WARSAW UNIVERSITY OF TECHNOLOGY

Faculty of Geodesy and Cartography

Institute of Geodesy and Geodetic Astronomy

EXPERIENCES AND PROJECTS IN THE DOMAIN OF ABSOLUTE GRAVITY DETERMINATIONS ON THE POLAND TERRITORY

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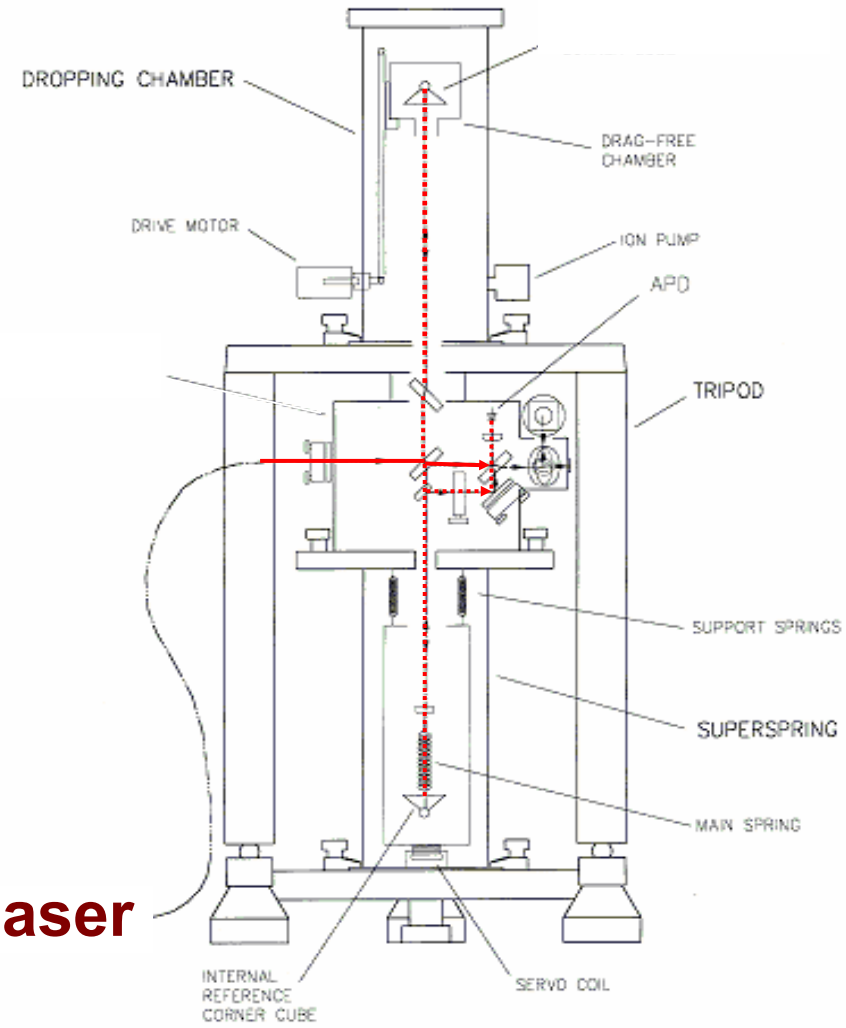
History of the FG5 gravimeter

- Dr James Faller – construction of interferometer and lower mirror superspring – since 1962
- Joint Institute Laboratory Astrophysics g (1985) joined DMA, NOAA, CGS, FGI
- AXIS (1986 – 1992)
- Micro-g Solutions Inc. (since 1998)

Main technical features

- **Uncertainity:** 2 μGal (observed agreement between instruments)
- **Precision:** ~ 0.2 μGal after 24 hours of observations
- **Can be using:** Worldwide
- **Temperature range:** 15°C to 30°C
- **Mobitity** – weight „only” 300 kG

Scheme of the construction of FG5



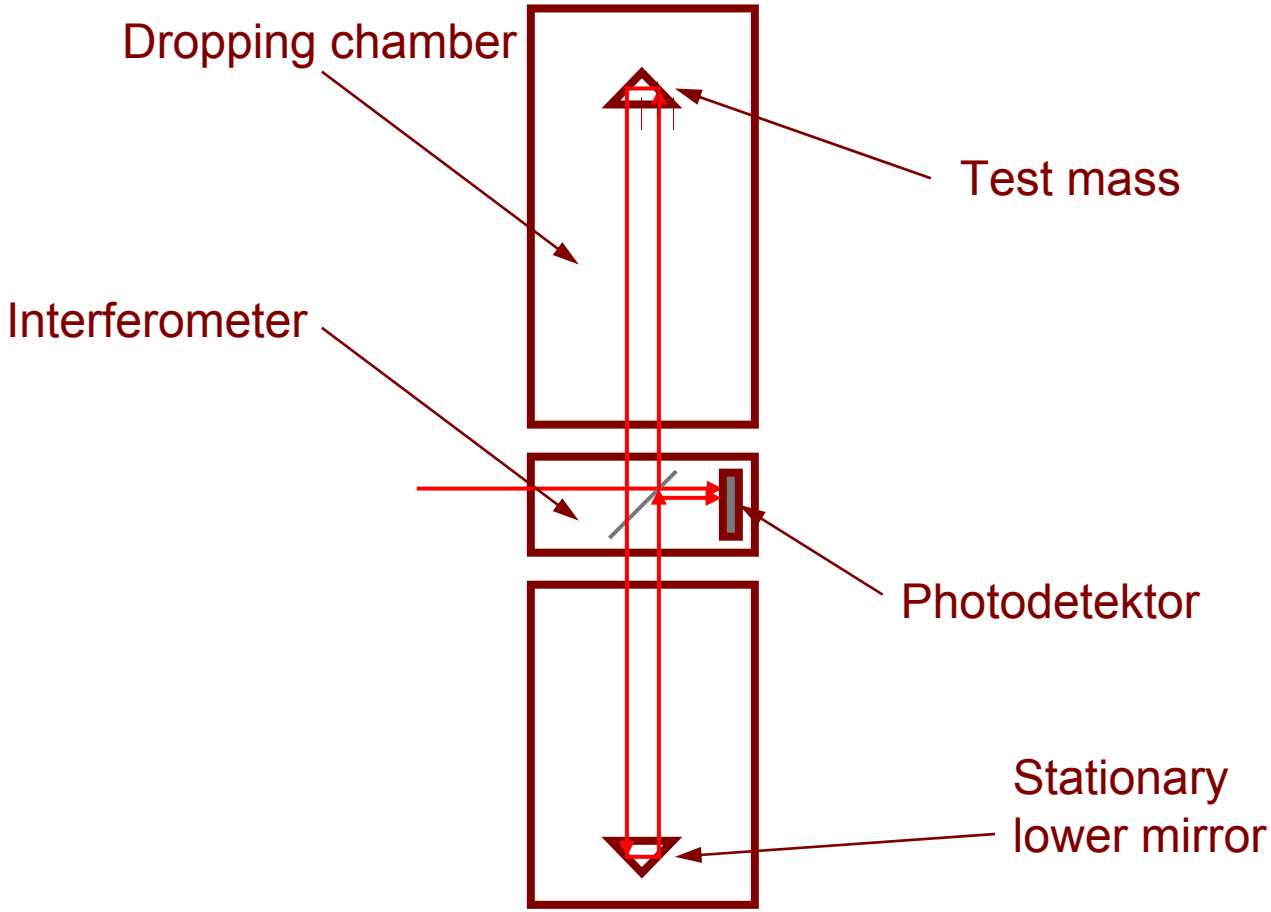
Dropping Chamber

Interferometer

Superspring

Laser

The concept



Registration of position and time of the test mass.

Determination of the *g* value

- Approximation of the position and time relation x_i, t_i :

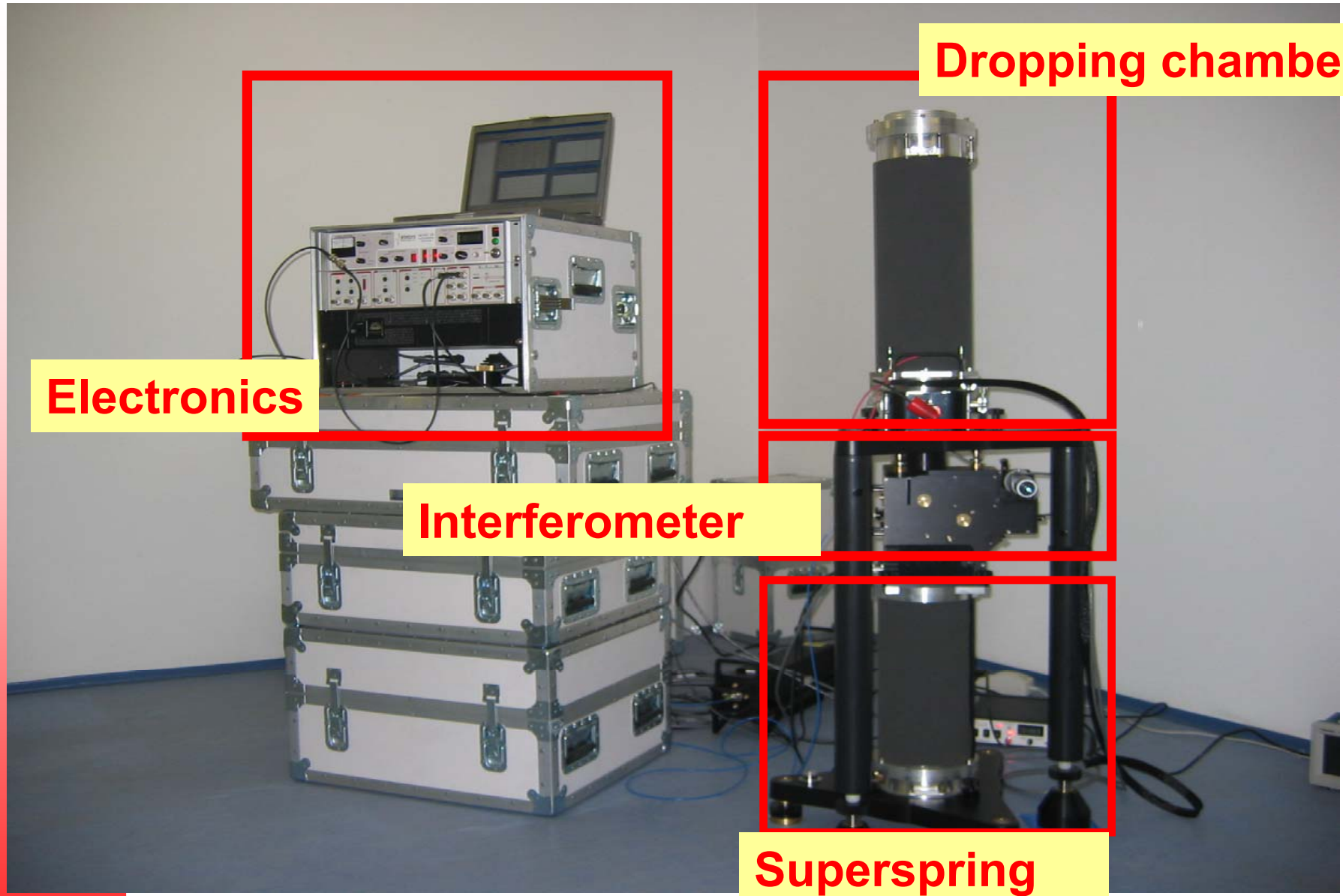
$$x_i = x_0 + v_0 \cdot t_i + \frac{g \cdot \tilde{t}_i^2}{2} + \frac{\gamma \cdot x_0 \cdot \tilde{t}_i^2}{2} + \frac{1}{6} \cdot \gamma \cdot g \cdot \tilde{t}_i^3 + \frac{1}{24} \cdot \gamma \cdot g \cdot \tilde{t}_i^4$$

$$\tilde{t}_i = t_i - \frac{(x_i - x_0)}{c}$$

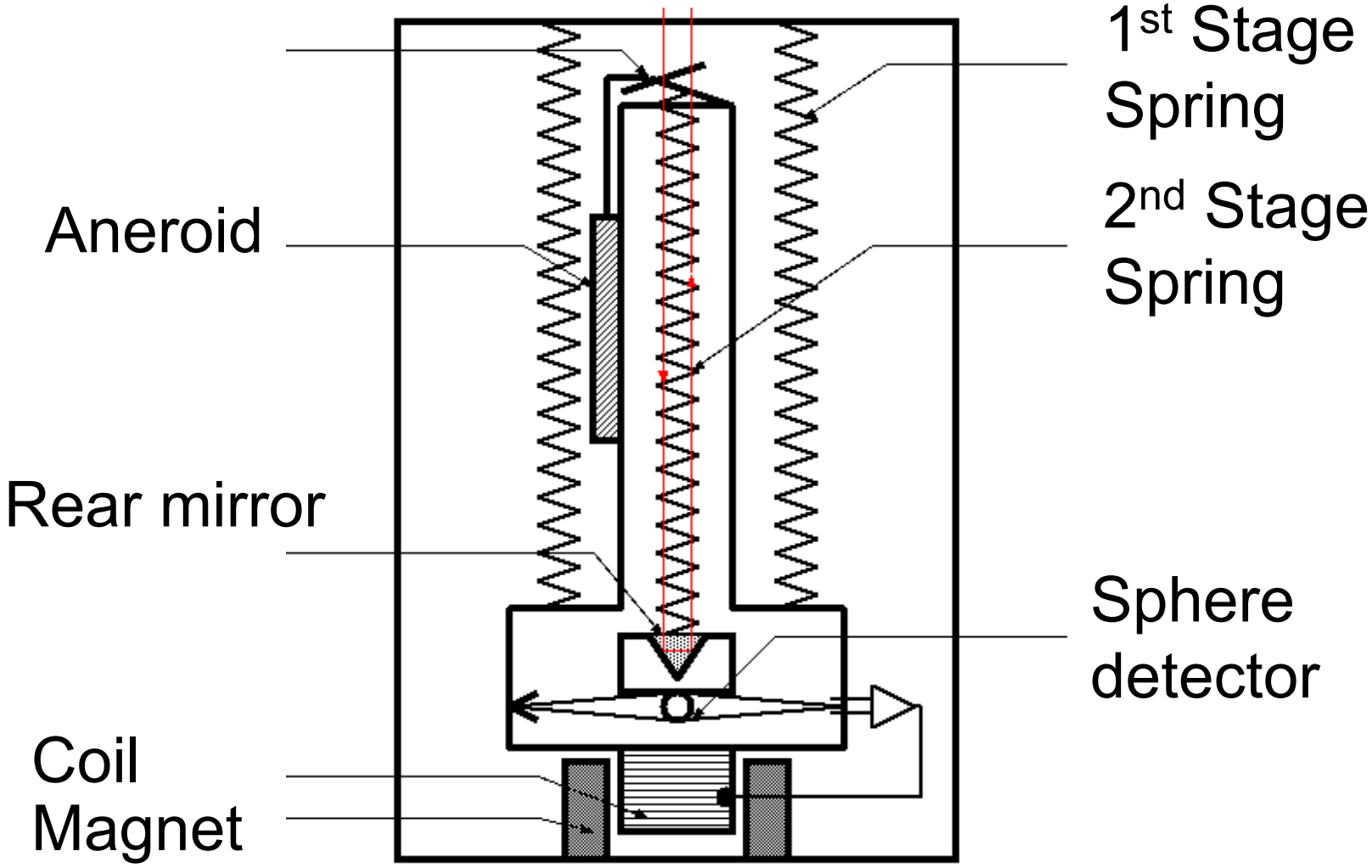
x_i, t_i, i = 1, …,700

- γ – vertical gravity gradient (~3 μGal/cm),
- c – light velocity
- x_0 – starting position
- v_0 – starting velocity

***g* – the gravity value on the *h* elevation above gravity mark**

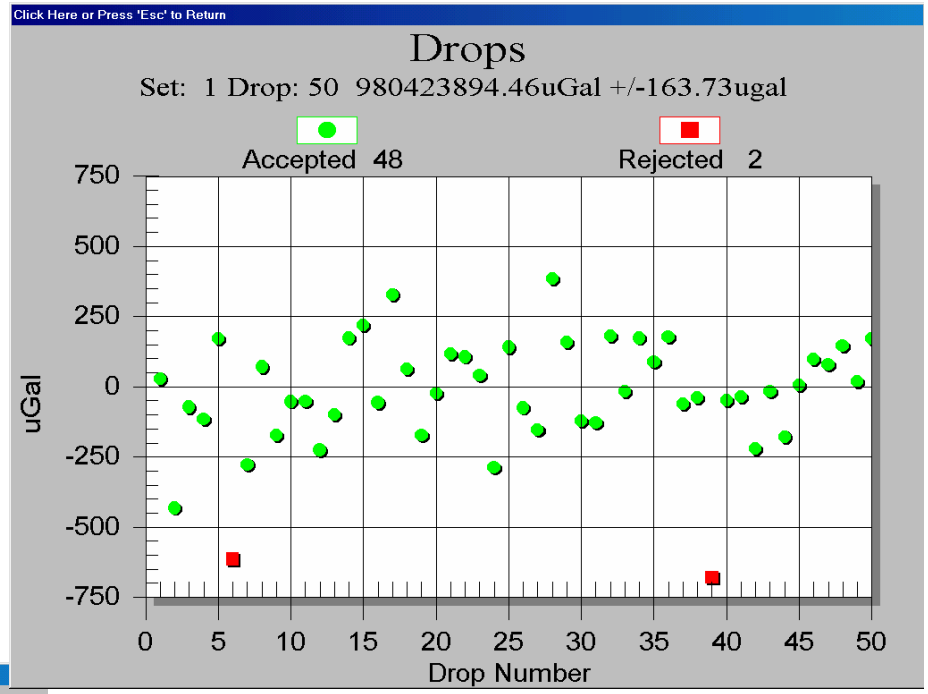

Dropping chamber
Electronics
Interferometer
Superspring

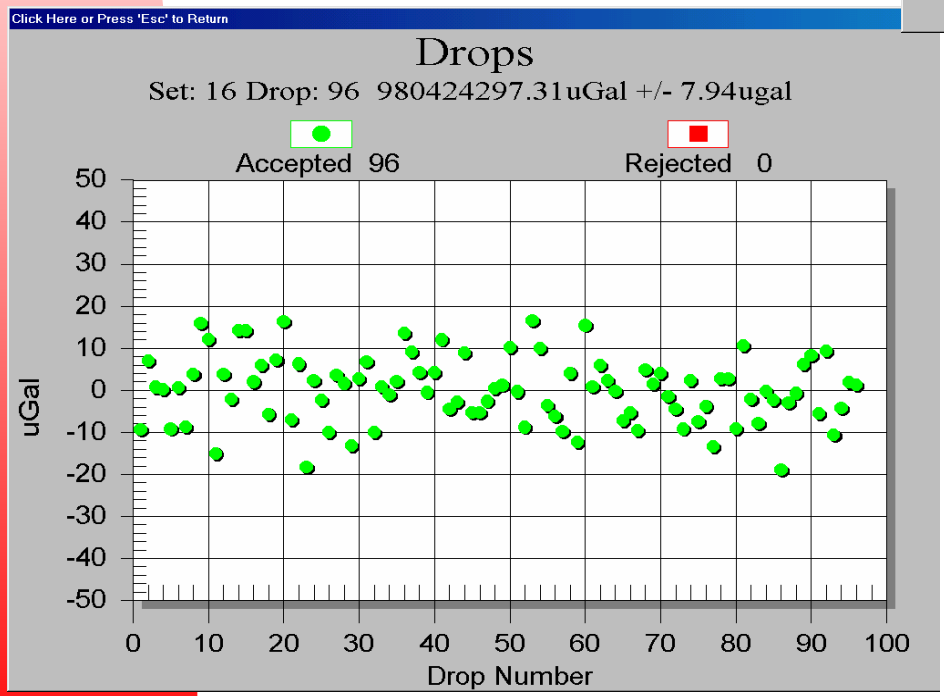
Superspring - scheme



The role of the Superspring

without compensation





with compensation

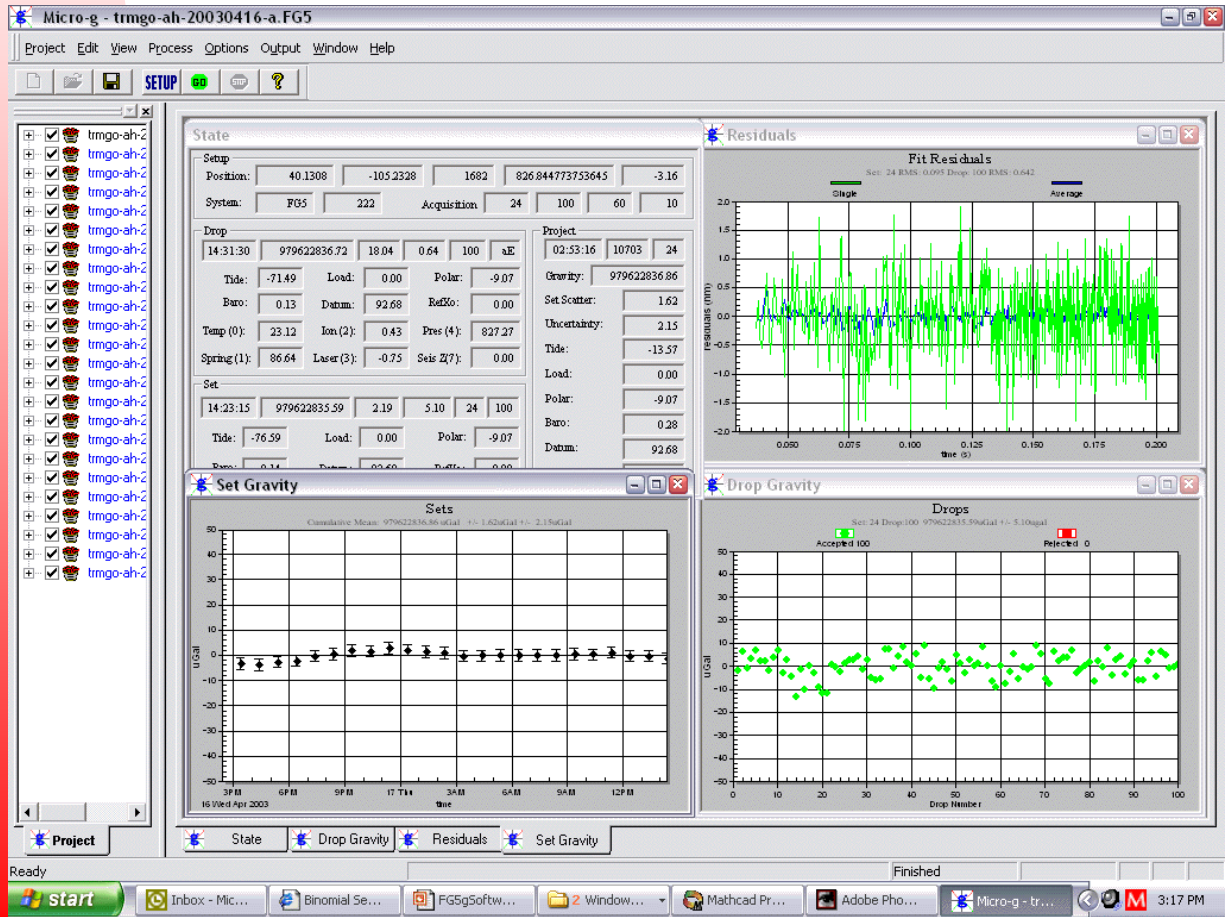
Laser WEO 100

- **Primary Standard (BIPM Certified)**
- **Stability 1 part per 10^{11}**

  (mikroGal is ca. 10^{-9} part of g)
- Automatic peak locking
- Fiberoptics from laser head into the interferometer

„g" software – data acquisition and processing software

- system MS Windows,
- raw data registrations,
- posibilities of recomputation



Reduction of g value:

- tidal correction (Earth an ocean mass loading),
- polar motion,
- atmospheric correction,
- reduction on the reference level.

Preparation to the measurements on a station

Station parameters

- Latitude
- Longitude
- Hight – elevation above sea level
- Vertical gradient of gravity
- Polar motion
- Tidal model

Data acquisition

- Once ***g*** value = one ***drop***
- Typical set = 100 drops
- Min. 24 hour of observation

Uncertainity of g value

Symbols:

- σ = drop scatter
- δ_{stat} = measurement precision
- δ_{mod} = uncertainties of corrections
- δ_c = total uncertainty

$$\delta_{stat} = \sigma / \sqrt{N_{drops}}$$

$$\delta_c = \sqrt{\delta_{mod}^2 + \delta_{stat}^2}$$

Processing report (1)

```
...
Processing Results
Date: 02/05/06
Time: 05:38:14
DOY: 036
Year: 2006
Gravity:   981213793.66 uGal
Set Scatter:  0.73 uGal
Measurement Precision:  0.15 uGal
Total Uncertainty:  2.06 uGal
...
Number of Sets Collected:   24
Number of Drops/Set:  100
Total Drops Accepted:    2371
Total Drops Rejected:      29
```

Processing report (2)

```
Gravity:   981213793.66 uGal
Set Scatter:  0.73 uGal
Measurement Precision:  0.15 uGal
Total Uncertainty:  2.06 uGal
...
Uncertainties
Earth Tide Factor: 0.001
Average Earth Tide Uncertainty:  0.03 uGal
Ocean Load Factor:  0.10
Average Ocean Load Uncertainty:  0.00 uGal
Barometric:  1.00 uGal
Polar Motion:  0.05 uGal
Laser:  0.01 uGal
Clock:  0.50 uGal
System Type:  1.10 uGal
System Setup:  1.00 uGal
Gradient:  0.87 uGal ( 0.03 uGal/cm)
```

Calibration

Station: TMGO, Colorado

Grawimetr	Data	g	m_g
222	16/5/2005	979622836.7	2,1
103	16/5/2005	979622837.4	2,1
210	19/5/2005	979622839.9	2,1
104	20/5/2005	979622839.4	2,1
230	26/5/2005	979622837.2	2,1
102	13/6/2005	979622838.0	2,1

Max differences 3,2 μGal
Min – FG5 no 230 = 0,5 μGal
Max – FG5 no 230 = 2,7 μGal

Values in μGal

Station: 15W UNIGRACE, Józefosław

$g_{\text{FG-5 no. 230}}$ = 981 212 751,9 μGal (23.04.2006r.)

$g_{\text{FG-5 no. 206}}$ = 981 212 753 μGal (06.1999r.)

Calibration

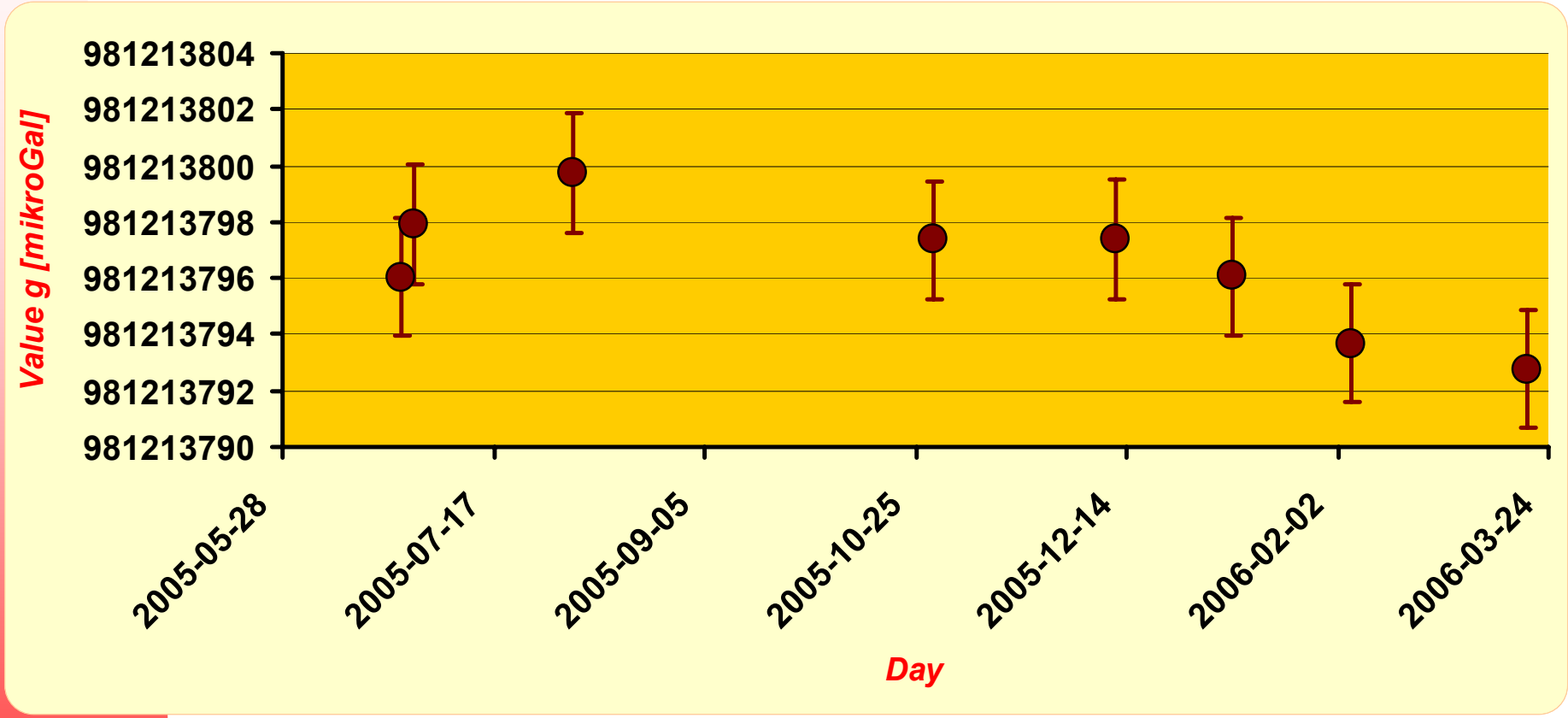
The recent comparison measurements have been done from 15.06 to 20.06.06 at two stations: PECNY in Czech Republic and BAD HOMBURG in Germany.

These measurement had a different strategy than both earlier comparisons. The measurements have been provided simultanously with a different models of FG5 gravimeters: FG5 no. 215 (VOGIT Czech) and FG5 no. 301 (BKG Germany).
Gravity was measured at two different points at each station.

Preliminary results agree the scatter between FG5 no. 230 and different FG5 models is less than 1,5μGal

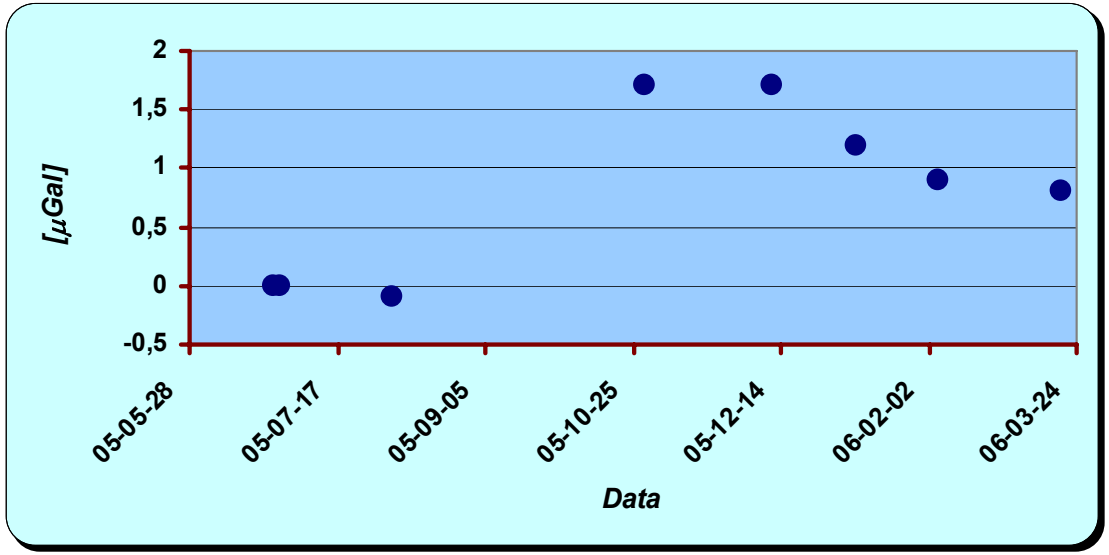
First results at Józefosław

Raw data from Jozefosław station

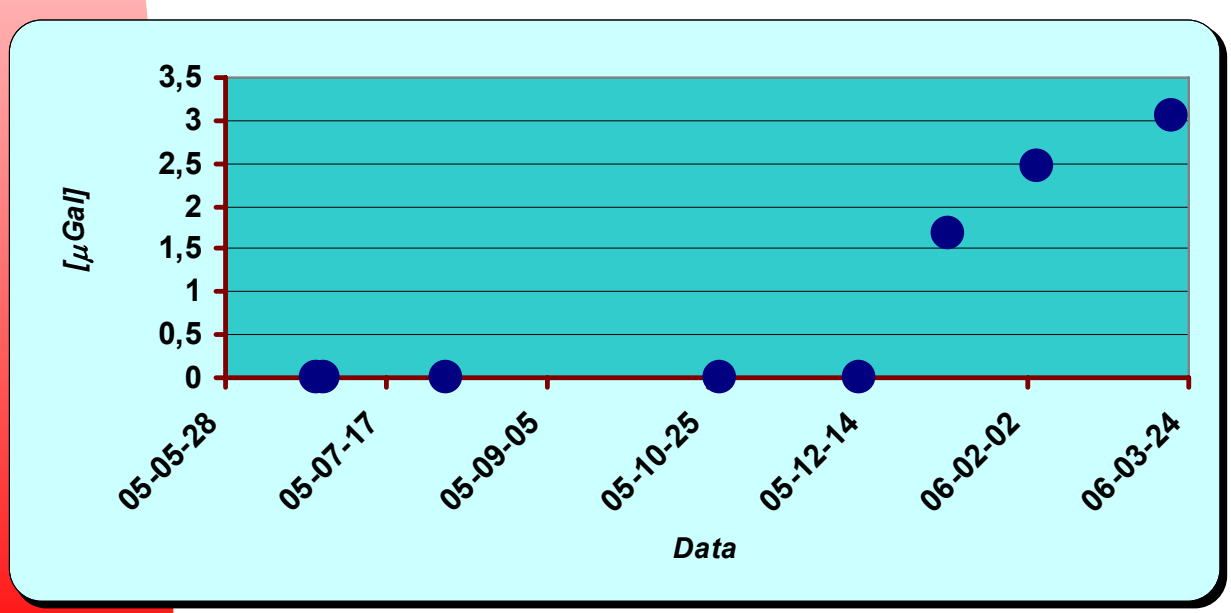


Correction from enviromental effects: water table, snow layer gravity influence

Results



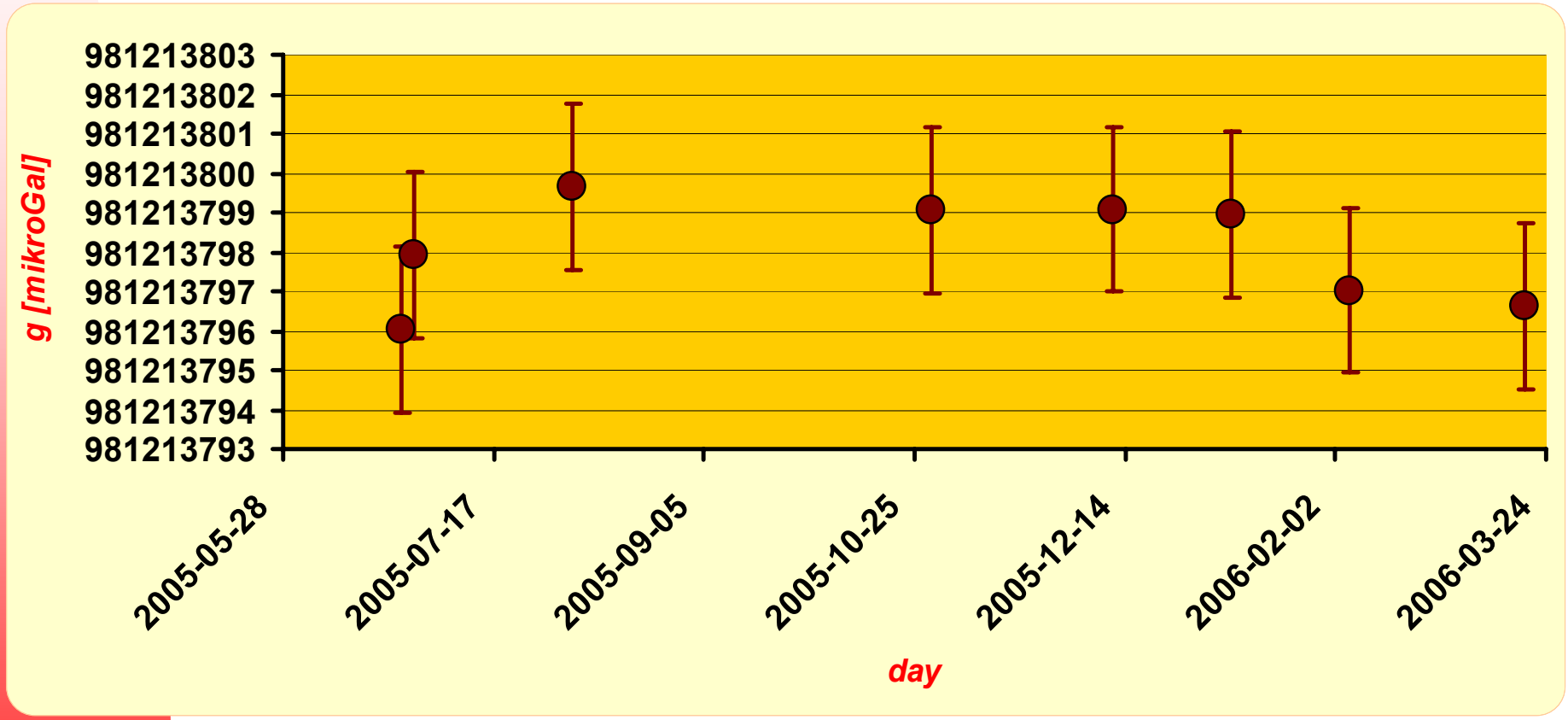
Observed *g* value vs. ground water level



Observed *g* value vs. gravitational effect of snow layer

Results

Corrected *g* value

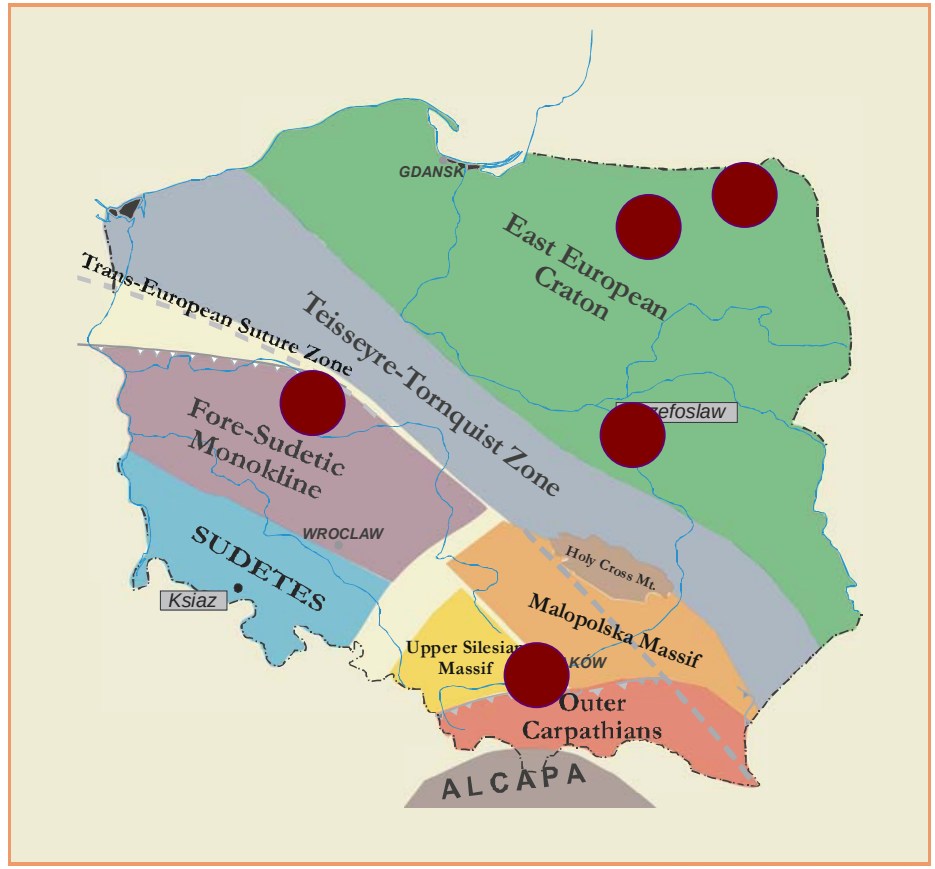


Scientifical plans

„Monitoring of the long period gravity changes on the main geological units on Poland territory”

Project chairman: Prof. Dr. Marcin Barlik

- Localisation on the earlier observed points;
- Three epochs.

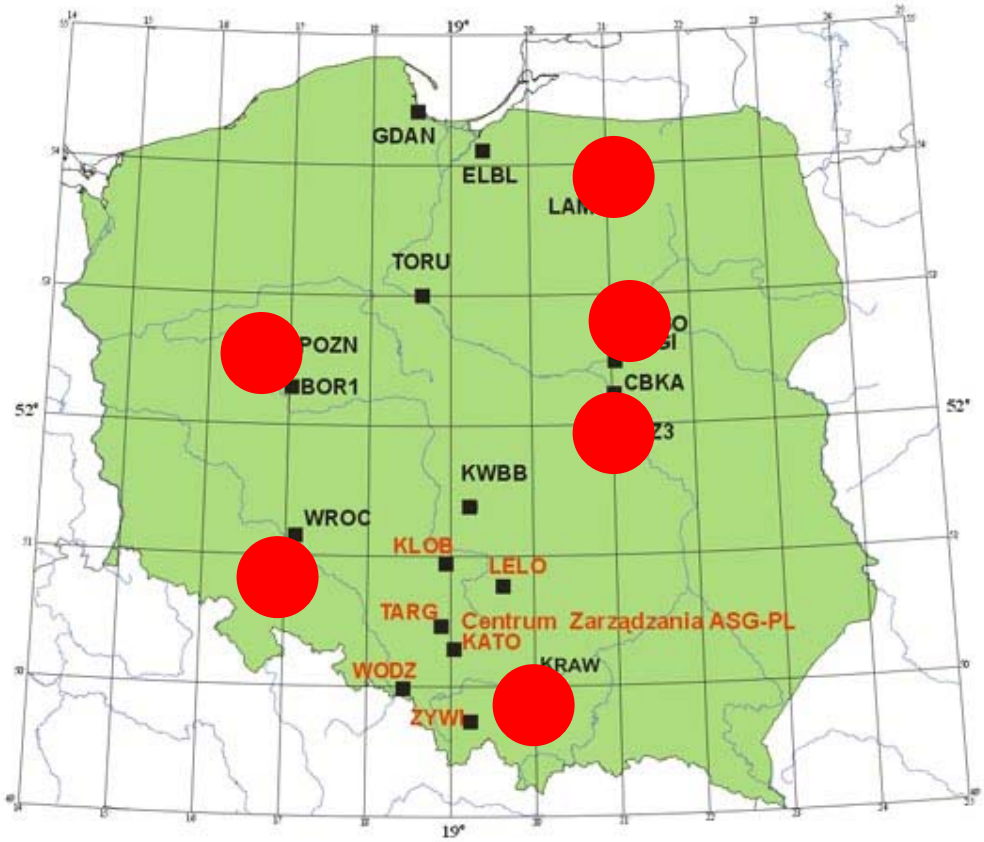


Scientifical plans

„Unified gravimetrical reference system for Polish permanent GNSS stations and geodynamical test fields”

Project chairman: Prof. Dr. Kazimierz Czarnecki

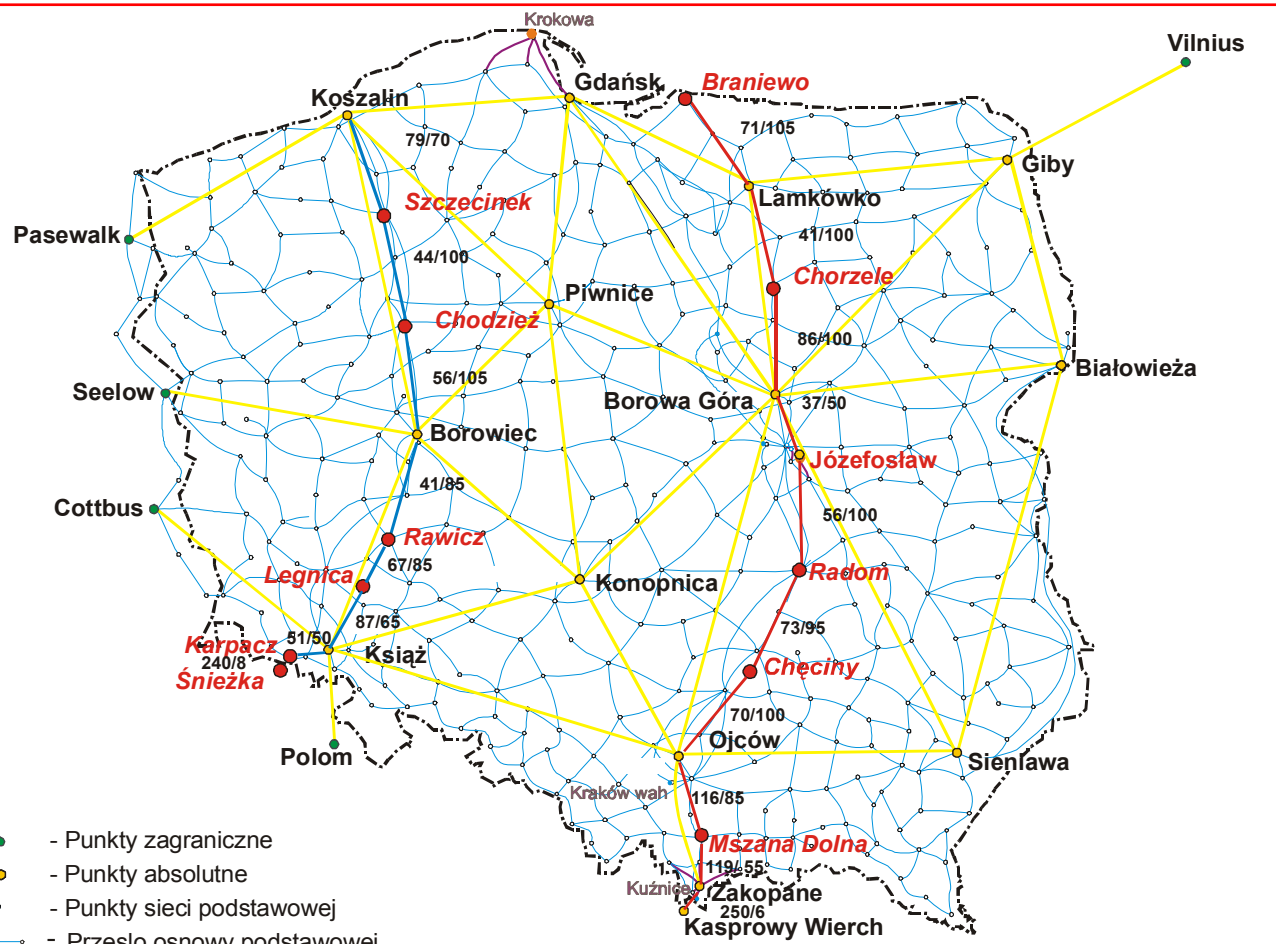
- Two observation epochs



Absolute gravity stations in the Polish fundamental gravity network

15 existing points.
21 points are needed

Gravimetric calibration base lines – propositions



- Punkty zagraniczne
- Punkty absolutne
- Punkty sieci podstawowej
- Przeslo osnowy podstawowej
- tzw. “długie” przęsło
- Baza Centralna
- Baza Zachodnia
- Przęsło nawiązujace do osnowy podstawowej
- Projektowane punkty absolutne

154/115 - różnica g w mGal / odległość między punktami w km

Rysunek: IGiK