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Real-time structural monitoring of the School of Engineering Main Building at the University of Naples Federico II

Records of dynamic effects induced by Abruzzo earthquake on April 6th, 2009

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Summary:

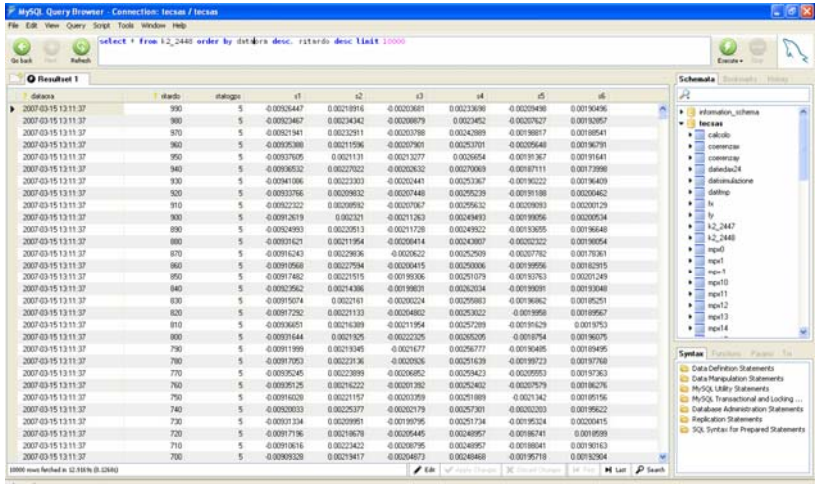
In the following, some measures obtained from the continuous monitoring system of the School of Engineering at the University of Naples Federico II are proposed.

An algorithm able to perform automated identification of dynamic characteristics of structures is used and a specific software has been developed and installed as a part of the structural health monitoring (SHM) system in the framework of Reluis project by UniMol *StreGa* Laboratory.

The algorithm is based on a specific technique of Operational Modal Analysis, the Frequency Domain Decomposition (FDD), that provides the dynamic characteristics of the structures in output only conditions.

A synthesis of recorded data is given and a tracking of modal parameters in terms of the main three frequencies of the structure and of the related values of damping is presented.

The SHM System



Remote MySQL database

The School of Engineering
Main building (Naples)

Sensors	DAQ hardware	Sampling frequency [Hz]
Kinemetrics Epi-Sensor FBA ES-U2 (5 V/g sensitivity, 0.5 g FS range)	Kinemetrics K2 Digital Recorder (24 bit DSP)	100

III Floor

547 (Channel 9 Block 2)

551 (Channel 10 Block 2)

553 (Channel 11 Block 2)

558 (Channel 12 Block 2)

VII Floor

555 (Channel 4 Block 1)

556 (Channel 3 Block 1)

544 (Channel 5 Block 1)

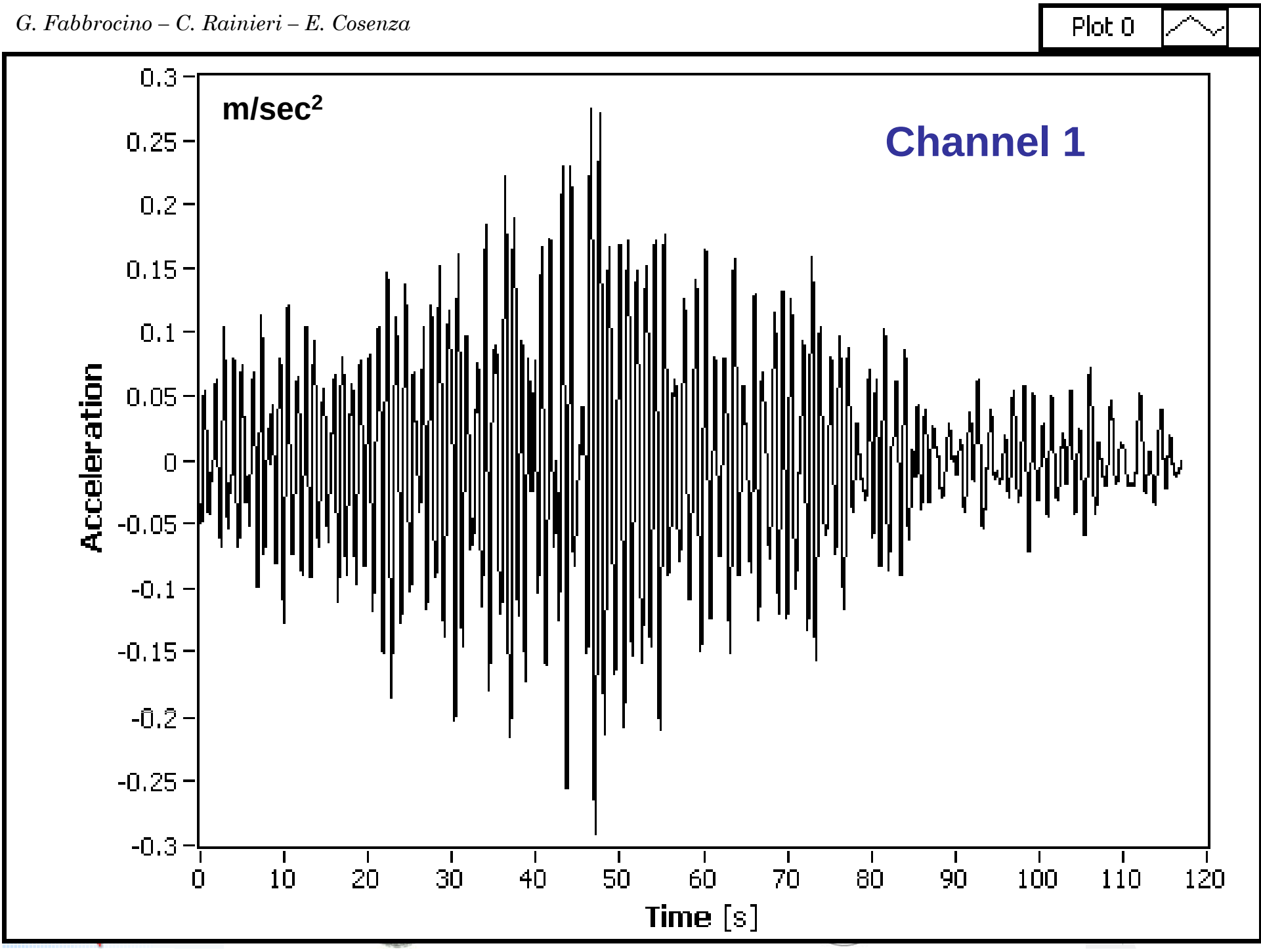
546 (Channel 6 Block 1)

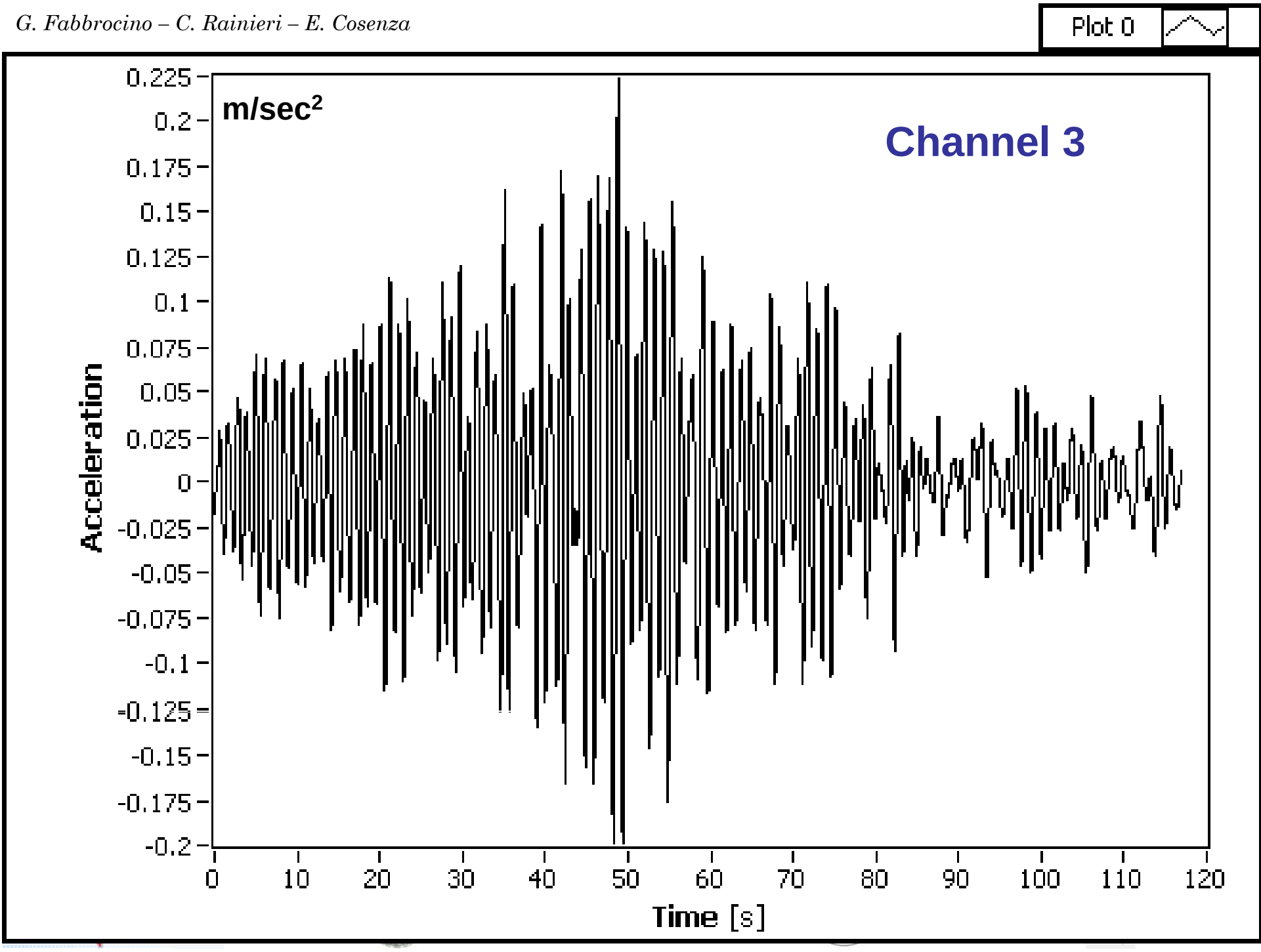
XI Floor

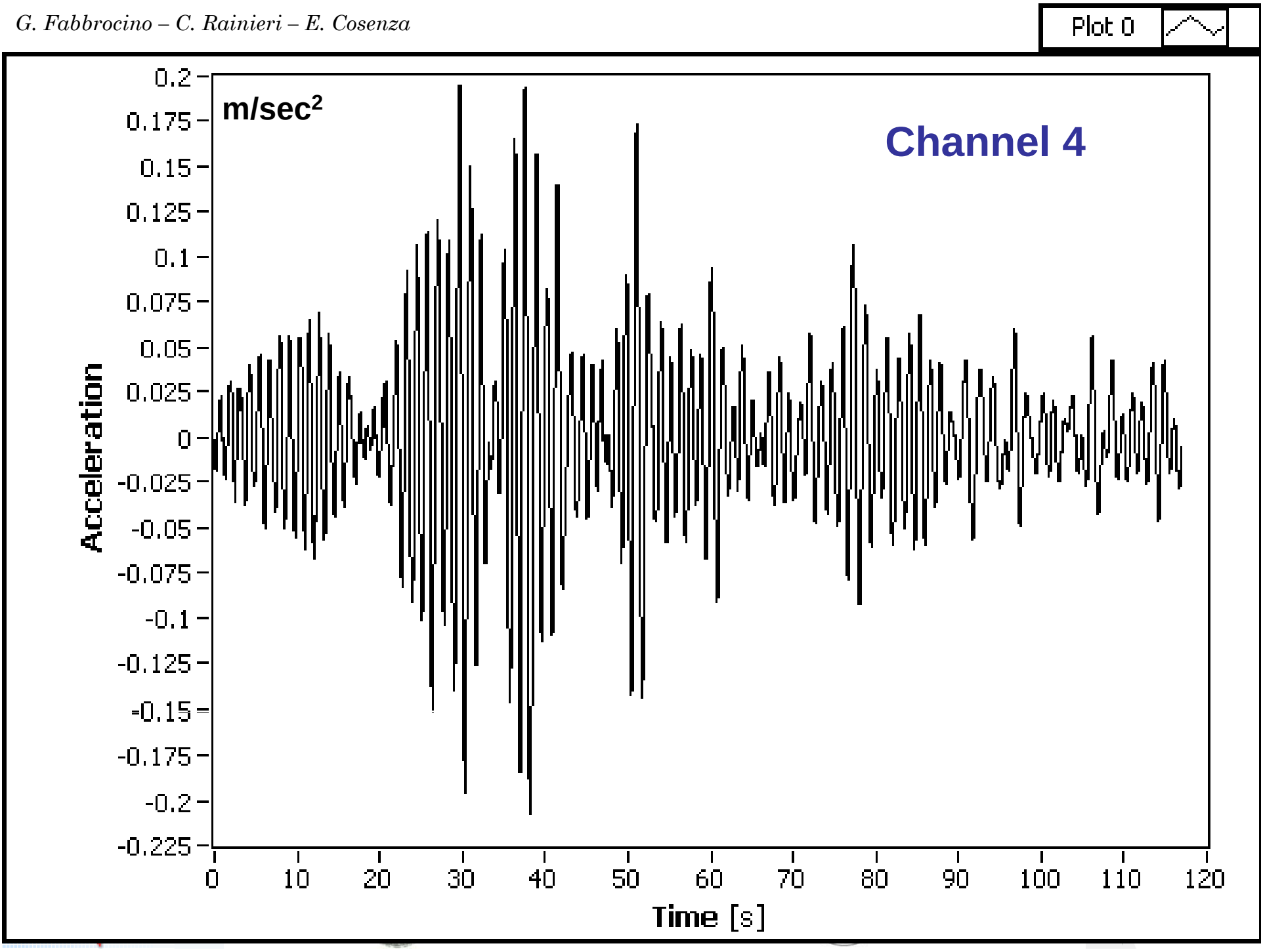
548 (Channel 7 Block 2)

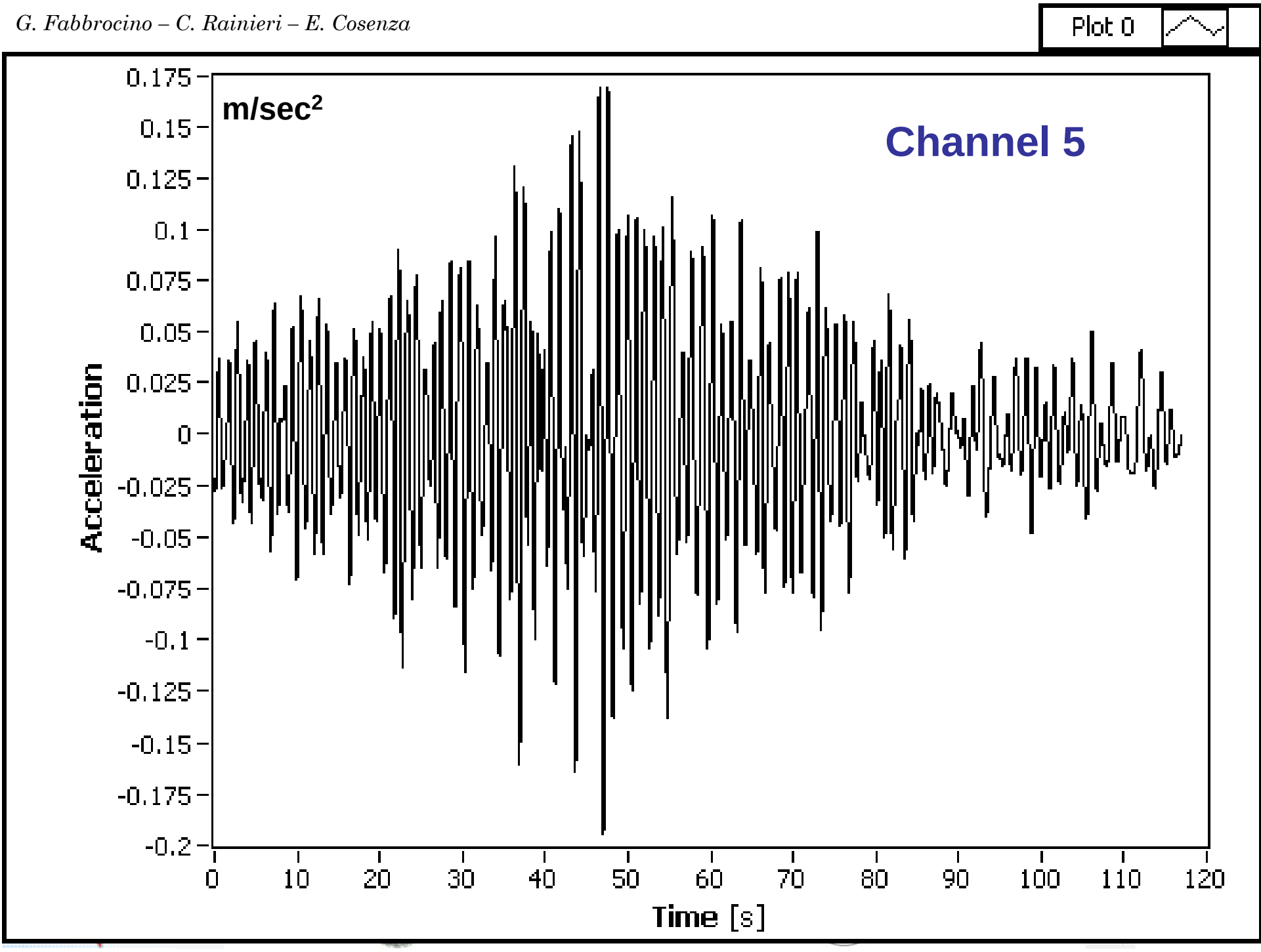
554 (Channel 8 Block 2)

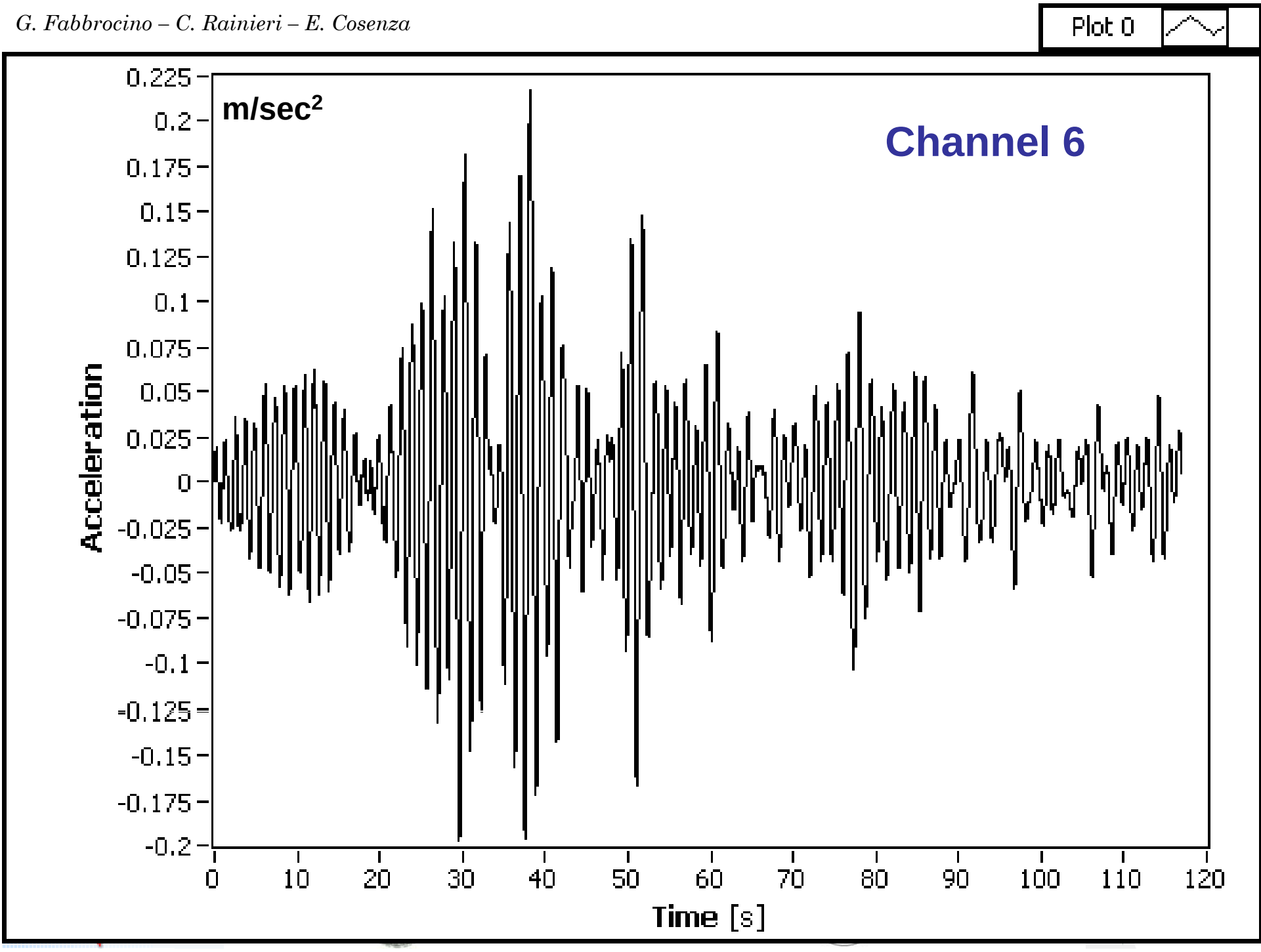
552 (Channel 1 Block 1)

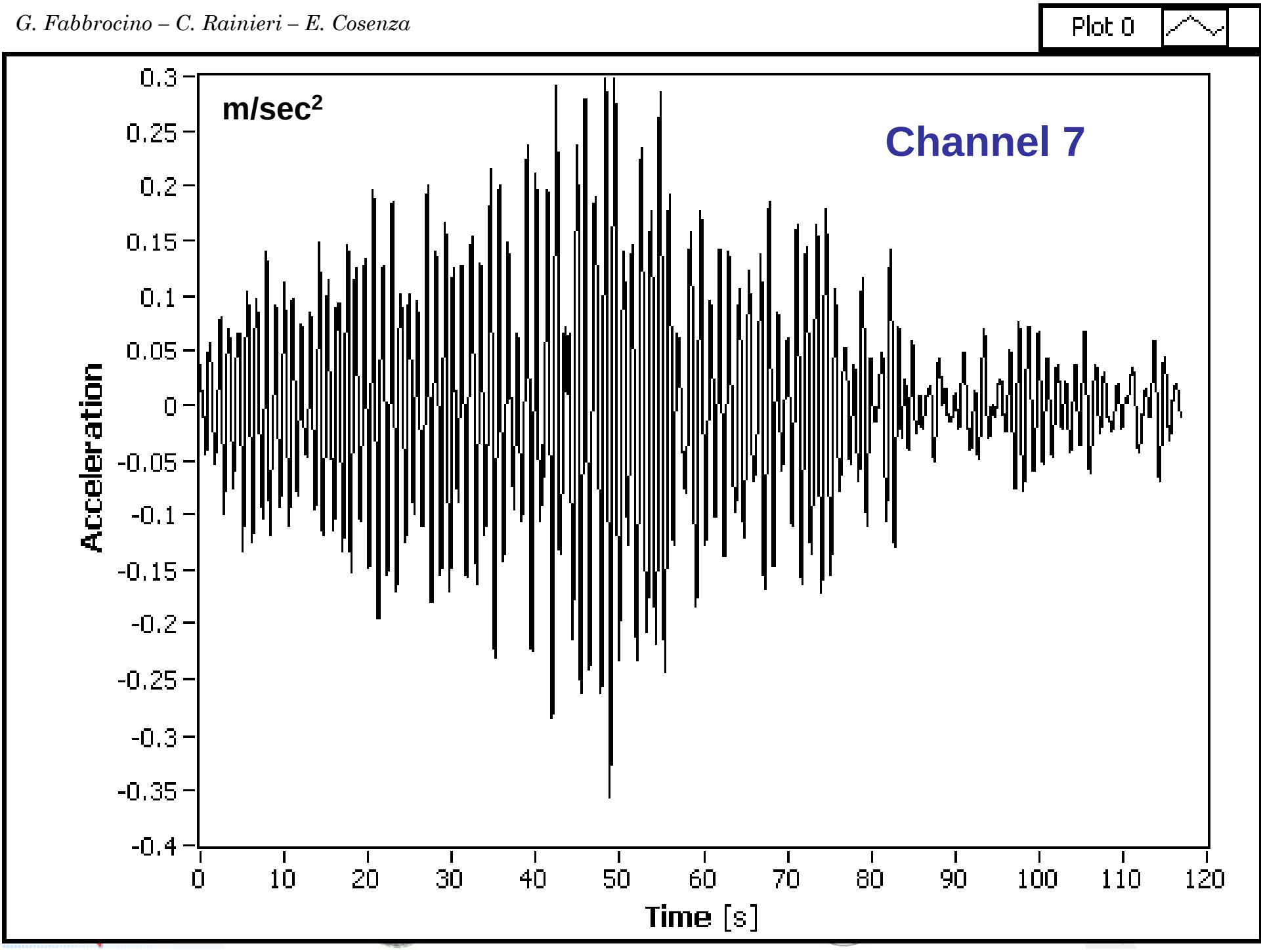

Plot 0
m/sec²
Channel 1
Acceleration
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]

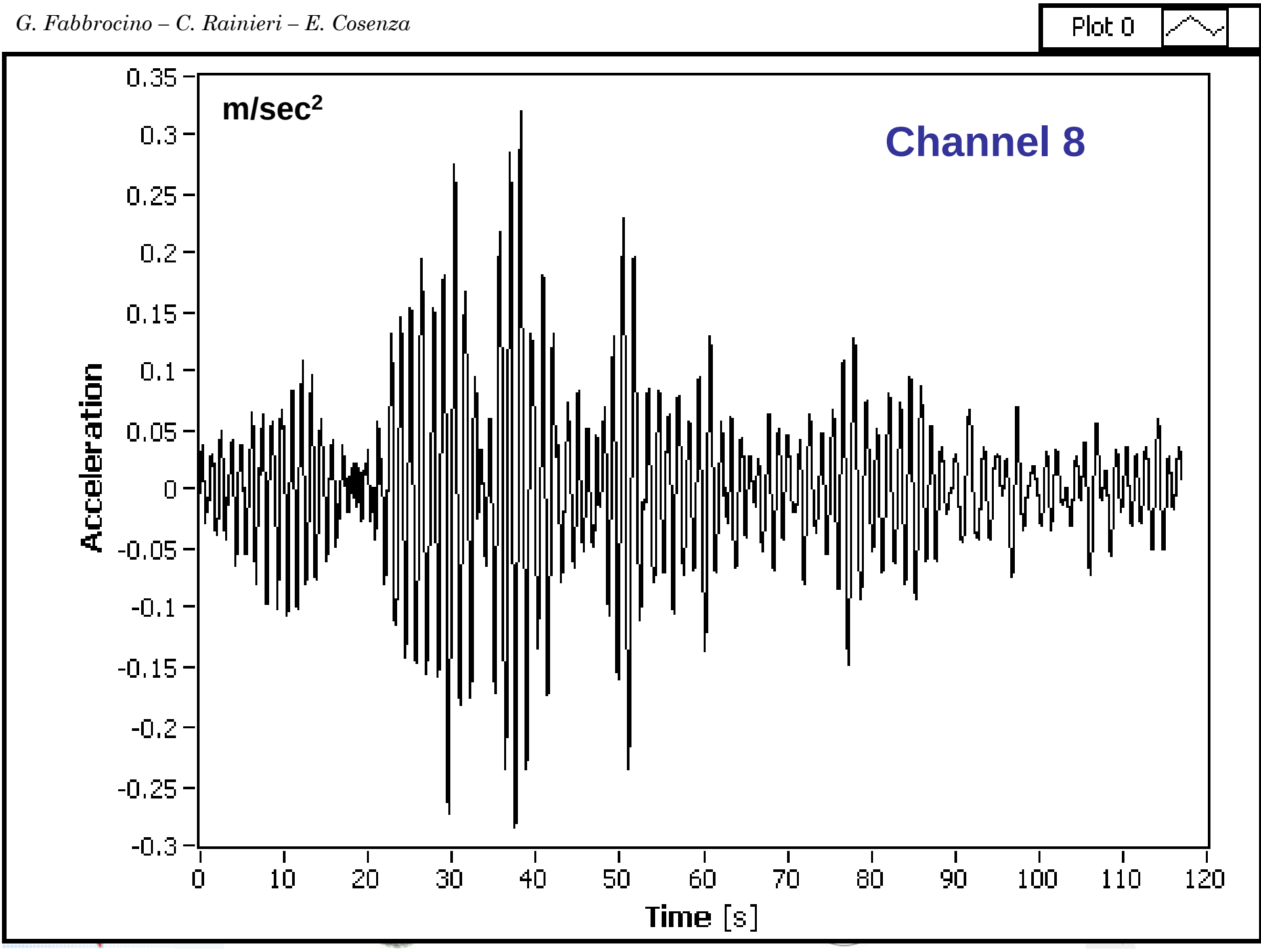

Plot 0
m/sec²
Channel 3
Acceleration
0.225
0.2
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
-0.025
-0.05
-0.075
-0.1
-0.125
-0.15
-0.175
-0.2
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]

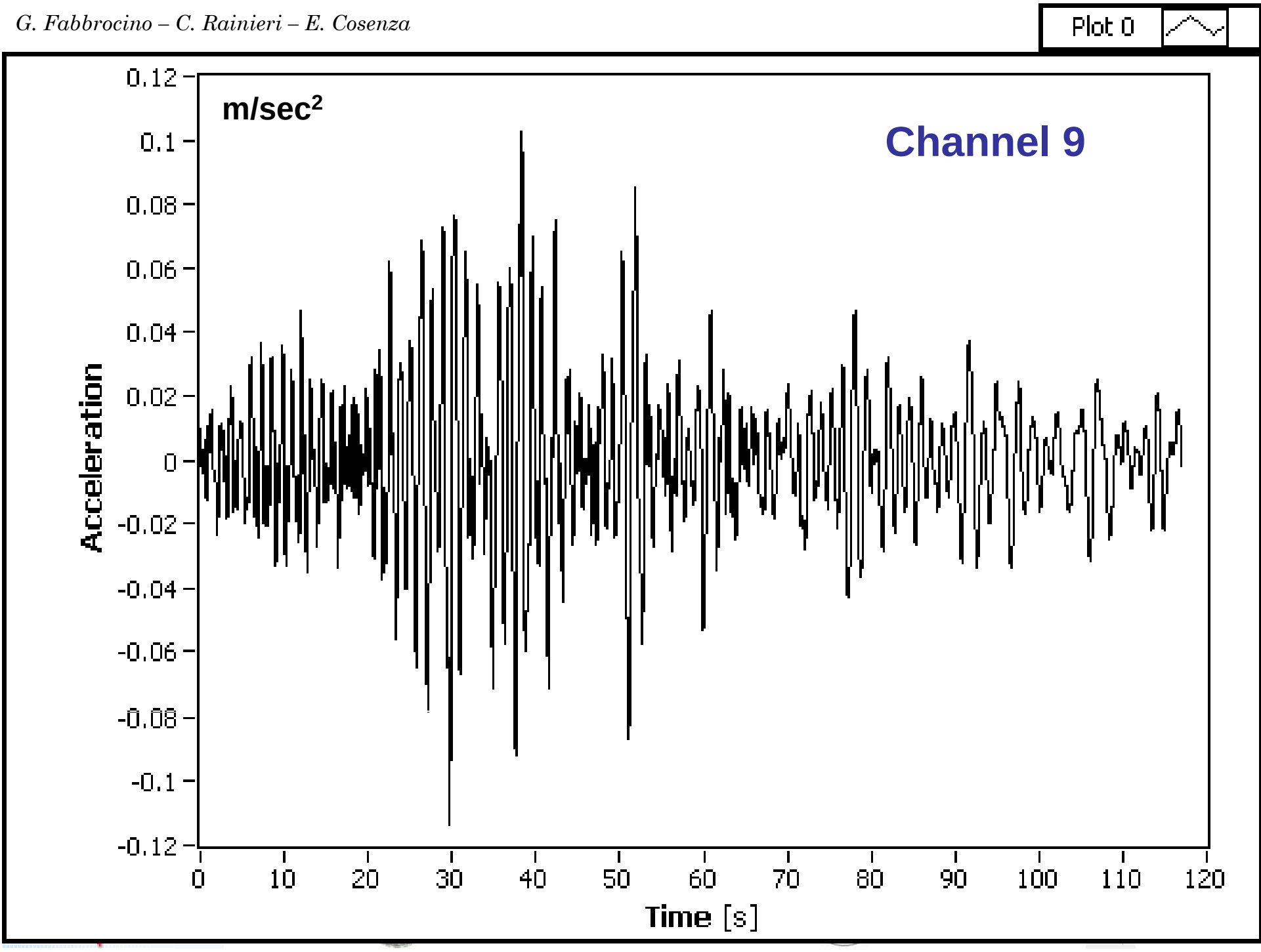

Plot 0
m/sec²
Channel 4
Acceleration
0.2
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
-0.025
-0.05
-0.075
-0.1
-0.125
-0.15
-0.175
-0.2
-0.225
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]

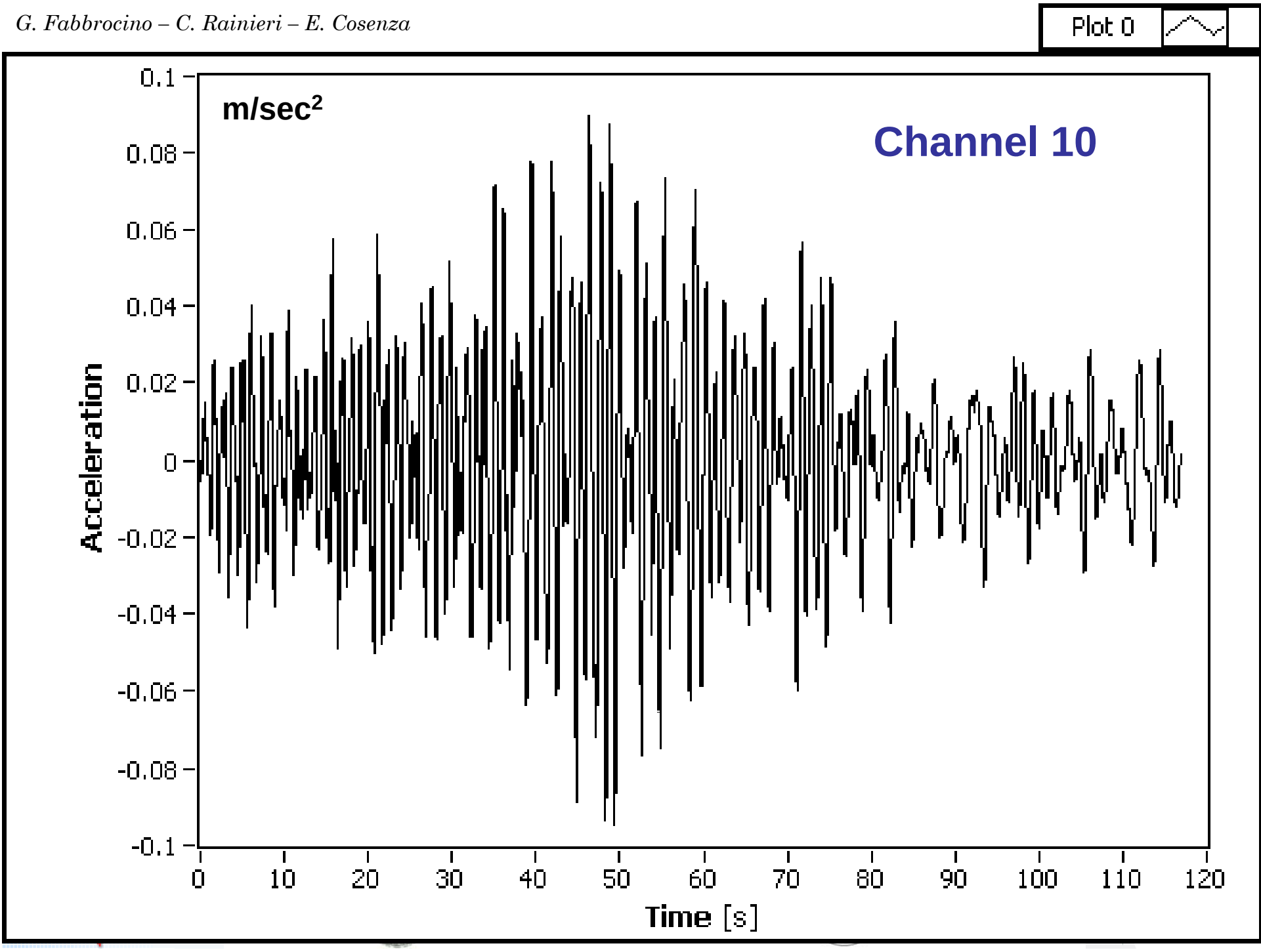

Plot 0
m/sec²
Channel 5
Acceleration
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
-0.025
-0.05
-0.075
-0.1
-0.125
-0.15
-0.175
-0.2
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]

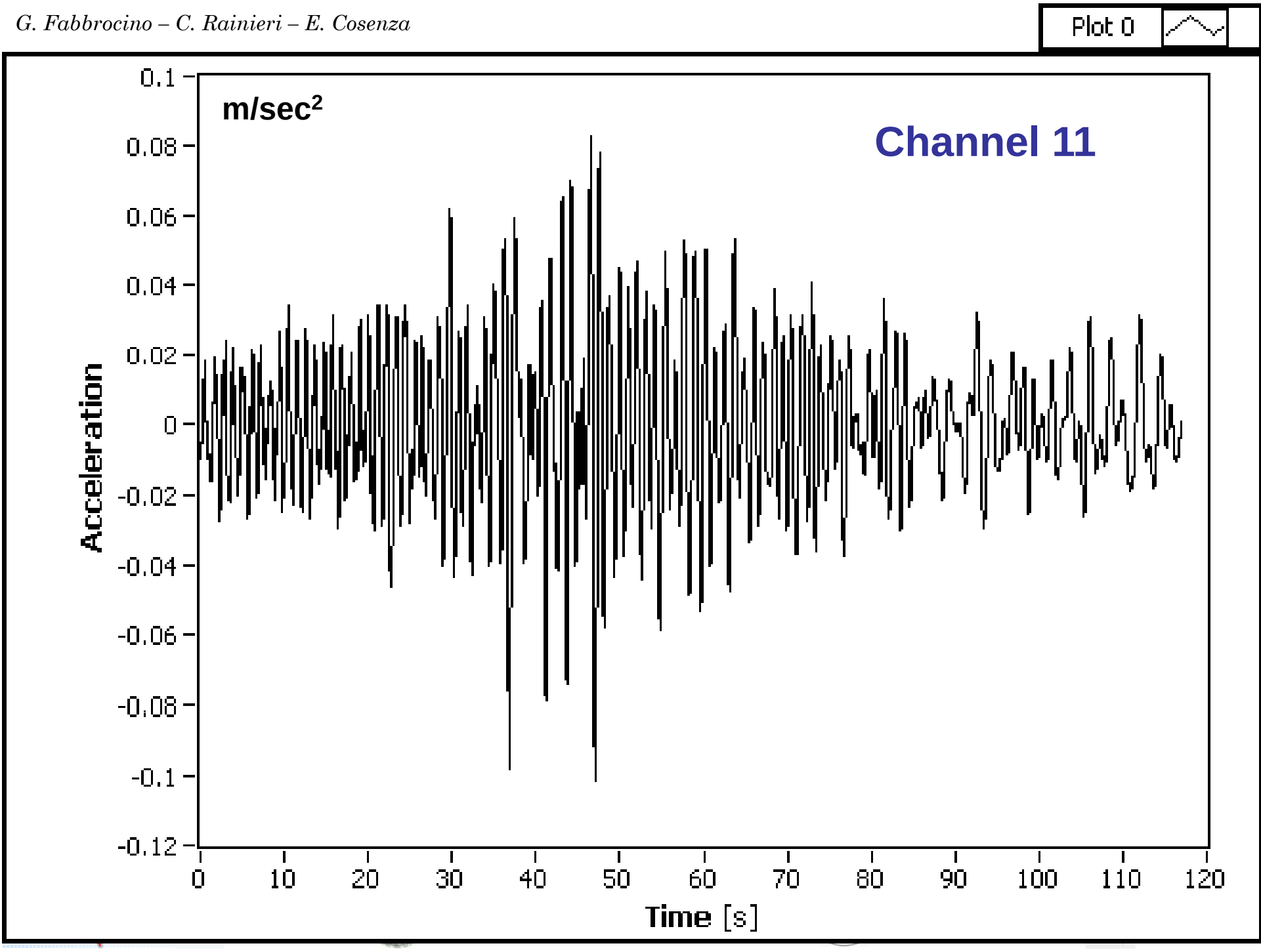

Plot 0
m/sec²
Channel 6
Acceleration
0.225
0.2
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
-0.025
-0.05
-0.075
-0.1
-0.125
-0.15
-0.175
-0.2
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]

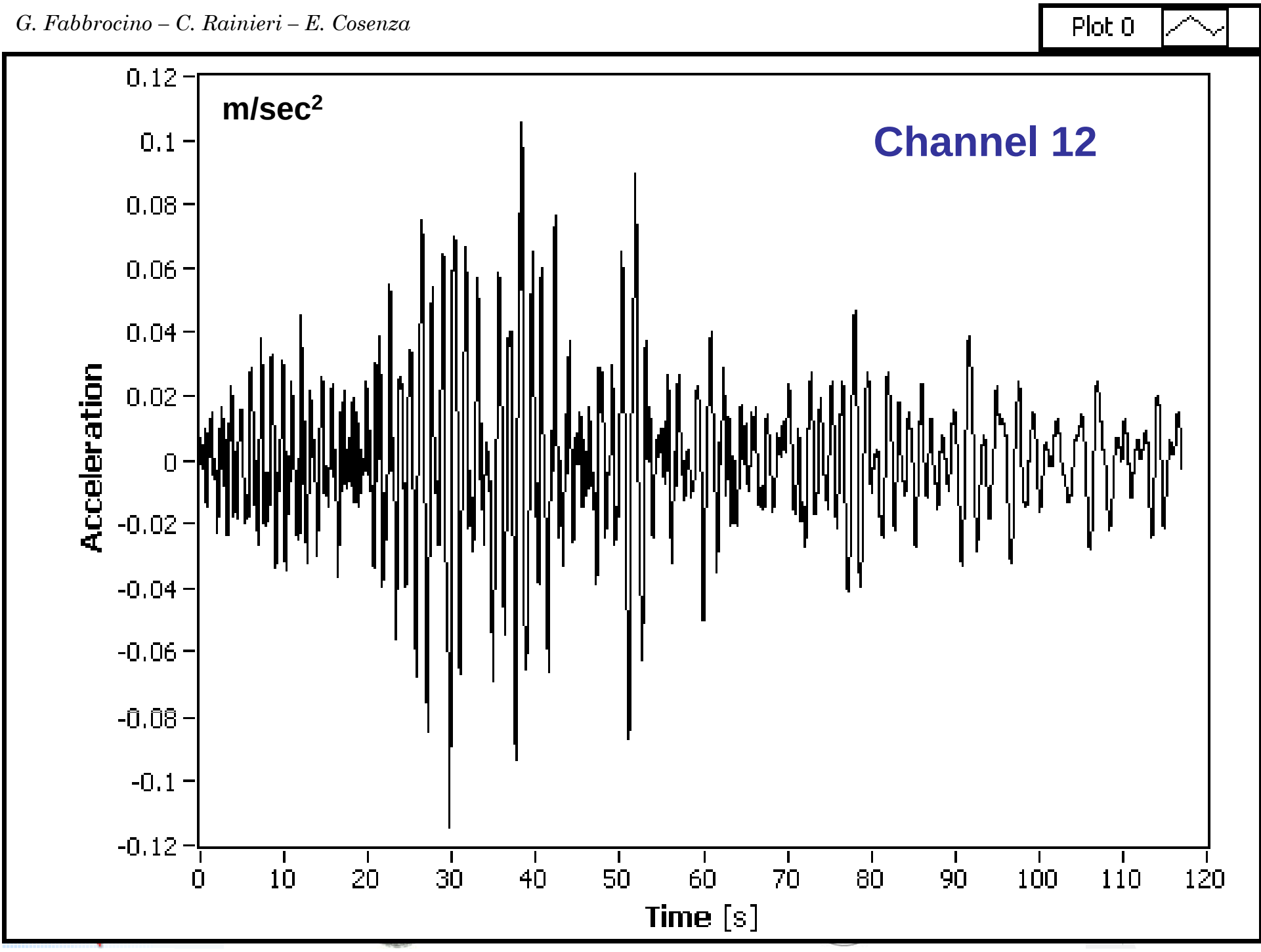

Plot 0
m/sec²
Channel 7
Acceleration
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]


Plot 0
m/sec²
Channel 8
Acceleration
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]


Plot 0
m/sec²
Channel 9
Acceleration
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]


Plot 0
m/sec²
Channel 10
Acceleration
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]


Plot 0
m/sec²
Channel 11
Acceleration
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]


Plot 0
m/sec²
Channel 12
Acceleration
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [s]

Peak accelerations at the roof (XI floor)

- **~0.03g ÷ 0.035g in x direction**
- **~0.028g in y direction**

Duration of relevant structural vibrations:

117 sec

Tracking of modal parameters:

Frequencies (f_i) and damping (ξ_i) before and after the shock

Time	f_1 [Hz]	f_2 [Hz]	f_3 [Hz]	ξ_1 [%]	ξ_2 [%]	ξ_3 [%]
3:20-3:30	0.94	1.00	1.31	1.20	1.09	0.60
3:40-3:50	0.88	0.97	1.28	1.73	1.51	2.36
3:50-4:00	0.9	0.97	1.29	1.24	0.97	1.25
5:30-5:40	0.9	0.97	1.28	0.74	1.10	0.58

References:

- ✓ *RAINIERI C., FABBROCINO G., COSENZA E. (2007): Automated Operational Modal Analysis as structural health monitoring tool: Theoretical and applicative aspects, KEY ENGINEERING MATERIALS Vol. 347 pp. 479-484, 2007. http://www.scientific.net/0-87849-444-8/479/*

- ✓ *RAINIERI C., FABBROCINO G., COSENZA E.: Continuous monitoring for performance evaluation of the dynamic response of the School of Engineering Main Building at University of Naples Federico II, The 6th International Workshop on Structural Health Monitoring, Stanford, USA, 2007.*

- ✓ *RAINIERI C., FABBROCINO G., COSENZA E., "Hardware and software solutions for continuous near real-time monitoring of the School of Engineering Main Building in Naples" IABSE Conference 2008, Helsinki, June, 2008.*