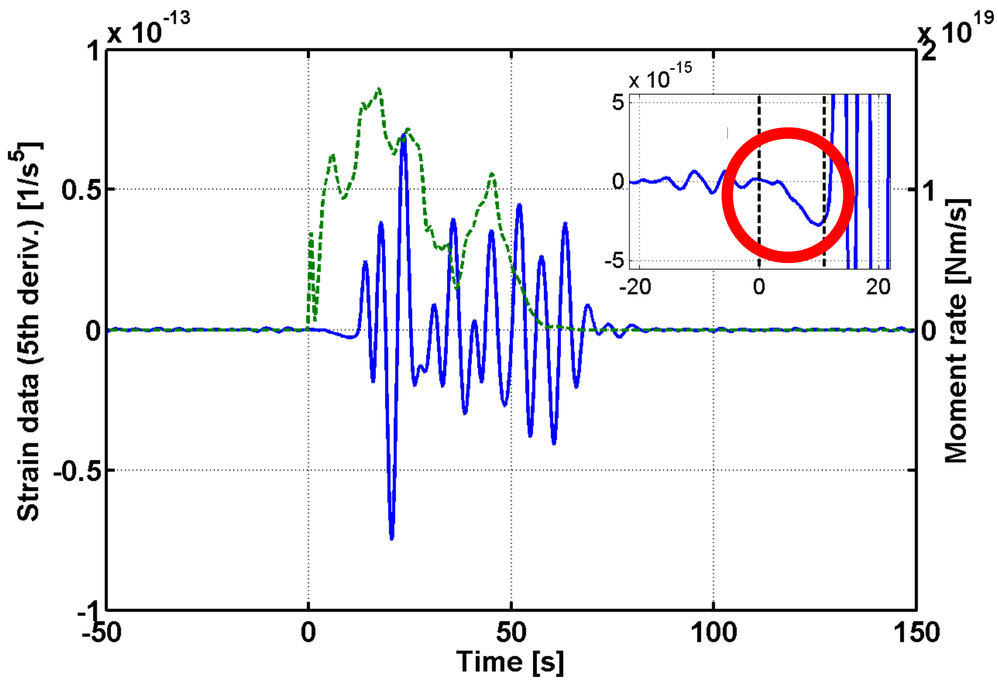
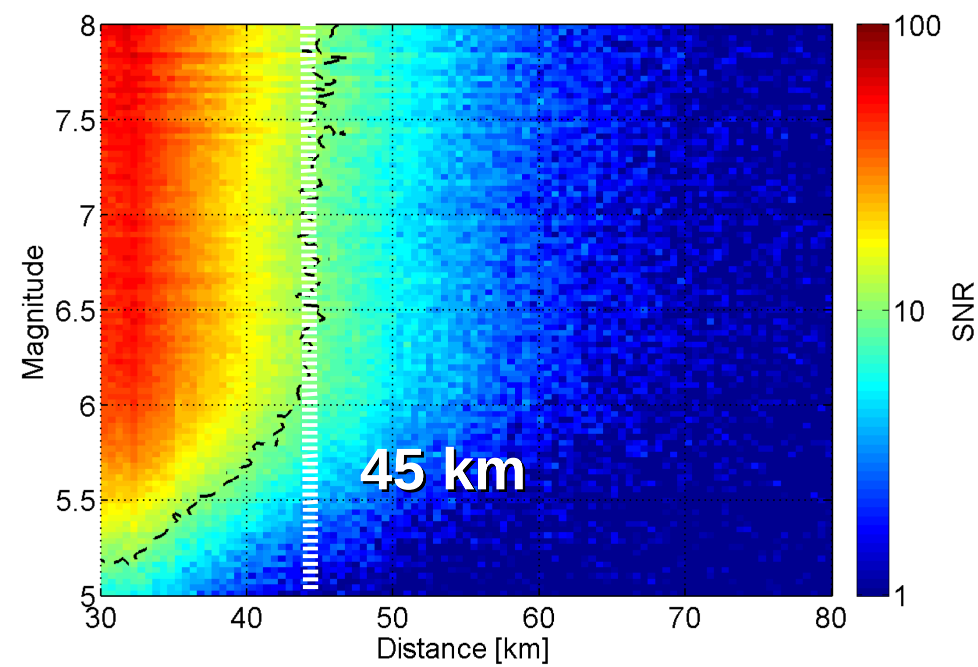
Summary on gravity strain signal from distant earthquakes

Gravity strain signal $\langle h \rangle \propto I_4[M_0(t)]/r^5$ $I_4[M_0(t)] \propto t^7$



Simulated gravity time series of the Pakistan earthquake, band-passed filtered between 10mHz and 0.2 Hz



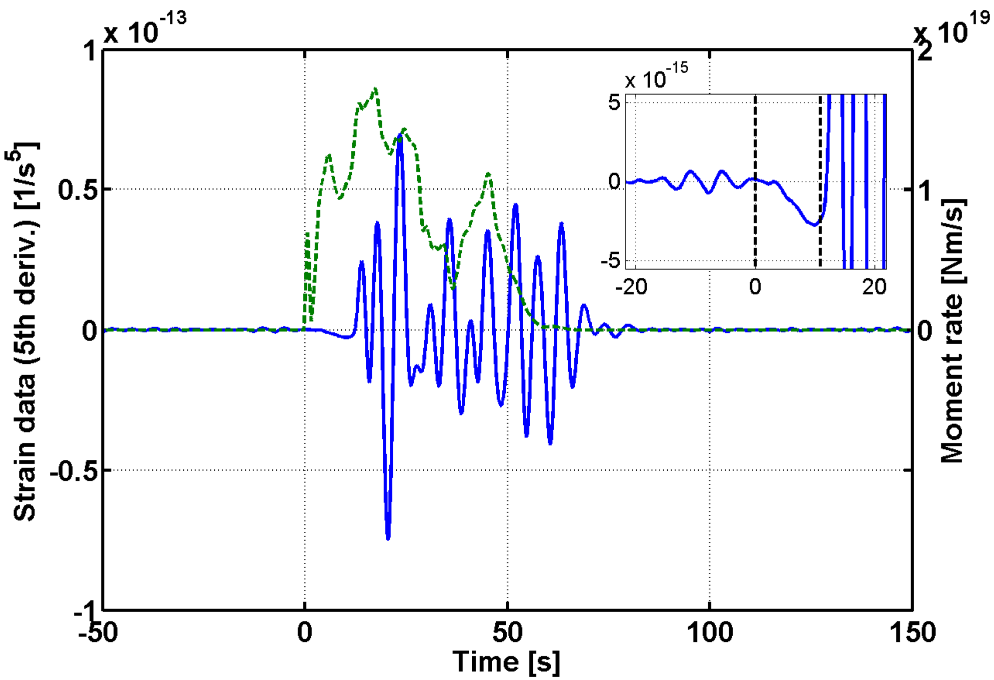
Signal-to-noise ratio accumulated within the **first 5 s** or within P-wave travel time if shorter

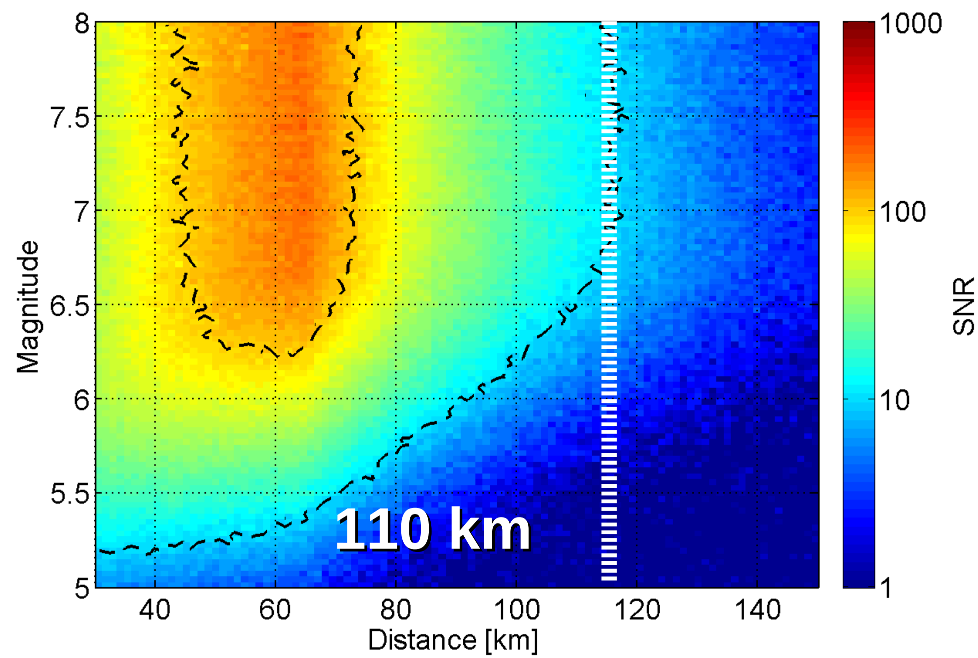
"Next-stage" detector

From J Harms et al., 2014

Summary on gravity strain signal from distant earthquakes

Gravity strain signal $\langle h \rangle \propto I_4[M_0(t)]/r^5 \quad I_4[M_0(t)] \propto t^7$





Simulated gravity time series of the Pakistan earthquake, band-passed filtered between 10mHz and 0.2 Hz

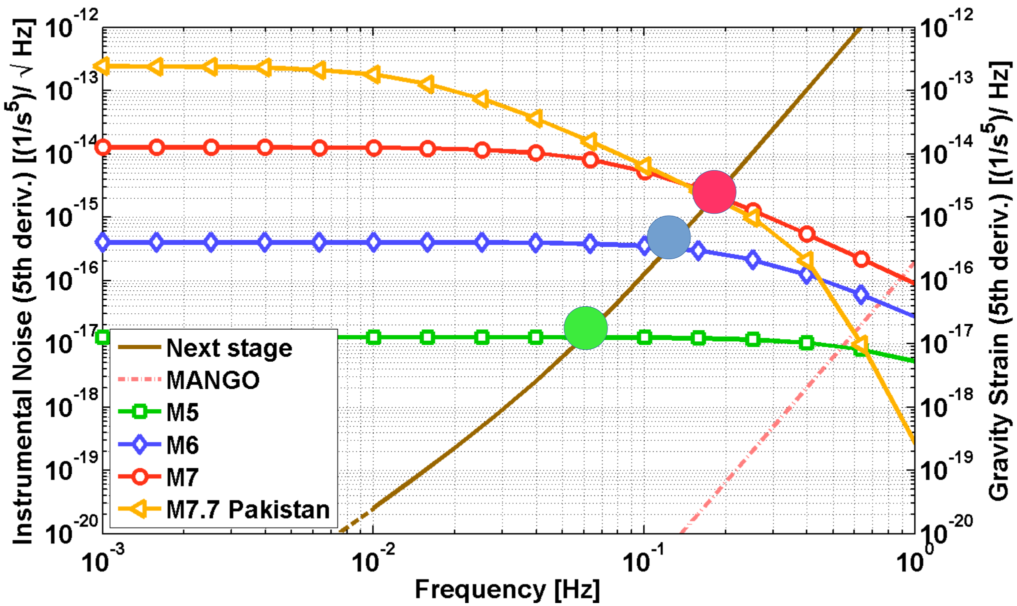
Signal-to-noise ratio accumulated within the **first 10 s** or within P-wave travel time if shorter

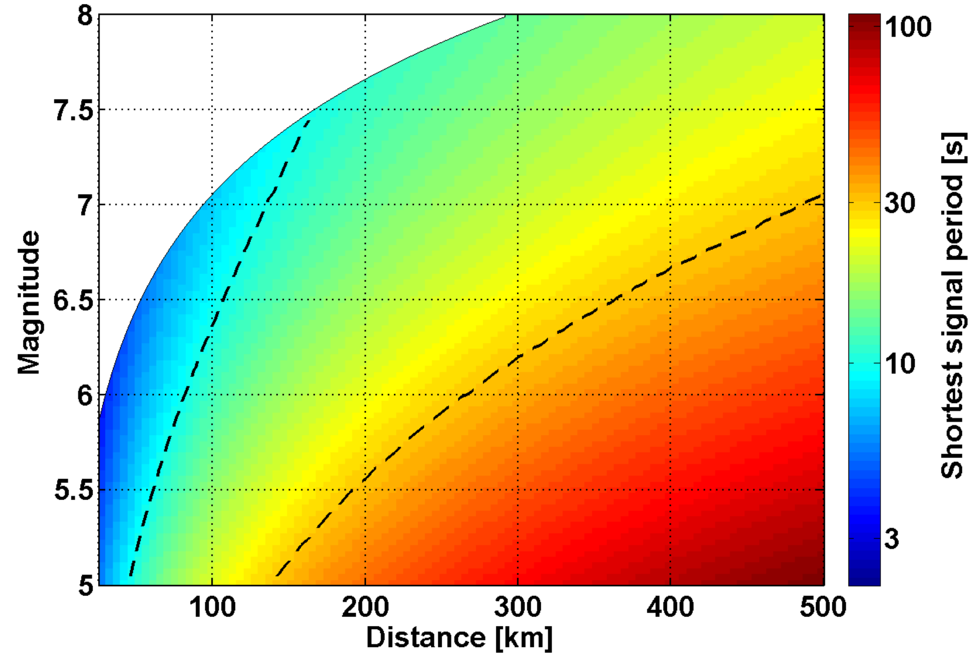
"Next-stage" detector

From J Harms et al., 2014

Summary on gravity strain signal from distant earthquakes

Gravity strain signal $\langle h \rangle \propto I_4[M_0(t)]/r^5$ $I_4[M_0(t)] \propto t^7$





Direction averaged Fourier spectra of the fifth time derivative of gravity strain

Resolvable timescale – determines alert latency

Detector at 70 km from hypocenter

From J Harms et al., 2014

Summary on gravity strain signal from distant earthquakes

Gravity strain signal $\langle h \rangle \propto I_4[M_0(t)]/r^5$ $I_4[M_0(t)] \propto t^7$

- Steep decay with distance → detection possible “locally” within 50 to 100 km from the source
- Slowly raising signal and autosimilar (first seconds are marginally dependent of magnitude)
- Delay in time-of-arrival negligeable compared to resolvable timescale

Open problems

Implications for Earthquake early warning

Detection strategy with controlled false alarm rate
Detector network required for regional coverage → global processing

Detection

- How to extract signal from noise?
  Excess power. Signal variability depending on fault rupture?
- How to assess event significance?
  Background due to unrelated gravity perturbations close to the detector
- How to detect with a detector array?
  $1/r^5$ steep decay → detection is **local**

Source characterization

- Magnitude and direction estimates
  Two major difficulties: no delay between detectors and signal "autosimilarity" (weak dependence of first seconds on magnitude)

  Can't rely on triangulation → use source emission pattern?

Strategy

Detection with a sensor array

- **Testbed for testing**: simulated data from a regional array including realistic signals/emission pattern from a variety of fault rupture and try several detector types (sensitivity models, non-gaussian perturbation)

  → Test ideas: detector geometry/density, detection algorithms

Source characterization

- **Maximum likelihood estimators and** their Cramer-Rao lower bounds → potential science reach, identify degeneracies
- Validation of the estimators with testbed

Scope definition

- Target major Earthquakes? Off-shore events?
- Combined analysis with dense seismoter arrays?