International Institute of Earthquake Engineering and Seismology, Tehran, Iran

T3.1-O9

The Feasibility of Using MEMS Technology for Monitoring Large Earthquakes

Anooshiravan Ansari- Ehsan Karkooti

Accelerometers in Engineering Seismology

- Weak motion measurement
  - structural health monitoring
  - site effect measurements

ad-hoc
Dynamic Range > 140 db
small number of sensors

- Strong motion measurement
  - post-earthquake inspections
  - shakemap (damage map- fatality map- …)
  - rapid response applications (shut-off systems)

continuous measurement
Dynamic Range < 100 db
large number of sensors

A Question

Is it possible to use MEMS technology to record strong motion of large earthquakes for engineering seismology purposes?

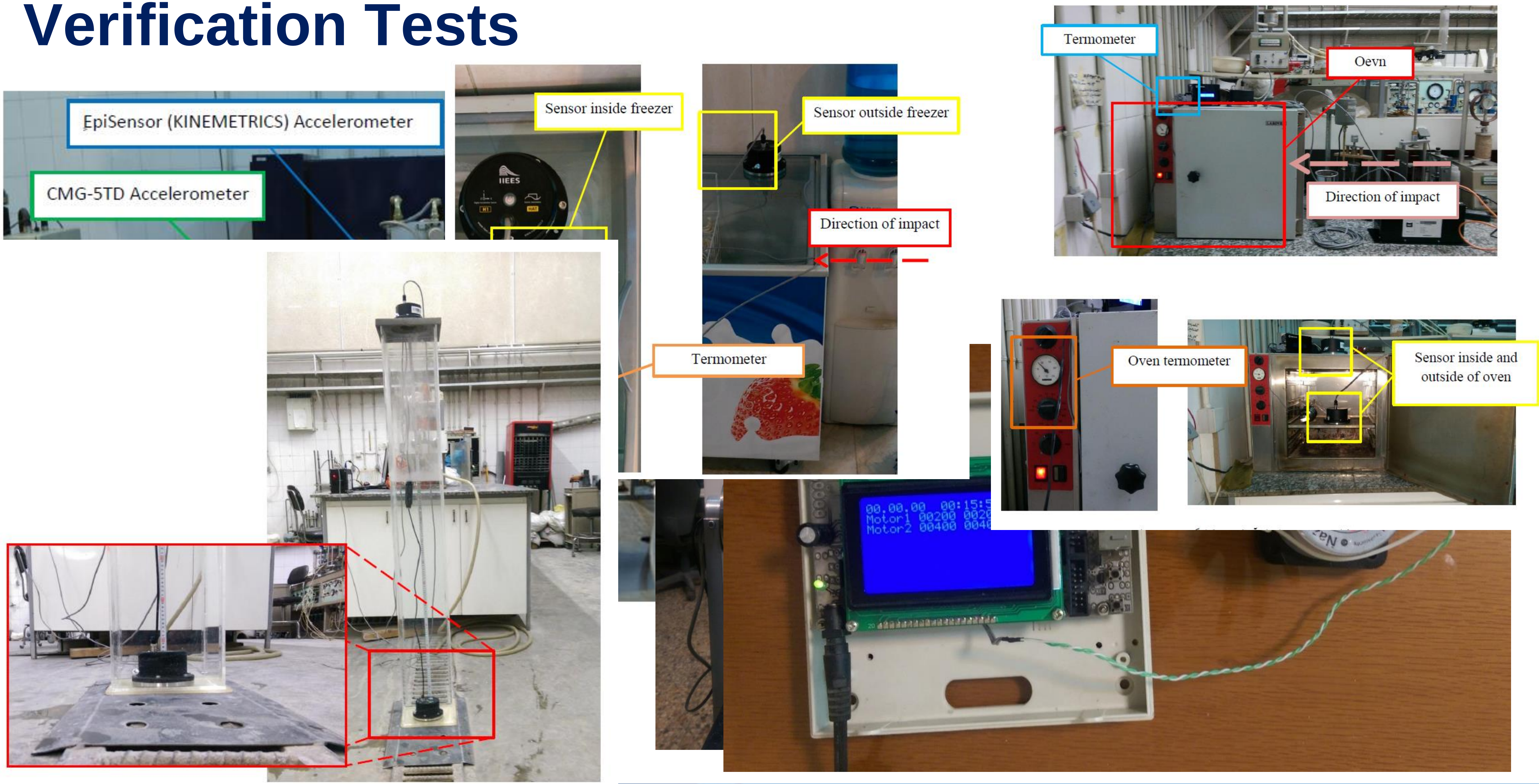
Why MEMS?

It is cheap → It is possibly to deploy hundreds of sensors

HAT Sensors

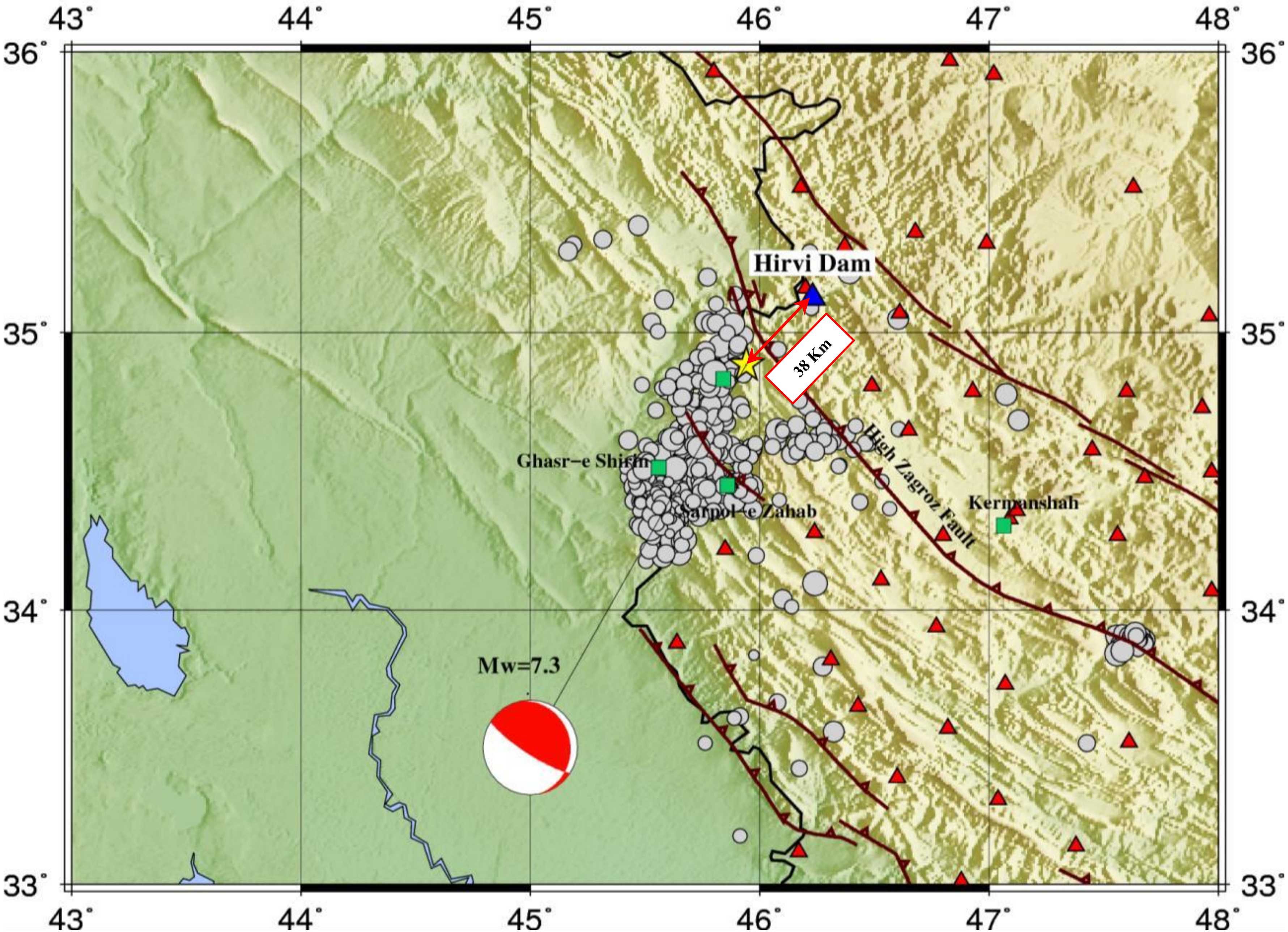
No.x	Performance Metric	Value
1	Number of Components/axes	3
2	Clip-level	1.7g
3	Sensor Dynamic Range	89dB
4	Self-noise (RMS)	<15 µg / Hz
5	Sensitivity Accuracy	<1% <10Hz
6	Cross axis coupling	<-35 dB
7	Linearity	<-35 dB
8	Temperature-Induced Sensitivity Errors	<0.5% over -20 to +40°C
9	Operational Temperature Range	-20~60 °C
10	Sensor output	Digital- RS485
11	Sampling rate	50,100,200 Hz

Verification Tests

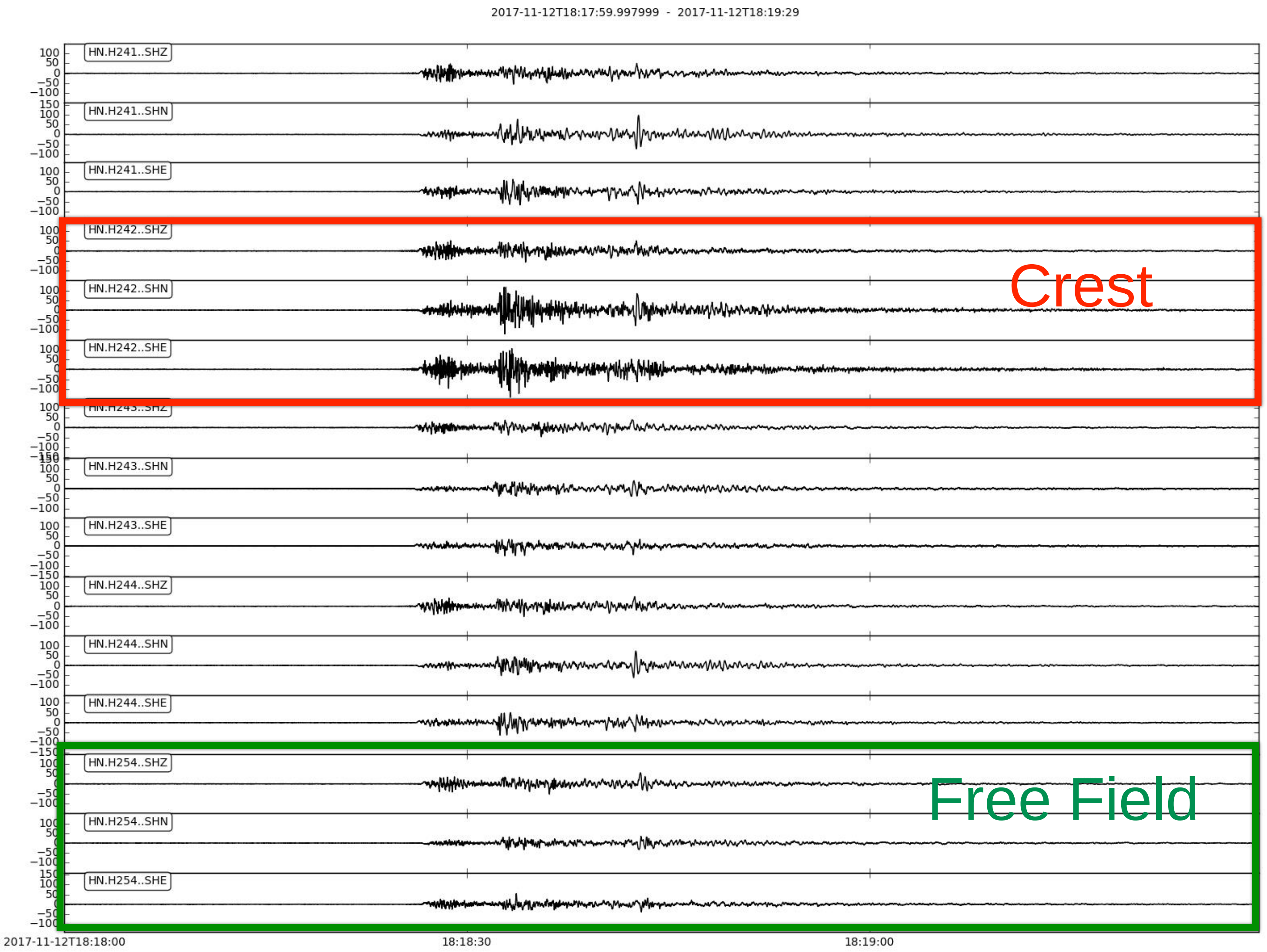


Applications

Installation of HAT sensors in HIRVI Dam

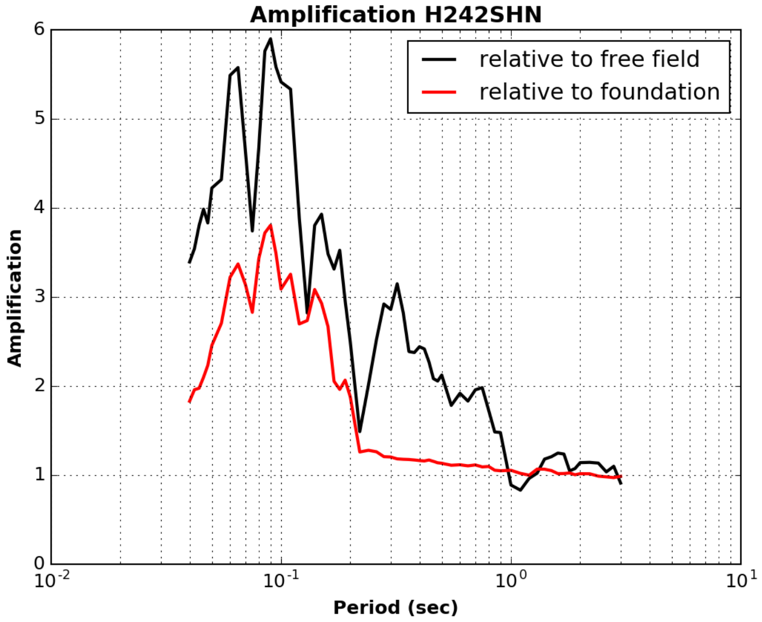


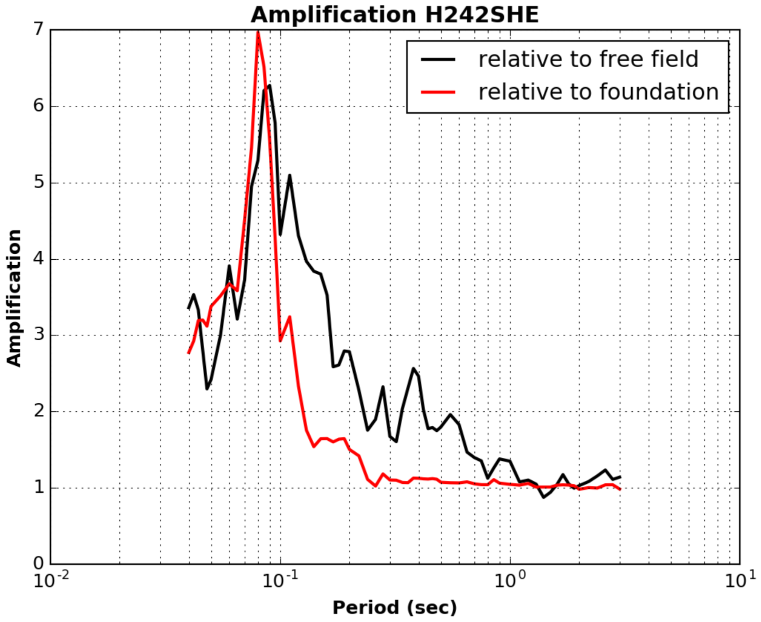
M_w7.3 Sarpol-e Zahab, Iran earthquake on November 12, 2017

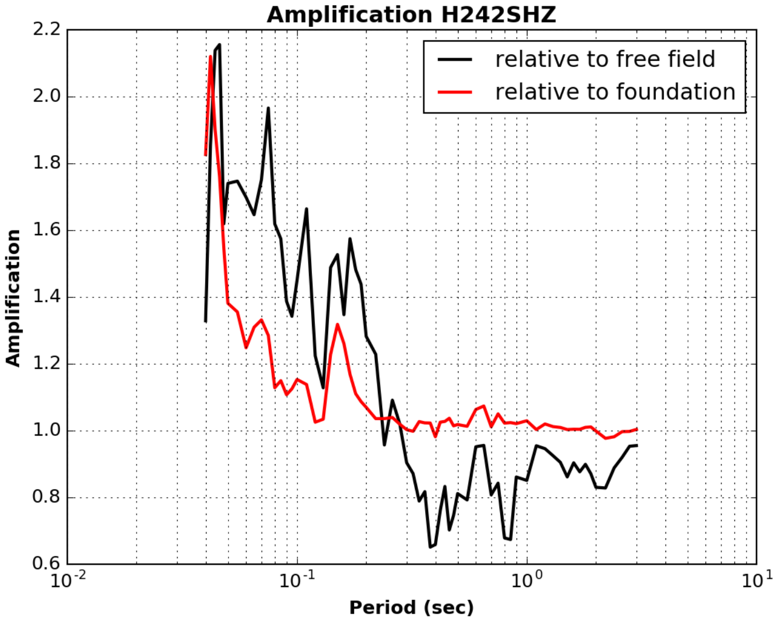


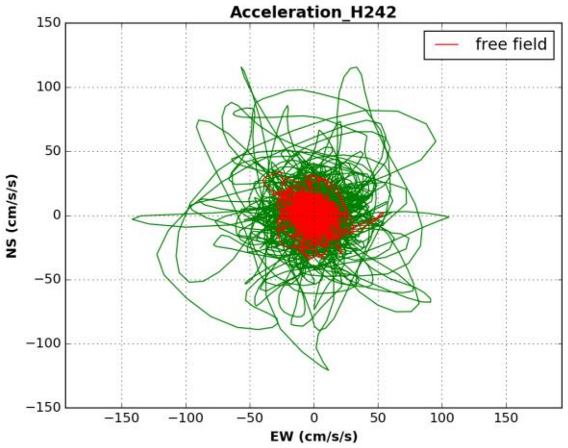
Location	Code	PGA s/s/cm
Left Abutment	H241SHE	67.12
	H241SHN	96.88
	H241SHZ	55.70
Crest	H242SHE	141.76
	H242SHN	120.72
	H242SHZ	56.88
Right Abutment	H243SHE	49.75
	H243SHN	41.13
	H243SHZ	46.69
Basement	H244SHE	63.74
	H244SHN	72.92
	H244SHZ	52.59
Free Field	H254SHE	54.47
	H254SHN	34.12
	H254SHZ	56.62

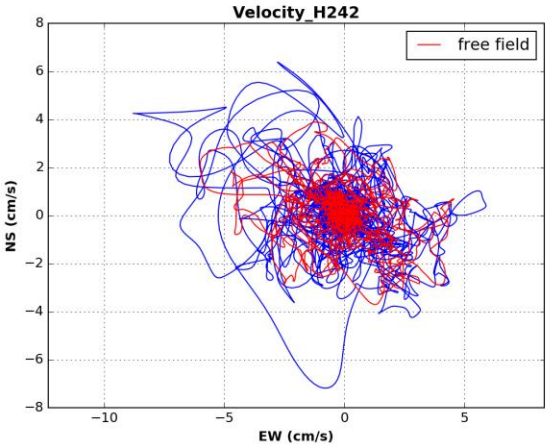
Amplification of Motion on Crest

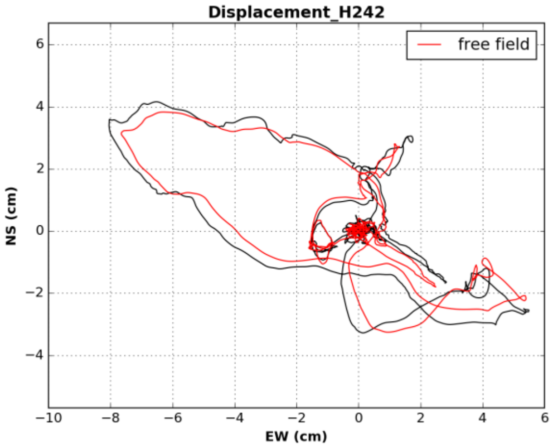


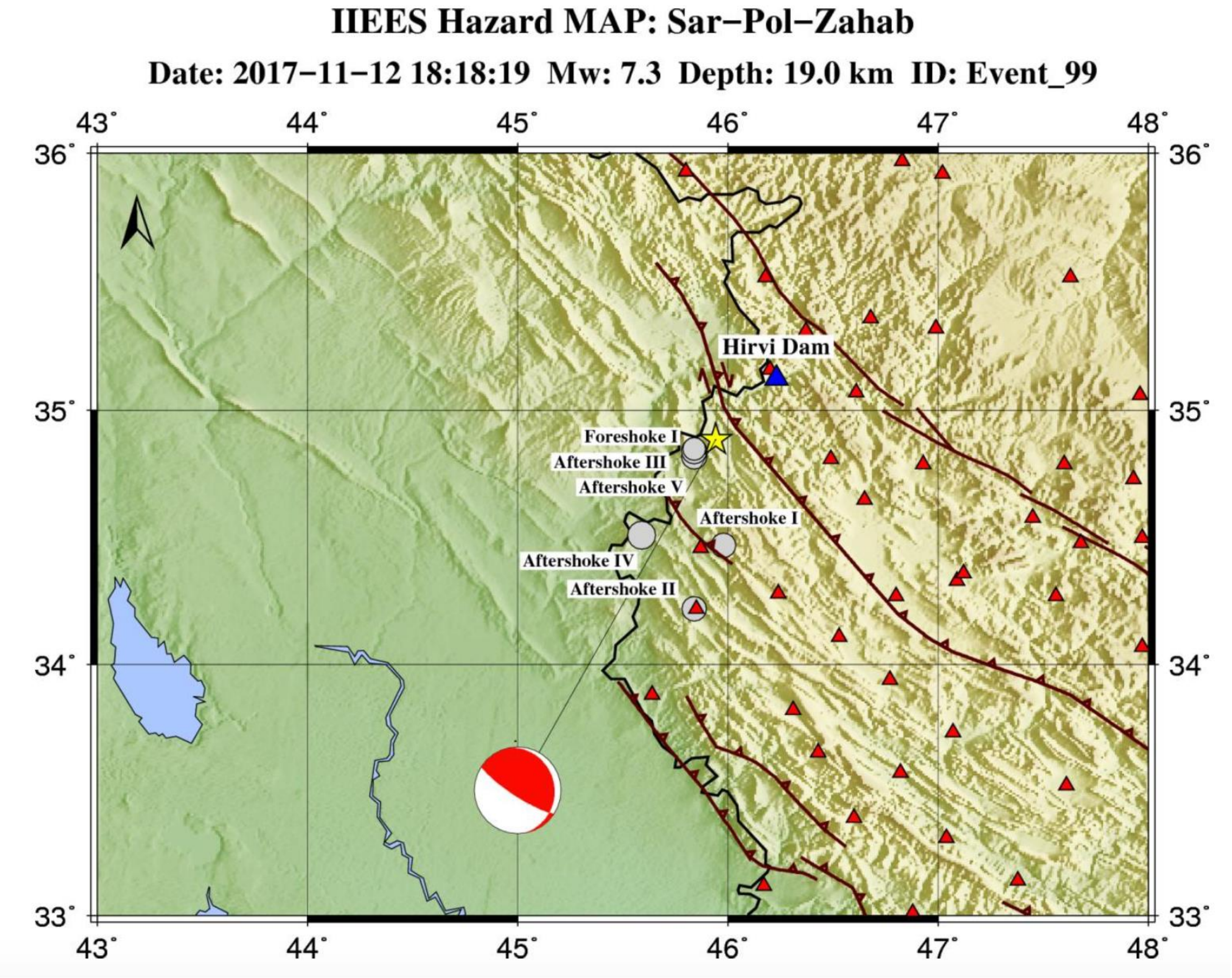








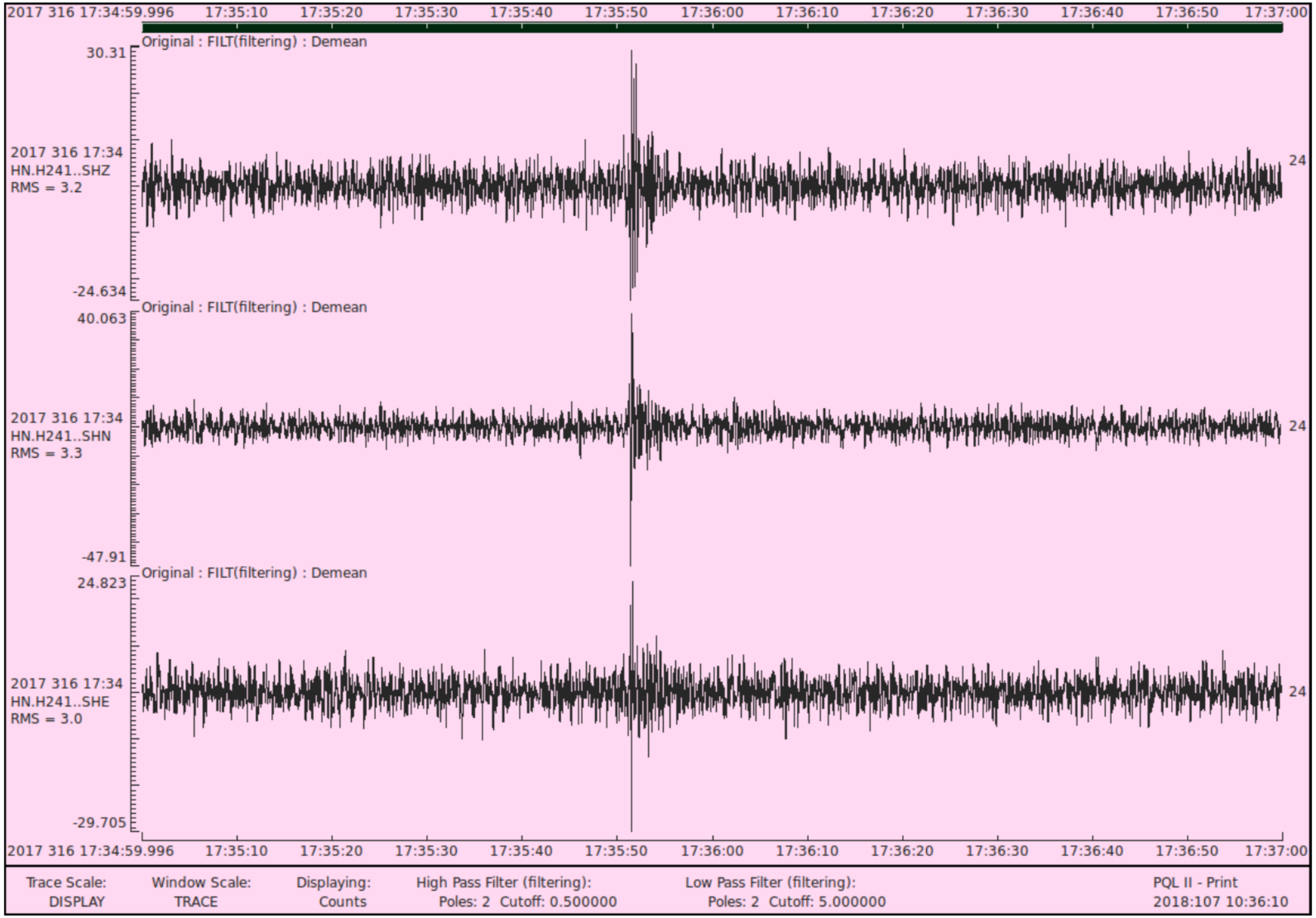




Aftershocks

Aftershock	Date	Magnitude	Distance from Dam (km)
I	2017/11/12	4.4	45.5
II	2017/11/13	4.7	75.6
III	2017/11/13	4.7	106.6
IV	2017/12/6	4.9	47.5
V	2017/12/11	5.4	89.7
VI	2017/12/11	4.9	47.4

The unit of the y axis is x10 cm/s/s



Aftershock I

M 4.4

Distance from Dam:

45.5 Km

It is possible to

record PGA

Conclusions

- It is possible to use MEMS technology for engineering seismology applications like calculation of Shakemap or damage maps
- Low price of these sensors makes it possible to use a large number of them in real applications
- Low dynamic range of these sensors is not suitable for most seismology applications

Thank You