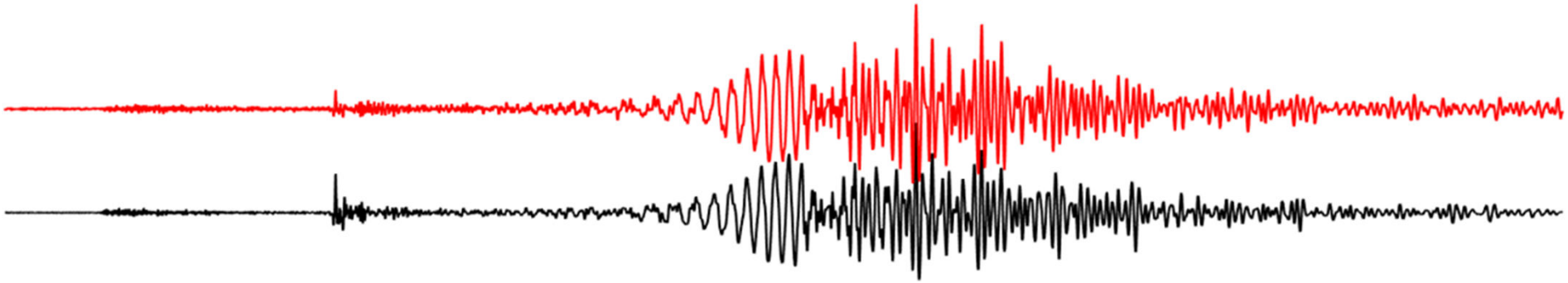
The **ROMY** project:

ROtational ground **M**otions: a new observable for seismolog**Y**



Werner Bauer, Felix Bernauer[1], Moritz Bernauer[1], Bryant Chow[1], Stefanie Donner[1], Sven Egdorf, Celine Hadziioannou[1], Heiner Igel[1], Chin-Jen Lin[1], Andreas Fichtner[2], Andre Gebauer[2,1], Frederic Guattari[7], Fabian Lindner[1], Maria-Fernanda Nader-Nieto[1], Michael Reinwald[1], Johannes Salvermoser[1], Karl Ulrich Schreiber[2], Andrea Simonelli[6,1], Toshiro Tanimoto[5], Frank Vernon[4], Joachim Wassermann[1], and others

ROMY funded

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[2] TU Munich, Germany
[3] ETH Zurich, Switzerland
[4] UCSD, La Jolla, CA
[5] UC Santa Barbara, CA
[6] University of Pisa, Italy
[7] iXBlue, St. Germain-en-Laye

ROMY - facts

- Funded by the European Research Council
- Duration (5+1) years, 2014-2020
- 2.5 million Euro (plus support for ring laser construction by LMU)
- 12 postdoctocal years
- Approx. 1 million for instruments, hardware
  - Ring laser
  - Portable sensors
  - Seismic arrry
  - Field studies

ROMY
ROtational Motions in seismologY

Current ROMY activities

[Instrumentation]

- **ring lasers – the ROMY ring (talk Schreiber)**
- **array rotations vs. direct rotations (ROMY)**
- fibre-optic gyros (talk, poster Bernauer, Guattari)
- **ocean bottom seismometry (paper Lindner)**

[Observations]

- **ring laser event data base (poster Salvermoser, Chow)**
- understanding ocean-generated seismic noise (talk Tanimoto, poster Hadziioannou)
- array-derived rotation and strain (talk Lin)

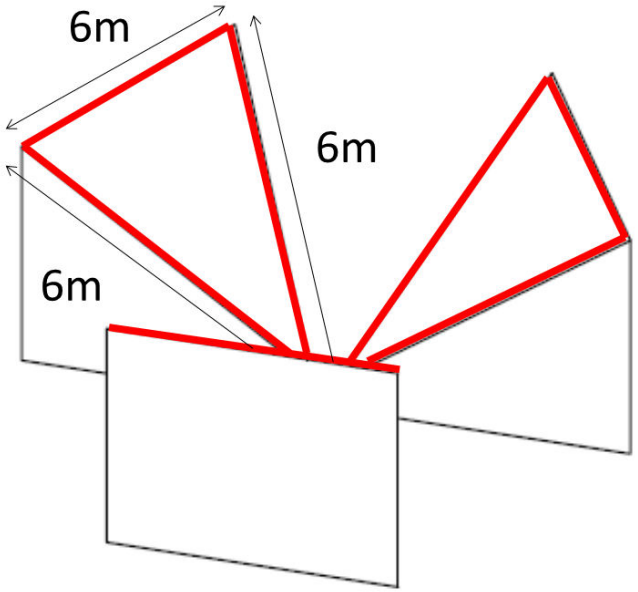
[Theory]

- **earthquake source inversion (poster Donner)**
- wavefield separation (poster Nakata)
- **tomography with rotations**

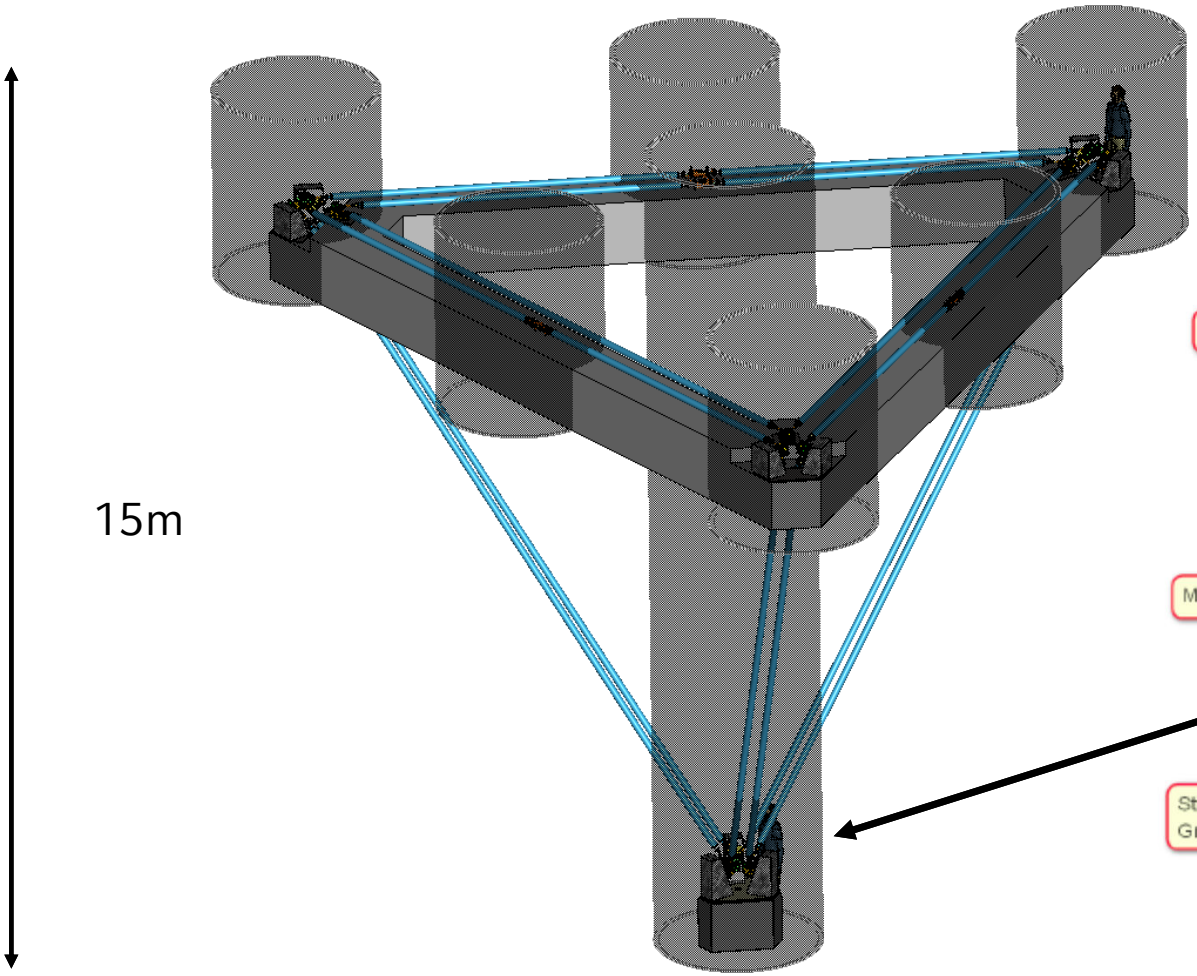
[Outlook]

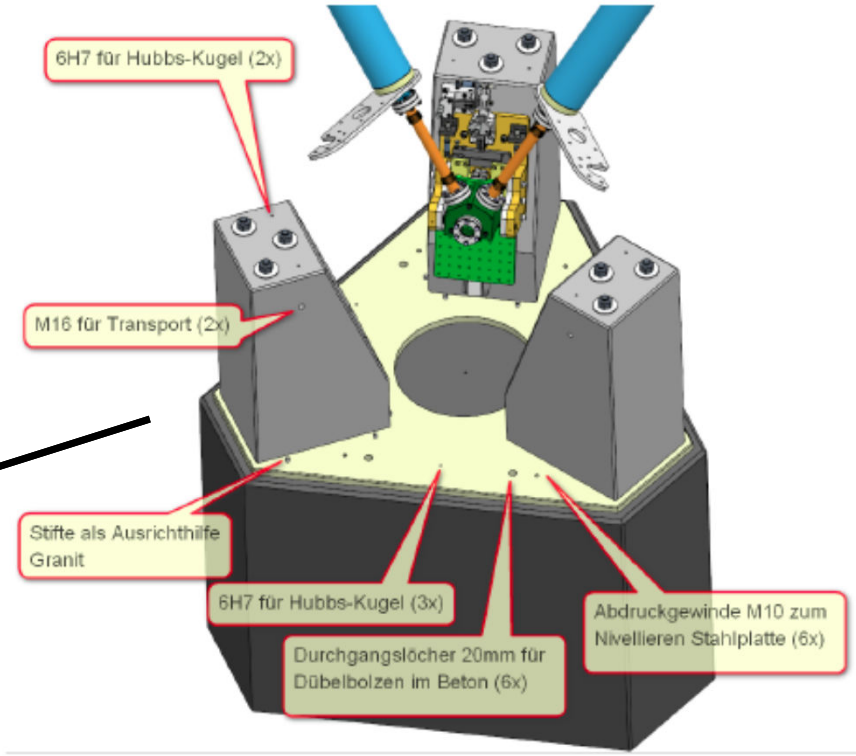
Multi-component ring laser for geodesy and seismology

- High resolution >=3-component observations of rotational motions for Earth‘s free oscillations, ocean generated seismic signals, Earth rotation, space geodesy

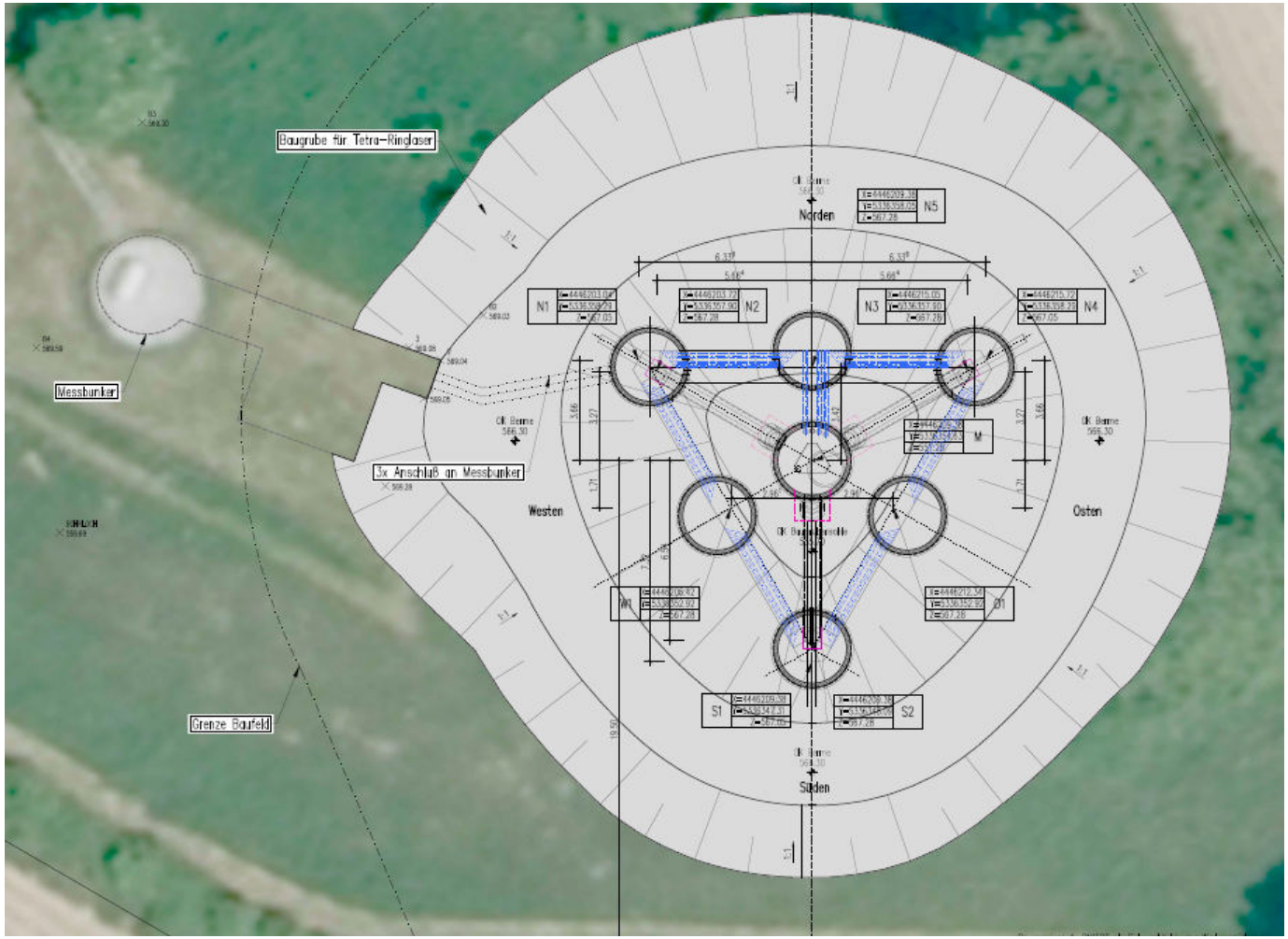


The ROMY ring – the first 4C ring laser

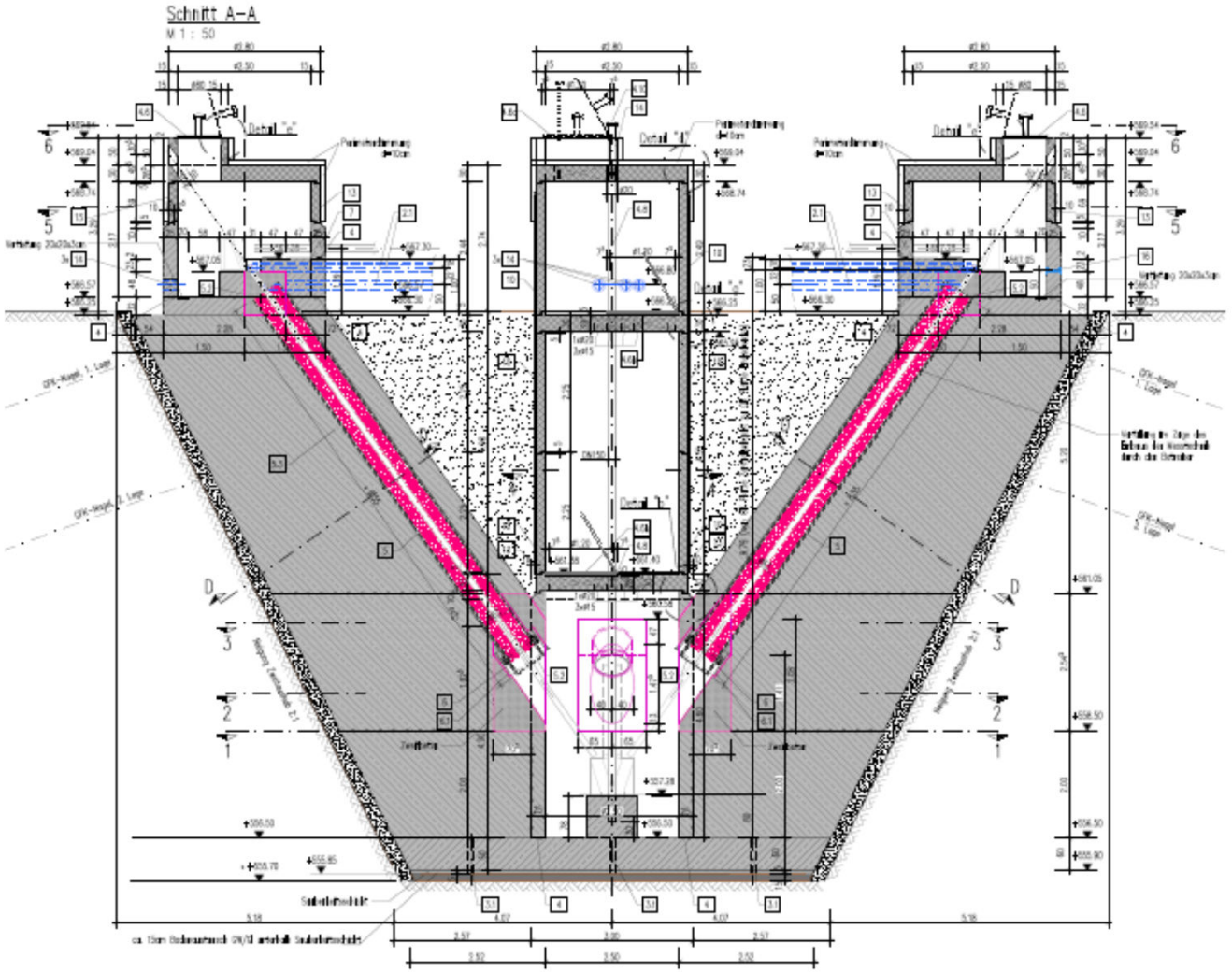




ROMY ring - Construction



Construction - side view

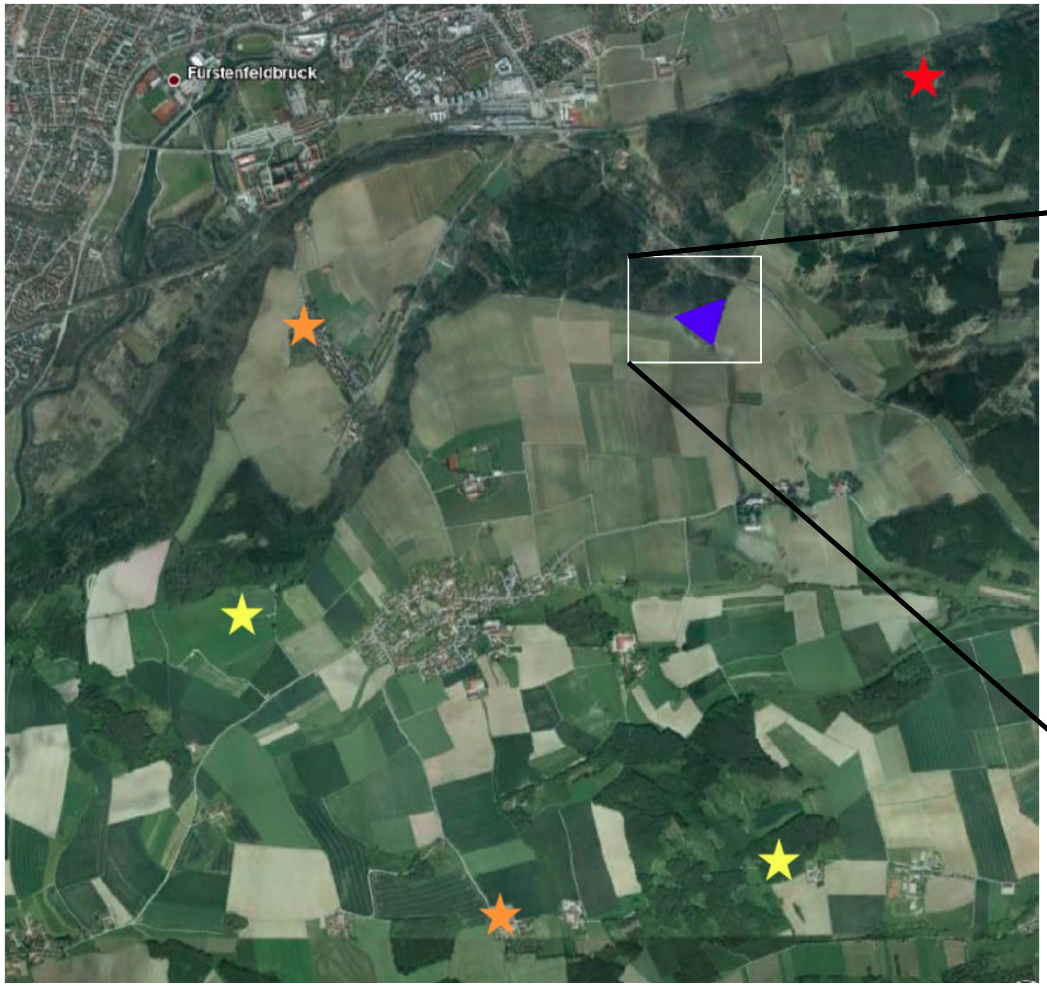


Expected sensitivity

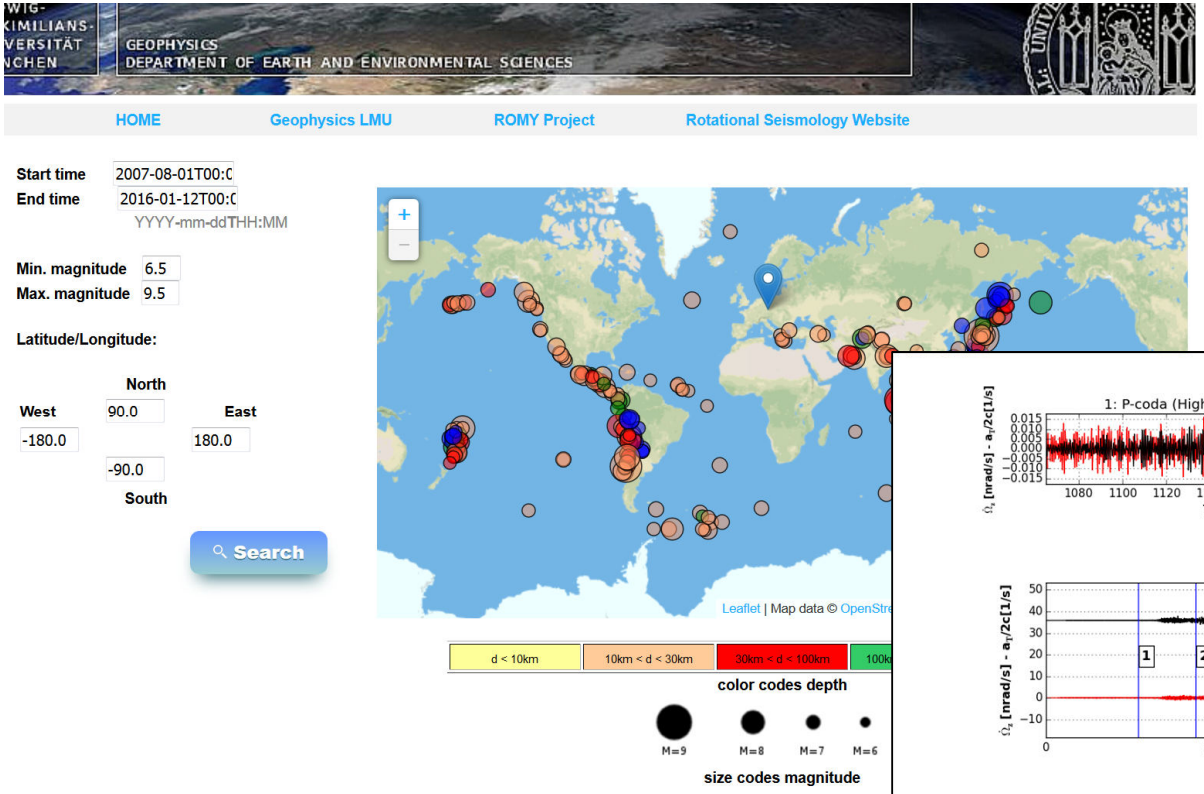
Sagnac frequencies:
RL-horitzontal: 593Hz
RL-S1 (az 60° clockwise, dip 70.5°): 448Hz
RL-S2 (az 180° clockwise, dip 70.5°): 302Hz
RL-S3 (az 300° clockwise, dip 70.5°): 448Hz

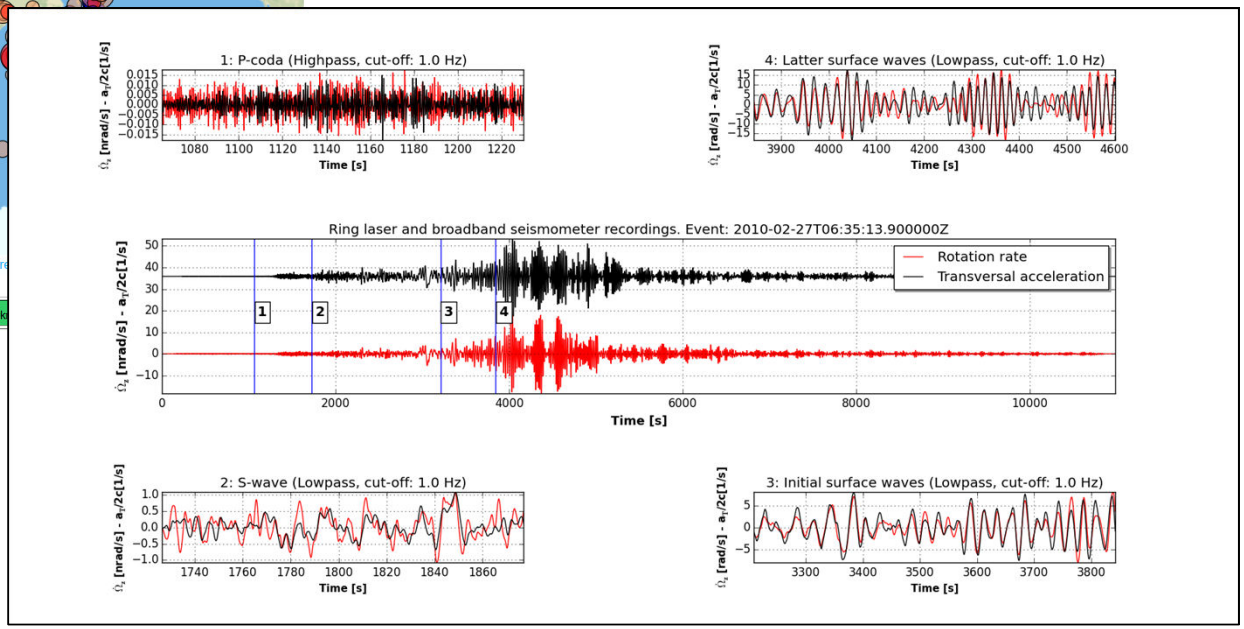
Sensitivity:
0.02-0.05 prad/s

3D – 3C Array Observations

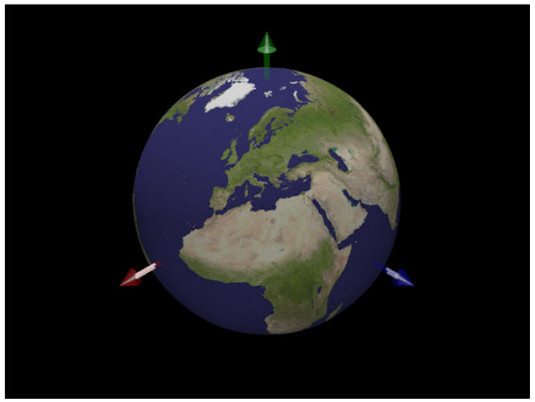


Event Data Base (G-Ring *+ ROMY)*

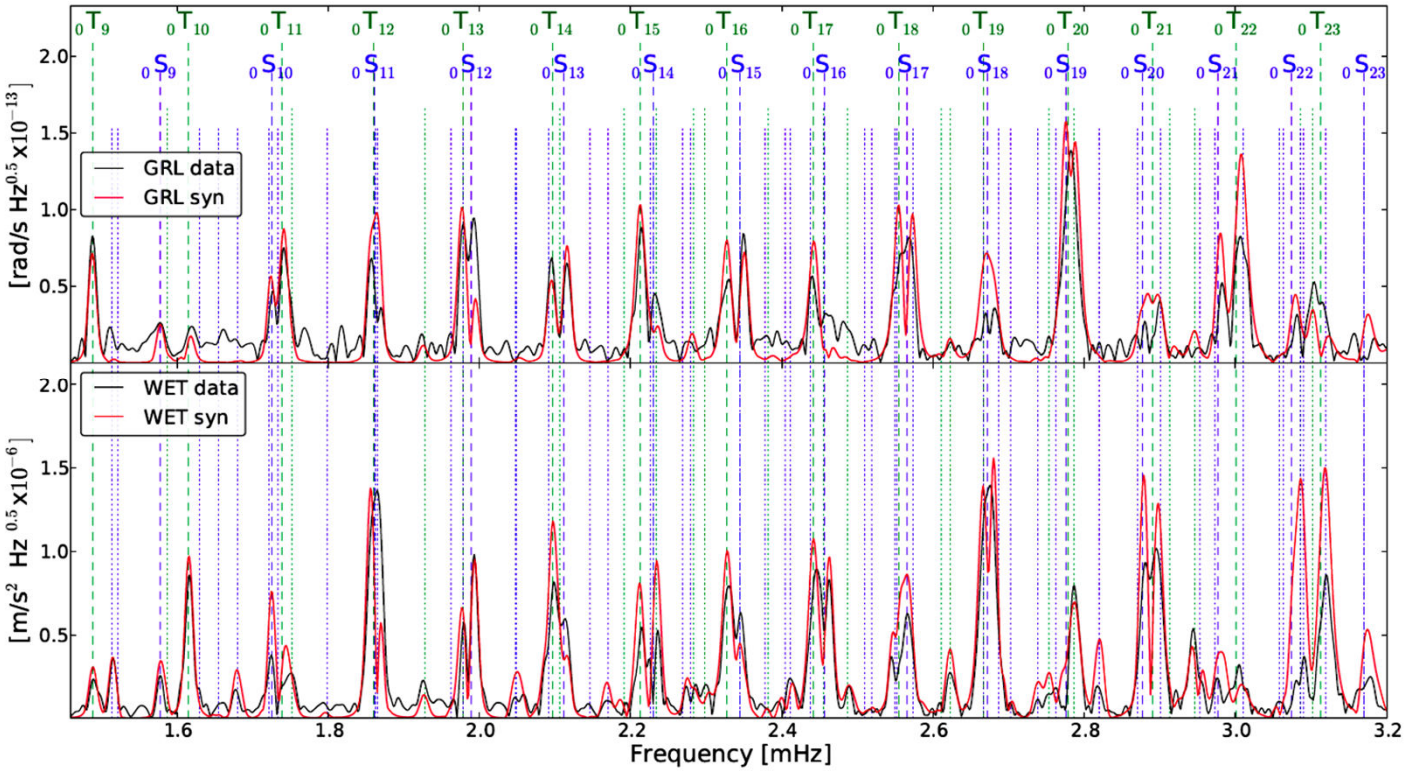




Observations – Earth‘s free oscillations

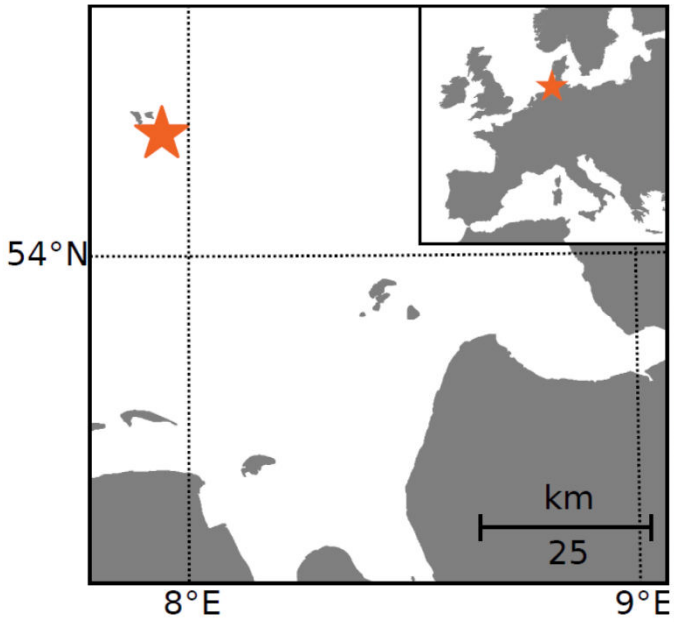


M9.1. Tohoku-Oki earthquake March 11, 2011

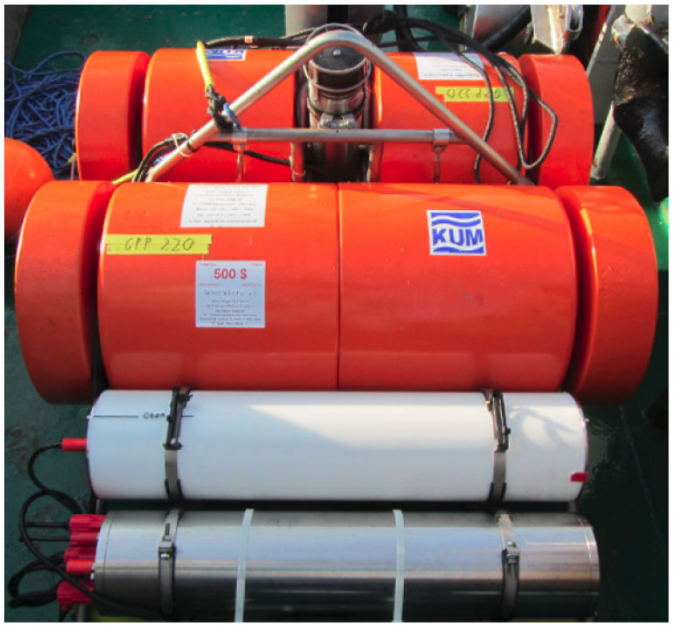


Nader-Nieto et al., 2015

Rotations and ocean bottom observations - the experiment



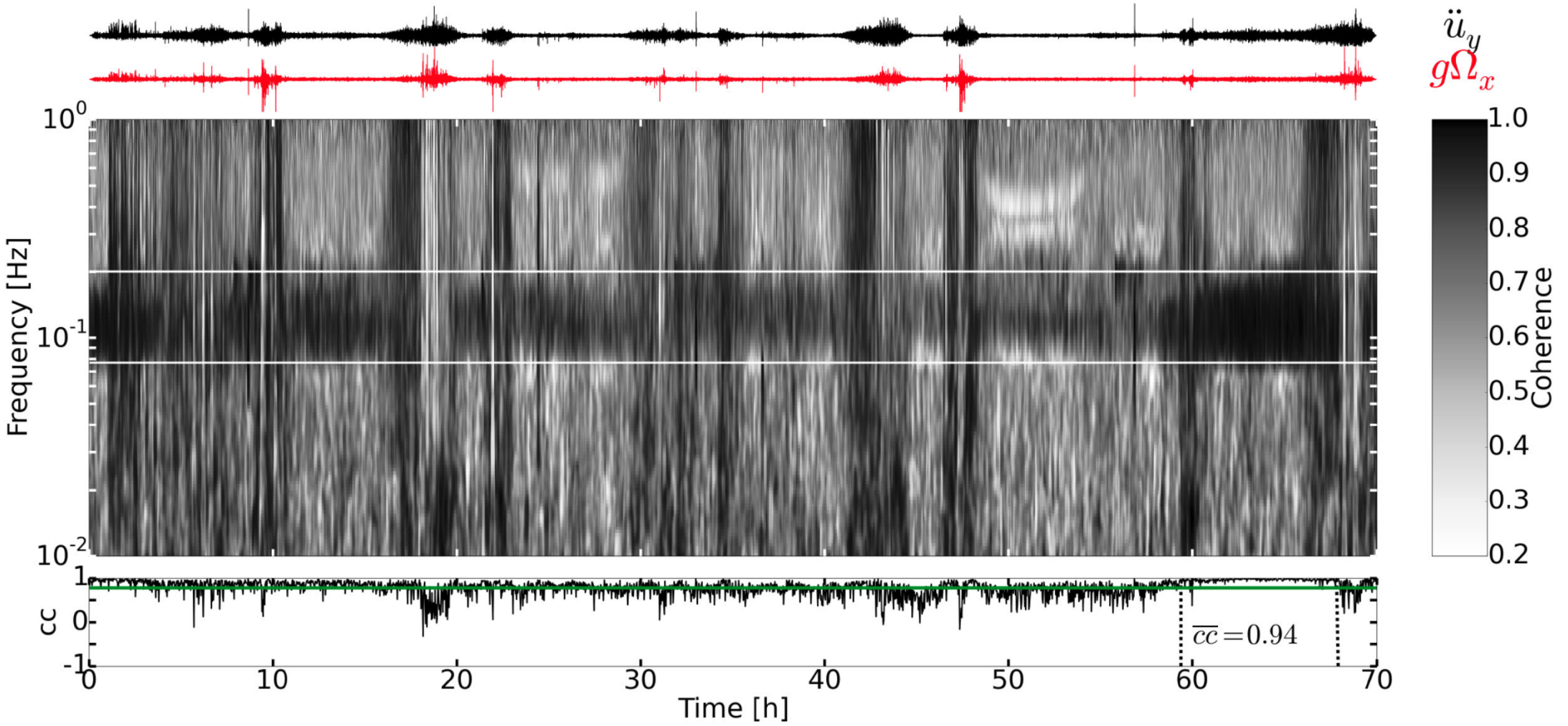
Experiment site



OBS System

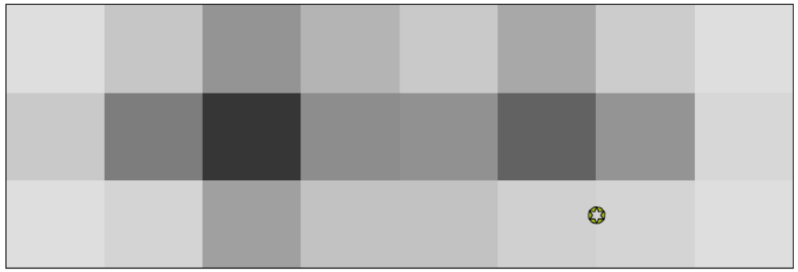
Fiber-optic gyro

Rotations and ocean bottom observations - data



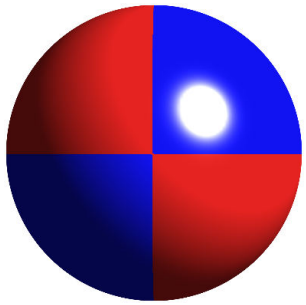
Theory – Earthquake Model Parameters

Finite Source



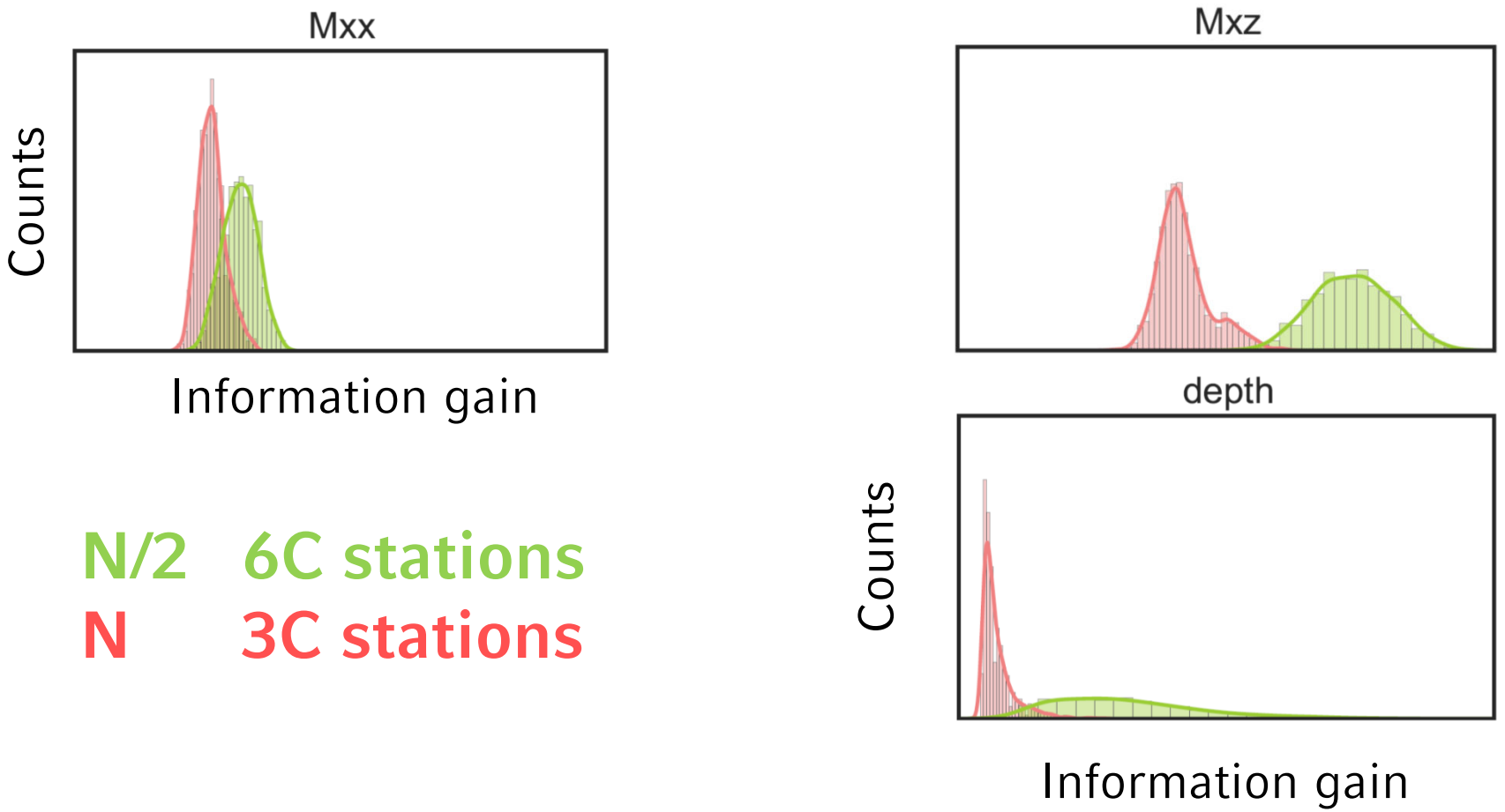
- Rupture velocity
- Rise time
- Static slip

Point Source



- Source location
- Moment tensor components

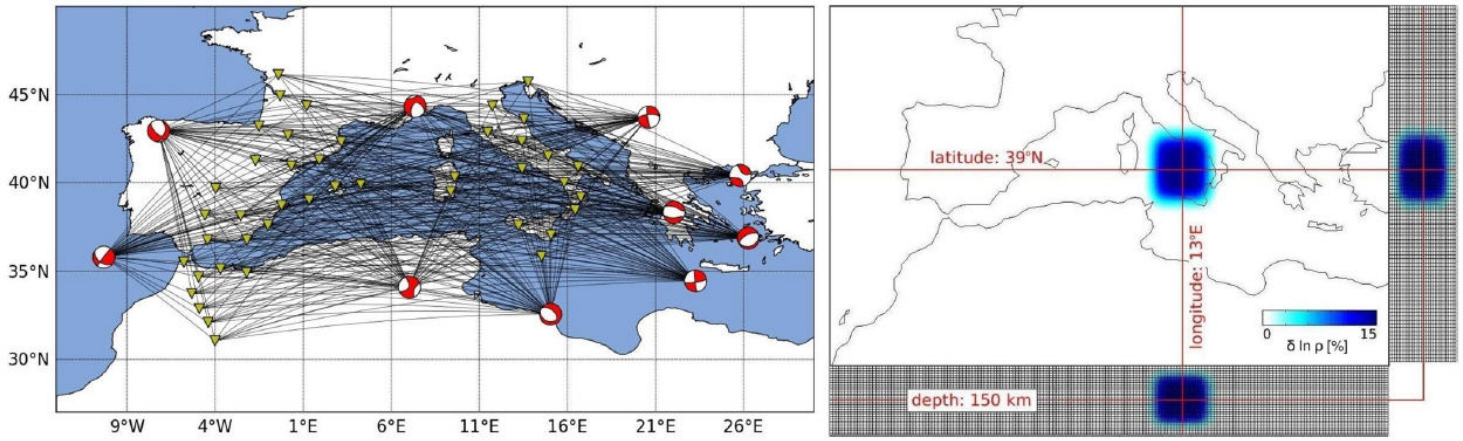
Theory – Point source inversion



N/2 6C stations
N 3C stations

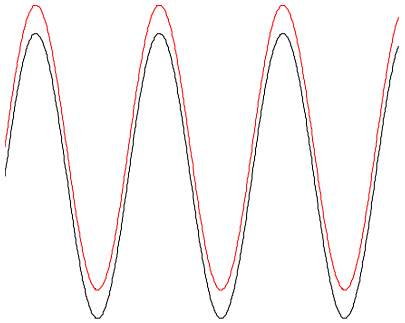
Donner et al., GJI, submitted

Tomographic inverse problem



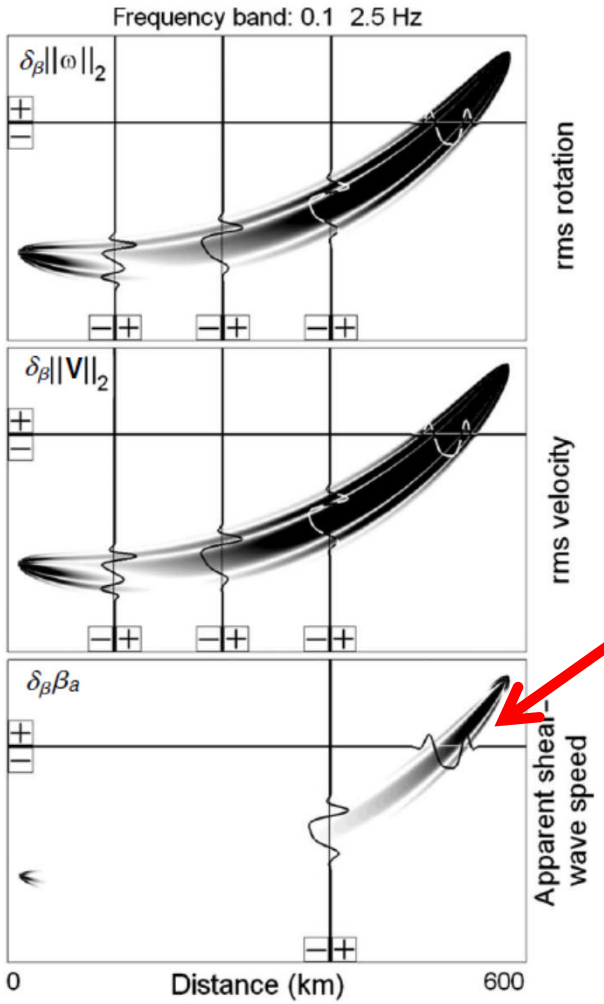
Let s define a new observable…

$$\beta_a(\mathbf{x}^r) = \frac{\|\mathbf{V}(\mathbf{x}^r)\|_2}{\|\boldsymbol{\omega}(\mathbf{x}^r)\|_2}$$

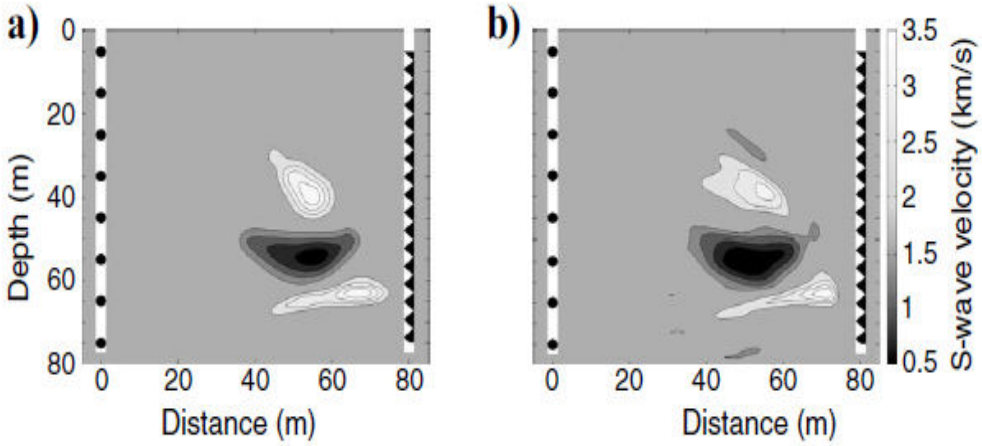


… and call it **apparent shear velocity** (the same principle works with translations and strain) …

… and calculate sensitivity kernels …



Tomography without travel times!
(Bernauer et al., 2009, 2012,205)



ROMY Outlook

- ROMY construction finished August 2016
- ROMY 4 ring laser components operational … sometime after
- Realtime data aquisition and display (translations, direct rotations, array-derived rotation, strain)
- Cross-correlation of rotational motions (G-Ring - ROMY)
- Analysis of free oscillations, ocean-generated noise, earthquakes etc etc
- Prototype Blueseis September 2016
- Labtests, field tests (volcano, near field, active seismology, etc)
- OBS prototype with 6C -> ocean noise model
- Blueseis pool of sensors -> extensive field studies

Papers, more info on www.romy-erc-eu