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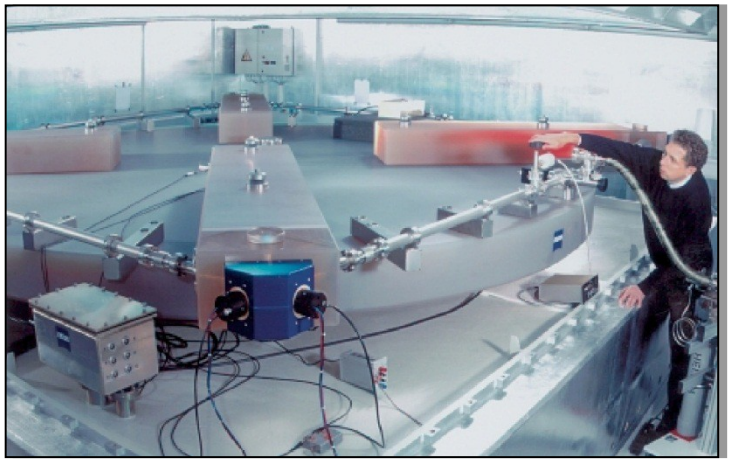

The ROMY project:

Towards stable broadband observations of rotational motions

… from seismology to cosmology …

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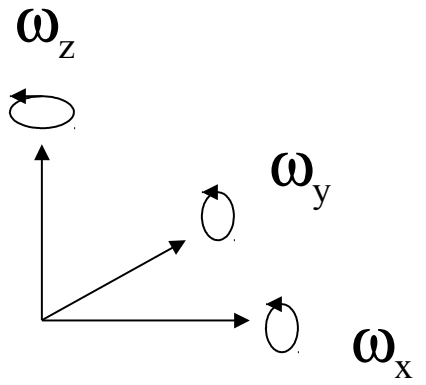
Some premises

- The measurement of the complete ground motion is an unsolved problem
- Pure tilt (horizontal components of rotation) has never been observed in the broad seismological frequency band
- There is no appropriate (portable, weak motion) rotation sensor for seismology today
- Collocated >3C observations have a lot of potential for seismic inverse problems

ROtational Motions: a new observable for seismologY

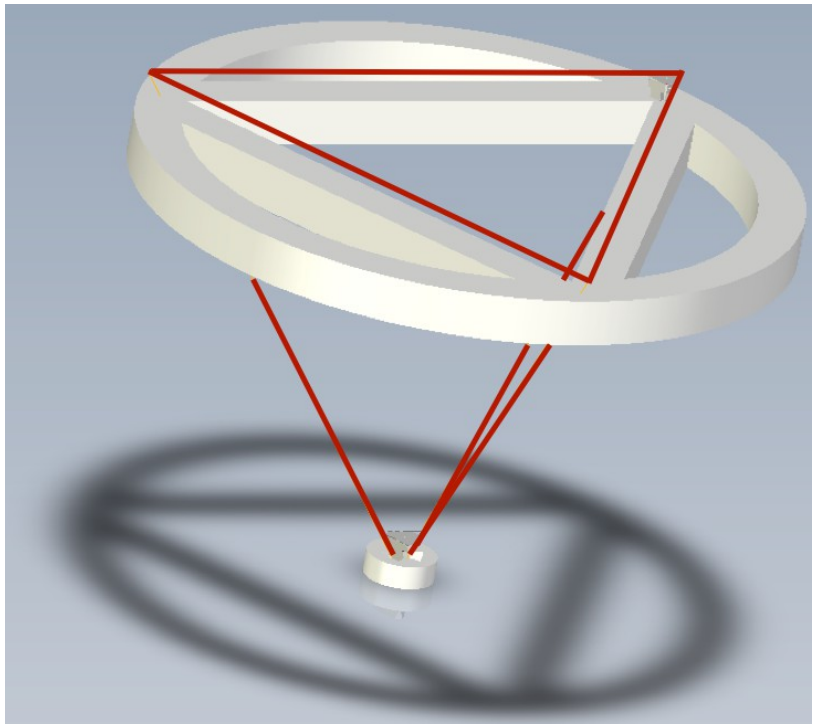
- Progress in all aspects of rotational seismology
- Application domains
  - Instrumentation
    - Ring laser
    - Fibre-optic gyros
    - OBS
  - **Seismotectonics (source inversion)**
  - Seismic tomography (joint observables)
  - **Ambient noise studies**
  - Earthquake engineering
  - Long-period seismology
  - Volcanology
  - Exploration seismics
  - Geodesy and fundamental physics



ROMY – Observational strategy

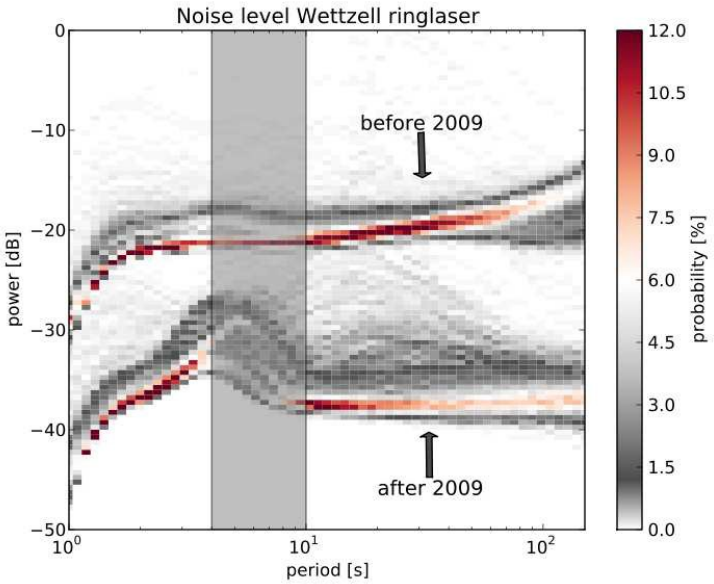
4C ring laser

- 4C tetrahedral shaped ring laser
- Side length 12m
- Installation in the Geophysical Observatory Fürstenfeldbruck
- Subsurface installation (minimal invasion)
- Target sensitivity 10^{-12} rad/s
- Embedded in 3D seismic array (min. 9 stations)



Objectives – 4C ring laser

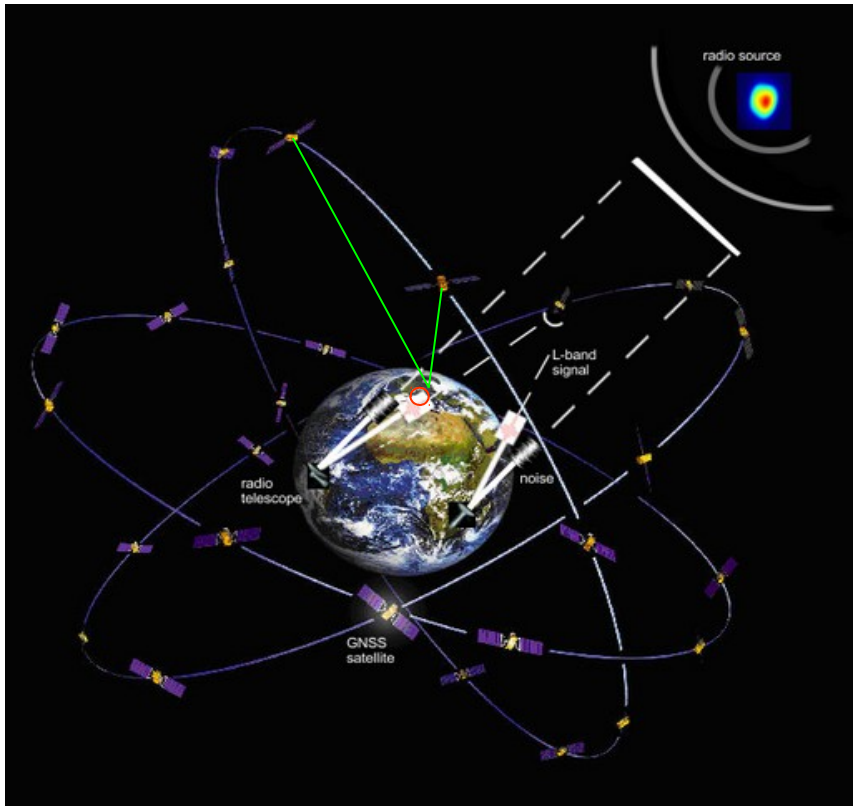
- High resolution measurements of broadband rotational ground motions (i.e., tilt – rate) for the first time
- Cross-validation of observations with 3D array and Wettzell ring laser (1C)
- Cross-correlation analysis of rotational motions (WET-FUR)
- Free-oscillations and hum on all components?
- **High-resolution observations of Earth‘s rotation vector - geodesy**
- Cosmological applications (Lense-Thirring effect)



(How) does the Earth rotate?

Reference frames for GPS

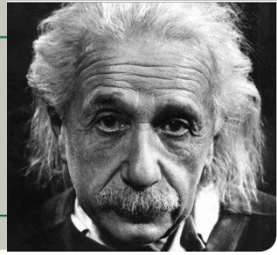
- GPS: “see” only center of gravity (SLR link to “Earth”)
- VLBI: connected to stellar sources
- Ring laser: connected to inertial frame -> complementary technique to VLBI



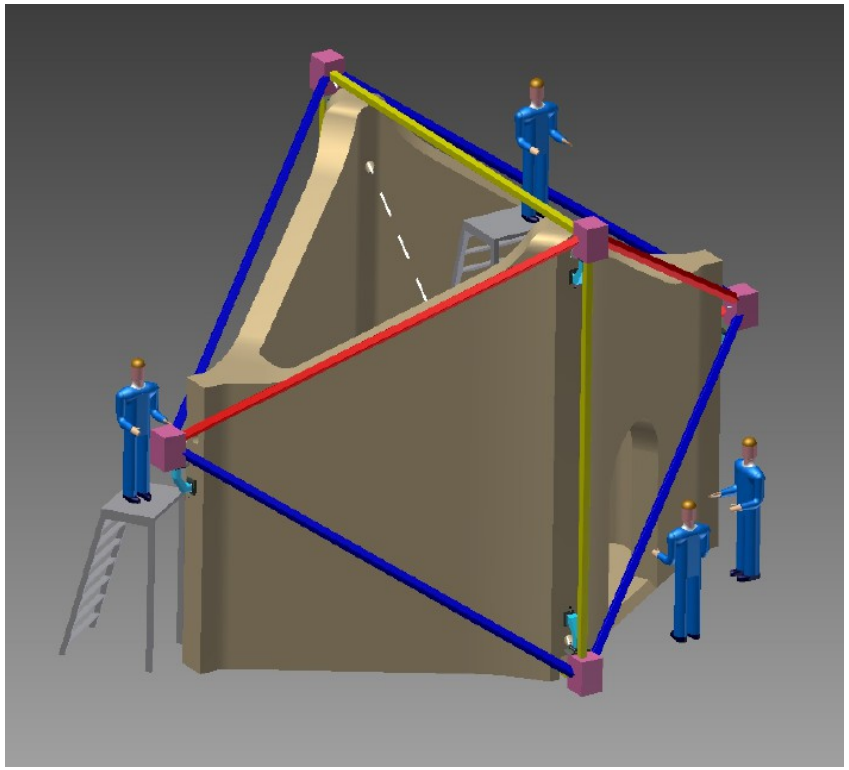
Advantages ring laser:

- Independent from stellar source, other telescopes, atmosphere, clocks, …
- Continuous operation
- Cheap in comparison to VLBI-antennas

Lense-Thirring Effect

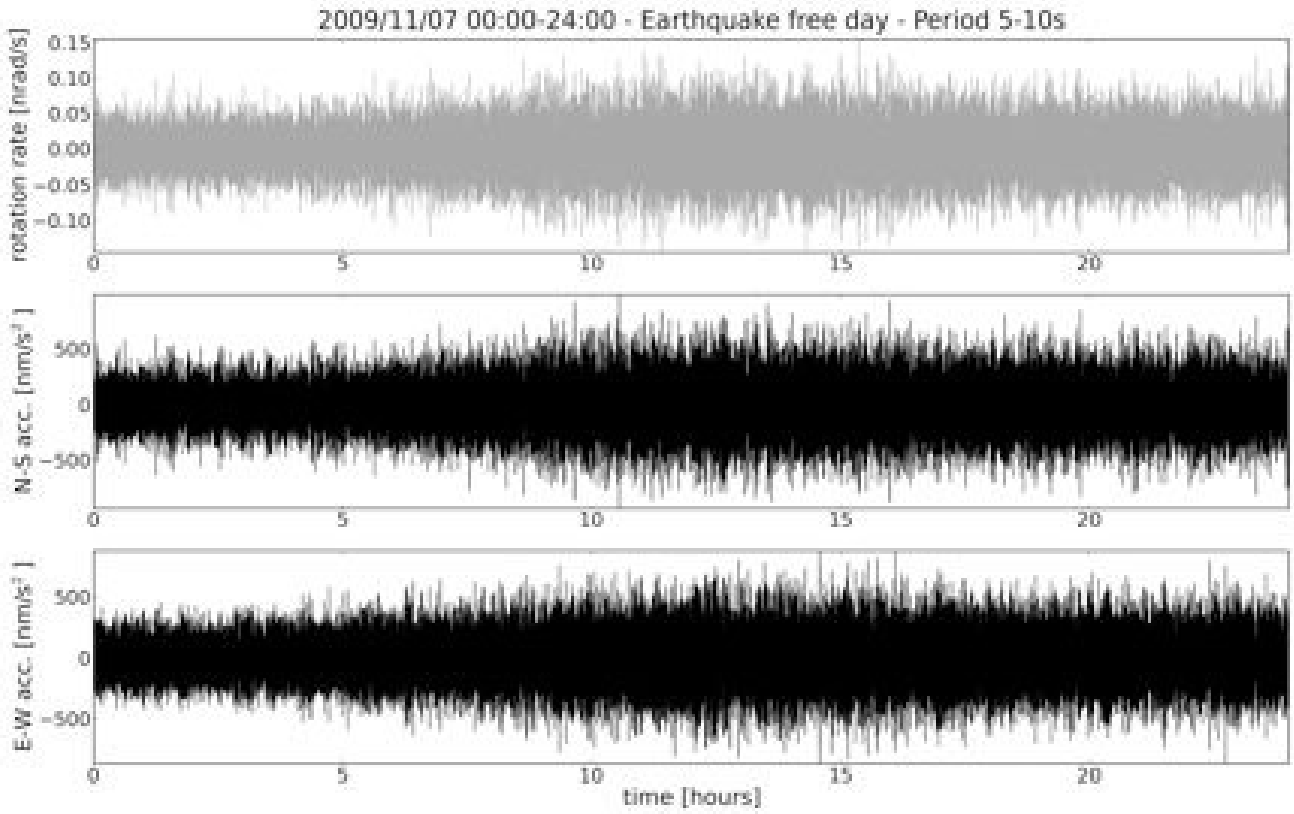


- The LT effect is a corrective term to a gyroscope measurement near a large rotating object (here: Earth)
- Has never been observed by an Earth based observation
- Ring laser is in principle accurate enough to observe the effect (with full vector)
- Long term stability required
- Project planned in Gran Sasso laboratory (Univ Pisa)



Ambient Noise

Observations



Ring laser

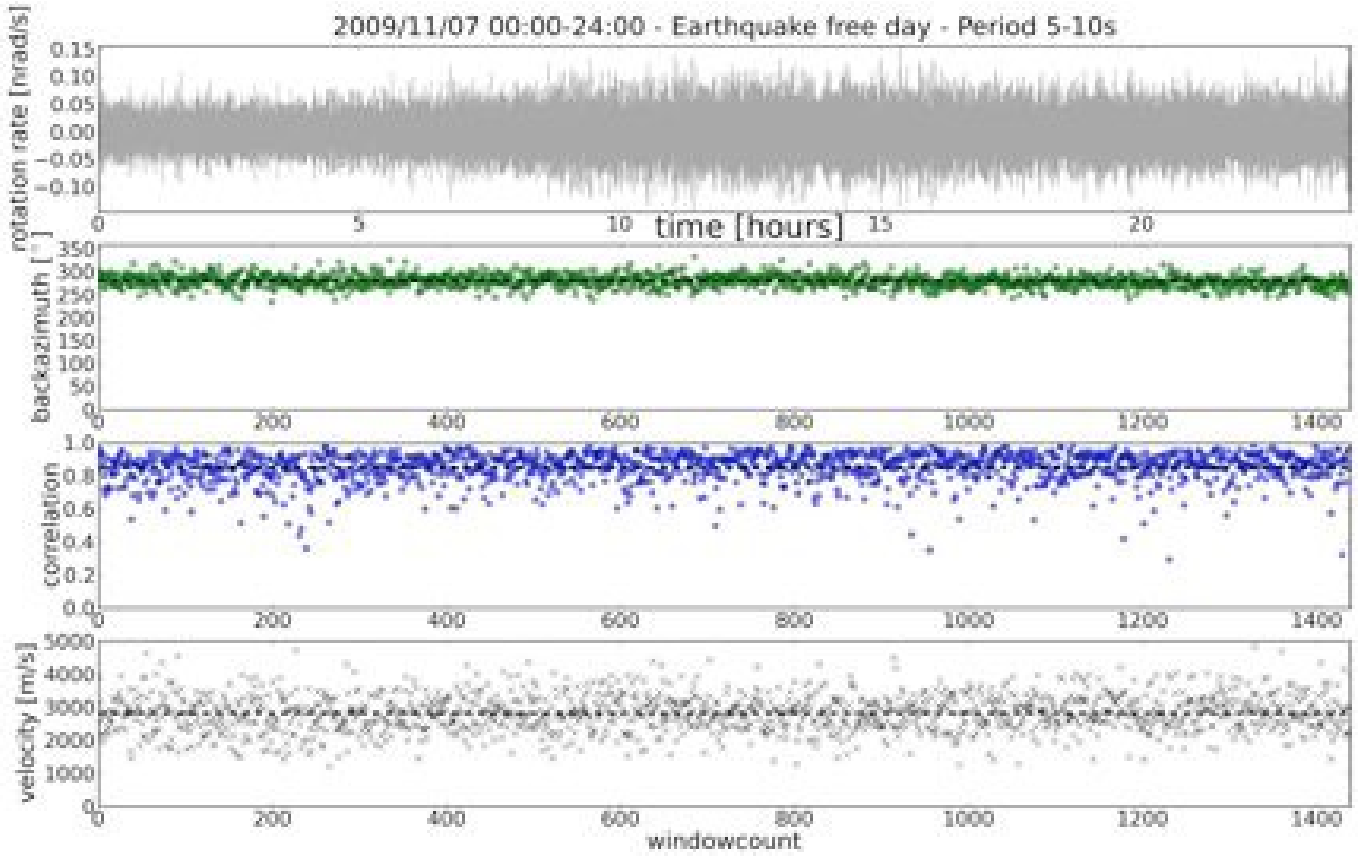
Seismo NS

Seismo EW

Are they systematically related?

Ambient Noise

Observations



Rotation rate

Back azimuth

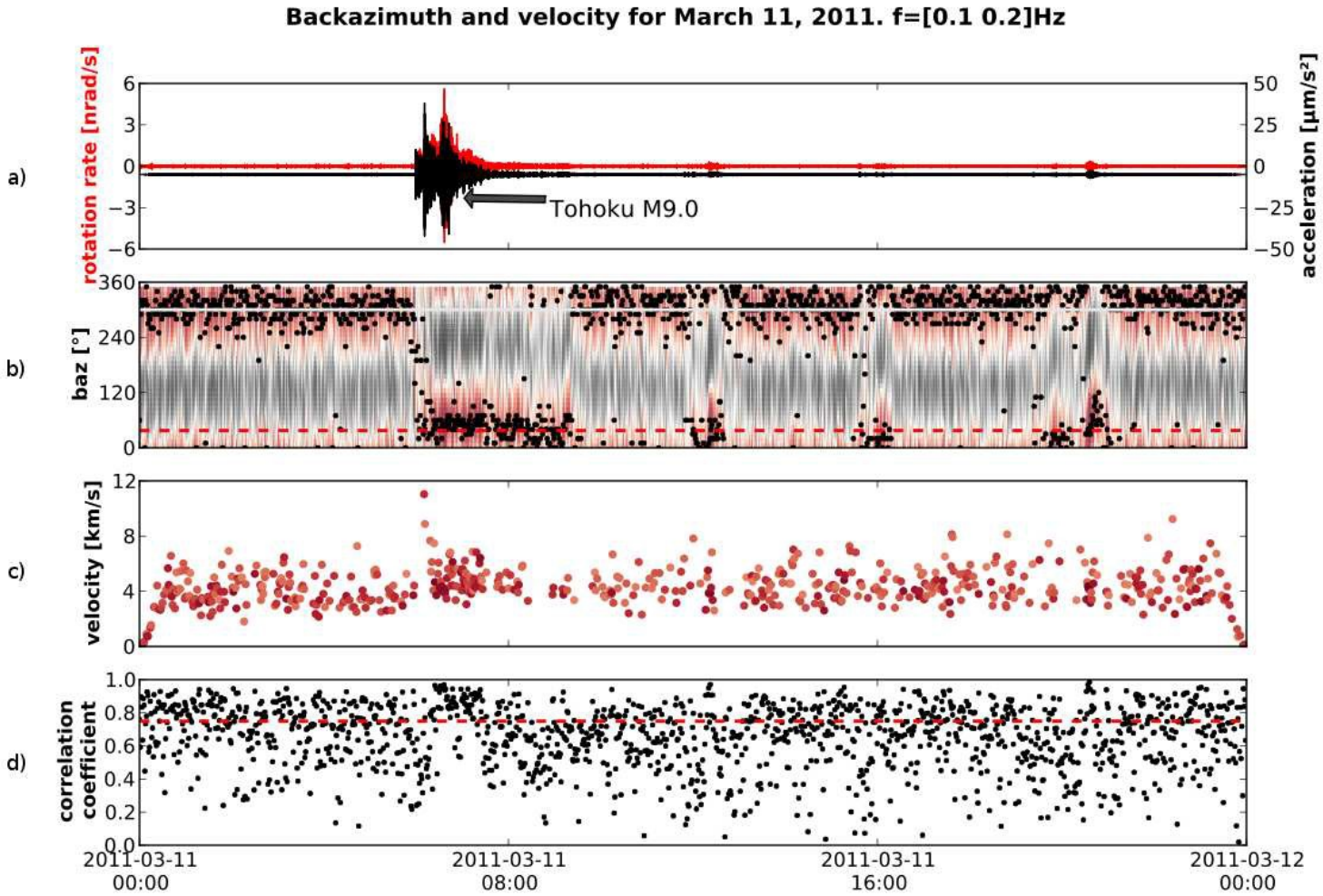
Correlation coefficient

Phase velocity

Total length 24 hours, window length 1 minute

Ambient Noise

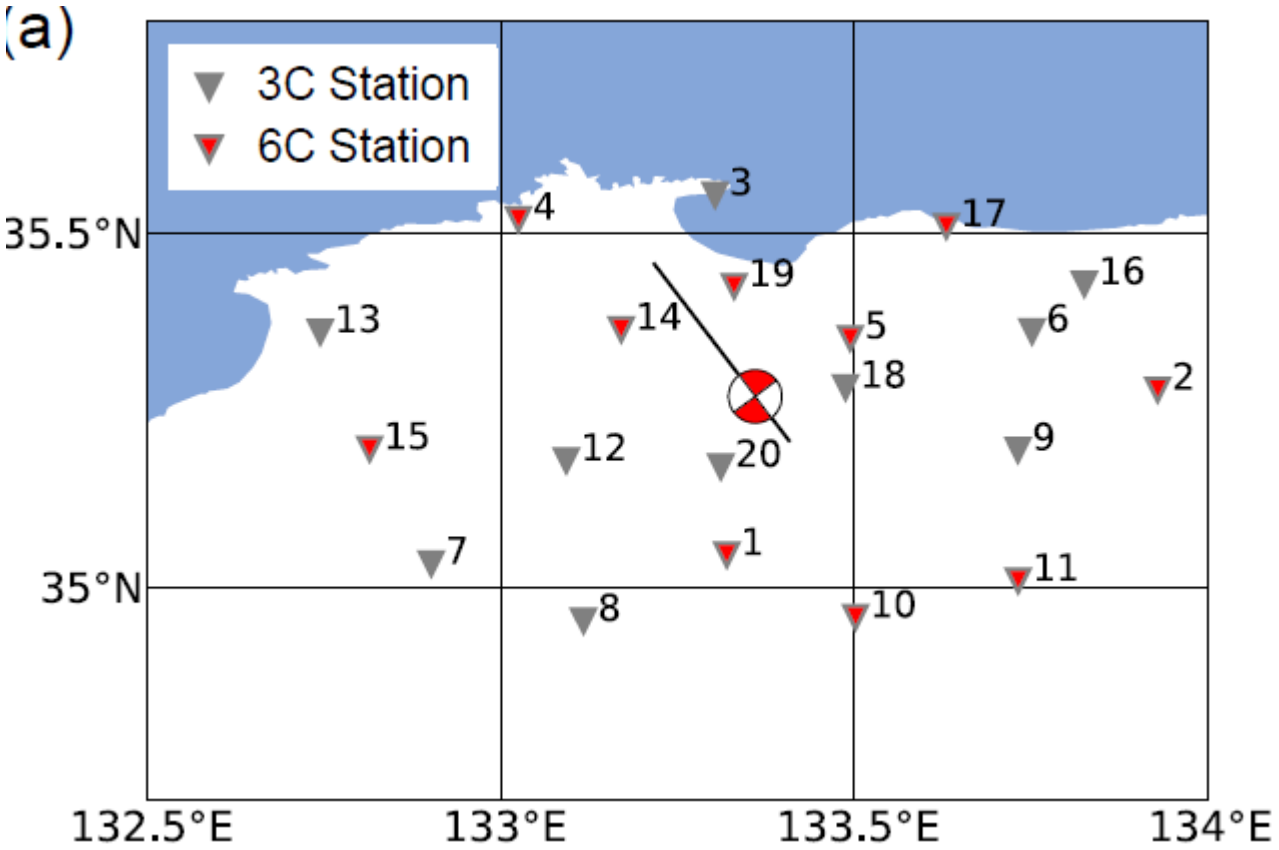
Observations



(From Hadziioannou et al., J. Seis. 2012)

Kinematic source inversion

What

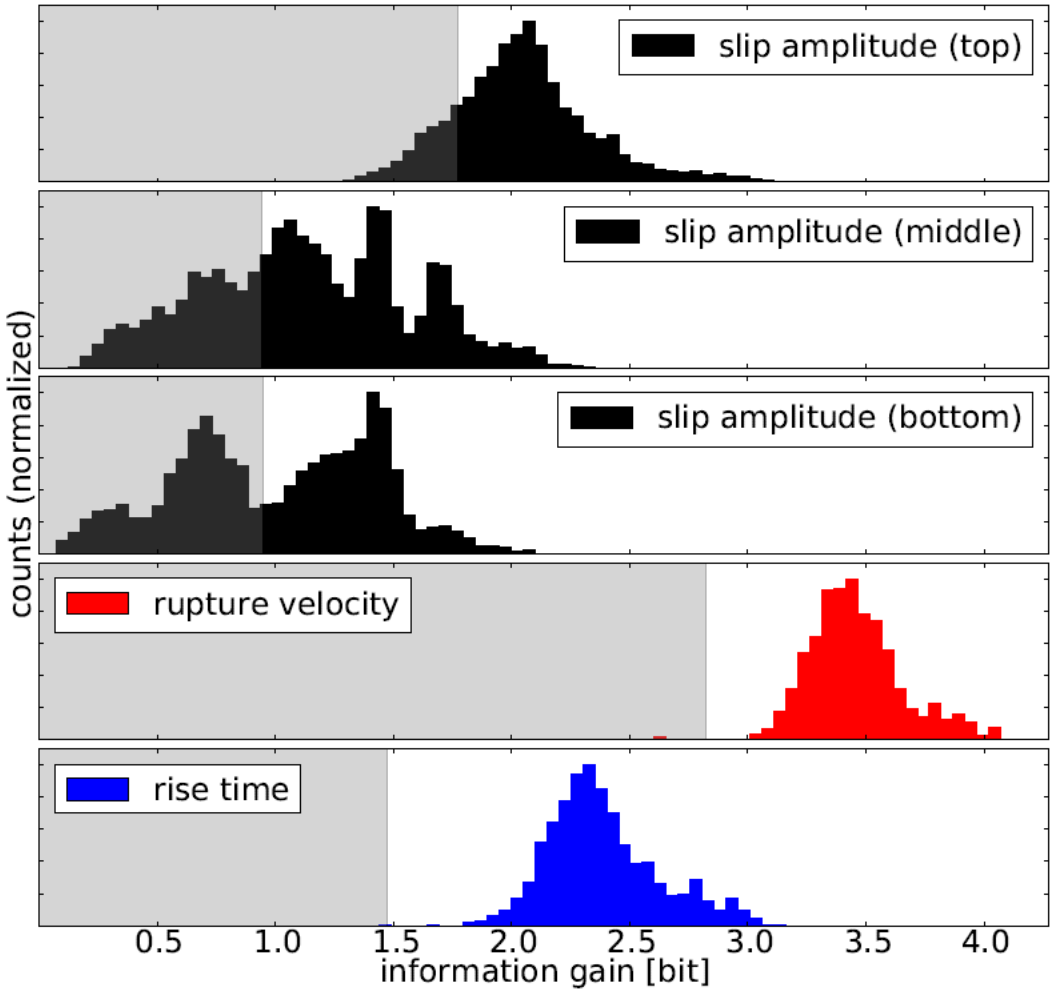


What happens to the kinematic source inverse problem when we replace 20 3C seismometers by 10 6C seismometers?

(From Bernauer et al., JGR 2014)

Kinematic source inversion

- With the 6C sensors rupture velocity and rise time are (almost) always better resolved in the case of 10 receivers
- Reduced logistic effort if one uses >3C sensors
- Rotational motions contain (vertical) gradient information



(From Bernauer et al., JGR 2014)

Conclusions and Outlook

- With ring laser technology we aim at high-resolution measurements for long-period seismology, geodesy, and fundamental physics
- Portable sensors need to be developed that allow the inversion strategies now available for multicomponent observations to be tested with real data (FOGs seem to be the way to go)
- There are many interesting potential application domains (engineering, OBS, planetary seismology, volcanology, etc.)

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- … to CAS to allow us to host this meeting and provide support for catering and logistics! Thanks also for the support of Prof Tanimoto‘s visit!
- … to Celine and Stefanie for all their preparatory work!
- … to all speakers and other contributors!