

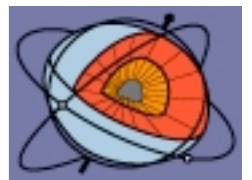


TECHNISCHE
UNIVERSITÄT
WIEN
VIENNA
UNIVERSITY OF
TECHNOLOGY

GEODETIC VERSUS GEOPHYSICAL EARTH ROTATION

Mendes Cerveira P.J.
and Schuh H.

94th "Journées Luxembourgeoises
de Géodynamique" (JLG)



Luxembourg, 12-14 November, 2007

Earth rotation & geodynamics

Schiaparelli

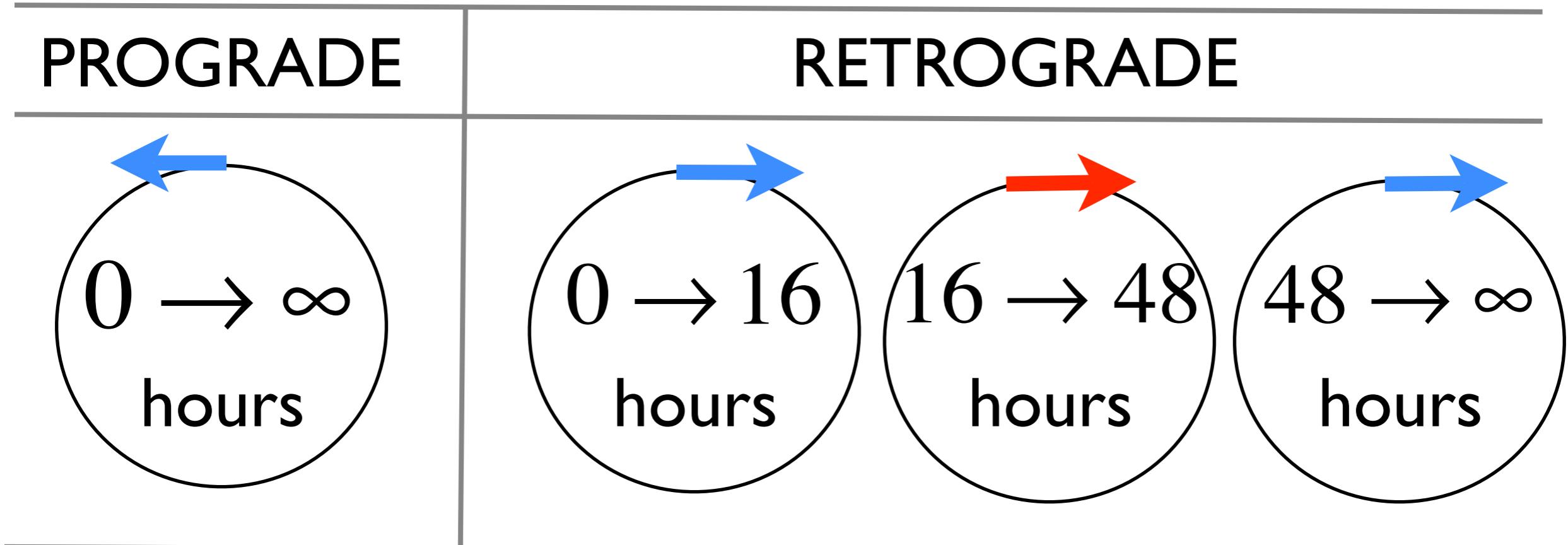
*De la rotation de la Terre
sous l'Influence des
Actions Géologiques.* St.
Petersbourg, Acad. Impériale
des Sciences, 32 p., **1889.**



SCHIAPARELLI. — DE LA ROTATION DE LA TERRE SOUS L'INFLUENCE DES ACTIONS GÉOLOGIQUES. — Mémoire présenté à l'Observatoire de Pulkovo, à l'occasion de sa fête semi-séculaire. Saint-Pétersbourg, **1889.** Grand in-8°,
32 pages.

Problem: physics vs. conventions

IERS Conventions 2003



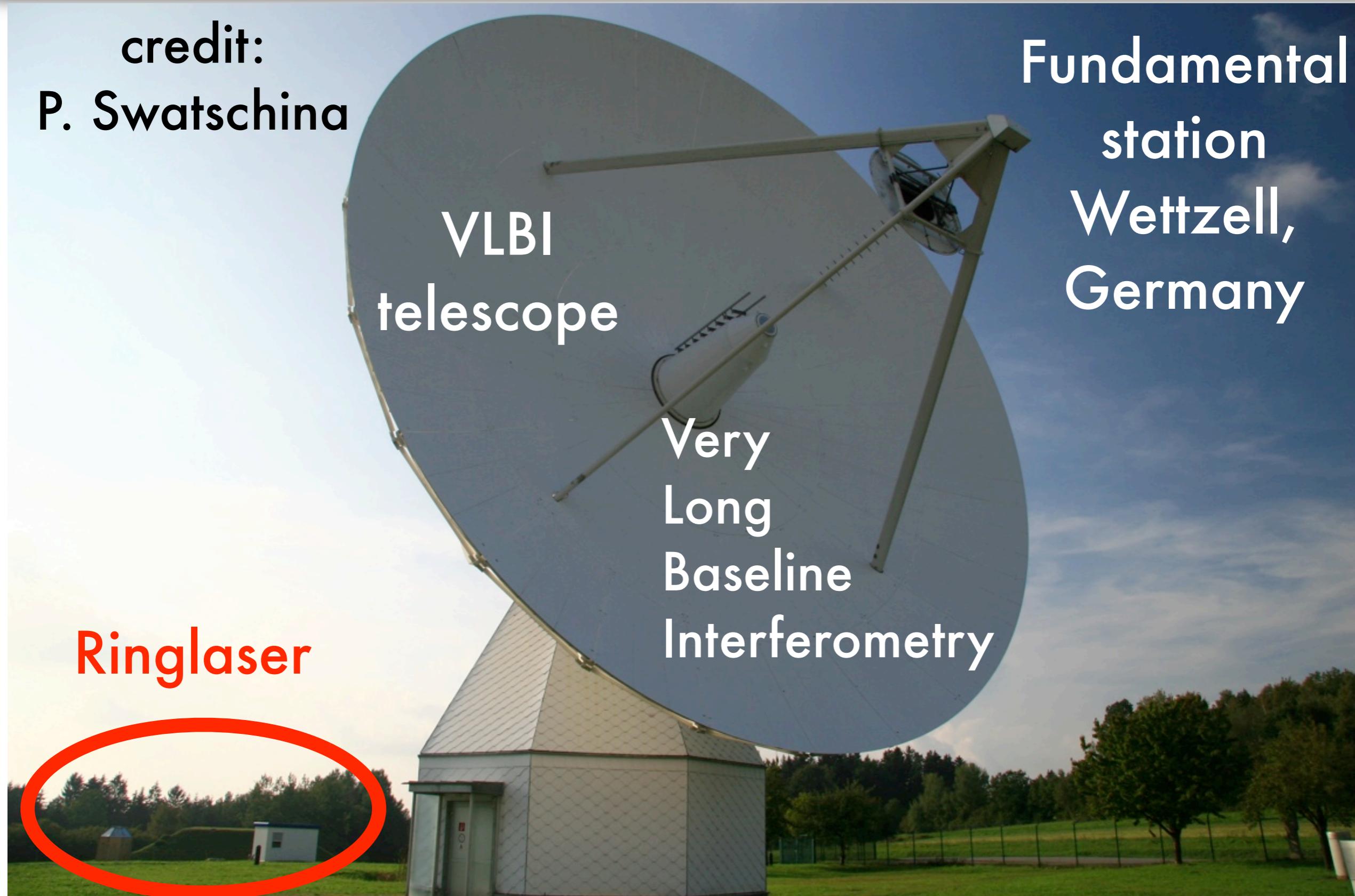
- **Polar Motion (PM)**
- **Nutation**

Periods (sidereal) w.r.t.
Terrestrial Reference Frame

Wettzell: VLBI & Ringlaser

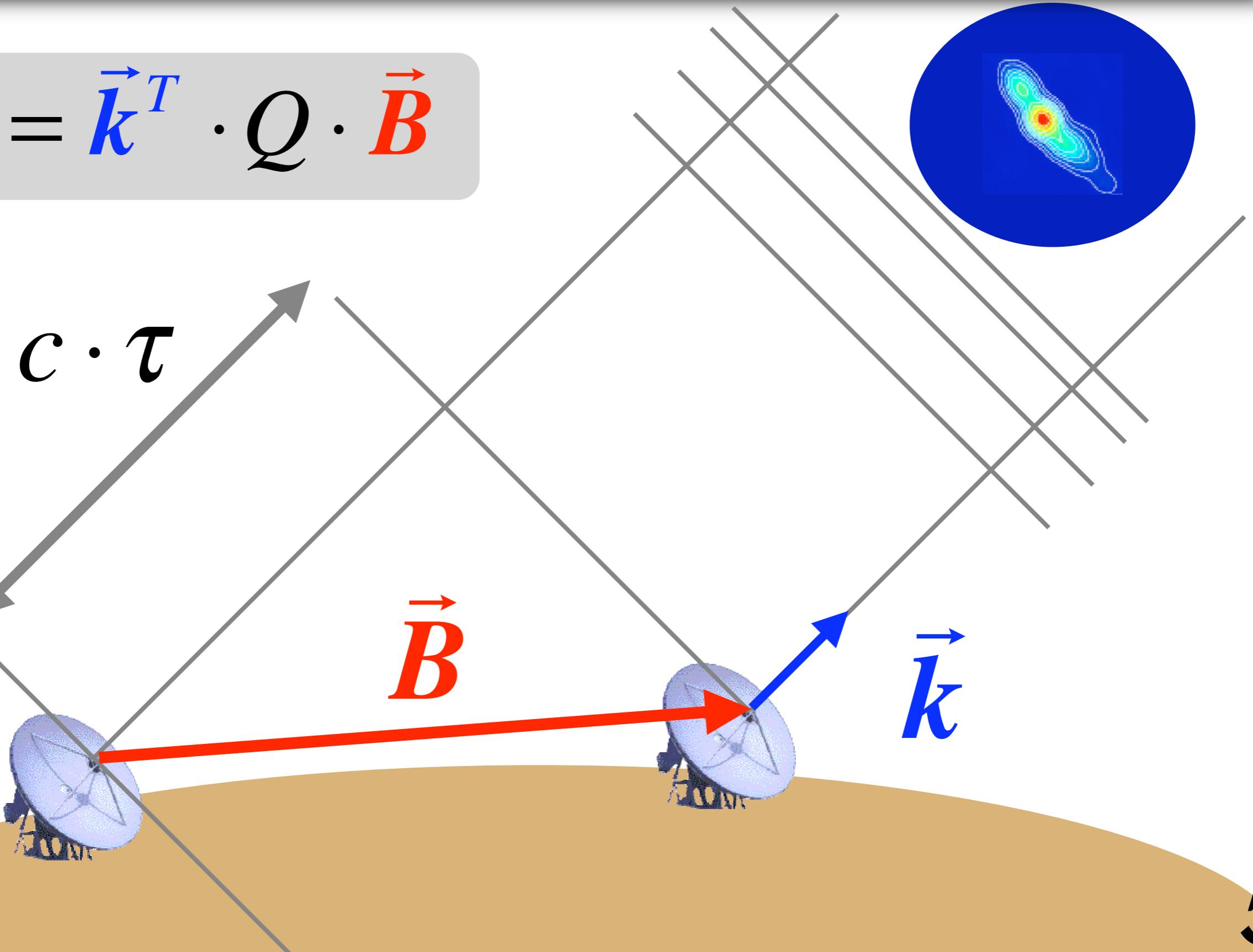
credit:
P. Swatschina

Fundamental
station
Wettzell,
Germany



VLBI: observable

$$c \cdot \tau = \vec{k}^T \cdot Q \cdot \vec{B}$$



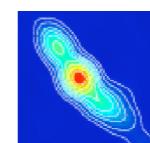
VLBI: observable

$$c \cdot \tau = \vec{k}^T \cdot Q \cdot \vec{B}$$

CRF Celestial Reference Frame
TRF Terrestrial Reference Frame

c speed of light in vacuum

τ time delay

\vec{k} unit vector of quasar in CRF 

\vec{B} baseline vector of stations in TRF 

Q transformation matrix TRF to CRF

VLBI: transformation matrix

predictable?: 300 μ as

$$Q = P \cdot N(\Delta\psi, \Delta\varepsilon) \cdot R_3(\theta) \cdot R_1(y) \cdot R_2(x)$$

precession

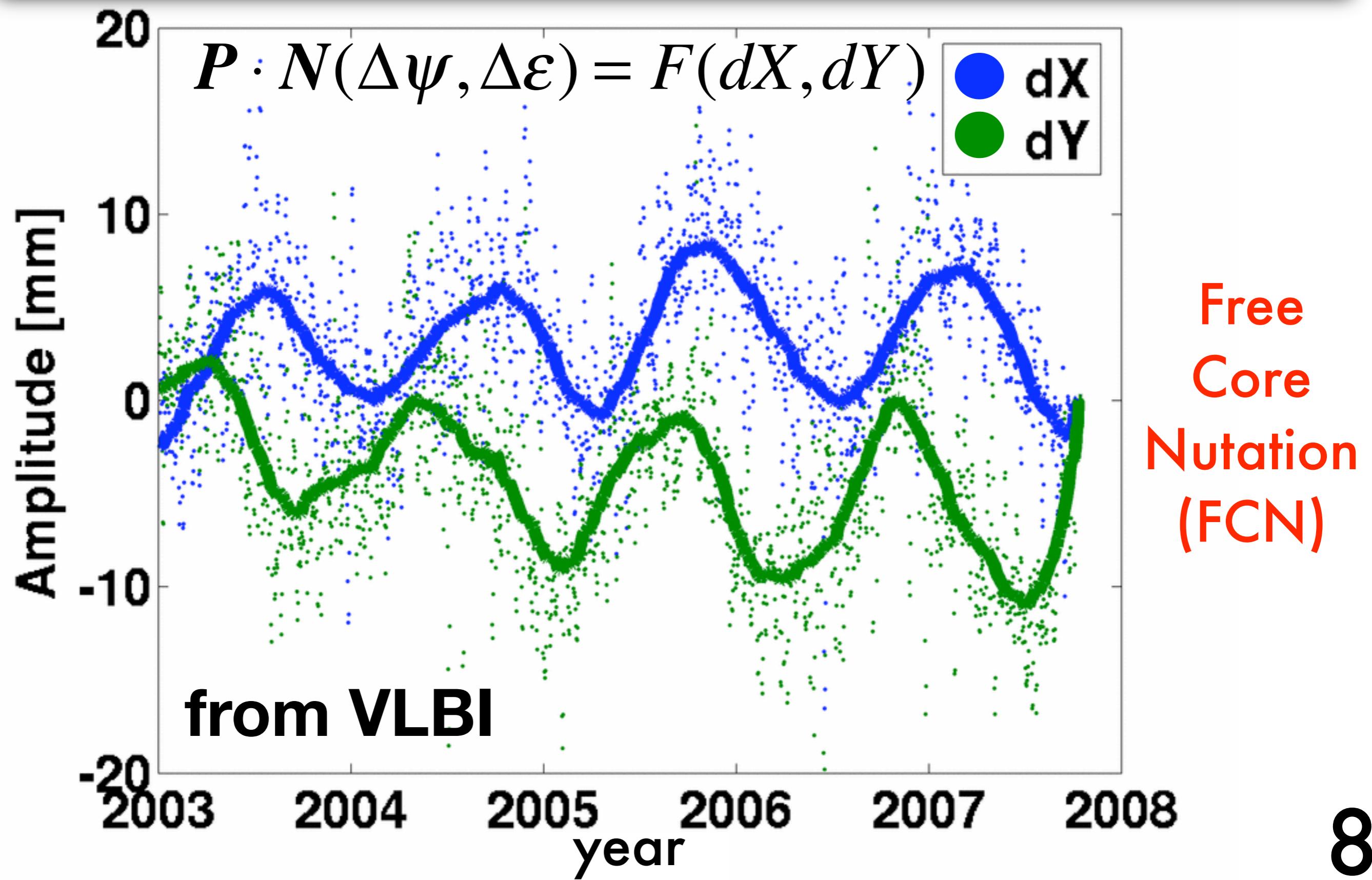
nutation

sidereal time

function of
universal time

geodetic
polar motion

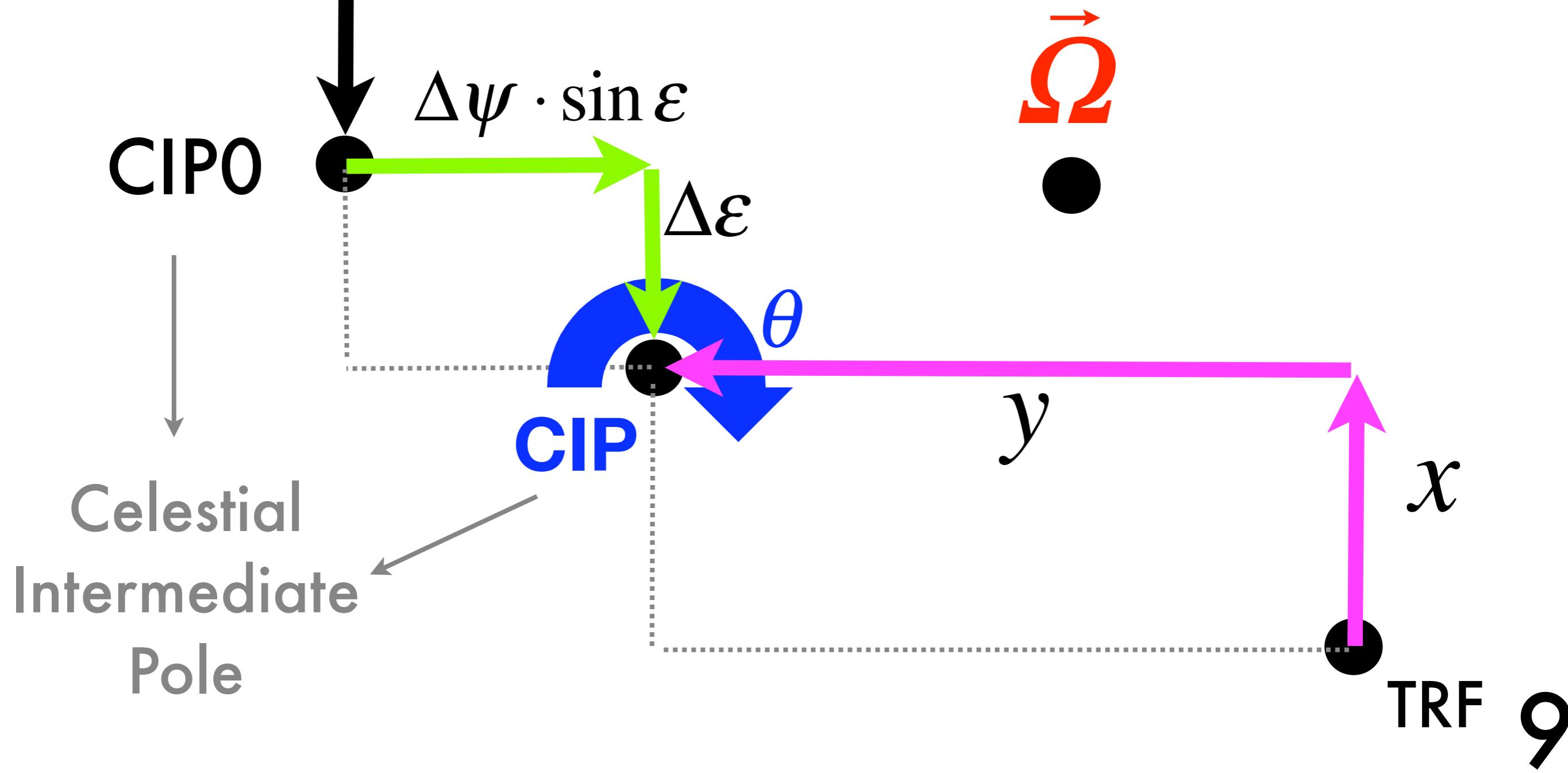
Nutation: residuals w.r.t MHB2000



VLBI: reference poles

CRF
CIPO

where is the Earth rotation
vector w.r.t TRF?



Earth rotation vector from VLBI

$$Q^T \cdot \dot{Q} = \begin{pmatrix} 0 & \Omega_3 & -\Omega_2 \\ -\Omega_3 & 0 & \Omega_1 \\ \Omega_2 & -\Omega_1 & 0 \end{pmatrix}$$

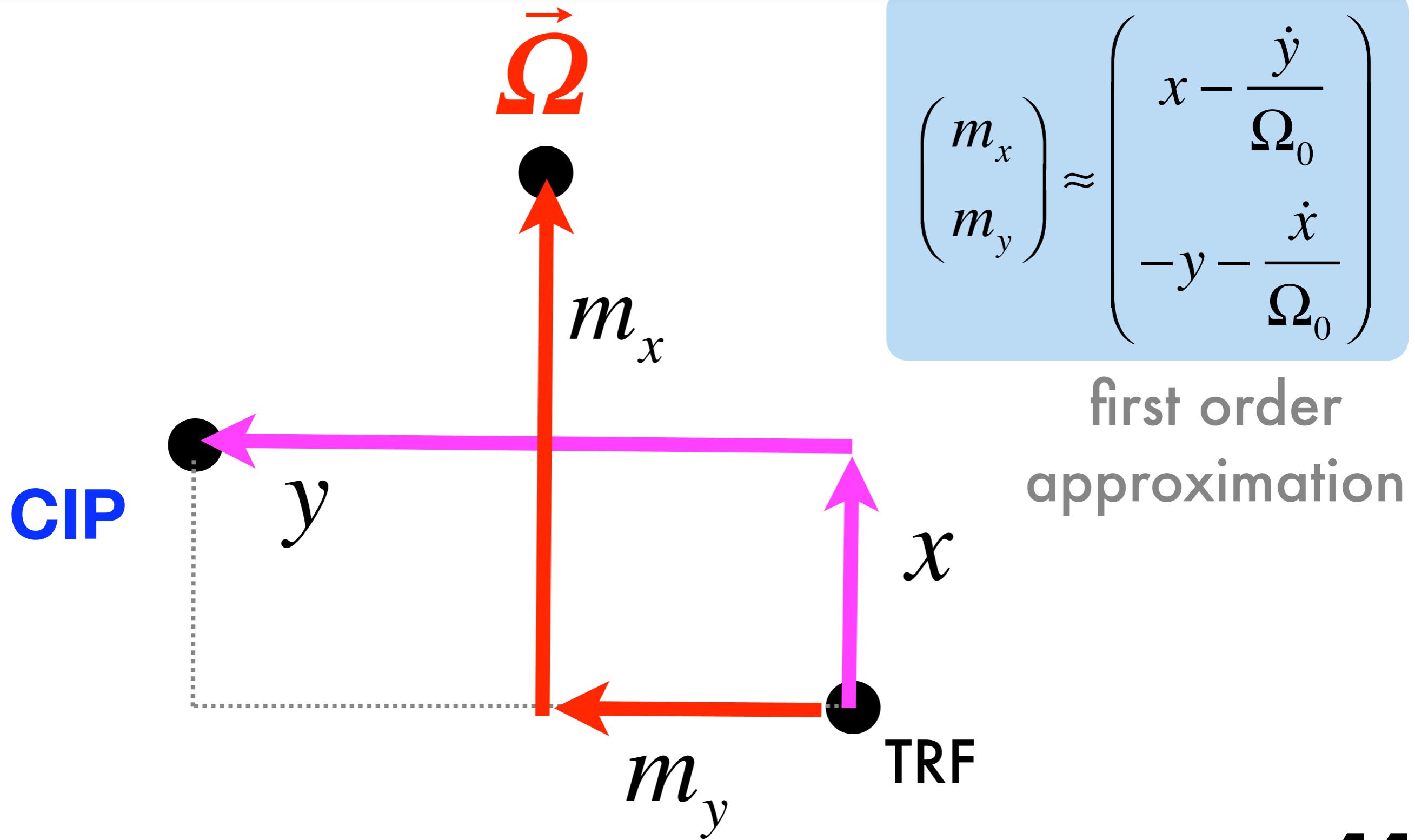
Earth
rotation
tensor
w.r.t
TRF

to first order approximation

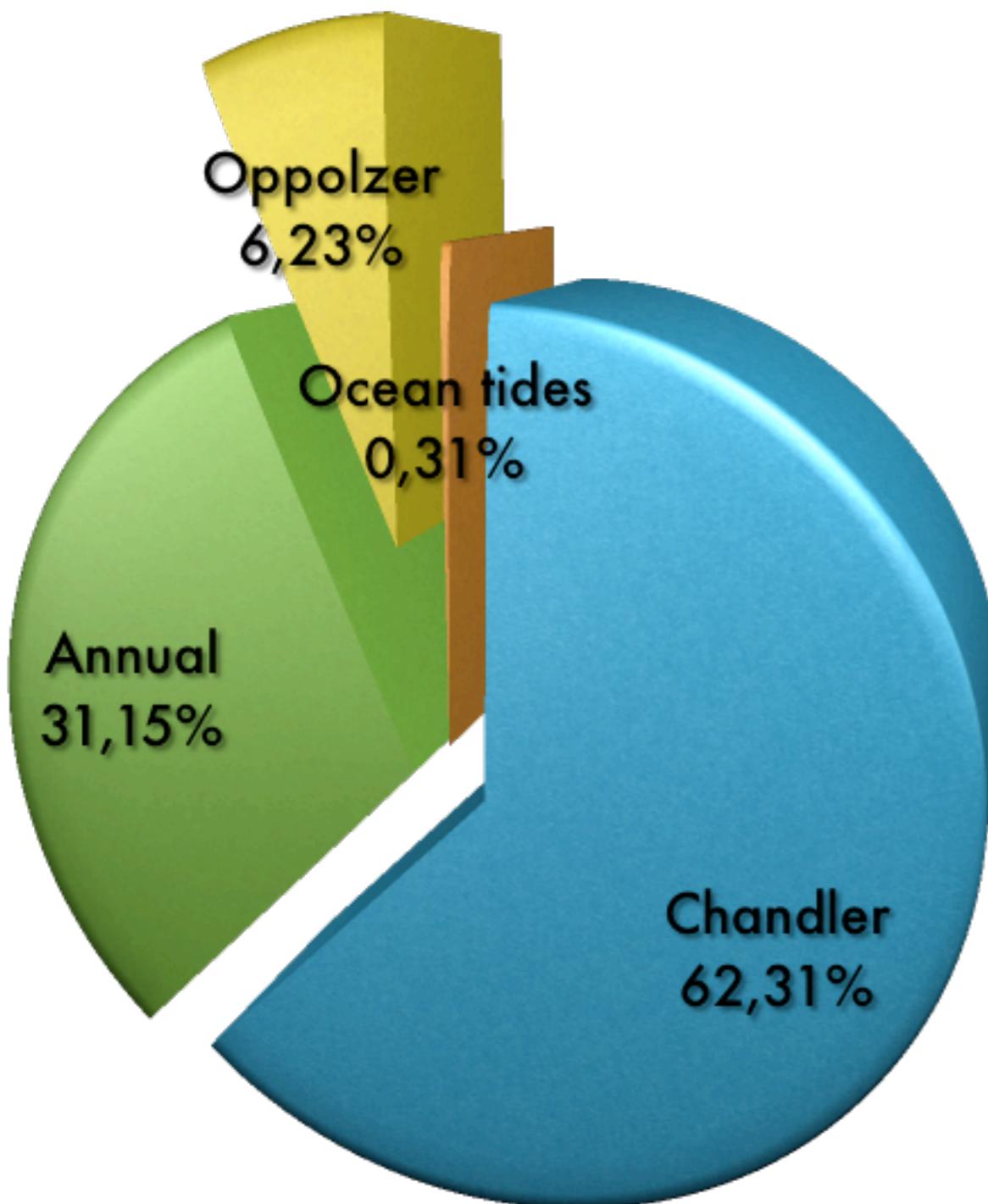
$$\vec{\dot{\Omega}} = \begin{pmatrix} \Omega_1 \\ \Omega_2 \\ \Omega_3 \end{pmatrix} = \begin{pmatrix} \Omega_0 \cdot x - \dot{y} \\ -\Omega_0 \cdot y - \dot{x} \\ \Omega_0 \cdot [1 + z] \end{pmatrix}$$

$$\theta = \int \Omega_0 \cdot [1 + z] dt$$

Geodetic vs. geophysical PM

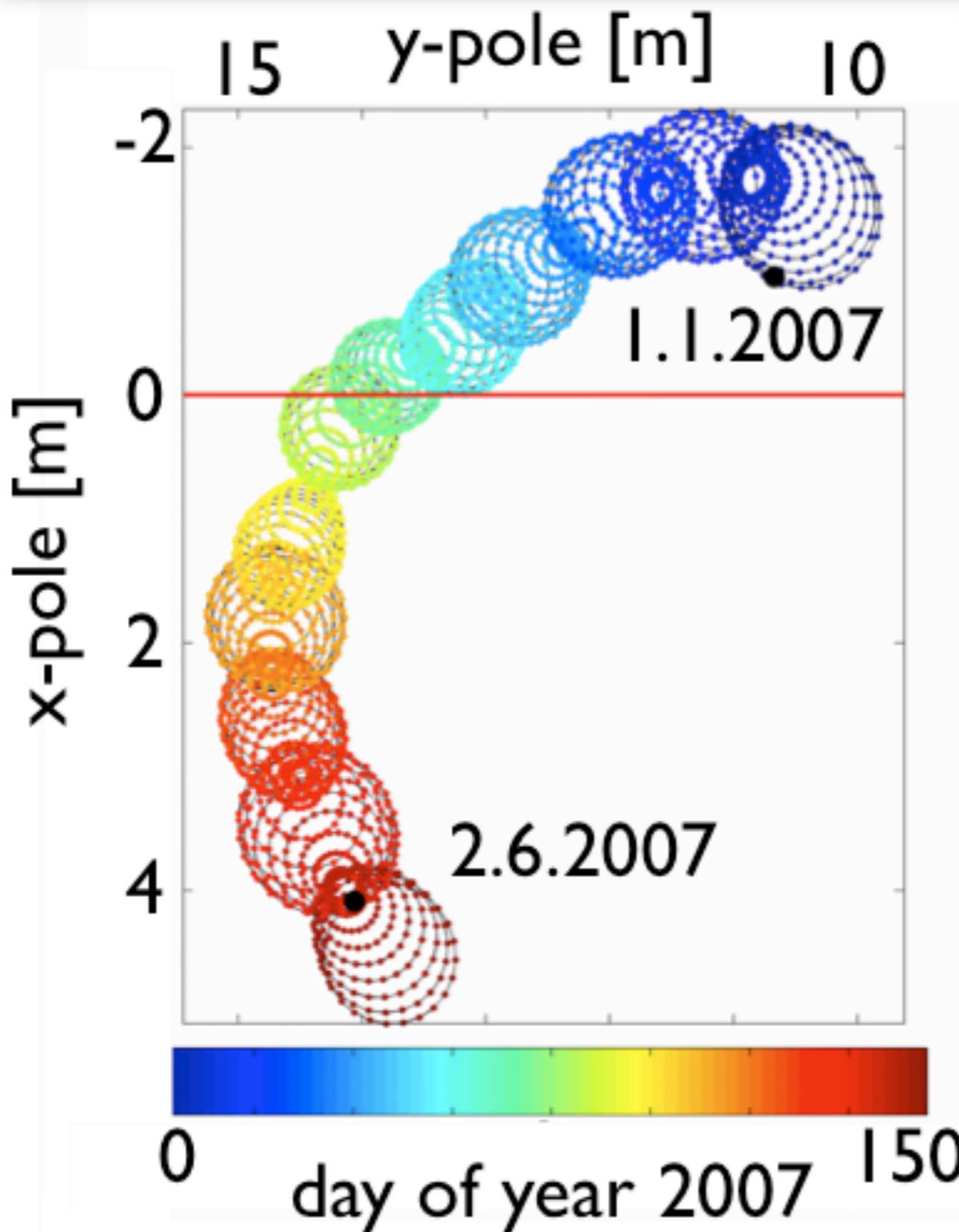


Composition of polar motion



Amplitude	
Chandler	600 cm
Annual	300 cm
Oppolzer	60 cm
Ocean tides	3 cm

Polar motion (incl. Oppolzer)



diurnal retrograde motion (Oppolzer)

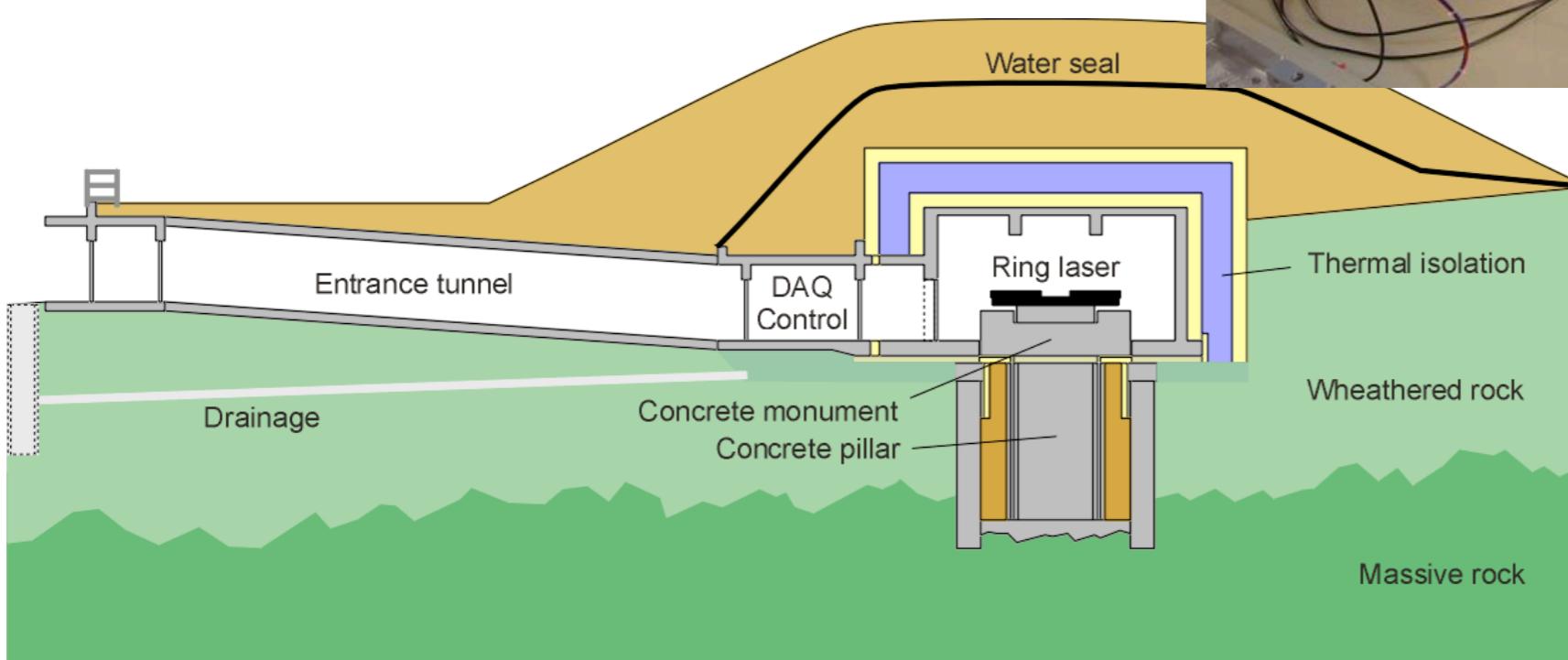
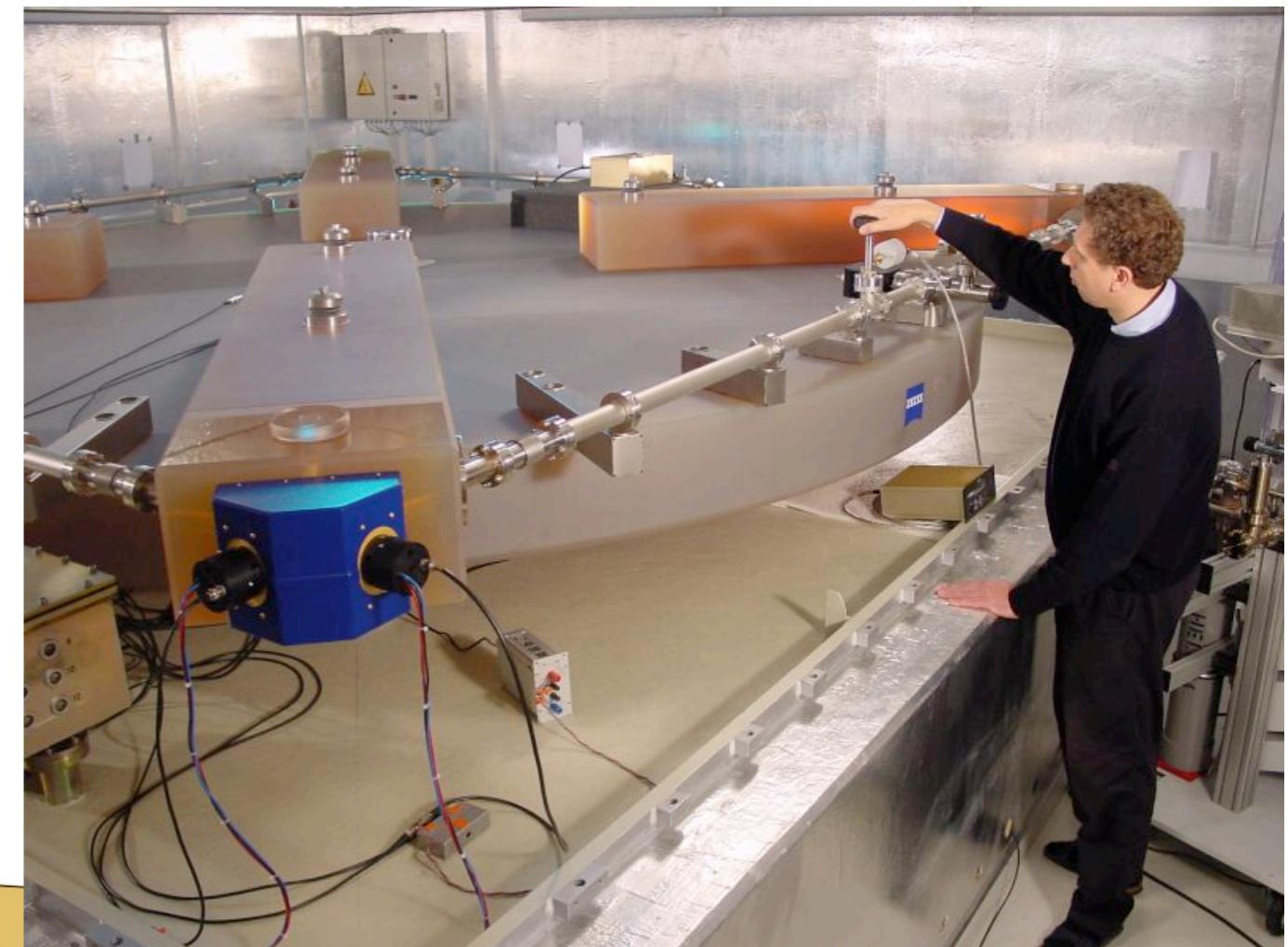
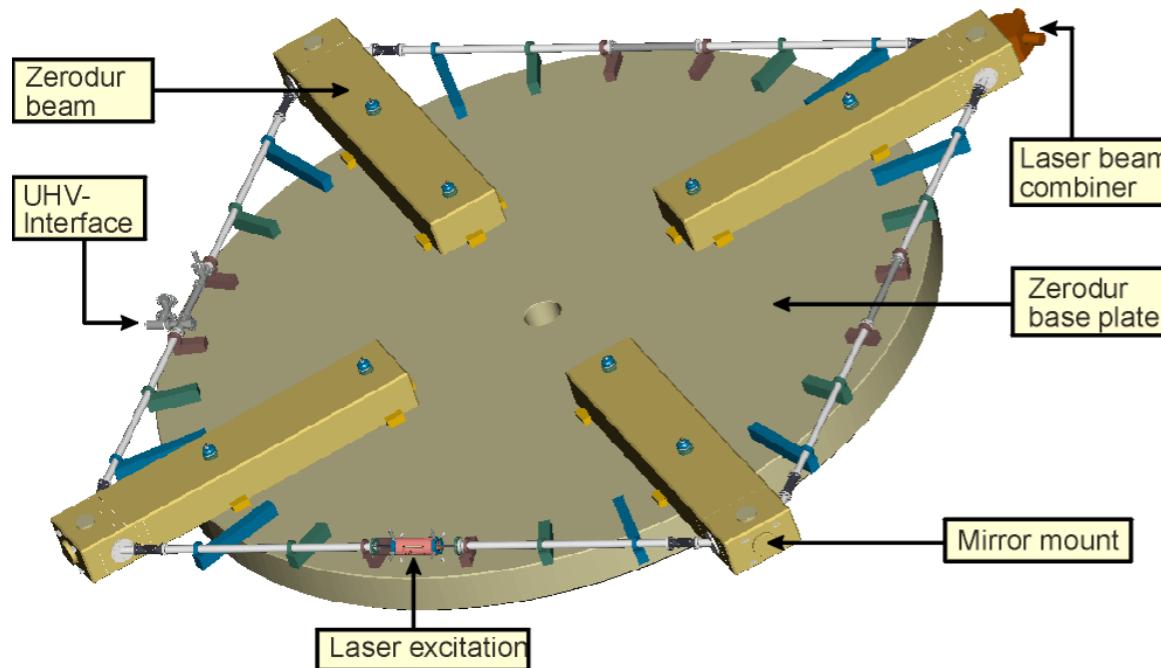


170 amplitudes for an elastic Earth with liquid core by Brzezinski (1986)

Contribution to the theory of polar motion for an elastic earth with liquid core, *manuscripta geodaetica*, Vol. 11, pp. 226-241.

without effect
of ocean tides

Ringlaser Wettzell, Germany



Sagnac frequency variation

$$\delta f(t) = \frac{4 \cdot A}{\lambda_s \cdot P} \vec{n}^T(t) \cdot \vec{\Omega}(t)$$

$\delta f(t)$ Sagnac frequency variation

λ_s optical wavelength

A area

P perimeter

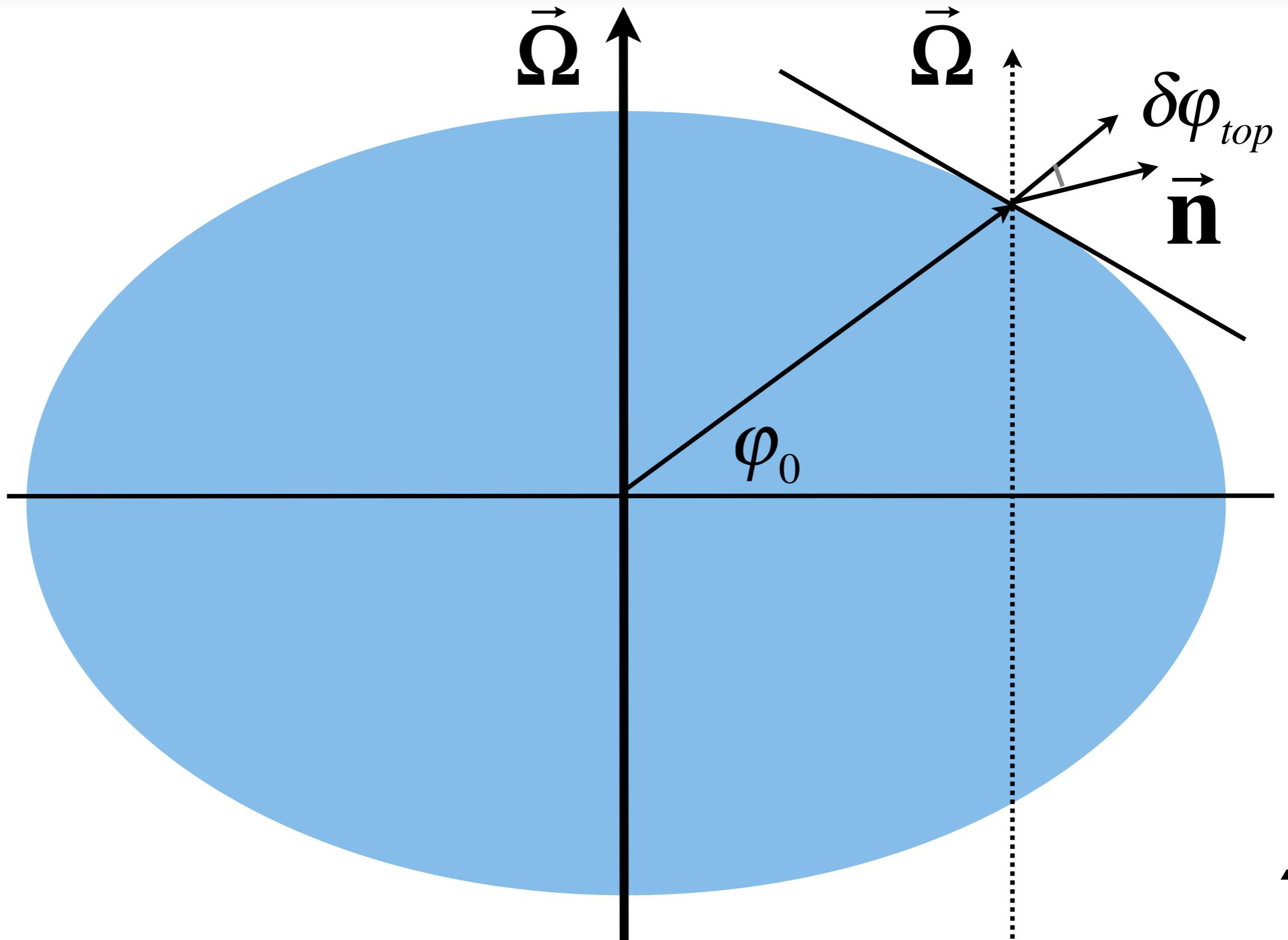
\vec{n} normal to plane

$\vec{\Omega}$ Earth rotation vector

nominal
angular speed

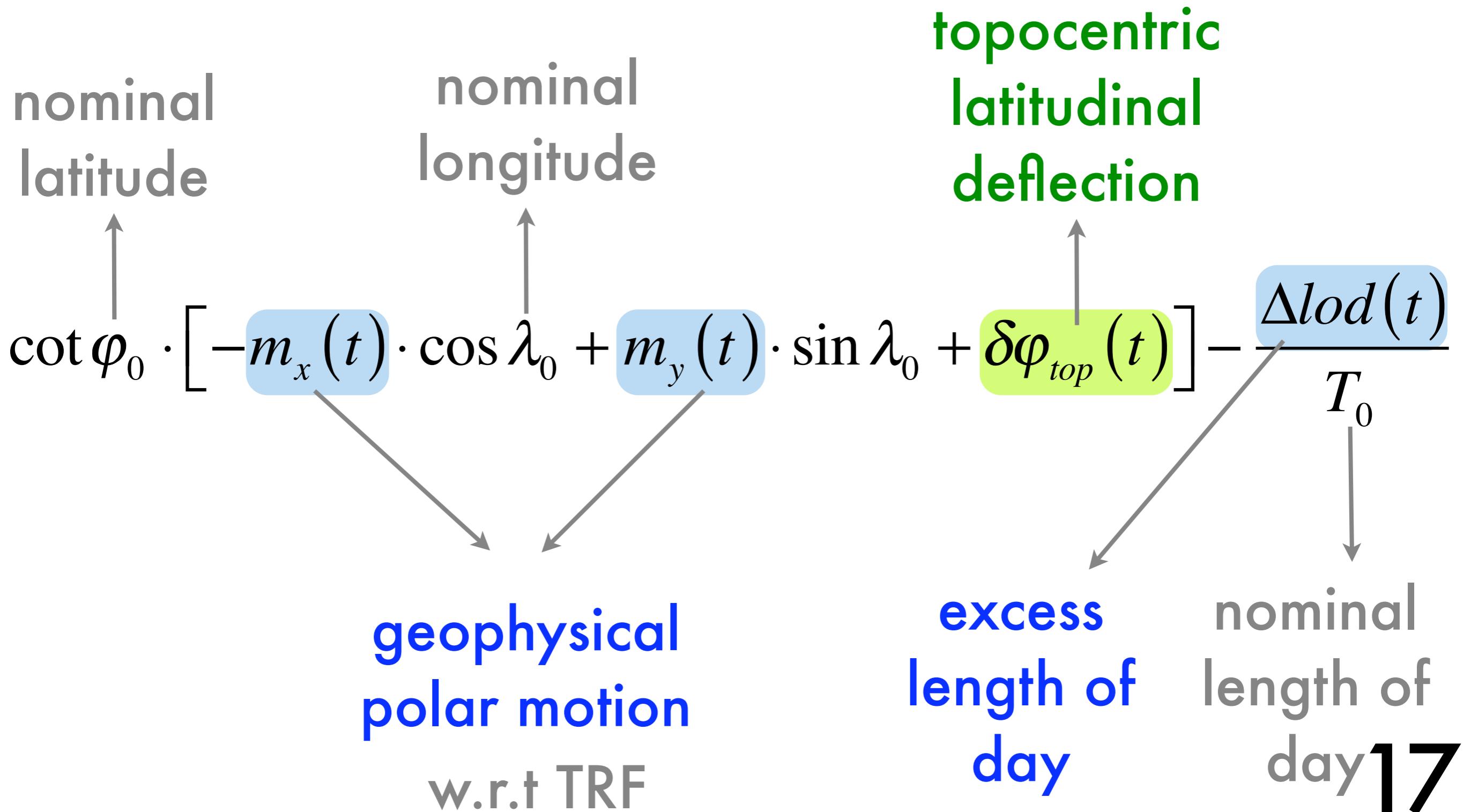
$$\vec{\Omega}(t) = \begin{pmatrix} -\Omega_0 \cdot m_x(t) \\ \Omega_0 \cdot m_y(t) \\ \Omega_0 + \delta\Omega \end{pmatrix}$$

Latitudinal deflection

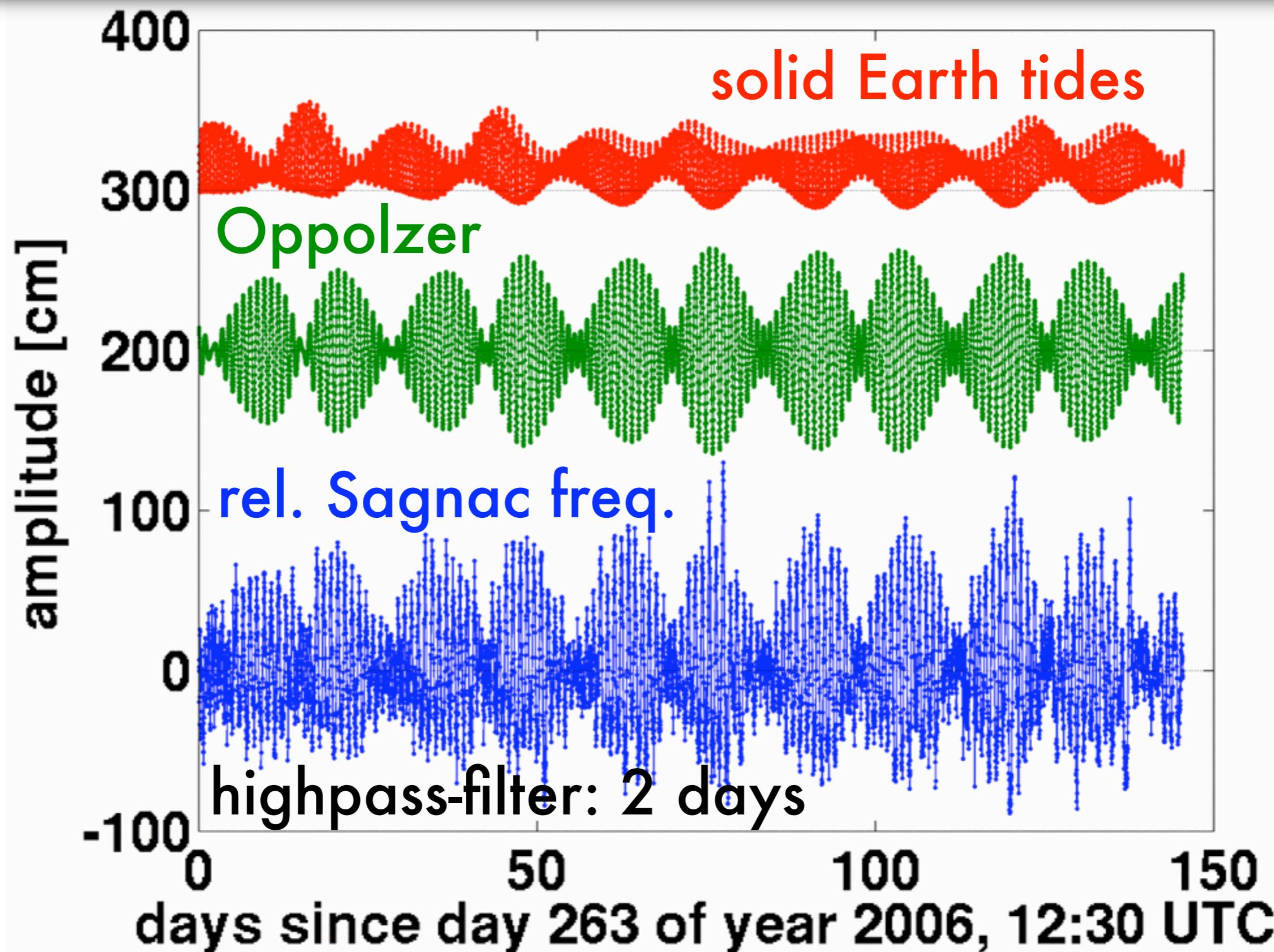


Rel. Sagnac frequency variation

What does the ringlaser “see”?

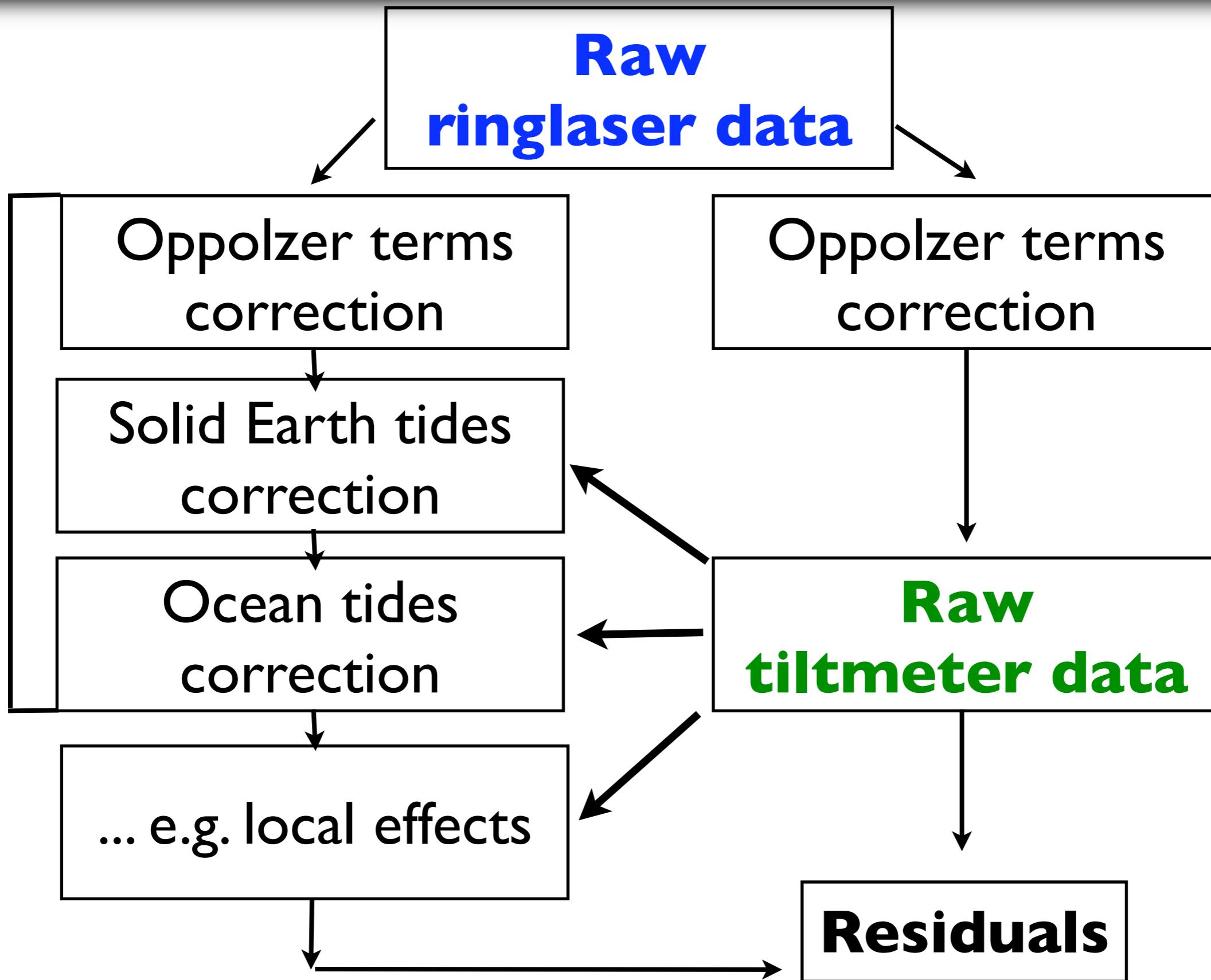


Rel. Sagnac frequency variation



Ringlaser: processing strategies

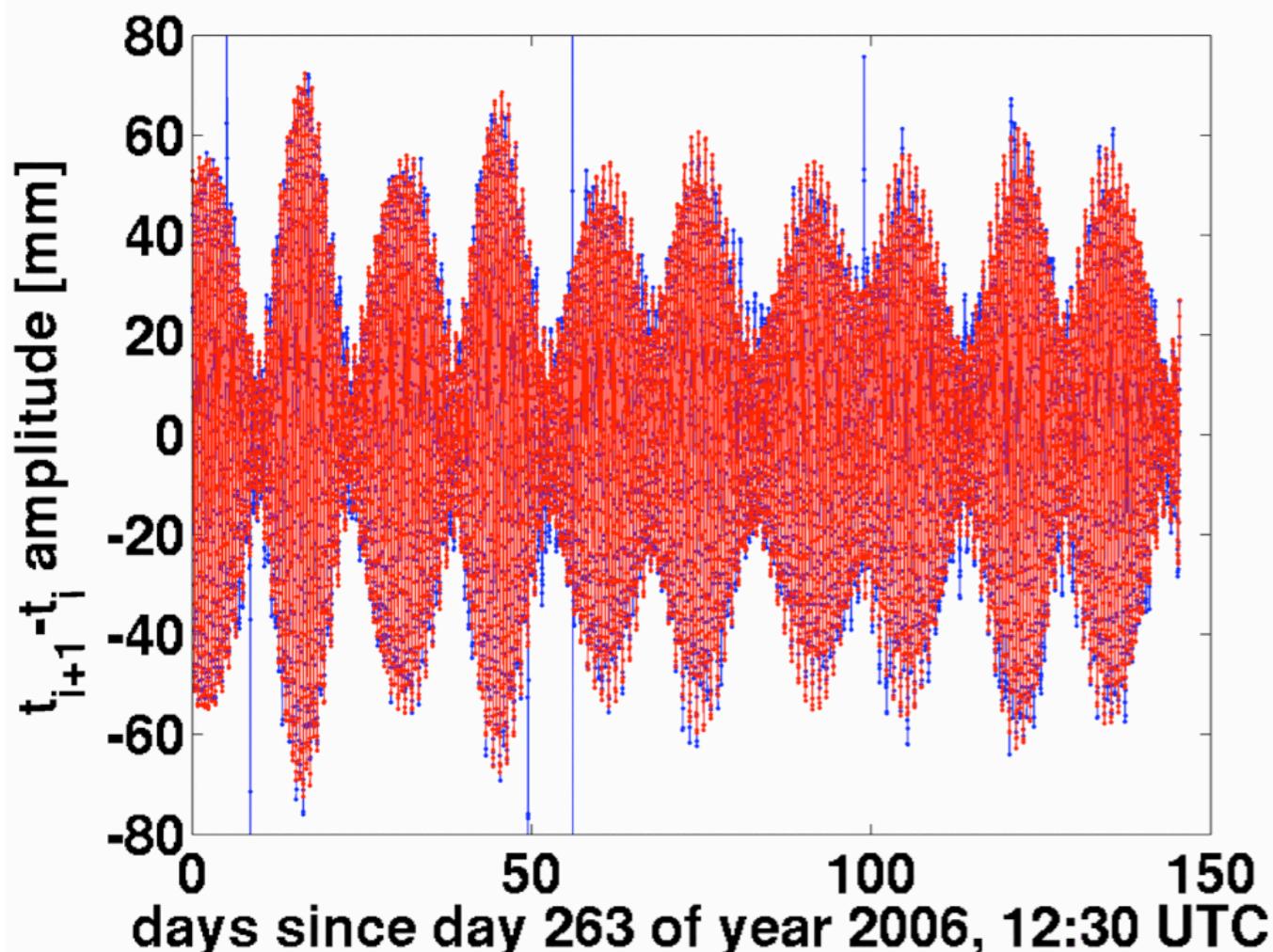
models



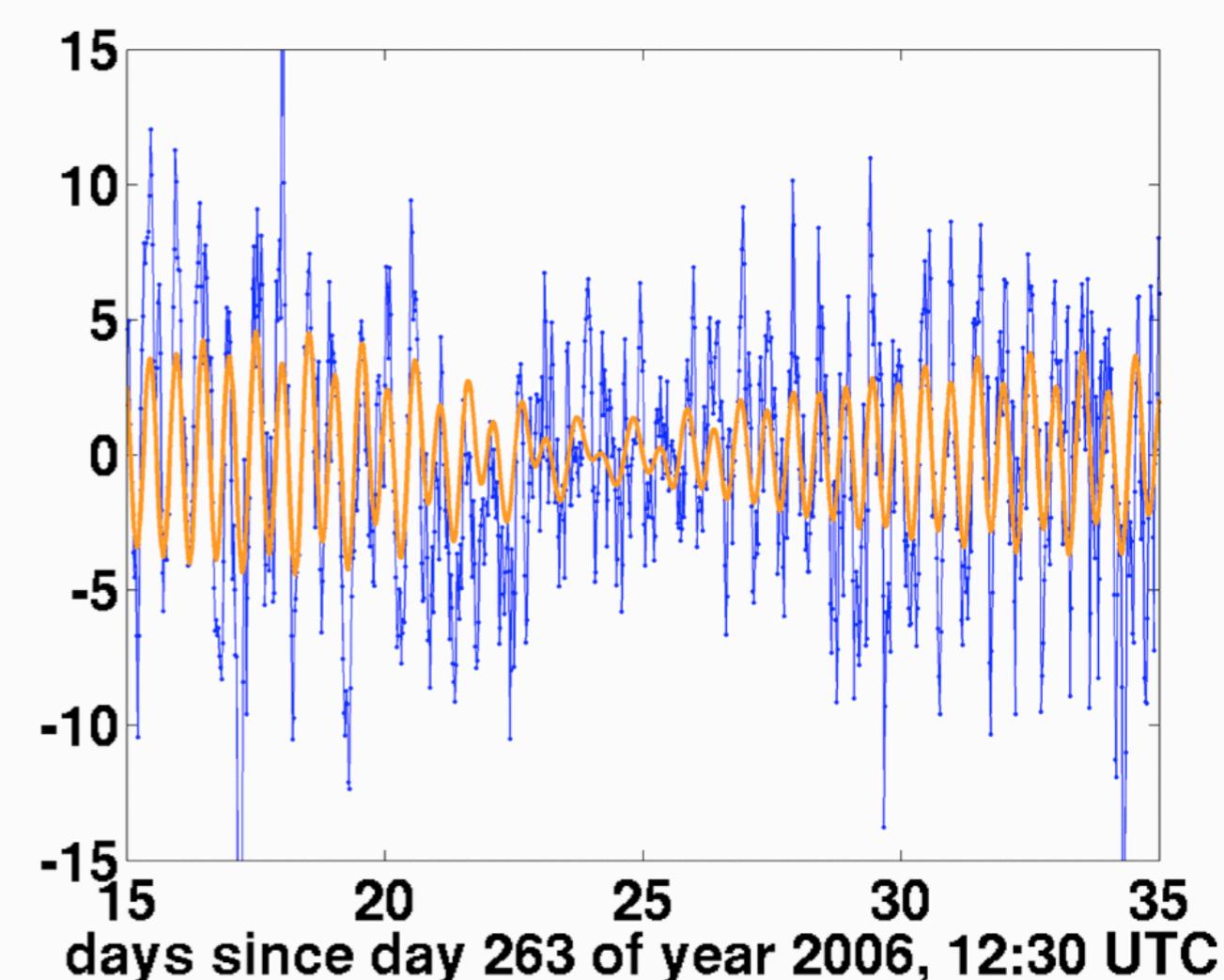
Tiltmeter

What does the tiltmeter “see”?

solid Earth tides
(Mathews)



ocean tides
(i.e. polar tides)



Conclusions 1

- VLBI and ringlaser technology are complete and complementary techniques
- Both techniques used jointly are, in principle, able to distinguish and recover the physics of phenomena contributing to nutation and polar motion variations
- No conventions (nutation vs. polar motion) would be required anymore

Conclusions and Outlook

- Strengths of **ringlaser**: **real-time data acquisition** and sensitive to **Earth rotation vector**, especially useful for **subdiurnal phenomena**
- Strengths of **VLBI**: only technique with such **accurate estimates of daily universal time and nutation parameters**
- VLBI2010 system**: **more precise and accurate Earth rotation parameters**
- Ringlaser network** would be a **breakthrough** in Earth rotation science



Merci

mendes@mars.hg.tuwien.ac.at