Acoustic positioning system update: towards KM3NeT-IT

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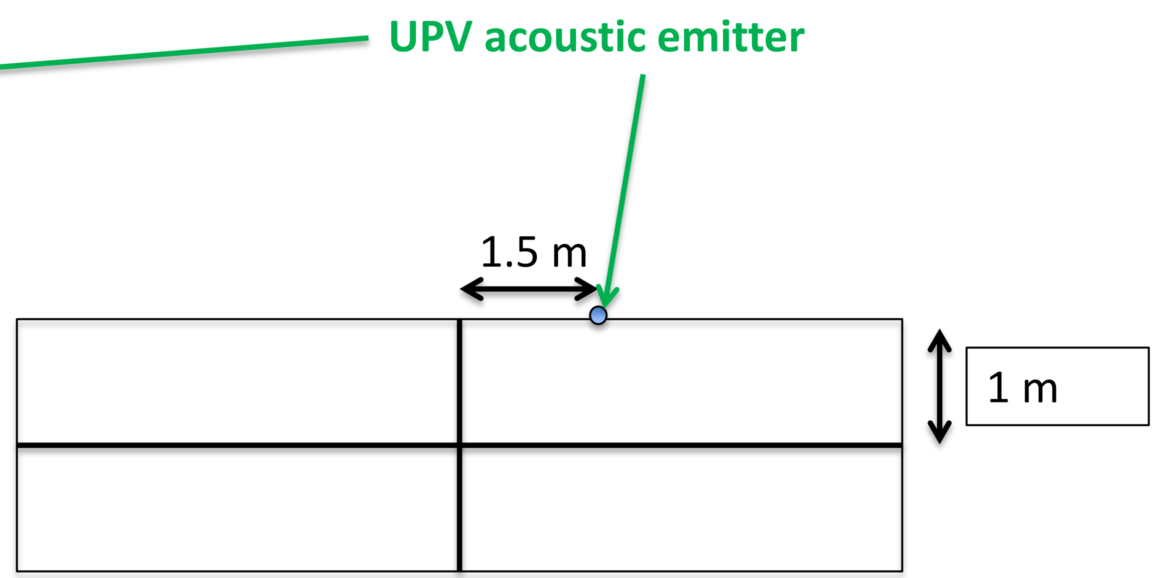
Catania, 21/03/2014

UPV Acoustic Beacon

FFR SX30 + Sound Emission Board (SEB), placed in the tower-base

- Acoustic emission time-synchronized with the GPS time
- Programmable acoustic signal emission (frequency, amplitude and waveform) through RS-232 link



Acoustic Beacon-UPV test: test-signals

Tests on Acoustic Beacon-UPV have been performed on 14/02/2014

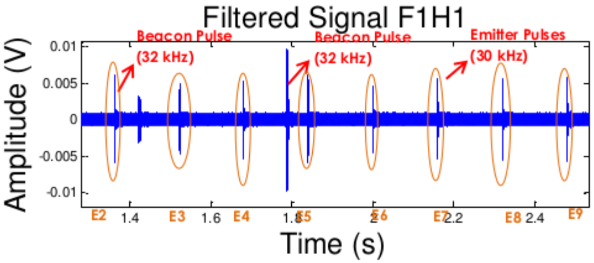
Different test-signals were emitted:

- Sine of 20 kHz. Maximum amplitude. Signal duration: 600 µs.
- Sine of 30 kHz. Maximum amplitude. Signal duration: 600 µs.
- Sine of 40 kHz. Maximum amplitude. Signal duration: 300 µs.
- Sine Sweep 28 kHz-44 kHz. Maximum amplitude. Signal duration: 800 µs.
- MLS 1 1. Signal duration: 5.2 ms

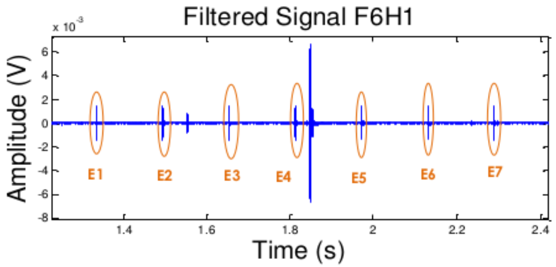
Five sequence emissions for each kind of signal.
Every sequence is composed of 20 acoustic pulses.

Analysis on 30 kHz test signal

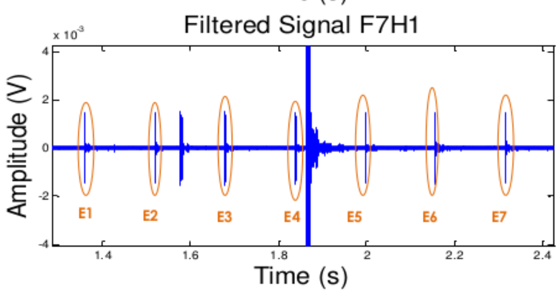
Same signal sequence recorded by different hydrophones (30 kHz Sine signal)



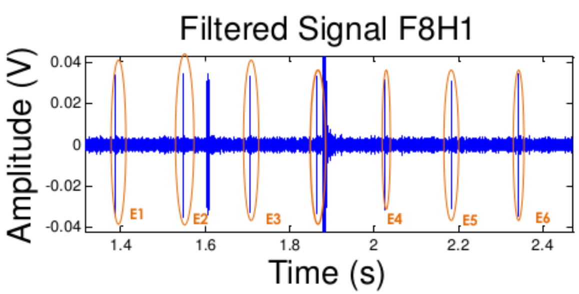
SMID Hydrophone (Floor 1)



SMID Hydrophone (Floor 6)



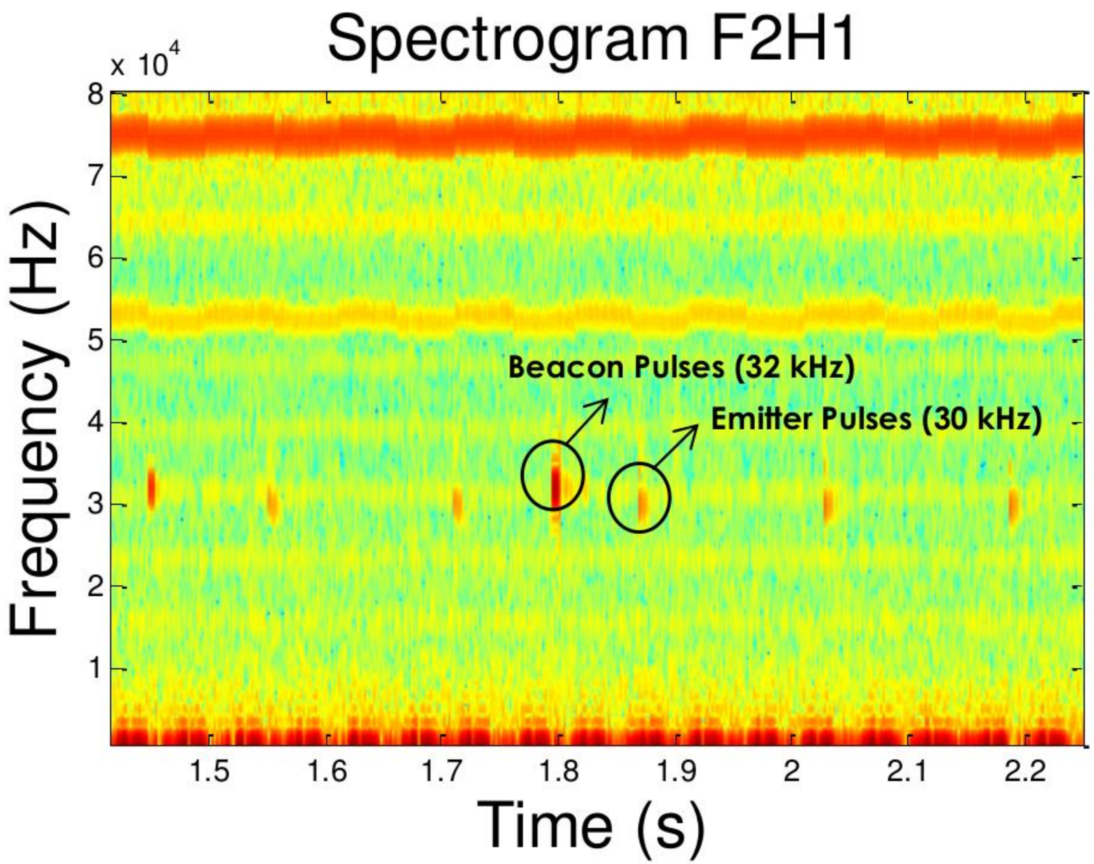
FFR Hydrophone (Floor 7)

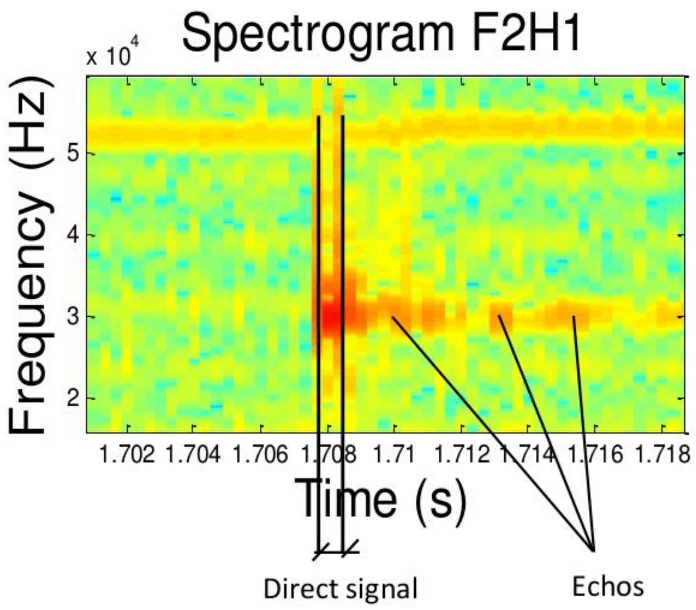


ECAP piezo (Floor 8)

(analysis performed by UPV)

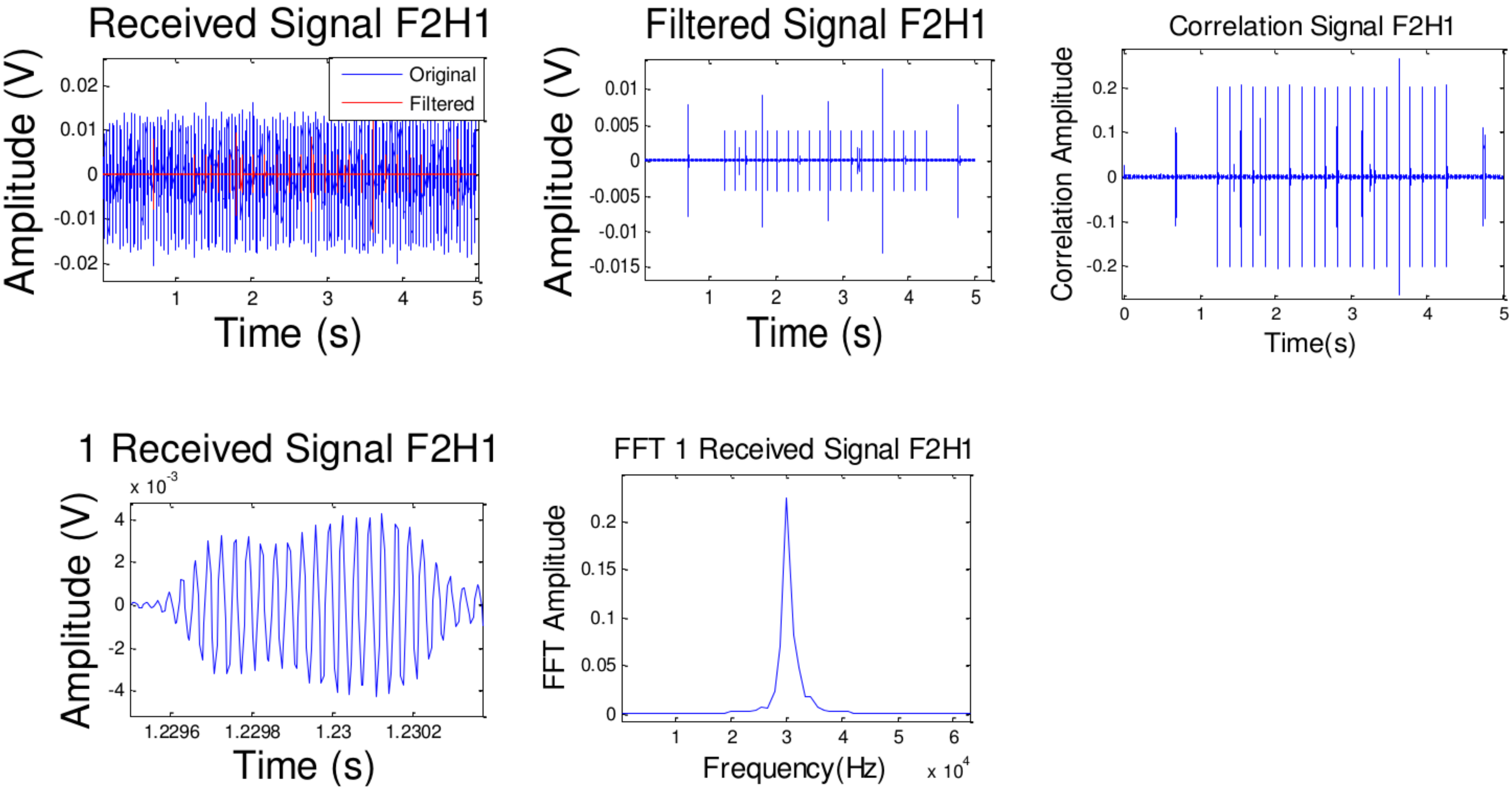
Analysis on 30 kHz test signal





(analysis performed by UPV)

Analysis on 30 kHz test signal



(analysis performed by UPV)

Acoustic Beacon-UPV test: power emission

The power emission value has been estimated by the received pressure values on each floor taking into account the nominal distances from each hydrophone and the acoustic absorption in sea water

$$P(r) = \frac{Po}{r}\, e^{-\alpha \cdot r} \quad \rightarrow P(1m) = P(r)\, r\, e^{\alpha(r-1)}$$

Power amplitude per floor (dB ref 1 µPa @ 1m)			
CALCULATED FROM FLOOR	Sine of 20 kHz	Sine of 30 kHz	Sine of 40 kHz
1	168.3411	171.4392	176.4939
2	163.2675	172.5461	174.8665
3	161.8884	171.1654	173.3895
4	163.3292	171.8446	174.6004
6	158.0311	165.9481	173.9801
7	155.3400	162.2207	166.9849
8	152.3371	167.9482	-

Measured on shore	164.6	171.8	171.2

(analysis performed by UPV)

Time of Flight (ToF) measurements

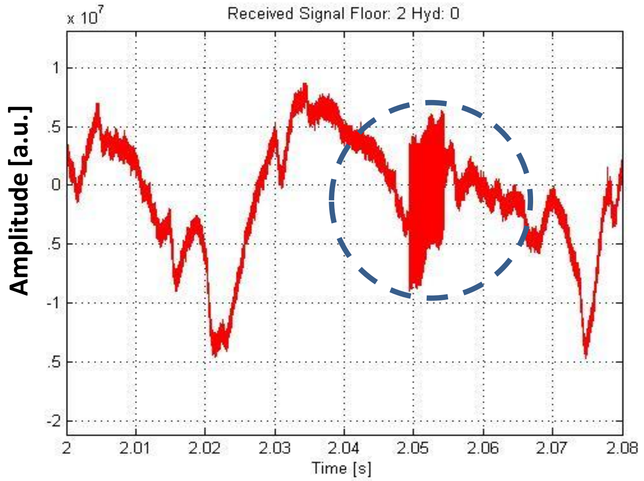
The time of flight is determined by the difference between the emission time and the initial time of the receiving signal.

TIME OF ARRIVAL (ToA) *CORRELATION METHOD*								
HYDRO	20 kHz Sine Signal		30 kHz Sine Signal		40 kHz Sine Signal		28kHz-44KhZ Sine Sweep Signal	
	MEAN (ms)	DEV. (ms)	MEAN (ms)	DEV. (ms)	MEAN (ms)	DEV. (ms)	MEAN (ms)	DEV. (ms)
1	66.097	0.153	66.178	0.040	66.151	0.026	66.156	0.027
2	65.931	0.143	66.073	0.045	66.0523	0.027	66.032	0.026
3	92.029	0.131	92.194	0.029	92.1526	0.026	92.132	0.027
4	92.058	0.068	92.149	0.030	92.1422	0.027	92.127	0.027
5	118.122	0.072	118.232	0.029	118.2705	0.027	118.207	0.027
6	118.208	0.029	118.182	0.030	118.1531	0.029	118.156	0.027
7	144.071	0.109	144.274	0.030	144.2573	0.049	144.247	0.027
8	144.224	0.103	144.309	0.030	144.2677	0.027	144.268	0.027
9	196.133	0.860	196.447	0.029	196.4832	0.027	196.449	0.026
10	195.731	0.120	195.850	0.029	196.4727	0.027	195.452	0.027
11	222.760	0.030	222.632	0.030	222.6264	0.031	222.631	0.026
12	222.471	0.114	222.688	0.036	222.6226	0.027	222.627	0.026
14	248.575	0.096	249.567	3.343	66.1510	0.027	-	-
MEAN		0.103		0.046		0.029		0.027
DEV.		0.207		0.882		0.006		0.0004

(analysis performed by UPV)

ExtractTOA module

In view of KM3NeT-Italia project, an independent software module for real-time beacon pulse recognition and TOA extrapolation has been developed. The module is fully integrated in the DAQ acquisition architecture. **(module written by C. Pellegrino)**



Module steps:

For each hydrophone, sample by sample:

1. A sliding window of 10s is buffered

2. Application of a frequency filter

3. Measurement of the median of energy in the filtered window

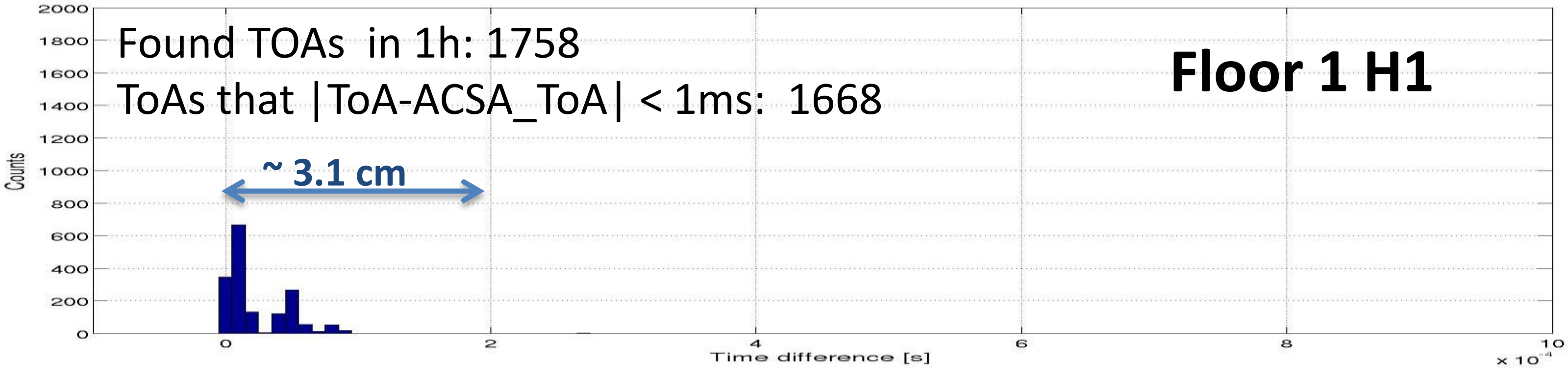
4. If a pulse with amplitude higher than 2 x median is present

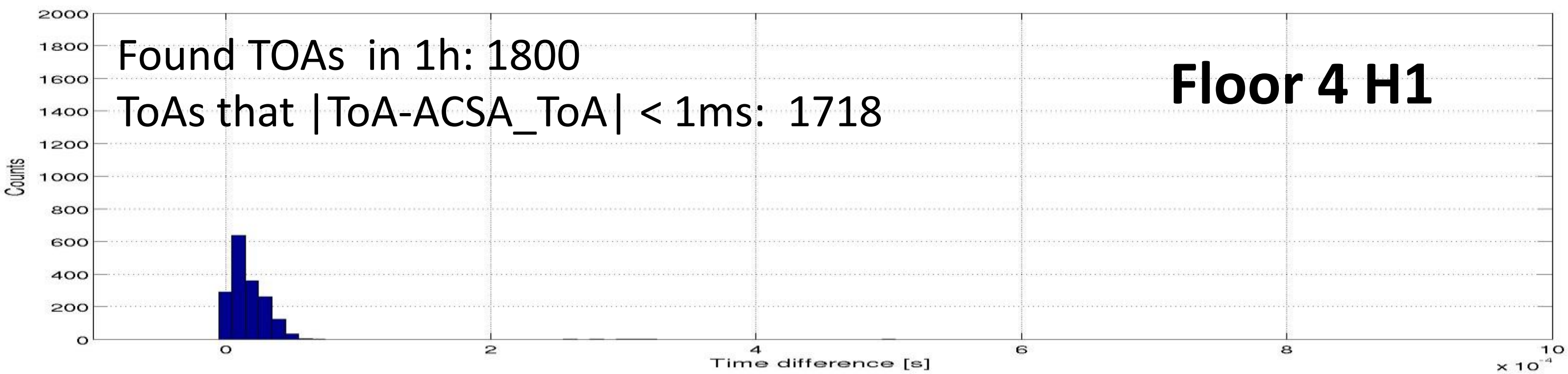
- 15 ms of acquired data are cross-correlated with the expected signal (5 ms long)

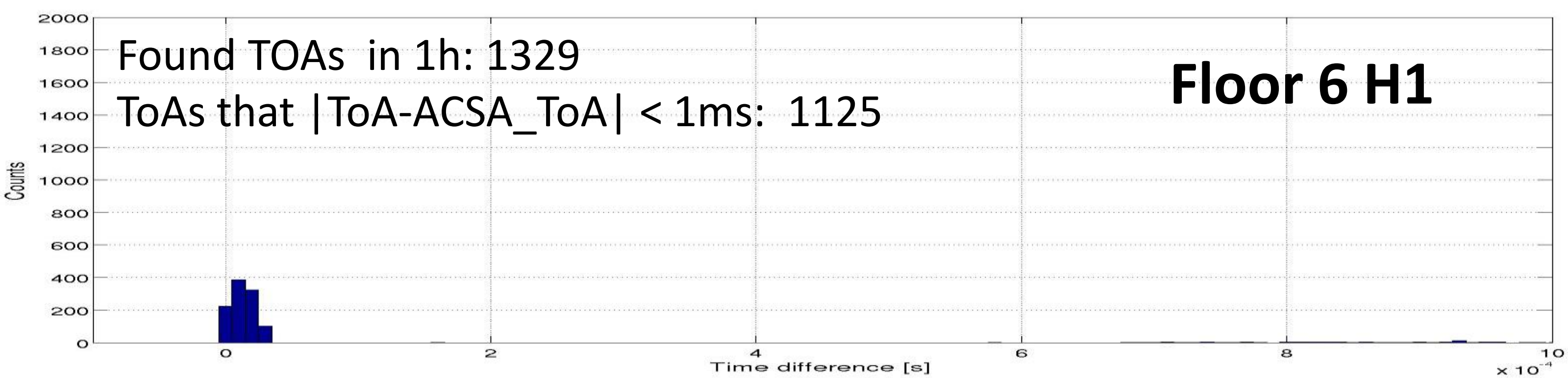
- GPS time related to maximum of the cross-correlation is assigned to the pulse (with a quality factor)

Comparison with ACSA ExtractToA

BEACON TOWER-BASE

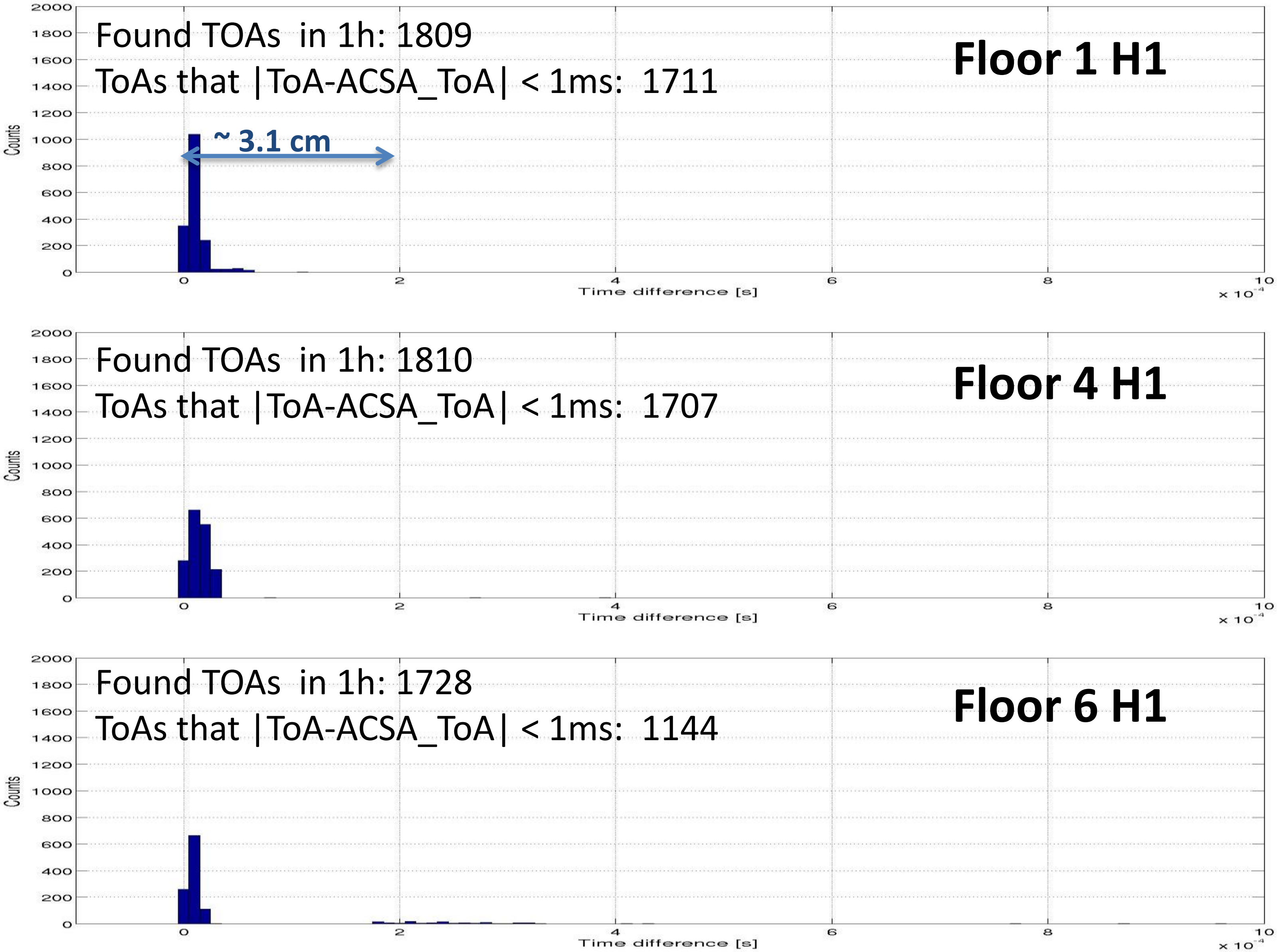




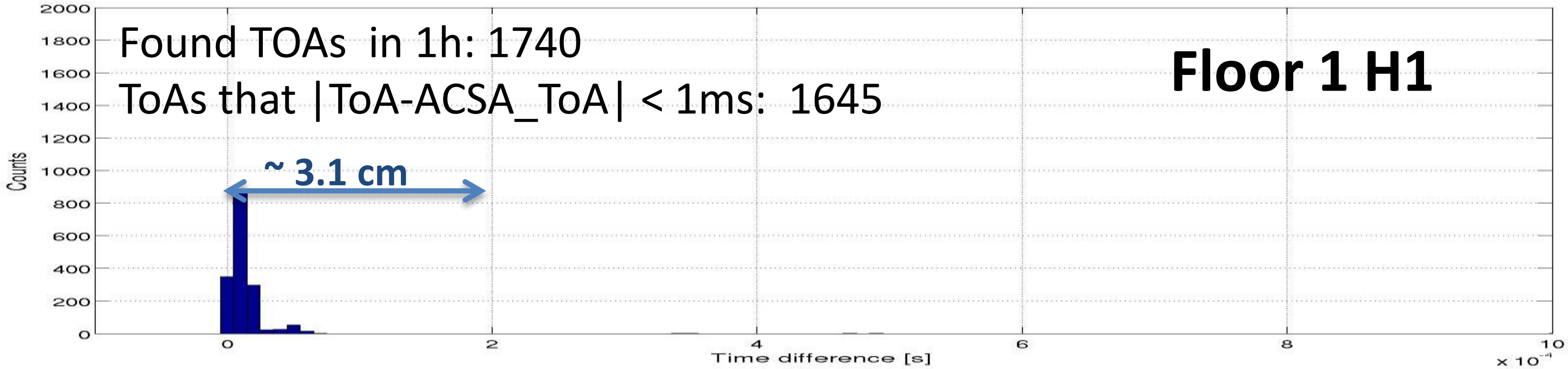


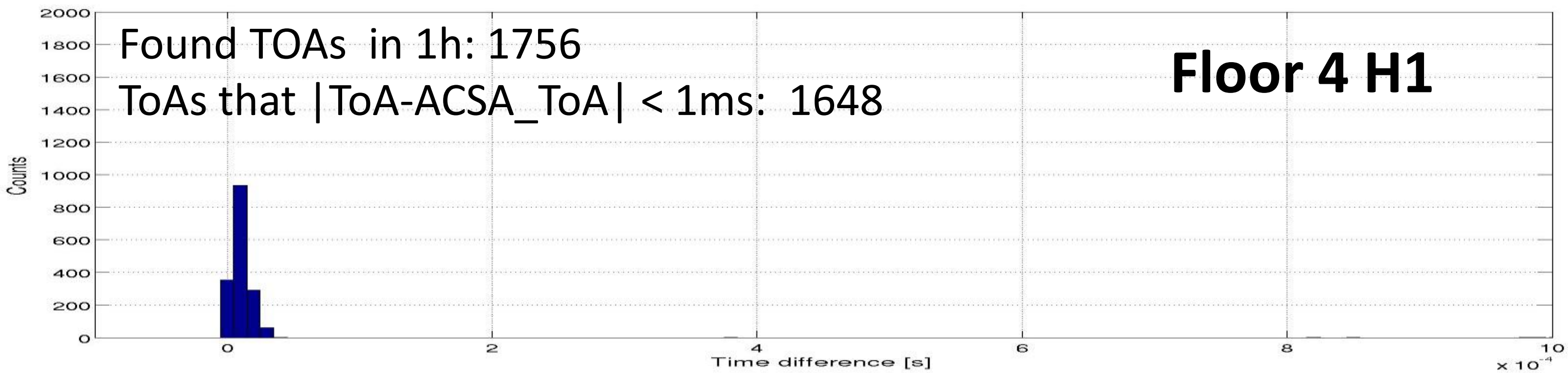
Comparison with ACSA ExtractToA

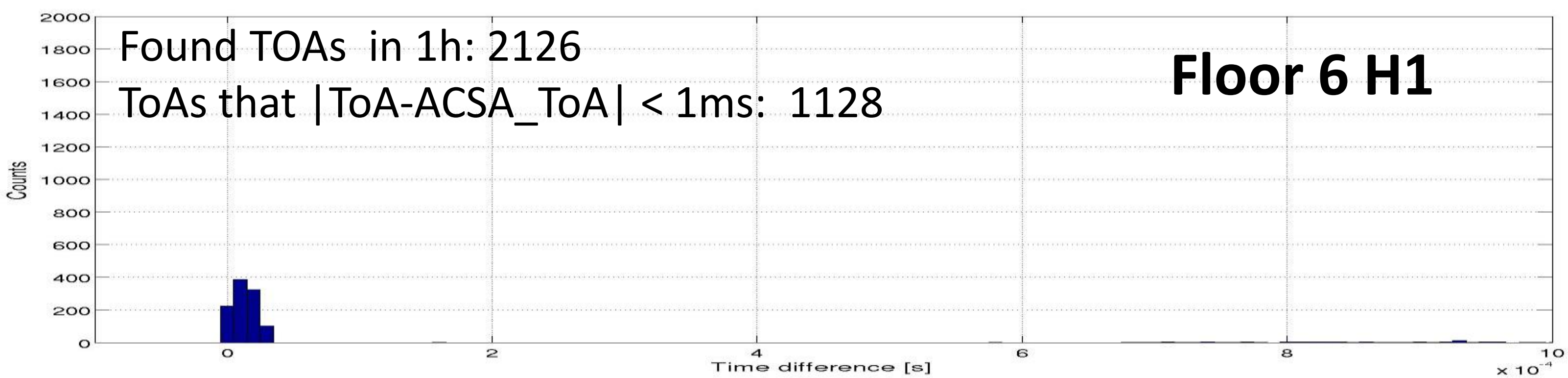
EXTERNAL BEACON #2



EXTERNAL BEACON #3







Conclusions and perspectives

UPV acoustic emitter

- UPV emitter works properly
- UPV acoustic signals are detected by all sensors of the tower (excpeted piezo F8H0)
- Good time accuracy (< 30 us → < 5cm)
- UPV emitter data will be included in the positioning global fit
- Positioning improvements have to be evaluate
  - ToAs asymmetry for hydrophones on floor 1
  - Distances hydrophones floors 1 – UPV emitter
  - Depth of floor 1 from CTD
  - Heading of floor 1 by the already existing positioning algorythm

Can we use hydrophones on floor 1 as monitoring station?

ExtractToA module

- The module is fully integrated in the acoustic DAQ
- A single PC can manage all sensors of the tower
- The module performances must be improved (tuning threshold, cuts on quality factor, …)

Thank you