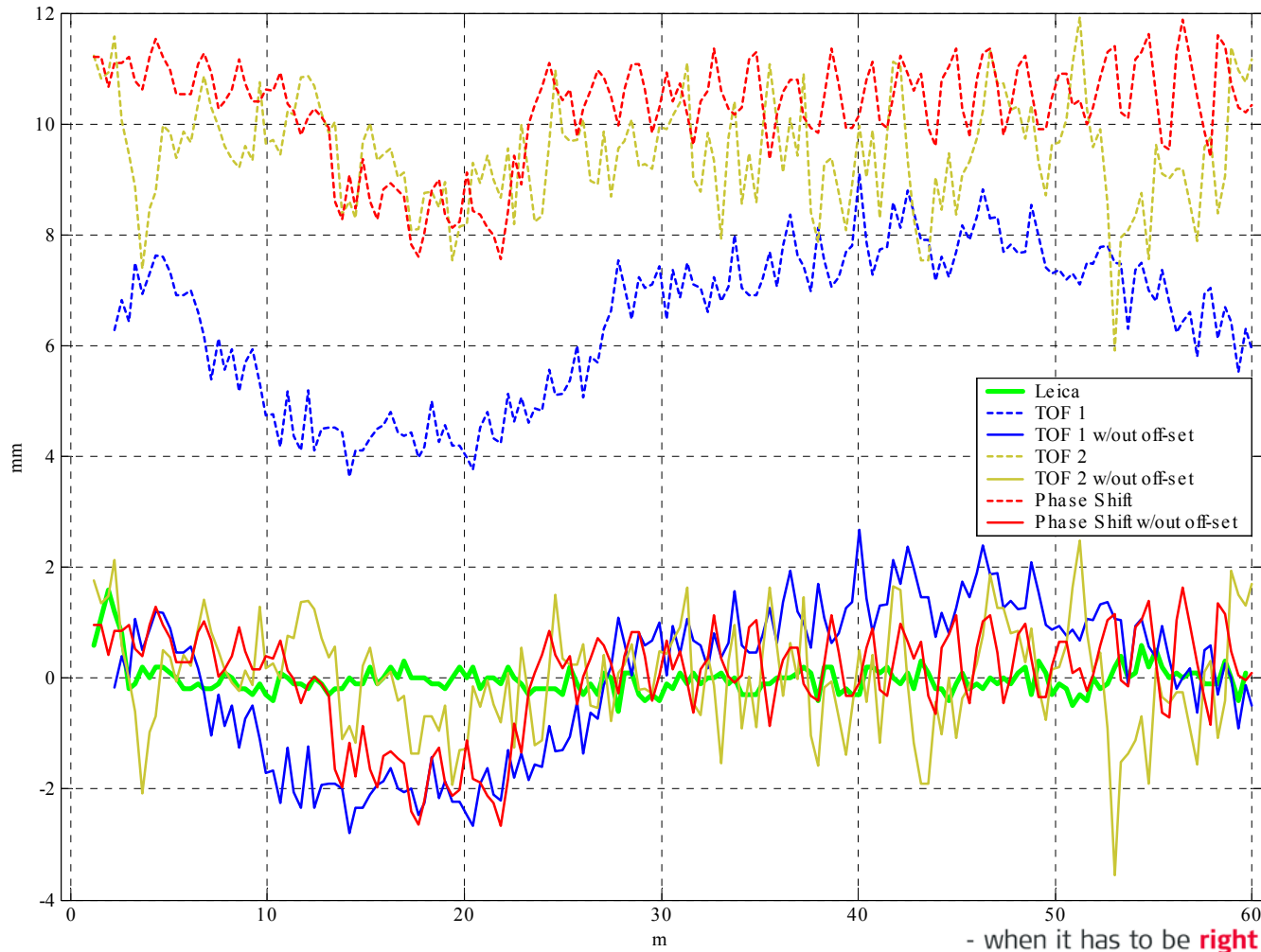


- when it has to be **right**

**Leica**  
Geosystems

# Leica's EDM Accuracy (1)

Comparison with an Interferometer: up to 60 meter with a 30 cm step

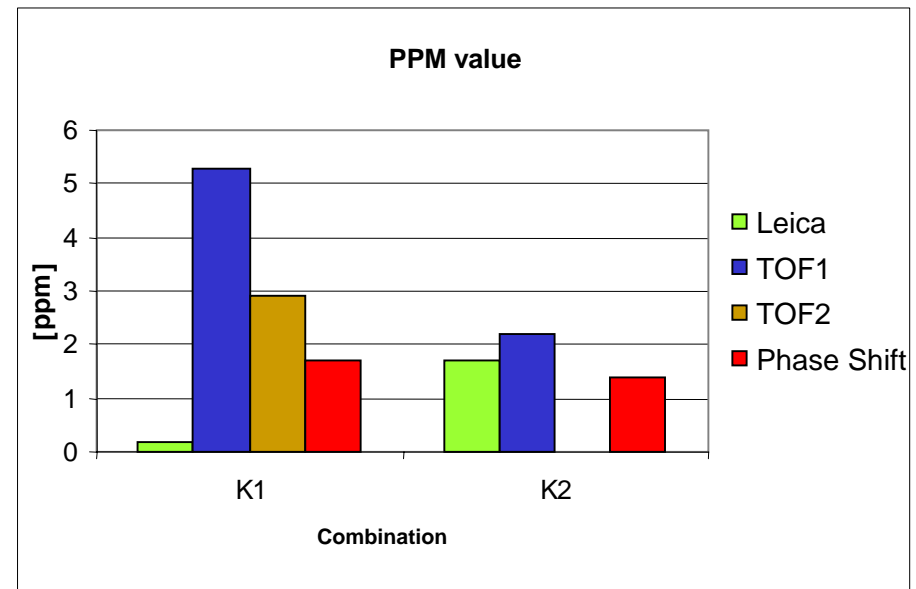
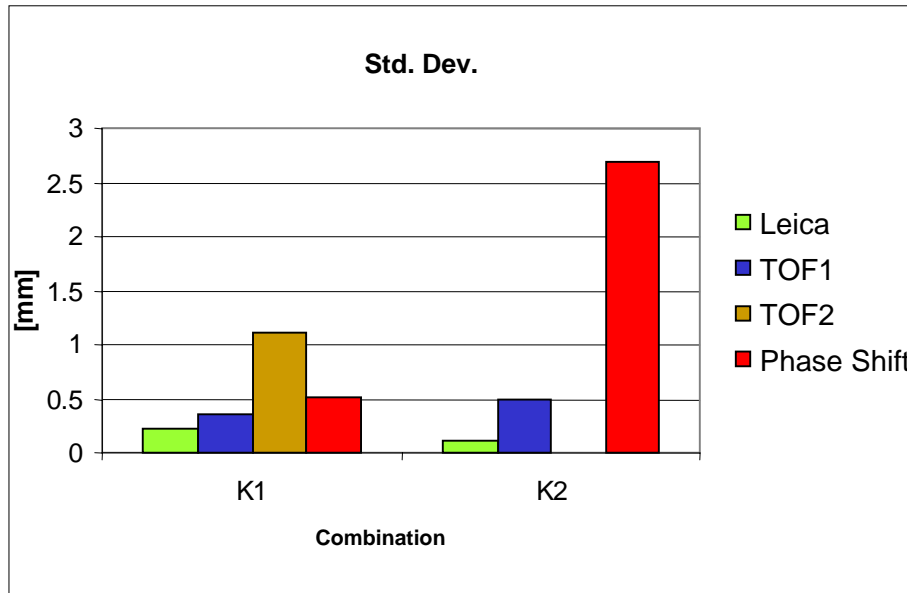


- when it has to be **right**



# Leica's EDM Accuracy (2)

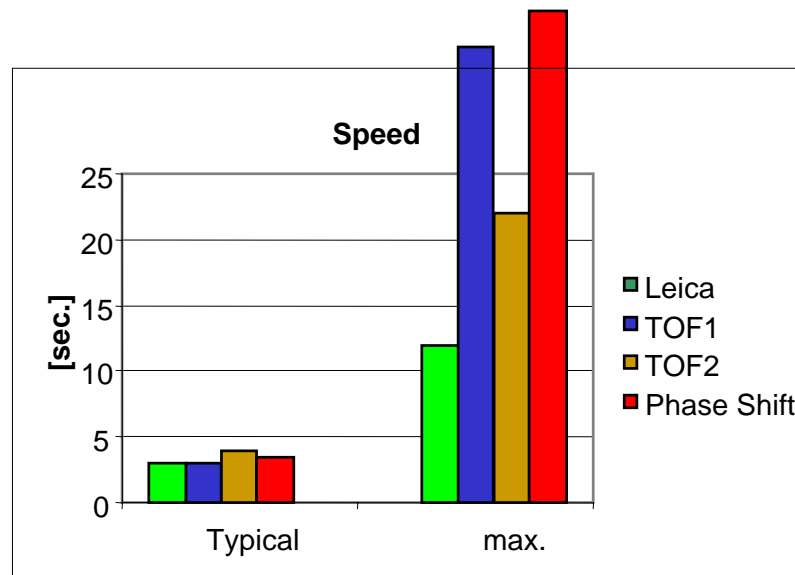
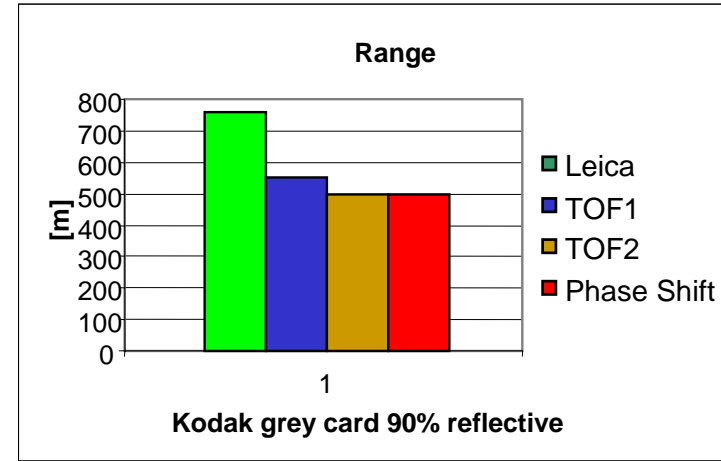
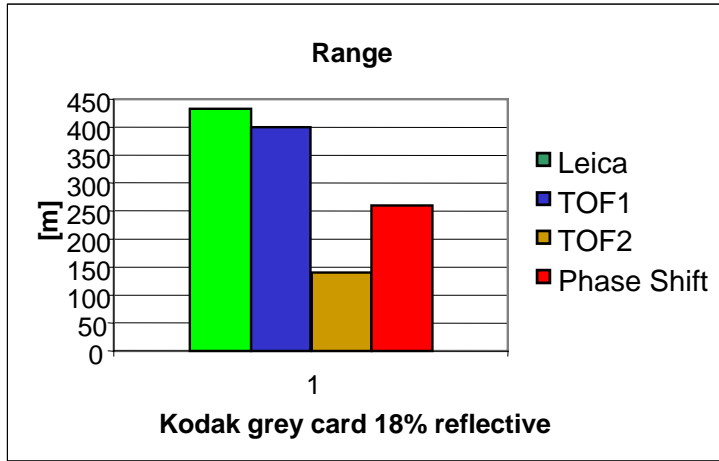
ISO range measurements; max.dist.: K1 = 500m , K2 = 1000



- when it has to be **right**

**Leica**  
Geosystems

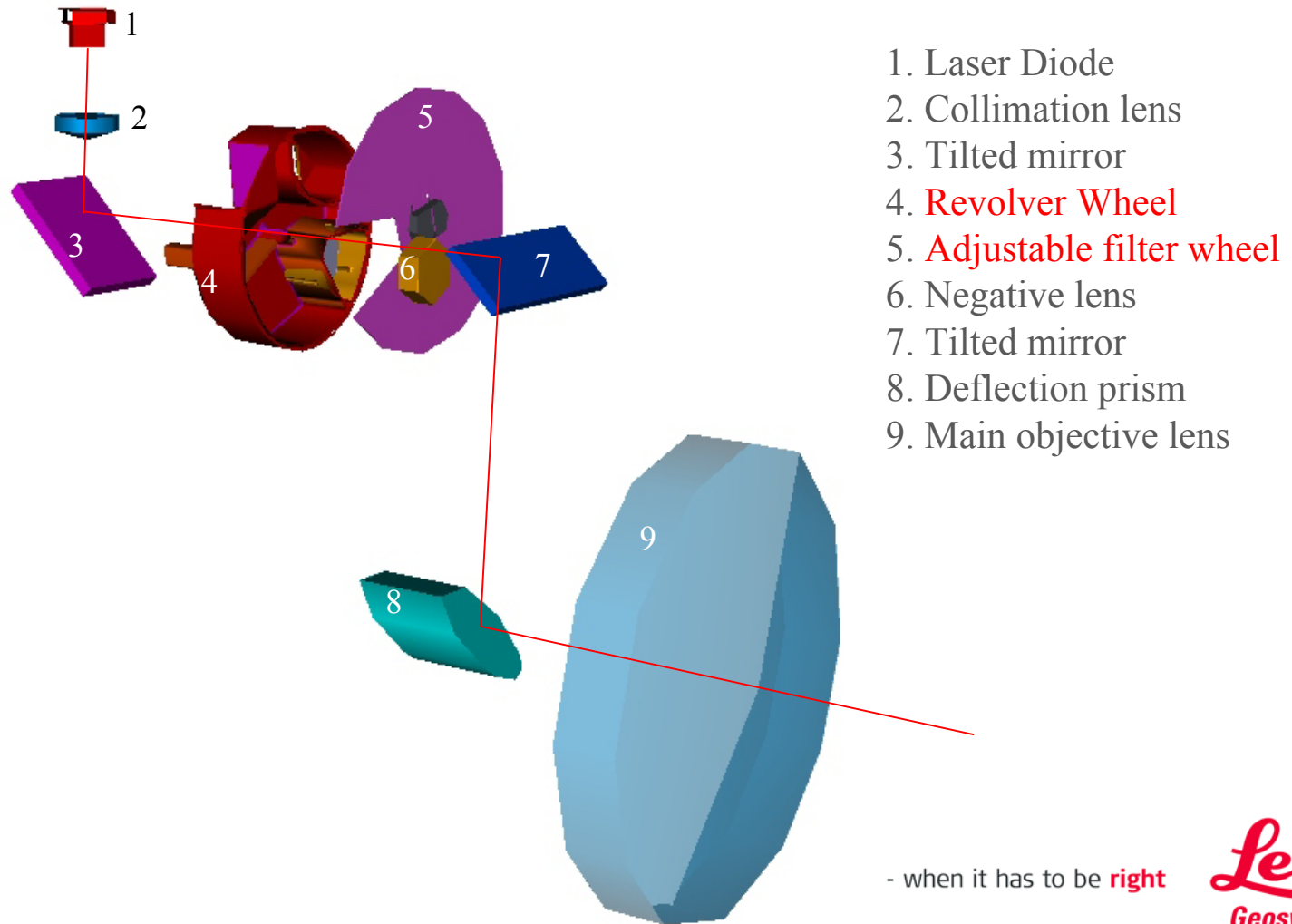
# Range and Speed



- when it has to be **right**

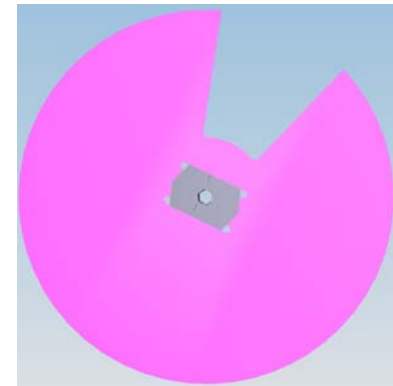
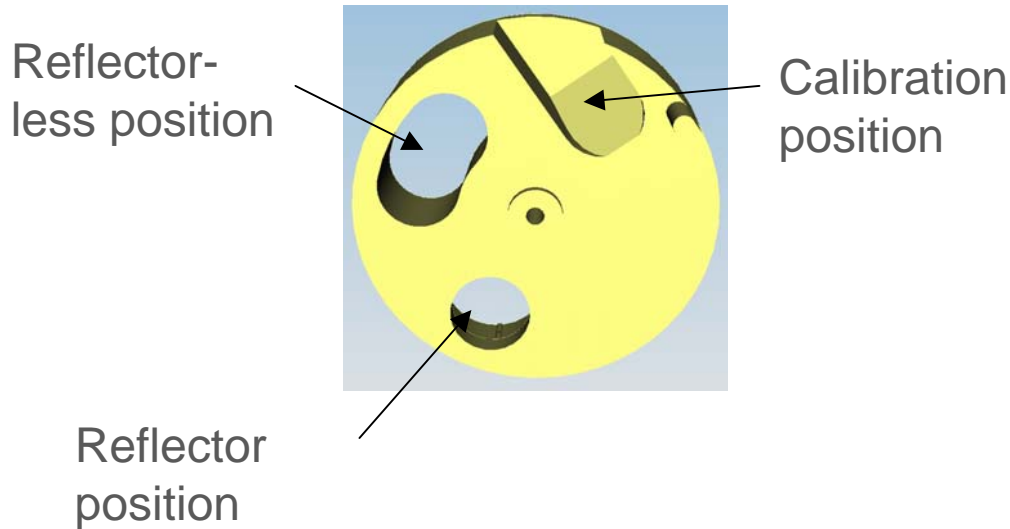


# New Optomechanical Design



# New Optomechanical Design

## Movable parts



It intelligently takes a position that depends on the strength of the reflected laser

- when it has to be **right**

**Leica**  
Geosystems

# Design Improvements

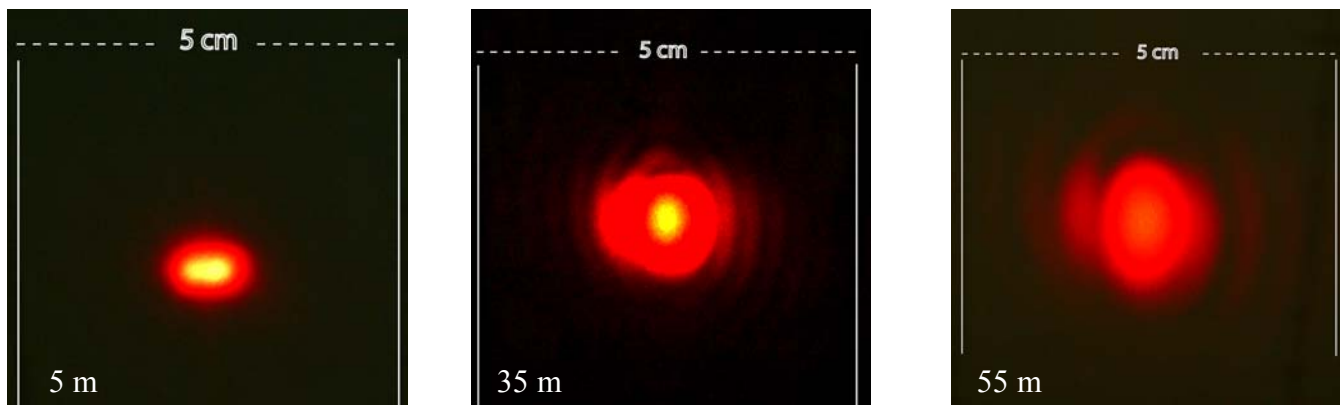
Thus:

- Improving optical beam path
  - Due to the reduced number of parts in the optical path
- Improving beam stability
  - Due to the lack of moving mirrors/lenses and improvements of the geometric coupling
- Improving the MTF (Modulation Transfer Function)
  - Sharper optical picture/impression for optical sighting through telescope
- Eliminating the need for user adjustment of the laser beam
- Allowing no misalignments or deviations between the reflector and reflectorless beam

- when it has to be **right**

**Leica**  
Geosystems

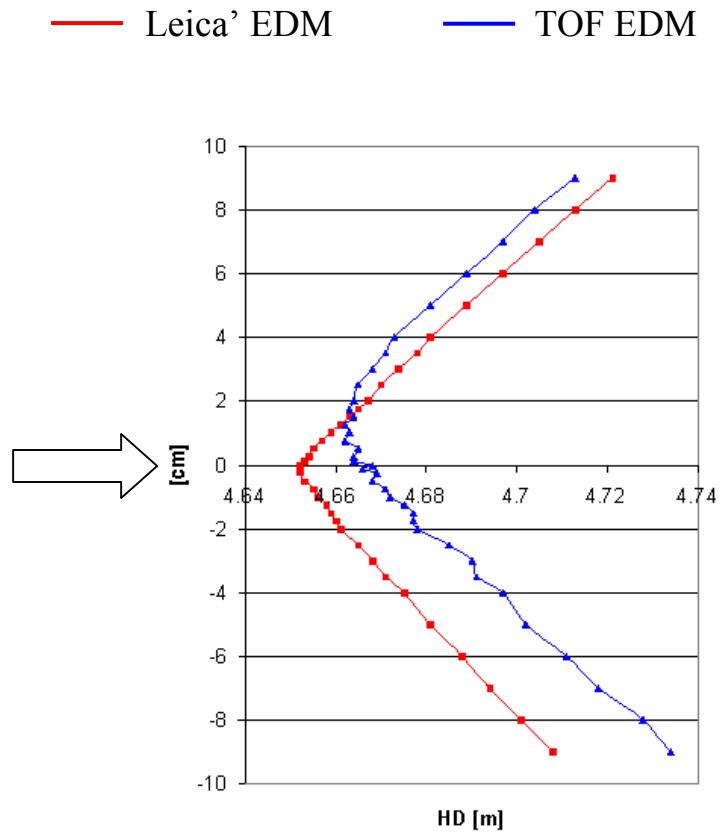
# Laser Spot



- when it has to be **right**

*Leica*  
Geosystems

# Effectiveness of Laser Spot



- when it has to be **right**



# Conclusions

- Leica's EDM "System Analyser" is superior to existing technology
  - Able to measure accurate distances with 4 to 6 times lower signals than with a conventional phase-method. Measures routinely to distance > 650 m with maximum time of 12 sec
  - Further investigations are carried out to improve the maximum likelihood approach model in order to measure ranges to more than 1000m on bright diffusive targets.
- A new optomechanical design that overcomes potential disadvantages found in the old design, especially in terms of beam stability, image quality, laser beam spot geometry, etc.

- when it has to be **right**

**Leica**  
Geosystems

**Thank you!**

- when it has to be **right**

**Leica**  
**Geosystems**